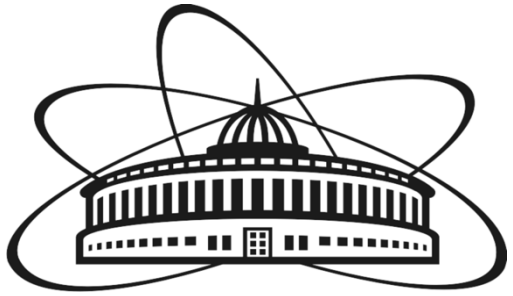


Preliminary Test Beam Results for the Muon Range System Prototype

Alexander Verkheev (DLNP, JINR)
for the SPD Muon System Group

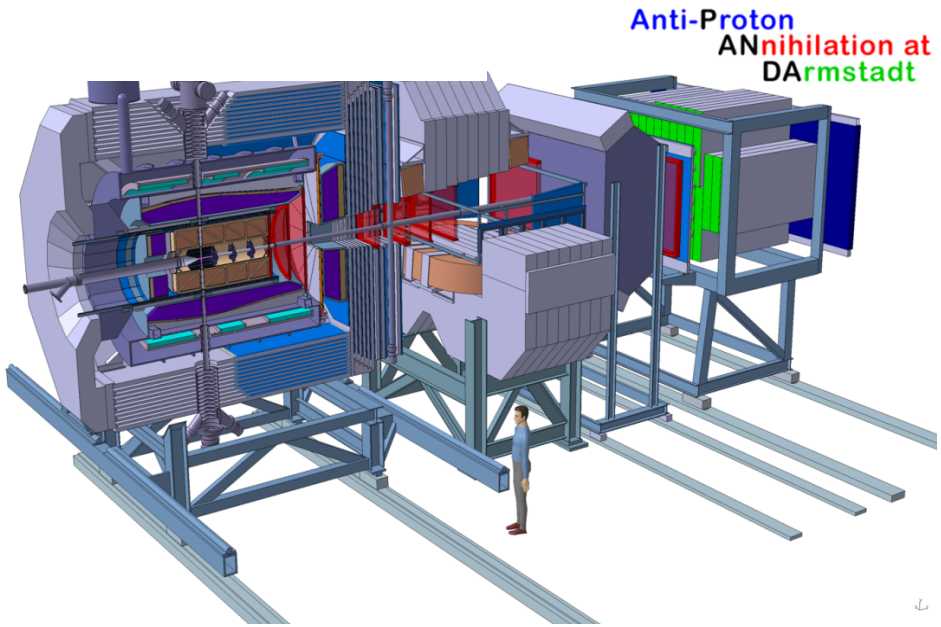
9-13 July 2018

Outline

- PANDA experiment and Muon System Detector
- SPD Muon System Design
- Results for the Muon System Prototype at CERN

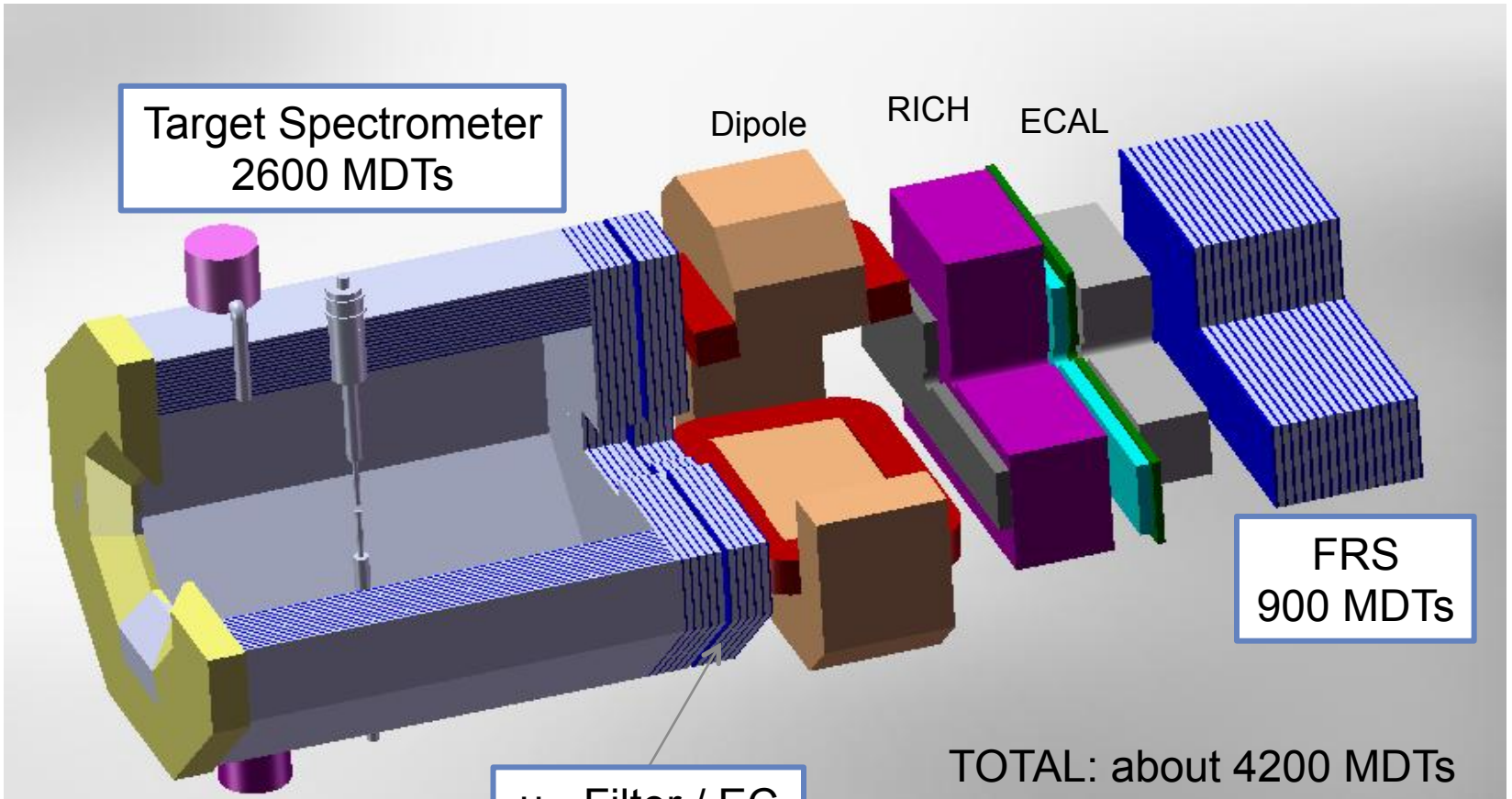
PANDA/FAIR Setup

Topics of research: hadron structure and spectroscopy, strange and charm physics, hypernuclear physics with anti-proton beams.



- ppbar, pbarA collisions
  p = 1.5 – 15 GeV/c ,
  (√s from 2.25 up to 5.46 GeV)
- Luminosity up to
  $2 \cdot 10^{32}$ $cm^{-2}s^{-1}$
- Nearly 4π solid angle for large acceptance
- Tracking : ~50 μm vertex resolution
- Different PID techniques for π±, K±, e±, μ±, γ identification, good momentum resolution

PANDA/FAIR Setup



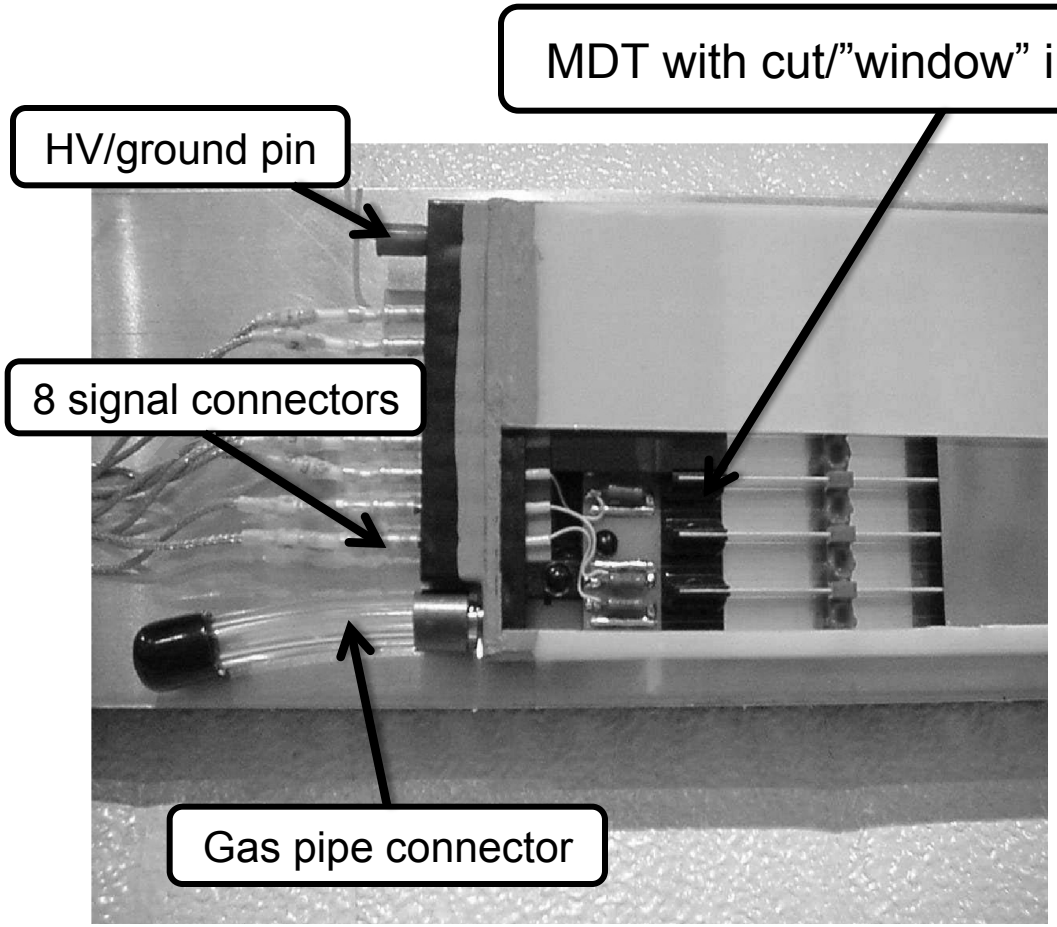
TOTAL: about 4200 MDTs

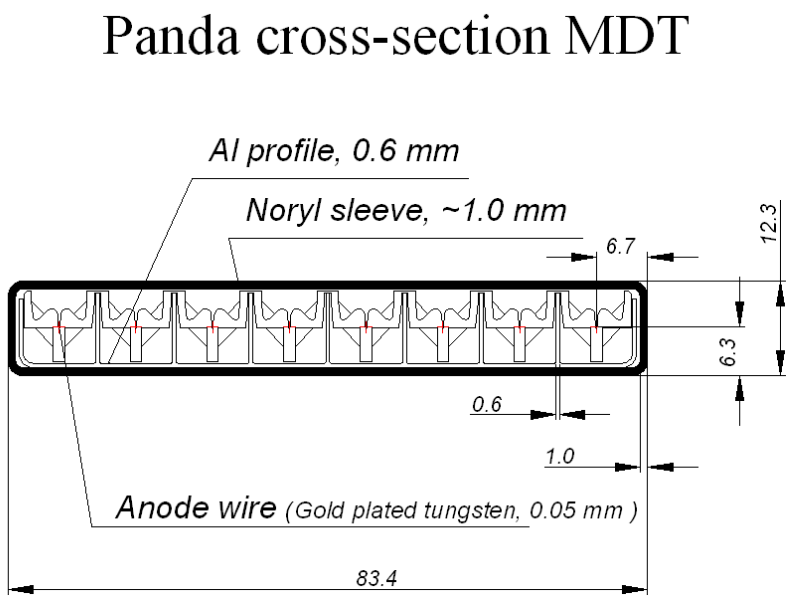
Muon System indicated in blue

Muon System as PID

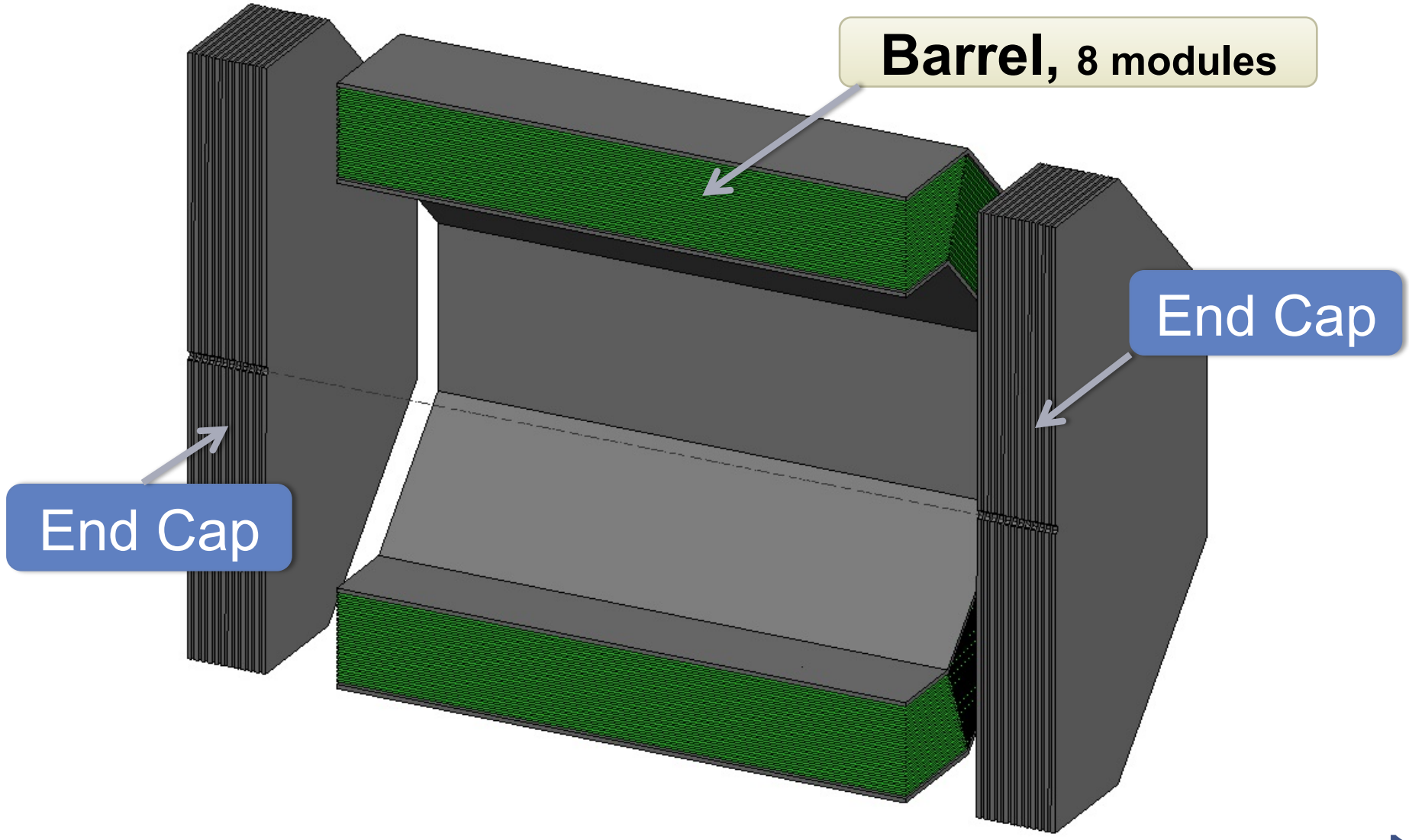
- PANDA/FAIR (SPD/NICA) Muon System based on range system technique is a good PID system for muon-to-hadron separation.
- It works in full energy range of secondary particles at PANDA (0.5 ÷ 10 GeV).
- It resolves muons and hadrons with ~ 100% efficiency (zero hadron contamination) above ~ 1 GeV by obviously different response pattern.
- Separation of muons vs pions (the main rival) below 1 GeV is less efficient and requires test beam measurements for calibration.
- Important feature of range system is possibility to be used as coarse sampling (30 mm to 60 mm of Fe in our case)
  hadron calorimeter – > very important for neutron registration!

Mini-Drift Tube (MDT) Detector as Basis for the Muon System



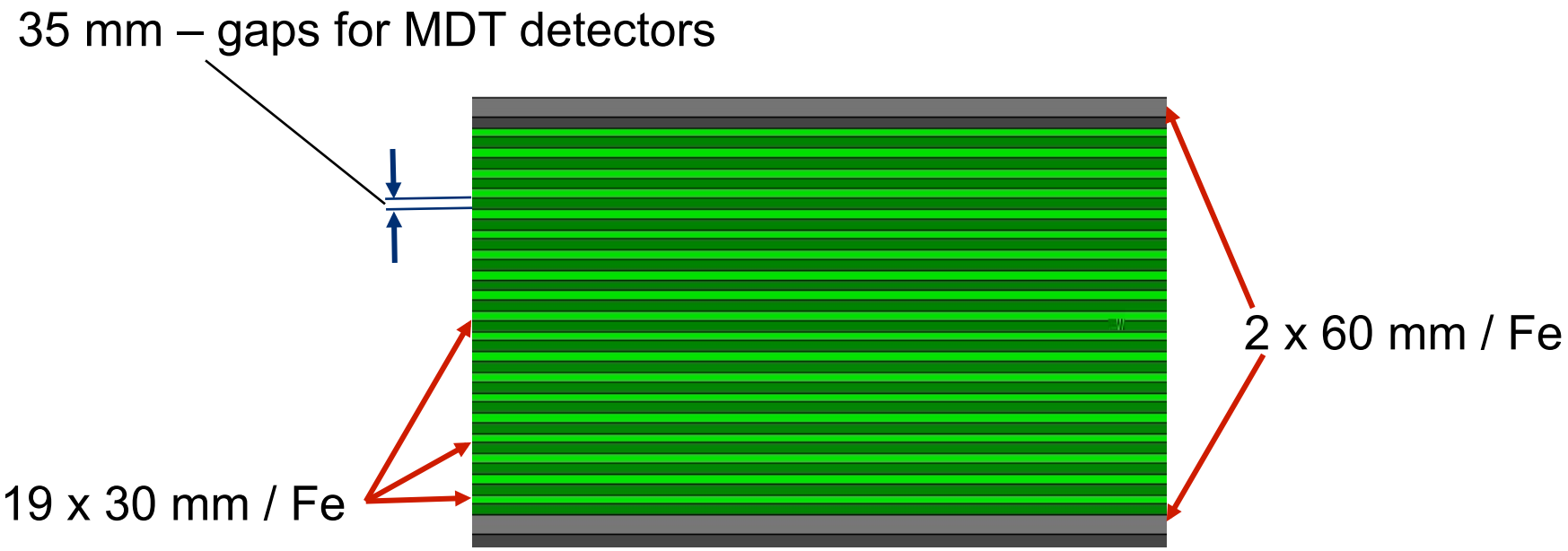


SPD/NICA Range System



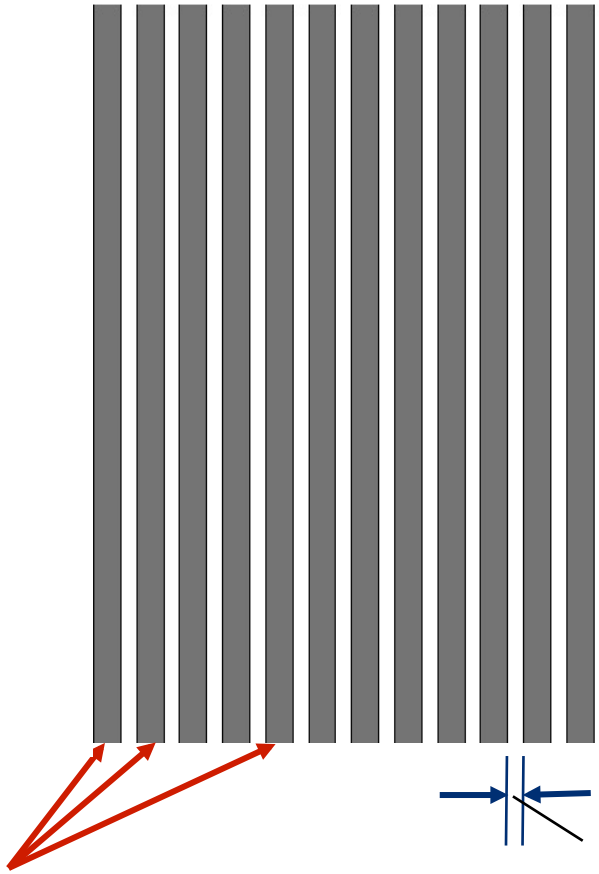
3D model, vertical cross section

SPD Barrel Structure (Cross Section)



2 layers x 60 mm + 19 layers x 30 mm => Nuclear interaction length (4.1 λ_I)

SPD End Cap Structure (Cross Section)

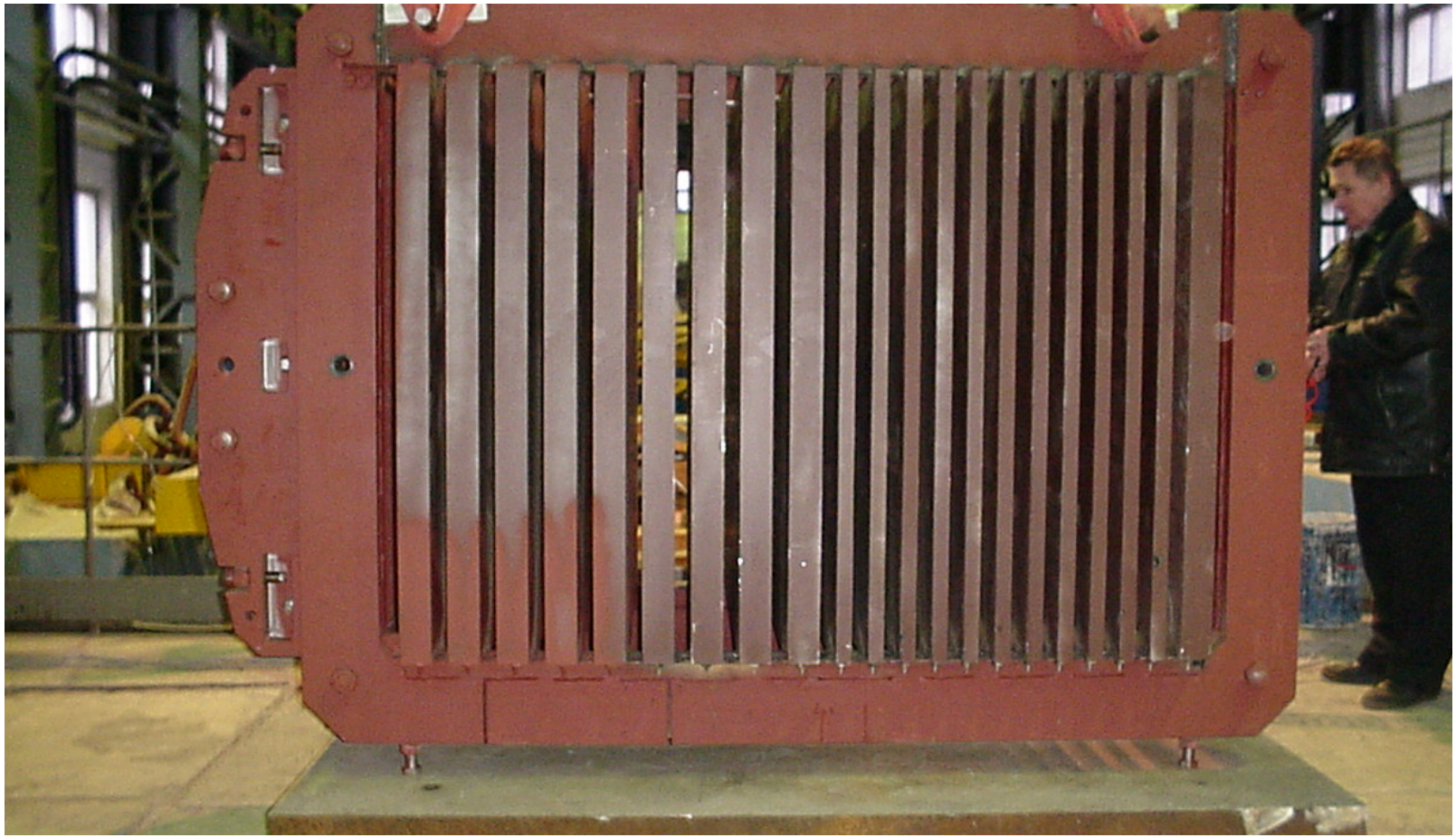


12 x 60 mm / Fe

35 mm – gaps for MDT detectors

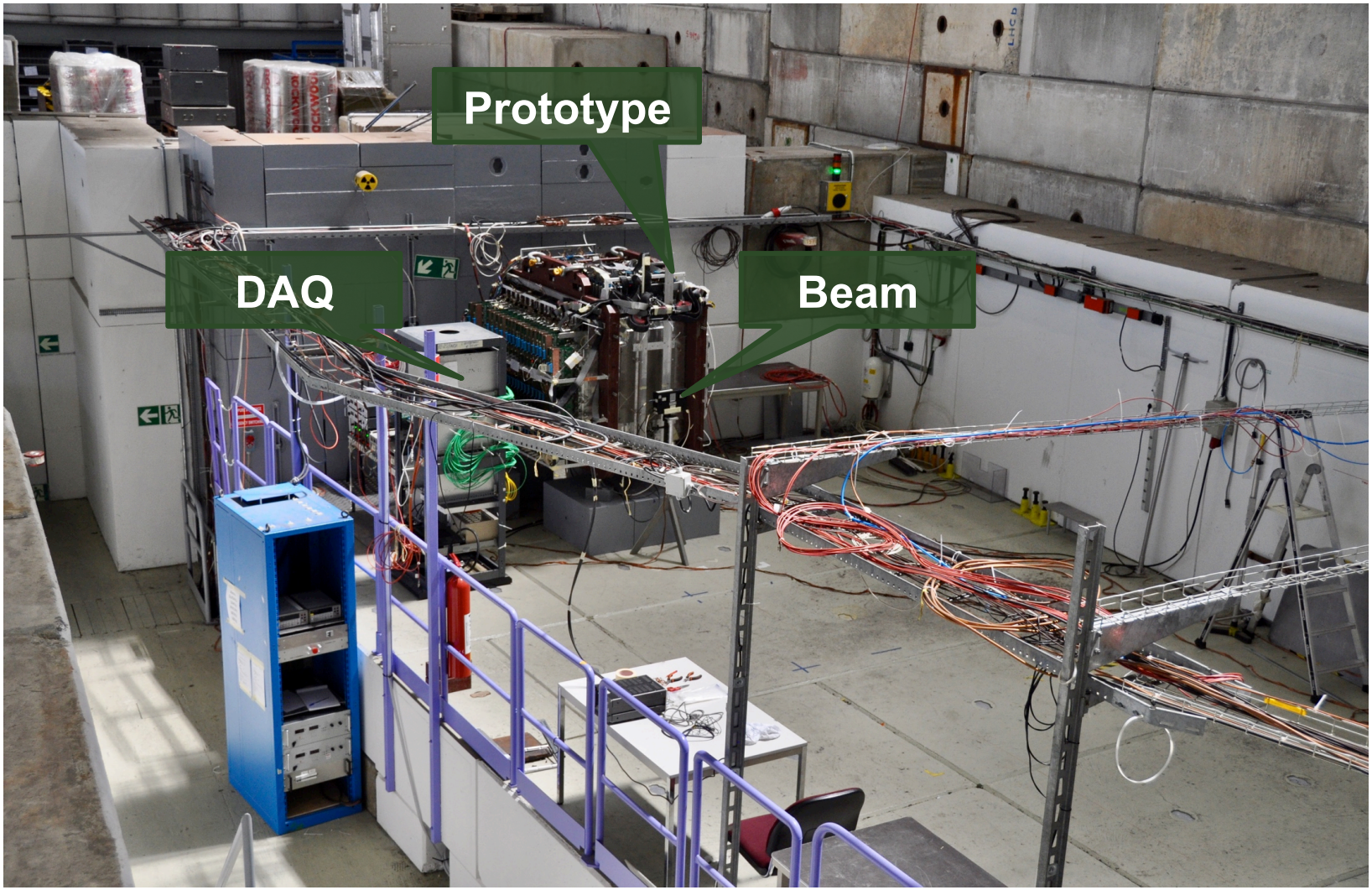
12 layers x 60 mm => Nuclear interaction length (4.3 λ_I)

PANDA Range System Prototype

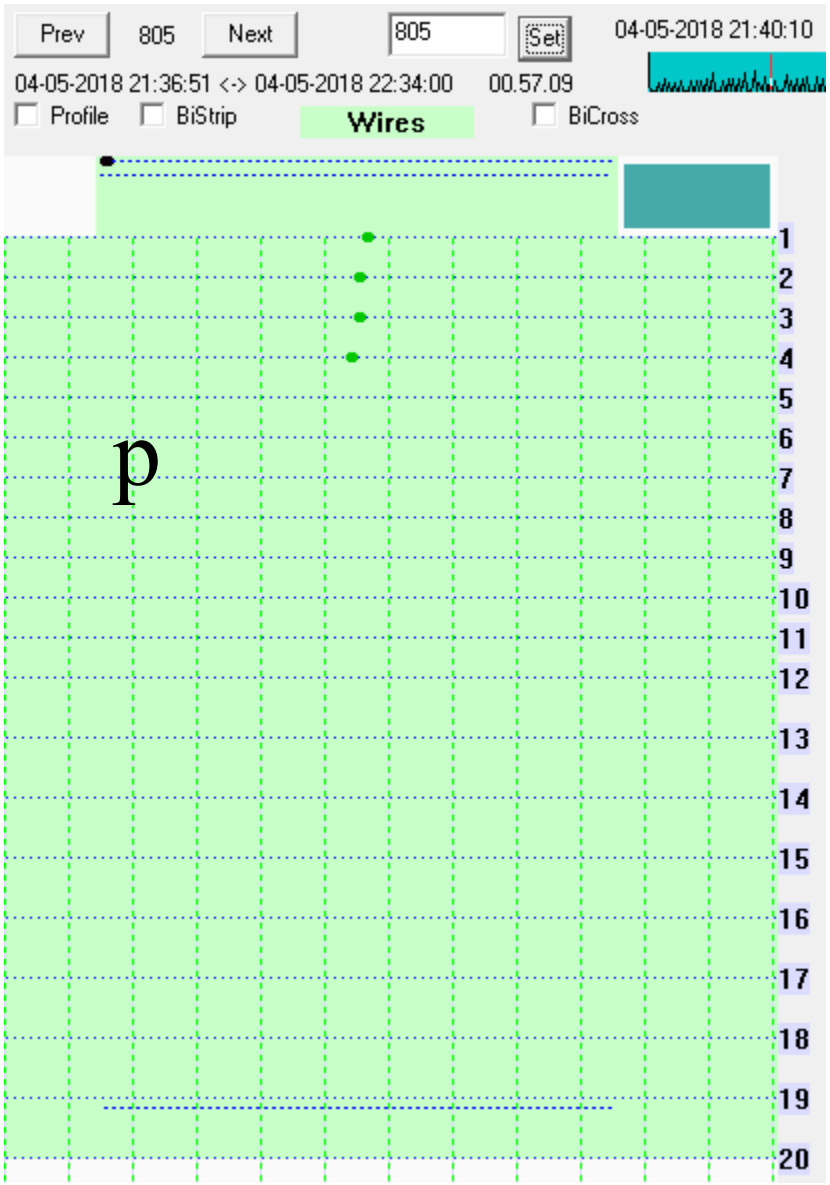


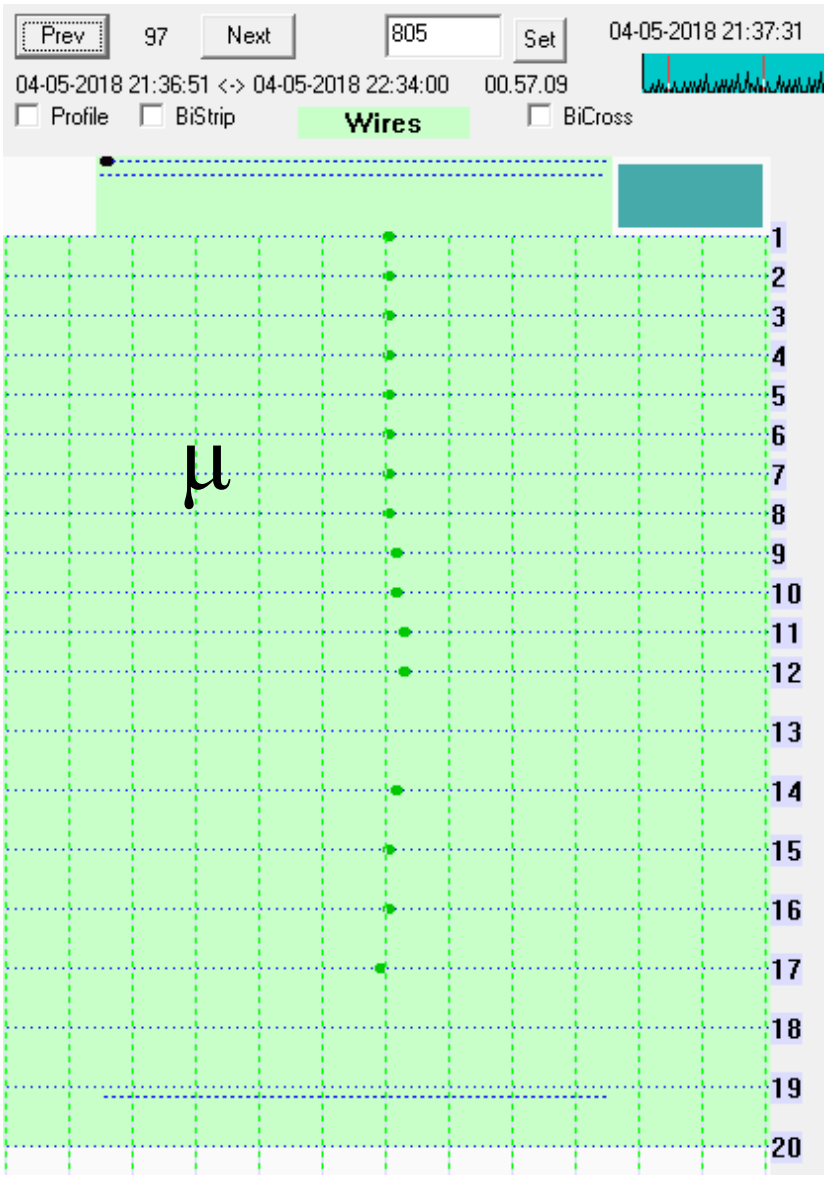
The absorber structure in horizontal position

PANDA Muon System Prototype @ PS/T9/CERN Beam Line

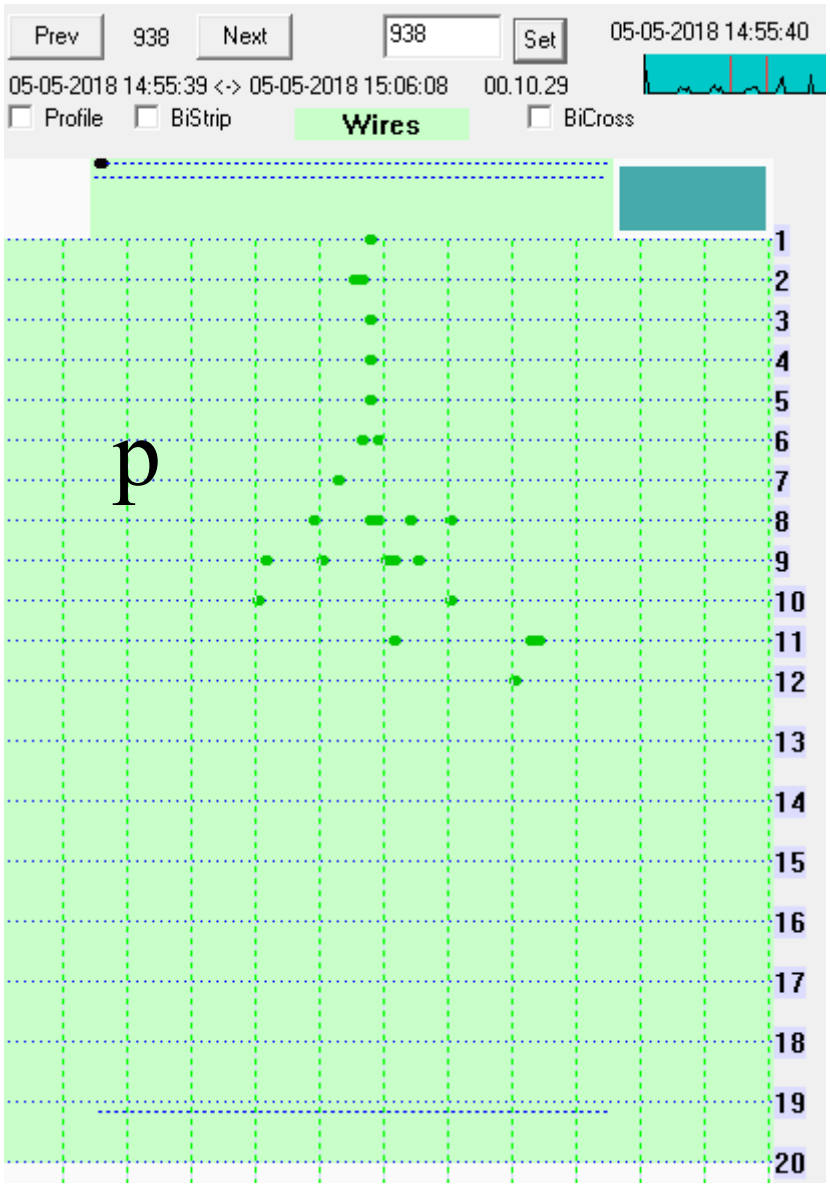


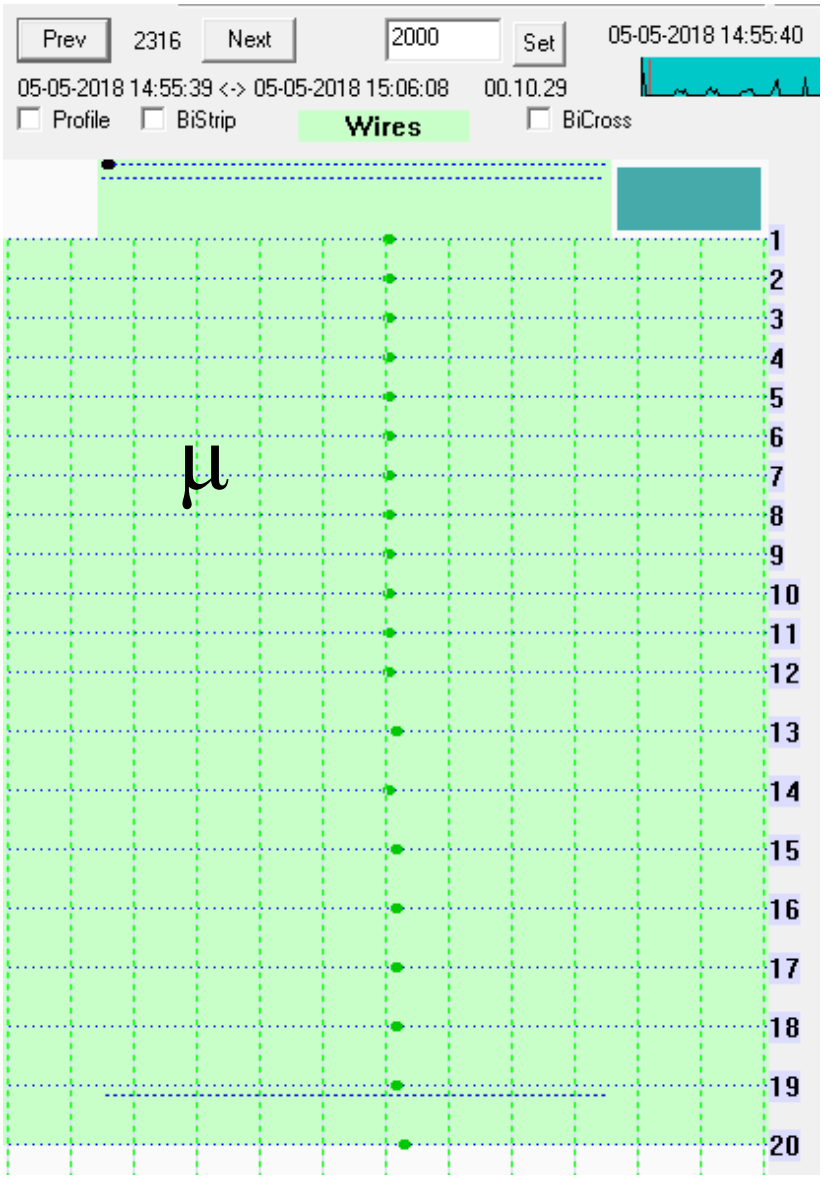
Event Examples (Run 822, P = 1 GeV/c)



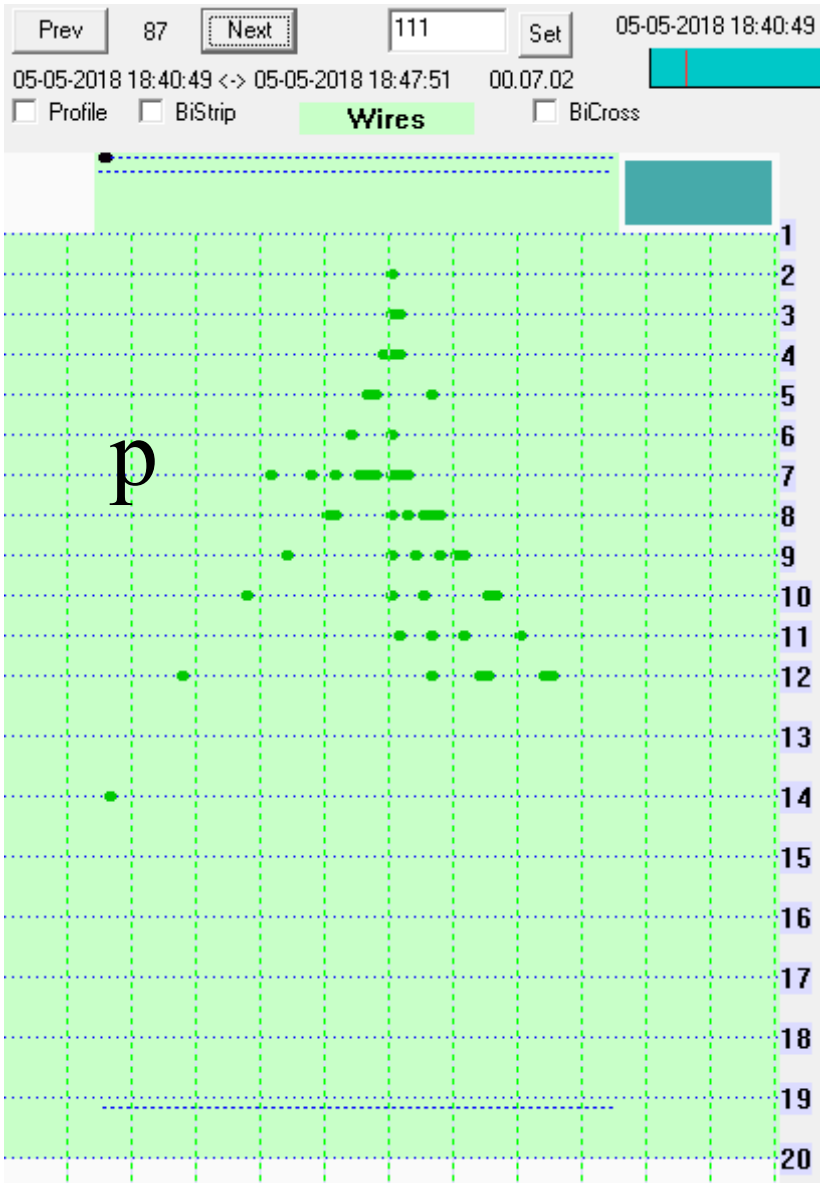


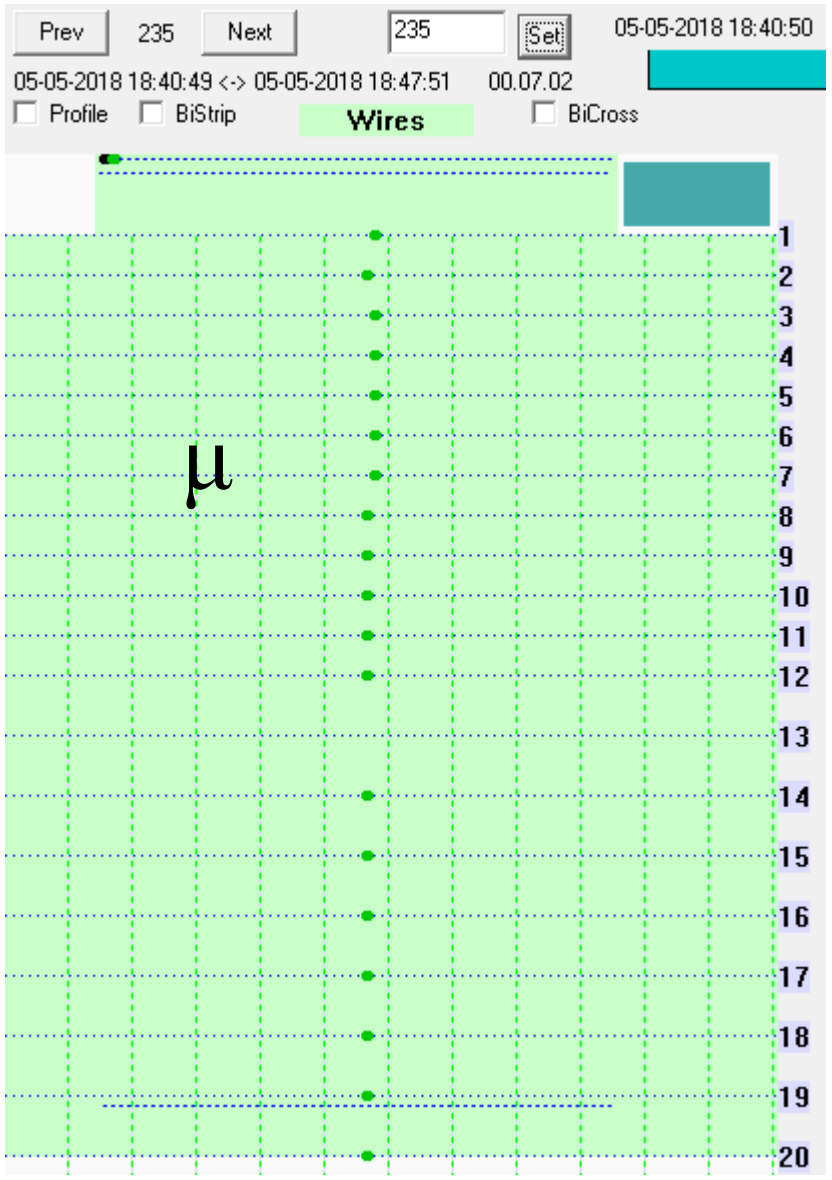
Event Examples (Run 829, P = 5 GeV/c)





Event Examples (Run 835, P = 10 GeV/c)



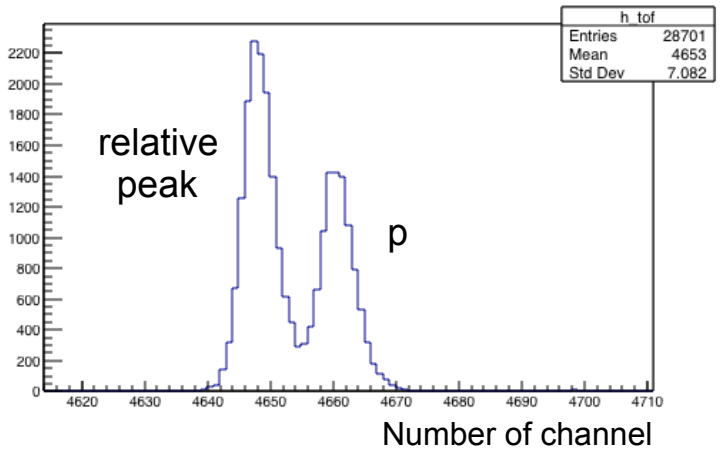


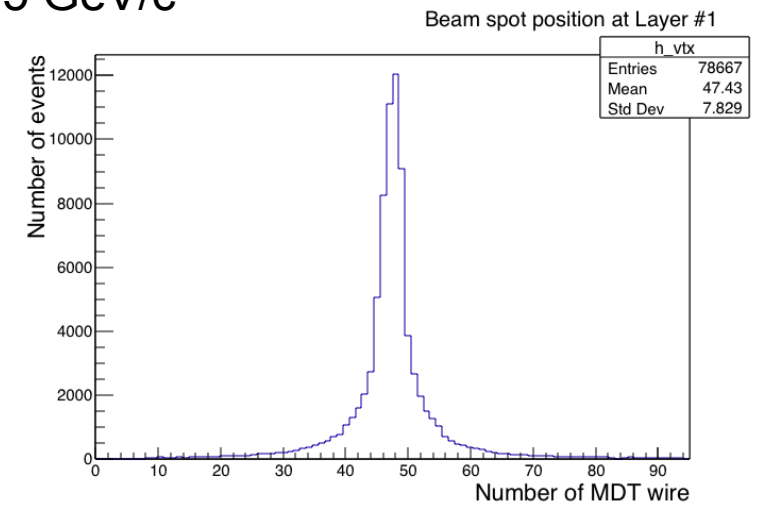
Selection Criteria for protons and antiprotons

For Calorimetry we estimate the energy of protons (antiprotons) by measuring the number of hits in event

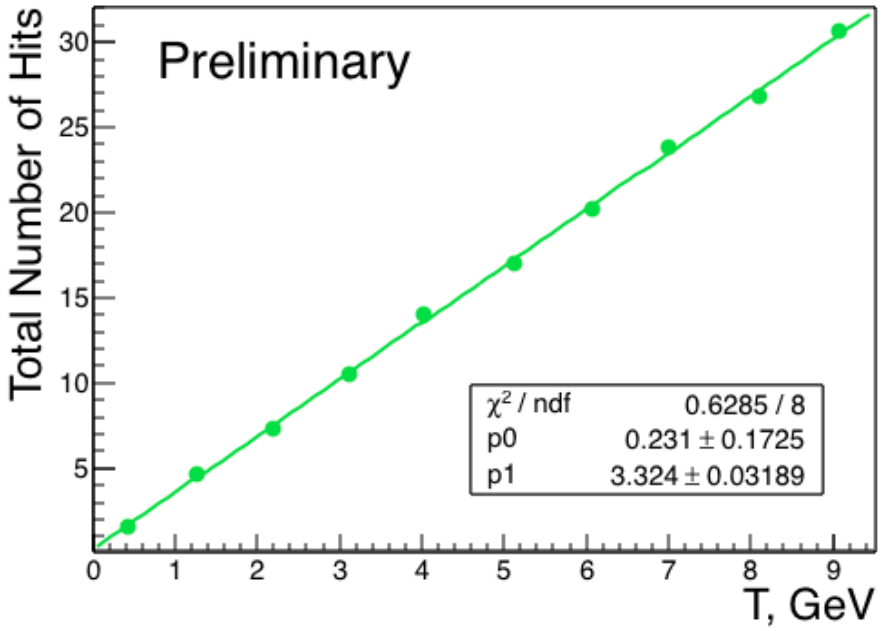
1) Two scintillation counters of the TOF system (up to 5 GeV/c)
2) Cherenkoff counters (> 5 GeV/c)
   Cher(A): 2 bar of CO_2 <-> reject electron/pion/muon
3) Beam entrance spot

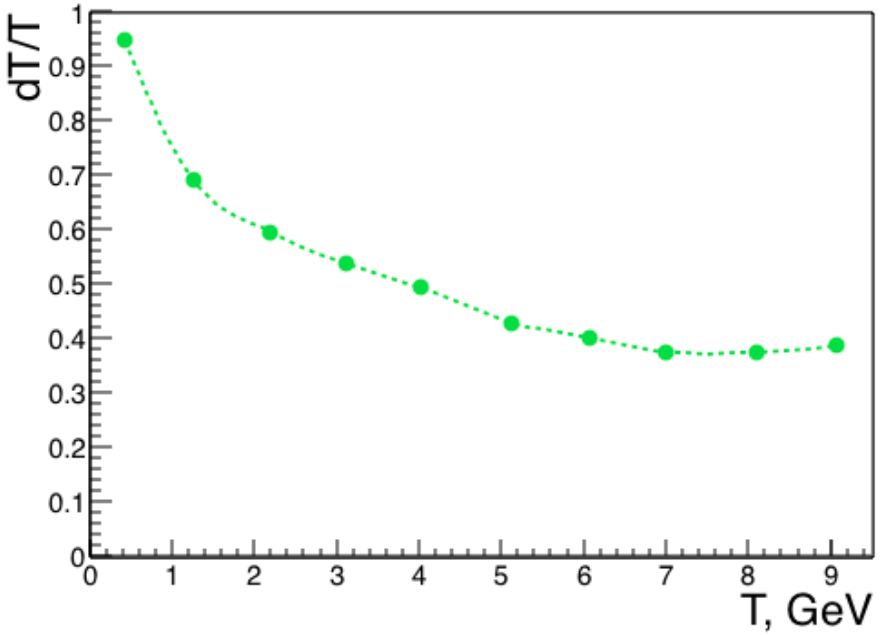
Run 829, P = 5 GeV/c





Calorimetry: PANDA FRS Structure

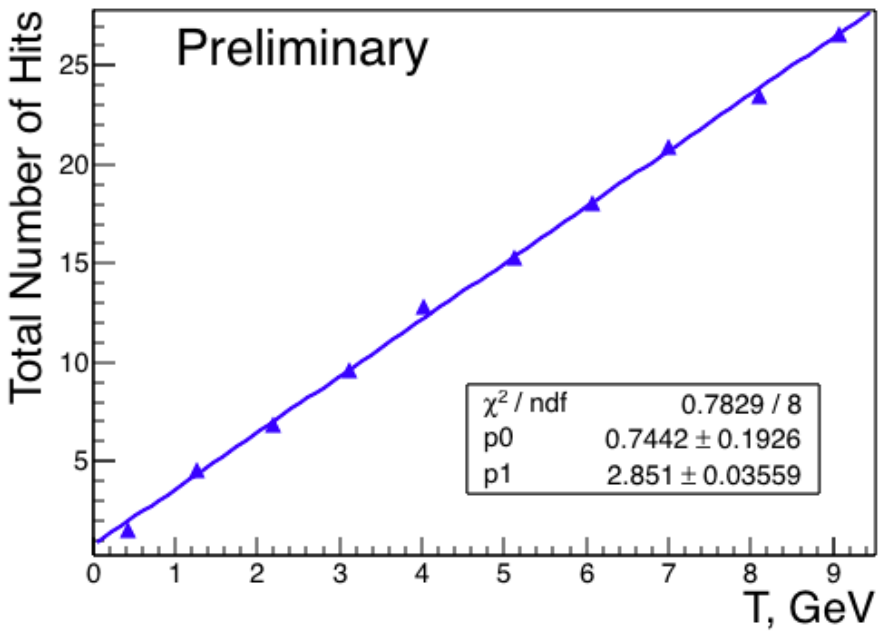


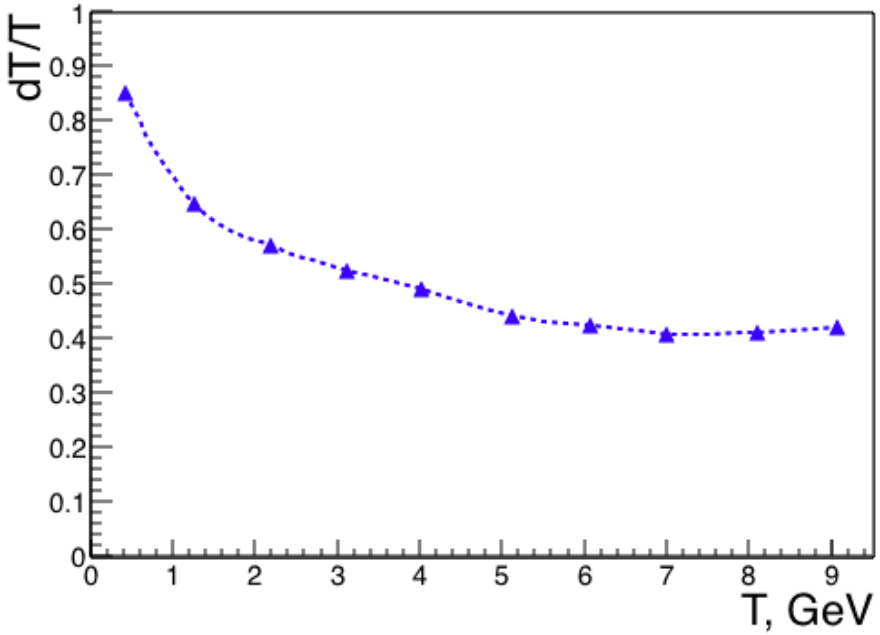


Sampling: 60 mm / Fe

Nuclear interaction length $\lambda_I \approx 5.2$

Calorimetry: PANDA MF+EC Structure

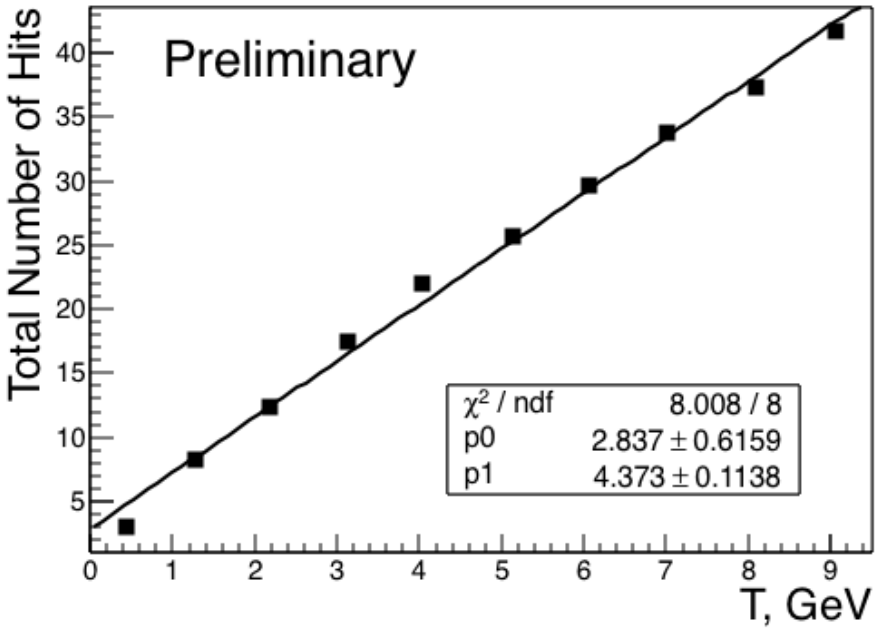


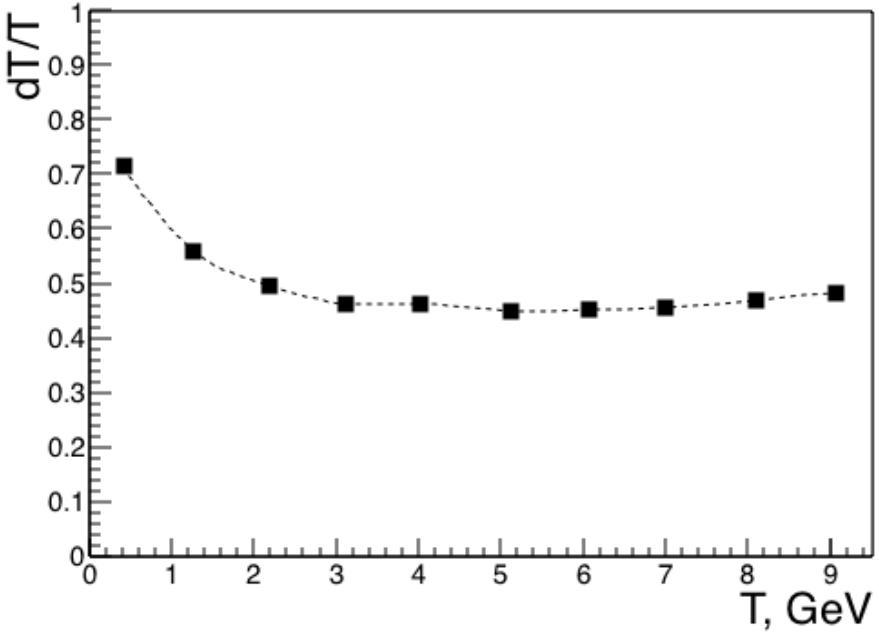


Sampling: 60 mm / Fe

Nuclear interaction length $\lambda_I \approx 3.4$

Calorimetry: PANDA Barrel Structure

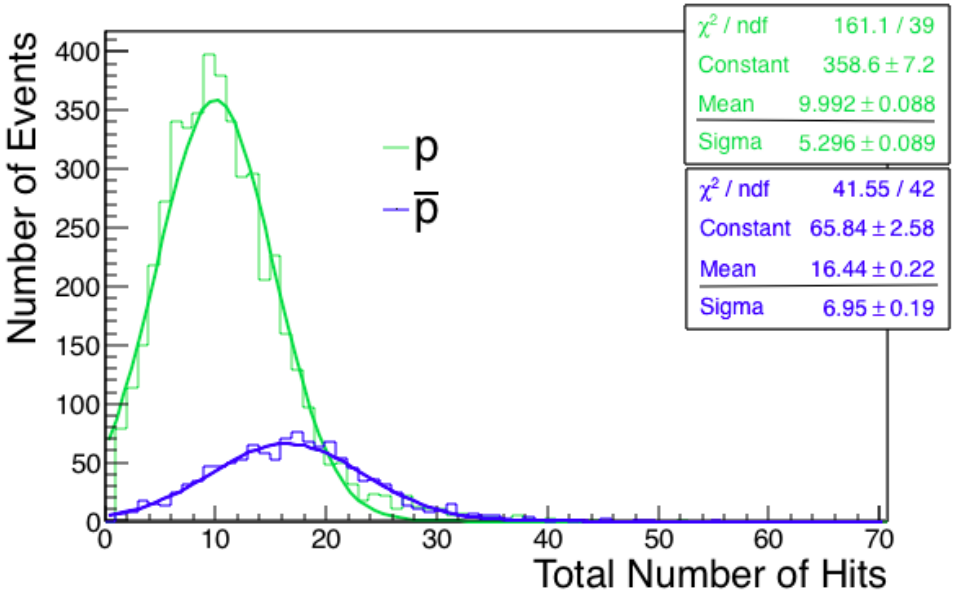


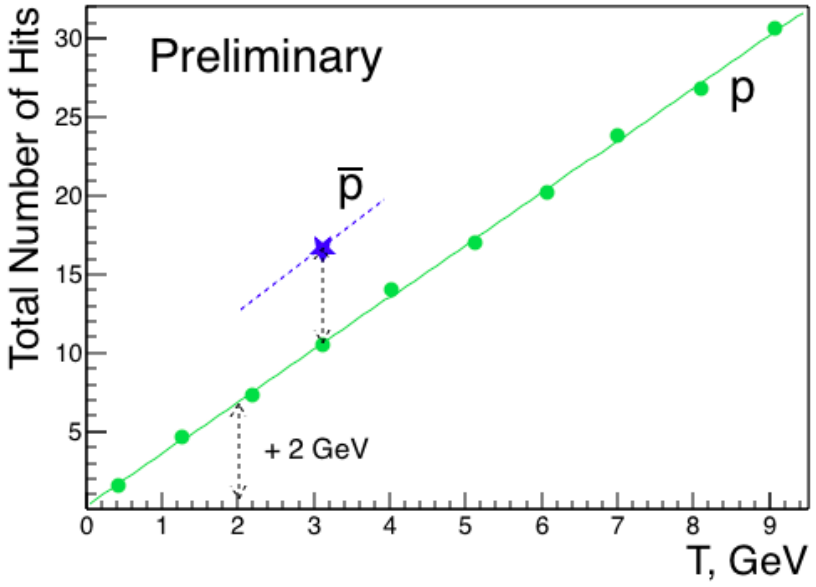


Sampling: 30 mm / Fe

Nuclear interaction length $\lambda_I \approx 2.3$

Protons vs Antiprotons





PANDA FRS Structure, T = 3.1 GeV

Summary and Plans

- SPD Muon system design is suggested.
- Calorimetry of PANDA Muon System Prototype for protons is performed using test beam data.

Plans:

- Developing 3D mechanical model of Muon System (detector geometry).
- Transferring the detector geometry from Computer-Aided Design system to particle transport Monte Carlo code like GEANT4 / ROOT.
- Digitization / pattern recognition of hadrons and muons.
- Calibration of the SPD system's response to the different particles and energies.
- Test of algorithms for μ/π separation (at low energies ~0.5 GeV).

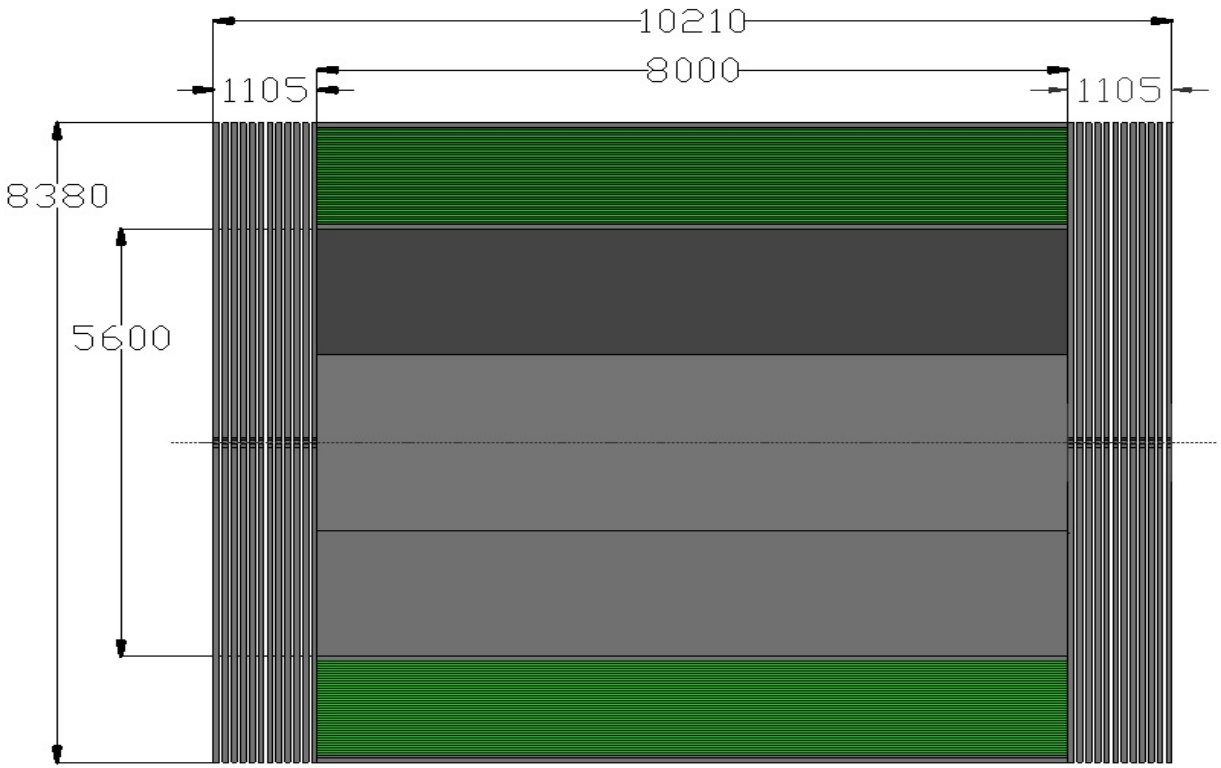
Děkuji za pozornost!

Backup Slides

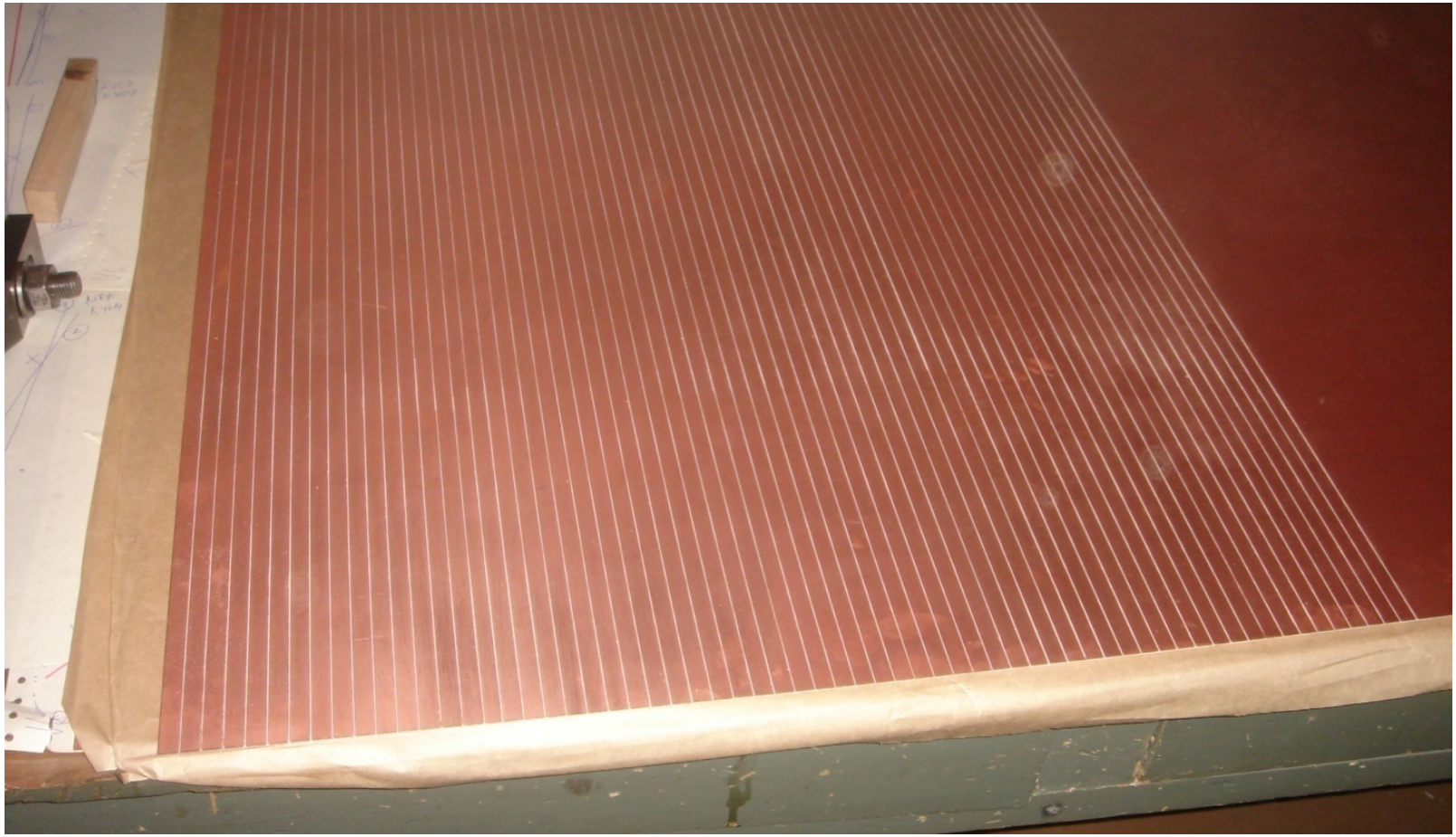
SPD/NICA Range System

Barrel/Fe: 60 + 19 x 30 + 60 mm (4.1 λ_I);
End Caps/Fe : 12 x 60 mm (4.3 λ_I);
Air gaps: 35 mm;
L/barrel: 8000 mm;
W = 997.3 + 2 x 326.6 = 1650.5 ton

Version : 06.2018

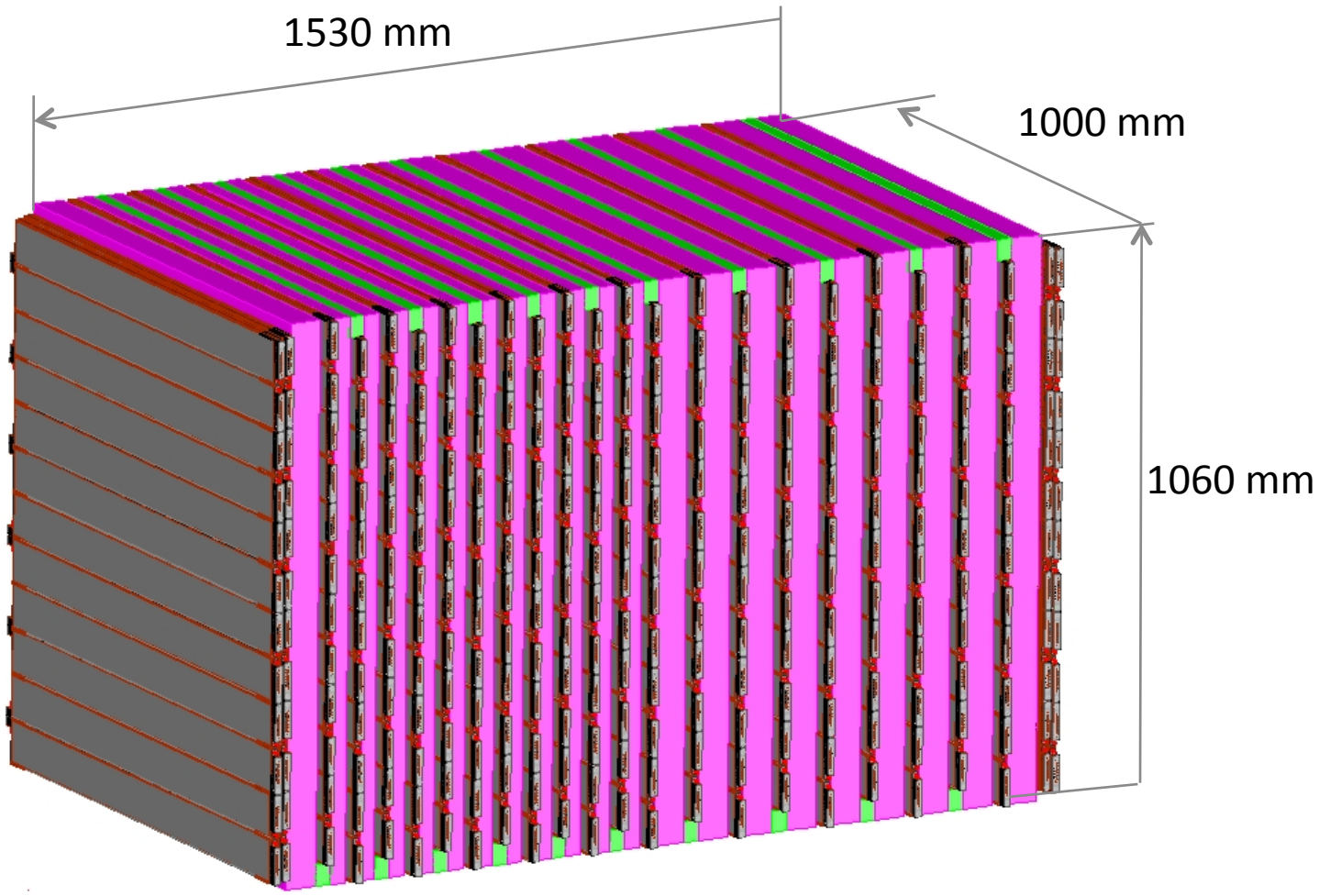


G10 Fiberglass Strip Board



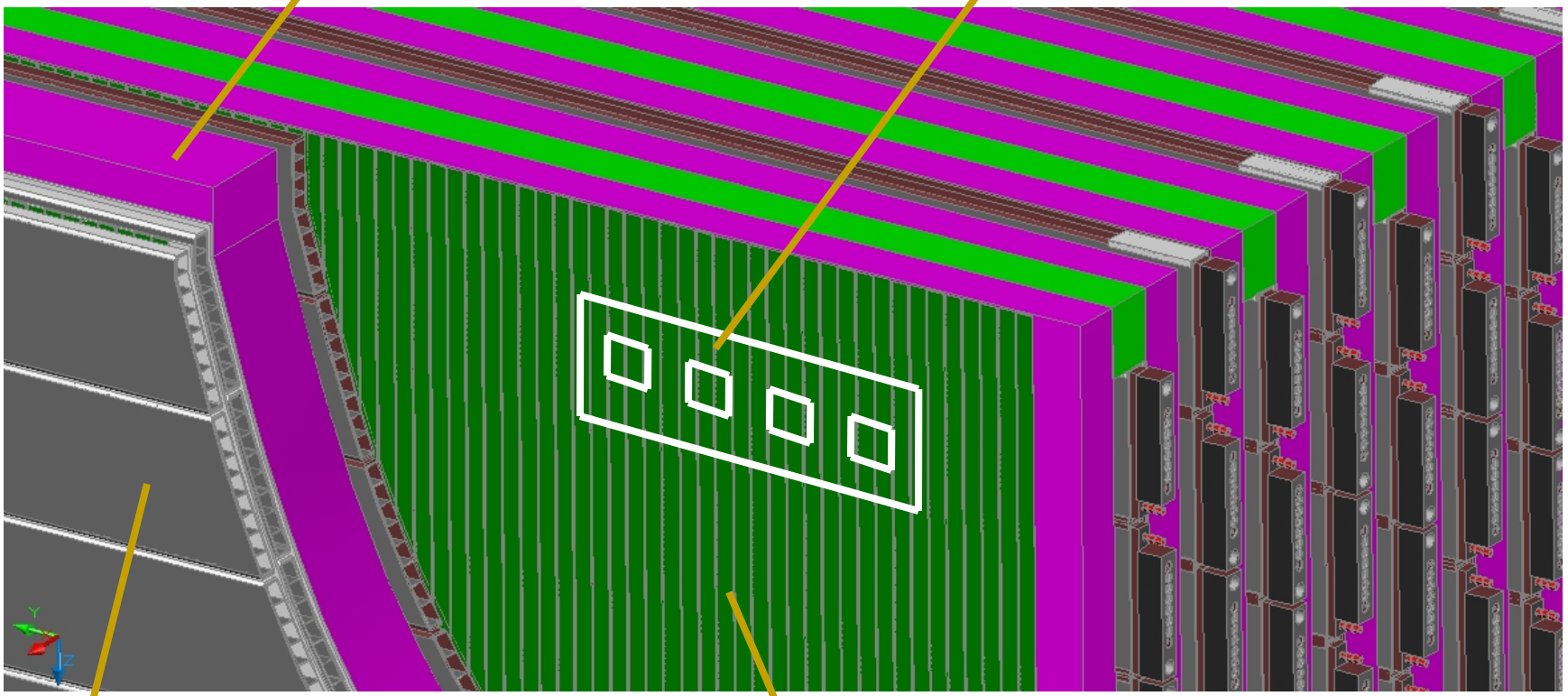
1 cm wide strips

RS Prototype for Beam Test

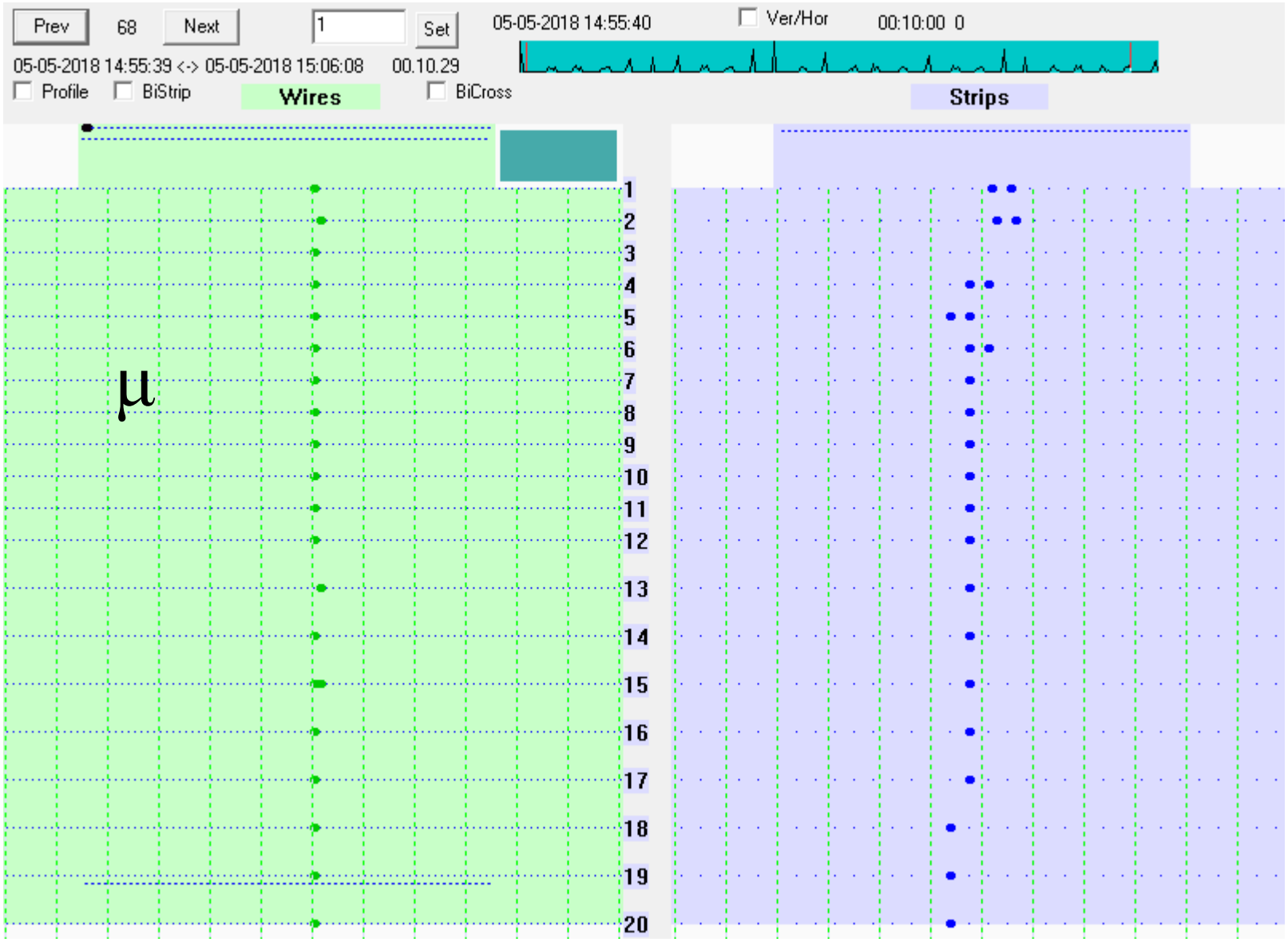


Fe volume ~ 1 m^3 (~ 10 t), 288 MDTs 1 m long
2000 channels of wire R/O + 2000 channels of strip R/O

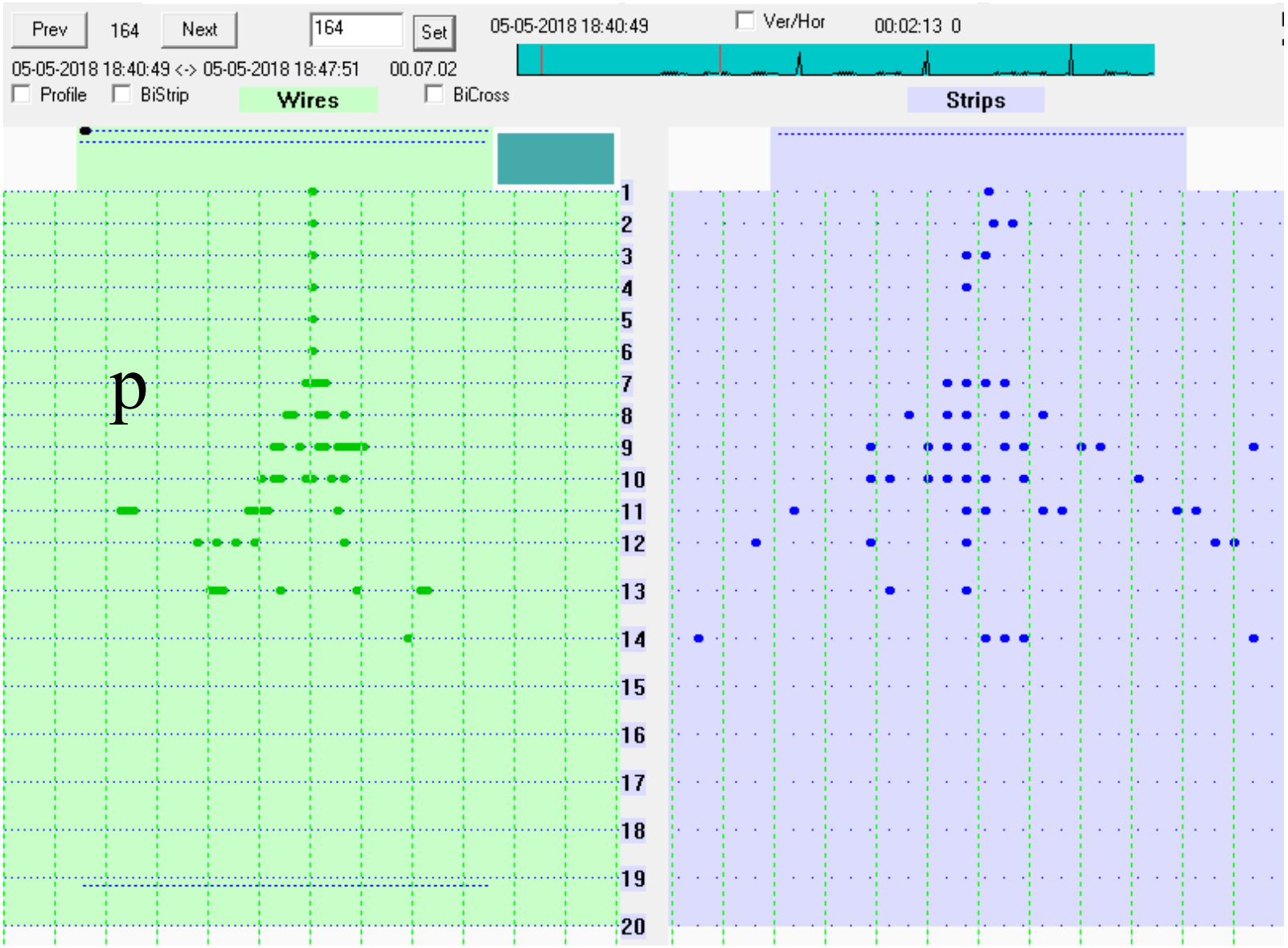
Strip R/O from RS Prototype



Event Examples (Run 829, P = 5 GeV/c)

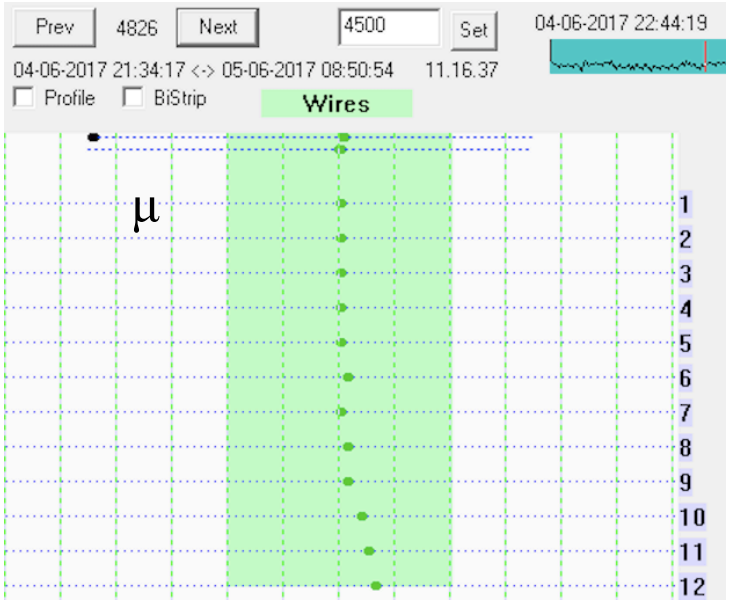


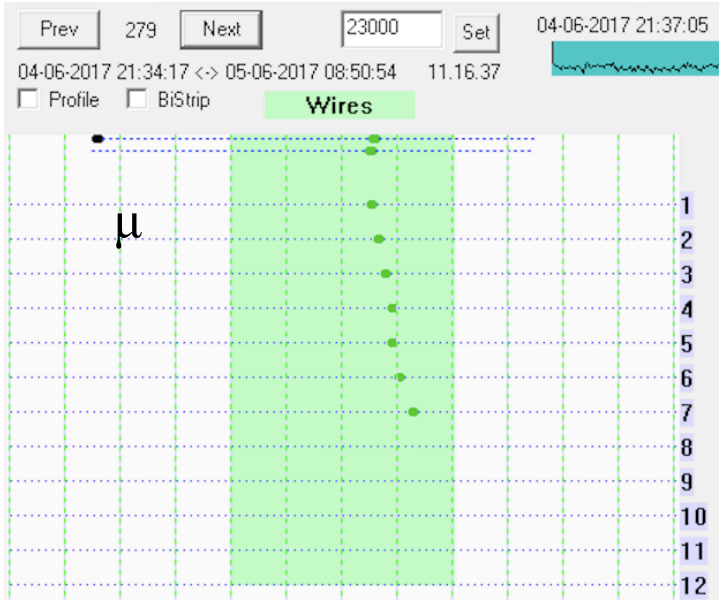
Event Examples (Run 835, P = 10 GeV/c)

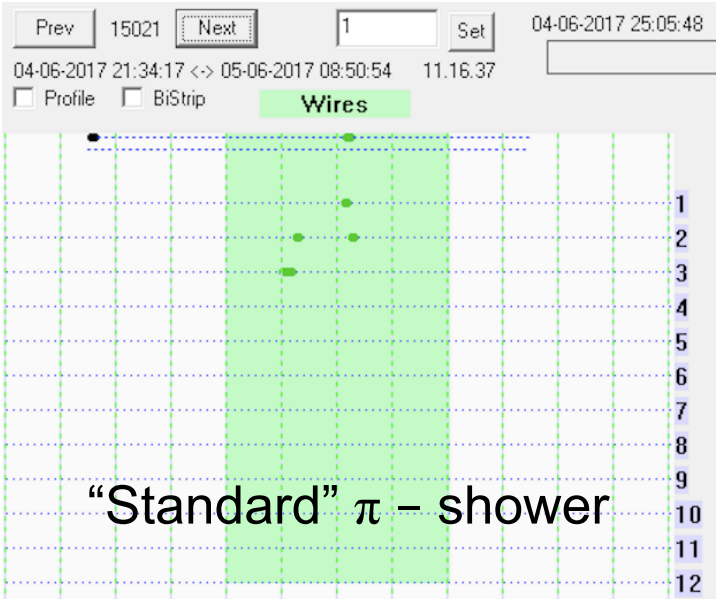


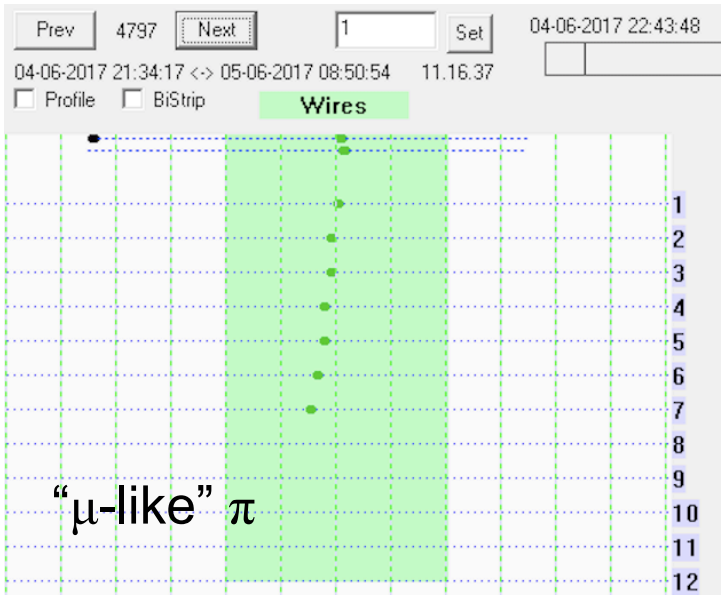
Prototype Data (μ vs π)

Run 605
P = 0.5 GeV/c

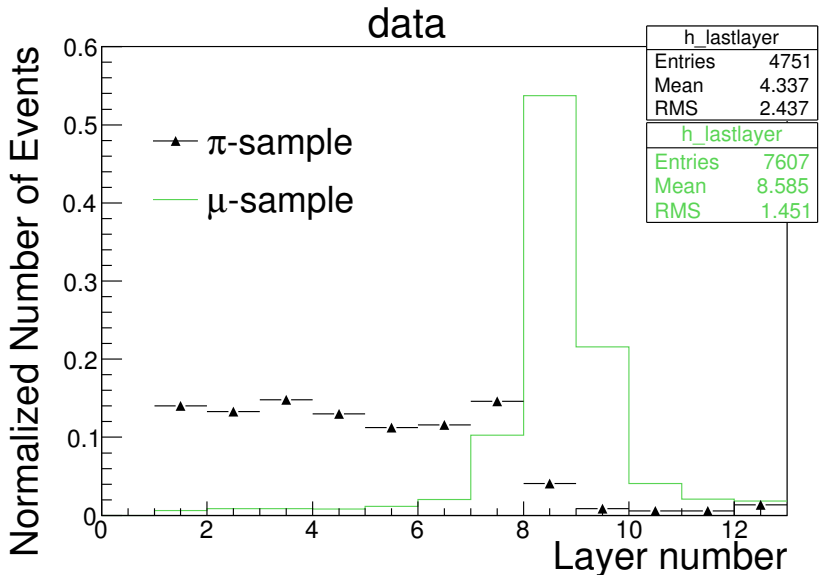


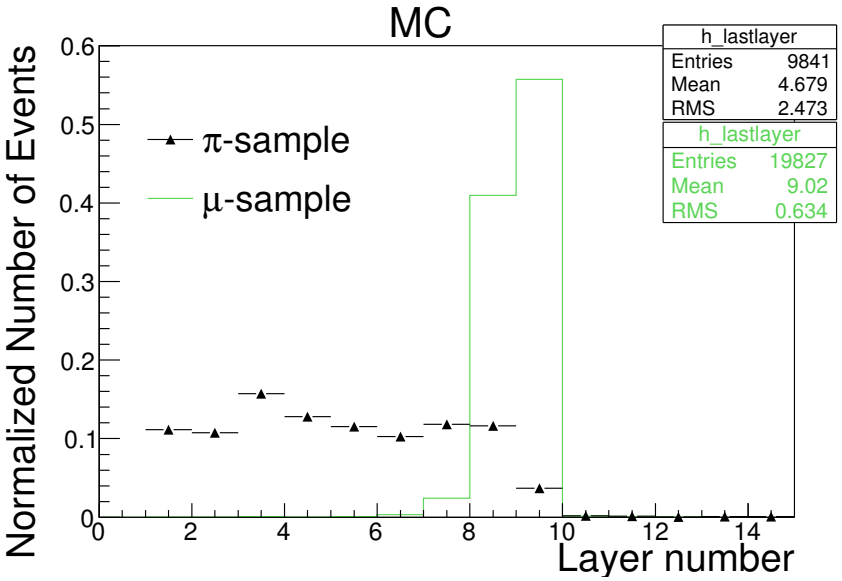






Test Beam Results (Preliminary)





EPJ WoC, Volume 177 (2018) 04001

Run 605, autumn 2017
momentum = 0.5 GeV/c

Selection -> after layer #7:
22% - pion contamination and
93% - muon efficiency

FairBoxGenerator, PandaROOT
P = 0.5 GeV/c

Selection -> after layer #7:
27% - pion contamination and
99% - muon efficiency

Estimated maximum flux in beam @ T9