Eols related to RPCs, MPGDs

Silvia Dalla Torre, Beatrice Mandelli
• Preliminary analysis

- EoIs related to *gaseous detectors (GD)*: 34 [related ≠ dedicated]
  - related to RPCs: 10
  - related to MPGDs: 18
  - related to large volume GDs and DCs: 6 (2 about drift chamber for HEP, 3 related to HPgTPC for ν physics, Dune near detector, 1 gas studies for DCs)

- A firm classification not always straightforward, f. i.:
  - R&D of GD for calorimetry application: *GD or calorimetry?*
  - R&D of MPGDs for TPC read-out: *large volume GD of MPGD?*
  - FE electronics for MPGDs, technology of analysis tool for tracking with GDs: *GD or electronics/data analysis?*

- Strategy for this report:
  - Include everything with appropriate comments, apart *large volume GDs &DCs* (different report)
The various proponents have interpreted the EoIs prescription differently:
- Very focused single tasks (sometimes spotting crucial items)
- Extremely wide research program (sometime so wide to miss focusing power)
- Well defined task(s) with a wide research program

The guidelines are not always followed:
- Number of participants (<2; >6)
- Max total cost (> 600 k€)
- Missing information (f.i., contact person of a participant)

Attitude:
- Try to underline the validity of a proposal, in any case
- “broken rules” will be accounted for later

NOTE:
In the following the labels extension or new are set with reference to AIDA2020, not to world-wide R&D studies: “new” is not always truly new
**EoI 56:**

**Study of eco-friendly gas mixtures for Resistive Plate Chamber detectors**

- Tests at GIF++, test beam, cosmics
- Extension with focus on eco-gas irradiation, recirculation and impurities
- Of interest IF merged/synergic with novel RPC geometries and materials

(Eois: 87, 153, …)

**EoI 135:**

**GRPC Digitizer for Hadronic Calorimeter**

- Glass RPC: simulating with GEANT4 of the signal formation
- SDHCAL applications, but MC approach and gas studies make it of general interest
- Also in view of gas choice (eco-gasses) [cross-sections are NOT known …]
- Possibility to merge/synergies with 58 (4-D SDHCAL) or 25 (ultra high res. MRPC by thin glass)
Eol 33:

**New materials for high rate (M)RPC**

- new materials: ceramics, low resistivity Bakelite, glasses and new plastics (also mentioned in 11 and 87)
- evaluating the resistivity (bulk, surface), homogeneity and ageing properties
- Method: by rate response and the ageing properties of small area (M)RPCs exposed to intense source/beams
- Merging with 11 (also overlap of Institutions)?
EoI 11:

Development of innovative planar gaseous detectors with high time and spatial resolution, and improved rate capability for FCC

- RPC with lower resistivity for high rates (O(10 kHz/cm²)) (also mentioned in 87 and 33)
- Sub-mm space resolution (strategy not specified)
- Large scale production
- Also low-noise electronics included, both exploring what existing and considering the design of a new ASIC (detail missing)
- Very wide program, not yet well-focused, clarification and prioritization needed
- Merging with 33 (also overlap of Institutions) ?

EoI 57:

New readout structure to read out large RPC detectors

- RPCs with pads for high rates
- New r-o scheme connecting pads in rows
- Coordinate reconstructions thanks to the illumination of several adjacent pads
- Already tested on small-size detectors
• EoI 87: **RPCs for Medium High Rates**
  - 1 Khz/cm²
  - cover large surfaces
  - new materials for the resistive plate electrodes (also mentioned in 33 and 11)
  - different gas gap widths different electrodes widths
  - Appropriate for merging with 153 and/or 11?

• EoI 153: **100 kHz/cm² classic RPCs with ultimate time resolution working with inexpensive gases**
  - classic RPCs with inexpensive gasses
  - new RPC design changing geometry (in particular, electrode thickness) and material resistivity
  - Appropriate for merging with 87?
• EoI 58:  
**Timing for SDHCAL**

- In SDHCAL replacing RPCs with MRPCS for 5D imaging
- emphasis on new FE chip (new PETIROC), MRPC dedicated, for precise timing
- R&D related to “RPC&MPGD”, to calorimetry, to electronics?

• EoI 25:  
**MRPCs for fast timing at high incident flux of charged particles**

- MRPC with increased t-res (20 ps) and rate capability (50 kHz/cm2);
- thin low resistance glass needed for smaller gaps and increased n. of layers;
- 400um commercial gas (Picotech SAS) to be studied
- t-res dependence on gas flow to be studied
- *Highly needed, in particular in the hadron physics experiments*
Eol 12:
Innovative neutron gaseous detectors with solid converters and imaging capabilities

- n detection by MRPC with improved space, time res, rate capability, efficiency
- **Converters:** Gd (efficiency for thermal n) or $^{10}\text{B}$ (photon discrimination thanks to alpha emission)
- Also for HEP, added value in calorimetry, evaluation in situ of the n-contamination in muon detectors
2 innovative EoIs where fine time resolution is the central parameter
- Different application field:
  - 5D imaging calorimetry, PID by TOF in extended systems
    - Both for applications highly required by the community: e+e-, h-physcs
- Common approach: MRPC
- Different emphasis: electronics, new glass and geometrical configuration
- Clearly distinct projects with synergic aspects

1 innovative EoI for n detection
- Certainly highly needed, less obvious for HEP applications

3 EoIs dedicated to studies of general interest that can receive added values if merged within targeted projects
- Extension respect to AIDA2020 (a part signal simulations which is new)
- Eco-gasses, materials, signal simulation simulations

4 EoIs dedicated to upgrades of the standard RPC
- A new idea: new read-out scheme (pads organized in rows)
- Aiming at improved performance, also with elements present in more than one EoI → selection and merging needed
7 “new” Eols, 3 “extension” Eols
   - Good variety of proposals, non-negligible “overlap” of items

Eols also related to other sectors
   - Calorimetry: 58
   - Electronics: 58
   - PID (by TOF): 25

Mainly non-HEP applications: 12

Frontier R&D: 25

Synergies/merging (?)
   - 56-87-153; 25-58-135; 11-33
ABOUT INSTITUTIONS & INDUSTRIES

RPC
## AIDA++ Open meeting

### AIDA++

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### Institutions

- 3 PIs: INFN Bari, CNRS Lyon
- 2 PIs: INFN Roma 2
- 1 PI: LIP, INFN Bologna

### Summary

- **20 EC Institutions (good!), 4 non EC Institutions (good!), 1 industry**
- **recursive Institutions suggest some merging (as already mentioned)**
## EC beneficiaries

| Eol | CERN | GENT (B) | Centro Fermi (I) | CIEMAT (E) | CLERMONT-FERRAND (F) | INFN Bari (I) | INFN Bologna (I) | INFN Cagliari (I) | INFN Casaccia (I) | INFN Frascati (I) | INFN Roma2 (I) | INFN Torino (I) | HZDR (D) | IGFAE | LIP (P) | LPC (F) | Lyon (F) | OMEGA (F) | Torino Politecnico (I) | Weizmann (IL) |
|-----|------|----------|------------------|------------|----------------------|--------------|------------------|-------------------|-------------------|-----------------|----------------|----------------|-------------|--------|---------|--------|--------|---------|-----------------|----------------|----------------|
| 56  | 1    | 1        | 1                | 1          | 1                    | 1            | 1                | 1                 | 1                 | 1               | 1              | 1            | 1          | 1       |        |        |        |         |                   |                |
| 135 |      |          |                  |            |                      |              |                  |                    |                   |                 |                |              |            |         |        |        |        |         |                   |                |
| 33  |      |          |                  |            |                      |              |                  |                    |                   |                 |                |              |            |         |        |        |        |         |                   |                |
| 11  |      |          |                  |            |                      |              |                  | 1                  | 1                 | 1               | 1              | 1            | 1          | 1       | 1       |        |        |         |                   |                |
| 57  | 1    | 1        | 1                |            |                      | 1            |                  |                   |                   |                 |                |              |            |         |        |        |        |         |                   |                |
| 87  |      |          |                  |            |                      |              |                  | 1                  | 1                 | 1               | 1              | 1            | 1          |        |        |        |        |         |                   |                |
| 153 | 1    |          | 1                |            |                      | 1            |                  |                   |                   |                 |                |              |            |         |        |        |        |         |                   |                |
| 58  | 1    | 1        | 1                |            |                      | 1            |                  |                   |                   |                 |                |              |            |         |        |        |        |         |                   |                |
| 25  |      |          |                  |            |                      |              |                  |                   |                   |                 |                |              |            |         |        |        |        |         |                   |                |
| 12  |      |          |                  |            |                      |              |                  |                   |                   |                 |                |              | 1          |         |        |        |        |         |                   |                |

**recursive** Institutions require attention in preparing the proposal
• EoI 114: Development of **resistive electrodes** for MPGD detectors for future collider experiments
  
  ▪ for GEMs, MMs, uR-WELL
  ▪ Main motivation: spark protection = detector stability
  ▪ specific applications: photocathode, fully resistive MPGD, signal spread (space res.)
  ▪ **Various material considered:** DLC, multilayer graphene
  ▪ Synergies/merging with 126
  ▪ Complementary to 111

• EoI 126: Application of Diamond Like Carbon (DLC) coating in Gas Electron Multipliers (GEM) based detectors for future experiments and applications.
  
  ▪ DLC in GEMS
  ▪ **extensive and complete set of studies:** single foil protection, single foil sectorization, discharge mitigation, readout protection, low material budget and metal free electrodes, radiation hardness studies
  ▪ Synergies/merging with 114
**EoI 111:**

*Investigation & Mitigation of Discharges* in MPGD detectors for future collider experiments

- Complete program to study discharges in GEMs & MMNs
- Construction of dedicated acoustic, optical and e.m. antennas
- Simulations (important for deep understanding of discharge phenomena)
- Dependence on gasses and resistivity for MM
- Tests (also under n flux)
- Highly needed for HEP (intensity frontier)
- Complementary to 114

**EoI 160:**

*Systematic quality testing of GEM and ThickGEM type detectors – “Leopard”, gain mapping, optical mapping*

- “leopard” application to study the intrinsic properties of GEMs and THGEMs
- Also support to producers with in-house studies of uniformity
EoI 85: 
R&D towards MPGD based SDHCAL for high radiation environments

- To increase the rate capability of SDHCAL
- An idea on the table since a while
- Use of RPWELL (resistive plate WELL); also uR-WELL can be considered
- R&D related to “RPC&MPGD”, to calorimetry?

EoI 161: 
Applied optical readout gaseous detectors

- MPGD optical read-out with commercial cameras
- search for possible alternative to CF4
- applications: beam monitoring, portable version for archeology, …
- Not in competition with Eol 125
• **Eol 5:**

**Development of a wide dynamic range, radiation hardness beam monitor based on μ-RWELL detector for use in future accelerators and hadron therapy**

- Proposed as replacement of ionization chambers in beam monitoring based on uR-WELL:
  - Effective also at very low fluxes
  - Fundamental science and hadrotherapy
- R&D related to “RPC&MPGD”, to upgrade of infrastructures?
EoI 124: Precise fast timing (tens of psec) with large area segmented Micro Pattern Gaseous Detector: a scalable multichannel PICOSEC MicroMegas detector module

- progress of the picosec project: an engineered PICOSEC MM module scalable up
- photocathodes (protection for CsI and new materials)
- electronics (amplifiers, digitizers)
- Mechanics
- Frontier R&D

EoI 125: High-speed and time-resolved optical readout of MPGDs with FPGA-accelerated image processing and TimePix readout

- MPGD optical read-out
- high-bandwidth interfaces between ultra-high-speed cameras and FPGAs for real-time image processing
- in parallel, photodetection with Timepix3 ASIC
- optical read-out of TPCs; beam monitoring
- Frontier R&D
• **EoI 102:**

**Pixelated Micromegas Detectors with Innovative Resistive Spark Protection System and Integrated Electronics for High Rates Applications**

- MMs with minipads
- **electronics on the rear face**, new anode structure to develop
- applications:
  - pre-shower for an electromagnetic calorimeter
  - muon tracking
  - readout layer of a Time Projection Chamber

• **EoI 120:**

**GAseouS deteCtOrs for tIme taGged Neutrino bEams (GASCOIGNE)**

- **ν-physics**
- **photon veto using RD51 psec principle** (EoI 124)
- prototype of **realistic size** to be tested at CERN-PS
- Also suitable electronics
- R&D related to “RPC&MPGD”, to **ν-physics**?
**Eol 24:**

**Photon detectors for hadron particle identification at high momenta with compact RICHes**

- Upgraded hybrid MPGD-based single photon detectors
- Comparatively considered: Solid-state (commercial SiPM) and vacuum-based (MPC: LAPPD) single photon detectors
- Both for compact (= short in length) RICHes for high p ( > 10 GeV/c)
- Answering one of the major quests in hadron physics
- R&D related to “RPC&MPGD” & to “PID”
• **EoI 106:**

**Development of high performance readout electronics for gas detectors**

- main requests: designed for MPGDs, radiation tolerant
- new ASIC in CMOS technology, designed using EDA tools
- development of firmware
- An analysis of what exists and what is been developed is missing
- R&D related to “RPC&MPGD”, more to electronics?

• **EoI 127:**

**High throughput MPGDs Readout System based on SRS/VMM3a for laboratory, test beam and small-medium size experiment**

- Dedicated DAQ system
- High throughput not available in SRS!
• **EoI 51:**
  Development and characterisation of integrated electronics for the readout of pixelated μRWELL detectors
  - development of ASIC for uR-WELL
    - ASIC connected to sensor via flip-chip assembly
  - Development of dedicated firmware and software
  - R&D related to “RPC&MPGD”, more to electronics?

• **EoI 62:**
  Development of Machine Learning algorithms for Micro Pattern Gaseous Detectors
  - Development of ML methods tested by MC data samples
  - R&D related to “RPC&MPGD”, to software?
Eol 147:

UV photocathode characterization and aging test facility for Timing and Particle Identification (RICH) applications at CERN

- Characterization of (UV) photocathode
- Absolute QE measurements
- A crucial facility for progress of MPGDs as Psec, for PID photon detectors
- R&D related to “RPC&MPGD” & to “PID”
Eol 52:

Industrial engineering of high-rate $\mu$-RWELL detectors with bi-dimensional readout

- TT of the high-rate version of uR-WELL
- Answering to one of the major request in the MPGD sector
• **5 EoIs dedicated to novel detectors, relevant perspectives for future exp.s**
  - MPGD Psec (HiLumi LHC and beyond) 124
  - Fast optical read-out of MPGDs (TPC r-o, beam monitoring) 125
  - far UV single photon detectors for **PID** (compact high p RICHes, EIC and flavor physics) 24
  - Pixelized MMs with embedded FE (tracking, calorimetry) 102
  - Psec photon veto for ν-physics 120

• **4 EoIs dedicated to studies of general interest to improve MPGDs**
  - Resistive materials, DLC GEMs, discharge studies→ presently at focus 114, 126, 11
  - Uniformity study with Leopard (also for industrialization) 160

• **3 EoIs dedicated to MPGD applications:**
  - HEP: beam monitoring by uR-WELL (also for facilities) 5, SDHCAL by RPWELL 85
  - Other appl.s: optical r-o by commercial cameras 161

• **5 EoIs dedicated to Tools**
  - 2 dedicated to novel FE ASIC + … *(rationalization needed !!, electronics chapter ?)* 51, 106
  - Fast DAQ for VMM3a (needed by the community) 127
  - Facility for photocathode characterization *(also highly needed by PID)* 147
  - ML *(software chapter?)* 62

• **1 Eol dedicated to industrialization**
  - uR-WELL for high rate → major relevance 52
• 15 “new” Eols, 1 “extension” Eols, 2 “new/extension” Eols
  ▪ great variety of proposals, limited “overlap” of items

• Eols also related to other sectors
  ▪ Calorimetry: 85
  ▪ Electronics: 51, 106
  ▪ PID: 24, 147
  ▪ Software: 62
  ▪ ν-physics: 120

• Mainly non-HEP applications: 5, 161

• Frontier R&D: 102, 124, 125, 24

• Synergies/merging (?)
  ▪ 114-126
ABOUT INSTITUTIONS & INDUSTRIES

MPGD
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26 EC Institutions (good!), 2 non EC Institutions, 5 (+1) industries (good!)
recursive Institutions suggest some merging (as already mentioned)
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*Institutions require attention in preparing the proposal*
ABOUT MONEY
Organizational questions to be addressed:
- EoI relative to which WP?

Political questions to be addressed:
- How much space for non-HEP applications?

Indication of money also implies a judgement, while this is a comprehensive report ...

Therefore, just a feeling

With some guessing about these points and using criteria similar to AIDA2020, ~ 1-1.5 M€

(according to how much is moved elsewhere)