# Current state of ATLAS's New Small Wheel simulation software and construction effort of the small-strip thin gap chambers

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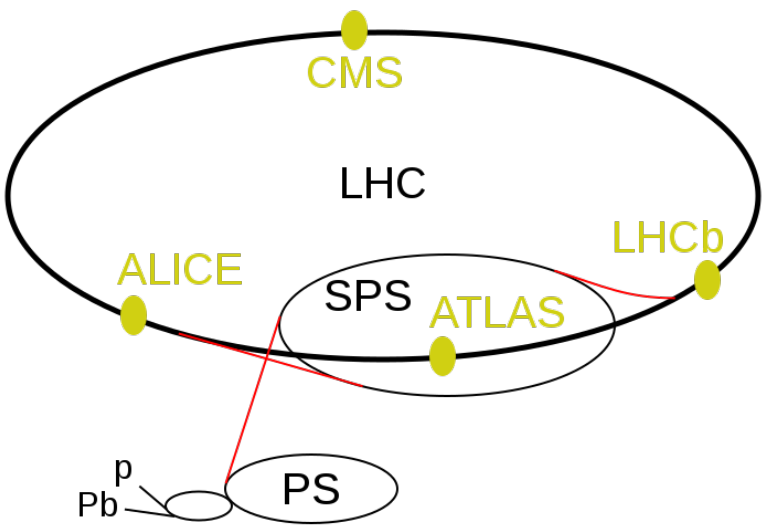
WNPPC, February 2018

# Outline

- ATLAS experiment
- The New Small Wheel (NSW)
- Simulation process and efforts
- NSW hardware

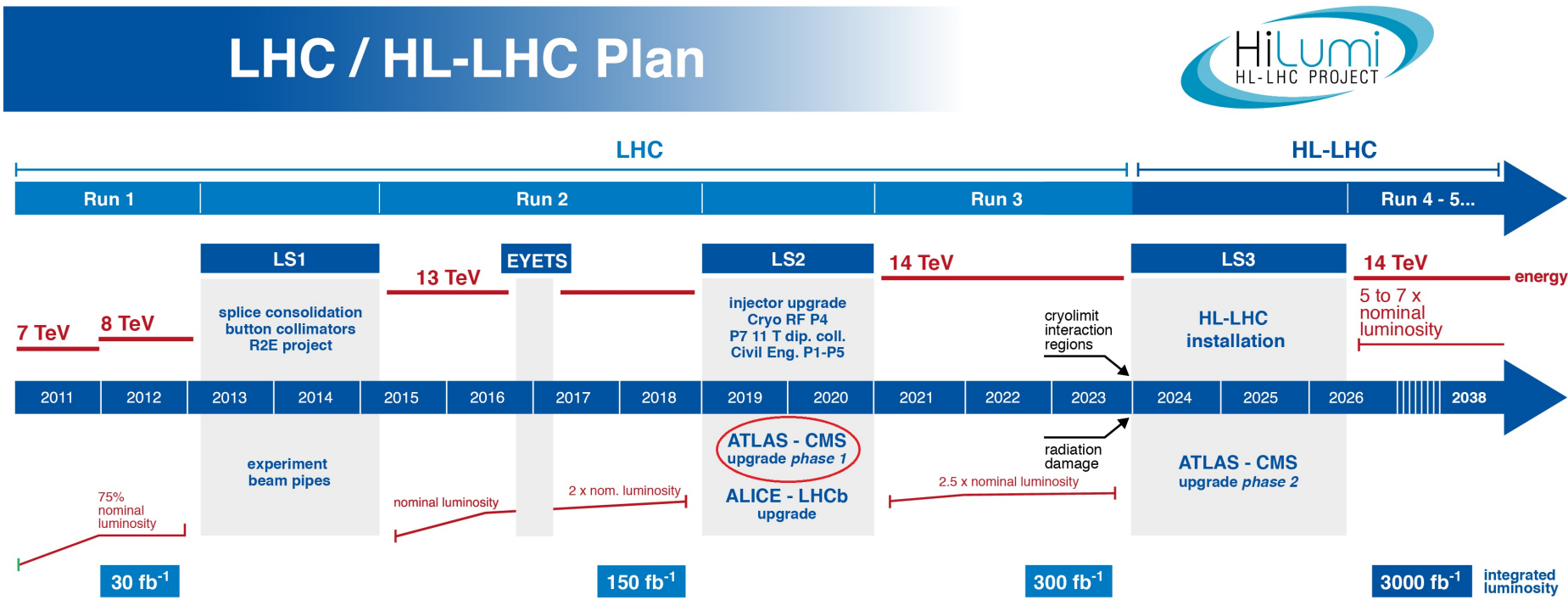
# ATLAS experiment

- One of four LHC experiments.
- LHC scheduled to keep running until the late 2030s, with upgrades.
- To keep up with high luminosity, detectors need to be upgraded.
- In our case, the New Small Wheel will replace the Small Wheel.



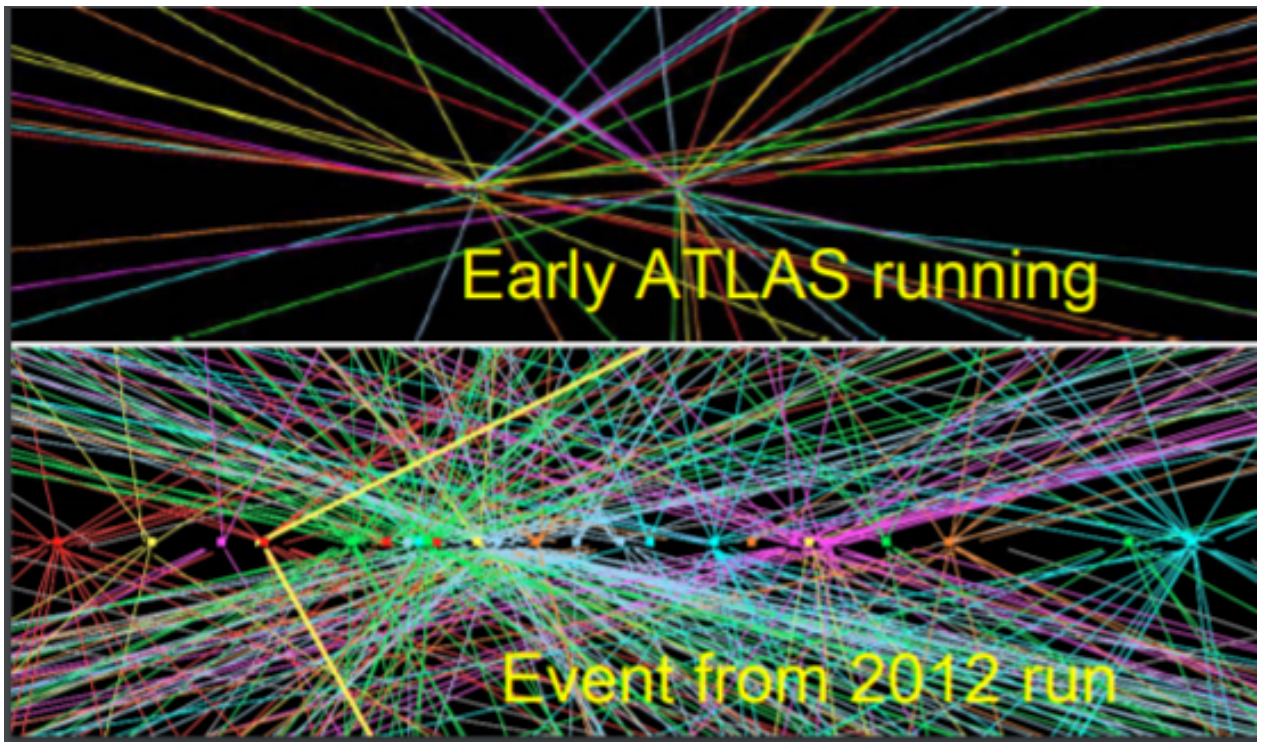
# ATLAS upgrade plan

More luminosity + more energy + more collisions/time = many more interactions!



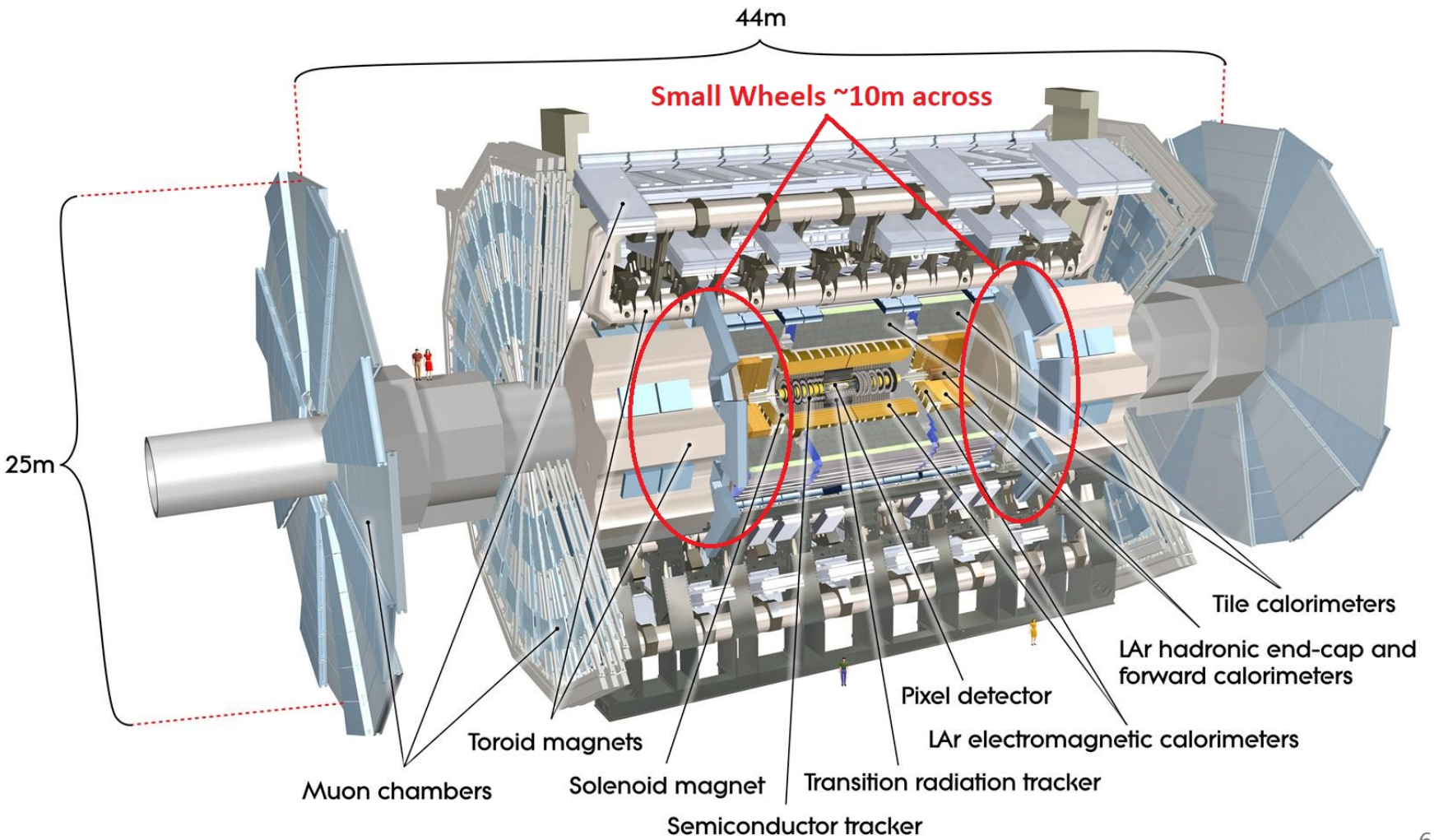
# Data collecting

- ATLAS collision rate is huge! A bunch crossing every 25ns with 100 proton-proton collisions!
- Discriminate for events with discovery potential: **Trigger**
- Look for energetic muons



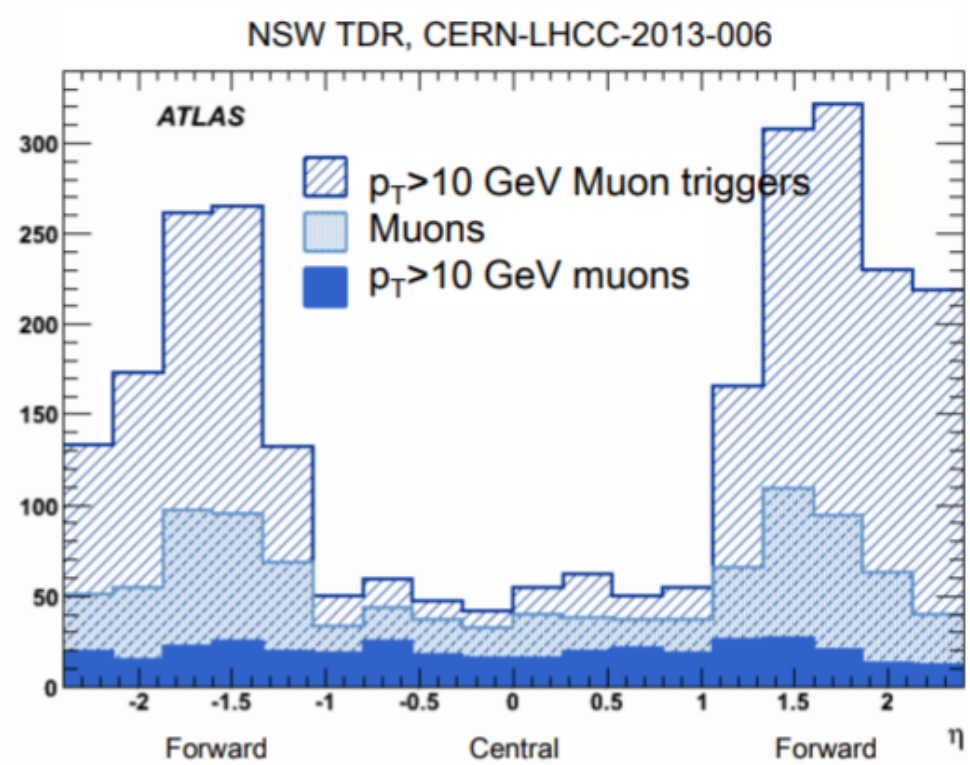
# ATLAS - Replacing the "Small Wheels"

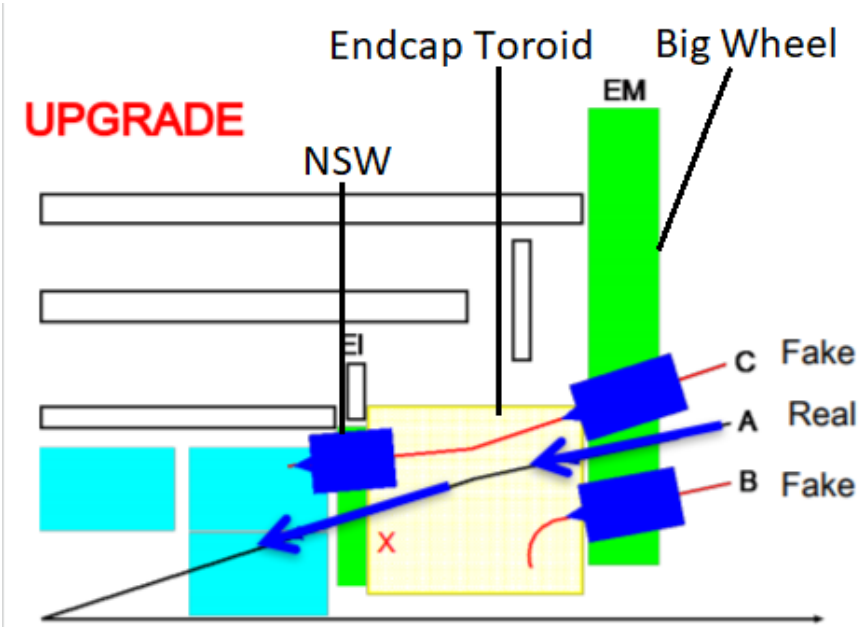
The Small Wheels are part of the Muon Spectrometer and are to be replaced with the New Small Wheels (NSW)



# Why change the Small Wheel?

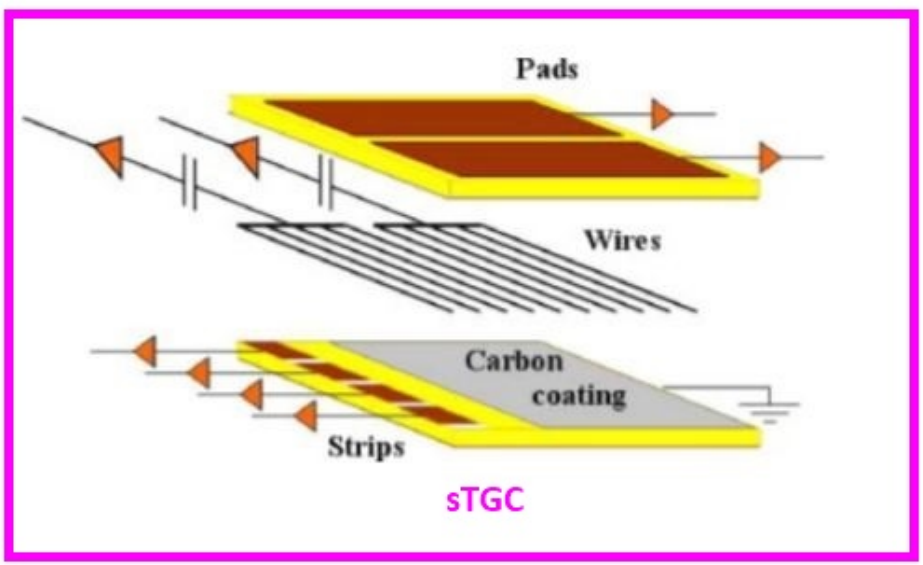
- Higher collision rate means more fake muons
- Too much unhelpful data; discriminate using a better **Trigger**
- The NSW will reduce **Trigger** fakes by an order of magnitude
- **Trigger** must point muons to interaction point within 2mrad

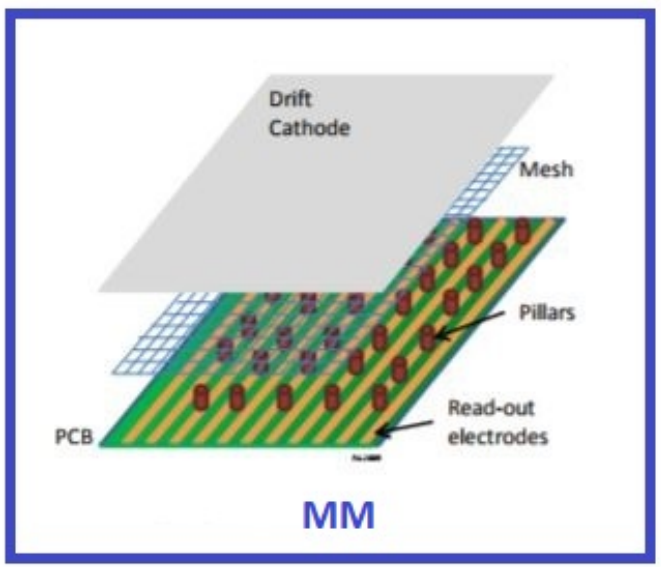


# NSW Description

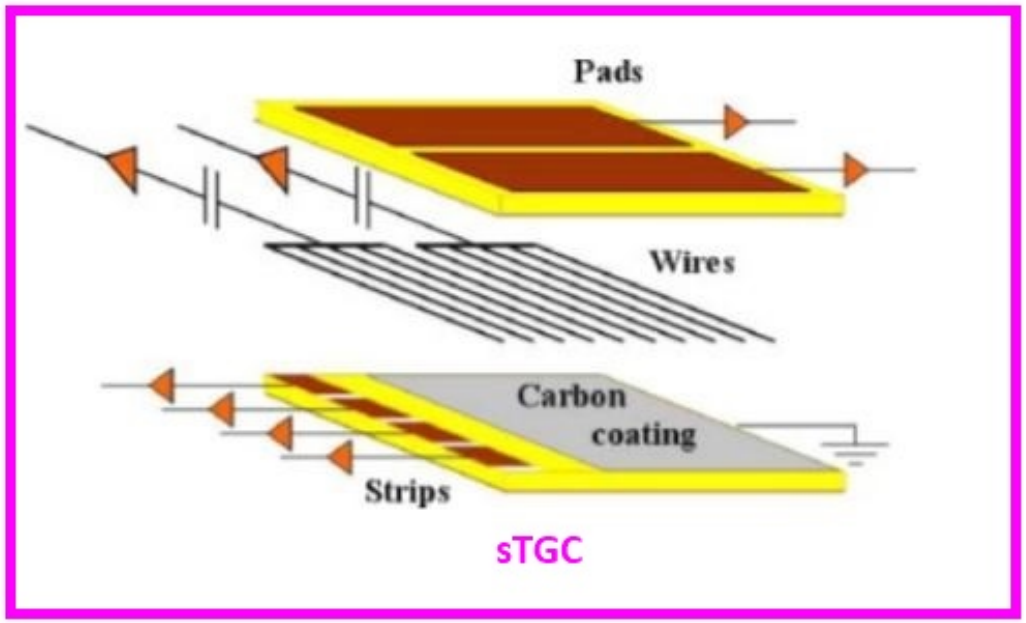
- Part of the Muon Spectrometer, ie muon detector
- **Trigger** (pads) and precision **Tracking** (strips) detector
- Higher precision on **Trigger** and **Tracking** than Small Wheel
- Posseses 2 detector technologies : Small-Thin strip Gap Chambers (sTGC) and MicroMegas (MM)
- Combined, allows for very good spatial and angular resolution for triggering and tracking



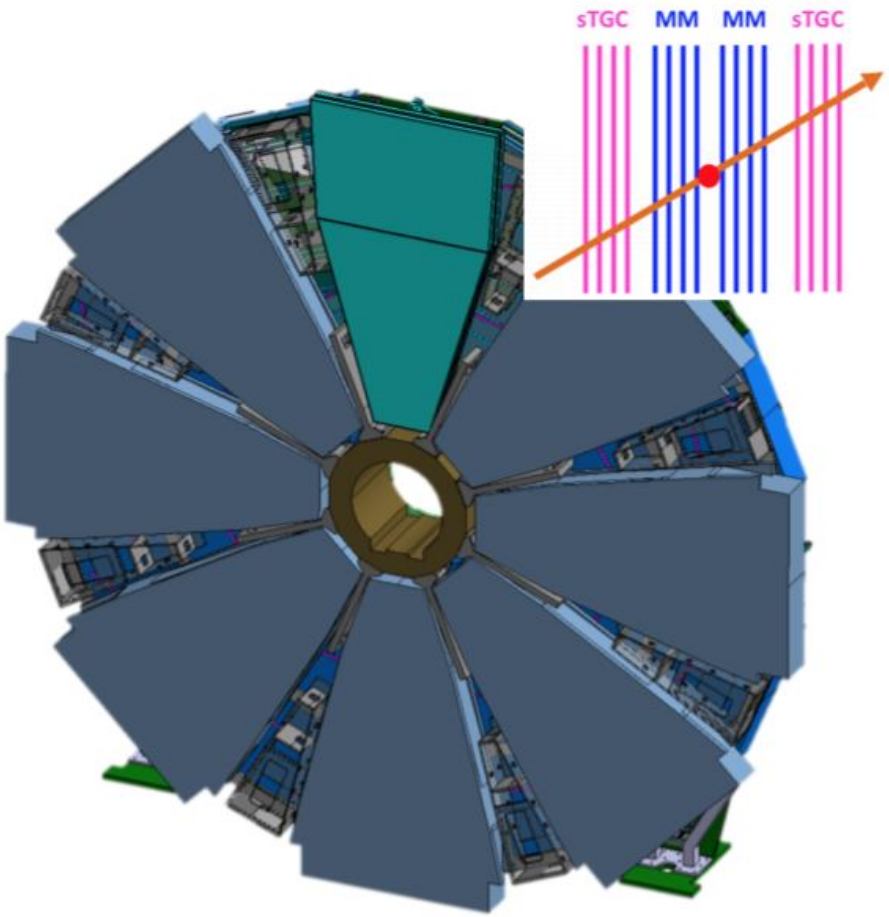
# Physics of the small-strip Thin Gap Chamber

- Is a multi-wire proportional chamber
- Whole gas chamber is held under high-voltage
- Muon passes through the chamber and ionizes the gas
- Electron avalanches towards the wires
- Charge is measured on the pads and strips
- Pads only trigger if charge is above response threshold
- Bunches of strips are activated



# NSW General Geometry

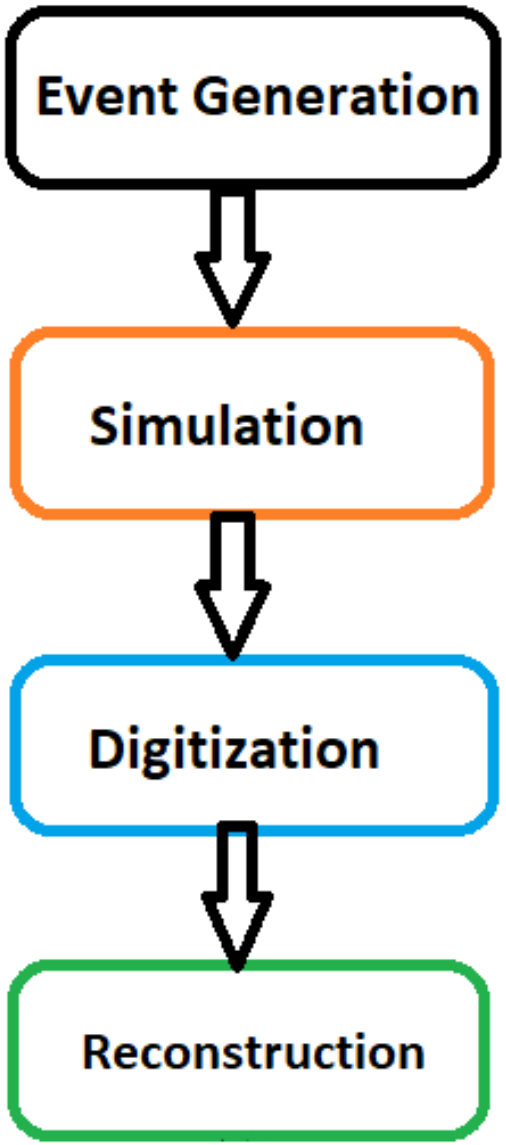
- NSW is constructed of 16 sectors : 8 Large and 8 Small
- Eight sTGC and MM detector layers in each sector
- Sectors are overlapped with eachother



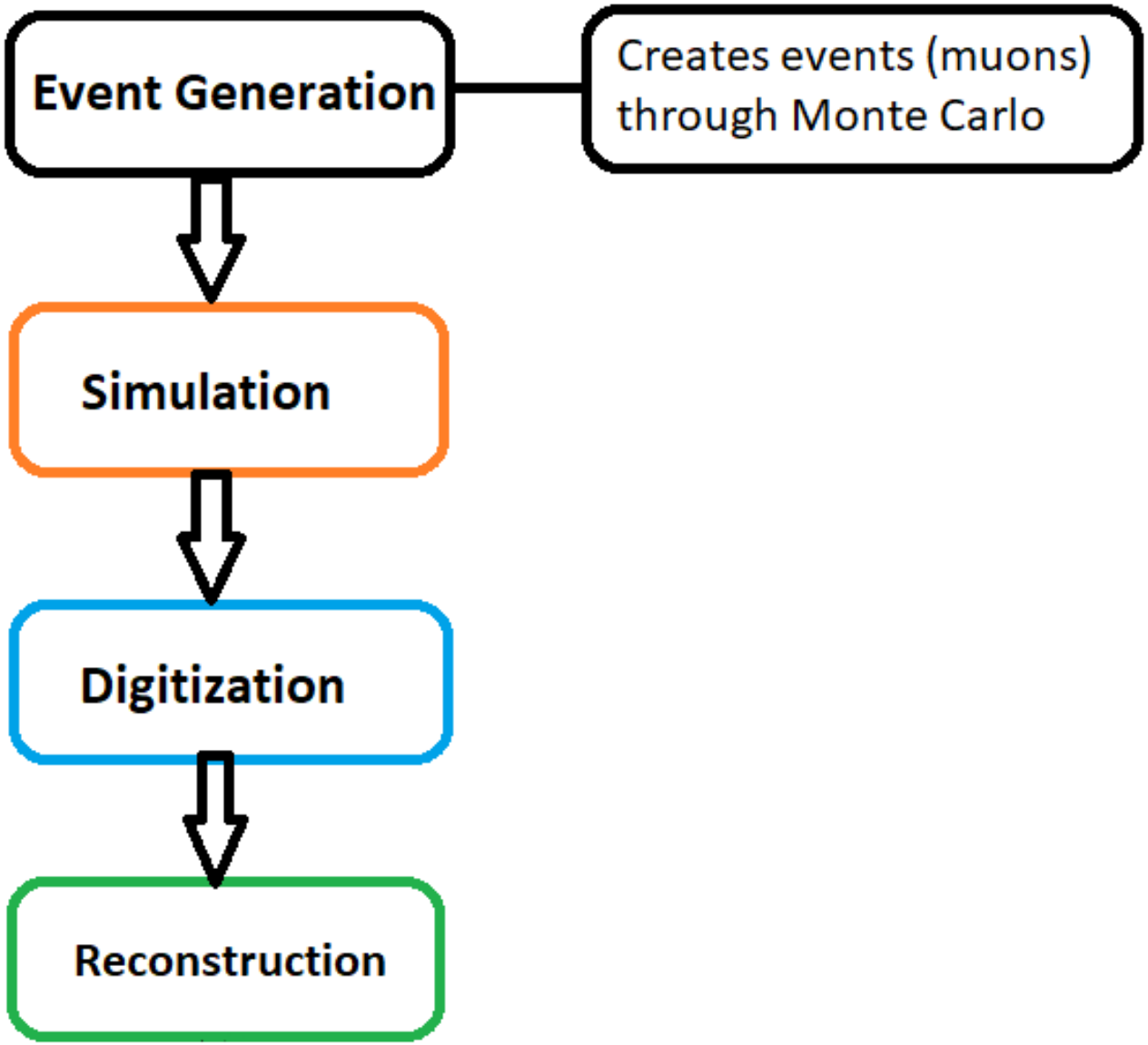
# Why Simulate the NSW?

- Need a benchmark against which to compare the constructed detector response
- Calibration tool
- Troubleshooting unexpected problems
- Eventually, do physics with muons!

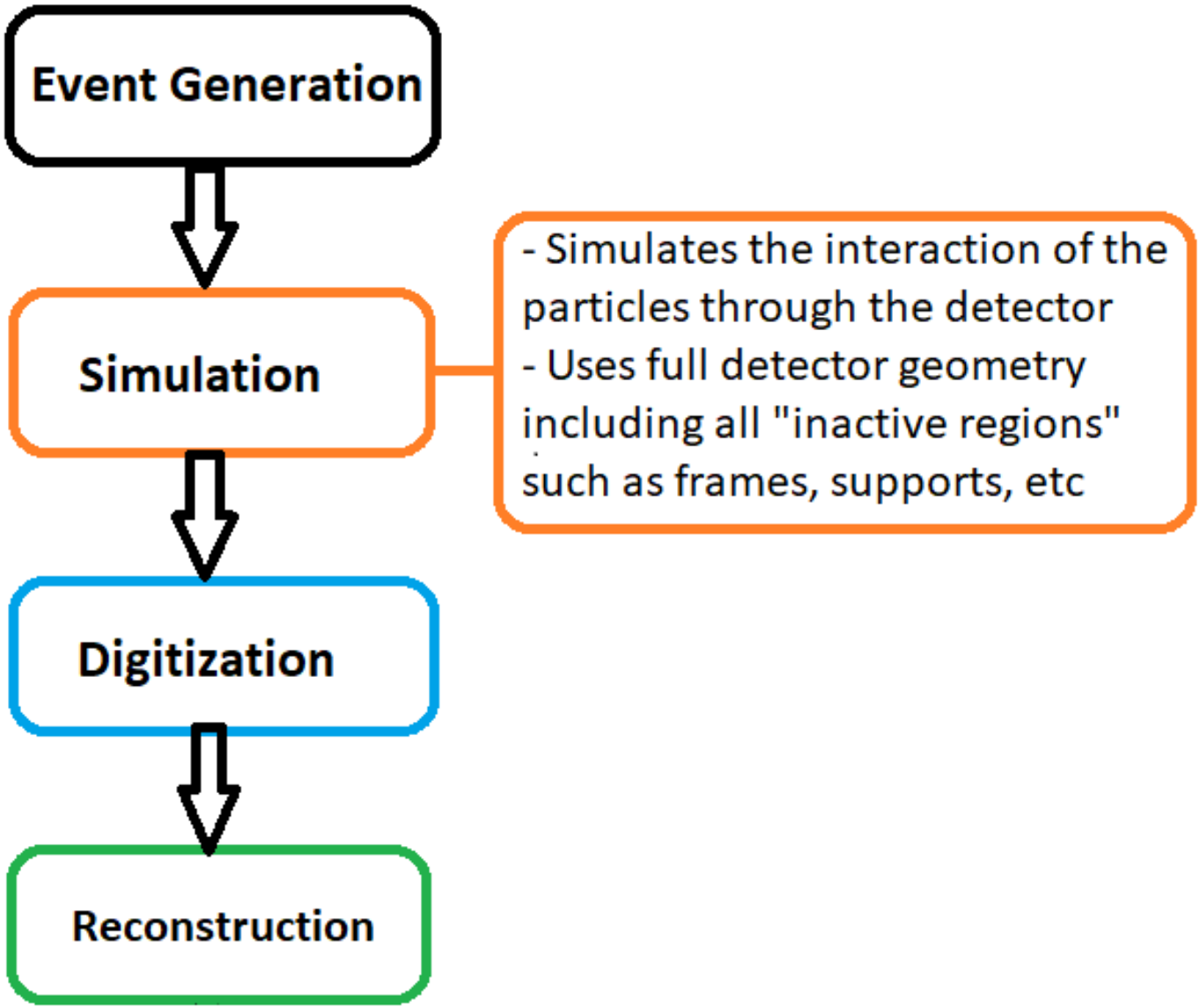
# Simulation steps done quick



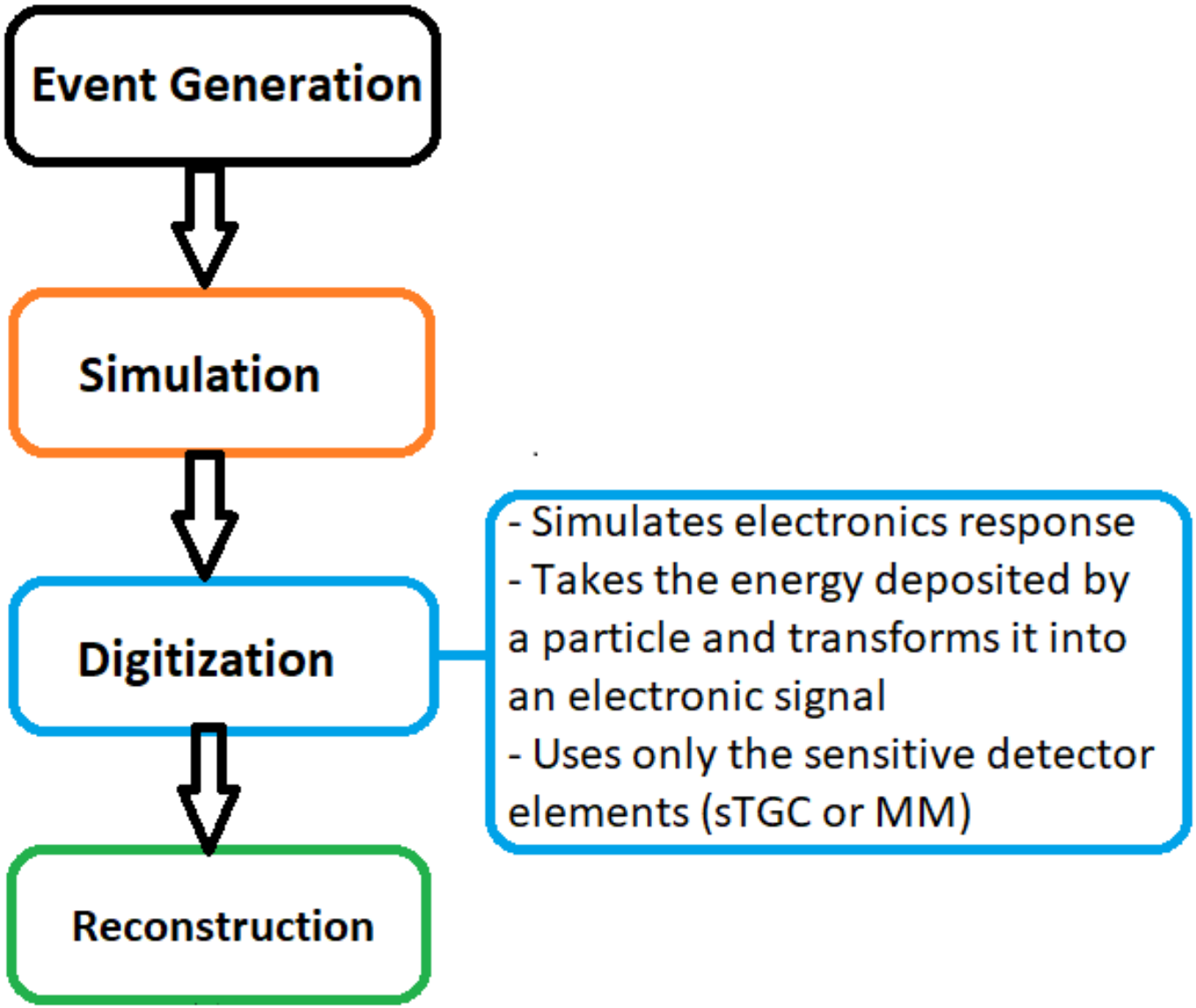
# Simulation steps done quick - Step 1



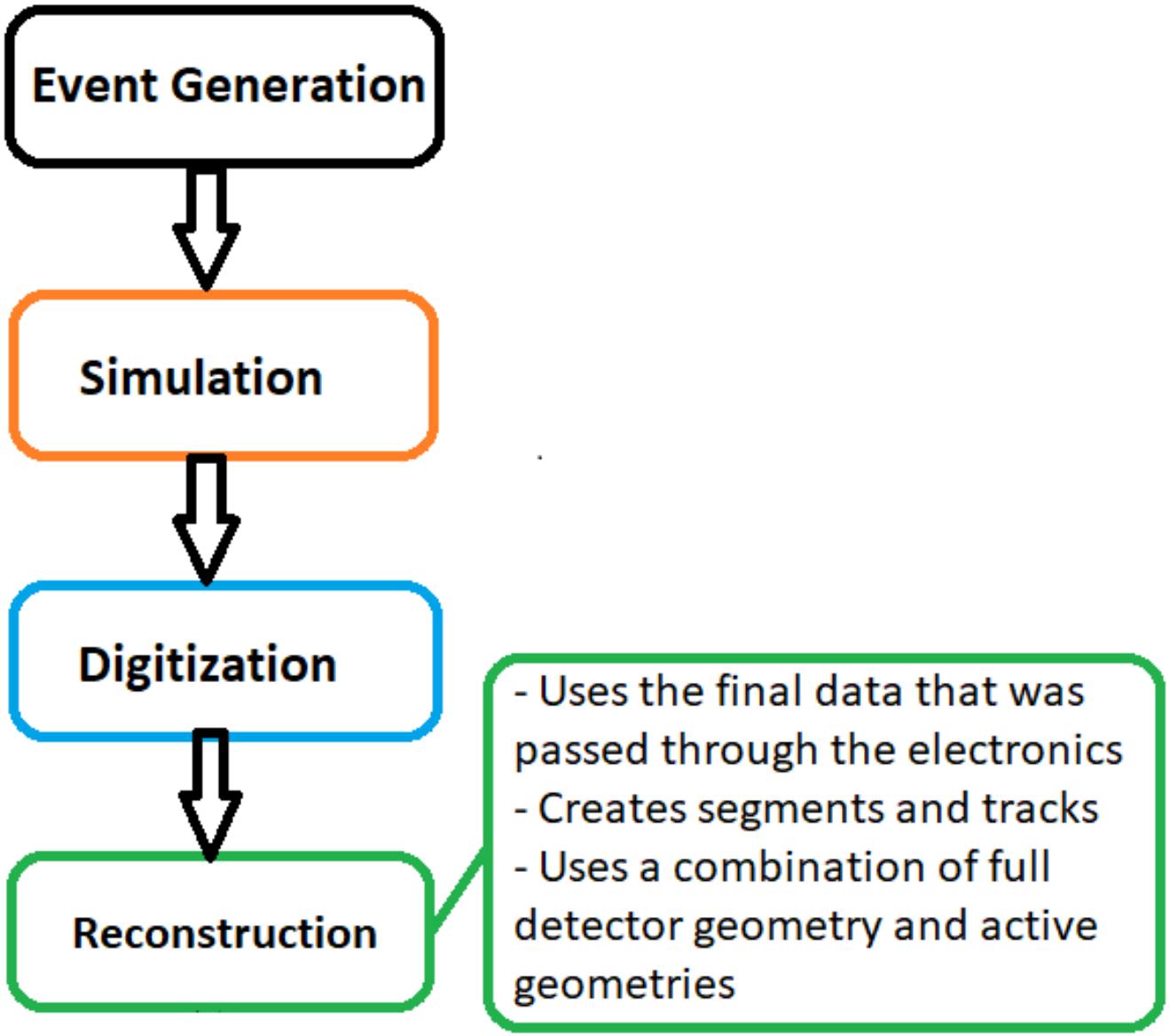
# Simulation steps done quick - Step 2



# Simulation steps done quick - Step 3



# Simulation steps done quick - Step 4



# Simulation looks easy, what could go wrong?

In short, everything!

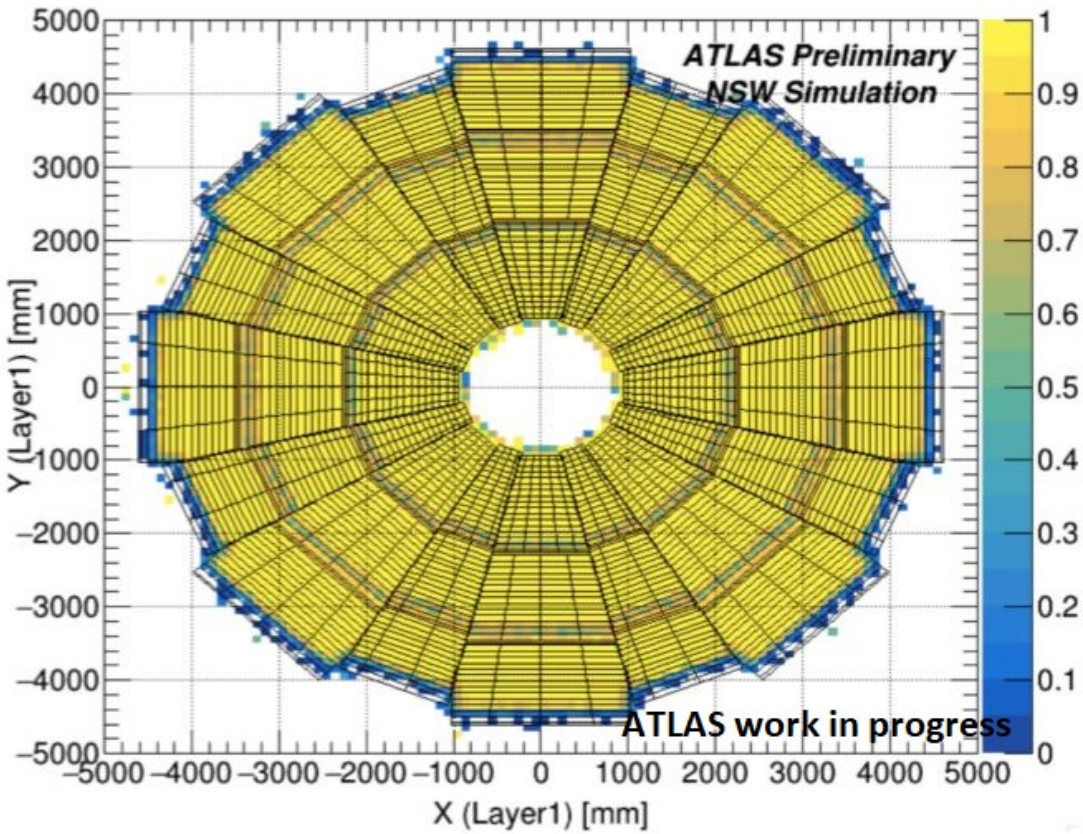
- Geometry of the whole NSW must be exact
- 25 ns time between events. Must account for all the delays from electron drifting, electronics timing, etc
- Need to properly replicate hardware response
- Energy deposition, particle types, etc all affect the simulation greatly
- Very precise **Trigger** detector, every component must be aligned towards the I.P. with mrad precision levels.

# Current status of NSW-sTGC software

- The whole software chain is functional
- Current tests show simulation reaches sTGC pad **Trigger** efficiency of **98** %
- Simulation tests also show a tracking efficiency of **98** % on muons through the NSW
- Work in progress to improve the software efforts: more accurately reproduce electronics timing and response

# sTGC as Trigger detector

- sTGC is a **Trigger** and precision **Tracking** detector
- Hardware discriminates and keeps only the most likely events
- Requires hit coincidence of least 6 out of 8 layers (for sTGC)
- Picture looks pretty; months of work by teams of people

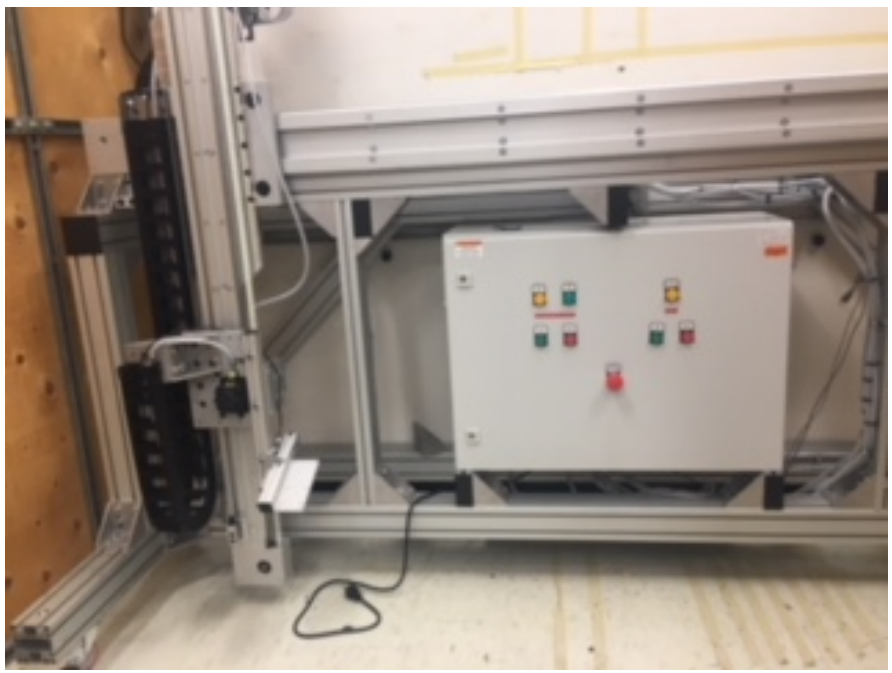


# sTGC construction

At Carleton, we are tasked to construct and test some of the sTGCs for the NSW.

# Hardware to software?

- We test the sTGCs with an x-ray scanner
- Read the current from the ionization of the gas
- Create maps of hot/cold spots as well as dead readout elements
- Make sure sTGCs are up to construction specs

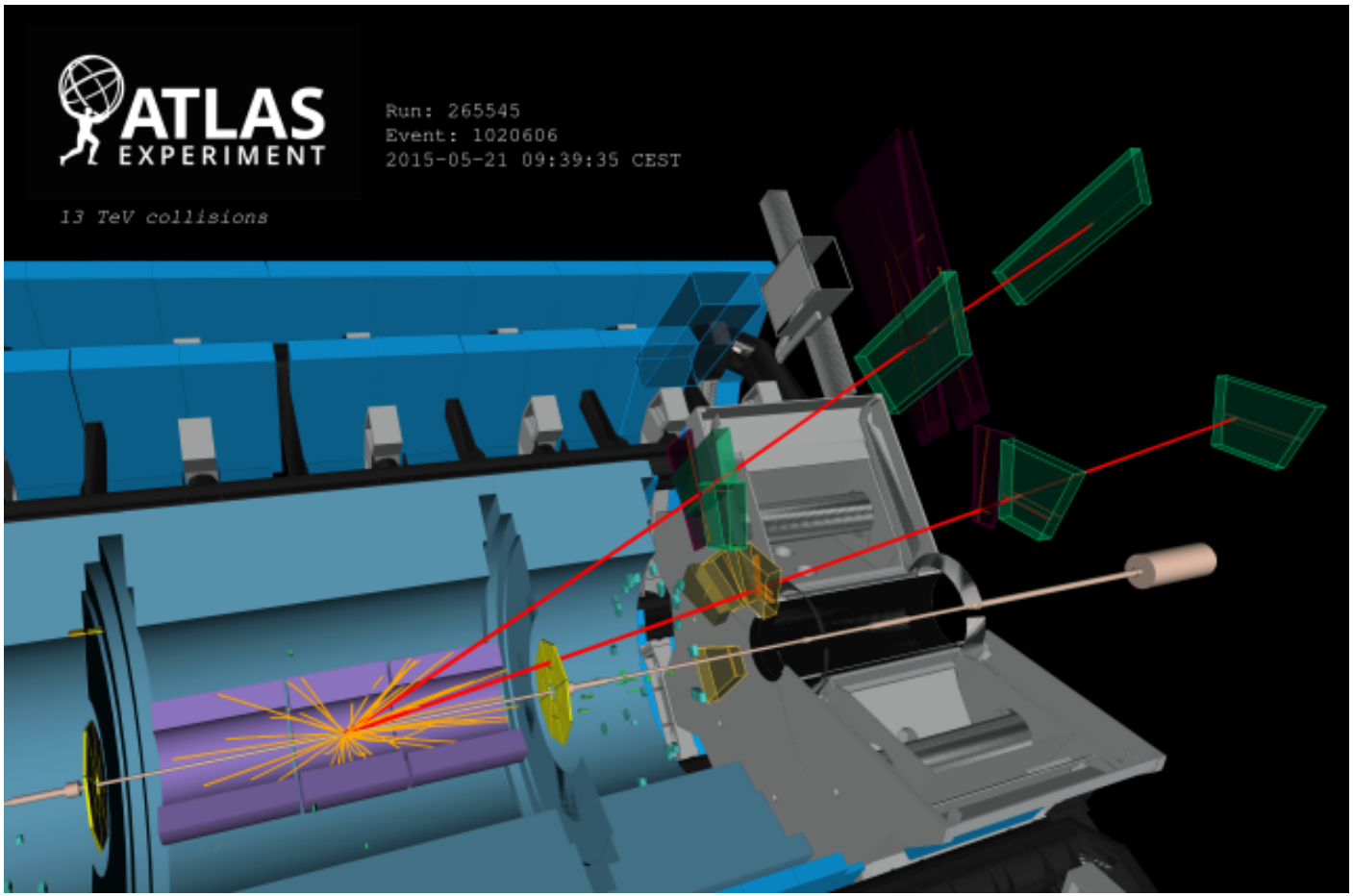


# Relating Hardware and Software efforts

- During construction or testing, we must log as much information as possible.
- Software must reproduce hardware response with high fidelity and accounting for any cold/dead spots or broken components is critical.
- Must modify the software (eventually) to exactly replicate the defects in the hardware.
- Entails having a thourough list and knowing which of the many detectors has what exact behaviour.
- High precision measurements like we do in particle physics don't allow us much leeway, we must account for everything.

# Conclusion

- sTGC simulation software making strong progress
- sTGC construction and testing also quickly progressing
- Goal is to finally do physics with muons!



# Questions

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