OPERA Experiment, Brick Finding Program

A. Chukanov

Joint Institute for Nuclear Research

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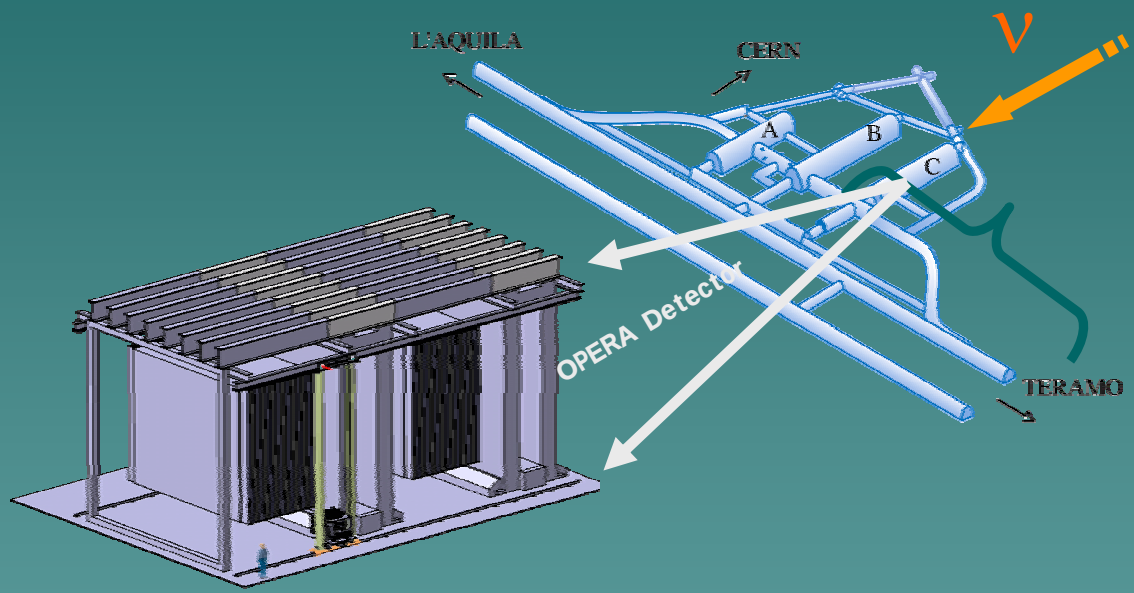
Outline

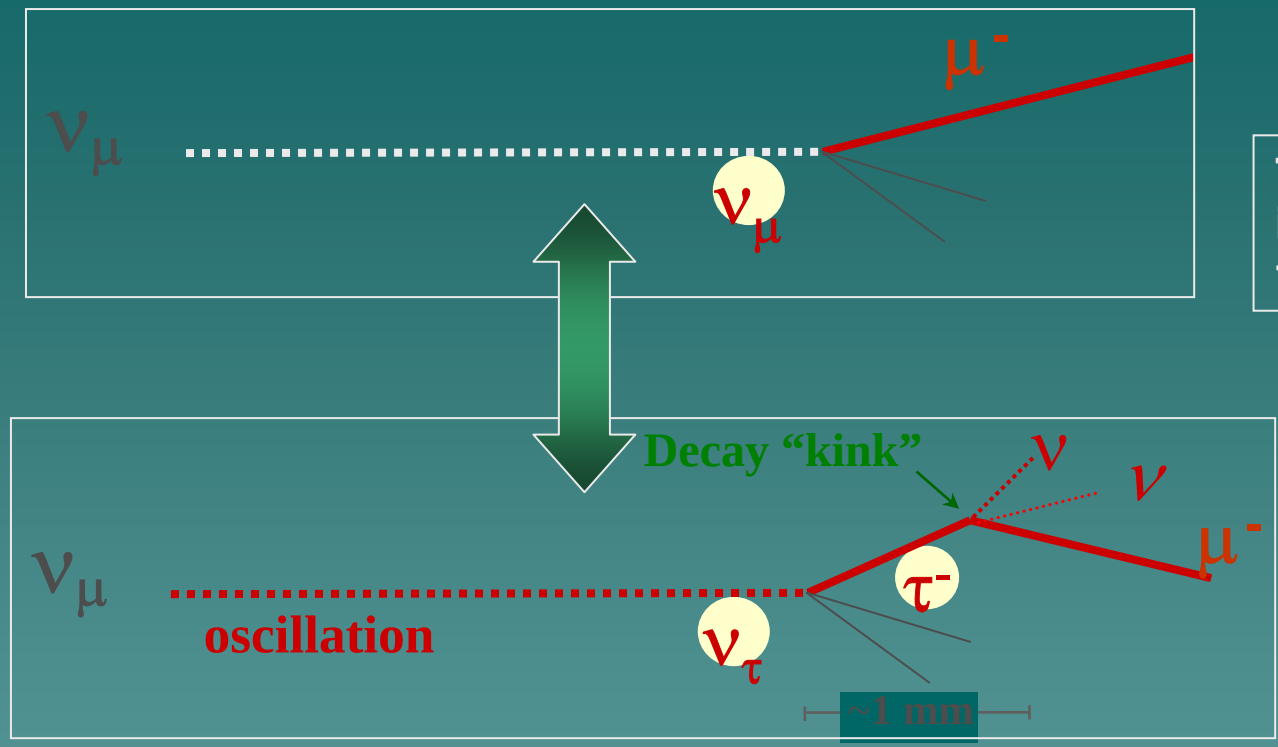
- OPERA experiment
- Status of the OPERA detector
- BrickFinder program description
- Results
- Conclusion

OPERA: Oscillation Project with Emulsion tRacking Apparatus



- **Long baseline experiment**
- Direct search for $\nu_\mu \rightarrow \nu_\tau$ oscillations by looking at the **appearance** of ν_τ in a pure ν_μ beam to explain atmospheric neutrinos anomaly and results of K2K and MINOS.
- Search for the sub-dominant $\nu_\mu \rightarrow \nu_e$ oscillations for Θ_{13} measurement

Detection of the ν_τ appearance signal



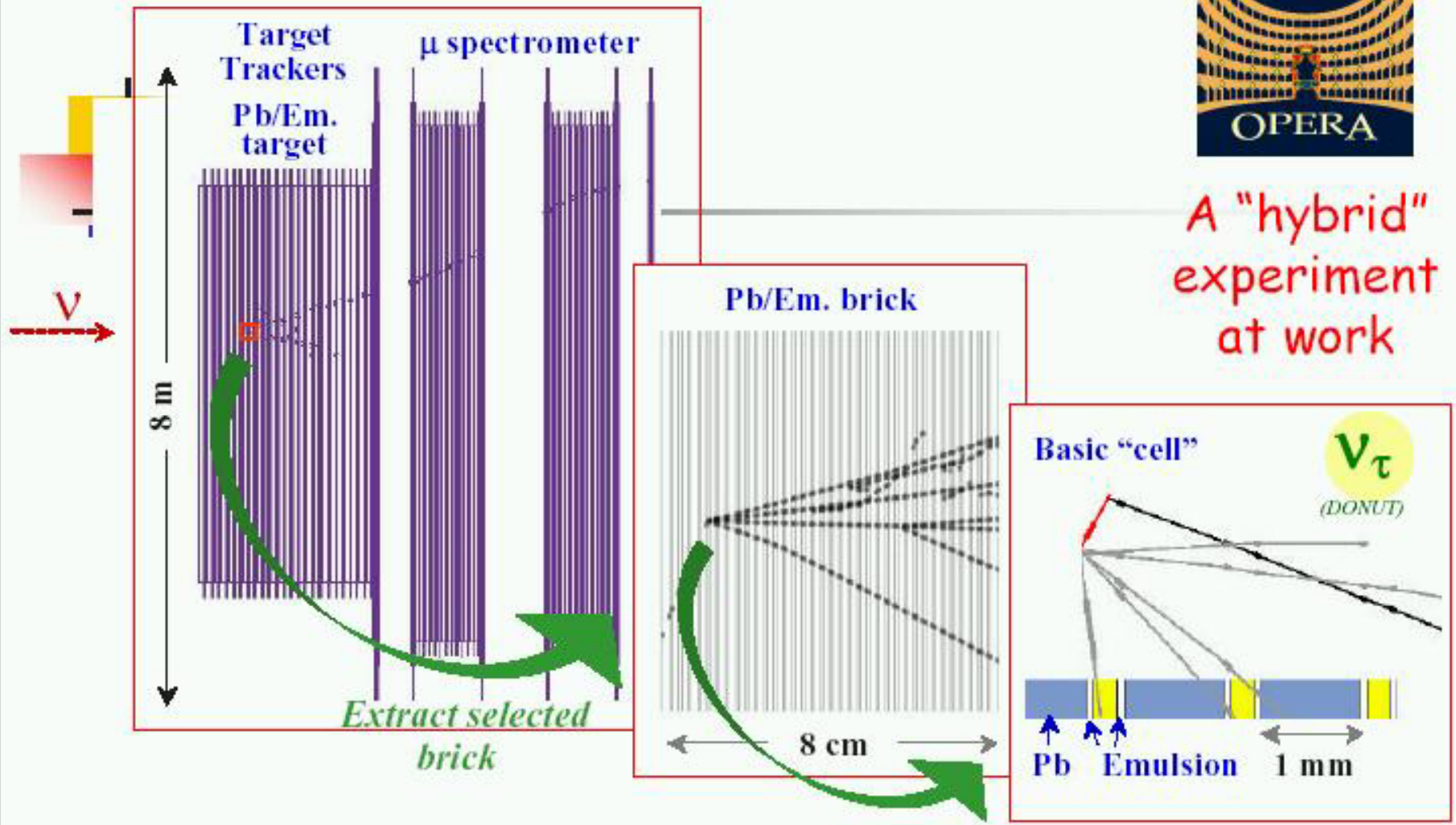
The challenge is to identify ν_τ interactions from ν_μ interactions

Toplogy selection:
⇓
Kink signature

Two conflicting requirements:
- Large mass ➔ low Xsection
- High granularity
  - ➔ signal selection
  - ➔ background rejection

Target: 1800 tons, 5 years running

- 30 000 neutrino interactions
- ~150 ν_t interactions
- ~15 ν_t identified
- < 1 event of background



OPERA

A "hybrid" experiment at work

Electronic detectors

→ select ν interaction brick

→ μ ID, charge and p

Emulsion analysis

→ vertex search

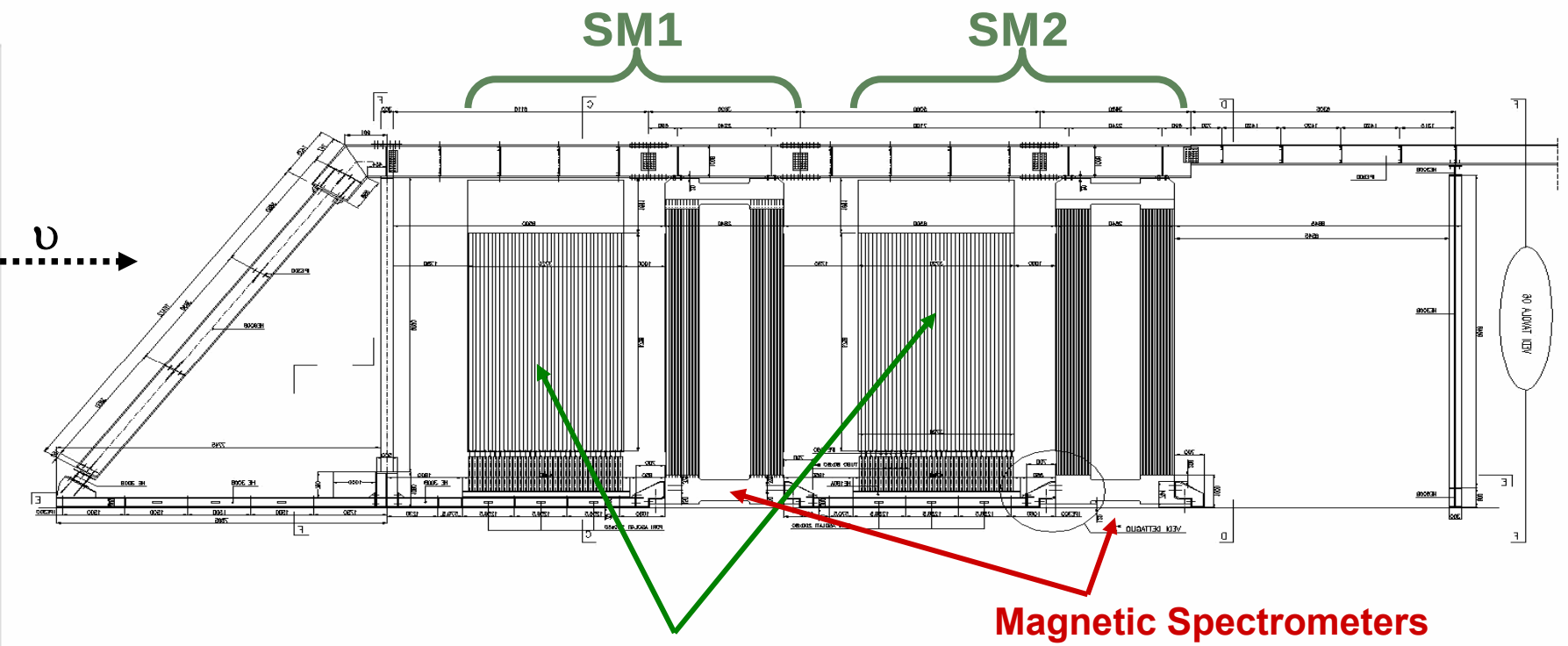
→ decay search

→ e/γ ID, kinematics

The OPERA detector

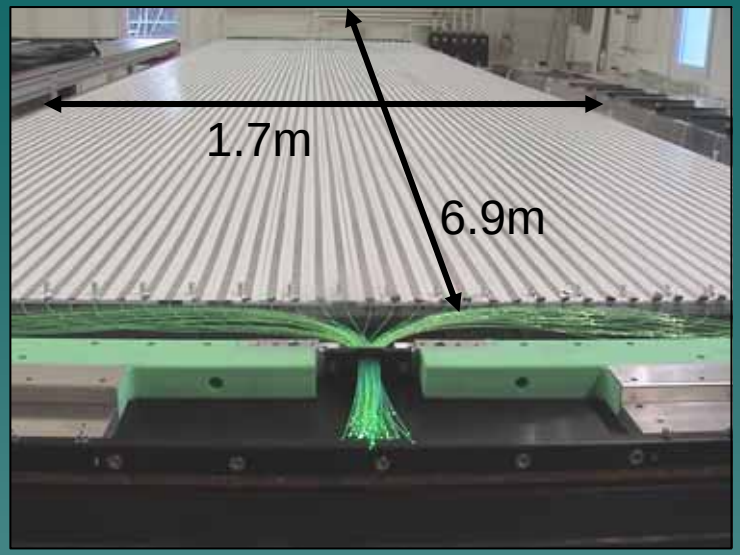
Modular structure:

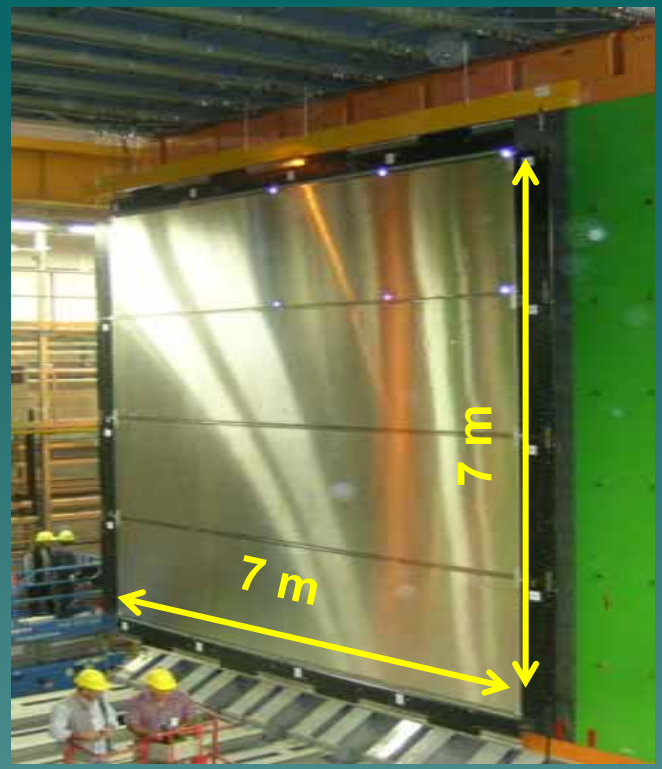
2 super-modules



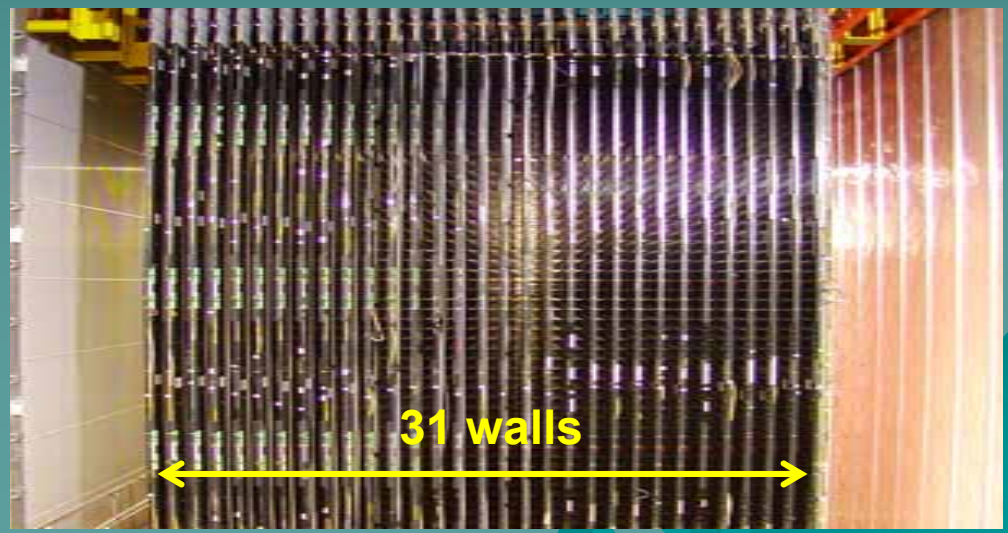
Total target mass: 1.8 kt

Target Tracker





Plastic scintillator strips
(AMCRYS-H, 6.7m x 2.6cm x 1cm)
readout by Kuraray WLS fibres +
Hamamatsu PMT's (64 channels)



Target Tracker tasks

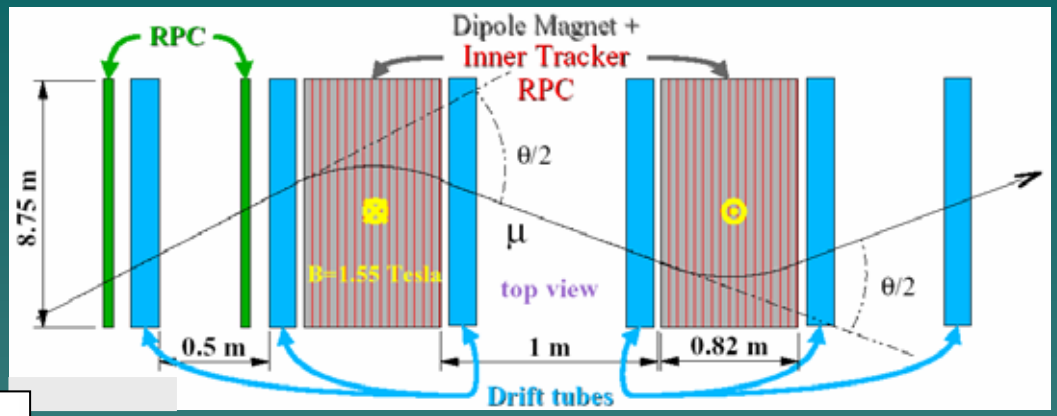
- Trigger: $\varepsilon > 99\%$
- Brick finding : $\varepsilon \approx 70 \div 80\%$
- Initiate muon tagging

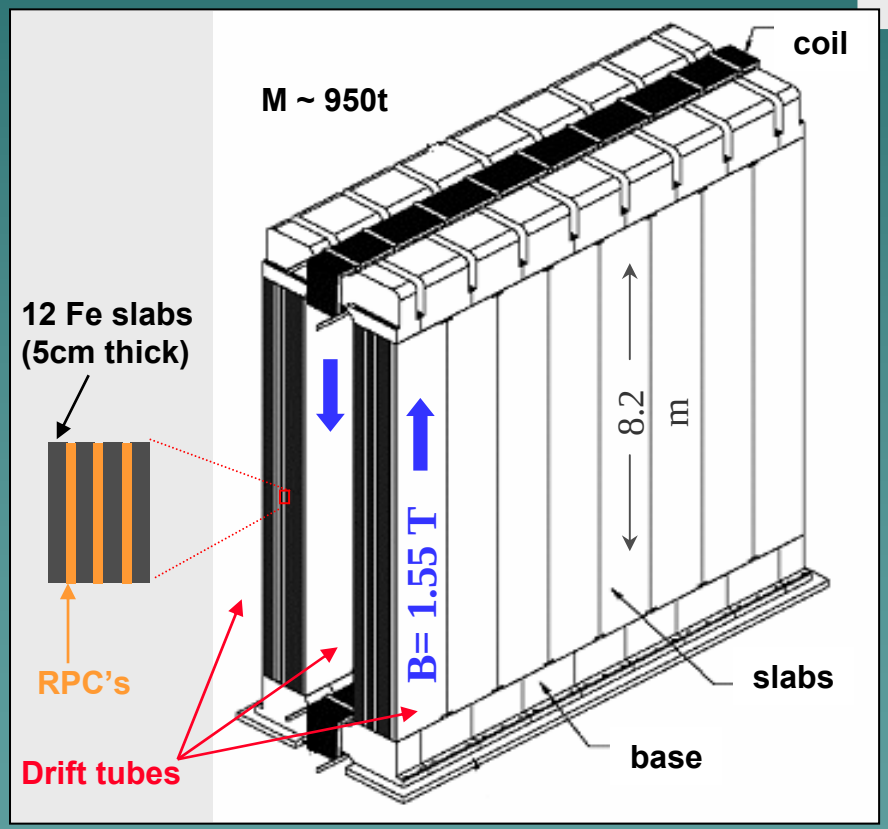
Muon spectrometer

μ identification: ε > 95% (TT)

Δp/p < 20% , p < 50 GeV/c

misidentified μ charge prob. < 0.3%





Inner Tracker

11 + 11 planes of RPC's

21 bakelite RPC's (2.9x1.1m²) / plane

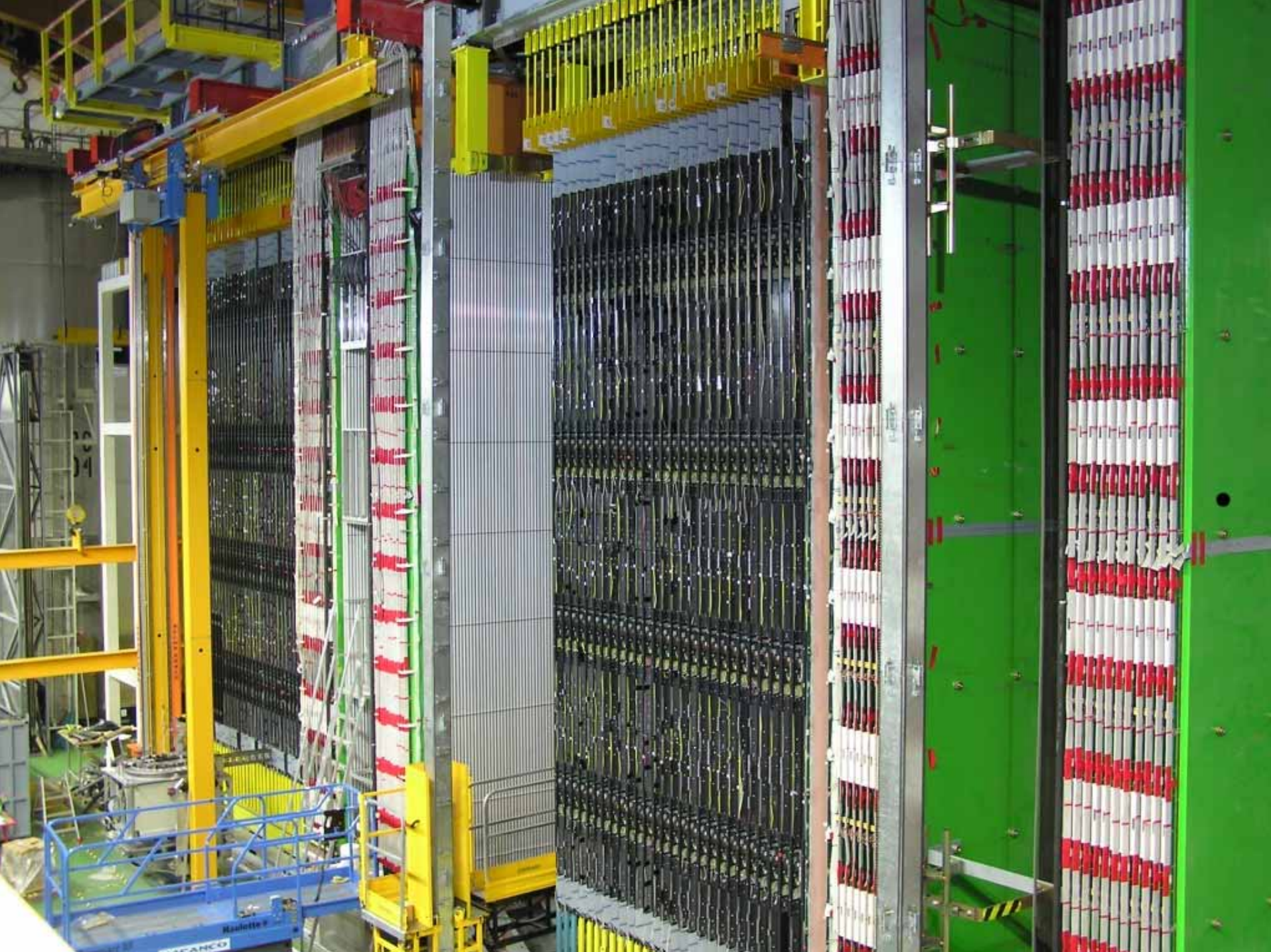
- muon identification (TT)
- range measurement

Precision Tracker

6 planes of drift tubes

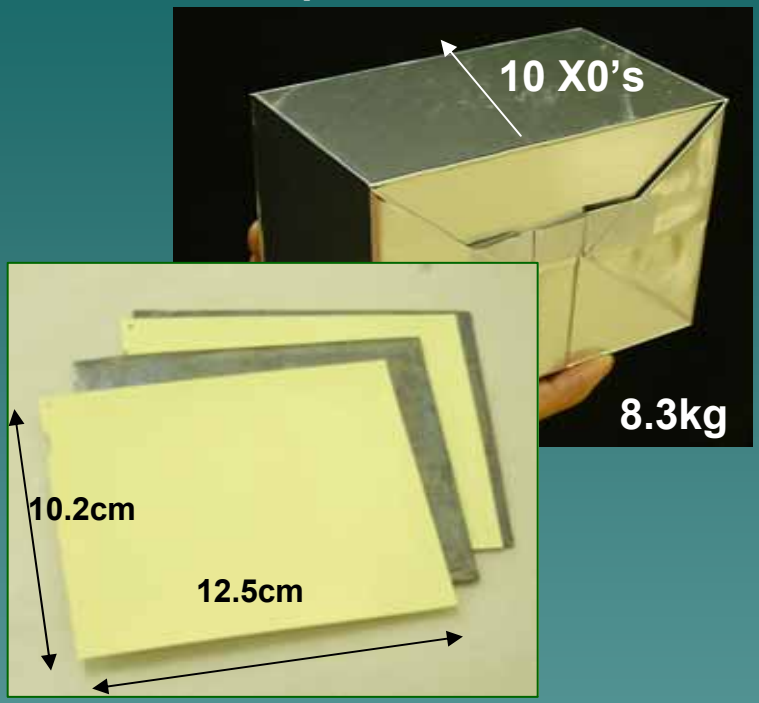
space resolution: ~300μm

- momentum measurement



Lead – Emulsion target

brick (target unit)
56 Pb plates + 57 emulsions



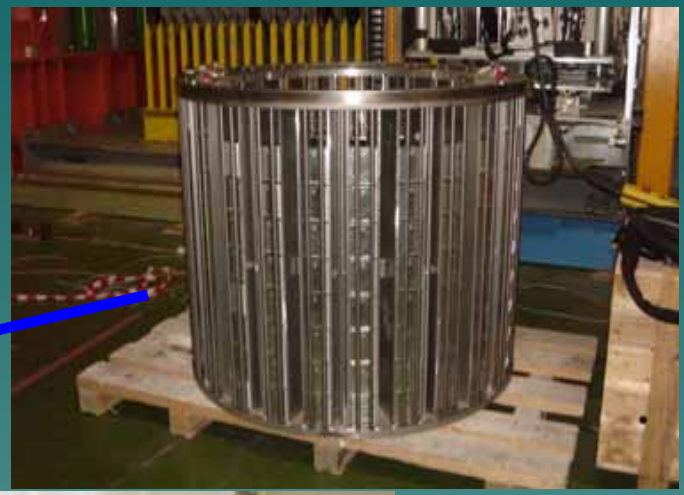
2 emulsion layers
(44 μm thick)
poured on a
200 μm plastic base

Total target mass : 1766 t
(206336 bricks, 12 M emulsions and Pb plates)

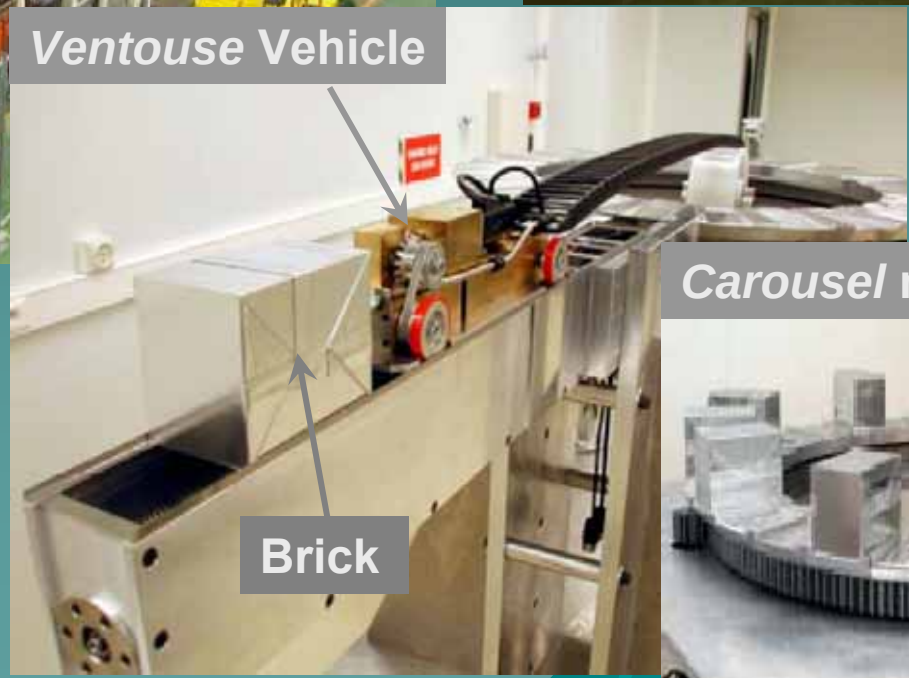
- Micro-metric space resolution (Emulsion) + target mass (Lead)
- Compact and modular structure

Brick Manipulator System

Robot for brick insertion (target filling) and removal (during run)



Ventouse Vehicle



Carousel mechanism

Automatic scanning of nuclear emulsions

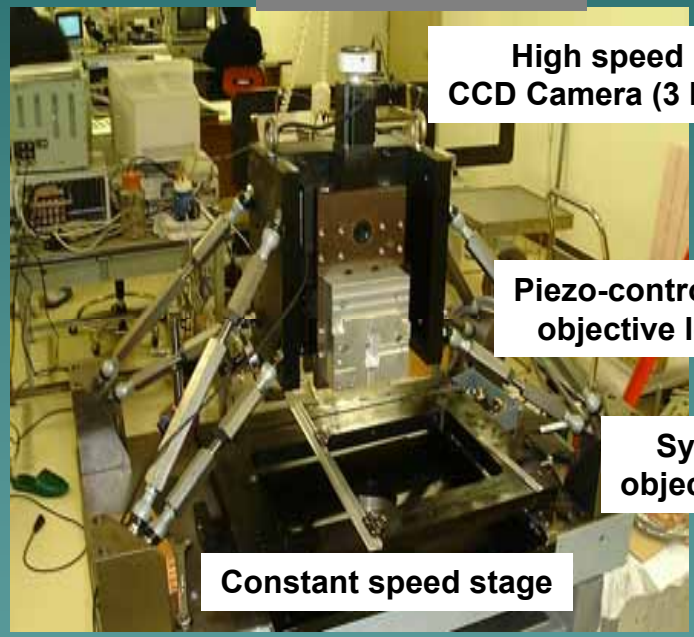
~ 30 bricks will be daily extracted from target and analyzed using high-speed automatic systems

European Scanning System

scanning speed ~ 20 cm² / h

Customized commercial optics and mechanics + asynchronous DAQ software

S-UTS (Japan)



Hard-coded algorithms

Two testing runs

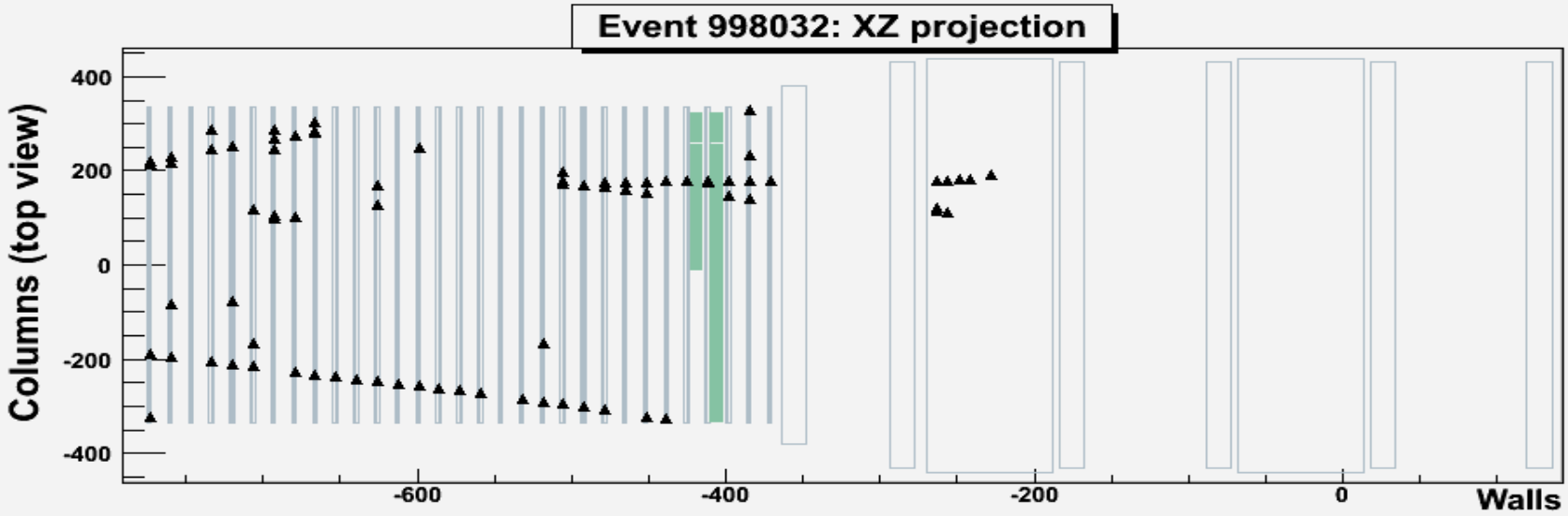
August 2006

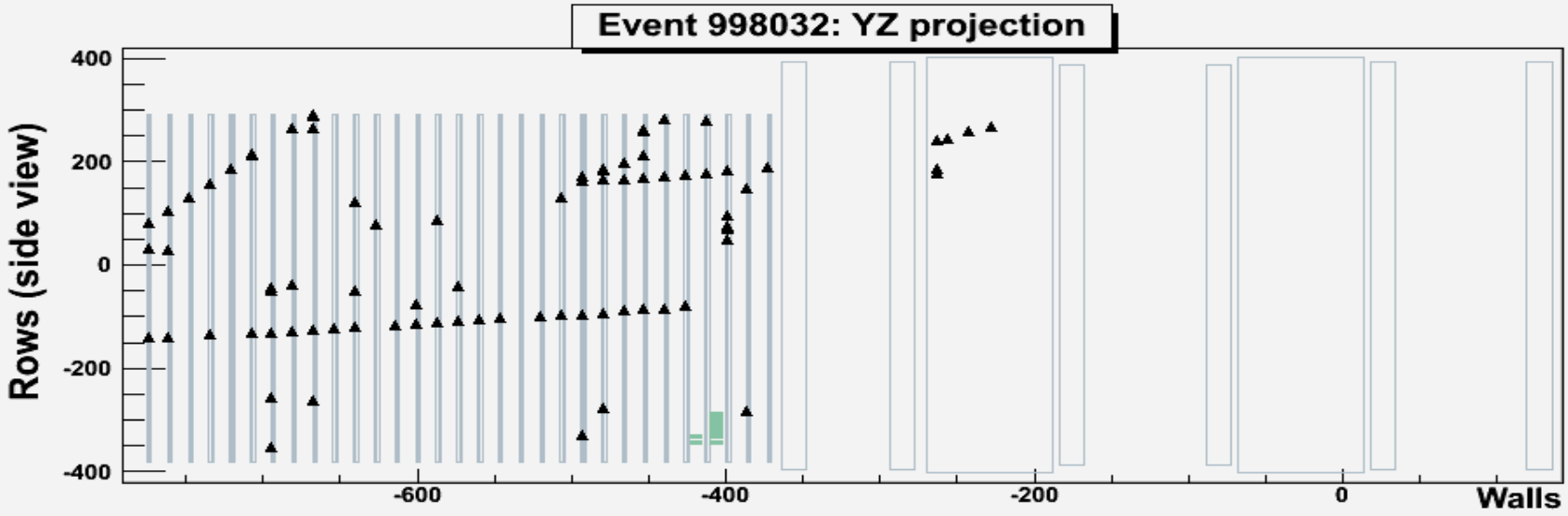
- testing CNGS beam ☺
- testing Changeable Sheet ☺

October 2006

- register events in real bricks ☹
- water leak in a reflector cooling system

There are 28 beam correlated events have been registered during october run



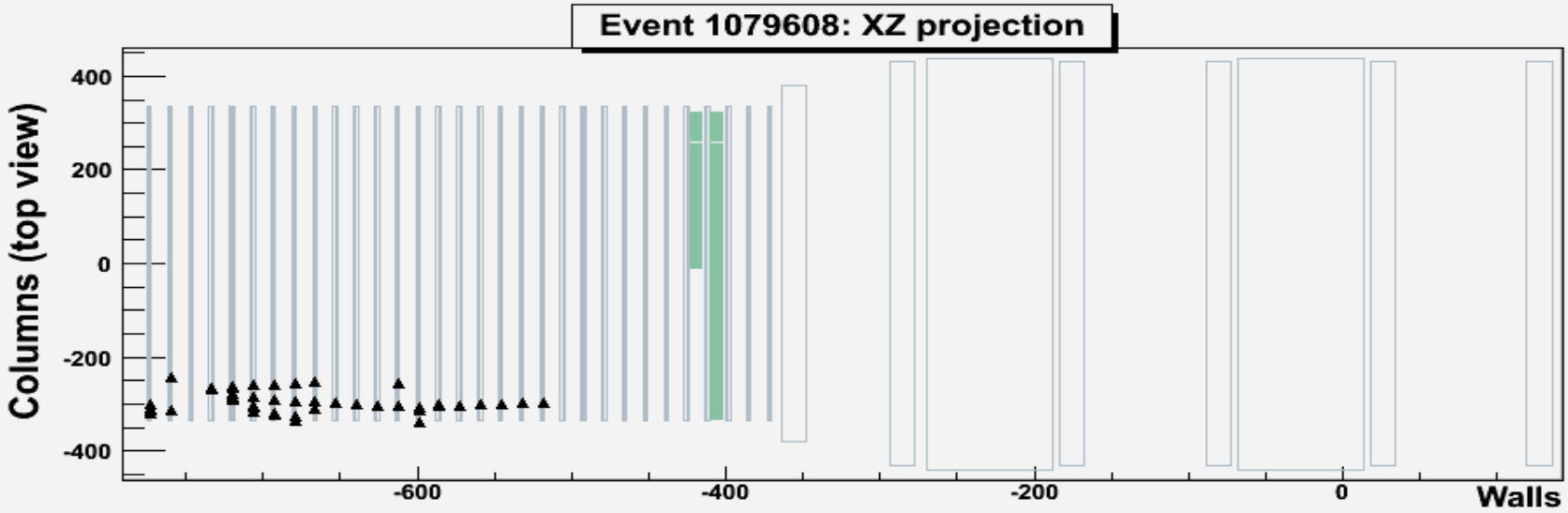


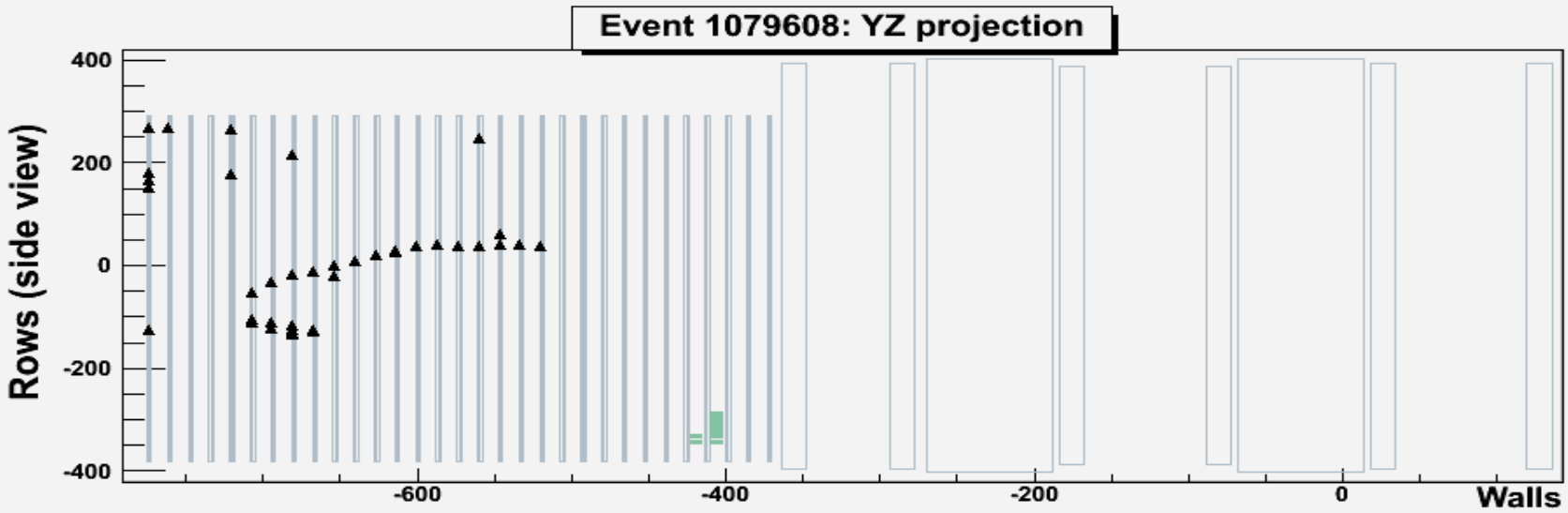
Brick finding information: Super module 1

	Wall	Column	Row	Prob
1st brick	-1	-1	-1	0.00
2nd brick	-1	-1	-1	0.00
3rd brick	-1	-1	-1	0.00

Data type: Real Data

Number of events in file: 26





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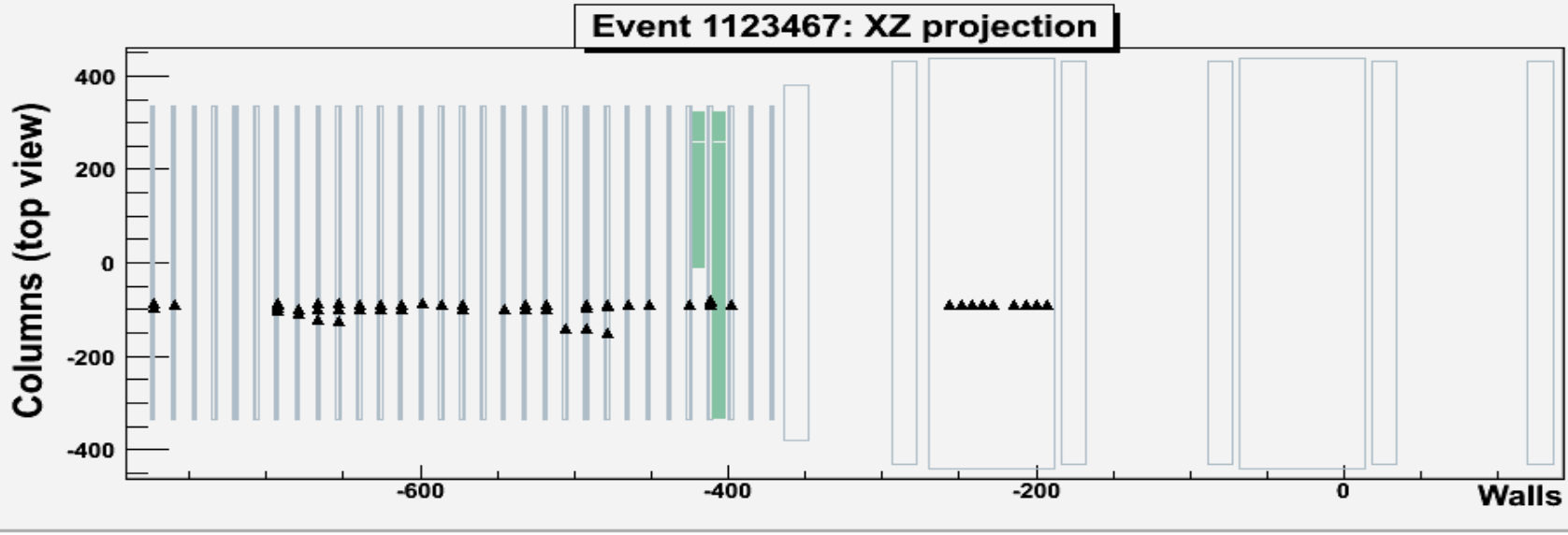

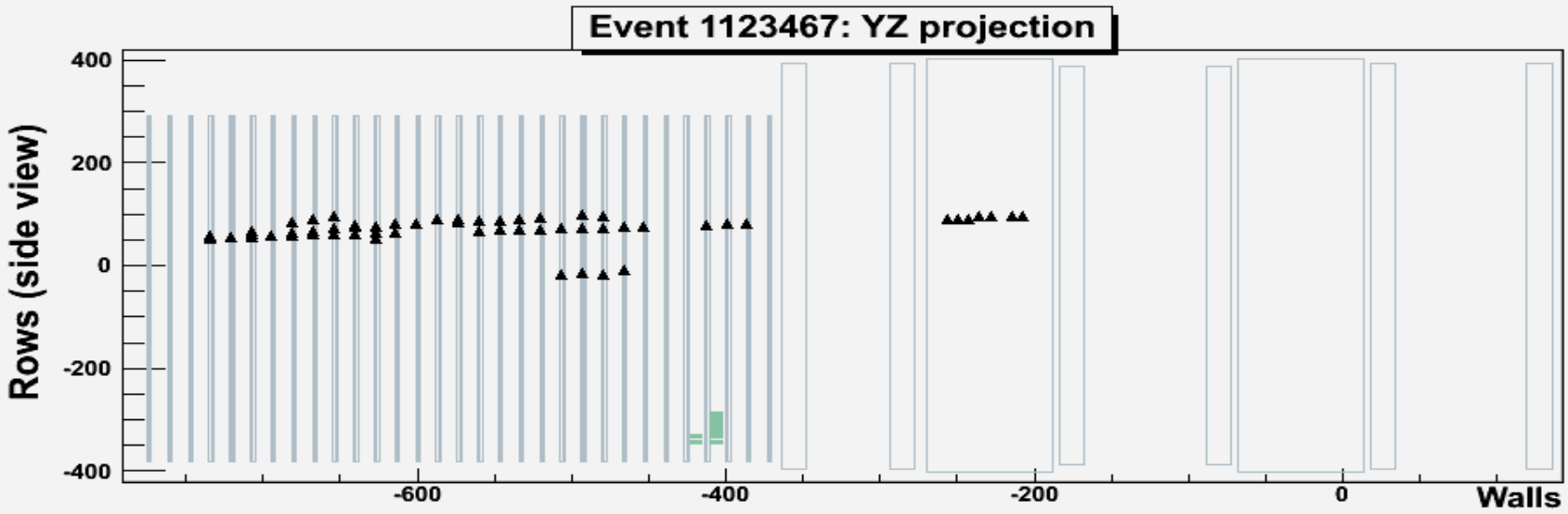

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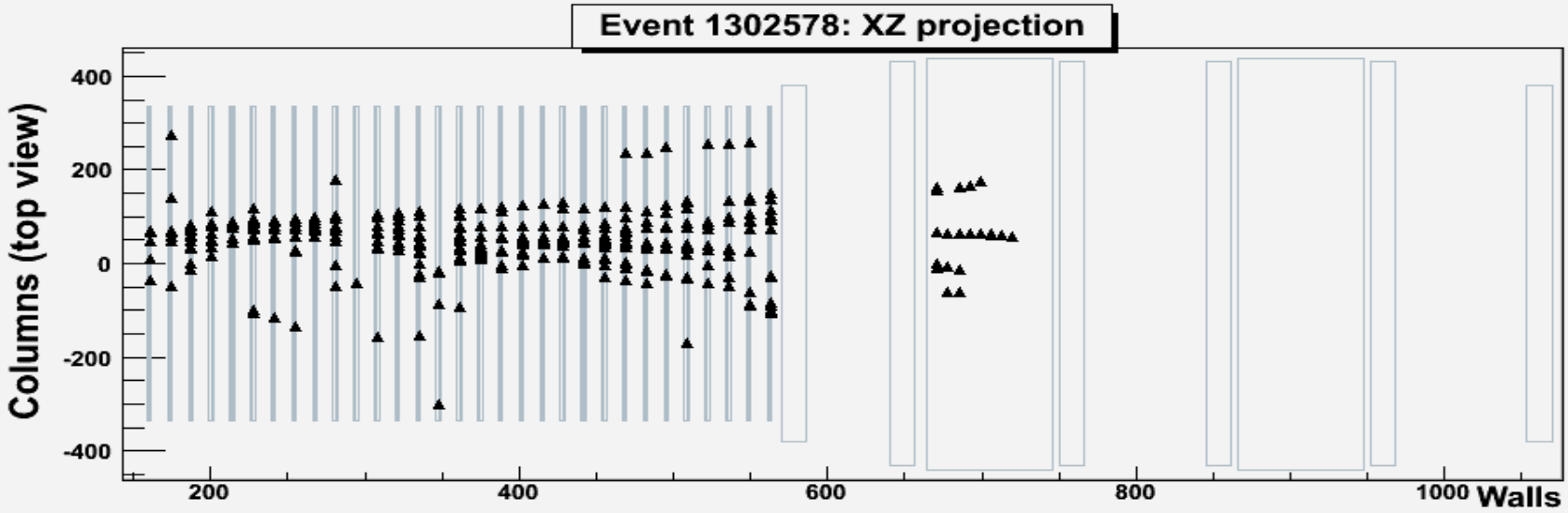
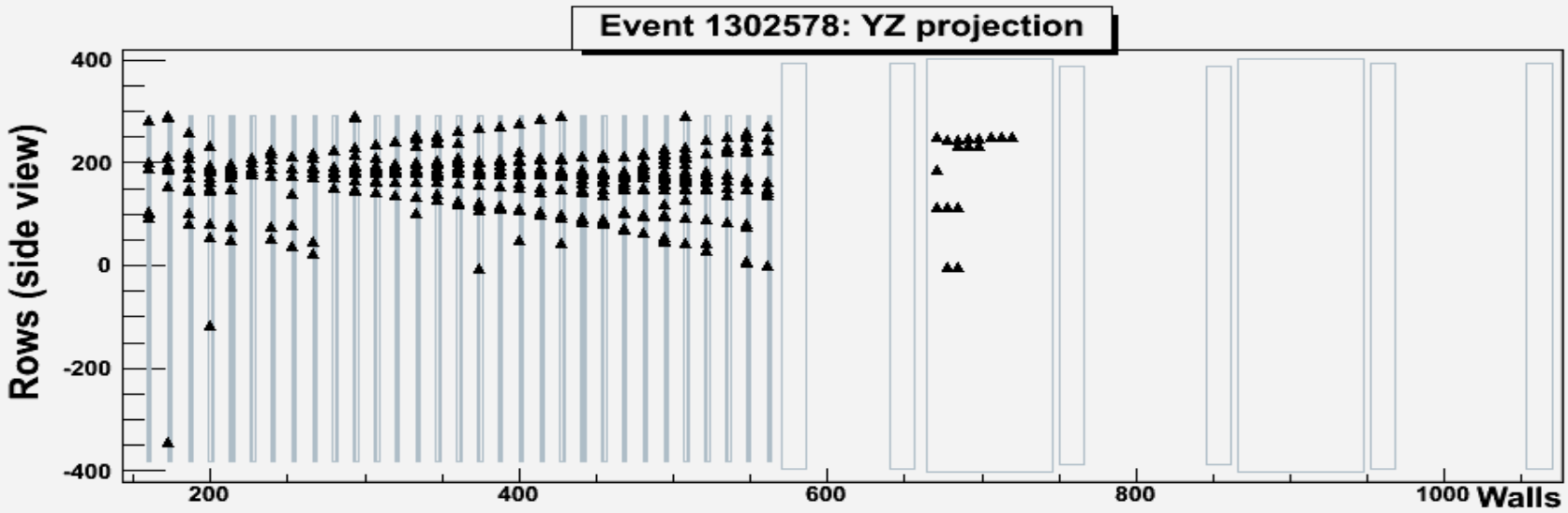
Data type: Real Data

Number of events in file: 26





Brick finding information: Super module 2

	Wall	Column	Row	Prob
1st brick	-1	-1	-1	0.00
2nd brick	-1	-1	-1	0.00
3rd brick	-1	-1	-1	0.00

Data type: Real Data

Number of events in file: 26

Brick Finder Program

Brick Finding Program requirements – high efficiency

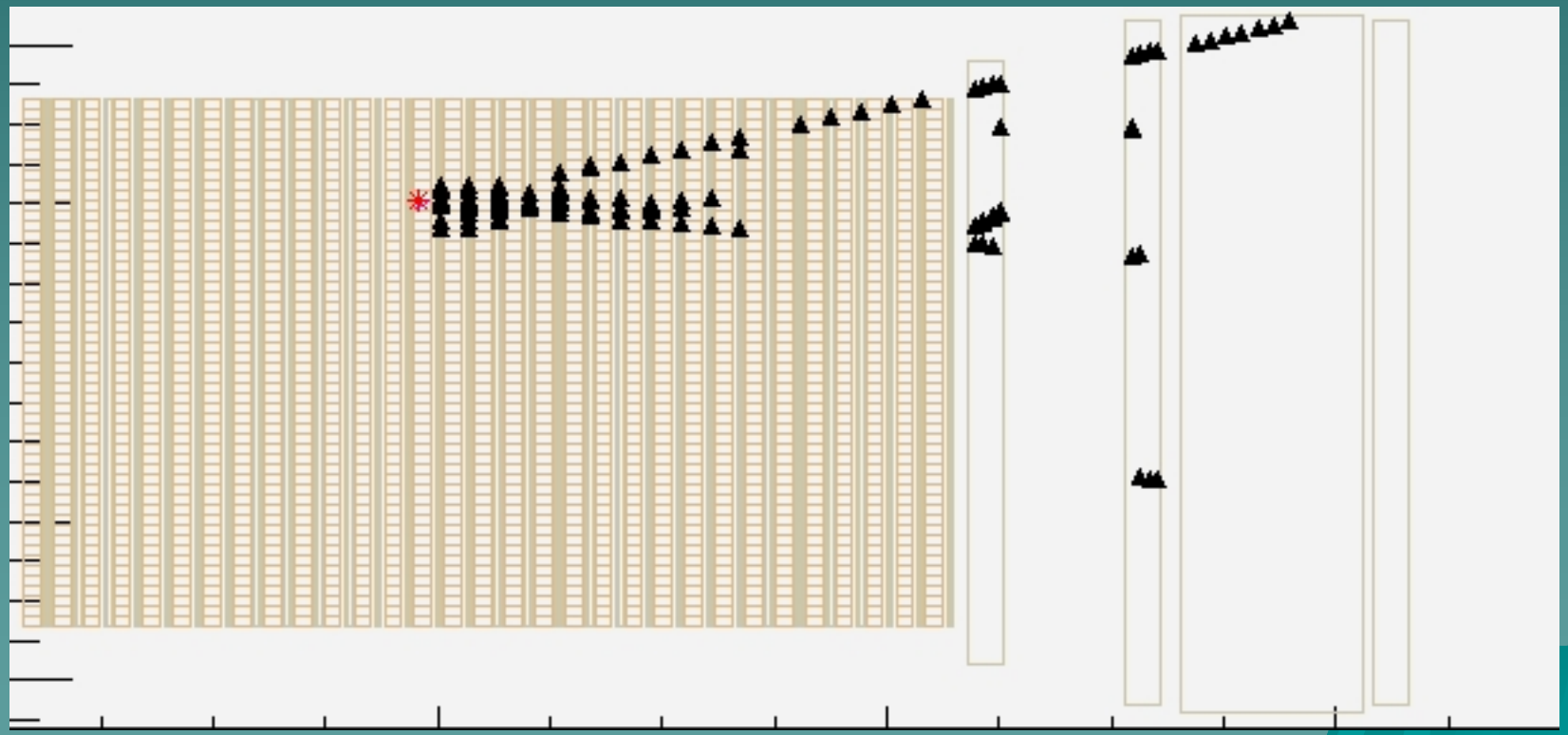
No new bricks will be inserted

(to save the effective mass of target)

~30 Bricks per day (5 years of data taking)

Cleaning Event

Cellular Automation

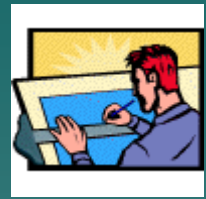


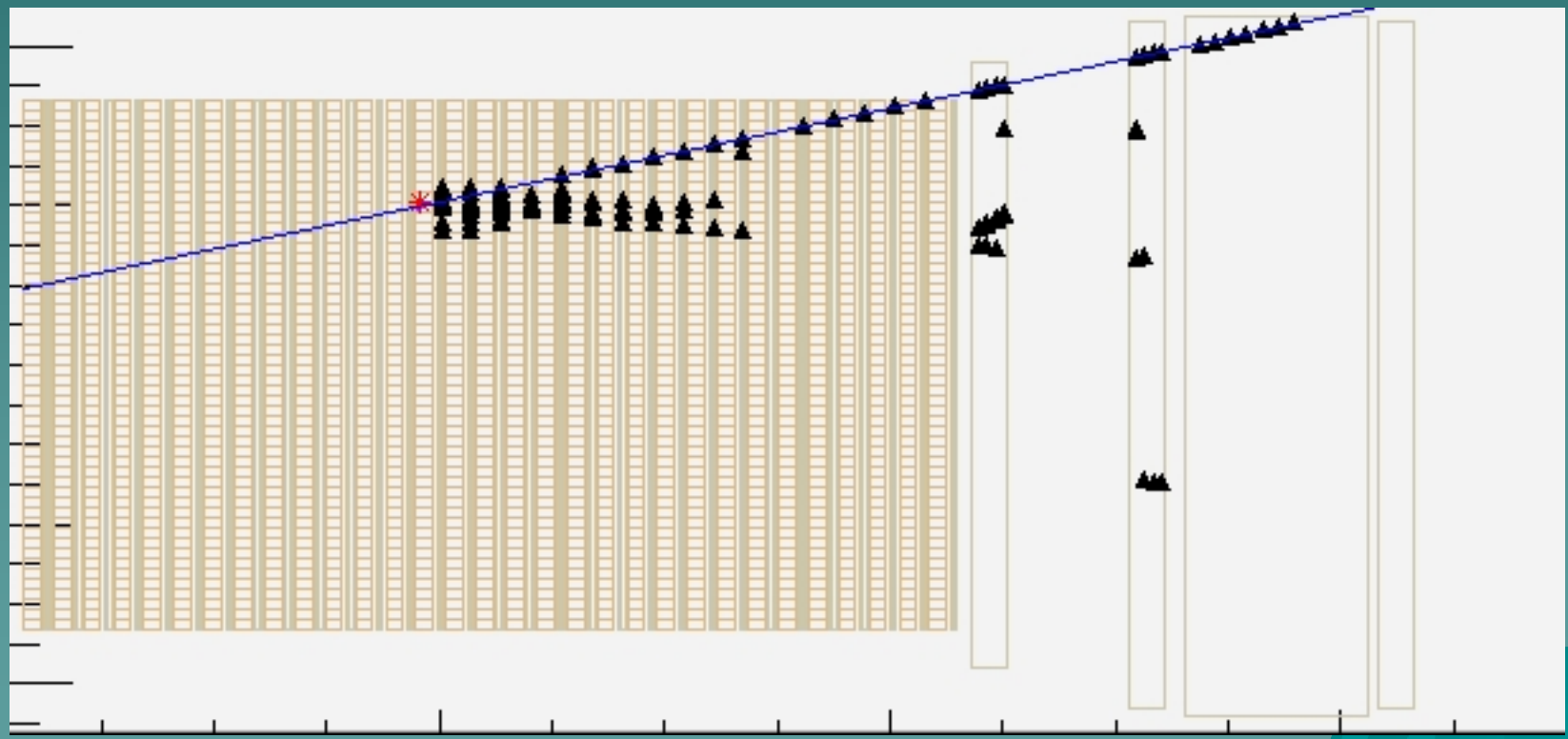
Reconstruction muon track direction

Hough Method

Kalman Filter

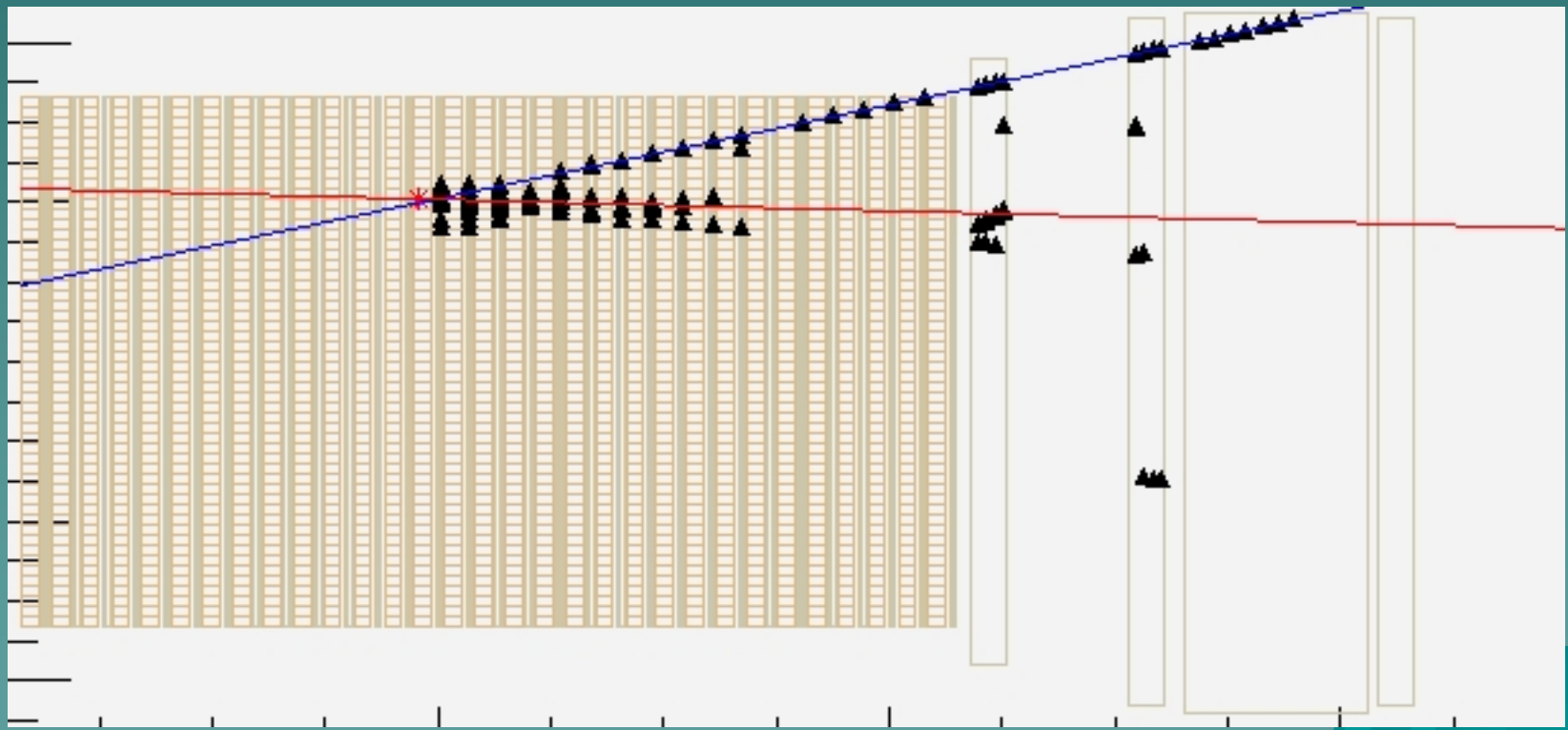
Tracing Method





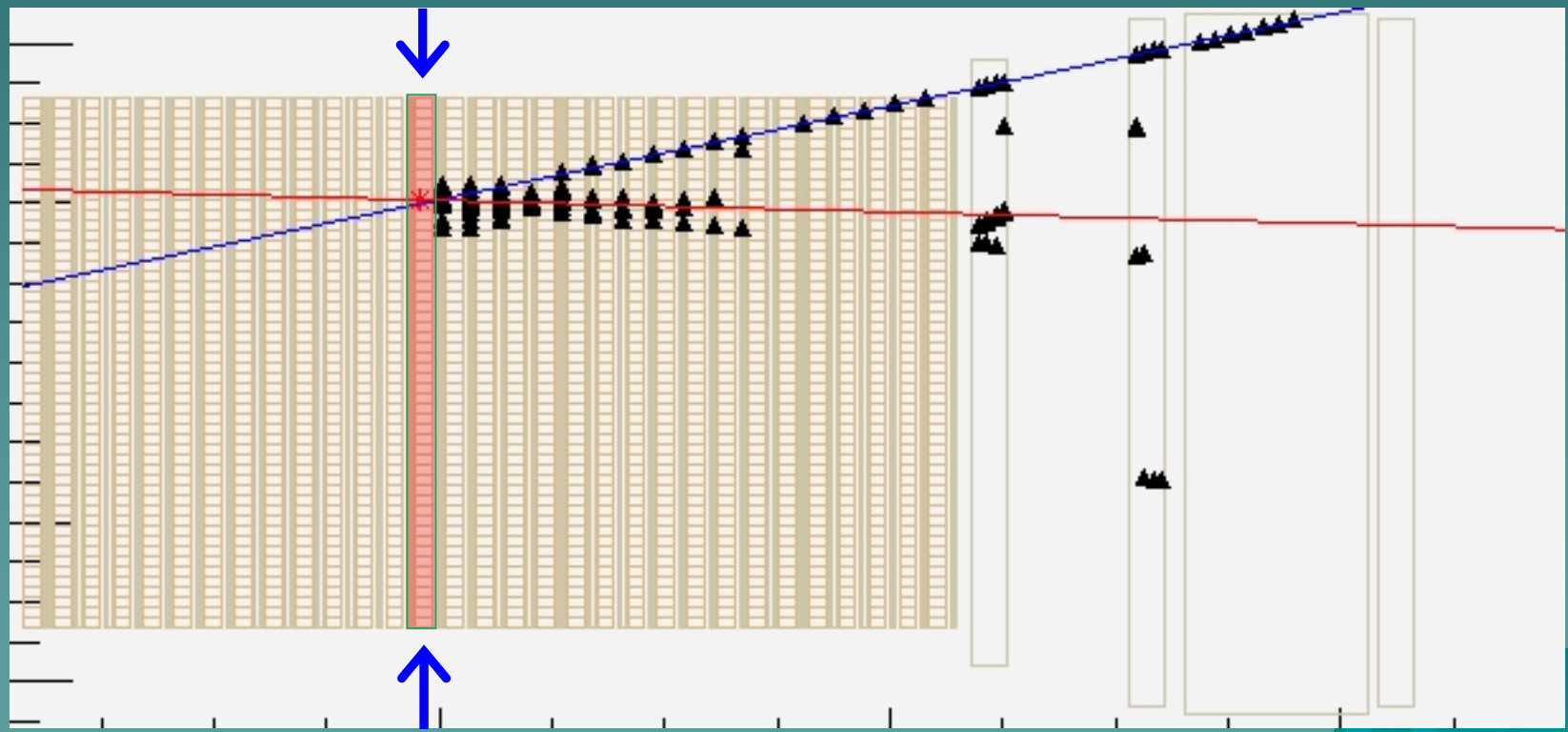
Reconstruction Hadron Jet direction

Reweighting hits method



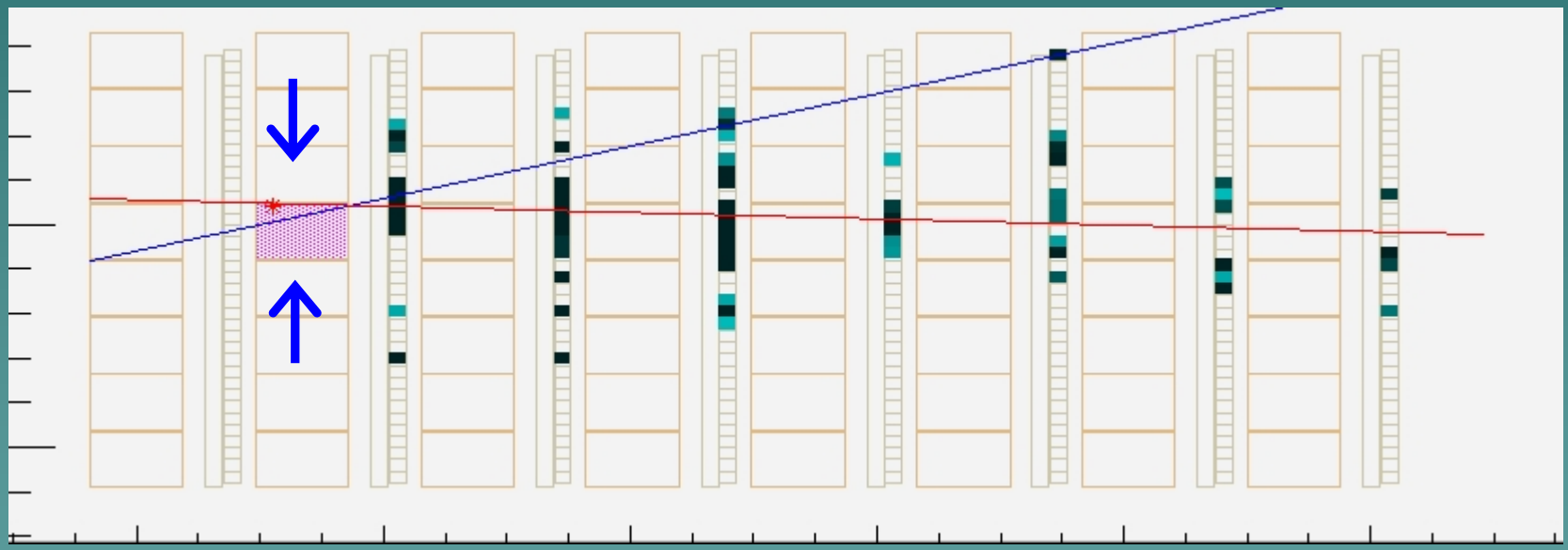
Define wall with interaction

Neural Network



Find Brick

Define most probable brick

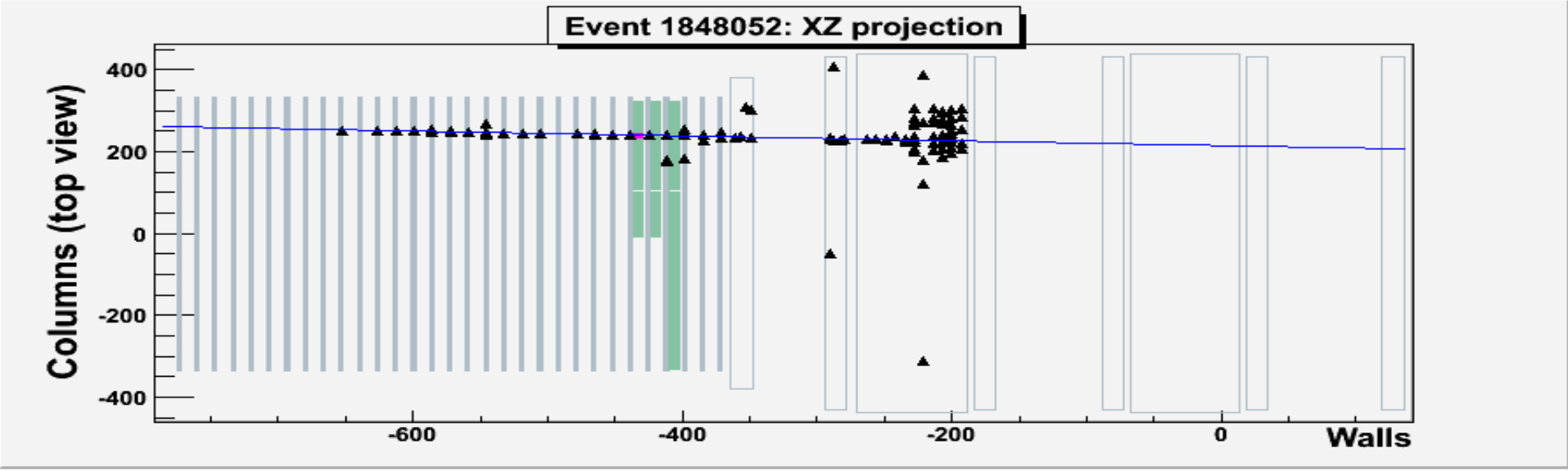


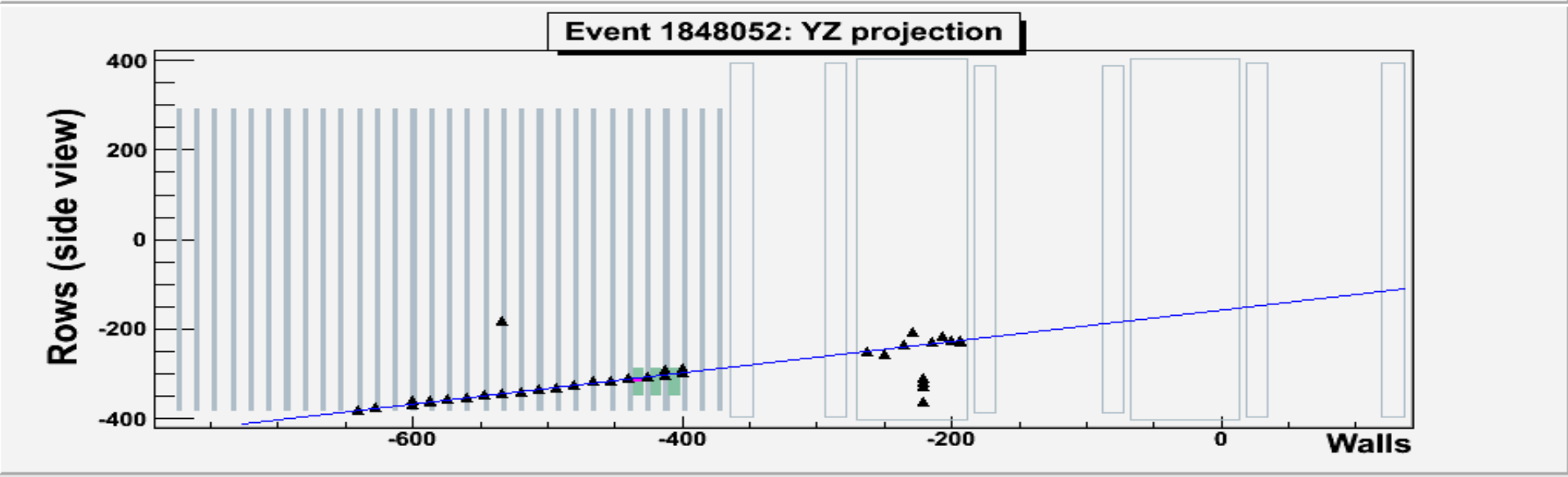
Results (ν_μ CC events)

	"1 of 3"	Full detector
Wall reconstruction efficiency:		
1 wall	**0.94**	0.85
Brick finding efficiency		
1 brick	**0.71**	0.70
2 bricks	**0.87**	0.85
3 bricks	**0.91**	0.92

Improvements

- Hits coordinate correction after TT modules alignment with the help of muon tracks (S. Zemskova analysis)
- Daily bricks map is used for the precise predictions



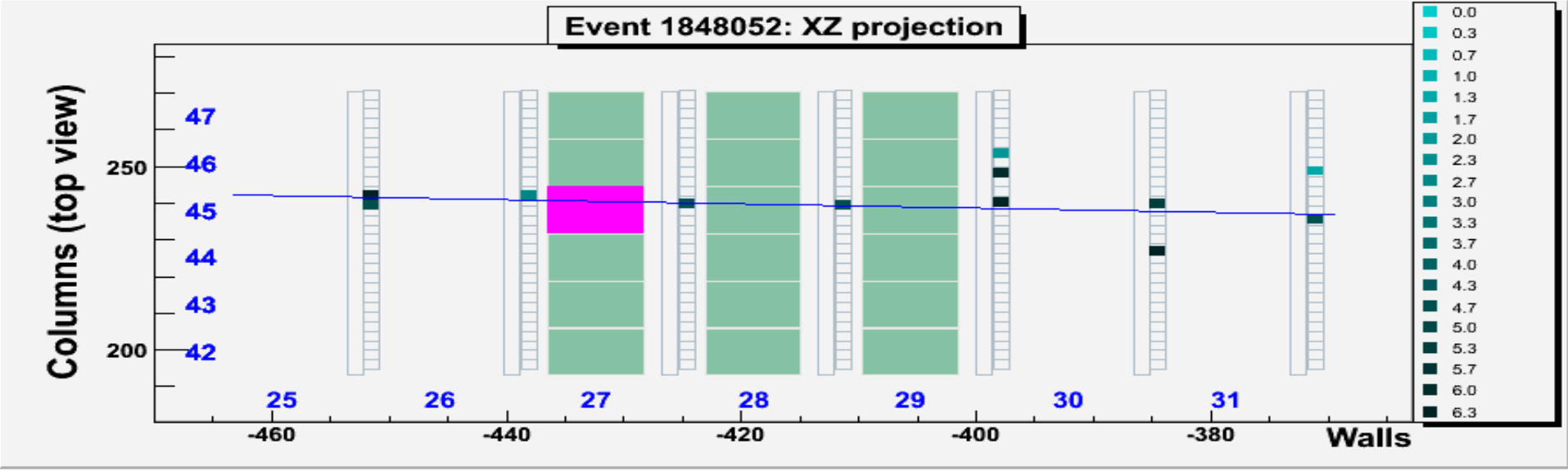


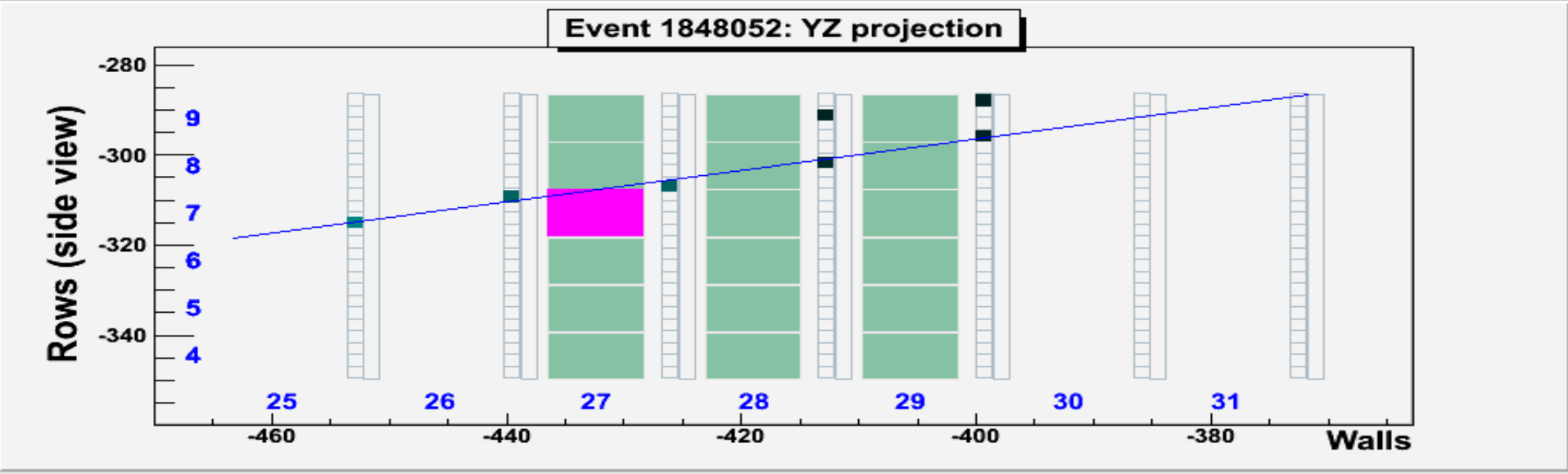
Brick finding information: Super module 1

	Wall	Column	Row	Prob
1st brick	27	45	7	0.52
2nd brick	27	45	8	0.48
3rd brick	27	46	7	0.00

Data type: Real Data

Number of events in file: 1917





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Number of events in file: 1917

Conclusion

- Developed BF program (91% efficiency)
- Daily bricks map is used for the precise predictions
- Implementation of TT alignment will be come in future