RD51 Annual Report
Development of Micro Pattern Gas Detector Technologies

Eraldo Oliveri, PH-DT-DD, CERN, Switzerland
On behalf of the RD51 Collaboration
• Introduction to RD51

• 2014-2015 Activity review through the RD51 structure
  • WG1: MPGD Technology and new structures.
  • WG2: Characterization and understanding of physical phenomena in MPGD.
  • WG3: Conferences / Schools, Academia-Industry Matching Events
  • WG4: Development of common software for MPGD Simulation.
  • WG5: Electronics optimization and integration with MPGD
  • WG6: CERN MPGD Workshop, Quality Control and Industrialization
  • WG7: Common Test Beam and Lab Facilities

• Conclusion
Recent reviews of Micro Pattern Gas Detector (MPGD) and RD51 collaboration

- High Rate Capability
- High Gain
- High Space Resolution
- Good Time Resolution
- Good Energy Resolution
- Excellent Radiation Hardness
- Good Ageing Properties
- Ion Backflow Reduction
- Photon Feedback Reduction
- Large Size
- Low Cost

MICRO-PATTERN GASEOUS DETECTOR TECHNOLOGIES AND RD51 COLLABORATION

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LESZEK ROPELEWSKI
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The main objective is to advance MPGD technological development and associated electronic-readout systems, for applications in basic and applied research”.

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

- Large Scale R&D program to **advance MPGD Technologies**
- Access to **the MPGD “know-how”**
- Foster **Industrial Production**

- More than 80 groups
- More than 400 people
- National and International Laboratories
- National Institutes and Universities
Historical Roadmap of the MPGD Technologies and RD51 Collaboration

Existing detection concepts have been improved and new ones introduced thanks to new and affordable techniques.

In summary, RD51 is a successful R&D Collaboration with well-defined and important future plans. In view of the above and given the modest request for resources for further work, the referees recommend that the RD51 R&D project be continued for five years beyond 2013 and for CERN to continue to provide the limited requested support to the Collaboration. A status report is expected to be submitted to the LHCC in one year’s time. The Committee agrees to the continuation of the project on this basis.

CERN/LHCC-2013-012
LHCC-114
12 June 2013

R&D Projects
RD51: The LHCC recommended that the RD51 project be continued for four years beyond 2014.
Impact of RD51 in the MPGD community

Last ....

FRONTIER DETECTORS FOR FRONTIER PHYSICS
13th Pisa Meeting on Advanced Detectors

....as a reference
Gas Detectors - Poster Session

A dedicated calibration tool for the MEG and MEG II positron spectrometer
Speaker: Dr. Oleksandr Sereda
Material: Slides

A compact View-Projected Chamber for the Crystal Ball
Speaker: Prof. Omer Shafir (Institute for Advanced Study, Princeton, NJ)
Material: Slides

A new construction technique of high granularity and high transparency drift chambers for modern high energy physics experiments
Speaker: Gianluca Ghia (INFN)
Material: Slides

A new cylindrical drift chamber for the RD11 experiment
Speaker: Riccardo Galli
Material: Slides

A novel method to estimate the impact parameter on a drift chamber cell by using the information of single ionization clusters.
Speaker: Ms. Soroosh Mansouri
Material: Slides

A proposal to upgrade the ALICE TPC gas system upgrade for the high luminosity LHC
Speaker: Ricardo van der Velden
Material: Slides

Building and Commissioning of a Setup to Study Aging Phenomena in Gas Detectors
Speaker: Dr. Virginie Mariotto (Inst. d’Etudes Scientifiques de l’Ecole Polytechnique, France)
Material: Slides

Characterization and Calibration of Large Area Resistive Strip Micromegas Detectors
Speaker: Dr. Guido Picone (Universita’ di Milano-Bicocca, Italy)
Material: Slides

Characterization of the ATLAS Micromegas-quadripole prototype
Speaker: Dr. Guido Picone (Universita’ di Milano-Bicocca, Italy)
Material: Slides

Characterization of GEM detector prototype
Speaker: Dr. Virginie Mariotto (Inst. d’Etudes Scientifiques de l’Ecole Polytechnique, France)
Material: Slides

Cylindrical Micromegas, an innovative solution for central trackers.
Speaker: Dr. Mandla Venter (CERN)
Material: Slides

Cylindrical Micromegas, an innovative solution for central trackers.
Speaker: Dr. Mandla Venter (CERN)
Material: Slides

Charge Transfer Properties Through Graphene for Application in Gaseous Detectors
Speaker: Dr. Roberto Bassetti (CERN)
Material: Slides

Photo Detectors and PID

Status of the Development of Large Area Photonic Detectors Based on THGEMs and Hybrid PMGD Architectures for Cernenkov Imaging Applications
Speaker: C. A. Santos (INPM, Sezaloni di Trieste, Trieste, Italy)
Material: Slides

Photo Detectors and PID - Poster Session

Fast Timing Detector R&D for the HL-LHC era
Speaker: Dr. Sebastian White (Princeton University)
Material: Slides

Performance simulation studies for the ALICE TPC GAS Upgrade
Speaker: Dr. Richard Sereda (University of Wisconsin, Madison, WI)
Material: Slides

Protons and Hydrogen Tracking Detectors and Readout Electronics for Operation at Very High Background Rates of Future Detectors
Speaker: Dr. David Bailey (Max-Planck-Institut für Kernphysik, Heidelberg, Germany)
Material: Slides

A delicate challenge: The front-end for ATLAS Micromegas
Speaker: Dr. Thomas Spangenberg
Material: Slides

Study of gain evolution as a function of physical parameters of GeM foil using Garmisch - (University of Wisconsin, Madison, WI)
Material: Slides

Study of gammadron efficiency impact on Micromegas performance with an Electromagnetic Prototype
Speaker: Dr. Richard Sereda (University of Wisconsin, Madison, WI)
Material: Slides

Systematic measurements of gain and energy resolution of single and double micromegas detectors
Speaker: Dr. Richard Sereda (University of Wisconsin, Madison, WI)
Material: Slides

The drift chamber with a new type of straws for operation in vacuum
Speaker: Dr. Gary Petran (LSU, Baton Rouge)
Material: Slides

Triple stack Resistive Micromegas Chamber with Strip Readout for Particle Identification in the BSM and HEP Experiments
Speaker: Dr. Dr. I. Malyshev (IHEP, Protvino, Russia)
Material: Slides

Upgrades of the ATLAS Muon Spectrometer with DMBH Chambers
Speaker: Dr. Martin Schubert (University of Potsdam, Germany)
Material: Slides

A Cylinder of Acquisition at an Analog Readout for the BESIII Experiment
Speaker: Dr. Y. Zhang (Beijing, China)
Material: Slides

Analog readout for the BES II drift chamber
Speaker: Dr. M. Tedeschini (INFN, Firenze)
Material: Slides

Photometric water chambers for TPC detector
Speaker: Dr. S. Brelsford (INFN, Firenze)
Material: Slides

Photo Detectors and PID

Status of the Development of Large Area Photonic Detectors Based on THGEMs and Hybrid PMGD Architectures for Cernenkov Imaging Applications
Speaker: C. A. Santos (INPM, Sezaloni di Trieste, Trieste, Italy)
Material: Slides

Photo Detectors and PID - Poster Session

Fast Timing Detector R&D for the HL-LHC era
Speaker: Dr. Sebastian White (Princeton University)
Material: Slides
Gas Detectors - Poster Session

A new fiber calibration tool for the Wits and Wits2 Positional Spectrometer
Speaker: Mr. David Snieg (University of the Witwatersrand)
Material: [Material]

A compact Time Proportional Chamber for the Crystal Ball
Speaker: Mr. Oliver Stutter (Institut für Kernphysik, Universität Heidelberg)
Material: [Material]

A new technique of high sensitivity and high-transparency drift chambers for neutrino high-energy physics experiments
Speaker: Dr. Giovanni Ciofi (SIFT)
Material: [Material]

A new cylindrical drift chamber for the RD51 experiment
Speaker: Dr. Emanuele Spera (INFN)
Material: [Material]

A novel method to determine the impact parameter on a drift chamber cell by using the information of single interaction chambers
Material: [Material]

A proposal to upgrade the ATLAS RPC system upgrade for the High Luminosity LHC
Speaker: Dr. Ricardo Paz (INFN)
Material: [Material]

Building and Commissioning of a Set of PET scanners for imaging phenomena in Gas Detectors
Speaker: Prof. Alison Thomas (University of Birmingham)
Material: [Material]

Characterization and calibration of large area resistive strip microstrip detectors
Speaker: Dr. Thierry Maret (CERN)
Material: [Material]

Characterization of the ATLAS Microstrip chamber prototype detector
Speaker: Dr. Johannes Giesen (University of Ioannina)
Material: [Material]

Characterization of GEM-detector prototype
Speaker: Dr. Gabriele Ferrari (INFN)
Material: [Material]

Characterization of gasless drift chambers
Speaker: Dr. Mike Ambrosia (University of Trieste), Dr. M. Armaon (University of Trieste)
Material: [Material]

Construction and performance studies of a microstrip detector with a flat silicon strip technology
Speaker: Dr. Pascal Charron (IN2P3, France)
Material: [Material]

Construction and commissioning of the SuperRAPID drift chamber detector
Speaker: Dr. Fabio Zambelli (University of Florence)
Material: [Material]

Design of a large area triple-GEM forward detector system based on industrially produced GEM foil
Speaker: Dr. J. Lecomte (CEA)
Material: [Material]

Determination of the seeds which position is a strain of the new type using visible light
Speaker: Dr. Luca Forti (CERN)
Material: [Material]

First tests and preliminary test results of triple-GEM drift chamber prototypes for the ATLAS experiment
Speaker: Dr. A. Coudal (CERN)
Material: [Material]

A novel imaging technology for three-dimensional imaging of GEM chambers
Speaker: Dr. T. Maren (Ruhr-Universität Bochum)
Material: [Material]

MCNP detectors for MAMPY photoluminescence experiment in Muon detectors (Princeton University, Princeton, New Jersey)
Speaker: Dr. M. Pedroni (UIUC)
Material: [Material]

Photoluminescence of a Triple-GEM detector with a CREST sensor
Speaker: Dr. A. Coudal (CERN)
Material: [Material]

Applications - Poster Session

Development of a novel Micro Pattern Gaseous Detector for cosmic rays studies
Speaker: Dr. David Snieg (University of the Witwatersrand)
Material: [Material]

Fast neutron and gamma-ray detection with (Gpd-30) detector for controlled detectors
Speaker: Dr. David Snieg (University of the Witwatersrand)
Material: [Material]

Microstrip tracker for particle therapy secondary emission flux measurements
Speaker: Dr. T. Maren (Ruhr-Universität Bochum)
Material: [Material]

Photo Detectors and PID - Poster Session

Fast Timing Detector R&D for the HL-LHC era
Speaker: Dr. Sebastian White (Princeton University)
Material: [Material]
Gas Detectors - Poster Session

A novel calibration tool for the MD5 and MD52 Position Sensitive Detectors
Speaker: Dr. Sebaslian White (University of Florida)
Material: Slides

Performance simulation studies for the BISD TPC GEM Upgrade
Speaker: Dr. Fabrice Menor (University of Geneva)
Material: Slides

Photo Detectors and PID - Poster Session

Fast Timing Detector R&D for the HL-LHC
Speaker: Dr. Sebaslian White (University of Florida)
Material: Slides

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= as a project they have/had permanent installation in the RD51 lab
Gas Detectors - Poster Session

**A Related Calibration Tool for the RD51 and RD52 Position Spectrometer**
Speaker: Dr. Gilles De Lente (University of Brussels)
Material: Slides

**Micromegas Detectors for the Muon Spectrometer Upgrade of the ATLAS Experiment**
Speaker: Michele Bianco (INFN)
Material: Slides

**A Continuous read-out TPC for the ALICE upgrade**
Speaker: Dr. Christian Lippmann (GSI Helmholtzzentrum für Schwerionenforschung)
Material: Slides

**TPC-like readout for thermal neutron detection using a GEM-detector**
Speaker: Mr. Bernhard Bier (JLU Munich)
Material: Slides

**Cylindrical Micromegas, an innovative solution for central trackers**
Speaker: Dr. Maxence Vandenbroucke (CEA Saclay)
Material: Slides

**Resistive MPGDS based on the WELL amplification concept**
Speaker: Marco Polla Neri (INFN)
Material: Slides

**Charge Transfer Properties Through Graphene for Applications in Gases**
Speaker: Dr. Filippo Rossetti (CERN)
Material: Slides

**Photo Detectors and PID**
Speaker: Dr. Sebastian White (Princeton University)
Material: Slides

**Applications of a Novel Micro Pattern Gas Detectors with Gas Microstrip for Particle Identification**
Speaker: Prof. Daniele Menoni (INFN)
Material: Slides

**NIST Microchannel Plate Detectors for Low Energy Electrons**
Speaker: Prof. Daniele Menoni (INFN)
Material: Slides

**Performance Studies with the RU-TPC GEM Upgrade**
Speaker: Prof. Daniele Menoni (INFN)
Material: Slides

**Study of gas ionisation as a function of physical parameters of GEM foil using Geant4**
Speaker: Prof. Daniele Menoni (INFN)
Material: Slides

**Study of ionised gas impact on Micromegas performance with an ECP Model**
Speaker: Prof. Daniele Menoni (INFN)
Material: Slides

**Results of Micromegas at the RD51 lab**
Speaker: Prof. Daniele Menoni (INFN)
Material: Slides

**A Proposal for Upgrade the ATLAS RPC System upgrade for the Large Hadron Collider**
Speaker: Prof. Riccardo Veril (INFN)
Material: Slides

**Building and Commissioning of a System for Studying Energetic Neutrons at the RD51 Lab**
Speaker: Prof. Riccardo Veril (INFN)
Material: Slides

**Characterization of Large Area Resistive Wire Micromegas Detectors**
Speaker: Prof. Riccardo Veril (INFN)
Material: Slides

**Characterization of the ATLAS Micromegas韓語prototype**
Speaker: Dr. Christian Lippmann (GSI Helmholtzzentrum für Schwerionenforschung)
Material: Slides

**Characterization of GEM-detector prototype**
Speaker: Dr. Christian Lippmann (GSI Helmholtzzentrum für Schwerionenforschung)
Material: Slides

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Material: Slides

**Characterization of GEM-detector prototype**
Speaker: Dr. Christian Lippmann (GSI Helmholtzzentrum für Schwerionenforschung)
Material: Slides
Gas Detectors - Poster Session

A compact Time Projection Chamber for the Crystal Ball
Speaker: Dr. Oliver Sartor (Institute for Applied Physics)
Material: Slides

A new cylindrical drift chamber for the TPC-57 experiment
Speaker: Dr. Simon Voss (KIT)
Material: Poster

A novel method to estimate the impact parameter on a drift chamber cell by using the information of single ionization chambers.
Speaker: Dr. Christian Lippert (University of Heidelberg)
Material: Poster

A new technique of high-accuracy and high-precision drift chambers for measurements using a high-precision spectrometer.
Speaker: Dr. Michael Hengstenberg (University of Heidelberg)
Material: Poster

A project to upgrade the ATLAS RPC system upgrade for the high luminosity LHC
Speaker: Dr. Daniel Schubert (CERN)
Material: Poster

Gas Detectors - Poster Session

Cylindrical Micromegas, an innovative solution for central trackers.
Speaker: Dr. Maximilian Vandenbroucke (CERN)
Material: Slides

Resistive Micropores based on the WELL amplification
Speaker: Marco Poli (INFN)
Material: Slides

Charge Transfer Properties Through Graphene for Applications in Gas Detectors
Speaker: Dr. Spanish (INFN)
Material: Slides

Photo Detectors and PID

Status of the Development of Large Area Photon Detectors and MPPD architectures for Cherenkov Imaging Applications
Speaker: C. A. Santos (INFN, Sezione di Trieste, Trieste, Italy)
Material: Slides

Photo Detectors and PID - Poster Session

Fast Timing Detector R&D for the HL-LHC
Speaker: Dr. Sebastian White (Princeton University)
Material: Poster

= project is in the list of RD51 member
= as a project they have/had permanent installation in the RD51 lab
= has used the RD51 lab for specific measurements
= has used the RD51 test beam facility
= has used the RD51 Scalable Readout System (SRS)
Gas Detectors - Poster Session

A new calibration tool for the WE0 and WE01 Position Spectrometer
Speaker: H. Geller (Fizika Okeanov, Institute of Oceanology)
Material: Slides

A compact Time Projection Chamber for the Crystal Ball
Speaker: P. Gerber (Universitat Wurzburg, Germany)
Material: Slides

A new construction technique of high-geometrical high-transparency drift chambers for neutrino high-energy physics experiments
Speaker: G. Giordano (INFN)
Material: Slides

A new cylindrical drift chamber for the RD51 experiment
Speaker: M. Giraudi (INFN)
Material: Slides

A novel method to estimate the impact parameter on a drift chamber cell by using the information of single track fragments
Speaker: K. Hagiwara (RIKEN, Japan)
Material: Slides

A proposal to upgrade the ATLAS SPC system upgrade for the High Luminosity LHC
Speaker: Ricardo (SPC)
Material: Slides

Semi-conductor drift chamber prototype for the RD51 experiment
Speaker: J. Knopp (IIHE, Université Libre de Bruxelles)
Material: Slides

Characterization of large area resistive strip micro-megas detectors
Speaker: G. Paganini (INFN)
Material: Slides

Characterization of large area resistive strip micro-megas detectors
Speaker: G. Paganini (INFN)
Material: Slides

The RD51 project is in the list of RD51 members
Material: Slides

As a project they have/had permanent installation in the RD51 lab
Material: Slides

Has used the RD51 Scalable Readout System (SRS)
Material: Slides

Has used simulation tool for MPGD (Garfield etc.)
Material: Slides

Has used the RD51 test beam facility
Material: Slides

Photo Detectors and PID - Poster Session

Fast Timing in R&D for the HL-LHC
Speaker: R. White (Princeton University)
Material: Slides

Performance simulations studies for the ALEPH TPC GEM Upgrade
Speaker: F. Eland (Imperial College London)
Material: Slides

Performance studies of Trackers and Neighbouring Electronics for Operation at Very High Background Rates of Muon Colliders
Speaker: R. Johnson (CERN, Geneva)
Material: Slides

Resistive Micro-Megas for the RD51
Speaker: S. Lemire (CERN)
Material: Slides

Small-Scale Thin Gap Chambers for the Muon Spectrometer Upgrade of the ATLAS Experiment
Speaker: J. Knopp (IIHE, Université Libre de Bruxelles)
Material: Slides

Study of pion attenuation in GEM foil using Garfield
Speaker: P. Gerber (Universitat Wurzburg, Germany)
Material: Slides

Study of various phenomena in resistive micro-megas performance with an emphasis on the dependence of GEM performance on the degree of hydration
Material: Slides

Systematic measurements of radiation hardness of resistive micro-megas detectors
Material: Slides

The drift chamber with a newly designed anode for operation at high-rates
Speaker: J. W. Knecht (MPI, Munich)
Material: Slides

Triplet-readout Resistive Wire Chamber with Strip Readout for Particle Identification in the ATLAS and Higgs Experiments
Material: Slides

A new prototype for the ATLAS Muon Spectrometer with MWT1 Chambers
Material: Slides

Upgrades of the RD51 Muon Spectrometer with MWT1 Chambers
Material: Slides

A prototype of an RD51 Test Beam Facility with Strip Readout for Particle Identification
Material: Slides

Photo Detectors
Material: Slides

A new photomultiplier technology for 150 nm signals
Material: Slides

Photoemission measurements in gas ionization detectors
Material: Slides

Charge Transfer Properties Through Grazing Angle Incidence and Gaseous Detectors
Material: Slides

Photoemission coefficients in Gaseous Detectors
Material: Slides

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Photoemission coefficients in Gaseous Detectors
Material: Slides
Gas Detectors - Poster Session

A compact time projection chamber for the Crystal Ball
Speaker: Dr. Oliver Stecher (Institut für Kernphysik, Universität Mainz)
Material: Slides

A new construction technique of high-granularity and high-transparency drift chambers for neutrino high-energy-physics experiments
Speaker: Gianluca Ghigi (INFN)
Material: Slides

A new cylindrical drift chamber for the MEG II experiment
Speaker: Massimo Gelli (INFN)
Material: Slides

A novel method to determine the impact parameter on a drift chamber cell by using the information of single hit locations.

A proposal for the ATLAS SPC system upgrade for the high luminosity LHC
Speaker: Riccardo Venanzi (INFN)
Material: Slides

Building a prototype of a study to test a new concept for gas detectors
Speaker: Silvan Pasqualino (INFN)
Material: Slides

Characterisation of a wafer-scale silicon drift detector prototype on a sapphire substrate
Speaker: Tommaso Garavolli (INFN)
Material: Slides

Cylindrical Micromegas, an innovative concept for central trackers
Speaker: Dr. Maxence Vandenbroucke (CERN)
Material: Slides

Resistive MPGDs based on the Wrapping Technology
Speaker: Marco Poll Lener (CERN)
Material: Slides

A new prototype for the construction of a drift chamber for the MEG II experiment
Speaker: Fabrizio De Vittorio (INFN)
Material: Slides

Construction and commissioning of the SuperPHEMO drift chamber tracker prototype
Speaker: Paolo Lompré (CERN)
Material: Slides

Design of a gas-chamber based GEM Forward Detector system based on industrially produced detectors
Speaker: Lukas Sand (Universität München)
Material: Slides

Determination of the seeds which position is a straw of the new type using visible light
Speaker: Dr. Leonid Gesh (CERN)
Material: Slides

Flow imaging system (FIS) sensors as Fommos and mechanical stretching sensors
Speaker: Leopold Böhm (CERN)
Material: Slides

High resolution tracking for muon detectors at future colliders
Speaker: Lukas Sand (Universität München)
Material: Slides

High resolution tracking for muon detectors at future colliders
Speaker: Lukas Sand (Universität München)
Material: Slides

Design of GEM detector prototypes with the silicon-based high-granularity tracker at CERN
Speaker: Luis Gallo (ATLAS)
Material: Slides

Prototype gas detectors for the MEG II experiment
Speaker: Riccardo Venanzi (INFN)
Material: Slides

Photo Detectors and PID - Poster Session

Final status of the R&D for the HLT-LHC of the CMS collaboration
Speaker: C. A. Santos (INP, Sezione di Trieste, Trieste, Italy)
Material: Slides

Photo Detectors - Poster Session

Performance simulation studies for the ALEPH TPC GEM Upgrade
Speaker: Marie-Lise Lagrange (Université de Liège)
Material: Slides

Precision mass tracking Detectors and Readout Electronics for Operation at Very High Background Rates of Tracks Colliders
Speaker: Robert Iono (Institut für Kernphysik, Universität Mainz)
Material: Slides

Remote Interferometric Monitors for RD52
Speaker: Dr. Marlies Pfeiffer (Technische Universität München)
Material: Slides

Small-Scale Thin Gap Chambers for the Muon Spectrometer Upgrade of the ATLAS Experiment
Speaker: C. A. Santos (INP, Sezione di Trieste, Trieste, Italy)
Material: Slides

Study of pion polarisation and its impact on the physical parameters of GEN foil using Garfield
Speaker: Prof. Gianni Pani (Università di Milano)
Material: Slides

Study of the upgrade of the Muon detection system in the CMS experiment
Speaker: Dr. Christian Lippmann (GSI, Helmholtz-Zentrum für Schwerionenforschung)
Material: Slides

Systematic uncertainties in the total energy resolution of the CMS muon detectors
Speaker: C. A. Santos (INP, Sezione di Trieste, Trieste, Italy)
Material: Slides

The drift chamber with a new type of anodes for operation in vacuum
Speaker: Dr. Jürgen Pelikan (DESY, Hamburg)
Material: Slides

Upgrades of the CMS Muon Spectrometer with MDT chambers
Speaker: Dr. C. A. Santos (INP, Sezione di Trieste, Trieste, Italy)
Material: Slides

A cylindrical Micromegas-GEM Readout System for the CMS experiment
Speaker: Dr. Christian Lippmann (GSI, Helmholtz-Zentrum für Schwerionenforschung)
Material: Slides

Aging tests for the MEG II drift chamber
Speaker: Dr. Paolo Tesoriero (INFN)
Material: Slides

Prototype water clusters in TPC detector
Speaker: Dr. Thomas Mitter (Universität München)
Material: Slides

Photo Detectors and PID - Poster Session

Final status of the R&D for the HLT-LHC of the CMS collaboration
Speaker: C. A. Santos (INP, Sezione di Trieste, Trieste, Italy)
Material: Slides

Gas Detectors

Status of the Development of a large resolution drift chamber for CERN's high-luminosity LHC experiments
Speaker: Dr. Christian Lippmann (GSI, Helmholtz-Zentrum für Schwerionenforschung)
Material: Slides

Micromegas Detectors for the MEG II experiment
Speaker: Michele Bianco (INFN)
Material: Slides

A continuous read-out TPC for the CD with a 15° opening angle
Speaker: Dr. Christian Lippmann (GSI, Helmholtz-Zentrum für Schwerionenforschung)
Material: Slides

TPC-like readout for thermal neutron detectors using a GEM-detector
Speaker: Mr. Bernhard Bierich (JHU Munich)
Material: Slides

Cylindrical Micromegas, an innovative concept for central trackers
Speaker: Dr. Maxence Vandenbroucke (CERN)
Material: Slides

Resistive MPGDs based on the Wrapping Technology
Speaker: Marco Poll Lener (CERN)
Material: Slides

Charge Transfer Properties through Readout in Gaseous Detectors
Speaker: Filippo Rossetti (CERN)
Material: Slides

Photo Detectors and PID

Status of the Development of a large resolution drift chamber for CERN's high-luminosity LHC experiments
Speaker: Dr. Christian Lippmann (GSI, Helmholtz-Zentrum für Schwerionenforschung)
Material: Slides

Micromegas Detectors for the MEG II experiment
Speaker: Michele Bianco (INFN)
Material: Slides

A continuous read-out TPC for the CD with a 15° opening angle
Speaker: Dr. Christian Lippmann (GSI, Helmholtz-Zentrum für Schwerionenforschung)
Material: Slides

TPC-like readout for thermal neutron detectors using a GEM-detector
Speaker: Mr. Bernhard Bierich (JHU Munich)
Material: Slides

Cylindrical Micromegas, an innovative concept for central trackers
Speaker: Dr. Maxence Vandenbroucke (CERN)
Material: Slides

Resistive MPGDs based on the Wrapping Technology
Speaker: Marco Poll Lener (CERN)
Material: Slides

Charge Transfer Properties through Readout in Gaseous Detectors
Speaker: Filippo Rossetti (CERN)
Material: Slides
Gas Detectors

Status Report of the Upgrade of the TPC and GEM-
GEM project is in the list of RD51 member

Speaker: Dr. Gilles De Lomberdoker (Université Libre de Bruxelles)
Material: Slides

Micromegas Detectors for the MPT (MPT)

Speaker: Pasquale Sacati (INFN)
Material: Slides

A continuous read-out TPC for 15 - 15°

Speaker: Dr. Christian Lippmann (GSI, Fachhochschule für Schwerpunktforßchung)
Material: Slides

TPC-like readout for thermal neutron detection using a GEM-detector 15°

Speaker: Dr. Bernd Dietrich (UZH Munich)
Material: Slides

Cylindrical Micromegas, an innovation for central trackers, 15°

Speaker: Dr. Maxence van den Broucke (ESA, Saclay)
Material: Slides

Residive MPGDs based on the WFG Detector

Speaker: Marco Lamer (CERN)
Material: Slides

Charge Transfer Properties Through Gaseous Detectors in Large Area Micromegas

Speaker: Dr. Filippo Rossetti (CERN)
Material: Slides

Photo Detectors and PID

Status of the Development of LAr-TPC at TRIUMF

Speaker: C. A. Santos (INP, Sezione di Trieste, Trieste, Italy)
Material: Slides

Photo Detectors and PID - Poster Session

Photo Detectors and PID - Poster Session

Speaker: Alberto Del White (Princeton University)
Material: 

Gas Detectors - Poster Session

A new innovative technique for high-granularity and high-transparency drift chambers for future detectors

Speaker: Dr. Stefan Steinke (Institut für Physik, Universität Mainz)
Material: Slides

A new construction technique for the RD51 lab

Speaker: Riccardo Cerretti (INFN)
Material: Slides

A new cylindrical drift chamber for the RD51 lab

Speaker: Riccardo Cerretti (INFN)
Material: Slides

A novel readout for the RD51 Scalable Readout System (SRS)

Speaker: Ricardo Cerretti (INFN)
Material: Slides

A new proposal for the RD51 lab

Speaker: Riccardo Cerretti (INFN)
Material: Slides

Characterization of Large Area Micromegas Detectors

Speaker: Riccardo Cerretti (INFN)
Material: Slides

Characterization of Large Area Micromegas Detectors

Speaker: Riccardo Cerretti (INFN)
Material: Slides

Charge transfer properties of Micromegas Detectors

Speaker: Riccardo Cerretti (INFN)
Material: Slides

Construction and commissioning of the Supercell-MPD detector tracker prototype

Speaker: Riccardo Cerretti (INFN)
Material: Slides

Design of a new fully-professional Micromegas detector prototype

Speaker: Riccardo Cerretti (INFN)
Material: Slides

Determination of the new model parameter in a new type of cell using visible light

Speaker: Riccardo Cerretti (INFN)
Material: Slides

Filter Imaging (FIMM) sensors as Panem and mechanical stretching sensors

Speaker: Riccardo Cerretti (INFN)
Material: Slides

High resolution imaging for micro-detectors at future colliders

Speaker: Riccardo Cerretti (INFN)
Material: Slides

The impact of the performance of the sensors on the RD51 lab

Speaker: Riccardo Cerretti (INFN)
Material: Slides

Applications - Poster Session

MCP-GEM detector for Mixed Detectors

Speaker: Lee-guk Poon (PI)
Material: Slides

MCP-GEM detector with CREST sensor

Speaker: Lee-guk Poon (PI)
Material: Slides

MCP-GEM detector with L{_sup 2}O{sub 2} for Directed Detectors

Speaker: Lee-guk Poon (PI)
Material: Slides

MCP-GEM detector with a CREST sensor

Speaker: Lee-guk Poon (PI)
Material: Slides

MCP-GEM detector with a CREST sensor

Speaker: Lee-guk Poon (PI)
Material: Slides

MCP-GEM detector with a CREST sensor

Speaker: Lee-guk Poon (PI)
Material: Slides
RD51 (well consolidated) Working Groups

Technological Aspects and Development of New Detector Structures

Common Characterization and Physics Issues

Academia-Industry Matching Events, Training, Education

Common Facilities: Test Beam and Laboratory

Production, quality control, industrialization

MPGD Related Electronics

WG1: RD51

WG2: Simulations and Software Tools

WG3/NEW WG: GARFIELD & Co.

WG4: MPGD Related Electronics

WG5:

WG6:WG7:

WG4:

WG5:

WG6:

WG7:
Technological Aspects and Development of New Detector Structures

R&D support for experiments and LHC upgrades
Examples of CERN/LHC Upgrades ("large" achievement for MPG community)

**ALICE (GEM)**
- The ALICE upgrade strategy
- ALICE TPC overview
- Operation from RHIC to LHC
- GEM readout for the TPC
- Ion backflow optimization
- Prototype tests
- Expected performance in RHIC
- Read-out electronics
- Summary and Outlook

**ATLAS NSW (mm)**
- In the Barrel Region the ATLAS Muon Spectrometer is surrounded by RPCs and MRS detectors, while in the End Cap Regions CSC, MDT and TGC detectors are used
- The Small Wheel (Unmanned Endcap Muon Station) is the region with highest background rate in the present ATLAS Muon Spectrometer
- The present system is a Scintillating Crystal Strip Chambers (SCS), Monitored Ring Tubular Muonotope (MRM) and TGC for particle tracking
- Located between muon calorimeter and endcap torus

**IBF optimized configuration (2)**
- Satisfactory performance could not be achieved with 3 GEM stack
- Best results in terms of IBF and energy
- Standard GEM 50x50 mm, 65x65 mm

**IBF optimized configuration (7)**
- Electrons transport properties for IBF optimized voltage settings
- Interaction length, ionization efficiency
- Energy resolution, BGO segmentation
- Saturation effects of IBF and standard GEM

**Prototype beam tests: PID**
- Performance under standard conditions
- Measurement of momentum, energy, charge
- Simulation of interaction length, ionization efficiency

**Prototype beam tests: Stability**
- Performance under standard conditions
- Measurement of momentum, energy, charge
- Simulation of interaction length, ionization efficiency

LHC Upgrades: Original R&D efforts emerged from RD51 activities.
Today: production phase under the project effort, access to RD51 facilities (laboratory, test beam, workshops) and tools (simulation, electronics,...) to facilitate this particular phase
Examples of CERN/LHC Upgrades ("large" achievement for MPGD community)

CMS (GEM)

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

**CMS (GEM)**

- **R&D: 6 generations of triple-GEMs**
- **Aging studies**

**Performances**

- Test with GE1/1 at the CERN Gamma Irradiation Facility (GIF):
  - Incident rate = 300 kHz
  - 100% hit rate (30% muon flux)
  - 

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

**COMPASS RICH-1 (THGEM+mm)**

- **Motivation**
  - **Elba 2015**
  - **Status of the Development of Large Area Photon Detectors based on THGEMs and Hybrid MPGD architectures for Cherenkov Imaging Applications, C.A.Santos, Elba 2015**
WG2

Common Characterization and Physics Issues

Generic R&D

RD51 Common Projects
Examples of new ideas, applications....

Calorimetry with MPGD

Resistive Micromegas for Sampling Calorimetry

- New version using carbon sputtering is being tested
- Resistive GEM
- Resistive micro-PIC
- Resistive electrodes are made by very thin (50–300 nm) material
- It will improve the signal gain
- We have just made it, and it is being tested now.

A. Ochi

Resistive Material

O8/2014 KUBEC Workshop

New Large Area Thin Detectors

The μ-RWELL performance (1)

- Gain up to 10^6
- In the Lab
- 24A Amile source neutron moderated with PE
- Over 10kHz
- ϕ/τ > 10kHz
- 30μm thick Cu strips stop the 325L

A. Ochi

Neutrons Detection

European Spallation Source (ESS)

O3/2015

New Materials (Glass GEM)

The Latest Results of Crystalized Glass GEM, Y. Mitsuia, RD51 miniweek (GDD/RD51 lab)

B10

Gd

Fast Timing

MicroMegas based:
(initial tests March/April 2015)
Ne-Ethane(10%)-200 micron drift+50 micron Micro Bulk
μ-VME

≈50phe

≈50phe

36 picosecond rms on first try!!

Elba 2015

07/2015

New Large Area Thin Detectors
..with “open eyes” to new requirements

RD51 invited at the “Future Detector Technologies for FCC-hh” workshop

..and FCC present in one of the RD51 meetings
WG3

Applications - organization of series of specialized workshops disseminating MPGD applications beyond fundamental physics – RD51, potential users and industry (e.g. dosimetry, neutron detection, medical physics, ...)

New WG

MPGD Education and Training: organization of schools for students and newcomers & academic training
Academia-Industry Matching Events (understanding requirements, applications, approaching new communities and technologies)

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

- **14-15 October 2013**

Neutron Detection 1st

- **16-17 March 2015**

Neutron Detection 2nd

- **15-16 June 2015**

10-11 June 2015 (next week)

Photon Detection

Press release

Summary (arXiv 1410.1070)
RD51 & International School

RD51 schools

MPGD assembly

MPGD Simulation

MPGD Electronics

XII ICFA School (Bogota, Colombia)

Danube School on Instrumentation in Elementary Particle & Nuclear Physics (Novi Sad Serbia)

RD51 MPGD Lectures:

MPGD students lectures (1 week) at the International Workshop on Advance Detectors & RD51 CM in Kolkata

October 2014

End 2014 (Novi Sad)
Continuous implementation of the available tools and simulation capabilities

Aims:
- Accurate auger cascade model for ionisation of inner shells to give:
  1. Calculation of fano factors $W$, $F_1$, $F_2$, $F_3$ for photons and electron beam.
  \[ W = \text{e}/\text{ion pair} \quad F_1 = \text{width} \quad F_2 = \text{skew} \quad F_3 = \text{kurtosis} \]
  2. Single or double beta decay calculation to give electron cloud size, shape and numbers of electrons and photons (excimers)
  3. Calculation of number of clusters/cm and cluster size for particle tracks and $dE/dx$. (Uses infinitely thin gas plane). Can be of use in TPC analysis/simulation to give $N_{eff} = \text{number of clusters/cm} \times \text{cluster size}$

Uludag University, Bursa, Turkey
S.F. Biagi
RD51
17 JUNE 2014

Simulation & data for the better understanding of the detectors physics

Recent gas gain calculations:
Xe-TMA, C$_3$H$_8$- and CH$_4$-based TEG, Ne-CO$_2$

Ozkan Sahin & Tadeusz Kowalski
Uluedag University, Physics Department, Bursa – TURKEY
Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Krakow – POLAND

Detector Modelling

Mesh models

March 2015

Speeding Up the Garfield++

March 2015

Othmane Bouhali, Ali Sheharyar
Texas A&M University at Qatar

March 2015
... strong efforts in very specific needs.. ALICE TPC

Special Alice TPC / /RD51 workshop – June 2014

RD51 mini week


... strong efforts in very specific needs.. ALICE TPC

Special Alice TPC / /RD51 workshop – June 2014

RD51 mini week

- Cluster Ions
- Clustering Dynamics

Clustering Dynamics

Clustering Dynamics

Clustering Dynamics
Development and Maintenance of the SRS Electronics; An extended support for the SRS including new developments and implementations of additional features
The RD51 Scalable Readout System (SRS)

### SRS & APV25 FE chip
Worldwide use in the RD51 community (>2000 hybrids)

**SRS+SiPM (NEXT TPC)**
- Ongoing – Baseline
- SRS-FEC+TOTEM DAQ
- Closed to commissioning in UCS
- SRS+Timepix (LC-TPC) – Bonn/Desy

Very appealing for the future: VMM (**NSW ATLAS FE chip**)

**Baseline solution for RD51 SRS community.**

Interest and support from ESS (European Spallation Source) and ALICE FOCAL

**SRS: Different System**

- SRS for R&D on Detectors
- SRS for experiments (ATCA)
- SRS for spatially distributed system (optical SRS)

**Finalization of SRS ATCA**

**SRS+SiPM** (NEXT TPC)

**2015**

**SRS+Timepix (LC-TPC)** – Bonn/Desy

**Ongoing - scaled up**

**Half Done (started early 2014)**

http://indico.cern.ch/event/356113/session/6/contribution/29/material/slides/1.pdf
Laboratory equipments for MPGD developed by the RD51 community, few examples:

1. **GAVD board and E-fuse board**
   - 36 to 54 e-fused sectors per G-AVD Unit*
   - 18 HV wires to GEM sectors/board
   - 2..3 stacked E-fuse boards
   - 1st board by 27/03
   - (*) SRS compliant
   - [CERN]
   - Ongoing

2. **APIC Analogue Pickup box**
   - (* SRS compliant)
   - APIC box
   - CSA preamplifier dual polarity 100 ns shaper
   - Variable gain max. 900mV
   - Calibration 10 kHz 50 fc
   - [CERN]
   - Ongoing

3. **QUAD MPGD signal amplifier**
   - 2 GHz, 25dB
   - [CERN]
   - Ongoing

4. **Femtometer V 1.3**
   - (*) SRS compliant
   - [CERN]
   - Ongoing

5. **Floating Multichannel Pico Ammeter**
   - (Optical data transmission)
   - March 2015
   - [Zagreb Univ.]

6. **MoCoS: Monitoring and control system**
   - [CERN]
   - November 2014
   - (*) SRS compliant
MPGD Industrialization and QA Control - GEM, MicroMegas, Thick GEM; Completion of the industrialization of main technologies
Technology: MPGD Production @ CERN

Interesting Workshop Overview Capabilities

MPGD Projects....

- SBS tracker
- ALICE TPC upgrade
- CMS muon
- ATLAS NSW muon
- COMPASS pixel Micromegas
- BESIII
- KLOE
- SOLID
- CLAS 12
- LSBB (geoscience)
- Prad
- CBM
- ASACUSA

Most of them are still at the R&D phase but some are already in production:

- ATLAS NSW: 1300 m²
- SBS Tracker: 100 GEMs
- ALICE TPC upgrade: 350 GEMs
- COMPASS pixel Micromegas: 20 GEMs + Micromegas
- BESIII: 15 GEMs
- CLAS 12: 30 Micromegas
- CMS: 450 GEMs

New Capabilities....

- UV exposure unit limited to 2m x 0.6m → 2.2m x 1.4m
- Resist developer limited to 0.6m width → 1.2m
- Resist stripper
- Copper etcher
- Dryer
- GEM electro etch limited to 1m → 2m
- GEM polyimide etch limited to 1m → 2m
- Ovens limited to 1.5m x 0.6m → 2.2m x 1.4m
- Laminator limited to 0.6m width → 1.2m

Installation of the new infrastructure (to fabricate 2x1m² Bulk MM & 2x0.5m² GEM) COMPLETED

Construction of the new workshop’s building:

Start: beginning 2012
End: end 2017
Technology: Industrialization

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

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

**THGEM Technology (contacts):**
- ELTOS S.p.A. (Italy),
- PRINT ELECTRONICS

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

**MicroMegas Technology (contacts):**
- ELTOS S.p.A. (Italy)
- TRIANGLE LABS (USA, Nevada)
- SOMACIS (Italy, Castelfidarco)
- ELVIA (France, CHOLET)

**GEM Industrialization Status (today):**

**TECH-ETCH**
- Single Mask process fully understood. Many 10cm x 10cm produced and characterized.
- 40cm x 40cm GEM successfully produced
- CMS GE1/1 size of 1m x 0.5m started

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

**MECHARONICS**
- 10cm x 10cm double mask produced and tested
- 30cm x 30cm double mask under evaluation @ CERN
- CMS GE1/1 size of 1m x 0.5m started

**Micromegas Industrialization Status (today):**

**ELVIA**
- Bulk Micromegas detectors are routinely produced with sizes up to 50cm x 50 cm.
- Contract for ATLAS NSW module-0 signed
- Tendering process for full production ongoing

**ELTOS**
- Many small size bulk Micromegas detectors have been produced.
- Contract for ATLAS NSW module-0 signed
- Tendering process for full production ongoing
WG7

Maintenance and extension of the RD51 Lab and Test-Beam Infrastructure
PH-DT-DD GDD Laboratory ... Laboratory available for the RD51 collaboration

Permanent installations (Today): ALICE, ATLAS, ESS
CMS moved roughly two years ago to TIFF, access to the lab for specific measurements
More than 15/20 groups per year coming to perform measurements

Clean Rooms

Mechanical and Electronic Workshop

Technical support
MPGD Detectors
Gas system and services
Readout electronics (std and custom RD51 SRS&APV)
Radioactive Sources
Interface with CERN services (RP, gas, metrology, irradiation facilities,...)

Continuously running....." twenty-four seven"
Semi permanent test beam in the SPS extraction Line

Three periods of two weeks each per year
About fifteen-twenty users per year

Goliath Magnet → Ship?

A warm and special thanks to the SPS, the North Area Facility and to all the people that supports our installations

2014 test Beam

December 2014

CMS (GEM)  WIS/A/C(WELL, THGEM)  ATLAS NSW (mm)  BESS III & SHIP (GEM)  LAPP/DEM/IRFU(mm)  ALICE TPC (GEM and mm)

2015 test Beam: May-June (now), July, October
IWAD conference & RD51CM

October 2014 (Kolkata)

MPGD conferences & RD51CM

October 2015 (Trieste)
The Collaboration would like to ask LHCC for continuation of:

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

And:

- Extra space for electronics laboratory for development near to the detector laboratory to facilitate the advances on the new activities (VMM FE chip in particular).
- Extra office space (for RD51 members, visitors and students)
RD51 Achievements Highlights [2008-2013]

- Consolidation of the Collaboration and **MPGD community integration** ( >80 Institutes, >400 members);

- Major progress in the MPGD technologies development in particular **large area GEM** (single mask), **MicroMegas** (resistive), **THGEM**; some picked up by experiments (including LHC upgrades);

- **Secured future** of the MPGD technologies development through the TE MPE workshop upgrade and FP7 AIDA contribution;

- Contacts with industry for large volume production, **MPGD industrialization** and industrial runs;

- Major improvement of the MPGD **simulation software** framework for small structures allowing first applications;

- **Development of common, scalable readout electronics (SRS)** (many developers and > 50 user groups); Production (PRISMA company and availability through CERN store); **Industrialization** (re-design of SRS in ATCA in EISYS);

- **Infrastructure** for common RD51 test beam and lab facilities (>20 user groups)
RD51 Achievements Summary and future

- Consolidation of the Collaboration and MPGD community integration (>80 Institutes, >400 members);
  - **WORLDE DISSEMINATION** and large support to **NEW COMMUNITIES**
  - **ACADEMIA-INDUSTRY MATCHING EVENTS**
  - **TRAINING & SCHOOLS**

- Major progress in the MPGD technologies development in particular large area GEM (single mask), MicroMegas (resistive), THGEM; some picked up by experiments (including LHC upgrades);
  - **MPGD SELECTED FOR EXPERIMENTS** AND **LHC UPGRADES** as a result of these major progresses.
  - **PHASE-DRIVEN** (R&D or production) **SUPPORT**
  - **NEW REQUIREMENTS** (future experiment driven) and **NEW AREA of USE**

- Secured future of the MPGD technologies development through the TE MPE workshop upgrade and FP7 AIDA contribution;
  - **CERN MICRO PATTERN TECHNOLOGY WORKSHOP** scaled up to **SQUARE METERS** detector size

- Contacts with industry for large volume production, MPGD industrialization and industrial runs;
  - **CONSOLIDATION** of the industrial **PRODUCTION** and manufacturing **QUALITY** for **ALL** the main MPGD families.

- Major improvement of the MPGD simulation software framework for small structures allowing first applications;
  - **IMPROVEMENTS** on **SIM. METHODS** and **TECHNIQUES** with direct **APPLICATION** for MPGD optimization in **LHC EXPERIMENTS**

- Development of common, scalable readout electronics (SRS) (many developers and >50 user groups); Production (PRISMA company and availability through CERN store); Industrialization (re-design of SRS in ATCA in EISYS);
  - **SUPPORT** and continuous **DEVELOPMENT**
  - **NEW BASELINE FE ASICS** (from experiment development) and **SRS STRUCTURES**
  - Development of **EASILY** accessible MPGD laboratory **INSTRUMENTATION**.

- Infrastructure for common RD51 test beam and lab facilities (>20 user groups)
  - Largely **ENLARGED** infrastructure for the **RD51 LAB.** **REFINEMENT** of the **TEST BEAM** infrastructure.
backup
2 members in the Management Board

10 groups

3 groups

10 members in the Management Board

58 groups

15 groups

1 members in the Management Board
MPGD & Calorimetry (P. Colas)

Dedicated Session (P. Colas) in one of the RD51 meeting

Sampling with MPDG/Micromegas

Still, (Micro Pattern) gas detectors present several advantages
Cheap (argon), proportional mode, large area, fine segmentation, no ageing, no rate dependency
Micromegas, 3 mm drift gap, 1x1 cm² pads
MIP ~ 0.3 keV (15 e-MV), Moliere radius already high (4.5 cm) but fine for H⁺
HCAL (1.5 cm Fe absorbers), 50 GeV pion shower (Ge4)
@ shower max.: 200 keV/layer, 50 keV in central pad with flux of
in usual Ar-CO₂ mix.: all electrons arrive at the mesh in < 75 µs
ECAL (2.5 mm W absorbers), 50 GeV electron shower:
200 keV in central pad

Resistive pads micromegas (M. Chefdeville et al.)

The μ-RWELL: a novel architecture (I)

The goal of this study is the development of a novel MPGD by combining in a novel approach the solutions and improvements proposed in the last years in the field (RD51).

The μ-RWELL is produced using a “suitable patterned GEM foil” with the readout PCB and a resistive deposition (100 µM). The resistive deposition is performed by screen printing robust against discharges.
The μ-RWELL is realized on a 50 µm thick polycarbonate foil, with conical channels (top) diameter and 140µm pitch.
A GEM electrode, defining the gas conversion drift gap, completes the detector compact & simple to build.

GEM & resistive WEL (G. Bencivenni et al.)

Test beam results - SRWELL for (S)DHCAL

Beam test evaluation:
- SRS/APV readout
  - 4.8 - 6.3 mm thick single- and double-stage configurations
  - Gains 1000-8000
  - Detection efficiency > 95% @ pad multiplicity ≤ 1.2

SRWELL and resistive WELL (S. Bressler et al.)

THGEM & resistive WELL (S. Bressler et al.)

Studies with MICOROC
- THGEM/MICOROC: successful operation in μ-beam and π-beam, inc. showers
- SRWELL/MICOROC: promising preliminary lab R&D

S. Bressler et al., JINST 8 P09013 (2013)
Particle Flow calorimetry

Production steps (1)
- Standard PCB with Cu backplane and xtal, thickness 0.4 mm, 35.μm Cu
- Filling over metalized film with glue (Inkjet and Laser UV cure)
- Photoelectrographic deposition of Resistive strips
  - Coating the Cu surface with resistive paint (SU-8)
  - Coating of a spot in order to prevent micro- and voids
- Etching of the copper up to reaching the Cu image
- Hot pressing onto the front plane of the mother PCB

Sampling with MPDG/Micromegas

Still, (Micro Pattern) gas detectors present several advantages
Cheap (argon), proportional mode, large area, fine segmentation, no ageing, no rate dependence

Micromegas, 3 mm drift gap, 1x1 cm² pads
- MIP = 0.3 keV (15 e- MPV). Motere radius already high (4.5 cm) but fine for HCAL
- HCAL: (2.5 cm Fe absorbers), 50 GeV pion shower (G4)
- @ shower max: 300 keV / layer, 60 keV in central pad with fluctuations up to 300 keV
- In normal Ar CO2 mix, all electrons arrive at the mesh in < 75 ns
- ECAL: (2.5 mm W absorbers), 50 GeV electron shower (G4): 180 keV in central pad

Electrode resistivity

Resistive electrode shape
Horizontal R not suited for large-area (R linearly adds up), through PCB via not cost effective
Vertical R fully scalable – stick to embedded R and minimise rate effects, i.e. minimise RC

What is the effect of RC on signal magnitude?

Experimental protocols

Rate scan @ constant dE/dx: X-gain
dE/dx scan @ constant rate: O&M injector
Rate scan @ variable dE/dx: pion beam (shower)
Fast Timing MPGD

Fast Timing for High-Rate Environments: A Micromegas Solution (Giomataris et al.)

Primary ionization: photoelectrons

- Cherenkov light produced by charged particles crossing a MgF₂ crystal
- Photoelectrons extracted from a photocathode (CsI)
  → Simultaneous & well localized ionization of the gas

Reflective mode

Semitransparent mode

MicroMegas based:
(initial tests March/April 2015)
Ne-Ethane(10%)-200 micron drift+50micron Micro Bulk

Preliminary

36 picosecond rms on first try!!

https://agenda.infn.it/getFile.py/access?contribId=23&sessionId=12&resId=0&materialId=slides&confId=8397

Tests with femtosecond laser

https://indico.cern.ch/event/365380/session/6/contribution/52/material/slides/1.pdf
MPGD & Resistive Materials: spark protection and ....

Resistive Micromegas for Sampling Calorimetry

- Calorimetry at future collider will be based on Particle Flow (PF)
  - highly segmented calorimeters (small pads, many layers)
- Micromegas meets most of the technical and performance requirements (m²-size prototypes)...
  ...but sparking might result from dense shower ionisation (e.g. nuclear recoils, EM shower core)
  - spark suppression by means of resistive coatings

What resistive coating? Embedded resistor

- Allows charge evacuation from top-to-bottom
  - no lateral charge dispersion
- maintain calorimeter imaging capability

The μ-RWELL: a novel architecture (I)

The goal of this study is the development of a novel MPGD by combining in a unique approach the solutions and improvements proposed in the last years in the MPGD field (RD51).

- The μ-RWELL is realized by coupling a “suitable patterned GEM foil” with the readout PCD plane coated with a resistive deposition (100 MO).)
- The resistive coating is performed by screen printing to robust against discharges.
- The WELL matrix is realized on a 50 μm thick polyamide foil, with conical channels 70μm (50 μm) top (bottom) diameter and 140μm pitch.
- A cathode electrode, defining the gas conversion/drift gap, completes the detector → compact & simple to build.

Other MPGD development using carbon sputtering

- Resistive μ-PIC
  - New version using carbon sputtering is being tested
- Resistive GEM
  - The resistive electrodes are made by very thin (50 - 300nm) material
    - It will improve the signal gain
    - We have just made it, and it is being tested now.
      - (Scienergy + Raytech)

As low as possible to keep the rate capabilities and response linearity

Space resolution Improvement
Conversion Layers: neutrons & MPGD & ESS (European Spallation Source)

In the Lab

$^{241}$AmBe source
neutron moderated with PE
Over 10x10cm²:
- $n < 100\text{Hz}$
- $\gamma/X >> 100\text{kHz}$

50µm thick Cu strips
stop the $\alpha/\text{Li}$
Resolution evaluated from the sharpe edge

B-GEM TPC

Data

Spectra and detection efficiency

- Spectra comparable to simulated spectra for 10 mm drift
- First estimation of neutrons detection efficiency: $> 9\%$
  - Neutron rate with beam of 2cm x 2cm and He3 tube in front of GEM: 11 kHz
  - Rate in GEM with beam of 2cm x 2cm (without He3 tube): 4.7 kHz
  - Background rate in GEM with beam of 2cm x 2cm with Cd sheet in front: 3.7 kHz

Electron tracking

- The conversion electrons leave long more or less straight tracks in the drift space
- Centroid calculation not sufficient to determine position
- Tracking method like $\mu$TPC method is needed to determine the start point of the track
- Fit more complicated than in case of alpha particles (see talk by F. Resnat)

Position resolution 2cm x 2cm beam

- Resolution with very simple method (last time bin over threshold): 1.4 mm
- Improvement likely with better fit, better collimation and less background

Strong interaction with RD51
MPGD Detector R&D and electronics (RD51 SRS & ATLAS NSW VMM)
MPGD & New Materials... new applications and fields

The Glass GEM

**Univ. Tokyo, Fujiwara group**

![Image of Glass GEM](image_url)

**Photo Etchable Glass 3: PEG3**

GEM fabricated with photo-etchable glass
- No outgas
- Stable material

- Substrate: PEG3
- Thickness: 680 μm
- Hole dia.: 170 μm

**Development of Glass GEM**

- **Univ. Tokyo, CNS group**

- Possible applications
  - Neutron counter: no hydrogen -> small background
  - Gaseous PMT: clean material
- Photosensitive Etching Glass: HOYA PEG3C
- Pitch 140 μm & hole size 70 μm & thickness 100 μm
- Reasonable gain & resolution with Ne/CF4 (90/10) & Ne/CO2 (80/20)

**Gaseous PMT**

**Yamagata U. TMU, HAMAMATSU**

- To suppress the ion- and photon-feedback, we have been developing a gaseous PMT using MPGDs such as GEM, Micromegas and glass capillary plate (CP).

<table>
<thead>
<tr>
<th>Sensor type</th>
<th>Sensitivity</th>
<th>Position Resolution</th>
<th>Timing Resolution</th>
<th>Uniformity</th>
<th>Price</th>
<th>Magnetic Field</th>
<th>Effective Area</th>
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</thead>
<tbody>
<tr>
<td>Vacuum PMT</td>
<td>★</td>
<td>△</td>
<td>★</td>
<td>△</td>
<td>O</td>
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<td>⃝</td>
<td>×</td>
<td>★</td>
<td>△</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Gaseous PMT</td>
<td>★</td>
<td>△</td>
<td>★</td>
<td>×</td>
<td>×</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

- The advantage of the gaseous PMT:
  - It can achieve a very large effective area with moderate position and timing resolutions.
  - It can be easily operated under a very high magnetic field.

**Development of GasPMT with MB-CP and CsI photocathode (TMU, Yamagata U., Hamamatsu)**

- Effect of Ion-feedback is observed. Ni mesh suppresses the effect.
Consolidation of existing structures: Cylindrical detectors as an example
Kapton Etching

Ethylene and soap Tank for large detectors
Ethylene Tank for Microbuls
Kapton Etching online

Screen Printed Resistive Layer for ATLAS

50um Kapton + resistive strips + glue + hole
25um solid Glue
High temp Gluing
Resistor HV connection ESL 1901 SD by local screen Printing (manual)
Pillars creation
We Need a large screen printer

https://indico.cern.ch/event/352483/

Large GEM PRAD and CMS

Standard pattern 140um pitch/70um holes : 40 000 000 holes

ATLAS Detectors

- Picture : 2m x 1m x 10 mm Aluminum honeycomb drift panel
- Mesh stretched and glued on a frame
- Max size: 3.4m x 2.2m in one piece

- Picture : 2m x 1m x 0.5 mm read-out board with pillars in 4 parts
- 10 mm thick Aluminum honeycomb
- Max size for 1 PCB : 2.2m x 0.6m

01/06/2015

LHCB CMS ALICE PRAD SBS SOLIDE KLOE
CERN E.U.
INFIN
Micromegas with Embedded Resistors

1. Press the Coverlay already drilled on the PCB R/O board
2. Screen print the vias (fill the holes with Silver paste, polymerized 1h at 170 degrees)
3. Screen print the embedded resistors (polymerized 2 h at 170 degrees)
4. Press the Coverlay already drilled
5. Screen print the Vias (polymerized 1h at 170 degrees)
6. Screen print the top layer resistors (pads or another shape, polymerized 2 h at 170 degrees)
7. Manufacture the BULK.

We can choose the shape and the resistive value.

Shapes and Values
Mr. Chefdeville Detectors for the LAPP

- $R = 0.33 \, \text{cm}$
  - $R(100 \, \text{kOhm}) = 800 \, \text{kOhm}$
  - $R(1 \, \text{kOhm}) = 40 \, \text{kOhm}$

- $L = 1.3 \, \text{cm}$
  - $R(100 \, \text{kOhm}) = 40 \, \text{kOhm}$
  - $R(1 \, \text{kOhm}) = 400 \, \text{kOhm}$

Real values:
- 40 to 60 kOhms with 10kOhm/sq
- 40 to 750 kOhms with 100kOhm/sq

MCM-C
Multi Chip Module ceramic

Semi Automatic Screen Printer
MPT & Large MPGD assembly

Open

Closed

https://indico.cern.ch/event/342026/session/20/contribution/240/material/slides/0.pptx
**Scalable Readout System (SRS)**

& **APV25... few examples**

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**Beam Data (ATLAS)**

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**Laboratory Measurements (GDD)**

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**X-Ray Imaging (Glass GEM, Tokyo @GDD)**

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**B-GEM TPC**

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**Neutron & B10 (ESS)**

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**Muon Tomography @ FIT**

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**Uniformity Map (CMS-GEM)**

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New Projects:

- Measurement and calculation of ion mobility of some gas mixtures of interest (GSI/LIP Coimbra /University of Bursa (Turkey)/ VECC, Kolkata (India))

- Development of a novel Micro Pattern Gaseous Detector for Cosmic Ray Muon Tomography (INFN Roma 3 and Universita’ di RomaTre/National Technical University of Athens/CERN-ATLAS)

- Fast Timing for High-Rate Environments: A Micromegas Solution (RD51: IRFU-Saclay/NCSR Demokritos/CERN/RD51&Uludag University/Universidad de Zaragoza; Ext. Coll.: Rockefeller-FNAL/Princeton University)