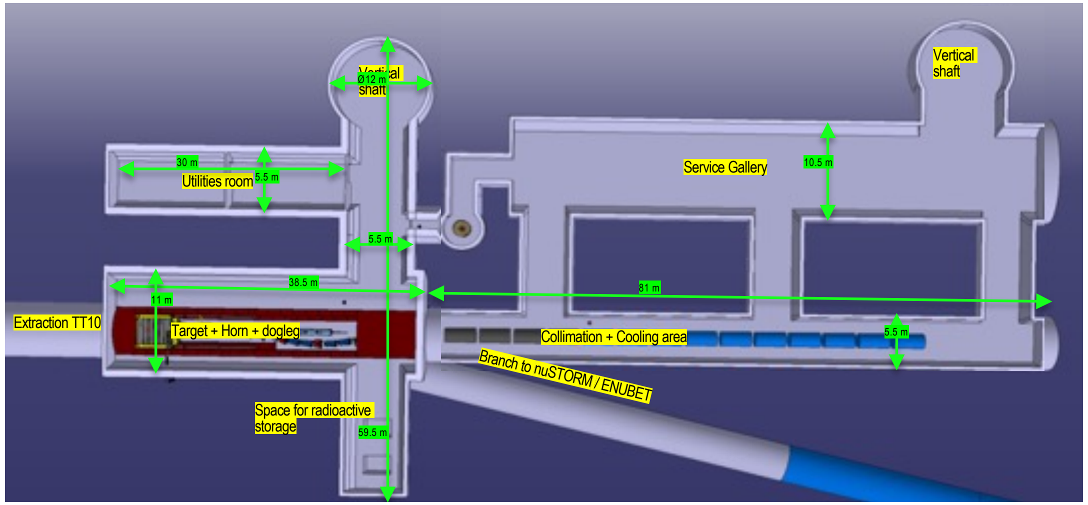
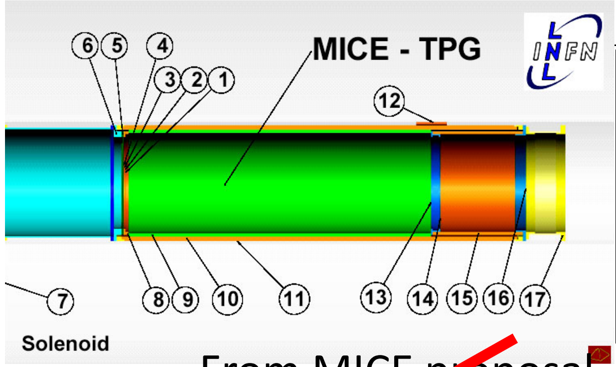
# The Demonstrator will produce a large number of muons/neutrinos of few hundred MeV or less

A TPC can be used for emittance measurement in the cooling sector and/or (if pressurized) as an active target to detect neutrinos.




From MICE proposal

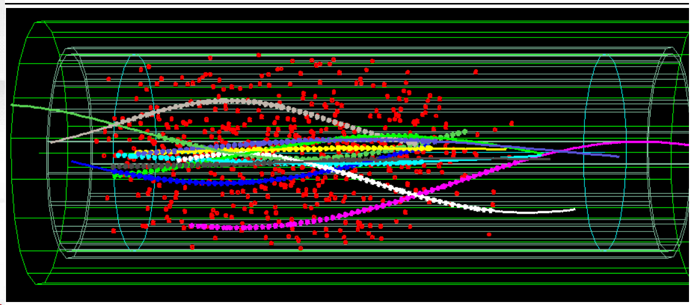
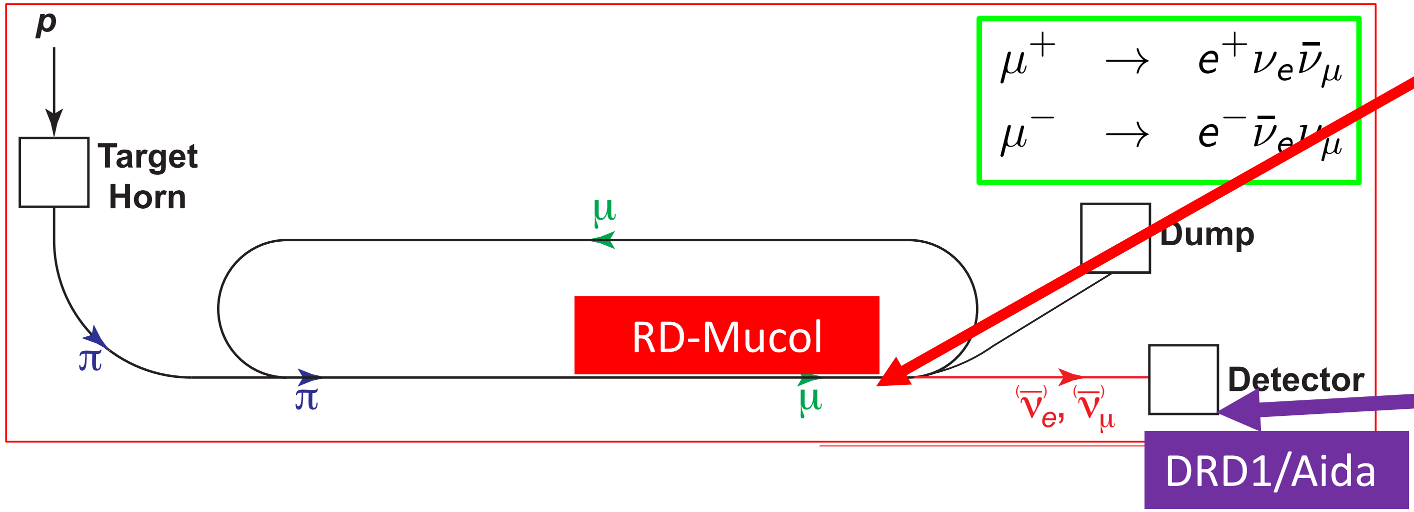
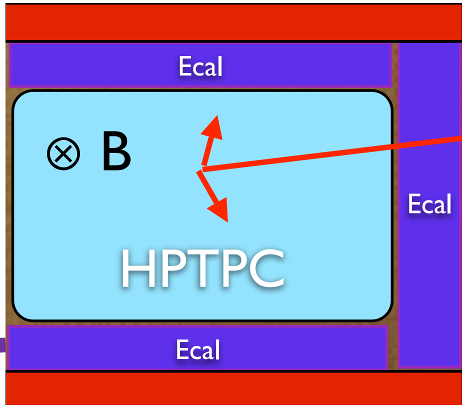


**Figure 8.7**: top: simulated track and noise hits in the TPG; middle: highlighted hits are those assigned by the pattern recognition to belong to the same track; bottom: track fitted on the selected hits.

a unique facility for neutrino physics and muon-collider test bed




Concept for a neutrino X-sec measurement

# Why a TPC as a muon monitor in the cooling sector

- Full particle parameters (x, p) reconstructed in 3D
- Very low material budget, excellent track resolution
- It was already in the MICE proposal, but it can now made much better with an optical readout
- It still requires studies to design and test the readout, and find the optimal gas mixture in optical mode

We propose to realize a prototype of a TPC with optical readout (TimePix4 or similar) tailored to precise, particle-by-particle muon emittance measurement during beam setup phases

- A field-cage suitable for atmospheric-pressure operation is already available.
- The readout part can be easily replaced with an optical one.
- Once ready, the size allows to insert it in a solenoid (we know of one available at CERN) and test it in a muon beam.
- MPGD TPCs were already studied for beam monitoring, e.g. https://web2.infn.it/GEMINI/index.php/compact-tpc

- The optical readout has in this case the advantage to allow lighter structures and higher rate w.r.t. a traditional pad plane
- The development of this device may be synergic with the development of a TPC as an active target and both fit very well the **DRD1,W8/W4 Program**
- This application requires non-pressurized operation.

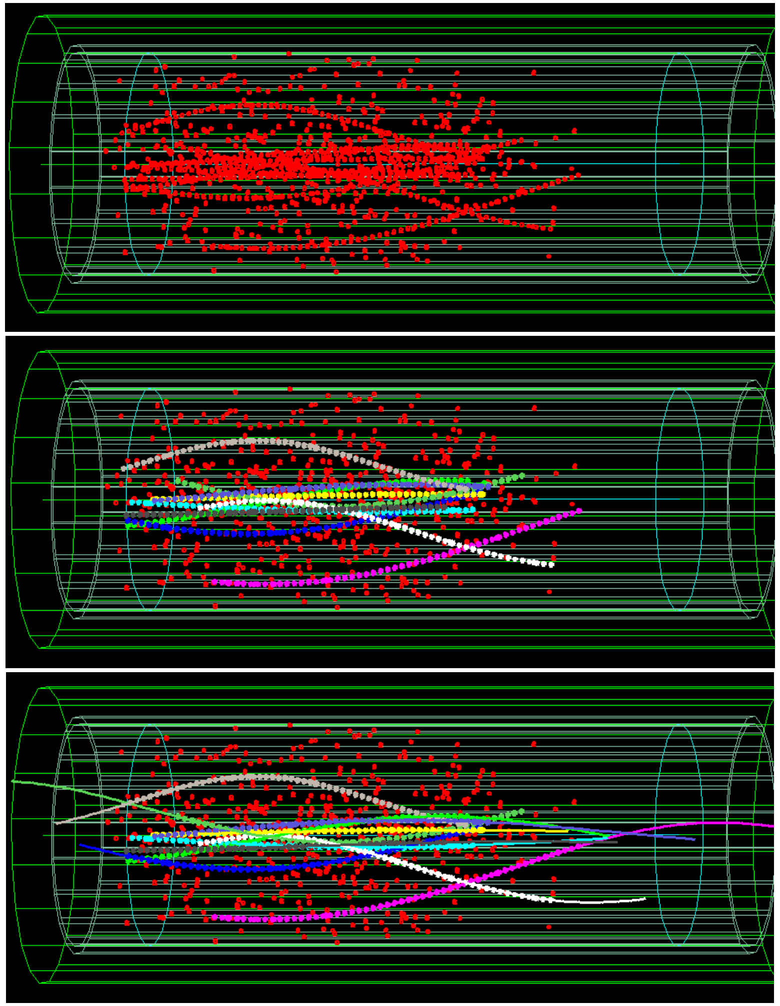
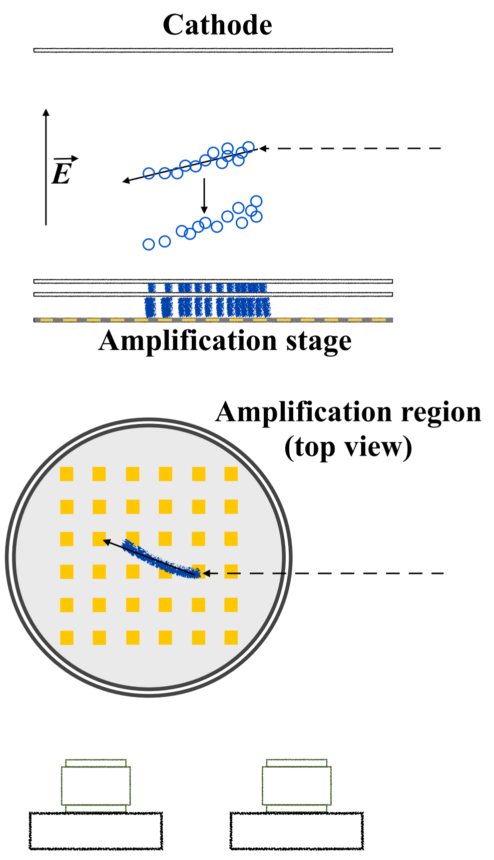


**Figure 8.7**: top: simulated track and noise hits in the TPG; middle: highlighted hits are those assigned by the pattern recognition to belong to the same track; bottom: track fitted on the selected hits.

# TPCs with optical readout




Readout camera

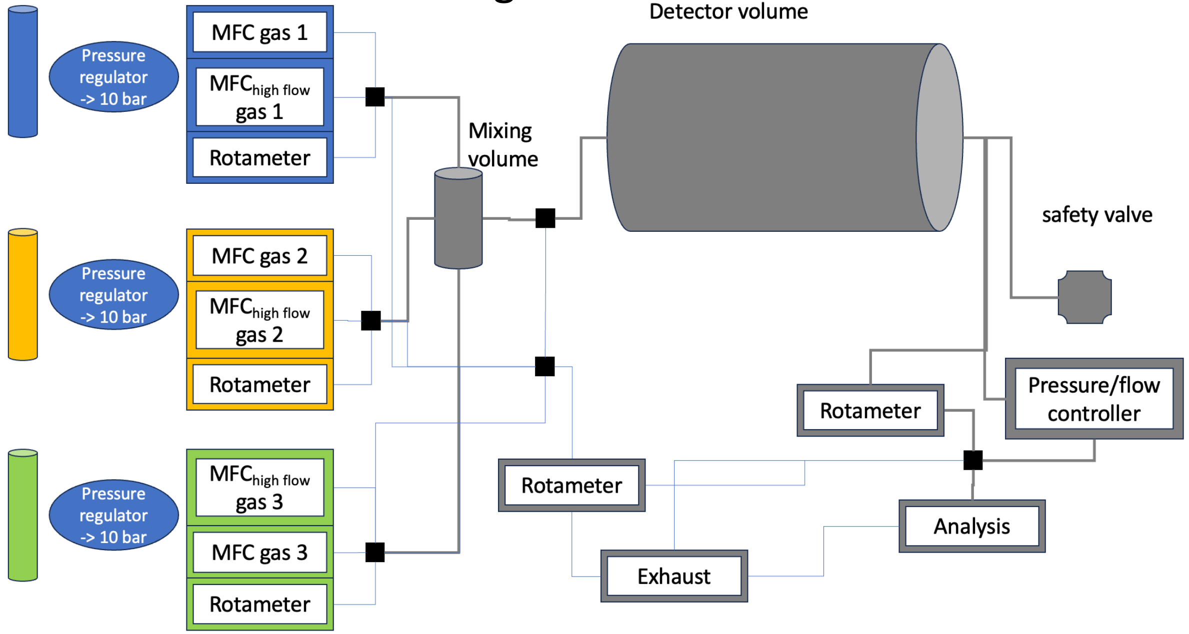
- Primary ionisations in the drift region are guided to the amplification region by an electric field
- Amplification produces electrons and photons
- Cameras record continuously the image created by the electroluminescence photons. This creates the equivalent of a continuous charge readout in more traditional pad-plane collection structures.
- Depending on camera resolution, highly segmented readouts ($\sim 100 \times 100\ \mu m^2$) at low cost per pixel are possible

NB: optical readout is of obvious interest for the beam instrumentation case:

- Removing the need of a charge collection plane and associated electronics makes the structure much lighter, reducing the material budget along the beam line
- To maximize the tolerable track density, gas mixtures can be studied to optimize the light yield and reduce the amplification factor

# Stato attuale

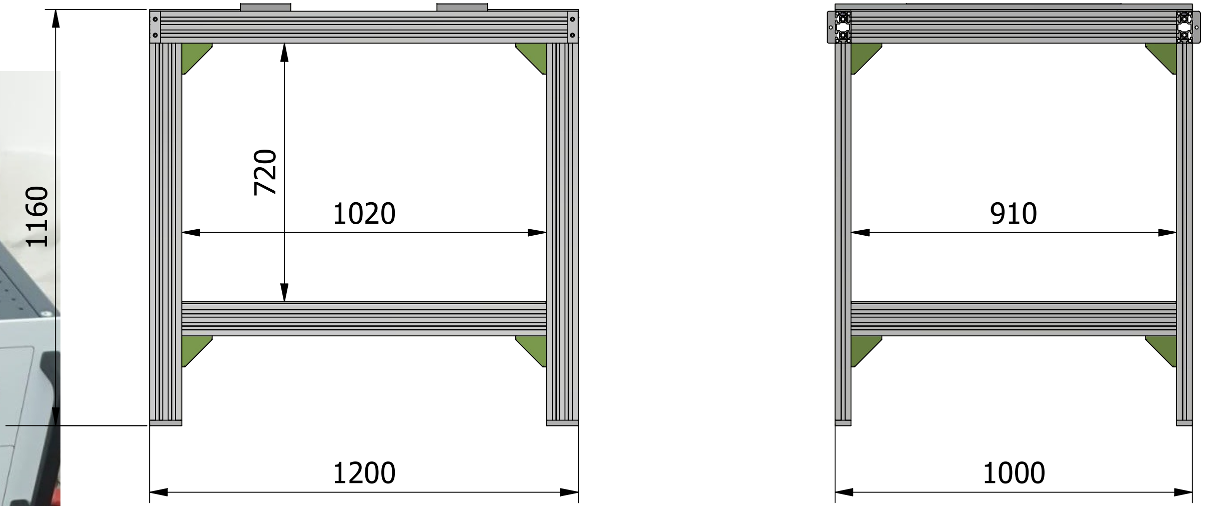
Schema del gas system che verrà realizzato con l'aiuto dei servizi di sezione. I flowmeter sono già stati testati in Labview




Field-cage come quella da trasportare a Bari. Circa 100x50x50 $cm^3$

Modello di HV PS ordinato

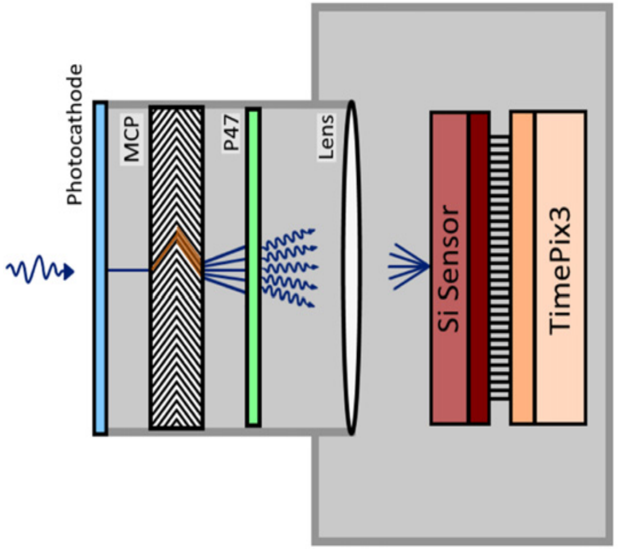

Disegno del tavolo di supporto per detector e strumenti, pronto entro fine anno




Servizi di sezione assegnati per il 2025: 1.5 mp disegno meccanico, 1.5 mp officina

# Piano di spesa 2024-2026

| YEAR | Item | Cost (Keuro) | Total/Year (investment) | Possible connection & synergy with DRD1 |
|---|---|---|---|---|
| 2024 | HV (100KV) | 21 | 21 | WP4 ,WP8 |
| 2025 | Image Intensifier | 22 | 31 | WP4, WP8 |
| | Obiettivo fotografico | 5 | | |
| | 2 piani di Thick GEM (30 cm ) | 4 | | |
| 2025 | Gas | 1 | | |
| | Trasporti | 1 | | |
| 2026 | TimePiX4 | 50 (?) | 50(?) | WP8, WP4 |
| **Tot.** | | | **102** | |




Come per il 2024 le richieste 2025 riguardano solo la parte non pressurizzata della TPC. In particolare ci concentriamo sulla parte relativa all'Image Intensifier (sulla sinistra nel disegno schematico). Oltre all'Image Intensifier medesimo questa parte include 2 piani di thick gem (30 cm di diametro) e un obiettivo fotografico. In attesa di poter acquistare un TIMEPIX nel 2026 potremo contare sul prestito di un gruppo di colleghi con cui collaboriamo.

Richieste di metabolismo e conferenze/workshop non sono menzionate qui perché già incluse altrove

# DRD1 – WP8: HP-TPC

# DRD1 – HP-TPC in WP8

- Roadmap of the HP-TPC is framed in **DRD1-WP8**.
- We participate in a line of research on HP-TPCs as targets in Neutrino Beams with the **University of Geneva and IFAE Barcelona**
- **Plan by 2026 in DRD1 WP8 Project A**: construct and operate a realistic scale (50cm drift, 30cmx30cm transverse) prototype and test facility for high-pressure with different gas mixtures and readout structures. This should serve as the test-bed for a final detector design. The goals are in line with the collaborating institutes (U Geneva and IFAE).
- The goal is to exploit the full potential of Neutrino Oscillation experiments thanks to a precise knowledge of neutrino interaction cross-sections  Accessing the full phase-space of the interaction and recording all secondaries down to a few MeV/c would be the ultimate goal of a cross-section measurement. This is possible by observing interactions in a gas target by using a TPC in a magnetic field with a neutrino beam.
- The possibility of a 10-fold increase in the gas target mass by operating a TPC at high pressure is considered an enabling technique to achieve the desired statistics and measurement precision. The possibility to change the TPC gas mixture is an additional benefit, permitting a study of the A-dependence of the neutrino cross-sections on a range of different targets.
- For these reasons, we are constructing a vessel large enough to study the effects of readout performance, drift length, attachment, etc in realistic conditions. These will be key in assessing the parameters for a final design of the experiment.
- The group aims, on the longer term, to evaluate possible optimizations of the dE/dx performances of such a detector by studying the cluster-counting capabilities in optical-readout mode.

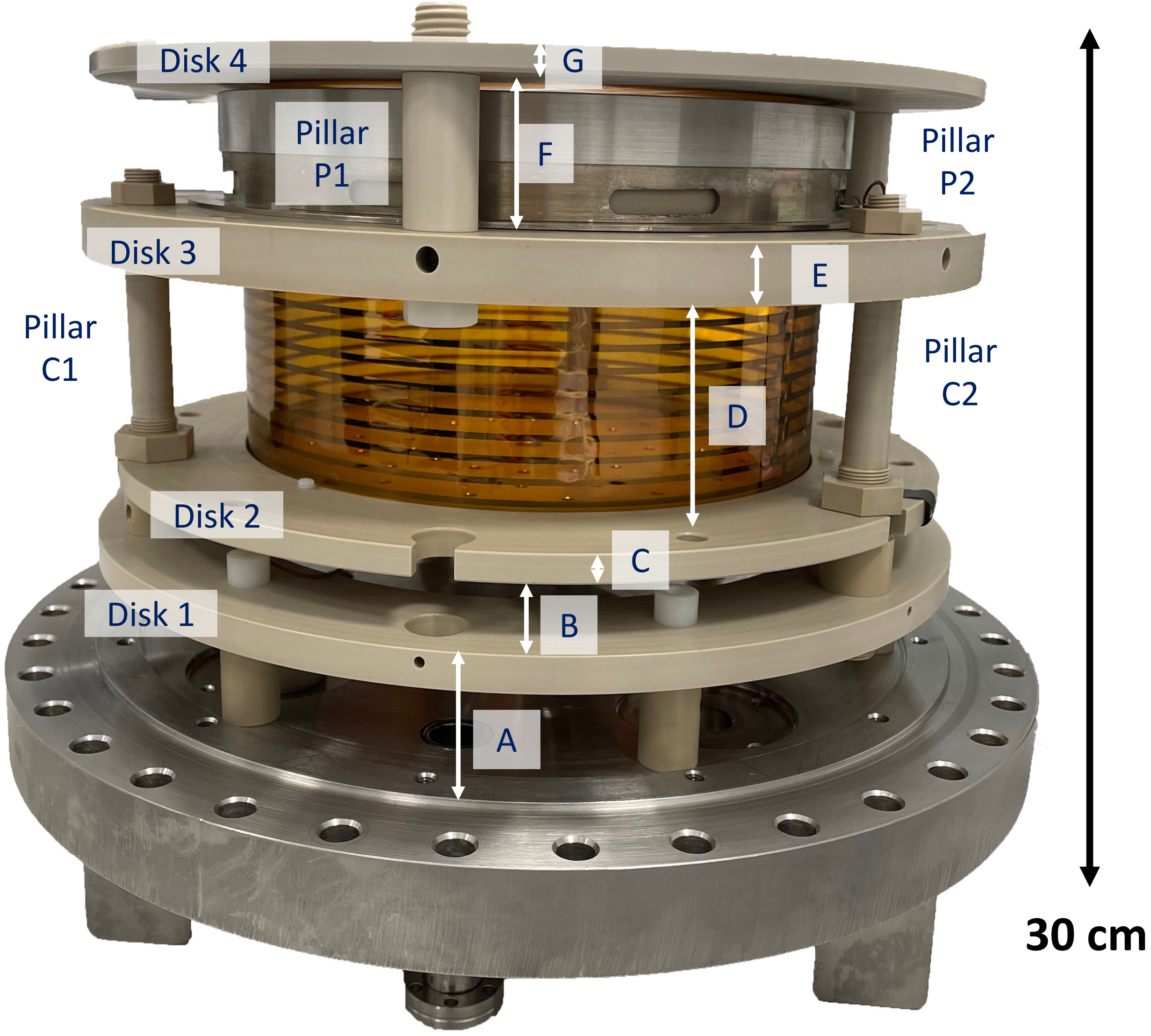
# First studies with a reduced-size prototype

- First common paper with UniGE and IFAE: Gaseous argon time projection chamber with electroluminescence enhanced optical readout https://arxiv.org/abs/2212.02385
- Goal of the paper is finding ways of increase the photon yield and matching the wavelenght to the sensitivity of the readout
- *Light production based on a ThGEM and an additional region of low electric field called the EL gap. The TPC is read by a photomultiplier tube and uses PEN as a wavelength-shifting material.*
- A second paper based on a SiPM array is in preparation

# Initial studies: TPC body borrowed from IFAE and modified to house a ThGEM and the optical readout (PMT and SiPM array)

## The TPC main body

- Bottom: Cathode flange
- Right: Lens flange
- Frame made of PEEK
- Disk 2: cathode
- Between Disk 2 and 4: drift cage
- Disk 4: ThGEM + Mesh
- Hollow pillars for HV cables.




# Attività a Bari

- Sullo stesso schema del prototipo piccolo, stiamo preparando un prototipo di grandezza sufficiente
  - A studiare gli effetti più macroscopici (drift velocity, attachment, diffusion ...)
  - A essere usato come test-bed per arrivare a un disegno finale di un esperimento
  - A poter essere usato in un test-beam, possibilmente in un campo magnetico
- La richiesta 2025 (foglio di strip per la costruzione della field-cage) sono da interpretare in questo contesto. La field-cage verrà costruita nella nostra officina.
- La consegna del vessel pressurizzato in cui verrà inserita la field-cage è prevista entro settembre