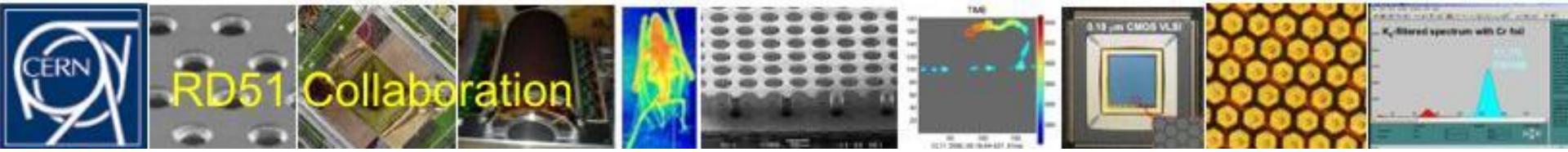


WP5: Micropattern Gas Detectors status report

Leszek Ropelewski
CERN – PH - DT

[RD51 Collaboration Site]

WP5 Micropattern Gas Detectors: Mandate and Objectives

Within this work package PH department will **help initiating an R&D collaboration for MPGD**, in analogy to RD50. Its goal is to bundle and coordinate detector development and simulation work, which is currently being performed in numerous groups at universities and research institutes. The collaboration will allow to:

- structure, coordinate and focus ongoing R&D efforts;
- share knowledge, experience and infrastructure, agree on common test and quality standards;
- coordinate widespread simulation efforts towards setting-up a common maintainable software package for gas detector simulations;
- share investment of common projects (e.g. larger mask sets for GEMs).

Besides the initiating task, specific development work on MPGD (mostly GEM) will be carried out. **General performance properties** like rate capability and radiation tolerance of detectors and materials used for construction will be evaluated. This will comprise measurements of the maximal gain, temporal and spatial stability, rate capability, time resolution and discharge probability. The performance will be compared with alternative gas detector technologies (Bulk Micromegas; Thick GEM).
Main emphasis is put on the **development of large size (~m^2) planar detectors**, including their full characterization and integration towards priority applications.

CERN-PH will also contribute towards the common maintainable **software package**.

Deliverables	Description	Nature	Date
1	Construction of small prototypes	Prototypes	30-Aug-08
2	Full characterization of small prototypes	Beam and lab tests	31-Dec-08
3	Technology assessment report within new collab. framework	Report	30-Apr-09
4	Construction of large detector prototype	Prototype	30-Aug-09
5	Full characterization of large prototype	Beam and lab tests	30-Jun-10
6	Prototype maintainable simulation package	Software+Report	30-Jun-10
7	Construction of integrated large detector prototype	Demonstator	31-Mar-11
8	Full characterization of integrated detector prototype	Beam and lab tests	31-Dec-11
9	Full maintainable simulation package	Software+Report	31-Dec-11

WP5 Micropattern Gas Detectors: Resources

People involved:

M. Alfonsi Fell (1), S. Martoiu Fell (1), R. Veenhof PA (1), G. Croci Doct (1) **WP5**

M. Villa Doct (1), H. Schindler Doct (1) **other programs**

L. Ropelewski (0.5), H. Taureg (0.7) , S. Duarte Pinto Doct (1), E. David (.5), M. Van Stenis (0.7), B. Brunel (0.5) **PH-DT**

H. Muller (0.3), A. Sharma (0.3), J. Wotschack (0.3) **experiments**

5	Micropattern Gas Detectors				
WP5-1				Begin	01-Jan-08
				End	31-Dec-11
Year	2008	2009	2010	2011	total
Staff existing (in RRP)	0.5	2.0	3.0	tbd	5.5
Staff new cat2 (FTE)	0.0	1.0	2.0	tbd	3.0
Staff new cat3-4 (FTE)	0.0	0.5	0.5	tbd	1.0
Fell/Ass/Stud (FTE)	1.5	2.0	2.0	2.0	7.5
M (project) (kCHF)	150	200	200	150	700
M (oper.) (kCHF)	20	60	90	60	230

WP5 - DT RD51 Activities Indico [MPGD]

RD51 organization proposal approved by CERN RB; coordination; 4 MPGD workshops 94th LHCC Meeting Agenda (02-03 July 2008) CERN-LHCC-2008-011 186th Research Board meeting

Large area GEM detectors development new technology development and evaluation, prototype construction, paper presented in IEEE NSS/MIC Symposium in Dresden test beam test– electronics, DAQ

New amplifiers structures and geometries blind (TH)GEMs with/without resistive anode; spherical GEM

Development of large UV photon detectors for RICH applications based on THGEM technology technology evaluation, beam test, paper presented in IEEE NSS/MIC Symposium in Dresden

Development of radiation hard MPGD technologies construction materials, detector components, detectors (GEM, Micromegas) radiation hardness evaluation, progress reported during RD51 workshop

Development of electronics for MPGD requirements definition, chip matrix, scalable readout system

Software tools development for MPGD simulations GARFIELD model refinements for electron transport and field calculation, interface to GEANT4 and ROOT, comparison with experimental data, RD51 WG coordination, detector seminar, progress reported during RD51 workshop (Rob, Heinrich, Gabriele, Matteo) micro tracking and neBEM field calculation implementation

General support in detectors construction and tests CERN groups, experiments and external institutes

Gas detector lab infrastructure gas system, new X-ray generators, DAQ, support

Beam facility for RD51 RD51 WG coordination, requirements and contributions for the beam and irradiation facilities, CERN contribution (trigger, tracker), services installation SPS Schedule

MPGD Production aspects RD51 WG coordination, IP, production facility requirements, industrial partners, EN ICE DEM workshop upgrade

RD51 Collaboration: Milestones

- **CERN MPGD workshop (10-11 September 2007)**

  Micro Pattern Gas Detectors. Towards an R&D Collaboration. (10-11 September 2007)

- **1st draft of the proposal presentation during Nikhef meeting (17 April 2008)**

  Micro-Pattern Gas Detectors (RD-51) Workshop, Nikhef, April 16-18, 2008

  Gas detectors advance into a second century - CERN Courier

- **Proposal presentation in LHCC open session (2 July 2008)**

  94th LHCC Meeting Agenda (02-03 July 2008);

  CERN-LHCC-2008-011 (LHCC-P-011)

- **LHCC closed session (24 September 2008)**

  Meeting with LHCC referees (23 September 2008); LHCC-095 minutes

- **2nd RD51 Collaboration meeting (Paris 13-15 October 2008)**

  2nd RD51 Collaboration Meeting (13-15 October 2008)

- **CERN Research Board approval(5 December 2008)**

  186th Research Board meeting minutes

- WG2 meeting (10 December 2008)
- WG1 meeting: large area MPGDs (21 January 2009)
- GEM & Micromegas detector assembly training session (16 February 2009)
- RD51 Mini-Week (27-29 April 2009)
- 3rd RD51 Collaboration Meeting (Kolympari, Crete, June 16-17, 2009)
- MPGD2009 Conference
- RD51 Mini-Week (CERN, September 23-25, 2009)
- 4th RD51 Collaboration Meeting (CERN, Nov. 23-25, 2009)

- **LHCC review (17-18 February 2010)**

Collaboration of ~70 institutes worldwide, ~ 400 authors
MoU -70% signed
Common Fund – 50% collected

RD51 Collaboration – Activities

Consolidation around common projects: large area MPGD R&D, CERN/MPGD Production Facility, electronics developments, software tools, beam tests

WG1: large area Micromegas, GEM; THGEM R&D; MM resistive anode readout (discharge protection); design and detector assembly optimization; large area readout electrodes and electronics interface

WG2: radiation tolerance, discharge protection, rate effects, single-electron response, avalanche fluctuations, photo detection with THGEM, TPC (IBF) readout optimization

WG3: applications beyond HEP, industrial applications (X-ray diffraction, homeland security)

WG4: microtracking; neBEM field solver, electroluminescence simulation tool, Penning transfers, GEM charging up; MM transparency and signal, MM discharges

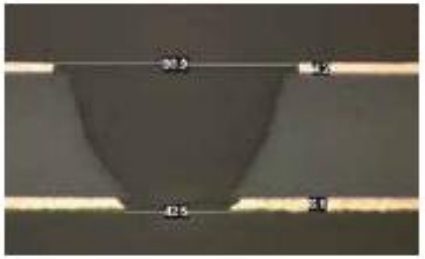
WG5: scalable readout system; Timepix multi-chip MPGD readout

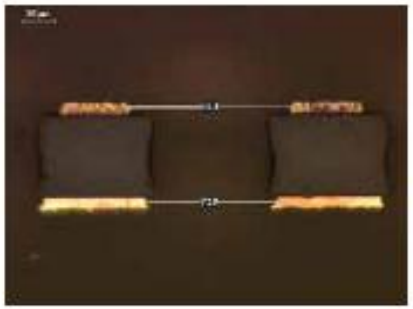
WG6: CERN MPGD Production Facility; TT Network

WG7: RD51 test beam facility (November 2009 - 8 groups/5 setups)

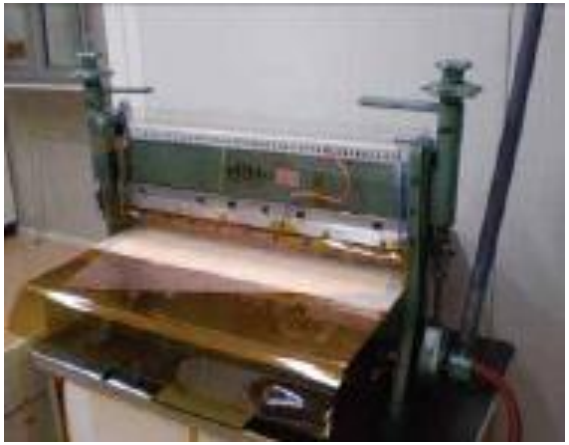
Large Area GEM Detectors Development

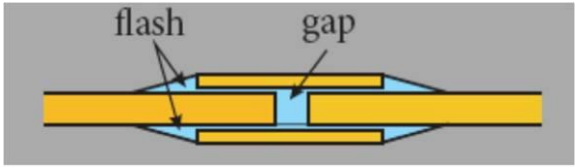
New single mask technology:
Development and evaluation
with small prototypes

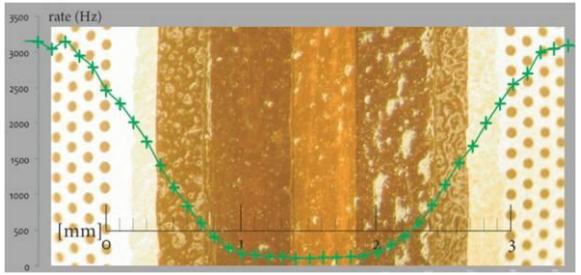




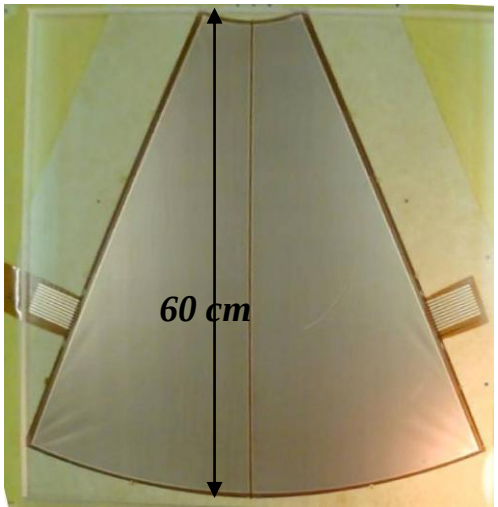
Technology picked up by:
KLOE, TOTEM, CMS

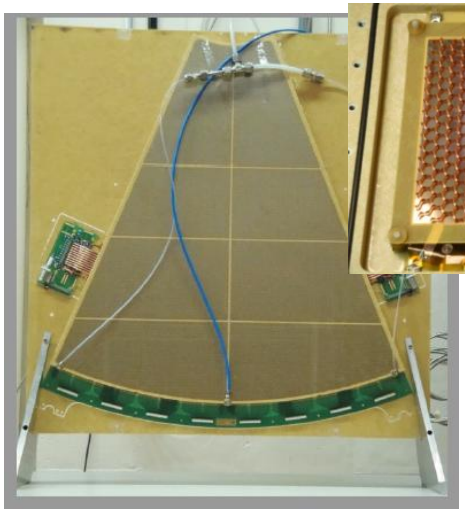


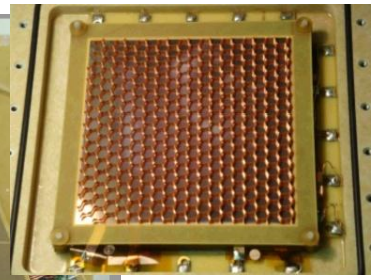




Two-sectors triple-GEM prototype
for
TOTEM T1 upgrade
(60x60 cm^2)
Tested in the RD51 beam facility

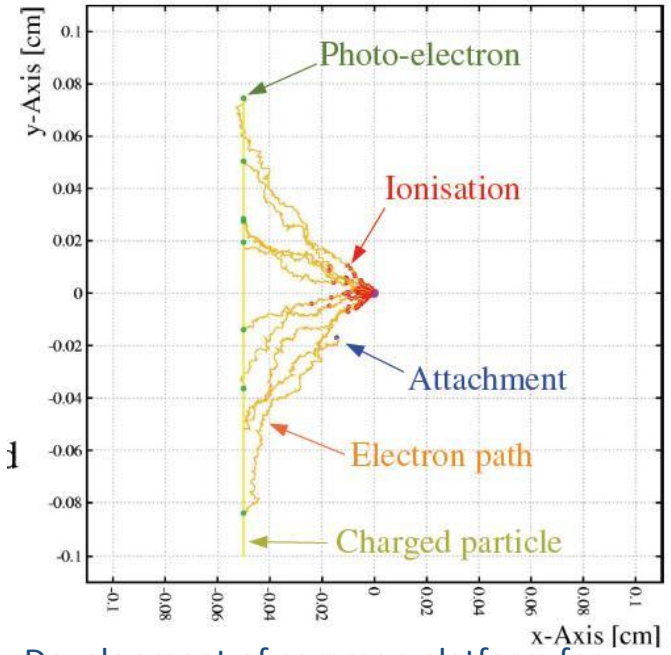


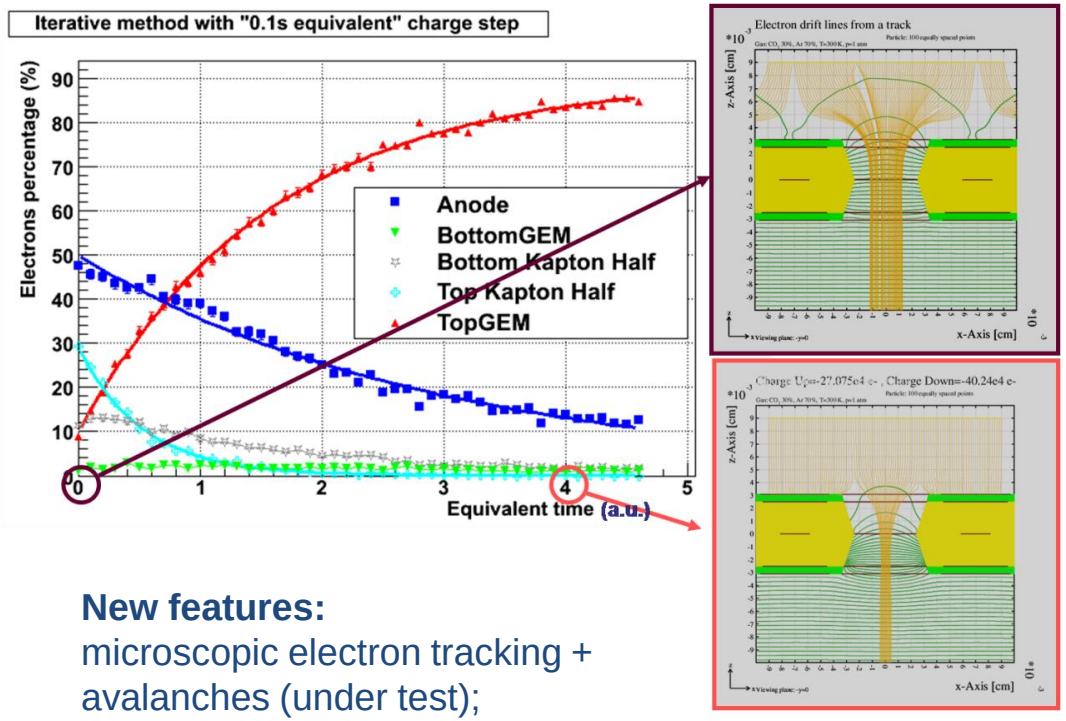




Software Tools Development for MPGD Simulations

Objective: Development of common, open access software and documentation for MPGD simulations





- Development of common platform for detector simulations (gas detector simulation in Geant4, interface to ROOT).

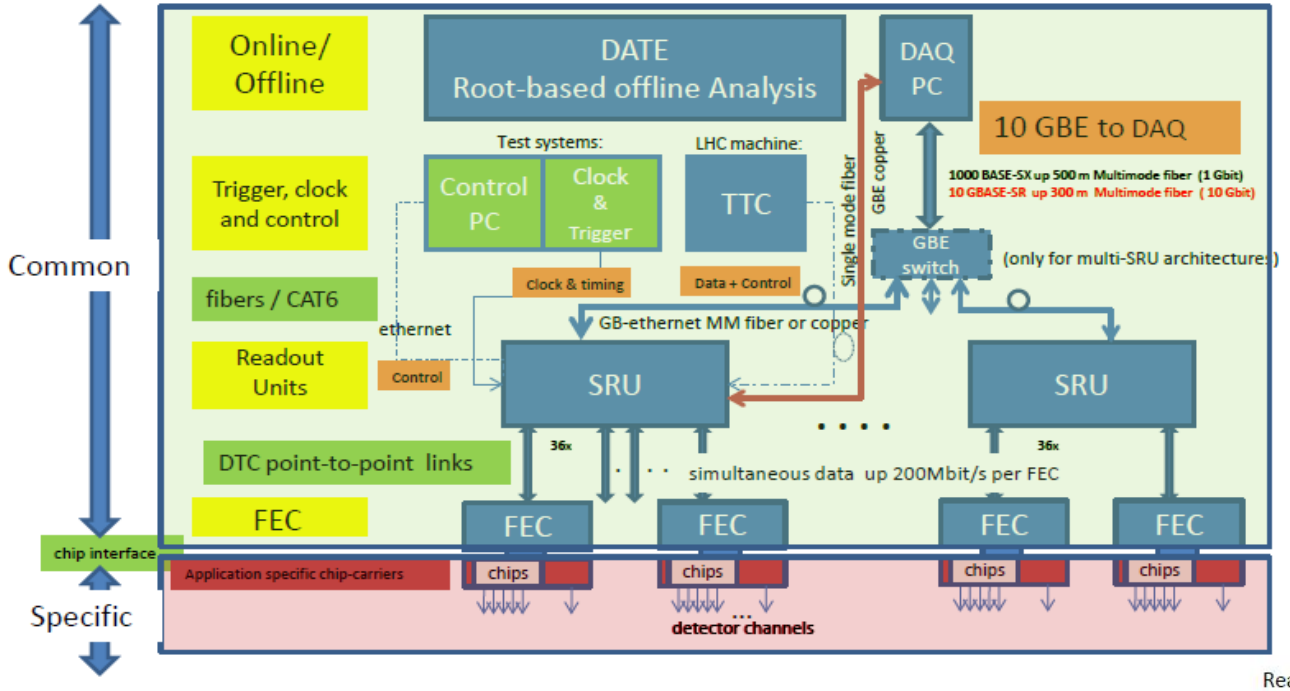
- Development of algorithms (in particular in the domain of very small scale structures - implementation of nearly exact boundary element method interfaced to Garfield).

- Simulation improvements (penning transfer studies, photon excitation via excimers)

New features:
microscopic electron tracking + avalanches (under test);
updates of the gas parameters (regularly);
boundary element field calculations);
root+Geant4 interface (prototypes).

In progress:
avalanche statistics;
Penning transfer from experimental data.

Development of Portable Multichannel DAQ Systems for MPGD

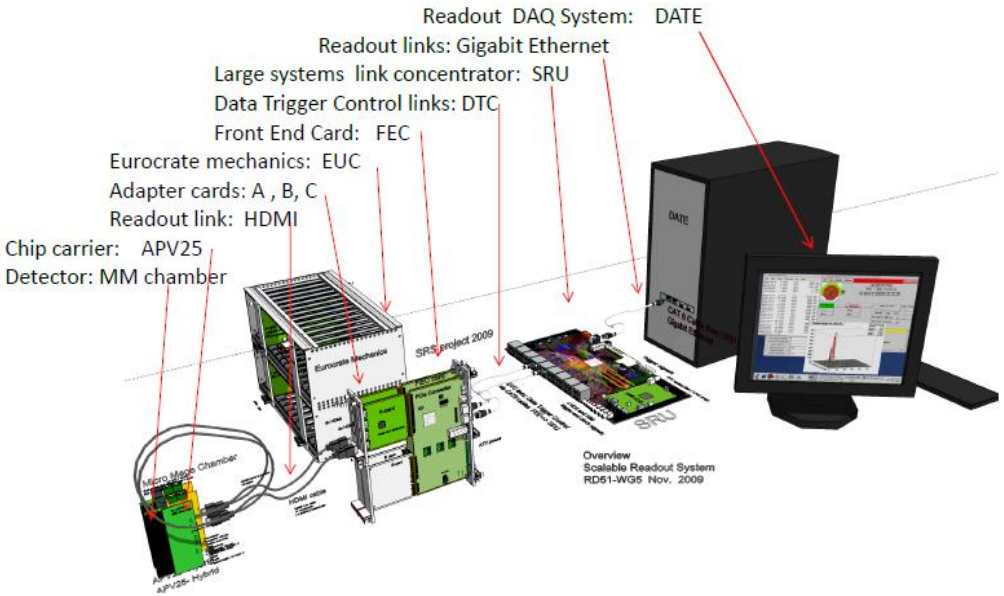


First prototype system to be ready in Fall 2010

LHC exp. upgrade users:
ATLAS Micromegas upgrade (MAMMA)
ALICE: DCAL and EMCal readout upgrade

- Scalability from small to large system
- Common interface for replacing the chip frontend
- Integration of proven and commercial solutions for a minimum of development
- Default availability of a very robust and supported DAQ software package.

→ Scalable Readout System

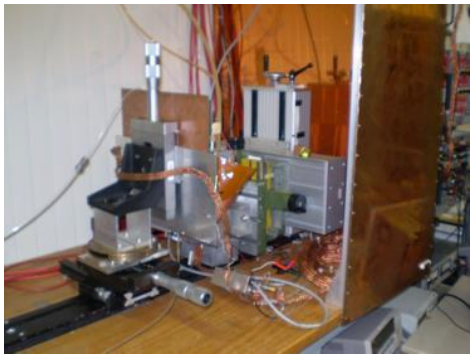


H. Muller, RD51 Collab. Meet., Nov.23-25, 2009, WG5 Meeting

Gas Detector Lab Infrastructure – bld 154

Lab infrastructure:

Clean room
3 X-Ray tubes
4 test stations
assembly space

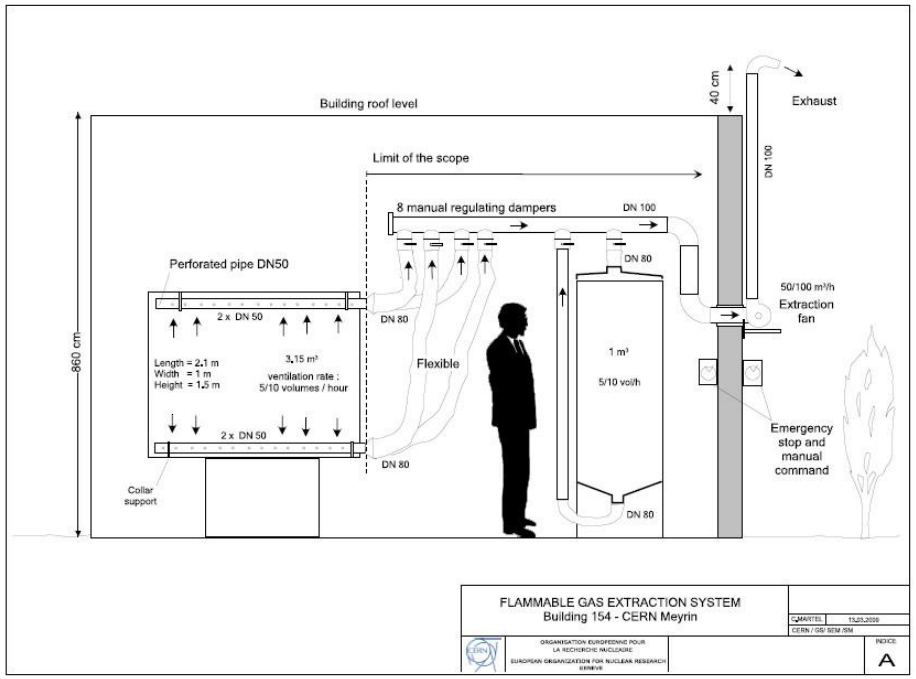


Gas system:

Upgrade to flammable
gas mixtures

Une installation de détection constituée de

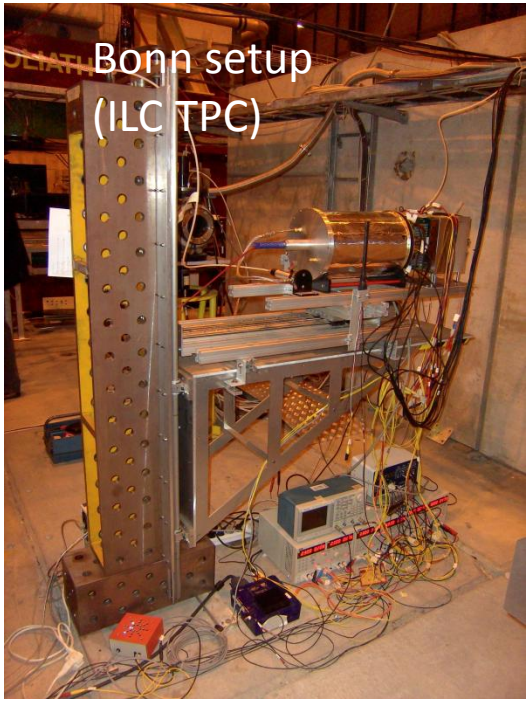
- 8 capteurs OLC20 avec ses supports et ses liaisons NG4
- 4 interfaces WB
- 6 panneaux lumineux avec leur liaison 2 x 2.5
- 4 sirènes avec leur liaison 2 x 2.5
- 1 interface d'acquit sirène
- la pose des chemins de câble et des câbles nécessaires à l'installation
- 1 électrovanne avec leur liaison 3 x 1.5
- 1 coupure électrique avec leurs liaisons NG4
- 1 commande ventilation/extraction
-1 mode maintenance

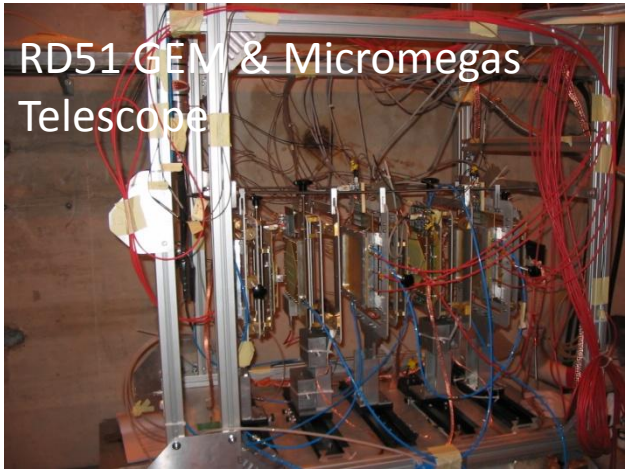


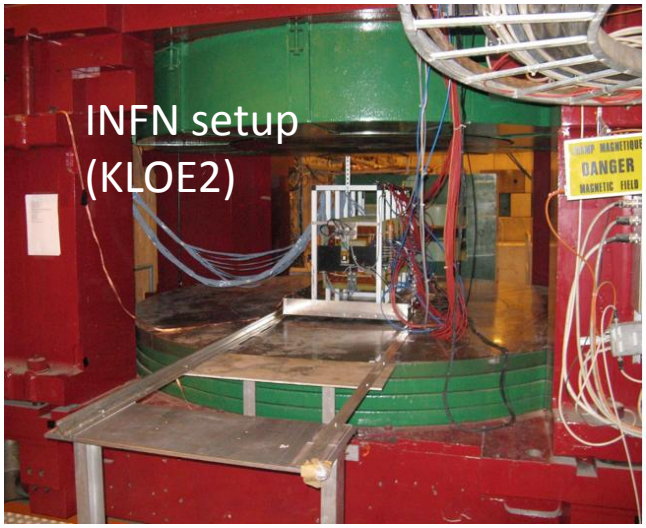
Lab is being used by several groups including ATLAS, CMS, TOTEM, COMPASS

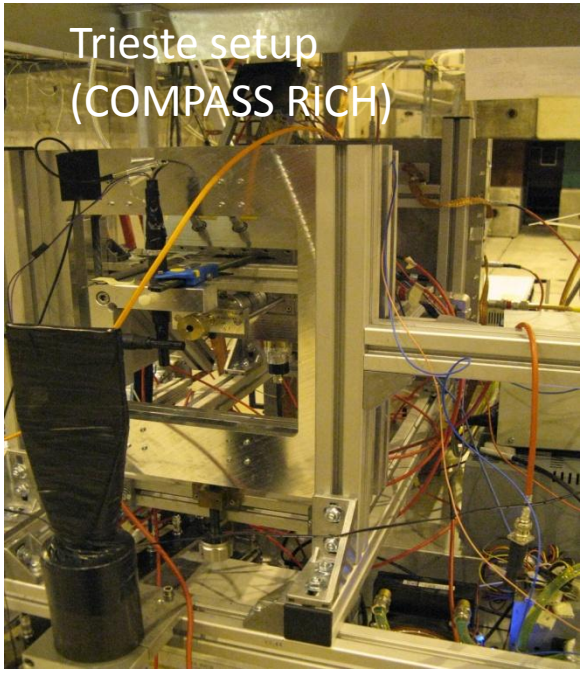
RD51 Common Beam Test Facility

Objective: Design and maintenance of common infrastructure for detector characterization ("semi-permanent" test-beam infrastructure at CERN SPS@H4 beam)









Common infrastructure:
Services, trigger, tracking
Telescope, DAQ, Slow control

8 RD51 groups have been taking data in parallel during the last test beam campaign (Oct. 22 – Nov. 2, 2009)

MPGD in the sLHC Upgrades – Requests from Experiments

Atlas	-	Nigel Hessey
CMS	-	Jordan Nash
LHCb	-	Sheldon Stone
ALICE	-	Paolo Giubellino
TOTEM	-	Angelo Scribano
PANDA	-	Bernd Voss

- ATLAS – Micromegas (muon)
- CMS – GEM (muon)
- LHCb – GEM (muon)
- ALICE – THGEM (photon detector)
- TOTEM – GEM (tracker & trigger)

- Panda & GSI – GEM (tracker)
- LC Time Projection Chamber – Micromegas & GEM
- LC Hadronic Calorimeter (DHCAL) - Micromegas & GEM
- STAR & RHIC – GEM (tracker)
- KLOE2 – GEM (tracker)
- JLAB – GEM & Micromegas
- Potential clients from neutrino community

Potential Interest of the ATLAS Collaboration in the MPGD Technology:

***MPGD Technology* / Detector upgrade**	**Total detector size**	**Timescale**
Gridpix (Micromegas/Ingrid + CMOS pixel ASIC)		
B-layer Pixel detector ATLAS TRT	~ 0.2 m^2 ~ 5 m^2 ~ 100 m^2	2018-2019
Micromegas		
ATLAS Muon System (add chambers to inner ring of a small wheel)	~100 m^2 (single module size ~ 1-2 m^2)	2013-2014 (demonstrator prototypes ready in 2010-2011)
ATLAS Muon System (replacement of a small wheel and inner ring of a large wheel)	~ 1000 m^2	2018-2019

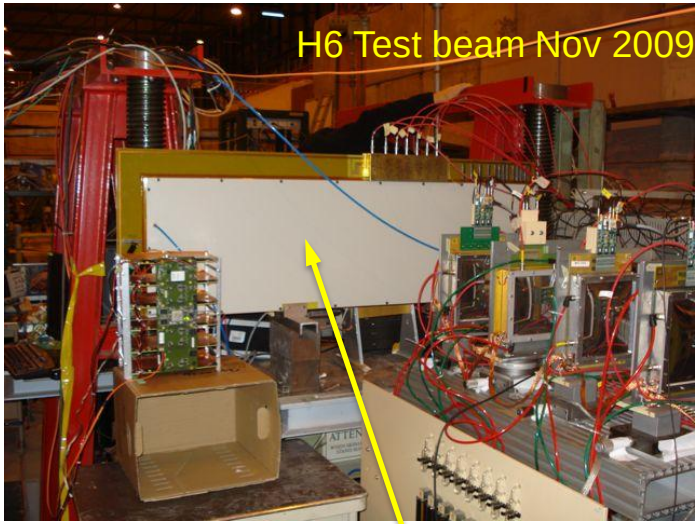
Complementary Developments:

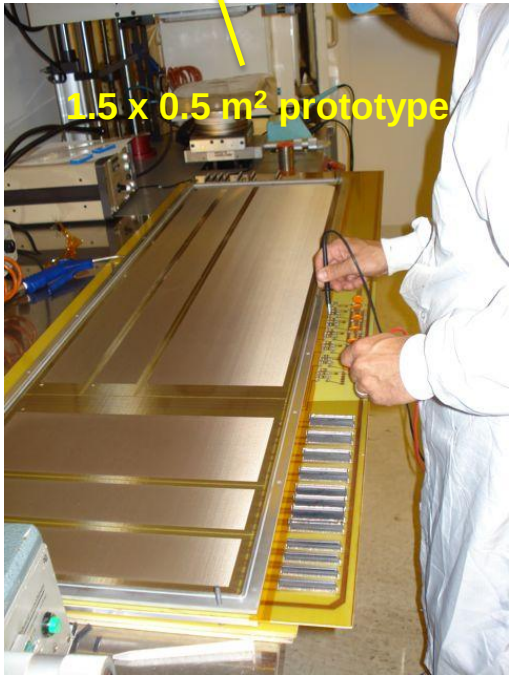
Development	**Function Required**	**Timescale**
Timepix2 /Gossip CMOS pixel chip	Time information & resolution ~ few ns, external triggering capability, radiation hardness	2011-2013
General purpose electronics chip for ATLAS Muon/Micromegas	Time information, external triggering capability, radiation hardness, integration to long strips (~ 1 m)	2011-2012
Software / MC simulation	Integration of gas detector packages (Garfield, Magboltz) into GEANT4 framework	2010-2011

ATLAS Micromegas R&D (MAMMA)

Purpose: Development of large-area muon chambers based on bulk Micromegas technology
Collaboration: 19 institutes (most) in ATLAS, but also active in RD51
Main lines of R&D activities:

1. Spark neutralization and/or suppression
   - Resistive coating on readout strips
   - Multi-stage amplification schemes
2. Large-area chambers
   - P3 (1.5 x 0.5 m^2) successfully tested in H6; strips of 400 and 1000 mm length, strip pitches 250 and 500 µm
   - Full-size chamber (1.2 x 1.2 m^2) under construction; with front-end electronics (demonstrator project with APV25) and services integration.
     To be tested in 2010 test beam (October)
3. Front-end end readout electronics
   - Scalable Readout System (RD51, H. Muller)
   - Readout chip specs and design (BNL, LAPP, CEA, CERN)

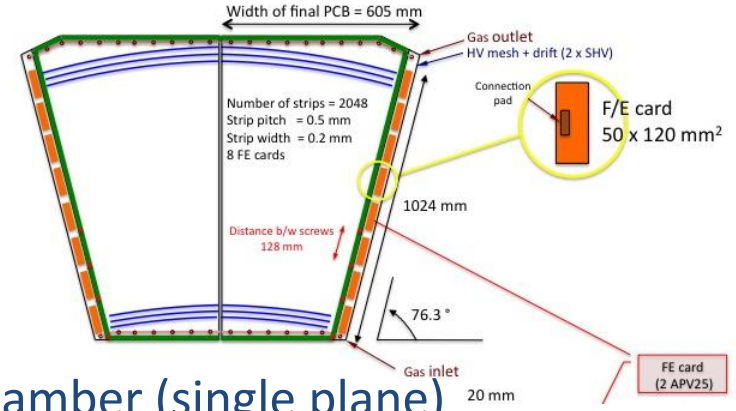




ATLAS micromegas … cont'd

- Close collaboration with EN-ICE workshop (R. de Oliveira)
- Heavy use of PH-DT services (very much appreciated)
  - Common lab & clean room (L. Ropelewski)

    Sharing of infrastructure, instrumentation, manpower, and know-how
  - Engineering support (A. Catinaccio)
  - Technical support (H. Danielsson)



- Plans for 2010/12 @ CERN
  - 2010: construction and test of full-size chamber (single plane)
  - 2011: construction and test of module-0 multi-plane chamber
  - 2012: installation of module-0 in ATLAS ??

Count and rely on continued collaboration with PH-DT groups

CMS R&D and Feasibility studies for high eta

Purpose: Evaluation and development of Triple GEMs technology for high eta muon trigger and tracker
Collaboration: 6 institutions in CMS, 1 TOTEM

Comparison of small-size prototypes in the two technologies. Two small detectors of identical size and built with comparable quality, are compared for various aspects of performance and robustness.

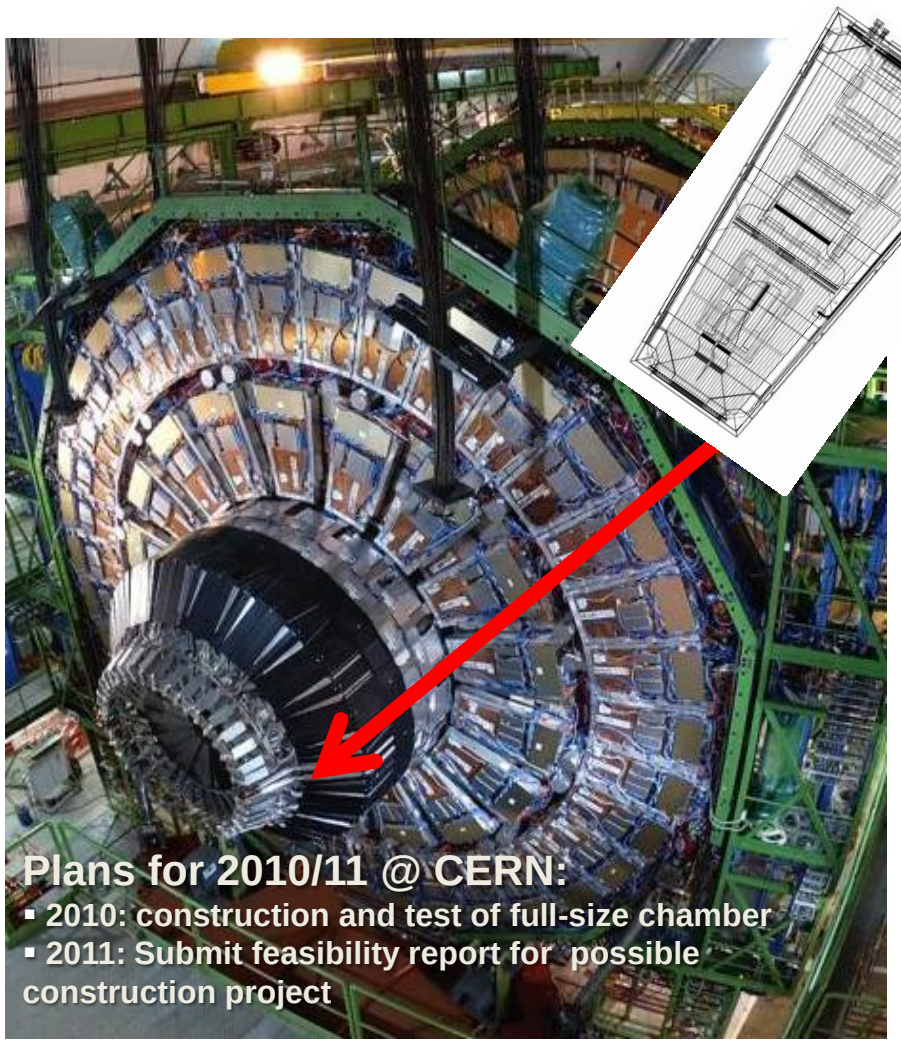
3D modeling of a full-scale detector and services integration.

Detailed modeling of a full-scale detector, to support construction of mock-up & functional prototype. Analysis of integration of power & readout, including routing of cables.

Construction of full-scale mock-up
Mechanical prototype to study handling and integration aspects.

Construction and test of a full-scale functional prototype

Demonstrate performance of a real-size detector with realistic readout electronics. Investigate in detail all construction aspects.



MPGD Production

Objective: Development of cost-effective technologies and industrialization

1) Current: CERN-MPGD workshop is the UNIQUE MPGD production facility (generic R&D, detector components production, quality control)

Detector Technology	Currently produced	Future Requirements
GEM	40 * 40	50 * 50
GEM, single mask	70 * 40	200 * 50
THGEM	70 * 50	200 * 100
RTHGEM, serial graphics	20 * 10	100 * 50
RTHGEM, Kapton	50 * 50	200 * 100
Micromegas, bulk	150 * 50	200 * 100
Micromegas, microbulk	10 * 10	30 * 30

GEM Technology
- New Flex (Korea, Seoul)
- Tech-ETCH (USA, Boston)
- Scienergy (Japan, Tokyo)

Micromegas Technology
- TRIANGLE LABS (USA, Nevada)
- SOMACIS (Italy, Castelfidarco)
- CIRE (France, Paris)

THGEM Technology
ELTOS S.p.A. (Italy)

2) Future MPGD R&D: Reinforcement of CERN-MPGD workshop infrastructure to produce 2x1m; Bulk Micromegas and 2x0.5 m GEMs has been approved by CERN Management (Nov. 2009); Participation the AIDA proposal

3) Technology Industrialization → transfer "know-how" from CERN workshop to industrial partners for MASS PRODUCTION

Summary

- Consolidation of the RD51 Collaboration and MPGD community integration

- Considerable progress in MPGD technologies in particular large area GEM, THGEM, Micromegas; some picked up by experiments (including sLHC upgrades) for feasibility studies and prototyping

- Secured future of the MPGD technologies development through the ICE DEM workshop upgrade and AIDA contribution

- Improved MPGD simulation software framework allowing first applications

- Infrastructure - open Gas Detectors lab, common RD51 test beam facility

- Development of common, scalable electronics system

- TT, IP issues and contacts with industry

Future Plans and Perspectives

- **Maintenance of the open Gas Detector lab and RD51 beam facility**

- **Focus on the LHC experiment upgrade projects (CMS – high η trigger and tracking; TOTEM T1; ATLAS - MAMMA)**

- **CERN based technical support for the upgraded ICE DEM workshop**

- **Completion of the scalable readout system for MPGD**

- **Strategic R&D** (pixel detectors, MPGD photo detectors, integration of large readout structures with fast electronics)