

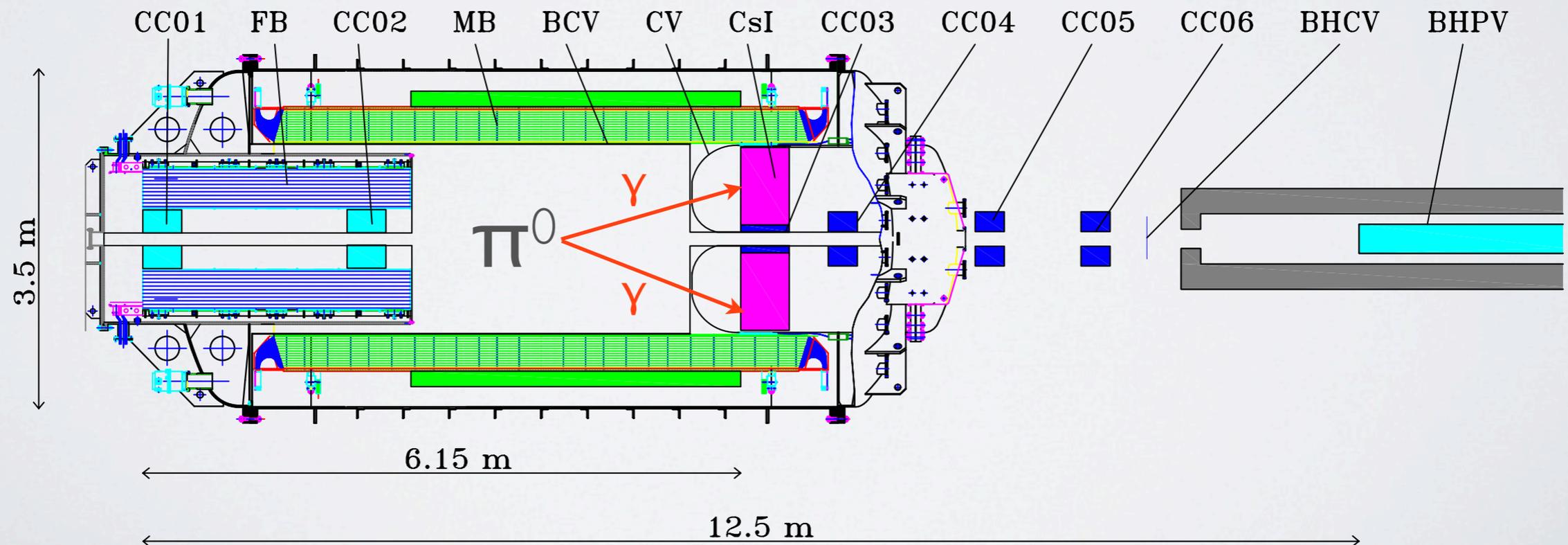
KOTO実験のためのビーム軸 周辺のVETO用検出器の設計

Design of the veto detector around beam axis
for the KOTO experiment

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ABOUT KOTO EXPERIMENT

- Observation of the rare decay $K_L \rightarrow \pi^0 \nu \bar{\nu}$
- CsI Calorimeter detects 2γ to reconstruct π^0



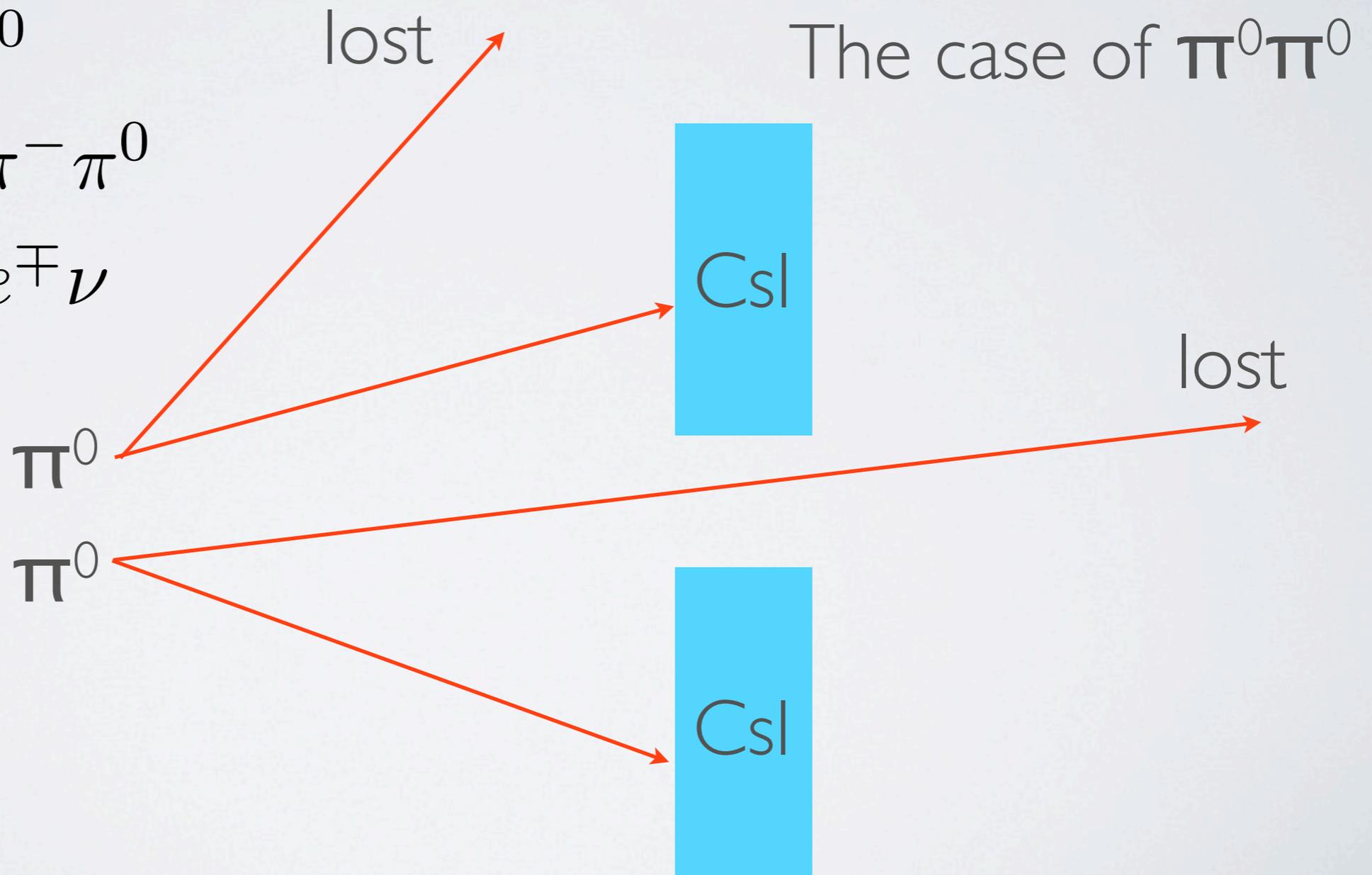
BACKGROUND

- Other kaon decays with particles escaping detection

$$K_L \rightarrow \pi^0 \pi^0$$

$$K_L \rightarrow \pi^+ \pi^- \pi^0$$

$$K_L \rightarrow \pi^\pm e^\mp \nu$$



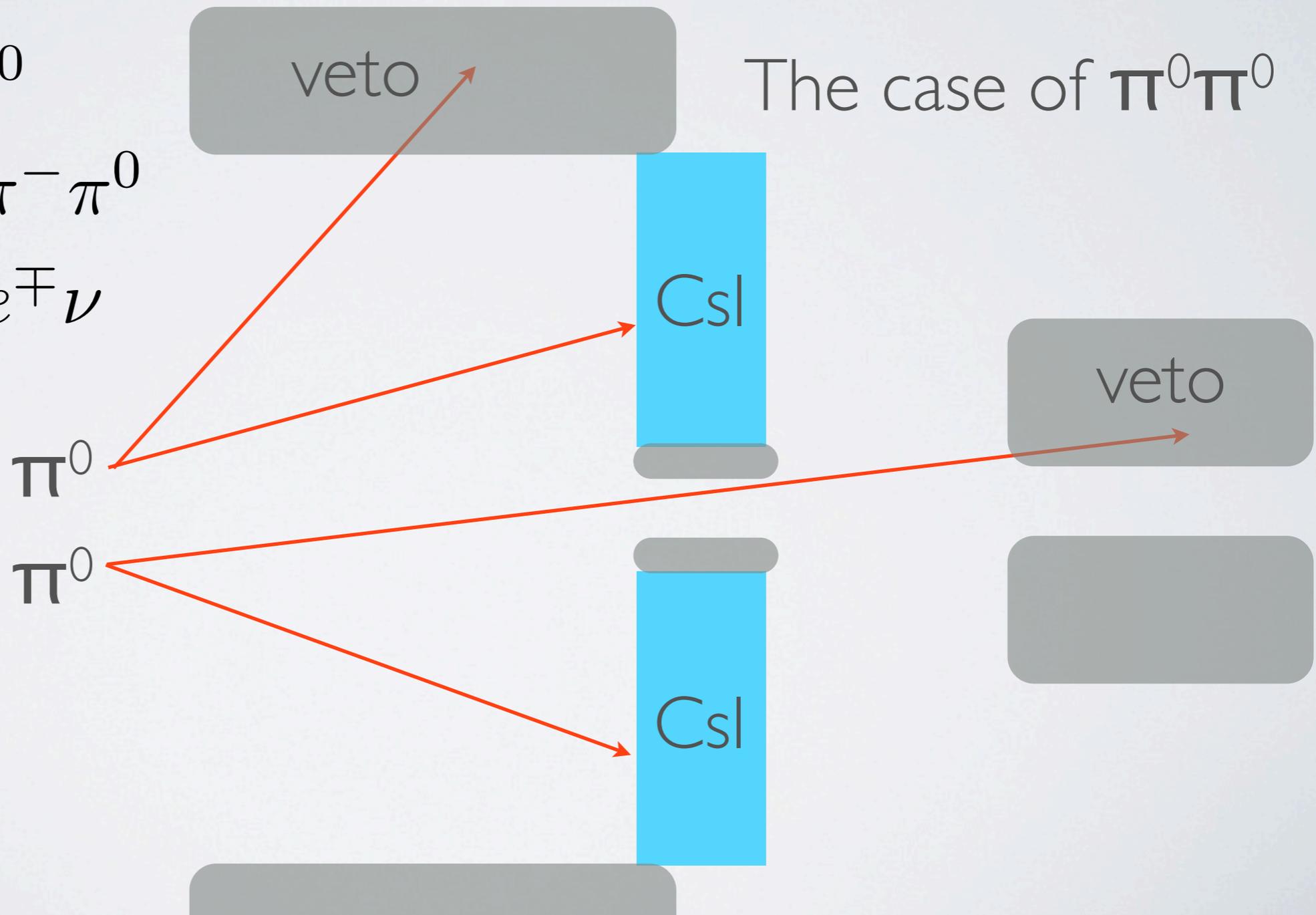
BACKGROUND

- Other kaon decays with particles escaping detection

$$K_L \rightarrow \pi^0 \pi^0$$

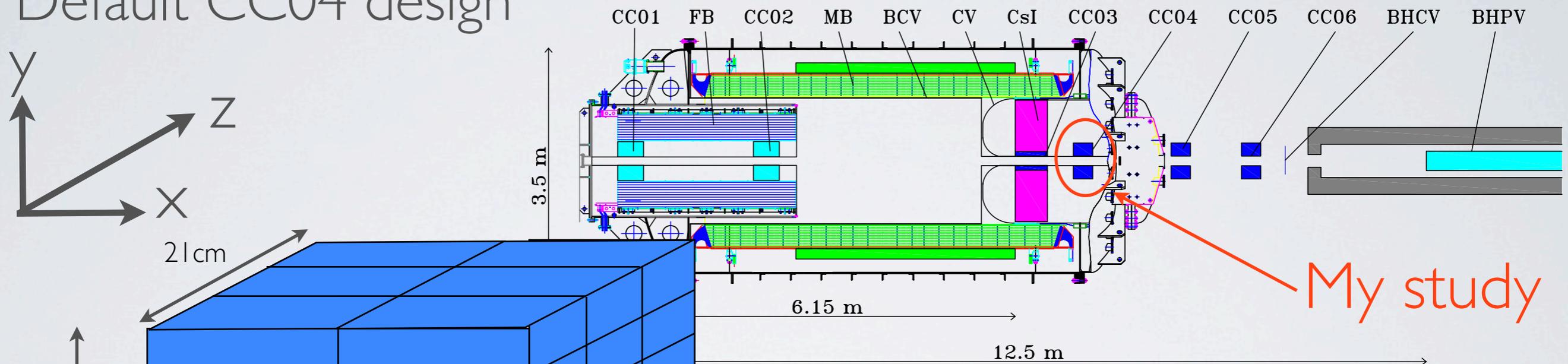
$$K_L \rightarrow \pi^+ \pi^- \pi^0$$

$$K_L \rightarrow \pi^\pm e^\mp \nu$$



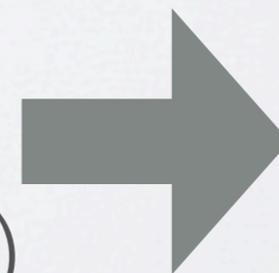
VETO DETECTOR (CC04)

- Default CC04 design



- $30 \times 7 \times 7$ cm CsI crystals
- $30 \times 3 \times 7$ cm CsI crystals

Today, shift to
downstream
(about 7.4mm)



need redesign?

SIMULATION METHOD①

- particles which don't decay of total beam particles

beam

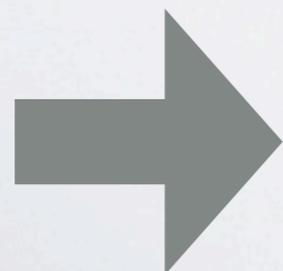


CC03

plate

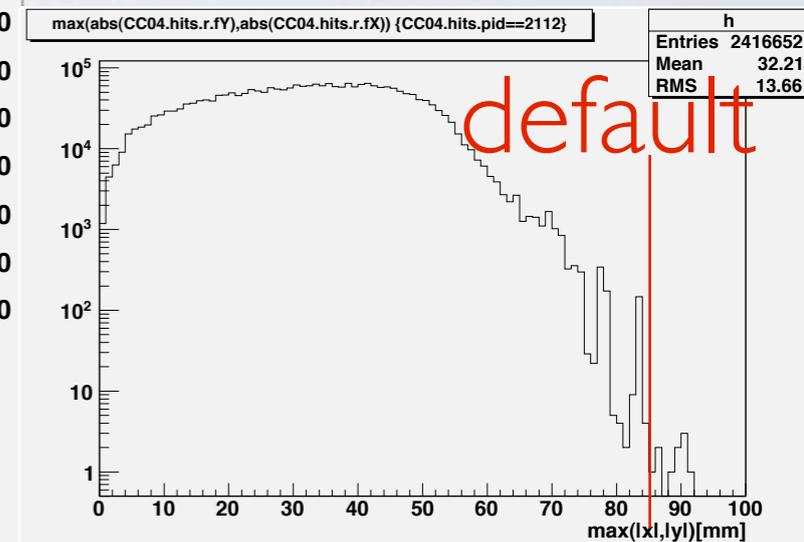
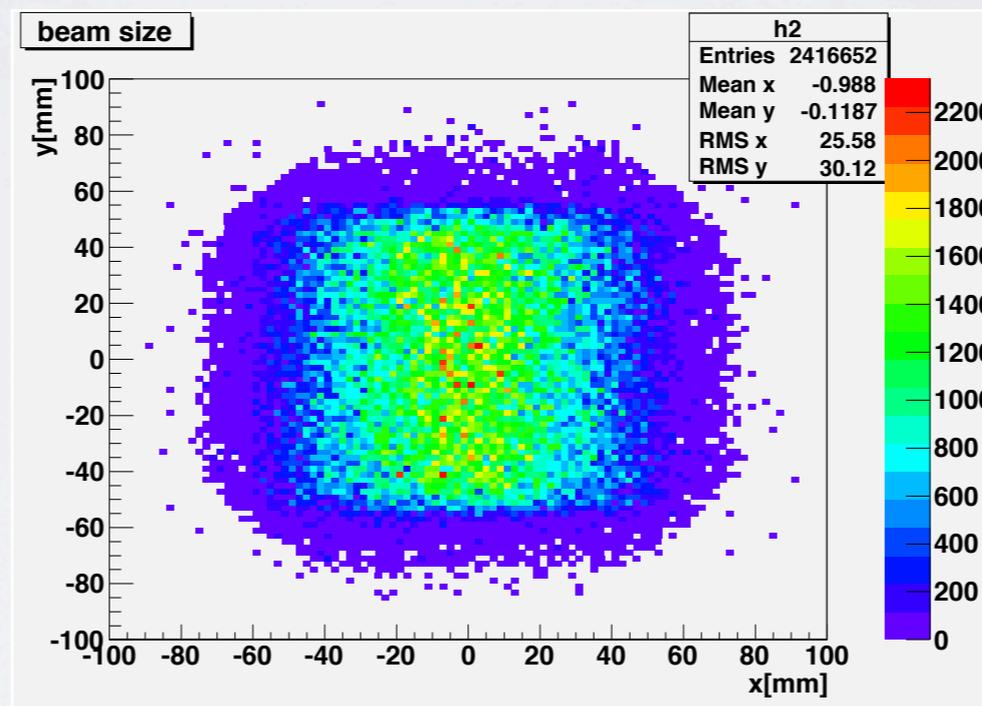
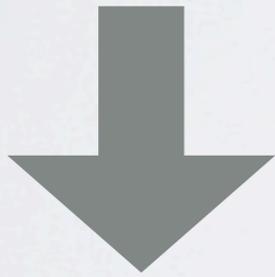
CC04 rear position

study the CC04 hole size



BEAM SIZE

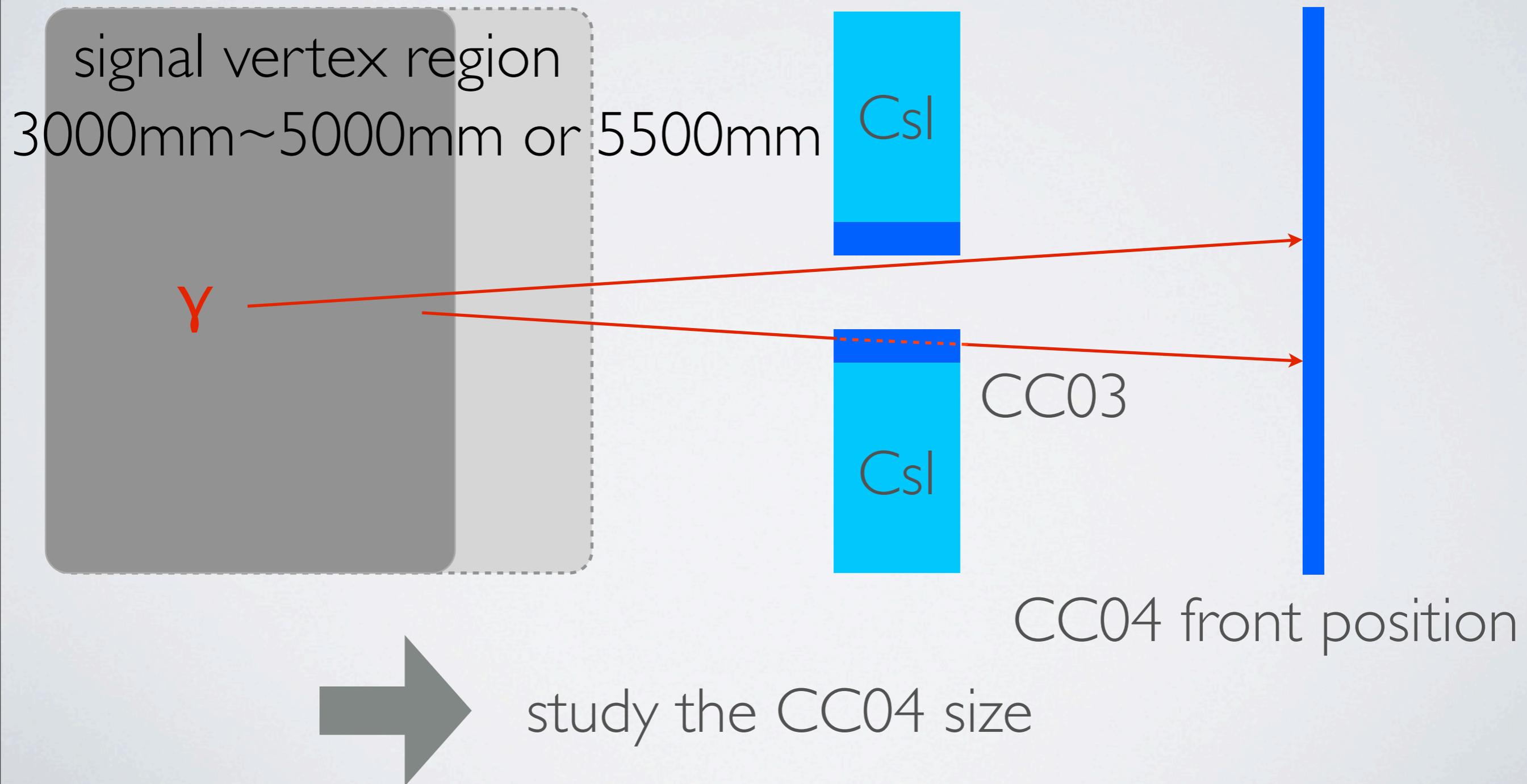
- 2416652 neutrons which hit on the CC04 rear position of 4678099 total beam
- 10 neutrons hit out of $\pm 85\text{mm}$ region



For the default design, 99.99996% neutrons get through the CC04 hole

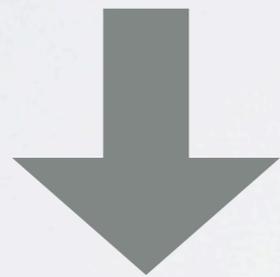
SIMULATION METHOD②

- only $K_L \rightarrow \pi^0 \pi^0$

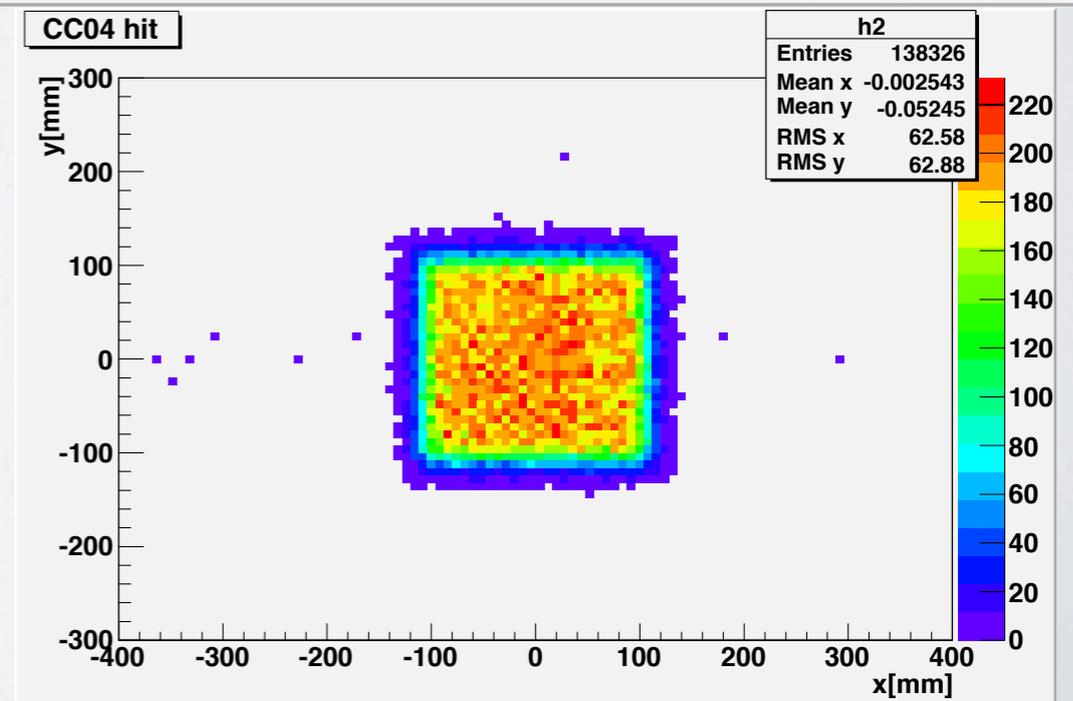
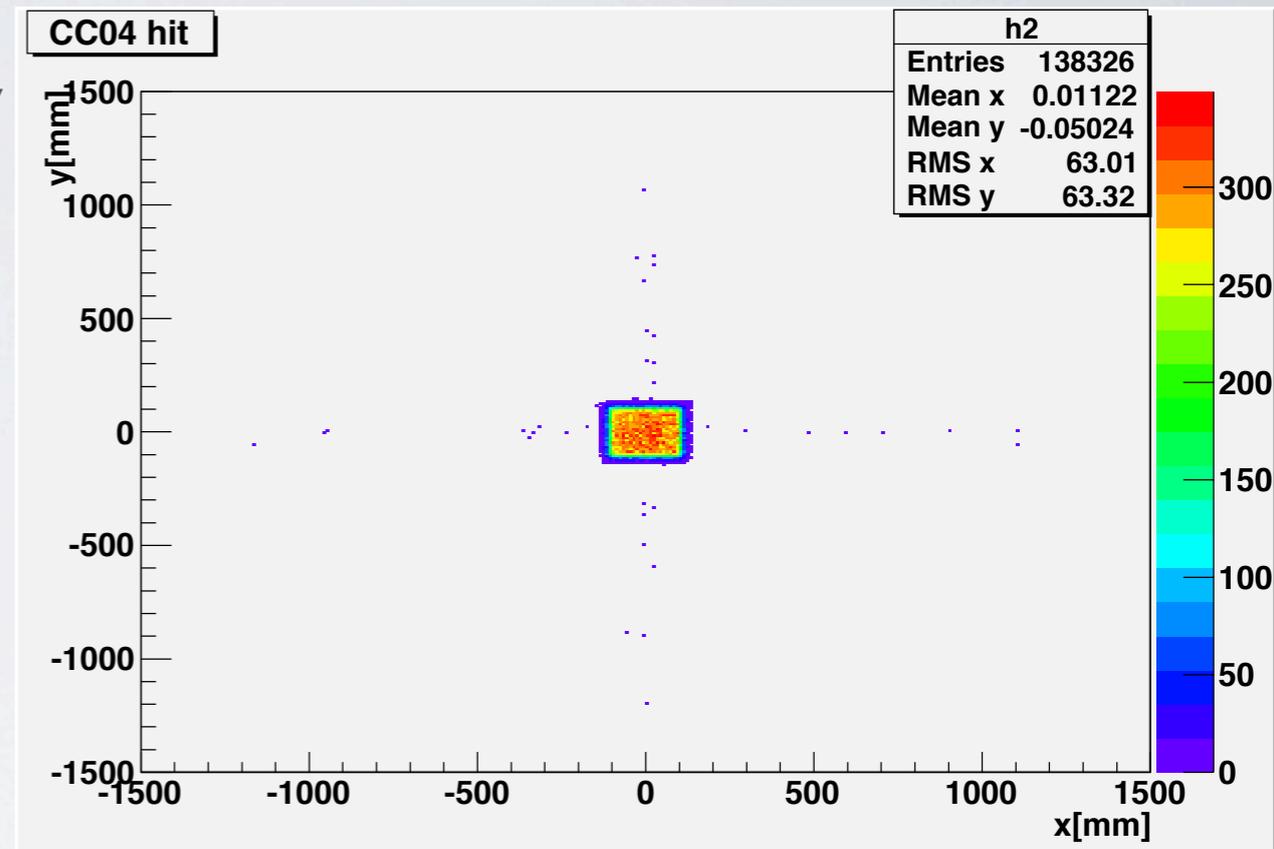


DIRECT HITS ON THE CC04

- statistics of $K_L \rightarrow \pi^0 \pi^0$ are 6×10^7
- 1/1000 of 3 years run
- vertex cut $3000 < z_{\text{vtx}} < 5000 \text{mm}$

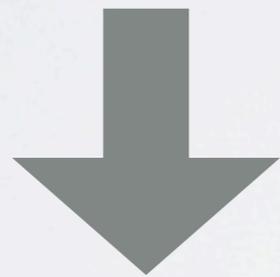


almost hits are within $\pm 140 \text{mm}$

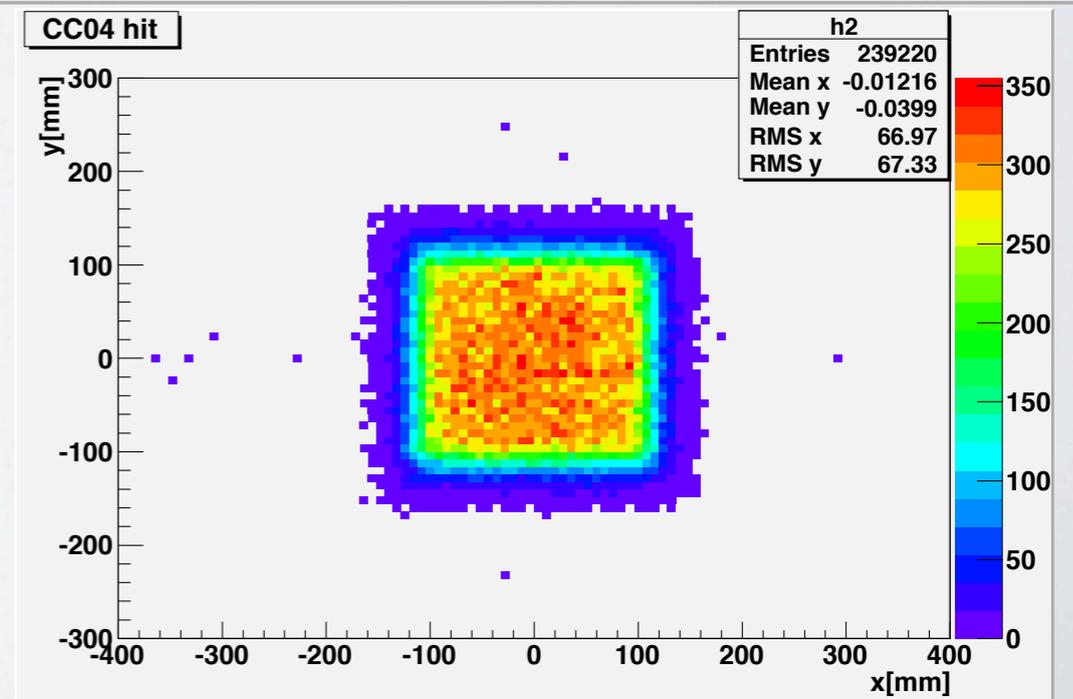
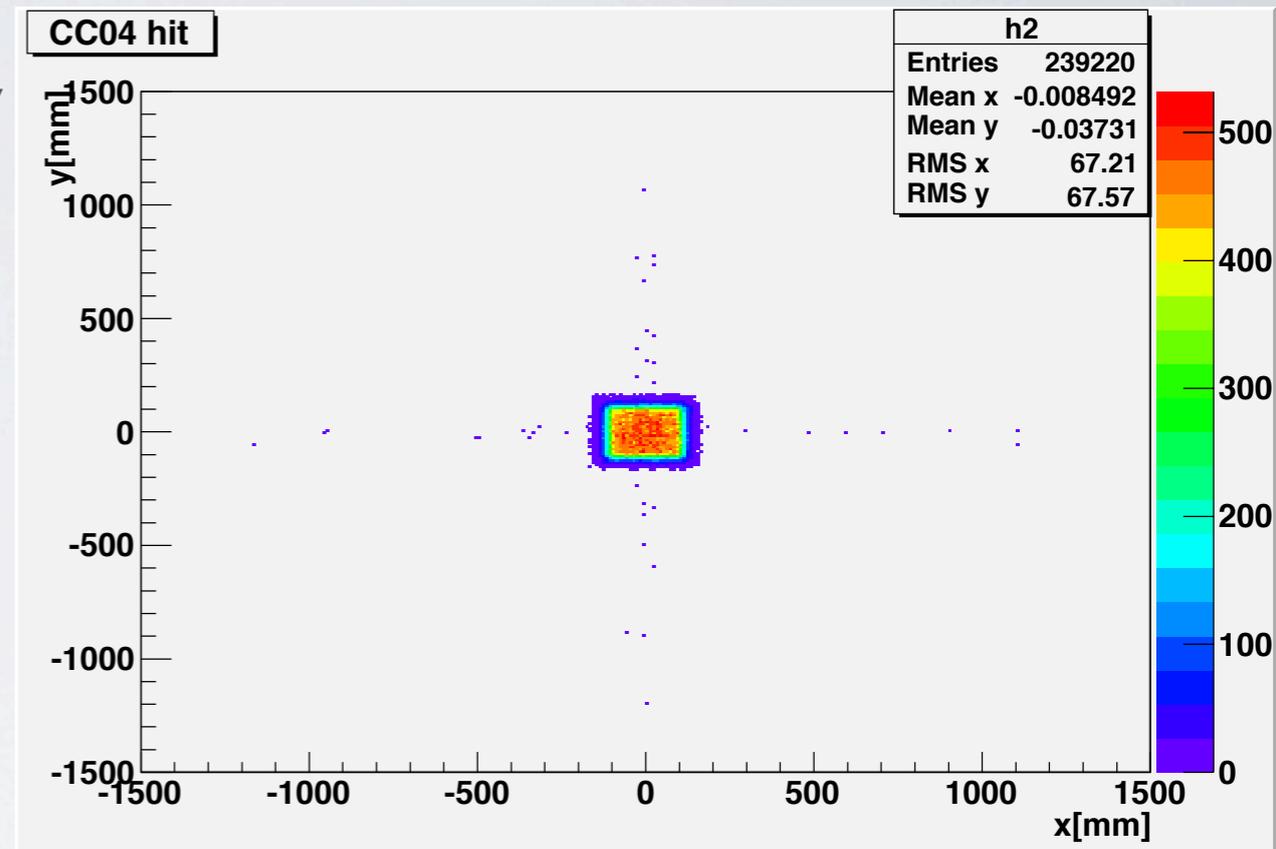


DIRECT HITS ON THE CC04

- statistics of $K_L \rightarrow \pi^0 \pi^0$ are 6×10^7
- 1/1000 of 3 years run
- vertex cut $3000 < z_{\text{vtx}} < 5500 \text{mm}$

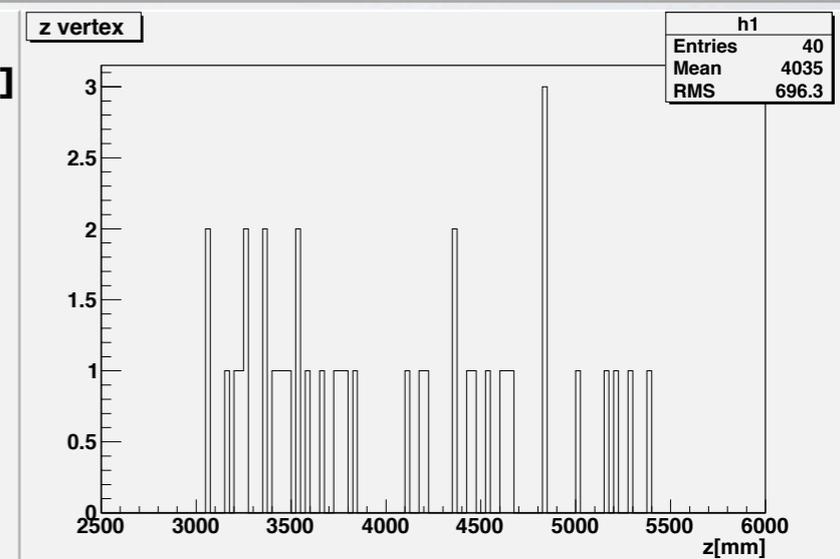
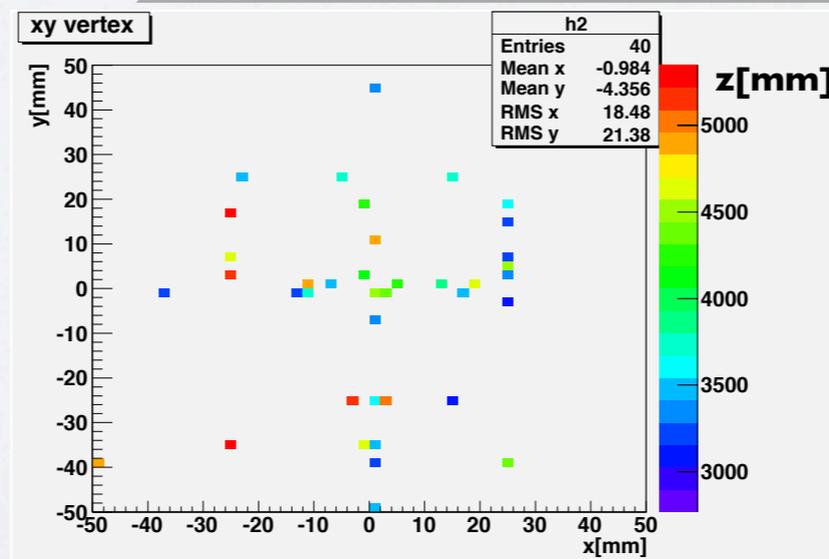
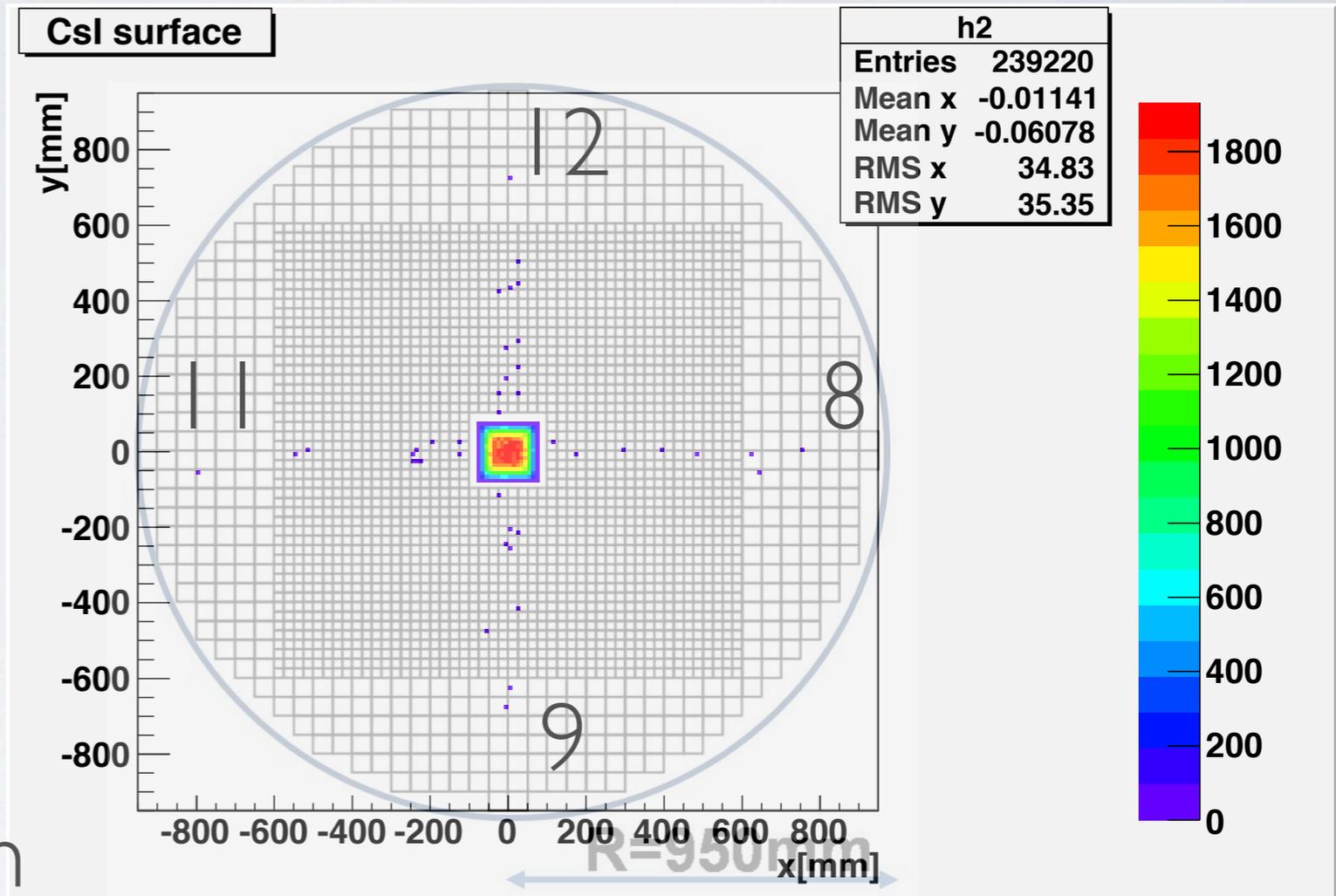
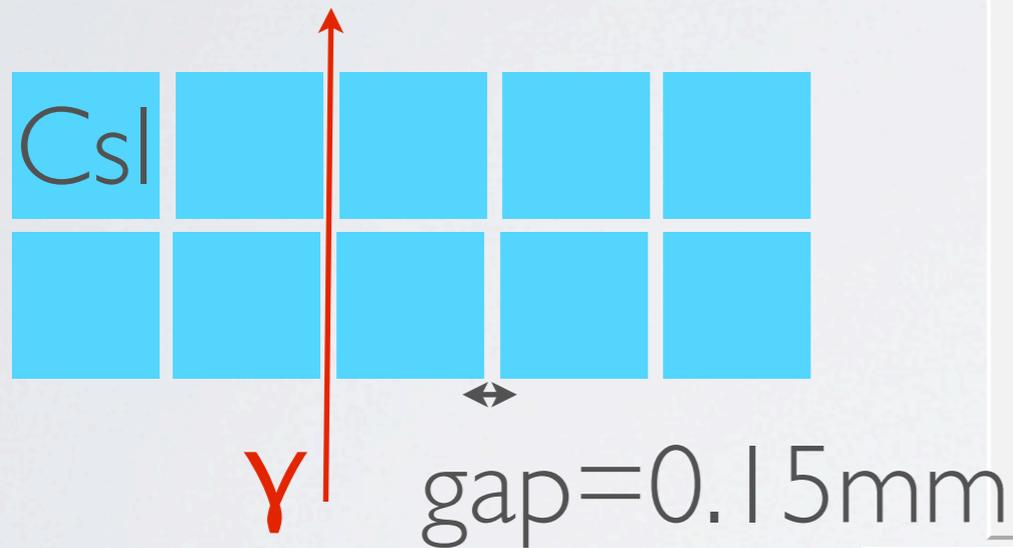


almost hits are within $\pm 170 \text{mm}$



CSI GAP PROBLEM

- γ flies parallel to the gap of Csl



PUNCH THROUGH(CC03)

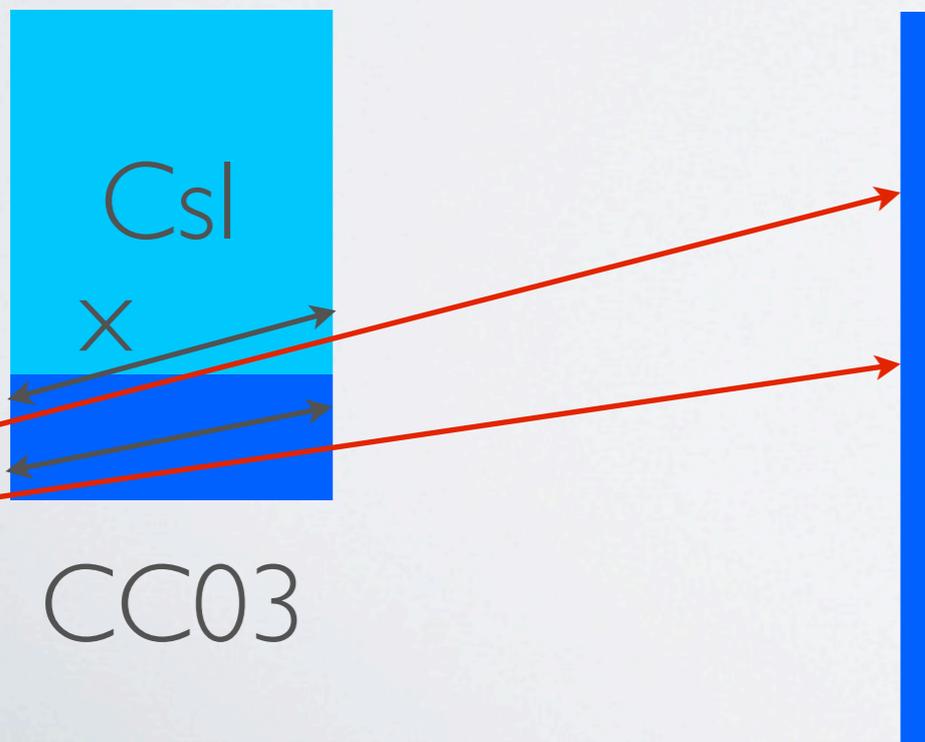
- the probability for a particle not to suffer an interaction in a distance x

$$P(x) = e^{-\frac{x}{\lambda}} \quad \lambda : \text{mean free path}$$

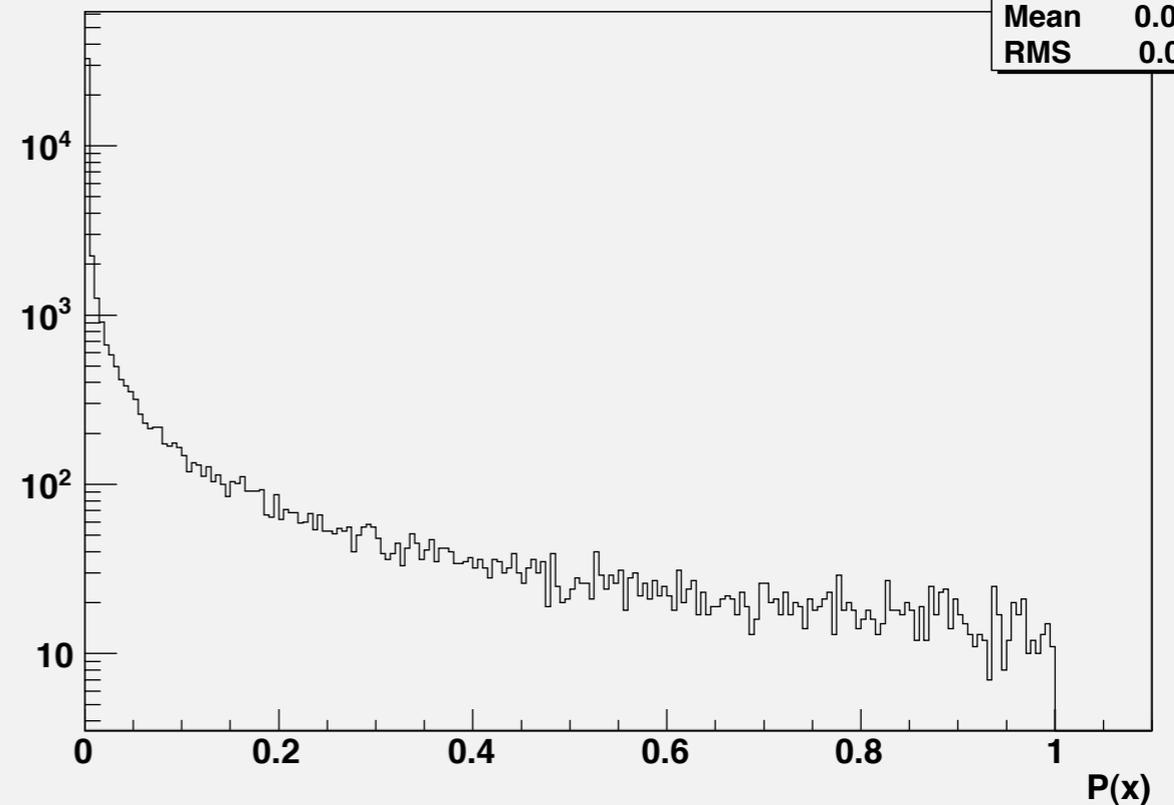
- for γ $\lambda = \frac{9}{7} [X_0]$

punch through

$$P(x) = e^{-\frac{7}{9}x} \quad , x[X_0]$$



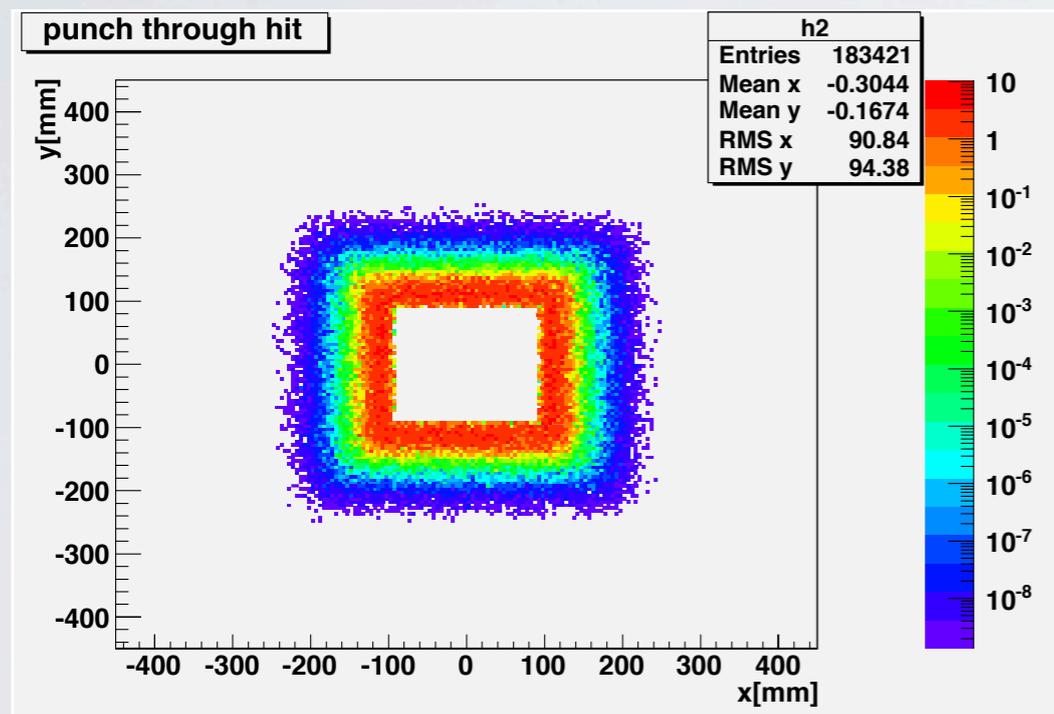
probability of punch through



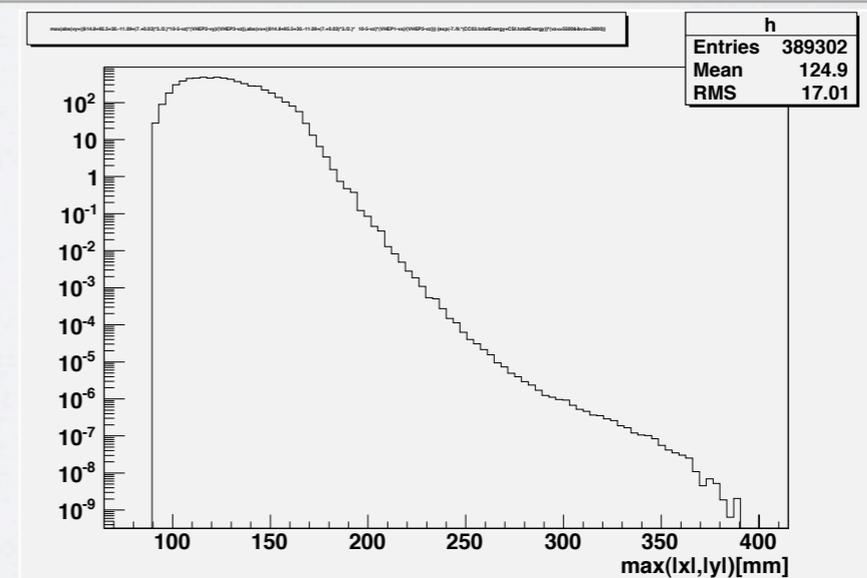
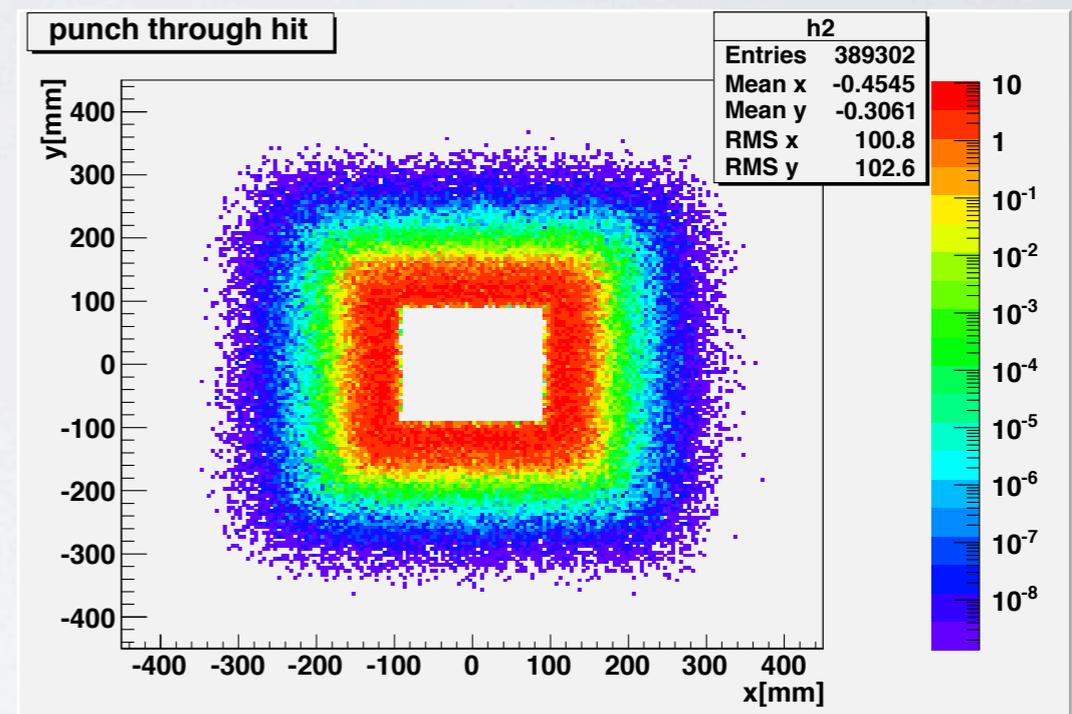
h1	
Entries	183421
Mean	0.01569
RMS	0.08661

HITS(PUNCH THROUGH CC03)

- vertex cut
 $3000 < z_{\text{vtx}} < 5000 \text{mm}$



- vertex cut
 $3000 < z_{\text{vtx}} < 5500 \text{mm}$



Almost $\pm 300 \text{mm}$ is enough,
 $\pm 400 \text{cm}$ is desirable ?

SUMMARY

- The hole size of the default CC04 is enough
- Considering CC03 punch through, wider coverage ($\sim \pm 400\text{mm}$) may be required
- There are some γ s that pass through the gap of the CsI crystals

TO DO

- To estimate the background number using inefficiency of CC04
- To study γ s that pass through the gap