MPGDs: Recent Advances, Current R&D, and the European Strategy

- Klaus Dehmelt on behalf of all WP1 contributors

- Seattle Snowmass Summer Meeting 2022
- July 22, 2022

Stony Brook University | The State University of New York

RECENT ADVANCES - MPGD

- Micro Pattern Gas Detectors → MPGD
  - Motivation and goal for MPGD development → cost-effective, large-scale detectors with excellent position and timing resolution in high-rate applications
  - Significant development time invested
    - understanding optimal manufacturing techniques for MPGDs
    - understanding their operation
    - mitigation of undesirable effects, for instance discharges and ion backflow
  - Culmination in formation of CERN-RD51 collaboration → 2008
  - CERN PCB workshop → source of essential expertise in production, mitigation and correction of production issues, critical input for R&D

CURRENT R&D: THE SOURCE

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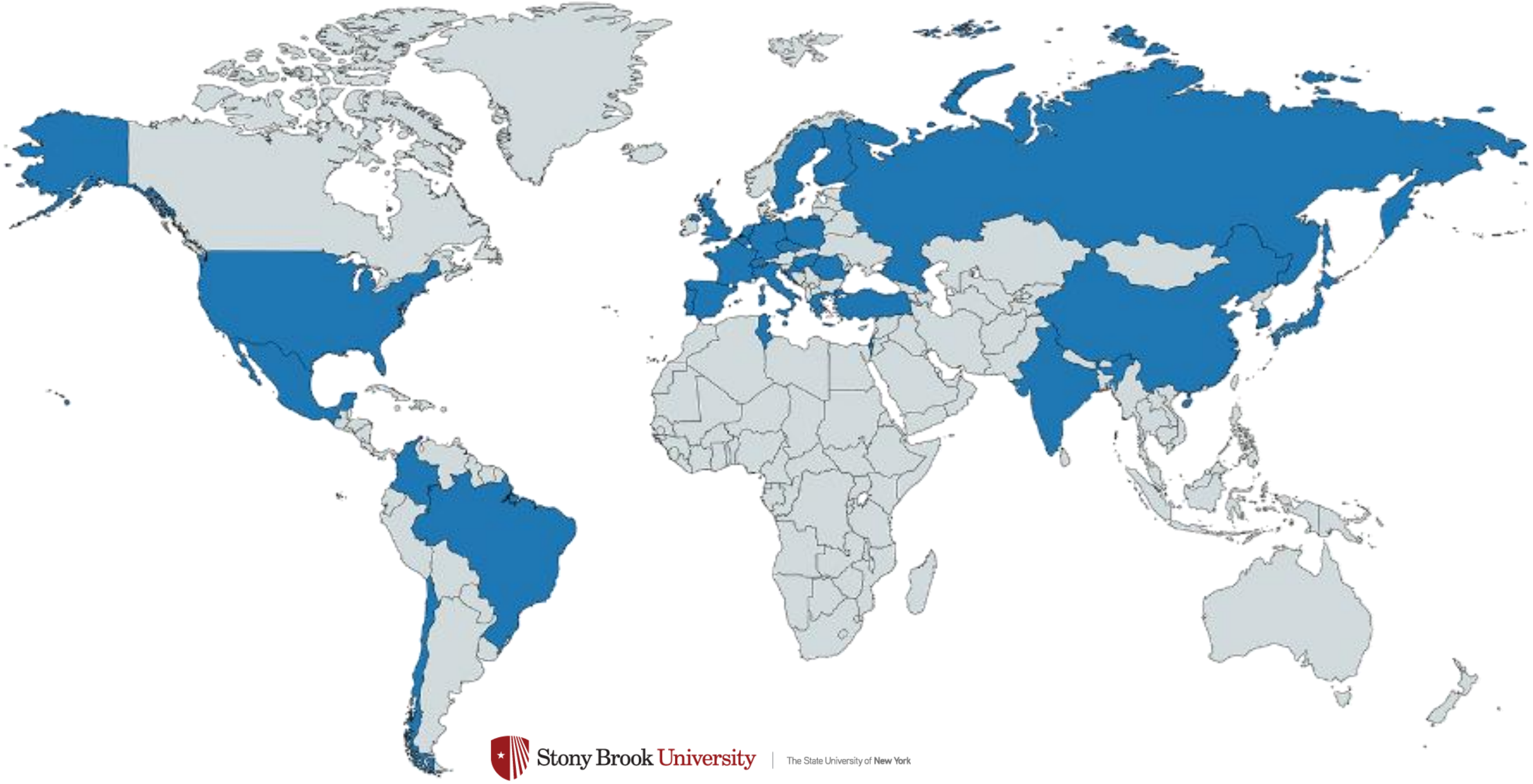

CURRENT R&D: THE SOURCE

- CERN-RD51 collaboration → technical collaboration, established in 2008
  - Comprises ~450 collaborators from 89 institutes from 31countries
  - Well organized and managed
  - Driver for the coordinated efforts within the MPGD community
    - more techniques becoming available or affordable
    - new detection concepts are still being introduced
    - existing ones are being substantially improved
  - Seven Working Groups WG
    - Transversal to RD51 activities, covering all aspects of R&D

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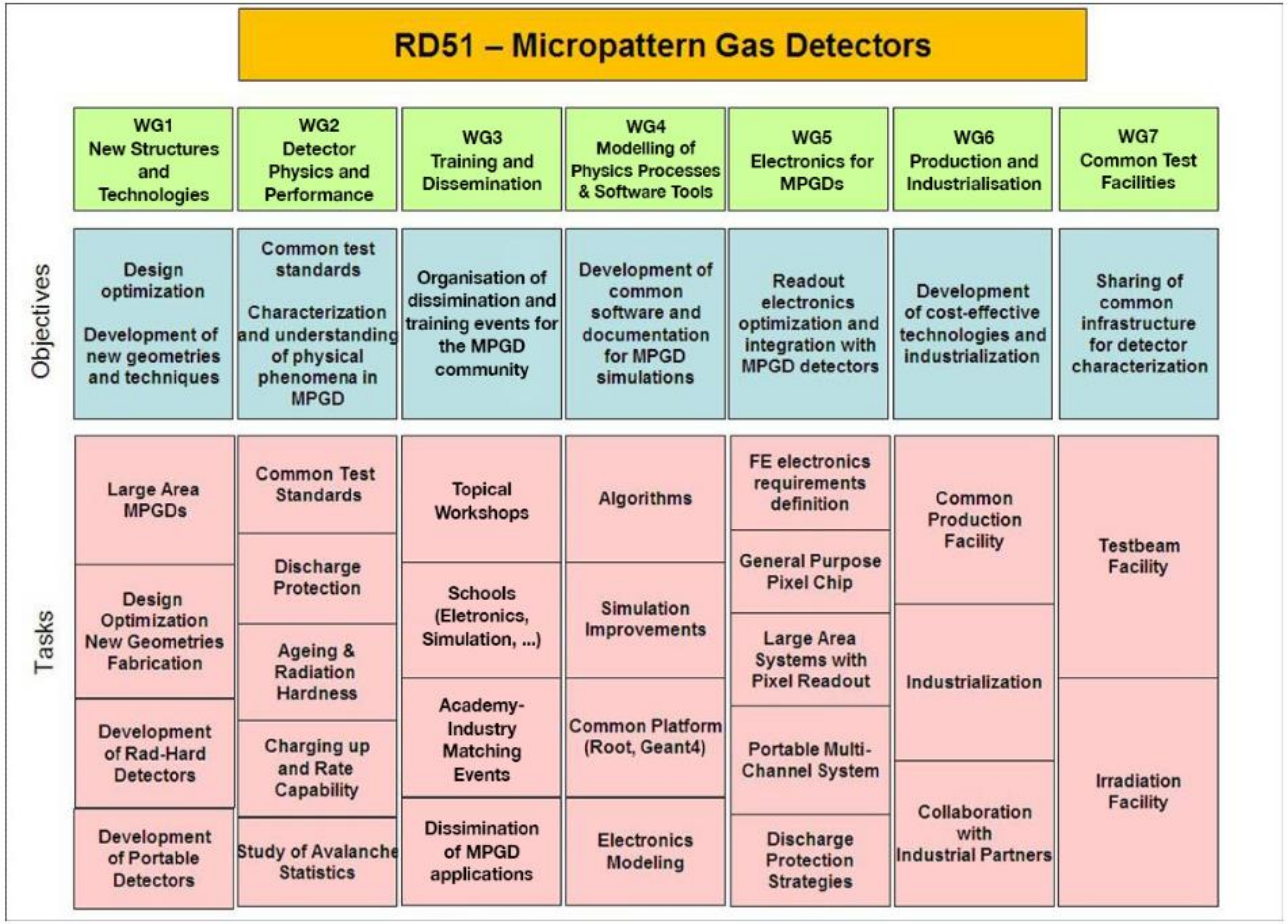
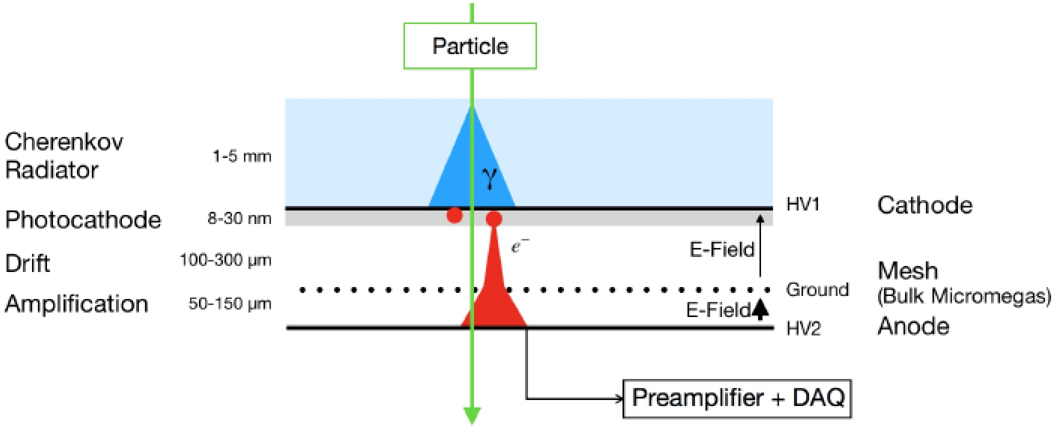


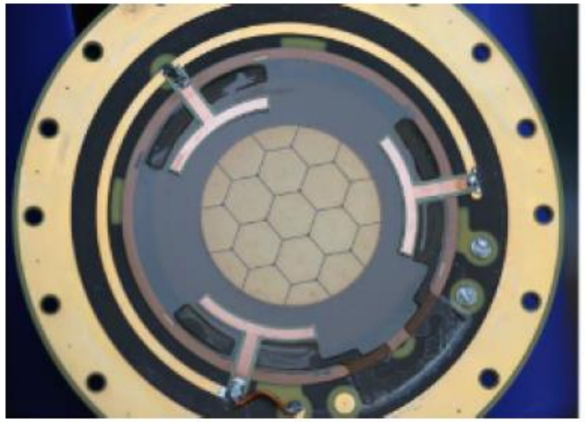
CURRENT R&D

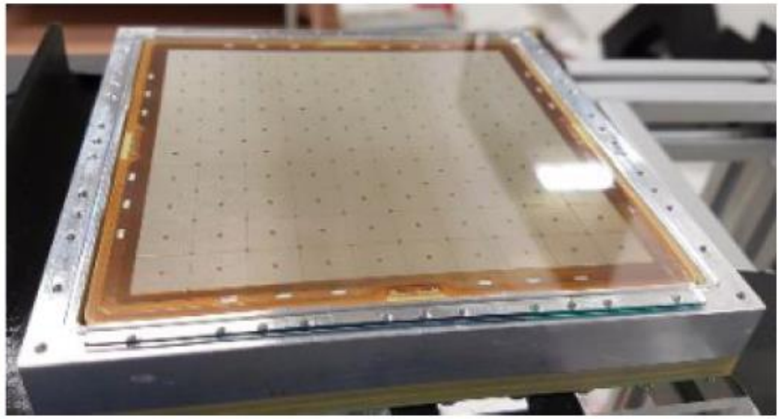
- **G**as **E**lectron **M**ultiplier (GEM) + **Micro-Mesh Ga**seous **S**tructure (Micromegas) → well established MPGD devices
  - More to come → THGEM, μRWell, …
  - Finding applications in many fields
    - HEP, NP, Astrophysics, Medical applications, Homeland Security, Commercial applications, …
  - Tracking, particle identification, timing, photo-detectors
  - Triggered electronics development
- Number of LOIs received → illustration of ongoing developments and expansion of MPGD use

CURRENT R&D

- High-precision timing → the Micromegas PICOSEC concept
- Prototypes show excellent timing resolution $\sigma_t=\mathcal{O}(20ps)$ for MIPs, $\sigma_t=\mathcal{O}(70ps)$ for photons
- Few pads' prototypes → many pads' prototypes







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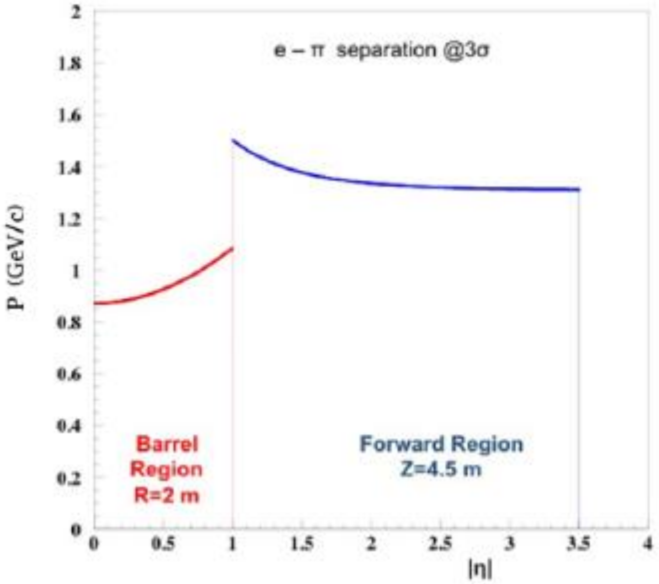
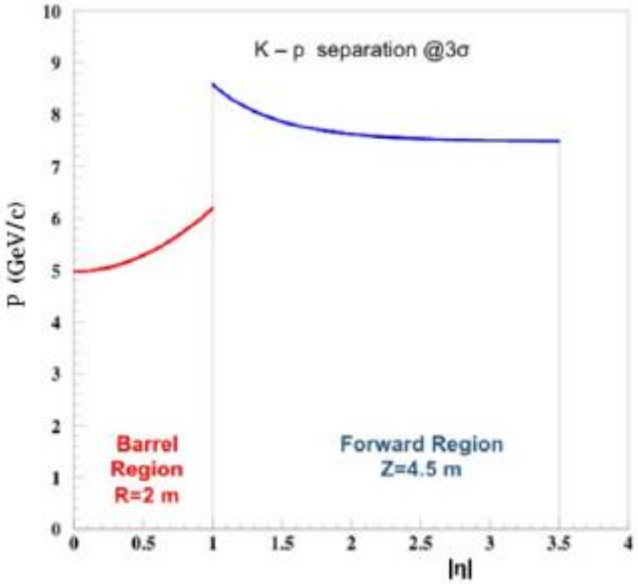
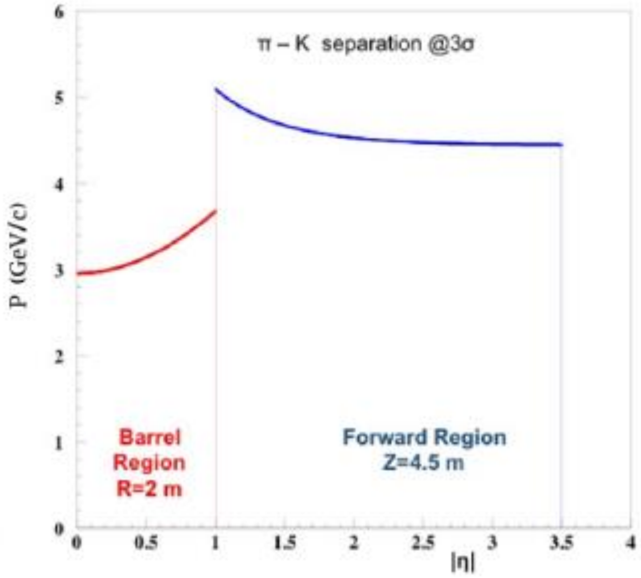
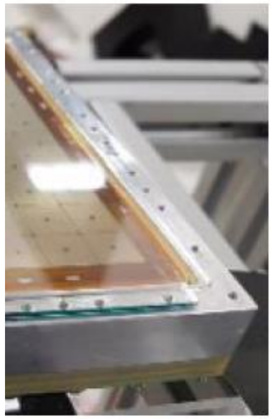
Cherenkov Radiator	1-5 mm
Photocathode	8-30 nm
Drift	100-300 µm
Amplification	50-150 µm



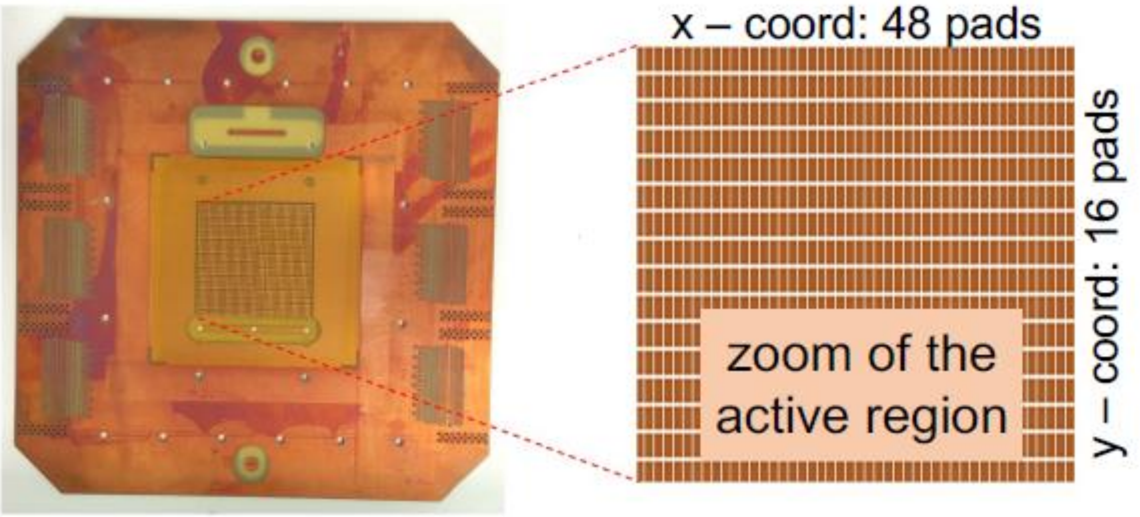


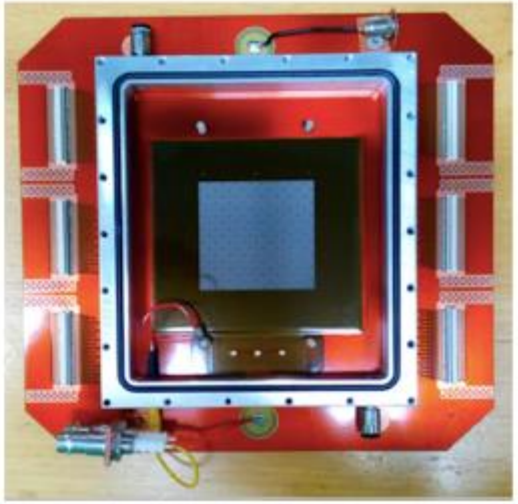




CURRENT R&D

- Pixelated resistive Micromegas for high-rate environments
- Rate capability goal 10s MHz/cm^2 with stable and efficient operation
- Development toward large areas
- Diamond-like Carbon DLC resistive layer techniques





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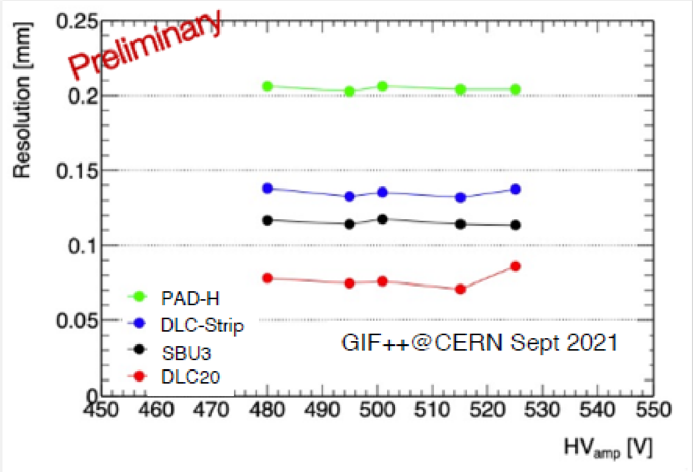

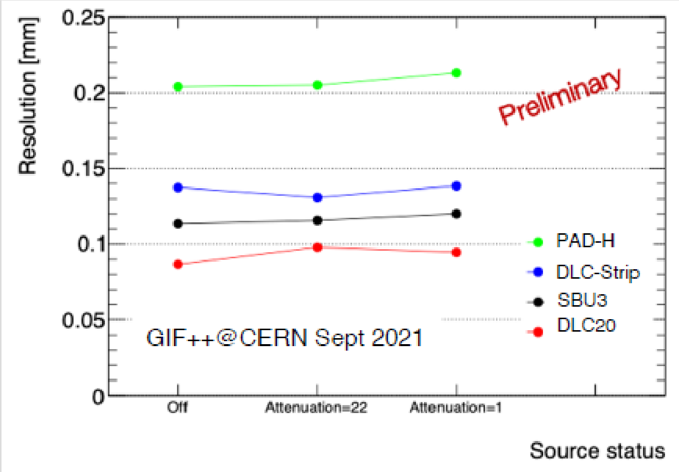

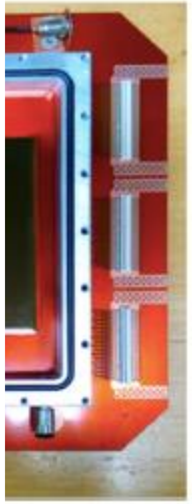

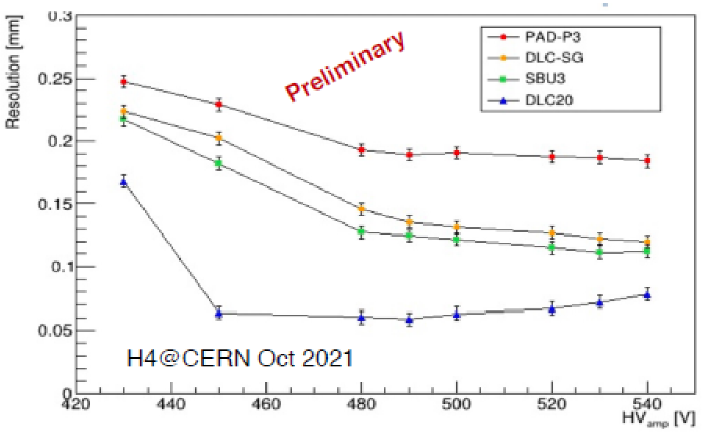

CURRENT R&D

- Scalable Readout System SRS established readout system
  - designed for scalability from desktop stems to rack-sized readout systems running under the same Online DAQ and Control system
- Extended SRS-e paradigm adds real-time trigger functionality, deep trigger pipelines and generalized frontend link

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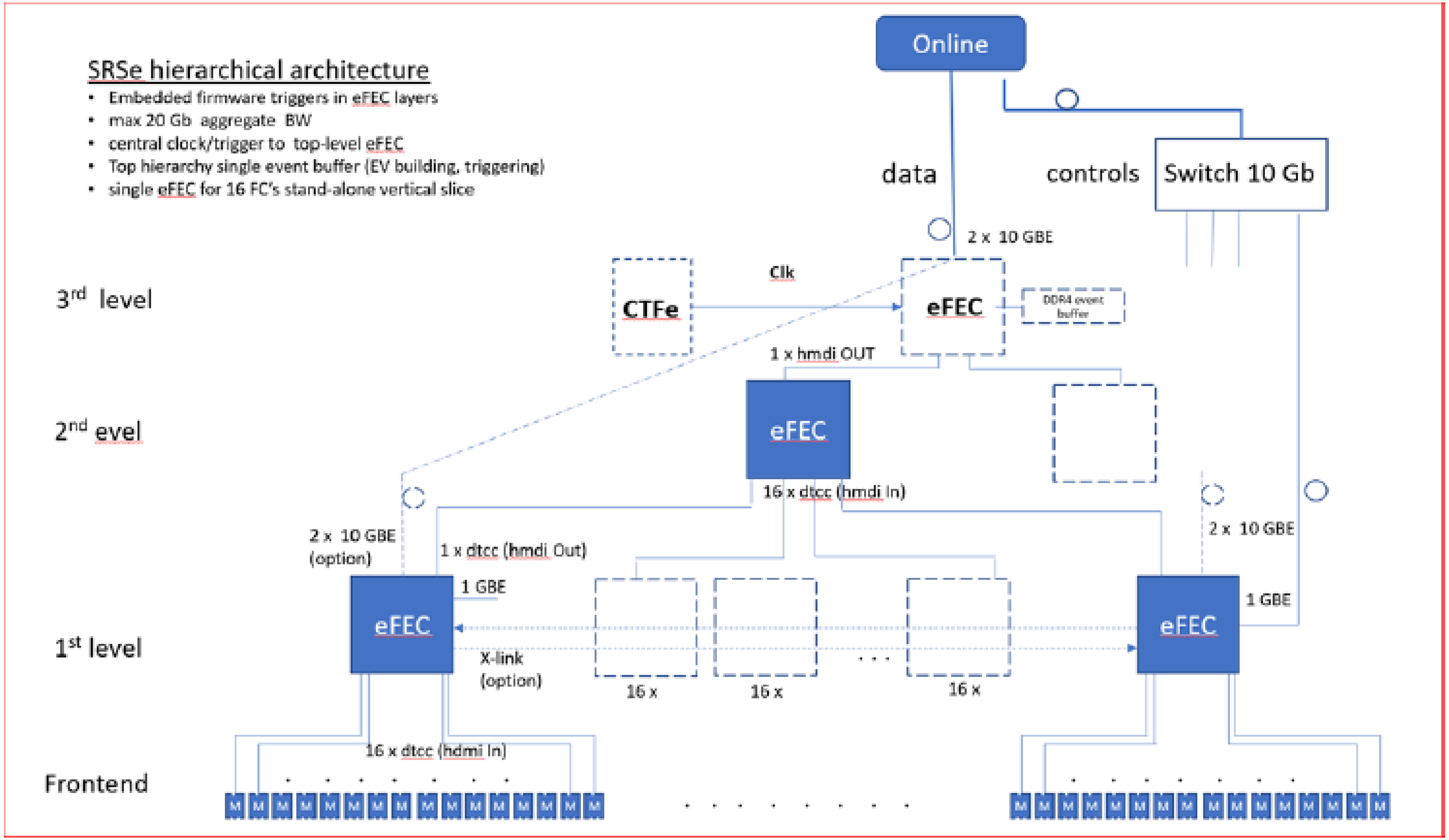

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- Scalable Readout System SRS established readout system
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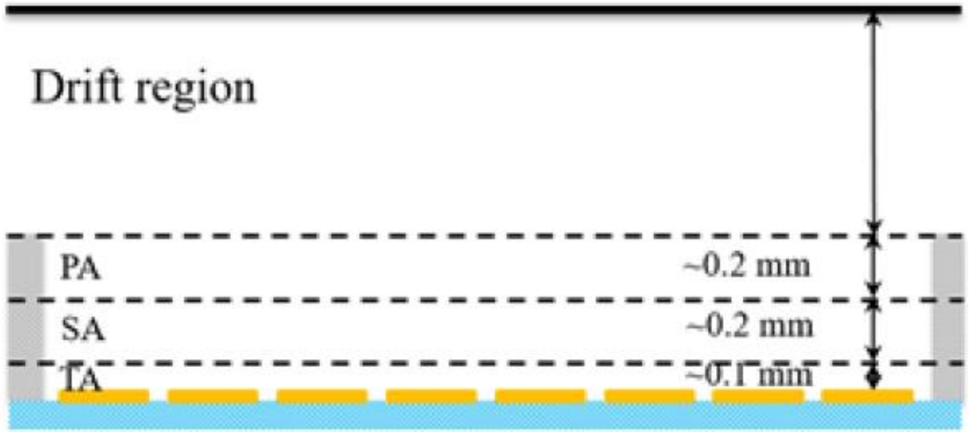
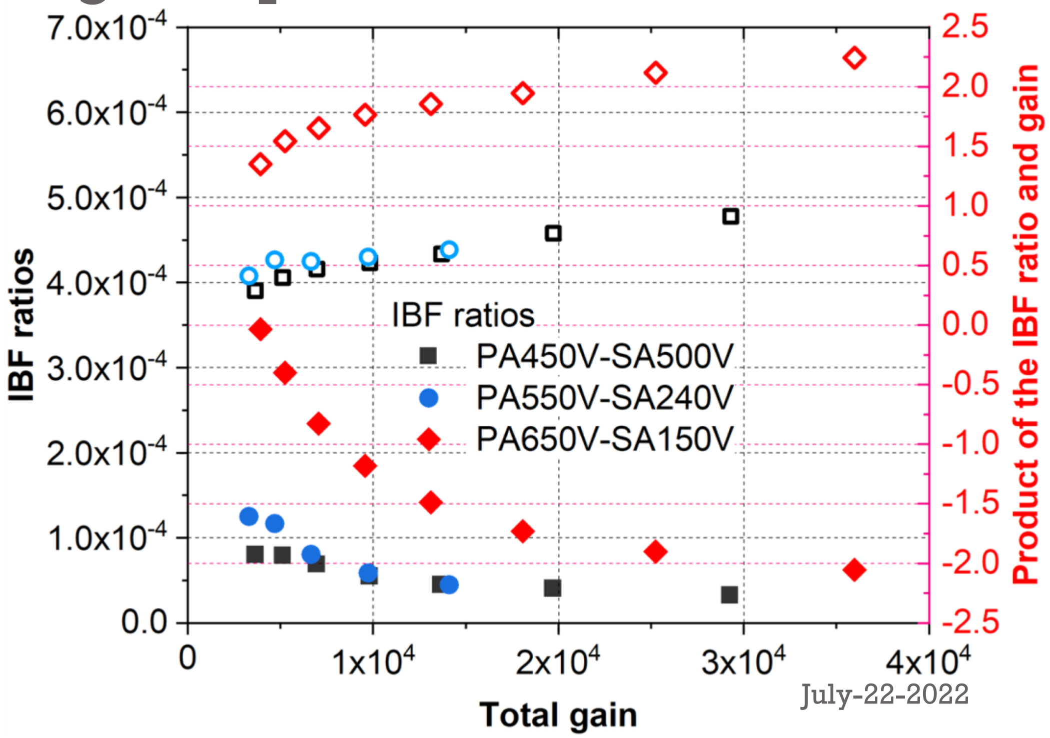
- Extended SRS-e paradigm adds real-time trigger functionality, deep trigger pipelines and generalized frontend link
- Workplan developed

- Use existing frontends (VMM3a, SiPM adapter) as well-known frontend as baseline
- Establish a common user forum modelled after RD51 WG5.1 user group to identify priorities and agree on code exchange rules and practices
- With first eFEC prototypes, establish a basic set of uPython test procedures for eFEC sanity checks and register-level access to all connected resources via I2C, SPI and JTAG
- Establish a Linux-based control and monitoring environment on the embedded multicore system
- Afer initial production of 2 pilot eFECs, launch a first batch production
- Deploy first stand-alone eFEC readout systems with VMM in testbeam-like environment
- If required, develop a MAC and/or Windows-based GUI for embedded use of uPython register level procedures
- Work with new experiments on the implementation of basic sets of triggers (fast-or, veto, coincidence, region, topology, etc)

CURRENT R&D

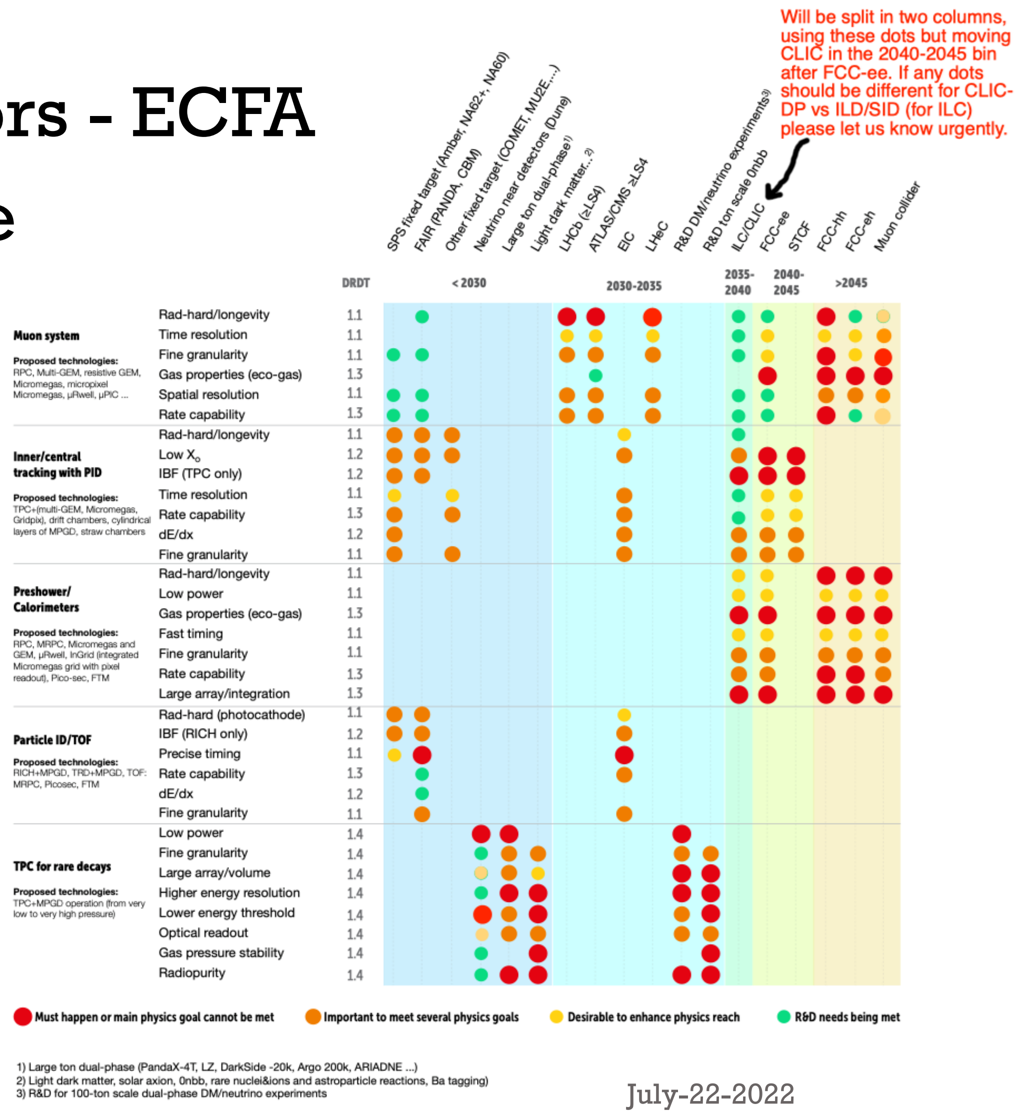
- High gain, low IBF multilayer Micromegas
- Motivated by painful IBF issue for every Time Projection Chamber → need to gateless for high readout speed application
- MPGD intrinsically IBF blocker → Micromegas superior





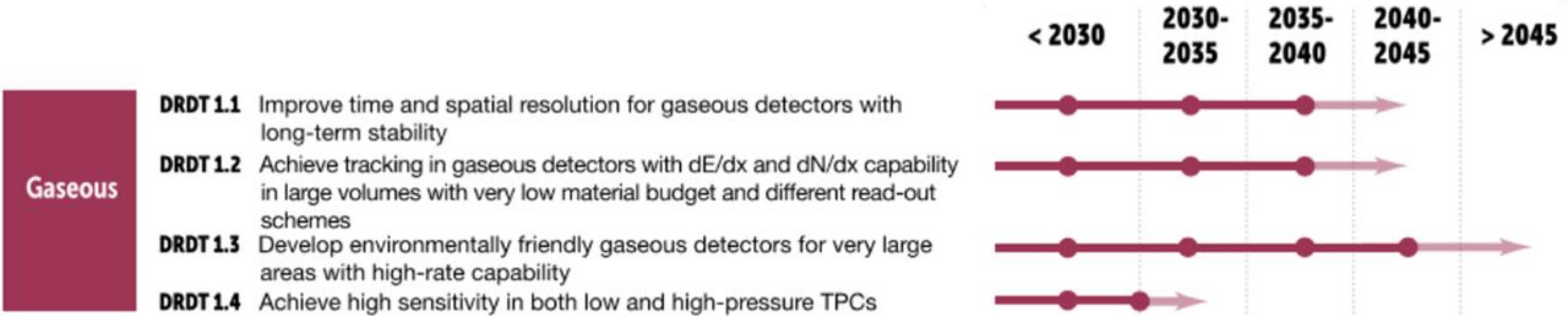
THE EUROPEAN STRATEGY

- European Committee for Future Accelerators - ECFA mandated to develop a roadmap to balance R&D efforts in Europe
- After extensive expert and community consultation phase → final roadmap approved end of 2021
- Gaseous detectors as one of the many work-packages → TF1



THE EUROPEAN STRATEGY

- Detector R&D Roadmap → Detector R&D Themes DRDT



THE EUROPEAN STRATEGY

- Plan is to restructure RD51
  - Formation of DRDC1 in 2023(?)
  - RD51 will cease to exist after 15 successful years of operation
  - Restructuring and implementation within the ECFA Detector R&D roadmap
  - Basic Research Needs BRN study analogous to ECFA Detector R&D roadmap
    - BRN roadmap did not have gaseous detectors as topic
    - SNOWMASS 2021 study introduced gaseous detectors as topic
    - U.S. community planning should be synergistic: BRN → ECFA Detector R&D roadmap
    - U.S. community should stay engaged with DRDC
    - U.S. community should establish MPGD facility/center within the country