PANDA experiment at FAIR

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FAIR Facility for **A**ntiproton and **I**on **R**esearch

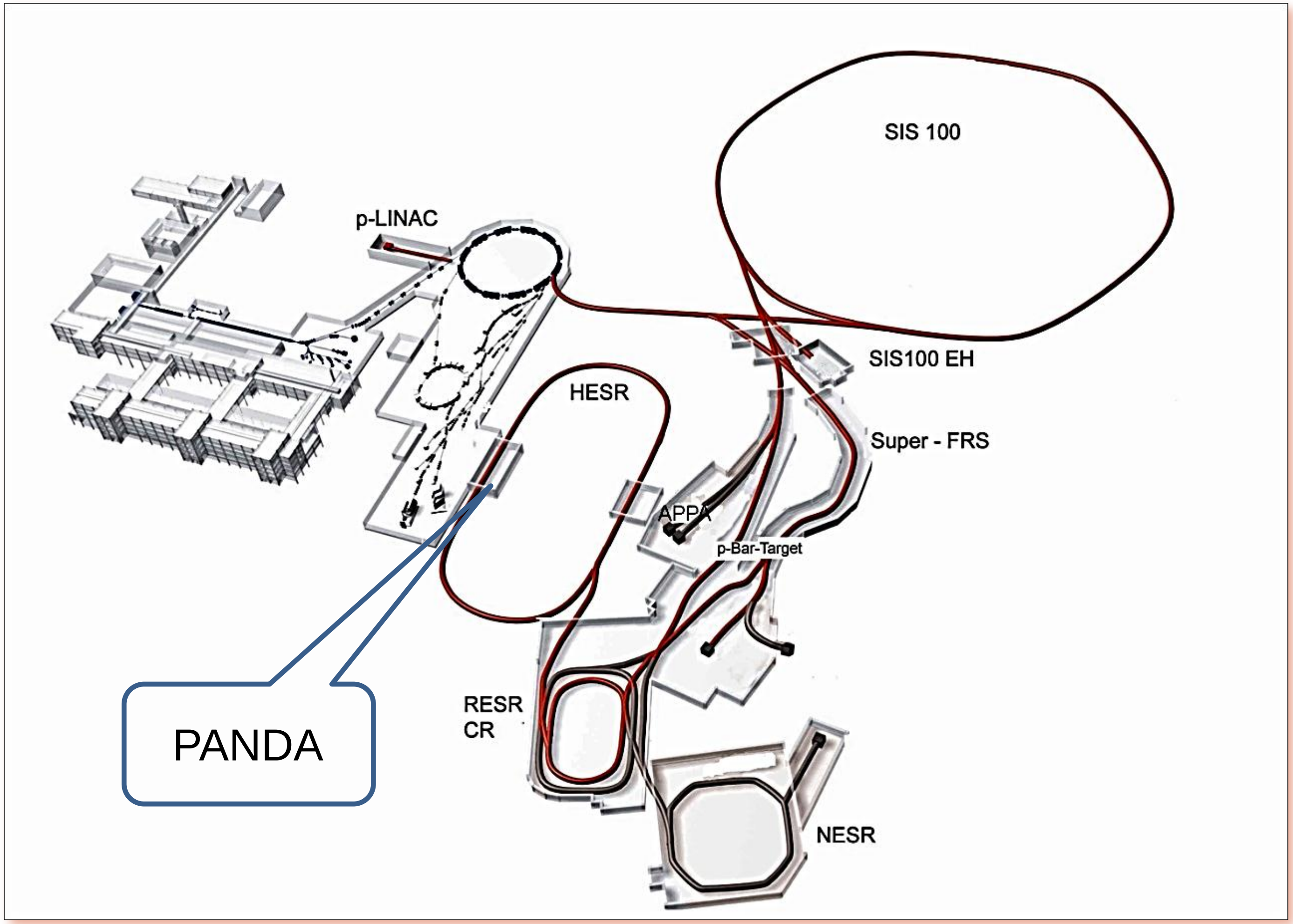
PNPI in FAIR

PANDA

R3B

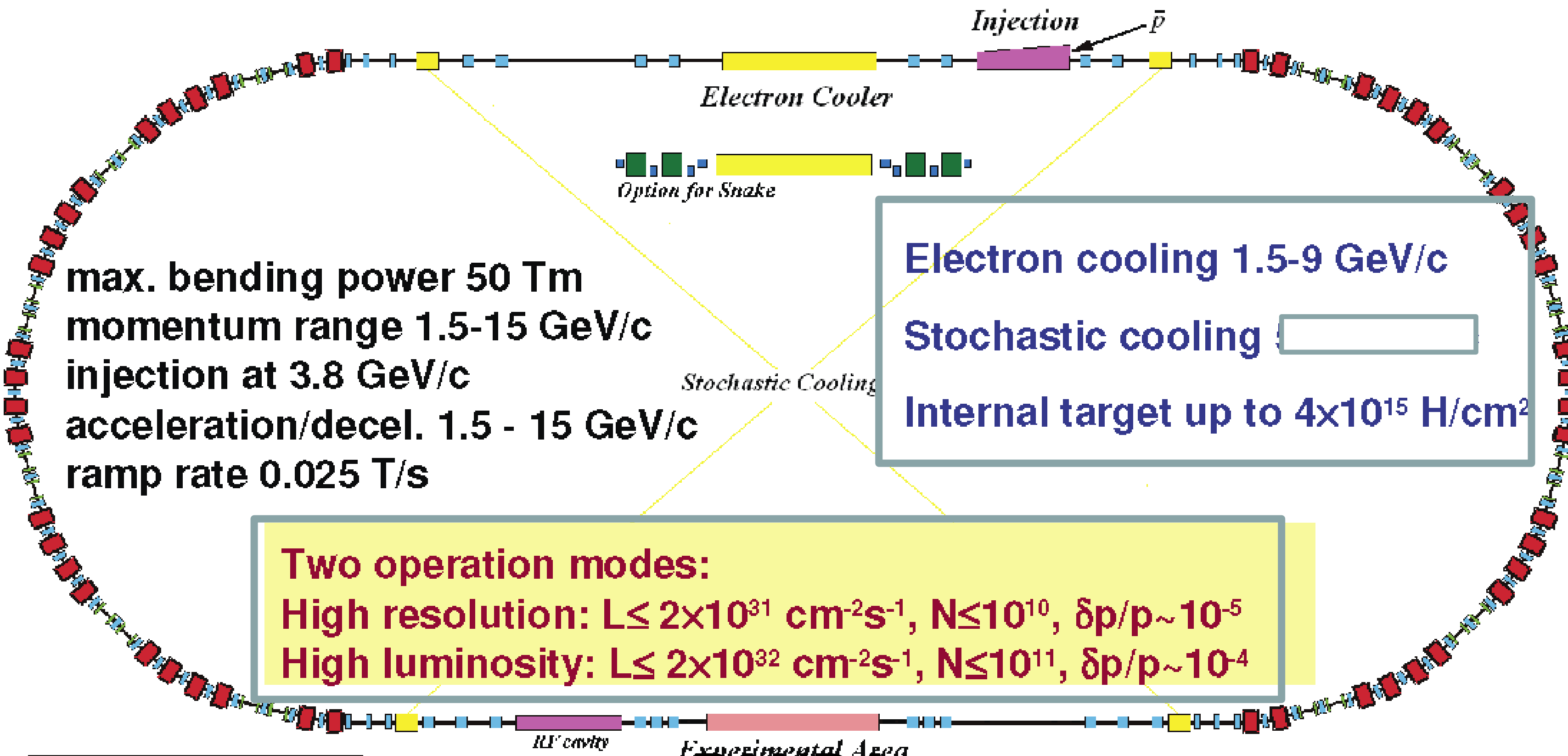
CBM

MATS



The High Energy Storage Ring HESR

designed by a consortium between FZ Jülich, TSL Uppsala, GSI



max. bending power 50 Tm
momentum range 1.5-15 GeV/c
injection at 3.8 GeV/c
acceleration/decel. 1.5 - 15 GeV/c
ramp rate 0.025 T/s

Electron cooling 1.5-9 GeV/c

Stochastic cooling

Internal target up to 4×10^{15} H/cm^2

Two operation modes:
High resolution: $L \leq 2\times10^{31}$ cm^{-2}s^{-1}, $N \leq 10^{10}$, $\delta p/p \sim 10^{-5}$
High luminosity: $L \leq 2\times10^{32}$ cm^{-2}s^{-1}, $N \leq 10^{11}$, $\delta p/p \sim 10^{-4}$

PANDA

straight sections of 132 m length
ring circumference 574 m.

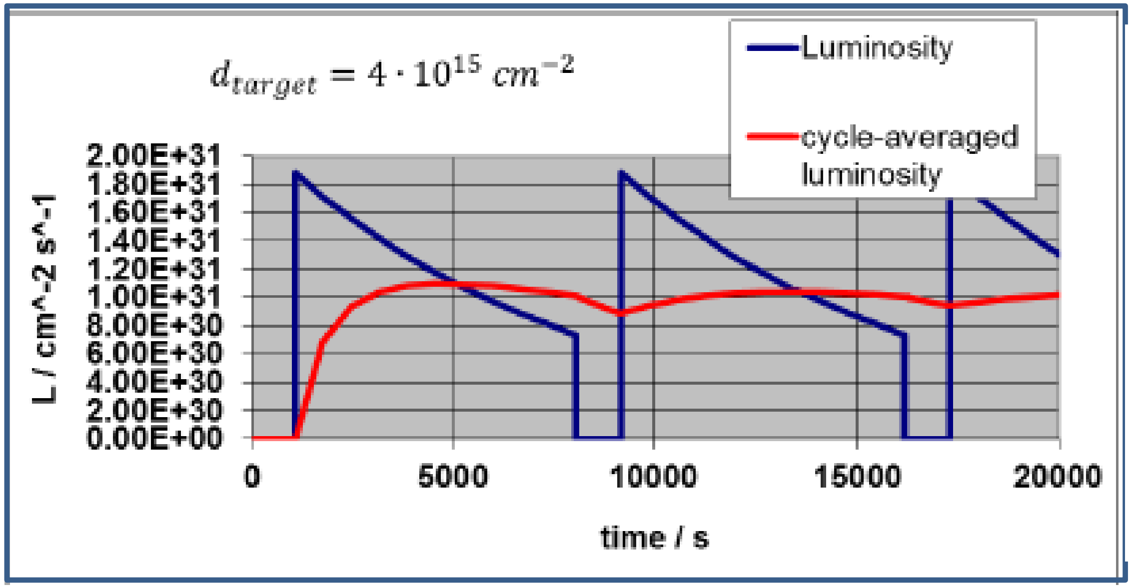
HESR ANTI PROTONS

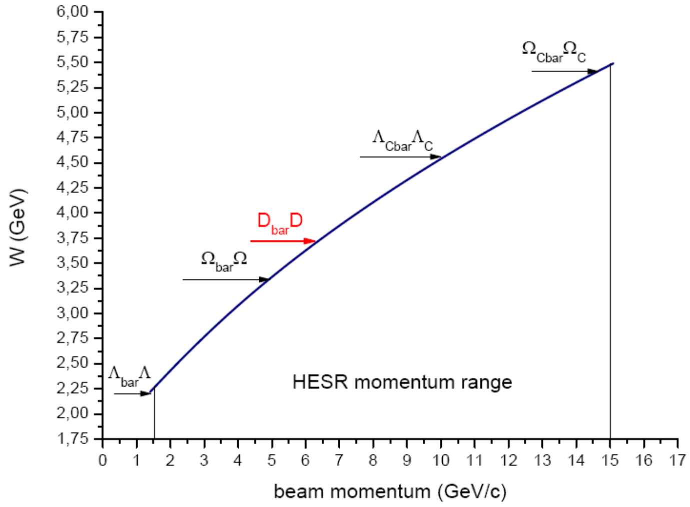
Momentum range *1.5 -8.9 Gev* L= $2x10^{31}$ $cm^{-2}s^{-1}$ $\Delta p/p=5x10^{-5}$

at 5 GeV ΔE=250 KeV !!

Momentum range *1.5 -15 GeV* L= $2x10^{32}$ $cm^{-2}s^{-1}$ $\Delta p/p=5x10^{-4}$

In CM E_{max} =5.47 GeV





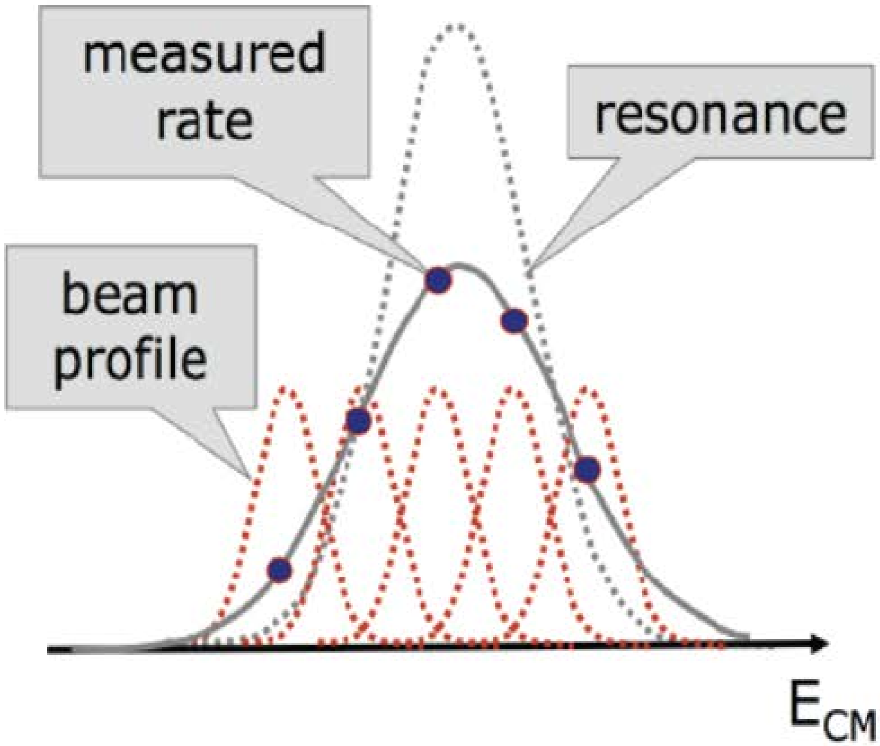
High resolution mode of HESR

- Stochastic and electron cooling of beam for p < 8.9 GeV/c
- Momentum resolution: $\Delta p/p \leq 4 \times 10^{-5}$
- Peak luminosity: 10^{31} cm^{-2} s^{-1}

Precise measurement of masses and widths of resonances

- only dependent on beam momentum resolution

→ unique at PANDA



PANDA Physics in General

Charmonium Spectroscopy. A precise measurement of all states below and above the open charm threshold. All charmonium states can be formed directly in annihilation in the invariant mass range GeV;
Search for Gluonic Excitations. i.e., hadrons consisting of **pure glue** and **hybrids**, which consist of a qqbar pair and excited glue. These objects may have exotic quantum numbers J^{PC},. Exploration of X, Y, and Z (cc-like) states, multi-quarks, quark molecules, etc.

Electromagnetic Processes. Study of proton form factors in the time-like region up to 14 (GeV)^2 . $\bar{p}p \to e^+e^-$, $\bar{p}p \to e^+e^-\pi$

Study of Hadrons in Nuclear Matter. So far, experiments have been focused on the light quark sector. The high-intensity antiproton beam of up to 15 GeV/c will allow an extension of this program to the charm sector both for hadrons with hidden and open charm.

Hyperon Physics. Efficient production of hypernuclei with **more than one strange hadron**. Measurement of the cross sections and polarization parameters in exclusive reactions like $\bar{p}p \to \bar{\Lambda}\Lambda$, $\bar{p}p \to \bar{\Xi}\Xi$, $\bar{p}p \to \bar{\Omega}\Omega$, $\bar{p}p \to \bar{\Lambda}_c\Lambda_c$

Of particular interest is the study of production of multi-strange and charm baryons.

PANDA Collaboration, Physics Performance Report

Example X(3872)

HESR: average luminosity 1170 nb^{-1}/d (MSV0-3, no RESR)

- PANDA: estimate of cross section:
  σ(pbar p -> X(3872)) = 100nb i.e. 1.17×10^5 X(3872) produced per day
  X(3872) -> $J/\psi\rho^0 \to e^+e^-/\mu^+\mu^-\ \pi^+\pi^-$ only:
  statistics: ~120 reconstructed events per day (full simulation)
  with RESR: factor 10 more
  precise measurement of width/line shape by energy scan ~100keV,
  decisive for 4 quark states
- BELLE II:
  estimated statistics: 1500 events in 4 years
- BES III:
  statistics: ~20 events in 4 weeks

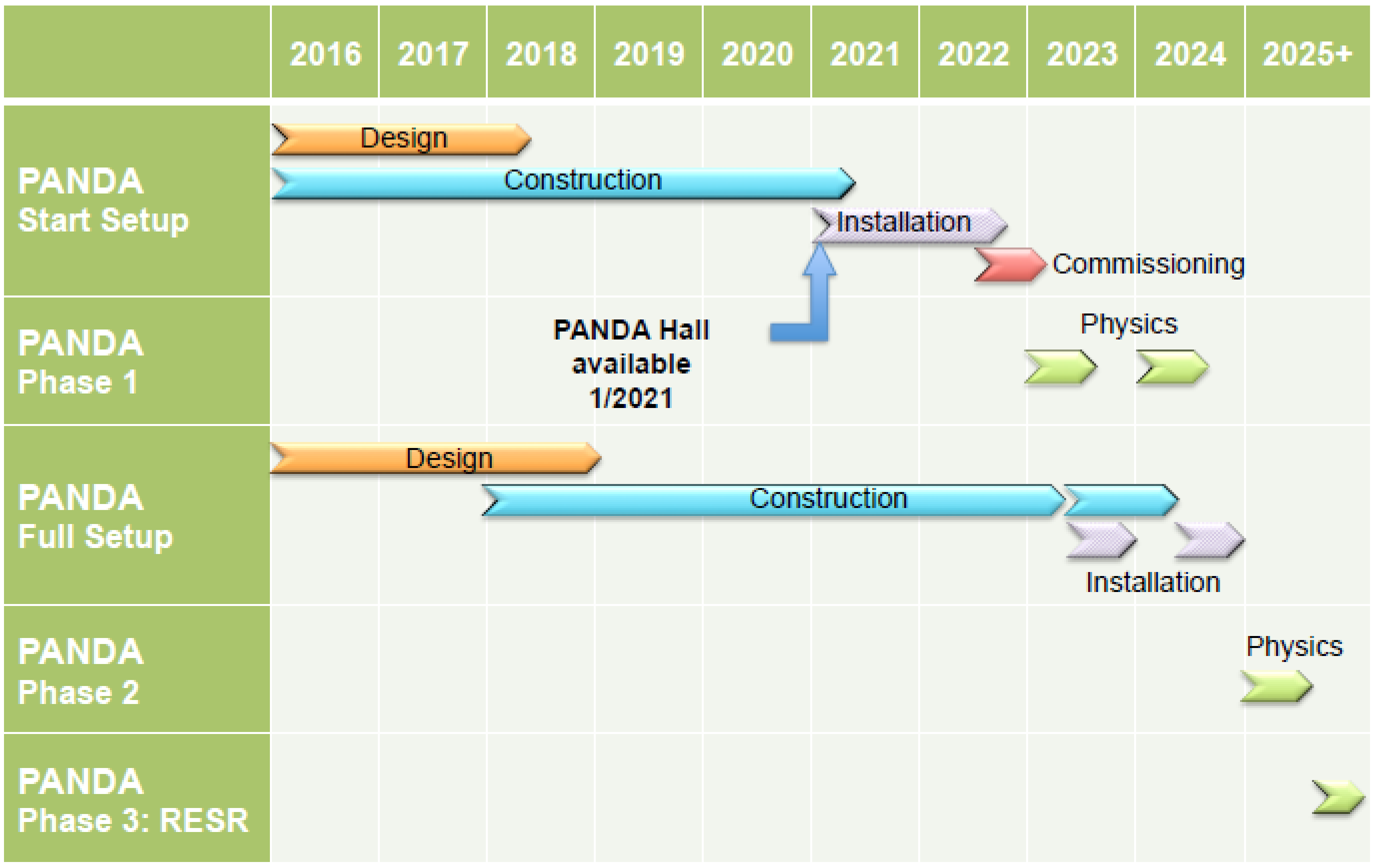
PANDA: ~120 X(3872)/day, 820 Y(4260)/day, 180 Z(3900)/day

PANDA is a X,Y,Z factory
high statistics X,Y,Z data sample

PANDA Release Note
RN-QCD-2016-002, QWG 2016

Sept. 13th 2016:
FAIR got the formal approval to start going to the market for inquiry, award and execution of civil works contracts

PANDA Phases



PANDA Collaboration

More than 520 physicists from 70 institutions in 19 countries

Aligarh Muslim University
U Basel
IHEP Beijing
U Bochum
Magadh U, Bodh Gaya
BARC Mumbai
IIT Bombay
U Bonn
IFIN-HH Bucharest
U & INFN Brescia
U & INFN Catania
NIT, Chandigarh
AGH UST Cracow
JU Cracow
U Cracow
IFJ PAN Cracow
GSI Darmstadt

Karnatak U, Dharwad
TU Dresden
JINR Dubna
U Edinburgh
U Erlangen
NWU Evanston
U & INFN Ferrara
FIAS Frankfurt
LNF-INFN Frascati
U & INFN Genova
U Glasgow
U Gießen
Birla IT&S, Goa
KVI Groningen
Sadar Patel U, Gujart
Gauhati U, Guwahati
IIT Guwahati
IIT Indore

Jülich CHP
Saha INP, Kolkata
U Katowice
IMP Lanzhou
INFN Legnaro
U Lund
U Mainz
U Minsk
ITEP Moscow
MPEI Moscow
U Münster
BINP Novosibirsk
Novosibirsk State U
IPN Orsay
U & INFN Pavia
Charles U, Prague
Czech TU, Prague
IHEP Protvino

PNPI St. Petersburg
U of Sidney
U of Silesia
U Stockholm
KTH Stockholm
Suranree University
South Gujarat U, Surat
U & INFN Torino
Politecnico di Torino
U & INFN Trieste
U Tübingen
TSL Uppsala
U Uppsala
U Valencia
SMI Vienna
SINS Warsaw
TU Warsaw

PANDA detector

- 100 KeV mass resolution by beam momentum scan
- 1 % produced particle momentum resolution
- $2 \times 10^{7}\ s^{-1}$ event rate capability
- stand $10^{32}\ cm^{-2}\ s^{-1}$ inst. luminosity
- nearly 4π acceptance, high detection efficiency
- secondary vertex reconstruction for D, K^0_S, Λ ($c\tau$ = 317 μm for $D^{\pm}$)
- PID (γ, e, μ, π, K, p)
- photon detection 1 MeV – 10 GeV

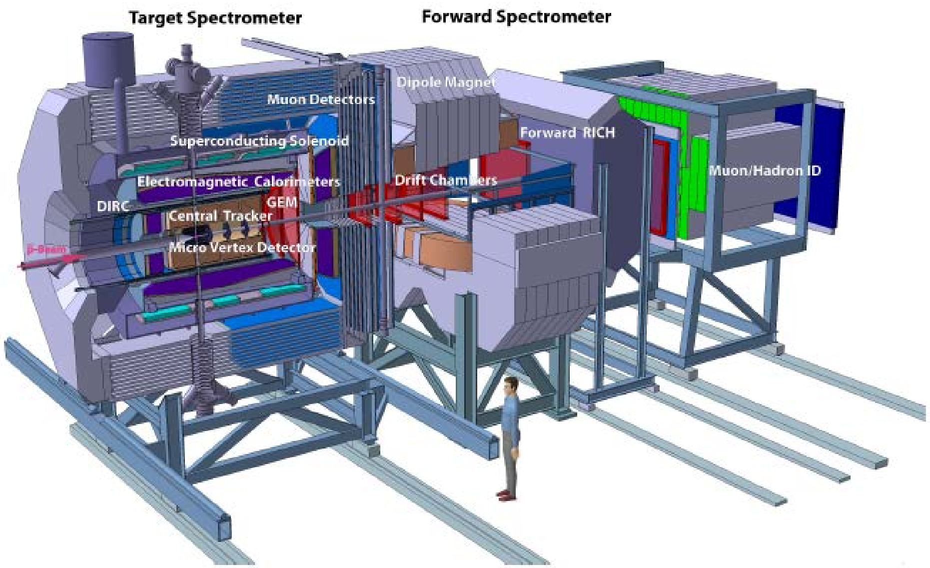


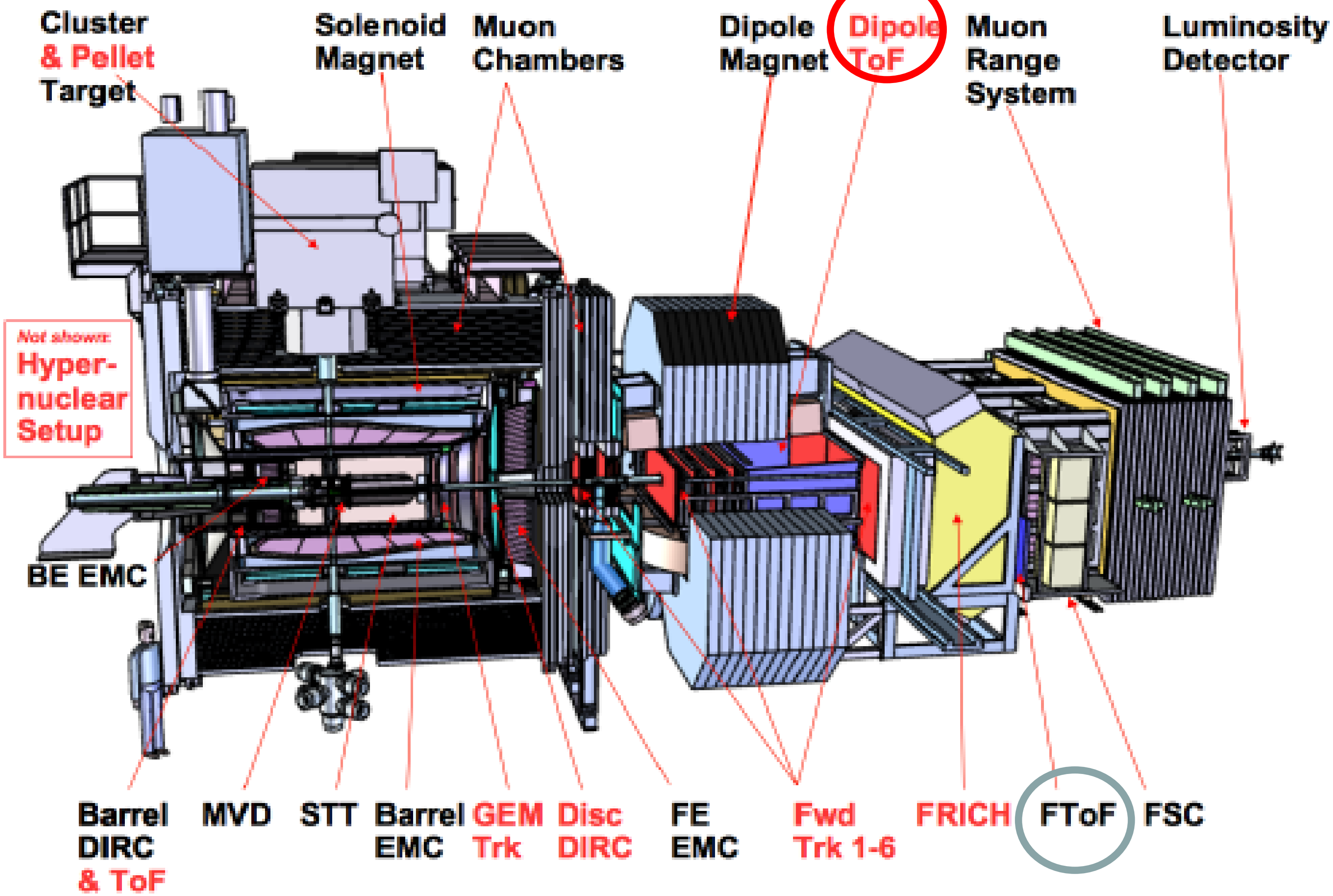
Figure 2.1: Artistic view of the $\overline{\mathrm{P}}$ANDA Detector

Targets: pellet H(D) target

frozen drops of 25-40μm, controlled position;
Target station for hyper-nucleus physics;
Wire targets for pbar-A interaction

Total integrated luminosity about 1.5 fb-1/year

PANDA startup/ full configuration detector



Forward TOF wall functions

- **PID of forward emitted particles** using time-of-flight information:
  protons < 4.5 GeV, kaons < 3.5 GeV, pions < 3. GeV
  where forward RICH is not effective

  time resolution of 50-100 ps required
  FS momentum resolution 0.01
  Δl_{track} ~ 2-3 mm (10 ps)

- **Event start stamp reference time → T_0**

  with RICH identification Δ **T_0 =100 ps**
  without any PID for MI particles ΔT_0 ≈ few ns

- **Possibility to use Λbar for detector calibration**

  very high Λbar detection efficiency

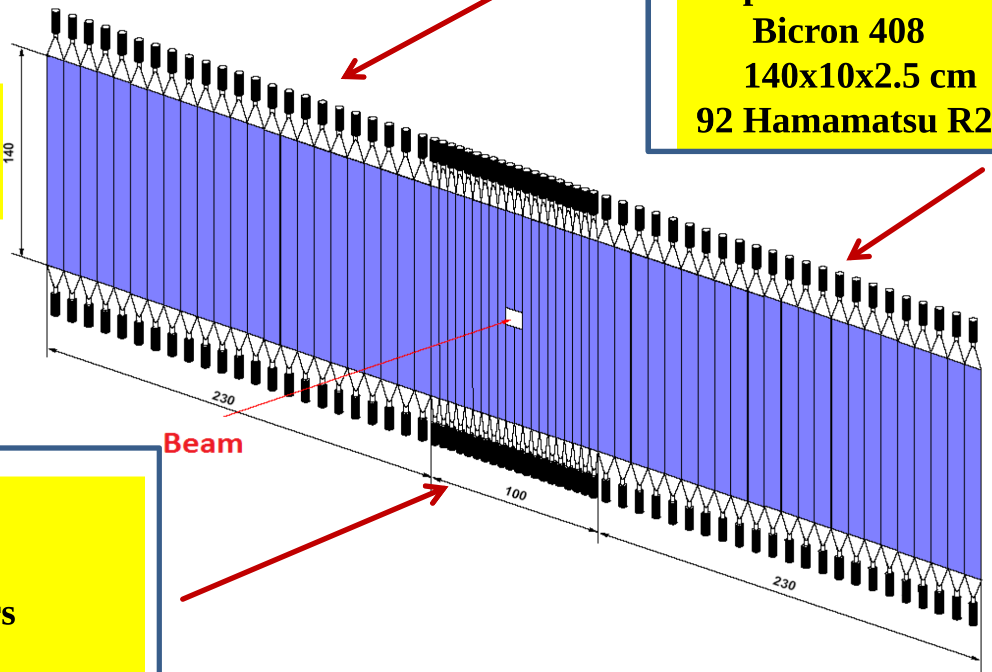
- Can be used as start for determination of the drift time in DCs

Forward TOF wall configuration

Project cost 471 kEU

positioned at 7.5 m from IP

Side parts
2x23 counters
46 plastic scintillators
Bicron 408
140x10x2.5 cm
92 Hamamatsu R2083 (2”)



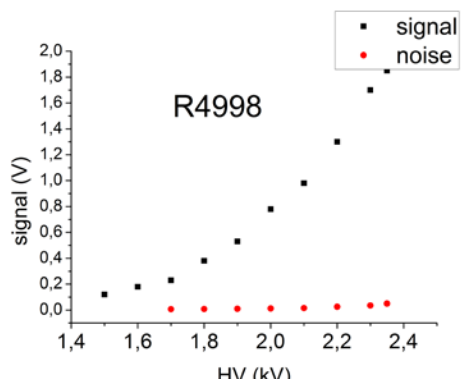
Central part
20 counters
20 plastic scintillators
Bicron 408
140x5x2.5 cm
40 Hamamatsu R4998 (1”)

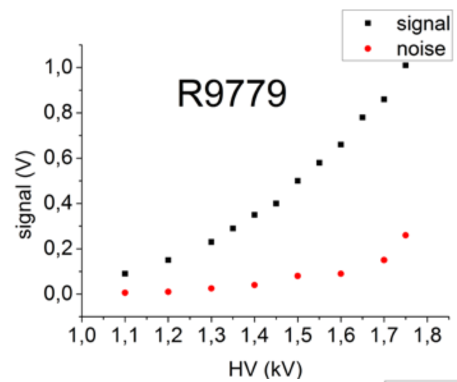
Sensitive area
width = 5600 cm
height= 1400 cm

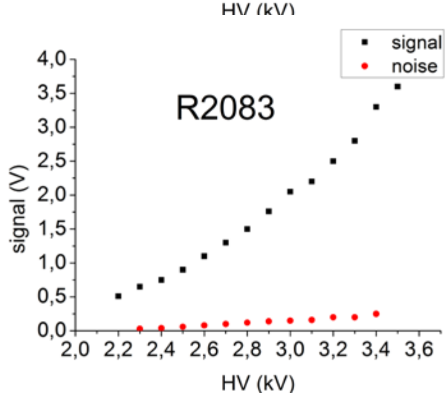
Bicron 408		***Fast PMTs** (hamamtsu)*	
(recommended for large TOF counters)		**R4998 1” (R9800) , R2083 2” (R9779)**	
Rise time	0.9 ns	Anode pulse rise time	0.7-1.8ns
Decay time	2.1 ns	TTS	250-370ps (FWHM)
1/e light attenuation length	210cm	Gain	$1.1\text{-}5.7\text{x}10^6$

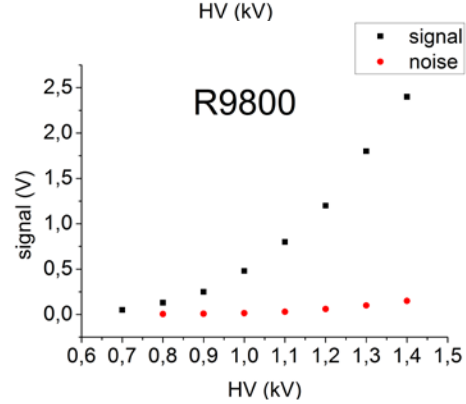
Prototyping / PMT characteristics

PMT	Photocathode diameter (mm)	Anode pulse rise time (ns)	Electron transition time (ns)	Transition time spread (ps)	Gain / 10^6	Typical voltage (V)
R4998	25 (1 inch)	0.7	10	160	5.7	2250
R9800	25 (1 inch)	1.	11	270	1.1	1300
R2083	51 (2 inch)	0.7	16	370	2.5	3000
R9779	51 (2 inch)	1.8	20	250	0.5	1500
XP2020	51 (2 inch)	1.6	28	??	30	2000

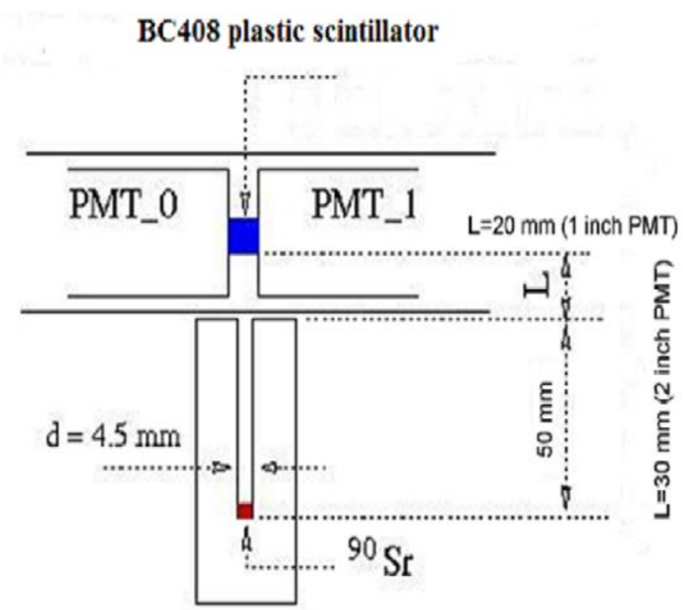








Prototyping at test station



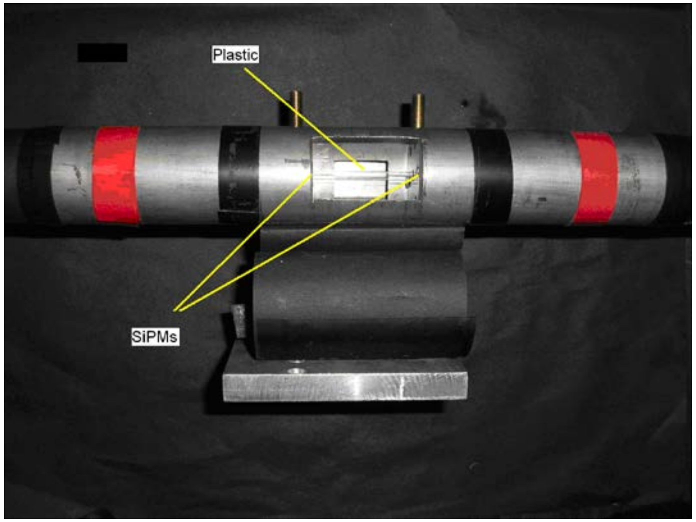
After offline amplitude corrections

PMT_1	σ_{TDC_1} (ps)	σ_{PMT} (ps)
R4998 (4998/4998)	72.	63.7
R9800 (4998/9800)	86.	79.2
R2083 (2083/2083)	72.6	64.4
R9779 (2083/9779)	64	54.5
XP2020 (2.5, 2.36kV)	82	74.8

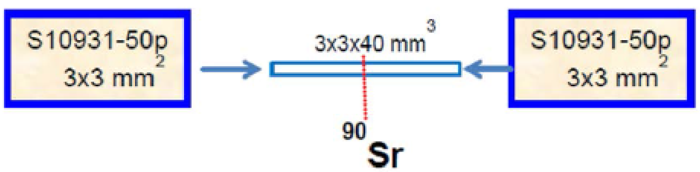
2 MeV energy deposition, $2x10^4$ photons
Track walk in scintillator $\sigma_{tr.w.}$ = 15 ps
Electronics contribution σ_{el} = 30 ps

After corrections for electronics and track walk

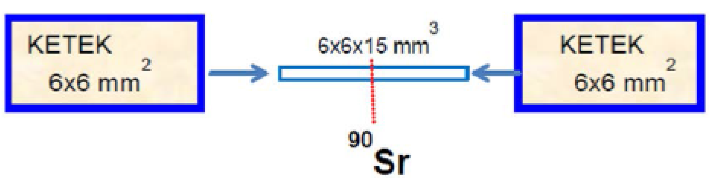
SiPM timing tests



Variant A



Variant B mm



Amplitude correction $$\Delta t = \Delta t_0 - a\left(\frac{1}{\sqrt{q_1}} - \frac{1}{\sqrt{q_2}}\right) - b$$

variant A S10931

after corrections $\boldsymbol{\sigma}$ **=103 ps**

variant B KETEK 6660

after corrections $\boldsymbol{\sigma}$ **=65 ps**

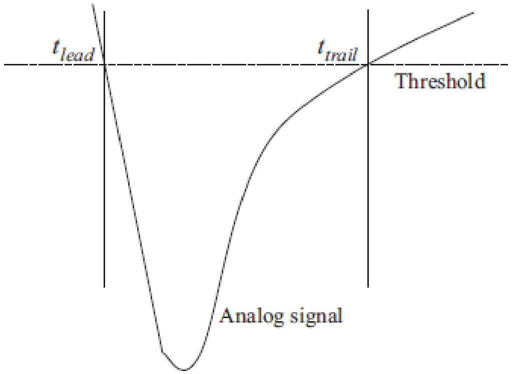
Table 4. Main parameters and time resolution of KETEK 6660.

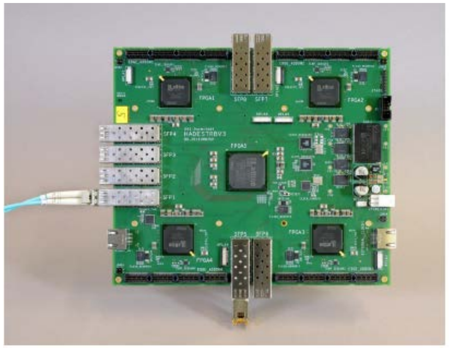
Supply voltage (V)	Signal amplitude (mV)	Noise amplitude (mV)	Current without ^{90}Sr (mkA)	Current with ^{90}Sr (mkA)	σ_{TDC_1} (ps)	$\frac{\sigma_{TDC\_1}}{\sqrt{2}}$ (ps)	σ_{KETEK} (ps)
26.35	20÷30	~ 0.3	7.5	9	120	84.8	81.1
26.85	70÷90	~ 0.5	11	13	100	70.7	66.1

Readout electronics

- In prototyping, available at home electronics (LEDs, TDCs,QDCs) used

- In real experiment, PPGA standard based on TRB-3 and Padiwa 2(3) developed in GSI planned:
  - -TRB 256 channel programmable TDC;
  - - Padiwa 8/16 channel discriminator
  - - for amplitude correction TOT principle used





Test results

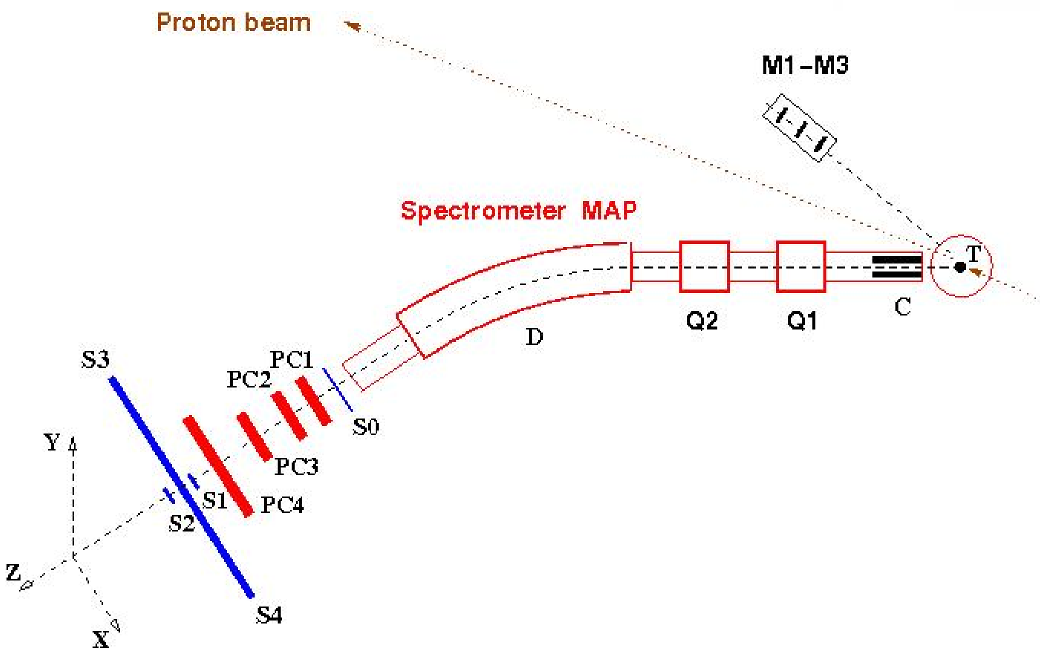
Measured

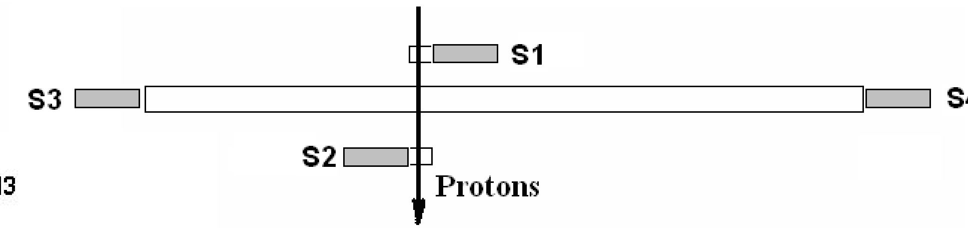
- TRB+PADIWA resolution with pulser 25-30 ps
- With KETEK's -112 ps
- Dependency of TRB on temperature
  - With pulser –shift 10 ps
  - With KETEK's – shift 100 ps

Online TOF calibration

Beam tests at 1 GeV PNPI SC

1 GeV proton beam





S_3S_4 scintillation slabs B408:
length 100, 140cm
width 2.5, 5,10cm
thickness 1.5, 2.5cm
S_1S_2 1x1x1cm
R4998, R2083, Electron187

Scattered protons up to 10^6 / cm^2

Proton energy E_p=740 and 920MeV, $\sigma(E_p)$ about 0.5%

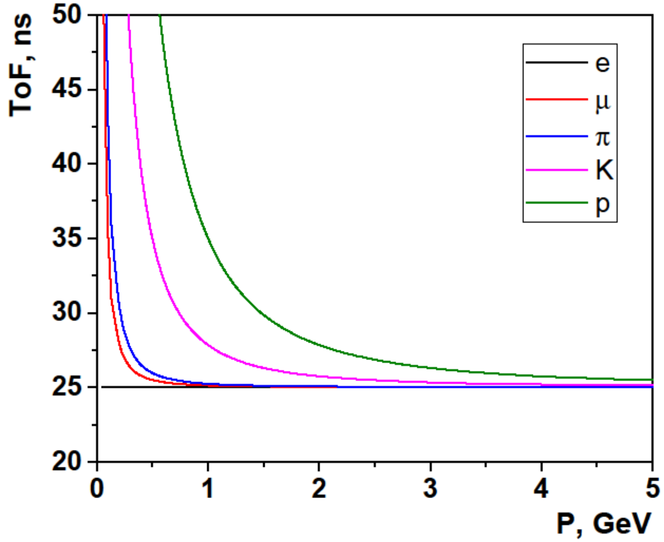
B408 thickness 2.5cm
Energy deposition ≈ 5MeV

Scintillation Efficiency several 10^4 photons/MeV

Beam tests using 920 MeV protons (summary)

scintillation slab dimensions (cm)	PMT	timing resolution σ (ps)	comment
140 × 10 × 2.5	**Hamamatsu R2083 (both ends)**	**70 (64.4 ^{90}Sr)**	**Recommended for a prototype for the FTOF wall.**
140 × 5 × 2.5	**Hamamatsu R4998 (both ends)**	**67 (63.7 ^{90}Sr)**	**Recommended for a prototype for the FTOF wall**
140 × 2.5 × 2.5	Hamamatsu R4998 (both ends)	55	a variant of a prototype with smaller stintillator width
140× 5 × 1.5	Hamamatsu R4998 (both ends)	≈ 90	projected originally for the FTOF wall
140 × 2.5 × 2.5	Electron PMT 187 (both ends)	80	magnetic field protected,

MC studies. FTOF wall particle ID



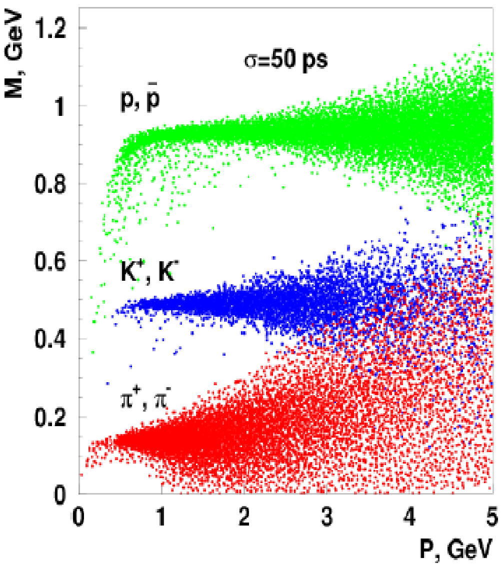
TOF resolution σ_{TOF} = 50 - 100 ps

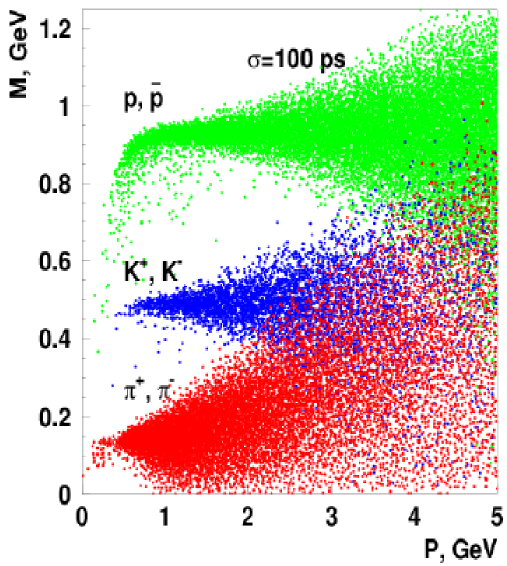
FS momentum resolution $\Delta p/p=0.01$

$\Delta L/L$ neglected

$$m = p\sqrt{\frac{t^2}{t_c^2} - 1}, \qquad t_c = L_{track}/c$$

$$\frac{\delta m}{m} = \sqrt{\left(\frac{\delta p}{p}\right)^2 + \gamma^4\left(\frac{\sigma_{TOF}}{t}\right)^2}$$





MC studies. Count rates of FTOF wall at 10 GeV and e⁺ e⁻ background

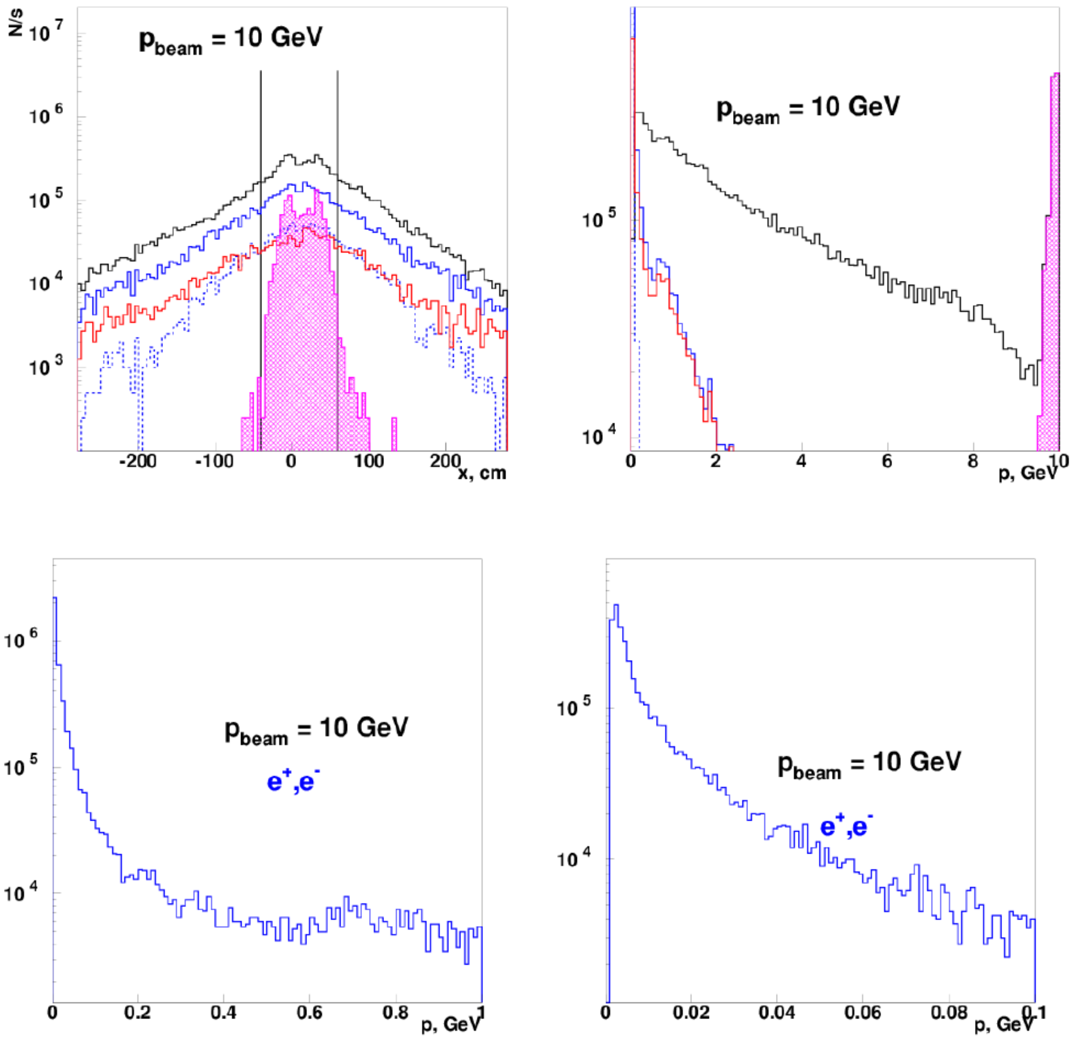
All

Pbar forward peak

e⁺ e⁻ all

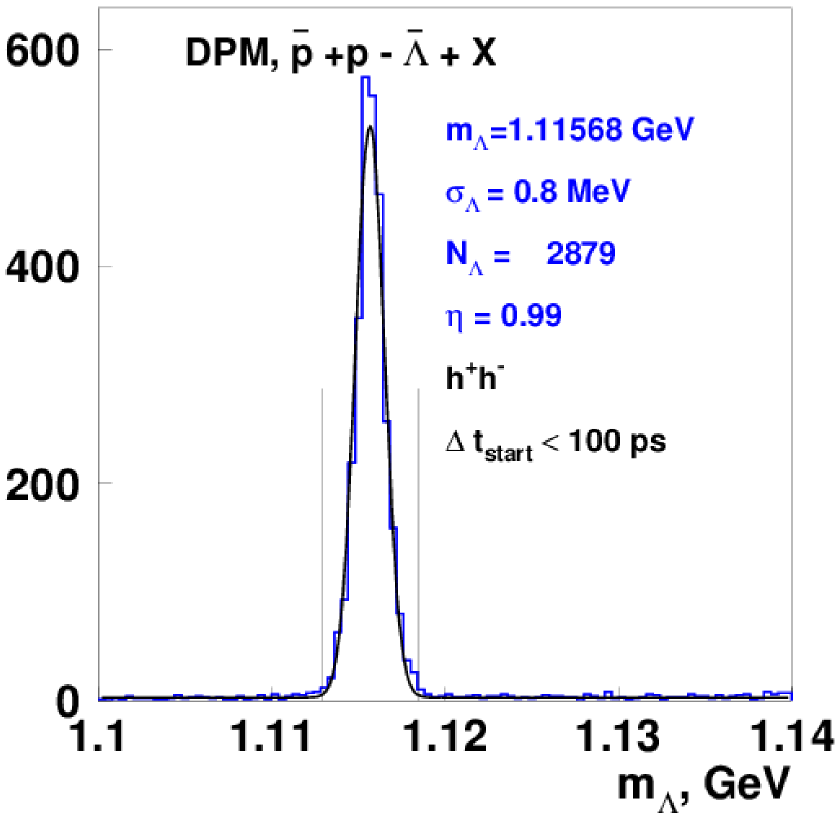
e⁺ e⁻ produced in vacuum pipe

e⁺ e⁻ backward scattering from EMC (dashed)



MC studies. Λbar detection with FTOF

$$\bar{p} + p \rightarrow \bar{\Lambda} + X \quad \bar{\Lambda} \rightarrow \bar{p} + \pi^{+}$$



$0.72 \times 10^{6}\ \bar{p}p$ interactions,10 GeV

$\bar{\Lambda}$ detected with high efficiency (20%) at weak selection criteria

$N_\Lambda / N_{\bar{\Lambda}} \approx 1/40$

Λ events also well detected

@$10^6 s^{-1}$target interactions ($L \approx 10^{31} s^{-1} cm^{-2}$)

$N_{\bar{\Lambda}} = 4 \times 10^{3}\, s^{-1}$!!

can be used to tag exclusive reactions, e.g.,

$\bar{p}p \rightarrow \bar{\Lambda}\Lambda$ production 25×10^{6} events / 7days

Summary

- **MC simulation demonstrates functionality of FTOF wall:**
  - FTOF wall can stand to maximum count rate in central part of FTOF wall at $L = 10^{32}\ cm^{-2}\ s^{-1}$ Background related to e^+e^- pairs production peaked at very low momenta is small;
  - FTOF provides PID for forward emitted particles with momenta below 3-4 GeV;
  - FTOF provides determination of event start time stamp within 100 ps
  - High rate and good efficiency - Λbar detection with FTOF wall may be used for calibration.
- **Prototyping is completed. Geometry of FTOF wall and its components is optimized.**
  - Preliminary selection of photo detectors (PMTs and SiPMs) is performed using test station. For Hamamatsu PMTs timing resolution about 60 ps is obtained. A similar result is obtained for KETEK PM6660 (6x6 mm^2) samples .
  - Big counters (mounted on scintillation slabs of 140 cm length) has been investigated at proton beams. Thickness of the slabs is optimized.
  - Timing resolution of 70-75 ps is obtained at the PNPI SC using 920 MeV under condition that hit position is measured
  - Without hit position independent information, timing resolution better than 80 ps can be obtained by measuring T3+T4 combination.

The obtained results on FTOF design, prototyping and obtained experimentally timing resolution meet the requirements of PANDA experiment.

Supporting slides

Key experiments of the start phase

Concentration on unique and forefront physics topics

- Precise measurement of the line shape of narrow XYZ-states, e.g. X(3872)
  (only possible in proton–antiproton, counting experiment, clarification of the nature of the states)
- Resonant formation of the negative and uncharged partners of the Z-States
  (only possible in proton–antiproton, clarification of the nature of the states)
- Production of multi-strangeness baryons
  (unexplored, new territory, „Strangeness-Factory“)
- Production of high spin charmonia (only possible in proton–antiproton)
  light mesons, baryons and production of hybrides und glueballs
- Measurement of the electromagnetic form factors of the proton in the time-like domain with electrons and muons in the final state

XYZ-, hyperon factory

Forward TOF wall functions

- **PID of forward emitted particles** using time-of-flight information:
  protons < 4.5 GeV, kaons < 3.5 GeV, pions < 3. GeV
  where forward RICH is not effective
  time resolution of 50-100 ps required
  FS momentum resolution 0.01

- **Event start stamp reference time**

- **Possibility to use Λbar for detector calibration**

- Can be used as start for determination of the drift time in DCs

Open questions

- **MC simulation.**

  - time dependent event reconstruction analysis ?? lack of manpower

- **Related to FSTT.**

  - FS momentum resolution $\Delta p/p$ must be 1%

  -vertical hit position uncertainty ? Δy=1 mm corresponds 5.3 ps (BC-408)

  expected at present design FSTT Δy=5-10 mm → up to Δ(tof) ≈ 60 ps

  -uncertainty in track reconstruction? $\Delta L_{track} / L_{track}$ = 0.1% → Δ(tof) ≈ 30 ps

- **FTOF wall position behind RICH.**

  - RICH width is smaller than sensitive area of FTOF wall, deterioration of track information at FTOF wall side slabs

- **FTOF wall width is 5.6 m while FSTT last station width is 3.9 m, thus side parts of FTOF wall are out of FSTT acceptance.**

  reduce FTOF wall width ??

- **Hardware:**

  - finalize TRB-3 readout tests

  - definitive decision on Hamamatsu PMs (type, housing, divider, price,.).

  - on-line laser calibration system (??)

  - HV-power supply: commercial or PNPI production HVDS3200

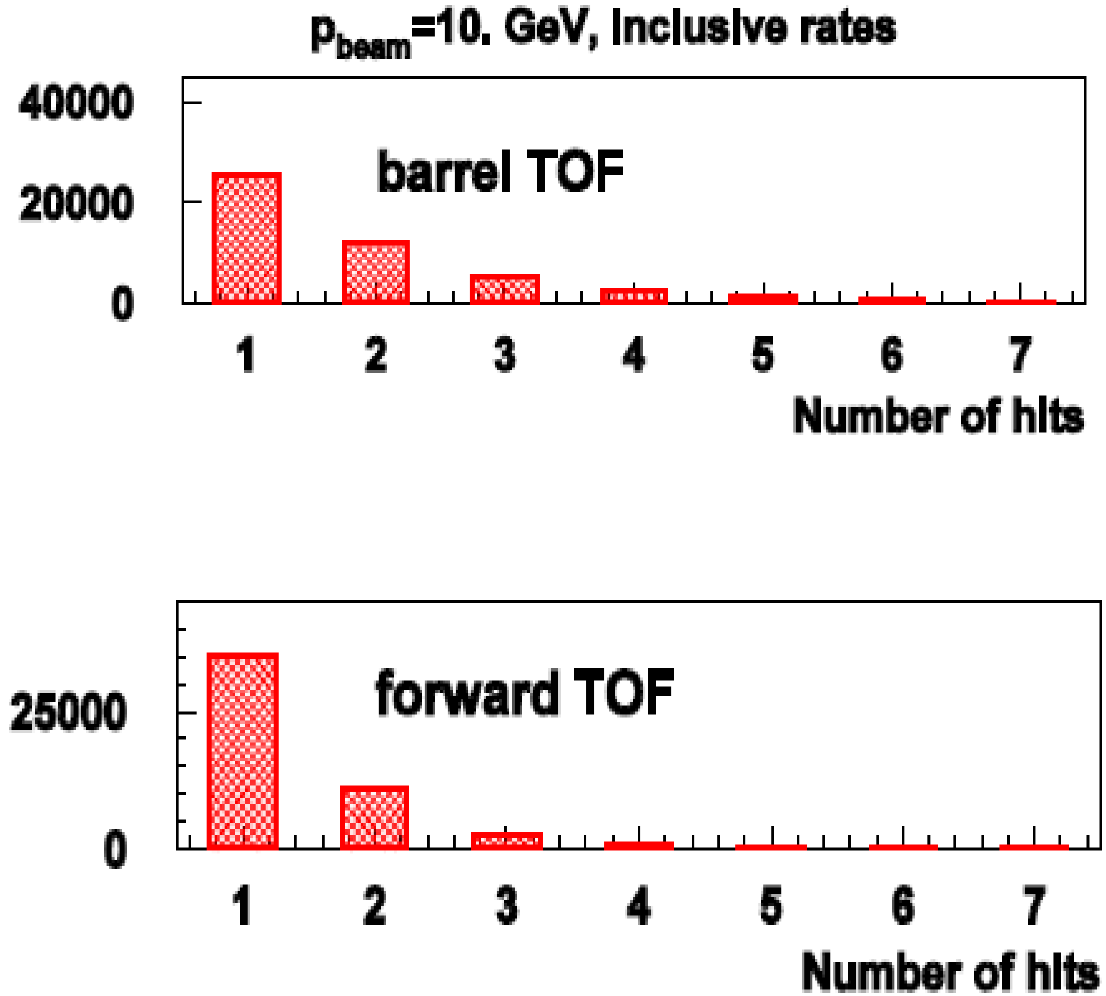
Track multiplicity/event in TOF detectors at 10 GeV

No dedicated start counter

coincidence efficiency

SciTil ≈ 50%

FTOF wall ≈ 31%

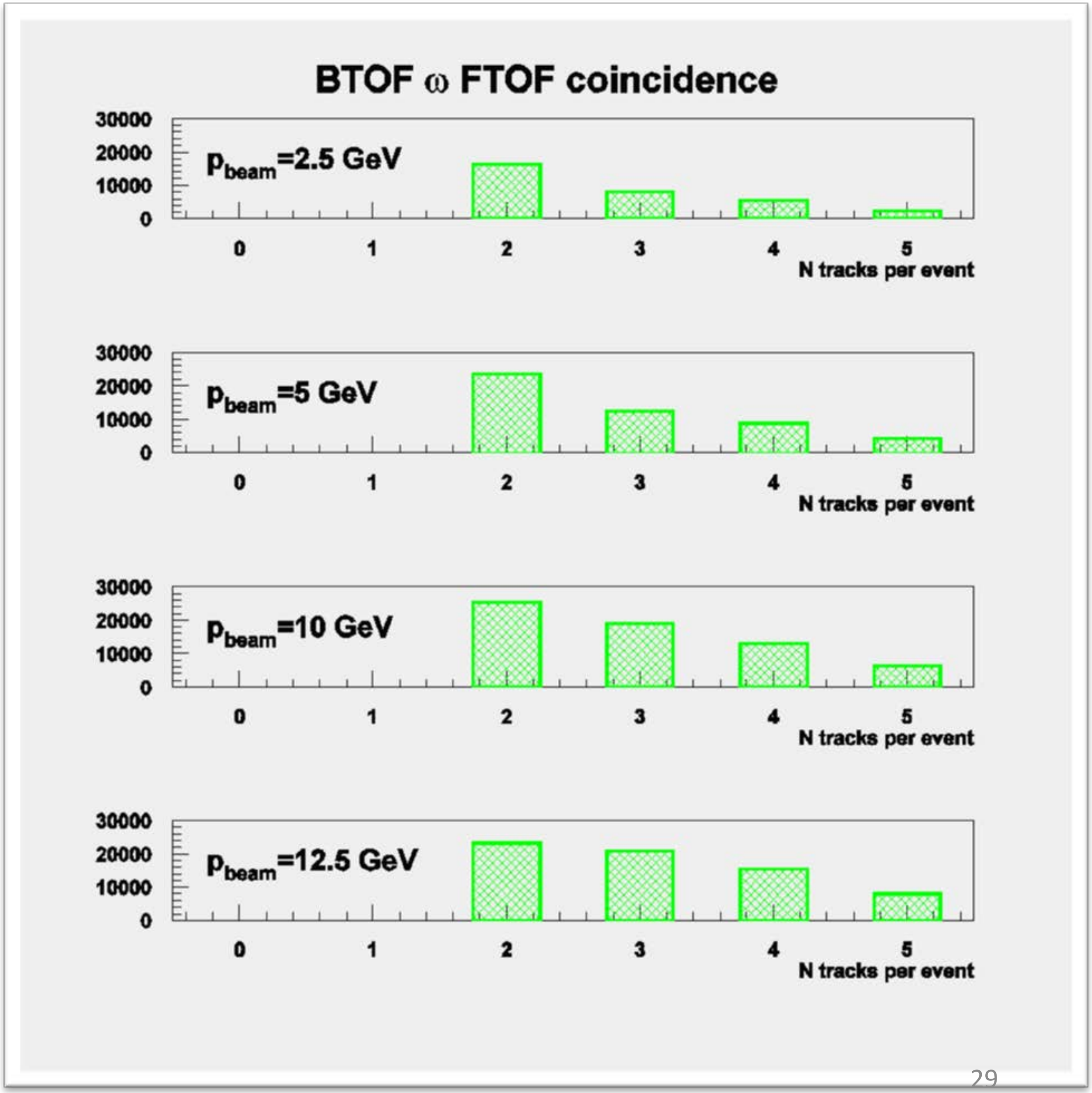


FTOF wall and barrel TOF interplay

No dedicated start counter

FTOF•BTOF coincidence probabilities

2.5 GeV	23.6%
5.GeV	35.1%
10.GeV	45.4%
12.5GeV	48.3%



Detection Efficiency of FTOF wall

$$0.72\times10^{6}\ \bar{p}p\ \text{ interactions @10 GeV},\ \frac{\sigma(p)}{p}=0.01,\ \sigma(TOF)=50\,ps$$

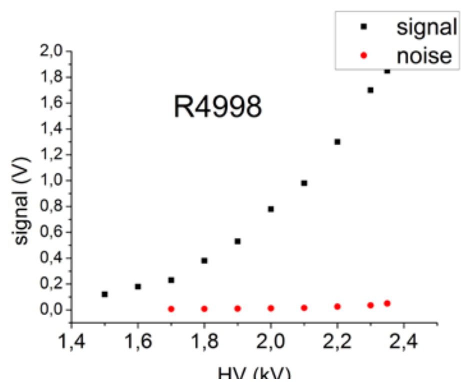
$$\text{acceptance of FS}\ \ \pm10\,\text{deg. hor.}\ \pm5\,\text{deg. ver.}\ \rightarrow\ \Omega_{FS}=0.09\,sr$$

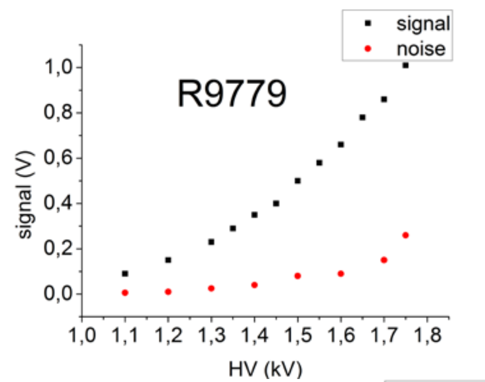
	Generated by DPM	Detected by FTOF wall	detection efficiency
π^-	880346	172188	0.195
π^+	877255	150440	0,171
K^-	30179	5820	0.192
K^+	26811	2863	0.107
$\bar{p}$	453293	202174	0.446
p	398323	51241	0.129
$\bar{\Lambda}\rightarrow\bar{p}+\pi^+$	19874	3840	0.193
$\Lambda\rightarrow p+\pi^-$	19518	≈100	$\approx5\cdot10^{-3}$

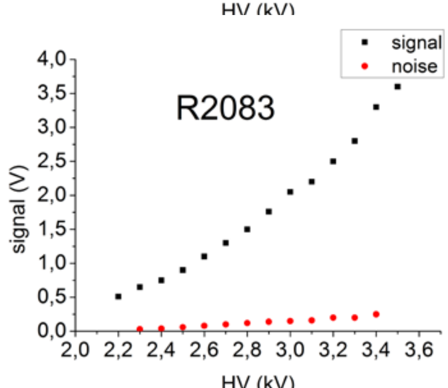
Both proton and pion detected with FTOF

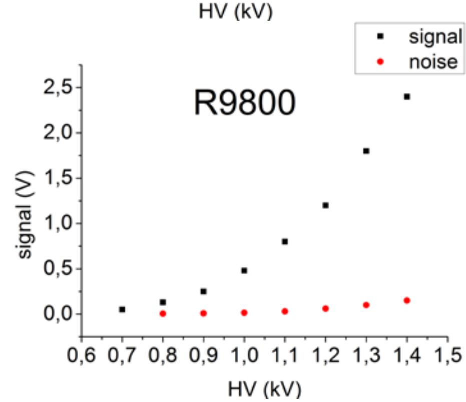
PMT characteristics

PMT	Photocathode diameter (mm)	Anode pulse rise time (ns)	Electron transition time (ns)	Transition time spread (ps)	Gain / 10^6	Typical voltage (V)
R4998	25 (1 inch)	0.7	10	160	5.7	2250
R9800	25 (1 inch)	1.	11	270	1.1	1300
R2083	51 (2 inch)	0.7	16	370	2.5	3000
R9779	51 (2 inch)	1.8	20	250	0.5	1500
XP2020	51 (2 inch)	1.6	28	??	30	2000



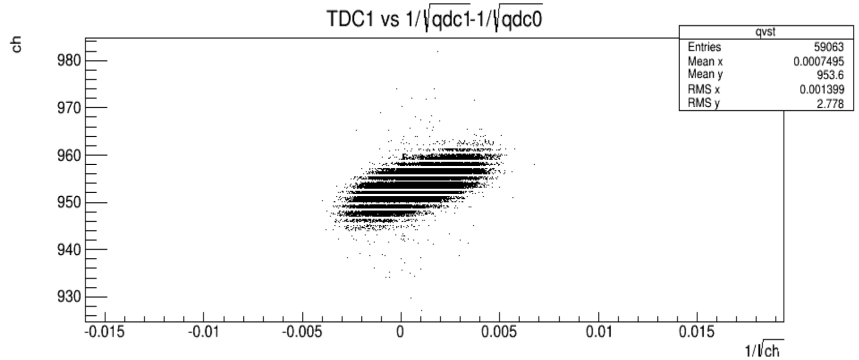






Test station results

After offline amplitude corrections

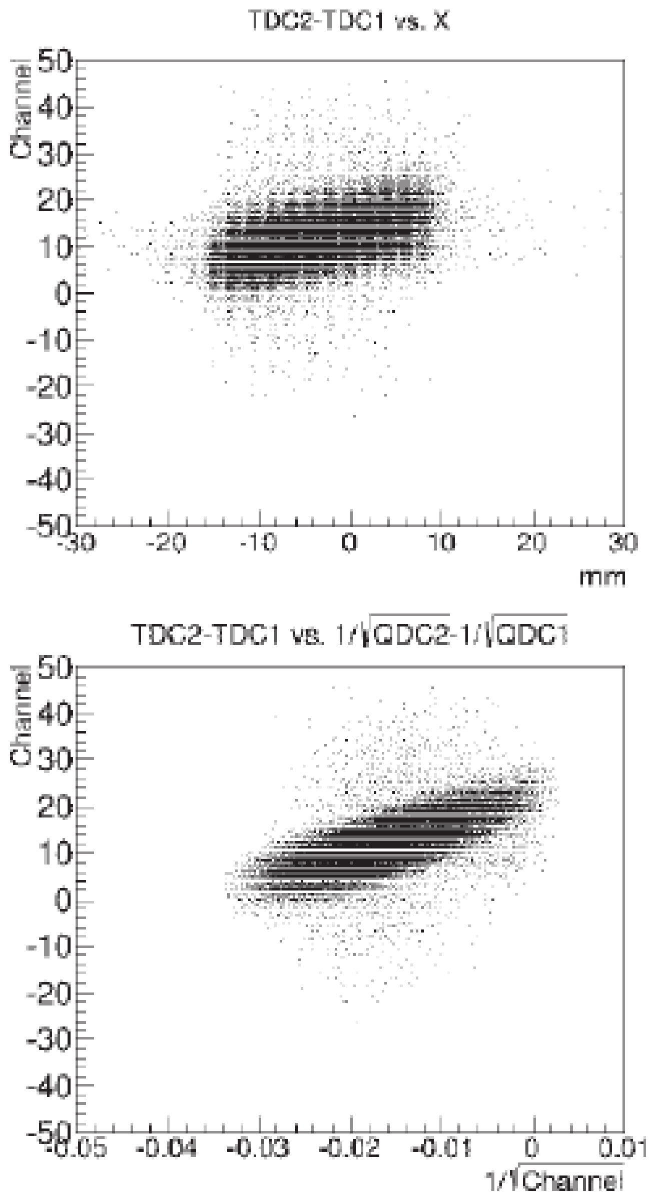


$$\frac{1}{\sqrt{Q_i}} - \frac{1}{\sqrt{Q_k}}$$

PMT_1	σ_{TDC_1} (ps)	σ_{PMT} (ps)
R4998 (4998/4998)	72.	44.4
R9800 (4998/9800)	86.	64.6
R2083 (2083/2083)	72.6	44.9
R9779 (2083/9779)	64	56.5
XP2020 (2.5, 2.36kV)	82	52,3

After corrections
for electronics and track walk

Off-line time resolution



Hit position and pulse amplitude corrections

on event basis calculated are

$$\tau_{13}, \tau_{14}, \tau_{23}, \tau_{24}, \tau_{34}$$

$$\tau_{nk} = t_n - t_k - a\left(\frac{1}{\sqrt{q_n}} - \frac{1}{\sqrt{q_k}}\right) - bx - c,$$

x hit position along the scintillation slab,

t_n, t_k time stamp measured with TDC,

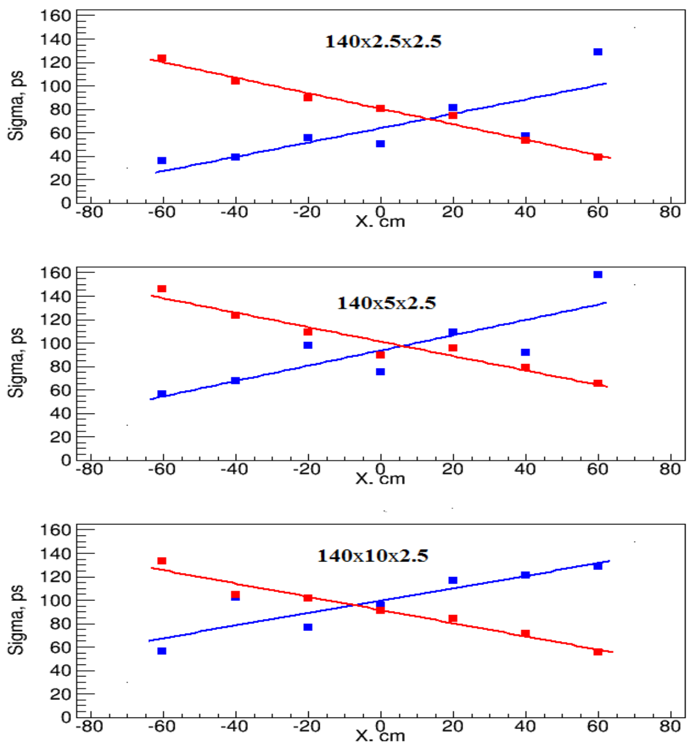
q_n, q_k measured with QDC,

a,b,c free parameters to minimize τ_{nk}

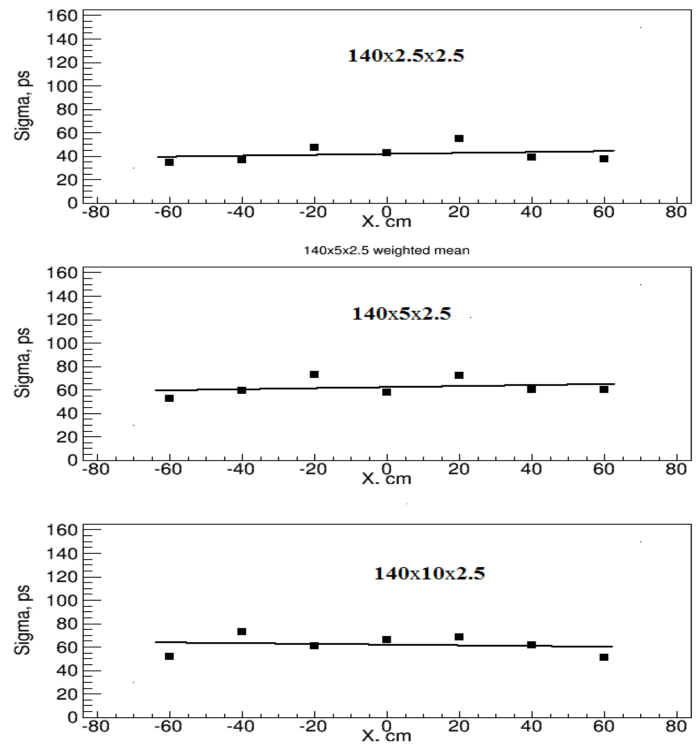
timing resolution is σ of

(corrected) τ_{nk} distribution.

Timing resolution results from 1 GeV PNPI SC



σ_{TOF} vs hit position



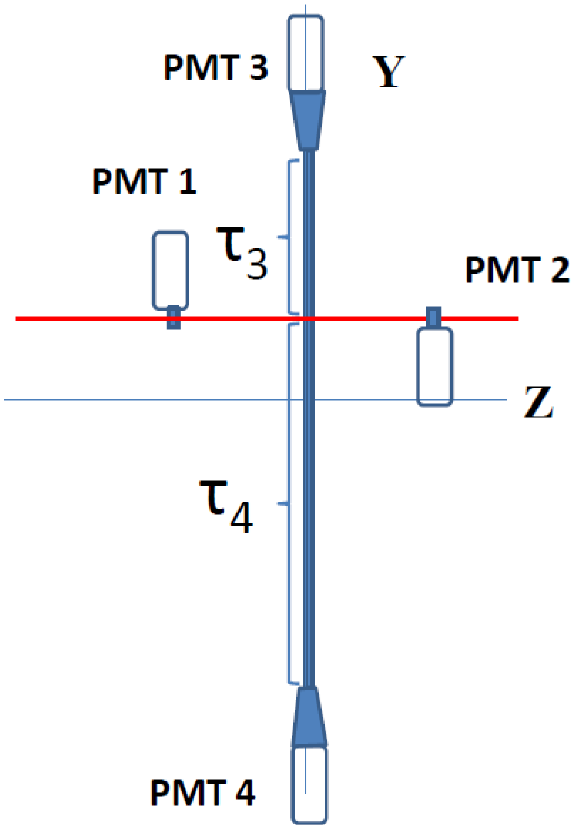
σ_{TOF} weighted means

weighted mean

$$\frac{1}{\sigma^2_{TOF}} = \frac{1}{\sigma^2_{TDC3}} + \frac{1}{\sigma^2_{TDC4}}$$

in the middle of slab $\sigma_{TOF} \approx \frac{\sigma_{TDC3}}{\sqrt{2}} \approx \frac{\sigma_{TDC4}}{\sqrt{2}}$

Time resolution without hit position correction



$\tau_3 + \tau_4 = \tau$ constant

light propagation

time through slab

$$T_3 = T_1 + t + \tau_3 \quad T_4 = T_1 + t + \tau_4$$

$$(T_3 - T_1) + (T_4 - T_1) = T_{31} + T_{41} = 2t + \tau$$

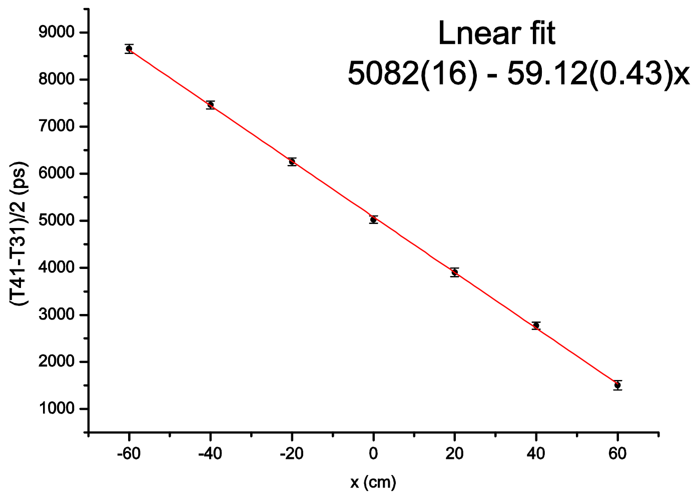
sensitive to measured time, not sensitive to hit position

$$(T_3 - T_1) - (T_4 - T_1) = T_3 - T_4 + \tau - 2\tau_4$$

sensitive to hit position, not sensitive to measured time

Time and hit position measurements using TDC information only

x	$(T_{41}-T_{31})/2$	σ_{431}-	$(T_{41}+T_{31})/2$	σ_{431}+	$(T_{42}-T_{32})/2$	σ_{432}-	$(T_{42}+T_{32})/2$	σ_{432}+
cm	ps	**ps**	ps	**ps**	ps	**ps**	ps	**ps**
60	1504	**99**	11950	**148,5**	1503,5	**100,5**	11580	**120,5**
40	2770,5	**74**	11865	**138,5**	2770,5	**74,5**	11510	**102**
20	3904	**90,5**	11975	**145,5**	3904	**90,5**	11630	**114**
0	5025	**76**	11920	**136,5**	5025	**75,5**	11580	**103,5**
-20	6255	**81,5**	11940	**150**	6255	**82,5**	11630	**115,5**
-40	7460	**84**	11895	**143,5**	6890	**85**	11560	**112,5**
-60	8655	**93,5**	11945	**148,5**	8655	**93,5**	11600	**121**



$$\tau = 59.12\,\text{ps}/\text{cm} \times 140\,\text{cm} = 8276.8\,\text{ps}$$

v_{BC408} = 1/59.12 = 0.17mm/ps
speed of light in BC408 = 0.19 mm/ps

hit position resolution
80ps x 0.17mm/ps = 13.6 mm

Count rates in frame of DPG

Number of events selected from 100 generated $\bar{p}p$ *collisions chosen arbitrarily, at 10 GeV*

$\bar{p}p \to \bar{p}p$	24	$\bar{p}p \to \bar{p}p\pi^0$	5
$\bar{p}p \to \bar{n}n\pi^0$	3	$\bar{p}p \to \bar{p}n\pi^+$	3
$\bar{p}p \to \bar{p}p\pi^+\pi^-$	2	$\bar{p}p \to \bar{n}p\pi^0\pi^-$	2
$\bar{p}p \to \bar{p}n\pi^+\pi^0$	2	$\bar{p}p \to \bar{p}p\pi^0\pi^+\pi^-$	9
$\bar{p}p \to \bar{n}p\pi^0\pi^+\pi^-\pi^-$	4	$\bar{p}p \to \bar{p}p\pi^0\pi^+\pi^-\pi^+\pi^-$	4
$\bar{p}p \to \bar{\Lambda}n\bar{K}^0\pi^0\pi^+\pi^-$	1		

Hadron count rate by TOF wall at 0.35×10^7/s interactions in target

$\bar{p}$ beam momentum, GeV/*c*	Pion rate, 1/s	Kaon rate, 1/s	Proton rate, 1/s	Antiproton rate, 1/s
2	3.9×10^5	2×10^3	1.2×10^4	1.07×10^6
5	6×10^5	7.8×10^3	3.8×10^4	9.5×10^5
15	9.6×10^5	4.7×10^4	3.2×10^4	8.2×10^5

High rate of π^0

Bgr expected from

$\pi\to2\gamma$ $\gamma\to e^+ e^-$

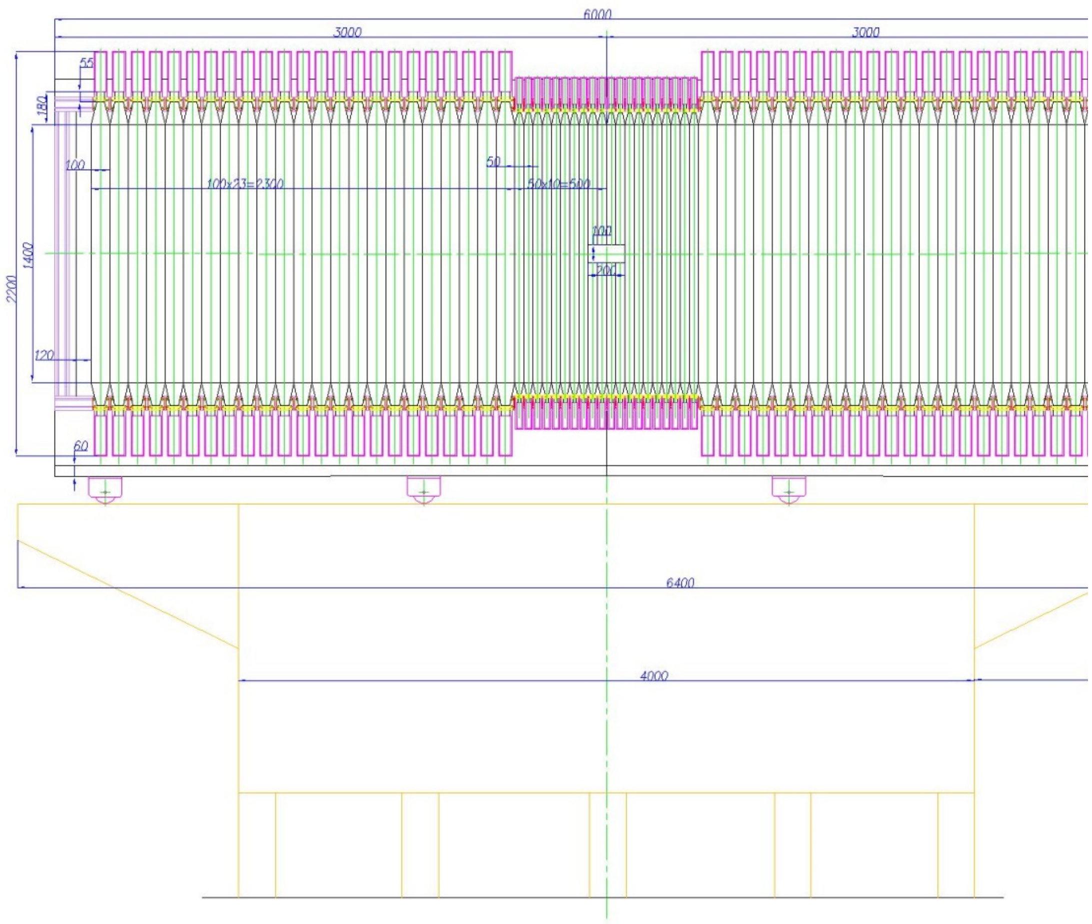
Cost estimation update

FTOF wall

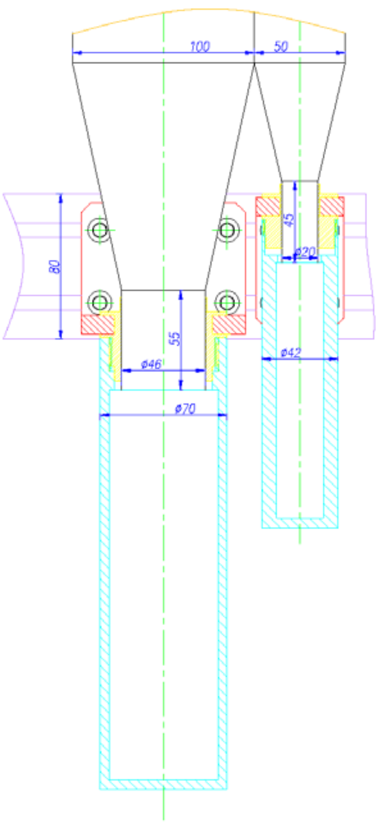
Plastic scintillators	
B408 20u.140x5x2.5cm+46u.140x10x2.5cm	40 k€
PMTs 1” 760 € 40u. +5u.(spare)	42
PMTs, 2” 1270 € 92u.+20u.(spare)	155
FEE+DAQ	35
HV power supply	22
Monitoring/calibration system	25
Supporting structure , mechanical items	75
Test stand for mass production	35
Transportation, custom expenses	42
....	
	471 k€

From RRB February 2014 470 k€

FTOF wall mechanics.



FTOF wall front view



Scintillation counter mechanical components

LIGHT GUIDES FOR 1” AND 2” PMTs

Plexiglas, Mylar wrapping,
Magnetic field protected housing