J-Parc K^0TO実験における横方向光子検出器の高精度化

detector material for Main Barrel upgrade

Dec. 19. 2011
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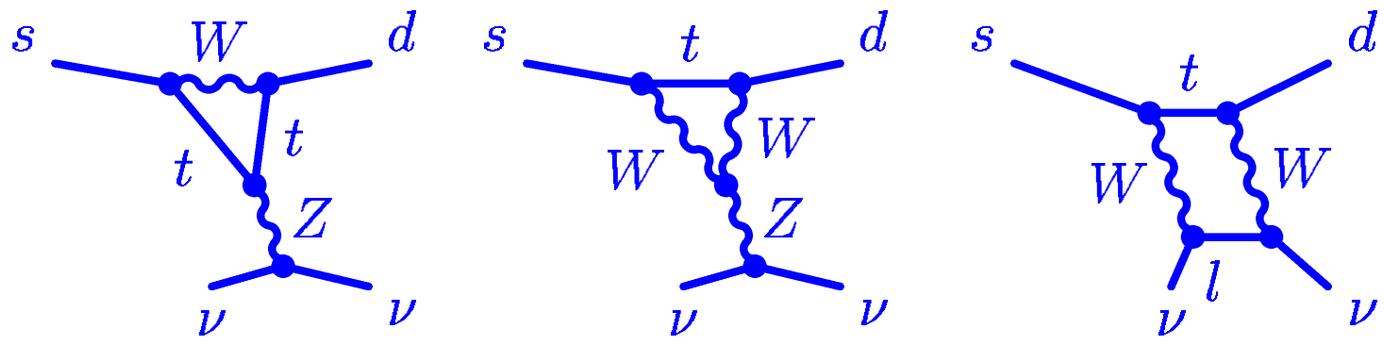
K^0TO exp.

- $K_L \rightarrow \pi^0 \nu\nu$ branching ratio

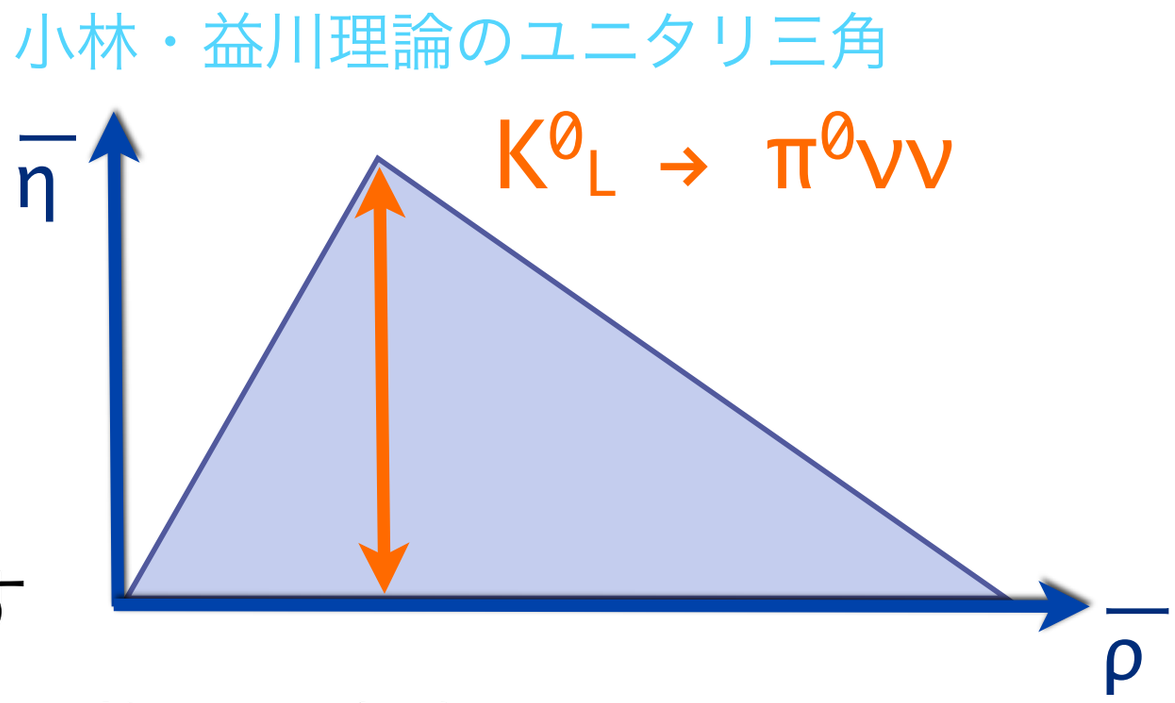


- <u>Golden Mode</u> ... Few % fluctuation about imaginary part η in CKM matrix

- rare decay

  Standard Model predict BR=3×10^{-11}

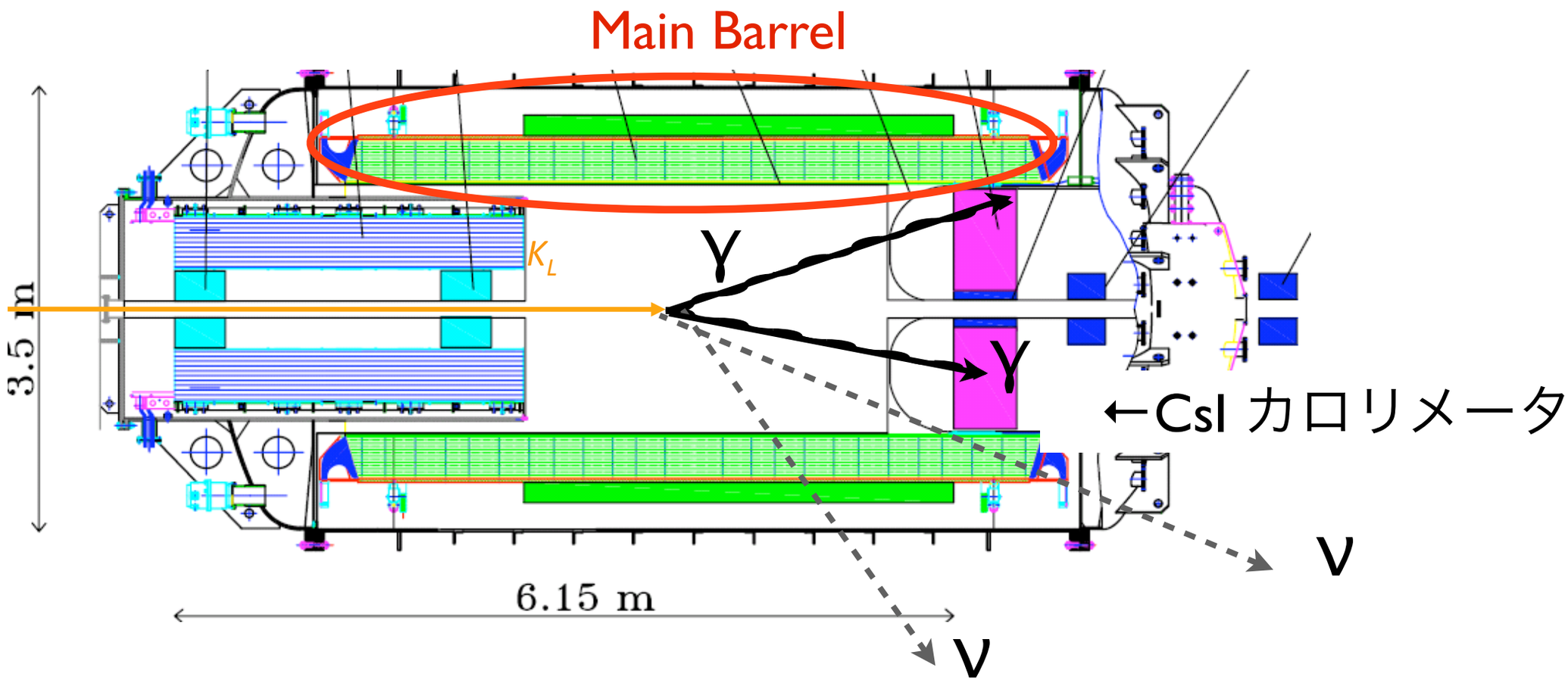
  E391a ex.：2.6×10^{-8} (90% level)



K^0TO実験ではSMの感度を目指す

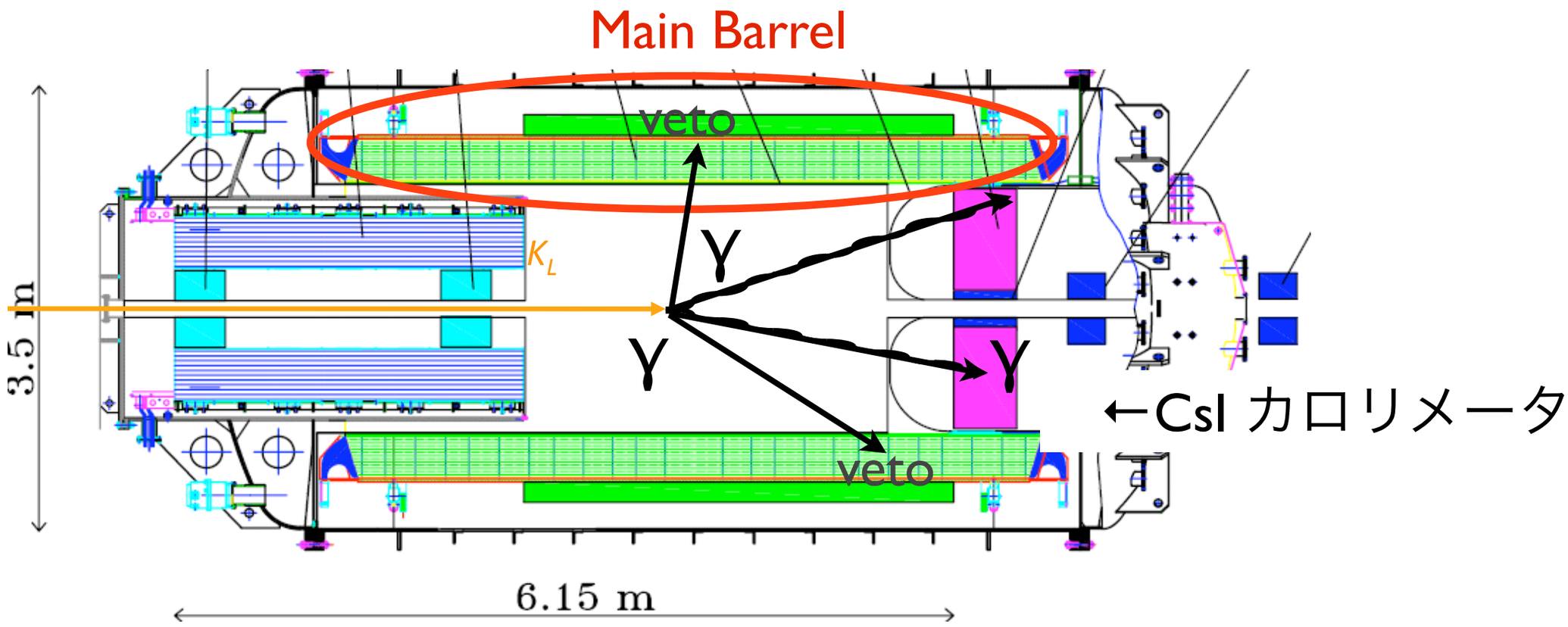
分岐比がより大きければ、 新しい物理の存在を示す

signal detection in KOTO



- CsIカロリメータにてπ^0からの2γを検出
- CsIカロリメータ以外の全ての検出器にて他粒子がないこと(veto)を要求

$2\pi^0$ 事象の除去と横方向光子検出器(Main Barrel(MB))



- 主back groundは $K_L \to \pi^0\pi^0$事象。計4γのうち2γをloss
- 他の各BG ＜ 0.3events

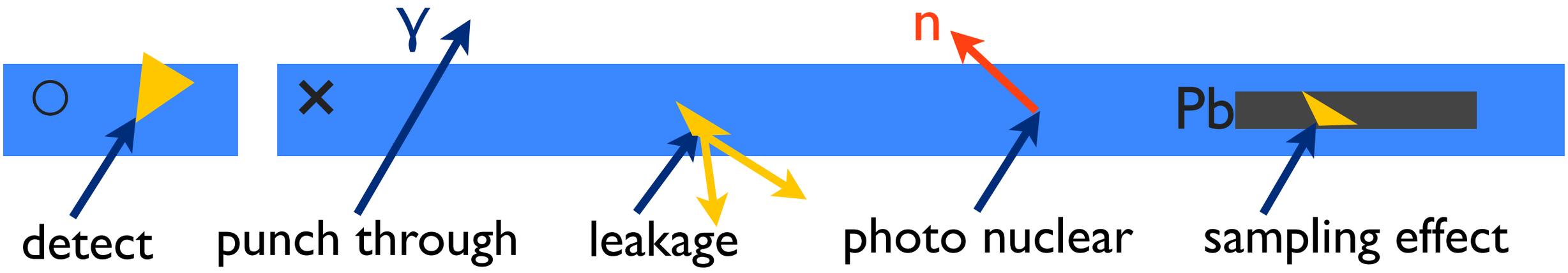
予想されるシグナルと主なBG
（MB改良前）

		event数
# signal		3.42±0.02
2π0 BG	MB concern	2.56±0.19
	other detectors	0.24

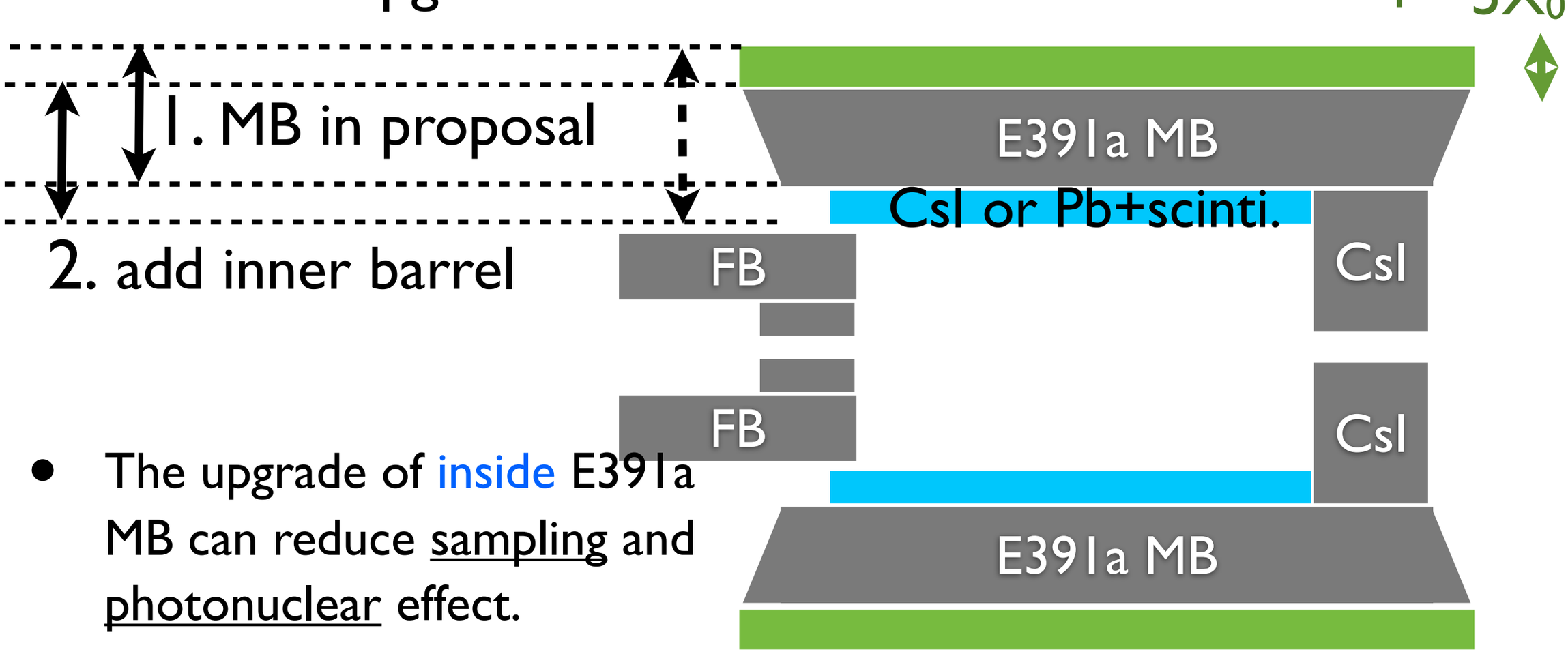
- MBは、E391a実験の鉛・シンチレータ積層型検出器を再利用

inefficiency source and MB upgrade

- Gamma inefficiency



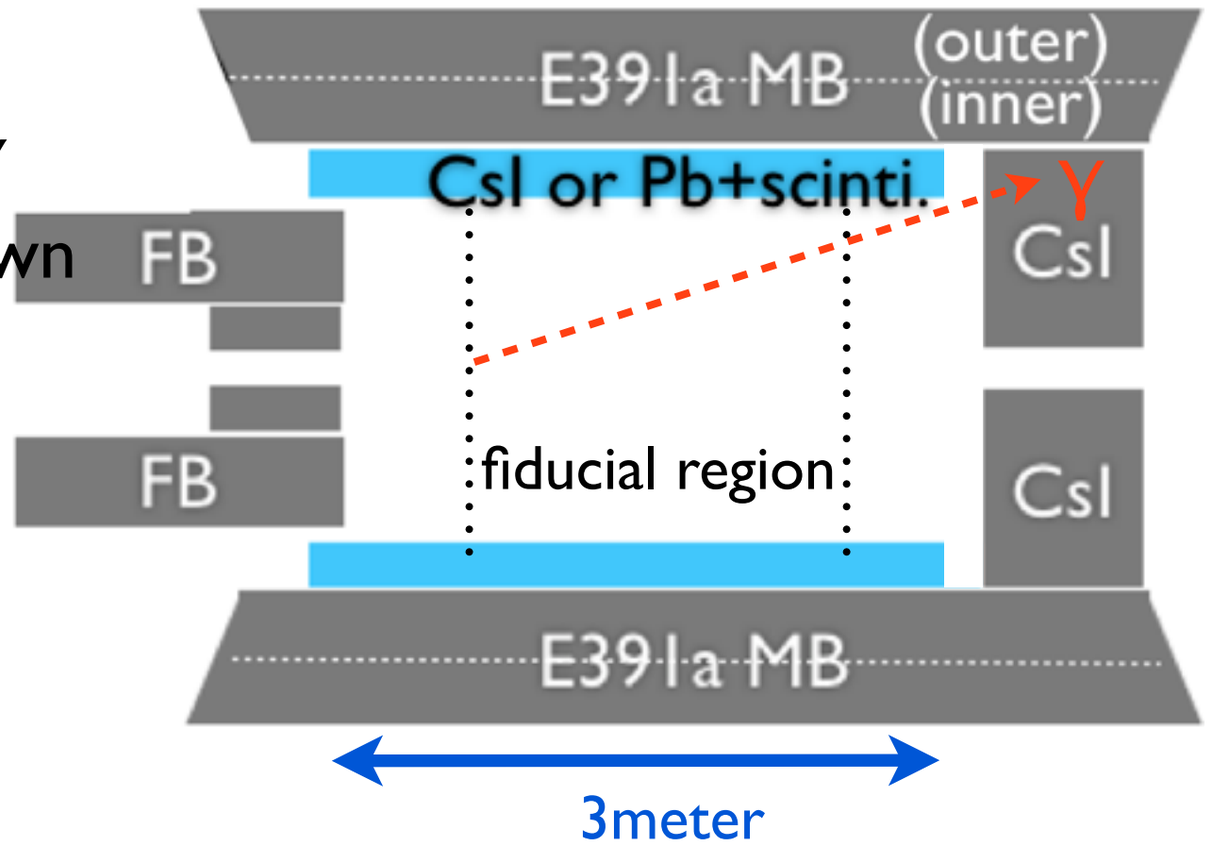
- idea for MB upgrade



- The upgrade of inside E391a MB can reduce sampling and photonuclear effect.

inside upgrade configurations

- Needed length is 3meters
- Thickness is limited by geometry of γ into calorimeter. (Max = 23cm at down stream end)
  - if "Pb1mm+scinti.5mm" $5X_0$ → 16cm
  - need to add structure thickness



	size	number	covered Z	X_0
KTeV CsI	50×50×500	392+α	1500	2.7
E391a CsI	75×75×300	400−α	1200	4.0
Pb+scinti.	free×160×free	free	free	5.0

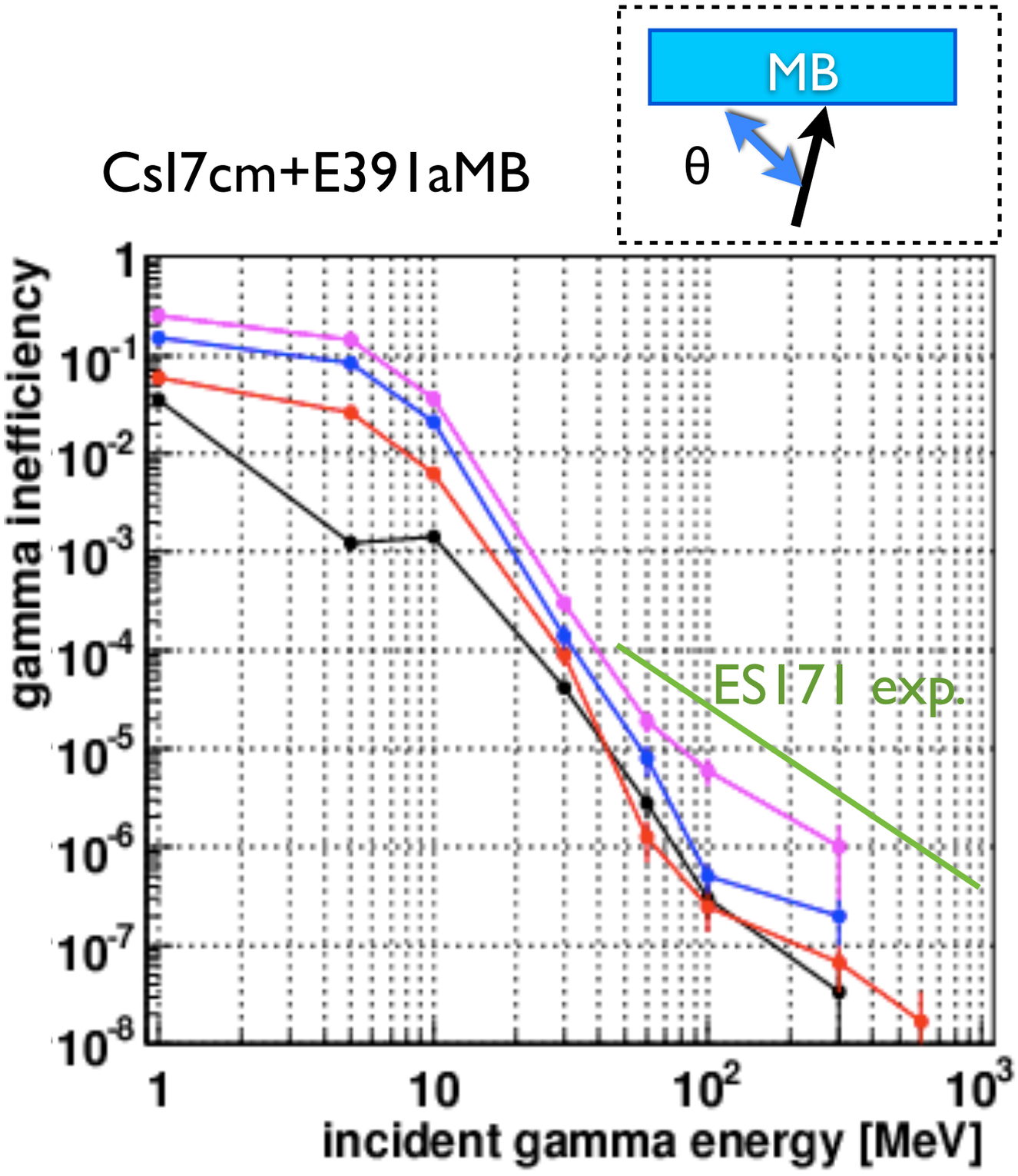
gamma inefficiency for #2π0 estimate

- #2π0 estimate

  1. calc. gamma inefficiency at each energy and angle in each detector

  2. calc missing possibility at each 2π0 event from gamma inefficiency

- apply ES171 result ?
  - Geant3 didn't contain photonuclear (PN) interaction
  - PN in Geant4 agree to ES171 exp. ?

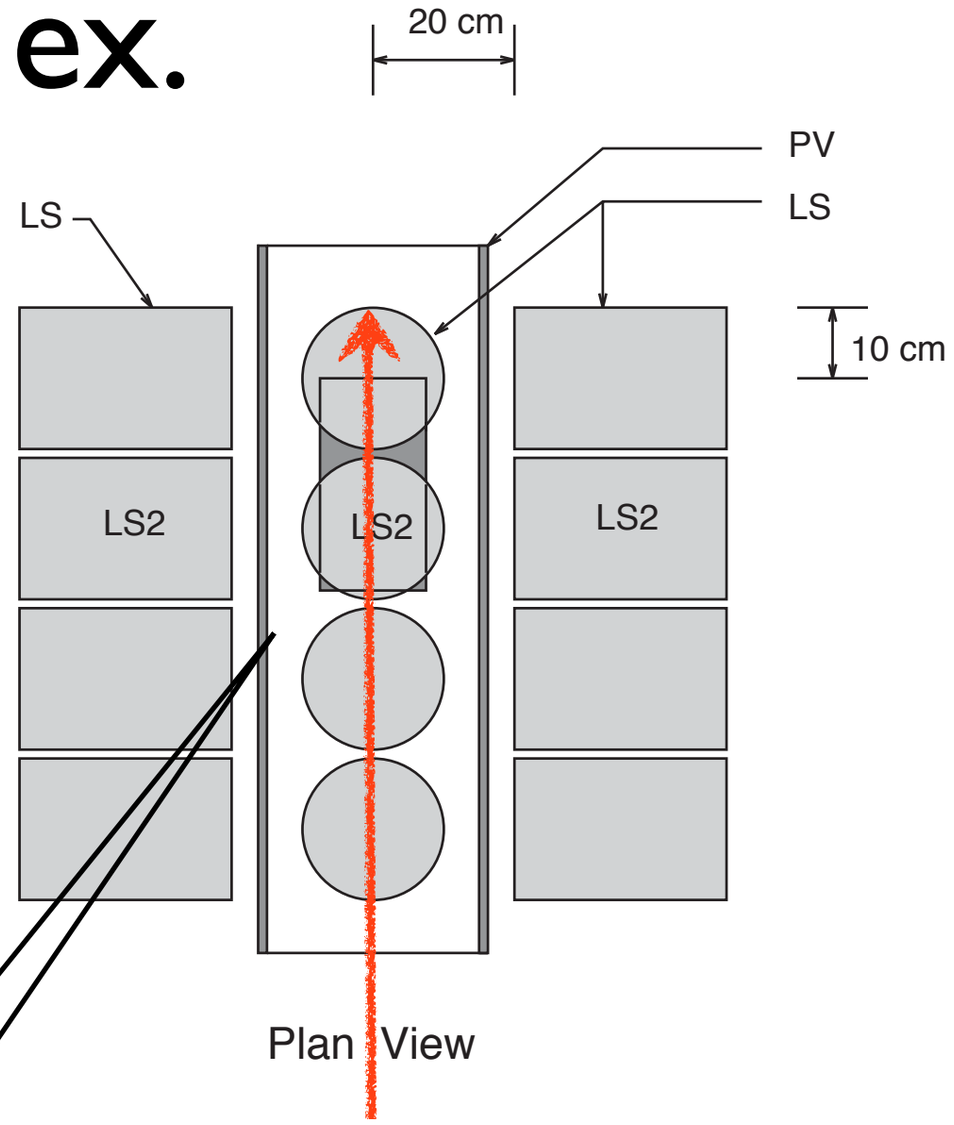


1)

ES171 ex.

NIM A 552 (2005) 263–275

LS... neutron detector
PV... plastic scinti. veto



measured detector
- CsI
- Pb+scinti.

γ beam

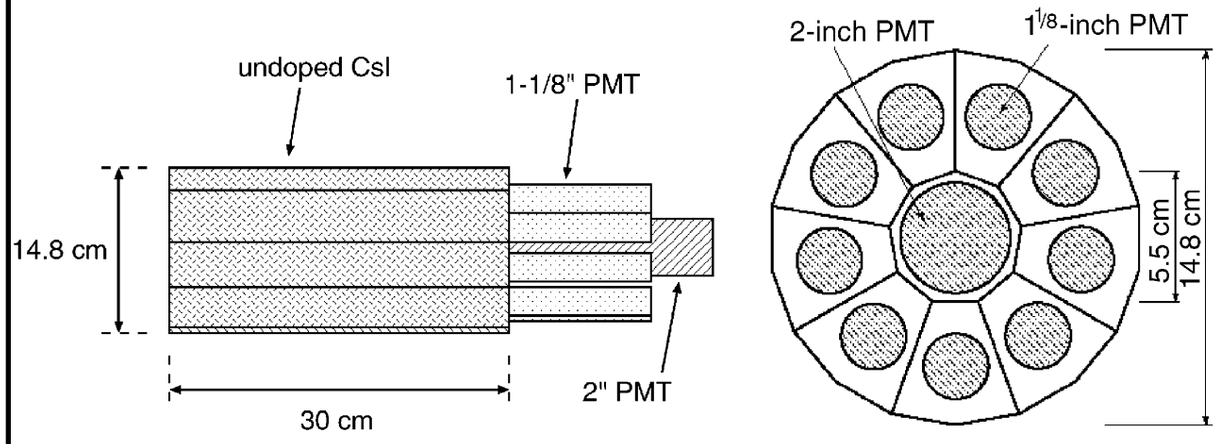
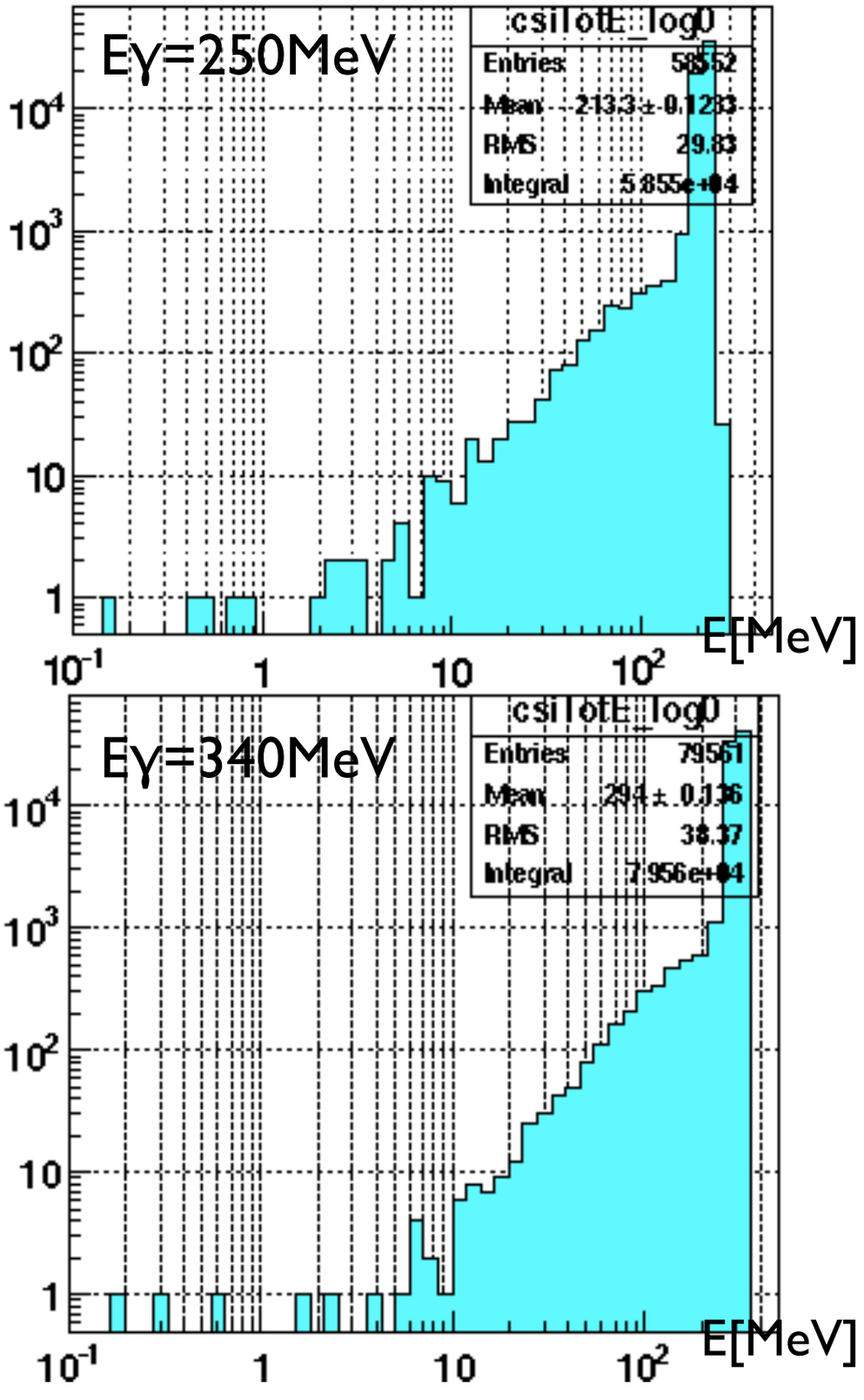


Fig. 3. Side and rear views of the undoped-CsI calorimeter (CsI-(I)).

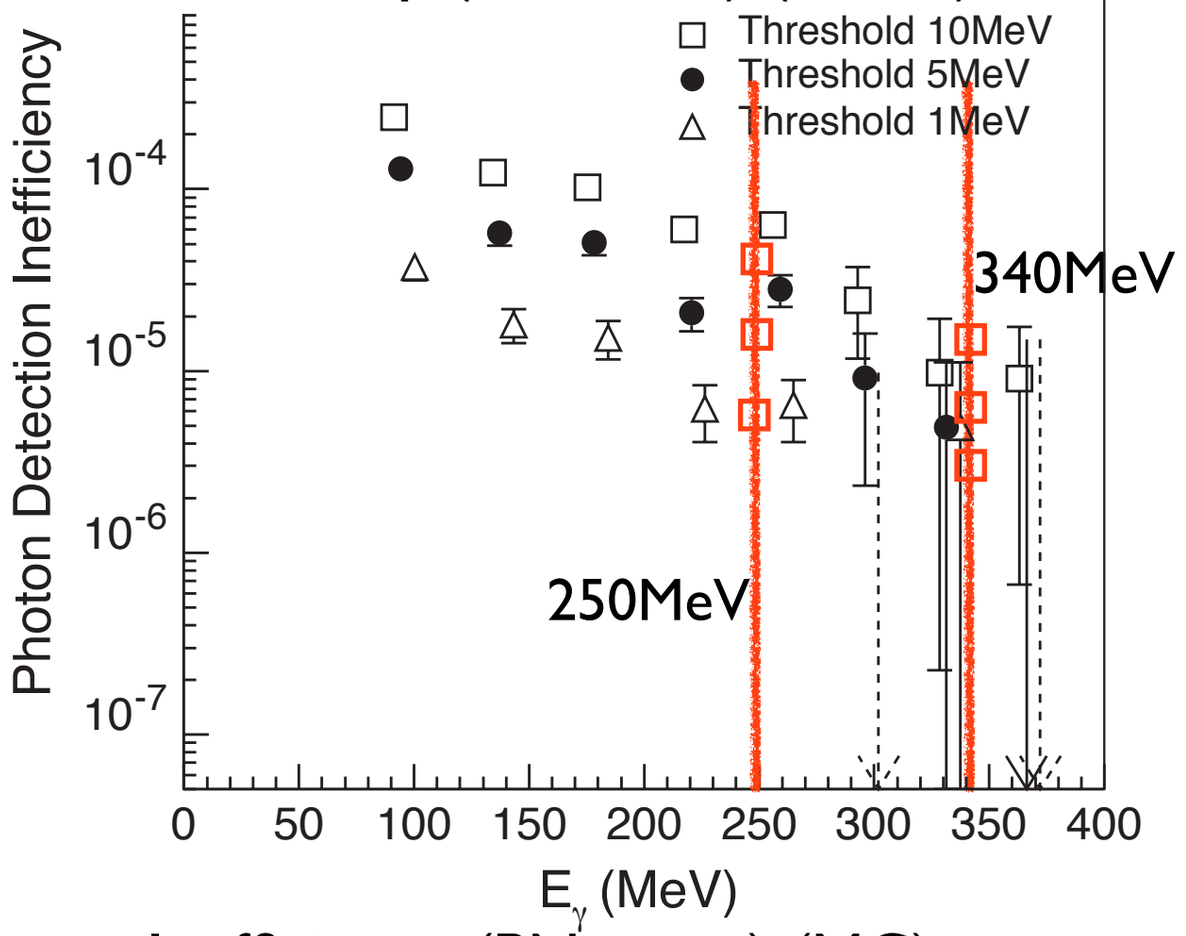
1)

PN inefficiency at ES171 (CsI)

- Edep in CsI (PN event) (MC)



- Inefficiency (PN event) (ES171)



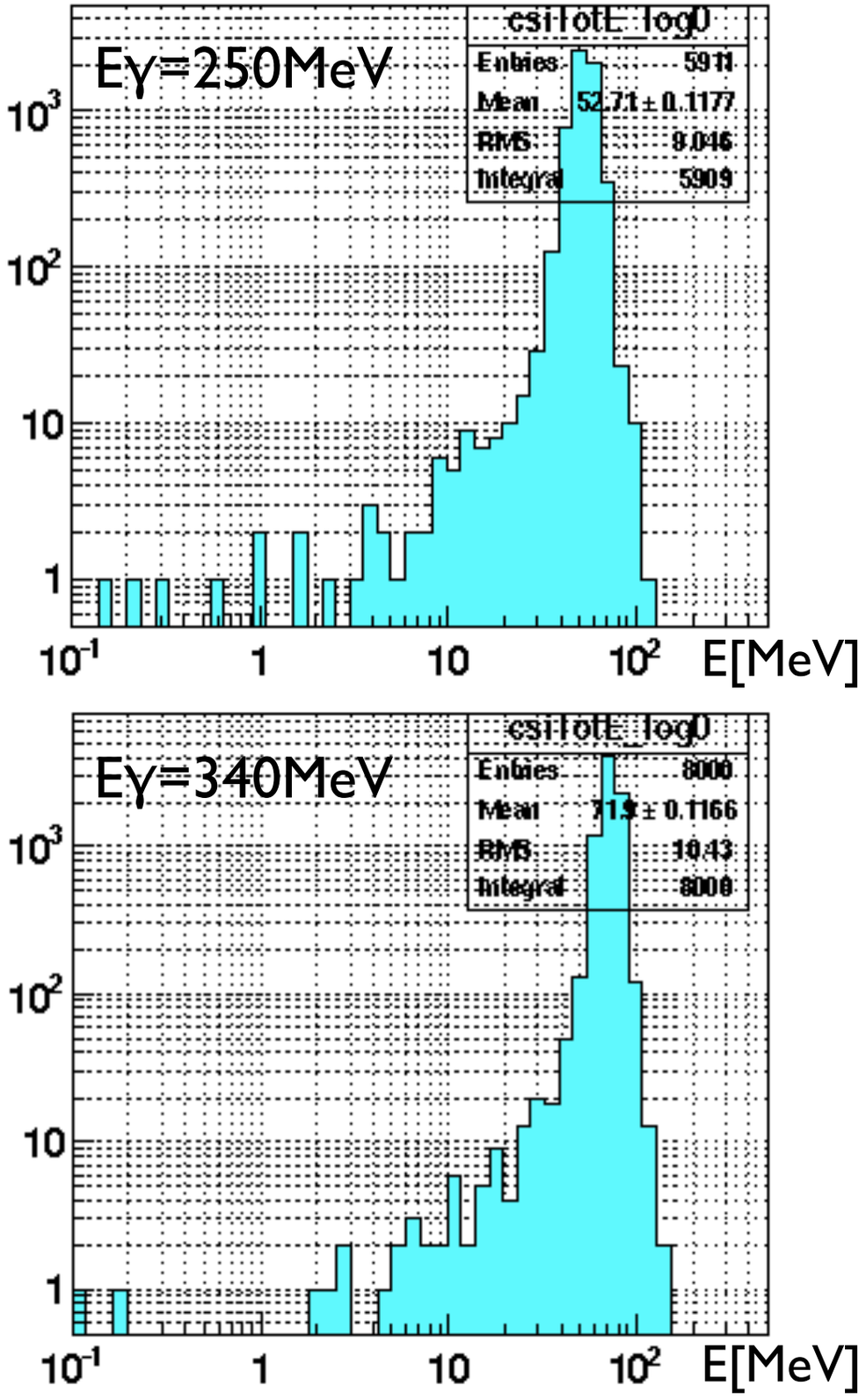
- Inefficiency (PN event) (MC)

Threshold\ inefficiency	250MeV	340MeV
1MeV	5 e-06	3 e-06
5MeV	1.4 e-05	6 e-06
10MeV	3.9 e-05	1.4 e-05

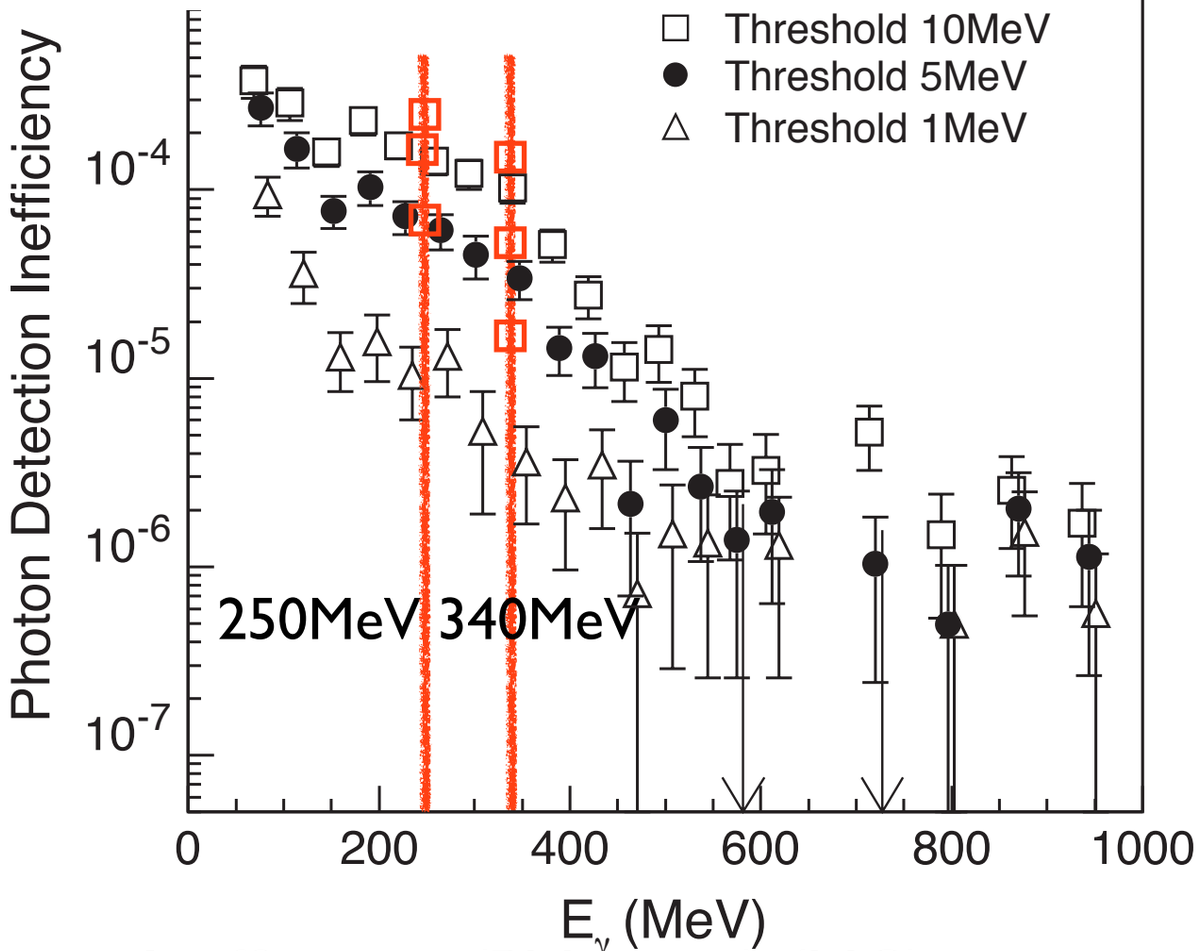
- ES171 and MC are consistent.

1) PN inefficiency at ES171 (Pb+scinti.)

- Edep in scinti (PN event)(MC)



- Inefficiency (PN event) (ES171)

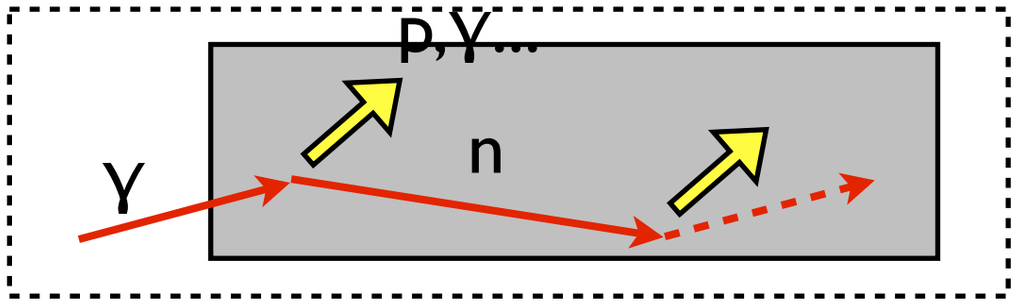


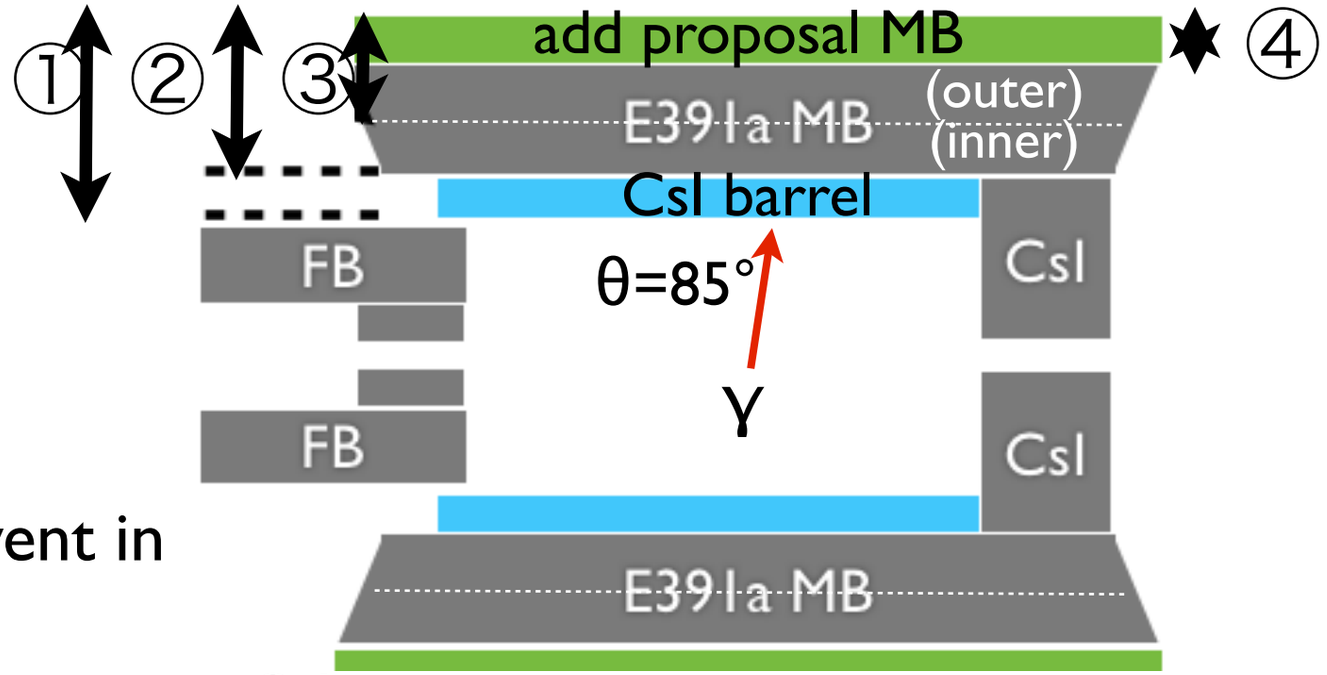
- Inefficiency (PN event) (MC)

Threshold\ inefficiency	250MeV	340MeV
1MeV	6 e-05	2 e-05
5MeV	1.7 e-04	7 e-05
10MeV	2.8 e-04	1.7 e-04

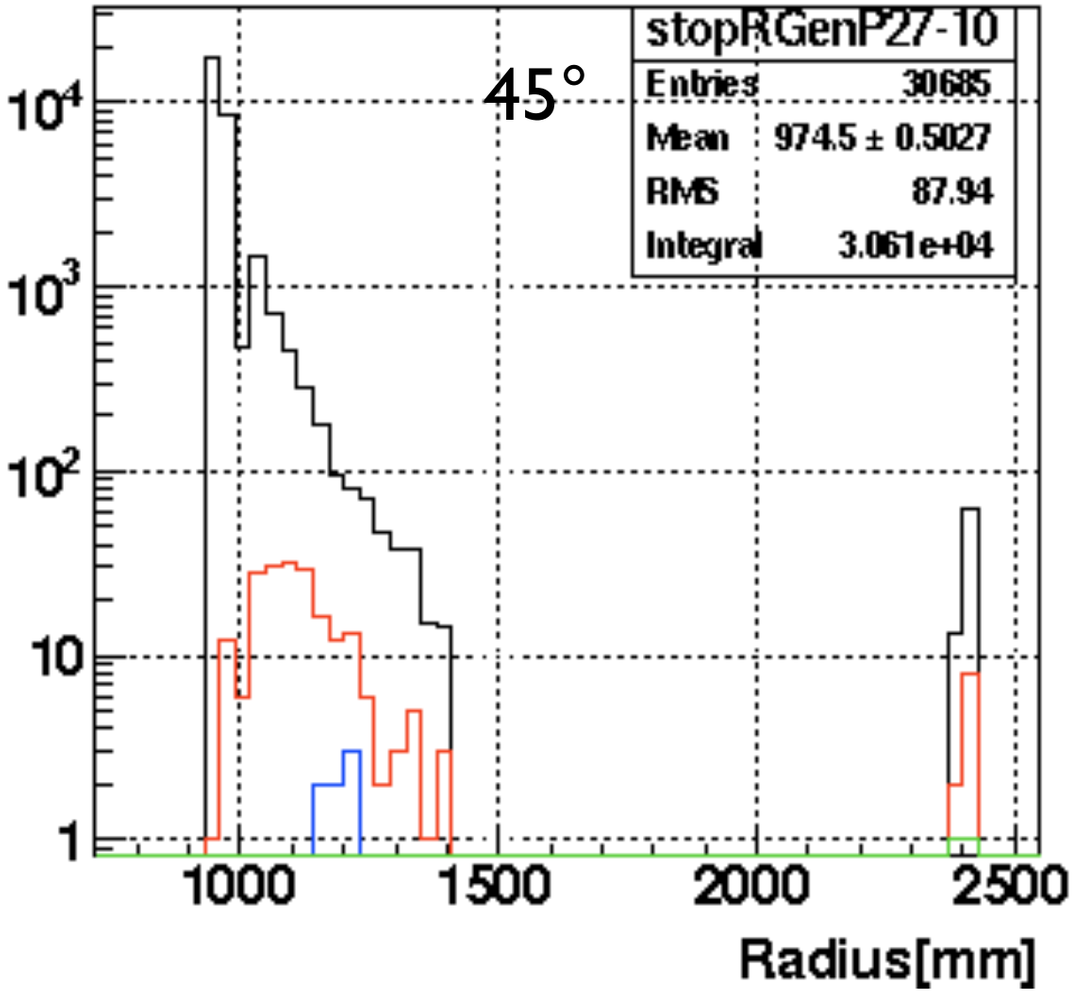
- Consistent in factor 3.

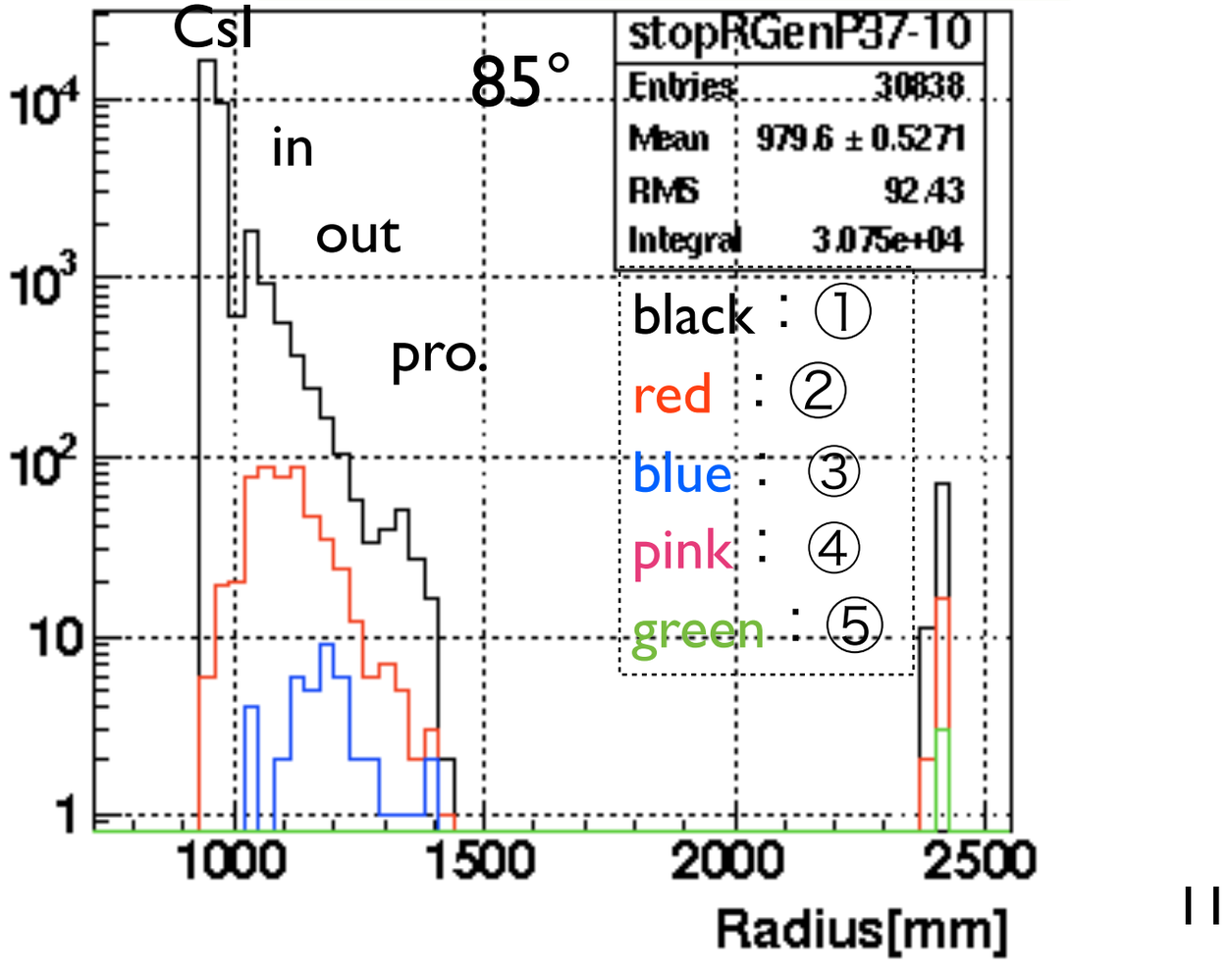
2) γ angle dependence in PN





- neutron stop position R in # PN event in 10^7 gamma incident





gamma inefficiency for #2π0 estimate

- #2π0 estimate

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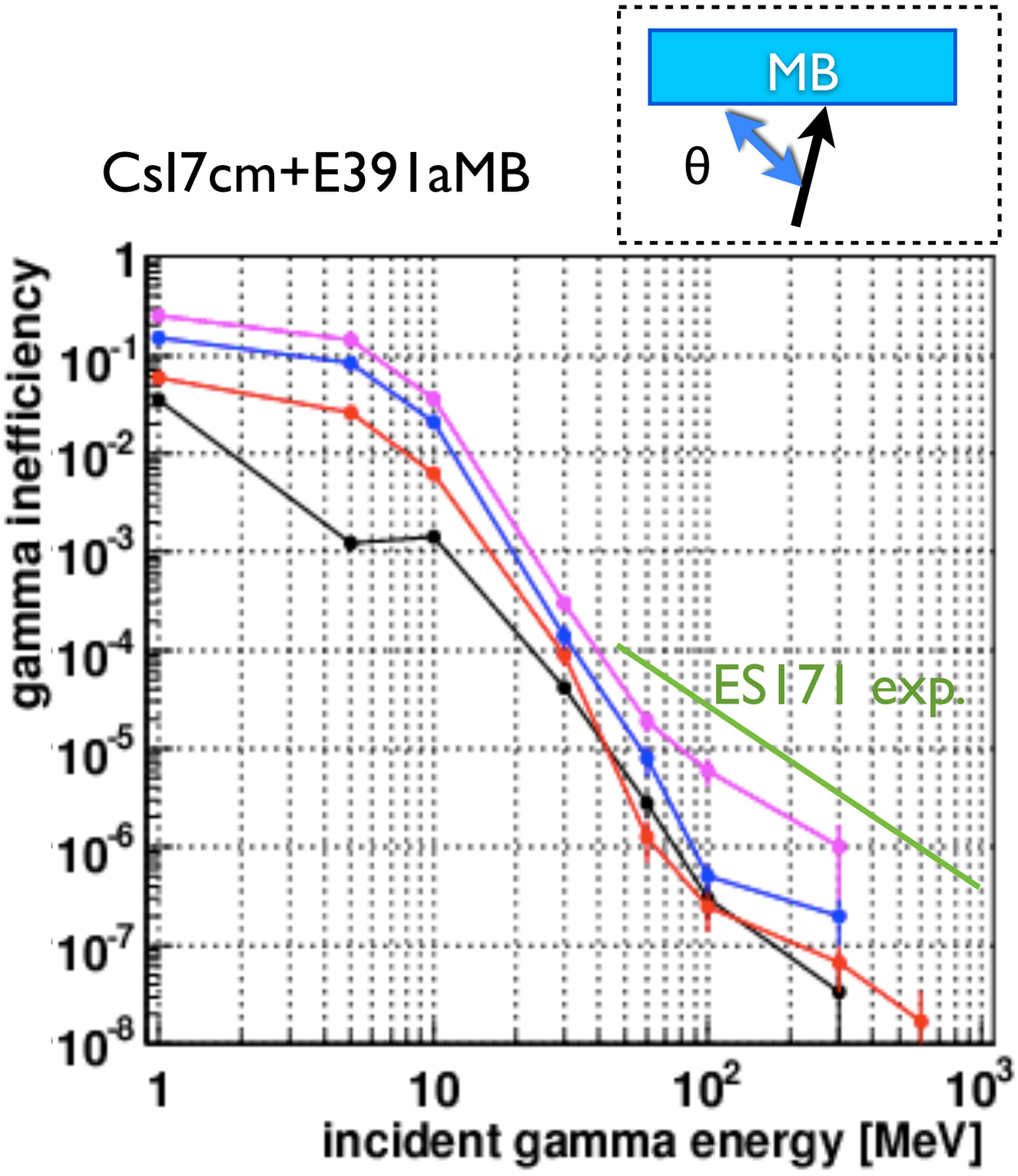
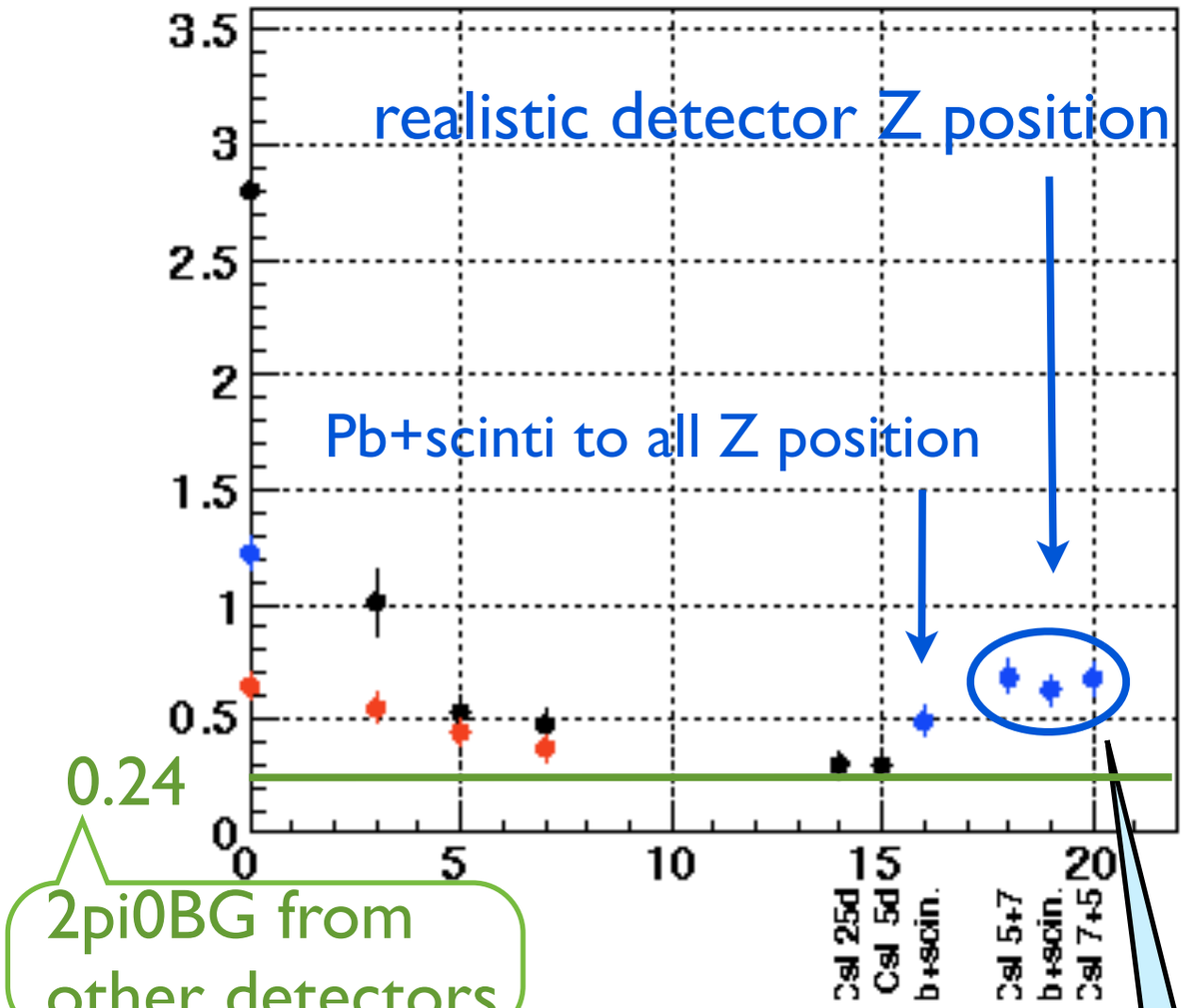


$\pi^0\pi^0$ background

2π0 BG



- Black shows mainly punch through effect.
- Red shows sampling or photo nuclear effect.

CsI thickness (0~15) [cm],
other condition (16~)

black：E391aMB+CsI Xcm to all Z

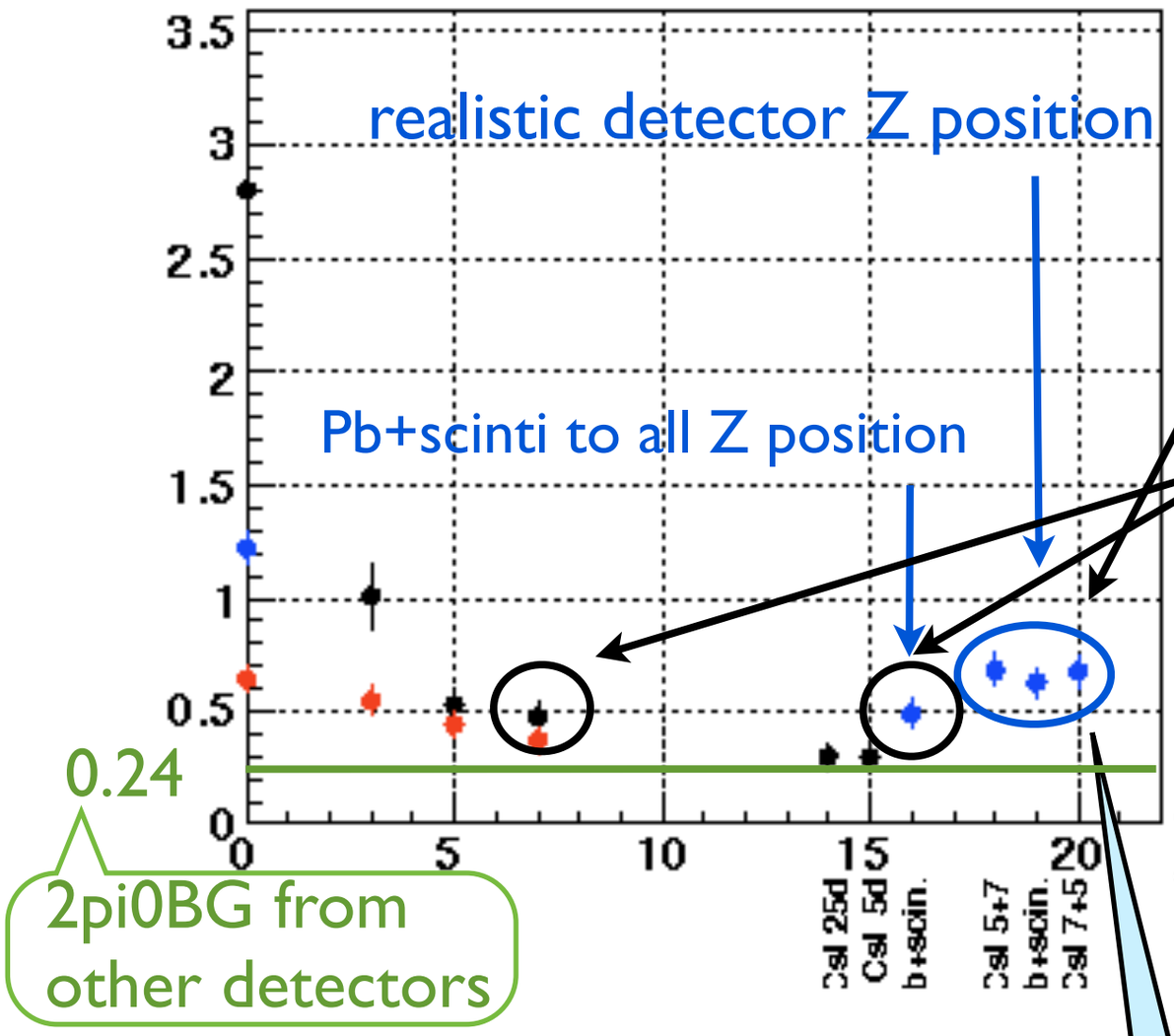
red ：proposalMB+CsI Xcm to all Z

blue：else

18... CsI 7cm(middle z)+5cm(lower z) in real position,
19... Pb+scinti in real position,
20... CsI 5cm(middle z)+7cm(lower z) in real position

$\pi^0\pi^0$ background

2π0 BG



- Realistic length detectors show ~0.7
- 7cm CsI(~4X0) and Pb+scinti.(5X0) show almost same value

→next page

CsI thickness (0~15) [cm],
other condition (16~)

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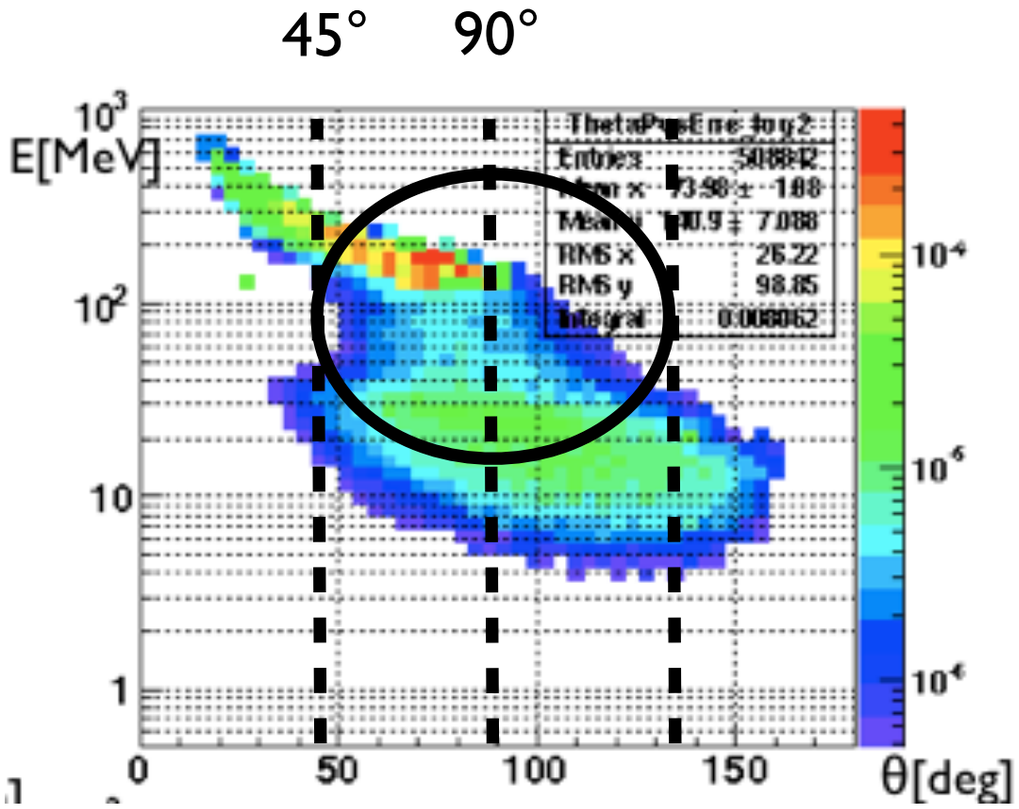
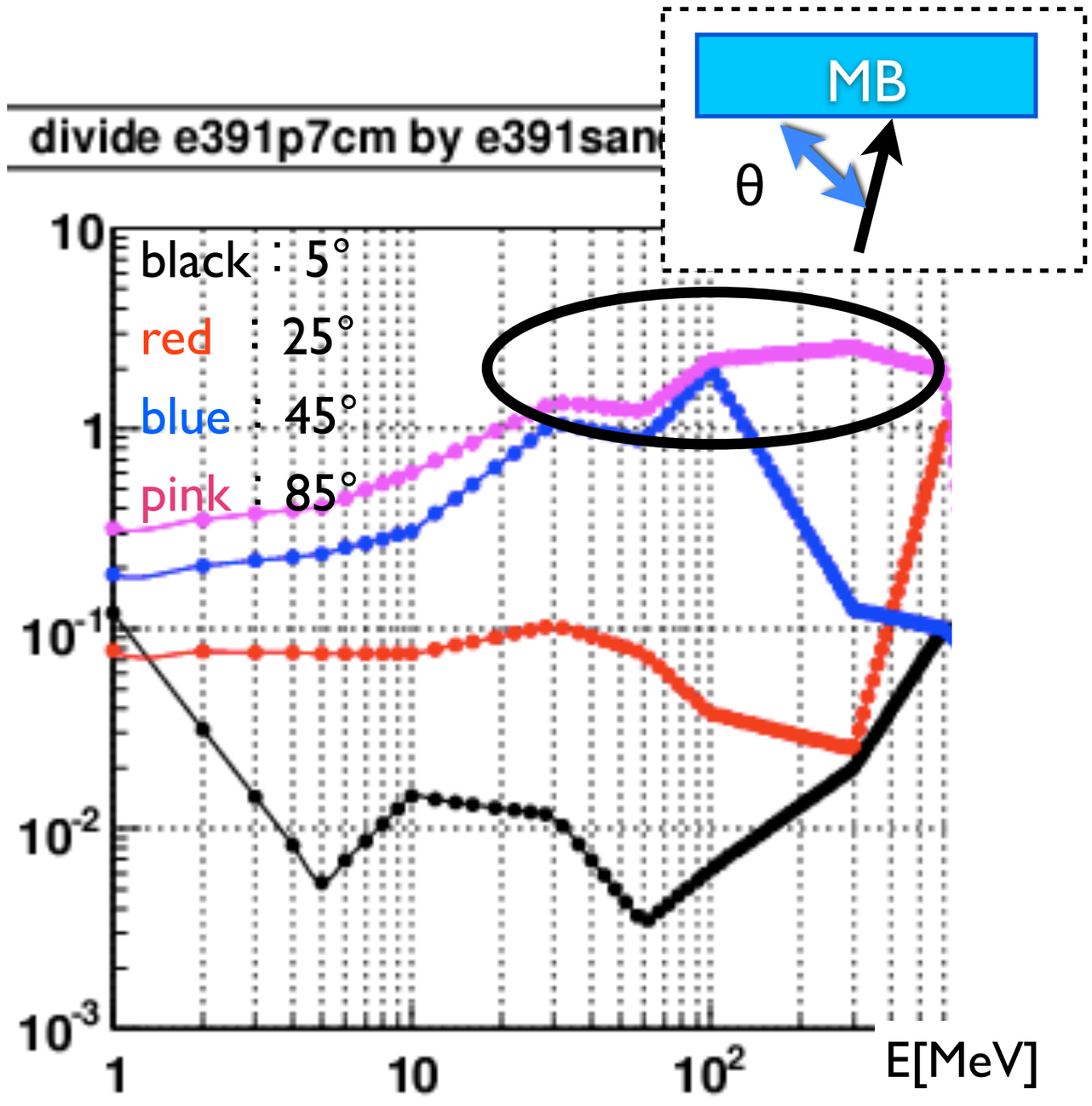
red ：proposalMB+CsI Xcm to all Z

blue：else

18... CsI 7cm(middle z)+5cm(lower z) in real position,
19... Pb+scinti in real position,
20... CsI 5cm(middle z)+7cm(lower z) in real position

inefficiency comparison (CsI7cm/ Pb+scinti.25)





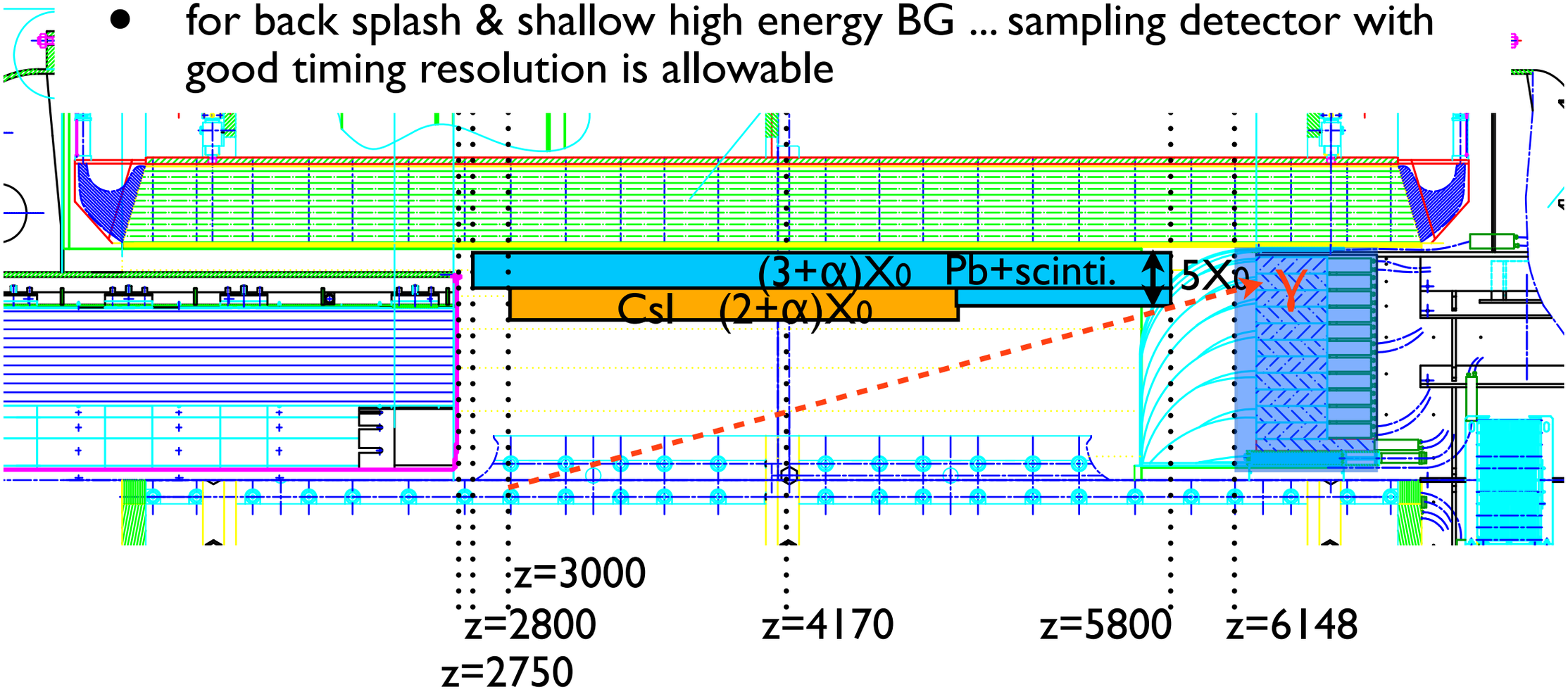
- Events affected by lack of CsI thickness is not negligible
  → should not be thrifty less than 5X0

- Photo nuclear or sampling effect of CsI seems to be lower than that of sandwich detector.

※there are not enough CsI to satisfy the amount of material.

High performance configuration

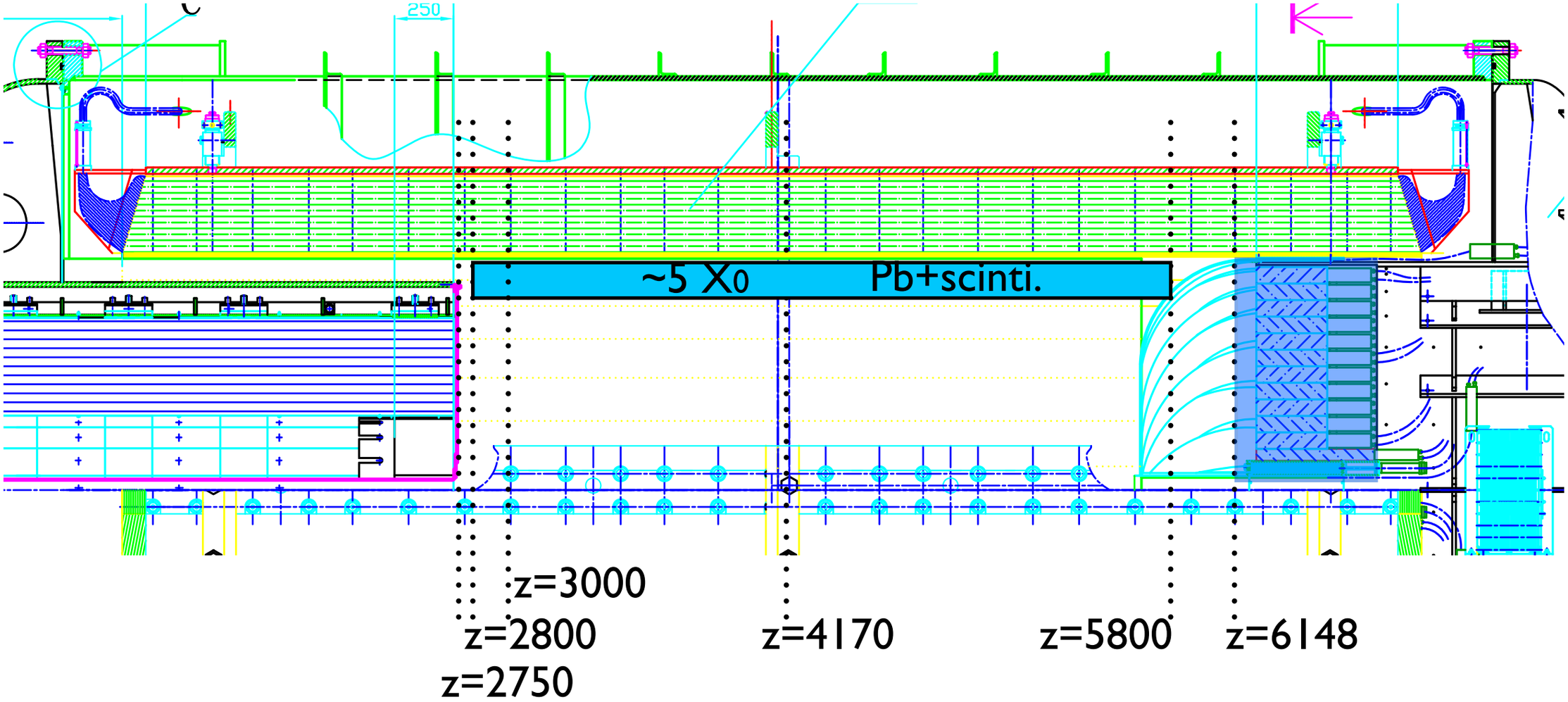
- for punch through ... need $5X_0$
- for low energy (10MeV~100MeV) ... full active or high sampling ratio
- for back splash & shallow high energy BG ... sampling detector with good timing resolution is allowable



- The thicker "inner" is made, the closer #2pi0 BG come to 0.3 low limit. But "inner" should have better sampling ratio than "E391aMB (outer)" (=Pb2mm).

possible and reasonable to construct

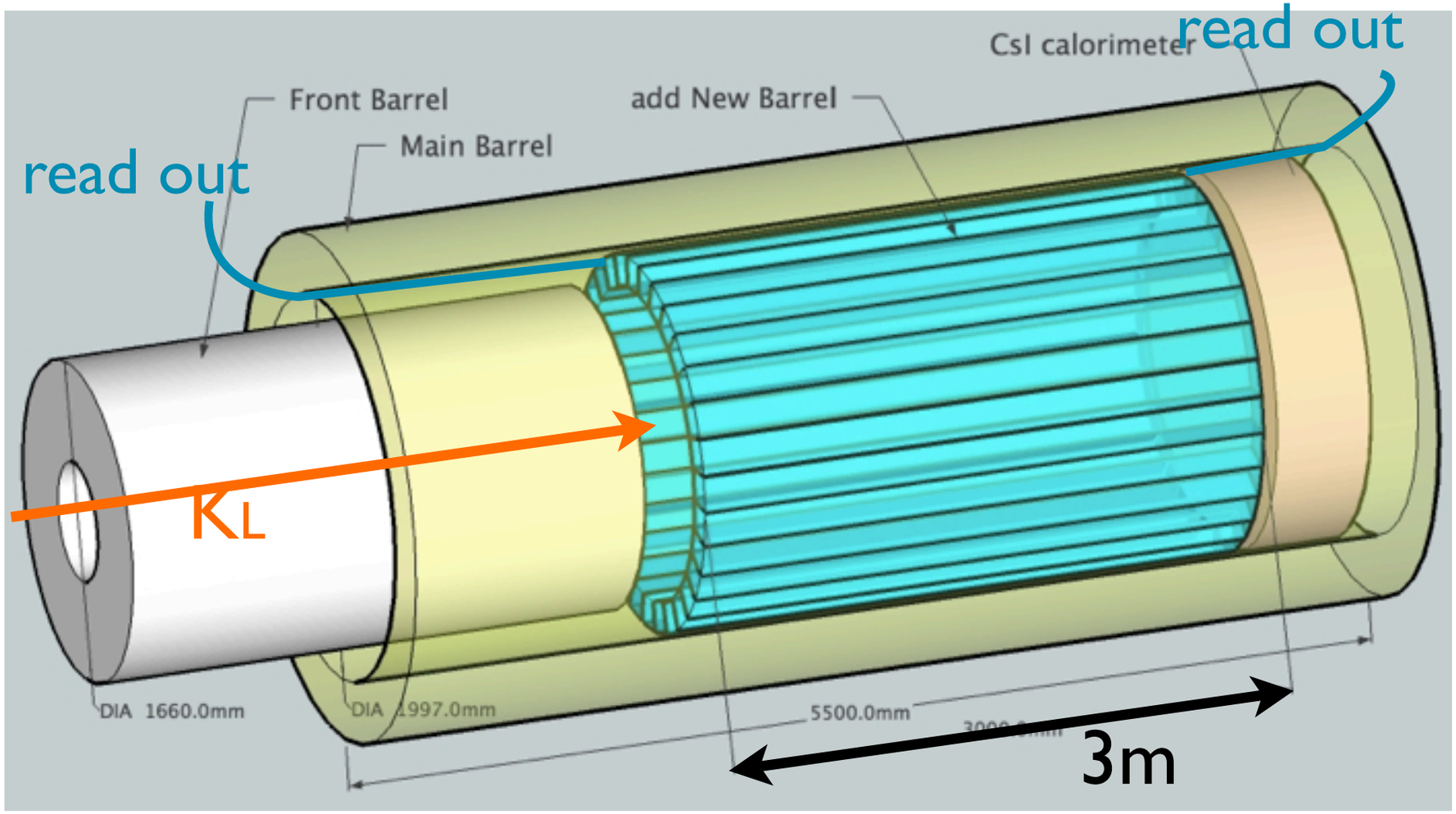
- 5X0 Pb+scinti. simple detector. (possible to add CsI in middle stream in future.)

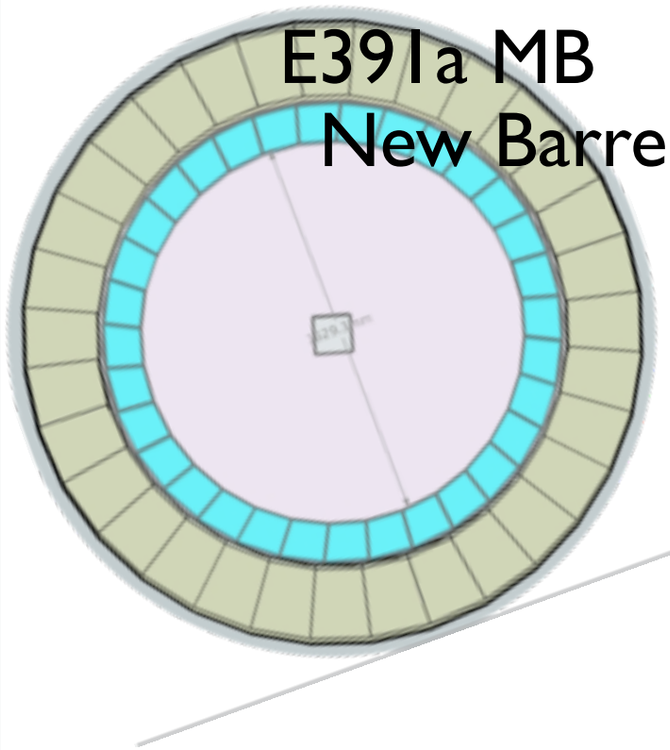


		old	5X0 sandwich	high performance
2π0 BG	MB	2.56±0.19	0.63 ± 0.03	0.4 ± 0.0
	other	0.24		

subject from now

- satisefy required timing resolution and light yield
- support structure





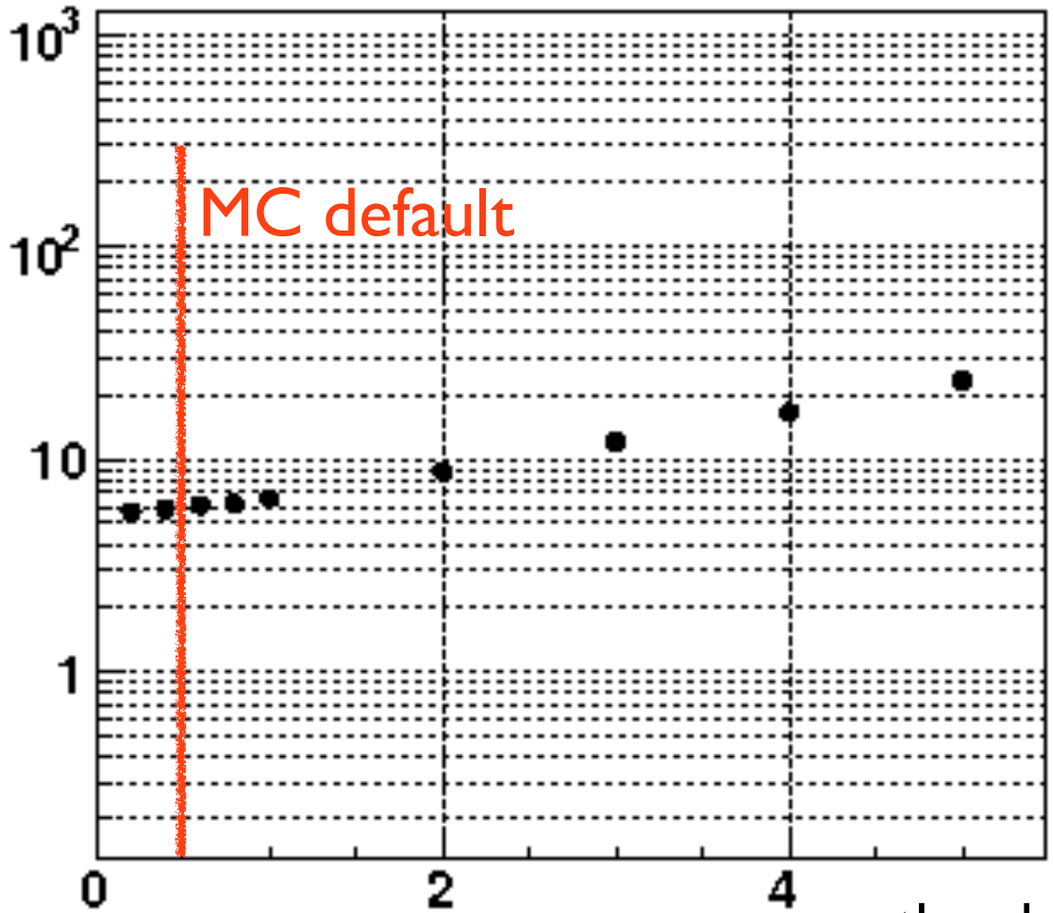
Summary

- The upgrade of inside E391a MB can reduce 2pi0 BG well.
- CsI shows good performance because of reduction of sampling and photonuclear effect. But CsI does not saticefy the amount of material.
- 5X0 of "Pb+scinti." reduce #2pi0 BG to 0.63±0.03 from original 2.8±0.2.
- CsI&"Pb+scinti." hybrid configuration has maximum effect and #2pi0 BG will be 0.4.
- It is possible to plan to add CsI to inside of upgraded "Pb +scinti." in the future.

backup

#BG in each threshold at Pb+scinti. 5X0

- #2pi0BG



※ E14lib default is 0.3 or 0.5MeV

※ acceptance 50% 7E13 K_L