



# *PANDA FTOF*

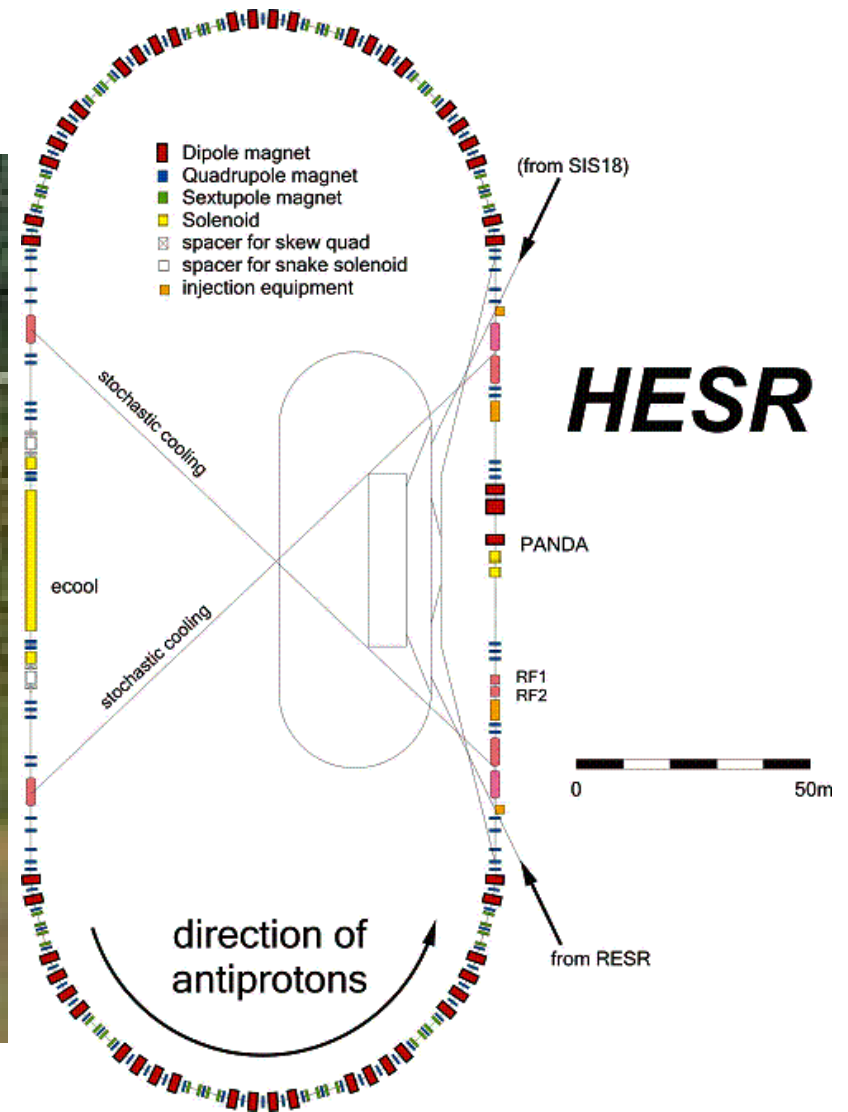
## *Prototyping*

*Anton A. Izotov,*

*Gatchina 25.12.13*



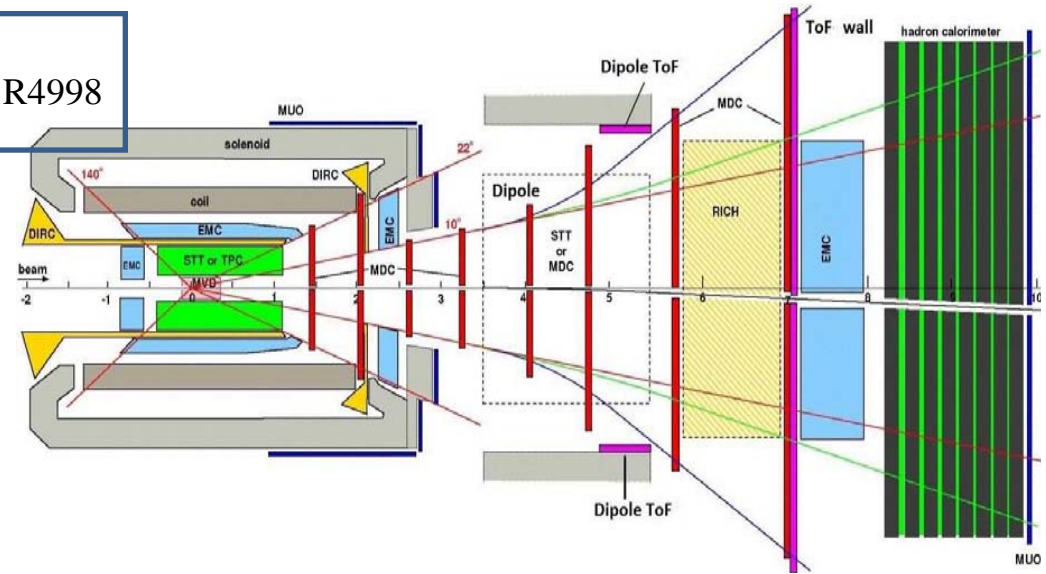
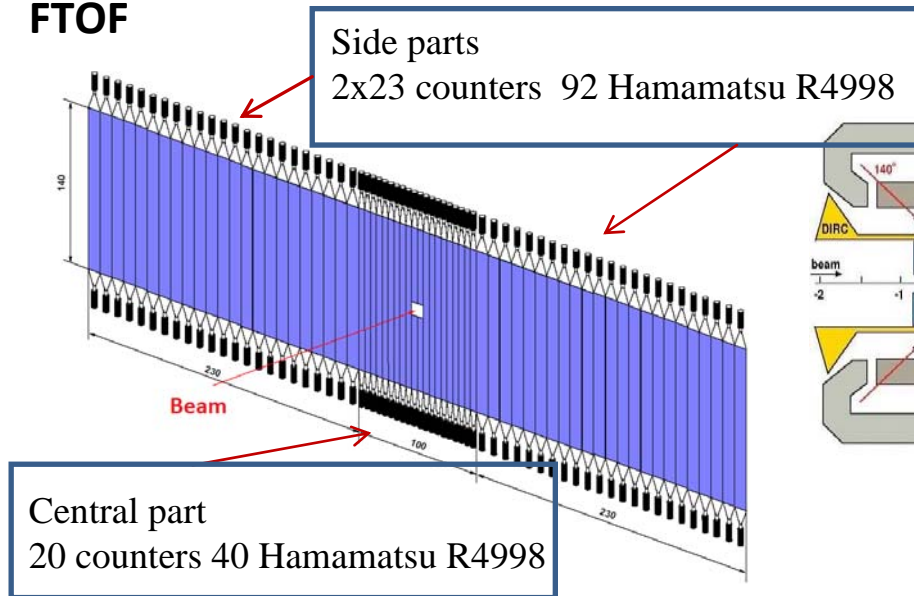
# FAIR, HESR, PANDA.



# Forward TOF and Dipole TOF DETECTORS



**FTOF**



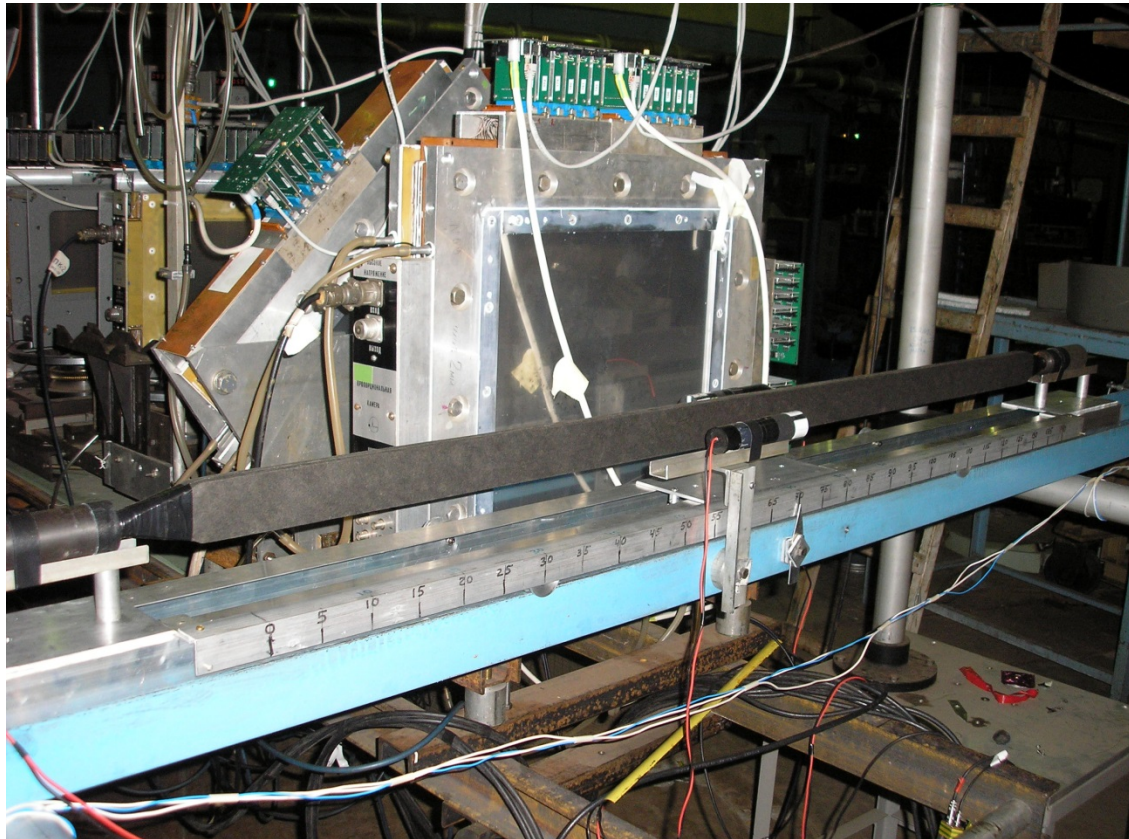
Scintillation slab dimensions	Photo multiplier tube	Comments
140 cm × 10 cm × 2.5 cm	Hamamatsu R 2083	Accepted as a prototype for the FTOF wall
140 cm × 5 cm × 2.5 cm	Hamamatsu R 4998	Accepted as a prototype for the FTOF wall
140 cm × 2.5 cm × 2.5 cm	Hamamatsu R 4998	Variant of a prototype with smaller scintillator width
140 cm × 10 cm × 1.5 cm	Hamamatsu R2083	Projected originally for the FTOF wall
140 cm × 5 cm × 1.5 cm	Hamamatsu R4998	Projected originally for the FTOF wall
140 cm × 5 cm × 2.5 cm	Electron PMT 187	Magnetic field protected, tentatively projected for the dipole TOF
100 cm × 10 cm × 2.5 cm	Electron PMT 187	Magnetic field protected, tentatively projected for the dipole TOF

Configuration of **DTOF** not yet finalized, 40-80 PM 187 (Electron) ?

# *Tests in 2009-2013:*

- @ PNPI, April 2009: **Yes, we can!** But thickness  $\geq 2.5$  cm,
- @ PNPI, November 2012: **Better than 100 ps FTOF prototype resolutions,**
- @ COSY-2012, December 2012, **PANDA Readout prototype,**
- @PNPI, June 2013,
- @PNPI, December 2013.

# PNPI-2013 proton beam tests



Protons: 920 MeV

Plastic: B408

140x5x2.5/1.5 cm

140x10x2.5 /1.5 cm

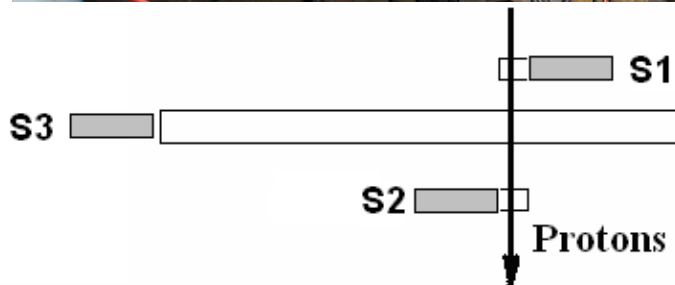
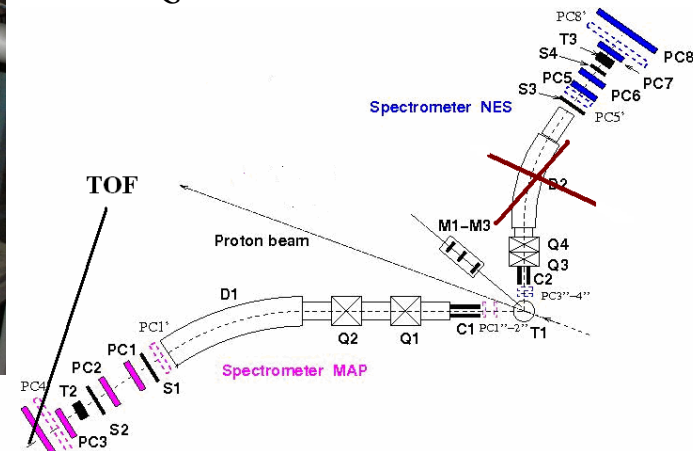
100x10x2.5 cm

140x2.5x2.5 cm

PMT's: R4998, R2083, FEU187,  
FEU 143

TDC: CAEN V775N

QDC: CAEN V792

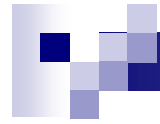


$$\Delta t = t_n - t_k - \left( \frac{a}{\sqrt{q_n}} - \frac{b}{\sqrt{q_k}} \right) - cx - d, n \neq k = 1,2,3,4$$

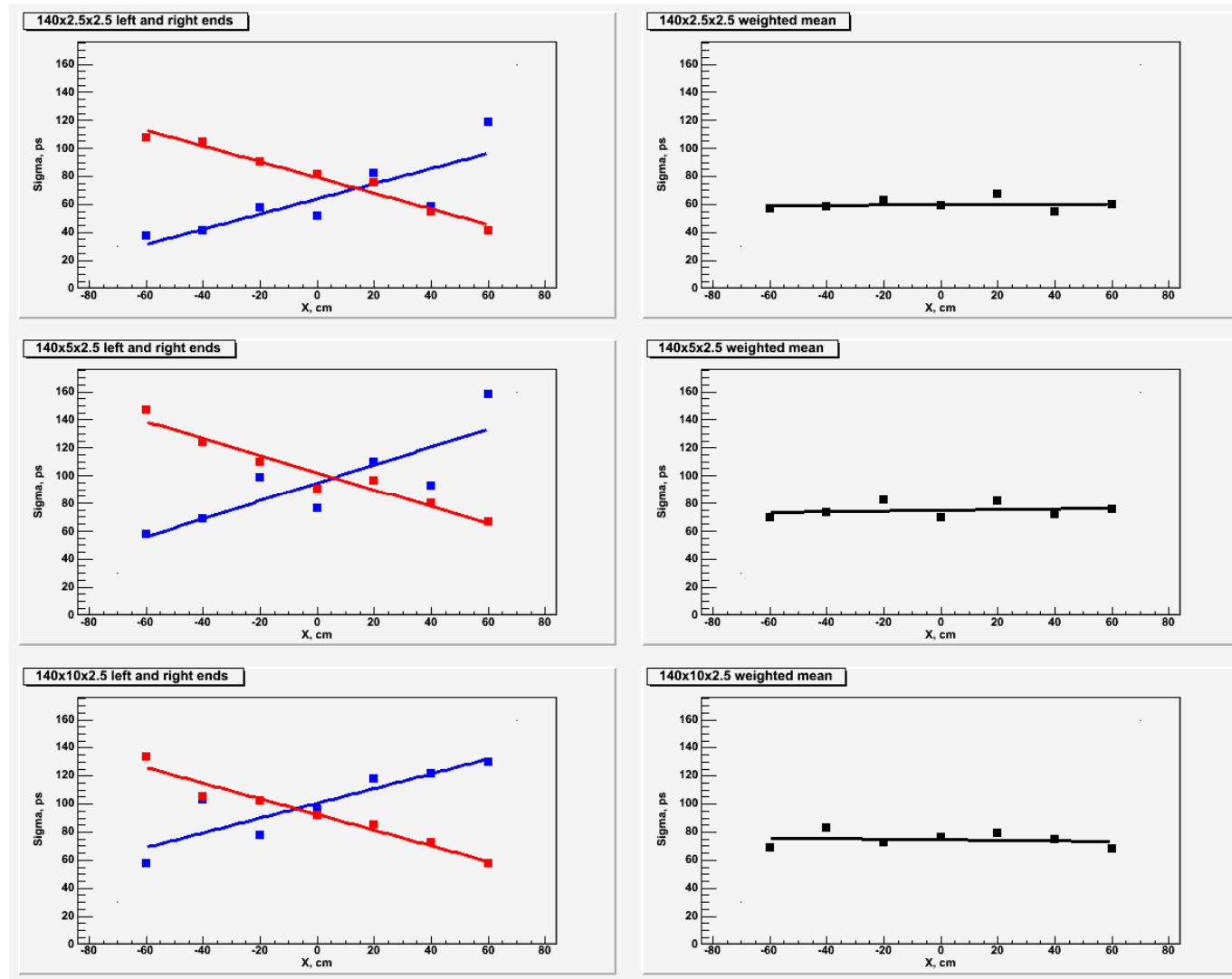
# Prototyping @ PNPI June 2013

- *Protons, 920 MeV,*
- *1.5x5x140 cm<sup>3</sup> with Hamamatsu R4998, worse than 120 ps*
- *1.5x10x140 cm<sup>3</sup> with Hamamatsu R2083, worse than 150 ps*
- *2.5x5x140 cm<sup>3</sup> with Hamamatsu R4998, better than 80 ps*
- *2.5x10x140 cm<sup>3</sup> with Hamamatsu R2083, better than 80 ps*
- *2.5x10x100 cm<sup>3</sup> with PMT 187, with and without PA, worse than 150 ps*
- *2.5x5x140 cm<sup>3</sup> with PMT 187, with and without PA, worse than 150 ps*
- *2x2x2 cm<sup>3</sup> with combination of R4998 and PMT 187 51-70 ps*





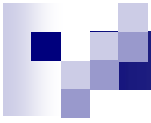
# Hamamatsu R4998 and R2083 results



# Prototyping @ PNPI December 2013

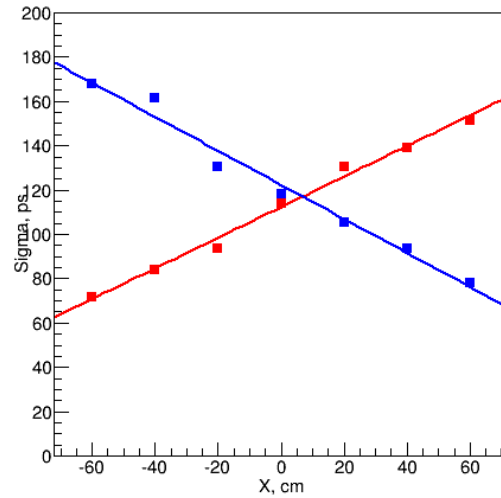
- *Protons, 920 MeV,*
- *2.5x5x140 cm<sup>3</sup> with PMT187, 2.5 cm along beam,* *worse than 200 ps*
- *2.5x5x140 cm<sup>3</sup> with PMT187, 5cm along beam,* *worse than 160 ps*
- *2.5x10x100 cm<sup>3</sup> with PMT143,* *worse than 400 ps*
- *2.5x5x140 cm<sup>3</sup> with Hamamatsu R4998,*
  - Count rate 230 k/sec* *better than 100 ps*
  - Count rate 430 k/sec* *better than 100 ps*
  - Count rate 700 k/sec* *better than 130 ps*
  - Count rate 820 k/sec* *worse than 150 ps*
- *2.5x2.5x140 cm<sup>3</sup>, PMT187* *better than 80 ps*



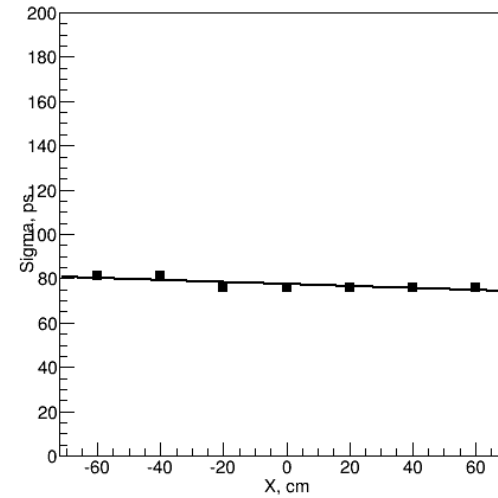


# ФЭУ187 Электрон

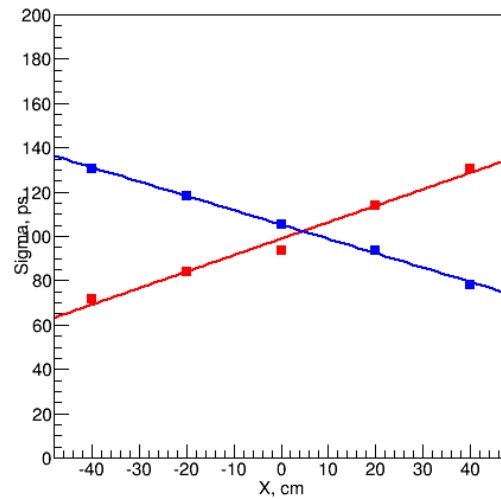
2.5x2.5x140 cm slab



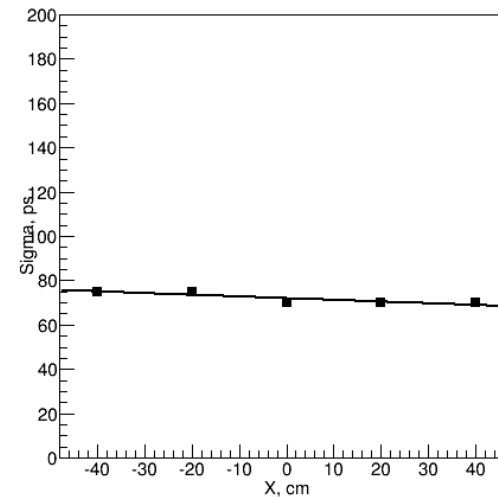
Weighted Mean



2.5x2.5x100 cm slab



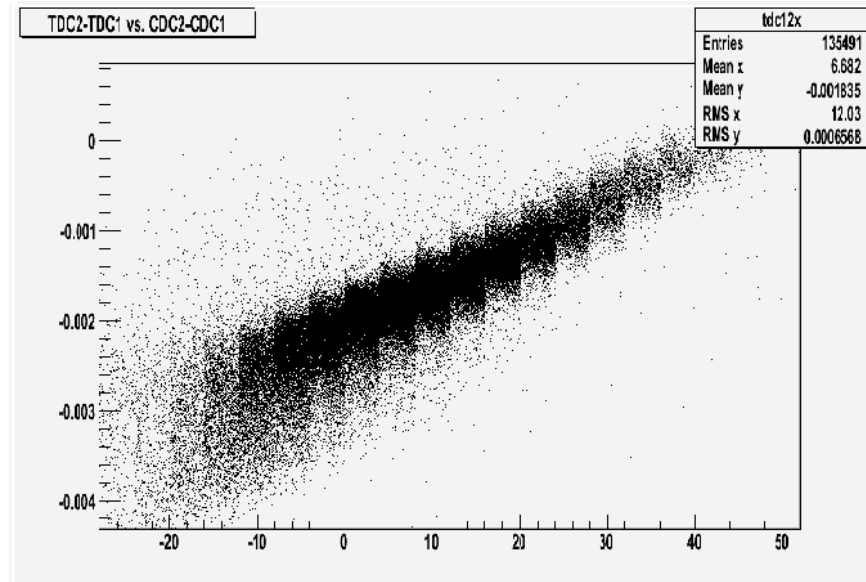
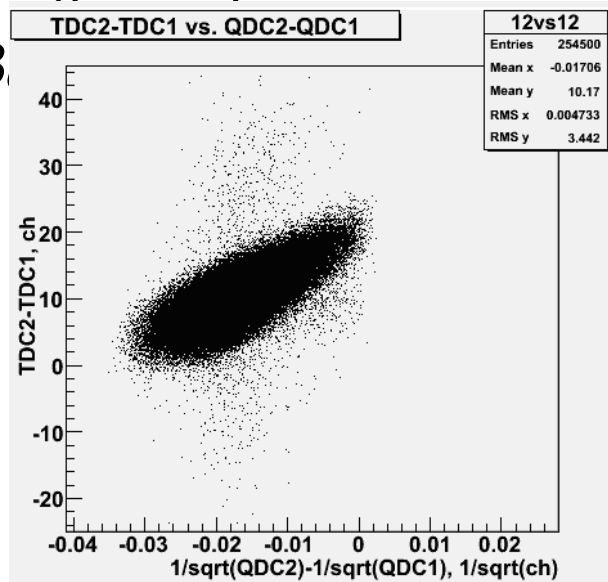
Weighted Mean



# Prototyping Status Quo - December 2013

- *Forward TOF Wall prototypes are done* *better than 80 ps*
- *Intensity higher than 1MHz?* *worse than 120 ps*
- *Side TOF Walls 187 3x3cm without light guides?* *better than 80 ps*
- *Magnetic field?* *to do*

■ B



# Global plan for FTOF / DTOF design, fabrication and installation 2014-2018

1. TDR approval, funding, tender, agreement, manufacturing concept. from 01.01.2014 to 31.05.2015 17 months

2. Material procurement, manufacturing and final prototype tests, manufacturing all components, detector pre-assembly. from 01.06.2015 to 31.03.2017 22 months

3. Shipment to FAIR: good inspection, test inspection, approval for installation, shipment from 01.04.2017 to 31.12.2017 9 months

4. Installation at HESR from 01.01.2018 to 30.09.2018 9 months

5. Commissioning from 01.10.2018 to 31.12.2018 3 months

**M3 9/2014**

**M8 04/2016**

**M10 06/2017**

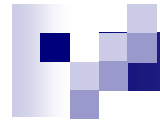
**M11 10/2018**

Approval of TDR

Prototype tested  
pre-series accepted

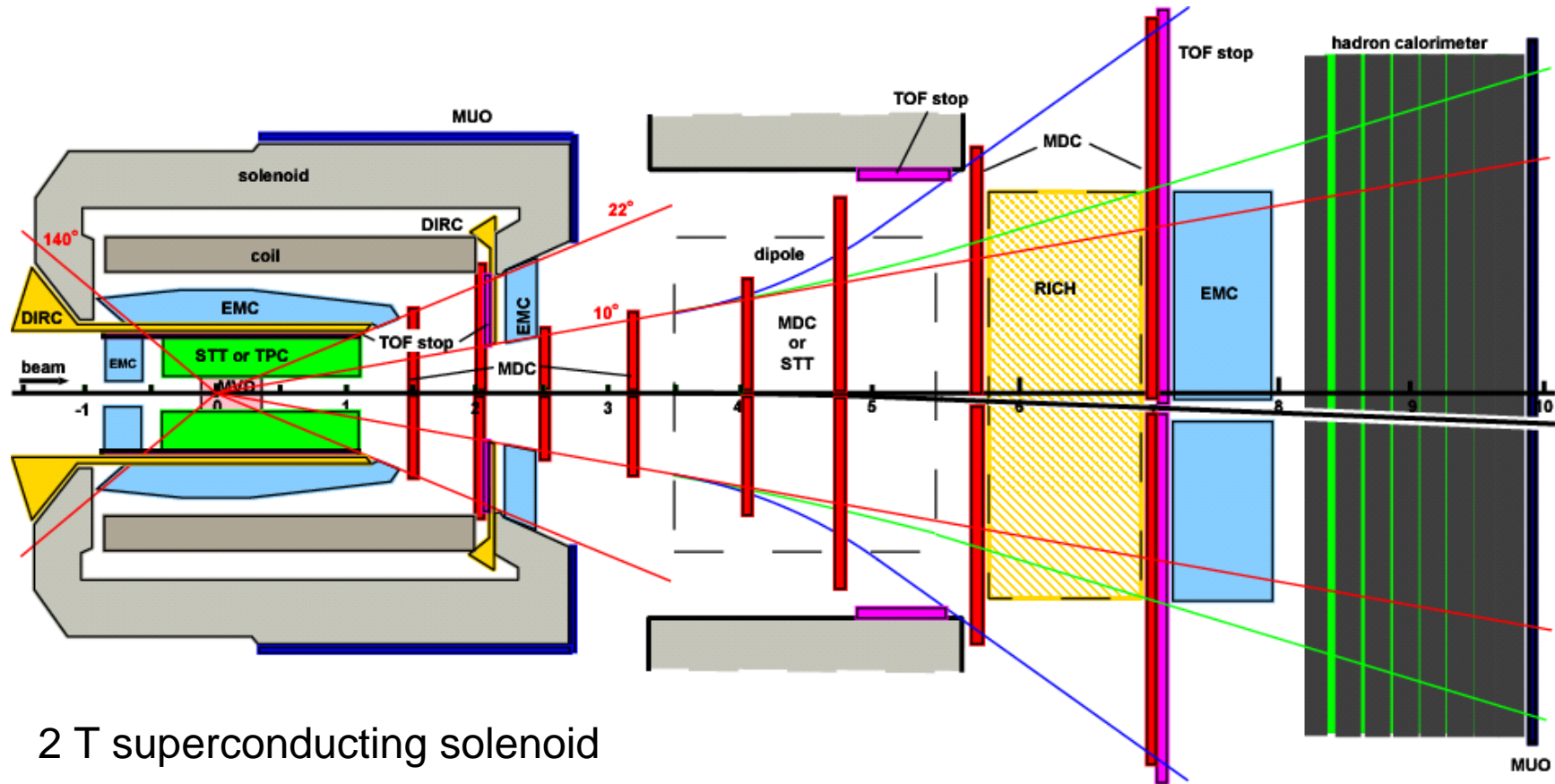
Approval for  
installation

Ready for beam



# Supporting slides

# Time-of-flight PANDA stop detectors (top view)



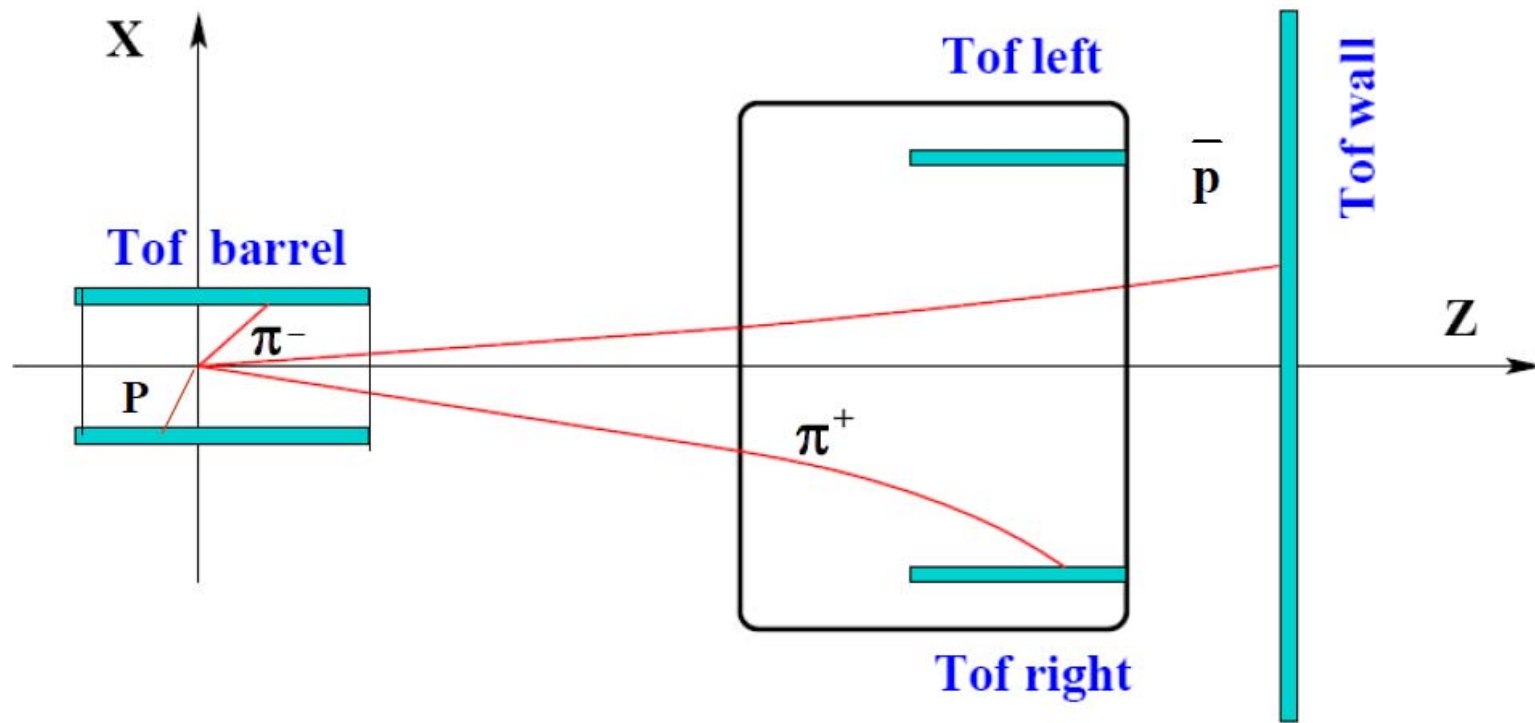
2 T superconducting solenoid

Barrel TOF

DIRC TOF

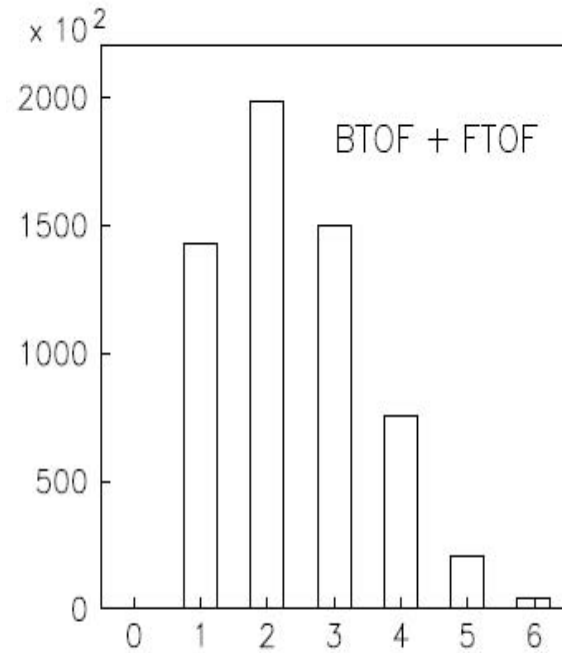
Dipole TOF

Forward TOF wall



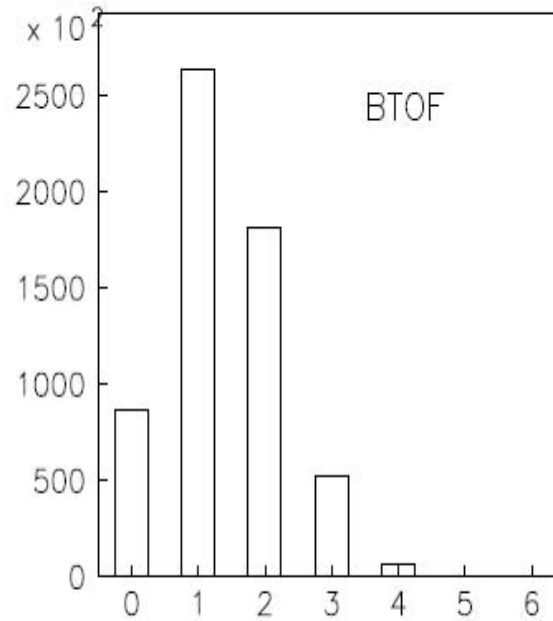


$N=1156000$



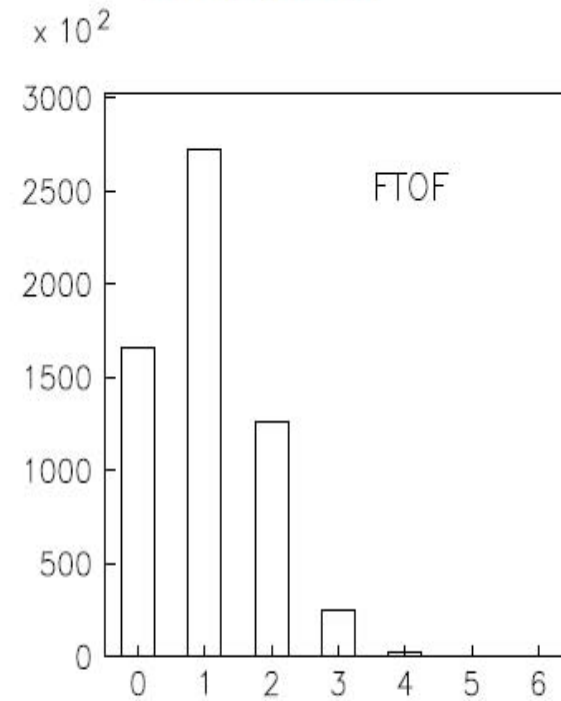
**BTOF + FTOF**  
 $\langle n \rangle = 2.40$

$N=658000$



**BTOF**  
 $\langle n \rangle = 1.61$

$N=498000$



**FTOF**  
 $\langle n \rangle = 1.43$



***Monte Carlo simulation  
In PANDAROOT Framework***

- *Study various PID options  
using TOF/DTOF detectors;*
- *Optimize configuration  
of DTOF in the dipole;*
- *Update calculations of  
Individual FTOF/DTOF slabs at  
max luminosity;*

***Design and prototyping***

- Finalize prototyping  
FTOF counters;
- Complete study of PM-187  
in strong magnetic field for  
DTOF prototyping;
- Work out project of GMS
- Work out project of supporting  
mechanical structures and cabling

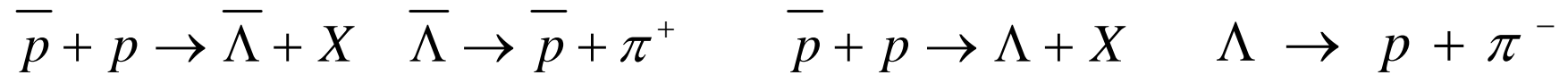
**TDR** first draft ready by March,  
approval September

# Global Detection Efficiency

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

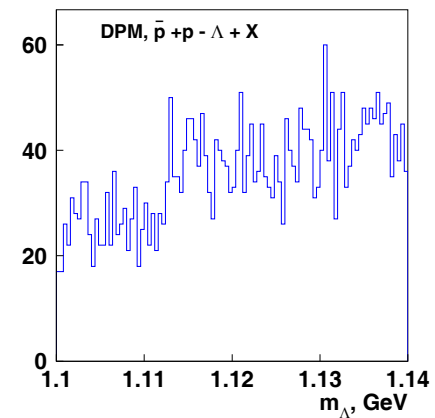
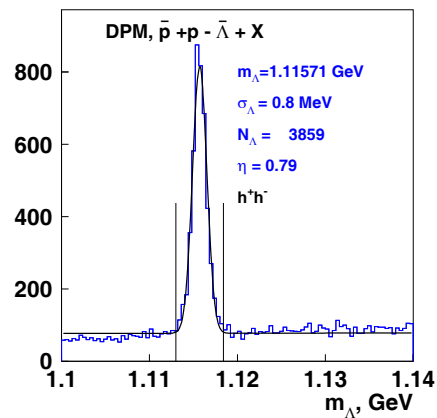
	Generated by DPM	Detected by FTOF wall	detection efficiency
$\pi^-$	880346	172188	0.195
$\pi^+$	877255	150440	0,171
$K^-$	30179	5820	0.192
$K^+$	26811	2863	0.107
$\bar{p}$	453293	202174	0.446
$p$	398323	51241	0.129
$\bar{\Lambda} \rightarrow \bar{p} + \pi^+$	19874	3840	0.193
$\Lambda \rightarrow p + \pi^-$	19518	12	$\approx 0.6 \cdot 10^{-3}$

# $\Lambda$ selection using FTOF wall

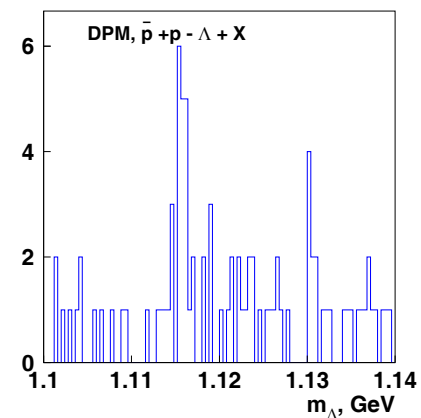
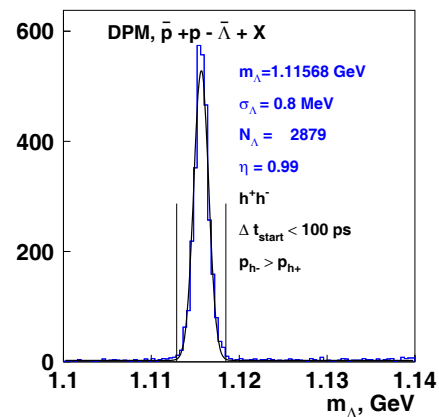


*2-hadrons of opposite charge are detected*

$$m(H^-) = m_p \quad m(H^+) = m_\pi \quad \text{for } \bar{\Lambda} \quad m(H^-) = m_\pi \quad m(H^+) = m_p \quad \text{for } \Lambda$$



*Same with time-of-flight and kinematic criteria*





# planning January 2014 to July 2016



Unique No	PSP Code	Activity	Estimated Cost	Start	End
1	1.4.1.9	01_04_01_09 Forward TOF	€ 0,00	01.01.2014	20.12.2018
2		<b>Design and planning</b>	€ 0,00	01.01.2014	31.05.2015
3		Compile TDR [A3]	€ 0,00		
4	1.4.1.9	Approval of TDR [M3]	€ 0,00		30.09.14
5		Prepare funding request (EXP) [AE1]	€ 0,00		
6		Funding established (EXP) [ME1]	€ 0,00		30.11.14
7		Tendering (EXP) [AE2]	€ 0,00		
8		Tender completed (EXP) [ME2]	€ 0,00		01.02.15
9		Prepare contract [A4]	€ 0,00		
10		Contract is signed [M4]	€ 0,00		31.03.15
11		Prepare manufacturing concept and documentation [A7]	€ 0,00		
16		FDR accepted / planning completed [M7]	€ 0,00		31.05.15
17		<b>Production / Procurement</b>	€ 0,00	01.06.2015	20.12.15
18		Acquire material [AX1]	€ 0,00		
19		All material is acquired [MX1]	€ 0,00		20.12.15
20		<b>Manufacturing of pre-series / prototype</b>	€ 0,00	01.01.2016	30.06.2016
21		Manufacturing of pre-series / construction of prototype [A8]	€ 0,00		
22		Testing of pre-series / prototype [A89]	€ 0,00		
23	1.4.1.9	Pre-series accepted / prototype tested [M8]	€ 0,00		30.06.16
24		<b>Manufacturing of series / component</b>	€ 0,00	01.07.2016	20.31.2016
47		Series production started [M81]	€ 0,00		
28		Component construction (EXP) [A92]	€ 0,00		
29		Component testing (EXP) [A92]	€ 0,00		
30		Component shipment (EXP) [A94]	€ 0,00		
31		Module pre-assembly (EXP) [A95]	€ 0,00		
32		Module testing (EXP) [A96]	€ 0,00		
33		FAT accepted / acceptance test completed [M9]	€ 0,00		

# TOF Detector

**Goal:** identification of forward going charged particles detected by FS with momenta below 4-5 GeV/c. TOF resolution ~50 ps.

## TOF detector consist of :

- scintillation wall (1.4\*5.6 m<sup>2</sup>, 66 strips, 132 PMT)
- side-TOF, inside the dipole magnet -two (1\*1 m<sup>2</sup>, 10 strips 20 PMT)

## Cost estimation:

- materials (scintillators, light-guides, optical cement..)	- 43000 €
- PMT (PMT, housings, dividers, $\mu$ -metal shielding,...)	- 170000 €
- electronics (TDC, CFD, VME crates, .....)	- 120000 €
- HV power supply, cabling	- 60000 €
- Support structure	- 20000 €
- Test stand	- 35000 €
<hr/>	
total	- 448000 €