TileCal Maintenance and Operations

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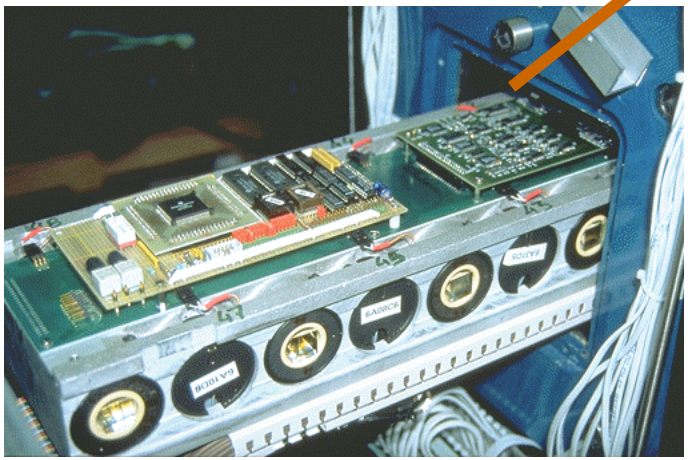
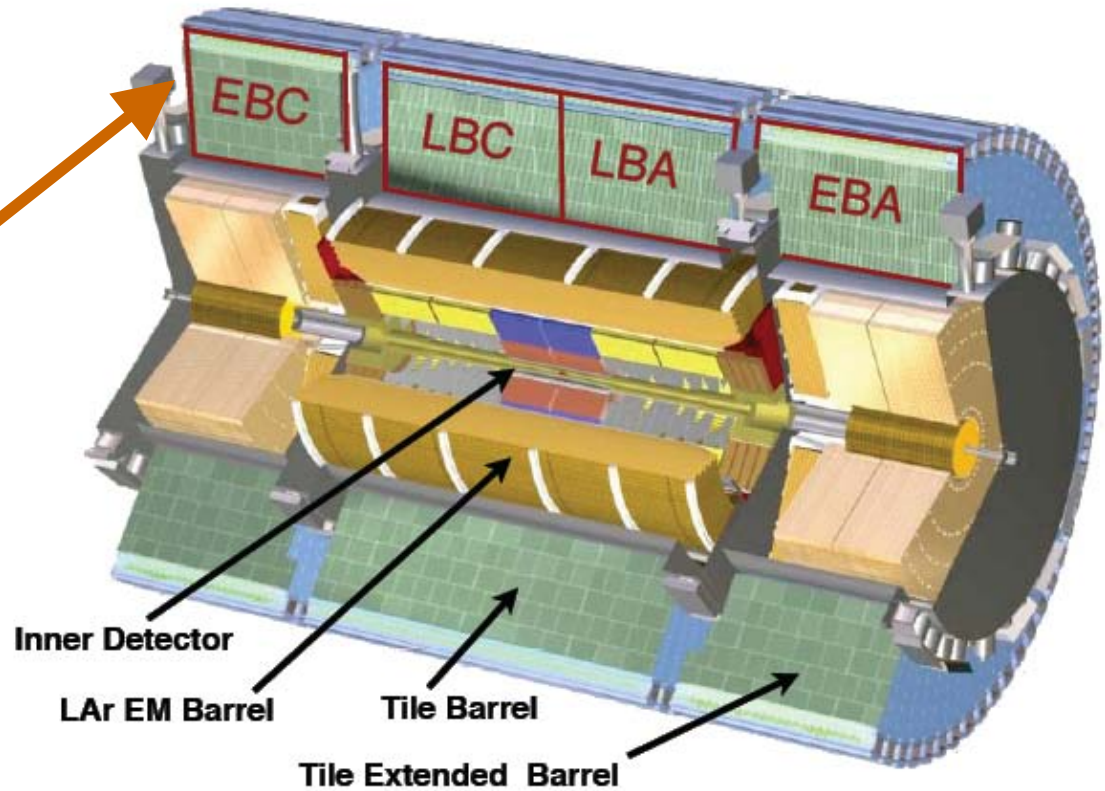
ATLAS Tile Calorimeter

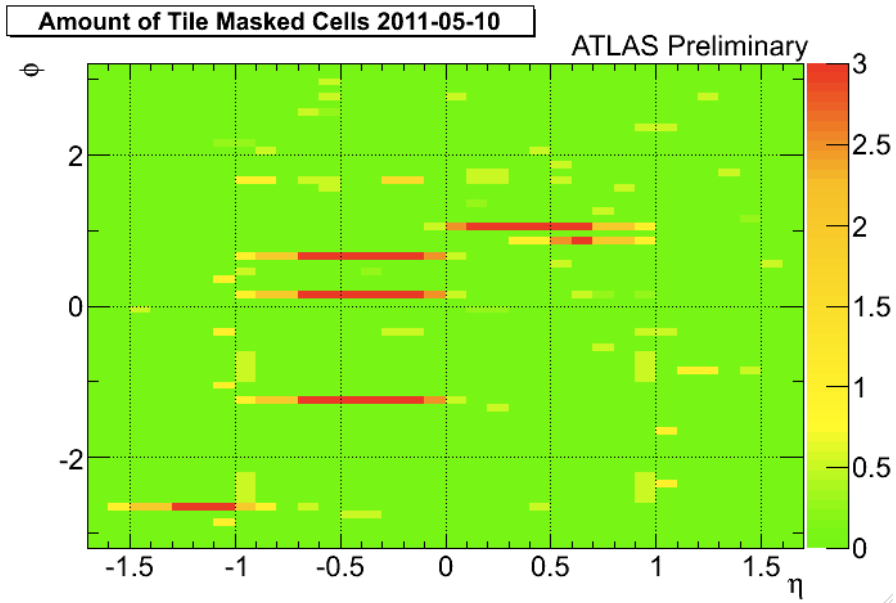
- Covers $|\eta|<1.7$ with granularity $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$
- Depth = 7.4 interaction lengths
- 3 depth segments
- 9856 PMT-based readout channels (2 per cell)
- 256 readout drawers
- Resolution = $50\%/\sqrt{E} \oplus 3\%$



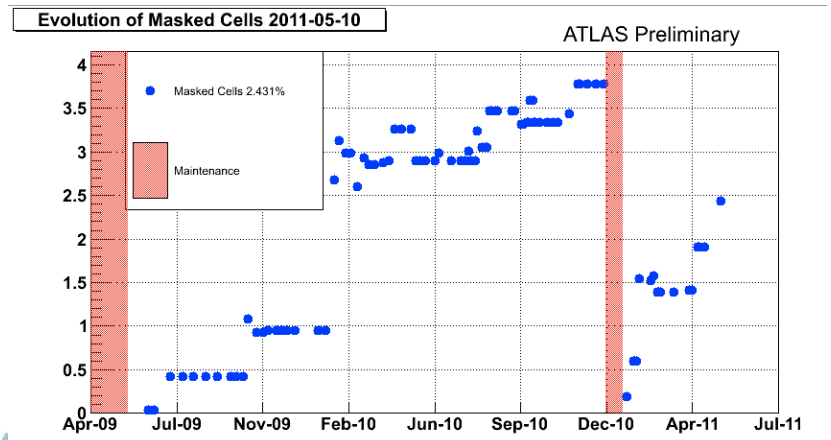
Readout Drawer in girder at outer radius of calorimeter



Operational Status of TileCal



- Current status
  - 100% of data is tagged as good in 2010 and 2011
  - 97.1% cells are operating and read out
  - Can take triggers at design 75 kHz
- Complicated instrument
  - Continued success takes constant vigilance
  - …and work
- Argonne is a key institute in operating and maintaining TileCal



Module	Failure date	Maintained	Synthoms
LBC52	17th Jan 2011	No	No power to interface card
LBA11	18th Jan 2011	Yes (LVPS)	LVPS trip after 1 min
EBC37	24th Jan 2011	No	LVPS does not start
LBA24	9th Feb 2011	No	HV side of LVPS trips (non optimal voltage on PMT)
LBC07			No power to interface card
LBC02			LVPS does not start

Success takes constant attention

- Number of LVPS trips during data taking is increasing with luminosity.
  - Auto-recovery: We have implemented an automatic recovery that powers ON the modules and re-include them into the acquisition in 1-2LB (lumiblocks) or 2-3 minutes to minimize the data losses.
  - Monitoring: ANL has created web-base tools to monitor the number of trips per module
  - Test of modified LVPS
  - Design and production of new LVPS

- High trigger rate tests
- Tile Calibration
  - Regular calibrations to provide conversion factors and check stability of the system
  - Recently a non-linearity at the level of 2-3% was found in the laser system used to calibrate TileCAL (maybe explain briefly the calibration system).
  - Schedule special calibration runs to test the linearity of the laser
- Digital errors in some modules
- EM scale precision improvement
- New Laser system near completion
- Follow-up of the observed up-drift response of ~1% per year in cesium calibration runs
- Integrate calibration runs into the data Quality display so that shifter knows if a run was good or needs to be retaken

ANL People

- Management and Coordination
  - L Price
  - B Salvachua
  - R Yoshida
  - R Stanek
- Data Quality monitoring
  - L Nodulman
  - C Suhr
- LVPS Monitoring
  - J Proudfoot
  - S Chekanov
  - S Norberg
- Shifts
  - All above
  - T LeComte
- LVPS
  - G Drake
  - T Cundiff
  - P DeLurgio
  - A Kreps
  - C Adams
- Software
  - A Artamonov
  - G Lima
- Detector Open Maintenance
  - T Nephew/Other techs

Argonne Contributions

- Funded through US ATLAS
  - LVPS maintenance and analysis (Drake, DeLurgio)
  - LVPS replacement (Drake, DeLurgio)
    - Design, prototyping, testing, construction
  - Software development and maintenance (Artamonov, Lima)
  - TileCal maintenance while detector is open (Techs)
  - Operation and maintenance of Calibration and Test Facility (B175) (Drake, Kreps)
- Funded through Base program
  - Shifts (many physicists)
  - Run Coordinator (Belen Salvachua)
  - Data Quality (Larry Nodulman, Chad Suhr)
  - Institute Board Chairman (L. Price to April)
  - TileCal Project Leader (R. Stanek to February 2009)
  - (Jet/ETMiss performance group) (Proudfoot former co-chair)

LVPS overview

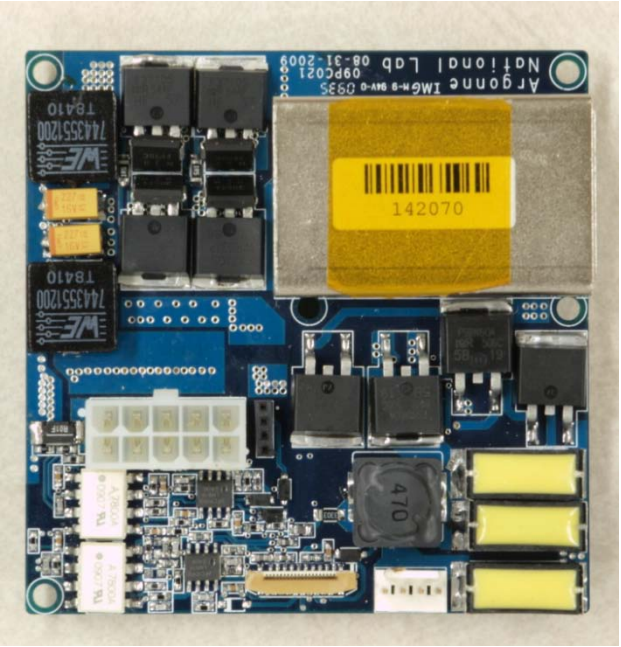
- Argonne stepped in to work on Tile low voltage power supplies (LVPS) in 1996, when the original supplies were found to have severe problems
- After evaluation, the team of Gary Drake and other engineers designed modifications of existing boards
  - Under strong time pressure
  - Installed in detector in 2008
- Resulting supplies have worked very well but not perfectly
  - ~2% stop working per year
  - Recent phenomenon of LVPS trips requiring reset
    - Rate proportional to luminosity
- A redesign of the LVPS system is underway
  - Planned installation in 2013-4
  - Following analysis of remaining issues in modified supplies
- Argonne has recently developed a new monitoring tool for LVPS trips
  - Collect statistics
  - Analyze circumstances (and causes if possible) of trips
  - ***Try*** to understand ***all*** current problems before new design is finalized

LVPS (Re)Design Team

- Personnel:
  - ANL Engineers & Electronics Support
    - Gary Drake - Senior Engineer
    - Patrick De Lurgio - Design Engineer
    - Andrew Kreps - Engineer (Software Support)
    - Tim Cundiff - Engineering Assistant
    - Carolyn Adams - Technician
  - ANL Physicists
    - Larry Price – Senior Physicist
    - Bob Stanek – Physicist
  - Support at CERN
    - Stanislav Nemecek – Physicist
    - Irakli Minashvili – Physicist
    - Denis Santos – Physicist
    - Anna Ershova – Technician

Redesign Project History

- Prototype design cycle begun ~June, 2009
- V7.1.0 – December, 2009, Quantity 10 bricks
  - Tested at CERN in Bldg 175 - 8 bricks in Box 066
    - ⇨ *Running in long-term test since March 2010*
    - ⇨ *No significant problems, Still running*
- V7.3.0 – October, 2010, Quantity 10 bricks
  - Tested at CERN in Bldg 175 - 8 bricks in Box 304
    - ⇨ *Ran in long-term test Oct.-Dec., 2010 → ~90 days*
    - ⇨ *No significant problems*
- V7.3.1 – November, 2010, Quantity 64 (→ 80) bricks
  - Delivered 4 boxes to CERN (+ 1 from Oct. = 5 boxes total)
  - Tested in Building 175, "medium-term" test, ~1-2 months
  - **Boxes 1-5 installed on detector during shutdown**
    - ⇨ *Ran in long-term test Nov.-Dec., 2010 → ~30-45 days*
    - ⇨ *No significant problems*
- Performed radiation measurements 2011
  - Protons @ Massachusetts General Hospital
  - Neutrons @ Univ. of Mass., Lowell
  - Gammas @ Brookhaven



fLVPS ver.7.3.1 installed:				
MODUL	BOX#	BY	BOX#	ELMB
LBA47	59		304	C582
LBC33	176		305	E315
LBC36	145		306	C256
LBC40	83		307	I924
EBC39	169		308	F031

Locations of 5 Boxes in Detector

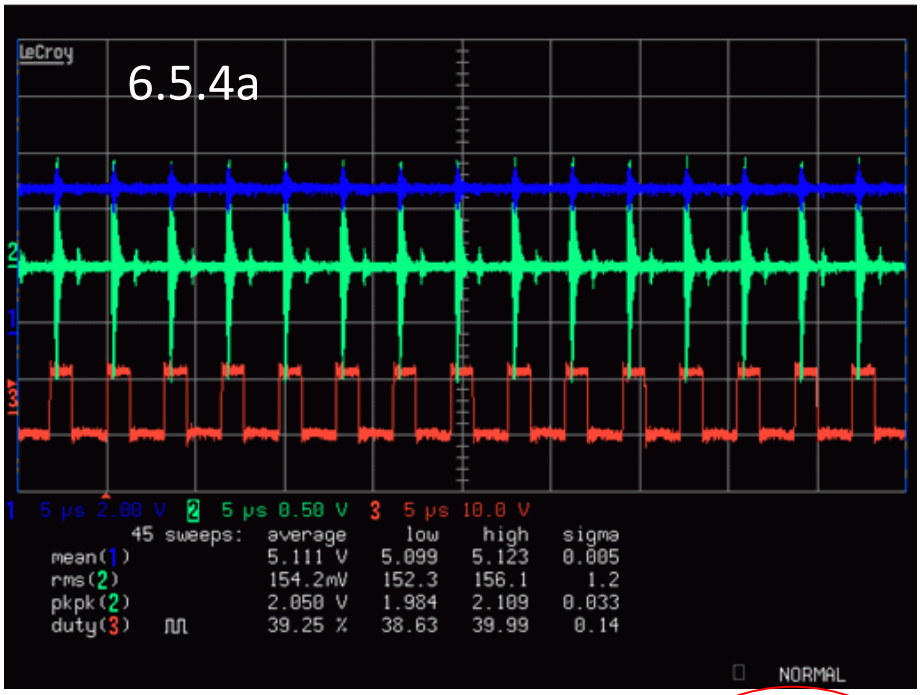
Summary of LVPS Design Changes

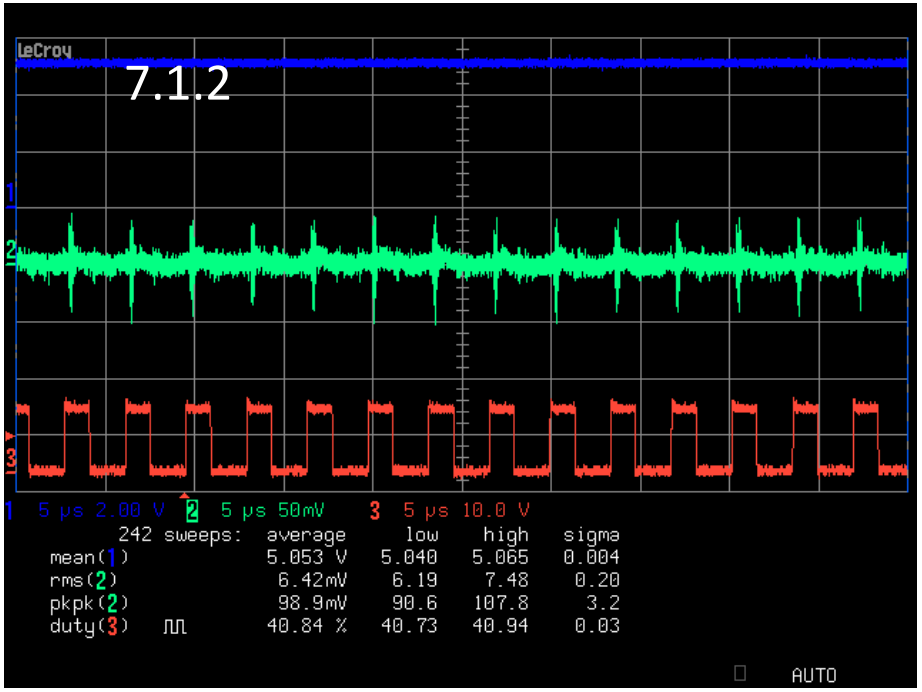
- **Critical Issues**
  - Reduce Noise……
  - Opto-Isolators……
  - Thermal Management……
  - Better input protection of U2…..
- **Medium-Impact Issues**
  - Address stability……..
  - Improve trip circuitry……
  - Power sequencing…….
  - No kludges ……
  - Fabrication and soldering quality
  - Tantalum capacitors……
- **Non-Critical But Highly Desirable**
  - Start-up Pulse current……
  - Eliminate pre-loads…….
  - Improve monitoring circuitry…..
  - IPC specs for assembly…….
  - Eliminate tuning OVP & OCP…

- **What we have done:**
  - ⇨ More ground planes; improved filtering
  - ⇨ Filter supply & input pins
  - ⇨ U1 & U2 over cold plate; Use Gap Pad
  - ⇨ Add diode protection of inputs
  - ⇨ New fast-feedback design; Slow FB redesigned
  - ⇨ Simplify secondary; OVP & OCP Logical OR
  - ⇨ New regulator with programmable delay
  - ⇨ No kludges in production
  - ⇨ Will use approved vendors
  - ⇨ Eliminate most; Use 35V caps on 15V sec. out.
  - ⇨ New regulator with programmable delay
  - ⇨ No preloads → New feedback design
  - ⇨ Differential techniques
  - ⇨ Design adheres to IPC specs
  - ⇨ Should be OK due to reduced noise

Critical Issue: Noise Reduction

- Measurement of Noise in the Time Domain
  - Comparison of +5MB @ 13 Amps → ~X20 less noise





Measurement	6.5.4a	7.1.2	6.5.4a/7.1.2
RMS (mV)	154	6.19	24.9
Peak-to-Peak (mV)	2050	98.9	20.7

Output Voltage (DC Coupled)

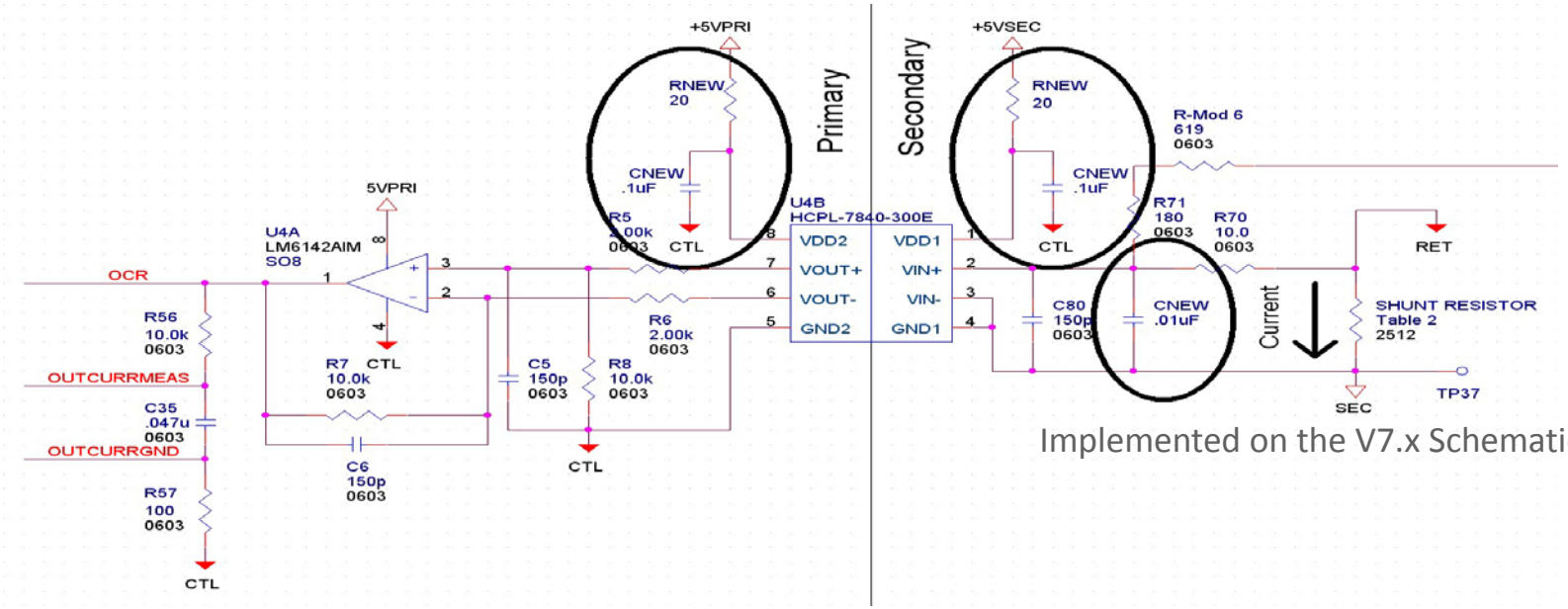
Output Voltage (AC Coupled)

LT1681 Pin 16 (PWM Output)

Note: Measurements at Load, Using Differential Probe

Critical Issue: Latch-Up of Opto-Isolators

- Addressing Latch-up of Opto-Isolators → Critical Issue
  - Problem with part discovered while analyzing trips
    - Confirmed with manufacturer
  - There is a known problem with latch-up in these parts due to fast noise spikes
  - Primary approach: Add filtering on power pins & input



Implemented on the V7.x Schematics

⇨ ***Have not observed any latch-up on V7 bricks…***

LVPS Radiation Testing

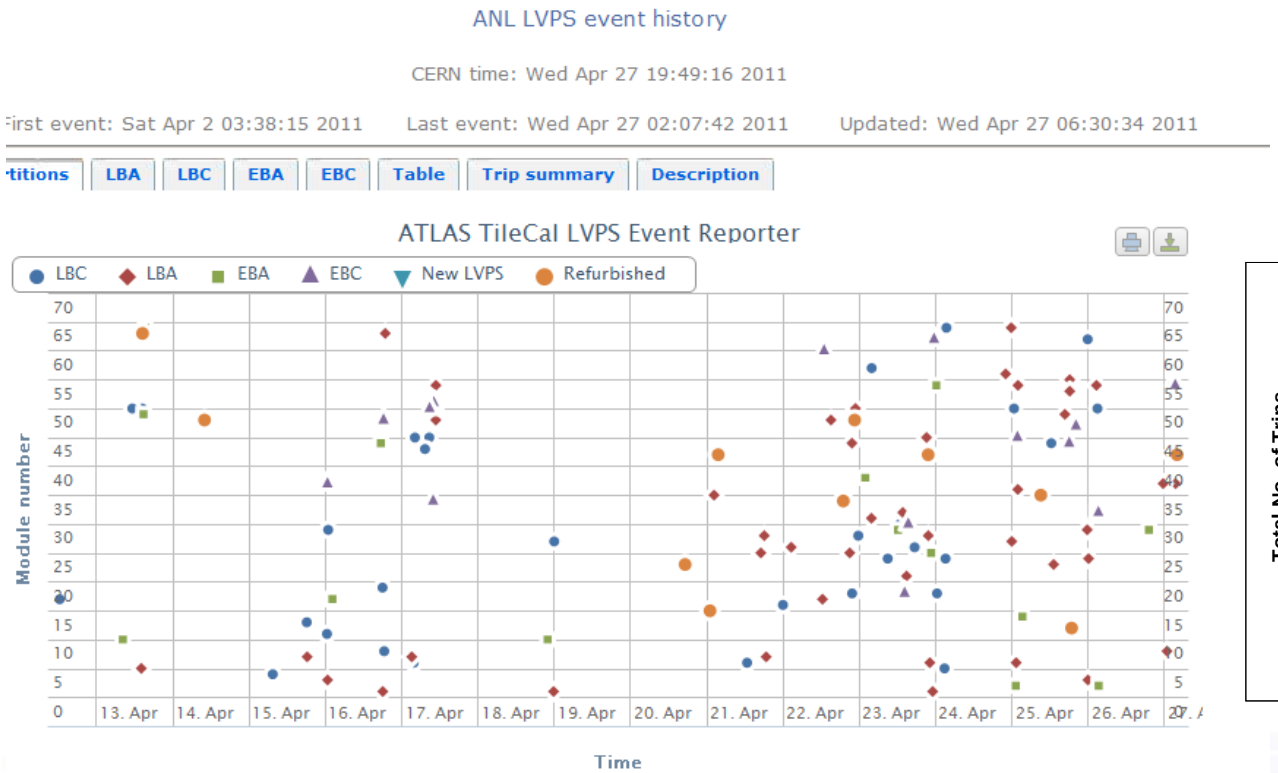
- Redesigned LVPS tested to ATLAS specs with gammas, neutrons, and protons
  - Protons @ Massachusetts General Hospital
  - Neutrons @ Univ. of Mass., Lowell
  - Gammas @ Brookhaven
  - Survived all tests, except...
  - ...Single event upsets (SEU) found with protons
- SEU issue has been traced to one component and is understood
- Circuit has been modified to prevent tripping by SEUs
  - Effects of increased overshoot at turn-on and small sag in output voltage after SEU is being evaluated
    - Tests on readout drawers at CERN have shown no interruption of data taking
    - Possible subtle effects in data are being looked for in detailed analysis

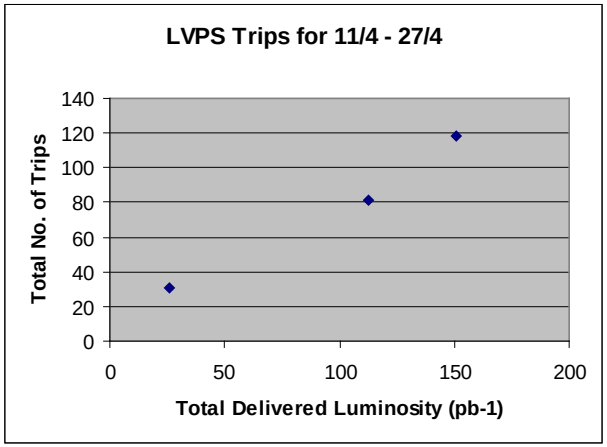
LVPS Replacement Project Plan

- Schedule (assuming success with current circuit in CERN tests)
  - May, 2011: Test modifications at CERN
  - June, 2011: Order long lead-time parts
  - July, 2011: ATLAS Production Readiness Review
  - August , 2011: Begin production
  - Dec., 2011: Minimum of 25 boxes ready for installation onto detector
  - Jan. – Dec., 2012: Complete production and testing
  - Jan. – Dec., 2013: Installation on ATLAS Detector and in-place testing
  - Jan. – ~June, 2014: Continued in-place testing until detector closing
- Production will be centered at and led by ANL
  - Testing at ANL and CERN
    - Technicians from multiple TileCal institutes
- Installation will be done by TileCal maintenance crew with ANL contribution
- Total Construction Cost ~$1.5M
  - Argonne portion of cost ~$1.1M

LVPS monitoring tools

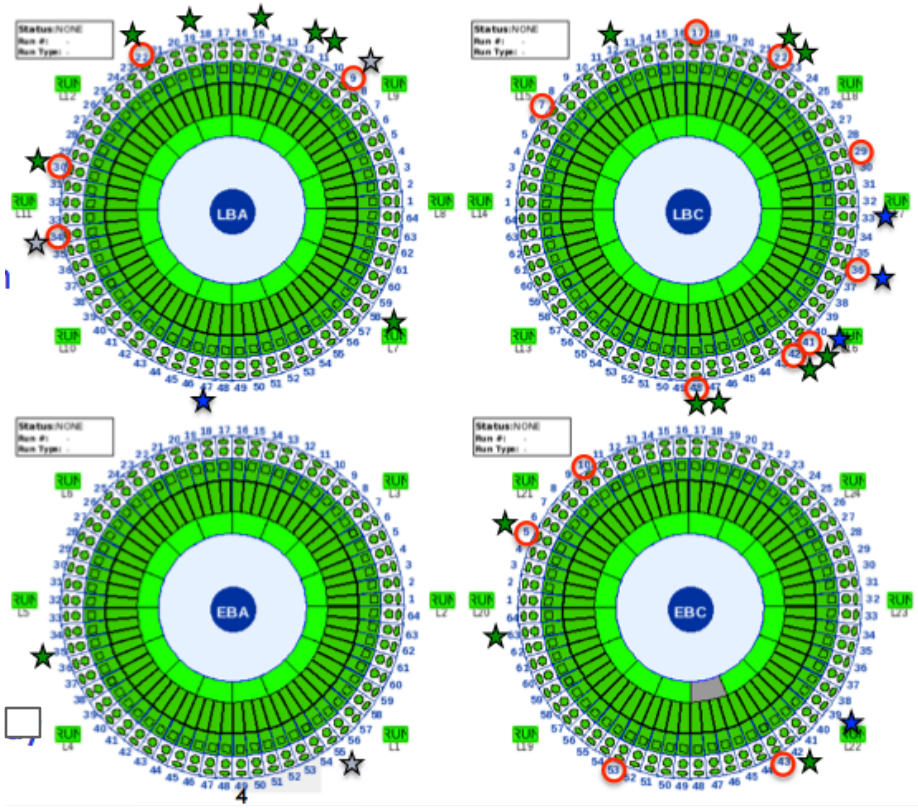
- New LVPS monitoring tool developed at ANL in 2011
- Observations
  - Trip rate is proportional to luminosity
  - “MB” subset of bricks in supplies trips much more often than “HV” subset does
    - Rules out SEU as primary cause of LVPS trips
  - Some “HV” trips may be caused by overcurrent
  - None of the 5 redesigned supplies (2% of total) has tripped since installation
    - (Outside of “massive” trips cause by external events)
  - All very preliminary still





Short shutdown 2010-2011

- Maintenance during Xmas Shutdown
  - LVPS
    - Replace 9 boxes either not working or suspicious
    - Replace 9 other boxes with “refurbished” supplies (extra filtering)
    - Install 5 new-design LVPS
  - Readout superdrawers
    - 18 superdrawers repaired
    - Variety of problems but most involved connectors
  - All drawers showed green in FSM display on 1/17



Future Shutdowns

- Dec 2011-Jan 2012
  - Maintenance of LVPS and Drawers
  - Add some number of redesigned LVPS
- Dec 2012-June (?) 2014 ("Phase 0 Upgrades")
  - Install new LVPS system (256 supplies)
  - Maintenance of drawers
  - Install 1 or a few drawers pointing to upgraded TileCal readout system
- 2015-Jan 2017 Short year-end maintenance
  - Maintenance of LVPS and Drawers
- 2017-8 or 2018-9 ("Phase 17 Upgrades")
  - Install some fraction of upgraded Tile readout drawers (scope to be decided during 2011)

Software development and maintenance

- A Artamonov
  - Maintenance and improvement of the LVPS tracking database
  - Responsibility for the TileCal part of the ATLAS Conditions Database
    - Implementation of ATLAS “Fast calibration loop”
    - Frequent need for new capabilities from those responsible for data preparation and data quality monitoring
  - Online and offline software for calculating and loading optimal filtering constants for per channel energy reconstruction
  - Maintenance of offline Tile reconstruction code
    - Bug fixes in code from many authors
    - CPU and memory use optimization
  - Improvement of execution speed in Tile-related trigger code
- G Lima
  - Tools for “Overlay” or pileup of multiple events for TileCal in ATLAS simulation
  - Co-software coordinator for TileCal

Summary

- Argonne playing central leadership roles in ATLAS Tile Calorimeter M&O
  - Run Coordination, Data Quality Coordination, Upgrade Coordination, Institute Board Chairman, Speaker Committee,….
- TileCal is working well as a result
- LVPS is a continuing issue, though not impacting data quality significantly
  - Argonne has stepped in with leadership on new design to replace current LVPS (Gary Drake's poster)
- A number of other issues are not critical but are receiving due attention