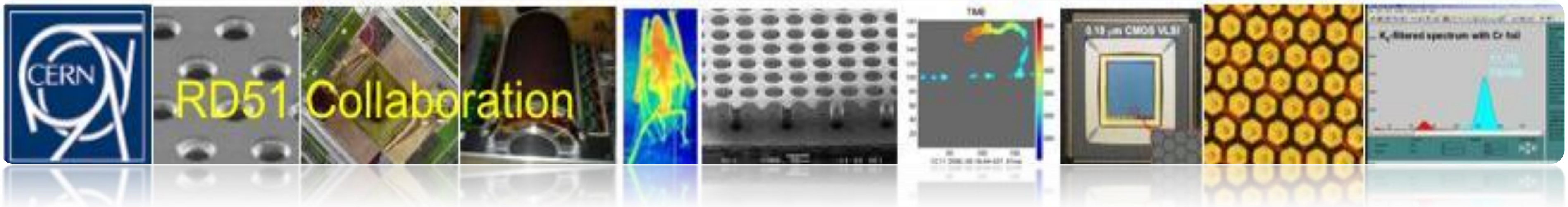



# RD51 Annual Report
# Development of Micro Pattern Gas Detector Technologies

Leszek Ropelewski, EP-DT-DD, CERN, Switzerland

On behalf of the RD51 Collaboration

CERN Courier October 2015
Detector R&D

# RD51 and the rise of micro-pattern gas detectors

Since its foundation, the RD51 collaboration has provided important stimulus for the development of MPGDs.

Improvements in detector technology often come from capitalizing on industrial progress. Over the past two decades, advances in photolithography, microelectronics and printed circuits have opened the way for the production of micro-structured gas-amplification devices. By 2008, interest in the development and use of the novel micro-pattern gaseous detector (MPGD) technologies led to the establishment at CERN of the RD51 collaboration. Originally created for a five-year term, RD51 was later prolonged for another five years beyond 2013. While many of the MPGD technologies were introduced before RD51 was founded (figure 1), with more techniques becoming available or affordable, new detection concepts are still being introduced, and existing ones are substantially improved.

In the late 1980s, the development of the micro-strip gas chamber (MSGC) created great interest because of its intrinsic rate-capability, which was orders of magnitude higher than in wire chambers, and its position resolution of a few tens of micrometres at particle fluxes exceeding about 1 MHz/mm$^2$. Developed for projects at high-luminosity colliders, MSGCs promised to fill a gap between the high-performance but expensive solid-state detectors, and cheap but rate-limited traditional wire chambers. However, detailed studies of their long-term behaviour at high rates and in hadron beams revealed two possible weaknesses of the MSGC technology: the formation of deposits on the electrodes, affecting gain and performance ("ageing effects"), and spark-induced damage to electrodes in the presence of highly ionizing particles.

These initial ideas have since led to more robust MPGD structures, in general using modern photolithographic processes on thin insulating supports. In particular, ease of manufacturing, operational stability and superior performances for charged-particle tracking, muon detection and triggering have given rise to two main designs: the gas electron-multiplier (GEM) and the micro-mesh gaseous structure (Micromegas). By using a pitch size of a few hundred micrometres, both devices exhibit intrinsic high-rate capability (> 1 MHz/mm$^2$), excellent spatial and multi-track resolution (around 30 μm and 500 μm, respectively), and time resolution for single photoelectrons in the sub-nanosecond range.

Coupling the microelectronics industry and advanced PCB technology has been important for the development of gas detectors with increasingly smaller pitch size. An elegant example is the use of a CMOS pixel ASIC, assembled directly below the GEM or Micromegas amplification structure. Modern "wafer post-processing technology" allows for the integration of a Micromegas grid directly on top of a Medipix or Timepix chip, thus forming

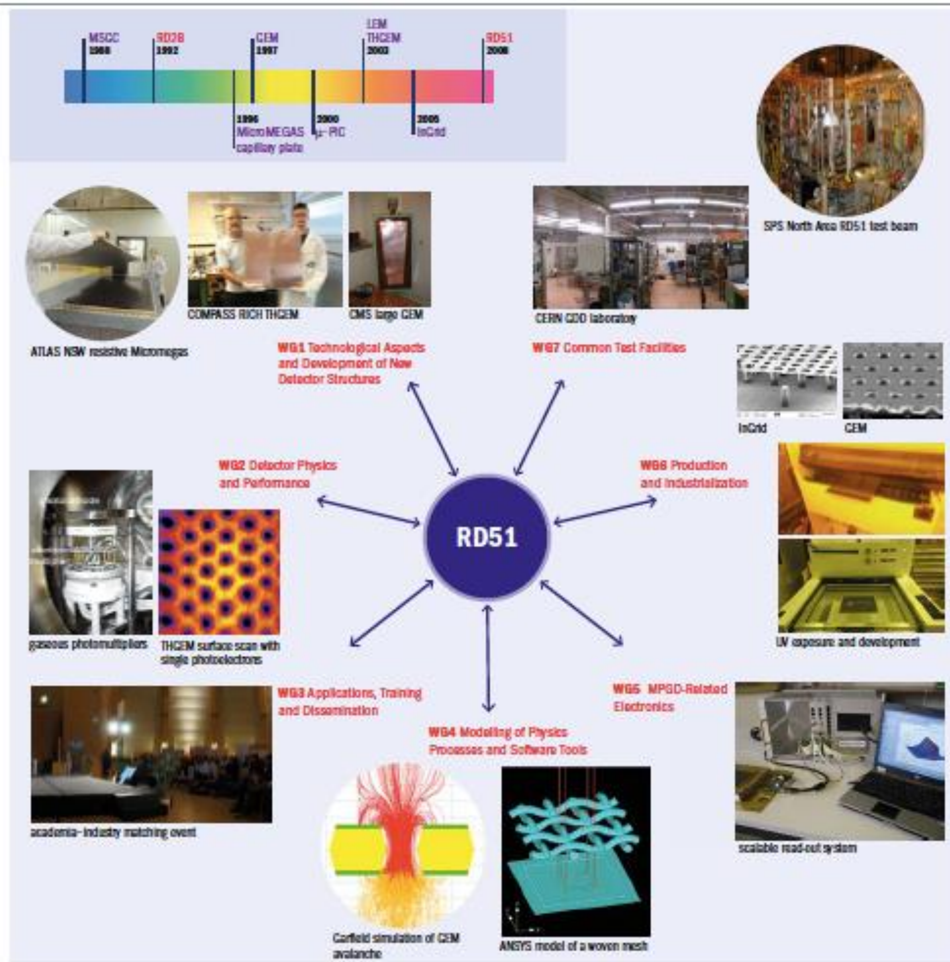



*Fig. 1. The seven working groups of RD51, with illustrations of just a few examples of the different kinds of work involved. Top left: the 20-year pre-history of RD51. (Image credits: RD51 Collaboration.)*

integrated read-out of a gaseous detector (InGrid). Using this approach, MPGD-based detectors can reach the level of integration, compactness and resolving power typical of solid-state pixel devices. For applications requiring imaging detectors with large-area coverage and moderate spatial resolution (e.g. ring-imaging Cherenkov (RICH) counters), coarser macro-patterned structures offer an interesting economic solution with relatively low mass and easy construction – thanks to the intrinsic robustness of the PCB electrodes. Such detectors are the thick GEM (THGEM), large electron multiplier (LEM), patterned resistive thick GEM (RETGEM) and the resistive-plate WELL (RPWELL).

## RD51 and its working groups

The main objective of RD51 is to advance the technological development and application of MPGDs. While a number of activities have emerged related to the LHC upgrade, most importantly, RD51 serves as an access point to MPGD "know-how" for the worldwide community – a platform for sharing information, results and experience – and optimizes the cost of R&D through the sharing of resources and the creation of common projects and infrastructure. All partners are already pursuing either basic- or application-oriented R&D involving MPGD concepts. Figure 1 shows the organization of seven Working Groups (WG) that cover all of the relevant aspects of MPGD-related R&D.

*WG1 Technological Aspects and Development of New Detector Structures.* The objectives of WG1 are to improve the performance of existing detector structures, optimize fabrication methods, and develop new multiplier geometries and techniques. One of the most prominent activities is the development of large-area GEM, Micromegas and THGEM detectors. Only one decade ago, the largest MPGDs were around 40 × 40 cm$^2$, limited by existing tools and materials. A big step towards the industrial manufacturing of MPGDs with a size around a square metre came with new fabrication methods – the single-mask GEM, "bulk" Micromegas, and the novel Micromegas construction scheme with a "floating mesh". While in "bulk" Micromegas, the metallic mesh is integrated into the PCB read-out, in the "floating-mesh" scheme it is integrated in the panel containing drift electrodes and placed on pillars when the chamber is closed. The single-mask GEM technique overcomes the cumbersome practice of alignment of two masks between top and bottom films, which limits the achievable lateral size to 50 cm. This technology, together with the novel "self-stretching technique" for assembling GEMs without glue and spacers, simplifies the fabrication process to such an extent that, especially for large-volume production, the cost per unit area drops by orders of magnitude. ▷




http://cerncourier.com/cws/article/cern/62507

# RD51 Achievements and Highlights

- Consolidation of the Collaboration and MPGD community integration ( 86 Institutes, ~500 members);
- Major progress in the MPGD technologies development in particular large area GEM (single mask), MicroMegas (resistive), THGEM; some picked up by experiments (including LHC upgrades);

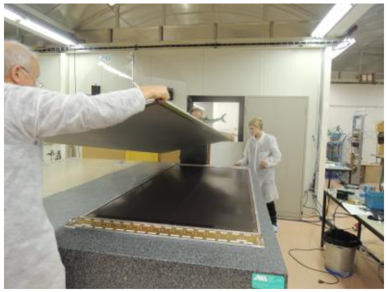
  ALICE, TPC read-out, 130 $m^2$ to be instrumented
  ATLAS, small wheels, 1200 $m^2$ to be instrumented
  CMS, forward detectors, 1000 $m^2$ of GEM foils
  COMPASS RICH, 4.5 $m^2$ to be instrumented, single photon detection

- Secured future of the MPGD technologies development through the EP DT MPT workshop upgrade and FP7 AIDA & AIDA2020 contribution;
- Contacts with industry for large volume production, MPGD industrialization and first industrial runs;
- Major improvement of the MPGD simulation software framework for small structures allowing first applications;
- Development of common, scalable readout electronics (SRS) (many developers and > 50 user groups); Production (PRISMA company and availability through CERN store); Industrialization (re-design of SRS in ATCA in EISYS);
- Infrastructure for common RD51 test beam and lab facilities (>20 user groups)

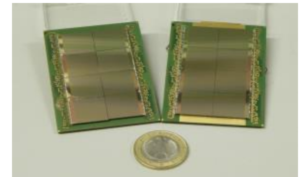
# RD51 Collaboration

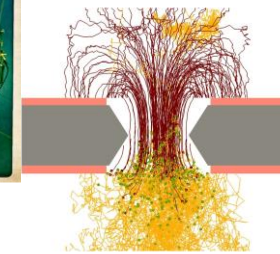
**RD51**

**WG1:** Technological Aspects
New Detector Structures

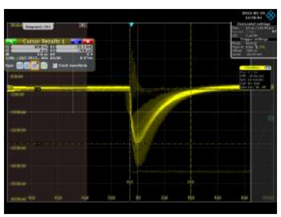
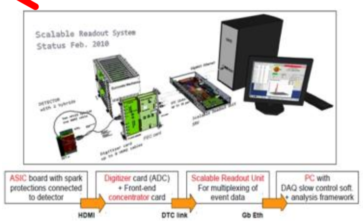


**WG2:** Detector Physics and Performance
RD51 Common Projects





**WG5:** MPGD Electronics

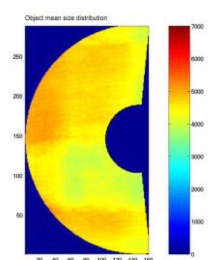




**WG4:** Modeling of Physics Processes
Software Tools

**WG7:** Common Test Facilities

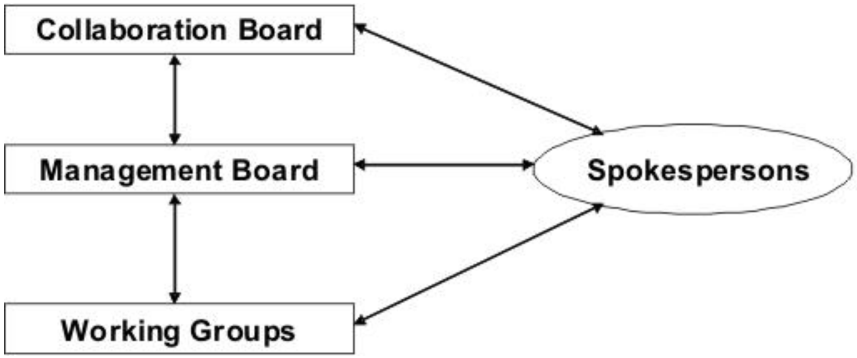

**WG3:** Applications, Training and Dissemination






**WG6:** Production and Industrialization


# RD51 New Scientific Organization




**Members of the RD51 Collaboration Management Board (MB):**

**two Co-Spokespersons:** Silvia Dalla Torre, Leszek Ropelewski
**CB Chairperson and its deputy:** João Veloso, Atsuhiko Ochi
**Scientific Secretary:** Maxim Titov
**Technical Coordinator:** Eraldo Oliveri
**MB members:** Amos Breskin, Paul Colas, Klaus Dehmelt, Ioannis Giomataris, Hans Taureg (Finances), Andy White
+ 3 to be elected

**Working Groups Conveners:**

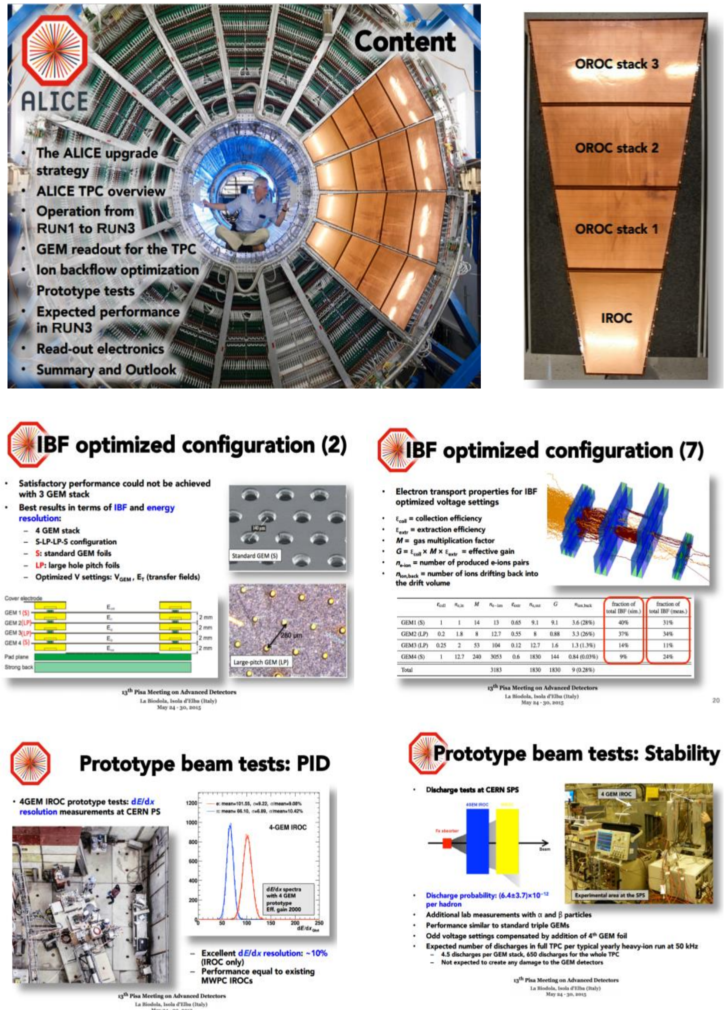
WG1 - **New Structures and Technologies** (Paul Colas, Filippo Resnati)
WG2 - **Detector Physics and Performance** (Diego Gonzalez Diaz, Max Chefdeville)
WG3 - **Training and Dissemination** (Fabrizio Murtas, João Veloso)
WG4 - **Modeling of Physics Processes and Software Tools** (Ozkan Sahin, Rob Veenhof)
WG5 - **Electronics for MPGDs** (Jochen Kaminski, Hans Muller)
WG6 - **Production and Industrialization** (Fabien Jeanneau, Hans Danielsson, Rui de Oliveira)
WG7 - **Common Test Facilities** (Eraldo Oliveri, Yorgos Tsipolitis)

# RD51 present and future activities

- Continuation of the R&D support for the experiments and LHC upgrades WG1
- Generic R&D (new structures, ideas, detector physics) – RD51 Common Projects WG2
  Development of new structures and consolidation of the existing structures
- Applications - organization of series of specialized workshops disseminating MPGD applications beyond fundamental physics – RD51, potential users and industry (e.g. dosimetry, neutron detection, medical physics, …) WG3
- MPGD Education and Training : organization of schools for students and newcomers & academic training WG3
- Development and Maintenance of Software & Simulation Tools; basic studies & software support for the RD51 community WG4
- Development and Maintenance of the SRS Electronics; An extended support for the SRS including new developments and implementations of additional features WG5
- MPGD Industrialization and QA Control - GEM, MicroMegas, Thick GEM; WG6
- Maintenance of the RD51 Lab and Test-Beam Infrastructure WG7

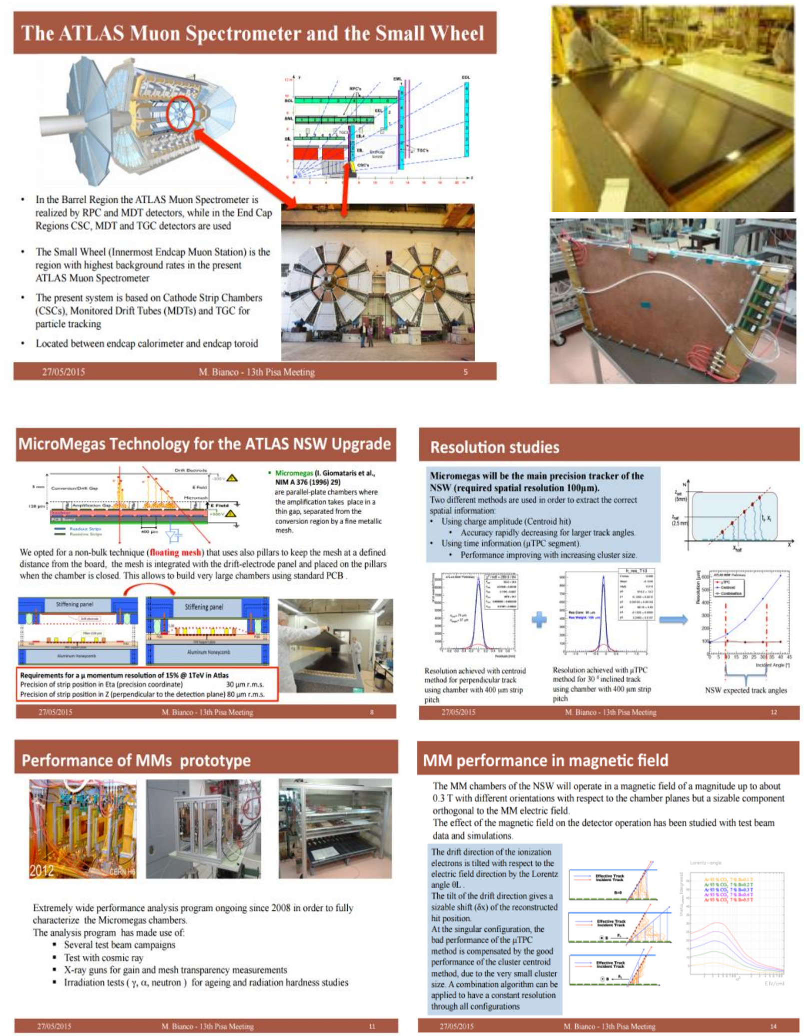
# Examples of CERN/LHC Upgrades

## ALICE (GEM)




A continuous read-out TPC for the ALICE upgrade, C. Lippmann, Elba 2015

## ATLAS NSW (mm)



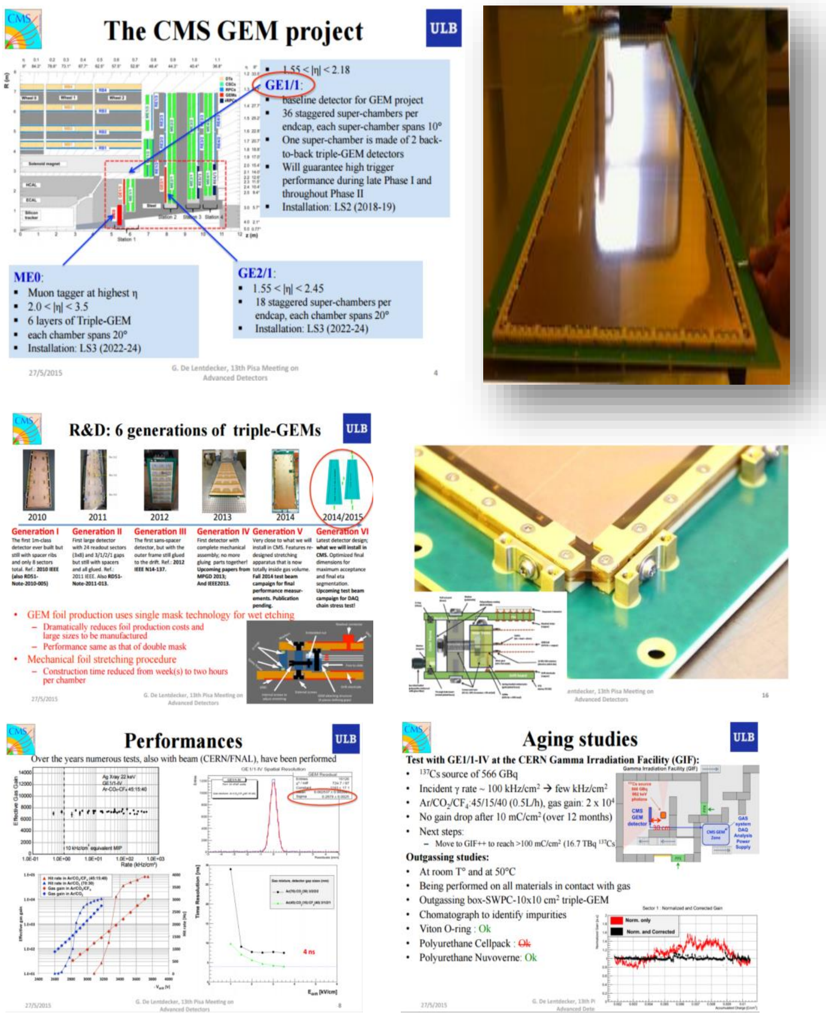

Micromegas Detectors for the Muon Spectrometer Upgrade of the ATLAS Experiment; M. Bianco, Elba 2015

LHC Upgrades: Original R&D efforts emerged from RD51 activities.
Today: production phase under the project effort , access to RD51 facilities (laboratory, test beam, workshops) and tools (simulation, electronics,…) to facilitate this particular phase

# Examples of CERN/LHC Upgrades

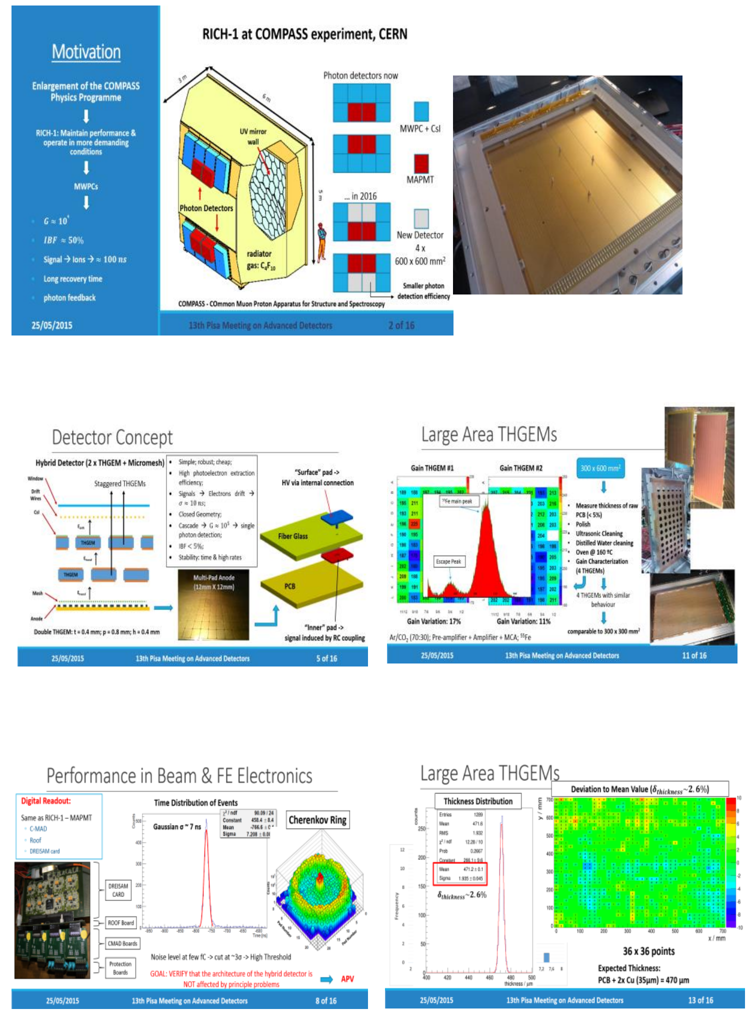
## CMS (GEM)

Status Report of the Upgrade of the CMS muon system with triple-GEM detectors, G. De Lentdecker, Elba 2015




## COMPASS RICH-1 (THGEM+mm)

Status of the Development of Large Area Photon Detectors based on THGEMs and Hybrid MPGD architectures for Cherenkov Imaging Applications , C.A.Santos, Elba 2015




LHC Upgrades: Original R&D efforts emerged from RD51 activities.

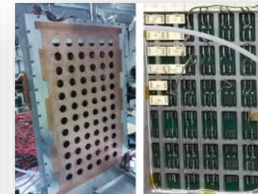
Today: production phase under the project effort , access to RD51 facilities (laboratory, test beam, workshops) and tools (simulation, electronics,…) to facilitate this particular phase

# Activities in the GDD/RD51 Laboratory

## *Experiments*

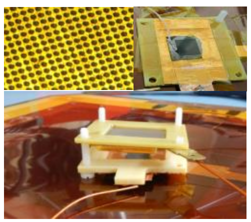
ATLAS NSW: Quadruplet, Environmental Effects, Thinner Gaps mm


ALICE: out gassing, Aging and stability

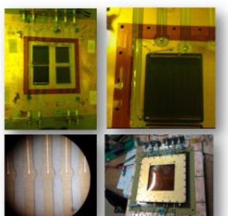


THGEM – Micromegas - Electronics Compass RICH

## *Detectors R&D*

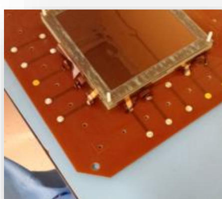


Diamond GEM



CC MSGC

Thick-Groove



Target Exp. GEM TPC

*3 Permanent Installation (ALICE TPC, ATLAS NSW, ESS)*

*> 15 groups in visit to perform measurements*

*Several activities in synergy with external companies*

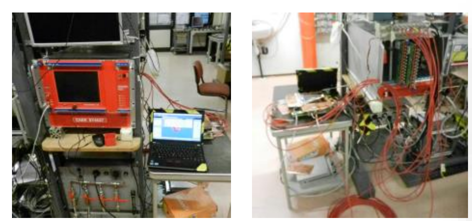
## *Electronics*

ATLAS VMM2

ALICE FoCAL VMM2 and SRS


MPGD Instrumentation Development

## *External Companies*



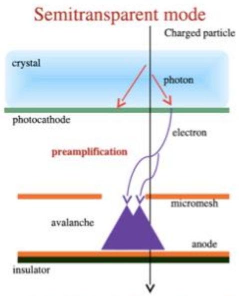
CAEN (HV power Supply)

eicSys (ATCA SRS)

# Generic Detector R&D

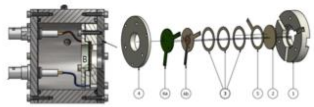
Collaboration with Saclay and Princeton

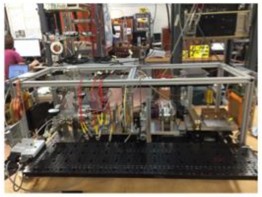
## Fast timing with MM

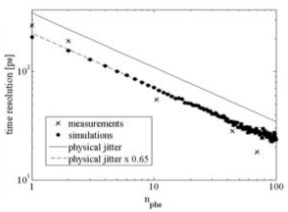


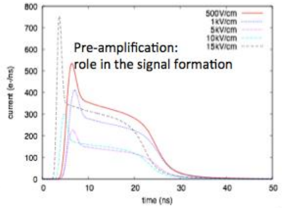

Aim at < 50ps resolution
- Cherenkov radiator
- Photocathode
- 200um drift
- MicroMeGas

R&D on:
- photocathode protection
- photocathode alternatives
- secondary emitter materials





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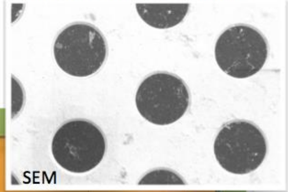
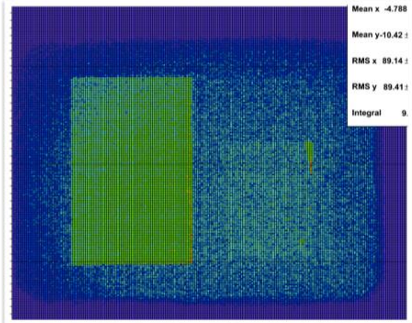
Collaboration with UCL

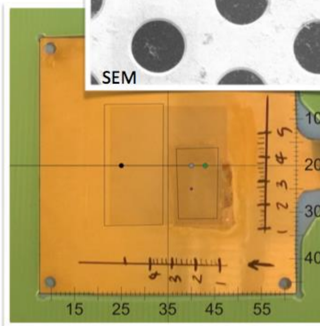
## Graphene

Membrane opaque to ions and transparent to electrons
- solution of the ion back-flow in gaseous detectors
- protective layer on photocathodes
- enhancement of electron emission

~99% (suspended)
graphene tri-layer coverage

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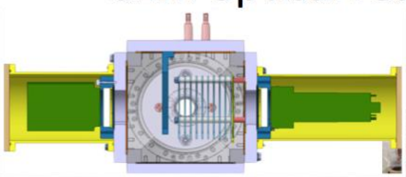
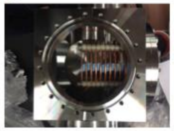
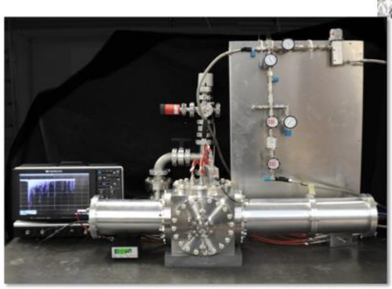
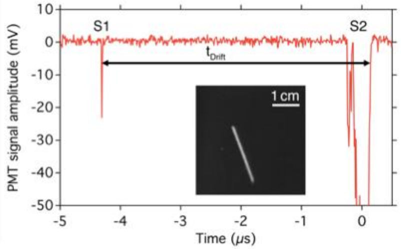
## GEM optical readout and OTPC



Study:
- Visible (near UV and near IR) scintillation of gasses
- Event topology study
- Imaging





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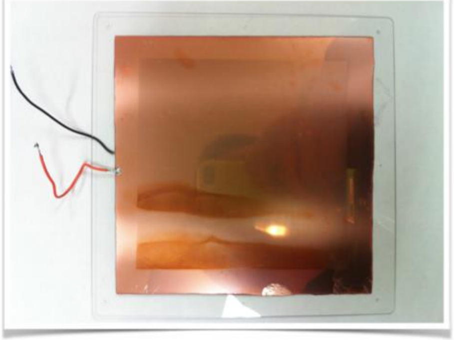
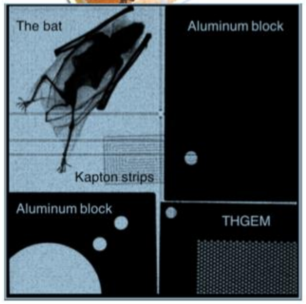
Collaboration with Tokyo University

## Glass GEM

Photo Etchable Glass 3 (PEG3):
Rigid (self sustained structure)
'Laser assisted etching' opens new possibilities
Slightly conductive (milder charge-up)
Clean and low outgassing (sealed operation)

Imaging with electronic readout



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# MPGD 2015 and RD51 CM in Trieste

[MPGD2015 and RD51 CM]

**New Developments in MPDGs**
**Production techniques**
**Material and Ageing Tests**
**MPGD Detector Physics**
**Simulation and Software**
**Electronics**
**Applications**

140 participants
120 abstracts

Charpak Young Scientist Award

[MPGD contributions in recent and running experiments]

[Conference Summary]

## Academia-Industry Matching Event
## Second Special Workshop on Neutron Detection with MPGDs

16-17 March 2015
CERN
Europe/Zurich timezone

Search

- Event Description
- Detailed agenda
- Registration
- Participant List
- How to get CERN
- List of Recommended Hotels
- 15th RD51 Collaboration Meeting
- Organising Commitee

### Event Description

The specialized workshop "Neutron Detection with Micro-Pattern Gaseous Detectors" organised by RD51 in collaboration with HEPTech, will take place at CERN on March 16 and 17, 2015.

**The goal of the workshop is to help disseminating MPGD technologies beyond fundamental physics, where academic institutions, potential users and industry could meet together.**

The shortage of the Helium-3 in the world brings new challenges to neutron detection, especially in the areas of homeland security, non-proliferation, neutron scattering science and other fields. Micro-Pattern Gaseous Detectors offer attractive alternative solutions for neutron detection, compared to Helium-3 based proportional counters. Moreover, this event provides a platform for discuss prospects of the MPGD use for the thermal and fast neutron detection, commercial requirements and possible solutions. This workshop aims to foster collaboration between the particle physics community and the industry of neutron detectors, and to discuss the potential of the MPGD technologies for the field. This event is jointly organized by the RD51 collaboration, the HEPTech Network and CERN KT Group. It is open to all researchers and commercial partners interested or working in the field of neutron detection.

RD51 HEPTech Leading HEP technologies for industry Technology Transfer opportunities CERN

**Dates:** 16 to 17 March 2015
**Venue:** The Globe, CERN
Route de Meyrin 385, 1217 Meyrin



RD51-NOTE-2015-012

# Prospects in MPGDs development for neutron detection

Summary of RD-51 Academia-Industry Matching Event
Second Special Workshop on Neutron Detection with MPGDs

Gabriele Croci (University of Milano-Bicocca, INFN & CNR),
Fabrizio Murtas (INFN & CERN),
Filippo Resnati (CERN)

Organising committee of the Academia-Industry Matching Event
A. Breskin (Weizmann Institute), A. Delbart (CEA),
S. Duarte Pinto (CERN), I. Giomataris (CEA),
B. Guerrard (ILL), R. Hall-Wilton (ESS),
J. Le Goff (CERN), F. Murtas (INFN & CERN),
A. Pacheco (CERN), L. Ropelewski (CERN),
M. Titov (CEA), T. Tsarfati (CERN)

## 1 Introduction

The aim of this document is to summarise the discussion and the contributions from the 2nd Academia-Industry Matching Event on Detecting Neutrons with MPGDs [1] which took place at CERN on the $16^{th}$ and the $17^{th}$ of March 2015. The first event of this kind [2], organised in 2013, was summarised in [3]. These events provide a platform for discussing the prospects of Micro-Pattern Gaseous Detectors (MPGDs) [4] for thermal and fast neutron detection, commercial constraints and possible solutions. The aim is to foster the collaboration between the particle physics community, the neutron detector users, instrument scientists and fabricants. This document is not meant to be a comprehensive review of the neutron detection with gaseous detectors, instead it is an addendum and a continuation of the previous summary.

Very good position resolution, high particle flux capability, radiation tolerance, low material budget, large surfaces and low energy threshold are the key features which make MPGDs flexible and widespread devices in High Energy Physics experiments. These features make them interesting solutions also for the next generation neutron scattering instruments and beam monitors. The development of *non-standard* neutron detectors, possibly based on MPGDs, is important not only because of the $^3$He shortage, which

1

https://indico.cern.ch/event/365840/

https://arxiv.org/abs/1601.01534

# RD51 Academia-Industry Matching Event
# Special Workshop on Photon Detection with MPGDs

10-11 June 2015
CERN
Europe/Zurich timezone

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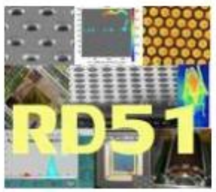
- Event Description
- Detailed agenda
- Registration
- Participant List
- How to get CERN
- List of Recommended Hotels
- 14th RD51 Collaboration Meeting
- Organising Committee
- Videoconference Rooms

## Event Description



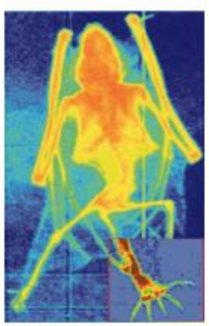

HEPTech
Leading HEP technologies for industry
Technology Transfer opportunities

The specialized workshop "Photon Detection with Micro-Pattern Gaseous Detectors" organised by RD51 in collaboration with HEPTech, will take place at CERN on June 10-11, 2015.

**The goal of the workshop is to help disseminating MPGD technologies beyond fundamental physics, where academic institutions, potential users and industry could meet together.**

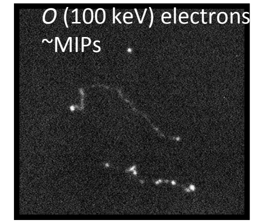
This workshop aims to foster collaboration between the particle physics community and the industry of photon detection, and to discuss the potential of the MPGD technologies for the field. This event is jointly organized by the RD51 collaboration, the HEPTech Network and CERN KT Group. It is open to all researchers and commercial partners interested or working in the field of photon detection.

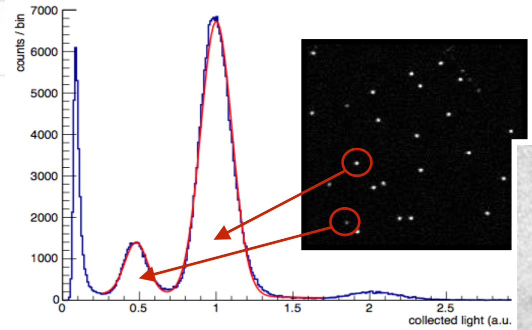
**Dates:** 10th and 11th June 2015
**Venue:** The Council Chamber, CERN
Route de Meyrin 385, 1217 Meyrin



CERN

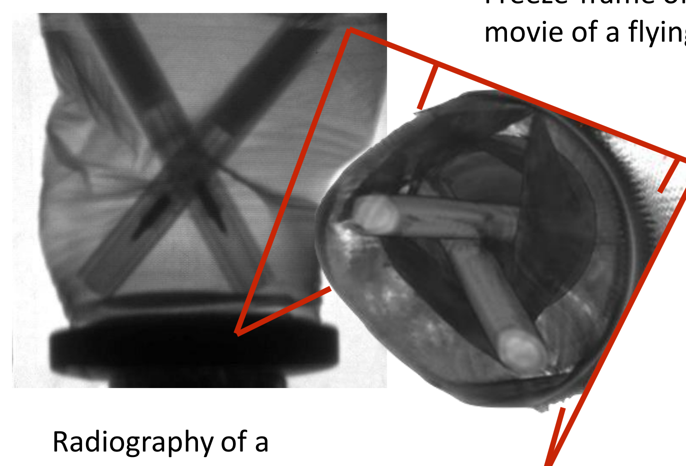
https://indico.cern.ch/event/392833/


Single X-rays from $^{55}$Fe and the energy spectrum extracted from the images

Freeze-frame of an X-ray movie of a flying drone



Radiography of a crushed cup with pens and its 3D tomographic reconstruction

# Topical Workshop on Resistive Electrodes

December 2015

09:00 → 16:20 **WG1,WG2,WG6: topical workshop on resistive electrodes** 160-1-009 Join 160-1-009

**Conveners:** Harry Van Der Graaf (Nikhef National institute for subatomic physics (NL)) , Diego Gonzalez Diaz (Uludag University (TR)) , Maximilien Chefdeville (Centre National de la Recherche Scientifique (FR))

09:00 Introduction, problems and some common wisdom — 25m
**Speakers:** Diego Gonzalez Diaz (Uludag University (TR)) , Paul Colas (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR))
20151209Res... 20151209Res... WorkshopEle... WorkshopEle...

09:25 Spark quenching in resistive Micromegas — 15m
**Speaker:** Maximilien Chefdeville (Centre National de la Recherche Scientifique (FR))
20151209_rd...

09:40 Resistive materials and their patterning methods for MPGDs — 15m
**Speaker:** Atsuhiko Ochi (Kobe University (JP))
resistive_ochi... resistive_ochi...

09:55 Cluster size and position resolution for carbon-loaded kapton and diamond-like carbon — 15m
**Speaker:** Paul Colas (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR))
ChargeSpread... ChargeSpread...

10:10 Surface uniformity in graphite-painted sTGCs and its impact — 15m
**Speaker:** George Mikenberg (Weizmann Institute of Science (IL))
Resistive_cat... Resistive_cat...

10:25 coffee break — 20m

10:45 Electric fields and signals in detectors with resistive materials — 30m
**Speaker:** Werner Riegler (CERN)
rd51_dec_9_2... rd51_dec_9_2...

11:15 Low resistivity Chinese Glass — 15m
**Speaker:** Yi Wang (Tsinghua University)
Chinese low r...

11:30 Robust ceramic composites with tunable electric properties — 15m
**Speaker:** Carlos Pecharroman (ICNM)
RobustCeram...

11:45 Resistive Well — 15m
**Speaker:** Shikma Bressler (Weizmann Institute of Science (IL))
2015_12_RD5...

12:00 A simple model for the gain drop in micro-Resistive WELL — 15m
**Speaker:** Gianfranco Morello (LNF)
Morello_RD51...

12:15 lunch — 1h 45m

14:00 Characterization of resistive foils as a function of humidity, temperature and integrated charge — 15m
**Speaker:** Ourania Sidiropoulou (Bayerische Julius Max. Universitaet Wuerzburg (DE))
9_12_15_RD5...

14:15 Characterization of protection layers in pixelised MPGDs — 15m
**Speaker:** Frederik Hartjes (Nikhef National institute for subatomic physics (NL))
Protection lay... Protection lay...

14:30 Graphite coating at Tsinghua University — 15m
**Speaker:** Yi Wang (Tsinghua University)

14:45 Screen-printing at Saclay workshop — 15m
**Speaker:** Fabien Jeanneau (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR))
resist_saclay...

15:00 Resistive paste, spiders, buried resistors and other photolithography tricks — 20m
**Speaker:** Rui De Oliveira (CERN)
2015 decemb... 2015 decemb...

15:20 Round table — 30m
**Speakers:** Maximilien Chefdeville (Centre National de la Recherche Scientifique (FR)) , Rui De Oliveira (CERN) , Diego Gonzalez Diaz (Uludag University (TR)) , Silvia Dalla Torre (Universita e INFN, Trieste (IT))

https://indico.cern.ch/event/457639/

# Topical Workshop on Discharges in MPGDs

March 2016

09:00 → 12:20 **WG2 - Detector Physics and Performance**

**Conveners:** Diego Gonzalez Diaz (Uludag University (TR)), Maximilien Chefdeville (Centre National de la Recherche Scientifique (FR)), Harry Van Der Graaf (Nikhef National institute for subatomic physics (NL))

09:00 **Discharge studies for ALICE GEMs** — 30m
**Speaker:** Piotr Gasik (Technische Universitaet Muenchen (DE))
gasik_11032016_... | Sparks_SD_new...

09:30 **Discharge measurements in Trieste** — 20m
**Speaker:** Silvia Dalla Torre (Universita e INFN, Trieste (IT))
dallatorre_RD51_... | dallatorre_RD51_...

09:50 **Discharge studies in Micromegas with floating electrodes** — 20m
**Speaker:** Jona Bortfeldt (CERN)
rd51mar16_jona...

10:10 **Streamer phenomenology in streamer-mode RPCs** — 20m
**Speaker:** Alessandro Paoloni (Istituto Nazionale Fisica Nucleare Frascati (IT))
rd51March16_dis...

10:30 **Coffee Break** — 20m

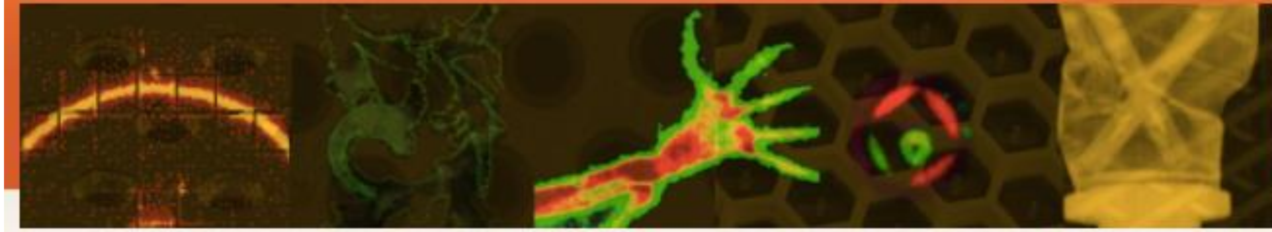
10:50 **Photon and ion induced breakdown** — 20m
**Speaker:** Vladimir Peskov (Johann-Wolfgang-Goethe Univ. (DE))
Photon and ions ... | Photon and ions ...

11:10 **Simulation of photon-assisted streamers** — 20m
**Speaker:** Diego Gonzalez Diaz (Uludag University (TR))
Discharges2.pdf | Discharges2.pptx

11:30 **Simulation of diffusion-assisted streamers** — 20m
**Speaker:** Filippo Resnati (CERN)
discharges.pdf

11:50 **Simulation of streamers triggered by high ionization densities** — 20m
**Speaker:** Sebastien Procureur (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR))
Procureur - 2016-... | Procureur - 2016-...

https://indico.cern.ch/event/496113/timetable/#20160311.detailed



## *MPGD Applications Beyond Fundamental Science Workshop* and the *18th RD51 Collaboration Meeting*, Aveiro, Portugal

12-16 September 2016
Other Institutes
Europe/Zurich timezone

**Registration opening soon**

- Overview
- Scientific Programme
- Committees
- Venue
- Accomodation
- Timetable
- My Conference
- Participant List
- Social Program
- Welcome to Aveiro
- How to reach Aveiro
- Previous RD51 collaboration meetings

Support
cdazevedo@ua.pt

Dear Colleagues:
It is a pleasure to invite you for the *18th RD51 Collaboration Meeting* together with the *workshop on MPGD Applications Beyond Fundamental Science*, that will be held, from 12th to 16th of September 2016, in Aveiro, Portugal.

***18th RD51 Collaboration Meeting*** (from 12th-14th September)

The meeting program will consist on working group sessions of Technological Aspects and Development of New Detector Structures, Common Characterization and Physics Issues, MPGD Related Electronics, Software and simulations, Production, and Common Test Facilities.

***Workshop MPGD Applications Beyond Fundamental Science*** (from 15th-16th September)

From their beginning, MPGDs have played a fundamental role in HEP and Nuclear Physics. Today, due to the mature development stage of MPGDs, their applications are being extended beyond fundamental Science. The workshop on MPGD Applications Beyond Fundamental Science, intends to gather scientists and developments of applications in the fields of (but not limited to):

- Medicine
- Astrophysics
- Material analysis

# Schools, visits, events…

1st October 'extended NNV visit' of Dutch high school students at CERN

## NNV High-School Student Programme

chaired by Michael Jonker (CERN), Marcel Vlastuin (NNV)

from Tuesday, 29 September 2015 at 08:00 to Friday, 2 October 2015 at 18:00 (Europe/Zurich)

CERN

**Description** Extended visit program for Dutch High school students, co-organized by NNV, Visit-service and Michael Jonker.
The participants of this extended visit are high school students who are in their last class of high school and have chosen a PWS (Profiel WerkStuk / practical work) which is linked to Research at CERN.

NNV program optie...

**Contact:** *Email:* Michael.Jonker@cern.ch *Telephone:* 0041 22 76 76 393

### Thursday, 1 October 2015

09:00 - 12:10 Detector koeling *3h10'* ( 154 )
Speaker: Kurt Oskar Edvin Martensson (University of Umeå (SE))

09:00 - 12:10 Gas detectoren *3h10'* ( 154/R-007 )
Speakers: Eraldo Oliveri (CERN), Yalcin Kalkan (Uludag University (TR))

09:00 - 12:10 Medipix *3h10'* ( 14/5-022 )
Speaker: Erik Heijne (Czech Technical University (CZ))

09:00 - 12:10 LHCb Master Class *3h10'* ( training centre 593/24 )
Speakers: Suzanne Klaver (University of Manchester (GB)), Ana Trisovic (University of Cambridge (GB))

12:20 - 13:55 Lunch ( Restaurant 1 )

14:00 - 17:10 LHCb masterclass *3h10'* ( training centre 593/24 )
Speakers: Suzanne Klaver (University of Manchester (GB)), Federico Leo Redi (Imperial College Sci., Tech. & Med. (GB))

14:00 - 17:10 Gas detectoren *3h10'* ( 154/R-007 )
Speakers: Eraldo Oliveri (CERN), Yalcin Kalkan (Uludag University (TR))

14:00 - 17:10 Medipix *3h10'* ( 14/5-022 )
Speaker: Erik Heijne (Czech Technical University (CZ))

6-7 October (M. Hoffmann)

GS General Infrastructure Services Department

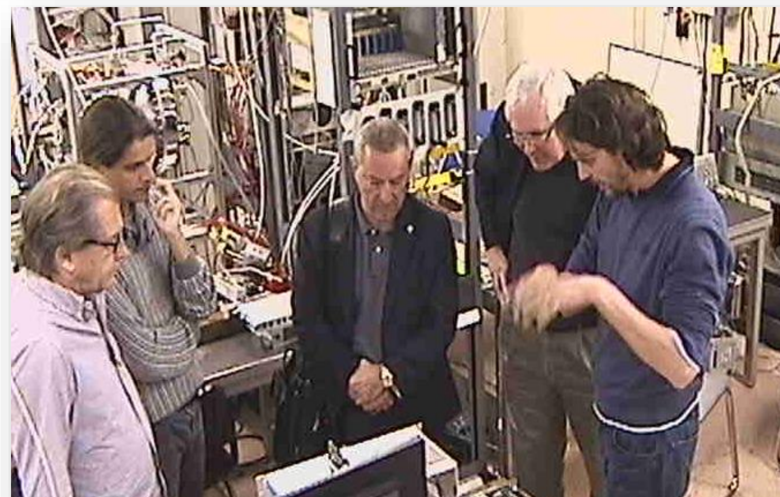
Emergencies Housing Service Maps and plans Medical Service Mobility Registration Service Shuttle Service Waste

Denmark@CERN - 6-7 October 2015

For more information: http://gs-dep.web.cern.ch/en/Service/Industrial_Exhibitions

Submitted by Caroline Laignel on Wed, 09/02/2015 - 13:48

DOE and Fermilab



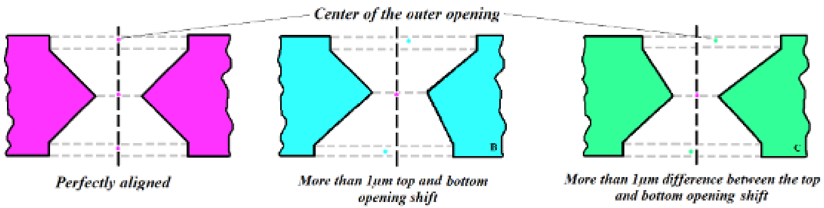
Students Visit:
24th November (Zagreb) M. Planinic

# WG4 - Modeling of Physics Processes and Software Tools

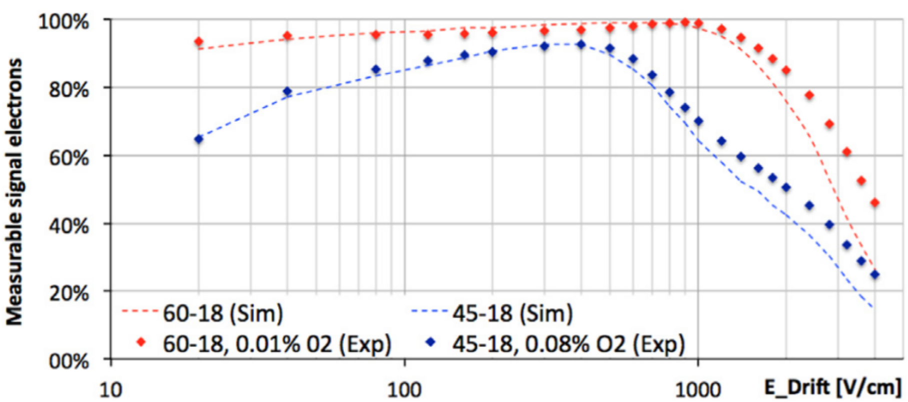
## Software Tools:

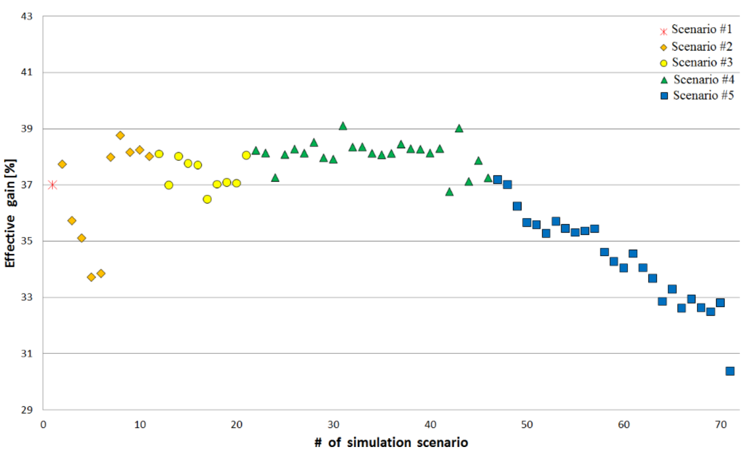
- Magboltz (transport equations) and Degrad (cluster size distribution)
- Speeding up Garfield++
- Optimization of charging up processes simulation

## Modeling of Physics Processes:




- Penning energy transfers in Ne based gas mixtures
- Impact of CO2 cluster ions on the constant field detectors
- Dependence of the gas gain on the Gem hole diameter
- Impact of the mesh geometry on the performance the Micromegas



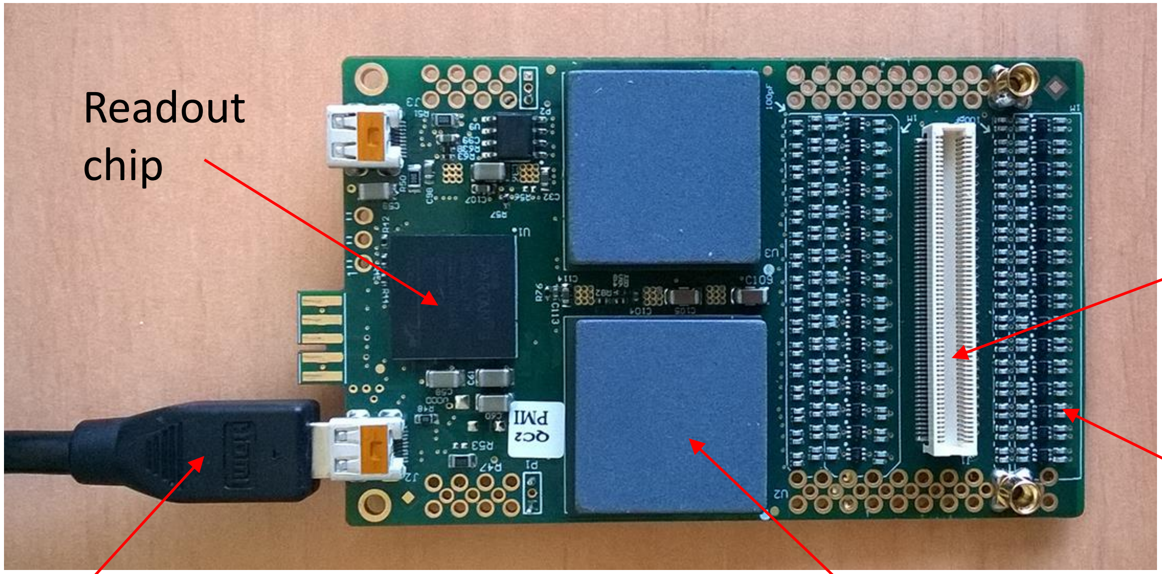
# WG5 - Electronics for MPGDs

# SRS progress

- VMM128 = 1 MHz frontend for SRS
- DVM= digital SRS adapter for VMM /GEMRoc frontends
- APV = analogue pickup amplifier/shaper box for MPGD's
- AVD = active voltage divider for MPGD's
- Femtometer

# 1 MHz frontend for SRS: VMM hybrid

APV hybrids : max 3 kHz ➔ VMM hybrids: up 1 MHz



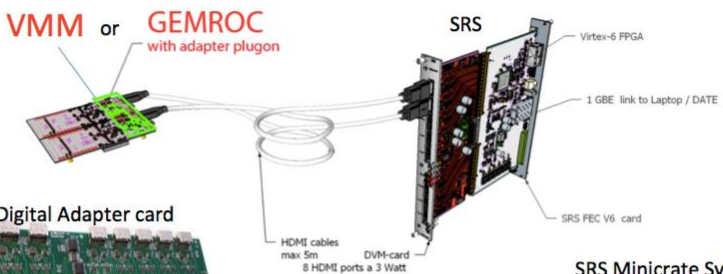

<u>VMM-128 status:</u>

2015 : VMM-2/BGA prototypes produced & tested in GDD lab in collaboration with ATLAS NSW

2016 : VMM-3 revision ( wire-bonded hybrid, imminent)*

* major delays due to BGA packaging issues of VMM, RD51 decided for wire-bonded hybrid production

# Adapter for digital frontends





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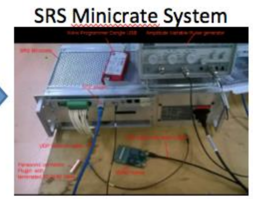



Adapter Status:
2015 : tests with prototype card
2016 : revised adapter card for volume production



# APIC pickup amplifier/shaper

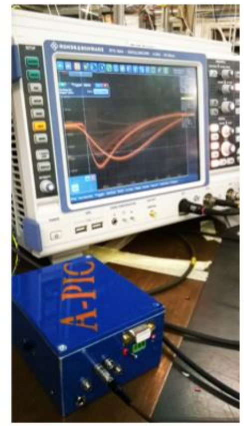
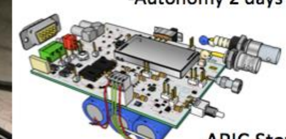



Photo: APIC with test pulse , short and long shaper

APIC= Single battery-operated box with:

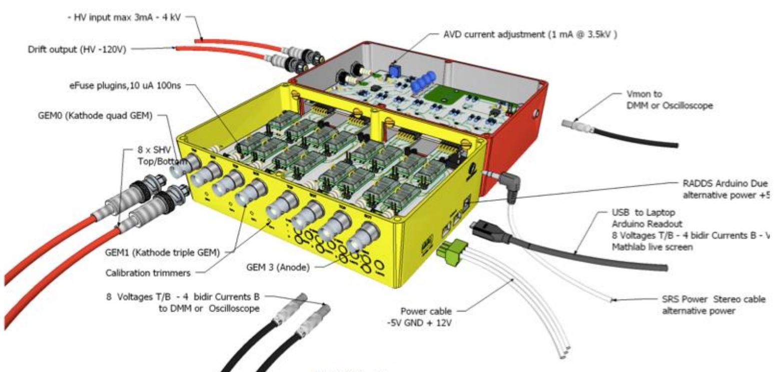
-spark-protected CSA preamplifier 2mV/fC
-pickup from meshes up to 4kV
-Voltage gain-potentiometer 1 ... 100
-complementary 50 OHM outputs, analogue
-baseline-potentiometer +/- 1V
-shaping times switch: short (0.1us) - long (1us)
-test pulse
-battery or power cable (DSUB-9)
-Plug for 5W solar LiPo battery charger
-Autonomy 2 days



APIC Status:
2015 : prototyping ( summer students)
2016 : preparing for commercial reproduction



# AVD Active Voltage Divider




AVD Status:
2015 : AVD prototyping ( sponsored by ALICE TPC )
2016 : upgrade of HV-insulated monitoring (summer student)



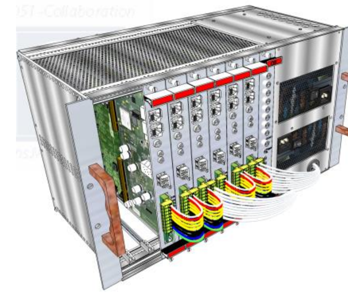
# Femtobox

-log range from 10 fA to 1 uA
-negative and positive input
-sparc protected
-analogue readout (100ns), average or prompt
-battery operated
-temperature compensated
-Tera-Ohm meter AUX function

Femtobox Status:
2015 : 3 Femtoboxes in field tests
2016 : upgrade to faster and HV-insulated monitoring (summer student)

# SRS Users Status

1. ALICE EMCal Calorimeter upgrade, ORNL, SRS readout backend via DTCC links and 24 SRU's , DATE Online system,
2. ATLAS upgrade CERN, MAMMA project NSW , µMEGAS , APV frontend SRS Eurocrates-SRU, MMDAQ Online,
3. ATLAS upgrade Mainz, µMEGAS for MBTS, APV frontend- SRS Eurocrate, MMDAQ Online,
4. ATLAS Muon upgrade R&D, INFN Rome, APV frontend SRS Eurocrate, MMDAQ Online,
5. ATLAS Saclay, µMEGAS R&D, APV frontend SRS Minicrate, MMDAQ Online,
6. NA62 CERN straw tracker upgrade with µMEGAS, APV frontend with SRS Minicrate, MMDAQ Online,
7. CMS upgrade CMS GEM collaboration CERN, Muon Endcaps, design of VFAT frontend digital readout SRS
8. TOTEM upgrade GEMs Baris testlab, OPTO-Rx card design, Minicrate,Eurocrate, SRU, DATE Online,
9. BNL GEM detectors, APV frontend-SRS Minicrate, RCDAQ Online,
10. Stony Brook GEM detector R&D, APV frontend SRS Minicrate, RCDAQ Online,
11. Bonn Phys. Inst. R&D for ILC, T24 DESY testbeam, Timepix Array Ingrid Module adapter for SRS , Eurocrate, Online unknown,
12. Florida Inst Tech GEMs, Muon Tomografy for Homeland security, 15k channel SRS prototype Eurocrate, DATE Online,
13. Géosciences Azur-CNRS-UNSA, Muon Tomography w.µMEGAS for geology, APV frontend SRS Eurocrate, Date Online,
14. GDD lab RD51, CERN, R&D for GEM and µMEGAS, APV frontend SRS Euro and Minicrates, DATE, Labview MMDAQ,
15. HIP, HELSINKI, characterization MPGAD detectors, APV frontend SRS Eurocrate, DATE and Labview,
16. INFN Napoli, ATLAS. Development of SRS Hardware and Firmware, Labview,
17. Jefferson Lab, Virginia UVa upgrade GEM readout system, APV frontend SRS Eurocrate, DATE online,
18. Yale University , GEM development ALICE, APV frontend SRS Eurocrate, DATE Online,
19. NEXT Coll. small Xenon TPC with PM and Si PMs, SRS readout electronics co-development, SRS Eurocrate and SRU, DATE
20. UNAM, MEXICO, MX , R&D on THGEM, APV frontend SRS Minicrate, DATE Online,
21. Radiation Laboratory, Nishina Center, RIKEN , APV frontend SRS Eurocrate, Online unknown,
22. J-PARC /E16 experiment, GEM based tracking, APV frontend SRS Minicrate, Online Unknown,
23. Jefferson Lab SHM spectrometer triple GEM, APV frontend SRS Eurocrate, DATE Online,
24. Harvard Univ. Physics, APV frontend SRS Minicrate, Online unknown,
25. Tokyo Univ. ATLAS, APV frontend SRS Eurocrate, Online unknown,
26. WIS and Aveiro Univ. GEM validation, APV Frontend SRS Eurocrate, MMDAQ and Labview,
27. East Carolina University, Health Physics, APV frontend, SRS Eurocrate, Labview,
28. Munich LMU / ATLAS µMEGAS, APV frontend SRS Eurocrate –SRU, MMDAQ Online,
29. NCSR Democritos ATHENS, APV frontend SRS Minicrate, Online unknown,
30. IFIN-HH-Bucharest new Detector lab, APV and VFAT frontend, SRS Eurocrate and SRU, Labview,
31. ATLAS NSW CERN, SRS-ATCA pilot system, MMDAQ Online,
32. ALICE FOCAL ORNL, SRS-ATCA pilot system, DATE Online,
33. NEXT Collaboration, SRS-ATCA pilot system, DATE Online,
34. Lunds Univ, ILC TPC, SRU for 24 channel DTCC link readout, Online unknown
35. INFN Trieste for R&D activities



07.89.00 - RD51 SRS PROJECT

For any further technical information additional - click here

General description

LOW CAP DIODE NUP4114UPXV6T1G : 08.51.49.960.0

FEMALE CONNECTOR 130 CONTACTS : 09.55.42.400.3

MALE CONNECTOR 130 CONTACTS : 09.55.42.410.6

| Buy | SCEM Code | Unit | Unit Price | DESIGNATION | TYPE / REF | FIG. |
|---|---|---|---|---|---|---|
| | 07.89.00.005.9 | PC | 144.0 | RD51 APV25 HYBRID MASTER | EDA-02075-V4-0 | 1 |
| | 07.89.00.010.2 | PC | 128.0 | RD51 APV25 HYBRID SLAVE | EDA-02075-V4-0 | 2 |
| | 07.89.00.020.0 | PC | 722.0 | MINICRATE CHASSIS | - | - |
| | 07.89.00.030.8 | PC | 736.0 | EUROCRATE CHASSIS | - | - |
| | 07.89.00.100.1 | PC | 1460.0 | RD51 SRS FEC CARD | - | 3 |
| | 07.89.00.105.6 | PC | 1123.54 | RD51 SRS ADC CARD | - | 4 |
| | 07.89.00.115.4 | PC | 109.0 | TRANSCEIVER 1.25 GBD SFP 3.3V | AVAGO ABCU-5710RZ | - |
| | 07.89.00.125.2 | PC | 282.0 | PLATFORM CABLE IIG | XILINX HW-USB-IIG | - |
| | 07.89.00.200.6 | PC | 4.8 | MMCX 50 OHM MICRO MINI CONNECTOR VERTICAL THROUG-HOLE FEMALE | SAMTEC MMCX J P H ST TH1 | 5 |
| | 07.89.00.205.3 | PC | 4.8 | MMCX 50 OHM MICRO MINI CONNECTOR VERTICAL THROUG-HOLE MALE | SAMTEC MMCX P P H ST TH1 | 6 |
| | 07.89.00.210.6 | PC | 28.5 | FLAT CABLE MASTER-SLAVE CONNECTION 100 mm | SAMTEC FFSD-08-D-04.00-01-N | 7 |
| | 07.89.00.211.5 | PC | 21.6 | FLAT CABLE MASTER-SLAVE CONNECTION 200mm | SAMTEC FFSD-08-D.00-01-N | 7 |
| | 07.89.00.215.1 | PC | 26.9 | HDMI CABLE D-A 2m STANDARD CABLE | MOLEX 68786-0003 | 8 |
| | 07.89.00.216.0 | PC | 51.45 | HDMI CABLE A-A 5m STANDARD CABLE | PRO SIGNAL 127810 | 8 |
| | 07.89.00.217.9 | PC | 18.81 | ADAPTOR HDMI FEMALE-HDMI FEMALE | MULTICOMP 1901119 | - |

# New SRS Users

1. LAPP, Annecy, SRS hybrid with MicroROC chip for ATLAS
2. Pacific Northwest National Laboratory, Radiation detection and Nucl. Sci, interest in APV SRS system,
3. Radcore LTD Republic of Korea, GEM production , small SRS system ,
4. Newflex GEM production, South Korea , small SRS system ,
5. GIF++ team CERN, interested in SRS as GIF++ base installation with DATE Online system ,
6. Budker INP, Novosibirsk, Deuteron Exp. @ VEPP-3 , APV readout SRS , APV order impossible, radhard export restriction
7. Tsinghua Univ. China , R&D on GEM Imaging detectors, APV readout SRS , APV order impossible, radhard export restriction
8. SAHA Inst Nucl Phys,KOLKATA, IN , Laboratory for characterization of MPGDs , APV order impossible, radhard export restriction
9. USTC Shanghai, CN , characterization of GEM and MicroMega with SRS , APV order impossible, radhard export restriction
10. Univ . Texas, DOE proposal with 18 GEMs ,
11. National Univ. of Colombia, Dosimetry for mediical appl,
12. BNL Phenix upgrade, small SRS systems already delivered ,
13. Helsinki University, Totem
14. Freiburg University, verbal enquiry for SRS system,
15. Univ Calabria It, email enquiry for SRS,
16. Uni. Kobe, JP J-PARC /E16 upgrade , large SRS system,
17. ALICE ITS, SRS 16 ch. ADC card for test of ITS chips ,
18. NEOHM Italy, SRS system for test of hybrid production for CERN store
19. Geoazur-CNRS-UNSA, Valbonne, FR, upgrade of existing SRS uMega readout systrem, APV readout Eurocrates ,

A main feature of SRS, apart from its scalability, portability and affordable cost (< 2 EUR/ channel), possible choice of the frontend ASIC (APV, VFAT, Beetle, VMMx, Timepix).

**System was used for R&D for upgrades in ATLAS, CMS, ALICE ECAL and for SiPM readout**

# WG6 - Production and Industrialization

EP DT MPT workshop projects in progress in 2016

## Production:

| | | |
|---|---|---|
| •SBS tracker | GEM 600mm x 500mm | 150 GEM |
| •ALICE TPC upgrade | GEM 600mm x 400mm | 350 GEM |
| •CMS muon | GEM 1.2m x 450mm | 450 GEM |
| •BESIII | GEM 600mm x 400mm | 30 GEM +read-out |
| •SOLID | GEM 1.1m x 400mm | 8 GEM + 2 read-out |
| •CLAS 12 | Micromegas 500mm x 500mm | 30 Micromegas |
| •LSBB (geoscience) | Micromegas 1m x 500mm | 2 detectors |
| •CBM | GEM 1m x 450mm | 100 GEMs |
| •Nika | GEM detectors 1.8m x 0.6m | 6 full detectors |

## R&D projects:

- ATLAS resistive Micromegas Muon System large pitch
- ATLAS resistive Micromegas embedded resistors for high granularity high rate
- CMS FTM multiple resistive well detectors for sub ns time resolution
- CMS R-well Muon detectors
- Resistive micro gap for calorimetry
- Embedded front end electronics in read-out boards

**CMS production :**
more than 70 GEM produced
Production rate 20 GEM/month

**ALICE production:**
more than 40 GEM foils produced
Production rate 36 GEM/month

# Technology: Industrialization

Technology Industrialization → transfer "know-how" from CERN workshop to industrial partners

GEM Technology (contacts)

- Mecharonix (Korea, Seoul)
- Tech-ETCH (USA, Boston)
- Scienergy (Japan, Tokyo)
- TECHTRA (Poland, Wroclaw

THGEM Technology (contacts):

- ELTOS S.p.A. (Italy),
- PRINT ELECTRONICS

**GEM Licenses signed by:**

- Mecharonics, 21/05/2013
- TECH-Etch, 06/03/2013
- China IAE, 10/01/2012
- SciEnergy, 06/04/2009
- Techtra, 09/02/2009
- CDT, 25/08/2008
- PGE, 09/07/2007

MicroMegas Technology(contacts):

- ELTOS S.p.A. (Italy)
- TRIANGLE LABS(USA, Nevada)
- SOMACIS (Italy, Castelfidarco)
- ELVIA (France, CHOLET)

## GEM Industrialization Status (today):

*TECH-ETCH*

- Single Mask process fully understood. Many 10cm x 10cm produced and characterized.
- 40cm x 40cm GEM successfully produced
- CMS

*TECHTRA*

- Production Line Operational
- Stable process for 10cm x 10cm
- Single Mask process completely understood – 10cm x 10cm produced
- 30cm x30cm Single Mask Produced

*MECHARONICS*

- 10cm x 10cm double mask produced and tested
- 30cm x 30cm double mask under evaluation @ CERN
- CMS

## Micromegas Industrialization Status (today):

*ELVIA*

- Bulk Micromegas detectors are routinely produced with sizes up to 50cm x 50 cm.
- ATLAS

*ELTOS*

- Many small size bulk Micromegas detectors have been produced.
- ATLAS

# B107 status

Construction of the new workshop's building

Start : beginning 2012 **completion date: June 2018**

**All machines for MPGD production are now at CERN**

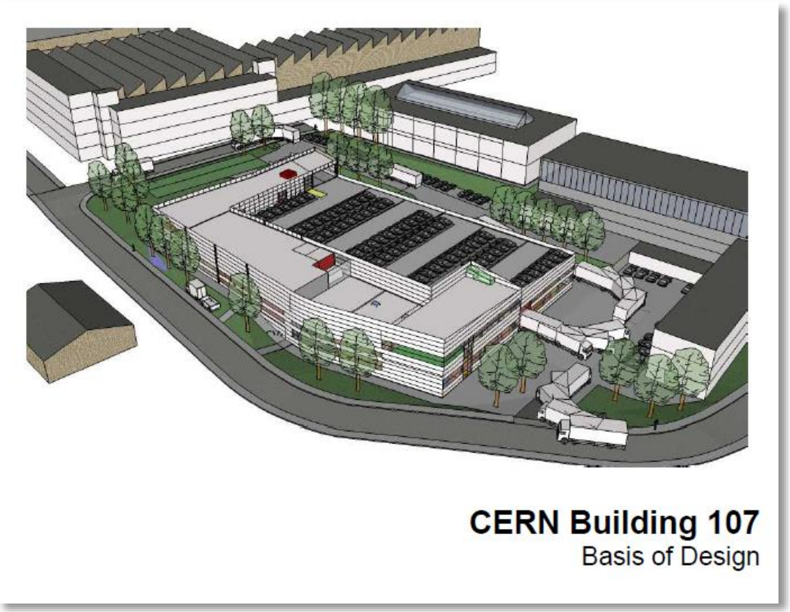
**GEM:**
- Continuous polyimide etcher
- Cu electroetch line

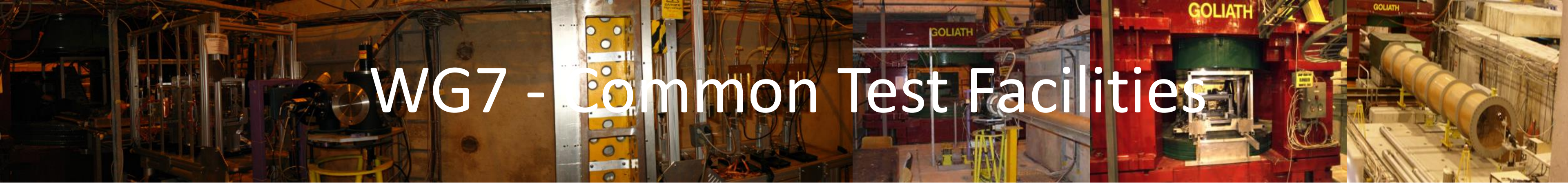
**MicroMegas:**
- Large laminator
- Large Cu etcher
- Large UV exposure unit
- Large resist developer
- Large resist stripper
- Large oven
- Large dryer

**Building status**

**Done:**
- Concrete
- Walls external/internal
- EL study
- HVAC study
- Plumbing Study

**To be done**
- Electricity
- Plumbing
- HVAC
- Clean room

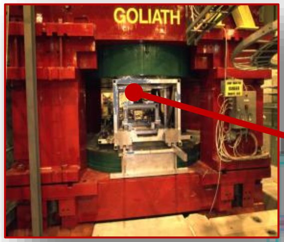




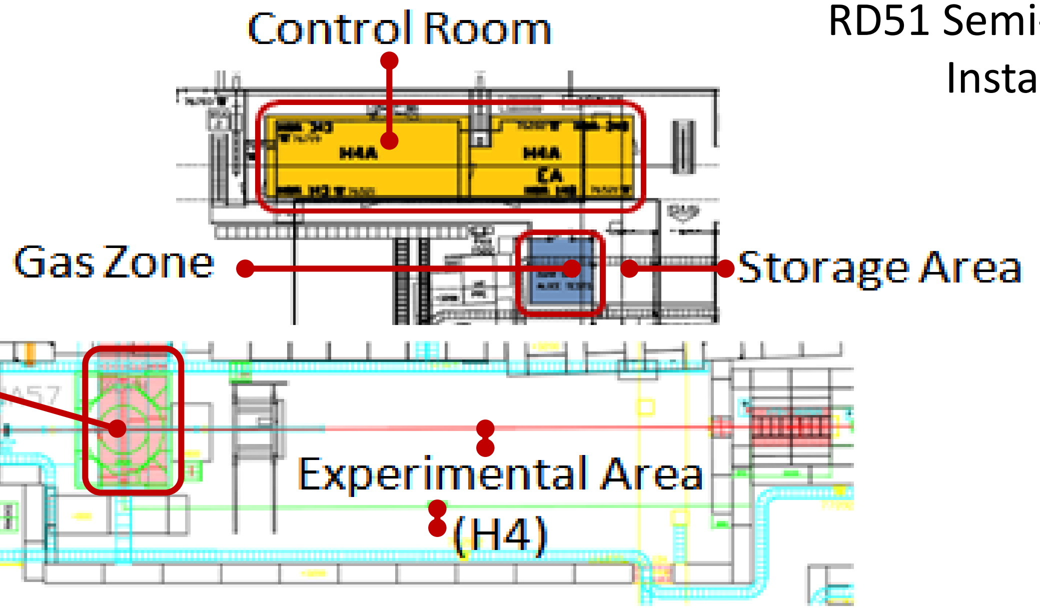
# WG7 - Common Test Facilities

EHN1-H4 North Area

GOLIATH
(1.5T Max, 1mt gap)



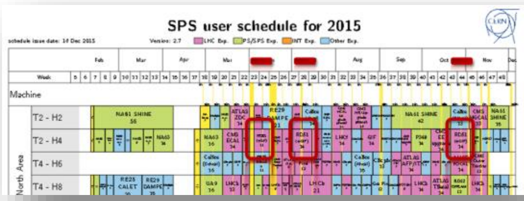

RD51 Semi-Permanent Installation




*2015 RD51 Test Beams :*

*3 periods of 2 weeks each with GIF++ parasitic*
*12 experiments running in total*

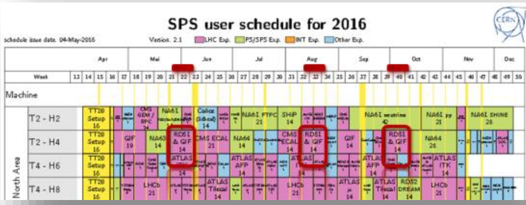
*2015*




*2016 RD51 & GIF++ Test beams:*

*3 periods of 2 weeks each together with GIF++*
*More than 10 experiments expected*

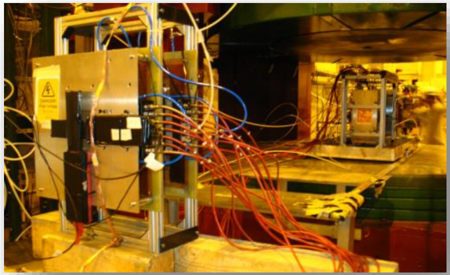
*2016*



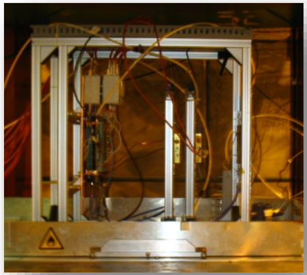
# 2015 Test Beam

*June*

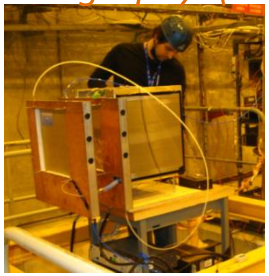
BESIII (Cylindrical GEM)



µRWell



*Proton range radiography (TERA)*



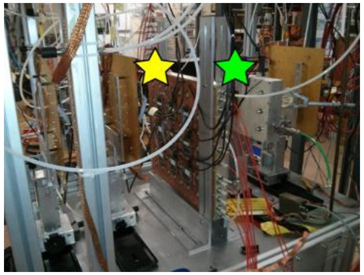
*SRS DAQ*

https://indico.cern.ch/event/392637/session/5/contribution/27/attachments/785354/1076521/RD51MiniweekMeeting2015.06.09.pdf
https://indico.cern.ch/event/392637/session/5/contribution/28/attachments/785358/1076536/MiniWeeek_2015_test_beam.pdf
https://indico.cern.ch/event/365380/session/6/contribution/54/attachments/726455/996903/Bucciantonio_PRR_2015_03_20.pdf

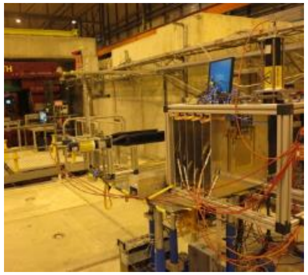
*July*

*ATLAS NSW RmmVMM2*

RPWELL



SCREAM -Emb Rmm



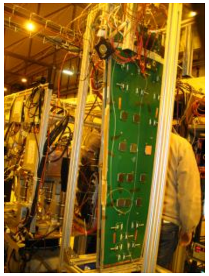
*P348*

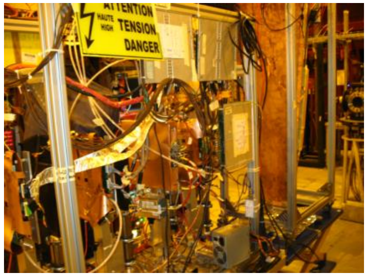
https://agenda.infn.it/getFile.py/access?contribId=8&sessionId=2&resId=0&materialId=slides&confId=8839
https://indico.cern.ch/event/392637/session/5/contribution/31/attachments/785379/1076570/wg7_09062015.pdf
https://indico.cern.ch/event/385594/contribution/7/7/attachments/1171005/1690559/p348_gninenko_SPSC.pdf
https://agenda.infn.it/getFile.py/access?contribId=55&sessionId=2&resId=0&materialId=slides&confId=8839

***R&D for Experiment***
***HEP Experiments:***
***LHC upgrades***
***CERN & Others***
***Applications***
***Electronics***

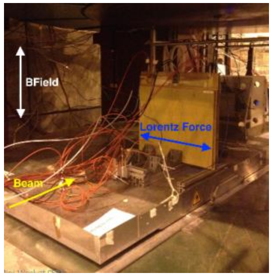
*October*

CMS GEM muons Upgrade & FTM

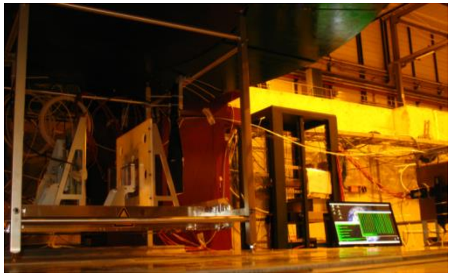




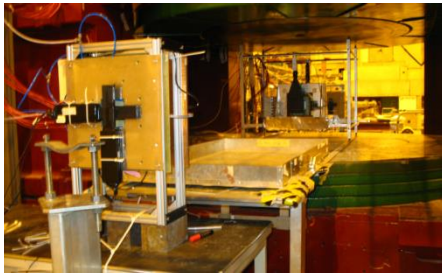
*ATLAS NSW Rmm*




*SHIP (Emulsion & MPGD)*



*BESIII (Cylindrical GEM)*



https://indico.cern.ch/event/457639/contributions/1128062/attachments/1202312/1750374/cibinetto_RD51_20151209.pdf
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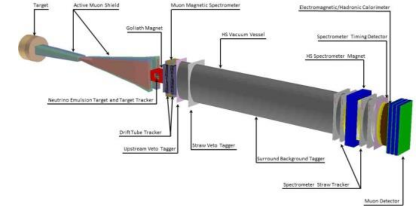
https://indico.cern.ch/event/457639/contributions/1128048/attachments/1202562/1750820/BDorneyIVai_RD51MiniWeek_20151209.pdf

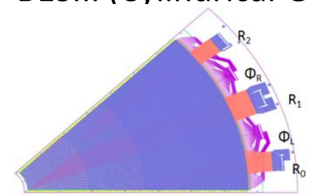
# 2016 Test Beam: planned activities

## *Non LHC experiments*

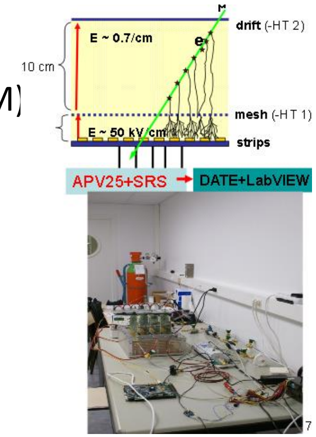
BESIII (Cylindrical GEM)



SHIP (MPGD & Emulsions)



Proton Electric Dipole Moment EDM exp. (R-ϕ Micromegas )




T2DM2 Mouns Tomography (Res. Micromegas)

Cosmic Shower Detection (Res. Micromegas)

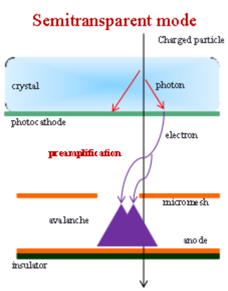
## *LHC MPGD-Based upgrades*

ALICE TPC (GEM)

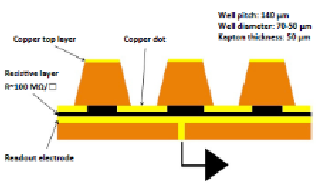
ATLAS NSW (Res. MicroMegas)

CMS (GEM)

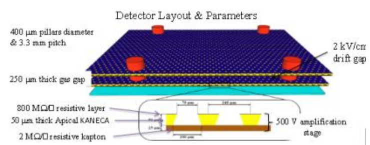
## *Novel MPGDs (Timing, High Rate, PF calorimetry, …)*



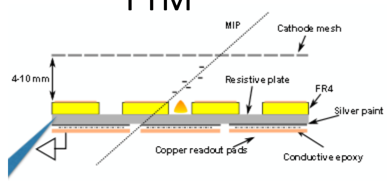

picosec



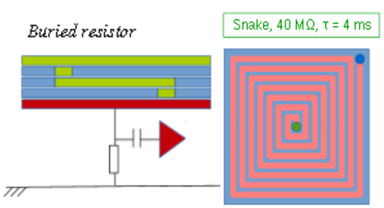

µRWELL




FTM




RPWELL




Embedded Resistor Pad Micromegas

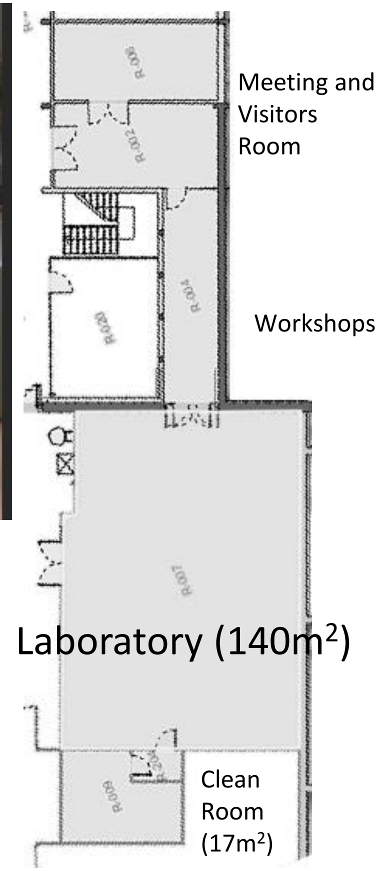
## *Electronics*

ATLAS VMM2/3

ATCA SRS

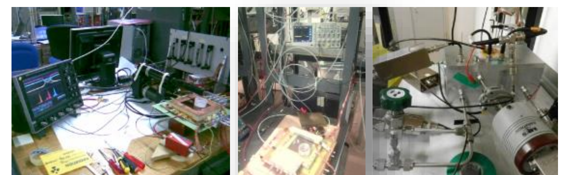
APV25 and SRS Zero Suppression Firmware

# EP-DT-DD GDD Laboratory (Detector R&D)




Permanent Users (ALICE, ATLAS, ESS) station

Temporary Users Working station

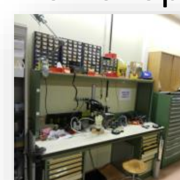


Active (X-Ray) and Radioactive Sources

Cosmic Stands

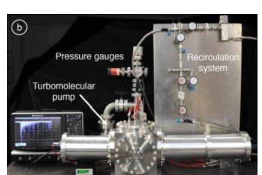
Clean Room

Workshops



MPGD Electronics

Optical Readout




Vacuum & Gas System

Technical support
MPGD Detectors
Gas system and services
MPGD Readout electronics
Radioactive Sources
Interface with CERN services (RP, gas, metrology, irradiation facilities,…)

# List of activities in the GDD/RD51 Laboratory

***Permanent setup:***

- ATLAS NSW Micromegas
- ALICE TPC Upgrade
- ESS

***Temporary setup:***

- CRAD Gamma Ray Imaging for Medical Application (G. Norberg): Characterization of the transparency of a focusing field shaper.
- COMPASS RICH (S.Levorato,M. Alexeev): Data readout with SRS/APV and Commissioning at high rate of final electronics.
- LHCb Scifi (L.Gavardi, C.Joram): Aging test of Fibers under X-Ray Irradiation.
- SCREAM (M.Chefdeville, T. Geralis): Embedded pad resistor micromegas for calorimetry - rate capabilities.
- Texas University (J.Medford, J.Yu): Peritoneal Carcinomatosis II Tumor Mapping with GEM, - SRS and APV readout (hardware and remote support).
- NA64-P348 (D. Banerjee): SRS/APV25 with resistive micromegas and genetic readout.
- CAPP/IBS (S.Park): Polarimeter Detector development using GEM technology for Proton EDM
- Measurement - SRS and APV25 on detector measurement and software support.
- University of Tessaloniki (G. Fanurakis, S. Tzamarias): Cosmic Ray Shower Detection with Large TPC micromegas and R-Phi Micromegas for Proton EDM Measurement .
- Dubna (V Karzhavin, S. Vassiliev): BM@N Central Tracker with GEM - Test on Large Area Triple GEM-NS2 technique.
- Lebedev Physical Institute (M.Negodaev): Gas electron multiplier based on laser-perforated CVD diamond film - Operation of the detector and resistivity measurements.
- Uludag University (Y. Kalkan): PI polyamide Conductivity Measurements.
- Lund University (J. Cederkall): Large TPC for Active Target Nuclear Reaction - Introduction to assembly and basic operation of GEM detector.
- PSI, nanodosimetry
- LSBB (T. Serre, I. Lazaro): T2DM2 Temporal Tomography Densitometric by the Measure of Muons - Self Triggering (Mesh Signal) micromegas and SRS/APV25 readout.
- Neutrons detectors for gas monitoring (NA62)

***Support to external companies:***

- CAEN (A. Iovine, F.Neri): Multi channel high voltage power supply for Triple/Quadruple GEMs detectors (CMS/ALICE)- Test on small prototype.
- Prisma (K. Panagiotis): Support for the SRS/ADC cards validation tests
- eicSys (T. Jezynski, W. Jalmuzna): Support on the test (commissioning with the standard SRS software) for SRS ATCA and APV25 for standalone chips and on-detectors tests.

# RD51 Resources

- **Internal Collaboration resources**
  - From Collaboration fees, ~ 200 k CHF/year
  - Used for :
    - Support of 1 scientist dedicated to tools
    - Support (material) for the SRS development
    - Schools, MPGD conferences, RD51 meetings
    - RD51 infrastructure (lab, test beam equipment)
    - Limited punctual support to starting R&Ds (common projects)
- **CERN resources**
  - 2.5 staffs (including 2 physicists)
  - CERN EP Budget to CERN group in RD51
  - EP DT MPT workshop & GDD lab infrastructure
- **External resources**
  - BrightnESS: 4 students/postdocs (CERN based) from ESS
  - AIDA2020 resources to MPGD activities, in total ~500 k€
  - **The resources of the participating Institutions for the specific MPGD projects**

# RD51 Request

The Collaboration would like to ask LHCC for continuation of:

- Access to SPS H4 test beam facility (including the possibility to keep “semi-permanent” setup)
- Access to CERN PH-DT MPT (Micro Pattern Technology) Workshop (similar to present availability level)
- Access to central computing resources for MPGD simulations

And:

- Extra space for electronics laboratory (50 $m^2$) for development near to the detector laboratory to facilitate the advances on the new activities (VMM FE chip in particular).
- Extra office (for RD51 members, visitors and students)