Времяпролетный детектор PANDA

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Seminar 19.05.15

PANDA. Motivation.

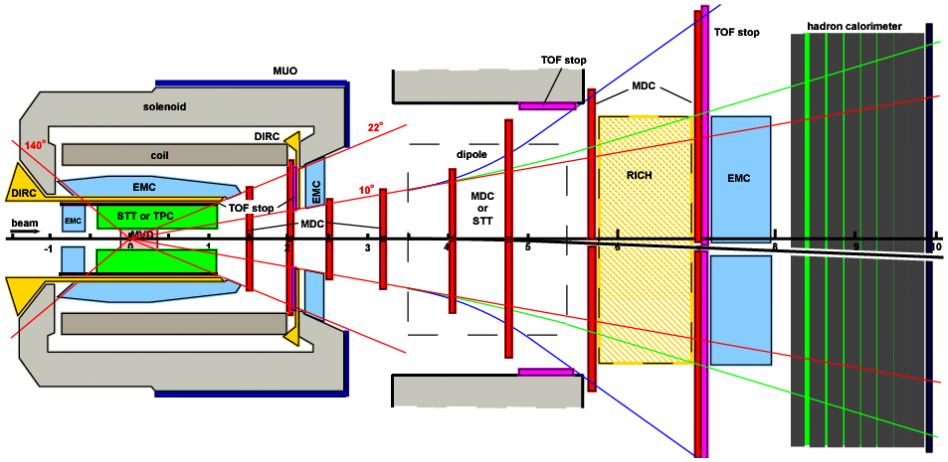
- Hadron spectroscopy,
  - Exotic (glueballs, hybrids)
  - Charmonium spectroscopy,
  - D-spectroscopy,
  - Barion spectroscopy,
- Hadron modification in nuclear,
- Nuclon structure,
  - Generalized Parton Distributions,
  - Time-like Form Factor of the Proton
- Hypernuclei.

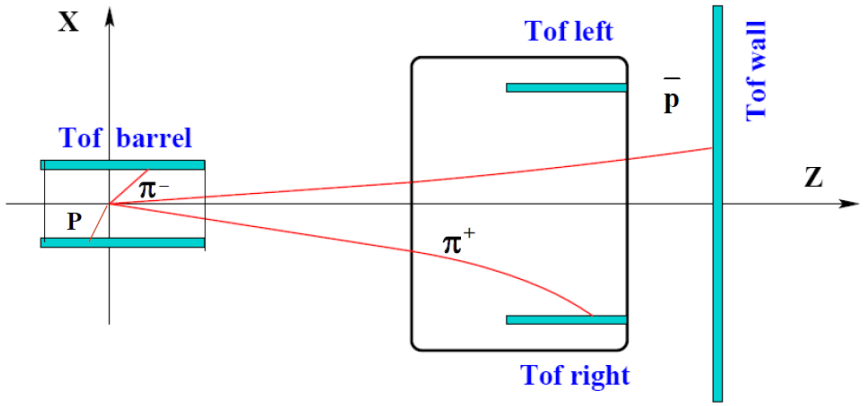
PANDA TOF WALS

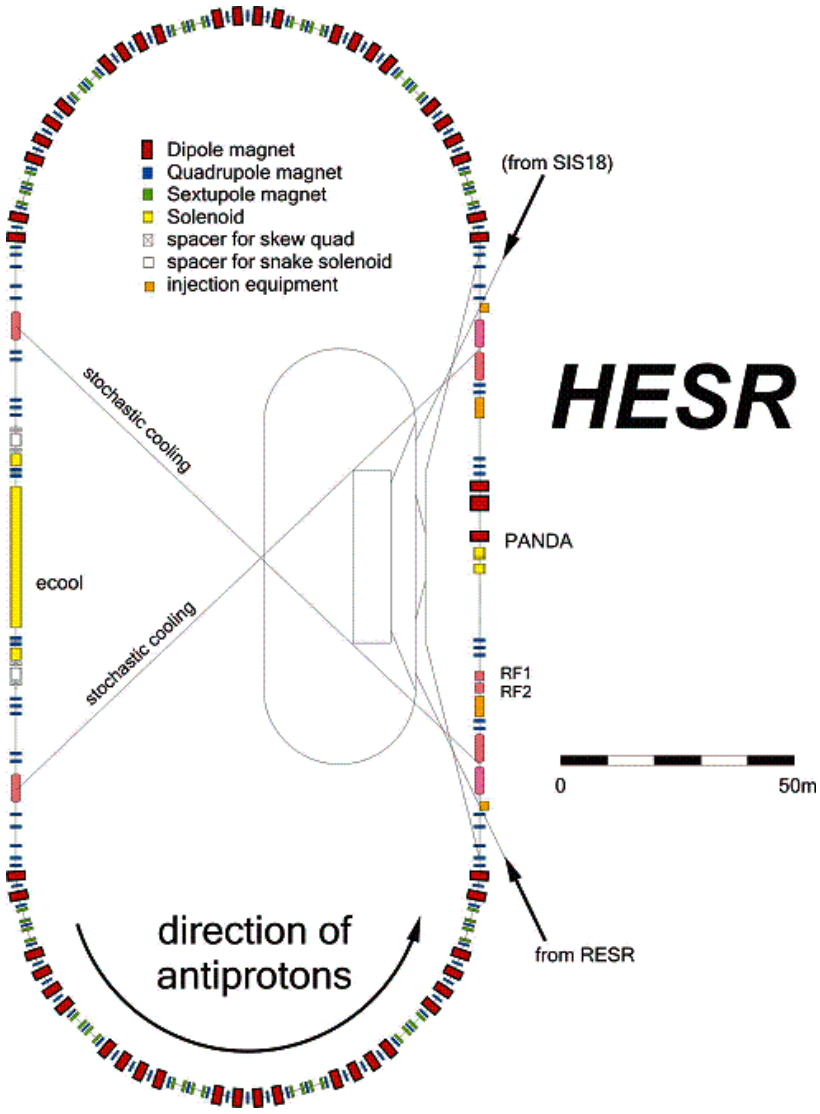
P=1.5-15 Gev/c

$\Delta P = 10^{-5}$

$Lumi = 2x10^{32}\ 1/cm^2 s$

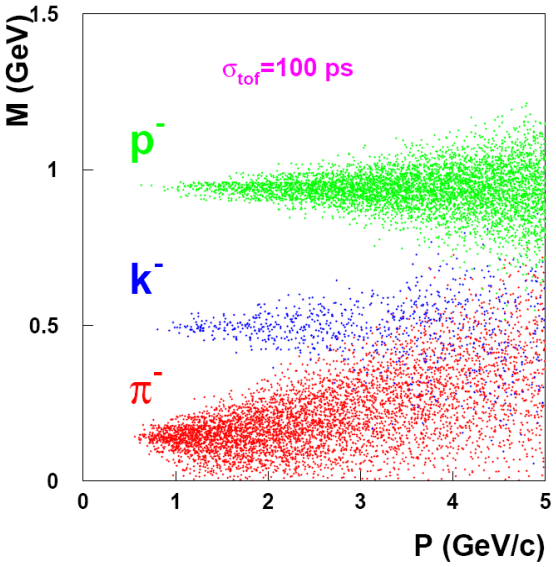




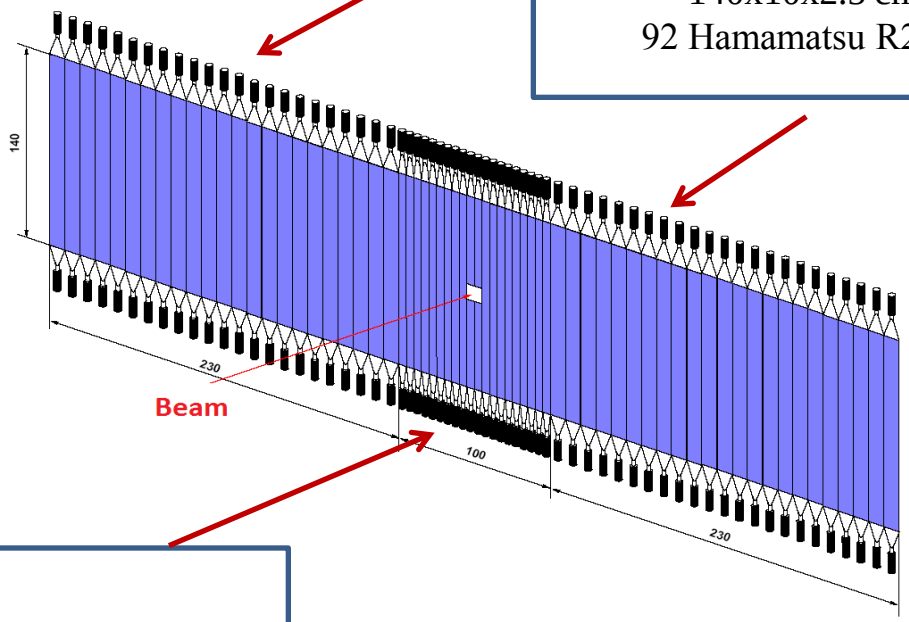


FTOF wall

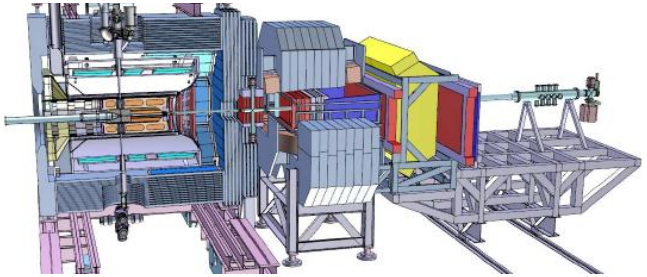
positioned at 7.5 m
from the IP



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")

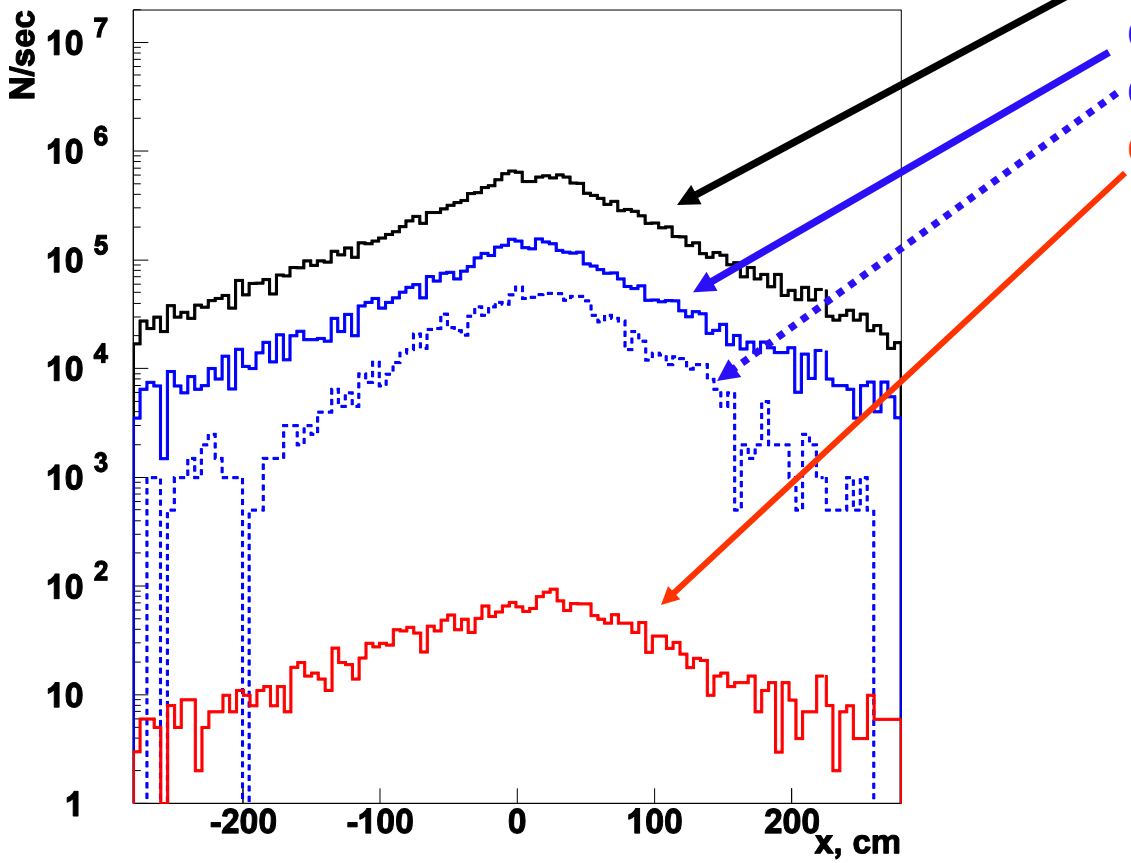


Detection efficiency and count rates of charged hadrons

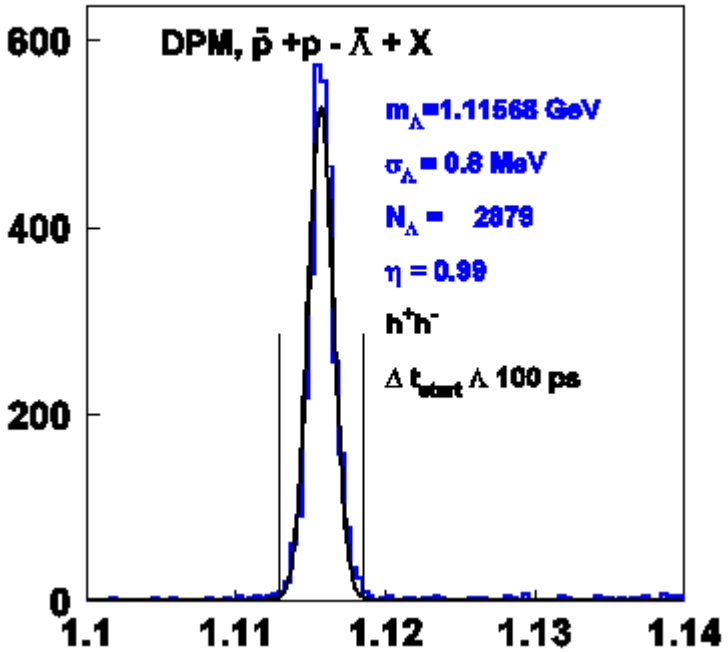
Count rates scaled to 10^7 interactions in target

	Generated by DPM (80K events)	Detected by BTOF (eff / N per sec)	Detected by DTOF (eff / N per sec)	Detected by FTOF (eff / N per sec)
π^-	90693	0.36 / 4.08 · 10^6	0.01 / 0.14 · 10^6	0.23 / 2.59 · 10^6
π^+	90725	0.44 / 5.03 · 10^6	0.002 / 0.03 · 10^6	0.18 / 2.07 · 10^6
K^-	3022	0.09 / 0.03 · 10^6	0.001 / 0.0004 · 10^6	0.26 / 0.1 · 10^6
K^+	3082	0.25 / 0.09 · 10^6	0.003 / 0.001 · 10^6	0.12 / 0.046 · 10^6
p-bar	42095	0.007/ 0.04 · 10^6	0.0002 / 0.001 · 10^6	0.62 / 3.24 · 10^6
p	42003	0.61 / 3.19 · 10^6	0.002 / 0.012 · 10^6	0.07 / 0.35 · 10^6

Background

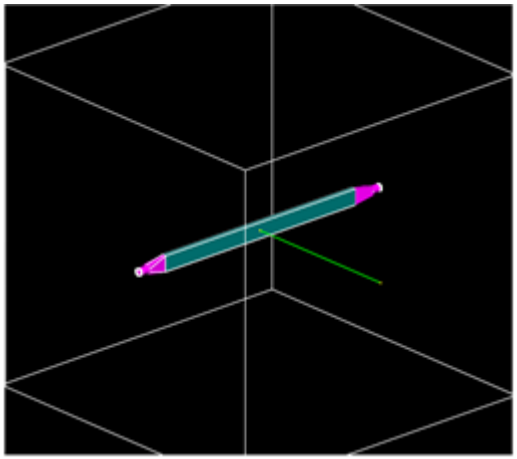

N/sec
10 7
10 6
10 5
10 4
10 3
10 2
10
1
-200
-100
0
100
200
x, cm
All charged hadrons
e+e- all
e+e- from EMC
e+e- from π 0 → γ γ

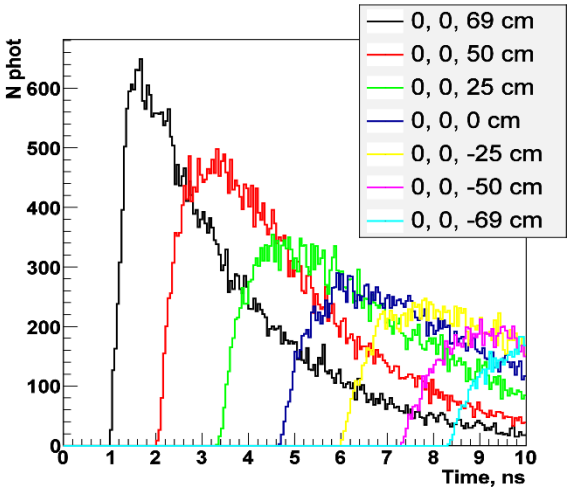
Lambda MC

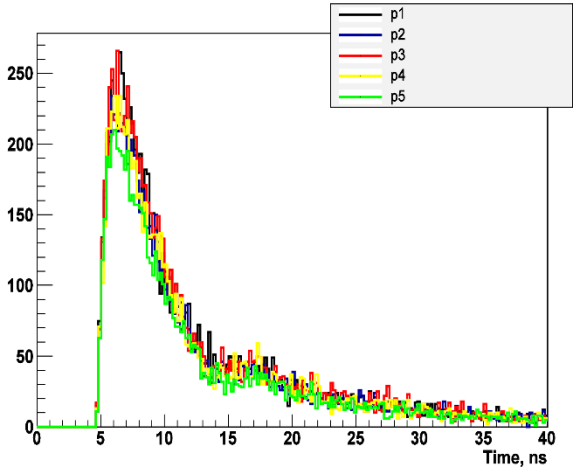


. Invariant Lambda-bar mass peak for the particles detected by forward TOF wall. Combination of hadron-hadron pairs with opposite charge and hypotesis that negative particle is anti-proton and positive particle is a pion used and calculated start time used: ($t_{\text{start p-bar}} - t_{\text{start pion}} < 100$ ps).

Prototype MC

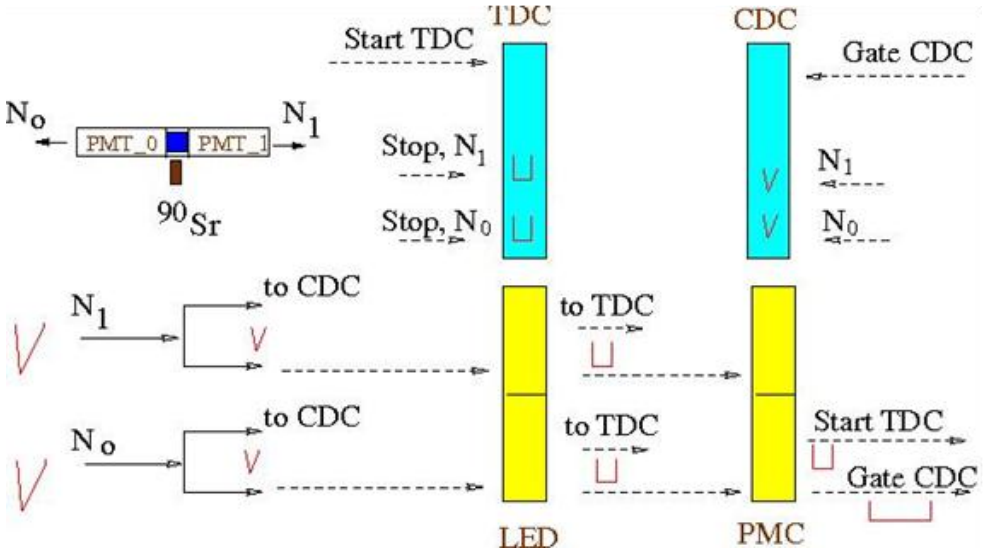


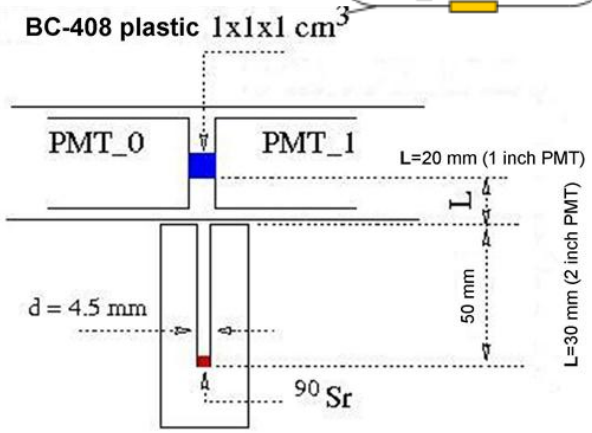


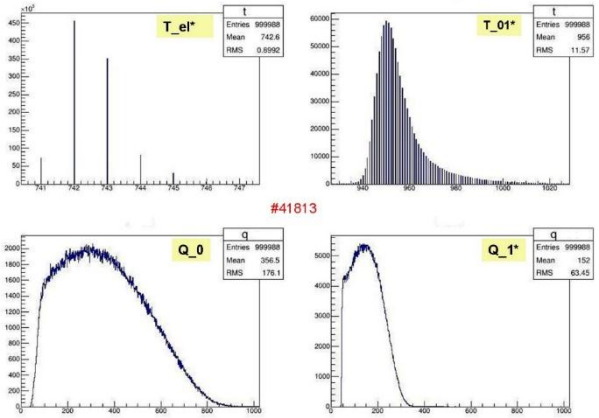


- *BC408 2.5x10x140 cm³*
- *1000,1500,2000 MeV*
- *X = 0, 25, 50 cm*
- *Y = 0, 2, 4 cm*

Test Station



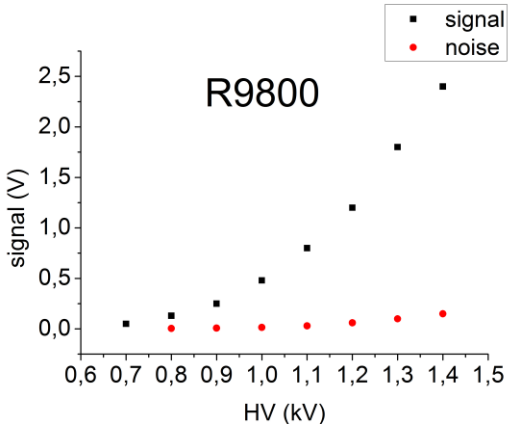


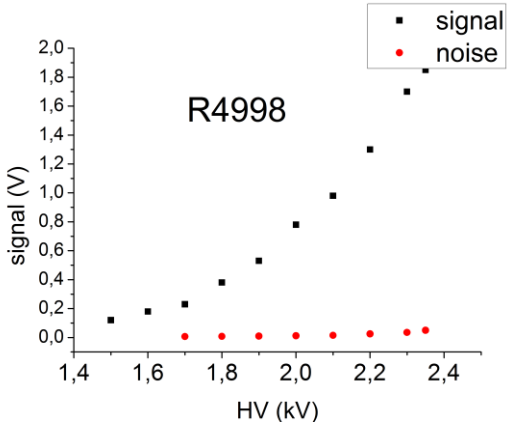


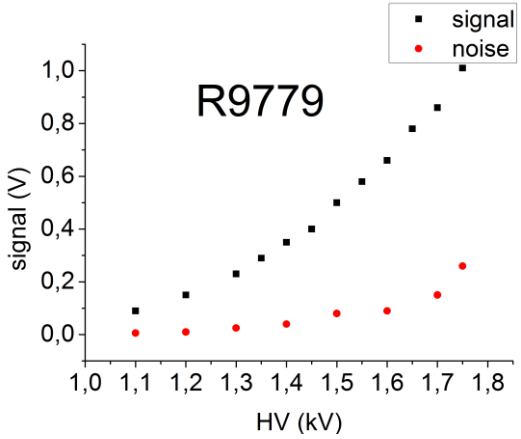
- *R4998* 1”
- *R2083* 2”
- *R9779* 1”
- *R9800* 2”
- *XP2020* 2”
- *Electron FEU187* 1”
- *SiPM S10931-50p* 3x3 mm^2

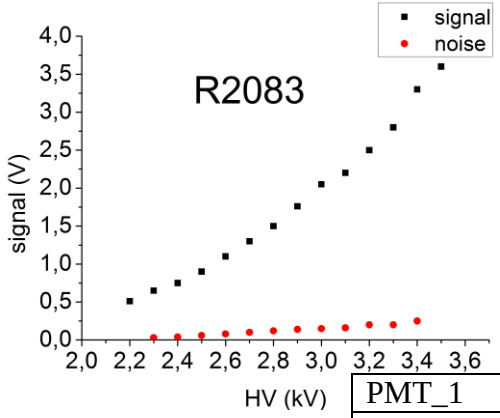
PMT	Photocathode diameter (mm)	Anode pulse rise time (ns)	Electron transition time (ns)	Transition time spread (ps)	Gain / 10^6	Typical voltage (V)
R4998	25 (1 inch)	0.7	10	160	5.7	2250
R9800	25 (1 inch)	1.	11	270	1.1	1300
R2083	51 (2 inch)	0.7	16	370	2.5	3000
R9779	51 (2 inch)	1.8	20	250	0.5	1500
XP2020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

Test Station 2



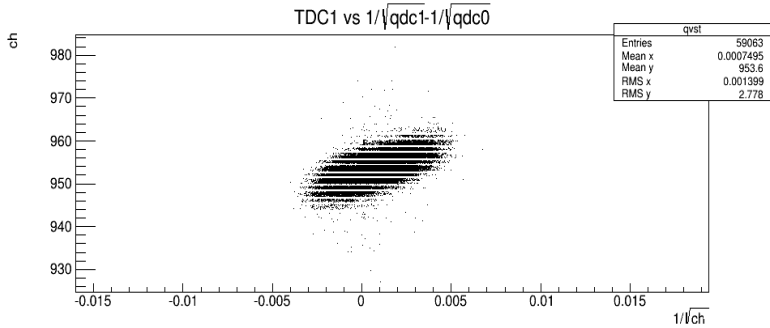






Photocathode 1”			
PMT_0	PMT_1	Applied HV_0 (kV)	Applied HV_1 (kV)
R4998	R4998	2.	1.9
R4998	R9800	2.	1.35

Photocathode 2”			
PMT_0	PMT_1	Applied HV_0 (kV)	Applied HV_1 (kV)
R2083	R2083	2.7	2.7
R2083	R9779	2.7	1.6
XP2020	XP2020	2.35	2.25
XP2020	XP2020	2.5	2.36

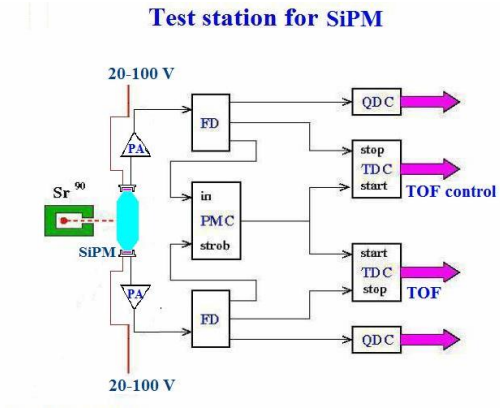


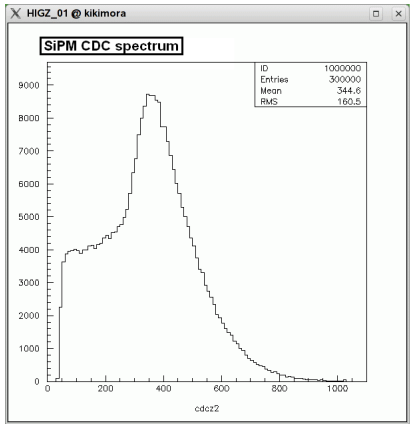
PMT_1	σ_{TDC_1} (ps)	σ_{PMT} (ps)
R4998 (4998/4998)	72.	44.4
R9800 (4998/9800)	86.	64.6
R2083 (2083/2083)	72.6	44.9
R9779 (2083/9779)	64	56.5
XP2020 (2.5, 2.36kV)	82	52,3

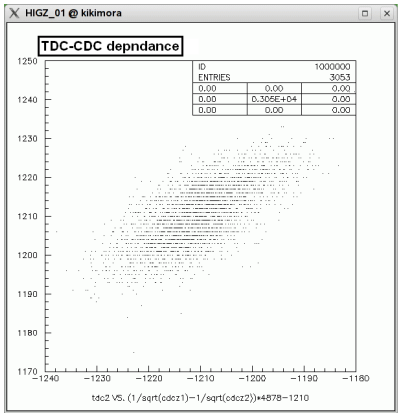
PMT R4998 & SiPM S10931-50p at the Test Stand.

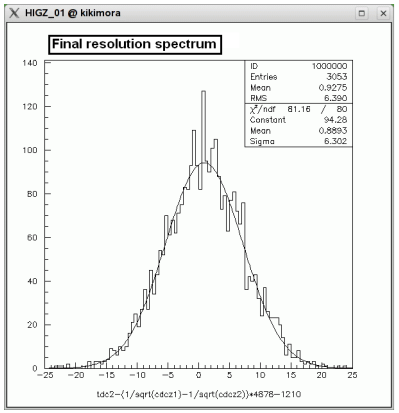
SiPM NxN matrixes!

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

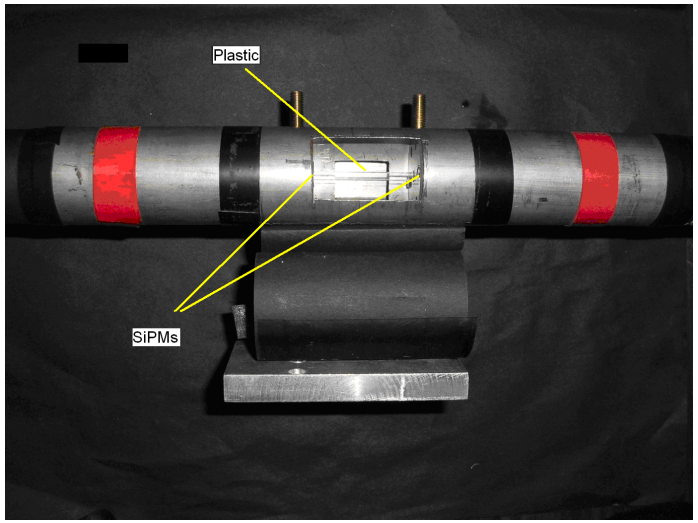


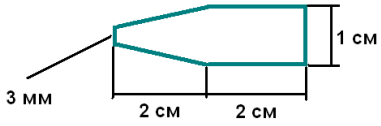






B408 – 3x3x40 mm³
TDC – 25 ps/chan
PA - ~8 times
Source - ^{90}Sr





σ worse than 160 ns

R4998

Run	σ_0	σ_1	σ_2
40366	326	168	149
40367	497	170	142
40368	486	176	147

S10931-50p

Run	σ_0	σ_1	σ_2
40366	608	195	157
40367	543	199	151
40368	557	193	150

SiPM Radiation Hardness Test @ 1GeV PNPI Proton Beam.

- The absolute beam intensity was determined in a standard way by measuring induced radioactivity of irradiated aluminum foils.
- The beam intensity during the tests was varied in the range 1.3 - 2.1x10^8 $cm^{-2}s^{-1}$.
- The SiPM sample was not powered!
- Radiation was exposed in 10 successive periods about 10 minutes each. The integrated number of protons passing through the sensitive surface of the SiPM sample with the cross-section of 3x3 mm^2 was 0.9*10^{11}. By our estimations, such dose corresponds approximately to irradiation to be collected by a similar SiPM installed on a central scintillation bar of the Forward wall during 10 years of continuous beam producing hadrons off the PANDA target.
- SiPM parameters (dark noise, amplitude and time characteristics for different values of high voltage) were measured before and after the radiation test using test station with ^{90}Sr electron source.

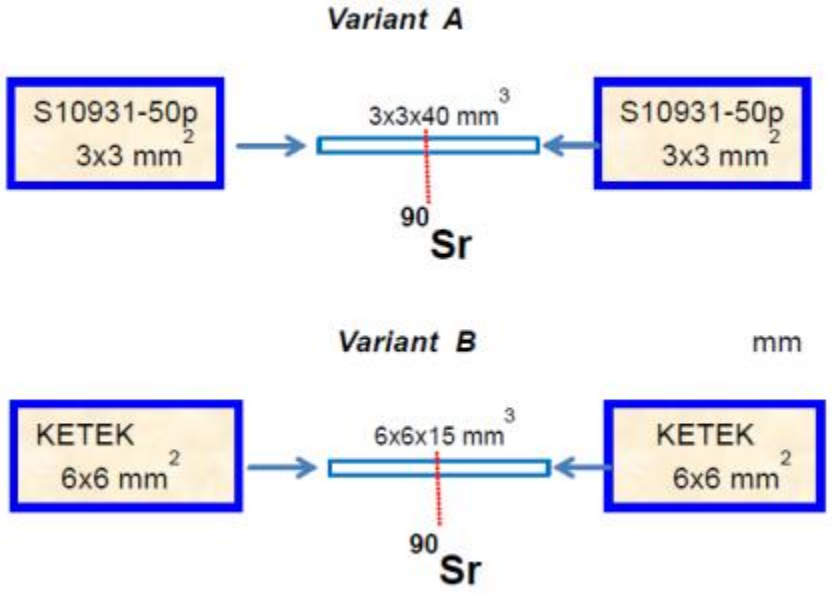
U,V	I, μA	A, mV	Noise	Noise+^{90}Sr
72.06	0.15	40	1550	8700
72.53	0.30	80	4230	18500
72.06	81.0	4	2800	6200
72.53	113.0	6	99000	102000

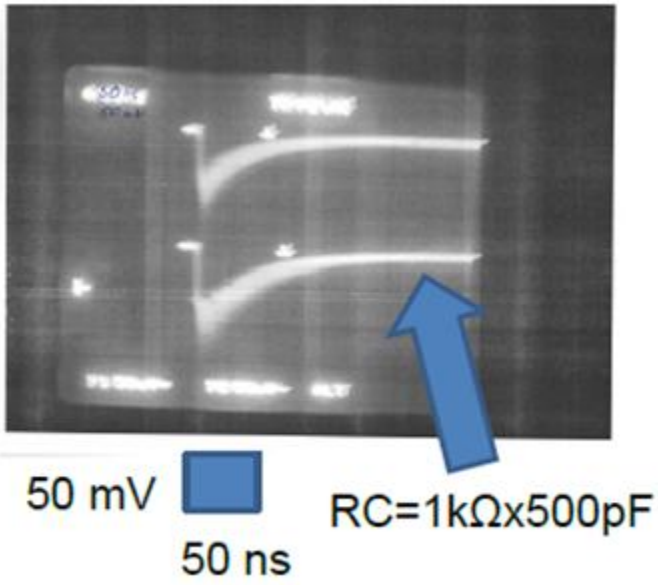
As it is seen from the table the SiPM was practically killed by this dose the value of which can be taken as upper limit,

- Yet it is important to find out at which dose the sample start malfunctioning,
- It is also important to compare irradiation effect on unpowered and powered samples,
- All this will constitute our nearest experimental program with SiPM samples.

$\Delta T = 0.056\ C^o$ *this is not heat!*

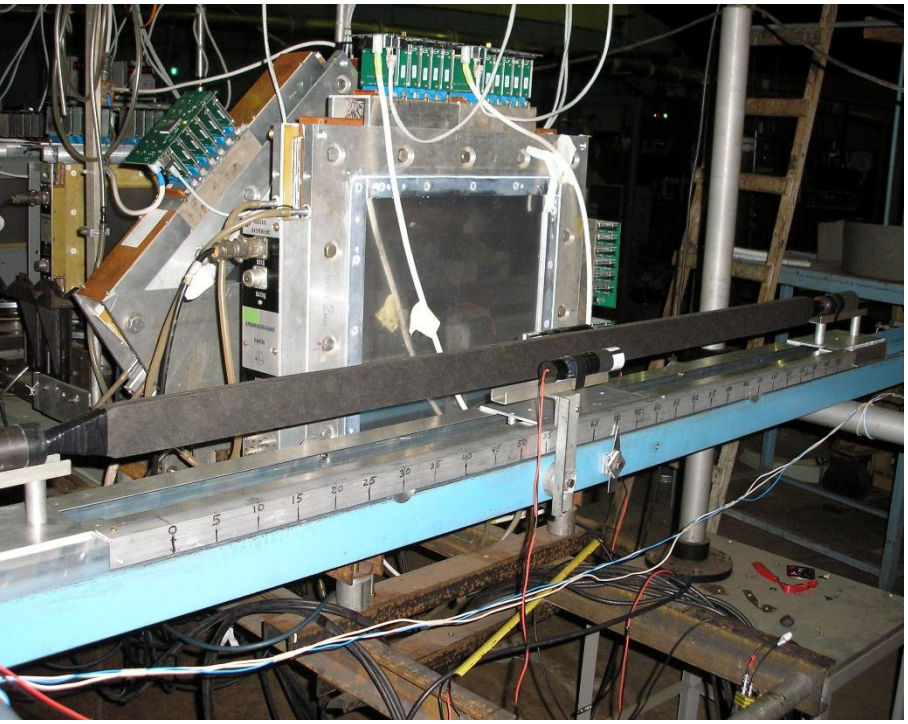
SiPM KETEK 6660.

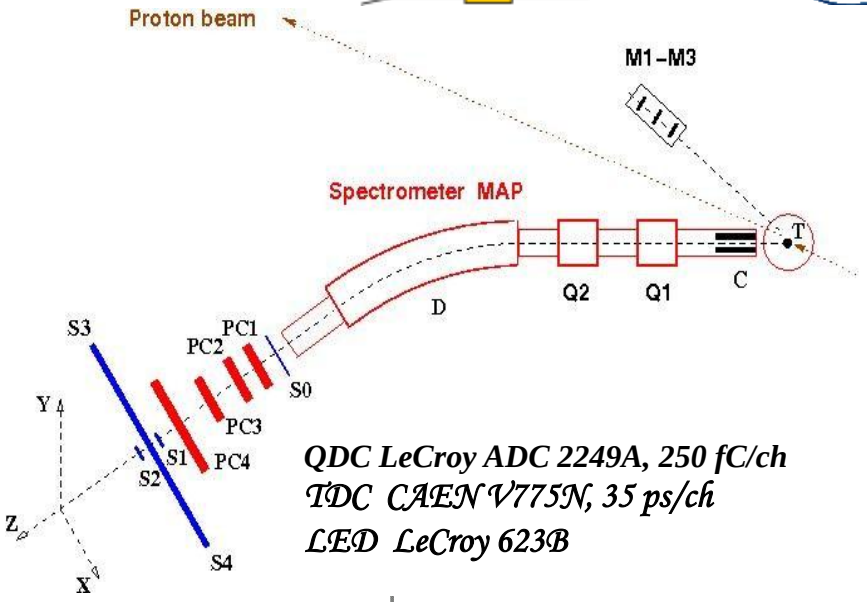




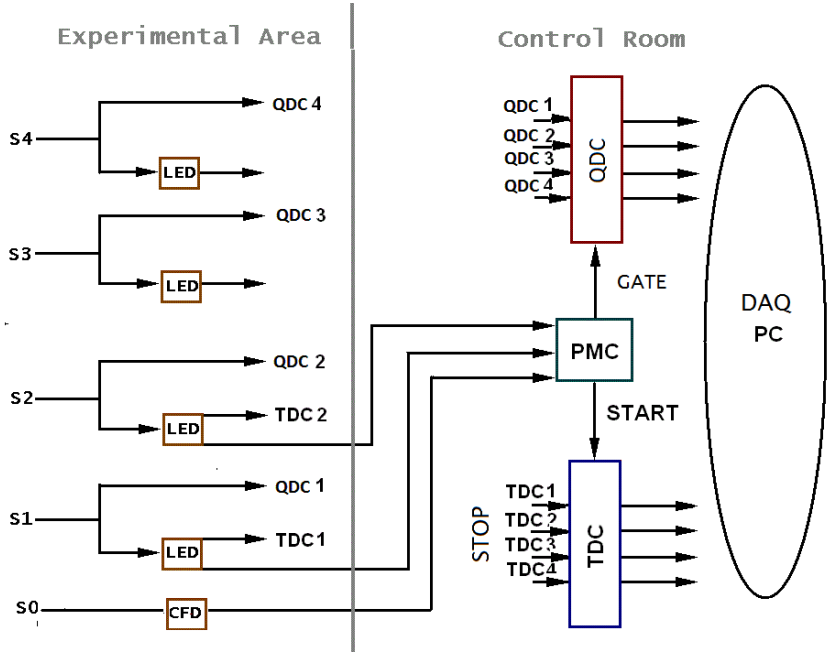
Supply voltage (V)	Signal amplitude (mV)	Noise amplitude (mV)	Current without ^{90}Sr (mkA)	Current with ^{90}Sr (mkA)	σ_{TDC_1} (ps)	(ps)	σ_{KETEK} (ps)
26.35	20÷30	~ 0.3	7.5	9	120	84.8	81.1
26.85	70÷90	~ 0.5	11	13	100	70.7	66.1

On beam setup at PNPI

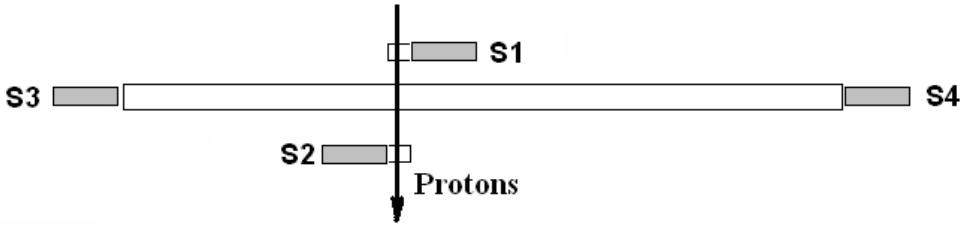




QDC LeCroy ADC 2249A, 250 fC/ch
TDC CAEN V775N, 35 ps/ch
LED LeCroy 623B



Protons 730 and 920 MeV

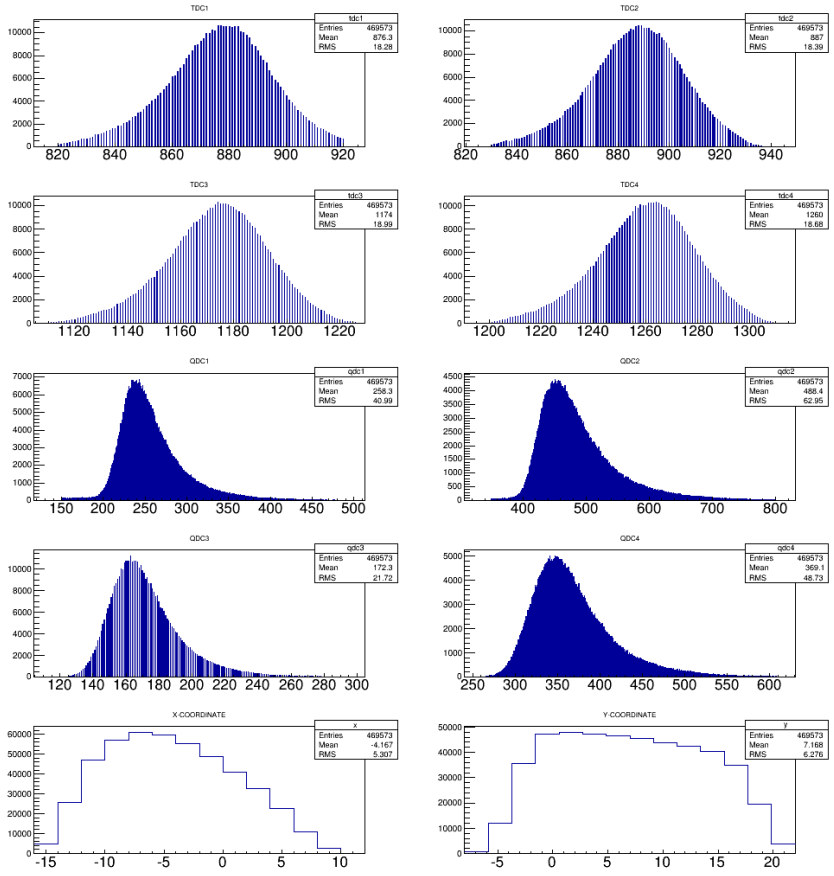


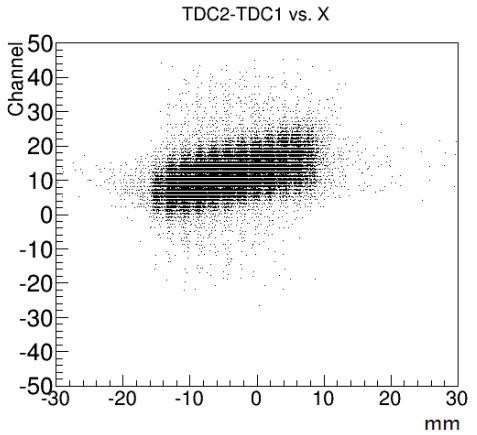
Offline analysis

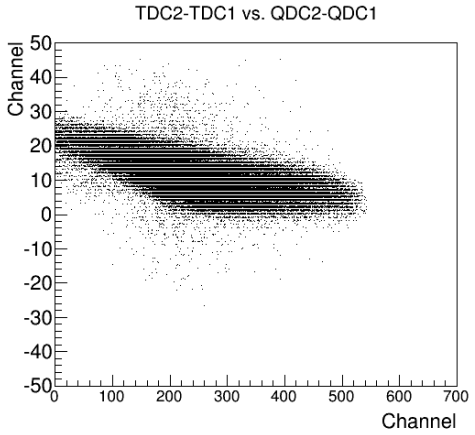
$$\Delta t = t_i - t_k - a\left(\frac{1}{\sqrt{q_i}} - \frac{1}{\sqrt{q_k}}\right) - bx - c, i \neq k = 1,2,3,4$$

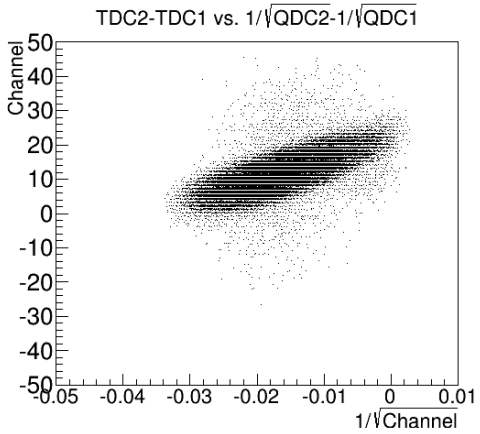
1. Coincidence of 8 planes of 4 PC
2. Coincidence of 4 TDC channels
3. Coincidence of 4 QDC channels

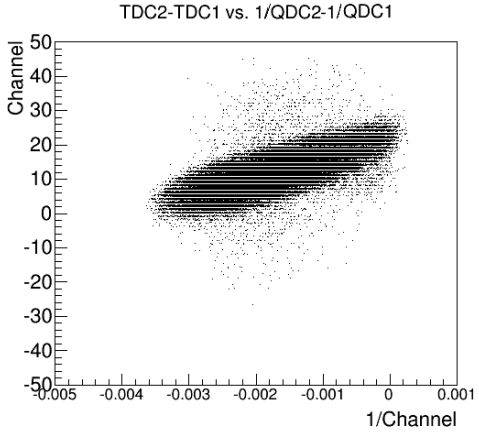
$$\left\langle t_{ik}^2 \right\rangle - \left\langle t_{ik} \right\rangle^2 = \frac{1}{N}\sum_{n=1}^{N} t_{ik,n}^2 - \left(\frac{1}{N}\sum_{n=1}^{N} t_{ik,n}\right)^2.$$



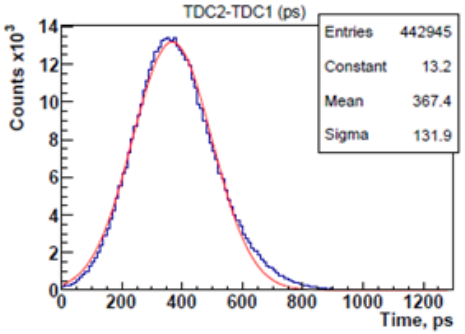


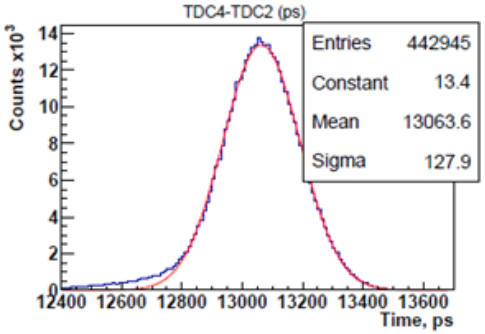


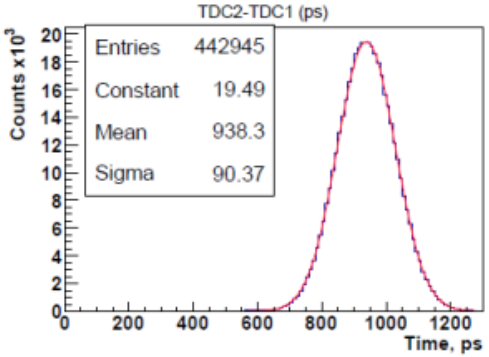


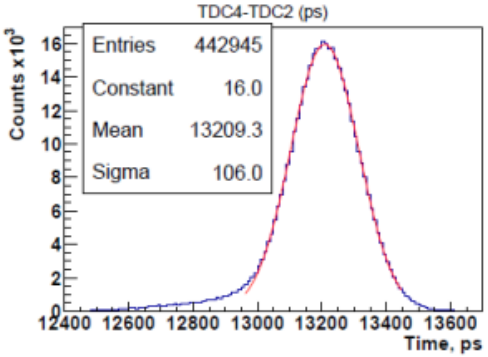


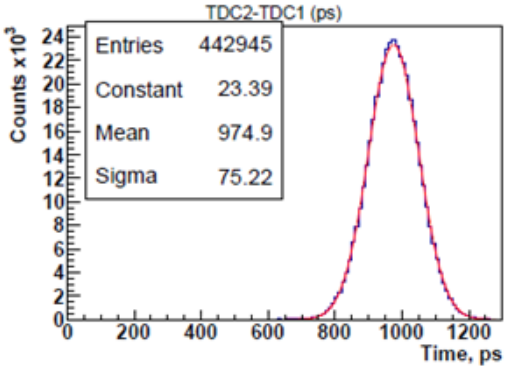
Offline analysis. Corrections.

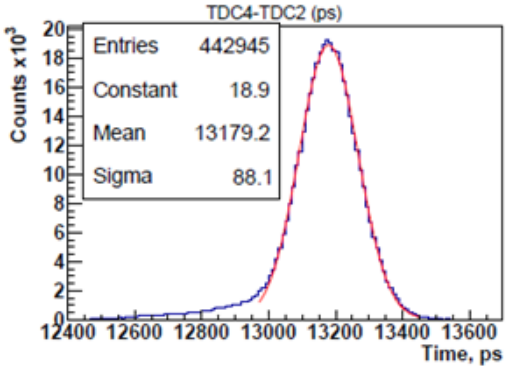




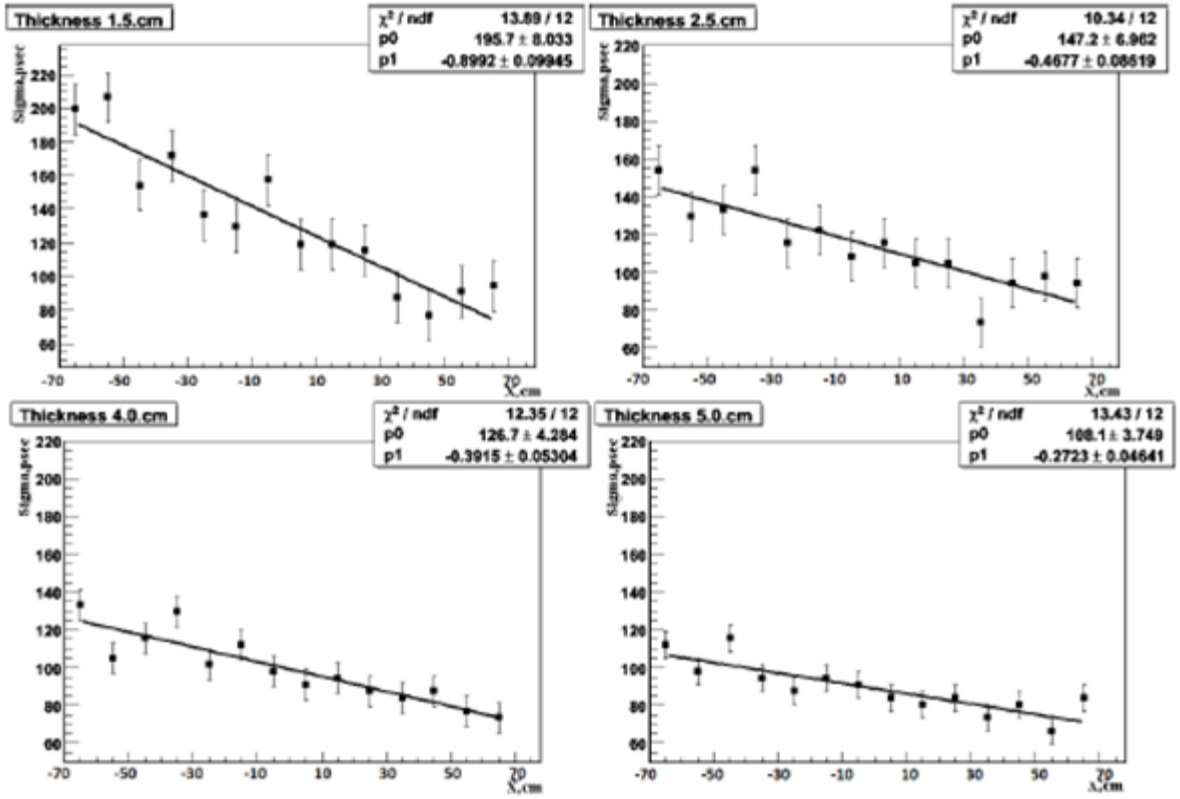








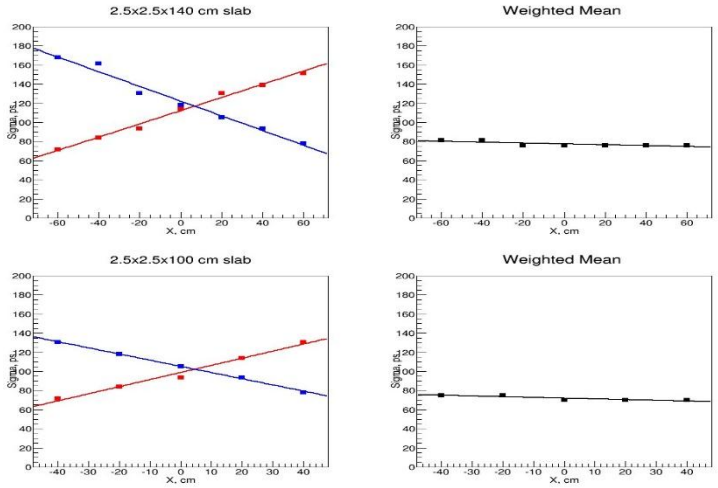
Results at 730 MeV.



On beam results

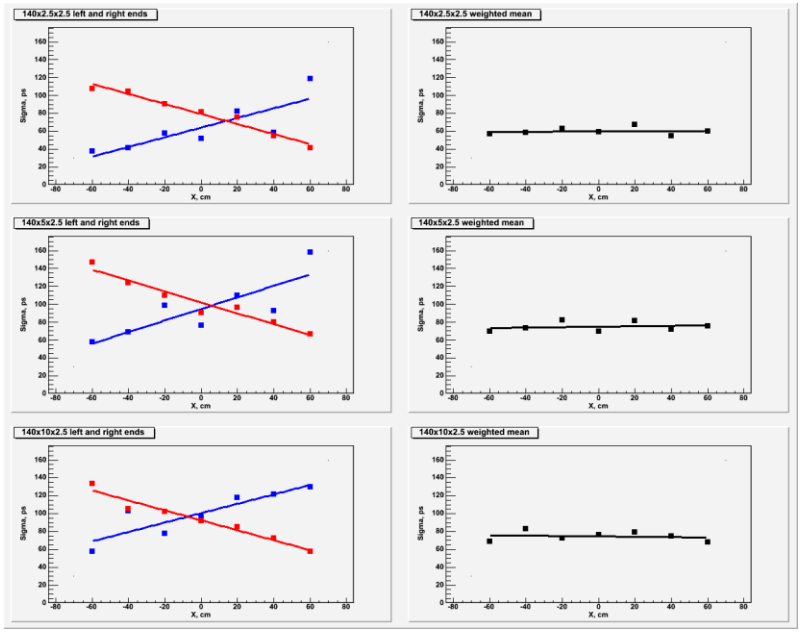
Thickness x width x length, cm	Photomultiplier
1.5 x 5 x 140	Hamamatsu PMT R4998 (both ends)
1.5 x 10 x 140	Hamamatsu PMT R2083 (both ends)
2.5 x 2.5 x 140	Hamamatsu PMT R4998 (both ends)
2.5 x .5 x 140	Hamamatsu PMT R4998 (both ends)
2.5 x 10 x 140	Hamamatsu PMT R2083 (both ends)
2.5 x 2.5 x 140	Electron PMT 187 (both ends)
2.5 x 5 x 140	Electron PMT 187 and Hamamatsu R4998
2.5 x 5 x 140	Electron PMT 187 (both ends)
2.5 x 10 x 100	Electron PMT 187 (both ends)
2.5 x 10 x 100	Electron PMT 187 and Hamamatsu R4998

Y-scan



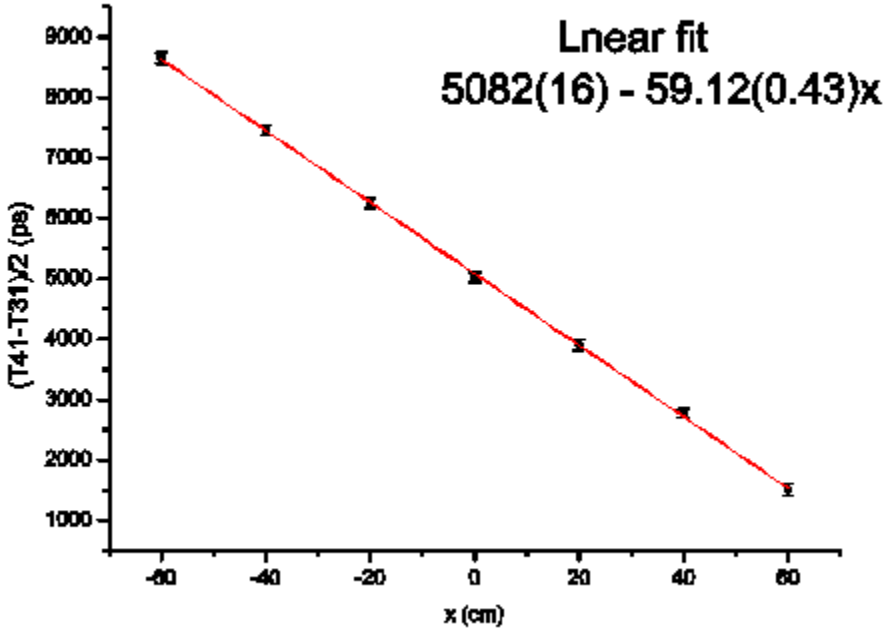
Intensity tests R4998 (May 2014)

Inclusive count rate, kHz	500	1000	1400	1500
σ (weighted mean), ps	67	76	75	76



Result Analysis.

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



Prototyping @ COSY.

- Beam: protons E=2GeV, d=3cm,
- Collimator 0.2x3 cm,
- Counter: B408, 140x5x1.5 cm^3, R4998X2,
- Two counters: B408, 1x1x1 cm^3, PMT-187,
- TRB2 24 ps/ch

Marek Palka, Jagellonian University, Krakow,

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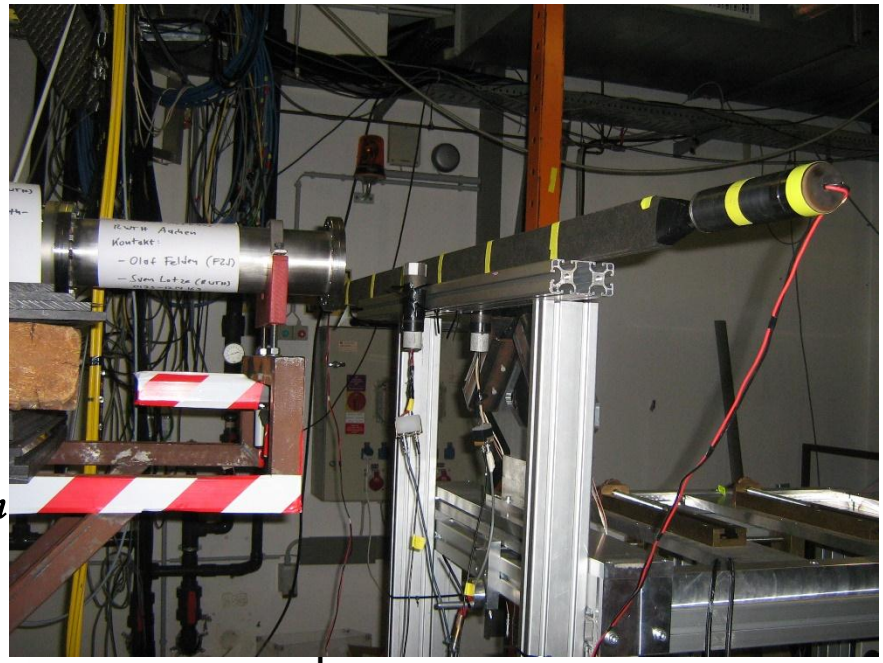

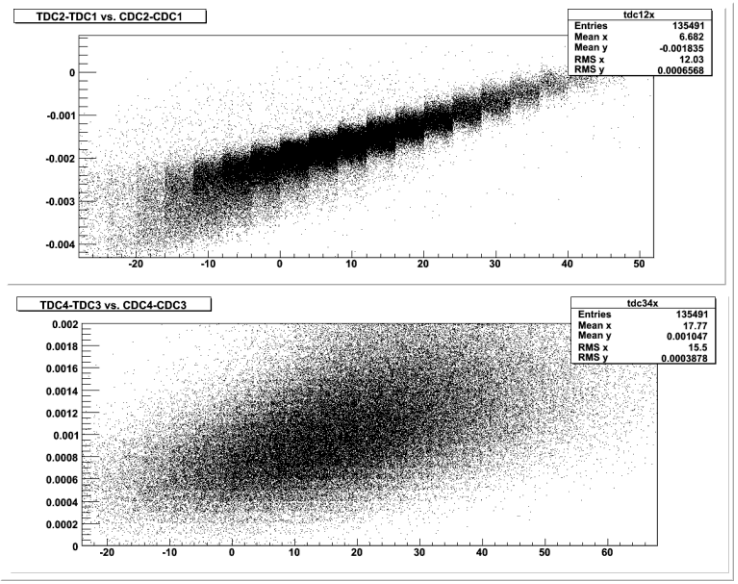

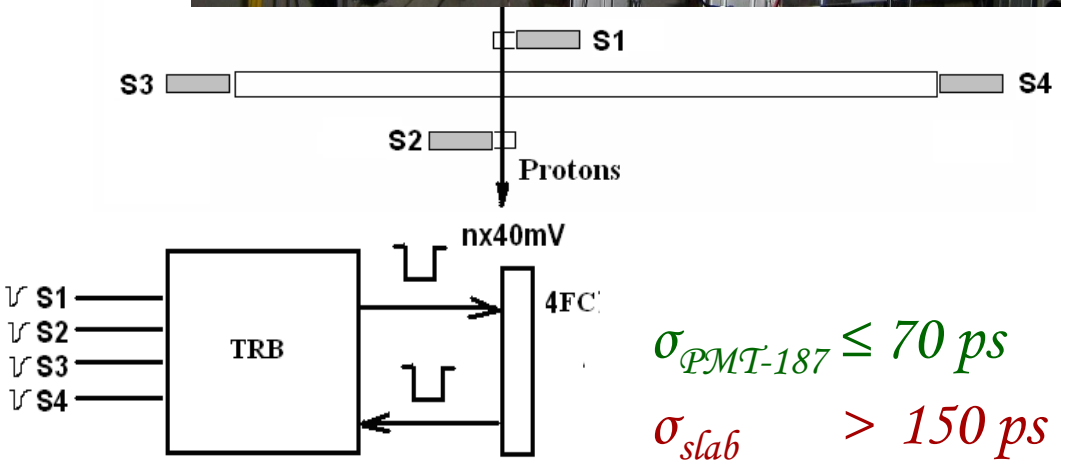

$\sigma_{PMT\text{-}187} \leq 70\ ps$

$\sigma_{slab} > 150\ ps$