P̄ANDA experiment at FAIR

- The FAIR project;
- The P̄ANDA experiment;
- P̄ANDA Central Tracker;
- Detector construction.

Paola Gianotti

The FAIR project

On October, 4th 2010, ten international owners founded the FAIR GmbH.

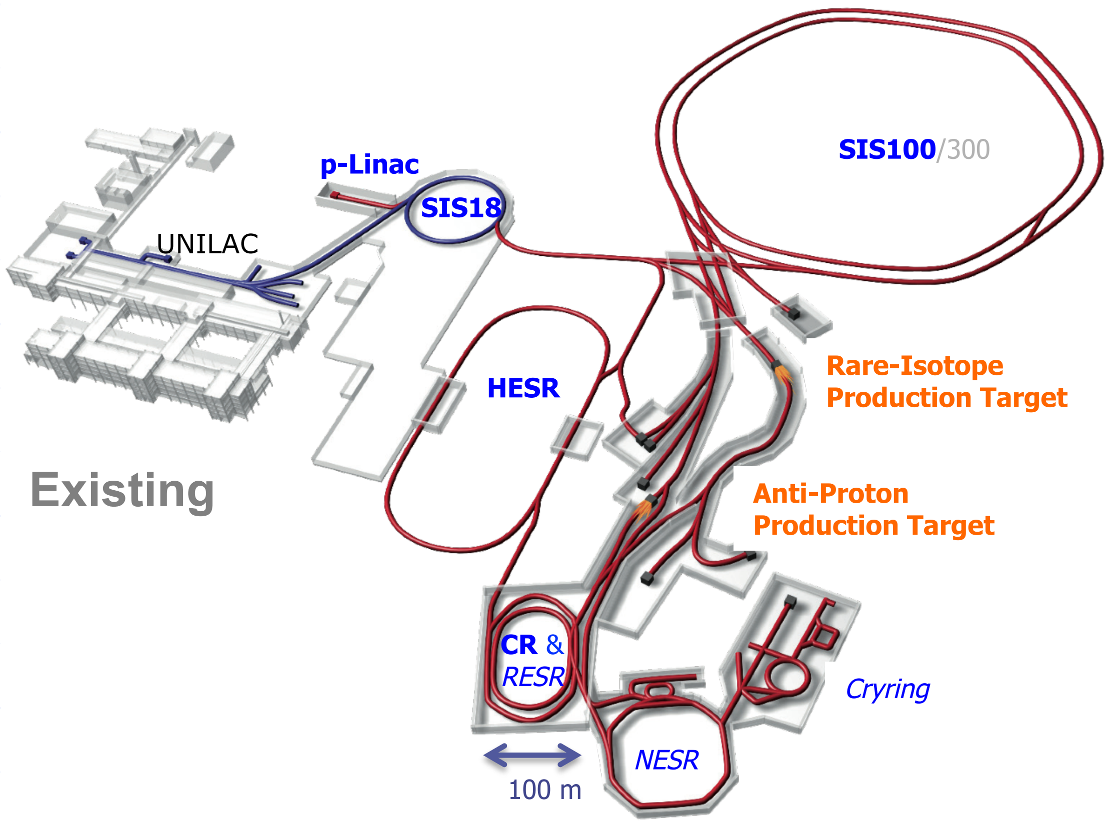
Finland France Germany India Poland Romania Russia Slovenia Spain Sweden

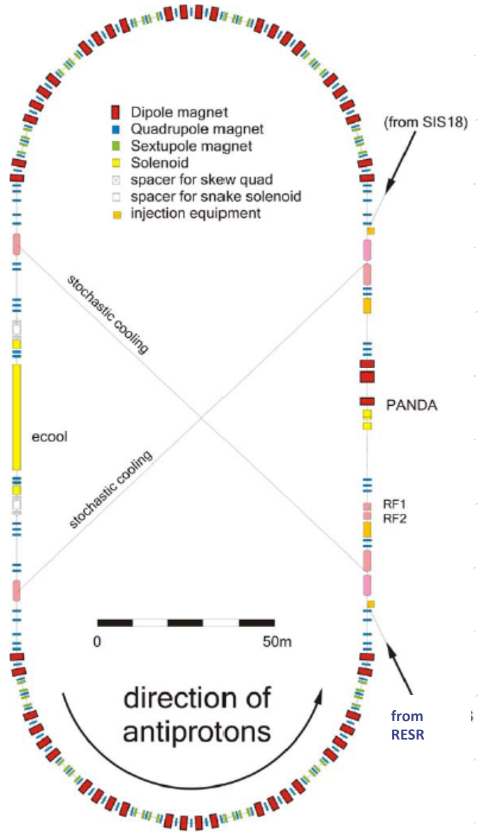
FAIR GmbH is coordinating the construction of the accelerator and experiment facilities.
The participating countries contribute with their technical and scientific expertise to the project, in addition to their financial and in–kind input.

Facility for Antiproton and Ion Research

FAIR

Antiproton production
- Proton Linac 50 MeV
- Accelerate p in SIS18 / 100
- Produce $\bar{p}$ on target
- Collect in CR, cool in RESR

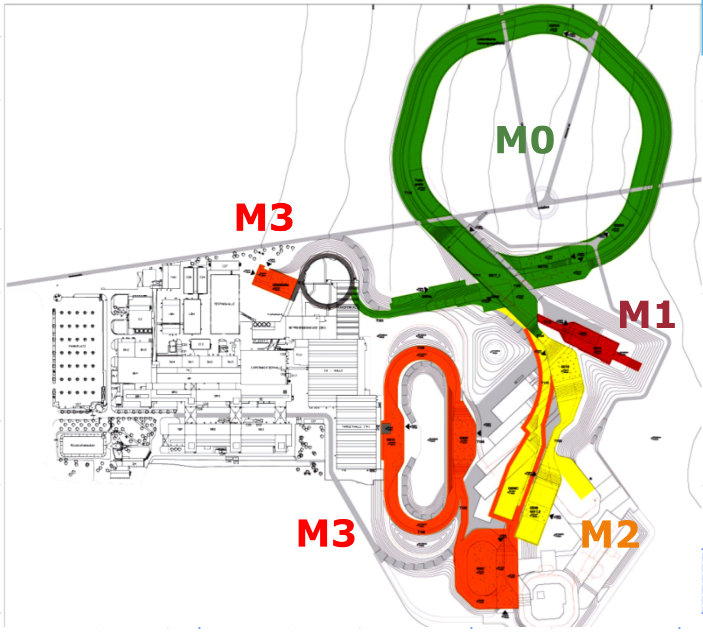




HESR: Storage ring for $\bar{p}$
- Injection of $\bar{p}$ at 3.7 GeV/c
- Slow synchrotron (1.5-15 GeV/c)
- Luminosity up to L~ 2×10^{32} $cm^{-2}s^{-1}$
- Beam cooling (stochastic & electron)

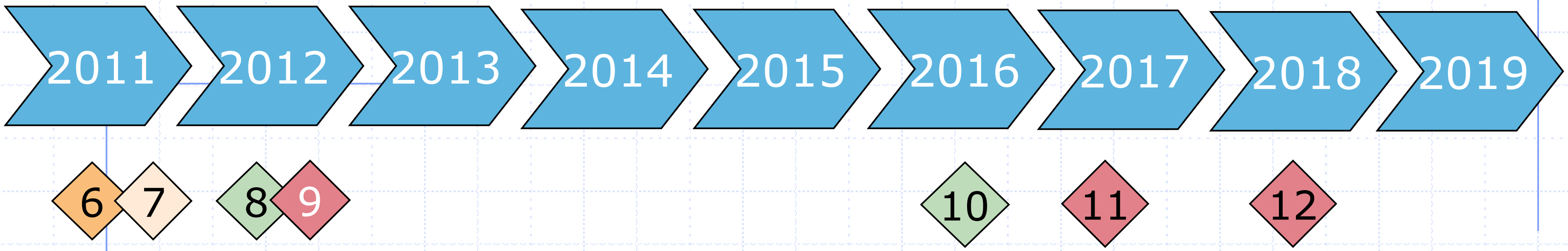
Staging

Start Version Phase A (SIS100)						Phase B (SIS300)
Modularised Start Version						
Module **0**	Module **1**	Module **2**	Module **3**	Module **4**	Module **5**	
SIS100	**Exp. halls** for CBM & APPA	**Super-FRS** for NuSTAR	**Antiproton Facility** for PANDA & options for NuSTAR	**LEB, NESR, FLAIR** for NuSTAR & APPA	**RESR** for PANDA, NuSTAR & APPA	



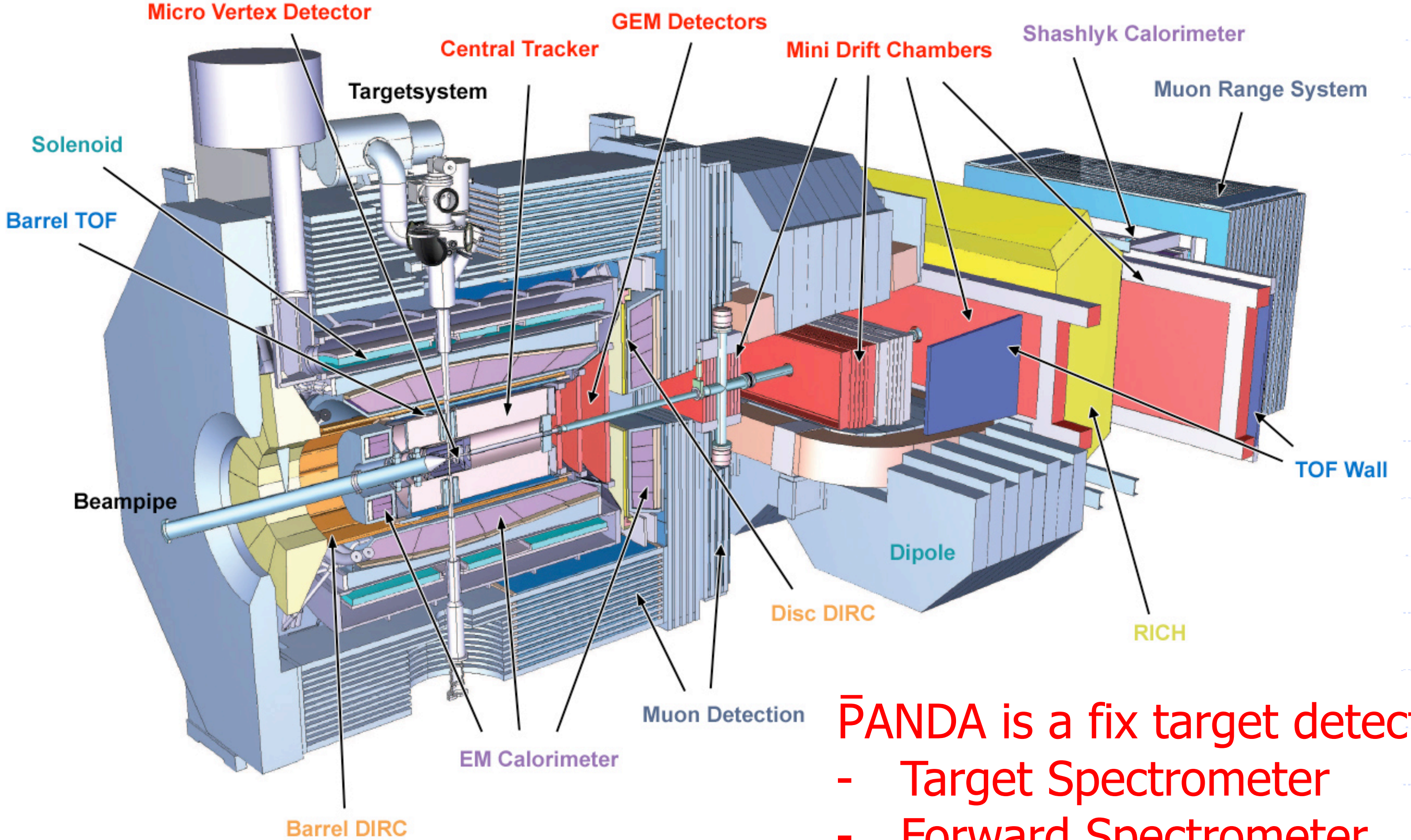
2017/18

Timeline Modularised Start Version



- 6 Building permits
- 7 Site preparation
- 8 Civil construction contracts
- 9 Building of accelerator & detector components
- 10 Completion of civil construction work
- 11 Installation & commissioning of accelerators and detectors
- 12 Start Data taking

The P̄ANDA spectrometer



P̄ANDA is a fix target detector:
- Target Spectrometer
- Forward Spectrometer

Italian group's activity

P̄ANDA Italian groups are involved in the following activities:

- Design of the 2T superconducting solenoid, realization of the gas beam dump of the Cluster-jet target: Genova
- Micro Vertex Detector: Torino_ge
- Muon detector & general DAQ: Torino_mu
- Internal target for hypernuclear program: Politecnico di Torino e LNL
- Straw Tube Tracker: LNF, Ferrara
- General and Tracking Software: Pavia, Torino_mu, Ferrara

Italian leadership roles

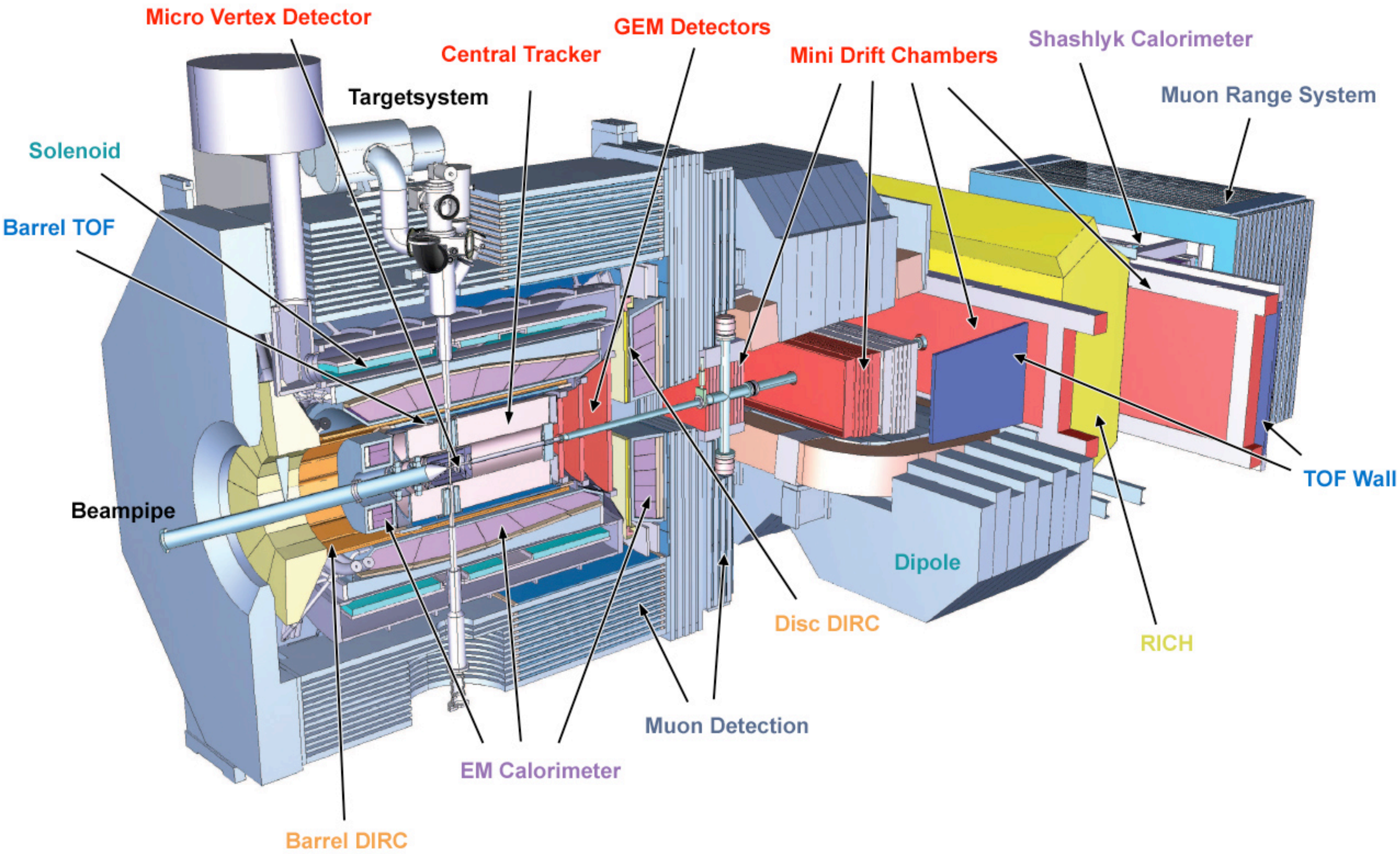
P. Gianotti: deputy spokesperson and Tracking system coordinator
D. Bettoni: Physics coordinator and publication board chair
S. Spataro: Deputy Computing coordinator
D. Calvo: MVD coordinator
A. Rivetti: Electronics coordinator

D. Greco, M. Savriè: pubblication board members

F. Iazzi: conveener of hypernuclear physics program
M. Maggiora: conveener of electromagnetic physics program

R. Parodi: responsible of the design of the "superconducting coil"

Main tasks of the Central Tracker



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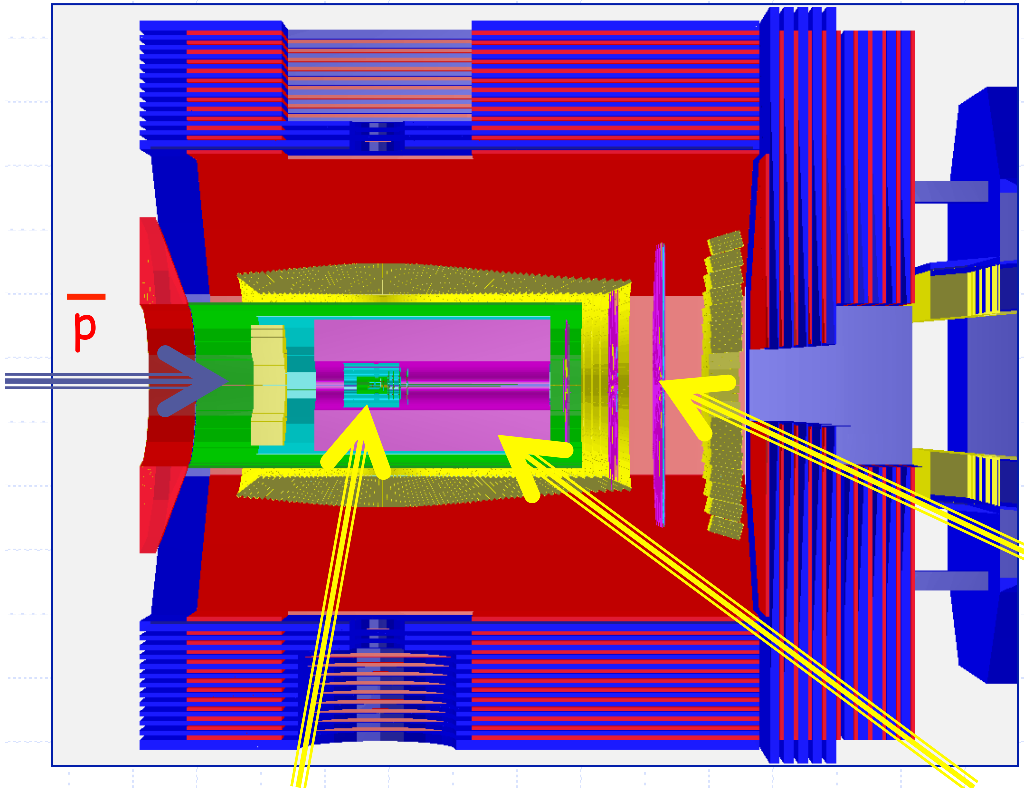
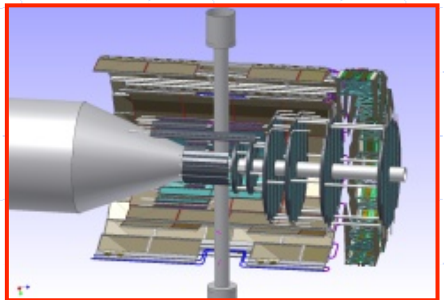
Central Tracker TDR

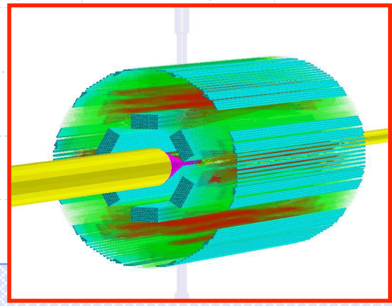


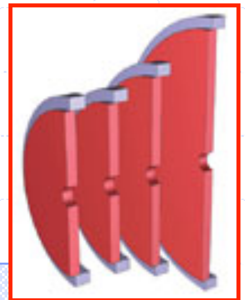
MVD: Giessen, Torino, Julich

STT: LNF, Pavia, Julich, Krakow

GEM: TUM, GSI





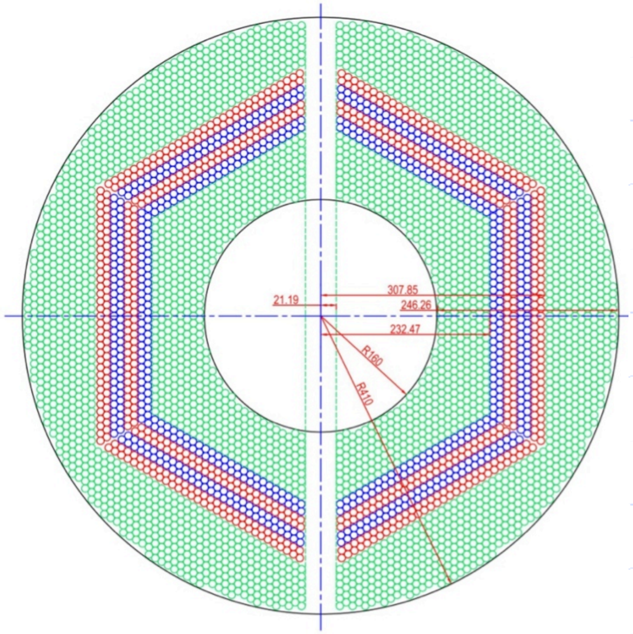


…Habemus central tracker

The Collaboration Board acknowledged the high-quality work done by the tracking group, which went into an external review of the PANDA CT projects. Very nice results were accomplished in the past by both groups. Finally it was decided that the STT will serve as solution for the central tracker for PANDA.

STT layout

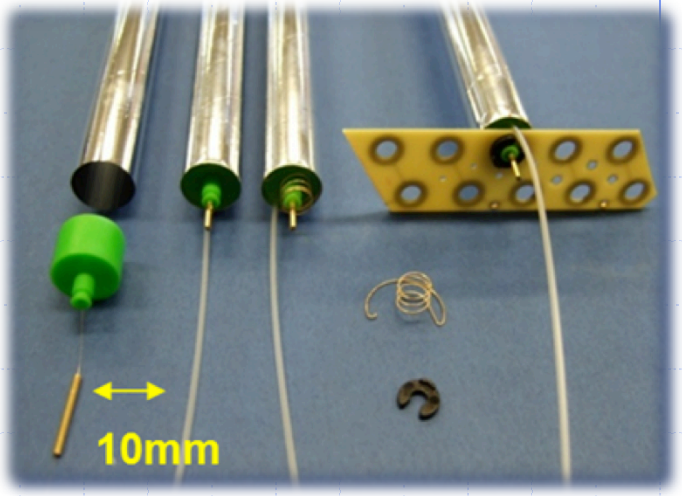
- 4636 Straw tubes in
- 23-27 planar layers in 6 hexagonal sectors
  - 15-19 axial layers (green)
  - 4 stereo double-layers for 3D reconstr.
  - ±2.89° skew angle (blue / red)
- Time readout (isochrone radius)
- Amplitude readout (energy loss)
- $\sigma_{r\Phi}$ ~ 150 μm, s_z~ 3.0 mm (single hit)
- σ_p ~ 1 - 2% at B=2 Tesla
- X/X_0 ~ 1.2% ($^2/_3$ tube wall + $^1/_3$ gas)



- R_{in}/R_{out}: 150 / 418 mm
- Length: 1500mm + 150mm (RO upstr.)

Straw Tube Design

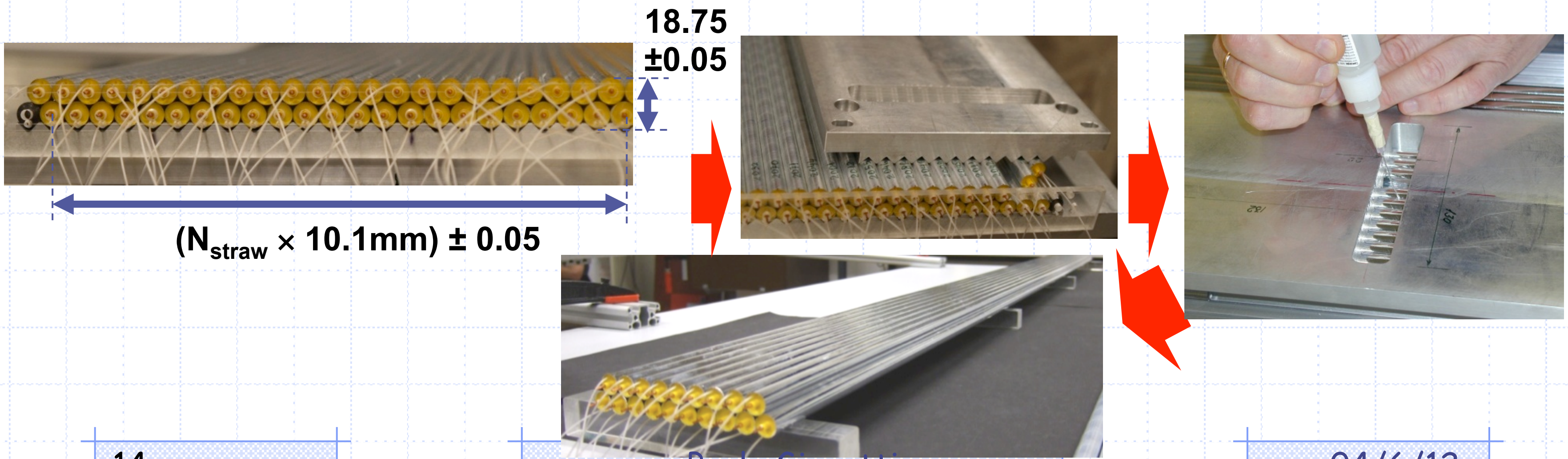
- Straw tube materials:
  - Al-mylar film, d=27µm, ∅=10mm, L=1500mm
  - 20µm sense wire (W/Re, gold-plated)
  - End plug (ABS thermo-plastic)
  - Crimp pin (Cu, gold-plated)
  - Gas tube (PVCmed, 150µm wall)
  - Cathode spring contact (Cu/Be, gold-plated)
  - Locator ring (POM)
  - Attachment strip (GFK) with electric ground
  - 2.5 g weight per tube
  - $X/X_0 = 4.4\times10^{-4}$ per straw tube



Element	Material	X [mm]	X_0 [cm]	X/X_0
Film Tube	Mylar, 27µm	0.085	28.7	3.0×10^{-4}
Coating	Al, 2× 0.03µm	2×10^{-4}	8.9	2.2×10^{-6}
Gas (2bar)	Ar/CO_2 (10%)	7.85	6131	1.3×10^{-4}
Wire	W/Re, 20µm	3×10^{-5}	0.35	8.6×10^{-6}
			Σ_{Straw}	4.4×10^{-4}

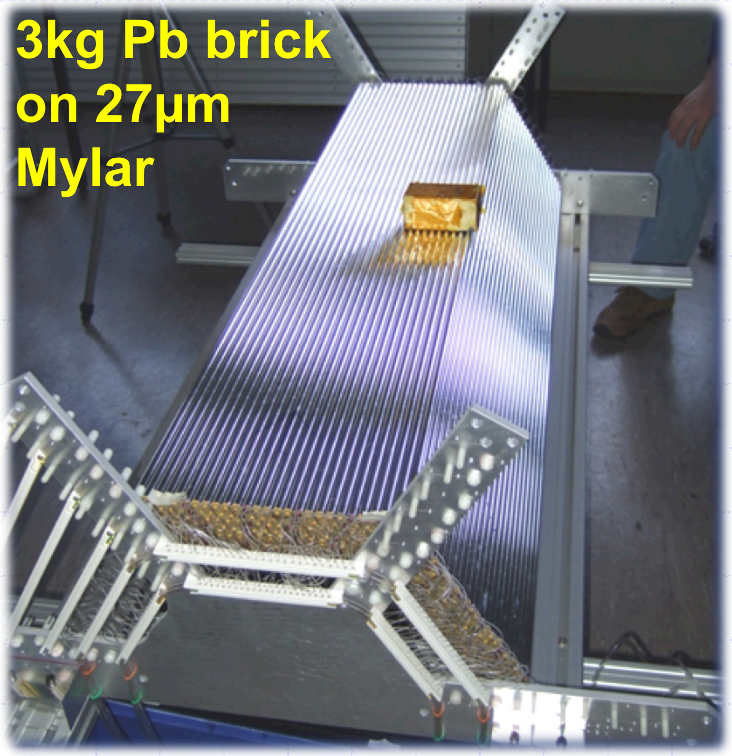
Self-Supporting Straw Layers

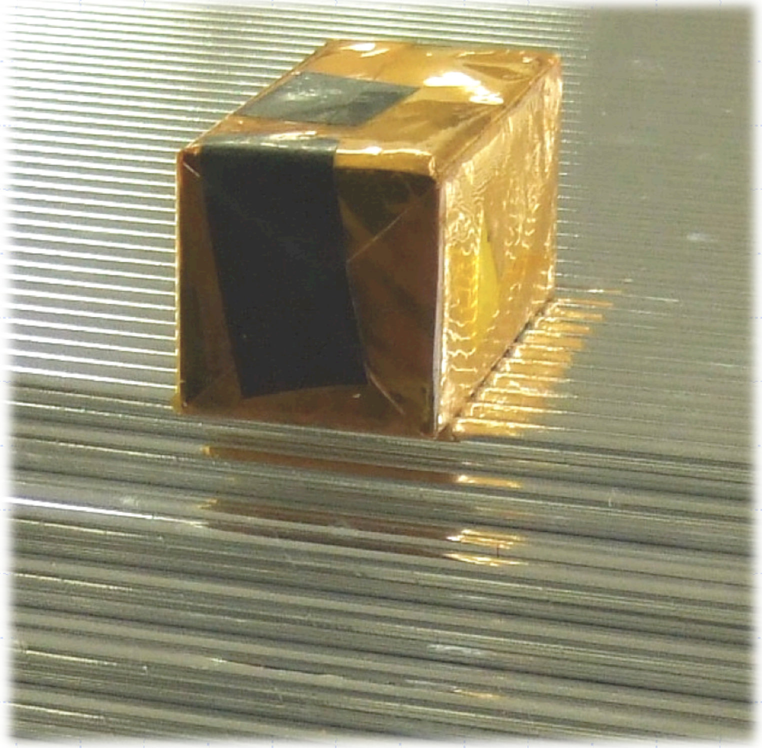
- Novel technique:
  - Straw tubes are assembled under overpressure (Δp=1bar)
  - Pressurized straws are close-packed (~20μm gap) in planar layers on a reference groove table and glued together (glue dots)
  - Strong rigidity: multi-layer straw module is self-supporting
  - No stretching from mechanical frame, no straw reinforcements needed
  - Perfect and strong cylindrical tube shape by inner gas overpressure
  - Lowest weight, precise geometry, maximal straw density



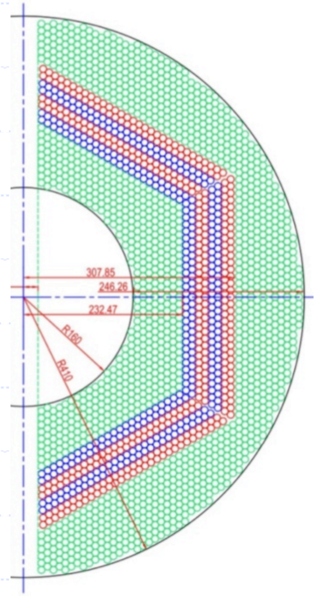
Self-Supporting Straw Layers ..

- Pressurized, close-packed straw layers show strong rigidity, demonstrated here by 3kg Pb-brick.

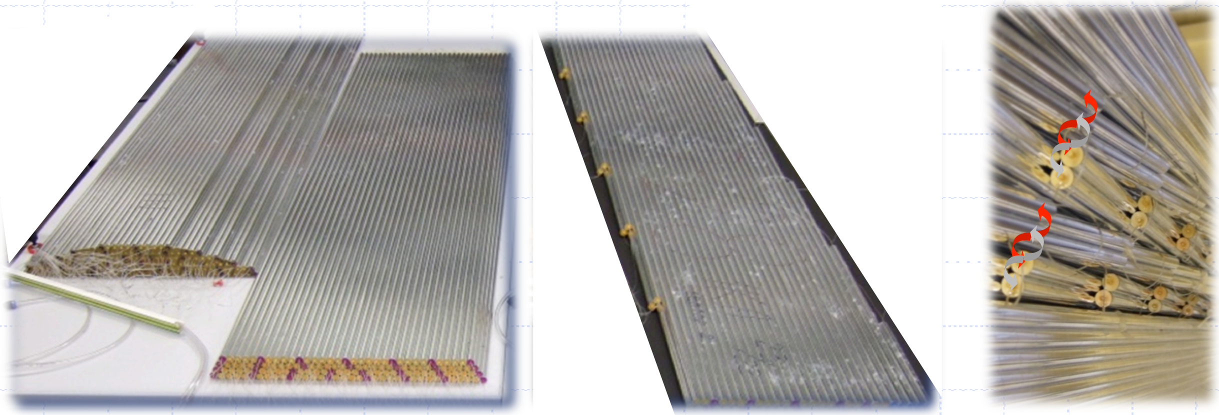




Axial and Stereo Layer Modules

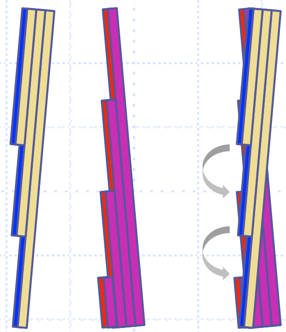


- Axial quad-layer module:
  - 4 close-packed axial layers, glued together (glue dots)
  - Increased rigidity compared to double-layer
  - Even number of straws and gas lines per module
  - Replacement of inner faulty single straws possible
- Stereo quad-layer module:
  - 2 Skewed double-layers (+2.89° / -2.89°)
  - Shorter tubes at corners, connected to next skew. dlayer



Axial and stereo straw layer modules

Connection scheme of skewed d-layers:



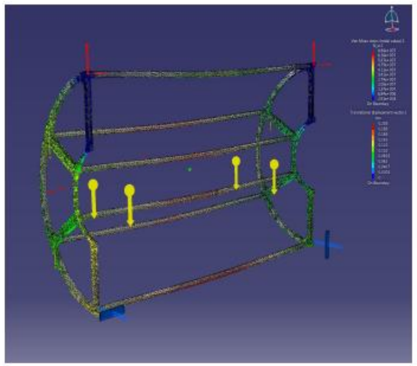
+2.89° -2.89° view from top

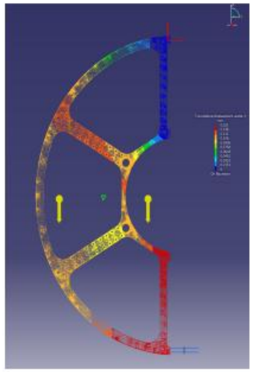
STT Mechanical Frame

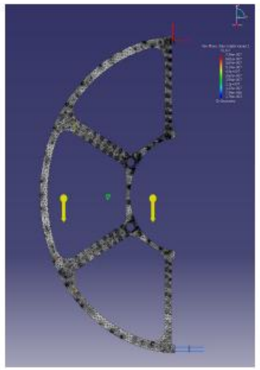
- 2 Separate **semi-barrels with end flanges**, connected by spacer bars
- Flanges are **mounted to "Central Support Frame"**
- Flanges with precision holes to fix straw modules
- FEM analysis: **0.03mm max. deflection**
- Inner & outer protection skins (~0.1% X/X_0 Cfiber)
- **Mechanical frame weight: 2× 9 kg**
- **11.6 kg Straw tubes (4636× 2.5g)** with
  - strong wire stretching (230kg equiv.)
  - strong tube stretching (3.6t equiv.)

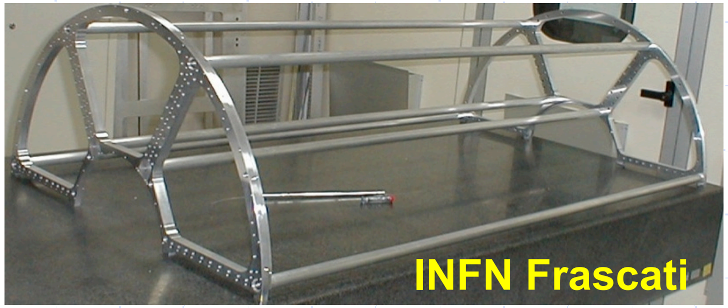
Semi-barrel components for	FEM analys
2 End flanges	60 N
6 Connecting bars (4 needed)	30 N
2300 Straw tubes	60 N
Straw grounding, boards	20 N
Electronics, gas supply	110 N
Total weight	**280 N**

Material	Aluminum
Density	2.7 g/cm^3
Youngs modulus	70 GPa
Radiation length (X_0)	9 cm
Thermal expansion	24 ppm/°C

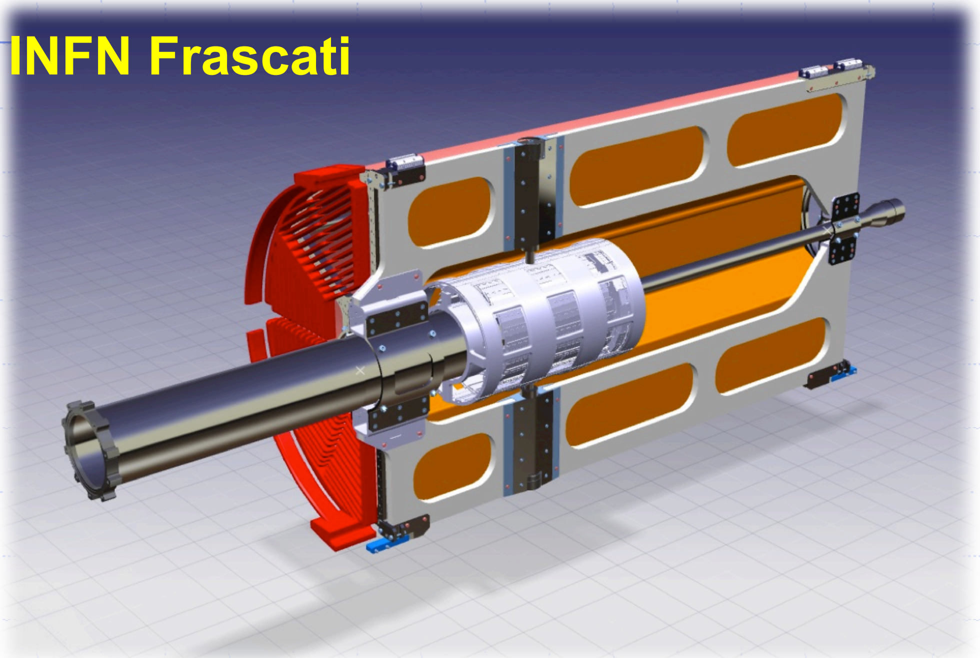


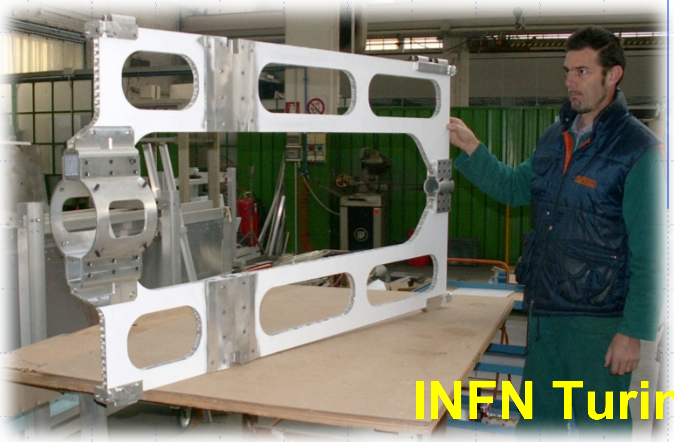






Central Tracker Mechanics





- "CENTRAL SUPPORT FRAME" (INFN Turin WShop)
- "STRAW SUPPORT FRAME" (INFN Frascati)
- "AUXILIARY INSERTION STRUCTURE" (INFN Frascati)
- "VERTEX" mechanical prototype under development
- "CROSS-PIPE" prototype planned in the next months

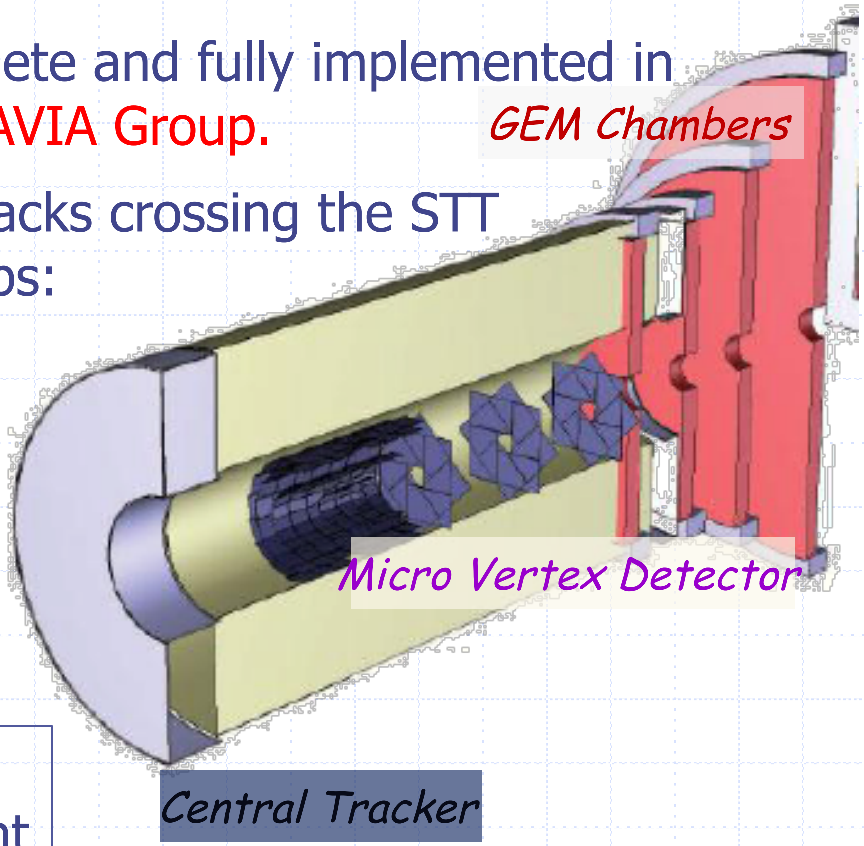
STT Software

STT simulation software is complete and fully implemented in PANDARoot. Full responsibility PAVIA Group.

The track finder procedure for tracks crossing the STT detector is divided in several steps:

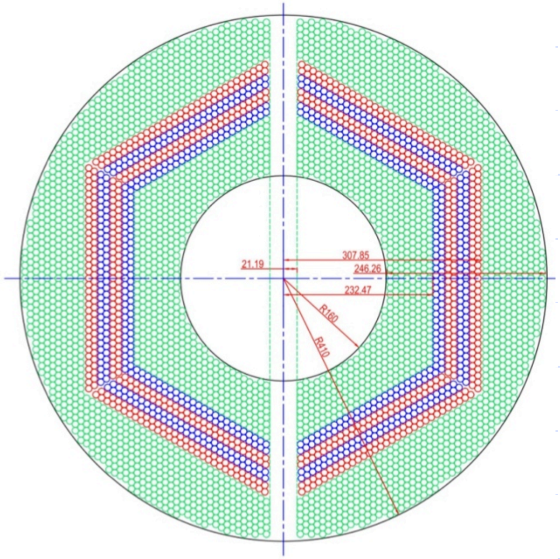
- STT local track finding
- MVD + STT track finding
- GEM extension

Event mixing and clean-up procedure are ready.



Pattern recognition of secondary vertices is still under development

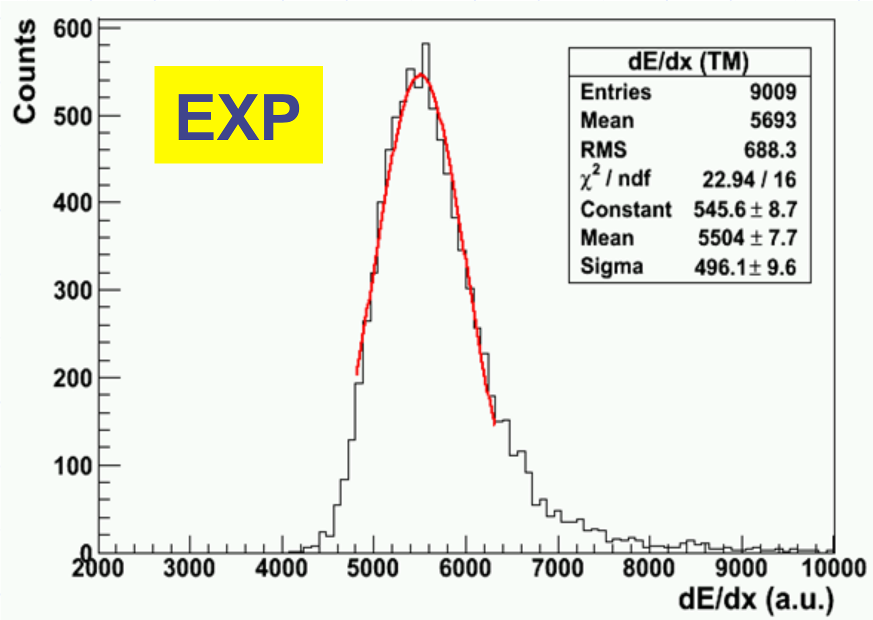
dE/dx Simulations

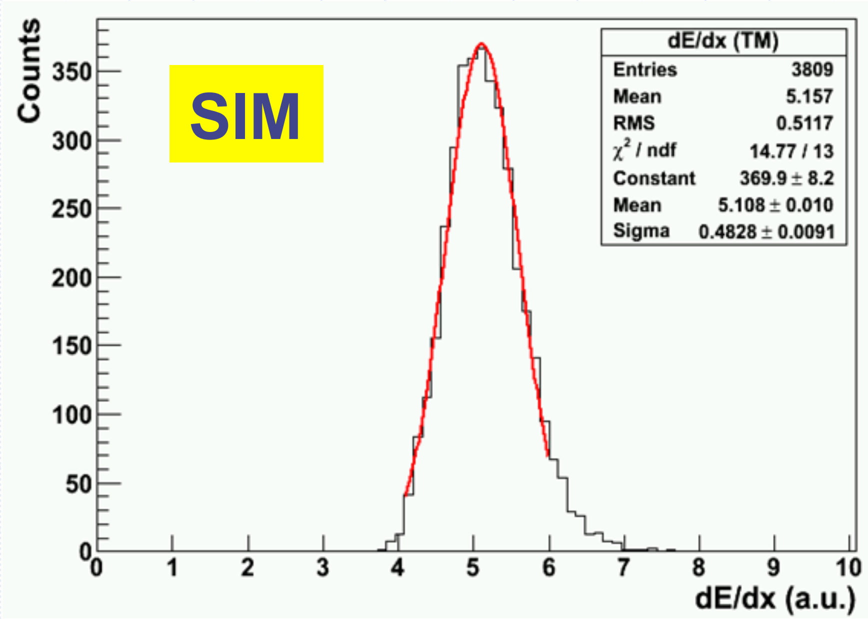


Within the PandaROOT framework:
5000 protons @ 2.9 GeV/c traversing the PANDA STT

1. Simulation, digitization and reconstruction (with Kalman filter)
2. Track selection: number of hits/track in STT limited to 16 to compare with test measurement
3. *dx* calculation (3D): $dx = 2 \cdot \sqrt{r_{tube}^2 - r_{drift}^2} / \cos\lambda$
4. *dE/dx* per track (as for experimental data)

dE/dx: data *vs.* simulation





$(\sigma/\mu)_{exp} = (9.01 \pm 0.17)\ \%$

$(\sigma/\mu)_{sim} = (9.45 \pm 0.18)\ \%$

Statistical significance

$$\frac{|9.45 - 9.01|}{\sqrt{0.18^2 + 0.17^2}} \approx 1.8$$

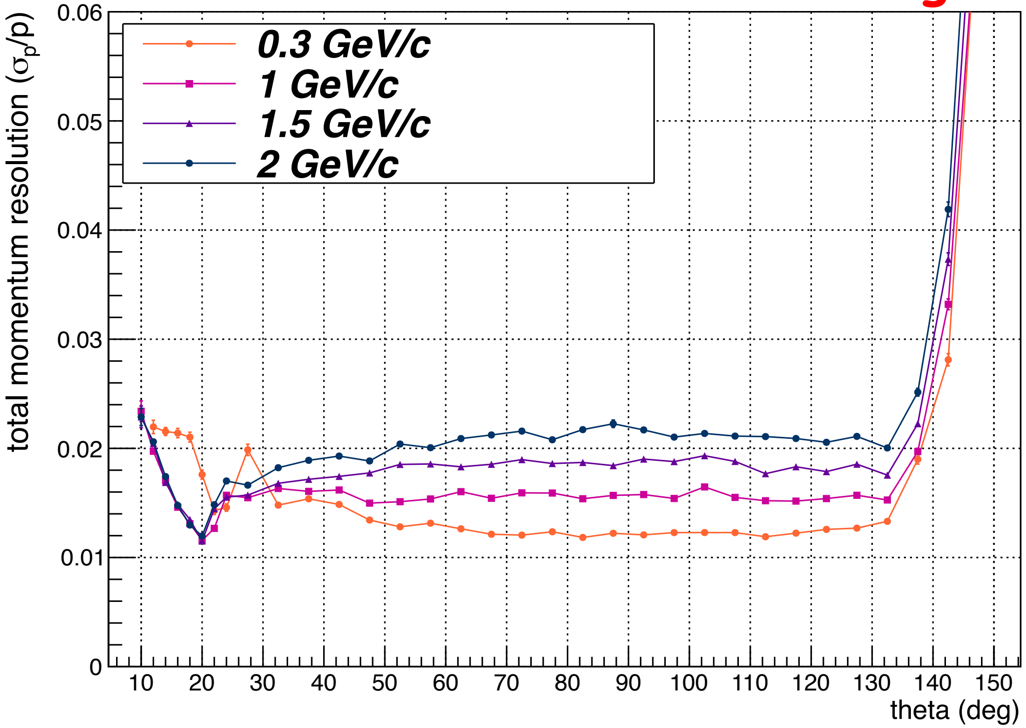
Good agreement between experimental data and simulations!

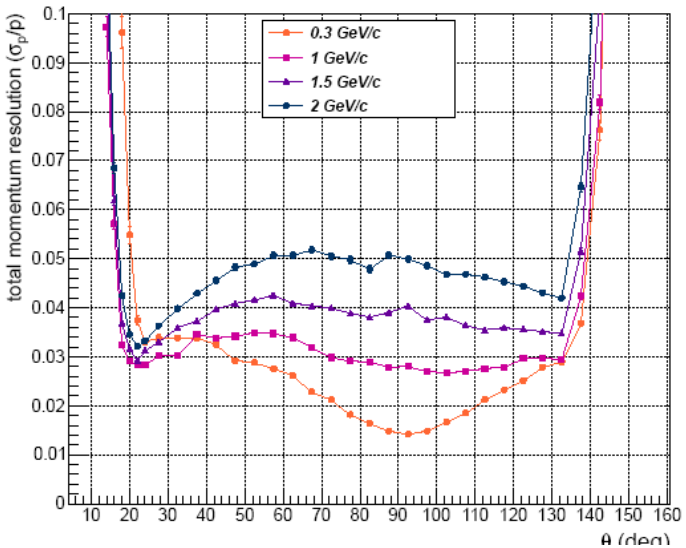
Single track studies

Simulation parameters:

- 5000 single muon events each point.
- Fixed total momentum 0.3, 1, 1.5, 2 GeV/c
- θ : [5° - 25°] in steps 2° ; [25° - 160°] in steps 5°
- φ Uniform: [0° - 360°]

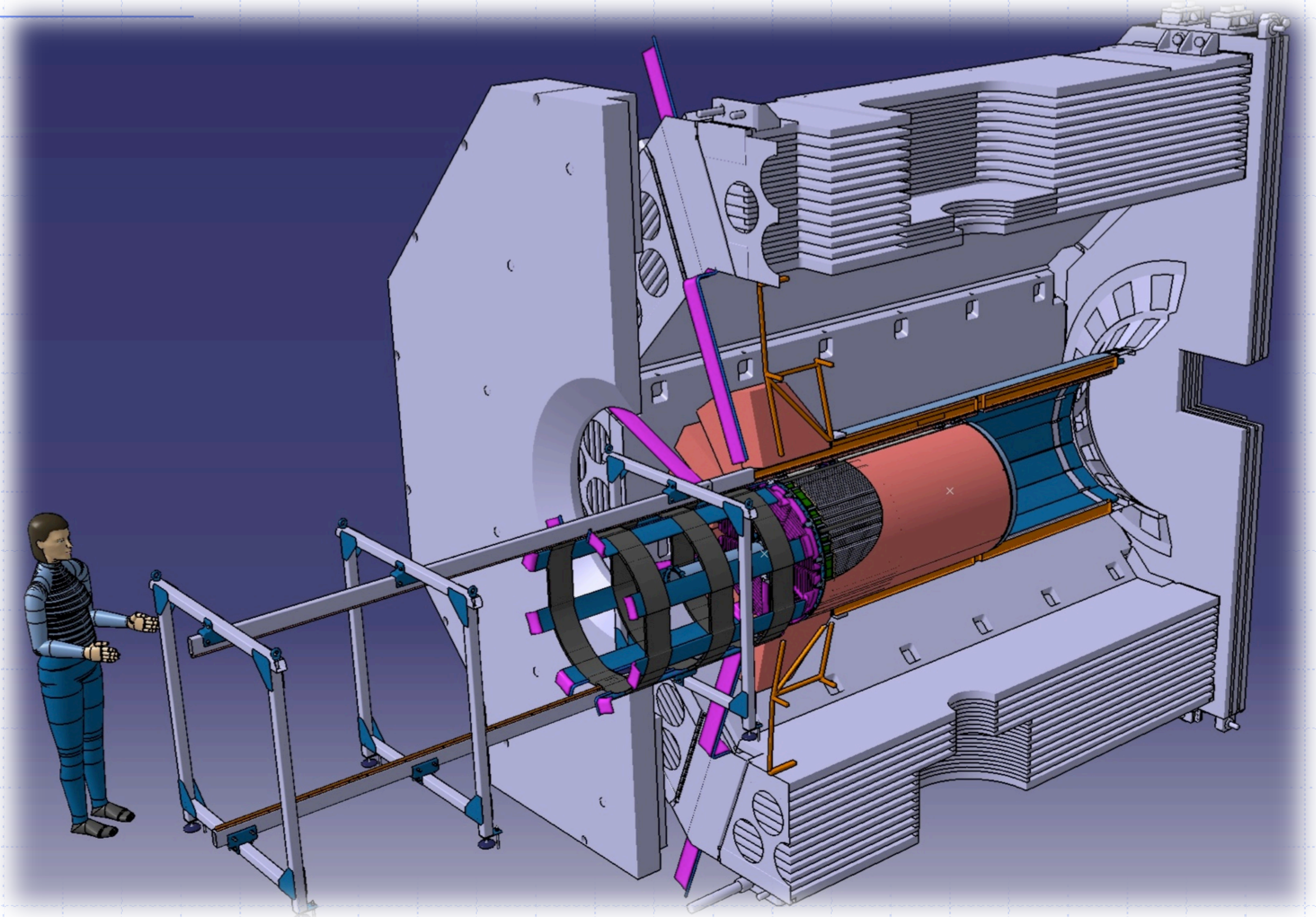
STT+MVD+GEM Pattern Recognition

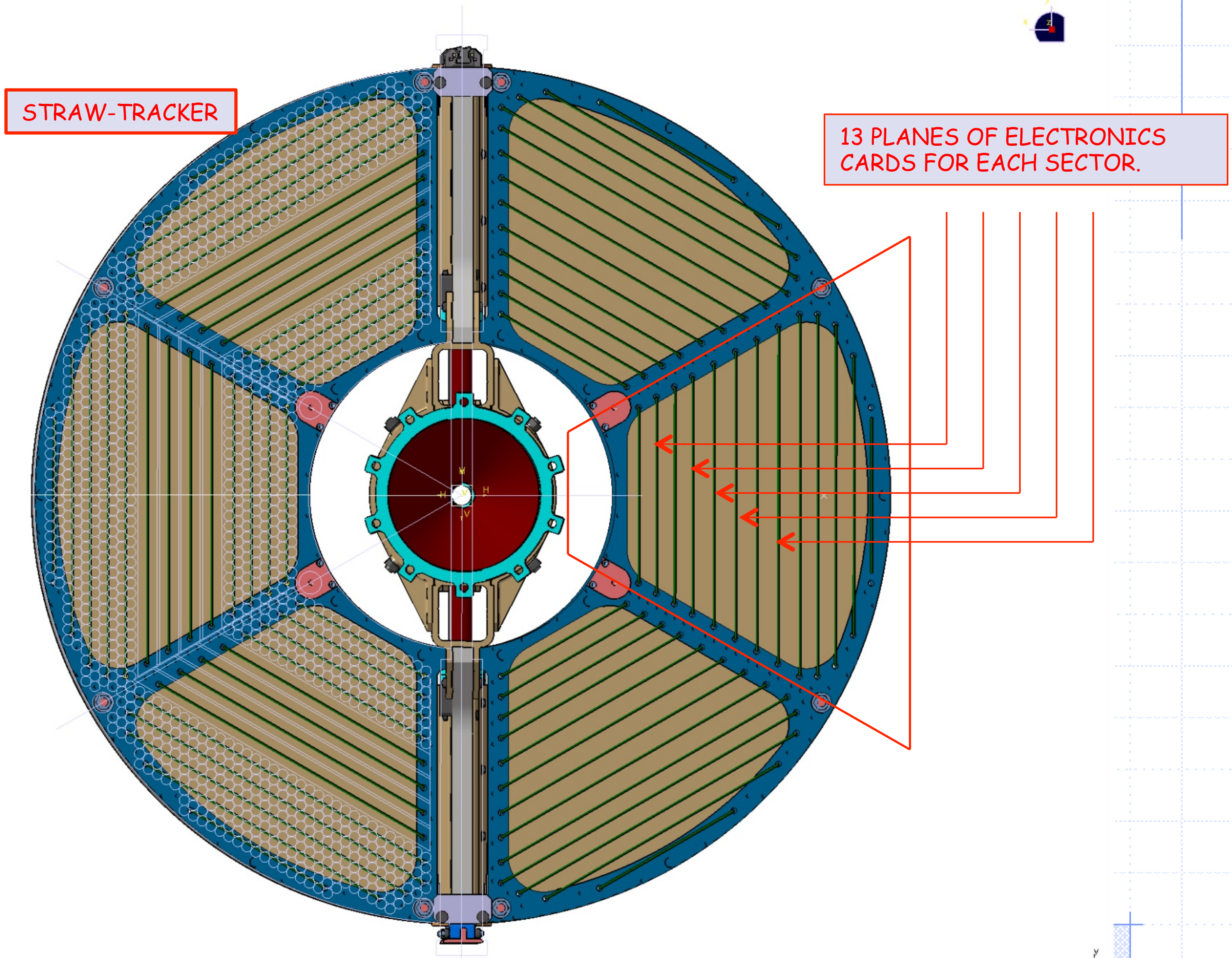




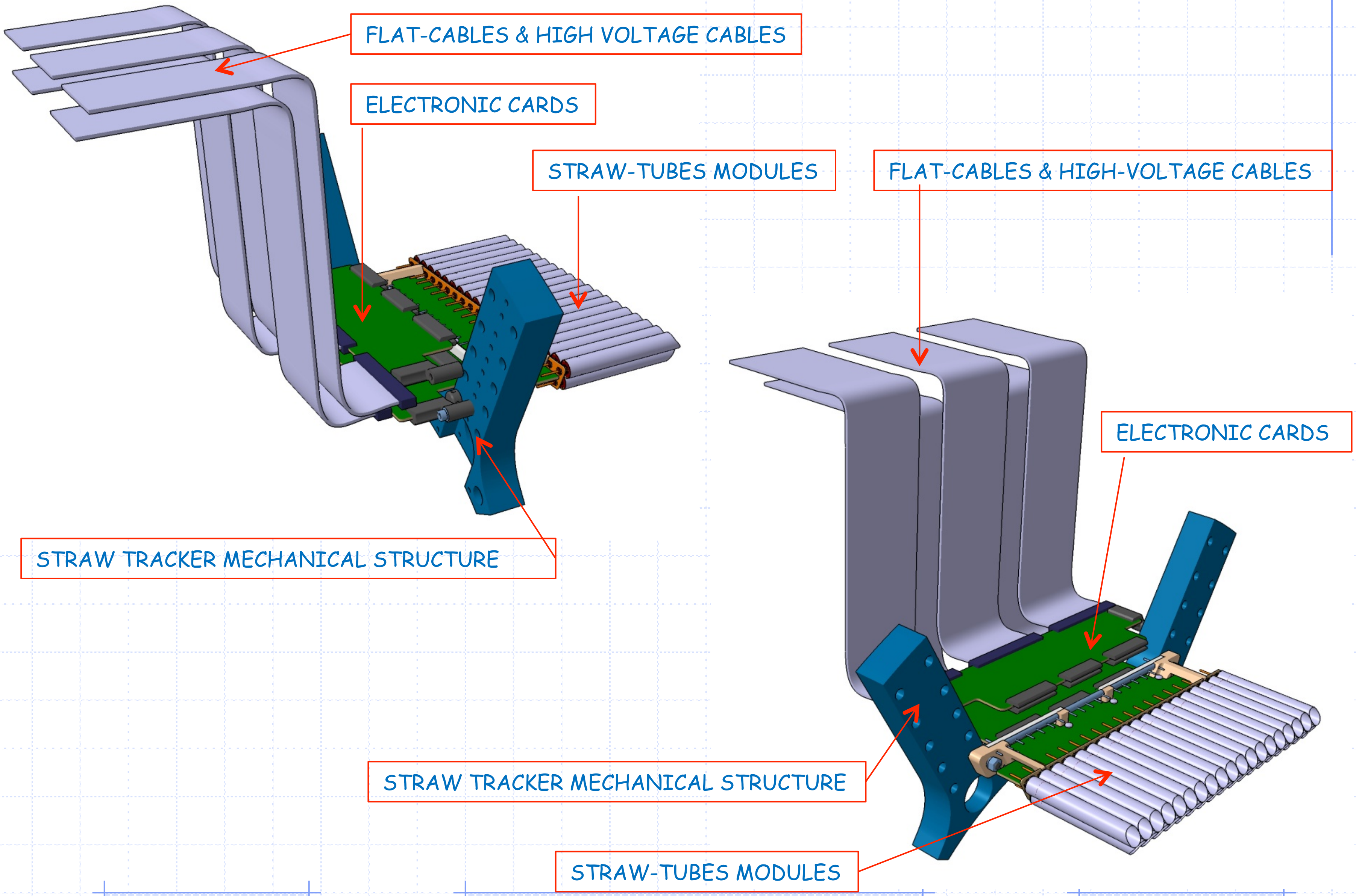
STT alone Pattern Recognition

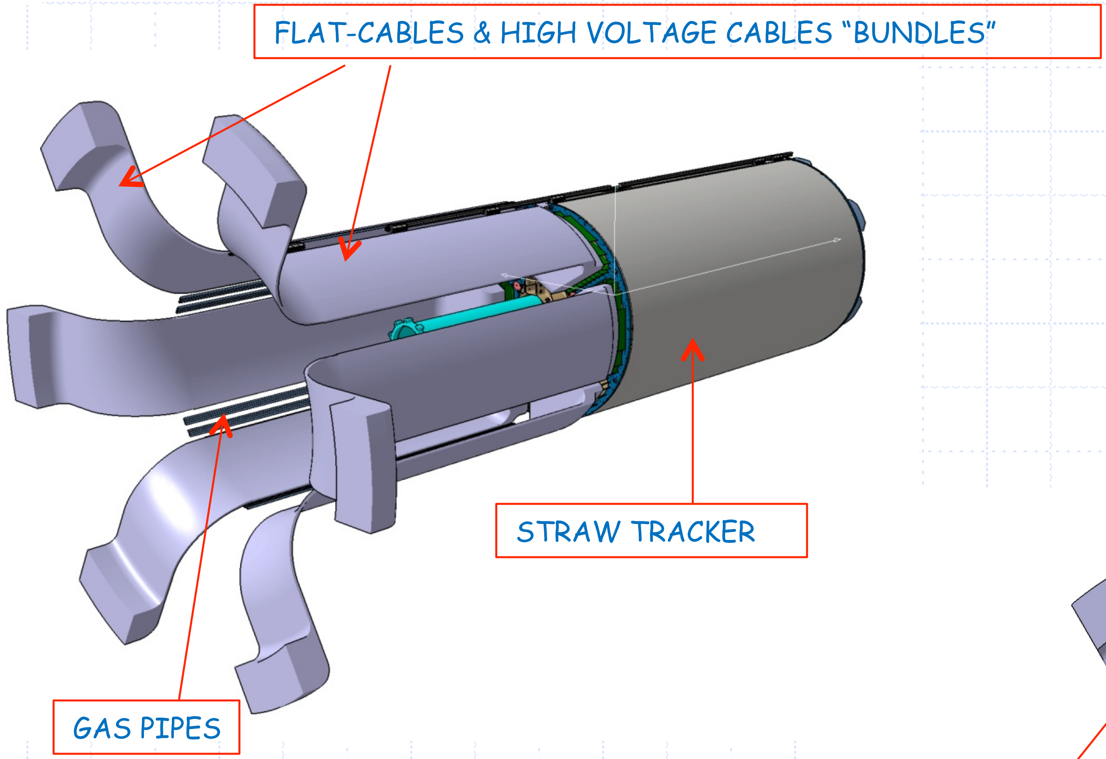
CT cable routing

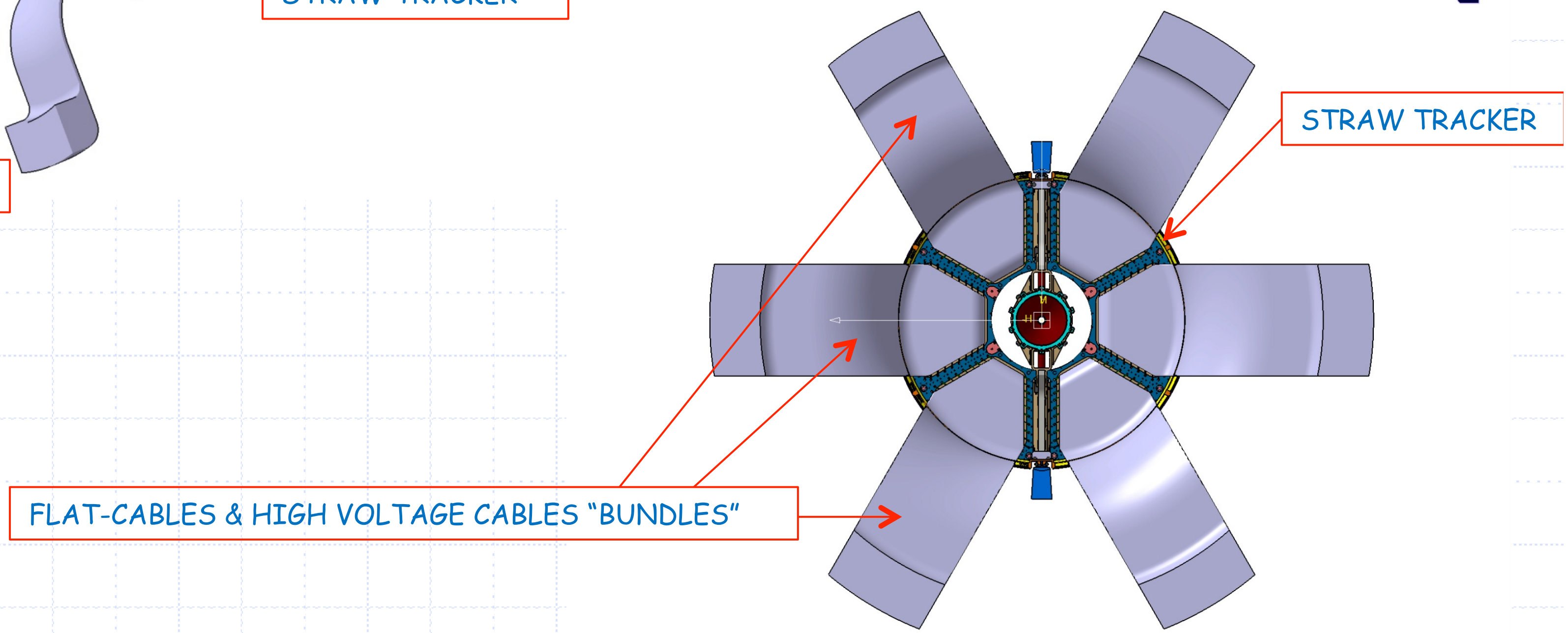



STRAW-TRACKER
13 PLANES OF ELECTRONICS CARDS FOR EACH SECTOR.

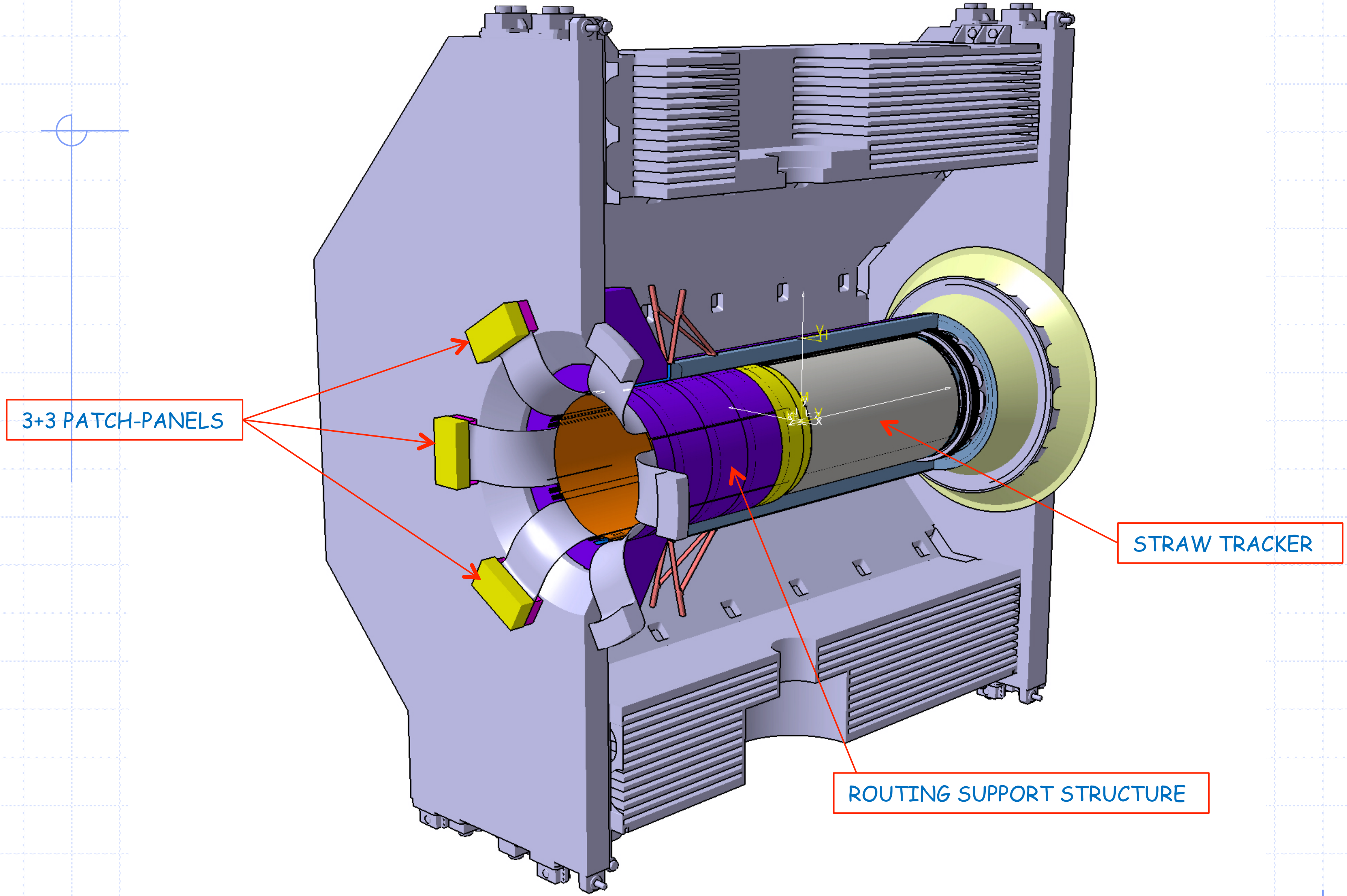
- TYPICAL STRAW TUBE MODULE WITH ELECTRONICS.

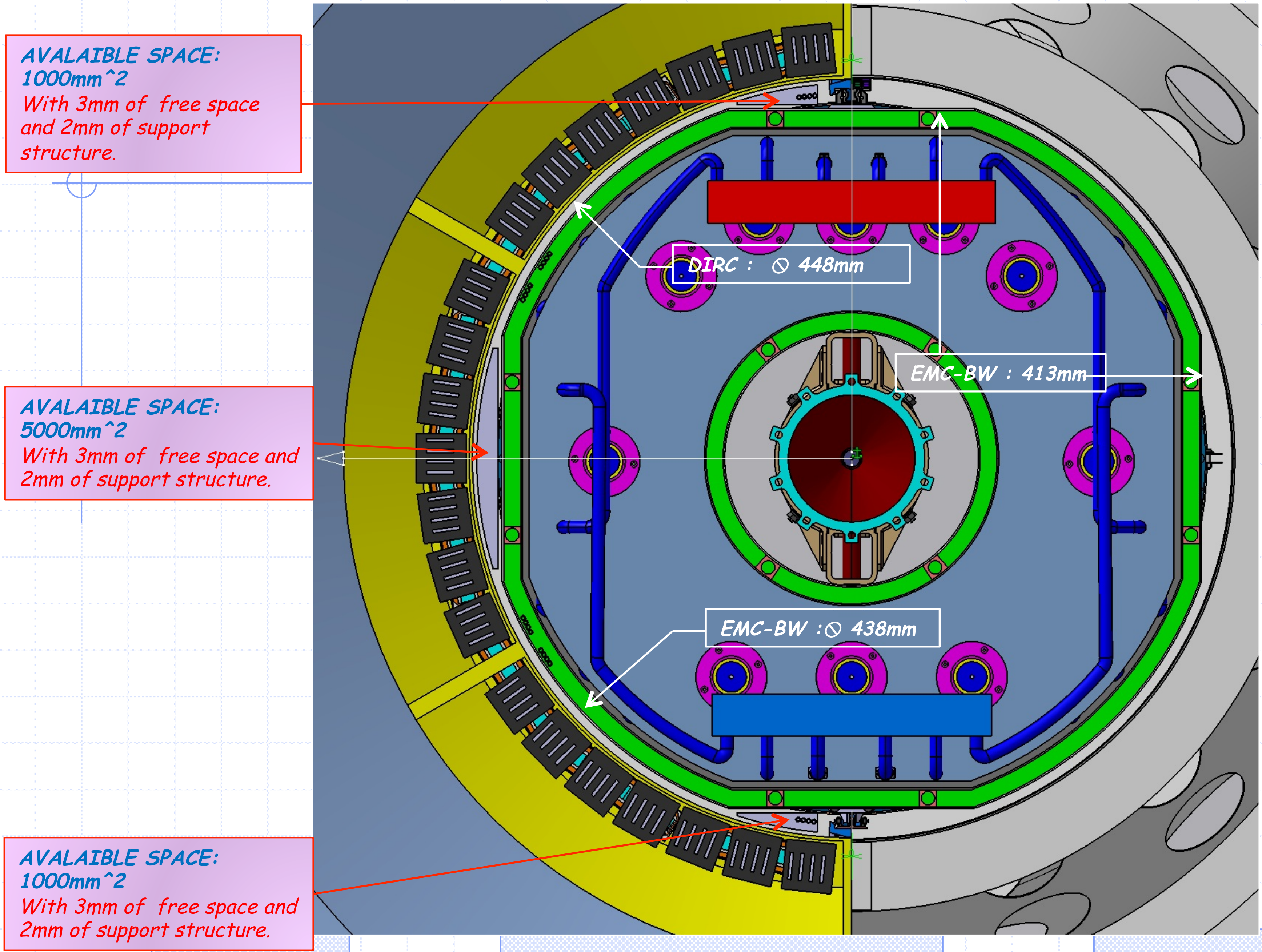



FLAT-CABLES & HIGH VOLTAGE CABLES "BUNDLES"
STRAW TRACKER
GAS PIPES


STRAW TRACKER
FLAT-CABLES & HIGH VOLTAGE CABLES "BUNDLES"

1° HYPOTHESIS: PATCH PANELS FIXED ON THE MAGNET DOORS.




AVALAIBLE SPACE:
1000mm^2
With 3mm of free space and 2mm of support structure.
AVALAIBLE SPACE:
5000mm^2
With 3mm of free space and 2mm of support structure.
AVALAIBLE SPACE:
1000mm^2
With 3mm of free space and 2mm of support structure.
DIRC : ⦸ 448mm
EMC-BW : 413mm
EMC-BW :⦸ 438mm

Summary

Italy is involved in PANDA since the very beginning.

in these years LNF has been involved in STT detector design:

- Straw materials optimised: thinnest mylar film tube (27μm)
- Self-supporting straw layer technique with strongest rigidity at lowest weight reduces mechanical frame structure
  - Dense filling with 23-27 layers in radial direction
  - X/X_0 = 1.2% ($^2/_3$ wall + $^1/_3$ gas)
- STT TDR submitted to FAIR March 2012
- Construction will start next year
- LNF has the responsibility for the straw construction, the mechanics, and the detector integration

BACKUP SLIDES