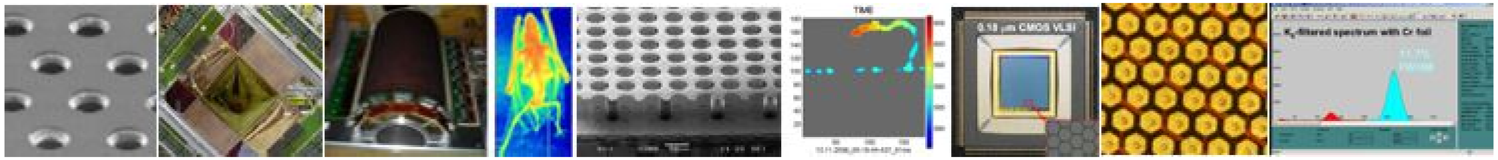


R&D Proposal

Development of Micro-Pattern Gas Detector Technologies

Leszek Ropelewski (CERN) & Maxim Titov (CEA Saclay)

94th LHCC Committee Meeting, July 2 2008

MPGD Collaboration

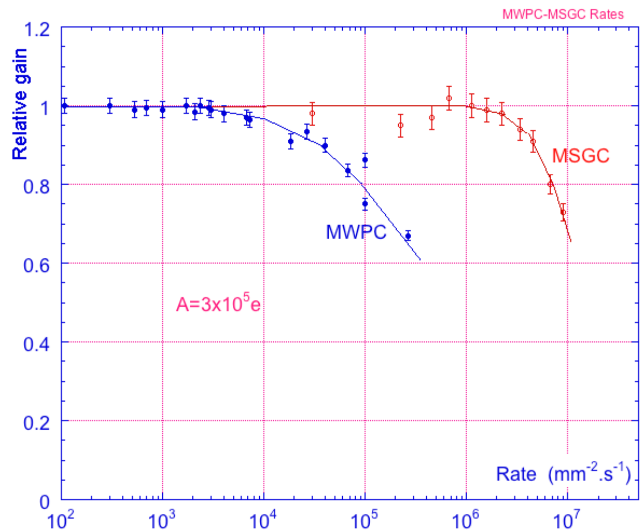
Alessandria, Italy, Dipartimento di Scienze e Technologie Avanzate, Universita del Piemonte Orientale and INFN sezione Torino
Amsterdam, Netherlands,Nikhef
Annecy-le-Vieux, France, Laboratoire d'Annecy-le-Vieux de Physique des Particules (LAPP)
Argonne, USA, High Energy Physics Division, Argonne National Laboratory
Arlington, USA, Department of Physics, University of Texas
Athens, Greece, Department of Nuclear and Elementary Particle Physics, University of Athens
Athens, Greece, Institute of Nuclear Physics, National Centre for Science Research "Demokritos"
Athens, Greece, Physics Department, National Technical University of Athens
Aveiro, Portugal, Departamento de Física, Universidade de Aveiro
Barcelona, Spain, Institut de Fisica d'Altes Energies (IFAE), Universtitat Autònoma de Barcelona
Bari, Italy, Dipartimento Interateneo di Fisica del'Universtà and sezione INFN
Bonn, Germany, Physikalisches Institut, Rheinische Friedrich-Wilhelms Universität
Braunschweig, Germany, Physikalisch Technische Bundesanstalt
Budapest, Hungary, Institute of Physics, Eötvös Loránd University
Budapest, Hungary, KFKI Research Institute for Particle and Nuclear Physics, Hungarian Academy of Sciences
Bursa, Turkey, Institute for Natural and Applied Sciences, Uludag University
Cagliari, Italy, Dipartimento di Fisica dell'Universtà and sezione INFN
Coimbra, Portugal, Departemento de Fisica, Universidade de Coimbra
Coimbra, Portugal, Laboratorio de Instrumentacao e Fisica Experimental de Particulas
Columbia, USA, Department of Physics and Astronomy, University of South Carolina
Frascati, Italy, Laboratori Nazionale di Frascati, INFN
Freiburg, Germany, Physikalisches Institut, Albert-Ludwigs Universität
Geneva, Switzerland, CERN
Geneva, Switzerland, Département de Physique Nucléaire et Corpusculaire, Universite de Genève
Grenoble, France, Laboratoire de Physique Subatomique et de Cosmologie (LPSC)
Hefei, China, University of Science and Technology of China
Helsinki, Finland, Hesinki Institute of Physics
Kolkata, India, Saha Institute of Nuclear Physics
Lanzhou, China, School of Nuclear Science and Technology, Lanzhou University
Melbourne, USA, Department of Physics and Space Science, Florida Institute of Technology
Mexico City, Mexico, Instituto de Ciencias Nucleares, Universidad Nacional Autonoma de Mexico
Montreal, Canada, Département de physique, Université de Montréal
Mumbai, India, Tata Institute of Fundamental Research, Department of Astronomy & Astrophysics
Műnchen, Germany, Physik Department, Technische Universität
Műnchen, Germany, Max Planck Institut fűr Physik
Naples, Italy, Dipartimento di Scienze Fisiche dell'Universtà and sezione INFN
New Haven, USA, Department of Physics, Yale University
Novara, Italy, TERA Foundation
Novosibirsk, Russia, Budker Institute of Nuclear Physics
Ottawa, Canada, Department of Physics, Carleton University
Rehevot, Israel, Radiation Detection Physics Laboratory, The Weizmann Institute of Sciences
Rome, Italy, INFN Sezione di Roma, gruppo Sanità and Istituto Superiore di Sanità
Saclay, France, Institut de recherche sur les lois fondamentales de l'Univers, CEA
Sheffield, Great Britain, Physics Department, University of Sheffield
Siena, Italy, Dipartimento di Fisica dell'Università and INFN Sezione di Pisa
St Etienne, France, Ecole Nationale Superieure des Mines
St Petersburg, Russia, St Petersburg Nuclear Physics Institute
Thessaloniki, Greece, Physics Department Aristotle University of Thessaloniki
Trieste, Italy, Dipartimento di Fisica dell'Università and Sezione INFN
Tucson, USA, Department of Physics, University of Arizona
Tunis, Tunisia, Centre Nationale des Sciences et Technologies Nucléaire
Upton, USA, Brookhaven National Laboratory
Valencia, Spain, Instituto de Fisica Corpuscular
Valencia, Spain, Universidad Politécnica
Zaragoza, Spain, Laboratorio de Física Nuclear y Astropartículas, Universidad de Zaragoza

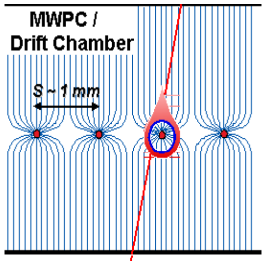
285 authors from 54 Institutes from 20 countries and 4 continents

Current Trends in Micro-Pattern Gas Detectors (Technologies)

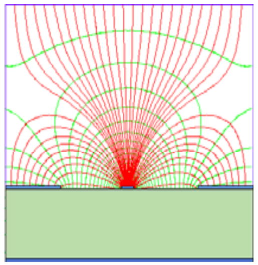
Semiconductor Industry technology:

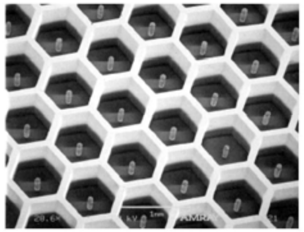
Photolithography
Etching
Coating
Doping

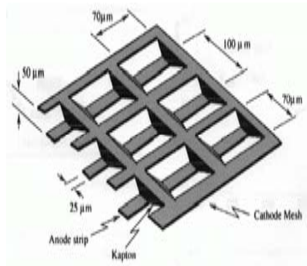




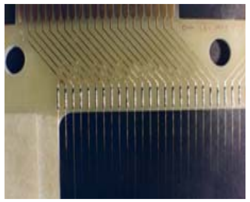
Amplifying cell reduction by factor of 10



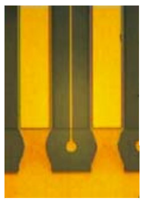




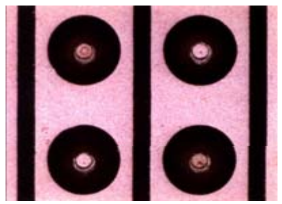
Operational instabilities:

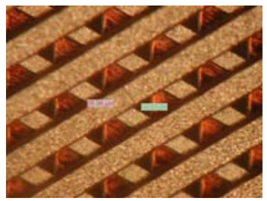


Rate Capability>10^6/mm^2
Position Resolution ~40μm
2-track Resolution ~400μm



Substrate charging-up
Discharges
Polymer deposition (ageing)



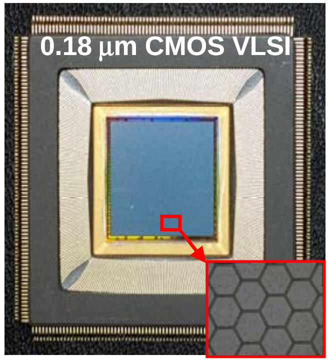


MWPC

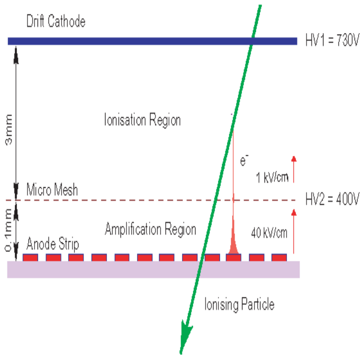
MSGC

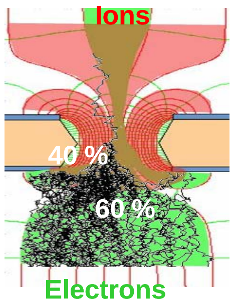
Current Trends in Micro-Pattern Gas Detectors (Technologies)

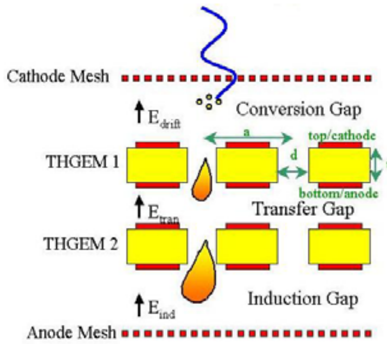
- Micromegas
- GEM
- Thick-GEM, Hole-Type Detectors and RETGEM
- MPDG with CMOS pixel ASICs
- Ingrid Technology

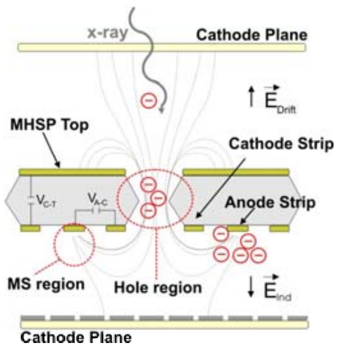


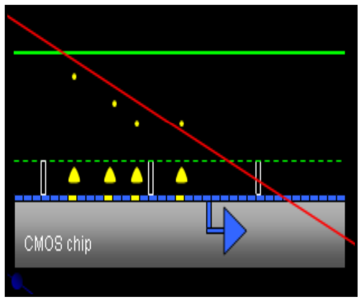
CMOS high density readout electronics

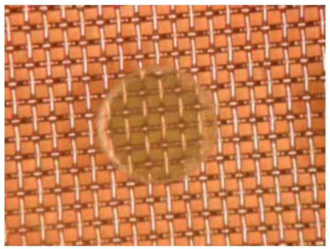




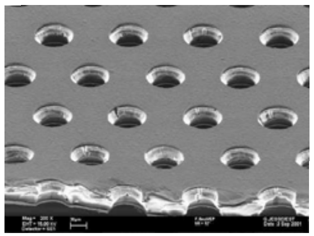




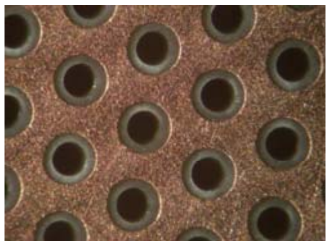




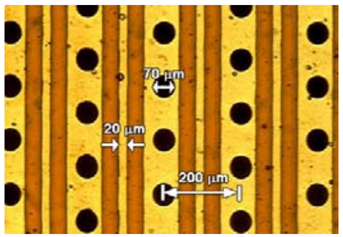
Micromegas



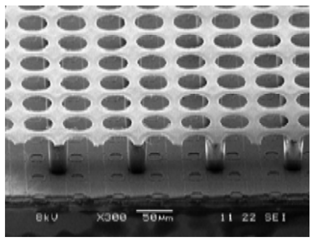
GEM



THGEM



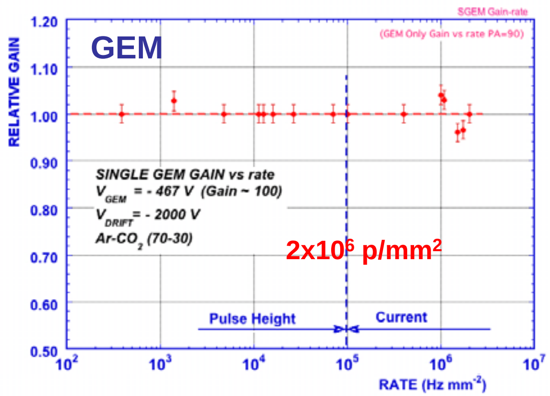
MHSP

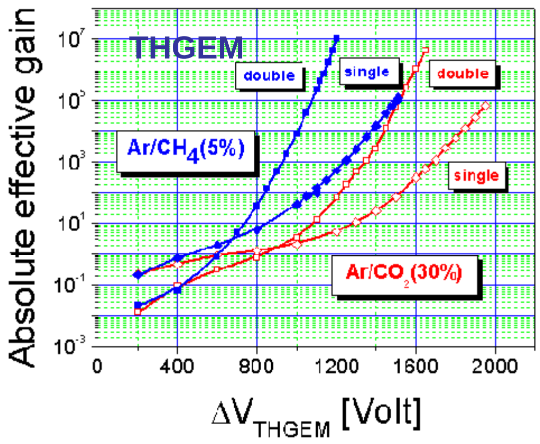


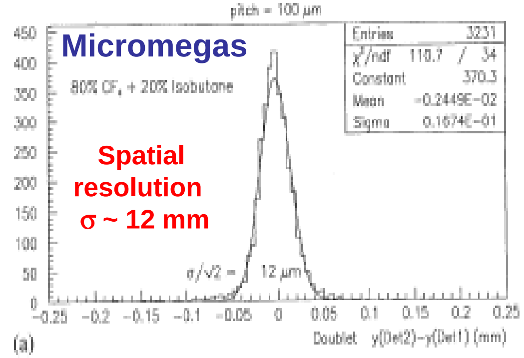
Ingrid

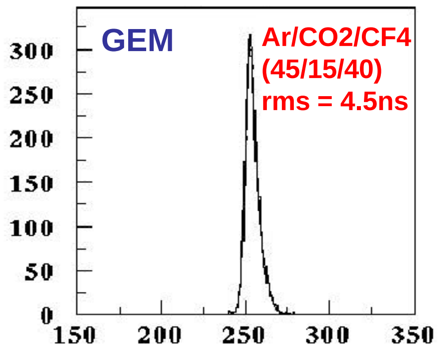
Current Trends in Micro-Pattern Gas Detectors (Performance)

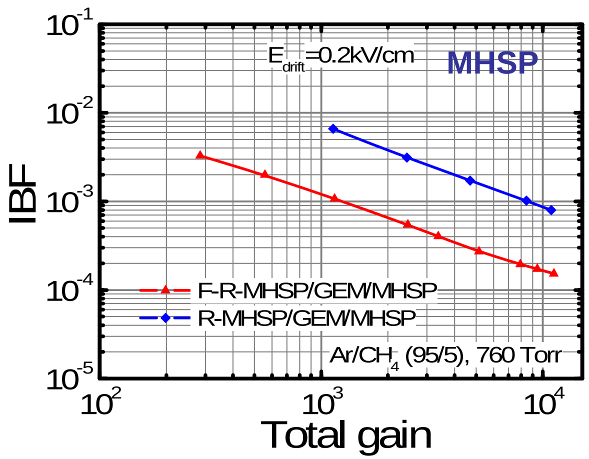
- Rate Capability
- High Gain
- Space Resolution
- Time Resolution
- Energy Resolution
- Ageing Properties
- Ion Backflow Reduction
- Photon Feedback Reduction

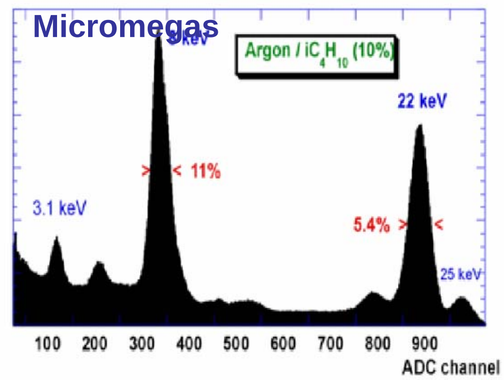


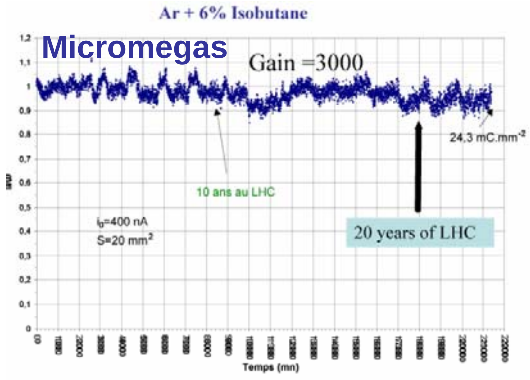












Computer Simulations

MAXWELL; ANSYS ***(Ansoft)***

electrical field maps in 2D& 3D, finite element calculation for arbitrary electrodes & dielectrics

HEED ***(I.Smirnov)***

energy loss, ionization

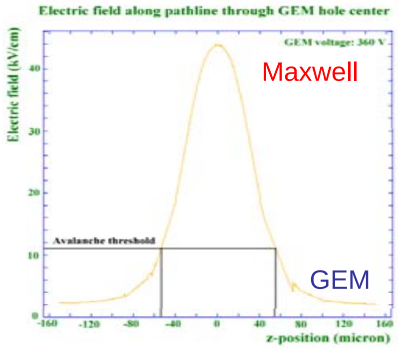
MAGBOLTZ ***(S.Biagi)***

electron transport properties: drift, diffusion, multiplication, attachment

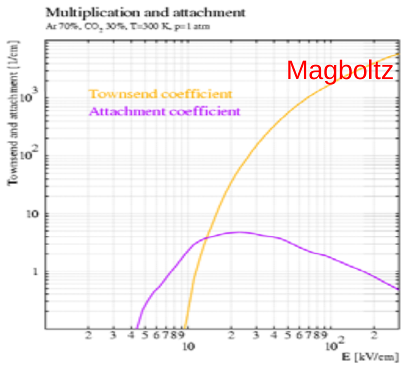
Garfield ***(R.Veenhof)***

fields, drift properties, signals (interfaced to programs above)

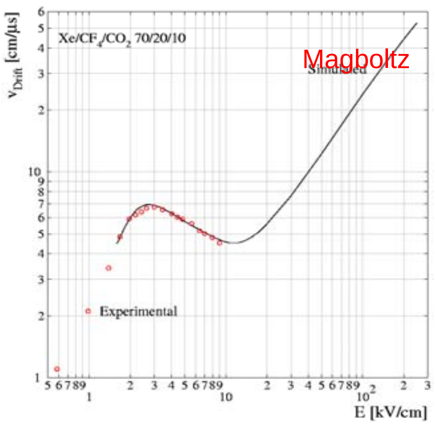
PSpice ***(Cadence D.S.)*** **electronic signal**



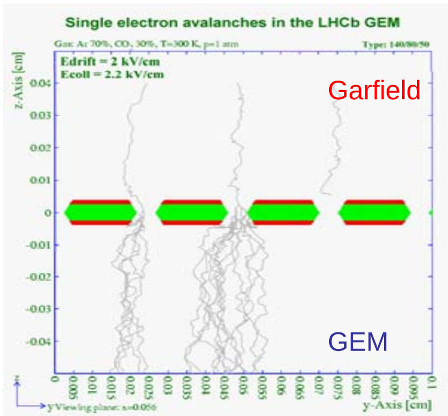
E Field strength



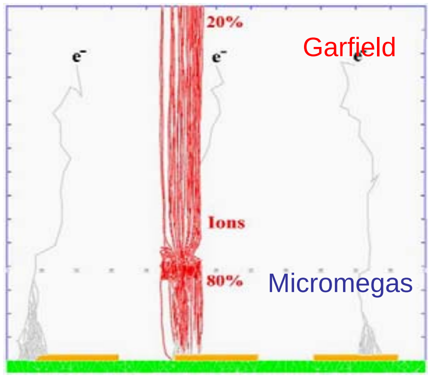
Townsend coefficient



Drift velocity



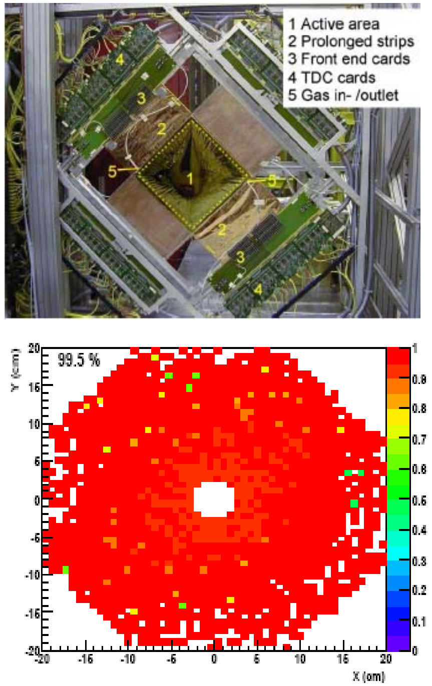
Electrons paths and multiplication



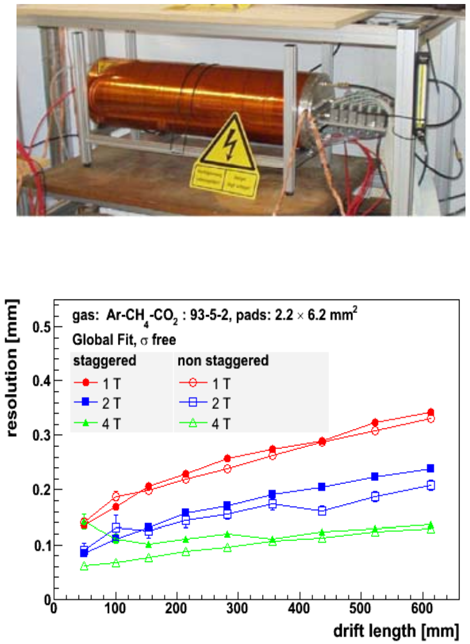
Positive ion backflow

Current Trends in Micro-Pattern Gas Detectors (Applications)

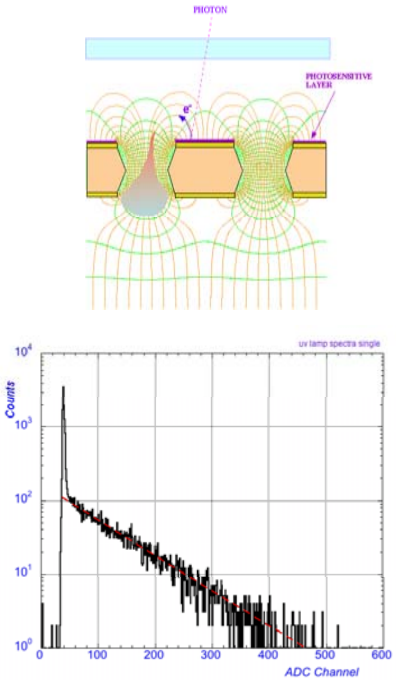
- High-Rate Particle Tracking and Triggering
- Time Projection Chamber Readout
- Photon Detectors for Cherenkov Imaging Counters
- X-Ray Astronomy
- Neutron Detection and Low Background Experiments
- Cryogenic Detectors
- Medical Applications
- Homeland Security and Prevention of Planetary Disasters



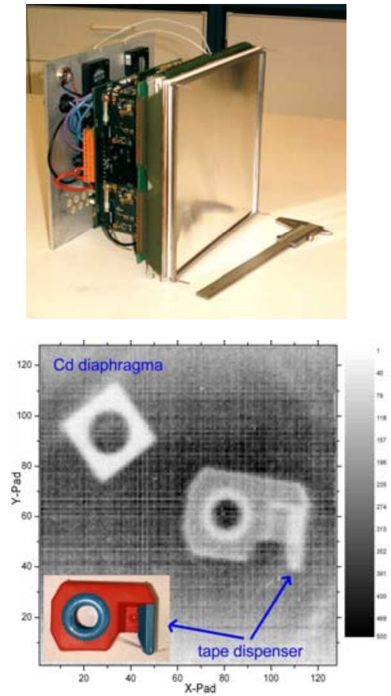
Tracking - Micromegas



TPC readout - GEM



UV photon detection - GEM



Neutron detection - GEM

Future Trends in Micro-Pattern Gas Detectors (Physics requirements)

Mostly driven by HEP applications:

Large area coverage
- Muon chambers @ SLHC
- Long-baseline ν experiments
- Calorimetry

Radiation hard detectors
- SLHC

High rate detectors
- Vertexing at collider experiments
- Tracking in the beam

Minimization of ion backflow
- TPC Readout
- Photon detection

Beyond HEP:

Low Mass Detectors
- Nuclear Physics

High or low pressure detectors
- Dark matter studies (high P)
- Low energy nuclear physics (low P)

Low radioactivity detectors
- Low energy and rare events experiments

Portable, sealed detectors
- Applications beyond the fundamental research studies

Collaboration Workshops/Meetings:

2-Day Workshop at CERN, Geneva, September 10-11 2007
Micro Pattern Gas Detectors. Towards an R&D Collaboration. (10-11 September 2007)

3-Day Workshop at Nikhef, Amsterdam, April 16-18 2008
RD51 Collaboration Workshop (16-18 April 2008)

3-Day Meeting, Saclay, Paris, October 13-15 2008
RD51 Collaboration Meeting (13-15 October 2008)

1. **Review present technologies and experimental results (~ 100 participants registered, 40 talks)**
2. **Initiate discussion on the need and way to setup collaboration**
3. **Technology-based (MPGD) vs. Application-based (e.g. SLHC, ILC) Collaboration**

Ongoing R&D Efforts are widely spread over the many particle physics labs:
1. steer ongoing R&D activities and facilitate exchange results (working groups)
2. share resources, develop common infrastructure
3. allows to search/apply for (inter-)national funding (collaboration effort)

MPGD Collaboration: Motivation and Main Objectives

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

Estimated time scale – 5 years

1. Optimize detectors design, develop new multiplier geometries and techniques

2. Develop common test and quality standards

3. Share common infrastructure (e.g. test beam and radiation hardness facilities, detectors and electronics production and test facilities)

4. Share investment of common projects (e.g. technology development, electronics development, submissions/production)

5. Setup a common maintainable software package for gas detectors simulations

6. Common production facility

7. Optimize communication and sharing of knowledge/experience/results

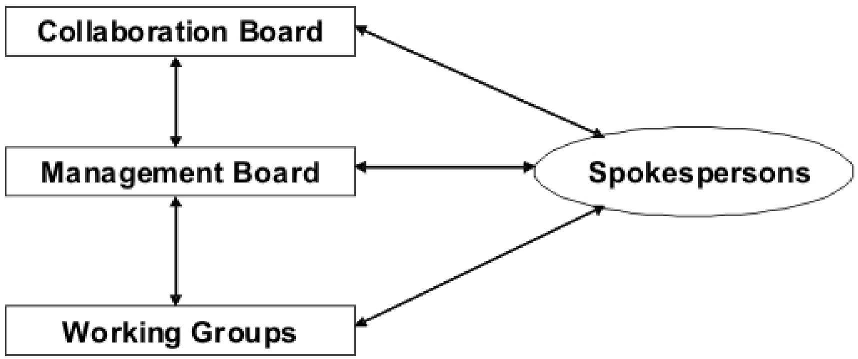
8. Collaboration with industrial partners

9. The existence of the RD51 collaboration, endorsed by the LHCC, will support and facilitate the acquisition of funding from national and other agencies.

RD51 – Micropattern Gas Detectors

	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

Scientific Organization:



Home - RD51 Collaboration
Collaboration Web Page

Draft MoU

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

the two Co-Spokespersons: L.Ropelewski, M.Titov
the CB Chairperson and its deputy: S.Dalla Torre, K.Desch
MB members: A.Breskin, I.Giomataris, F.Sauli, L.Linssen, J.Timmermans, A.White

Working Groups Conveners:

WG1 MPGD Technology & New Structures	P.Colas, S.Dalla Torre, A.E.Bondar
WG2 Common Characterization & Physics	H. van der Graaf , V.Peskov
WG3 Applications	F.Simon, A.White
WG4 Software & Simulations	A.Bellerive, R.Veenhof
WG5 Electronics	M.Campbell, W.Riegler
WG6 Production	E. van der Bij, I.Giomataris, H.Taureg
WG7 Common Test Facilities	M.Alfonsi

WG1: Technological Aspects and Developments of New Detector Structures

Objective: Detector design optimization, development of new multiplier geometries and techniques.

Task 1: Development of large-area Micro-Pattern Gas Detectors (large-area modules, material budget reduction).

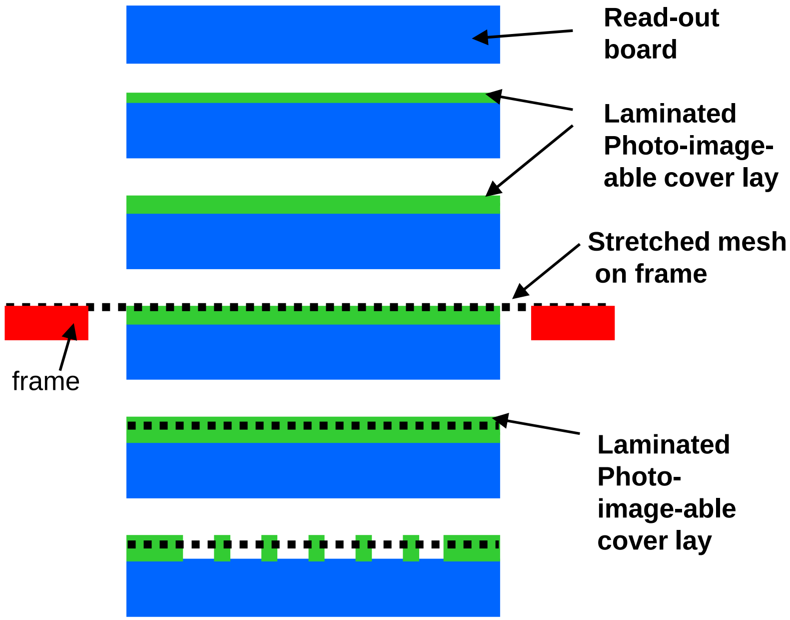
Task 2: Detector design optimization including fabrication methods and new geometries (Bulk Micromegas, Microbulk Micromegas, single-mask GEM, THGEM, RETGEM, MHSP, charge-dispersive readout, Ingrid).

Task 3: Development of radiation-hard and radiopurity detectors.

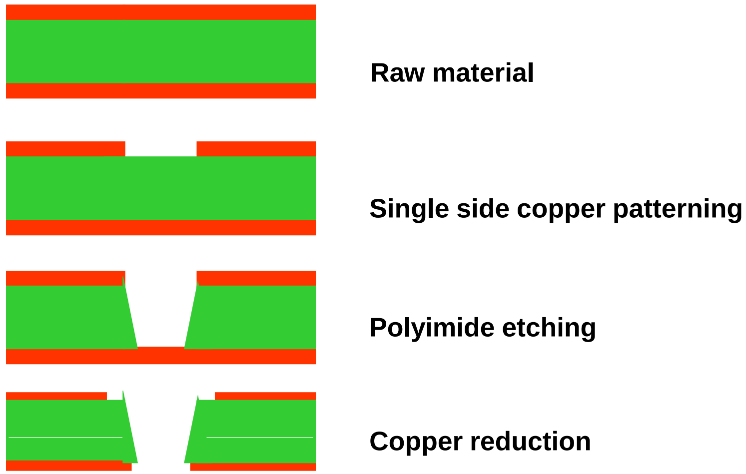
Task 4: Design of portable sealed detectors.

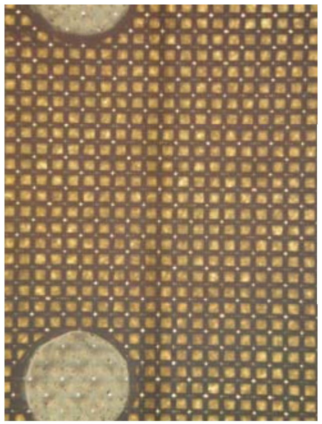
Development of large-area Micro-Pattern Gas Detectors

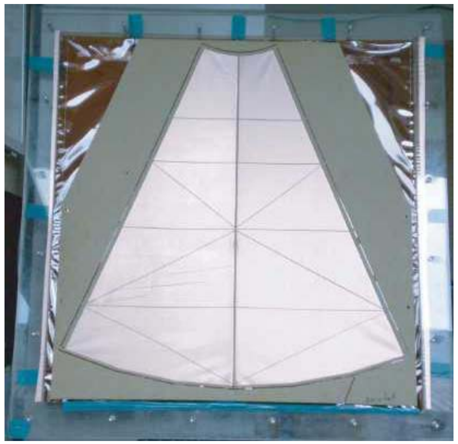
Bulk Micromegas

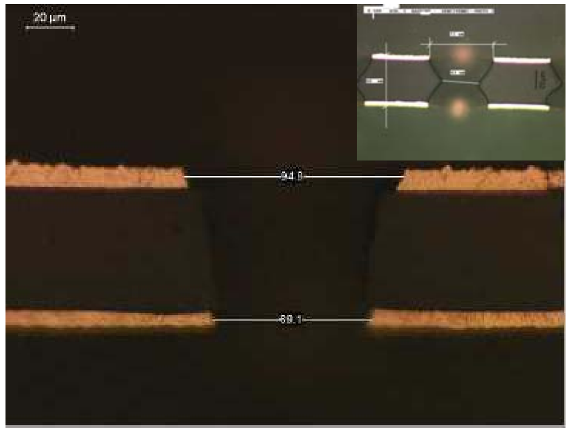


Single mask GEM



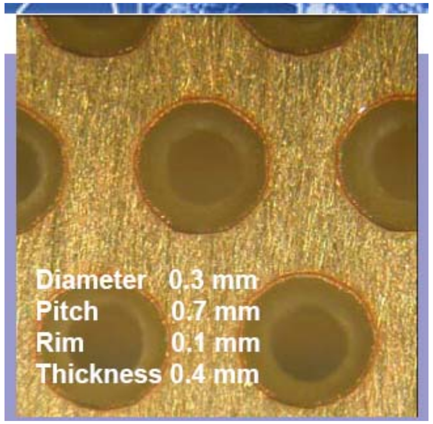


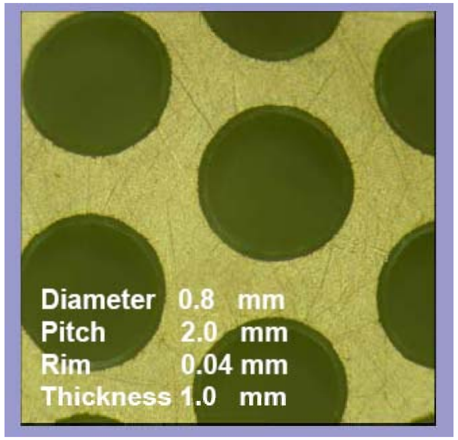


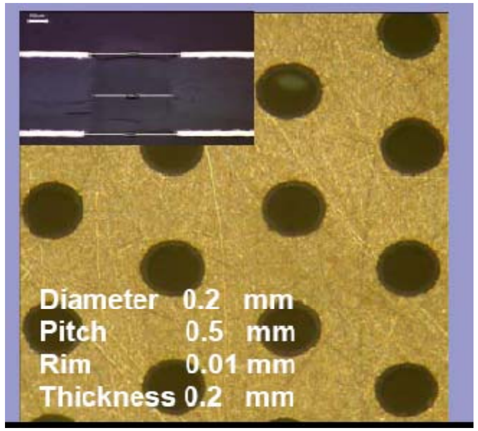


Detector design optimization, fabrication methods and new geometries

THGEM Example

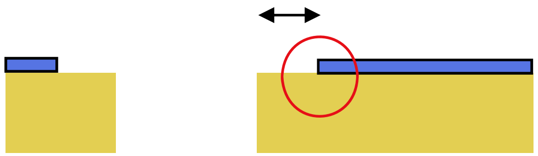


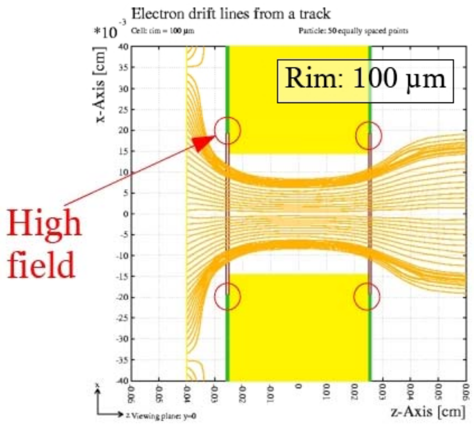


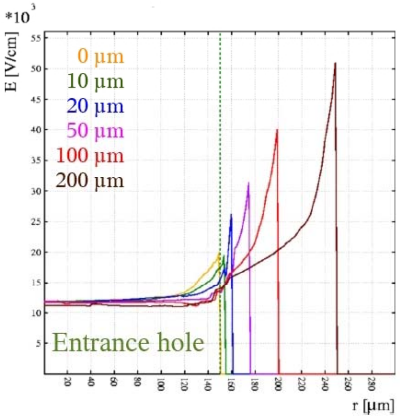


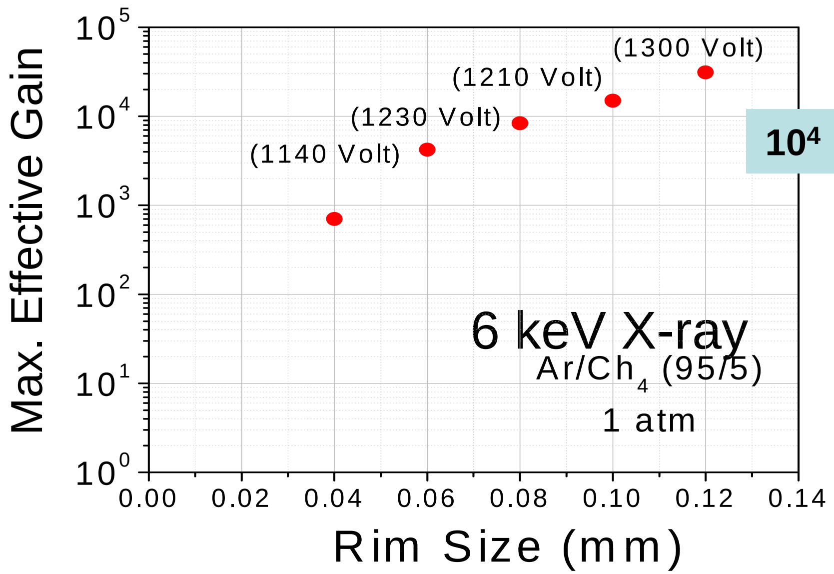
Mask etching + drilling; rim = 0.1mm

drilling + chemical rim etching without mask









pitch = 1 mm; **diameter** = 0.5 mm;
rim=40; 60; 80; 100; 120 mm

Task & Milestones:

Development of large-area Micro-Pattern Gas Detectors (large-area modules, material budget reduction).

Task/Milestone Reference	Participating Institutes	Description	Deliverable Nature	Start/Delivery Date
WG1-1/Development of large-area Micro-Pattern Gas Detectors - Micromegas	CEA Saclay, Demokritos, Napoli, Bari, Athens Tech. U., Athens U., Lanzhou, Geneva, PNPI, Thessaloniki, Ottawa/Carleton	Development of large area Micromegas with segmented mesh and resistive anodes	First prototype (1x0.5m^2)	m1/m12
			SLHC full size	m13/m60
	CEA Saclay, Ottawa/Carleton Demokritos, Athens Tech. U., Athens U.		ILC full size	m13/m36
WG1-1/Development of large-area Micro-Pattern Gas Detectors - GEM	Bari, CERN, Pisa-Siena, Roma, Arlington, Melbourne, TERA, PNPI, MPI Munich, Argonne	GEM R&D	Report, small size prototypes	m1/m18
	Bari, CERN, Pisa-Siena		Full scale prototype	m6/m18
			Development completed	m19/m30
	Arlington		Medium-size prototype	m1/m6
			1 m^2 prototype	m13/m18
			1 m^3 stack	m19/m30
	Roma, Bari		JLab HallA full scale prototype	m18/m30

WG2: Common Characterization and Physics Issues

Objective 1: Development of common standards and comparison of different technologies, performance evaluation of different MPGD detectors.

Objective 2: Development of radiation-hard gaseous detectors operating beyond the limits of present devices.

Task 1: Development of common test standards (comparison of different technologies in different laboratories).

Task 2: Discharge studies and spark-protection developments for MPGDs.

Task 3: Generic aging and material radiation-hardness studies (creation of database of "radiation-hard" materials & detectors depending on application, commercially available materials, cleanliness requirements, validation tests for final detector modules, gas system construction, working remedies).

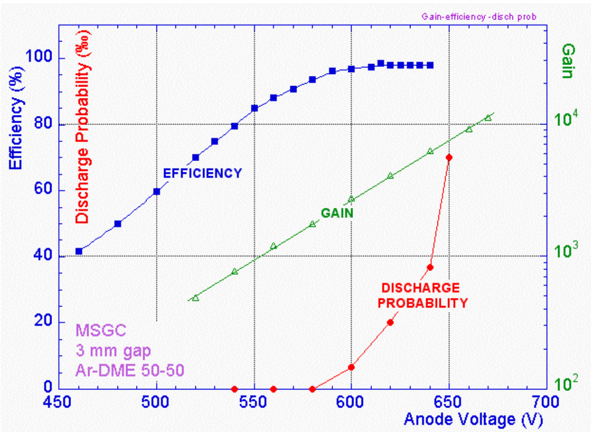
Task 4: Charging up (gain stability issues) and rate capability.

Task 5: Study of avalanche statistics: exponential versus Polya (saturated-avalanche mode).

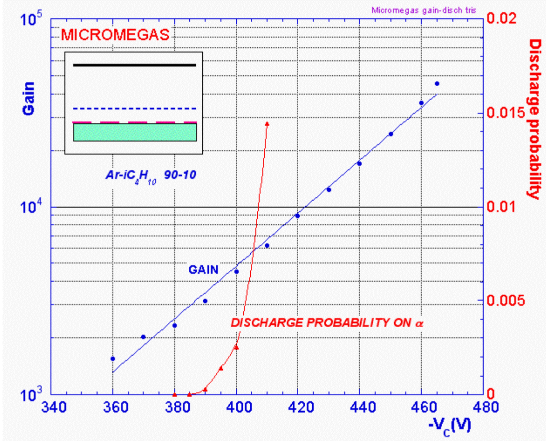
Development of common test standards (comparison of different technologies in different laboratories)

- MPGD Geometry
- Detector dimensions and gas gain uniformity over the active area
- Gas mixture composition
- Detection efficiency
- Maximum gas gain and rate capability
- Energy, spatial and time resolution
- Gas gain calibration (charge pulse injection, ^{55}Fe signal monitoring, current measurements)
- Discharge probability
- If relevant: track position resolution per unit track length

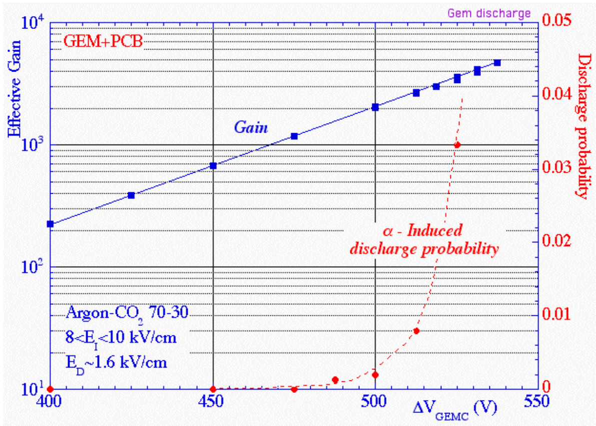
Discharge studies and spark-protection developments for MPGDs.



MSGC



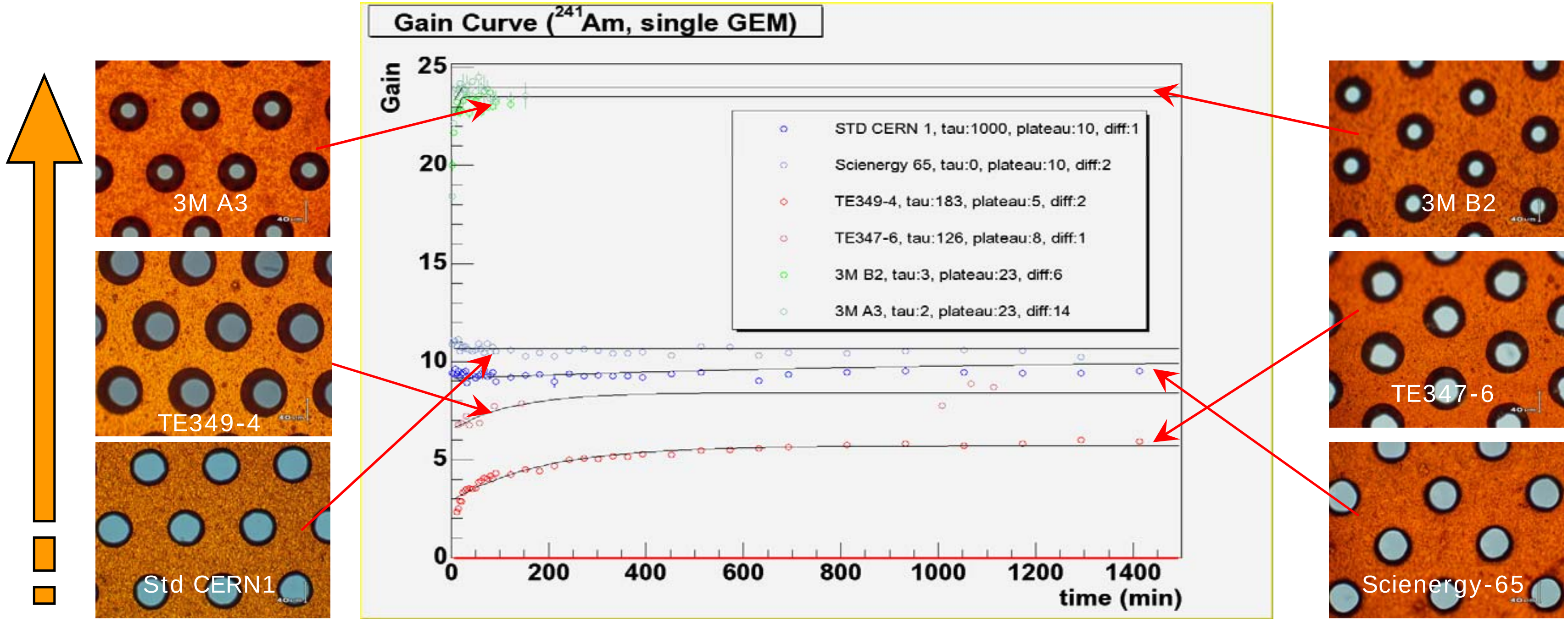
Micromegas



GEM

Charging up (gain stability issues) and rate capability

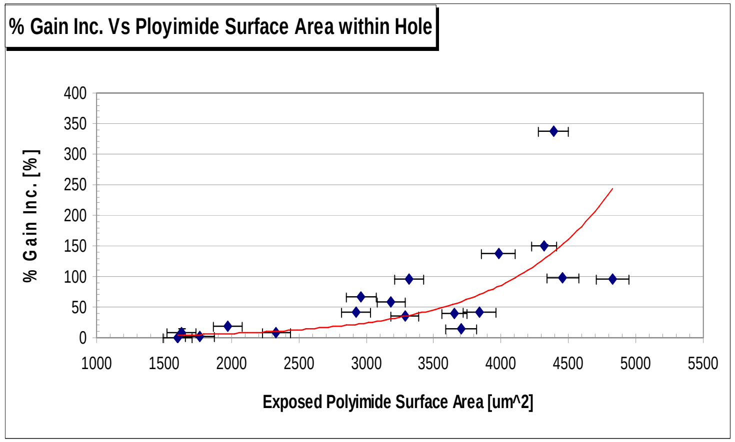
More Polyimide Exposed

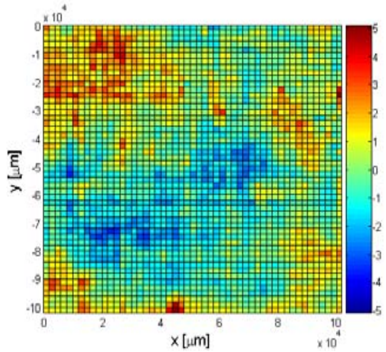


(BNL)

More exposed polyimide
(more conical hole)

⇒ Larger gain increase





Generic aging and material radiation-hardness studies

Large area MPGDs open new challenges:

- Large area irradiation
- New detector materials: minimum material budget, rad-hard and outgassing-free
- New assembly procedures
- For large experiments: distributed, cost-effective, mass production procedures

Creation of database of "radiation-hard" materials &
detectors depending on application, commercially available materials

Source	Product	Outgas	Effect in G.D.	Note
CERN/GDD	**STYCAST 1266 (A+B)**	NO	NO	Long curing time
HERA-B/OTR	**STYCAST 1266 (A+Catalyst 9)**	NO	NO	In Use
CERN/GDD	**HEXCEL EPO 93L**	NO	NO	Out of production
HERA-B/ITR	**ECCOBOND 285**	NO	NO	In Use
CERN/GDD ATLAS/TRT	**ARALDITE AW103 (Hardener HY 991)**	NO	NO	In Use
ATLAS/TRT	**TRABOND 2115**	NO	NO	In Use

Low Outgassing room-T epoxies

Source	Product	Outgas	Effect in G.D.	Result
CERN/GDD ATLAS/TRT	**ARALDITE AW 106 (Hardener HV 935 U)**	YES		**BAD**
CERN/GDD	**DURALCO 4525**	YES	YES	**BAD**
CERN/GDD	**DURALCO 4461**	YES	YES	**BAD**
CERN/GDD	**HEXCEL A40**	YES	-	**BAD**
CERN/GDD	**TECHNICOLL 8862 + (Hardener 8263)**	YES	-	**BAD**
CERN/GDD	**NORLAND NEA 155**	YES	-	**BAD**
CERN/GDD	**EPOTEK E905**	YES	-	**BAD**
CERN/GDD	**NORLAND NEA 123 (UV)**	YES	-	**BAD**

Outgassing room-T epoxies

WG3: Applications

Objective: Evaluation and optimization of MPGD technologies for specific applications.

Task 1: MPGD based detectors for tracking and triggering (including Muon Systems).

Task 2: MPGD based Photon Detectors (e.g. for RICH).

Task 3: Applications of MPGD based detectors in Calorimetry.

Task 4: Cryogenic Detectors for rare events searches.

Task 5: X-ray and neutron imaging.

Task 6: Astroparticle physics applications.

Task 7: Medical applications.

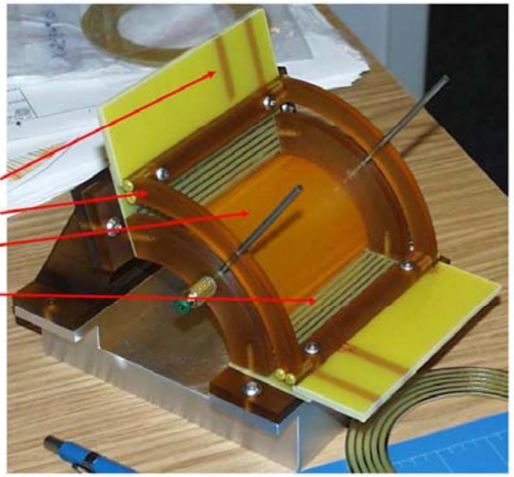
Task 8: Synchrotron Radiation, Plasma Diagnostics and Homeland Security applications.

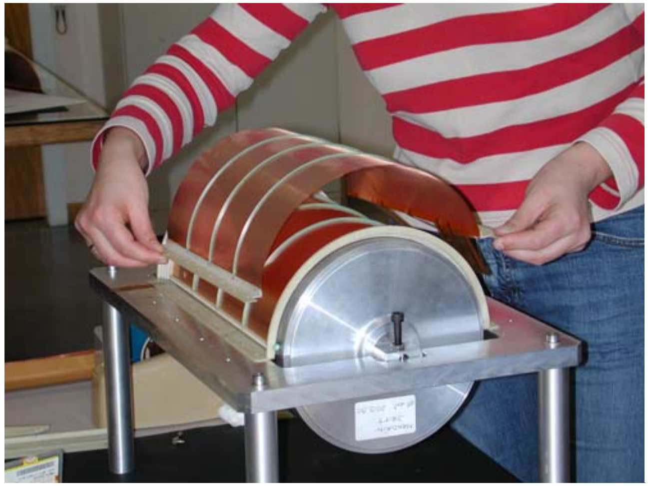
Applications area will benefit from the technological developments proposed by the Collaboration; however the responsibility for the completion of the application projects lies with the institutes themselves.

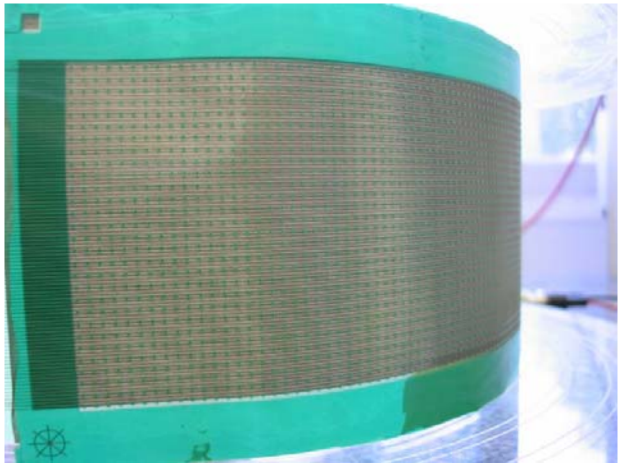
MPGD based detectors for tracking and triggering

- Curved Prototype Test Fit

GEM HV Connections
ULTEM® Frame Parts
Drift Region Cathode
Field Cage Electrodes
(GEMs and Readout Board are not shown)







WG4: Simulations and Software Tools

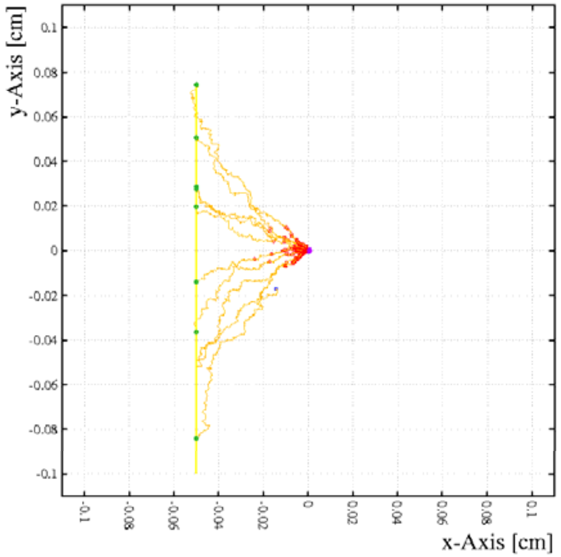
Objective: Development of common, open access software and documentation for MPGD simulations.

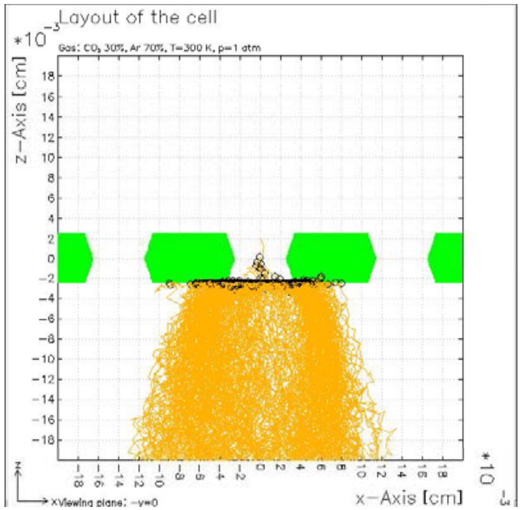
Task 1: Development of algorithms (in particular in the domain of very small scale structures).

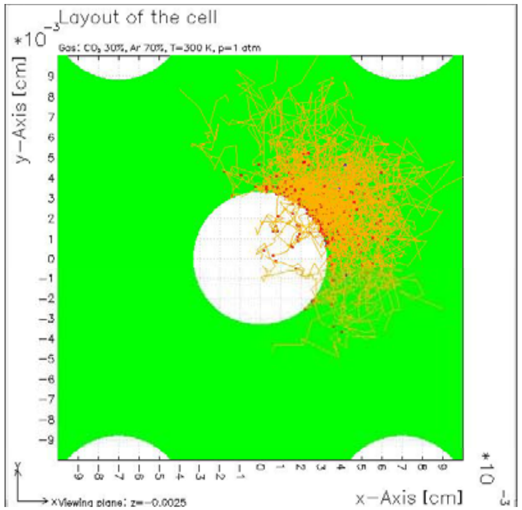
Task 2: Simulation improvements.

Task 3: Development of common platform for detector simulations (integration of gas-based detector simulation tools to Geant4, interface to ROOT).

Task 4: Explore possibilities to further integrate detector and electronics simulation.







WG5: MPGD Related Electronics

Objective: Readout electronics optimization and integration with detectors.

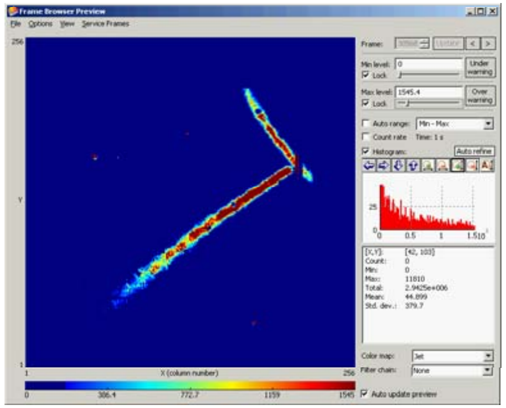
Task 1: **Definition of front-end electronics requirements for MPGDs.**
Conventional readout systems: GASSIPLEX, ASDQ, CARIOCA, ALTRO, SUPER ALTRO; APV, VFAT

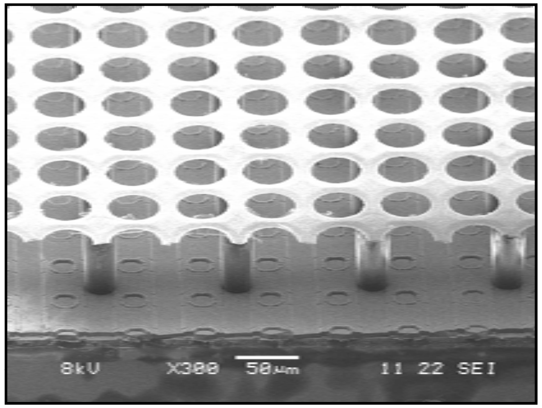
Task 2: Development of general-purpose pixel chip for active anode readout.
GOSSIP (Gas On Slimmed Si Pixels)

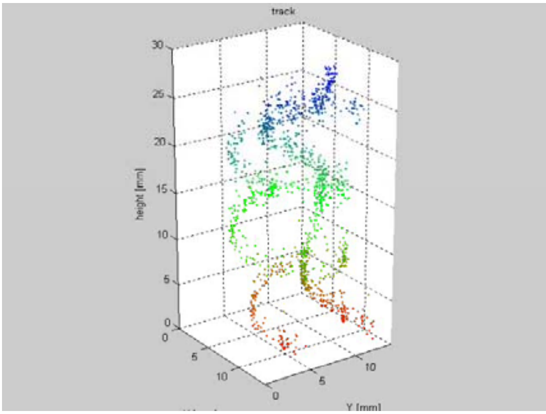
Task 3: Development of large area detectors with pixel readout.
Medipix2, Timepix

Task 4: Development of portable multichannel systems for detector studies.

Task 5: Discharge protection strategies.







Timepix+Siprot+Ingrid

WG6: Production

Objective: Development of cost-effective technologies and industrialization (technology transfer)

Task 1: Development and maintenance of a common "Production Facility".

Task 2: MPGD production industrialization (quality control, cost-effective production, large-volume production).

Task 3: Collaboration with Industrial Partners.

1. Production requirements
   - detector dimensions
   - GEM (single mask) 120*50 cm^2 , Micromegas (bulk) 200*100 cm^2

2. Inventory of production capabilities
   - material limitations
   - equipment limitations
   - today: GEM (single mask) 70*40 cm^2 , Micromegas (bulk) 150*50 cm^2

3. Common facility to produce prototypes at CERN TS workshop (production facility improvements, if technological developments in the RD51 will require this, participation in the upgrade of production infrastructure from common investments.)

4. Industrialization
   - which production steps do we transfer to industry
   - how to teach and check industrial partners
   - IP and licensing issues treated with the help of DSU/TT

WG7: Common Test Facilities

Objective: Design and maintenance of common infrastructure for detector characterization.

Task 1: Development and maintenance of a common Test-Beam Facility.

1. A basic setup in the first year, including trigger devices and logic, tracking telescope and high precision mechanics, gas system and infrastructures.
2. A flexible DAQ and slow control system.
3. A common approach in data analysis and the development of a common analysis framework.

Task 2: Development of common irradiation infrastructures and irradiation test programme.

For this task the collaboration will provide to the facilities experts:

1. A common list of material and components to be validated in PS-T7;
2. The specifications requested to the new GIF++ facility;
3. The infrastructures and devices (trigger, DAQ.. see test beam facility) required inside GIF++ facility

Partners and Their Fields of Contribution:

town	institute	WG1				WG2					WG3								WG4				WG5					WG6			WG7		
		T1	T2	T3	T4	T1	T2	T3	T4	T5	T1	T2	T3	T4	T5	T6	T7	T8	T1	T2	T3	T4	T1	T2	T3	T4	T5	T1	T2	T3	T1	T2	sum
Alessandria	University																																0
Amsterdam	NIKHEF	1	1	1		1	1	1	1	1	1		1				1		1		1	1	1	1	1					1	1	1	20
Annecy	LAPP	1					1						1																				3
Argonne	Argonne Nat'l Lab	1									1												1										3
Arlington	University of Texas	1					1						1												1						1		5
Athens	NCSR "Demokritos"	1		1				1			1	1	1		1	1	1														1	1	11
Athens	Nat.Tech.Univ. Athens	1	1	1		1	1	1	1		1				1	1	1			1	1								1	1	1	1	17
Athens	University					1			1		1						1			1	1										1		7
Aveiro, Coimbra	University	1	1					1	1			1		1	1	1	1			1	1									1			12
Barcelona	Universitat Autònoma	1	1																1	1													4
Bari	University		1	1				1			1				1				1	1			1										8
Bonn	University		1								1													1	1				1		1		6
Braunschweig	PTB														1																	1	2
Budapest	RMKI		1				1		1		1						1																5
Budapest	University		1				1		1																								3
Bursa	Uludag University									1									1	1	1												4
Cagliari	University							1			1																						2
Coimbra	LIP							1			1						1																3
Columbia, SC	Univ. South Carolina	1					1						1																				3
Frascati	LNF, INFN										1												1										2
Freiburg	University					1					1													1									3
Geneva	University	1				1																									1		3
Geneva	CERN	1	1	1	1	1	1	1	1		1									1	1		1	1				1	1	1	1	1	18
Grenoble	LPSC					1										1			1		1		1	1	1								7
Hefei	USTC	1	1			1	1	1	1	1																							7
Helsinki	HIP	1		1				1																									3
Kolkata	Saha Institute																		1	1	1	1											4
Lanzhou	University	1	1												1		1																4
Melbourne	Florida Inst of Tech	1																1					1		1								4
Mexico City	Univ. Nacional Aut	1	1				1		1		1	1	1	1																			8
Montreal	University			1									1		1	1	1								1								6
Mumbai	Tata Institute														1								1										2
M nchen	MPI		1										1																				2
M nchen	Technische Universität	1		1			1		1		1														1	1							7
Napels	University	1				1					1															1					1		5
New Haven, CT	Yale		1					1	1		1																		1	1			6
Novara	TERA Foundation	1		1					1								1						1										5
Novosibirsk	Budker Institute													1	1	1	1							1									5
Ottawa	Carleton University	1	1			1										1			1		1	1									1	1	9
Rehovot	Weizmann Institute	1	1				1		1	1	1	1	1	1	1	1	1													1			13
Rome	Sanita Group, INFN	1									1																						2
Saclay	IRFU, CEA	1	1	1	1	1	1	1	1	1	1				1	1							1	1	1	1	1	1	1	1		1	21
Sheffield	University	1	1									1		1		1																	5
Siena	University	1															1						1										3
St Etienne	Ecole Nat. Sup. des Mines	1		1	1		1		1									1															6
St Petersburg	NPI	1	1			1	1																										4
Tessaloniki	Aristotle University	1		1		1		1			1						1			1											1		8
Trieste	University		1						1			1																	1				4
Tucson	University of Arizona	1	1														1									1			1	1			6
Tunis	CNSTN																1			1	1												3
Upton	BNL	1		1							1	1					1						1						1	1			8
Valencia	IFIC							1												1													2
Valencia	Universidad Politecnics																									1							1
Zaragoza	University		1											1		1			1	1													5
	sum of participants/task	30	22	13	3	13	15	14	16	5	22	7	9	6	11	11	17	2	8	12	10	3	12	7	8	5	1	2	8	9	11	7	

Resources and Infrastructure

- micro-structure production facilities
- gas detector development laboratories
- clean room, assembly facilities
- gas and gas purification systems
- facilities for gas and materials studies
- facilities for thin film deposition
- facilities for electronics development, production and testing
- irradiation facilities

infrastructure / institute	Micro-structure production facility	gas detector development lab	clean room, assembly facility	gas and gas purification systems	facilities for gas and materials studies	facilities for thin film deposition	facilities for electronics deveopment,	irradiation facilitiy
Alessandria								
Amsterdam / NIKHEF			•			•		•
Annecy								
Argonne / Nat'l Lab								
Arlington, TX			•					
Athens NCSR Demokritos				•			•	
Athens NTU								
Athens Univ.								
Aveiro + Coimbra				•		•		
Barcelona								
Bari			•	•			•	
Bonn				•				
Braunschweig								•
Budapest / RMKI			•					
Budapest Univ.								
Bursa								
Cagliari		•		•			•	
Coimbra								
Columbia, SC								
Frascati								
Freiburg			•			•		
Geneva / CERN	•	•	•	•	•	•	•	•
Geneva Univ.								
Grenoble								•
Hefei								
Helsinki		•	•		•			•
Kolkata								
Lanzhou				•			•	
Melbourne, FL								
Mexico City								
Montreal							•	•
Mumbai								
Munich / MPI								
Munich TU			•			•		•
Napels								
New Haven, CT / Yale								
Novara								
Novosibirsk			•	•			•	•
Ottawa / Carleton		•	•					•
Rehovot / Weizmann		•	•	•		•	•	
Rome / INFN Sanita Group			•			•		
Saclay	•	•	•	•			•	•
Sheffield		•		•				•
Siena		•	•				•	
St Etienne			•	•				
St Petersburg								
Thessaloniki								
Trieste			•			•		
Tucson, AZ								
Tunis								
Upton / BNL		•	•	•			•	
Valencia / IFIC								
Valencia / Iniv. Politec.								
Zaragoza				•				

Resources requested from CERN as a host lab:

RD51 does not request a direct financial contribution from CERN.

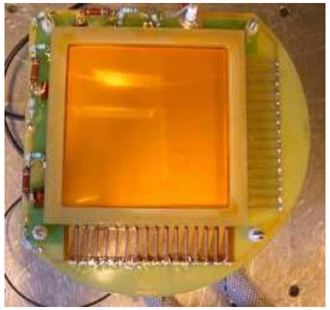
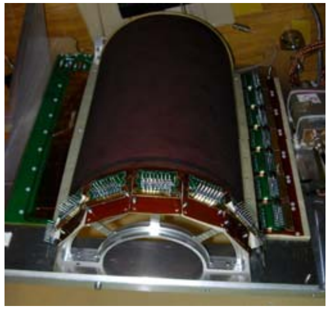
The collaboration would like to ask for the following resources and infrastructure at CERN:

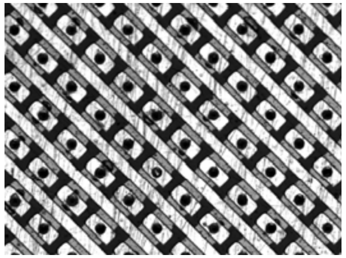
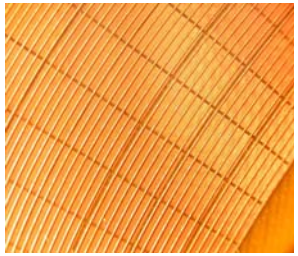
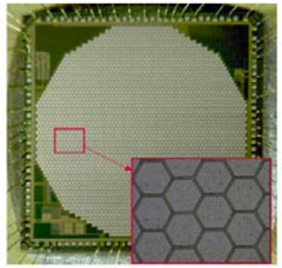
- Access to irradiation and test beam facilities (including the possibility to keep "semi-permanent" setup). The collaboration foresees typically 2 annual test beam campaigns each of a few weeks duration.
- Privileged access to CERN TS-DEM Printed Circuit Workshop (similar to present availability level). Participation in investments for production infrastructure to stay in line with technology advances.
- Access to Silicon Bonding Laboratory
- Access to central computing resources and Grid access for MPGD simulations.
- Limited amount of office space

Spares

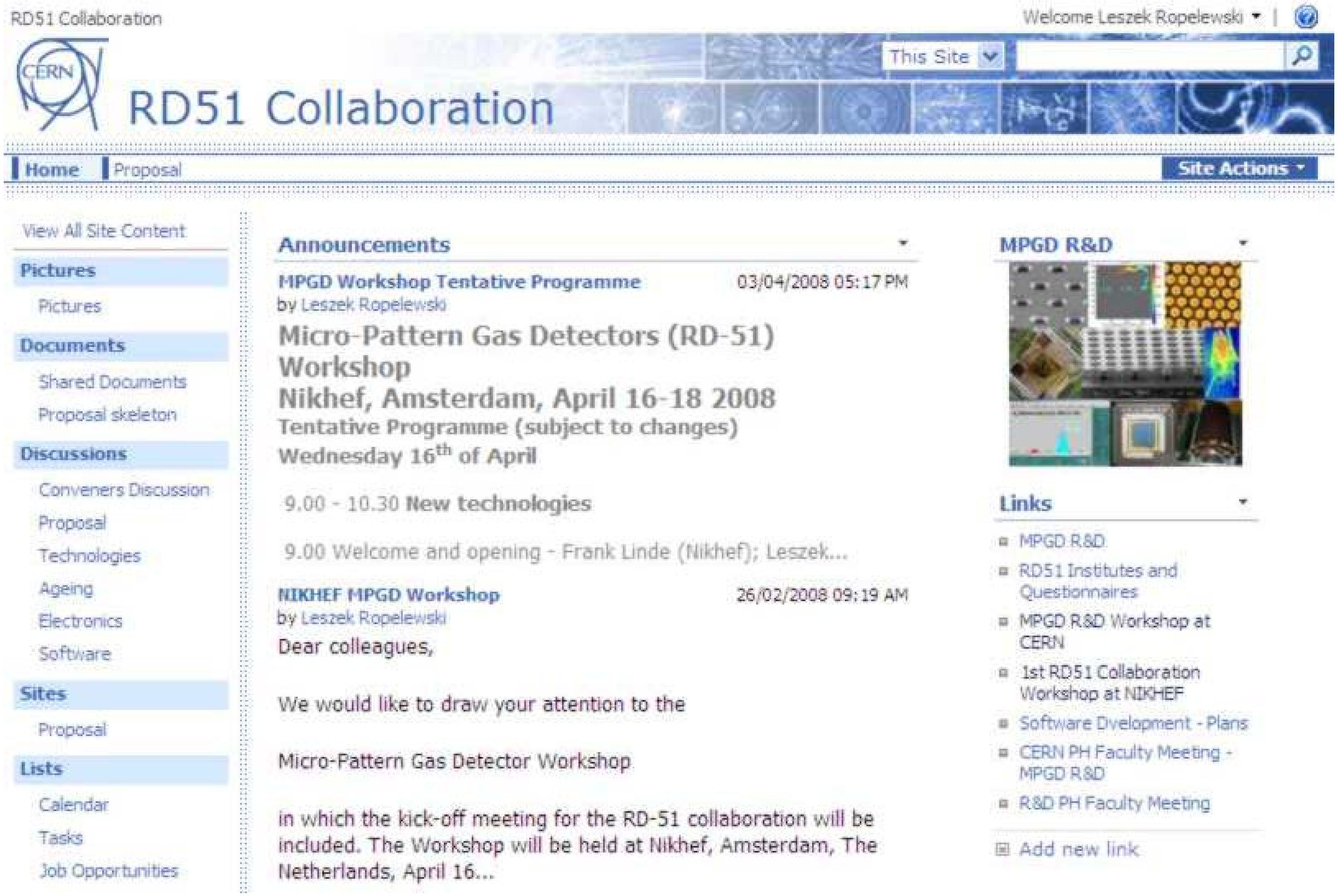
Current Trends in Micro-Pattern Gas Detectors (Performance)

- Low Material Budget
- Geometrical Flexibility
- Readout Structures

Collaboration Web Page:



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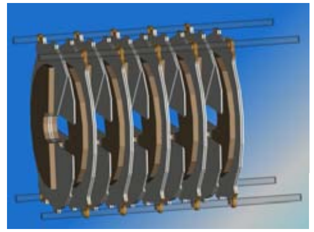
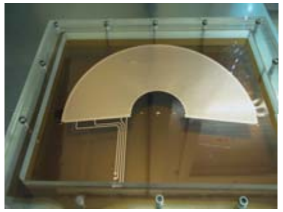
MPG Detectors

Detector Design & Development

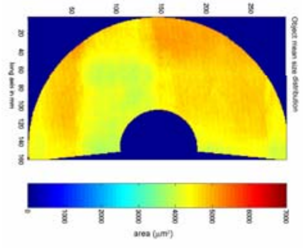




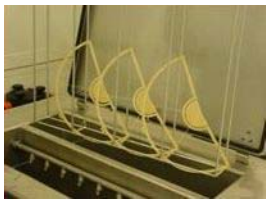
Component Production

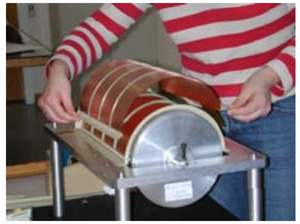




Component Quality Control

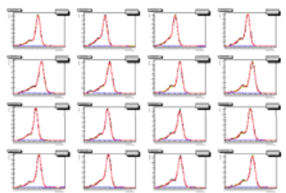
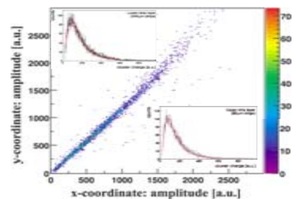


Detector Assembly



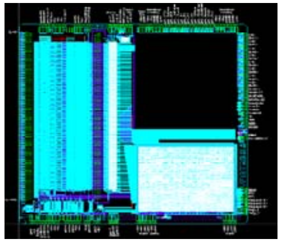


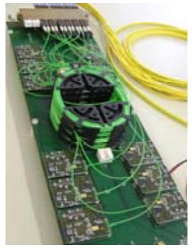
Detector Test

MPG Detectors

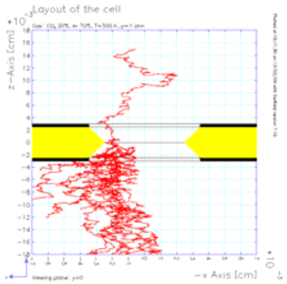
Electronics

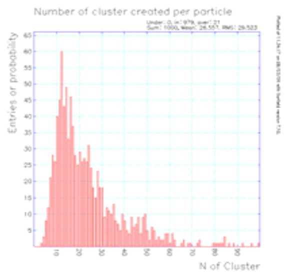


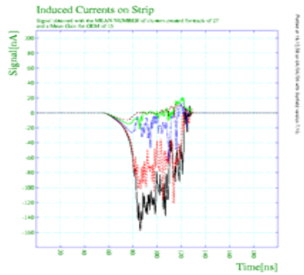


APV
VFAT
GP5
ALTRO
MEDIPIX

Detector Simulations

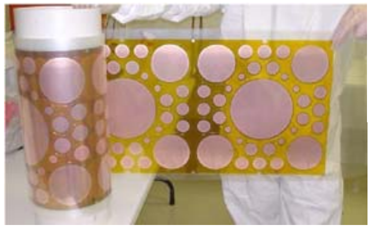


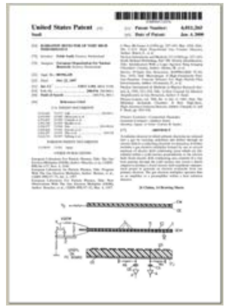




Garfield
Maxwell
Magboltz
Imonte
Heed

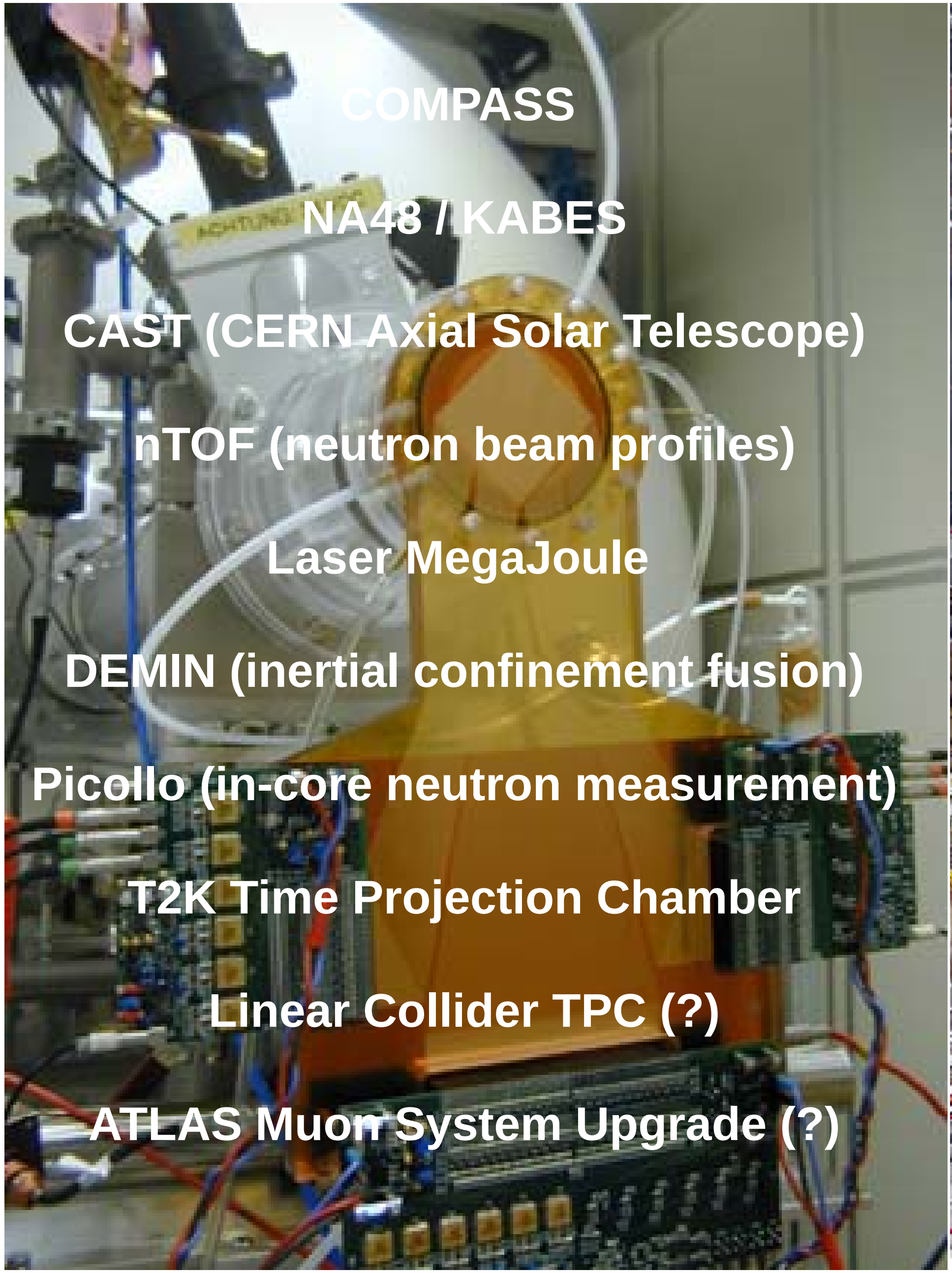
Technology Dissemination

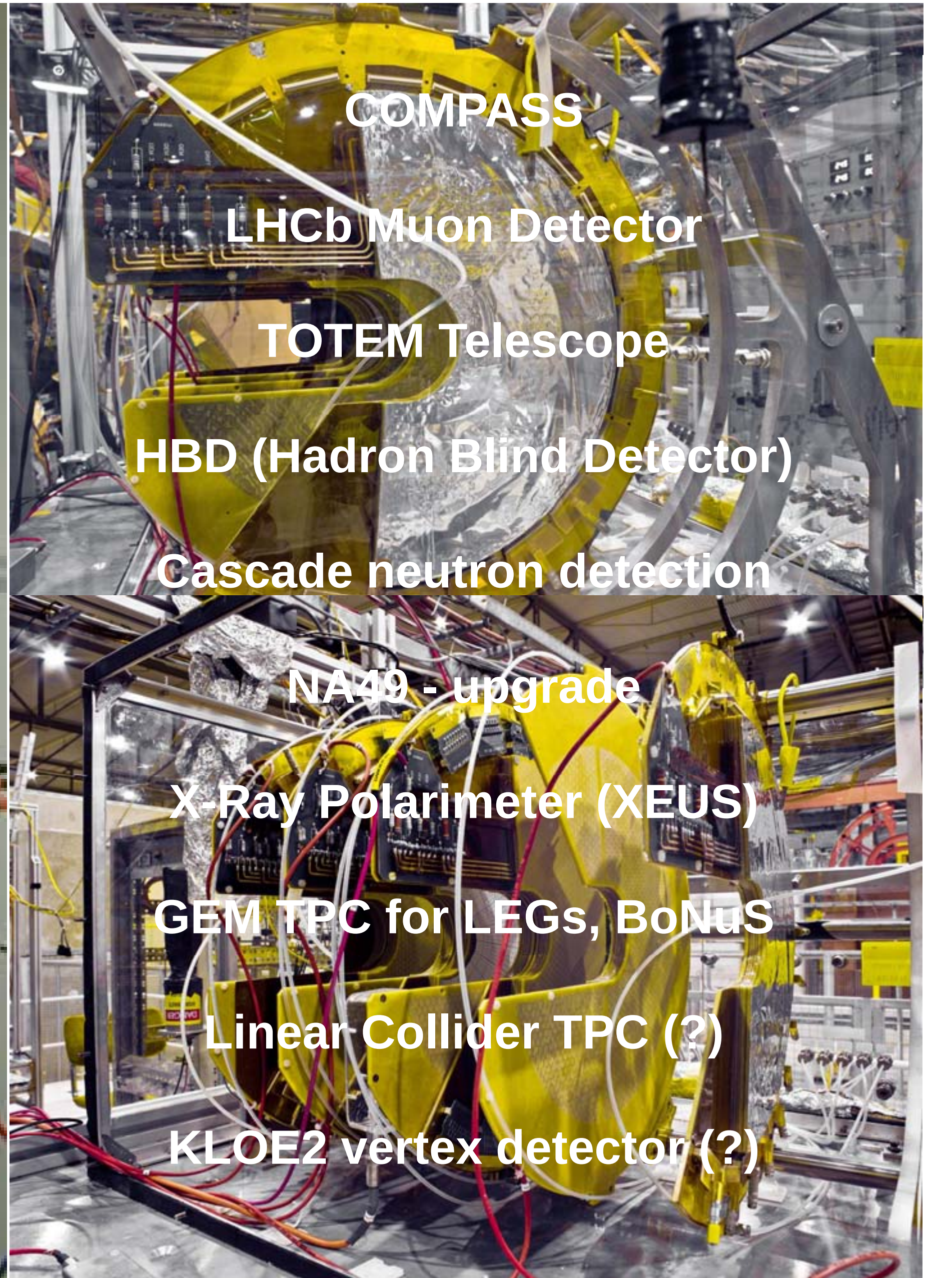


PANalytical
3M
TechEtch
Techtra
Centronic
G&A

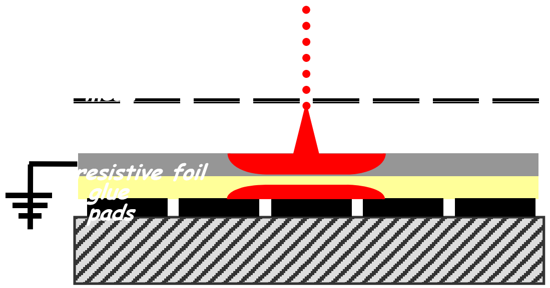
Current Trends in Micro-Pattern Gas Detectors (Current and Future Applications)



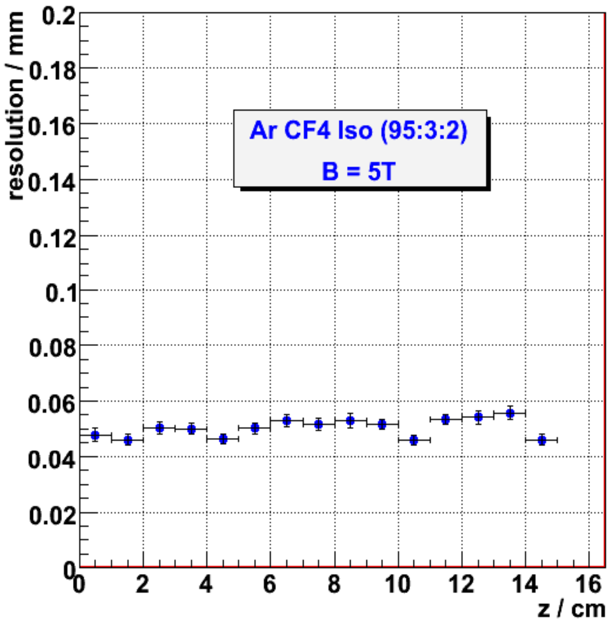


Discharge studies and spark-protection developments for MPGDs

Resistive anode:
Charge dispersion readout

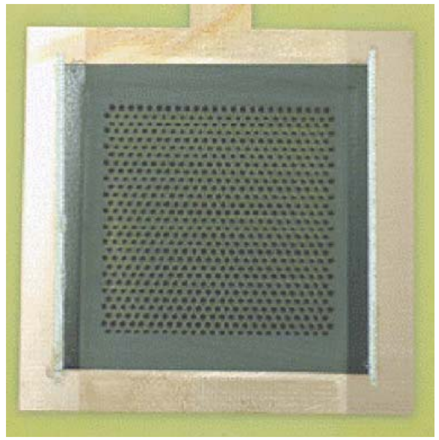


1 MΩ/□ plastic foil



RTGEM: resistive electrode THGEM

$3 \div 10$ GΩ/□ copper oxide layer



Gain of RETGEM in various gases: