



Tpetra Memory Transfer Tracking in Action

2023 Trilinos Users Group meeting

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Profiling Tools in Action



Goal: show snapshot of H2D/D2H transfers in Trilinos solvers for various application matrices

Model problem – 3D Laplacian, 27-point stencil

First order Stokes matrix from Albany Antarctic ice sheet simulation

Thermal Fluids performance proxy

SPARC performance proxy, tri-diagonal solver

Model Problem Description



Matrix:

- 3D Laplacian, 27 point FE stencil
- 1e6 rows
- Uniform distribution of rows across MPI ranks

4 MPI ranks, one GPU per rank

Conjugate gradient

AMG preconditioner

- Three level V-cycle
- Polynomial smoother
- Rebalancing on level 1
- LU coarse grid solve

Summary of H2D/D2H recurring patterns in solve

- 2 instances of zeroing out residual
- 1 instance of lazy initialization in coarse LU

Summary of H2D/D2H recurring patterns in setup

- 8 instances of TAFC (transfer and fill complete)
- 23 instances of map construction
- 2 instances of aggregation
- 1 instance of rebalancing*

Belos/MueLu Solve for 3D Laplacian, 27-pt stencil

```
1 | Driver: 5 - Belos Solve: 0.092458 - 8.77991% [1]
2 | | Belos: Operation Op*x: 0.000570107 - 0.616611% [1]
3 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.14323e-05 - 2.00528% [1]
4 | | Remainder: 0.000558675 - 97.9947%
5 | | Belos: PseudoBlockCGSolMgr total solve time: 0.090128 - 97.4799% [1]
6 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.55588e-05 - 0.0172629% [2]
7 | | Belos: Operation Prec*x: 0.0823409 - 91.3599% [12]
8 | | MueLu: Brick3D: Hierarchy: Solve (total): 0.0822411 - 99.8789% [12]
9 | | MueLu: Brick3D: Hierarchy: Solve (level=0): 0.0350726 - 42.646% [21]
10 | | MueLu: Brick3D: Hierarchy: Solve : smoothing (level=0): 0.00827787 - 23.6021% [24]
11 | | | Ifpack2::Chebyshev::apply: 0.00809126 - 97.7457% [24]
12 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000284189 - 3.5123% [48]
13 | | | Remainder: 0.00780707 - 96.4877%
14 | | | Remainder: 0.000186608 - 2.2543%
15 | | MueLu: Brick3D: Hierarchy: Solve : residual calculation (level=0): 0.00283266 - 8.07714% [12]
16 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 7.10675e-05 - 2.5086% [12]
17 | | | Remainder: 0.00276179 - 97.4913%
18 | | MueLu: Brick3D: Hierarchy: Solve : restriction (level=0): 0.0040801 - 11.6333% [12]
19 | | | Kokkos::deep_copy [Host=>Cuda] {(none)=>MV::DualView}: 0.000110573 - 2.71005% [36]
20 | | | Remainder: 0.00396953 - 97.29%
21 | | MueLu: Brick3D: Hierarchy: Solve : import (level=1): 0.000771687 - 2.20026% [12]
22 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 6.1079e-05 - 7.915% [12]
23 | | | Remainder: 0.000710608 - 92.085%
24 | | MueLu: Brick3D: Hierarchy: Solve : export (level=1): 0.0165228 - 47.1103% [12]
25 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 5.2514e-05 - 0.317828% [12]
26 | | | Remainder: 0.0164703 - 99.6822%
27 | | MueLu: Brick3D: Hierarchy: Solve : prolongation (level=0): 0.00232889 - 6.6402% [12]
28 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 5.32413e-05 - 2.28612% [12]
29 | | | Remainder: 0.00227565 - 97.7139%
30 | | Remainder: 0.000258379 - 0.736698%
31 | MueLu: Brick3D: Hierarchy: Solve (level=1): 0.0449524 - 54.6592% [16]
32 | MueLu: Brick3D: Hierarchy: Solve : smoothing (level=1): 0.00377343 - 8.39428% [24]
33 | | Ifpack2::Chebyshev::apply: 0.00358362 - 94.9699% [24]
34 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000212587 - 5.93218% [48]
35 | | | Remainder: 0.00337103 - 94.0678%
36 | | | Remainder: 0.000189806 - 5.03008%
37 | MueLu: Brick3D: Hierarchy: Solve : residual calculation (level=1): 0.000869459 - 1.93418% [12]
38 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 5.321e-05 - 6.1199% [12]
39 | | Remainder: 0.000816249 - 93.8801%
40 | MueLu: Brick3D: Hierarchy: Solve : restriction (level=1): 0.00151991 - 3.38116% [12]
41 | | Kokkos::deep_copy [Host=>Cuda] {(none)=>MV::DualView}: 0.000111333 - 7.32499% [36]
42 | | Remainder: 0.00140858 - 92.675%
43 | MueLu: Brick3D: Hierarchy: Solve : import (level=2): 0.000718785 - 1.59899% [12]
44 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 4.9339e-05 - 6.86422% [12]
45 | | Remainder: 0.000669446 - 93.1358%
46 | MueLu: Brick3D: Hierarchy: Solve : export (level=2): 0.0364644 - 81.1178% [12]
47 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 7.6167e-05 - 0.208881% [12]
48 | | Remainder: 0.0363882 - 99.7911%
49 | MueLu: Brick3D: Hierarchy: Solve : prolongation (level=1): 0.00137372 - 3.05595% [12]
50 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 5.6894e-05 - 4.1416% [12]
51 | | Remainder: 0.00131683 - 95.8584%
52 | | Remainder: 0.000232674 - 0.517601%
53 | MueLu: Brick3D: Hierarchy: Solve (level=2): 0.0534256 - 64.9621% [12]
54 | MueLu: Brick3D: Hierarchy: Solve : coarse (level=2): 0.0533833 - 99.9209% [12]
55 | | Kokkos::deep_copy_small [Host=>Cuda] {>nonContigGids}: 1.7968e-05 - 0.0336584% [37]
56 | | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 0.000442659 - 0.829208% [37]
57 | | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 5.6532e-05 - 0.105898% [37]
58 | | Kokkos::deep_copy [Host=>Cuda] {lgMap_mirror=>lgMap}: 0.000167901 - 0.314519% [37]
59 | | Tpetra : TAFc All:MMLegacy: 0.00179299 - 3.35871% [1]
60 | | | Tpetra : TAFc getOwningPIDs all local entries: 2.142e-06 - 0.119465% [1]
61 | | | Tpetra : TAFc reallocate buffers: 1.069e-06 - 0.0596211% [1]
62 | | | Tpetra : TAFc pack and prepare: 8.0971e-05 - 4.51598% [1]
63 | | | Kokkos::deep_copy_small [Host=>Cuda] {>export_lids}: 3.83e-07 - 0.473009% [1]
64 | | | Kokkos::deep_copy [Host=>Cuda] {>export_pids}: 4.445e-06 - 5.48962% [1]
65 | | | Remainder: 7.6143e-05 - 94.0374%
66 | | | Tpetra : TAFc getOwningPIDs exchange remote data: 4.62e-07 - 0.025767% [1]
67 | | | Tpetra : TAFc unpack-count-resize + copy same-perm-remote data: 0.000666903 - 37.195% [1]
68 | | | | Tpetra::Details::unpackAndCombineIntoCrsArrays_new: unpackAndCombineWithOwningPIDsCount: 8.8272e-05 - 13.2361% [1]
69 | | | | Tpetra::Details::unpackAndCombineIntoCrsArrays_new: resize CRS pointers: 5.3012e-05 - 7.94898% [1]
70 | | | | Tpetra::Details::unpackAndCombineIntoCrsArrays_new: create mirror views from inputs: 8.8458e-05 - 13.264% [1]
71 | | | | Kokkos::deep_copy [Host=>Cuda] {>src_pids}: 4.368e-06 - 4.93794% [1]
72 | | | | Kokkos::deep_copy [Host=>Cuda] {>_mirror}: 4.3531e-05 - 49.2109% [1]
73 | | | | Remainder: 4.0559e-05 - 45.8511%
74 | | | | Tpetra::Details::unpackAndCombineIntoCrsArrays_new: unpackAndCombineIntoCrsArrays: 0.000244025 - 36.5908% [1]
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75 | | Tpetra::Details::unpackAndCombineIntoCrsArrays_new: copy back to host: 7.382e-05 - 11.0691% [1]
76 | | Kokkos::deep_copy [Cuda=>Host] {_mirror=>}: 6.2344e-05 - 84.4541% [1]
77 | | Remainder: 1.1476e-05 - 15.5459%
78 | | Remainder: 0.000119316 - 17.8911%
79 | | Tpetra : TAFc makeColMap: 0.000832606 - 46.4367% [1]
80 | | Kokkos::deep_copy [Host=>Cuda] {>owningPIDs}: 4.2389e-05 - 5.09112% [1]
81 | | Kokkos::deep_copy_scalar [Host=>Cuda] {Scalar=>UnorderedMap hash list}: 3.45e-05 - 4.14362% [2]
82 | | Kokkos::deep_copy_scalar [Host=>Cuda] {Scalar=>UnorderedMap next index}: 2.2269e-05 - 2.67461% [2]
83 | | Remainder: 0.000733448 - 88.0906%
84 | | Tpetra : TAFc restrict colmap: 8.36e-07 - 0.046626% [1]
85 | | Tpetra : TAFc sortCrsEntries: 6.257e-06 - 0.34897% [1]
86 | | Tpetra : TAFc setAllValues: 1.708e-05 - 0.952599% [1]
87 | | Tpetra : TAFc build importer and esfc: 9.5526e-05 - 5.32775% [1]
88 | | | Tpetra : TAFc notMMblock: 9.3422e-05 - 97.7975% [1]
89 | | | Tpetra : TAFc notMMCreateImporter: 9.1595e-05 - 98.0444% [1]
90 | | | Tpetra : notMMdestMat->expertStaticFillComplete: 8.8108e-05 - 96.193% [1]
91 | | | Tpetra Tpetra : notMM eSFC: eSFC-all: 8.2136e-05 - 93.222% [1]
92 | | | Tpetra Tpetra : notMM eSFC: eSFC-M-Graph: 7.3144e-05 - 89.0523% [1]
93 | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-Setup: 2.3427e-05 - 32.0286% [1]
94 | | | | Kokkos::deep_copy [Cuda=>Host] {>rowPtrsUnpacked_host_}: 1.7972e-05 - 76.7149% [1]
95 | | | | Remainder: 5.455e-06 - 23.2851%
96 | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-Maps: 8.55e-07 - 1.16893% [1]
97 | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-mIXcheckI: 8.57e-07 - 1.17166% [1]
98 | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-mIXcheckE: 4.71e-07 - 0.643935% [1]
99 | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-mIXmake: 8.156e-06 - 11.1506% [1]
100 | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-FLG: 5.126e-06 - 7.00809% [1]
101 | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-cGc (const): 2.1097e-05 - 28.8431% [1]
102 | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-cIS: 3.12e-07 - 0.426556% [1]
103 | | | | Remainder: 1.2843e-05 - 17.5585%
104 | | | | Tpetra Tpetra : notMM eSFC: eSFC-M-FLGAM: 3.179e-06 - 3.87041% [1]
105 | | | | Tpetra Tpetra : notMM eSFC: eSFC-M-cIS: 1.732e-06 - 2.1087% [1]
106 | | | | Remainder: 4.081e-06 - 4.96859%
107 | | | | Remainder: 5.972e-06 - 6.77805%
108 | | | | Remainder: 3.487e-06 - 3.80698%
109 | | | | Remainder: 1.827e-06 - 1.95564%
110 | | | | Remainder: 2.104e-06 - 2.20254%
111 | | | | Remainder: 8.9138e-05 - 4.97147%
112 | | Tpetra : ESFC-all: 5.4404e-05 - 0.101912% [1]
113 | | | Tpetra : eSFC-M-Graph: 4.6618e-05 - 85.6886% [1]
114 | | | Tpetra : ESFC-G-Setup: 2.2625e-05 - 48.5328% [1]
115 | | | | Kokkos::deep_copy [Cuda=>Host] {>rowPtrsUnpacked_host_}: 1.8216e-05 - 80.5127% [1]
116 | | | | Remainder: 4.409e-06 - 19.4873%
117 | | | | Tpetra : ESFC-G-Maps: 7.92e-07 - 1.69891% [1]
118 | | | | Tpetra : ESFC-G-mIXcheckI: 8.53e-07 - 1.82977% [1]
119 | | | | Tpetra : ESFC-G-mIXcheckE: 2.87e-07 - 0.615642% [1]
120 | | | | Tpetra : ESFC-G-mIXmake: 4.279e-06 - 9.17886% [1]
121 | | | | Tpetra : ESFC-G-FLG: 2.663e-06 - 5.71239% [1]
122 | | | | Tpetra : ESFC-G-cGc (const): 2.563e-06 - 5.49788% [1]
123 | | | | Tpetra : ESFC-G-cIS: 4.43e-07 - 0.950277% [1]
124 | | | | Remainder: 1.2113e-05 - 25.9835%
125 | | | | Tpetra : eSFC-M-FLGAM: 2.391e-06 - 4.3949% [1]
126 | | | | Tpetra : ESFC-M-cIS: 1.539e-06 - 2.82884% [1]
127 | | | | Remainder: 3.856e-06 - 7.08771%
128 | | | Kokkos::deep_copy [Cuda=>Host] {lgMap=>lgMap_mirror}: 1.3335e-05 - 0.0249797% [1]
129 | | | Kokkos::deep_copy [Cuda=>Host] {>rowPtrsUnpacked_host_}: 1.6805e-05 - 0.0314799% [1]
130 | | | Kokkos::deep_copy [Cuda=>Host] {>_mirror}: 0.000187265 - 0.350793% [2]
131 | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>dst}: 0.000213609 - 0.400142% [12]
132 | | | Kokkos::deep_copy [Host=>Cuda] {dst=>MV::DualView}: 0.000191079 - 0.357938% [12]
133 | | | Remainder: 0.0502288 - 94.0908%
134 | | | Remainder: 4.2252e-05 - 0.0790857%
135 | | | Remainder: -0.0512094 - -62.2673%
136 | | | Remainder: 9.9705e-05 - 0.121088%
137 | | | Belos: Operation Op*x: 0.00110056 - 1.2211% [11]
138 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 7.14168e-05 - 6.48916% [11]
139 | | | Remainder: 0.00102914 - 93.5108%
140 | | | Remainder: 0.00667103 - 7.40173%
141 | | | Remainder: 0.00175993 - 1.9035%
```

Multigrid grid transfer
Initializing residual

Belos/MueLu Solve for 3D Laplacian, 27-pt stencil

```
1 | Driver: 5 - Belos Solve: 0.092458 - 8.77991% [1]
2 | | Belos: Operation Op*x: 0.000570107 - 0.616611% [1]
3 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.14323e-05 - 2.00528% [1]
4 | | Remainder: 0.000558675 - 97.9947%
5 | | Belos: PseudoBlockCGSolMgr total solve time: 0.090128 - 97.4799% [1]
6 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.55588e-05 - 0.0172629% [2]
7 | | Belos: Operation Prec*x: 0.0823409 - 91.3599% [12]
8 | | MueLu: Brick3D: Hierarchy: Solve (total): 0.0822411 - 99.8789% [12]
9 | | MueLu: Brick3D: Hierarchy: Solve (level=0): 0.0350726 - 42.646% [21]
10 | | MueLu: Brick3D: Hierarchy: Solve : smoothing (level=0): 0.00827787 - 23.6021% [24]
11 | | | Ifpack2::Chebyshev::apply: 0.00809126 - 97.7457% [24]
12 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000284189 - 3.5123% [48]
13 | | | Remainder: 0.00780707 - 96.4877%
14 | | | Remainder: 0.000186608 - 2.2543%
15 | | MueLu: Brick3D: Hierarchy: Solve : residual calculation (level=0): 0.00283286 - 8.07714% [12]
16 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 7.10675e-05 - 2.50869% [12]
17 | | | Remainder: 0.00276179 - 97.4913%
18 | | MueLu: Brick3D: Hierarchy: Solve : restriction (level=0): 0.0040801 - 11.6333% [12]
19 | | | Kokkos::deep_copy [Host=>Cuda] {(none)=>MV::DualView}: 0.000110573 - 2.71005% [36]
20 | | | Remainder: 0.00396953 - 97.29%
21 | | MueLu: Brick3D: Hierarchy: Solve : import (level=1): 0.000771687 - 2.20026% [12]
22 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 6.1079e-05 - 7.915% [12]
23 | | | Remainder: 0.000710608 - 92.085%
24 | | MueLu: Brick3D: Hierarchy: Solve : export (level=1): 0.0165228 - 47.1103% [12]
25 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.0164703 - 99.6822%
26 | | | Remainder: 0.0164703 - 99.6822%
27 | | MueLu: Brick3D: Hierarchy: Solve : prolongation (level=0)
28 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.00227565 - 97.7139%
29 | | | Remainder: 0.00227565 - 97.7139%
30 | | | Remainder: 0.000258379 - 0.736698%
31 | MueLu: Brick3D: Hierarchy: Solve (level=1): 0.0449524 - 54.65
32 | MueLu: Brick3D: Hierarchy: Solve : smoothing (level=1): 0
33 | | Ifpack2::Chebyshev::apply: 0.00358362 - 94.9699% [24]
34 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.00337103 - 94.0678%
35 | | | Remainder: 0.000189806 - 5.03008%
36 | | MueLu: Brick3D: Hierarchy: Solve : residual calculation (
37 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000816249 - 93.8801%
38 | | | Remainder: 0.000816249 - 93.8801%
39 | MueLu: Brick3D: Hierarchy: Solve : restriction (level=1):
40 | | Kokkos::deep_copy [Host=>Cuda] {(none)=>MV::DualView}
41 | | | Remainder: 0.00140858 - 92.675%
42 | MueLu: Brick3D: Hierarchy: Solve : import (level=2): 0.00
43 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000669446 - 93.1358%
44 | | | Remainder: 0.000669446 - 93.1358%
45 | MueLu: Brick3D: Hierarchy: Solve : export (level=2): 0.0364644 - 81.1178% [12]
46 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 7.6167e-05 - 0.208881% [12]
47 | | | Remainder: 0.0363882 - 99.7911%
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49 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 5.6894e-05 - 4.1416% [12]
50 | | | Remainder: 0.00131683 - 95.8584%
51 | | | Remainder: 0.000232674 - 0.517601%
52 | MueLu: Brick3D: Hierarchy: Solve (level=2): 0.0534256 - 64.9621% [12]
53 | MueLu: Brick3D: Hierarchy: Solve : coarse (level=2): 0.0533833 - 99.9209% [12]
54 | | Kokkos::deep_copy_small [Host=>Cuda] {>nonContigGids}: 1.7968e-05 - 0.0336584% [37]
55 | | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>outputSpace}: 0.000442659 - 0.829208% [37]
56 | | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 5.6532e-05 - 0.105898% [37]
57 | | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 5.6532e-05 - 0.105898% [37]
58 | | Kokkos::deep_copy [Host=>Cuda] {lgMap_mirror=>lgMap}: 0.000167901 - 0.314519% [37]
59 | | Tpetra : TAF All:MMLegacy: 0.00179299 - 3.35871% [1]
60 | | Tpetra : TAF getOwningPIDs all local entries: 2.142e-06 - 0.119465% [1]
61 | | Tpetra : TAF reallocate buffers: 1.069e-06 - 0.0596211% [1]
62 | | Tpetra : TAF pack and prepare: 8.0971e-05 - 4.51598% [1]
63 | | Kokkos::deep_copy_small [Host=>Cuda] {>export_lids}: 3.83e-07 - 0.473009% [1]
64 | | Kokkos::deep_copy [Host=>Cuda] {>export_pids}: 4.445e-06 - 5.48962% [1]
65 | | | Remainder: 7.6143e-05 - 94.0374%
66 | | Tpetra : TAF getOwningPIDs exchange remote data: 4.62e-07 - 0.025767% [1]
67 | | Tpetra : TAF unpack-count-resize + copy same-perm-remote data: 0.000666903 - 37.195% [1]
68 | | | Tpetra::Details::unpackAndCombineIntoCrArrays_new: unpackAndCombineWithOwningPIDsCount: 8.8272e-05 - 13.2361% [1]
69 | | | Tpetra::Details::unpackAndCombineIntoCrArrays_new: resize CRS pointers: 5.3012e-05 - 7.94898% [1]
70 | | | Tpetra::Details::unpackAndCombineIntoCrArrays_new: create mirror views from inputs: 8.8458e-05 - 13.264% [1]
71 | | | Kokkos::deep_copy [Host=>Cuda] {>src_pids}: 4.368e-06 - 4.93794% [1]
72 | | | Kokkos::deep_copy [Host=>Cuda] {>mirror}: 4.3531e-05 - 49.2109% [1]
73 | | | Remainder: 4.0559e-05 - 45.8511%
74 | | | Tpetra::Details::unpackAndCombineIntoCrArrays_new: unpackAndCombineIntoCrArrays: 0.000244025 - 36.5908% [1]
```

Coarse grid direct solve on host. Possibly lazy initialization, but only happens once.

```
75 | | Tpetra::Details::unpackAndCombineIntoCrArrays_new: copy back to host: 7.382e-05 - 11.0691% [1]
76 | | Kokkos::deep_copy [Cuda=>Host] {>mirror=>}: 6.2344e-05 - 84.4541% [1]
77 | | | Remainder: 1.1476e-05 - 15.5459%
78 | | | Remainder: 0.000119316 - 17.8911%
79 | Tpetra : TAF makeColMap: 0.000832606 - 46.4367% [1]
80 | | Kokkos::deep_copy [Host=>Cuda] {>owningPIDs}: 4.2389e-05 - 5.09112% [1]
81 | | Kokkos::deep_copy_scalar [Host=>Cuda] {>Scalar=>UnorderedMap hash list}: 3.45e-05 - 4.14362% [2]
82 | | Kokkos::deep_copy_scalar [Host=>Cuda] {>Scalar=>UnorderedMap next index}: 2.2269e-05 - 2.67461% [2]
83 | | | Remainder: 0.000733448 - 88.0906%
84 | Tpetra : TAF restrict colmap: 8.36e-07 - 0.046626% [1]
85 | Tpetra : TAF sortCrEntries: 6.257e-06 - 0.34897% [1]
86 | Tpetra : TAF setAllValues: 1.708e-05 - 0.952599% [1]
87 | Tpetra : TAF build importer and esfc: 9.5526e-05 - 5.32775% [1]
88 | | Tpetra : TAF notMMblock: 9.3422e-05 - 97.7975% [1]
89 | | | Tpetra : TAF notMMCreateImporter: 9.1595e-05 - 98.0444% [1]
90 | | | Tpetra : notMMdestMat->expertStaticFillComplete: 8.8108e-05 - 96.193% [1]
91 | | | Tpetra Tpetra : notMM eSFC: eSFC-all: 8.2136e-05 - 93.222% [1]
92 | | | Tpetra Tpetra : notMM eSFC: eSFC-M-Graph: 7.3144e-05 - 89.0523% [1]
93 | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-Setup: 2.3427e-05 - 32.0286% [1]
94 | | | | | Kokkos::deep_copy [Cuda=>Host] {>rowPtrsUnpacked_host_}: 1.7972e-05 - 76.7149% [1]
95 | | | | | | Remainder: 5.455e-06 - 23.2851%
96 | | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-Maps: 8.55e-07 - 1.16893% [1]
97 | | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-mIXcheckI: 8.57e-07 - 1.17166% [1]
98 | | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-mIXcheckE: 4.71e-07 - 0.643935% [1]
99 | | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-mIXmake: 8.156e-06 - 11.1506% [1]
100 | | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-FLG: 5.126e-06 - 7.00809% [1]
101 | | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-cG (const): 2.1097e-05 - 28.8431% [1]
102 | | | | | Tpetra Tpetra : notMM eSFC: eSFC-G-cIS: 3.12e-07 - 0.426556% [1]
103 | | | | | | Remainder: 1.2843e-05 - 17.5585%
104 | | | | | | Tpetra Tpetra : notMM eSFC: eSFC-M-FLGAM: 3.179e-06 - 3.87041% [1]
105 | | | | | | Tpetra Tpetra : notMM eSFC: eSFC-M-cIS: 1.732e-06 - 2.1087% [1]
106 | | | | | | | Remainder: 4.081e-06 - 4.96859%
107 | | | | | | | Remainder: 5.972e-06 - 6.77805%
108 | | | | | | | Remainder: 3.487e-06 - 3.80698%
109 | | | | | | | Remainder: 1.827e-06 - 1.95564%
110 | | | | | | | Remainder: 2.104e-06 - 2.20254%
111 | | | | | | | Remainder: 8.9138e-05 - 4.97147%
112 | Tpetra : ESFC-all: 5.4404e-05 - 0.101912% [1]
113 | | Tpetra : eSFC-M-Graph: 4.6618e-05 - 85.6886% [1]
114 | | | Tpetra : ESFC-G-Setup: 2.2625e-05 - 48.5328% [1]
115 | | | | Kokkos::deep_copy [Cuda=>Host] {>rowPtrsUnpacked_host_}: 1.8216e-05 - 80.5127% [1]
116 | | | | | Remainder: 4.409e-06 - 19.4873%
117 | | | | | Tpetra : ESFC-G-Maps: 7.92e-07 - 1.69891% [1]
118 | | | | | Tpetra : ESFC-G-mIXcheckI: 8.53e-07 - 1.82977% [1]
119 | | | | | Tpetra : ESFC-G-mIXcheckE: 2.87e-07 - 0.615642% [1]
120 | | | | | Tpetra : ESFC-G-mIXmake: 4.279e-06 - 9.17886% [1]
121 | | | | | Tpetra : ESFC-G-FLG: 2.663e-06 - 5.71239% [1]
122 | | | | | Tpetra : ESFC-G-cG (const): 2.563e-06 - 5.49788% [1]
123 | | | | | Tpetra : ESFC-G-cIS: 4.43e-07 - 0.950277% [1]
124 | | | | | | Remainder: 1.2113e-05 - 25.9835%
125 | | | | | | Tpetra : eSFC-M-FLGAM: 2.391e-06 - 4.3949% [1]
126 | | | | | | Tpetra : ESFC-M-cIS: 1.539e-06 - 2.82884% [1]
127 | | | | | | | Remainder: 3.856e-06 - 7.08771%
128 | | | | | | | Kokkos::deep_copy [Cuda=>Host] {lgMap=>lgMap_mirror}: 1.3335e-05 - 0.0249797% [1]
129 | | | | | | | Kokkos::deep_copy [Cuda=>Host] {>rowPtrsUnpacked_host_}: 1.6805e-05 - 0.0314799% [1]
130 | | | | | | | Kokkos::deep_copy [Cuda=>Host] {>mirror}: 0.000187265 - 0.350793% [2]
131 | | | | | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>dst}: 0.000213609 - 0.400142% [12]
132 | | | | | | | Kokkos::deep_copy [Host=>Cuda] {dst=>MV::DualView}: 0.000191079 - 0.357938% [12]
133 | | | | | | | | Remainder: 0.0502288 - 94.0908%
134 | | | | | | | | Remainder: 4.2252e-05 - 0.0750857%
135 | | | | | | | | Remainder: -0.0512094 - -62.2673%
136 | | | | | | | | Remainder: 9.9705e-05 - 0.121088%
137 | | | | | | | | Belos: Operation Op*x: 0.00110056 - 1.2211% [11]
138 | | | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 7.14168e-05 - 6.48916% [11]
139 | | | | | | | | | Remainder: 0.00102914 - 93.5108%
140 | | | | | | | | | Remainder: 0.00667103 - 7.40173%
141 | | | | | | | | | Remainder: 0.00175993 - 1.9035%
```

Multigrid Setup – Pattern: Aggregation



```
MueLu: Brick3D: UncoupledAggregationFactory_kokkos: Build (total): 0.0304605 - 84.1859% [1]
| Kokkos::deep_copy [Host=>Cuda] {(none)=>MV::DualView}: 4.6239e-05 - 0.1518% [2]
| Kokkos::deep_copy_scalar [Host=>Cuda] {Scalar=>aggregation status}: 5.0546e-05 - 0.165939% [1]
| MueLu: Brick3D: UncoupledAggregationFactory_kokkos: Algo 'Graph Coloring' (sub, total): 0.023461 - 77.0211% [1]
| | MueLu: Brick3D: UncoupledAggregationFactory_kokkos: Algo 'Graph Coloring': KokkosGraph Call (sub, total): 0.0234169
| | | Kokkos::deep_copy [Cuda=>Host] {>}: 0.0120759 - 51.5692% [2]
| | | Kokkos::deep_copy_scalar [Host=>Host] {Scalar=>Forbidden}: 0.000102404 - 0.43731% [1]
| | | Kokkos::deep_copy [Host=>Cuda] {Graph Colors_mirror=>Graph Colors}: 0.000326908 - 1.39604% [1]
| | | Remainder: 0.0109117 - 46.5975%
| | | Remainder: 4.41343e-05 - 0.188117%
| MueLu: Brick3D: UncoupledAggregationFactory_kokkos: Algo 'Phase - (Dirichlet)' (sub, total): 0.000616076 - 2.02254% [1]
| | MueLu: PreserveDirichletAggregationAlgorithm_kokkos: BuildAggregates (total): 0.000117639 - 19.0948% [1]
| | | Kokkos::deep_copy_small [Cuda=>Host] {aggCount=>aggCount_mirror}: 2.29775e-05 - 19.5323% [1]
| | | Remainder: 9.46612e-05 - 80.4677%
| | | Remainder: 0.000498438 - 80.9052%
| MueLu: Brick3D: UncoupledAggregationFactory_kokkos: Algo 'Phase 1 (main)' (sub, total): 0.000465391 - 1.52785% [1]
| | MueLu: AggregationPhase1Algorithm_kokkos: BuildAggregatesRandom (total): 0.000415617 - 89.3049% [1]
| | | Kokkos::deep_copy_scalar [Host=>Cuda] {Scalar=>aggCount}: 1.09378e-05 - 2.63169% [1]
| | | Kokkos::deep_copy_small [Cuda=>Host] {aggCount=>Scalar}: 1.7844e-05 - 4.29337% [1]
| | | Remainder: 0.000386836 - 93.0749%
| | | Remainder: 4.9774e-05 - 10.6951%
| MueLu: Brick3D: UncoupledAggregationFactory_kokkos: Algo 'Phase 2a (secondary)' (sub, total): 0.00059788 - 1.9628% [1]
| | MueLu: AggregationPhase2aAlgorithm_kokkos: BuildAggregatesRandom (total): 0.000561404 - 93.8991% [1]
| | | Kokkos::deep_copy_small [Host=>Cuda] {numLocalAggregates_mirror=>numLocalAggregates}: 1.1643e-05 - 2.07391% [1]
| | | Kokkos::deep_copy_small [Cuda=>Host] {numLocalAggregates=>numLocalAggregates_mirror}: 1.50178e-05 - 2.67503% [1]
| | | Remainder: 0.000534743 - 95.2511%
| | | Remainder: 3.64758e-05 - 6.10085%
| MueLu: Brick3D: UncoupledAggregationFactory_kokkos: Algo 'Phase 2b (expansion)' (sub, total): 0.00196377 - 6.44692% [1]
| | MueLu: AggregationPhase2bAlgorithm_kokkos: BuildAggregatesRandom (total): 0.00186696 - 95.0705% [1]
| | | Kokkos::deep_copy_scalar [Host=>Cuda] {Scalar=>connectWeight}: 4.35035e-05 - 2.33017% [1]
| | | Kokkos::deep_copy_scalar [Host=>Cuda] {Scalar=>aggWeight}: 0.000297216 - 15.9197% [27]
| | | Remainder: 0.00152624 - 81.7501%
| | | Remainder: 9.68035e-05 - 4.92948%
| MueLu: Brick3D: UncoupledAggregationFactory_kokkos: Algo 'Phase 3 (cleanup)' (sub, total): 0.00180537 - 5.9269% [1]
| | MueLu: AggregationPhase3Algorithm_kokkos: BuildAggregatesRandom (total): 0.00166551 - 92.2531% [1]
| | | Kokkos::deep_copy_scalar [Host=>Cuda] {Scalar=>numAggregates}: 2.18103e-05 - 1.30953% [1]
| | | Kokkos::deep_copy [Cuda=>Cuda] {aggregation status=>Initial aggregation status}: 0.000558812 - 33.5521% [28]
| | | Kokkos::deep_copy_scalar [Host=>Cuda] {Scalar=>numNonAggregated}: 1.0706e-05 - 0.642808% [1]
| | | Kokkos::deep_copy_small [Cuda=>Host] {numNonAggregated=>numNonAggregated_mirror}: 1.39142e-05 - 0.835437% [1]
| | | Kokkos::deep_copy_small [Cuda=>Host] {numAggregates=>numAggregates_mirror}: 1.57945e-05 - 0.948331% [1]
| | | Remainder: 0.00104447 - 62.7118%
| | | Remainder: 0.000139859 - 7.74687%
| | Remainder: 0.00145424 - 4.77416%
```

One aggregation instance per coarse level (so two in this example).

Primarily small transfers. Needed, e.g., for reporting statistics from host.

`deep_copy_small` indicates <64 byte data transfer.

`deep_copy_scalar` indicates array fill.

Multigrid Setup Pattern: Transfer and Fill Complete (TAFC)



```
1 Tpetra Brick3D: MueLu::R*(AP)-implicit-1: TAFC pack and prepare: 0.000522858 - 2.79445% [1]
2 Kokkos::deep_copy [Host->Cuda] {=>export_lids}: 4.20825e-06 - 0.804854% [1]
3 Kokkos::deep_copy [Host->Cuda] {=>export_pids}: 1.48035e-05 - 2.83126% [1]
4 Kokkos::deep_copy_small [Cuda->Host] {error=>error_mirror}: 2.42785e-05 - 4.64342% [1]
5 Kokkos::deep_copy_small [Cuda->Host] {offsets=>(none)}: 9.25975e-06 - 1.77099% [1]
6 Kokkos::deep_copy [Cuda->Host] {mirror=>}: 1.34432e-05 - 2.57111% [1]
7 Remainder: 0.000456865 - 87.3784%
8 Tpetra Brick3D: MueLu::R*(AP)-implicit-1: TAFC getOwningPIDs exchange remote data: 0.000795577 - 4.25201% [1]
9 Tpetra::Details::reallocDualViewIfNeeded: 0.000147503 - 18.5404% [1]
10 Kokkos::deep_copy [Cuda->Host] {exports=>exports_mirror}: 0.00021304 - 26.778% [1]
11 Remainder: 0.000435034 - 54.6816%
12 Tpetra Brick3D: MueLu::R*(AP)-implicit-1: TAFC unpack-count-resize + copy same-perm-remote data: 0.00432325 - 23.1059% [1]
13 Kokkos::deep_copy [Host->Cuda] {imports_mirror=>imports}: 0.000692981 - 16.0292% [1]
14 Kokkos::deep_copy [Host->Cuda] {numImportPacketsPerLID_mirror=>numImportPacketsPerLID}: 1.55575e-05 - 0.359856% [1]
15 Tpetra::Details::unpackAndCombineIntoCrsArrays_new: unpackAndCombineWithOwningPIDsCount: 0.000122504 - 2.83361% [1]
16 Tpetra::Details::unpackAndCombineIntoCrsArrays_new: resize CRS pointers: 0.00033965 - 7.85636% [1]
17 Tpetra::Details::unpackAndCombineIntoCrsArrays_new: create mirror views from inputs: 0.000283006 - 6.54613% [1]
18 Kokkos::deep_copy [Host->Cuda] {=>src_pids}: 1.25843e-05 - 4.44664% [1]
19 Kokkos::deep_copy [Host->Cuda] {=>_mirror}: 0.000214044 - 75.6323% [1]
20 Remainder: 5.63777e-05 - 19.9211%
21 Tpetra::Details::unpackAndCombineIntoCrsArrays_new: unpackAndCombineIntoCrsArrays: 0.00189961 - 43.9393% [1]
22 Tpetra::Details::unpackAndCombineIntoCrsArrays_new: copy back to host: 0.000268323 - 6.20651% [1]
23 Kokkos::deep_copy [Cuda->Host] {mirror=>}: 0.000251786 - 93.8369% [1]
24 Remainder: 1.6537e-05 - 6.16309%
25 Remainder: 0.000701623 - 16.229%
26 Tpetra Brick3D: MueLu::R*(AP)-implicit-1: TAFC makeColMap: 0.011035 - 58.9775% [1]
27 Kokkos::deep_copy [Host->Cuda] {=>owningPIDs}: 0.000216305 - 1.96016% [1]
28 Kokkos::deep_copy_scalar [Host->Cuda] {Scalar=>UnorderedMap hash list}: 4.0832e-05 - 0.370021% [2]
29 Kokkos::deep_copy_scalar [Host->Cuda] {Scalar=>UnorderedMap next index}: 3.20622e-05 - 0.290549% [2]
30 Kokkos::deep_copy_scalar [Host->Cuda] {(none)>Kokkos::SortImpl::BinSortFuncor::bin_count}: 1.00198e-05 - 0.0907994% [4]
31 Kokkos::deep_copy [Cuda->Host] {PDLlist=>}: 1.42518e-05 - 0.12915% [1]
32 MapCtblNumInds,entryList(Kokkos::View,indexBase,comm): 0.00187306 - 16.9737% [1]
33 Kokkos::deep_copy [Cuda->Host] {ColIndices=>entryList_host}: 4.63235e-05 - 2.47315% [1]
34 Tpetra::Details::FixedHashTable::init(7-arg): 0.000164544 - 8.7848% [1]
35 Kokkos::deep_copy [Cuda->Host] {ColIndices=>ColIndices}: 2.0419e-05 - 12.4094% [1]
36 Remainder: 0.000144125 - 87.5906%
37 Tpetra::Details::FixedHashTable::ctor(InDeviceType): 6.20625e-05 - 3.31343% [1]
38 Kokkos::deep_copy [Cuda->Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 1.63068e-05 - 26.2747% [1]
39 Kokkos::deep_copy [Cuda->Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 2.9502e-05 - 47.536% [1]
40 Remainder: 1.62537e-05 - 26.1893%
41 Kokkos::deep_copy [Host->Cuda] {lqMap_mirror=>lqMap}: 2.12412e-05 - 1.13404% [1]
42 Remainder: 0.00157888 - 84.2946%
43 Remainder: 0.00884852 - 80.1856%
44 Tpetra Brick3D: MueLu::R*(AP)-implicit-1: TAFC restrict colmap: 6.7125e-07 - 0.00358754% [1]
45 Tpetra Brick3D: MueLu::R*(AP)-implicit-1: TAFC sortAndMergeCrsEntries: 0.00100522 - 5.37244% [1]
46 Tpetra Brick3D: MueLu::R*(AP)-implicit-1: TAFC setAllValues: 3.55785e-05 - 0.190152% [1]
47 Tpetra::CrsMatrix::setAllValues: 2.51888e-05 - 70.7977% [1]
48 Tpetra::CrsGraph::setAllIndices: 1.1604e-05 - 46.0682% [1]
49 Remainder: 1.35848e-05 - 53.9318%
50 Remainder: 1.03897e-05 - 29.2023%
51 Tpetra Brick3D: MueLu::R*(AP)-implicit-1: TAFC build importer and esfc: 0.000652109 - 3.48524% [1]
52 Tpetra Brick3D: MueLu::R*(AP)-implicit-1: TAFC notMMblock: 0.000649983 - 99.674% [1]
53 Tpetra Brick3D: MueLu::R*(AP)-implicit-1: TAFC notMMCreateImporter: 0.000648278 - 99.7376% [1]
54 Tpetra::Import::init: 0.000477858 - 73.7118% [1]
55 Tpetra::Import::setupSamePermuteRemote: 8.02455e-05 - 16.7928% [1]
56 Kokkos::deep_copy [Host->Cuda] {permuteFromLIDs=>permuteFromLIDs_mirror}: 5.00525e-06 - 6.23742% [1]
57 Remainder: 7.52403e-05 - 93.7626%
58 Kokkos::deep_copy [Host->Cuda] {permuteFromLIDs=>permuteFromLIDs_mirror}: 1.7257e-05 - 3.61133% [1]
59 Tpetra::iport_ctor::setupExport:3 : 0.000304354 - 63.6914% [1]
60 Tpetra::iport_ctor::setupExport:4 : 4.5293e-05 - 9.47834% [1]
61 Kokkos::deep_copy [Host->Cuda] {exportLIDs=>exportLIDs_mirror}: 4.242e-06 - 9.36569% [1]
62 Remainder: 4.1051e-05 - 90.6343%
63 Remainder: 3.0708e-05 - 6.42618%
64 Tpetra Brick3D: MueLu::R*(AP)-implicit-1: notMMdestMat->expertStaticFillComplete: 0.000133844 - 20.6462% [1]
65 Tpetra Tpetra Brick3D: MueLu::R*(AP)-implicit-1: notMM eSFC: ESFC-all: 0.000124909 - 93.3238% [1]
66 Tpetra Tpetra Brick3D: MueLu::R*(AP)-implicit-1: notMM eSFC: eSFC-M-Graph: 0.000114128 - 91.3695% [1]
67 Tpetra Tpetra Brick3D: MueLu::R*(AP)-implicit-1: notMM eSFC: ESFC-G-Setup: 5.70457e-05 - 49.9838% [1]
68 Kokkos::deep_copy [Cuda->Host] {SortedMerged rowmap=>rowPtrsUnpacked_host_}: 5.15158e-05 - 90.306% [1]
69 Remainder: 5.53e-06 - 9.69397%
```

8 instances

Recent work has improved TAFC ([#11689](#)).
Additional improvements are planned.

deep_copy_small indicates a small (<64 byte) data transfer and deep_copy_scalar indicates array fill.

Map ctor. More on this next.

Multigrid Setup Pattern: Map Construction



8 instances

```
Map(gblNumInds,entryList(Teuchos::ArrayView),indexBase,comm): 0.000616291 - 90.4259% [1]
| Kokkos::deep_copy [Host=>Cuda] {=>nonContigGids}: 1.9875e-05 - 3.22494% [1]
| Tpetra::Details::FixedHashTable::init(7-arg): 0.00019759 - 32.0611% [1]
| | Kokkos::deep_copy [Cuda=>Host] {nonContigGids=>nonContigGids}: 4.58825e-05 - 23.2211% [1]
| | Remainder: 0.000151707 - 76.7789%
| Tpetra::Details::FixedHashTable::ctor(InDeviceType): 0.000132621 - 21.5192% [1]
| | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 3.38407e-05 - 25.5169% [1]
| | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 7.19507e-05 - 54.2529% [1]
| | Remainder: 2.68295e-05 - 20.2302%
| Kokkos::deep_copy [Host=>Cuda] {lgMap_mirror=>lgMap}: 1.83932e-05 - 2.98451% [1]
| Remainder: 0.000247812 - 40.2103%
```

13 instances

```
Map(gblNumInds,entryList(Kokkos::View),indexBase,comm): 0.00216757 - 32.828% [1]
| Kokkos::deep_copy [Cuda=>Host] {ColIndices=>entryList_host}: 4.58113e-05 - 2.11349% [1]
| Tpetra::Details::FixedHashTable::init(7-arg): 0.000188087 - 8.67736% [1]
| | Kokkos::deep_copy [Cuda=>Host] {ColIndices=>ColIndices}: 4.6877e-05 - 24.923% [1]
| | Remainder: 0.00014121 - 75.077%
| Tpetra::Details::FixedHashTable::ctor(InDeviceType): 9.9199e-05 - 4.57652% [1]
| | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 2.33933e-05 - 23.5822% [1]
| | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 4.93463e-05 - 49.7448% [1]
| | Remainder: 2.64593e-05 - 26.673%
| Kokkos::deep_copy [Host=>Cuda] {lgMap_mirror=>lgMap}: 2.5379e-05 - 1.17085% [1]
| Remainder: 0.00180909 - 83.4618%
```

105 deep_copy's

Tpetra team has done initial redesign planning.

Potentially go from 5 to 1 deep_copy per ctor.

Albany Antarctic Icesheet Simulation



Matrix:

- 35,336,280 rows

64 MPI ranks, one GPU per rank

Block GMRES

AMG preconditioner

- Three level V-cycle
- Polynomial smoother
- Specialized semicoarsening from level 0 -> level 1, then standard AMG
- No rebalancing
- Polynomial coarse grid solve

Summary of H2D/D2H recurring patterns in solve

- Orthogonalization
- SpMV

Summary of H2D/D2H recurring patterns in setup

- Semi-coarsening
- Otherwise very similar to Laplace3D

MueLu Setup: Semicoarsening



```
MueLu: SemiCoarsenPFactory_kokkos: BuildSemiCoarsenP (sub, total): 0.449237 - 36.7713% [9]
| Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.00489934 - 1.09059% [23]
| Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.0077263 - 1.71987% [42]
| Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000399 - 0.0888173% [18]
| Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.00044961 - 0.100083% [18]
| Kokkos::deep_copy [Host=>Cuda] {LineLayer2Node_mirror=>LineLayer2Node}: 0.000915631 - 0.203819% [9]
| Kokkos::deep_copy_small [Host=>Cuda] {CLayer2FLayer_mirror=>CLayer2FLayer}: 0.000104872 - 0.0233444% [9]
| Kokkos::deep_copy_small [Host=>Cuda] {CLayer2StartLayer_mirror=>CLayer2StartLayer}: 9.23499e-05 - 0.0205571% [9]
| Kokkos::deep_copy_small [Host=>Cuda] {CLayer2StencilSize_mirror=>CLayer2StencilSize}: 8.70789e-05 - 0.0193837% [9]
| Kokkos::deep_copy_scalar [Host=>Host] {Scalar=>Pptr_mirror}: 0.000928144 - 0.206604% [9]
| Kokkos::deep_copy [Host=>Cuda] {Pptr_mirror=>Pptr}: 0.00235083 - 0.523294% [9]
| Kokkos::deep_copy_scalar [Host=>Host] {Scalar=>layerBuckets}: 3.40445e-05 - 0.00757828% [9]
| Kokkos::deep_copy [Host=>Cuda] {CLayer5Node2PptrOffset_mirror=>CLayer5Node2PptrOffset}: 0.000101936 - 0.022691% [9]
| MueLu: SemiCoarsenPFactory_kokkos: Fill P (sub, total): 0.189396 - 42.1595% [9]
| Kokkos::deep_copy_small [Host=>Cuda] {=>nonContigGids}: 6.85892e-06 - 0.00152679% [9]
| Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 0.000119225 - 0.0265394% [9]
| Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 2.03013e-05 - 0.00451906% [9]
| Kokkos::deep_copy [Host=>Cuda] {lgMap_mirror=>lgMap}: 0.00012186 - 0.027126% [9]
| Tpetra : ESFC-all: 0.00513981 - 1.14412% [9]
| | Tpetra : eSFC-M-Graph: 0.00506735 - 98.5902% [9]
| | | Tpetra : ESFC-G-Setup: 0.00349394 - 68.9502% [9]
| | | | Kokkos::deep_copy [Cuda=>Host] {Pptr=>rowPtrsUnpacked_host_}: 0.00344302 - 98.5426% [9]
| | | | Remainder: 5.09211e-05 - 1.45741%
| | | Tpetra : ESFC-G-Maps: 4.63095e-06 - 0.0913882% [9]
| | | Tpetra : ESFC-G-mIXcheckI: 4.51411e-06 - 0.0890823% [9]
| | | Tpetra : ESFC-G-mIXcheckE: 2.43744e-06 - 0.0481009% [9]
| | | Tpetra : ESFC-G-mIXmake: 8.00509e-06 - 0.157974% [9]
| | | Tpetra : ESFC-G-fLG: 4.24651e-05 - 0.838015% [9]
| | | Tpetra : ESFC-G-cGC (const): 0.00143317 - 28.2825% [9]
| | | Tpetra : ESFC-G-cIS: 2.25991e-06 - 0.0445974% [9]
| | | Remainder: 7.59167e-05 - 1.49815%
| | Tpetra : eSFC-M-fLGAM: 4.42874e-05 - 0.861655% [9]
| | Tpetra : ESFC-M-cIS: 3.44958e-06 - 0.0671149% [9]
| | Remainder: 2.47258e-05 - 0.481064%
| Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.000494278 - 0.110026% [18]
| Remainder: 0.23585 - 52.5%
```

Albany is considering calculating lines upstream of MueLu, which will address much of this.

Thermal Fluids Performance Proxy



Matrix:

- 29,360,128 point rows, implicit 7x7 blocks
- Uniform distribution of rows across MPI ranks

Run on 16 MPI ranks, one GPU per rank

Ifpack2 block tri-diagonal solver



Thermal Fluids Proxy – Preconditioner Setup (Init. + Compute)

```

1 Init preconditioner: 47.072 - 45.6938 [1]
2 Ipaoc2: Additive Schwarz: initialize: 28.287 - 60.8958 [1]
3 I OverlappingBlock: construct: 6.911 - 24.1369 [1]
4 I Kokkos::deep_copy [Host-Cuda] [nonContigIds] : 0.00089189 - 0.0129696 [3]
5 I Kokkos::deep_copy [Host-Cuda] [nonContigIds] : 0.001113 - 0.0161048 [1]
6 I Kokkos::deep_copy [Host-Cuda] [nonContigIds] : 0.0009534 - 0.00063166 [3]
7 I Kokkos::deep_copy [Host-Cuda] [FixedHostTable: pairs->Tetra: FixedHostTable: val]: 0.0019254 - 0.0282526 [1]
8 I Kokkos::deep_copy [Host-Cuda] [lqMap_mirrored] : 0.000776206 - 0.0112158 [3]
9 I Tetra: Import: init: 0.291297 - 4.21498 [1]
10 I Tetra: Import: setupGlobalMatrix: 0.016280 - 5.56439 [1]
11 I Kokkos::deep_copy [Host-Cuda] [permuteFrontIds=permuteFrontIds_mirrored] : 0.00038275 - 2.08697 [3]
12 I Remainder: 0.0158706 - 97.9138 [1]
13 I Kokkos::deep_copy [Host-Cuda] [permuteFrontIds=permuteFrontIds_mirrored] : 0.00045666 - 0.157978 [3]
14 I Kokkos::deep_copy [Host-Cuda] [exportIDs=exportIDs_mirrored] : 0.000130579 - 0.113485 [1]
15 I Remainder: 0.27428 - 94.1643 [1]
16 I Tetra: DistObject: doTransferHost: 2.72816 - 39.4766 [1]
17 I Tetra: DistObject: doTransferIndices: 5.88613e-05 - 0.000164314 [2]
18 I Tetra: Details: realLocalViewNeeded: 0.0039842 - 0.117131 [1]
19 I Tetra: DistObject: doPackAndPrepare: 0.488772 - 17.9158 [2]
20 I Tetra: CrsGraph: packAndPrepare: 0.063968 - 12.9299 [1]
21 I Tetra: CrsMatrix: packAndPrepare: 0.425181 - 66.9879 [1]
22 I Remainder: 8.4986e-05 - 0.0173865 [1]
23 I Tetra: DistObject: doTransferNew: doPostsAndInit: 0.697798 - 25.5776 [1]
24 I Tetra: Details: realLocalViewNeeded: 0.0152355 - 2.18326 [2]
25 I Remainder: 0.68262 - 97.8166 [1]
26 I Tetra: DistObject: doUnpackAndCombine: 1.50823 - 55.2838 [2]
27 I Tetra: CrsGraph: unpackAndCombine: 0.213499 - 14.1566 [1]
28 I Tetra: CrsMatrix: applyCrsPadding: 0.0153116 - 17.1717 [1]
29 I Tetra: CrsGraph: allocateIndices: 0.000748529 - 4.83648 [1]
30 I Kokkos::deep_copy [Host-Host] [(none)->Tetra: CrsGraph: numRowsEntries] : 0.000112045 - 15.1346 [1]
31 I Remainder: 0.00026852 - 84.8548 [1]
32 I Kokkos::deep_copy [Cuda-Cuda] [Tetra: CrsGraph: ptrs->row_ptr_beg] : 2.12746e-05 - 1.30519e [1]
33 I Kokkos::deep_copy [Host-Cuda] [Tetra: CrsGraph: numRowsEntries->num_rows_entries] : 0.000156875 - 1.02455 [1]
34 I Kokkos::deep_copy [Host-Cuda] [row_ptr_end->row_ptr_end_mirrored] : 0.000121272 - 0.792026 [1]
35 I Kokkos::deep_copy [Host-Cuda] [row_ptr_beg->row_ptr_beg_mirrored] : 0.000114363 - 0.7465146 [1]
36 I Kokkos::deep_copy [Host-Cuda] [newLocalPerfMirror->newLocalPerf] : 0.000137672 - 0.891396 [1]
37 I Kokkos::deep_copy [Host-Cuda] [num_rows_entries->CrsGraph: numRowsEntries] : 0.000113742 - 0.03321 [1]
38 I Remainder: 0.013614 - 99.5292 [1]
39 I Kokkos::deep_copy [Host-Cuda] [row_ptr_beg->row_ptr_beg_mirrored] : 0.000201549 - 0.044026 [1]
40 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph column indices->Tetra: CrsGraph column indices_mirrored] : 0.00276689 - 1.2956 [1]
41 I Remainder: 0.19522 - 91.4833 [1]
42 I Tetra: CrsMatrix: unpackAndCombine: 1.29463 - 85.8376 [1]
43 I Tetra: CrsMatrix: applyCrsPadding: 0.0181832 - 2.46278 [1]
44 I Tetra: CrsMatrix: allocateValues: 0.00186633 - 5.85364 [1]
45 I Tetra: CrsGraph: allLocalIndices: 0.0012008 - 65.4119 [1]
46 I Kokkos::deep_copy [Host-Host] [(none)->Tetra: CrsGraph: numRowsEntries] : 0.000276232 - 12.6271 [1]
47 I Remainder: 0.00094571 - 77.3729 [1]
48 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: ptrs->row_ptr_beg] : 0.00045805 - 29.3893 [1]
49 I Remainder: 9.70234e-05 - 5.13962 [1]
50 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: ptrs->row_ptr_beg] : 2.71389e-05 - 0.0851196 [1]
51 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: numRowsEntries->Tetra: CrsGraph: numRowsEntries] : 0.00033749 - 1.05808 [1]
52 I Kokkos::deep_copy [Host-Host] [row_ptr_end->row_ptr_end_mirrored] : 0.00074271 - 0.86235 [1]
53 I Kokkos::deep_copy [Host-Host] [row_ptr_beg->row_ptr_beg_mirrored] : 0.00025129 - 0.793246 [1]
54 I Kokkos::deep_copy [Host-Host] [newLocalPerfMirror->newLocalPerf] : 0.00013112 - 1.03854 [1]
55 I Kokkos::deep_copy [Host-Host] [num_rows_entries->Tetra: CrsGraph: numRowsEntries] : 0.00033573 - 1.05251 [1]
56 I Remainder: 0.024583 - 89.258 [1]
57 I Kokkos::deep_copy [Host-Cuda] [row_ptr_beg->row_ptr_beg_mirrored] : 0.00018664 - 0.028511 [1]
58 I Kokkos::deep_copy [Host-Host] [Tetra: CrsMatrix values->Tetra: CrsMatrix values_mirrored] : 0.00063788 - 0.49169 [1]
59 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph column indices->Tetra: CrsGraph column indices_mirrored] : 0.00005179 - 0.467453 [1]
60 I Remainder: 1.24994 - 96.5412 [1]
61 I Remainder: 0.00010219 - 0.00675568 [1]
62 I Remainder: 0.0383859 - 1.11086 [1]
63 I Tetra: CrsGraph: makeIMap: 0.88022 - 12.7423 [1]
64 I Kokkos::deep_copy [Host-Host] [nonContigIds] : 0.00045328 - 0.0514748 [1]
65 I Kokkos::deep_copy [Host-Host] [nonContigIds->nonContigIds] : 0.00056308 - 0.0640011 [1]
66 I Kokkos::deep_copy [Host-Host] [Tetra: FixedHostTable: pairs->outputSpace] : 0.000254419 - 0.0288988 [1]
67 I Kokkos::deep_copy [Host-Host] [Tetra: FixedHostTable: pairs->Tetra: FixedHostTable: val]: 0.00111588 - 0.126625 [1]
68 I Kokkos::deep_copy [Host-Host] [lqMap_mirrored] : 0.000202965 - 0.0374698 [1]
69 I Remainder: 0.877905 - 99.6915 [1]
70 I Tetra: CrsGraph: makeIndicesLocal: 0.0005108 - 0.875578 [1]
71 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: numRowsEntries->Tetra: CrsGraph: numRowsEntries] : 0.000163751 - 0.270317 [1]
72 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph column indices->Tetra: CrsGraph column indices] : 0.0015474 - 2.52328 [1]
73 I Remainder: 0.0588025 - 97.1768 [1]
74 I Tetra: CrsGraph: sortAndMergeAllIndices: 0.0466919 - 0.675617 [1]
75 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: lclInd->Tetra: CrsGraph: lclInd_mirrored] : 0.00025266 - 1.98164 [1]
76 I Remainder: 0.0457666 - 98.0148 [1]
77 I Tetra: CrsGraph: makeImportExport: 0.196817 - 2.84789 [1]
78 I Tetra: Import: init: 0.136686 - 99.3926 [1]
79 I Tetra: Import: setupGlobalMatrix: 0.0075598 - 3.84146 [1]
80 I Kokkos::deep_copy [Host-Cuda] [permuteFrontIds=permuteFrontIds_mirrored] : 0.00016467 - 2.17646 [1]
81 I Kokkos::deep_copy [Host-Cuda] [permuteFrontIds=permuteFrontIds_mirrored] : 4.02828e-05 - 0.532408 [1]
82 I Remainder: 0.0075324 - 27.0128 [1]
83 I Kokkos::deep_copy [Host-Cuda] [permuteFrontIds=permuteFrontIds_mirrored] : 0.000169398 - 0.01648 [1]
84 I Kokkos::deep_copy [Host-Cuda] [exportIDs=exportIDs_mirrored] : 0.000146429 - 0.0744442 [1]
85 I Remainder: 0.188833 - 96.8026 [1]
86 I Remainder: 0.00021669 - 0.00218148 [1]
87 I Tetra: CrsGraph: computeGlobalConstants: 0.00243113 - 0.0351777 [1]
88 I Tetra: CrsGraph: computeLocalConstants: 4.08913e-05 - 1.68199 [1]
89 I Remainder: 0.00292404 - 96.3128 [1]
90 I Kokkos::deep_copy [Host-Host] [lclInd] : 0.61376e-05 - 0.00095931 [1]
91 I Tetra: Details: Spaces: space_instance: 5.06276e-05 - 0.000735876 [6]
92 I Tetra: CrsMatrix: fillComplete: 2.1821 - 31.5615 [1]
93 I Tetra: CrsMatrix: allLocalIndices: 1.58732 - 72.7728 [1]
94 I Tetra: CrsGraph: makeIndicesLocal: 0.069362 - 2.77534 [1]
95 I Kokkos::deep_copy [Host-Cuda] [Tetra: CrsGraph: numRowsEntries->Tetra: CrsGraph: numRowsEntries] : 0.000484026 - 0.799565 [1]
96 I Kokkos::deep_copy [Host-Cuda] [Tetra: CrsGraph column indices->Tetra: CrsGraph column indices] : 0.00530533 - 8.7639 [1]
97 I Remainder: 0.064766 - 90.4343 [1]
98 I Tetra: CrsMatrix: sortAndMergeIndicesAndValues: 0.0021061 - 4.2227 [1]
99 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: lclInd->Tetra: CrsGraph: lclInd_mirrored] : 0.00005823 - 2.23463 [1]
100 I Remainder: 0.0900478 - 97.7654 [1]
101 I Tetra: CrsGraph: makeImportExport: 0.395276 - 18.1218 [1]
102 I Tetra: Import: init: 0.275927 - 99.8062 [1]
103 I Tetra: Import: setupGlobalMatrix: 0.0068489 - 2.47024 [1]
104 I Kokkos::deep_copy [Host-Cuda] [permuteFrontIds=permuteFrontIds_mirrored] : 0.000159368 - 2.32964 [1]
105 I Remainder: 0.0066152 - 97.6794 [1]
106 I Kokkos::deep_copy [Host-Cuda] [permuteFrontIds=permuteFrontIds_mirrored] : 0.000201166 - 0.079936 [1]
107 I Kokkos::deep_copy [Host-Cuda] [exportIDs=exportIDs_mirrored] : 0.000152811 - 0.0553811 [1]
108 I Remainder: 0.268729 - 97.3914 [1]
109 I Tetra: Export: export: 0.119274 - 30.175 [1]
110 I Tetra: Export: setupGlobalMatrix: 0.18134 - 99.0446 [1]
111 I Kokkos::deep_copy [Host-Cuda] [permuteFrontIds=permuteFrontIds_mirrored] : 0.000214779 - 0.181806 [1]
112 I Kokkos::deep_copy [Host-Cuda] [permuteFrontIds=permuteFrontIds_mirrored] : 0.000176002 - 0.149746 [1]
113 I Remainder: 0.117442 - 99.6684 [1]
114 I Remainder: 0.00114005 - 0.0599036 [1]
115 I Remainder: 7.44524e-05 - 0.0188326 [1]
116 I Tetra: CrsMatrix: fillLocalGraphAverages: 0.0312967 - 1.43483 [1]
117 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: numRowsEntries->counts] : 0.000223864 - 1.03482 [1]
118 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: lclInd->Tetra: CrsGraph: lclInd_mirrored] : 0.00024982 - 8.14726 [1]
119 I Kokkos::deep_copy [Host-Host] [Tetra: CrsMatrix values->Tetra: CrsMatrix values_mirrored] : 0.00082684 - 31.3996 [1]
120 I Remainder: 0.0189562 - 59.4189 [1]
121 I Tetra: CrsGraph: computeLocalConstants: 0.0140228 - 0.678999 [1]
122 I Tetra: CrsGraph: computeLocalConstants: 4.76124e-05 - 0.252526 [1]
123 I Remainder: 0.0145792 - 99.6744 [1]
124 I Remainder: 5.85281e-05 - 0.00063828 [1]
125 I Remainder: 0.517797 - 7.49237 [1]
126 I Reordering: 1.0236 - 3.62586 [1]
127 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: ptrs->row_ptr_beg] : 0.000372239 - 0.0363659 [1]
128 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: ptrs->row_ptr_end] : 0.0017638 - 0.172369 [1]
129 I Kokkos::deep_copy [Host-Host] [offset->offset] : 0.00020735 - 0.0410348 [1]
130 I Kokkos::deep_copy [Host-Host] [adjIndices->adjIndices] : 0.0041388 - 0.409717 [1]
131 I Remainder: 1.01685 - 99.3498 [1]
132 I Filter construction: 0.29263 - 1.14726 [1]
133 I Kokkos::deep_copy [Host-Cuda] [Tetra: CrsMatrix: values_mirrored->Tetra: CrsMatrix: values] : 0.00146157 - 0.451169 [1]
134 I Kokkos::deep_copy [Host-Cuda] [Tetra: CrsGraph: lclInd->Tetra: CrsGraph: lclInd_mirrored] : 0.00013465 - 0.18937 [1]
135 I Kokkos::deep_copy [Host-Cuda] [Tetra: CrsMatrix: values_mirrored->Tetra: CrsMatrix: values] : 0.000993278 - 0.000993278 [1]
136 I Kokkos::deep_copy [Host-Cuda] [reversePerm_mirrored->reversePerm] : 0.00021582 - 0.0714866 [1]
137 I Tetra: Details: Spaces: space_instance: 1.31524e-05 - 0.0047114 [5]
138 I Tetra: CrsGraph: makeImportExport: 2.1686e-06 - 0.00069226 [1]
139 I Tetra: CrsGraph: computeLocalConstants: 0.28689 - 88.4428 [1]
140 I Tetra: CrsGraph: computeLocalConstants: 0.28642 - 99.9908 [1]
141 I Remainder: 2.64923e-05 - 0.0024668 [1]
142 I Remainder: 0.0348782 - 10.7802 [1]
143 I RIILU: initialize: 19.9727 - 79.7468 [1]
144 I Kokkos::deep_copy [Host-Host] [Filtered rows->Filtered rows] : 0.00046278 - 0.00231676 [1]
145 I Kokkos::deep_copy [Host-Host] [Filtered entries->Filtered entries] : 0.0003005 - 0.0150888 [1]
146 I Kokkos::deep_copy [Host-Host] [level_list->level_list] : 0.00056068 - 0.0027976 [1]
147 I Kokkos::deep_copy [Host-Host] [level_list->level_list] : 0.00027961 - 0.00140096 [1]
148 I Kokkos::deep_copy [Host-Host] [Scalar->level] : 0.00022852 - 0.00104101 [1]
149 I Kokkos::deep_copy [Host-Host] [Scalar->level] : 0.002626 - 0.121416 [1]
150 I Kokkos::deep_copy [Host-Host] [level_list->level_list] : 0.0004765 - 0.00214008 [1]
151 I Kokkos::deep_copy [Host-Host] [level_list->level_list] : 0.000191802 - 0.000966881 [1]
152 I Kokkos::deep_copy [Host-Host] [level_list->level_list] : 0.00034954 - 0.00174248 [1]
153 I Kokkos::deep_copy [Host-Host] [l_row_map_mirrored->l_row_map] : 0.00021346 - 0.0016808 [1]
154 I Kokkos::deep_copy [Host-Host] [l_row_map_mirrored->l_row_map] : 0.00135352 - 0.0769474 [1]
155 I Kokkos::deep_copy [Host-Host] [l_row_map_mirrored->l_row_map] : 0.00022637 - 0.00161547 [1]
156 I Kokkos::deep_copy [Host-Host] [l_row_map_mirrored->l_row_map] : 0.0153385 - 0.0768014 [1]
157 I Tetra: CrsGraph: makeIndicesLocal: 5.39606e-05 - 0.000790178 [1]
158 I Tetra: CrsGraph: makeIndicesLocal: 1.35892e-05 - 6.76421e-05 [1]
159 I Tetra: CrsGraph: sortAndMergeAllIndices: 2.31762e-06 - 1.16846e-05 [1]
160 I Tetra: CrsGraph: makeImportExport: 5.43988e-06 - 2.7238e-05 [1]
161 I Tetra: CrsGraph: computeLocalConstants: 0.00010021 - 0.000949028 [1]
162 I Tetra: CrsGraph: computeLocalConstants: 8.7794e-05 - 87.1868 [1]
163 I Remainder: 1.29225e-05 - 12.8348 [1]
164 I Tetra: Details: Spaces: space_instance: 1.95881e-05 - 8.8979e-05 [1]
165 I Kokkos::deep_copy [Host-Host] [(none)->Tetra: CrsMatrix: values] : 2.06416e-05 - 0.000103354 [2]
166 I Tetra: CrsMatrix: fillComplete: 2.90212e-05 - 0.000145312 [2]
167 I Tetra: CrsMatrix: fillLocalMatrix: 7.09425e-06 - 24.4589 [2]
168 I Remainder: 2.13229e-05 - 75.5411 [1]
169 I Tetra: MW ctor (map_numVecs_zeroOut): 0.00038424 - 0.0012934 [1]
170 I Kokkos::deep_copy [Host-Host] [lqMap->lqMap_mirrored] : 0.00031012 - 0.0015677 [1]
171 I Remainder: 0.96978 - 99.6088 [1]
172 I Remainder: 0.0004319 - 0.00219358 [1]
173 I Remainder: 18.796 - 39.9659 [1]
174 Compute preconditioner: 50.6869 - 49.2497 [1]
175 Ipaoc2: Additive Schwarz: compute: 24.6286 - 48.5799 [1]
176 I Halo Import: 4.4681 - 18.1478 [1]
177 I Tetra: Details: Spaces: space_instance: 1.11575e-05 - 0.000248796 [6]
178 I Tetra: DistObject: doTransferHost: 2.2338 - 49.9404 [2]
179 I Tetra: DistObject: doTransferIndices: checkLocal: 0.000158276 [1]
180 I Tetra: Details: realLocalViewNeeded: 0.0026993 - 0.11919 [2]
181 I Tetra: DistObject: doPackAndPrepare: 0.41821 - 18.726 [1]
182 I Tetra: CrsMatrix: packAndPrepare: 0.41819 - 99.9026 [1]
183 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: lclInd->Tetra: CrsGraph: lclInd_mirrored] : 0.00079134 - 0.17958 [1]
184 I Kokkos::deep_copy [Host-Host] [Tetra: CrsMatrix values->Tetra: CrsMatrix values_mirrored] : 0.0012084 - 0.28958 [1]
185 I Remainder: 0.416263 - 99.5911 [1]
186 I Remainder: 2.06274e-05 - 0.00274906 [1]
187 I Tetra: DistObject: doTransferNew: doPostsAndInit: 0.52687 - 23.5911 [1]
188 I Tetra: Details: realLocalViewNeeded: 0.0111681 - 2.11869 [1]
189 I Remainder: 0.515708 - 97.6889 [1]
190 I Tetra: DistObject: doUnpackAndCombine: 1.27316 - 57.0066 [1]
191 I Tetra: CrsMatrix: unpackAndCombine: 1.27312 - 99.9926 [1]
192 I Tetra: CrsMatrix: applyCrsPadding: 0.018763 - 2.44959 [1]
193 I Tetra: CrsMatrix: allocateValues: 0.0012754 - 5.55937 [1]
194 I Tetra: CrsGraph: allocateIndices: 0.0124822 - 72.25 [1]
195 I Kokkos::deep_copy [Host-Host] [(none)->Tetra: CrsGraph: numRowsEntries] : 0.000231257 - 18.527 [1]
196 I Remainder: 0.00016166 - 81.4738 [1]
197 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: ptrs->row_ptr_beg] : 0.0003988 - 22.6205 [1]
198 I Remainder: 8.86183e-05 - 5.12945 [1]
199 I Kokkos::deep_copy [Cuda-Cuda] [Tetra: CrsGraph: ptrs->row_ptr_beg] : 2.61386e-05 - 0.0841116 [1]
200 I Kokkos::deep_copy [Host-Host] [Tetra: CrsGraph: numRowsEntries->Tetra: CrsGraph: numRowsEntries] : 0.00016443 - 1.01828 [1]

```

Additional Schwarz setup has D2H/H2D transfers throughout. This hasn't been looked at yet.

Thermal Fluids Proxy – Solve



```
65 Belos: PseudoBlockGmresSolMgr total solve time: 4.82393 - 4.68715% [1]
66 | Tpetra::MV ctor (map,numVecs,zeroOut): 0.0257886 - 0.534598% [33]
67 | Kokkos::deep_copy [Cuda=Cuda] {MV::DualView=>MV::DualView}: 1.43192e-05 - 0.000296836% [1]
68 | Belos: ICGS[2]: Orthogonalization: 2.79582 - 57.9573% [15]
69 | | Belos: ICGS[2]: Ortho (Norm): 0.130224 - 4.65781% [15]
70 | | | Tpetra::MV::dot (Teuchos::ArrayView): 0.130155 - 99.947% [15]
71 | | | | Tpetra::multiVectorSingleColumnDot: 0.130104 - 99.9607% [15]
72 | | | | Remainder: 5.11121e-05 - 0.0392701%
73 | | | Remainder: 6.90087e-05 - 0.0529922%
74 | | Belos: ICGS[2]: Ortho (Inner Product): 2.17127 - 77.6612% [28]
75 | | | Tpetra::MV::dot (Teuchos::ArrayView): 0.150318 - 6.92303% [2]
76 | | | | Tpetra::multiVectorSingleColumnDot: 0.150311 - 99.9956% [2]
77 | | | | Remainder: 6.66906e-06 - 0.00443664%
78 | | | Tpetra::MultiVector::putScalar: 0.000371268 - 0.0170991% [26]
79 | | | | Kokkos::deep_copy_small [Host=>Cuda] {<=>}: 0.000109559 - 29.5093% [14]
80 | | | | Kokkos::deep_copy [Host=>Cuda] {<=>}: 9.13506e-05 - 24.605% [12]
81 | | | | Remainder: 0.000170359 - 45.8856%
82 | | | Tpetra::MV::multiply: 2.01497 - 92.8012% [26]
83 | | | | Tpetra::MV::multiply-call-gemm: 0.000583166 - 0.0289417% [26]
84 | | | | Tpetra::MV::reduce: 2.01419 - 99.9615% [26]
85 | | | | | Kokkos::deep_copy_small [Cuda=>Host] {<=>}: 0.0010486 - 0.0520605% [28]
86 | | | | | Kokkos::deep_copy_small [Host=>Cuda] {<=>}: 0.000444412 - 0.0220641% [14]
87 | | | | | Kokkos::deep_copy_small [Cuda=>Cuda] {<=>}: 0.000120305 - 0.00597288% [14]
88 | | | | | Kokkos::deep_copy [Cuda=>Host] {<=>}: 0.000875667 - 0.0434749% [24]
89 | | | | | Kokkos::deep_copy [Host=>Cuda] {<=>}: 0.000363469 - 0.0180454% [12]
90 | | | | | Kokkos::deep_copy [Cuda=>Cuda] {<=>}: 0.00010304 - 0.00511572% [12]
91 | | | | | Remainder: 2.01123 - 99.8533%
92 | | | | | Remainder: 0.000193283 - 0.00959237%
93 | | | | Kokkos::deep_copy_small [Cuda=>Host] {<=>}: 0.000513469 - 0.0236483% [14]
94 | | | | Kokkos::deep_copy [Host=>Host] {<=>}: 0.0026512 - 0.122104% [19]
95 | | | | Kokkos::deep_copy_small [Host=>Host] {<=>}: 9.77813e-06 - 0.000450341% [7]
96 | | | | Kokkos::deep_copy [Cuda=>Host] {<=>}: 0.000440681 - 0.020296% [12]
97 | | | | | Remainder: 0.0020011 - 0.0921626%
98 | | | Belos: ICGS[2]: Ortho (Update): 0.493503 - 17.6514% [28]
99 | | | | Tpetra::MV::update(alpha,A,beta): 2.49923e-05 - 0.00506427% [2]
100 | | | | Kokkos::deep_copy_small [Host=>Host] {<=>}: 2.39406e-05 - 0.00485117% [14]
101 | | | | Tpetra::MV::multiply: 0.492372 - 99.7709% [26]
102 | | | | | Kokkos::deep_copy_small [Host=>Cuda] {<=>}: 0.000402805 - 0.081809% [14]
103 | | | | | Tpetra::MV::multiply-call-gemm: 0.491391 - 99.8007% [26]
104 | | | | | Kokkos::deep_copy [Host=>Cuda] {<=>}: 0.000347407 - 0.0705578% [12]
105 | | | | | Remainder: 0.000231194 - 0.0469552%
106 | | | | Kokkos::deep_copy [Host=>Host] {<=>}: 1.99955e-05 - 0.00405175% [12]
107 | | | | | Remainder: 0.00106169 - 0.215133%
108 | | | | | Remainder: 0.000826226 - 0.0295522%
109 | | | Tpetra::MV::update(alpha,A,beta,B,gamma): 0.000419398 - 0.00869411% [27]
110 | | | Tpetra::MV::norm2 (host output): 0.0114746 - 0.237868% [7]
111 | | Belos: Operation Op*x: 0.0459722 - 0.953003% [19]
112 | | | Tpetra::CrsMatrix::apply: 0.0459057 - 99.8552% [19]
113 | | | | Tpetra::CrsMatrix::apply: Import: 0.043743 - 95.2889% [19]
114 | | | | | Tpetra::DistObject::doTransfer[Host]: 0.0435503 - 99.5594% [38]
115 | | | | | | Tpetra::DistObject::doTransferNew::checkSizes: 3.42809e-05 - 0.0787156% [19]
116 | | | | | | Tpetra::DistObject::doTransferNew::copyAndPermute: 0.000648135 - 1.48824% [19]
117 | | | | | | Tpetra::MultiVector::copyAndPermute[Device]: 0.000580102 - 89.5034% [19]
118 | | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000255539 - 44.0507% [19]
119 | | | | | | | | Remainder: 0.000324563 - 55.9493%
120 | | | | | | | | Remainder: 6.80323e-05 - 10.4966%
121 | | | | | | Tpetra::DistObject::doPackAndPrepare: 0.000376398 - 0.864285% [19]
122 | | | | | | | Tpetra::MultiVector::packAndPrepare[Device]: 0.000306955 - 81.5505% [19]
123 | | | | | | | | Tpetra::Details::reallocDualViewIfNeeded: 1.99652e-05 - 6.50428% [19]
124 | | | | | | | | Remainder: 0.000286989 - 93.4957%
```

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125 | | | | | | | | Remainder: 6.94438e-05 - 18.4495%
126 | | | | | | | | Kokkos::deep_copy [Cuda=>Host] {<=>}: 0.00353923 - 8.12677% [19]
127 | | | | | | | | Tpetra::Details::reallocDualViewIfNeeded: 4.63523e-05 - 0.106434% [38]
128 | | | | | | | | Tpetra::DistObject::doTransferNew::doPostsAndWaits: 0.0287958 - 66.1208% [19]
129 | | | | | | | | Tpetra::DistObject::doUnpackAndCombine: 0.00368221 - 8.45508% [19]
130 | | | | | | | | | Tpetra::MultiVector::unpackAndCombine[Device]: 0.0035963 - 97.6669% [19]
131 | | | | | | | | | Kokkos::deep_copy [Host=>Cuda] {<=>}: 0.00313623 - 87.2071% [19]
132 | | | | | | | | | | Remainder: 0.000460071 - 12.7929%
133 | | | | | | | | | | Remainder: 8.59088e-05 - 2.33308%
134 | | | | | | | | | | Remainder: 0.00642787 - 14.7597%
135 | | | | | | | | | | | Remainder: 0.00019275 - 0.440641%
136 | | | | | | | | | | | Tpetra::CrsMatrix::localApply: 0.00201358 - 4.38634% [19]
137 | | | | | | | | | | | | Remainder: 0.000149063 - 0.324715%
138 | | | | | | | | | | | | | Remainder: 6.65753e-05 - 0.144816%
139 | | | | | | | | | | | | | Belos: Operation Prec*x: 1.91168 - 39.6291% [14]
140 | | | | | | | | | | | | | Ifpack2::AdditiveSchwarz::apply: 1.91162 - 99.9966% [14]
141 | | | | | | | | | | | | | | Tpetra::MultiVector::putScalar: 0.00108162 - 0.0565815% [56]
142 | | | | | | | | | | | | | | Kokkos::deep_copy [Host=>Cuda] {<=>}: 0.000665301 - 61.5095% [56]
143 | | | | | | | | | | | | | | | Remainder: 0.000416377 - 38.4905%
| | | | | | | | | | | | | | | | MV::DualView=>MV::DualView}: 0.000215803 - 0.011289% [14]
| | | | | | | | | | | | | | | | | [Host]: 0.0323605 - 1.69283% [56]
| | | | | | | | | | | | | | | | | sferNew::checkSizes: 6.05694e-05 - 0.187171% [28]
| | | | | | | | | | | | | | | | | sferNew::copyAndPermute: 0.00103701 - 3.20456% [28]
| | | | | | | | | | | | | | | | | opyAndPermute[Device]: 0.00091958 - 88.6758% [28]
| | | | | | | | | | | | | | | | | [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000389175 - 42.321% [28]
| | | | | | | | | | | | | | | | | 0405 - 57.679%
| | | | | | | | | | | | | | | | | - 11.3242%
| | | | | | | | | | | | | | | | | AndPrepare: 0.000333644 - 1.03102% [14]
| | | | | | | | | | | | | | | | | ackAndPrepare[Device]: 0.000270599 - 81.1042% [14]
| | | | | | | | | | | | | | | | | eallocDualViewIfNeeded: 2.12383e-05 - 7.84862% [14]
| | | | | | | | | | | | | | | | | | Remainder: 0.00019361 - 92.1514%
145 | | | | | | | | | | | | | | | | | | Remainder: 6.30445e-05 - 18.8958%
146 | | | | | | | | | | | | | | | | | | Kokkos::deep_copy [Cuda=>Host] {<=>}: 0.00537215 - 16.6009% [14]
147 | | | | | | | | | | | | | | | | | | Tpetra::Details::reallocDualViewIfNeeded: 4.27109e-05 - 0.131984% [28]
148 | | | | | | | | | | | | | | | | | | Tpetra::DistObject::doTransferNew::doPostsAndWaits: 0.0151135 - 46.7036% [14]
149 | | | | | | | | | | | | | | | | | | Tpetra::DistObject::doUnpackAndCombine: 0.00529809 - 16.3721% [14]
150 | | | | | | | | | | | | | | | | | | | Tpetra::MultiVector::unpackAndCombine[Device]: 0.0052385 - 98.8753% [14]
151 | | | | | | | | | | | | | | | | | | | | Kokkos::deep_copy [Host=>Cuda] {<=>}: 0.00489841 - 93.508% [14]
152 | | | | | | | | | | | | | | | | | | | | | Remainder: 0.000340083 - 6.492%
153 | | | | | | | | | | | | | | | | | | | | | | Remainder: 5.95878e-05 - 1.1247%
154 | | | | | | | | | | | | | | | | | | | | | | Remainder: 0.00510284 - 15.7687%
155 | | | | | | | | | | | | | | | | | | | | Tpetra::MV ctor (map,numVecs,zeroOut): 0.0328857 - 1.7203% [28]
156 | | | | | | | | | | | | | | | | | | | | RILUK::apply: 1.83877 - 96.1891% [14]
157 | | | | | | | | | | | | | | | | | | | | | Tpetra::MV ctor (map,numVecs,zeroOut): 0.013828 - 0.752024% [14]
158 | | | | | | | | | | | | | | | | | | | | | | Remainder: 1.82494 - 99.248%
159 | | | | | | | | | | | | | | | | | | | | | | Tpetra::MV::update(alpha,A,beta): 0.000215111 - 0.0112528% [14]
160 | | | | | | | | | | | | | | | | | | | | | | Remainder: 0.00609164 - 0.318664%
161 | | | | | | | | | | | | | | | | | | | | | | Remainder: 6.4601e-05 - 0.00337927%
162 | | | | | | | | | | | | | | | | | | | | | | Kokkos::deep_copy [Host=>Host] {<=>}: 7.48225e-06 - 0.000155107% [5]
163 | | | | | | | | | | | | | | | | | | | | | | Tpetra::MV::multiply: 0.000313679 - 0.00650255% [5]
164 | | | | | | | | | | | | | | | | | | | | | | Kokkos::deep_copy [Host=>Cuda] {<=>}: 0.00016359 - 52.152% [5]
165 | | | | | | | | | | | | | | | | | | | | | | Tpetra::MV::multiply-call-gemm: 8.98731e-05 - 28.6513% [5]
166 | | | | | | | | | | | | | | | | | | | | | | | Remainder: 6.02158e-05 - 19.1966%
167 | | | | | | | | | | | | | | | | | | | | | | | Remainder: 0.0324359 - 0.672396%
168 | | | | | | | | | | | | | | | | | | | | | | Tpetra::MV 2-arg "copy" ctor: 8.21437e-05 - 7.98146e-05% [1]
169 | | | | | | | | | | | | | | | | | | | | | | Tpetra::MV ctor (map,numVecs,zeroOut): 4.66663e-05 - 56.8106% [1]
170 | | | | | | | | | | | | | | | | | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.56371e-05 - 19.0362% [1]
171 | | | | | | | | | | | | | | | | | | | | | | | Remainder: 1.98403e-05 - 24.1532%
172 | | | | | | | | | | | | | | | | | | | | | | Tpetra::MV::norm2 (host output): 0.000444227 - 0.000431632% [2]
173 | | | | | | | | | | | | | | | | | | | | | | | Remainder: 0.0225537 - 0.0219142%
```

Orthogonalization within GMRES

Thermal Fluids Proxy – Solve



```
65 Belos: PseudoBlockGmresSolMgr total solve time: 4.82393 - 4.68715% [1]
66 | Tpetra::MV ctor (map,numVecs,zeroOut): 0.0257886 - 0.534598% [33]
67 | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.43192e-05 - 0.000296836% [1]
68 | Belos: ICGS[2]: Orthogonalization: 2.79582 - 57.9573% [15]
69 | | Belos: ICGS[2]: Ortho (Norm): 0.130224 - 4.65781% [15]
70 | | | Tpetra::MV::dot (Teuchos::ArrayView): 0.130155 - 99.947% [15]
71 | | | | Tpetra::multiVectorSingleColumnDot: 0.130104 - 99.9607% [15]
72 | | | | Remainder: 5.11121e-05 - 0.0392701%
73 | | | Remainder: 6.90087e-05 - 0.0529922%
74 | | Belos: ICGS[2]: Ortho (Inner Product): 2.17127 - 77.6612% [28]
75 | | | Tpetra::MV::dot (Teuchos::ArrayView): 0.150318 - 6.92303% [2]
76 | | | | Tpetra::multiVectorSingleColumnDot: 0.150311 - 99.9956% [2]
77 | | | | Remainder: 6.66906e-06 - 0.00443664%
78 | | | Tpetra::MultiVector::putScalar: 0.000371268 - 0.0170991% [26]
79 | | | | Kokkos::deep_copy_small [Host=>Cuda] {(none)=>}: 0.000109559 - 29.5093% [14]
80 | | | | Kokkos::deep_copy [Host=>Cuda] {(none)=>}: 9.13506e-05 - 24.605% [12]
81 | | | | Remainder: 0.000170359 - 45.8856%
82 | | | Tpetra::MV::multiply: 2.01497 - 92.801
83 | | | | Tpetra::MV::multiply-call-gemm: 0.
84 | | | | Tpetra::MV::reduce: 2.01419 - 99.9
85 | | | | | Kokkos::deep_copy_small [Cuda=>Cuda]
86 | | | | | Kokkos::deep_copy_small [Host=>Cuda]
87 | | | | | Kokkos::deep_copy_small [Cuda=>Cuda]
88 | | | | | Kokkos::deep_copy [Cuda=>Host]
89 | | | | | Kokkos::deep_copy [Host=>Cuda]
90 | | | | | Kokkos::deep_copy [Cuda=>Cuda]
91 | | | | | Remainder: 2.01123 - 99.8533%
92 | | | | | Remainder: 0.000193283 - 0.00959237%
93 | | | Kokkos::deep_copy_small [Cuda=>Host] {=>}: 0.000513469 - 0.0236483% [14]
94 | | | Kokkos::deep_copy [Host=>Host] {=>}: 0.0026512 - 0.122104% [19]
95 | | | Kokkos::deep_copy_small [Host=>Host] {=>}: 9.77813e-06 - 0.000450341% [7]
96 | | | Kokkos::deep_copy [Cuda=>Host] {=>}: 0.000440681 - 0.020296% [12]
97 | | | | Remainder: 0.0020011 - 0.0921626%
98 | | Belos: ICGS[2]: Ortho (Update): 0.493503 - 17.6514% [28]
99 | | | Tpetra::MV::update(alpha,A,beta): 2.49923e-05 - 0.00506427% [2]
100 | | | Kokkos::deep_copy_small [Host=>Host] {=>}: 2.39406e-05 - 0.00485117% [14]
101 | | | Tpetra::MV::multiply: 0.492372 - 99.7709% [26]
102 | | | | Kokkos::deep_copy_small [Host=>Cuda] {=>}: 0.000402805 - 0.081809% [14]
103 | | | | Tpetra::MV::multiply-call-gemm: 0.491391 - 99.8007% [26]
104 | | | | Kokkos::deep_copy [Host=>Cuda] {=>}: 0.000347407 - 0.0705578% [12]
105 | | | | Remainder: 0.000231194 - 0.0469552%
106 | | | Kokkos::deep_copy [Host=>Host] {=>}: 1.99955e-05 - 0.00405175% [12]
107 | | | | Remainder: 0.00106169 - 0.215133%
108 | | | | Remainder: 0.000826226 - 0.0295522%
109 | Tpetra::MV::update(alpha,A,beta,B,gamma): 0.000419398 - 0.00869411% [27]
110 | Tpetra::MV::norm2 (host output): 0.0114746 - 0.237868% [7]
111 | Belos: Operation Op*x: 0.0459722 - 0.953003% [19]
112 | | Tpetra::CrsMatrix::apply: 0.0459057 - 99.8552% [19]
113 | | | Tpetra::CrsMatrix::apply: Import: 0.043743 - 95.2889% [19]
114 | | | | Tpetra::DistObject::doTransfer[Host]: 0.0435503 - 99.5594% [38]
115 | | | | | Tpetra::DistObject::doTransferNew::checkSizes: 3.42809e-05 - 0.0787156% [19]
116 | | | | | Tpetra::DistObject::doTransferNew::copyAndPermute: 0.000648135 - 1.48824% [19]
117 | | | | | Tpetra::MultiVector::copyAndPermute[Device]: 0.000580102 - 89.5034% [19]
118 | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000255539 - 44.0507% [19]
119 | | | | | | Remainder: 0.000324563 - 55.9493%
120 | | | | | | Remainder: 6.80323e-05 - 10.4966%
121 | | | | | Tpetra::DistObject::doPackAndPrepare: 0.000376398 - 0.864285% [19]
122 | | | | | | Tpetra::MultiVector::packAndPrepare[Device]: 0.000306955 - 81.5505% [19]
123 | | | | | | Tpetra::Details::reallocDualViewIfNeeded: 1.99652e-05 - 6.50428% [19]
124 | | | | | | Remainder: 0.000286989 - 93.4957%
```

Op*X

```
125 | | | | | | Remainder: 6.94438e-05 - 18.4495%
126 | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.00353923 - 8.12677% [19]
127 | | | | | Tpetra::Details::reallocDualViewIfNeeded: 4.63523e-05 - 0.106434% [38]
128 | | | | | Tpetra::DistObject::doTransferNew::doPostsAndWaits: 0.0287958 - 66.1208% [19]
129 | | | | | Tpetra::DistObject::doUnpackAndCombine: 0.00368221 - 8.45508% [19]
130 | | | | | | Tpetra::MultiVector::unpackAndCombine[Device]: 0.0035963 - 97.6669% [19]
131 | | | | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.00313623 - 87.2071% [19]
132 | | | | | | Remainder: 0.000460071 - 12.7929%
133 | | | | | | Remainder: 8.59088e-05 - 2.33308%
134 | | | | | | Remainder: 0.00642787 - 14.7597%
135 | | | | | | Remainder: 0.00019275 - 0.440641%
136 | | | | | Tpetra::CrsMatrix::localApply: 0.00201358 - 4.38634% [19]
137 | | | | | Remainder: 0.000149063 - 0.324715%
138 | | | | | Remainder: 6.65753e-05 - 0.144816%
139 | Belos: Operation Prec*x: 1.91168 - 39.6291% [14]
140 | | Ifpack2::AdditiveSchwarz::apply: 1.91162 - 99.9966% [14]
141 | | | Tpetra::MultiVector::putScalar: 0.00108162 - 0.0565815% [56]
142 | | | Kokkos::deep_copy [Host=>Cuda] {(none)=>MV::DualView}: 0.000665301 - 61.5095% [56]
143 | | | | Remainder: 0.000416322 - 38.4905%
144 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000215803 - 0.011289% [14]
145 | | Tpetra::DistObject::doTransfer[Host]: 0.0323605 - 1.69283% [56]
146 | | | Tpetra::DistObject::doTransferNew::checkSizes: 6.05694e-05 - 0.187171% [28]
147 | | | Tpetra::DistObject::doTransferNew::copyAndPermute: 0.00103701 - 3.20456% [28]
148 | | | | Tpetra::MultiVector::copyAndPermute[Device]: 0.00091958 - 88.6758% [28]
149 | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000389175 - 42.321% [28]
150 | | | | | Remainder: 0.000530405 - 57.679%
151 | | | | | Remainder: 0.000117433 - 11.3242%
152 | | Tpetra::DistObject::doPackAndPrepare: 0.000333644 - 1.03102% [14]
153 | | | Tpetra::MultiVector::packAndPrepare[Device]: 0.000270599 - 81.1042% [14]
154 | | | | Tpetra::Details::reallocDualViewIfNeeded: 2.12383e-05 - 7.84862% [14]
155 | | | | | Remainder: 0.000249361 - 92.1514%
156 | | | | | Remainder: 6.30445e-05 - 18.8958%
157 | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.00537215 - 16.6009% [14]
158 | | Tpetra::Details::reallocDualViewIfNeeded: 4.27109e-05 - 0.131984% [28]
159 | | Tpetra::DistObject::doTransferNew::doPostsAndWaits: 0.0151135 - 46.7036% [14]
160 | | Tpetra::DistObject::doUnpackAndCombine: 0.00529809 - 16.3721% [14]
161 | | | Tpetra::MultiVector::unpackAndCombine[Device]: 0.0052385 - 98.8753% [14]
162 | | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.00489841 - 93.508% [14]
163 | | | | | Remainder: 0.000340083 - 6.492%
164 | | | | | Remainder: 5.95878e-05 - 1.1247%
165 | | | | | Remainder: 0.00510284 - 15.7687%
166 | | Tpetra::MV ctor (map,numVecs,zeroOut): 0.0328857 - 1.7203% [28]
167 | | RILUK::apply: 1.83877 - 96.1891% [14]
168 | | | Tpetra::MV ctor (map,numVecs,zeroOut): 0.013828 - 0.752024% [14]
169 | | | | Remainder: 1.82494 - 99.248%
170 | | | Tpetra::MV::update(alpha,A,beta): 0.000215111 - 0.0112528% [14]
171 | | | | Remainder: 0.00609164 - 0.318664%
172 | | | | Remainder: 6.4601e-05 - 0.00337927%
173 | Kokkos::deep_copy [Host=>Host] {=>}: 7.48225e-06 - 0.000155107% [5]
174 | Tpetra::MV::multiply: 0.000313679 - 0.00650255% [5]
175 | | Kokkos::deep_copy [Host=>Cuda] {=>}: 0.00016359 - 52.152% [5]
176 | | Tpetra::MV::multiply-call-gemm: 8.98731e-05 - 28.6513% [5]
177 | | | Remainder: 6.02158e-05 - 19.1966%
178 | | | Remainder: 0.0324359 - 0.672396%
179 | Tpetra::MV 2-arg "copy" ctor: 8.21437e-05 - 7.98146e-05% [1]
180 | | Tpetra::MV ctor (map,numVecs,zeroOut): 4.66663e-05 - 56.8106% [1]
181 | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.56371e-05 - 19.0362% [1]
182 | | Remainder: 1.98403e-05 - 24.1532%
183 | Tpetra::MV::norm2 (host output): 0.000444227 - 0.000431632% [2]
184 | | Remainder: 0.0225537 - 0.0219142%
```


Thermal Fluids Proxy – Solve



```
65 Belos: PseudoBlockGmresSolMgr total solve time: 4.82393 - 4.68715% [1]
66 | Tpetra::MV ctor (map,numVecs,zeroOut): 0.0257886 - 0.534598% [33]
67 | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.43192e-05 - 0.000296836% [1]
68 | Belos: ICGS[2]: Orthogonalization: 2.79582 - 57.9573% [15]
69 | | Belos: ICGS[2]: Ortho (Norm): 0.130224 - 4.65781% [15]
70 | | | Tpetra::MV::dot (Teuchos::ArrayView): 0.130155 - 99.947% [15]
71 | | | | Tpetra::multiVectorSingleColumnDot: 0.130104 - 99.9607% [15]
72 | | | | Remainder: 5.11121e-05 - 0.0392701%
73 | | | Remainder: 6.90087e-05 - 0.0529922%
74 | | Belos: ICGS[2]: Ortho (Inner Product): 2.17127 - 77.6612% [28]
75 | | | Tpetra::MV::dot (Teuchos::ArrayView): 0.150318 - 6.92303% [2]
76 | | | | Tpetra::multiVectorSingleColumnDot: 0.150311 - 99.9956% [2]
77 | | | | Remainder: 6.66906e-06 - 0.00443664%
78 | | | Tpetra::MultiVector::putScalar: 0.000371268 - 0.0170991% [26]
79 | | | | Kokkos::deep_copy_small [Host=>Cuda] {(none)=>}: 0.000109559 - 29.5093% [14]
80 | | | | Kokkos::deep_copy [Host=>Cuda] {(none)=>}: 9.13506e-05 - 24.605% [12]
81 | | | | Remainder: 0.000170359 - 45.8856%
82 | | | Tpetra::MV::multiply: 2.01497 - 92.8012% [26]
83 | | | | Tpetra::MV::multiply-call-gemm: 0.000583166 - 0.0289417% [26]
84 | | | | Tpetra::MV::reduce: 2.01419 - 99.9615% [26]
85 | | | | | Kokkos::deep_copy_small [Cuda=>Host] {=>}: 0.0010486 - 0.0520605% [28]
86 | | | | | Kokkos::deep_copy_small [Host=>Cuda]
87 | | | | | Kokkos::deep_copy_small [Cuda=>Host]
88 | | | | | Kokkos::deep_copy [Cuda=>Host]
89 | | | | | Kokkos::deep_copy [Host=>Cuda]
90 | | | | | Kokkos::deep_copy [Cuda=>Cuda]
91 | | | | | Remainder: 2.01123 - 99.8533%
92 | | | | | Remainder: 0.000193283 - 0.0095923%
93 | | | Kokkos::deep_copy_small [Cuda=>Host] {
94 | | | | Kokkos::deep_copy [Host=>Host] {=>}: 0
95 | | | | Kokkos::deep_copy_small [Host=>Host] {
96 | | | | | Kokkos::deep_copy [Cuda=>Host] {=>}: 0
97 | | | | | Remainder: 0.0020011 - 0.0921626%
98 | | Belos: ICGS[2]: Ortho (Update): 0.493503 - 17.6514% [28]
99 | | | Tpetra::MV::update(alpha,A,beta): 2.49923e-05 - 0.00506427% [2]
100 | | | | Kokkos::deep_copy_small [Host=>Host] {=>}: 2.39406e-05 - 0.00485117% [14]
101 | | | | Tpetra::MV::multiply: 0.492372 - 99.7709% [26]
102 | | | | | Kokkos::deep_copy_small [Host=>Cuda] {=>}: 0.000402805 - 0.081809% [14]
103 | | | | | Tpetra::MV::multiply-call-gemm: 0.491391 - 99.8007% [26]
104 | | | | | Kokkos::deep_copy [Host=>Cuda] {=>}: 0.000347407 - 0.0705578% [12]
105 | | | | | Remainder: 0.000231194 - 0.0469552%
106 | | | | | Kokkos::deep_copy [Host=>Host] {=>}: 1.99955e-05 - 0.00405175% [12]
107 | | | | | Remainder: 0.00106169 - 0.215133%
108 | | | | | Remainder: 0.000826226 - 0.0295522%
109 | | Tpetra::MV::update(alpha,A,beta,B,gamma): 0.000419398 - 0.00869411% [27]
110 | | Tpetra::MV::norm2 (host output): 0.0114746 - 0.237868% [7]
111 | Belos: Operation Op*x: 0.0459722 - 0.953003% [19]
112 | | Tpetra::CrsMatrix::apply: 0.0459057 - 99.8552% [19]
113 | | | Tpetra::CrsMatrix::apply: Import: 0.043743 - 95.2889% [19]
114 | | | | Tpetra::DistObject::doTransfer[Host]: 0.0435503 - 99.5594% [38]
115 | | | | | Tpetra::DistObject::doTransferNew::checkSizes: 3.42809e-05 - 0.0787156% [19]
116 | | | | | Tpetra::DistObject::doTransferNew::copyAndPermute: 0.000648135 - 1.48824% [19]
117 | | | | | Tpetra::MultiVector::copyAndPermute[Device]: 0.000580102 - 89.5034% [19]
118 | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000255539 - 44.0507% [19]
119 | | | | | | Remainder: 0.000324563 - 55.9493%
120 | | | | | | Remainder: 6.80323e-05 - 10.4966%
121 | | | | | Tpetra::DistObject::doPackAndPrepare: 0.000376398 - 0.864285% [19]
122 | | | | | | Tpetra::MultiVector::packAndPrepare[Device]: 0.000306955 - 81.5505% [19]
123 | | | | | | Tpetra::Details::reallocDualViewIfNeeded: 1.99652e-05 - 6.50428% [19]
124 | | | | | | Remainder: 0.000286989 - 93.4957%
```

Preconditioner
Apply

```
125 | | | | | Remainder: 6.94438e-05 - 18.4495%
126 | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.00353923 - 8.12677% [19]
127 | | | | | Tpetra::Details::reallocDualViewIfNeeded: 4.63523e-05 - 0.106434% [38]
128 | | | | | Tpetra::DistObject::doTransferNew::doPostsAndWaits: 0.0287958 - 66.1208% [19]
129 | | | | | Tpetra::DistObject::doUnpackAndCombine: 0.00368221 - 8.45508% [19]
130 | | | | | | Tpetra::MultiVector::unpackAndCombine[Device]: 0.0035963 - 97.6669% [19]
131 | | | | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.00313623 - 87.2071% [19]
132 | | | | | | Remainder: 0.000460071 - 12.7929%
133 | | | | | | Remainder: 8.59088e-05 - 2.33308%
134 | | | | | | Remainder: 0.00642787 - 14.7597%
135 | | | | | | Remainder: 0.00019275 - 0.440641%
136 | | | | | Tpetra::CrsMatrix::localApply: 0.00201358 - 4.38634% [19]
137 | | | | | Remainder: 0.000149063 - 0.324715%
138 | | | | | | Remainder: 6.65753e-05 - 0.144816%
139 | | Belos: Operation Prec*x: 1.91168 - 39.6291% [14]
140 | | | Ifpack2::AdditiveSchwarz::apply: 1.91162 - 99.9966% [14]
141 | | | | Tpetra::MultiVector::putScalar: 0.00108162 - 0.0565815% [56]
142 | | | | | Kokkos::deep_copy [Host=>Cuda] {(none)=>MV::DualView}: 0.000665301 - 61.5095% [56]
143 | | | | | Remainder: 0.000416322 - 38.4905%
144 | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000215803 - 0.011289% [14]
145 | | | | Tpetra::DistObject::doTransfer[Host]: 0.0323605 - 1.69283% [56]
146 | | | | | Tpetra::DistObject::doTransferNew::checkSizes: 6.05694e-05 - 0.187171% [28]
147 | | | | | Tpetra::DistObject::doTransferNew::copyAndPermute: 0.00103701 - 3.20456% [28]
148 | | | | | | Tpetra::MultiVector::copyAndPermute[Device]: 0.00091958 - 88.6758% [28]
149 | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000389175 - 42.321% [28]
150 | | | | | | Remainder: 0.000530405 - 57.679%
151 | | | | | | Remainder: 0.000117433 - 11.3242%
152 | | | | | Tpetra::DistObject::doPackAndPrepare: 0.000333644 - 1.03102% [14]
153 | | | | | | Tpetra::MultiVector::packAndPrepare[Device]: 0.000270599 - 81.1042% [14]
154 | | | | | | Tpetra::Details::reallocDualViewIfNeeded: 2.12383e-05 - 7.84862% [14]
155 | | | | | | Remainder: 0.000249361 - 92.1514%
156 | | | | | | Remainder: 6.30445e-05 - 18.8958%
157 | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.00537215 - 16.6009% [14]
158 | | | | | Tpetra::Details::reallocDualViewIfNeeded: 4.27109e-05 - 0.131984% [28]
159 | | | | | Tpetra::DistObject::doTransferNew::doPostsAndWaits: 0.0151135 - 46.7036% [14]
160 | | | | | Tpetra::DistObject::doUnpackAndCombine: 0.00529809 - 16.3721% [14]
161 | | | | | | Tpetra::MultiVector::unpackAndCombine[Device]: 0.0052385 - 98.8753% [14]
162 | | | | | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.00489841 - 93.508% [14]
163 | | | | | | | Remainder: 0.000340083 - 6.492%
164 | | | | | | | Remainder: 5.95878e-05 - 1.1247%
165 | | | | | | | Remainder: 0.00510284 - 15.7687%
166 | | | | | | Tpetra::MV ctor (map,numVecs,zeroOut): 0.0328857 - 1.7203% [28]
167 | | | | | | RILUK::apply: 1.83877 - 96.1891% [14]
168 | | | | | | | Tpetra::MV ctor (map,numVecs,zeroOut): 0.013828 - 0.752024% [14]
169 | | | | | | | Remainder: 1.82494 - 99.248%
170 | | | | | | Tpetra::MV::update(alpha,A,beta): 0.000215111 - 0.0112528% [14]
171 | | | | | | | Remainder: 0.00600164 - 0.218664%
172 | | | | | | | Remainder: 6.4001e-05 - 0.0037927%
173 | | | | | Kokkos::deep_copy [Host=>Host] {=>}: 7.48225e-06 - 0.000155107% [5]
174 | | | | | Tpetra::MV::multiply: 0.000313679 - 0.00650255% [5]
175 | | | | | | Kokkos::deep_copy [Host=>Cuda] {=>}: 0.00016359 - 52.152% [5]
176 | | | | | | Tpetra::MV::multiply-call-gemm: 8.98731e-05 - 28.6513% [5]
177 | | | | | | | Remainder: 6.02158e-05 - 19.1966%
178 | | | | | | | Remainder: 0.0324359 - 0.672396%
179 | | | | | Tpetra::MV 2-arg "copy" ctor: 8.21437e-05 - 7.98146e-05% [1]
180 | | | | | Tpetra::MV ctor (map,numVecs,zeroOut): 4.66663e-05 - 56.8106% [1]
181 | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.56371e-05 - 19.0362% [1]
182 | | | | | | Remainder: 1.98403e-05 - 24.1532%
183 | | | | | Tpetra::MV::norm2 (host output): 0.000444227 - 0.000431632% [2]
184 | | | | | | Remainder: 0.0225537 - 0.0219142%
```

RILUK::apply: 1.83877 - 96.1891% [14]

SPILUK kernel
(no deep copies!)

SPARC Performance Proxy



Matrix:

- 4,194,304 block rows, 7x7 blocks
- Application-specified rowmap

Run on 16 MPI ranks, one GPU per rank

Ifpack2 Block tri-diagonal solver

SPARC performance proxy – Setup



Some H2D transfers may be due to matrix starting life on host.

```
67 BlockTriDiagonalSolver: 0.402791 [1] {min=0.398697, max=0.405759, std dev=0.00208308} <2, 9, 5>
68 | Kokkos::deep_copy [Host=>Cuda] [(none)=>MV::DualView]: 1.15362e-05 - 0.00286406% [1] {min=9.457e-06, max=1.3476e-05, std dev=1.30905e-06} <4, 6, 6>
69 | Kokkos::deep_copy [Cuda=>Host] [MV::DualView=>MV::DualView_mirror]: 0.000219524 - 0.0545006% [1] {min=0.000201362, max=0.000261668, std dev=1.4902e-05} <13, 2, 1>
70 | Kokkos::deep_copy [Host=>Cuda] [=>nonContigGids]: 0.00149956 - 0.372292% [1] {min=8.8975e-05, max=0.00227763, std dev=0.000795955} <3, 5, 8>
71 | Kokkos::deep_copy [Cuda=>Host] [nonContigGids=>nonContigGids]: 0.00208483 - 0.517595% [1] {min=0.000141518, max=0.00332777, std dev=0.0010933} <3, 5, 8>
72 | Kokkos::deep_copy_small [Cuda=>Host] [Tpetra::FixedHashTable::ptr=>outputSpace]: 6.4396e-05 - 0.0159874% [1]
73 | Kokkos::deep_copy_small [Cuda=>Host] [Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val]: 4.7942e-05 - 0.0119025% [1]
74 | Kokkos::deep_copy [Host=>Cuda] [lgMap_mirror=>lgMap]: 0.00190606 - 0.473214% [1] {min=0.00129857, max=0.00234136, std dev=0.000387555} <5, 1, 10>
75 | Kokkos::deep_copy [Cuda=>Cuda] [MV::DualView=>MV::DualView]: 1.90867e-05 - 0.00473861% [1] {min=1.4634e-05, max=2.2814e-05, std dev=2.18449e-06} <4, 7, 5>
76 | Kokkos::deep_copy [Cuda=>Host] [exports=>exports_mirror]: 0.000155967 - 0.0387217% [1] {min=0.000136767, max=0.000179056, std dev=1.13794e-05} <4, 10, 2>
77 | Kokkos::deep_copy [Host=>Cuda] [imports_mirror=>imports]: 0.000180773 - 0.044888% [1] {min=0.000123796, max=0.000264773, std dev=5.37565e-05} <8, 2, 6>
78 | Kokkos::deep_copy [Host=>Cuda] [Tpetra::CrsGraph::lclInd_mirror=>Tpetra::CrsGraph::lclInd]: 0.000889705 - 0.220885% [1] {min=0.00061186, max=0.00136407, std dev=0.000238827} <8, 6, 2>
79 | Kokkos::deep_copy [Host=>Cuda] [val_mirror=>val]: 0.0839978 - 0.20539% [1] {min=0.0711581, max=0.097457, std dev=0.00845105} <7, 4, 5>
80 | Preconditioner setup: 0.16756 - 41.5996% [1] {min=0.135984, max=0.191585, std dev=0.014088} <3, 8, 5>
81 | | Kokkos::deep_copy [Host=>Cuda] [=>nonContigGids]: 2.70644e-05 - 0.0161521% [1] {min=1.2769e-05, max=3.4503e-05, std dev=6.11785e-06} <2, 5, 9>
82 | | Kokkos::deep_copy [Cuda=>Host] [nonContigGids=>nonContigGids]: 5.83015e-05 - 0.0347945% [1] {min=5.0779e-05, max=6.9708e-05, std dev=5.42165e-06} <8, 6, 2>
83 | | Kokkos::deep_copy_small [Cuda=>Host] [Tpetra::FixedHashTable::ptr=>outputSpace]: 3.60025e-05 - 0.0214864% [1] {min=3.0737e-05, max=4.1268e-05, std dev=7.44654e-06} <1, 0, 1>
84 | | Kokkos::deep_copy_small [Cuda=>Host] [Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val]: 3.37355e-05 - 0.0201334% [1] {min=2.8328e-05, max=3.9143e-05, std dev=7.64736e-06} <1, 0, 1>
85 | | Kokkos::deep_copy [lgMap_mirror=>lgMap]: 2.67858e-05 - 0.0159858% [1] {min=2.1038e-05, max=3.3766e-05, std dev=4.03181e-06} <7, 6, 3>
86 | | Kokkos::deep_copy [Host=>Cuda] [dm2cm_mirror=>dm2cm]: 0.000156 - 0.0931012% [1] {min=0.000138015, max=0.000181487, std dev=1.31207e-05} <8, 4, 4>
87 | | Kokkos::deep_copy [Host=>Cuda] [permuteFromLIDs=>permuteFromLIDs_mirror]: 5.63007e-05 - 0.0336004% [2] {min=5.0451e-05, max=6.1544e-05, std dev=3.30444e-06} <4, 8, 4>
88 | | Kokkos::deep_copy [Host=>Host] [importObjs=>exportObjs]: 6.88867e-06 - 0.0041117% [1] {min=4.525e-06, max=1.3158e-05, std dev=2.78209e-06} <6, 2, 1>
89 | | Kokkos::deep_copy [Host=>Host] [exports=>imports]: 6.1557e-06 - 0.00367374% [1] {min=2.398e-06, max=9.322e-06, std dev=1.98961e-06} <1, 7, 2>
90 | | Kokkos::deep_copy [Host=>Cuda] [exportLIDs=>exportLIDs_mirror]: 1.51041e-05 - 0.00901418% [1] {min=1.2427e-05, max=2.0263e-05, std dev=2.36384e-06} <9, 5, 2>
91 | | Kokkos::deep_copy_small [Host=>Cuda] [=>]: 6.21511e-05 - 0.037092% [2] {min=5.6556e-05, max=6.8392e-05, std dev=3.74721e-06} <5, 5, 6>
92 | | Kokkos::deep_copy [Host=>Cuda] [=>lids recv]: 4.39985e-05 - 0.0262584% [1] {min=3.9229e-05, max=5.0484e-05, std dev=2.90277e-06} <4, 11, 1>
93 | | Kokkos::deep_copy [lids send_mirror=>lids send]: 4.16972e-05 - 0.024885% [1] {min=3.7102e-05, max=4.7193e-05, std dev=3.27029e-06} <6, 6, 4>
94 | | Kokkos::deep_copy [Host=>Cuda] [partptr_mirror=>partptr]: 3.97446e-05 - 0.0237197% [1] {min=3.0635e-05, max=8.5843e-05, std dev=1.44949e-05} <14, 1, 1>
95 | | Kokkos::deep_copy [Host=>Cuda] [lclrow_mirror=>lclrow]: 0.000161403 - 0.0963254% [1] {min=0.0001107, max=0.000276019, std dev=4.9308e-05} <11, 3, 2>
96 | | Kokkos::deep_copy [Host=>Cuda] [part2packrowidx0_mirror=>part2packrowidx0]: 4.06942e-05 - 0.0242864% [1] {min=2.7149e-05, max=7.9001e-05, std dev=1.54671e-05} <11, 4, 1>
97 | | Kokkos::deep_copy [Host=>Cuda] [rowidx2part_mirror=>rowidx2part]: 0.000152562 - 0.0910494% [1] {min=0.000119641, max=0.000205769, std dev=3.05578e-05} <10, 2, 4>
98 | | Kokkos::deep_copy [Host=>Cuda] [packptr_mirror=>packptr]: 3.4065e-05 - 0.0203301% [1] {min=2.7626e-05, max=6.6363e-05, std dev=1.01909e-05} <13, 2, 1>
99 | | Kokkos::deep_copy_small [Cuda=>Host] [btm.flat_td_ptr=>btm.flat_td_ptr]: 4.54451e-05 - 0.0271217% [1] {min=4.191e-05, max=4.9215e-05, std dev=2.21033e-06} <5, 6, 5>
100 | | Kokkos::deep_copy [Cuda=>Host] [partptr=>partptr]: 8.83166e-05 - 0.0527076% [2] {min=7.1472e-05, max=0.000175214, std dev=2.39368e-05} <15, 0, 1>
101 | | Kokkos::deep_copy [Cuda=>Host] [lclrow=>lclrow]: 0.000151653 - 0.0905072% [1] {min=0.000135221, max=0.000203844, std dev=1.58521e-05} <13, 2, 1>
102 | | Kokkos::deep_copy [Cuda=>Host] [rowidx2part=>rowidx2part]: 0.00016809 - 0.100317% [1] {min=0.000137906, max=0.000243806, std dev=2.78406e-05} <12, 3, 1>
103 | | Kokkos::deep_copy [Cuda=>Host] [packptr=>packptr]: 3.95134e-05 - 0.0235817% [1] {min=3.4661e-05, max=5.5139e-05, std dev=4.78901e-06} <14, 1, 1>
104 | | Kokkos::deep_copy_scalar [Host=>Host] [Scalar=>col2row]: 0.000121891 - 0.072745% [1] {min=8.4187e-05, max=0.000167398, std dev=3.02439e-05} <7, 3, 6>
105 | | Kokkos::deep_copy [Cuda=>Host] [Tpetra::CrsGraph::lclInd=>Tpetra::CrsGraph::lclInd_mirror]: 0.000891747 - 0.532197% [1] {min=0.0006305, max=0.00124822, std dev=0.00022798} <9, 2, 5>
106 | | Kokkos::deep_copy [Cuda=>Host] [Tpetra::CrsGraph::ptr=>rowPtrsPacked_host]: 0.000331217 - 0.197671% [1] {min=0.000240064, max=0.000497482, std dev=8.07665e-05} <8, 6, 2>
107 | | Kokkos::deep_copy [Cuda=>Host] [btm.flat_td_ptr=>btm.flat_td_ptr]: 5.0545e-05 - 0.0301654% [1] {min=4.46e-05, max=6.4426e-05, std dev=5.23822e-06} <10, 5, 1>
108 | | Kokkos::deep_copy [Host=>Cuda] [btm.A.colindsub_mirror=>btm.A.colindsub]: 0.000367991 - 0.219618% [1] {min=0.00031059, max=0.000443933, std dev=5.13364e-05} <9, 2, 5>
109 | | Kokkos::deep_copy_small [Cuda=>Host] [btm.pack_td_ptr=>btm.pack_td_ptr]: 4.45901e-05 - 0.0266115% [1] {min=3.4254e-05, max=7.2808e-05, std dev=1.26127e-05} <13, 0, 3>
110 | | Kokkos::deep_copy [Host=>Cuda] [amd.rowptr_mirror=>amd.rowptr]: 0.000326203 - 0.194679% [1] {min=0.000227678, max=0.000374588, std dev=4.34378e-05} <3, 2, 11>
111 | | Kokkos::deep_copy [Cuda=>Cuda] [amd.A.colindsub_mirror=>amd.A.colindsub]: 0.000605561 - 0.3614% [1] {min=0.000364401, max=0.000772601, std dev=0.000103638} <2, 8, 6>
112 | | Kokkos::deep_copy [Cuda=>Host] [Tpetra::FixedHashTable::ptr=>outputSpace]: 3.6504e-05 - 0.0217857% [1] {min=3.112e-05, max=4.1018e-05, std dev=2.95408e-06} <3, 7, 4>
113 | | Kokkos::deep_copy [Cuda=>Host] [Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val]: 5.05683e-05 - 0.0301793% [1] {min=3.595e-05, max=7.3557e-05, std dev=1.02372e-05} <6, 6, 2>
114 | | Remainder: 0.163241 - 97.4227%
115 | Preconditioner compute: 0.00814887 - 2.0231% [1] {min=0.00765796, max=0.0083643, std dev=0.00015848} <1, 5, 10>
116 | | Kokkos::deep_copy [Host=>Cuda] [Tpetra::CrsGraph::lclInd_mirror=>Tpetra::CrsGraph::lclInd]: 0.00103259 - 12.6715% [1] {min=0.000555153, max=0.00117997, std dev=0.000142716} <1, 1, 14>
117 | | Remainder: 0.00711628 - 87.3285%
118 | Solve: 0.0679893 - 16.8795% [1] {min=0.0578111, max=0.0764768, std dev=0.00444419} <1, 12, 3>
119 | | Kokkos::deep_copy_scalar [Host=>Cuda] [Scalar=>MV::DualView]: 6.20339e-05 - 0.0912408% [1] {min=5.2039e-05, max=9.9635e-05, std dev=1.39067e-05} <14, 0, 2>
120 | | Remainder: 0.0679272 - 99.9088%
121 | | Kokkos::deep_copy [Cuda=>Host] [Tpetra::FixedHashTable::ptr=>outputSpace]: 0.00119007 - 0.295456% [1] {min=7.7788e-05, max=0.00188394, std dev=0.000602947} <3, 3, 9>
122 | | Kokkos::deep_copy [Cuda=>Host] [Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val]: 0.00386528 - 0.959623% [1] {min=0.000141391, max=0.0059952, std dev=0.0020569} <3, 2, 10>
123 | | Remainder: 0.0629607 - 15.6311%
```

SPARC performance proxy – Preconditioner Setup



Some H2D transfers may be due to matrix starting life on host.

```
67 BlockTriDiagonalSolver: 0.402791 [1] {min=0.398697, max=0.405759, std dev=0.00208308} <2, 9, 5>
68 | Kokkos::deep_copy [Cuda=>Cuda] {(none)=>MV::DualView}: 1.15362e-05 - 0.00286406 [1] {min=9.457e-06, max=1.3476e-05, std dev=1.30905e-06} <4, 6, 6>
69 | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.000219524 - 0.0545006 [1] {min=0.000201362, max=0.000261668, std dev=1.4902e-05} <13, 2, 1>
70 | Kokkos::deep_copy [Host=>Cuda] {=>nonContigGids}: 0.00149956 - 0.372292 [1] {min=8.8975e-05, max=0.00227763, std dev=0.000795955} <3, 5, 8>
71 | Kokkos::deep_copy [Cuda=>Host] {nonContigGids=>nonContigGids}: 0.00208483 - 0.517595 [1] {min=0.000141518, max=0.00332777, std dev=0.0010933} <3, 5, 8>
72 | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 6.4396e-05 - 0.0159874 [1]
73 | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 4.7942e-05 - 0.0119025 [1]
74 | Kokkos::deep_copy [Host=>Cuda] {lgMap_mirror=>lgMap}: 0.00190606 - 0.473214 [1] {min=0.00129857, max=0.00234136, std dev=0.000387555} <5, 1, 10>
75 | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.90867e-05 - 0.00473861 [1] {min=1.4634e-05, max=2.2814e-05, std dev=2.18449e-06} <4, 7, 5>
76 | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.000155967 - 0.0387217 [1] {min=0.000136767, max=0.000179056, std dev=1.13794e-05} <4, 10, 2>
77 | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.000180773 - 0.044888 [1] {min=0.000123796, max=0.000264773, std dev=5.37565e-05} <8, 2, 6>
78 | Kokkos::deep_copy [Host=>Cuda] {Tpetra::CrsGraph::lclInd_mirror=>Tpetra::CrsGraph::lclInd}: 0.000889705 - 0.220885 [1] {min=0.00061186, max=0.00136407, std dev=0.000238827} <8, 6, 2>
79 | Kokkos::deep_copy [Host=>Cuda] {val_mirror=>val}: 0.0839978 - 0.20539 [1] {min=0.0711581, max=0.097457, std dev=0.00845105} <7, 4, 5>
80 | Preconditioner setup: 0.16756 - 41.5996 [1] {min=0.135984, max=0.191585, std dev=0.014088} <3, 8, 5>
81 | | Kokkos::deep_copy [Host=>Cuda] {=>nonContigGids}: 2.70644e-05 - 0.0161521 [1] {min=1.2769e-05, max=3.4503e-05, std dev=6.11785e-06} <2, 5, 9>
82 | | Kokkos::deep_copy [Cuda=>Host] {nonContigGids=>nonContigGids}: 5.83015e-05 - 0.0347945 [1] {min=5.0779e-05, max=6.9708e-05, std dev=5.42165e-06} <8, 6, 2>
83 | | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 3.60025e-05 - 0.0214864 [1] {min=3.0737e-05, max=4.1268e-05, std dev=7.44654e-06} <1, 0, 1>
84 | | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 3.37355e-05 - 0.0201334 [1] {min=2.8328e-05, max=3.9143e-05, std dev=7.64736e-06} <1, 0, 1>
85 | | Kokkos::deep_copy [Host=>Cuda] {lgMap_mirror=>lgMap}: 2.67858e-05 - 0.0159858 [1] {min=2.1038e-05, max=3.3766e-05, std dev=4.03181e-06} <7, 6, 3>
86 | | Kokkos::deep_copy [Host=>Cuda] {dm2cm_mirror=>dm2cm}: 0.000156 - 0.0931012 [1] {min=0.000138015, max=0.000181487, std dev=1.31207e-05} <8, 4, 4>
87 | | Kokkos::deep_copy [Host=>Cuda] {permuteFromLIDs=>permuteFromLIDs_mirror}: 5.63007e-05 - 0.0336004 [2] {min=5.0451e-05, max=6.1544e-05, std dev=3.30444e-06} <4, 8, 4>
88 | | Kokkos::deep_copy [Host=>Host] {importObjs=>exportObjs}: 6.88867e-06 - 0.0041117 [1] {min=4.525e-06, max=1.3158e-05, std dev=2.78209e-06} <6, 2, 1>
89 | | Kokkos::deep_copy [Host=>Host] {exports=>imports}: 6.1557e-06 - 0.00367374 [1] {min=2.398e-06, max=9.322e-06, std dev=1.98961e-06} <1, 7, 2>
90 | | Kokkos::deep_copy [Host=>Cuda] {exportLIDs=>exportLIDs_mirror}: 1.51041e-05 - 0.00901418 [1] {min=1.2427e-05, max=2.0263e-05, std dev=2.36384e-06} <9, 5, 2>
91 | | Kokkos::deep_copy_small [Host=>Cuda] {=>}: 6.21511e-05 - 0.037092 [2] {min=5.6556e-05, max=6.8392e-05, std dev=3.74721e-06} <5, 5, 6>
92 | | Kokkos::deep_copy [Host=>Cuda] {=>lids recv}: 4.39985e-05 - 0.0262584 [1] {min=3.9229e-05, max=5.0484e-05, std dev=2.90277e-06} <4, 11, 1>
93 | | Kokkos::deep_copy [Host=>Cuda] {lids send_mirror=>lids send}: 4.16972e-05 - 0.024885 [1] {min=3.7102e-05, max=4.7193e-05, std dev=3.27029e-06} <6, 6, 4>
94 | | Kokkos::deep_copy [Host=>Cuda] {partptr_mirror=>partptr}: 3.97446e-05 - 0.0237197 [1] {min=3.0635e-05, max=8.5843e-05, std dev=1.44949e-05} <14, 1, 1>
95 | | Kokkos::deep_copy [Host=>Cuda] {lclrow_mirror=>lclrow}: 0.000161403 - 0.0963254 [1] {min=0.0001107, max=0.000276019, std dev=4.9308e-05} <11, 3, 2>
96 | | Kokkos::deep_copy [Host=>Cuda] {part2packrowidx0_mirror=>part2packrowidx0}: 4.06942e-05 - 0.0242864 [1] {min=2.7149e-05, max=7.9001e-05, std dev=1.54671e-05} <11, 4, 1>
97 | | Kokkos::deep_copy [Host=>Cuda] {rowidx2part_mirror=>rowidx2part}: 0.000152562 - 0.0910494 [1] {min=0.000119641, max=0.000205769, std dev=3.05578e-05} <10, 2, 4>
98 | | Kokkos::deep_copy [Host=>Cuda] {packptr_mirror=>packptr}: 3.4065e-05 - 0.0203301 [1] {min=2.7626e-05, max=6.6363e-05, std dev=1.01909e-05} <13, 2, 1>
99 | | Kokkos::deep_copy_small [Cuda=>Host] {btm.flat_td_ptr=>btm.flat_td_ptr}: 4.54451e-05 - 0.0271217 [1] {min=4.191e-05, max=4.9215e-05, std dev=2.21033e-06} <5, 6, 5>
100 | | Kokkos::deep_copy [Cuda=>Host] {partptr=>partptr}: 8.83166e-05 - 0.0527076 [2] {min=7.1472e-05, max=0.000175214, std dev=2.39368e-05} <15, 0, 1>
101 | | Kokkos::deep_copy [Cuda=>Host] {lclrow=>lclrow}: 0.000151653 - 0.0905072 [1] {min=0.000135221, max=0.000203844, std dev=1.58521e-05} <13, 2, 1>
102 | | Kokkos::deep_copy [Cuda=>Host] {rowidx2part=>rowidx2part}: 0.00016809 - 0.100317 [1] {min=0.000137906, max=0.000243806, std dev=2.78406e-05} <12, 3, 1>
103 | | Kokkos::deep_copy [Cuda=>Host] {packptr=>packptr}: 3.95134e-05 - 0.0235817 [1] {min=3.4661e-05, max=5.5139e-05, std dev=4.78901e-06} <14, 1, 1>
104 | | Kokkos::deep_copy_scalar [Host=>Host] {Scalar=>col2row}: 0.000121891 - 0.072745 [1] {min=8.4187e-05, max=0.000167398, std dev=3.02439e-05} <7, 3, 6>
105 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::CrsGraph::lclInd=>Tpetra::CrsGraph::lclInd_mirror}: 0.000891747 - 0.532197 [1] {min=0.0006305, max=0.00124822, std dev=0.00022798} <9, 2, 5>
106 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::CrsGraph::ptr=>rowPtrsPacked_host}: 0.000331217 - 0.197671 [1] {min=0.000240064, max=0.000497482, std dev=8.07665e-05} <8, 6, 2>
107 | | Kokkos::deep_copy [Cuda=>Host] {btm.flat_td_ptr=>btm.flat_td_ptr}: 5.0545e-05 - 0.0301654 [1] {min=4.46e-05, max=6.4426e-05, std dev=5.23822e-06} <10, 5, 1>
108 | | Kokkos::deep_copy [Host=>Cuda] {btm.A.colindsub_mirror=>btm.A.colindsub}: 0.000367991 - 0.219618 [1] {min=0.00031059, max=0.000443933, std dev=5.13364e-05} <9, 2, 5>
109 | | Kokkos::deep_copy_small [Cuda=>Host] {btm.pack_td_ptr=>btm.pack_td_ptr}: 4.45901e-05 - 0.0266115 [1] {min=3.4254e-05, max=7.2808e-05, std dev=1.26127e-05} <13, 0, 3>
110 | | Kokkos::deep_copy [Host=>Cuda] {amd.rowptr_mirror=>amd.rowptr}: 0.000326203 - 0.194679 [1] {min=0.000227678, max=0.000374588, std dev=4.34378e-05} <3, 2, 11>
111 | | Kokkos::deep_copy [Cuda=>Cuda] {amd.A.colindsub_mirror=>amd.A.colindsub}: 0.000605561 - 0.3614 [1] {min=0.000364401, max=0.000772601, std dev=0.000103638} <2, 8, 6>
112 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 3.6504e-05 - 0.0217857 [1] {min=3.112e-05, max=4.1018e-05, std dev=2.95408e-06} <3, 7, 4>
113 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 5.05683e-05 - 0.0301793 [1] {min=3.595e-05, max=7.3557e-05, std dev=1.02372e-05} <6, 6, 2>
114 | | Remainder: 0.163241 - 97.4227%
115 | Preconditioner compute: 0.00814887 - 2.0231 [1] {min=0.00765796, max=0.0083643, std dev=0.00015848} <1, 5, 10>
116 | | Kokkos::deep_copy [Host=>Cuda] {Tpetra::CrsGraph::lclInd_mirror=>Tpetra::CrsGraph::lclInd}: 0.00103259 - 12.6715 [1] {min=0.000555153, max=0.00117997, std dev=0.000142716} <1, 1, 14>
117 | | Remainder: 0.00711628 - 87.3285%
118 | Solve: 0.0679893 - 16.8795 [1] {min=0.0578111, max=0.0764768, std dev=0.00444419} <1, 12, 3>
119 | | Kokkos::deep_copy_scalar [Host=>Cuda] {Scalar=>MV::DualView}: 6.20339e-05 - 0.0912408 [1] {min=5.2039e-05, max=9.9635e-05, std dev=1.39067e-05} <14, 0, 2>
120 | | Remainder: 0.0679272 - 99.9088%
121 | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 0.00119007 - 0.295456 [1] {min=7.7788e-05, max=0.00188394, std dev=0.000602947} <3, 3, 9>
122 | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 0.00386528 - 0.959623 [1] {min=0.000141391, max=0.0059952, std dev=0.0020569} <3, 2, 10>
123 | | Remainder: 0.0629607 - 15.6311%
```

SPARC performance proxy – Preconditioner Compute



Some H2D transfers may be due to matrix starting life on host.

```
67 BlockTriDiagonalSolver: 0.402791 [1] {min=0.398697, max=0.405759, std dev=0.00208308} <2, 9, 5>
68 | Kokkos::deep_copy [Host=>Cuda] {(none)=>MV::DualView}: 1.15362e-05 - 0.00286406 [1] {min=9.457e-06, max=1.3476e-05, std dev=1.30905e-06} <4, 6, 6>
69 | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.000219524 - 0.0545006 [1] {min=0.000201362, max=0.000261668, std dev=1.4902e-05} <13, 2, 1>
70 | Kokkos::deep_copy [Host=>Cuda] {=>nonContigGids}: 0.00149956 - 0.372292 [1] {min=8.8975e-05, max=0.00227763, std dev=0.000795955} <3, 5, 8>
71 | Kokkos::deep_copy [Cuda=>Host] {nonContigGids=>nonContigGids}: 0.00208483 - 0.517595 [1] {min=0.000141518, max=0.00332777, std dev=0.0010933} <3, 5, 8>
72 | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 6.4396e-05 - 0.0159874 [1]
73 | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 4.7942e-05 - 0.0119025 [1]
74 | Kokkos::deep_copy [Host=>Cuda] {lgMap_mirror=>lgMap}: 0.00190606 - 0.473214 [1] {min=0.00129857, max=0.00234136, std dev=0.000387555} <5, 1, 10>
75 | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.90867e-05 - 0.00473861 [1] {min=1.4634e-05, max=2.2814e-05, std dev=2.18449e-06} <4, 7, 5>
76 | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.000155967 - 0.0387217 [1] {min=0.000136767, max=0.000179056, std dev=1.13794e-05} <4, 10, 2>
77 | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.000180773 - 0.044888 [1] {min=0.000123796, max=0.000264773, std dev=5.37565e-05} <8, 2, 6>
78 | Kokkos::deep_copy [Host=>Cuda] {Tpetra::CrsGraph::lclInd_mirror=>Tpetra::CrsGraph::lclInd}: 0.000889705 - 0.220885 [1] {min=0.00061186, max=0.00136407, std dev=0.000238827} <8, 6, 2>
79 | Kokkos::deep_copy [Host=>Cuda] {val_mirror=>val}: 0.0839978 - 0.20539 [1] {min=0.0711581, max=0.097457, std dev=0.00845105} <7, 4, 5>
80 | Preconditioner setup: 0.16756 - 41.5996 [1] {min=0.135984, max=0.191585, std dev=0.014088} <3, 8, 5>
81 | | Kokkos::deep_copy [Host=>Cuda] {nonContigGids}: 2.70644e-05 - 0.0161521 [1] {min=1.2769e-05, max=3.4503e-05, std dev=6.11785e-06} <2, 5, 9>
82 | | Kokkos::deep_copy [Cuda=>Host] {nonContigGids=>nonContigGids}: 5.83015e-05 - 0.0347945 [1] {min=5.0779e-05, max=6.9708e-05, std dev=5.42165e-06} <8, 6, 2>
83 | | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 3.60025e-05 - 0.0214864 [1] {min=3.0737e-05, max=4.1268e-05, std dev=7.44654e-06} <1, 0, 1>
84 | | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 3.37355e-05 - 0.0201334 [1] {min=2.8328e-05, max=3.9143e-05, std dev=7.64736e-06} <1, 0, 1>
85 | | Kokkos::deep_copy [Host=>Cuda] {lgMap_mirror=>lgMap}: 2.67858e-05 - 0.0159858 [1] {min=2.1038e-05, max=3.3766e-05, std dev=4.03181e-06} <7, 6, 3>
86 | | Kokkos::deep_copy [Host=>Cuda] {dm2cm_mirror=>dm2cm}: 0.000156 - 0.0931012 [1] {min=0.000138015, max=0.000181487, std dev=1.31207e-05} <8, 4, 4>
87 | | Kokkos::deep_copy [Host=>Cuda] {permuteFromLIDs=>permuteFromLIDs_mirror}: 5.63007e-05 - 0.0336004 [2] {min=5.0451e-05, max=6.1544e-05, std dev=3.30444e-06} <4, 8, 4>
88 | | Kokkos::deep_copy [Host=>Host] {importObjs=>exportObjs}: 6.88867e-06 - 0.0041117 [1] {min=4.525e-06, max=1.3158e-05, std dev=2.78209e-06} <6, 2, 1>
89 | | Kokkos::deep_copy [Host=>Host] {exports=>imports}: 6.1557e-06 - 0.00367374 [1] {min=2.398e-06, max=9.322e-06, std dev=1.98961e-06} <1, 7, 2>
90 | | Kokkos::deep_copy [Host=>Cuda] {exportLIDs=>exportLIDs_mirror}: 1.51041e-05 - 0.00901418 [1] {min=1.2427e-05, max=2.0263e-05, std dev=2.36384e-06} <9, 5, 2>
91 | | Kokkos::deep_copy_small [Host=>Cuda] {=>}: 6.21511e-05 - 0.037092 [2] {min=5.6556e-05, max=6.8392e-05, std dev=3.74721e-06} <5, 5, 6>
92 | | Kokkos::deep_copy [Host=>Cuda] {=>lids recv}: 4.39985e-05 - 0.0262584 [1] {min=3.9229e-05, max=5.0484e-05, std dev=2.90277e-06} <4, 11, 1>
93 | | Kokkos::deep_copy [Host=>Cuda] {lids send_mirror=>lids send}: 4.16972e-05 - 0.024885 [1] {min=3.7102e-05, max=4.7193e-05, std dev=3.27029e-06} <6, 6, 4>
94 | | Kokkos::deep_copy [Host=>Cuda] {partptr_mirror=>partptr}: 3.97446e-05 - 0.0237197 [1] {min=3.0635e-05, max=8.5843e-05, std dev=1.44949e-05} <14, 1, 1>
95 | | Kokkos::deep_copy [Host=>Cuda] {lclrow_mirror=>lclrow}: 0.000161403 - 0.0963254 [1] {min=0.0001107, max=0.000276019, std dev=4.9308e-05} <11, 3, 2>
96 | | Kokkos::deep_copy [Host=>Cuda] {part2packrowidx0_mirror=>part2packrowidx0}: 4.06942e-05 - 0.0242864 [1] {min=2.7149e-05, max=7.9001e-05, std dev=1.54671e-05} <11, 4, 1>
97 | | Kokkos::deep_copy [Host=>Cuda] {rowidx2part_mirror=>rowidx2part}: 0.000152562 - 0.0910494 [1] {min=0.000119641, max=0.000205769, std dev=3.05578e-05} <10, 2, 4>
98 | | Kokkos::deep_copy [Host=>Cuda] {packptr_mirror=>packptr}: 3.4065e-05 - 0.0203301 [1] {min=2.7626e-05, max=6.6363e-05, std dev=1.01909e-05} <13, 2, 1>
99 | | Kokkos::deep_copy_small [Cuda=>Host] {btm.flat_td_ptr=>btm.flat_td_ptr}: 4.54451e-05 - 0.0271217 [1] {min=4.191e-05, max=4.9215e-05, std dev=2.21033e-06} <5, 6, 5>
100 | | Kokkos::deep_copy [Cuda=>Host] {partptr=>partptr}: 8.83166e-05 - 0.0527076 [2] {min=7.1472e-05, max=0.000175214, std dev=2.39368e-05} <15, 0, 1>
101 | | Kokkos::deep_copy [Cuda=>Host] {lclrow=>lclrow}: 0.000151653 - 0.0905072 [1] {min=0.000135221, max=0.000203844, std dev=1.58521e-05} <13, 2, 1>
102 | | Kokkos::deep_copy [Cuda=>Host] {rowidx2part=>rowidx2part}: 0.00016809 - 0.100317 [1] {min=0.000137906, max=0.000243806, std dev=2.78406e-05} <12, 3, 1>
103 | | Kokkos::deep_copy [Cuda=>Host] {packptr=>packptr}: 3.95134e-05 - 0.0235817 [1] {min=3.4661e-05, max=5.5139e-05, std dev=4.78901e-06} <14, 1, 1>
104 | | Kokkos::deep_copy_scalar [Host=>Host] {Scalar=>col2row}: 0.000121891 - 0.072745 [1] {min=8.4187e-05, max=0.000167398, std dev=3.02439e-05} <7, 3, 6>
105 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::CrsGraph::lclInd=>Tpetra::CrsGraph::lclInd_mirror}: 0.000891747 - 0.532197 [1] {min=0.0006305, max=0.00124822, std dev=0.00022798} <9, 2, 5>
106 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::CrsGraph::ptr=>rowPtrsPacked_host}: 0.000331217 - 0.197671 [1] {min=0.000240064, max=0.000497482, std dev=8.07665e-05} <8, 6, 2>
107 | | Kokkos::deep_copy [Cuda=>Host] {btm.flat_td_ptr=>btm.flat_td_ptr}: 5.0545e-05 - 0.0301654 [1] {min=4.46e-05, max=6.4426e-05, std dev=5.23822e-06} <10, 5, 1>
108 | | Kokkos::deep_copy [Cuda=>Cuda] {btm.A.colindsub_mirror=>btm.A.colindsub}: 0.000367991 - 0.219618 [1] {min=0.00031059, max=0.000443933, std dev=5.13364e-05} <9, 2, 5>
109 | | Kokkos::deep_copy_small [Cuda=>Host] {btm.pack_td_ptr=>btm.pack_td_ptr}: 4.45901e-05 - 0.0266115 [1] {min=3.4254e-05, max=7.2808e-05, std dev=1.26127e-05} <13, 0, 3>
110 | | Kokkos::deep_copy [Host=>Cuda] {amd.rowptr_mirror=>amd.rowptr}: 0.000326203 - 0.194679 [1] {min=0.000227678, max=0.000374588, std dev=4.34378e-05} <3, 2, 11>
111 | | Kokkos::deep_copy [Cuda=>Cuda] {amd.A.colindsub_mirror=>amd.A.colindsub}: 0.000605561 - 0.3614 [1] {min=0.000364401, max=0.000772601, std dev=0.000103638} <2, 8, 6>
112 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 3.6504e-05 - 0.0217857 [1] {min=3.112e-05, max=4.1018e-05, std dev=2.95408e-06} <3, 7, 4>
113 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 5.05683e-05 - 0.0301793 [1] {min=3.595e-05, max=7.3557e-05, std dev=1.02372e-05} <6, 6, 2>
114 | | Remainder: 0.163241 - 97.4227%
115 | Preconditioner compute: 0.00814887 - 2.0231 [1] {min=0.00765796, max=0.0083643, std dev=0.00015848} <1, 5, 10>
116 | | Kokkos::deep_copy [Host=>Cuda] {Tpetra::CrsGraph::lclInd_mirror=>Tpetra::CrsGraph::lclInd}: 0.00103259 - 12.6715 [1] {min=0.000555153, max=0.00117997, std dev=0.000142716} <1, 1, 14>
117 | | Remainder: 0.00711628 - 87.3285%
118 | Solve: 0.0679893 - 16.8795 [1] {min=0.0578111, max=0.0764768, std dev=0.00444419} <1, 12, 3>
119 | | Kokkos::deep_copy_scalar [Host=>Cuda] {Scalar=>MV::DualView}: 6.20339e-05 - 0.0912408 [1] {min=5.2039e-05, max=9.9635e-05, std dev=1.39067e-05} <14, 0, 2>
120 | | Remainder: 0.0679272 - 99.9088%
121 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 0.00119007 - 0.295456 [1] {min=7.7788e-05, max=0.00188394, std dev=0.000602947} <3, 3, 9>
122 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 0.00386528 - 0.959623 [1] {min=0.000141391, max=0.0059952, std dev=0.0020569} <3, 2, 10>
123 | | Remainder: 0.0629607 - 15.6311%
```

SPARC performance proxy – Solve



```
67 BlockTriDiagonalSolver: 0.402791 [1] {min=0.398697, max=0.405759, std dev=0.00208308} <2, 9, 5>
68 | Kokkos::deep_copy [Host=>Cuda] {(none)=>MV::DualView}: 1.15362e-05 - 0.00286406 [1] {min=9.457e-06, max=1.3476e-05, std dev=1.30905e-06} <4, 6, 6>
69 | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.000219524 - 0.0545006 [1] {min=0.000201362, max=0.000261668, std dev=1.4902e-05} <13, 2, 1>
70 | Kokkos::deep_copy [Host=>Cuda] {=>nonContigGids}: 0.00149956 - 0.372292 [1] {min=8.8975e-05, max=0.00227763, std dev=0.000795955} <3, 5, 8>
71 | Kokkos::deep_copy [Cuda=>Host] {nonContigGids=>nonContigGids}: 0.00208483 - 0.517595 [1] {min=0.000141518, max=0.00332777, std dev=0.0010933} <3, 5, 8>
72 | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 6.4396e-05 - 0.0159874 [1]
73 | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 4.7942e-05 - 0.0119025 [1]
74 | Kokkos::deep_copy [Host=>Cuda] {lgMap_mirror=>lgMap}: 0.00190606 - 0.473214 [1] {min=0.00129857, max=0.00234136, std dev=0.000387555} <5, 1, 10>
75 | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.90867e-05 - 0.00473861 [1] {min=1.4634e-05, max=2.2814e-05, std dev=2.18449e-06} <4, 7, 5>
76 | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.000155967 - 0.0387217 [1] {min=0.000136767, max=0.000179056, std dev=1.13794e-05} <4, 10, 2>
77 | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.000180773 - 0.044888 [1] {min=0.000123796, max=0.000264773, std dev=5.37565e-05} <8, 2, 6>
78 | Kokkos::deep_copy [Host=>Cuda] {Tpetra::CrsGraph::lclInd_mirror=>Tpetra::CrsGraph::lclInd}: 0.000889705 - 0.220885 [1] {min=0.00061186, max=0.00136407, std dev=0.000238827} <8, 6, 2>
79 | Kokkos::deep_copy [Host=>Cuda] {val_mirror=>val}: 0.0839978 - 0.20539 [1] {min=0.0711581, max=0.097457, std dev=0.00845105} <7, 4, 5>
80 | Preconditioner setup: 0.16756 - 41.5996 [1] {min=0.135984, max=0.191585, std dev=0.014088} <3, 8, 5>
81 | | Kokkos::deep_copy [Host=>Cuda] {nonContigGids}: 2.70644e-05 - 0.0161521 [1] {min=1.2769e-05, max=3.4503e-05, std dev=6.11785e-06} <2, 5, 9>
82 | | Kokkos::deep_copy [Cuda=>Host] {nonContigGids=>nonContigGids}: 5.83015e-05 - 0.0347945 [1] {min=5.0779e-05, max=6.9708e-05, std dev=5.42165e-06} <8, 6, 2>
83 | | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 3.60025e-05 - 0.0214864 [1] {min=3.0737e-05, max=4.1268e-05, std dev=7.44654e-06} <1, 0, 1>
84 | | Kokkos::deep_copy_small [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 3.37355e-05 - 0.0201334 [1] {min=2.8328e-05, max=3.9143e-05, std dev=7.64736e-06} <1, 0, 1>
85 | | Kokkos::deep_copy [Host=>Cuda] {lgMap_mirror=>lgMap}: 2.67858e-05 - 0.0159858 [1] {min=2.1038e-05, max=3.3766e-05, std dev=4.03181e-06} <7, 6, 3>
86 | | Kokkos::deep_copy [Host=>Cuda] {dm2cm_mirror=>dm2cm}: 0.000156 - 0.0931012 [1] {min=0.000138015, max=0.000181487, std dev=1.31207e-05} <8, 4, 4>
87 | | Kokkos::deep_copy [Host=>Cuda] {permuteFromLIDs=>permuteFromLIDs_mirror}: 5.63007e-05 - 0.0336004 [2] {min=5.0451e-05, max=6.1544e-05, std dev=3.30444e-06} <4, 8, 4>
88 | | Kokkos::deep_copy [Host=>Host] {importObjs=>exportObjs}: 6.88867e-06 - 0.0041117 [1] {min=4.525e-06, max=1.3158e-05, std dev=2.78209e-06} <6, 2, 1>
89 | | Kokkos::deep_copy [Host=>Host] {exports=>imports}: 6.1557e-06 - 0.00367374 [1] {min=2.398e-06, max=9.322e-06, std dev=1.98961e-06} <1, 7, 2>
90 | | Kokkos::deep_copy [Host=>Cuda] {exportLIDs=>exportLIDs_mirror}: 1.51041e-05 - 0.00901418 [1] {min=1.2427e-05, max=2.0263e-05, std dev=2.36384e-06} <9, 5, 2>
91 | | Kokkos::deep_copy_small [Host=>Cuda] {=>}: 6.21511e-05 - 0.037092 [2] {min=5.6556e-05, max=6.8392e-05, std dev=3.74721e-06} <5, 5, 6>
92 | | Kokkos::deep_copy [Host=>Cuda] {=>lids recv}: 4.39985e-05 - 0.0262584 [1] {min=3.9229e-05, max=5.0484e-05, std dev=2.90277e-06} <4, 11, 1>
93 | | Kokkos::deep_copy [Host=>Cuda] {lids send_mirror=>lids send}: 4.16972e-05 - 0.024885 [1] {min=3.7102e-05, max=4.7193e-05, std dev=3.27029e-06} <6, 6, 4>
94 | | Kokkos::deep_copy [Host=>Cuda] {partptr_mirror=>partptr}: 3.97446e-05 - 0.0237197 [1] {min=3.0635e-05, max=8.5843e-05, std dev=1.44949e-05} <14, 1, 1>
95 | | Kokkos::deep_copy [Host=>Cuda] {lclrow_mirror=>lclrow}: 0.000161403 - 0.0963254 [1] {min=0.0001107, max=0.000276019, std dev=4.9308e-05} <11, 3, 2>
96 | | Kokkos::deep_copy [Host=>Cuda] {part2packrowidx0_mirror=>part2packrowidx0}: 4.06942e-05 - 0.0242864 [1] {min=2.7149e-05, max=7.9001e-05, std dev=1.54671e-05} <11, 4, 1>
97 | | Kokkos::deep_copy [Host=>Cuda] {rowidx2part_mirror=>rowidx2part}: 0.000152562 - 0.0910494 [1] {min=0.000119641, max=0.000205769, std dev=3.05578e-05} <10, 2, 4>
98 | | Kokkos::deep_copy [Host=>Cuda] {packptr_mirror=>packptr}: 3.4065e-05 - 0.0203301 [1] {min=2.7626e-05, max=6.6363e-05, std dev=1.01909e-05} <13, 2, 1>
99 | | Kokkos::deep_copy_small [Cuda=>Host] {btm.flat_td_ptr=>btm.flat_td_ptr}: 4.54451e-05 - 0.0271217 [1] {min=4.191e-05, max=4.9215e-05, std dev=2.21033e-06} <5, 6, 5>
100 | | Kokkos::deep_copy [Cuda=>Host] {partptr=>partptr}: 8.83166e-05 - 0.0527076 [2] {min=7.1472e-05, max=0.000175214, std dev=2.39368e-05} <15, 0, 1>
101 | | Kokkos::deep_copy [Cuda=>Host] {lclrow=>lclrow}: 0.000151653 - 0.0905072 [1] {min=0.000135221, max=0.000203844, std dev=1.58521e-05} <13, 2, 1>
102 | | Kokkos::deep_copy [Cuda=>Host] {rowidx2part=>rowidx2part}: 0.00016809 - 0.100317 [1] {min=0.000137906, max=0.000243806, std dev=2.78406e-05} <12, 3, 1>
103 | | Kokkos::deep_copy [Cuda=>Host] {packptr=>packptr}: 3.95134e-05 - 0.0235817 [1] {min=3.4661e-05, max=5.5139e-05, std dev=4.78901e-06} <14, 1, 1>
104 | | Kokkos::deep_copy_scalar [Host=>Host] {Scalar=>col2row}: 0.000121891 - 0.072745 [1] {min=8.4187e-05, max=0.000167398, std dev=3.02439e-05} <7, 3, 6>
105 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::CrsGraph::lclInd=>Tpetra::CrsGraph::lclInd_mirror}: 0.000891747 - 0.532197 [1] {min=0.0006305, max=0.00124822, std dev=0.00022798} <9, 2, 5>
106 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::CrsGraph::ptr=>rowPtrsPacked_host}: 0.000331217 - 0.197671 [1] {min=0.000240064, max=0.000497482, std dev=8.07665e-05} <8, 6, 2>
107 | | Kokkos::deep_copy [Cuda=>Host] {btm.flat_td_ptr=>btm.flat_td_ptr}: 5.0545e-05 - 0.0301654 [1] {min=4.46e-05, max=6.4426e-05, std dev=5.23822e-06} <10, 5, 1>
108 | | Kokkos::deep_copy [Host=>Cuda] {btm.A.colindsub_mirror=>btm.A.colindsub}: 0.000367991 - 0.219618 [1] {min=0.00031059, max=0.000443933, std dev=5.13364e-05} <9, 2, 5>
109 | | Kokkos::deep_copy_small [Cuda=>Host] {btm.pack_td_ptr=>btm.pack_td_ptr}: 4.45901e-05 - 0.0266115 [1] {min=3.4254e-05, max=7.2808e-05, std dev=1.26127e-05} <13, 0, 3>
110 | | Kokkos::deep_copy [Host=>Cuda] {amd.rowptr_mirror=>amd.rowptr}: 0.000326203 - 0.194679 [1] {min=0.000227678, max=0.000374588, std dev=4.34378e-05} <3, 2, 11>
111 | | Kokkos::deep_copy [Host=>Cuda] {amd.A.colindsub_mirror=>amd.A.colindsub}: 0.000605561 - 0.3614 [1] {min=0.000364401, max=0.000772601, std dev=0.000103638} <2, 8, 6>
112 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 3.6504e-05 - 0.0217857 [1] {min=3.112e-05, max=4.1018e-05, std dev=2.95408e-06} <3, 7, 4>
113 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 5.05683e-05 - 0.0301793 [1] {min=3.595e-05, max=7.3557e-05, std dev=1.02372e-05} <6, 6, 2>
114 | | Remainder: 0.163241 - 97.4227%
115 | Preconditioner compute: 0.00814887 - 2.0231 [1] {min=0.00765796, max=0.0083643, std dev=0.00015848} <1, 5, 10>
116 | | Kokkos::deep_copy [Host=>Cuda] {Tpetra::CrsGraph::lclInd_mirror=>Tpetra::CrsGraph::lclInd}: 0.00103259 - 12.6715 [1] {min=0.000555153, max=0.00117997, std dev=0.000142716} <1, 1, 14>
117 | | Remainder: 0.00711628 - 87.3285%
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119 | | Kokkos::deep_copy_scalar [Host=>Cuda] {Scalar=>MV::DualView}: 6.20339e-05 - 0.0912408 [1] {min=5.2039e-05, max=9.9635e-05, std dev=1.39067e-05} <14, 0, 2>
120 | | Remainder: 0.0679272 - 99.9088%
121 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::ptr=>outputSpace}: 0.00119007 - 0.295456 [1] {min=7.7788e-05, max=0.00188394, std dev=0.000602947} <3, 3, 9>
122 | | Kokkos::deep_copy [Cuda=>Host] {Tpetra::FixedHashTable::pairs=>Tpetra::FixedHashTable::val}: 0.00386528 - 0.959623 [1] {min=0.000141391, max=0.0059952, std dev=0.0020569} <3, 2, 10>
123 | | Remainder: 0.0629607 - 15.6311%
```

Solve looks good!
Single H2D transfer due to
array initialization.

Summary



New Tpetra profiling tools have proved extremely useful for identifying H2D/D2H movement.

Just preparing this talk has led to improvements in the tools and yielded some surprising results.

FY24 work will include

- Continue to improve Transfer and Fill Complete
- Refactor Map construction
- Ifpack2 overlapping Schwarz (possibly)