E14 (KOTO) Status

Taku Yamanaka / Osaka Univ.

Oct. 16, 2008
J-Parc PAC

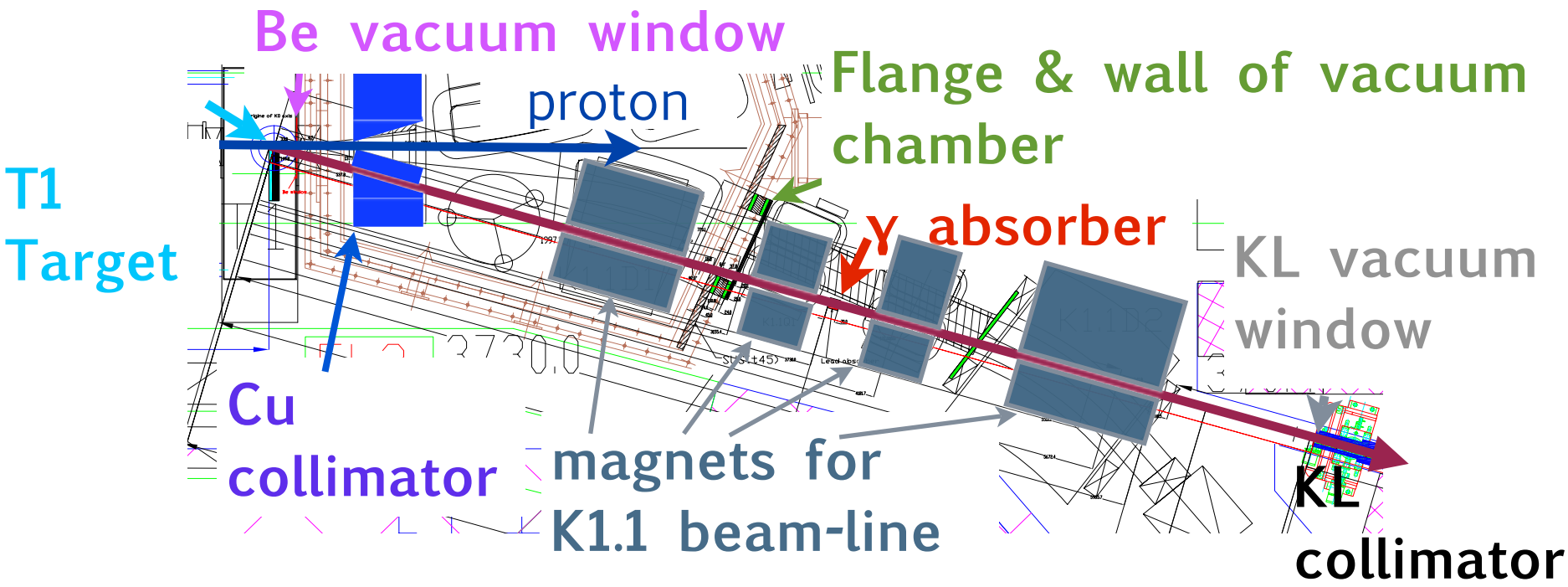
Outline

- Beamline
- Beam survey
- Detector status
  - CsI calorimeter
  - readout system
  - veto counters

Beamline

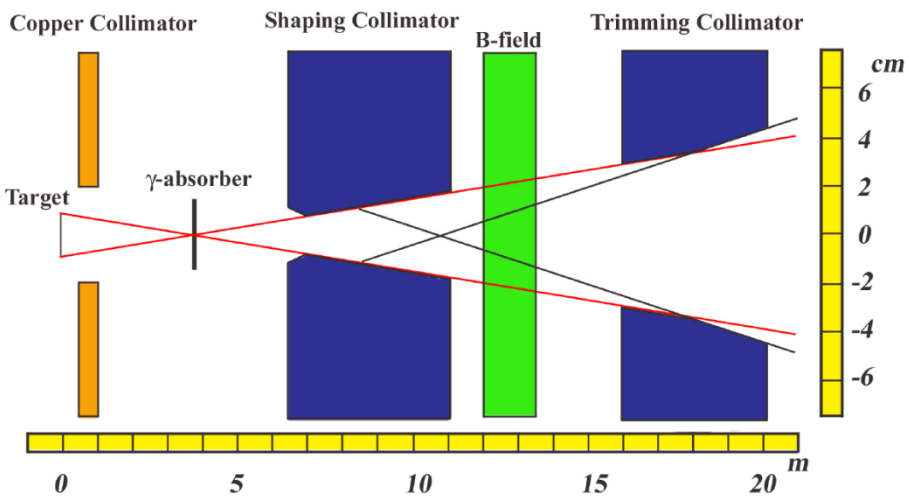
Beamline Monte Carlo

- Injected neutrons from the target (to study beam halo)
- Increased statistics
- Geant simulation with all the K1.1 magnets

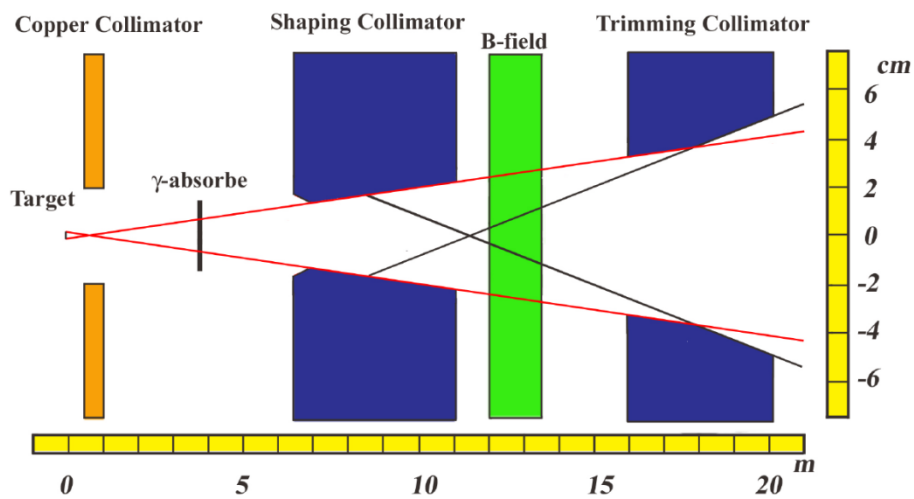


Collimators

- Optimized in horizontal and vertical directions separately
- Square beam at the CsI calorimeter



horizontal plane

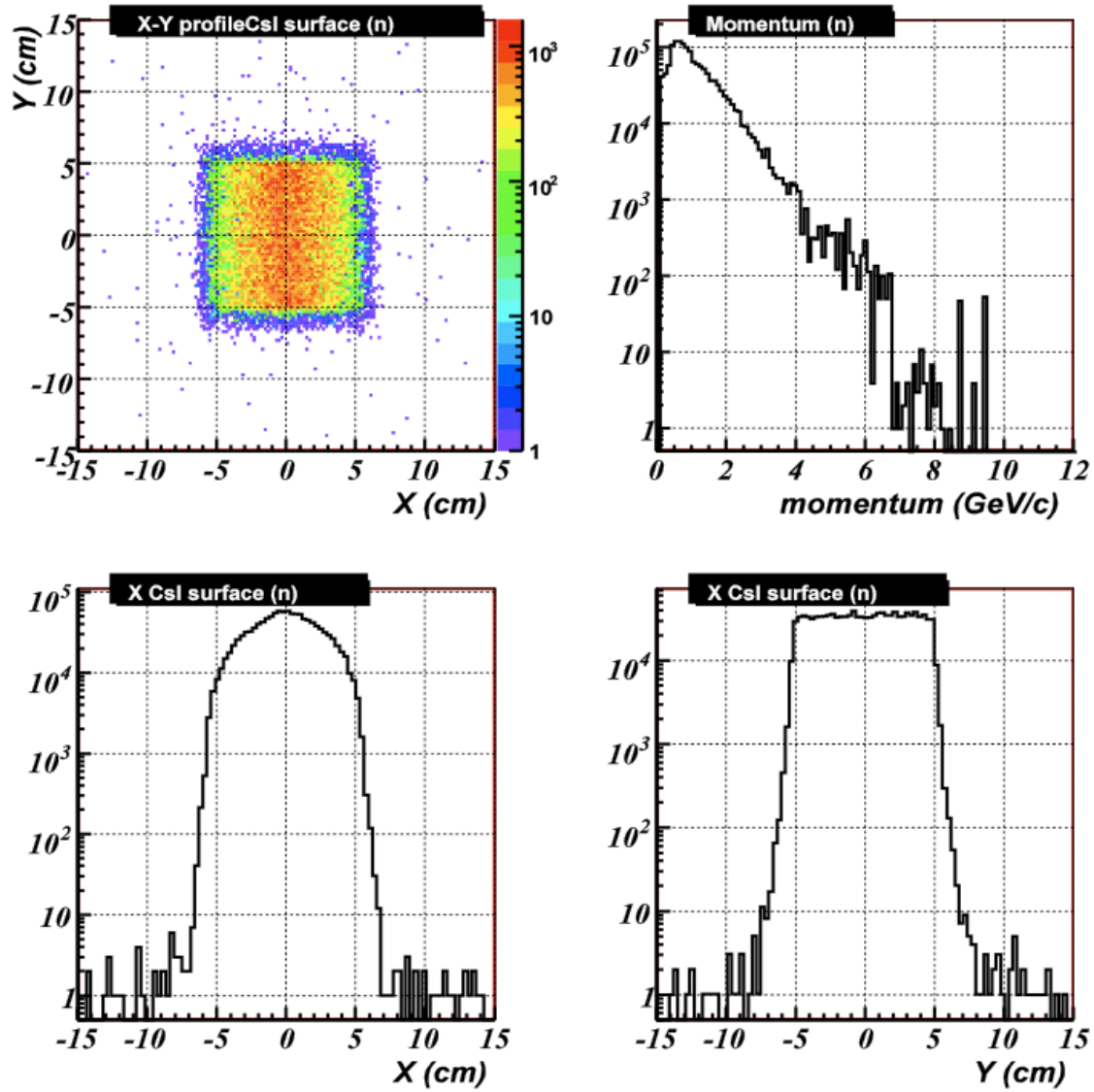


vertical plane

Beam profile

- Achieved sharp edges
- neutron: halo / core

  = 8.5 x 10^{-5}

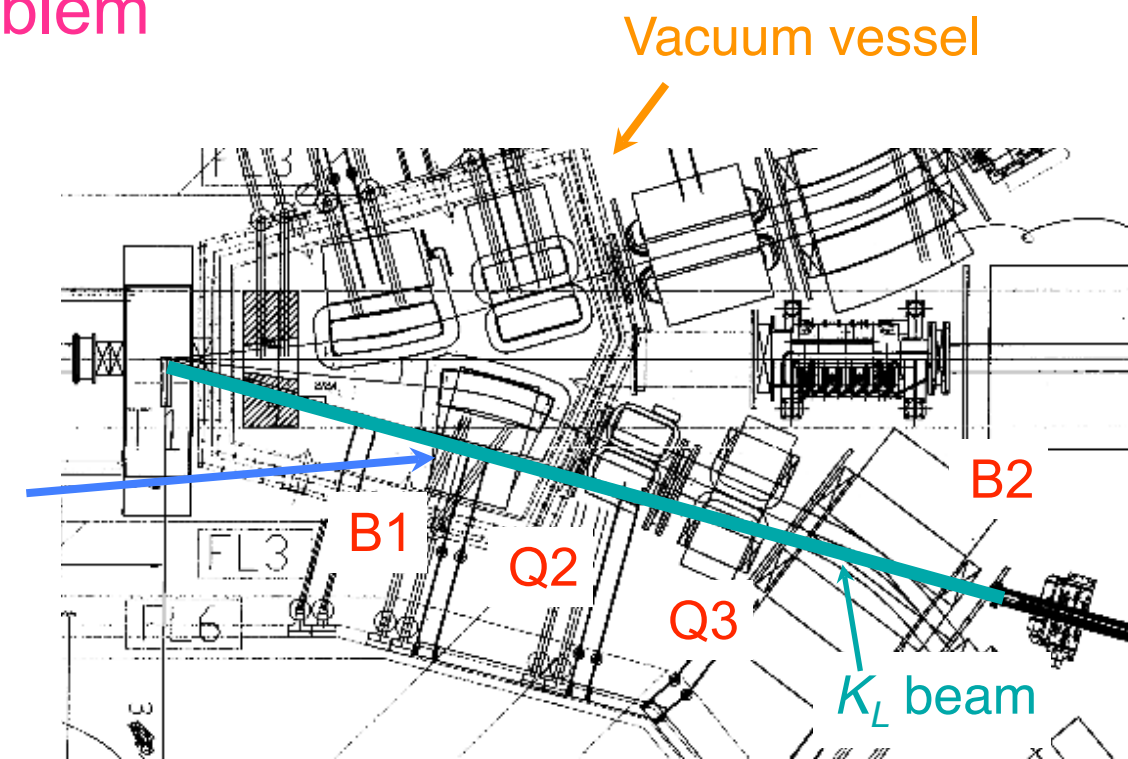


Comments on the K_L beam

- A 3-cm diameter or square hole in the B1 yoke does not disturb the B1 field quality : no problem
- To accommodate a similar size of the K_L beam path in B2, a special type of window-frame magnet will be required : no problem
- Q2 and Q3 will have such a yoke structure to avoid the K_L beam path : no problem

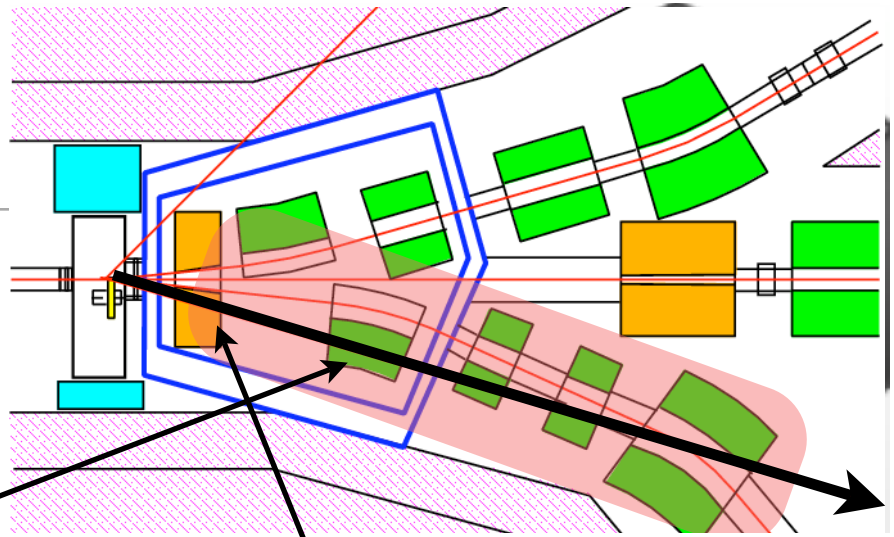
The installation position accuracy of B1 in the vacuum vessel will be a few 100 μm.

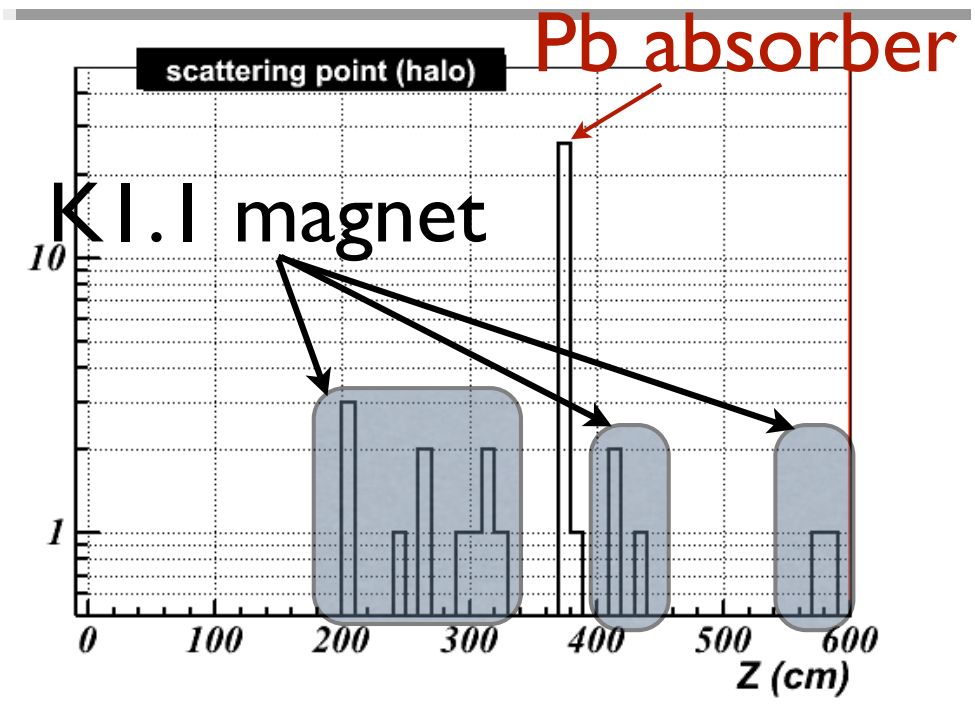
J. Imazato, 5th PAC (June, 2008)



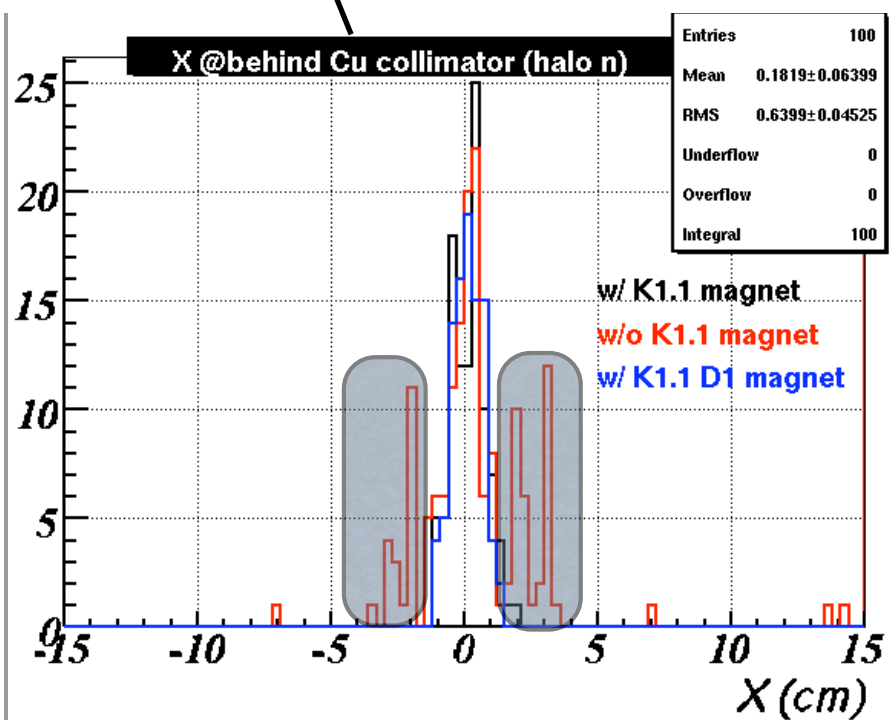
Effects of K1.1 elements

- Pb absorber (to absorb photons) is a major halo neutron source
- K1.1 D1 magnet acts as a shield





scattering points



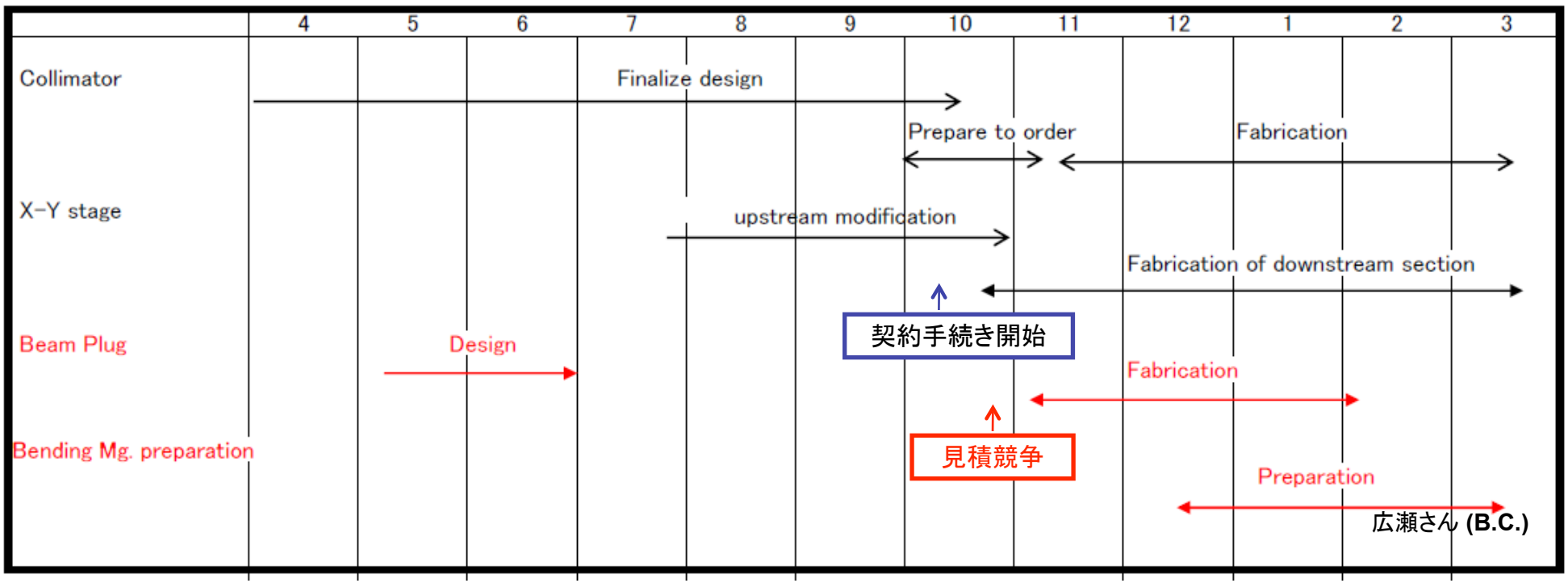
x at the Cu collimator

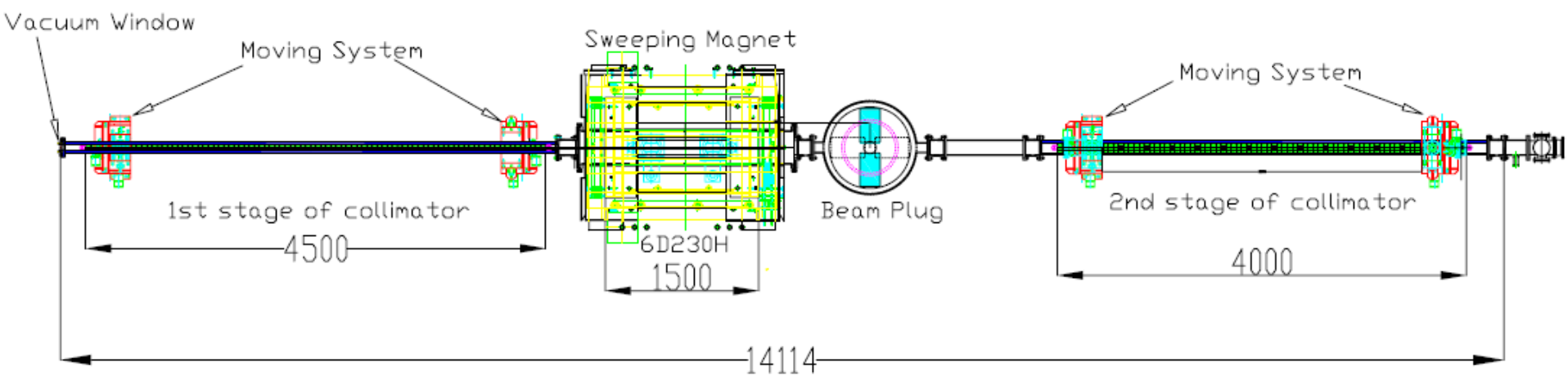
Effects of K1.1 materials

- neutron halo / core ratio is suppressed by ~30% with K1.1 materials

	With all K1.1 materials	Without K1.1 materials	With K1.1-D1 only
Core n	$4.7X10^{8}$	$5.0X10^{8}$	$4.8X10^{8}$
Halo n	$(4.0\pm0.4)X10^{4}$	$(6.3\pm0.5)X10^{4}$	$(3.8\pm0.4)X10^{4}$

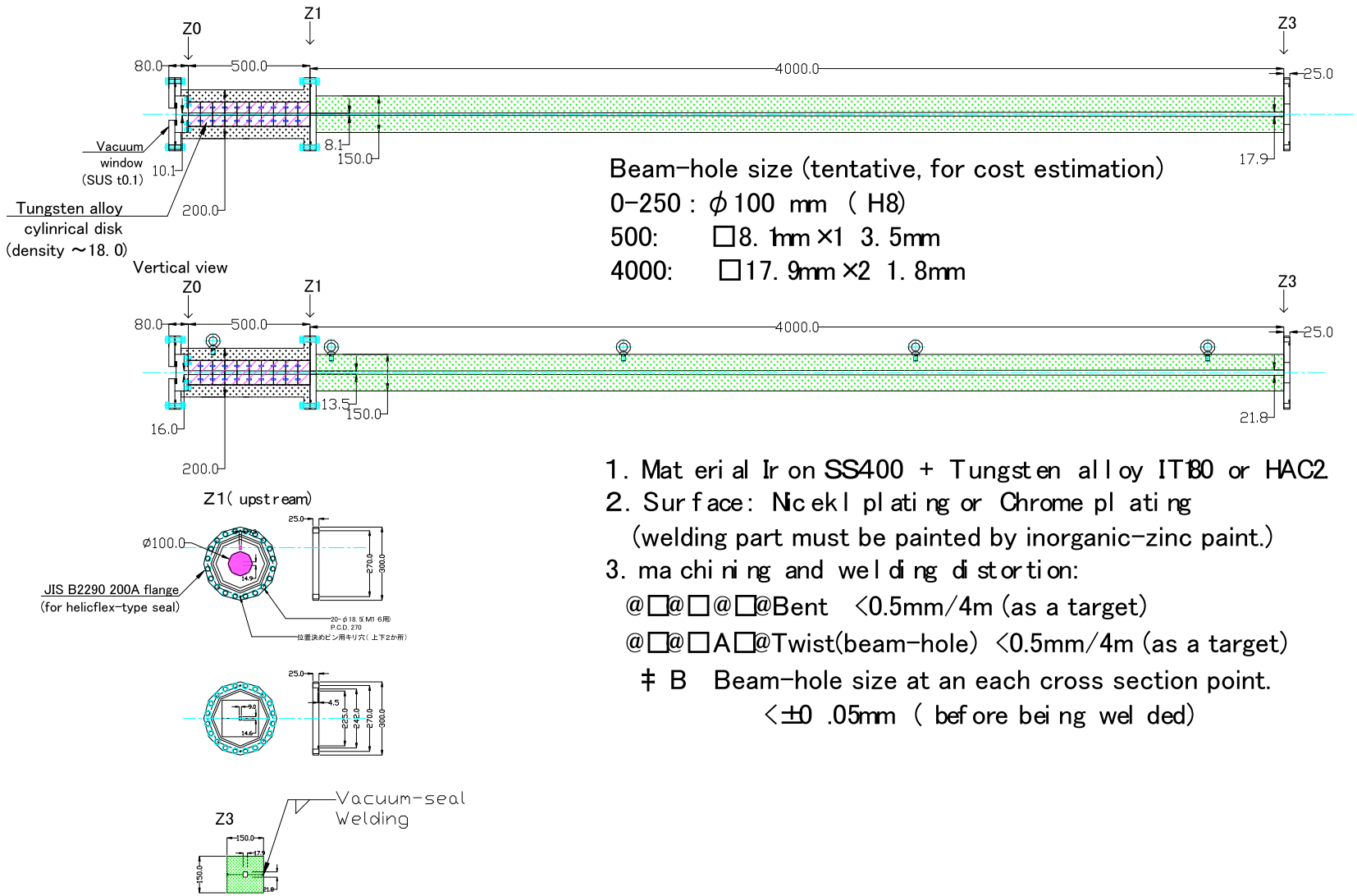
Schedule in FY2008





We have drawings to be used for discussion with engineers

Sample of KL-collimator drawing



Beam-hole size (tentative, for cost estimation)

0-250 : φ100 mm (H8)

500: □8.1mm×1 3.5mm

4000: □17.9mm×2 1.8mm

1. Material Iron SS400 + Tungsten alloy IT180 or HAC2
2. Surface: Nickel plating or Chrome plating
   (welding part must be painted by inorganic-zinc paint.)
3. machining and welding distortion:
   @□@□@□@Bent <0.5mm/4m (as a target)
   @□@□A□@Twist(beam-hole) <0.5mm/4m (as a target)
   ‡ B Beam-hole size at an each cross section point.
   <±0.05mm (before being welded)

Manufacturing collimators

- Similar to a collimator made for a neutron beamline
- Vacuum tight
- 3 months total
  - material production + annealing : 4 weeks
  - machining : 4 weeks
  - washing + Ni (or Cr) coating: 1 week
  - welding : <1 week

KL movable stage (upstream-half)

Beamline summary

- Same requests to K1.1 as before
  - 30 mm diameter holes for the KL beamline
  - <0.2 mm thick vacuum windows
- Fabrication of beamline components will be finished by Mar. 2009
- Installation by September 2009, for the beam survey

Review by FIFC

- Fabrication of main beam-line collimators is delayed.

  Final decision about the shape of the collimator hole (circular or rectangular) yet to be made.

  Will fix by the end of Oct.

  Discussion on fabrication detail has not yet started. No engineering drawings!

  Started

- FIFC recommend strongly that the group should fix the final design of the collimators, contact a manufacture and start the fabrication as soon as possible.

- In order to complete the construction of KL beam line in the first half of JFY 2009 on time, the experimental group and facility construction team should have close contact and start preparation of beam line elements needed in the early days of the construction.

  Yes

- FIFC recommends the experimental team to ask for some support by the mechanical engineering group to IPNS.

  Yes

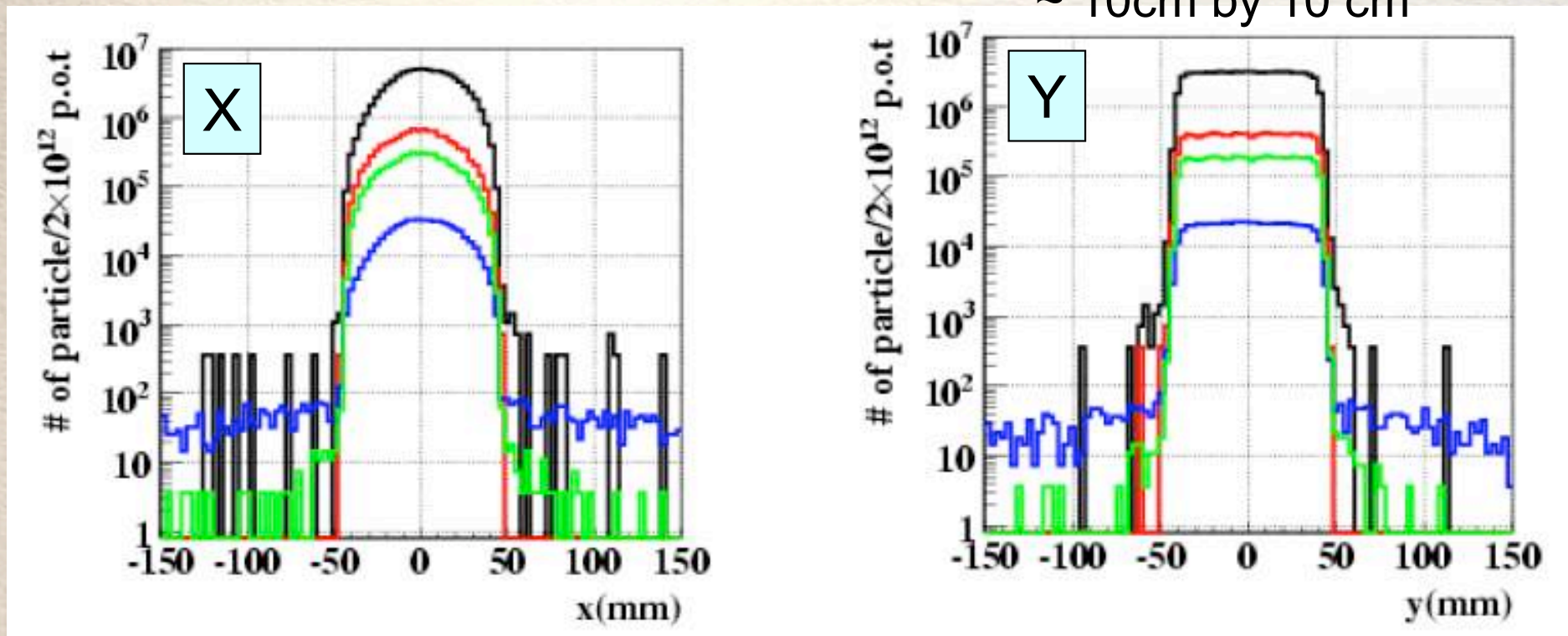
Beam survey

Beam survey in 2009

- The purpose is to measure:
  - K_L yield and energy spectrum [Priority 1]
    - x3 difference in the yield between FLUKA, Geant3, and Geant4
  - Core neutron yield [Basic information]
    - to confirm n/K ratio (x2 difference between MC packages)
  - Halo neutron yield [optional for 2009]
- Conditions:
  - 1% of full intensity (a few kW)
  - no K1.1 components are required

Profile at the Exit of Beam-line

Beam size @ meas. plane
~ 10cm by 10 cm



Black (γ) and red (n) : w/o absorber
Blue (γ) and green (n) : w/ 7cm absorber

Profile Counter

- Start consideration with counters used in E391a survey

Charged → • 4x5x1cm scinti. slab

Neutron → • 4x5x6cm scinti. block

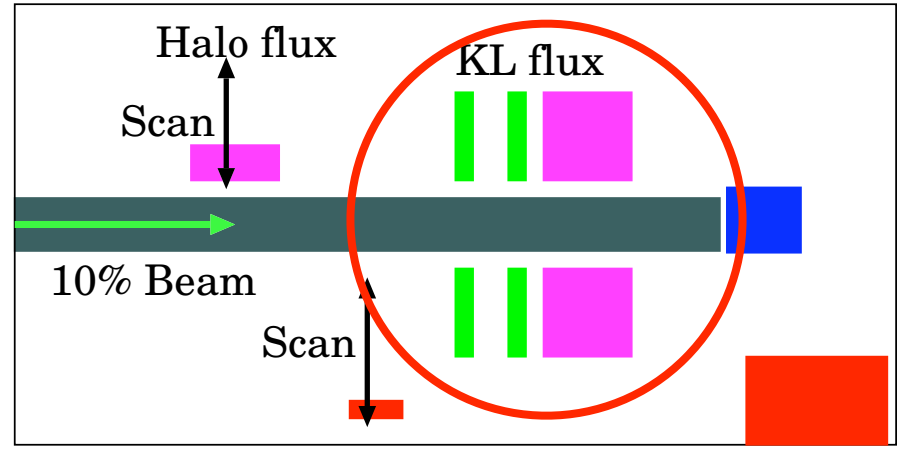
Photon → • 4x5x9cm sandwich
(1mm Pb+5mm scinti, 15 layers)

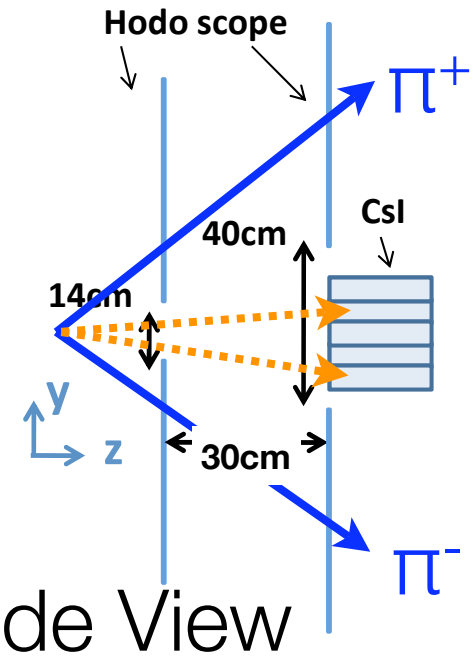
Rate @ 1% of FULL	Scinti.slab (>0.5MeV)	Scinti.block (>7.3MeV)	Sandwich (>8.8MeV)
with absorber	50 kHz	220 kHz	350 kHz
w/o absorber	800 kHz	3 MHz	12 MHz

- Should improve rate capability and segmentation
- prefer lower intensity

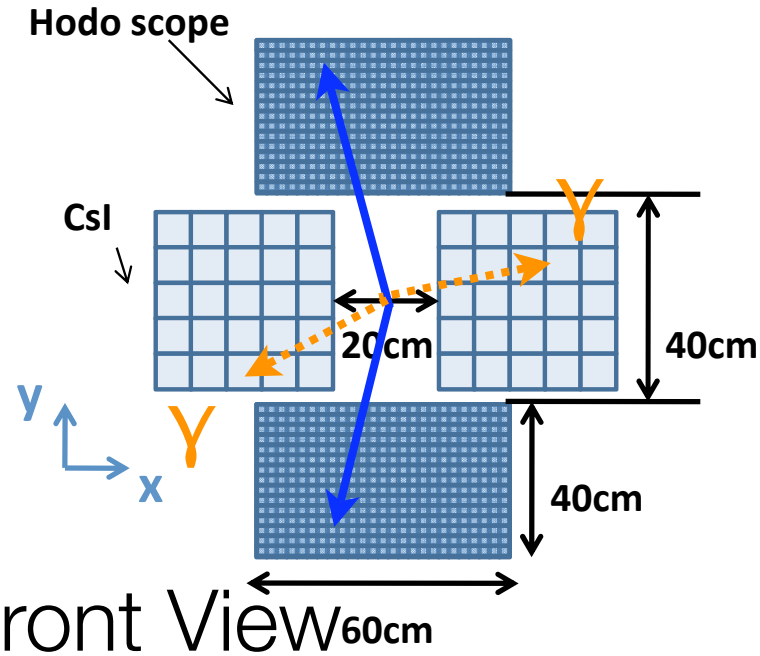
4. K_L Flux Measurement

- Use $K_L \rightarrow \pi^+\pi^-\pi^0$
- scintillator + 1cm pitch wave length shifting fibers
- 25x2 E391a CsI crystals
- No magnets





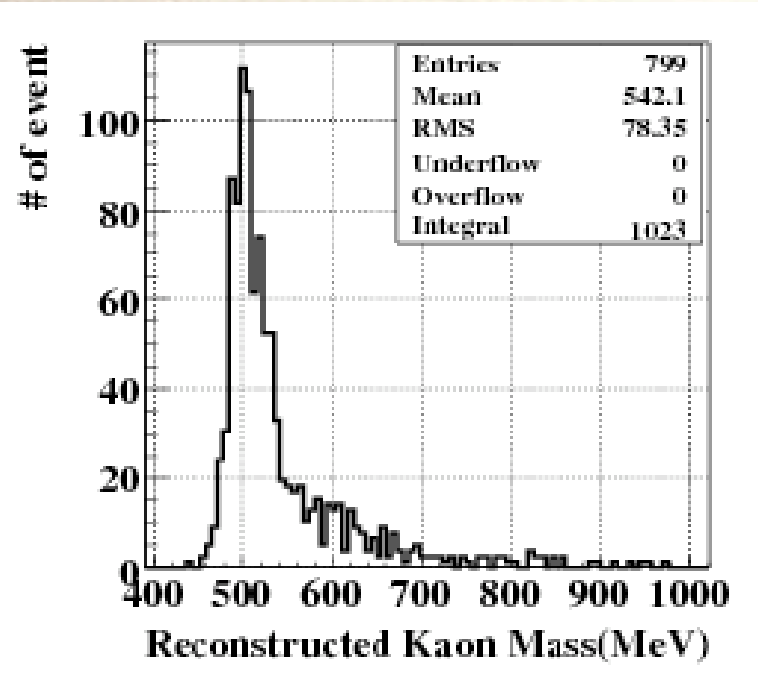
Side View



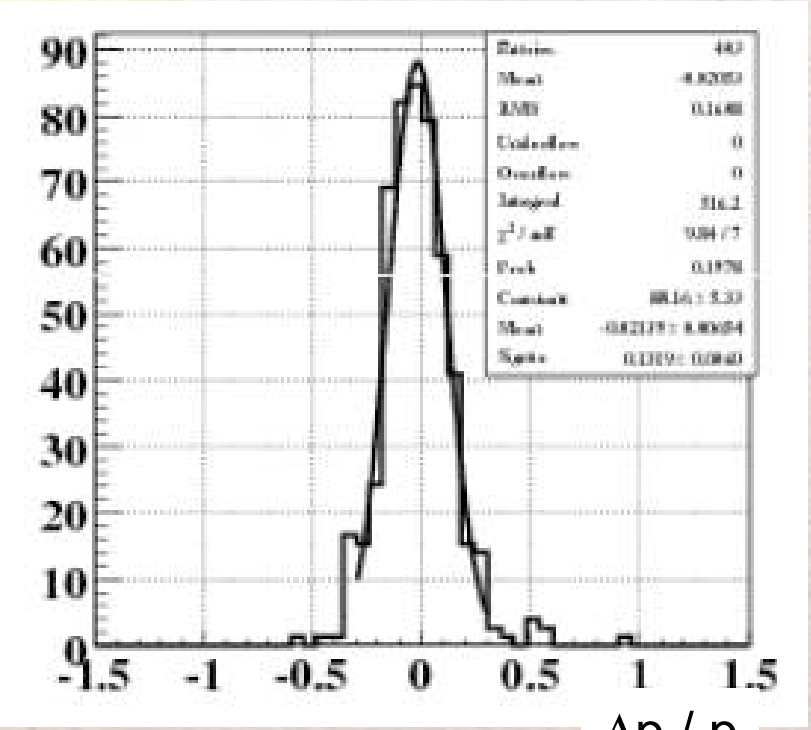
Front View

Expected Performance

Reconstructed K_L mass



K_L Momentum resolution:
{P(Recons)-P(True)}/P(True)



Expected Performance

1% of FULL INTENSITY

- Trigger
  - >=1 hit in each bank
  - Eγ,thr.=5MeV
- Event / day

	Geom	Good recons	KL mass cut
KL→$\pi^+\pi^-\pi^0$	~1500	~1250	~500
KL→$\pi^0\pi^0\pi^0$	16	4	N/A

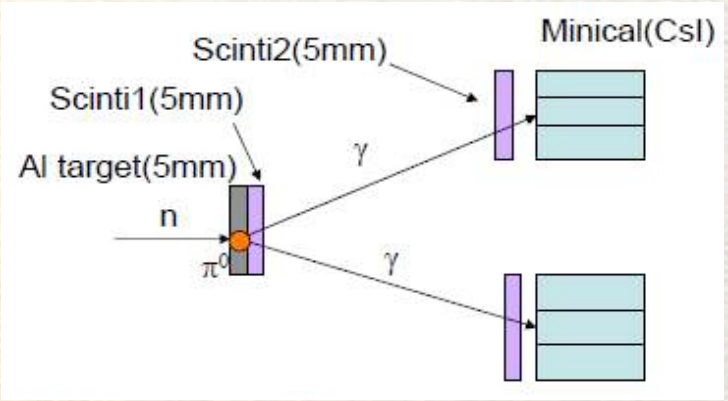
Source	Rate (Hz)
KL→$\pi^+\pi^-\pi^0$	2.3
KL→$\pi e\nu$	0.8
KL→$\pi\mu\nu$	0.2
KL→$\pi^0\pi^0\pi^0$	0.2
Core n	
He bag	0.25
Air(*)	2.9

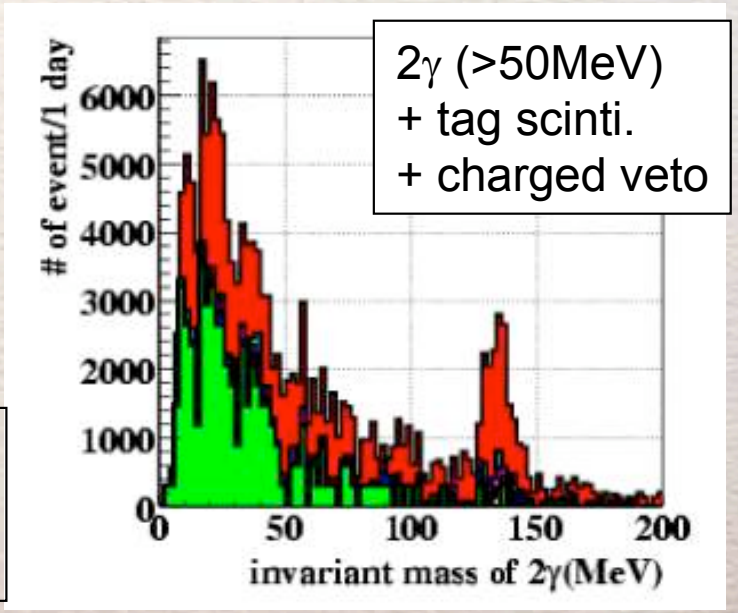
(*) Among 100 triggers, no events left after all cuts

10kHz singles rate, 8% loss if we cut on extra hits

Calibration of mini-calorimeter

- Cosmic ray
- "Al plate run"
  - Al plate in the core
    - On moving stage for profile scan
  - Reconstruct π^0 mass with given Z position

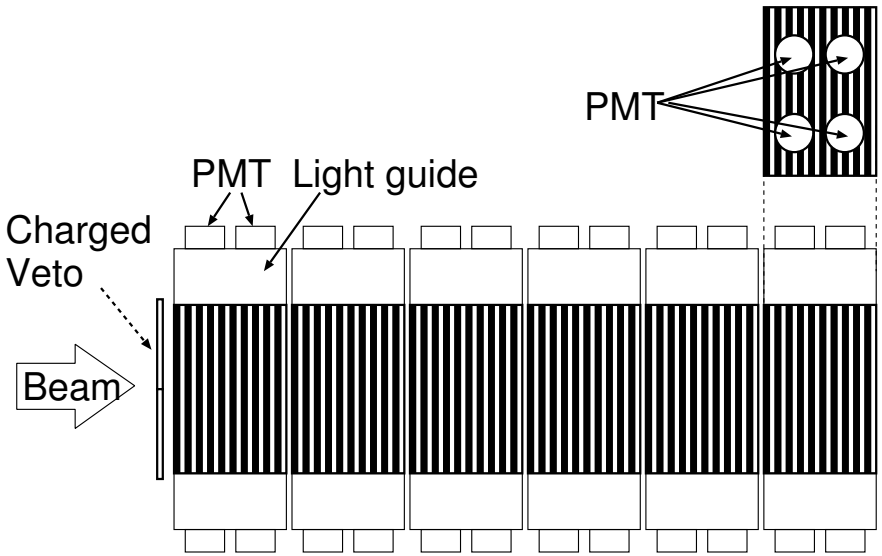




Red : core (π^0)
Green : core (no π^0)
Others: K decay

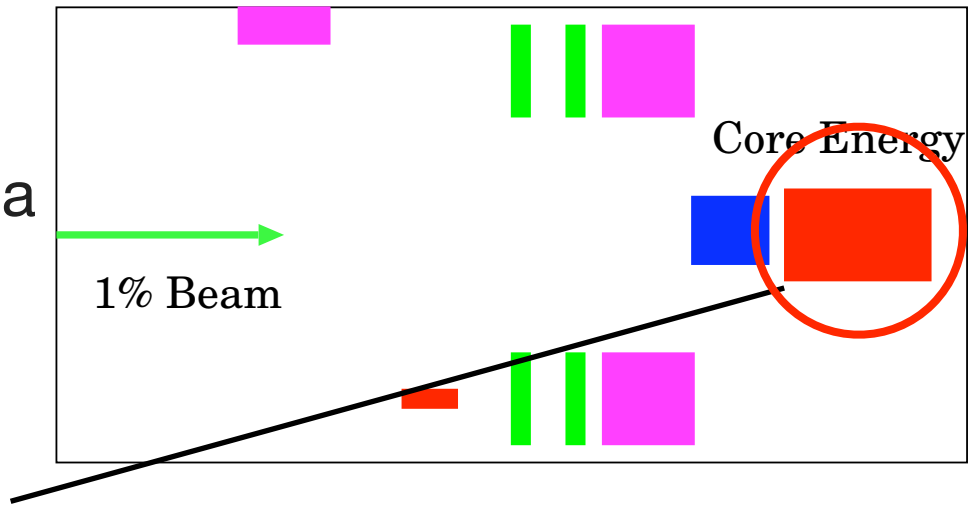
Core neutron flux and spectrum Measurement

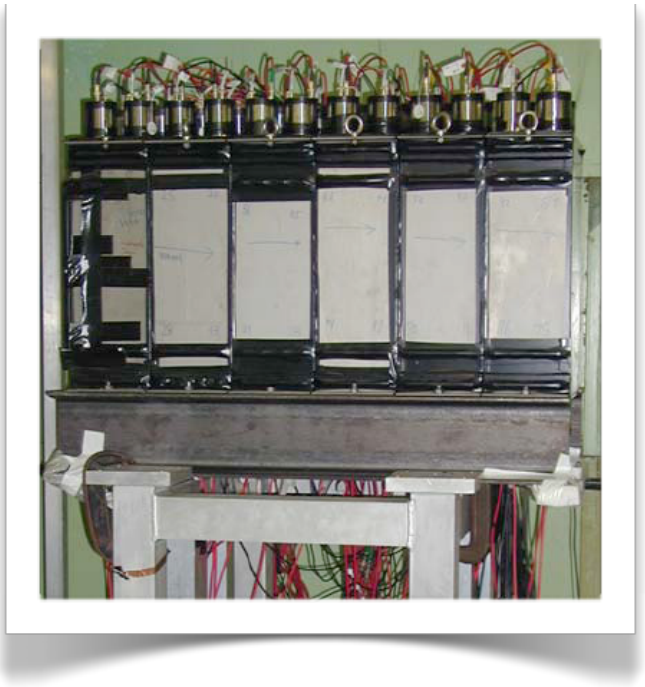
- Hadron calorimeter ("Cerberus") used for E391a



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

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





Core Neutron Measurement

- The issue is
  its counting rate
  (in MHz)

Upper : w/ 7cm absorber
Lower : w/o absorber

Will apply much higher threshold

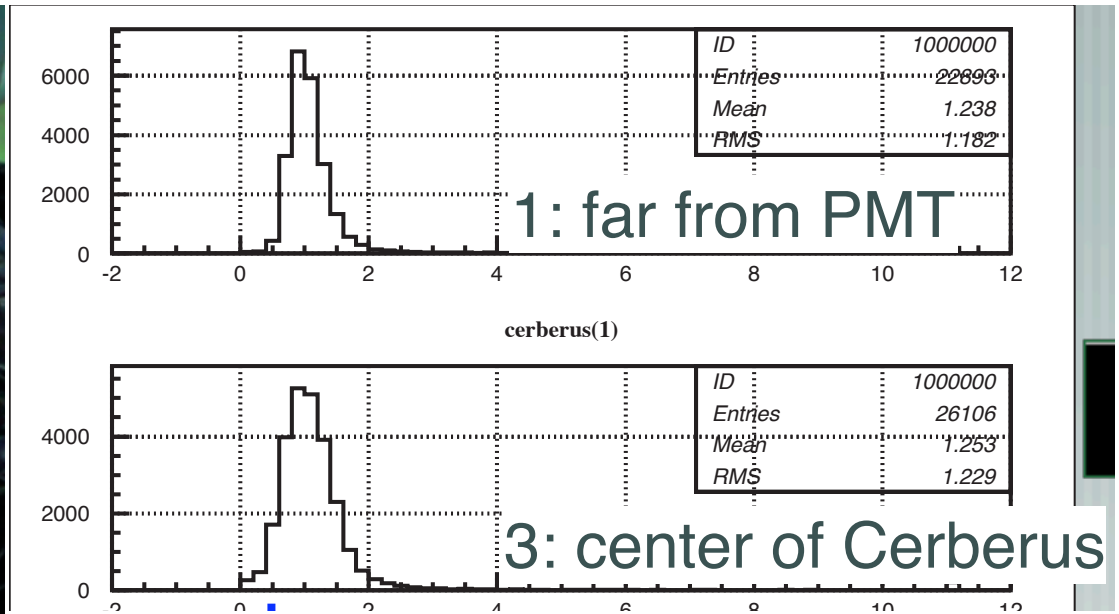
threshold	1MeV	5MeV	10MeV
EM	4.6	3.6	3
Had0	4	3	2.4
Had1	2.4	1.7	1.3
Had2	1.3	0.9	0.7
Had3	0.6	0.4	0.3
Had4	0.3	0.2	0.1

	1MeV	5MeV	10MeV
EM	91.6	44.2	27.3
Had0	13.5	6.7	4.9
Had1	5.1	3.3	2.5
Had2	2.52	1.75	1.3
Had3	1.2	0.83	0.63
Had4	0.6	0.4	0.3

Prefer lower intensity
(0.1% of FULL)

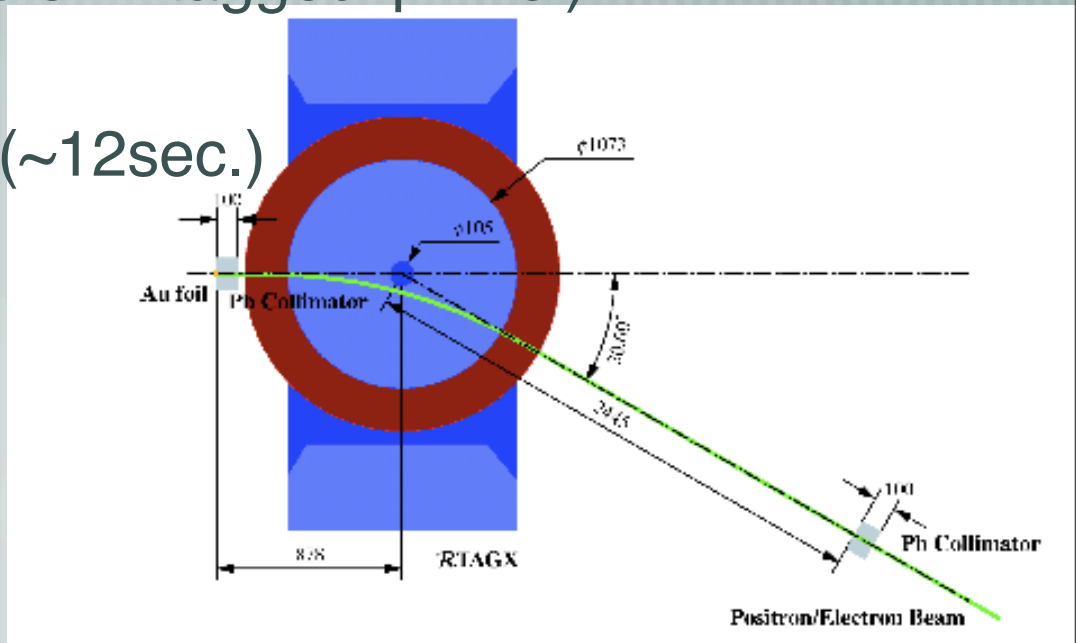
Cerberus - core neutron detector

- Tested all the phototubes
- Testing with cosmic rays



Beam test @Tohoku Univ.

- Dec.8-12 @Tohoku Univ. LNS (Sendai)
  - 2days: Cerberus, 3days: CC03
- electron beam information
  - (tertiary beam: 1.2GeV/c e^- → tagged γ → e^-)
  - energy: 100-800MeV/c
  - rate: ＜3000events/spill(~12sec.)
  - size: FWHM ~50mmϕ
  - dE/E ~1% (>200MeV/c)



4. Halo Neutron measurement

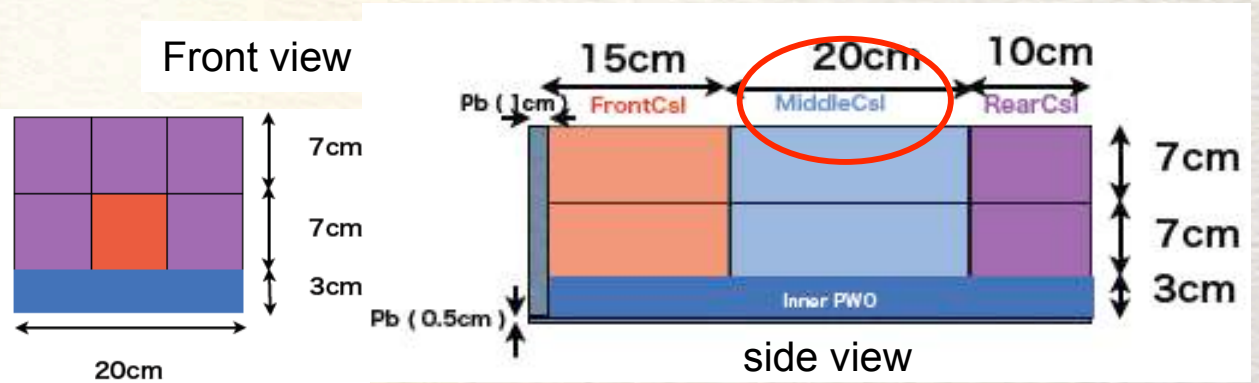
- Feasibility depends on beam quality
- Bothersome in preparation and analysis
  - Need subtraction of K decay contribution
  - Need beam pipe
    to avoid core n interaction

Expected event rate after cuts	
halo n (vacuum)	0.53
core n (vacuum)	0.08
core n in air	6.9
core n in He bag	1.1

→Anyway, we will prepare for it

Method

- Detection in "middle"



- Reject KL originated events

- γ rejection cut
  - 1: energy deposit in Front =0
  - 2: E_ratio_Inner<0.05
  - 3: Middle E>50MeV
  - 4: E_ratio_Rear>0.1||MiddleE<300MeV

Stat.	#/spill	#/day
Halo n	0.49	13000
K_L origin	0.125	3250

1% of FULL

Summary

Desired operation plan

1. 0.1% of FULL for 1 week
   - Alignment, Core measurement
2. 1% of FULL (as will be) for 1 week
   - KL measurement

Break here is preferable

3. Additional 1% of FULL for 1-2 weeks
   - KL measurement, Halo measurement

“FIFC’s view”

- “No redundancy measurement”

  Kinematics just determined by all the measurements other than KL mass constraint

  Can check tracks with pi0 vertex

  Very little tolerance for background hit. Stability against background is not clear.

  See background study results

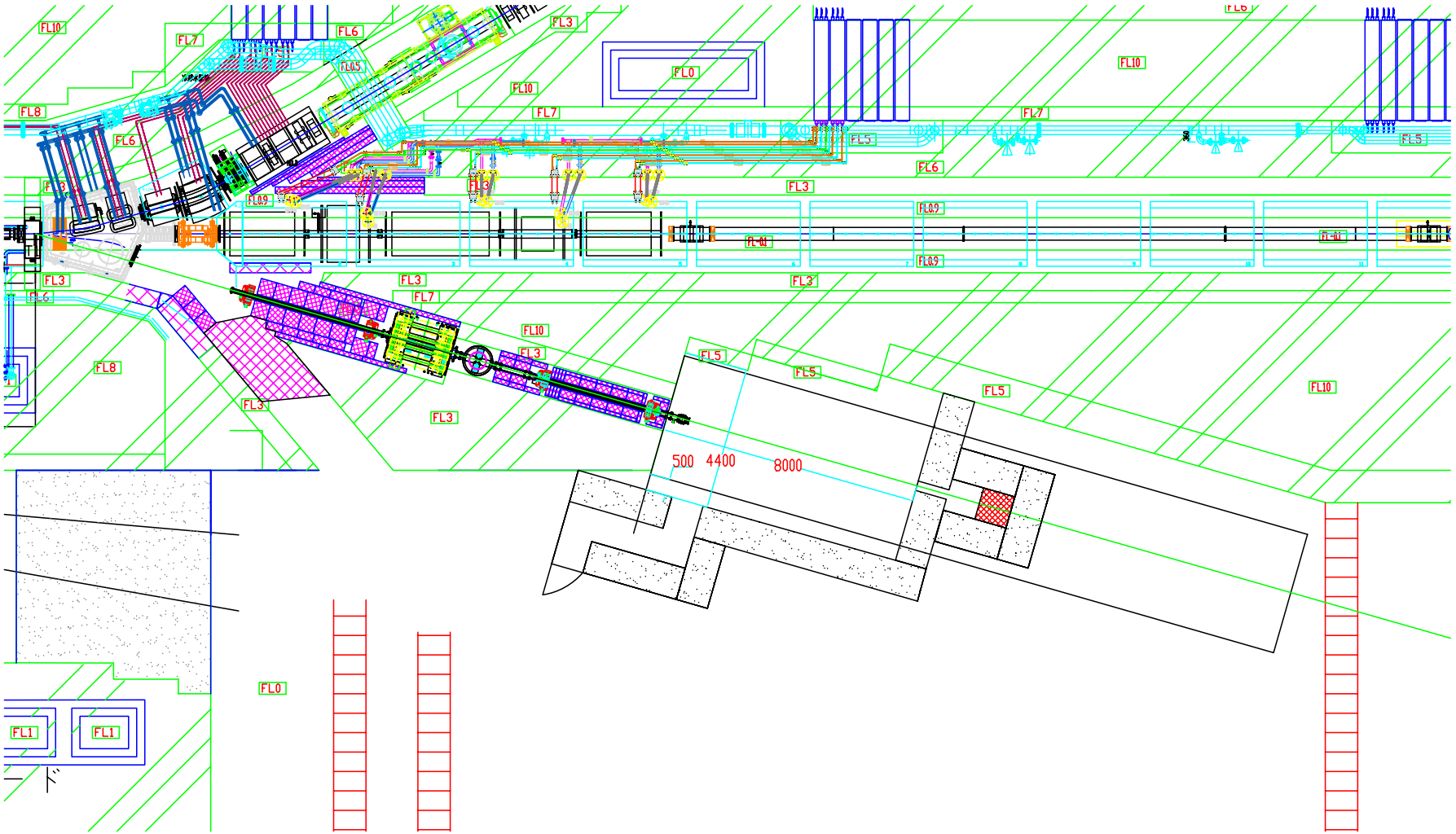
- Independent check/ measurement of acceptance/ efficiency seems important.

  Will think about it.

- Stability /monitor of primary beam condition (intensity, position, time structure …) is essential. Not yet been investigated fully.

  Beam monitor exists (Tanaka)

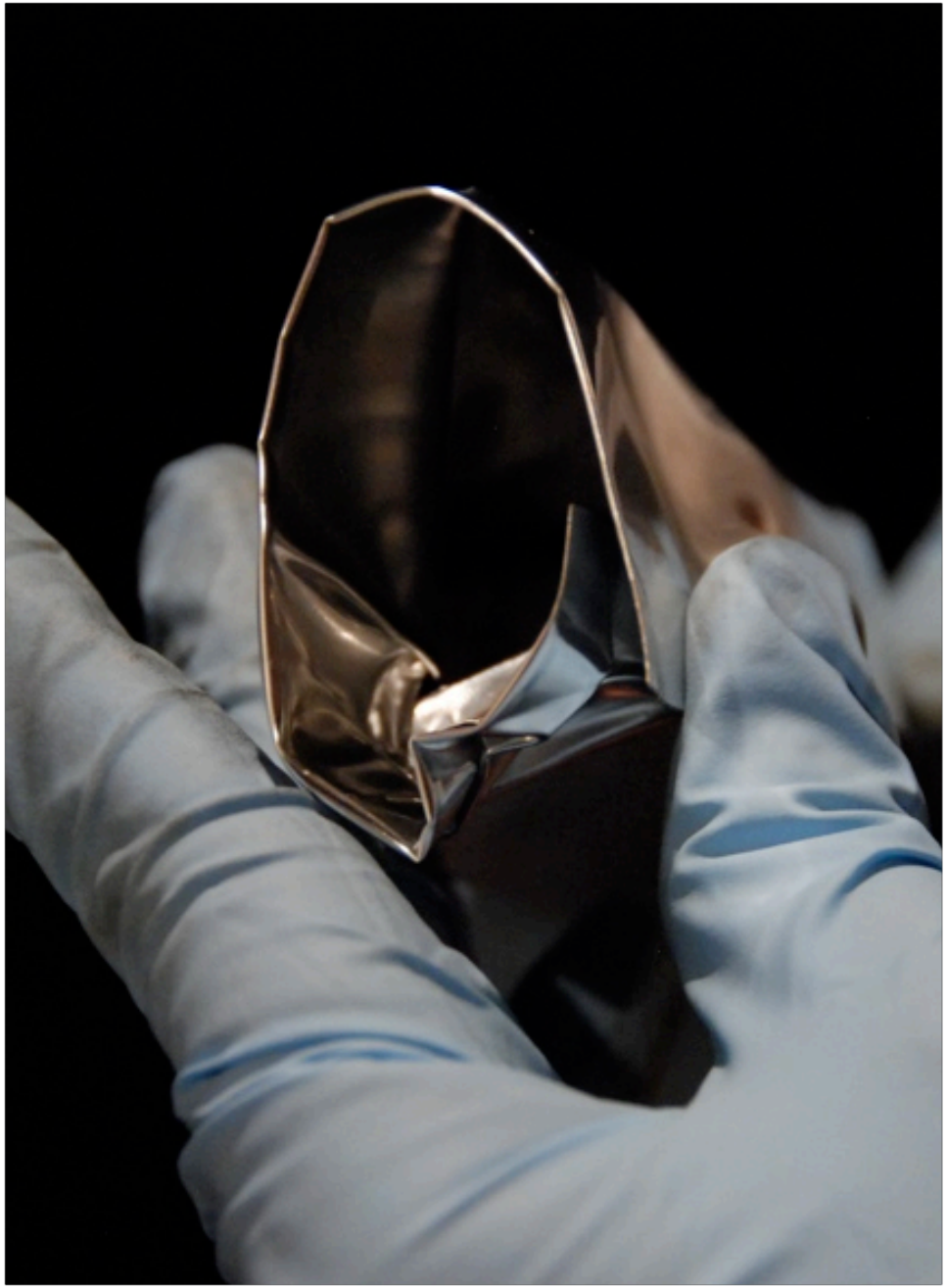
Drawing submitted for rad safety calculation



Detector Preparation Status

CsI Electromagnetic Calorimeter

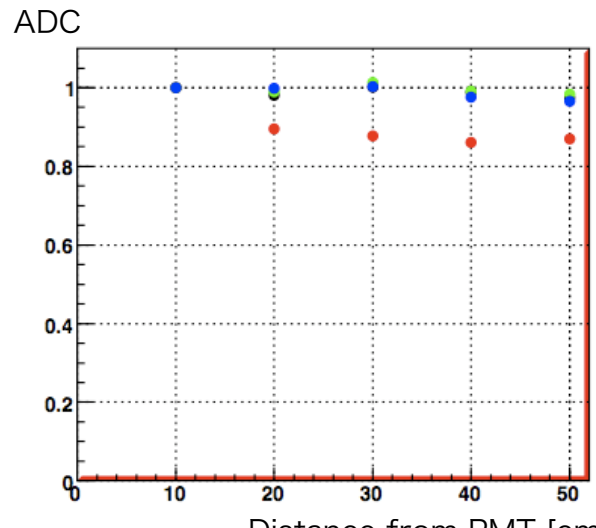
- Unstacking: 5/8 done
- Unstacking and shipping ~400 crystals/month
- All the crystals will be unstacked in Dec. 2008.

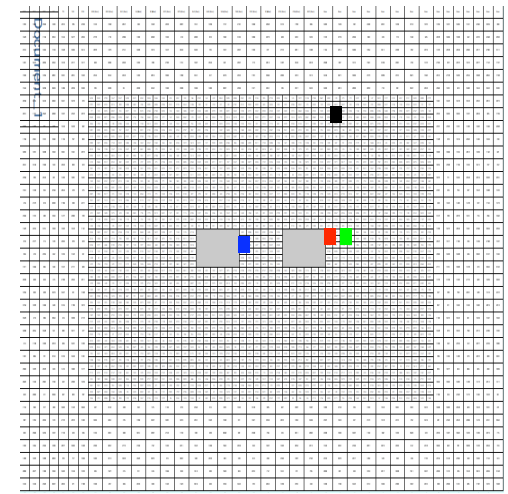


wrap excessive ESD bag, and insert the glass plate into rubber groove on Al angle

CsI light uniformity tests

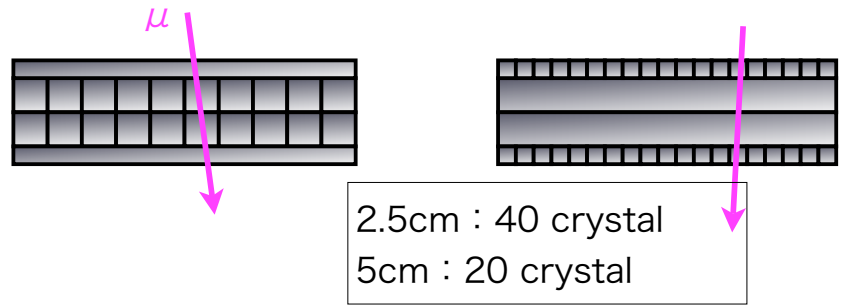
- Light uniformity test with source: Found 1 yellow crystal with 15% drop, but others <5%

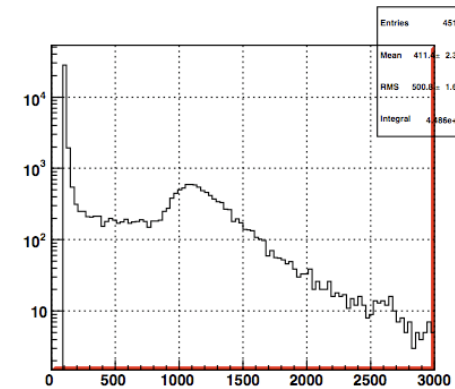




- Will test all crystals with cosmic rays (~120 crystals / day)

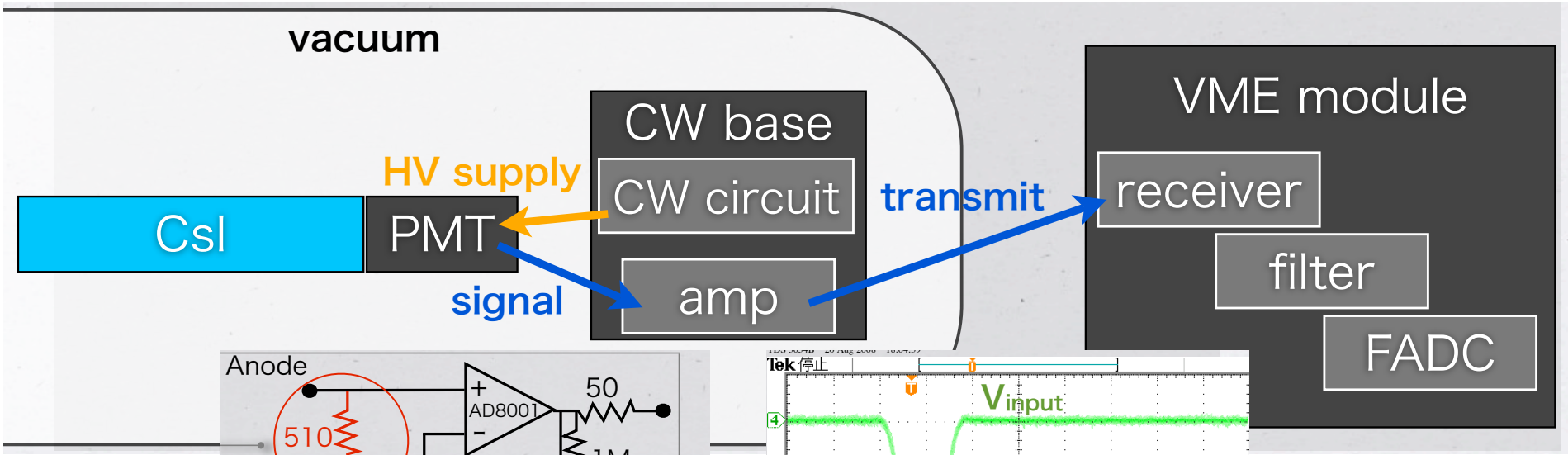
●Test by cosmic ray

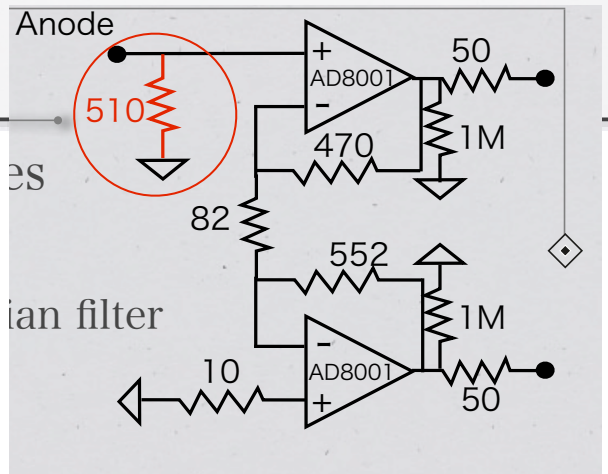


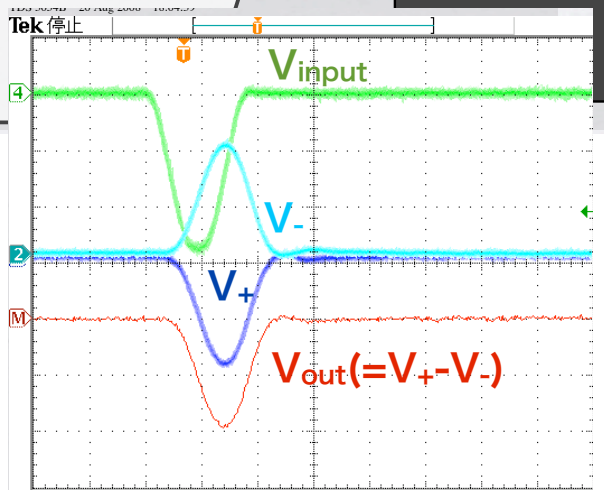


Readout system

- Low power Cockcroft-Walton base for CsI phototubes in vacuum + preamp to send differential analog signal
- Energy range: 1MeV ~ 1.3GeV; ~ 1mV/MeV

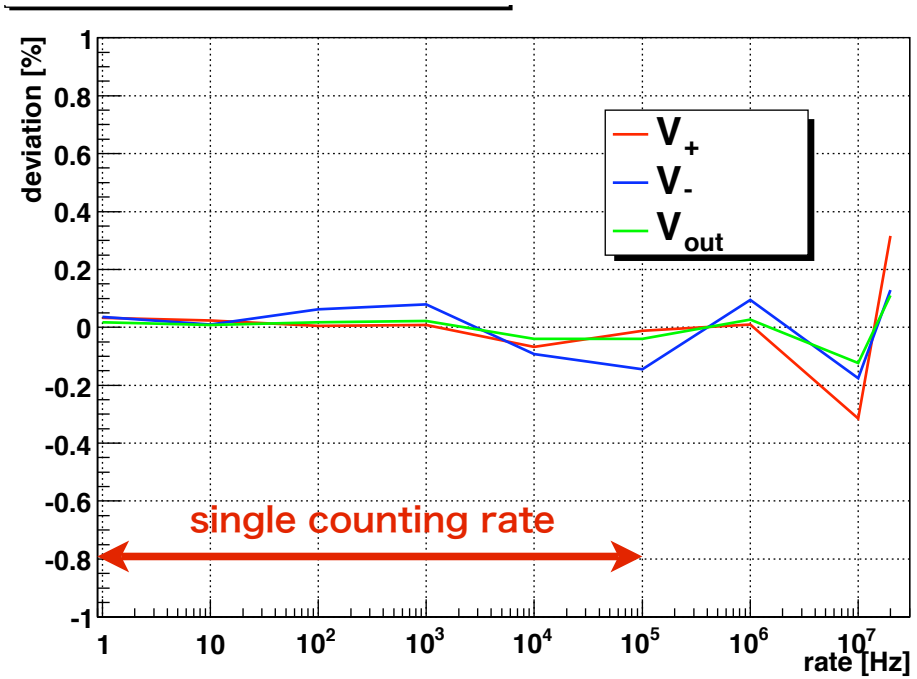


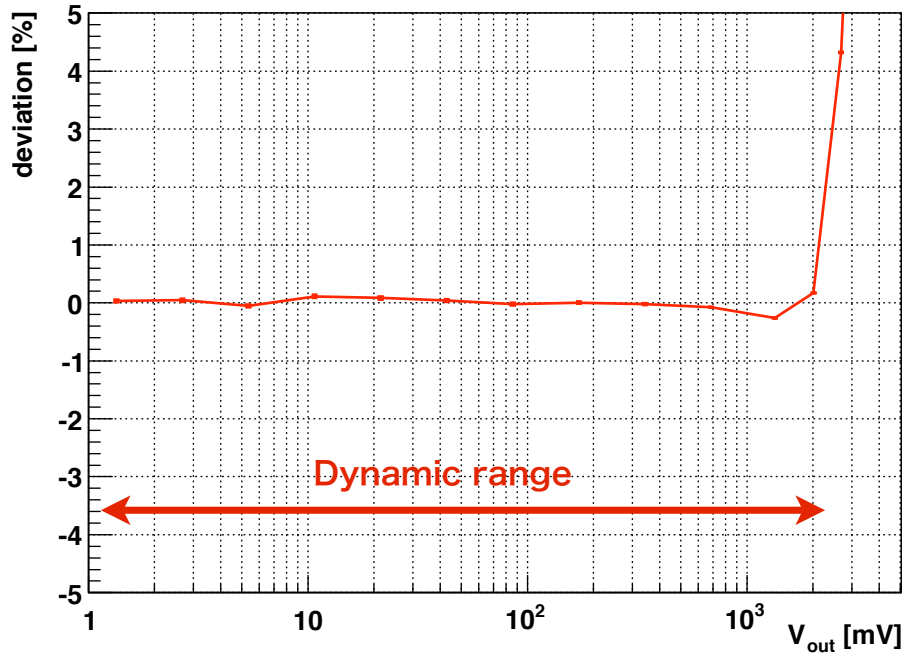




Performance of the CW base + preamp

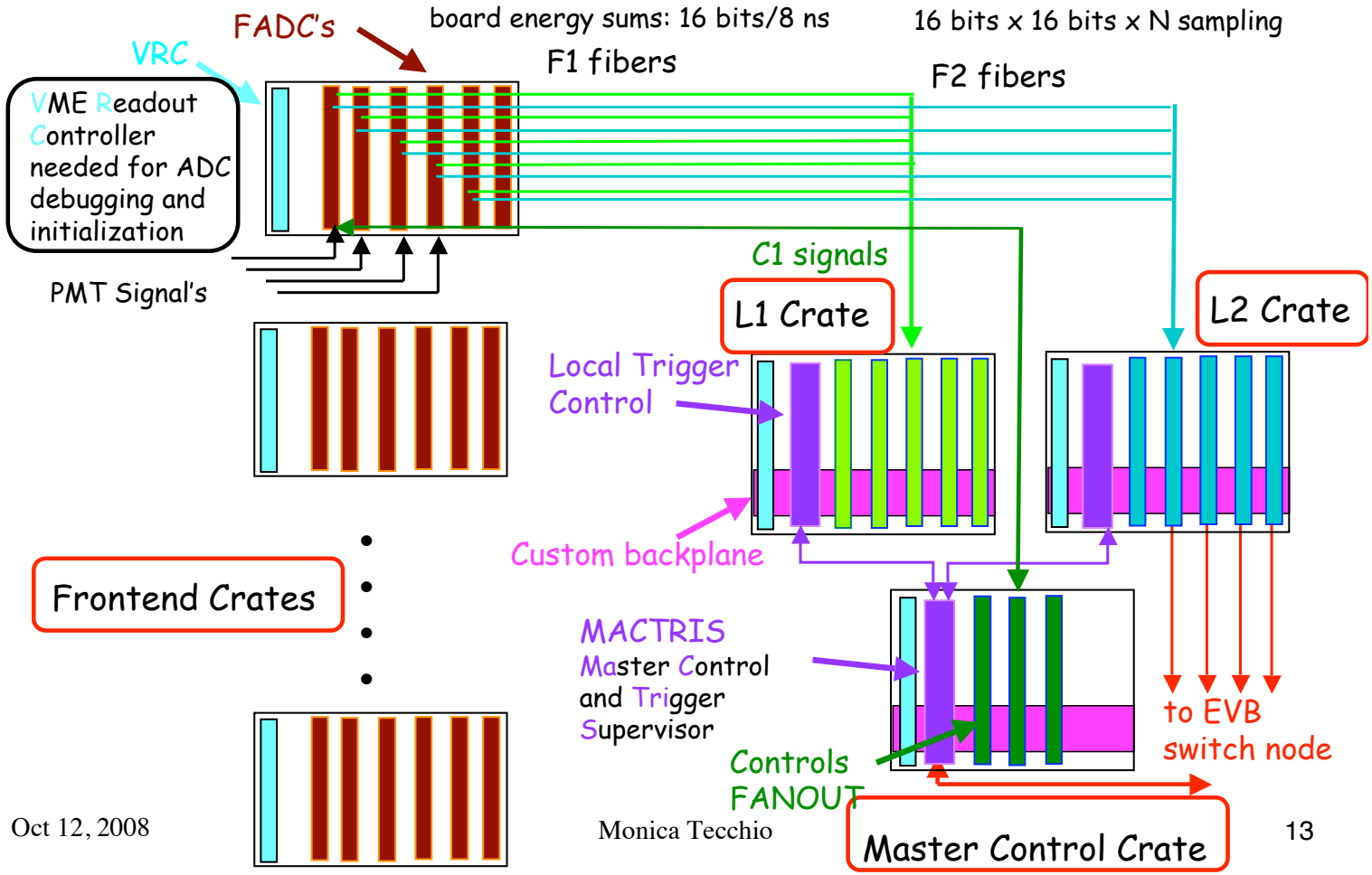
- Rate dependence < 0.15% up to $2V_{pp}$ x 100kHz
- Pulse linearity < 0.2% up to 1.3GeV





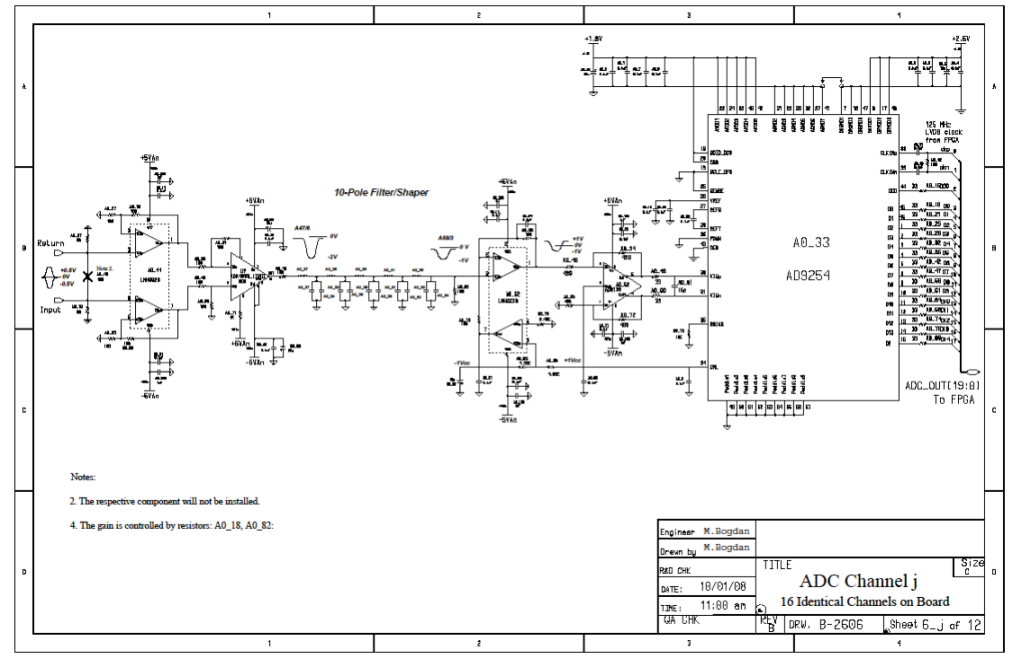
FADC / Trigger / DAQ system

- Simplified design. FADC, trigger crates connected with 3Gbps optical fiber



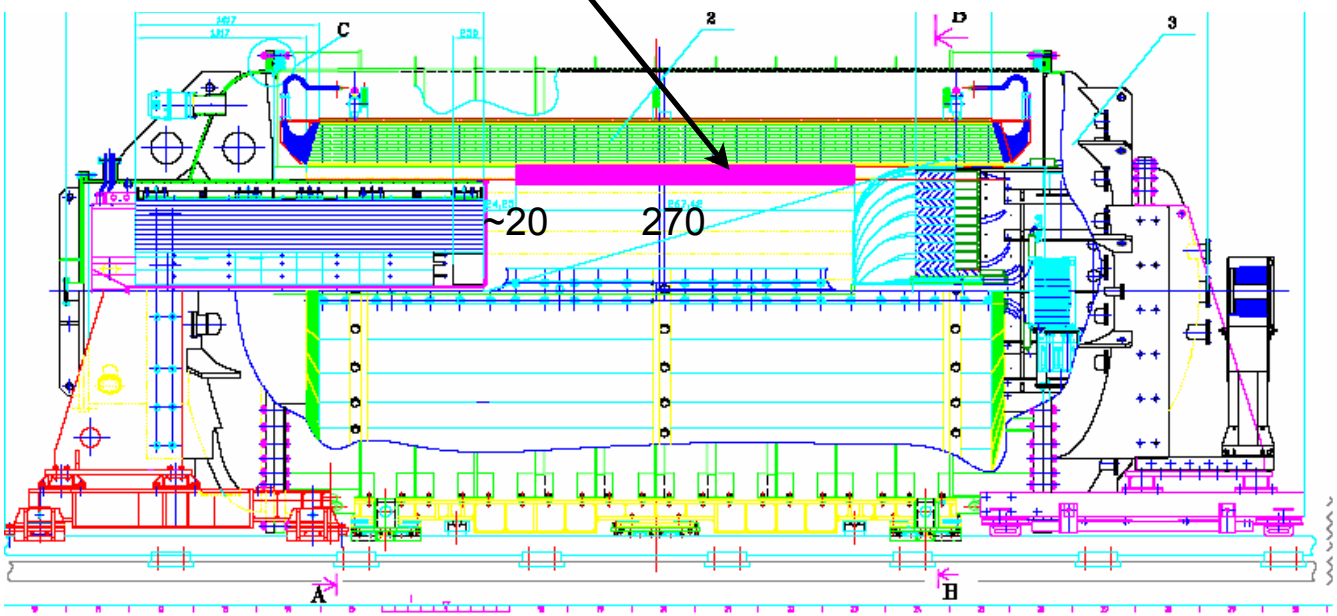
Flash ADC

- 14bit, 125MHz FADC
- Checked basic performance in Dec. 2007 at beam test.
- Flash ADC design is almost done.
- 2nd version of FADC module by December.
- CsI + PMT + FADC with laser calibration system at Osaka next spring
- 100 channel beam test planned in summer 2009.

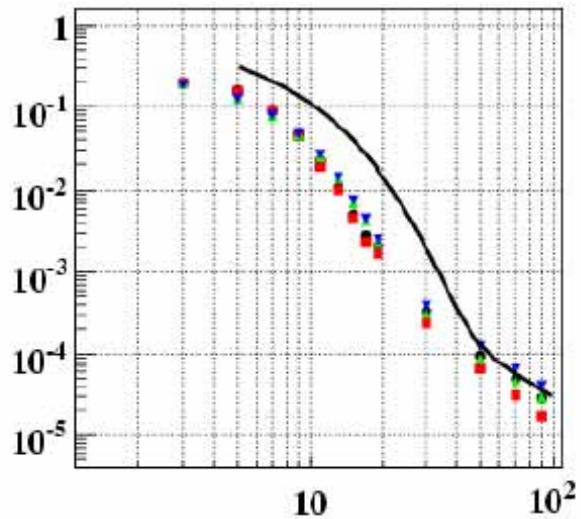


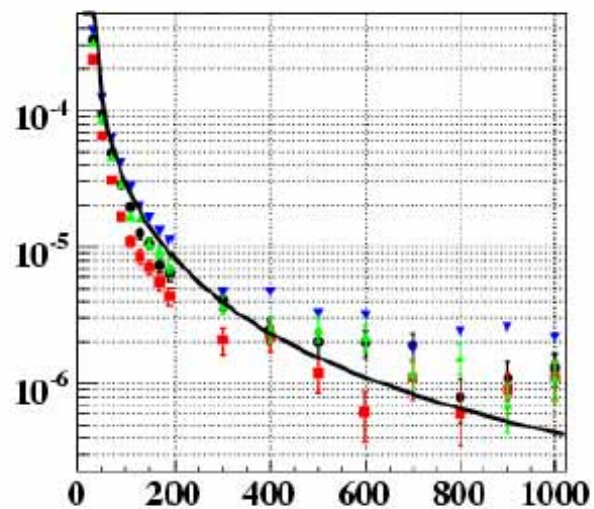
Veto counters - Main Barrel Veto

- Main Barrel veto counters
  - Studying an option to install additional layers in inside to veto low energy photons [(1mm Pb + 5mm scintillator)x 25 layers, for example (black dots)]
  - to reduce 2pi0 bkg by 25%



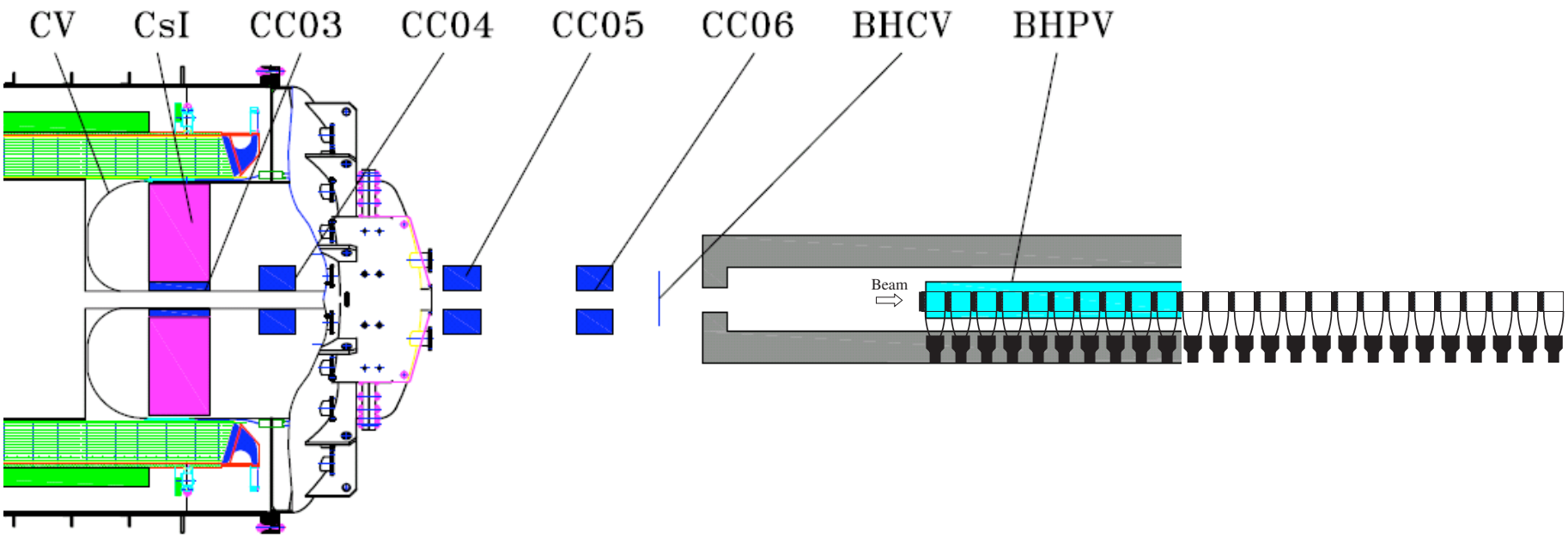
Inefficiency



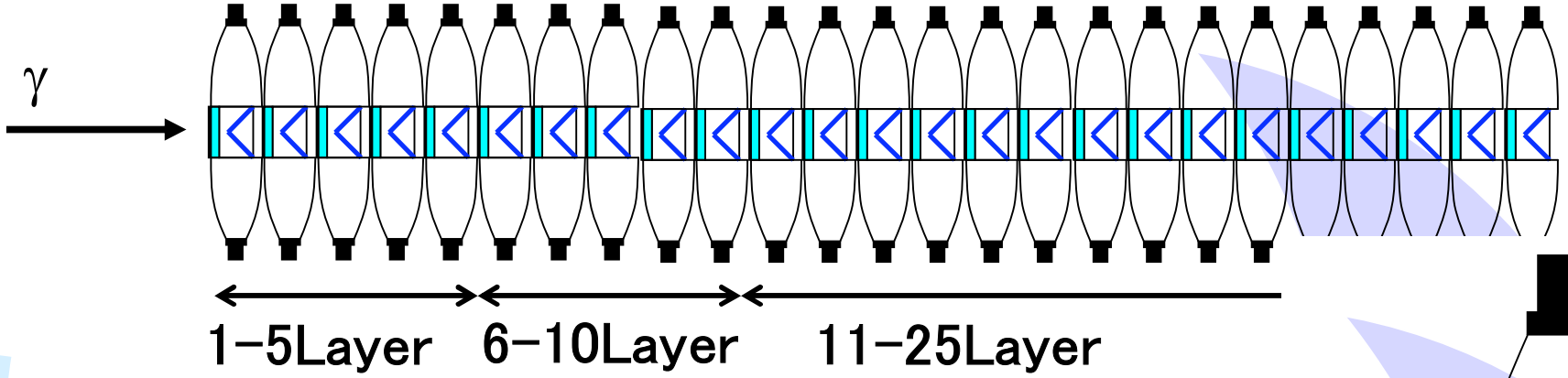


Egamma (MeV)

Beam Hole Photon Veto



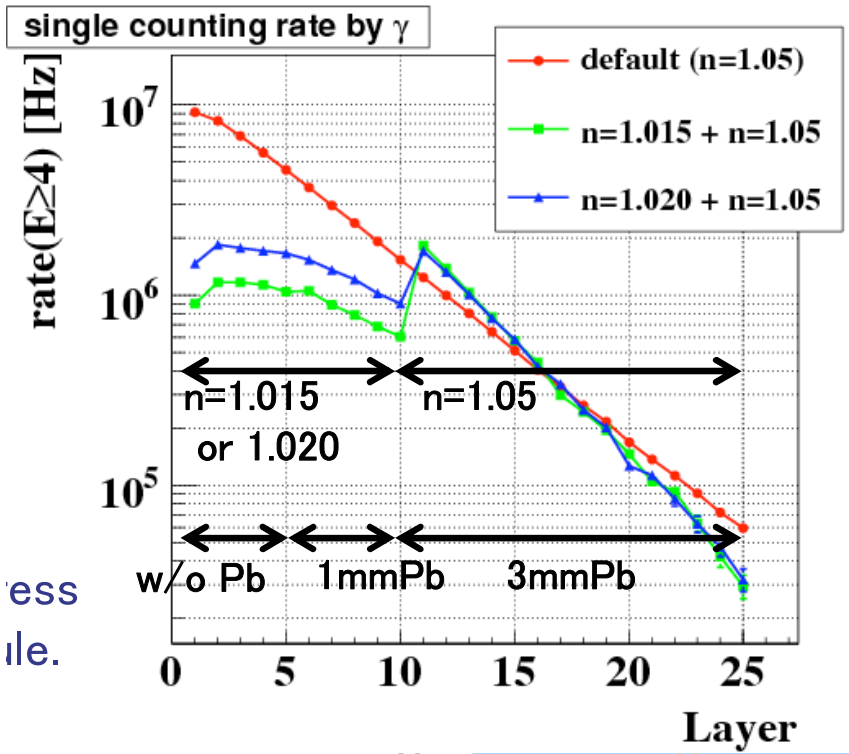
- Studying to reduce rates by
  - segmenting mirrors
  - making insensitive to low energy gammas

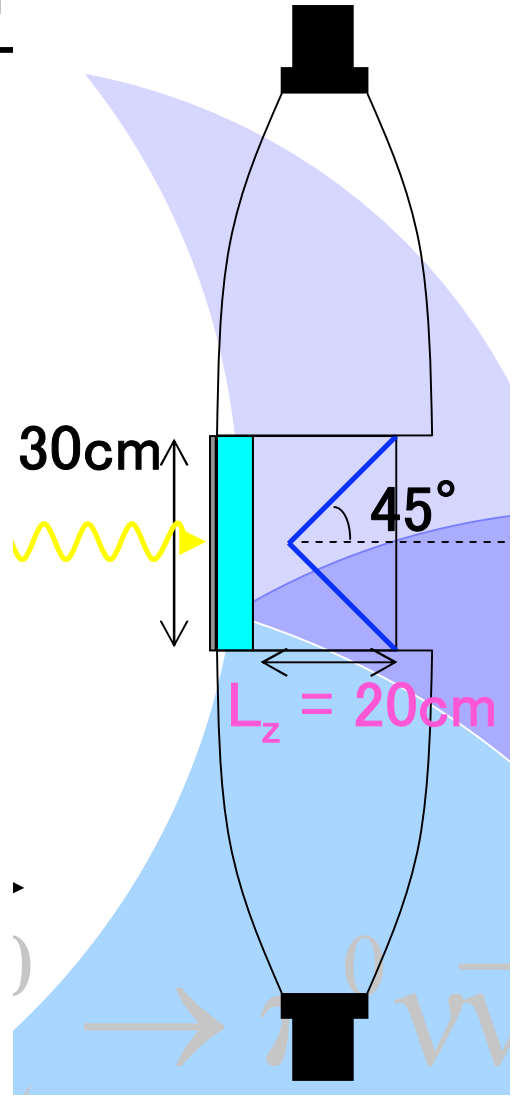


w/o Pb
n=1.015
or 1.020

1mm Pb
n=1.015
or 1.020

3mm Pb
n=1.05





Summary

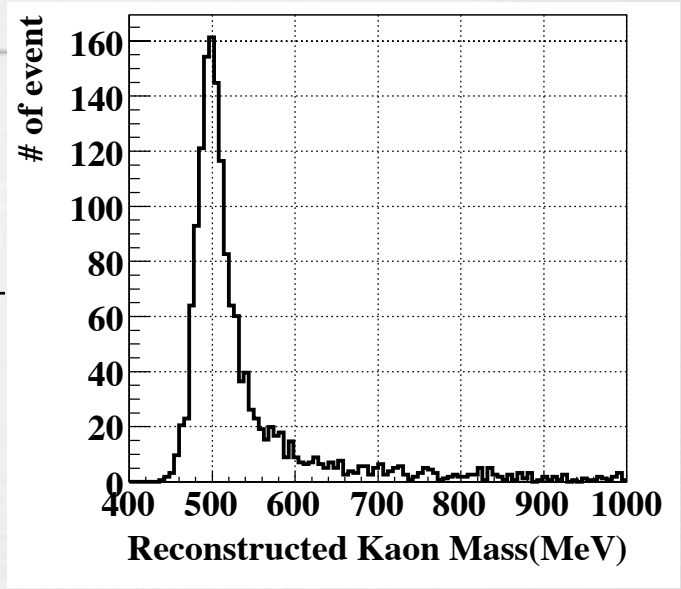
- Collimator design will be fixed by the end of October
- Collimators will be made by March 2009
- Detector for beam beam survey are being prepared / tested
- Waiting for an approval for a beam survey in 2009.

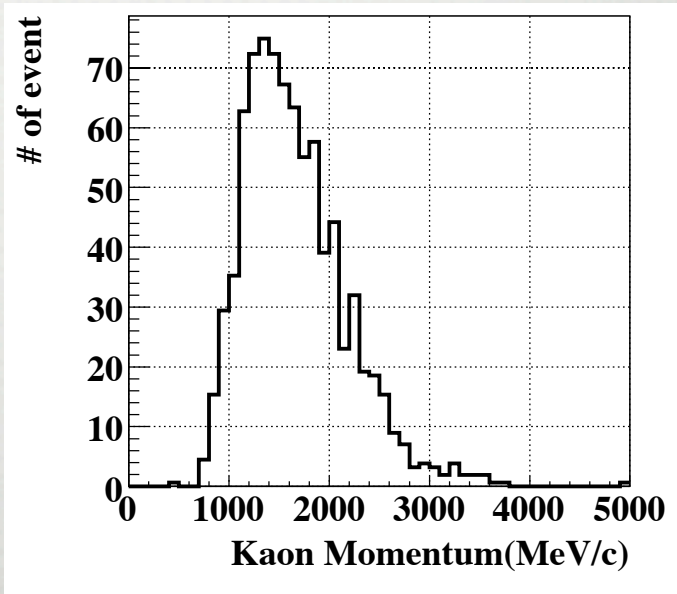
- CsI, readout system, veto counter preparations are under way

4. K_L Flux Measurement

- Assume π^0 mass and get z vertex
- 2 unknowns: π^+ and π^- momenta p^+, p^-
- 2 equations: $p_x^+ + p_x^- + k_{1x} + k_{2x} = 0$

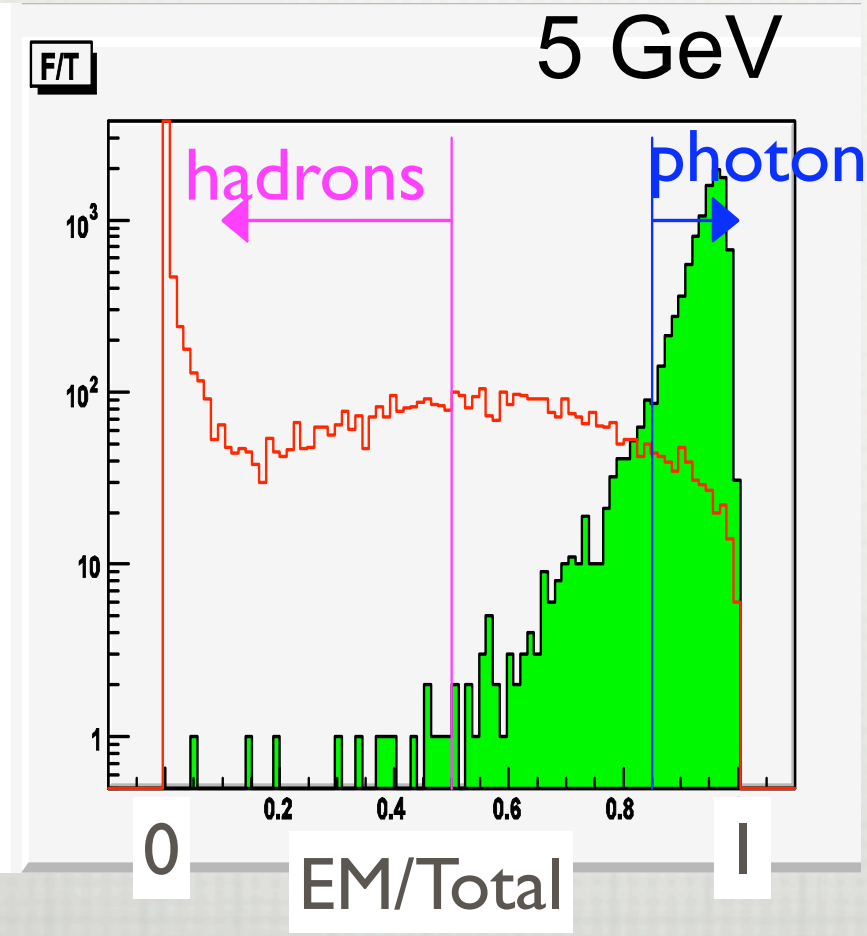
  $p_y^+ + p_y^- + k_{1y} + k_{2y} = 0$
- ~1000 reconstructed K_L / day with 1% intensity (2E12 protons/pulse)
- Background ~ several events from $3\pi^0$ with Dalitz decays





Performance Of "Cerberus"

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



Energy Resolution