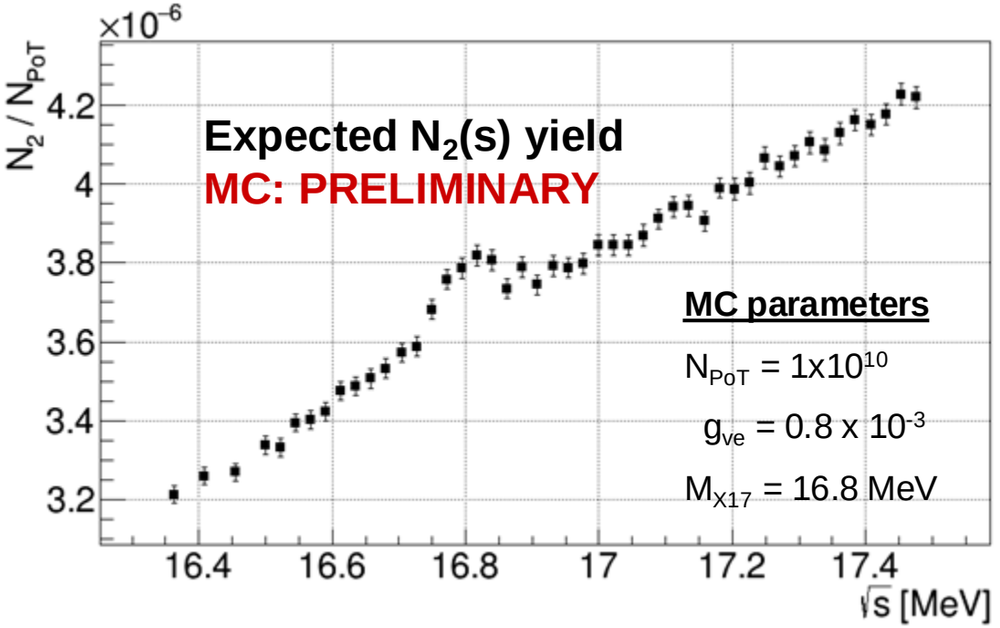
PADME Status and perspectives for RUN IV

X17 analysis status: Run III [end 2022]

- Discriminate

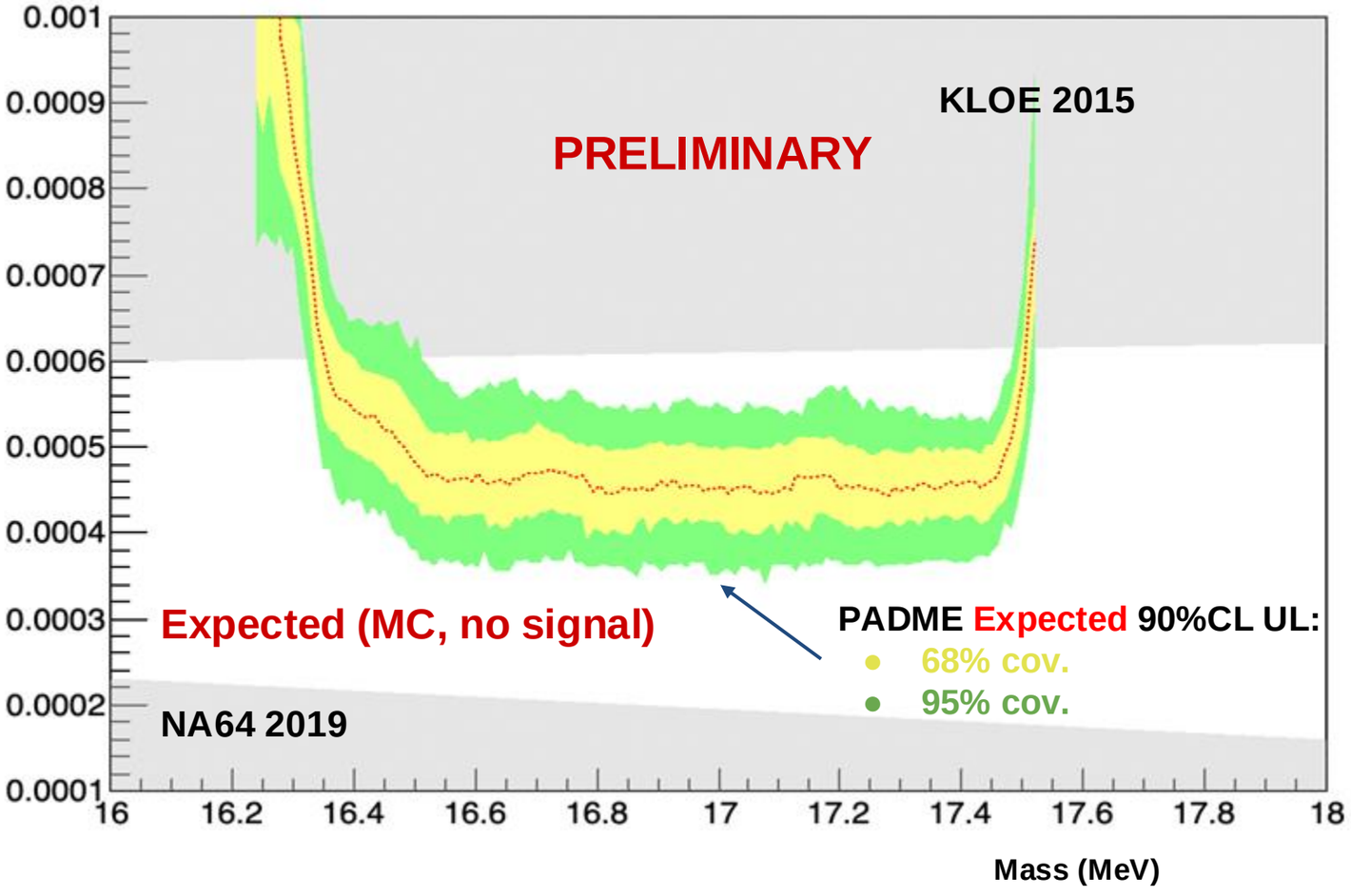
$N_2(s) = N_{PoT}(s) \times [\, B(s) + S(s; M_{X17}, g)\ \varepsilon_S(s)\,]$ **vs** $N_2(s) = N_{PoT}(s) \times B(s)$

  - $\mathbf{N_{PoT}}$ - positrons on target
  - **B(s)** - background yield per PoT
  - $\mathbf{S(s,M_{X17},g)}$ - signal production as a function of mass and coupling
  - $\boldsymbol{\varepsilon_S(s)}$ - signal selection efficiency
  - $\sqrt{\mathbf{s}}$ - measured from E_{beam} run by run



- Procedure for results extraction fully developed
- Signal shape **S** now available [*Phys.Rev.Lett.* 132 (2024) 26, 261801]
- Working on providing the “proper” and the most “reliable” input
- Many of the inputs are already fixed
  - Positrons on target $\mathbf{N_{PoT}}$: a sophisticated calibration and verification procedure developed
  - Beam energy $\sqrt{\mathbf{s}}$: systematic error evaluated
  - Acceptance and selection efficiency $\boldsymbol{\varepsilon_S(s)}$: analysis cuts tuned to minimise the systematic error

Using independent counting



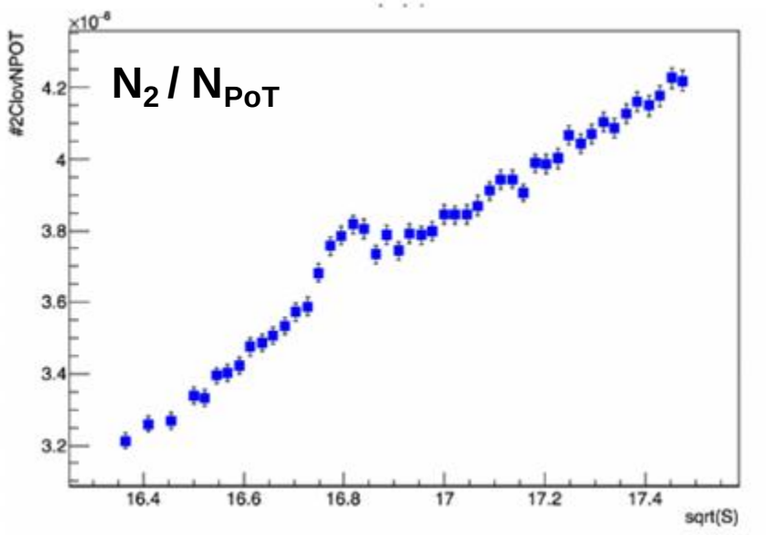
- Expected 90% CL upper limits are obtained with the CLs method
  - ATL-PHYS-PUB-2011-11/CMS NOTE-2011/005
- Likelihood fits performed for the separate assumptions of signal + background vs background only

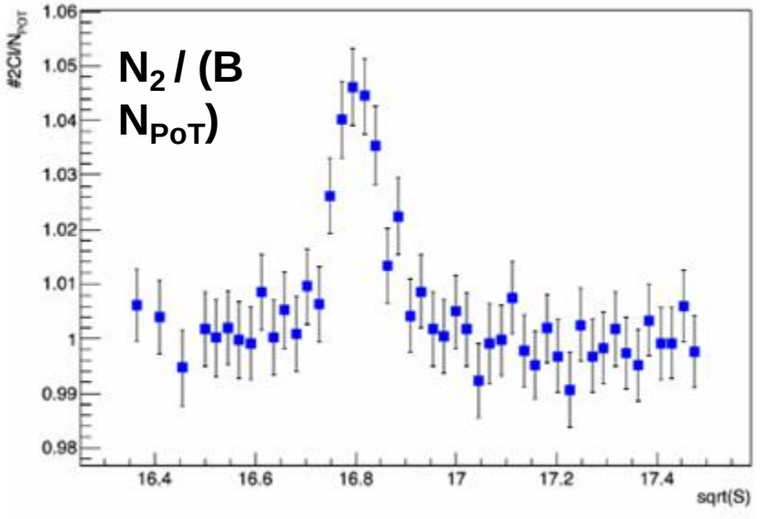
$$Q_{statistics} = -2\, ln\, (L_{s+b} / L_b)$$

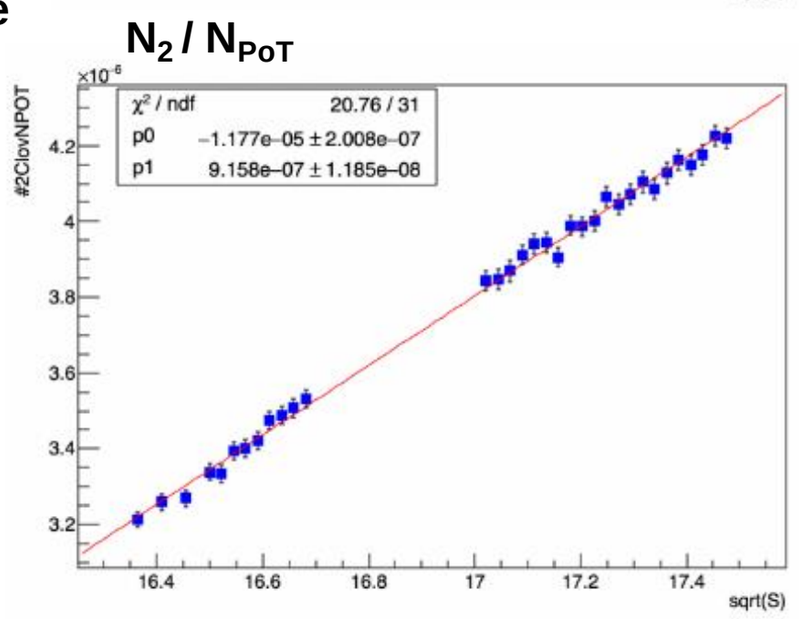
- Pseudo data (SM background) is generated accounting for the expected uncertainties of nuisance parameters + statistical fluctuations
- **147 Nuisance parameters:**
  - POT of each scan point
  - Common error on POT (scale error)
  - Signal efficiency for each scan point
  - Background counts for each scan point
  - Signal shape parameters: signal yield @ a given X17 mass and g_{ve}
  - Signal shape parameter: beam-energy spread

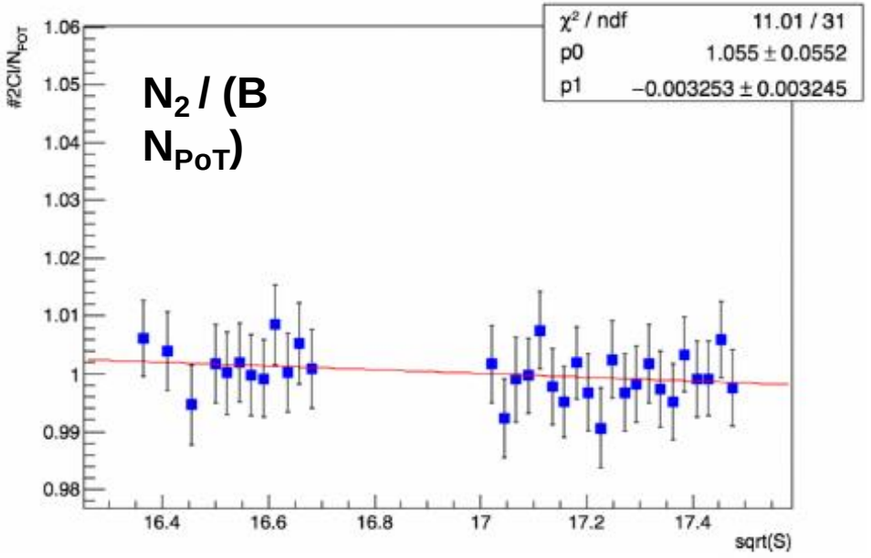
X17 analysis: alternative using sideband fit

- To be included in a dedicate paper
- Signal efficiency ~ background efficiency: data-driven sideband **blind fit** to constrain the background expected yield
- Slope and constant term of fit (P0,P1) receive many % contributions from radiative corrections
- **Use P0,P1 to strongly reduce the number of nuisance parameters (carefully evaluate expected errors for them)**





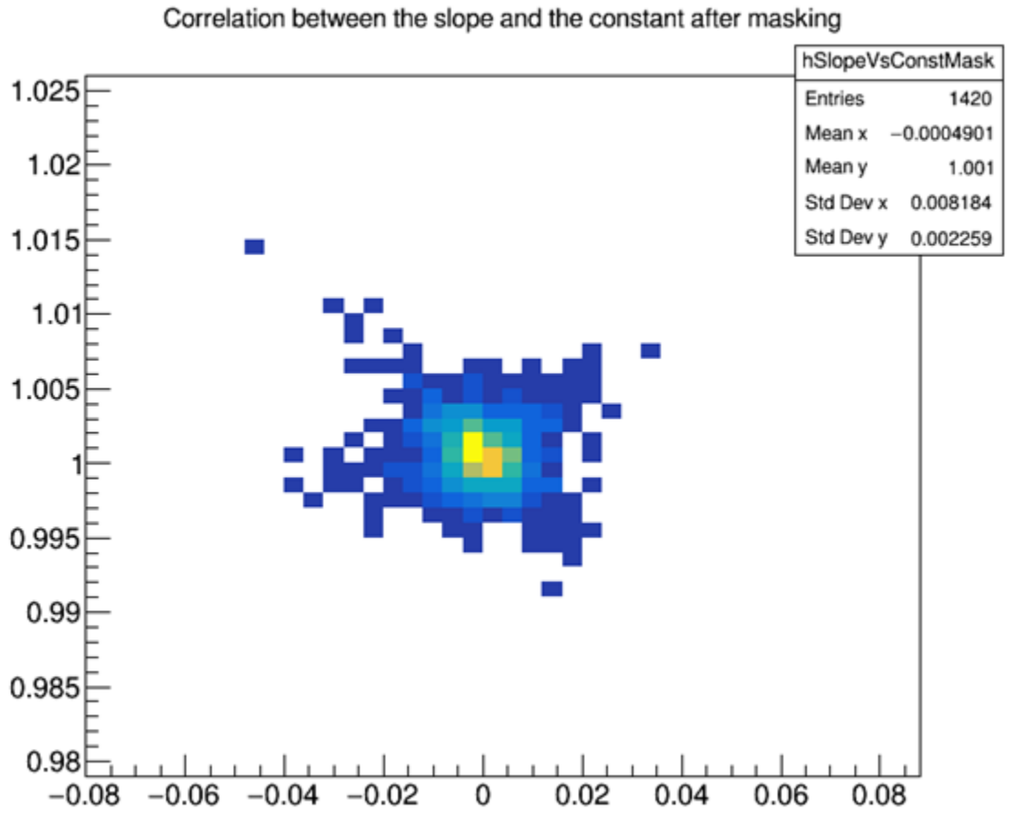




X17 analysis status:

Goal to unblind in time for the November meeting of the LNF Scientific Committee, to do so:

- New MC to be generated with the effect of O(10G) residual magnetic field
- Validate the toy-MC values for the signal efficiency used in the CLs method
- Exploit the full information of the $N_2(\sqrt{\mathbf{s}})$ / Acc(2cl) , corrected for N_{PoT}
- Determine again the expected sensitivity → **do not expect anyway to cover full parameter space**



Close the X17 with a further run: Run IV

Idea to close the X17 parameter space with a new run, so-called Run IV

Main pillars of the new run:

- Substitute the ETag with a micromega-based tracker to evaluate N(e+e-)/N(gamma-gamma) vs √s
- Decrease by x2 the number of points in √s, take 4x statistics per point
- Precisely evaluate the beam features (beam spot, angle, energy, beam focus) per √s point using TimePix

Goals: be ready for beginning of 2025

New collaborators for the new tracker: G. Mancini, M. Antonelli, C. Arcangeletti, F. Anulli (RM1), P. Iengo (NA) P. Massarotti (NA), G. Sekhniadze (NA)

Leading contributions from B. Ponzio, E. Capitolo for the tracker building, installation, commissioning, etc.

Tracker construction: ELTOS/CERN/LNF, for financial details see referee presentation at Sep 2024 Group 1 meeting

PADME planned schedule

Requested period	Hall	Beam	Objective	Prerequisites
30 September - 6 October **Week 40**	BTFEH2	Electron beam (secondary)	- Timepix wrt Leadglass efficiency measurement - Timepix calibration - Leadglass calibration: response dependence wrt to HV (scan) and beam multiplicity	- Timepix transport to BTFEH2
4 - 17 November **Week 45** **Week 46**	BTFEH1	No beam	- Connection of PADME chamber to the the BTF line - Timepix and LeadGlass installation in place - Installation of Micromegas tracker with the gas infrastructure	- Green light from PADME Calorimeter crystals resurrection - Operational Micromegas, validated with cosmic in LAB - Green light from beam group
		Positron beam (secondary)	- Switch ON the detectors in the setup (warm up) - Common DAQ with event synchronization test - Micromegas first test with beam	- Installed Micromegas together with the gas (consumables) infrastructure - Installed Timepix and precise position survey
9 - 16 December **Week 50**	BTFEH1	Positron beam (primary, if possible)	- Full PADME operation - Detectors commissioning for RUN IV (efficiency, LeadGlass calibration, etc.) - Test and validate the new PADME Micromegas tracker	- LeadGlass positioning wrt Timepix - Operational Micromegas attached to the PADME ECal
20 - 31 January	BTFEH1	Primary positron beam	- Beam commissioning - Focusing at ECal / Timepix3 plane	- Operational PADME experiment - Operational Timepix/ECal
February - July	**BTFEH1**	**Primary positron beam**	**COLLECT GOOD DATA**	

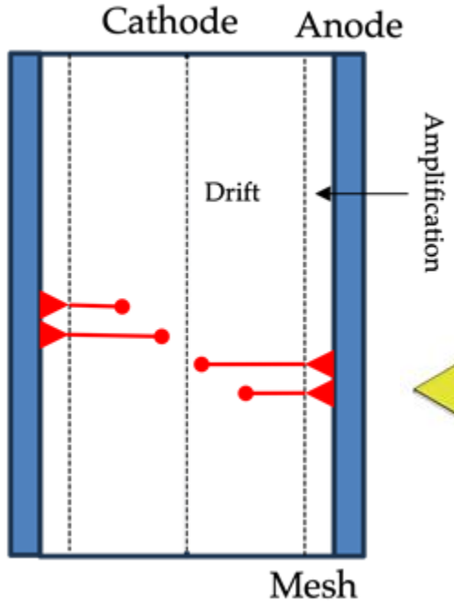
BTF test run I detailed plan

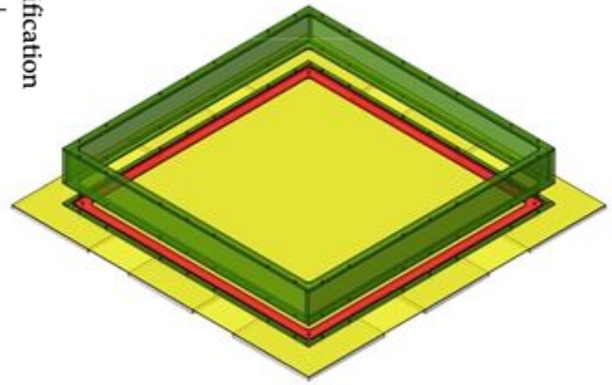
- 30.09 - review of activities, installation and instructions. Transport of Timepix to the BTF experimental hall on 30.09
- 1.09 - Timepix DAQ, LeadGlass DAQ setup and data taking for beam adjustment
- 2.09 - till the end:
  - energy scan
  - multiplicity scan (1, 10, 100, 500, 1000, 2000, 3000) e-/e+ per bunch
  - Timepix position scan (i.e. we have to place the Timepix on the movable table, horizontal most important) - cover +/- 5 cm, to illuminate the whole Timepix
  - LeadGlass position scan to verify the MC simulation of the transversal energy leakage of the LeadGlass by keeping the Timepix in place and moving just the leadglass. i.e. LeadGlass position scan.
- Parasitic activities
  - measurement the residual magnetic field of the PADME dipole magnet. During the installation of Timepix and LeadGlass in the experimental hall

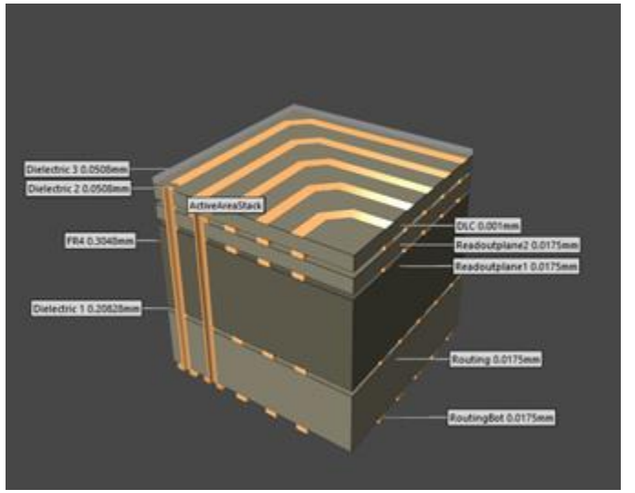
Subsequent test periods depend on the progress of PADME Micromegas detector

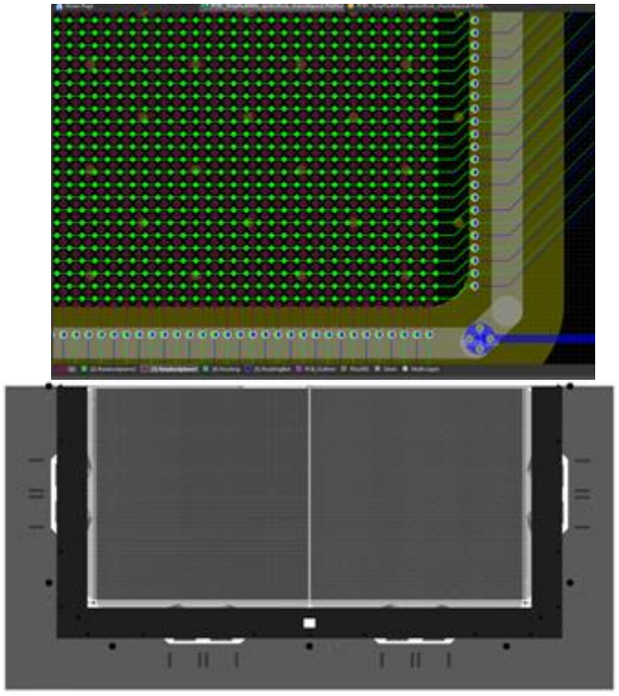
Detector status

- PCB production done
- Detector assembly imminent
- GAS ordering to be completed
- FEE purchased

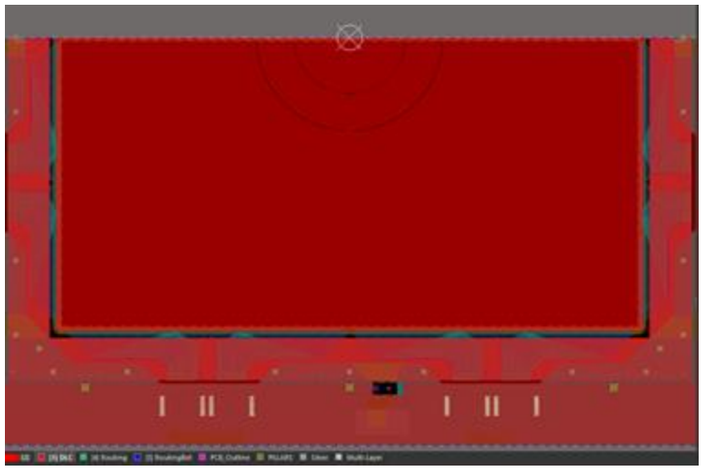


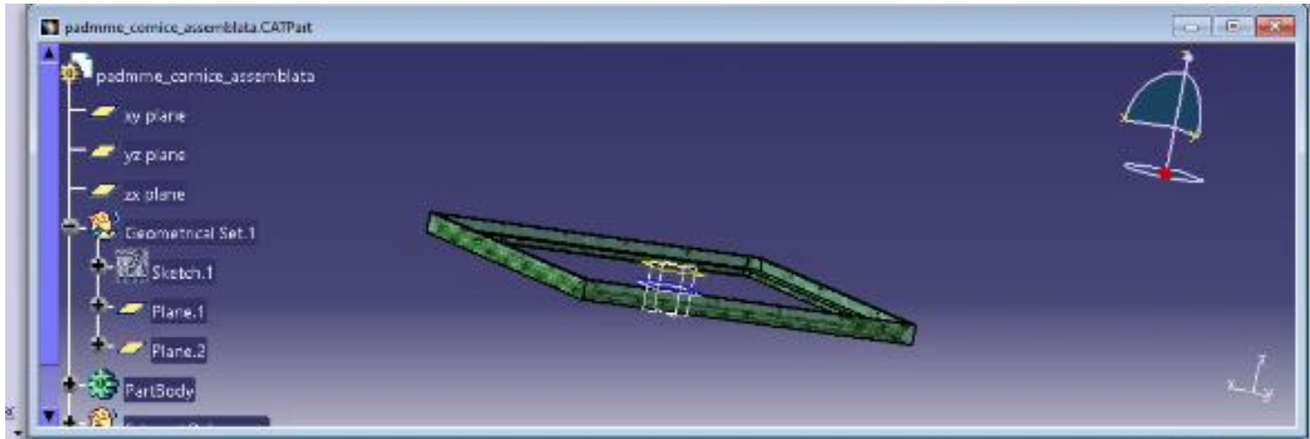






3 HV zones

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Sketch.1
Plane.1
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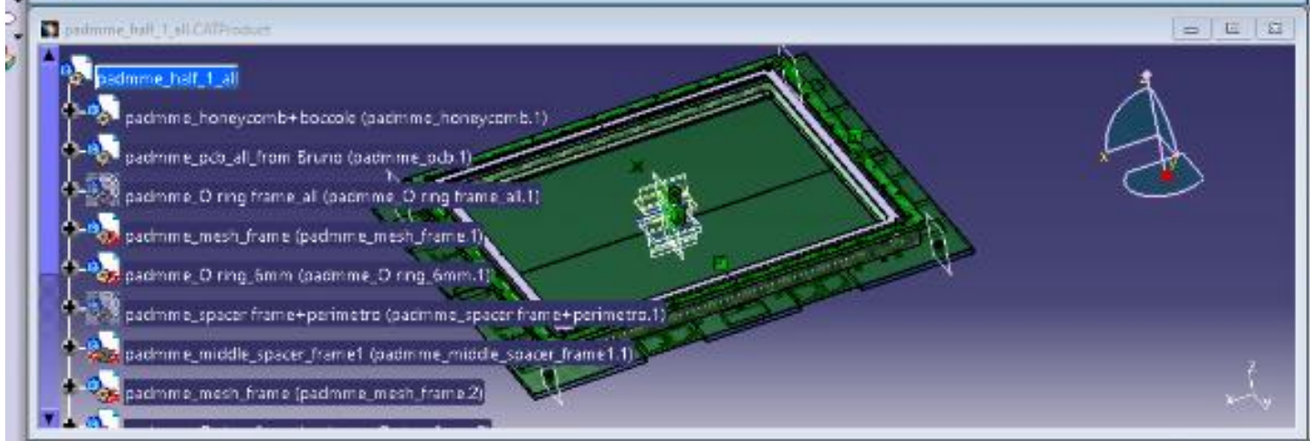
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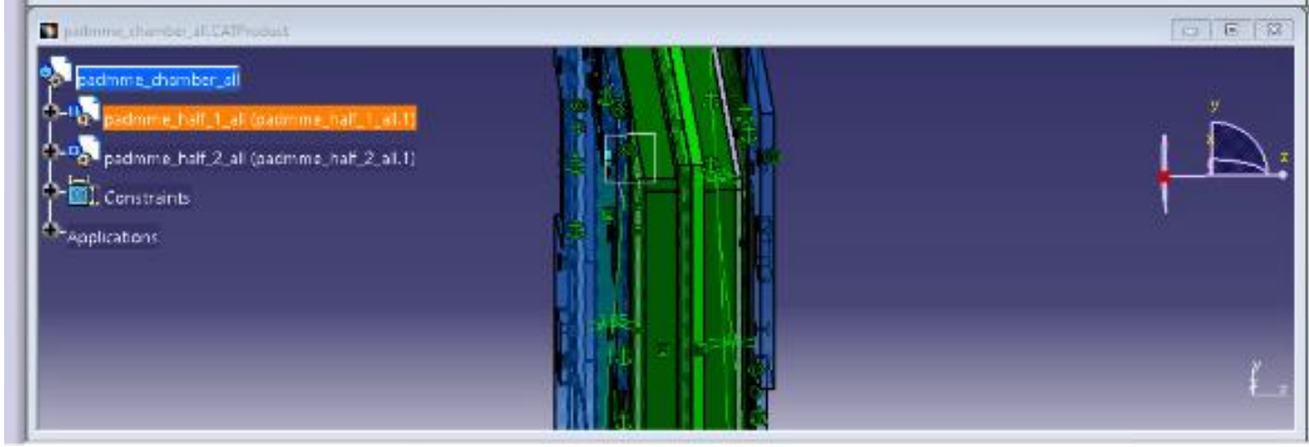
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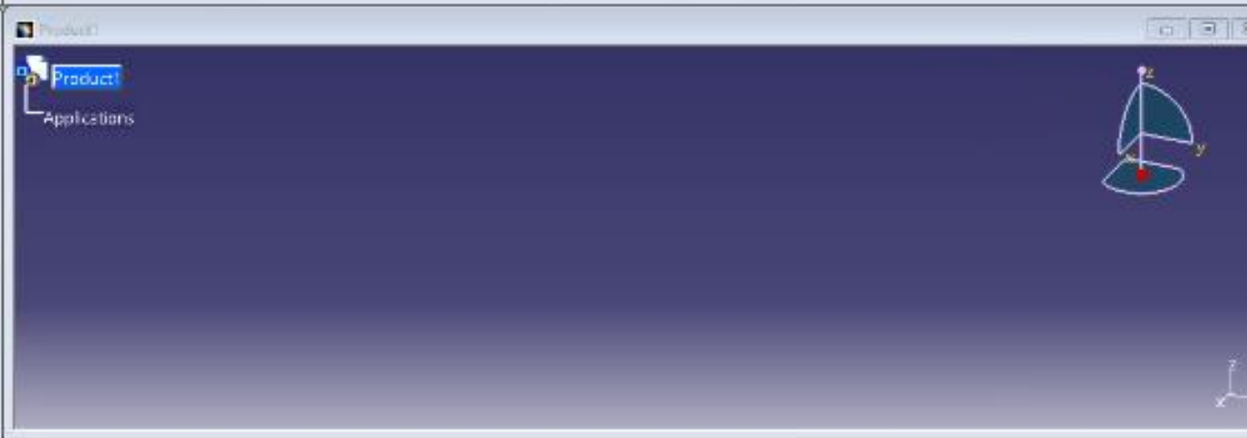
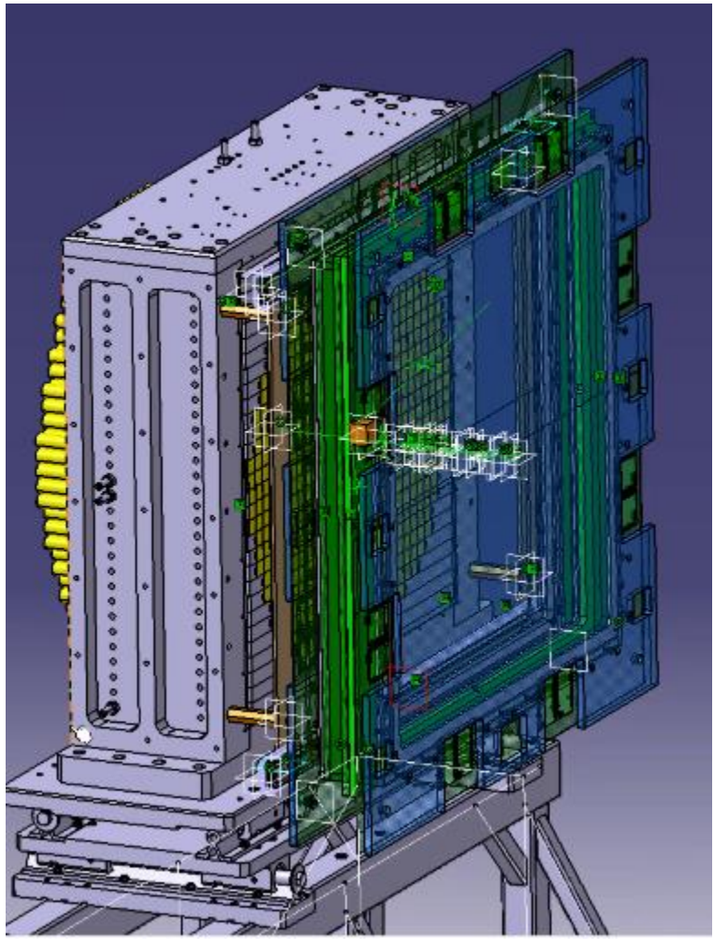
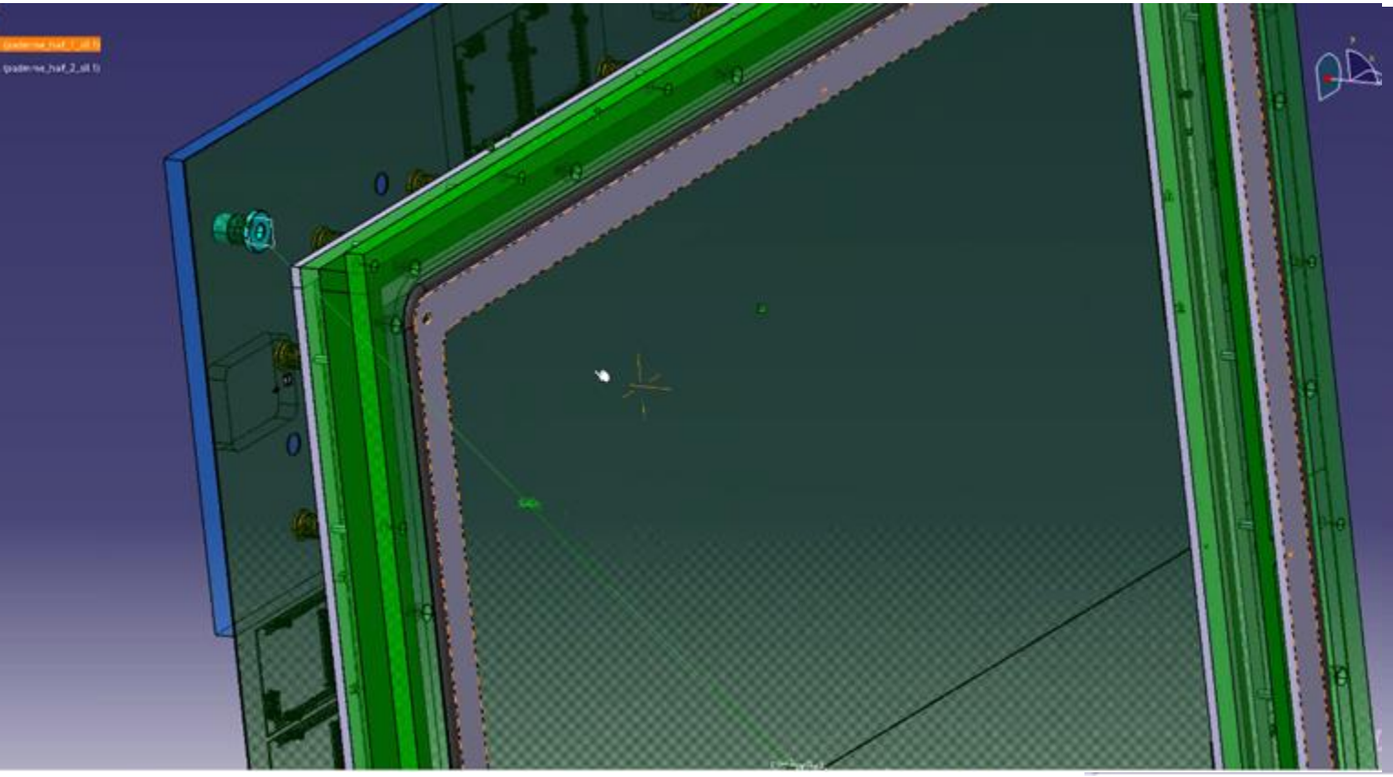
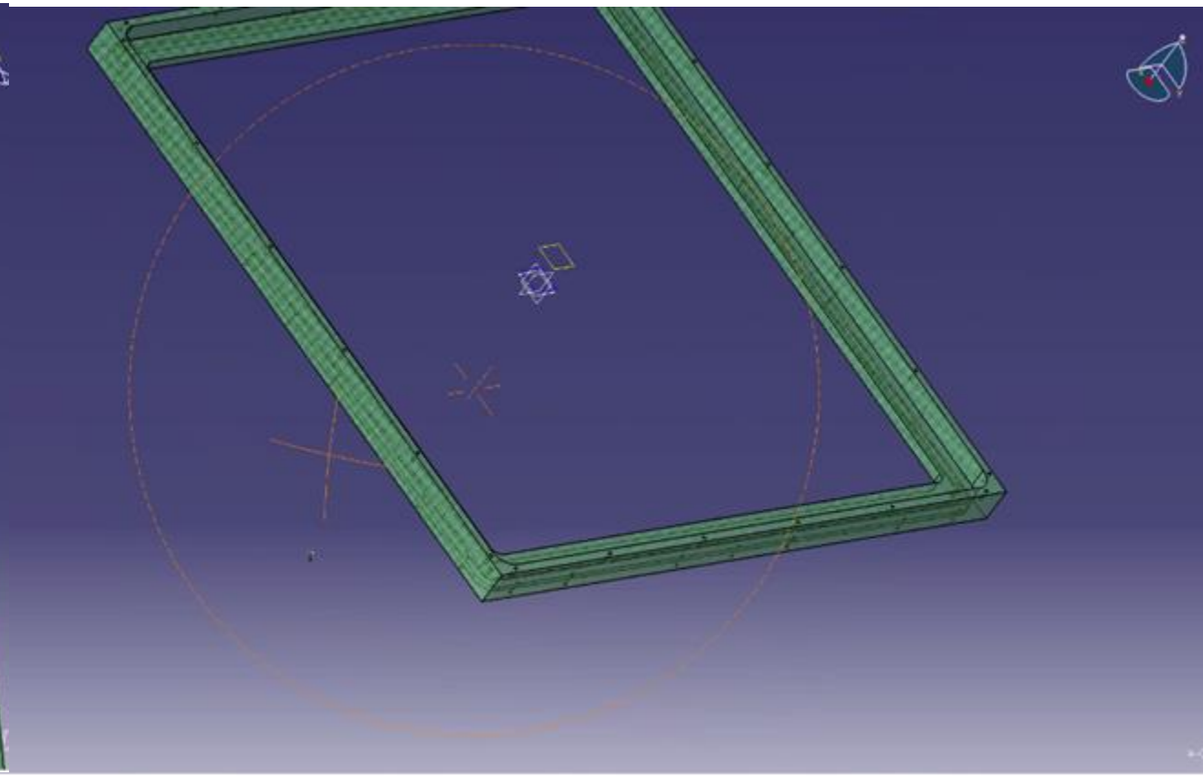

Product1
Product1
Applications

Micromegas

- 8 PCBs is ready
- The connectors welded
  - Monday Emilio goes to Geneva by car to take the PCB
  - Take the parts of the frame, if possible
    - The mesh frame is already done, 3 mesh frames
- Glue the screwing parts (~100 bash) on the honeycomb to fix the O-ring
  - The chamber will be screwed, not glued, to allow opening
- Nuova saltini - production of the FR4 frames, status unknown (the frame in the middle)
    - Glue the PCB on the support honeycomb , 2011 glue (glass fiber)
- Missing - the working :)
- Gluing of the bashes will take 2-3 days
- Fix the PCB on the honeycomb, 2-3 days



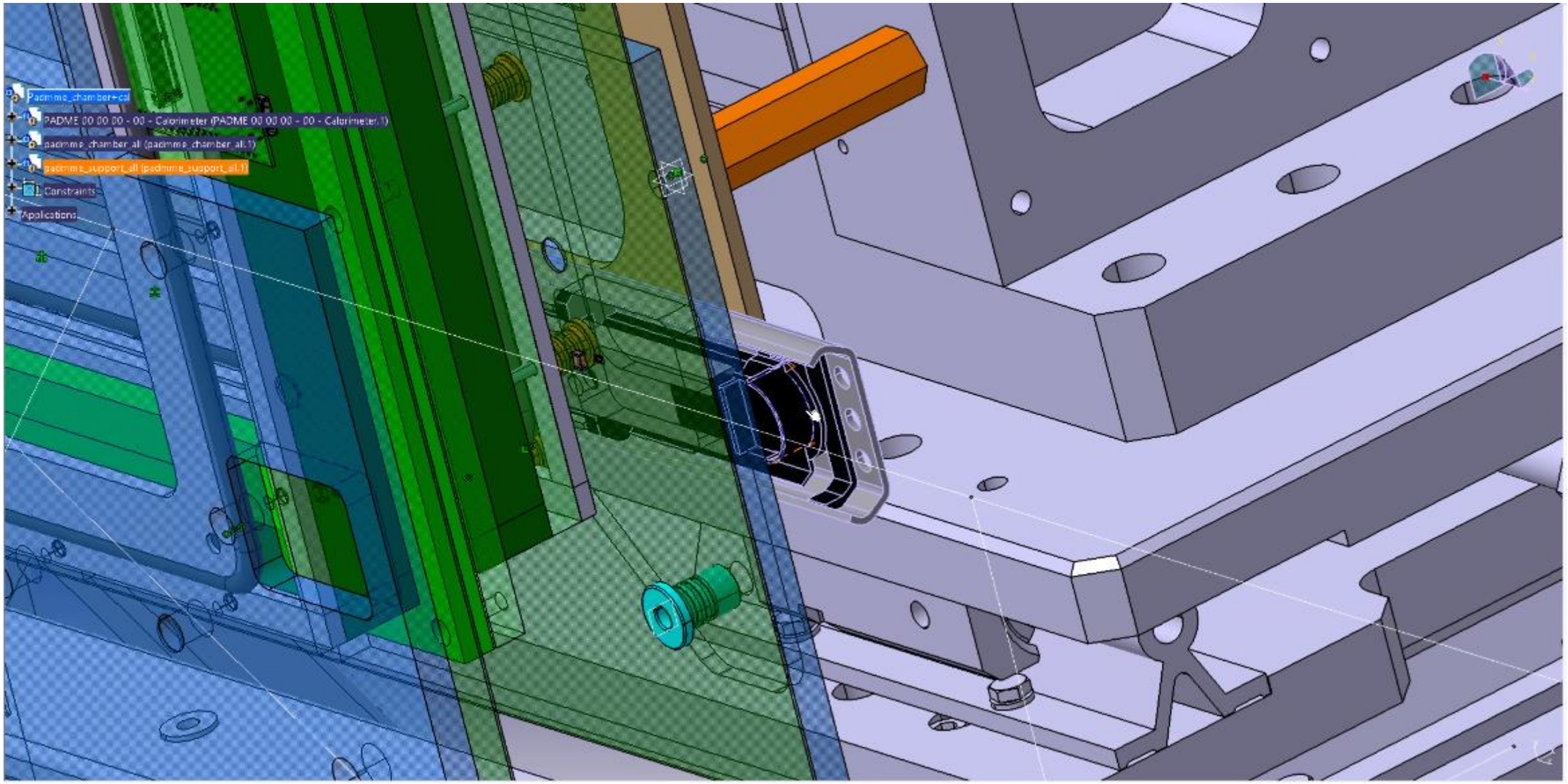




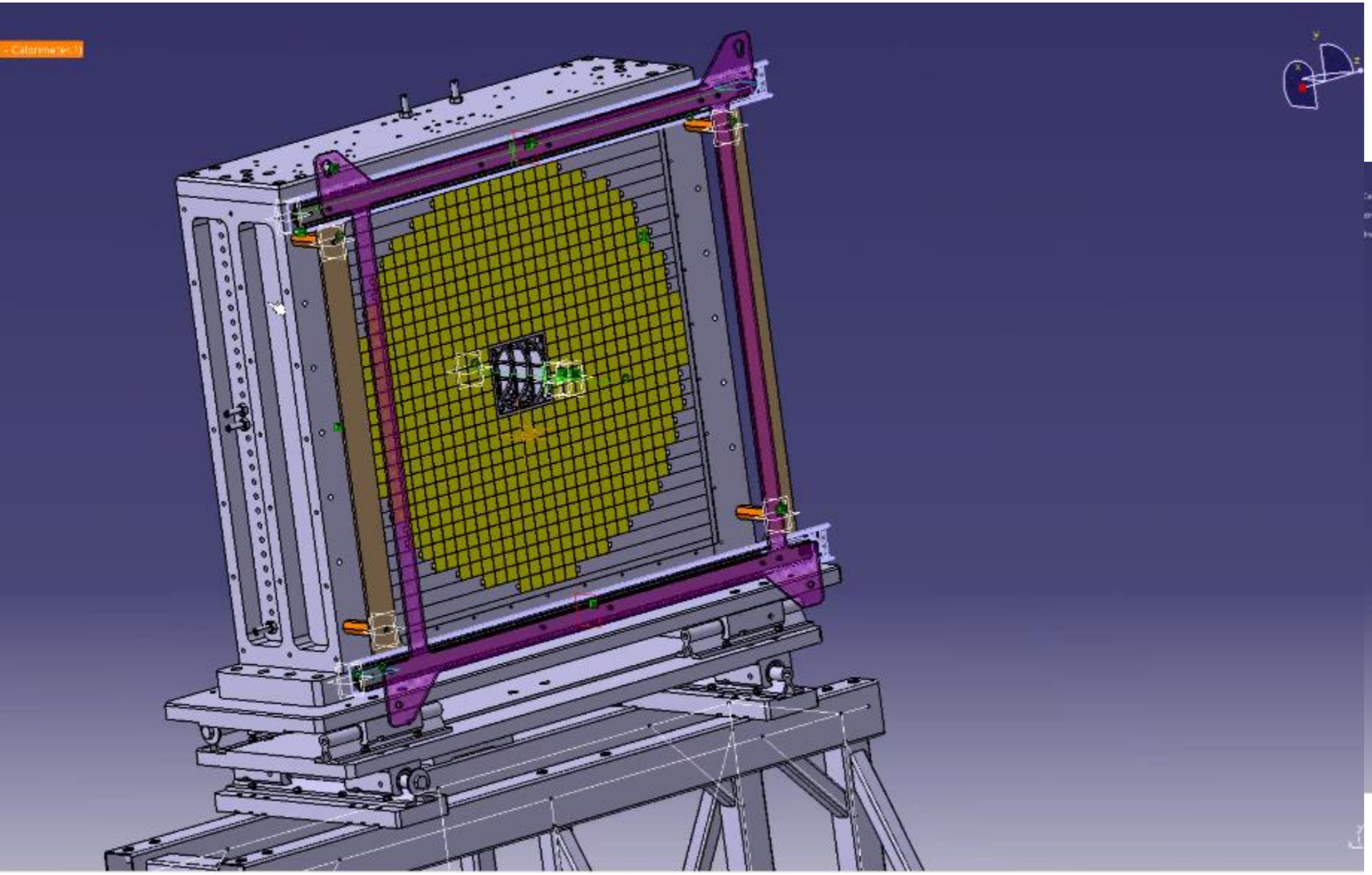
- Nuova saltini - production of the FR4 frames

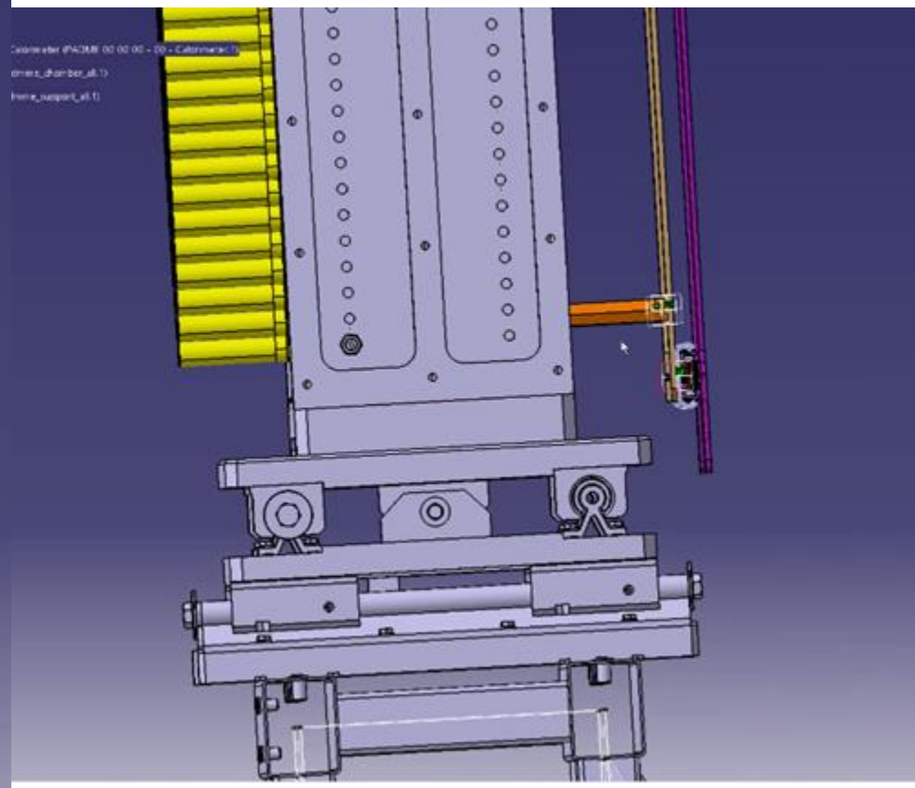
Micromegas schedule

- Second week of October - possible to have each chamber done
  - Connection to the gas and readout
- Spacers between the chamber and the ECal are to be done
  - Ordered to LNF workshop
  - Space between the ECal and the Micromegas - 80 mm
- Support for the power supply of the Micromegas
  - Attached to the two sides of the ECal
  - To be defined and designed, 1 week of work
- Aligning with the ECal
- Need a survey after the installation
  - Marks on the feet of the ECal before we start the installation
  - Work in the free space with ECal rotated
  - Return it to the same place and then a survey
  - Align the centers of the Timepix and the ECal



Springs, which ensure the position, 5 kg to be pushed





- Space between the ECal and the Micromegas - 80 mm

Preliminary work on ECal

- Safe storage place to put the ETAGGER
- Remove the ETAG
- Put the available front closure of the ECal, Tetrahoneycomb
- Switch ON the ECal to check for light leaks
- In case of no issues, assembly the structure of new tracker

- For MICROMEGAS, the mechanics could be ready by mid-October
- If the chamber works, 2 weeks of tests with cosmic rays
- **4-10 November installation is still possible, a bit optimistic**
  - In case of no problems with the chamber and if everything goes well
  - Horizontal and vertical position of the chamber - internal dust changes position, to be tested

Conclusions

- Fervent activity to open the X17 box based on Run-III data: goal of opening by November SciCom
- New run proposed for beginning of 2025:
  - New micromega tracker under construction, schedule slightly tight but still doable
  - Preparation for new run already started: test beam program agreed with BTF team
  - First test beam imminent