

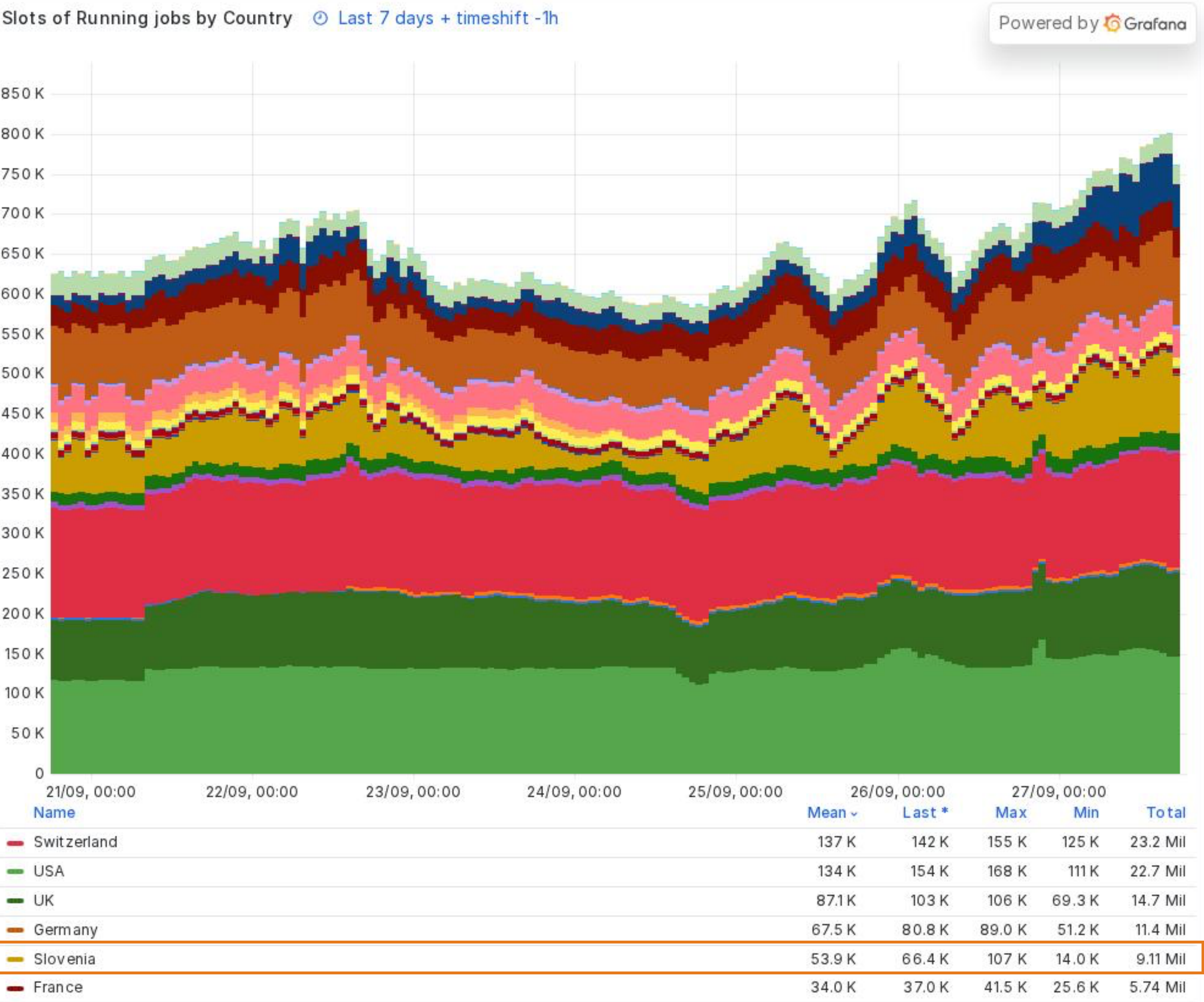
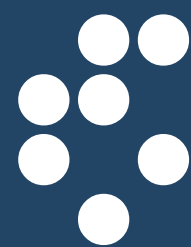
ATLAS SOFTWARE & COMPUTING

F9 Strategic Meeting
September 28, 2026

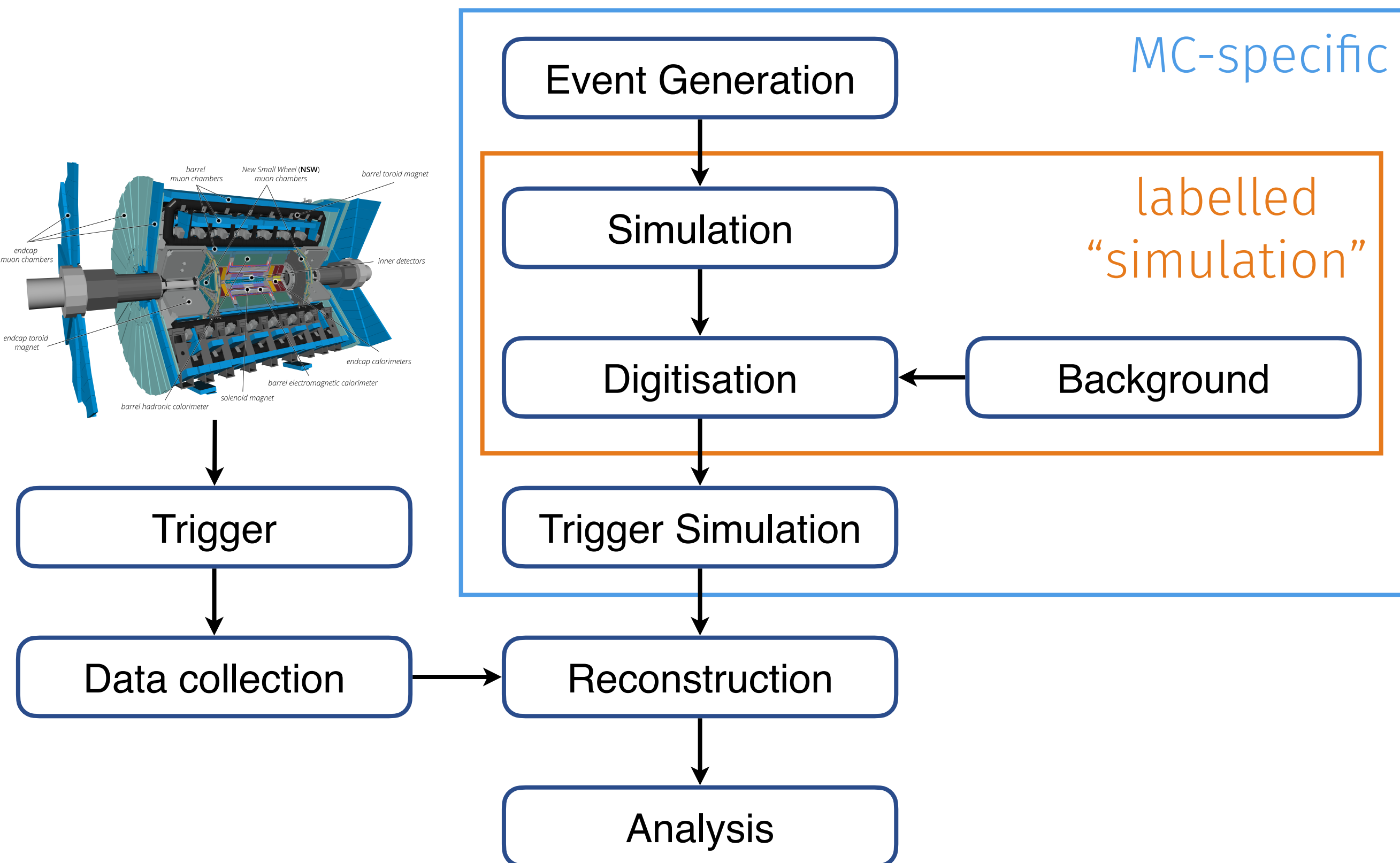
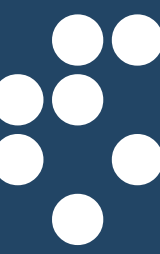
Tadej Novak
Jožef Stefan Institute



- **ATLAS Software** develops, releases and validates the offline software framework (Athena) used for reconstruction, simulation and analysis.
- **ATLAS Distributed Computing** operates ATLAS's share of the worldwide grid (WLCG). That means moving data and running production and user jobs across computing sites around the world.
- **F9 very active in ATLAS Software & Computing activities since many years:**
 - distributed computing
 - simulation and digitisation software
 - event generation
 - analysis software
- Note that detector software is in principle not covered under this category.
 - F9 also very active in the ATLAS High Granularity Timing Detector software efforts.



- Andrej F. and Gašper J. will talk more about the distributed computing activities and this talk will focus on software.

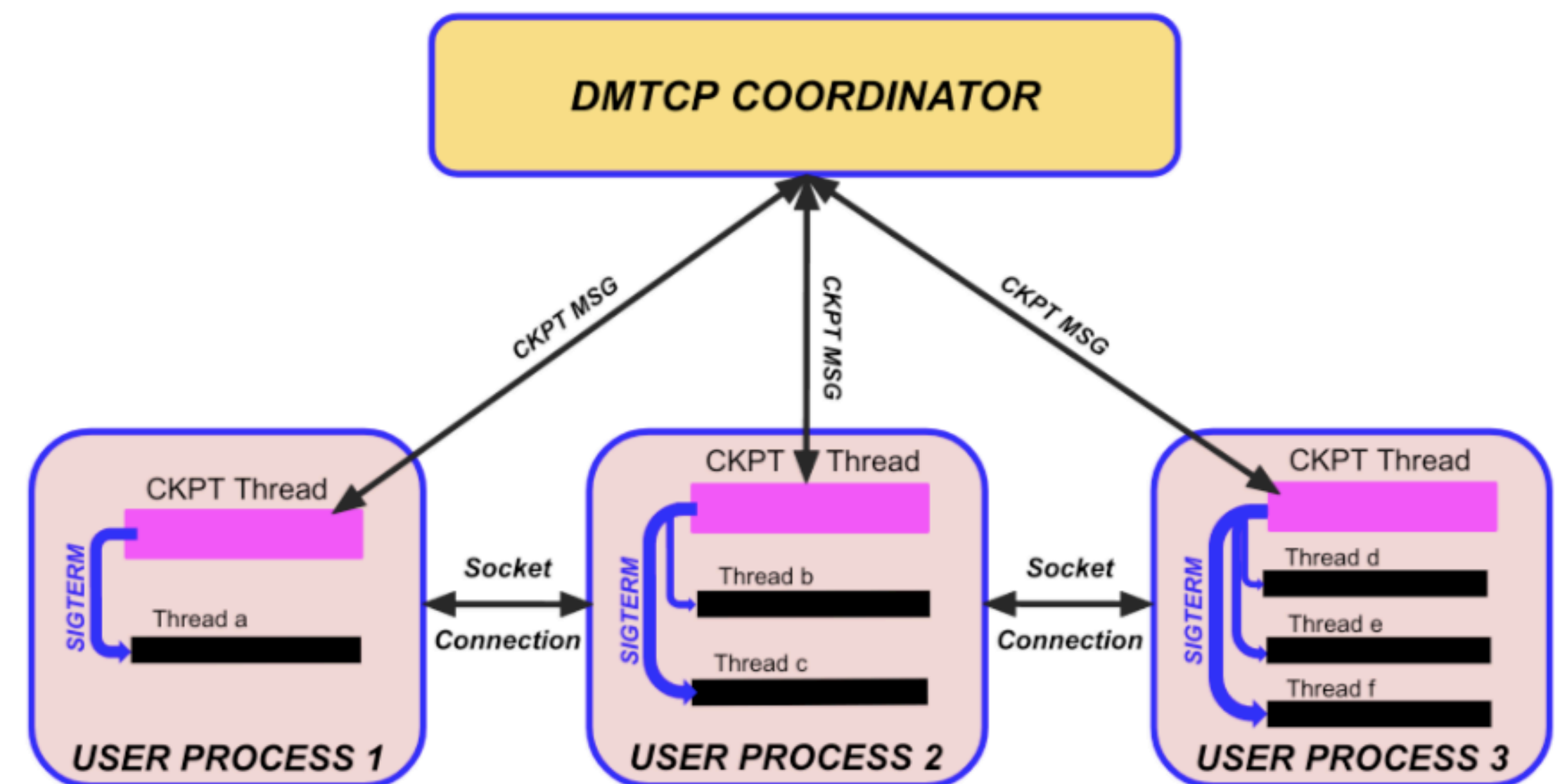


- Monte Carlo event generation and simulation fully integrated in the ATLAS software framework **Athena**.
- “Simulation” in ATLAS context usually covers **detector and readout simulation**.
 - Detector simulation nominally using Geant4.
 - Possibilities to switch to fast calorimeter or tracker simulation.
- Reconstruction and downstream analysis processing the same for data and MC.



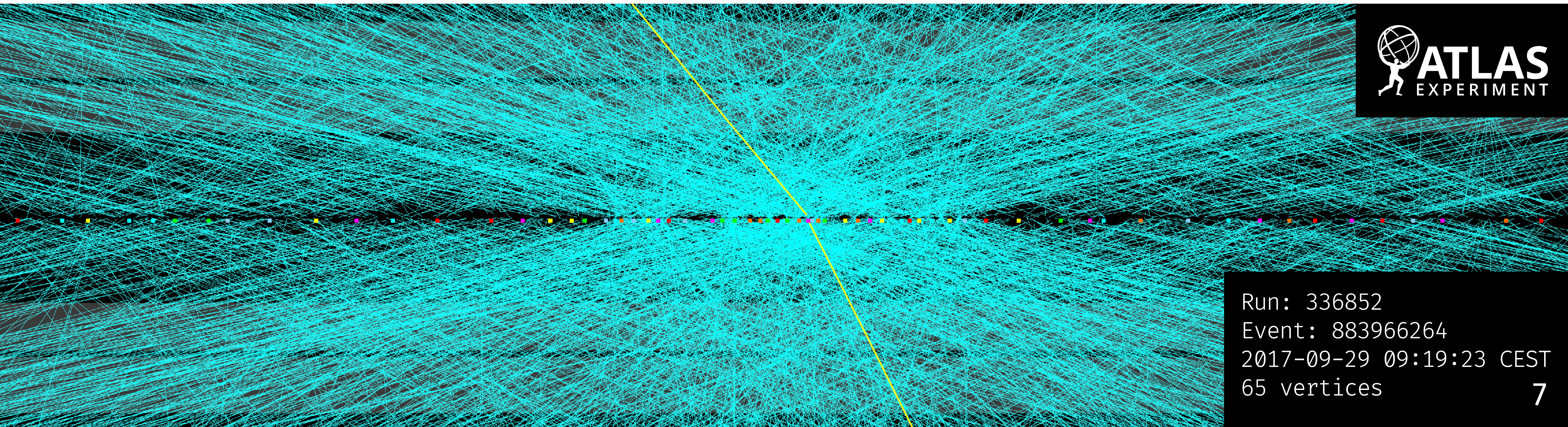
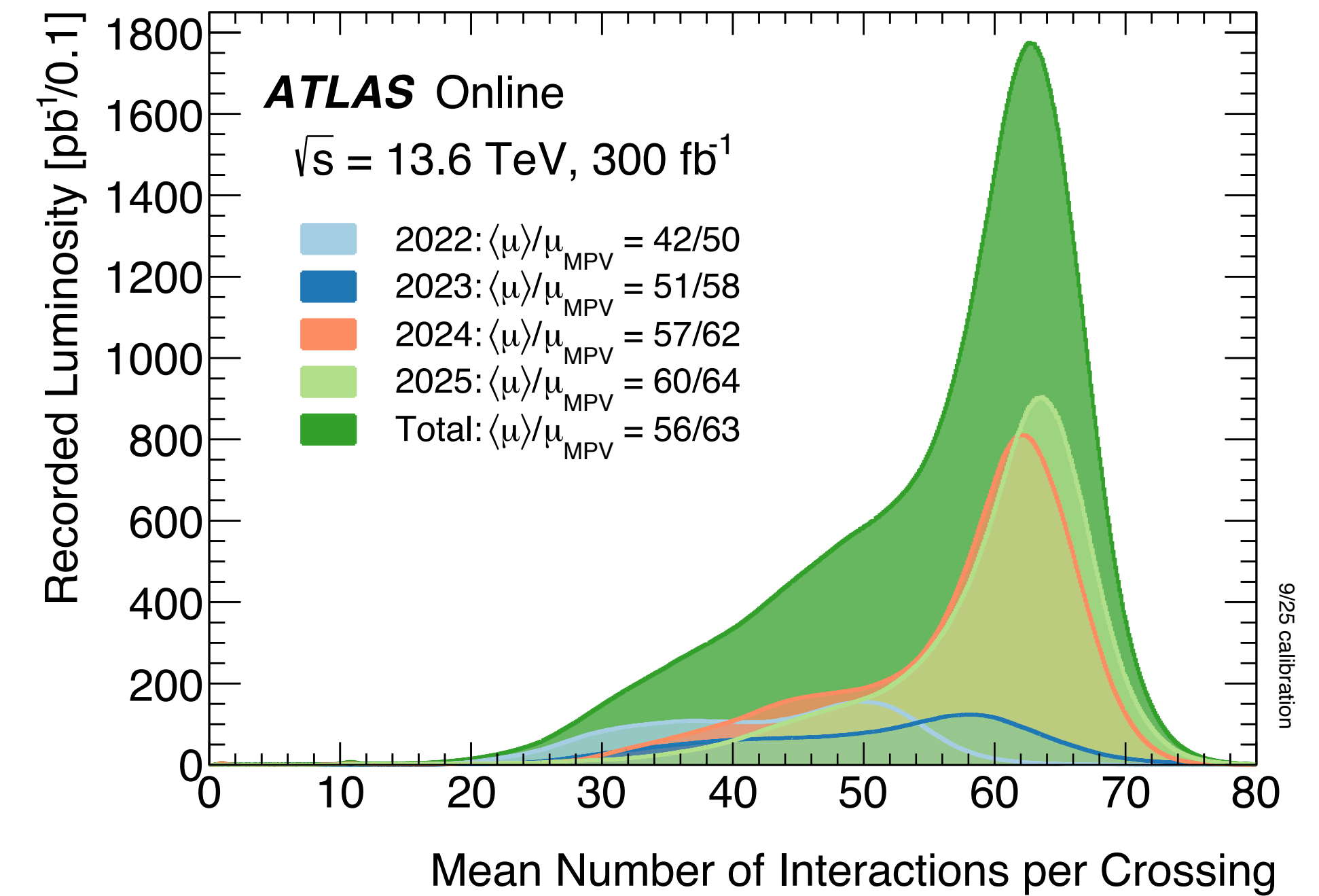
- MC generators and samples: develops and validates the MC generators and the samples used in analyses.
 - ATLAS recorded ~18 billion events in Run 2 and simulated ~2-3x more.
- Miha M. will become one of the two coordinators of the group starting October 1st 2026.
- F9 involved in several technical efforts:
 - job configuration modernisation
 - checkpointing
 - improvements to generator modelling (Lenart J. will talk more about this)

- Some of our event generation duration can be measured in **weeks if not months**.
- Jobs may be interrupted due to infrastructure issues or just can not run on standard grid queues.
- **Idea:** What if we can checkpoint the job.
- Using **DMTCP** — a transparent user-level distributed checkpoint-restart toolkit.
 - Stores the state of the memory.
 - Needs to run on the same architecture.
- A prototype implemented by Jakob N. and now being tested for ATLAS.



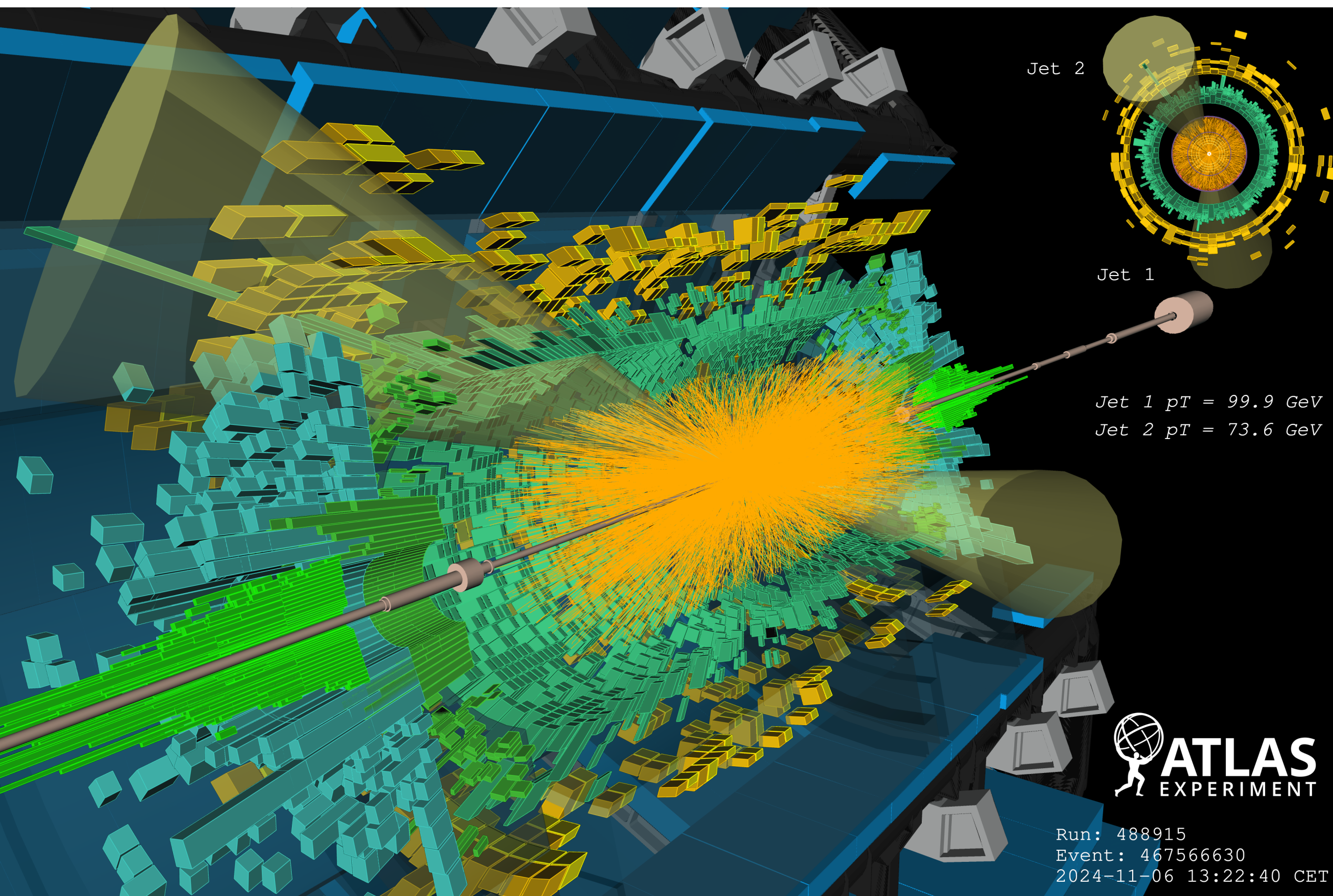


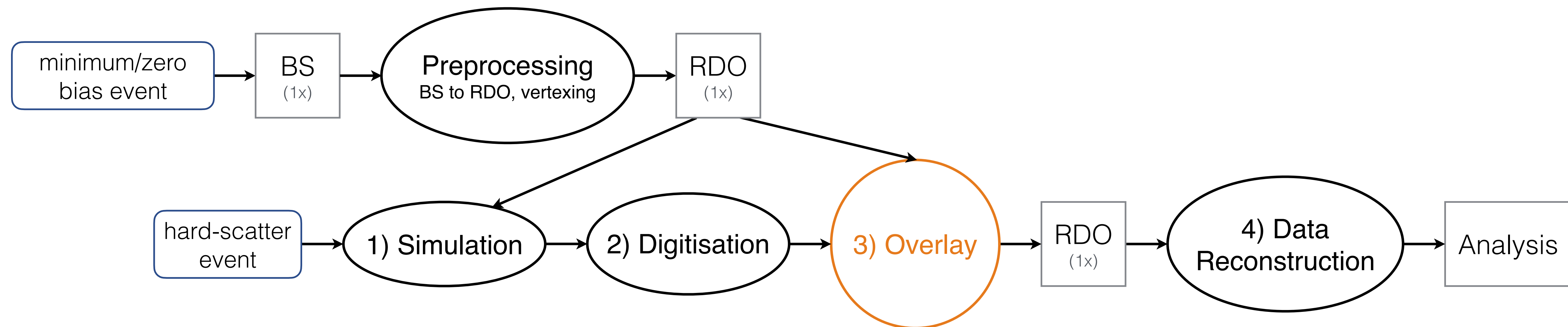
- Beam backgrounds and pile-up are important for accurate simulation of our detectors but also hard to simulate.
 - Pile-up: soft collisions in current and surrounding bunch crossings.
- F9 involved in pile-up simulation for a while now.





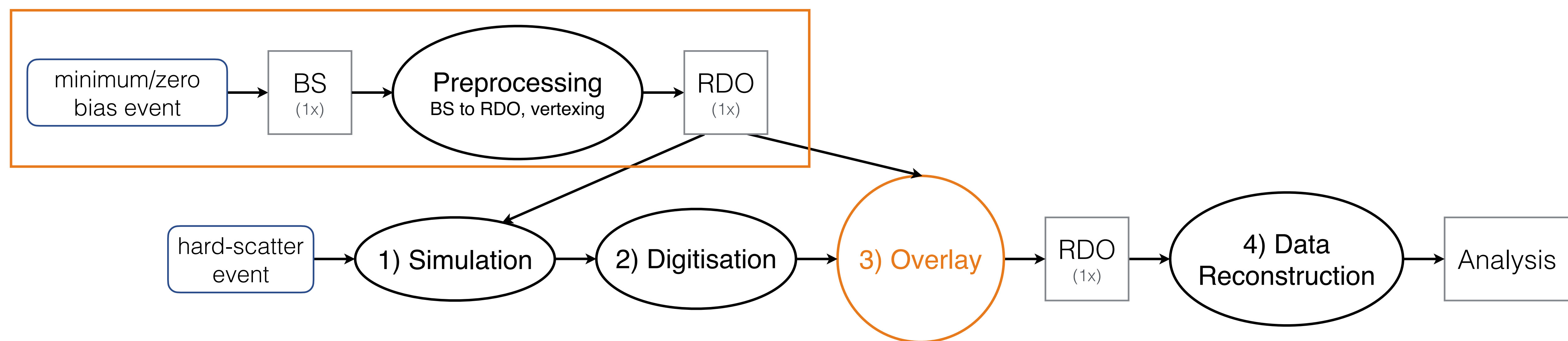
- Standard proton-proton collisions observe the **pile-up** background as **additional interactions besides hard-scattering one**, for Run 3 $\langle\mu\rangle = 56$.
- In heavy-ion collisions (e.g. Pb-Pb) there is usually a single pair of ions interacting, the effect similar to pile-up due to **large number of nucleons**.
- Standard pile-up is simulated using pre-sampling of independent individual pp interactions.
 - Not possible easily for ions.
- **Idea:** Use the **heavy-ion minimum-bias data as recorded in the detector** and **overlay signal** on top.
- Oxygen-oxygen collisions from 2025 were used for a recent study.





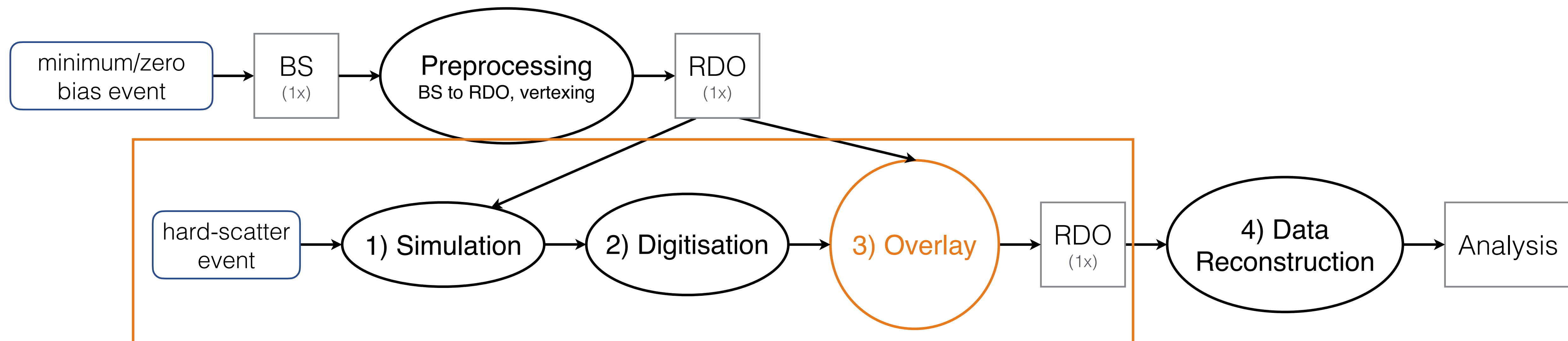


1. Convert byte-stream into raw data objects format and reconstruct the primary vertex.



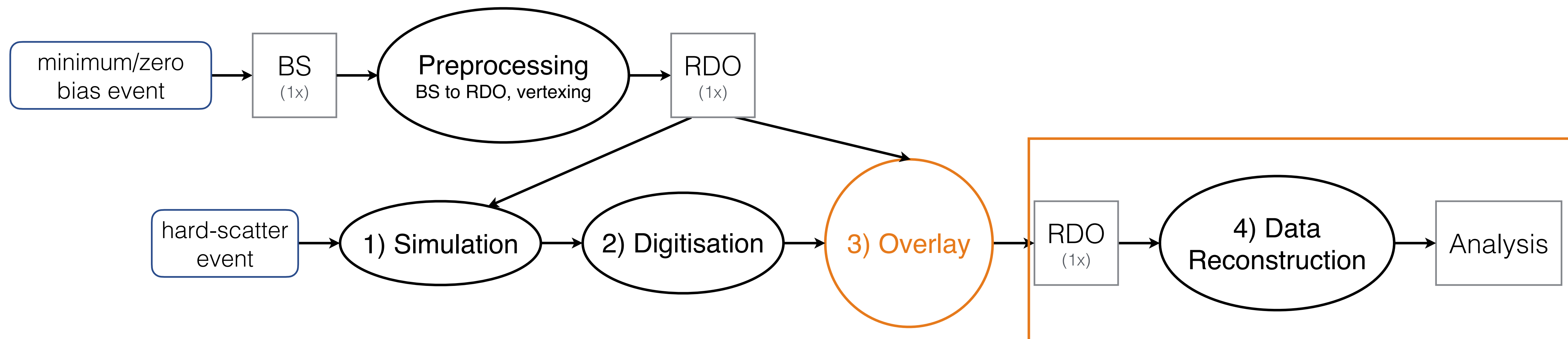


1. Convert byte-stream into raw data objects format and reconstruct the primary vertex.
2. Simulate the hard-scatter event at the same position and with same conditions as in the minimum bias data event. Digitise and overlay hard scatter on the background RDO at the detector channel level.



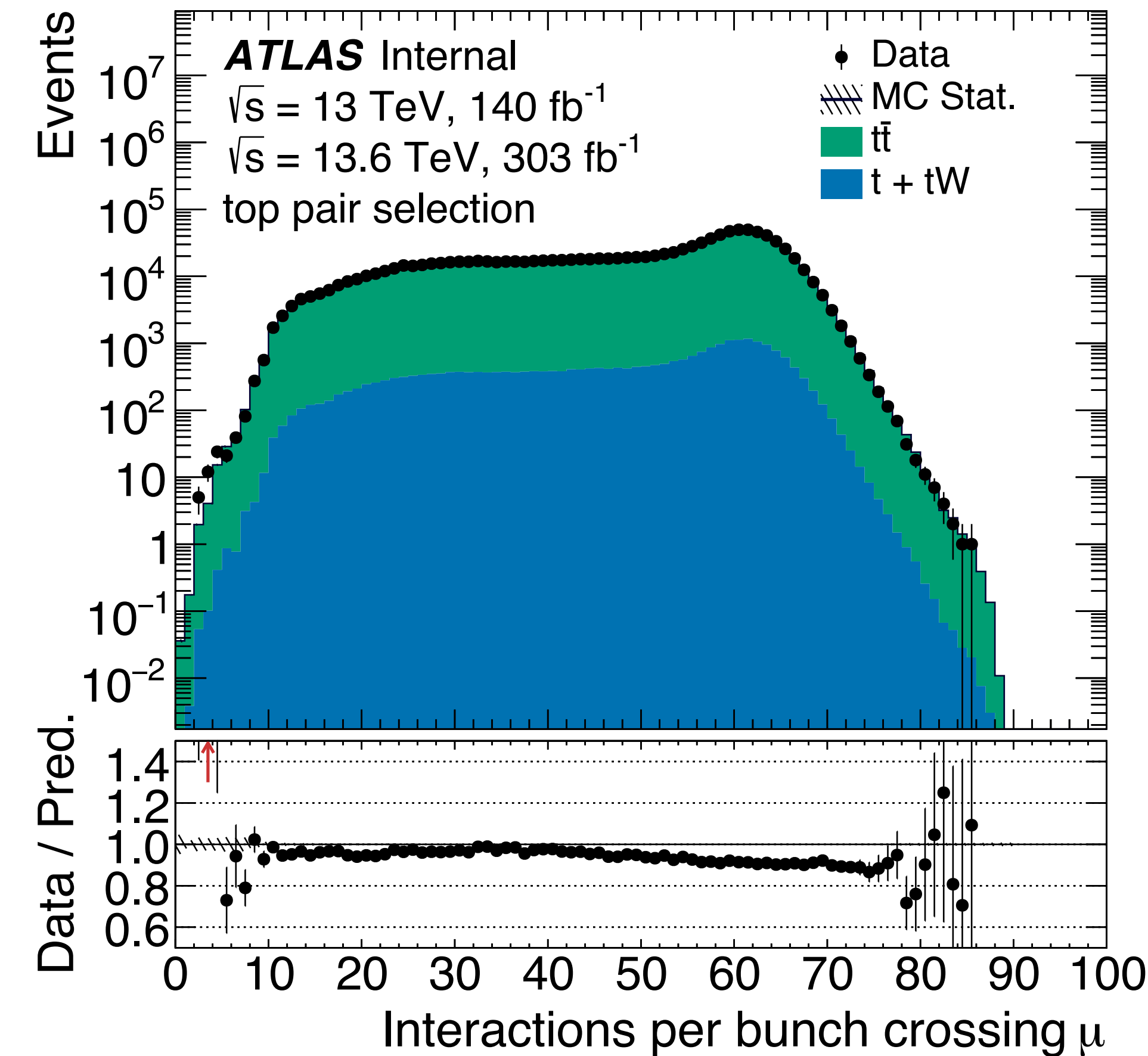


1. Convert byte-stream into raw data objects format and reconstruct the primary vertex.
2. Simulate the hard-scatter event at the same position and with same conditions as in the minimum bias data event. Digitise and overlay hard scatter on the background RDO at the detector channel level.
3. Reconstruct as normal data.



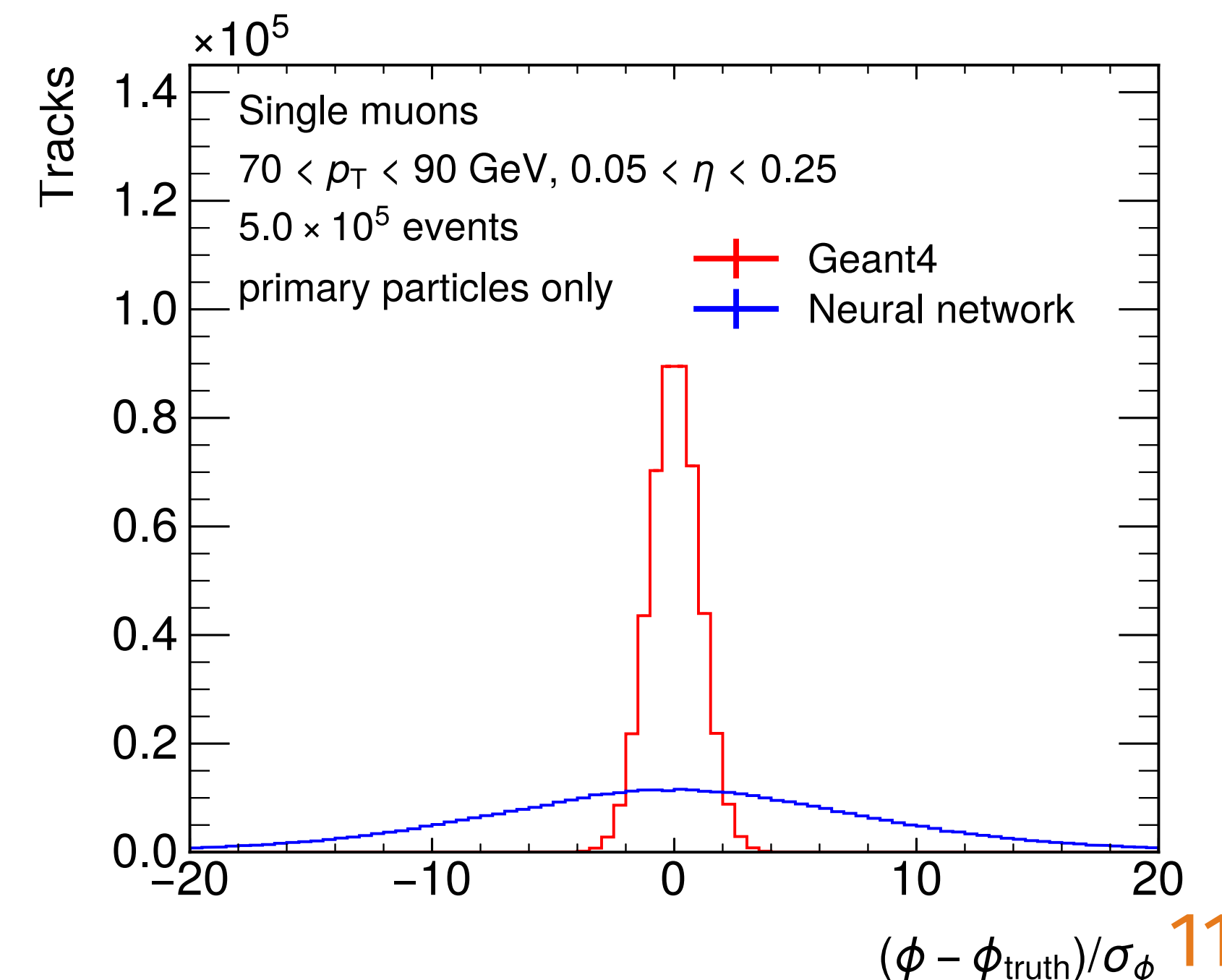
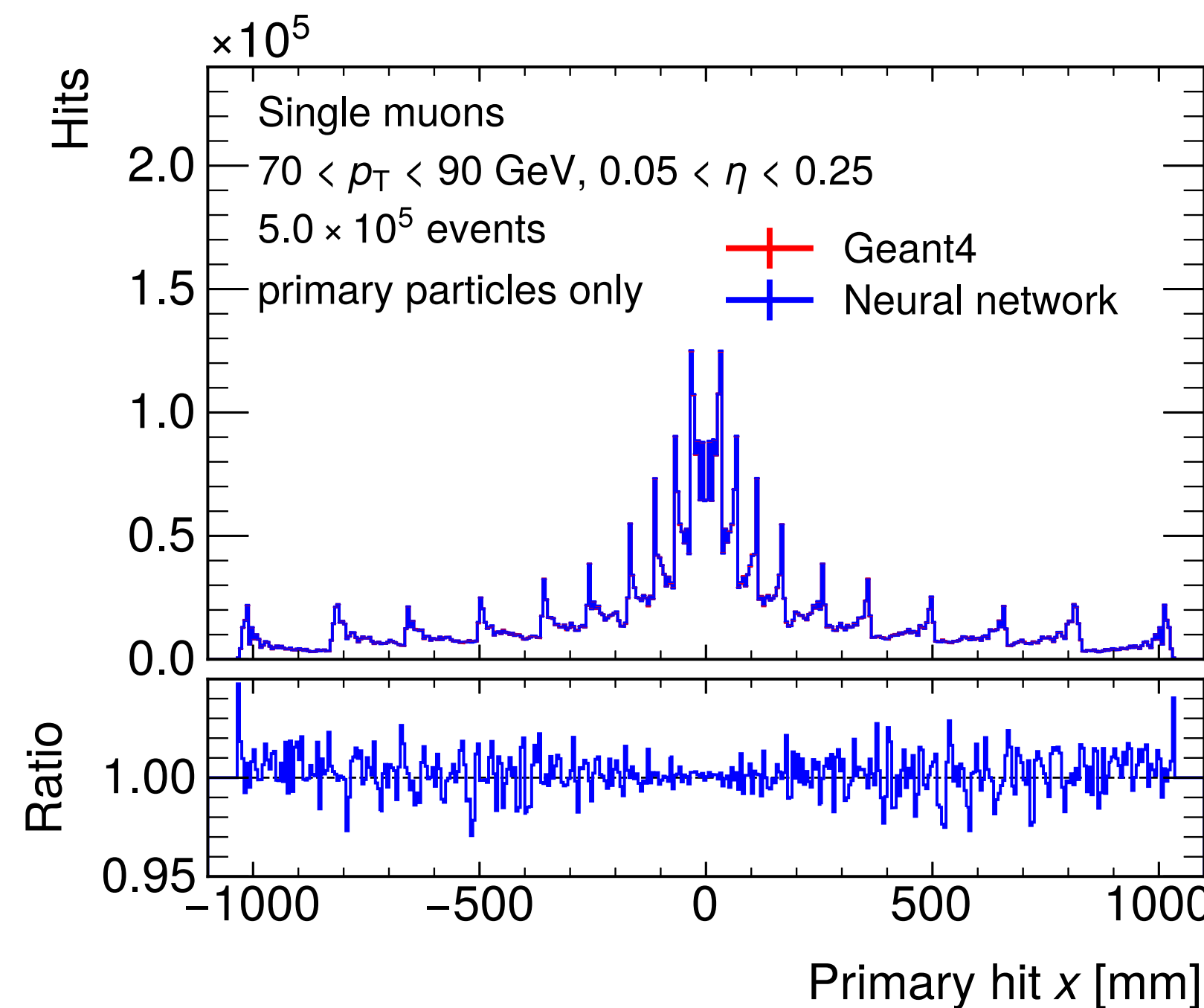
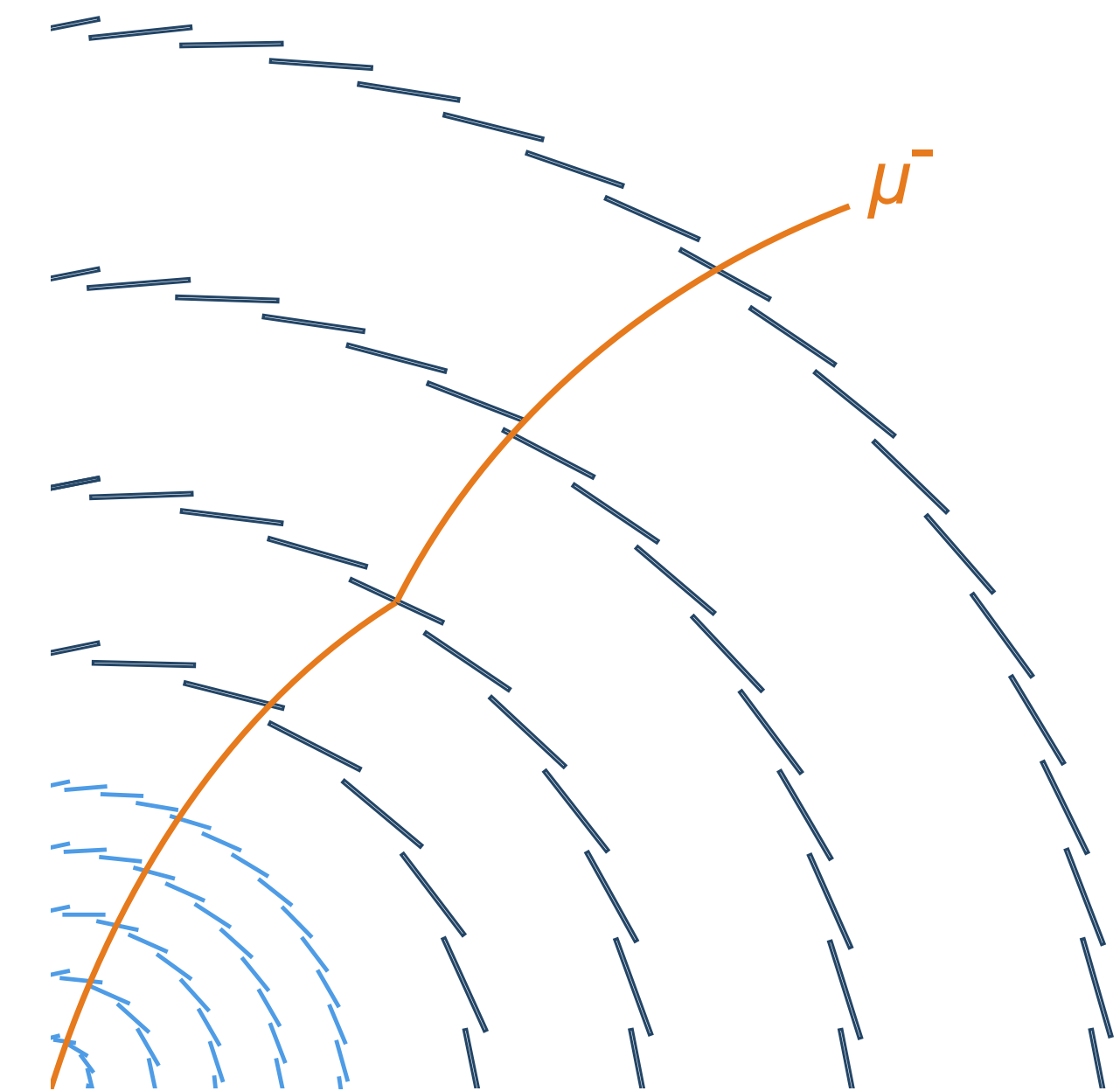


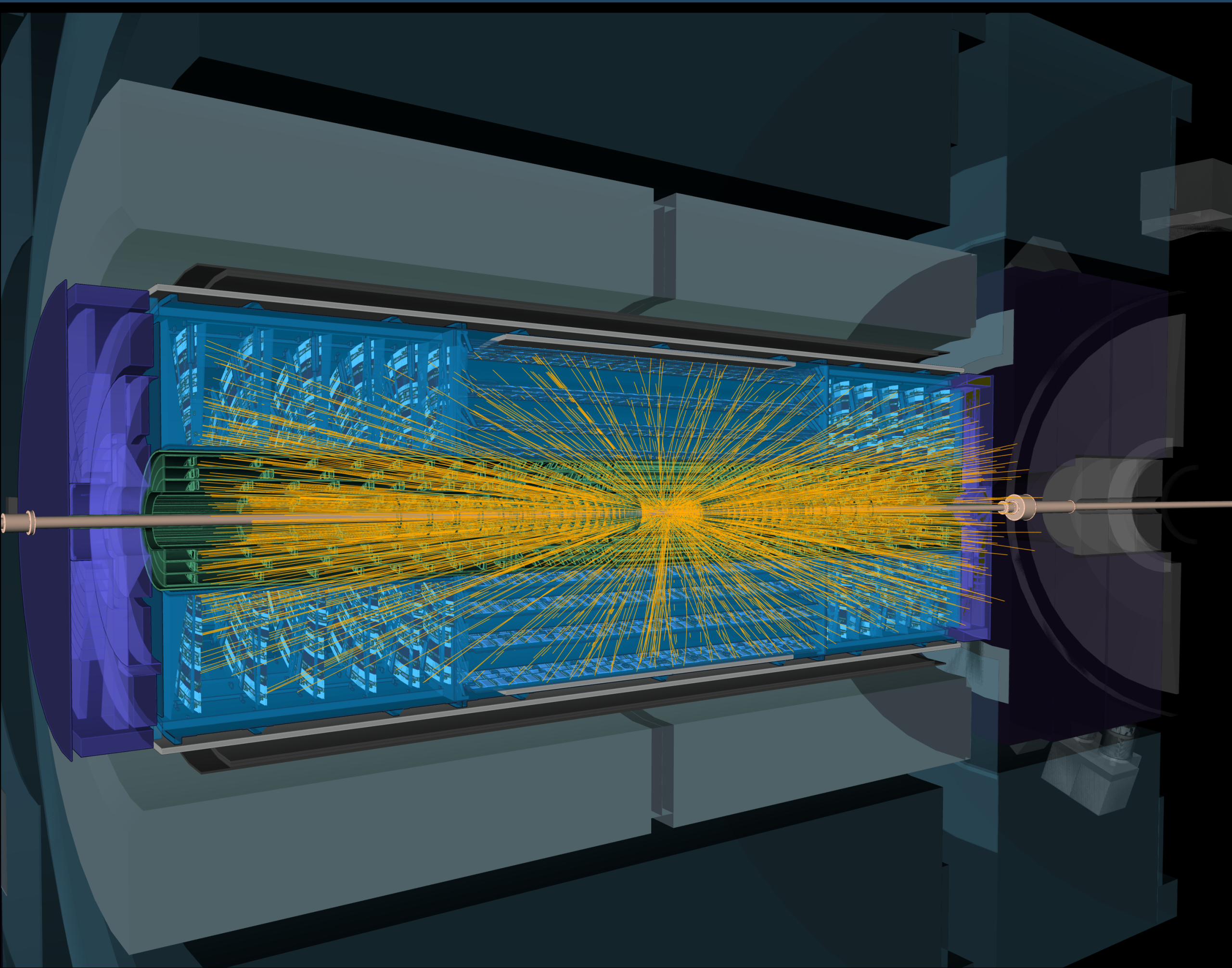
- Joint activity by S&C and Physics Coordination.
 - Tadej N. one of the coordinators starting October 1st.
- The purpose is planning and coordination of analysis workflows for ATLAS.
 - Defining common analysis data formats.
 - Developing common tools, algorithms and putting all together with consistent configuration.
 - Providing tutorial for (new) ATLAS members.
- Works closely with distributed computing and physics groups.
- F9 involved closely in central analysis code development.





- Investigated as part of the **SMASH** programme if silicon tracking detectors can be simulated using machine learning, specifically **transformers**.
 - Should be significantly faster than the existing Geant4-based simulation.
- Good performance can be achieved at hit level for muons.
- Not all reconstructed track properties modelled well.
 - Also electrons and pions do not have their low-probability interactions modelled properly.





- Many interesting efforts ongoing in F9 to improve ATLAS software and computing.
 - Also involved in maintenance tasks such as code modernisation and release coordination.
- Many of the tasks are crucial for the experiment.
- Now focus shifting towards HL-LHC and future detectors.



ATLAS Simulation
 $\sqrt{s}=14$ TeV, HL-LHC
 $t\bar{t}$, $\langle\mu\rangle=200$

