DATA MONITORING OF THE ATLAS MUON SYSTEM AND COMMISSIONING OF THE NEW SMALL WHEEL (NSW) DATA QUALITY SYSTEM

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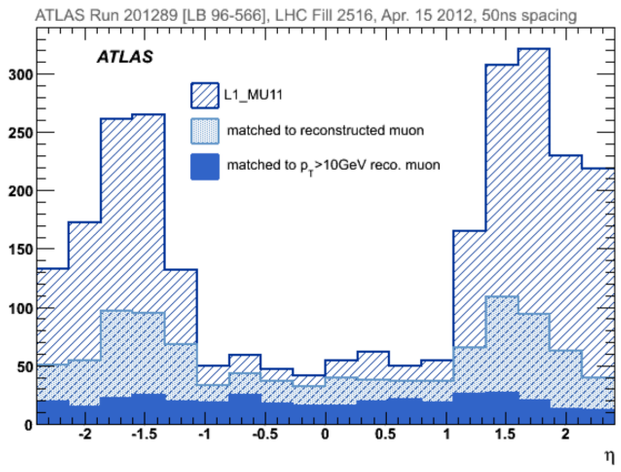
ON BEHALF OF THE ATLAS MUON COLLABORATION

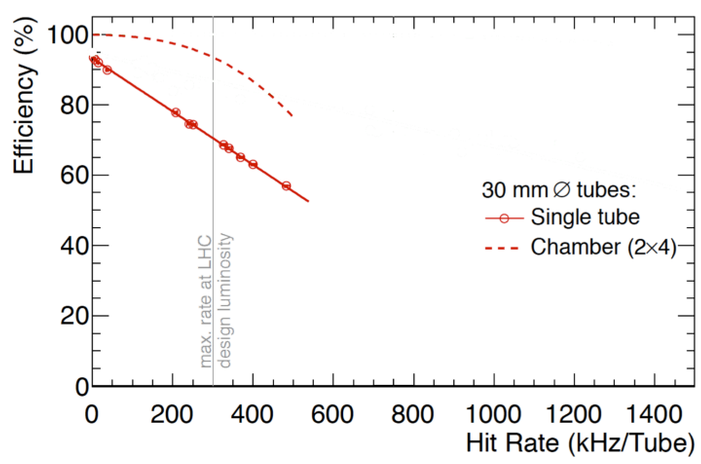
Motivation

- The Large Hadron Collider (LHC) will undergo several major upgrades until 2032 [1]:
  - From LS2 until end of Run 3: $L \gtrsim 2\times10^{34}$ cm^{-2}s^{-1}, L_{int} ~500 fb^{-1}
  - From LS3 until end of Run 4: $L \gtrsim 5\times10^{34}$ cm^{-2}s^{-1} L_{int} ~1500 fb^{-1}
- **Two main challenges for ATLAS muon spectrometer [2]:**

High L1 (Level-1) Muon trigger fake rate in the end-cap



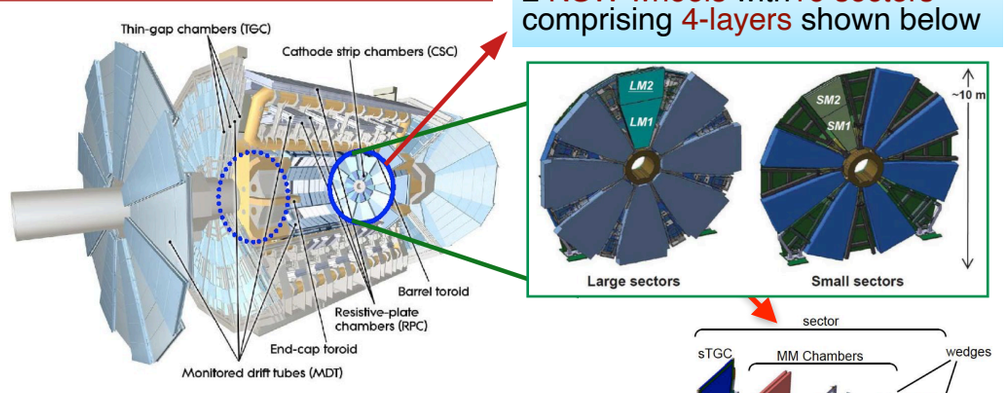
Deterioration of MDT's tracking performance



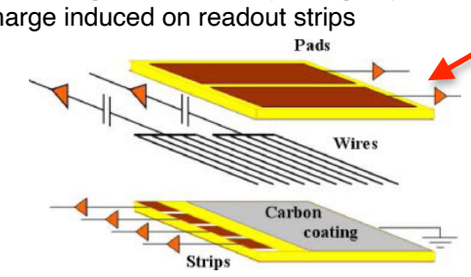
Small Wheel → New Small Wheel [3]

Goal: L1 trigger track segments online reconstruction with **"angular resolution ~ 1 mrad"**
Offline track reconstruction with **"spatial resolution ~ 100 µm"**

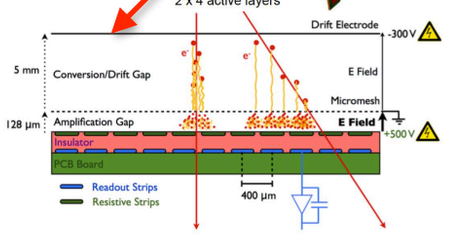
NSW Layout



- Small-strip Thin Gas Chamber (sTGC): strips with pitch ~3.2 mm, pads and wires
- MicroMegas (MM): strips with pitch ~400 µm
- Based on gas ionization by charged particle
- Charge induced on readout strips

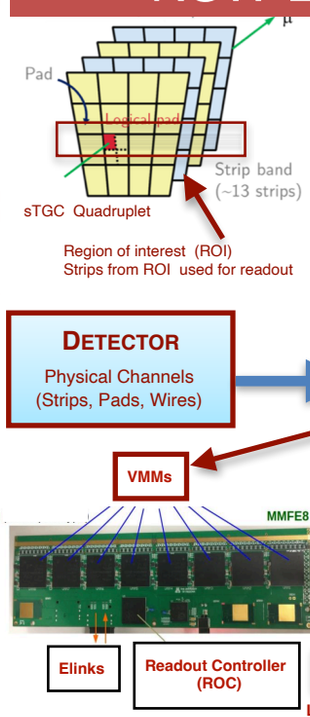


sTGC: mainly for trigger, complementary precision tracking, 1 mrad angular resolution (for online reconstructed segments), spatial resolution ~100-120 µm

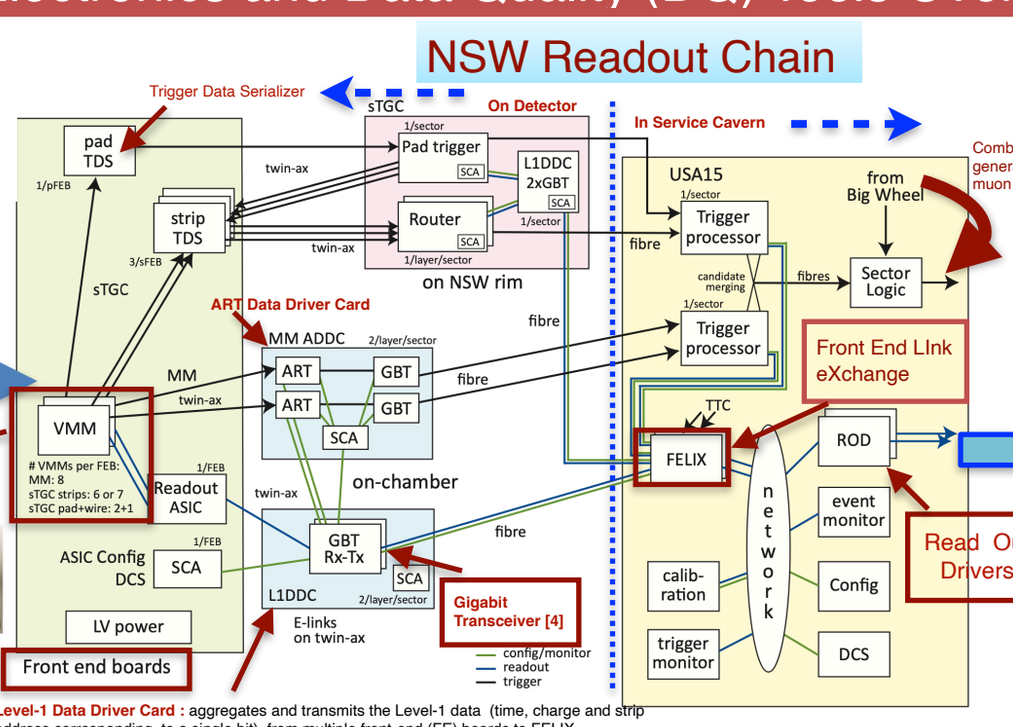


MM: mainly for precision tracking complementary trigger
spatial resolution ~100 µm

NSW Electronics and Data Quality (DQ) Tools Overview



NSW Readout Chain



DETECTOR
Physical Channels (Strips, Pads, Wires)

VMMs

Elinks | Readout Controller (ROC)

Level-1 Data Driver Card : aggregates and transmits the Level-1 data (time, charge and strip address corresponding to a single hit) from multiple front-end (FE) boards to FELIX

How do we monitor data?

Data from RODs after L1 trigger, rejection factor ~400

Data taken after high level triggers (HLT): Calibration Stream, rejection factor ~100

Gnam
Light-weight raw data analysis, for online monitoring

During Run2, more than 70k histograms have been checked by automatic DQ algorithms,

Data Quality Monitoring Framework (DQMF)
Automatic DQ check of histograms produced by Gnam

Servers at experiment site store histograms

Online Histogram Presenter (OHP)
Provide Histograms to Shifters/Experts

Athena
offline analysis framework

In case, automatic assessment is not possible or not reliable, also provide WEB browser option

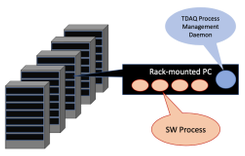
Express Stream: small sample of physics analysis after HLT

DQ Assessment based on
→ **physics events analysis**
→ **Events Analysis Framework**
→ **Information Service (IS)**

Backbone of Online Monitoring System, results produced by **Gnam** and **Athena** in the form of Histograms are published to IS [5]

Commissioning of NSW DQ System

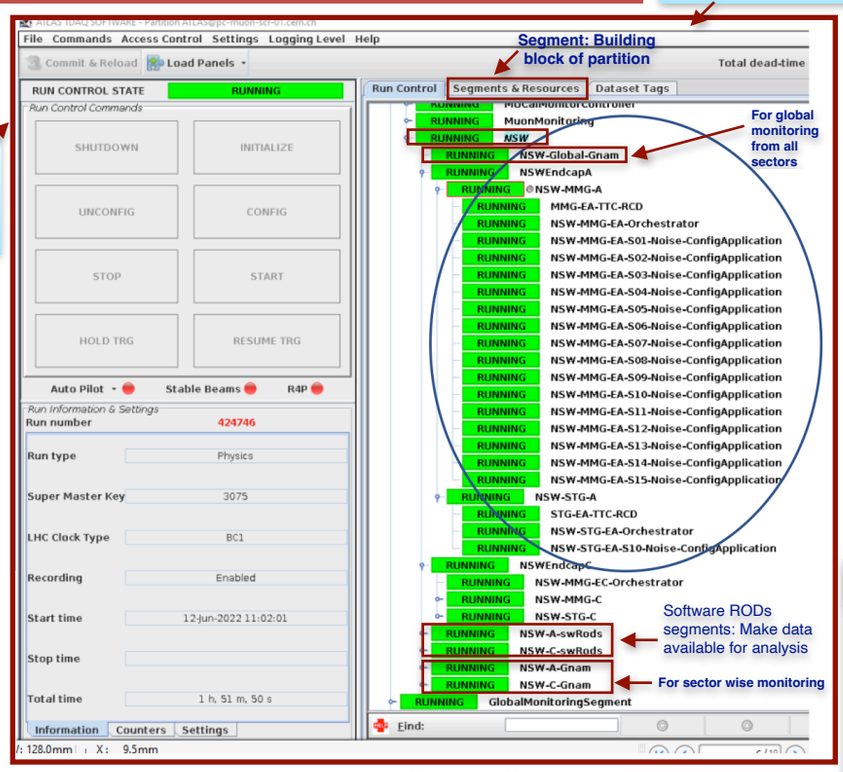
The ATLAS Trigger & Data AcQuisition (TDAQ) System



Partition
Self-contained TDAQ system [6]

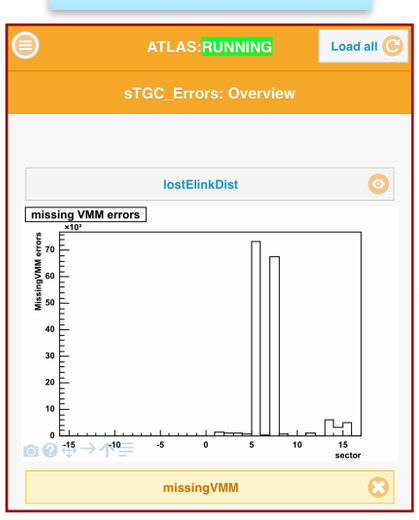
- Software (SW) processes ~O(10K) running on ~3K rack-mounted PCs
- Processes-to-PC mapping is described in Configuration Database (base on OKS service, use XML files to store information)

NSW Gnam: Commissioned in private partition
Ready for data taking and segments are included in ATLAS Global Partition

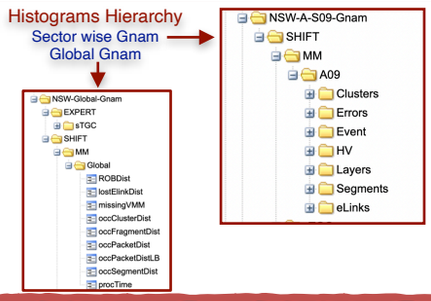


- Extendable GUI (Graphical User Interface) that can be configured via XML:
  - Most popular/key histograms are displayed by graphical plugins
- All OHP configurations available at P1 are automatically converted to HTML pages:
  - These pages are accessible world-wide

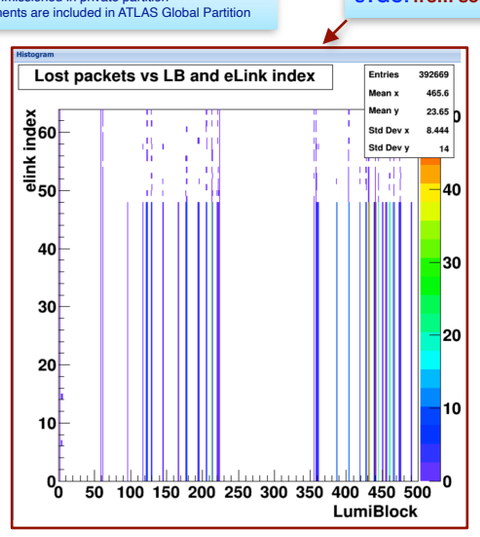
Online Histogram Presenter (OHP)



Histograms Hierarchy
Sector wise Gnam → Global Gnam

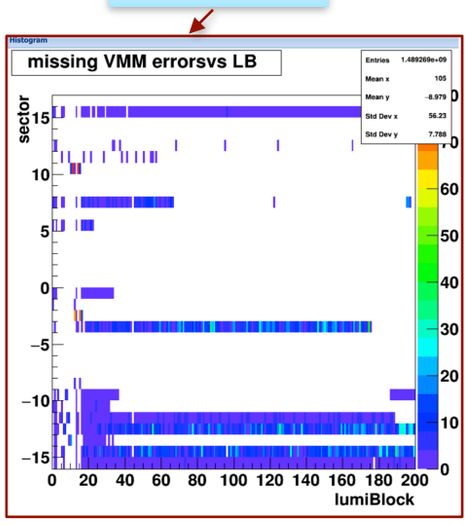


sTGC: from sector wise Gnam



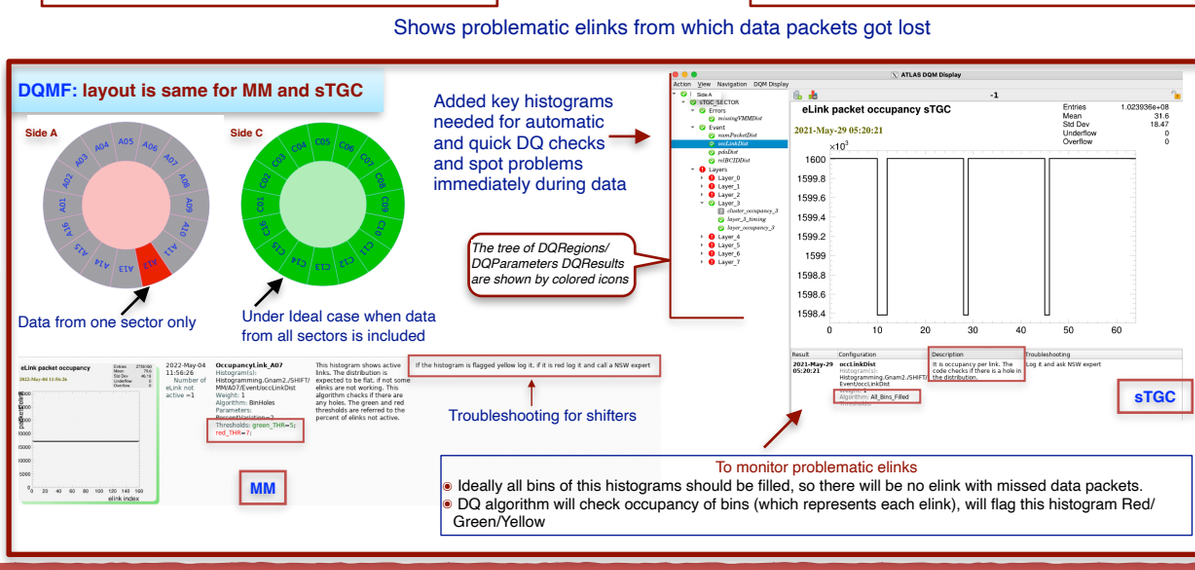
- NSW readout read data from each sector in the form of "data packets"
- Each packet represents data from one elink
- Each elink has unique ID label
- Elinks store data as an array of NSW channel objects (4 bytes of data from one VMM channel)

MM: from global Gnam



Shows problematic elinks from which data packets got lost

DQMF: layout is same for MM and sTGC



To monitor problematic elinks
- Ideally all bins of this histograms should be filled, so there will be no elink with missed data packets.
- DQ algorithm will check occupancy of bins (which represents each elink), will flag this histogram Red/ Green/Yellow

Conclusion

Status @P1

- **First version of NSW DQ tools (Gnam, OHP, DQMF) with basic set of histograms are integrated in ATLAS TDAQ and running successfully**
- Trying to understand problems while having first look at data collected during milestone weeks and Splash events
- Keep updating the current configuration with advanced level histograms as ATLAS is approaching towards real data taking for Run3

Data Quality (DQ) monitoring is crucial

- Overall premise: collect good data
- **Online DQ = "first line of defense" to catch and mitigate data loss**
- Essential to spot problems early while taking data
- Specifies sets of 'good' luminosity blocks → **"The Good Runs List (GRL)"**

This data goes into "Physics Analyses" via the "GRL" !!

References

[1] https://lhc-commissioning.web.cern.ch/schedule/LHC-long-term.htm, https://project-hl-lhc-industry.web.cern.ch/content/project-schedule
[2] ATLAS Collaboration,The ATLAS Experiment at the CERN Large Hadron Collider, JINST 3 (2008) S08003
[3] ATLAS Collaboration, *New Small Wheel Technical Design Report*, CERN-LHCC-2013-006, ATLAS-TDR-020, https: //cds.cern.ch/record/1552862
[4] ATLAS Collaboration, The GBT-SCA, a radiation tolerant ASIC for detector control and monitoring applications in HEP experiments, JINST 10 (2015) C03034.
[5] https://atlas-tdaq-monitoring.web.cern.ch/IS/Welcome.htm
[6] https://twiki.cern.ch/twiki/bin/viewauth/Atlas/DaqHltConfigOverview