# TPCs

DRD1 survey analysis

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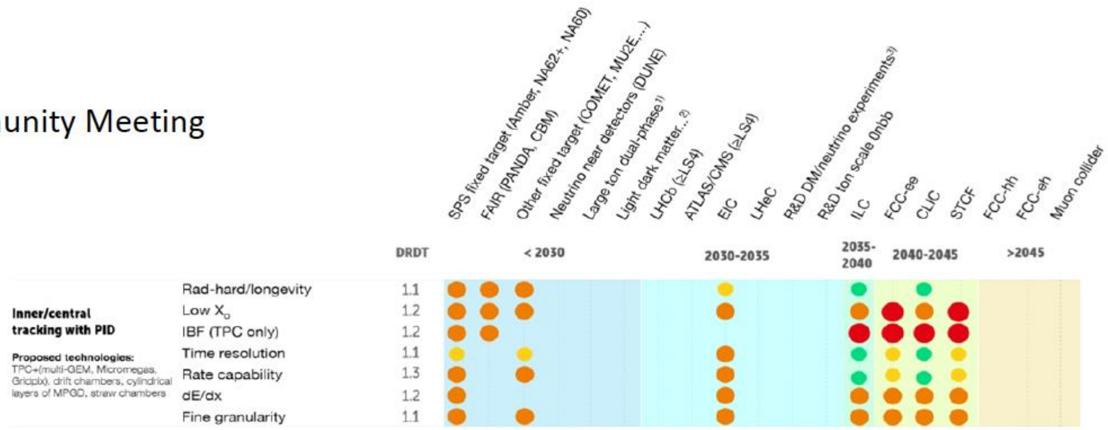
| Facility | Technologies | Challenges | Most challenging requirements at the experiment |
|---|---|---|---|
| HL-LHC | MPGD | High spatial resolution, high rate/occupancy, radiation hardness, low mass | **LHCb option:** replace Scintillating Fibre tracker<br>Spatial resolution:70 µm bending plane |
| 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)**<br>Fluxes: ≥10 kHz $cm^{-2}$ $s^{-1}$<br>Time resolution: 1 ns<br>X/X0 = 1%<br>Spatial resolution: ~100 µm<br>**Central tracker (CepC)**<br>Max. rate: >100 kHz/$cm^2$<br>Spatial resolution: ~100 µm<br>Time resolution: ~ 100 ns<br>dE/dx: <5%<br>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<br>**(Mu2e II)**: Thinner straw material: 8 µm<br>X/X0 ~ 0.02% per layer, X/X0 ~ 1% total<br>**(COMET+)**: Diameter = 4.8 mm<br>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/$cm^2$<br>Spatial resolution ~50 µm<br>X/X0 = 5%<br>dE/dx=12%, continuos running |

# Inner and central tracking with particle identification capability: TPC

## Main Challenges

F. Garcia
Preparation for DRD1 Community Meeting

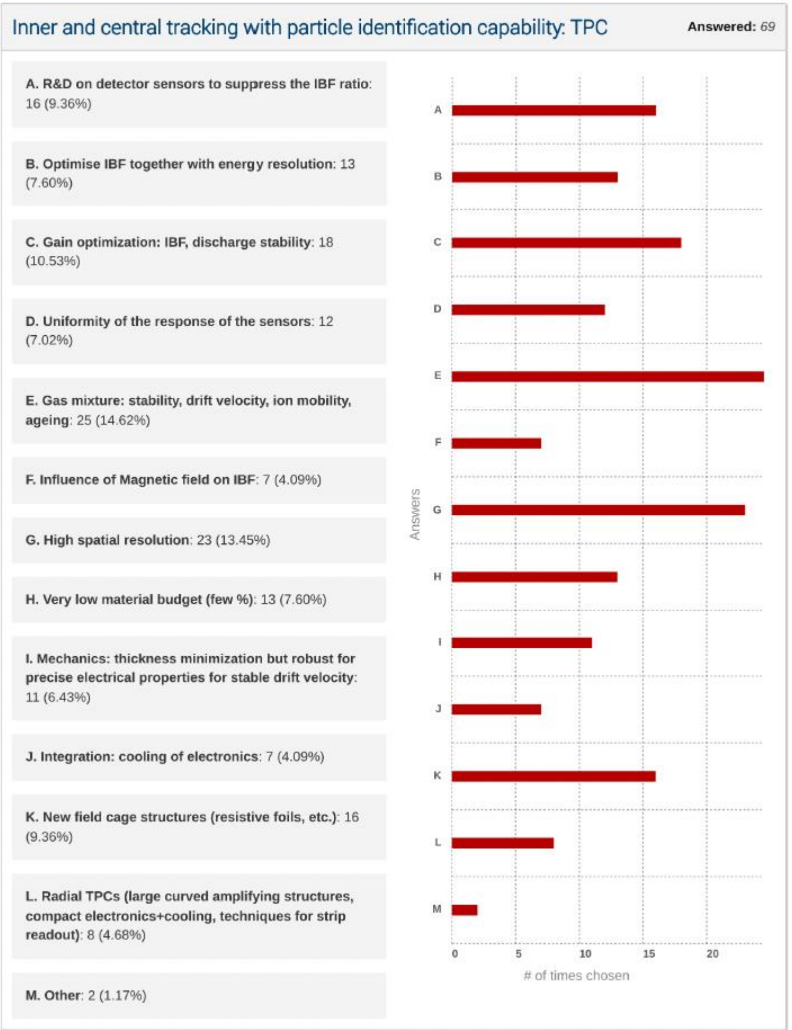



- Planar and Cylindrical MPGDs
  - **Multi-GEMs**
  - Resistive GEMs
  - Micromegas
  - μ-RWELLs
  - μ-PICs
  - FTM
- Straw tubes trackers
- Dirft cambers
- **RPCs**

- **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

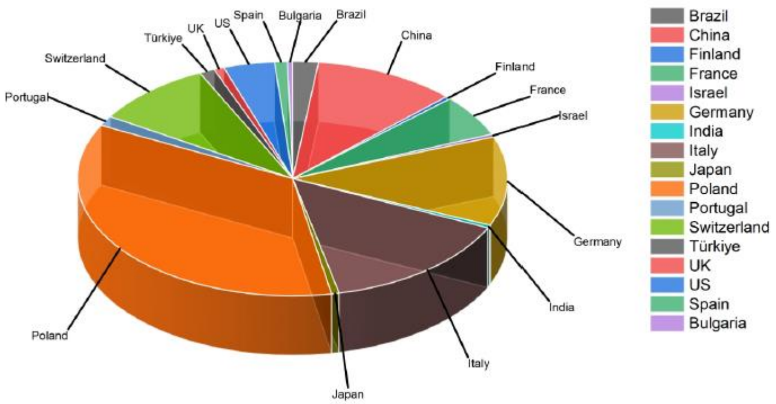
# Inner and central tracking with particle identification capability: TPC

## Survey results

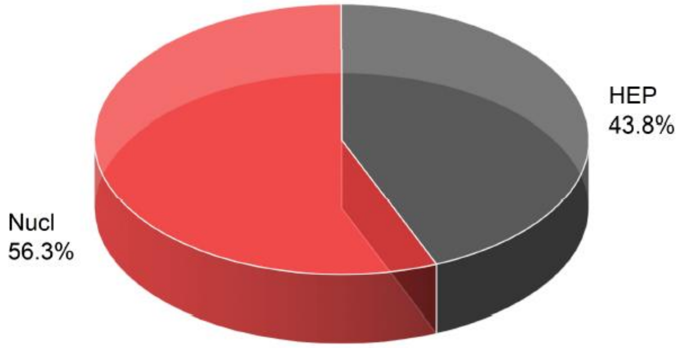



- **Gas mixture: stability, drift velocity, ion mobility, ageing**
- **High spatial resolution**
- **Gain optimization: IBF, discharge stability**
- R&D on detector sensors to suppress the IBF ratio
- New field cage structures (resistive foils, etc.)
- Optimise IBF together with energy resolution
- Very 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

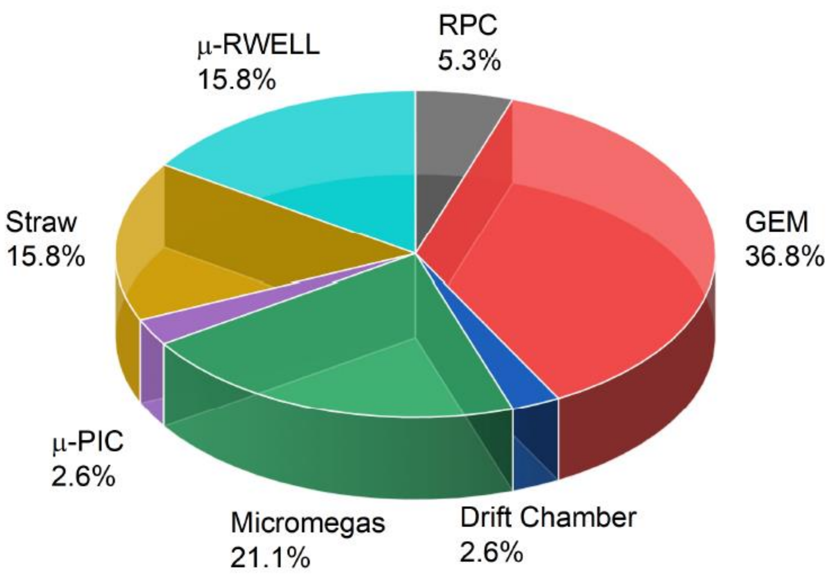


# Inner and central tracking with particle identification capability: TPC

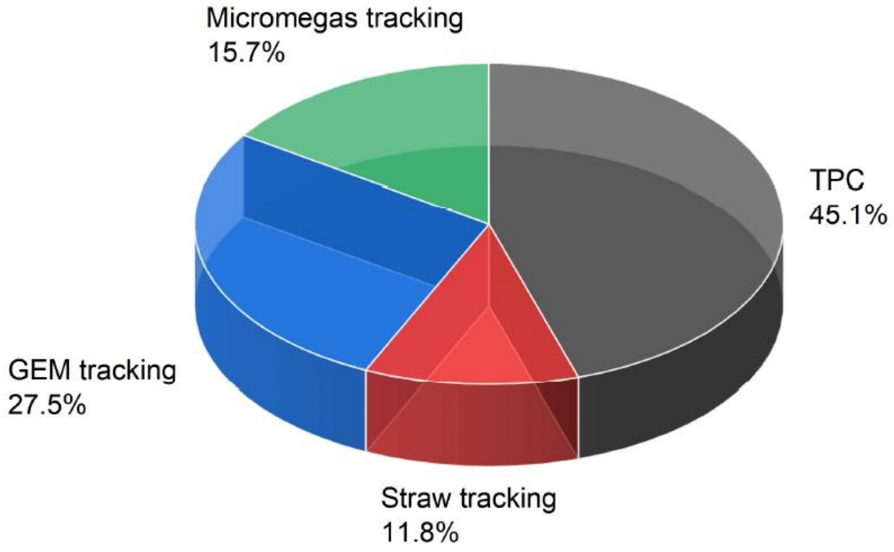
- **High rate capability**
- High time and spatial resolution
- Large area coverage with stable operation
- Low material budget
- Use with Eco-friendly gas mixtures

- **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. <u>Pixel TPC</u>**
  - 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