Обзор результатов работ по проекту PANDA

(семинар для продления темы 1108/PANDA)

Алексеев Г.Д.

- Спектрометр PANDA/FAIR
- Физическая программа эксперимента
- Вклад группы ОИЯИ (software/hardware)
- Мюонная система PANDA
- Мюонные детекторы: мини-дрейфовые трубки
- Электроника: аналоговая и цифровая
- Прототип мюонной системы
- Основные результаты тестов на пучке PS/CERN
- Синергия проектов PANDA/FAIR и SPD/NICA

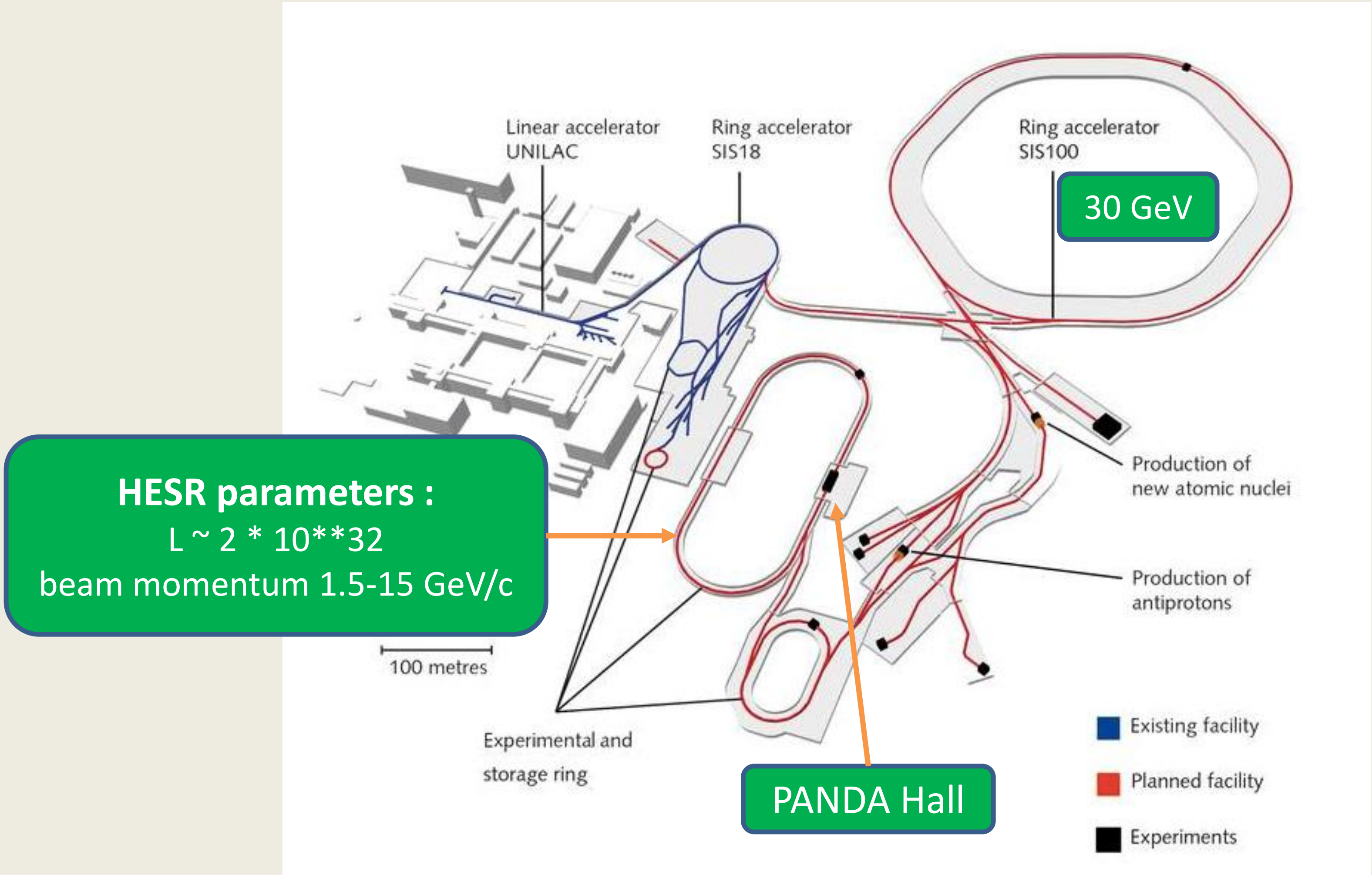
The list of participants from JINR in PANDA experiment:

V.M.Abazov, Gh.Adam, G.D.Alexeev, V.A.Arefiev, V.I.Astakhov, M.Yu.Barabanov, M.A.Baturitsky, V.Kh.Dodokhov, A.A.Efremov, A.Fechtchenko, A.S.Galoyan, G.A.Golovanov, E.K.Koshurnikov, D.I.Krestnikov, S.A.Kutuzov, V.I.Lobanov, Yu.Yu.Lobanov, P.V.Nomokonov, I.A.Olex, A.A.Piskun, I.K.Prokhorov, A.M.Rozhdestvensky, A.G.Samartsev, A.V.Semenov, S.S.Shimansky, N.B.Skachkov, A.N.Skachkova, A.S.Sorin, E.A.Strokovsky, O.V.Teryaev, V.V.Tokmenin, V.P.Volnykh, V.V.Uzhinsky, A.Yu.Verkheev, L.S.Vertogradov, Yu.L.Vertogradova, A.S.Vodopyanov, N.I.Zhuravlev.

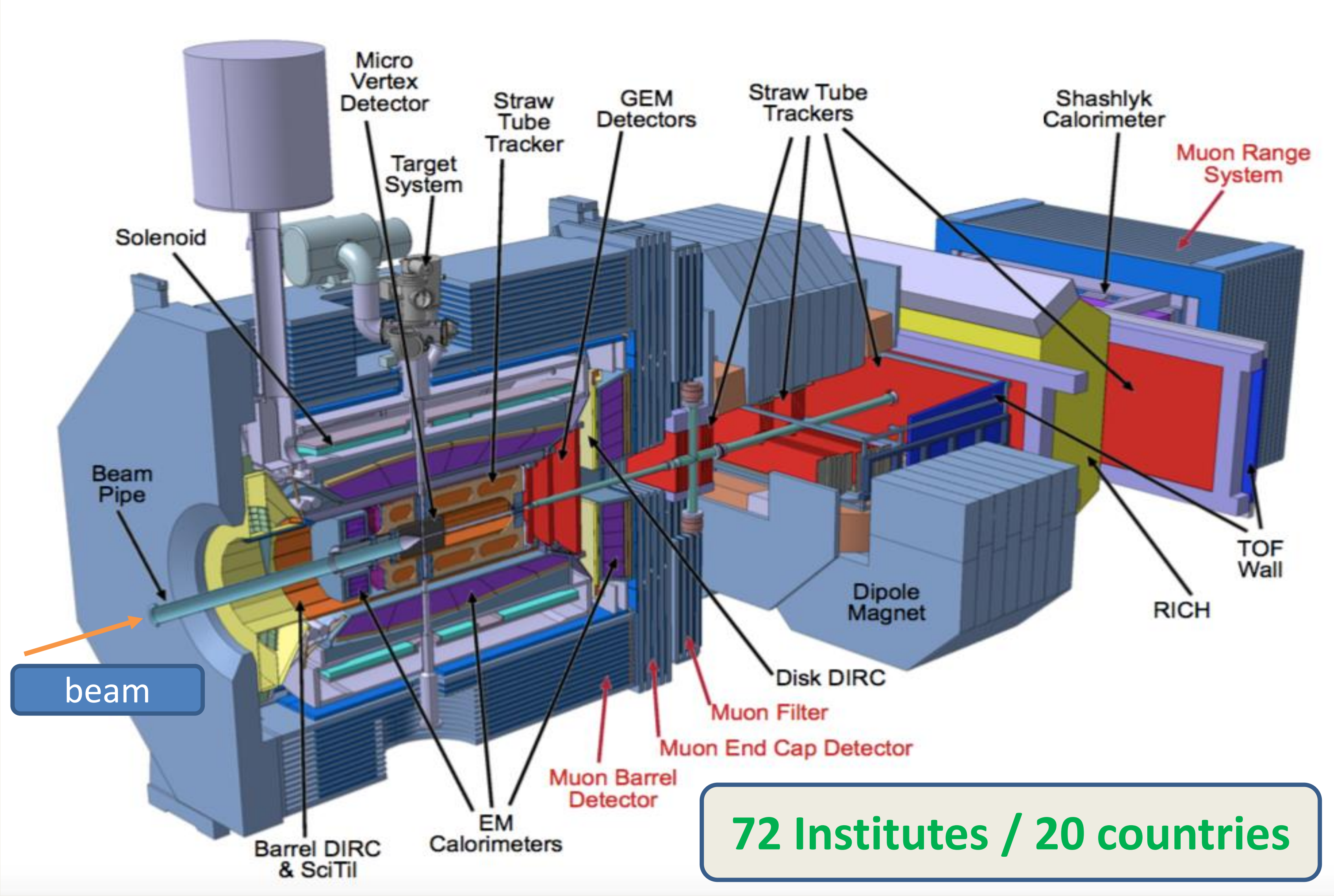
JINR Laboratories involved: DLNP, VBLHEP, BLTP and LIT

GSI & FAIR Laboratories (areal view)

FAIR Accelerator Complex



The view of PANDA setup: the Muon System elements (Barrel, End Cap, Filter and Range systems) are indicated in red



72 Institutes / 20 countries

Panda physics overview

Nucleon Structure

Transition Distribution Amplitudes (TDA) (meson production)
Generalised Distribution Amplitudes (GDA) (time-like Compton, hard exclusive processes)
Time-like Electromagnetic Form Factors (Low and high E, e and μ pairs production)
Transverse Parton Distributions (Drell Yan process)

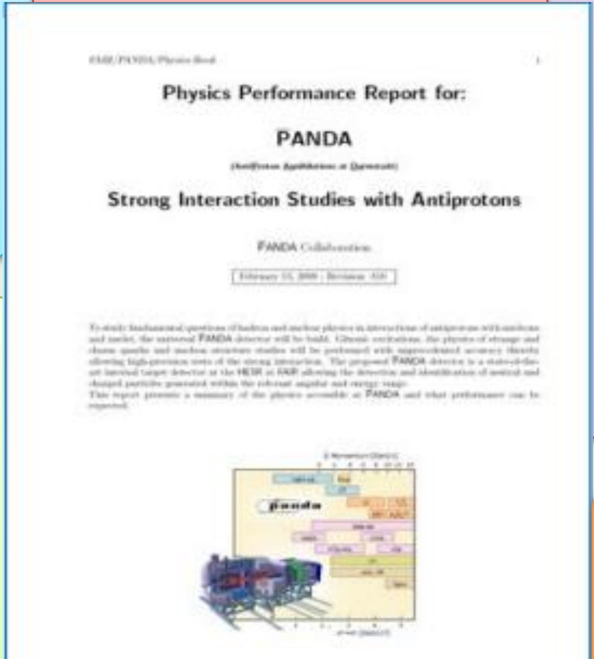
Bound states and Dynamics of strong interactions

Hadron spectroscopy

Production of states of all quantum numbers
Resonance scanning with high resolution
Precision determination of mass, width & quantum numbers J^{PC} of resonances
Charm hadrons: charmonia, D-mesons, charm-baryons –> Understand new XYZ states, $D_s(2317)$ and others
Production of exotic QCD states:
Glueballs, hybrids, multi-quarks

Nuclear Physics

Hypernuclear physics:
Double Λ hypernuclei
γ-spectroscopy of hypernuclei
Hyperon interaction
Antihyperon in Nucleai
Hadrons in nuclei:
Charm and strangeness in the medium


Physics Performance Report for:

PANDA

Strong Interaction Studies with Antiprotons

arXiv:0903.3905v1

Strangeness

Strange baryons:
Specroscopy
Polarisation

Staging of physics program: flagship showcases

Timeline *Conceptual compilation*

2025

- **Phase-C:** *reduced setup, proton beam*
  - Commissioning of detector components
  - Physics in p+p: under investigation

2026

- **Phase-1:** *reduced setup, reduced luminosity, antiproton beam* — 0.5 fb^{-1}
  - light: Electromagnetic form factors in dilepton channel at low energies
  - strange: Spin observables in hyperon production: S=1,2 systems
  - charm: Exploration of charmonium(like) states; line shape studies

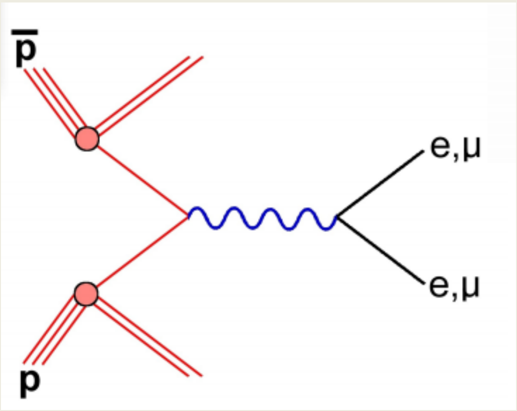
2027

- **Phase-2:** *full setup, reduced luminosity, antiproton beam* — 1 fb^{-1} total MSV0-3
  - light: light-meson spectroscopy: gluonic excitations
  - strange: S=2,(3) baryon spectroscopy
  - charm: high-spin charmonium spectroscopy

2027+

- **Phase-3:** *full setup, full luminosity, antiproton beam* — >10 fb^{-1} with P3
  - light: Drell-Yan, GDA's, TDA's
  - strange: Spin observables in S=3 hyperon production + CP violation; hypernuclei (S=2)
  - charm: Ds scan and open-charm decays & spectroscopy

Drell-Yan background study



Direct access to TMD-PDFs and the 3-D nucleon structure

Unpolarised Drell-Yan: gaussian shape of TMDs, energy dependence of <k⊥>, Boer-Mulder functions, TMD evolution

@PANDA unique energy range up to s~30 GeV²

- **Continuation of work on background suppression for the DRELL-YAN process with e+e- pairs** in the final state with the use of **PYTHIA and PANDARoot** software has shown that the large set of different kinematic variables, that have been studied, does not allow to suppress a background to a reasonable level. **Thus this mode of Drell-Yan process was considered hopeless for study at PANDA.**

- **The Drell-Yan process has been studied in details for mu+mu- channel on the basis of PYTHIA6 Monte-Carlo generator.** Calculations of DY cross sections for the whole spectrum of antiproton energies available at PANDA (3.5 - 15.5 GeV) were done together with estimations of the number of di-muon events expected at various accelerator modes. Detailed kinematical and correlation distributions of muons for each of the studied energies were also obtained.

- **A search for new kinematic background suppression criteria for the Drell-Yan process in mu+mu- mode** and optimization of their parameters using **PYTHIA6** was performed. Efficiencies of different criteria were evaluated.

- **Simulation of background to Drell-Yan process with standalone DPM generator was performed**. Comparison of obtained spectra and cross sections with PYTHIA ones was carried out.

- **Full simulation of background events with DPM & PandaRoot is started.** The first evaluation of efficiencies of the previously developed suppression criteria was carried out.

- **The work on the backgrounds suppression for prompt photons production was also continued using PYTHIA and PANDARoot software.** Different sets of new variables that can be used for background suppression were considered. Some intermediate estimations were obtained.

Software tools and physics

- **Current versions of PANDARoot from GIT with corresponding versions of external libraries FAIRSoft and FAIRRoot were installed at heterogeneous cluster "HybriLIT" at LIT JINR.** That gave a possibility to perform full simulations, reconstruction and analysis of **Pbar-P** and **Pbar-A** processes in **PANDARoot** at cluster **HybriLIT/Govorun** for PANDA users from JINR and Russia.

- **New probabilities of strange quark-antiquark pair and diquark-antidiquark pair productions were proposed and implemented in the FTF model of Geant4.** Good agreement was reached between the improved **FTF** model calculations and the NA61/SHINE experimental data. Kinematical properties of **Λ-hyperons** and **K-mesons** produced in **pbar-p** -reactions were calculated in the improved **FTF** model and compared with the experimental data at various initial momenta. Good description of the experimental data was obtained in the **FTF** model with the rotating strings and the new probabilities. Application of the **FTF** model is demonstrated for the physical program of **Panda Phase0 and Panda Phase1**.

- **Simulations of elastic P-P and Pbar-P interactions in the proposed frame of the Unified Systematic of Elastic Scattering Data (USESD) are performed** in a wide range of energy – from 100 MeV up to 10 TeV. **Calculations of inelastic P-P interactions at various energies are performed in the frame of improved FTF model of Geant4 toolkit.** These results can be used for developing of physical program of **PANDA Phase 1.**

- **Full simulation using PANDARoot at HybriLIT cluster was performed for reconstruction and analysis of inelastic and elastic P-P interactions with 2,4,6 hadrons in the final states with large Pt in the frame of FTF model**. The analysis results show that such processes can be studied in the frame of **PANDA Phase 1**.

- **The scaling and asymptotic properties of slow neutrons spectra (produced in interactions of protons with various nuclei in the energy range from 747 MeV up to 8.1 GeV) were implemented in the Geant4 FTF model.**

- **For the first time, charmed quark production is implemented in the Geant4 hadronic models - FTF and QGS. Smearing of resonance mass was also implemented in FTF model of Geant4**

- **Participation in preparation of LoI for 'Phase-C' of PANDA, which is devoted to high Pt physics studies during commissioning of PANDA.**

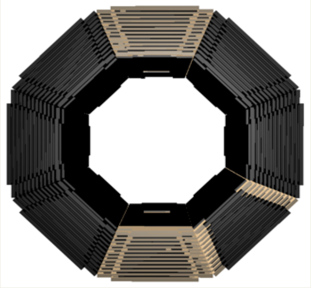
Full geometrical description/model of the Muon System

• **In 2018-2019 the final design of the Muon System was agreed with BINP** (Novosibirsk) who are engaged in the design and production of the Solenoid Magnet yoke.

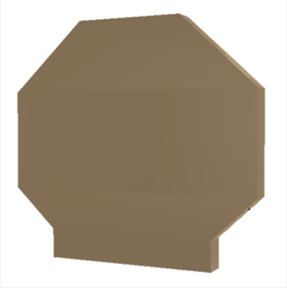
• **The Barrel part of the Muon System has undergone significant changes** (the number of detecting layers has decreased (to 12) compared to the previous design, the dimensions of the installation also have changed).

• As a result, the **geometrical model of the Barrel part of the Muon System was modified**. Also, the **geometrical models of the End Cap, Muon Filter and Forward Range System are now ready for integration into PANDARoot framework**.

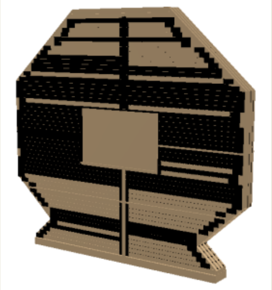
• **The software was rewritten** using a geometry package in Root **and now ready for implementation into the PANDARoot package.**



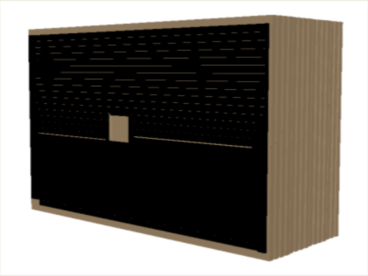
Barrel



End Cap

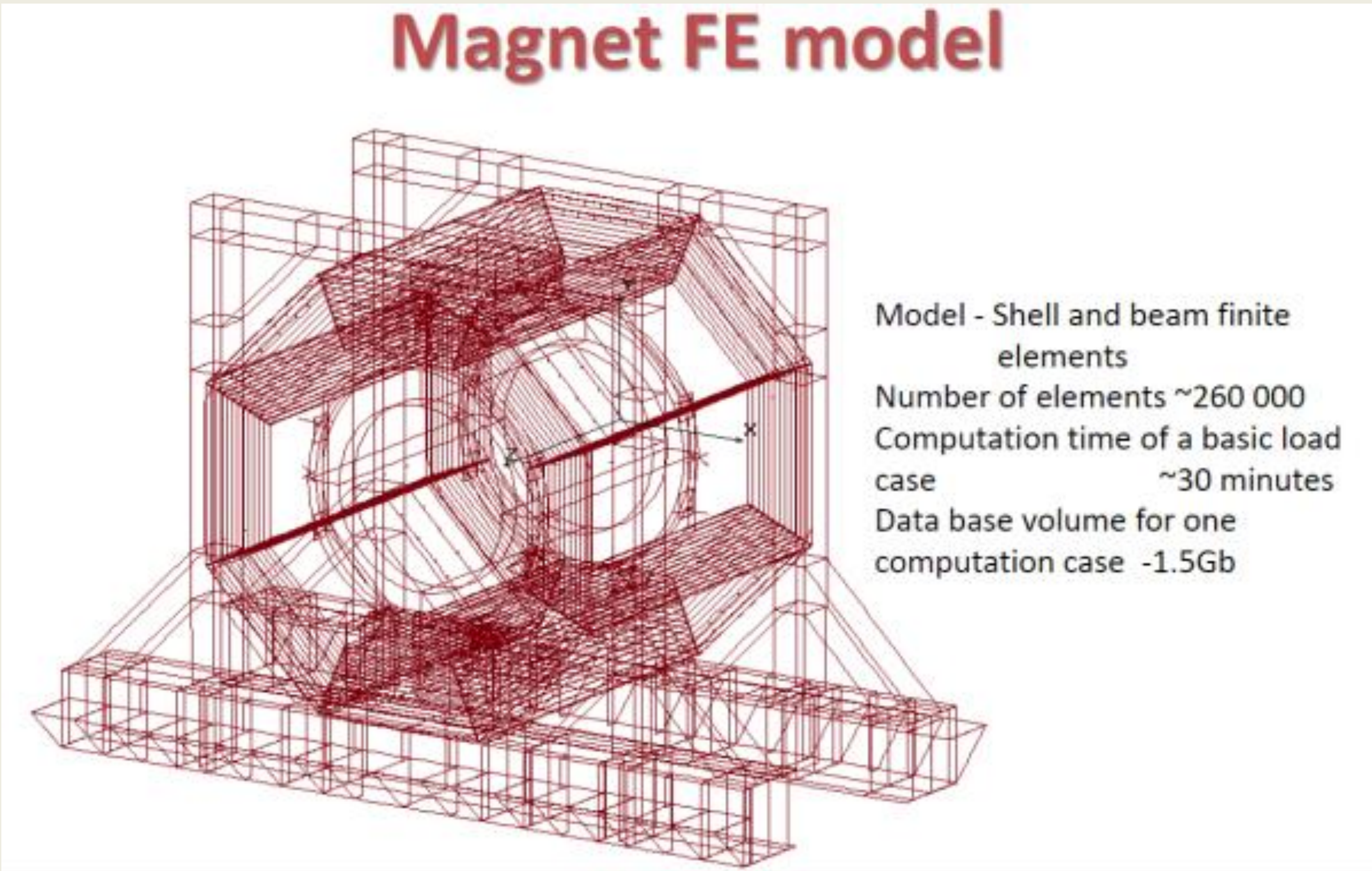


Muon Filter

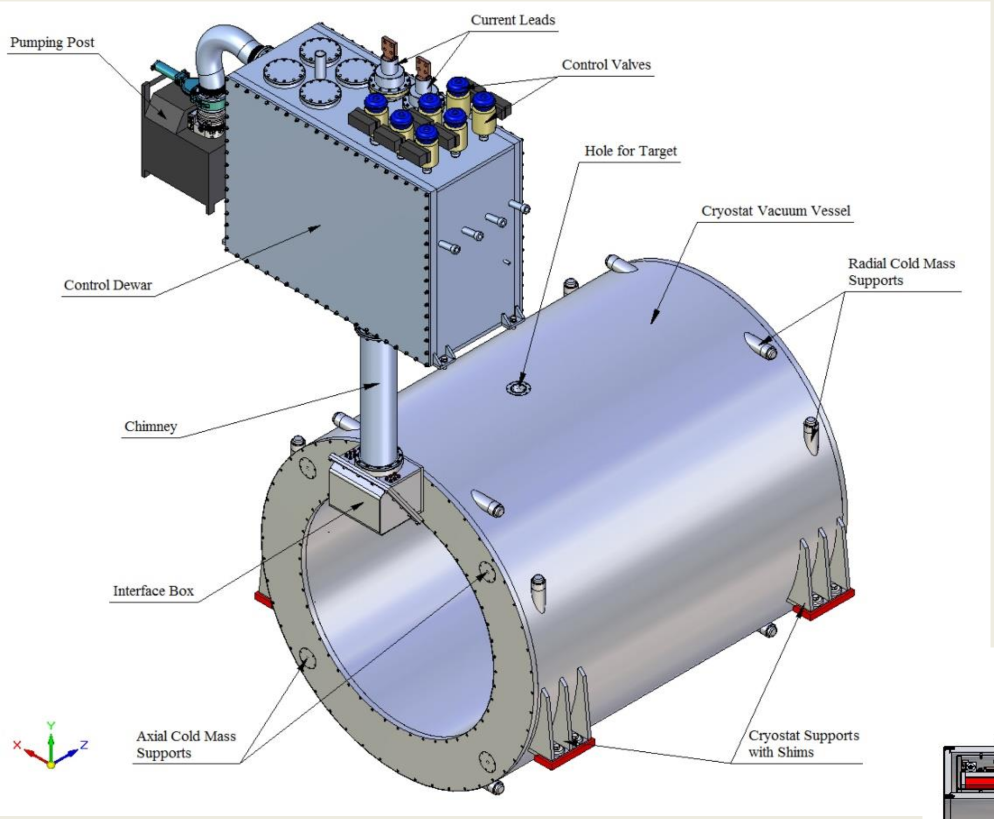


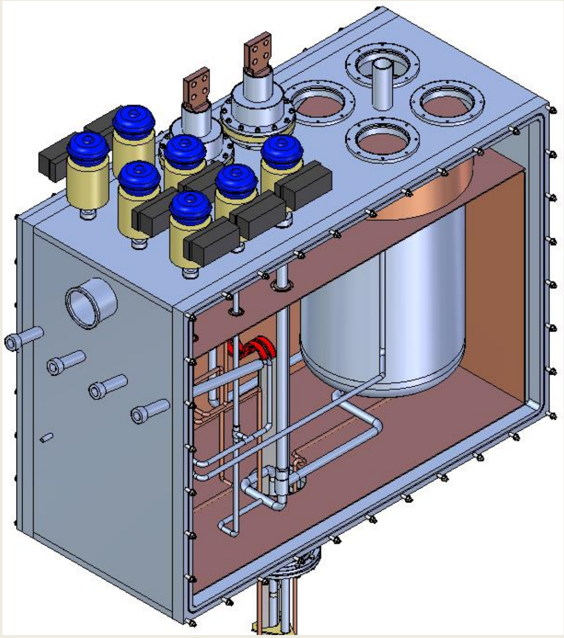
Forward Range System

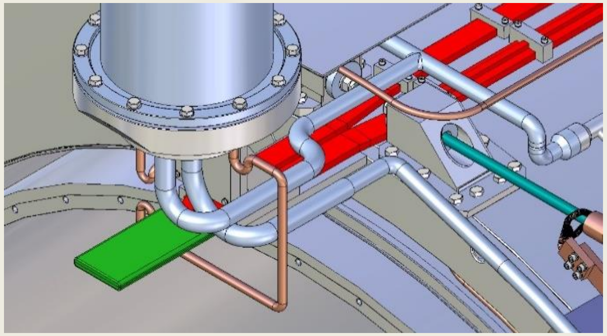
Example of strength analysis of the PANDA magnet

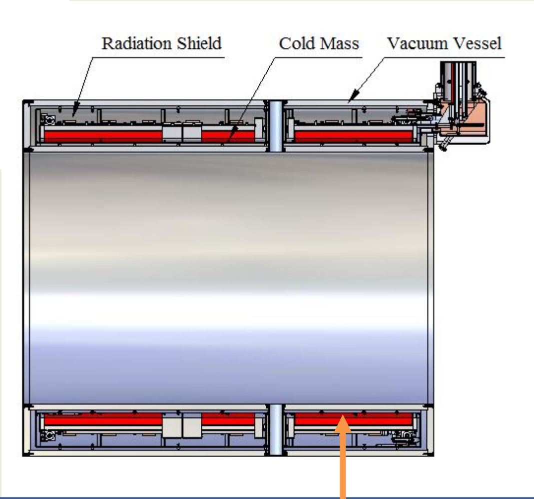


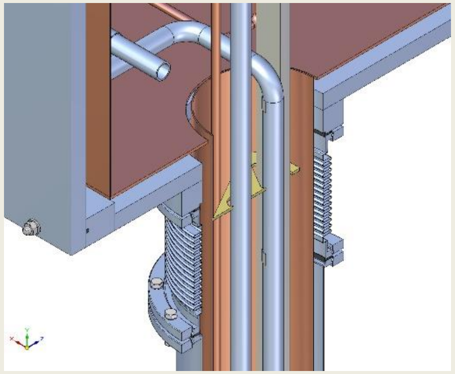
Cryostat and control Dewar





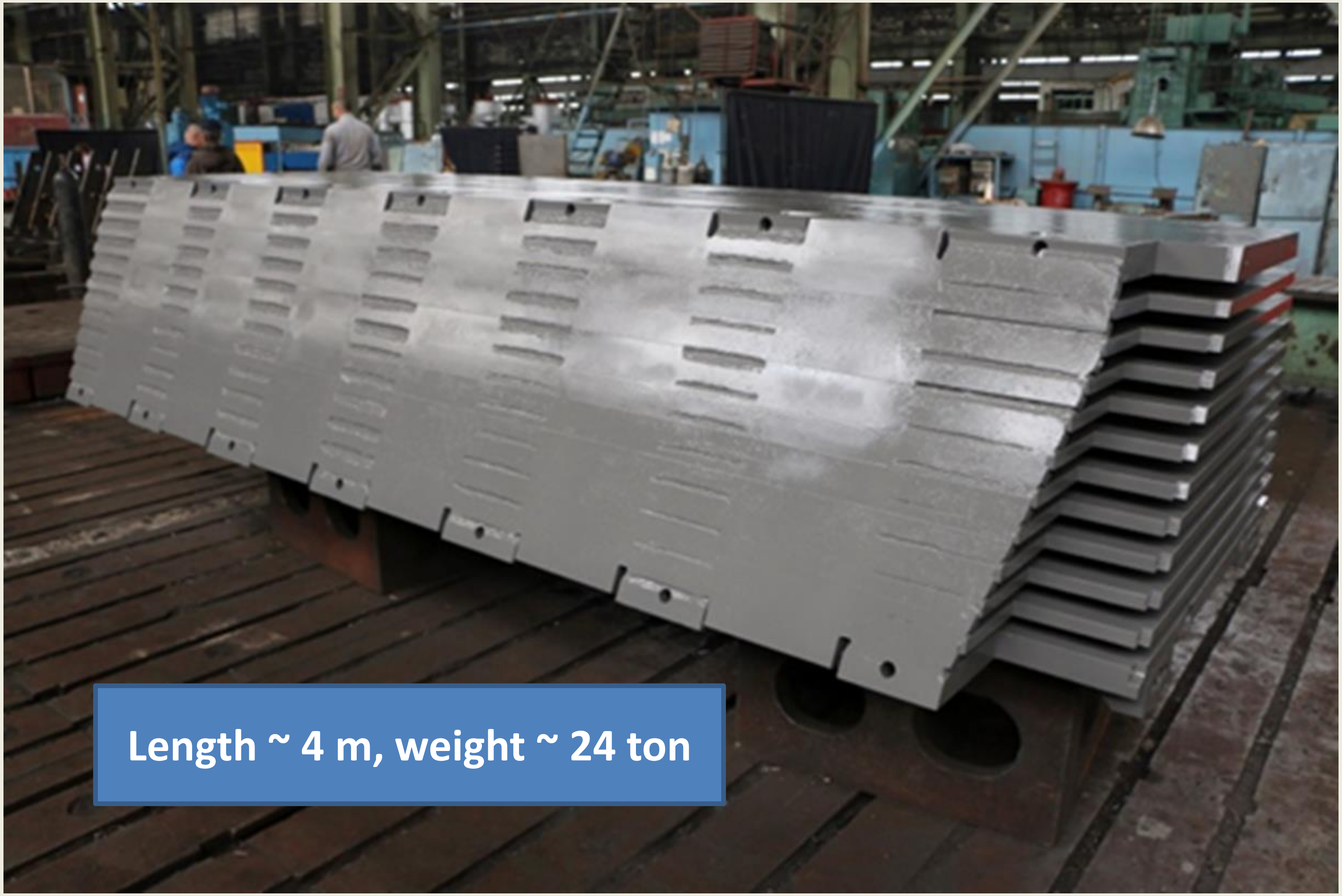




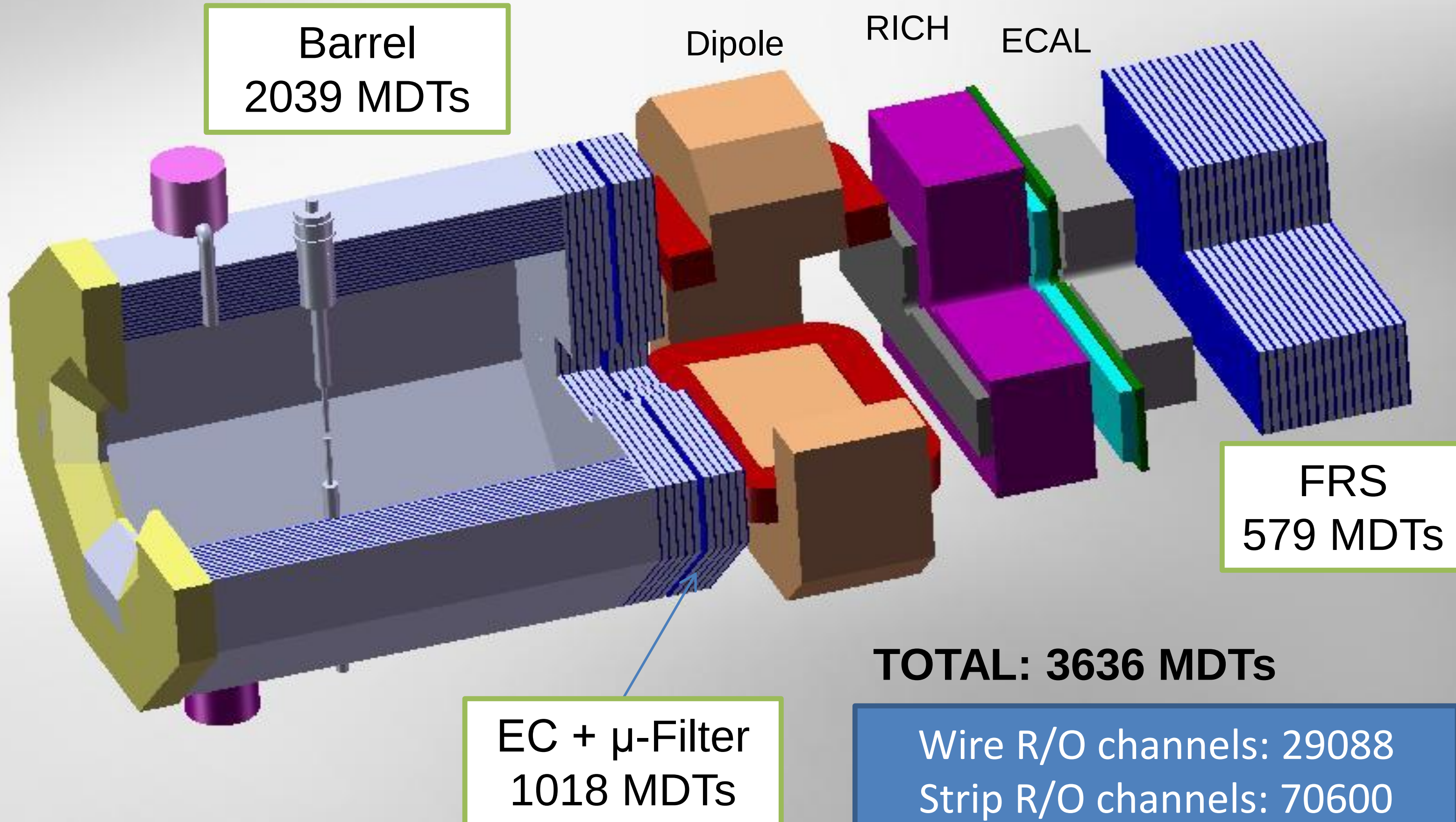


displacement of the sc coil under action of the magnetic forces of not more than 0.5 mm

First Barrel module (out of 8) fabricated at Novosibirsk factory



PANDA/FAIR setup



TOTAL: 3636 MDTs

Wire R/O channels: 29088
Strip R/O channels: 70600
(1cm wide)

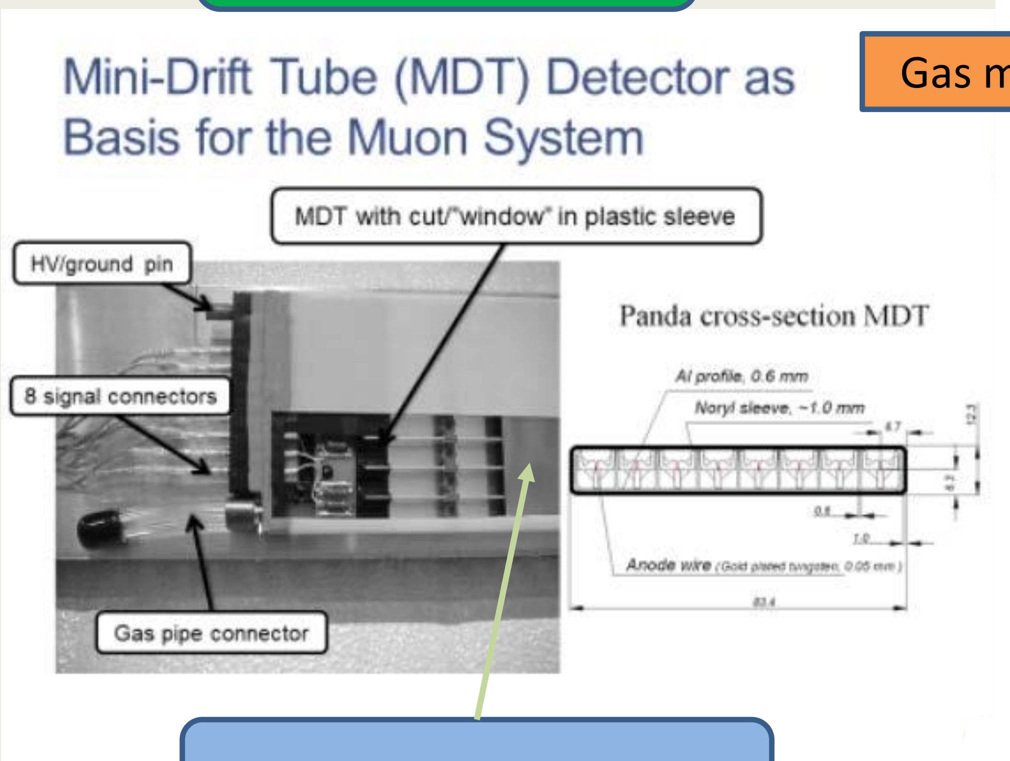
Muon System indicated in blue

Mini Drift Tube (MDT) detectors

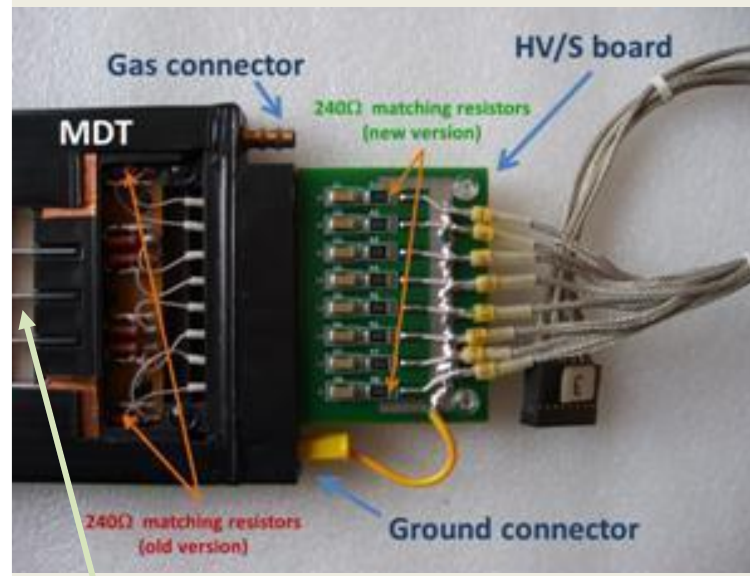
(D0/FNAL&COMPASS/CERN-wire R/O (left), PANDA/FAIR&SPD/NICA – wire&strip R/O (right)

- HV on ALU cathode

+ HV on the wires



Gas mixture -> Ar:CO2 = 70:30



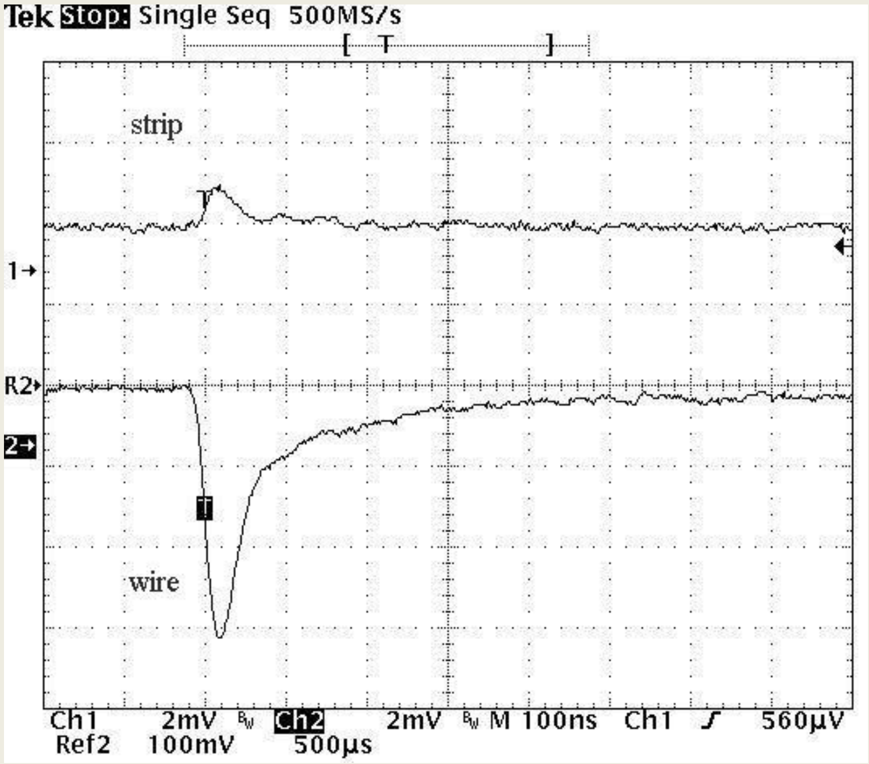
'closed cathode' geometry

'open cathode' geometry

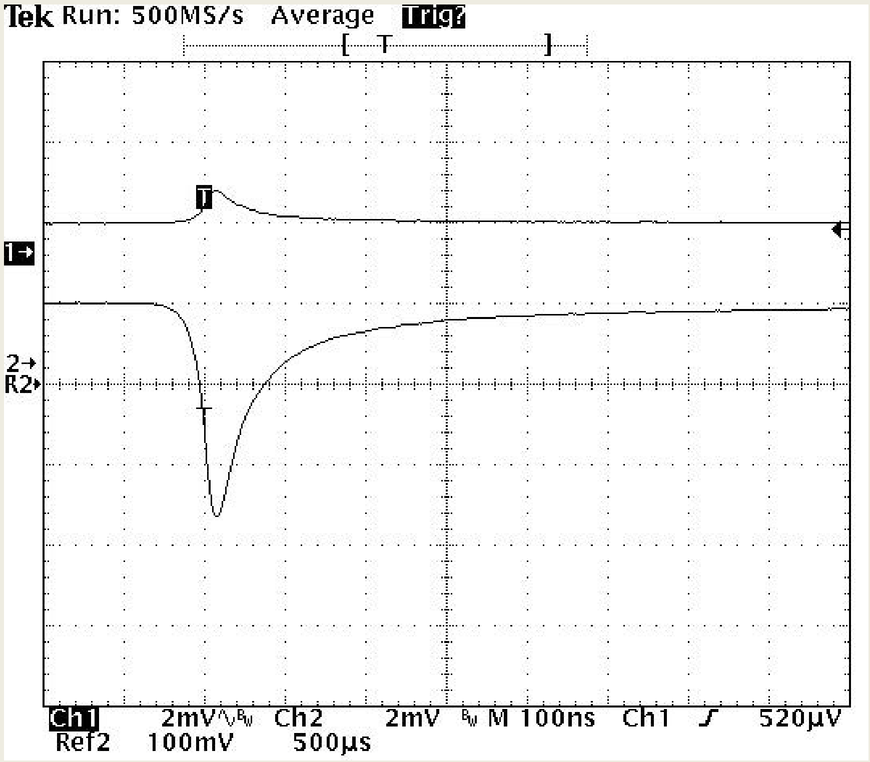
Wire and strip signals

Signals after the AMPL-8.3 on 50 Ohm load

Single event

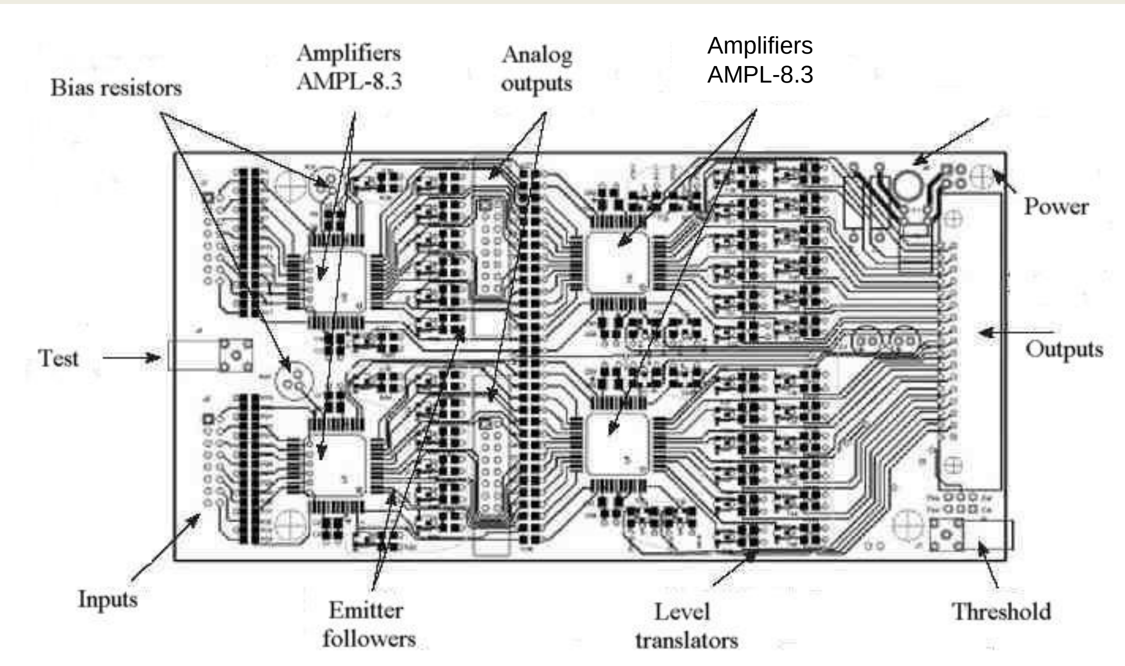


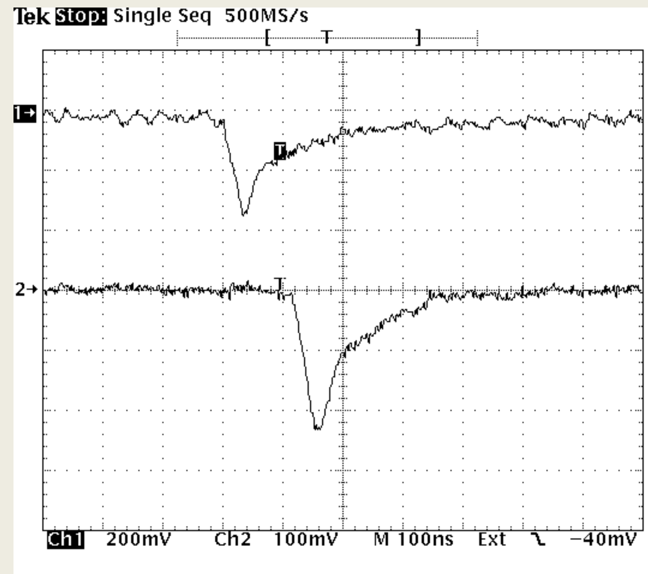
Averaged

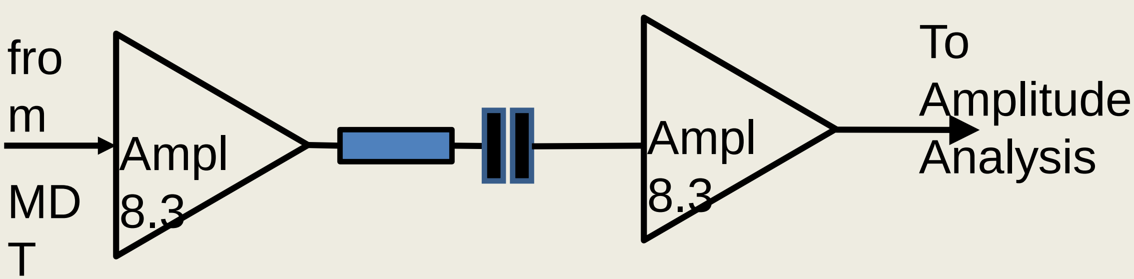


Strip Readout Card

A2B-16 card (two cascade Ampl-8.3 with analog outputs).





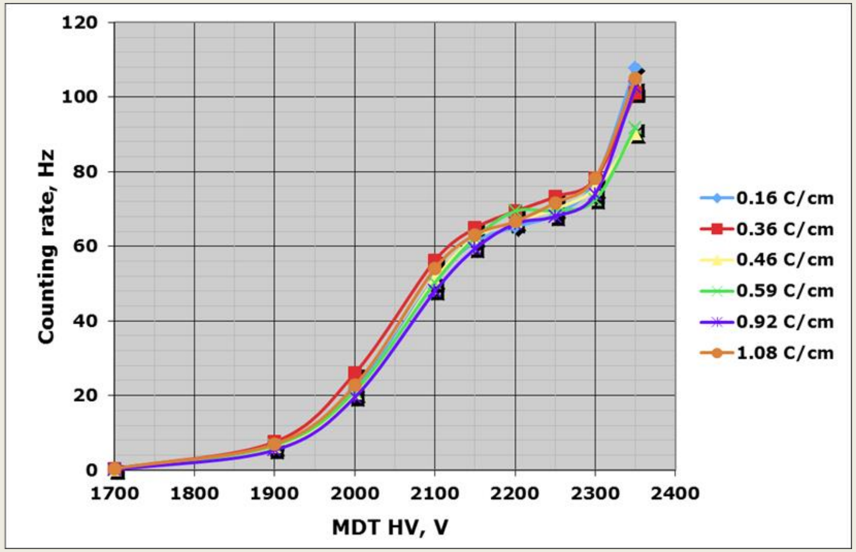


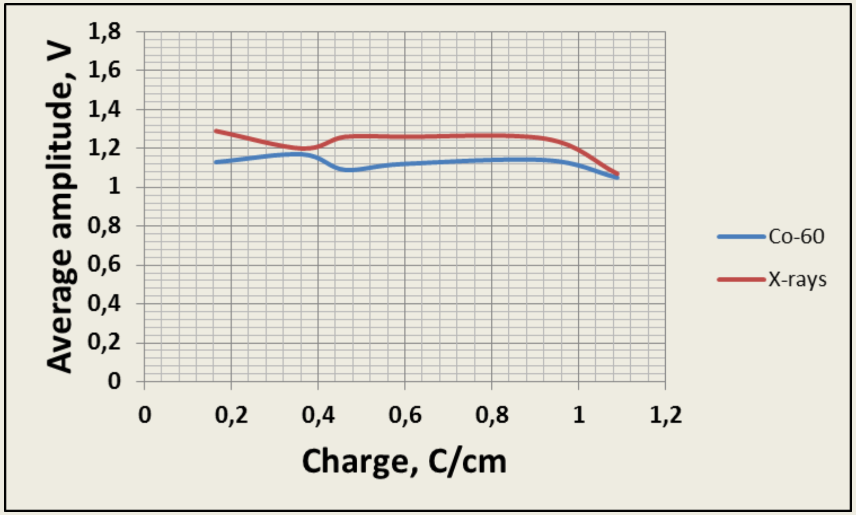
Trace 1: Anode signal,

K≈60 mV/μA

Trace 2: Strip signal, inverted, K≈480 mV/μA

‘No ageing’ MDT tests for ‘open geometry’
(for strip readout)



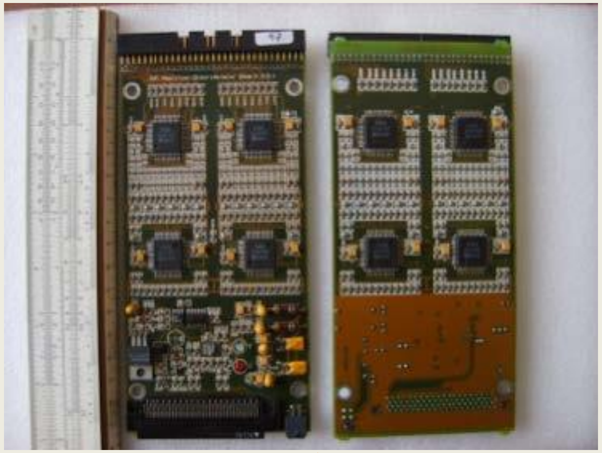


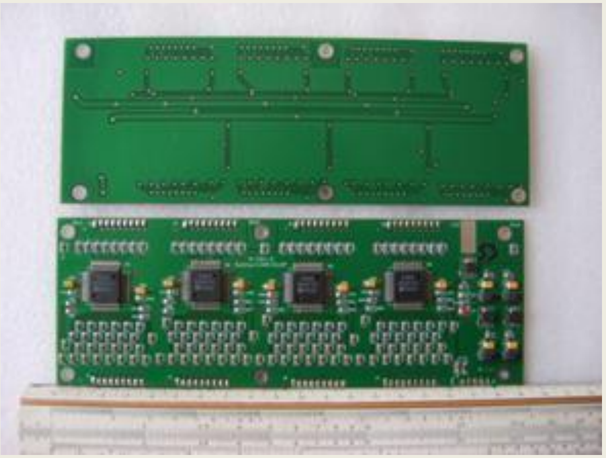
Provided rather small rates inside a volume of the Muon System (typically few Hz/cm^2 - thanks to the screening effect of electromagnetic calorimeters and steel absorber plates of range system itself) and average charge per single pulse (~5pC at normal/working operational voltage 2200 V) **we may estimate the life time for the most of apparatus as practically infinite: (1C/cm^2) / (10Hz/cm^2×5pC) = 2×10^{10} sec (more or about 6×10^2 years; even without accounting for duty factor of PANDA operation) !**

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

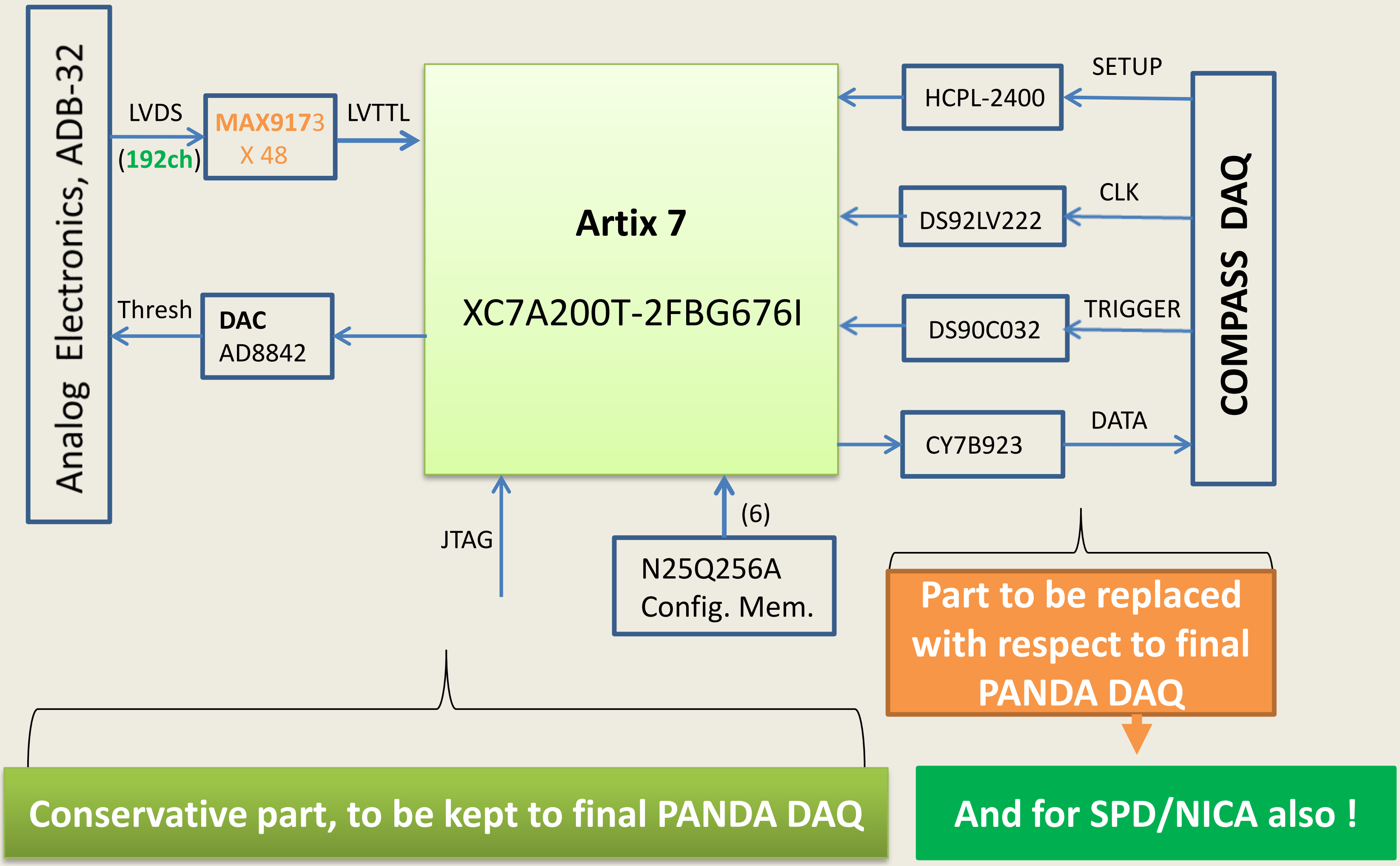




Necessary number of cards (30) to equip **SPD/NICA prototype** exists

Simplified Schematic of Xilinx FPGA Prototype R/O Module (192ch)

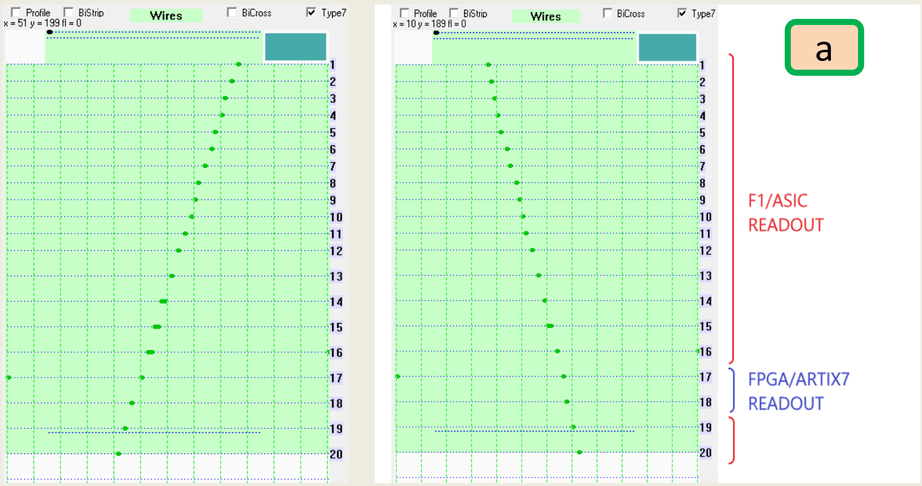
(to be tested with Range System Prototype at CERN; if results will be positive, the Artix 7 chip may be regarded as basis for the final PANDA/DAQ)

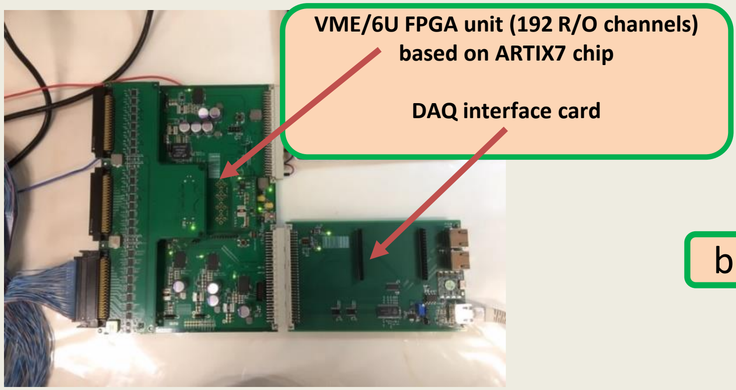


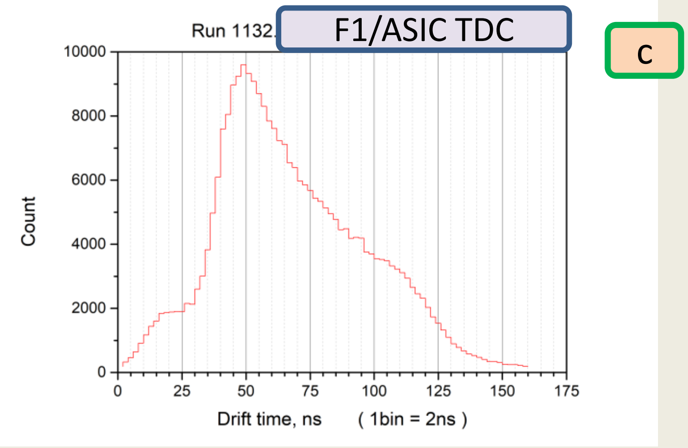
FPGA digital readout test

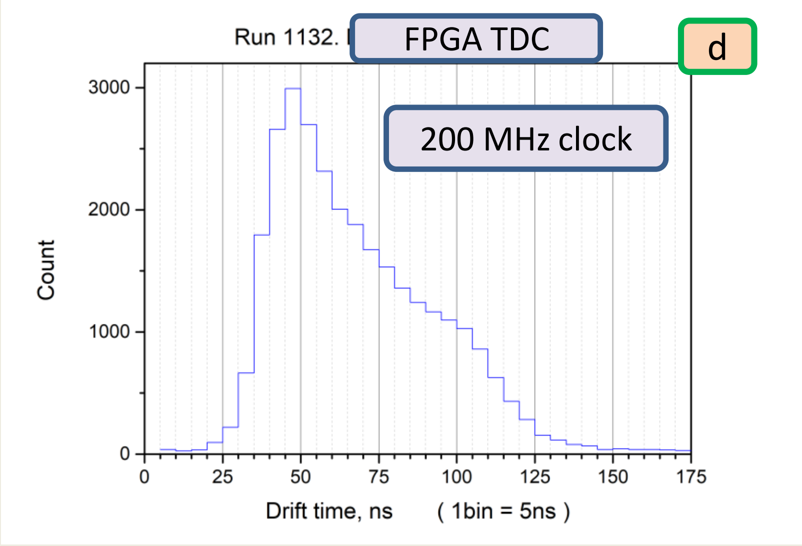
(a) - prototype's wires R/O, (b) - VME/FPGA R/O unit, (c,d) – comparison of time spectra (ASIC vs FPGA)

Typical cosmic events





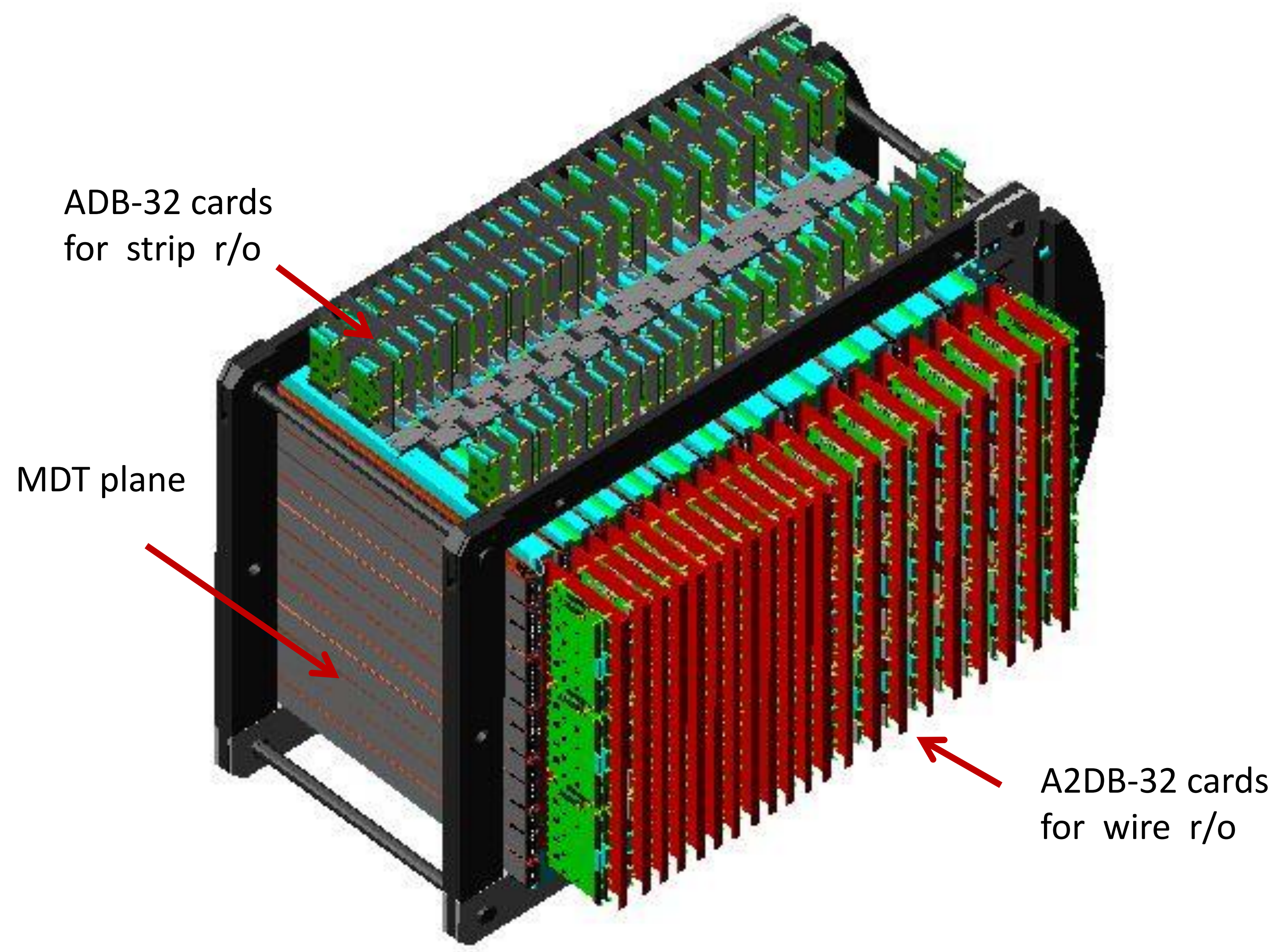




Muon System as PID

* PANDA 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
* Fake muons from pion-to-muon decay may not be recognized as such by Muon System working in 'stand along' mode !
* Range system will be used as a coarse hadron calorimeter – > very important for neutron registration (the only system in PANDA)!

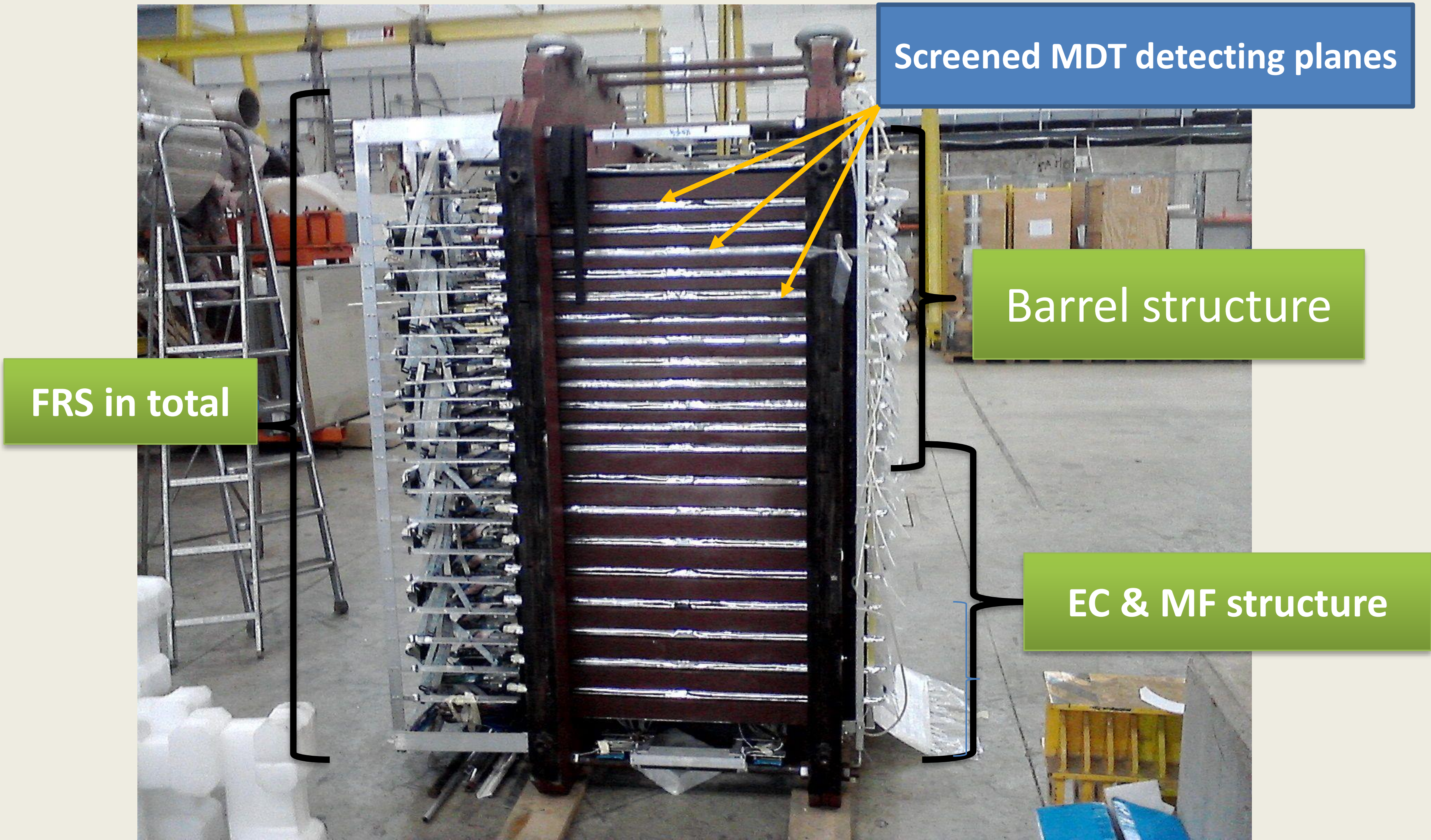
RS Prototype equipped with analog f/e electronics (3D model)



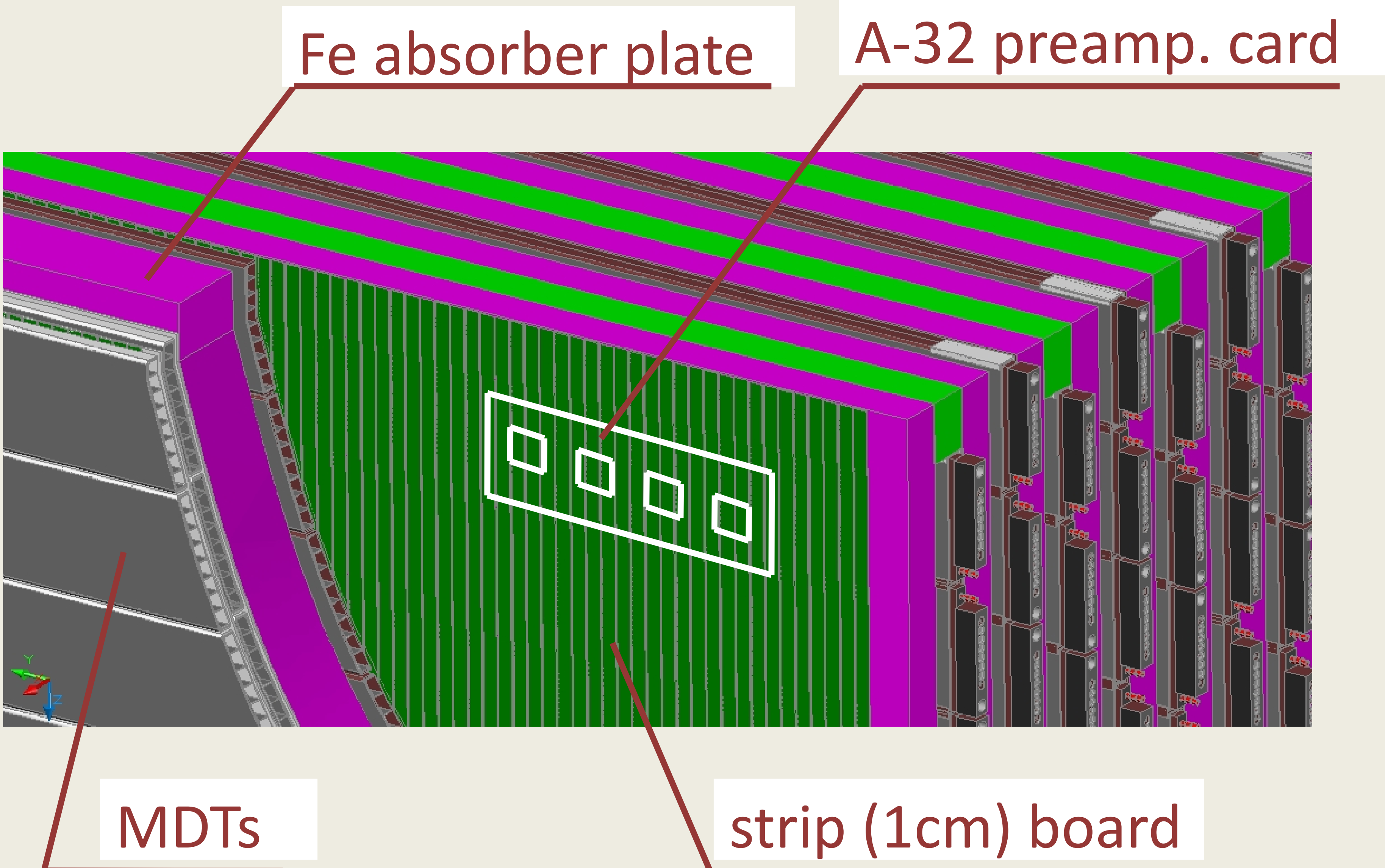
RSP in vertical (cosmic test) position

‘bottom side’ (for RSP position on beam) is pictured

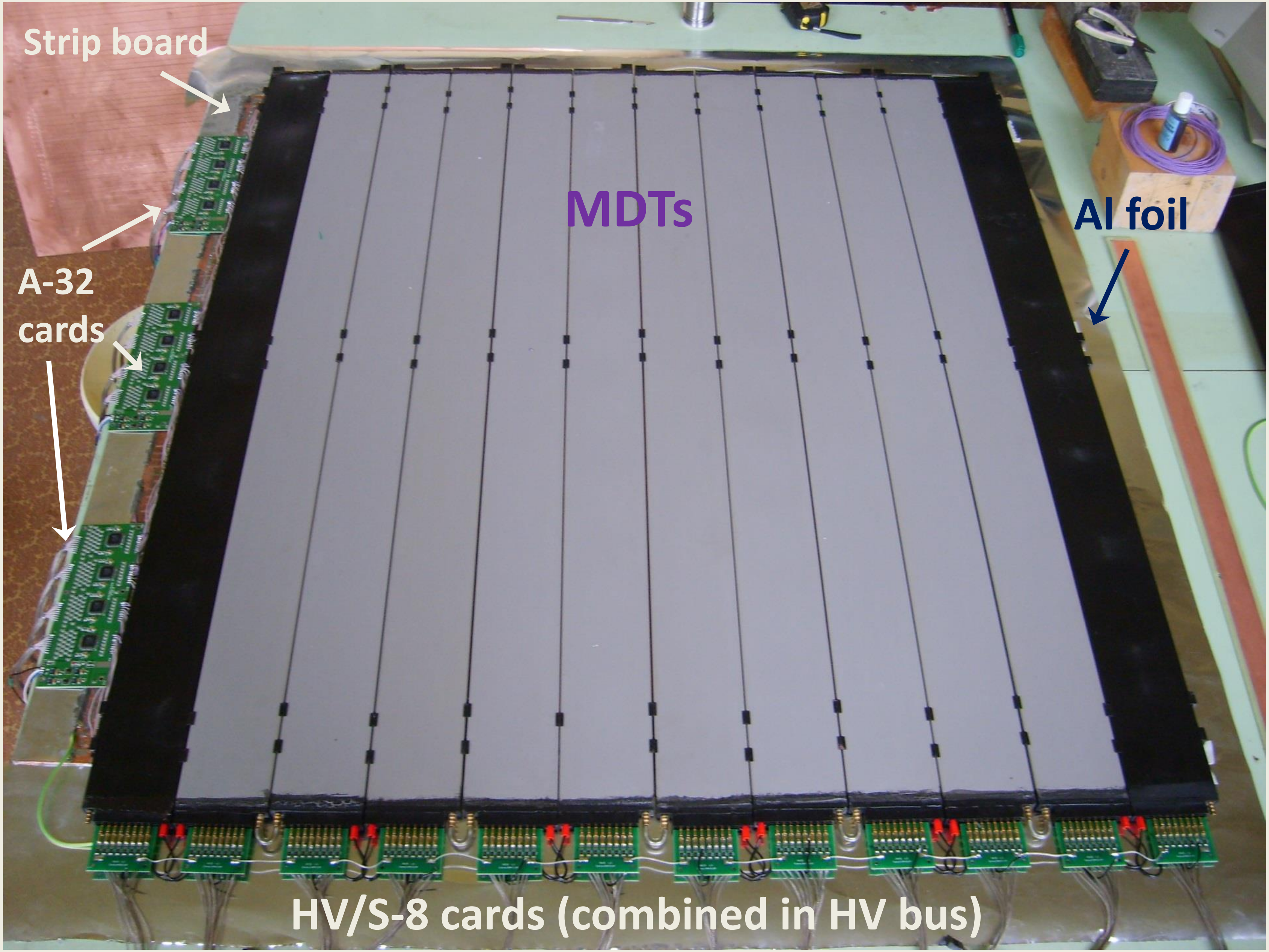
(3 structures in 1 prototype)



Strip R/O from RS Prototype



Detector plane (1x1 m) prepared for shielding

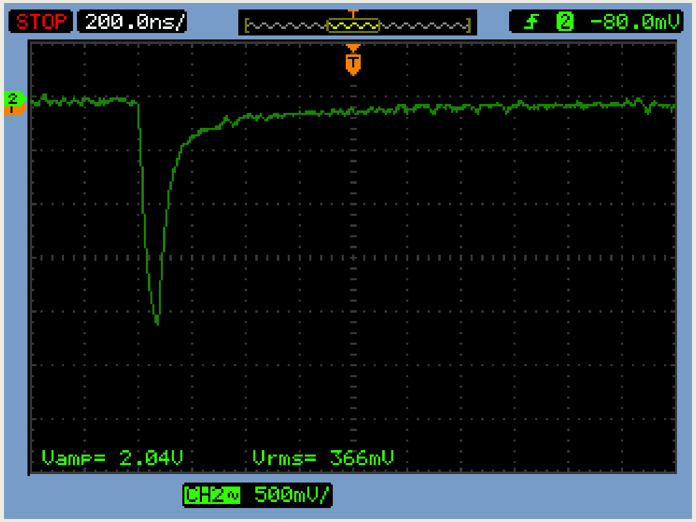


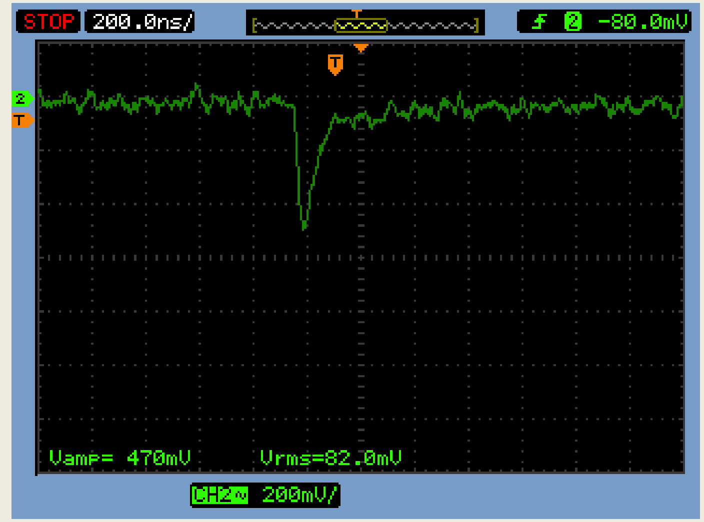
Typical strip signals from cosmic

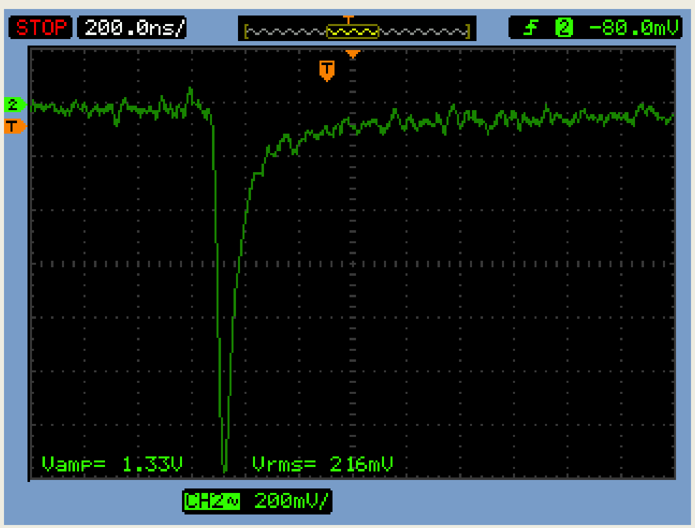
(final variant of shielding)

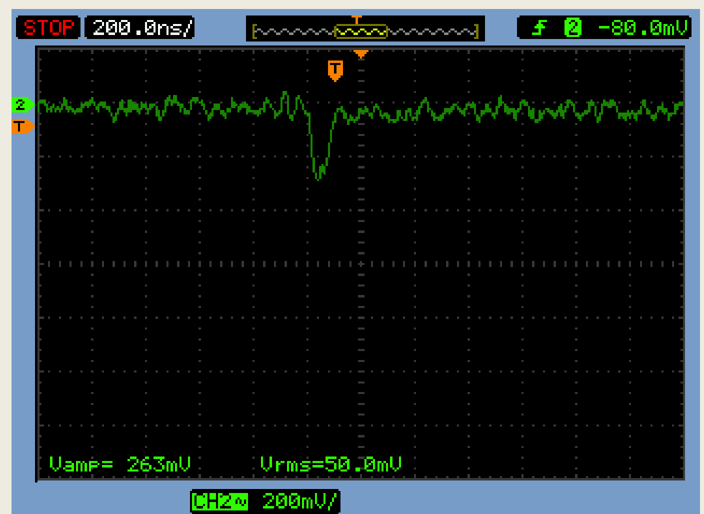
MDT HV = 2,3 kV   Amplification ~ 400 mV/μA

Low noise amplitude level ~ 80 mV (0,2μA @input)

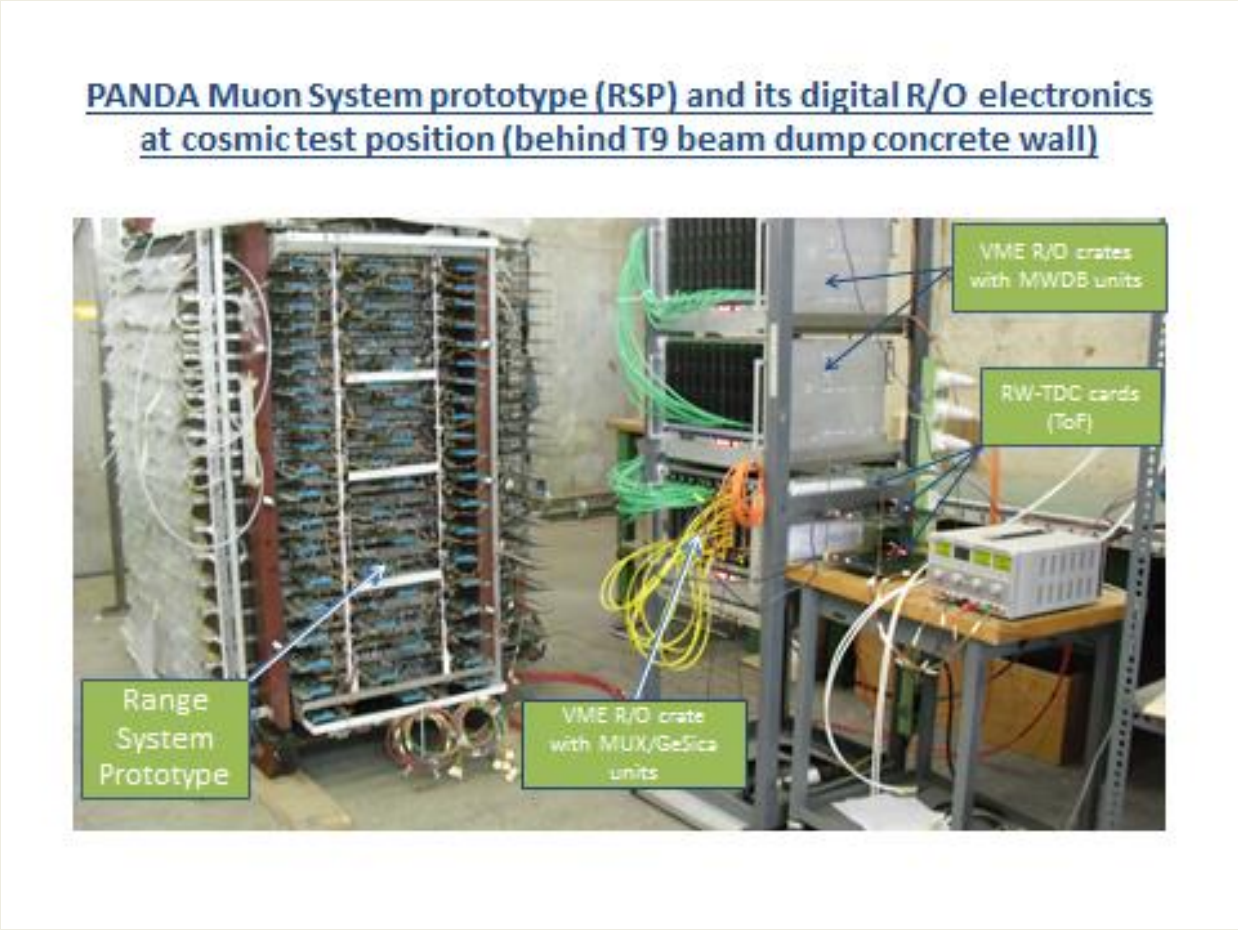






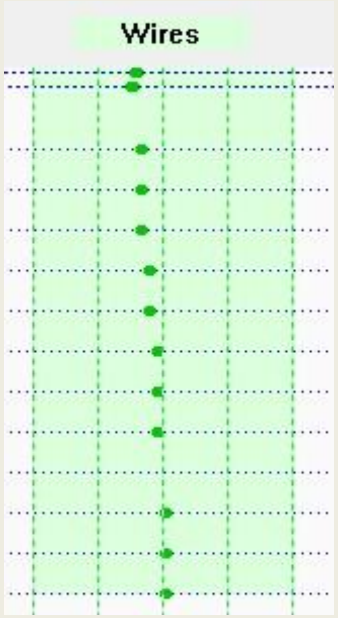


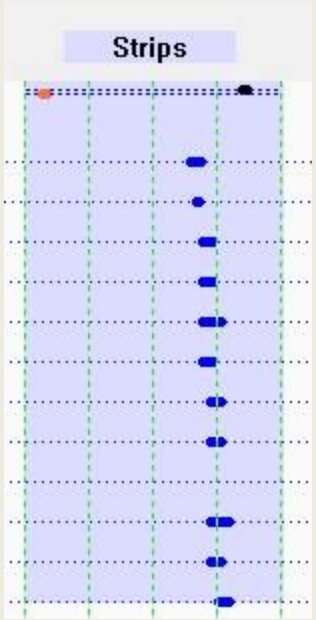
Range System Prototype equipped with FEE and DAQ; staying in ‘cosmic test’ position behind the concrete wall (beam dump) at T9/PS experimental area



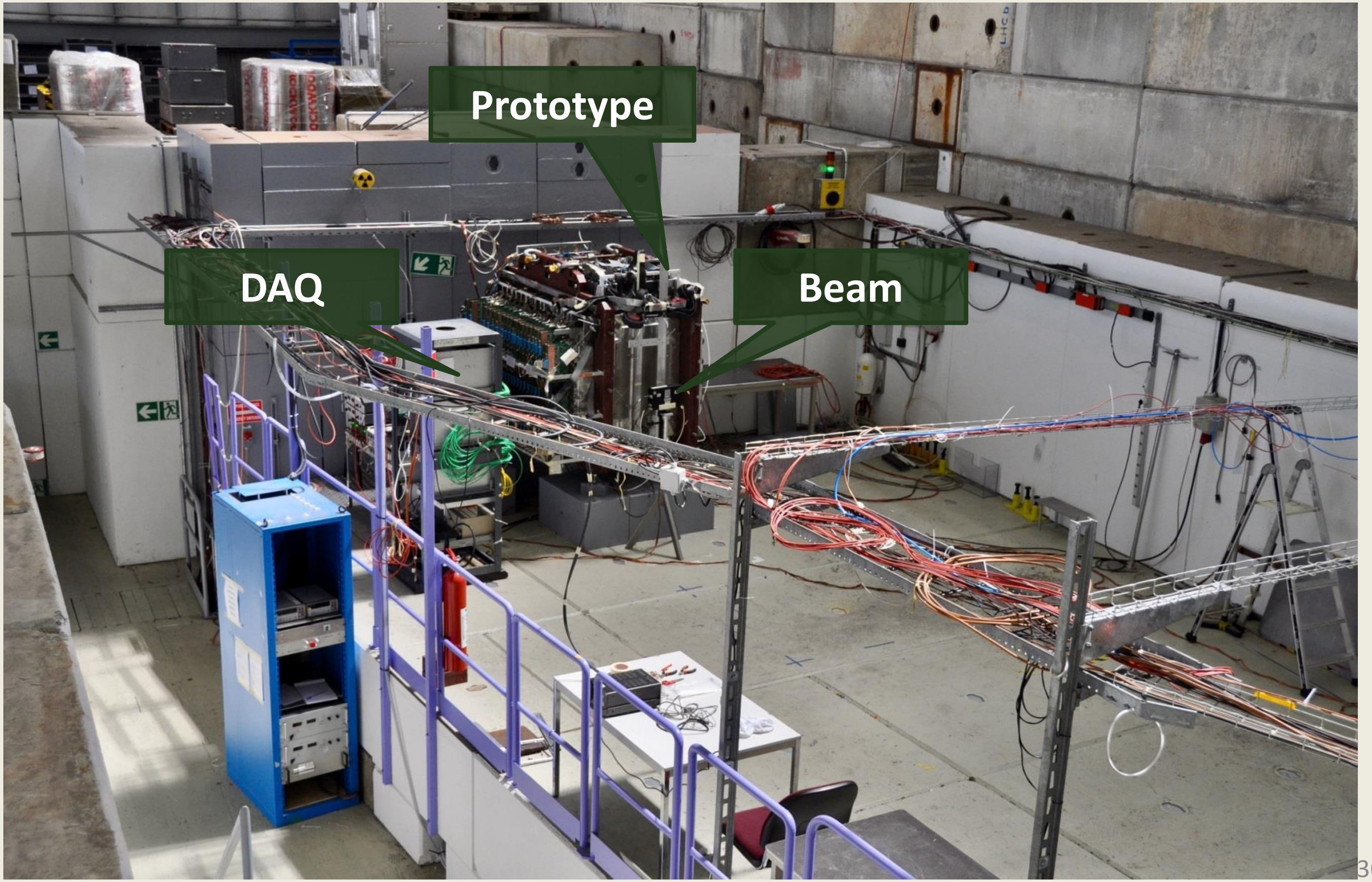
Cosmic muon (run 307 event 478)

written after putting the prototype in action and start/debugging of DAQ



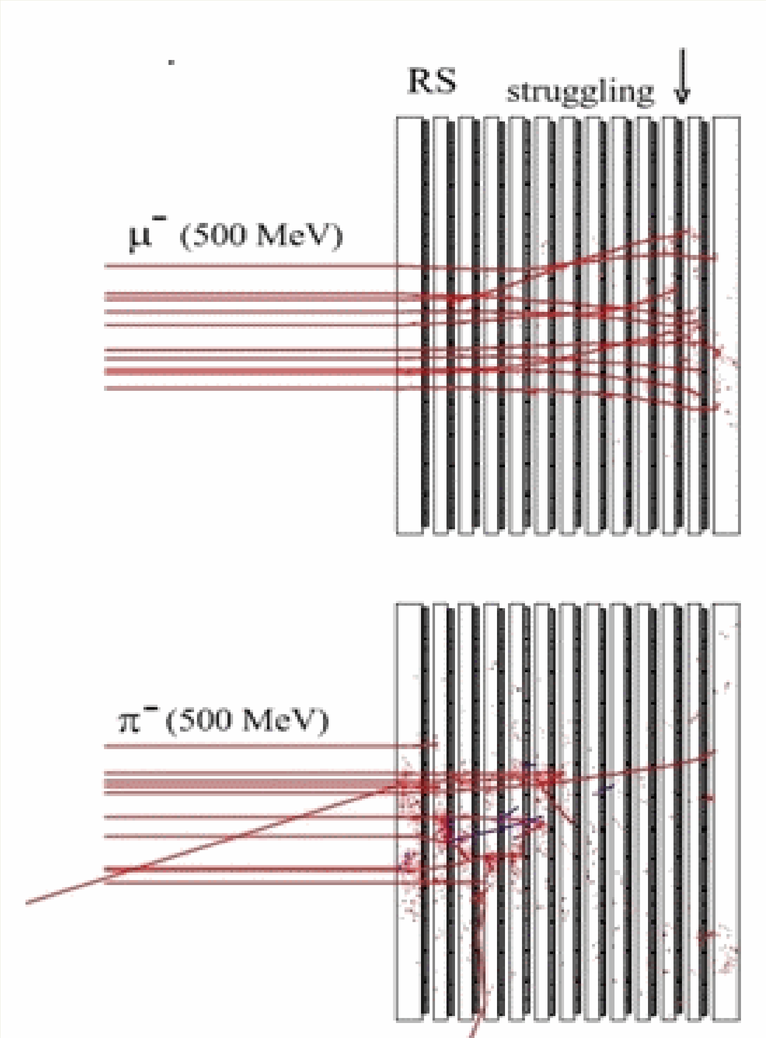


PANDA Muon System Prototype @ PS/T9/CERN Beam Line



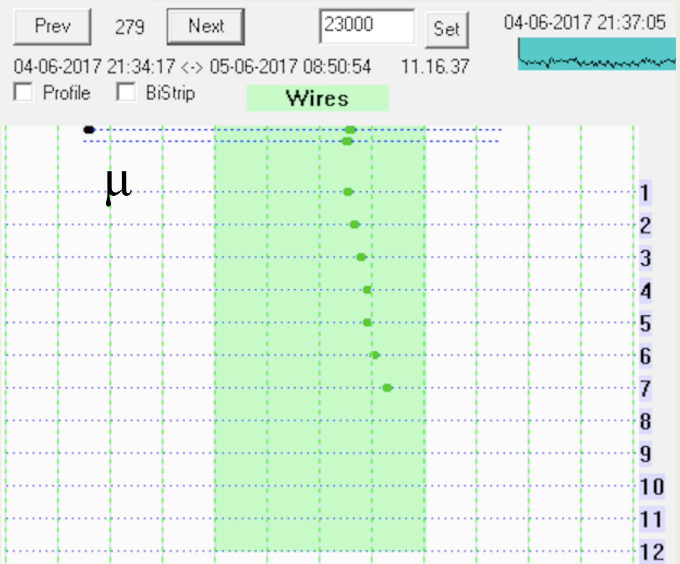
Low energy case (Barrel)

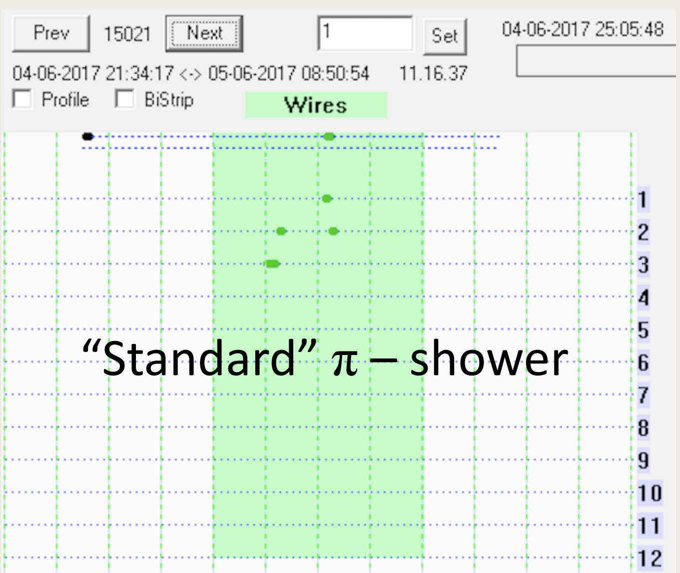
RS response to muons and pions with initial kinetic energy of 500 MeV; MC sample for 20 events is shown for demonstration

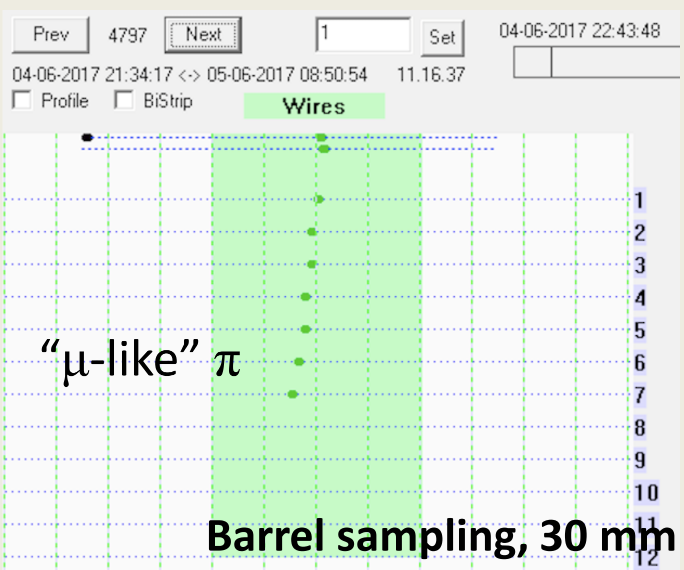


Prototype Data (μ vs π)
Barrel

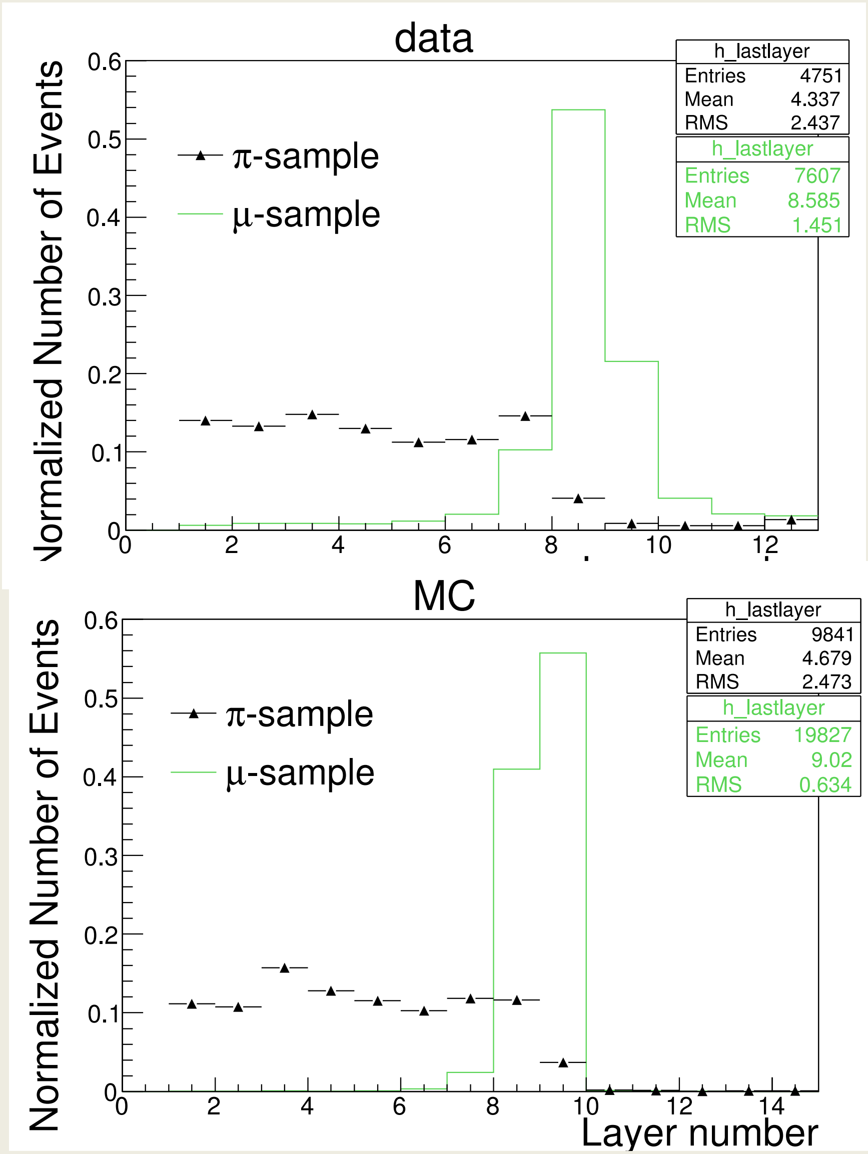
Run 605
P = 0.5 GeV/c







Test beam results (preliminary)



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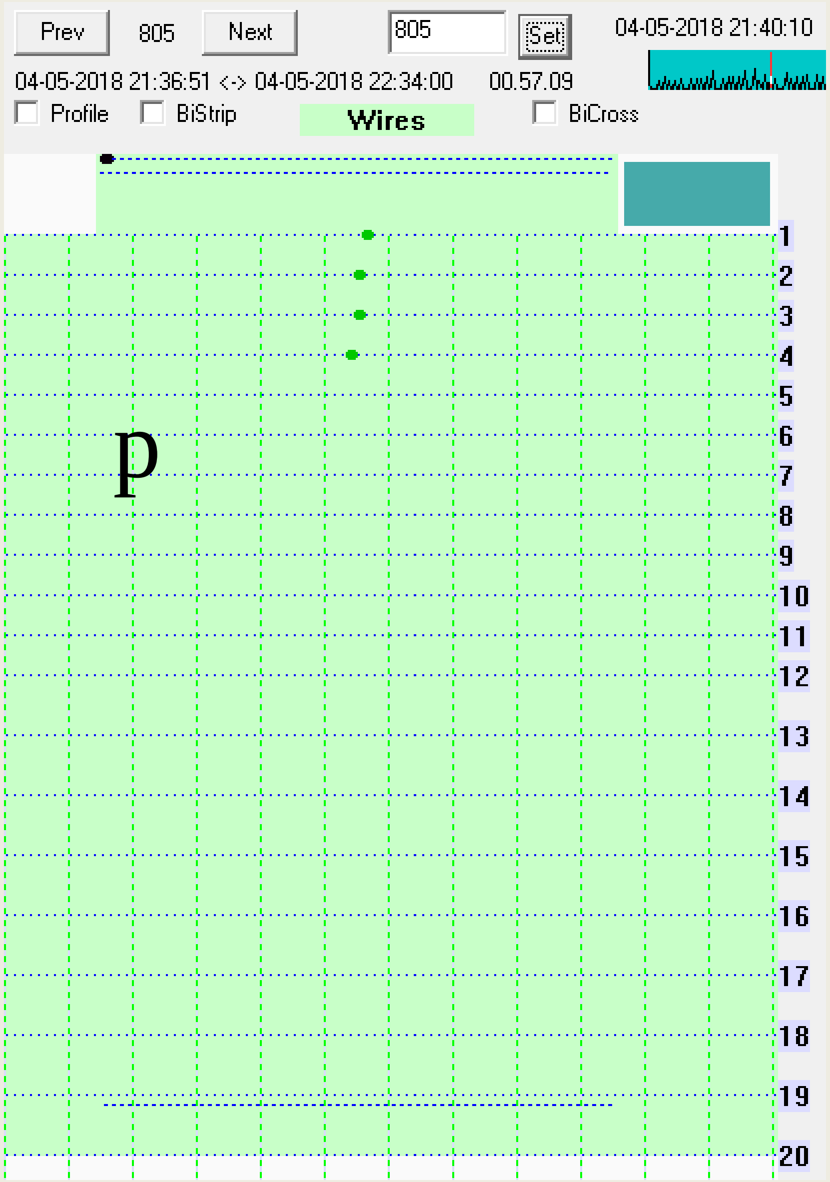
Run 605, autumn 2017
momentum = 0.5 GeV/c

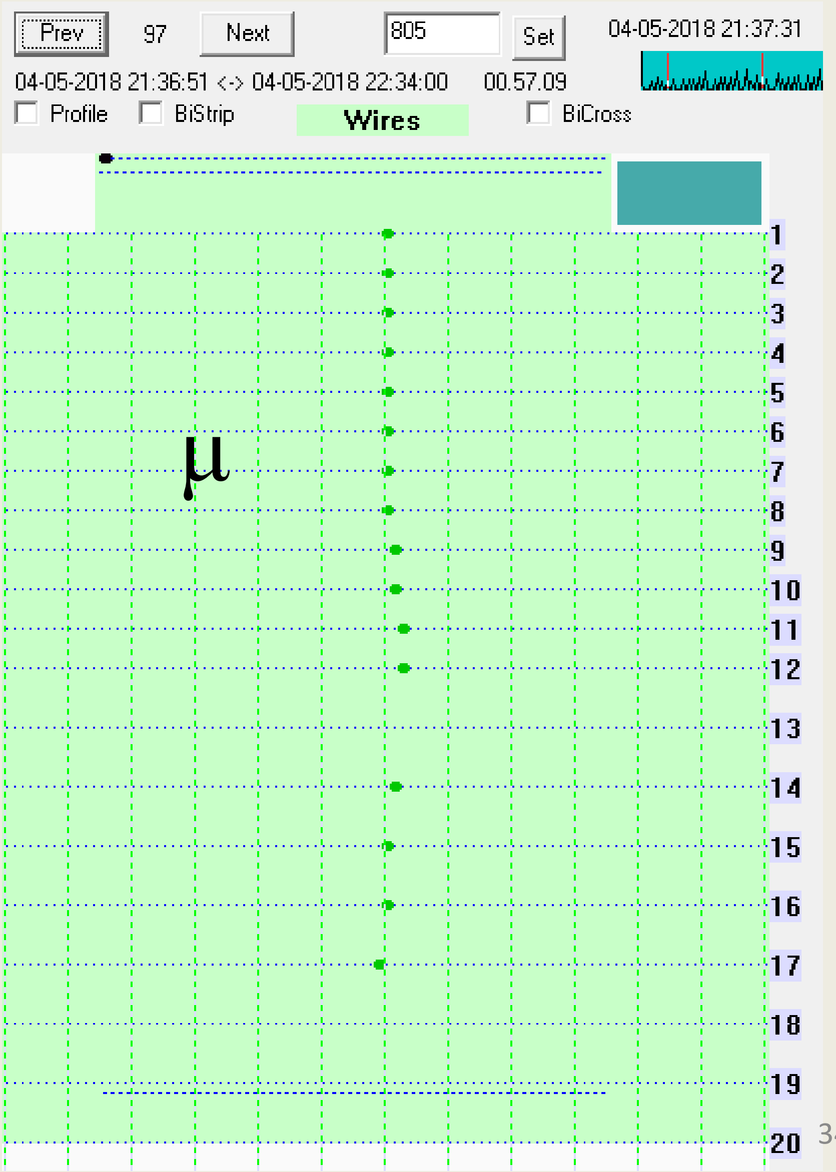
Selection -> after layer #7:
22% - pion contamination and
93% - muon efficiency

FairBoxGenerator, PandaROOT
E = 0.5 GeV/c

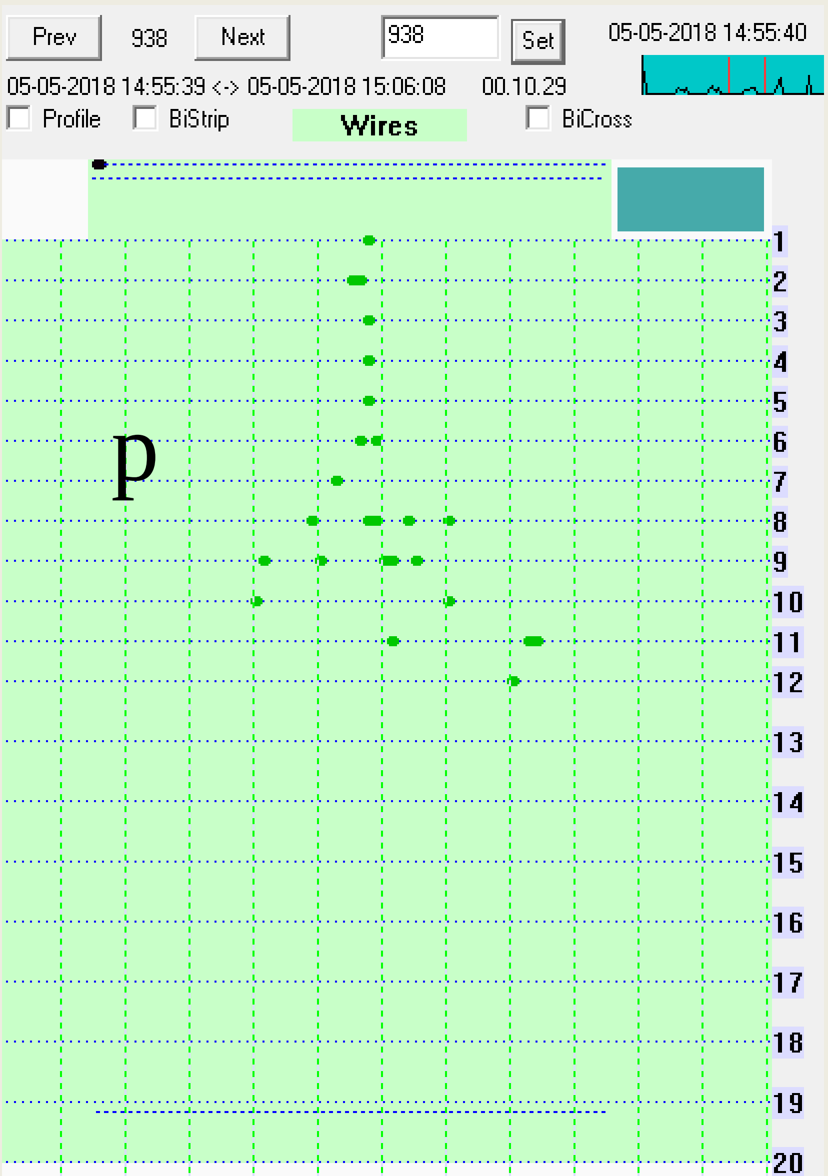
Selection -> after layer #7:
27% - pion contamination and
99% - muon efficiency

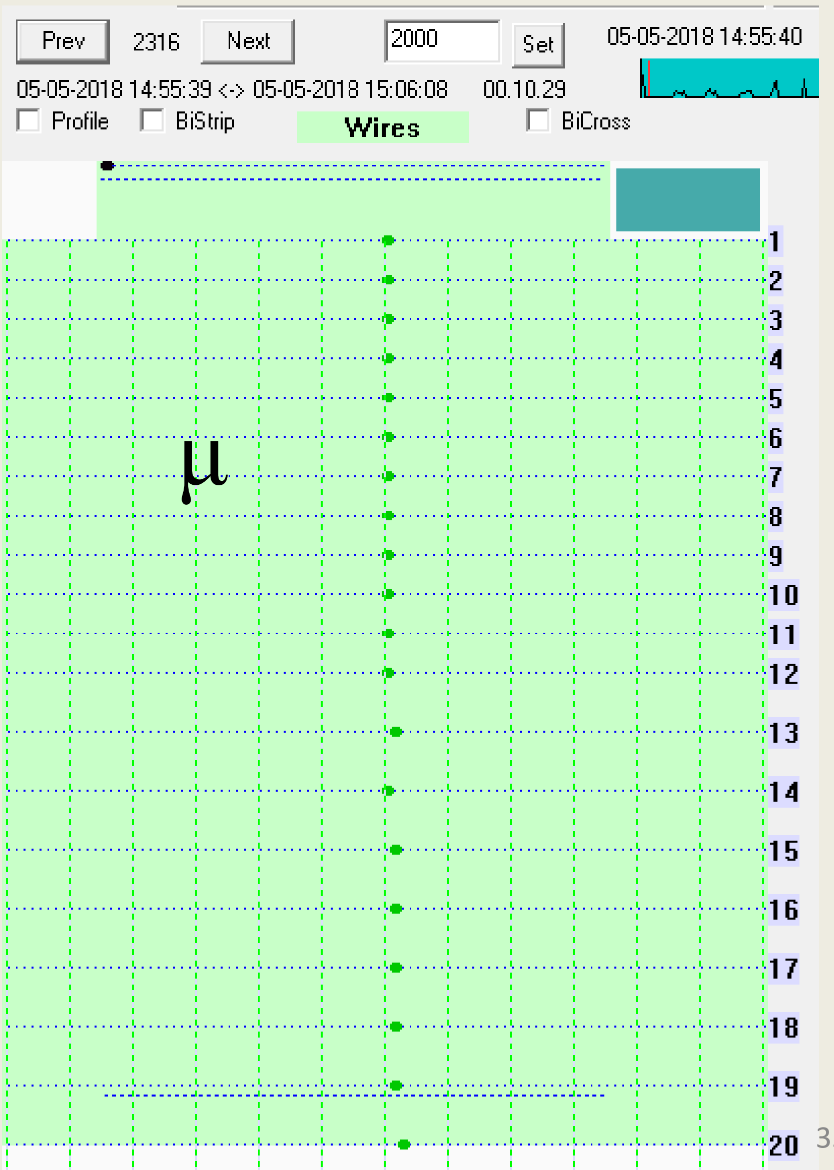
Event Examples (Run 822, P = 1 GeV/c)



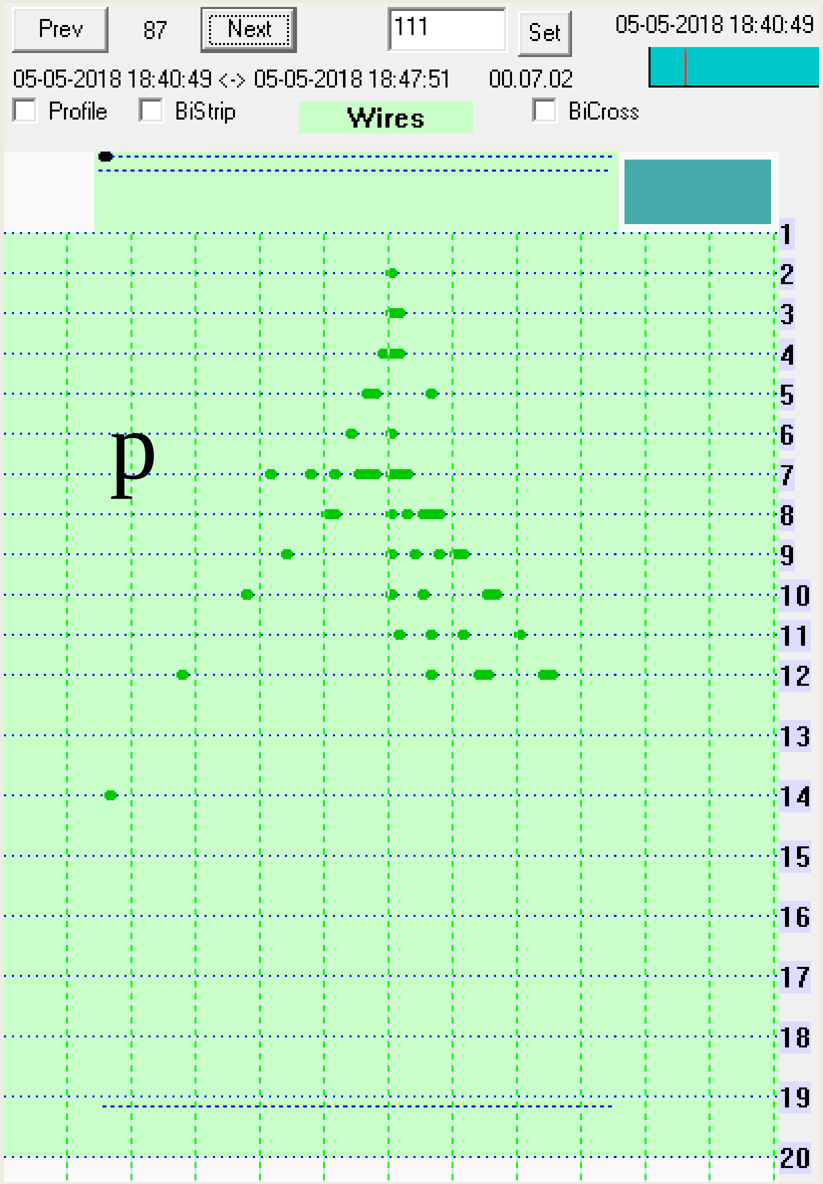


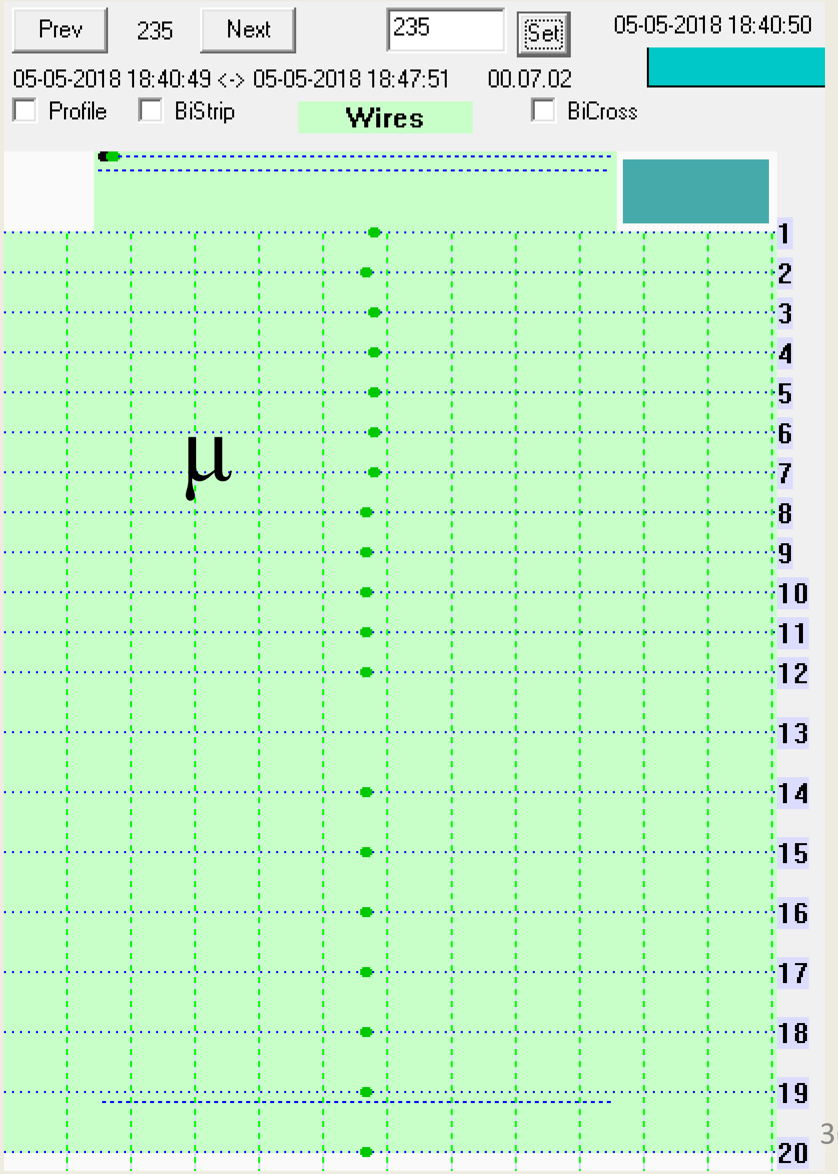
Event Examples (Run 829, P = 5 GeV/c)



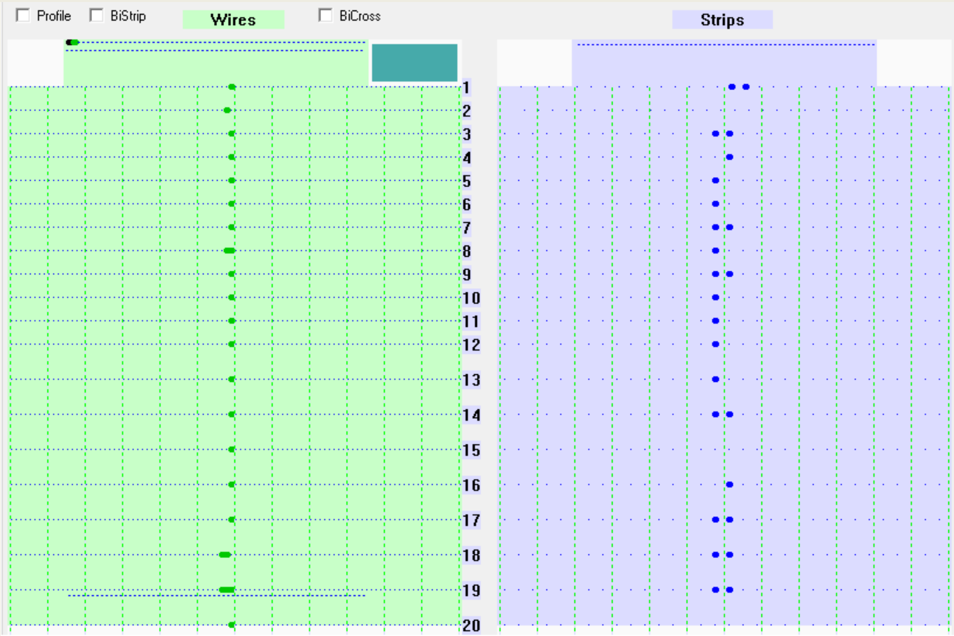


Event Examples (Run 835, P = 10 GeV/c)

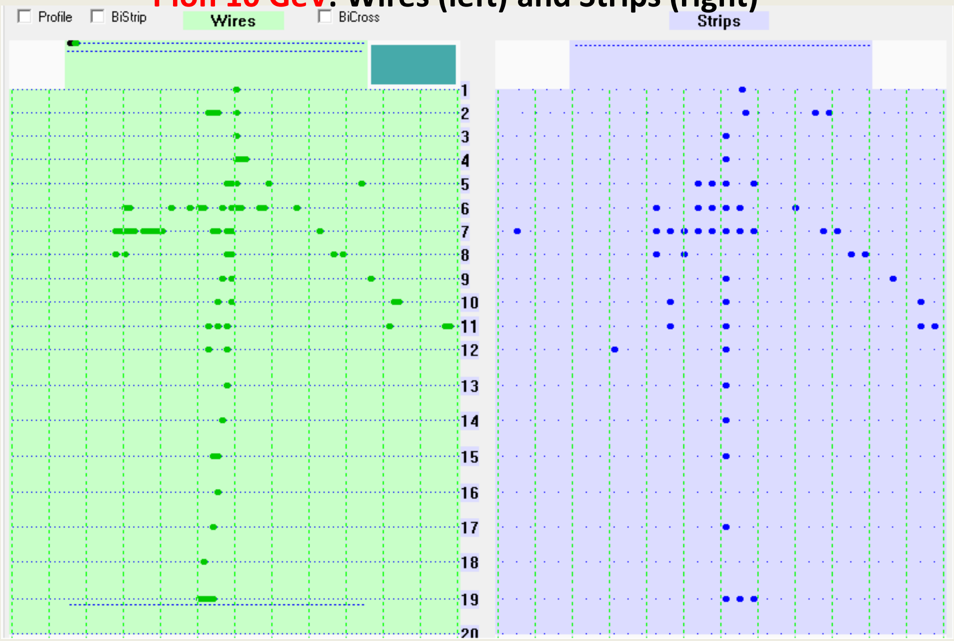




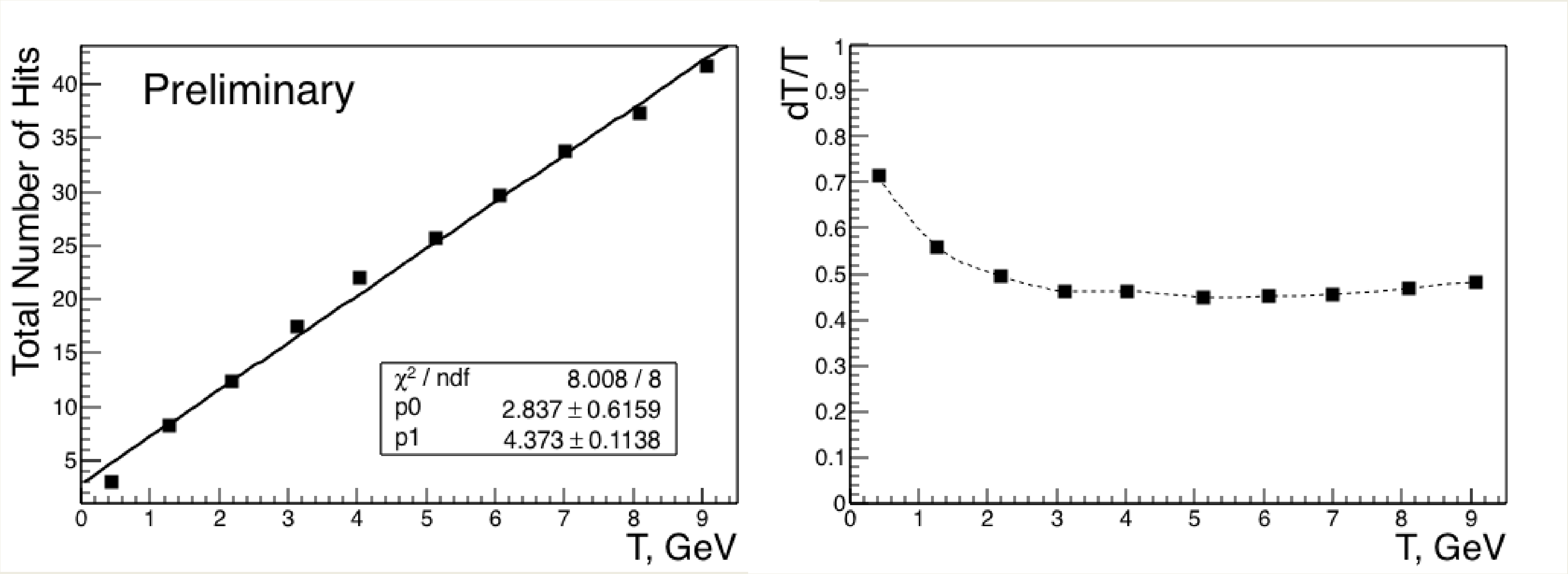
Muon 10 GeV: Wires (left) and Strips (right)



Pion 10 GeV: Wires (left) and Strips (right)



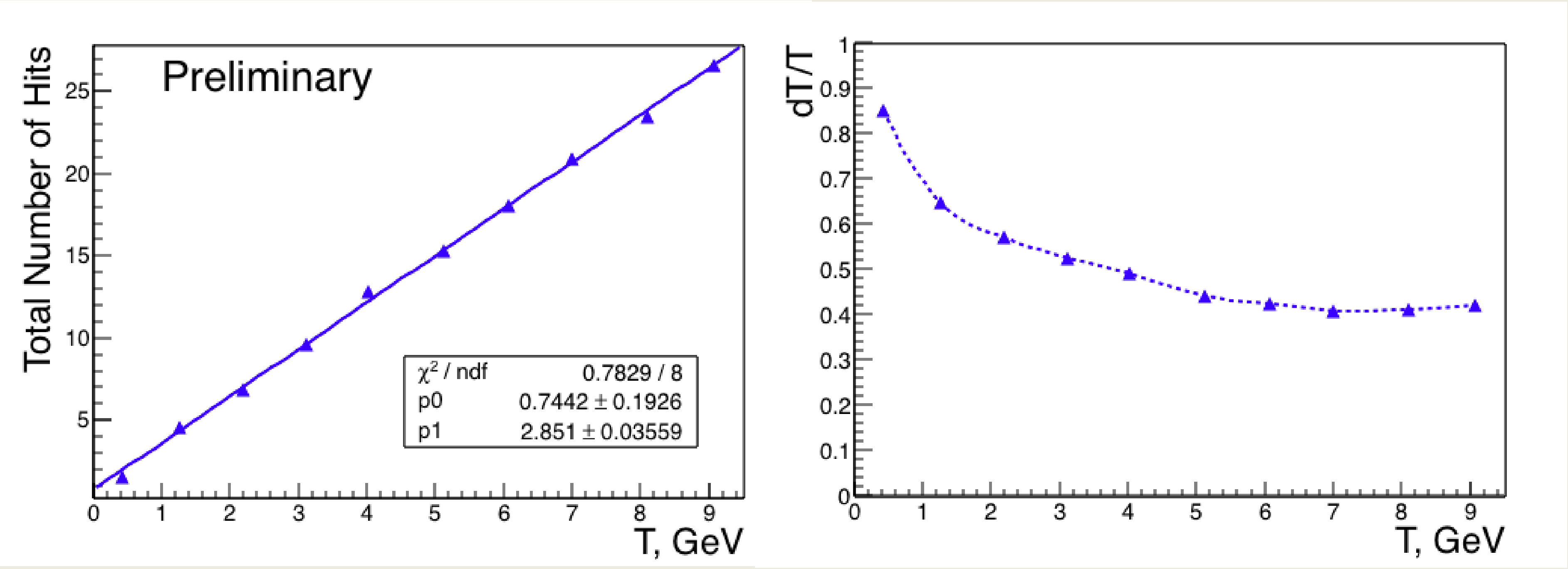
Calorimetry for protons: PANDA Barrel Structure



Sampling: 30 mm / Fe

Nuclear interaction length $\lambda_I \approx 2.3$

Calorimetry for protons: PANDA MF+EC Structure

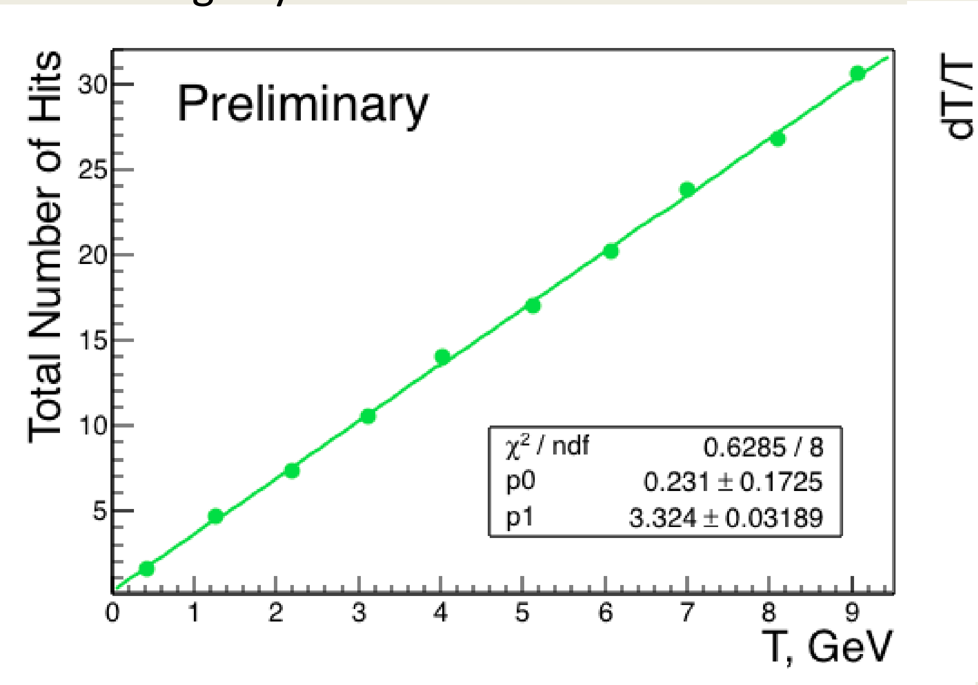


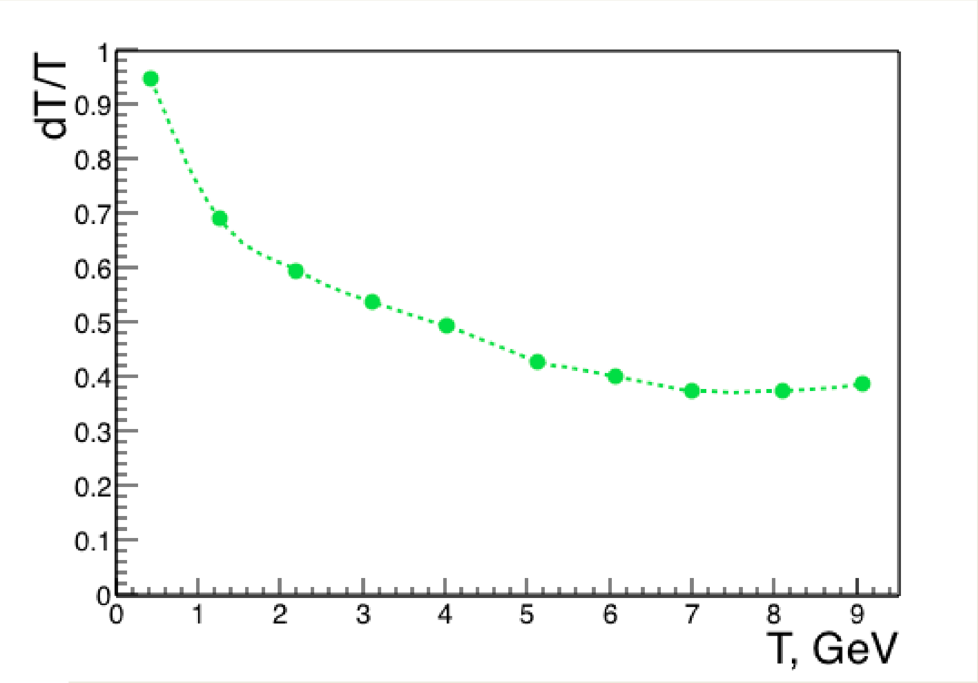
Sampling: 60 mm / Fe

Nuclear interaction length $\lambda_I \approx 3.4$

Calorimetry for protons: PANDA FRS Structure

Various combination of layers can be used to simulate different parts of Muon Range System.

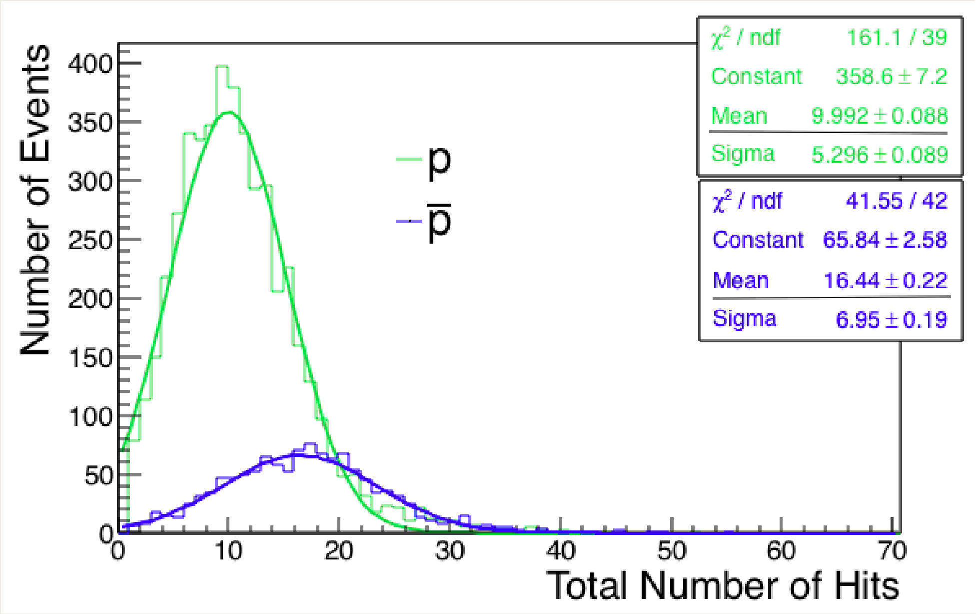


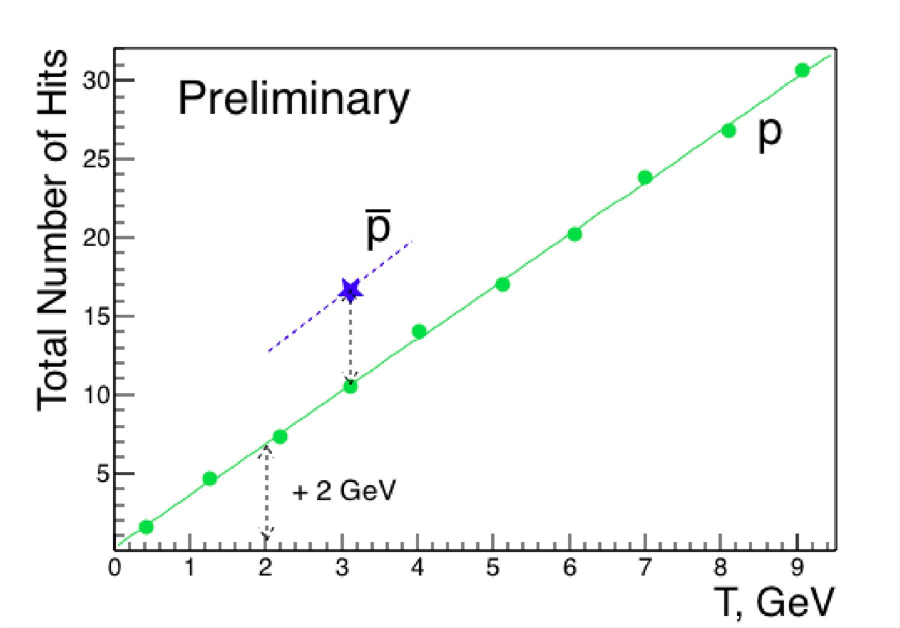


Sampling: 60 mm / Fe

Nuclear interaction length $\lambda_I \approx 5.2$

Protons vs Antiprotons

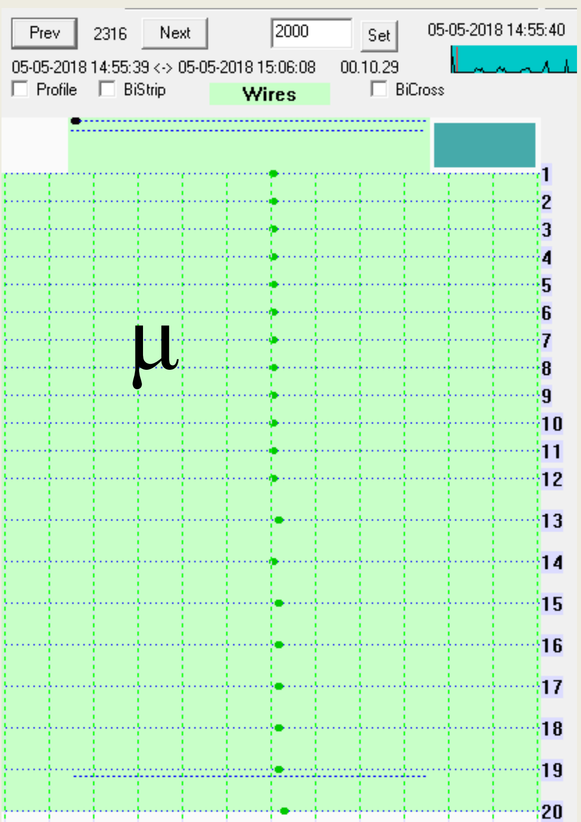




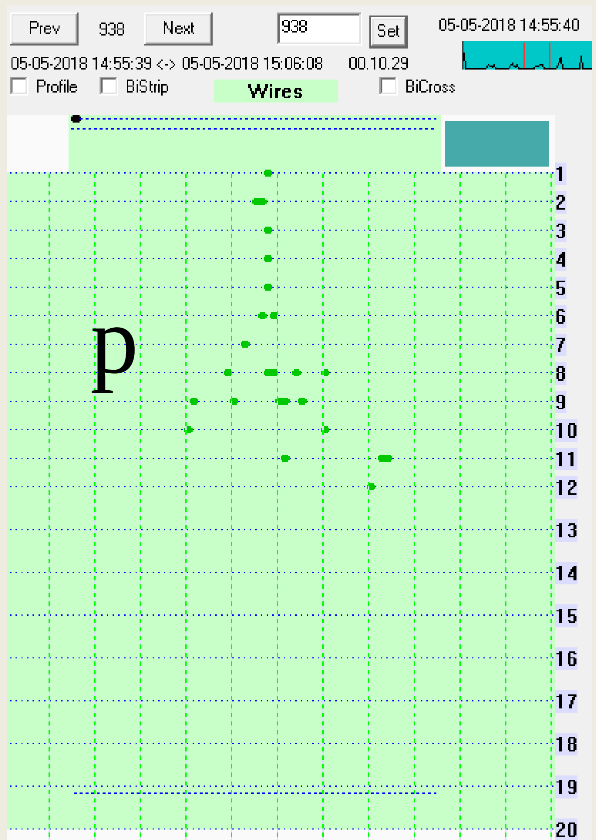
PANDA FRS Structure, T = 3.1 GeV (P = 4 GeV/c)

Event Examples (P = 5 GeV/c)

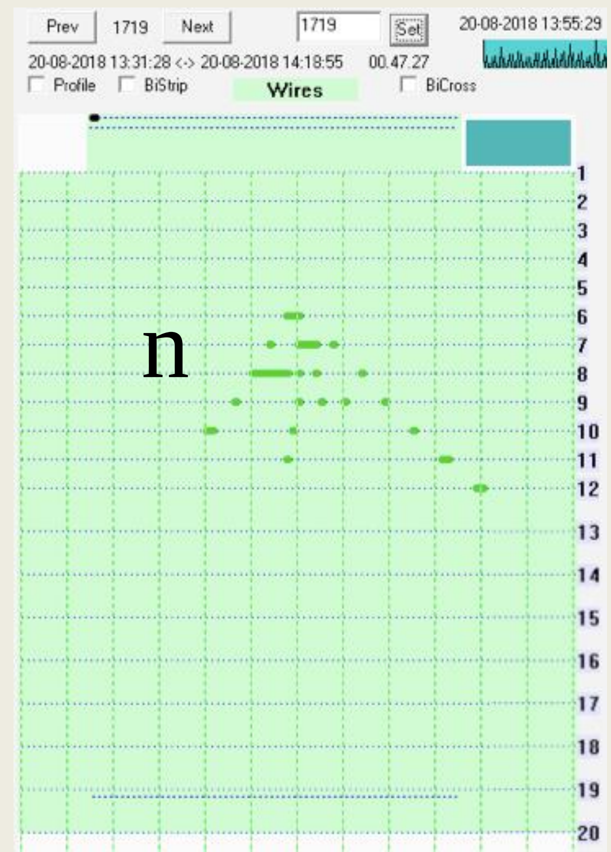
Range System will also be used as a coarse hadron calorimeter – >
very important for neutron registration (the only system in PANDA)!



Run 829



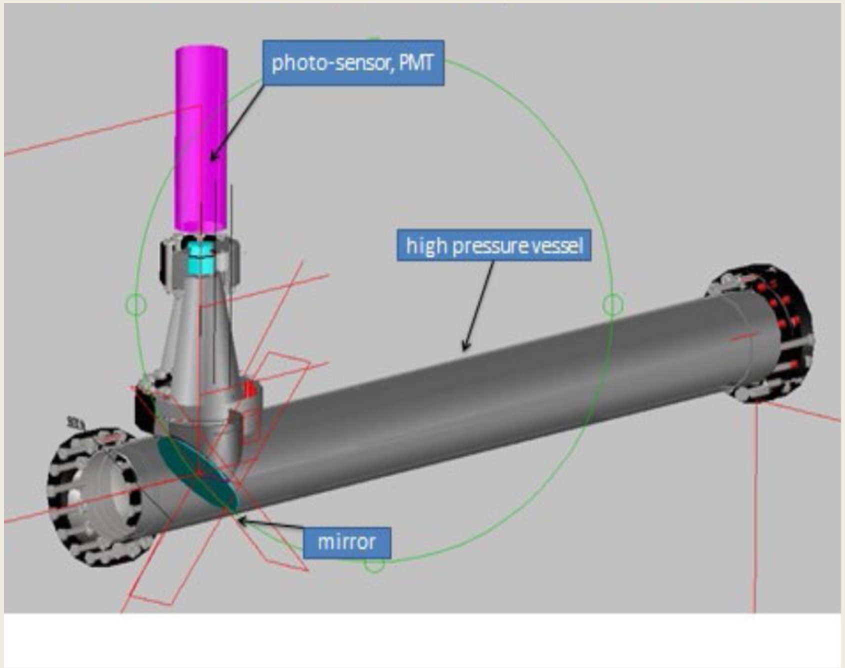
Run 829



Run 951

pressurized Cherenkov counter (up to 60 bar CO2) for PANDA/FAIR & SPD/NICA test beams (< 1,5 GeV/c) for pion-to-muon separation

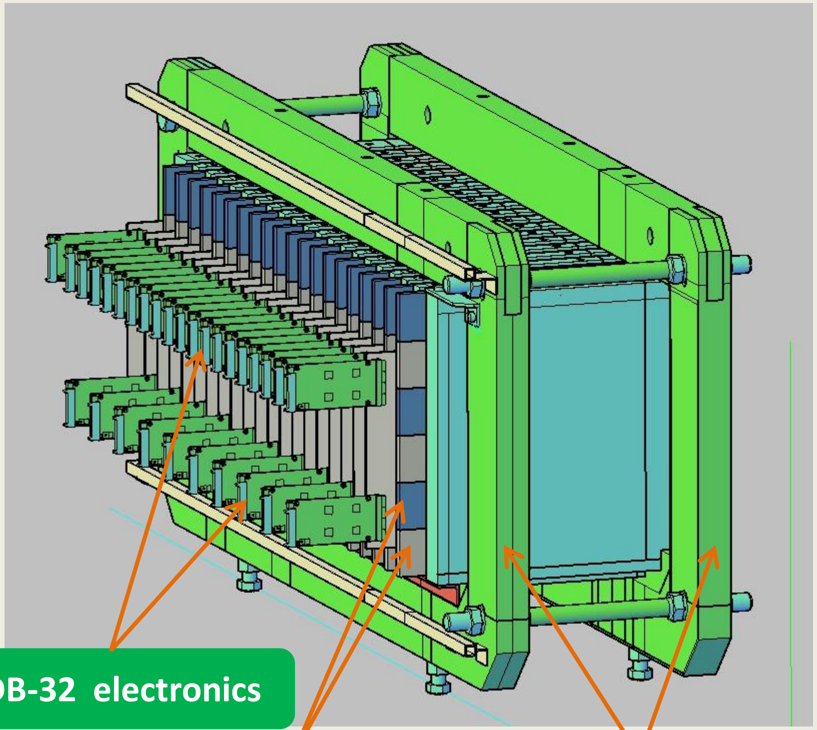
3D engineering view



Manufatured counter at DLNP test stand

SPD/NICA Range System Prototype

3D model of SPD Muon (Range) System Prototype



ADB-32 electronics

6 MDTs per plane

Support frame

120 MDTs, 960 wire R/O channels, strips ?

Prototype absorber (1.5 ton) manufactured at DLNP/JINR

Fe absorber plates:
60mm + 19 layers x 30 mm + 60 mm;
total thickness ~ 4λ

Synergy between PANDA/FAIR & SPD/NICA muon systems:

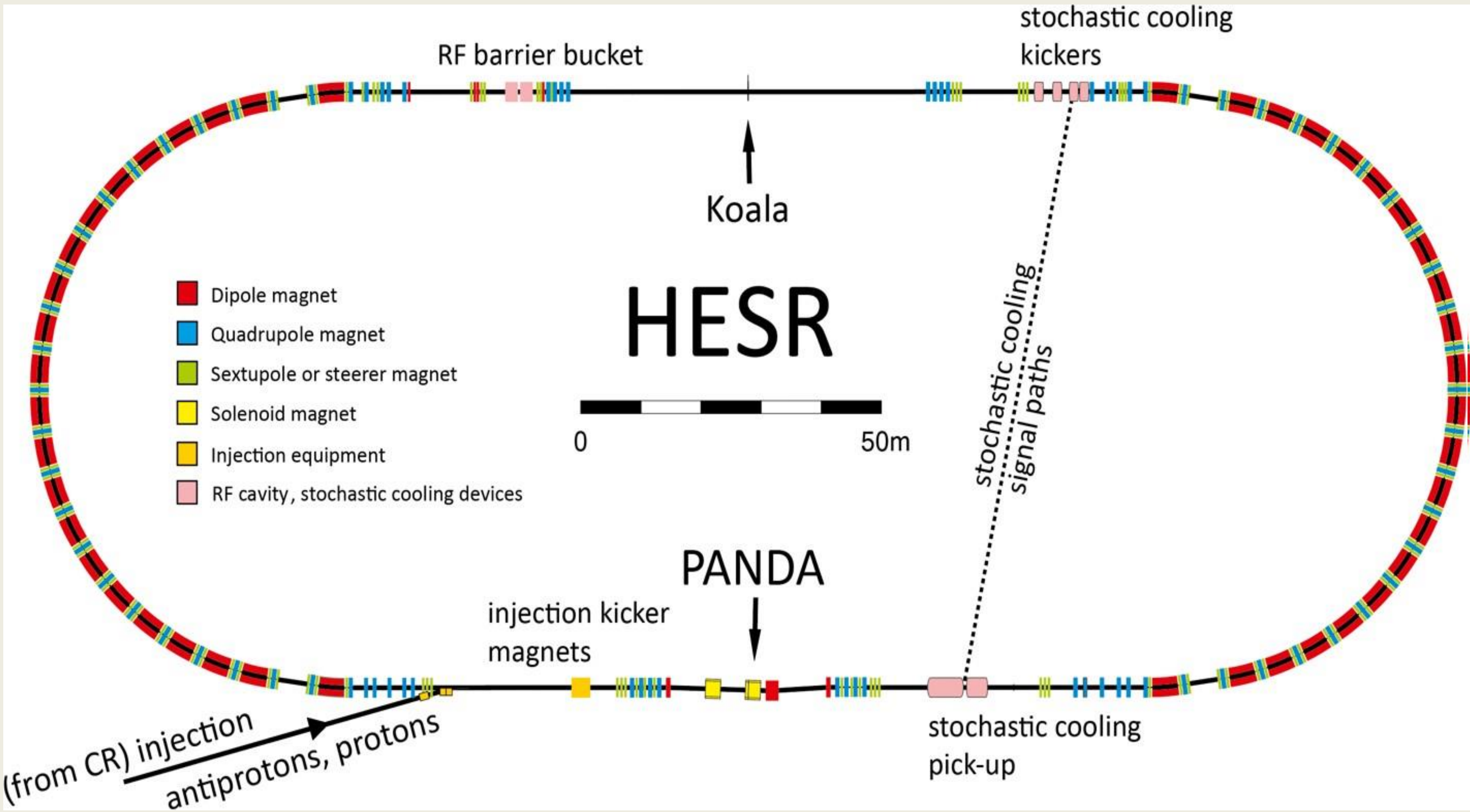
- MDT detectors -> 100%
- Analog electronics -> 100%
- Digital electronics (FPGA based) -> ~ 90%
- Beam tests -> 100%
- Algorithms of pattern recognition -> 100%

CONCLUSION: ALMOST FULL SYNERGY !

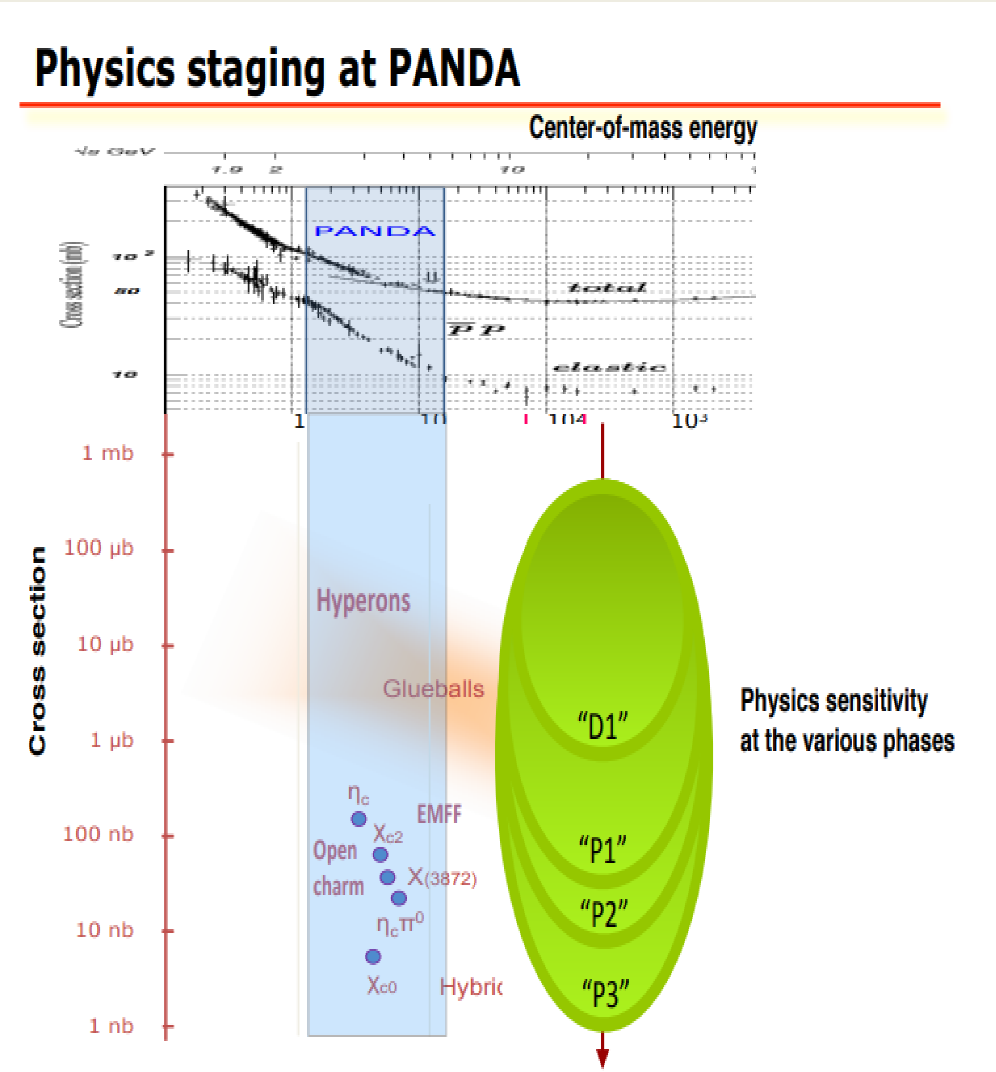
Backup slides

High Energy Storage Ring at FAIR

The PANDA detector is located in one of the straight sections where the antiproton beam interacts with a fixed target. Koala is a precision scattering experiment for systematic luminosity studies.



Physics with PANDA at "Day-1"



Flagship studies:

- Strangeness (|S|=1,2) production in pbar-p and pbar-A.
- Spectroscopy in light-meson sector: search for gluon-rich matter.

Feasibility studies with discovery potential:

- |S|=2 baryon spectroscopy.
- Search for new unconventional hidden-charm states.

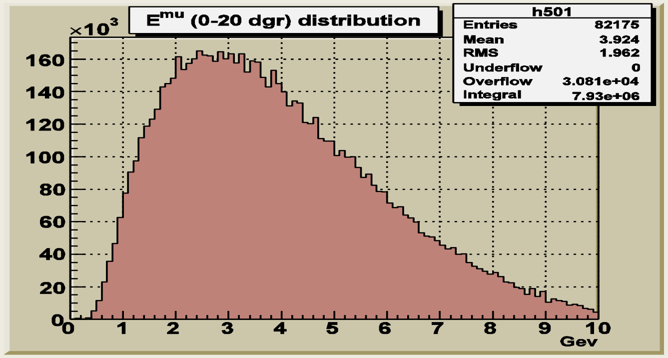
Development studies:

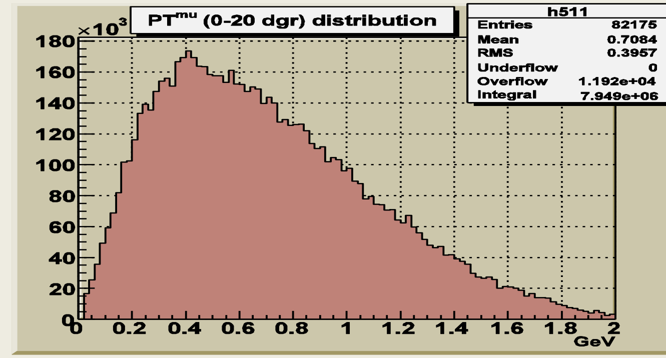
- Database on multi-pion production: tune QCD models for electromagnetic form factor studies etc..
- Line-scan performance studies on conventional hidden-charm states.

… as a first step of phase-1

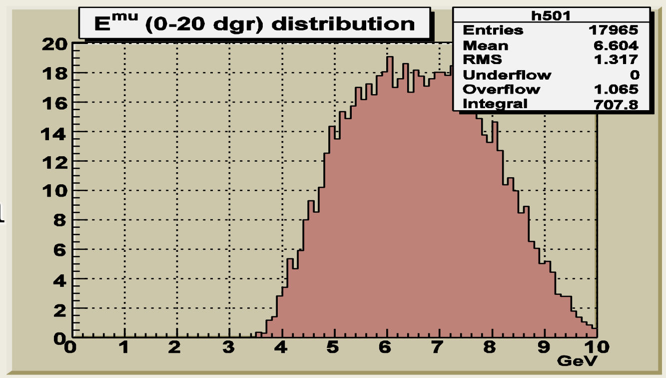
μ distributions in the sector 0° – 20°

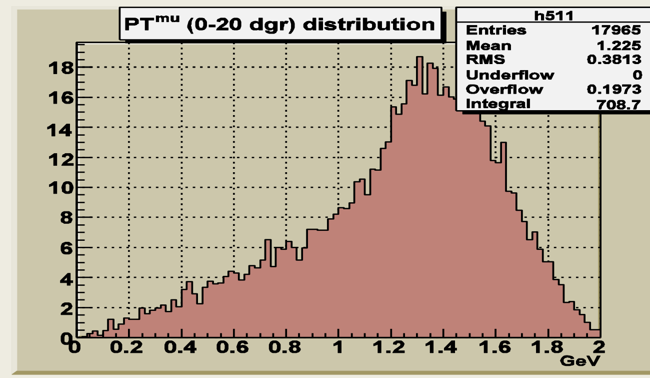
Di - muon production



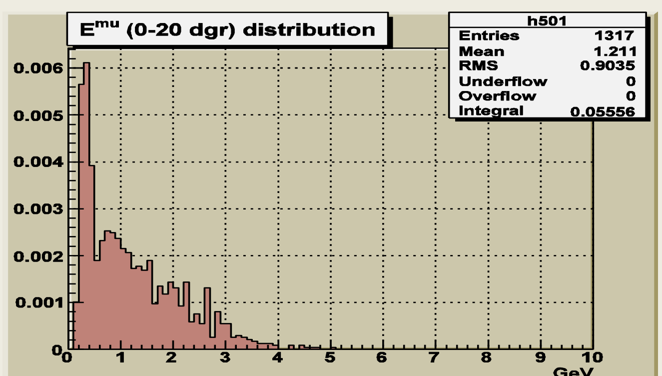


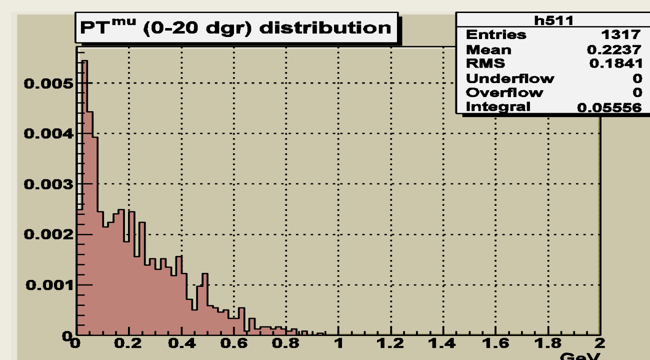
J/Ψ production



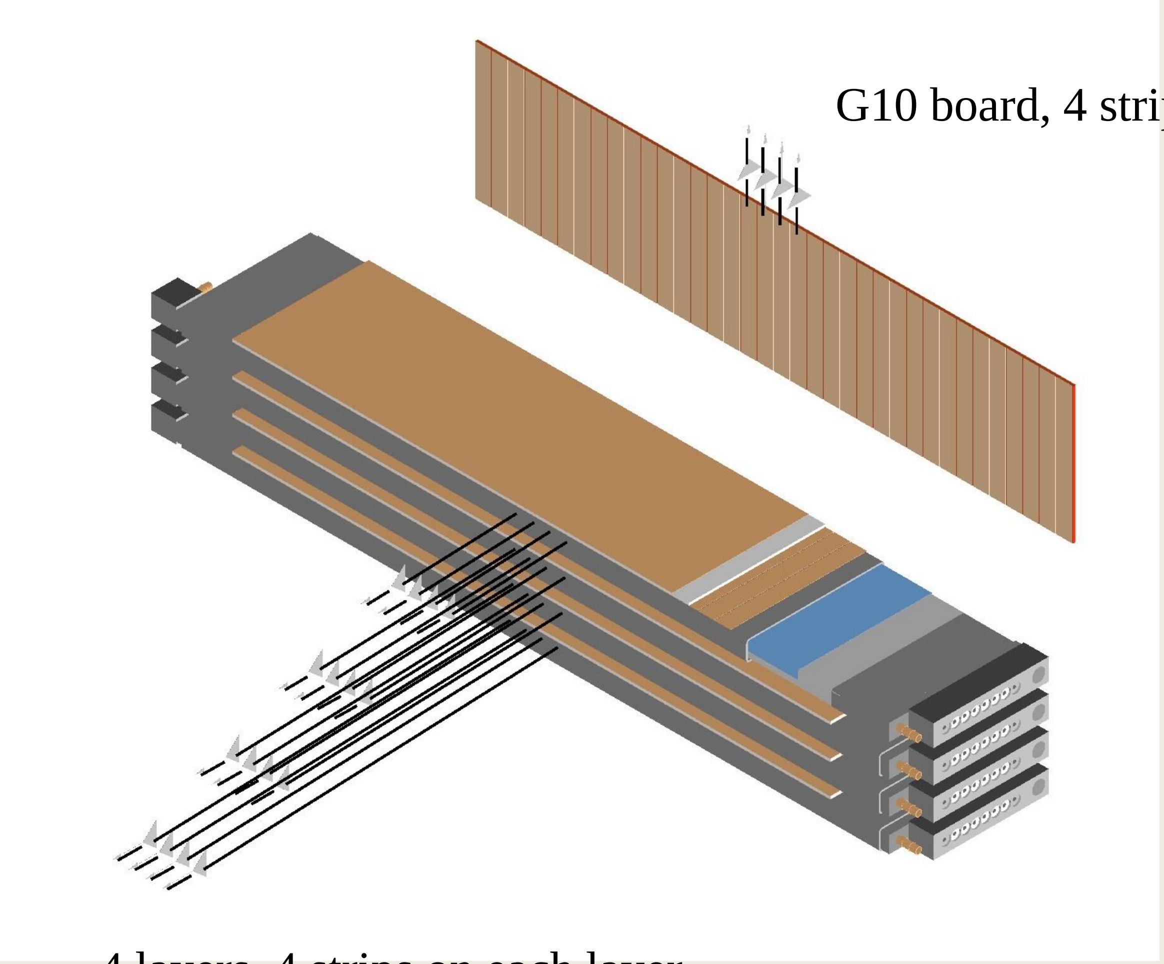


D - meson production (non-direct)





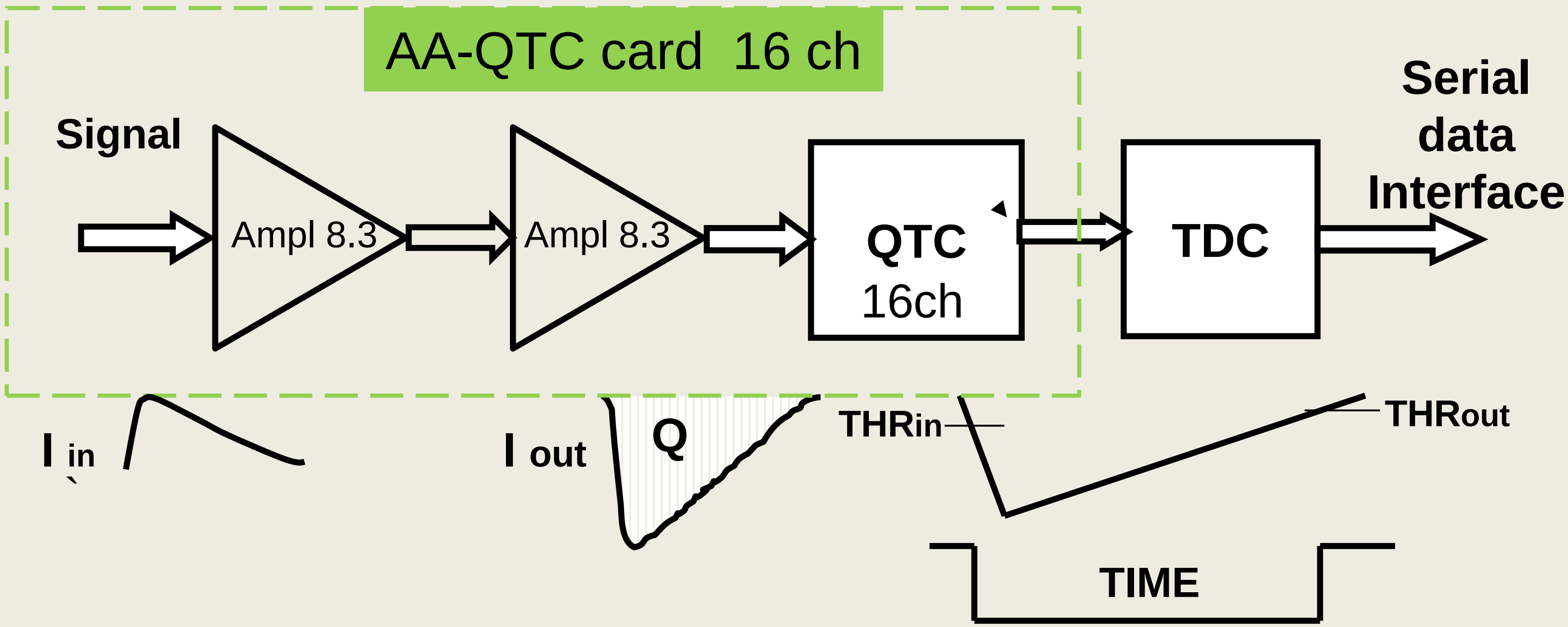
An artistic view of tested MDTs



G10 board, 4 strips, 1cm wide each

4 layers, 4 strips on each layer

MDT signals analog R/O of the PANDA MUON TRACKER



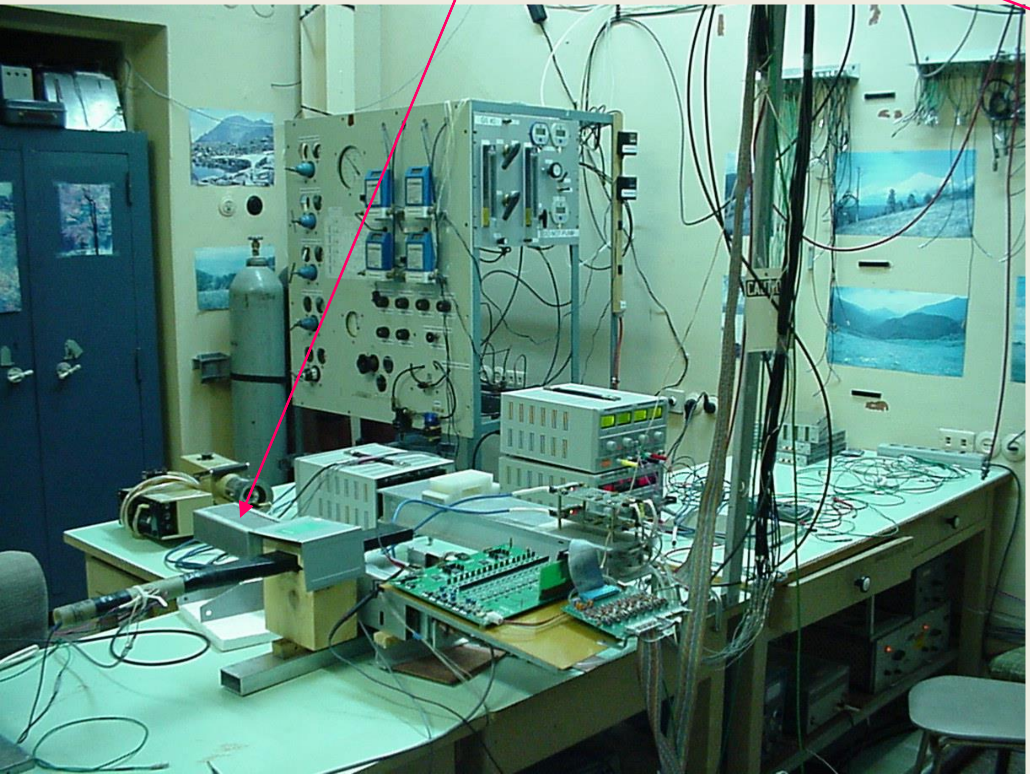
- **Analog R/O for MDT (strips &/or pads)**
- **Using well known Wilkinson principle for Charge-to-Time Conversion**
- **Using TDC chip as proven solution for pipe-line R/O**

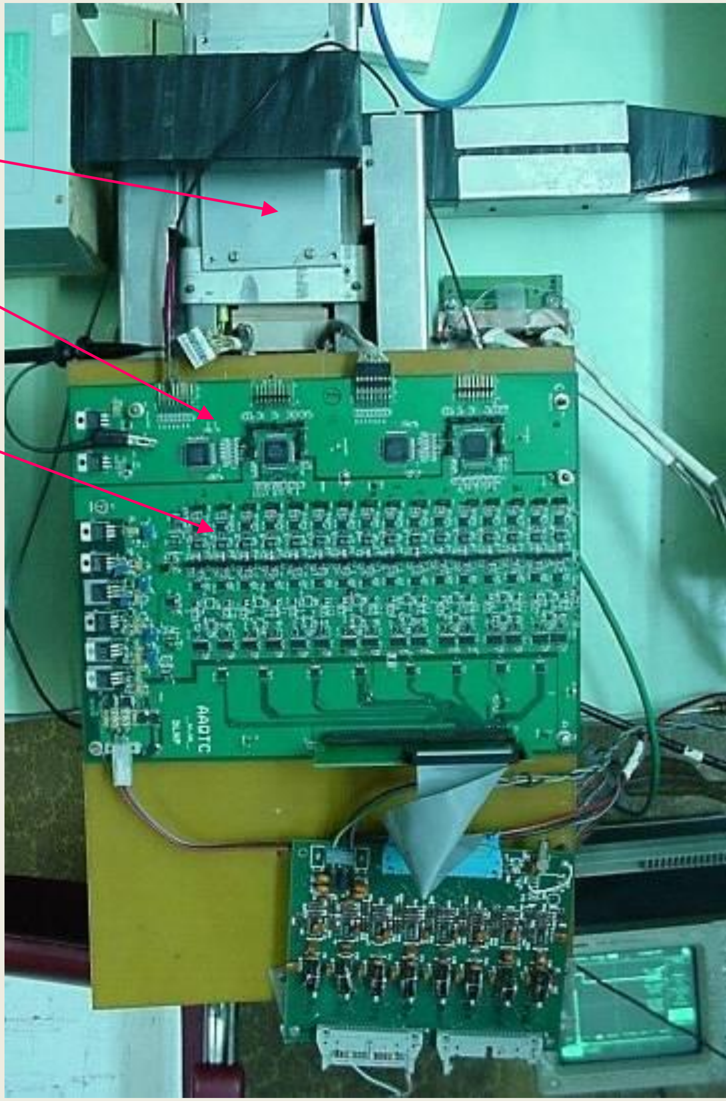
Test setup and A2QTC card

MDT module

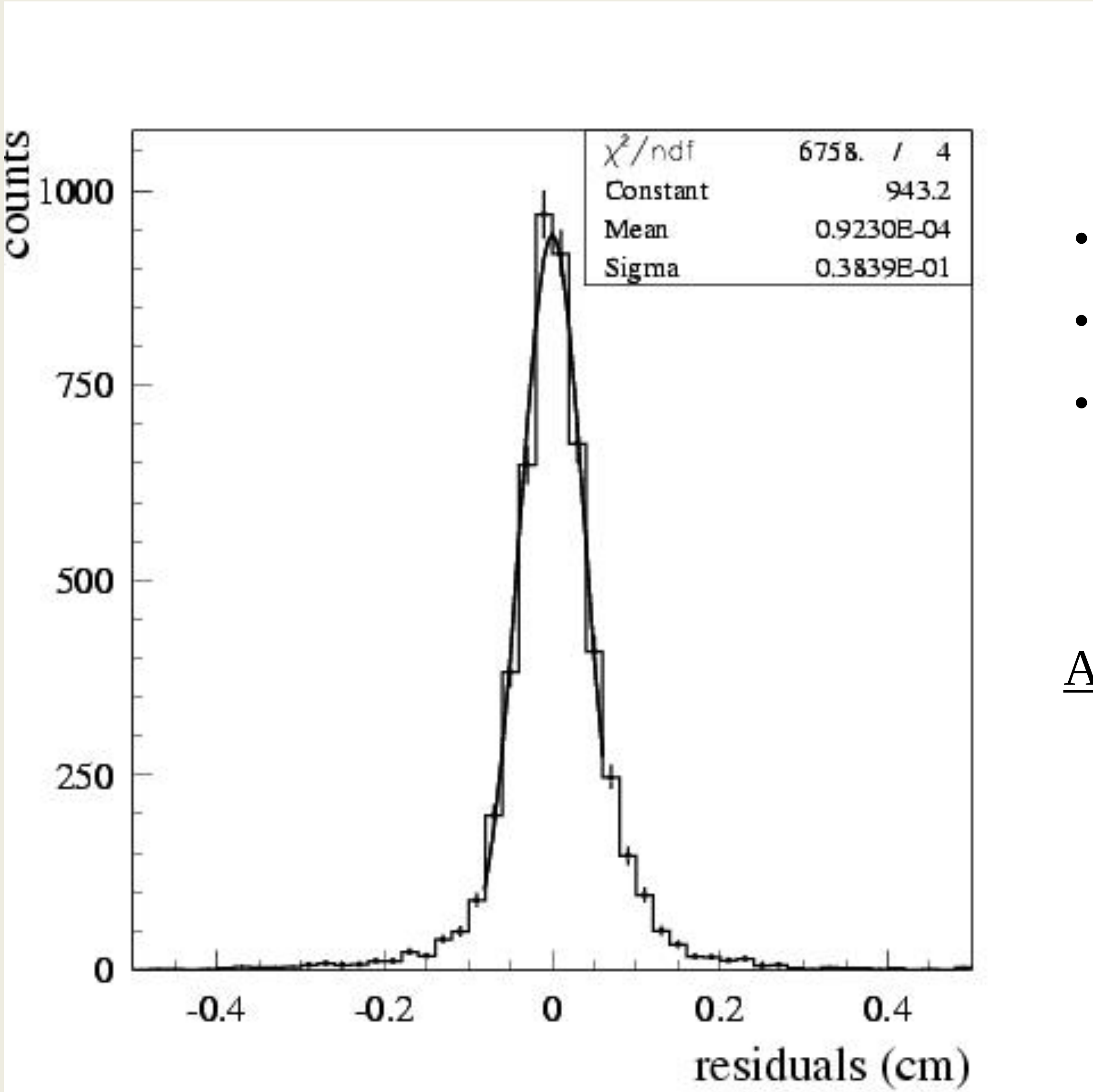
Ampl-
8.3

QTC part





MDT spatial accuracy of the strip readout



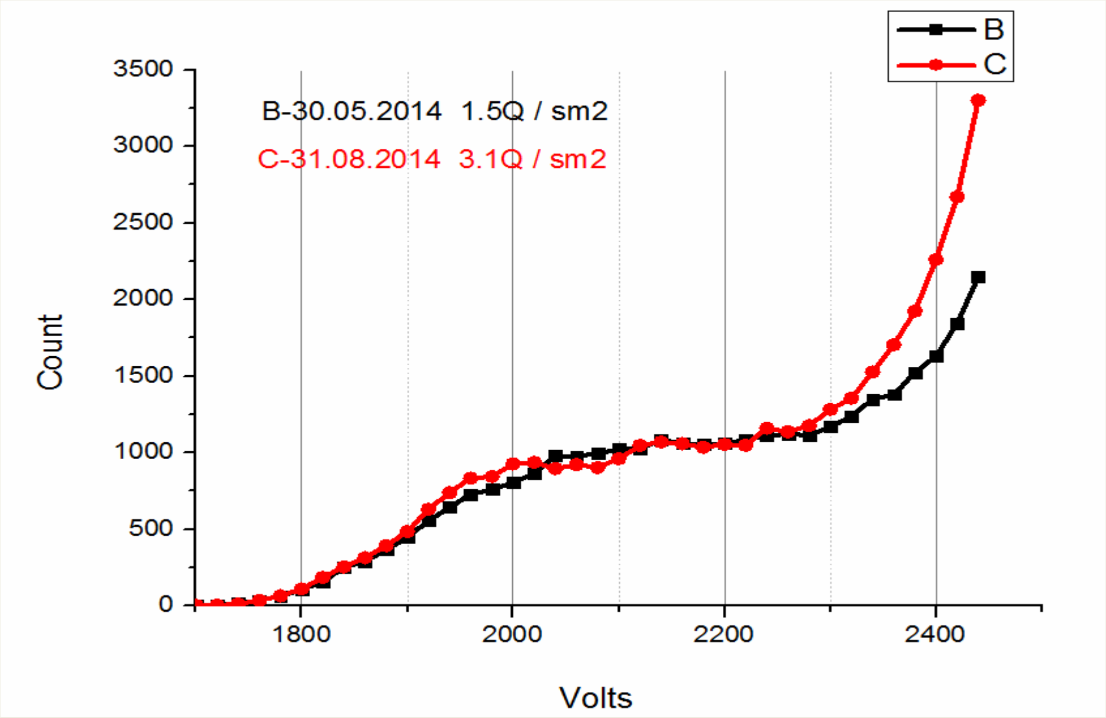
- 1 cm wide, 10 cm long strips
- 4 MDT layers
- near vertical cosmic tracks

<u>Achieved spatial accuracy:</u>

σ~0.4 мм

MDT counting characteristics after irradiation by 1.5 and 3.1 Coulomb / cm2

NO AGEING !



No 'rate effects' in MDTs (both, for wires & strips)

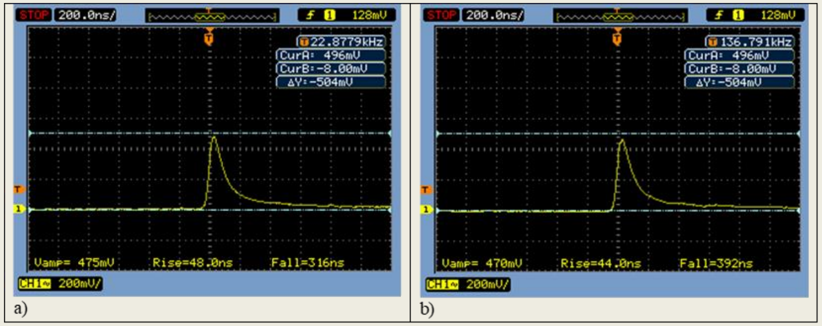


Fig.9 Average strip signals for (a) 70 kHz and (b) 250 kHz strip r/o channel loads

To check the stability of MDT operation at very high irradiation intensities we also made a measurement of counting rate curves for different loads up to 900 kHz. Normalized (to the plateau) counting rate curves are presented in Fig. 10. No counting rate curve plateau (2150 – 2300 V; spread of plateau beginnings is within 20 V) constriction was observed up to the 900 kHz load.

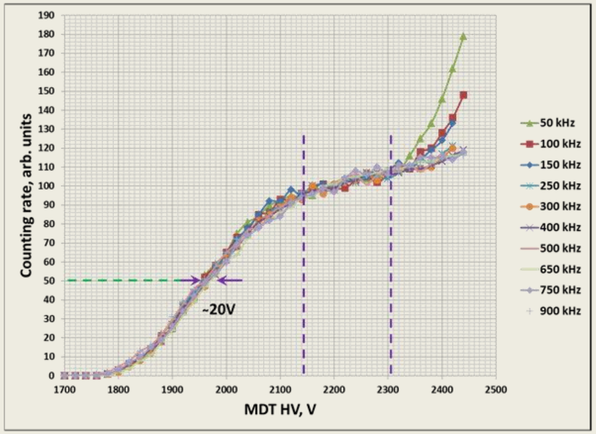


Fig.10 Normalized MDT counting rate curves for different wire channel loads (X-ray intensities)

Thus, the data presented above demonstrate absence of the rate effects dangerous for the MDT operation, both for nominal luminosity and its instant fluctuations.

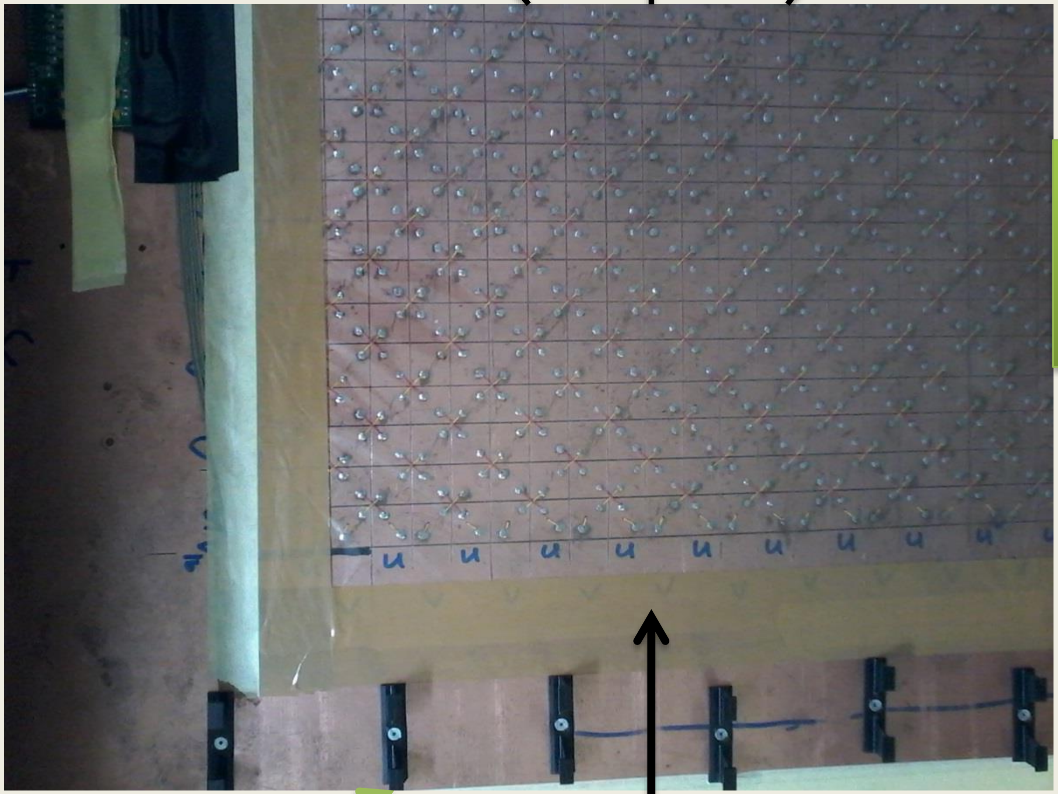
RS prototype: ALU profiles for MDTs -> cut to size and prepared for wiring (300 pcs)

'Chess board' zero bi-layer (fragment)

wire direction

U-strip, -45 deg.

V-strip, + 45 deg.

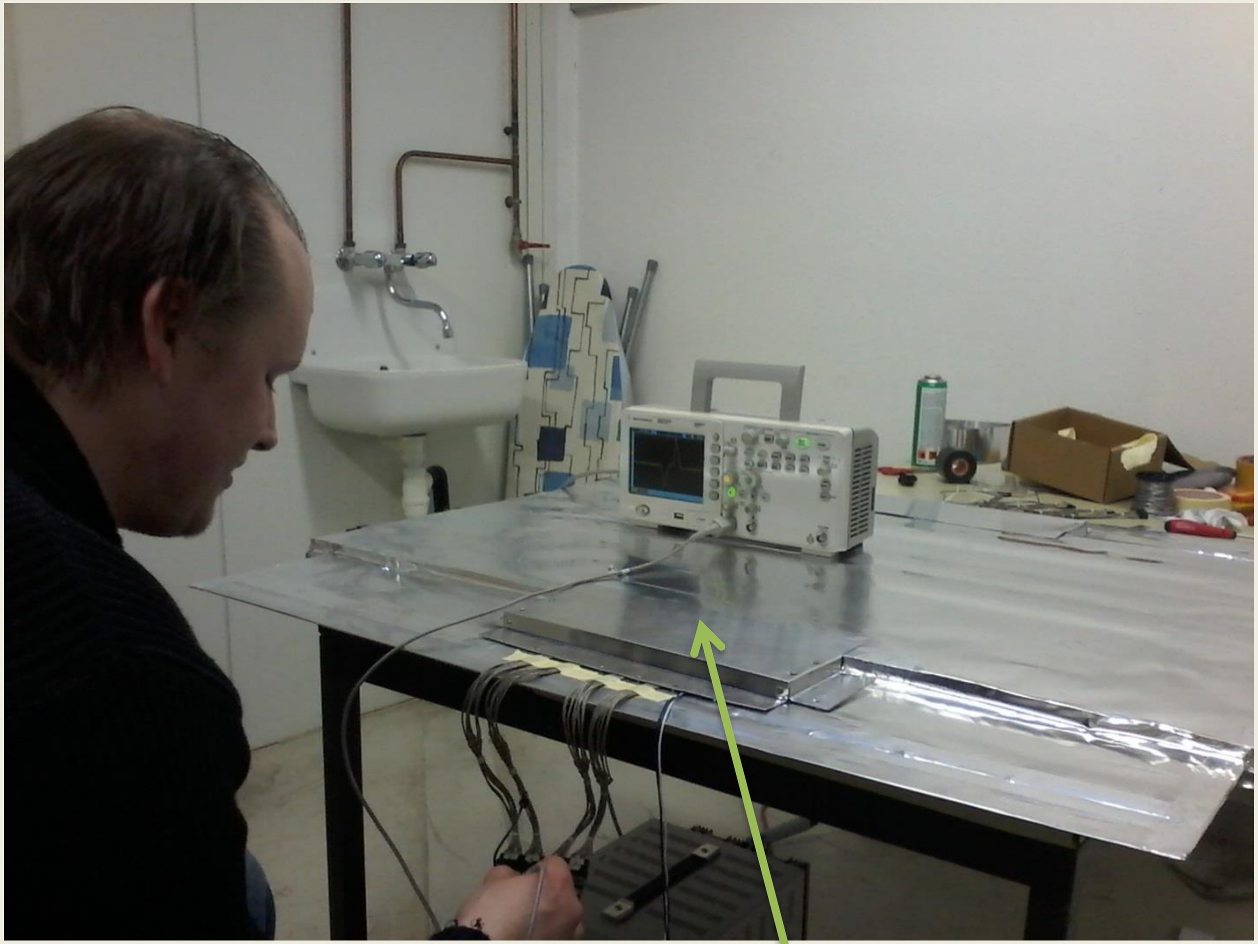


Strips are formed from 2 cm x 2cm squares by soldering

Brackets to fix MDTs to strip board

MDT tube

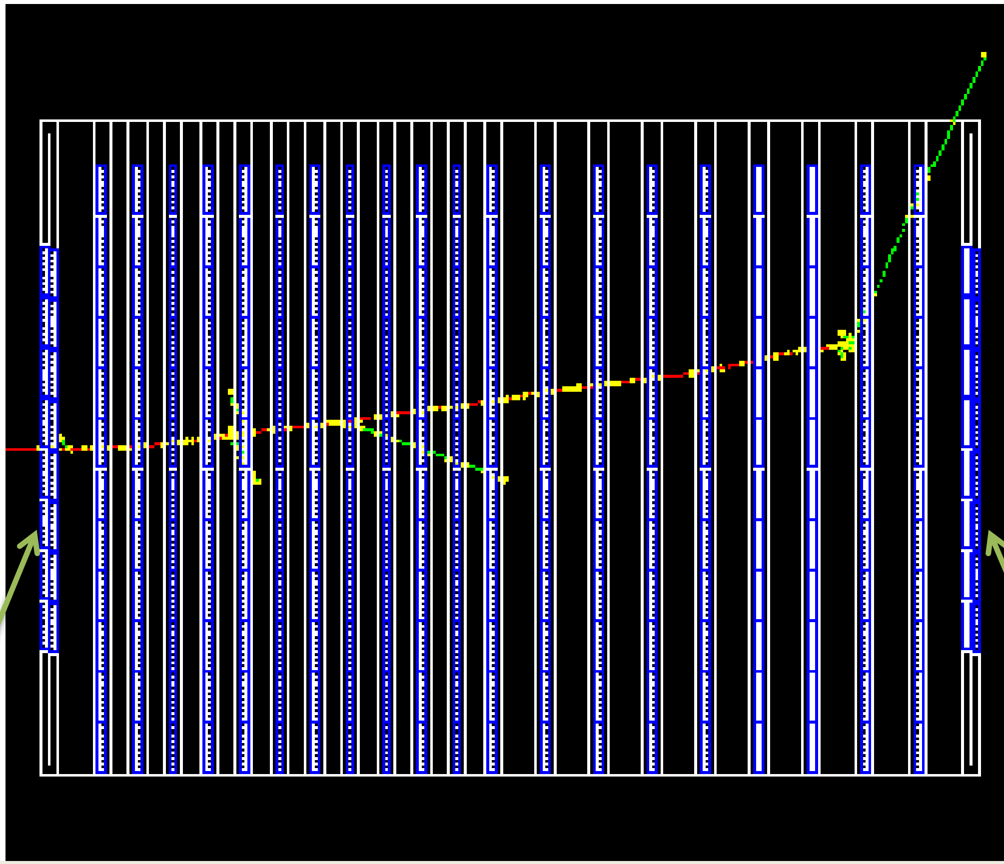
Test of ‘chess board’ zero bi-layer fully screened with aluminum foil (~ 0,1 mm thick)



A-32 preamplifier box

RSP model and data collected at T9/PS/CERN run 2012 are being used to tune digitization algorithm

The Range System Prototype Geant4 simulation



Example with 1GeV muon entering from the left

All hits generated by Geant4 are shown

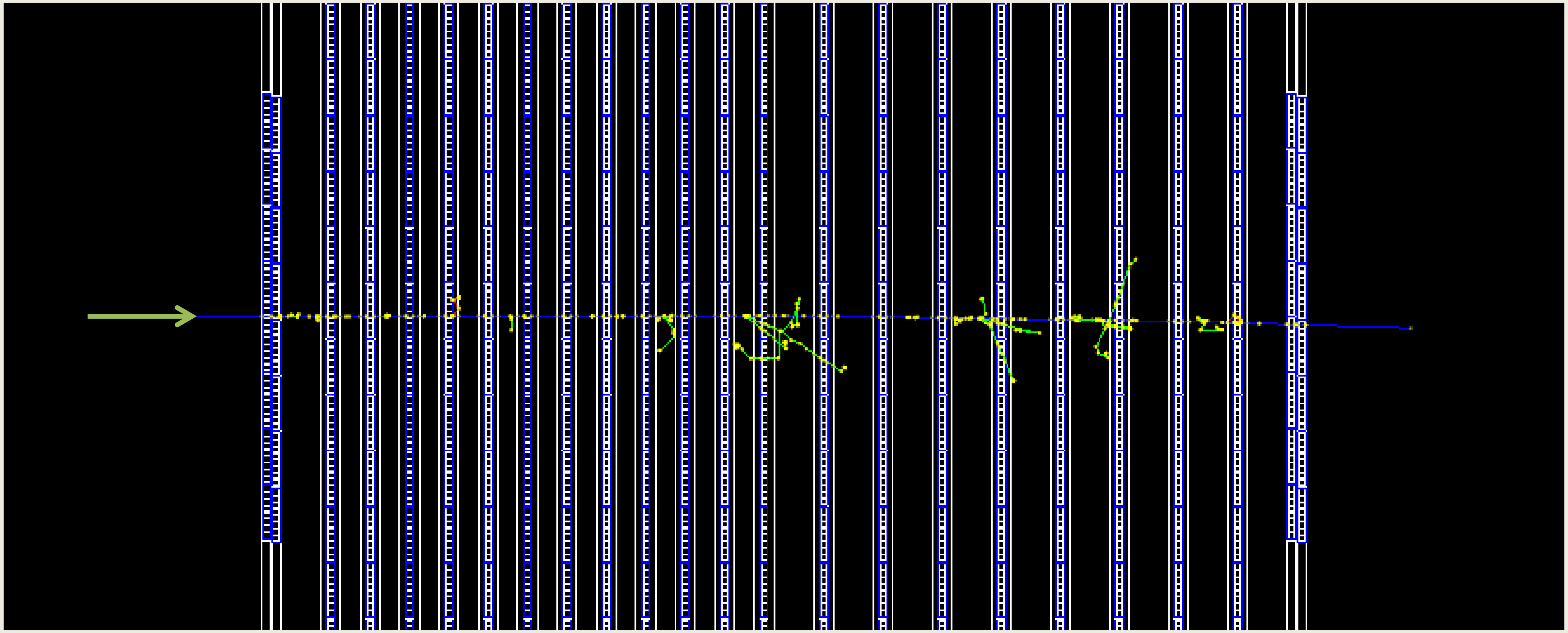
Our task is to analyze them and simulate the signals from MDT wires (and also strips, later…)

digitization

'chess board' zero bi-layer

'standard' bi-layer

5 GeV muon generated in RSP



5 GeV pion generated in RSP

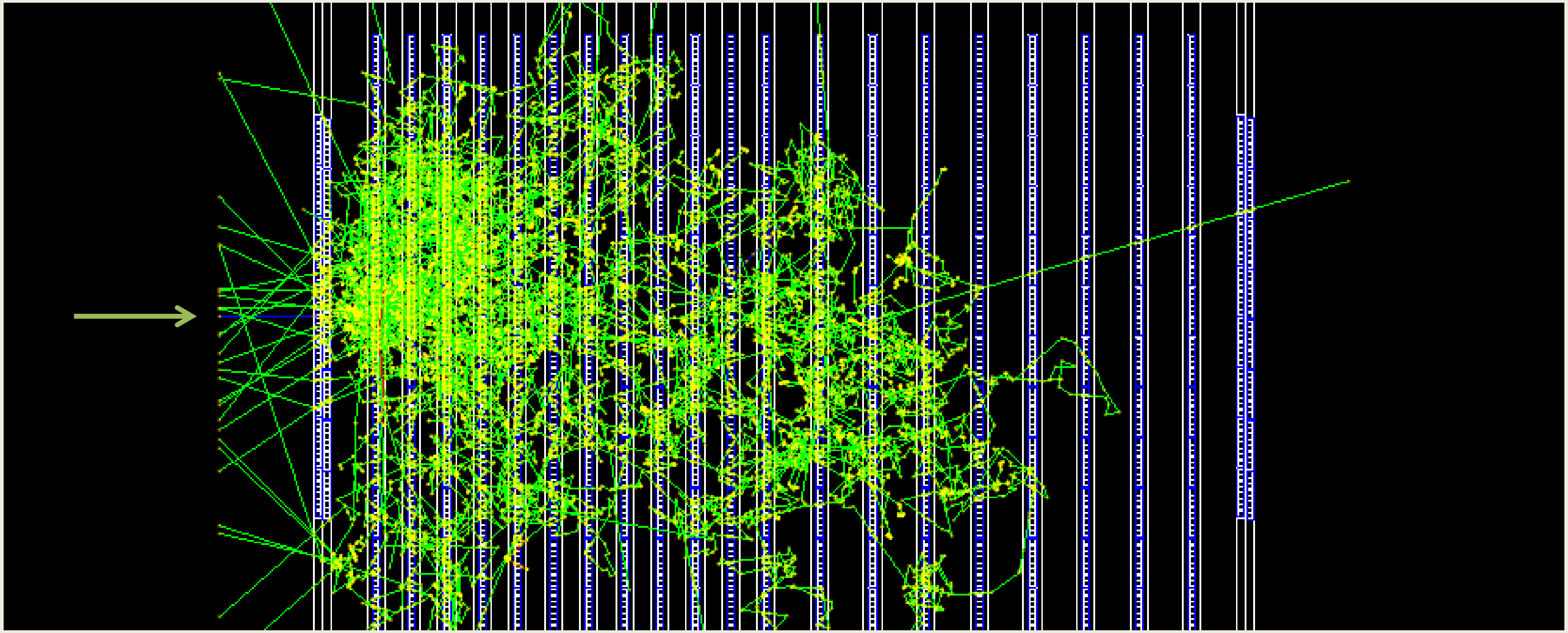
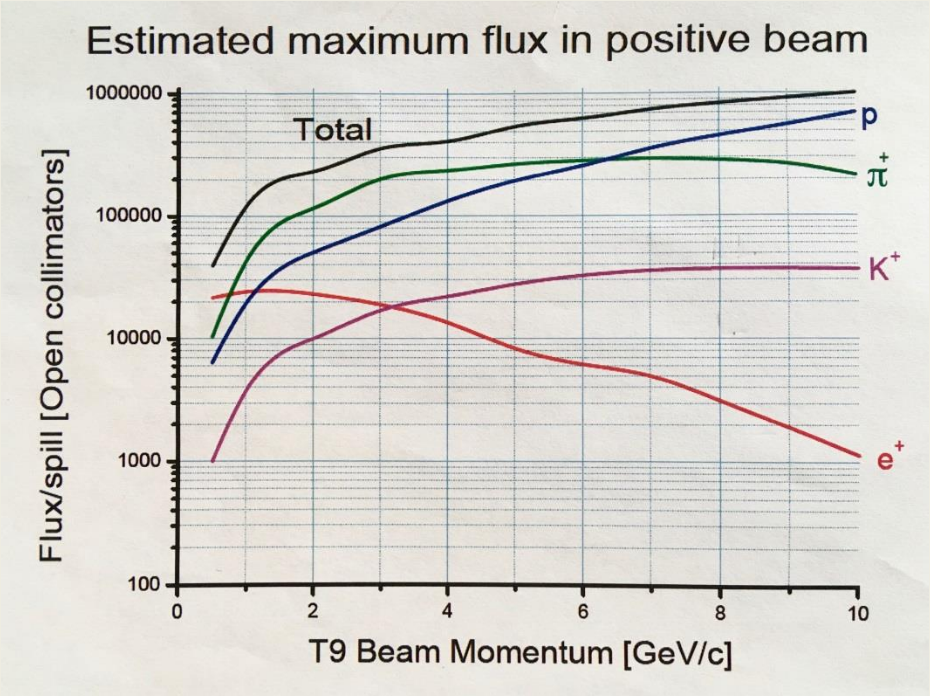
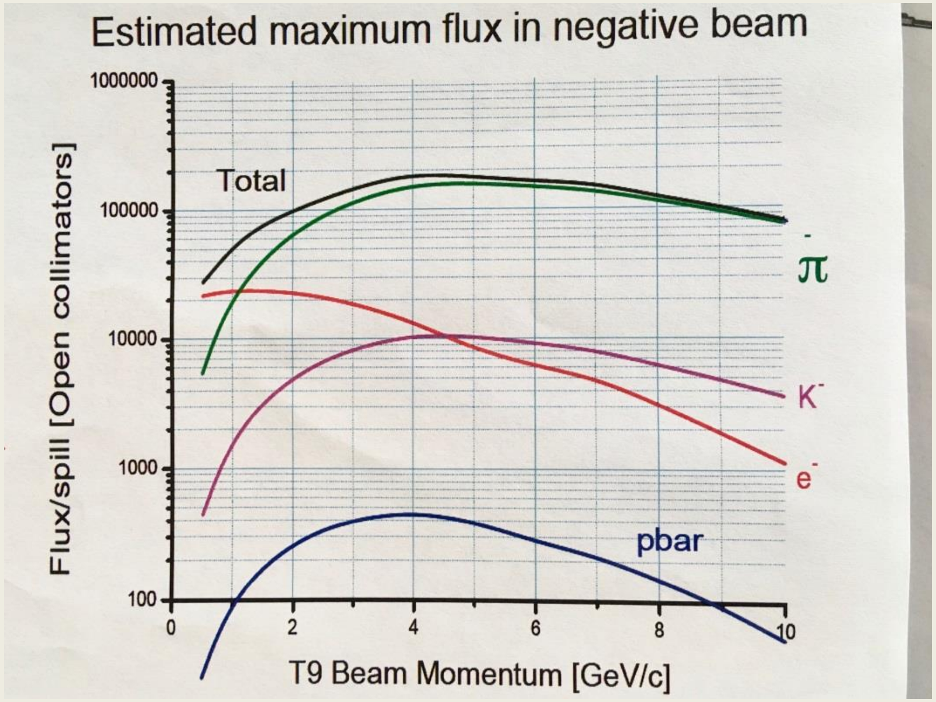


Table of conditions for written events; T9/PS/CERN (example of one of the runs)

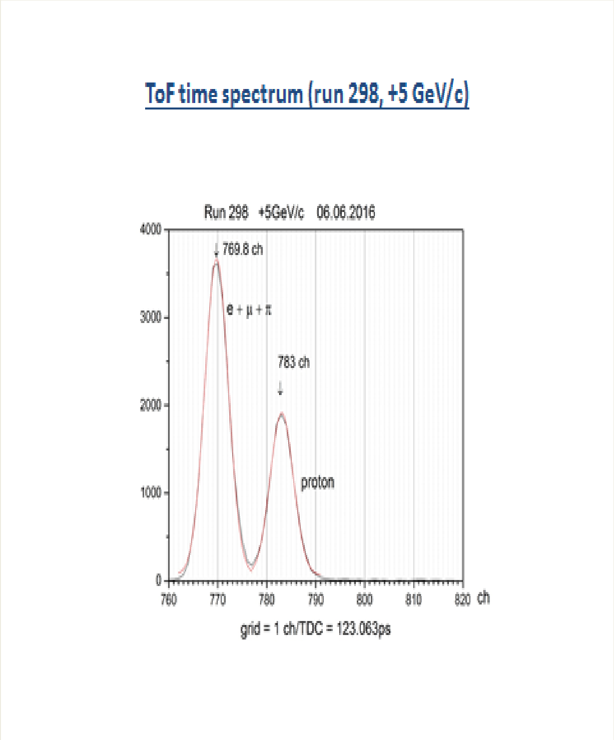
P[Gev/c]	Trigger	Composition	N of events	file # , Comments
Spectrum	S3*S4	cosmic	635	f39, S3 & S4 on RSP top
Spectrum	S3*S4	cosmic	8375	f41,S3 on top & S4 on bottom
0.5	S1*S2	- (e,μ,π)	6575	f85, strips on
0.5	S1*S2	+ (e,μ,π,p)	27374	f83, strips on
1	S1*S2	+ (e,μ,π,p)	3087	f65
1	S1*S2*vetoC1	+ (μ,π,p)	90 000	f68
2	S1*S2	+ (e,μ,π,p)	3161	f80, strips on
2	S1*S2+Pb	+ (μ,π,p)	1087	f81, 2.5 cm Pb brick in beam, strips on
3	S1*S2	+ (e,μ,π,p)	11766	f77
3	S1*S2*C2	+ (e,μ)	3283	f78
3	S1*S2*C2+Pb	+ (μ)	299	f79, 2.5 cm Pb brick in beam, strips on
5	S1*S2	+ (e,μ,π,p)	9702	f56
5	S1*S2*C1*C2	+ (e)	2181	f57
5	S1*S2*C1*C2	+ (e,μ)	1217	f58
5	S1*S2*C1*C2	+ (e,μ)	200 000	f59
5	S1*S2	+ (e,μ,π,p)	6407	f69, strips on
5	S1*S2*C2	+ (e,μ)	3201	f70, strips on
5	S1*S2*C2	+ (e,μ)	13266	f71, strips on
7	S1*S2	+ (e,μ,π,p)	11940	f75, strips on
7	S1*S2*C2	+ (e,μ)	3492	f76, strips on
10	S1*S2	+ (e,μ,π,p)	9899	f72, strips on
10	S1*S2*C2	+ (e,μ)	1213	f73, strips on
10	S3*S4	+ (e,μ,π,p)	7405	f74, beam + halo, strips on

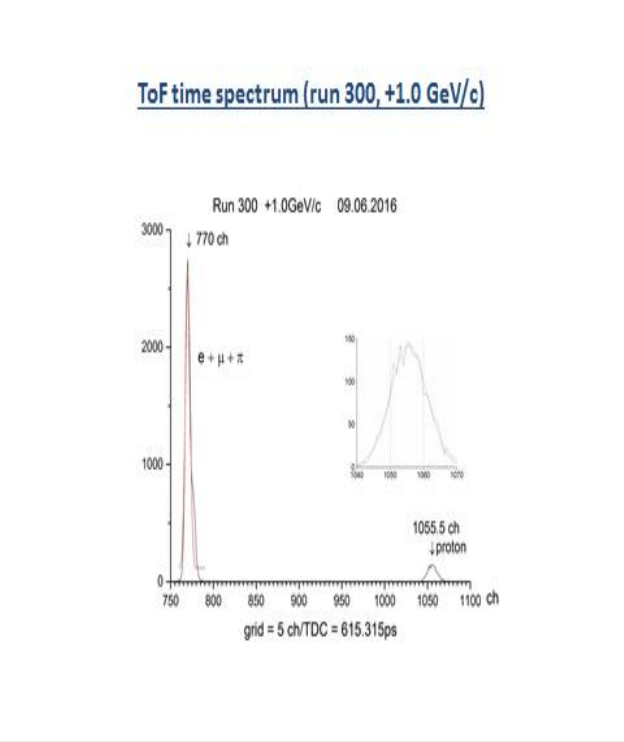
Estimated maximum flux in beam @ T9/PS/CERN



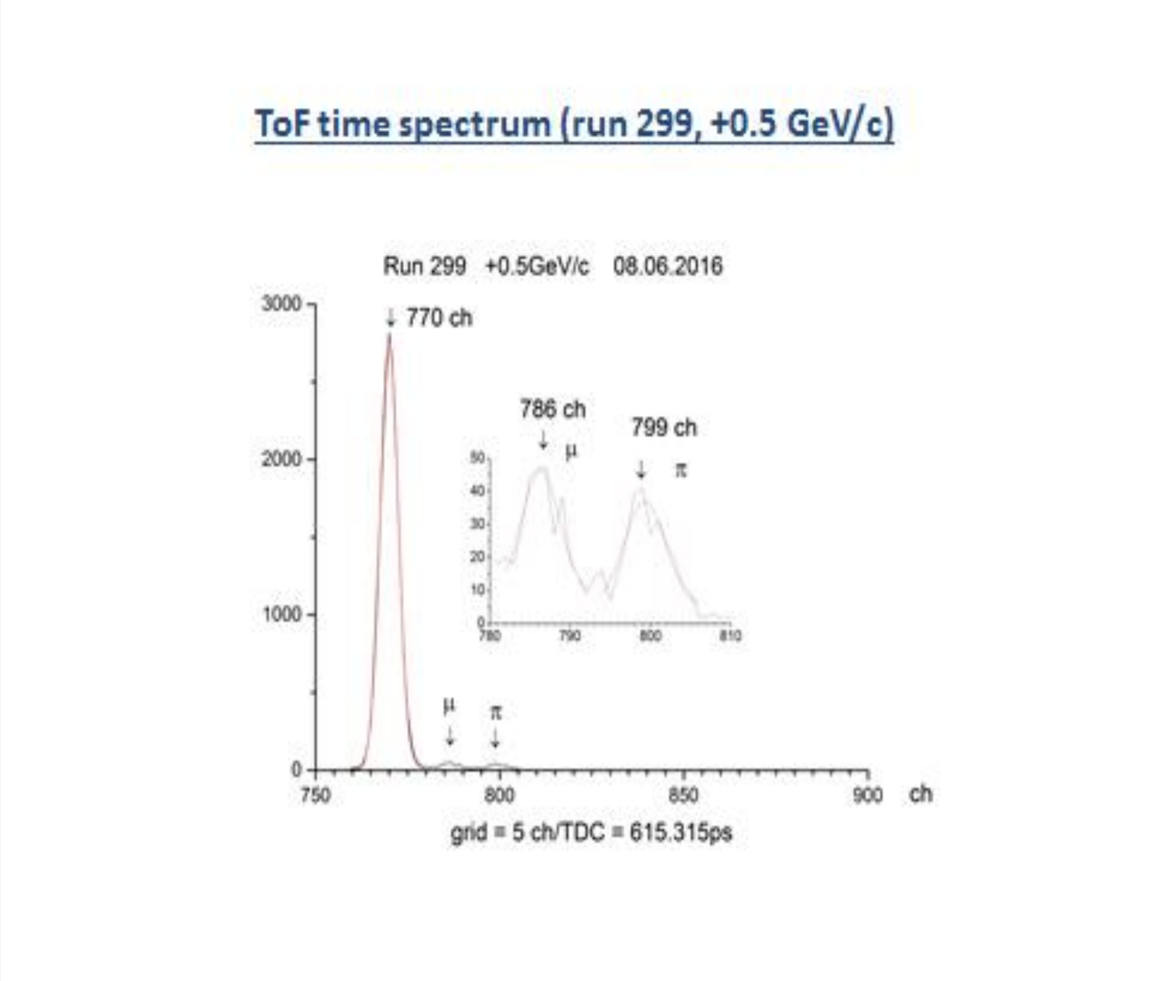


Reliable separation of protons in T9/PS beam with existing ToF up to ~ 5 GeV/c momentum



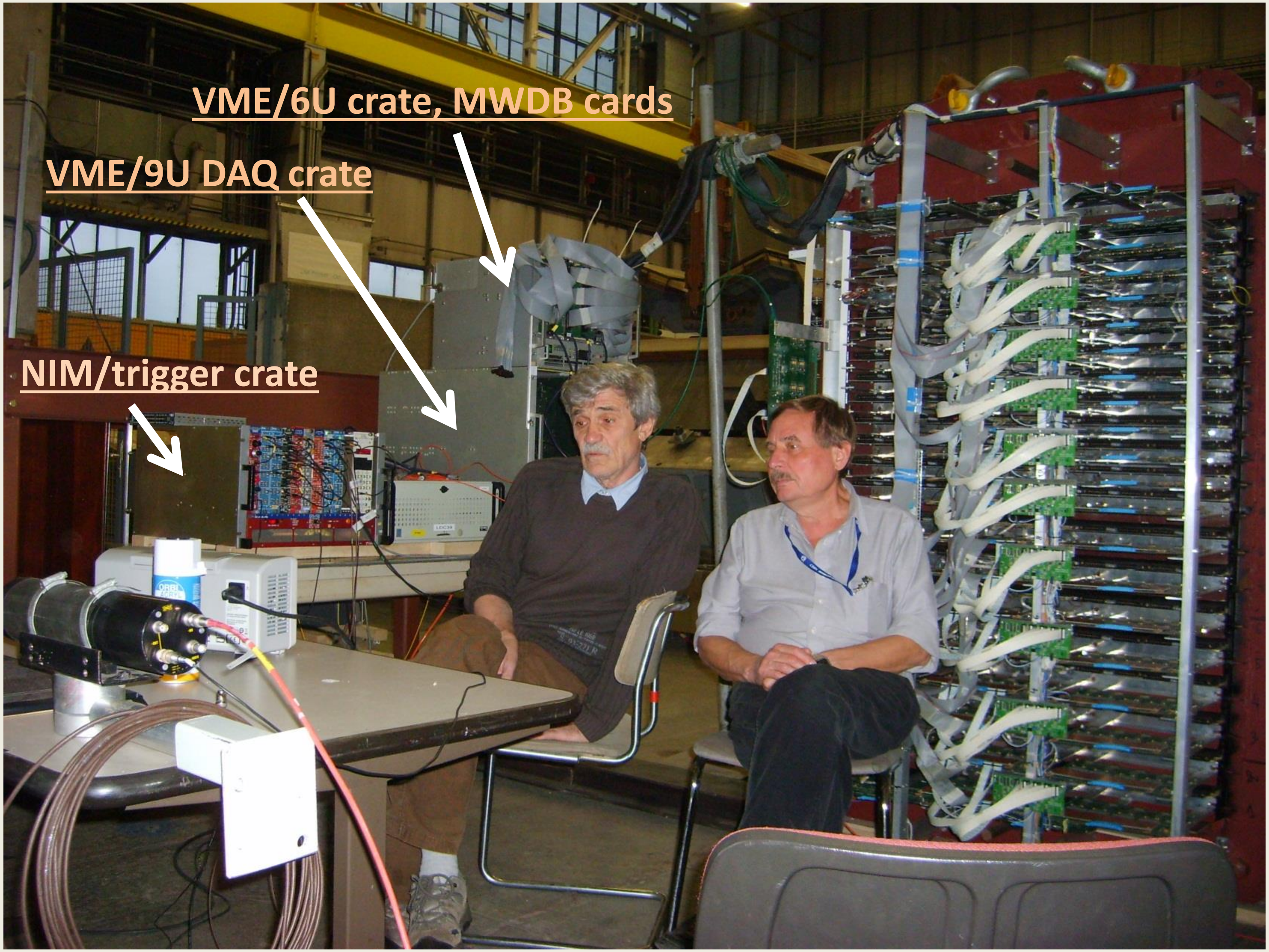


ToF spectrum at the lowest T9/PS momentum of 0,5 GeV/c: muon-to-pion separation looks possible

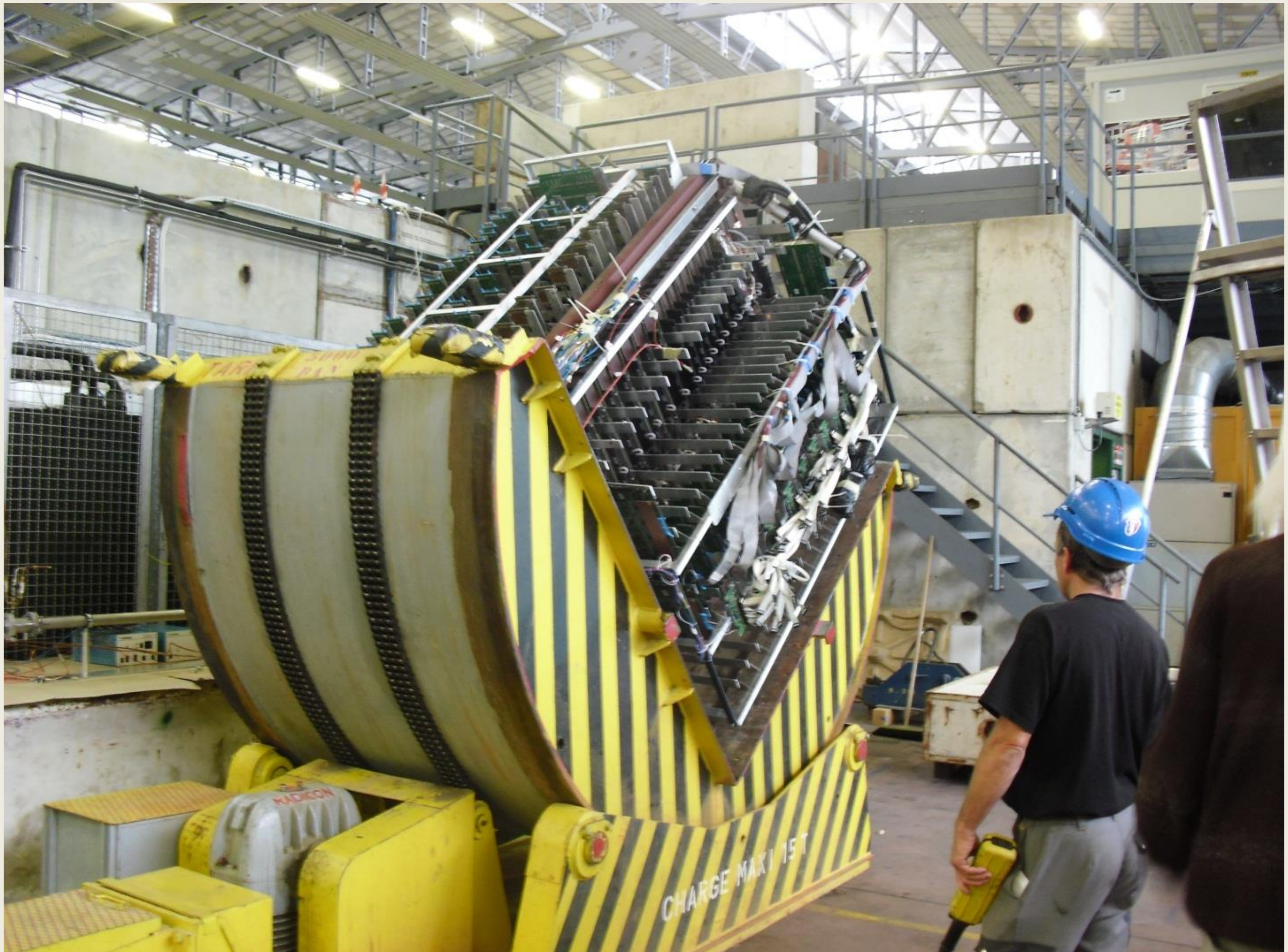


Assembly of RSP

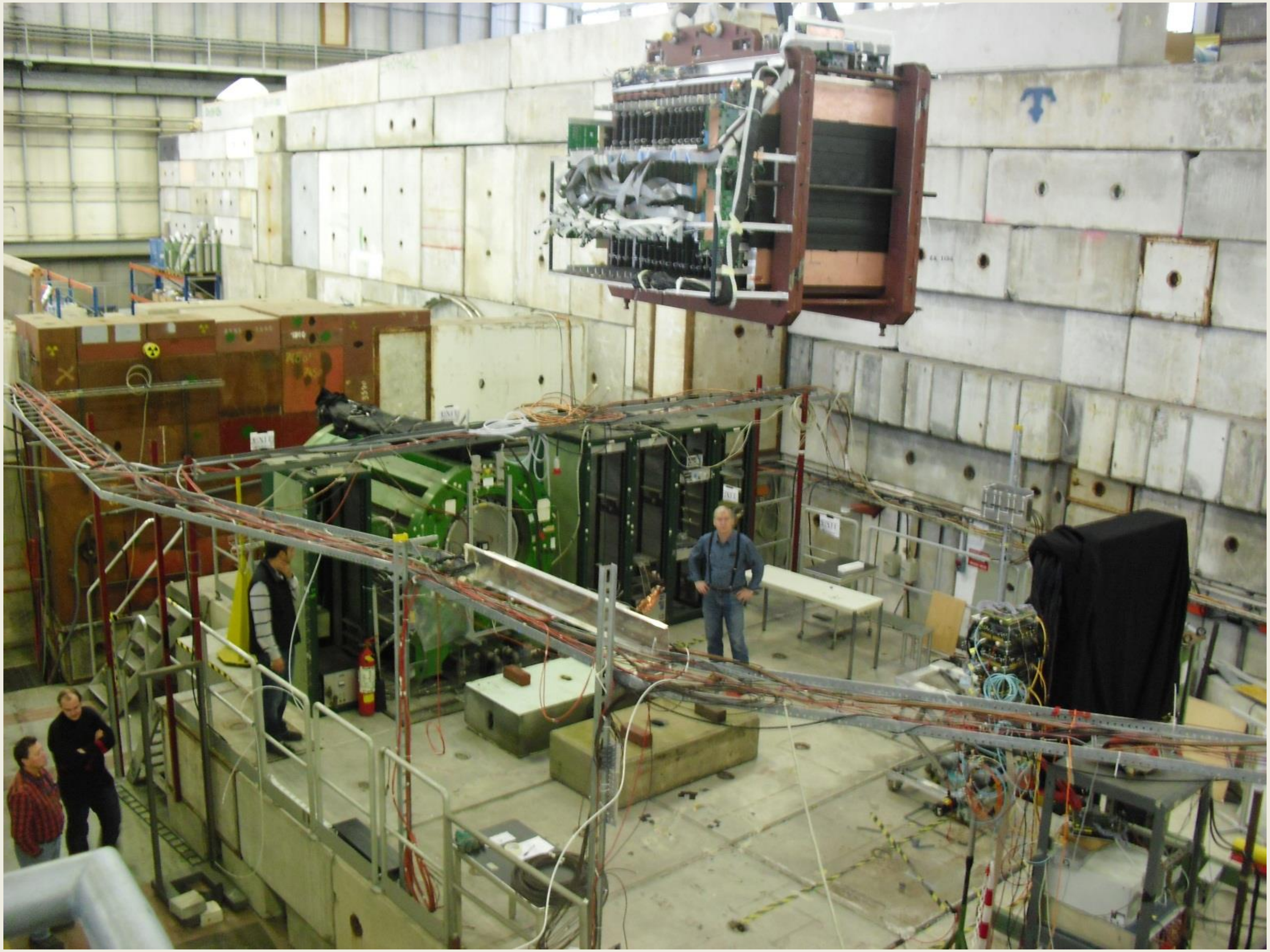
Debugging and adjustment of DAQ on cosmic; RSP is fully equipped with A2DB-32, ADB-32 , Asum-96 and QTC cards



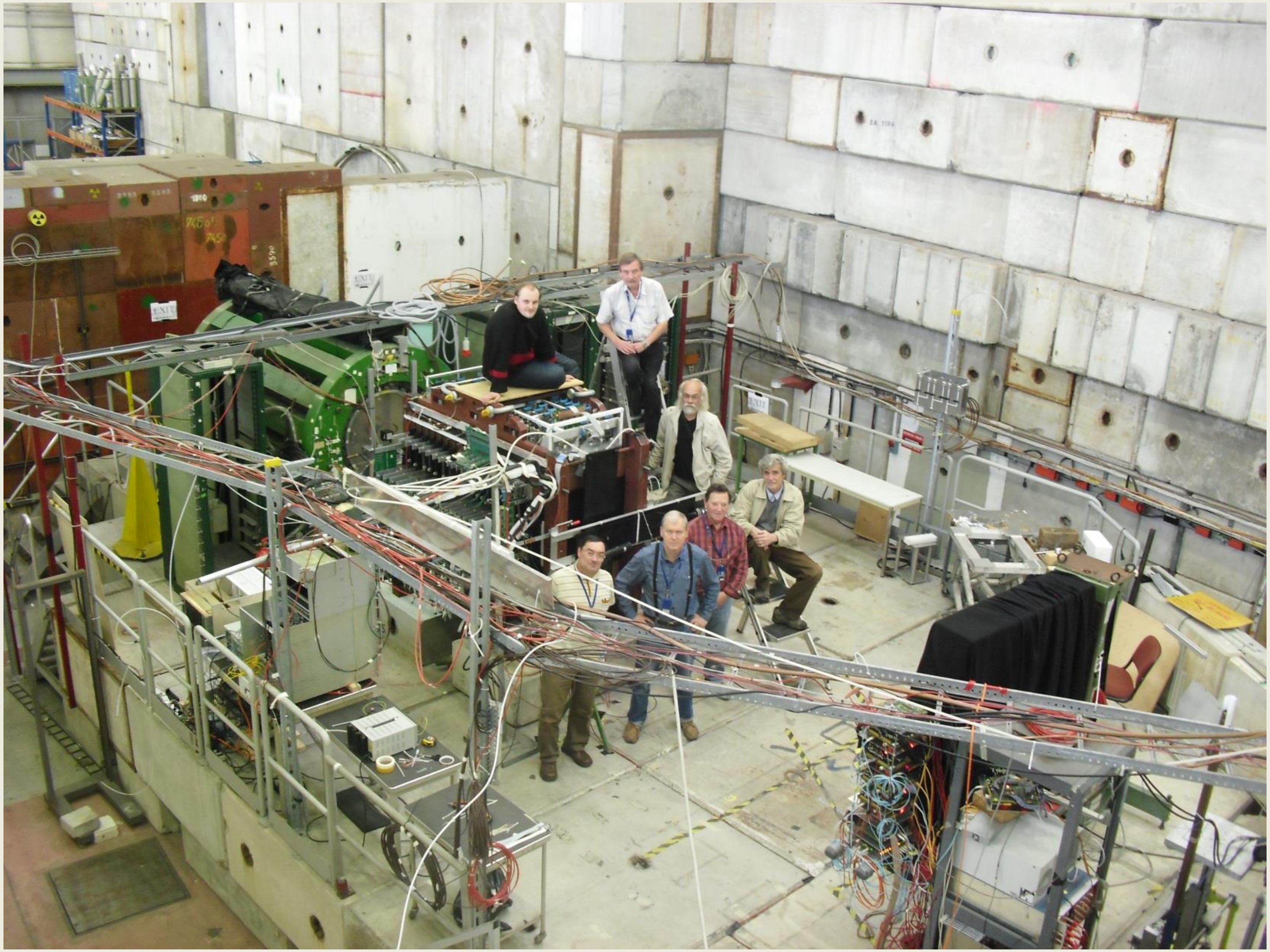
RSP rotation from vertical (cosmic) to horizontal (on beam) position



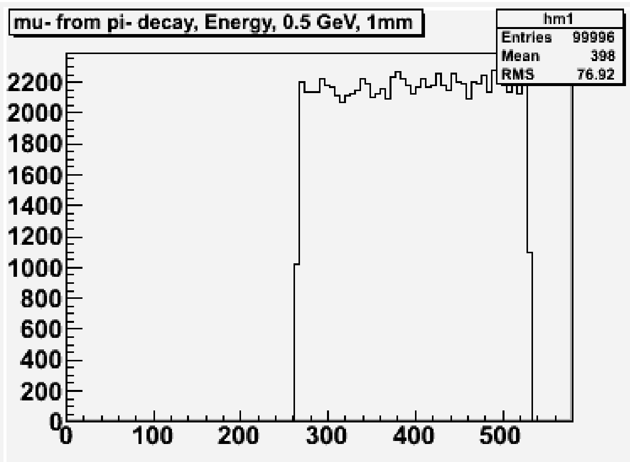
Placement of the RSP in T9 beam zone

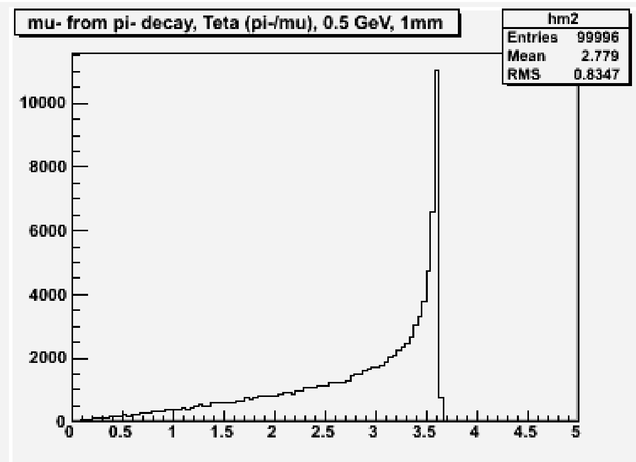


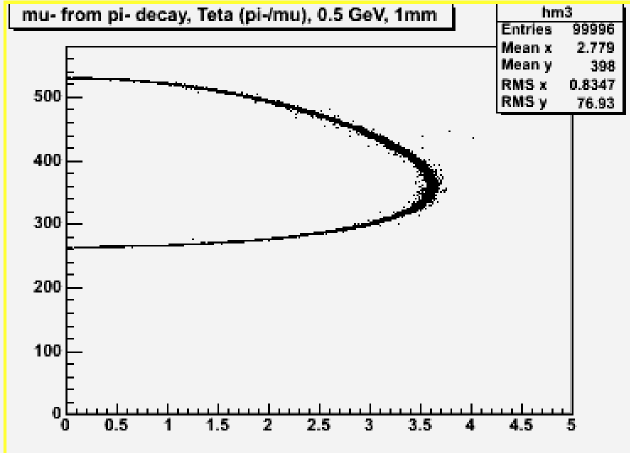
Happy end for RSP beam test !



Muons from $\pi \to \mu\nu$ decay







E_{π}=0.5 GeV

Muon energy, angle and

correlation distributions

Parameters of ToF and pressurized Cherenkov counters for PANDA/FAIR & SPD/NICA test beams

P, МэВ/с	**tπ-tμ, псек/м**	**p, атм**	**e, ф.э.**	**μ, ф.э.**	**π, ф.э.**
600	37.8	60.0	1020	240	0
750	24.7	29.5 51.4 60.0	510 900 1020	0 380 520	0 0 150
1000	13.9	16.7 29.0 41.5	290 500 710	0 220 430	0 0 220
1250	8.9	10.7 18.6 26.6	180 320 460	0 140 280	0 0 140
1500	6.2	7.4 12.9 18.6	130 220 320	0 100 190	0 0 100