

wg7

2015 Test Beam Activities

# RD51 2015 Test Beam

- Brief Summary of June and July Test Beam
- Plans for the October/November Test beam
- Test Beam 2016

## SPS: June 2015



schedule issue date: 26-May-2015

Version: 2.2

	Mon 1 Jun	Tue 2 Jun	Wed 3 Jun	Thu 4 Jun	Fri 5 Jun	Sat 6 Jun	Sun 7 Jun	Mon 8 Jun	Tue 9 Jun	Wed 10 Jun	Thu 11 Jun	Fri 12 Jun	Sat 13 Jun	Sun 14 Jun	Mon 15 Jun	Tue 16 Jun	Wed 17 Jun	Thu 18 Jun	Fri 19 Jun	Sat 20 Jun	Sun 21 Jun	Mon 22 Jun	Tue 23 Jun	Wed 24 Jun	Thu 25 Jun	Fri 26 Jun	Sat 27 Jun	Sun 28 Jun	Mon 29 Jun	Tue 30 Jun	Wed 1 Jul	Thu 2 Jul	Fri 3 Jul	Sat 4 Jul	Sun 5 Jul														
Week	23							24							25							26							27																				
Machine	Scrubbing							CMS GRPC							TS							Scrubbing							RE29 DAMPE							CMS ECAL													
T2 - H2								D. Lazic PPE172							X. Wu PPE172																					CMS ECAL													
T2 - H4								Y. Tsiopolitis PPE134							RD51 (+GIF)							D. Lazic PPE164							CMS ECAL							ALICE ITS (+GIF)							RD51 (+GIF)						

## SPS: July 2015



schedule issue date: 26-May-2015

Version: 2.2

	Mon 29 Jun	Tue 30 Jun	Wed 1 Jul	Thu 2 Jul	Fri 3 Jul	Sat 4 Jul	Sun 5 Jul	Mon 6 Jul	Tue 7 Jul	Wed 8 Jul	Thu 9 Jul	Fri 10 Jul	Sat 11 Jul	Sun 12 Jul	Mon 13 Jul	Tue 14 Jul	Wed 15 Jul	Thu 16 Jul	Fri 17 Jul	Sat 18 Jul	Sun 19 Jul	Mon 20 Jul	Tue 21 Jul	Wed 22 Jul	Thu 23 Jul	Fri 24 Jul	Sat 25 Jul	Sun 26 Jul	Mon 27 Jul	Tue 28 Jul	Wed 29 Jul	Thu 30 Jul	Fri 31 Jul	Sat 1 Aug	Sun 2 Aug														
Week	27							28							29							30							31																				
Machine	RE29 DAMPE							UAG							Calice (Alcal)							SHIP ECAL							CMS HCAL Upgrade phase2																				
T2 - H2	D. Lazic PPE172							CMS ECAL							F. Sefkow PPE172														R. Jacobsson PPE172																				
T2 - H4	ALICE ITS							Y. Tsiopolitis PPE134							RD51 (+GIF)							F. Ravotti PPE154							GIF							RE22 PANDA MVD (+GIF)							LHCf						

## SPS: October 2015



schedule issue date: 15-Oct-2015

Version: 2.7

	Mon 28 Sep	Tue 29 Sep	Wed 30 Sep	Thu 1 Oct	Fri 2 Oct	Sat 3 Oct	Sun 4 Oct	Mon 5 Oct	Tue 6 Oct	Wed 7 Oct	Thu 8 Oct	Fri 9 Oct	Sat 10 Oct	Sun 11 Oct	Mon 12 Oct	Tue 13 Oct	Wed 14 Oct	Thu 15 Oct	Fri 16 Oct	Sat 17 Oct	Sun 18 Oct	Mon 19 Oct	Tue 20 Oct	Wed 21 Oct	Thu 22 Oct	Fri 23 Oct	Sat 24 Oct	Sun 25 Oct	Mon 26 Oct	Tue 27 Oct	Wed 28 Oct	Thu 29 Oct	Fri 30 Oct	Sat 31 Oct	Sun 1 Nov							
Week	40							41							42							43							44													
Machine	UA9							NA61 SHINE							UA9							Calice (Sdhalc)							CMS HGAL													
T2 - H2	A. Aduszkiewicz PPE152														Laktineh PPE172																											
T2 - H4	S. Gninenko PPE134							P348							D. Lazic PPE164							CMS EE upgrad							Y. Tsiopolitis PPE134							RD51 (+GIF)						

## SPS: November 2015



schedule issue date: 15-Oct-2015

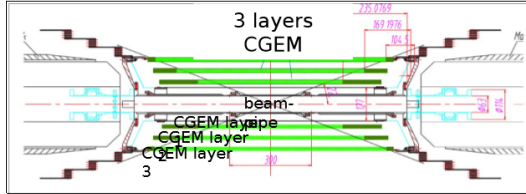
Version: 2.7

	Mon 2 Nov	Tue 3 Nov	Wed 4 Nov	Thu 5 Nov	Fri 6 Nov	Sat 7 Nov	Sun 8 Nov	Mon 9 Nov	Tue 10 Nov	Wed 11 Nov	Thu 12 Nov	Fri 13 Nov	Sat 14 Nov	Sun 15 Nov	Mon 16 Nov	Tue 17 Nov	Wed 18 Nov	Thu 19 Nov	Fri 20 Nov	Sat 21 Nov	Sun 22 Nov	Mon 23 Nov	Tue 24 Nov	Wed 25 Nov	Thu 26 Nov	Fri 27 Nov	Sat 28 Nov	Sun 29 Nov	Mon 30 Nov	Tue 1 Dec	Wed 2 Dec	Thu 3 Dec	Fri 4 Dec	Sat 5 Dec	Sun 6 Dec														
Week	45							46							47							48							49																				
Machine	UA9							Coldes							setup							UA9																											
T2 - H2	D. Lazic PPE172							CMS HGAL							A. Aduszkiewicz PPE152							NA61 SHINE																											
T2 - H4	RD51 (+GIF)							G. Tallot PPE134							NA58 ECAL							H. Dong PPE134							HERD							NUCLEON							RE21 CBM						

# A CGEM Inner Tracker for BESIII

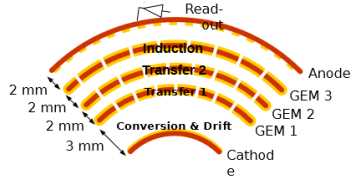
The Italian group is leading the development of a cylindrical GEM inner tracker for BESIII.

The project has been recently selected as one of the project funded by the European Commission within the call H2020-MSCA-RISE-2014.



## Requirements

- Rate capability:  $\sim 10^4$  Hz/cm<sup>2</sup>
- Spatial resolution:  $\sigma_{xy} \sim 120 \mu\text{m}$ ;  $\sigma_z \sim 1 \text{ mm}$
- Momentum resolution:  $\sigma_{p_t}/p_t \sim 0.5\%$  @1GeV
- Efficiency =  $\sim 98\%$
- Material budget  $\leq 1.5\%$  of  $X_0$  all layers
- Coverage: 93% 4 $\pi$
- Operation duration  $\sim 5$  years



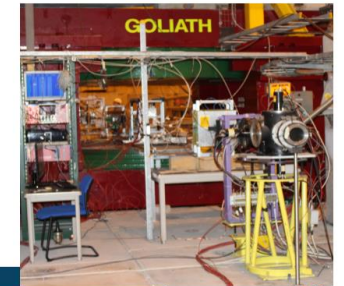
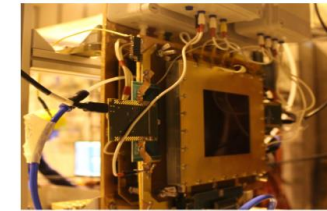
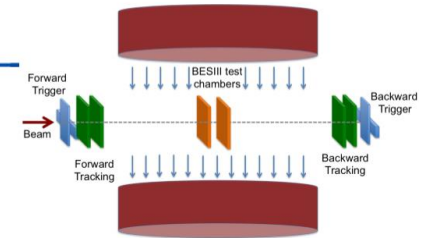
(LNF, Ferrara)

[https://indico.cern.ch/event/392637/session/5/contribution/27/attachments/785354/1076521/RD51\\_MiniweekMeeting2015.06.09.pdf](https://indico.cern.ch/event/392637/session/5/contribution/27/attachments/785354/1076521/RD51_MiniweekMeeting2015.06.09.pdf)

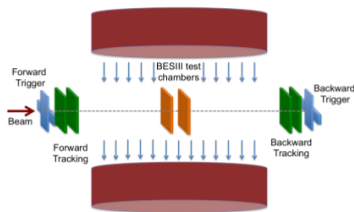
## The new setup

We are performing a new beam test to complete the planned set of measurements.

A new chamber with a different anode layout has been added to the setup.

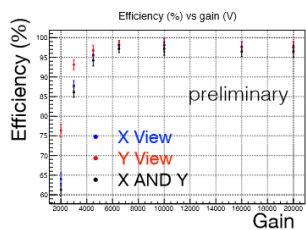


## Test Beam Results



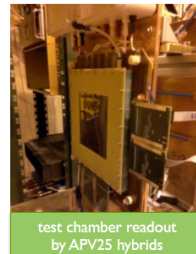
We performed two beam test at CERN to test planar prototypes inside a magnetic field.

- validate analogue readout
- validate Garfield simulation
- test different gas and geometry configurations



The efficiency plateau starts at about a gain of 6000. Efficiency for 2 dimensional clusters  $\sim 97\%$ .

With **no magnetic** field and 650  $\mu\text{m}$  strip pitch we achieved about 90  $\mu\text{m}$  of spatial resolution with Ar/Isob (90/10) gas mixture.

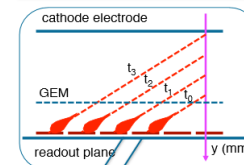


test chamber readout by APV25 hybrids



## $\mu$ TPC readout feasibility study

For diagonal tracks and/or in high magnetic field



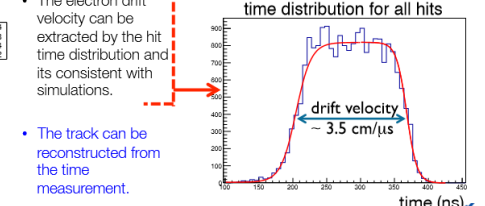
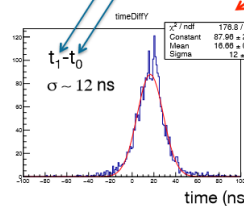
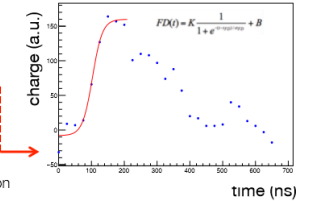
- Exploring a  $\mu$ TPC readout to further improve the spatial resolution

- Fit the charge samples to extract the drift time

- $\sim 12$  ns time resolution

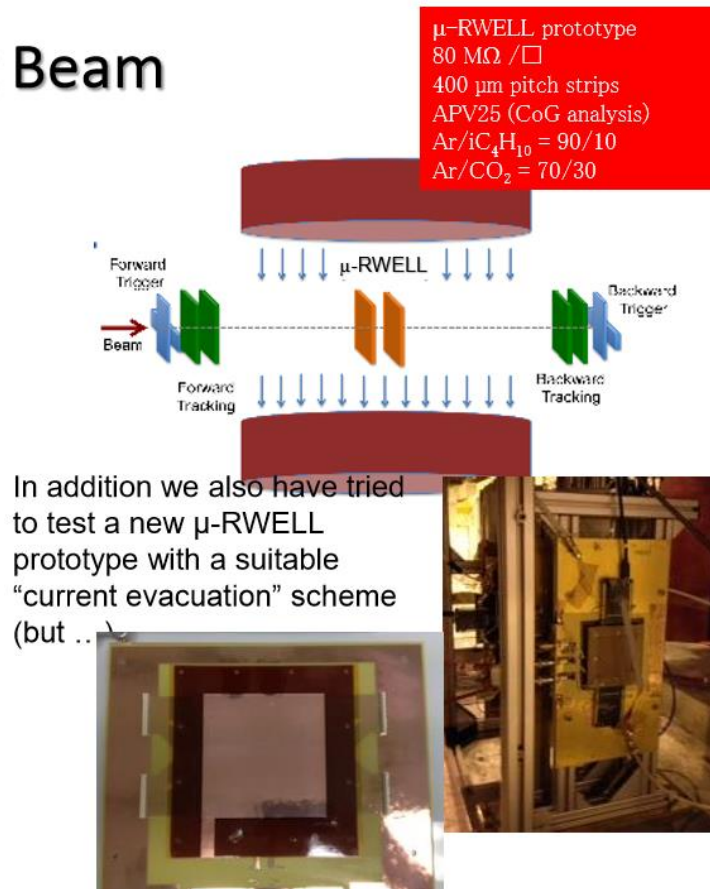
- The electron drift velocity can be extracted by the hit time distribution and its consistent with simulations.

- The track can be reconstructed from the time measurement.

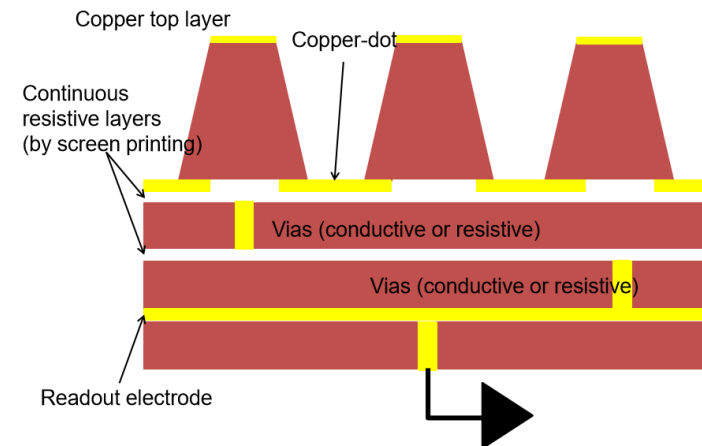
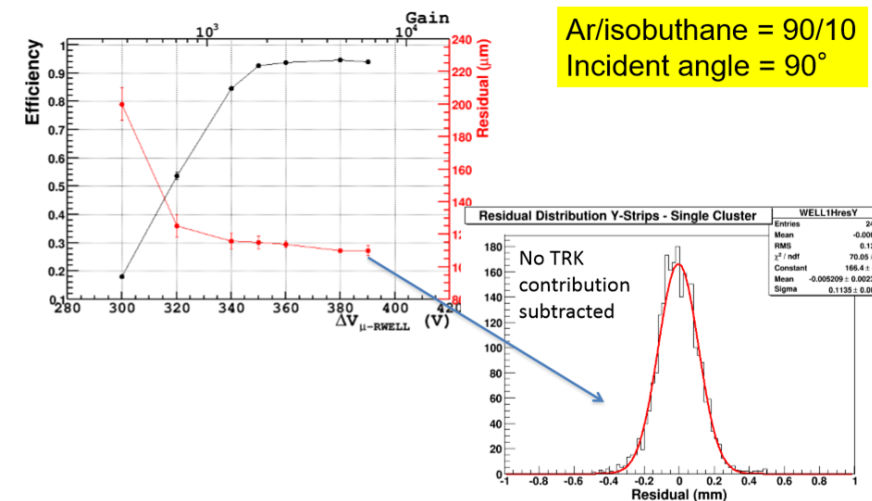


# June 2015 Test Beam

- $\mu$ -RWELL prototype  
80 M $\Omega$  /  $\square$   
400  $\mu$ m pitch strips  
APV25 (CoG analysis+  
micro-TPC mode)  
Ar/iC<sub>4</sub>H<sub>10</sub> = 90/10  
Ar/CO<sub>2</sub> = 70/30
- 4 GEM Trackers outside  
magnetic field
- HV scan, B scan
- Incident angle scan

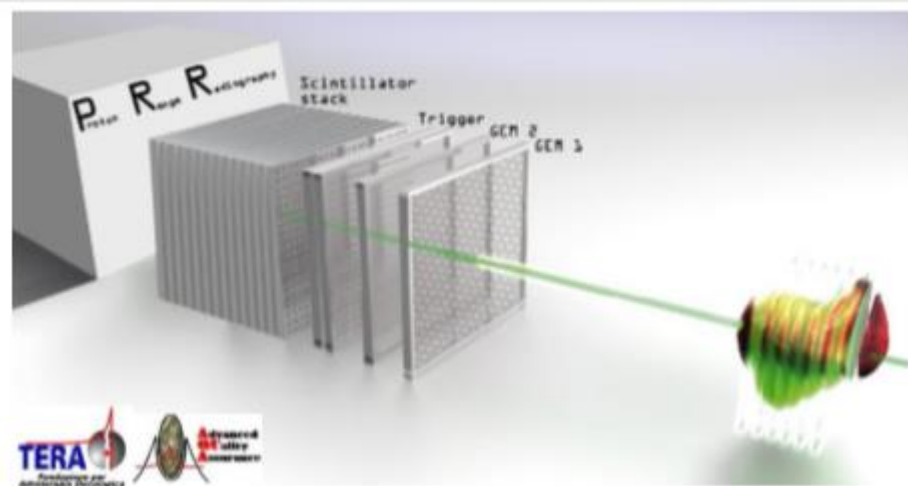


# Test Beam Results 2015



[https://indico.cern.ch/event/392637/session/5/contribution/28/attachments/785358/1076536/MiniWeeek\\_2015\\_test\\_beam.pdf](https://indico.cern.ch/event/392637/session/5/contribution/28/attachments/785358/1076536/MiniWeeek_2015_test_beam.pdf)

## Proton Range Radiography (TERA)



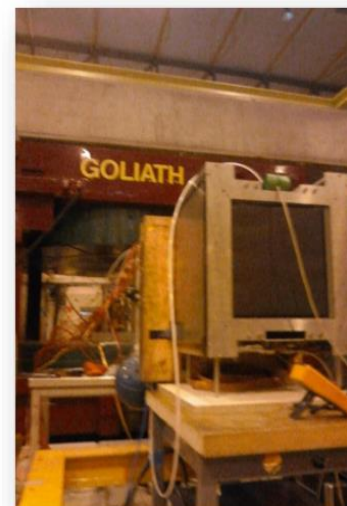
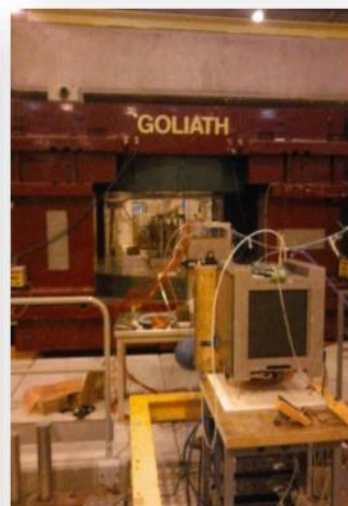
## New Proton Range Radiography telescope – PRR30

## - Scintillator stack

- 48 Plastic scintillators 30x30 cm<sup>2</sup>  
3 mm each (15 cm water equivalent)
- WLS fiber to SiPM 30MeV to 190MeV Residual Energy

## - Tracker

- Two 30x30 cm<sup>2</sup> triple-GEM detectors (Compass style)
- 2D XY strip readout (800 um pitch)
- Readout electronics capable of 1M events/sec

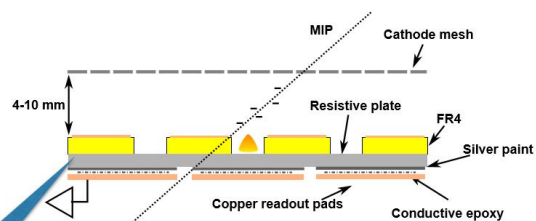

New electronic development


[https://indico.cern.ch/event/365380/session/6/contribution/54/attachments/726455/996903/Bucciantonio\\_PRR\\_2015\\_03\\_20.pdf](https://indico.cern.ch/event/365380/session/6/contribution/54/attachments/726455/996903/Bucciantonio_PRR_2015_03_20.pdf)

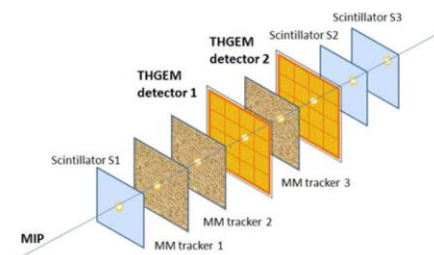
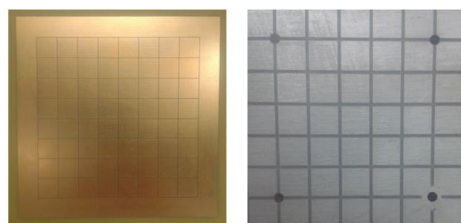
# The RPWELL (WIS/Coimbra/Aveiro)

# Test beam setup

a single sided THGEM coupled to anode through a resistive plate  
<http://iopscience.iop.org/1748-0221/8/11/P11004>



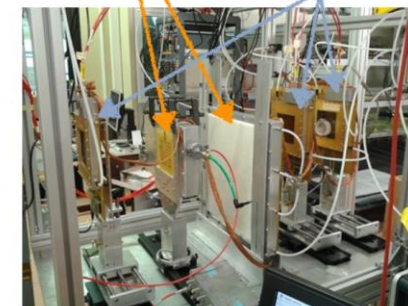
0.4 mm Semitron ESD225 (bulk resistivity  $10^8 \Omega\text{cm}$ )



- RD51 mm telescope
  - 3 scintillators ( $100 \times 100 \text{ mm}^2$  coverage)
  - 3 micromegas for precision tracking
- Two THGEM chambers
- Common DCS (HV control and monitoring)

THGEM detectors

mm telescope



[https://indico.cern.ch/event/392637/session/5/contribution/30/attachments/785380/1076571/RD51\\_MiniWeek-1506.pdf](https://indico.cern.ch/event/392637/session/5/contribution/30/attachments/785380/1076571/RD51_MiniWeek-1506.pdf)

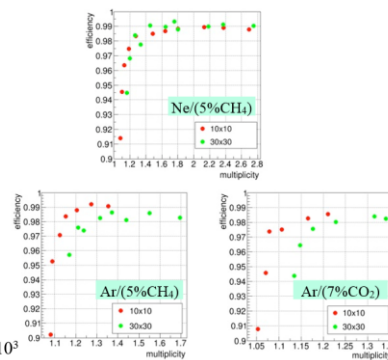
## MPGD 2015 – RD51 Collaboration Meeting:

<https://agenda.infn.it/getFile.py/access?contribId=8&sessionId=2&resId=0&materialId=slides&confId=8839>

### Beam studies Ne/(5%CH<sub>4</sub>) - Ar/(5%CH<sub>4</sub>) - Ar/(7%CO<sub>2</sub>)

#### 150 GeV $\mu$ & $\pi$ beams Efficiency & Multiplicity

- Higher multiplicity for  $30 \times 30 \text{ cm}^2$  compared to that of  $10 \times 10 \text{ cm}^2$  detectors
- Analysis not final
- Also related to the naive production used
- Misalignment between the readout pads and painted pads on the resistive sheet
- Will be done more carefully in the new detector



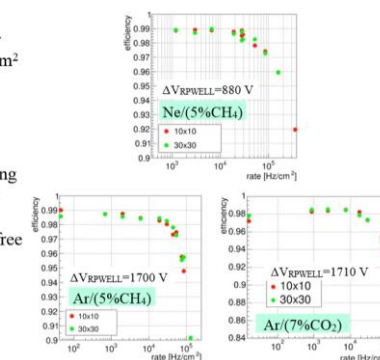
Gas gain  $\sim 10^4$ ; effective gain  $\sim 10^3$

$10 \times 10 \text{ cm}^2$  - Discharge-free operation also at high rate  $\pi$ -beam

### Beam studies Ne/(5%CH<sub>4</sub>) - Ar/(5%CH<sub>4</sub>) - Ar/(7%CO<sub>2</sub>)

#### 150 GeV $\mu$ & $\pi$ beams Rate capabilities

- Similar rate dependence for both  $10 \times 10 \text{ cm}^2$  &  $30 \times 30 \text{ cm}^2$  detectors
- $\sim 5\%$  efficiency loss over 3 orders of rate magnitudes
- Can be avoided by defining higher nominal operation voltage
- Still maintain discharge-free operation



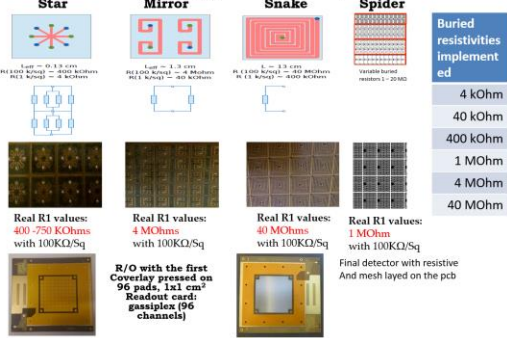
$10 \times 10 \text{ cm}^2$  - Discharge-free operation also at high rate  $\pi$ -beam

# Development of Resistive Micromegas for Sampling Calorimetry

Sampling Calorimetry with Resistive Anode Micromegas (SCREAM)

(LAPP/NCSR/CEA)

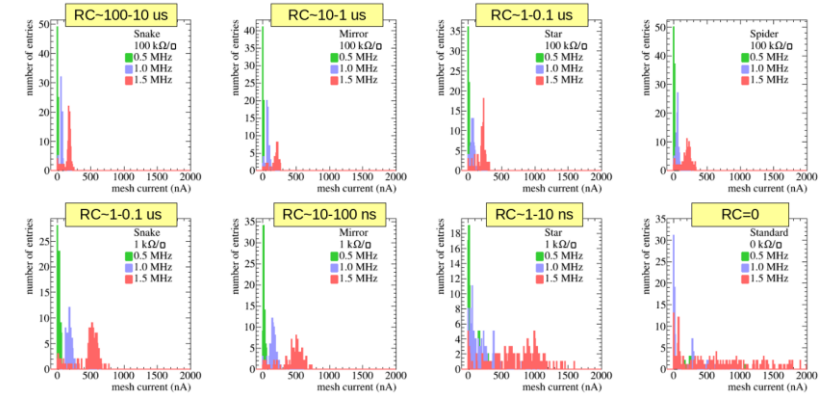
Buried resistance configuration used for these studies



MPGD 2015 – RD51 Collaboration Meeting:  
<https://agenda.infn.it/getFile.py/access?contribId=109&sessionId=2&resId=0&materialId=slides&confId=8839>

## 2) Rate scan with pions – One detector at a time in the same position (II)

The lowest resistivity prototype (Star1 – 4 kOhm) presents strong variations and high currents at high rates  
 The rest of the prototypes do not draw high mesh currents  
 → Lowest limit on RC (1 – 10) ns



12/10/2015

Theo Geralis

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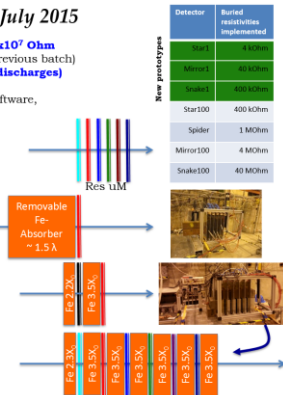
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## RD51 SPS/H4 testbeam in July 2015

- Explore buried resistance range:  $4 \times 10^2 - 4 \times 10^7$  Ohm
- 3 new detectors of lower resistivity (+ 4 of previous batch)
- Run with muons (mips, efficiency), pions (discharges) and electrons (charge-up)
- DAQ: VME, Gassiplex FE, C++ Demokritos software, acquisition rate up to 1.4 kHz.

Main tests

- 1) Muon beam: Mips, efficiencies
- 2) Rate scan with pions – One detector at a time in the same position
- 3) Electron beam. Test all Resistive  $\mu$ M at shower maximum one by one using as reference a standard  $\mu$ M
- 4) Build mini calorimeter with 6 res.  $\mu$ M and a total of  $\sim 20 X_0$ . Test with electrons



Detector	Buried resistivities implemented
Star	100kOhm
Mirror	4 MOhm
Snake	40 MOhm
Spider	1 MOhm
Star100	400 kOhm
Mirror100	4 MOhm
Snake100	40 MOhm

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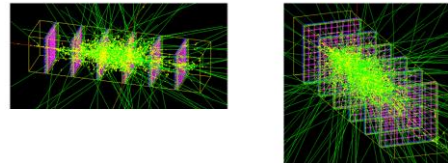
## 4) Build mini calorimeter with 6 res. $\mu$ M and a total of $\sim 20 X_0$ . Test with electrons



Electron Beam: 30, 50, 70, 90, 130, 200 GeV  
 Gas Gain: 1500, 3000

Use the first chamber to reduce the pion contamination

Simulated Events (Geant4): Exact geometry, 90 GeV shower

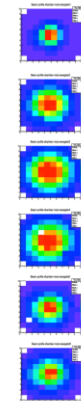
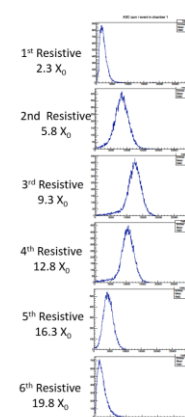


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## 200 GeV Electron Beam: Detector spectra



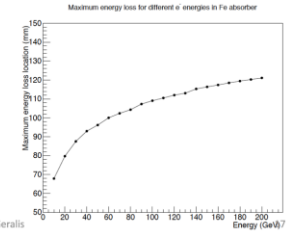
Energy deposition in every detector for 200 GeV electrons (left)

Shower profile (average) in every one of the 6 layers

Shower maximum is visible in the 3<sup>rd</sup> Detector

The first chamber is used to suppress the pion contamination of the beam

Differences in the gain will be corrected from the mips spectra





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[https://indico.cern.ch/event/392637/session/5/contribution/31/attachments/785379/1076570/wg7\\_09062015.pdf](https://indico.cern.ch/event/392637/session/5/contribution/31/attachments/785379/1076570/wg7_09062015.pdf)

# ATLAS & VMM (ATLAS NSW mm)

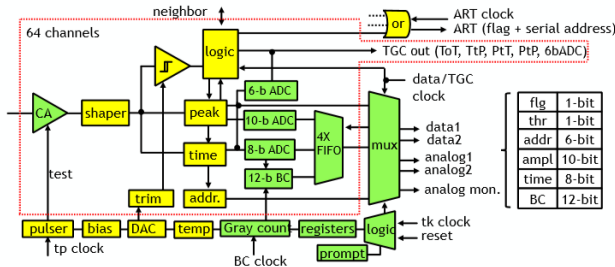
## VMM - An ASIC for Micropattern Detectors

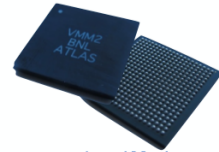
**George Iakovidis**  
 Physics Department of  
 Brookhaven National Laboratory  
 Upton, New York  
 on behalf of the ATLAS Muon Collaboration

**BROOKHAVEN**  
 NATIONAL LABORATORY

## VMM2 - Second ASIC prototype in 2014 (digital)

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flg	1-bit
thr	1-bit
addr	6-bit
ampl	10-bit
time	8-bit
BC	12-bit

**custom 400-pin  
21 x 21 mm<sup>2</sup> BGA  
1mm pitch**

- All the bugs of VMM1 fixed plus additional functionality
- New **Configuration logic registers**: 80-bit + 24-bit / channel (1616bits)
- **Charge amplifier**: input transistor: PMOS 180 nm x 20 mm, 2 mA, adjustable gain 0.5, 1, 3, 4.5, 6, 9, 12, 16 mV/fC (max charge 2 to 0.06 pC)
- **Peak detector**, measurement of the peak amplitude - ADC with current-mode domino architecture **10-bit**, **200 ns**, sub-mW, for peak amplitude conversion, adjustable conversion time and offset + **6-bit** ADC with 25ns conversion time
- **Time detector**: sub-ns resolution measurement of peak time, **8-bit**, **100 ns**, same as the 10bit architecture - **12-bit timestamp** - from shared 12-bit Gray-code counter, external BC clock - **Complete timing information of 20-bit**
- **ART**: serial output of a flag+ address with a clock reception
- **Logic**: direct digital output per channel with additional outputs (ToT, TtP, PIt, PIP)
- **4-deep FIFO**: threshold-crossing indicator, 10-bit ADC, 8-bit ADC, 12-bit BC
- **Readout**: 38bit event continuous self-reset operation fully digital continuous up to 200 MHz (additional to the 2 phase analog mode)
- **PROMPT** (courtesy of CERN): **export regulations (ITAR) compliance circuit**

George Iakovidis - MPGD 2015
15/10/2015



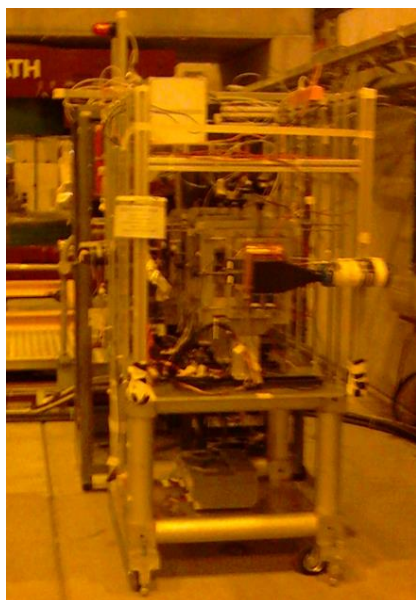
Preliminary test during the July test beam of the VMM2 on the RD51 Hybrid (SRS)



# P348: Search for new physics in missing-energy events

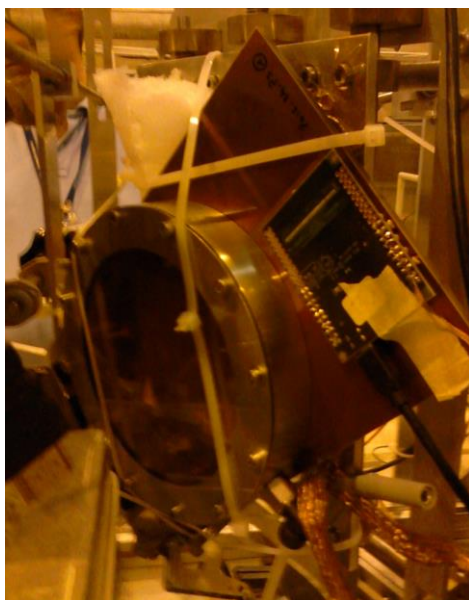
D.Banerjee (ETH, Zurich)

P348 Test Beam Report:  
[https://indico.cern.ch/event/385594/contribution/7/7/attachments/1171005/1690559/p348\\_gninenko\\_SPSC.pdf](https://indico.cern.ch/event/385594/contribution/7/7/attachments/1171005/1690559/p348_gninenko_SPSC.pdf)



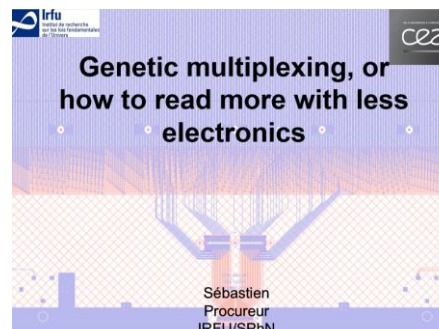
RD51 Tracker

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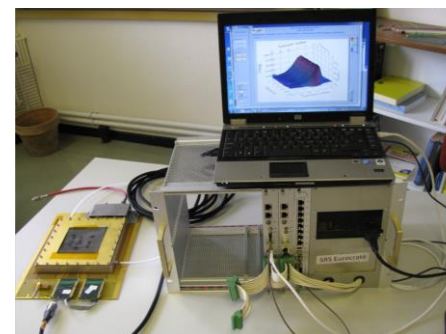


P348 resistive mm with RD51 APV25

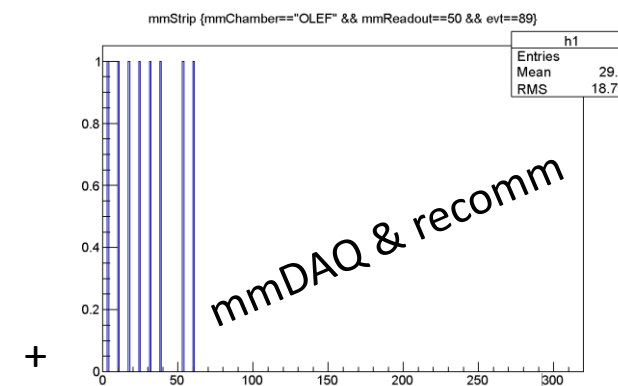
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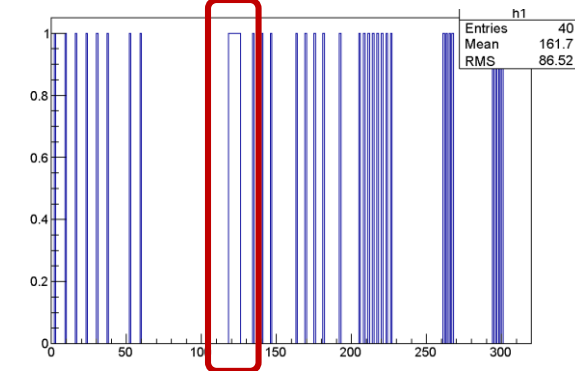
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Essential support from the ATLAS NSW mm group for the DAQ (mmDAQ) and analysis (recomm)



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Konstantinos Ntekas

Preliminary test during the RD51 July test beam (few days of the full period) in view of the P348 Test Beam

## SPS: October 2015



schedule issue date: 15-Oct-2015

Version: 2.7

	Mon 28 Sep	Tue 29 Sep	Wed 30 Sep	Thu 1 Oct	Fri 2 Oct	Sat 3 Oct	Sun 4 Oct	Mon 5 Oct	Tue 6 Oct	Wed 7 Oct	Thu 8 Oct	Fri 9 Oct	Sat 10 Oct	Sun 11 Oct	Mon 12 Oct	Tue 13 Oct	Wed 14 Oct	Thu 15 Oct	Fri 16 Oct	Sat 17 Oct	Sun 18 Oct	Mon 19 Oct	Tue 20 Oct	Wed 21 Oct	Thu 22 Oct	Fri 23 Oct	Sat 24 Oct	Sun 25 Oct	Mon 26 Oct	Tue 27 Oct	Wed 28 Oct	Thu 29 Oct	Fri 30 Oct	Sat 31 Oct	Sun 1 Nov
Week	40				41				42				43				44																		
Machine	A. Aduszkiewicz PPE152				P348				D. Lazic PPE164				CMS EE upgrade				Y. Tsiopolitis PPE134				RD51 (+GIF)														
	NA61 SHINE																Calice (Sdhcal)				CMS HGCAL														

## SPS: November 2015

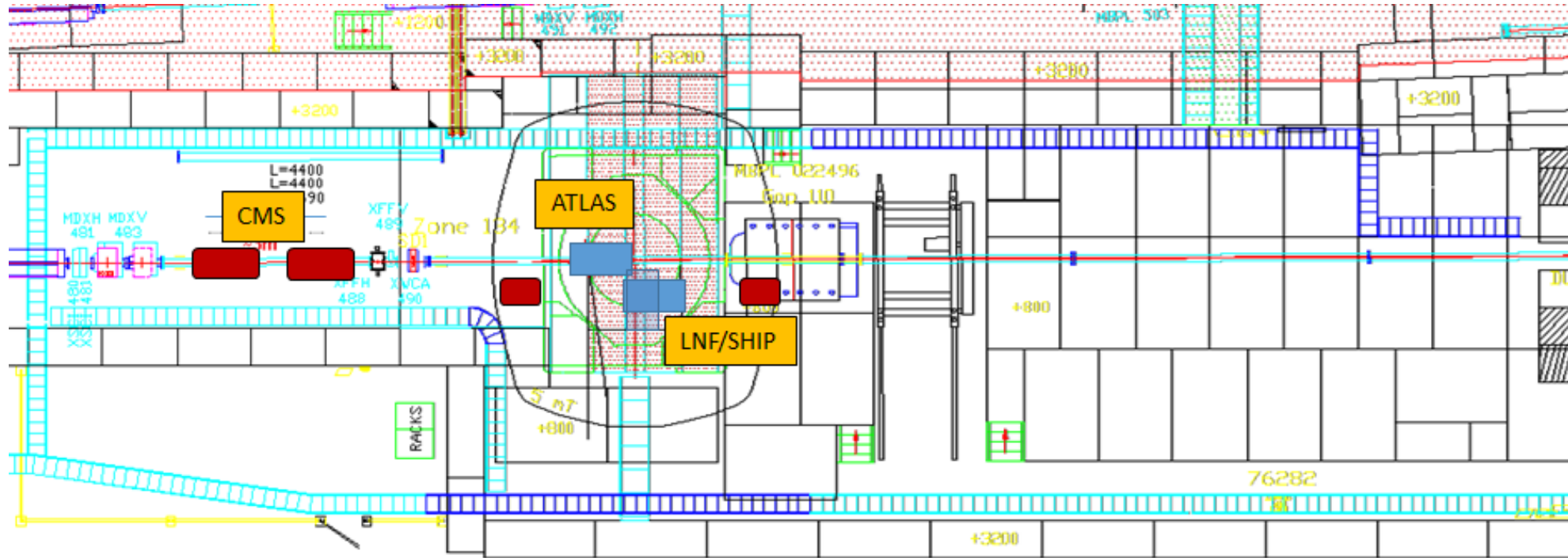


schedule issue date: 15-Oct-2015

Version: 2.7

	Mon 2 Nov	Tue 3 Nov	Wed 4 Nov	Thu 5 Nov	Fri 6 Nov	Sat 7 Nov	Sun 8 Nov	Mon 9 Nov	Tue 10 Nov	Wed 11 Nov	Thu 12 Nov	Fri 13 Nov	Sat 14 Nov	Sun 15 Nov	Mon 16 Nov	Tue 17 Nov	Wed 18 Nov	Thu 19 Nov	Fri 20 Nov	Sat 21 Nov	Sun 22 Nov	Mon 23 Nov	Tue 24 Nov	Wed 25 Nov	Thu 26 Nov	Fri 27 Nov	Sat 28 Nov	Sun 29 Nov	Mon 30 Nov	Tue 1 Dec	Wed 2 Dec	Thu 3 Dec	Fri 4 Dec	Sat 5 Dec	Sun 6 Dec
Week	45				46				47				48				49																		
Machine	D. Lazic				NA58 ECAL				H. Dong PPE134				HERD				L. Tkachev PPE134				D. Emschermann PPE134														
	UA9				Cold				setup								NA61 SHINE				UA9														
T2 - H2	A. Aduszkiewicz PPE152				CMS HGCAL				A. Aduszkiewicz PPE152																										
T2 - H4	RD51 (+GIF)				G. Mallot PPE134												NUCLEON				RE21 CBM														

October-November 2015



ATLAS NSW micromegas upgrade: test of mm and of the new FE electronics (ATLAS VMM) in magnetic field.

CMS GEM collaboration: test of the super module detectors for the slice test, of the new electronics and DAQ and timing and efficiency test of a new prototype.

LNF(SHIP): Space resolution studies of GEM and microResistiveWELL in magnetic field. Both detectors will be coupled with emulsion bricks for a reduced part of the measurements.

## Request for Beam Time at the PS & SPS in 2016

Please fill out this form by editing its electronic version ([http://sps-schedule.web.cern.ch/sps-schedule/2016/beam\\_request\\_form\\_2016.docx](http://sps-schedule.web.cern.ch/sps-schedule/2016/beam_request_form_2016.docx)) on your computer using *Word* or *OpenOffice*, save the file as **EXPERIMENT\_NAME-beam\_request\_2016.docx**, and upload it to the share point: <https://espace.cern.ch/PS-SPS-User-Documents/2016%20Beam%20time%20requests> latest by **November 21<sup>st</sup> 2015**.

Three periods of two weeks each: Spring (May/June), Summer (July/August), Fall (October/November)

## Summary

About 6 weeks and 9 users in total

- R&D on (new) MPGD structures (RPWELL,  $\mu$ RWELL, embedded Pad Resistive Micromegas)
- Detector (prototypes) optimization and characterization (BESIII CGEM, CMS GEM, ATLAS mm)
- Detector (final design or very close) Characterization (PRR30, ATLAS NSW, CMS GEM)
- FE Electronics and DAQ (ATLAS NSW mm - VMM, CMS GEM VFAT2 & DAQ, P348 genetic readout resistive micromegas and SRS/APV25)
- Operation in Magnetic Field (1.5T max) – Very precious tool for the community

2016 request: 3 periods of 2 weeks each (deadline: November 21<sup>st</sup>)