Micro Pattern Gas Detector Technologies and Applications

The work of the RD51 Collaboration

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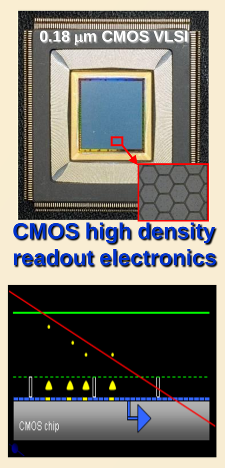
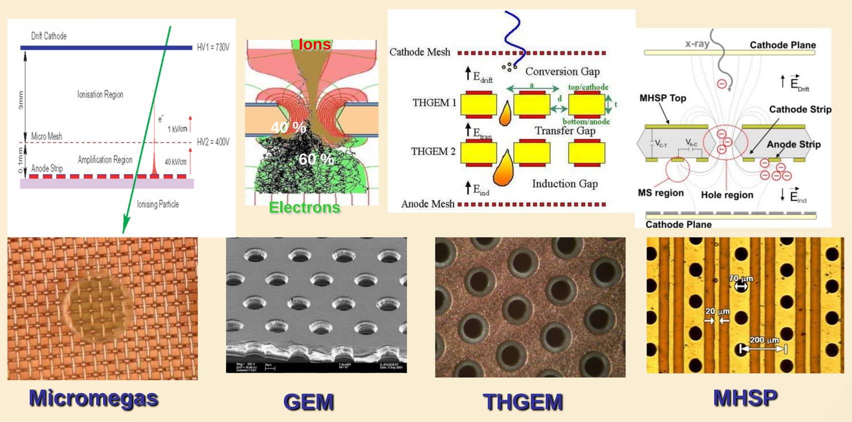
Current Trends in MPGD: Technologies

The Micro-Strip Gas Chamber, introduced by Oed in 1988 (NIMA 263, 351), was the first Micro-Pattern Gaseous Detector; exploiting photolithography techniques for the production of micrometric structure of electrodes. This family of gaseous detectors led to significant improvements in terms of rate capability and spatial resolution with respect to the Multi-Wire Proportional Chambers.

After 20 years, MPGD technologies are well established. Beside well-known representatives, such as *GEM* (*Gas Electron Multiplier*, F. Sauli, NIM A 386 (1997), 531) and *Micromegas* (*Micro Mesh Gaseous Structure*, Y. Giomataris, NIM A 376 (1996), 29), other examples of current R&D on technologies are: *Thick-GEM*, *Micro Hole & Strip Plates* and other hole-type detectors; structures with resistive electrodes; integration of the MPGD with CMOS pixel ASICs; production of the two in the same process as in the case of Ingrid

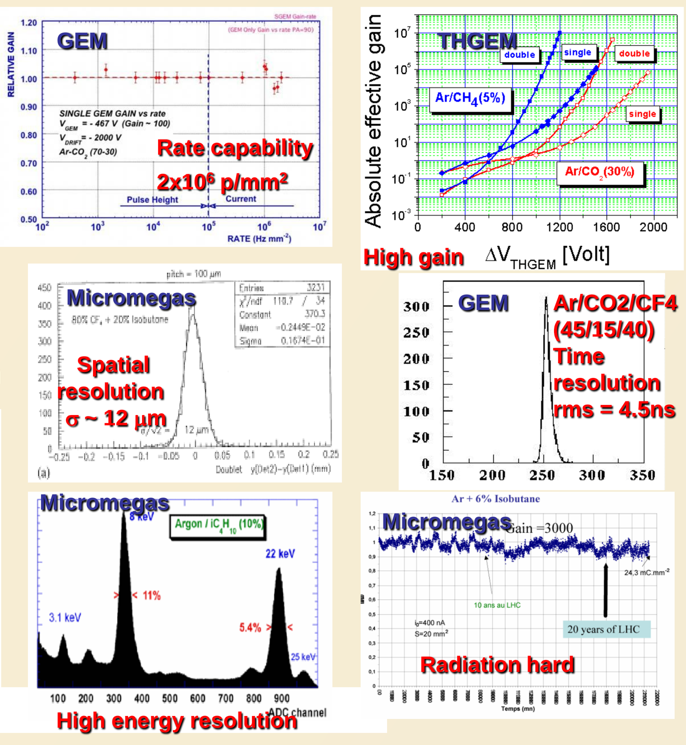


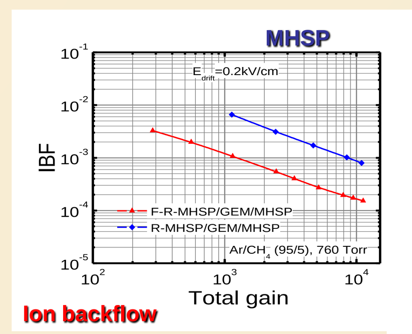


Current Trends MPGD: Performance

MPGDs can be optimize in order to achieve challenging performance in terms of:

- Rate Capability
- High Gain
- Space Resolution
- Time Resolution
- Energy Resolution
- Ageing Properties
- Ion Backflow Reduction
- Photon Feedback Reduction

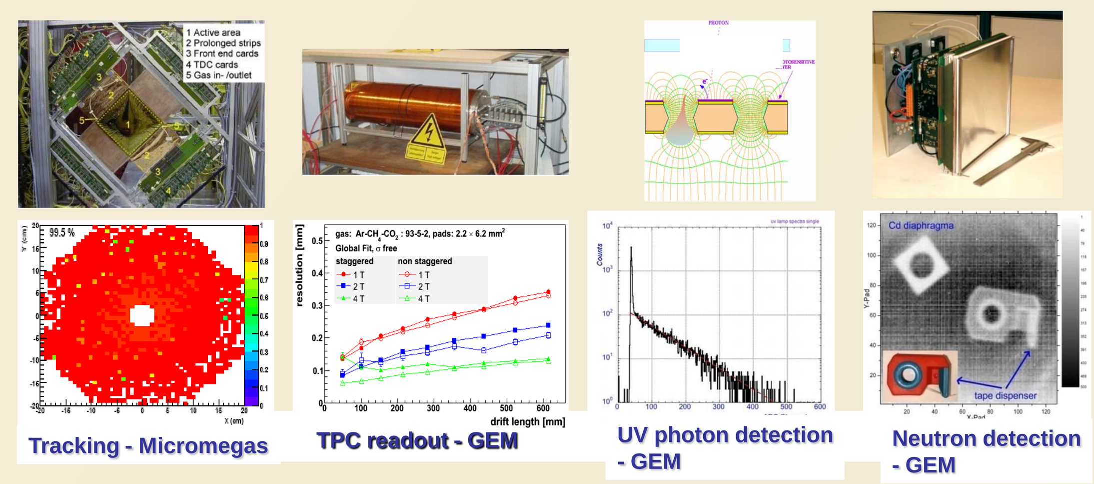




Current Trends in MPGD: Applications

COMPASS experiment at CERN has been the first application of GEM and Micromegas detectors and MPGD are also present in the apparatus of LHC experiments (LHCb and TOTEM).
Actually applications range in High Energy physics environment as well as other fields:

- High-Rate Particle Tracking and Triggering
- Time Projection Chamber Readout
- Photon Detectors for Cherenkov Imaging Counters
- X-Ray Astronomy
- Neutron Detection and Low Background Experiments
- Cryogenic Detectors
- Medical Applications
- Homeland Security and Prevention of Planetary Disasters

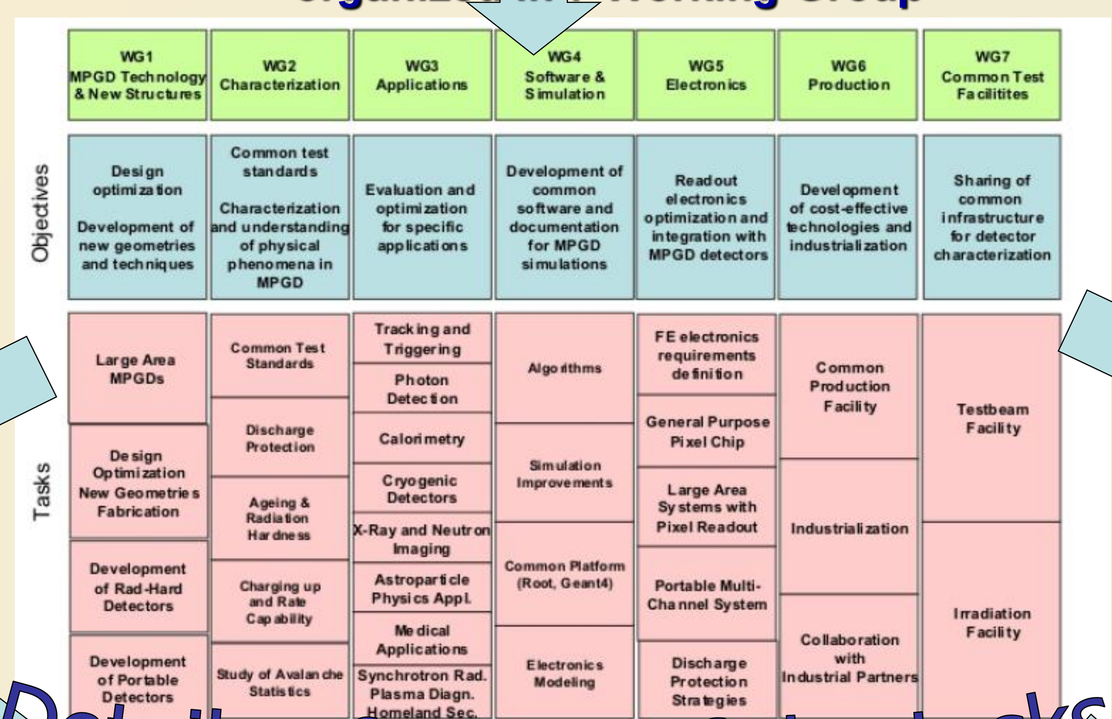


More than 50 institutes from 20 countries and 4 continents decided to optimize efforts and resourses joining forces in

RD51 collaboration

http://rd51-public.web.cern.ch/RD51-Public/

organized in 7 Working Group



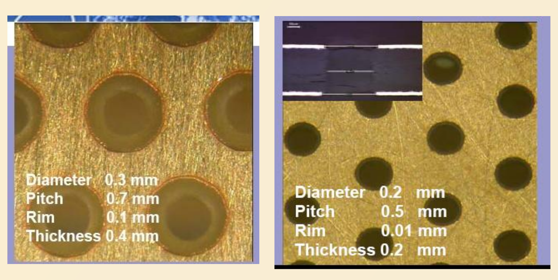
Details of some of the tasks

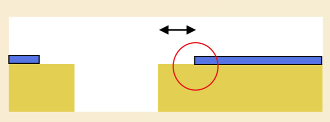
Conferences and Workshops:

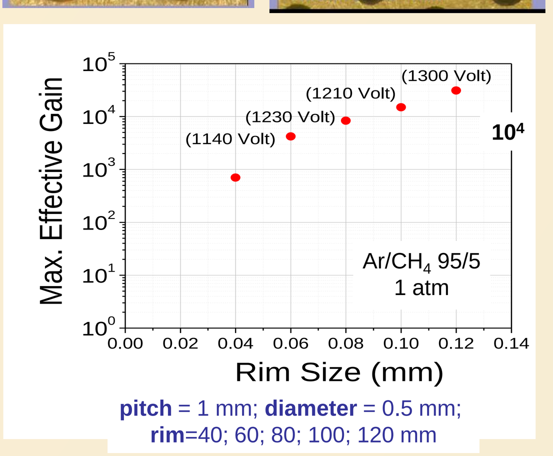
- **Micro Pattern Gas Detectors. Towards an R&D Collaboration. (CERN, September 10-11, 2007)**
- **1st RD51 Collaboration Meeting (NIKHEF, April 16-19, 2008)**
- **2nd RD51 Collaboration meeting (Paris, October 13-15, 2008)**
- **MPGD2009 and 3rd RD51 Collaboration Meeting (Crete, June 12-15, 2009)**
- **4th RD51 Collaboration Meeting (CERN , November 23-25, 2009)**
- **5th RD51 Collaboration Meeting (Freiburg, May 24-27, 2010)**

WG1: Detector design optimization – Thick GEM rim example

A Thick GEM is a copper-clad fiberglass layer with a matrix of holes realized by mechanical drilling and, in some cases, chemical etching. Typical dimension are sub-millimetric.



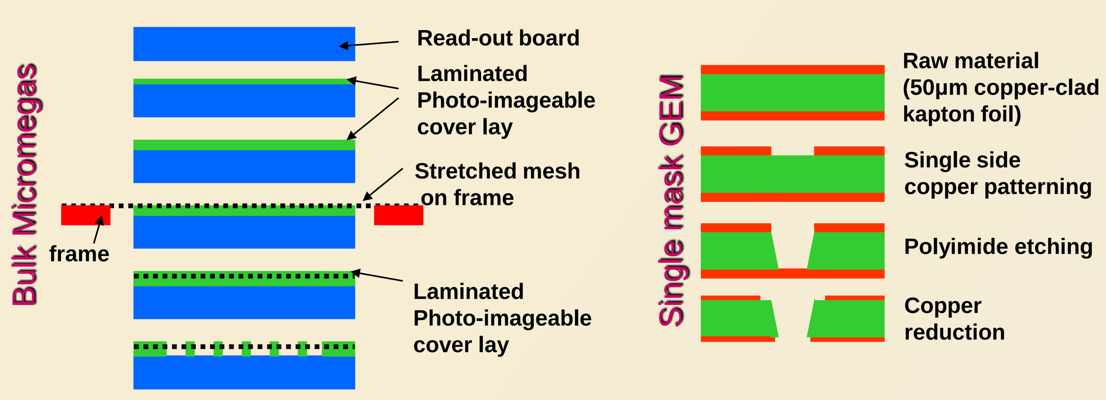




The introduction of a rim on the two copper layers is effective for the increase of the maximum achievable gain.
On the other hand, due to the larger dielectric surface exposed to the charges produced in the avalanche, a larger rim shows also larger and longer charging-up effects, increasing the time to arrive to a stable operation

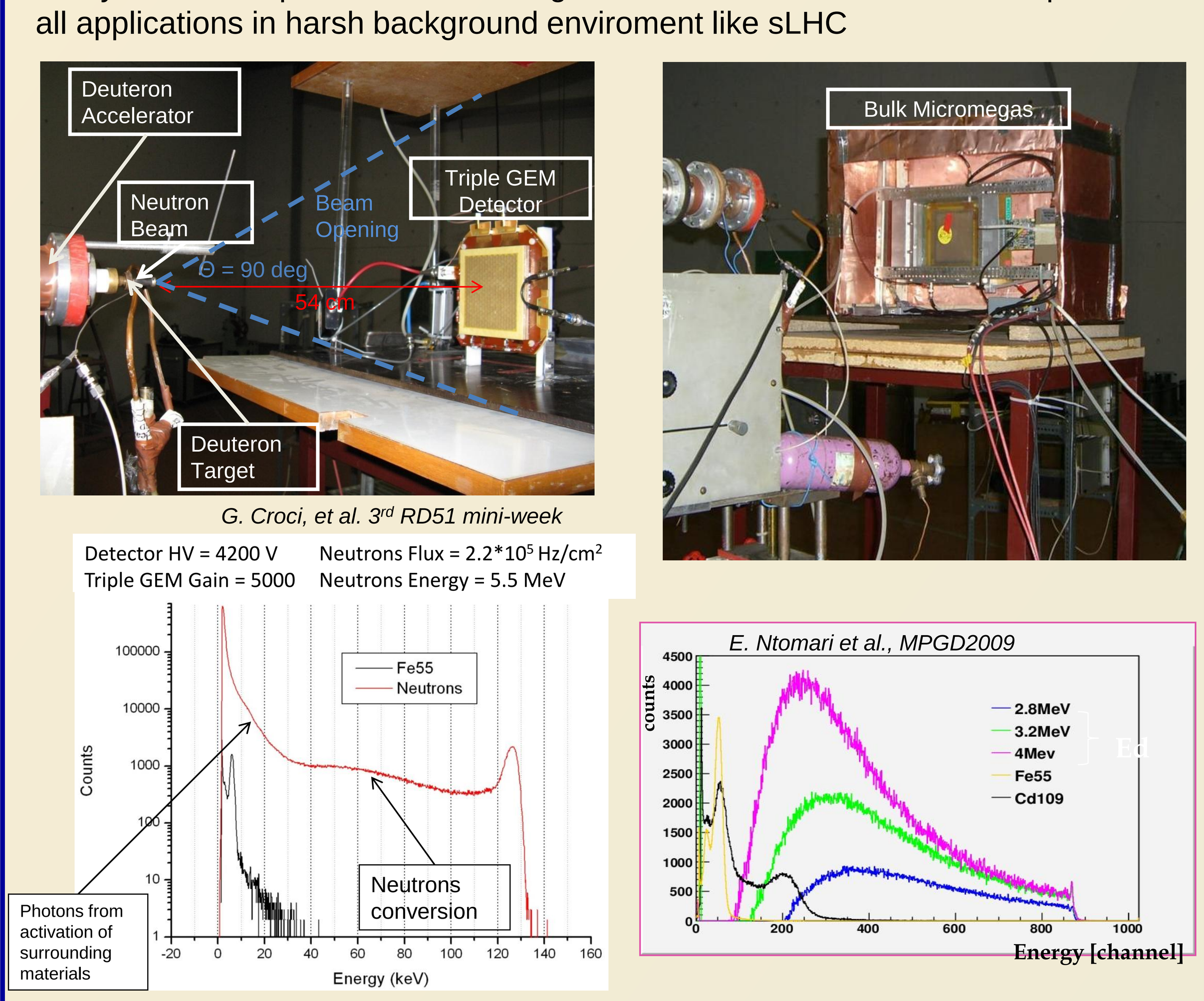
WG1: Large area MPGD

Limitations in MPGD size can come from the production technique or the available instrumentations and raw material. New production techniques can overcome these limitations and open the way to larger detectors, as in the case of *bulk micromegas* and *single mask GEM foils*



WG2: Radiation Hardness

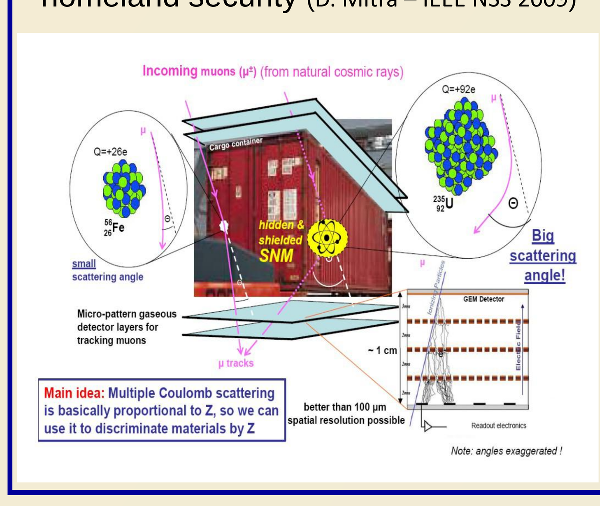
Study of MPGDs performance in a high flux neutron beam is a crucial aspect for all applications in harsh background enviroment like sLHC

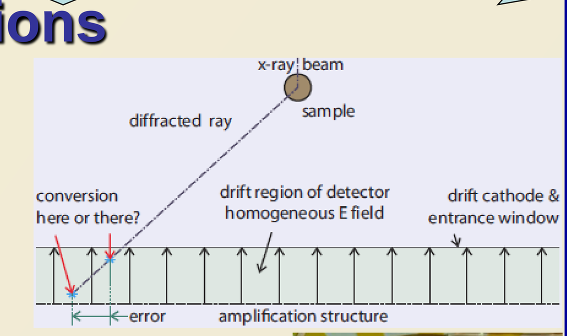


Neutrons PH spectra of Triple GEM Detector (left) and Bulk Micromegas (right).

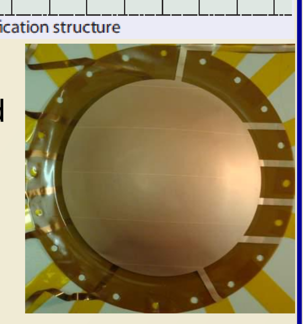
WG3: MPGDs applications

Cosmic muon tomography for homeland security (D. Mitra – IEEE NSS 2009)





X–ray diffractometry parallax issue solved by truly spherical conversion gap → spherical GEM formig from planar GEM

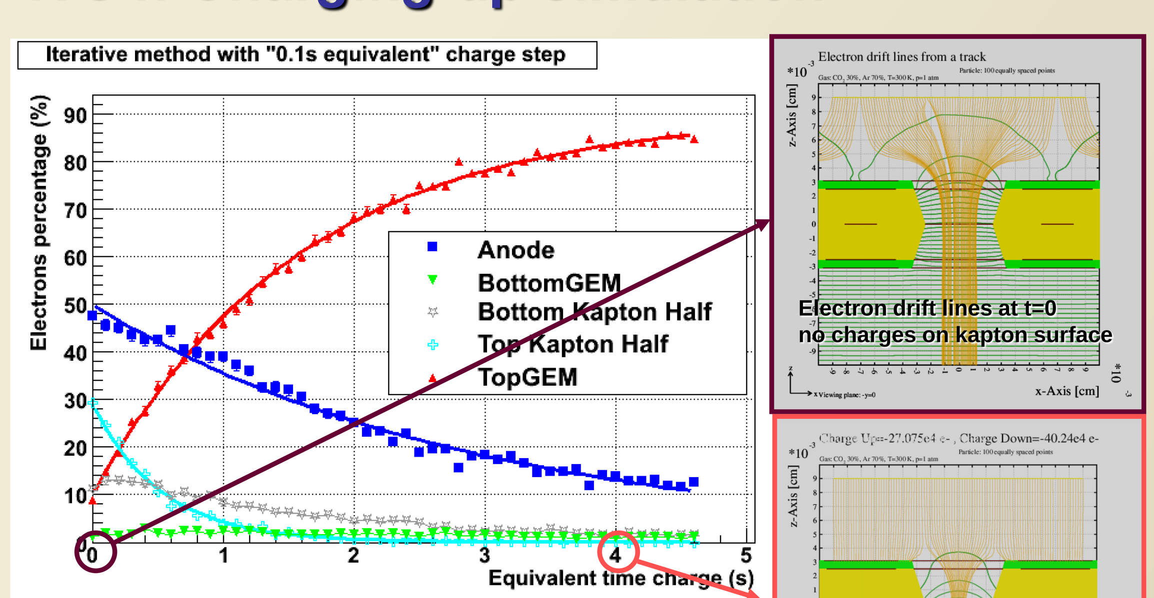


WG4: Simulation improvements

New features have been introduced or are under way in Garfield, the main software for gas detector simulation, in order to take into account the smaller scale of MPGD technologies:

- a new algorithm for microscopic electron tracking and avalanche
- the introduction of Penning transfer mechanism
- the introduction of a Boundary Element Solver (NeBEM) for field calculations
- the integration of Garfield in common platforms such as ROOT and Geant4

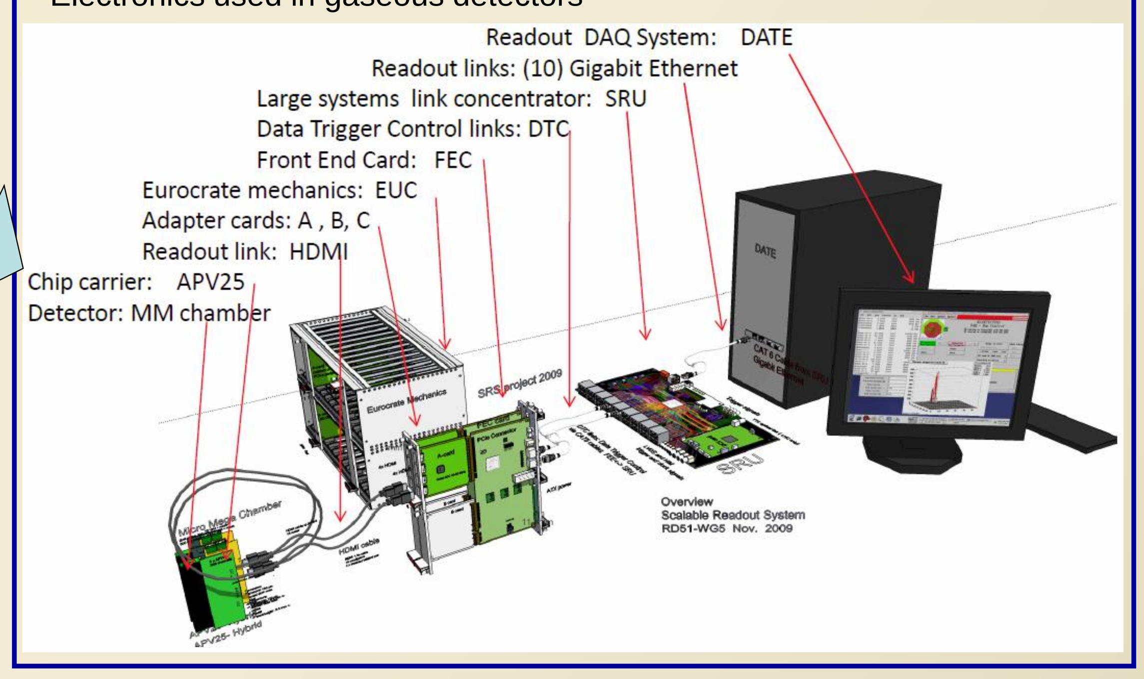
WG4: Charging-up simulation



Discrepancies in GEM detectors simulation with respect to measurements can be explained by the charging-up of the dielectric. Studies are under way to include this dynamic process in the simulation.

WG5: Multi-channel Readout System

The development of a multi-channel scalable (from small test system to very large LHC-like system) is under way. A special effort is dedicated to make it compatible to the largest possible set of current Front-End Electronics used in gaseous detectors



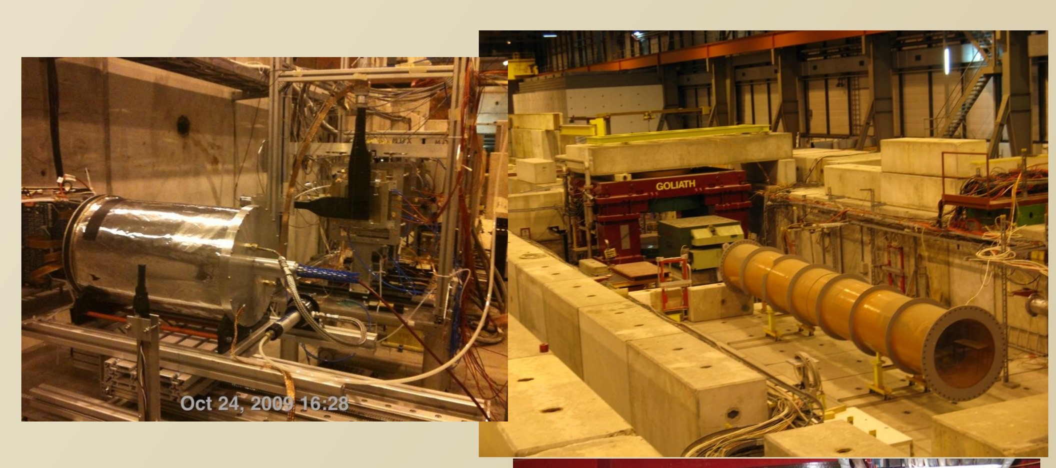
WG6: Common Production facilities

One of the main WG6 task is to promote the upgrade of the production facilities according to the requirements of the future applications

Detector Technology	Currently produced	Future Requirements
	cm * cm	cm * cm
GEM	40 * 40	50 * 50
GEM, single mask	70 * 40	200 * 50
THGEM	70 * 50	200 * 100
RTHGEM, serial graphics	20 * 10	100 * 50
Micromegas, bulk	150 * 50	200 * 100
Micromegas, microbulk	10 * 10	30 * 30
MHSP (Micro-Hole and Strip Plate)	3*3	10*10

WG7: Common test beam facility

RD51 has built up a semi-permanent test setup on the SPS/H4 beam line at CERN. Common infrastructures such as cables, gas pipes, gas mixing system, as well as common devices for trigger and a tracking telescope, common DAQ and analysis software will reduce installation dead times and will avoid duplication of efforts and resourses.



SPS/H4 beam line has been chosen for the availability of the large "Goliath" dipole magnet, and for the large amount of space of the experimental zone, that allows many groups to take data at the same time.

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