Search for KL0 $\rightarrow \pi^0 \nu \bar{\nu}$ Decay (KLOD project at IHEP).

A.Kurilin

Joint Institute for Nuclear Research

JINR, Dubna

2004/8/3

	BNL	Fermilab		KEK	
	KOPIO	KTeV-99	KAMI	E391A	JHF
Proton energy	24 GeV	800 GeV	120 GeV	12 GeV	50 GeV
Protons/pulse	5×10^{13}	1×10^{13}	3×10^{13}	2×10^{12}	2×10^{14}
Cycle time	3.6 sec	80 sec	2.9 sec	2.5 sec	3.42 sec
Flat-Top	1.6 sec	40 sec	1.0 sec	0.5 sec	0.75 sec
Ext.angle	45°	4.8 mr	24 mr	4°	10°
Beam profile	4mr×125mr	0.22mr×0.22mr	0.6mr×0.6mr	4 mr^{ϕ}	2.6 mr^{ϕ}
Solid Angle	500 μstr	0.048 μstr	1 μstr	12.6 μstr	5.5 μstr
$Y_{K_L^0}$/p/str	4.8×10^{-3}	4.8×10^{2}	3.7	5.9×10^{-2}	0.96
Av.K_L^0 mom.	0.7 GeV/c	70 GeV/c	10 GeV/c	2 GeV/c	2 GeV/c
Decay region	3.5 m	38 m	34 m	2.7 m	2.7 m
Decay prob.	16 %	2.1 %	10 %	4.3 %	4.3 %
K_L^0/pulse	1.2×10^{8}	2.3×10^{7}	1.1×10^{8}	1.5×10^{6}	1.1×10^{9}
K_L^0-decay/pulse	1.9×10^{7}	4.8×10^{5}	1.1×10^{7}	6.5×10^{4}	4.7×10^{7}
Av.K_L^0-decay/sec	5.3×10^{6}	6×10^{3}	3.8×10^{6}	2.6×10^{4}	1.4×10^{7}
Inst.decay-rate	12 MHz	12 kHz	11 MHz	130 kHz	63 MHz
Acceptance	1.6 %	5 %	7.4 %	8 %	16 %
Run Time	3×10^{7} sec	6×10^{5} sec	3×10^{7} sec	1×10^{7} sec	3×10^{7} sec
Running Eff.	50 %	50 %	50 %	50 %	50 %
Sensitivity	7.8×10^{-13}	1.1×10^{-8}	2.3×10^{-13}	1.0×10^{-10}	3.0×10^{-14}
Events(3×10^{-11})	38 events		130 events		1000 events

- KTeV
- KAMI
- KOPIO
  ????
- E391A
- JHF (JPARK)

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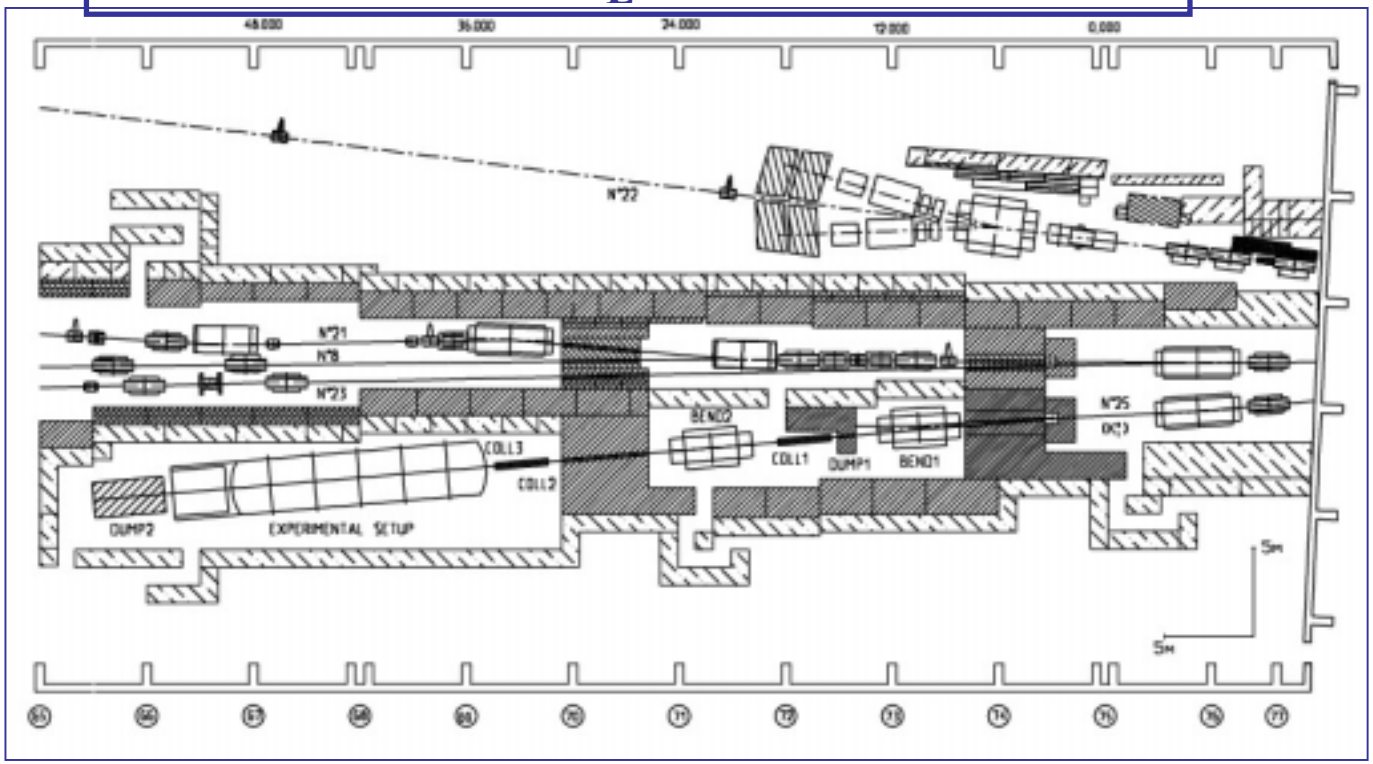
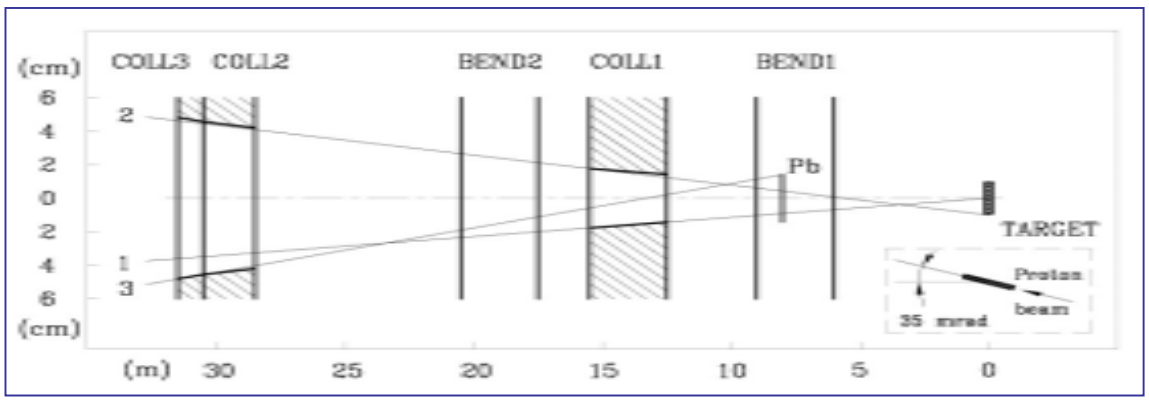
"T.Inagaki, Proceedings of the International Workshop on CP Violation in K, Tokyo, 1998"

Beam line K_L at U-70 IHEP





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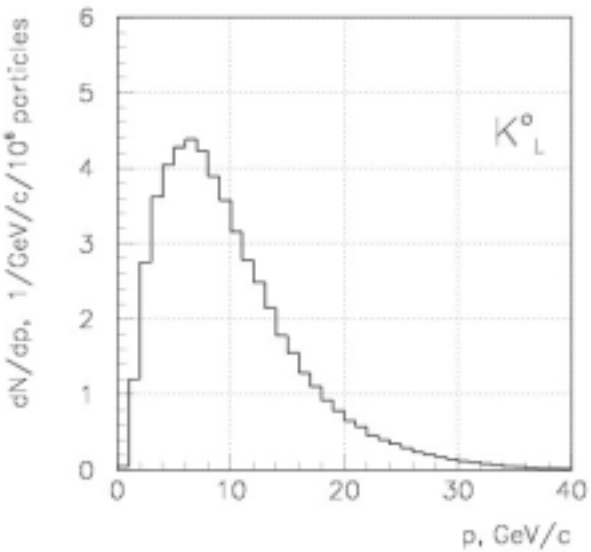
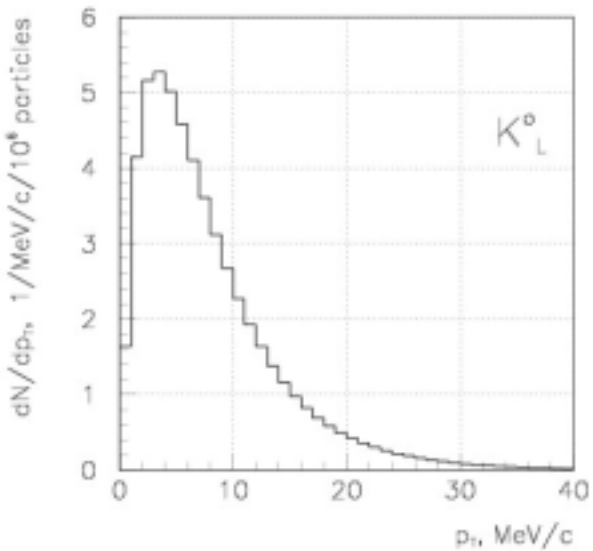
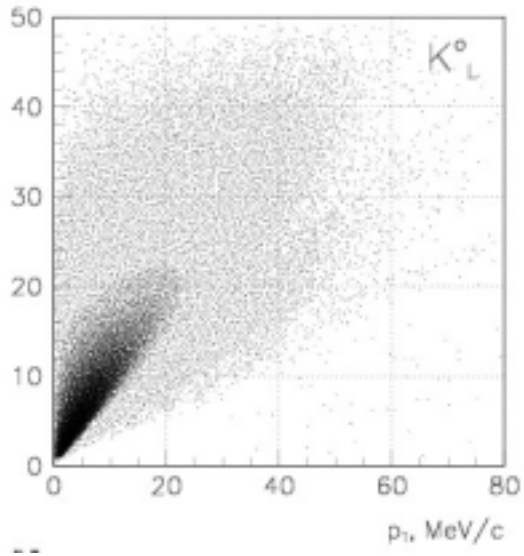
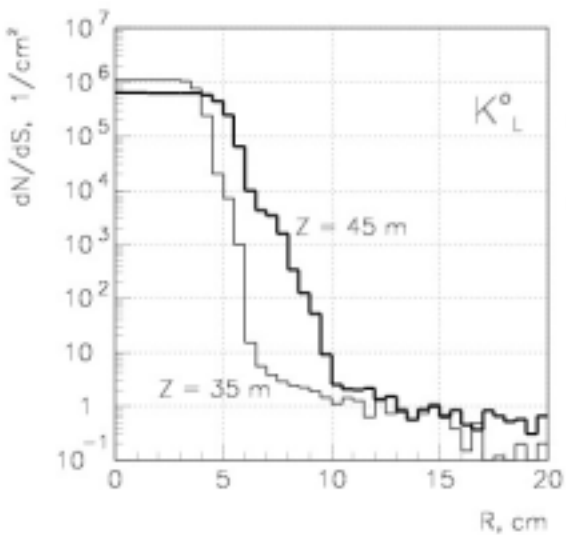
10^{13} 60 GeV p/cycle, Cu-target 25 cm (80% interaction), 35 mrad, Pb 5cm

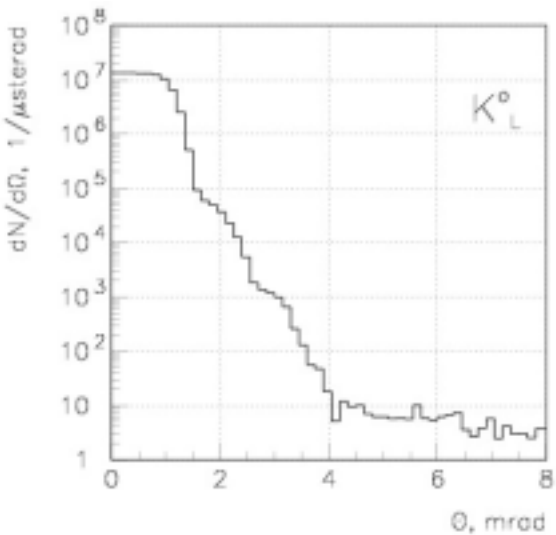
Beam line KL at U-70 IHEP











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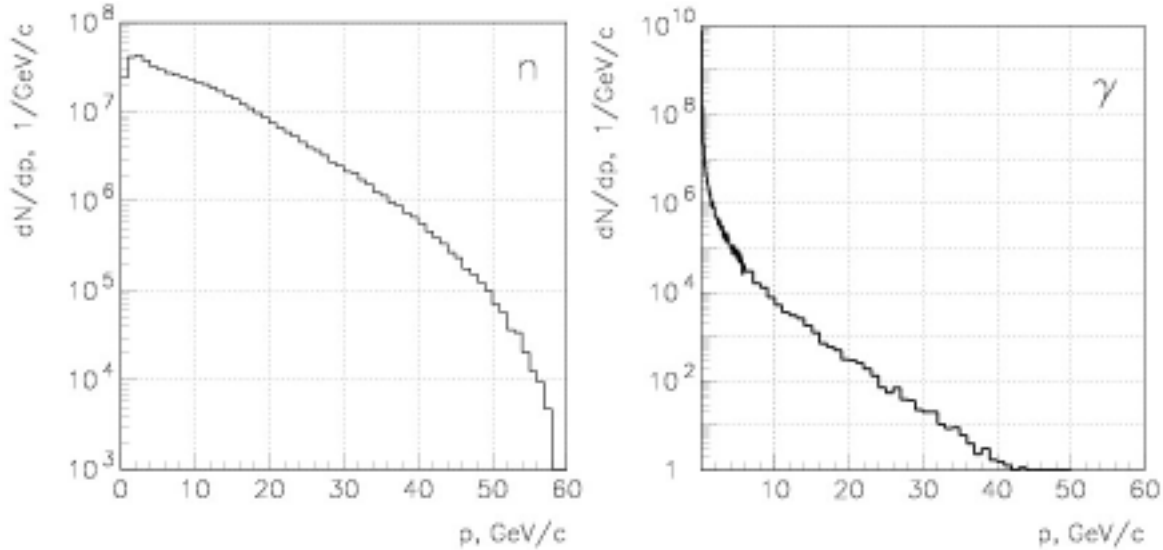
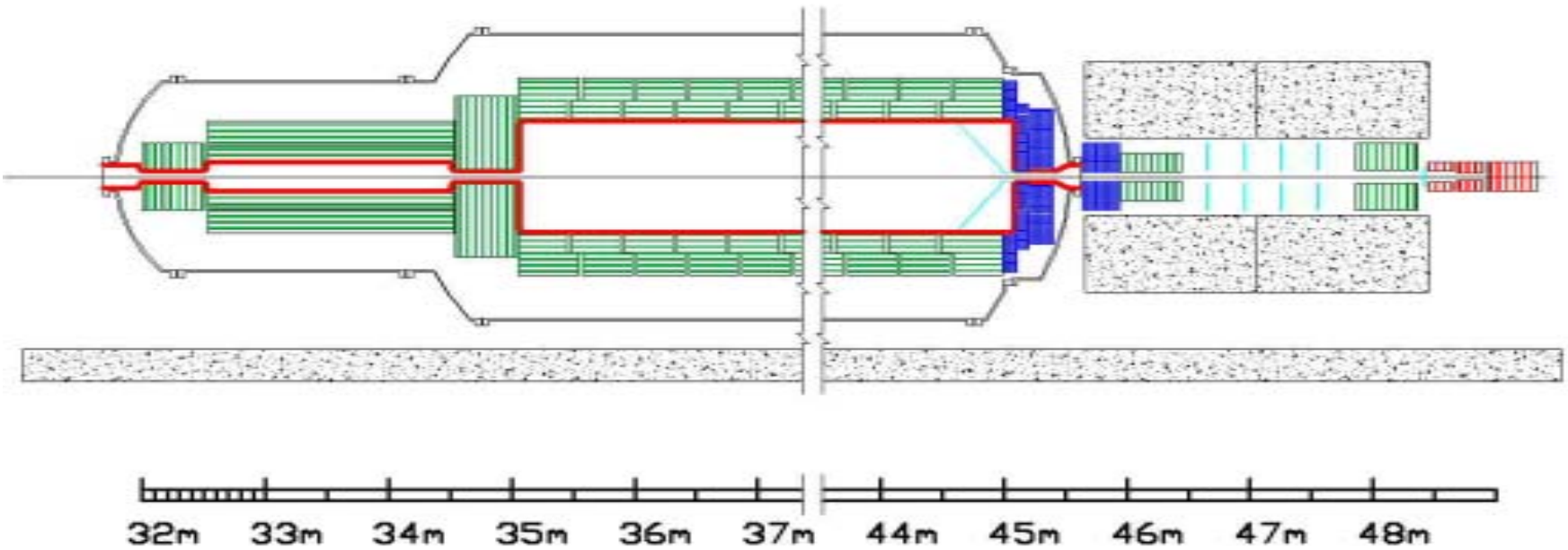
“n” and “γ” background

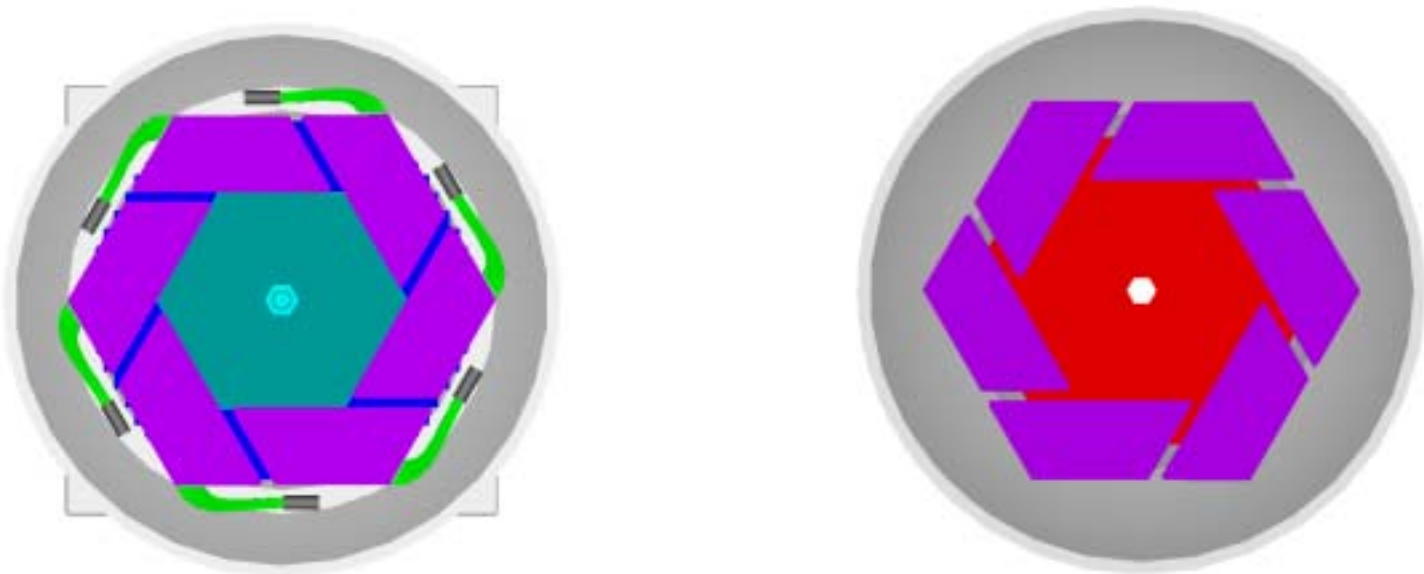


	Интенсивности			Отношения		
	K_L°	n	γ	n/K_L°	γ/K_L°	γ/n
Без конвертера	$7.7{\cdot}10^7$	$8.3{\cdot}10^8$	$3.1{\cdot}10^{10}$	11	402	37
С конвертером	$5.4{\cdot}10^7$	$5.2{\cdot}10^8$	$7.4{\cdot}10^8$	10	14	1.4

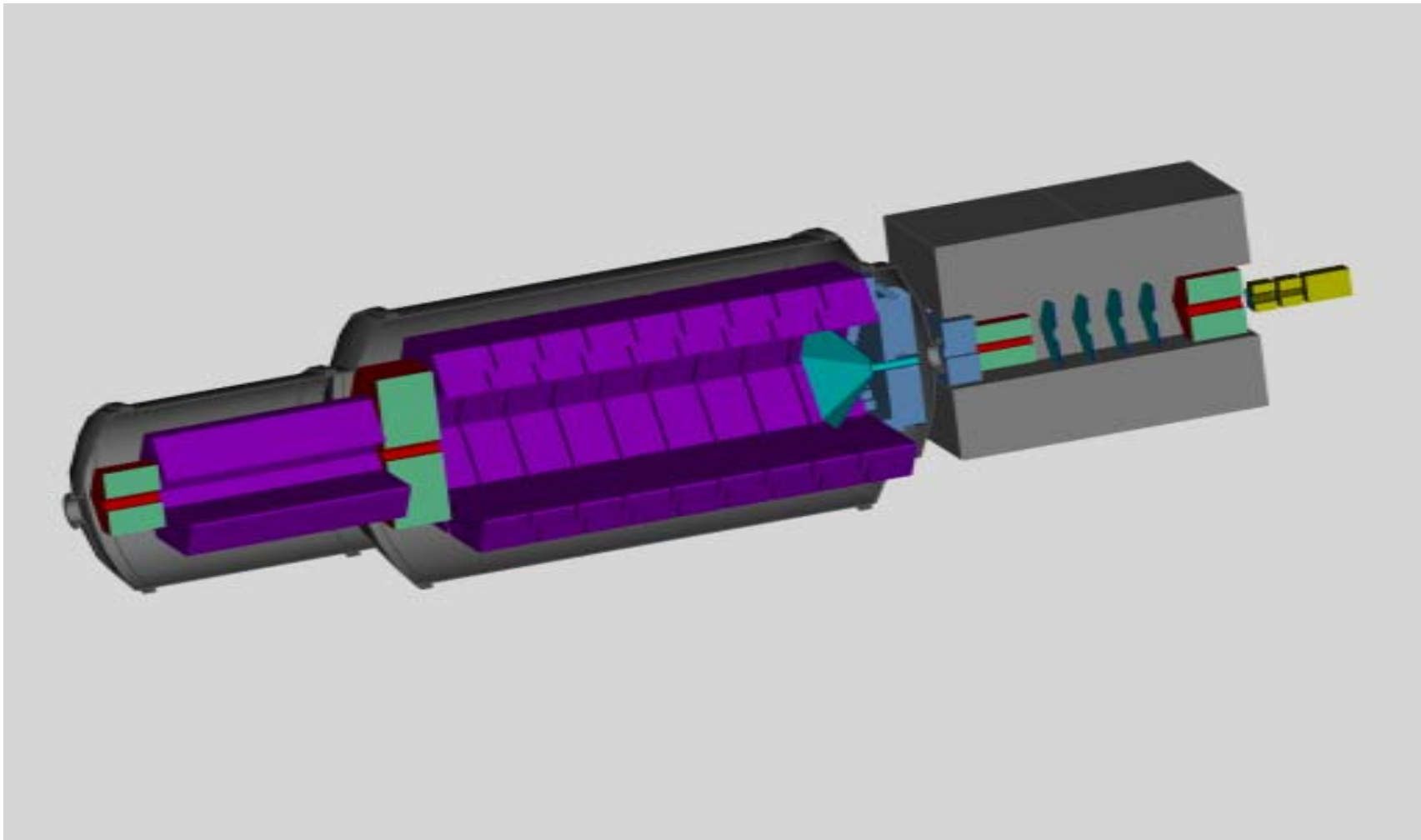
KLOD setup



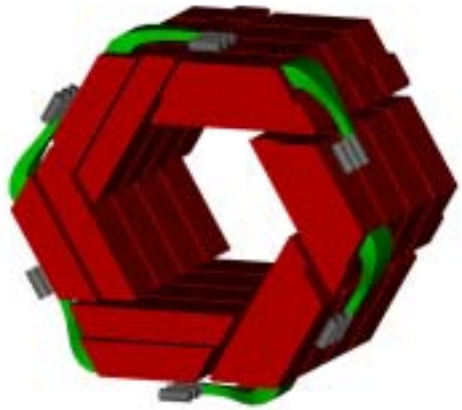
KLOD setup

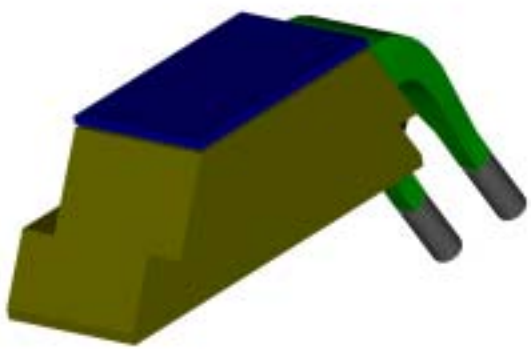


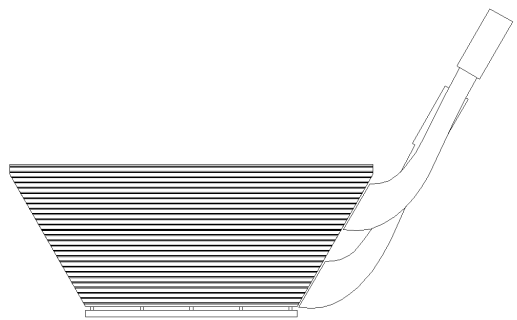
KLOD setup

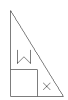


Veto barrel (I)

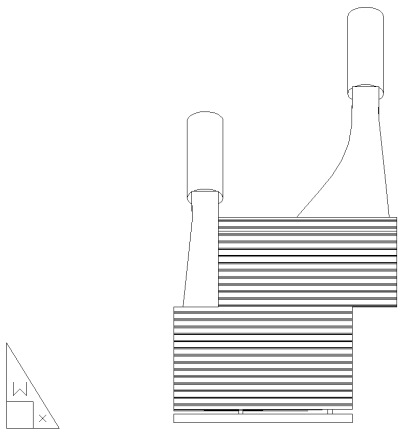


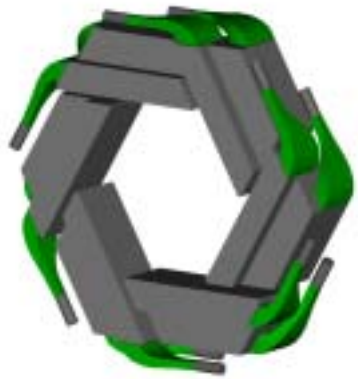


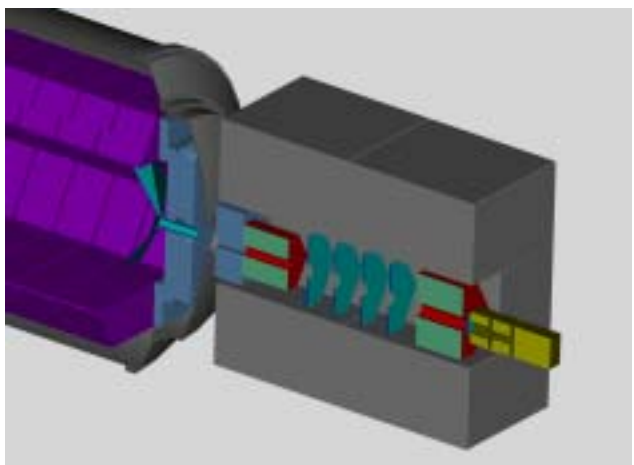


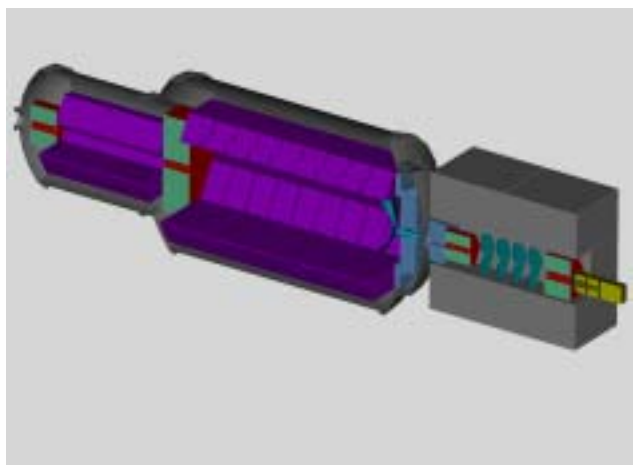


Veto detectors (I)









Veto barrel (II)

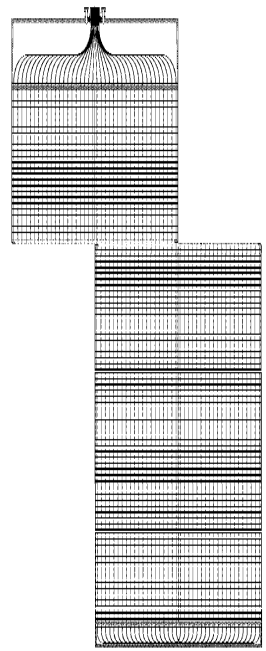
Inefficiency of γ detection:

- **"Punch-through"** @>1 GeV ⇒ 18 X_0 ⇒ 8×10^{-7}
- **Photonuclear reactions**
  @(0.1÷1)GeV $(10^{-4} \div 10^{-6})$ for 10MeV threshold
  ⇒ reduction of threshold
- **«Sampling»-effect** @<100 MeV
  ~1% @ 20 MeV for (1mm Pb+ 5mm Scintil.)
  ⇒ «thin» structure
  ⇒ reduction of threshold

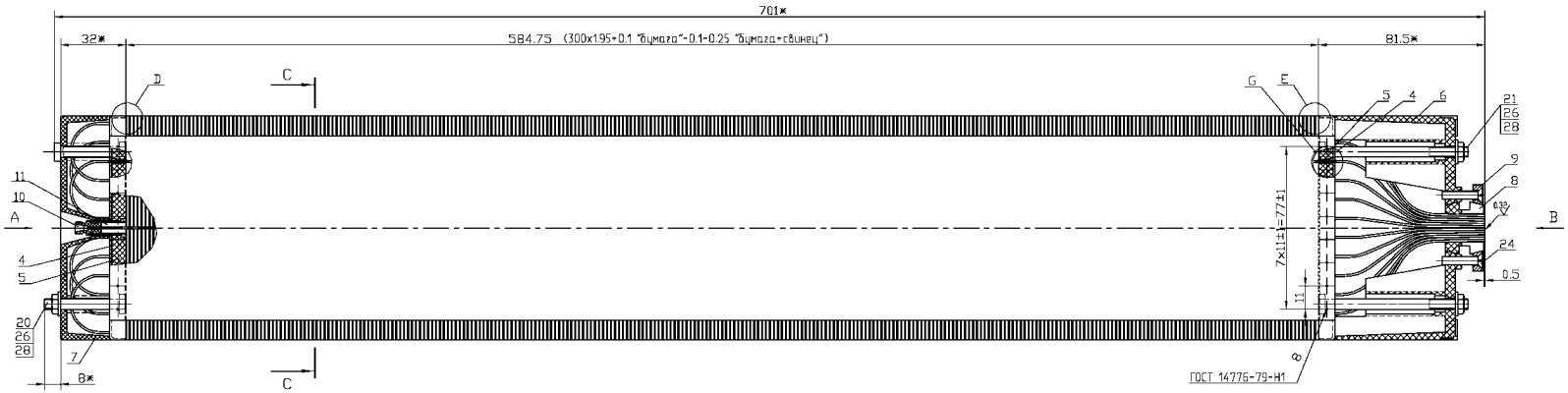
«Shashlik» - calorimeter

(0.3mm Pb + 1.5mm scintillator)

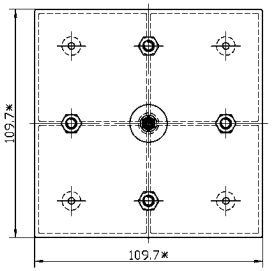
- 30000 photons/ 1 GeV γ
- 5.5 ph.e./plate/ *mip*
- 18 ph.e./ 1 MeV «visible» energy
- $\sigma_E/E \approx 3\%/\sqrt{E}$



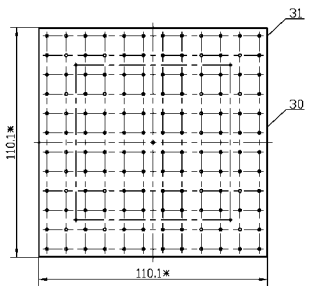
Size of module along beam	**300 mm**	**Segmentation along beam – 100 mm**
Size of module across beam	**200 mm**	
Scintillator thickness	**1.5 mm**	
Lead thickness	**0.275 mm**	**0.55 mm for first part**
Radiation length, X_0	**35.5 mm**	**17.75 mm for second part**
Length of module (active part)	**500 mm**	**(355 + 145) mm, (10 + 8) X_0**
Full length of module	**600 mm**	**Without PMT**
Weight of module	**80 kg**	
Length of fibres/module	**268 m**	
Total of modules veto	**1400**	**(28 -- across beam) x (50 -- along)**
Full length of fibres (veto)	**375 km**	



A (Бумага поз.31 и лента поз.30 условно не показаны)



C–C



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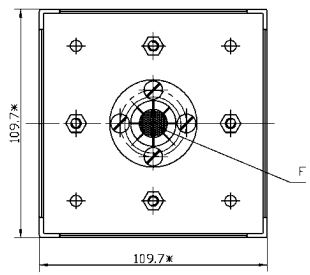
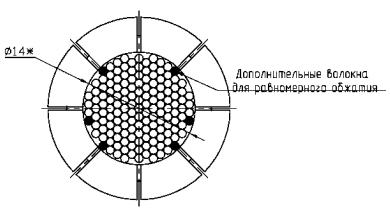
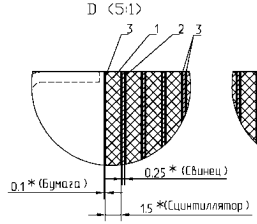


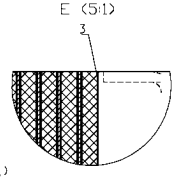
F (4:1)



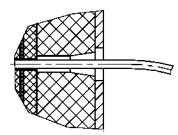
D (5:1)



E (5:1)



G (4:1)



Техническая характеристика

1.Количество сцинтилляционных пластин (шт)	-300
2.Количество свинцовых пластин (шт)	-299
3.Количество бумажных пластин (шт)	-600
4.Диаметр фибера (мм)	-1
5.Суммарный вес свинцовых пластин (кг)	-17.3
6.Суммарный вес сцинтилляционных пластин (кг)	-5.7
7.Вес модуля (кг)	-18.2
8.Габаритный размер модуля (мм)	-110.1x110.1x701

Техническая требования

1.h14,±IT14/2

2*.Размеры для справок

3.Сборку модуля производит заказчик.

4.Остальные технические требования по ОСТ 95 227-83

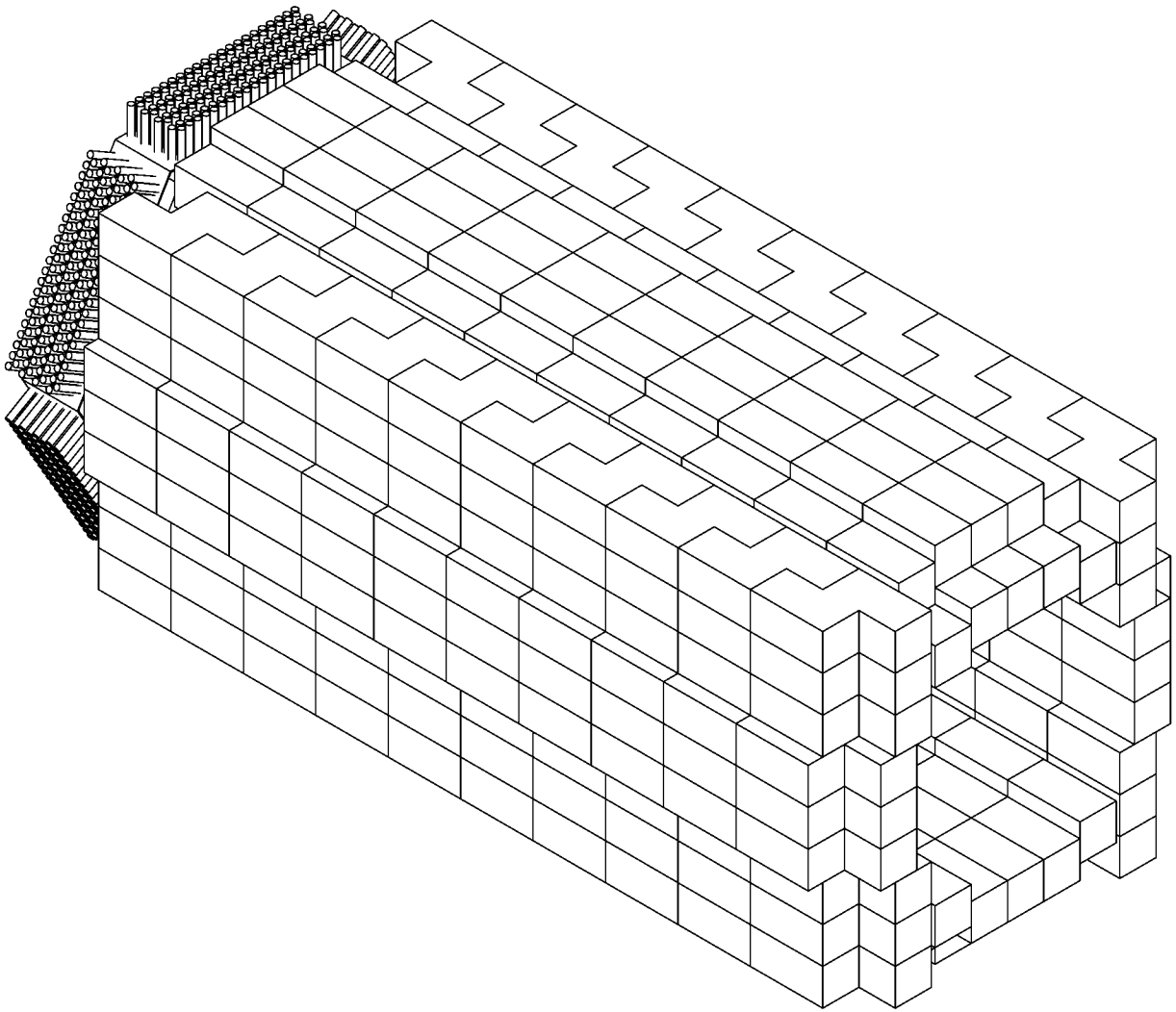
Согласовано: Нач. лаборатории ОНФ Солдатов А.П.

Изм.	Лист	№ докум.	Подпись	Дата	7730-00-00-00СБ		
Разраб.		Сабодаш			Модуль КОРПО 1.5/0.25 Сборочный чертеж	Лит.	Масса	Масштаб
Пров.		Сабодаш				И		1:1
Т. контр.						Лист	Листов 1	
Н. контр.					КОНСТРУКТОРСКИЙ ОТДЕЛ			
Утв.		Любань						

Копировал Формат А1

Инв.№ подл. | Подп. и дата | Взам. инв.№ | Инв.№ дубл. | Подп. и дата | Справ.№ | Перв. прим. 7730-00-00-00

Veto barrel (II)



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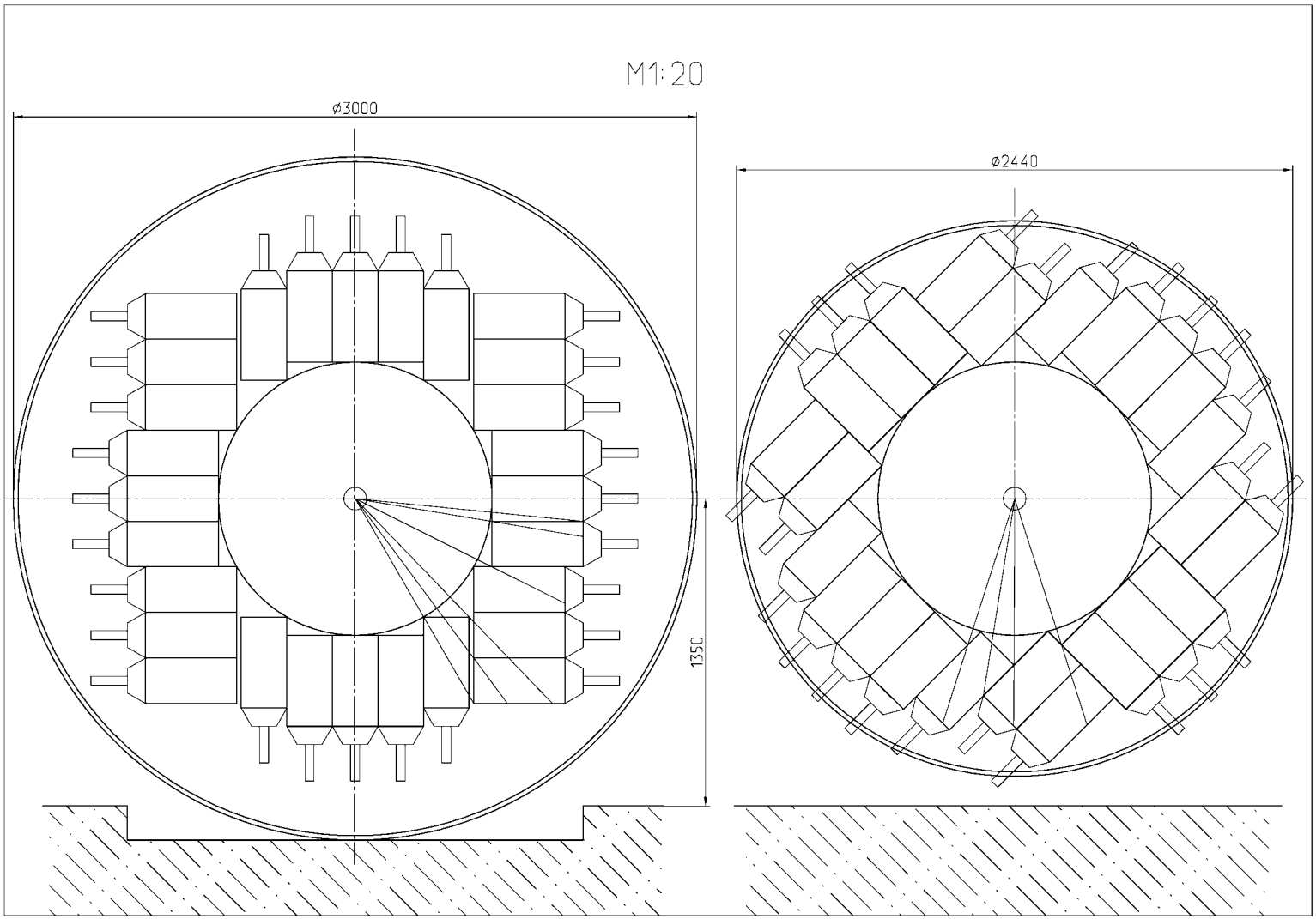

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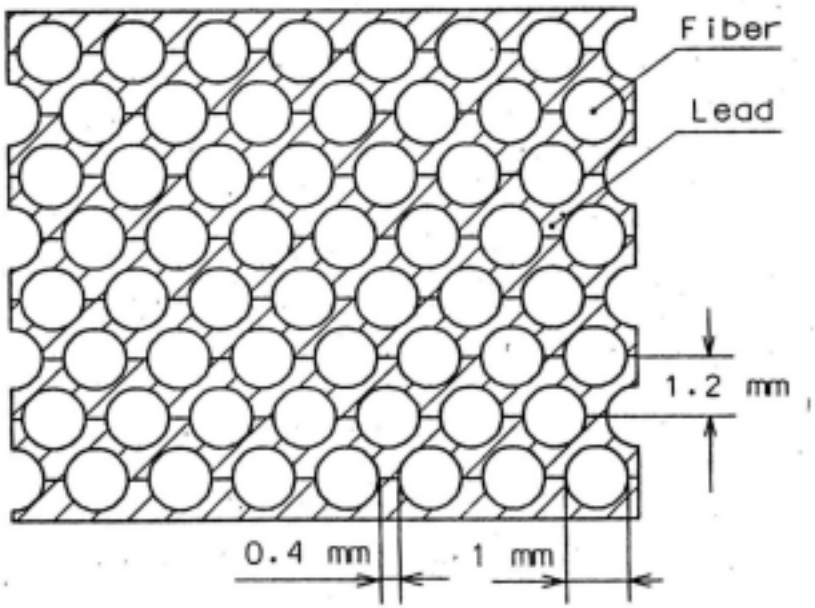
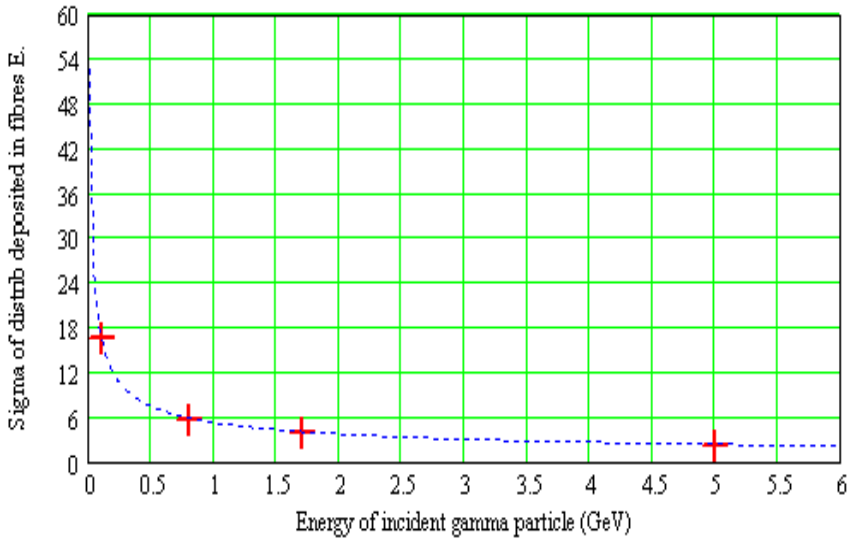
Calorimeter

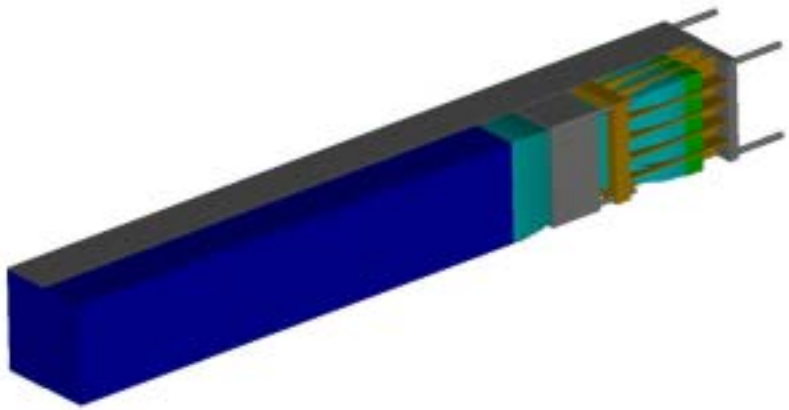


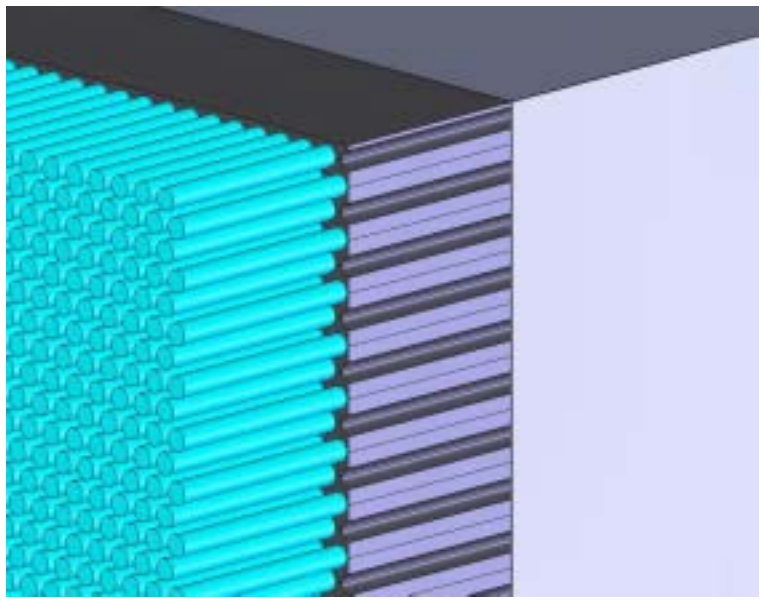


$$\sigma(E)/E = 4.7\%/\sqrt{E(GeV)}$$

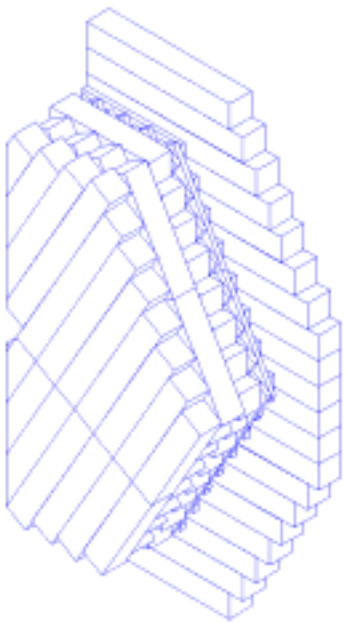
$$\sigma_t = 52ps/\sqrt{E(GeV)}$$

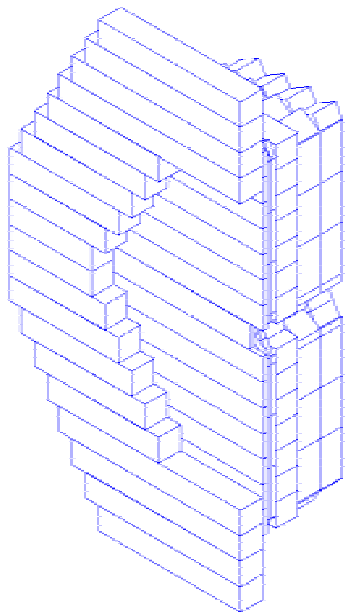
Calorimeter





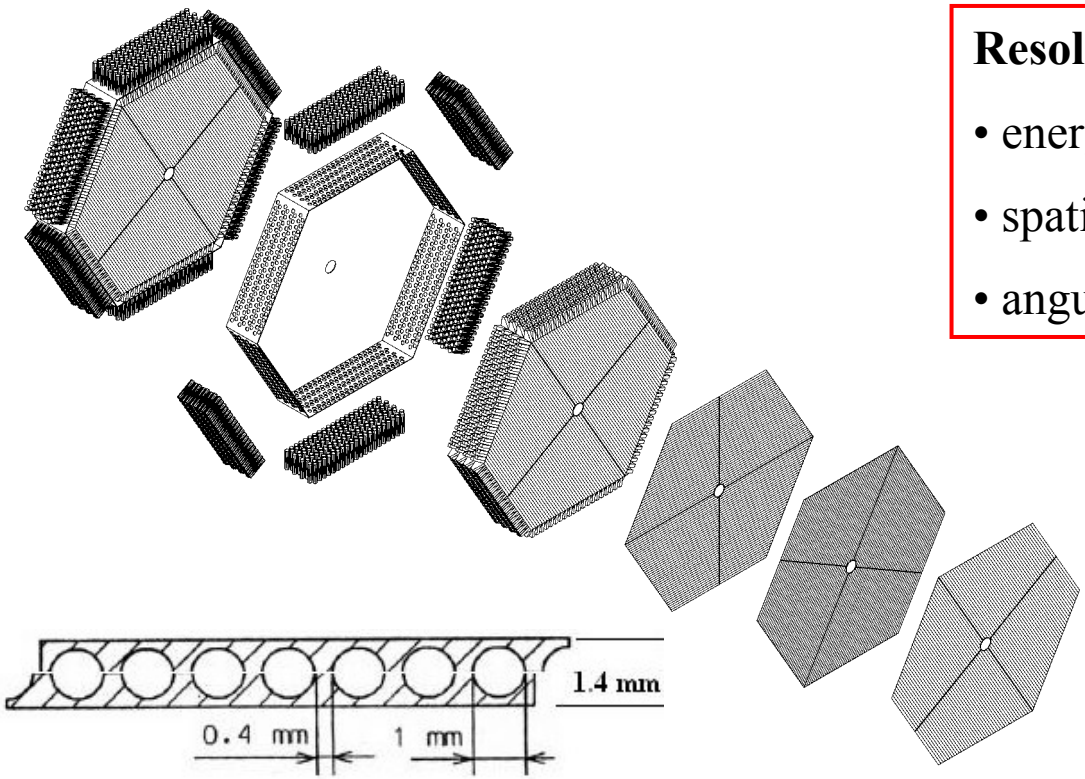
Calorimeter





Calorimeter

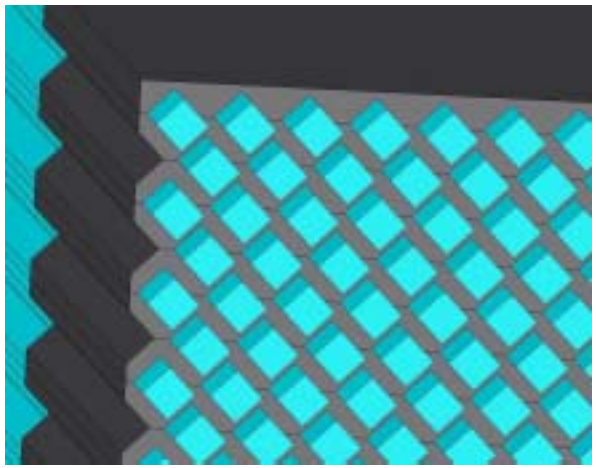
Size across beam	**∅120 cm**	**Entered circle**
Radiation length, X_0	**13 mm**	
Size along beam	**312 mm**	**24 X_0**
Size of strip	**15 mm**	
Total of channels	**1920**	**160 (plane) x 3 (X,U,W) x 4 (segment)**
Full length of fibers	**220 km**	
Total weight of lead	**700 kg**	

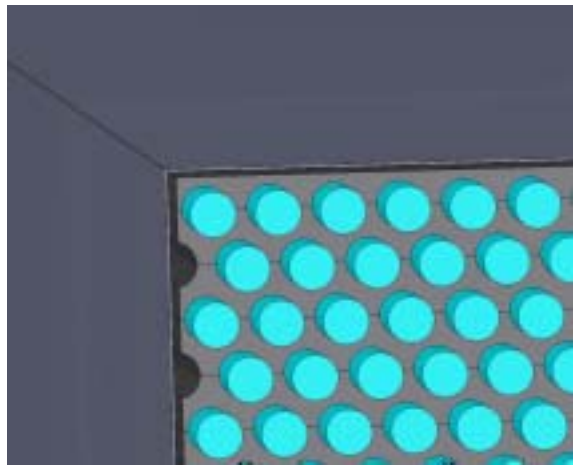


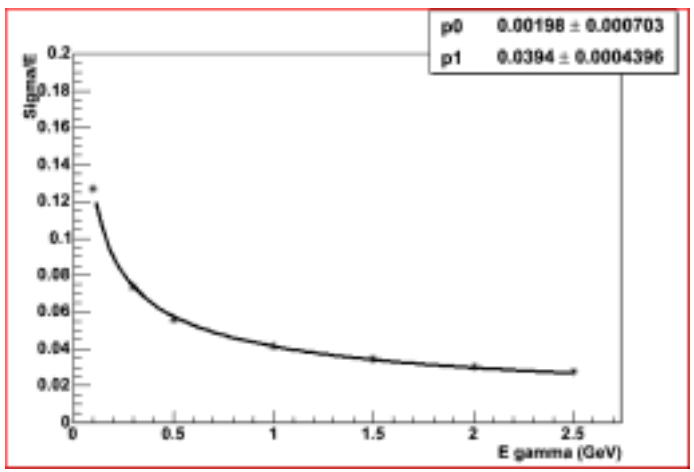
Resolution

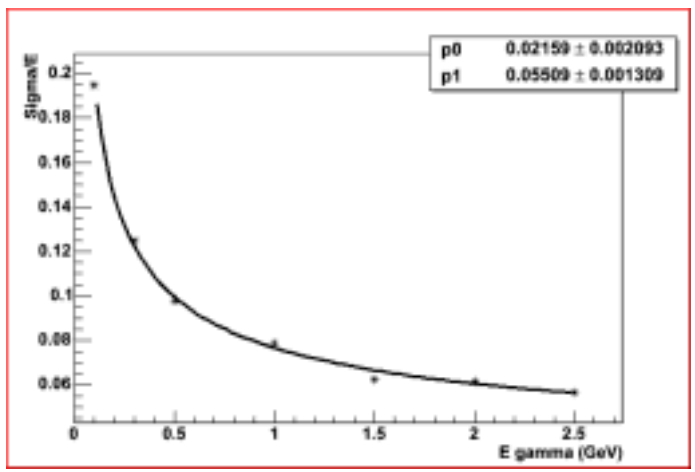
- energy $\sigma_E/E \approx 5.5\%/\sqrt{E}$
- spatial 2.5мм/sqrt(E)
- angular 20мрад/sqrt(E)

Calorimeter

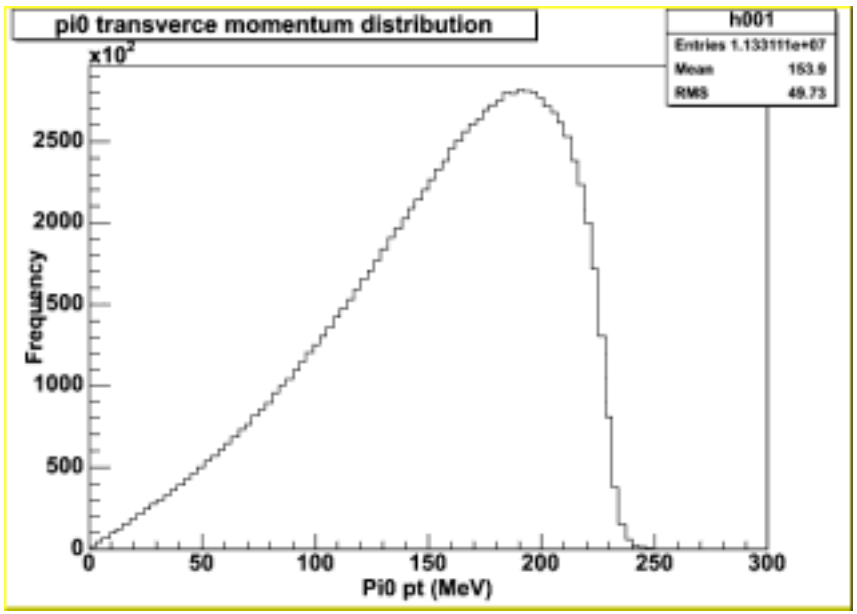


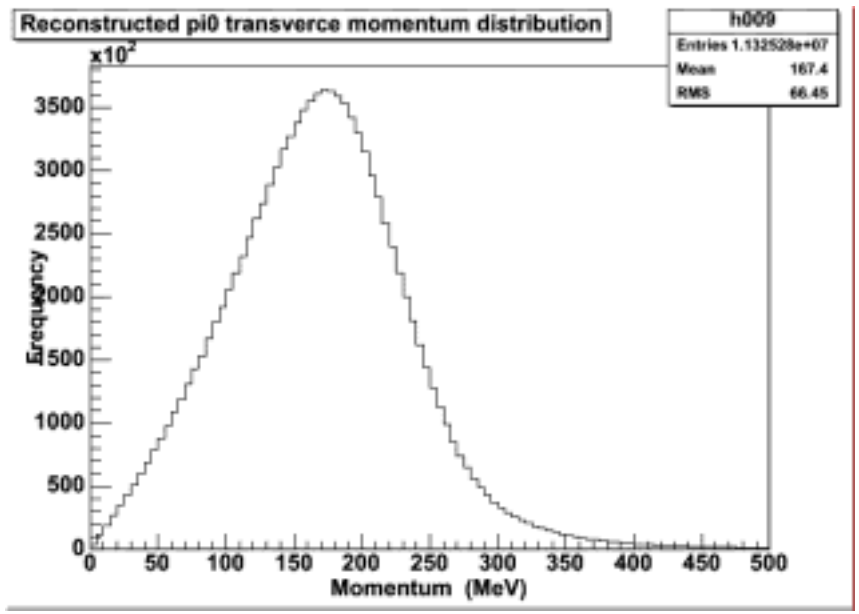




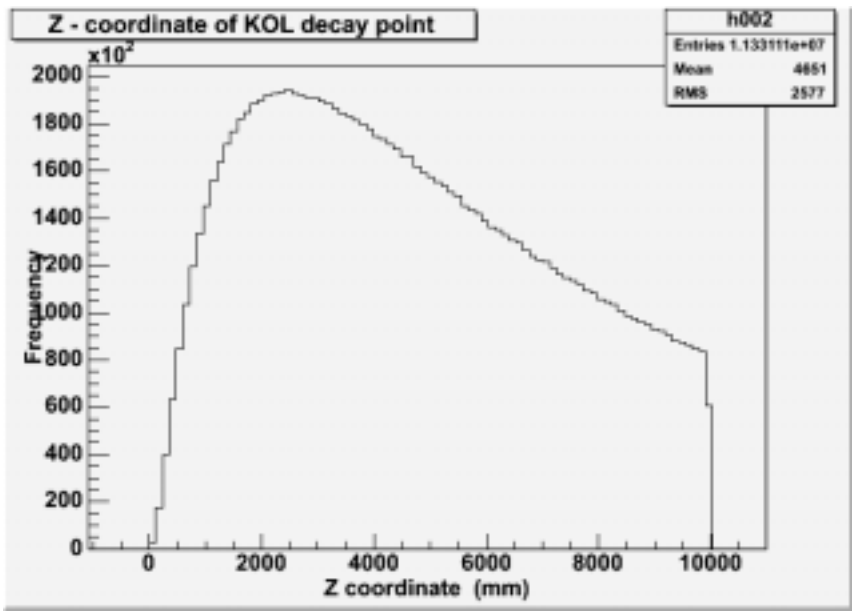


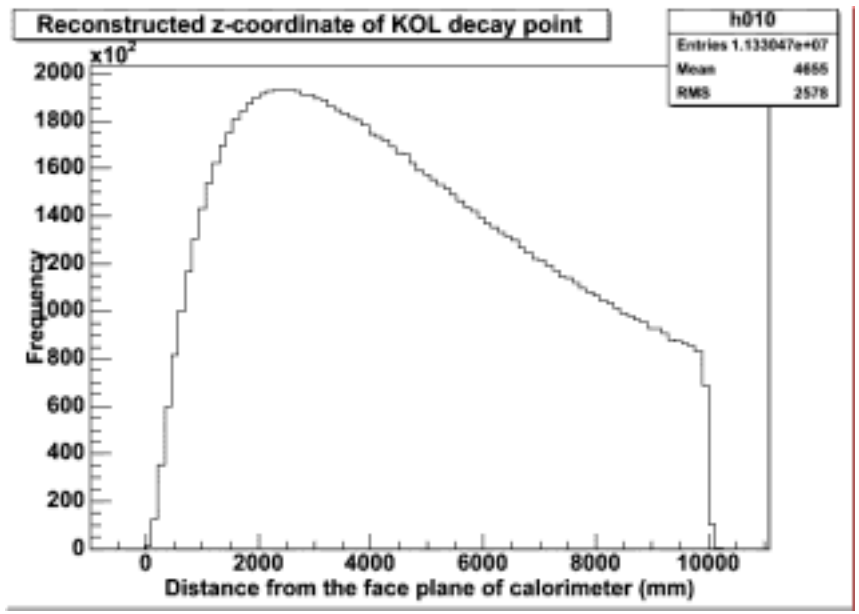
Simulation of setup KLOD



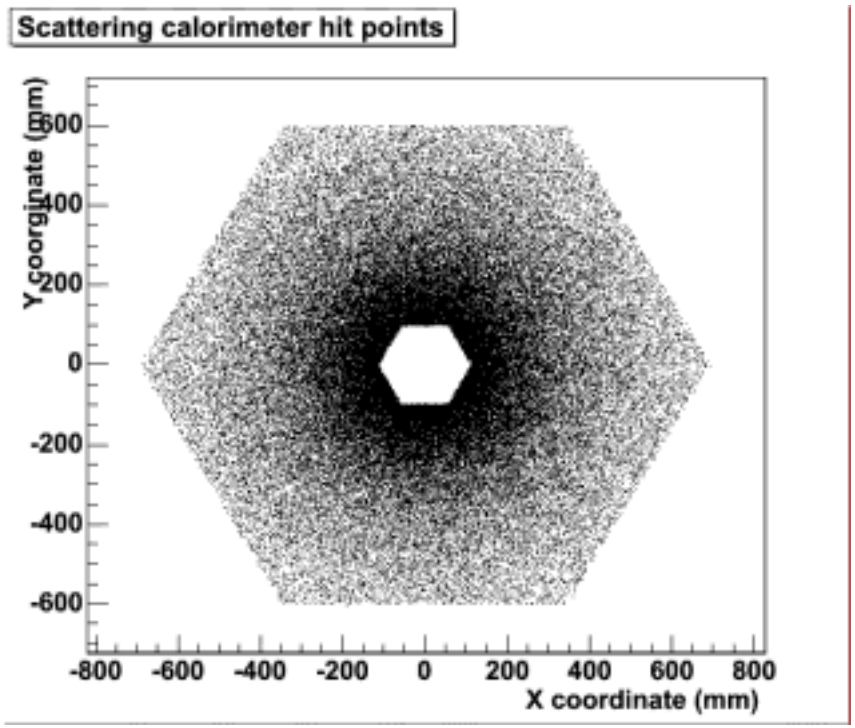


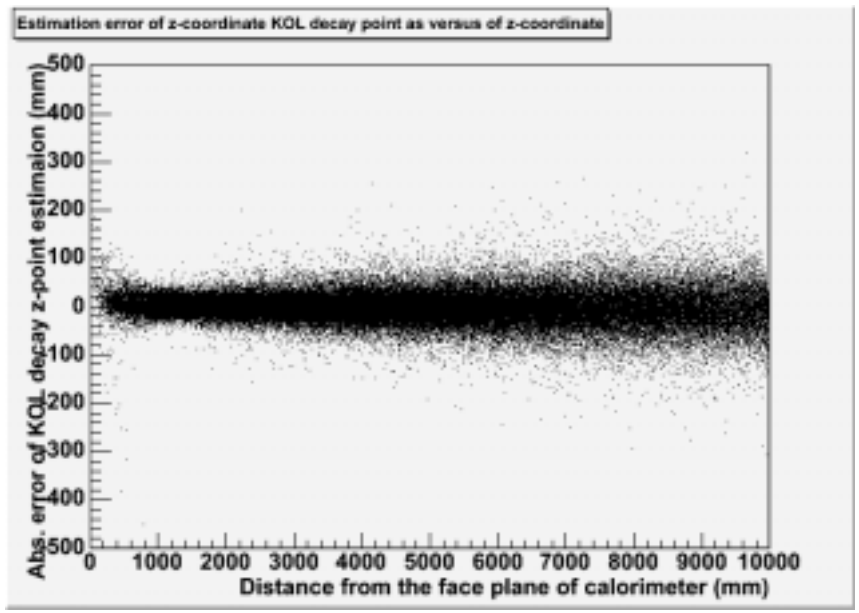
Simulation of setup KLOD



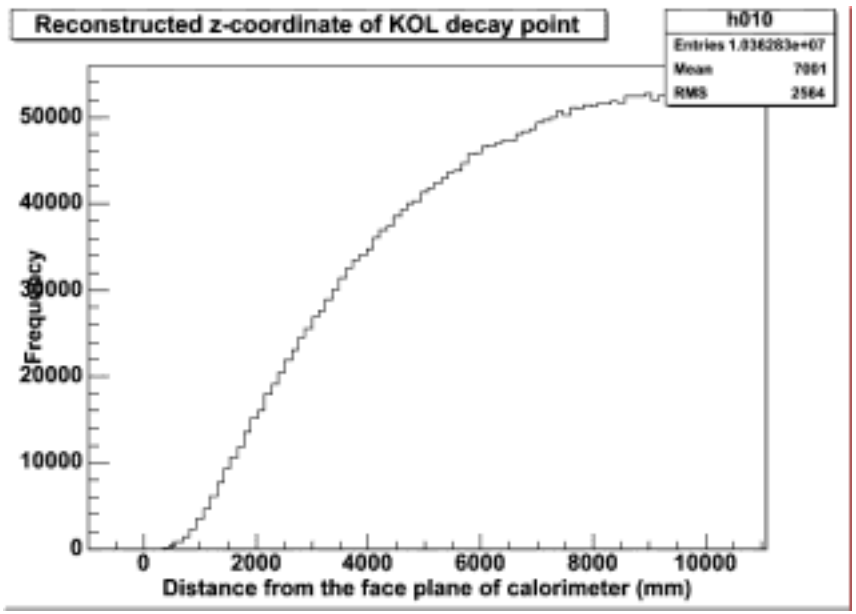


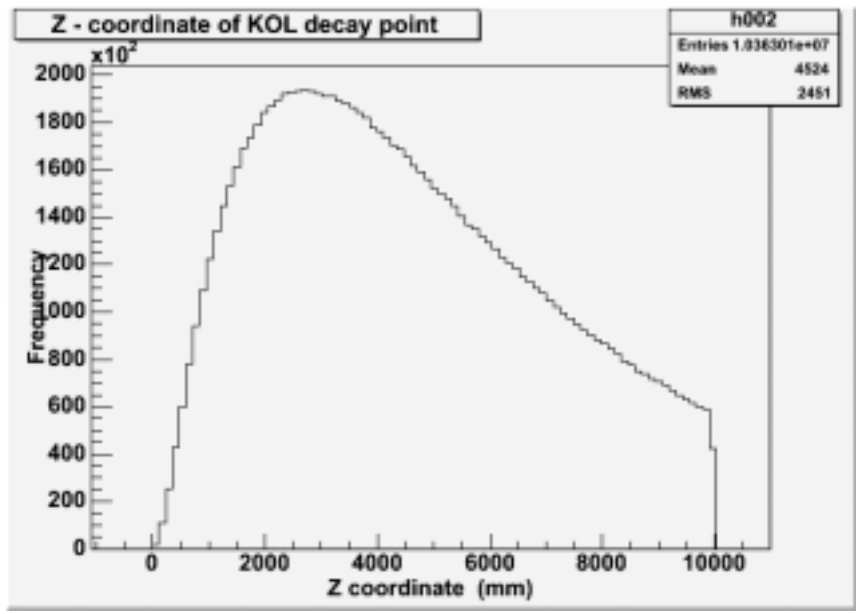
Simulation of setup KLOD





Simulation of setup KLOD





Background and sensitivity

- No. of background events (at a sensitivity of $Br(K_L^0 \rightarrow \pi^0 \nu \bar{\nu}) = 2 \times 10^{-11}$)
- Other K_L decay with gammas, detection inefficiency of gamma $0.28(\pi^0 \pi^0)$, $<0.1(\gamma\gamma)$, $<0.1(\pi^0 \pi^0 \pi^0)$
- K_L decays outside the region $<<0.1$
- π^0 production by neutrons in residual gas(10^{-7} Pa) < 0.2
- π^0 production by halo neutrons <0.1

- One day sensitivity $1/10^8 * 10^4 * .0562 * .181 = 10^{-10}$

Plans

- 2004 –beam line construction at IHEP, production and test of prototypes, simulation.
- 2005 – end of beam construction, measurement of beam characteristics, production of detectors and units of setup, preparation of experimental zone.
- 2006 – setup assembly, test of setup and first run.
- 2007 – runs, data analysis, first results.

Summary

- There is a possibility to make at IHEP setup for registration of $K^0_L \to \pi^0 \nu \bar{\nu}$ decays.
- Sensitivity of setup allows for reasonable time (100 days) to register about 30 (SM) decays at a level of a background near 9 decays.
- R&D for production and test of prototypes of the basic detectors is necessary.
- The further simulation for more exact calculation of signals and background processes is necessary.

Possible scenario

- 2004 E391a Data taking, data analysis
- 2004 –beam line construction at IHEP, production and test of prototypes, simulation.
- 2005 E391a Data taking, data analysis
- 2005 – end of beam construction, measurement of beam characteristics, production of detectors and units of setup, preparation of experimental zone.
- 2006 – setup assembly, test of setup and first run.
- 2006 JPARC Beam line construction
- 2007 – runs, data analysis, first results.
- 2007 JPARC ……