R&D fase 2 – RPC
1st meeting

Previous presentations at:

- ATLAS+CMS referees (09/05/2014)→
  https://agenda.infn.it/getFile.py/access?contribId=3&resId=1&materialId=slides&confId=8009

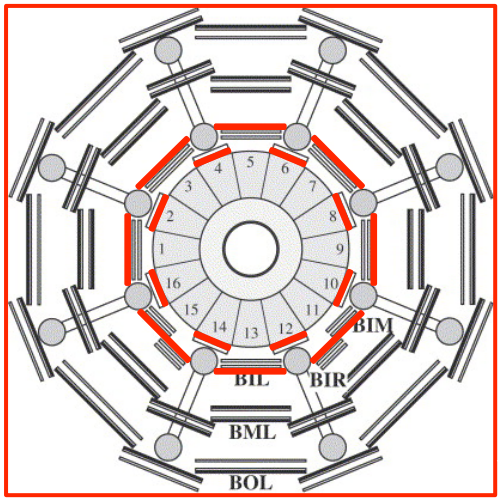
- R&D fase 2 referees (23/09/2014)→
  https://agenda.infn.it/getFile.py/access?contribId=9&resId=0&materialId=slides&confId=8544

- CSN1 (01/10/2014) →
  https://agenda.infn.it/getFile.py/access?contribId=69&resId=0&materialId=slides&confId=8515

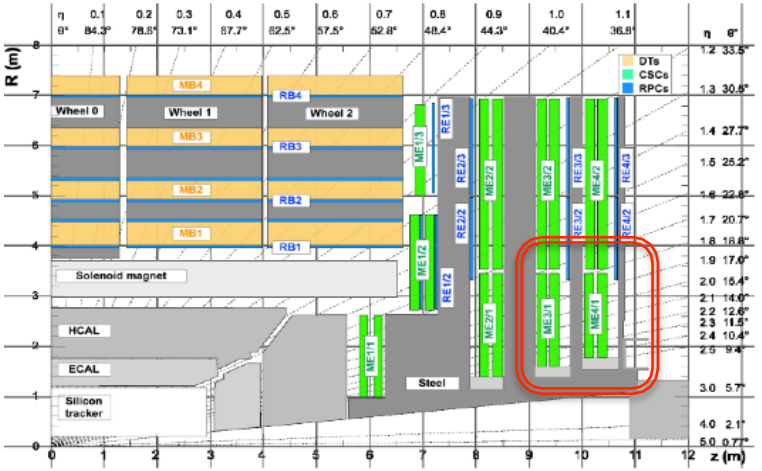
S.Bianco (CMS-LNF), D.Boscherini (ATLAS-Bologna), G.Pugliese(CMS-Bari)

R&D fase 2 - RPC – CERN, 26/11/2014

RPC projects for Phase 2



ATLAS



CMS

Similar projects ➔ Common R&Ds

1. **Detector completion:**
   ATLAS: inner RPC layer **BI** (currently equipped only with MDTs)
   CMS: **RE31 and RE41 stations** in high eta region 1.6< |h| <2.4 (now only CSC)
2. **New eco gas:**
   search for new gas mixture candidate with lower environment impact **(ATLAS & CMS)**
2. **Detector longevity:**
   certify the detector longevity for 10 years of HL - LHC **(ATLAS & CMS)**

ATLAS RPC Requirements

Main requirements:

1. Expected max rate in new inner layer ~ **600 Hz/cm²**:

need to improve the long term RPC rate capability to sustain the HL- LHC

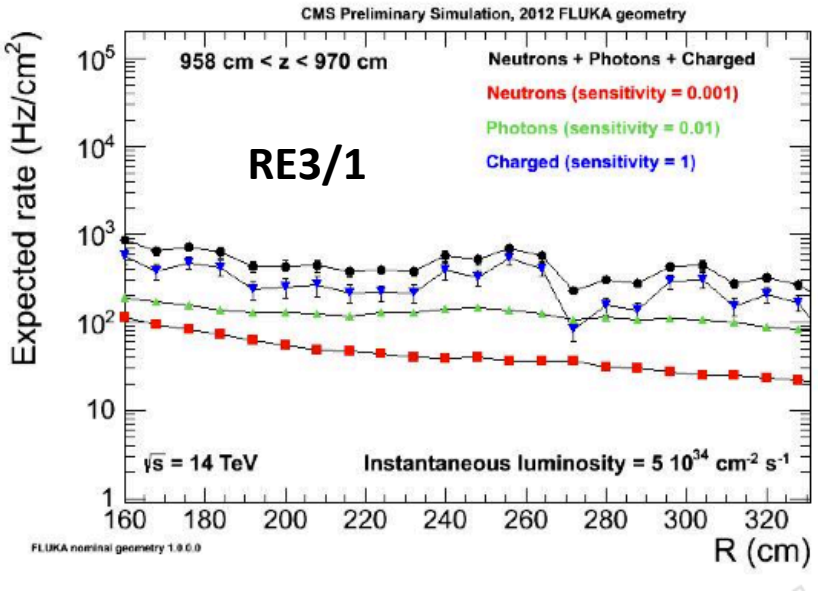
2. Limited space available for the installation in the inner layer: **~ 5cm**

Reduced gas gain:
- increased Signal/Noise in front-end electronics
- thinner gap 2 → 1 mm
- thinner electrodes (improved ratio prompt/total charge) 1.8 → 1.2 mm

Improved spatial and time resolution:
- timing is improved by reducing the gap thickness
- improve spatial resolution through charge centroid by exploiting electronics sensitivity

Reduced detector thickness
- higher-quality mechanical structures is required
- thinner electrodes and gas gaps

CMS RPC Requirements



Main requirements:

1. **Max rate of ≈ 700 Hz/cm^2**
2. **Int. charge of ≈ 0.6 C/cm^2** @ 3000fb^{-1}

Fattori di sicurezza da aggiungere

3. Compatible with trigger/DAQ input
4. Space available similar to RE4 space

R&D Strategy for higher rate:

- **Electrode with lower resistivity**
- **Reduced gas gain**
- **New detector configuration:**

electrode thickness, multi-gap and new material (low resistivity Glass)

RPC R&D plan

WP1: Electrodes

WP2: Chamber prototypes

WP3: FEE electronics (+ ATLAS Trigger)

WP4: Eco-gases

WP5: Tests at Irradiation/Test-beam facilities

Personnel

- **ATLAS RPC …….. 3.8 FTE**
  - Bologna ……. 1.6
  - Napoli ……. 0.5
  - Roma 1 ……. 0.6
  - Roma 2 ……. 1.1

- **CMS RPC …….. 5.0 FTE**
  - Bari ……. 1.4
  - Frascati …… 1.0
  - Napoli ….. 1.8
  - Pavia ….. 0.8

ATLAS Staff

Detector			
Institute	*FTE*	*Name*	*FTE*
Bologna	1.4	Alberghi	0.4
		Bellagamba	0.2
		Boscherini	0.2
		Bruni A.	0.2
		Polini	0.2
		Guerzoni	0.2
Roma2	0.9 (+0.5)	Aielli	0.2
		Camarri	0.1
		Cardarelli	0.2
		Di Ciaccio	0.1
		Liberti	0.2
		Paolozzi	0.1
		Santonico	(0.5)
Tot	2.3		

Trigger			
Institute	*FTE*	*Name*	*FTE*
Bologna	0.2	Massa	0.2
Napoli	0.5	Della Pietra	0.1
		Izzo	0.2
		Perrella	0.2
Roma1	0.6	Corradi	0.2
		Luci	0.2
		Vari	0.2
Roma2	0.2	Liberti	0.2
Tot	1.5		

CMS Staff

R&D RPC Phase 2	Bari	Frascati	Napoli	Pavia	
Abbrescia	0,2				
Iaselli	0,5				
Maggi	0,2				
Pugliese	0,5				
Piccolo		0,4			
Saviano		0,4			
Ferrini		0,2			
Paolucci			0,2		
Buontempo			0,2		
Cavallo			0,6		
Fabozzi			0,2		
Meola			0,1		
Thyssen			0,3		
Breglio			0,2		
Vitulo				0,4	
Riccardi				0,1	
Salvini				0,1	
Braghieri				0,1	
Montagna				0,1	
	1,4	**1**	**1,8**	**0,8**	**5**

Richieste/Assegnazioni 2014-17 riunione CSN1 ottobre

	2014			2015			2016			2017			
	com	ATL	CMS	com	ATL	CMS	com	ATL	CMS	com	ATL	CMS	
Electrode				20		5	15		5				**45**
Chamb/Proto				20			14	8	8	10			**60**
Front-end				45	6	5	11	2			5		**74**
Eco-gas	10			15			7			4			**36**
GIF++				20			14			14			**48**
	10			**120**	**6**	**10**	**61**	**10**	**13**	**28**	**5**		
	10			**136**			**84**			**33**			**263**

Nostra proposta in CSN1 a Catania, accettata dai referee!

Milestones

Proposed milestones:

30/09/2015 sviluppo e produzione di elettrodi (HPL) a bassa resistivita' e piu` sottili

31/12/2015 produzione e inizio fase di test alla GIF++ di prototipi di piccole dimensioni

30/06/2016 produce 40 FEE prototype circuits

30/06/2016 select best 2 candidate eco-gases

30/09/2016 full size chamber prototype

Conclusions from presentation at CSN1

Italy had a leading role in CMS & ATLAS RPC projects

HL-LHC program triggered a new R&D pushing toward **new generations of RPC** to fulfill the very demanding needs

ATLAS – CMS R&D collaboration already started (see DCS for GIF++)
Plan to have **regular meetings** to define strategies and discuss results
Plan to have common **papers** (see for ex. results from GIF++ tests)

In order to strengthen the international collaboration among the RPC groups, the setting up of an **R&D coll. (RD##)** is under way

Agenda tipica

https://agenda.infn.it/conferenceDisplay.py?confId=8864

1mo meeting RPC ATLAS+CMS

Wednesday, 26 November 2014 from **14:00** to **18:10** (Europe/Rome)

Description VIDYO:
http://vidyoportal.cern.ch/flex.htmlroomdirect.html&key=zqt0poB0bJz7y9H925QpJLE8uHY

PIN:
2014

Room @ CERN:
40-R-A10

Wednesday, 26 November 2014

14:00 - 14:10	Welcome *10'*
14:10 - 14:30	WP1: Elettrodi *20'*
14:35 - 14:55	WP2: Prototipi *20'*
15:00 - 15:20	Wp3: Elettronica *20'*
15:25 - 15:45	WP4: eco-gas *20'*
15:50 - 16:10	WP5: GIF++ *20'*
16:10 - 17:00	DISCUSSIONE *Tutti*

Per ogni talk: 5 min + 15 min discussione
stato dell'arte
planning: misure / acquisti / riunioni
Discussione

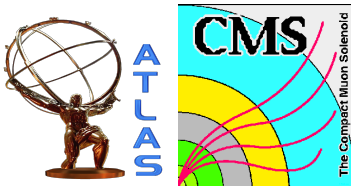
Info varie

Mailing list:
Comunicazioni attraverso le due liste
atlas-it-rpc-rd2@cern.ch
CMS-RPC-Italy@cern.ch

Twiki page:
Sharing dei documenti in:
https://twiki.cern.ch/twiki/bin/viewauth/IFD2014/ATLAS-CMS-RPC

Calendario riunioni:
Cadenza bi-mensile

Prossima riunione il 17/12 ore 14:30 per:
- formazione WG
- programmazione misure
- programmazione acquisti



BACKUP

Financial Requests (2014-2017)

ITEM	TASK	ATLAS/CMS keuro	ATLAS/CMS comments	CMS keuro	CMS comments	ATLAS keuro	ATLAS comments
		219		23		21	
Electrode	Tot	**35**		**10**			
	HPL	20	development low Res and thin				
	Glass			10	2 chambers		
	Transportation	5	from company to Lab				
	Resistivity Meas	10	production resistivity and long term				
Chamb/Proto	Tot	**44**		**8**		**8**	
Thin/multi Gap	Chamber prod.	30	10 small prototypes				
			precision frame for 4 chambers + local gas				
	Multiplet mech. frame	2	distrib syst				
	Gas comp. & distrib.	2	design and test of new gas I & T				
	prototype -1			8	CMS layout prototype	8	ATLAS layout prototype
	Consumable	10					
Front-end	Tot	**56**		**5**		**13**	
	Chip prototype	45	Chip design and development				
	Adaptor board			5	Adapt. Board cms	13	On chamber LVL1 Roma 1
	Test in lab	11	Single Event Effects				
Eco-gas	Tot	**36**		**0**		**0**	
	Gas	20	unit cost 2 Keuro				
	Consumable	2					
	equipment	4	flowmeters				
	interaction w/ materials	10	chemical materials and sensors				
GIF++, BTF	Tot	**48**		**0**		**0**	
	Electronics	12	DAQ/DCS epool rent				
	RPC user gas system	10					
	Cables and sensors	4					
	Gas use	12					
	Running test consumable	8					
	Trolley and support	2					

WP1: Electrodes

Lower resistivity materials will be investigated

- construction of **low resistivity HPL** electrodes → higher rate
- Investigation of **low resistivity glass** electrodes developed by Chinese Tech. Univ. → higher rate

Thinner electrodes

Thinner electrodes will be tested to improve the S/N ratio, the detector thickness and weight.

- construction of gas volumes with thin HPL electrodes
- construction of multi-gap RPC based on thin HPL electrodes

Acquisto di 2 batch di HPL (80 lastre = circa 5 prototipi)
Costruzione di uno strumento portatile per la misura di resistività
Test di long term conductivity sull'HPL

WP2: Chamber prototypes

1. construction of a set of **small size prototypes** (thin, multi-gap, different resistivity...) for a max. of **10 chambers** to test in common
   - Test in the lab and GIF++
2. construction of **2 full size prototypes** that fits all the specific requirements of the two experiments
   - Test in the lab and GIF++

- Technological improvements:
  - Gas inlets and connection to the internal pipes
  - Gas distribution and connectors (simulation and test)
  - High voltage connection on the gap and connectors
  - Mechanics for the thin gap and multigap
  - Readout electrodes and integration to FE electronics

WP3: New front-end board

Goal: Improve by a factor 10 the S/N ratio
New Prototype developed by R.Cardarelli
Very preliminary results from (already started) common R&D

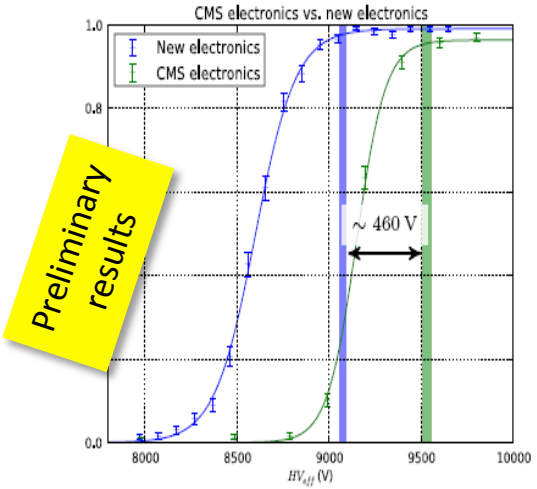
CMS: turn-on efficiency curve shifted by ~460 V

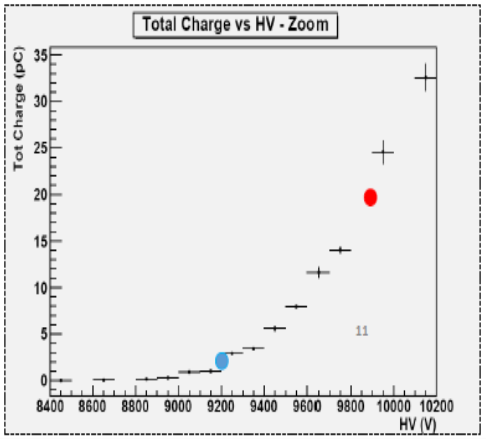
ATLAS: comparison in lab with the ATLAS FE
at the same efficiency: x7 reduced charge;
fully efficient up to 7 kHz/cm^2 at GIF

R&D phases:
1. Chip design development
2. Adaptor board (for CMS)
3. Irradiation test (SEE)

Lanciato run di fonderia pre-prototipo chip con amplificatore e discriminatore in SiGe
→ risultati per fine anno

Test on standard CMS chamber





Total charge vs HVeff
Highlighted points at 90% efficiency
Red: ATLAS FE / **Blue**: new Si FE

ATLAS R&D: new trigger electronics

The current system is not compatible with the Phase-2 trigger requests

- 2 trigger levels (L0 + L1)
- minimum 500 kHz L0 rate, minimum 200 kHz L1 rate
- 6 μs L0 latency, 30 μs L1 latency
- use of GBT system for the distribution of the LHC timing signals
- readout system based on Felix

The current on-detector electronics will be replaced with the new DCT boxes (Data Collector Transmitter, about 800 in total)

- use of FPGAs instead of ASICs for the on-detector electronics
- the DCT box will collect RPC front-end data, and perform some simple logic before sending the data off-detector

Most of the trigger logic will be located in the off-detector (USA15) new Sector Logic boards (64 in total):

- increased algorithm flexibility, easier operations and maintenance, no radiation

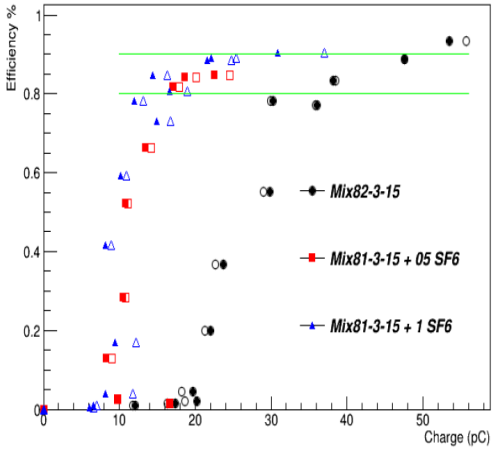
WP4: new eco-gas mixture

- Explore alternative "eco" gases with the same performance of the present one.

Two R&D phases:

1. Study the compatibility of new eco-gas candidates with RPC materials.
2. Chamber performance study with proposed eco-gases (see back-up slides) using cosmics muon in labs.
3. Move to GIF ++ to test aging of final detector with "new" gas mixture.

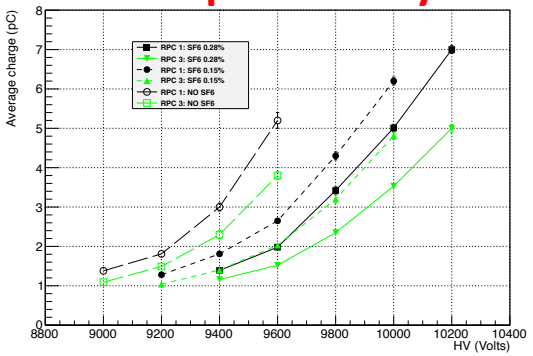
Ref: B. Liberti et al, RPC2014 Beijing



Average charge vs. efficiency
Gas mixtures: Ar/C_4H_{10}/TP 83-3-15 with increasing % of SF_6

- **R&D activity already started beginning of 2014 at ATLAS TorVergata and LNF laboratories.**
- Funding request for 2014 needed for missing flow-meters and initial eco-gas candidates procurements

CMS preliminary



WP5: Irradiation Tests

Motivation:

- **Upgrade**:new chambers (BI and RE3-1 & RE4-1) have to be study and certify for 10 HL-LHC years
- **Consolidation:** previous aging studies assessed detector longevity up to «10 LHC years»
- Ecological **gas mixtures** require study of aging properties on detectors and materials
- **Electronics:** aging and SEE of the electronics (new or old one)

	RPC certification for 10y LHC	Expected conditions @ HL – LHC for 3000 fb^{-1}			
		ATLAS		CMS	
		consolidation	upgrade	consolidation	upgrade
Max. Rate	≈ 200-300 (Hz/cm2)	300 Hz/cm2	600 Hz/cm2	300 Hz/cm2	700 Hz/cm2
Int. Charge	0,05 - 0,3 (C/cm2)	0,4	0,8 - 0,9	0,3	0,6

Fattori di sicurezza da aggiungere!

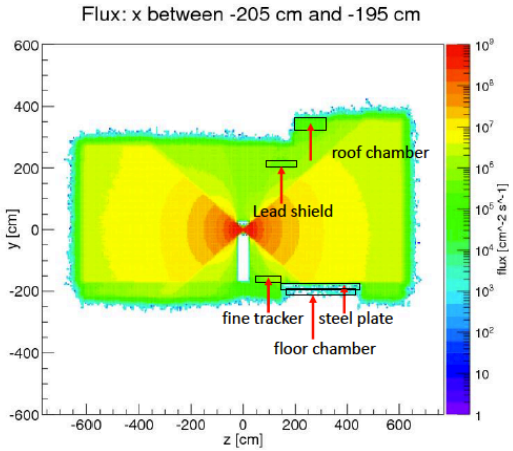
Irradiation Facilities

Facilities:

1. **CERN Gamma Irradiation Facility (GIF++)**
2. **Beam test facility at Frascati** → electronics
3. **Louvain** → electronics

New Gamma Irradiation Facility

1. **16 TBq radioactive ^{137}Cs source (30 times more intense** than the old GIF)
2. γ-irradiation in the two directions **(upstream and downstream)**, adjustable intensity by moving filters
3. **SPS secondary muon beam line** (available 6-8 weeks/year)
4. **cosmics and beam triggers**



Advanced European Infrastructures for Detectors at Accelerators

Involved in realization of user infrastructure

- **ATLAS Bologna – Roma Tor Vergata:** RPC for cosmic telescope & DCS
- **CMS Frascati – Bari**: T-P-H sensors

AIDA will provide to the users:

1. GAS analysers: (Gas chromatograph - O2 monitor - IR analyser - H2O analysis)
2. Cooling system (for racks and chamber electronics)
3. Environmental sensors
4. Trigger for cosmic and beam muon

No other hardware and software will be provided to the users.

GIF++ requests for R&D

Motivation of founding requests:

- To perform the R&D program a full range of prototypes will be tested at GIF++ for a total of **16 chambers**
- No electronics boards can be taken out from ATLAS and CMS spare
- The electronic boards will be rent by the Pool (50% of needed)
- Gas system for new eco-gas not provided by GIF++
- Gas consumption (eco gas & standard mixture)
- The duration of the aging test should be **about 2 years** (to integrate an equivalent charge of 10 HL – LHC years)

Requests for irradiation tests are vital for both consolidation and upgrade projects

ATLAS main Frame

CMS main Frame

Common activity already started on DCS