DRD1-WG6

G. Charles (IJCLab), Wires
A. Delbart (Irfu Saclay), TPC
R. De Oliveira (Cern), MPGD
G. Iaselli (INFN), RPC/MRPC
F. Jeanneau (Irfu Saclay), MPGD
I. Laktineh (IP2I), RPC/MRPC

Outline

- RD51- WG6 mandate
- Presentation of survey results
- Suggestions for future actions and processes of interest (picked from the survey)
- Directions for future and processes to investigate (from experts)
    - Wire Chambers
    - RPC/MRPC
    - TPCs
    - MPGD
- Questions / Conclusion

Mandate of RD51 Working Group 6 (reminder)

- Objectives → development of cost effective technologies and industrialization

- Task 1 → set up common production facilities
  - Development and maintenance of common "Production Facilities“
  - Machines and processes open to the collaboration
  - New processes R&D

- Task 2 → industrialize the processes
  - Quality control
  - Cost-effective processes
  - Large-volume compatible processes

- Task 3 → collaboration with industrial partners
  - When demand for is larger than the common production facility can provide
  - Allow price reductions due to large scale or industrial manufacturing methods
  - Assure the availability for commercial applications

Presentation of survey results

Technology of interest

A. MPGD: 52 (29.38%)

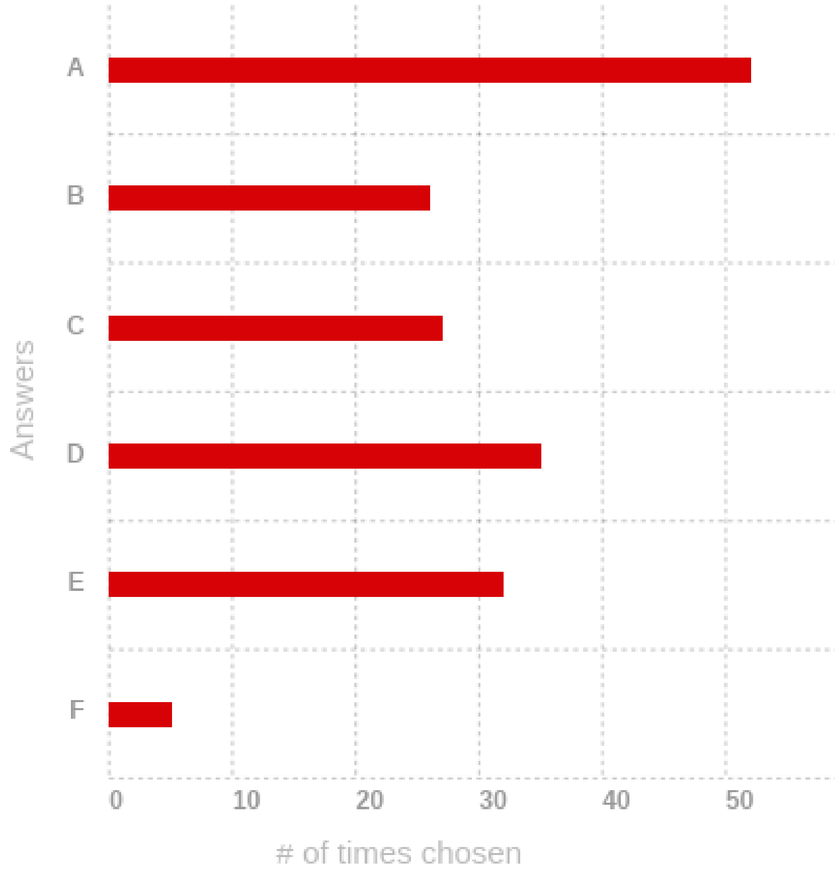
B. RPC and MRPC: 26 (14.69%)

C. Wire chambers (incl. Straws, TGC, CSC, ..): 27 (15.25%)

D. Large Volume Detectors (drift chambers, TPCs): 35 (19.77%)

E. New amplifying structures: 32 (18.08%)

F. Other: 5 (2.82%)



Well-balanced interest between technologies

Do you have production capabilities at your institute?

Answered: *69*

Answer If yes , please list them in the facility section at the beginning of the survey and specify if they are accessible to external users.

A. Yes: 34 (49.28%)

B. No: 35 (50.72%)

MPGD : 52 institutes interested by MPGD
29 have production capabilities

Wire detectors : 22 institutes interested by Wire technologies
14 have production capabilities

RPC/MRPC : 28 institutes interested by RPC/MRPC technology
9 have production capabilities

The community has a lot of production capabilities
50% of the institutes have production capabilities in their field (30% for RPC/MRPC)

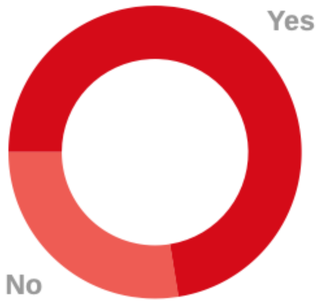
Is your group planning to produce detectors (components) or to support facilities (in your institute or external) that can do it?

Answered: 69

If yes, please add in the comment section more information

A. Yes: 50 (72.46%)

B. No: 19 (27.54%)



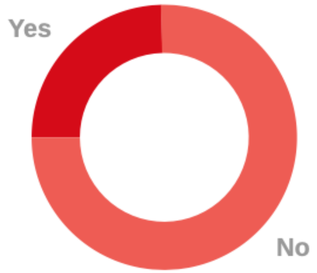
Most of the groups want to produce in their lab or help others to produce for them.

Are you interested in financially supporting the development of existing or future facilities?

Answered: *69*

A. Yes: 17 (24.64%)

B. No: 52 (75.36%)



This comes directly in contradiction with the previous slide !

Or institutes prefer to finance specific facilities for dedicated project and not for a collaboration common facility ?

Interest in the following existing or future common facilities

A. CERN EP-DT Micro Pattern Technology (MPT) **Workshop**: 52 (33.12%)

B. **Saclay MPGD workshop**: 21 (13.38%)

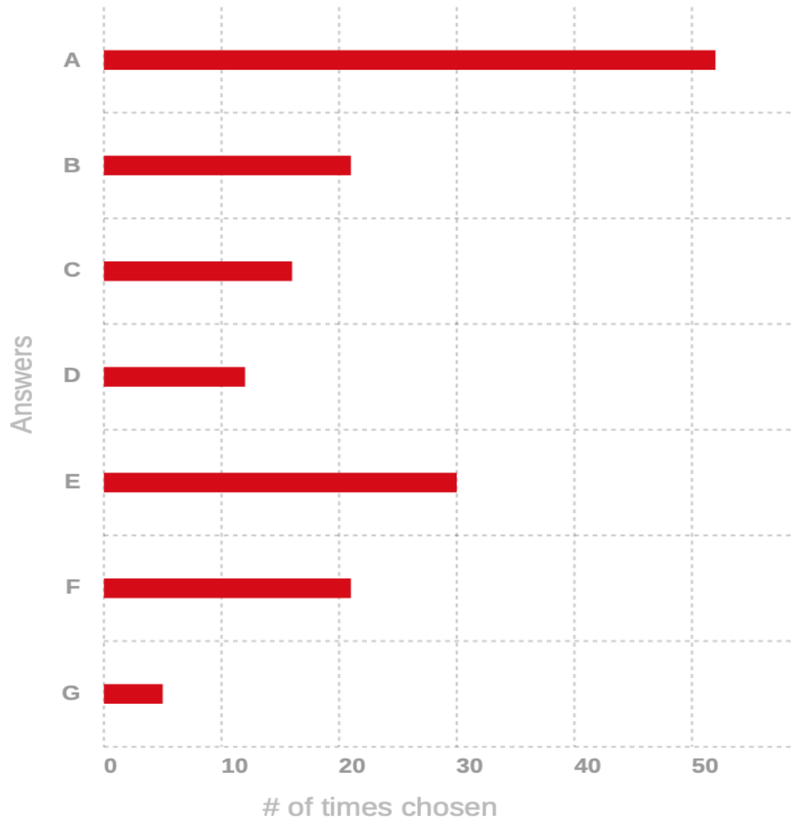
C. **RPC/MRPC workshop**: 16 (10.19%)

D. **Wire chambers workshop**: 12 (7.64%)

E. **Novel detector production methods**: 30 (19.11%)

F. **CERN EP Thin Film & Glass service (photocathodes, coratings, ceramic)**: 21 (13.38%)

G. **Other**: 5 (3.18%)



There is a great interest for common facilities!

Should DRD1 set up new common facilities?

Knowledge Dissemination

Answered: *69*

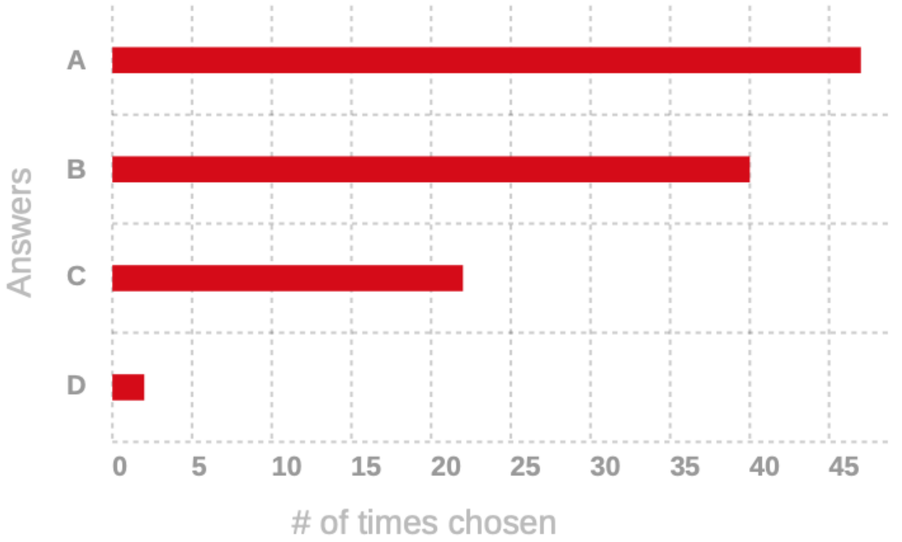
Answer If of interest, select potential ways to improve the knowledge transfer to your research group. Please add in the next Comments/Notes section if not listed.

A. Seminar: 47 (42.34%)

B. Courses: 40 (36.04%)

C. Training from industrial partners: 22 (19.82%)

D. Other: 2 (1.80%)



Big request for knowledge dissemination

Strong synergy with WG 8 !

Relationships of your group with industry

Answered : 69

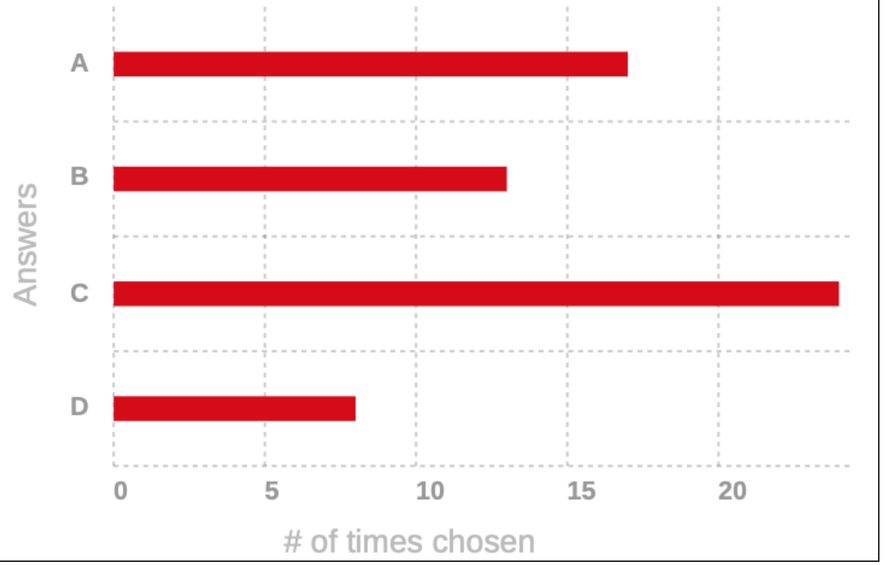
Please, if possible, specify which type or interest or relationship with industry your group has.

A. Development of new manufacturing processes: 17 (27.42%)

B. Responsible of Technology Transfer : 13 (20.97%)

C. Production: 24 (38.71%)

D. Other: 8 (12.90%)



MPGD
Eltos → THGEM , MM, uRwell
Elvia → THGEM , MM
Mecaro → GEM

RPC MRPC
General technical →RPC
Teknemica → HPL

Wire Chambers

Others
RADKOR → dosimeters

A good proportion of institutes are involved in R&D or TT to industry
But with few industries

Should technology transfer to industry be strengthened?

Suggestions for future (picked up from the survey)

- Create Common RPC/MRPC facility at Cern
- Fund common facilities (ex: sputtering)

Common facilities

- Trigger a composite material survey
- Survey on low background materials
- Create a database of base material available in institutes

Materials

TT and production processes

- Improve technology transfer to industry
- How can we use efficiently the existing QA/QC expertise
- Investigate additive manufacturing
- GEM manufacturing survey
- Survey for DLC deposition equipments / companies (RF or Ion beam)

R&D

- Develop detectors compatible with Optical R/O
- Develop High pressure detectors
- Develop detector compatible with cryogenic temperatures
- Develop negative ion amplifying structures
- Develop Field Cages with fully resistive (and highly homogeneous) electrodes

Processes of interest (picked up from the survey)

- 3D printing
- Laser machining
- Sand blasting machining
- Ultrasonic welding techniques
- New resistive layers and deposition methods
- Improve screen printing resistive layer
- Sputtering for resistive material

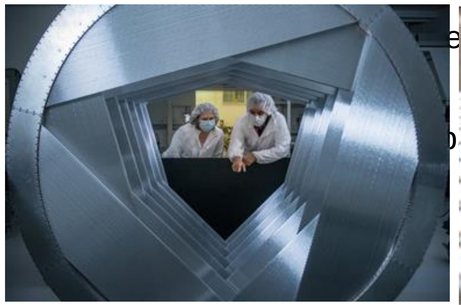
- Technics to produce novel photo-converters
- Technics to produce bore based neutron converters
- Technics to produce micro-pattern structures at the level of 1 to 10 µm
- Technics to produce MPGDs on Ceramics , glass , quartz.
- Technics to produce ultra flat substrates for Pico-seconds timing resolution detectors
- Technics to produce Polymer based X-Ray detectors (OFETs)
- Technics to deposit wave length shifters

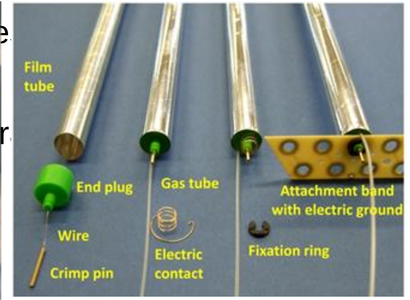
Directions for future
Processes to investigate

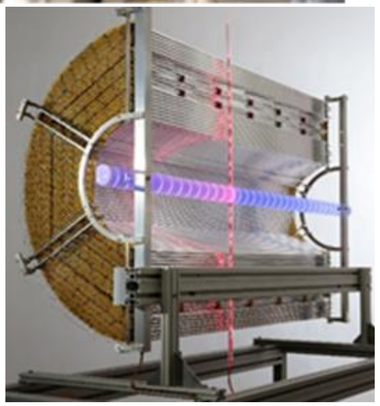
DRD1 – Wires (slide from P. Wintz)

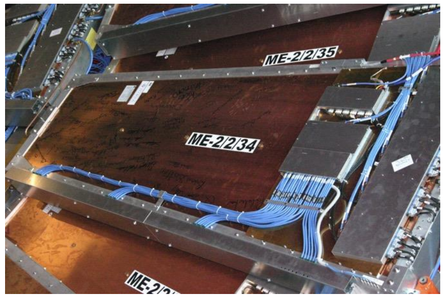
(Technology R&D Topics from Survey)

- **Fast timing** (< 80ns) and **less occupancy**
  - **Smaller straw diameter**: from “standard“ 10mm down to **5mm**
  - Items: wire centering, **high-resolution time readout**, trailing edge timing
  - Smaller diameter sMDT, sTGC with smaller cathode strip widths
- **Low material budget,** e.g. X/X0 ~ 0.02% per straw
  - **Thinner straw film walls**: from “standard“ 30µm down to **15µm**
  - Items: film tube winding, gluing or ultrasonic welding, cathode coating
  - **Operation in vacuum** and leakage control
- **Long straw film tubes**: up to 5m length
  - Items: Wire centering, sag control, long-term material relaxation
  - Large straw area detector designs (50m^2) and in vacuum
- **New wire materials**, new alloys, metallized carbon wire, ..
  - Items: wire corrosion, coating quality, .. thinner field wires for low X/X0





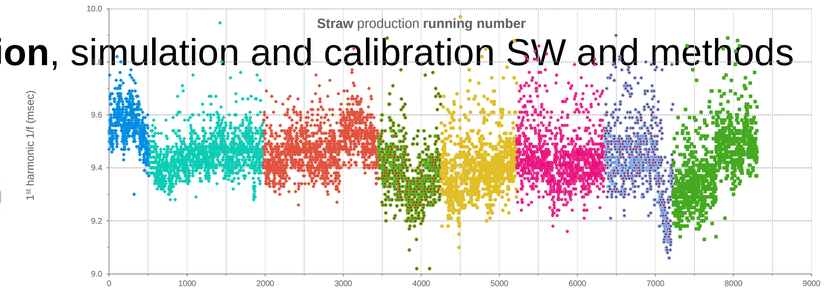


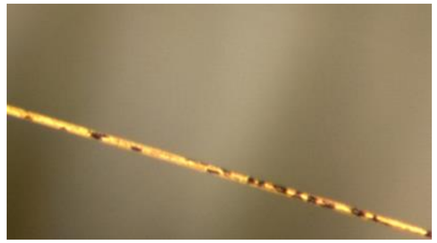


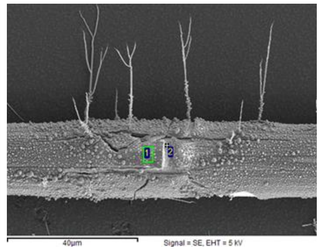
DRD1 – Wires (slide from P. Wintz)

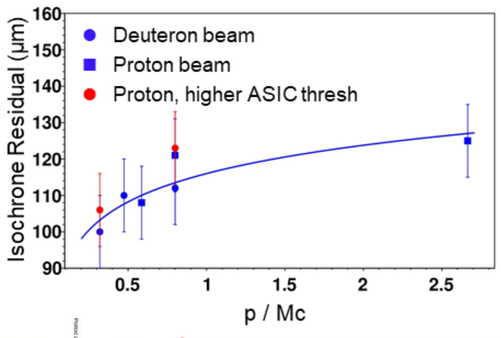
(Transversal Technology R&D)

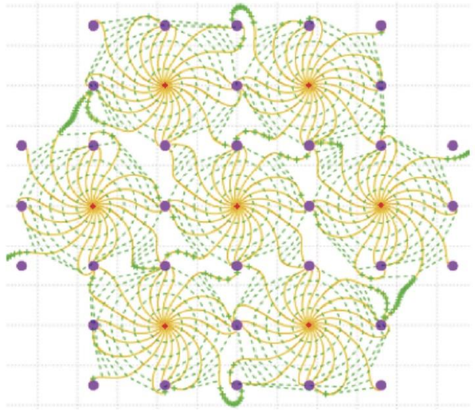
- **Gas system** design with high purity
- **Global Warming**: replace gas admixtures with high GW potential
- **Ageing prevention**
  - “Aging-free“ gas mixtures, materials and components
  - Ageing curing recipes for wires and cathodes
- **Detector designs** incl. front-end
  - Low X/X0 materials and frame structures, foils and coating
  - Detector alignment techniques and measures
  - Cooling scheme and system, detector control system
- **Assembly techniques**
  - Wiring robot, precise positioning; series production and QA
- **Electronic readout**
  - Time resolution, EMI shielding & grounding, low noise, low threshold
- **Detector calibration**, simulation and calibration SW and methods

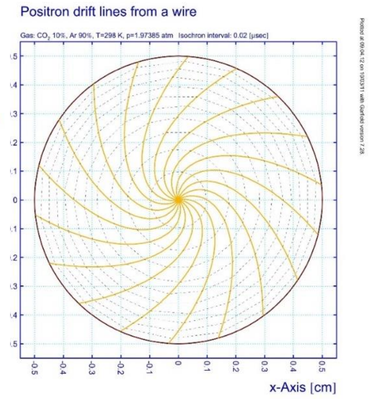


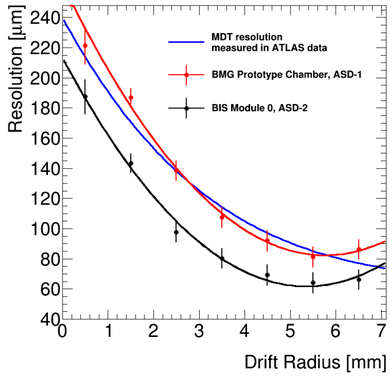












RPC/MRPC

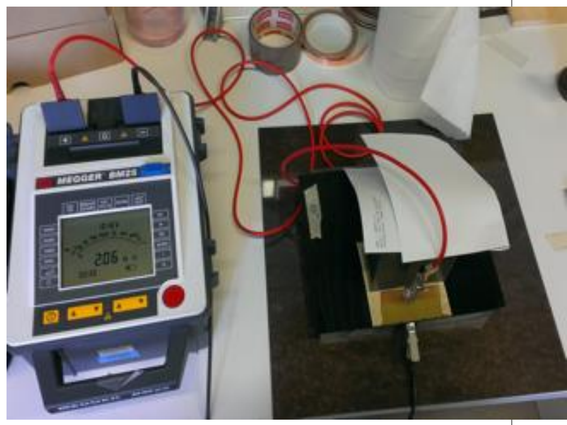
Directions for future

- High rate
- Large area
- Better Homogeneity
- Sub-centimeter spatial resolution
- Exploitation of fast timing (sub-nasosecond time resolution for RPC and tens of picoseconds for MRPC)
- New material for electrode
- Detectors with resistive plates and cylindrical geometry
- Ensure quality control and production capability for HPL electrodes
- Ensure quality control of new resistive glass and other resistive materials as electrodes for high rate application

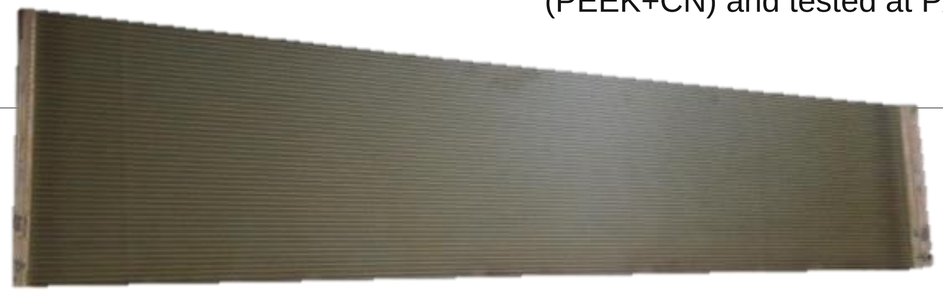
Processes to investigate

- New resistive materials
- Low noise electronics
- Thinner gas gaps

- Homogeneity
- Tightness
- Coating
- Large PCB



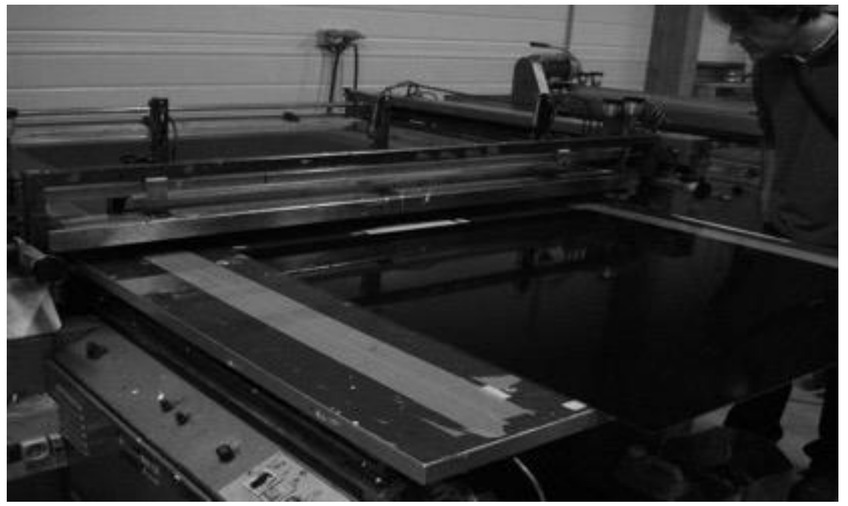
New material developed by Lyon (PEEK+CN) and tested at PAVIA



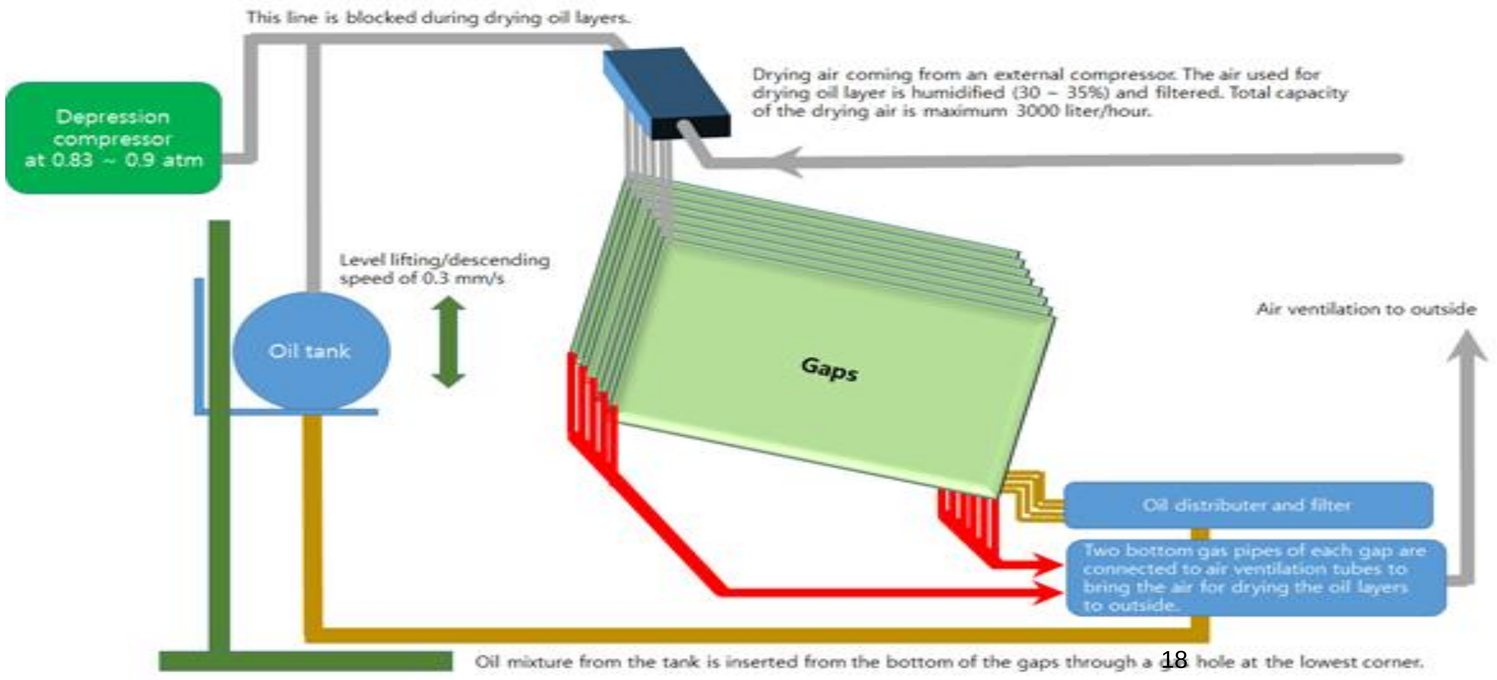
3-layer large PCB (1600 mm long) developed with ELVIA for CMS-iRPC project

RPC/MRPC future facility

- Cutting & cleaning of resistive materials (HPL, glass, etc..)
- Silk print serigraphy for coating
- Assembling following the technology (RPC/MRPC)
- Oiling for HPL-based RPC
- QC
- Functional tests (gas tightness, HV, etc….)



Picture taken in a mirror company for the SDHCAL glass plates coating



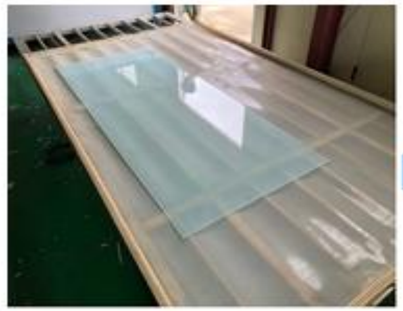
Production tools

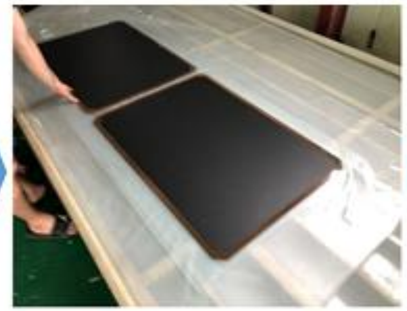
RPC/MRPC

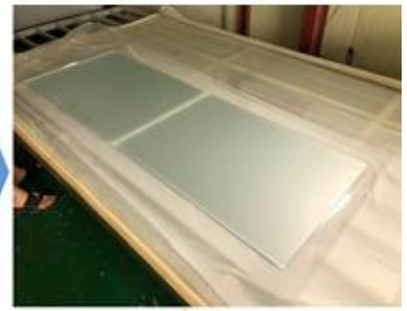
- 3D-print to produce components (spaces, gas inlets….)
- Tool for painting and coating
- Tools for new material resistivity measurements (Ar based method is used once the chamber is built…)
- Tools to measure chemical products (HF,…etc)
- Tools for assembling
- Tools for QC (thickness, gas tightness…)

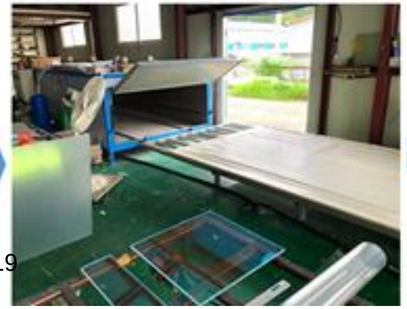
Glue extrusion facility for PET coating @KODEL

Vacuum gluing facility @Yurim









TPCs

Directions for future

- High rate TPCs for future High-luminosity colliders
  - reduce IBF
  - high granularity readout Vs cost
  - resistive technologies for readout
  - low budget materials (composite structures, resistive field cage)
- Low background / rare events TPCs
  - large volume, high density (pressure) TPCs
  - radiopure materials
  - cryogenic TPCs
- Large gas volume management : use of Eco-Gas, sealed TPCs
- TT transfer for “Giant” TPC field cages (ex: GTT for DUNE/Far detector)

Processes to investigate

- Gating grid/mesh technologies
  - very high wire density
  - Multi-grid structures
  - Very fast High Voltage power supply systems
- “Mutliplexed” readout sensors
- Survey of materials (mechanical Vs electrical properties) for new large (Very High Voltage) & light field cage structures
- Survey of industrials for partnerships on mechanical & High voltage engineering for production of field cages

MPGD

Directions for future

- Low background
- High timing resol → Pico sec
- Reduce cost
- TT to industry
- Sealed detectors/TPCs
- High dynamic range detectors
- Low IBF detectors

Processes to investigate

- Vacuum deposition
- Subtractive micro-structuring
  - Chemical
  - Laser
  - Reactive Ion Etching Plasma (RIE)
  - Directive RIE Plasma (DRIE)
- Additive micro-structuring
  - 3D ink jet printing

Pulsed DC magnetron reactive vacuum deposition

- Max foil size:
  - -1.7m x 0.7m.
- Useful size:
  - -1.7m x 0.6m.

- Can deposit
  - -metals
  - -Dielectrics
  - -B4C
  - -DLC etc..

- 5 targets
- 3 simultaneous deposition
- 3 gas inputs
- Built in heater
- Built in plasma cleaner

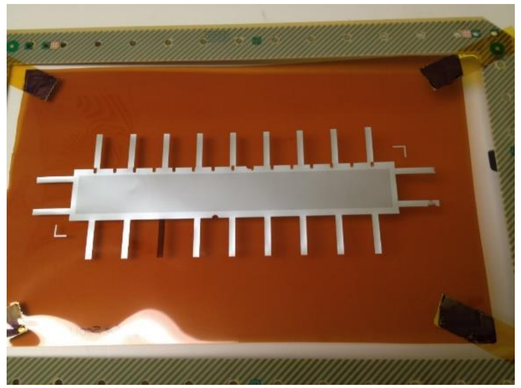
- Budget:
  - -25% INFN
  - -75% CERN

- Market survey → 04/21
- Invitation to tender → 05/21
- Purchase order → 08/21
- Delivery → 10/22
- Operation → 11/22

- Machine Design
  - Serge Ferry
  - Large Inputs from DLC group

Future program with vacuum deposition machine

Aluminum GEM



-Aluminium GEMs

-Low mass detectors

-Continue to explore DLC possibilities

-Improve Uniformity : target → less than +/-5% error (1m x0.6m)

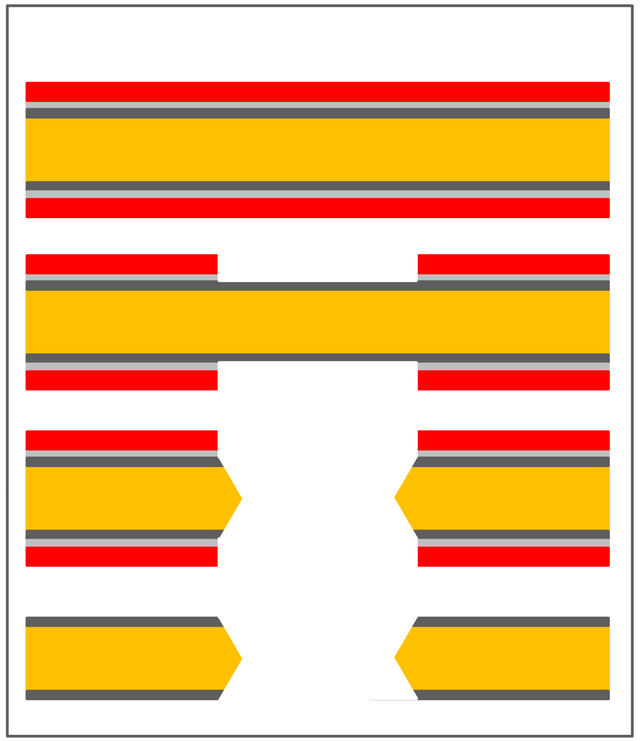
-DLC/Cr/Cu deposition needed for Micromegas high rate detectors and resistive GEM

-Photocathodes for PICOSEC detectors

-Neutron converter layers deposition like B4C

-Explore other resistive materials like Ge

DLC resistive GEM



Subtractive micro-structuring with chemistry
(Polyimide etching)

Now

Future

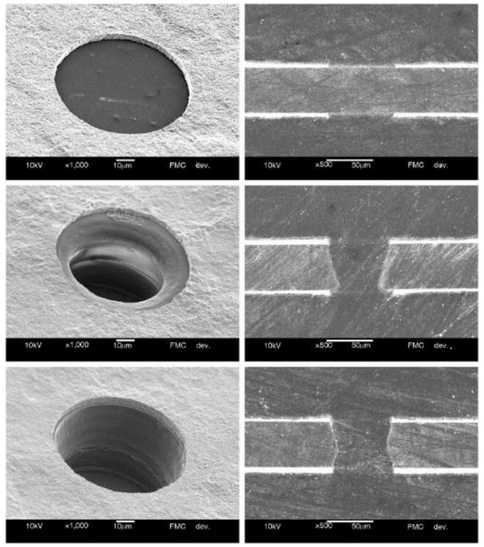
Dead Baths in a dedicated hood with scrubber :
-Ok up to 1000m2 projects

Automatic Horizontal etching line :
- Above 1000 m2 projects.
- Facilitate TT to industry

Laser or plasma subtractive micro-structuring

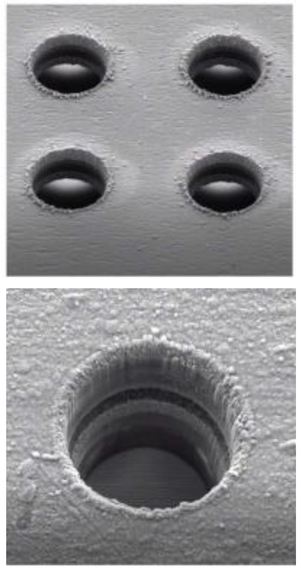
Future

CO2 laser

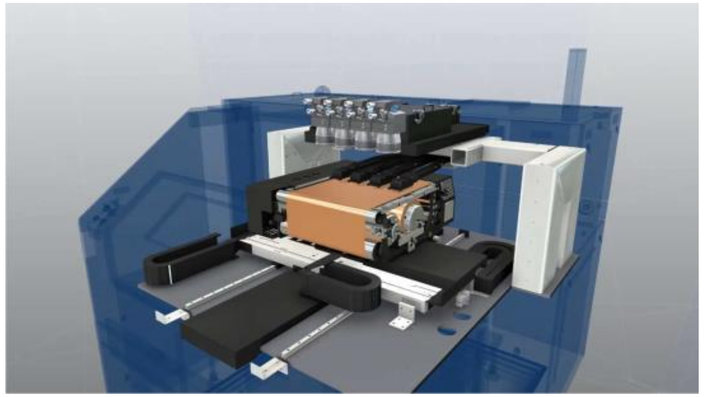


-Many possible base Materials.
-Holes perfectly clean.
-Small patterns
-Synergies with Solid state detectors

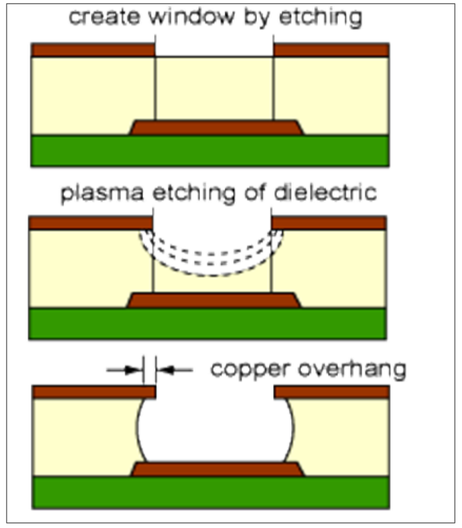
UV laser



-Many possible base Materials.
-Machines can drill both metals and polymers
-Roll to roll machines available now on the market

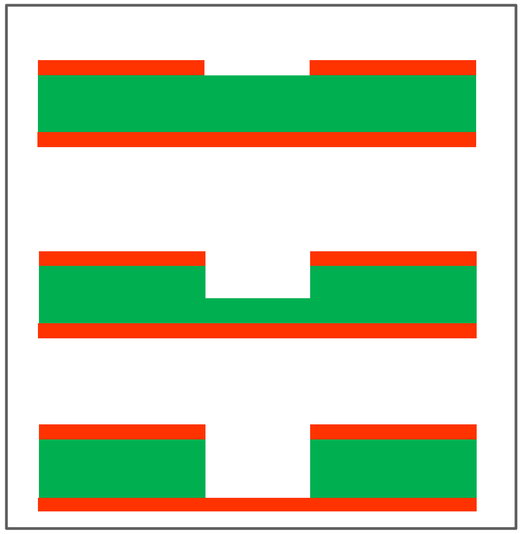


RIE Plasma



-Moderate machine cost .
-Holes perfectly clean
-Relatively large areas
-Possibility to couple with Chemical etching

DRIE Plasma



-Perfect cylindrical holes.
-Holes perfectly clean
-Ultra precise patterns

Additive Micro-structuring ink-jet printers

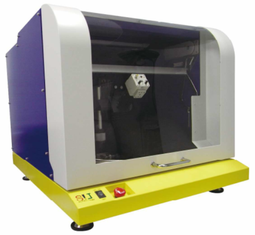
Future

Super Inkjet printer (SIJ-S050)

◇**Super fine patterning**
Droplet volume:0.1fl (femtoliter) ～10pl (picoliter)

◇**Wide range of viscosity**
Viscosity range:0.5～10,000cps (non-heated)

◇**Large variety of usable fluids**



Type	SIJ-S050 (desktop system) ※includes PC, monitor and software
Data format	Vector form data
Patterning design	Arbitrary shape (dot, line, circle, polygonal shape)
Patterning area	50×50mm
Number of nozzles	Single nozzle
Repeatability of work stage	±0.2μm
Fiducial camera	Real-time observation camera×1, Alignment camera×1
Power	AC100-120V 50/60Hz ※Including a transformer.
Body size	620(W)×880(D)×690(H) mm
Weight	Approximately 64Kg

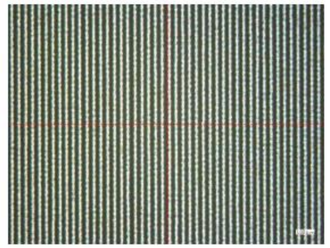
Features

■Droplet volume:0.1fl (femtoliter)～10pl (picoliter), Line width 0.5μm ～ several dozen μm Smallest droplet volume !

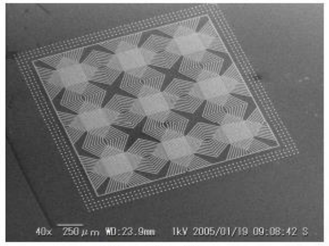
■Viscosity range :0.5～10,000cps (non-heated) Wide range of viscosity !

■Large variety of usable fluids:Conductive ink, Insulating ink, Resist ink, UV ink, Solvent ink, Protein material, etc No special ink !

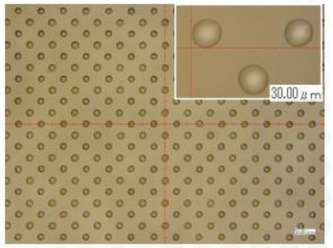
Patterning Example



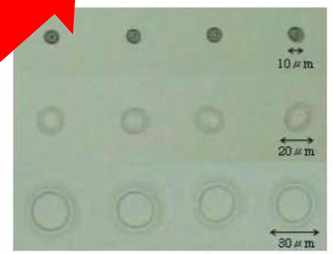
Silver ink, L/S=1μm



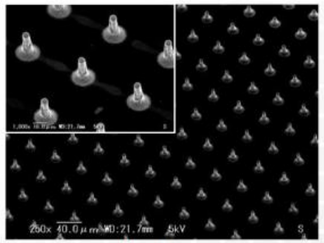
Circuit pattern



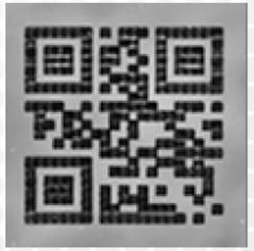
Microlens (resin ink)



Protein material (albumin)



Microbump
Diameter=5μm, Height=20μm



Micro QRcode (750μm×750μm)

Questions / Suggestions to DRD1

- How DRD1 can help setting up new technologies, buy equipment, set up new facilities ?

- The access of CERN MPT is defined in the RD51 MoU, should we extend that to other workshops ?

- Technology transfer to industry
  - Could DRD1 select some companies and keep working closely with them ?
  - Or this will stay impossible due to purchasing rules

- If we want to create a useful “facilities” data base to help DRD1 members, could we tag the facilities as following ?
  - Type 1 → open to any request from members of the collaboration without any conditions
  - Type 2 : → open with special agreements (collaboration between institutes)
  - Type 3 :→ closed to any type of collaboration