Muon (range) system for SPD/NICA

G.Alexeev (on behalf of Muon group)
JINR, 4 February, 2019

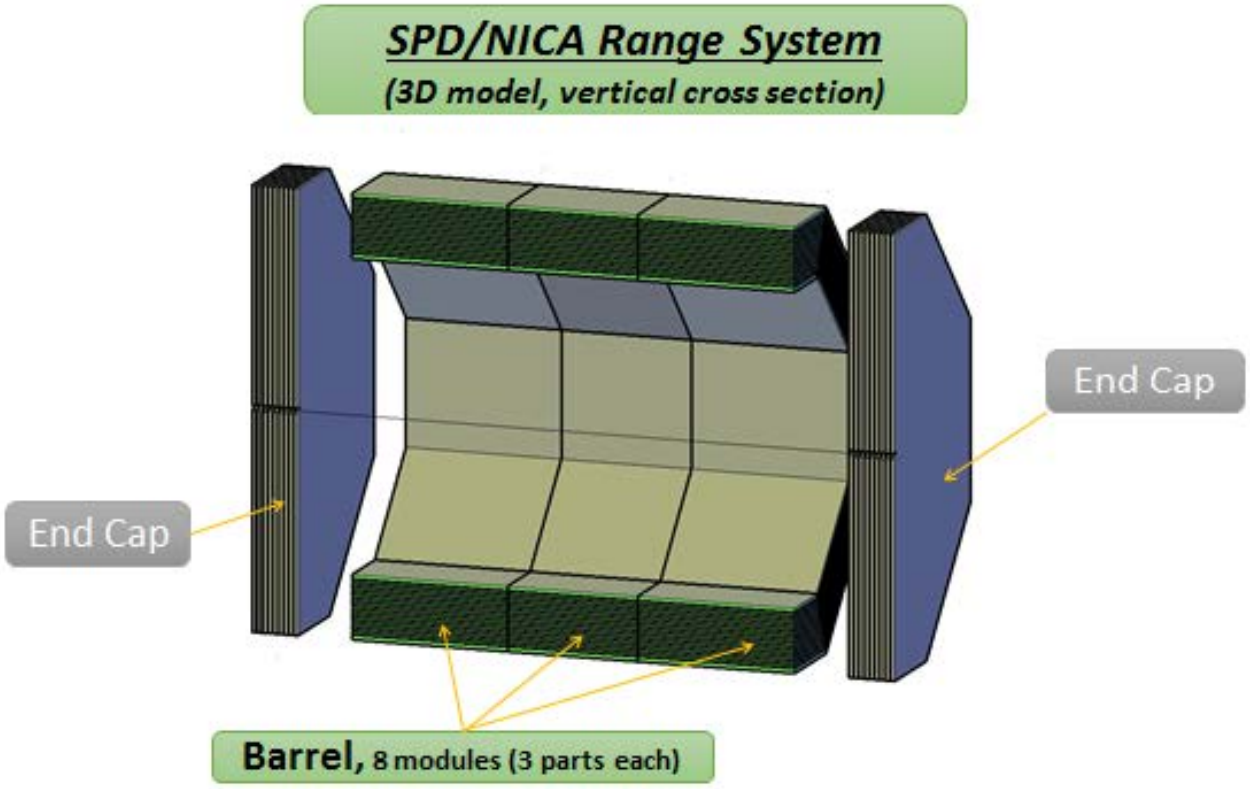
- Physics/detector task, general concept
- Current status
- Results to be achieved and included into CDR by 30.09.2019
- Work plan for year 2019 with time lines
- Available/needed resources

Muon System as PID

- **SPD/NICA** (PANDA/FAIR) **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 SPD (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!**

3D model of SPD/NICA Muon System

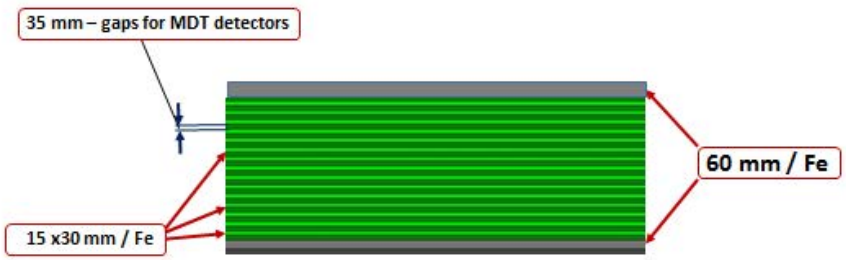
(total weight ~ 1270 ton, number of MDTs ~ 15'000,
R/O channels ~ 120'000 (wires) + strips ?



Structures of Barrel & End Cap(s)

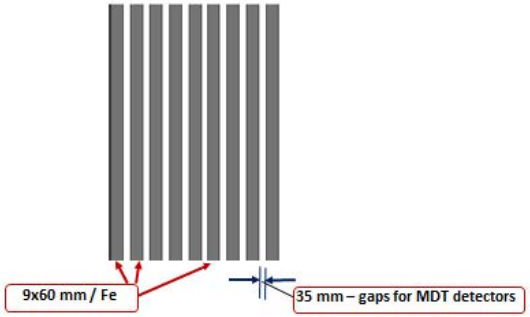
Barrel Structure (cross section)

2x60mm+15 layers x30 mm => (3 λi)



End Cap Structure (cross section)

9 layers x60mm => (2.8 λi)

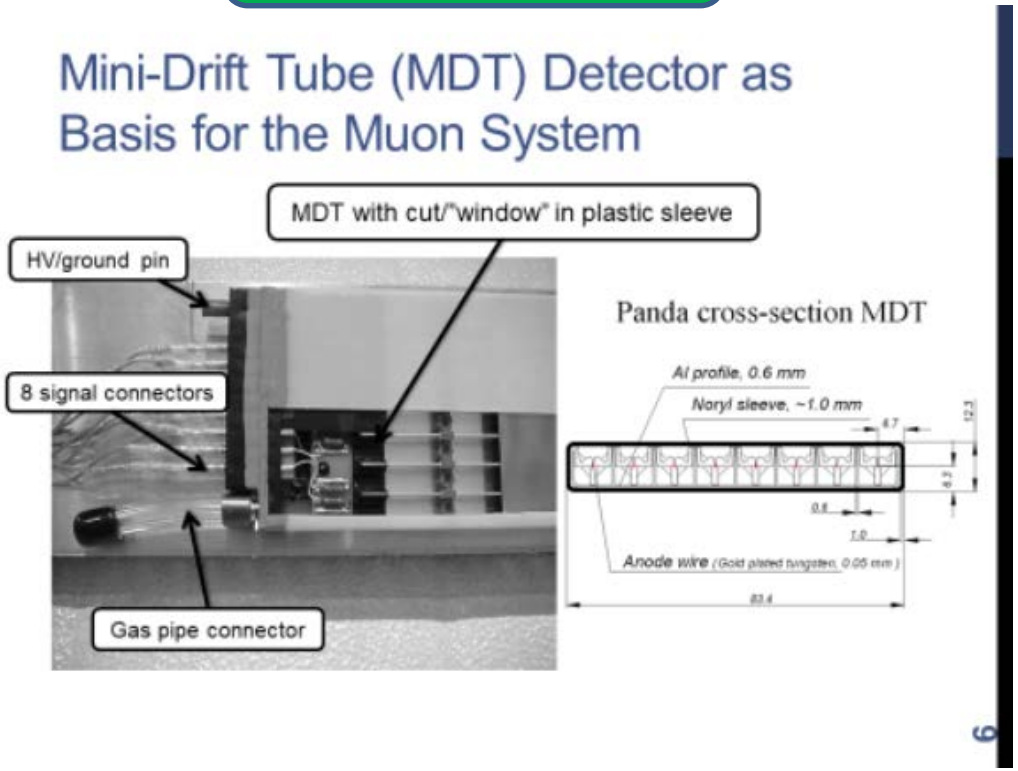


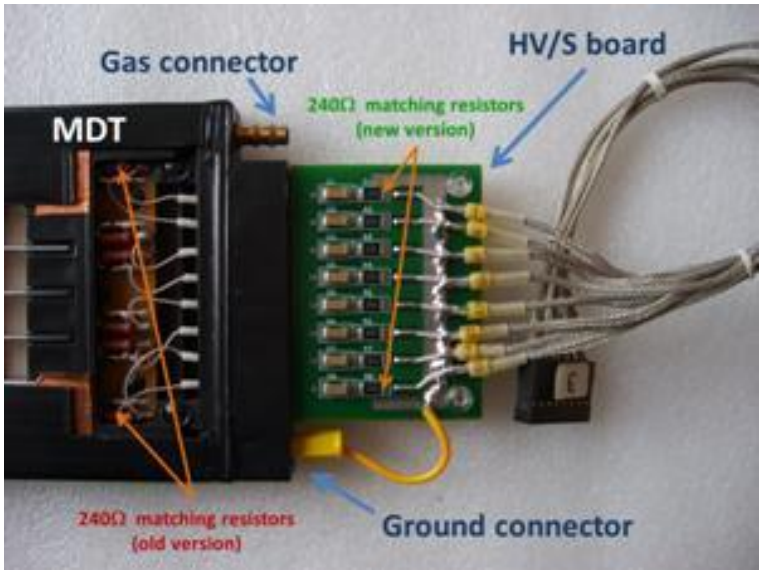
Mini Drift Tube (MDT) detectors

(D0/FNAL&COMPASS/CERN-wire R/O (left), PANDA/FAIR&SPD/NICA – wire&strip R/O (right)

HV on ALU cathode

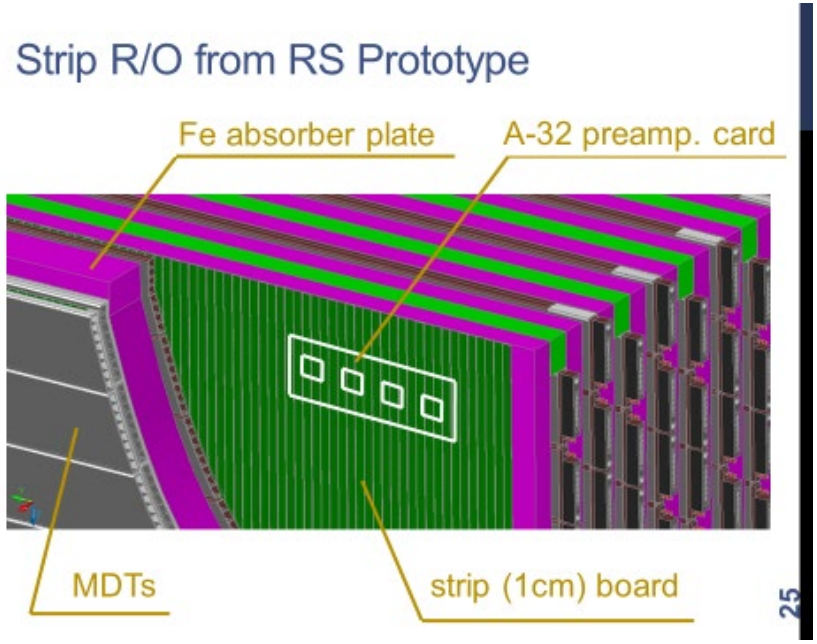
HV on the wires





MDT's strip readout

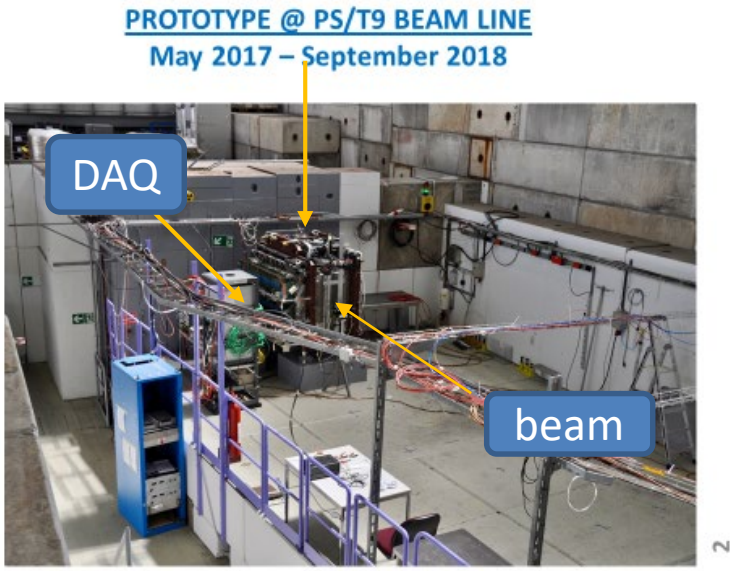
3D model of prototype with strip R/O



Strip board cut on G10

Range System Prototype

beam position

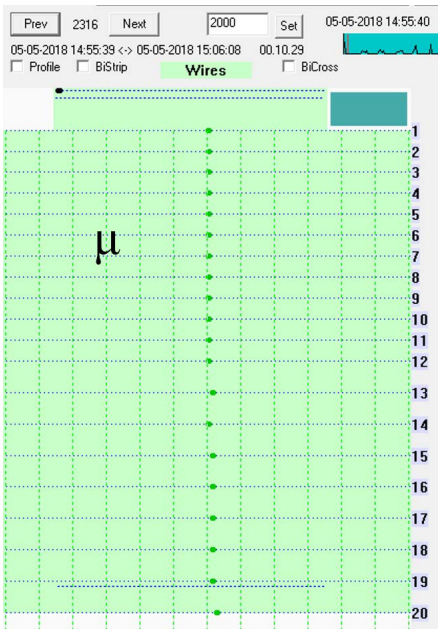


cosmic test position

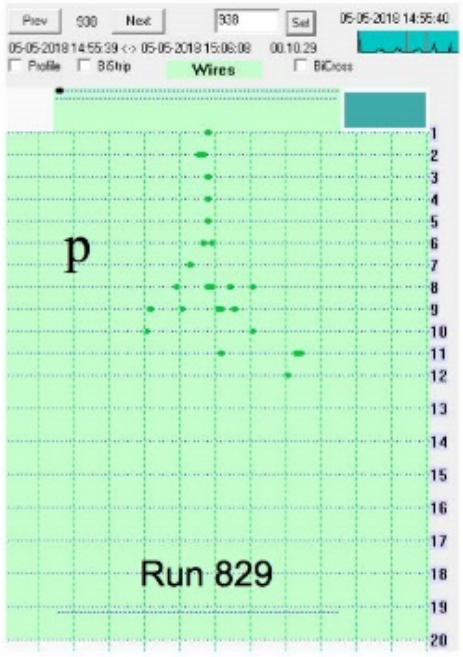
PID pictures of Muon System

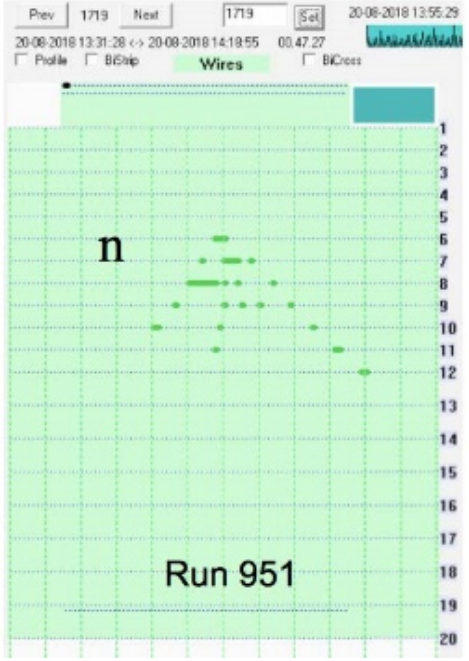
(single point equals one hit wire – 1x1 cm2)

muonic sample -> ‘straight’ line

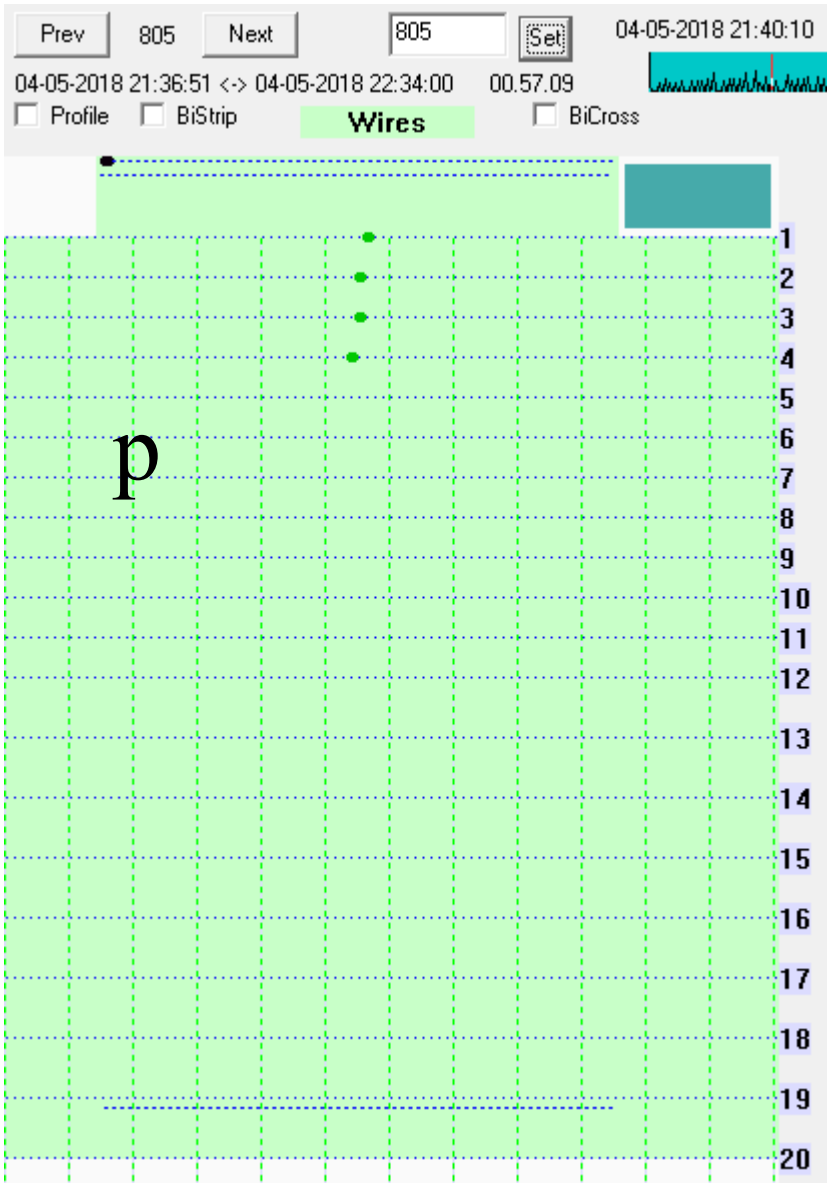


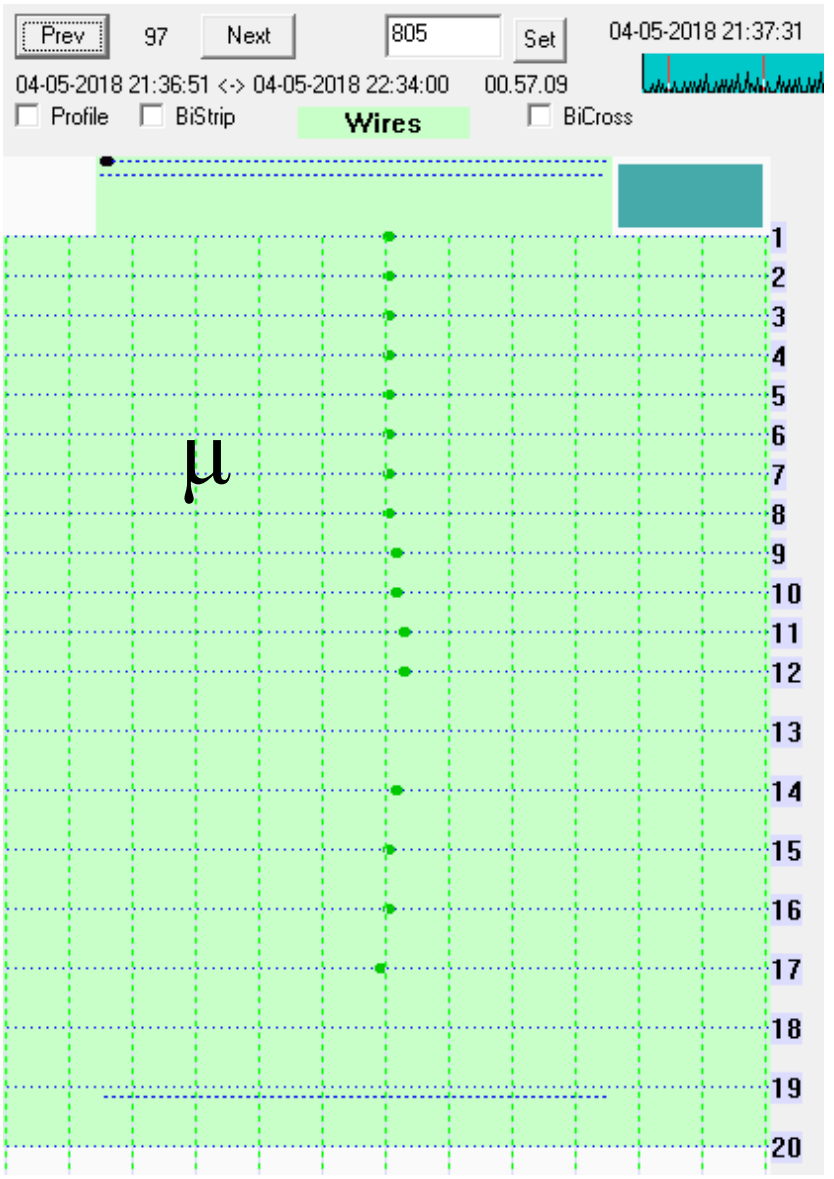
hadronic sample -> shower



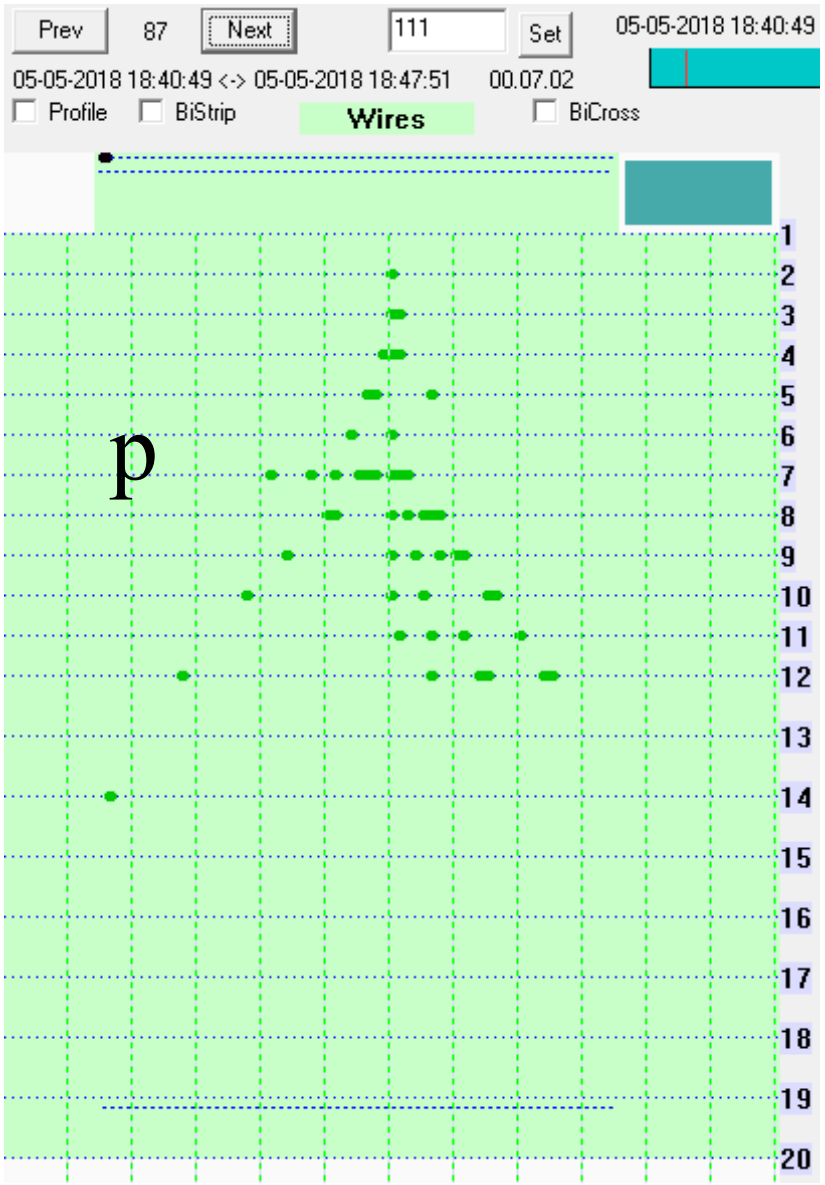


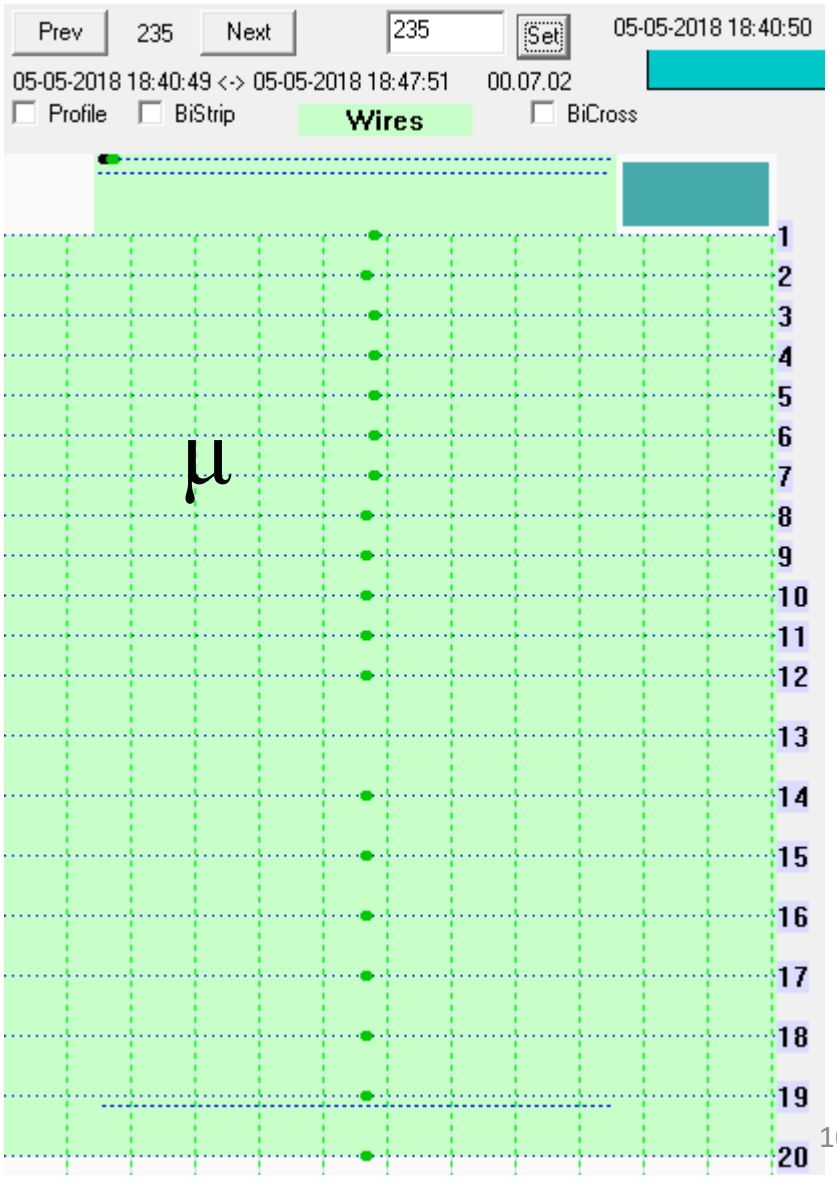
Event Examples (Run 822, P = 1 GeV/c)



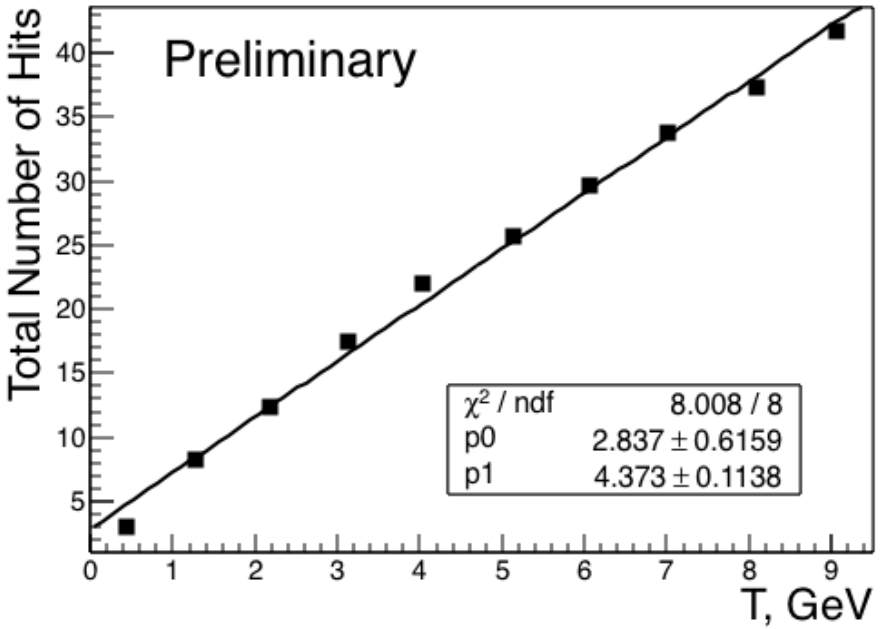


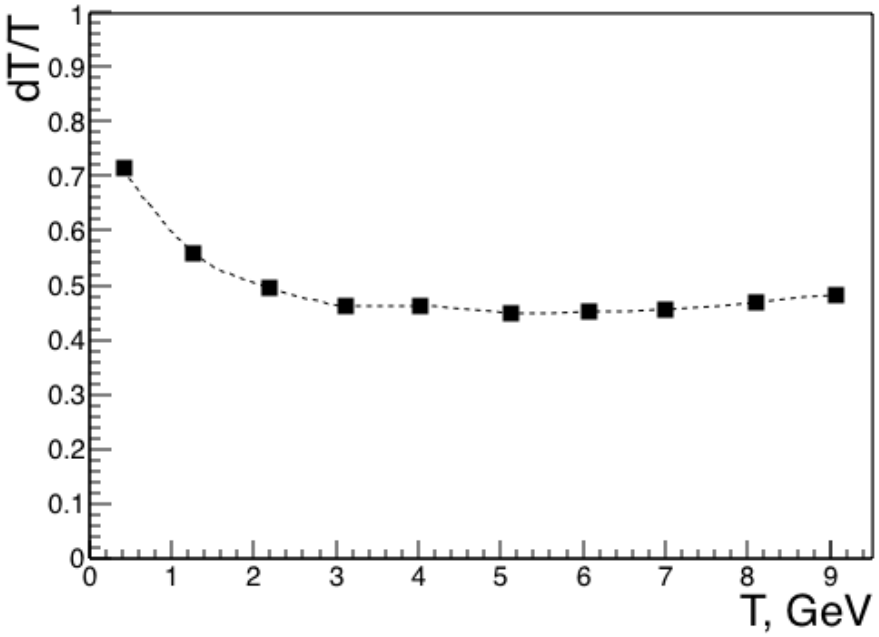
Event Examples (Run 835, P = 10 GeV/c)





Calorimetry: PANDA Barrel Structure

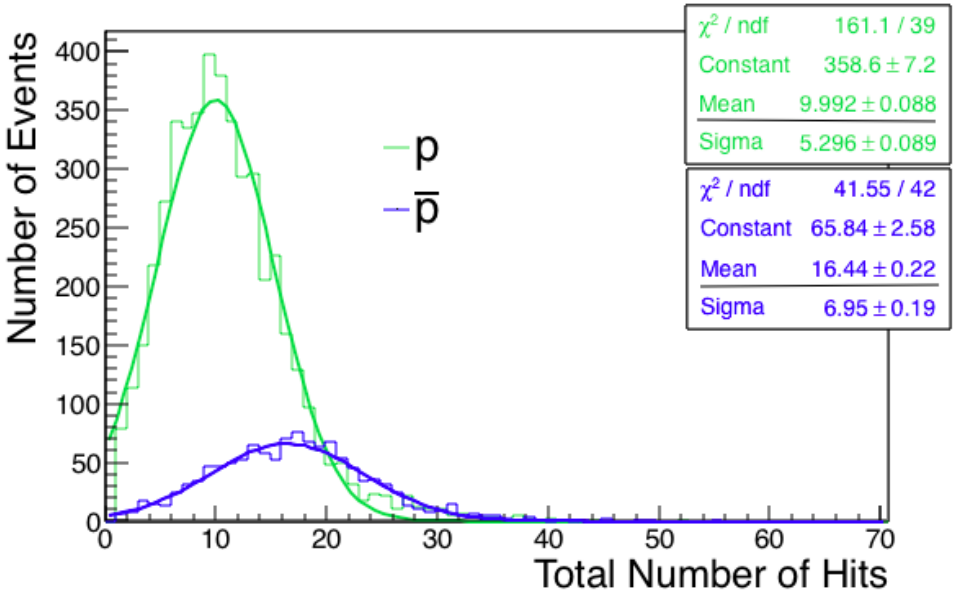


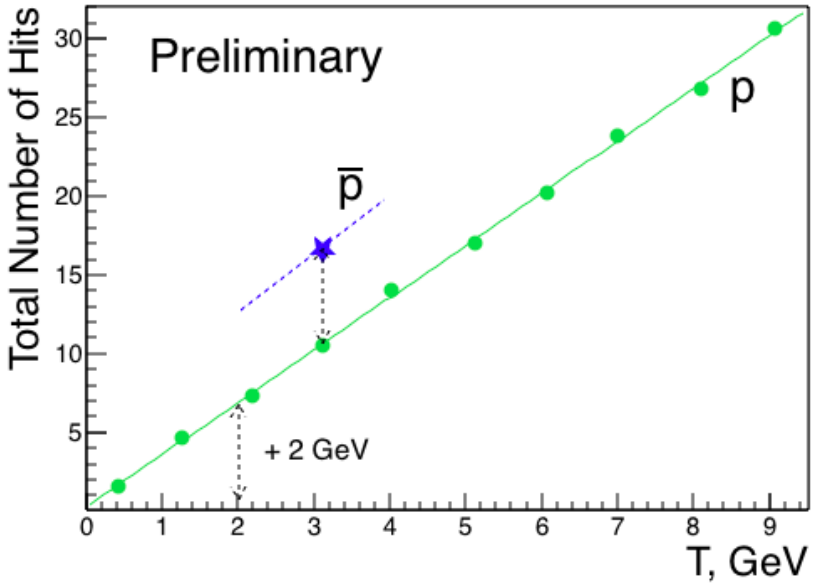


Sampling: 30 mm / Fe

Nuclear interaction length $\lambda_I \approx 2.3$

Protons vs Antiprotons

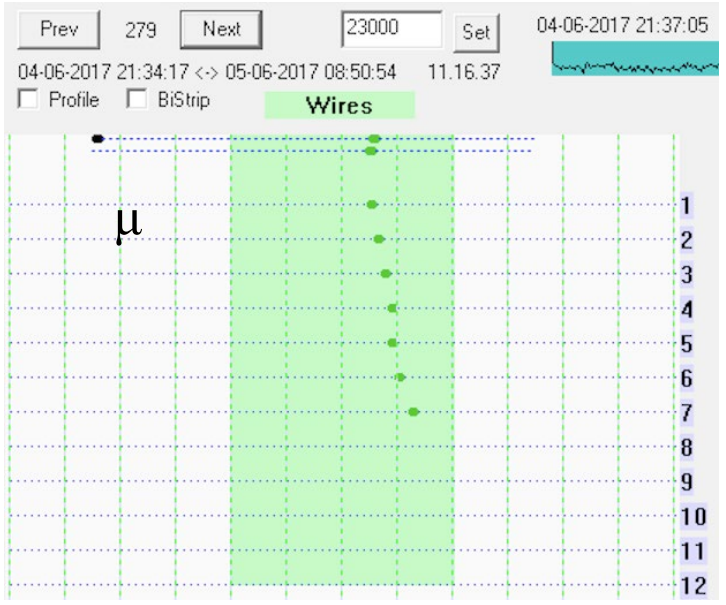


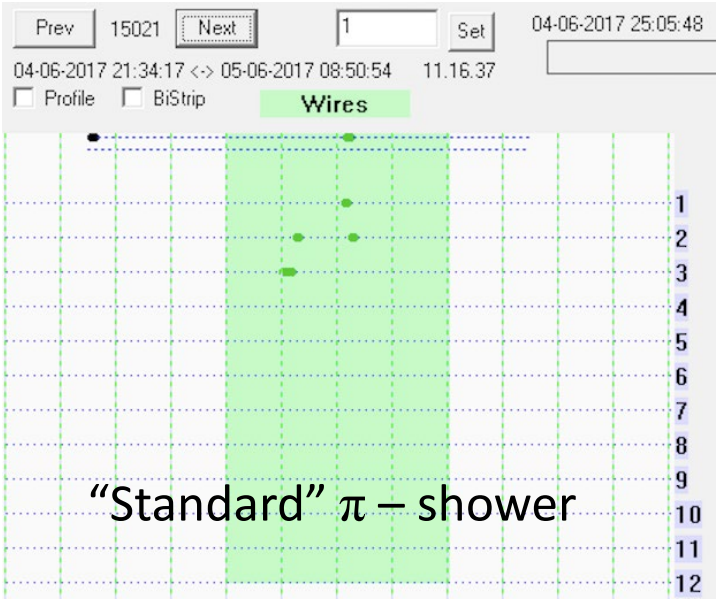


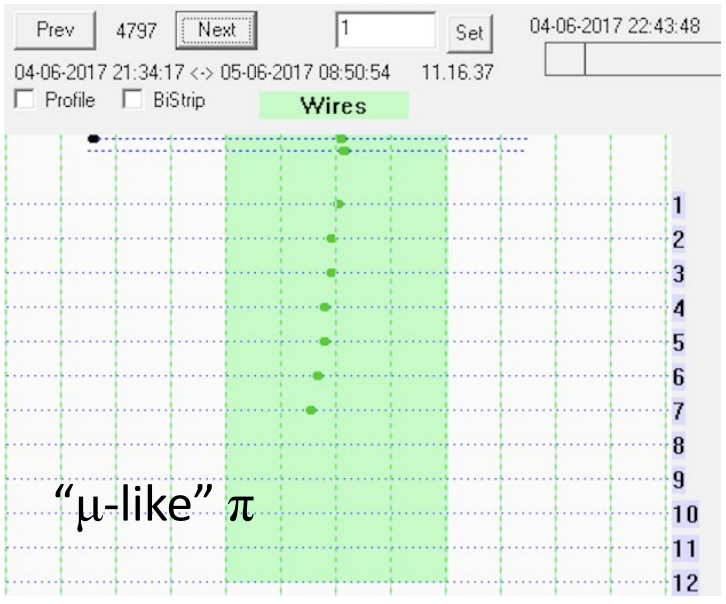
* - PANDA FRS Structure, T = 3.1 GeV

Prototype Data (μ vs π)

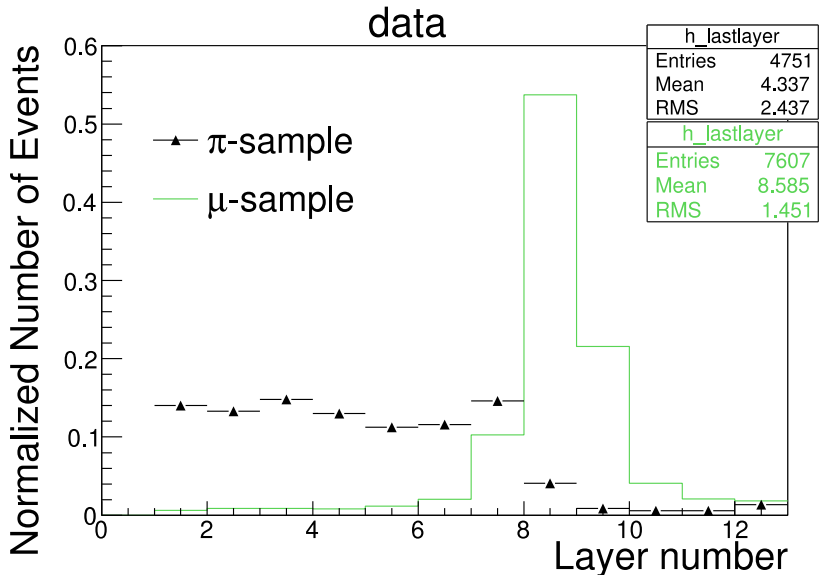
Run 605
P = 0.5 GeV/c

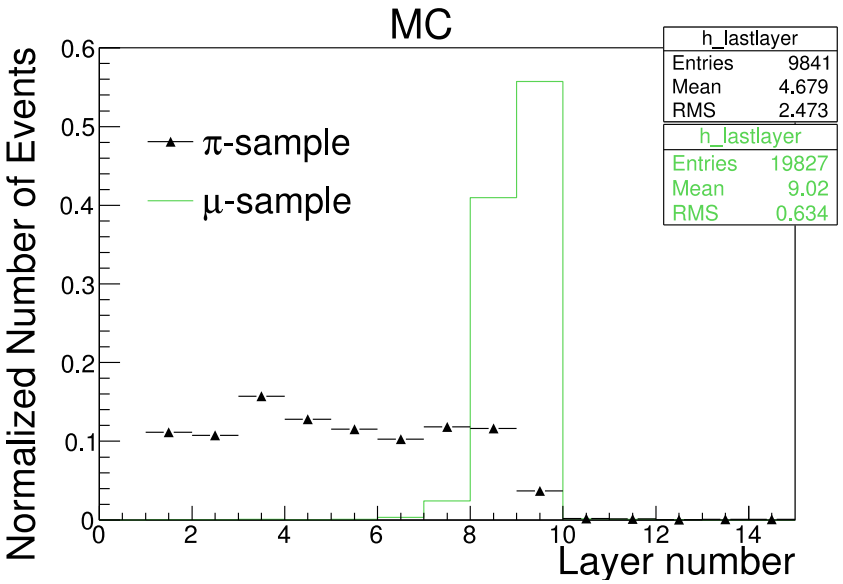






Test Beam Results (Preliminary)





EPJ WoC, Volume 177 (2018) 04001

Run 605, autumn 2017
momentum = 0.5 GeV/c

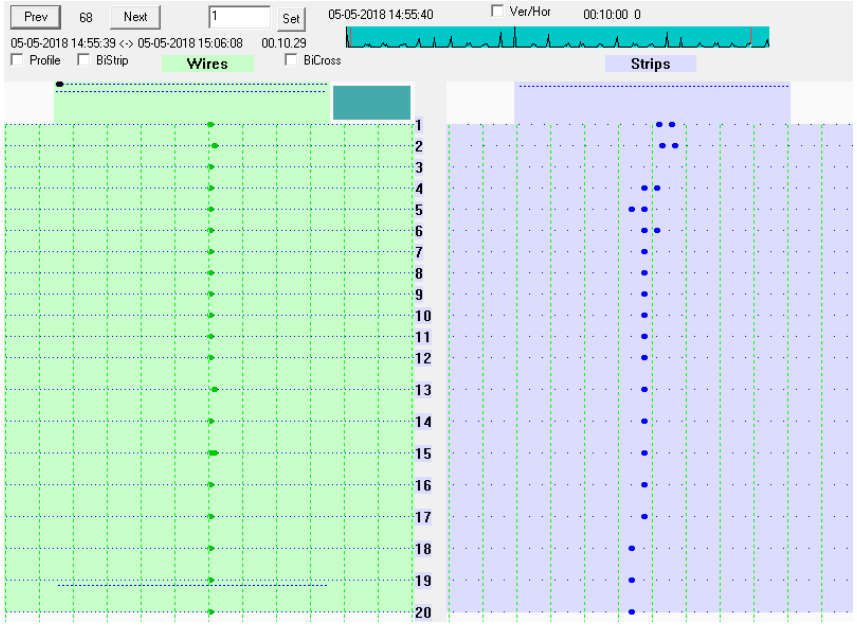
Selection -> after layer #7:
22% - pion contamination and
93% - muon efficiency

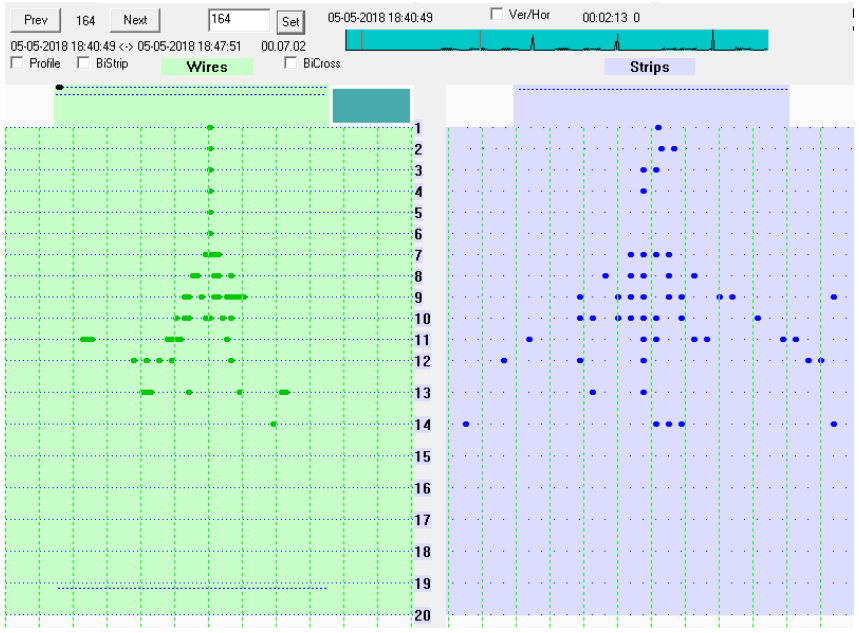
FairBoxGenerator, PandaROOT
P = 0.5 GeV/c

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

Wire & Strip Response

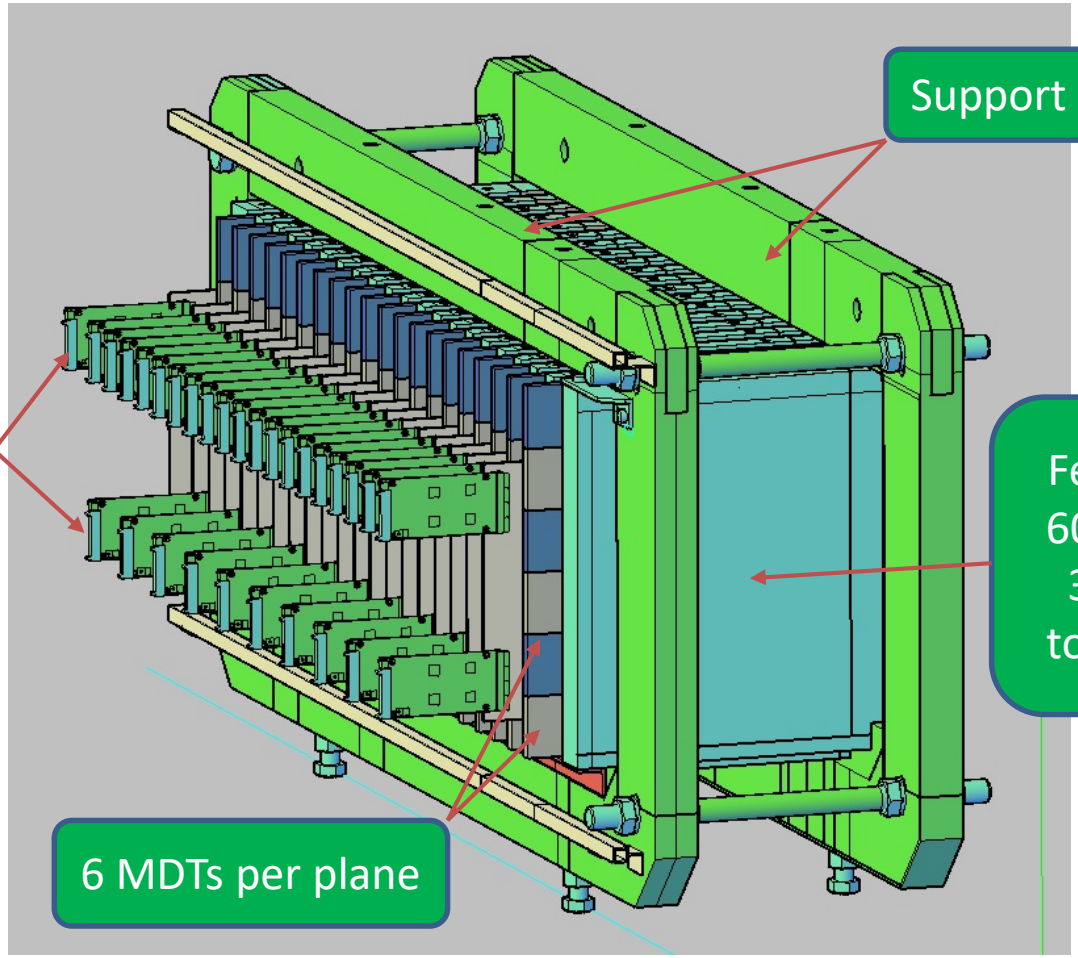
(left – muon, 5 GeV/c; right – proton, 10 GeV/c; strip width – 3 cm)





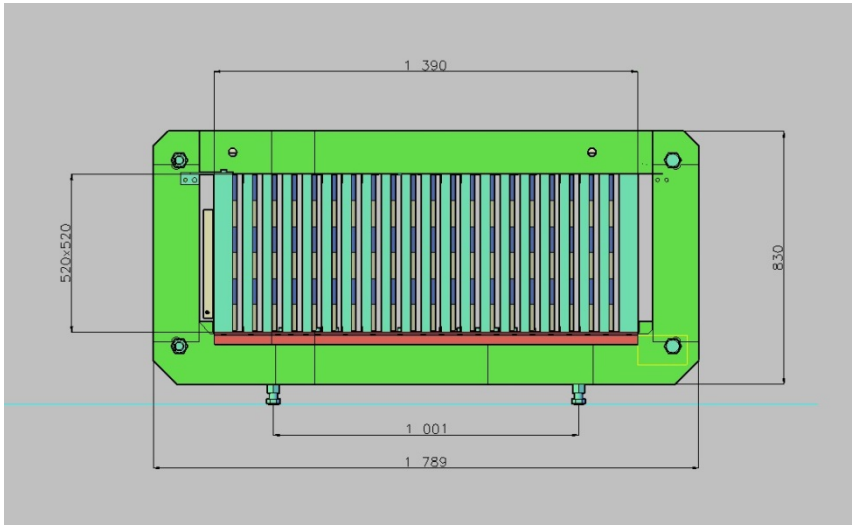
3D model of SPD Muon (Range) System Prototype

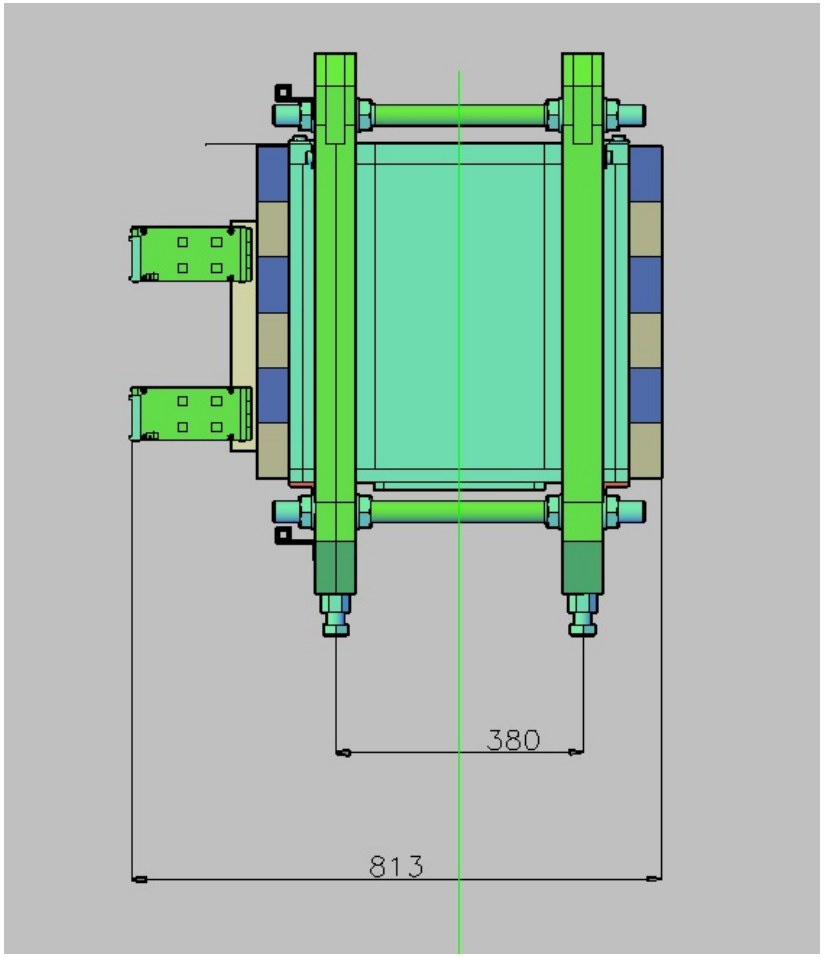
(total weight ~ 1,5 ton, 120 MDTs, 960 wire R/O channels, strips ?)



SIDE & FRONT VIEWS

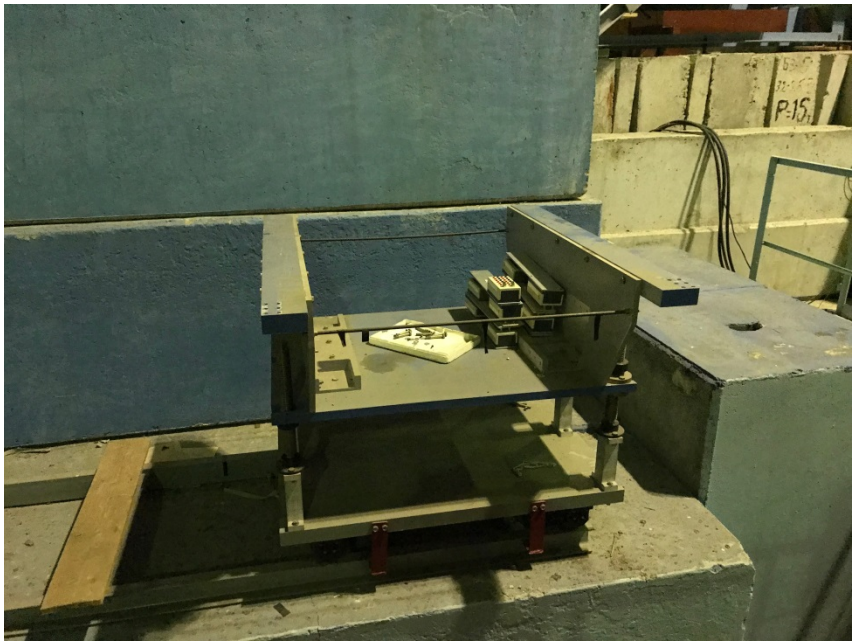
of the Prototype





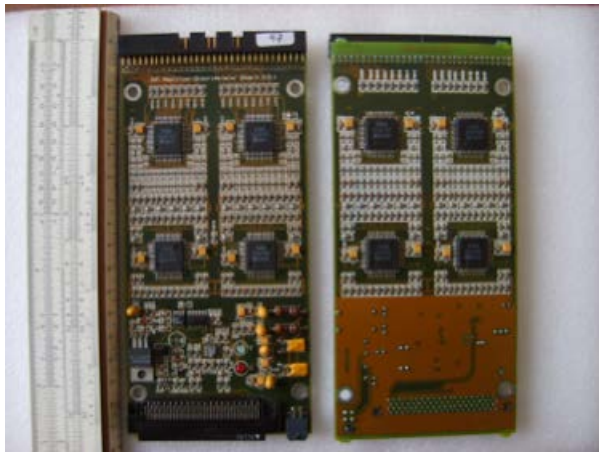
Support structure for the Prototype

(exists at the SPD Test Beam Area, agreed to be given to muon group)

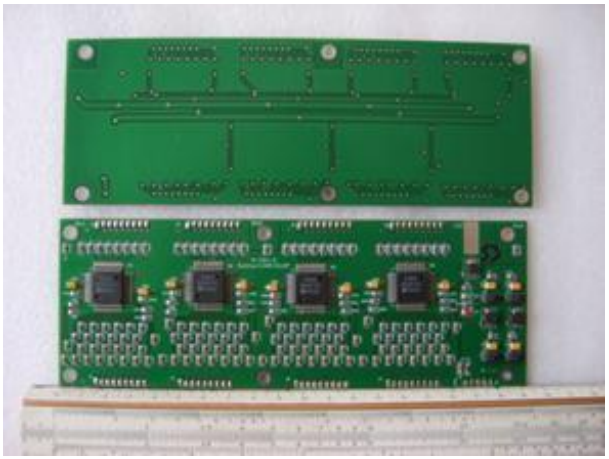


Analog Front End Electronics (FEE) cards

Amplifier-Discriminator Board, 32 channels,
ADB-32 for wire R/O



Preamplifier Board, 32 channels,
A-32 for strips R/O



Necessary number of cards (30) to equip the Prototype exist

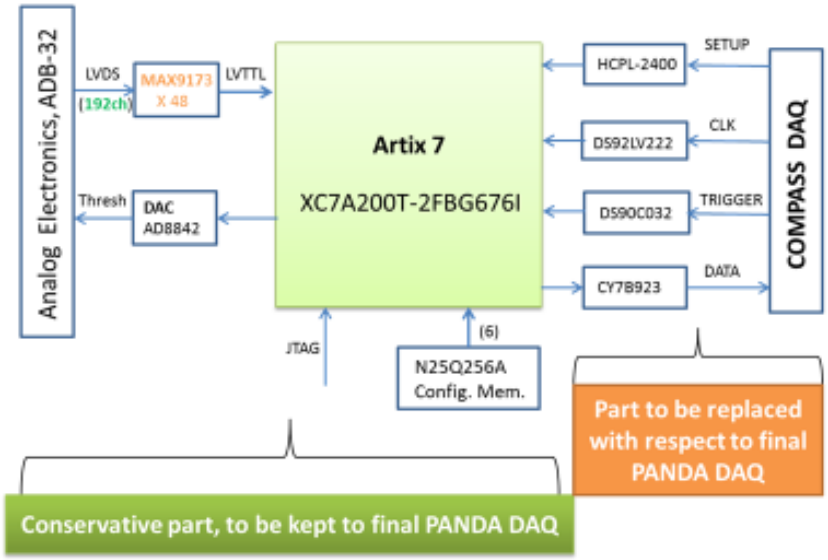
Digital Front End Electronics (FEE) cards

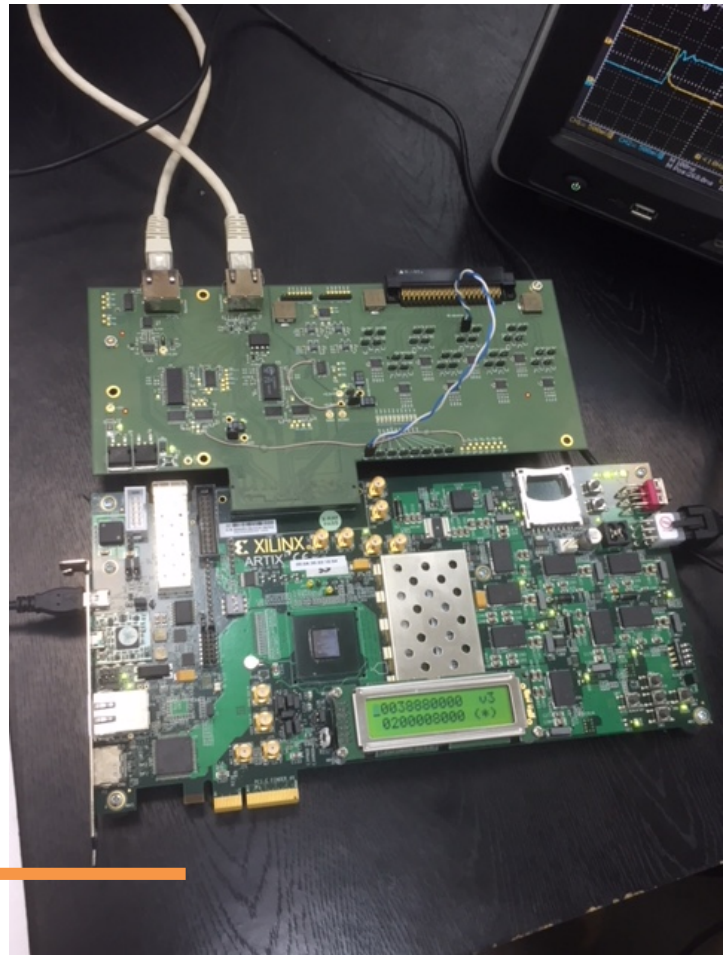
Design concept

32 channel card tested at CERN

Simplified Block-diagram of Xilinx FPGA Prototype R/O Module (192ch)

(to be tested with Range System Prototype at CERN; if the results will be positive, the Artix 7 chip may be regarded as the basis for the final PANDA/DAQ)

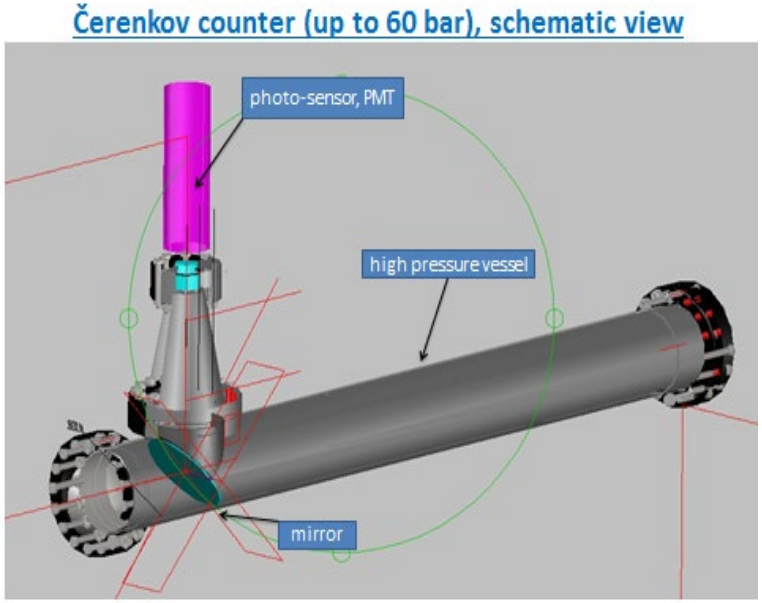


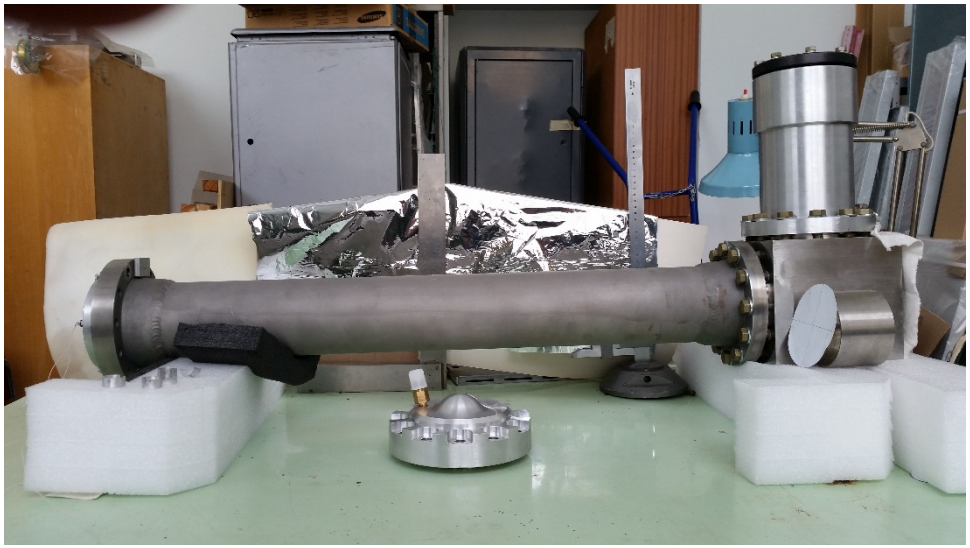


To be developed in full 192 chanel unit in VME, 6U standard

Cerenkov counter for SPD test beam

(main task -> π/μ separation < 1,5 GeV/c; high pressure (up to 60 bar) of CO2)





3D model/design

Ready device at DLNP test stand, tuning of optics

PLANS FOR 2019:

- **MC development:**
  - Digitization of signal 09.2019
  - Pattern recognition algorithms 12.2019
- **Treatment of CERN test beam data** 12.2019
- **Participation in SPD Test Beam Area:**
  - Production of Prototype absorber 12.2019
  - Assembly of MDTs 12.2019
  - Prototype module of digital FEE unit 10.2019
  - Assembly of Cerenkov counter 12.2019

CONCLUSION:

- Muon (Range) System of SPD/NICA is powerful PID instrument in full energy scale
- Existing set of experimental data is adequate for new SPD CDR (and even TDR)
- MC requires serious development !
- Preparation for SPD test beam is on track
- Existing resources are enough for 2019 plans