



# Tpetra Memory Transfer Tracking in Action



2023 Trilinos Users Group meeting  
Jonathan Hu, Chris Siefert

# 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 - 2.2545%
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}: 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 - 7.36698%
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: 0.0363887 - 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 - 51.7601%
53 | | | | MueLu: Brick3D: Hierarchy: Solve (level=2): 0.0534256 - 64.9621% [12]
54 | | | | MueLu: Brick3D: Hierarchy: Solve : coarse (level=2): 0.0533833 - 99.9029% [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] {flgMap_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 relocate 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]

```

```

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: EFC-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: PseudoBlockCGSolvMgr 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 - 97.7475% [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}: 0.000110573 - 2.71005% [36]
26 | | | | | Remainder: 0.0164703 - 99.6822%
27 | | | | MueLu: Brick3D: Hierarchy: Solve : prolongation (level=0)
28 | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000110573 - 2.71005% [36]
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}: 0.000110573 - 2.71005% [36]
35 | | | | | Remainder: 0.00037103 - 94.0678%
36 | | | | MueLu: Brick3D: Hierarchy: Solve : residual calculation (Level=1)
37 | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000110573 - 2.71005% [36]
38 | | | | | Remainder: 0.000189806 - 5.03008%
39 | | | | MueLu: Brick3D: Hierarchy: Solve : import (level=2): 0.000816249 - 93.8801%
40 | | | | | Kokkos::deep_copy [Host=>Cuda] {none=>MV::DualView}: 0.000110573 - 2.71005% [36]
41 | | | | | Remainder: 0.00140858 - 92.675%
42 | | | | | Remainder: 0.000140858 - 92.675%
43 | | | | MueLu: Brick3D: Hierarchy: Solve : export (level=2): 0.00364644 - 81.1178% [12]
44 | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 7.6167e-05 - 0.208881% [12]
45 | | | | | Remainder: 0.000669446 - 93.1358%
46 | | | | MueLu: Brick3D: Hierarchy: Solve : prolongation (level=1): 0.00137372 - 3.05595% [12]
47 | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 5.6894e-05 - 4.1416% [12]
48 | | | | | Remainder: 0.00363882 - 99.7911%
49 | | | | MueLu: Brick3D: Hierarchy: Solve : coarse (level=2): 0.0534256 - 64.9621% [12]
50 | | | | | Kokkos::deep_copy [Host=>Cuda] {none=>MV::DualView}: 0.000110573 - 2.71005% [36]
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] {flgMap_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 relocate 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]

```

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

# 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%
| | | Remainder: 0.000498438 - 80.9052%
| | | 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%
| | | | | | | Remainder: 3.64758e-05 - 6.10085%
| | | | | | 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 - 16.092% [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: 5.6377e-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] {_mirrors=>}: 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<BinSortFunctor::bin_count>}: 1.00198e-05 - 0.0907994% [4]
31 | Kokkos::deep_copy [Cuda=>Host] {PIDList=>}: 1.42518e-05 - 0.12915% [1]
32 | Map<gb1NumInds,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] {lMap_mirror=>lMap}: 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 notMMCCreateImporter: 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_ctors::setupExport:3 : 0.000304354 - 63.6914% [1]
60 | | | | | Tpetra::iport_ctors::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%
```

105 deep\_copy's

Tpetra team has done initial redesign planning.

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%
```

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

# Belos/MueLu Solve



```

1 NOX Total Linear Solve: 10.7284 - 66.8191% [9]
2 | Stratimikos: BelosLWS: 10.7283 - 99.9989% [9]
3 | | Belos: Operation Op*x: 0.0369792 - 0.344689% [9]
4 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000238043 - 0.643723% [9]
5 | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.000315257 - 0.852527% [9]
6 | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.0035815 - 9.6852% [9]
7 | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.00345888 - 9.35359% [9]
8 | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.000324344 - 0.877098% [9]
9 | | | Remainder: 0.0290611 - 78.5879%
10 | | Belos::MVT::MvAddMv: 0.000273655 - 0.00255078% [9]
11 | | Belos: BlockGmresSolMgr total solve time: 10.6533 - 99.3014% [9]
12 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000258974 - 0.00243093% [9]
13 | | | Belos: ICGS[2]: Orthogonalization: 2.0993 - 19.7056% [774]
14 | | | | Belos: ICGS[2]: Ortho (Norm): 0.139408 - 6.64071% [774]
15 | | | | Belos::MVT::MvDot: 0.13888 - 99.6211% [774]
16 | | | | Remainder: 0.000528175 - 0.378869%
17 | | | Belos::MVT::MvScale: 0.0113616 - 0.541211% [774]
18 | | | Belos: ICGS[2]: Ortho (Inner Product): 1.11549 - 53.1363% [1530]
19 | | | | Belos::MVT::MvTransMv: 1.11408 - 99.8735% [1530]
20 | | | | Kokkos::deep_copy_small [Host=>Cuda] {=>}: 0.00332217 - 0.298199% [288]
21 | | | | Kokkos::deep_copy_small [Cuda=>Host] {=>}: 0.00540154 - 0.484844% [432]
22 | | | | Kokkos::deep_copy_small [Cuda=>Cuda] {=>}: 0.000249839 - 0.0224256% [144]
23 | | | | Kokkos::deep_copy [Host=>Cuda] {=>}: 0.0325087 - 2.91799% [2772]
24 | | | | Kokkos::deep_copy [Cuda=>Host] {=>}: 0.0524241 - 4.7056% [4158]
25 | | | | Kokkos::deep_copy [Cuda=>Cuda] {=>}: 0.00241294 - 0.216586% [1386]
26 | | | | Remainder: 1.01776 - 91.3543%
27 | | | | Remainder: 0.00141163 - 0.126548%
28 | | | Belos: ICGS[2]: Ortho (Update): 0.829134 - 39.4958% [1530]
29 | | | | Belos::MVT::MvTimesMatAddMv: 0.828181 - 99.885% [1530]
30 | | | | Kokkos::deep_copy_small [Host=>Cuda] {=>}: 0.00142865 - 0.172505% [144]
31 | | | | Kokkos::deep_copy [Host=>Cuda] {=>}: 0.0138005 - 1.66636% [1386]
32 | | | | Remainder: 0.812952 - 98.1611%
33 | | | | Remainder: 0.00095333 - 0.114979%
34 | | | | Remainder: 0.0039049 - 0.186019%
35 | | | Belos::MVT::MvAddMv: 0.000764627 - 0.00717736% [36]
36 | | | Belos::MVT::MvNorm: 0.0120865 - 0.113453% [18]
37 | | | Belos: Operation Prec*x: 7.16052 - 67.2139% [774]
38 | | | | Muelu: Hierarchy: Solve (total): 7.14877 - 99.8359% [774]
39 | | | | | Muelu: Hierarchy: Solve (level=0): 4.18281 - 58.5109% [1548]
40 | | | | | Muelu: Hierarchy: Solve : smoothing (level=0): 2.99655 - 71.6396% [1548]
41 | | | | | Ifpack2::Chebyshev::apply: 2.98201 - 99.5149% [1548]
42 | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.0720297 - 2.41547% [3096]
43 | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.0741557 - 2.48677% [2322]
44 | | | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.880038 - 29.5116% [2322]
45 | | | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.805647 - 27.0169% [2322]
46 | | | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.0746639 - 2.50381% [2322]
47 | | | | | Remainder: 1.07548 - 36.0655%
48 | | | | | Remainder: 0.0145351 - 0.485062%
49 | | | | | Muelu: Hierarchy: Solve : residual calculation (level=0): 1.10838 - 26.4984% [774]
50 | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.0189266 - 1.7076% [774]
51 | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.0243486 - 2.19678% [774]
52 | | | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.294378 - 26.5594% [774]
53 | | | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.267655 - 24.1484% [774]
54 | | | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.024676 - 2.22632% [774]
55 | | | | | Remainder: 0.478391 - 43.1615%
56 | | | | | Muelu: Hierarchy: Solve : restriction (level=0): 0.0274217 - 0.655582% [774]
57 | | | | | Muelu: Hierarchy: Solve : prolongation (level=0): 0.0366769 - 0.876849% [774]
58 | | | | | Remainder: 0.0137853 - 0.32957%
59 | | | | | Muelu: Hierarchy: Solve (level=1): 2.29154 - 32.055% [1548]
60 | | | | | Muelu: Hierarchy: Solve : smoothing (level=1): 1.75536 - 76.602% [1548]

```

Known issue in  
orthogonalization. Will be  
resolved this FY.

# Belos/MueLu Solve



```

1 NOX Total Linear Solve: 10.7284 - 66.8191% [9]
2 | Stratimikos: BelosLWS: 10.7283 - 99.9989% [9]
3 | | Belos: Operation Op*x: 0.0369792 - 0.344689% [9]
4 | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000238043 - 0.643723% [9]
5 | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.000315257 - 0.852527% [9]
6 | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.0035815 - 9.6852% [9]
7 | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.00345888 - 9.35359% [9]
8 | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.000324344 - 0.877098% [9]
9 | | | Remainder: 0.0290611 - 78.5879%
10 | Belos::MVT::MvAddMv: 0.000273655 - 0.00255078% [9]
11 | Belos: BlockGmresSolMgr total solve time: 10.6533 - 99.3014% [9]
12 | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000258974 - 0.00243093% [9]
13 | Belos: ICGS[2]: Orthogonalization: 2.0993 - 19.7056% [774]
14 | | Belos: ICGS[2]: Ortho (Norm): 0.139408 - 6.64071% [774]
15 | | | Belos::MVT::MvDot: 0.13888 - 99.6211% [774]
16 | | | Remainder: 0.000528175 - 0.378869%
17 | | Belos::MVT::MvScale: 0.0113616 - 0.541211% [774]
18 | | Belos: ICGS[2]: Ortho (Inner Product): 1.11549 - 53.1363% [15
19 | | | Belos::MVT::MvTransMv: 1.11408 - 99.8735% [1530]
20 | | | | Kokkos::deep_copy_small [Host=>Cuda] {=>}: 0.00332217
21 | | | | Kokkos::deep_copy_small [Cuda=>Host] {=>}: 0.00540154
22 | | | | Kokkos::deep_copy_small [Cuda=>Cuda] {=>}: 0.00024983
23 | | | | Kokkos::deep_copy [Host=>Cuda] {=>}: 0.0325087 - 2.91
24 | | | | Kokkos::deep_copy [Cuda=>Host] {=>}: 0.0524241 - 4.70
25 | | | | Kokkos::deep_copy [Cuda=>Cuda] {=>}: 0.00241294 - 0.2
26 | | | | Remainder: 0.1776 - 91.3543%
27 | | | | Remainder: 0.00141163 - 0.126548%
28 | | | Belos: ICGS[2]: Ortho (Update): 0.829134 - 39.4958% [1530]
29 | | | Belos::MVT::MvTimesMatAddMv: 0.828181 - 99.885% [1530]
30 | | | | Kokkos::deep_copy_small [Host=>Cuda] {=>}: 0.00142865 - 0.172505% [144]
31 | | | | Kokkos::deep_copy [Host=>Cuda] {=>}: 0.0138005 - 1.66636% [1386]
32 | | | | Remainder: 0.812952 - 98.1611%
33 | | | | Remainder: 0.00095333 - 0.114979%
34 | | | | Remainder: 0.0039049 - 0.18601%
35 | Belos::MVT::MvAddMv: 0.000764627 - 0.00717736% [36]
36 | Belos::MVT::MvNorm: 0.0120865 - 0.113453% [18]
37 | Belos: Operation Prec*x: 7.16052 - 67.2139% [774]
38 | | MueLu: Hierarchy: Solve (total): 7.14877 - 99.8359% [774]
39 | | | MueLu: Hierarchy: Solve (level=0): 4.18281 - 58.5109% [1548]
40 | | | | MueLu: Hierarchy: Solve : smoothing (level=0): 2.99655 - 71.6396% [1548]
41 | | | | Ifpack2::Chebyshev::apply: 2.98201 - 99.5149% [1548]
42 | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.0720297 - 2.41547% [3096]
43 | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.0741557 - 2.48677% [2322]
44 | | | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.880038 - 29.5116% [2322]
45 | | | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.805647 - 27.0169% [2322]
46 | | | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.0746639 - 2.50381% [2322]
47 | | | | | Remainder: 1.07548 - 36.0655%
48 | | | | | Remainder: 0.0145351 - 0.485062%
49 | | | MueLu: Hierarchy: Solve : residual calculation (level=0): 1.10838 - 26.4984% [774]
50 | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.0189266 - 1.7076% [774]
51 | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.0243486 - 2.19678% [774]
52 | | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.294378 - 26.5594% [774]
53 | | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.267655 - 24.1484% [774]
54 | | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.024676 - 2.2263% [774]
55 | | | | | Remainder: 0.478391 - 43.1615%
56 | | | MueLu: Hierarchy: Solve : restriction (level=0): 0.0274217 - 0.655582% [774]
57 | | | MueLu: Hierarchy: Solve : prolongation (Level=0): 0.0366769 - 0.876849% [774]
58 | | | | | Remainder: 0.0137853 - 0.32957%
59 | | | | | MueLu: Hierarchy: Solve (level=1): 2.29154 - 32.055% [1548]
60 | | | | | MueLu: Hierarchy: Solve : smoothing (level=1): 1.75536 - 76.602% [1548]

```

CUDA-aware MPI disabled  
(due to Perlmutter software upgrade?)

```

61 | | | | | Ifpack2::Chebyshev::apply: 1.74172 - 99.2229% [1548]
62 | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.067191 - 3.85773% [6192]
63 | | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.0776881 - 4.46042% [5418]
64 | | | | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.181194 - 10.4032% [5418]
65 | | | | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.174391 - 10.0125% [5418]
66 | | | | | | Remainder: 1.24126 - 71.2662%
67 | | | | | | Remainder: 0.0136401 - 0.777053%
68 | | | | | MueLu: Hierarchy: Solve : residual calculation (level=1): 0.212221 - 9.26106% [774]
69 | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.00862426 - 4.06382% [774]
70 | | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.0110141 - 5.18992% [774]
71 | | | | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.025926 - 12.2165% [774]
72 | | | | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.0242667 - 11.4346% [774]
73 | | | | | | Remainder: 0.14239 - 67.0951%
74 | | | | | MueLu: Hierarchy: Solve : restriction (level=1): 0.182937 - 7.98315% [774]
75 | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.00865041 - 4.72863% [774]
76 | | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.0109919 - 6.00858% [774]
77 | | | | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.025834 - 14.1218% [774]
78 | | | | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.0244806 - 13.382% [774]
79 | | | | | | Remainder: 0.11298 - 61.759%
80 | | | | | MueLu: Hierarchy: Solve : prolongation (level=1): 0.12661 - 5.52513% [774]
81 | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.0086247 - 6.81199% [774]
82 | | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.010803 - 8.53251% [774]
83 | | | | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.0134052 - 10.5877% [774]
84 | | | | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.0109857 - 8.67677% [774]
85 | | | | | | Remainder: 0.0827918 - 65.391%
86 | | | | | | Remainder: 0.014407 - 0.628706%
87 | | | | | MueLu: Hierarchy: Solve (level=2): 0.66272 - 9.27041% [774]
88 | | | | | | MueLu: Hierarchy: Solve : coarse (level=2): 0.660476 - 99.6613% [774]
89 | | | | | | | Ifpack2::Chebyshev::apply: 0.653466 - 98.9387% [774]
90 | | | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.0483691 - 7.40193% [4644]
91 | | | | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.0540708 - 8.27446% [3870]
92 | | | | | | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.0674611 - 10.3236% [3870]
93 | | | | | | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.0568374 - 8.69784% [3870]
94 | | | | | | | | Remainder: 0.426728 - 65.3022%
95 | | | | | | | | Remainder: 0.0770947 - 1.06128%
96 | | | | | | | | Remainder: 0.00224466 - 0.338705%
97 | | | | | | | | Remainder: 0.0117028 - 0.163704%
98 | | | | | | | | Remainder: 0.0117496 - 0.164088%
99 | | | | | | | | Belos: Operation Op*x: 0.074571 - 9.1105% [774]
100 | | | | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.0186463 - 1.92117% [774]
101 | | | | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.0240786 - 2.48087% [774]
102 | | | | | | | | Kokkos::deep_copy [Cuda=>Host] {MV::DualView=>MV::DualView_mirror}: 0.293998 - 30.2912% [774]
103 | | | | | | | | Kokkos::deep_copy [Host=>Cuda] {MV::DualView_mirror=>MV::DualView}: 0.26726 - 27.5364% [774]
104 | | | | | | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.0244502 - 2.51915% [774]
105 | | | | | | | | Remainder: 0.342138 - 35.2512%
106 | | | | | | | | Belos::MVT::MvTimesMatAddMv: 0.00301765 - 0.0283259% [9]
107 | | | | | | | | | Kokkos::deep_copy [Host=>Cuda] {=>}: 0.000141661 - 4.69443% [9]
108 | | | | | | | | | | Remainder: 0.00287598 - 95.3056%
109 | | | | | | | | | | Remainder: 0.406808 - 3.81861%
110 | | | | | | | | | | Remainder: 0.0376949 - 0.35136%
111 | | | | | | | | | | Remainder: 0.000118622 - 0.00110568%

```



# 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] {CLayerSNode2PptrOffset_mirror=>CLayerSNode2PptrOffset}: 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)



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

# Thermal Fluids Proxy – Solve



# Orthogonalization within GMRES

# Thermal Fluids Proxy – Solve



Op<sup>X</sup>

```

55 Belos: PseudoBlockGmresSolMgr total solve time: 4.82393 - 4.68715% [1]
56 | Tpetra::MV ctor (map,numVecs,zeroOut): 0.0257886 - 0.534598% [33]
57 | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.43192e-05 - 0.000296836% [1]
58 | Belos: ICGS[2]: Orthogonalization: 2.79582 - 57.9573% [15]
59 | Belos: ICGS[2]: Ortho (Norm): 0.130224 - 4.65781% [15]
60 | | Tpetra::MV::dot (Teuchos::ArrayView): 0.130155 - 99.947% [15]
61 | | Tpetra::multiVectorSingleColumnDot: 0.130104 - 99.9607% [15]
62 | | Remainder: 5.11121e-05 - 0.0392701%
63 | | Remainder: 6.90087e-05 - 0.0529922%
64 Belos: ICGS[2]: Ortho (Inner Product): 2.17127 - 77.6612% [28]
65 | Tpetra::MV::dot (Teuchos::ArrayView): 0.150318 - 6.92303% [2]
66 | | Tpetra::multiVectorSingleColumnDot: 0.150311 - 99.9956% [2]
67 | | Remainder: 6.66906e-06 - 0.00443664%
68 | Tpetra::MultiVector::putScalar: 0.000371268 - 0.0170991% [26]
69 | | Kokkos::deep_copy_small [Host=>Cuda] {none=>}: 0.000109559 - 29.5093% [14]
70 | | Kokkos::deep_copy [Host=>Cuda] {none=>}: 9.13506e-05 - 24.605% [12]
71 | | Remainder: 0.000170359 - 45.8856%
72 | Tpetra::MV::multiply: 2.01497 - 92.801
73 | | Tpetra::MV::multiply-call-gemm: 0.
74 | | Tpetra::MV::reduce: 2.01419 - 99.9
75 | | Kokkos::deep_copy_small [Cuda=>Cuda] {none=>}: 0.000193283 - 0.00959237%
76 | | Kokkos::deep_copy_small [Host=>Cuda] {none=>}: 0.000513469 - 0.0236483% [14]
77 | | Kokkos::deep_copy [Host=>Host] {>=}: 0.0026512 - 0.122104% [19]
78 | | Kokkos::deep_copy_small [Host=>Host] {>=}: 9.77813e-06 - 0.000450341% [7]
79 | | Kokkos::deep_copy [Cuda=>Host] {>=}: 0.000440681 - 0.020296% [12]
80 | | Remainder: 0.0020011 - 0.0921626%
81 Belos: ICGS[2]: Ortho (Update): 0.493503 - 17.6514% [28]
82 | Tpetra::MV::update(alpha,A,beta): 2.49923e-05 - 0.00506427% [2]
83 | Kokkos::deep_copy_small [Host=>Host] {>=}: 2.39406e-05 - 0.00485117% [14]
84 | Tpetra::MV::multiply: 0.492372 - 99.7709% [26]
85 | | Kokkos::deep_copy_small [Host=>Cuda] {>=}: 0.000402805 - 0.081809% [14]
86 | | Kokkos::deep_copy [Host=>Cuda] {>=}: 0.491391 - 99.8007% [26]
87 | | Kokkos::deep_copy [Host=>Cuda] {>=}: 0.000347407 - 0.0705578% [12]
88 | | Remainder: 0.000231194 - 0.0469552%
89 | Kokkos::deep_copy [Host=>Host] {>=}: 1.99955e-05 - 0.00405175% [12]
90 | | Remainder: 0.00106169 - 0.215133%
91 | | Remainder: 0.00826226 - 0.0295522%
92 Tpetra::MV::update(alpha,A,beta,B,gamma): 0.000419398 - 0.00869411% [27]
93 Tpetra::MV::norm2 (host output): 0.011474e-0 - 0.237866% [7]
94 Belos: Operation Op*x: 0.0459722 - 0.953003% [19]
95 | Tpetra::CrsMatrix::apply: 0.0459057 - 99.8552% [19]
96 | | Tpetra::CrsMatrix::apply: Import: 0.043743 - 95.2889% [19]
97 | | Tpetra::DistObject::doTransfer[Host]: 0.0435503 - 99.5594% [38]
98 | | | Tpetra::DistObject::doTransferNew::checkSizes: 3.42809e-05 - 0.0787156% [19]
99 | | | Tpetra::DistObject::doTransferNew::copyAndPermute: 0.000648135 - 1.48824% [19]
100 | | | Tpetra::MultiVector::copyAndPermute[Device]: 0.000580102 - 89.5034% [19]
101 | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000255539 - 44.0507% [19]
102 | | | | Remainder: 0.000324563 - 55.9493%
103 | | | | Remainder: 6.80323e-05 - 10.4966%
104 | | | | Tpetra::DistObject::doPackAndPrepare: 0.000376398 - 0.864285% [19]
105 | | | | Tpetra::MultiVector::packAndPrepare[Device]: 0.000306955 - 81.5505% [19]
106 | | | | | Tpetra::Details::reallocDualViewIfNeeded: 1.99652e-05 - 6.50428% [19]
107 | | | | | Remainder: 0.000286989 - 93.4957%
108 | | | | | Remainder: 0.000286989 - 93.4957%
109 | | | | | Remainder: 0.000286989 - 93.4957%
110 | | | | | Remainder: 0.000286989 - 93.4957%
111 | | | | | Remainder: 0.000286989 - 93.4957%
112 | | | | | Remainder: 0.000286989 - 93.4957%
113 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 7.48225e-06 - 0.000155107% [5]
114 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 0.000313679 - 0.00650255% [5]
115 | | | | | Kokkos::deep_copy [Host=>Cuda] {>=}: 0.00016359 - 52.152% [5]
116 | | | | | Kokkos::deep_copy [Host=>Cuda] {>=}: 8.98731e-05 - 28.6513% [5]
117 | | | | | Kokkos::deep_copy [Host=>Cuda] {>=}: 0.00016359 - 52.152% [5]
118 | | | | | Kokkos::deep_copy [Host=>Cuda] {>=}: 0.00016359 - 52.152% [5]
119 | | | | | Kokkos::deep_copy [Host=>Cuda] {>=}: 0.00016359 - 52.152% [5]
120 | | | | | Kokkos::deep_copy [Host=>Cuda] {>=}: 0.00016359 - 52.152% [5]
121 | | | | | Kokkos::deep_copy [Host=>Cuda] {>=}: 0.00016359 - 52.152% [5]
122 | | | | | Kokkos::deep_copy [Host=>Cuda] {>=}: 0.00016359 - 52.152% [5]
123 | | | | | Kokkos::deep_copy [Host=>Cuda] {>=}: 0.00016359 - 52.152% [5]
124 | | | | | Kokkos::deep_copy [Host=>Cuda] {>=}: 0.00016359 - 52.152% [5]
125 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 6.94438e-05 - 18.4495% [19]
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 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 0.000460071 - 12.7929%
133 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 8.59088e-05 - 2.33308%
134 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 0.00642787 - 14.7597%
135 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 0.00019275 - 0.440641%
136 | | | | | Tpetra::CrsMatrix::localApply: 0.00201358 - 4.38634% [19]
137 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 0.000149063 - 0.324715%
138 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 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=>}: 0.000665301 - 61.5095% [56]
143 | | | Kokkos::deep_copy [Host=>Host] {>=}: 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 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 0.000530405 - 57.679%
151 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 0.000117433 - 11.3242%
152 | | | | | Tpetra::DistObject::doPackAndPrepare: 0.000333644 - 1.03102% [14]
153 | | | | | Kokkos::deep_copy [Cuda=>Cuda] {exports=>exports_mirror}: 0.000270599 - 81.1042% [14]
154 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 0.000249361 - 92.1514%
155 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 6.30445e-05 - 18.8958%
156 | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.00537215 - 16.6009% [14]
157 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 4.27109e-05 - 0.131984% [28]
158 | | | | | Tpetra::Details::reallocDualViewIfNeeded: 0.000270599 - 81.1042% [14]
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 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 0.000340083 - 6.492%
164 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 5.95878e-05 - 1.1247%
165 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 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 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 1.82494 - 99.248%
170 | | | | | Tpetra::MV::update(alpha,A,beta): 0.000215111 - 0.0112528% [14]
171 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 0.00609164 - 0.318664%
172 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 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 | | | | | Kokkos::deep_copy [Host=>Cuda] {>=}: 8.98731e-05 - 28.6513% [5]
177 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 6.02158e-05 - 19.1966%
178 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 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 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 1.98403e-05 - 24.1532%
183 | | | | | Tpetra::MV::norm2 (host output): 0.000444227 - 0.000431632% [2]
184 | | | | | Kokkos::deep_copy [Host=>Host] {>=}: 0.02255537 - 0.0219142%
```

# Thermal Fluids Proxy – Solve



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=>  
87 | | | | Kokkos::deep\_copy\_small [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 | | | | Kokkos::deep\_copy [Host=>Host] {<=}>: 0.000193283 - 0.0095923  
93 | | | Kokkos::deep\_copy\_small [Cuda=>Host] {<=}>: 0  
94 | | | Kokkos::deep\_copy [Host=>Host] {=>}: 0  
95 | | | Kokkos::deep\_copy\_small [Host=>Host] {<=}>: 0  
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 - 55.9949%  
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::Dists::reallocDualViewIfNeeded: 1.99652e-05 - 6.50428% [19]  
124 | | | | | | | Remainder: 0.000286989 - 93.4957%

# Preconditioner Apply

```
1 | | | | | Remainder: 6.94438e-05 - 18.4495%
2 | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.00353923 - 8.12677% [19]
3 | | | | Tpetra::Details::reallocDualViewIfNeeded: 4.63523e-05 - 0.106434% [38]
4 | | | | Tpetra::DistObject::doTransferNew::doPostsAndWaits: 0.0287958 - 66.1208% [19]
5 | | | | Tpetra::DistObject::doUnpackAndCombine: 0.00368221 - 8.45508% [19]
6 | | | | | Tpetra::MultiVector::unpackAndCombine[Device]: 0.0035963 - 97.6669% [19]
7 | | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.00313623 - 87.2071% [19]
8 | | | | | Remainder: 0.000460071 - 12.7929%
9 | | | | | Remainder: 8.59088e-05 - 2.33308%
10 | | | | | Remainder: 0.00642787 - 14.7597%
11 | | | | | Remainder: 0.00019275 - 0.440641%
12 | | | | Tpetra::CrsMatrix::localApply: 0.00201358 - 4.38634% [19]
13 | | | | Remainder: 0.000149063 - 0.324715%
14 | | | | Remainder: 6.65753e-05 - 0.144816%
15 | | | | Below: Operation Prec*x: 1.91168 - 39.6291% [14]
16 | | | | Ifpack2::AdditiveSchwarz::apply: 1.91162 - 99.9966% [14]
17 | | | | | Tpetra::MultiVector::putScalar: 0.00108162 - 0.0565815% [56]
18 | | | | Kokkos::deep_copy [Host=>Cuda] {none=>MV::DualView}: 0.000665301 - 61.5095% [56]
19 | | | | | Remainder: 0.000416322 - 38.4905%
20 | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000215803 - 0.011289% [14]
21 | | | | Tpetra::DistObject::doTransfer[Host]: 0.0323605 - 1.69283% [56]
22 | | | | | Tpetra::DistObject::doTransferNew::checkSizes: 6.05694e-05 - 0.187171% [28]
23 | | | | | Tpetra::DistObject::doTransferNew::copyAndPermute: 0.00103701 - 3.20456% [28]
24 | | | | | | Tpetra::MultiVector::copyAndPermute[Device]: 0.00091958 - 88.6758% [28]
25 | | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 0.000389175 - 42.321% [28]
26 | | | | | | Remainder: 0.000530405 - 57.679%
27 | | | | | | Remainder: 0.000117433 - 11.3242%
28 | | | | | Tpetra::DistObject::doPackAndPrepare: 0.000333644 - 1.03102% [14]
29 | | | | | | Tpetra::MultiVector::packAndPrepare[Device]: 0.000270599 - 81.1042% [14]
30 | | | | | | Tpetra::Details::reallocDualViewIfNeeded: 2.12383e-05 - 7.84862% [14]
31 | | | | | | | Remainder: 0.000249361 - 92.1514%
32 | | | | | | | Remainder: 6.30445e-05 - 18.8958%
33 | | | | | Kokkos::deep_copy [Cuda=>Host] {exports=>exports_mirror}: 0.00537215 - 16.6009% [14]
34 | | | | | Tpetra::Details::reallocDualViewIfNeeded: 4.27109e-05 - 0.131984% [28]
35 | | | | | Tpetra::DistObject::doTransferNew::doPostsAndWaits: 0.0151135 - 46.7036% [14]
36 | | | | | Tpetra::DistObject::doUnpackAndCombine: 0.00529809 - 16.3721% [14]
37 | | | | | | Tpetra::MultiVector::unpackAndCombine[Device]: 0.0052385 - 98.8753% [14]
38 | | | | | Kokkos::deep_copy [Host=>Cuda] {imports_mirror=>imports}: 0.00489841 - 93.508% [14]
39 | | | | | | Remainder: 0.000340083 - 6.492%
40 | | | | | | Remainder: 5.95878e-05 - 1.1247%
41 | | | | | | Remainder: 0.00510284 - 15.7687%
42 | | | | | Tpetra::MV ctor (map,numVecs,zeroOut): 0.0328857 - 1.7203% [28]
43 | | | | RILUK::apply: 1.83877 - 96.1891% [14]
44 | | | | | Tpetra::MV ctor (map,numVecs,zeroOut): 0.013828 - 0.752024% [14]
45 | | | | | Remainder: 1.82494 - 99.248%
46 | | | | | Tpetra::MV::update(alpha,A,beta): 0.000215111 - 0.0112528% [14]
47 | | | | | | Remainder: 0.0000161 - 0.316614%
48 | | | | | | | Remainder: 6.4601e-05 - 0.00357927%
49 | | | | Kokkos::deep_copy [Host=>Host] {=>}: 7.48225e-06 - 0.000155107% [5]
50 | | | | Tpetra::MV::multiply: 0.000313679 - 0.00650255% [5]
51 | | | | | Kokkos::deep_copy [Host=>Cuda] {=>}: 0.00016359 - 52.152% [5]
52 | | | | | Tpetra::MV::multiply-call-gemm: 8.98731e-05 - 28.6513% [5]
53 | | | | | Remainder: 6.02158e-05 - 19.1966%
54 | | | | | Remainder: 0.0324359 - 0.672396%
55 | | | | Tpetra::MV 2-arg "copy" ctor: 8.21437e-05 - 7.98146e-05% [1]
56 | | | | Tpetra::MV ctor (map,numVecs,zeroOut): 4.66663e-05 - 56.8106% [1]
57 | | | | Kokkos::deep_copy [Cuda=>Cuda] {MV::DualView=>MV::DualView}: 1.56371e-05 - 19.0362% [1]
58 | | | | | Remainder: 1.98403e-05 - 24.1532%
59 | | | | Tpetra::MV::norm2 (host output): 0.000444227 - 0.000431632% [2]
60 | | | | | Remainder: 0.0225537 - 0.0219142%
```

# 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=0.002083081} <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_mirrored}: 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_mirrored=>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 - 0.04488% [1] {min=0.000123796, max=0.00264773, std dev=5.37565e-05} <8, 2, 6>
78 | Kokkos::deep_copy [Host=>Cuda] {Tpetra::CrsGraph::lclInd_mirrored=>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 - 20.8539% [1] {min=0.0711581, max=0.097457, std dev=0.00845105} <7, 4, 5>

80 | Preconditioner setup: 0.16/56 - 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_mirrored=>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] {permutationFromIDs=>permutationFromIDs_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] {importObjjs=>exportObjjs}: 6.88867e-06 - 0.00411117% [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=>exportIDs_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}: 3.49985e-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}: 0.000161493 - 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] {btmd.flat_td_ptr=>btmd.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_ptr=>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_mirrored=>Tpetra::CrsGraph::lclInd}: 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] {btmd.flat_td_ptr=>btmd.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] {btmd.A_colindsub_mirror=>btmd.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] {btmd.pack_td_ptr=>btmd.pack_td_ptr}: 4.45902e-05 - 0.0266115% [1] {min=3.42545e-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_mirrored=>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 [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] {Tpeta::FixedHashTable::ptr=>outputSpace}: 6.4396e-05 - 0.0159874% [1]
73 | Kokkos::deep_copy_small [Cuda=>Host] {Tpeta::FixedHashTable::pairs=>Tpeta::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 - 0.04488% [1] {min=0.000123796, max=0.00264773, std dev=5.37565e-05} <8, 2, 6>
78 | Kokkos::deep_copy [Host=>Cuda] {Tpeta::CrsGraph::lclInd_mIRROR=>Tpeta::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 - 20.8539% [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=6.9708e-05, max=5.42165e-06} <8, 6, 2>
83 | Kokkos::deep_copy_small [Cuda=>Host] {Tpeta::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] {Tpeta::FixedHashTable::pairs=>Tpeta::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=4.0318e-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] {permutationFromIDs=>permutationFromIDs_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] {importObjjs=>exportObjjs}: 6.88867e-06 - 0.00411117% [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=>exportIDs_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}: 3.9985e-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}: 0.000161493 - 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] {btmd.flat_td_ptr=>btmd.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_ptr=>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] {Tpeta::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] {Tpeta::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] {btmd.flat_td_ptr=>btmd.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] {btmd_A_colindsub_mIRROR=>btmd_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] {btmd.pack_td_ptr=>btmd.pack_td_ptr}: 4.45901e-05 - 0.0266115% [1] {min=3.42545e-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] {Tpeta::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] {Tpeta::FixedHashTable::pairs=>Tpeta::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] {Tpeta::CrsGraph::lclInd_mIRROR=>Tpeta::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] {Tpeta::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] {Tpeta::FixedHashTable::pairs=>Tpeta::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 - 0.04488% [1] {min=0.000123796, max=0.00264773, 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 - 20.8539% [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=5.779e-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] {permutationFromLIDs=>permutationFromIDs_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] {importObjjs=>exportObjjs}: 6.88867e-06 - 0.00411117% [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=>exportIDs_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}: 3.49985e-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}: 0.000161493 - 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] {btmd.flat_td_ptr=>btmd.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}: 0.00016803 - 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_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] {btmd.flat_td_ptr=>btmd.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] {btmd_A_colindsub_mIRROR=>btmd_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] {btmd.pack_td_ptr=>btmd.pack_td_ptr}: 4.45901e-05 - 0.0266115% [1] {min=3.42545e-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%
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=0.0059592, 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 - 0.04488% [1] {min=0.000123796, max=0.00264773, 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}: 0.0039978 - 20.8539% [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}: 0.0001012% [1] {min=0.000138015, max=0.000181487, std dev=1.31207e-05} <8, 4, 4>
87 | Kokkos::deep_copy [Host=>Cuda] {permutationFromLIDs=>permutationFromIDs_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] {importObjjs=>exportObjjs}: 6.88867e-06 - 0.00411117% [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=>exportIDs_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}: 3.99858e-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}: 0.000161493 - 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] {btmd.flat_td_ptr=>btmd.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_ptr=>rowidx2part}: 0.000168037 - 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] {btmd.flat_td_ptr=>btmd.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] {btmd.A_colindsub_mIRROR=>btmd.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] {btmd.pack_td_ptr=>btmd.pack_td_ptr}: 4.45901e-05 - 0.0266115% [1] {min=3.42545e-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%
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=0.0059592, 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)