Range (Muon) System for SPD/NICA: Status Report

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International Workshop "SPD at NICA-2019"
Dubna, 6 June, 2019

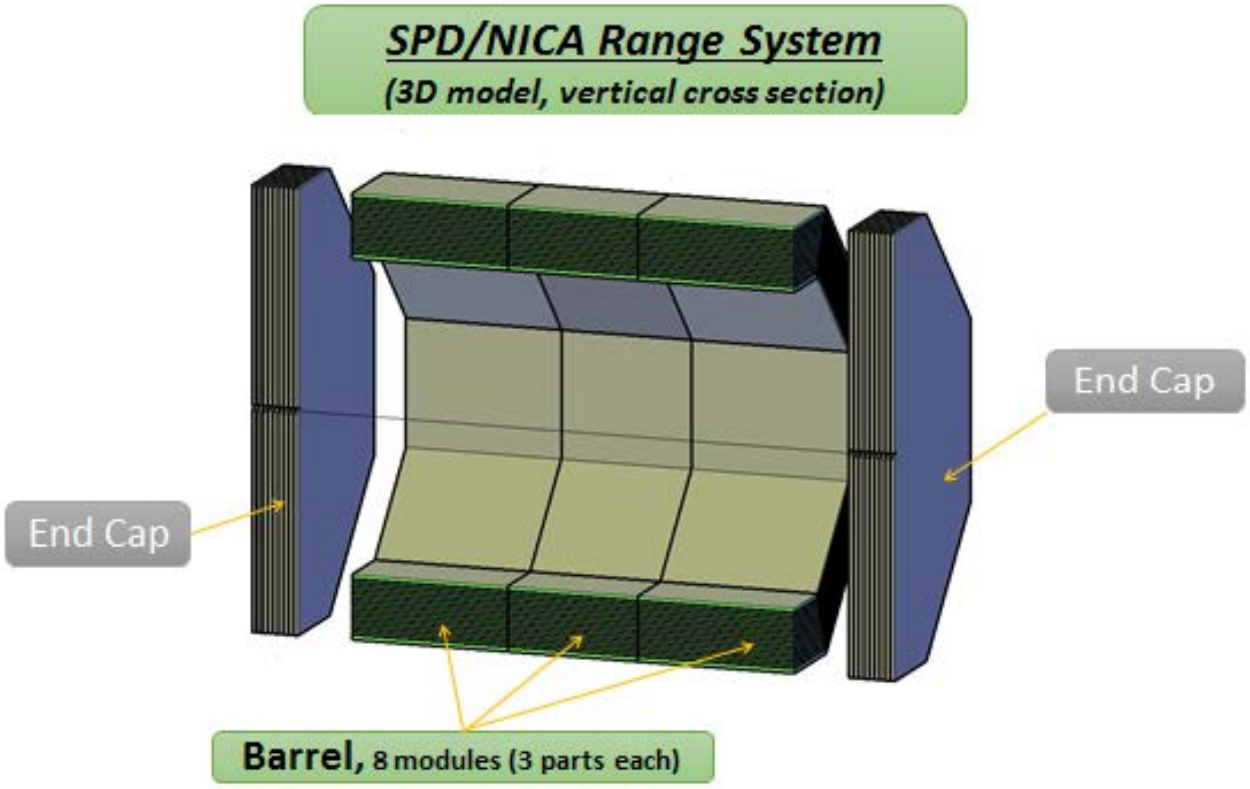
- Physics/detector tasks
- General concept (like PANDA/FAIR)
- Current status
- Results to be achieved/included into next CDR
- Work plan for year 2019

Muon System as PID

- **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 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

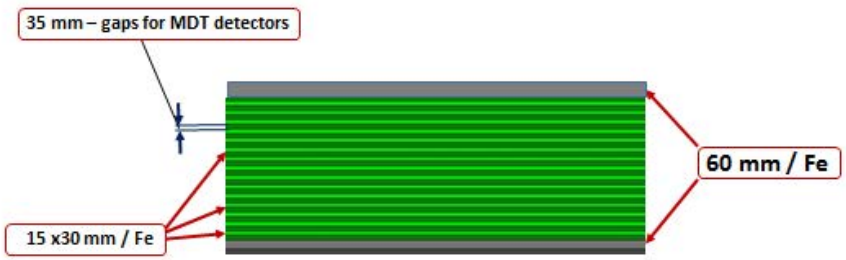
(total weight ~ 1270 ton, number of MDTs ~ 15'000,
R/O channels ~ 120'000 (wires) + strips ?



Structures of Barrel & End Cap(s)

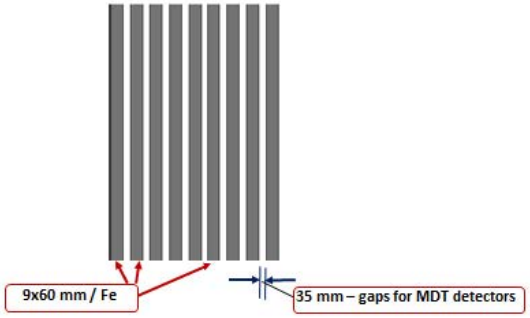
Barrel Structure (cross section)

2x60mm+15 layers x30 mm => (3 λi)



End Cap Structure (cross section)

9 layers x60mm => (2.8 λi)

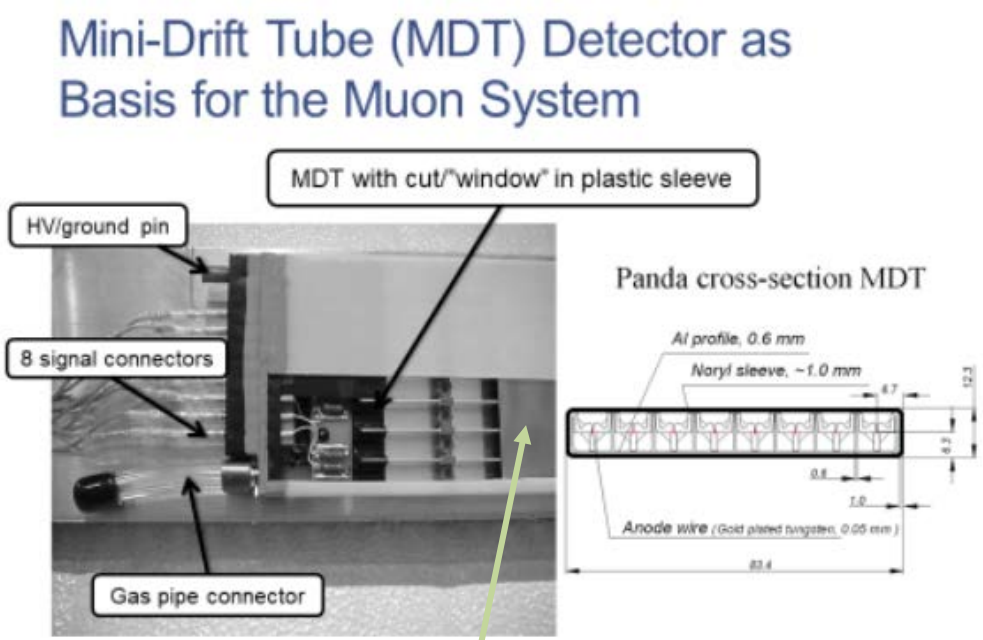


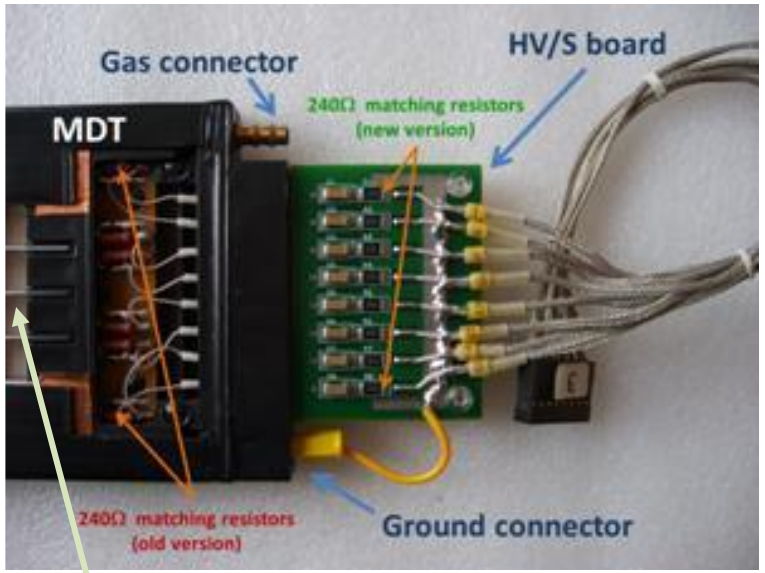
Mini Drift Tube (MDT) detectors

(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



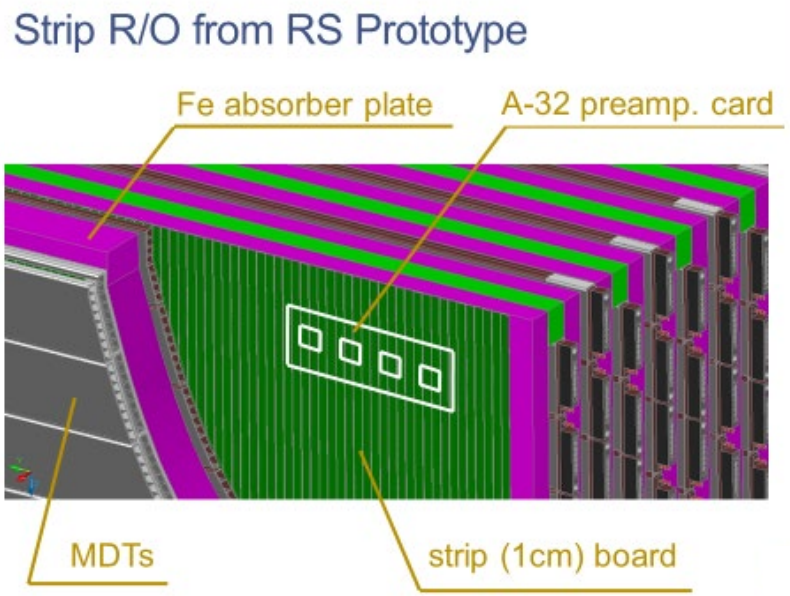


'closed cathode' geometry

'open cathode' geometry

MDT's strip readout

3D model of prototype with strip R/O

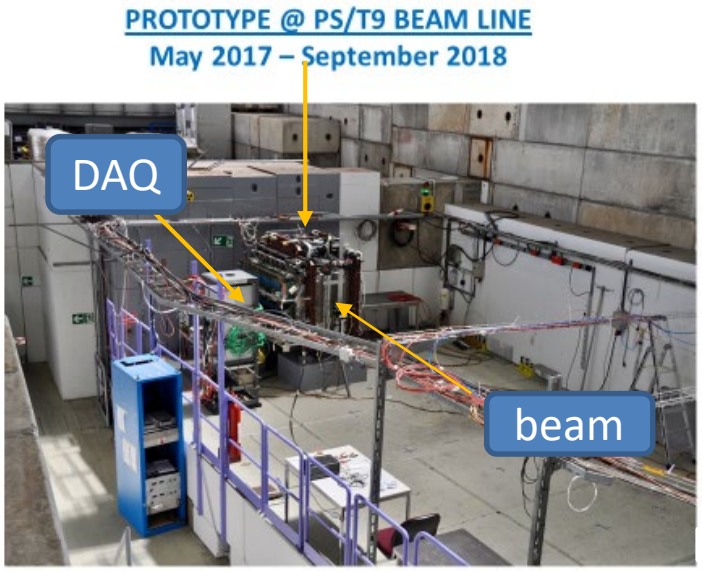


Strip board cut on G10

Range System Prototype

(~10 ton/Fe absorber plates; 276 MDTs; ~ 3000 R/O channels: 2200 wires + 672 strips)

beam position (horizontal)

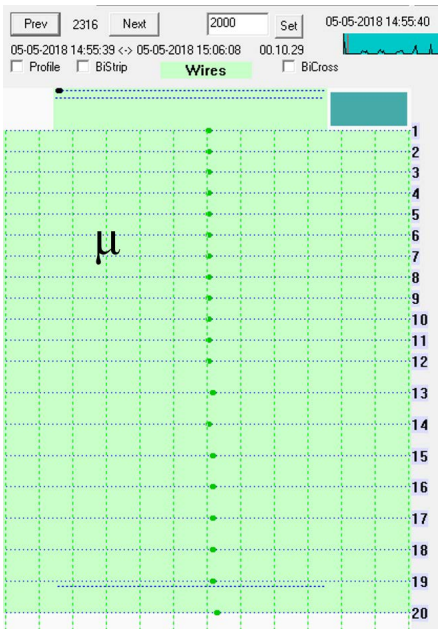


cosmic test position (vertical)

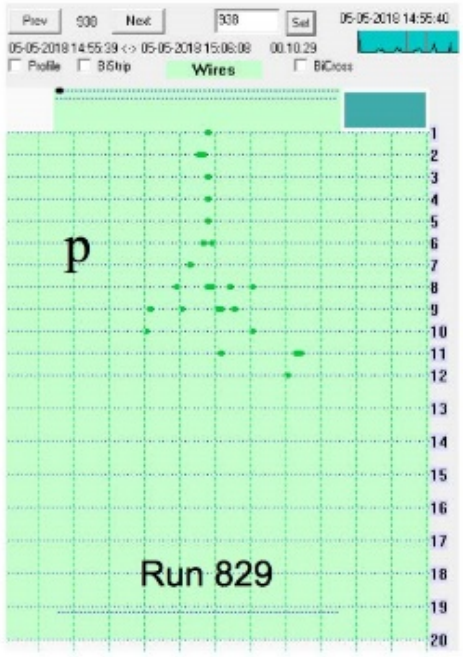
PID pictures of Muon System

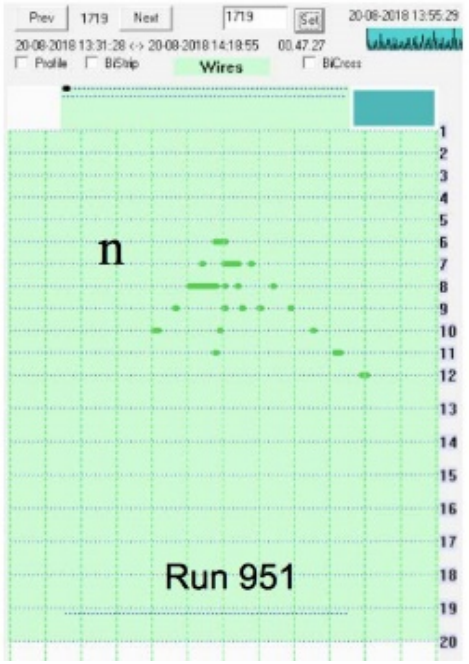
(single point equals one hit wire – 1x1 cm2; beam momentum – 5 GeV/c)

muonic sample -> ‘straight’ line

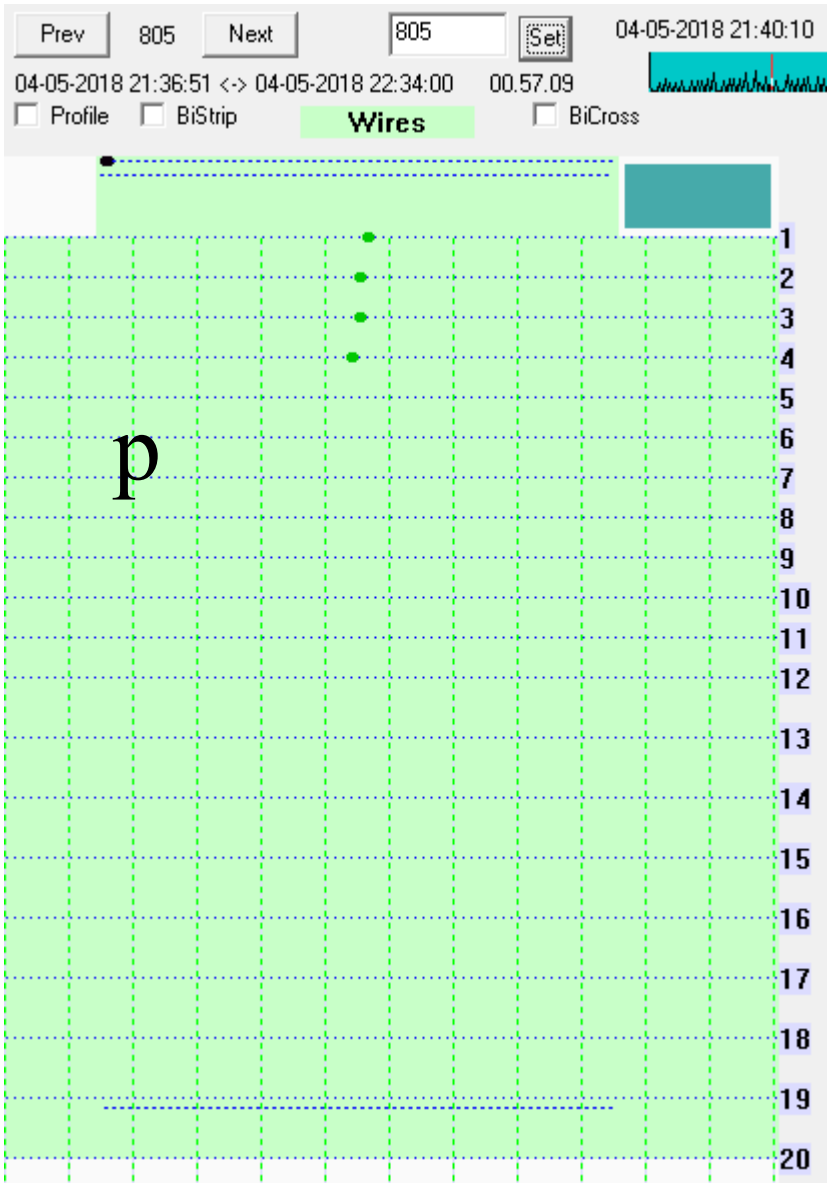


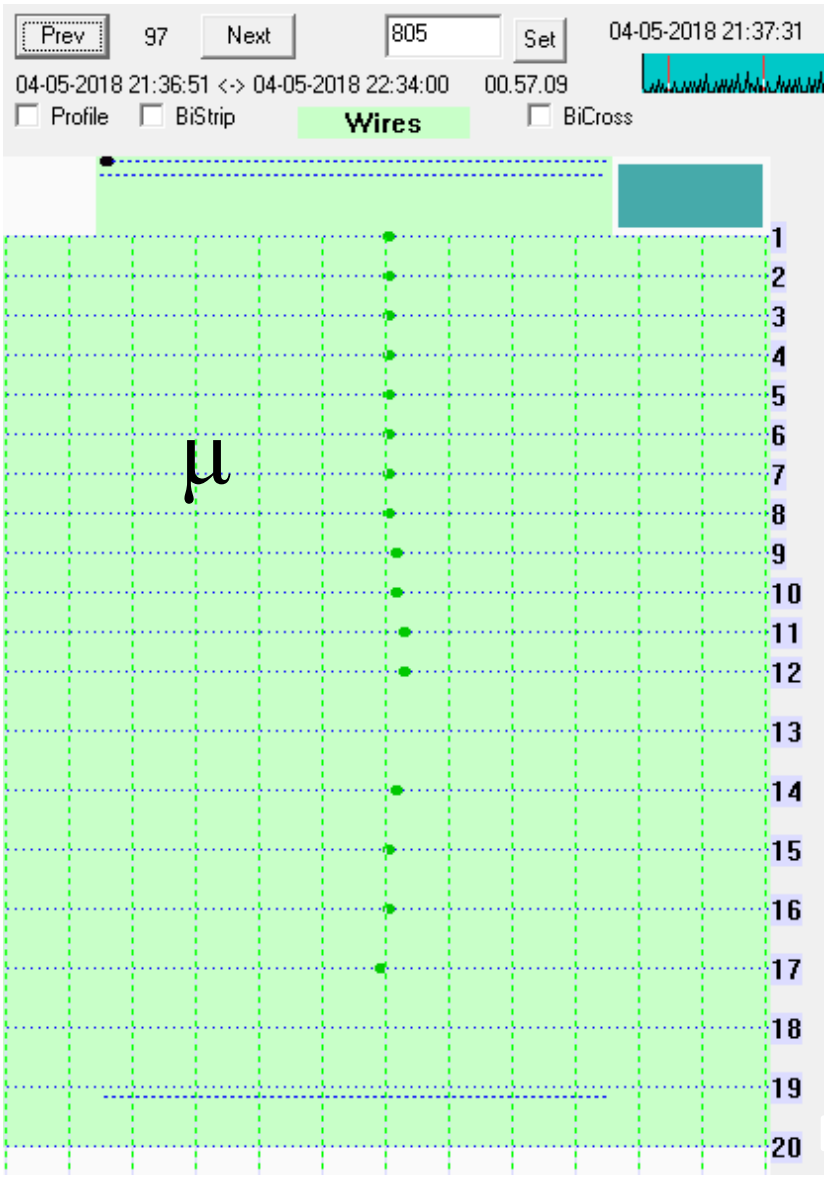
hadronic sample -> shower



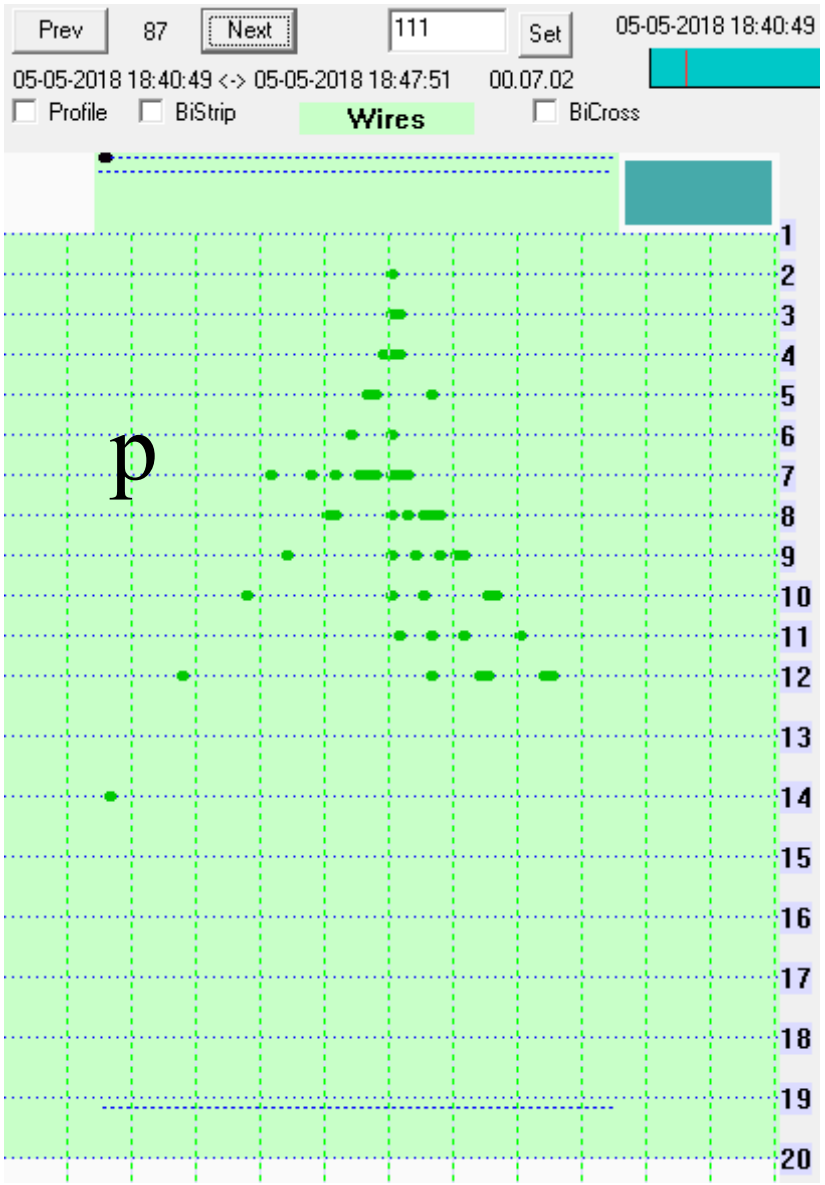


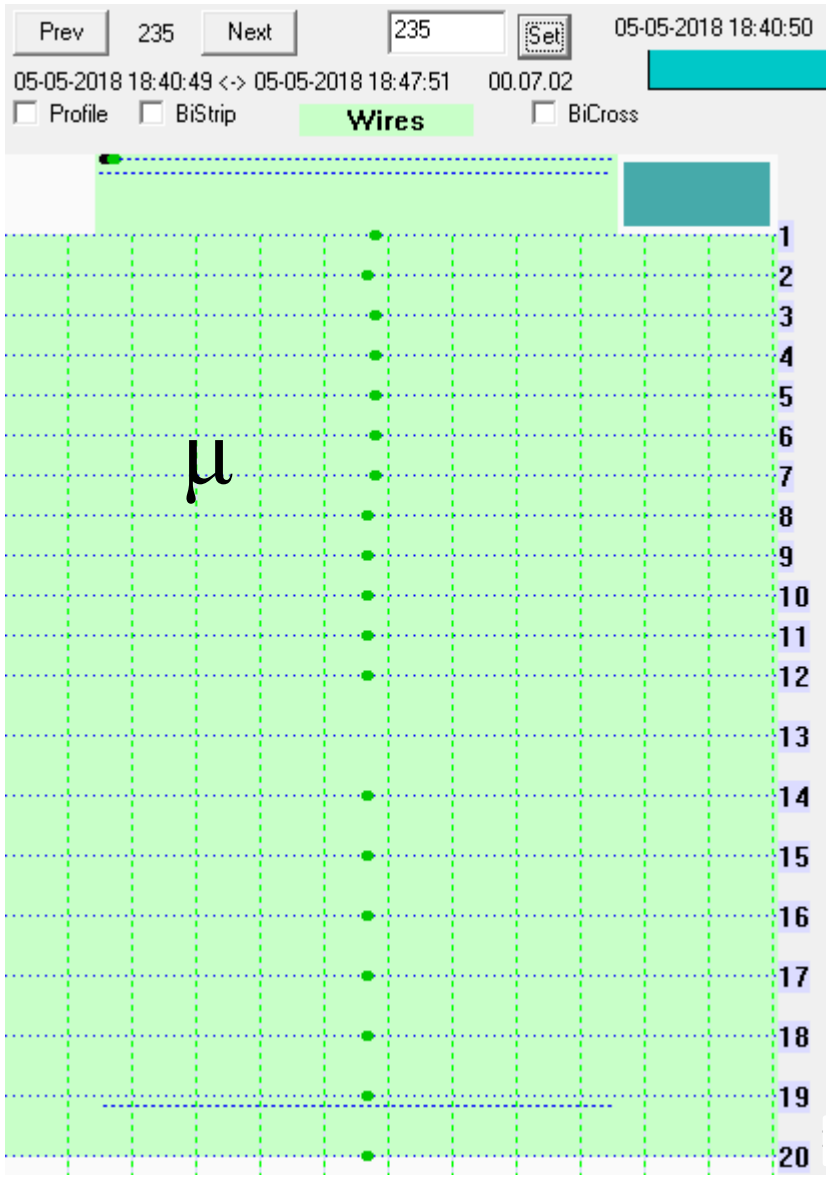
Event Examples (Run 822, P = 1 GeV/c)



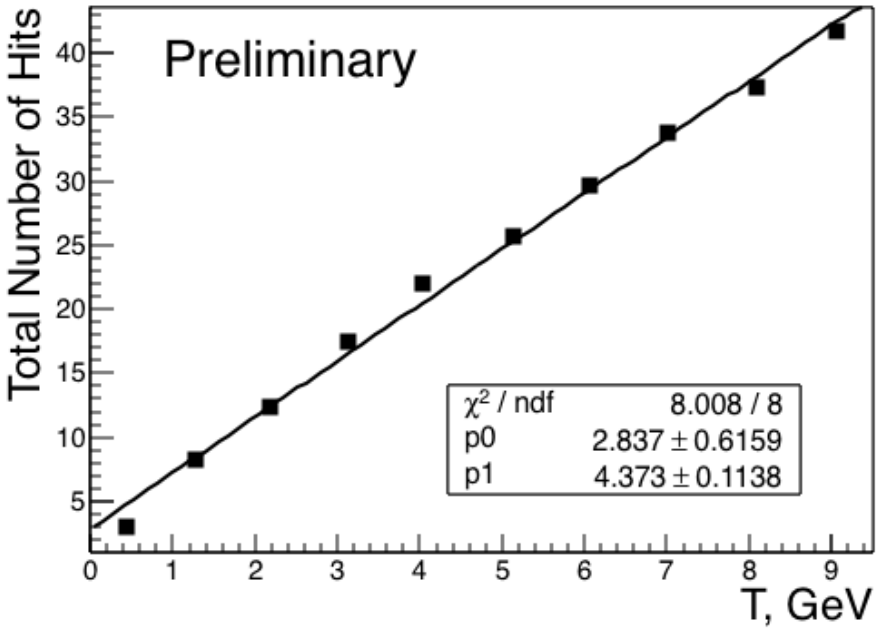


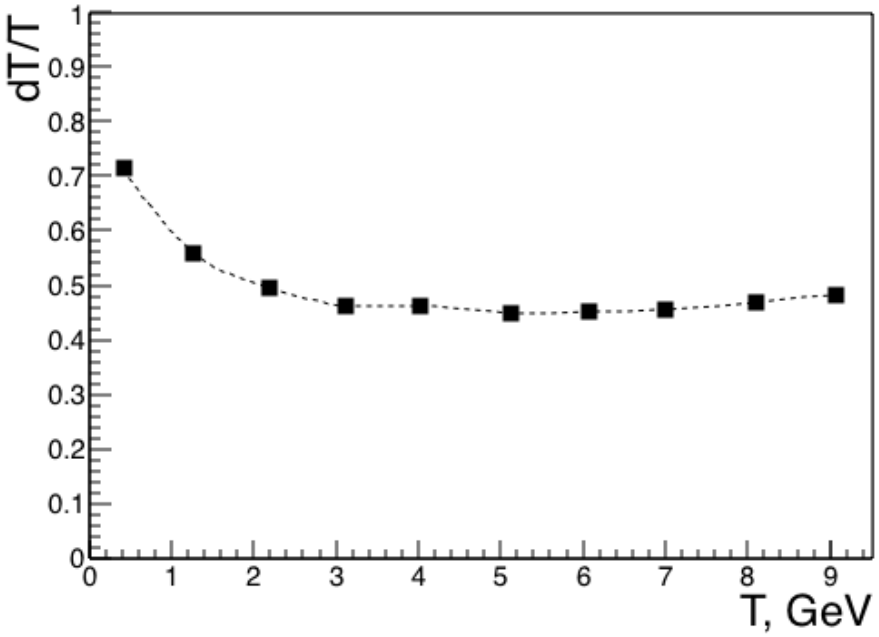
Event Examples (Run 835, P = 10 GeV/c)





Calorimetry: PANDA Barrel Structure

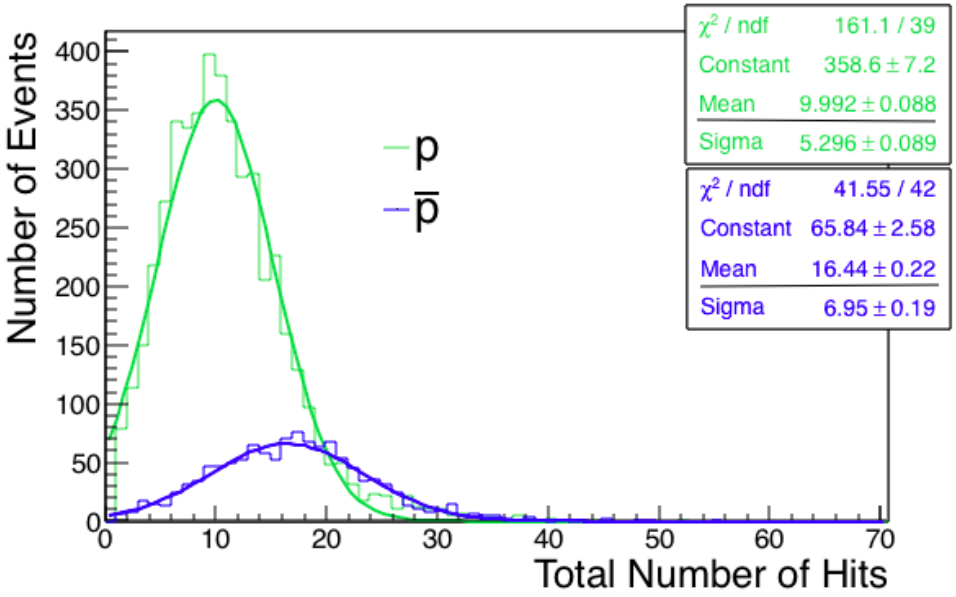


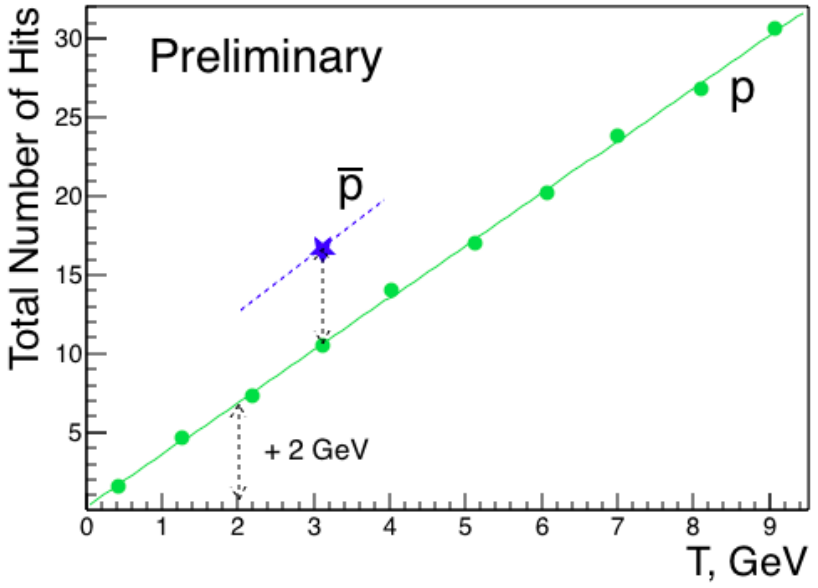


Sampling: 30 mm / Fe

Nuclear interaction length $\lambda_I \approx 2.3$

Protons vs Antiprotons

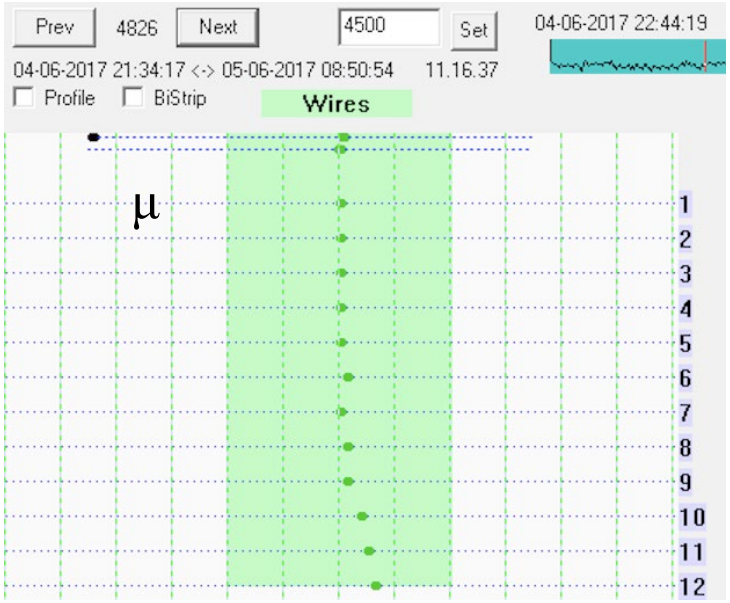


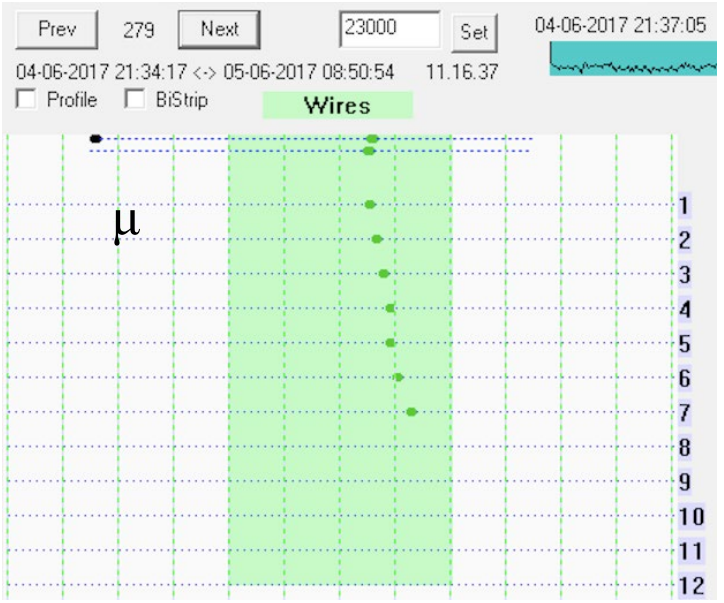


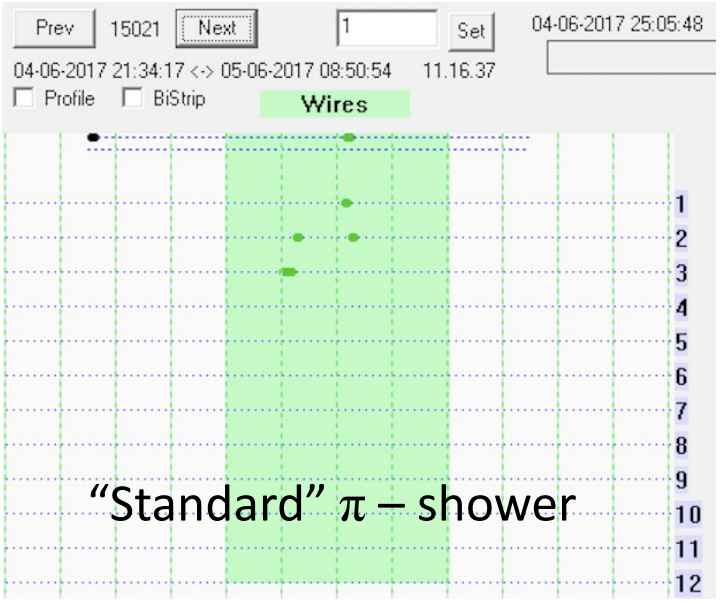
* - PANDA FRS Structure, T = 3.1 GeV

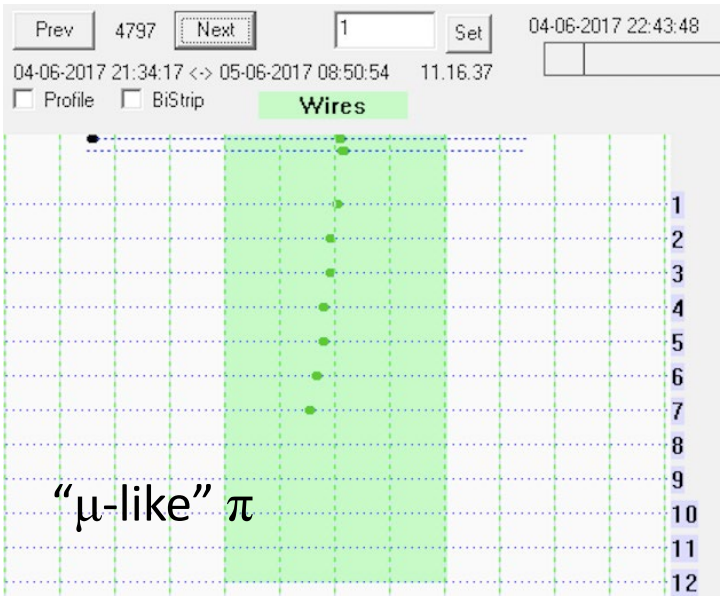
Prototype Data (μ vs π)

Run 605
P = 0.5 GeV/c

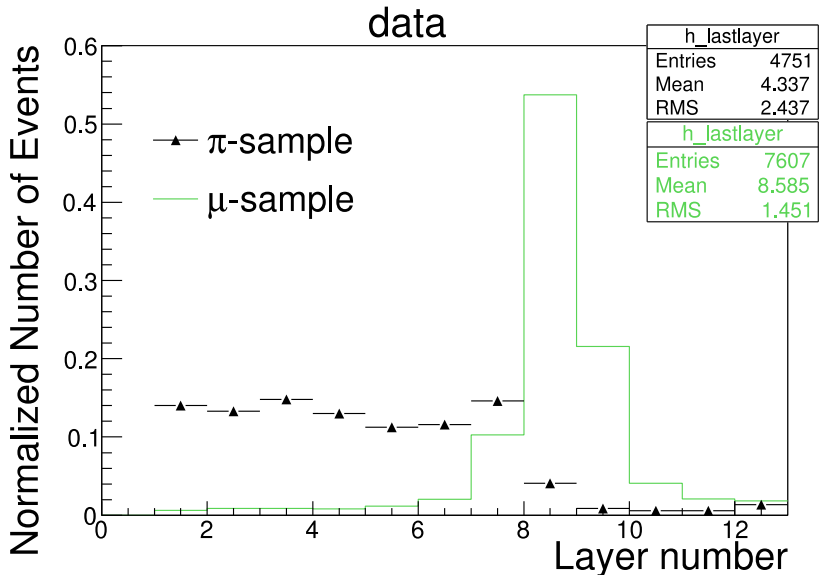


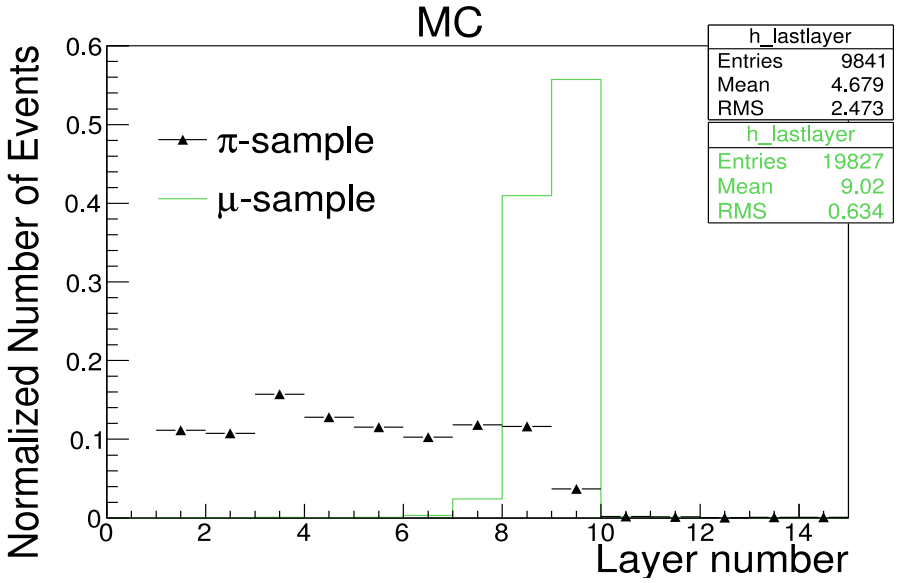






Test Beam Results (Preliminary)





EPJ WoC, Volume 177 (2018) 04001

Run 605, autumn 2017
momentum = 0.5 GeV/c

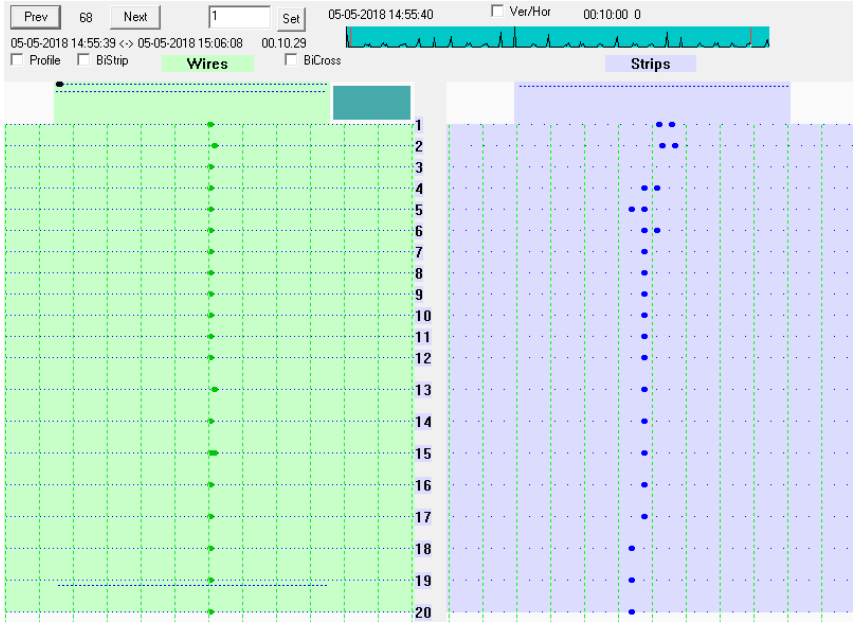
Selection -> after layer #7:
22% - pion contamination and
93% - muon efficiency

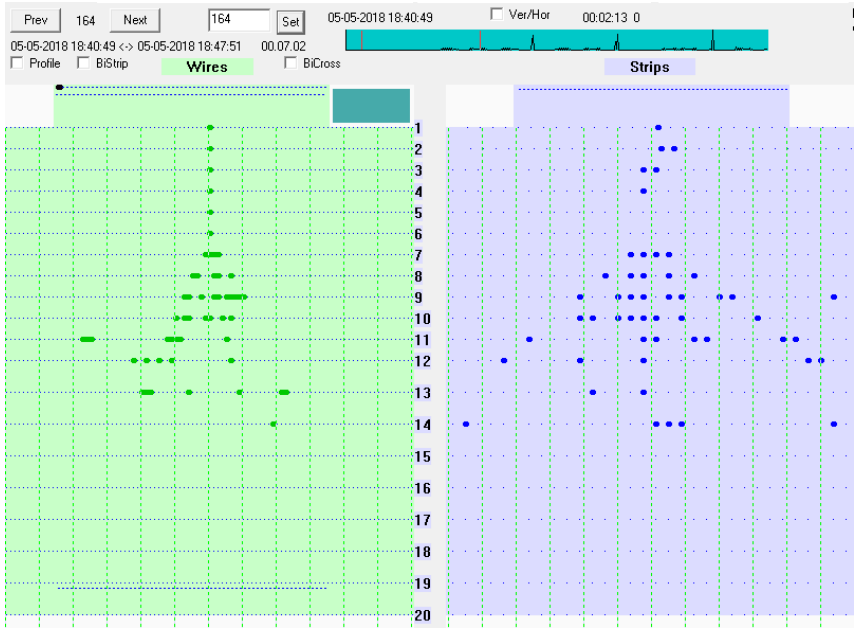
FairBoxGenerator, PandaROOT
P = 0.5 GeV/c

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)

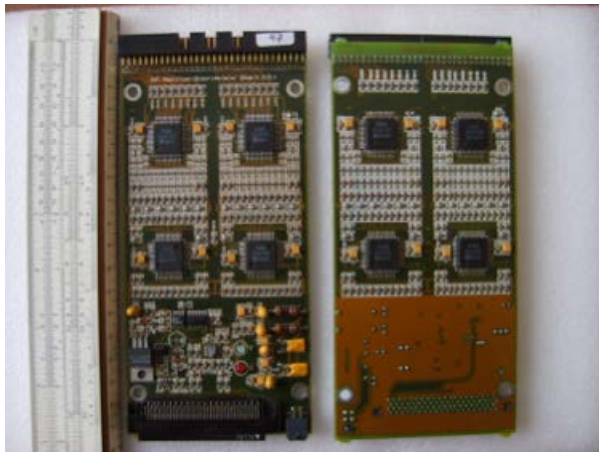




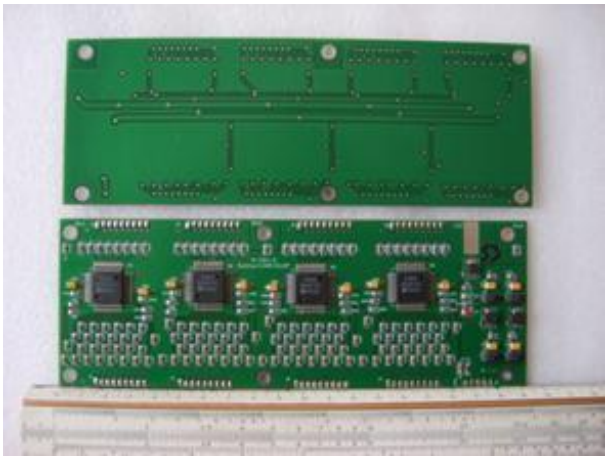
Analog Front End Electronics (FEE) cards

(conservative approach – D0/FNAL & COMPASS/CERN)

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 exists

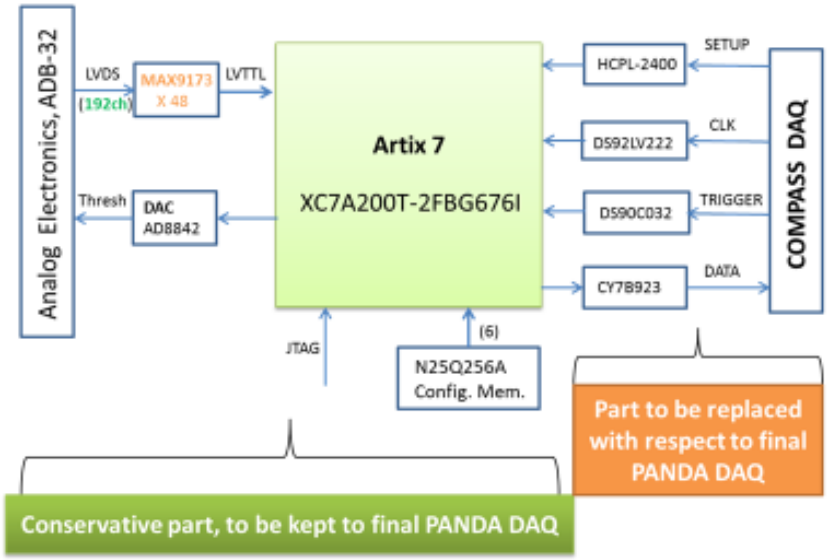
Digital Front End Electronics (FEE) cards

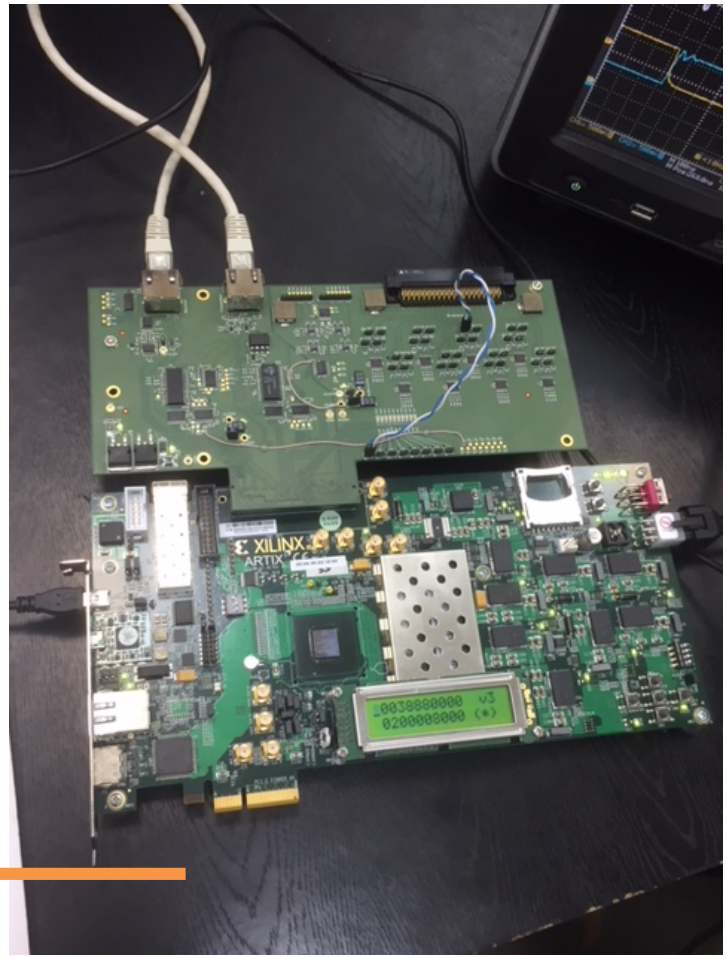
Design concept

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)

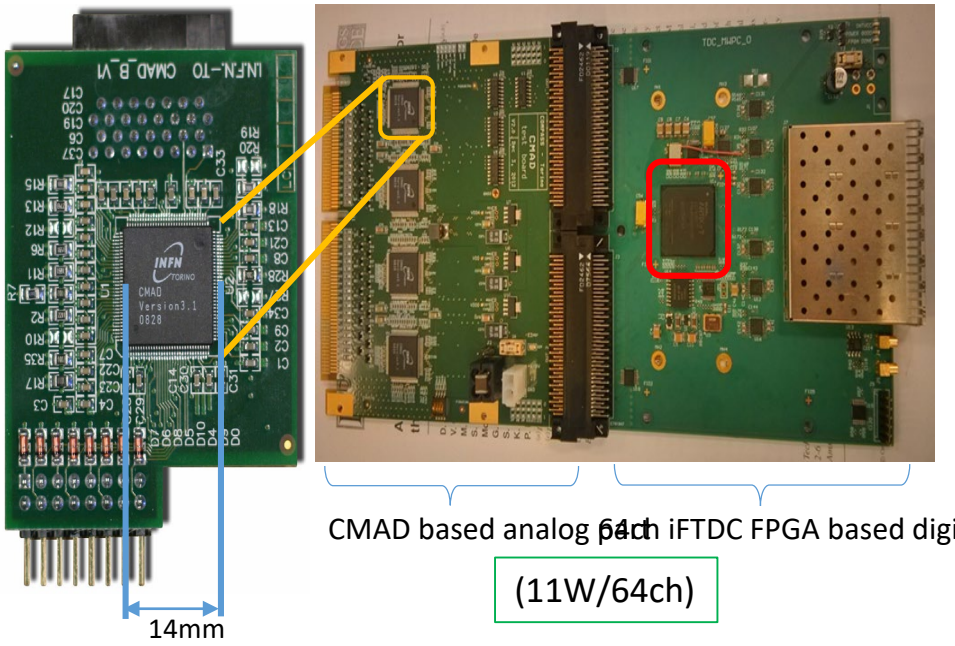




To be developed in full 192 channel unit in VME, 6U standard (design in progress)

FEE cards -> in discussion for tests with MDTs (in cooperation with INFN Torino)

CMAD



(11W/64ch)

Programmable gain : 0,4mV/fC – 4,4 mV/fC

8 channels per chip

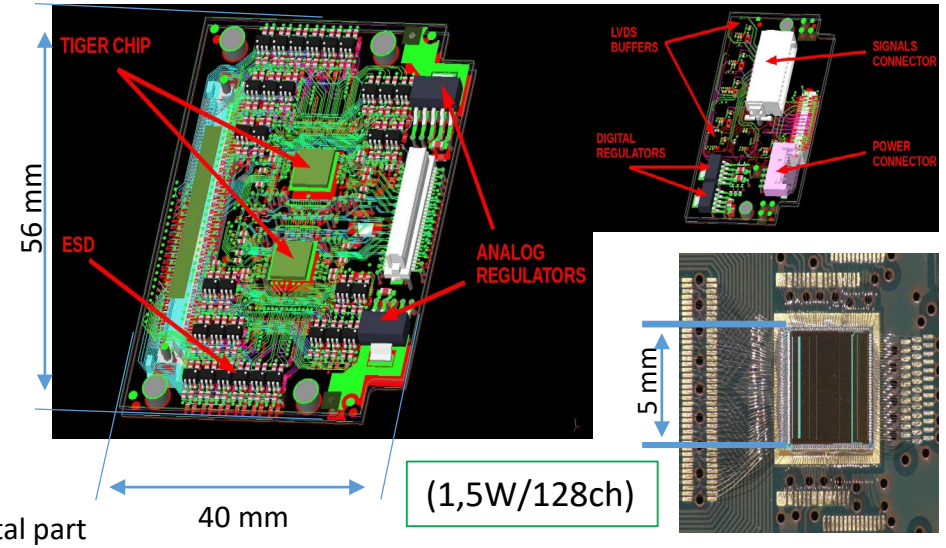
Gain programmable channel by channel

Threshold adjustable channel by channel (On board DACs+Logic)

Hit rate > 5 MHz

Power consumption < 30 mW/channel

Torino Integrated GEM Electronics for Readout (TIGER)



(1,5W/128ch)

64 channels: VFE, TDC/ADC, local controller

SEU protected digital backend

On-chip bias and power management

On-chip calibration circuitry

Fully digital output, LVDS IO

4 TX SDR/DDR links, 8B/10B encoding

SPI configuration link

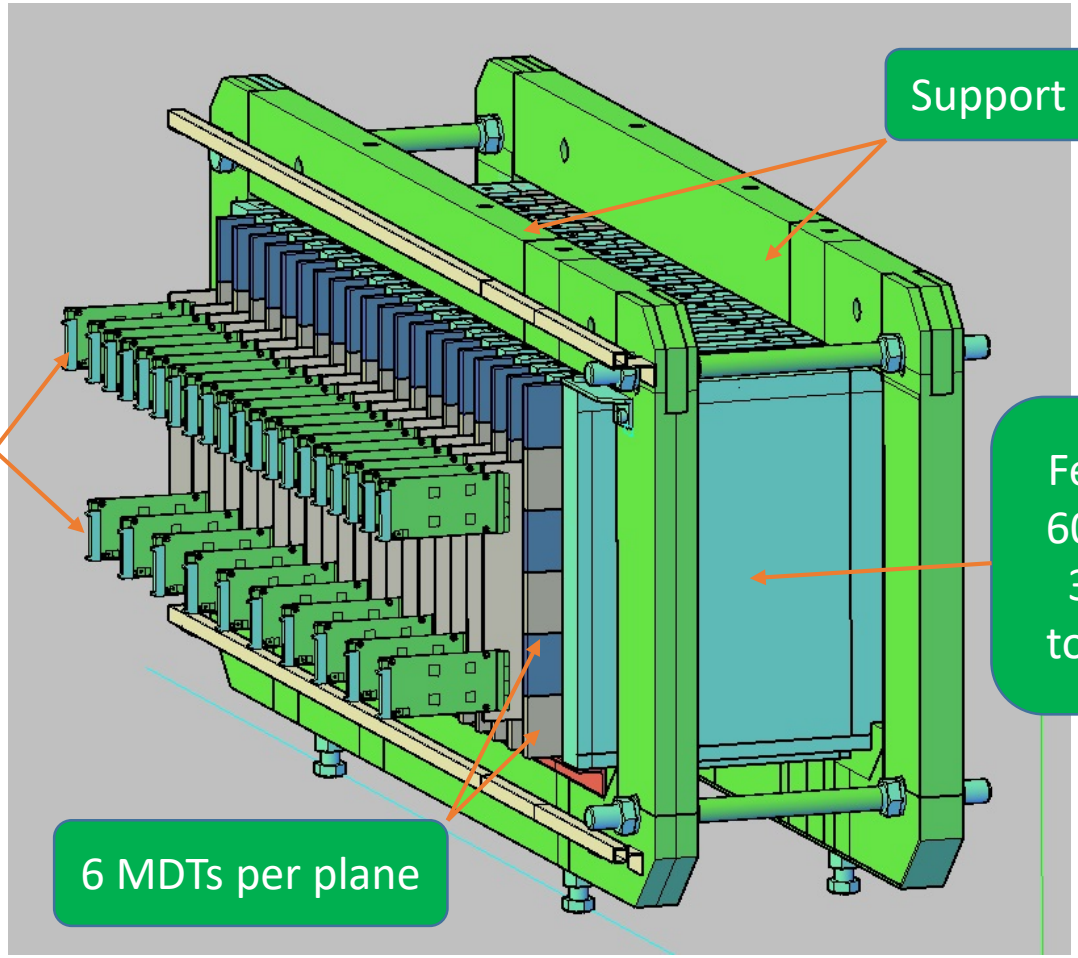
Power consumption < 12 mW/channel

Nominal 160 MHz system clock

Sustained rate per channel: above 100 kHz

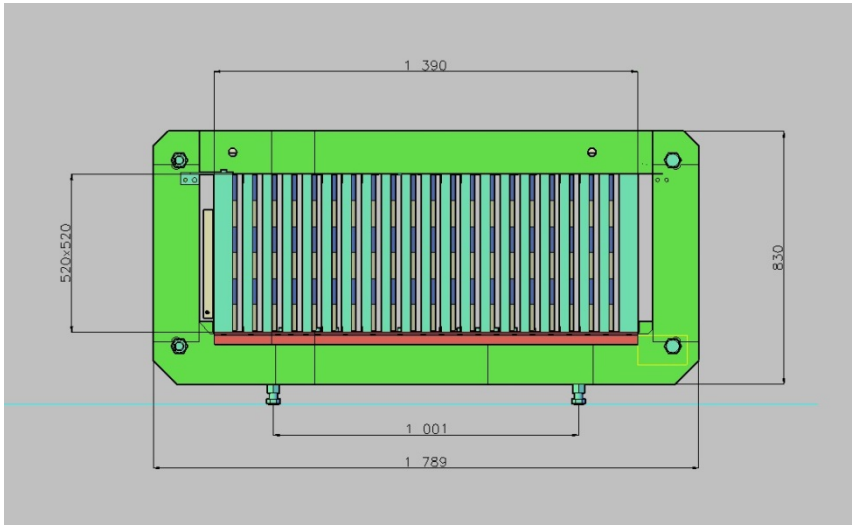
3D model of SPD Muon (Range) System Prototype

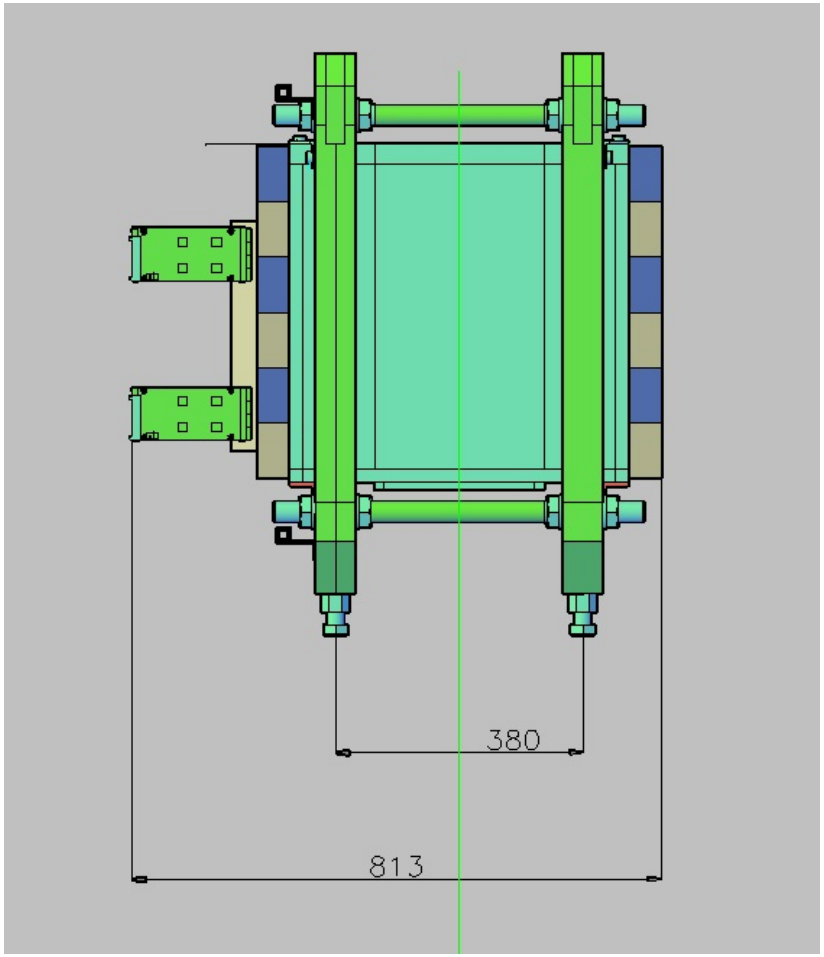
(total weight ~ 1,5 ton, 120 MDTs, 960 wire R/O channels, strips ?)



SIDE & FRONT VIEWS

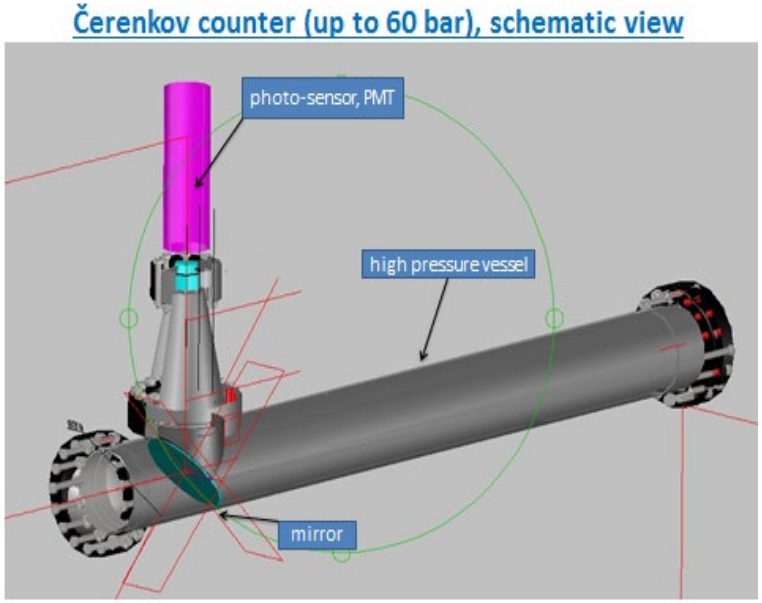
of the Prototype

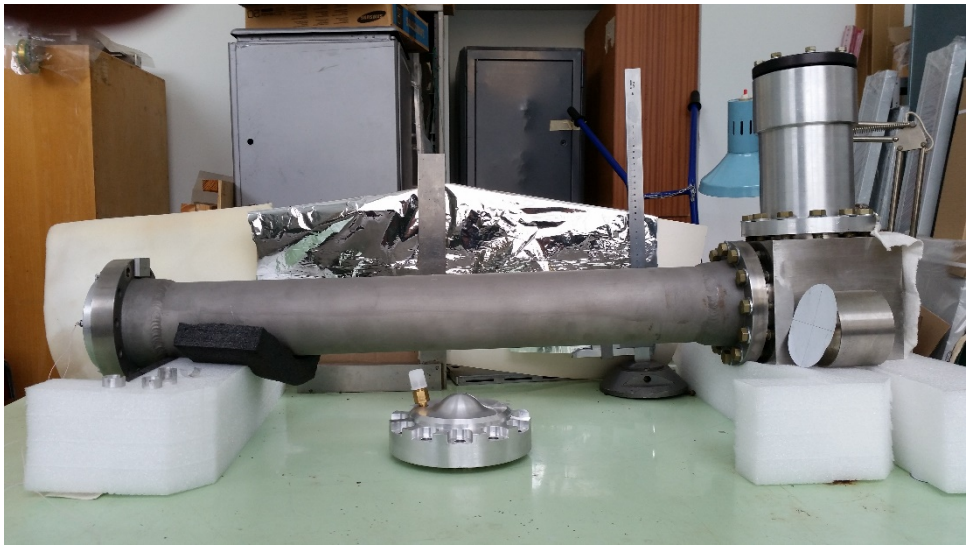




Cerenkov counter for SPD test beam

(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:

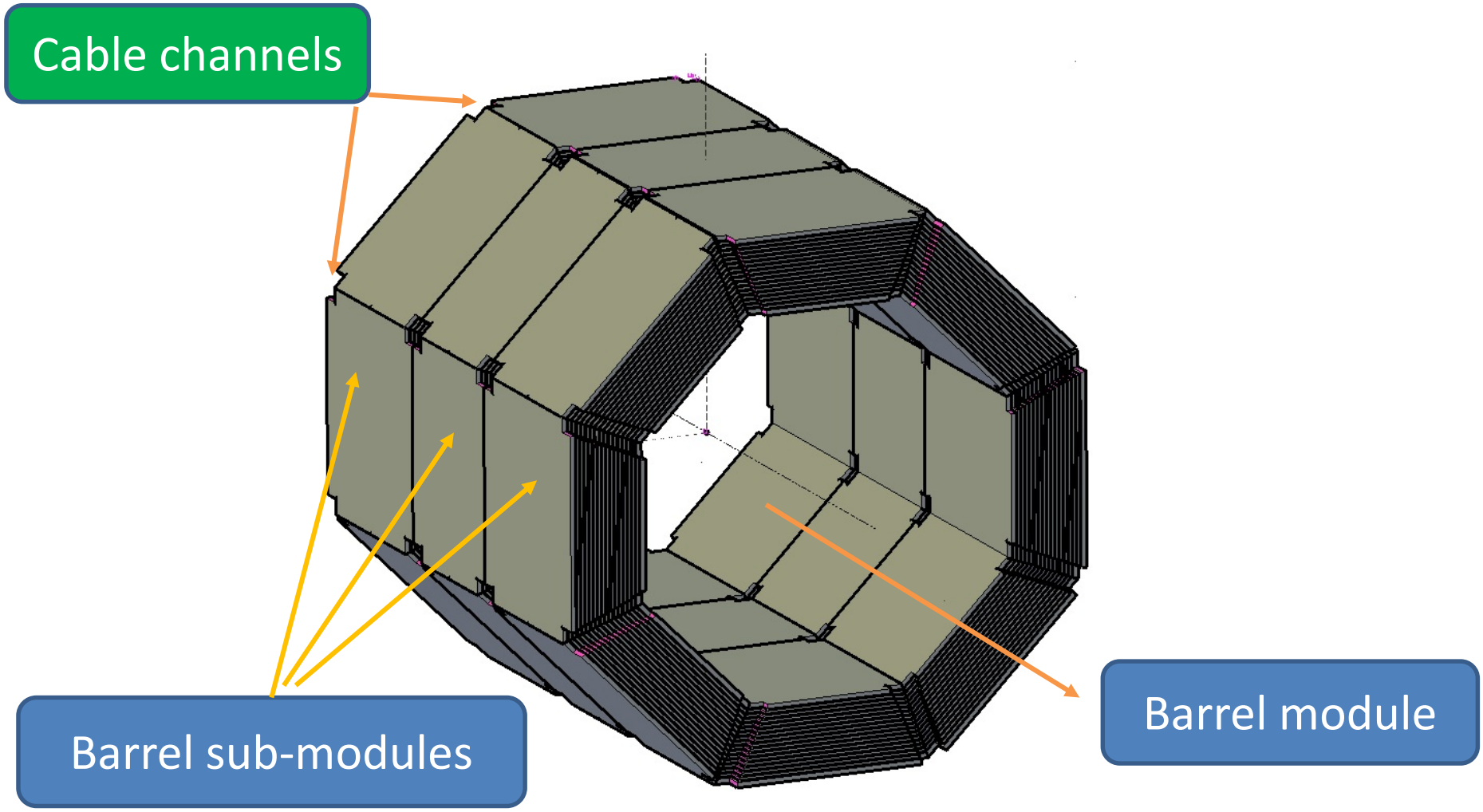
- **MC development:**
  - Digitization of signal 09.2019
  - Pattern recognition algorithms 12.2019
- **Treatment of CERN test beam data** 12.2019
- **Participation in SPD/Nuclotron Test Beam Area:**
  - Production of Prototype absorber 12.2019
  - Assembly of MDTs 12.2019
  - Prototype module of digital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

CONCLUSION:

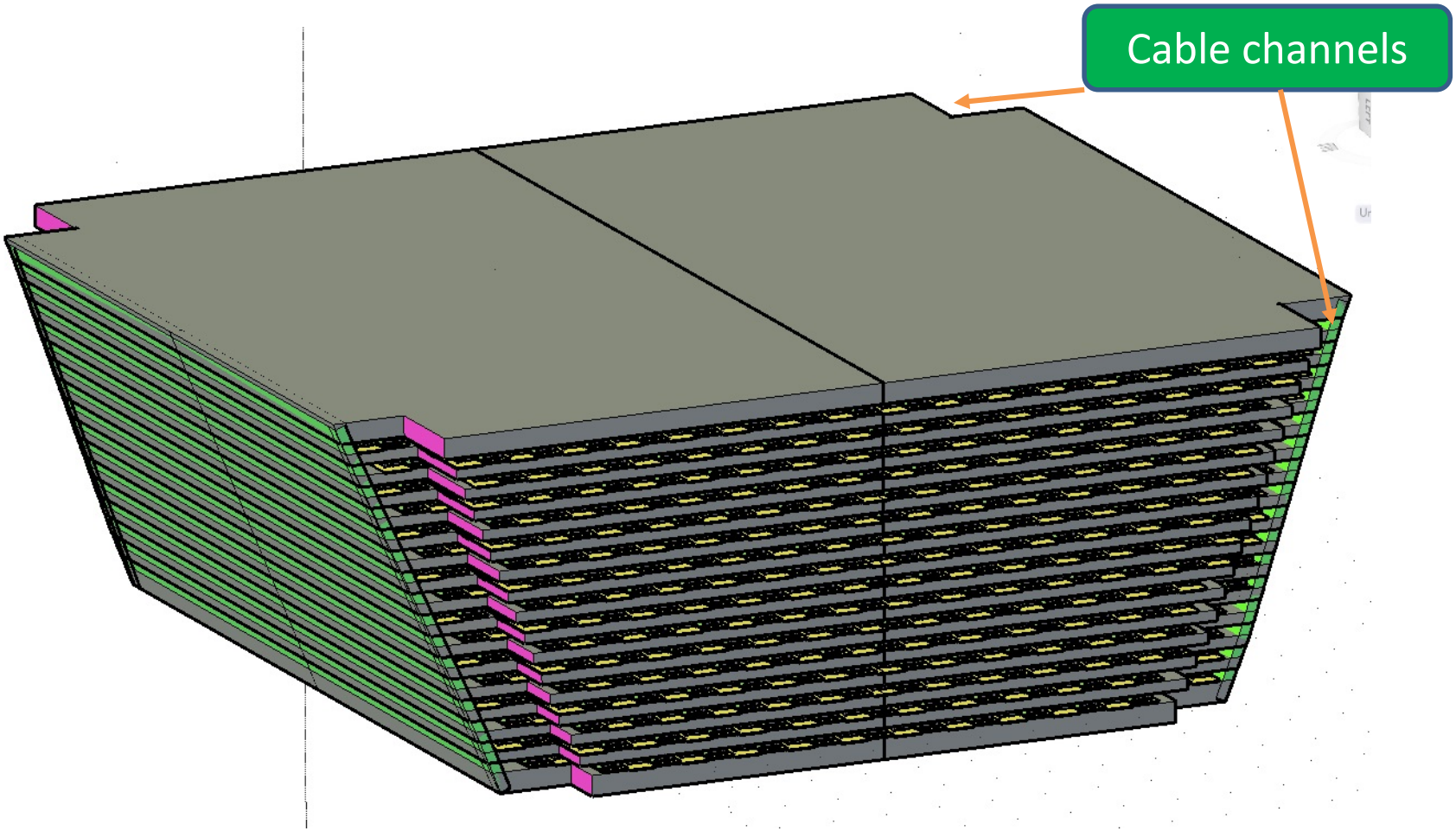
- Muon (Range) System of SPD/NICA is powerful PID instrument in full energy scale
- Existing set of experimental data is adequate for new SPD CDR
- MC requires serious development !
- Preparation for SPD test beam is on track

BACK UP SLIDES

3D model of SPD Barrel with cable channels



Barrel sub-module



Barrel sub-module

(half-size of Fe absorber plates is removed to demonstrate MDT detetector layers)