The KLOE-2 Inner Tracker: the First Cylindrical GEM Detector

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On behalf of KLOE-2 Collaboration

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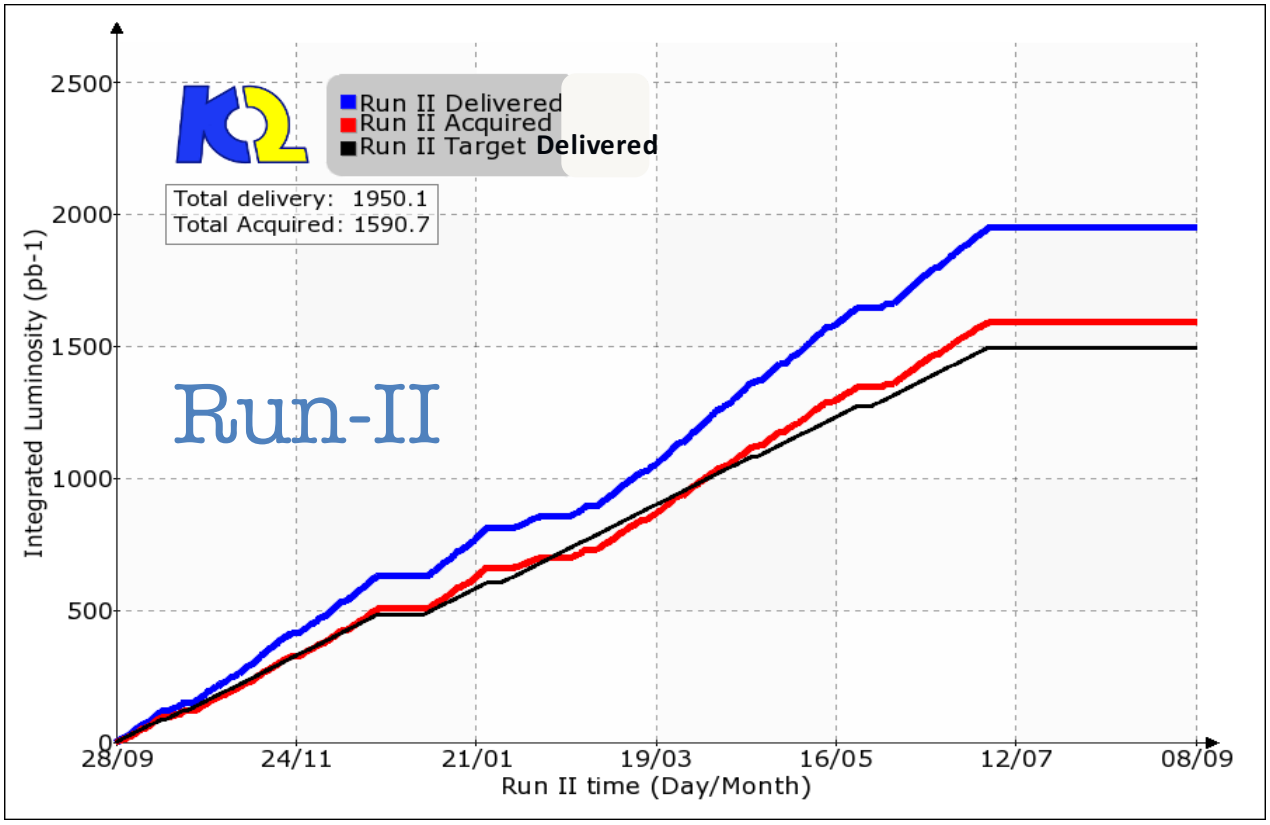
KLOE-2 at DAΦNE

- **DAΦNE Φ-facorty** e+e- collisions at 1020 MeV
- KLOE-2 Run started in November 2014
  - Daily record 16/04/2016: 13 (11.0) pb^{-1} delivered (acquired)
  - Peak Luminosity: $2.2x10^{32}$ cm^{-2} s^{-1}
- KLOE-2 is fully operational and taking data with all sub-detectors
- KLOE-2 Target > 5 fb^{-1} in the next 1-2 years



KLOE-2 at DAΦNE

Calorimeter System

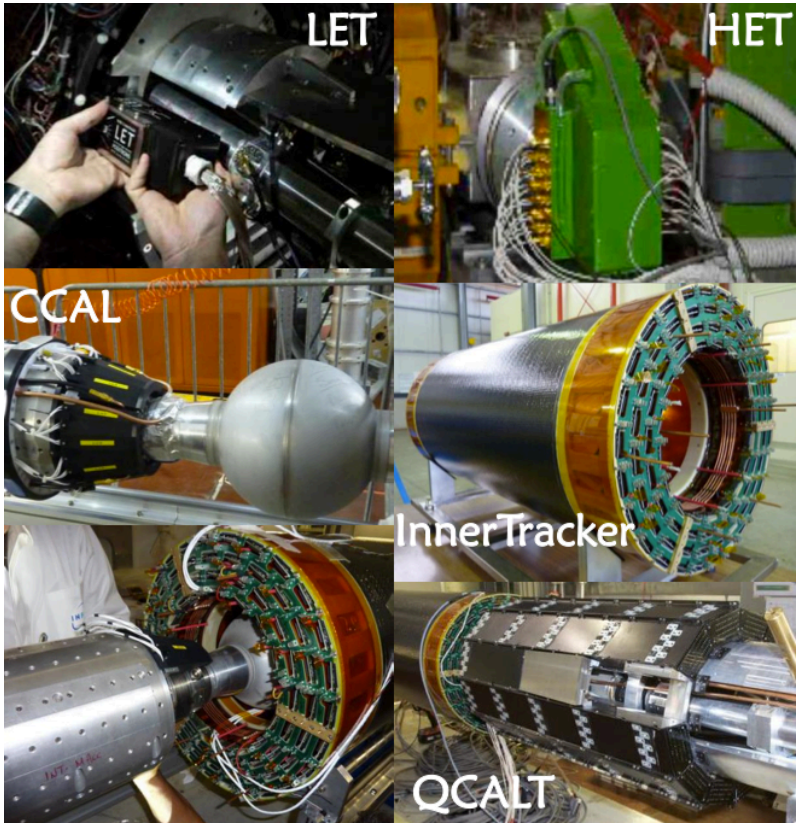
- **EMC** - Pb/Scint Fibers w PMTs Barrel & End-caps
- **LET** - LYSO+SiPMs
- **HET** - Scint+PMTs
- **QCAL** - Tungsten+ Scint Tiles w SiPMs Quadrupole Instrumentation
- **CCAL** - LYSO+APDs Low-β Insertions

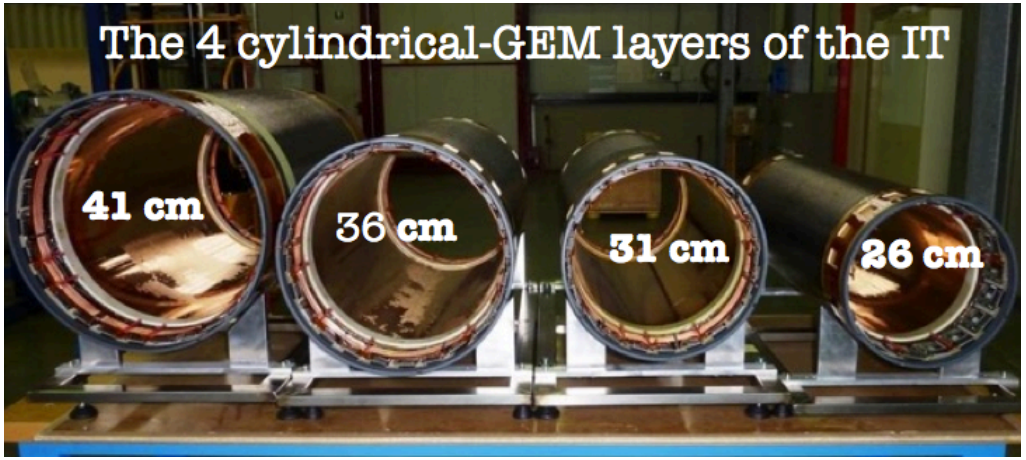
Tracking System

- **DC** - 4x4 m^2 He:Iso 90:10 gas mixture
- **Inner Tracker** – 4 cylindrical GEM tracking devices

Superconductive Magnet

- 0.52 T axial magnetic field



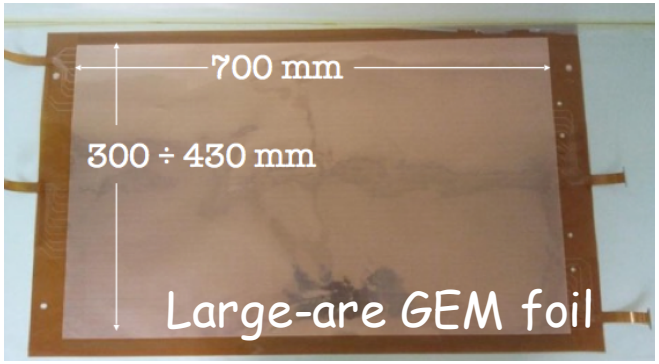


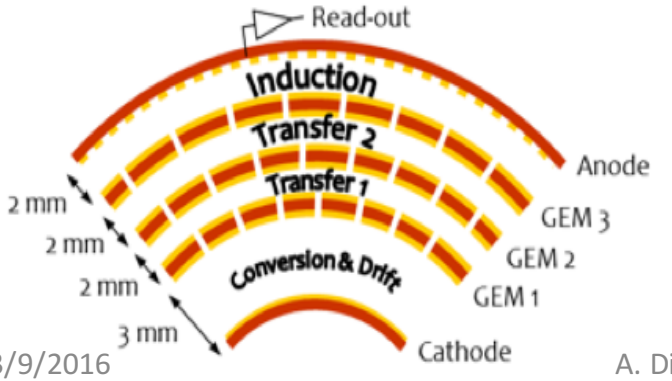
Physics Program [EPJ C68 (2010)]

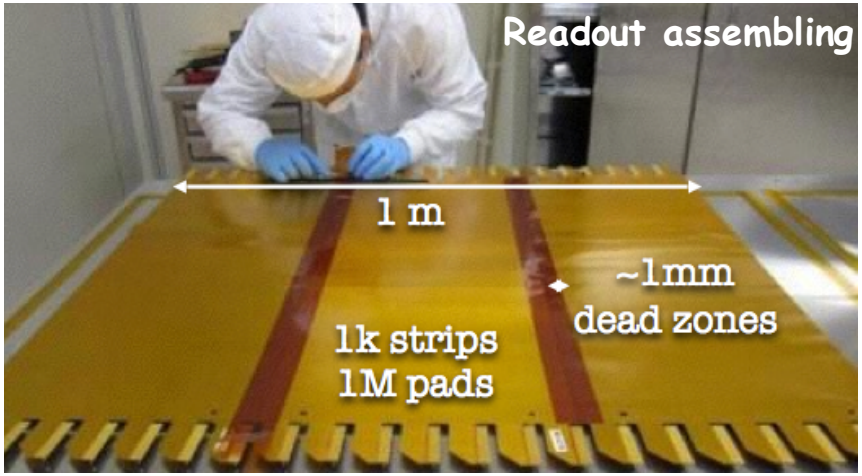
- K_S, η, $η_S$ rare decays
- Quantum Interferometry
- Dark Photon searches

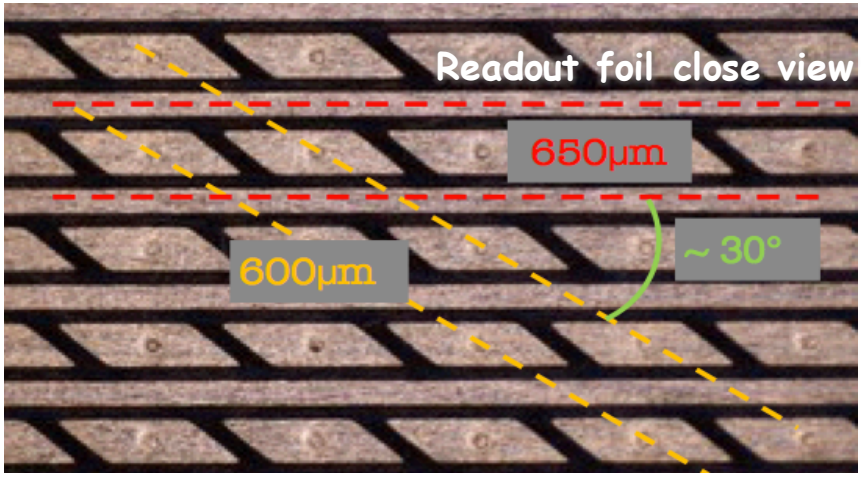
Inner Tracker Cylindircal GEM

- First GEM foils ever produced with a single-mask technique developed by CERN TE-MPE-EM & RD51 for large-area foils, 70 cm active length
- 1600 HV channels, 25k-cahnnel GASTONE FEE [NIM A732 (2013)]
- FEE DAQ System [JINST 08 T4004 (2013)]
- 3/2/2/2 mm triple-GEM layout
- Ar:Iso 90:10 gas mixture
- 12000 nominal gain
- 2% X_0 total material budget









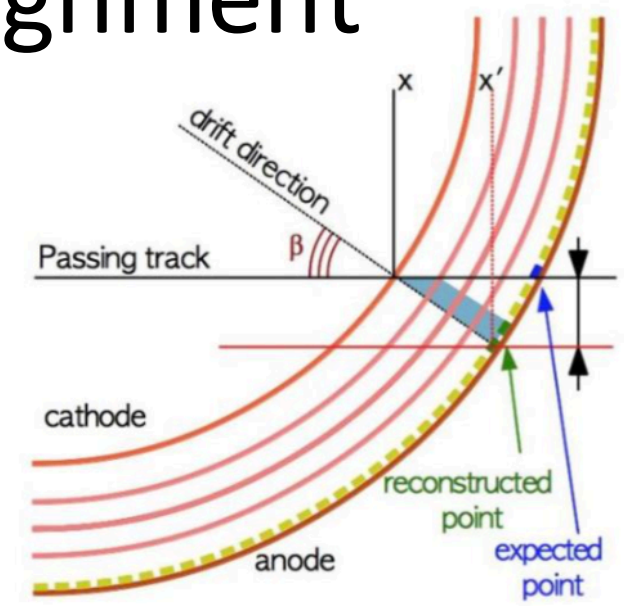
IT Calibration & Alignment

1. NON-RADIAL TRACKS

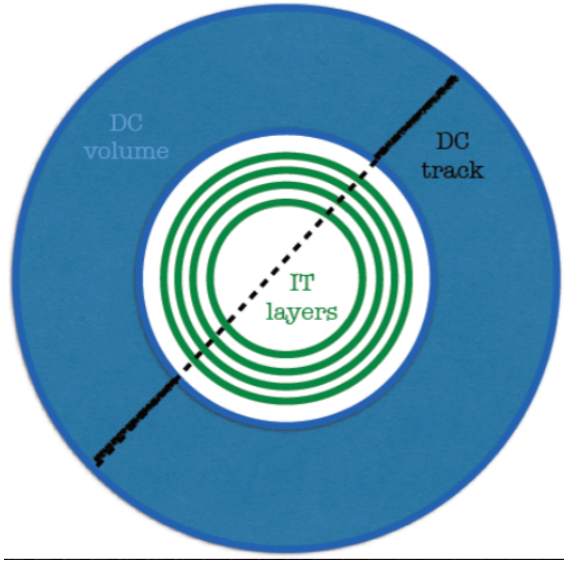
Angle between tracks and E-field radial direction: shift and a spread of e- cloud

2. MAGNETIC FIELD

KLOE-2 B-field orthogonal to GEMS: shift and larger spread of e- cloud



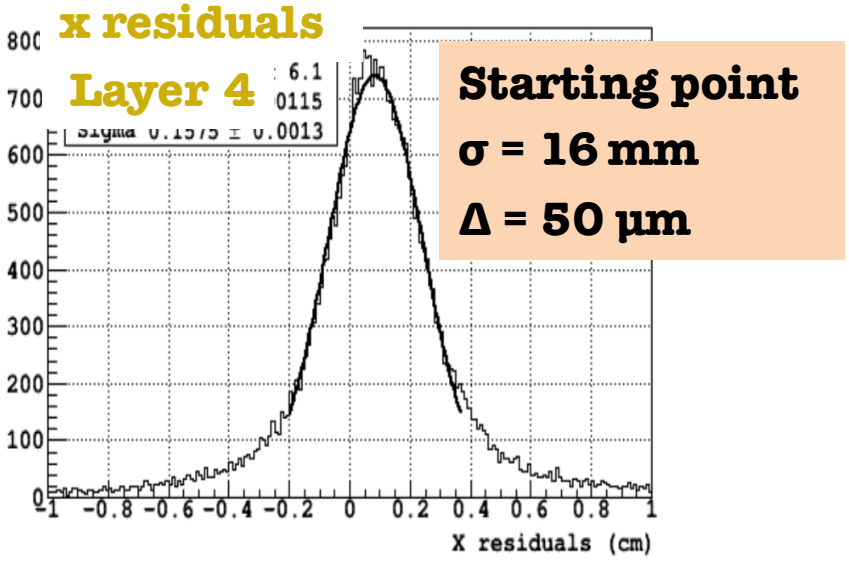
- **Cosmic-ray muon data acquired with B-field OFF**
  - Calibration of non-radial track effect
  - Select DC tracks crossing IT 2 points
  - Correction as a function of track parameters
  - Shifts and rotations to align IT
- **Cosmic-ray muon data acquired with B-field ON**
  - Calibration of magnetic field effect
  - Corrections, shifts and rotations from B OFF sample
  - Study and apply B-field effect corrections
- **Bhabha scattering events**
  - Calibration of non-radial track and B-field effects
  - Corrections, shifts and rotations from B ON sample
  - **Validation of IT+DC integrated tracking with all corrections inserted**

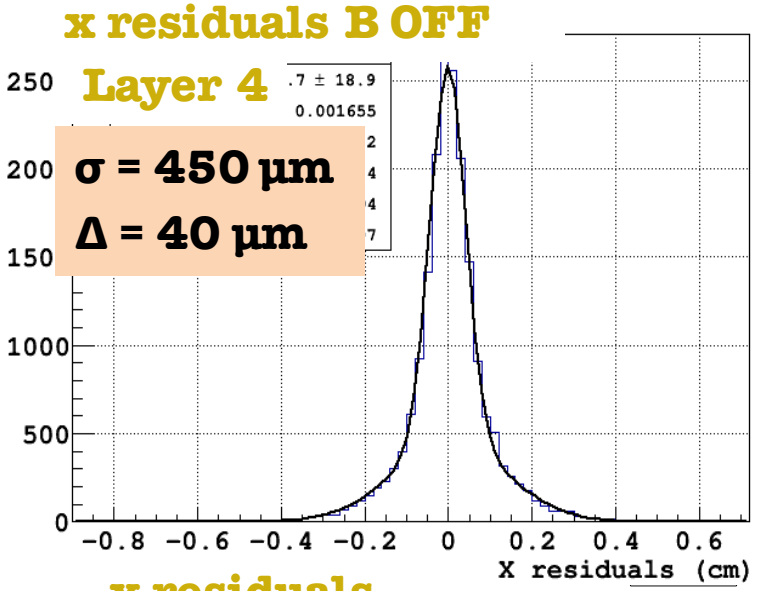


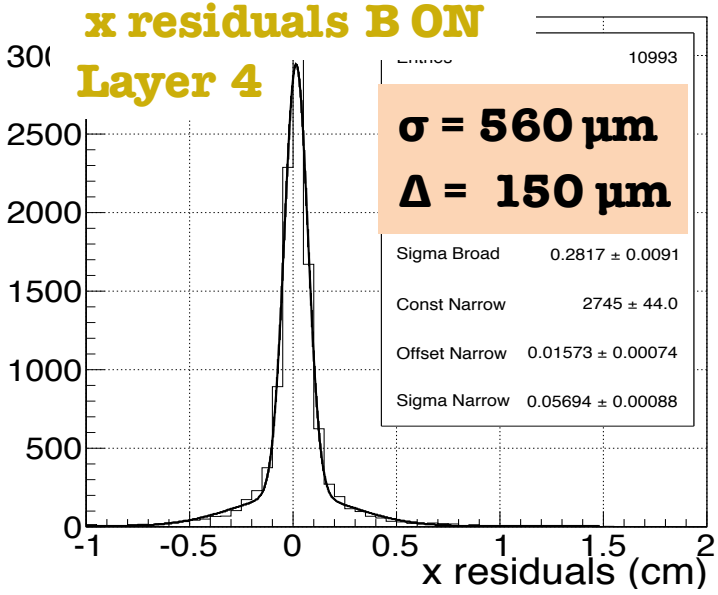
IT Calibration & Alignment

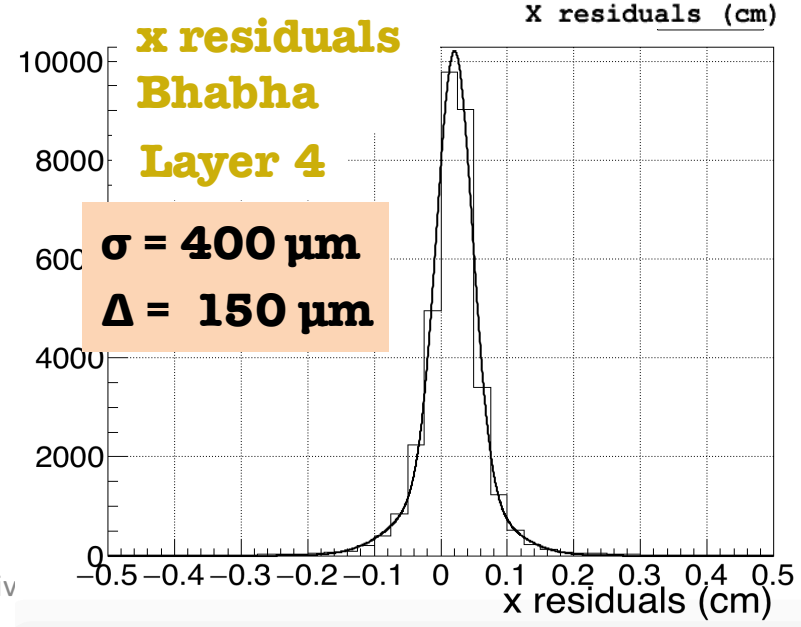
Residuals between DC track extrapolated tracks and closest IT clusters

All layers exhibits similar distributions



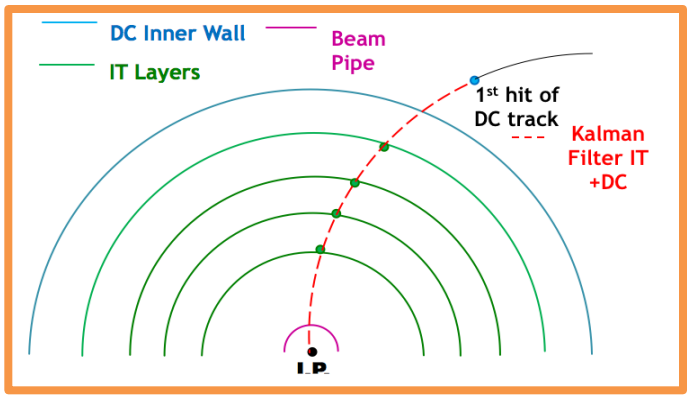






IT+DC Integrated Tracking

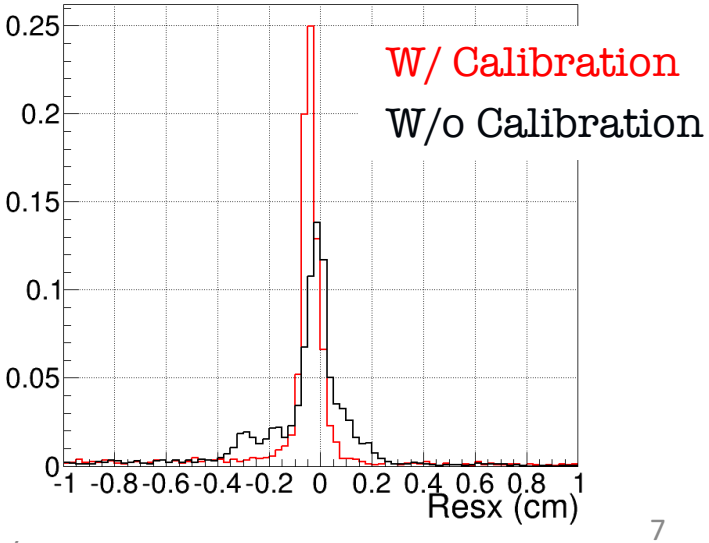
- **Bhabha scattering events** selection from pre-scaled Level-3 filter with very simple selection ciriteria
  - $R_{PCA} < 5$ cm, $|z_{PCA}| < 5$ cm
  - $p_T > 300$ MeV, $R_{FH} < 40$ cm, $N_{HIT,trkFIT} > 40$



- **Kalman Filter for IT+DC tracking**
  matches IT clusters to DC reconstructed tracks starting from first hit in DC and going inward
- **Corrections, shifts & rotations applied** from cosmic-ray data (B OFF & B ON) analysis
- **Validate procedure** of alignment and calibration
  compare **residuals between DC extrapolated tracks and closest IT clusters** obtained with standalone and Kalman procedures

Residuals between IT clusters and expected position from Kalman with and w/o calibration.

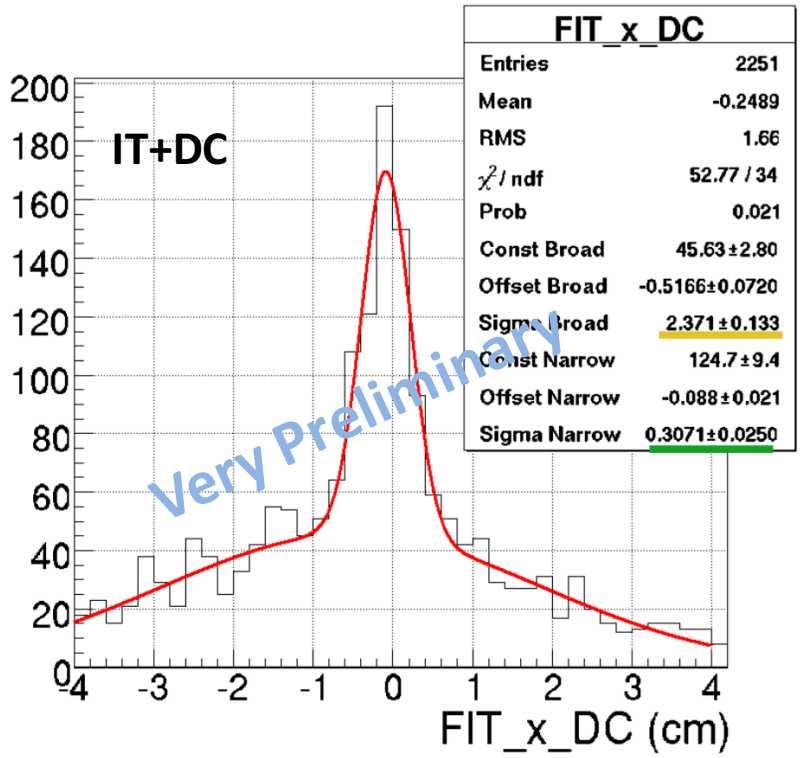
All IT clusters included, not only the closest to the extrapolated track.

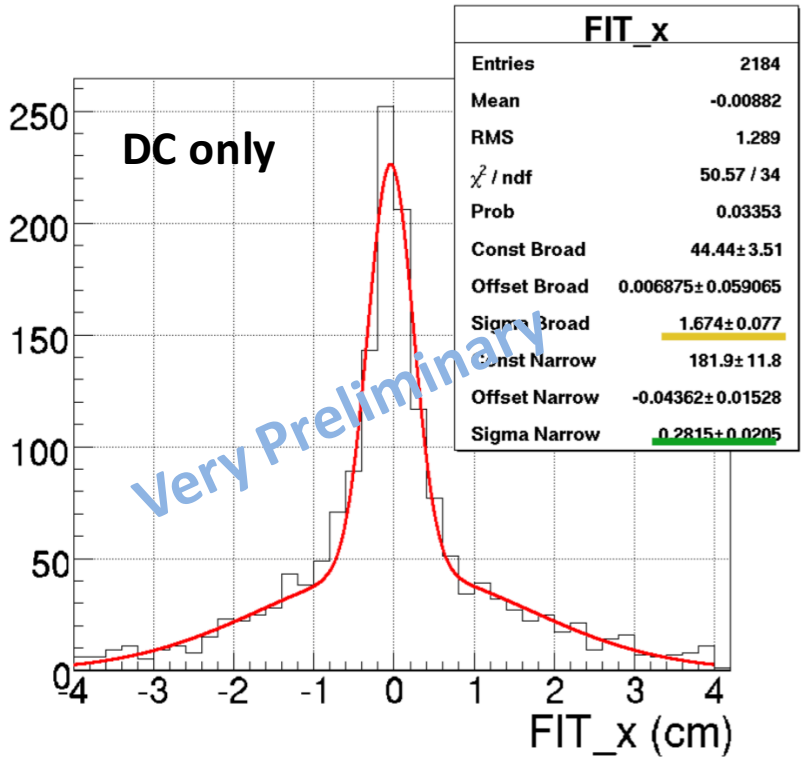


IT+DC Integrated Tracking

Simple vertex finding routine based on the minimum distance between extrapolated tracks.

Comparison between IT+DC and DC simple reconstructed vertex.





Setting up official reconstruction with IT+DC integrated tracking and official vertexing

Summary and Conclusions

- First fully-cylindrical GEM ever used in HEP experiments
- **Challenging alignment and calibration never done before**
- Successful first IT alignment and calibration using cosmic-ray muon data and Bhabha scattering events
- 450 μm B OFF sample, 540 μm B ON sample, 400 μm BHA sample
- **IT+DC tracking using corrected IT clusters**
- **Official tracking and official vertexing with IT+DC work in progress**
- BES-III inner tracking detector will be replaced with a cylindrical GEM profiting of the KLOE-2 progresses done in this filed