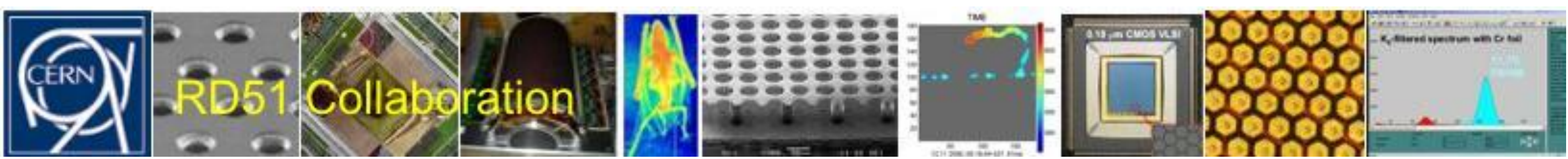
RD51

143rd LHCC Meeting

Eraldo Oliveri CERN EP DT GDD

on behalf of the RD51 Collaboration



Outline

- Collaboration Overview
- RD51 R&D Framework
  - Scientific Cultural Reference, Knowledge Transfer and Dissemination, Common Projects
  - Common Tools
  - Common Facilities and Infrastructures
- MPGD Technologies and Dissemination
- Summary

Remarks

It's **PAST YEAR UPDATE**.. If not mentioned or explicit

Slightly **CERN BIASED..** Because of speaker and because we are @ LHCC

For sure **NOT EXHAUSTIVE…** apologize to my colleagues

Collaboration Overview

Collaboration Overview: Extension 2019-2023

RD51 R&D environment

3rd five-Year term

People – core service; generic and support R&D group

Community:
- open information and experience exchange
- organization of the conferences, meetings, workshops, schools, lectures, trainings, AIMEs
- contribution to the development, maintenance and user support of the infrastructure, electronics and software tools
- education of the new generation of instrumental physicists

Common infrastructure – R&D lab and test beam facilities

Electronics support: dedicated to Detector R&D

Software & simulation tools for detector physics

Diversified Resources
- CERN
- Collaborating institutions and projects contributions
- Industry
- EU projects
- Project synergies

Generic R&D
- Moving performance to the limits
- Developing new concepts and applications
- Support grants to explore innovative ideas

Project Oriented R&D
- R&D support to the projects and experiments
- Access to the R&D environment

Interdisciplinary CERN wide Instrumentation R&D
- Access to CERN and external facilities :
- MPT
- Thin Film Deposition
- Mechanics, designer office, 3D printing
- Metrology
- Nano Lab (EPFL)
- Industry (strategic partnership) and TT
- …

Reminder

May 2018

arXiv:1806.09955v1 [physics.ins-det] 26 Jun 2018

R&D PROPOSAL
RD51 EXTENSION BEYOND 2018

EDITORS:
S. Dalla Torre (INFN Trieste), E. Oliveri (CERN), L. Ropelewski (CERN), M. Titov (CEA Saclay)

Abstract

The RD51 Collaboration, in charge of the development and dissemination of MicroPattern Gaseous Detectors (MPGD) since 2008, proposes to extend its activity, after 2018, for a further five-year term. Since the RD51 initial years, the community of MPGD developers and users has grown considerably. It is reflected by the many MPGD-based applications in high energy and nuclear physics experiments as well as in other basic and applied-research fields. They rely on the parallel progress of detector concepts and associated technologies. The cultural, infrastructure and networking support offered by RD51 has been essential in this process. The rich portfolio of MPGD projects, under constant expansion, is accompanied by novel ideas on further developments and applications.

The proposed next term of RD51 activities aims at bringing a number of detector concepts to maturity, initiating new projects and continuing the support to the community. Among leading proposed projects are ultrafast, high-rate MPGDs; discharge-free, high-resolution imaging detectors with resistive elements and high-granularity integrated electronics; novel noble-liquid detector concepts, including electroluminescence in gas bubbles; studies of environment-friendly counting gases and long-term sealed-mode operation; optical-readout detectors with radiation-hard imagers for fundamental research experiments, radiography and other domains.

The proposed R&D program is also expected to enrich our basic knowledge in detector physics, to form a generation of young detector experts - paving the way to new detector concepts and applications. The vast R&D program requires acquiring additional, up-to-date expertise in advanced technologies.

1

https://arxiv.org/pdf/1806.09955.pdf

CERN/LHCC-2018-018
LHCC-134
May 2018

LARGE HADRON COLLIDER COMMITTEE

s of the one-hundredth-and-thirty-fourth meeting held on

Wednesday and Thursday, 30-31 May 2018

›pment of Micro-Pattern Gas Detectors Technologies

s an established collaboration with the aim to develop Micro-Pattern Gas ›r (MPGD) technologies, to support experiments using this technology, and ›minate the technology within particle physics and in other fields. The ration is well organised into seven working groups covering activities from tector structures and electronics, to modelling, test facility management ustrialisation.

- The collaboration has achieved major progress in MPGD technologies, some of which have already been picked up by experiments: ALICE TPC readout, ATLAS NSW, CMS GE1/1 forward detectors, Compass RHICH detector. The committee congratulated the collaboration for its progress since the last review session.
- A prolongation request for 5 years has been submitted to the present session of the LHCC. Apart from the support of the ongoing projects, the proposal included plans to explore new materials and technologies to achieve ever better resolution in space and time and open the door to new use cases both in HEP and elsewhere.

- The **LHCC recommends** granting RD51 the 5-year extension requested, including CERN support at the level currently provided. Progress will be reviewed every year by the LHCC. The **LHCC considers** the working mode of RD51, with a small but focussed core team and corresponding infrastructure at CERN, attracting contributions and bright ideas to be explored from collaborators around the world, to be an excellent setup. The **LHCC notes** that the CERN contribution to RD51 as listed in the proposal is crucial for the collaboration, and **strongly encourages** CERN to maintain its support of RD51.

https://cds.cern.ch/record/2621145/files/LHCC-134.pdf

Collaboration Overview: Objectives and Achievements

Advance the technological development and application of MicroPattern Gas Detectors (MPGDs) and contribute to the dissemination of these technologies.

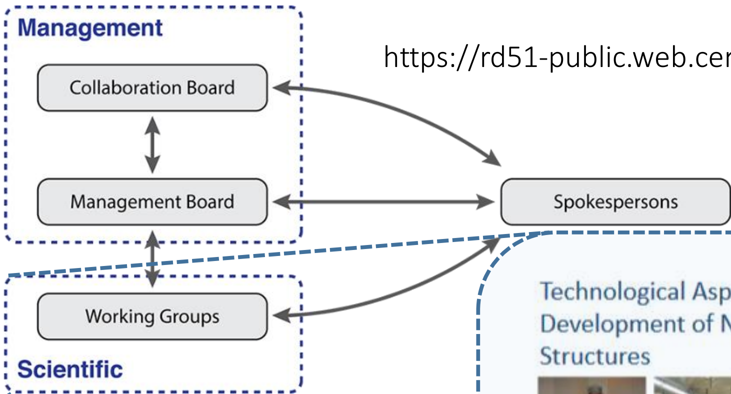
Development	Dissemination	Tools and facilities
Exploit existing technologies Large size single-mask GEMs Resistive Micromegas	**High-Energy Physics** ALICE, ATLAS, CMS, Compass, KLOE, BESIII	**Common infrastructures** (GDD lab, common test beam)
Develop novel technologies μPIC, μR-WELL, GRIDPIX	**Fundamental research beyond HEP** LBNO-DEMO, active-target TPCs	**Electronics** (Scalable Readout System SRS, instrumentation)
	Beyond fundamental research Muon radiography, n-detection, X-ray radiographies	**Simulation** (Garfield, Magboltz, Degrad, neBEM)

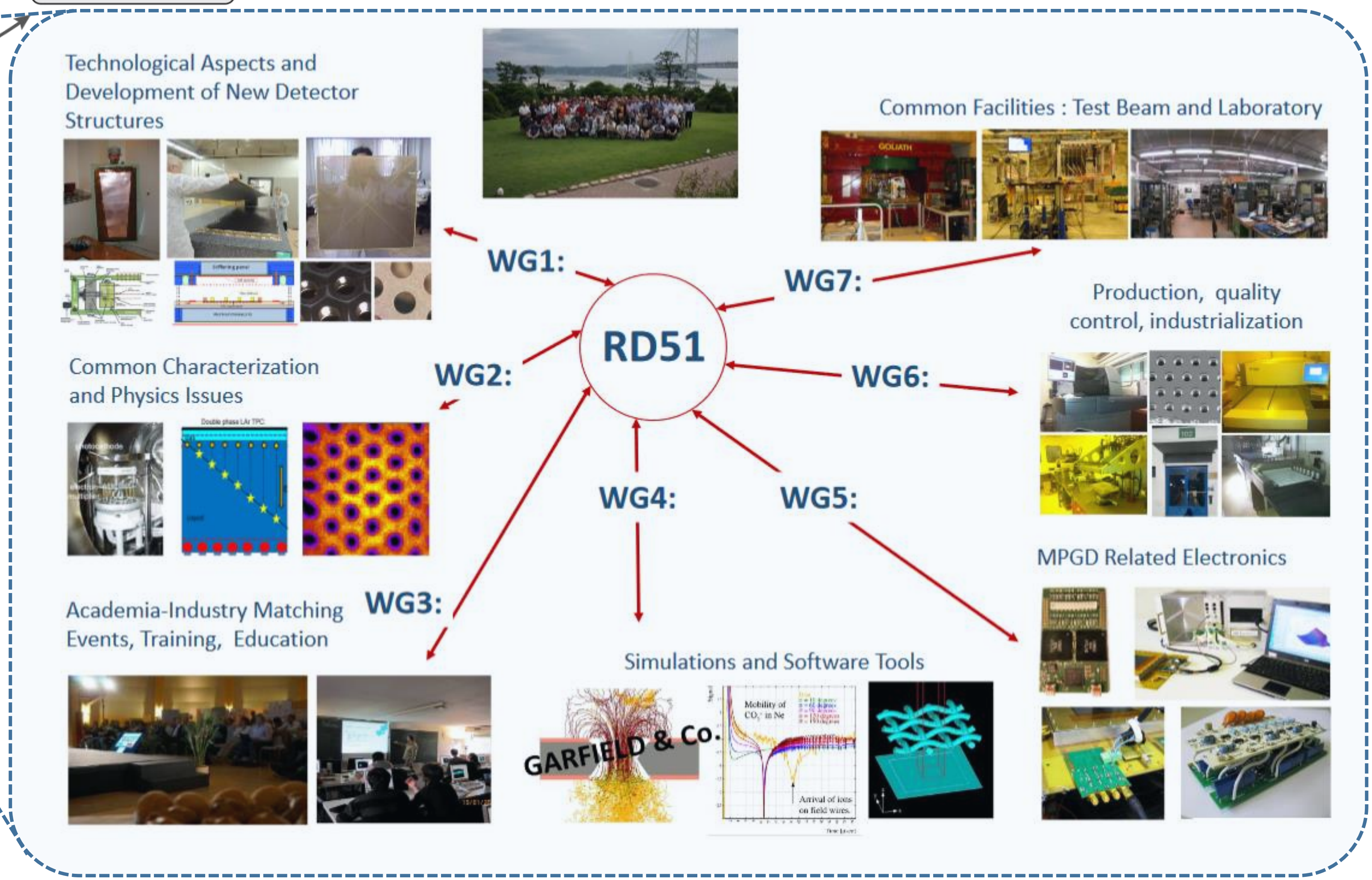
Reminder

F. Brunbauer, RD51Development of MicroPattern Gaseous Detector Technologies @ **EP R&D Day - Getting started**
https://indico.cern.ch/event/842794/contributions/3589907/attachments/1932549/3201341/RD51_EP-RD.pdf

Collaboration Overview: Working Groups

https://rd51-public.web.cern.ch/organisation-management

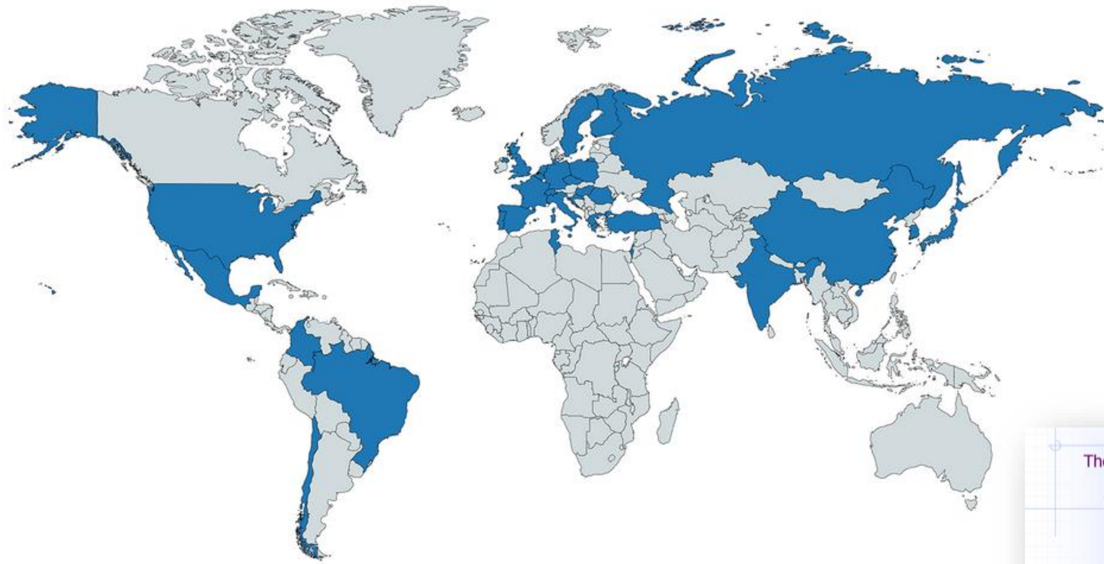




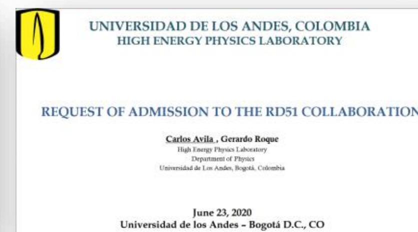
Reminder

Collaboration Overview: Teams

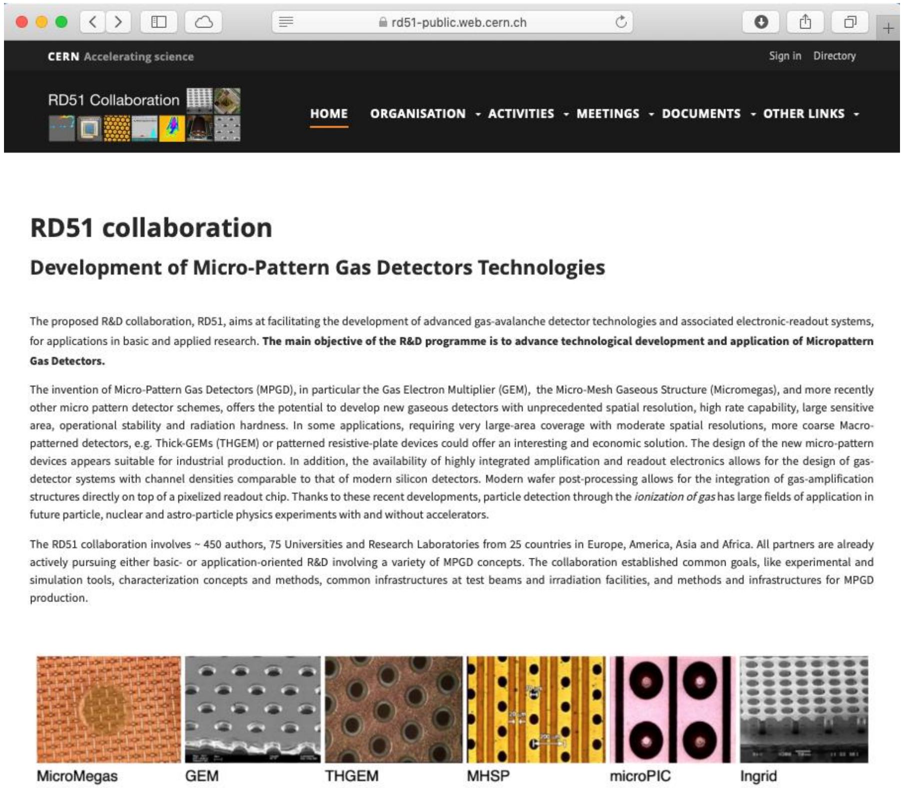
~450 Participants from 89 Institutes from 31 Countries



Past year new memberships



More info in the **re-designed** RD51 Web page



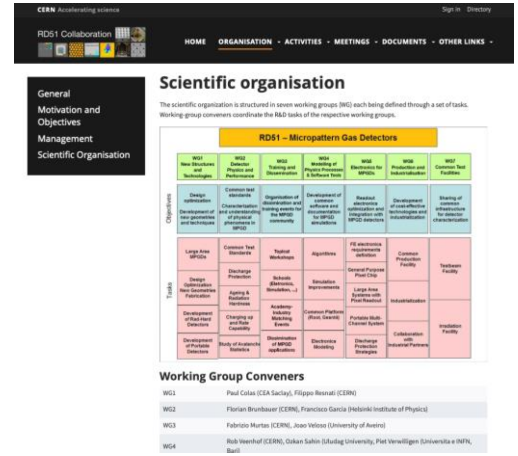
F. Brunbauer

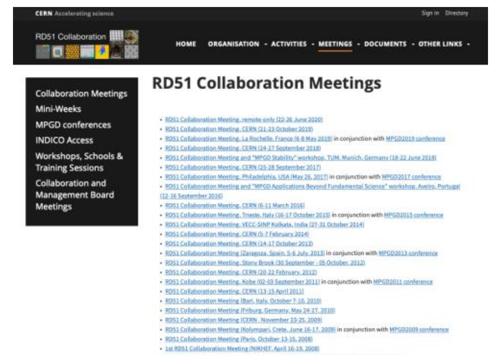
https://rd51-public.web.cern.ch/

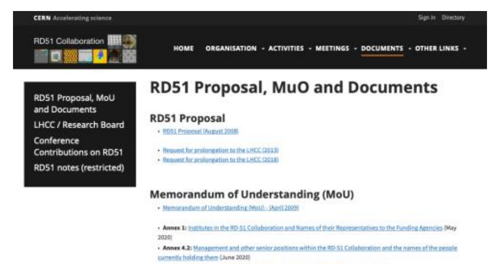
General overview
- Objectives
- Organisation
- Management
- Working Groups
- Common Projects

Meetings and conferences
- Collaboration Meetings & Mini Weeks
- MPGD conferences
- Workshops, Schools & Training Sessions

Documents
- RD51 Proposal
- MoU
- LHCC/Research Board
- Conference Contributions
- RD51 Notes

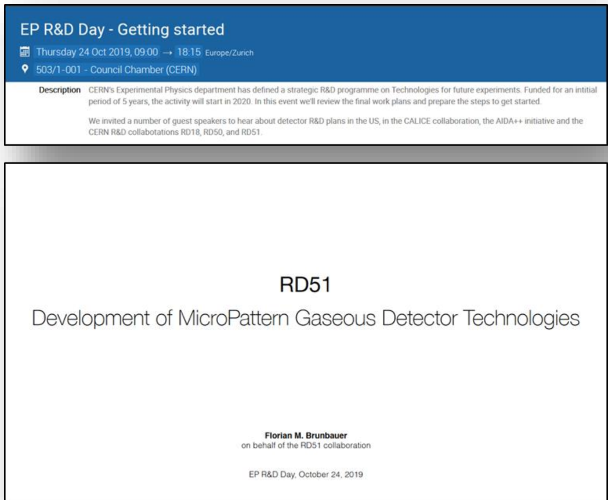






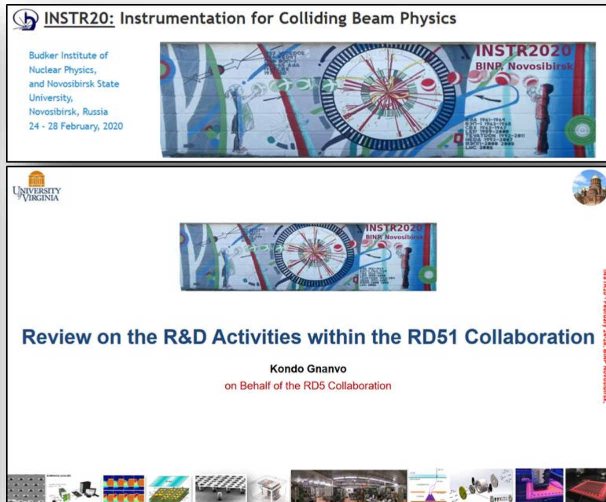
Past year invited “**RD51 review talks**” & “RD51 IN invited review contributions”

CERN EP R&D Day



https://indico.cern.ch/event/842794/contributions/3589907/attachments/1932549/3201341/RD51_EP-RD.pdf

INSTR20



https://indico.inp.nsk.su/event/20/contributions/795/attachments/524/609/INSTR20_KG_20200228.pdf

INSTR20

Not really fair…

https://arxiv.org/ftp/arxiv/papers/2006/2006.08239.pdf

RD51 model and achievements in the Instrumentation review talk of INSTR20

… by… M. Titov

RDS51 Contribution to **International Scientific Studies**

Input to the European Particle Physics Strategy Update 2018-2020

1 November 2018 to 19 December 2018

Development of the Micro-Pattern Gaseous Detector Technologies: an overview of the CERN-RD51 Collaboration

Development of the Micro-Pattern Gaseous Detector Technologies: an overview of the CERN-RD51 Collaboration

Contact persons: S. Dalla Torre (INFN Trieste), E. Oliveri (CERN), L. Ropelewski (CERN), M. Titov (CEA Saclay)

Representing the RD51 Collaboration

e-mail addresses: Silvia.DallaTorre@ts.infn.it, Eraldo.Oliveri@cern.ch, Leszek.Ropelewski@cern.ch, Maxim.Titov@cea.fr

EPPSU

Input for the EPPSU process:"Development of the MPGD Technologies: an overview of the CERN-RD51 Collaboration"–The RD51 model for detector R&D is presented https://indico.cern.ch/event/765096/contributions/3295721

New Technologies For Discovery

A report of the 2018 DPF Coordinating Panel for Advanced Detectors (CPAD) Community Workshop

arXiv:1908.00194v2 [physics.ins-det] 10 Aug 2019

4.3 Micro-Pattern Gas Detectors

4.3.1 MPGD Applications

CPAD

Document for the US BRN (Basic Research Needs) in preparation based on CPAD report "New Technologies For Discovery": Progress of MPGDs and RD51 model https://arxiv.org/abs/1908.00194

Letter of Interest for the Snowmass 2021

Development of the Micro-Pattern Gaseous Detector Technologies: an overview of the CERN-RD51 Collaboration

Representing the RD51 Collaboration

Contact persons: S. Dalla Torre (INFN Trieste), Klaus Dehmelt (Stony Brook University), E. Oliveri (CERN), L. Ropelewski (CERN), M. Titov (CEA Saclay), A. White (University of Texas, Arlington)

Silvia.DallaTorre@ts.infn.it, klaus.dehmelt@stonybrook.edu, Eraldo.Oliveri@cern.ch, Leszek.Ropelewski@cern.ch, Maxim.Titov@cea.fr, awhite@uta.edu

Abstract:

RD51 is a well-established collaboration with the aim to develop Micro-Pattern Gaseous Detector (MPGD) technologies, to support experiments using this technology, and to disseminate the technology within particle physics and in other fields. Originally created for a five-year term in 2008 [1], RD51 was extended for a third five years term beyond 2018 [2]. The rich portfolio of MPGD projects, under constant expansion, is accompanied by novel ideas on further developments and applications. The cultural, infrastructure and networking support offered by RD51 has been essential in this process: this effort will continue thanks to the RD51 extension. Also in the next years, a collaborative R&D phase and the right environment will have a strong impact on project-oriented activities - similarly to the current scenario where three of the major upgrades for the LHC experiments benefited from the RD51 framework. The vast R&D program requires acquiring additional, up-to-date expertise in advanced technologies; it is also expected to ... generation of young detector ... ations. ... *rforming R&D: combination of ... full sharing of "know-how", information, common infrastructures. This model has to be continued and can be exported to other detector domains.*

SNOWMASS21

https://www.snowmass21.org/docs/files/summaries/IF/SNOWMASS21-IF5_IF9-EF0_EF0-168.pdf

2020 European Strategy Update for Particle Physics

- ✓ Update of the European Strategy for Particle Physics: https://indico.cern.ch/event/931825/contributions/3915933/attachments/2061059/3457287/CERN-ESU-013.pdf
- ✓ Deliberation Document on the 2020 update of the European Strategy for Particle Physics: https://indico.cern.ch/event/931825/contributions/3915933/attachments/2061059/3457286/CERN-ESU-014.pdf

The success of particle physics experiments relies on innovative instrumentation and state-of-the-art infrastructures. To prepare and realise future experimental research programmes, the community must maintain a strong focus on instrumentation. *Detector R&D programmes and associated infrastructures should be supported at CERN, national institutes, laboratories and universities. Synergies between the needs of different scientific fields and industry should be identified and exploited to boost efficiency in the development process and increase opportunities for more technology transfer benefiting society at large. Collaborative platforms and consortia must be adequately supported to provide coherence in these R&D activities. The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels.*

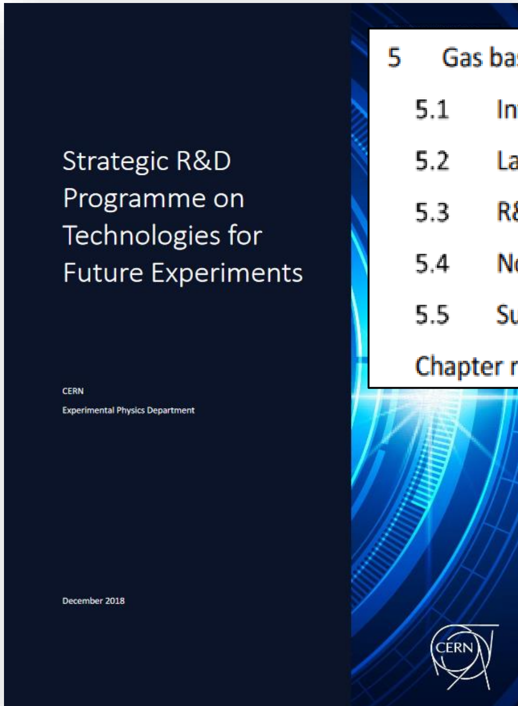
Strategy Document

Instrumentation R&D critical for present and future endeavours

- Delivering the near and long-term future research programme requires advances in instrumentation through focused and transformational R&D
- There is a clear need to strengthen existing R&D collaborative structures and to create new ones, and to foster an environment that stimulates innovation and collaboration with industry
- The National Laboratories and research institutes in Europe play a central role by providing access to dedicated infrastructures and test facilities, specialised expertise and user support
- A roadmap should be developed by the community (ECFA's role) taking into account progress with emerging technologies in adjacent fields

Deliberation Document

Synergies with the strategic **EP R&D program**



5 Gas based detectors (WP2) ....
5.1 Introduction and overview ....
5.2 Large area gaseous detector systems ....
5.3 R&D Framework and Tools ....
5.4 Novel technologies ....
5.5 Summary ....
Chapter references ....

https://ep-dep.web.cern.ch/sites/ep-dep.web.cern.ch/files/CERN-OPEN-2018-006.pdf

320737/files/LHCC-SR-006.pdf

May 2018

R&D PROPOSAL
RD51 EXTENSION BEYOND 2018

EDITORS:
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Abstract

3 RD51 Legacy, Expertize and Infrastructures
3.1 Community and Expertise . . . .
3.2 Detector physics, simulations and software tools . . . .
3.3 Electronics . . . .
3.4 Workshops . . . .
3.5 Common space and common test facilities . . . .

4 RD51 extension beyond 2018: the overall scope and objectives
4.1 R&D Program on Advanced MPGD Concepts . . . .
4.2 Support and Infrastructures . . . .

EP R&D will cover research activities of the CERN GDD team in the field of interest of RD51.
Beneficial and bidirectional support between the EP program and the Collaboration.

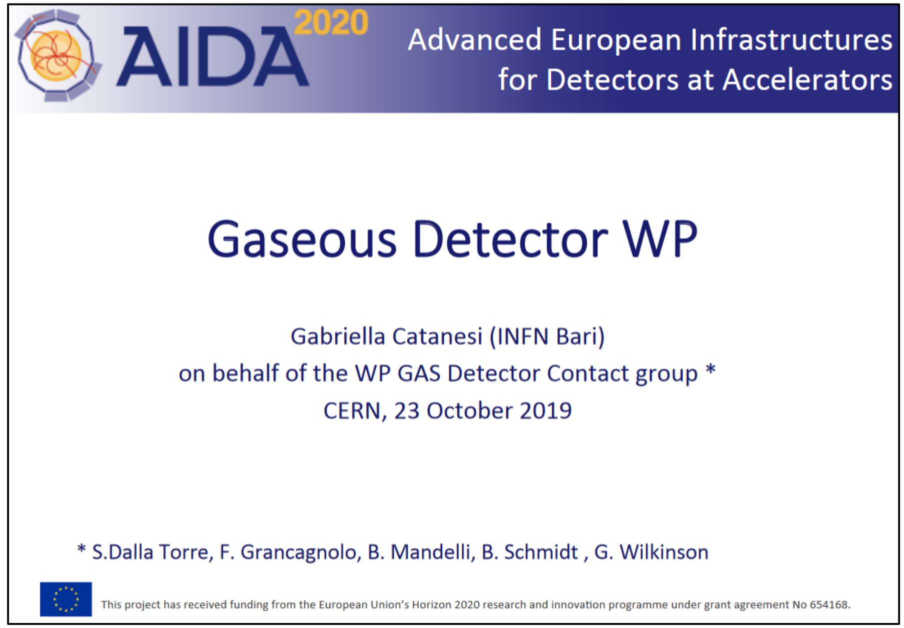
However personnel allocation for the maintenance, operation and consolidation of tools (electronics, simulation) and facilities (laboratory, test-beam, workshops) is not covered by the EP RD program. In the past this support was covered by the white paper – now partially by EP-DT-DD GDD human resources and operational budget.

Synergies with the **AIDAinnova** program

- R&D on MPGD for future colliders and their industrialization
- Large volume gas detectors for future colliders and neutrino beams
- Innovative developments on PID Cherenkov technologies

AIDAinnova submitted on 17 March 2020

Number of EoI (Expressions of Interest) submitted and related to MPGDs: 18 over a total of 159;



https://indico.cern.ch/event/838461/contributions/3608124/attachments/1931843/3199838/AIDA-2020-WP-GAS-Gabriella-V3.pdf

10 core activities linked to RD51 selected

2 suggested for Blue Sky R&D

1 included in in DAQ and test beam WP for RD51 common tools (SRS/VMM)

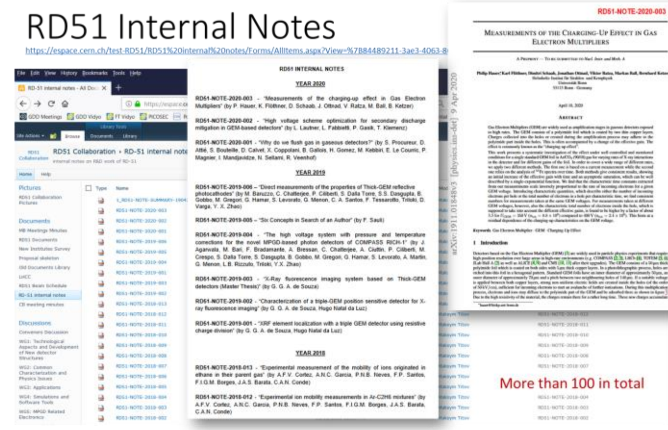
RD51 R&D Framework

- Scientific Cultural Reference, Knowledge Transfer and Dissemination
- Common Projects
- Common Tools
  - Modelling and Simulation
  - Electronics for MPGDs
- Common Facilities and Infrastructures
  - EP-DT Gas Detector Development (GDD) laboratory
  - Semi Permanent Test Beam Installation
- EP-DT MPT workshop

Past year **"Enriched"** meetings

- RD51 Collaboration Meeting (CM), 21-23 October 2019, CERN,
  https://indico.cern.ch/event/843711/
- RD51 Mini-Week **& DLC workshop**, 10-13 February 2020, CERN,
  https://indico.cern.ch/event/872501
- Remote RD51 CM **& Lectures**, 22-26 June 2020, remote-only by Vidyo,
  https://indico.cern.ch/event/911950/
- RD51 CM **& topical workshop on New Horizons in TPC** **5-9 October 2020** (COMING SOON, Remote)
  https://indico.cern.ch/event/889369/

RD51 Internal Notes



MPGD2019

Proceeding recently published:
https://iopscience.iop.org/issue/1742-6596/1498/1
More than 150 participants, more than 100 contributions, more than 50 peer-reviewed papers
Major contribution and support from RD51
RD51 in the conference committees
RD51 promoting and supporting young speakers for review talks

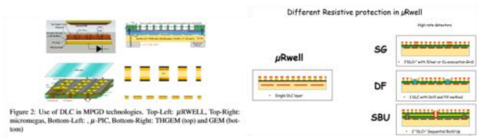
MPGD 2021 @ Weizmann, MPGD 2023 @ USTC

Workshops, Lectures, …

DLC workshop (Feb. 2020)

-> Discussion about the possibility of enlarging existing production capabilities with a DLC coater at CERN

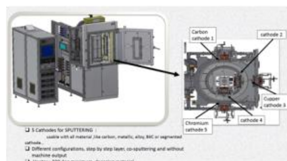
MPGD Technologies and Processes



Report in progress

Existing Research & Production Framework

Proposal for a machine at the CERN MPT workshop



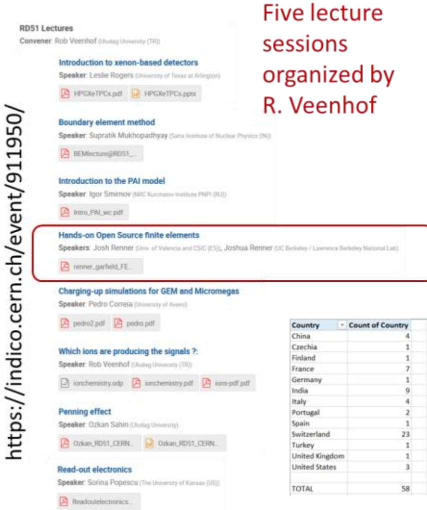
https://indico.cern.ch/event/872501

RD51 Lectures (June 2020)

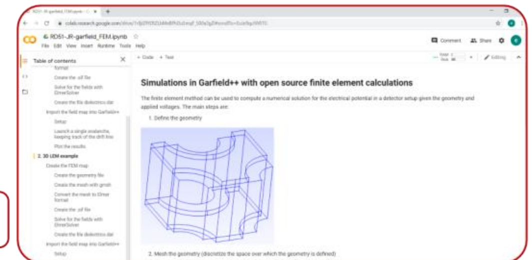
Remote

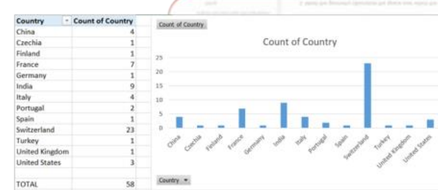
https://indico.cern.ch/event/911950/

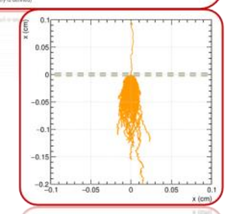
Five lecture sessions organized by R. Veenhof



One example: (Incredible) Remote Hands-on… by Josh Renner…







RD51 collaboration meeting and Topical workshop on New Horizons in Time Projection Chambers (October 2020)

Organising committee

The meeting is organized by:

D. González-Díaz (NEXT/DUNE), chair

J. Benlliure (FAIR/LaserPET)

D. Cortina (FAIR)

A. Gallas (LHCb)

J. A. Garzón Heydt (HADES)

A. Saa-Hernández (NEXT/DUNE)

M. Seco (technical support)

Remote

not only RD51

not only MPGD

A topical workshop on "New Horizons in Time Projection Chambers" will take place in parallel to the RD51 Collaboration Meeting, from Monday to Friday

The purpose of this workshop is to discuss upcoming developments and applications of TPCs, in relation with the current state of the art of this technological field. By bringing together specialists from the fields of direct Dark Matter detection and other Rare Event searches, Neutrino physics, Nuclear and Particle physics, and applied research, we are certain to bring a vibrant and inspiring atmosphere to the meeting.

https://indico.cern.ch/event/889369

Charge-based
Scintillation-based
Electroluminescent
Active Targets
Next-generation accelerator-based

Overview on electron transport
Overview on scintillation
Overview on ion transport
Ion backflow mitigation
Space-charge distortions

High pressure
Low pressure
Dual Phase

Dosimetry
Medical applications

Charge amplification
Charge-sharing
Resistive-protection techniques
Optical amplification and photodetectors
Ion detection
FE Electronics

New ideas
Unusual geometries

Everyone is invited ("profiting" from the remote format) to follow and contribute

Common Projects

SUPPORTING "BLUESKY" IDEAS and RESEARCHES NOT DIRECTLY LINKED TO PROJECT THAT COULD HAVE DIFFICULTIES TO BE SUPPORTED ELSEWHERE

- Technology R&D projects towards developments of novel techniques, improvements of existing technologies, characterization methods and dedicated tools;
- Development and optimization of MPGDs for novel applications;
- Improvement of the MPGD technology transfer to industry.
- The minimum number of participating institutes in the common project is 3, and at least 3 institutes should be regular member of RD51 collaboration.

Active Projects

Discharge Consortium in quest for Spark-Less-Avalanche-Microstructures, 2019, P. Gasik

Pixelated resistive bulk Micromegas with integrated electronics, 2019, F. Petrucci

Resistive materials and resistive-MPGD concepts & technologies, 2019, S. Bressler

Modular & General purpose Ultra Low Mass GEM Based Beam Monitors, 2018, G. Croci

DLC based electrodes for future resistive MPGDs, 2018, Y. Zhou

Study of negative ion mobility and ion diffusion for Negative Ion TPCs, 2018, A. Cortez

As well a tool for:

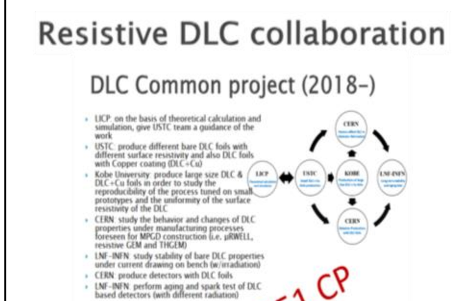
- promoting collaboration between institutes
- promoting self-sustaining collaborations with large potential and impact

Clustering groups around new ideas

https://indico.cern.ch/event/716539/contributions/3246636/attachments/1798790/2933615/Kordas_PICOSEC_VCI2019.pdf

2015 RD51 CP

Clustering groups working on the same fields to increase the impact



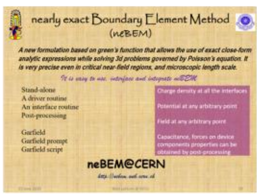
https://indico.cern.ch/event/761830/contributions/3236762/attachments/1765980/2867435/DLC_CP_Bro_Ochi_181205_v2.pdf

2018 RD51 CP

Modelling and simulation

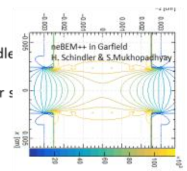
neBEM interface available in Garfield++

http://nebem.web.cern.ch/nebem /



https://indico.cern.ch/event/911950/contributions/3898133/attachments/2062186/3459881/BEMlectureRD51_Supratik.pdf

-----Original Message-----
From: Heinrich Schindler <Heinrich.Schindle
Sent: Friday, July 17, 2020 3:27 PM
To: garfield-users (Users of Garfield detector s
<garfield-users@cern.ch>
Cc: supratikmukhopadhyay.sinp@gmail.com
Subject: **Garfield++/neBEM interface**



Dear colleagues,
we are happy to announce that a working version of the neBEM interface is now available in the master branch of Garfield++, including a number of examples illustrating its use:
https://gitlab.cern.ch/garfield/garfieldpp/-/tree/master/Examples/neBEM
http://garfieldpp.web.cern.ch/garfieldpp/examples/nebem/

Please note that we had to add GSL (https://www.gnu.org/software/gsl/) as an additional prerequisite to build the project.
We hope that you will find the tool useful for your applications and are looking forward to your feedback.
There is still some room for improvement (in particular in terms of performance optimisation); if you have any suggestions please do let us know.
Best regards,
Supratik, Rob, Heinrich

Garfield++ and delayed weighting fields in the calulcation of the induced signal

Implementing delayed weighting fields in GARFIELD++

J. Hasenbichler, W. Riegler, H. Schindler, A. Wang

RD50 Workshop, 13 June 2019

NB.. RD50, not RD51...
IMPACT on several communities, not only MPGD

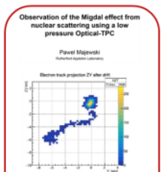
R&D framework and tools cross technologies and can boost synergies

Summary and outlook
- GARFIELD++ is a toolkit that can be used for the detailed simulation of silicon sensors.
- We have implemented the calculation of induced signals in resistive geometries based on the delayed weighting field formalism.
- Some optimisation in terms of speed and accuracy remains to be done.
- As a next step, apply the method to realistic devices.

New EP-RD PHD students working on this field of research with the goal of testing realistic devices and clustering groups of our community

Garfield++ & modelling the photon production

https://indico.cern.ch/event/911950/contributions/3879503/attachments/2062895/3461258/pinci_CYGNO_RD51.pdf



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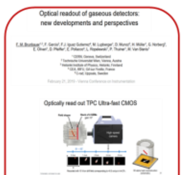


https://indico.cern.ch/event/716539/contributions/3245957/attachments/1798495/2935380/OpticalReadout_Brunbauer.pdf

Several research lines (2019) interested in MPGD readout optically..

Large interest in the photon production processes..

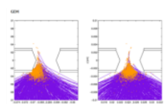
Previous studies (2010) implemented and available in our modelling framework

Electroluminescence

http://garfieldpp.web.cern.ch/garfieldpp/examples/electroluminescence/

Papers

- C. A. B. Oliveira et al., A simulation toolkit for electroluminescence assessment in rare event experiments, Phys. Lett. B 703 (2011) 217
- C. A. B. Oliveira et al., Energy Resolution studies for NEXT, J. Instrum. 6 (2011) P05007
- C. A. B. Oliveira et al., Simulation of VUV electroluminescence in micropattern gaseous detectors: the case of GEM and MHSP, J. Instrum. 7 (2012) P09006
- C. A. B. Oliveira et al., Simulation of gaseous Ar and Xe electroluminescence in the near infra-red range, NIM A 722 (2013) 1



Source files

- The program example.C calculates the number of VUV production in a uniform electric field.

Contact

Carlos Oliveira (carlos.oliveira.cacia@gmail.com)

Collaboration grants collaborative developments and sharing of "common tools" developed by individual groups but made available for everyone, even after several years...

Modelling Ions

Simulating ion motion

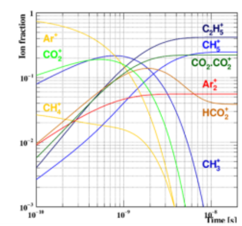
- Lines found in most Garfield++ avalanche programs:

```
// Load the ion mobilities.
gas->LoadIonMobility("/afs/cern.ch/user/r/rjd/GemGain/Charge/mob_Ar_Ar+");
```

- What do they do ?
- Why are they often inappropriate ?
- Detectors like Micromegas and wire chambers get their signal mostly from ion motion.
- Hence we better know the basics of ions:
  - *which ions* are produced in the avalache ?
  - *which ions* generate the signal ?
  - *how fast* do the ions move ?
  - are they subject to *diffusion* ?

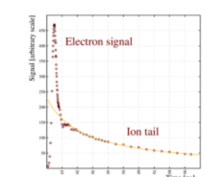
Evolution in Ar-CO_2-CH_4 (90-7-3)

- Initial ions:
  - Ar^+ →
    - CO_2^+,
    - CH_3^+,
    - Ar_2^+
  - CO_2^+ →
    - CH_4^+
    - $CO_2^+.CO_2$
    - HCO_2^+
  - CH_4^+ →
    - CH_5^+,
    - HCO_2^+
    - CH_3CO^+
  - CH_3^+ →
    - $C_2H_5^+$



Atlas TRT signals

- Data:
  - Xe-CO_2-CF_4 70/10/20
  - Straw tube
  - V_w=1530 V
  - r_w = 15 μm, r_t = 2 mm
- Fit:
  - $1/(t+t_0)$

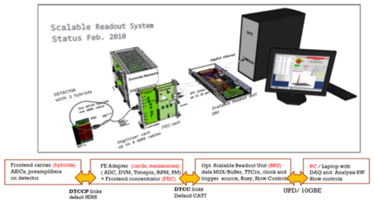


https://indico.cern.ch/event/911950/contributions/3898152/attachments/2063565/3463197/ions-pdf.pdf

[Data from Романюк Анатолий Самсонович]

Electronics for MPGDs

Focused on: Scalable Readout System (SRS) & BNL VMM3a



- Interface of the RD51 SRS with the BNL VMM3a FE ASIC
  - Overview
  - Production and procurement
  - Laboratory and beam measurements
  - RD51 Sub-working group WG5.1 focused on SRS/VMM

H. Muller
https://indico.cern.ch/event/843711/contributions/3613180/attachments/1931440/3199037/New_SRS_Hardware_.pdf

Logically following the large (more than expected) success of the RD51 SRS/APV25 developments where the system has been used for:

- generic R&D (several lab. and beam campaign, not only RD51 test beam),
- medium and large scale experiments (e.g. PRAD@JLAB),
- LHC upgrades (e.g. R&D for ATLAS mm NSW, QA for CMS GEM)

Hardware available soon for the community

Production

Successful pre-production using CERN facilities

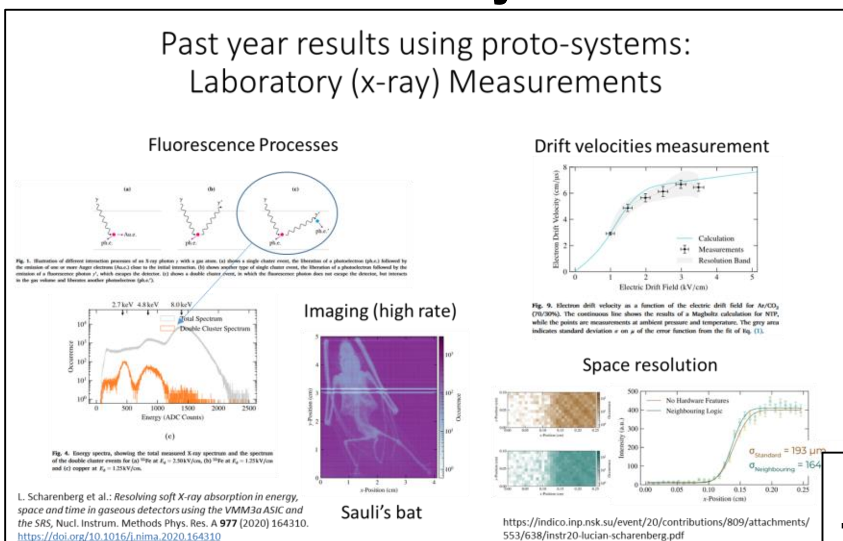
Firs fully commercial production done via SRS-Technology spin-off.

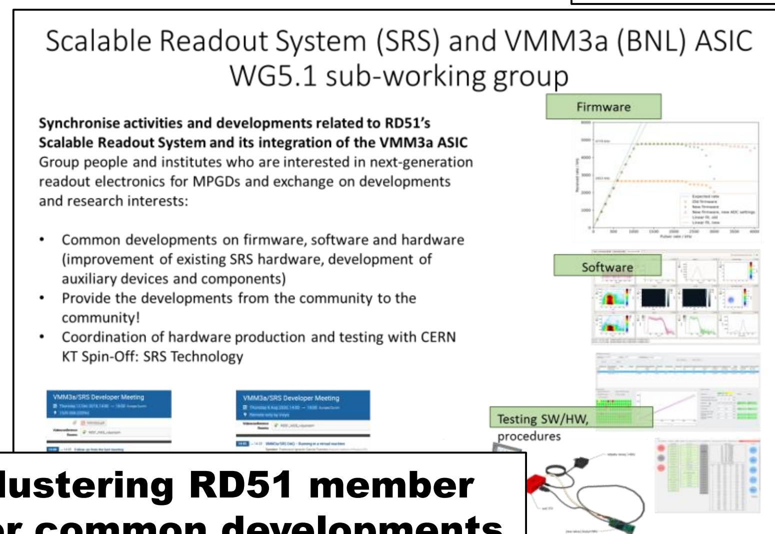
New and large production ongoing.

https://www.srstechnology.ch/

CERN support needed to integrate it in CERN store (as it is for SRS/APV25)

"Remarkable" laboratory tests





Clustering RD51 member for common developments

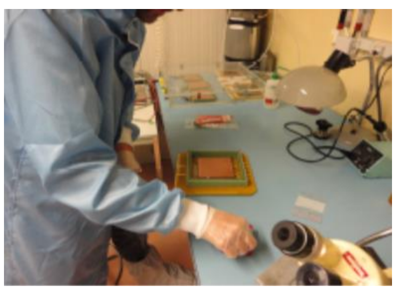
Supported by RD51 + individual RD51 groups + AIDA2020 resources. Included in AIDAinnova (DAQ and test beam WP)

154/R-007 GDD Laboratory

EP-DT-DD Gas Detector Development (GDD) lab

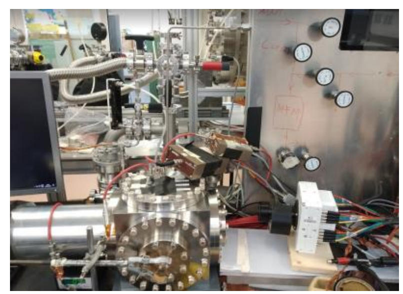
Common facility at CERN for the collaboration to perform detector R&D (design, mounting, testing and measuring). Technical (detector, electronics, instrumentation,..) and scientific (meetings, links, collaboration,..) support. Support during the RD51 test beam campaign. Access to technical CERN facilities. Close to Micro Pattern Technology Workshop and Thin Film and Glass laboratory. **Vital and important support from CERN (EP-DT) on maintenance and operation.**

- Expertize and links
- Equipment
- Close to MPT workshop
- Close to North Area Test beam

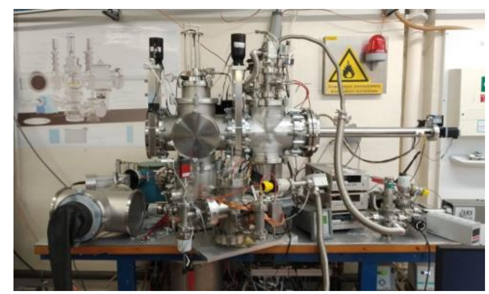


Clean Room

Irradiation



Charge and Optical readout



UV photocathode characterization

Semi Permanent Test Beam Installation (H4A)

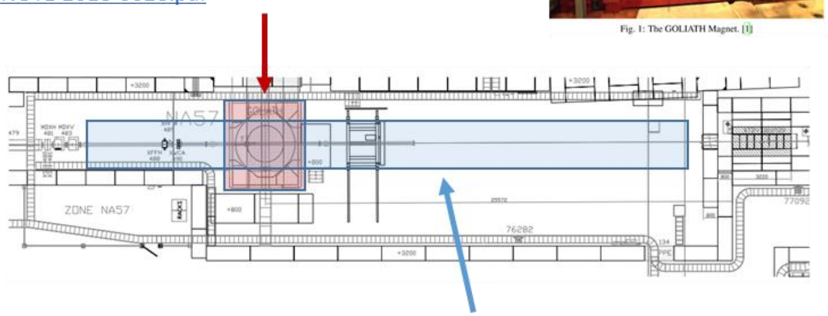
About three periods of two weeks each per year with more than 10 setup running in total.
Since few years beam time shared with GIF++

H4 it's a very Crowded Line, but..

GOLIATH magnet (1.5T, about 3Tm,
Opening: about 1m height and 2.4m wide)

https://cds.cern.ch/record/2310483/files/CERN-ACC-NOTE-2018-0028.pdf

Fig. 1: The GOLIATH Magnet. [1]



SPACE to allows the operation of several setup in parallel

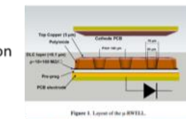
SERVICES (gas, power, signals, supports) organized in several years of works done together with the North Area teams.

Efforts from SPS to give us beam time recognized and appreciated.

Upgrading the common infrastructures (tracker)

A new tracker out of several new developments

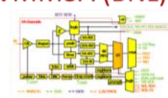
New Development on MPGD technologies



https://arxiv.org/pdf/1903.11017.pdf

New Detector Technology: µRWELL

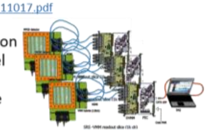
New FE ASICs: VMM3A (BNL)



New Developments on multichannel readout AISCs: VMM3A

https://cds.cern.ch/record/2309951/files/ATL-MUON-PROC-2018-003.pdf

New Development on MPGD multichannel Readout System: SRS/VMM interface



https://doi.org/10.1016/j.nima.2018.06.046

New Interface (VMM3) for the SRS

One example of an existing common tracker: micromegas & SRS/APV25

Important investment (about 40kCHF in total) of resources from the collaboration.

Additional Support may come from AIDAinnova test beam and DAQ WP

New common tracker available

Waiting for the beam to be back...

CERN MPT Workshop

Secured future of the MPGD technologies development

DT Training Seminars

L'atelier Micro-Pattern Technology: Nouvelles et projets clés

by Alexis Rodrigues (CERN), Antonio Teixeira (CERN), Olivier Pizzirusso (CERN), Rui De Oliveira (CERN)

Tuesday 16 Apr 2019, 11:00 → 12:00 Europe/Zurich

32/1-A24 (CERN)

https://indico.cern.ch/event/791893/

- UV exposure up to 2.2m x 1.4m
- Resist developers, stripper, etcher, dryer up to 1.2m width
- GEM electro etch up to 2m
- GEM polyimide etch up to 2m
- Ovens up to 2.2m x 1.4m
- Laminator up to 1.2m

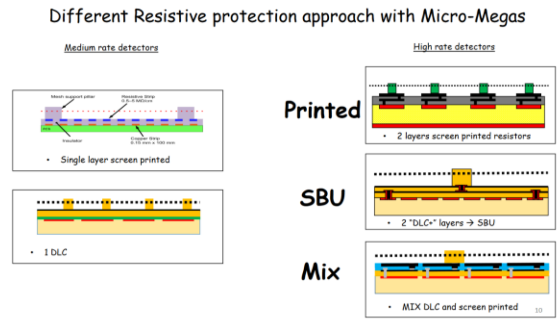
→ **GEM up to about $(2x0.5)m^2$, mm up to $(2x1)m^2$**

Almost all families of MPGD produced…

GEM, THGEM, MM-THGEM, Micromegas, mRWELL, RPWELL, DLC with MPGDs, …

R&D

Several ongoing R&D lines (here resistive layers and detectors based on DLC as one example)



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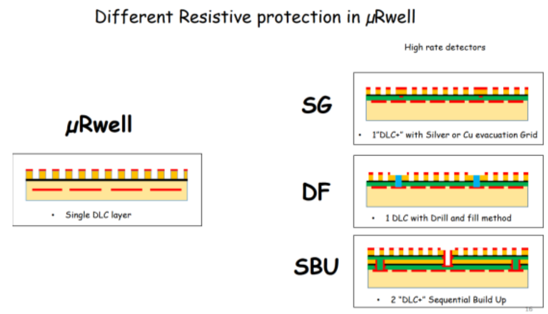
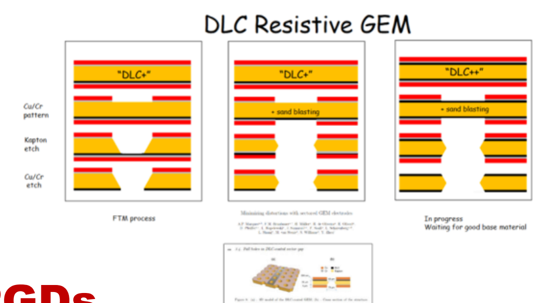




In synergy with:

https://indico.cern.ch/event/872501/contributions/3723338/attachments/1985981/3509025/DLC%20community%20contributions%20from%20RD51%20common%20project-TV.pdf

CERN MPT Workshop

Production

EP Newsletter of the EP department

A new home for GEM detectors at CERN

DT GEM detectors

Jun 19 2019

by Rui De Oliveira (CERN)

https://indico.cern.ch/event/791893/

GEM production for ALICE GEM TPC and CMS GE1/1

Fig. 3: GEM production team handling different type of GEMs

More than 1400 GEMs produced in the EP/DT/MPT

Production was spread over a period of 2 years and required the constant effort of a team of five people, up to seven at the peak of production.

The production yields of about 70% initially, reached 90% in average at the end of production, with peaks at 100% for some batches.

The deadlines fully respected.

Several experiments

COMPASS, LHC-B, KLOE, CBM @FAIR, BM @ N, Phoenix TPC, SBS tracker, T2K, Compass tracker, Compass RICH, ILC TPC prototypes, ILC Calorimeter prototypes, ATLAS NSW …

Industrialization

- Crucial role of the MPT workshop.
- Quite stable (↑/↓) scenario
- Several companies involved in he past years. "Difficult" market.
- Long-lasting Effort

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 x30cm Single Mask Produced

MECARO
- 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

MICROMEGAS industrialization status (today):

ELVIA
- Bulk MM detectors are routinely produced with size up to 50x50cm^2
- production for ATLAS NSW started

ELTOS
- Several small-zize Bulk MM detectors produced
- production for ATLAS NSW started

THGEM industrialization status (today):

ELTOS
- THGEM for COMPASS RICH upgrade (final polishing in house)
- LEMs for LBNO-DEMO

Some lessons learned:
- Industrialization possible if large involvement from large project
- Important to involve the industrial partner from the beginning (see μRWELL with ELTOS, Techtra already in initial R&D phase)

RD51 is a framework

to support and advance technological developments and applications of Micro Pattern Gas Detectors

where

each member group, with it own identity, will perform its own research (a few examples in the next slides)

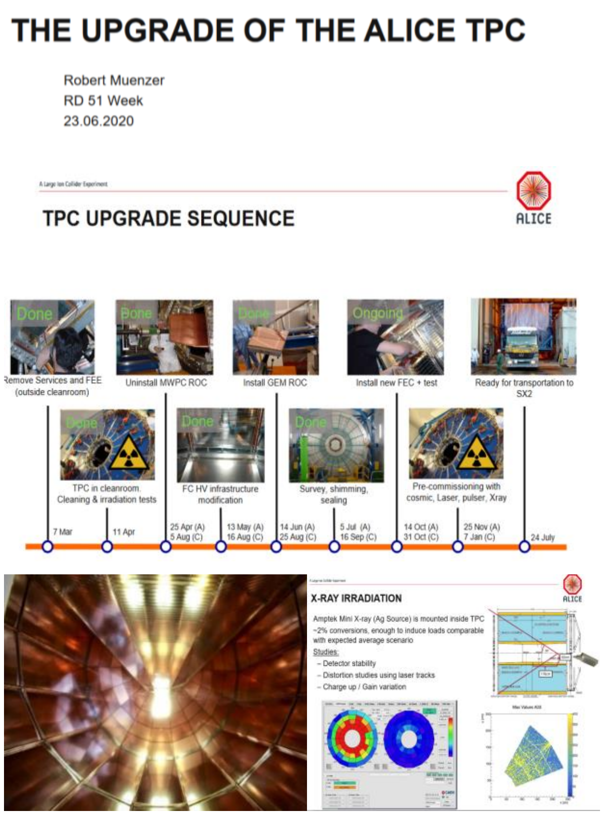
MPGD technologies and Dissemination

Past Year Highlights from RD51 Working Groups Activities

Material from: P. Colas (CEA Saclay), F. Resnati (CERN), F. Brunbauer (CERN), F. Garcia (Helsinki Institute of Physics) , R. Veenhof (CERN), O. Sahin (Uludag University, P. Verwilligen (Universita e INFN, Bari))

@ CERN, LHC upgrades

(June 2020 RD51 CM)



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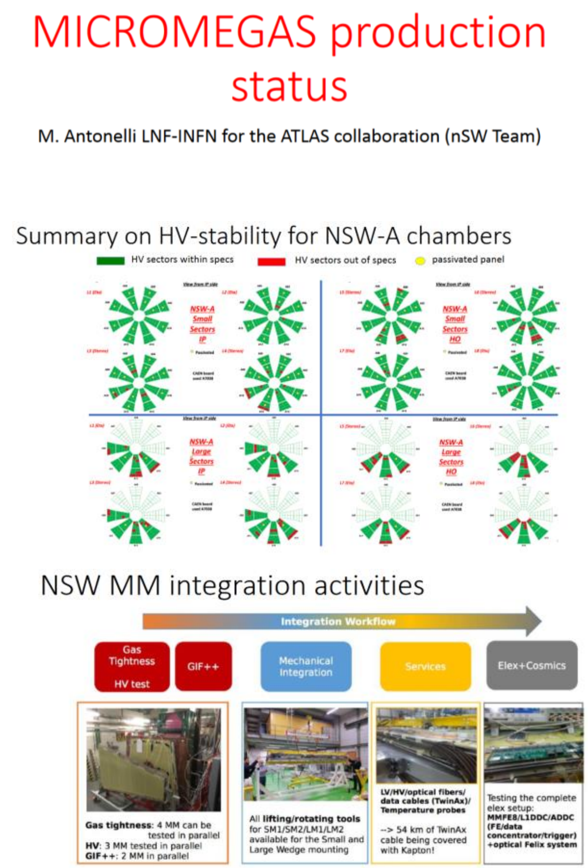
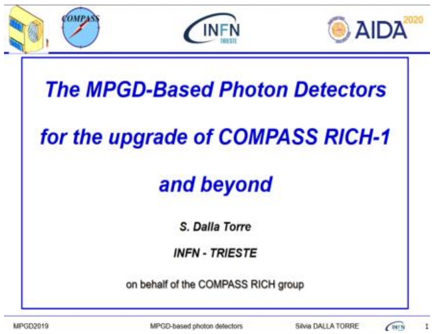
https://indico.cern.ch/event/911950/contributions/3876019/attachments/2061863/3458939/fsimone_GE11status_RD51.pdf

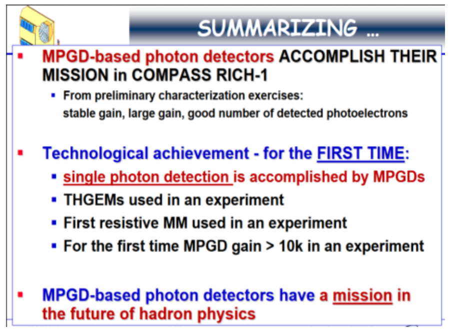


https://indico.cern.ch/event/911950/contributions/3876018/attachments/2062109/3459460/MMstatus_RD51.pdf

@ CERN, beyond LHC

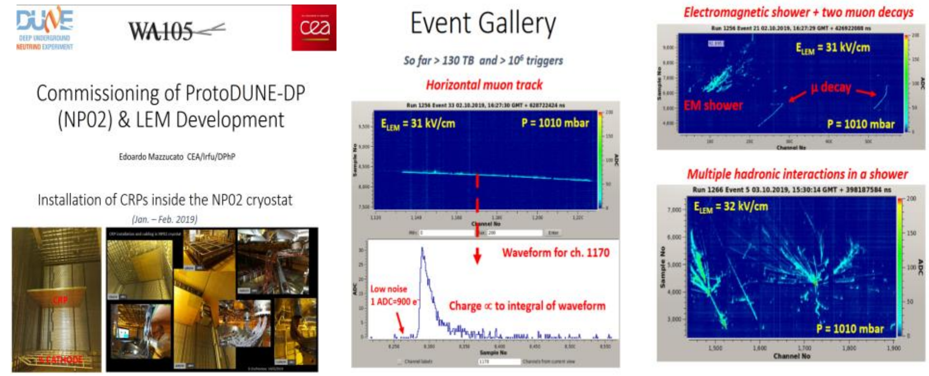
MPGD 2019





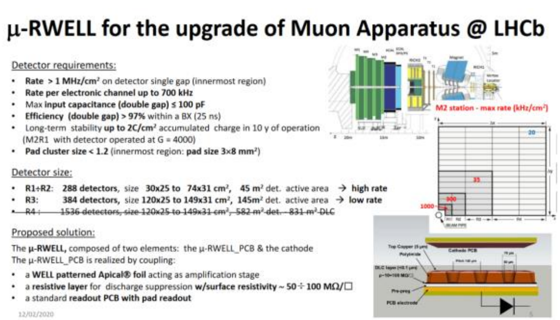
https://indico.cern.ch/event/757322/contributions/3384483/attachments/1838733/3013796/dallatorre_MPGD2019.pdf

Oct. 2019 RD51 CM



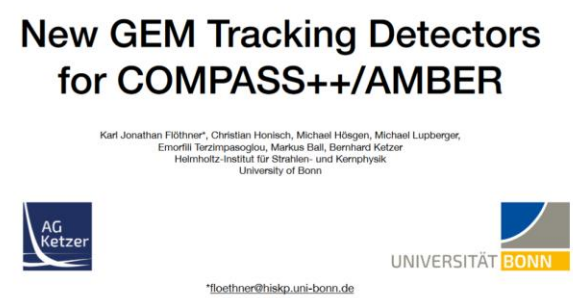
https://indico.cern.ch/event/843711/contributions/3575916/attachments/1930481/3197221/edoardo_2019_10_22.pdf

@ CERN, new proposals



https://indico.cern.ch/event/872501/contributions/3723333/attachments/1986092/3309414/Resistive_MPGDs-RD51-mini-week-Feb-2020.pdf

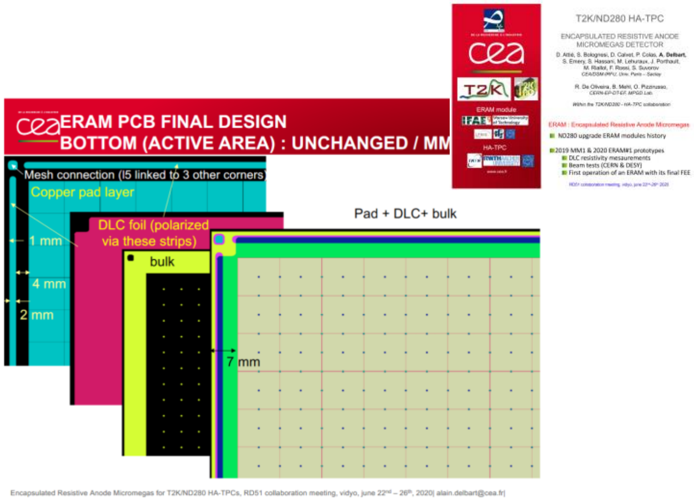
https://indico.cern.ch/event/911950/contributions/3879507/attachments/2062838/3460906/JMerlin_Xtalk_18052020_V2.pdf



https://indico.cern.ch/event/911950/contributions/3910311/attachments/2062117/3459474/Floethner-CompassGEM-RD51-2020_06_23.pdf

+ ....

Micromegas: DLC, Pads and strips readout

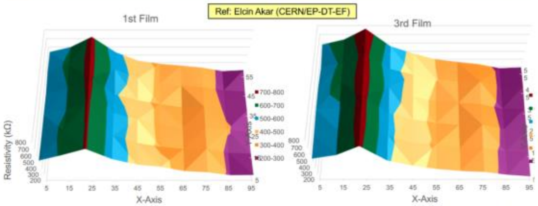


Resistivity measurements of foil #1 & #3 With CERN custom made probe

1st Film	5	15	25	35	45	55	65	75	85	95
5	532	615	708	554	467	430	360	339	290	293
15	526	625	708	559	442	384	348	350	286	270
25	525	597	712	556	462	377	342	346	305	270
35	520	600	726	512	431	376	327	338	293	278
45	546	623	728	570	453	380	349	328	282	267
55	537	599	721	532	425	383	360	332	283	296

3rd Film	5	15	25	35	45	55	65	75	85	95
5	540	593	723	512	430	378	345	329	281	255
15	554	599	742	526	419	392	342	333	282	264
25	569	593	738	516	432	378	348	354	287	273
35	570	625	745	565	445	380	360	340	275	275
45	547	615	733	532	460	403	368	370	283	296
55	582	642	765	561	472	398	365	334	280	292

Ref: Elcin Akar (CERN/EP-DT-EF)

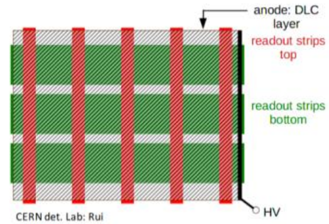


Encapsulated Resistive Anode Micromegas for T2K/ND280 HA-TPCs, RD51 collaboration meeting, vidyo, june 22nd – 26th, 2020| alain.delbart@cea.fr|

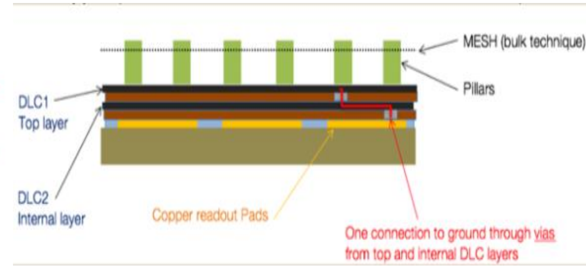
https://indico.cern.ch/event/911950/contributions/3912043/attachments/2064421/3464216/Delbart_T2K_ERAM_RD51_2020_06_26.pdf

1. Resistive Layer Micromegas (DLC)

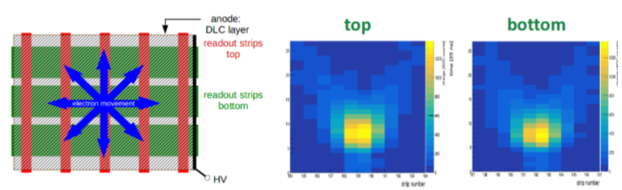
- Anode:
  - Resistive Diamond Like Carbon (DLC) layer
- 2 perpendicular readout strip layers, each with:
  - 360 readout strips, 250 μm pitch
- 120 μm height pillars
- Floating mesh
- Ar:CO_2 93:7



6/26/2020 CHRISTOPH JAGFELD 3

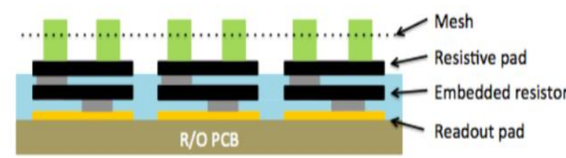


Signal after Avalanche (DLC)



- Electron spread in all directions on DLC layer
  ⇒Electron spread is observed on both readout strip layers
  - $v_{top} \approx 0.5-1\,\frac{strips}{25ns}$
  - $v_{bot} \approx 0.5-1\,\frac{strips}{25ns}$

https://indico.cern.ch/event/911950/contributions/3912047/attachments/2064130/3464160/First_Results_using_a_2D_Strip_Readout_DLC_anode.pdf



Micromegas with **small pads** (PADP) and **DLC** layer (SBU, 5-60 MΩ/sq) for spark suppression at rates up to 10 MHz/cm^2

https://indico.cern.ch/event/843711/contributions/3591285/attachments/1930604/3197497/Camerlingo_22_10_2019_RD51.pdf

Micromegas: fast and precise timing

PICOSEC detection concept

Precise timing with Micromegas

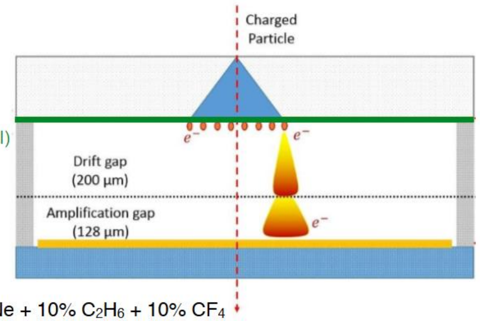
PICOSEC: Charged particle timing at sub-25 picosecond precision with a Micromegas based detector
J. Bortfeldt et. al. (RD51-PICOSEC collaboration), Nuclear. Inst. & Methods A 903 (2018) 317-325

Cherenkov radiator
(3 mm MgF_2)

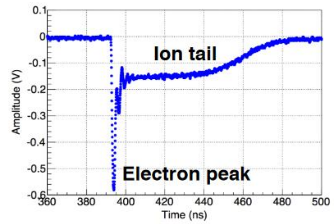
Photocathode
(3 nm Cr + 18 nm CsI)

Drift gap
(Pre-amplification)

Micromegas
(Amplification)



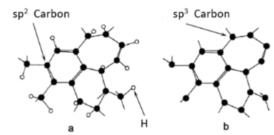
Gas mixture: 80% Ne + 10% C_2H_6 + 10% CF_4
(COMPASS gas)

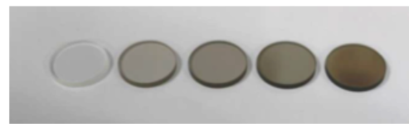


- **Signal with two distinct components:**
  Electron peak: fast (≈0.5 ns)
- Ion tail: slow (≈100 ns)

Photocathodes: DLC

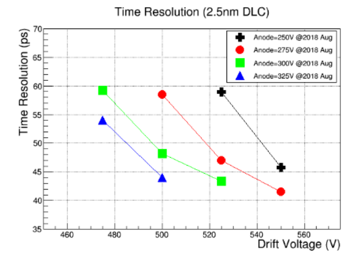
Diamond-like carbon (DLC) is a robust material which may also be used as photocathode.





https://indico.cern.ch/event/709670/contributions/3020862/attachments/1672921/2684467/

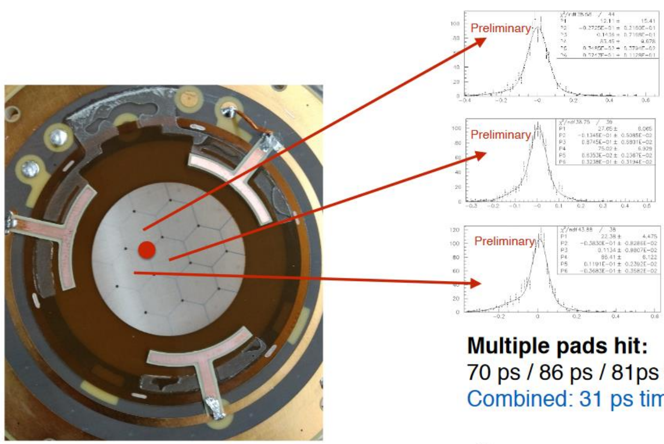
First beam tests show ≈3.5 pe/muon and 40-45 ps achievable time resolution

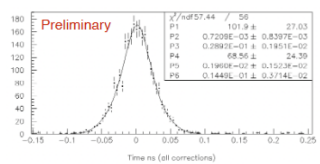


https://indico.inp.nsk.su/event/20/contributions/925/attachments/541/626/PicoSecINSTR20.pdf

Large-area coverage

Scaling up multi-channel PICOSEC



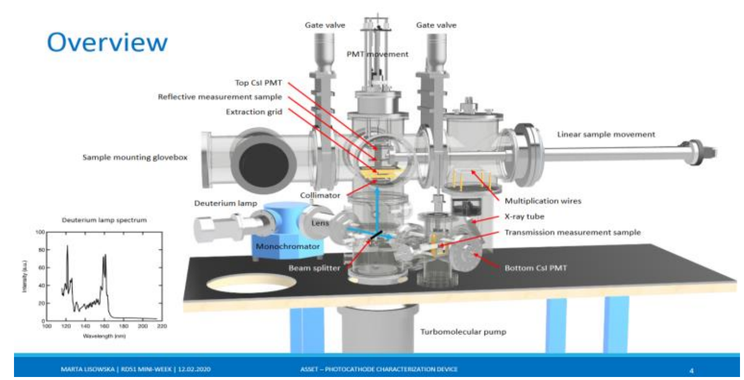


Single pad hit:
25 ps timing resolution for all pads

Multiple pads hit:
70 ps / 86 ps / 81ps timing resolution
Combined: 31 ps timing resolution

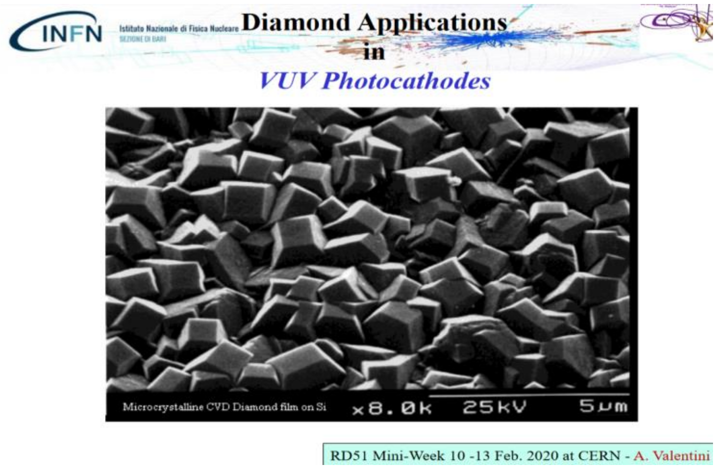
28

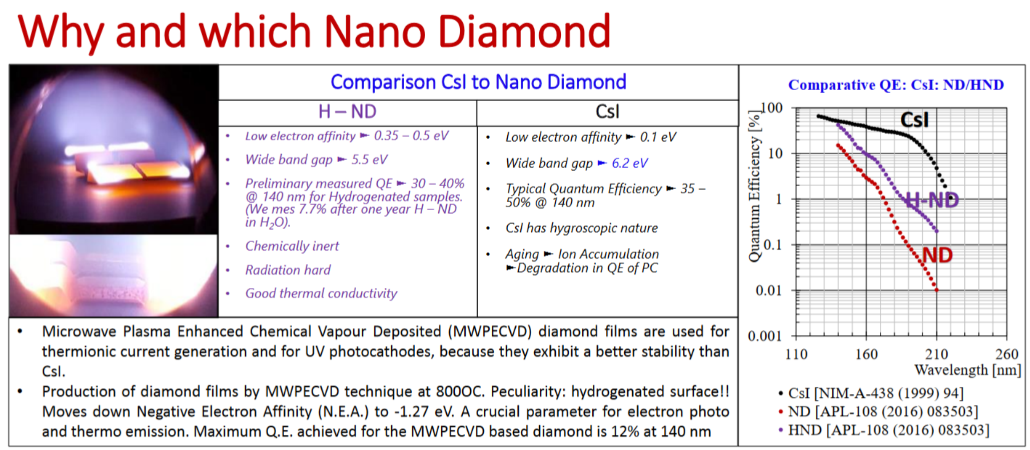
https://indico.cern.ch/event/716539/contributions/3246636/

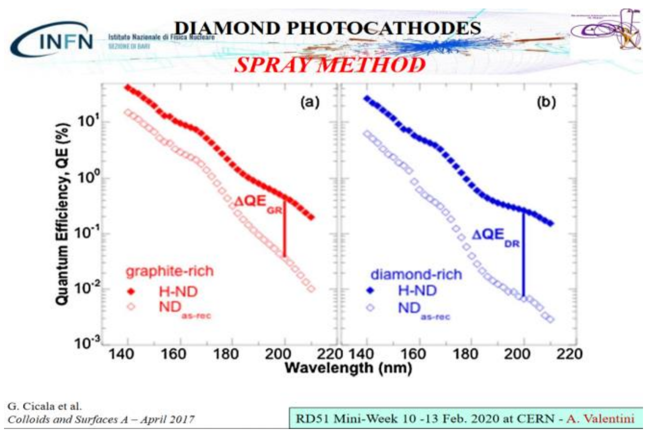


https://indico.cern.ch/event/872501/contributions/3726017/attachments/1985809/3308869/Marta_Lisowska_-_RD51_Mini_Week_-_Asset_photocathode_characterisation_device.pdf

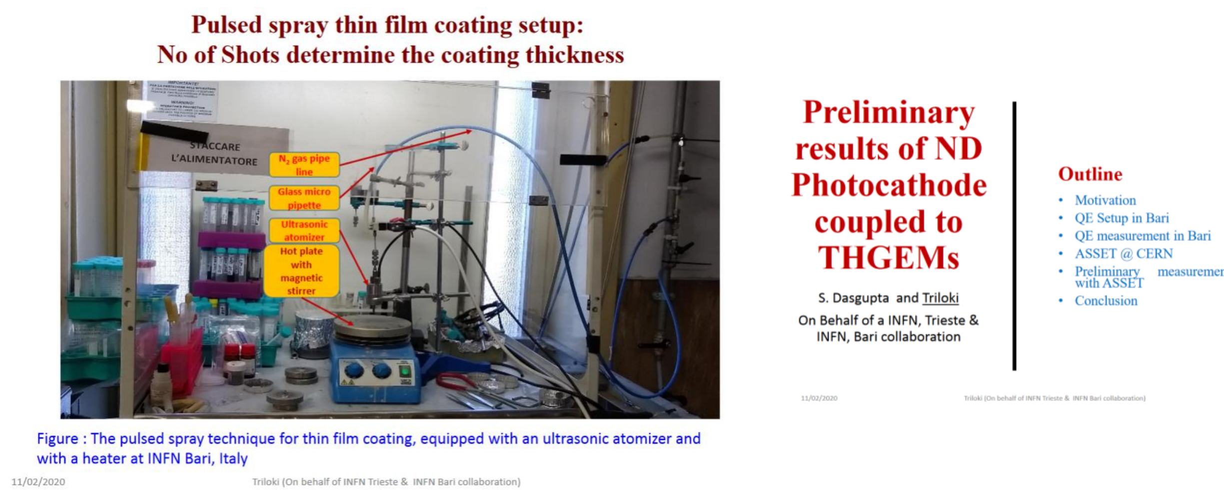
Photocathodes: in timing (previous slide) and RICH





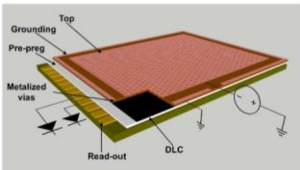


https://indico.cern.ch/event/872501/contributions/3740114/attachments/1984715/3306637/RD51_Miniweek_Valentini.pdf

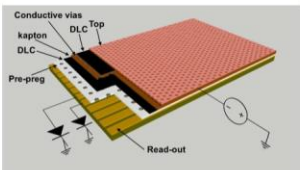


https://indico.cern.ch/event/872501/contributions/3728175/attachments/1985788/3308781/Triloki_NanoDiamond_RD51_20200212.pdf

μRWELL: High Rate Layouts

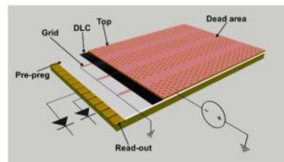


SRL: 2-D current evacuation scheme based on a single resistive layer with a conductive grounding all around the perimeter of the active area.



DRL: 3-D current evacuation scheme based on two stacked resistive layers connected through a matrix of conductive vias and grounded through a second matrix of vias to the underlying readout electrodes (Rui).

Detector parameters (II)



SG: 2-D current evacuation scheme based on a single resistive layer with a suitable conductive grounding grid realized on the DLC layer.

Since the presence of the conductive grid on the DLC can induce instabilities to the detector due to the discharge occurring over the DLC surface, a small dead zone in the amplification stage (a no-hole area) must be introduced.

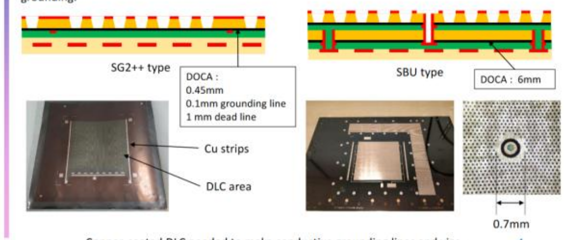
This current evacuation scheme, besides the surface resistivity of the DLC, is then characterized by the ***pitch*** of the conductive grid and the ***DOCA***, correlated with the ***dead_zone*** (*dead_zone = 2×DOCA + line_width*).

The SG is a very simple HR layout allowing an easy TT to industry.

High-rate layouts of μRWELL

1. SG2++ type (Cu grid): The copper clad on the DLC is etched to conductive grounding lines by photo-lithography.

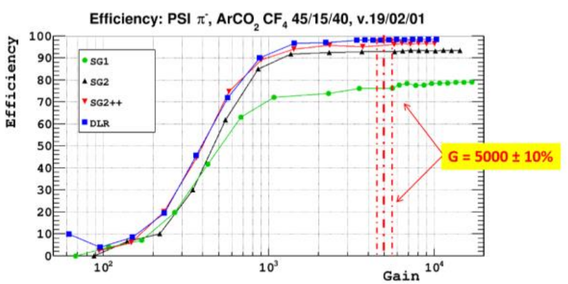
2. SBU type (Sequential Build Up): Current evacuation achieved by two stacked DLC layers. Matrix of conductive vias manufactured with SBU technology are used to connect DLC layer and grounding.



Copper-coated DLC needed to make conductive grounding lines and vias.

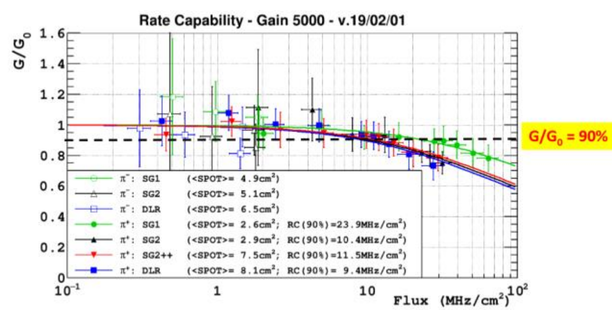
4

HR layouts performance: efficiency



The **DRL prototype** reaches a **full tracking efficiency** > **98%** (NO DEAD ZONE).
The **SG1, SG2 and SG2++** show lower efficiency **(76% -94% - 9(%) BUT higher than their geometrical acceptance (66% - 90% - 95%** respectively), thanks to the **efficient electron collection mechanism** that **reduces the effective dead zone.**

HR layouts performance: rate capability

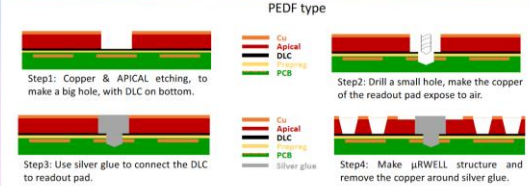


A gain drop of 10 % is acceptable since does not affect the detection efficiency (see previous slide).

https://indico.cern.ch/event/782786/contributions/3305986/attachments/1790790/2917715/CERN-meeting-RD51-February-2019.pdf

Novel idea (PEDF type)

PEDF type



Advantages:

- No copper-coated DLC needed, better resistivity control;
- No alignment problems even goes to large area;
- Larger contact area between DLC and silver glue, improving the connection.

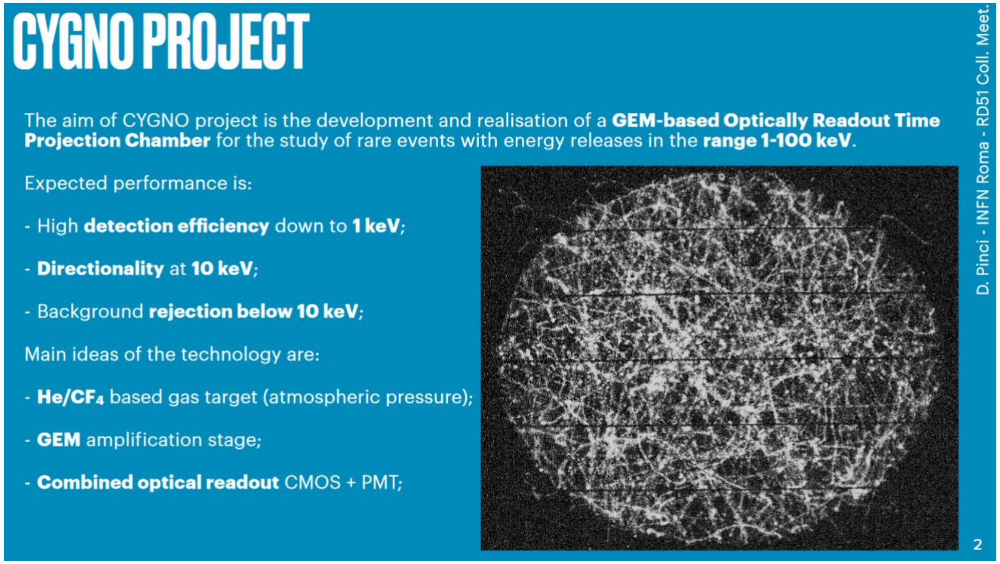
Detector plan:

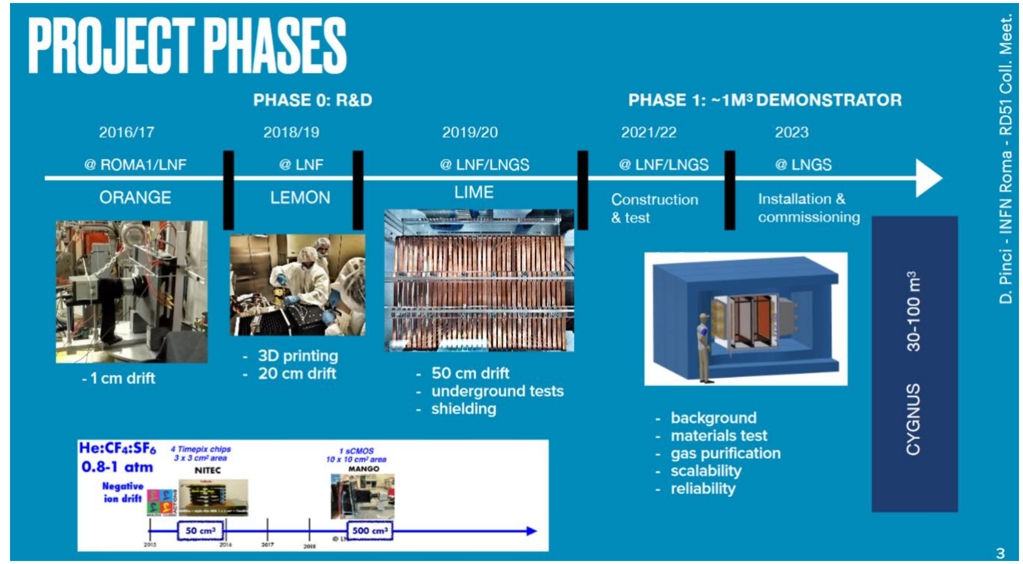
- A small-pad readout μRWELL with sensitive area of 5cm X 5cm was designed;
- If it is OK for small pad, then we will use this method to make a large area μRWELL;

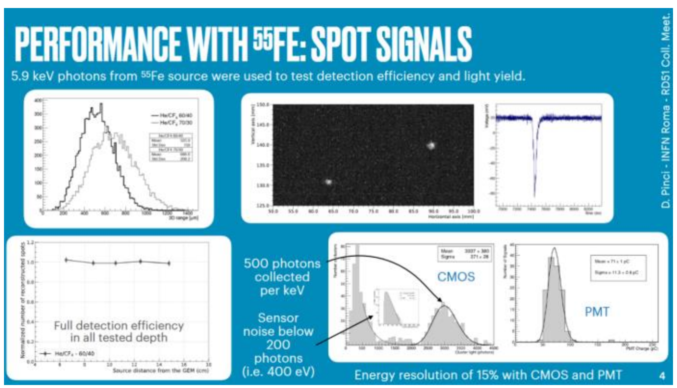
9

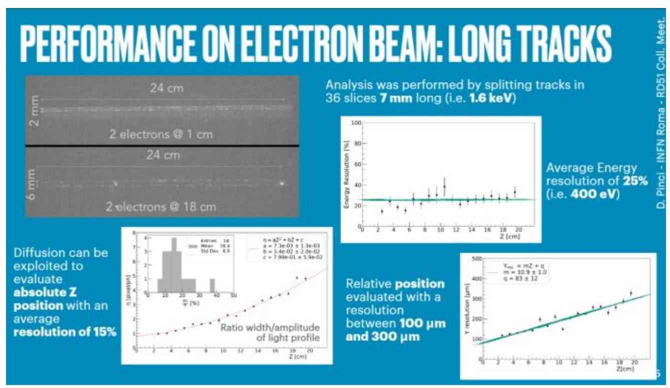
https://indico.cern.ch/event/911950/contributions/3912037/attachments/2064317/3464019/RD51_report_USTC_You_Guofeng.pdf

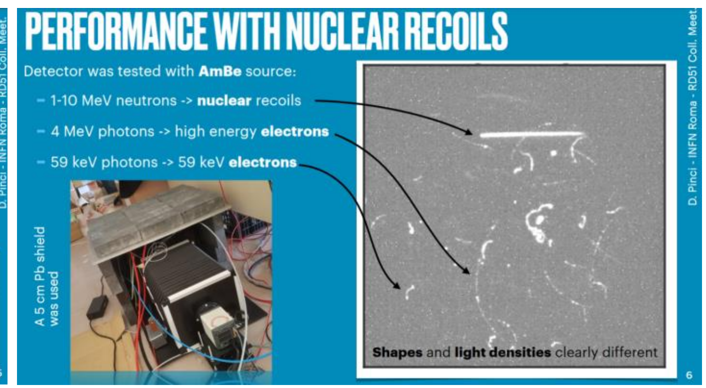
GEM and Optical Readout, TPC





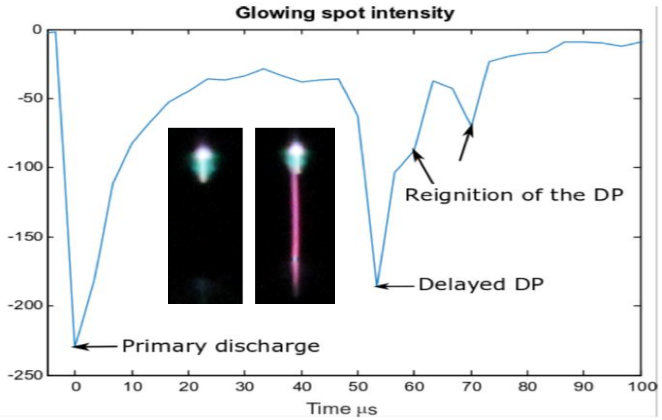






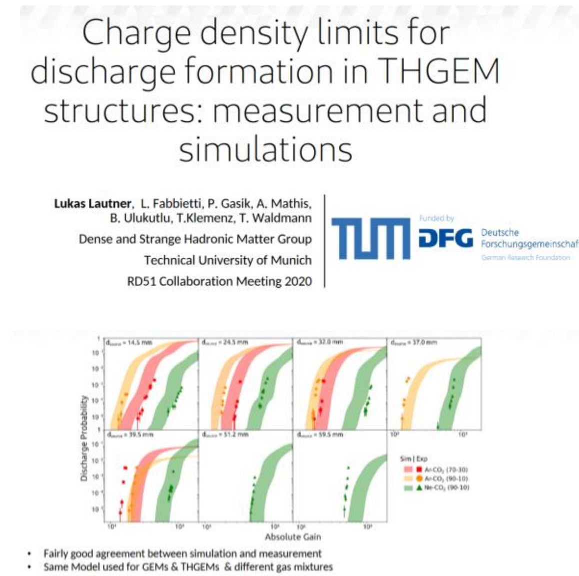
https://indico.cern.ch/event/911950/contributions/3879503/attachments/2062895/3461258/pinci_CYGNO_RD51.pdf

GEM and discharge studies

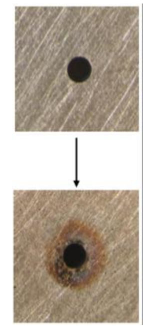


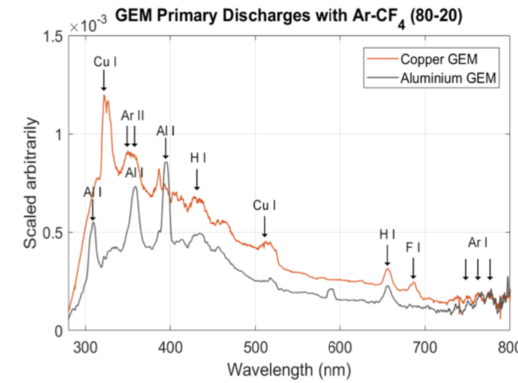
Correlation of electronic discharge signals with **high speed optical images** show sustained glow (thermionic emission) before secondary discharge

https://indico.cern.ch/event/757322/contributions/3396497/attachments/1839679/3015585/MPGD_delayed_DP.pdf



https://indico.cern.ch/event/911950/contributions/3911479/attachments/2063733/3462814/RD51_LukasLautner_25062020.pdf

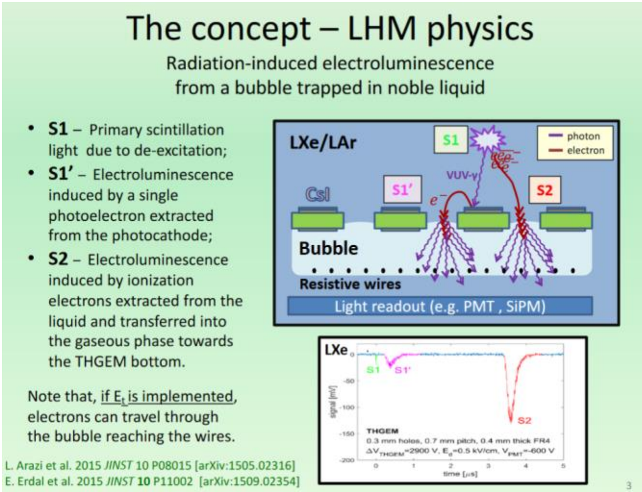


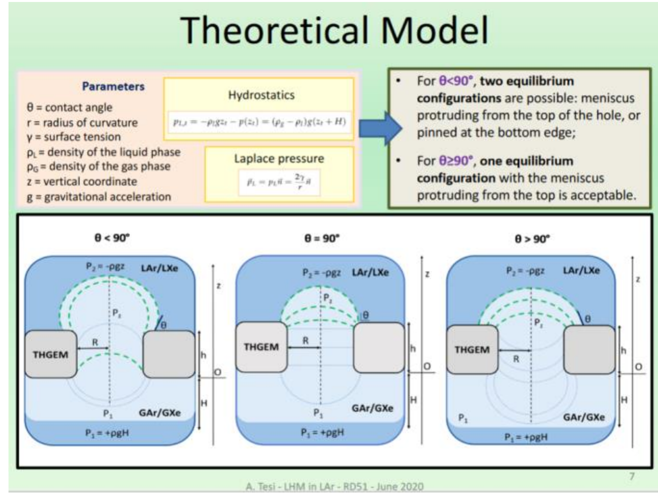


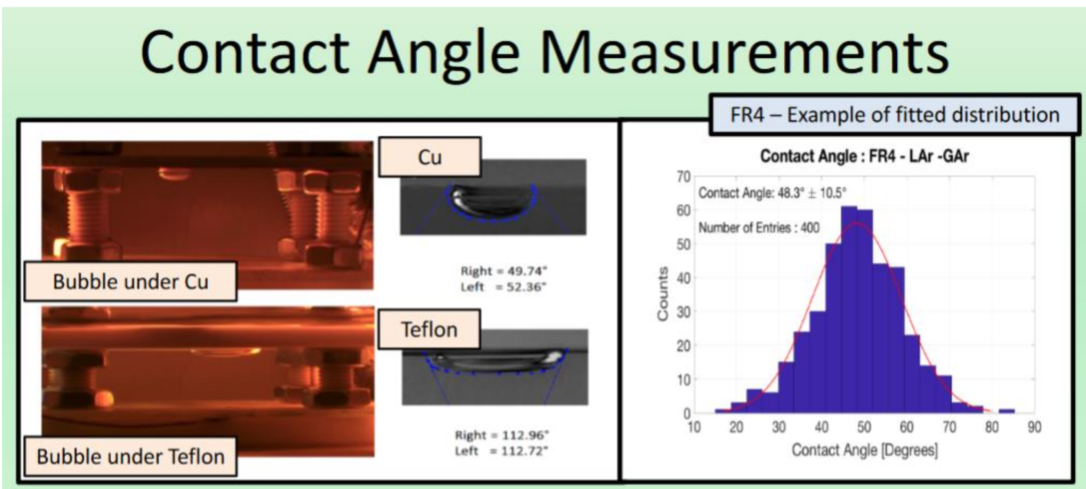
Spectroscopic discharges studies of different GEM electrode materials (Cu, Al, Mo) show evaporation of metal and varying secondary discharge probability

https://indico.cern.ch/event/843711/contributions/3571064/attachments/1930670/3197610/RD51_collaboration_meeting19_Berkin_U.pdf

THGEM & cryogenic: Gas Amplification in Trapped Bubbles







Material	Measured θ	Behaviour
Copper	$45.5^\circ \pm 8.5^\circ$	Argon-philic
FR4	$48.3^\circ \pm 10.5^\circ$	Argon-philic
Teflon	$108^\circ \pm 6.5^\circ$	Argon-phobic
Kapton	$59.3^\circ \pm 9.3^\circ$	Argon-philic

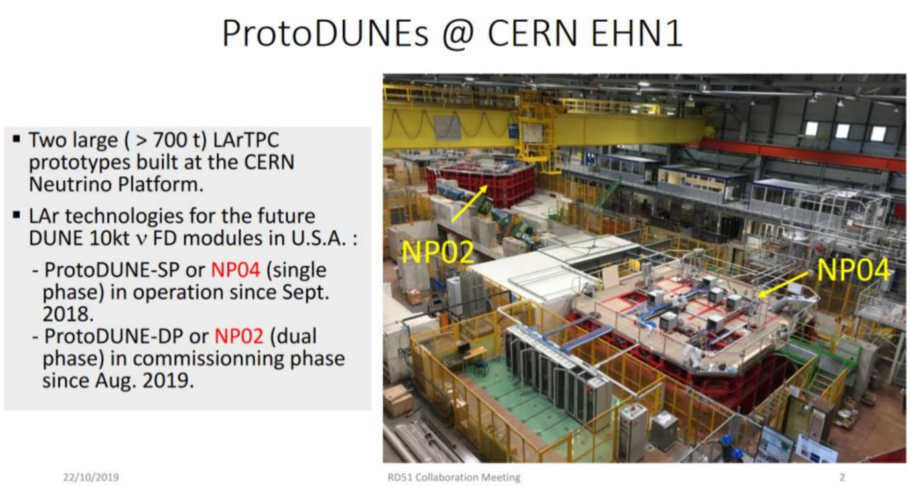
Results of the characterizations

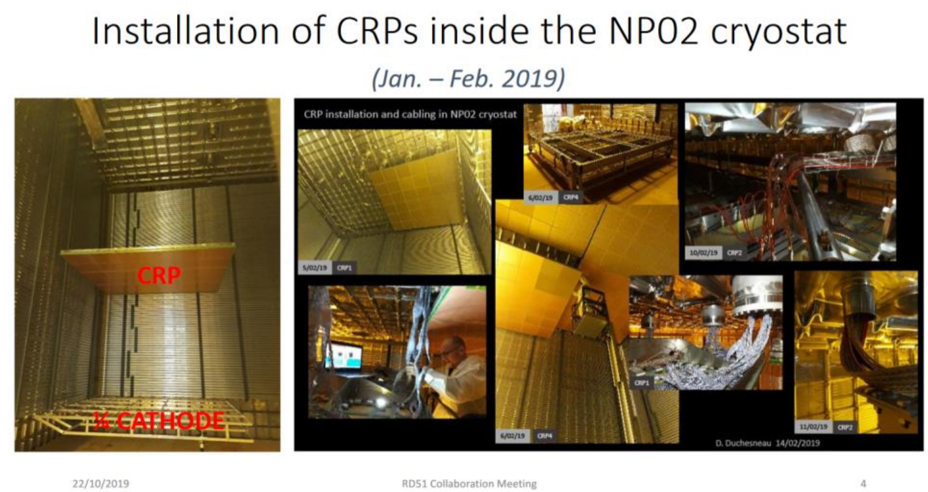
- 1000 frames/sample;
- Image selection and reconstruction using "DropSnake" – at the end: 400 points/sample;
- Fit of the resulting distribution → dynamical contact angle!!

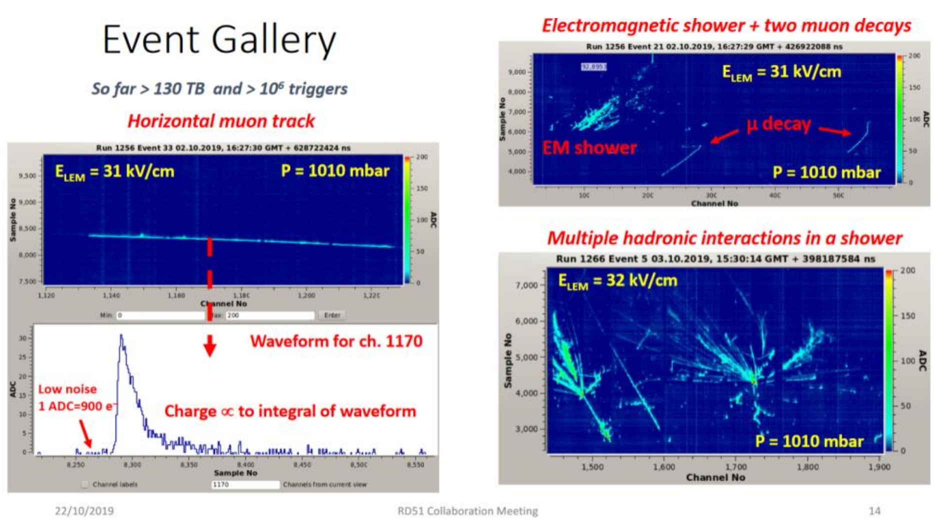
A. Tesi - LHM in LAr - RD51 - June 2020 9

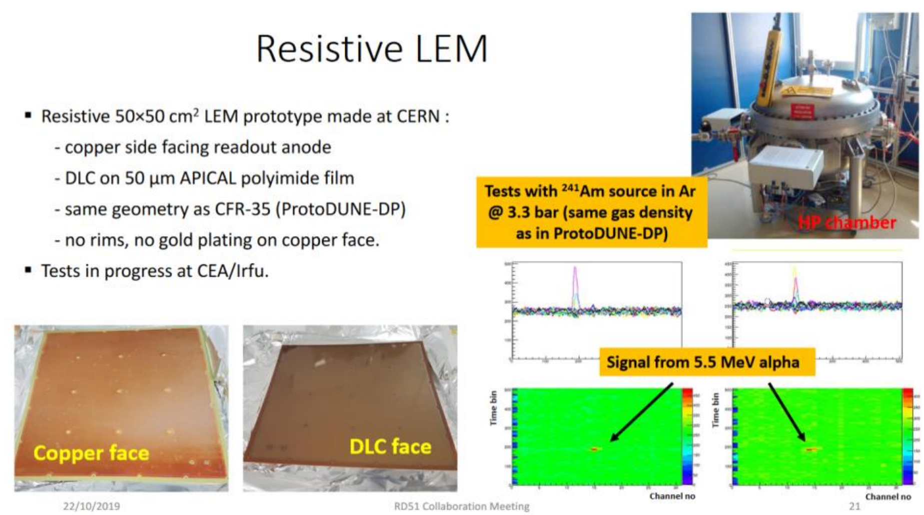
https://indico.cern.ch/event/911950/contributions/3909435/attachments/2061727/3458668/Tesi_RD51_2020_LAr-LHM.pdf

THGEM & cryogenic: NP02 - Dual Phase Proto Dune









Summary and conclusions

Summary (1/3)

- In the Third five-year Term (2019-2023), new membership applications in the past year (8), almost 90 institutes in total as of today.
- Contributions to international scientific studies (e.g. EPPSU, CPAD, Snowmass21)
- Good synergy with the CERN EP RD program. Well represented in AIDAinnova.
- Updated information at the new RD51 website: https://rd51-public.web.cern.ch/

- **RD51 R&D Framework**
  - Several collaboration events (meeting, workshop, lectures) in spite of pandemic
  - Upgrades of modelling and simulation tools (neBEM, DWF in Garfield++) and studies (photons, ions).
  - New SRS/VMM3a era started in the context of Electronics for MPGD.
  - Upgrades in GDD laboratory (charge/optical/photocathode) supported by CERN group R&D Activities.
  - Test beam: Waiting for the beam – upgrade of infrastructure (one additional common tracker).
  - MPT workshop, new facility fully functional, involved in new R&D (e.g. DLC, possibility to upgrade with new machine), excellent results in production for experiment (e.g. ALICE & CMS GEM), support to the industrialization processes (need of large projects, need to interact with industry in R&D).

Summary (2/3)

MPGD Technologies

- New developments (μRWELL, RPWELL, M(M)-THGEM,..) and consolidation of the existing (GEM, THGEM, micromegas, μPIC,..) MPGD technologies.
- Large interest in resistive layers for spark quenching and charge dispersion. DLC coating very attractive for its properties (resistivity, stability) and production processes.
- Groups clustering around photocathodes (RICH and timing). Some new lines of research on Carbon/Diamond based PC.
- Groups clustering around new materials (glass, ceramic, DLC, graphene,…) and novel manufacturing techniques (3D printing, laser,..).
- Groups clustering around Optically readout MPGD (DM searches as first).

MPGD Dissemination

- LHC (ALICE TPC, CMS GEM, ATLAS NSW mm) and beyond (COMPASS RICH) upgrades at CERN done or on the way to be completed.
- Several new proposal for future HEP (LHCb, CMS,..) and beyond (COMPASS, EIC..) experiments.
- All experimental needs: tracking, calorimetry, muon, PID, TOF,..
- Several applications beyond basic research: medical, cultural heritage, muon tomography, astrophysics, fusion plasma imaging,…

Summary (3/3)

- RD51 requests support from CERN at existing level.
  - Access to the CERN RD51 common facilities
    - Gaseous Detectors Development(GDD) laboratory
    - semi-permanent setup at the SPS H4 test beamline
  - Collaborative access to the:
    - the Micro Pattern Technology Workshop (EP-DT-EF MPT)
    - the Thin Film and Glass Laboratory (EP-DT-EF TFG)
  - Modelling and simulation: access to central computing resources for MPGD simulations
  - Electronics for MPGDs: access to laboratory and CERN services
  - Access to CERN technical facilities
  - Office space and administrative support.

Summary (3++/3)

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EXTRA

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Maintenance and Operation

RD51 underlines the importance of CERN core groups and of the present support received by EP-DT… and consequently advice to have it implemented and reinforced in future CERN human resources allocation plans.

Consolidating the future

Possible upgrade of the CERN MPT workshop with a new DLC coater machine. Scientifically supported by RD51 MB and several individual RD51 groups.

Facilitating the R&D

CERN support to facilitate the access to the SRS/VMM3a systems for CERN users (KT, Procurement Office, CERN store), as done in the past for SRS/APV25

Summary (3++/3)

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Thanks!