X17 @ n_TOF

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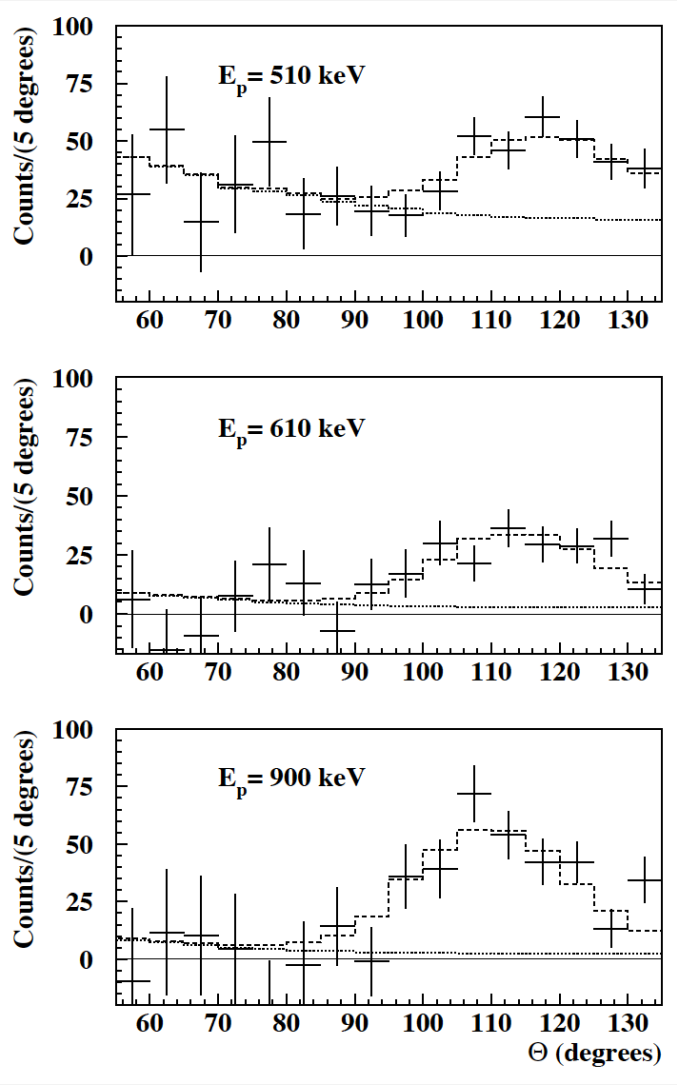
X17 ATOMKI results

A significant anomaly has been recently in the emission of electron-positron pairs in the $^{7}Li(p,e^{+}e^{-})^{8}Be$ and $^{3}H(p,e^{+}e^{-})^{4}He$ reactions:

Krasznahorkay, A.J.; et al.:
"*Observation of Anomalous Internal Pair Creation in 8Be: A Possible Indication of a Light, Neutral Boson*".
Physical Review Letters. 116 (42501): 042501 (2016).

Krasznahorkay, A.J.; et al.:
"A new anomaly observed in 4He supports the existence of the hypothetical X17 particle".
Physical Review C 104, 044003 (2021).

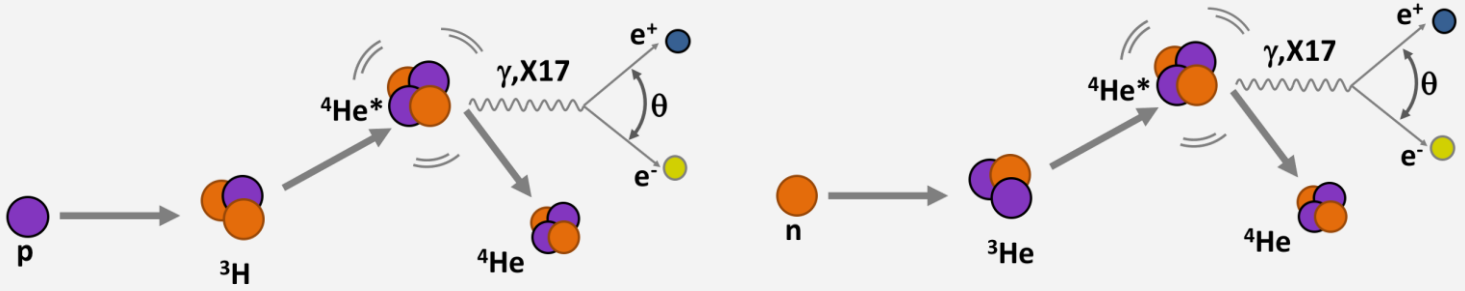


- ***This anomaly has been interpreted as the signature of a BOSON (hereafter X17) not foreseen in the standard model of particle physics.***
- ***X17 boson could be a mediator of a fifth force, characterized by a strong coupling suppression of protons compared to neutrons.***
- ***This evidence/scenario is presently not confirmed or excluded by other experiments or groups.***

X17 @ n_TOF

Basic idea: new study of excited ^{4}He exploiting the conjugated reactions:

^{3}**H**(**p**,e^+e^-)^{4}He ⟶ ^{3}**He**(**n**,e^+e^-)^{4}He



OBJECTIVES:

> Probing X17 existence

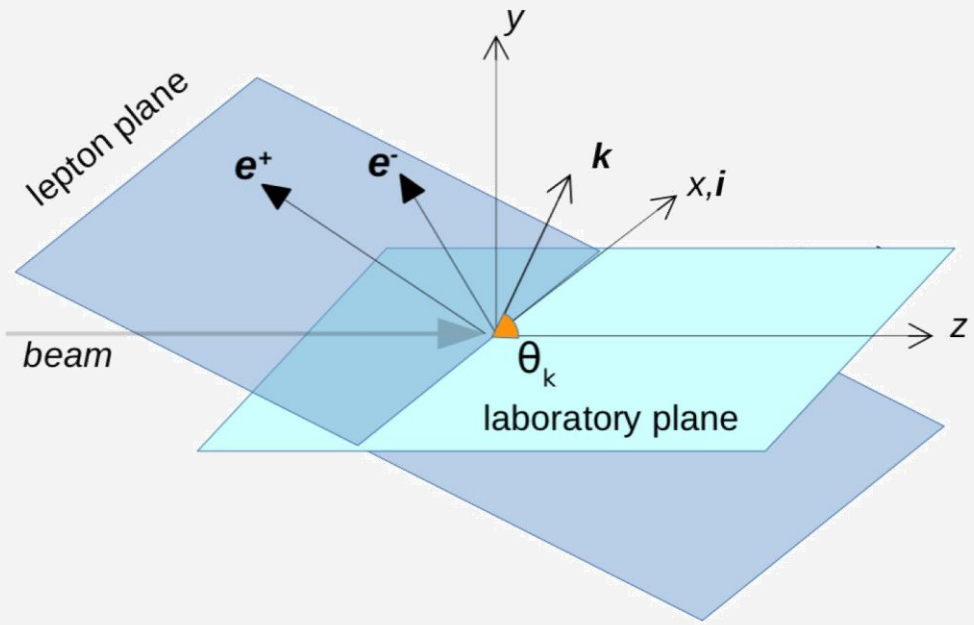
> X17 Mass, quantic numbers, coupling, life-time, ..

> Proto-phobic nature of the fifth force.

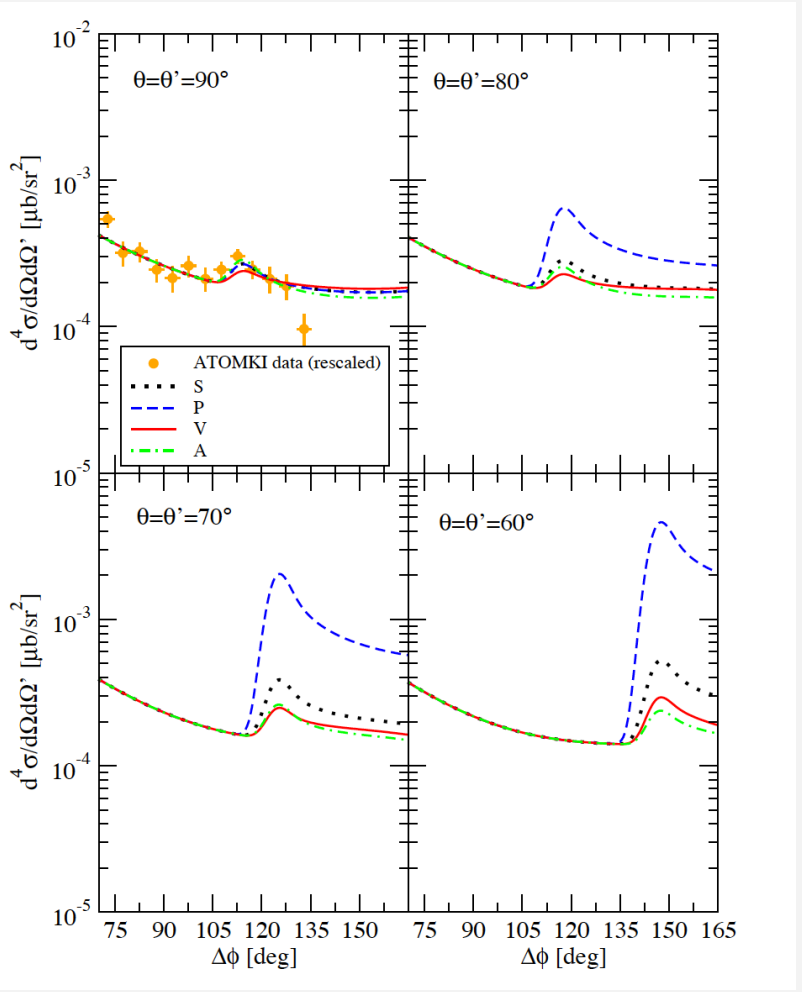
> Data Vs Theoretical nuclear physics

Theoretical calculations

- Theoretical calculations for kinematical signature for different X17 boson (scalar, pseudo-scalar, vector, axial).,
- Calculation for different center-of-mass energies.



M. Viviani et al.: PRC 105, 014001 (2022)



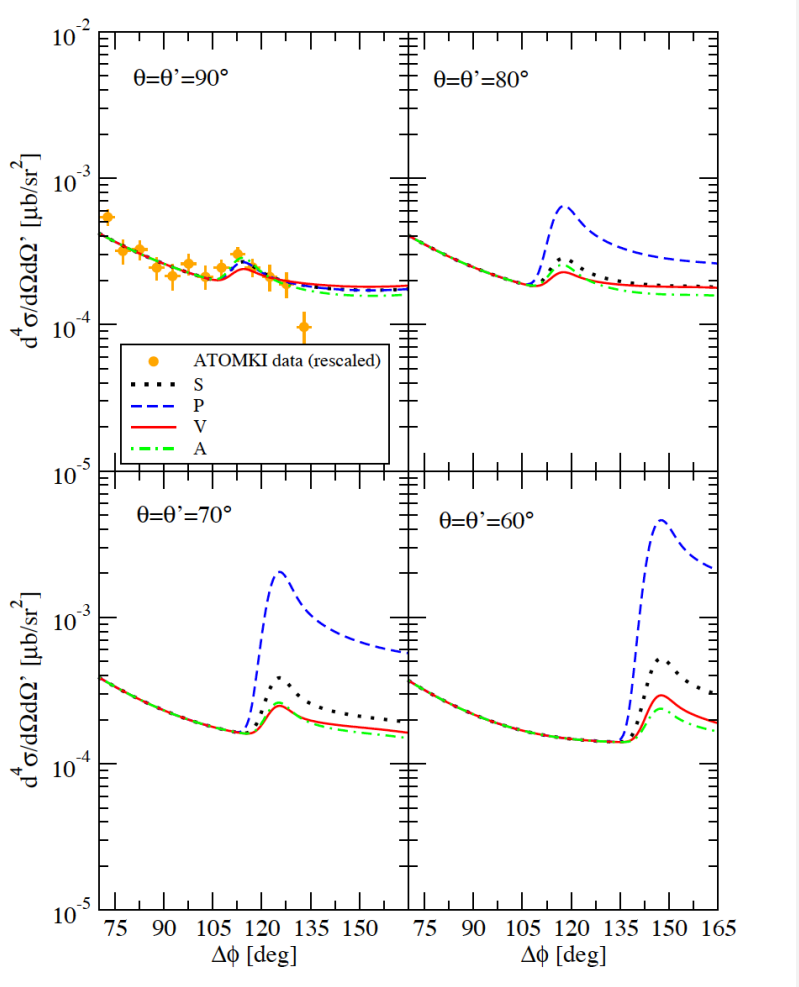
Theoretical calculations

M. Viviani et al.: PRC 105, 014001 (2022)

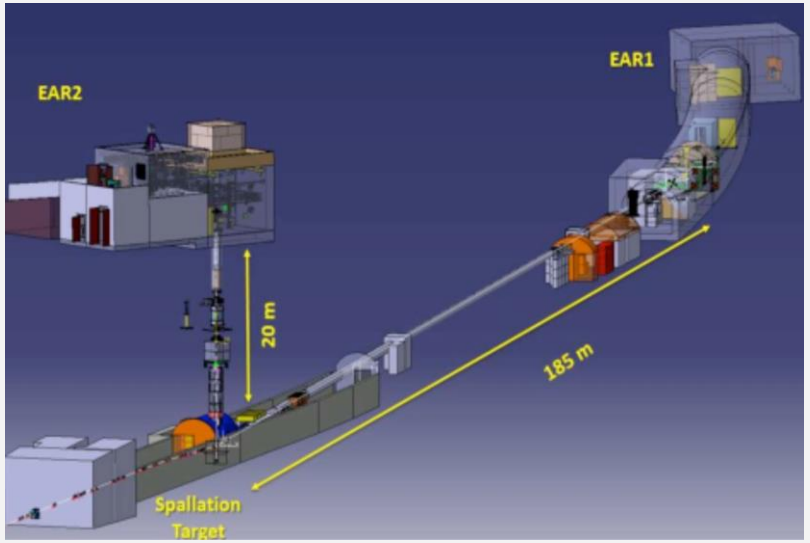
- Theoretical calculations of expected counts at different lepton plane angles,
- Calculation for different natures of the X17 boson (scalar, pseudo-scalar, vector, axial).

Wide energy range (protons and neutron beams) to explore all resonances with different J^{π}

Large detector acceptance for statistics and kinematics



Facilities



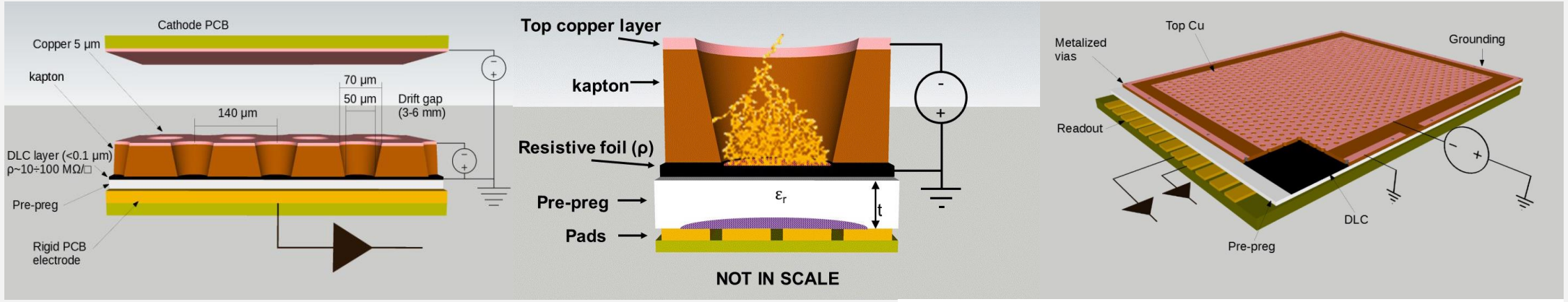
- **n_ToF @ CERN:** pulsed neutron beam in a wide energy range (thermal<En<100 MeV).
- Time of flight to establish the single neutron energy (10-108 eV)

^{3}He(n,X17)^{4}He
Measurements:
2022-24 (CERN LoI approved)

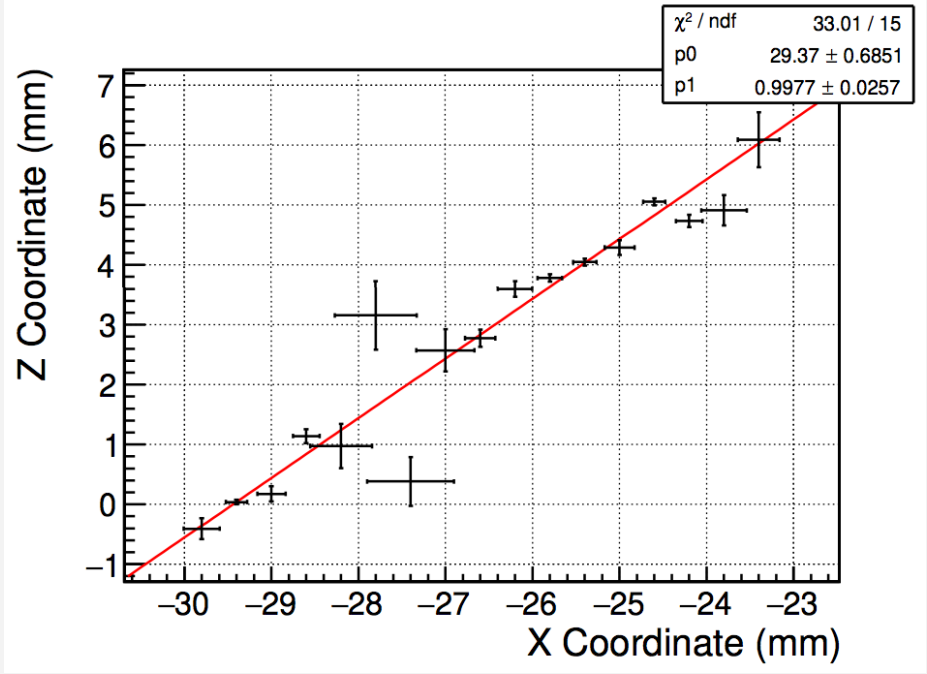
- **LUNA-MV @ LNGS:** high intensity proton beam and low background
- Terminal Voltage ~ 0.2 – 3.5 MV
- I max ~ 100 μA of protons
- Underground operation

^{3}H(p,X17)^{4}He
Measurements:
2023-25 (LoI in preparation)

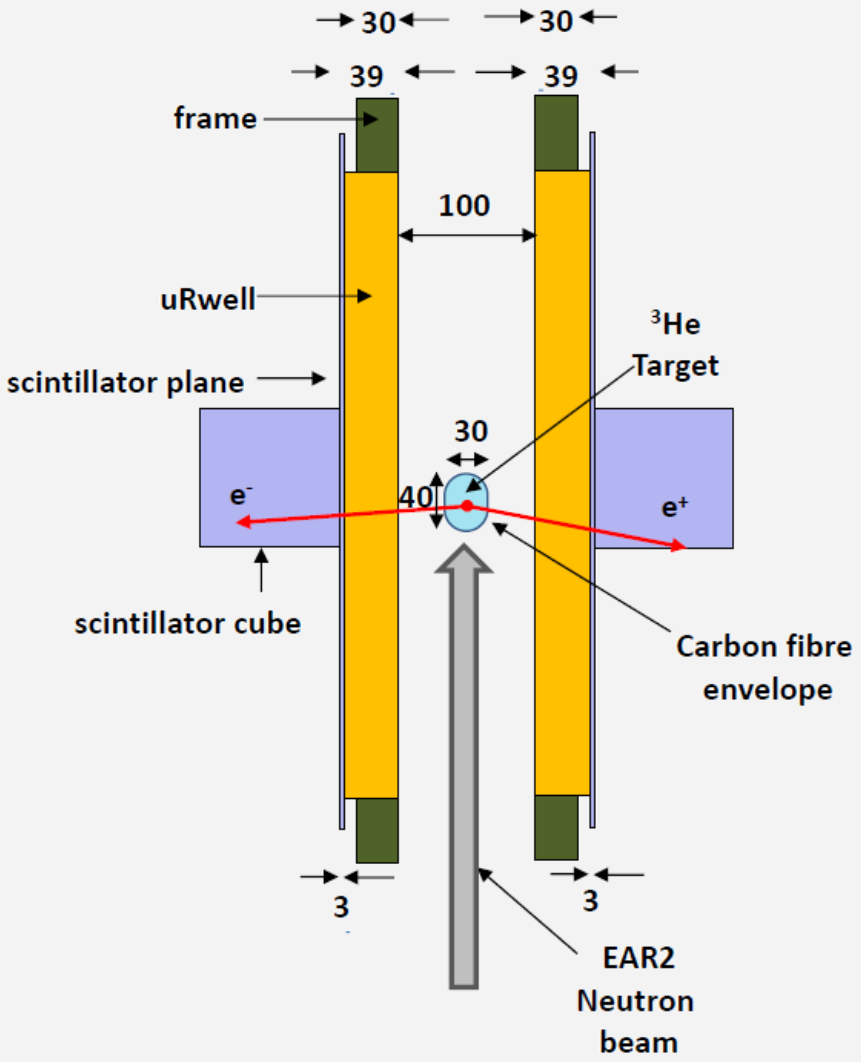
uRwell detector



- uTPC with drift gap and uRwell
- Active area of 38x46 cm2
- Ar/CF4/CO2 (60:20:20) gas mixture
- 3D track reconstruction
- Under construction at CERN



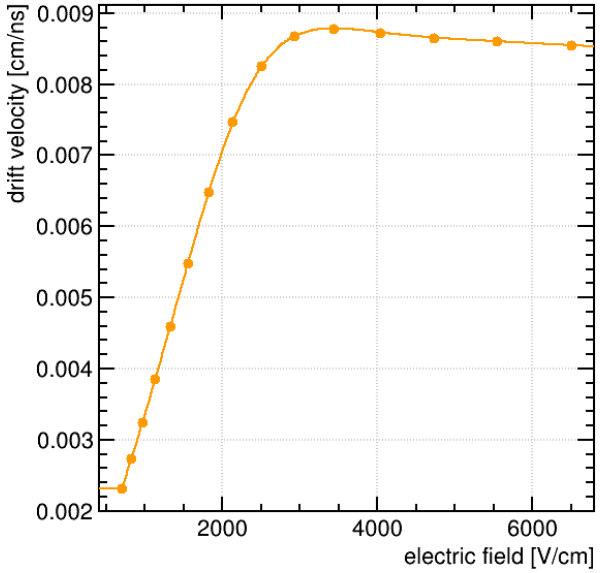
Demonstrator

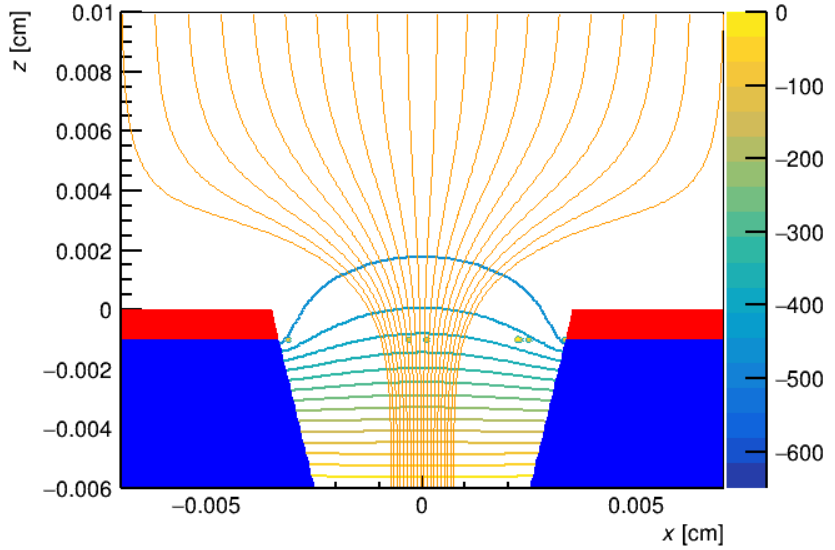


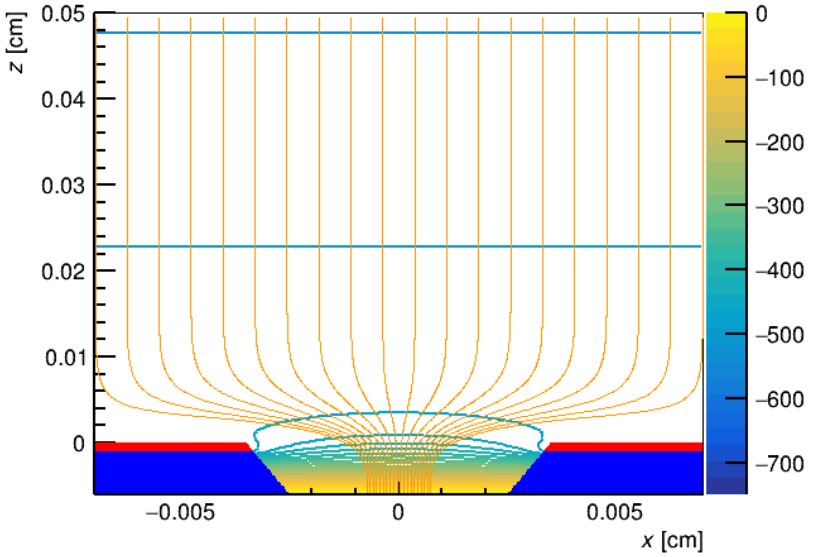
- Demonstrator funded by INFN
- Two uRwell detectors and two scintillator cubes
- Capsule holding ^{3}He gas
- Test at EAR2 @ n_TOF in 2023

uRwell Simulations

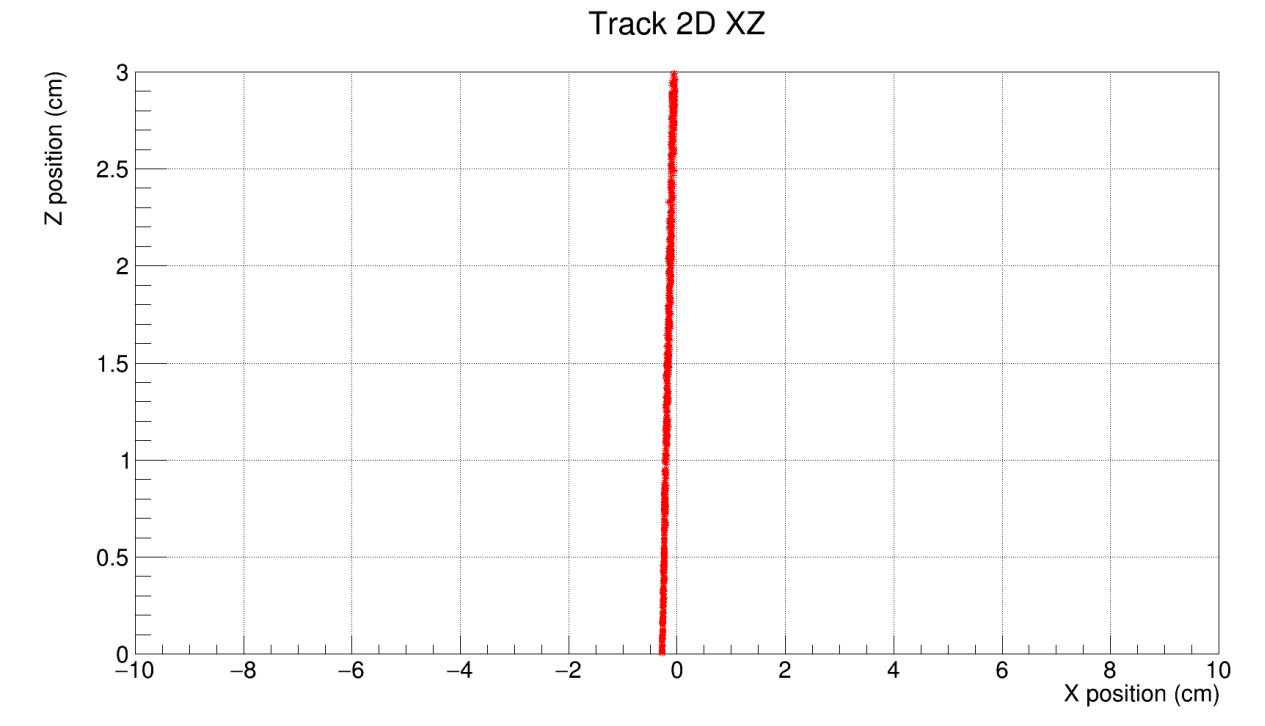
- GARFIELD simulations to study detector performances
- Electric field and electrons drift velocities simulated
- The track reconstruction in a magnetic field is being studied





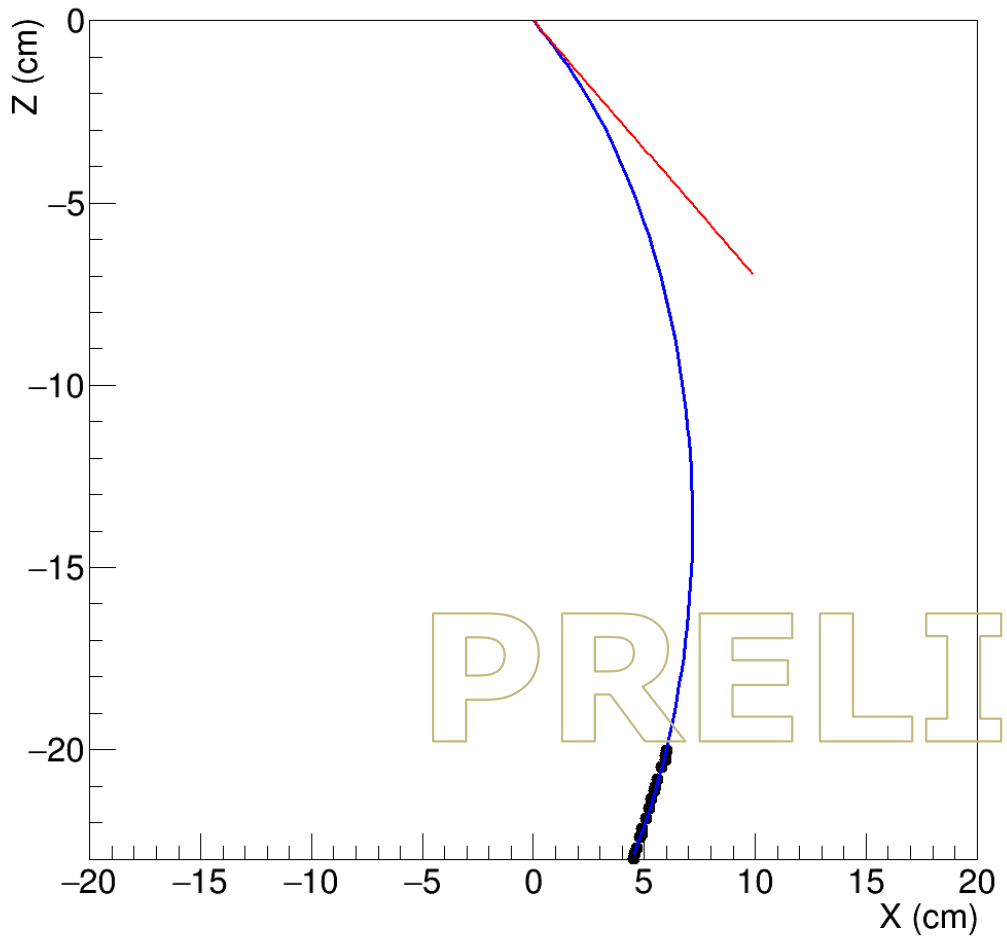


Garfield tracks



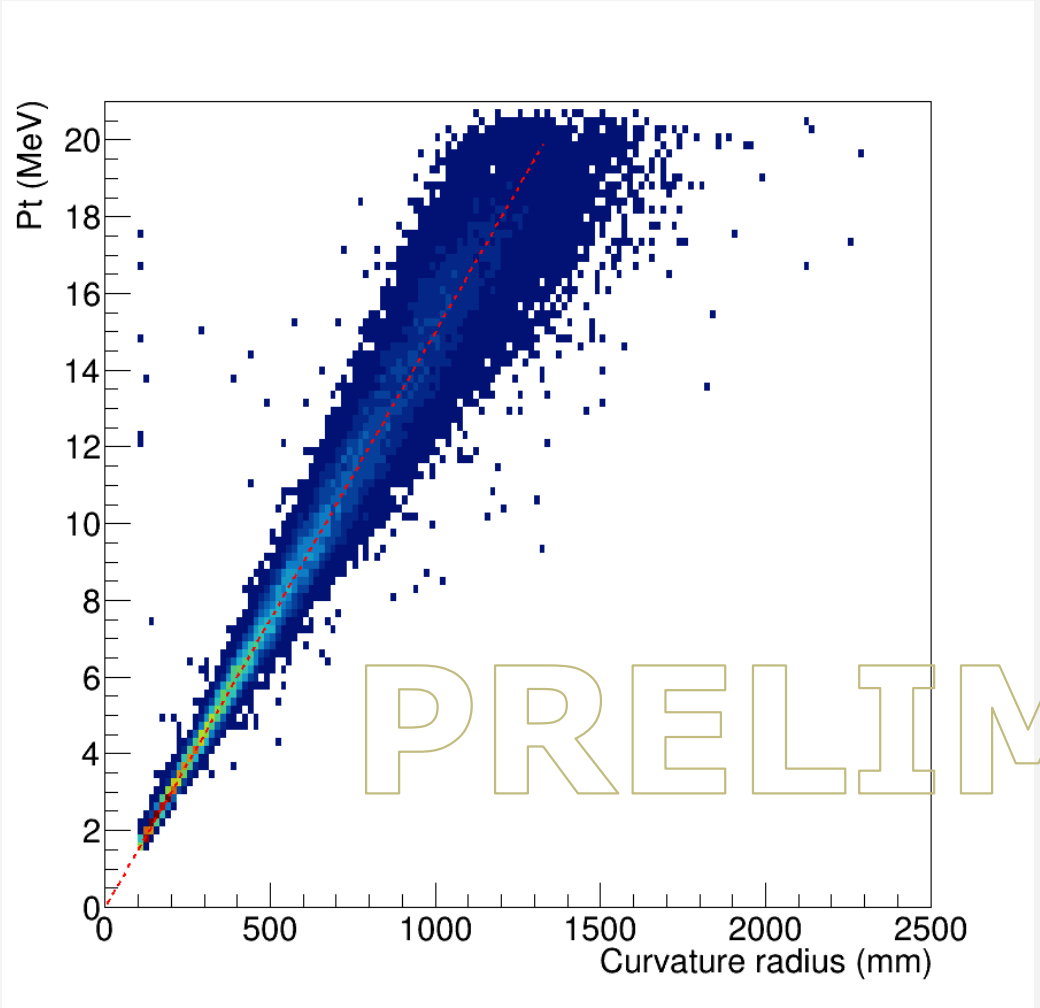
- **Tracks of different energies (2-18 MeV)**
- **Magnetic field of 500 G**
- **No visible curvature in the perpendicular plane**

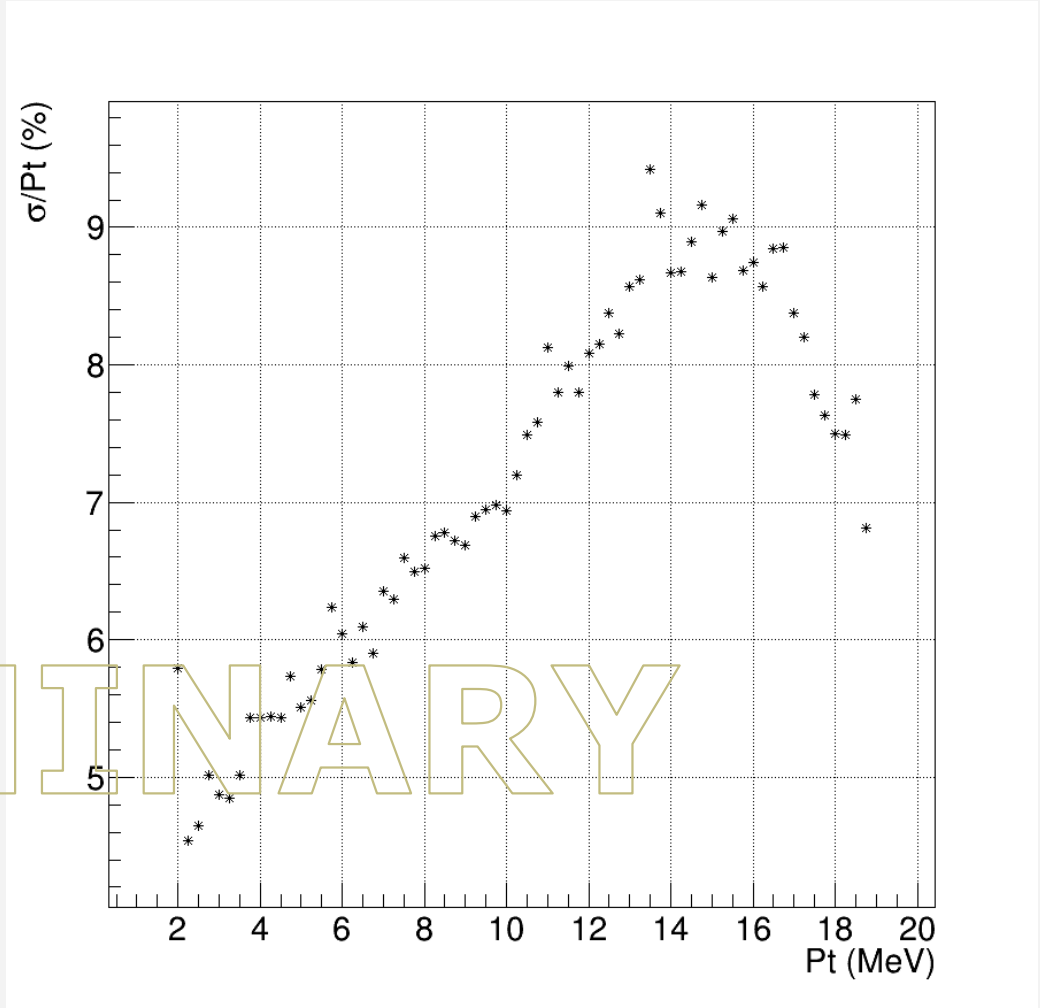
Energy reconstruction



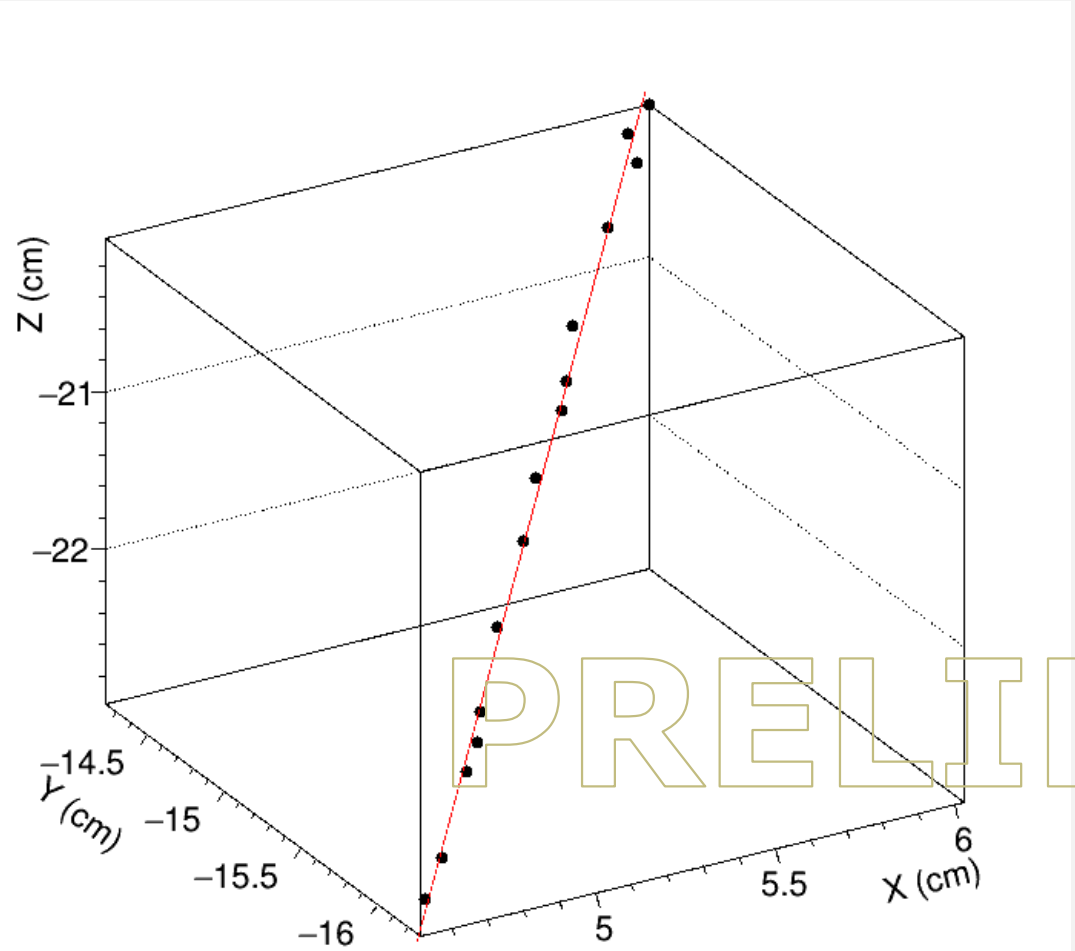
- Assume interaction vertex at the origin
- Fit circumference arc using straight track and vertex
- Tangent (red line) used for angle determination (see later)

Energy reconstruction



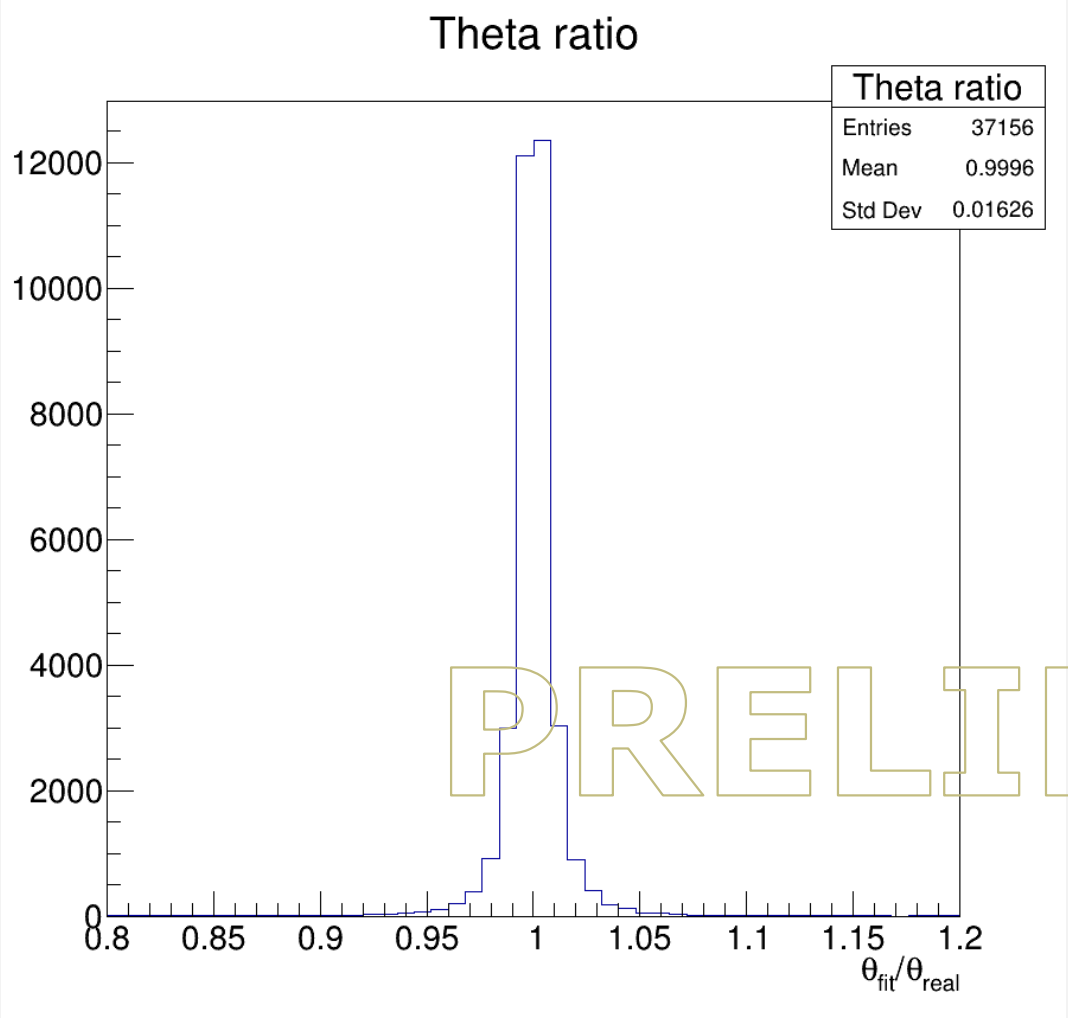


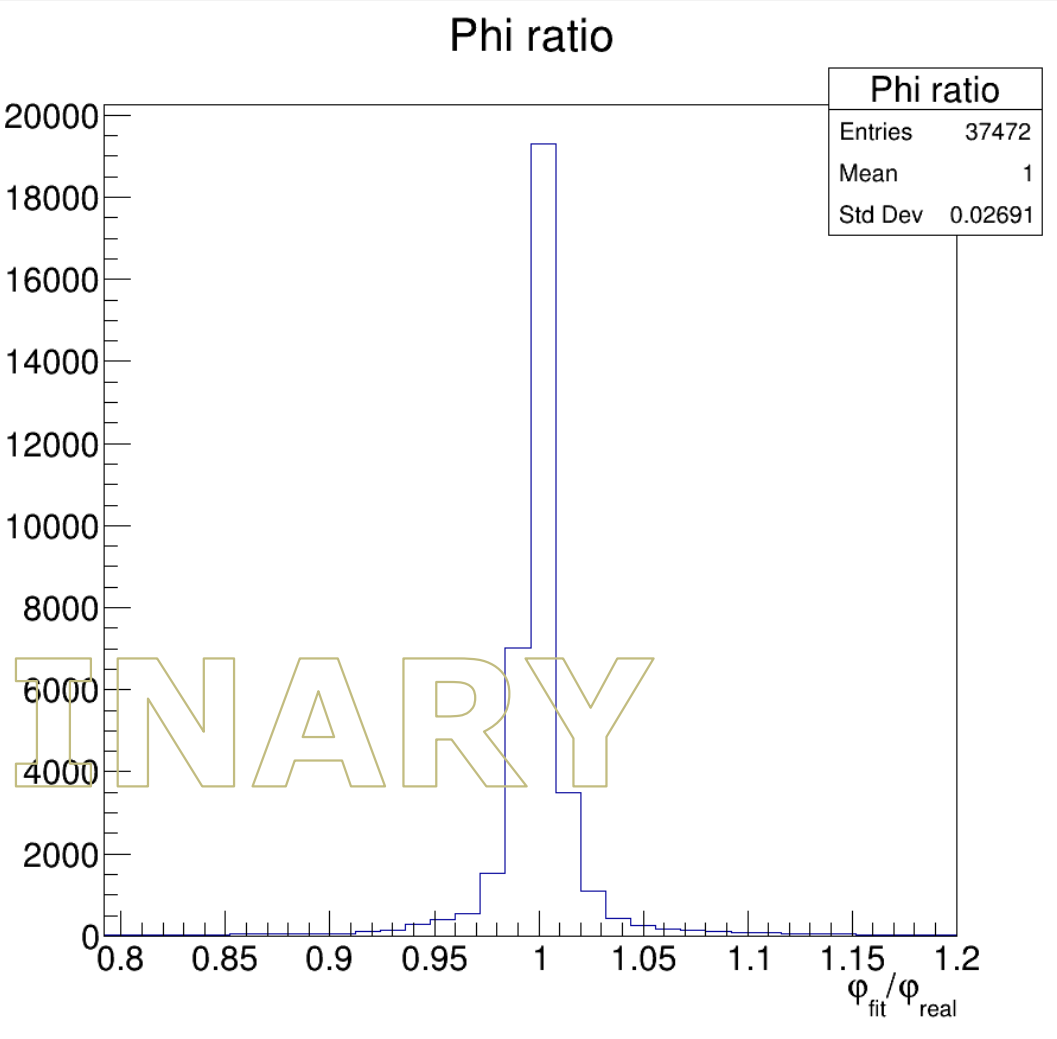
Emission Angle Reconstruction



- Theta reconstructed using linear fit of the track
- Phi reconstructed using tangent to circumference at emission vertex

Angles Recontruction





Conclusions

New detection setup for X17 based on uRwell to reach high angular acceptance,

Search of X17 mainly via $^{3}He(n, e^{+}e^{-})^{4}He$ reaction,

Simulations to study the feasibility of measurements with magnetic field are ongoing.

Demonstrator will be tested at EAR2 @ n_TOF at the end of 2023,

Possible measurements with protons beam at other facilities (e.g., LUNA),

Physics program will start in 2024->2025.

The X17 Team

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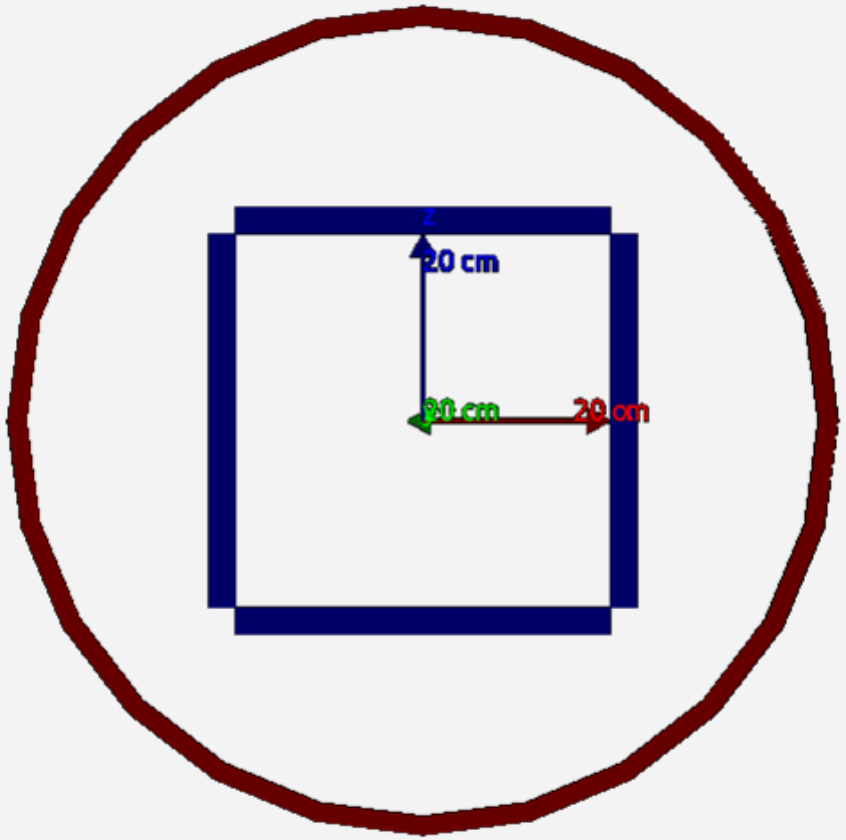
F. Santavenere (ISS ROMA)
M. Viviani (INFN PISA)
And others...

Thank you
for your attention!

Backup

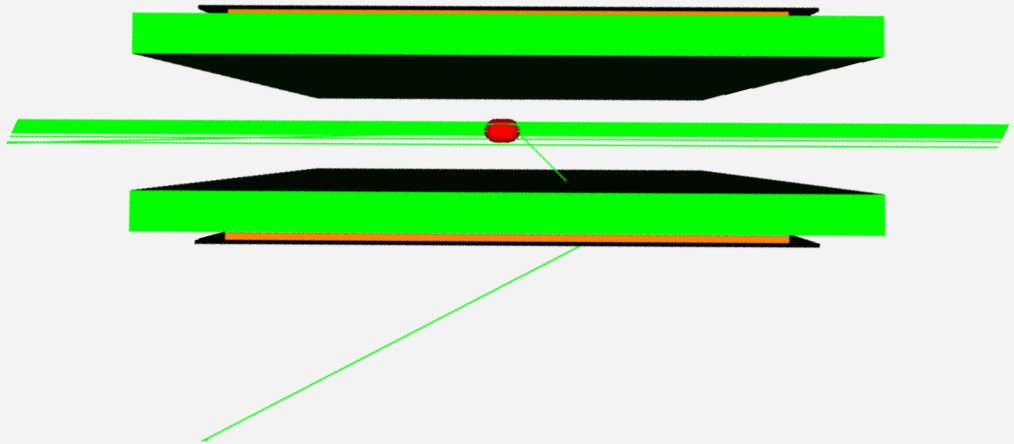
Geant4 setup



Simulations performed with Geant4 to study high number of events:

- **2/4 uRwell detectors,**
- **20 cm from beam,**
- **Magnetic field of max 500 G parallel to beam direction.**

Simulations



SIMULATION:

- SETUP with all used materials
- Realistic n_TOF beam
- IPC/X17 events rate (normalized to ATOMKI data)

OUTPUT:

- Acceptance/efficiency/MS
- Signal/Noise
- Detector performance
- e+e- ID and 4-momenta
- X17 invariant mass