HPC Fortran Compilers

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The Problem

- **Compare Compilers**
  - Improve compilers
  - Insights to help code-optimizers
- **I.e., Compare Small Code Blocks**
- **Means Time is Measure of Quality**
  - Assembler comparisons difficult
  - Cache management important

Outline

- **Compiler Rating System**

- **Sample results**

- **Problems with PAPI**

- **Recommendations & Desires**

Caveats

- These ratings were based on specific compiler versions.

- PAPI timing is suspect

- Assembly language misses memory hierarchy management

Rating a Loop

- **Only two options -O2 and "-fast"**

- **Compare execution time**
  - -fast to -O2
  - compare to PGI (ARSC default)

- **Looked at assembly code**
  - only a few (extremal ratio) loops
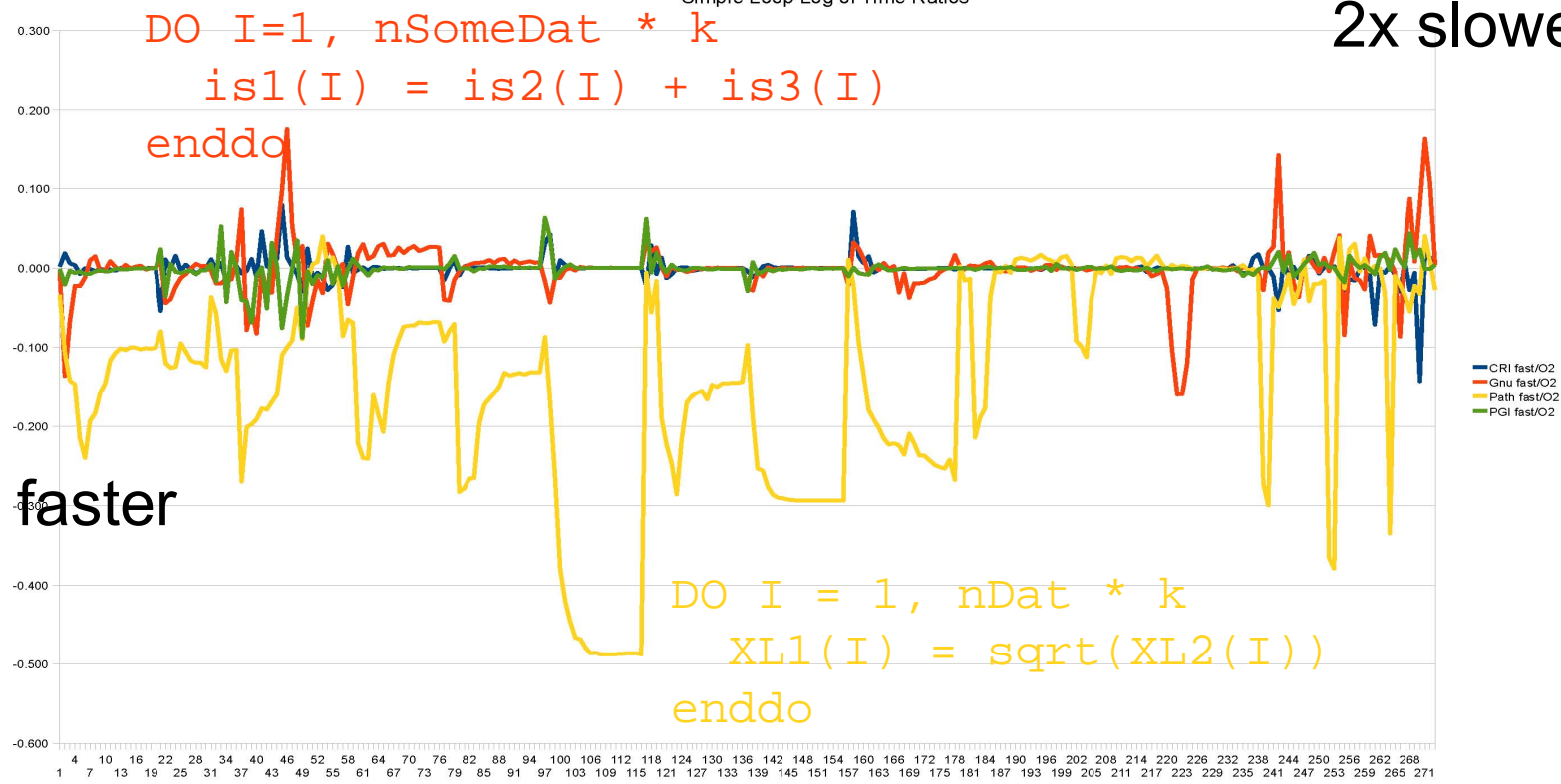 - hides memory hierarchy management

Intra-Compiler: Simple Loops

LogGraphs

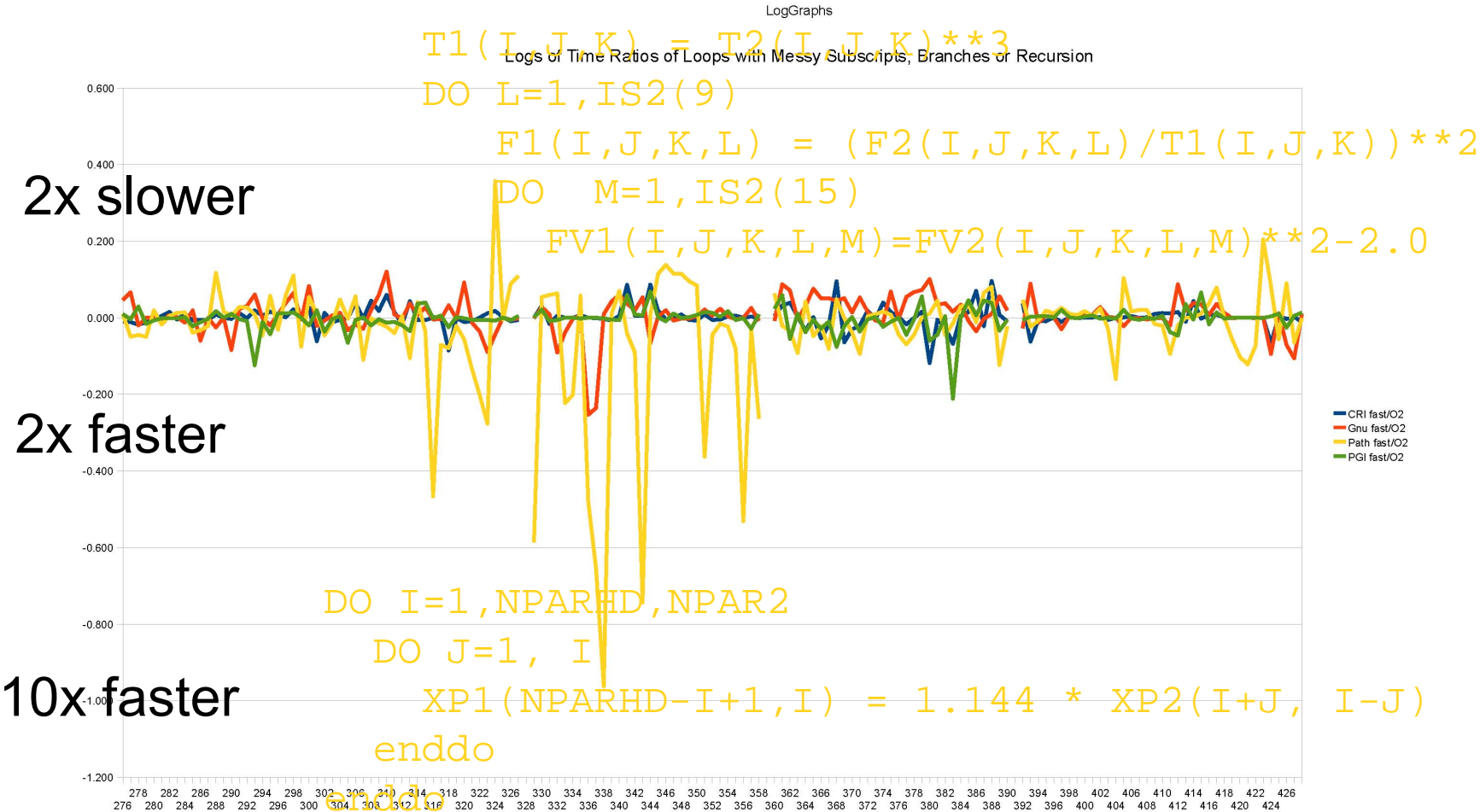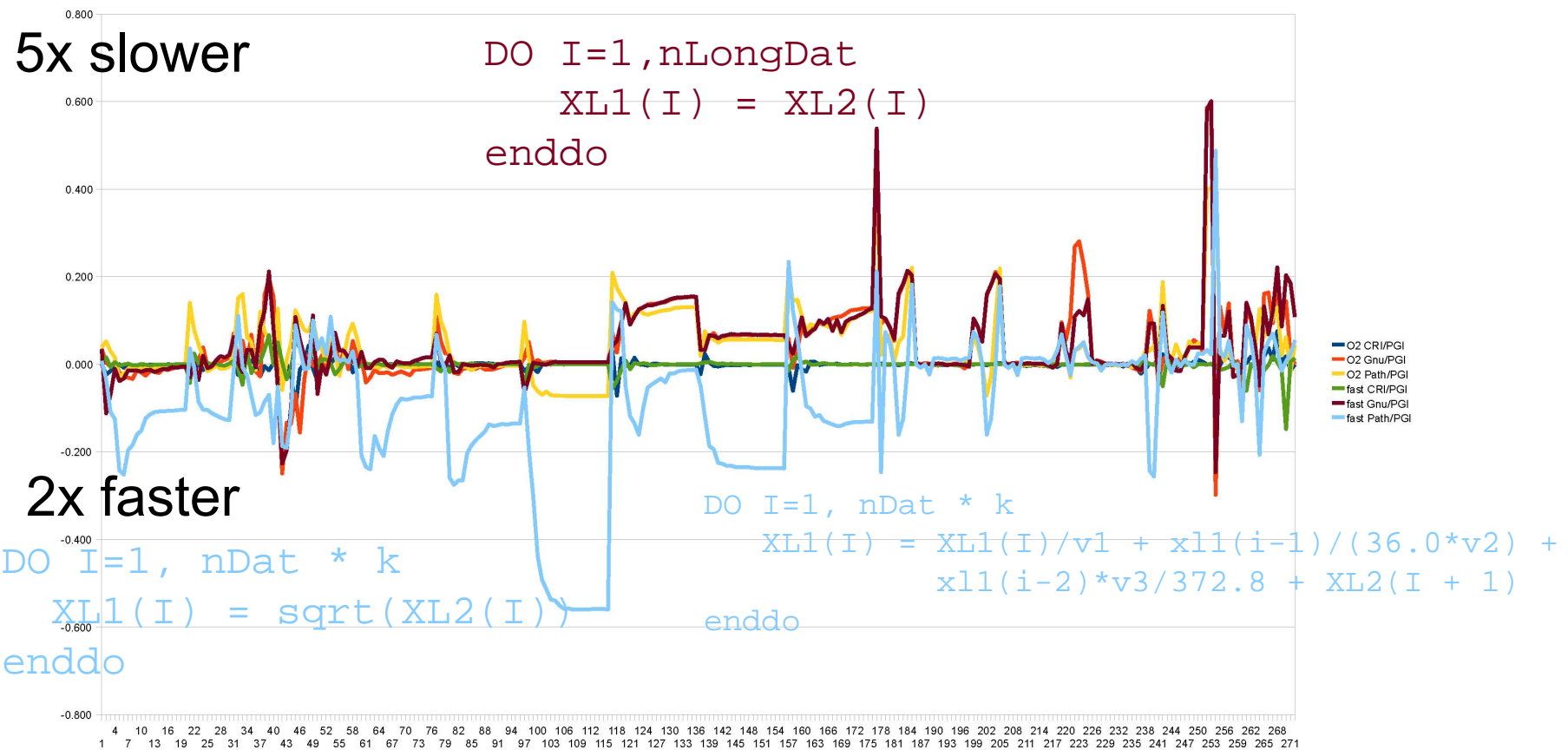Simple Loop Log of Time Ratios

```
DO I=1, nSomeDat * k
    is1(I) = is2(I) + is3(I)
enddo
```

2x slower

2x faster

```
DO I = 1, nDat * k
    XL1(I) = sqrt(XL2(I))
enddo
```

Legend:
- CRI fast/O2
- Gnu fast/O2
- Path fast/O2
- PGI fast/O2

Page 1
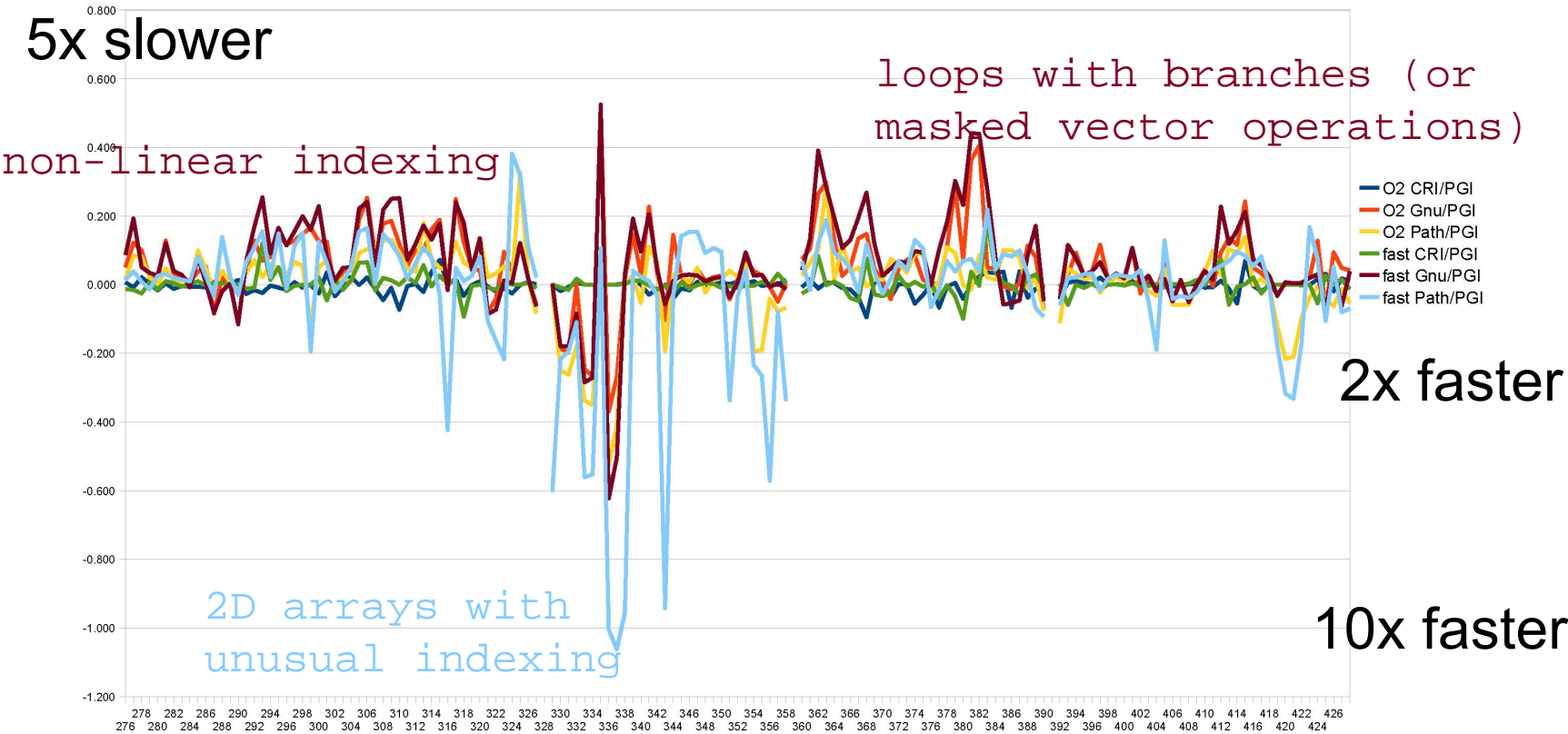
Intra: Subscr, Jumps, Rcrsn

LogGraphs

Logs of Time Ratios of Loops with Messy Subscripts, Branches or Recursion

```
T1(I,J,K) = T2(I,J,K)**3
DO L=1,IS2(9)
    F1(I,J,K,L) = (F2(I,J,K,L)/T1(I,J,K))**2
    DO  M=1,IS2(15)
        FV1(I,J,K,L,M)=FV2(I,J,K,L,M)**2-2.0
```

2x slower

2x faster

10x faster

```
DO I=1,NPARHD,NPAR2
    DO J=1, I
        XP1(NPARHD-I+1,I) = 1.144 * XP2(I+J, I-J)
    enddo
enddo
```

0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
-1.200

276 278 280 282 284 286 288 290 292 294 296 298 300 302 304 306 308 310 312 314 316 318 320 322 324 326 328 330 332 334 336 338 340 342 344 346 348 350 352 354 356 358 360 362 364 366 368 370 372 374 376 378 380 382 384 386 388 390 392 394 396 398 400 402 404 406 408 410 412 414 416 418 420 422 424 426

CRI fast/O2
Gnu fast/O2
Path fast/O2
PGI fast/O2

Inter-Compiler: Simple Loops

LogGraphs

Simple Loop Log of Time Ratios

5x slower

```
DO I=1,nLongDat
        XL1(I) = XL2(I)
enddo
```

2x faster

```
DO I=1, nDat * k
   XL1(I) = sqrt(XL2(I))
enddo
```

```
DO I=1, nDat * k
   XL1(I) = XL1(I)/v1 + xl1(i-1)/(36.0*v2) +
            xl1(i-2)*v3/372.8 + XL2(I + 1)
enddo
```

Legend:
- O2 CRI/PGI
- O2 Gnu/PGI
- O2 Path/PGI
- fast CRI/PGI
- fast Gnu/PGI
- fast Path/PGI

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Inter: Subscr, Jumps, Rcrsn

LogGraphs

Logs of Time Ratios of Loops with Messy Subscripts, Branches or Recursion

Problems with Loop Timing

- ## PAPI provided the only high-res, portable timer we found
  - MPI timers ~ 0.1 μs on one machine
- ## Repeatable errors
  - bizarre but reproducible results
  - error depends on total job time???
- ## PAPI library has bad Fortran

Compiler Conclusions

- Compiled code quality varies widely

- For best speed: Experiment
  – "fast" options speed operation, usually
  – "better" compilers => faster code, usually

- Industry cannot and should not expect users to experiment

Timing Conclusions

- ## We need high-resolution timers

- ## PAPI makes O/S call
  - Variable overhead
  - Makes timing small code sections difficult
  - Cray has better routines
    - Need them in Fortran Standard
    - Need them user-available

Thank you   Questions

- **Linked from www.arsc.edu/~higbie**
  - Complete program code

- **Spreadsheets of results and graphs**
  - additional families:
    - structures & F90 constructs
    - function or subroutine calls in loop
    - formatting
    - .... (10 total)

Comparing XT5 Compilers

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