RPC Status and Plans for Run-2

G.Aielli, D.Boscherini, L.Massa, A.Polini, M.Romano

Outline

- Summary of operation and performance in Run-1
- Status of RPC at start of Run-2
- Plans for Run-2

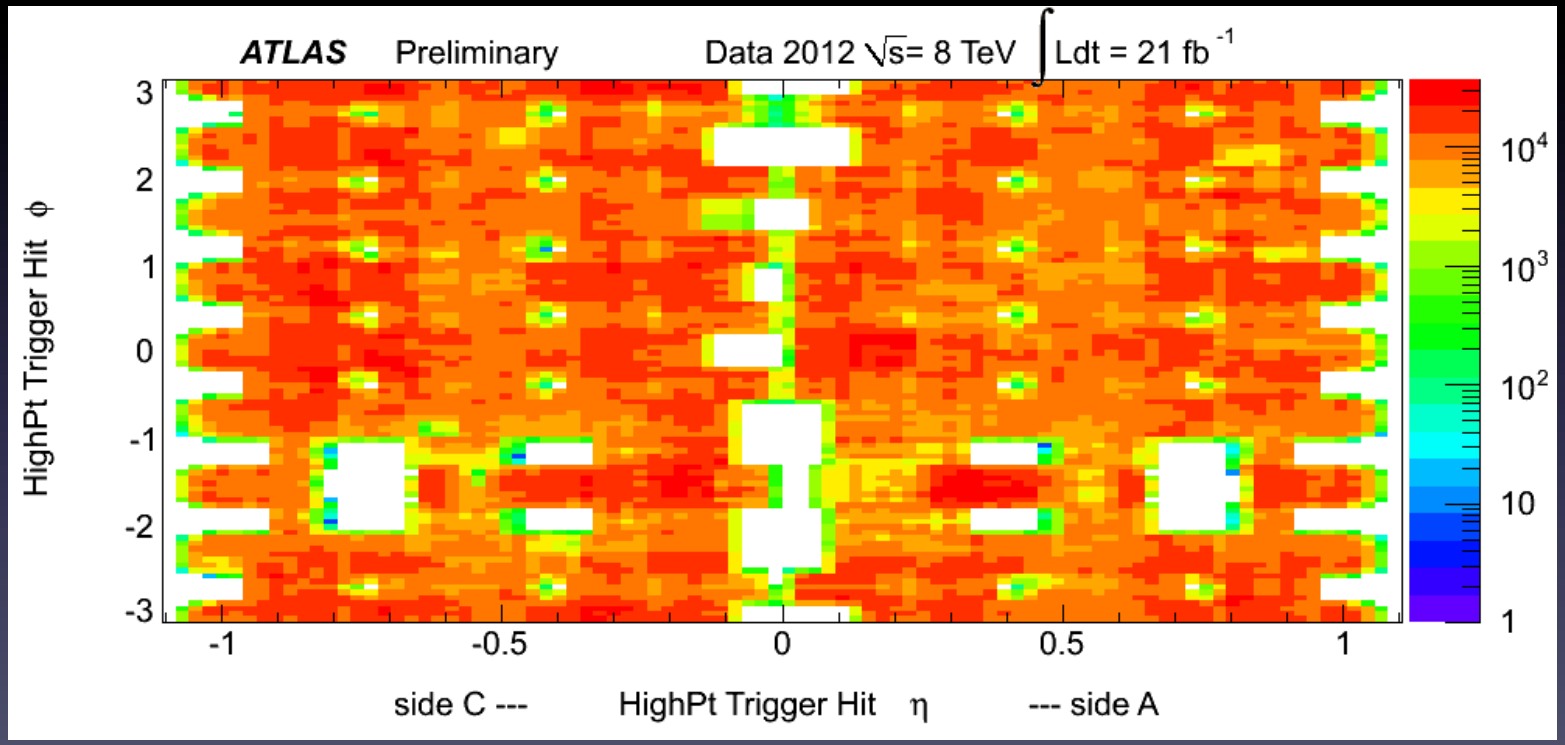
RPC-miniWorkshop - Roma La Sapienza, 26/03/2015

RPC performance during 2012

Data taking very stable:

- good data quality fraction: ~~99.8%~~
- **fraction of active readout channels: ~97%**
  dead channels due to disabled trigger towers, gaps off or dead front-end channels

High-pt trigger coverage (2012 full luminosity)



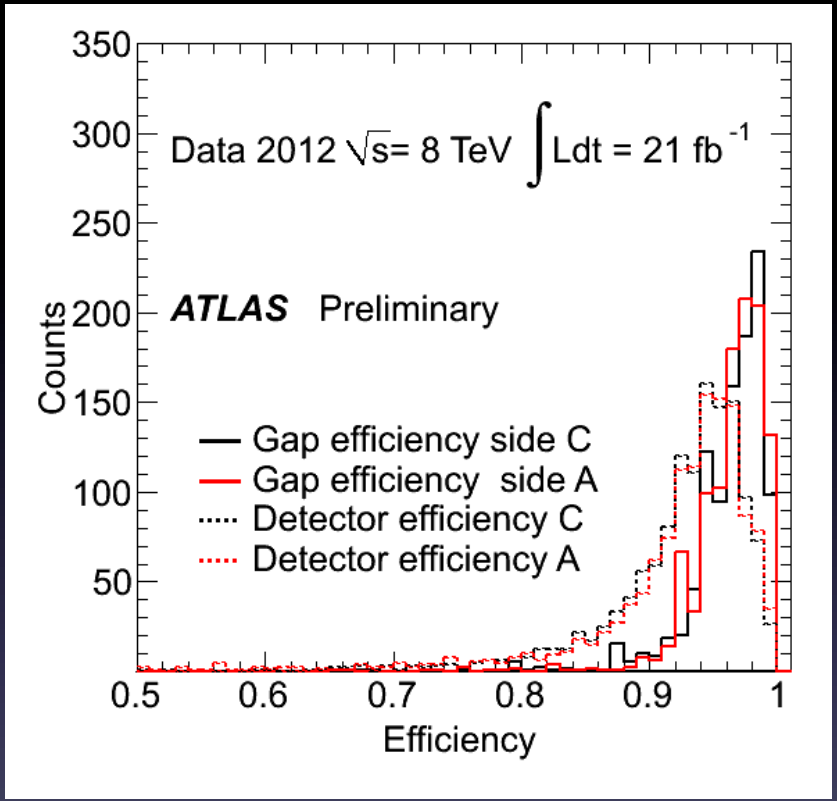
Spatial coincidence between η and ϕ RPC pivot strips generating a High Pt trigger
The empty regions are due to not instrumented areas needed for services, toroid support feet and toroid coils

RPC efficiency distributions in 2012

Measured 2012 RPC efficiencies
(ATLAS side A in red, side C in black):

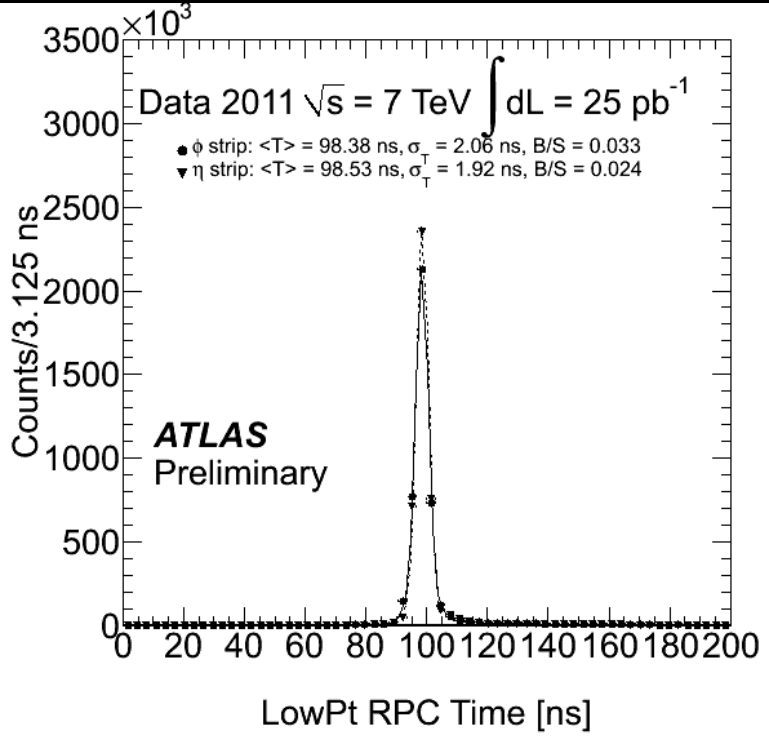
- gas volumes efficiency, defined by the positive response of at least one of the two views (full lines)

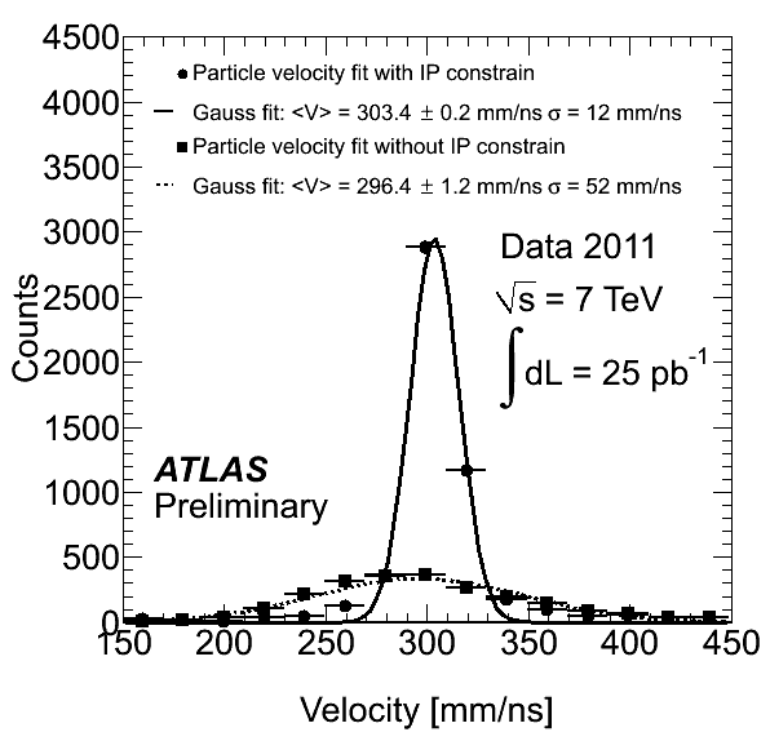
- detector efficiency, defined by the positive response of the single views (dashed lines)



The efficiency is measured using standalone RPC track projection obtained removing the layer under test and using cluster hits matched with a muon combined track ($\Delta\eta<0.1$ and $\Delta\varphi<0.1$)

RPC timing performance





Time distribution of RPC clusters matched to CM muons ($\Delta\eta,\Delta\varphi\Phi<0.1$), after strip-by-strip calibration and correction for signal propagation along the strip

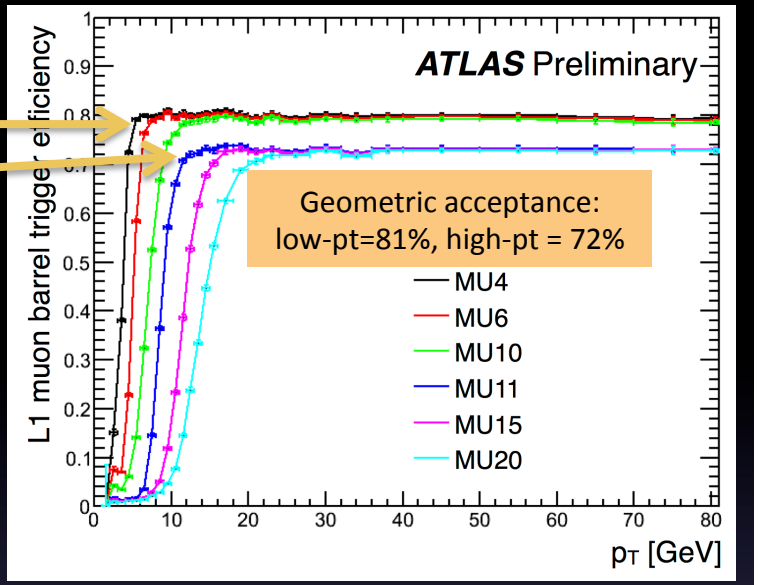
particle velocity measurements with and without IP constraint

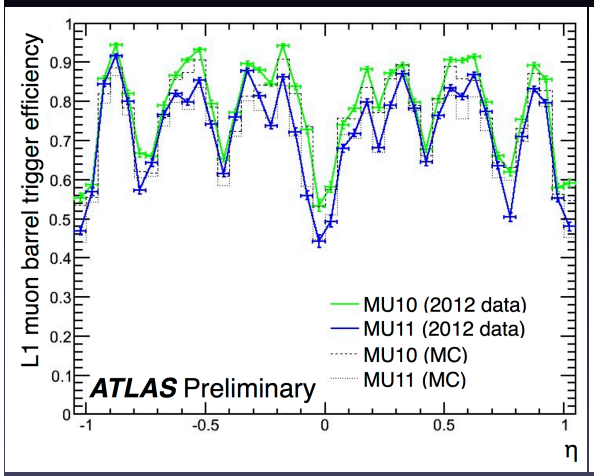
Time resolution ~2 ns (including 0.9 ns from TDC sampling)

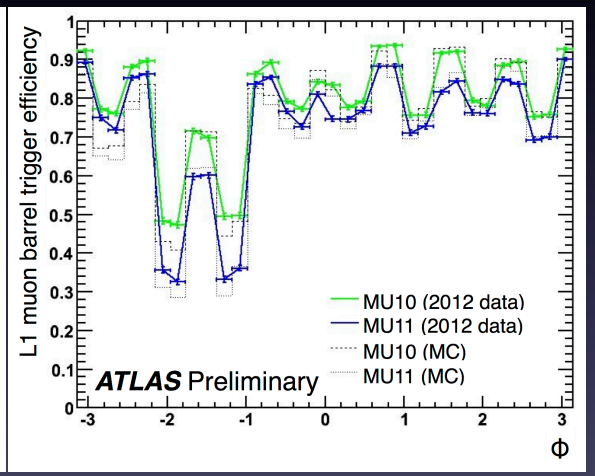
L1 barrel trigger efficiency

Efficiency for the 6 trigger thresholds in a late 2012 run
- 3 **low-p_T** with geometric acceptance of 81%
- 3 **high-p_T** with geometric acceptance of 73%

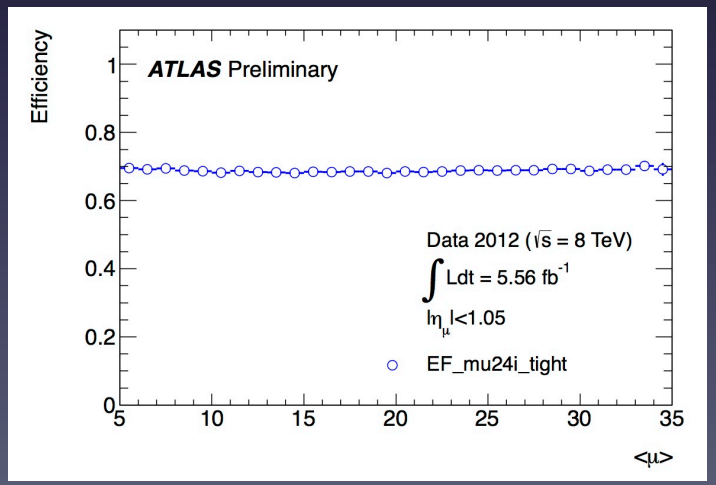
Measured also in the 25 ns runs: ok







Efficiency VS η and ϕ for:
MU10 (low-p_T) and MU11 (high-p_T) thresholds
Distributions follow the detector geometric acceptance, limited by services, toroid support feet and coils



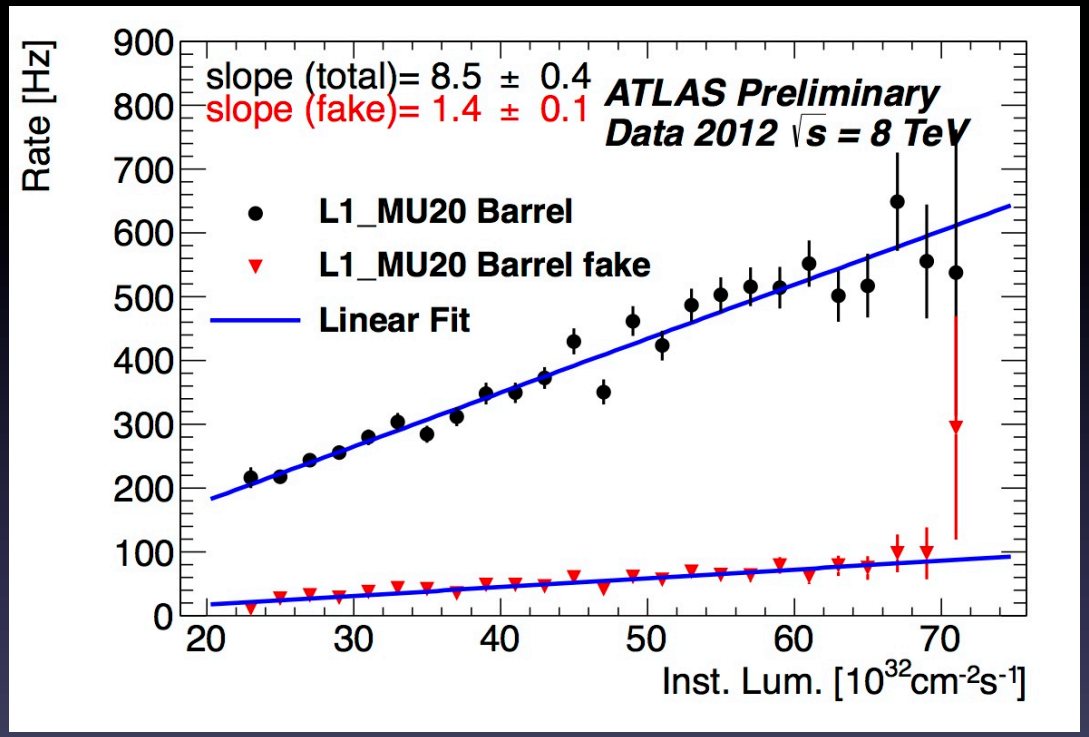
barrel muon trigger efficiency VS pile-up

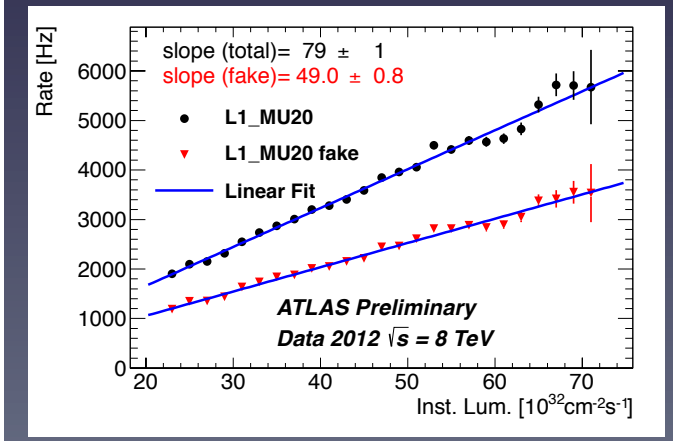
Barrel muon trigger rate VS luminosity

L1 MU20 barrel muon rates as a function of the instantaneous luminosity measured in 2012 data

The red points are the fake triggers defined as triggers that do not match with an offline reconstructed muon

Contamination from fake triggers very low in barrel already at L1





L1 MU20 trigger rate (total)

Background rates from 2012 data

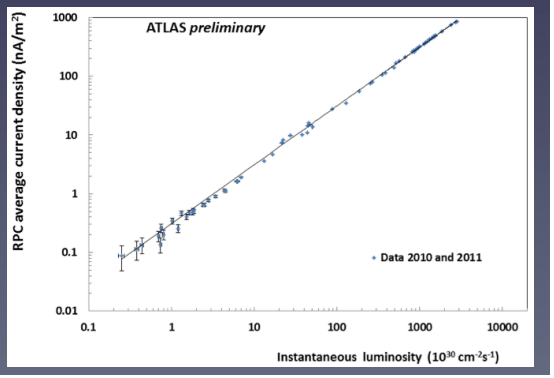
Extrapolated flow (Hz/cm^2) at L=1*10^{34} cm^{-2} s^{-1} from measurament at L=0.7*10^{34} cm^{-2} s^{-1} (x1.6 for the E_{cm} increase included)

Sector	ATLAS RPC BM extrapolated average rate density — RPC unit Id. along Z direction																	ATLAS *preliminary*					Average (Hz/cm^2)
Φ Id.	-7	-6.2	-6.1	-5	-4	-3.2	-3.1	-2.2	-2.1	-1.2	-1.1	01.01	01.02	02.01	02.02	03.01	03.02	4	5	06.01	06.02	7	
01.01	40	42	37	36	29	19	14	17	13		9	8	9	14	15	16	18	26	36	34	36	30	23
01.02		38	35	38	28	21	16	18	16		10	9	10	15	17	17	19	28	40	35	39	38	24
2		16	26	24	18	14	12	10	9	7	7	6	7	9	10	13	12	18	26	25	21		15
03.01		37	37	38	26	18	16	15	14	9	9	9	10	16	16	16	17	26	38	34	36		23
03.02		38	36	39	27	19	16	18	15	11	10	10	9	16	17	19	19	26	38	33	37		23
4		14	23	23	20	14	12	9	10	7	7	6	7	10	10	12	14	20	24	23	20		15
05.01	35	27	27	32	21	13	13	16	15	9	9	9	10	15	20	13	15	22	31	24	24	27	19
05.02		29	29	28	18	14	15	16	16	10	8	9	10	14	16	13	16	21	29	32	32		19
6		16	24	25	19	13	12	11	11	8	7	6	8	10	10	12	14	21	24	26	22		15
07.01	34	37	34	35	25	21	17	16	15		10	10		15	18	16	20	24	35	34	37	32	24
07.02		40	33	30	16	18	14	16	13		10	10		13	16	15	20	15	39	35	32	36	21
8		15	25	24	20	13	11	10	9	7	7	6	7	8	9	11	14	20	24	24	22		15
09.01	28	39	32	37	26	20	15	17	14		7	9		13	16	16	18	25	35	34	36	28	23
09.02		40	33	35	25	19	14	14	13		8	10		13	14	13	18	24	35	32	35		22
10		16	26	26	18	11	11	9	9	6	6	5	7	9	9	10	11	18	24	25	23		14
11.01	29	37	31	30	20	14	11	12	10		6	5		10	11	12	13	19	29	28	33	22	18
11.02		25	23	20	14	11	9	7	7		5	5		7	8	8	10	13	19	21	23	32	13
12						14	13	10	9	6	5	5	6	9	11	13	14						9
13.01	40	37	34	30		17	13	12	11	6	6	6	7	11	12	11	16		30	33	37	30	19
13.02		37	33	28		14	12	13	11	6	7	7	7	12	13	12	15		27	29	35	31	18
14						15	18	10	8	6	5	5	6	8	10	17	15						10
15.01	25	23	25	19	14	11	9	9	7		5	5		7	8	10	12	14	19	22	23	24	13
15.02	34	24	21	31	20	16	12	13	10		6	6		10	13	14	15	20	31	24	27		18
16		16	27	27	21	13	11	8	9	8	7	7	7	9	8	11	13	21	26	26	21		15
Average (Hz/cm^2)	34	25	29	29	21	15	13	12	11	7	7	7	8	11	12	13	15	21	29	28	28	29	17

Ageing qualification was done at 100 Hz/cm^2 for 10 years of LHC running

A safety factor 5 was included wrt the expected max rate of 20 Hz/cm^2

At large |η| the rates are above the expectations and will exceed the 100 Hz/cm^2 in phase-2



Measured RPC current VS luminosity
Linear correlation observed over few orders of magnitude

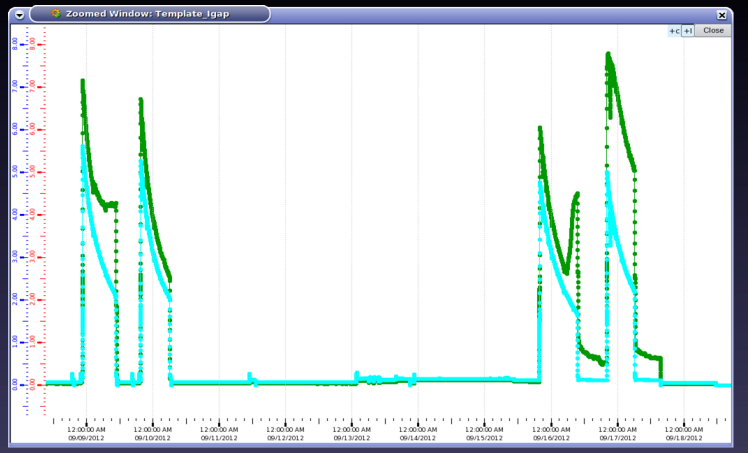
Experience from Run-1

HV connectors and PS connections failures until 2011: now fixed

- Breakdown of the insulator in a few HV connectors due to inappropriate cooling process at the manufacturer
  No failures observed after the refurbishment of all the connectors
- Melting of connectors in the 48V power system distribution due to the degradation of the electrical contact. Power distribution scheme rebuilt and connector fastened
  No more failures observed

Gap diagnostics

- At end of 2012, 91/3600 (2.5%) of gas volumes were disconnected due to gas problems, high gap current or electrical problems



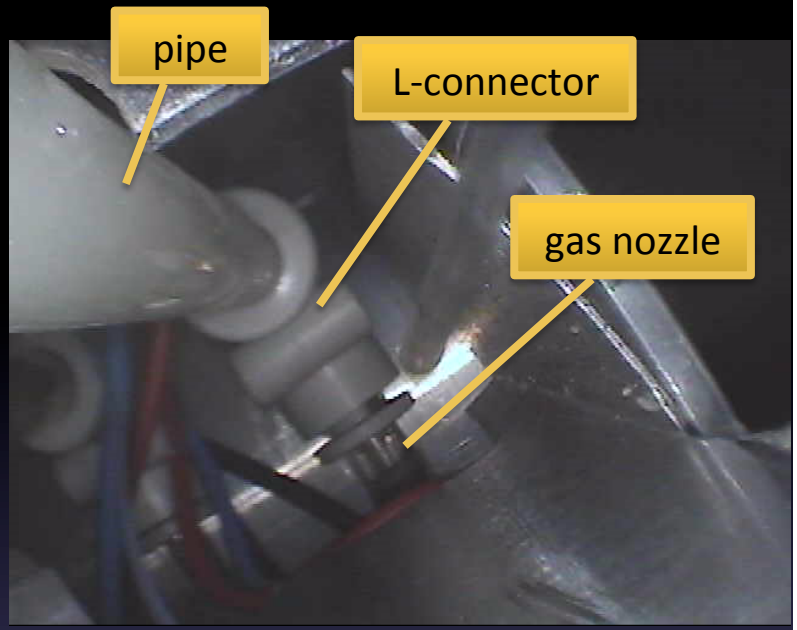
Temperature distribution in the cavern

- In the top side of the barrel spectrometer the cavern temperature was above 24°C, max value accepted for a long-term safe operation of the detector
- Gas volumes with T>26.0 °C were operated with HV = $HV_{nominal}$ -100 V
- Two attempts to re-distribute the cooling air flow only mitigated the problem, a more substantial upgrade of the cavern cooling system planned in LS1
- No evidence of temperature effects on the chamber operation

Experience from Run-1

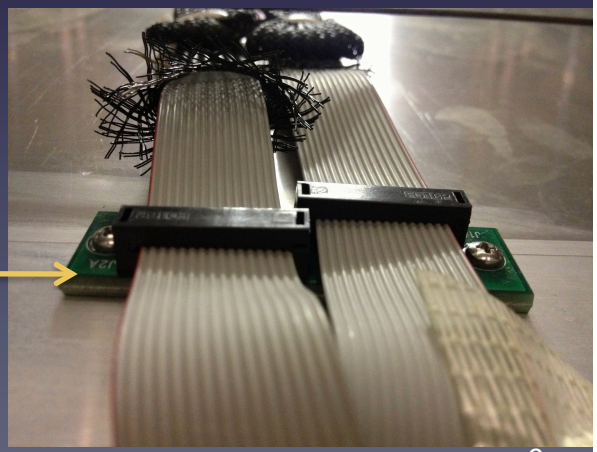
Gas leaks

- Some gas volume nozzles developed fractures or complete breakups due to the mechanical stress induced by the piping (~5% of nozzles affected)
- Most volumes could be normally operated
- Very intense repair campaign all over LS1, difficult task due to uneasy access to the nozzles



Weak grounding connections

- Weak grounding connection between readout panels and front-end electronics (affecting 6% of panels, operated with harder Vth)
- Enhancement of Faraday cage in affected chambers (installing grounding plates) fixes or mitigates the problem



Preparation for Run-2: gas system

Gas flow increase

Gas re-circulation flow in 2012 with an exchange rate of 1 volume / 2.5 h
wrt the design value of 1 volume / 1 h (at $L=1x10^{34}cm^{-2}s^{-1}$)
Additional pump installed in the system to reach the nominal flow
Further increase of the gas flow might be needed at higher luminosities

Replacement of gas impedances

Current impedances unsuitable for high gas flow (linearity loss)
and for high luminosity (increase background weight wrt chamber volume)
→ replacement of 2000 impedances
Impedances available at CERN since beginning of 2015
Installation postponed to next winter shutdown (luminosity still not critical, improved shielding, change in flow)

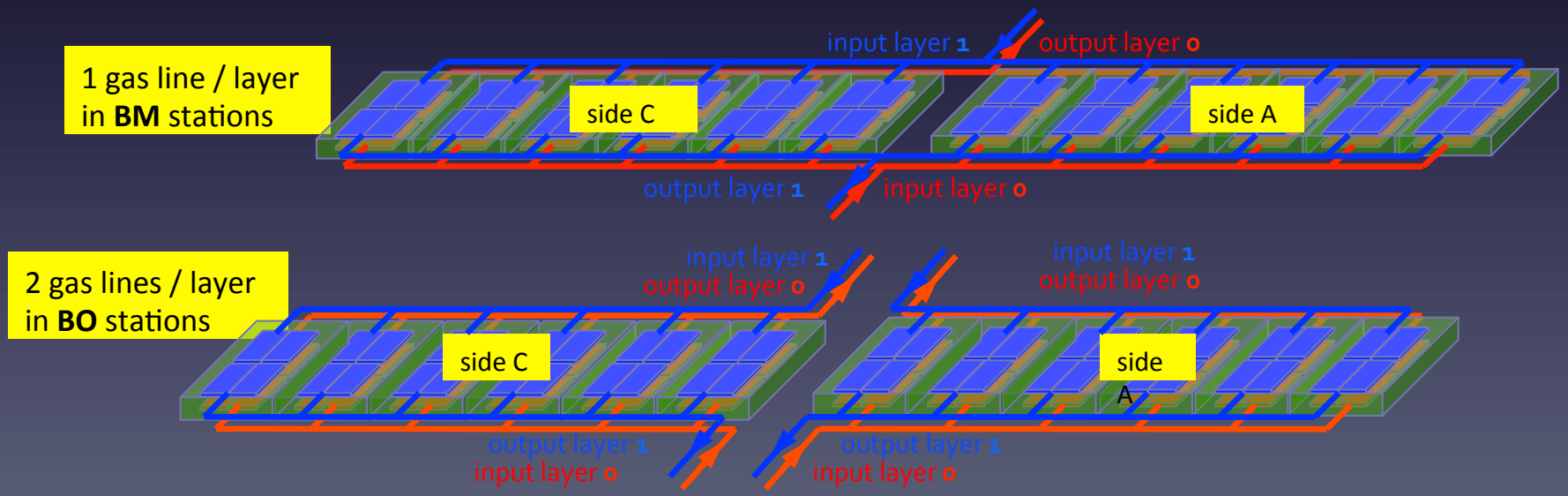
Gas system monitoring

Upgrade of gas flowmeters

Implement much finer monitoring (1/manifold → 1/chamber-layer): install ~1200 flowmeters

All flowmeters available, cable preparation and calibration setup at BB5

- 66 flowmeters installed in sectors 5C, 6C
- 60% of flowmeter chains ready at BB5
- remaining flowmeters to be installed during Technical Stops and next winter shutdown



Gas system

Gas leak repairs

Massive repair campaign all along LS1 (always 1 Russian team + ~always 1 Italian team)
Dedicated R&D (in Rome2 by E.Pastori) resulted in a repair technique using glue based on silane modified polymer
More “traditional” inlet replacement also used when applicable (i.e. access to broken inlet)

Unrepaired leaks / Total number of leaks detected in the system = **50 / 339** *(85%)*
For BOLs → **32 / 121** *(74%)*

Currently, fresh gas injected in the system to compensate for leaks: **~400 l/h**
including ~100 l/h due to leaks not on chambers
(to be compared with **800-900 l/h** at the end of 2012)

At end of LS1 chamber with leaks connected to the gas lines but with output in air
→ checking HV lines to see if unrepaired chambers can be operated

Interventions for repairing remaining and new leaks to be planned in next Technical Stops and Winter Shutdown

RPC at start of Run-2

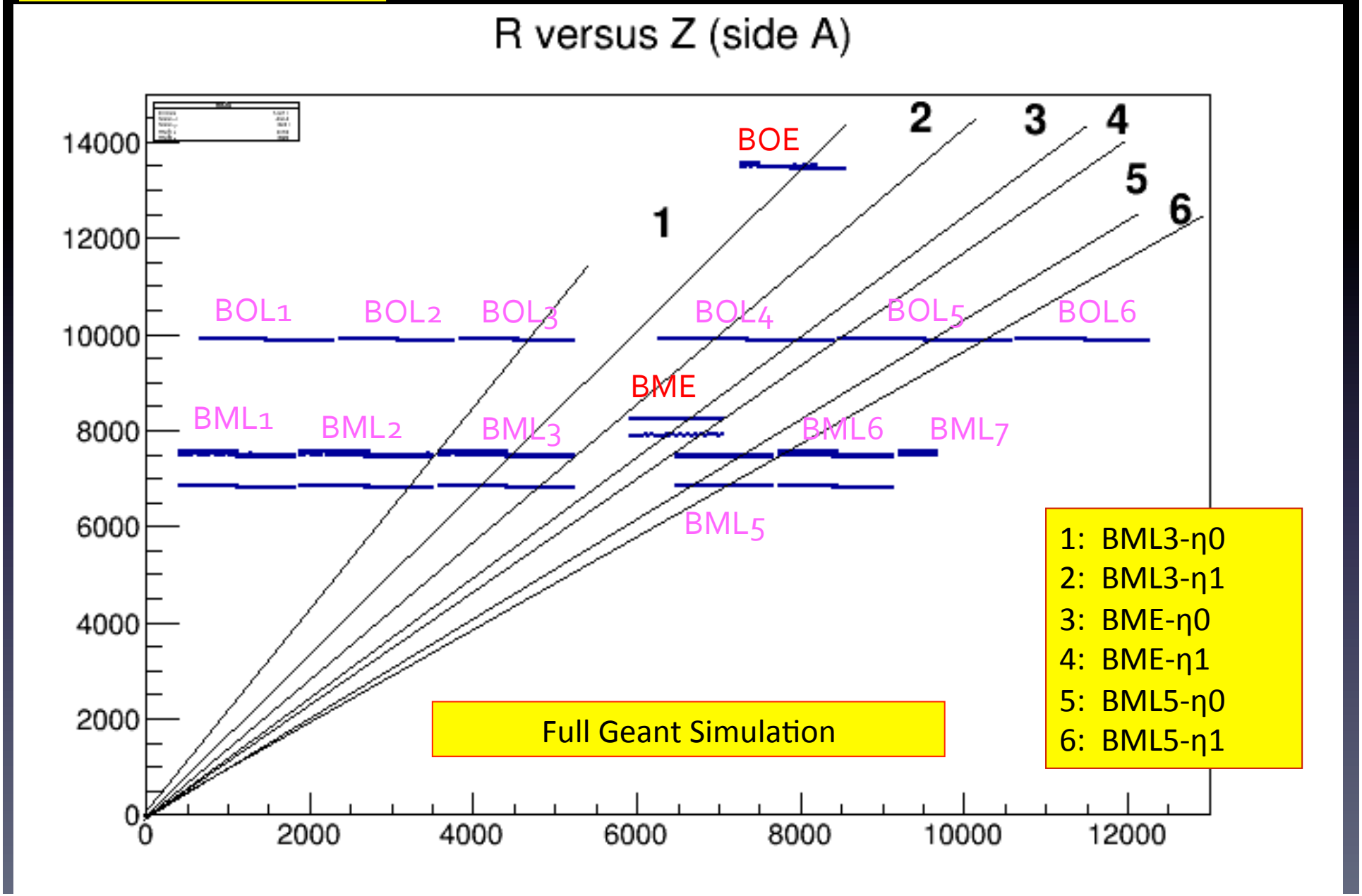
Detector re-commissioning

- restoring of all LV connections to ensure that all FE channels are powered and read out from the receivers. Several damaged connections found on chambers have been restored
- reconnecting of most of leaking gaps to the gas line to have them operative
- restoring of all HV channels by disconnecting singularly the leaky gaps which could not be operated
- new chambers: cabling completed at the very last moment. DCS channel map being validated. To be switched on and commissioned
- cavern temperature: at a first check, no sizeable improvement after the cooling upgrade (+10% total flow, improved distribution in sectors 4,5,6)

Gap status @ 16/03/2015	#(/3592)
in recovery	23 (0.6%)
disconnected	68 (1.9%)
disconnected from rack, but recoverable	30 (0.8%)
total disconnected	121 (3.4%)

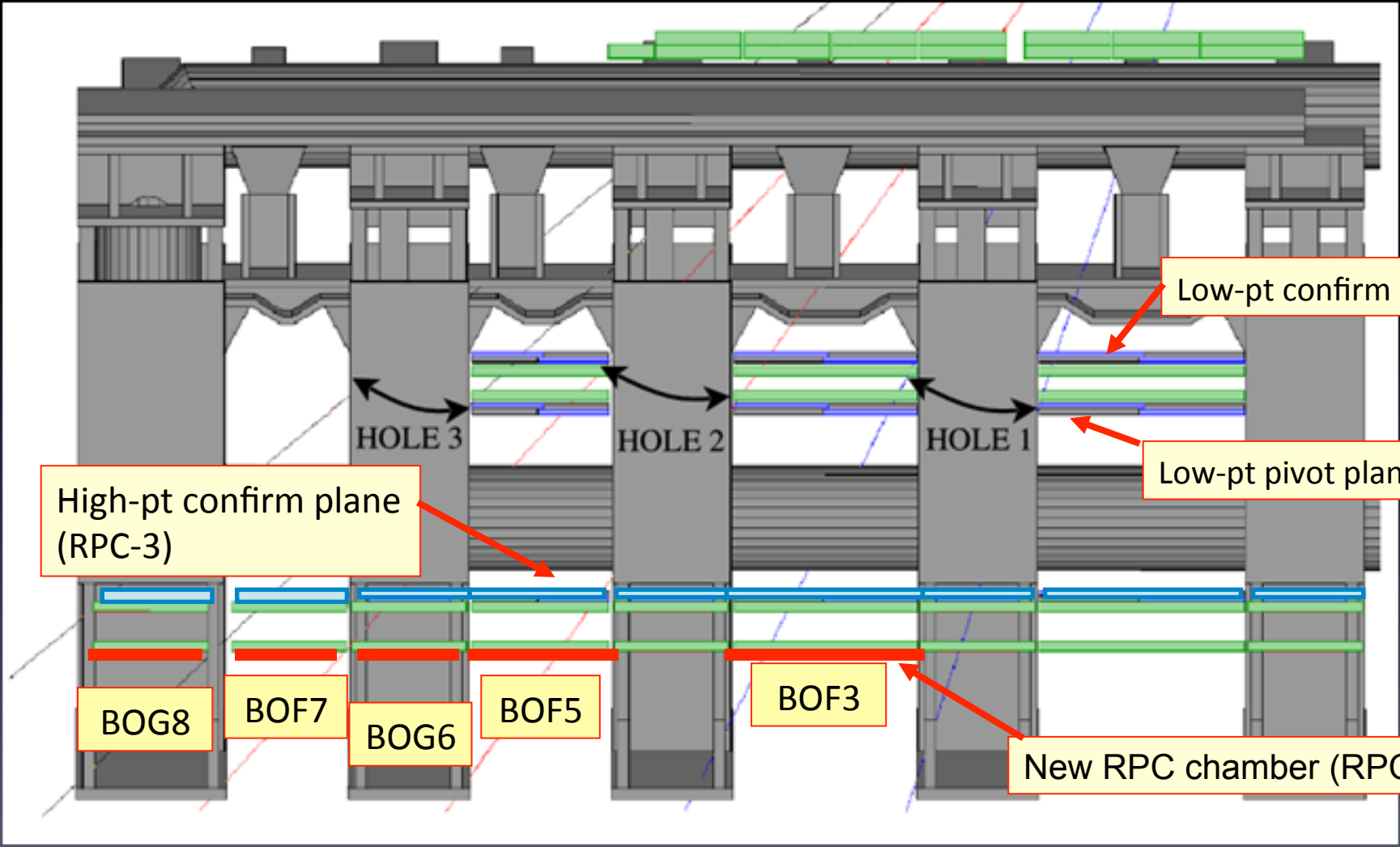
New elevator chambers (sector 13)

Barrel spectrometer acceptance: +0.9%



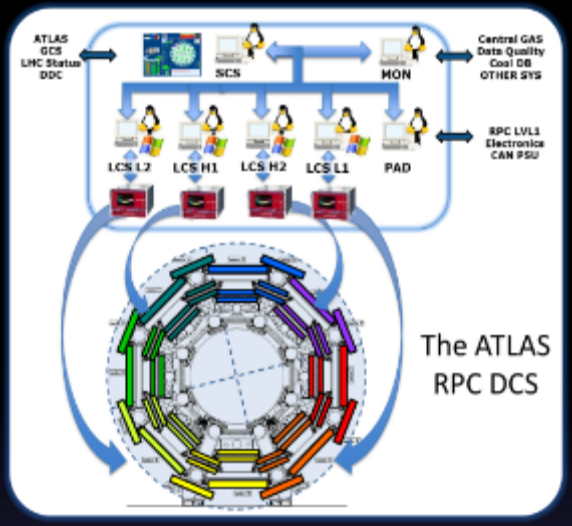
Barrel spectrometer acceptance: +2.8%

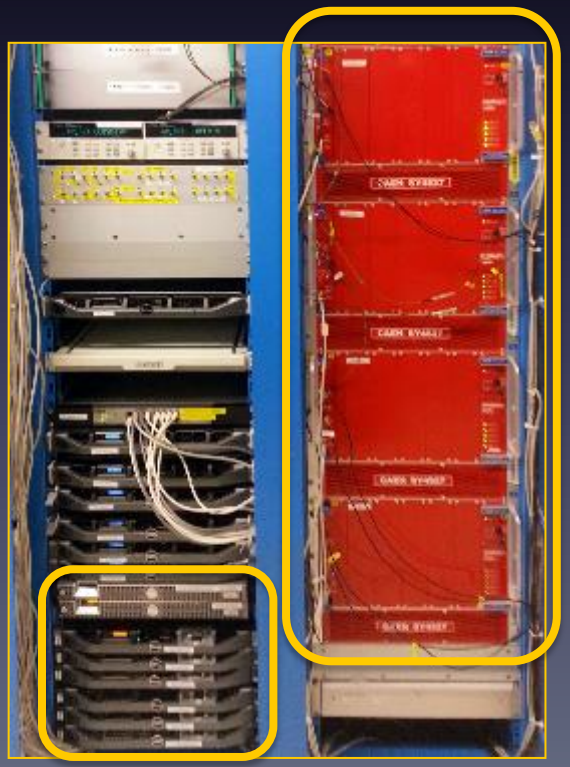
Feet chambers (sect. 12,14)



In every sector we have a second RPC plane in the BOF3-BOF5-BOG6-BOF7-BOG8 chambers

DCS status





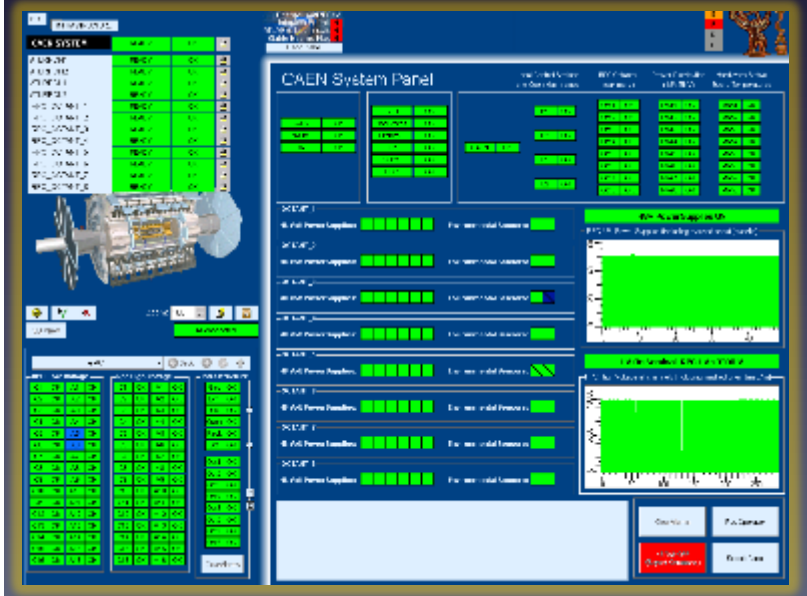
Overall Status

- System available full time for control and monitoring
- The DCS has been indeed the major tool for detector consolidation during all of LS-1
- HW and Software up-to-date (WinCC, Linux, Windows VM, New Mainframes, CAN drivers etc)
  - One out of 7 machines still to be replaced, operation can be done in half a day
- Running stably w/o failures during LS1
- One issue (bug in sorting) found in WinCC (not present in PVSS) requested for patching in new version

Caen Hardware

- UX hardware all ok. Spares ok.
- Recent failure of 5 ADC boards. Now repaired. Need to switch off equipment in case of missing cooling

DCS status



New Chambers:

- Channels for new chambers (sectors 12,13,14) recently included in DCS
- Final validation and tests ongoing

Operation:

- Operation by shifter since M7 (FSM +Alarm Screen)
- LHC Dry Run OK (simulation of LHC handshake and beam cycle)
- Performance similar or improved w.r.t. Run-1

New gas flowmeters:

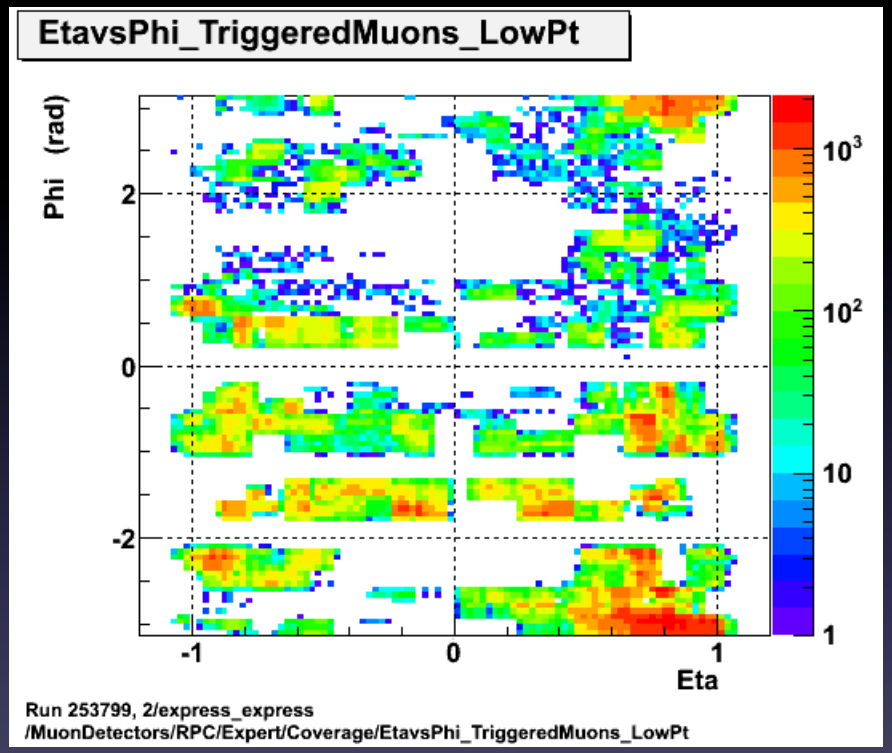
- Prototypes and principle of work tested
- Will be commissioned during 2015

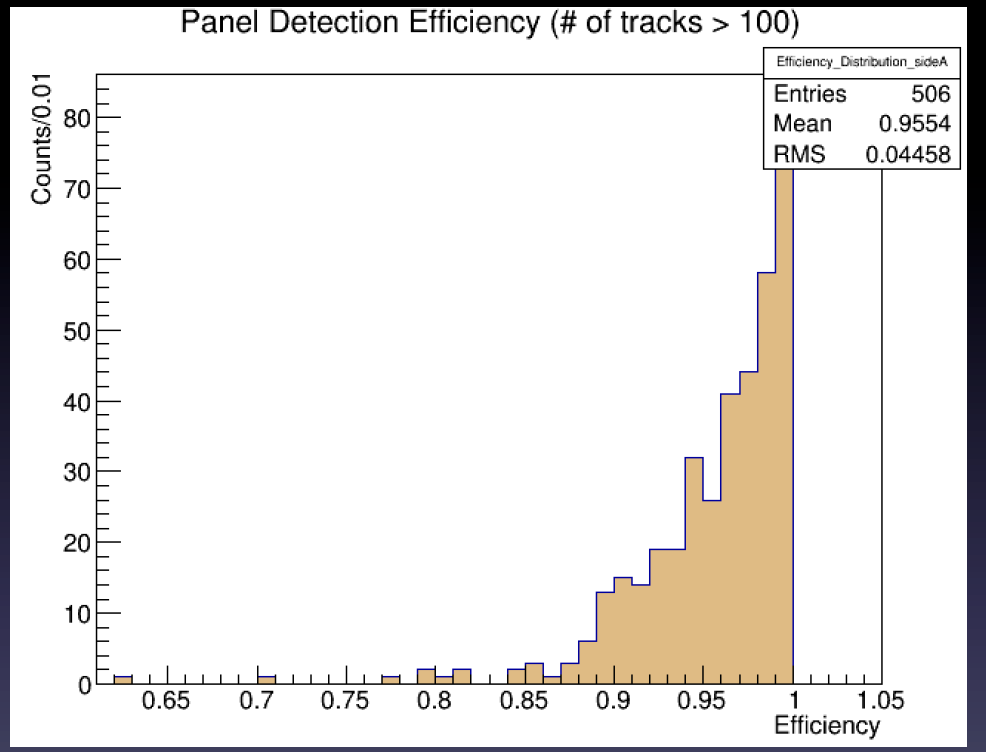
Still to be done:

- Commissioning of maps for new chambers
- Implementation of new flowmeter readout
- finalization and commissioning of luminosity dependent alerts
- Documentation and Alarm help
- Experts and on-calls being prepared

RPC coverage and efficiency (M8)

from offline DQ





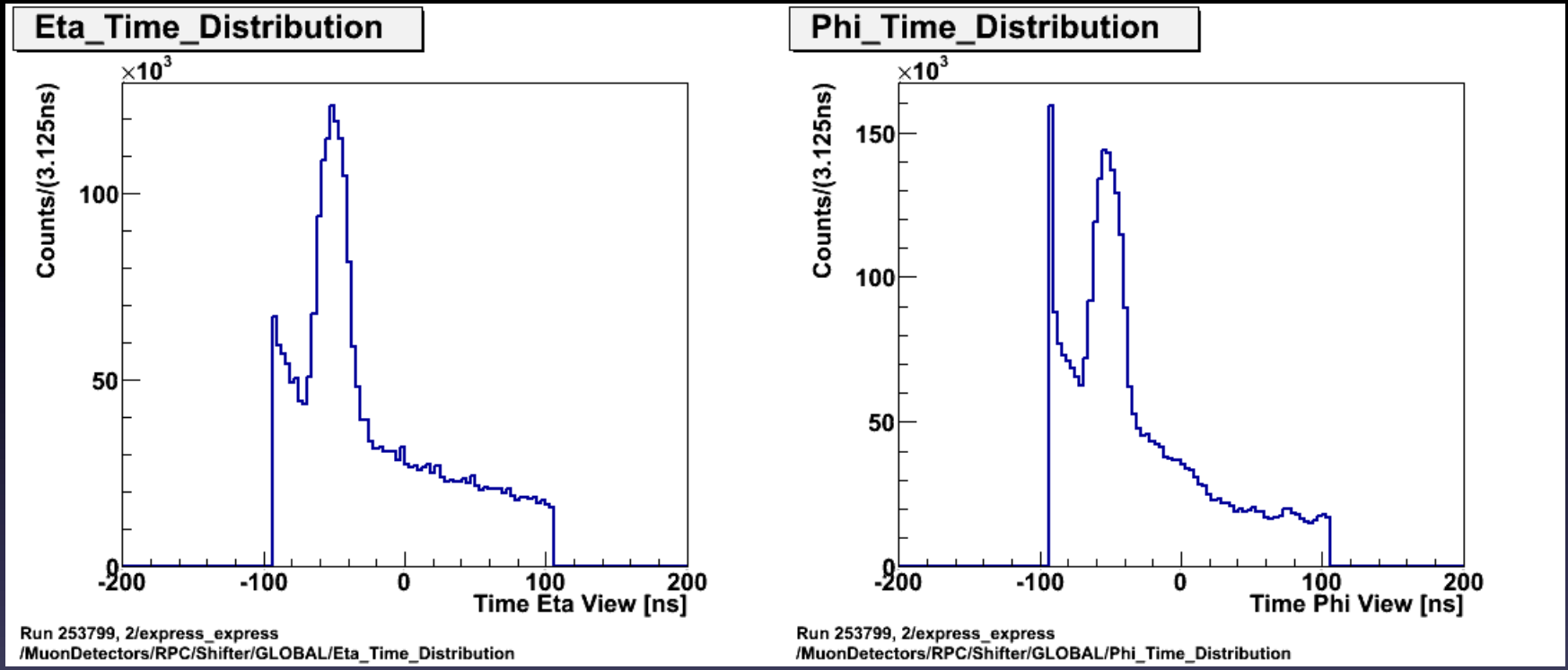
Coverage suffering for

- disconnected chambers
- problematic trigger sectors/towers

Efficiency seems ok

RPC time shift in cosmics (M8)

from offline DQ



RPC time offline was shifted by 100 ns to be zero for prompt collisions muons to match RPC time in MC simulations

Cosmic muon signals from top sectors at -50 ns as expected

Short term to-do-list

Residual interventions

- fix 3 HV channels with high current disconnected from rack, to be investigated
- fix 3 missing LV channels (UX access 1 day)
- fix a few groups of apparently disconnected T sensors (UX Access 1/2 day)
- reconnect all the gaps in recovery which can be operated (UX Access 1 day)
- install two missing HV cables for the recovery network (Sergei and Mito already contacted, UX 2h)

- fix V_{pd} issue on BOE/BME (UX access 1-2 days depending on problem)
- replace HV splitters on the BME/BOE on the rack side since the present one are functional but inappropriate, new ones being built in Rome2 (UX Access 1h)
- commissioning of the new DCS maps (a few days no access needed)
- commissioning of new BME/BOE/BOF/BOG

Medium term to-do-list

Activities to be scheduled

- complete installation of new gas flowmeters (UX access 1 week). To be scheduled for next technical stop
- continue with gas leaks repairs (50 known leaks + new leaks). To be scheduled at each technical stop (UX access, 1 week with organized shifts of technician crews)
- check in details 15 out of 128 gas lines suspected of residual hidden leaks (UX access, 1 week of organized shifts of technician crews)
- replace all gas impedances (UX access, 2 weeks with a team of 2 technicians)To be planned in next winter shutdown or in a Technical Stops if demanded by beam conditions)

Person-power

Detector experts
G.Aielli (RM2)
M.Bianco (CERN, limited to expert on-call)
P.Camarri (RM2)
B.Liberti (RM2)
L.Massa (BO)
L.Paolozzi (RM2)
M.Romano (BO)

DCS
G.Aielli (RM2)
P.Camarri (RM2)
L.Paolozzi (RM2)
A.Polini (BO)
M.Romano (BO)

LVL1 experts
A.Bruni (BO)
M.Della Pietra (NA)
P.Iengo (CERN, limited to expert on-call)
C.Luci (RM1)
V.Izzo (NA)
S.Perrella (NA)
F.Safai-Tehrani (RM1, solo remoto)
R.Vari (RM1)

DQ
A.Bruni (BO)
G.Chiodini (LE)
M.Della Pietra (NA)

Offline
G.Chiodini (LE)
S.Spagnolo (LE)

Summary

Excellent performance in Run-1

Huge work during LS1 (fundamental support from muons and TC)
Not finished, to be continued in Technical Stops and Winter Shutdown
New chamber commissioning to be started

New experts (being) prepared:
absolutely needed for a successful Run-2 …