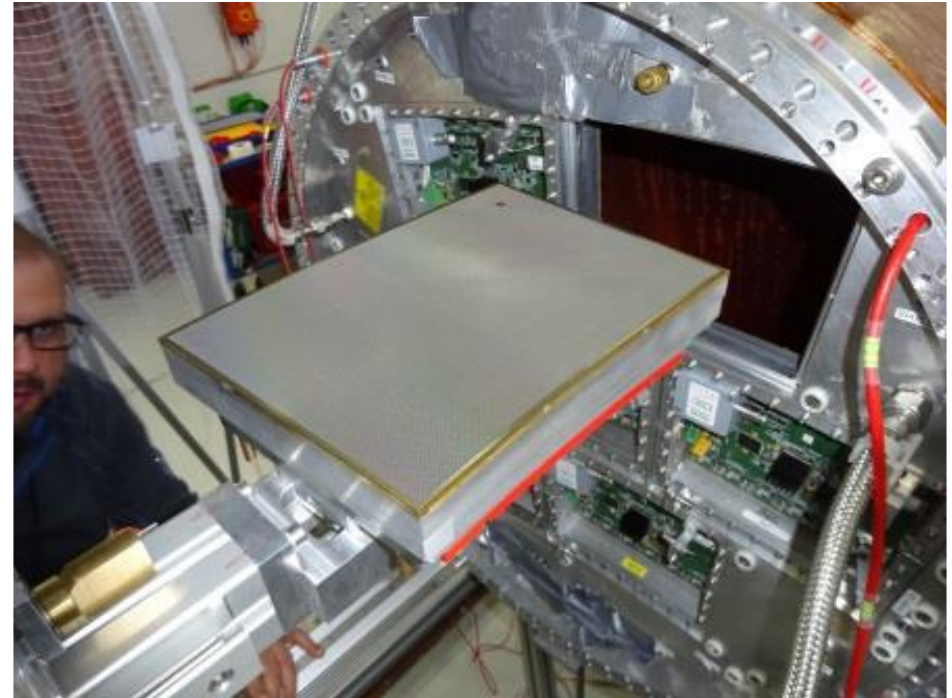


# REPORT FROM MICROMEAS GROUP

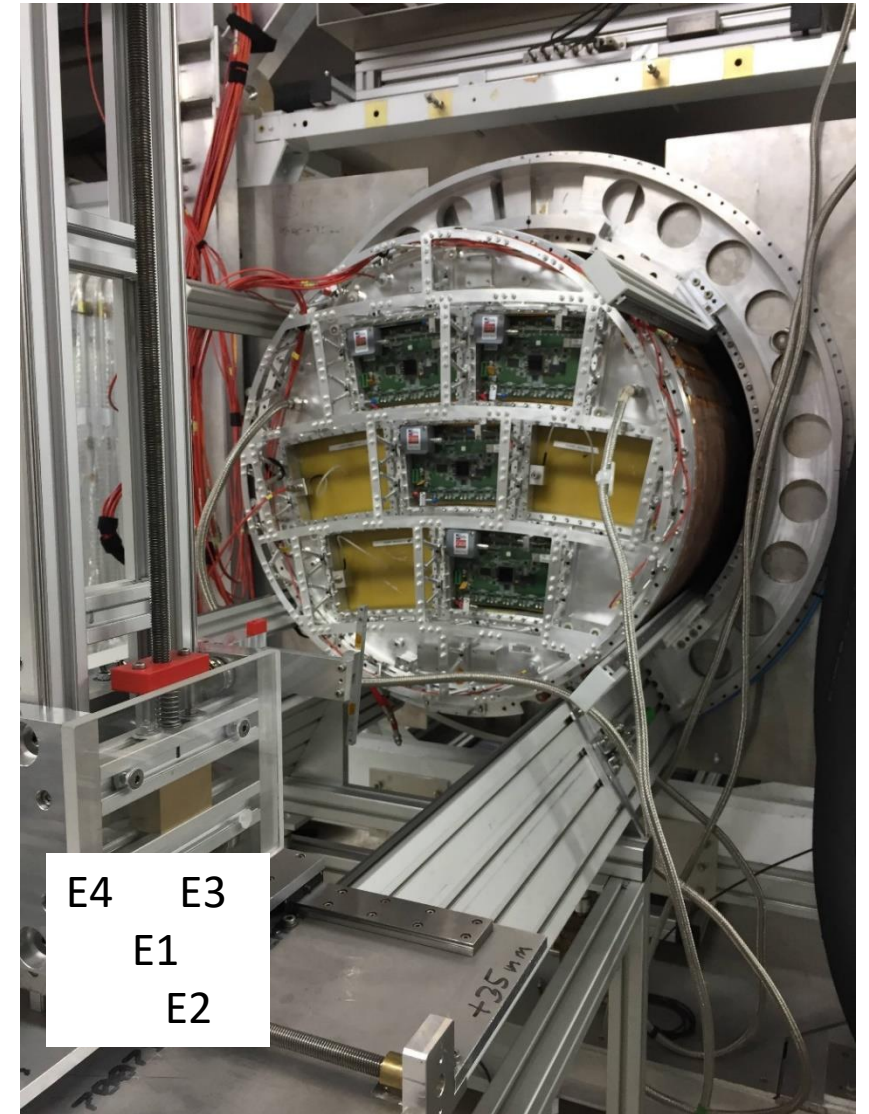
Paul Colas (CEA/Irfu Université Paris Saclay)

Summary of activity in 5 latest years  
Synergy with other detectors  
Running a TPC at circular colliders



# Micromegas TPC Activity in the latest 5 years

- Beam test in November 2018 at DESY: 4 new 'ERAM' modules
- Cosmic-ray test at Saclay, from January 2019 to March 2020 (interrupted by Covid and discontinued after this)
- TPC costing and detailed assessment of cabling, LV power, HV distribution, etc...
- Test of the cooling of one module with 2-phase CO<sub>2</sub>, with an aluminum 3D-printed cooling plate (started October 2021)
- Result so far : feasibility in ILC conditions demonstrated (space and dE/dx resolution, stability, flexibility, distortion mitigation, matter budget...)



# Still to be done : electronics and mechanics

- Electronics must be compact.  $O(10^6)$  channels) in  $\sim 10 \text{ mm}^2$  and must have low power consumption (few mW/channel). The 65nm project SALSA would fit this (see also Zhi Deng's talk)
- Mechanical design : systematics on the sagita must be below  $\sim 20 \mu\text{m}$ . Must damp vibrations and resist to earthquakes
- Needs to become an ongoing project with a defined timescale to progress further

# Synergies with other experiments

- T2K : also uses ERAM. Study charge sharing by Resistive-Capacitive anode, gain maps, RC maps (See [Shivam Joshi's](#) talk), track and V0 reconstruction
- ALICE : uses GEMs in a high track density environment. Experiences tracking with continuous data taking (important for circular e+e- colliders) and large distortions from space charge (see [Jens Wiechula's](#) talk)

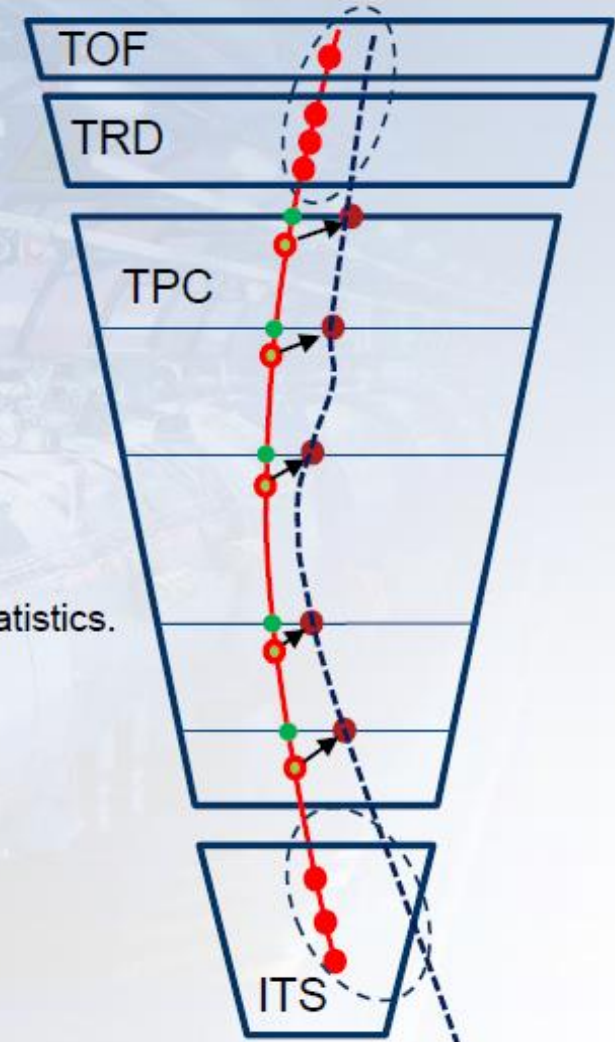
# New questions arising

- Would operation be possible at a circular collider, in particular at the Z peak at high lumi ( $2 \cdot 10^{36}$  /cm<sup>2</sup>/s per IP)?
  - Would the HV supplies stand the current drawn in the endplates?
  - Would the distortions due to ion space charge be moderate enough and could they be corrected?
  - Would the power consumption be under control, without power pulsing?
  - Would the reconstruction of data taken in triggerless mode be manageable?



# TPC Calibration

- Most complicated TPC calibration is for **space charge distortions (SCD)**.
    - We foresee 2 SCD calibrations in Run 3:
      1. **Track based:**
        - TPC Tracks reconstructed with relaxed cuts, matched to inner / outer detectors.
        - Track refit with only ITS / TRD / TOF information.
        - Collect residuals of TPC hits wrt. refitted tracks.
        - TPC volume voxelized, correction per voxel calculated.
        - Corrections smoothed compensating for bad TRD chambers, holes in acceptance, ...
      - Corrects also for several other effects: misalignment, drift velocity,  $E \times B$ , ...
      - Needs a certain number of tracks per voxel.
        - In Run 2, 40 minute calibration interval. Reduced to  $O(1)$  minute in Run 3 due to more statistics.
      - Distortions fluctuate over time:
        - Scales with instantaneous luminosity, i.e. TPC occupancy, e.g. by beam burn-off.
          - Scaling the average correction map with the luminosity.  
(To be precise, the difference to a static correction map at luminosity  $\sim 0$  is scaled.)
        - Short-term fluctuations by LHC bunch structure, collision centrality, etc:  
Not corrected for during Run 2, significant in Run 3.
- Need new method for short-term fluctuations in Run 3, fast calibration interval  $\sim 5$  ms.



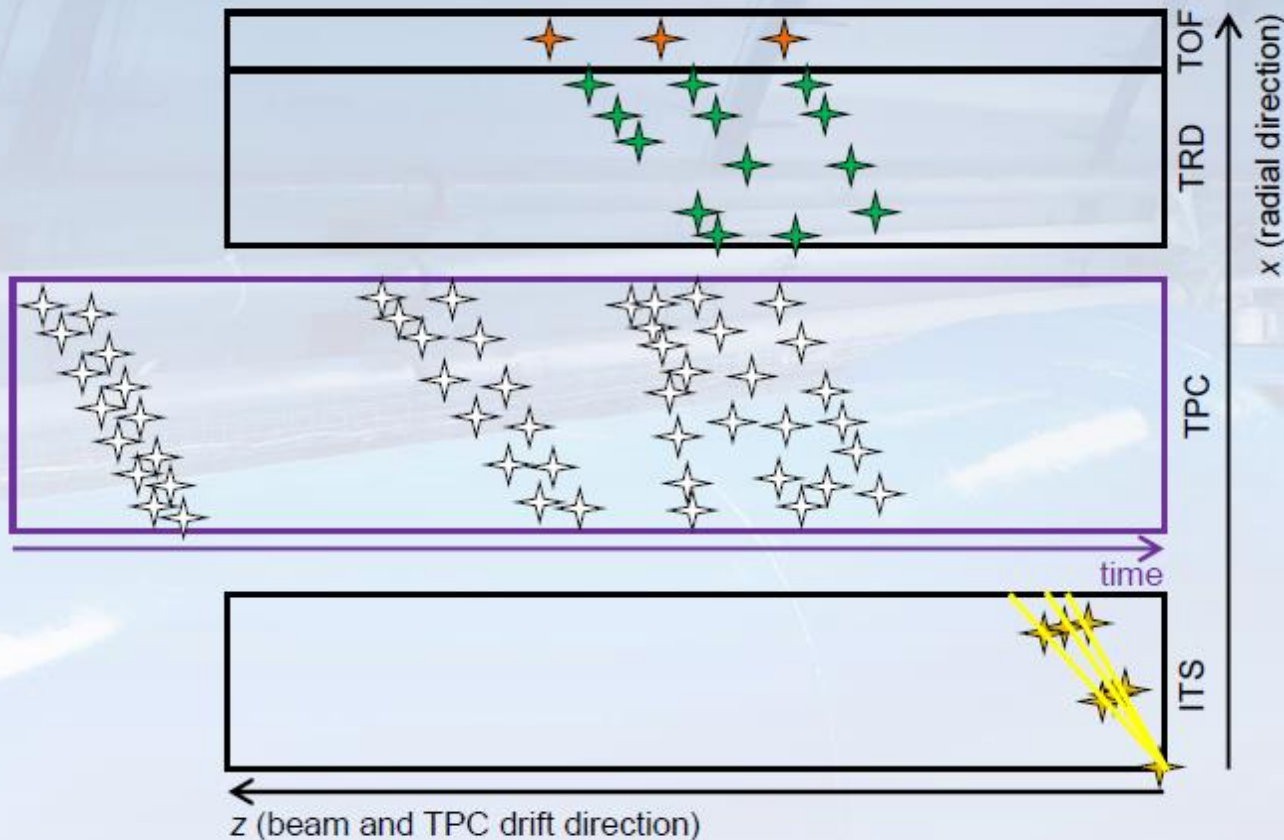


# The tracking challenge – How the tracking will work

- Tracking continuous data...

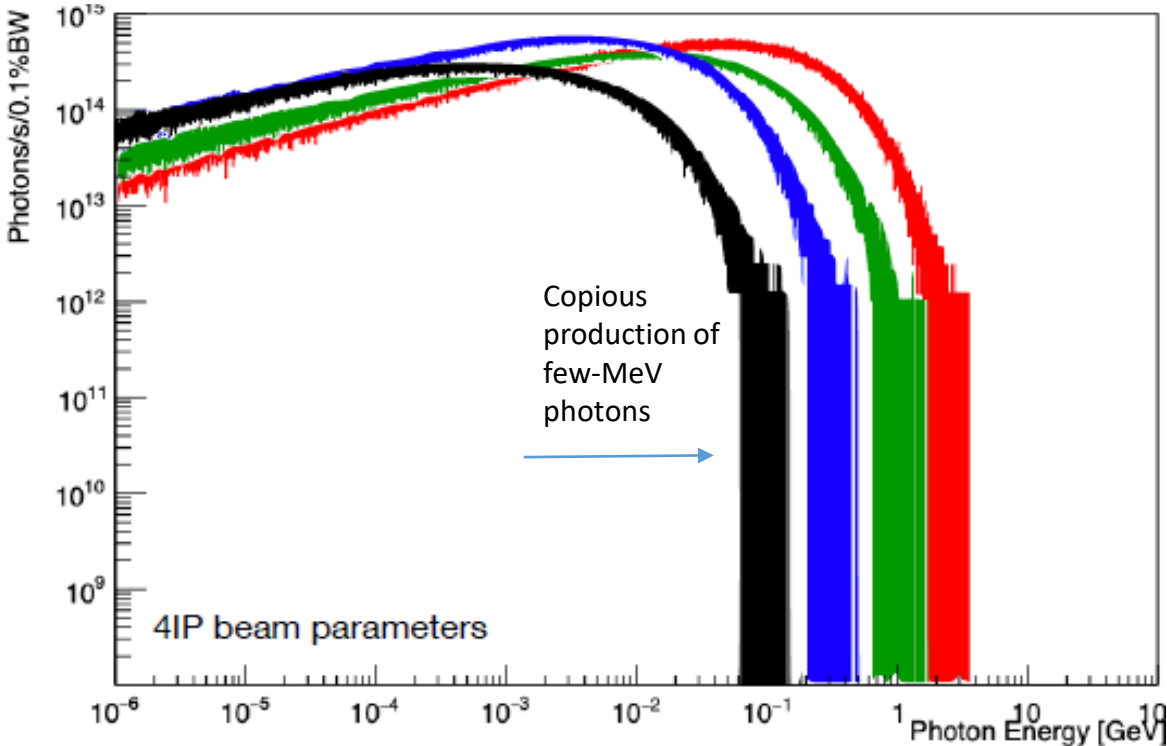
- The TPC sees **multiple overlapped collisions** (shifted in time).
- Other detectors know the (rough) time of the collision.

- Problem: TPC clusters have no defined z-position but only a time. They can be shifted in z arbitrarily.**
- GEM amplification produces ions that deflect the electrons during the drift. The correction of these space-charge distortions requires the absolute z position.**
- Standalone ITS tracking.



# Beamstrahlung photons at FCC

Enormous power radiated and copious photon production with energy of a few MeV: will produce e+e- pairs in the TPC gas if not extracted



	Total Power [kW]	Mean Energy [MeV]
<b>Z</b>	370	1.7
<b>WW</b>	236	7.2
<b>ZH</b>	147	22.9
<b>Top</b>	77	62.3



Primary ionization at the Z : maximum distortions of 330  $\mu\text{m}$  for IBF=1, however stable to a few microns.

### Background from incoherent pairs

Daniel Jeans used Andrea Ciarma simulated background events to estimate the ionization in the TPC : result is very large, an efficient shielding is absolutely needed (presented in SWANA meetings)

	primary ions / "event"	event rate	primary ions / 0.44 s "TPC frame"
Z_had ILD_I5_v02 @ 2T	1.27M	54 kHz	$30 \times 10^9$
pairs ILD_I5_v02 @ 2T	75 k	33 MHz	$1100 \times 10^9$
pairs ILD TPC only @ 2T	15 k	33 MHz	$220 \times 10^9$
pairs FCCee w/ TPC	0.43 M	33 MHz	$6200 \times 10^9$

\* maximum ion drift time in TPC = 0.44s

→ distortions  $O(100 \mu\text{m})$

D. Jeans  
PRELIMINARY

## **Running at the TeraZ with a TPC is a completely new challenge.**

Will require Space Charge Distortions corrections, monitoring of the current in the TPC with some granularity to be determined, and studies of shielding against several beam-induced background sources.

# DRD1

Transition from RD51 to DRD1 (ECFA)

M. Titov, E. Oliveiri.

Also Esther Ferrer-Ribas involved from Saclay.

Preparation of a survey. Discussion this afternoon.

## Survey

Indico Link:  
<https://indico.cern.ch/event/1235070/surveys/4042?token=5b384f78-555f-4830-8ceb-656473133506>

DRD1 Survey - Preliminary, to be used for survey evaluation  
Surveys can be saved and answers recovered before going for final submission.

\*\* means mandatory

**Institute\***

**url (url of the institute)**

**Contact person:\***

**Contact Person email\***

## Research Activities

Short description of research (achievements, applications, goals): (Maximum 12 lines)\*

## Personnel

### Group Personnel

Approximate personnel power in FTE/year. Split the personnel (FTE/year) into staff and temporary (students, postdocs, and researchers with limited-duration contracts).

FTE/y (Permanent)\*

Round to an Integer Number

FTE/y (Temporary)\*

Round to an Integer Number

### Additional Personnel\*

Indicate if your group is planning to request additional personnel in the context of activities that are connected to DRD1.

Additional FTE/y (Permanent)

Round to an Integer Number

Additional FTE/y (Temporary)

Round to an Integer Number

Comments/Notes