The New Preshower Detector for DIRAC Experiment

DIRAC Collaboration Meeting
CERN - 16 November 2006

CERN

IFIN-HH

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6. Preshower configuration
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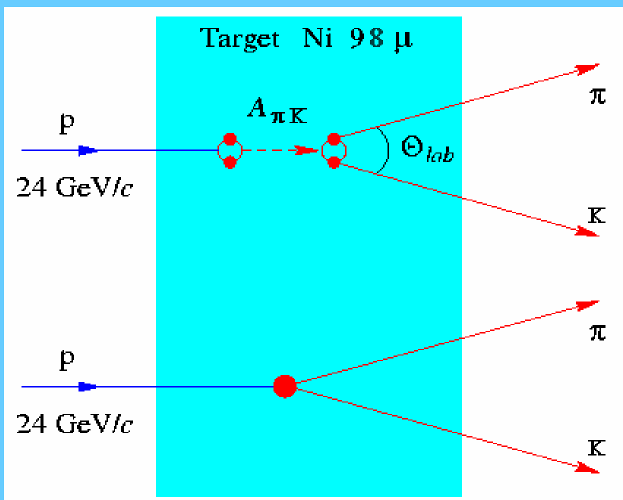
THE NEW DIRAC PROJECT

New tasks for DIRAC

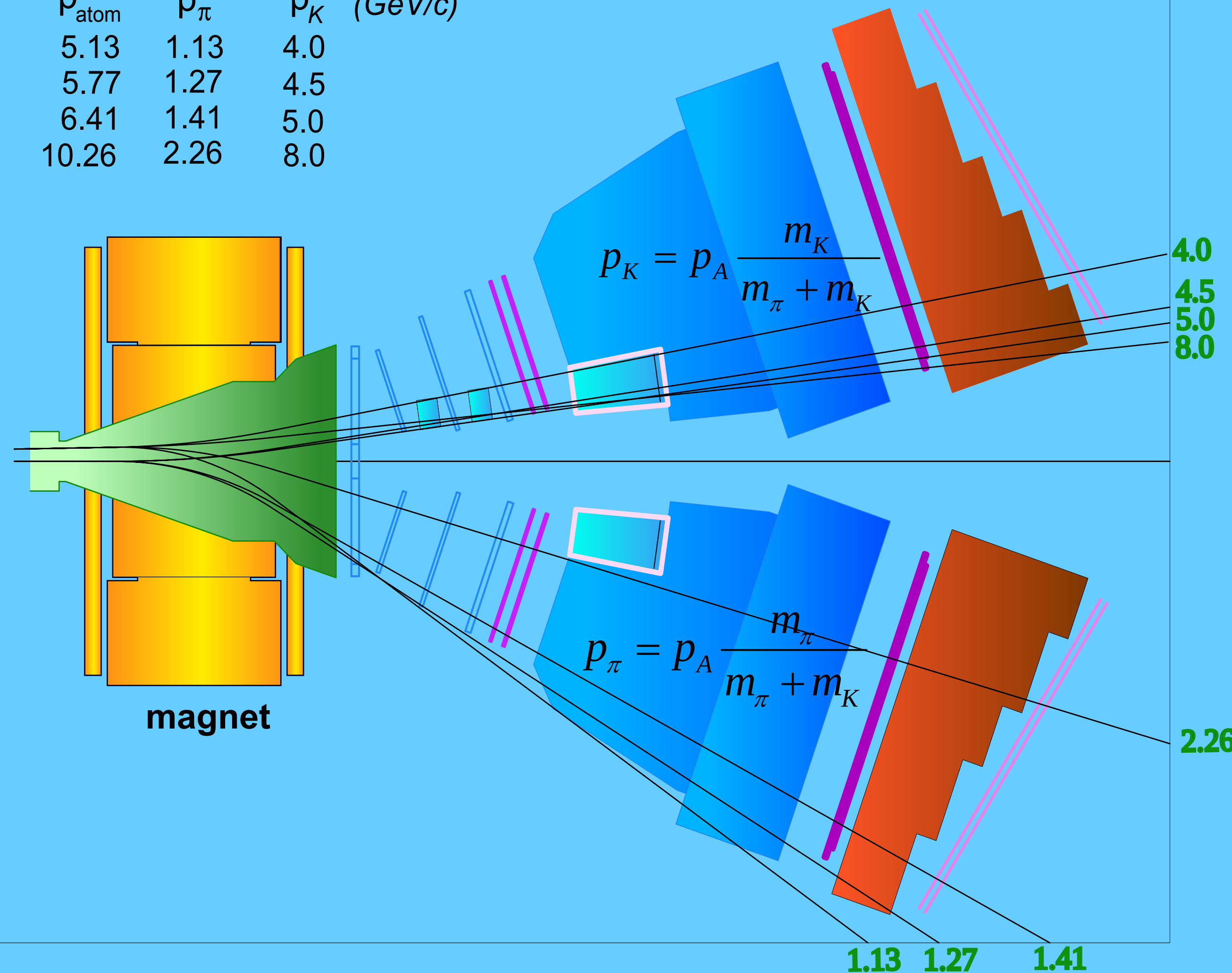
π K hadronic atom

(asymmetric system)



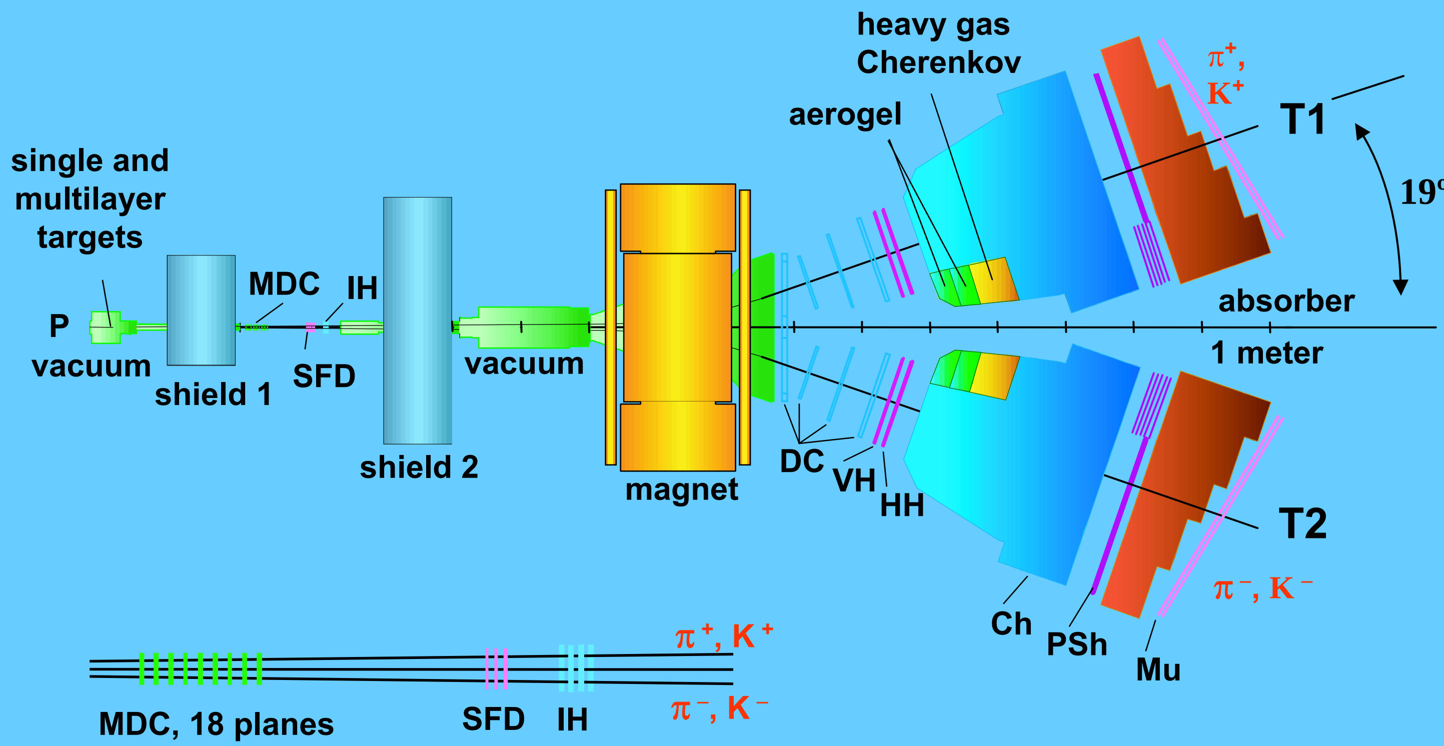
- Kaon detection
- Phase space modification
- *e – π separation*
- *π – K separation*
- *K – p separation*

p_{atom}	p_π	p_K	*(GeV/c)*
5.13	1.13	4.0	
5.77	1.27	4.5	
6.41	1.41	5.0	
10.26	2.26	8.0	



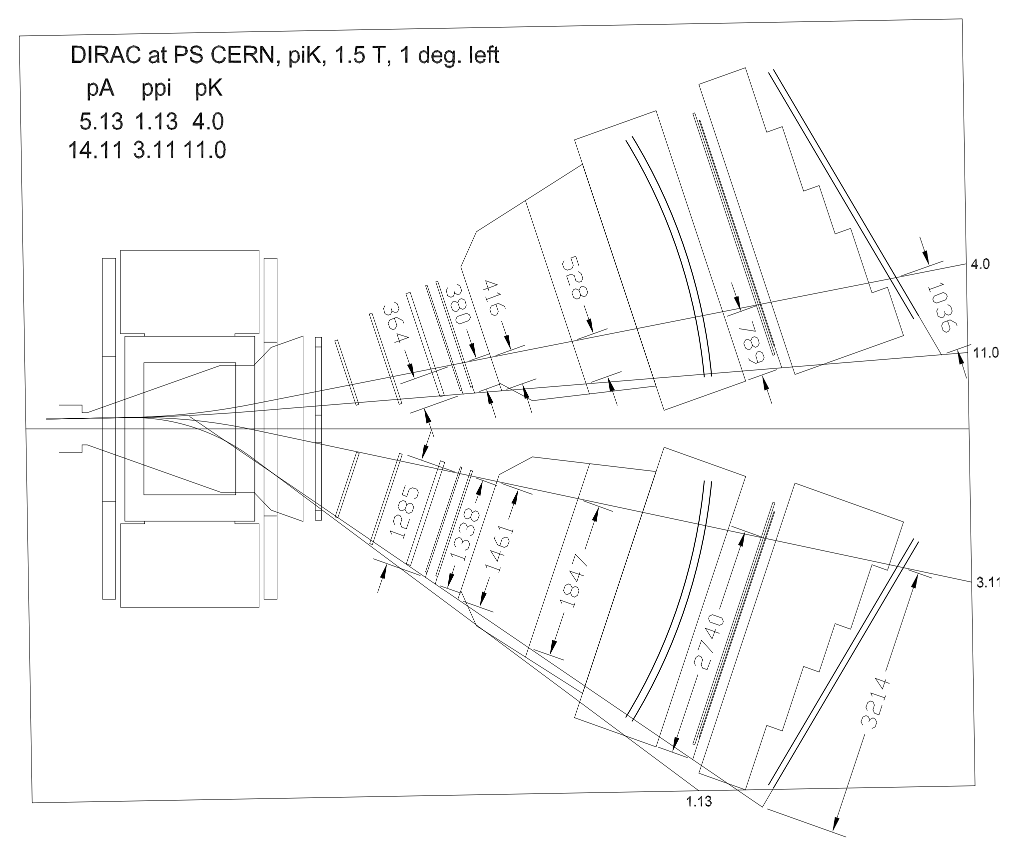
The π^- and K^+ tracks from $A_{\pi K}$ break up

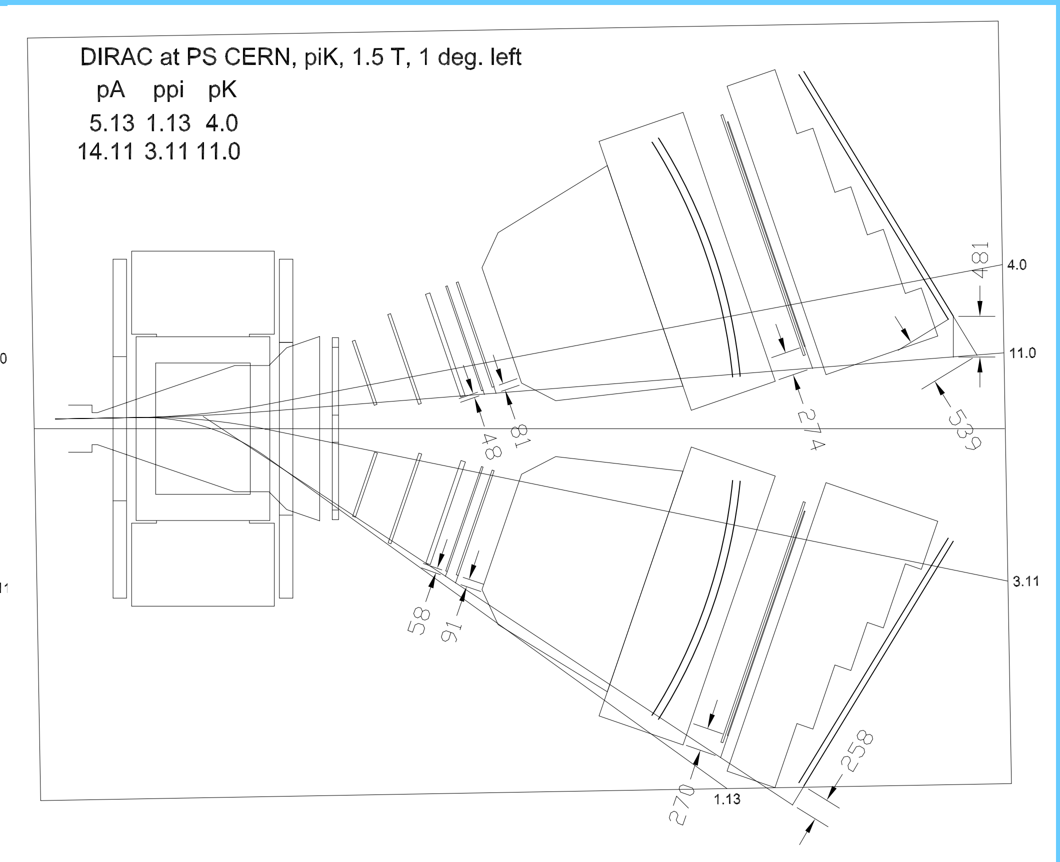
THE NEW DIRAC SPECTROMETER



Upstream of the magnet	Downstream of the magnet
MicroDrift Chambers (MDC) **Scintillating Fiber Detectors** (SFD) **Ionization Hodoscopes** (IH)	**Drift Chambers** (DC) **Vertical** and **Horizontal Hodoscopes** (VH, HH) **Aerogel Cherenkov** counters (aerogel) **Gas Cherenkov** counters (Ch, heavy gas Cherenkov) **Preshower** detector (PSh) **Muon** detector (Mu)

Phase space extension for the new experimental configuration





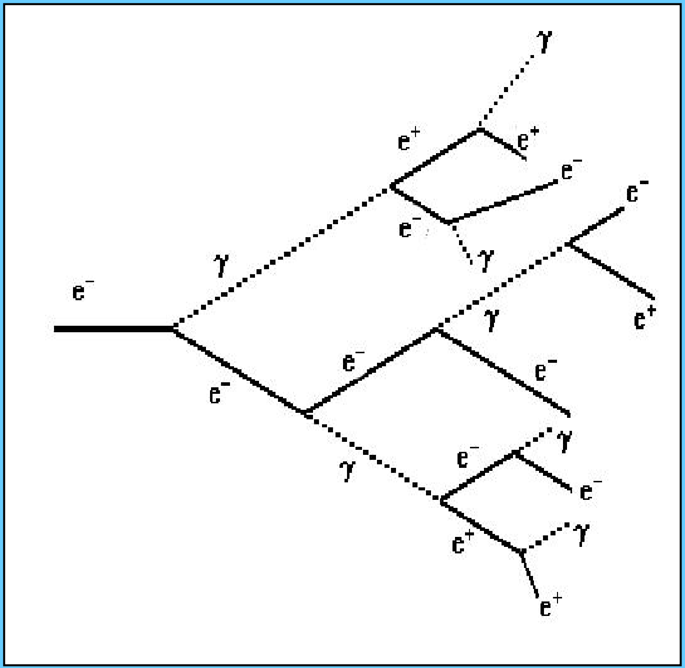
THE NEW PRESHOWER DETECTOR

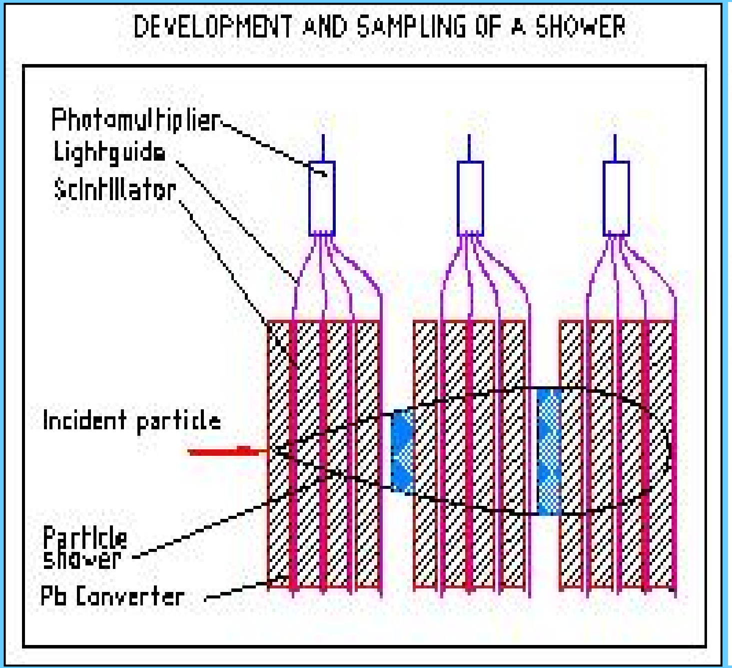
⇨ Tasks for the New PRESHOWER DETECTOR

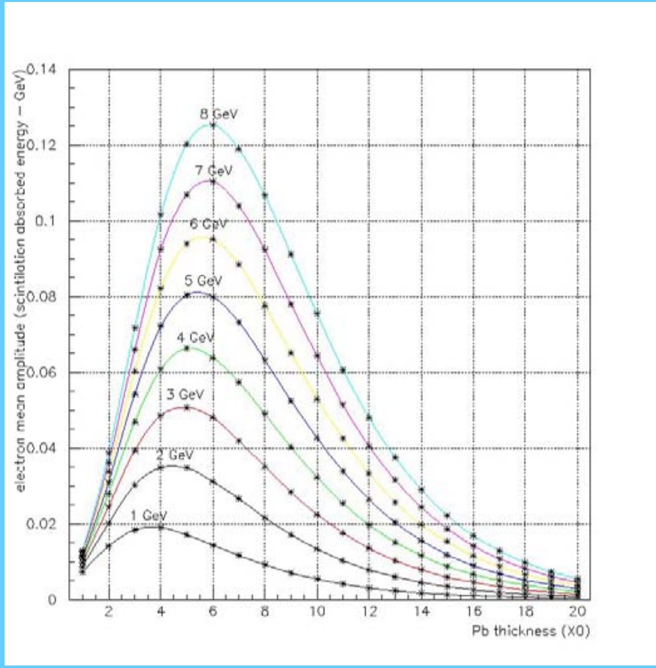
- Preshower aperture extension to include the pion and kaon phase space from πK atom breakup	⇒ 2 x 3500 mm x 750 mm
- Increase of the *electron rejection efficiency* in the kaon phase space region to compensate for the Cherenkov efficiency decrease in this region	⇒ Two - layer Preshower
- High counting rate in the kaon region	⇒ Two times increase of the counting rate
- Front-end electronics enlargement	⇒ 40 signal channels

PRESHOWER STUDIES

PSh detector samples the early part (1- $6X_0$) of the electron shower where it is in good shape, but the pion one is not yet initiated. Therefore the PSh detector has a high amplitude spectrum for electrons and low amplitude one for pions. This provides the electron/pion separation capability (see the next slides)

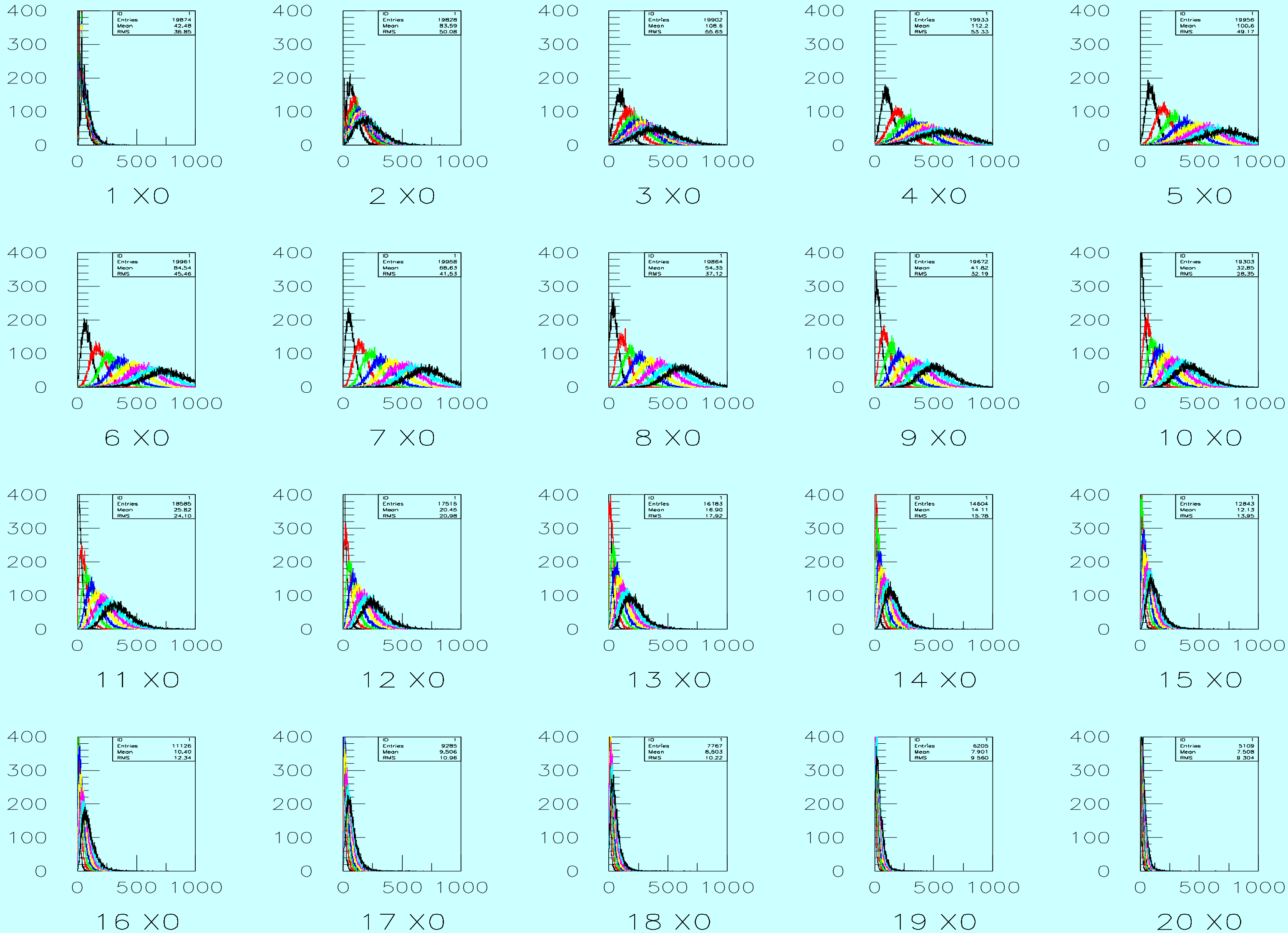




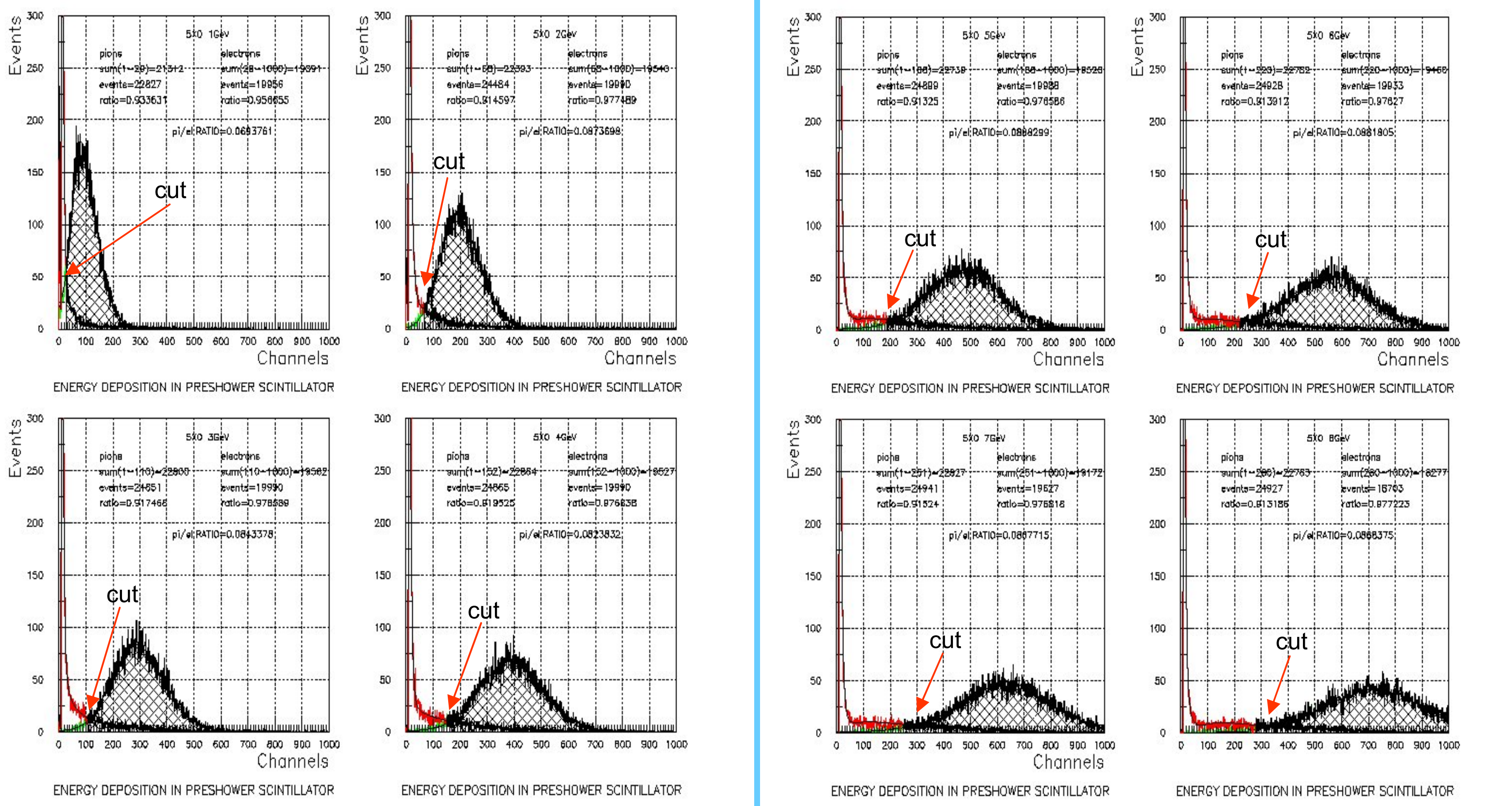


Production and development of the electromagnetic shower and the longitudinal distribution of the shower energy.

PRESHOWER STUDIES



PRESHOWER STUDIES



Preshower amplitude distribution for *e* and π 1–8GeV produced by shower development at $5X_0$ depth in Pb (X_0=0.56 cm).

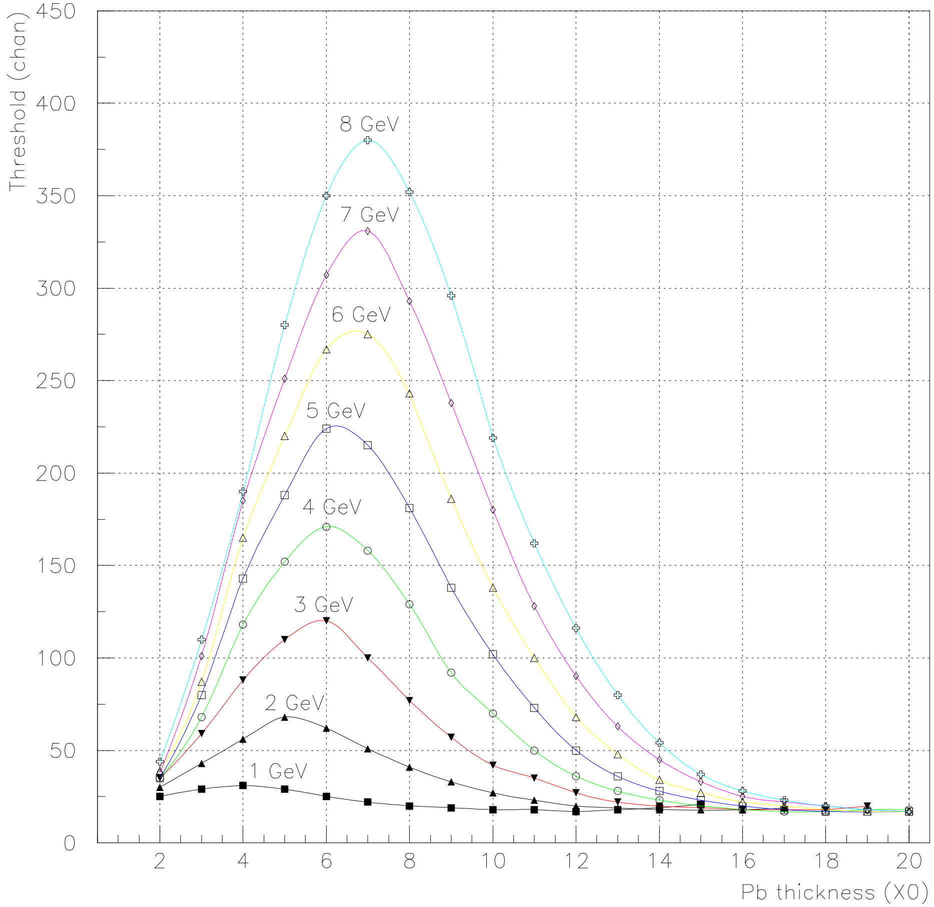
The *e*–π separation: cut at the intersection of the two distributions.

The cut level defines:

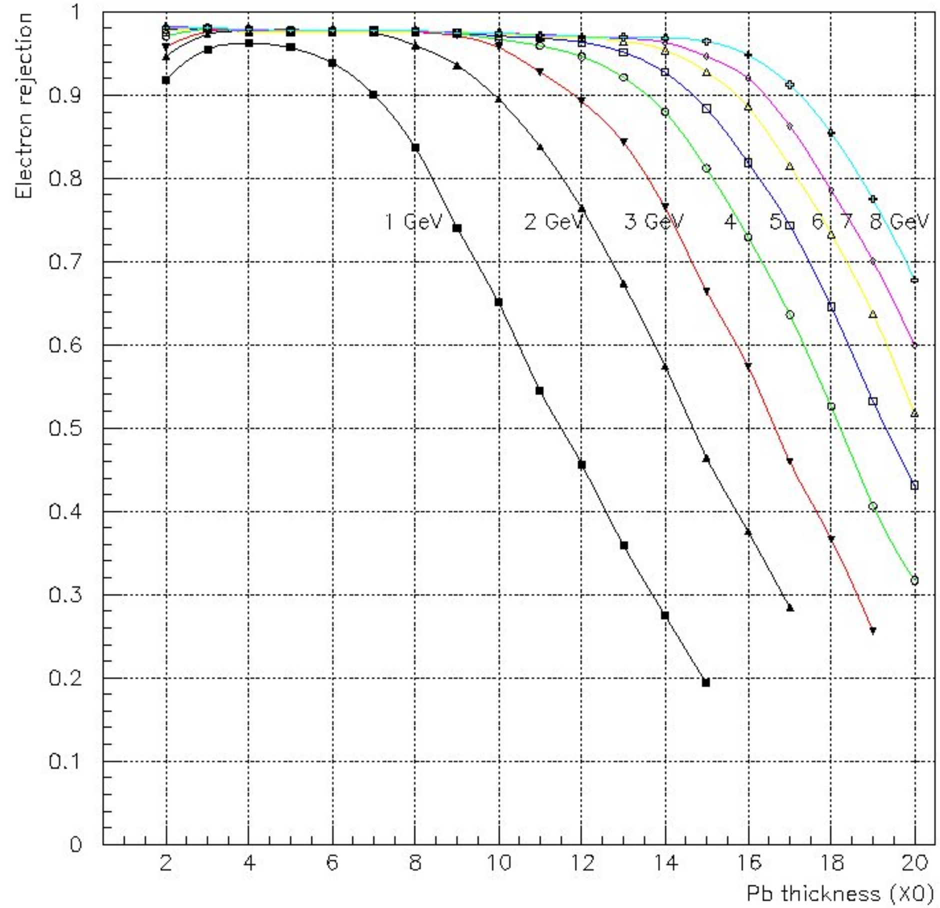
- ***electron rejection*** (e_{rej}) - ratio of the cut right side events and the total number of events in the electron spectrum.
- ***electron escape*** (e_{esc}) – ratio of the cut left side events and the total number of events in the electron spectrum.
- ***pion efficiency*** (π_{eff}) - ratio of the cut left side events and the total number of events in the pion spectrum.

PRESHOWER STUDIES

Electron – pion cut position (threshold)



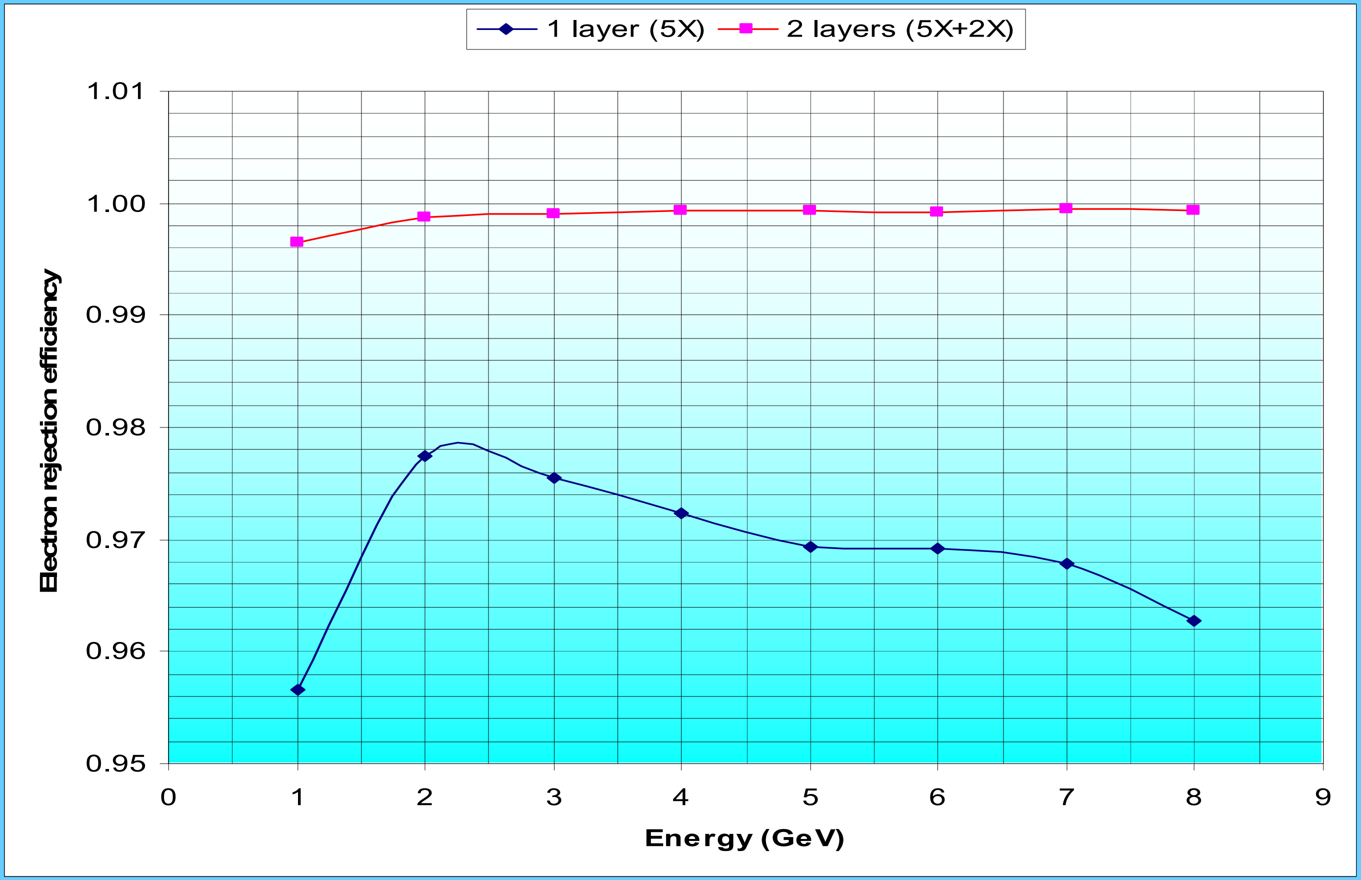
One-layer electron rejection efficiency



PRESHOWER STUDIES

Two-layers electron rejection efficiency:

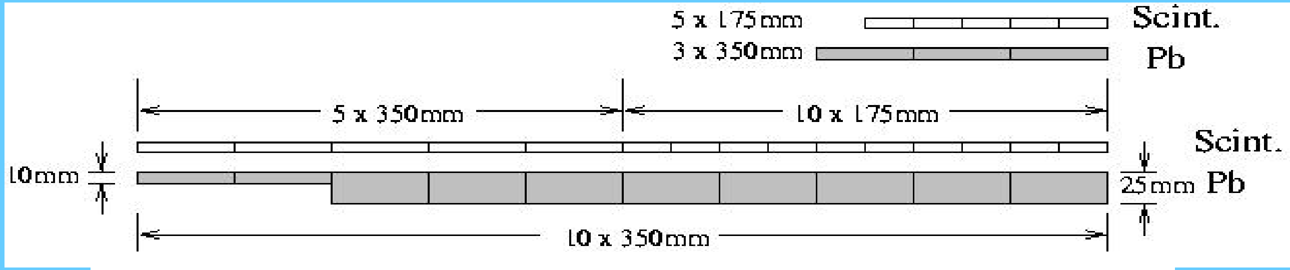
$$e_{rej}=e_{rej1}+ e_{esc1}{}^{*} e_{rej2}$$

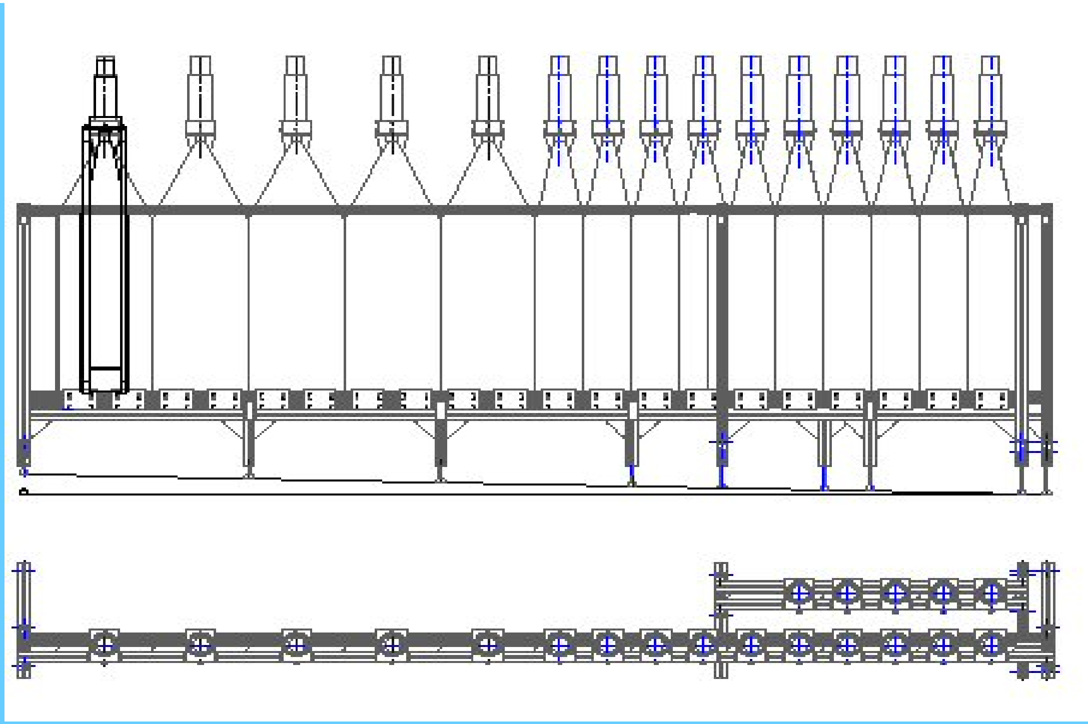


Energy (GeV)	1	2	3	4	5	6	7	8
e_{rej1} $(5X_0)$	0.956655	0.977489	0.975488	0.972286	0.969282	0.969147	0.967901	0.962680
$e_{esc1}{}^{*}e_{rej2}$ $(2X_0)$	0.039814	0.021306	0.023616	0.026992	0.030044	0.030125	0.031540	0.036707
e_{rej} $(5X_0 +2X_0)$	0.996469	0.998795	0.999104	0.999278	0.999326	0.999272	0.999441	0.999387

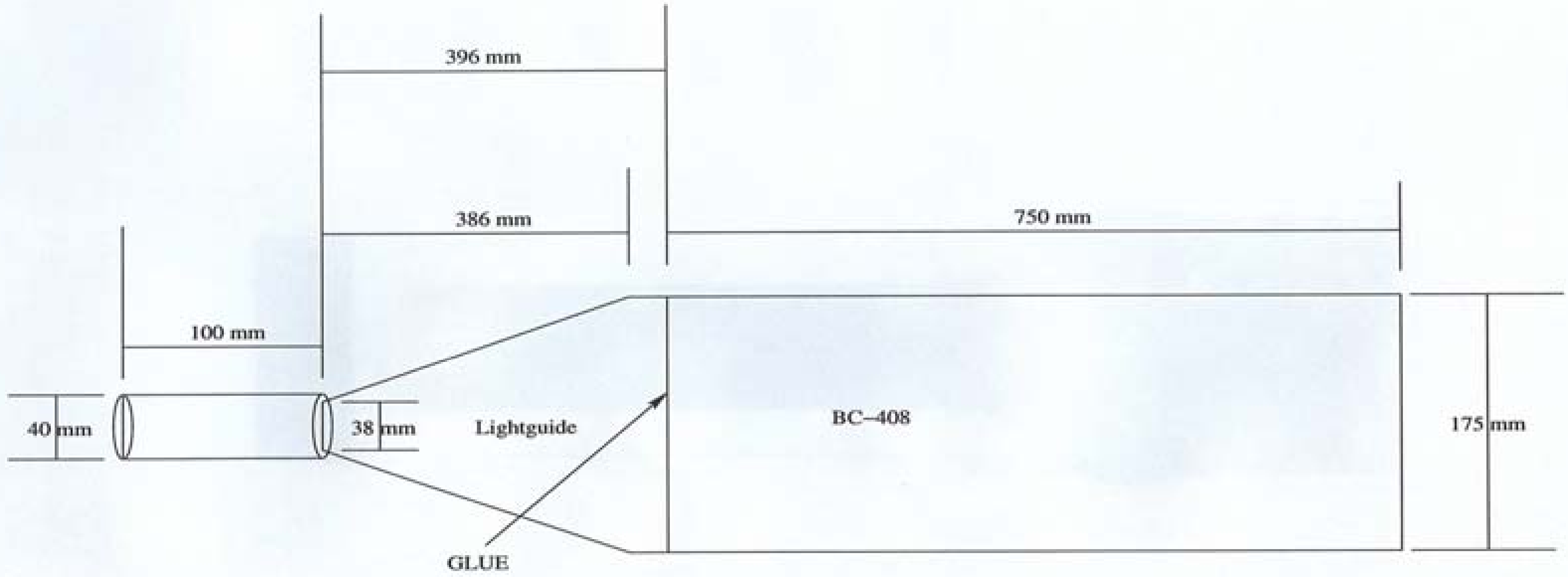
TECHNICAL SOLUTIONS

Layer	Dimensions	Pb Convertor	Scintillators (BC-408)
I	width thickness	10 x 350mm 2 x 10mm + 8 x 25mm	5 x 350mm + 10 x 175mm
II	width thickness	3 x 350mm 3 x 10mm	5 x 175mm





TECHNICAL SOLUTIONS

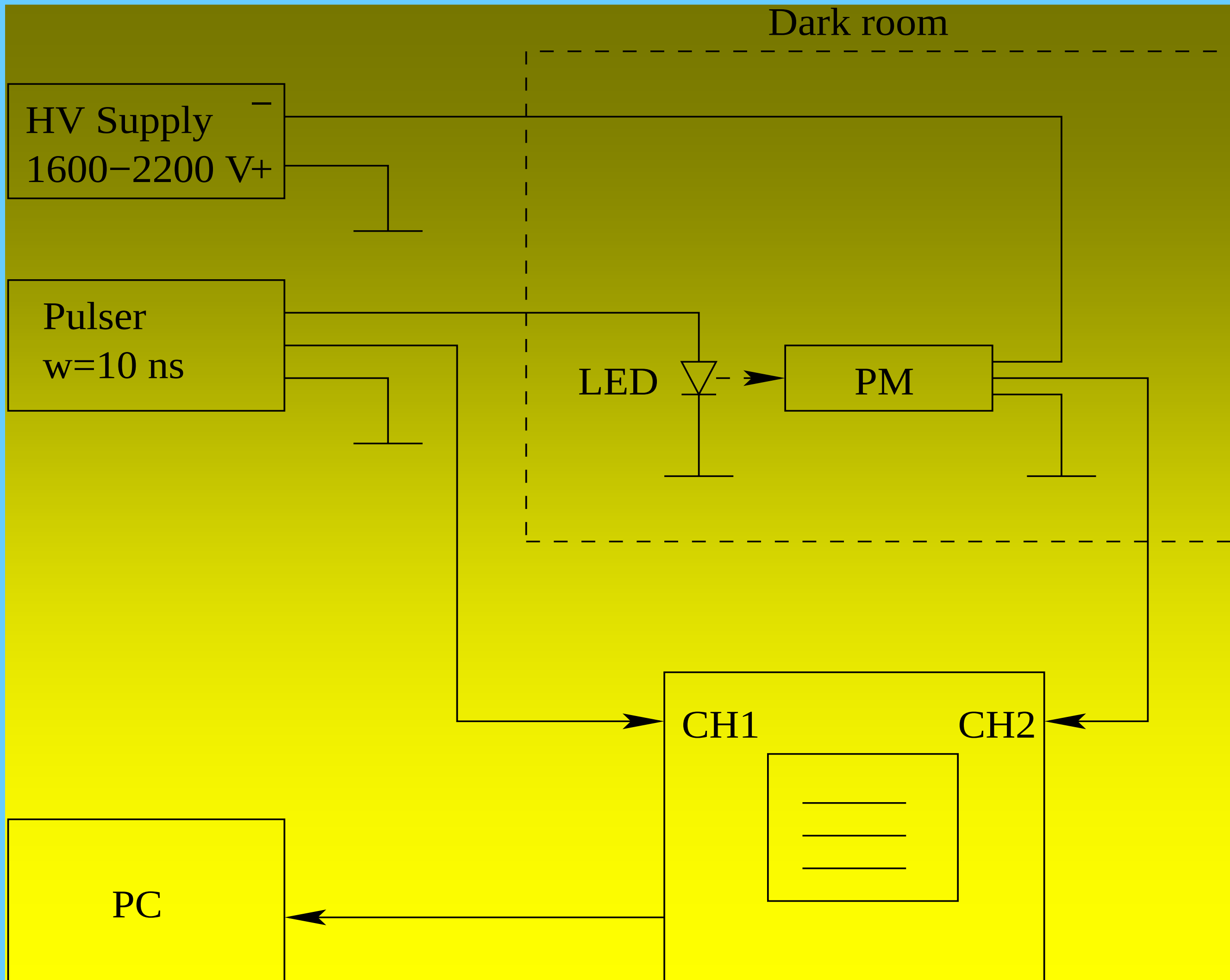


The scintillator and lightguide thickness will be 10 mm

The lightguide top end will be stucked in the cylinder guide 40 mm diam. x 100 mm high

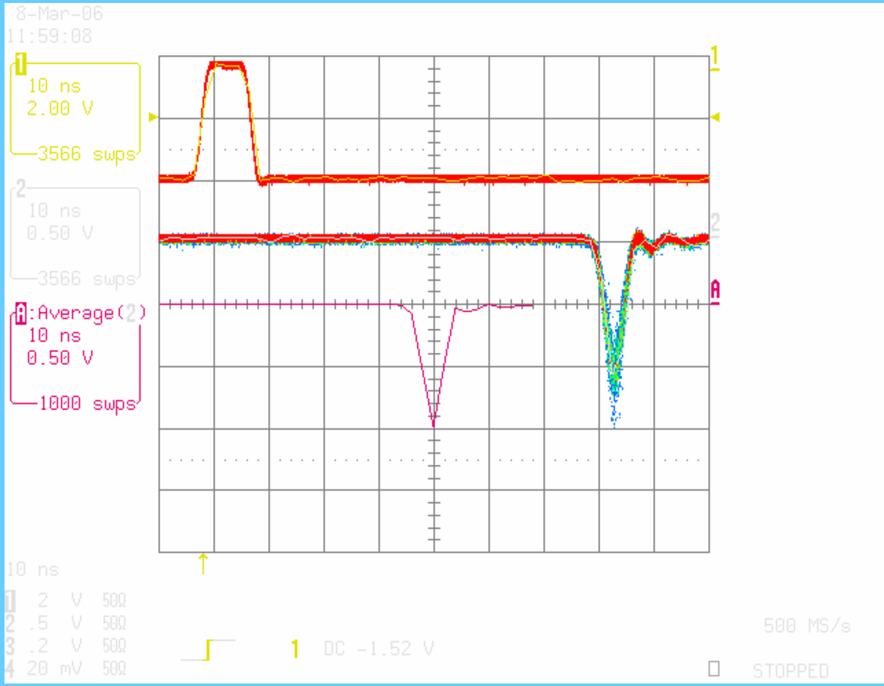
PSh ELEMENTS TESTS

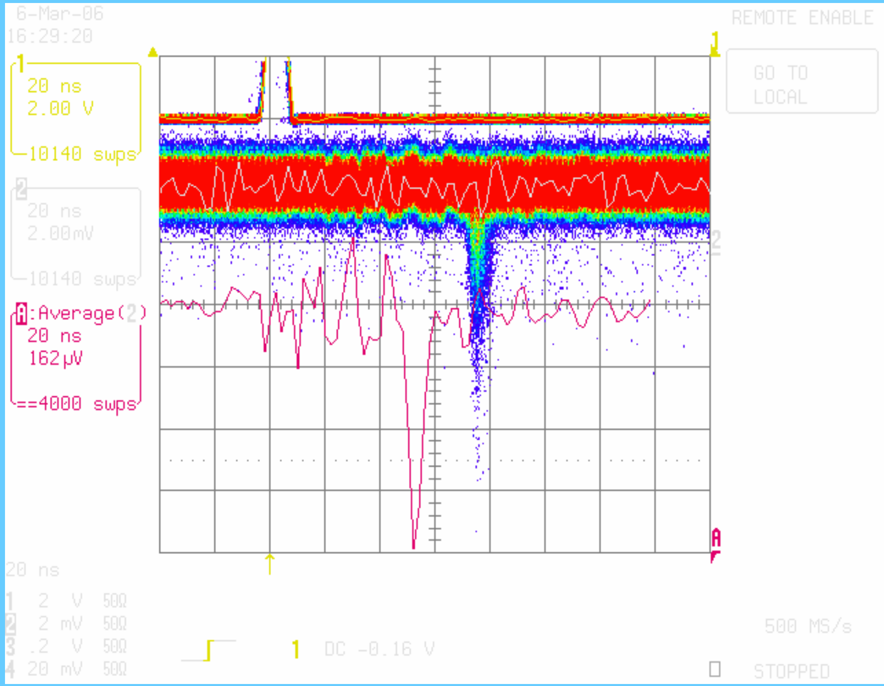
PM TESTS WITH LED



PSh ELEMENTS TESTS

PM TESTS WITH LED





Poisson: $f_P(x,\mu) = \dfrac{\mu^x}{x!} e^{-\mu}$

FOR $\mu = 1$

x	0	1	2	3	4
$f_P(x,\mu)$	0.368	0.368	0.184	0.061	0.015

PSh ELEMENTS TESTS

PM TESTS WITH LED

PM amplitudine (mV) with minimal LED - for 1p.e. (trigger on LED signal)

	1600 V	1700 V	1800 V	1900 V	2000 V	2100 V	2200 V
PM17	0.7	3	10	23.2	49.6	100.2	
PM18	0.33	1.65	4.7	12.5	25	60	
PM19	0.5	1.78	5.4	14	27.6		
PM20		0.61	1.4	3.85	7	17	26.8
PM21	0.7	2.32	6.2	16.8	33		
PM22	1.02	4.1	9.75	31.2	58.8	130	
PM23	0.285	1.05	3.6	9	19	38	
PM24	0.31	1.12	3.3	8.55	16	36	
PM25	0.58	1.92	5.6	12.8	27.2	57.6	
PM26	1.4	4.6	13.5	35	70		
PM27	0.58	2.32	5.82	15.2	31.6		
PM28	0.5	2.04	6	14.2	35.2	65.6	
PM29	0.55	2	5.5	14	28		
PM31	1.33	5	12	28.8	51.6		
PM32		1.3	4.1	9.2	23.2	40	
PM33	0.54	1.8	4.6	10.2	24	39.2	
PM53	0.32	1.42	4.3	10.6	24	51.2	
PM54		0.488	1.6	4.24	9.2	18.8	

	1600 V	1700 V	1800 V	1900 V	2000 V	2100 V	2200 V
PM55	0.55	2.66	5	14	27.6	60	
PM56	1.2	4.8	14.8	30.8	78.4	136	
PM57	0.74	2.6	7.44	17.2	40		
PM58	1.16	4.6	10.8	30	56		
PM59	0.6	2.4	6.8	17.8	35.6	84	
PM60	0.5	2	5	11	22	48	
PM62		0.82	2.08	4.9	11.25	22.4	
PM63	0.5	2.16	5.8	12	27.2		
PM64	0.656	2.4	6	15.6	30	60	
PM65	0.84	2.92	7.84	20	39.6	90	
PM66	0.608	2.04	5.52	14	26.4	56	
PM67	0.9	3.36	8	20	44	86	
PM68	0.65	2.2	6	15	28.8	60	
PM69	1.36	5.6	16	44	81		
PM70	0.64	3	8.2	16.4	36	64	
PM71		1.3	3.68	8.8	17.6	32.4	
PM72		0.65	2	4.8	9.2	22.8	

PSh ELEMENTS TESTS

PM TESTS WITH LED

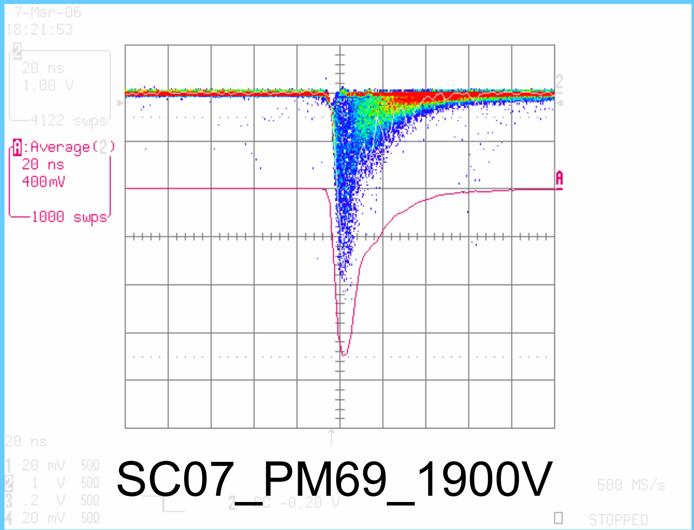
U_{pm}(V) for given output amplitude

PM	0.5 V	1 V	1.5 V	2 V	3 V	PM	0.5 V	1 V	1.5 V	2 V	3 V
17	1850	1918	1973	2014	2088	**54**	2018	2110	2169	2232	
18	1895	1993	2043	2083	2180	**55**	1903	1981	2033	2080	2180
19	1992	2016	2066	2114	2198	**56**	1780	1855	1917	1951	2000
20	2049	2190	2255			**57**	1865	1956	2025	2068	2128
21	1959	2040	2115	2189		**58**	1827	1915	1968	2009	2090
22	1810	1891	1960	1989	2057	**60**	1970	2064	2136	2225	
23	1940	2041	2095	2145	2245	**61**	1930	2016	2085	2145	2210
24	1956	2043	2108	2160	2270	**62**	2057	2207			
25	1886	1980	2025	2060	2128	**64**	1890	2000	2050	2092	2185
26	1805	1867	1917	1973	2043	**65**	1869	1967	2015	2046	2104
27	1896	1980	2032	2075	2186	**66**	1915	2012	2070	2104	2195
28	1844	1932	1981	2013	2074	**67**	1852	1956	2010	2043	2122
29	1879	2002	2052	2106	2190	**68**	1897	1997	2069	2112	2185
30	1908	2005	2053	2099	2185	**69**	1800	1864	1908	1959	2030
31	1805	1890	1961	1998	2063	**70**	1940	2026	2094	2154	
32	1912	1994	2051	2109	2188	**71**	1982	2077	2142	2230	
33	1930	2018	2103	2142	2202	**72**	2017	2108	2165	2222	
53	1906	1985	2042	2103	2169						

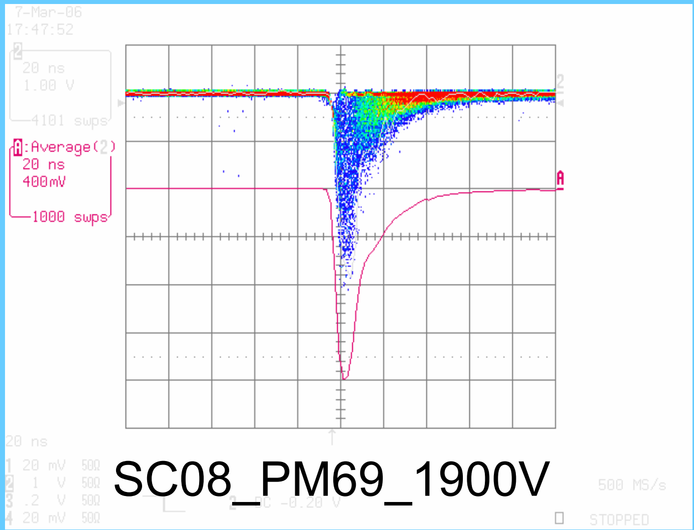
PSh ELEMENTS TESTS

SCINTILATORS TEST

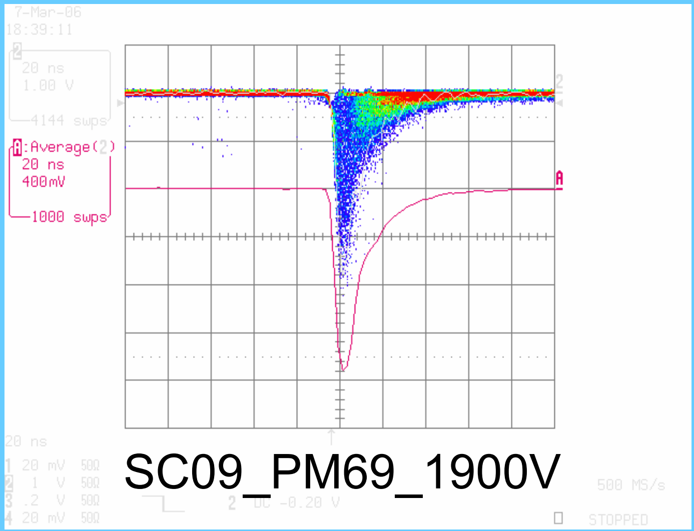
amplitude for ^{90}Sr 222 kBq at the far end of the scintillator



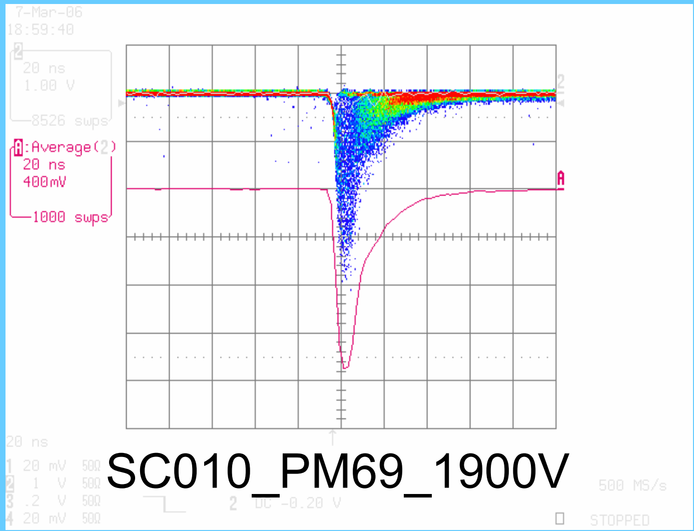
SC07_PM69_1900V



SC08_PM69_1900V



SC09_PM69_1900V



SC010_PM69_1900V

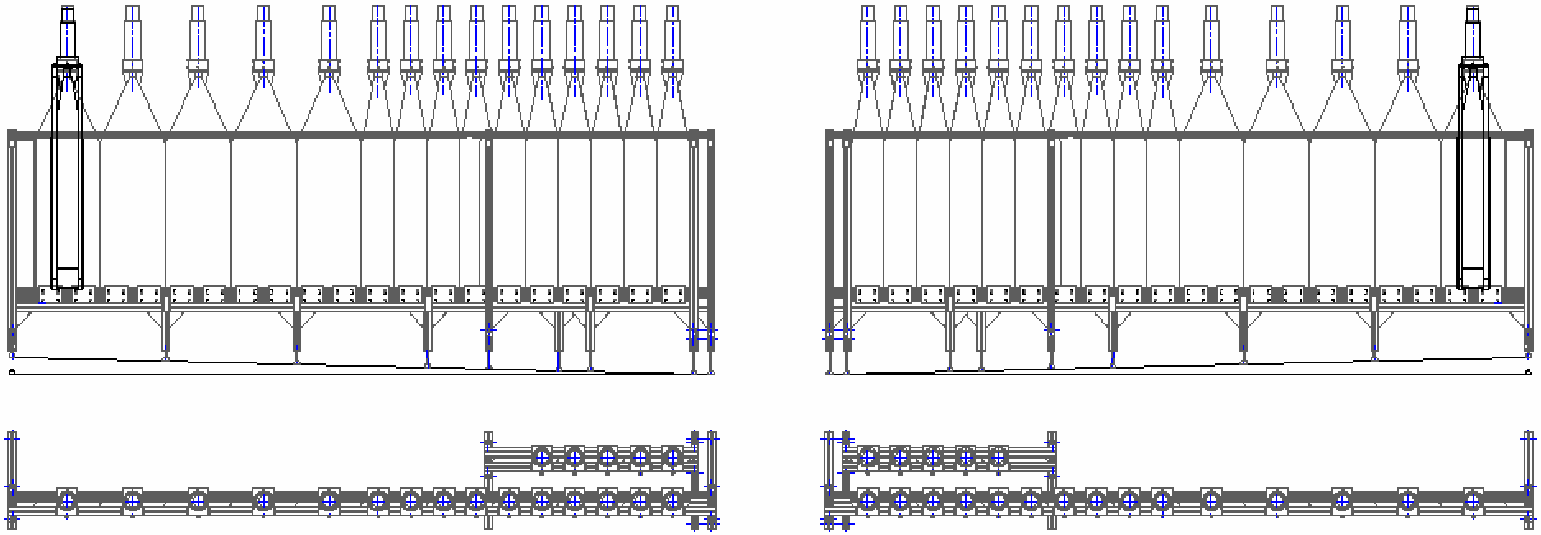
PSh ELEMENTS TESTS

SCINTILATOR + PM TESTS

Mean amplitude for ^{90}Sr 222 kBq at the far end of the scintillator

Sc_PM	HV	1700 V	1800 V	1900 V	2000 V	2100 V
1_17	A (mV)	200	600	1500	3000	4600
	Uthr (mV)	40	120	300	600	900
2_18	A (mV)	104	330	840	1700	3000
	Uthr (mV)	25	75	150	300	600
3_19	A (mV)	90	260	580	1160	2550
	Uthr (mV)	16	50	120	220	500
4_32	A (mV)	90	250	600	1400	2600
	Uthr (mV)	18	50	120	280	520
5_21	A (mV)	96	250	540	1300	2500
	Uthr (mV)	20	50	110	260	500
6_22	A (mV)	200	520	1350	2500	3600
	Uthr (mV)	40	100	250	500	700
7_63	A (mV)	100	260	600	1250	2400
	Uthr (mV)	20	54	115	240	440
8_23	A (mV)	65	200	500	1100	2000
	Uthr (mV)	15	40	100	220	400
9_24	A (mV)	75	230	520	1200	2400
	Uthr (mV)	15	40	100	250	460
10_25	A (mV)	125	340	950	2000	3400
	Uthr (mV)	25	66	180	400	640
11_26	A (mV)	400	1200	2500	4000	5200
	Uthr (mV)	80	250	500	800	1000
12_27	A (mV)	150	400	900	1800	3100
	Uthr (mV)	30	80	180	350	600
13_28	A (mV)	150	480	1250	2500	4000
	Uthr (mV)	30	100	260	500	600
14_29	A (mV)	160	410	1000	1800	3000
	Uthr (mV)	32	80	200	340	600
15_30	A (mV)	140	400	1000	1900	3200
	Uthr (mV)	28	80	190	380	640
16_31	A (mV)	320	800	1800	3200	4400
	Uthr (mV)	64	160	360	640	880
17_33	A (mV)	125	330	780	1650	2900
	Uthr (mV)	25	66	156	340	600
18_53	A (mV)	120	360	1000	2000	3500
	Uthr (mV)	25	72	200	400	700
19_55	A (mV)	120	340	760	1700	2700
	Uthr (mV)	25	66	150	340	540
20_56	A (mV)	350	1100	2550	4000	5000
	Uthr (mV)	70	230	500	800	1000
21_57	A (mV)	200	500	1200	2400	3800
	Uthr (mV)	42	120	240	480	760
22_58	A (mV)	300	800	1750	3000	4000
	Uthr (mV)	60	160	350	600	800
23_60	A (mV)	110	300	700	1450	2700
	Uthr (mV)	22	60	140	290	540
24_61	A (mV)	160	450	1200	2300	3700
	Uthr (mV)	32	90	240	460	740
25_68	A (mV)	200	500	1150	2200	3000
	Uthr (mV)	40	100	230	440	600
26_64	A (mV)	230	600	1400	2700	4000
	Uthr (mV)	46	120	280	540	800
27_65	A (mV)	220	640	2000	3800	5600
	Uthr (mV)	44	128	400	760	1120
28_69	A (mV)	360	1200	2800	4800	6000
	Uthr (mV)	72	240	560	960	1200
29_70	A (mV)	185	500	1250	2600	4400
	Uthr (mV)	37	100	250	520	880
30_59	A (mv)	135	400	1000	2100	3300
	Uthr (mV)	28	80	200	420	660
R1_67	A (mv)	300	720	1700	3200	4000
	Uthr (mV)	60	140	340	640	800
R2_66	A (mV)	125	350	800	1750	3200
	Uthr (mV)	25	70	160	350	640
R3_10	A (mV)	250	660	1500	2500	3000
	Uthr (mV)	52	132	300	500	600

NEW PRESHOWER CONFIGURATION



16	17	18	19	20
18	24	6	R1	11

40	39	38	37	36
27	1	29	25	30

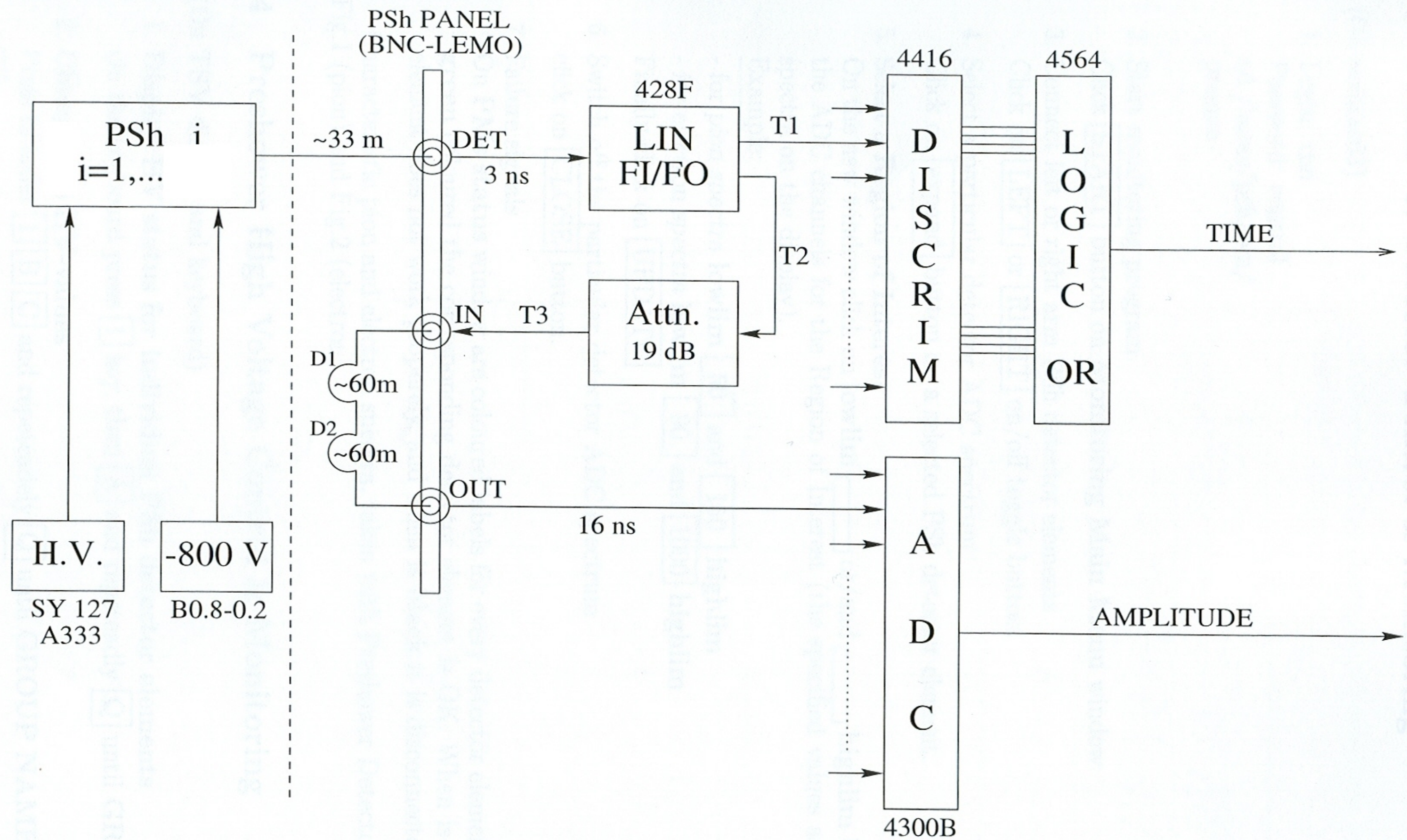
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
17	4	2	3	13	7	23	17	2	10	14	13	R3	16	28

35	34	33	32	31	30	29	28	27	26	25	24	23	22	21
20	22	26	21	15	12	R2	19	4	5	10	12	1	15	5

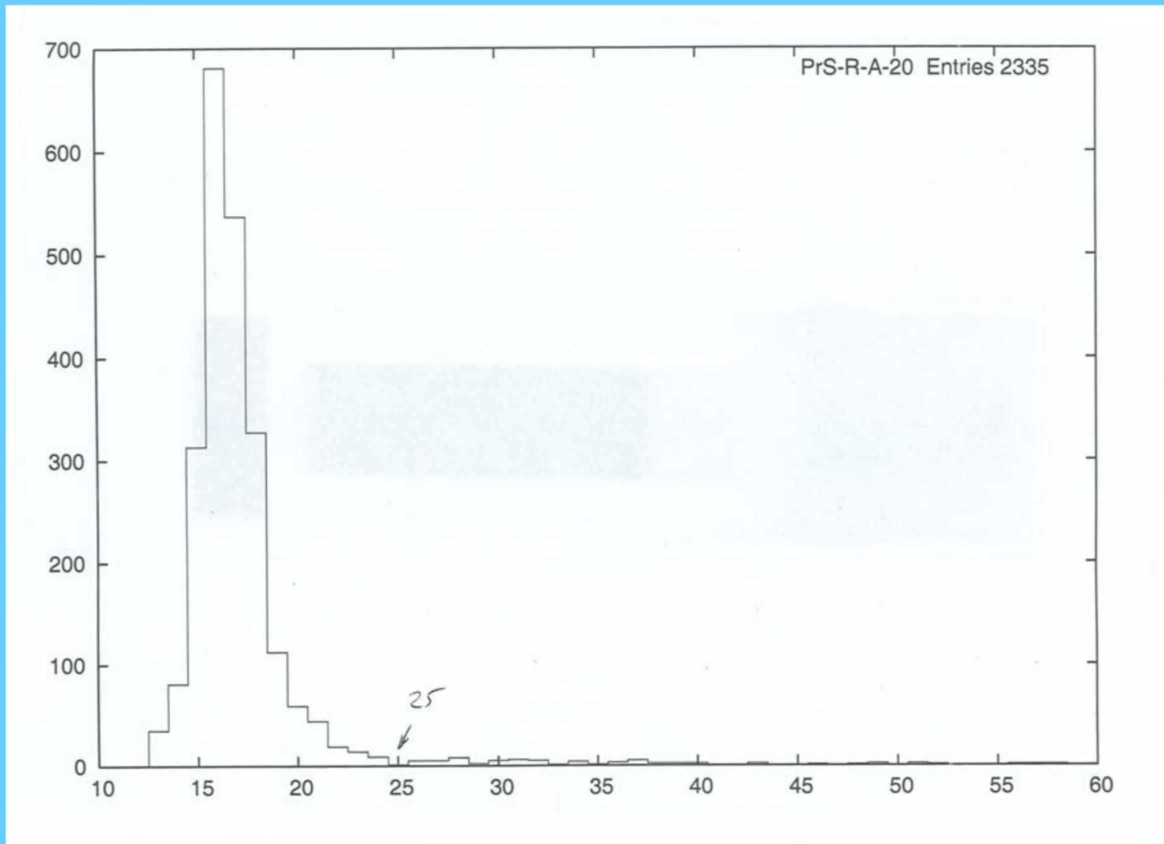
OLD NEW NEW OLD

NEW PRESHOWER CONFIGURATION

PRESHOWER SIGNALS



PSh DETECTOR ALIGNMENT



Pedestal determination

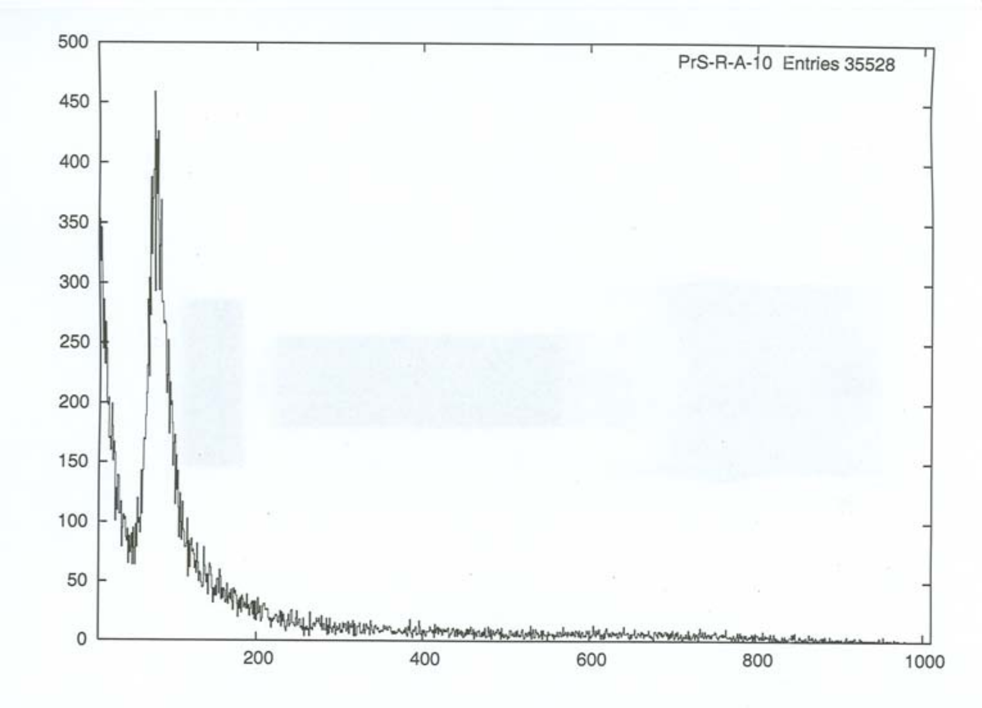
The characteristic ADC pedestal spectrum.

X-axis: ADC channel
Y-axis: events number

PSh slab	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
channel	45	51	46	47	47	44	53	47	51	44	53	57	52	49	62	33	32	35	25	38

PSh slab	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
channel	49	45	49	46	50	44	49	39	45	43	48	43	53	43	47	24	28	23	29	25

PSh DETECTOR ALIGNMENT



PM HV alignment

The ADC amplitude spectrum with pion trigger.

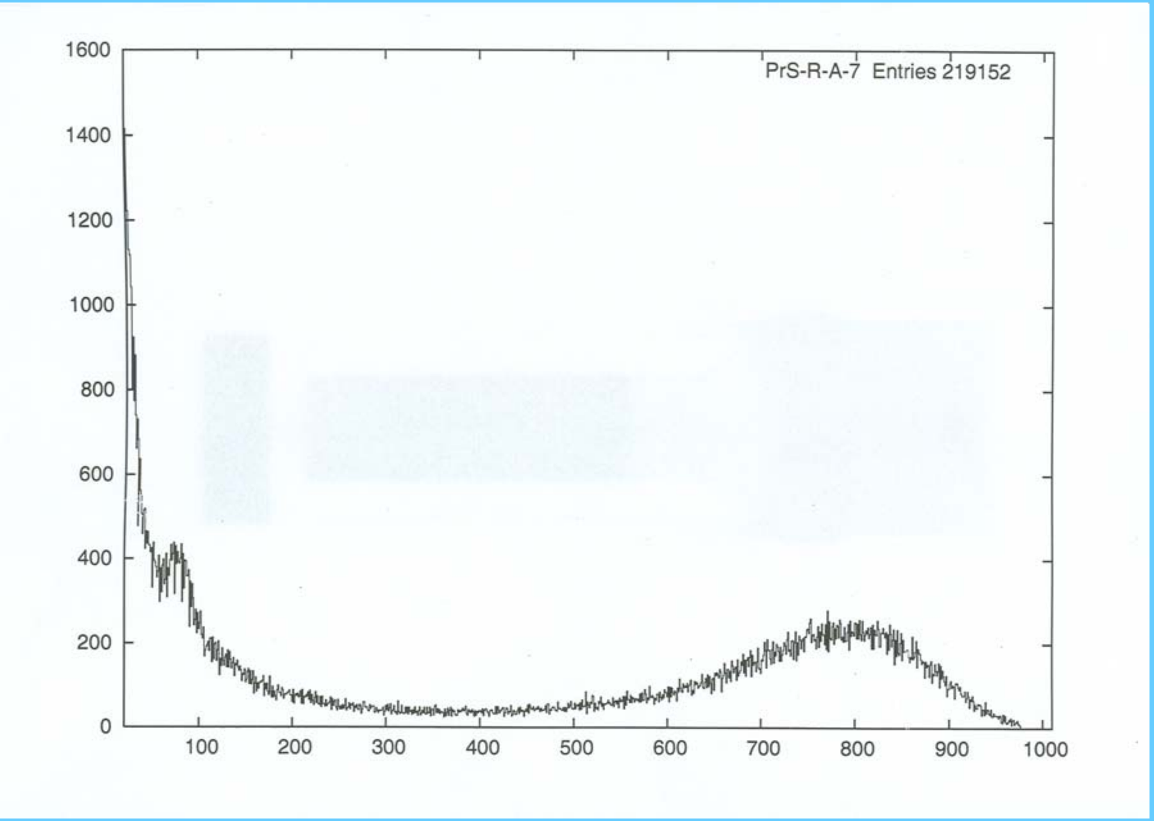
X-axis: ADC channel
Y-axis: events number

The HV for each PM's, as to see a good pion peak, are presented in the next Table.

PSh slab	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
HV (V)	1990	1950	1880	1870	1870	1840	1790	1770	1820	1770
PSh slab	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
HV (V)	1990	1780	1700	1710	1700	1750	1740	1750	1770	1750

PSh slab	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
HV (V)	1900	1970	1900	1790	1800	1825	1810	1760	1750	1770
PSh slab	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
HV (V)	1780	1720	1700	1690	1680	1750	1735	1725	1730	1735

PSh DETECTOR ALIGNMENT



Signal attenuation

The ADC amplitude spectrum with electron trigger.

X-axis: ADC channel
Y-axis: events number

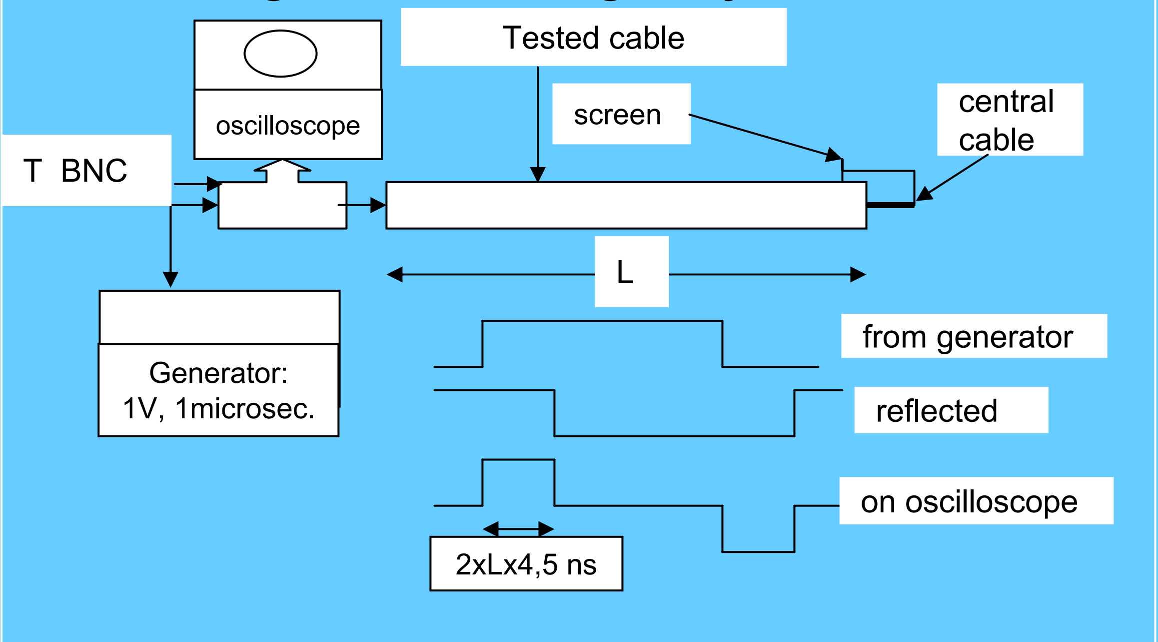
The attenuation values for each preshower channel, as to see the electron distribution within 1000 ADC channels, are presented in the next Table.

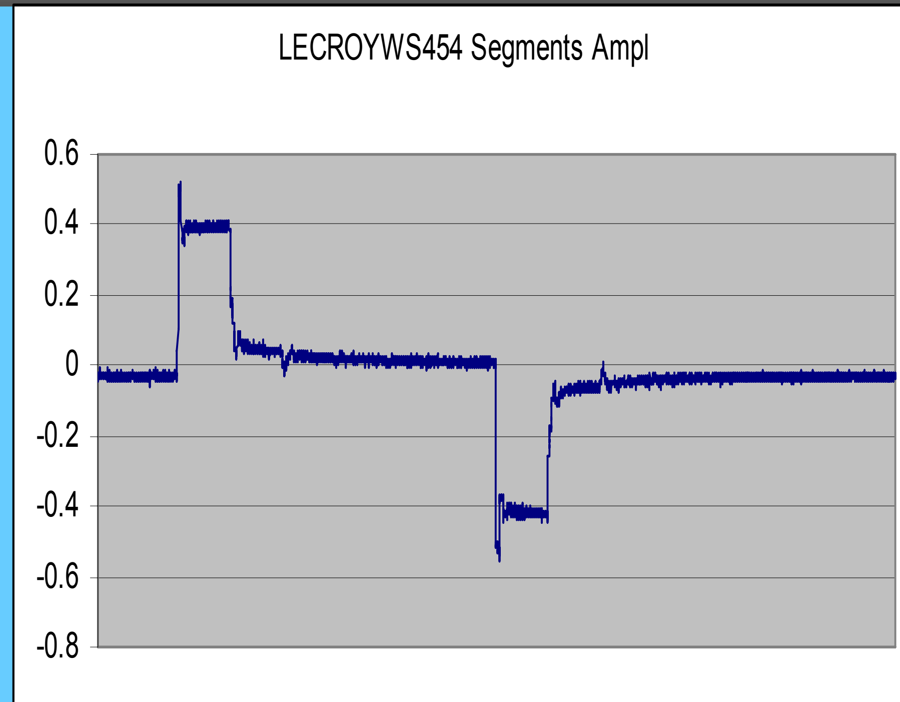
PSh slab	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
attn (dB)	18	18	18	18	18	18	18	18	18	18.5	19	19.5	19.5	20.5	21	20	22	21	23	24

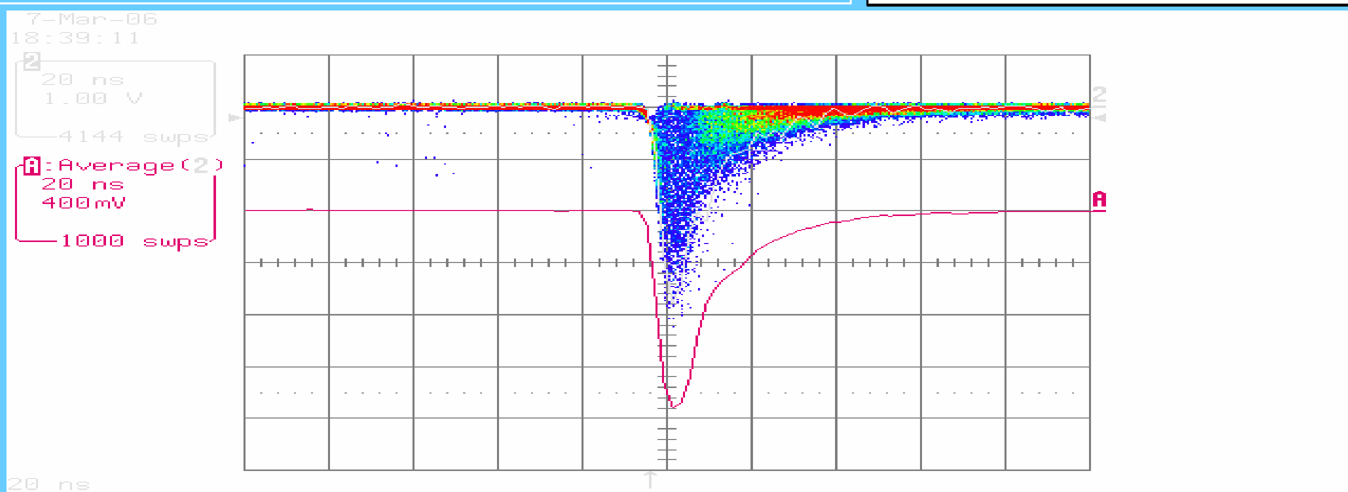
PSh slab	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
attn (dB)	17	16	18	18	20	18	18	18	18	18	19	18	19	19	19	20	20	19	21	20

PSh DETECTOR ALIGNMENT

Signal cable homogeneity test



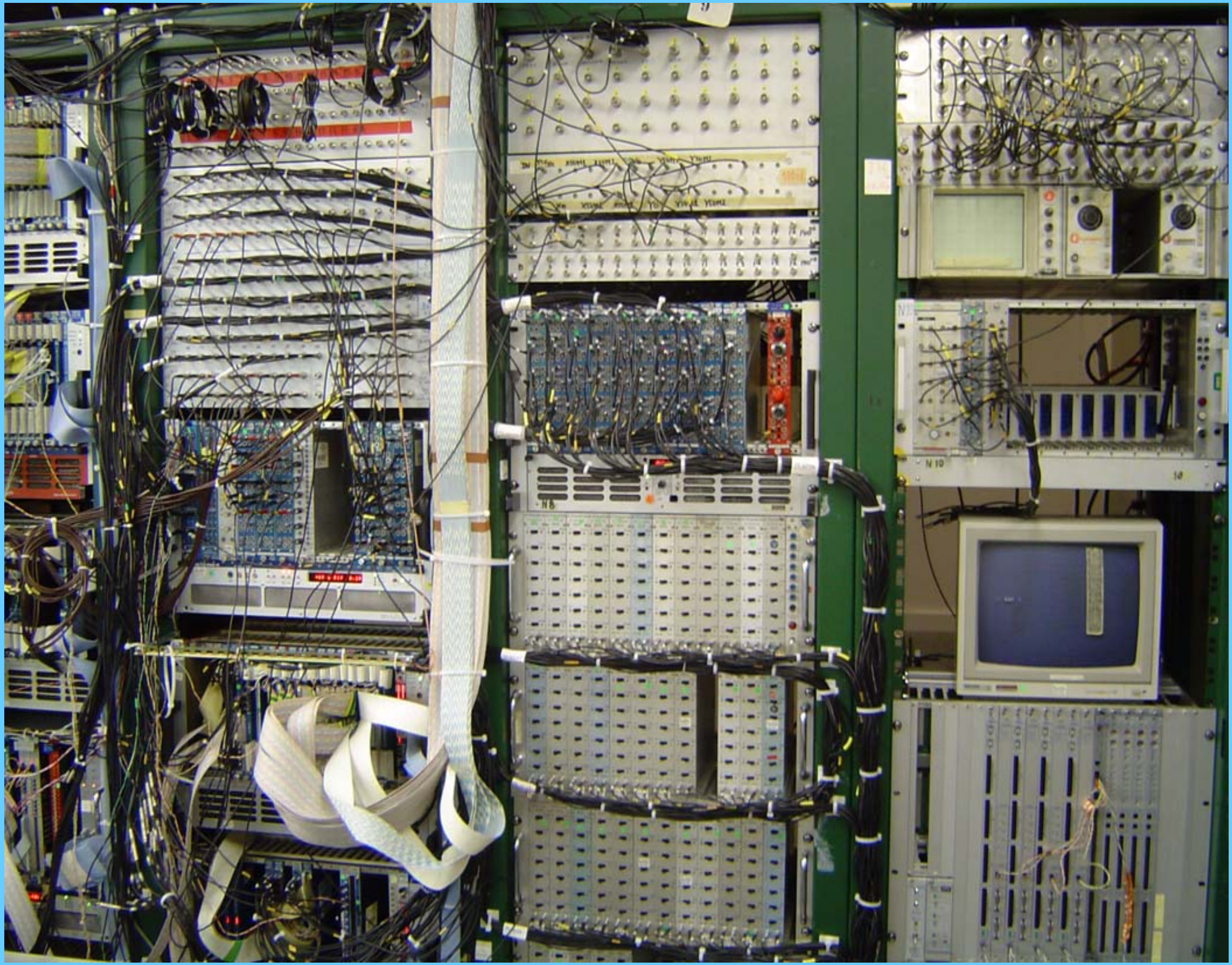




Preshower characteristic signal

Some PSh team members

THE PRESHOWER DETECTOR



CONCLUSIONS

1. PSh detector has been prepared, installed and tested within DIRAC setup

2. The new PSh characteristics:
   - larger aperture: 2 x 3500 mm x 750 mm
   - two layer configuration in the kaon region
   - increased electron rejection efficiency: **> 99.6%**
   - higher counting rate in the kaon region: 2 times
   - larger granularity: 40 signal channels

3. Ready to run

Thank you !