J-PARC E14 Experiment

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J-PARC PAC@KEK

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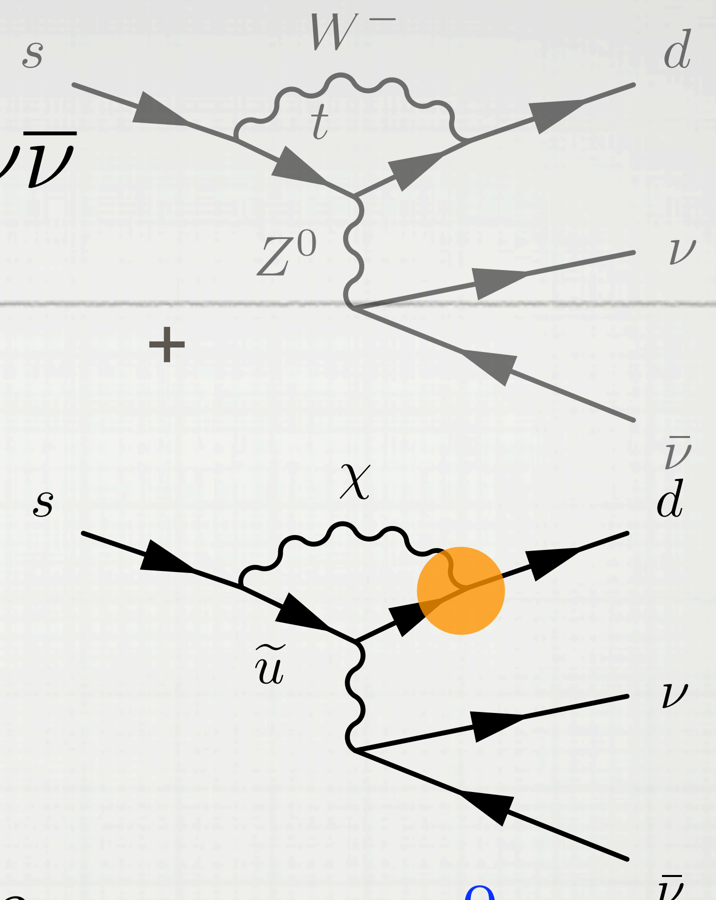
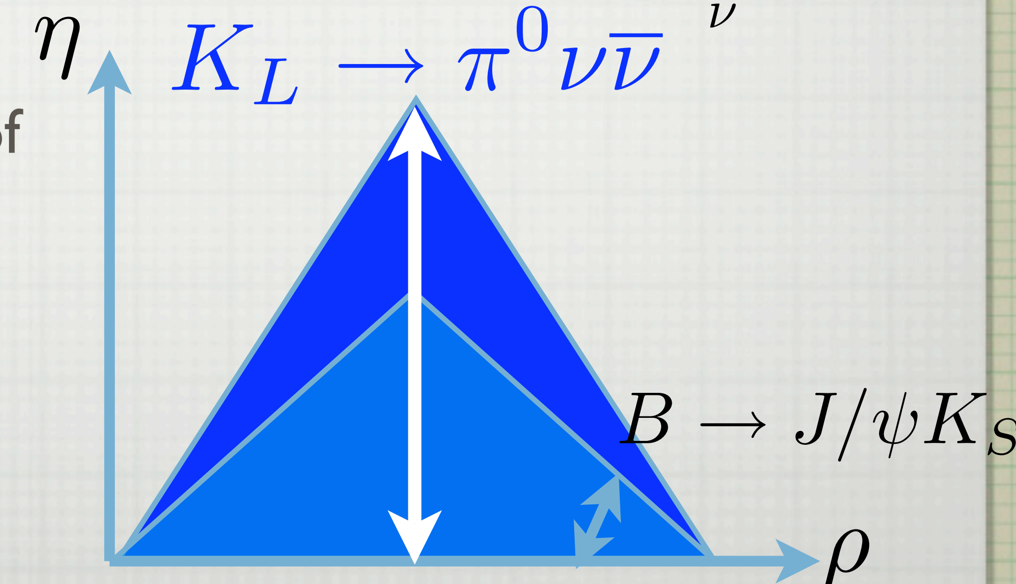
Contents

- Introduction to J-PARC E14
- Beamline design
- Beam survey
- Current status

J-Parc E14 - $K_L \rightarrow \pi^0 \nu \overline{\nu}$

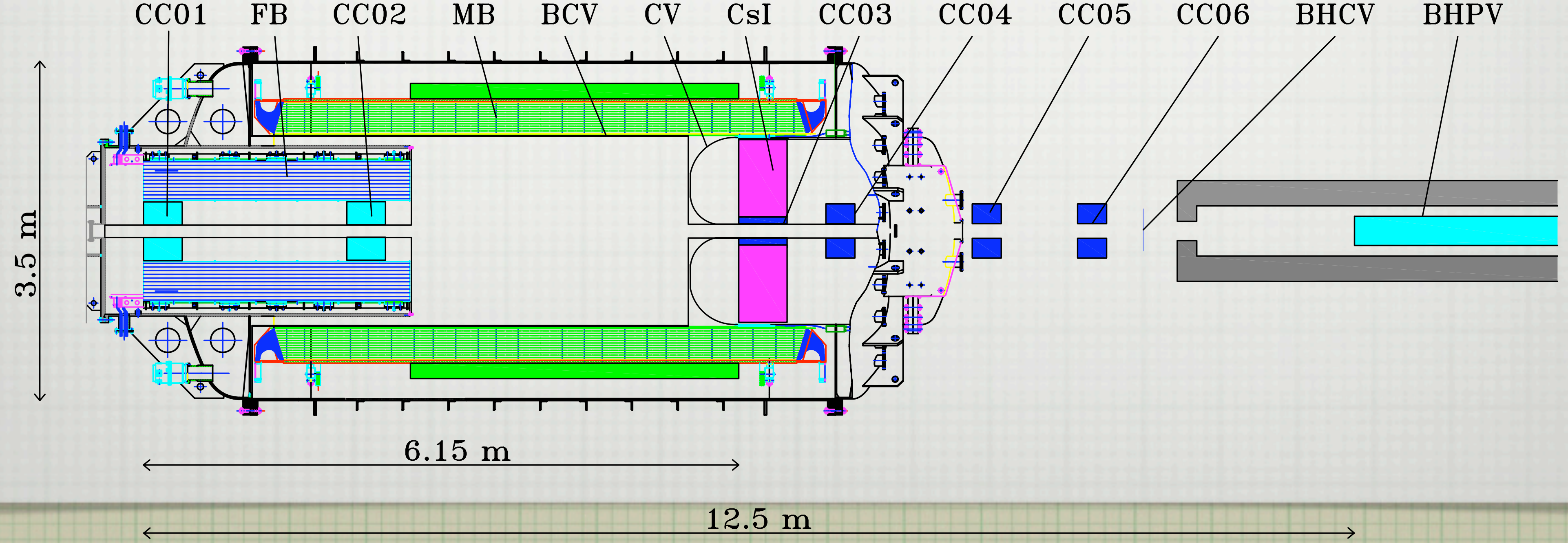


- Physics
  - Measure the imaginary part of CKM η and probe new physics beyond the standard model.
- Goals
  - Step 1(E14): First observation of the decay
  - Step 2: Measure BR to <10%



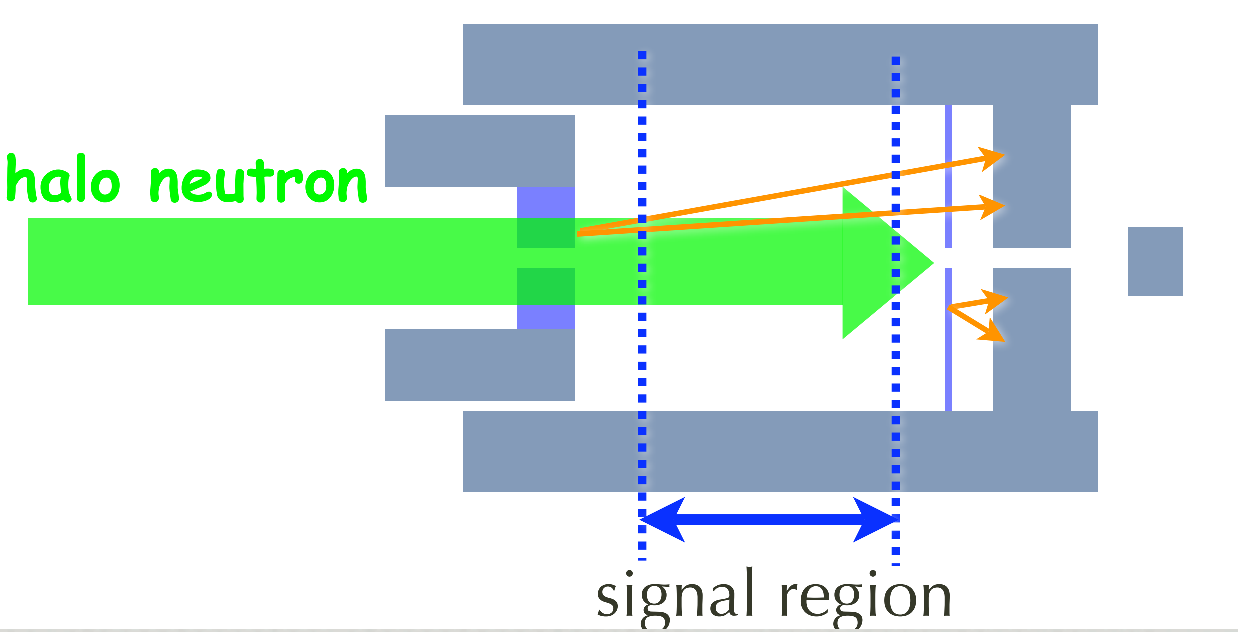
E14 Detector

- CsI : 7cm square x 30cm --> 2.5cm square x 50cm
- New photon veto in the beam
- Enhanced photon veto
- Wave form digitization

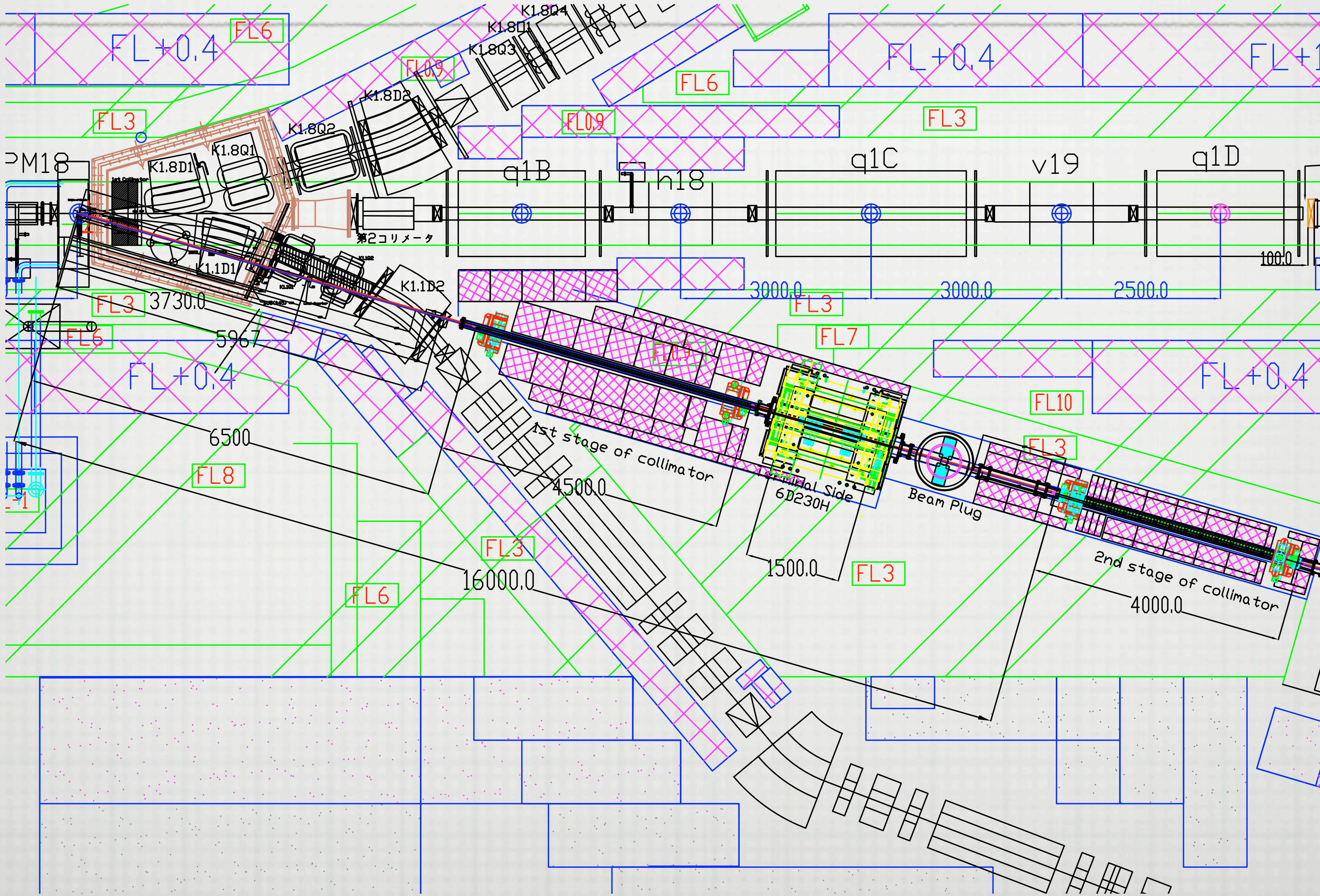


Beamline Design

- Goal: CLEAN BEAM = Small beam halo to suppress background caused by halo neutrons producing π^0s and eta's at detector
- Halo neutrons = neutrons that hit detector
- Many improvements since the last PAC in January 2008

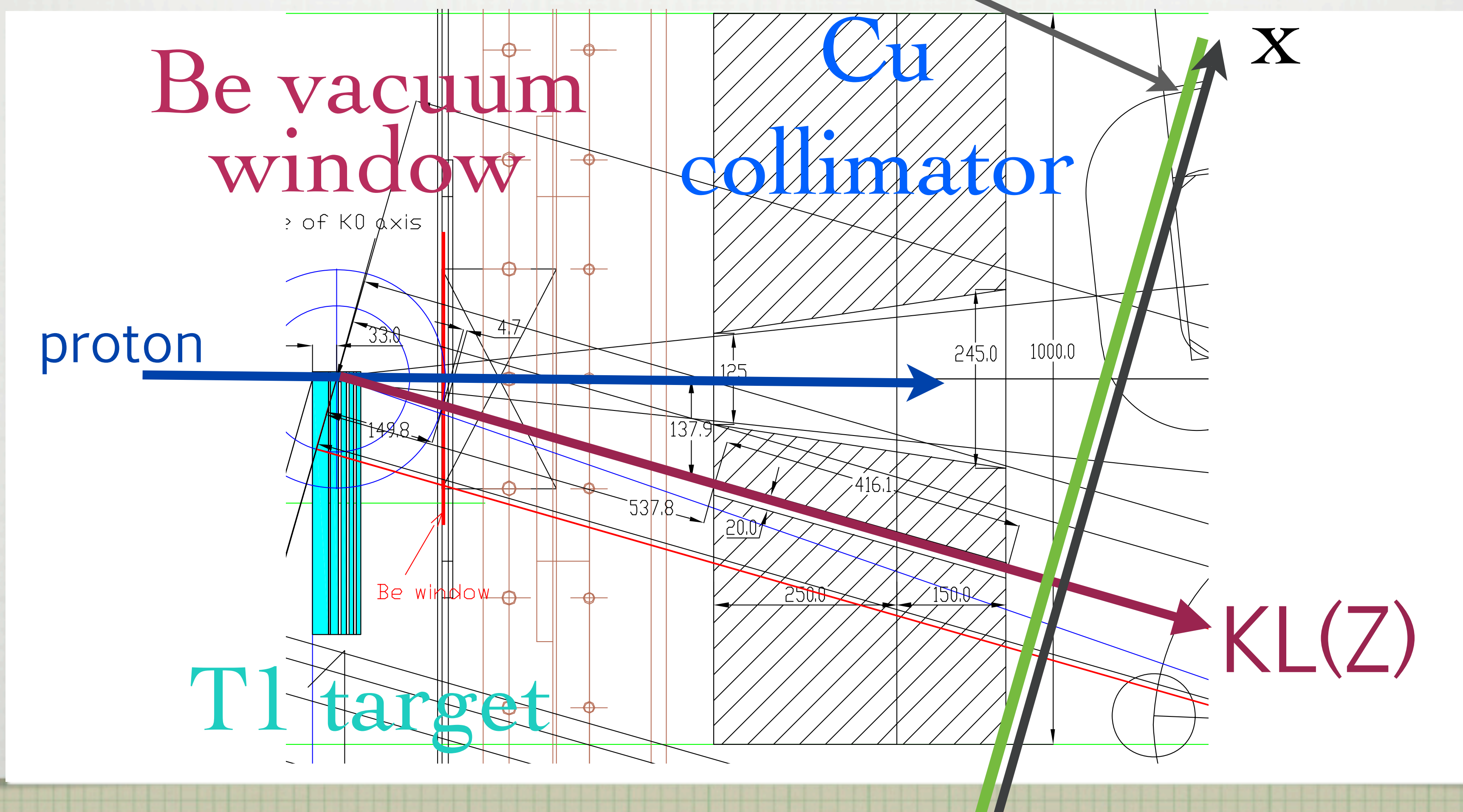


E14 Beamline



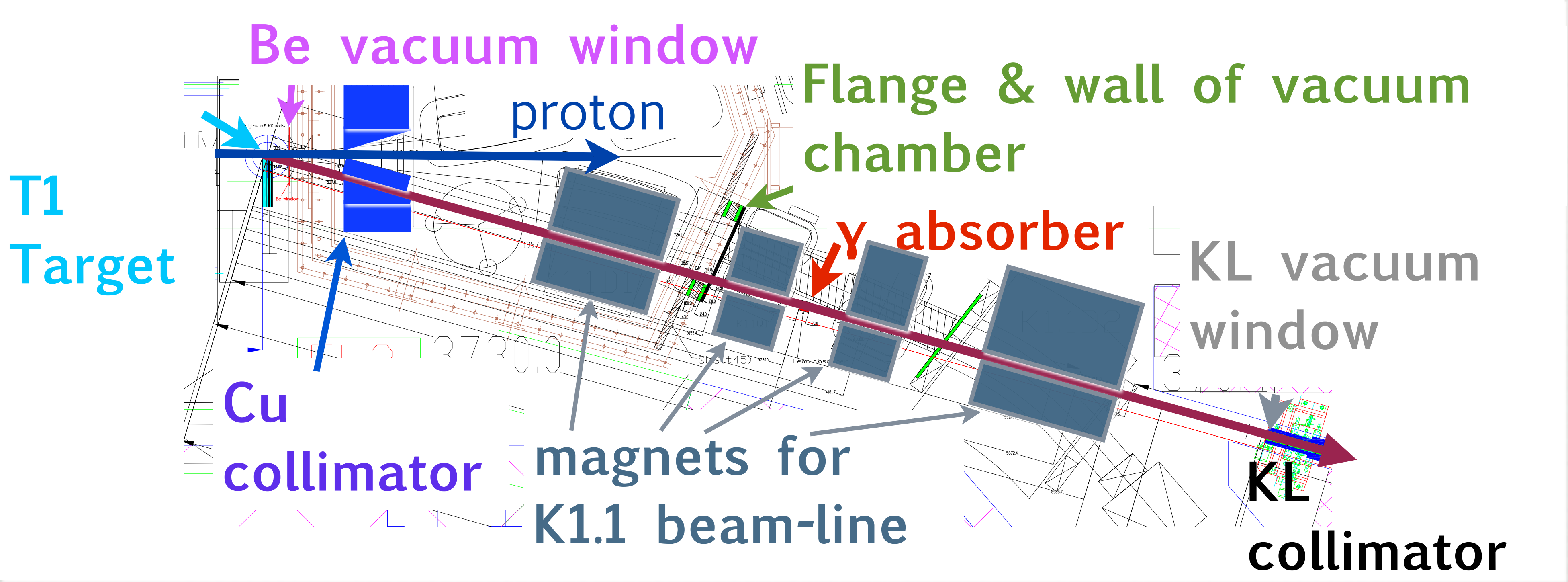
Improvement #1

- Collected neutrons at a plane coming from wide area (including large hole in Cu collimator) illuminating wide area of KL collimators.



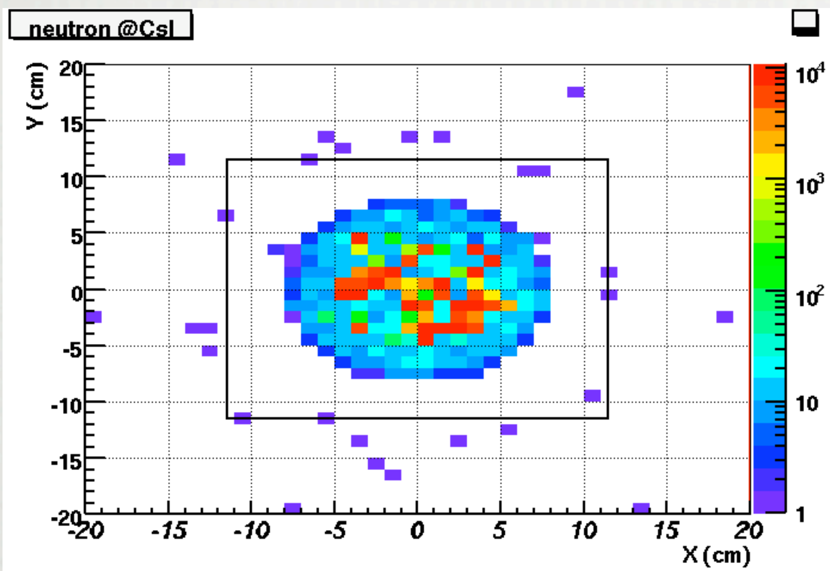
Improvement #2

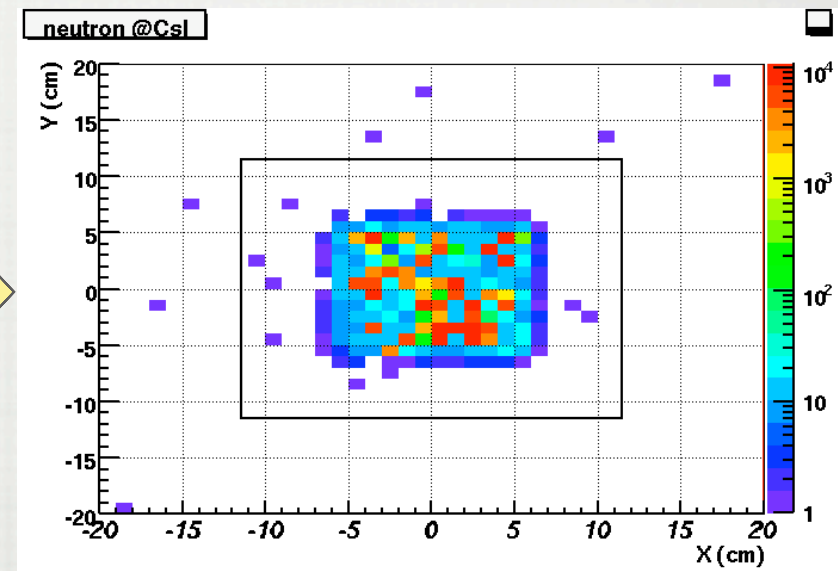
- ☐ Full simulation with K1.1 magnets



Improvement #3

- Changed from round beam to square beam, to optimize collimator edges to the horizontally long target image.





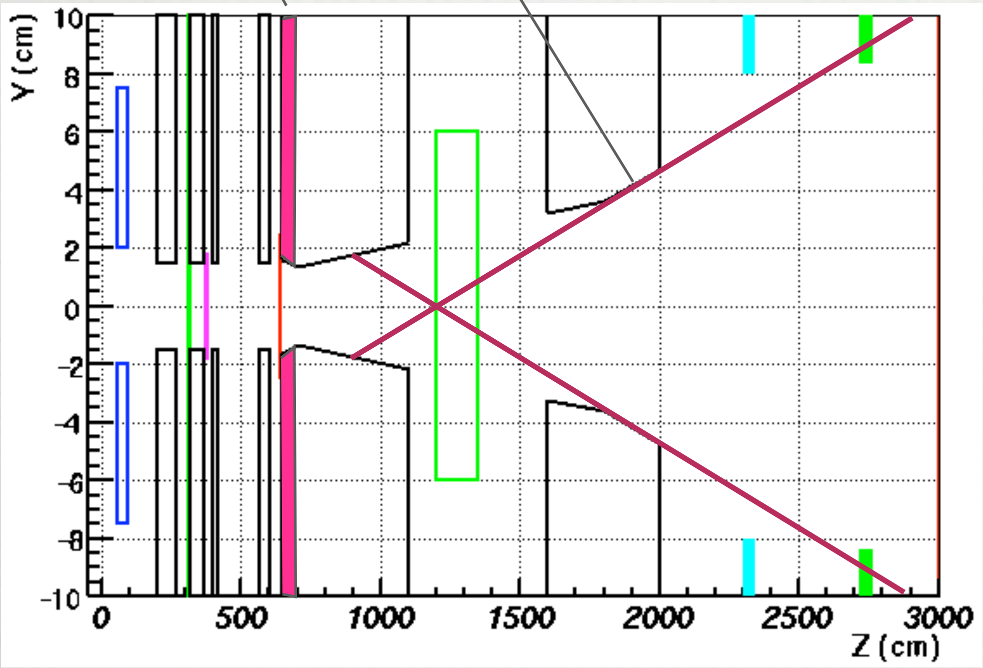
#halo n / #core n

$(1.57\pm0.25)\times10^{-4}$

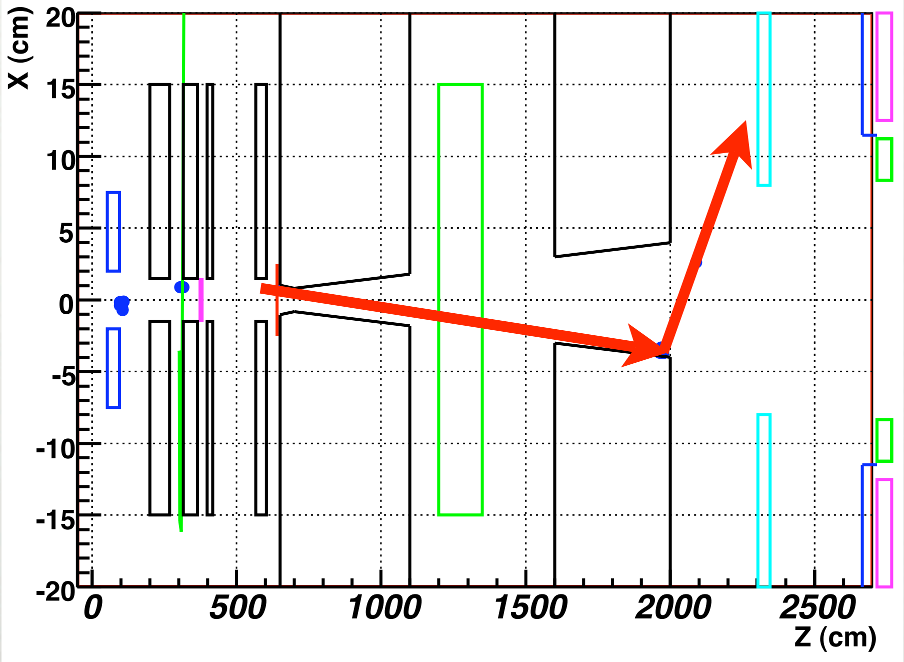
$(0.95\pm0.20)\times10^{-4}$

Improvement #4

- Changed upstream edge from Iron to Tungsten
- Widened the downstream half

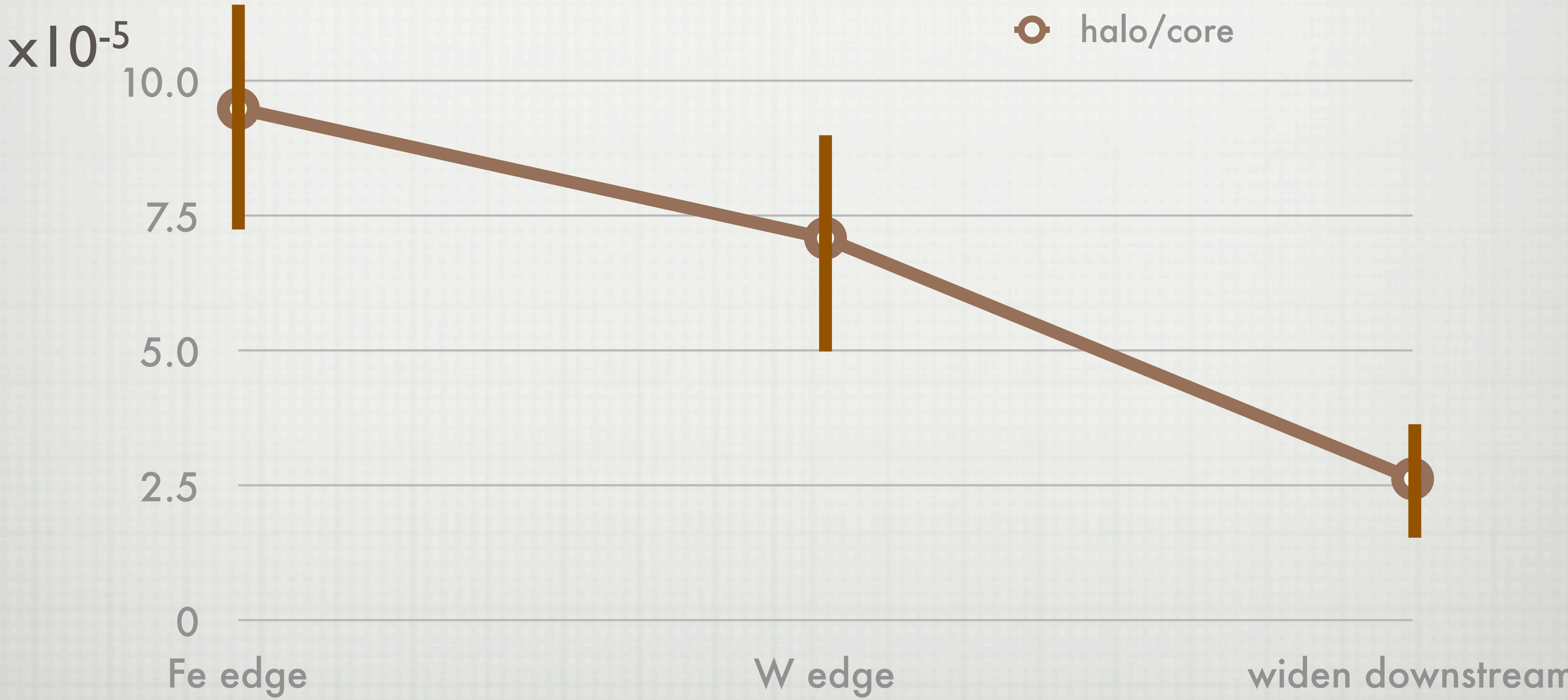


- Of 22 events,
  - penetrate front edge: 3→1
  - scatter at rear edge: 15→0
  - scatter multiple times: 5→5



Halo Neutrons

- $\frac{\#\text{Halo neutrons } (p>0.78\text{GeV/c}; \pi^0 \text{ production threshold})}{\#\text{Core neutrons } (T>0.1\text{GeV})}$



Now...

- Accumulating statistics with Geant4
- Running FLUKA to crosscheck the new design
- Plan
  - Finish design by August 2008
  - Start beamline installation in March or April 2009, finish by summer

Beam Survey

Beam Survey

- Fall of 2009
- to measure:
  - Kaon flux
  - Neutron flux
  - Halo neutron flux
  - Beam profile
  - charged particles, photons, neutrons in the experimental area

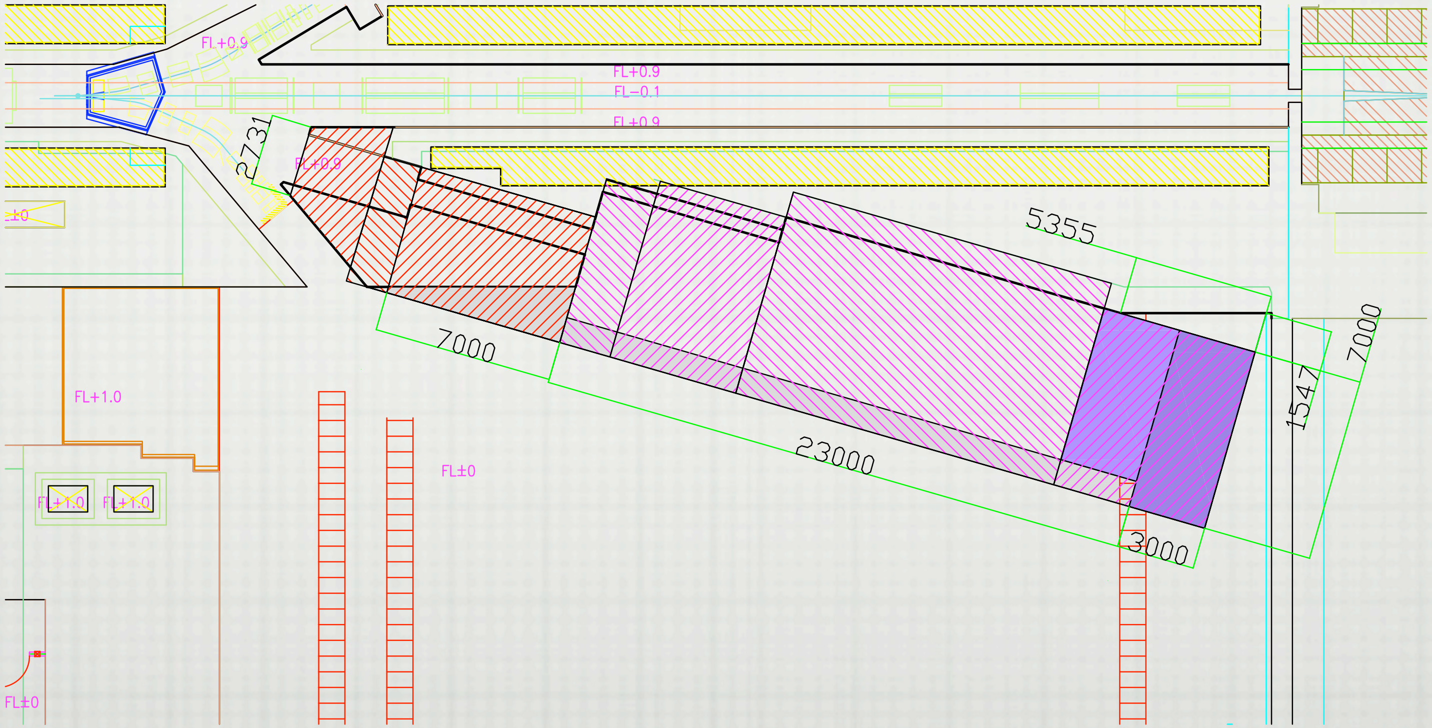
#KL for "Original K1.1" design

MC package	#KL
GEANT3	$(7.6\pm0.2)\times10^6$
GEANT4 (QGSP)	$(4.6\pm0.2)\times10^6$
GEANT4 (QBBC)	$(5.4\pm0.2)\times10^6$
FLUKA	$(16.6\pm0.2)\times10^6$

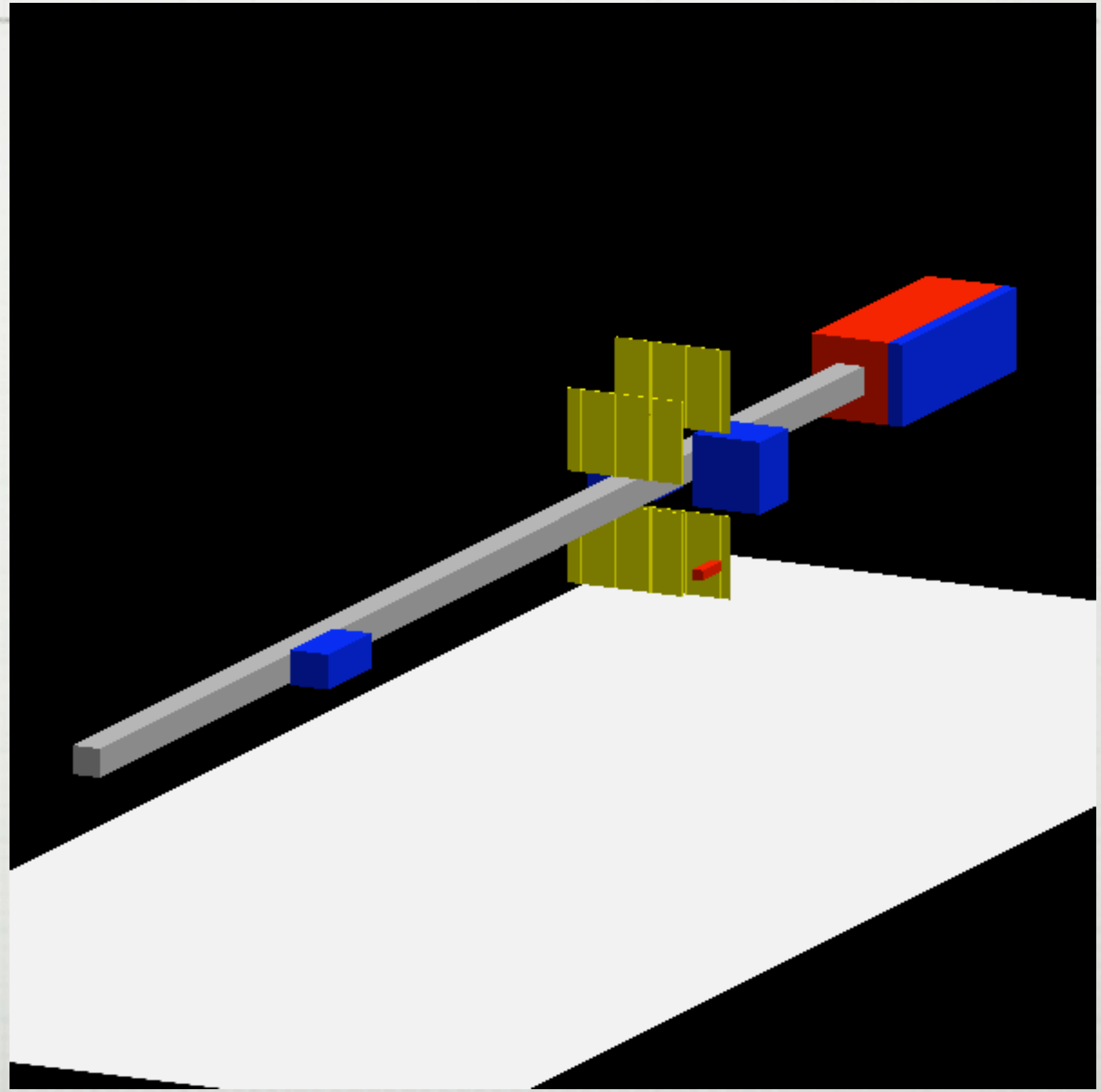
"Report to E14 Review/Planning Committee", Oct. 29, 2007

Beamline Area

- Expect concrete shields for the final configuration
- Discussing with Suzuki at Rad. Safety

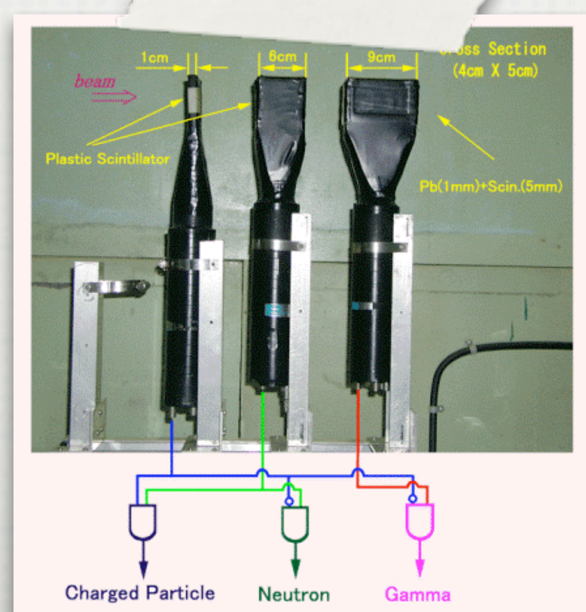


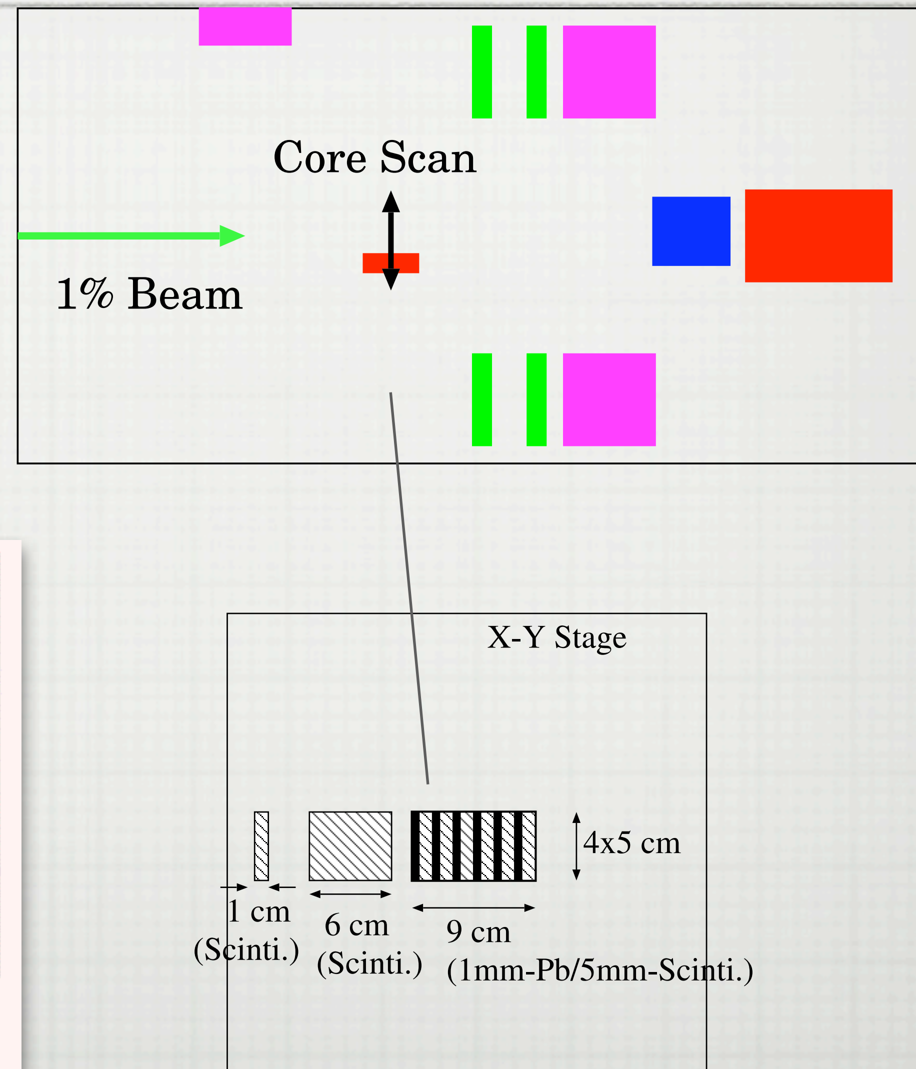
Detectors For The Beam Survey



1. Scan Beam Core

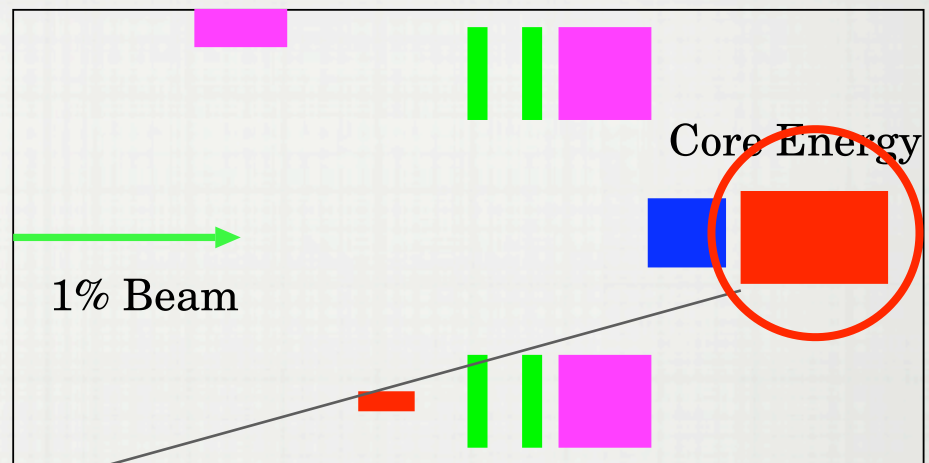
- Check the position and the shape of the beam core
- ~same detector as used for E391a

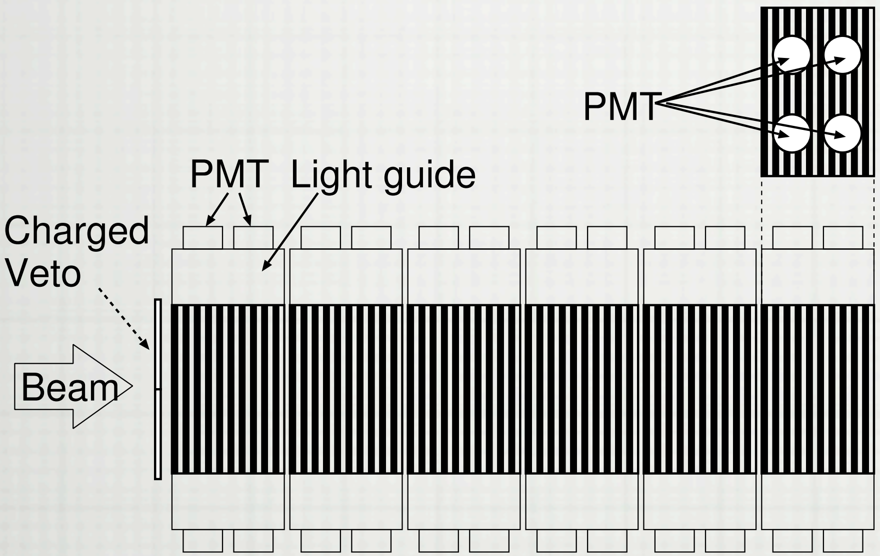




2. Core Neutron Flux And Spectrum Measurement

- Hadron calorimeter ("Cerberus") used for E391a



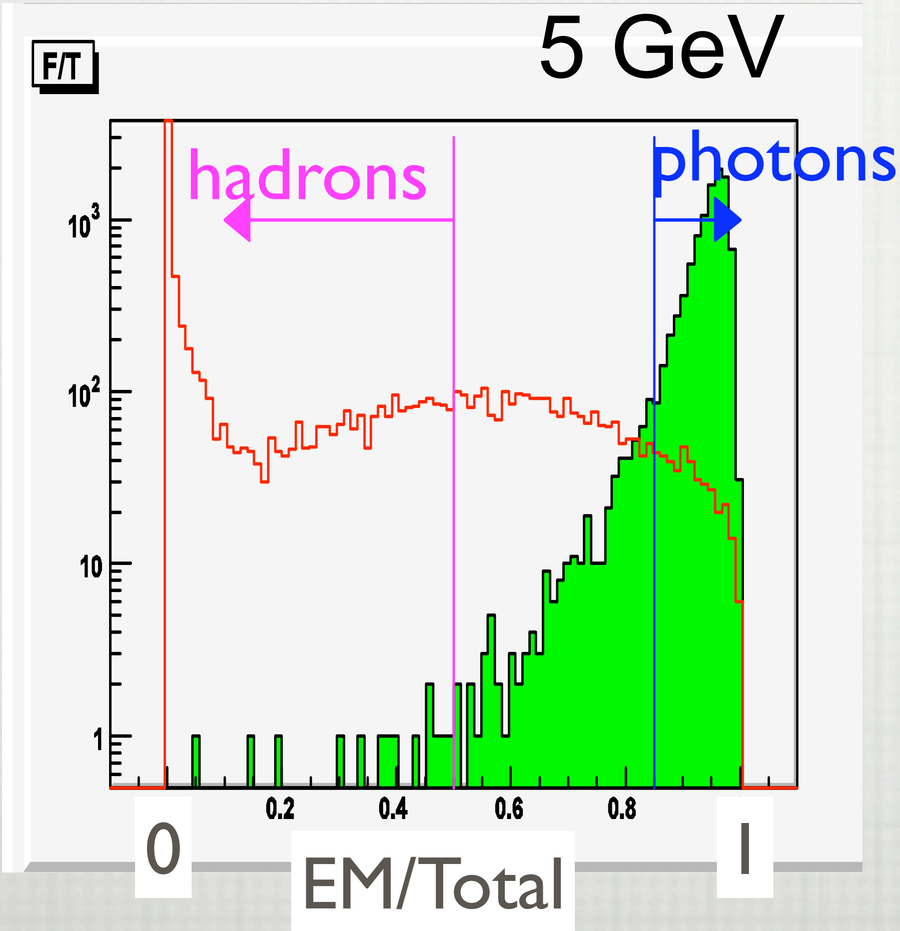


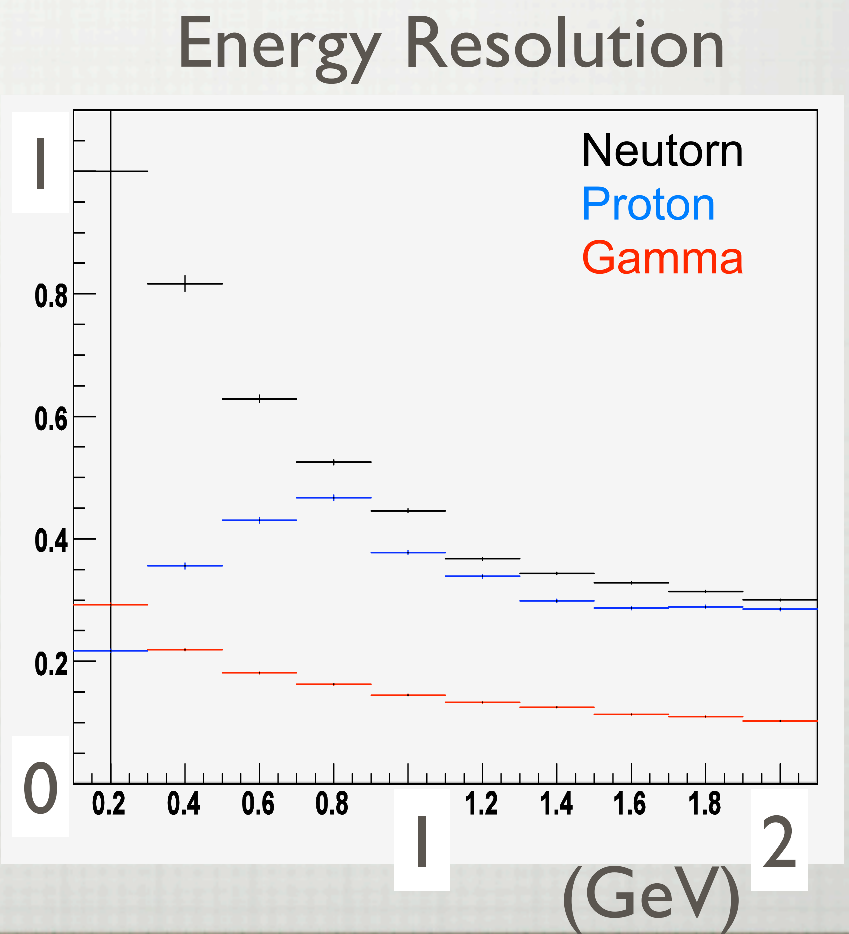
EM part
$18X_0$
(4mm Pb + 3.7mm scint)x25

Hadron part
$4.3\lambda_I$
(4mm Fe + 3.7mm scint)x25

Performance Of "Cerberus"

- Hadron part: visible ratio = 5%, detection efficiency = 60%

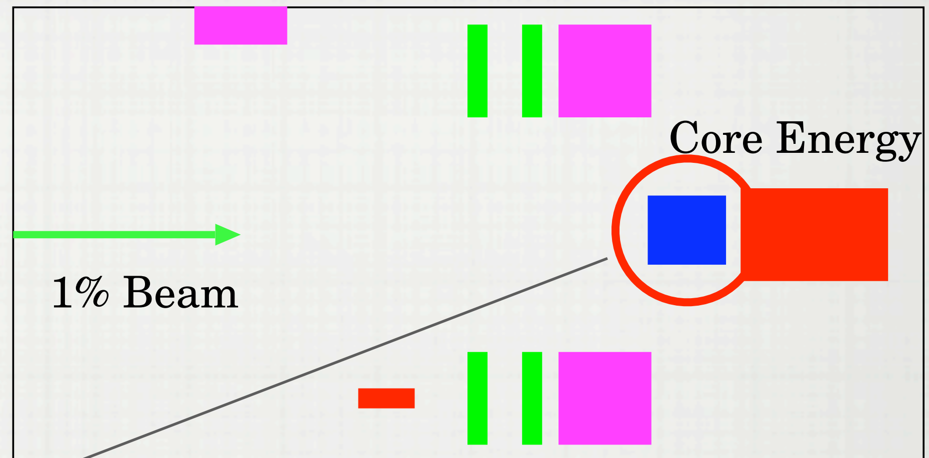


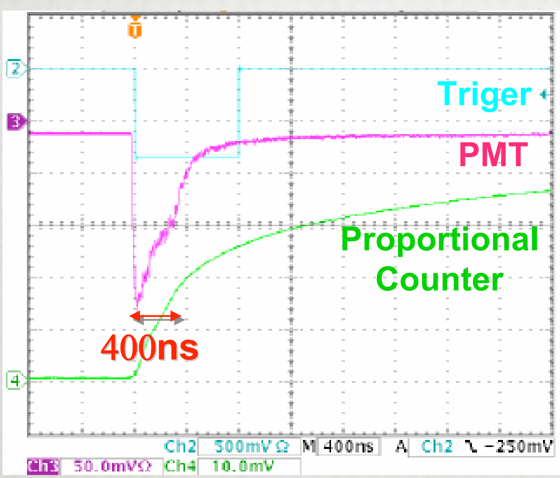


2b. Core Photon Measurement

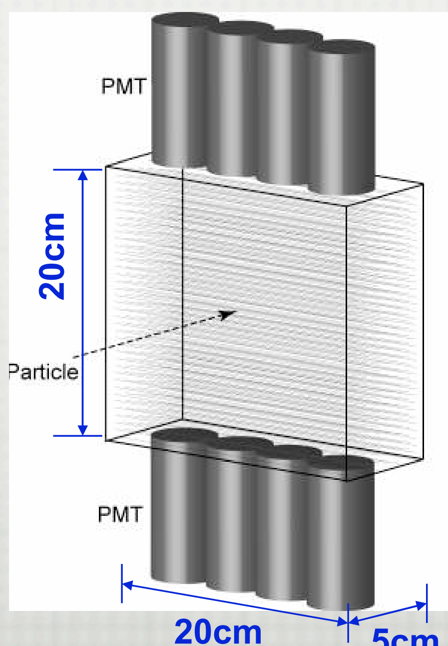
- Detect photons and charged particles in the beam with prototype detectors

- Charge veto: detect photons from avalanche

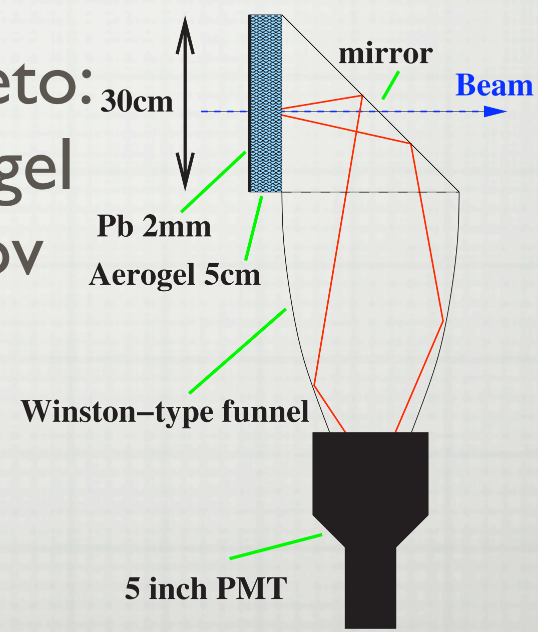




Pulse shape (Average mode)

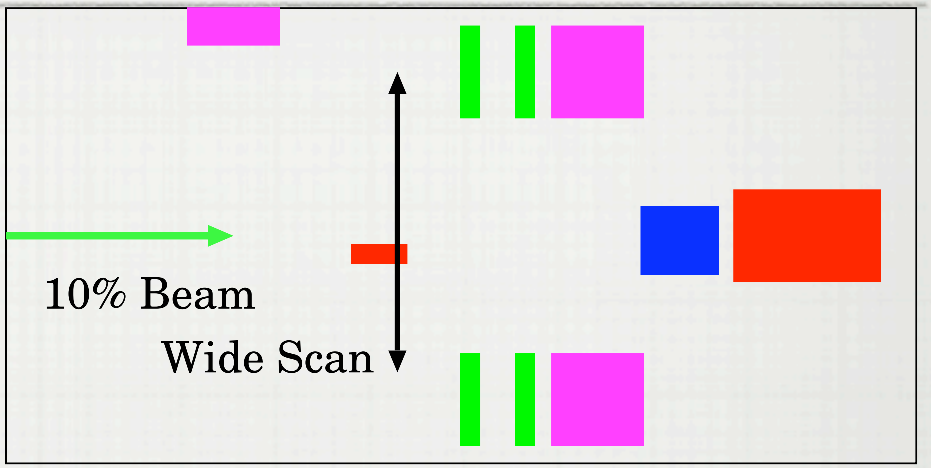


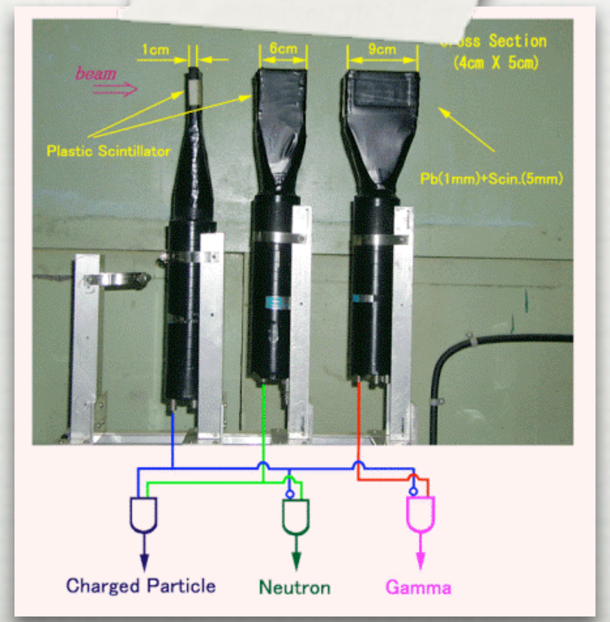
Photon veto: Pb+Aerogel Cerenkov



3. Wide Scan

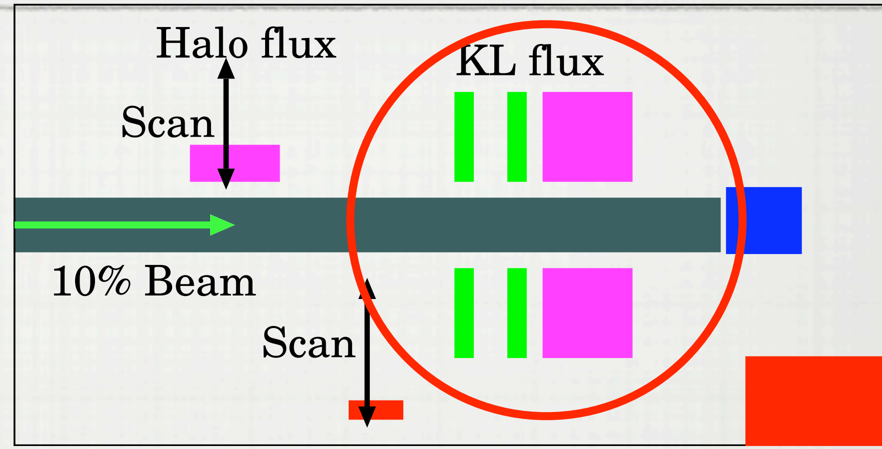
- ☐ At ~10% beam intensity, scan wider area with finger counters
- ☐ Measure tail that leads to "halo neutrons"

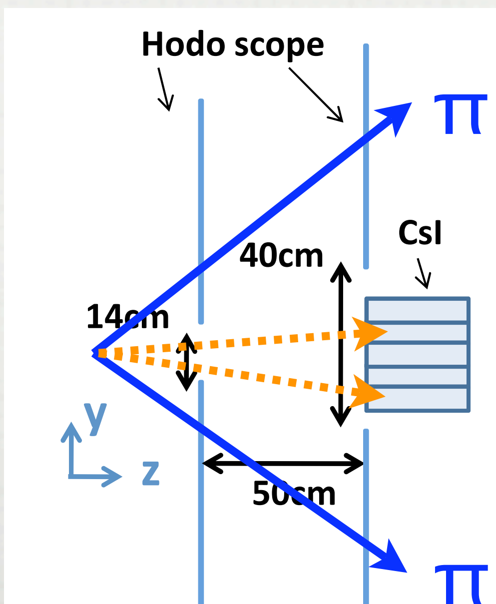




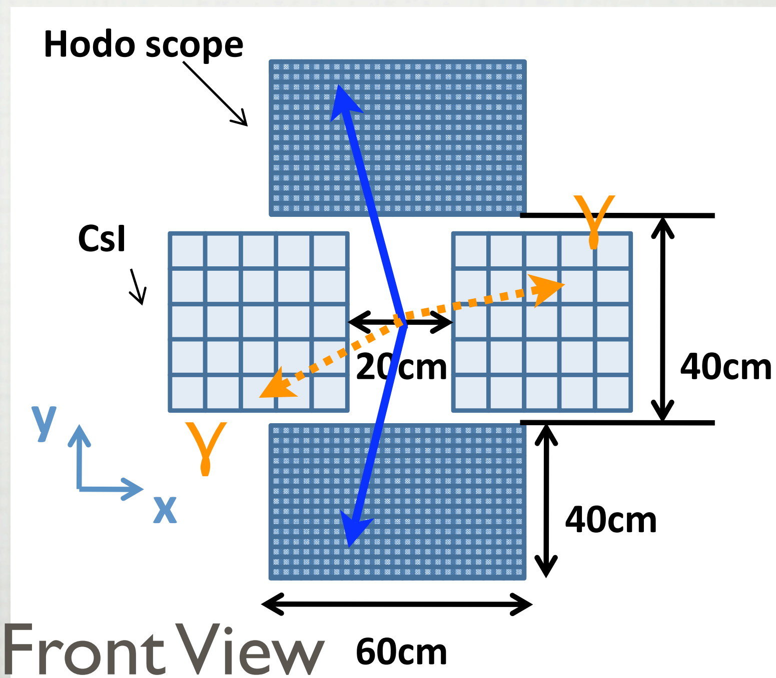
4. K_L Flux Measurement

- With a simple setup; no magnets, no chambers, ...
- Use $K_L \to \pi^+\pi^-\pi^0$





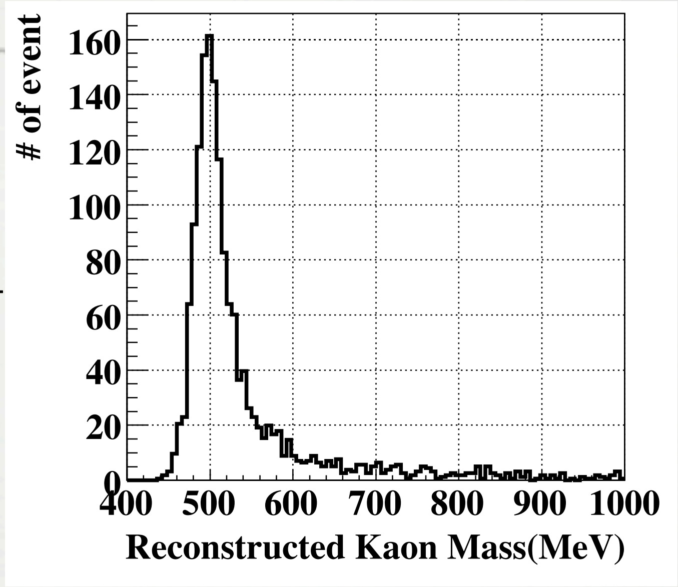
Side View

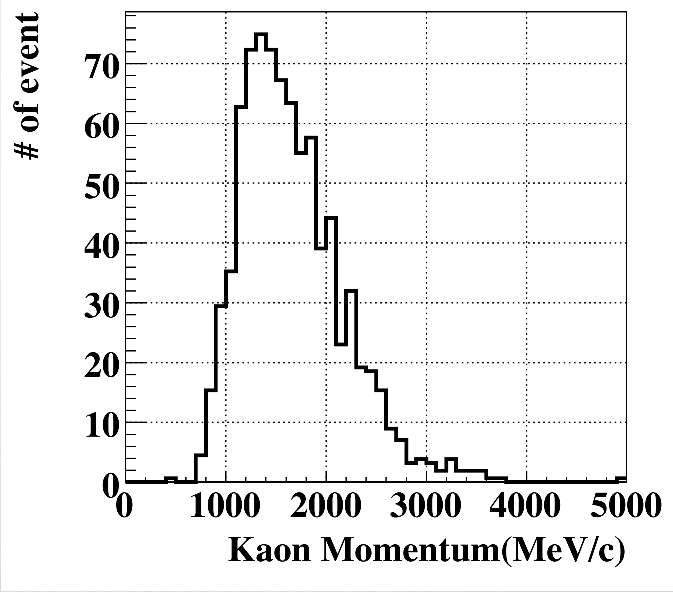


Front View

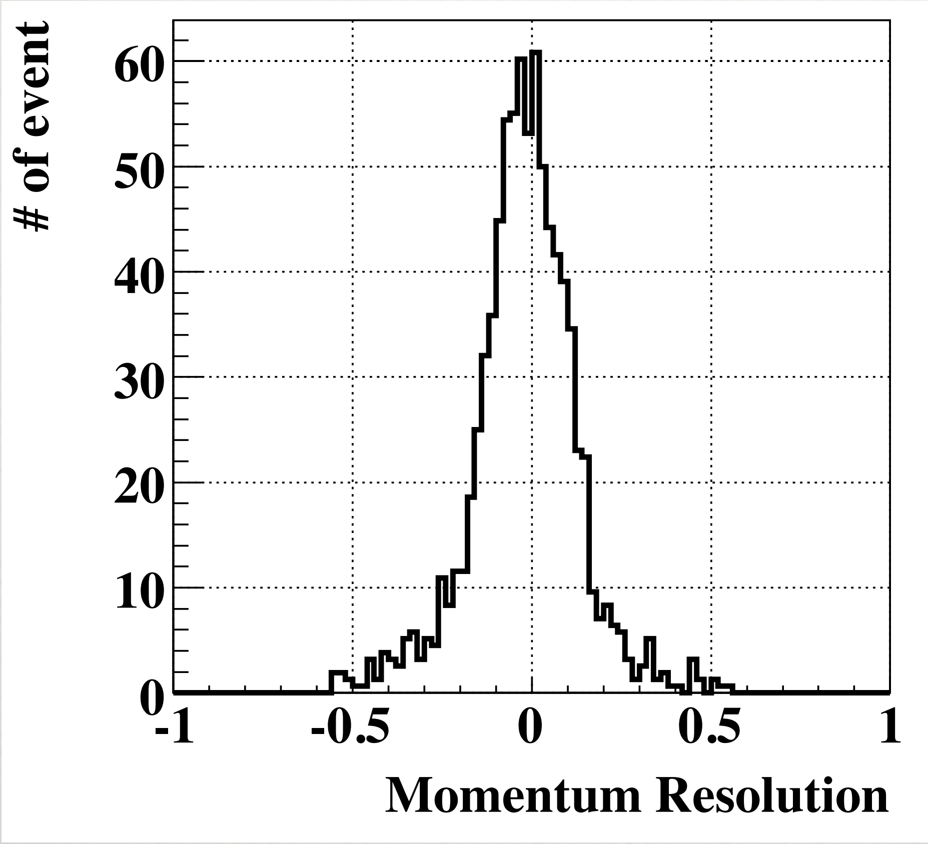
4. K_L Flux Measurement

- Assume π^0 mass and get z vertex
- 2 unknowns: π^+ and π^- momenta p^+, p^-
- 2 equations: $p_x^+ + p_x^- + k_{1x} + k_{2x} = 0$
  $p_y^+ + p_y^- + k_{1y} + k_{2y} = 0$
- ~1000 reconstructed K_L / day with 1% intensity (2E12 protons/pulse)
- Background ~ several events from $3\pi^0$ with Dalitz decays

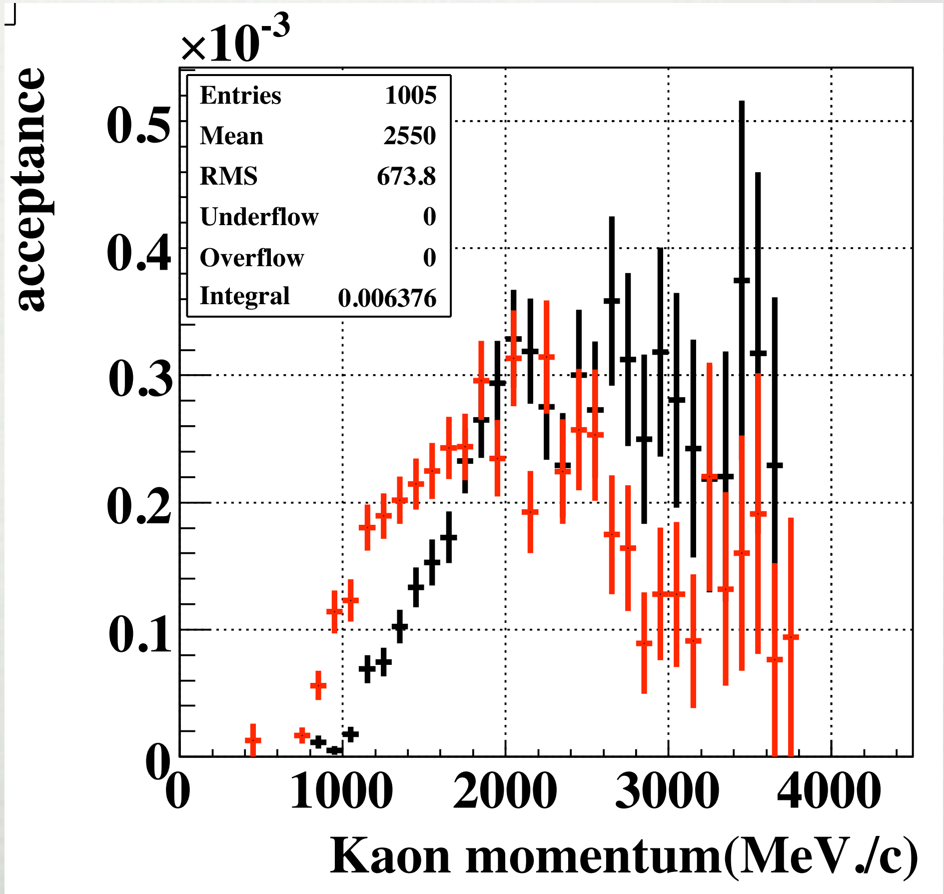




- K_L momentum resolution

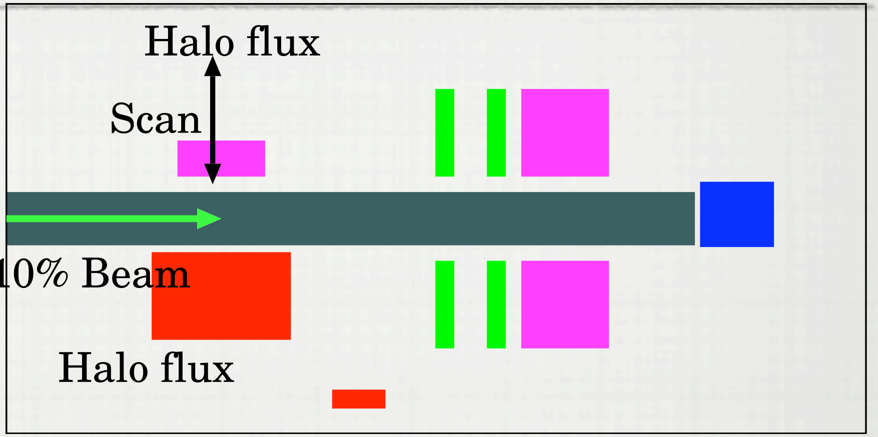


- Acceptance (RED LINE)



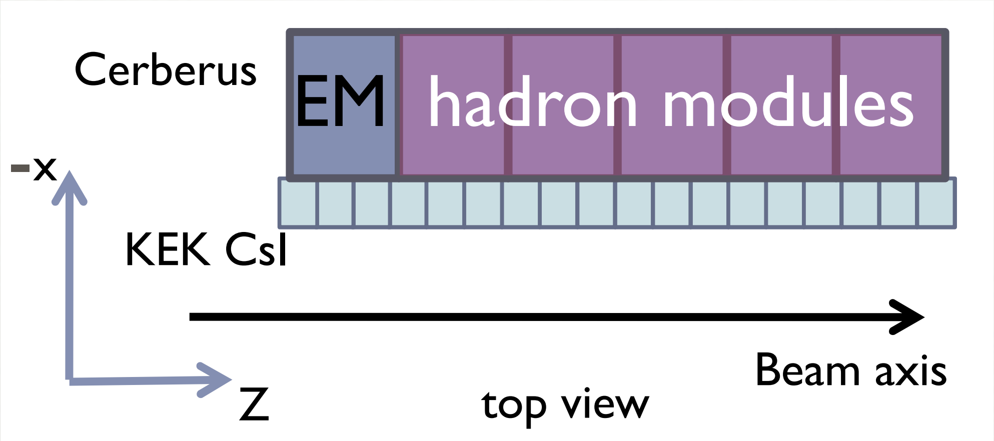
5. Halo Neutron Flux Measurements

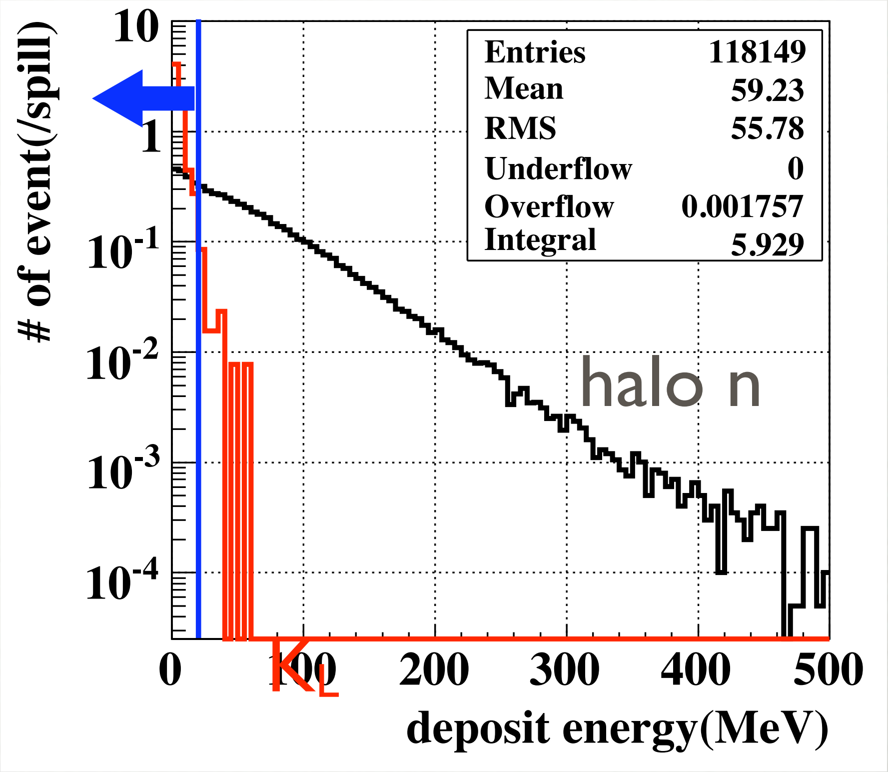
- Install a light beam pipe to avoid neutron interactions in the air
- Should suppress photon backgrounds from K_L decays
- 2 methods are being planned



Halo Neutron Rate Measurement #1 Cerberus + CsI Wall

- Cerberus + CsI Wall

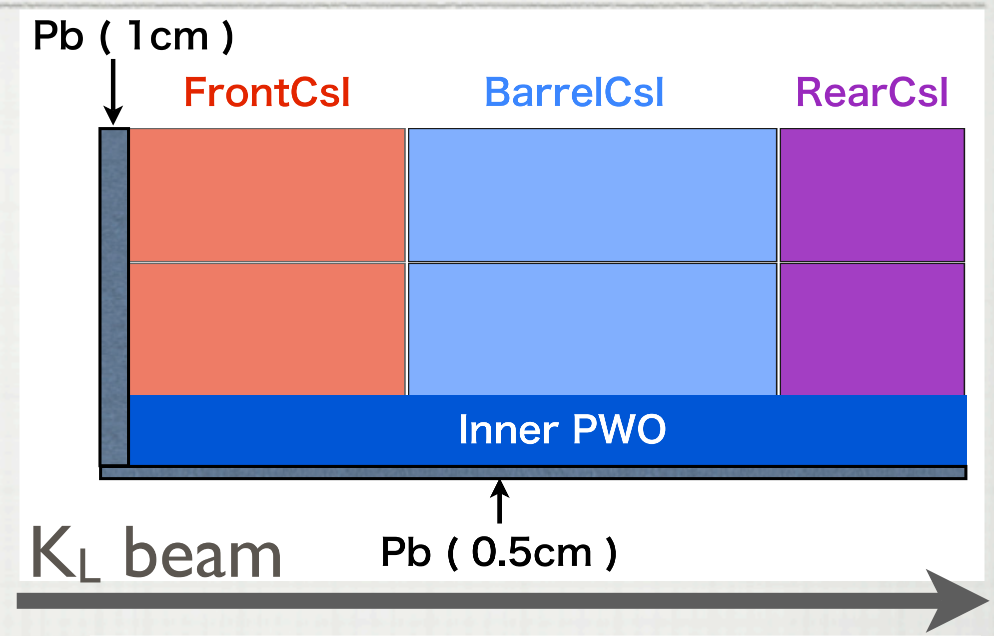


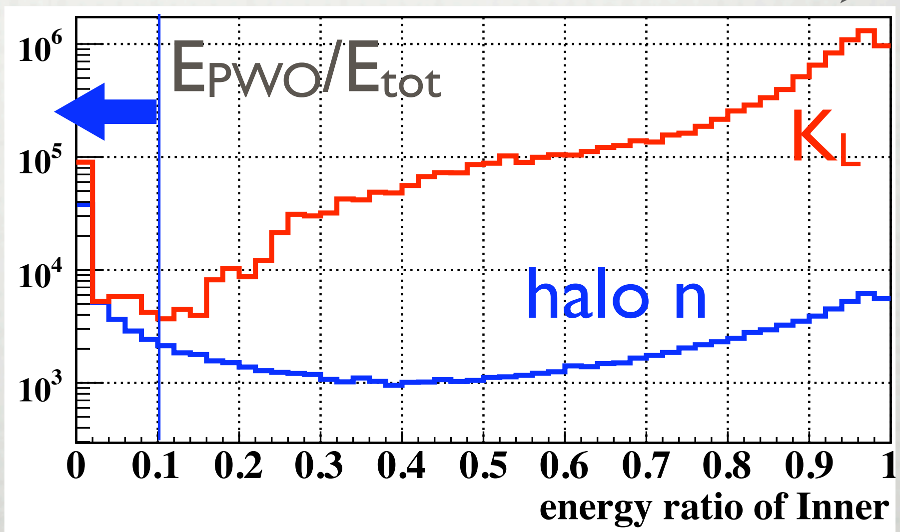


- 110k halo n events/day @ 1% intensity (2E12)
  K_L bkg/halo n = 4%

Halo Neutron Measurement #2
CsI + PWO

- CsI + PWO (prototype of upstream photon veto)
- Use Front CsI and PWO to veto photons
- 24k halo n events/day @1% beam intensity
- Background ~ 20%





Status

CsI Shipping

- Shipped

  216 large crystals and

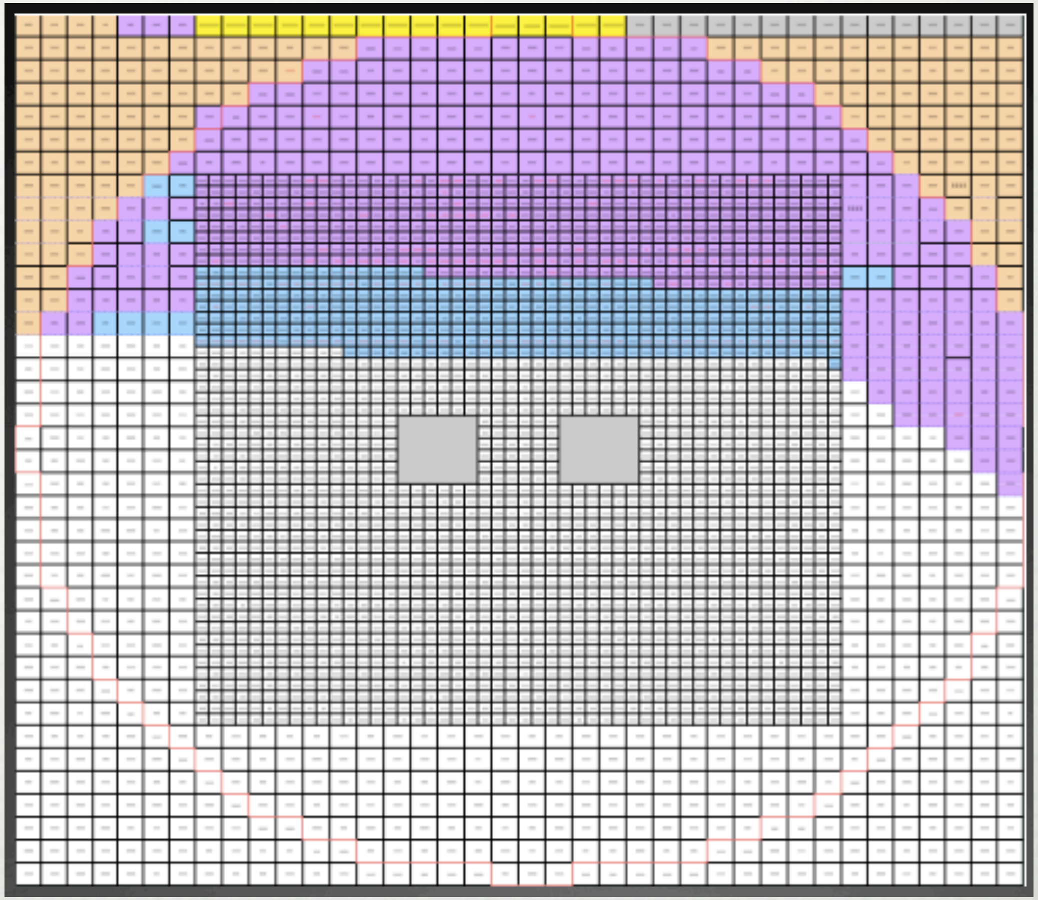
  384 small crystals to

  Osaka

- Stored in 5~10% RH dry room in Osaka

- 1month/cycle

- Will finish in November

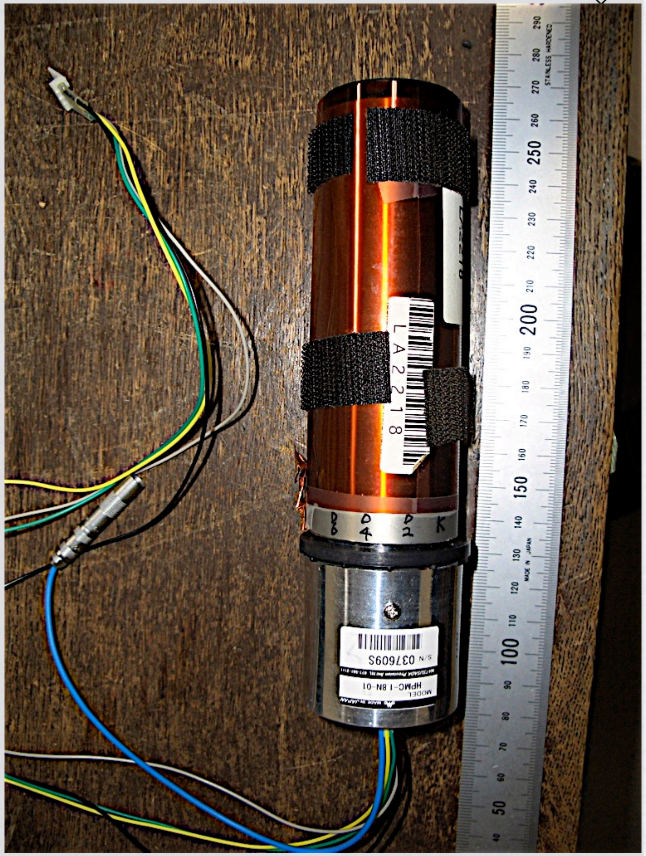


Cockcroft-Walton Base For CsI

CW base prototype

✓ Made by Matsusada Precision

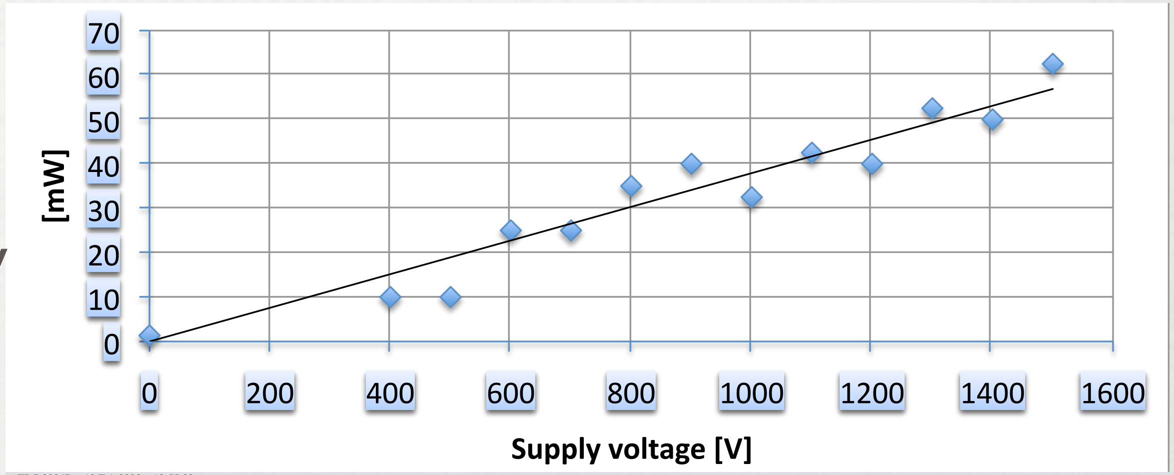
HPMC-1.8N-01 (for 5cmPMT)



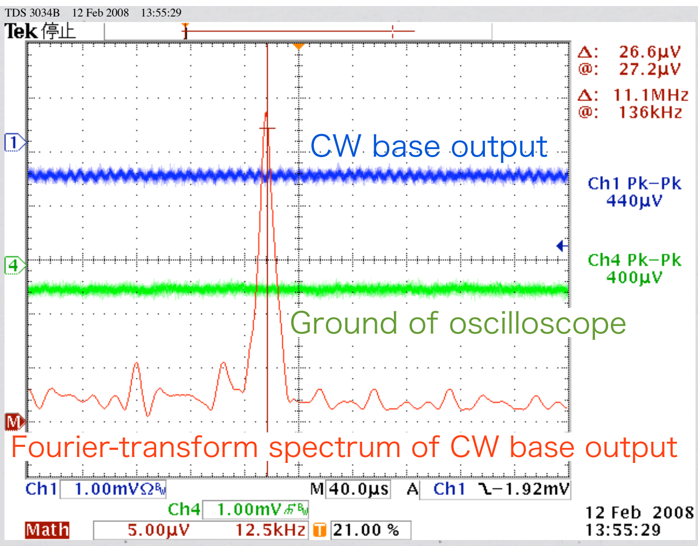
- divided ratio K 2:1:1:1:1:1:0.5 A
- maximum output voltage -1800V
- drive voltage Vin +5V (fixed)
- oscillation frequency 145kHz
- output voltage control method
  voltage control Vcon=0~1.8V

Cockcroft-Walton Base

- Power consumption: 740mW (KTeV) ➜ 50~70mW @1500V



- Ripple noise exists, but negligible



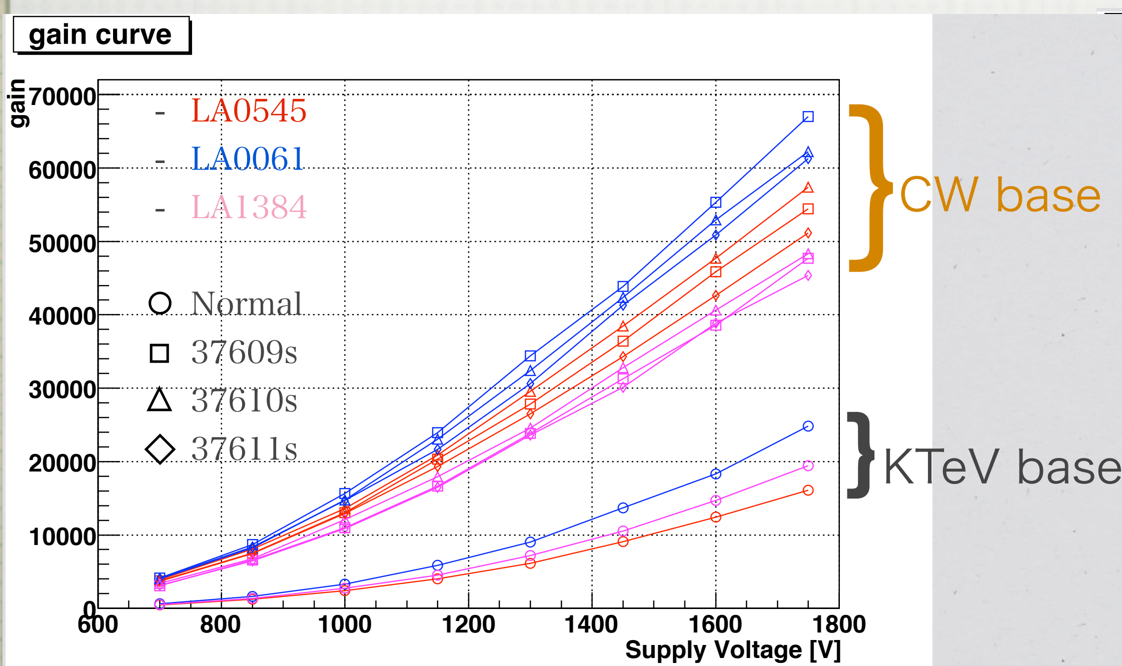
HV	μV_{p-p}	kHz
1000	10-20	130
1250	15-25	130
1500	20-30	135
1750	35-40	138

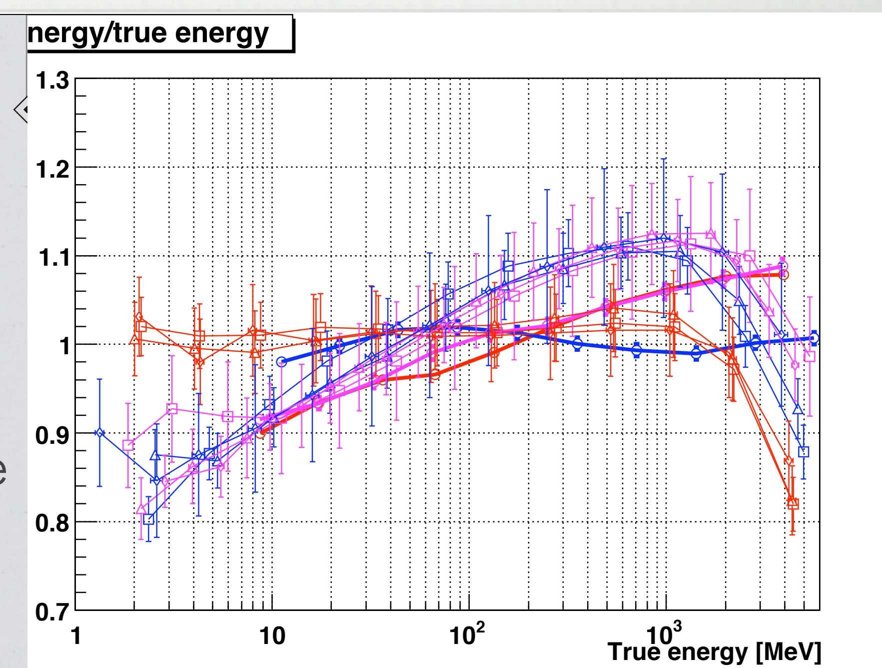
Ripple noise height & frequency vs. HV

negligible (～ 40keV)

Cockcroft-Walton Base

- Higher gain achieved (for 5cm crystals) with normal divider ratio
- Some non-linearity observed. Bad tubes?
  - (To control background, 5% non-linearity is good enough.)





One More Thing...

Decided The Name And Logo

- K°TO = KOTO = K0 at TOkai

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preliminary

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Summary

- First "close-to-final" beamline design
- Accumulating statistics and trying different packages (FLUKA, ...) for the beamline design
- Beam survey plan for
  - beam profile,
  - core neutron flux,
  - K_L flux,
  - halo neutron flux
- CsI shipping underway
- Designing and studying CW base, beam hole photon veto, DAQ, veto upgrade, ...

Backup Slides

Effect of K1.1 materials

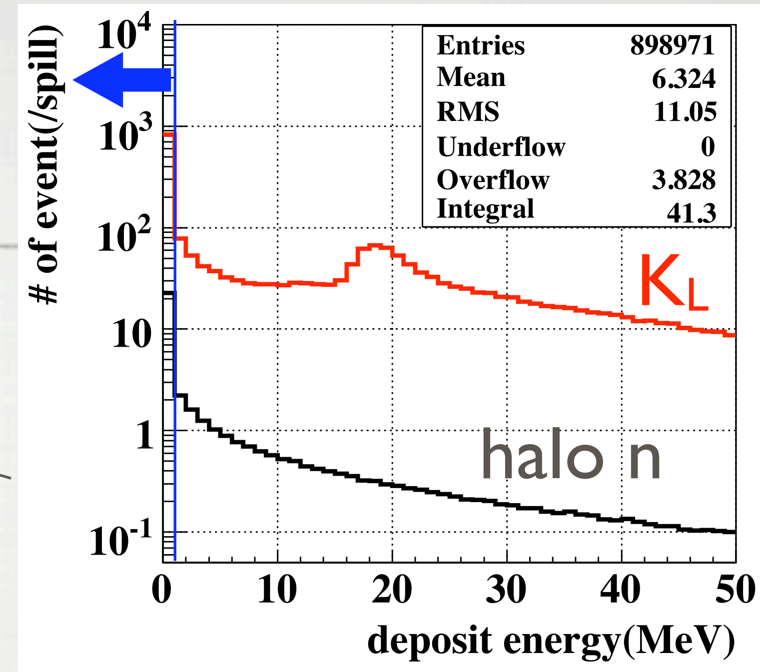
- At least, modification of K1.1 materials are needed to retain K_L yield
- "KL alone" is most preferable from the view point of halo neutron flux

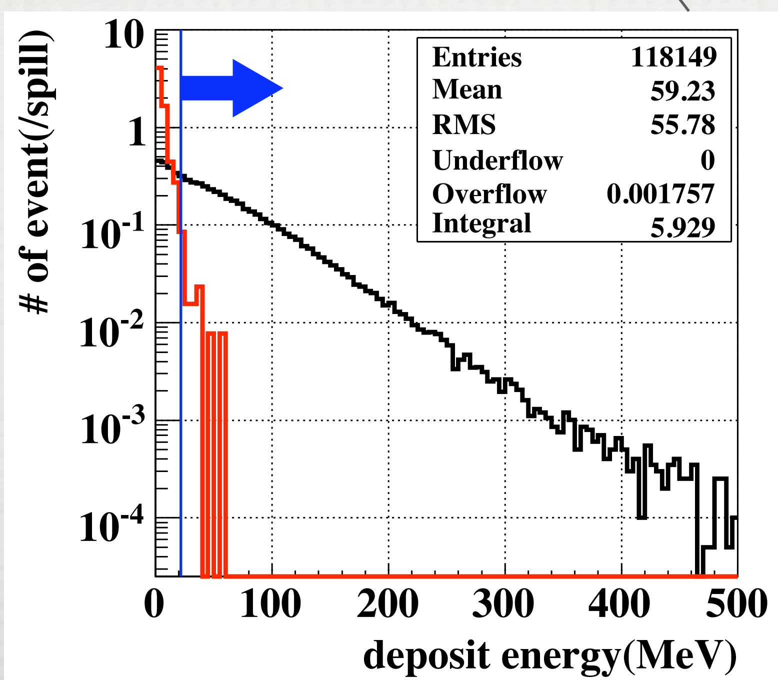
Table 3: Number of the core neutrons, halo neutorns and K_L's per spill (2×10^{14} protons) at the three different configurations.

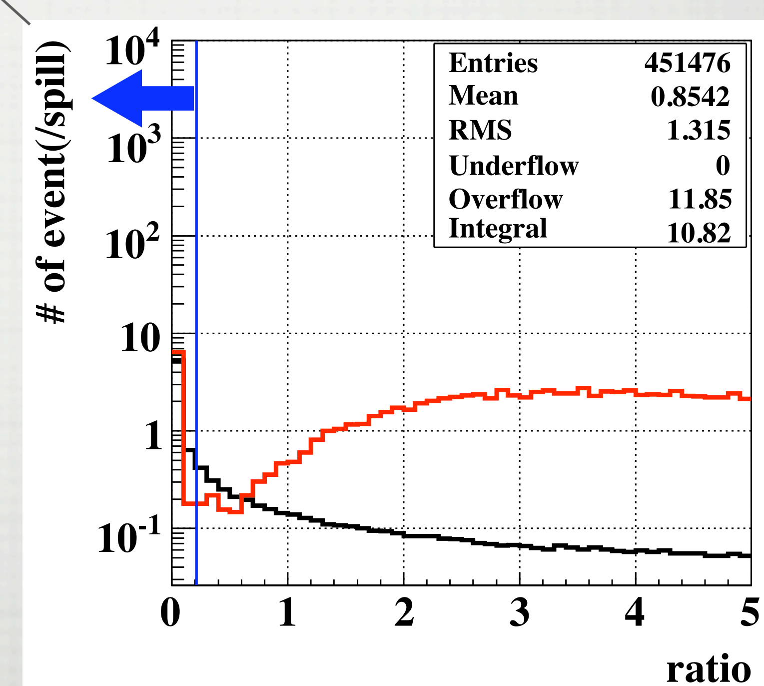
	Core neutron ($E_n > 100MeV$)	halo neutron ($R > 8cm$ at CsI Surface, $P_n > 2GeV/c$)	K_L (At the exit of beam line)
KL line alone	3.21×10^8	$(0.72 \pm 0.15) \times 10^4$	$(7.79 \pm 0.11) \times 10^6$
modified K1.1	3.15×10^8	$(1.17 \pm 0.19) \times 10^4$	$(7.77 \pm 0.11) \times 10^6$
original K1.1	1.53×10^8	$(1.38 \pm 0.20) \times 10^4$	$(4.56 \pm 0.08) \times 10^6$

Event Selection With Cerberus + CsI

1. Edep in EM module < 1MeV
2. E in CsI / E in hadron modules < 0.2
3. E in hadron modules > 20MeV







Effect Of Wider Hole

- No change in beam size