

# Nuclear emulsion analysis in SND@LHC

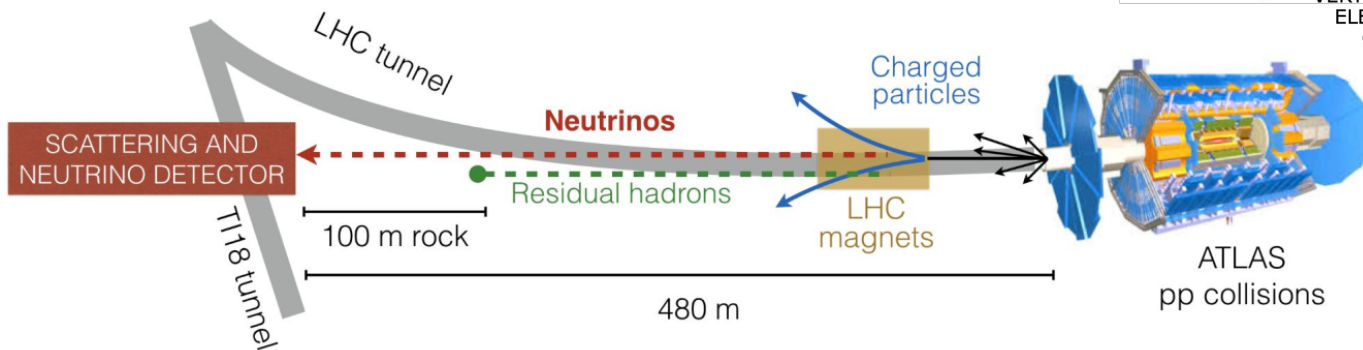
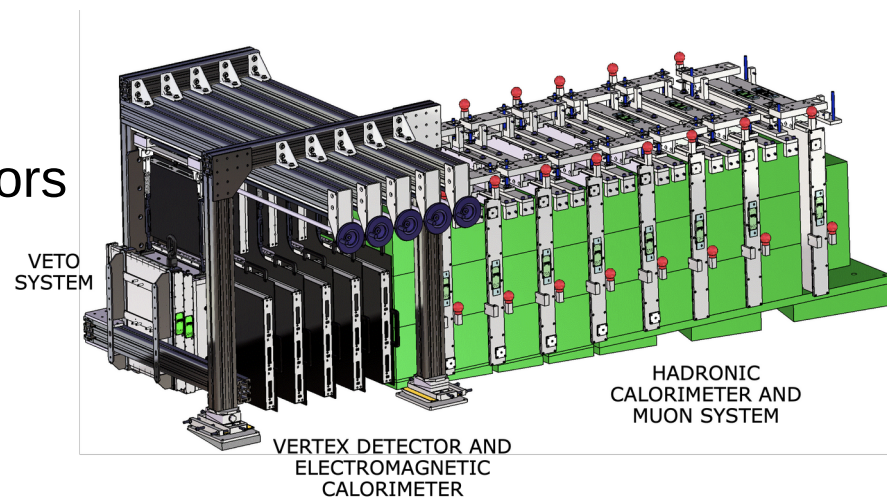
A. Iuliano (INFN Sezione di Napoli)  
On behalf of the SND@LHC Collaboration  
9 May 2024  
SM@LHC, Rome



Scattering and Neutrino Detector  
at the LHC

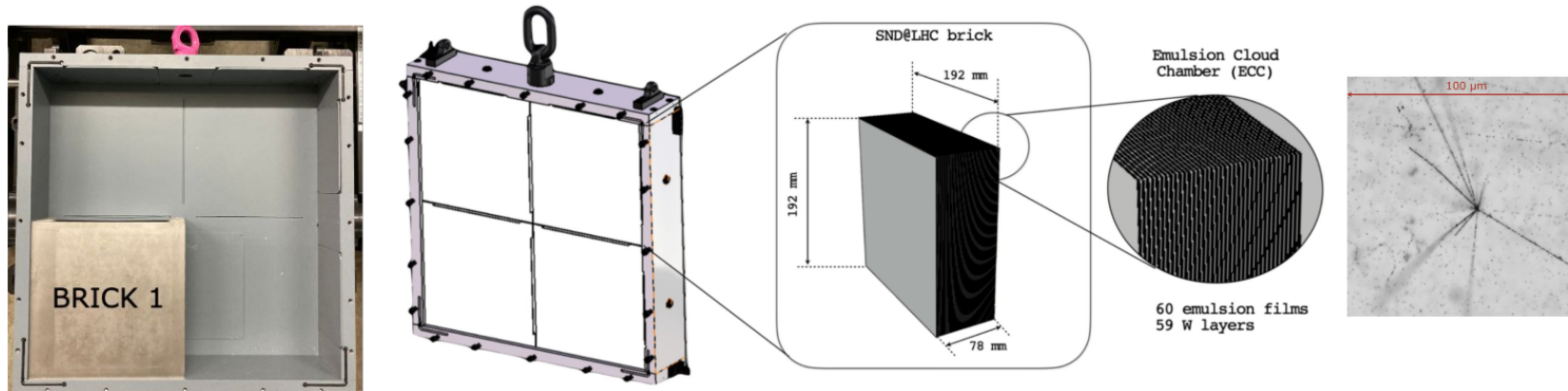
# The SND@LHC experiment

- Off-axis neutrino detector at pp collider
- About 480 m from ATLAS Interaction Point
- Employing both emulsions and electronic detectors
- Taking data from start of LHC Run 3 (2022)
- See M. Dallavalle talk tomorrow for details!



# Emulsion Target and Vertex Detector

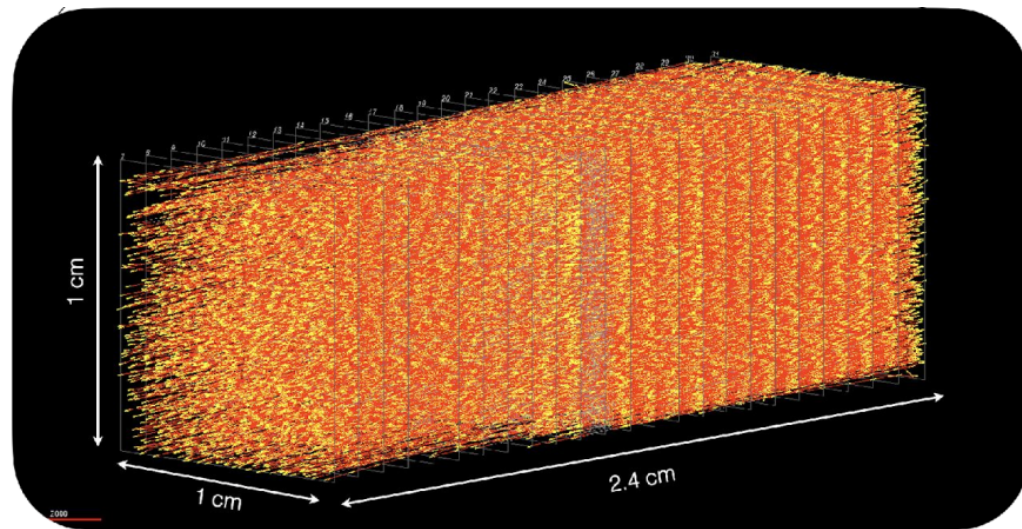
- Emulsion Cloud Chamber (ECC): films interleaved with passive layers
- In SND@LHC, five walls, each with four ECC bricks:
  - Each brick: 60 emulsions (0.3 mm) and 59 layers of tungsten (1 mm)
  - Wall thickness: 78 mm ( $17 X_0$ ). Sensitive transverse size:  $38.4 \times 38.4 \text{ cm}^2$
- Time-insensitive detector, keep under watch occupancy: need to replace every 1-2 months of activity, keep density under  $10^6 \text{ tracks/cm}^2$



# Emulsion scanning and analysis

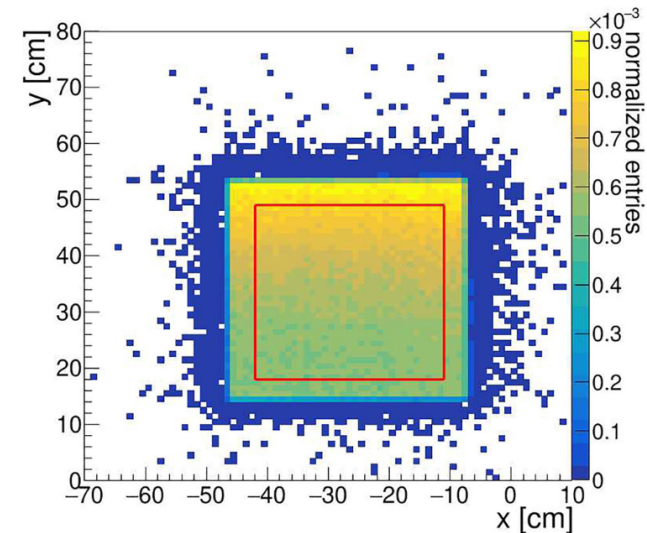
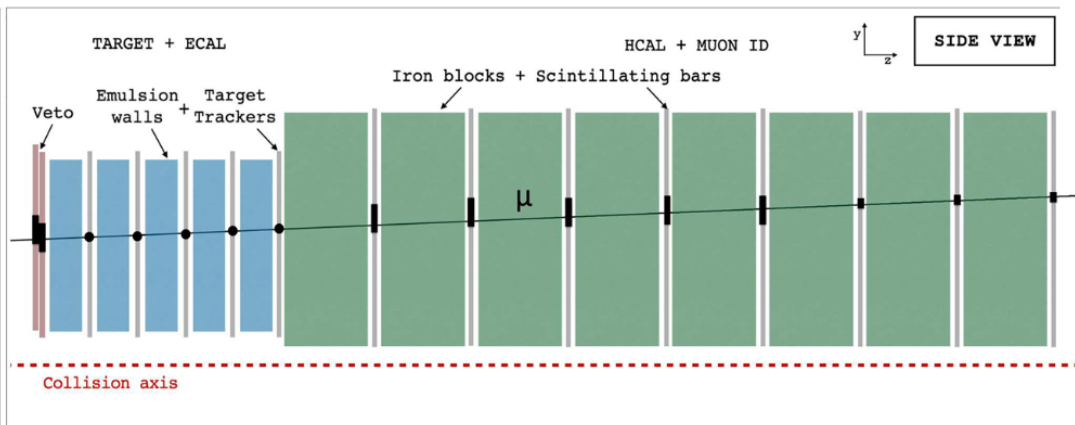
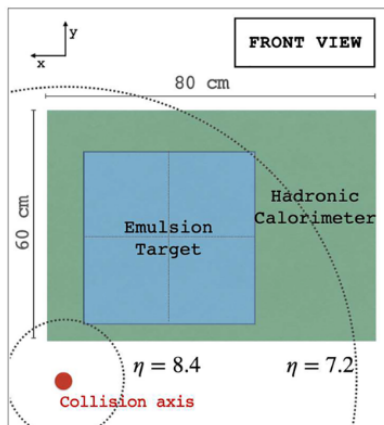
- Scanning performed with automated microscopes from multiple institutions
- 1 film scanned daily per microscope, currently moving towards 2 per day
- New facility at CERN, installed last year with 4 microscopes
- Three-dimensional reconstruction of tracks with ROOT C++ libraries

CERN



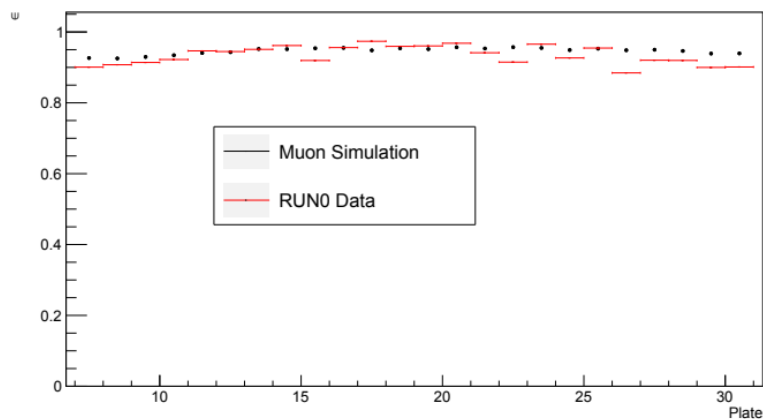
# Muon flux measurement

- Validation of Monte Carlo simulations
- Background assessment
- Density distribution in the transverse plane
- Comparison between subdetectors

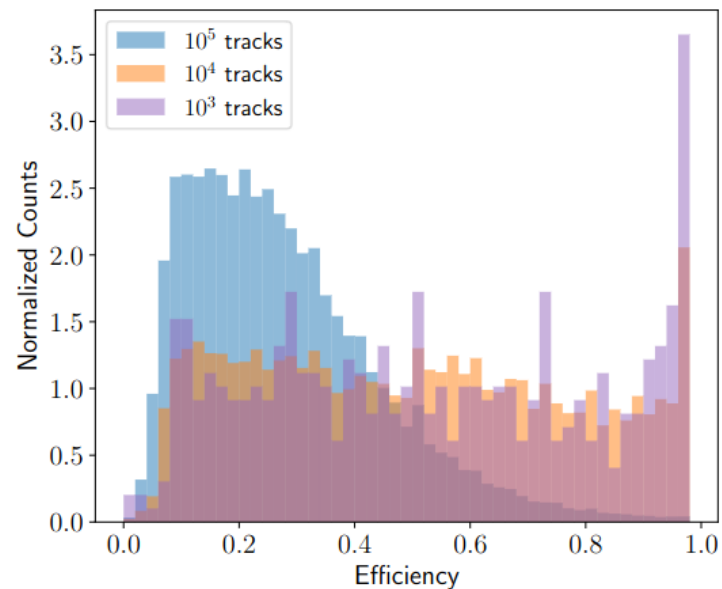


# Emulsion data and Monte Carlo

- Muons propagated with Geant4 according to the FLUKA fluxes
- Agreement between data and reconstructed Monte Carlo
- Effect of track density in reconstruction



Sample	Muon flux	$1 - \frac{sim}{data}$
Data	$(1.5 \pm 0.1) \times 10^4 \text{ fb/cm}^2$	-
Monte Carlo	$1.4 \times 10^4 \text{ fb/cm}^2$	$(6 \pm 7)\%$



# Comparison between SciFi and Emulsion

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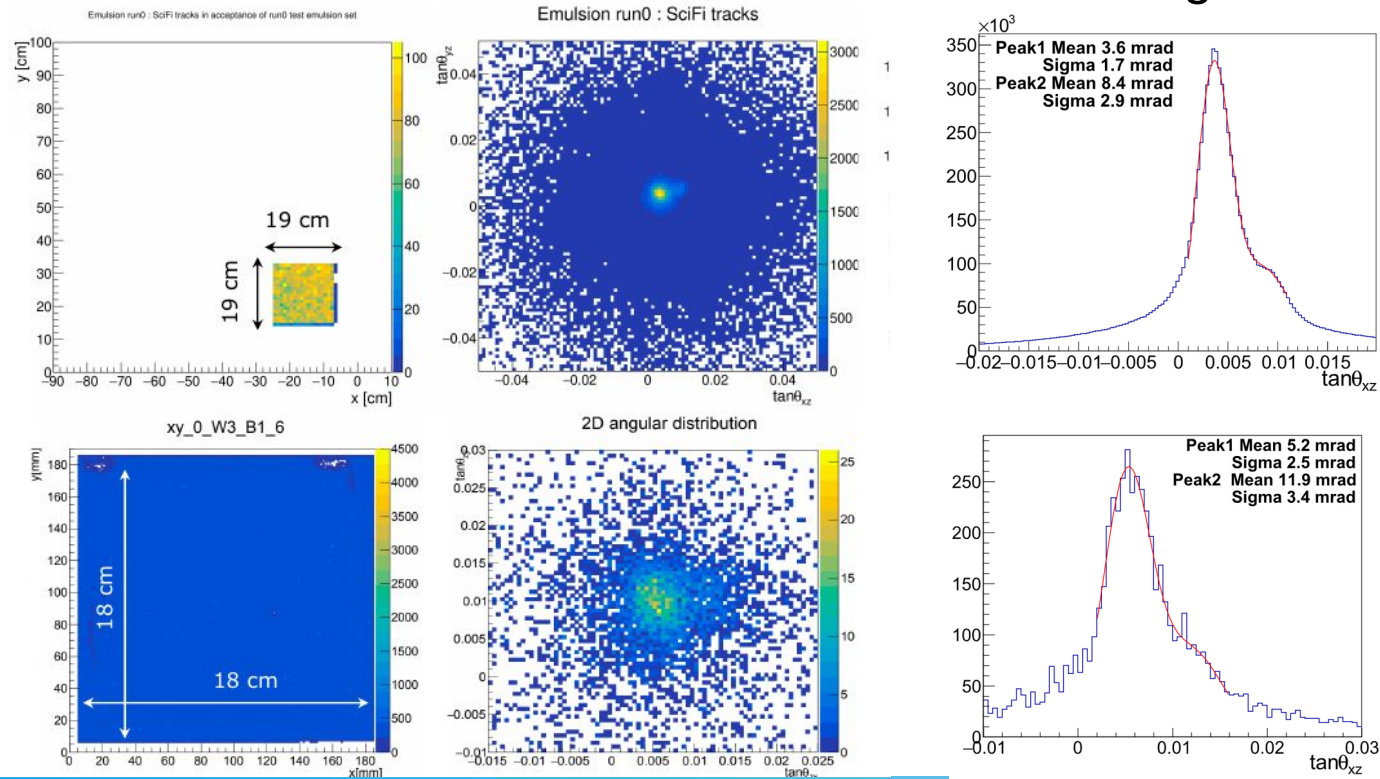
- Performed track reconstruction in electronic detectors and emulsion target

## SciFi

Measured rates on BRICK1 surface:  
 **$1.6 \times 10^4 \text{ cm}^{-2}/\text{fb}^{-1}$**

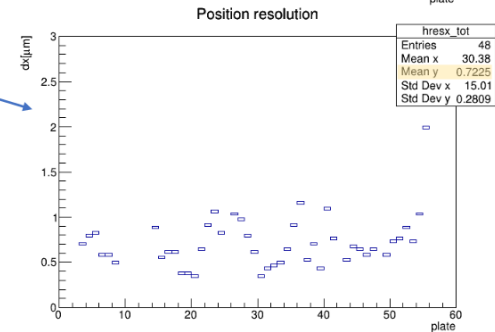
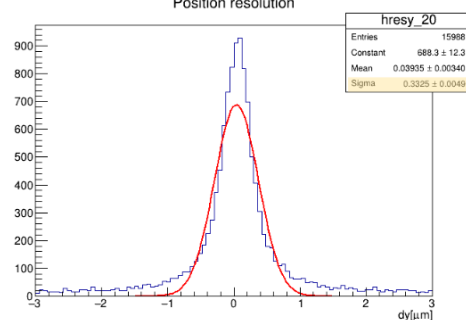
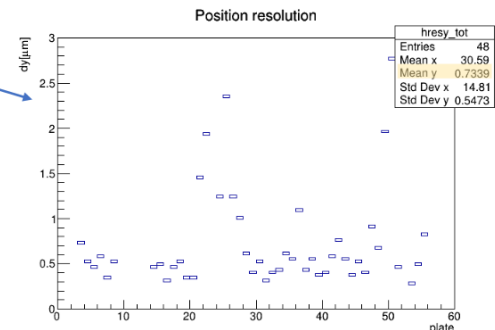
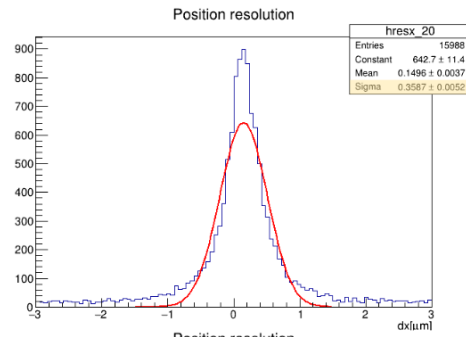
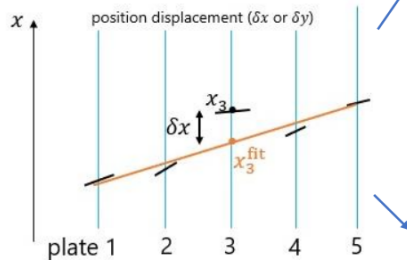
## Emulsion

Measured rates in BRICK1:  
 **$1.5 \times 10^4 \text{ cm}^{-2}/\text{fb}^{-1}$**



# Tracking resolution

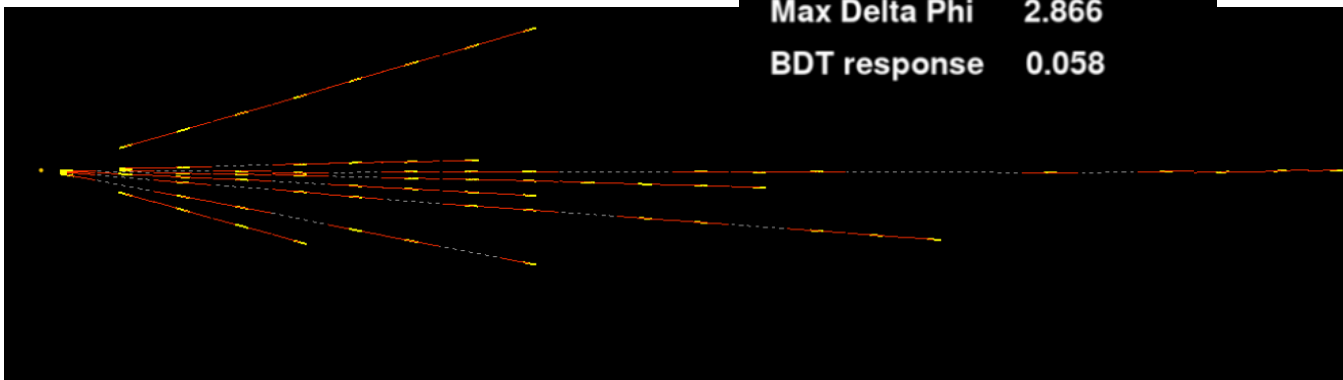
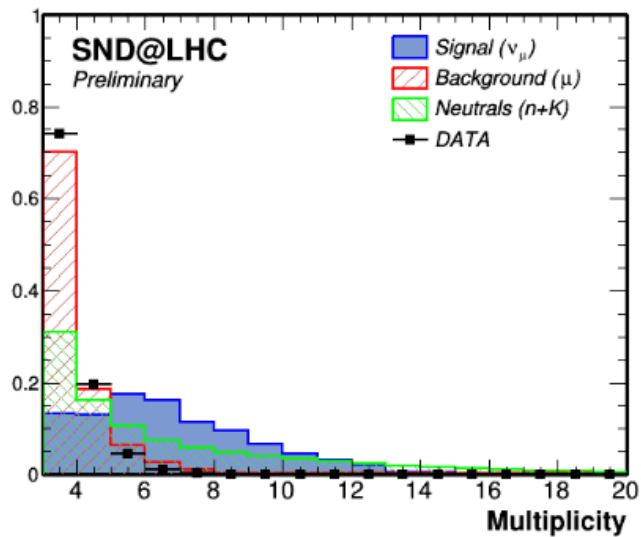
- Submicrometric resolution thanks to high emulsion granularity
- Accurate alignment applied during scanning and offline analysis
- Preserve single layer resolution to reconstructed tracks





# Vertex reconstruction and identification

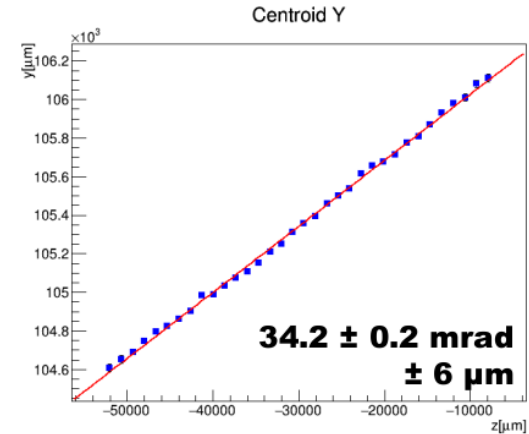
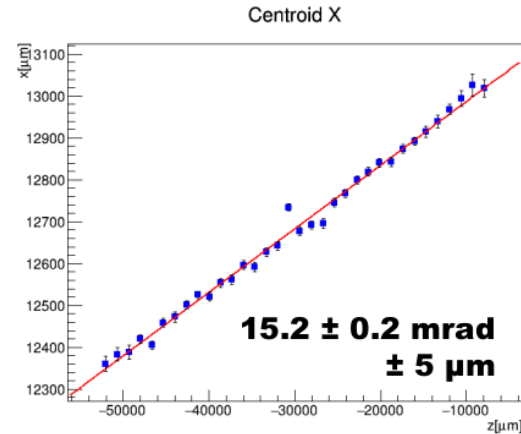
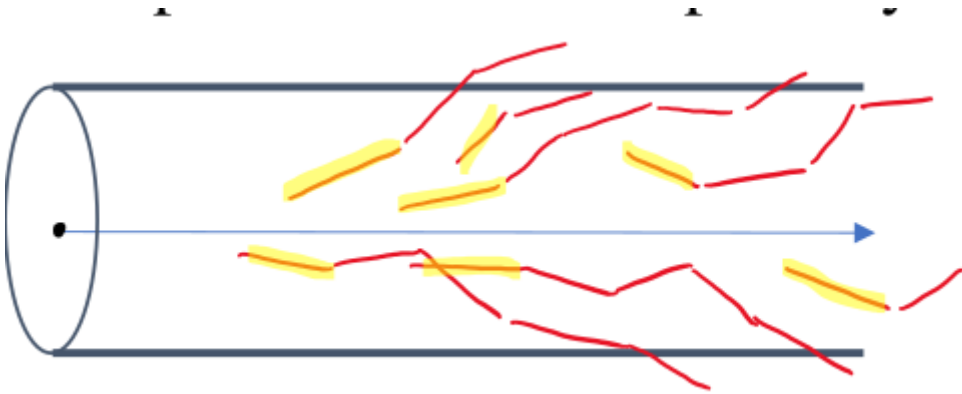
- Reconstructing vertices from interacting tracks
- Identification with multivariate analysis, trained with Monte Carlo
- Search for V0-like interactions -> neutrino events



Vertex ID	4 3 74859
N tracks	8
Mean FF	0.377
Mean IP [um]	6.596
Probability	1.000
Max Delta Phi	2.866
BDT response	0.058

# Shower identification

- Signal of a charged electron neutrino interaction
- Search of shower tracks within a cylinder
- Find shower centroid slope for vertex prediction



# Conclusions

- SND@LHC: neutrino detection at high-energy collider
- Emulsion films provide high resolution tracking and vertex capabilities
- General reconstruction, followed by optimized analysis for dedicated tasks:
  - Muon flux measurement;
  - Alignment and tracking;
  - Vertex Reconstruction;
  - Shower Identification;
- More emulsion data and analysis coming!

Thank  
You!

The text 'Thank You!' is written in a black, elegant cursive font. The word 'Thank' is on the top line and 'You!' is on the bottom line. The text is surrounded by decorative elements: a large red rose outline is positioned above the 'h' in 'Thank'; a smaller black rose outline is to the left of the 'T'; another black rose outline is to the right of the 'o' in 'You!'. There are also several red and black teardrop shapes and dots scattered around the text, adding a festive and celebratory feel.