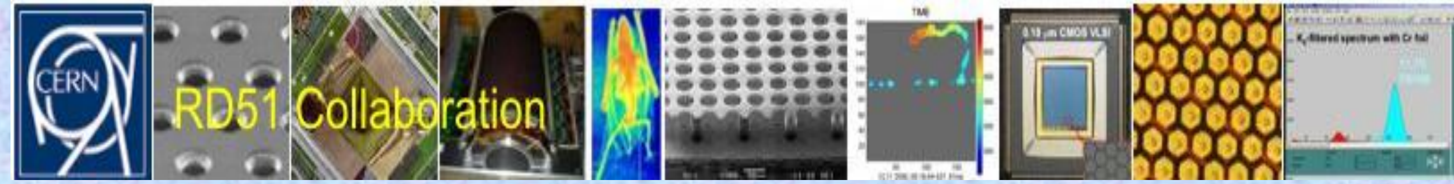
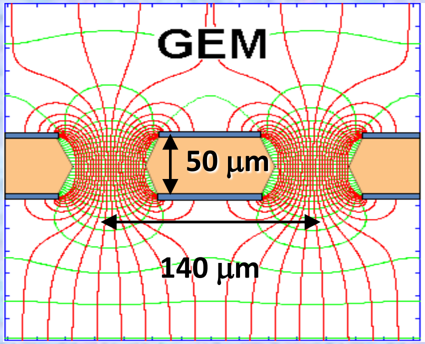
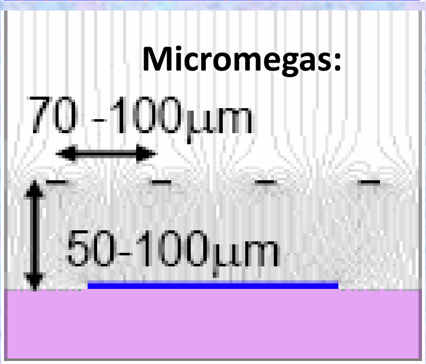
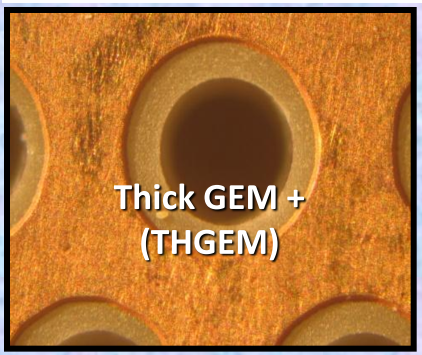
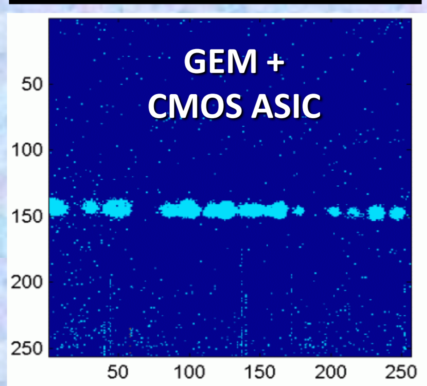










The RD51 Collaboration: « Development of Micro-Pattern Gas Detector Technologies »

Leszek Ropelewski, CERN, Switzerland

Maxim Titov, CEA Saclay, France

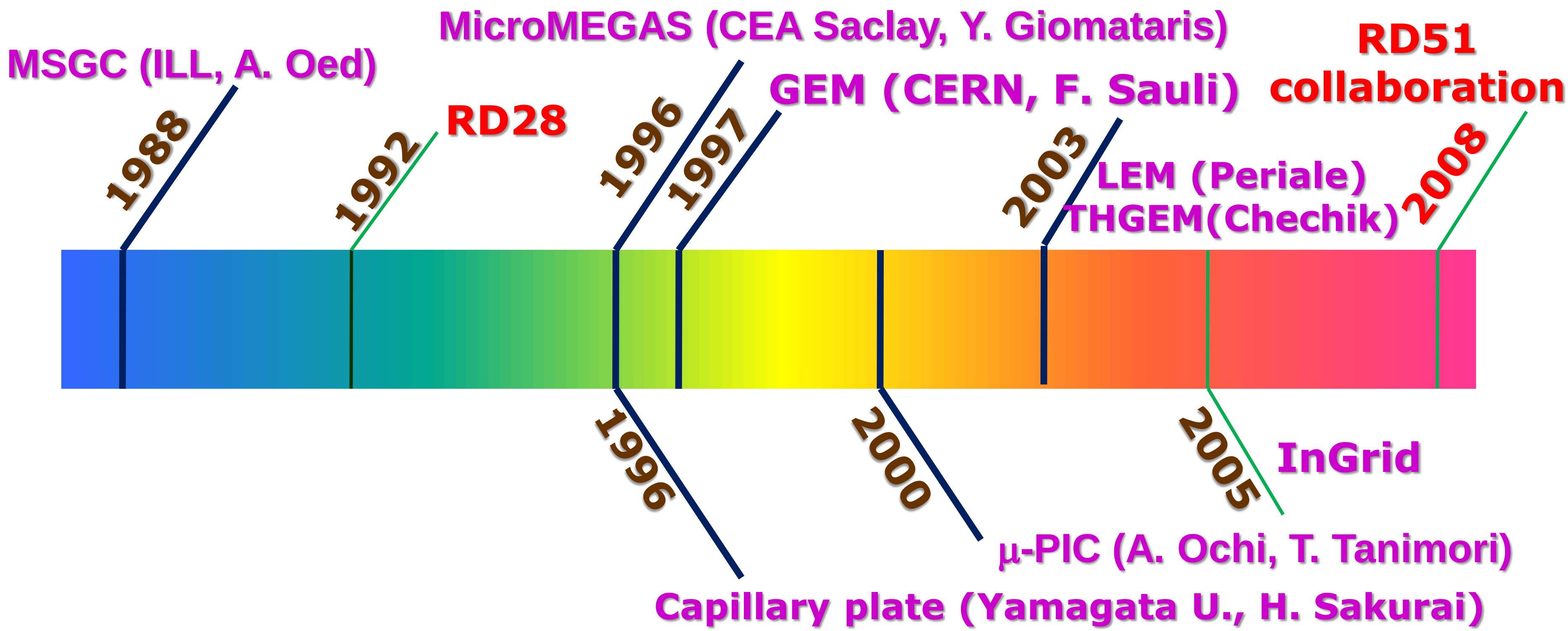
OUTLINE:

- **RD51 Motivation and Main Objectives**
- **RD51 Collaboration Activities and Results**
  (Large area MPGD developments, Software & Simulation, SRS Electronics, CERN MPGD Production Facility & Industrialization, RD51 Test Beam Facility, Training)
- **RD51 Plans and Outlook**

110th LHCC Meeting, CERN, 13-14 June 2012

MPGD Developments: Historical Roadmap*

(*Many more micro-pattern structures were developed; only widely spread technologies are shown)

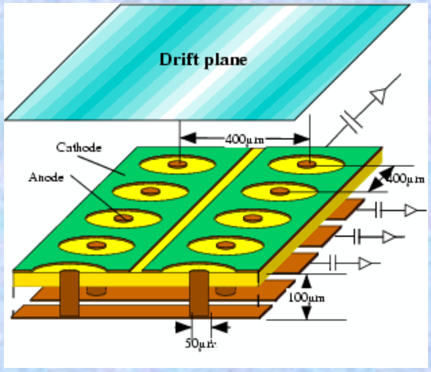


From A.Ochi ADA2012@Kolkata (updated)

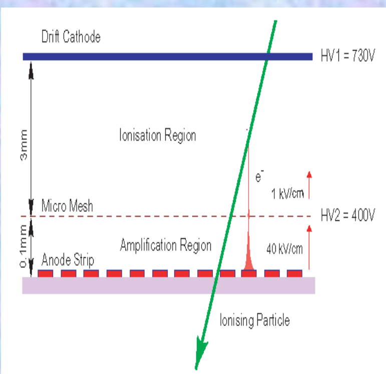
Micro-Pattern Gaseous Detectors: Technologies for Future Projects

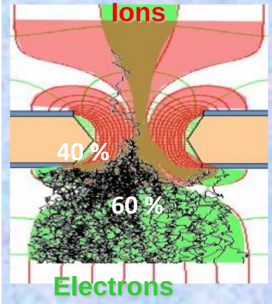
- **Micromegas**
- **GEM**
- **Thick-GEM, Hole-Type Detectors and RETGEM**
- **MPDG with CMOS pixel ASICs ("InGrid")**
- **Micro-Pixel Chamber (µPIC)**

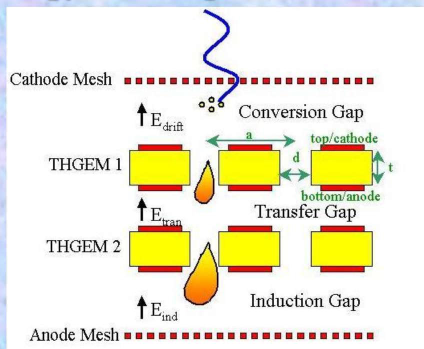
µPIC

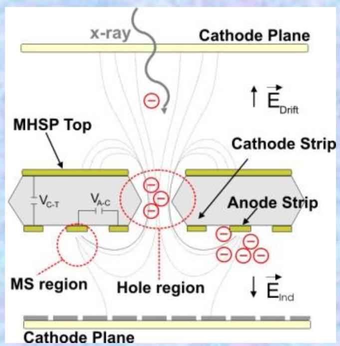


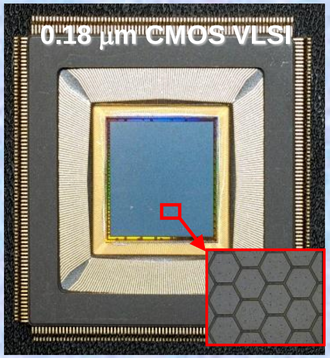
CMOS high density readout electronics

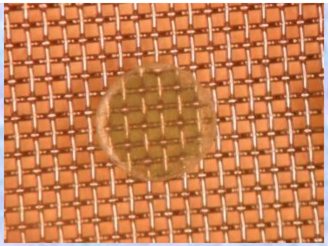




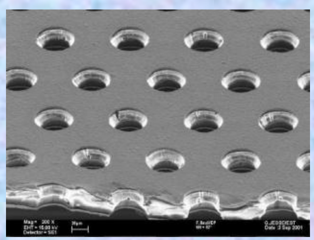




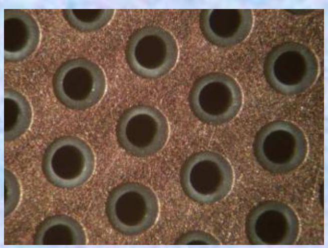




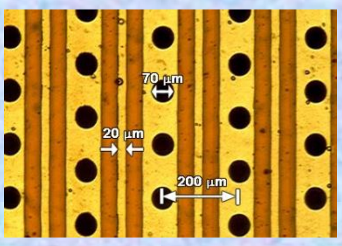
Micromegas



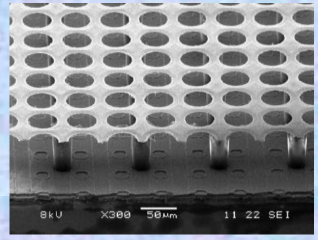
GEM



THGEM



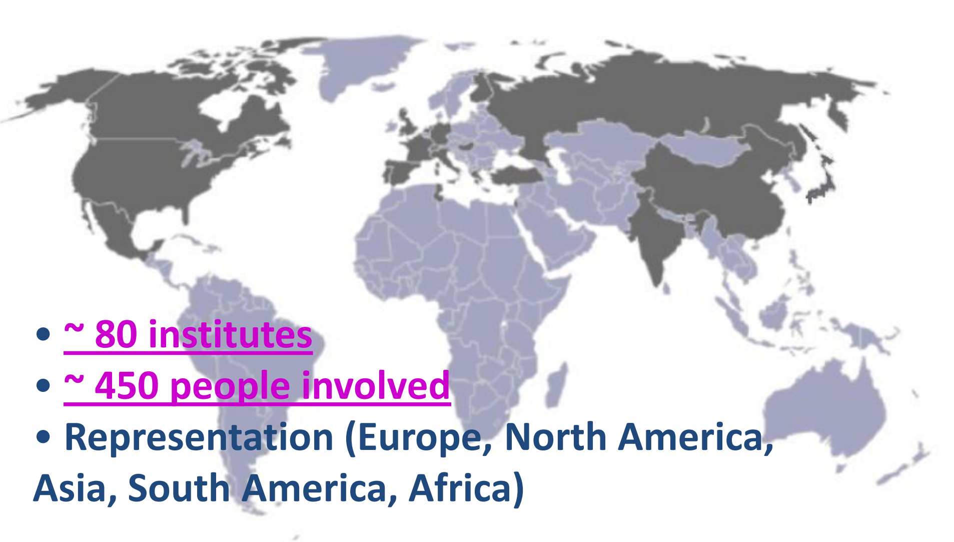
MHSP



Ingrid

RD51 Collaboration: "Development of MPGD Technologies"

The main objective of the R&D programme is to advance technological development of Micropattern Gas Detectors



- ~ 80 institutes
- ~ 450 people involved
- Representation (Europe, North America, Asia, South America, Africa)

MPGD2011, the first conference in the international series in Asia

Kobe, Japan, September 2011

"RD51 aims at facilitating the development of advanced gas-avalanche detector technologies and associated electronic-readout systems, for applications in basic and applied research"

RD51 contributes to the LHC upgrades, BUT, the most important is:
RD51 serves as an access point to MPGD "know-how" for the world-wide community

Bari, Italy, October 2010

Growing Demand for the Micro-Pattern Gaseous Detectors

… MPGD are mostly used/proposed for high-rate tracking and photodetectors

… not even a complete list …

- **COMPASS Upgrade:**
  - Micromegas and GEM detectors for high-rate tracking
  - Photon Detectors Using THGEM technology for RICH 1

- **KLOE2 Upgrade:**
  - Large-area cylindrical GEMs for Inner Tracker

- **RHIC Upgrades:**
  - GEM Tracking for STAR Experiment
  - GEM Tracking for PHENIX Experiment(+ drift micro-TPC); development of Ring Imaging version of HBD for particle ID

- **Future JLAB Projects:**
  - Thin-Curved Micromegas for JLAB/CLAS12
  - GEM Tracker for JLAB/Hall A High Luminosity (SBS) experiments

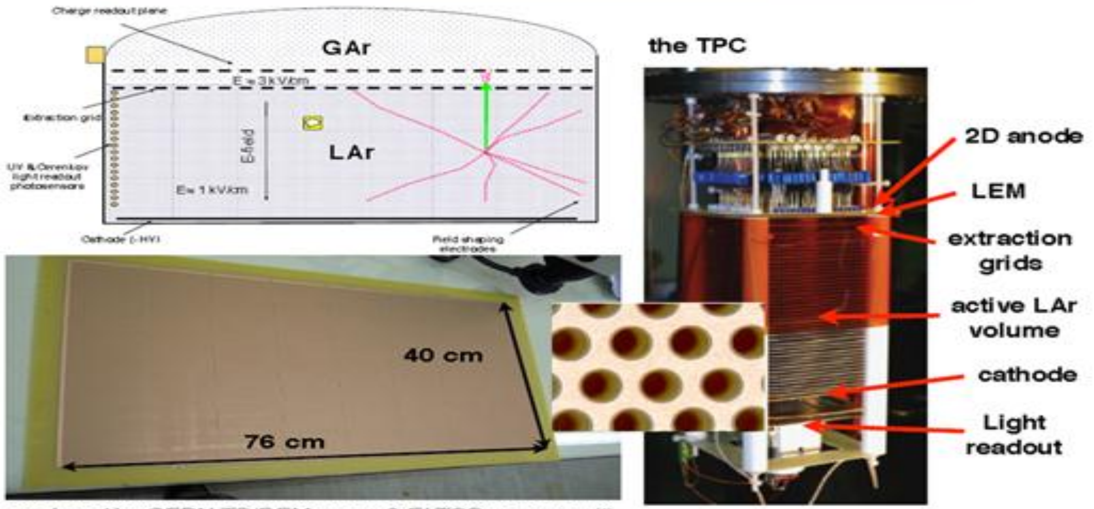
- **Future FAIR Facility:**
  - GEM Tracker and GEM TPC for the PANDA Experiment
  - GEM/Micromegas tracking in CBM Muon Chamber (MUCH)

- **Future Electron - Ion Collider Facility:**
  - Tracking and particle ID detectors based on MPGD-technology

Growing Demand for the Cryogenic MPGDs (LAr, LXe)

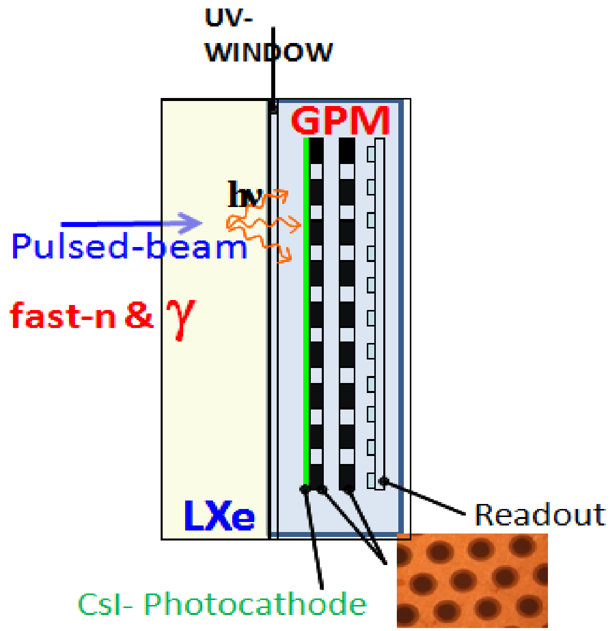
… MPGD are used/proposed for dark matter & rare event searches and neutrino physics

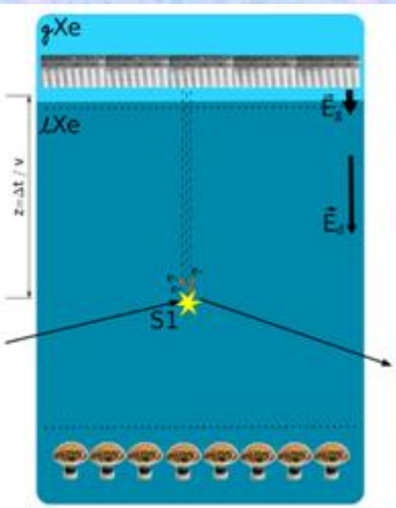
Double Phase LAr Large Area LEM/TPC for Neutrino Physics



produced by CERN TS/DEM group & ELTOS company (I)

Combined fast-n & γ imaging detector:



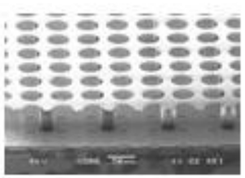


Direct charge readout under investigation
[DARWIN Consortium, arXiv:1012.4767]

GridPix technology interesting for high single electron efficiency

Main challenges:

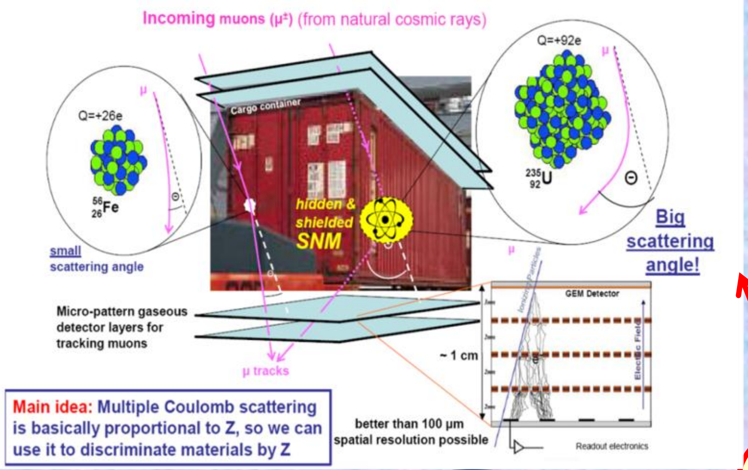
- Low temperature robustness
- Operation without quenchers
- Material outgassing and radiopurity



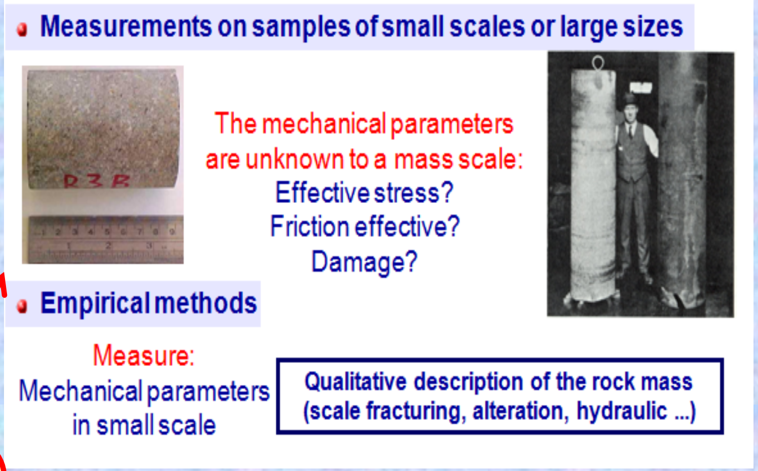
InGrid detector for Dark Matter Searches (DARWIN Consortium):

Spin off is important key word for the HEP labs to survive ...

Cosmic Ray Muon Tomography Using GEMs for Homeland security



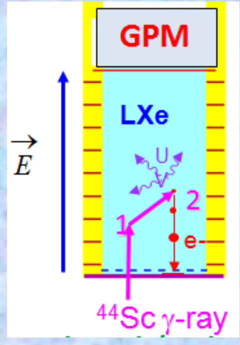
T2DM2: Temporal Tomography Densitometric by the Measure of Muons

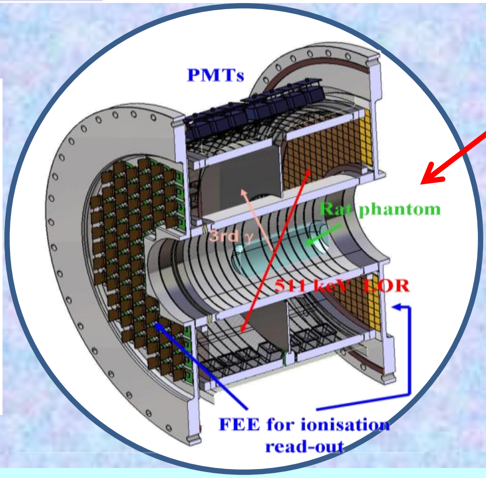


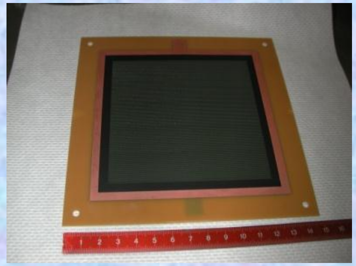
Technology

RD51

Technology







Liquid xenon detectors for functional medical imaging

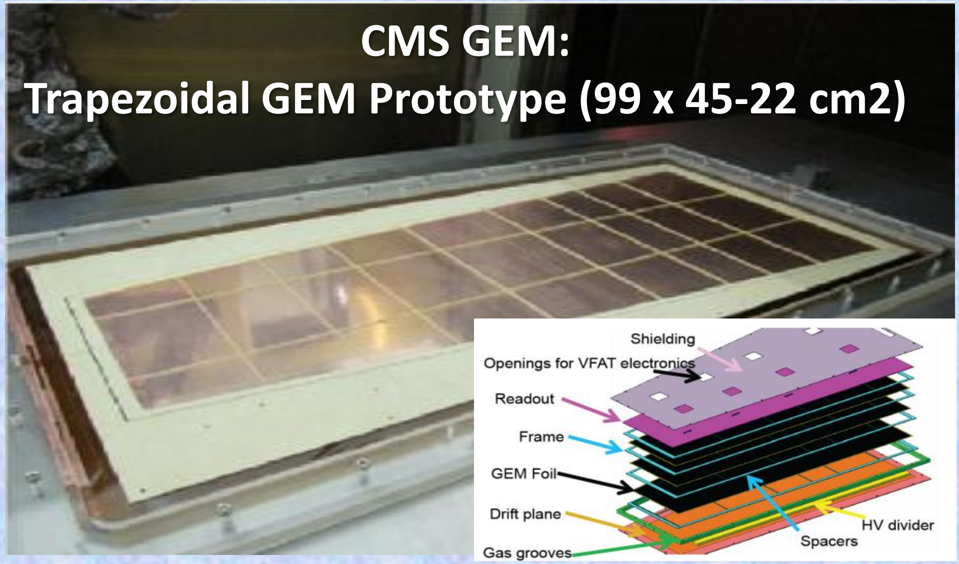
CsI-RETGEM for UV flame detection

- ❖ Applications area will benefit from the technological developments developed by the RD51
- ❖ The responsibility for the completion of the application projects lies with the institutes themselves

MPGD Technologies for Energy Frontier (sLHC, LC)

Ongoing R&D Projects using MPGDs in the framework of HEP Experiments

	Vertex	Inner Tracker	PID/ photo-det.	EM CALO	HAD CALO	MUON Track	MUON Trigger
ATLAS	GOSSIP /InGrid	GOSSIP /InGrid				Micromegas	Micromegas
CMS						GEM	GEM
ALICE		TPC (GEM)	VHPMID (CsI-THGEM)				
Linear Collider		TPC(MM, GEM, InGrid)			DHCAL (MM,GEM, THGEM)		



RD 51 Collaboration - Working Groups

"Transverse organization" of MPGD activities in 7 Working Groups

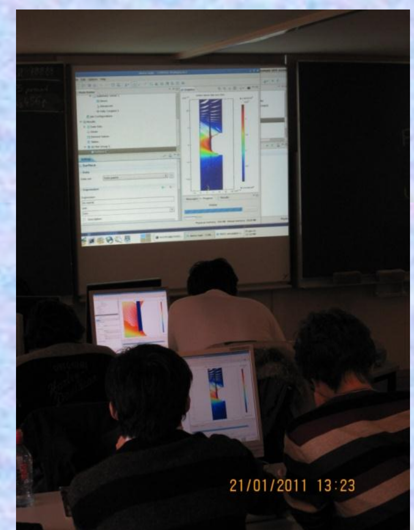
RD51 – Micropattern Gas Detectors

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

	WG1 MPGD Technology & New Structures	WG2 Characterization	WG3 Applications	WG4 Software & Simulation	WG5 Electronics	WG6 Production	WG7 Common Test Facilities
Objectives	Design optimization Development of new geometries and techniques	Common test standards Characterization and understanding of physical phenomena in MPGD	Evaluation and optimization for specific applications	Development of common software and documentation for MPGD simulations	Readout electronics optimization and integration with MPGD detectors	Development of cost-effective technologies and industrialization	Sharing of common infrastructure for detector characterization
Tasks	Large Area MPGDs Design Optimization New Geometries Fabrication Development of Rad-Hard Detectors Development of Portable Detectors	Common Test Standards Discharge Protection Ageing & Radiation Hardness Charging up and Rate Capability Study of Avalanche Statistics	Tracking and Triggering Photon Detection Calorimetry Cryogenic Detectors X-Ray and Neutron Imaging Astroparticle Physics Appl. Medical Applications Synchrotron Rad. Plasma Diagn. Homeland Sec.	Algorithms Simulation Improvements Common Platform (Root, Geant4) Electronics Modeling	FE electronics requirements definition General Purpose Pixel Chip Large Area Systems with Pixel Readout Portable Multi-Channel System Discharge Protection Strategies	Common Production Facility Industrialization Collaboration with Industrial Partners	Testbeam Facility Irradiation Facility

MPGD Training and Education Events

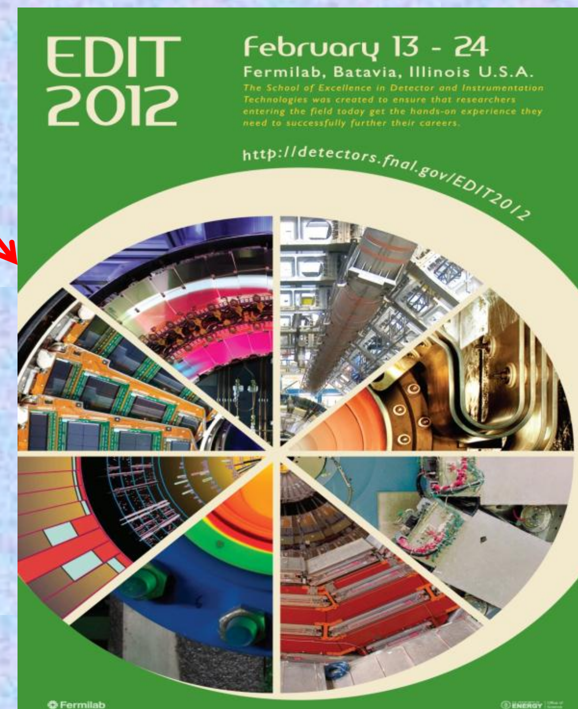
Feb. 2009 @ CERN: RD51 GEM & Micromegas & assembly and training



Jan. 2010 @ RD51 Simulation School

RD51

Contributions to the EDIT School: 2011 @ CERN; 2012 @ Fermilab



RD 51 Collaboration Organization

Consolidation around common projects: large area MPGD R&D, CERN/MPGD production facility, common 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: double phase operation, radiation tolerance, discharge protection, rate effects, single-electron response, avalanche fluctuations, photo detection with THGEM and GridPix

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

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

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

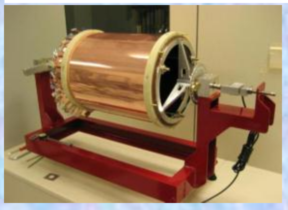
WG6: CERN MPGD Production Facility; industrialisation; TT Network

WG7: RD51 test beam facility

RD 51 Collaboration Organization

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

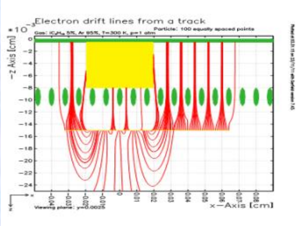
Large area (MM, GEM, THGEM) Design optimization (e.g. THGEM, Resistive MM)



WG1:

"RD51 Common Projects" (Generic R&D)

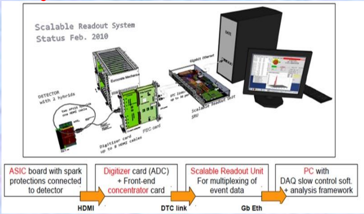
WG2:



RD51

WG5:

MPGD SRS Electronics



WG4:

Software and Simulation

WG7:

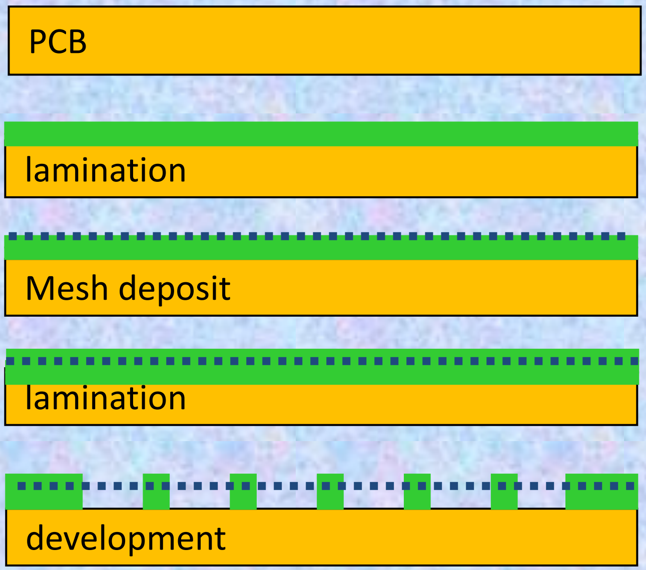
RD51 Common Test Beam Facility

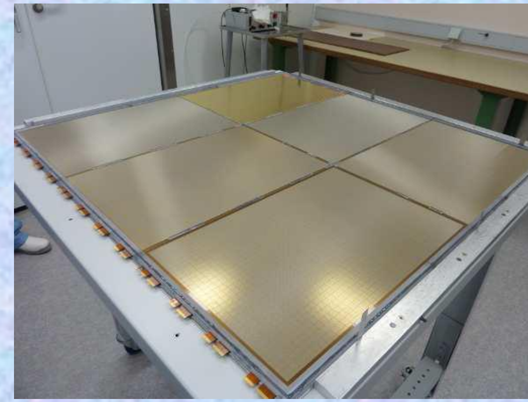
WG6:


CERN MPGD Workshop & Industrialization

WG1: Large Area Detectors – "Bulk Micromegas" Technology

Bulk Micromegas:





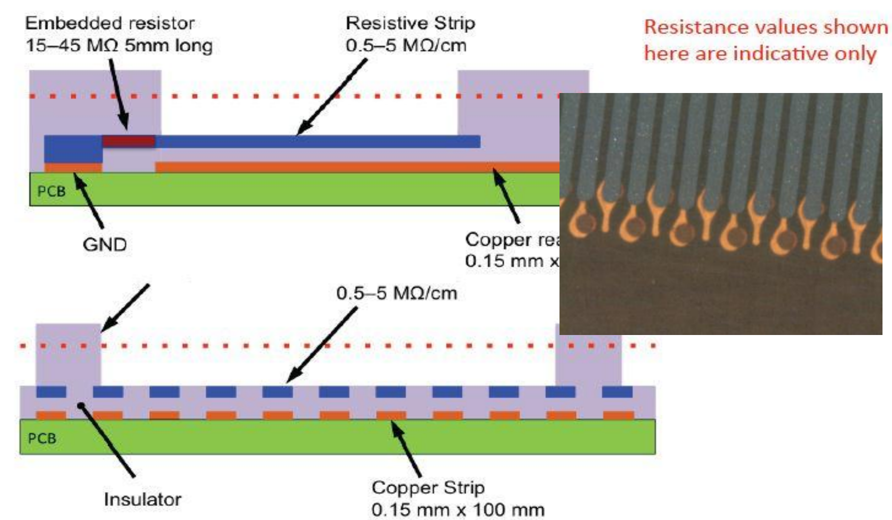
ILC DHCAL (Large area MM 1m^2 prototype: (6 Bulk of 32 *48 cm^2)

Since 2010: "Resistive Bulk Micromegas" Technology

- **Spark neutralization and/or suppression**
- **Resistive strip parallel to readout strips**

Uniformity, robustness, easy fabrication, large area detectors & small dead area→ "Full path of industrial production"

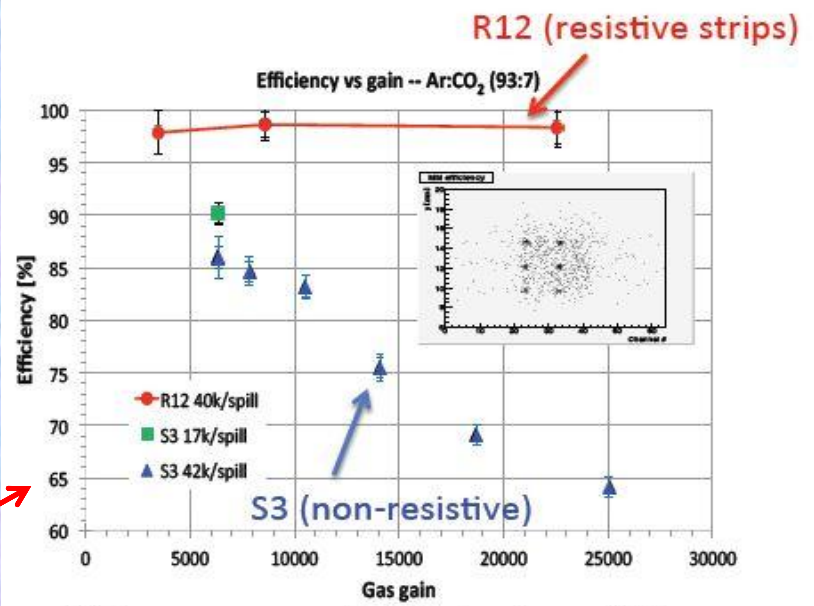
The resistive-strip protection concept



Resistive Bulk Micromegas for the ATLAS Muon System Upgrade

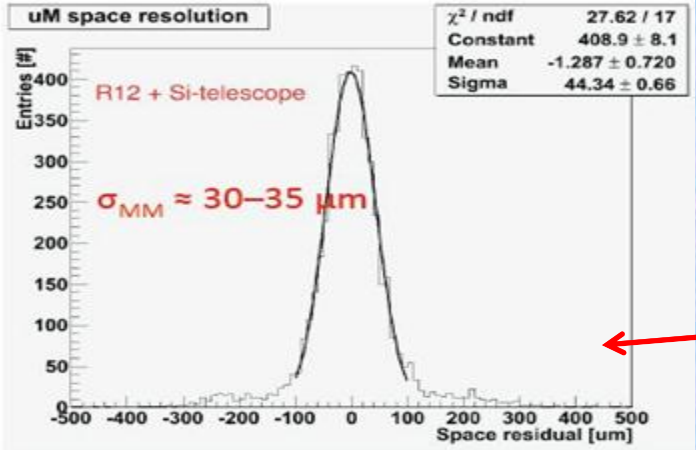
Development of large-area muon chambers for the ATLAS upgrade for high-luminosity:

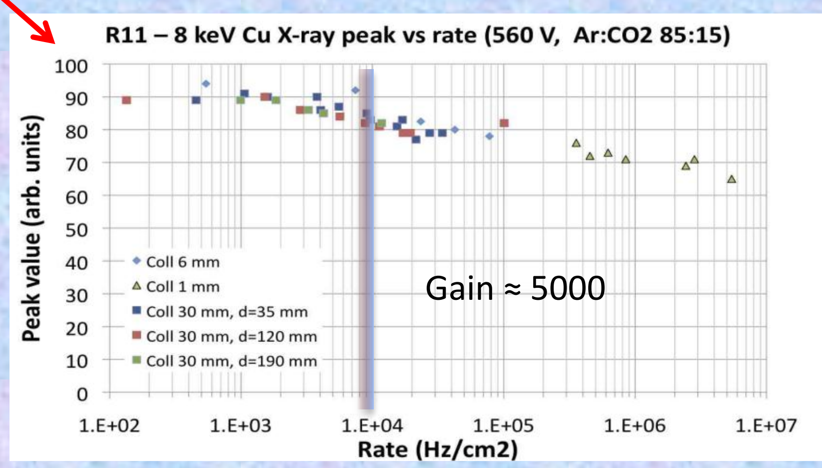
- **Rate: ≤15 kHz/cm²**
- **Spatial resolution: ≤100 μm (up to track angles of 30 degrees); efficiency ~ 98 %**
- **Trigger capability (time resolution: ≤10 ns)**
- **No ageing over 20 years of HL-LHC**



Efficiency measured in H6 pion beam (120 GeV/c); S3 is a non-resistive MM, R12 has resistive-strip protection

- **Efficiency**
- **Gas Gain**
- **Spatial Resolution**





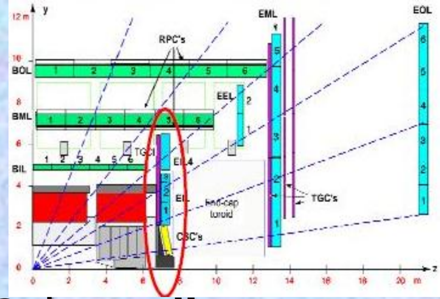
R&D Reached milestones

- Large area chambers
- 2D readout (x-y, x-u-v)
- Inverted HV scheme (mesh on GND)

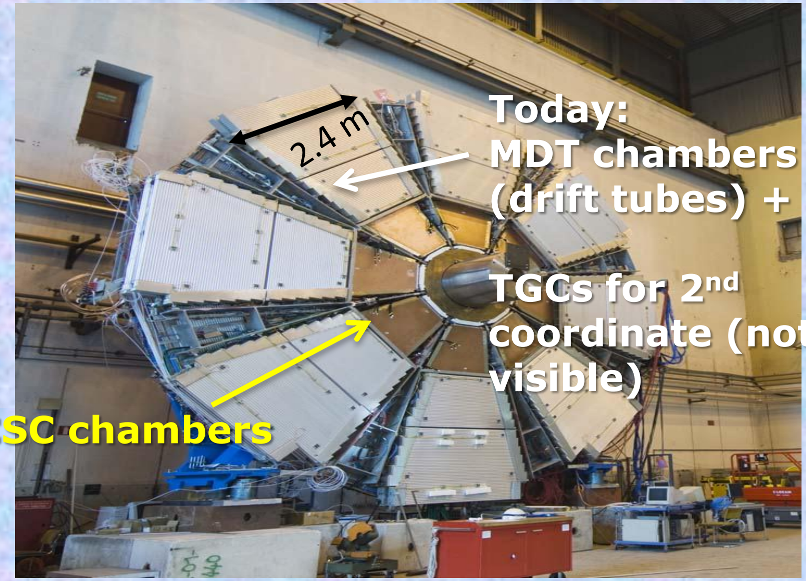
Short term plans

- Summer 2012 1x1 m² chamber
- End of 2012 1x2 m² chamber
- Readout integration to ATLAS DAQ

Resistive MM for the ATLAS Muon System Upgrade

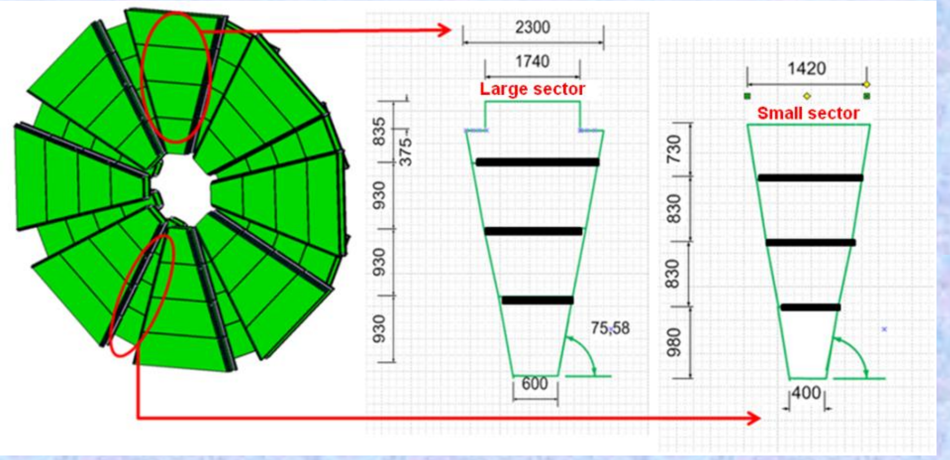


The ATLAS Small Wheel Upgrade:



Equip Small Wheels with 128 MM (0.5–2.5 m²):

→ Combine precision and 2nd coordinate meas. and trigger functionality in a single device



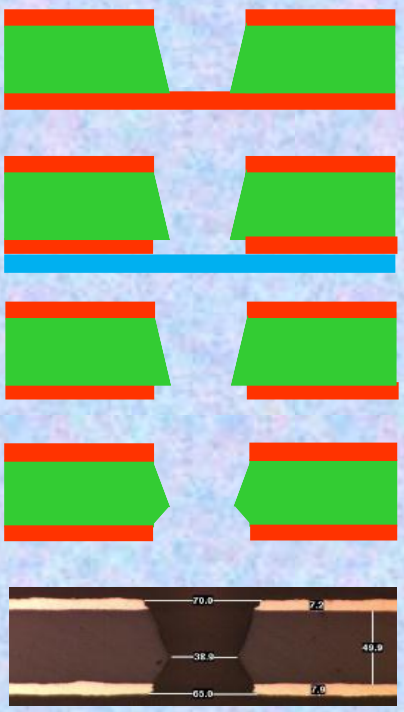
Resistive strip Micromegas has been chosen as the baseline option for the upgrade of the Small Wheel:

~ 1200 m² of Resistive MM

Sector	Nbr sectors Nbr chambers/sector MM layers/chambers	MM layer area (containing rectangle)	Total Nbr MM layers (w/o spares)	Total MM PCB area	Manufacturing plan (preliminary)
Small	8x2=16 4 4x2=8	From ~0.68m² (696x980) To ~1m² (1420x730)	512	0.88x512 = 450m²	Yrs 2015 +2016
Large	8x2=16 4 4x2=8	From ~0.96m² (1036X930) To ~1.9m² (2300x835)	512	1.5x512= 768m²	Yrs 2015 +2016

WG1: Large Area Detectors – Single Mask GEM Technology

Since 2009: Single Mask GEM:



Chemical Polyimide etching

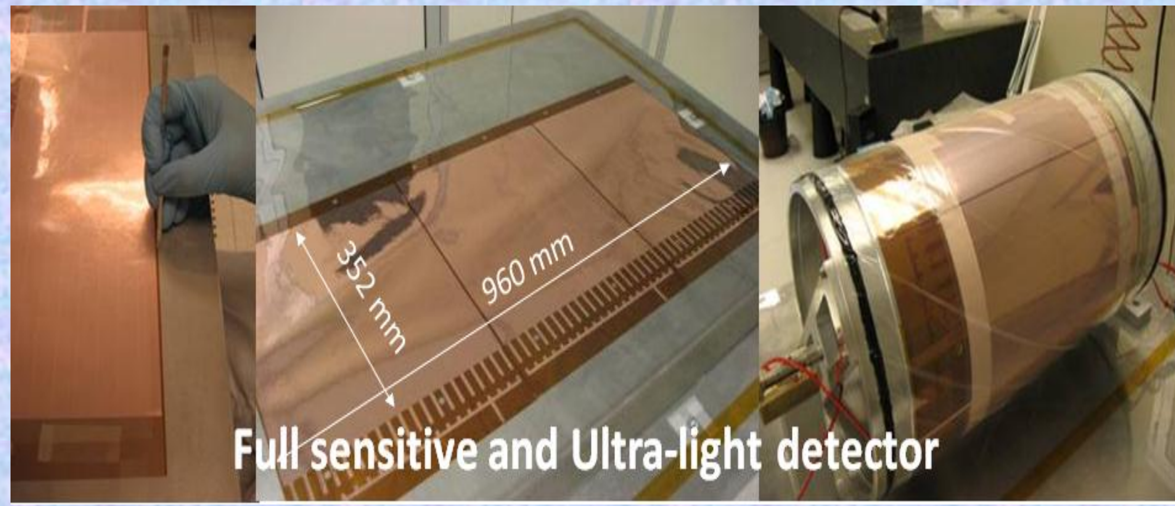
Copper electro etching

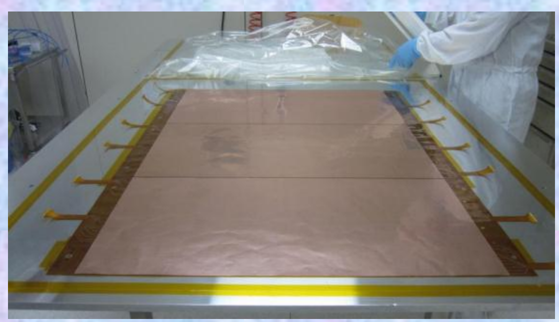
Stripping

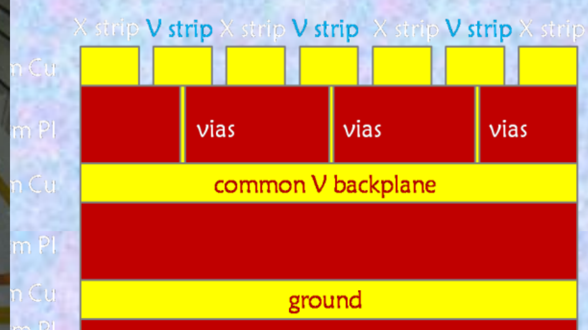
Second Polyimide etching

Result

Large Area Cylindrical GEM Detectors for KLOE2 Tracker:

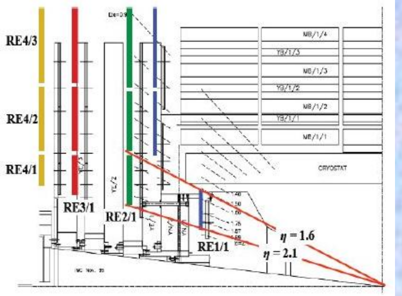






The readout is a multilayer flexible circuit on a polyimide substrate providing a 2-dim point with XV strips at 650 μm pitch

GEMs for CMS High Eta Project (1.6 > η > 2.1)



GEM for CMS Collaboration:

GEMs for High Eta Project:

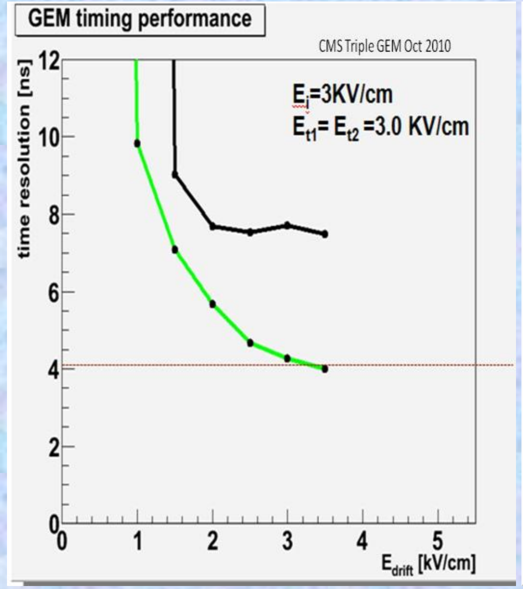
- **Rate capability : 10 kHz/cm²**
- **Spatial resolution: ≤100 μm; efficiency ~ 98 %**
- **Trigger capability (time resolution: ~4-5 ns)**
- **Excellent Long-Term Operation**

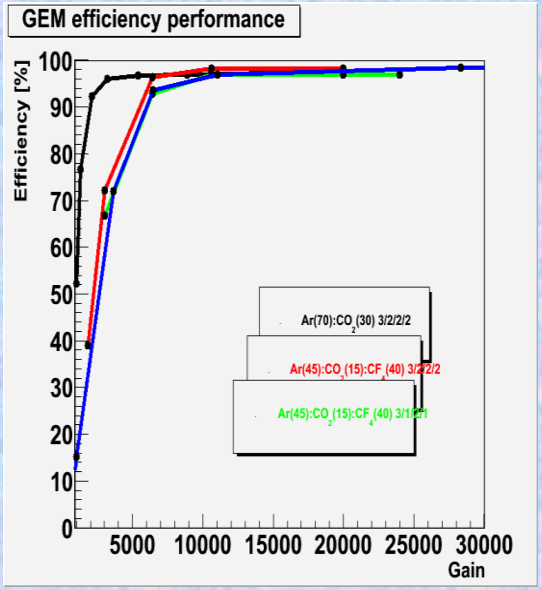
❖ Development and evaluation of large size GEM detectors for tracking and triggering

Assembly optimization for cost reduction

Self-stretching technique: assembly time reduction from 3 days → 2 hours

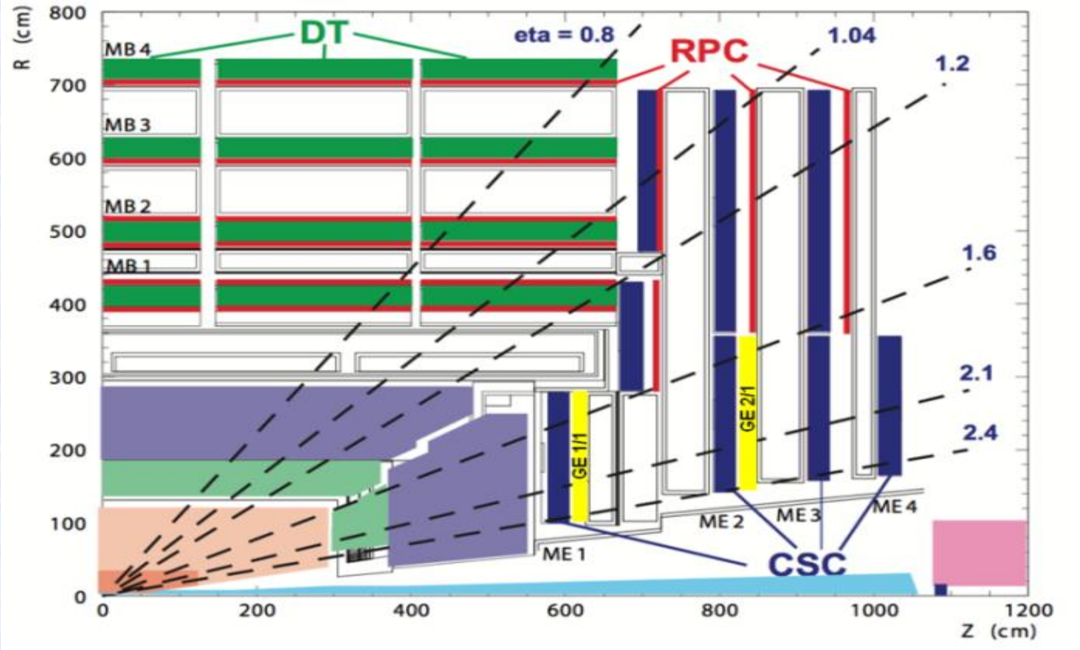
Triple-GEM Efficiency & Time Resolution:



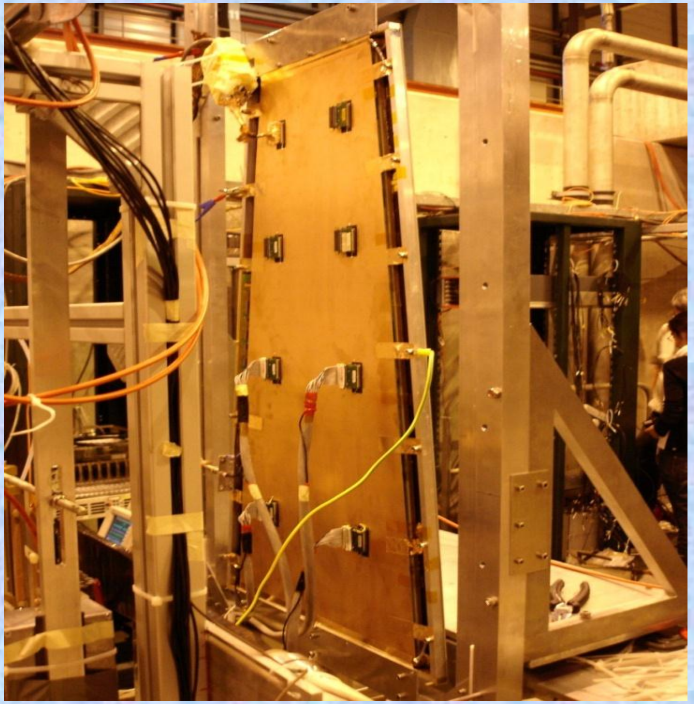


GEMs for CMS High Eta Project (1.6 > η > 2.1)

CMS missing redundant tracking capability in high h-region (in particular, ME1/1-2/1):



Large Prototype: GE1/1 Beam Test @ RD51 setup



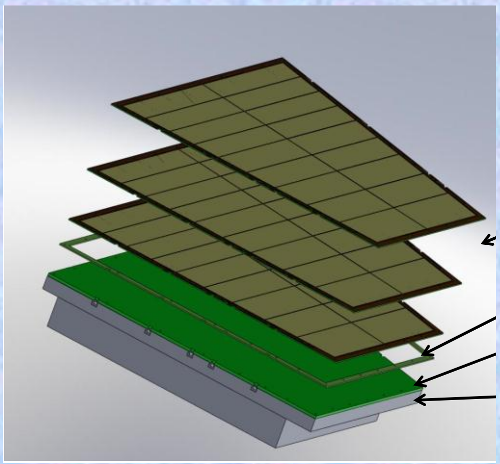
Formally approved as a CMS R&D project of interest (April 20, 2012)

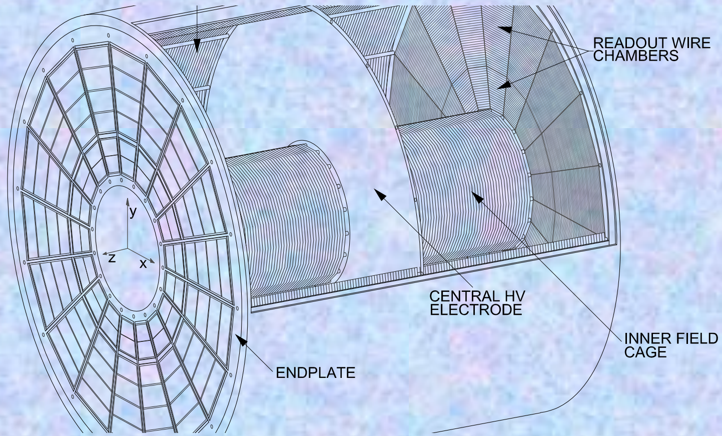
About 1000 m^2 ; 216 triple-GEM detectors

Station	Nbr of modules	Module area (containing rectangle)	Total Nbr of modules (w/o spares)	Total GEM foil area (3ple GEMs)	Manufacturing plan (preliminary)
1	18x2x2=72	~0.43m^2 (440x990)	72	0.43x72x3= 93m^2	Yrs 2014+2015
2	36x2=72 (long) 36x2=72 (short)	~2.4m^2 (1251x1911) ~1.6m^2 (1251x1281)	144	(2.4+1.6)x72x3= 864m^2	Yrs 2015+1016

ALICE Upgrade: TPC Endplate with GEMs

Recent activity (since April 2012):





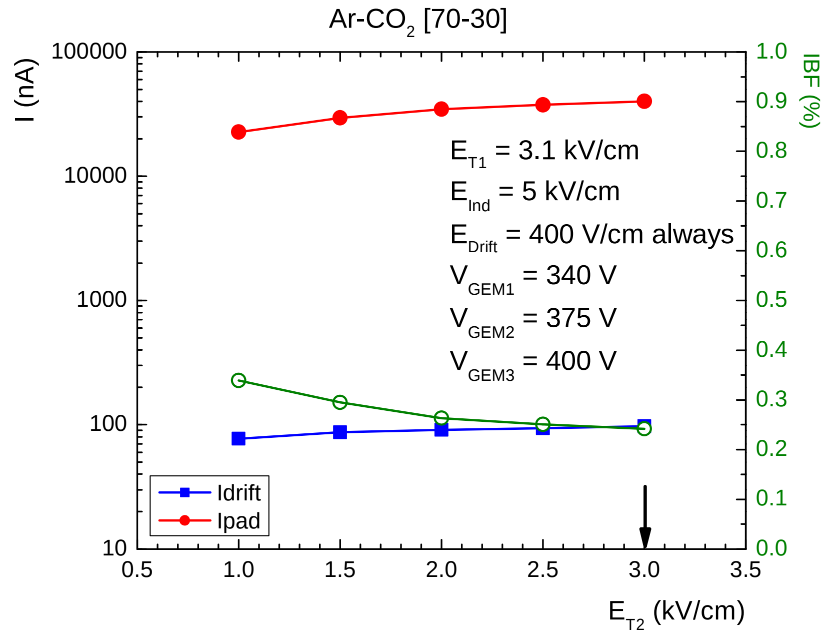
Total area: 32.5 m^2

detector sizes from: 46 x 50 cm^2 to 88 x 112 cm^2

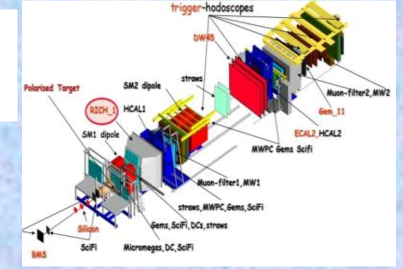
→Use single-mask GEM technology

Goals and Requirements:

- **Replace MWPC with GEMs** (Space-charge effects at 50 kHz Pb-Pb continuous readout too high with wires)
- **Limit GEM ion back-flow to 0.25% at gain 1500 (major R&D required)**
- **Maintain excellent dE/dx resolution for particle Id and time stability**



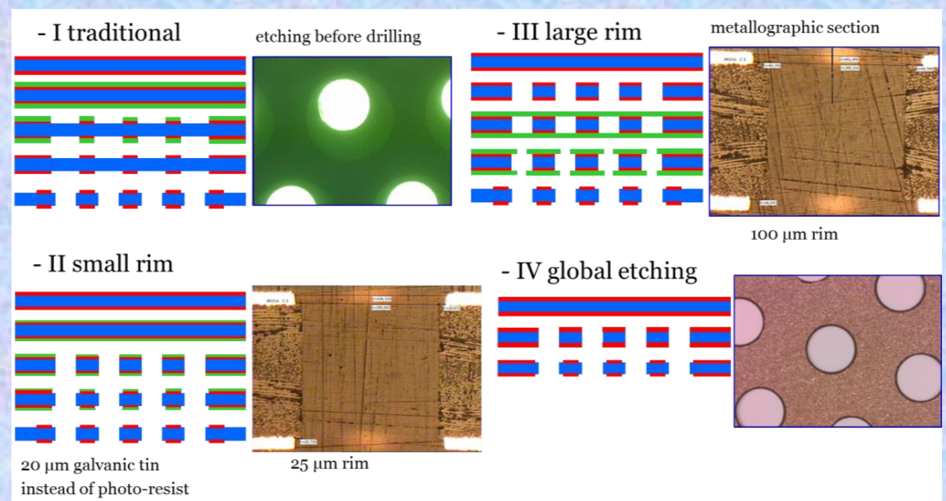
Thick-GEM for Photon Detection in COMPASS RICH 1



THGEM GENERIC R&D:

Novel Photon Detectors based on MPGDs offer:
- **Reduced photon and Ion backflow (IBF)**
- **Intrinsically fast gaseous detectors**

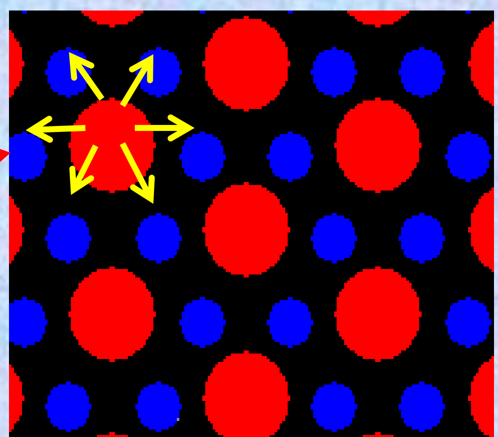
Reduced IBF in triple THGEM:
- Aligned holes : ~ 20%
- Staggered holes : < 5%
- Flower configuration: 2 THGEM layers: <5%

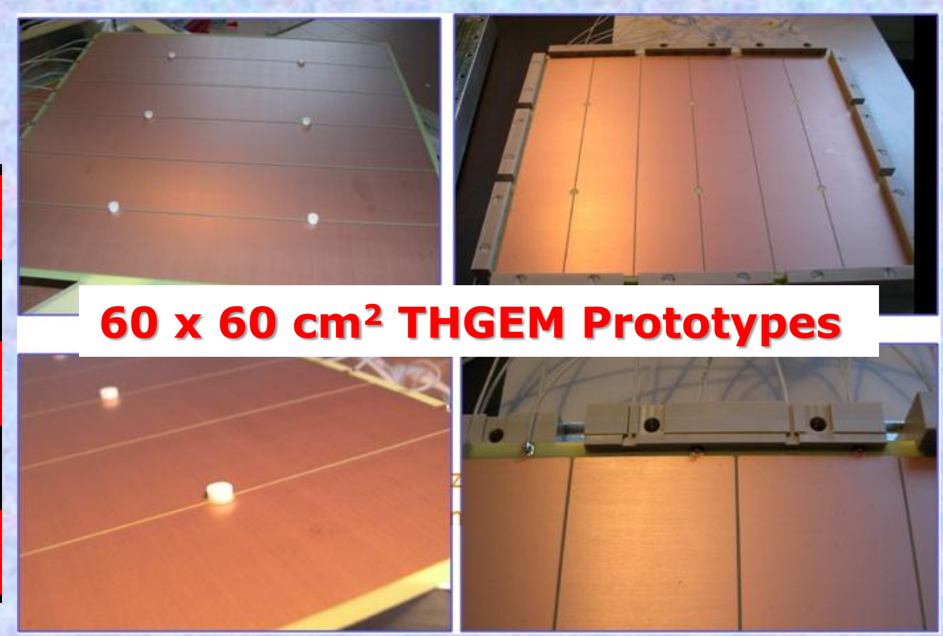


<u>"Flower THGEM" configuration:</u>

THGEM 1 - holes of 0.6 mm diameter, 1.2 mm pitch
THGEM 2 - holes of 0.3 mm diameter, 0.6 mm pitch, with 1/3 of the holes missing: the ones below the THGEM 1 holes

This configuration provides charge splitting and allows for ion backflow minimization





60 x 60 cm² THGEM Prototypes

RD51 WG4: MPGD Simulation Tools

- Focus on providing techniques for calculating electron transport in small-scale structures
- The main difference with traditional gas-based detectors is that the electrode scale (~ 10 μm) is comparable to the collision mean free path

❖ 1) Development and Maintenance of Garfield++:

Garfield++ is a collection of classes for the detailed simulation of small-scale detectors.

Garfield++ contains:
- electron and photon transport using cross sections provided by Magboltz
- ionisation processes in gases, provided by Heed and MIP
- ionisation and electron transport in semi-conductors
- field calculations from finite elements, boundary elements, analytic methods

- Magboltz cross sections (Ar, Xe, He, Ne; GeH_4, SiH_4, $C_2H_2F_4$) are frequently updated in collaboration with LXCAT (http://www.lxcat.laplace.univ-tlse.fr)

❖ 2) Simulation Improvements:

- Penning transfers; gain fluctuations; Neutron detection; Photon feedback; VUV fluorescence

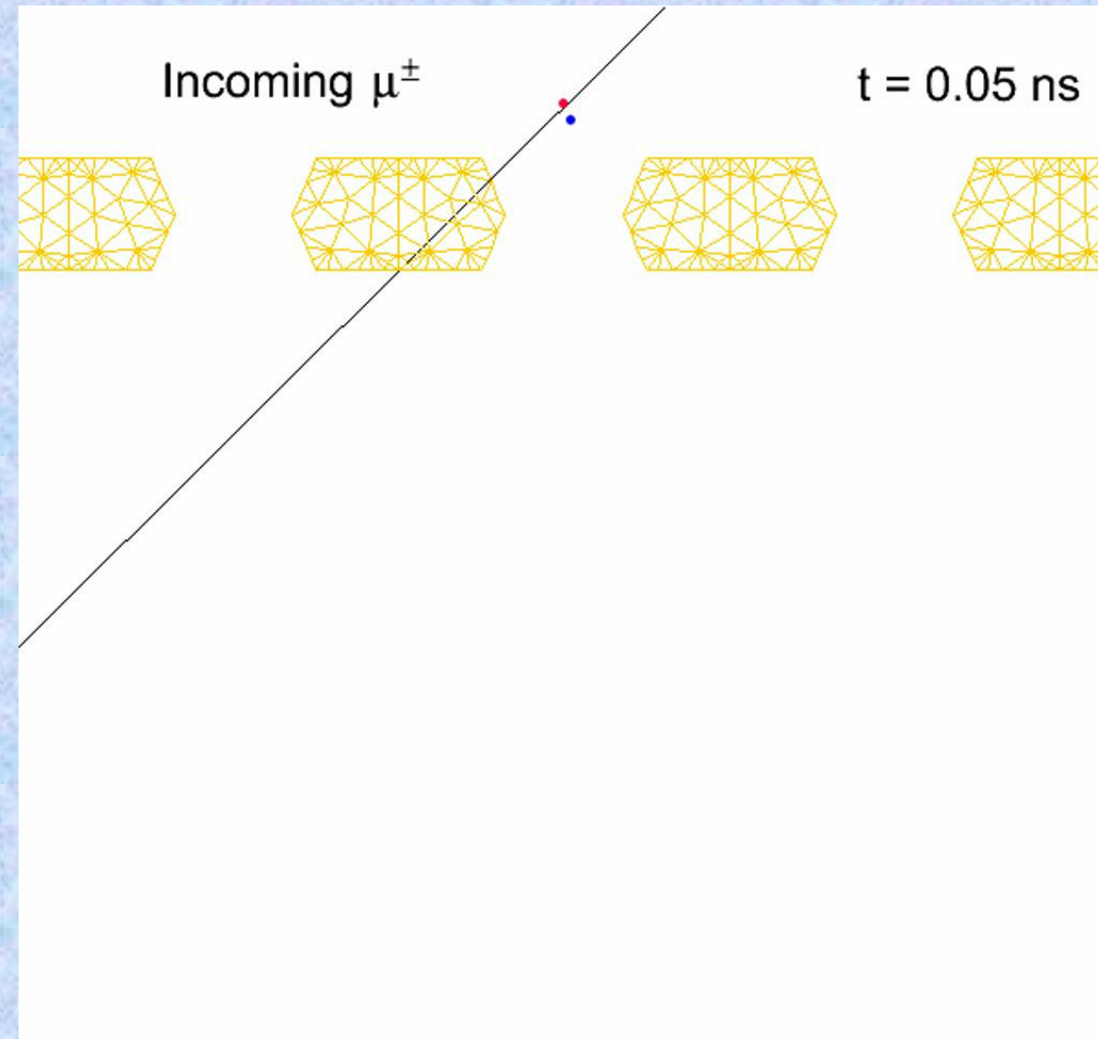
❖ 3) Modeling for MPGD Applications:

- Micromegas transparency
- GEM gain and charging up
- IBF for TPC Applications (e.g. ALICE GEM TPC)

WG4: MPGD Simulation Tools (Avalanche Simulation in GEM)

Animation of the avalanche process (monitor in ns-time electron/ion drifting and multiplication in GEM):

electrons are blue, ions are red, the GEM mesh is orange



- **ANSYS: field model**
- **Magboltz 8.9.6: relevant cross sections of electron-matter interactions**
- **Garfeld++: simulate electron avalanches**

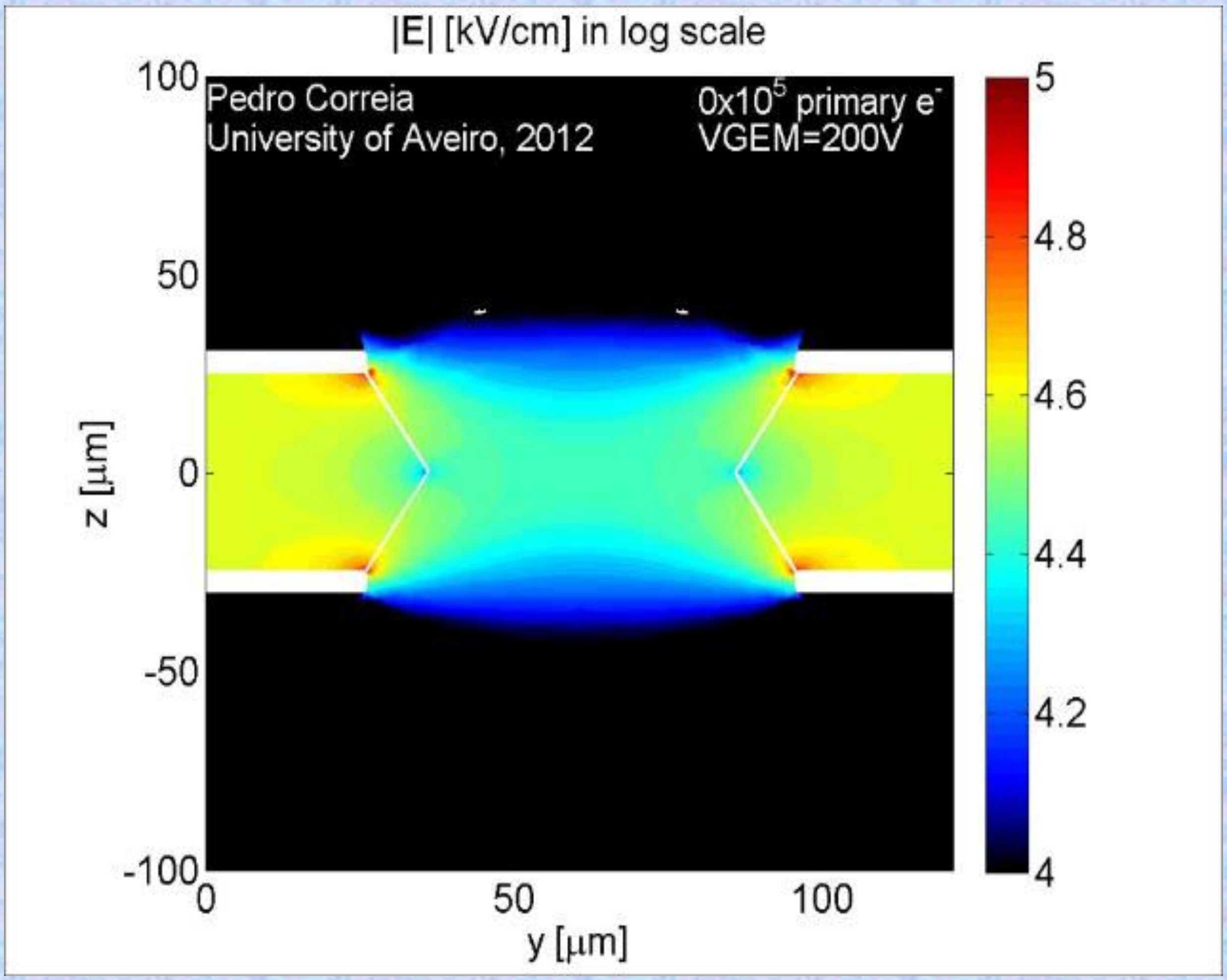
Sven Dildick,
Heinrich Schindler,
Rob Veenhof

http://cern.ch/garfieldpp/examples/gemgain

WG4: GEM Charging-Up Simulation

Electric Field Intensity during the charging-up process:

each iteration correspond to the number of primary electrons that already reached to the hole



- **ANSYS: field model**
- **Magboltz 9.0.1: relevant cross sections of electron-matter interactions**
- **Garfeld++: simulate electron avalanches**

Pedro Correia
Rob Veenhof

Charging effects are much smaller after (100 – 150) $*10^5$ avalanches
→ GEM gas gain stabilizes

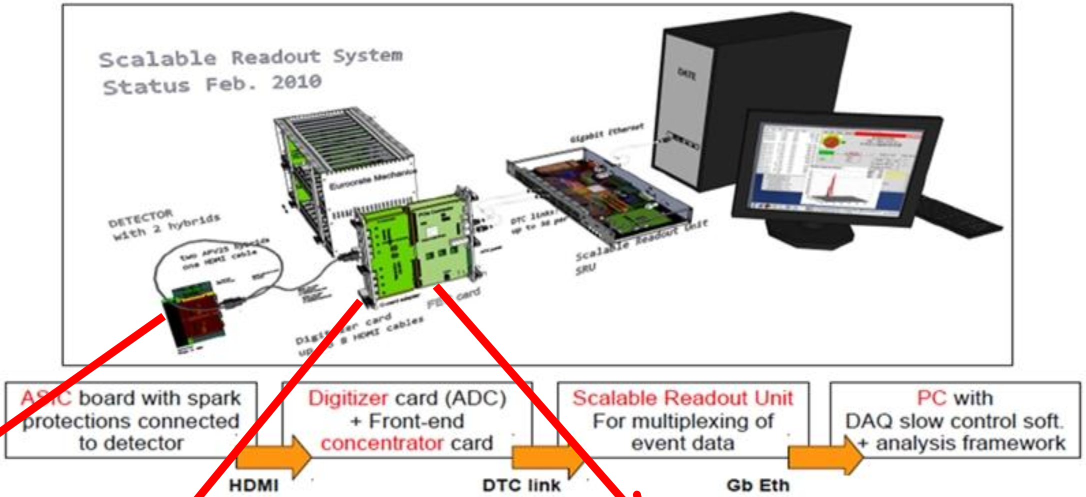
WG5: Development of Scalable Readout System (SRS) for MPGD

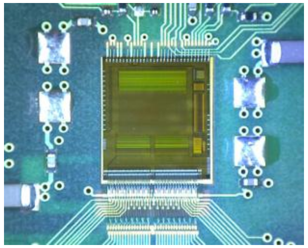
Development of a portable multi-channel readout system (2009-2012):

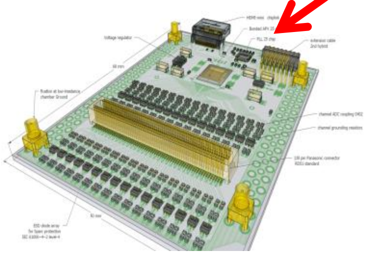
- **Scalable readout architecture:** a few hundreds channels up to very large LHC systems (> 100 k ch.)
- **Project specific part (ASIC) + common acquisition hardware and software**

Physical Overview of SRS:

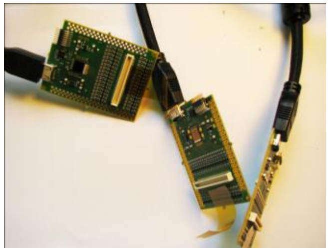
- Scalability from small to large system
- Common interface for replacing the chip frontend
- Integration of proven and commercial solutions for a minimum of development
- Default availability of a very robust and supported DAQ software package







Frontend hybrids: so far all based on APV25 chip, VFAT, Beetle, and Timepix being designed



ADC frontend adapter for APV and Beetle chips

ADC plugs into FEC to make a 6U readout unit for up to 2048 channels

FEC cards (common): Virtex-5 FPGA, Gb-Ethernet, DDR buffer, NIM and LVDS pulse I/O, High speed Interface connectors to frontend adapter cards

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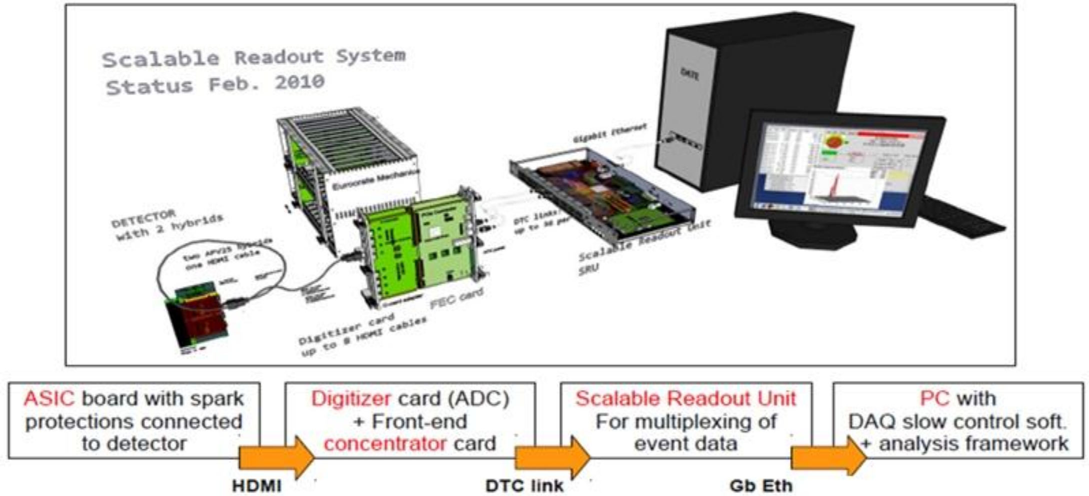


- **2011:** **12 full SRS system commissioned by CERN (project leader – Hans Muller (CERN))**
- **2012:** **Outsourcing to industrial production (PRISMA, Greece) and sales via CERN store**
  → Total volume of pending orders of SRS systems (for RD51) – 250 kEUR
- **Next step:** **Redesign SRS in Advanced TCA (EicSys / ELMA) → fully commercial product**

WG5: RD51 / MPGD SRS User Status

❖ CERN experiments (large systems, > 100 k ch., 2 EUR/ch.)

- ATLAS upgrade MMegas, (VMM1 readout chip developer, SRS Adapter by Arizona Univ, MMDAQ)
- ALICE EMCaL + FOCAL, SRU-based backend (50 kHz upgrade via SRS, DATE, new: Focal readout via SRS-Beetle ?)
- ALICE TPC upgrade, SRS readout electronics with DATE backend ?
- CMS high Eta GEM collaboration (VFAT hybrid and VFAT SRS adapter, in prep.)
- Totem upgrade R&D , SRS VFAT readout, DATE ?

SRS Minicrate up 4k ch.

❖ CERN/HEP experiments (medium systems > 10 k ch.)

- ATLAS upgrade MMegas (8kch APV-SRS systems, 1^{st} SRS testbeams, MMDAQ dev
- NA62 ref. tracker with Micro-Megas (1kCH-SRS Minicrate, MMDAQ)
- NEXT Coll., dual Beta decay, SiPM, PM (Collaboration on SRS HW & FW, FEC cards, DATE)
- BNL GEM detector readout (2kCH. APV Minicrate, PHENIX SRDAQ porting to SRS)
- Jeff. Lab Virginia Univ. GEM prototyping, (Minicrate , Offline Data evaluation via AMORE + DATE)

❖ R&D with MPGD's (small systems < 2 k ch.)

- Bonn/Mainz Univ, Timepix readout (SRS- Timepix adapter card)
- Helsinki HIP, GEM-MMega (SRS evaluation, Trigger pickup box via CSP)
- MEXICO UNAM, THGEM 2x (SRS Minicrate, DATE)
- C.E. Saclay, Micromegas (2k Ch SRS Minicrate , MMDAQ)
- WIS Israel, THGEM 3x (Minicrate, Beetle hybrid, SRS- Labview Beta tester
- INFN Naples (Minicrate, Labview for SRS developer, CTF card , Zero-supression code

SRS crate 16k ch.

❖ Applications with Cosmic Tomography (> 100 k ch.)

- FIT Florida, Muon Tompography for homeland security, GEMs (1^{st} 16K SRS application, DATE)
- Geoscienes CRNS- Waterquality in Rocks, MMegas (5kCh SRS Crate , DATE , Labview)

❖ Teams waiting for commercial SRS delivery (to be produced by PRISMA Greece) – 16 systems

- RD51 lab, Radcore, WIS, USTC, SAHA, INFN Bari, INFN Napoles, Stony Brook, Freiburg Univ
- Yale Univ, J-Parc-RIKEN, East Carol. Univ., Jeff-Lab, Tsinghua Univ, Univ Texas,

* in red: SRS developers in green: to be confirmed in blue: USER

WG6: CERN Workshop Upgrade for the MPGDs

- Today, CERN-MPGD workshop is the UNIQUE MPGD production facility (generic R&D, detector components production, Q&A quality control)

- Future Upgrade of the workshop has been approved by CERN management (Nov. 2009):

New infrastructure to fabricate 2x1m Bulk Micromegas and 2x0.5 m GEMs is delivered to CERN; installation to be completed in September 2012

2009 RD51 Survey:

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

2012 Status/Machine Delivery:

GEM	market survey	call for tender	order	received	ready
– 1 continuous polyimide etcher	x	x	x	x	06/2011
– 1 Cu electroetch line	x	x	x	x	06/2011
Micromegas					
– 1 large laminator	x	x	x	x	06/2011
– 1 large Cu etcher	x	x	x	x	09/2012
– 1 large UV exposure unit	x	x	x	x	06/2011
– 1 large resist developer	x	x	x	x	09/2012
– 1 large resist stripper	x	x	x	x	09/2012
– 1 large oven	x	x	x	x	06/2011
– 1 large dryer	x	x	x	x	06/2011

- Large Area Detectors: ATLAS Muon System Upgrade (Micromegas) and CMS Muon System Upgrade (GEM) has been approved as "official R&D projects" (April/May 2012)

WG6: MPGD Technology Industrialization

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

THGEM Technology: ELTOS S.p.A (Italy), PRINT ELECTRONICS (Israel)

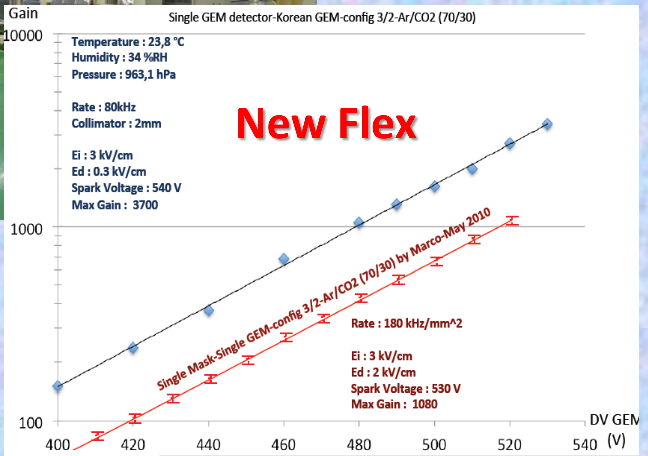
POTENTIAL PARTNERS:

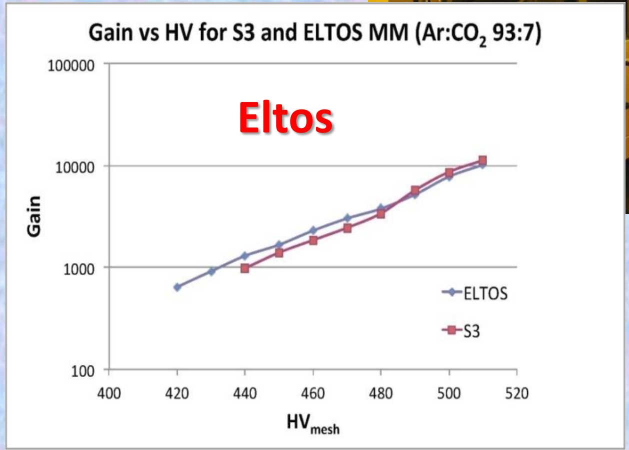
GEM Technology:
- New Flex (Korea, Seoul)
- Tech-ETCH (USA, Boston)
- Scienergy (Japan, Tokyo)
- Techtra (Poland)

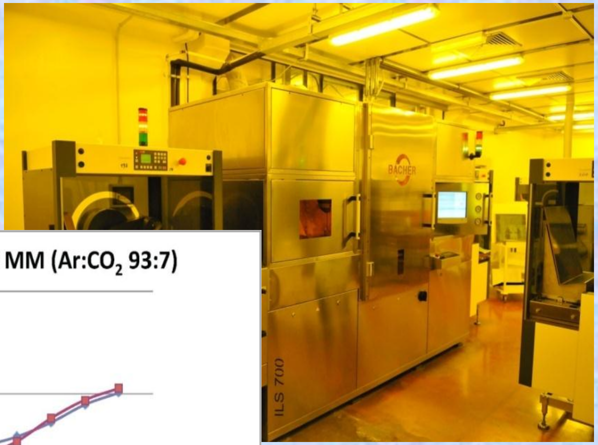
Micromegas Technology
- TRIANGLE LABS (USA, Nevada)
- ELTOS S.p.A. (Italy)
- SOMACIS (Italy, Castelfidarco)
- CIREA (France, CHOLET)

2011 - 2012: Industrial test runs for GEM and Micromegas Technology

First evaluation of 10*10 cm^2 GEM Foils and Bulk MMs







WG6: MPGD Technology Offer for Industry

Pooling of RD51 developments as a basis for common technology offer:

Scalable Readout systems:
European Organization for Nuclear Research

Scalable Readout System for Multi Channel Detector Systems

Abstract

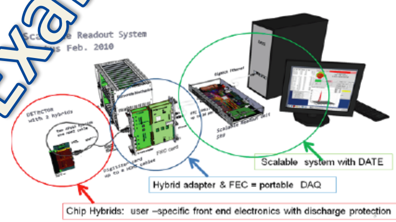
Based on developments for Micro Pattern Gas detectors for the detection of particles in many different application domains, the Scalable Readout System (SRS) for multi channel detectors to accommodate an interface to a wide range of commonly used readout ASICS, a scalability from low to large number of readout channels, a flexible data acquisition package enabling the implementation of various readout architectures and trigger schemes based on widely used industrial standards.

Technology stage

Various prototypes are available off the shelf or can be produced on short term. CERN and RD51 provide support and solutions (data acquisition, chip boards, readout software) for integration of the SRS with user specific detectors and support

- Scalable from few channel systems up to a few millions of readout channels.
- User programmable trigger and clock interface
- Possibility to integrate application specific front end cards
- Availability of low cost test systems for systems with few readout channels

Physical overview SRS of RD51



Specifications

- 10 Gigabyte Ethernet standard readout links.
- Programmable Front End Cards

Example

2011- 2012:

2 GEM industrialization licenses signed:

Technology Transfer - Summary:

After initial contacts with participants to the RD51 Collaboration, China Institute of Atomic Energy & NewFlex approached CERN to request a GEM license

KR1934/KT/TE/PH/023L

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

AGREEMENT KR1934/KT/TE/PH/023L

LICENSE AGREEMENT
FOR MANUFACTURING
AND COMMERCIALISATION OF GEM FOILS AND GEM-BASED PRODUCTS

Licensee:
Newflex Technology Co Ltd, Korea

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

AGREEMENT K 1949/TT/TS/PH/023L

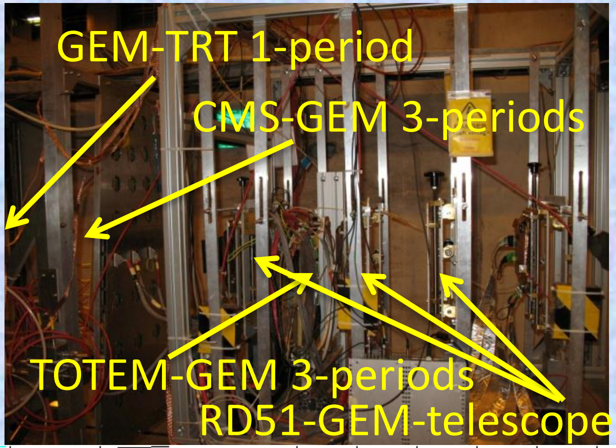
LICENSE AGREEMENT
FOR MANUFACTURING
AND COMMERCIALISATION OF GEM FOILS AND GEM-BASED PRODUCTS

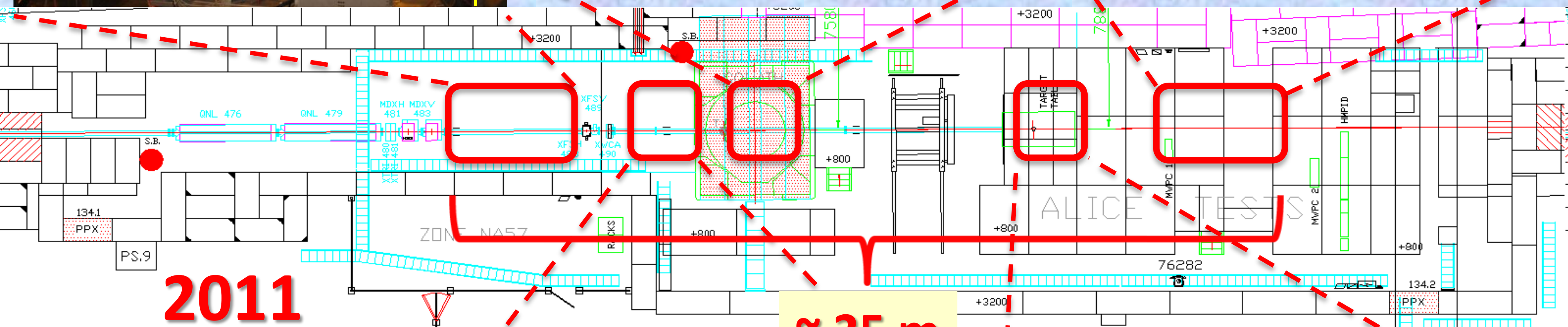
Licensee:
China Institute of Atomic Energy

Status of MM industrialization license:

- Both CEA and CERN will be entitled to grant licenses on Micromegas technology (based on co-ownership agreement)
- Licenses for ELTOS & CIREA for MM industrialization are under preparation

WG7: Common Test Beam Facility at H4 SPS





3-periods (9+12+6 days)

CMS-GEM 3-periods

JLAB-GEM 1-period

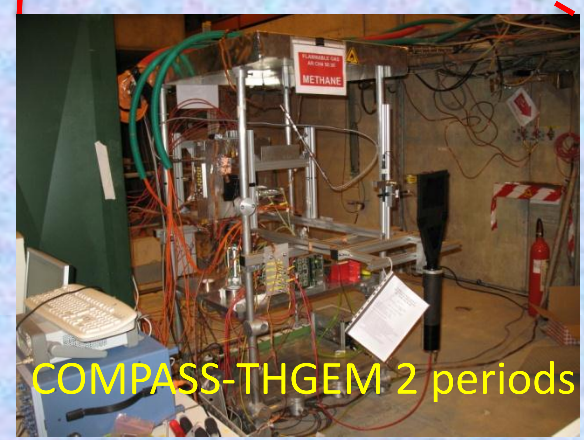
TOTEM-GEM 3-periods

COMPASS-THGEM 2 periods

DHCAL-THGEM 1 period

CALICE-umegas 1 period

GEM-TRT 1 period

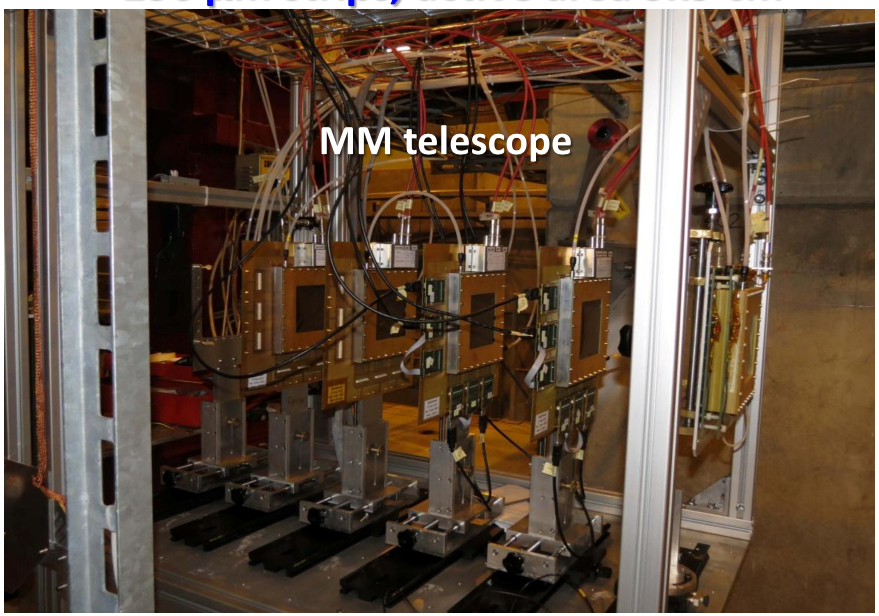


WG7: Common Test Beam Facility at H4 SPS

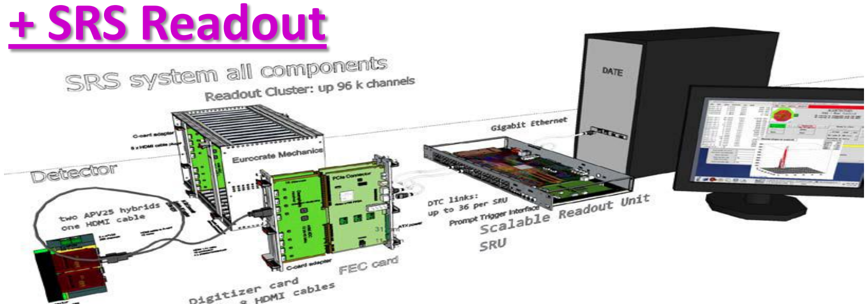
Common RD51 infrastructure: GEM and MMs beam telescopes, HV, gas & power lines …

Major WG7 organization & coordination efforts:
Y. Tsipolitis (NTU Athens) and E. Oliveri (CERN)

<u>2012: New beam telescope</u> with 5 resistive-strip μmegas chambers with x-y readout, 250 μm strips, active area 9x9 cm^2

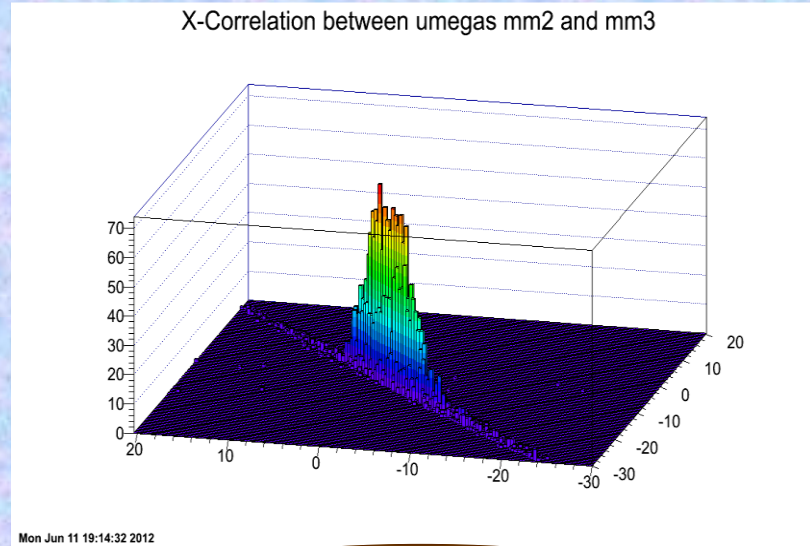


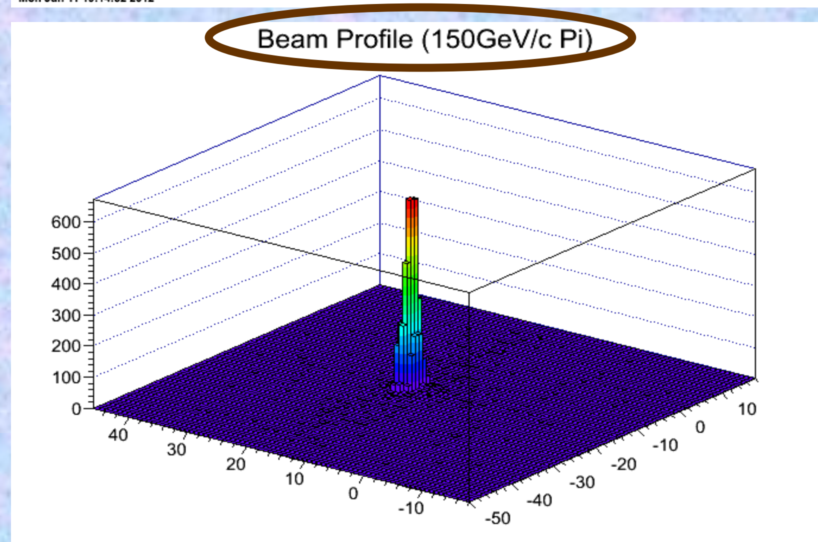
<u>+ SRS Readout</u>



2012: 3-periods (14+14+13days)

(4 – 18 June, 9 – 23 July, 2 – 15 November)





2012: RD51 Plans and Outlook

RD51 would like to continue common project activities:

- **Large area detectors and new MPGD technologies development**
- **Development and support of the simulation tools**
- **Support of SRS electronics**
- **Completion of the MPGD production upgrade**
- **MPGD Industrialization**
- **Maintenance of the RD51 beam facility**

The Collaboration would like to ask for continuation of limited support :

- **Access to RD51 test beam facility (keep "semi permanent" setup & extra beam time)**
- **Access to CERN MPGD Printed Circuit Workshop (manpower support of further knowledge and technical maintanance for the MPGD Technologies)**
- **Access to central computing resources for MPGD simulations**
- **Limited amount of office space**

RD51 is planning to submit request for prolongation (executive summary) to the LHCC for the next 5 years term (beyond 2013) in November'2012

BackUp Slides

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 CERN/LHCC open session (2 July 2008)

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

  CERN-LHCC-2008-011 (LHCC-P-011)
- CERN/LHCC committee close 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

RD51 Common Projects in 2011

SUPPORT FOR GENERIC R&D:

2011: 4 proposals approved under the call for Project Funding from the RD51 CF

- **Thin and high-pitch laser-etched mesh manufacturing and bulking** *(Saclay / CERN / Bari)*
- **Development of innovative resistive GEM alpha detectors for earthquakes prediction and homeland security** *(INFN Bari / UNAM, Mexico / INFN Padova / INFN Frascati)*
- **MPGDs technology laboratory for training, development, fabrication, applications and innovation** *(Universidad Antonio Nariño, Columbia / Brookhaven National Laboratory/ Helsinki Institute of Physics / HEPTech / GSI Helmholtzzentrum)*
- **A low mass microbulk with real XY strips structure** (*NCSR Demokritos / Saclay/ Laboratorio de Física Nuclear y Astropartículas, Universidad de Zaragoza / CERN*)

Advancing Concepts: Vertex / Inner Tracking

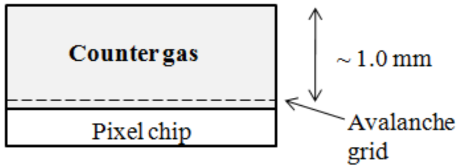
ATLAS sLHC Inner Tracking (r ~ 5 - 100 cm):

- **Baseline remains silicon** (Planar, 3D-silicon, Diamond)
- **GOSSIP & GridPix– ATLAS R&D Project (2010-2013)**

r ~ 5 -10 cm From IP

Gossip

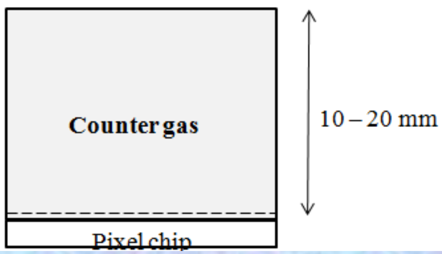
- **Gossip**: ~ **1 mm gas**
  - Short drift time (20 ns)
  - => **high rate performance**
  - Expected to operate at **B-layer of sLHC** (0.9 GHz/cm^2)



r ~ 70 -100 cm from IP

GridPix

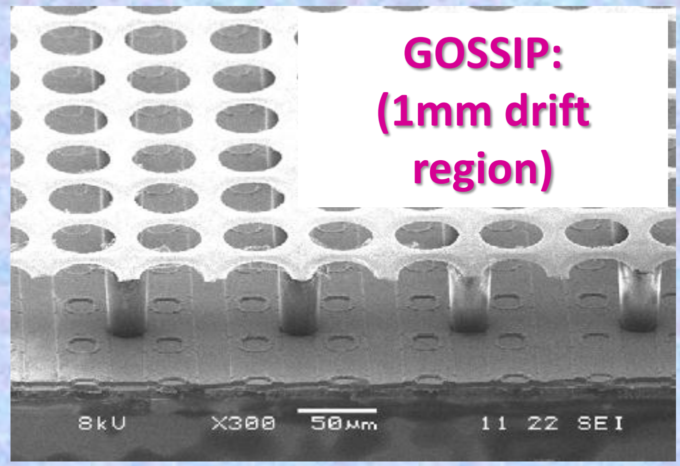
- **GridPix**: **10 – 20 mm gas**
  - Drift time 200 – 400 ns
  - => **very good angular resolution**
  - Well suited for **L1 trigger**



F. Hartjes, Detector R&D, March 2009

technology	Planar silicon	3D silicon	Diamond	Gossip
possible pos resolution (um)	< 10	< 10 ?	~ 14 (polycryst)	~20
resolution for inclined tracks	reasonable	reasonable	reasonable	mediocre
charge collection time (ns)	< 6	20 - 35	2	20 - 80
mass including cooling	pretty high	pretty high	medium	low
life time in SLHC (3000 fb-1)	20 - 50%?	~ 50%	~ 50%	> 100% poss
production technology	well known	difficult	difficult	much R&D
bias voltage control	easy	easy	easy	critical
ease of operation	reasonable	reasonable	relaxed	critical
cooling	critical	less critical	relaxed	relaxed
additional services	NO	NO	NO	HV + gas
additional DAQ channels	NO	NO	NO	probably
track efficiency	100%	>95%?	98-100%	98%
costs	75 - 300 €/cm2	150 - 300 €/cm2	~ 1000 €/cm2 ?	20-30 €/cm2
size of coll. (ATLAS institutes)	>10	10	6	2
approved R&D?	yes	yes	Yes	near submit

GOSSIP: (1mm drift region)



Major R & D still required for this development