Detector Operations and Detector R&D for Upgrades (Phase 2)

- Perform work to insure the continued high performance of the detector systems in which we had major construction roles
  - Region of Interest Builder
  - Tile Calorimeter

- Identify and pursue detector R&D opportunities which will allow ATLAS to continue to operate with high performance in high luminosity running during Phase 2
  - QIE as the front-end electronics to read out the tile PMTs
  - Redundant LVPS to power tile calorimeter front-end electronics
  - Optical modulator for readout link between tile electronics and ATLAS ROS

These activities also provide opportunities for students and postdocs visiting the ANL-ASC to work with us on detector systems and detector R&D (and in some cases obtain ATLAS authorship qualification)

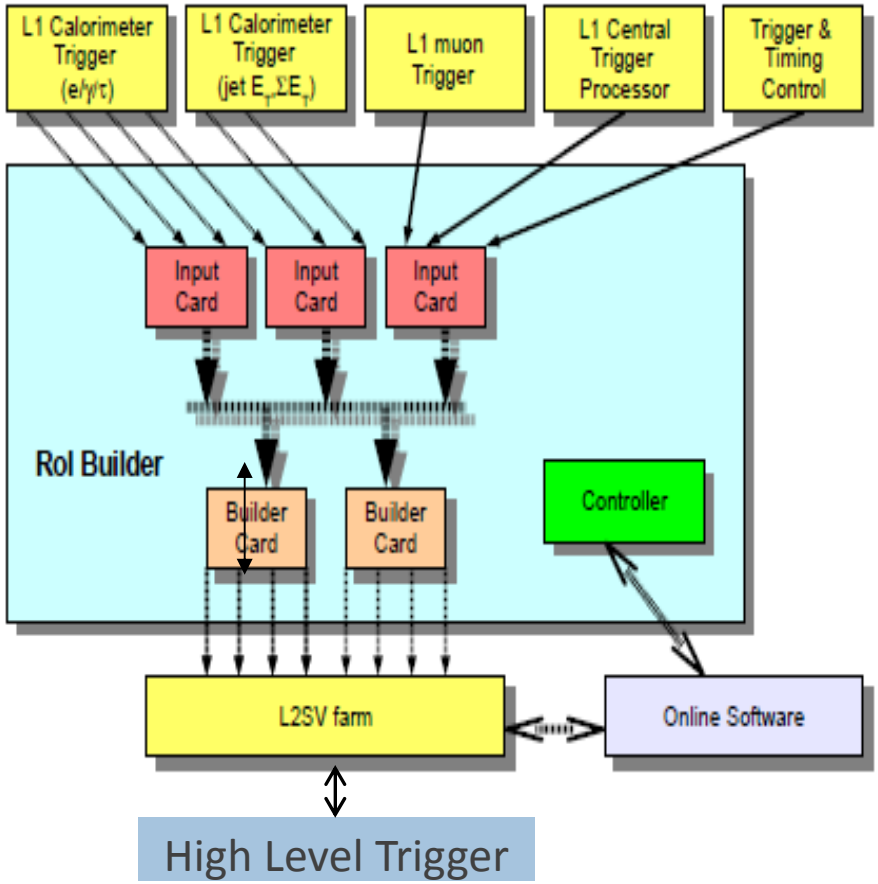
Region of Interest Builder (RoIB) operations

System designed and constructed by ANL and MSU

Critical component in the ATLAS trigger – passes Level 1 trigger data from Level 1 to Level 2 computer farm (no data to tape without it)

Operations support provided entirely by ANL and MSU

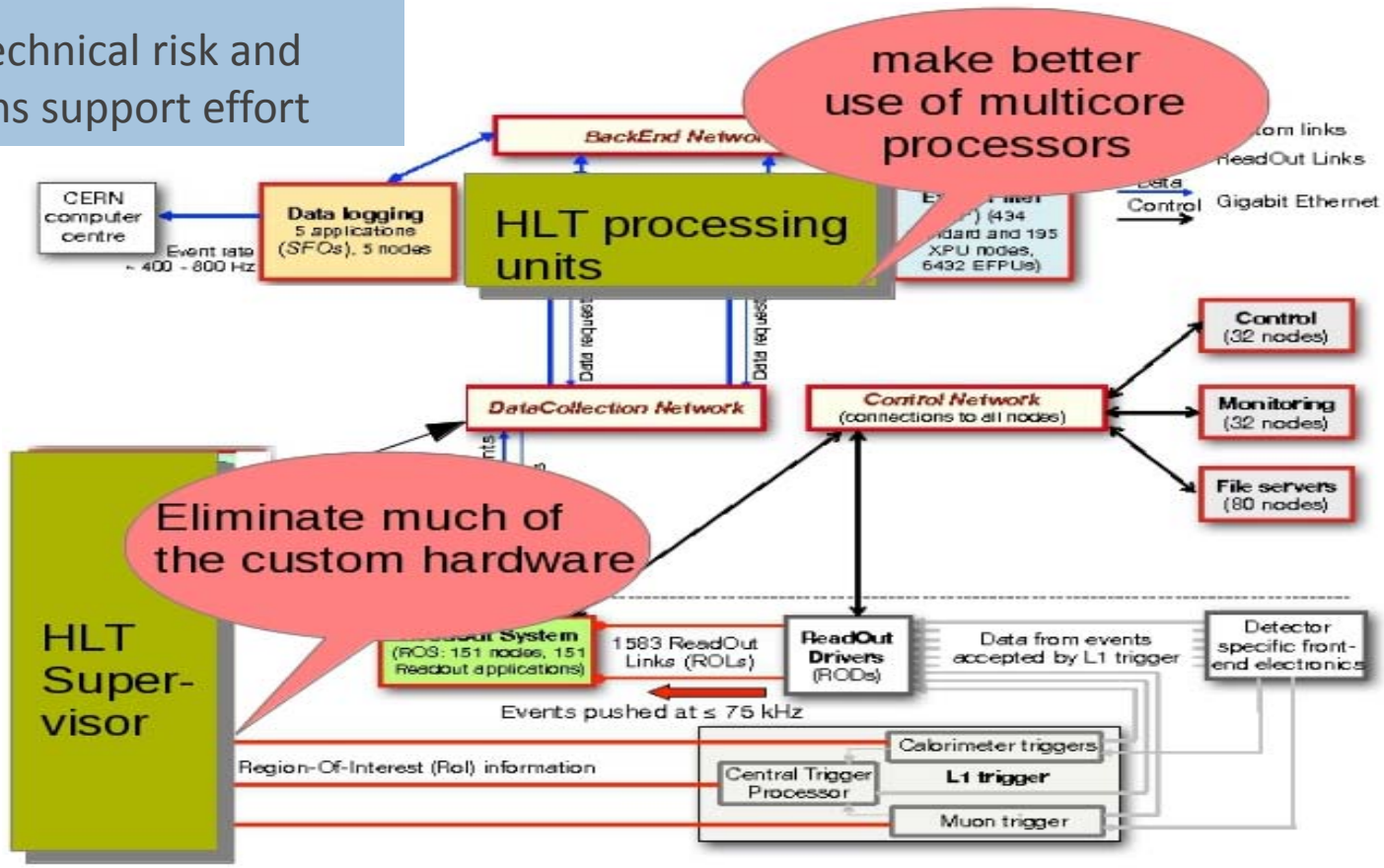
ANL responsibilities include coordination and training for 24/7 support at CERN, management of spares and maintenance of a test facility



FLAWLESS operation for 8 years and counting (ZERO data lost – cosmic AND pp runs)
TDAQ management concern nonetheless that this is a single point of failure in the trigger chain

Planned improvements to TDAQ system

Goal:
reduce technical risk and operations support effort



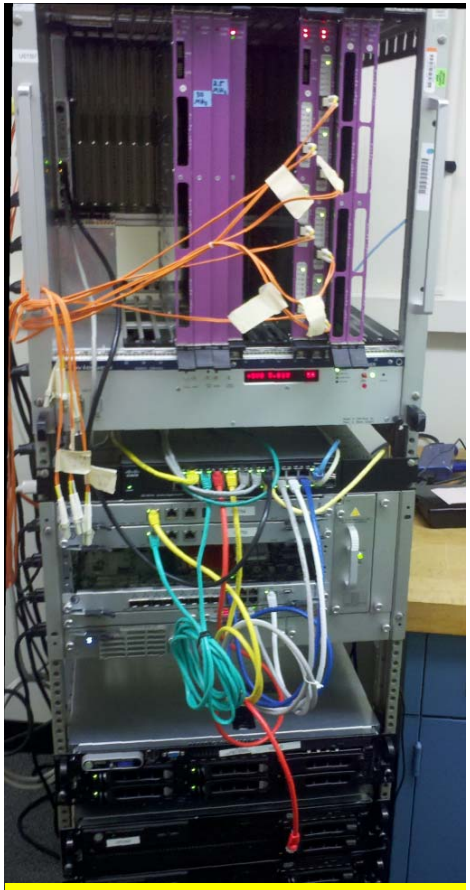
Simplify the system architecture
Decrease the amount of custom hardware and thereby the need for expert support.
HLT Supervisor encompasses RoIB functionality in a commodity PC with custom input cards.

Long Term Plan for RoIB – three options

- Maintain present system
  - Do this until a replacement approach is PROVEN
  - Requires testing of updates to components such as the single board computer
  - Maintain operational support for the software/hardware interface in the TDAQ framework
  - Continue to support test stand

- Develop software based replacement for deployment in a commodity PC, with only a few custom card
  - If proven then this is the best outcome - but needs extensive testing
  - Are basing development studies on software implementation considered a decade ago

- Engineer a hardware replacement -> the FLIC is a candidate implementation



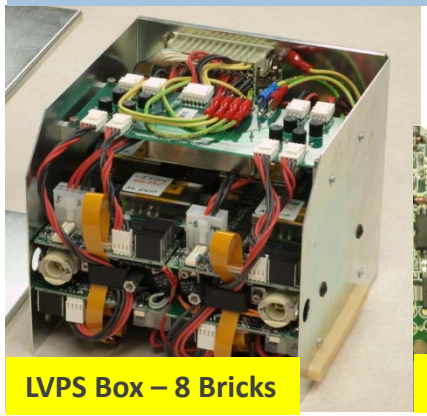
ANL RoIB Test Stand

Focus today is to determine if software approach is able to satisfy the 100kHz required level 1 input rate – decision on direction to be made in FY13

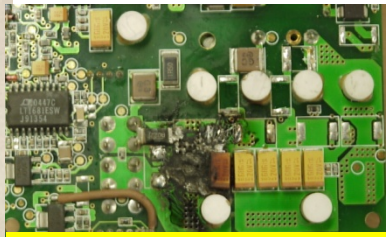
TileCal LVPS Redesign Project

- Challenging custom, high-performance electronics
  - Radiation environment, magnetic field, high-power
  - Compact size, switcher → noise
  - Infrequent access → High reliability
- Reliability concerns with original production
  - Bad board fabrication, bad assembly, substantial rework
  - Stability, noise, tripping
- Engaged ANL Elec. Eng. Group to study problems, and be responsible for redesign
  - 2009: First prototype
  - 2010: 5 boxes on detector
  - 2011: 41 boxes on detector
  - 2012: Full production of 260 boxes

ANL not part of original design team



LVPS Box – 8 Bricks



Burned caps – old design

New design has 20x Less Noise than Original Design

LVPS bricks trip during beam operations
Old bricks have tripped >10000 times
1 trip to date of production bricks

New bricks >900 times better than old bricks

Production on schedule (>50% complete) and on budget

Radiation Tests of Bricks

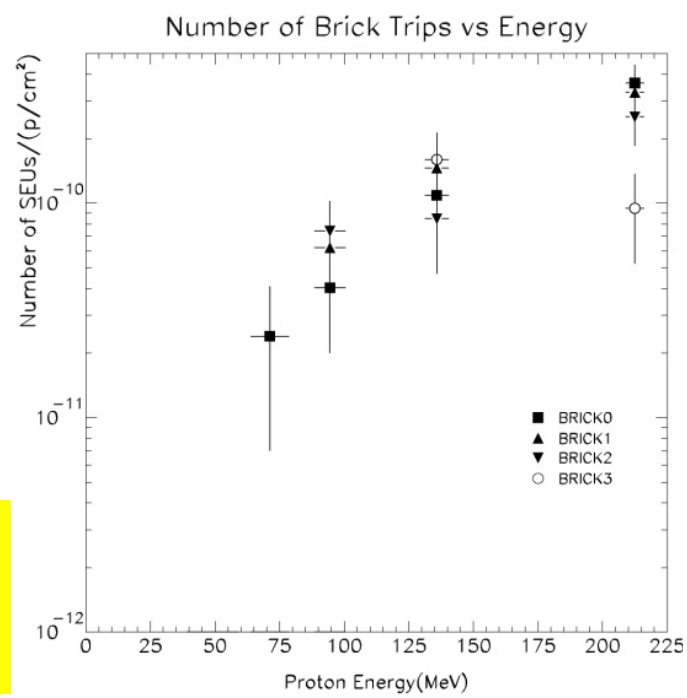
Requirements

Photons (TID)	Neutrons (NIEL)	Protons (SEU)
37 KRad	6E12 n/cm2-sec	1.7E12 p/cm2-sec
Safety Factor: 70	Safety Factor: 20	Safety Factor: 20

We used same parts, but questioned if something might have been missed
Also requested by ATLAS internal review committee

- Systematic studies not done well for original design
- We performed 8 Sessions – Dec. 2010 – Apr. 2012
  - Photons (TID) @ BNL, 1.2 MeV from Co-60
  - Neutrons (NIEL) @ UMass-Lowell, U-235 reactor
  - Protons (SEE) @ Mass Gen, 200 MeV radiation treatment
- Results:
  - Photons: Slow degradation; No failures
  - Neutrons: Slow degradation, No failures
  - *Protons: Found Single Event Upset with controller chip*
- Further study of SEU
  - Energy scan found threshold at ~80 MeV; (Not seen at 60 MeV)

SEU Trips vs. Energy
Measured @ MGH



We found a fix to the SEU problem – Confirmed fix in beam
Have now developed sophisticated tools & techniques to make these measurements in the future

Further Studies on LVPS Bricks

Two research projects established: ANL & UW-Madison + students

- ANL: J. Proudfoot, G. Drake, R. Stanek
- UW: Bruce Mellado, Abhirami Senthilkumaran, Anusha Gopalakrishnan

- Single Event Upset Energy Dependence
  - Phenomenological Theory: Bendel Parameters
    - Well known in space instrumentation
    - Not well known in HEP instrumentation
- Reliability – LVPS is a single point of failure, no redundancy – characterize failure rates and MTBF
  - No analytical study done on reliability of original bricks
    - Typically not done in HEP instrumentation

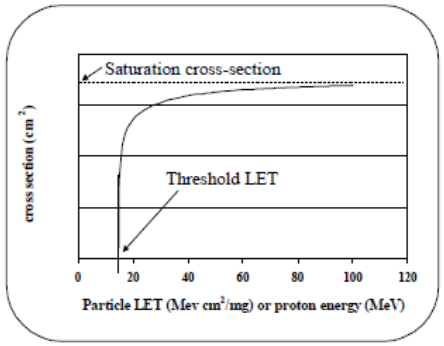
➢ Papers on both studies coming at 2012 IEEE NSS

R(t = 2 years)	R(t = 5 years)	R(t = 10 years)	R (t = 20 years)
0.992992	0.982573	0.965450	0.932094

Our result: Probability of Failure-free operation:

Function of Device Feature size

Device Cross-section (σ)

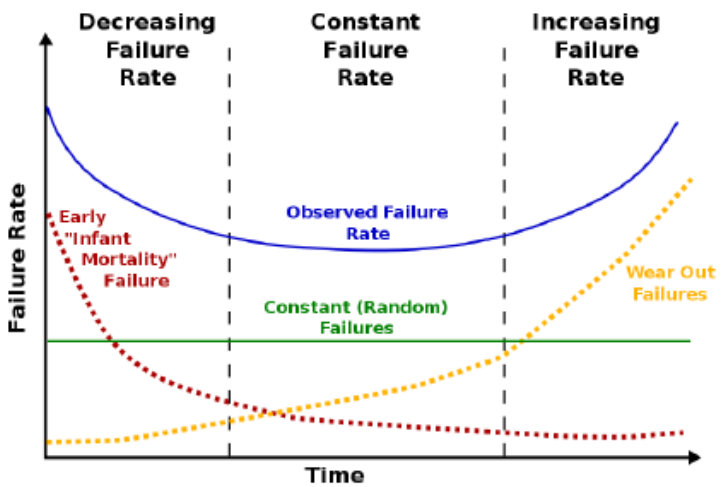


Proton beams:

$$\sigma = \frac{N_{events}}{\Phi} \quad (cm^2)$$

Heavy ion beams:

$$\sigma = \frac{N_{events}}{\Phi \cos\theta} \quad (cm^2)$$



General "Bathtub" Curve

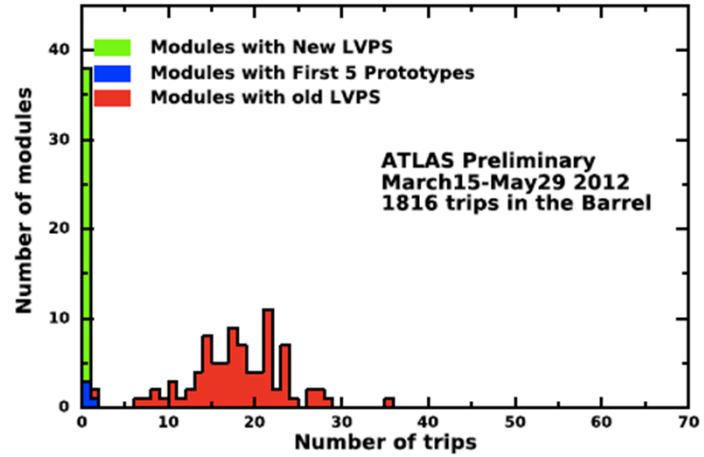
TileCal LVPS monitoring

One LVPS trips every ~1 pb^{-1}.

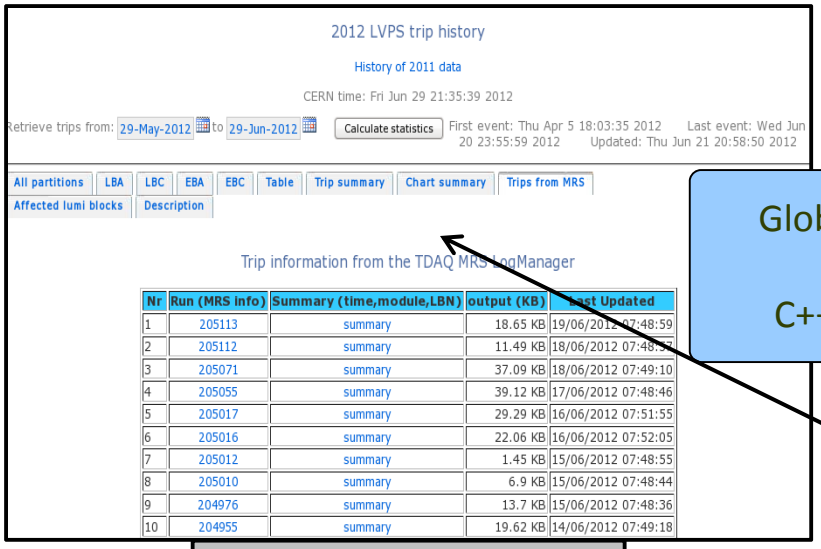
- Developed package to automatically identify and log LVPS trips (2011) {Chekanov, Proudfoot, Norberg}

Data are corrupted during module reconfiguration (~2 luminosity blocks, approximately 2 minutes of data)

- Extended software to identify data segments during which drawer electronics is being reconfigured following a trip (2012) {Chekanov}



Provides analyzers with luminosity blocks and ϕ-regions associated with LVPS trips (jets, MET studies)



Nr	Run (MRS info)	Summary (time,module,LBN)	output (KB)	Last Updated
1	205113	summary	18.65 KB	19/06/2012 07:48:59
2	205112	summary	11.49 KB	18/06/2012 07:48:57
3	205071	summary	37.09 KB	18/06/2012 07:49:10
4	205055	summary	39.12 KB	17/06/2012 07:48:46
5	205017	summary	29.29 KB	16/06/2012 07:51:55
6	205016	summary	22.06 KB	16/06/2012 07:52:05
7	205012	summary	1.45 KB	15/06/2012 07:48:55
8	205010	summary	6.9 KB	15/06/2012 07:48:44
9	204976	summary	13.7 KB	15/06/2012 07:48:36
10	204955	summary	19.62 KB	14/06/2012 07:49:18

atlaswww.hep.anl.gov

Global trip summary for all runs (including 2011)
C++ package for user analyses

Used to verify Data Quality/MET in SUSY Searches and Higgs→γγ+MET

Also provides automatic reporting of trips by module, brick- type, date, etc.

Atlas TileCal Upgrade (Phase 2)

Phase 2 plan is to replace all of the front-end electronics and provide digital data at the full detector granularity to the Level 1 trigger

Three options being considered for Tile Calorimeter PMT readout

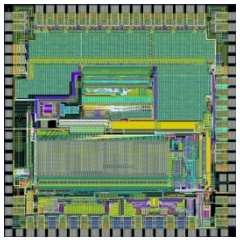
- New Front-End ASIC → QIE {ANL proposal}
- Passive shaper + digitizer as in present readout {U. Chicago proposal}
- Custom ASIC: current conveyor, signal shaping and 3-range ADC {Clermont-Ferrand proposal}

Redundant Front-End Power Supplies – LVPS

- *New: Point-of-load regulators*
- Argonne responsibilities
  - Design of new LVPS
  - Rad testing of POL Regulators

QIE10.3 chip

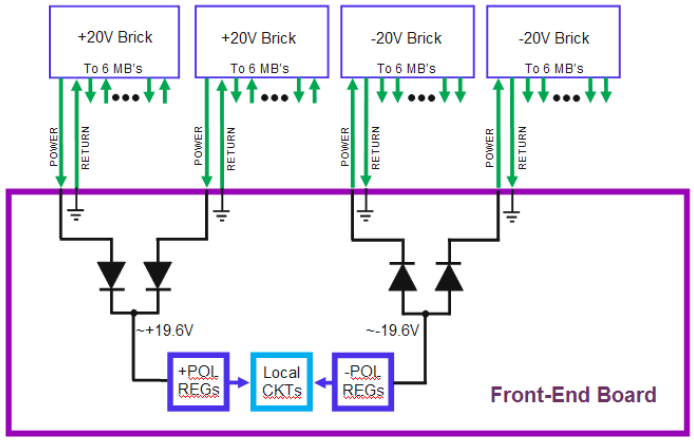
Current splitter with gated integrator
No Pulse Shaping
Best solution for high pile-up?



Collaboration with Fermilab/ANL to develop common solution for TileCal and CMS HCAL

4 ranges; 17-bits dynamic range;3 fC least count

- 2 test chips + 1 functional prototype in hand
- New Submission in November, 2012
- Target: Test beam in 2015

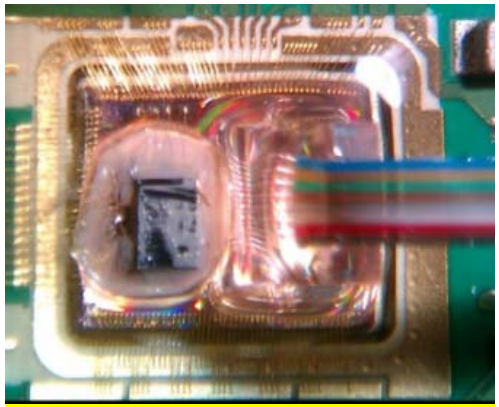


Prototype design of LVPS in progress
Target: Test beam in 2015

Also being explored

Optical Modulators for high bandwidth, radiation tolerant data links

- Idea came from work done in the ANL Detector R&D Group
- offer potential for significantly improved performance over VCSEL-based optical links
  - Availability: COTS devices 1st choice
  - Reliability: Proven in the field, BER 10^{-18}(10^{-12} for VCSEL)
  - Radiation tolerance: ~100 kRad TID, ~10^{12} had/cm2/s
  - Cost Savings over SNAP12 Baseline (single mode fiber)
  - Plan to deploy on demonstrator drawer in 2013



4 x 10Gb/s transceiver from Luxtera, 130nm Silicon on Insulator (SOI)

GEANT4 on Blue Gene using Blue Gene/P at Argonne as platform (testing done via otherwise unused cycles)

- These resources are big: BG/Q is ~20x the worldwide pledged CPU for ATLAS simulation
- Have succeeded in running G4 job on BG/P
- Our next step is to make ATLAS G4 run on BG/P.
  - That will take new effort

Blue Gene/P Node Card)

Summary

Physics analysis requires a functioning detector and the Argonne group has provided expertise in several key areas in the past and will continue to do so in the future:

The Region of Interest Builder :

- we are one of only 2 institutions responsible for the operation of this critical component in the ATLAS trigger
- we are investigating options regarding the long term future of this element of the trigger system

Tile calorimeter:

- we took on the responsibility to redesign a problematic power supply system
- we contributed automated software tools to provide rapid feedback on detector performance and data quality

We are engaged in several areas of R&D for Phase 2 upgrades

- Tile calorimeter front-end readout
- Design of redundant power supplies for the tile calorimeter
- High bandwidth optical links
- Hardware replacement option for Region of Interest Builder

Extras

Operations and R&D Tasks

Operations:

Tile Deputy Run coordinator (Fullana)
Tile Deputy Run Coordinator and Run Coordinator (Salvachua)
JetEtMiss Monte Carlo coordinator and validator (Fullana, Asquith)
MinBias Trigger Coordinator (Zhang, Paramonov†)
ATLAS Run Manager (Zhang)

Region Of Interest Builder Expert, 24x7 (Zhang, Blair, Paramonov†, Auerbach†)
Tile Replacement Power Supplies QA (Ngyuen†, LeCompte)
Tile Calorimeter Online Monitoring and Data validation (Chekanov†, Nodulman)
Tile LVPS trip monitoring (Chekanov, Proudfoot + Grad. Student Fellow Norberg†)
Tile signal reconstruction and validation (Fullana, Salvachua, Proudfoot + Grad. Student Fellow Kruse†)

Detector R&D:

Radiation studies (Stanek, Proudfoot + Electronic Engineer Drake)
QIE and LVPS upgrade for TileCal (Price + Electronic Engineer Drake)
Optical Links (Stanek, + applied physicist Fernando)

†Qualified/qualifying as ATLAS author based on these tasks