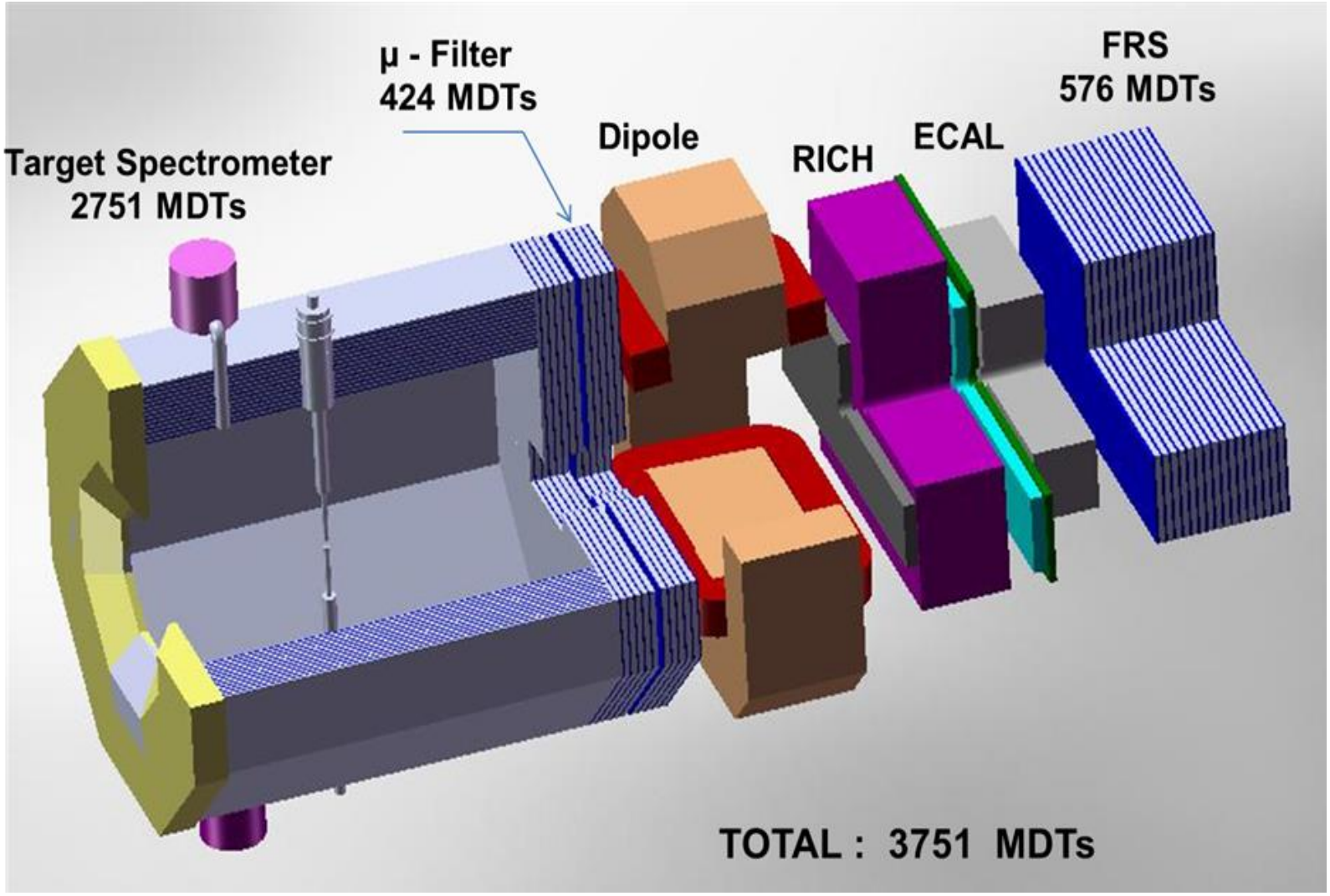
Г. Д. Алексеев (ЛЯП ОИЯИ)

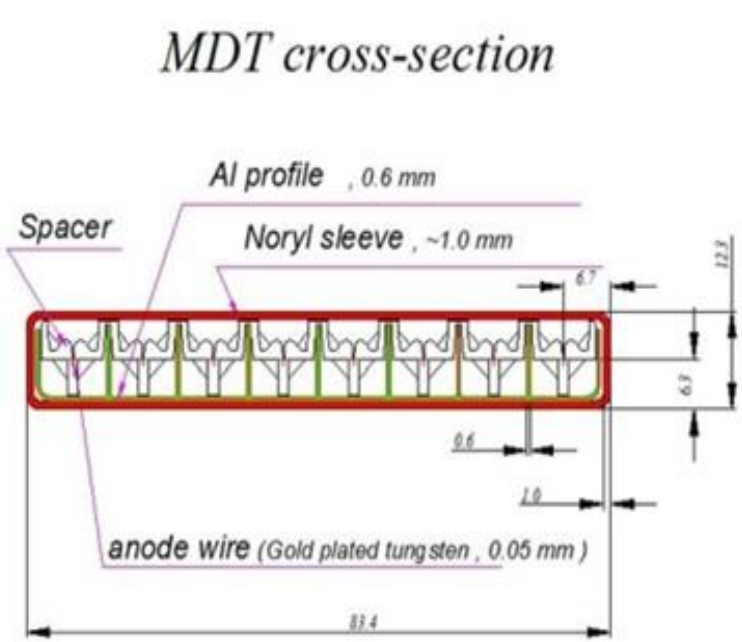
«Статус работ по мюонной системе эксперимента ПАНДА»

* **Краткий обзор системы :**
  - инженерное описание (под-системы, детекторы)
  - оптимизация системы (мюоны от разных процессов)
  - основные численные параметры
* **Принцип действия:**
  - пробежная система как линейный «калориметр» мюонов
  - пробежная система как грубый калориметр адронов (нейтроны !)
  - главная задача – подавление пионного фона
* **Прототипы:**
  - полноразмерный (~2м x 4м)
  - полномасштабный (10 тонн, ~4600 каналов считывания информации)
  - предварительные результаты пучковых испытаний в ЦЕРН
* **Текущее состояние дел:**
  - подготовка полномасштабного прототипа и модернизация пучка в ЦЕРН
  - одобрение проекта в FAIR (**принят -> сентябрь 2014**)

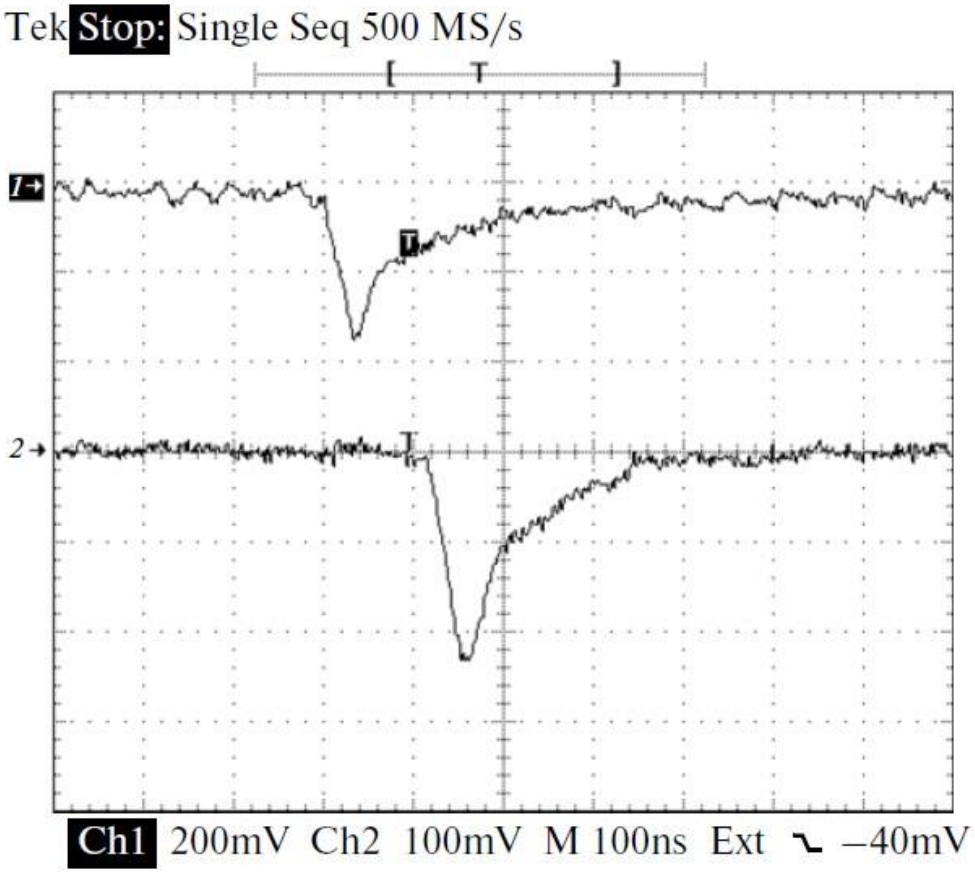
The layout of Muon System using the technique of Range System (with the number of MDT detectors for each particular subsystem)



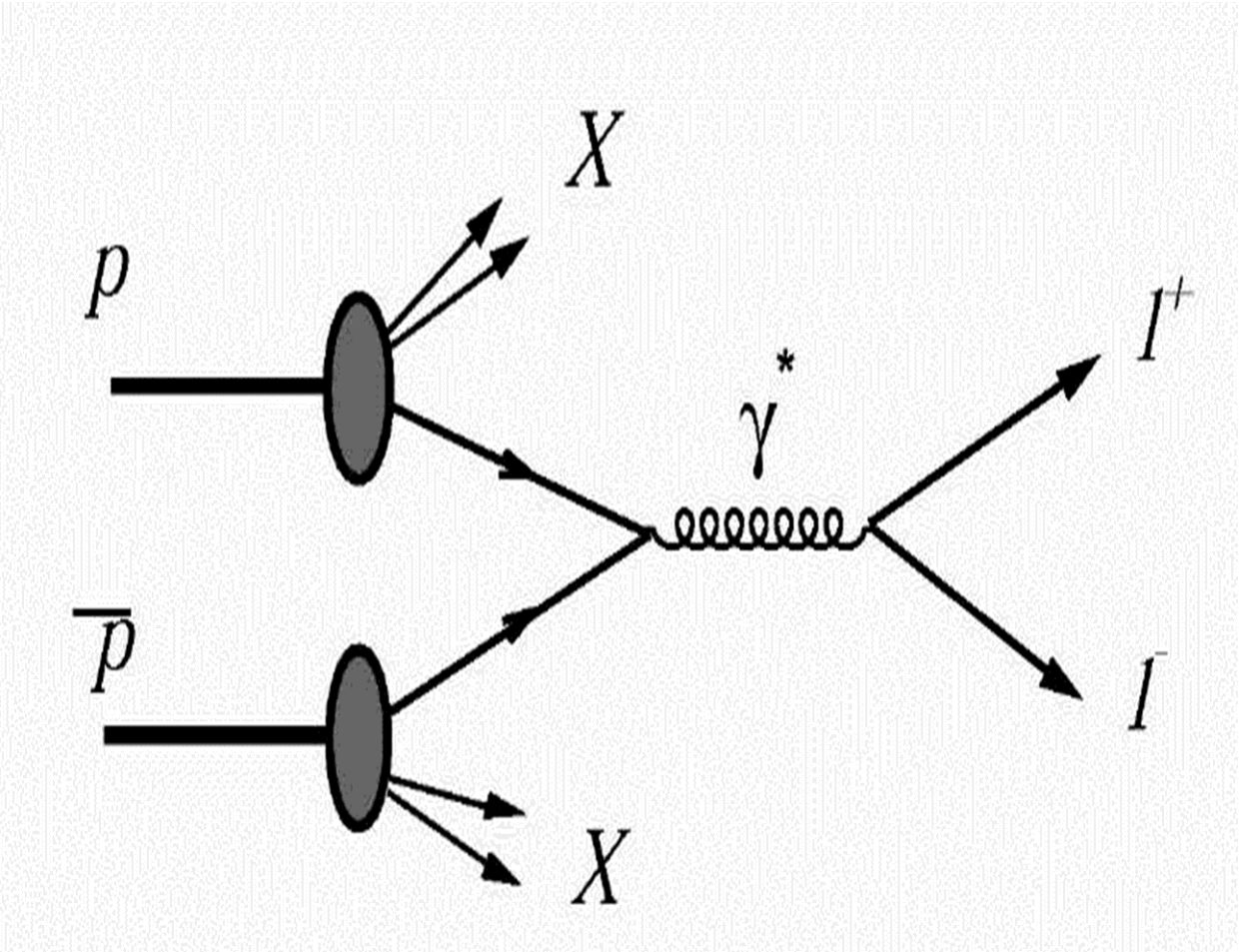
Mini Drift Tube cross section (left) and layout (right)



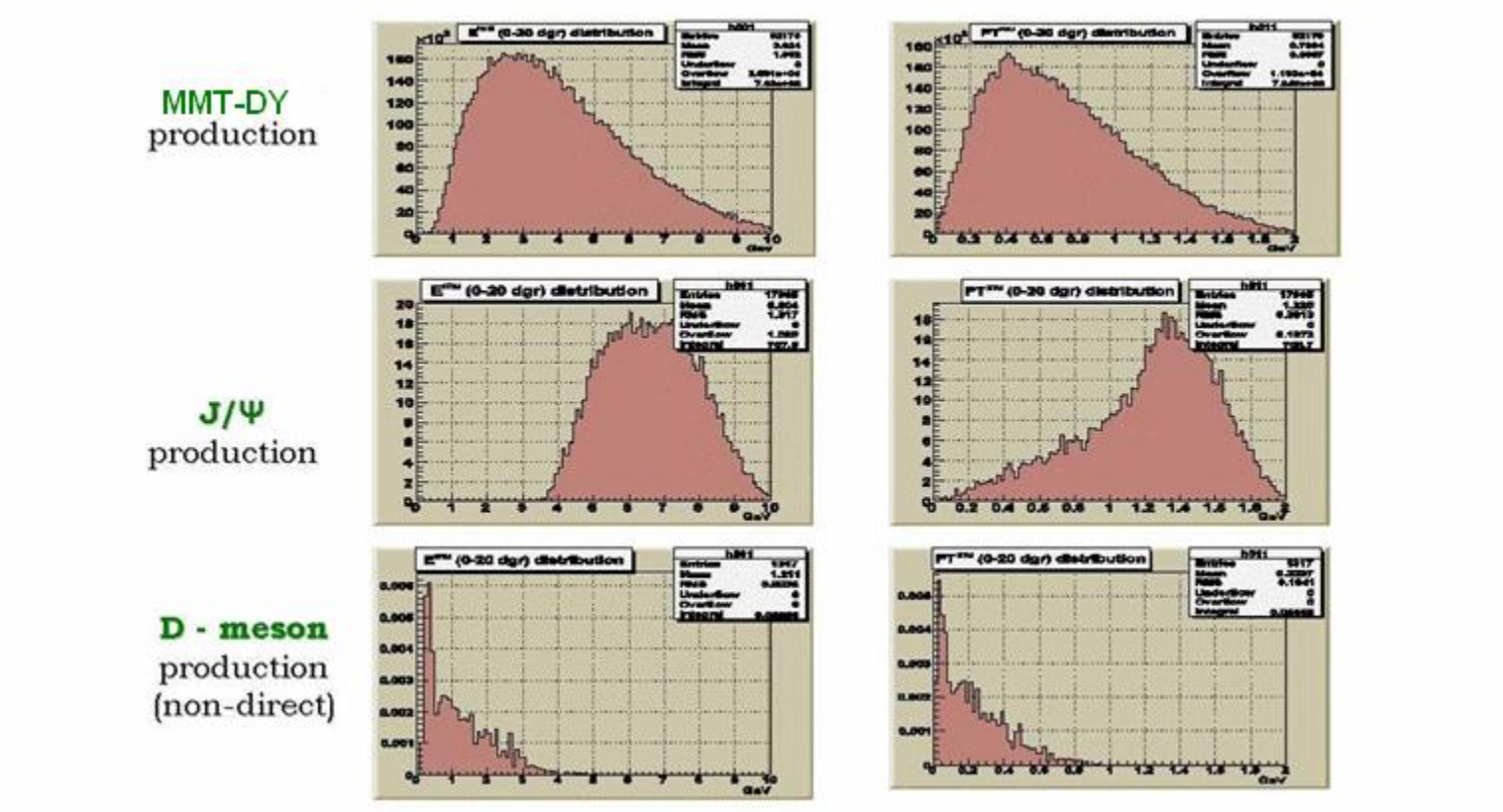
Oscillograms of single signals: from the anode wire (1)and the strip (2); the conversion factors are 60 and 480 mV/μA, respectively



$p\bar{p} \rightarrow l^+l^-$ + *X* process - selected as benchmark process for design/tuning of PANDA Muon System



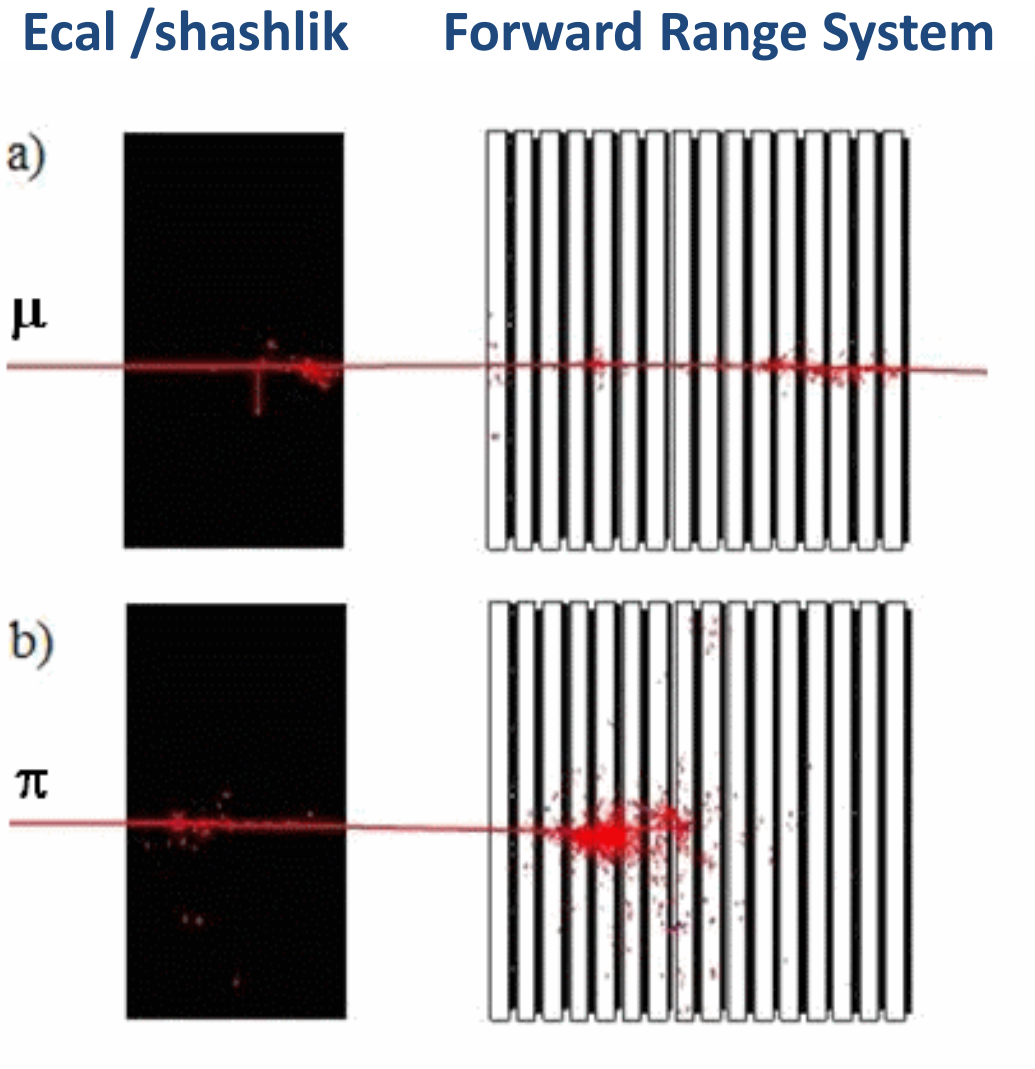
Muon momenta distributions for different processes in the sector 0°– 20° of polar angle



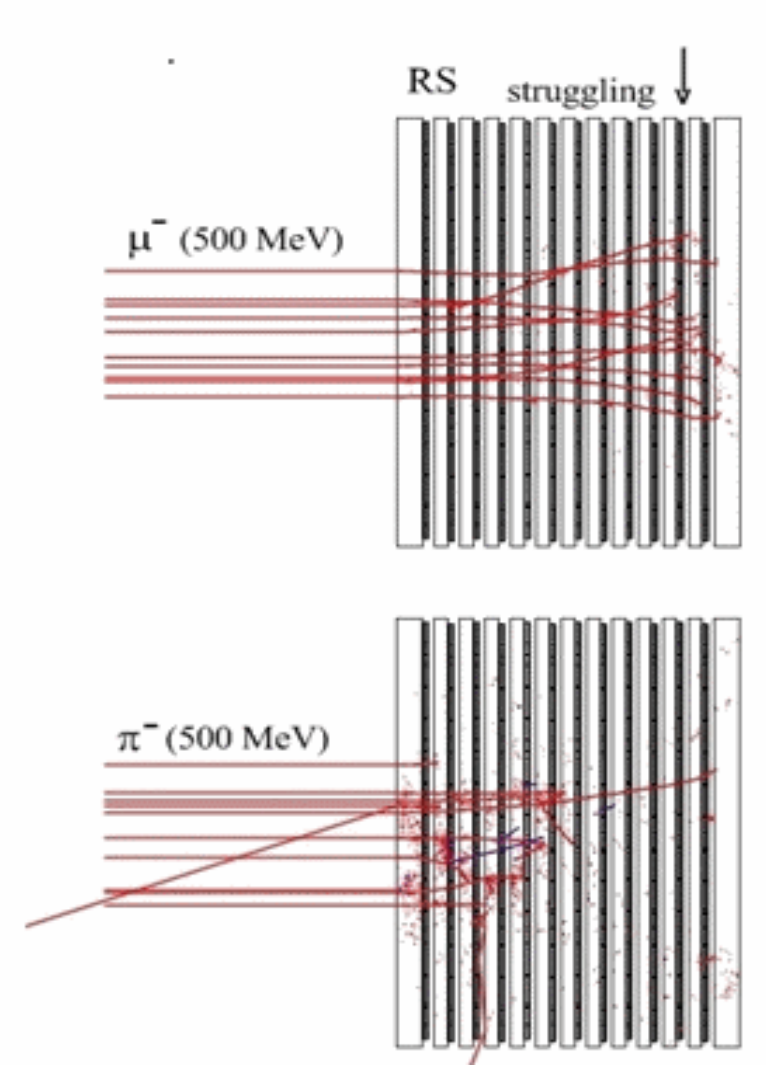
Basic numbers for Muon System instrumentation

	MDTs	wires	strips	% of resources
Barrel	2133	17064	49916	61.2
End Cap	618	4944	8911	14.9
Muon Filter	424	3392	6876	10.7
Forward Range System	576	4608	7128	13.2
Total	**3751**	**30008**	**72831**	**100**

Response of FRS to muon (a) and pion (b) at 5 GeV (single event)



RS response (Target Spectrometer Barrel structure) to muons and pions with initial kinetic energy of 500 MeV; MC sample for 20 events is shown for demonstration



Distributions of particle range in RS for muon and pion beams (dashed area) with initial kinetic beam energy of 200 MeV (a) and 500 MeV (b)

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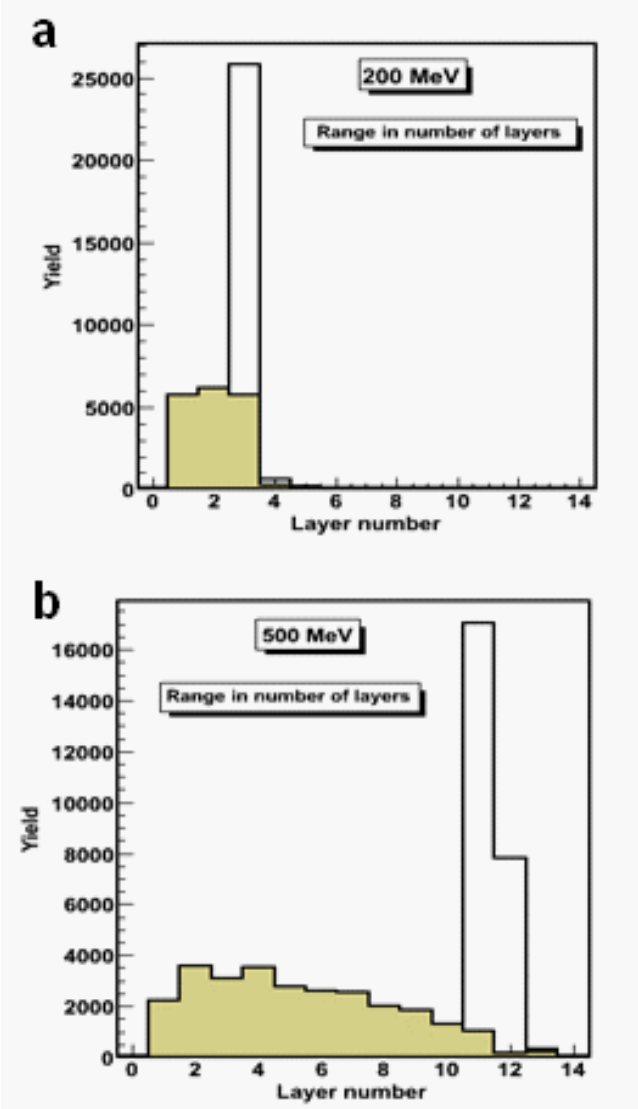
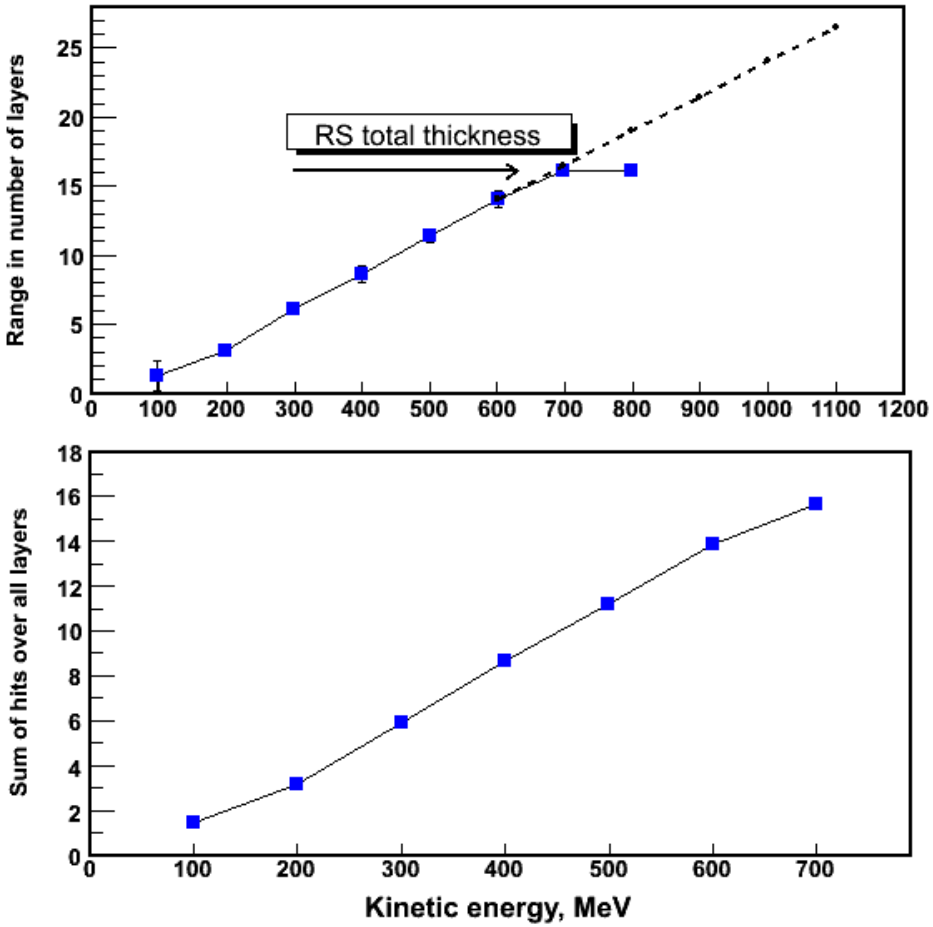
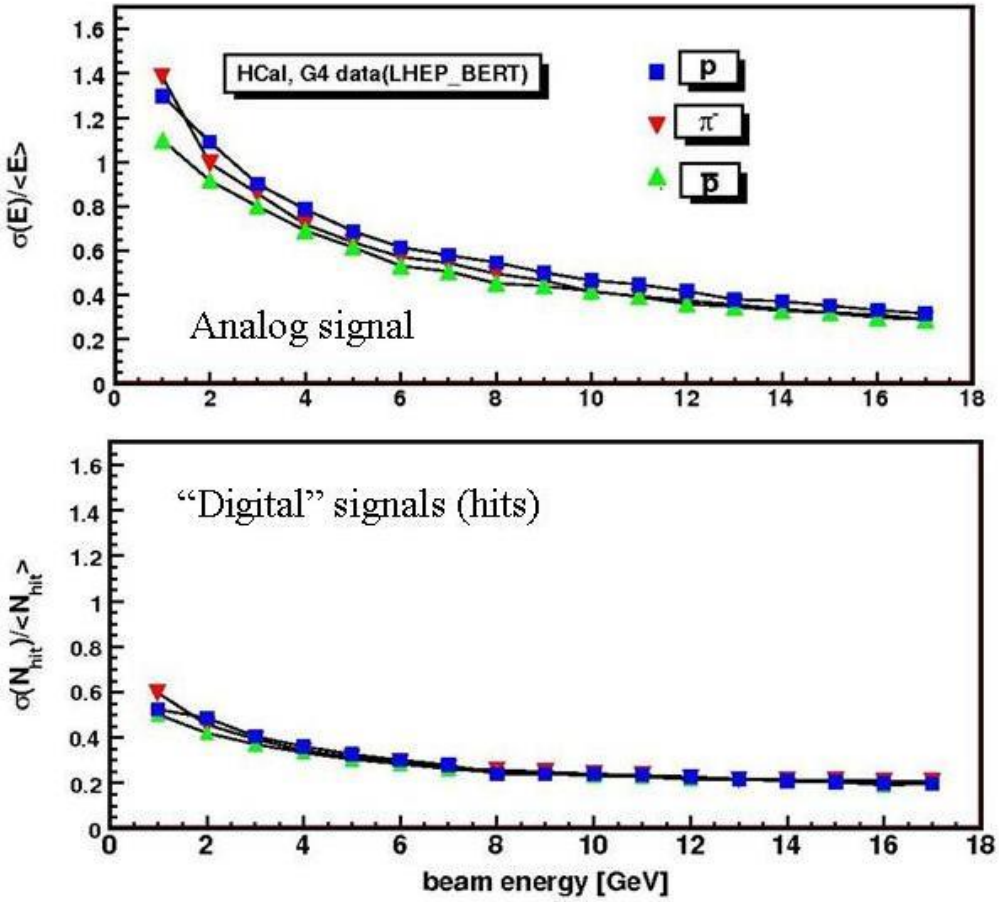


Muon range in number of layers(top) and the average number of hits (bottom) in RS as a function of initial kinetic energy

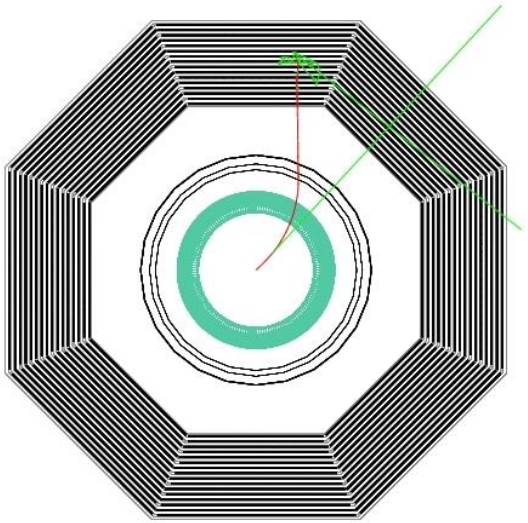


RS energy resolution for hadrons in different readout modes

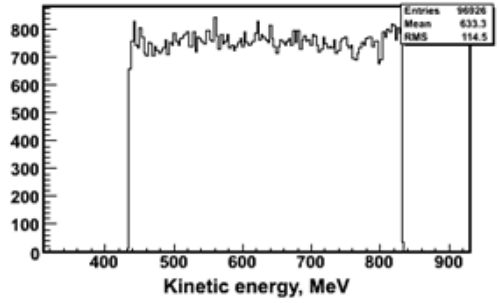


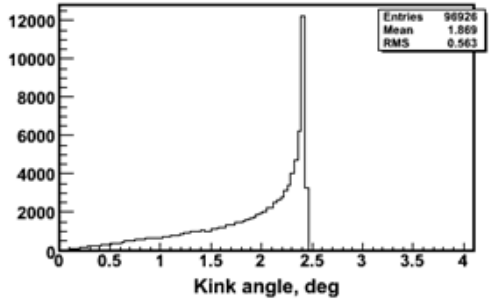
Suppression of fake muons from π→μν decay

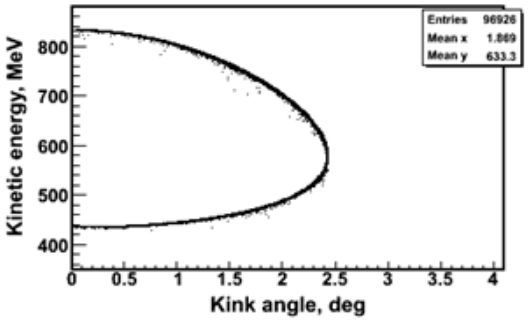
Demonstration of π→μν decay in the Inner detector of PANDA setup: decay muon (red) stops in the RS while neutrino (green) leaves the volume



The kinetic energy spectrum, kink angle distribution and the kinetic energy *versus* angle correlation plot for muons produced in π(800 MeV)→μν decay





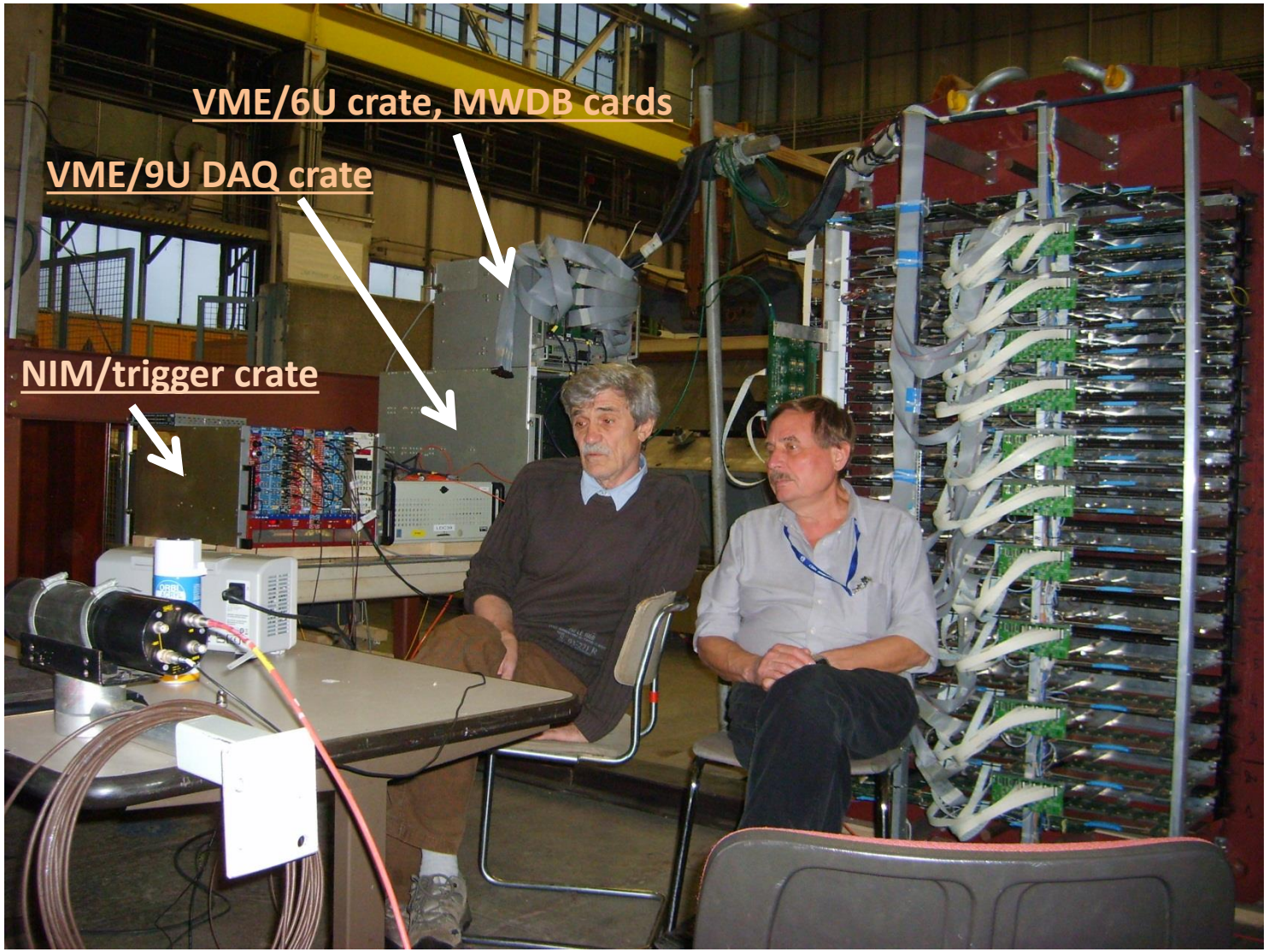


Full Scale (2 x 4 m^2) prototype in work position at CERN/COMPASS – study of long strips readout

Range System prototype (Fe absorber and support structure) in Dubna in vertical position (for further tests with cosmic at CERN)

Assembly of RSP

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



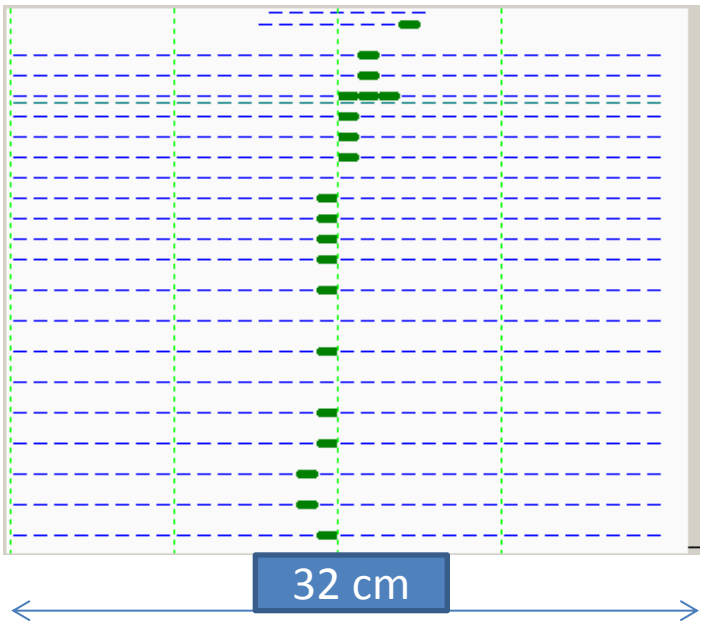
Assembly of RSP

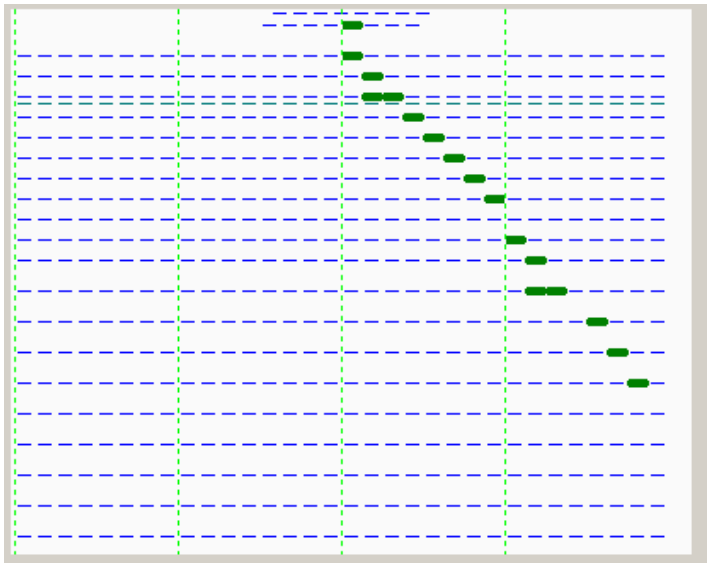
Restricted set (32 wires x 20 planes) of wire R/O is left for final DAQ configuration

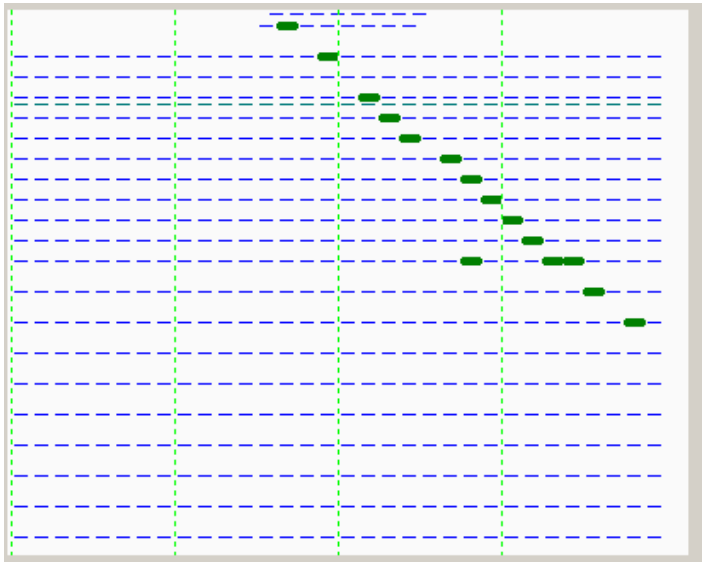
Restricted set of wire R/O (32 wires x 20 planes)

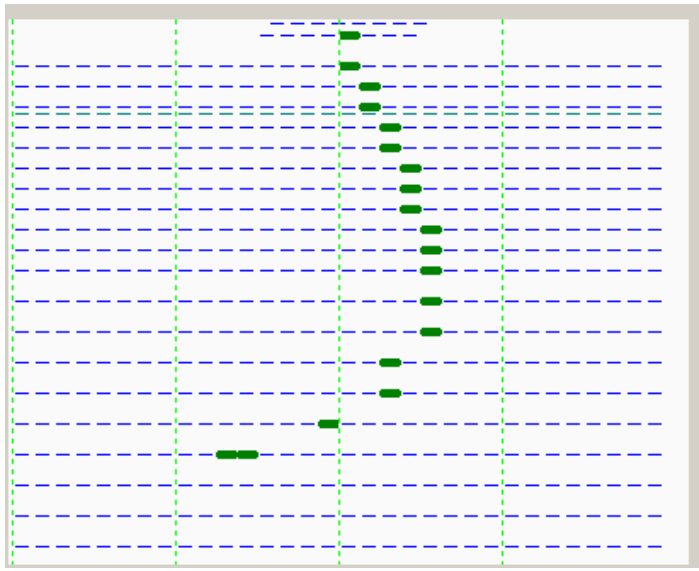
COSMIC MUONS

Trigger: S_3 (20x20cm^2) & S_4 (60x20 cm^2) on top of RSP



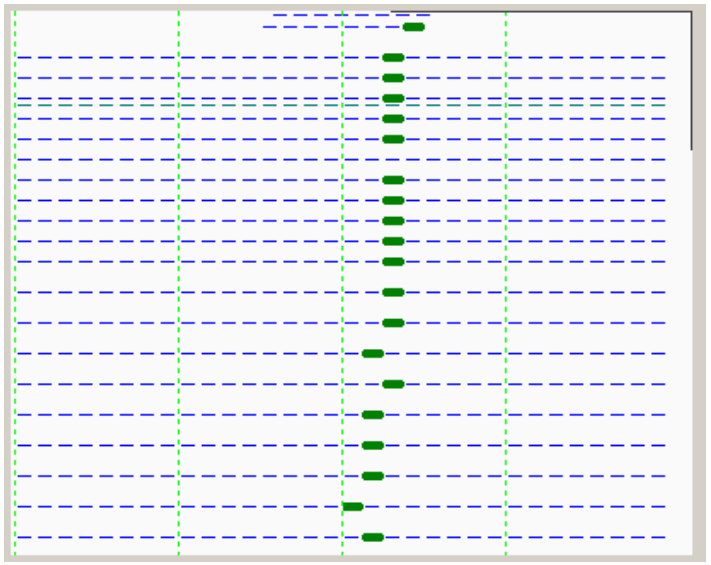




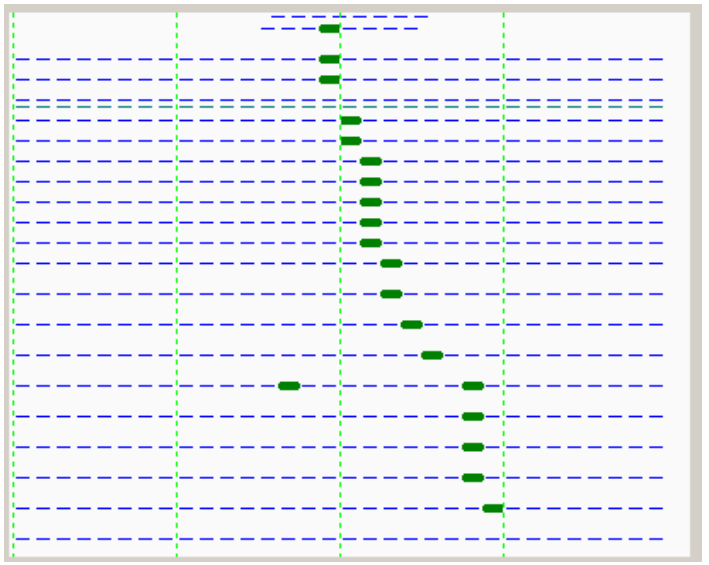


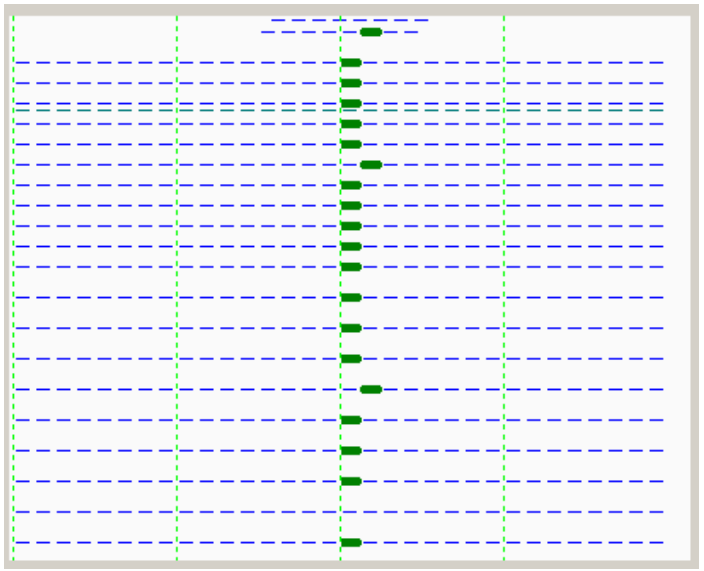
COSMIC MUONS

Trigger: S3 (20x20cm^2) on top & S4 (60x20 cm^2) on bottom of RSP



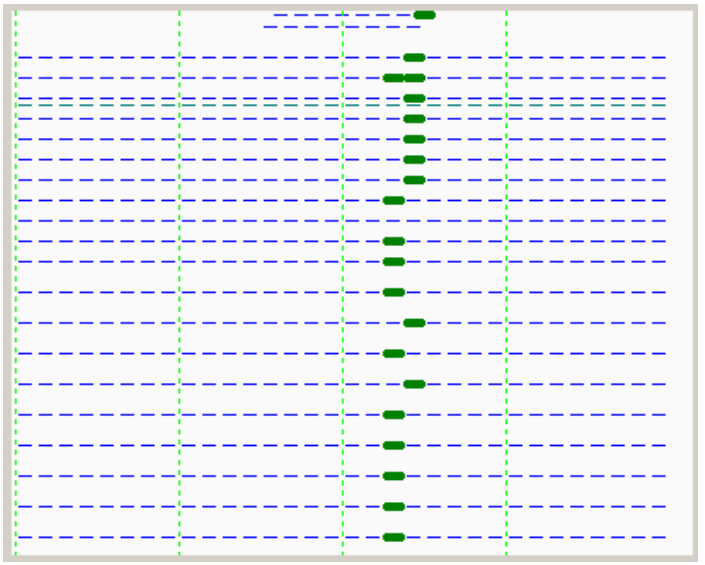
Barrel





FRS

EC+MF



Placement of the RSP in T9 beam zone

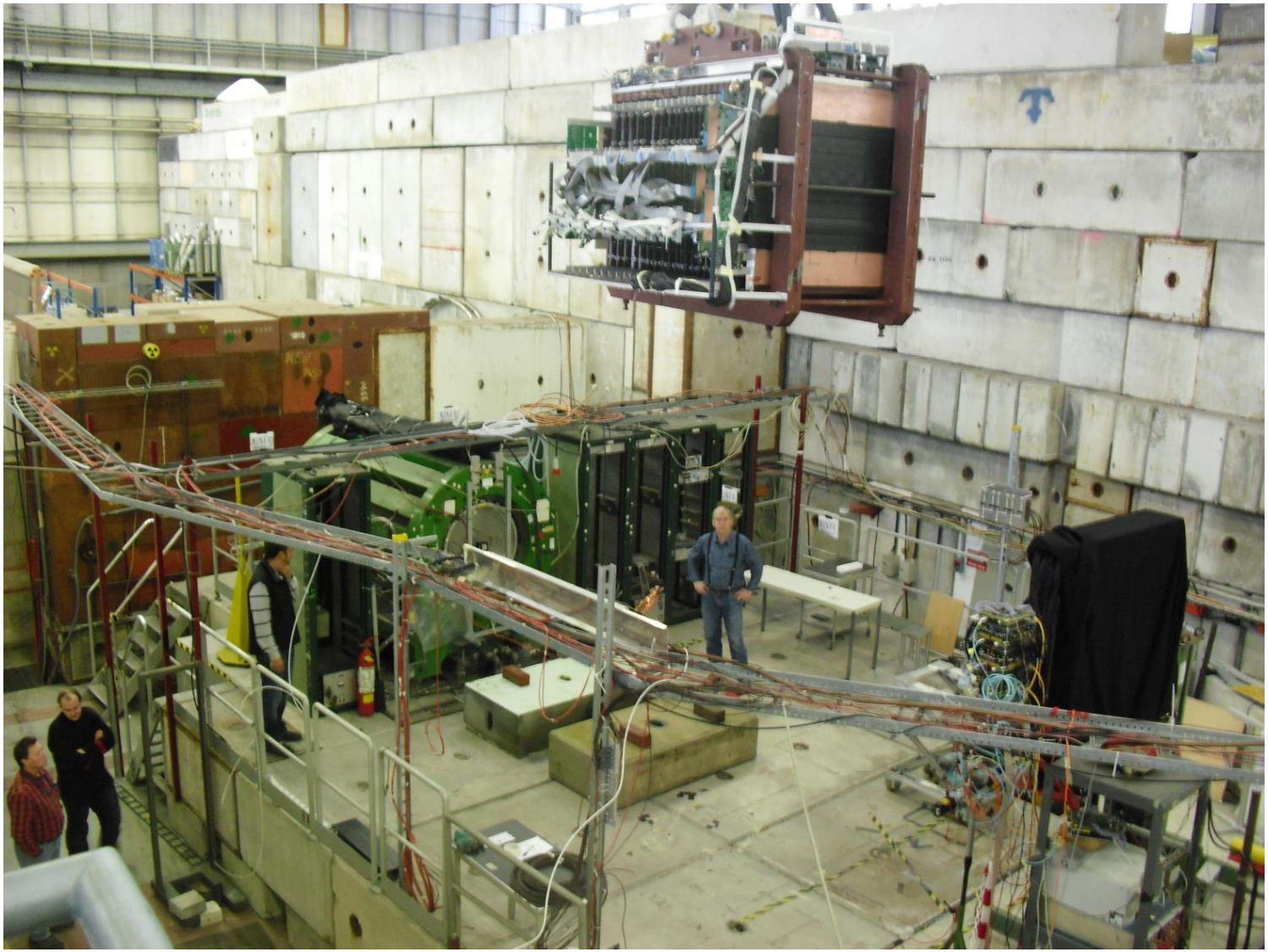


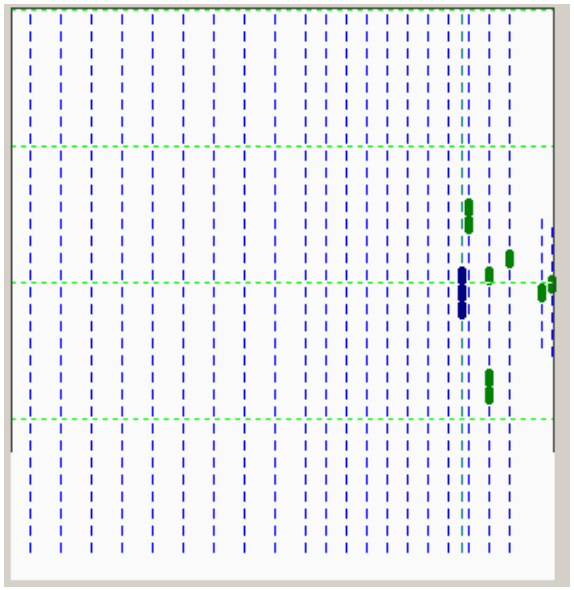
Table of conditions for written events

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

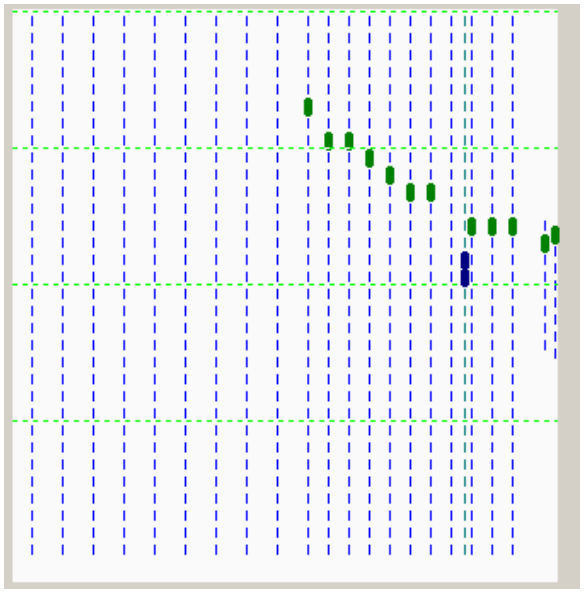
BEAM: e,μ,π,p

0,5 GeV/c, trigger: S_1 (Ø 11,5 cm) & S_2 (Ø 3,5 cm)

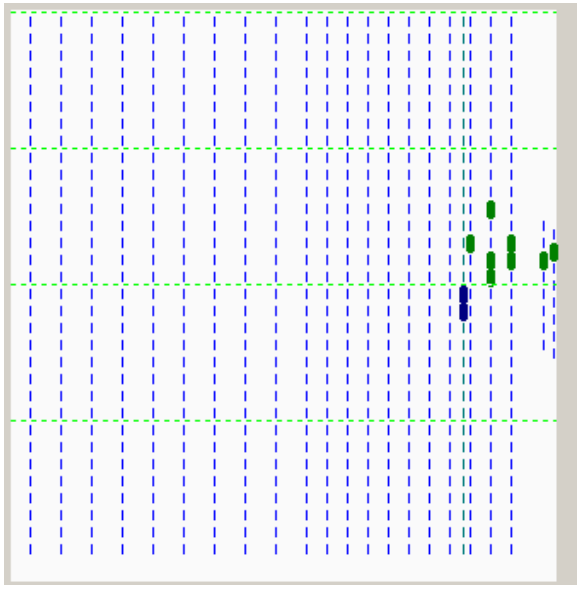
(here and below fired wires are given in green and strips – in blue, strip board is turned by 90 deg.)



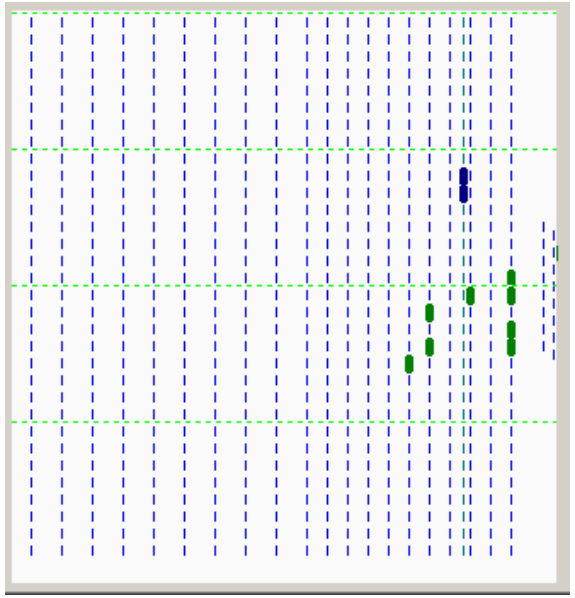
?



μ



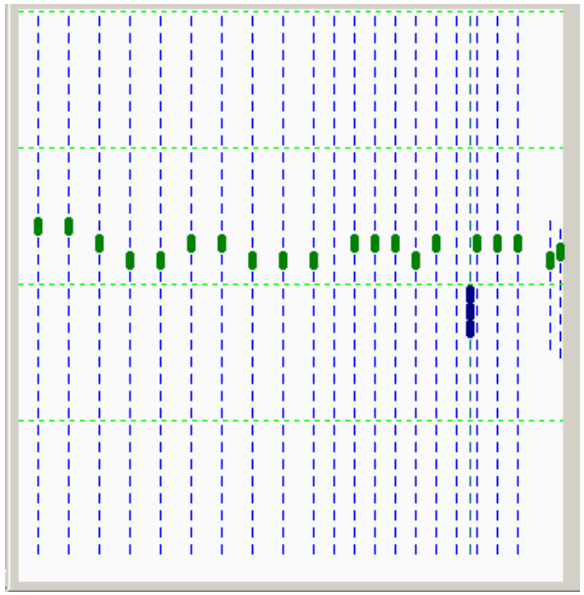
?



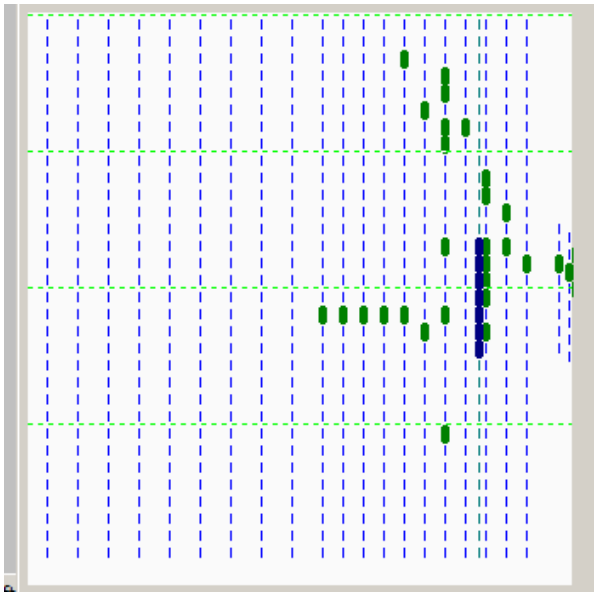
?

BEAM: e,μ,π,p

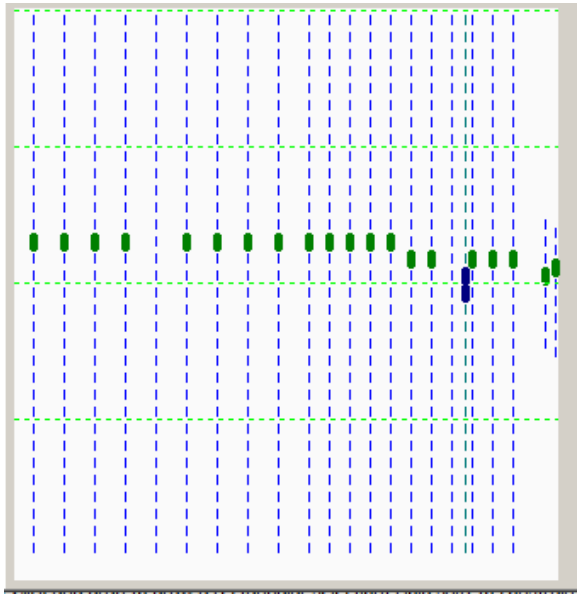
3 GeV/c, trigger: S_1 (Ø 11,5 cm) & S_2 (Ø 3,5 cm)



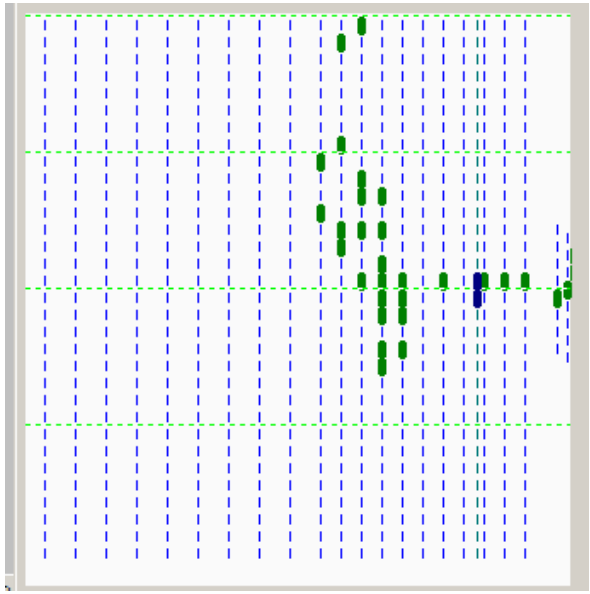
μ



h



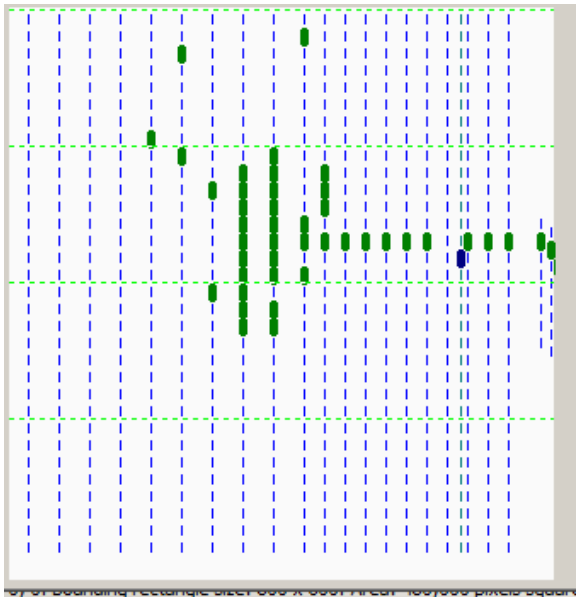
μ



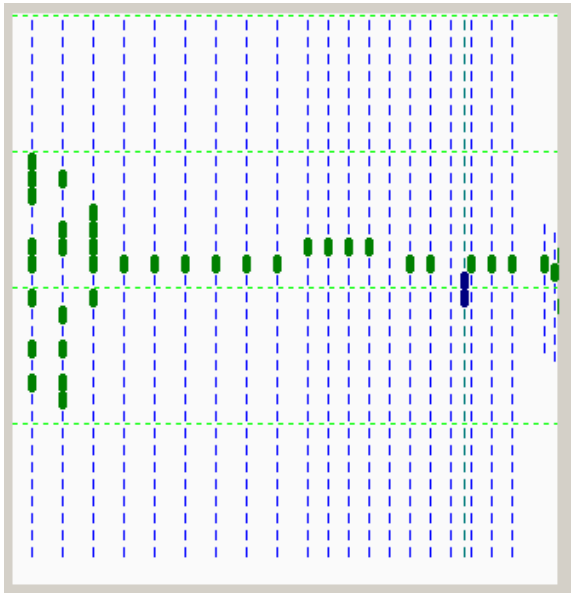
h

BEAM: e,μ,π,p

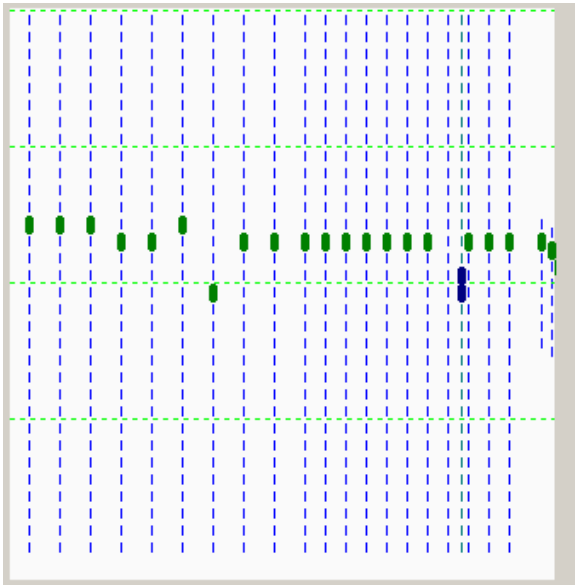
7 GeV/c, trigger: S_1 (Ø 11,5 cm) & S_2 (Ø 3,5 cm)



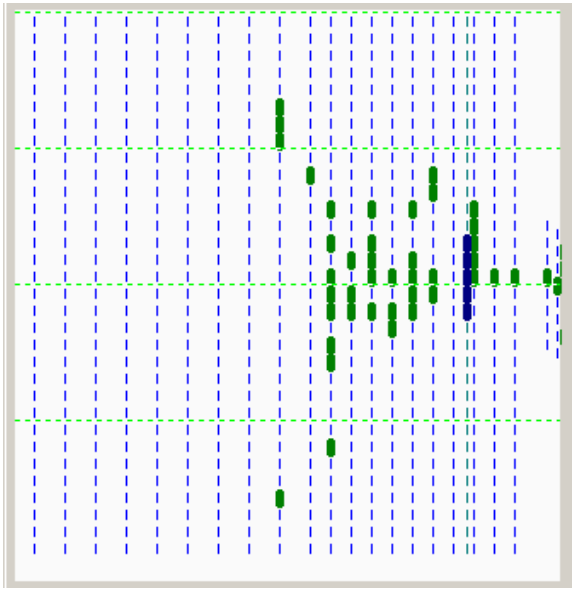
h



h?



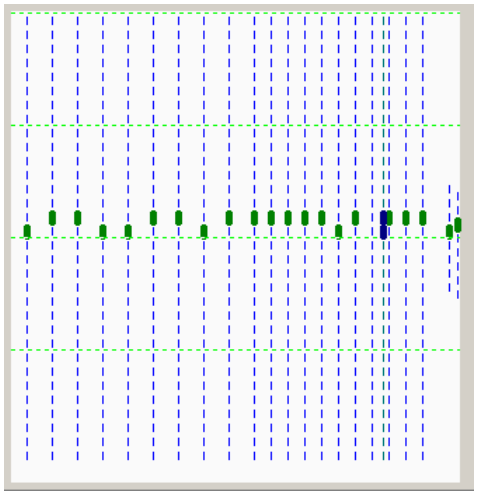
μ



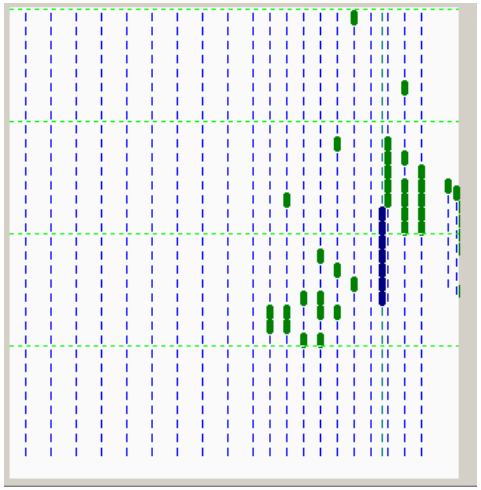
e?

BEAM: e,μ,π,p

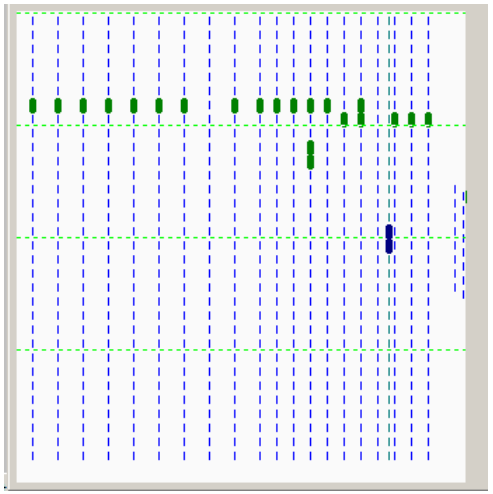
10 GeV/c, trigger: S3 & S4 (beam + halo)



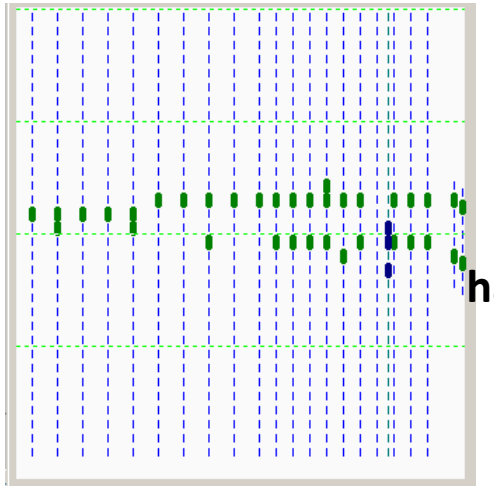
μ



e

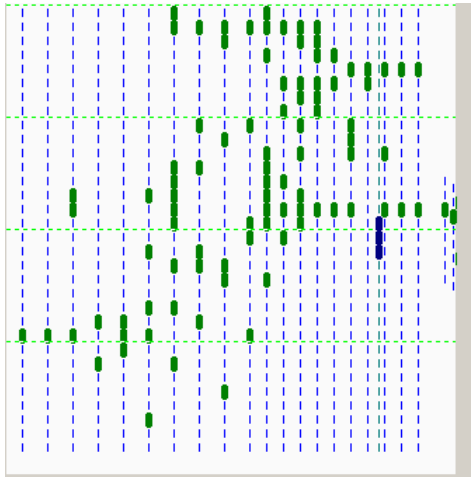


halo μ



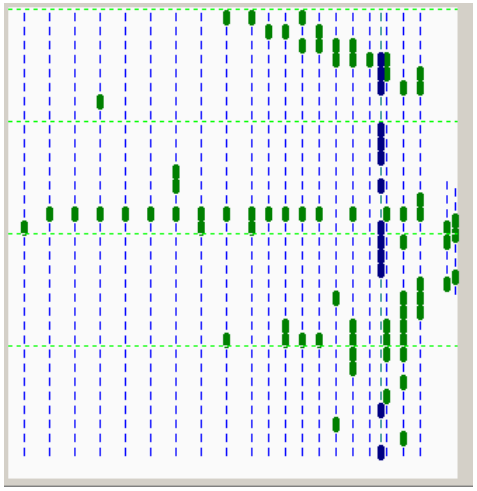
μ

halo μ



halo h

h



halo μ ?

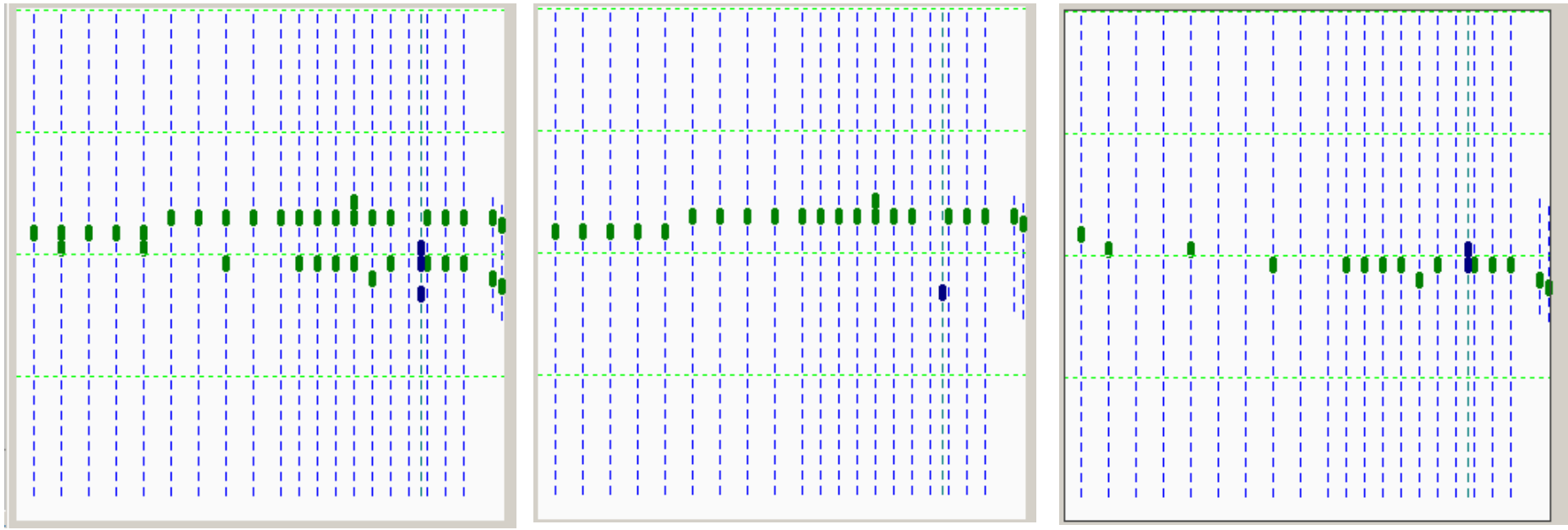
μ

halo h

10 GeV BEAM

Example of two superimposed muon tracks disentangled with timing information

run F74, event #164



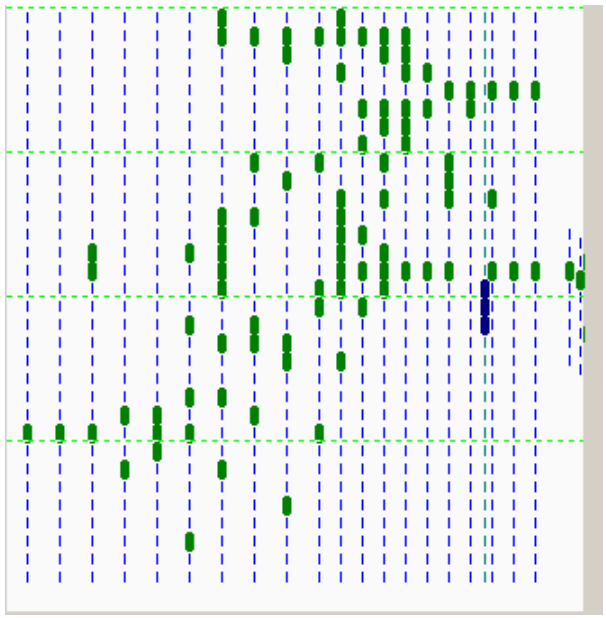
full event **beam muon** $\Delta t \sim 1000ns$ **halo muon**

DAQ R/O gate ~ 1.3 µs

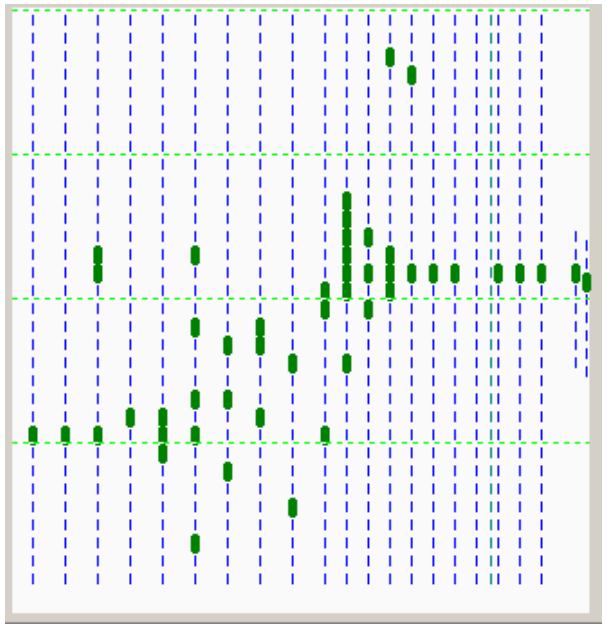
10 GeV BEAM

Example of two superimposed hadrons disentangled with timing information

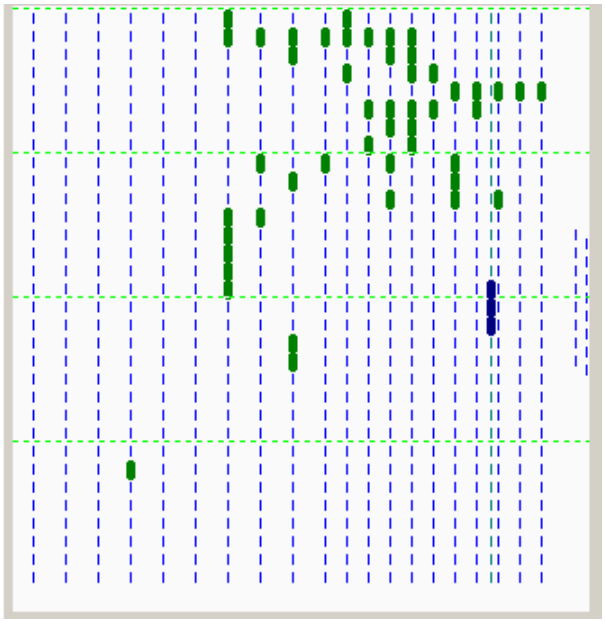
run F74, event #272



full event



beam hadron $\Delta t \sim 300ns$ **halo hadron**

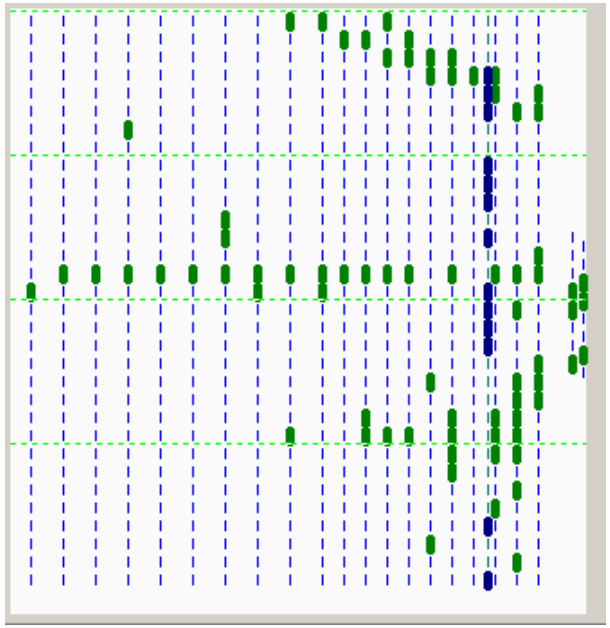


DAQ R/O gate ~ 1.3 μs

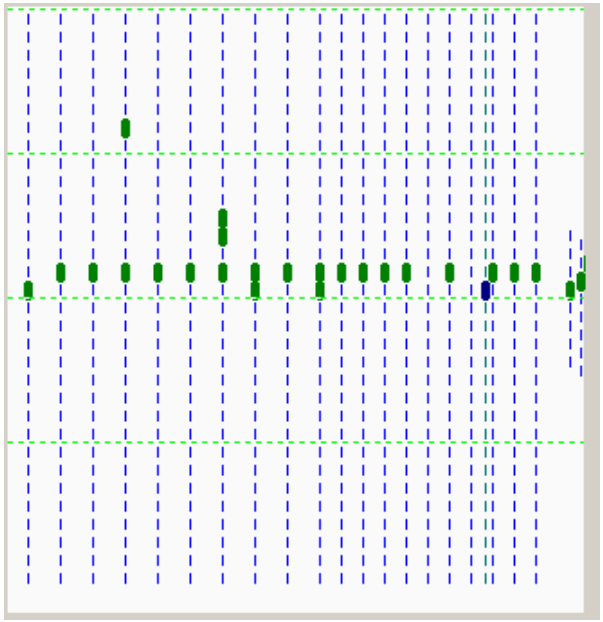
10 GeV BEAM

Example of few superimposed particles disentangled with timing information

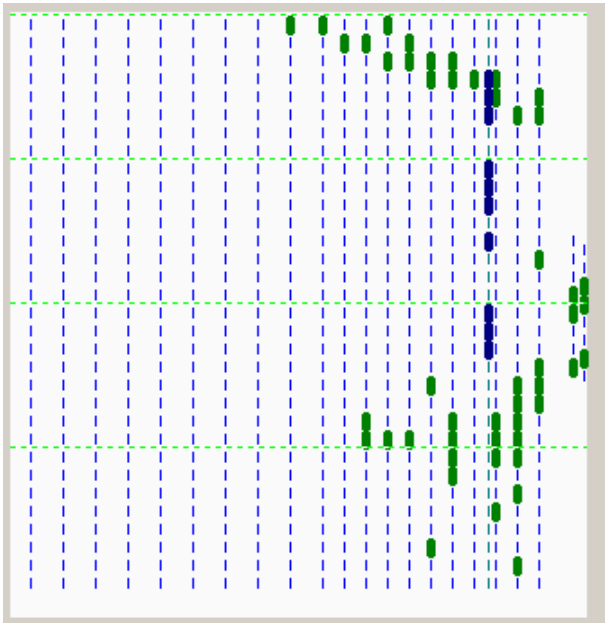
run F74, event #560



full event



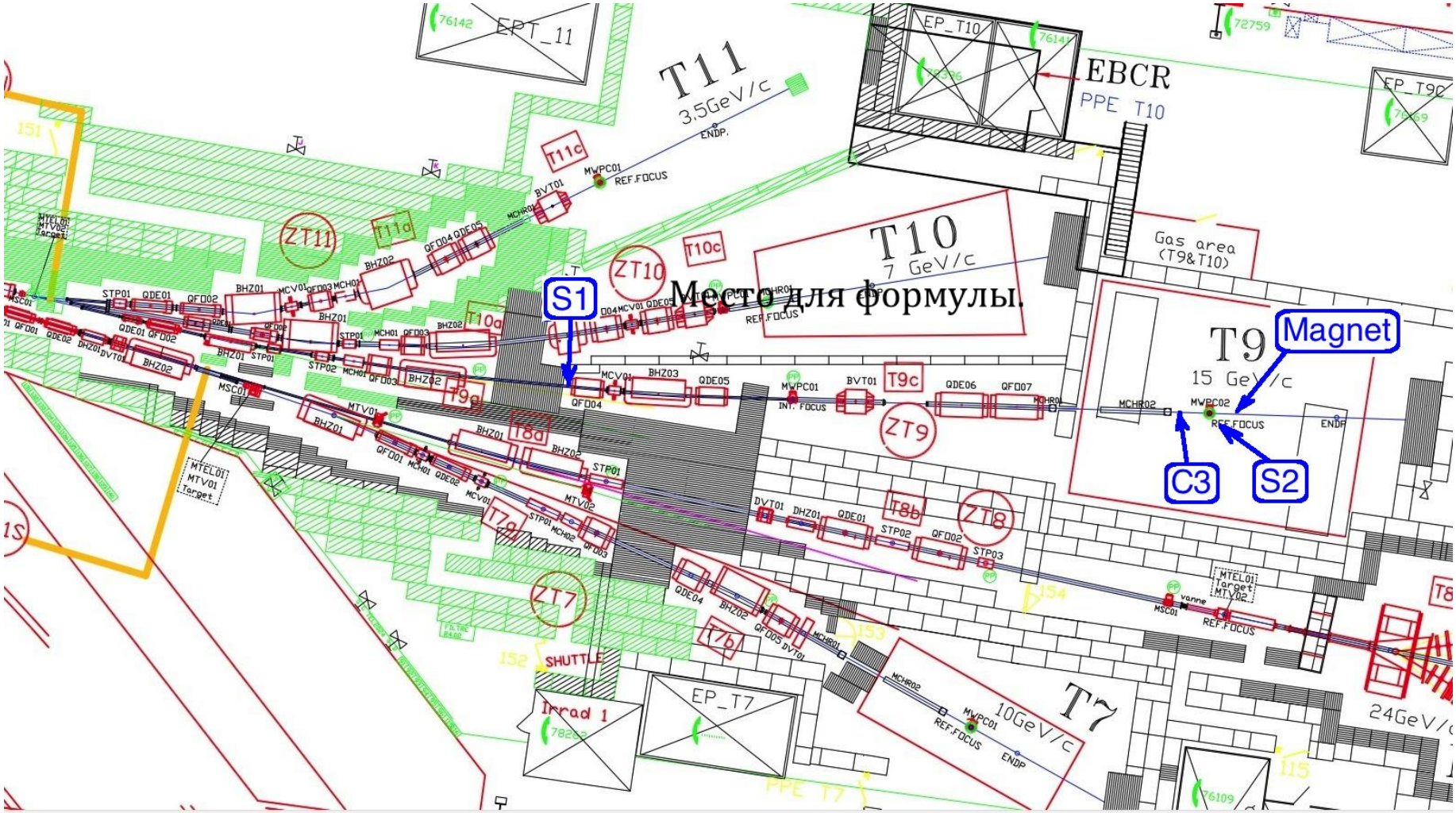
beam muon $\Delta t \sim 1050ns$ **halo particle(s) ?**



DAQ R/O gate ~ 1.3 μs

Assumed upgrades to T9 beam line for π/μ separation < 1-2 GeV/c:

S1,S2 time-of-flight scintillator counters based at ~ 20 m to each other,
pressurized Cherenkov counter C3,
magnetic analysis of incoming muon momenta with ~ +/- 1% accuracy



Статус мюонной системы на сегодня

- **Прототипы:**

- полномасштабный - дооборудование дополнительными экранами всех (22) детектирующих плоскостей, подключение цифровой электроники (4600 каналов), начало тестирования - с декабря 2014

- полноразмерный (~2м х 4м) – смонтирован в ЦЕРН на установке COMPASS, дооборудование дополнительным экраном и стриповой электроникой, начало тестирования – с марта 2015

- **Статус проекта:**

- первый запрос финансирования в Росатом – 2008

- первое представление проекта – июнь 2011, Протвино

- принятие проекта коллаборацией – сентябрь 2012, Париж

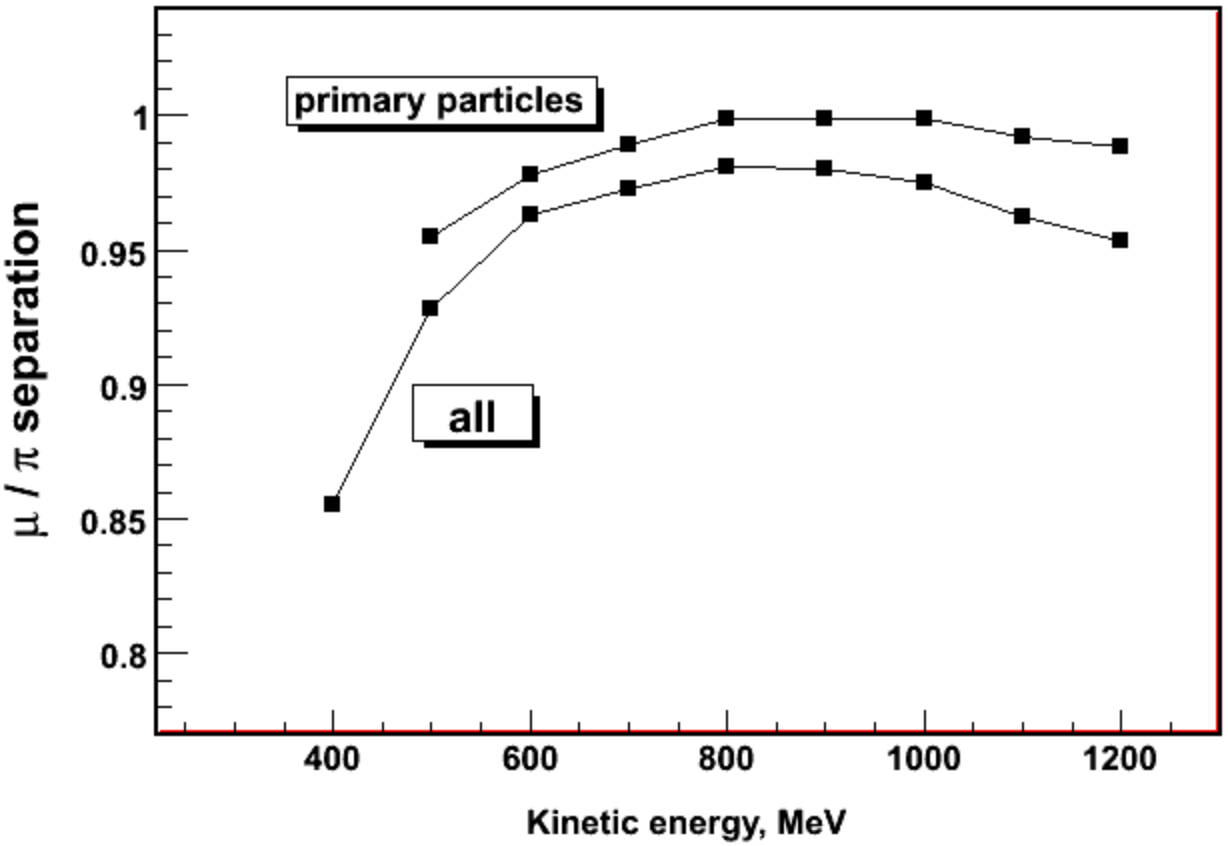
- положительная рекомендация рефери – июль 2014, ЦЕРН

- одобрение FAIR Council – проект принят,сентябрь 2014, FAIR

Backup slides

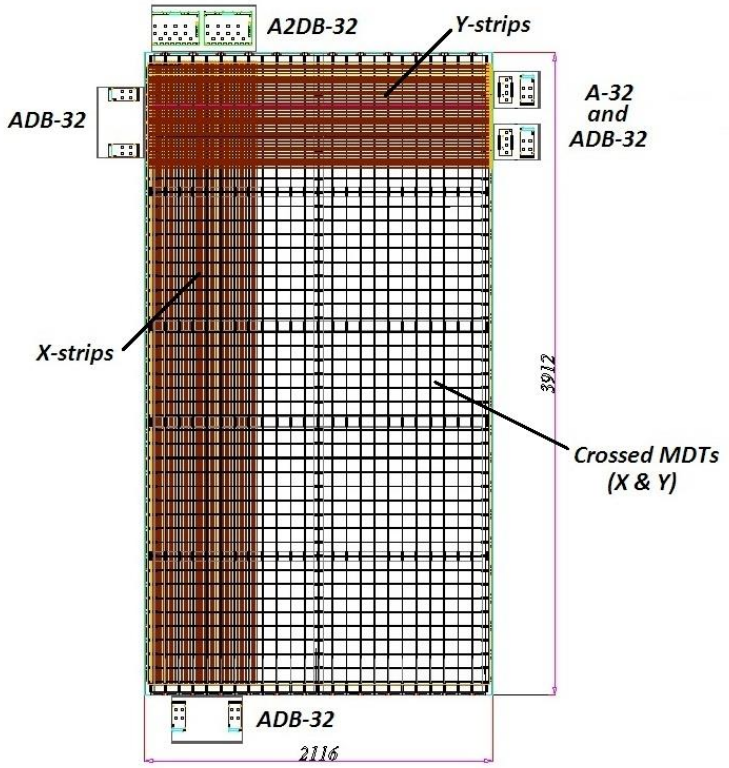
An efficiency of π/μ separation by range in RS:

primary particles - for those events in which only primary muons and pions passing through RS are taken into account; all - all particles, no event selection (combined MC setup -> ECal+Coil+RS)



Full Scale Prototype at CERN

Skeleton view of the Full Scale prototype package with crossed MDTs and strips with corresponding readout electronic cards

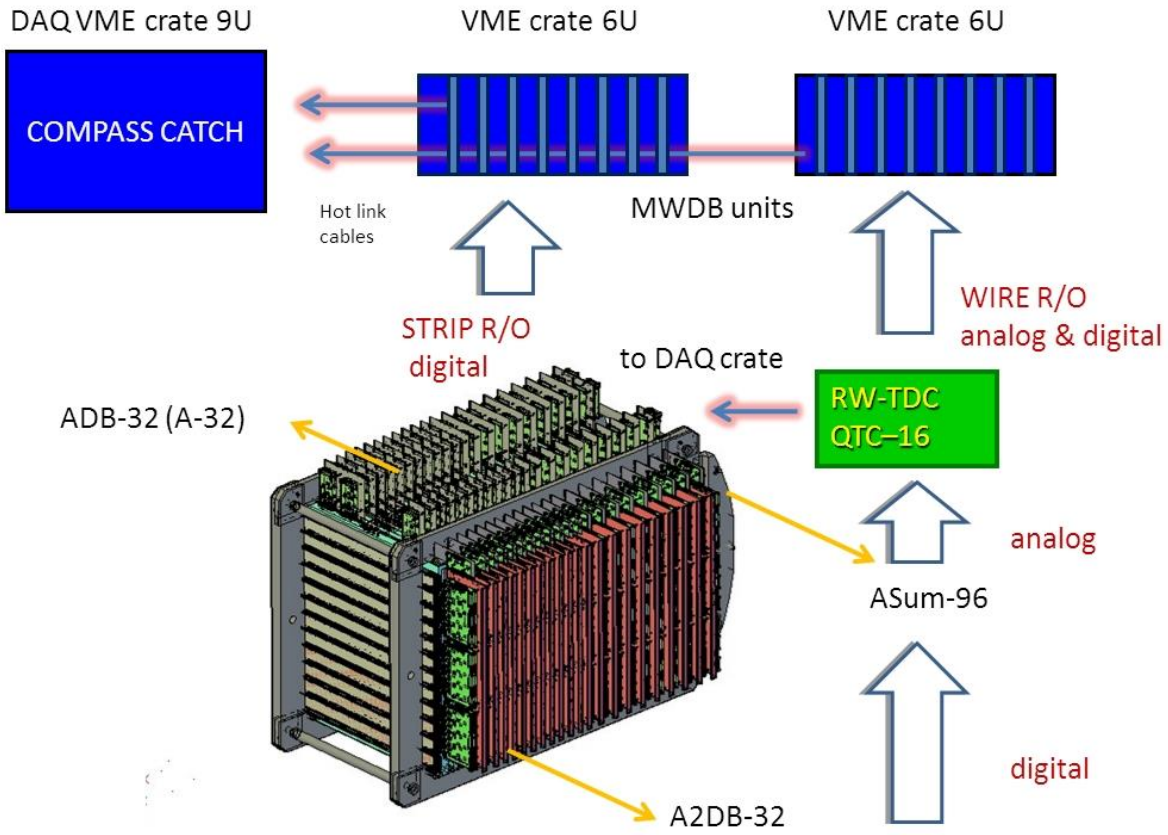


FSP position in the COMPASS experimental area; the prototype is marked with white dashed rectangle.

Full Scale (2 x 4 m^2) prototype in work position at CERN/COMPASS

RS Prototype equipped with detecting planes and electronics

RS prototype equipped with FE analog and digital electronics (4600 channels of wire and strip R/O)



Range System Prototype Readout Scheme

T9 beam particles ID

C1,C2,C3 - Cherenkov gas threshold counters with variable pressure up to 2, 3.5 and 60 bar (CO_2) .

TOF - time of flight plastic scintillator system (L=21.4m) with resolution ~ 100ps (scintillator - BC408, PMT - Hamamatsu R5946).

P[Gev/c]	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**≥3.5**
C1	*e*	*e*	*e*	*e*	*e*	*e*	*e+μ*
C2	*e*	*e*	*e*	*e*	*e+μ*	*e+μ*	*e+μ+π*
C3	*e*	*e+μ* *e+μ+π*	*e+μ* *e+μ+π*	*e+μ* *e+μ+π*	*e+μ+π*	*e+μ+π*	*e*
TOF	*e,μ,π,p*	*e,μ,π,p*	*p*	*p*	*p*	*p*	*p*

PANDA Collaboration Meeting, Protvino 9 June 2011

G.Alexeev (for muon group)

Technical Design Report for the

$\overline{\text{P}}$ANDA

(Antiproton Annihilations at Darmstadt)

Strong Interaction Studies with Antiprotons

Muon System

The $\overline{\text{P}}$ANDA Collaboration

May2011

(2nd Draft)