The design of neutral K^0_L beamline for J-PARC E14 K^{O}TO experiment.

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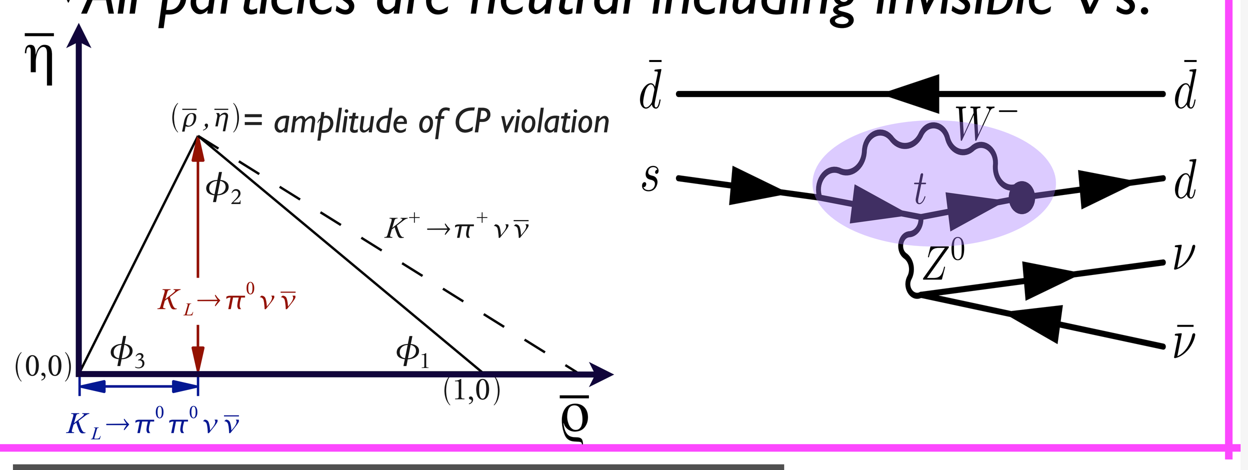
for the J-PARC E14 K^{O}TO collaboration*. (16 institutes, ~60 members)

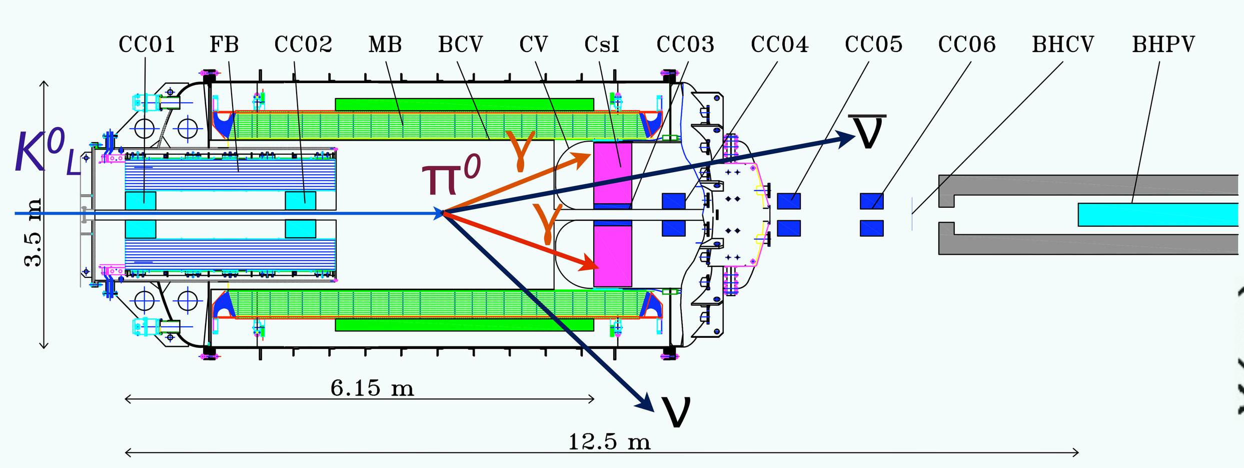
Physics motivation

- $K^0_L \to \pi^0 \nu\bar{\nu}$
  - Direct CP violation process.
    - $A(K^0_L \to \pi^0\nu\bar{\nu}) \propto \eta \Rightarrow Br(K^0_L \to \pi^0\nu\bar{\nu}) \propto \eta^2$
  - Theoretical uncertainty : 1~2%
  - Sensitive to new Physics through loop diagram.
- Challenging
  - Rare decay : $Br(K^0_L \to \pi^0\nu\bar{\nu}) \sim 2.5\times10^{-11}$ (S.M.)
  - All particles are neutral including invisible ν's.



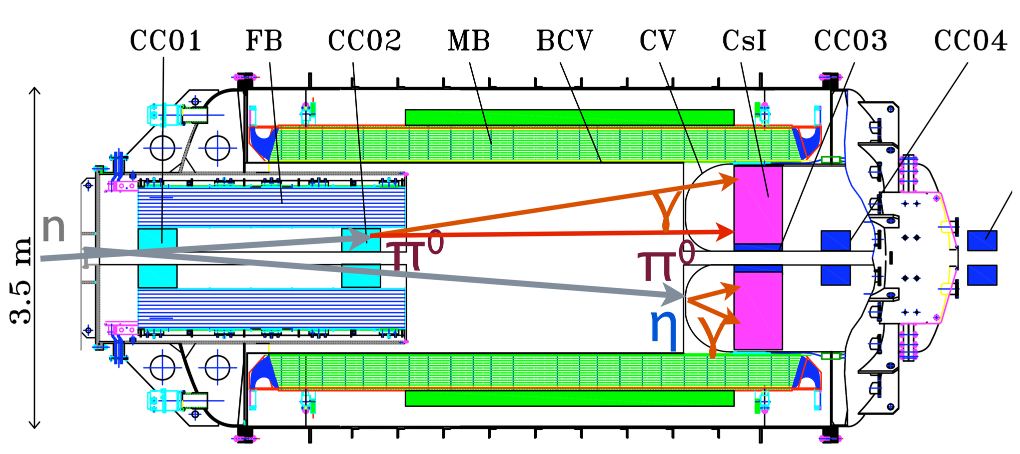
Event signature

- $K^0_L \to \pi^0\nu\bar{\nu}$ ($\pi^0 \to 2\gamma$ + nothing)
  - 2γ :To measure energy & position with CsI calorimeter.
  - Nothing:To confirm no other particle with high efficiency hermetic photon veto counters.
- Well collimated narrow neutral beam.
  - Reconstruct π^0 assuming decay on the beam axis.

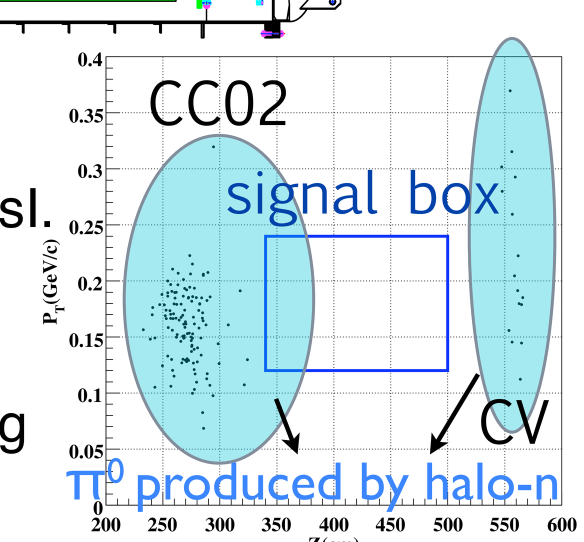


background related beam

- π^0 and η production by halo neutron at the detectors near the neutral beam.
  - n+A (CC02, CV) → π^0(→2γ) or η(→2γ) +X.



- "CC02-π^0"
  - Energy leakage of γ in CsI.
- "CV-π^0": π^0 + X
- "CV-η"
  - Reconstruction assuming $M_{2\gamma} = M_{\pi^0}$ (< M_η).



reconstructed π^0 vertex (E391a RunII analysis)

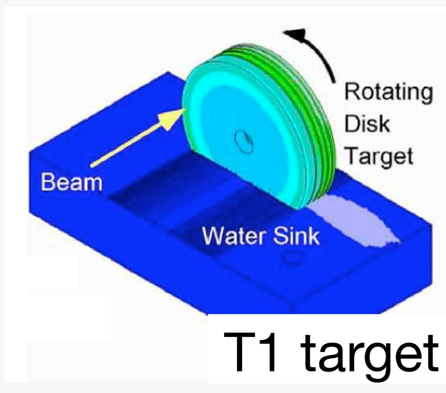
Halo neutron B.G. is one of the most dangerous and severe...
⇒Small halo-n/K^0_L beamline is absolutely imperative!!

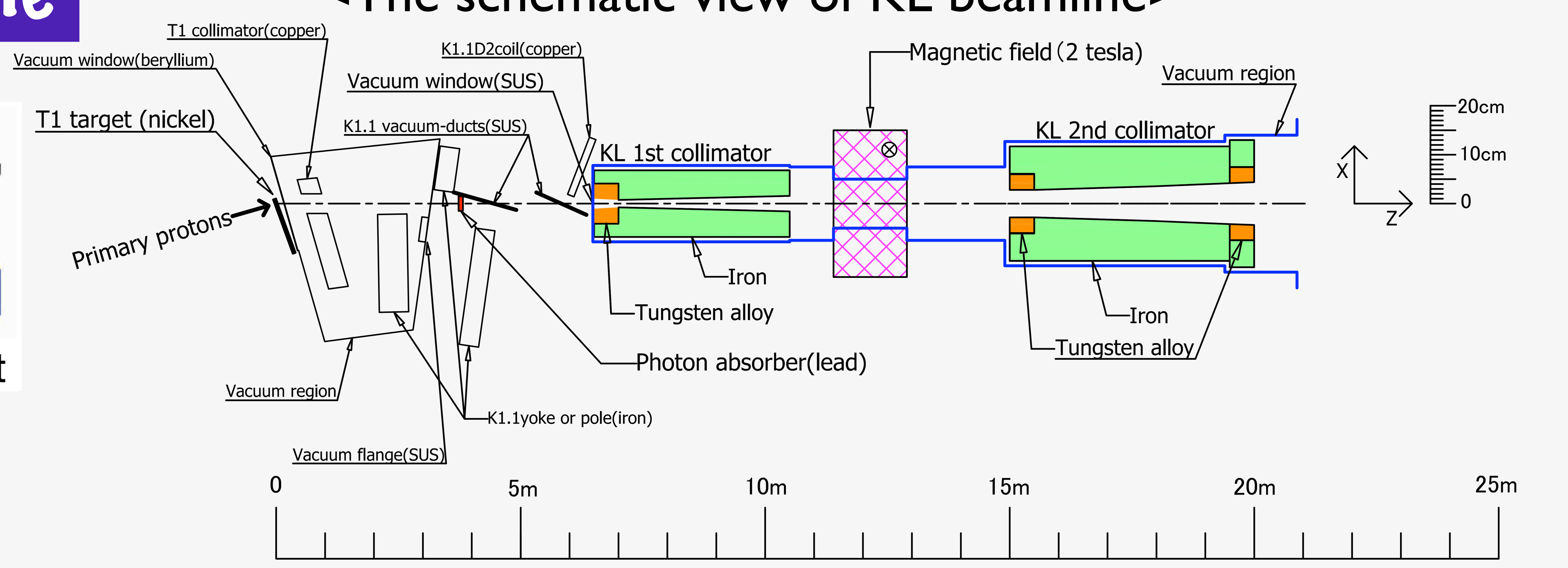
Requirement value of halo-n /K^0_L for K^{O}TO (halo-n B.G./signal≤0.1)

CC02-π^0	CV-π^0	CV-η
< 6.80×10^{-3}	< 1.35×10^{-3}	< 2.03×10^{-3}

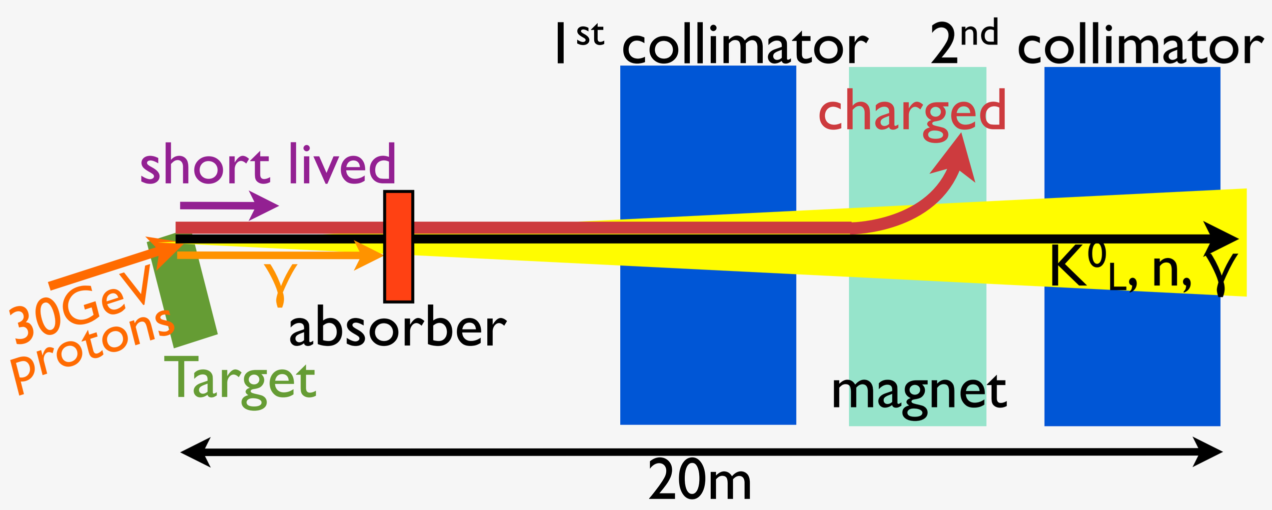
KL beamline

<The schematic view of KL beamline>





- *Extracted proton beam hits rotating common disk target.* ⇒ Many upstream materials to use common target.
- *The extraction angle is 16°* ⇒ Target image from experimental area is finite size.



- 2 stage long collimators are located at far from target.
- 20m long beam-line.
  - ✓To remove short lived particle. (hyperon, K^0_S...)
- Magnets for sweeping out charged particles.
- Large amount of neutron, γ exit in neutral beam.
  - ✓Pb absorber to reduce photon contamination.

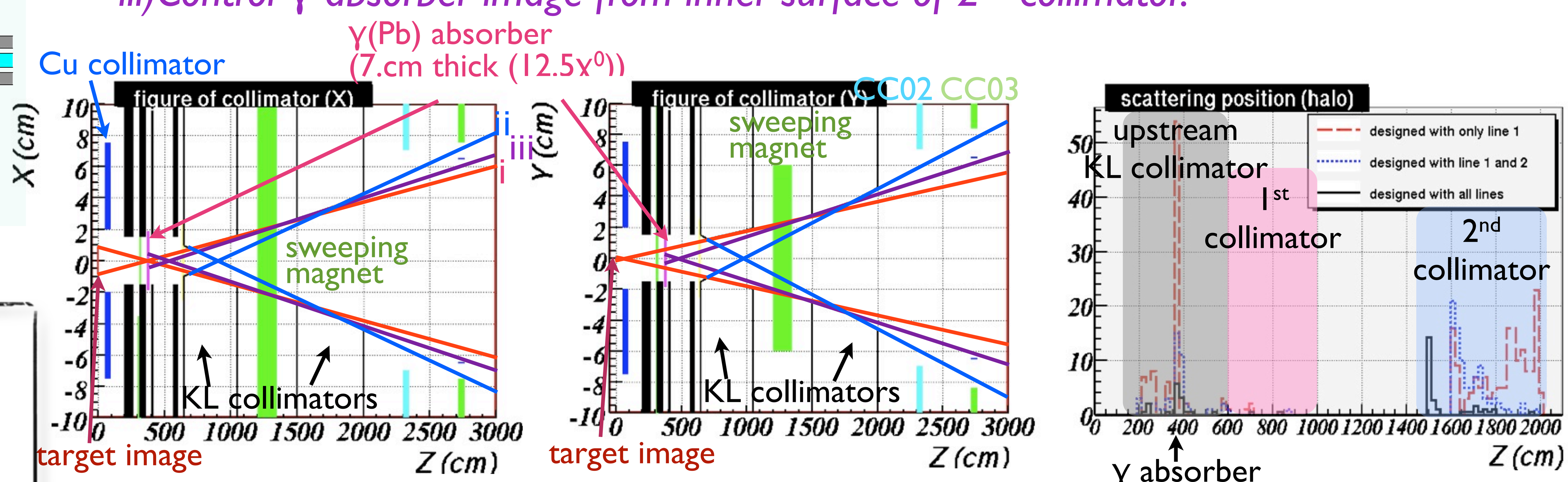
beamline design

- Design with 3 collimation lines for halo neutron suppression.

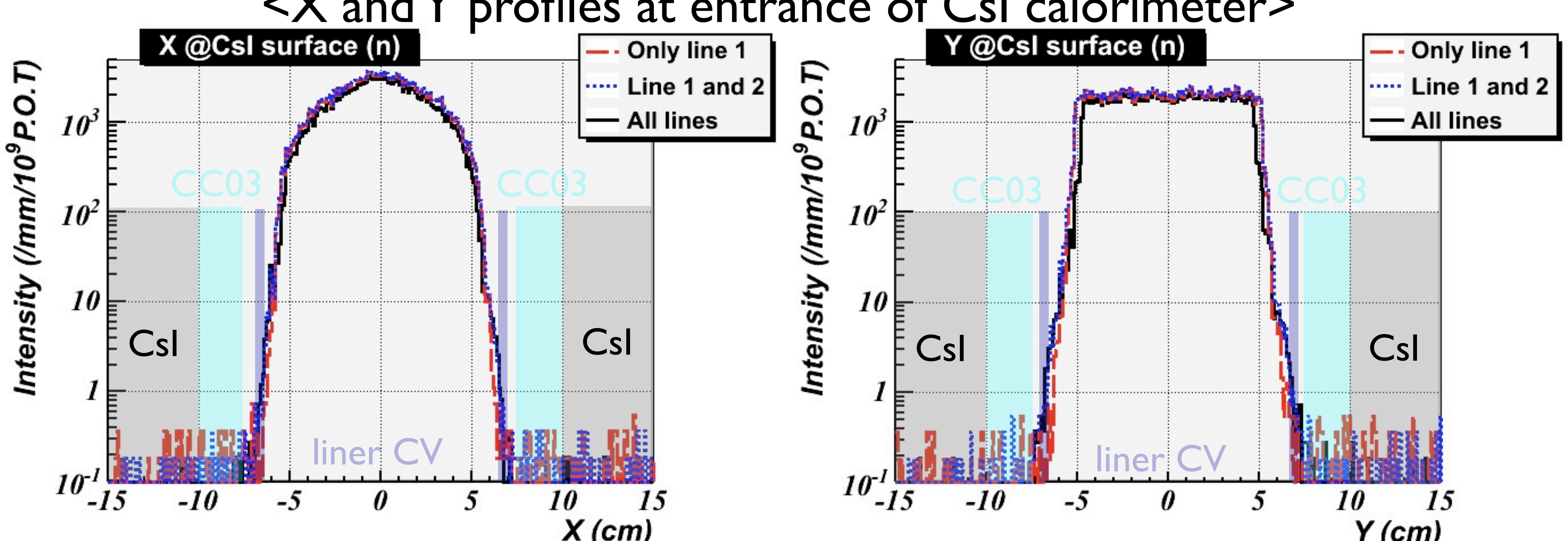
i) Define the beam size & profiles
⇒The inner surface of the collimators shouldn't be faced to the target.

ii) To avoid scattering at rear edge of 2^{nd} collimator.

iii) Control γ absorber image from inner surface of 2^{nd} collimator.



<X and Y profiles at entrance of CsI calorimeter>



The X,Y profiles have sharp edges.
halo-n/K^0_L = $0.70\pm(0.05)\times10^{-3}$

Conclusions

- Halo neutron is one of the most serious background sources in the K^{O}TO experiment.
- The neutral K^0_L beamline for K^{O}TO is designed to suppress the halo neutron with 3 collimation lines. ⇒ **halo-n/K^0_L = $0.70\pm(0.05)\times10^{-3}$**
- Major halo source is neutron scatter at γ (Pb) absorber and upstream wall/inner surface at 2^{nd} collimator. ⇒ Suppress scattering at 2^{nd} collimator with trimming lines.
- This neutral K^0_L beamline is being constructed at J-PARC now. (~ Autumn.'09)

*J-PARC E14 K^{O}TO collaboration :
KEK-Kyoto-NDA-Osaka-Saga-Yamagata (Japan), Arizona State-Chicago-Michigan AnnArbor (USA), JINR(Russia), National Taiwan (Taiwan), and Pusan National-Seoul-ChonBuk National-Jeju National (Korea).