CURRENT STATE OF THE ATLAS NEW SMALL WHEEL SIMULATION SYSTEM

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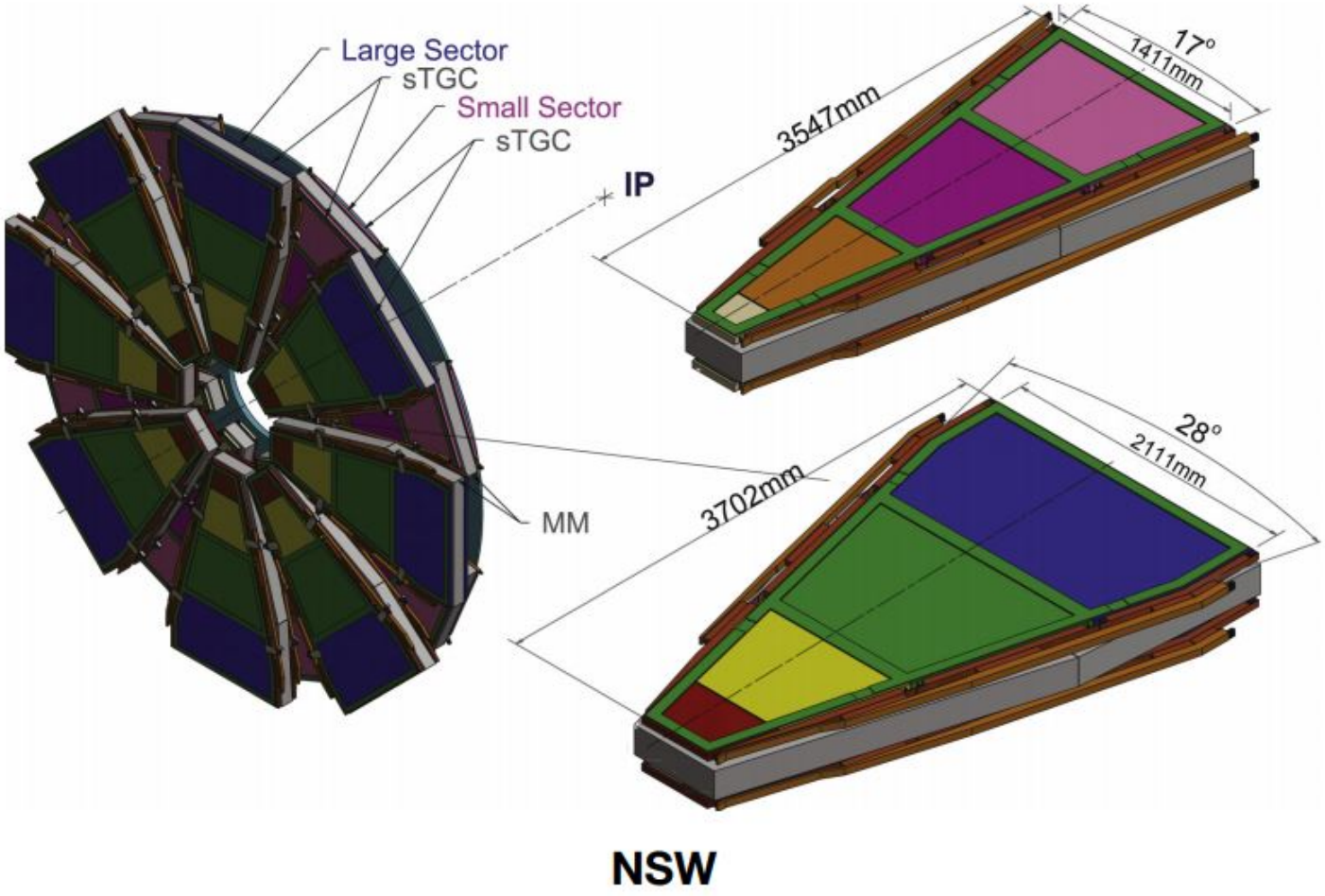
Outline

- The ATLAS experiment
- The New Small Wheel (NSW)
- ATLAS Simulation system
- Simulation of the NSW



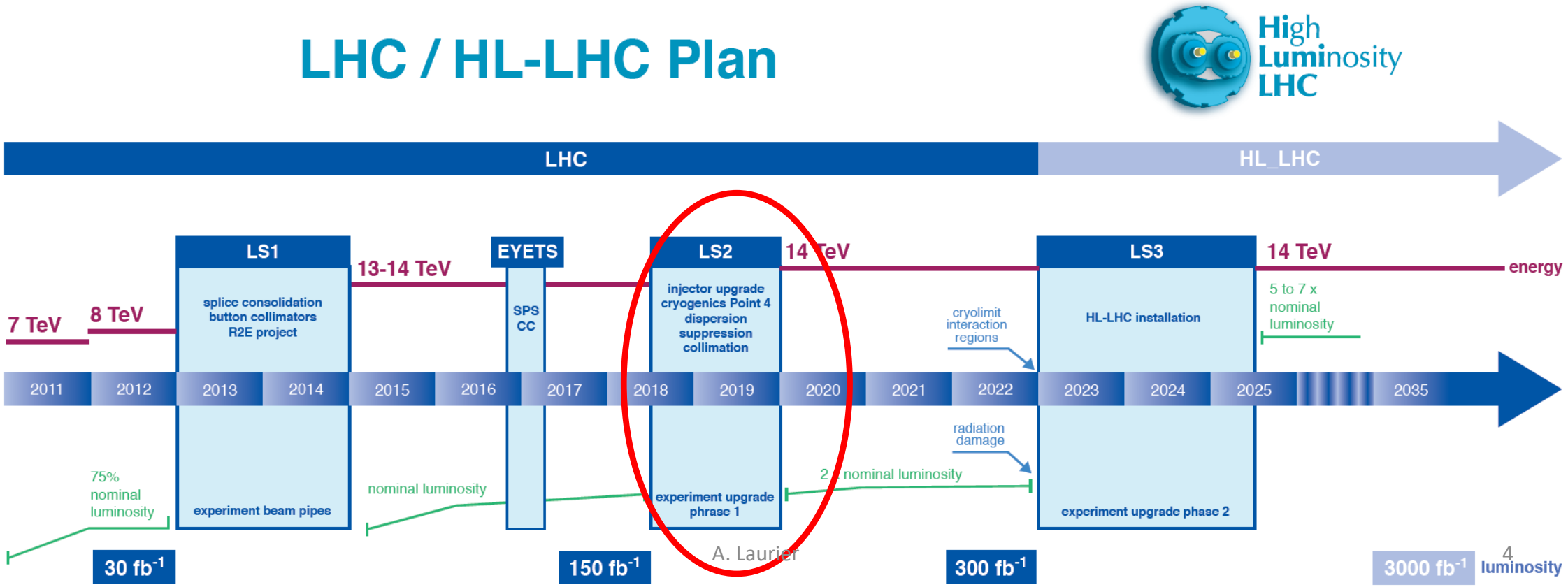
The ATLAS experiment

- One of four experiments situated in the Large Hadron Collider (LHC).
- LHC is undergoing extensive upgrade program, lasting over a decade!
- The upgrade will bring a seven-fold increase in designed instantaneous luminosity.
- One of the costs associated with increasing the luminosity is requiring new and better detectors!
- In order to benefit from the upgrade, replace the *Small Wheel* by the *New Small Wheel (NSW).*

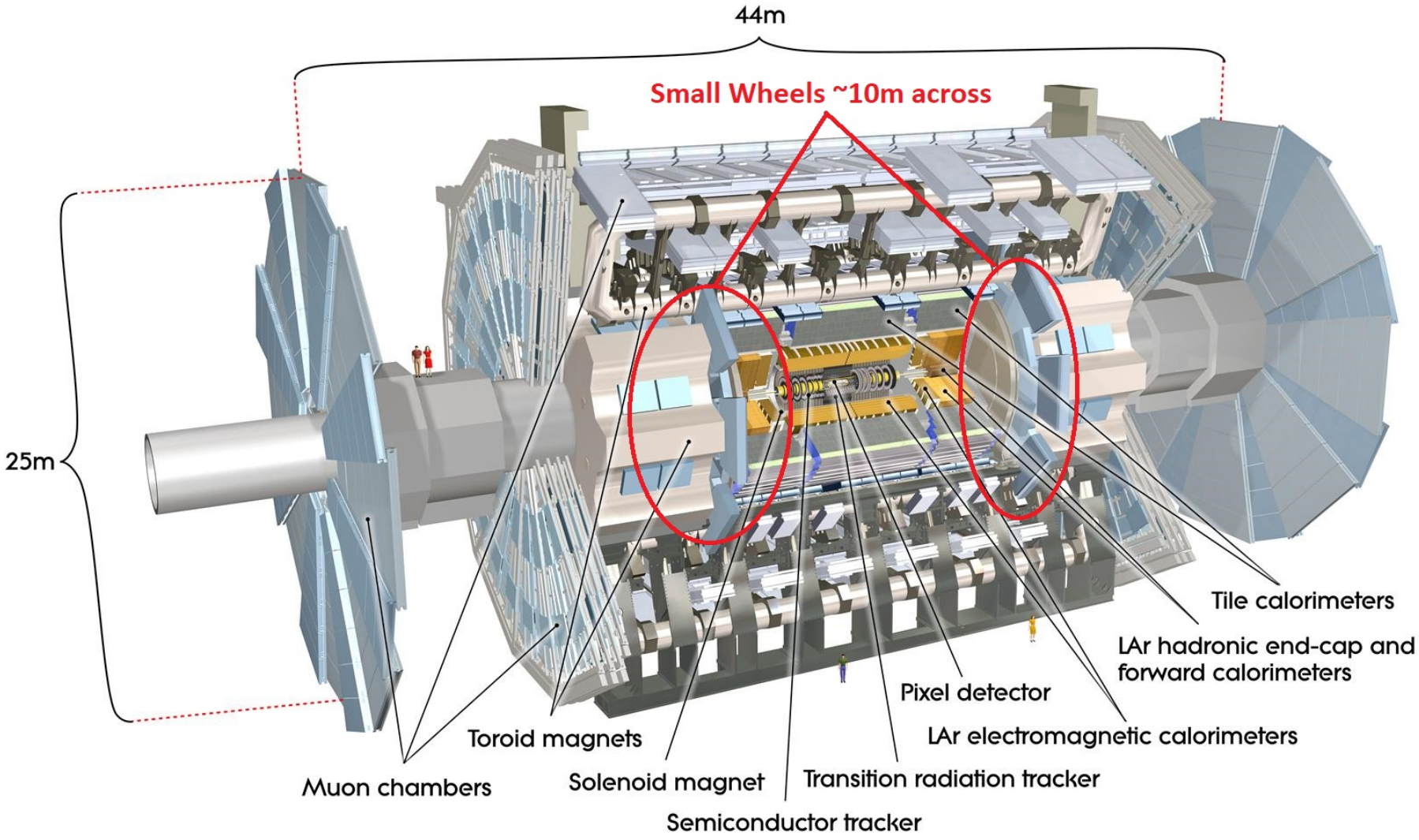
Mural of ATLAS on the ATLAS building at CERN

LHC Upgrade Plan

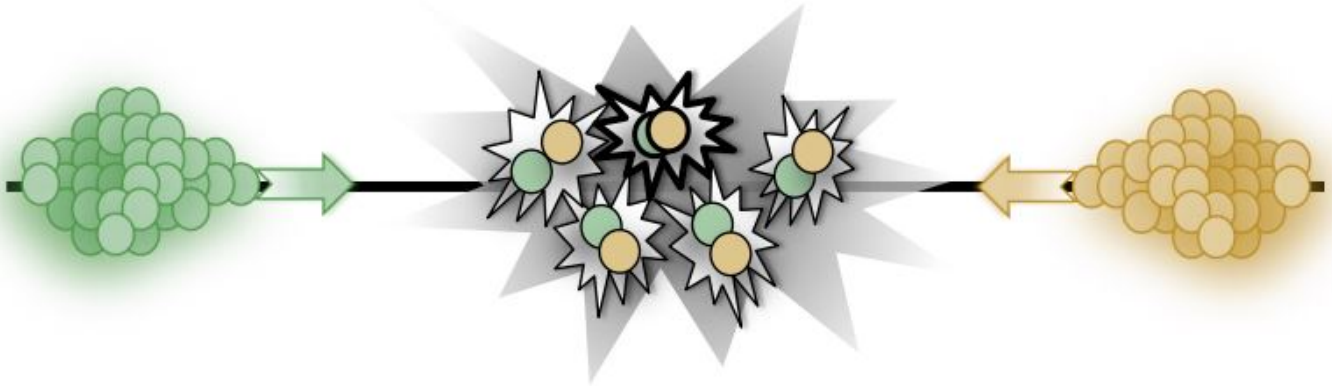
- Currently in a shut down phase: LS2.
- One of the major upgrades to ATLAS during this shut down, is replacing the small wheel which was designed for nominal luminosity.



ATLAS – Replacing the Small Wheels



Increased luminosity of the LHC



Proton bunches
$>10^{11}$ protons/bunch
colliding at **13 TeV** and at **~40MHz in Run-2**
collided at **7/8 TeV** and at **~20MHz in Run-1**

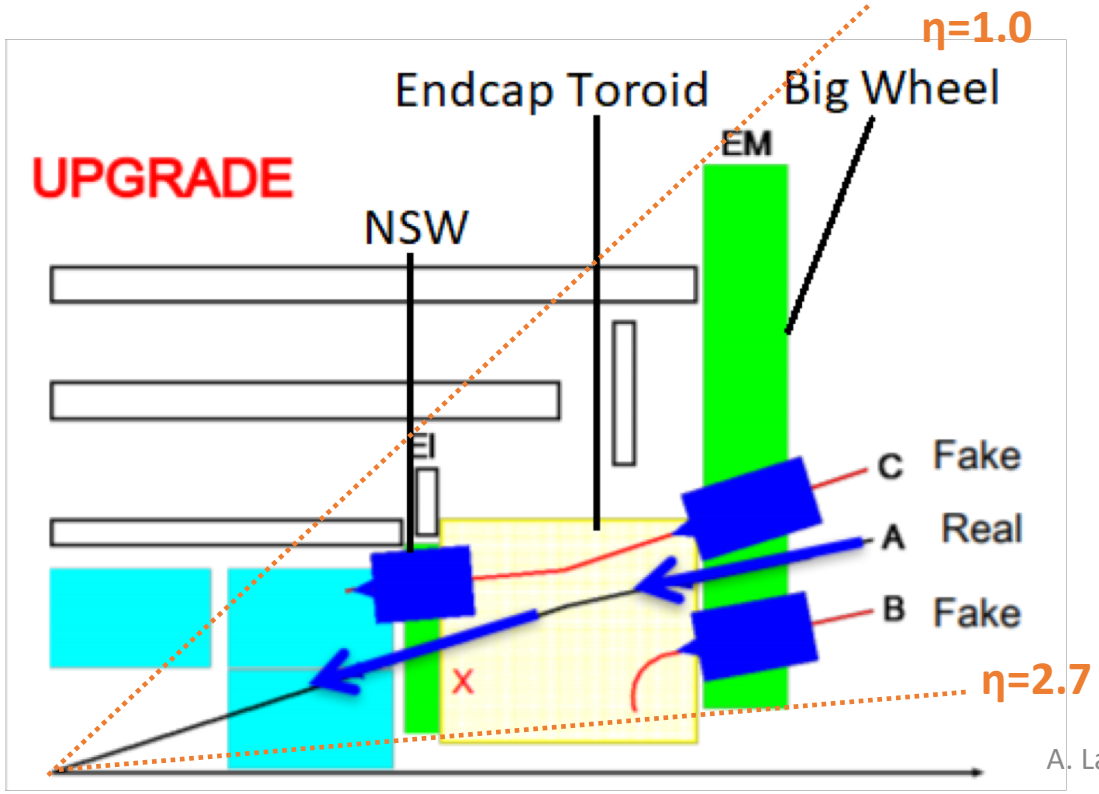
In 2018:
Up to 60 p-p collisions / bunch crossing

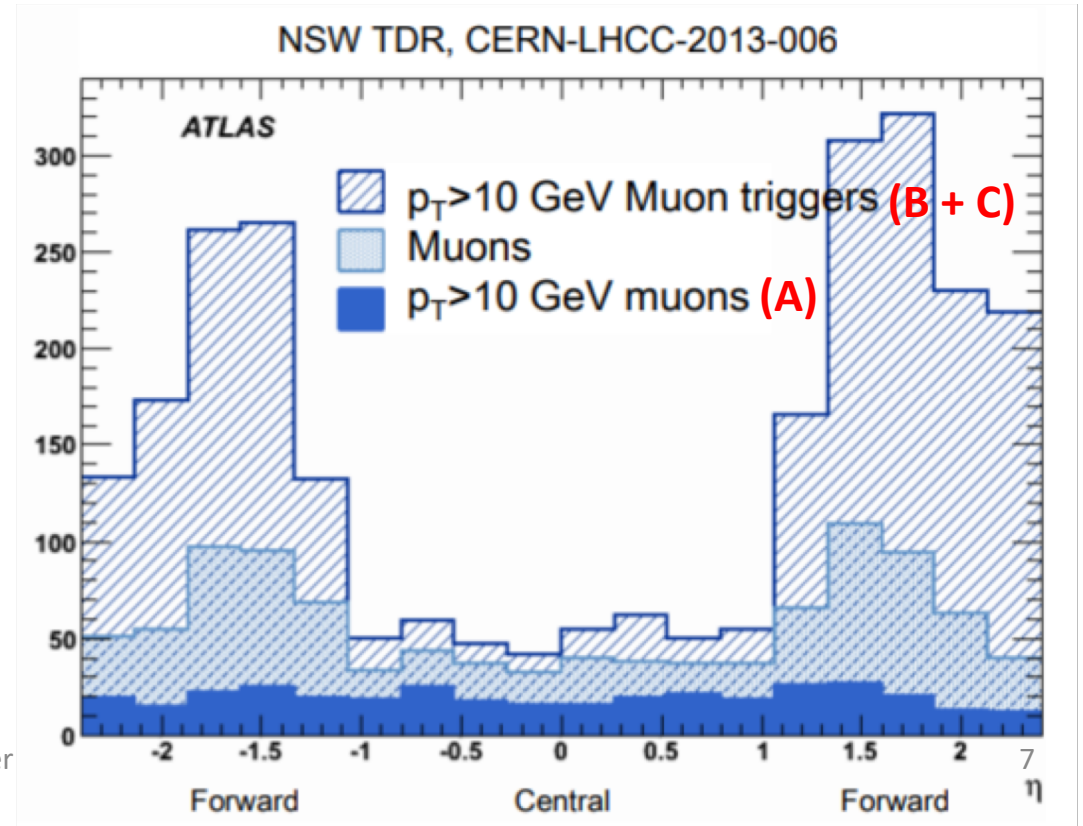
It is already much worse in 2018!

- Too much data!
- Rare and interesting events are buried under the noise!
- Need a better Trigger System!

The Goal of the New Small Wheel (NSW)

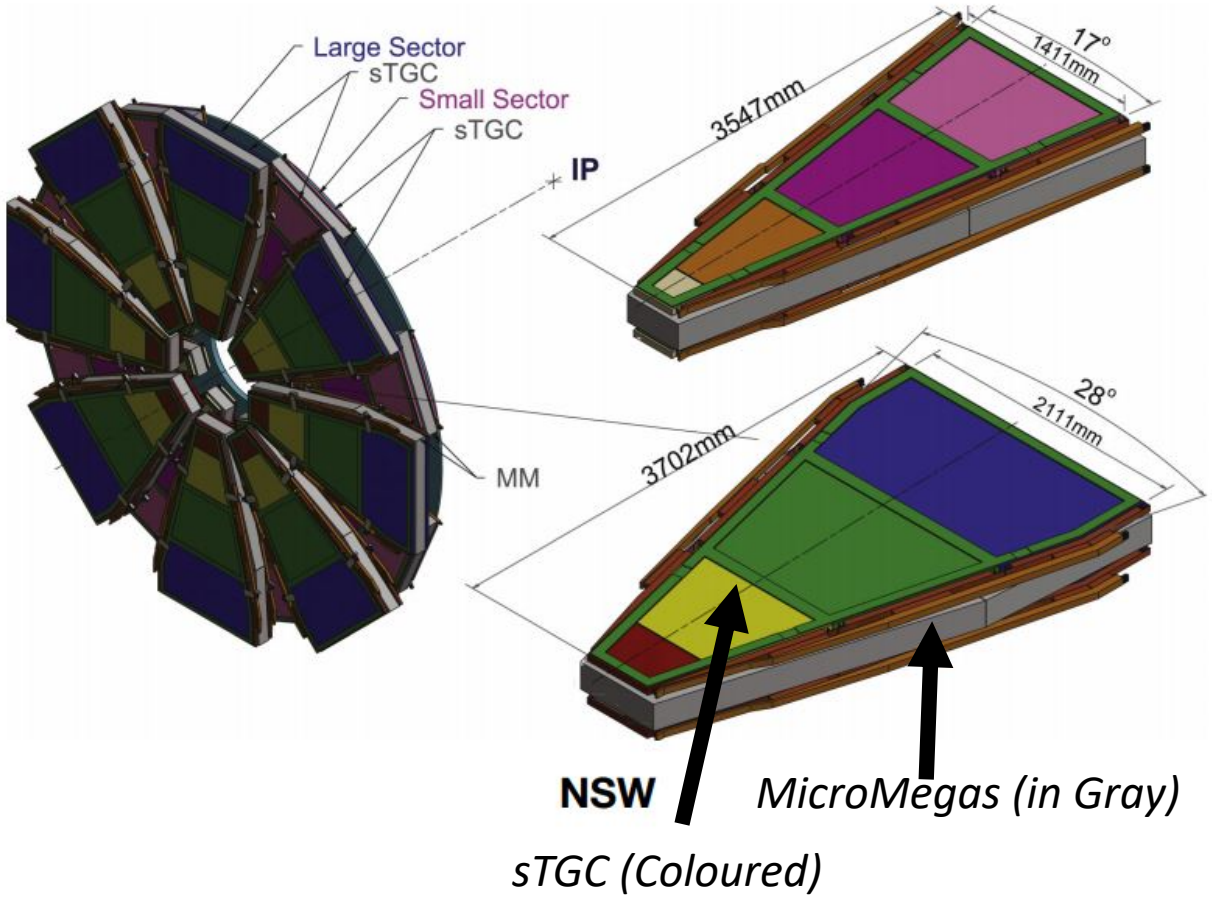
- Higher luminosity means more data and fake muons.
- A better Trigger System will discriminate against fake muons.





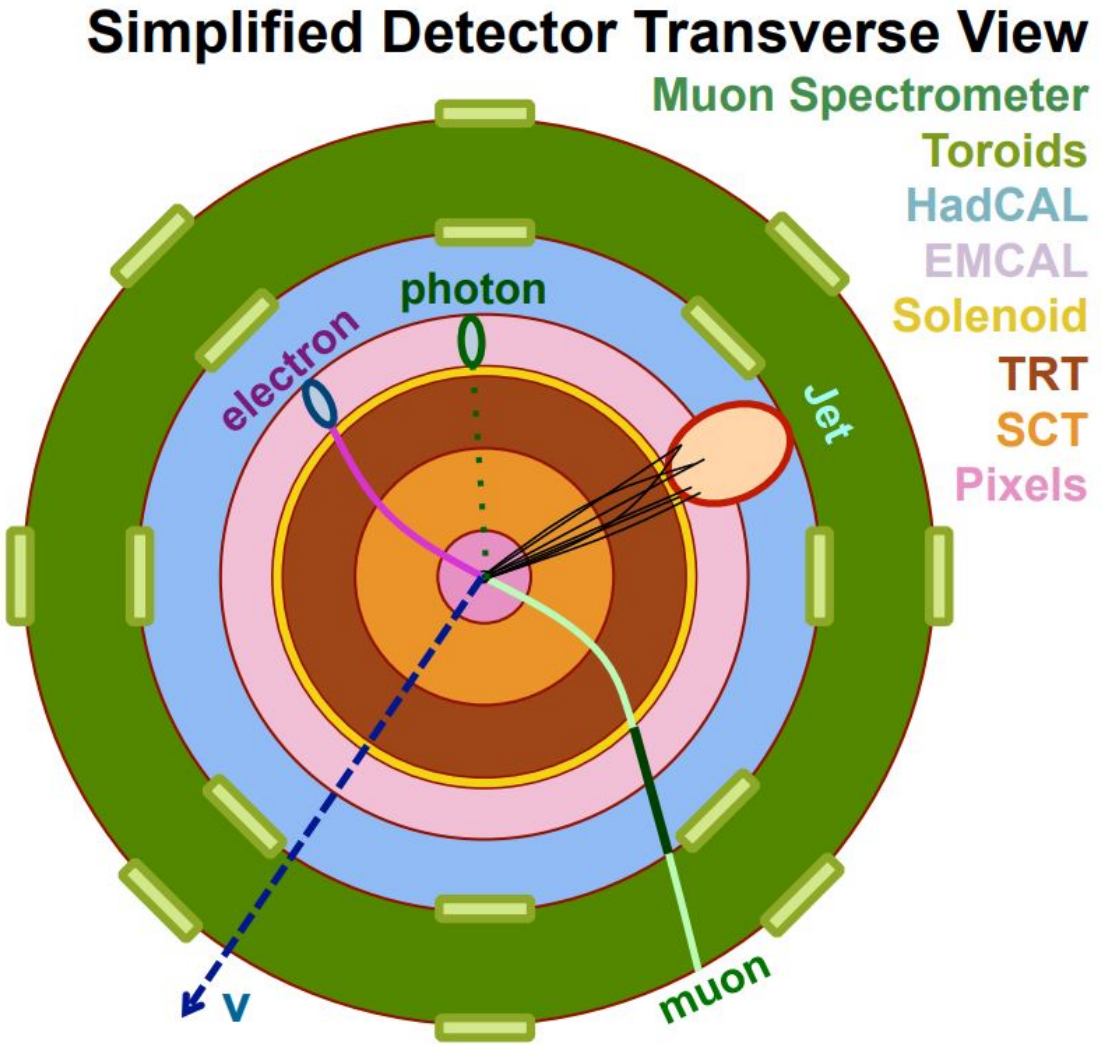
The New Small Wheel

- Part of the Muon Spectrometer, i.e muon detector.
- Built of 2 technologies: MicroMegas (MM) and small-strip Thin Gap Chambers (sTGC).
- MM act as a tracking system.
- sTGCs are the Trigger system, with an angular resolution of 1mrad and a response time within 1µs.
- More precise, better and quicker Trigger detector than the Small Wheel.

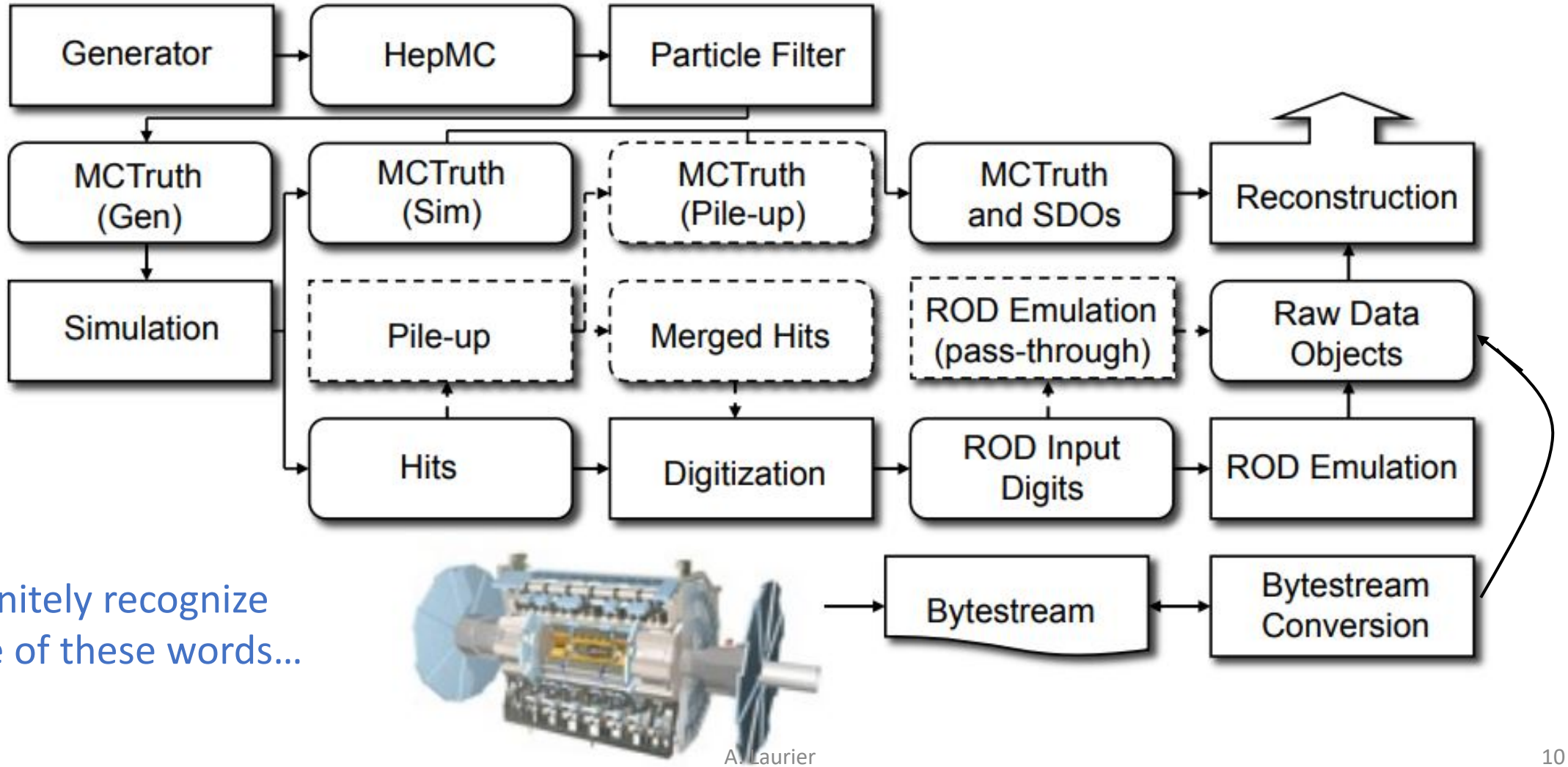


Going From an Event to Useful Data

- Simulate ATLAS in order to do physics analysis and MonteCarlo (MC) studies.
- Essentially, all the tools needed for doing physics!
- A good simulation shows that we understand well the detectors and the physics which we are studying.

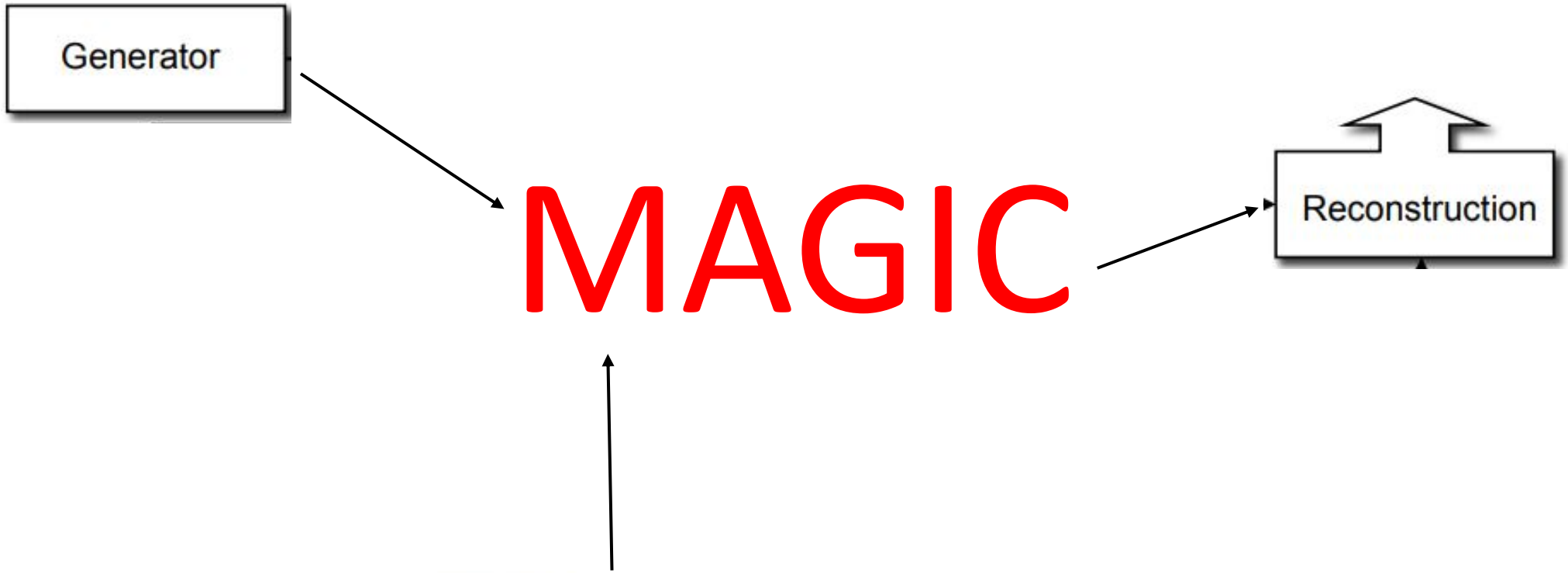


ATLAS Simulation for Sadists



I definitely recognize some of these words…

The Real ATLAS Simulation



*How the average ATLAS physicist sees it**

** Experts too.*

The Realistic NSW Simulation System

Event Generation

-Generate particles (muons).

-Simulate physics processes.

Nothing new here for the NSW.

Detector Simulation

-Simulate the interaction of the particles with the detector.

Need to create a full new working model of the NSW!

Digitization

-Simulates electronics response.

-Transforms particle interactions into an electronic signal.

Write a whole new process specific to the NSW.

Reconstruction

-Transform the signal back to real particles.

-This step is also done with real data!

Modify existing tools to include NSW.

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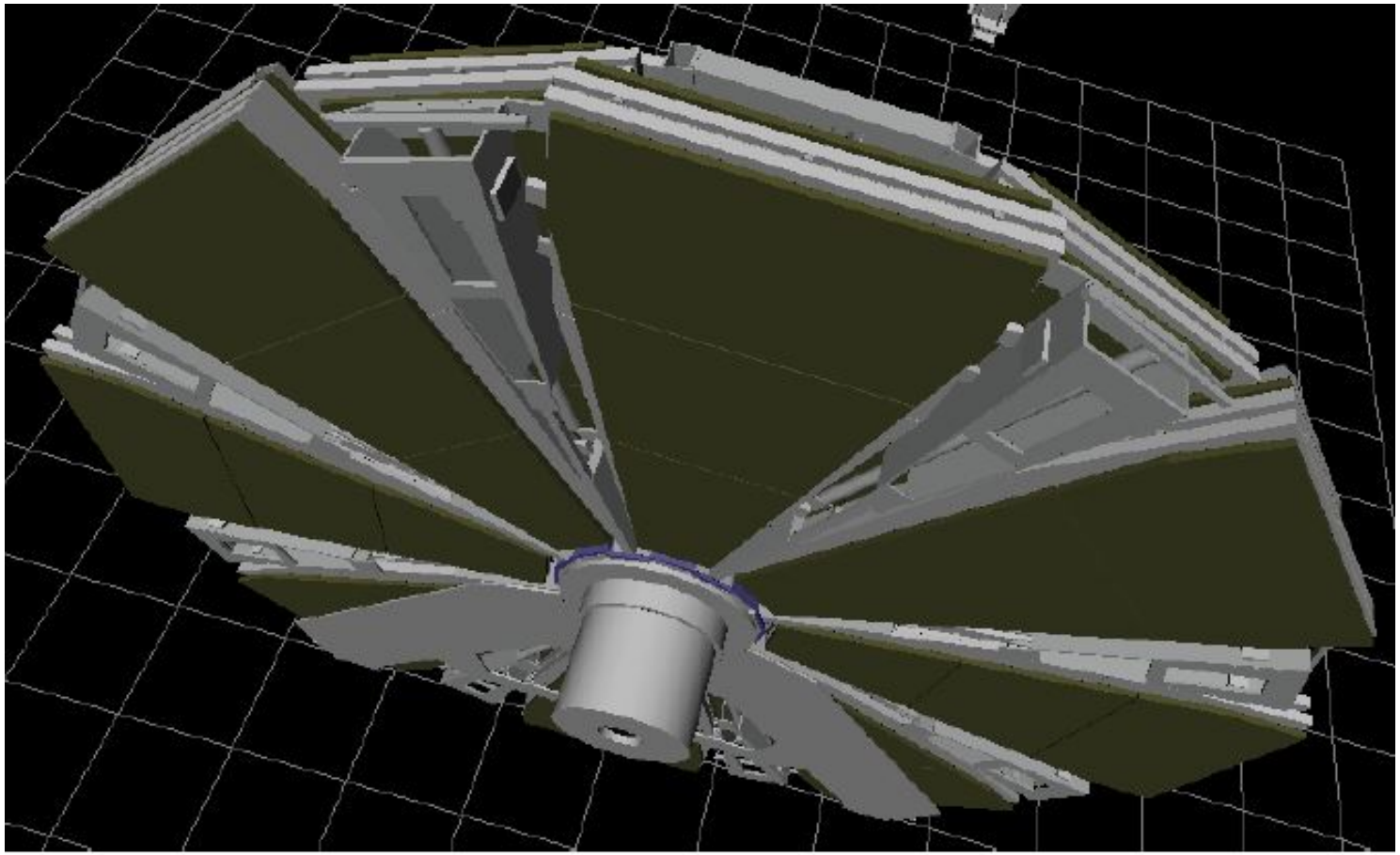
NSW Detector Simulation

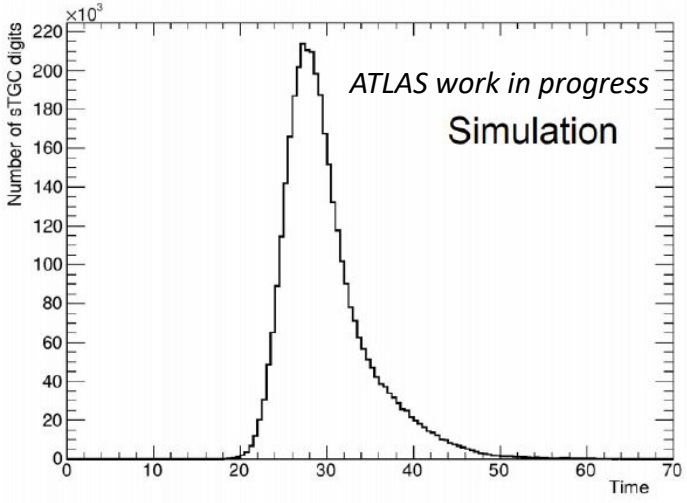
- Have to create a faithful description of the detector's geometry.
- Properly model interactions between particles and materials!



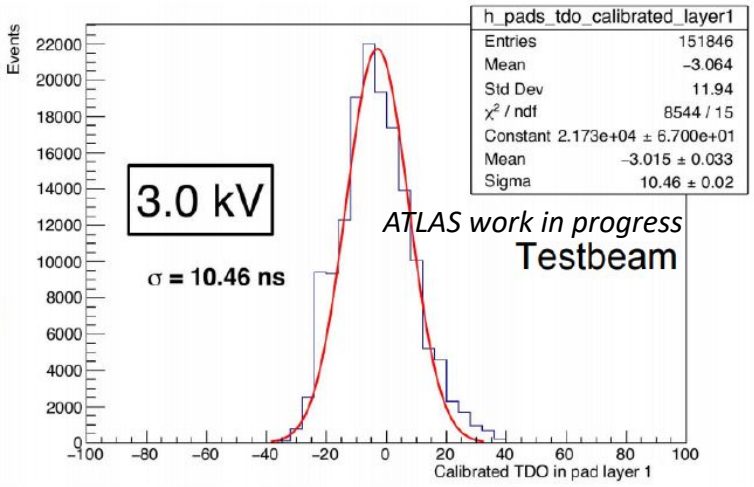
Zoomed in view of the NSW side A

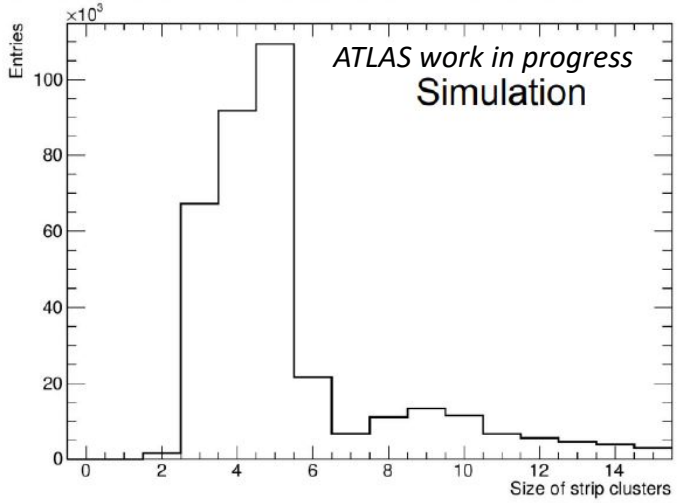
NSW Digitization

- Digitization models the electronic response of the detector.
- Best way to validate is to compare to test beam and experimental data!

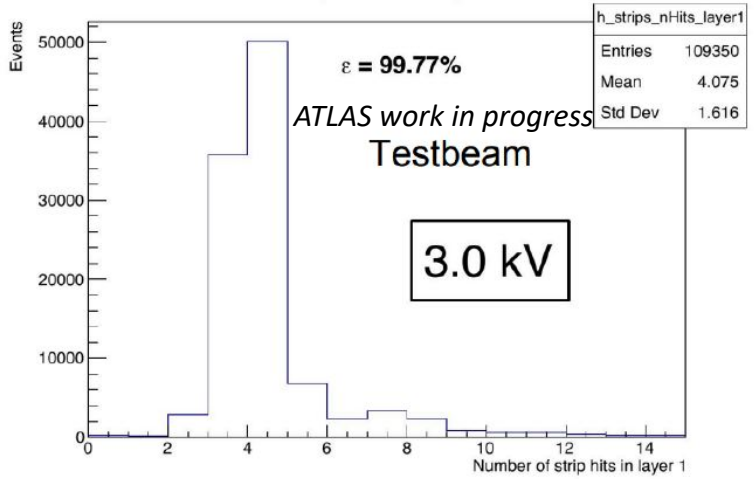


sTGC Time distribution



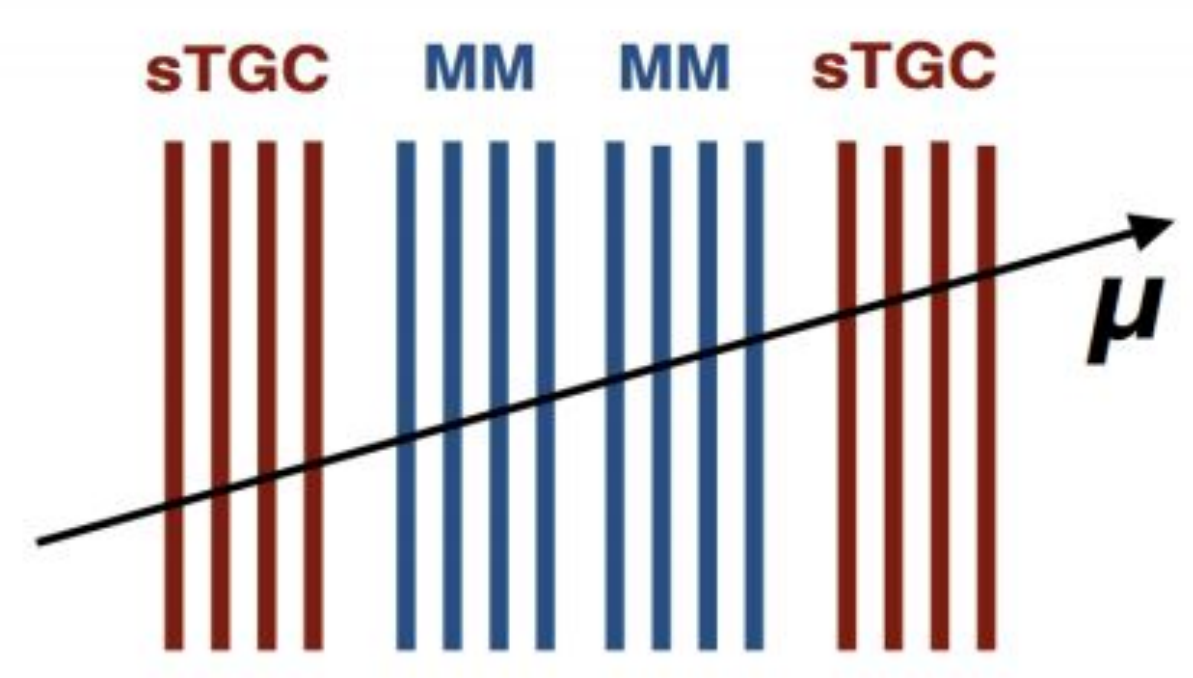


sTGC Strip cluster size



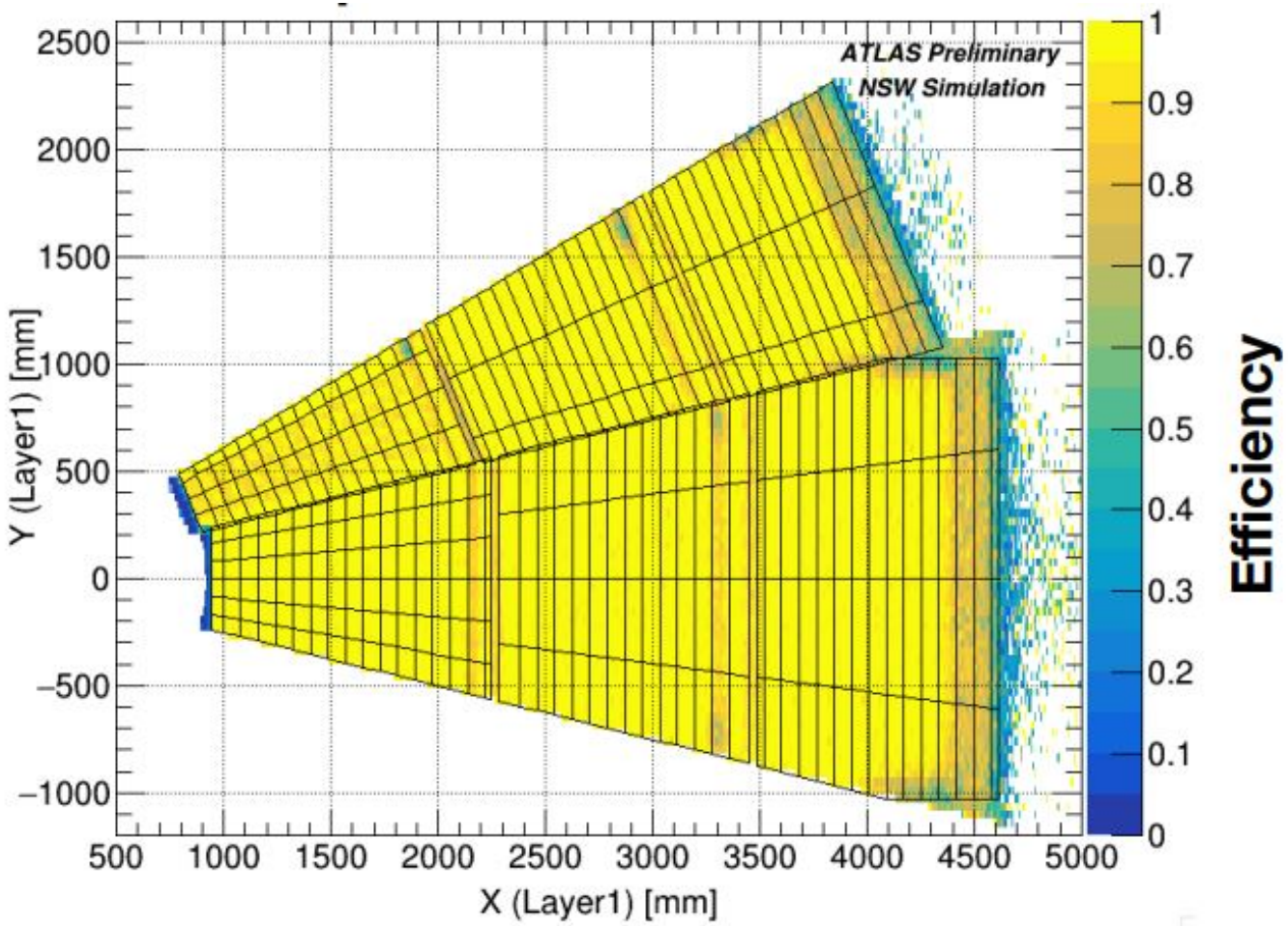
Trigger Simulation in the NSW

- The sTGCs act as the Trigger system.
- 8 layers of sTGCs surround 8 MM layers.
- Triggered when 2 x ¾ layers read signal in the correct time frame.
- Trigger simulation uses direct output of Digitization!



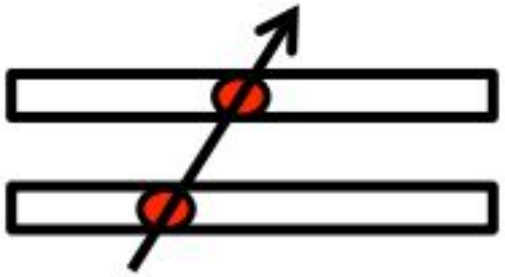
Testing the NSW Simulation

- When we generate particles, we can compare their reconstructed directions with their truth values.
- Look at the efficiency, the ratio of sTGC pad trigger candidates to truth for single muon events.



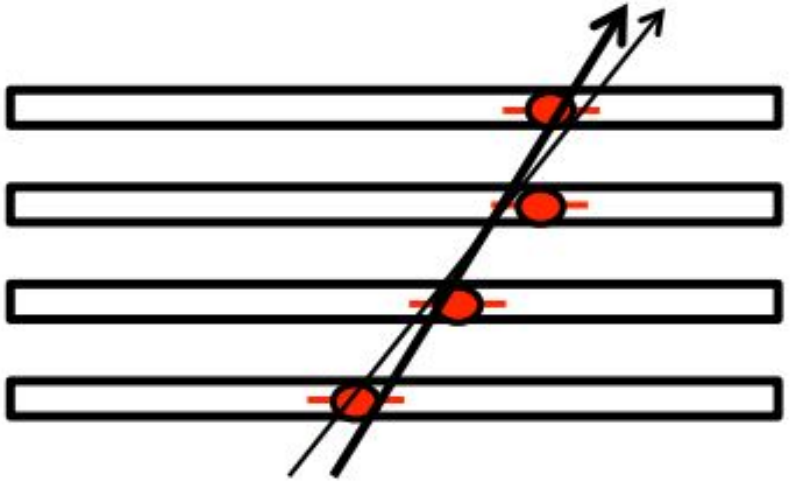
Reconstruction: A Primer

- We reconstruct tracks left by particles.
- More points and smaller errors improve tracking drastically.



Ideal measurement:
No errors

Reality:
Measurements with errors



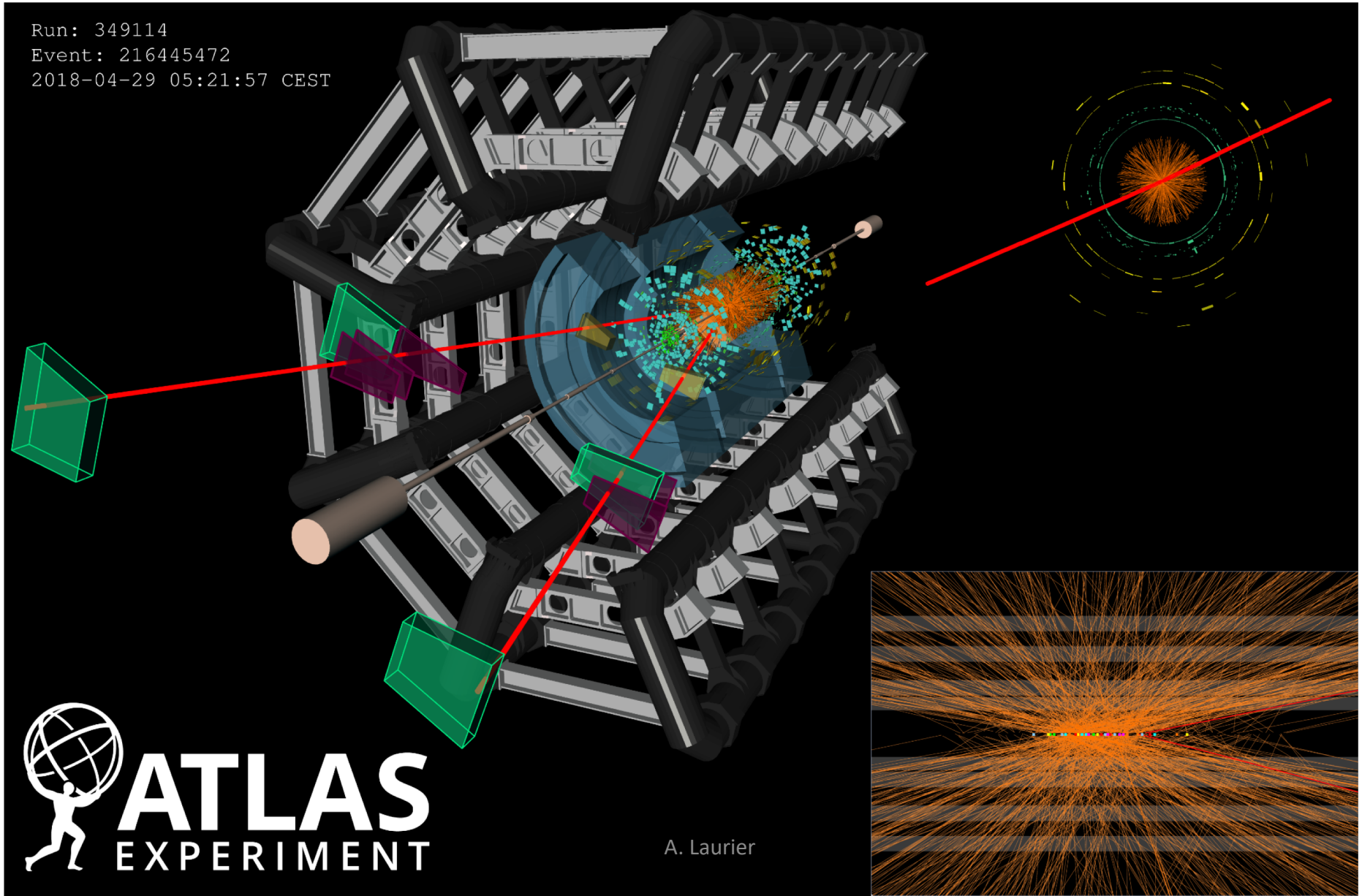
Smaller errors & more points

- NSW reaches an efficiency of 98% on track reconstruction for simulated nominal conditions.

Summary

- LHC is undergoing an extensive upgrade program lasting over a decade and increasing design luminosity by a factor of 7.
- To benefit from the increased performance, ATLAS is installing the New Small Wheel (NSW), a muon detector which will reconstruct muon tracks with high precision as well as serve as a L1 Trigger.
- A new simulation system had to be put in place to fully account for the NSW.
- Using test beam data, the NSW software is well behaved and produces consistent results for trigger and tracking efficiencies.

Almost time to do muon physics with our new detector!



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