RPC2012

Performance and Operation of the ATLAS RPC Detector in 2011

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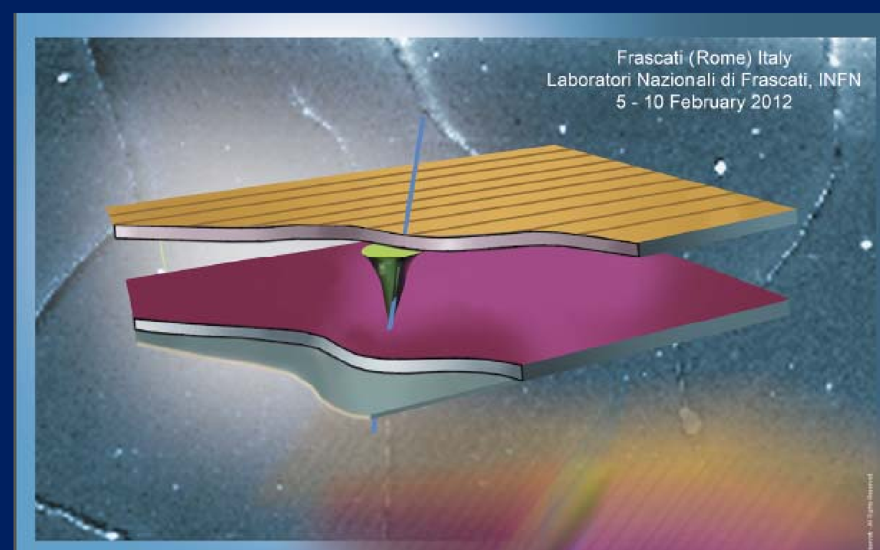
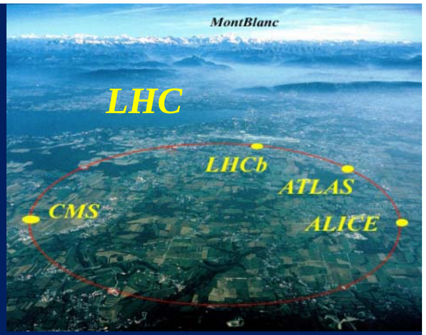
(on behalf of the ATLAS Muon Collaboration)

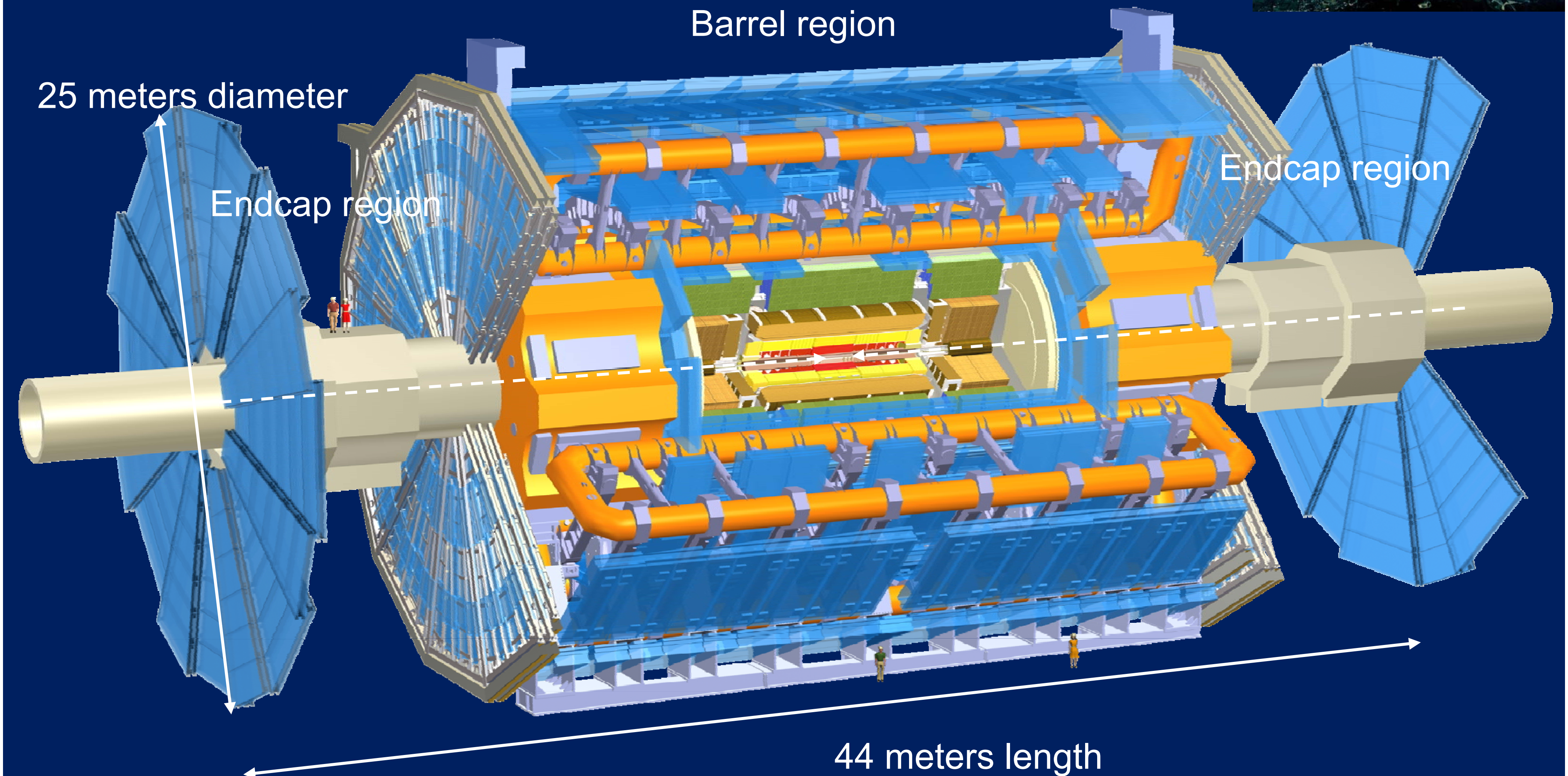
Outline:

- Detector Description
- Architecture and Special Features
- Status and Performance in 2011
- Operational Experience
- Future and Outlook

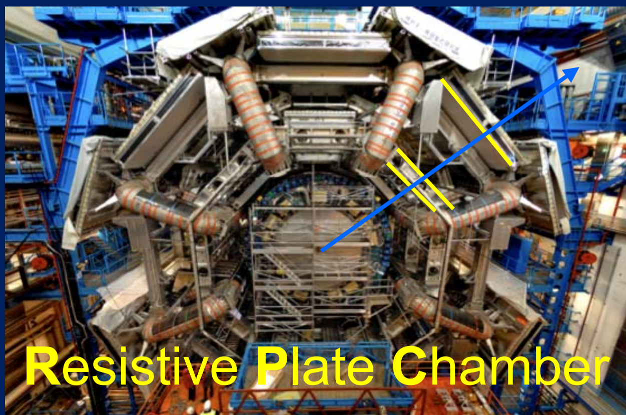


The ATLAS Detector

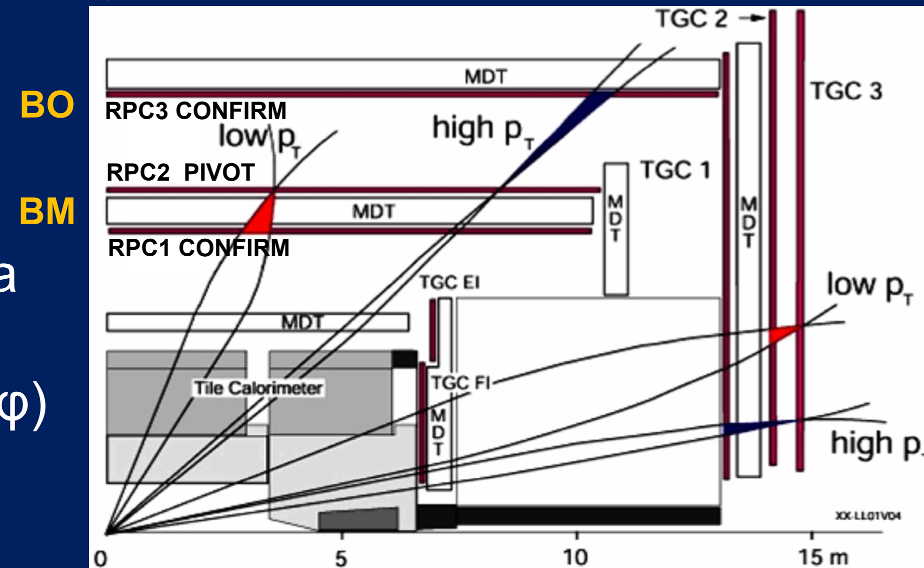


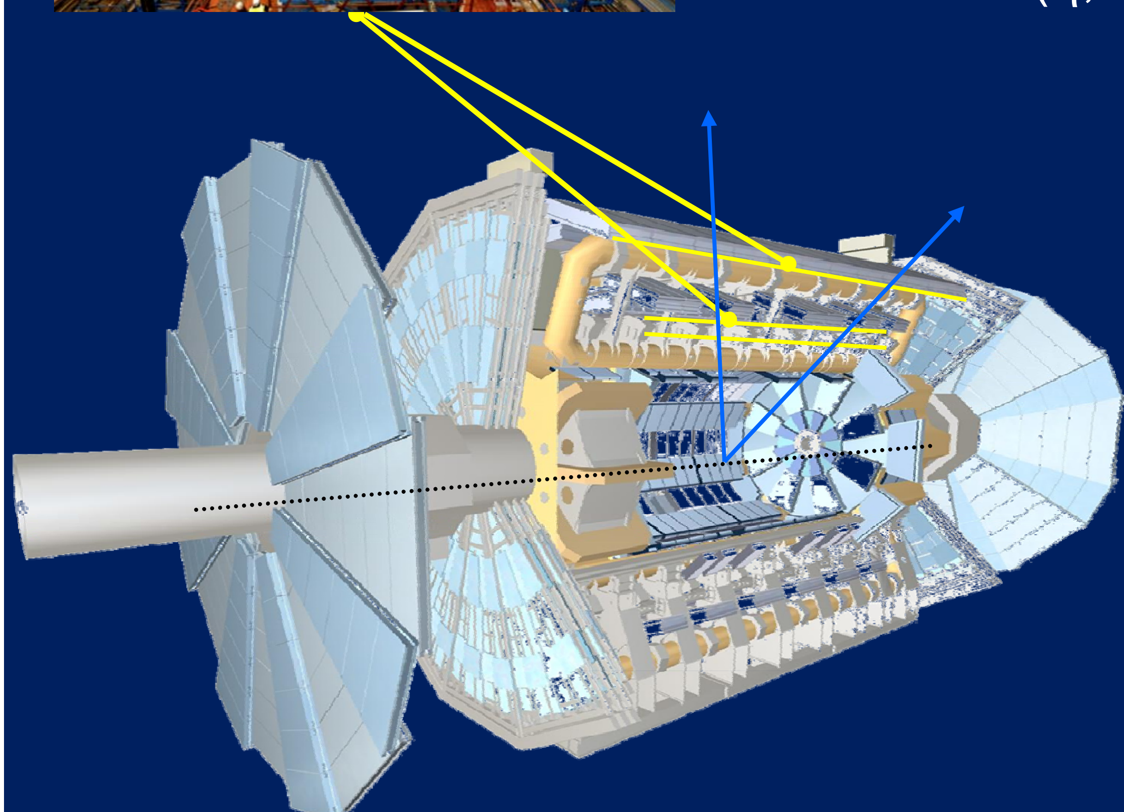


The ATLAS RPC System



|η| < 1.1
370k ch,
1100 units,
3650 m^2 det. area
used for Trigger
and Readout (η, φ)



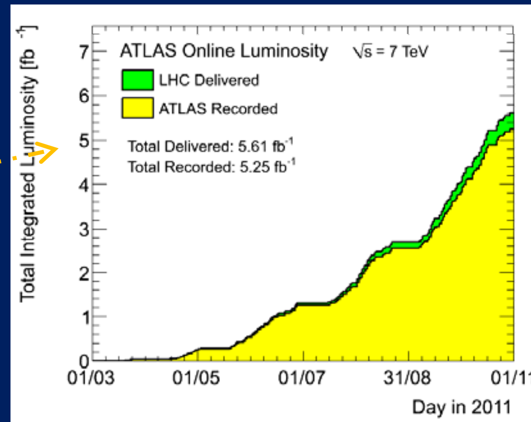


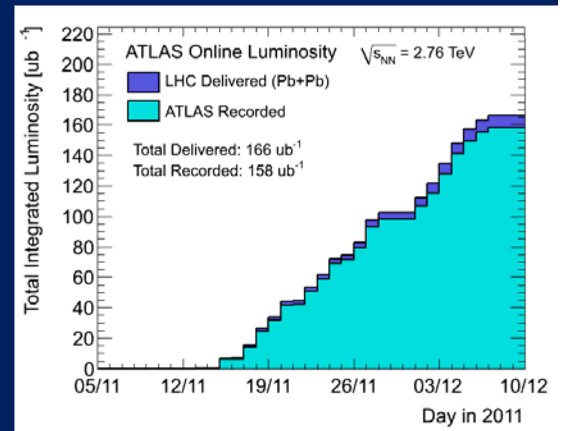
- 3 concentric shells of chambers (2 for low-p_T + 1 for high-p_T)
- Divided in 16 sectors of 12 RPC chambers (with exceptions)
- One chamber is made of two layers of independent detectors each providing an η and φ coordinate
- ~4000 gas volumes in total in hostile environment
- ~8000 readout strip panels ($3*10^5$ channels)

RPCs in 2011

2011 Run:

- Proton: 3.5 +3.5 TeV
- Integrated Luminosity > 5 fb^{-1}
- Peak inst. L 3.65×10^{33} $cm^{-2}s^{-1}$





RPC Generally running with

- active readout channels: 97%
- active trigger towers: 99.0 - 99.5%(0~3 off out of 404)

Disconnected Gas Gaps

- 47 (out of 3592) gaps disconnected from HV, mostly on BOL chambers (broken gas inlets)
- 23 gaps on HV Recovery channels

Detector usually very stable

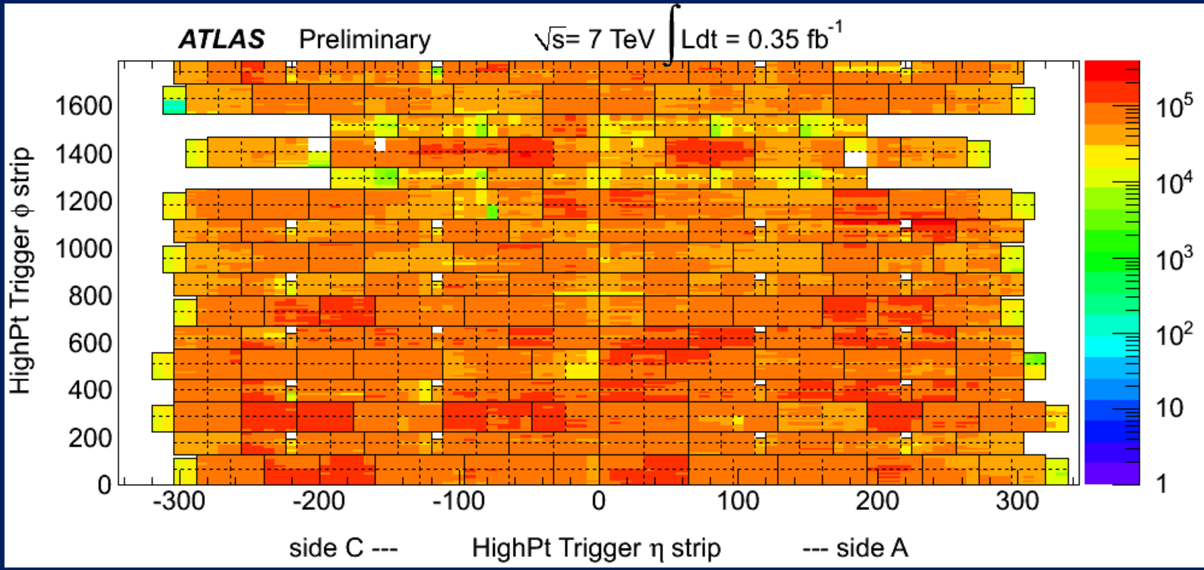
- RPC Data Quality ~99%

Detector and Trigger

Detector and Trigger Coverage:

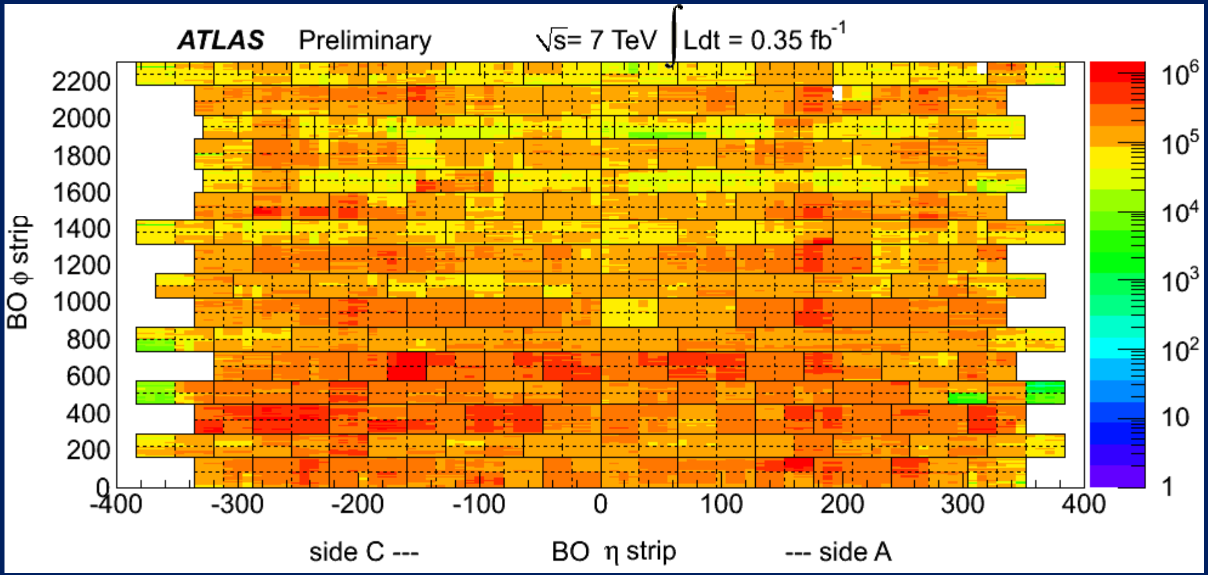
- Strip map for pivot layer

  Shown is the spatial coincidence between η and φ strips generating a high-p_T trigger

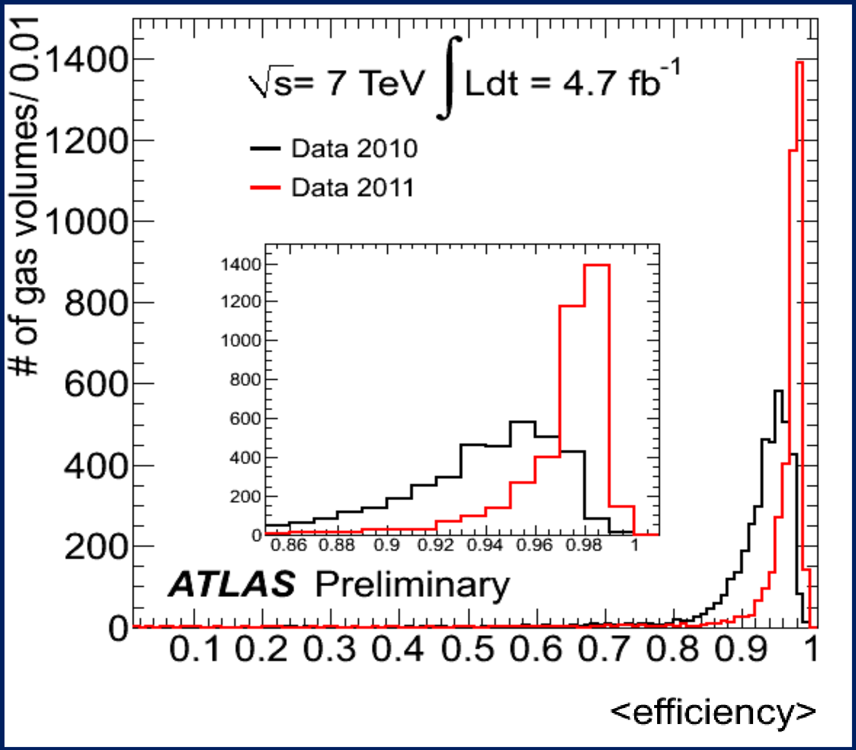


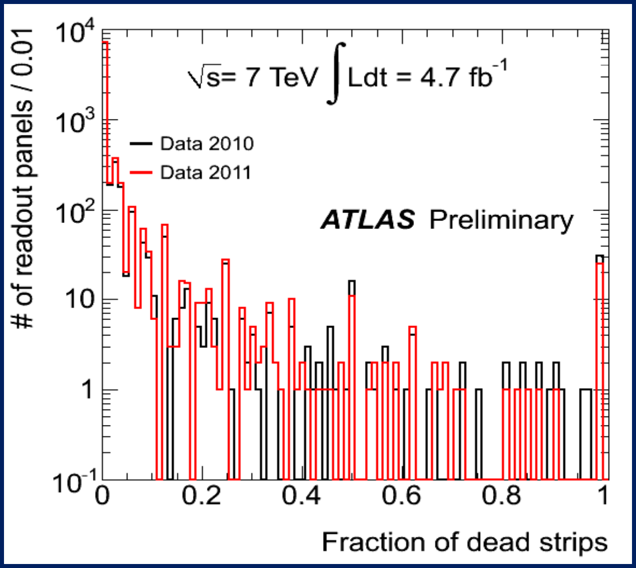
- Outer layer strip map

  Shown is the spatial coincidence between η and φ strips of both layers

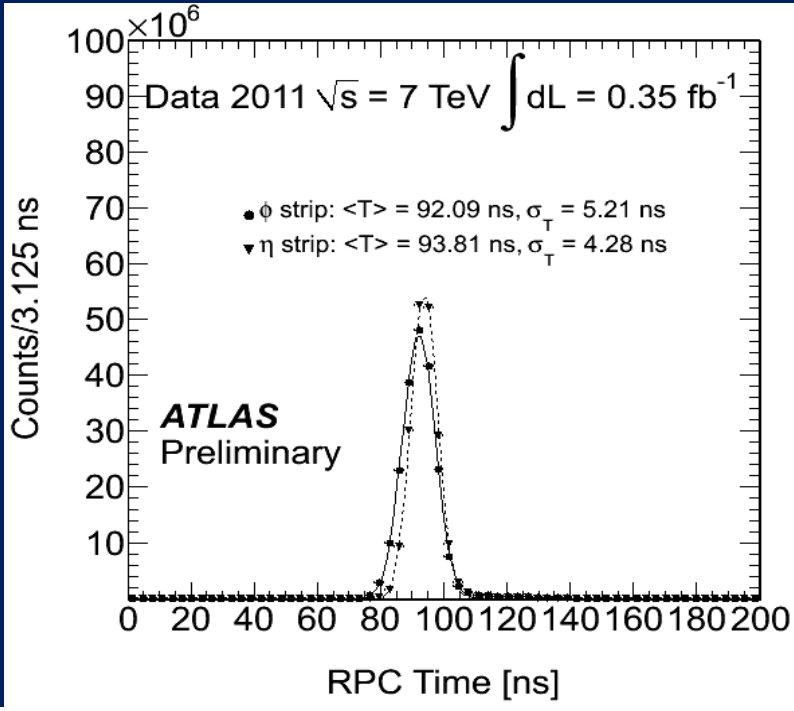


Detector Efficiency



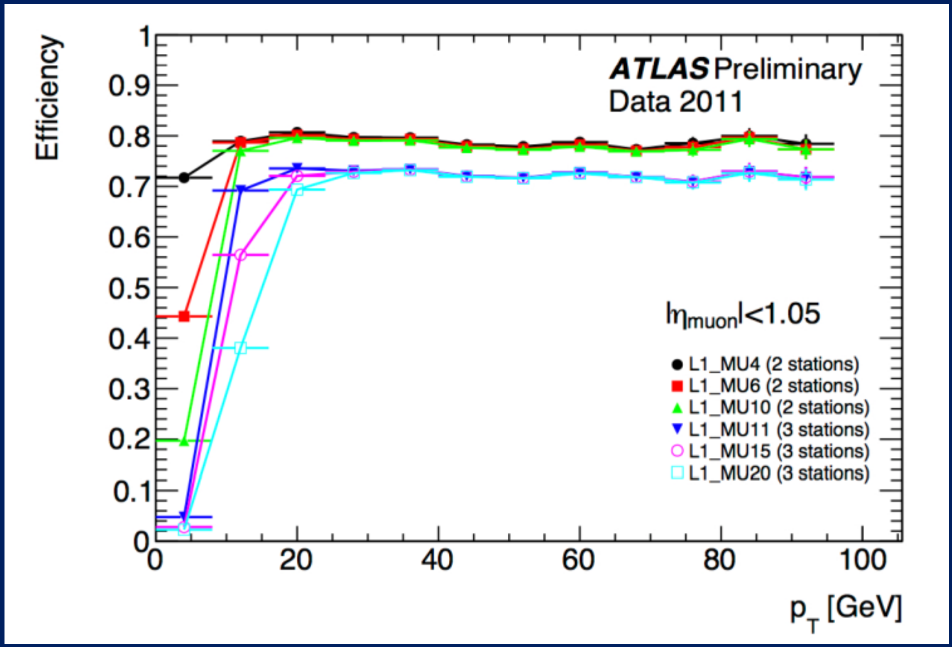


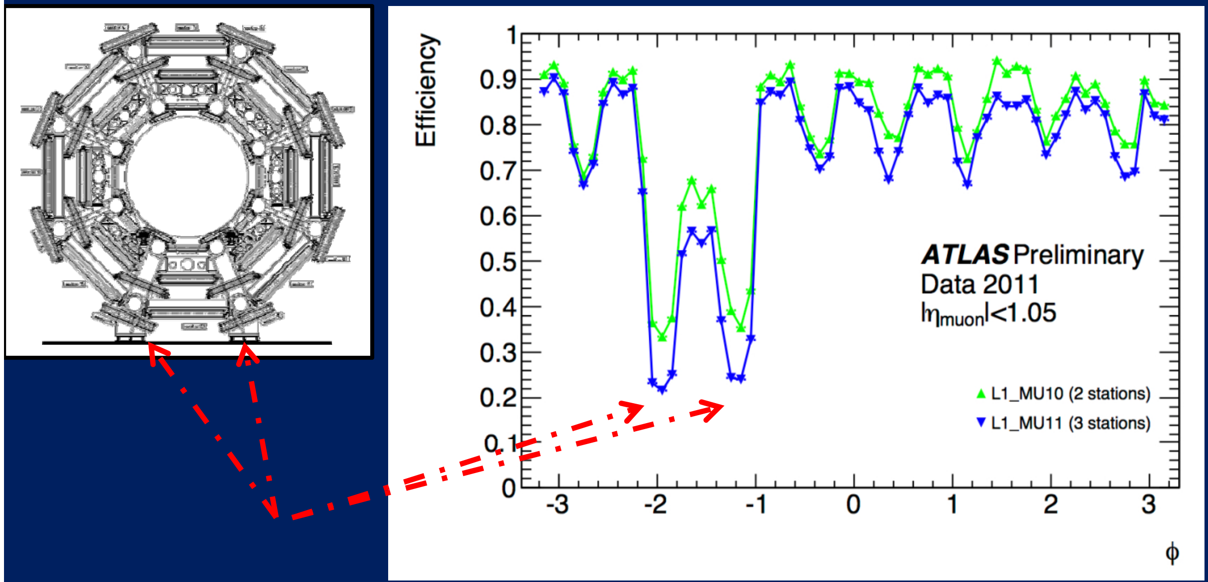
- Huge improvement in detector efficiency
  - HV working point (temperature and pressure) correction done via DCS
  - Timing well centered
  - The RPC can be used as a timing system
  - ➔ see presentation by G. Chiodini

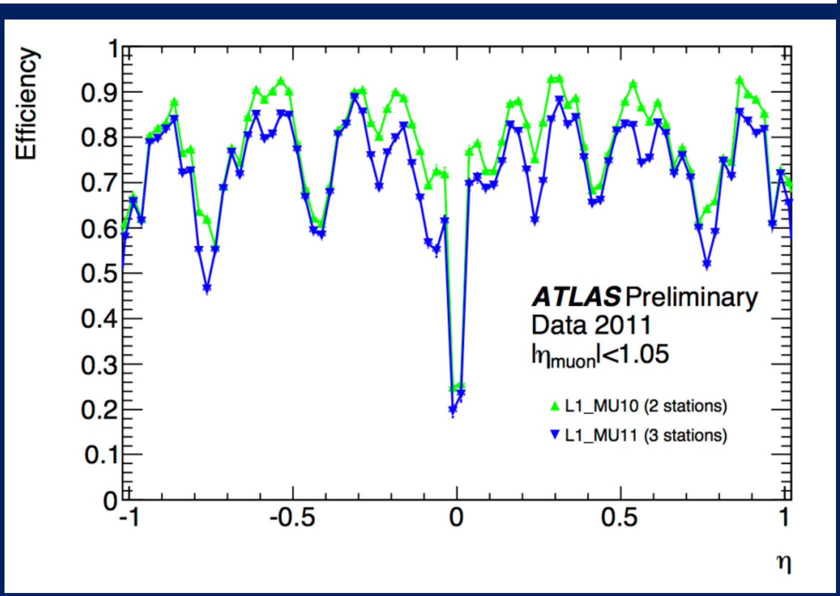


L1 Trigger Efficiency

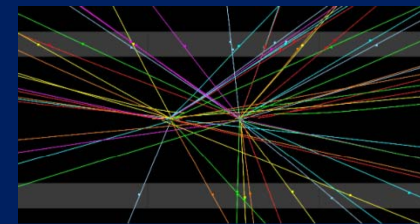
- Efficiency plots convoluted with detector acceptance
- Geometric coverage varies and is on average ~ 80 %
- Detector coverage is smaller for high-p_T (requiring hits in the outer chambers)



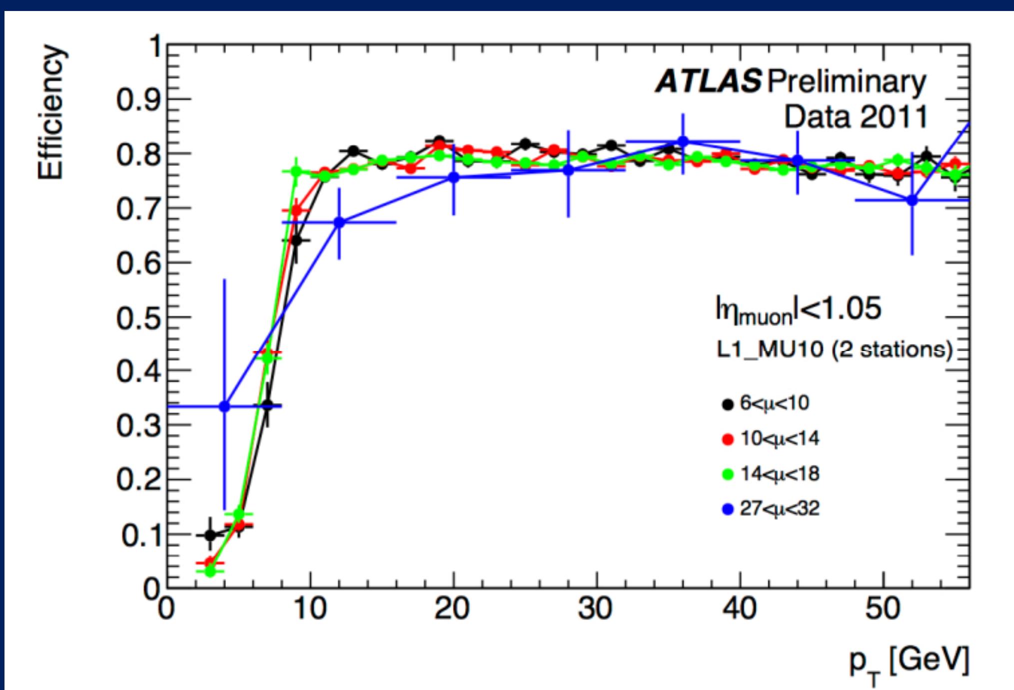


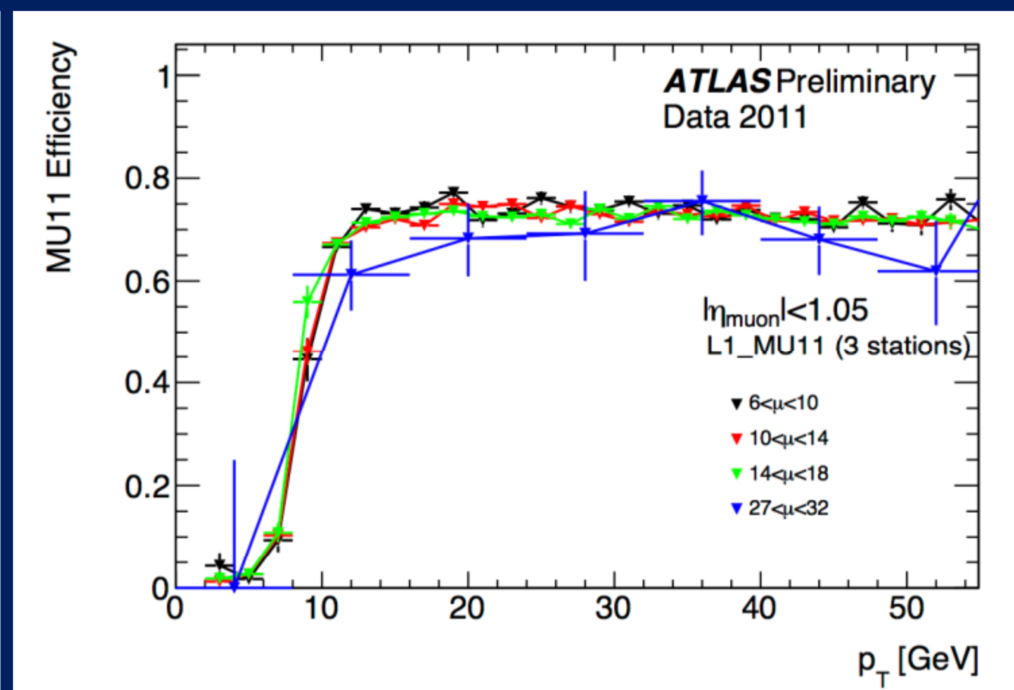


RPC Trigger and Pileup



- 2011 LHC typically running with 50ns bunch spacing
- Late 2011 run: average pileup <μ> ~15
- Low-p_T (mu10) & hi-p_T (mu11) trigger efficiency shown as a function of μ
- Pileup average < μ > is calculated per Luminosity Block (60s)
- Plots made on the last part of 2011 data taking
- No significant dependence of the trigger efficiency on pileup





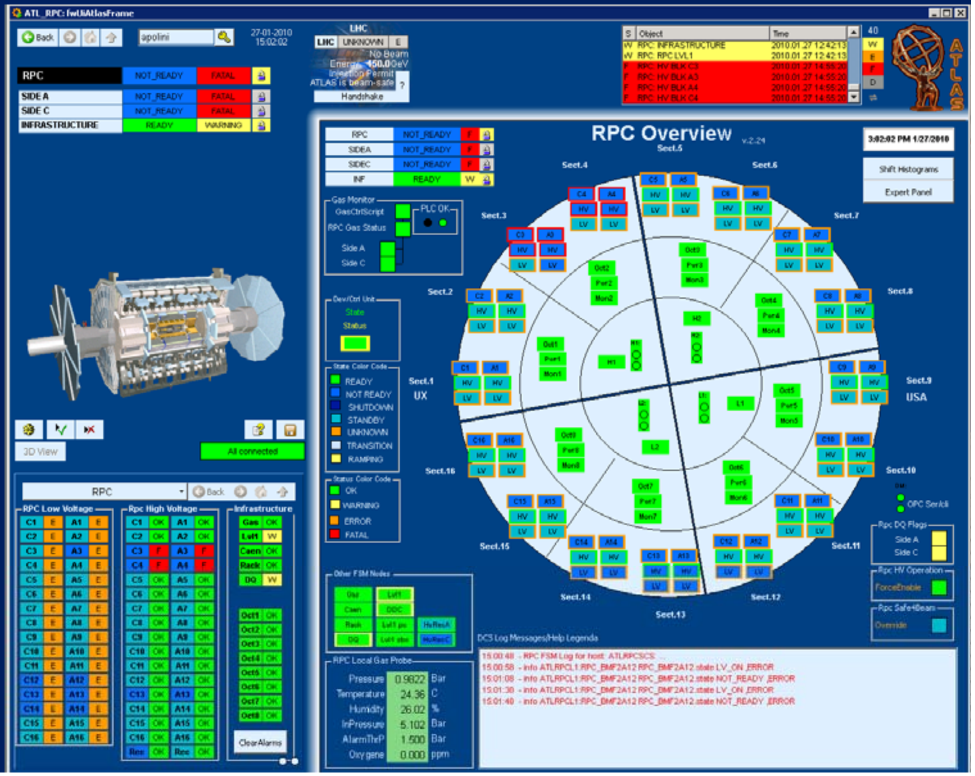
RPC Operation

2011 Running:

- System coherently integrated in Muon system (MDT, CSC, TGC) (single Muon Shift) and ATLAS
- Automatic HV handshake with LHC (HV STANDBY-READY)
- Monitor and automatic adjustment of HV set-points to T/p
- Monitor of detector noise, gap currents, correlation with trigger and luminosity
- Detailed monitoring of the infrastructure (to foresee hardware failures)

Key role played by the Detector Control System:

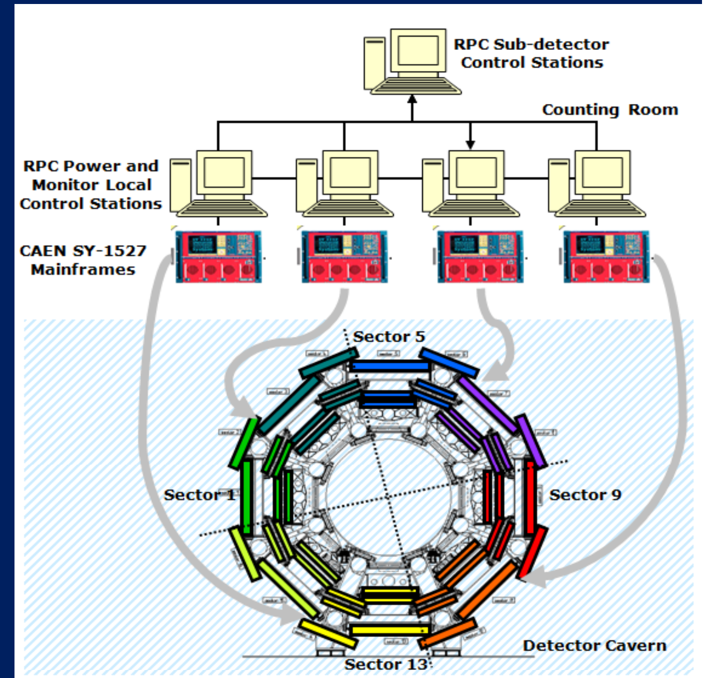
- Safe operation and detailed monitor the detector conditions
- Precise measurements of the current of each detector module:
  - Current of Each Gas Gap, LV Current drawn, Trigger Rates, Luminosity Correlations
- Large use of local sensors for monitoring of the environment:
  - Atm. Pressure, Temperature, Humidity, Gas Flow



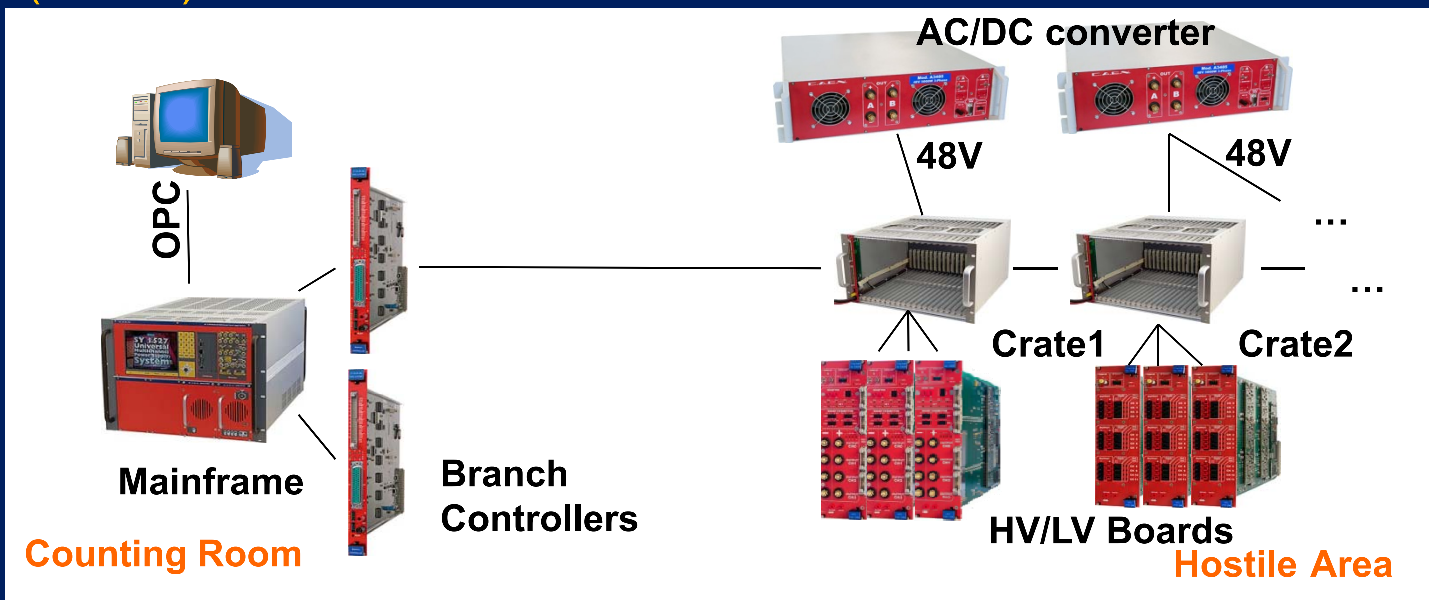
RPC Power and Control System

➔ Commercial Solution: CAEN EASY system

- Scalable system with huge number of HV/LV channels to control
- 4 Mainframes (SY1527) + branch controller boards in counting room
- Boards can operate in radiation area and magnetic field (up to 2kG)
- Dedicated modules: Power (A3486); High Voltage (12 KV, A3512AP); Low Voltage (A3009, A3025B)
- ADC module (A3801) with mean and peak measurement (~6400 ch.)
- DAC 128-channel ADC (A3802) ~ 3100 channels



$$\frac{N_{ch}^{DAQ}}{N_{ch}^{DCS}} \approx O(100)$$



RPC HV Working Point Correction

- Local T/P correction to the HV applied to the detector
  - $V_{applied} = V_{config} * \rho$ where $\rho = \rho_T \cdot \rho_P$
  - $\rho T = 1 + \alpha_T \cdot [(T/T_0) - 1]$
  - $\rho_P = 1 + \alpha_P \cdot [(P/P_0) - 1]$
  - RPC ~280 HV channels, ~ 350 T sensors
  - HV settings checked every few minutes

BM.Confirm

BM Temperature Measurements

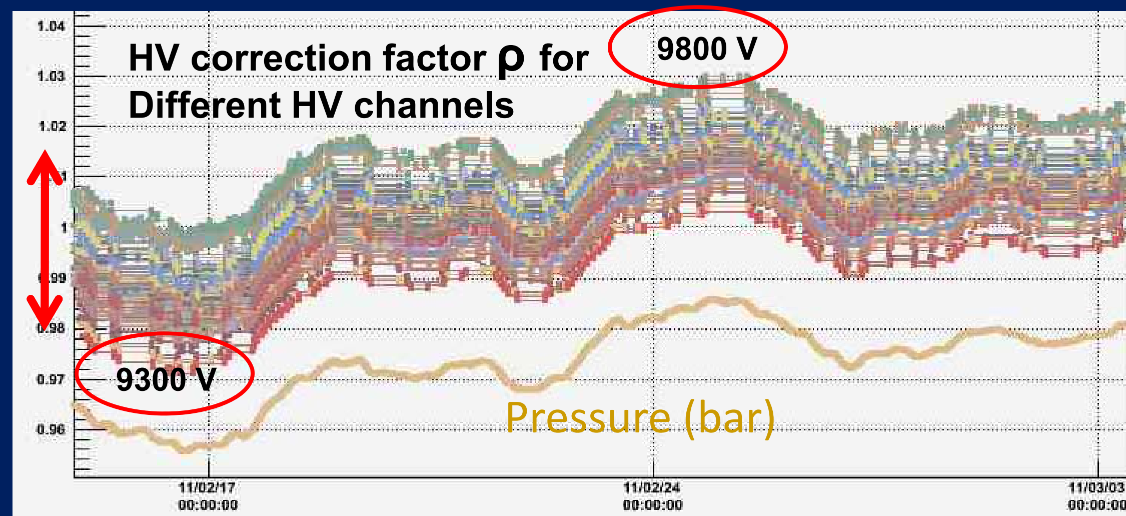
Sum of 16/02/2011 04:26 Column

Row Labels	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6
1	22,88		22,90		24,34			25,06		24,26		23,83
2		25,19		24,78		25,57	25,35				25,48	
3	24,75		24,01		25,91			26,02		24,47		24,59
4		27,48		26,18		26,33	27,69		25,39		27,10	
5	26,78		27,60		26,51			23,16		23,49		23,95
6		25,74		25,05		25,30	23,49		19,58		20,07	
7	23,79		24,99		24,41			24,63				24,19
8				25,97		24,65	24,06		25,06		25,91	
9	22,98		22,65		22,70			23,53		20,13		24,54
10		23,28		23,13		22,35	23,53		23,75		24,04	
11	23,13		23,45		21,53			23,03		22,84		23,05
12		21,43		21,43		21,74	21,61		21,53		22,48	
13	21,20		22,19		20,75			22,73		22,30		21,00
14				20,28		20,90	18,84		18,46		20,45	
15	22,46		22,98		23,30			22,02				22,07
16		24,16		24,09			22,35		23,50		24,39	

- 2011 Settings:
  - $V_{config} = 9600$ (9500 V*)
  - $P_0 = 0.970$ bar
  - $T_0 = 24$ °C
  - $\alpha_P = 0.8$; $\alpha_T = 0.5$

(* To limit chambers with T > 26°; ~ 5% of ch.)

- 2010 Settings
  - $V_{applied} = 9600$ (9400 V*)

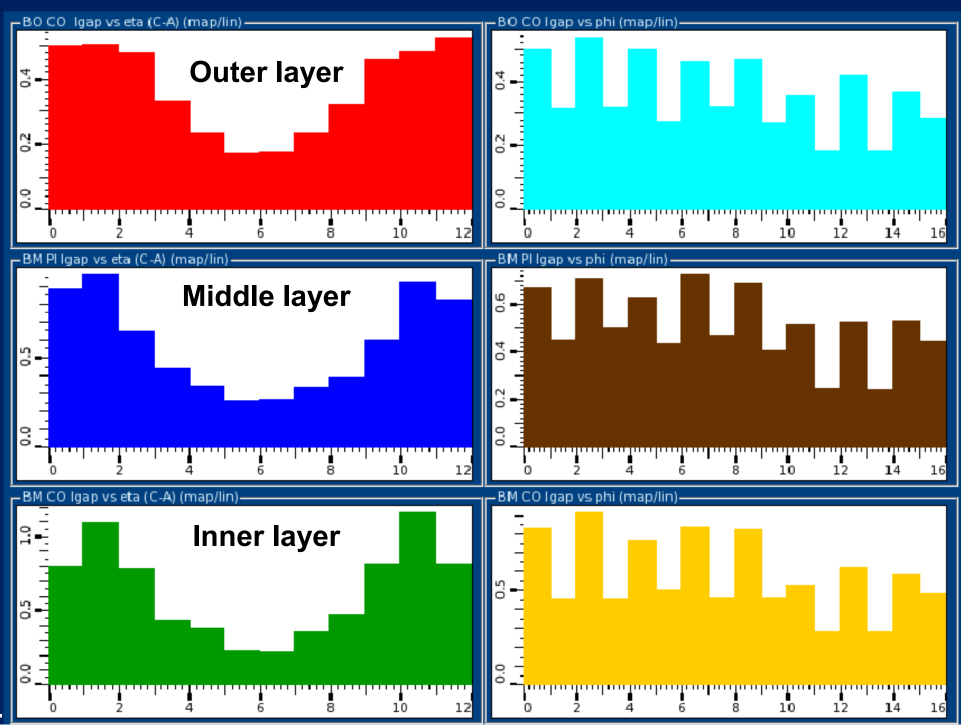


DCS and beyond: Background Maps

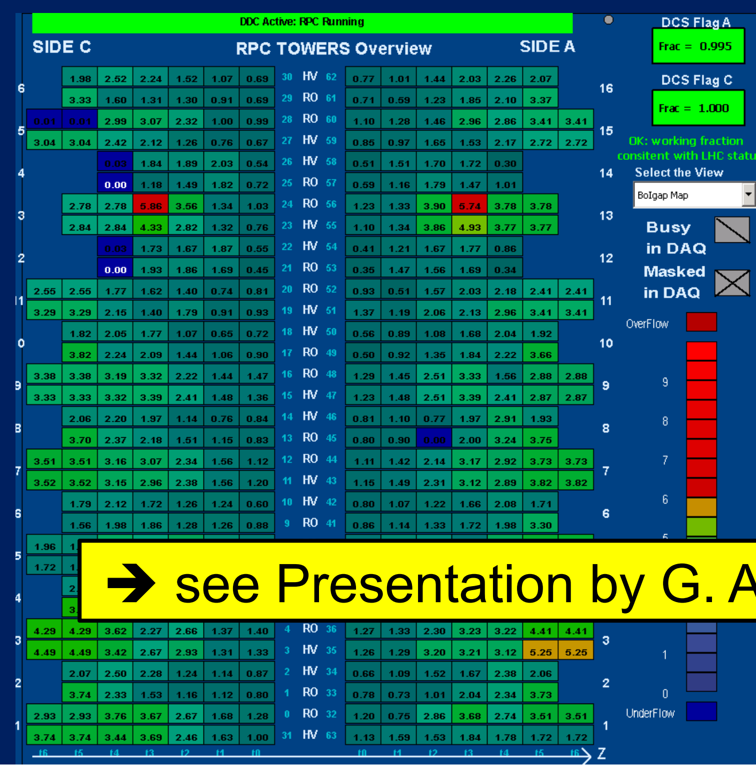
- The precision and high Granularity of the Gap currents can be used to
  - cross verify detector health; probe cavern background; measure inst. luminosity
- Typical current 100nA (no beam) single gap readout sensitivity 2nA
- Average charge per count 30pC at READY (for MIPS)
- HV Operation: Added delay (20 minutes) before going to STANDBY after a Beam dump from stable beams to study "after-glow" effects, activation, ….

→ Extrapolate to a luminosity of 10^{34} cm^{-2} t^{-1} to validate MC simulations and assumptions on RPC high luminosity operation (resistivity, rate capability, …)

RPC average current readings over 1min, [μA/m²]



DCS Data

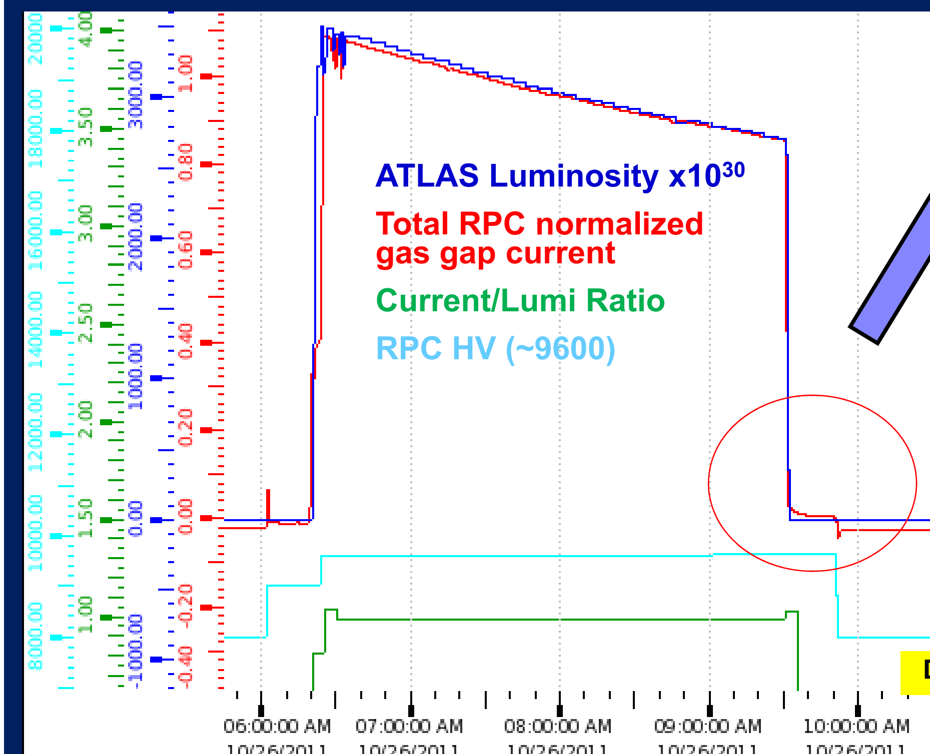


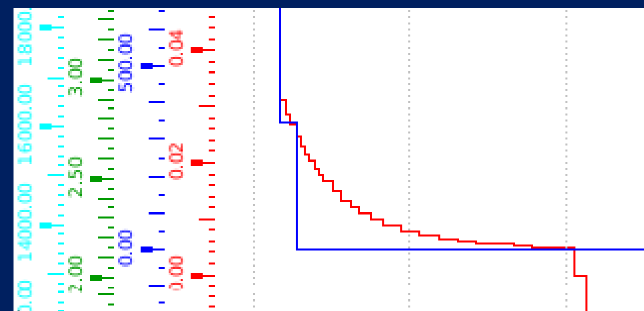
➔ see Presentation by G. Aielli

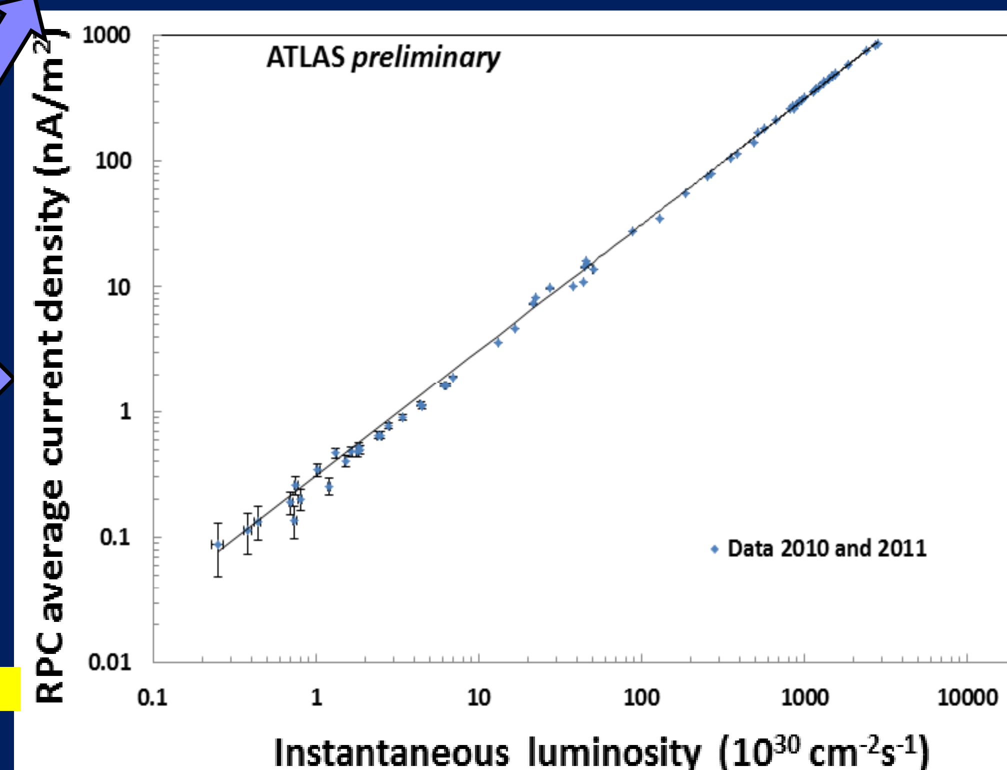
Luminosity and Afterglow

- Precise measurement of collisions-induced radiation measurement
- Independent and reliable measurement of Luminosity
- Stability and pileup dependence
- Afterglow cavern background measurement

➔ see presentation by M. Bindi

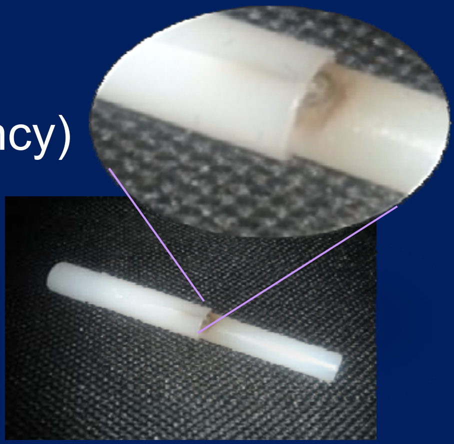






Outlook on Infrastructure Consolidation

- **HV connectors:**
  - 4 failures in 2011 (no direct dead area due to two-layer redundancy)
  - Connectors were replaced quickly in required shadow accesses
  - ➔ Full refurbishment during present shutdown



- **Noise Stability:**
  - ~ 5% of thresholds have been set to harder values due to e.m. radio-frequency pickup noise concentrated on the early installed chambers
  - ➔ Improve grounding in feet sectors: installation of cable-stops to enhance Faraday cage
- **Gas Leaks:**
  - Situation under control
  - ➔ Fix of major gas leaks ongoing

- **Gas System Consolidation:**
  - ➔ Equalize gas flow via tuned impedances to the chambers as function their volume and integrated radiation

➔ See poster by E. Pastori on Gas Distribution

New Powering Scheme

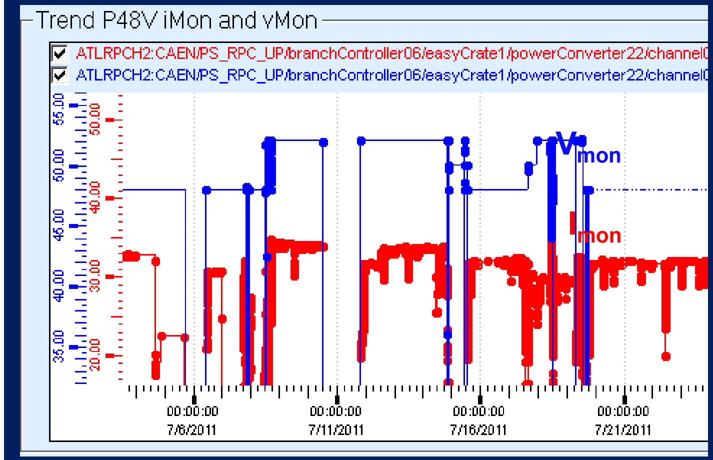
2011 Operation:

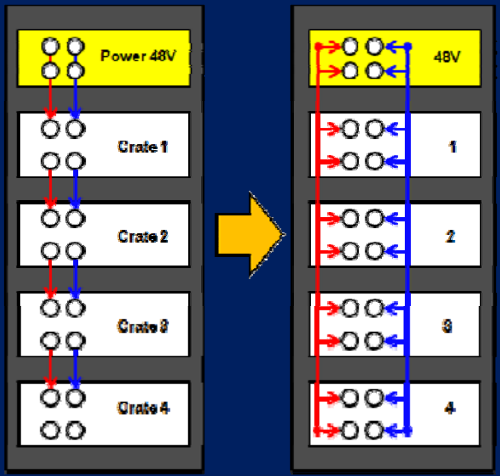
- During 2011 operation four occasions of partially melted connectors which required intervention
  - Anderson-Power connectors might develop resistance causing the observed faults
  - Daisy-chain connection on the power lines
  - Unbalanced currents due to common ground (-) between Service and Power lines
- Improved monitoring in DCS helped in cross-checking situation
- Helped in anticipating failures and plan controlled accesses

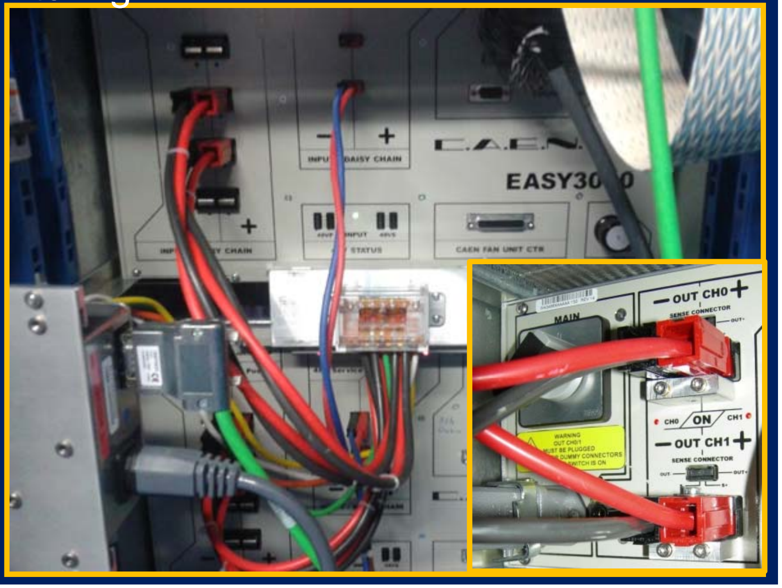
This shutdown: New powering scheme implemented

➔ Double redundancy + star connection (instead of daisy chain) + dedicated connector stops fully installed

➔ Other solutions (changing of backplane connectors, install monitoring shunt) were considered feasible during the present shutdown







Conclusions

- ATLAS RPCs have worked very well in 2011 delivering good trigger and data for physics
- Shifts and detector efficiency have been well integrated within ATLAS and MUONS and optimized by means of automatic controls and actions
- The detector redundancies along with the large monitoring capabilities have allowed to overcome promptly few weak points in infrastructure
- The detector control system is providing valuable data and tools on RPC detector physics and LHC running at higher luminosities
- Several activities during the shutdown shall improve the required robustness for 2012 and future running
- Great expectations for the running in 2012 and beyond