Advances of the profiling & optimization of the LSST Pipeline

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Science Pipelines Team Meeting, Feb. 12th 2025

(Full previous presentation available here about profling and optimization works with notebooks & more results.)

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  - **Key Motivations**: Reducing resource use (CPU time, memory, storage) for finance, ecology, performance.
  - **Code Context**: Open-source code developed primarily by the Rubin project (US), many different computing nodes (USA / UK / France (CC-IN2P3))
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- Difficulties:
  - **Operational Context**: Many implementations decisions already made, cannot be disrupted / Different sites may have differents architectures (e.g. AMD vs Intel CPU)
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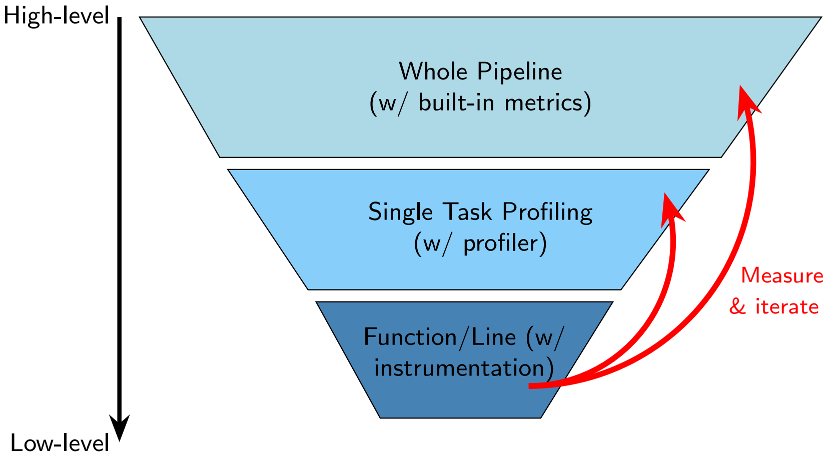
- Next steps:
  - **Set-up test case**: Profile with realistic datasets.
  - **Start optimization**: Piff package or **forcedPhotCoadd** seems promising targets.

- Broad-to-specific profiling to isolate bottlenecks.
- Improvement shall be measured
- Process is iterative and empirical



High-level profiling - Whole pipeline

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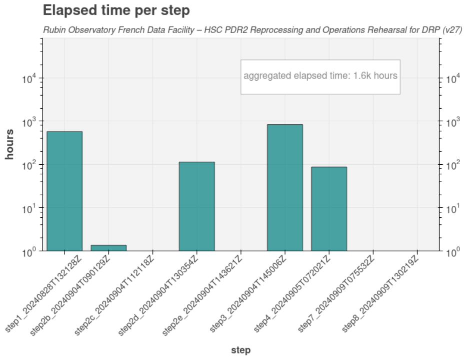

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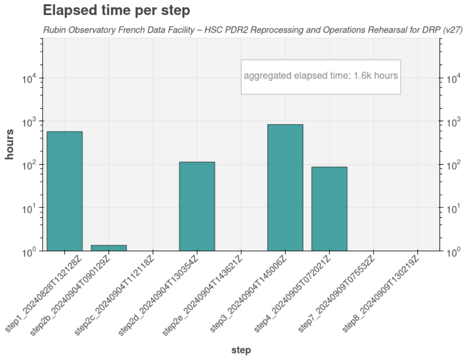

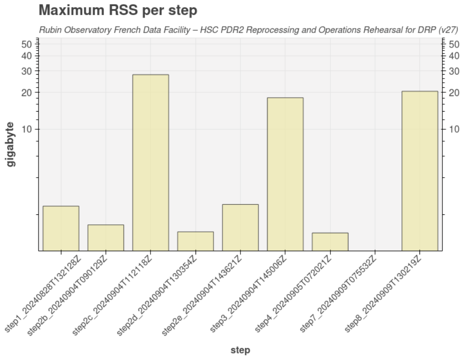

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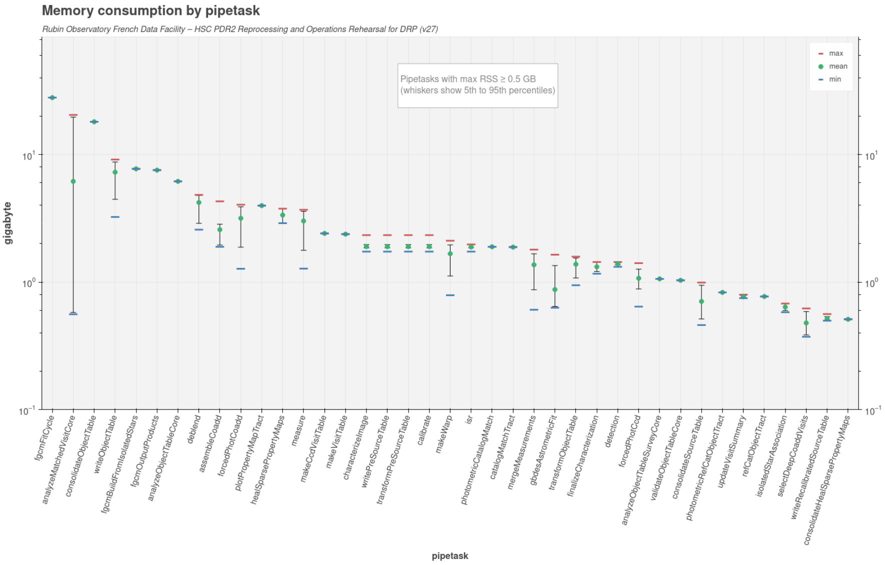

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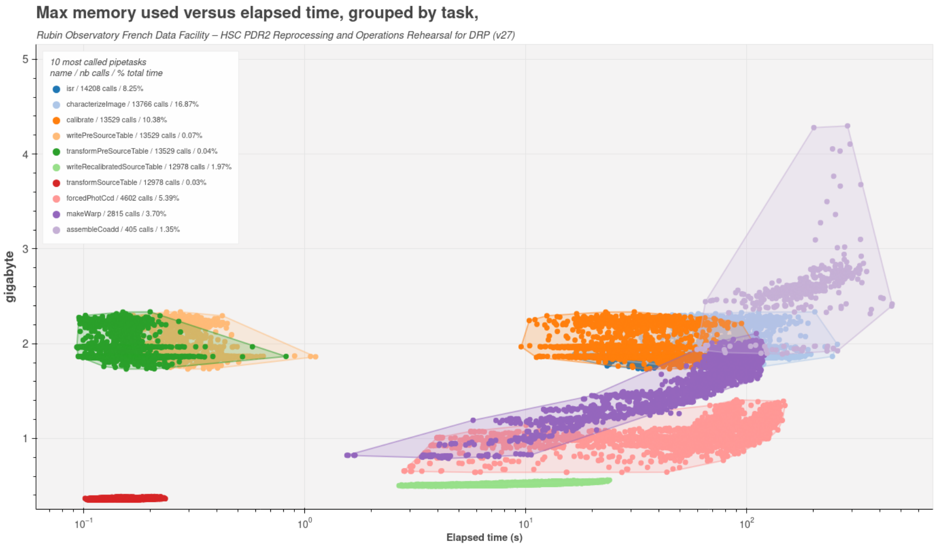

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Effective Time:	696.870s
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Top Hotspots

This section lists the most active functions in your application. Optimizing these hotspot functions typically results in improving overall application performance.

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func@0x63ea0	libm.so.6	41.466s	5.9%
Transform	libast.so.9	38.413s	5.5%
boost::math::tools::detail::evaluate_rational_c_imp<long double, long double, long double>	libmeas_base.so	29.715s	4.3%
DOUBLE_onemultadd	_sigtools.cpython-311-x86_64-linux-gnu.so	21.842s	3.1%
func@0x6b950	libm.so.6	20.688s	3.0%
[Others]	N/A*	546.386s	78.2%

*N/A is applied to non-summable metrics.

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Vectorization: 9.5%

Code modification

- Optimize:
  - tracked one consuming call stacks: **sincosf64x** and **sqrt** function used in **boost::math::detail::bessel_j1**,
  - in **meas_base** package, in **src/SincCoeffs.cc**, modified **calcImageKSpaceCplx** (see on Github),

```cpp
// compute the k-space values and put them in the cimg array
double const twoPiRad1 = geom::TWOPI * rad1;
double const twoPiRad2 = geom::TWOPI * rad2;
double const scale = (1.0 - ellipticity);
for (int iY = 0; iY < wid; ++iY) {
    int const fY = fftshift.shift(iY);
    double const ky = (static_cast<double>(iY) - ycen) / wid;

    for (int iX = 0; iX < wid; ++iX) {
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        // rotate
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  - Remove unecessary nested-loops
- Expected results:
  - More memory usage because pre-computation
  - Less runtime thanks to vectorization
  - Biggest chunk of time unaffected yet, cause Bessel function not vectorizable.

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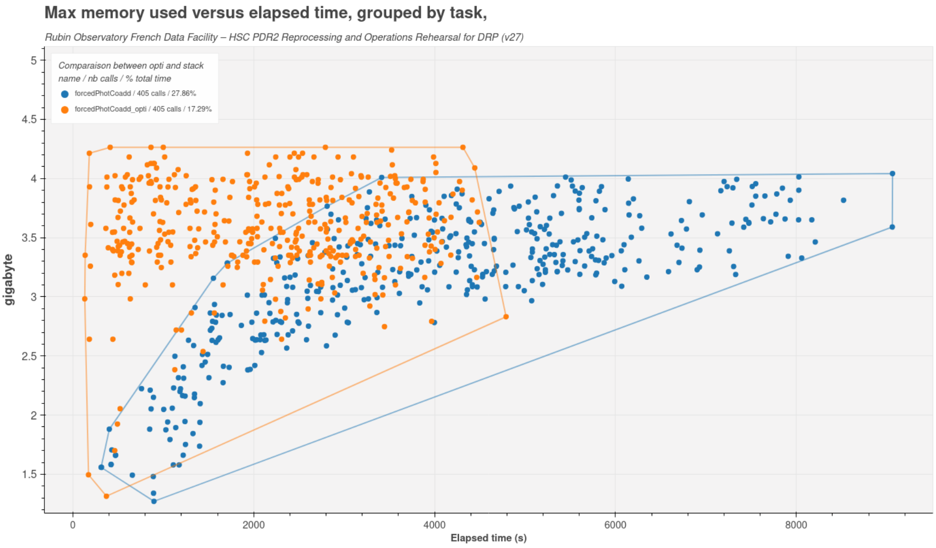
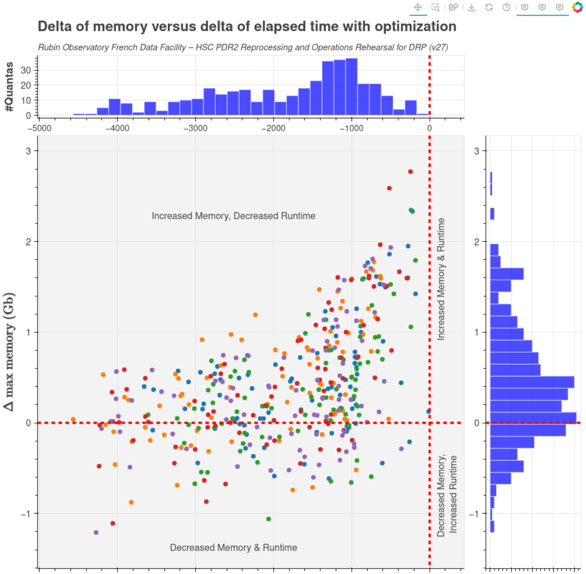


Max memory used versus elapsed time, grouped by task,
Rubin Observatory French Data Facility – HSC PDR2 Reprocessing and Operations Rehearsal for DRP (v27)
Comparaison between opti and stack
name / nb calls / % total time
forcedPhotCoadd / 405 calls / 27.86%
forcedPhotCoadd_opti / 405 calls / 17.29%
gigabyte
5
4.5
4
3.5
3
2.5
2
1.5
0
2000
4000
6000
8000
Elapsed time (s)



- Colors correponds to band,
- Every job runtime decreased,
- Approx 3/4 of the job memory increased,

	$\sum t_i$ (h)	$\sum m_i$ (Gb)	$\sum(t_i \cdot m_i)$ (Gb.h)
Whole Pipeline			
Base	1617.1	157045.7	4013.7
Opti	1410.5	157213.1	3367.1
Diff	206.6	-167.4	646.6
Relative (%)	-12.8%	0.1%	-16.1%
forcedPhotCoadd Task			
Base	450.5	1282.5	1525.5
Opti	243.9	1449.9	878.9
Diff	206.6	-167.4	646.6
Relative (%)	-45.9%	13.0%	-42.4%

- **Primary results:** 100s gain on a 700s run, seems great & code is more vectorized !
- **Global results:** -45.9% runtime for **forcedPhotCoadd** & -12.8% for the whole pipeline... for approx. 20 lines of codes

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Way too much performance gain ! That's suspicious !

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What could have gone wrong ?

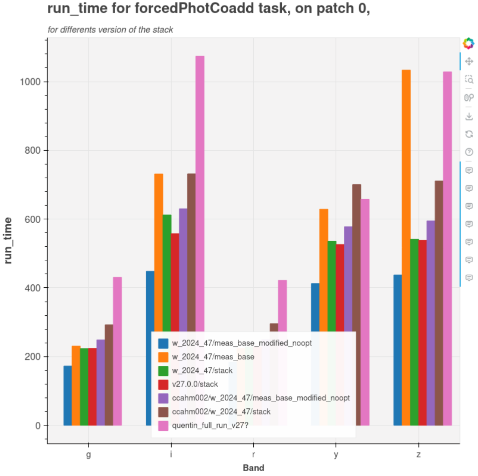
- Code improved between v27 and w_2024_47 ?
- Difference between interactive server and bacth-server ?
- Huge variability in runtime inherent to the processing ?

Machine impact

Interactive vs batch, & multiple stacks version

- **w_2024_47/meas_base_modified_noopt**: Using w_2024_47 of the stack, with package `meas_base` modified with base compilation option, run with `sbatch`.
- **w_2024_47/meas_base**: Using w_2024_47 of the stack, with package `meas_base` with base compilation option, run with `sbatch`.
- **w_2024_47/stack**: Using w_2024_47 version of the stack, run with `sbatch`.
- **v27.0.0/stack**: Using v27.0.0 version of the stack (dated approx. June 2024), run with `sbatch`.
- **ccahm002/w_2024_47/meas_base_modified_noopt**: Using w_2024_47 of the stack, with package `meas_base` modified with base compilation option, run on `ccahm002` interactive server.
- **ccahm002/w_2024_47/stack**: Using the w_2024_47 version of the stack, run on `ccahm002` interactive server.
- **quentin_full_run_v27?**: Results obtained from HSC-PDR2 run made by Quentin in early September 2024, using version v27.0.0. No info on the run's specifics.

Patch 0


run_time for forcedPhotCoadd task, on patch 0,
for differents version of the stack
run_time
0
200
400
600
800
1000
g
i
r
y
z
Band
w_2024_47/meas_base_modified_noopt
w_2024_47/meas_base
w_2024_47/stack
v27.0.0/stack
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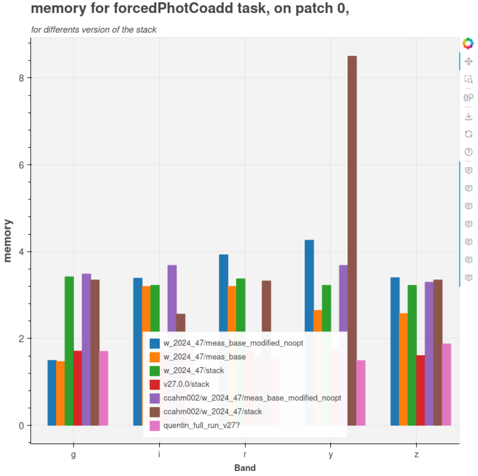
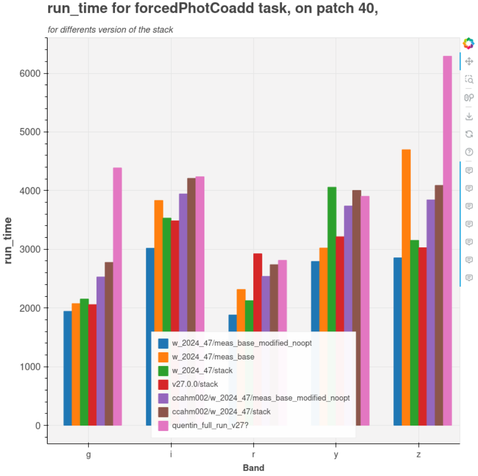
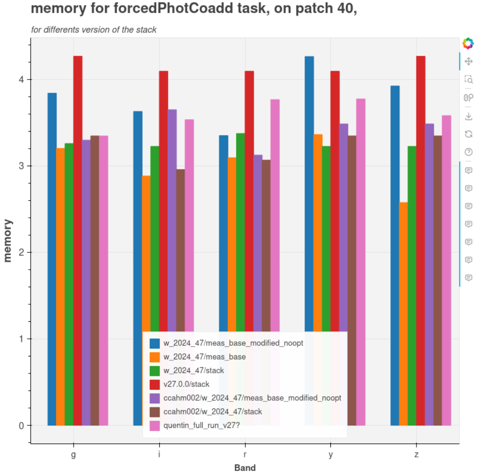
ccahm002/w_2024_47/stack
quentin_full_run_v27?

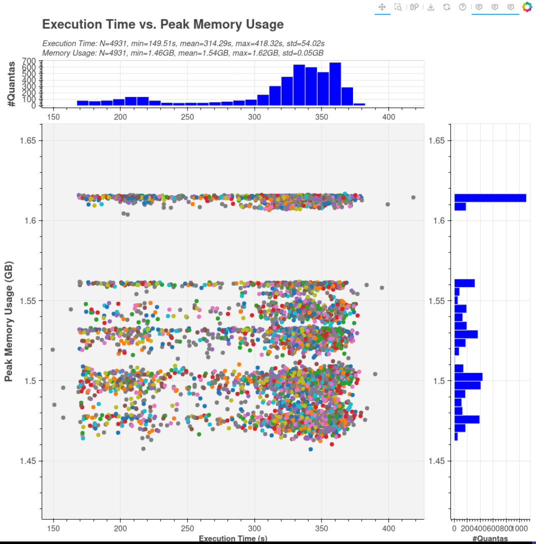

memory for forcedPhotCoadd task, on patch 0,
for differents version of the stack
memory
0
2
4
6
8
g
i
r
y
z
Band
w_2024_47/meas_base_modified_noopt
w_2024_47/meas_base
w_2024_47/stack
v27.0.0/stack
ccahm002/w_2024_47/meas_base_modified_noopt
ccahm002/w_2024_47/stack
quentin_full_run_v27?

Patch 40


run_time for forcedPhotCoadd task, on patch 40,
for differents version of the stack
run_time
6000
5000
4000
3000
2000
1000
0
g
i
r
y
z
Band
w_2024_47/meas_base_modified_noopt
w_2024_47/meas_base
w_2024_47/stack
v27.0.0/stack
ccahm002/w_2024_47/meas_base_modified_noopt
ccahm002/w_2024_47/stack
quentin_full_run_v27?

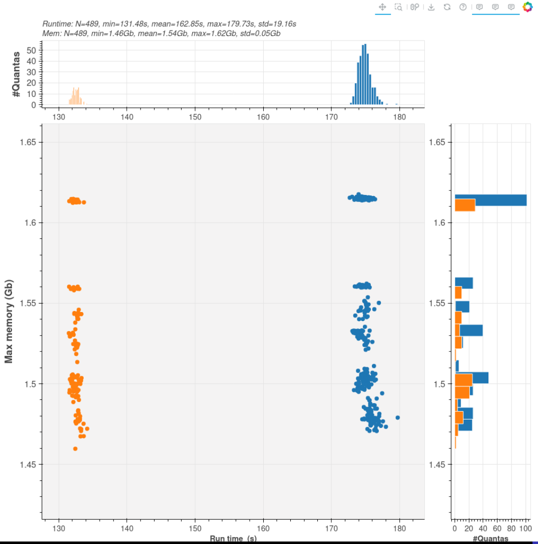

memory for forcedPhotCoadd task, on patch 40,
for differents version of the stack
memory
4
3
2
1
0
g
i
r
y
z
Band
w_2024_47/meas_base_modified_noopt
w_2024_47/meas_base
w_2024_47/stack
v27.0.0/stack
ccahm002/w_2024_47/meas_base_modified_noopt
ccahm002/w_2024_47/stack
quentin_full_run_v27?

Using all CC-IN2P3 node:

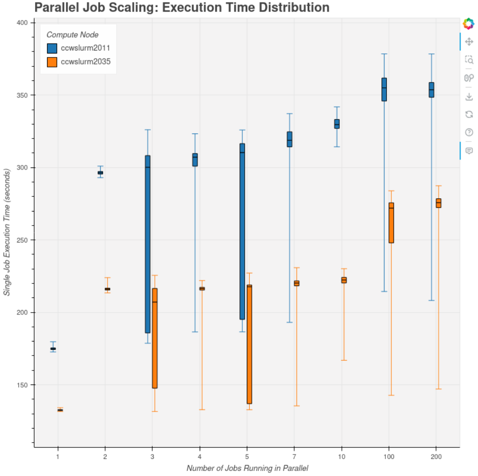


- Some memory threshold
- Runtime variability does not seems correlated to a particular server

Using 2 reserved nodes, 1 job at a time:



Using 2 reserved nodes:



- Difference between two nodes match nodes specs !
- Runtime bump even at 2 jobs in parallel seems to be slurm putting multiple thread on the same physical core,
- Hyperthreading ?
- Time per job in increase,

Notebooks here & more results here.

- Need to control the environnement to properly measure performance gain ...
- ... but we need to ensure our gains translate into a production environnement !

or

- We could just run $\tilde{1}00$ of runs to get a distribution and statistics each improvement,
- Coud work for short runtime tasks ...

Summary

- Need to control the environnement to properly measure performance gain ...
- ... but we need to ensure our gains translate into a production environnement !

or

- We could just run $\tilde{1}00$ of runs to get a distribution and statistics each improvement,
- Coud work for short runtime tasks ...

Strategy:

- Dedicate a machine to pursue testing on, simple fast case
- Test again with inputs thats take longer to process,
- Once improvements observed, tests how it scale on a loaded machine,