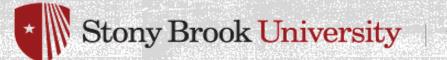
# MPGDs: RECENT ADVANCES, CURRENT R&D, and THE EUROPEAN STRATEGY

Klaus Dehmelt on behalf of all WP1 contributors

Seattle Snowmass Summer Meeting 2022

o July 22, 2022



### **RECENT ADVANCES - MPGD**



### • Micro Pattern Gas Detectors $\rightarrow$ MPGD

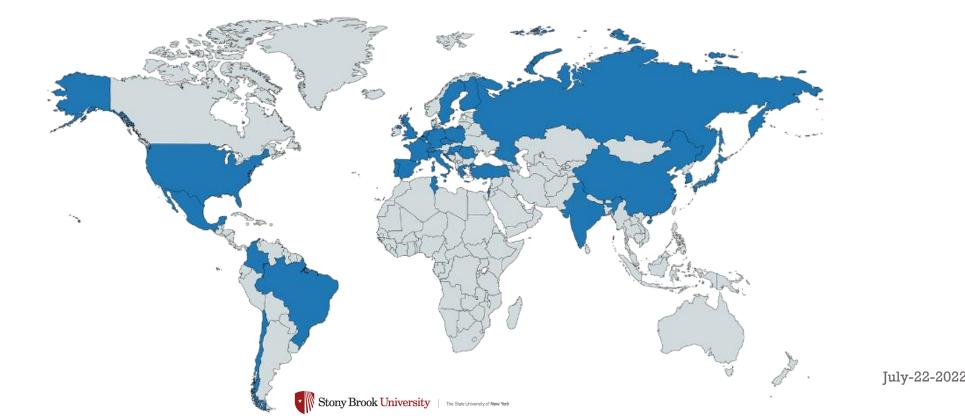
- ${\rm o}$  Motivation and goal for MPGD development  $\rightarrow$  cost-effective, large-scale detectors with excellent position and timing resolution in high-rate applications
- o Significant development time invested
  - understanding optimal manufacturing techniques for MPGDs
  - understanding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



- CERN-RD51 collaboration  $\rightarrow$  technical collaboration, established in 2008
  - o Comprises ~450 collaborators from 89 institutes from 31 countries



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



### • Seven Working Groups WG, transversal to RD51 activities, covering all

**RD51 – Micropattern Gas Detectors** WG1 WG2 WG4 WG3 WG5 WG6 WG7 **New Structures** Detector Modelling of Training and **Electronics for Common Test** Production and Physics Processes **Physics and** and Dissemination MPGDs Industrialisation Facilities & Software Tools Technologies Performance Common test Design standards **Development of** Objectives Organisation of Readout Sharing of Development optimization common dissimination and electronics common Characterization software and of cost-effective training events for optimization and infrastructure nd understanding Development of documentation technologies and the MPGD integration with for detector for MPGD new geometries of physical industrialization **MPGD** detectors characterization community and techniques phenomena in simulations MPGD **FE** electronics **Common Test** requirements Large Area Topical Standards Algorithms Common definition MPGDs Workshops Production Facility Testbeam **General Purpose** Discharge Facility **Pixel Chip** Protection Schools Design Simulation Tasks (Eletronics, Optimization Improvements Simulation, ... Large Area **New Geometries** Ageing & Systems with Fabrication Radiation **Pixel Readout** Industrialization Hardness Academy-Common Platform Industry Development Charging up (Root, Geant4) Portable Multi-Matching of Rad-Hard and Rate **Channel System** Events Detectors Irradiation Capability Facility Collaboration Dissimination with Development Discharge Electronics Study of Avalanche of MPGD Industrial Partners of Portable Modeling Protection Statistics applications Detectors Strategies

aspects of R&D

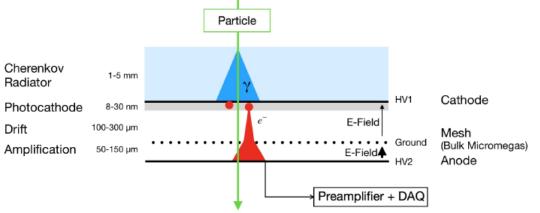


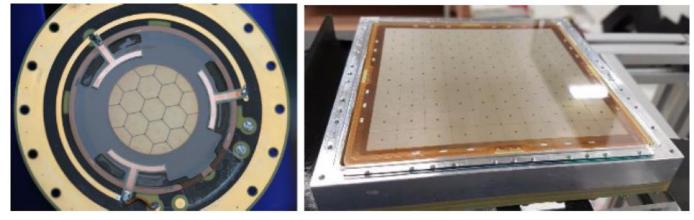
- Gas Electron Multiplier (GEM) + Micro-Mesh Gaseous Structure (Micromegas) → well established MPGD devices
  - o More to come  $\rightarrow$  THGEM,  $\mu \text{RWell}, \ldots$
  - Finding applications in many fields
    - \* HEP, NP, Astrophysics, Medical applications, Homeland Security, Commercial applications, ...
  - o Tracking, particle identification, timing, photo-detectors
  - o Triggered electronics development
- Number of LOIs received  $\rightarrow$  illustration of ongoing developments and expansion of MPGD use

- ${\rm o}$  High-precision timing  ${\rightarrow}$  the Micromegas PICOSEC concept
- $\circ$  Prototypes show excellent timing resolution  $\sigma_t = \textit{0}(20ps)$  for MIPs,  $\sigma_t = \textit{0}(70ps)$  for photons

\* Stony Brook University | The State University of New York

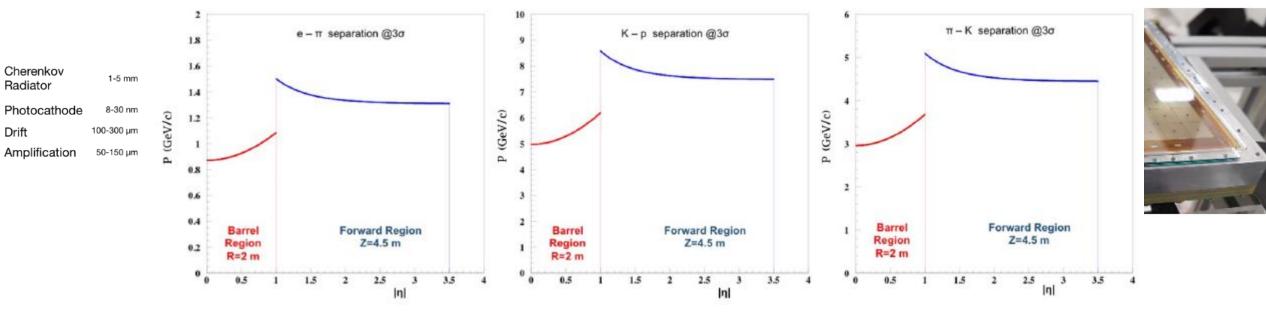
o Few pads' prototypes  $\rightarrow$  many pads' prototypes



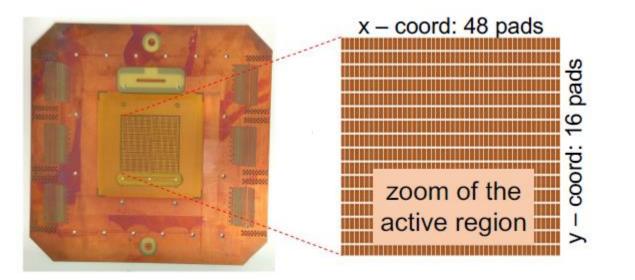


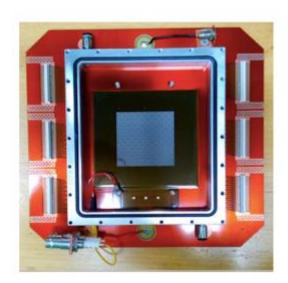


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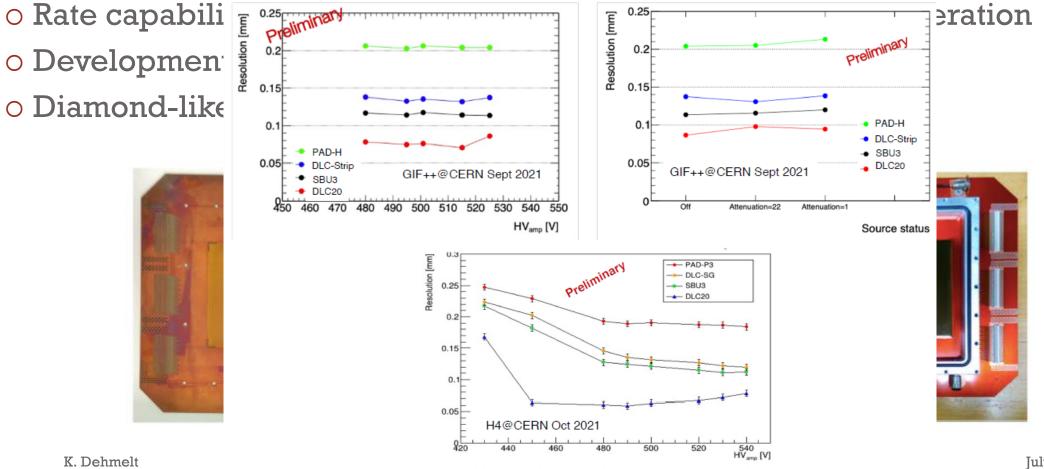
- Pixelated resistive Micromegas for high-rate environments
- o Rate capability goal 10s MHz/cm<sup>2</sup> with stable and efficient operation
- o Development toward large areas
- o Diamond-like Carbon DLC resistive layer techniques







### o Pixelated resistive Micromegas for high-rate environments

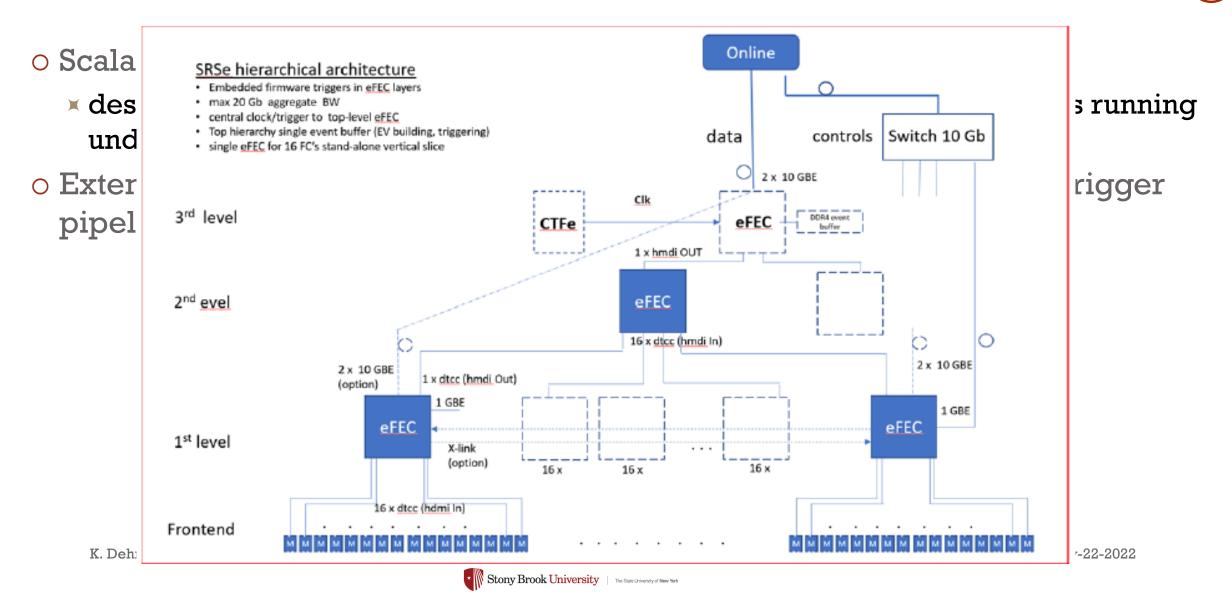


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o Scalable Readout System SRS established readout system

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







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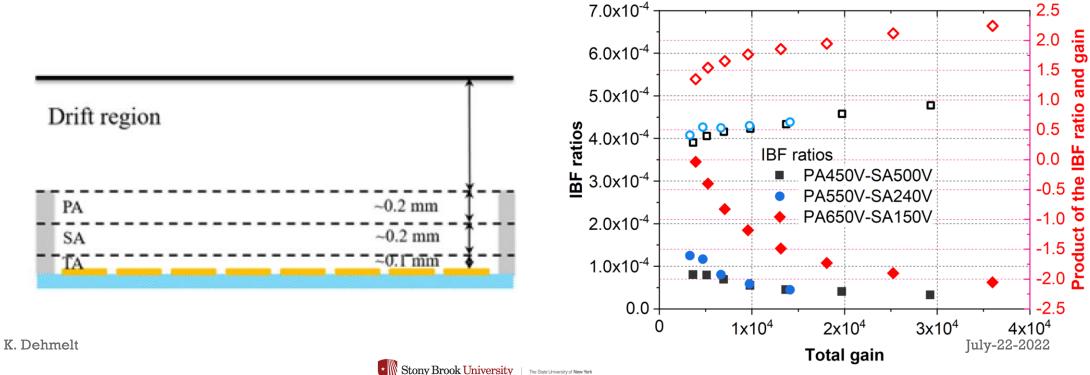
- designed for scalability from desktop stems to rack-sized readout systems running under the same Online DAQ and Control system
- o Extended SRS-e paradigm adds real-time trigger functionality, deep trigger • Use existing frontends (VMM3a, SiPM adapter) as well-known frontend as baseline pipelines and generalized frontend link
- Workplan developed

- 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
- After 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) July-22-2022



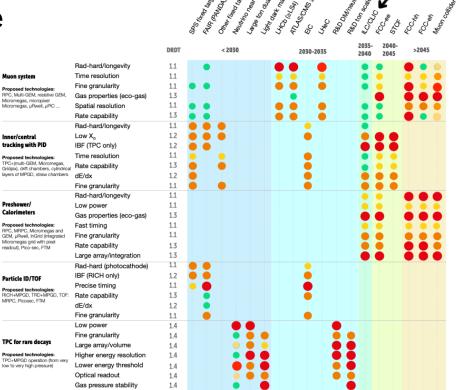


- o High gain, low IBF multilayer Micromegas
- ${\rm o}$  Motivated by painful IBF issue for every Time Projection Chamber  ${\rightarrow}$  need to gateless for high readout speed application



### 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  $\rightarrow$  TF1



Must happen or main physics goal cannot be met 🥚 Important to meet several physics goals

Radiopurity

Desirable to enhance physics reach

Large ton dual-phase (PandaX-4T, LZ, DarkSide -20k, Argo 200k, ARIADNE ...)
Light dark matter, solar axion, Ohb, rare nuclei&ions and astroparticle reactions, Ba tagging)
RBD for 100-ton scale dual-phase DM/neutrino experiments

1.4



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Will be split in two colum

ase let us know urge

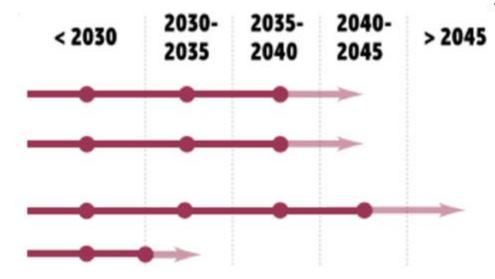
### THE EUROPEAN STRATEGY



### • Detector R&D Roadmap $\rightarrow$ Detector R&D Themes DRDT

	DRDT 1.1	Improve time and spatial resolution for gaseous detectors with long-term stability
Gaseous	DRDT 1.2	Achieve tracking in gaseous detectors with dE/dx and dN/dx capability in large volumes with very low material budget and different read-out
	DRDT 1.3	schemes Develop environmentally friendly gaseous detectors for very large areas with high-rate capability
		areas manual rate capacity

DRDT 1.4 Achieve high sensitivity in both low and high-pressure TPCs



### THE EUROPEAN STRATEGY

### • Plan is to restructure RD51

- o Formation of DRDC1 in 2023(?)
- o RD51 will cease to exist after 15 successful years of operation
- o Restructuring and implementation within the ECFA Detector R&D roadmap
- o 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
  - ${\color{red} {\tt V.S.}}$  community planning should be synergistic: BRN  $\rightarrow$  ECFA Detector R&D roadmap
  - **×** U.S. community should stay engaged with DRDC
  - **× U.S. community should establish MPGD facility/center within the country**