

TPCs

DRD1 survey analysis

F. Garcia
(Uni Helsinki)

Facility	Technologies	Challenges	Most challenging requirements at the experiment
HL-LHC	MPGD	High spatial resolution, high rate/occupancy, radiation hardness, low mass	LHCb option: replace Scintillating Fibre tracker Spatial resolution: 70 μm bending plane
Higgs-EW-Top Factories (ee) (ILC/FCC-ee/CepC/SCTF)	TPC+(multi-GEM, Micromegas, GridPix), Drift Chambers, Cylindrical layers of MPGD	Ultra-lightweight inner or central tracker, high spatial resolution, high rate/occupancy, radiation hardness, low mass, transparency, cluster counting, TPC continuous mode at high rate, (IBF x Gain) ~ 1	Inner tracker (SCTF) Fluxes: $\geq 10 \text{ kHz cm}^{-2} \text{ s}^{-1}$ Time resolution: 1 ns $X/X_0 = 1\%$ Spatial resolution: $\sim 100 \mu\text{m}$ Central tracker (CepC) Max. rate: $> 100 \text{ kHz/cm}^2$ Spatial resolution: $\sim 100 \mu\text{m}$ Time resolution: $\sim 100 \text{ ns}$ $dE/dx < 5\%$ Particle separation with cluster counting at 2% level
Rare processes, atomic and nuclear physics (SPS Kaons: K^+ Phase, K-Phase, Mu2eII/COMET-II, ELENA)	TPC, straw tubes	High spatial resolution, occupancy, fast/precise timing, radiation hardness, low mass, Gd-deposited MPGD detectors	Max rate = 500 kHz/straw (Mu2e II): Thinner straw material: 8 μm $X/X_0 \sim 0.02\%$ per layer, $X/X_0 \sim 1\%$ total (COMET+): Diameter = 4.8 mm Trailing time resolution = 1 ns per track
Hadron and nuclear physics (EIC, AMBER, PANDA and CMB@FAIR, PRES MAINZ, NA60+)	Micromegas, GEM, μ -RWELL, straw tubes	High spatial resolution, good timing, radiation hardness, tolerance to magnetic field	(EIC) Max rate = 100 kHz/cm ² Spatial resolution $\sim 50 \mu\text{m}$ $X/X_0 = 5\%$ $dE/dx = 12\%$, continuous running

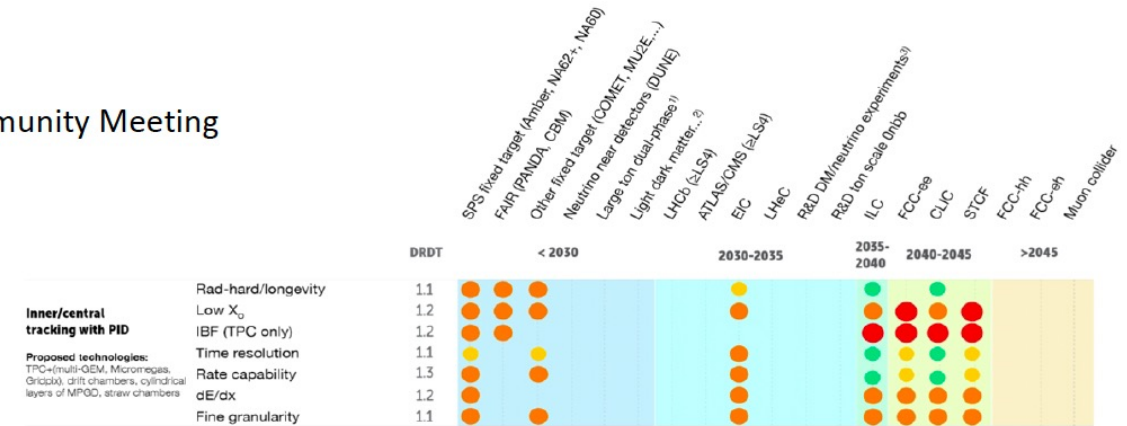
Inner and central tracking with particle identification capability: TPC

Main Challenges

- Planar and Cylindrical MPGDs
 - **Multi-GEMs**
 - Resistive GEMs
 - Micromegas
 - μ -RWELLS
 - μ -PICs
 - FTM
- Straw tubes trackers
- Drift chambers
- **RPCs**

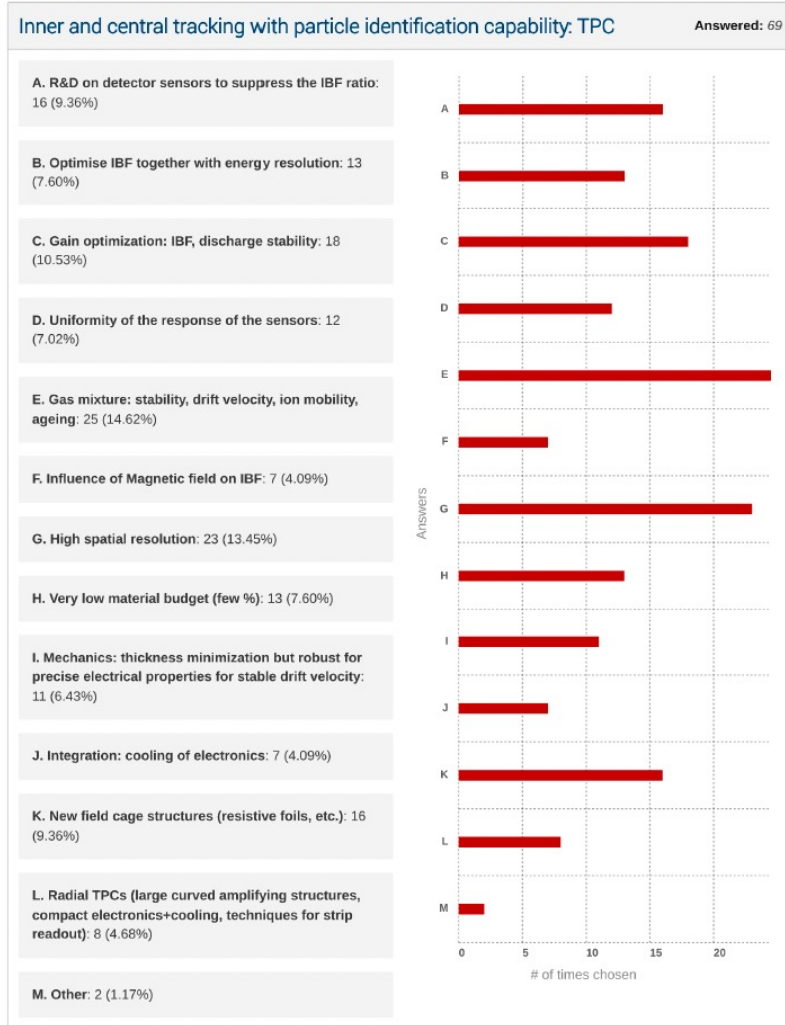
- **High-rate capability**
- **High spatial and time resolution for precision momentum measurement**
- Particle identification (PID)
- Minimal material Budget
- Lightweight mechanical support structures and low Cost
- Aging and radiation hard
- **Large area coverage and operation stability**
- Use of eco-friendly gas mixtures
- Highly scalable readout electronics and its miniaturization

F. Garcia
Preparation for DRD1 Community Meeting



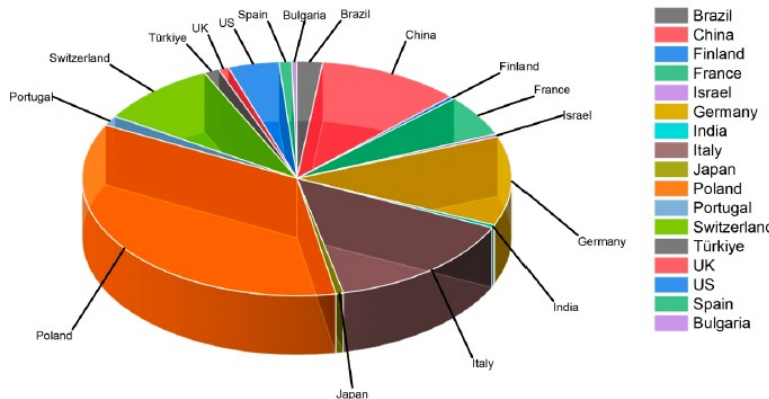
Inner and central tracking with particle identification capability: TPC

Survey results

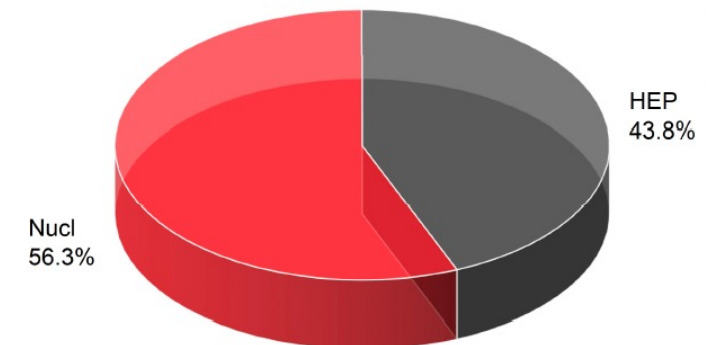


- **Gas mixture: stability, drift velocity, ion mobility, ageing**
- **High spatial resolution**
- **Gain optimization: IBF, discharge stability**
- R&D on detector sensors to suppress the IBF ratio
- New field cage structures (resistive foils, etc.)
- Optimise IBF together with energy resolution
- Very low material budget (few %)
- Uniformity of the response of the sensors
- Radial TPCs (large curved amplifying structures, compact electronics and cooling, techniques for strip readout)
- **Mechanics: thickness minimization but robust for precise electrical properties for stable drift velocity**
- Influence of Magnetic field on IBF
- Others

Contributions by Country in FTE



Contributions per Field of Applications

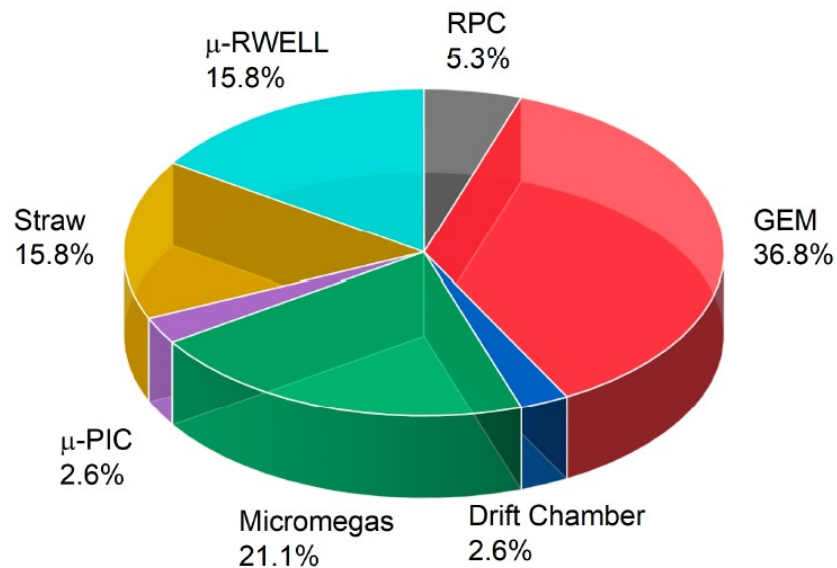


Inner and central tracking with particle identification capability: TPC

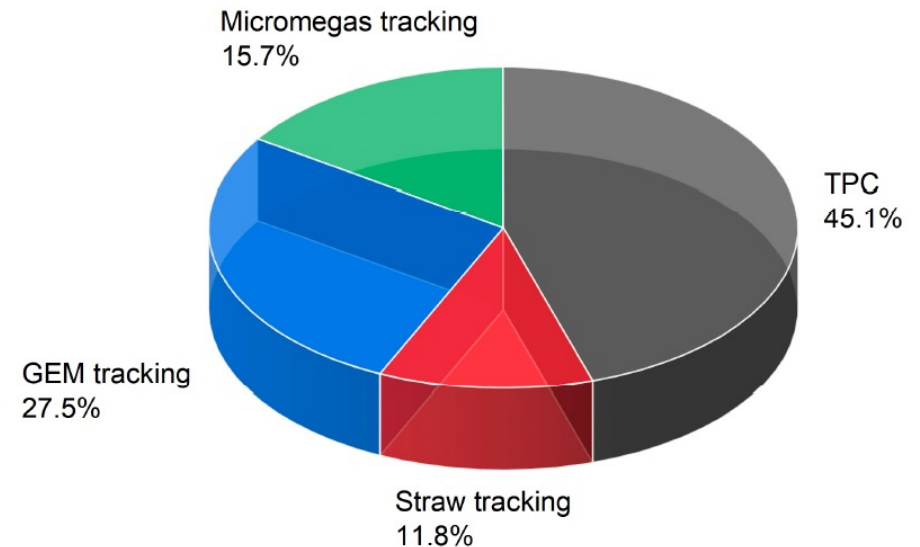
- High rate capability
- High time and spatial resolution
- Large area coverage with stable operation
- Low material budget
- Use with Eco-friendly gas mixtures

- The TPC developments are predominant in Nuclear Physics and non-HEP applications
- Suppression of the ion backflow
- Precise spatial and time resolution
- Low cost

Contributions per Technology



Contributions per Applications



Possible synergies

- **IBF reduction (together with other operational parameters optimisation)**

- MPGD amplification technology
- Multi-MPGD stacks and hybrids
- Gating (eg. CEPC)

- **Pad vs. Pixel TPC**

- InGrid developments

- **Mechanical structure, static distortions**

- Minimise insensitive area
- Laser systems

- **Low-power FEE development**

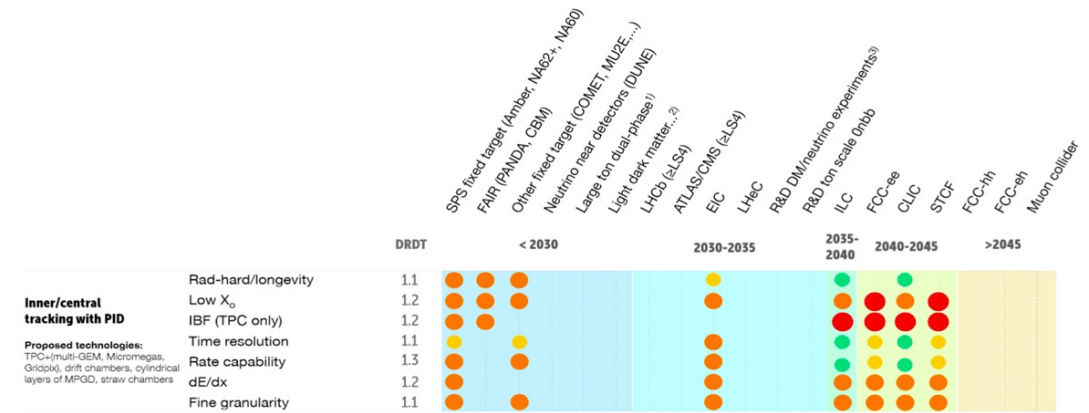
- Low-power ASICs, continues vs pulsed operation
- Cooling

- **Active target TPCs (current focus on the MPGD readout, many challenges to add**

- High pile-up, space charge (fluctuations)
- Final resolution of the reaction characteristic
- High dynamic range

TPC

- R&D on detector sensors to suppress the IBF ratio
- Optimize IBF together with energy resolution
- Gain optimization: IBF, discharge stability
- Uniformity of the response of the sensors
- Gas mixture: stability, drift velocity, ion mobility, aging
- Influence of Magnetic field on IBF
- High spatial resolution
- Very low material budget (few %)
- Mechanics: thickness minimization but robust for precise electrical properties for stable drift velocity
- Integration: cooling of electronics



DETECTOR RESEARCH AND DEVELOPMENT THEMES (DRDTs) & DETECTOR COMMUNITY THEMES (DCTs)

