

October 19 - 25, 2024

CHEP
2024



Conference on Computing in High Energy and Nuclear Physics

CHEP24 highlights (PoV)

Napoli, 19-20 novembre 2024

L. Rinaldi

CHEP 24 in numbers

470 participants

351 talks (XX morning plenary) & 143 posters

9 tracks (afternoon parallels)

Many interesting topics, but impossible to follow everything...

	Total Cost of Ownership and Evaluation of Google Cloud Resources for the ATLAS Experiment at the LHC David South						
	Large Hall 09:30 - 10:00						
10:00	Enhancing Data Management in Nuclear Physics and Cross-Domain Metadata Integration Ivan Knezevic						
	Large Hall 10:00 - 10:30						
	Coffee break						
	10:30 - 11:00						
11:00	ROOT RNTuple and EOS: The Next Generation of Event Data I/O Andreas Joachim Peters et al.						
	Large Hall 11:00 - 11:30						
	The WLCG Data Challenge Katy Ellis						
	Large Hall 11:30 - 12:00						
12:00	Global Networking Challenges for the Coming Decade Tony Cass						
	Large Hall 12:00 - 12:30						
	Lunch break						
	12:30 - 13:30						
	Benchmark Loren...	Monte Carlo Dr An...	Advanced m Brig K...	A RoCE-bas 曾德...	Fast Jet Rec Grae...	A graph neu David...	Recent Expe Hasa...
	Advanceme Bern...	Madgraph o Andr...	Whole-node Marta...	Front-End R Gabr...	Reconstructi Juan...	Charged Par Gagik...	DUNE Rucio Weni...
14:00	Zero-overhe, Dr Vi...	Hardware ac Zenn...	Unprivileged Maksi...	Near-Data C Aash...	The Real-Tim Maris...	TrackNET: D Mr P...	FTS as a par Rose...
	On-the-fly da Florh...	Event gener, Yutar...	Unified Expe Ewou...	Using the AT Joha...	Next generat Paul...	ML-Assisted Tom...	Distributed Lia L...
	QIL-free scal Jim P...	Monte Carlo Jame...	Designing O Dr Da...	Improving o Diana...	TGeoArbN Ben...	Neural netw Christ...	Data Movem Fabio...
15:00	Using and Visu, Julius ...	Navigating Pha, Salvato...	Addressing tok, Kyle K...	The Glance proj, Luis G...	The Belle II Raw, Tristan ...	Machine Learn, Torri J...	
	Poster session: Presentation with coffee						
	15:18 - 16:15						
16:00	Exhibition Hall						
	zfit: general Iason ...	WLCG Opera Pano...	Carbon, Pow Zach ...	A Pilot Anal, Enric ...	Towards a G Charl...	Improvement David...	Adoption of Marci...
	Model Buildi, Laer...	Implementat, Haek...	Allocating C, Alex ...	Evolution an, Thom...	Traccc: GPU Beom...	GPU Acceler Nuno...	RNTuple: A Nick...
	New RooFit, Jona...	Enhanceme, Alexa...	Heterogeneo, Eman...	Operational, Anton...	Application, Yizho...	Low-latency, Piero ...	ML-based A, Dr By...
17:00	BATJi, the B, Oliver...	Optimisation, Natali...	Taking on R, Eman...	Building Sc, Lincol...	Extending A, Matte...	Performance, Abhri...	Advanceme, Maci...
	Parameter Est, Ashik ...	Modernizing AT, Tatiana...	Heterogeneous, Daniel...	Computing Act, Pablo ...	Efficient metad, Mr Fab...	An online GPU, Felix ...	
	Novel Fitting Ap, Dr Yury...	Optimization of, Marco ...	Enhancing Net, Petya ...	Leveraging dist, Federic...	So FAIR, so goc, Lorenz...	SYCL-based o, Bartos...	
18:00							

What did we Release?



ATLAS DAOD_PHYSLITE format Run 2 2016 proton-proton collision data

ATLAS collaboration

Cite as: ATLAS collaboration (2024). ATLAS DAOD_PHYSLITE format Run 2 2016 proton-proton collision data. CERN Open Access Library. DOI:10.7483/OPENDATA.ATLAS-4ZES.DJHA

Dataset characteristics

5383448881 events, 45571 files, 35.4 TiB in total.

More on the web

More on the web

Documentation on PHYSLITE Variables for ATLAS Open Data

Page generated from sample: mc20_13TeV.410471.PhPy8EG_A14_ttbar_hdamp258p75_allhad.deriv.DAOD_PHYSLITE_e6337_s3681_13167_p5631

List of Containers:

[AnalysisElectrons](#) | [AnalysisJets](#) | [AnalysisLargerJets](#) | [AnalysisMuons](#) | [AnalysisPhotons](#) | [AnalysisTauJets](#) | [AnalysisTrigMatch](#) | [AntiK10TruthSoftDropBeta100Zcut10Jets](#) | [AntiK4TruthDressedWZJets](#) | [BTagging_AntiK4EMPFlo](#) | [CombinedMuonTrackParticles](#) | [egammaClusters](#) | [EventInfo](#) | [ExtrapolatedMuonTrackParticles](#) | [GSFConversionVertices](#) | [GSFTrackParticles](#) | [HardScatterParticles](#) | [HardScatterVertices](#) | [InDetTrackParticles](#) | [K4EMPFloEventShape](#) | [MET_Core_AnalysisMET](#) | [MET_Truth](#) | [MuonSpectrometerTrackParticles](#) | [PrimaryVertices](#) | [TauTracks](#) | [TruthBoson](#) | [TruthBosonsWithDecayParticles](#) | [TruthBosonsWithDecayVertices](#) | [TruthBottom](#) | [TruthElectrons](#) | [TruthEvents](#) | [TruthForwardProtons](#) | [TruthMuons](#) | [TruthNeutrinos](#) | [TruthPhotons](#) | [TruthPrimaryVertices](#) | [TruthTaus](#) | [TruthTop](#)

[AnalysisElectrons](#) (back to top)

Variable Name	Type	Description
ambiguityLink	vector<ElementLink<DataVector<<AOD::Egamma_v1>>>	Links Photon<-> Electron when ambiguous
ambiguityType	vector<unsigned char>	Ambiguity (almost surely electron 0 or photon 1, rel22/rel21) or ambiguous 1-6/5, (-= rel22)
author	vector<unsigned short>	Electron, Photon, Ambiguous, Fake
caloClusterLinks	vector<vector<ElementLink<DataVector<<AOD::CaloCluster_v1>>>>	Photon/electron -> Cluster
charge	vector<float>	Electron charge
DFCommonElectronsECIDS	vector<char>	Charge sign (element)
DFCommonElectronsECIDSResult	vector<double>	ECIDS result (the charge)
DFCommonElectronsHLoose	vector<char>	Loose selection decision
DFCommonElectronsHLooseBL	vector<char>	Loose selection decision

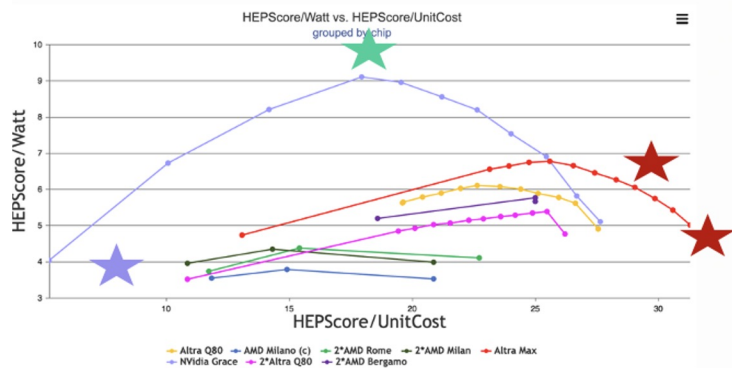
More on the web

- 2015+2016 Run 2 pp collision data
 - 45 TB of data, 6.3 kB/event, 7.1B events, 55k files in ~300 runs
 - 20 TB of MC, ~10 kB/event, 2B events, 16k files in ~300 MC datasets
- Explanation of [our nomenclature](#)
- Giant [tables of metadata](#)
 - Cross sections, k-factors, filters / efficiencies, processes, how to combine samples, configurations, ...
- PHYSLITE (ROOT-based) format
 - Already columnar — Uproot friendly
 - [Used for our own papers too](#)
- Pre-calibrated (first for ATLAS)
 - Just draw a plot!
- Extensive effort to document variables
- **Useful documentation for us as well!**

Simulating the Carbon Cost of Grid sites

- **Sustainability:** Can the CO₂e per unit work be reduced?

- Yes, tune hardware to optimal frequency, particularly when forecast Carbon Intensity is high.



- **Costs:** What hardware requires the minimum CapEx (most HS23/£) and the least OpEx (least power per unit work)?

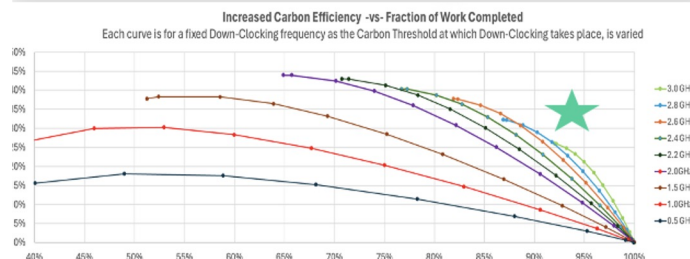
- CapEx decisions informed by the Smart Procurement utility.

- OpEx can be reduced by running at lower frequencies (compromise!)

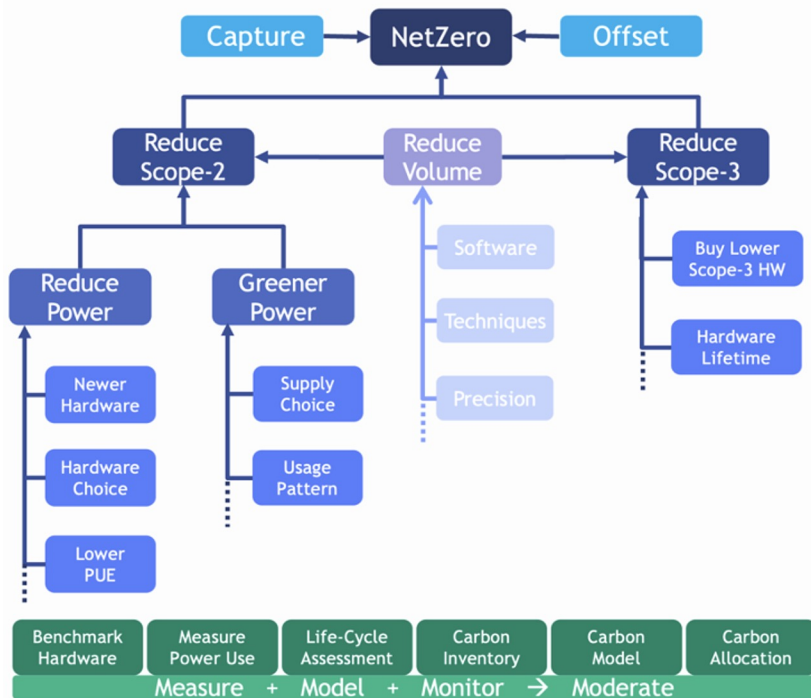
- **Power Supply:** In a crisis, how much power could be saved at peak times?

- With ARM: 40-75%

- With x86, 20-50% (Slide-11)



Simulating the Carbon Cost of Grid sites

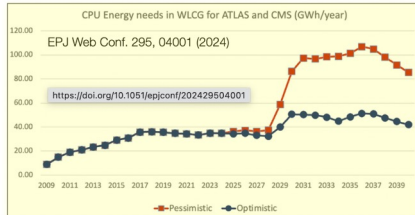


- Many things will need to contribute to the journey to NetZero.
- Those things depend on time and place.
- Money should be spent where it does the most good.
- There can be clear wins: In 2023/4 the adoption of ARM gave us more compute, for less money, *and* better carbon efficiency.
- There are also compromises: Our investigations of down-clocking suggest that for a modest 5-10% reduction in work-rate, we can reduce the carbon/job by up to 30%.
- There is a lot more to be done.

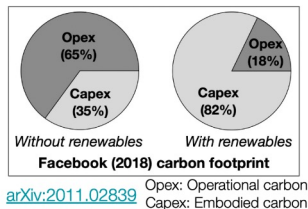
(Computing) Carbon footprints



- Much more attention to carbon footprints recently (CERN reports in [2021](#) and [2023](#); see [bkup](#))
 - Outside groups also looking: [EE HPC WG \(recommendations\)](#), [Open Compute Project](#), [GreenDISC](#)
- Computing is ~5% of CERN's footprint when the LHC runs (accelerator cooling ~80%)
 - CERN mostly draws power from the French (nuclear, quite low-carbon) grid
- About 10–20% of ATLAS computing is at CERN, much of the rest is on less green power
- Most studies focus on *power* (operational carbon); embodied carbon >15% of the total ([1](#), [2](#))
 - Relevance of embodied carbon (Scope 3) will increase as western power grids decarbonize
- [Extrapolating to HL-LHC](#), computing could be a **large** fraction of the ATLAS carbon footprint!



Carbon, Power, and Sustainability in ATLAS Computing — CHEP 2024 — 23 Oct. 2024

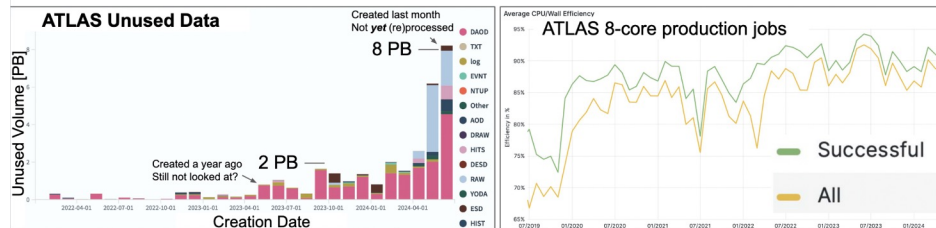


4

Waste, loss, and unused data



- *Using* carbon for important science is “allowed” — *wasting* carbon is never ok!
- Constantly monitoring *unused data* in the production system
 - Requests made, bug found, reproduced before the data were looked at
 - Processing done based on a too-inclusive pattern (mc*)
- **Steady progress to improve CPU/wall efficiency to over 90%** (below for 8-core production jobs)
 - Impact of failed jobs is visible; errors on copying output (after all the CPU has been consumed) are killer!
 - Constant effort to reduce serial portions of many-core jobs as well (wasted CPU and power)



ARM Physics Validation

Most LHC experiments (**ATLAS**, **CMS**, **ALICE**) have done a first round of extensive Physics Validation campaigns against our ARM cluster @ Glasgow:

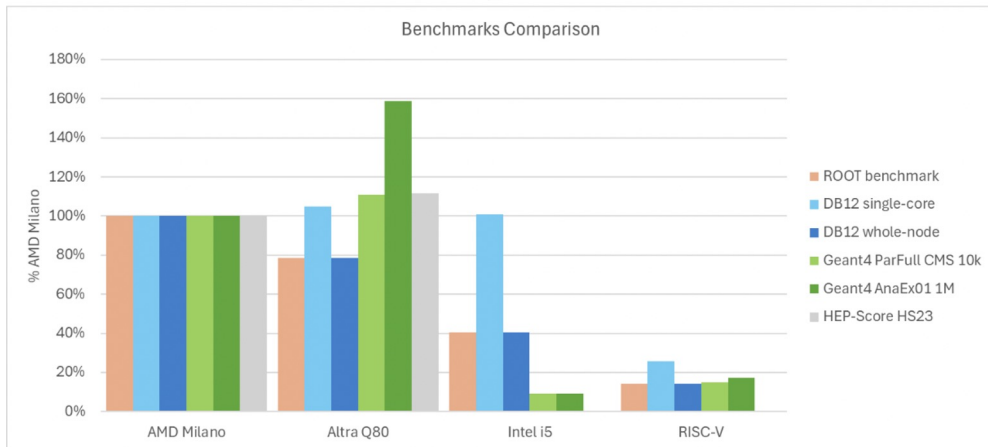
- 😊 • **ATLAS**: Full simulation and Reconstruction are physics validated.
ATLAS is ready for pledged ARM resources!
- 😐 • **CMS**: Physics validation on ARM mostly successful, but not conclusive.
CMS is not in a position to use ARM processors in production!
- 😐 • **ALICE**: Extensive test of MC simulation jobs, no analysis workflows.
Recommends ARM segregation or mixed queue with enable/disable!
- 😞 • **LHCb**: Groundwork & test samples done, full physics validation not done.
Production use of ARM unlikely before end of 2024!

Latest reports from **GDB** (June 2024 @ CERN): <https://indico.cern.ch/event/1356135/>

It's time for **VOs** to start sending ARM jobs our way ... we have over 4k ARM cores !

Benchmarks Comparison

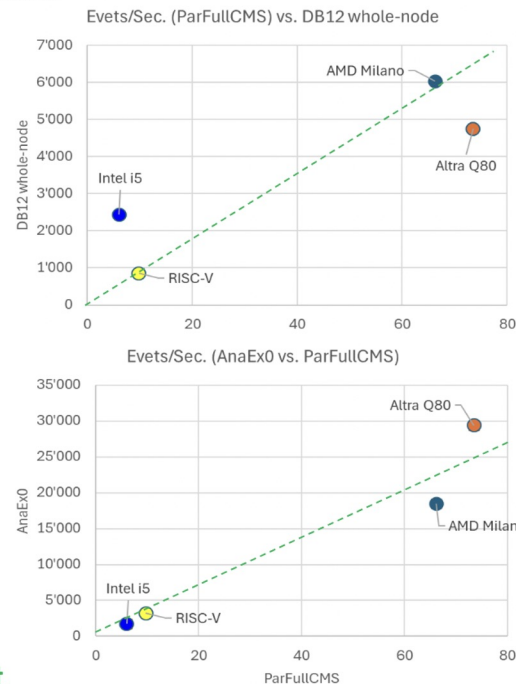
The histogram below compares the results of the benchmarks so far, normalized to the AMD server. On the two servers (**AMD & ARM**), the HEP-Score results are also shown.



As mentioned, the first two benchmark (**ROOT & DB12 single**) are single-threaded, the others are multi-threaded (**DB12 whole**, both **Geant4** simulations, and the **HEP-Score**).

The scatter plots on the right show how compatible are their results.

Note: the green line is not an actual fit.

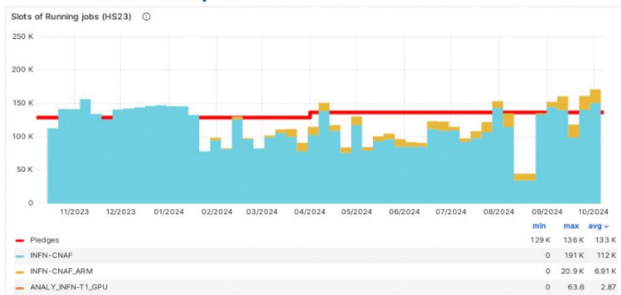


Experiment point of view: ATLAS



ATLAS has been running jobs on ARM@CNAF for one year

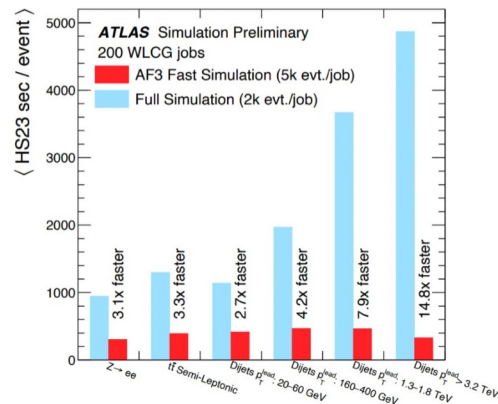
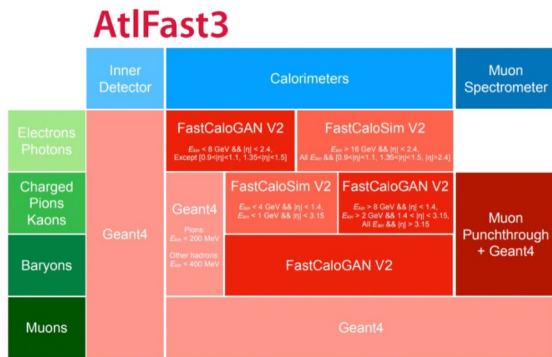
- initially, only test jobs
 - ATLAS Software already Physics-validated on ARM
 - Technical validation performed at CNAF (HTCondorCE, pilot/PanDA, containers)
- workflows:
 - Full and Fast MC Simulation
 - MC reconstruction
 - Group production
 - User Analysis



Very good performance observed

- Steady use of available resources. On peak: ~12% of ATLAS-dedicated resources at INFN-T1

- Machine learning methods are now fully integrated into the standard simulation of many experiments
 - Hybrid usage next to full Geant4 simulation and parametrised modeling



- Training runs **3-4x faster** on Leonardo (**A100** GPUs) and 2-3x faster on CNAF-HPC with respect to LXBATCH at CERN. **Supercomputers give a great performance boost!**
- To do:** run on other resources (also cloud), architectures (ARM) and for more particle types, code optimisation (both general and to take even more advantage of multi-CPU/GPU nodes).

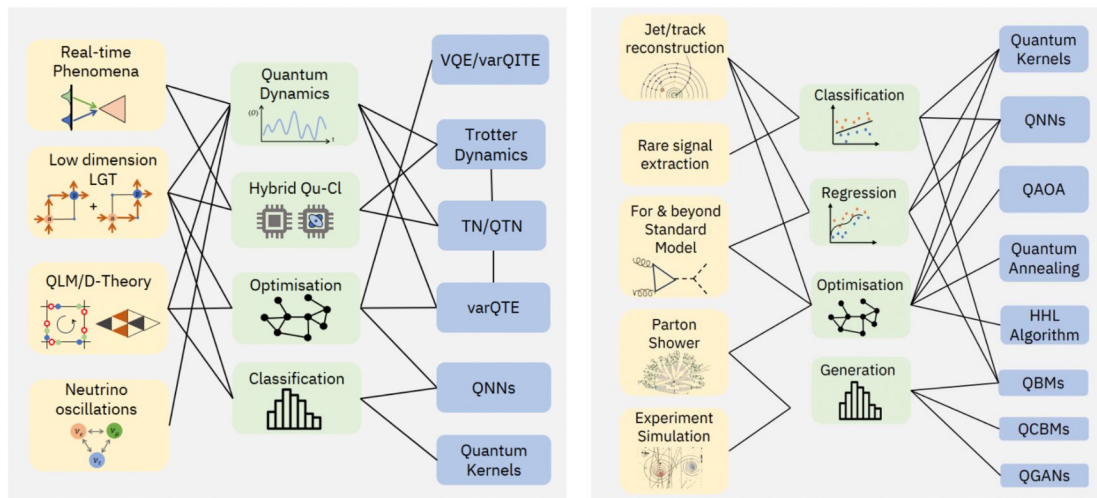


Quantum Computing?

QC topics

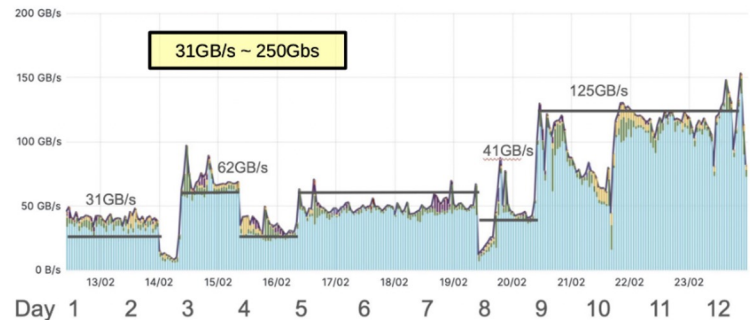
- IBM technology and roadmap
- CERN QTI provided examples of current implementation and use cases: integral acceleration with hybrid QA, quantum anomaly detection to detect BSM, quantum generative models to simulate calorimeter images, for parton shower, Hamiltonian moments calculation for elastic scattering
- Jet discrimination with QGNN, Jet reconstruction (annealing)
- Track reconstruction (HHL)
- Particle identification
- Quantum event generation

Methods and applications

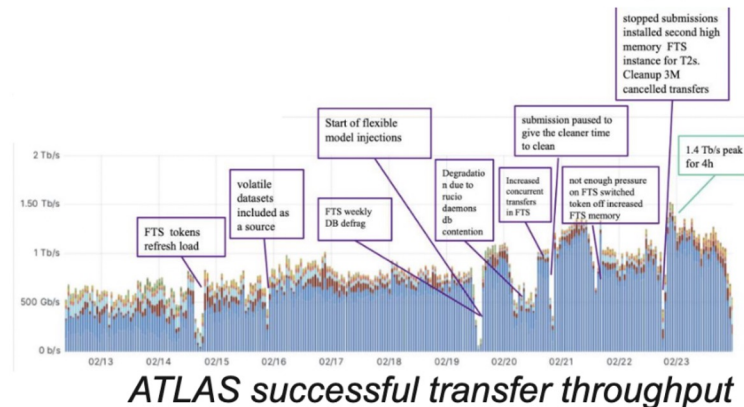


Data Challenge 24

- **Preparing for HL-LHC data rates:**
 - DC24: 25% HL-LHC
 - DC26: 50% HL-LHC (planned)
- **Experiments:**
 - ATLAS, CMS, ALICE, LHCb, Belle II, DUNE
- **FTS is a pillar technology for DC**
- **Observed bottlenecks:**
 - Scalability of FTS and Rucio, token handling, storage systems overload, network tuning
- **Positive outcome: improved production rates!**
- **Future DC26 priorities (2x DC24 rates):**
 - Network orchestration and monitoring (scitags); token support; focus on tape
 - Intermediate mini-challenges



CMS successful transfer throughput



ATLAS successful transfer throughput

Rucio highlights

Rucio was **omnipresent** in CHEP (mentions in plenary and side tracks).

Became de-facto platform used in HEP and Astrophysics organizations for scientific data management (**20+ sites and > 2 exabytes of data**)

1st IT department talk on behalf of the Rucio project: Advancing Large Scale Scientific Collaborations with Rucio

Public recognition of IT work on Rucio for experiments

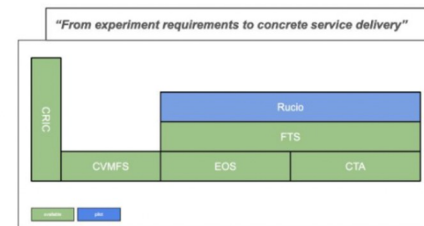


Increasing cooperation in the Rucio community



The CERN IT department is a new member of the Rucio community since early 2024, giving a hand in 3 axis:

1. Code development
2. DevOps for ATLAS and CMS
3. Managed Rucio service for Small and Medium Experiments (pilot)



2024-10-22

Improvements for tape transfer failures



● Improvement: overwrite-when-only-on-disk

- Contribution provided by the CERN IT department for CMS (Code changes in FTS & Rucio) 🏆
- CMS provides this flag to FTS via Rucio to make FTS overwrite the files on tape buffer (disk)
- Files that are on tape are still handled manually

Track 4 - Main Themes

- Tokens
 - Tokens being widely used and lessons are being learned
 - Current production setups
 - Development of best practice
 - Satellite services development (e.g. IAM)
 - Adoption of tokens outside WLCG - early stages
- Operations
 - Grid computing adapts to changing circumstances
 - Incorporation of modern resources such as ARM, HPCs, GPUs and Cloud.
 - Optimizing use of available resources
 - Monitoring
 - Security: It's not just technology, people matter, too. The pDNSSOC package was suggested as a lightweight way for smaller sites to get the benefits of a SOC
- Distributed computing as part of non-WLCG computing models:
 - Gaining popularity especially in Astronomy: SKA, LSST, Einstein Telescope, CTA, HERD, but also DUNE (not astronomy)
 - Predicted SKA data volumes easily comparable to WLCG, building on WLCG experience for large scale operations!

30 Talks
19 Posters

Tokens

- Tokens are now a reality! The infrastructure is almost token ready- time to focus on the operational models!
- DC24, a major milestone: millions of transfers with tokens!
- Token implementations of middleware need to improve: FTS/Rucio/Dirac workflows, IAM: all doing a lot of work:
 - Since August ATLAS has been running tokens to 15 sites: 1-2Hz with 5Hz spikes!
 - CMS also has most CEs and quite a few transfers running with tokens.
 - Will rely to the CERN-IT Vault instance
- Performance must be stress-tested
- The balance between operability, security and performance needs to be found:
 - Audience, lifetime, scopes are the three orthogonal Parameters that one needs to tweak to meet the operational needs without compromising too much security.



October 19 - 25, 2024

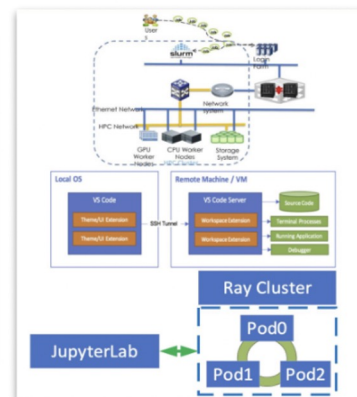
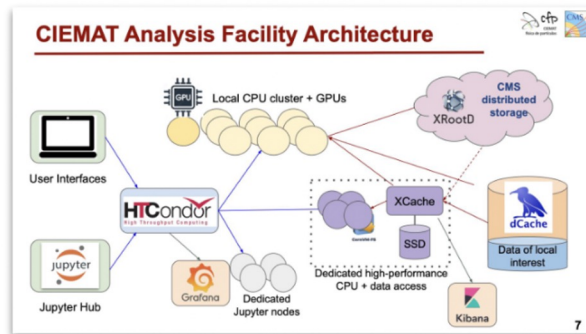
CHEP
2024



Overview of national Analysis Facilities

AF evolution, operational experience at:

- [Chinese HEPS](#)
- [German DESY NAF](#)
- [Spanish CIEMAT](#)



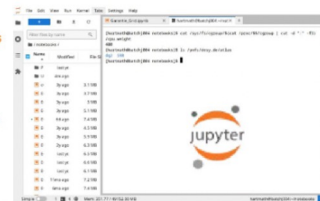
Recurrent themes:

- **Notebook-based interfaces** are widespread
- **Scale out** with Dask + HTCondor

NAF User Interfaces

Support and Auxiliary Infrastructure for smaller Groups

- Classic ssh
- Workgroup server pooled behind remote submit nodes
- Jupyter Notebooks
- Notebooks scale out as batch jobs
- Memory heavy notebooks
 - Highmem slots
 - Spark/Dask overlay cluster
- FastX browser X UI
- Seeing more & more VSCode
- Neat solution from Uni Bonn [<https://indico.cern.ch/event/1386170/contributions/6118491/>]
investigating how we can adapt it to the NAF





ALMA MATER STUDIORUM
UNIVERSITA DI BOLOGNA



CNAF, LNGS, LNF, Ferrara, Torino



SO FAIR SO GOOD

the INFN strategy for Data Stewardship

Stefano Bianco, Daniele Bonacorsi, Concezio Bozzi, Luca Dell’Agnello, Luciano Gaido, Francesca Marchegiani, Irene Piergentili, **Lorenzo Rinaldi**, Stefano Dal Pra

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Master degree in Archive and
Library theory and management



Lorenzo Rinaldi
Associate Professor @ UNIBO
and affiliation @ INFN
PhD in Physics



XXX YYY

User support plan

- The main objective is to support small research groups
- Data Management Plan drafting, according to a precise check-list
- publication (which Open Access level?)

Target:

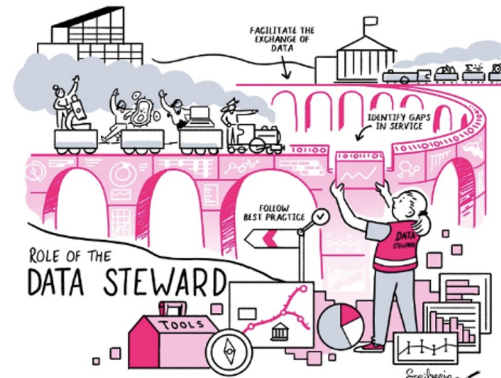


Researchers with no or few
knowledge of FAIR principles



Researchers (highly) familiar
with FAIR principles

Different levels of support



28th Conference on Computing in High-Energy and Nuclear Physics (CHEP 2026)

25-29 May 2026
Bangkok, Thailand

Phat Srimanobhas

Department of Physics, Faculty of Science,
Chulalongkorn University