The $K_L \to \pi^0 \nu \bar{\nu}$ Experiment at J-Parc

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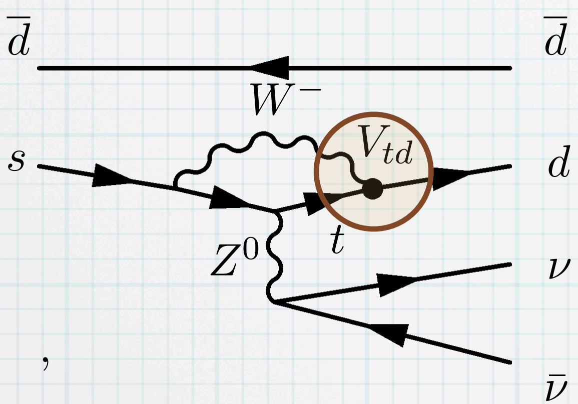
4th WS on Mass Origin and Supersymmetry Physics

Collaboration

* Arizona State Univ.
* Chicago Univ.
* JINR
* KEK
* Kyoto Univ.
* National Defense Academy
* National Taiwan Univ.
* Osaka Univ.
* Pusan Univ.
* Saga Univ.
* Yamagata Univ.

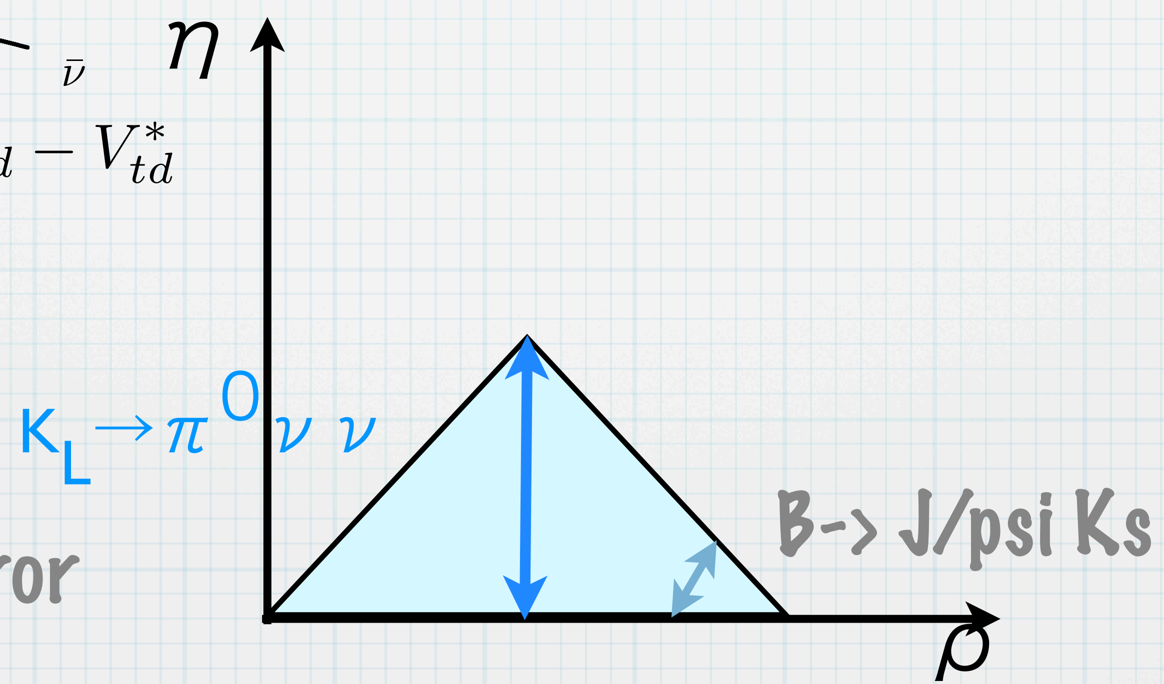
$K_L \to \pi^0 \nu\nu$ in Standard Model



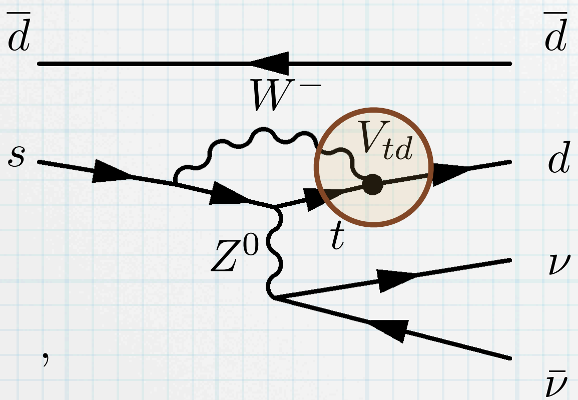
$$A(K_L \to \pi^0 \nu\overline{\nu}) \simeq V_{td} - V_{td}^*$$

BR = 3×10^{-11}

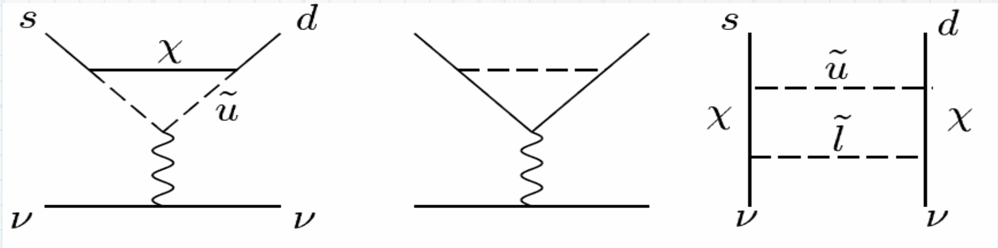
1~2%
theoretical error



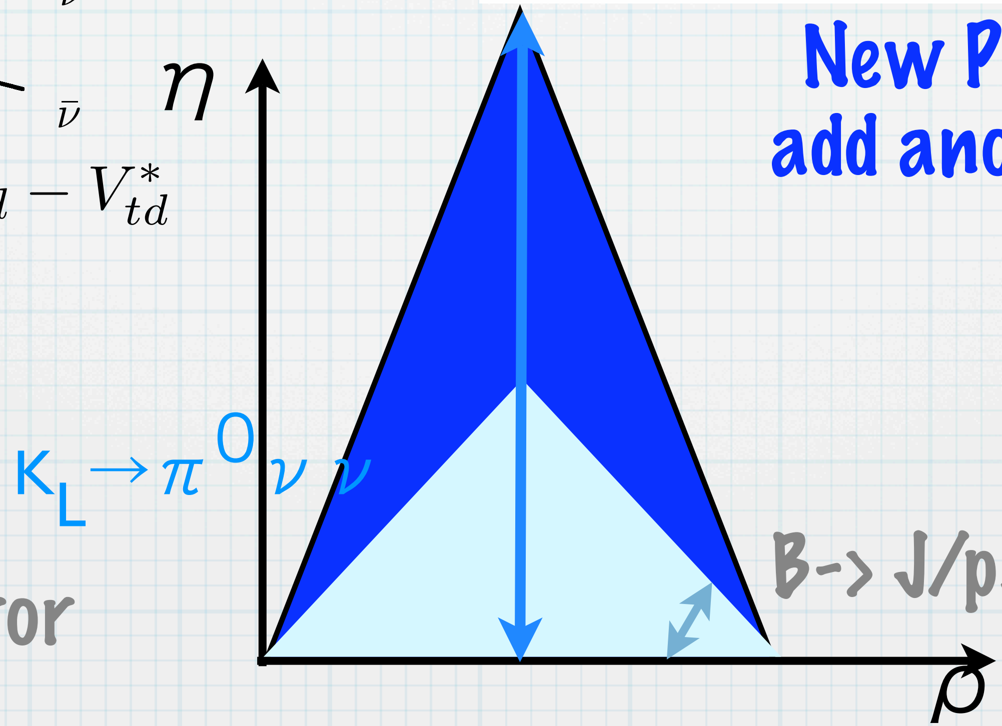
$K_L \to \pi^0 \nu\nu$ in Physics Beyond Standard Model



$$A(K_L \to \pi^0 \nu\bar{\nu}) \simeq V_{td} - V_{td}^*$$

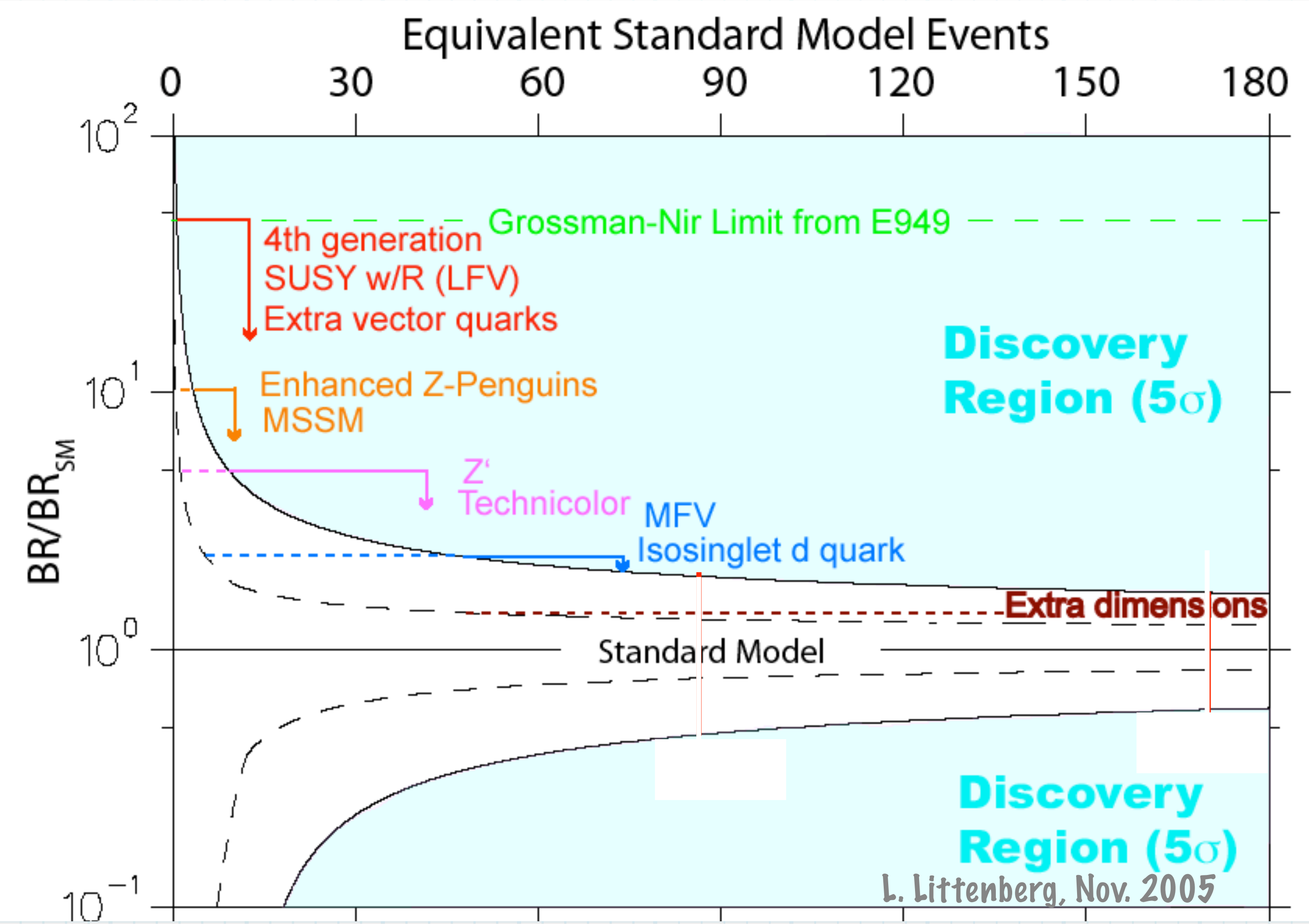


New Physics can add another phase



1~2% theoretical error

Sensitivity to New Physics



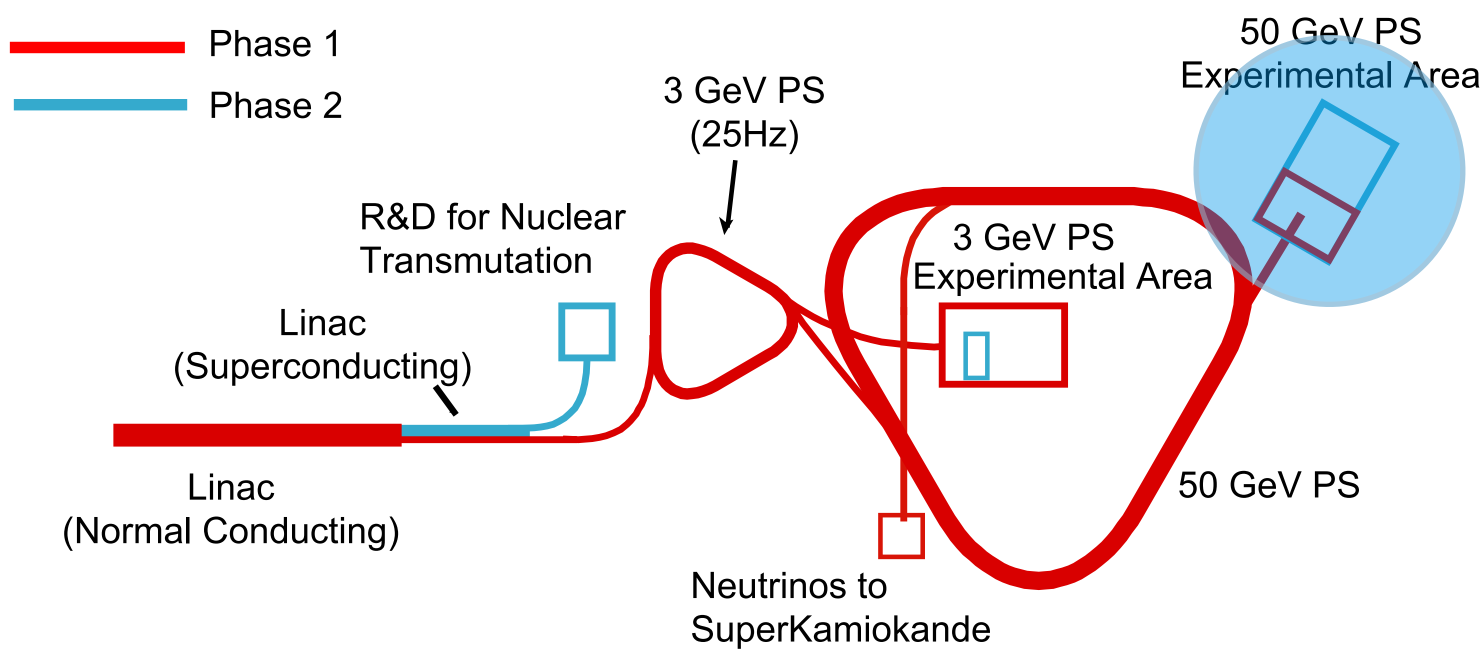
Goal

* Collect >100 $K_L \to \pi^0 \nu\nu$ events and measure the BR to <10%
* We need:
  * High K_L flux
  * High acceptance
  * Low background
  * Step by step approach

High K_L flux

J-Parc

* 30 - 50 GeV High intensity proton accelerator, 3E14 protons/3.4sec



- Phase 1 + Phase 2 = 1,890 Oku Yen (= $1.89 billion if $1 = 100 Yen).
- Phase 1 = 1,513 Oku Yen for 7 years.

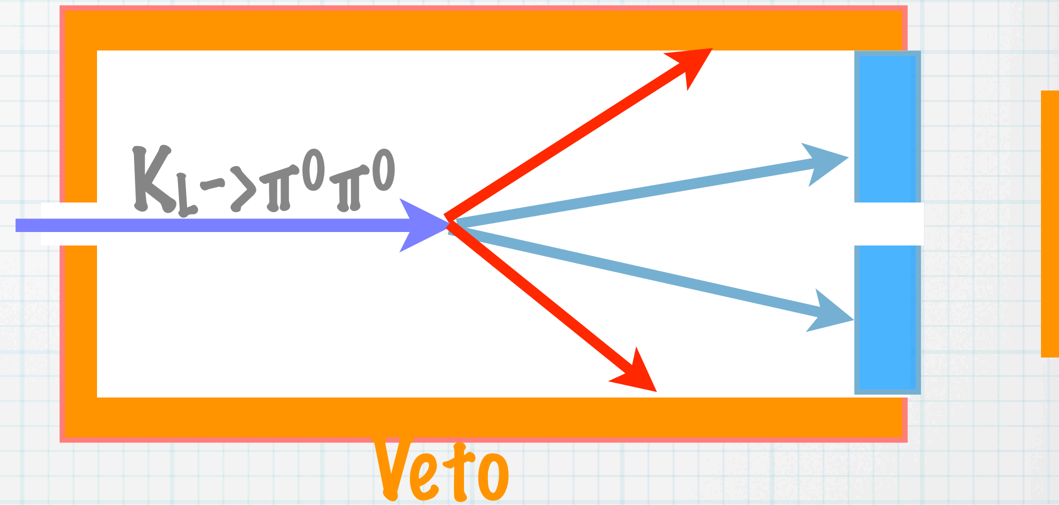
50GeV Main Ring

Slow extraction experimental hall

High Acceptance and Low Background

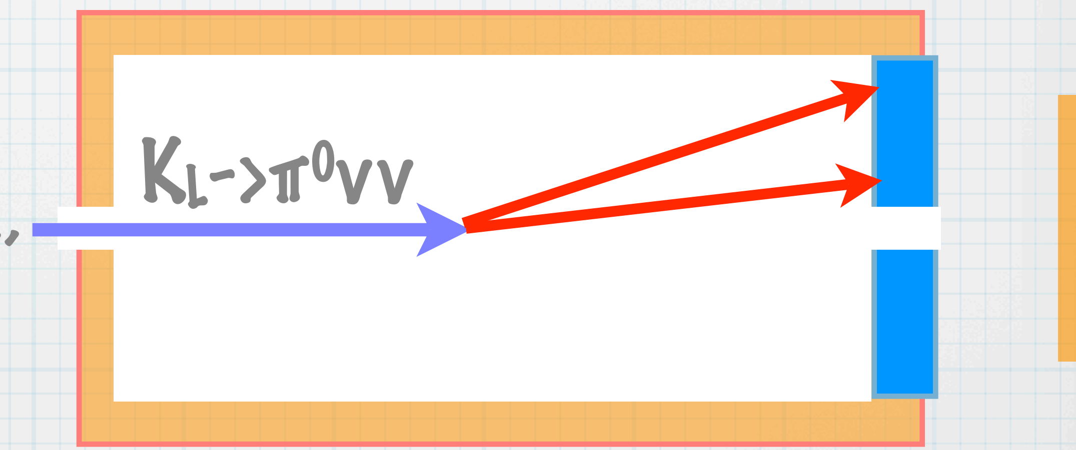
Hermetic veto, high Pt

* Hermetic veto to suppress $K_L \to \pi^0\pi^0 \to$ 4gamma background



* Reconstruct decay vertex assuming $m_{gg} = m_{\pi^0}$

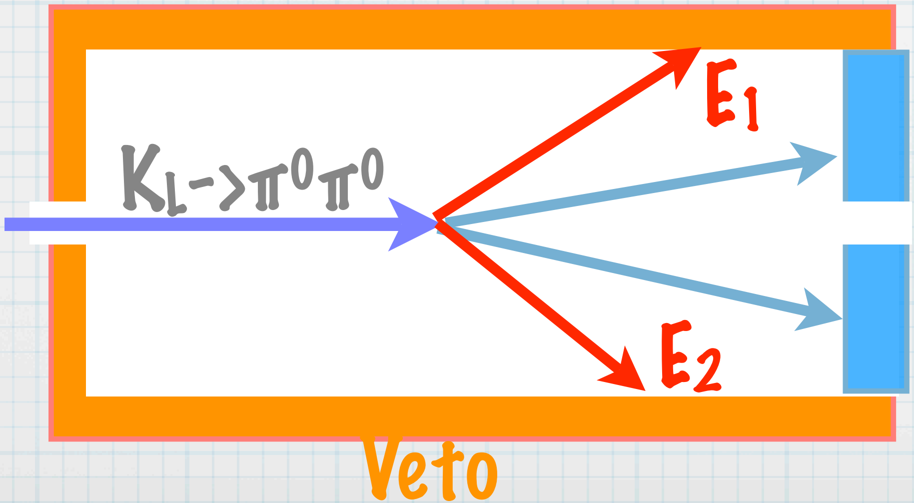
* Require high missing transverse momentum, Pt



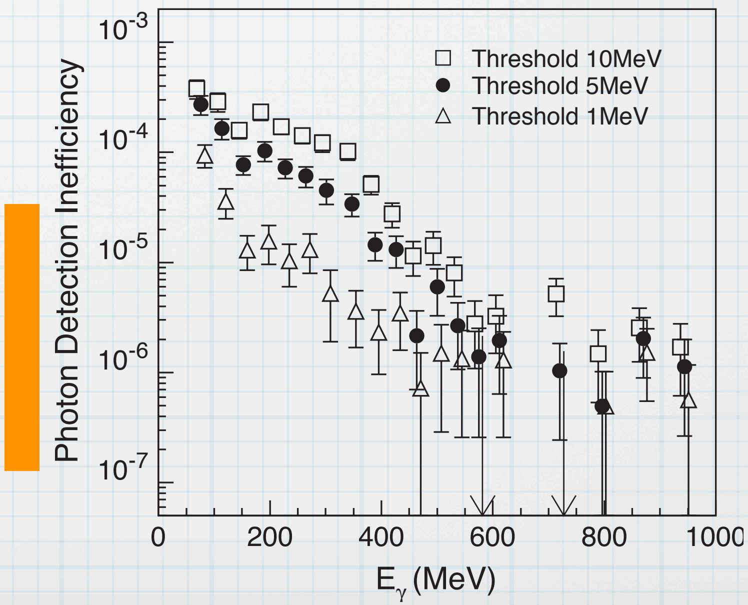
(Relatively) High Energy K

* for lower n/K ratio
* for better photon veto to reduce $K_L \to 2\pi^0$ background.

#bkg ∝ ineff(E_1)x ineff(E_2)



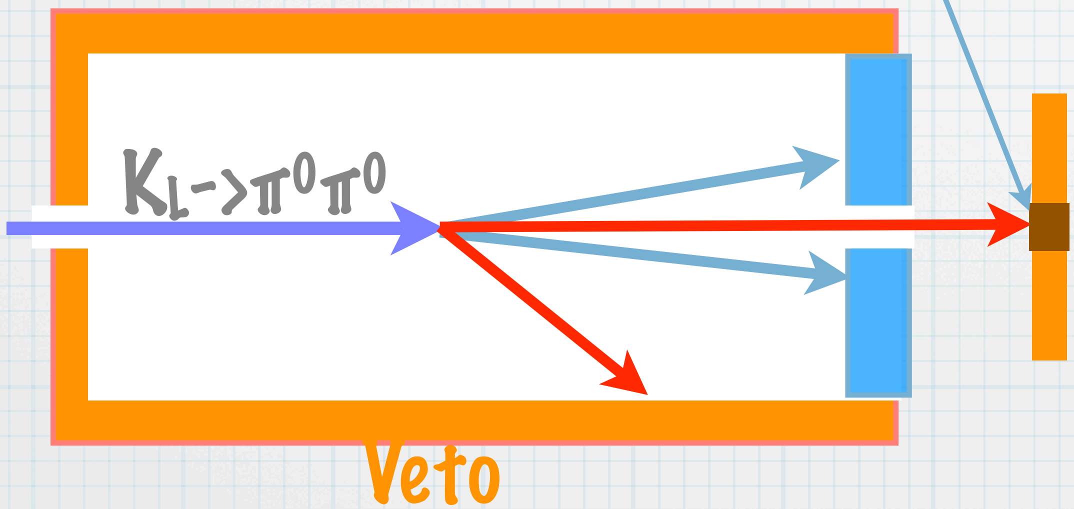
Pb/scintillator

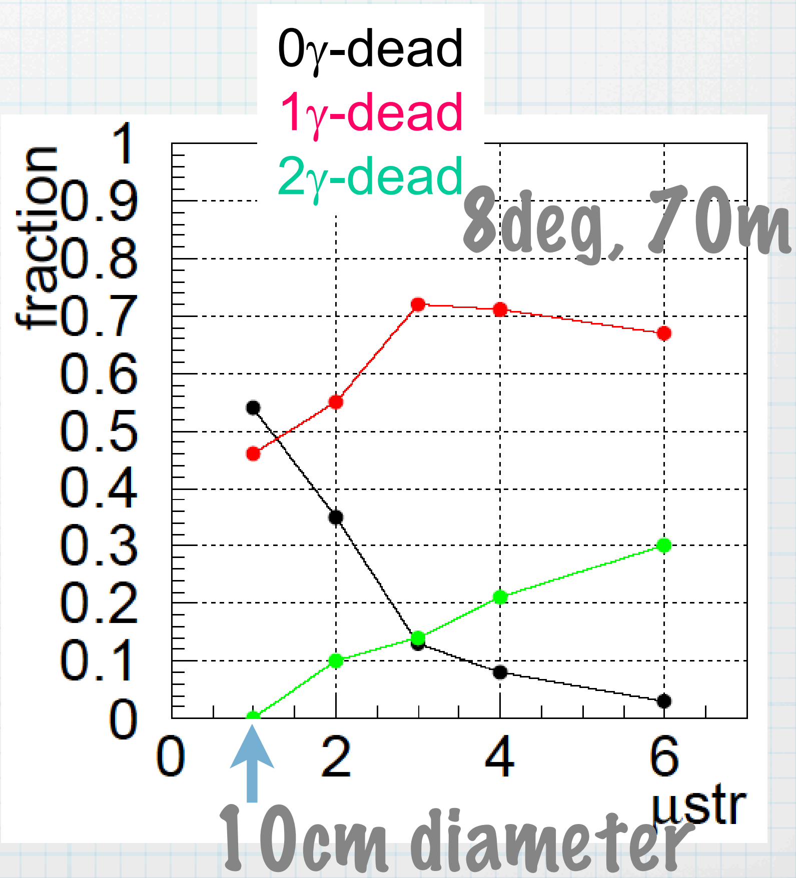


Small K_L Beam

* to suppress background photons escaping down the beam hole in the calorimeter

Lower efficienciency due to high rate neutrons





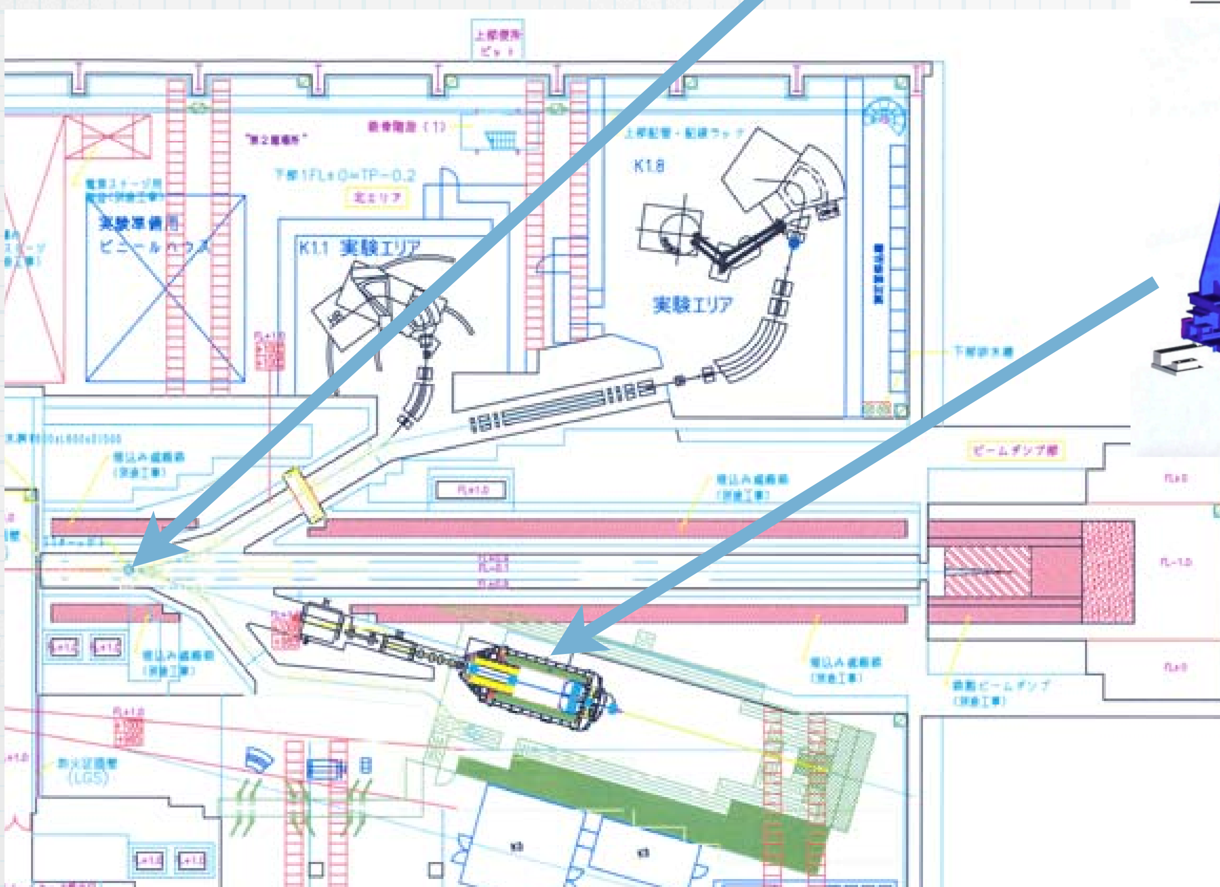
Step by Step Approach

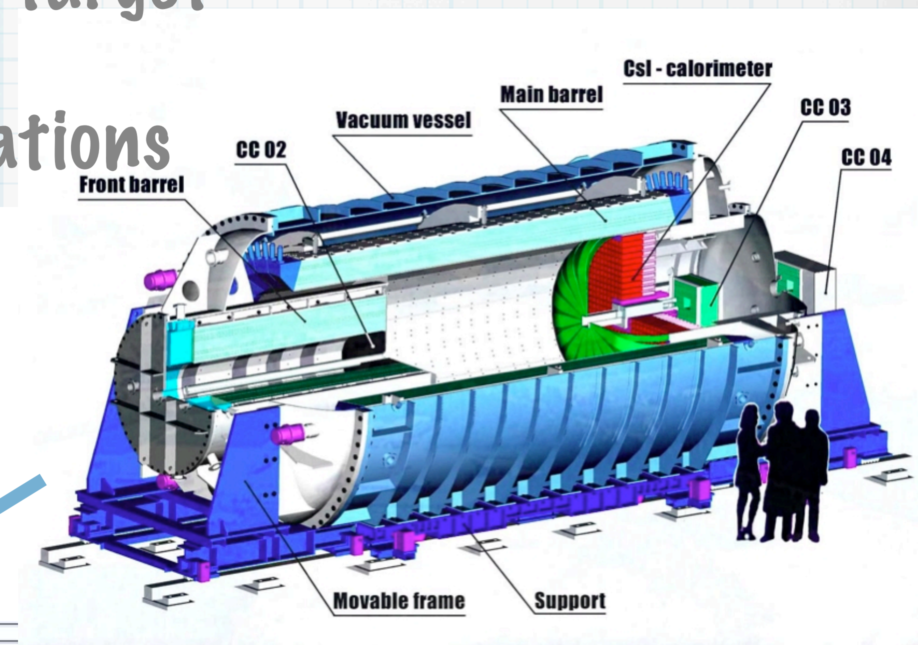
Step by Step Approach

* E391a = Step 0
* J-Parc Step 1
  * First observation / check for a large enhancements
  * learn for the Step 2
* J-Parc Step 2
  * >100 events

J-Parc Step 1

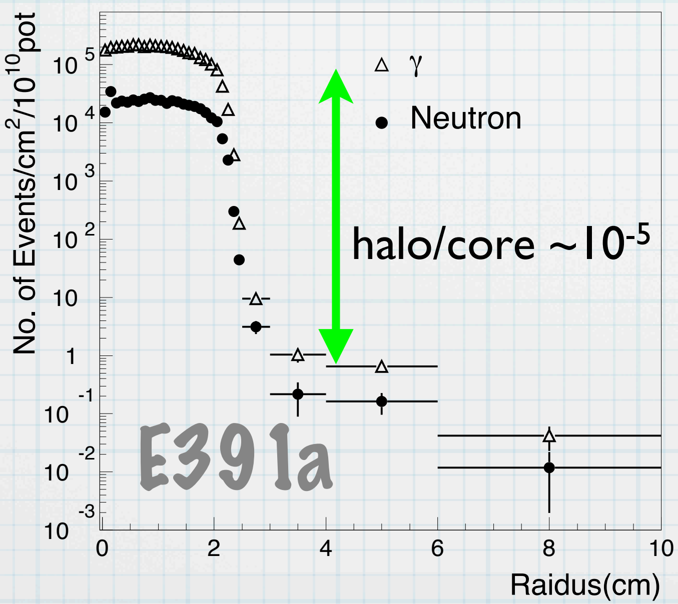
* 30GeV protons on 30% Common target
* Utilize E391a detector + modifications

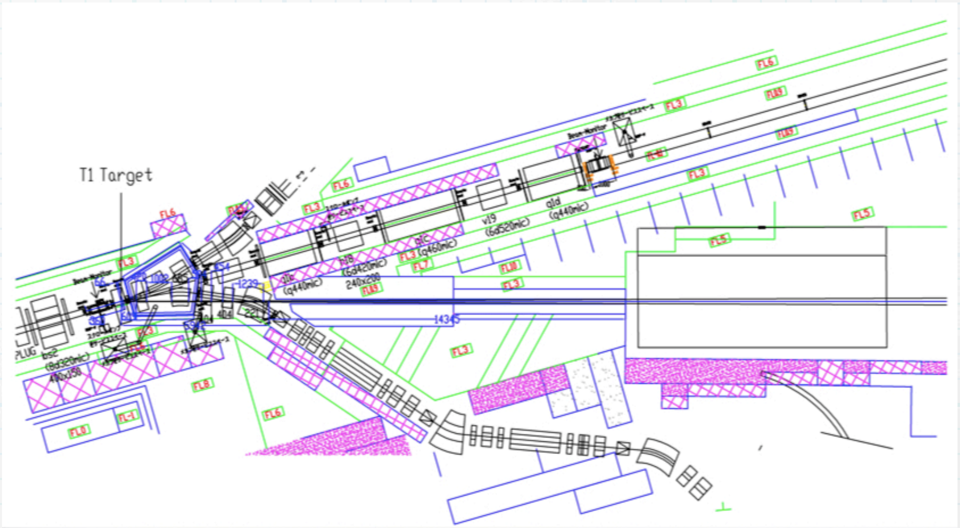


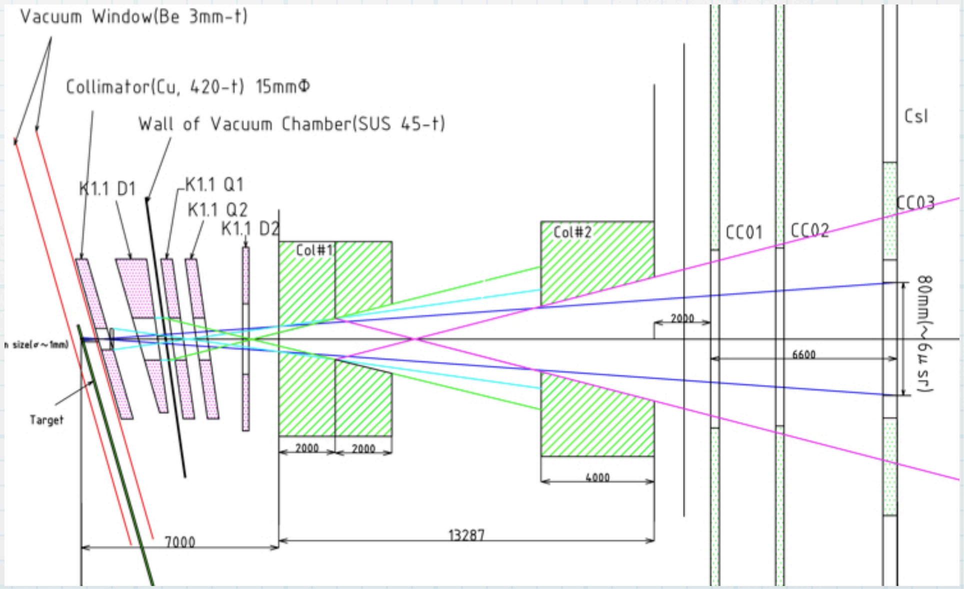


Step 1 Beamline

* 16deg targeting angle -> 2GeV K_L
* 9μstr neutral beam
* tight collimation for $<10^{-5}$ beam halo



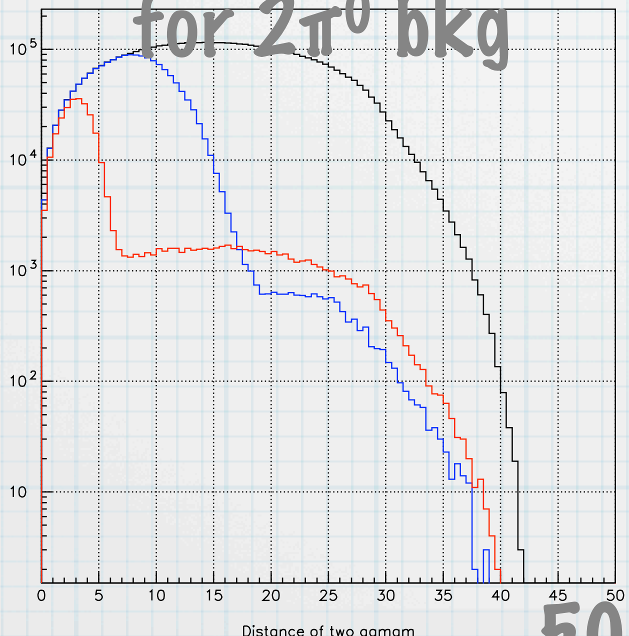




Step 1: Calorimeter

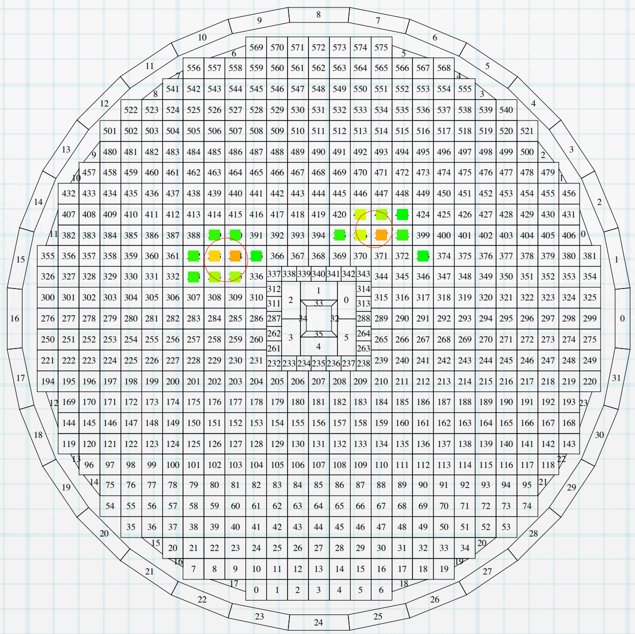
* To isolate fused clusters, change CsI

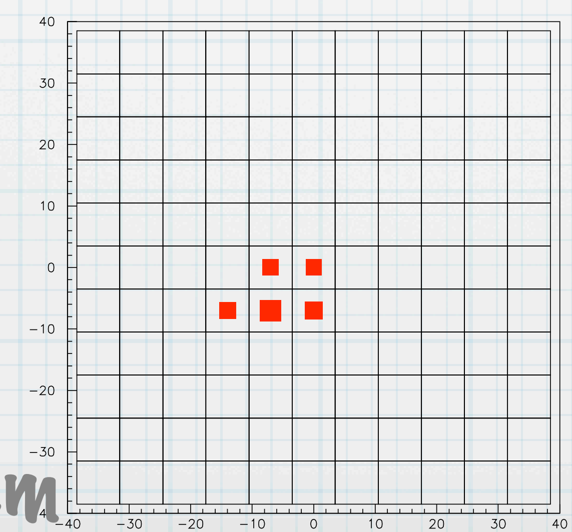
photon separation for $2\pi^0$ bkg



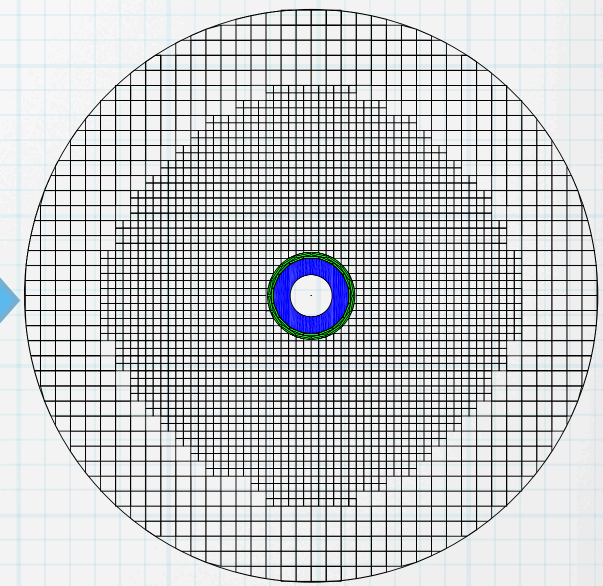
50cm

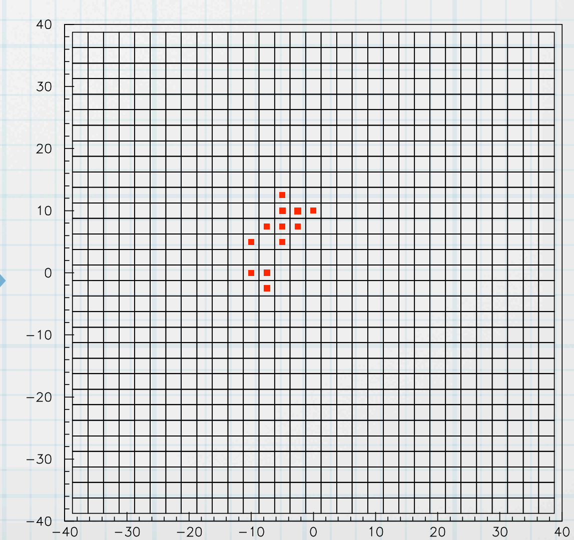
7cm E391a CsI



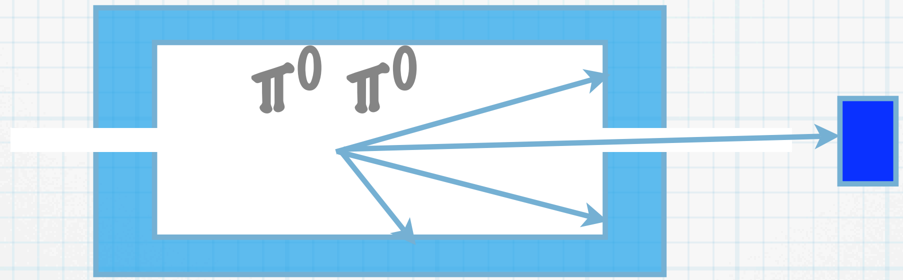


2.5cm KTeV CsI

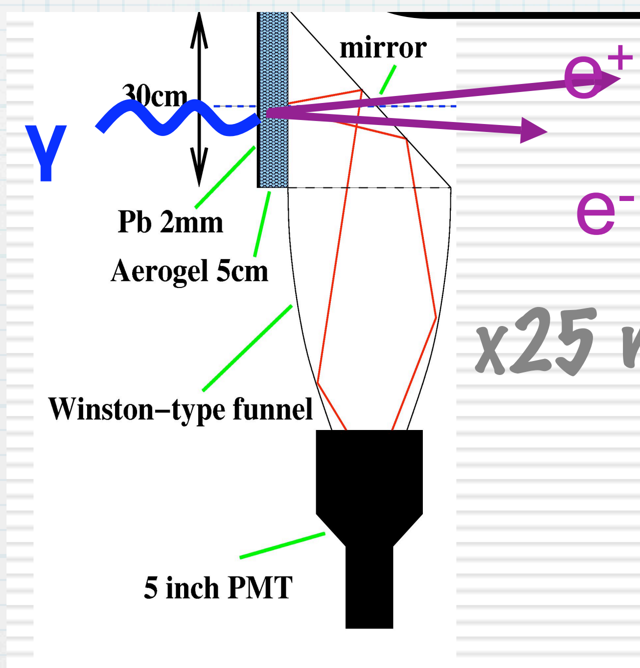




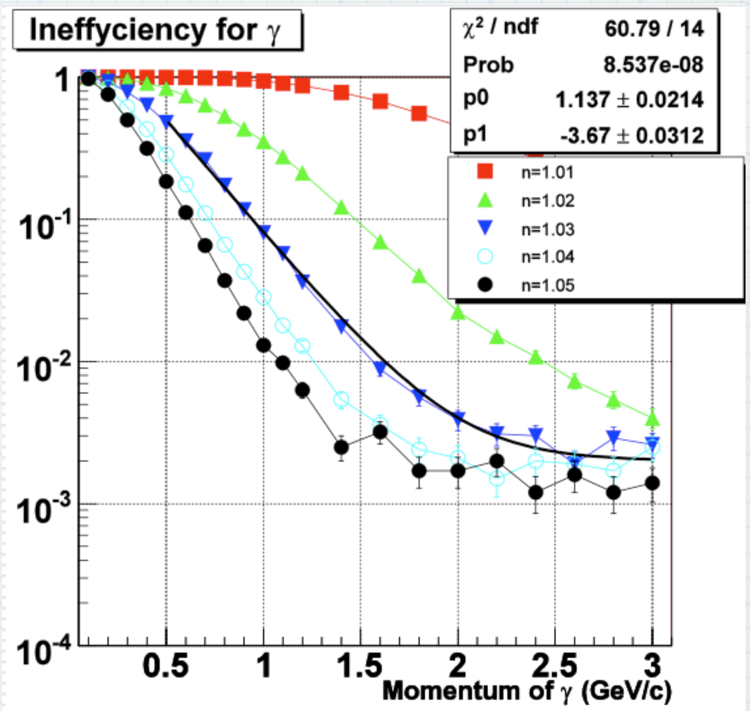
Step 1: Better Veto in Beam



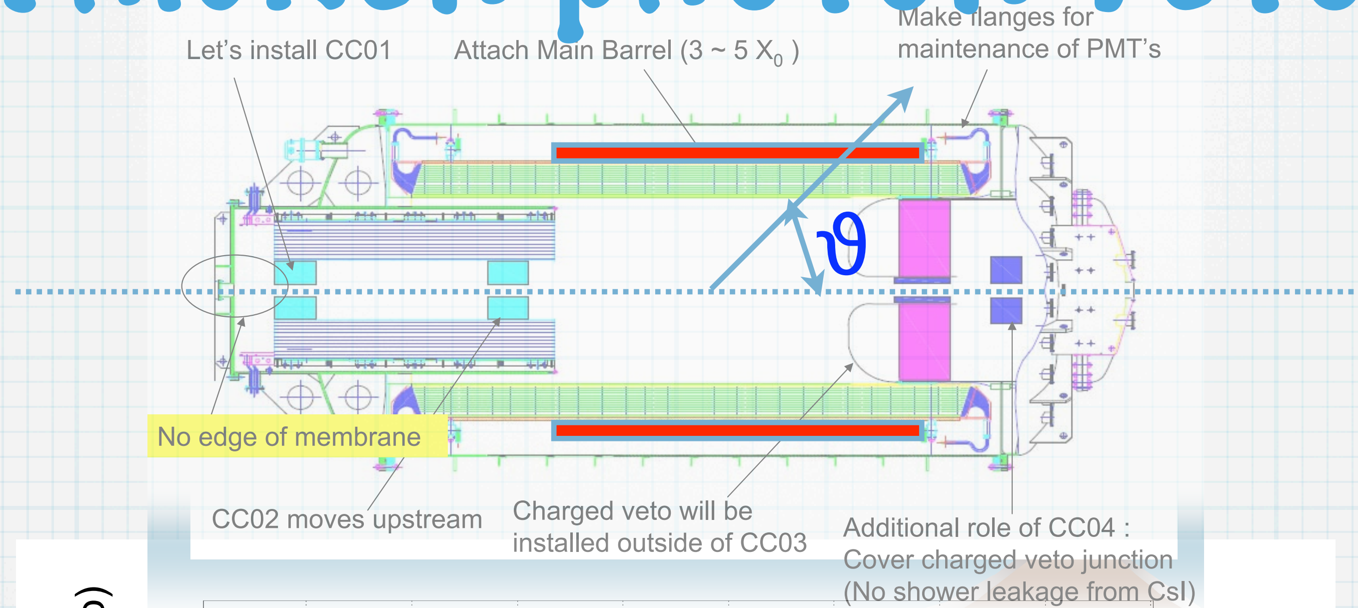
* KOPIO type Pb+Aerogel or PbWO

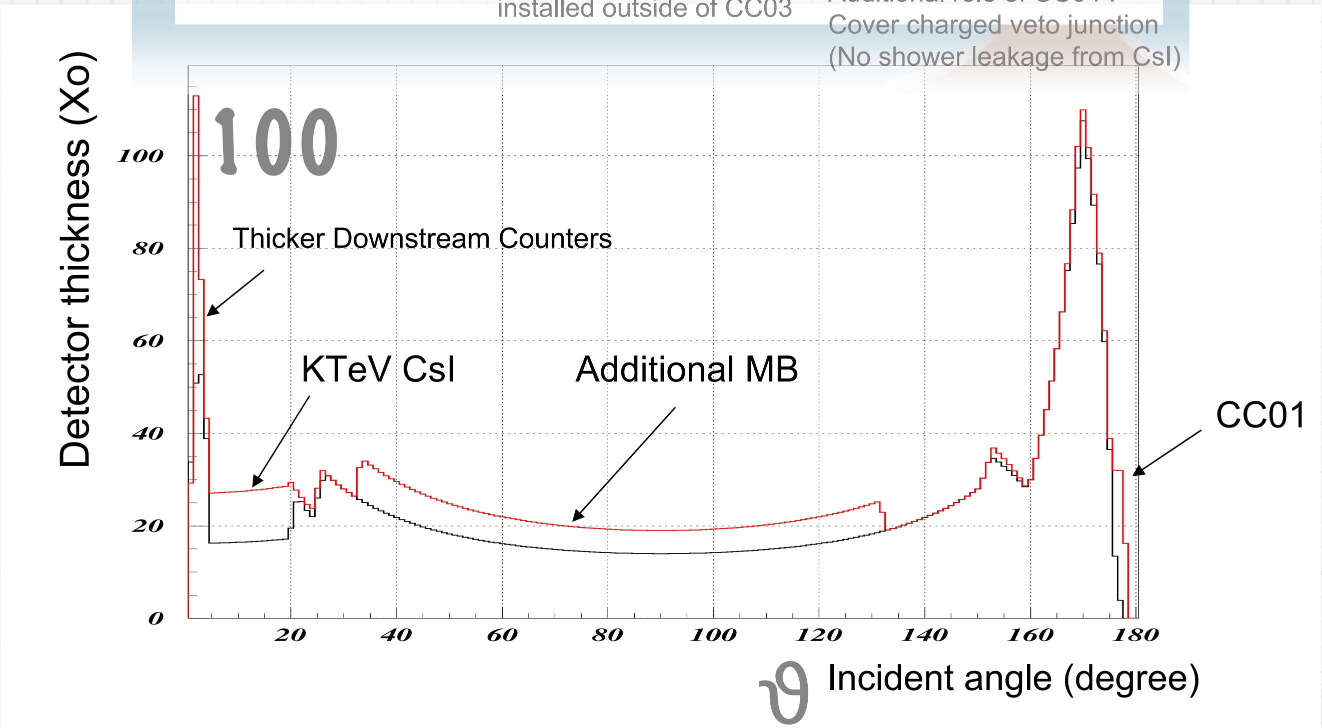


x25 modules



Thicken photon veto

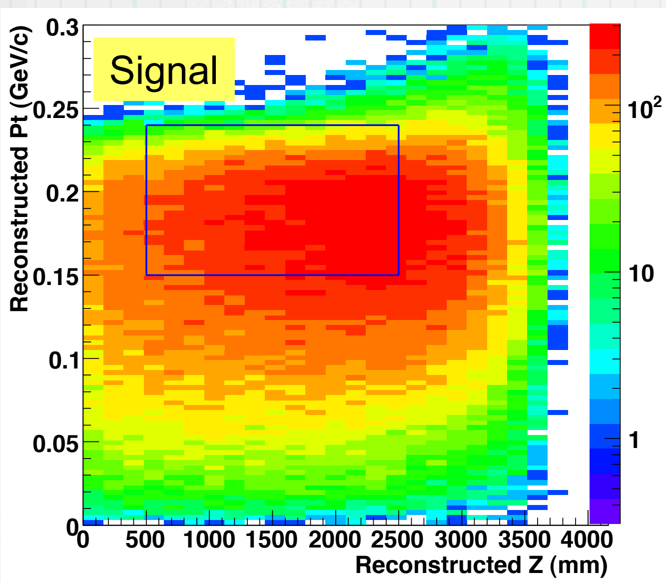


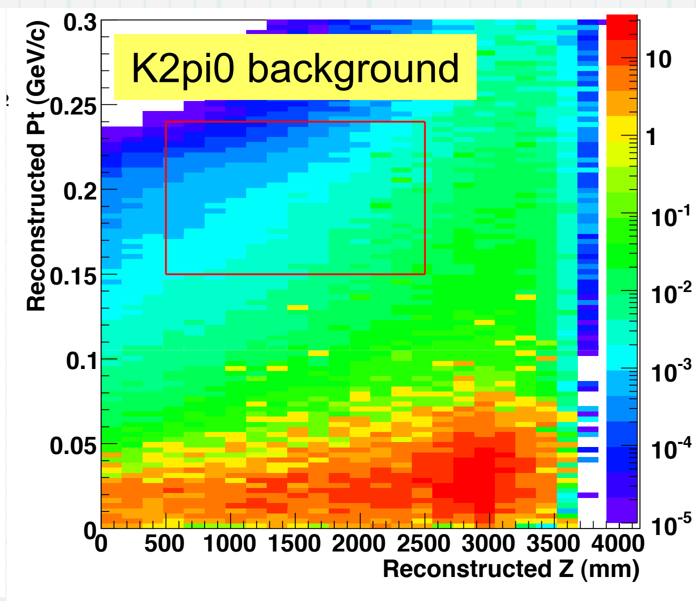


Step 1 Sensitivity

- 20-30 signal evts/3 x10^7 sec / full intensity
- Background depends on the photon fusion isolation

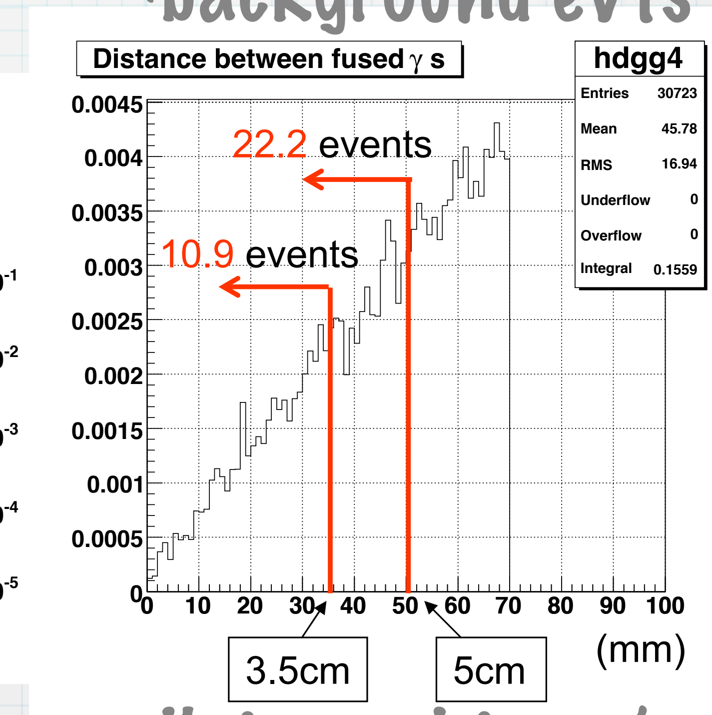
Pt





z vertex

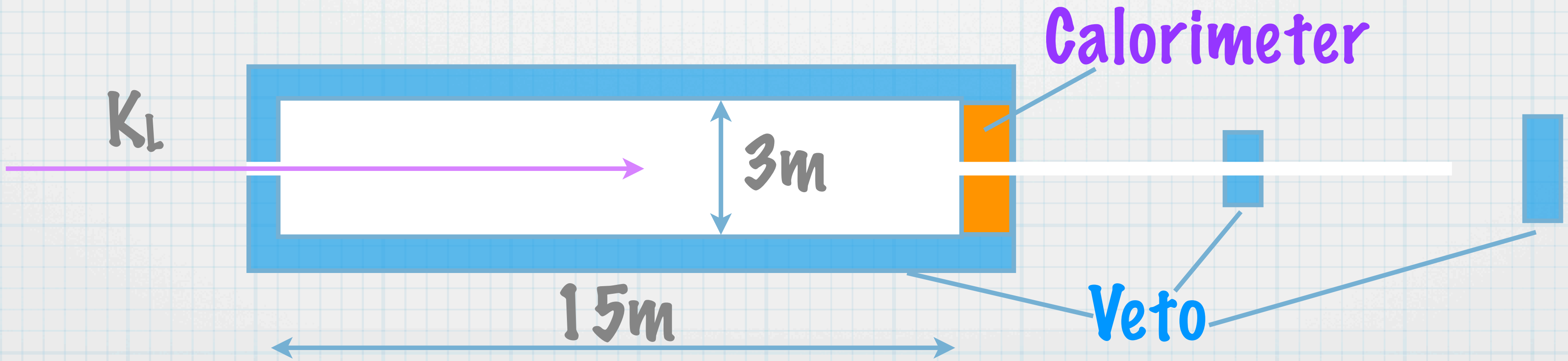
#background evts



distance btw γ's

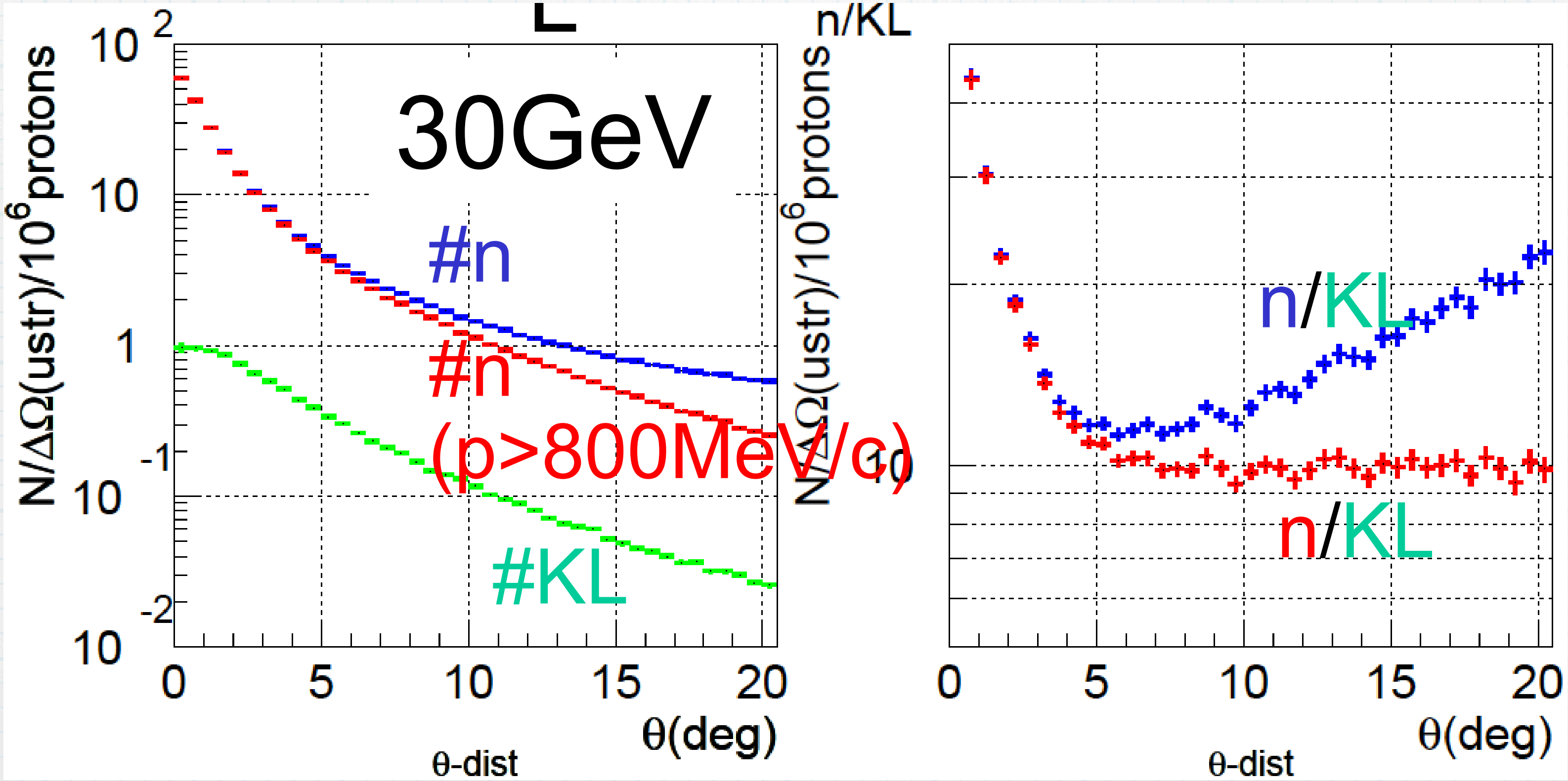
Step 2

* Longer decay volume (2m->8m) and detector
* Higher acceptance with larger calorimeter (2m->3m diameter)
* High rate capability
* either 16deg/20m or 5deg/50m



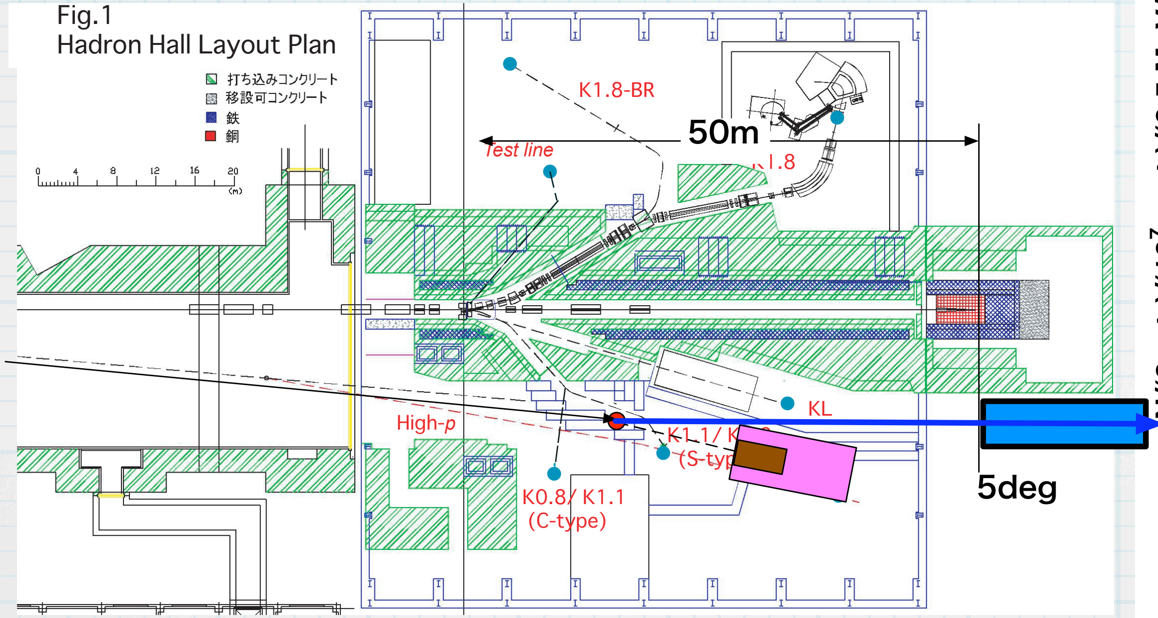
n/K ratio

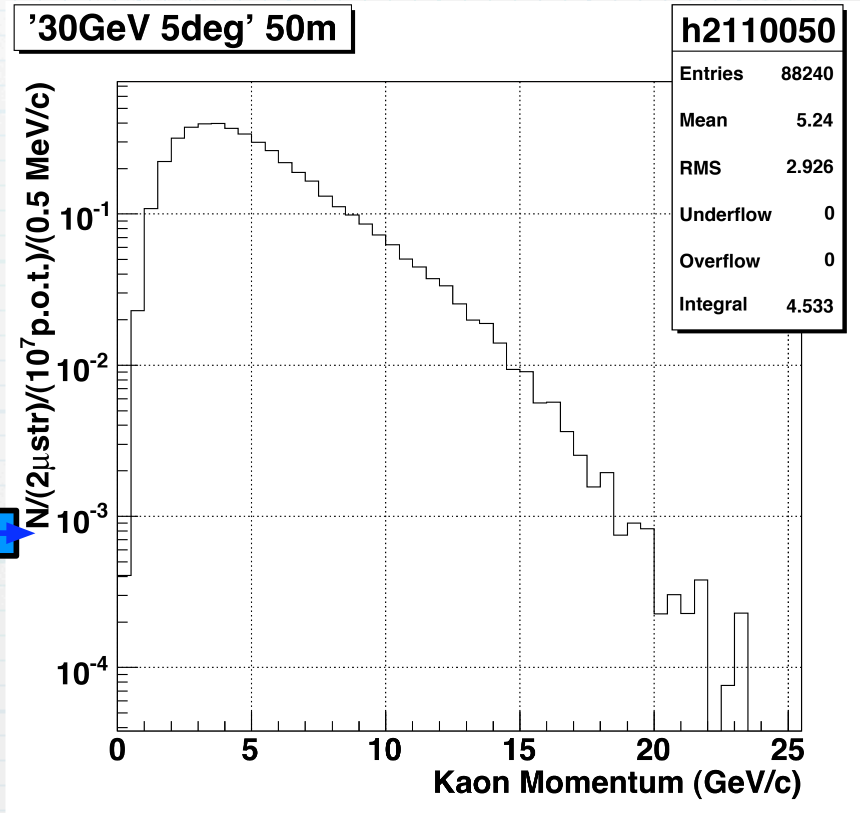
* n/K = 10 above 5 degrees for 30GeV protons (Geant3+GFLUKA)



Higher K_L energy option

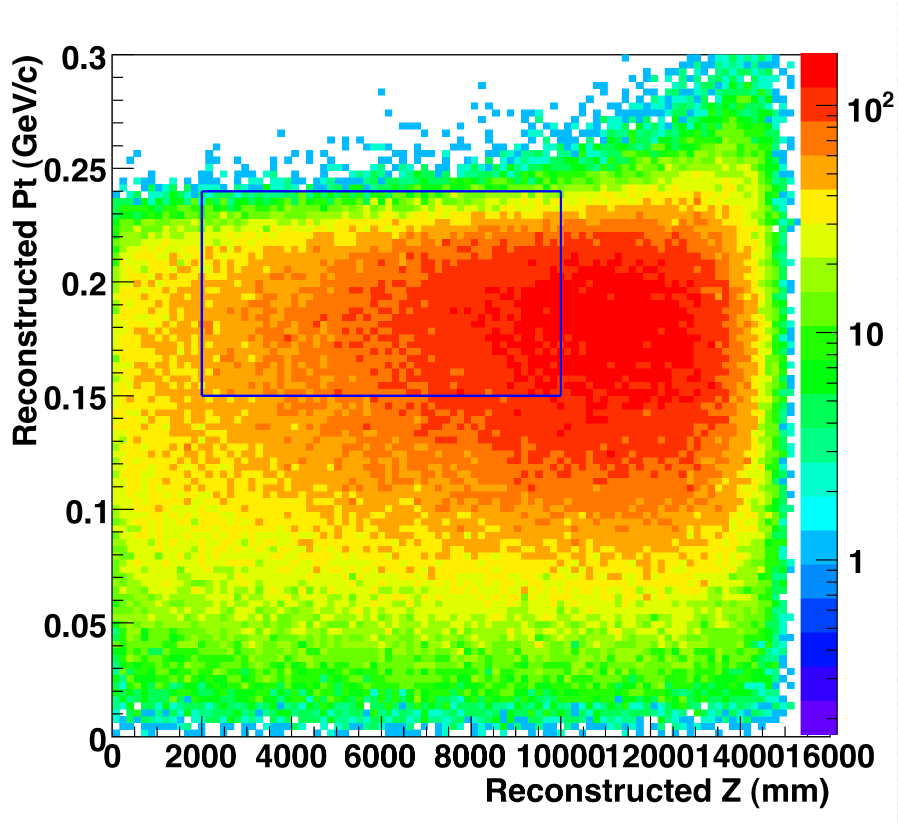
* 5deg angle, 2μstr beam, 50m from target
* 5.2GeV K_L

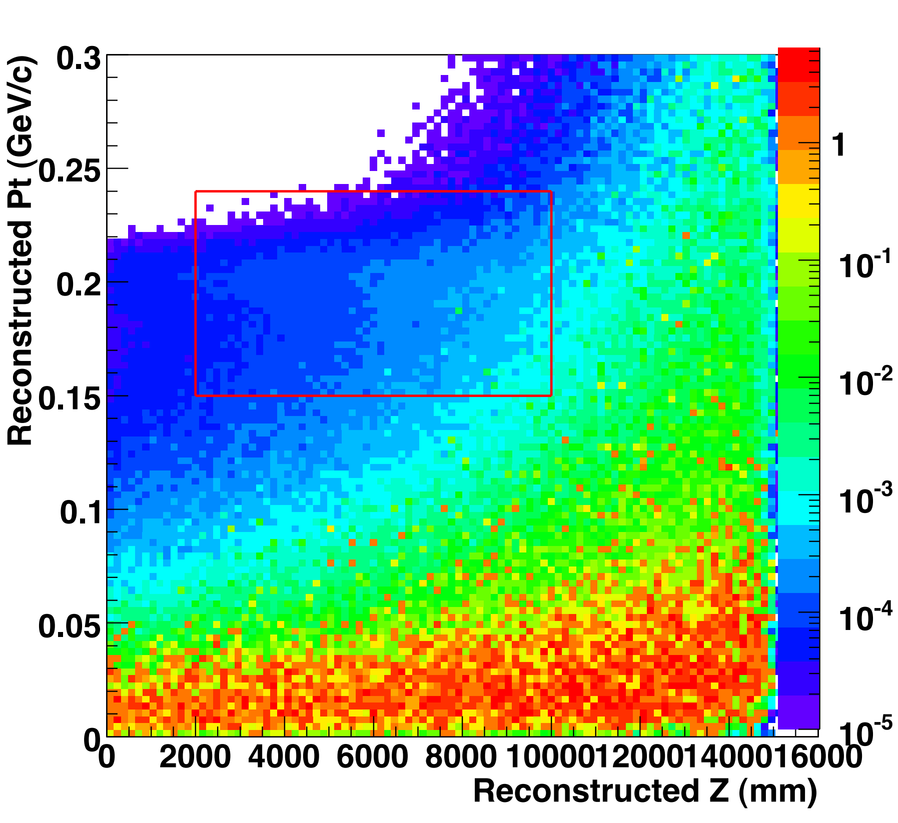




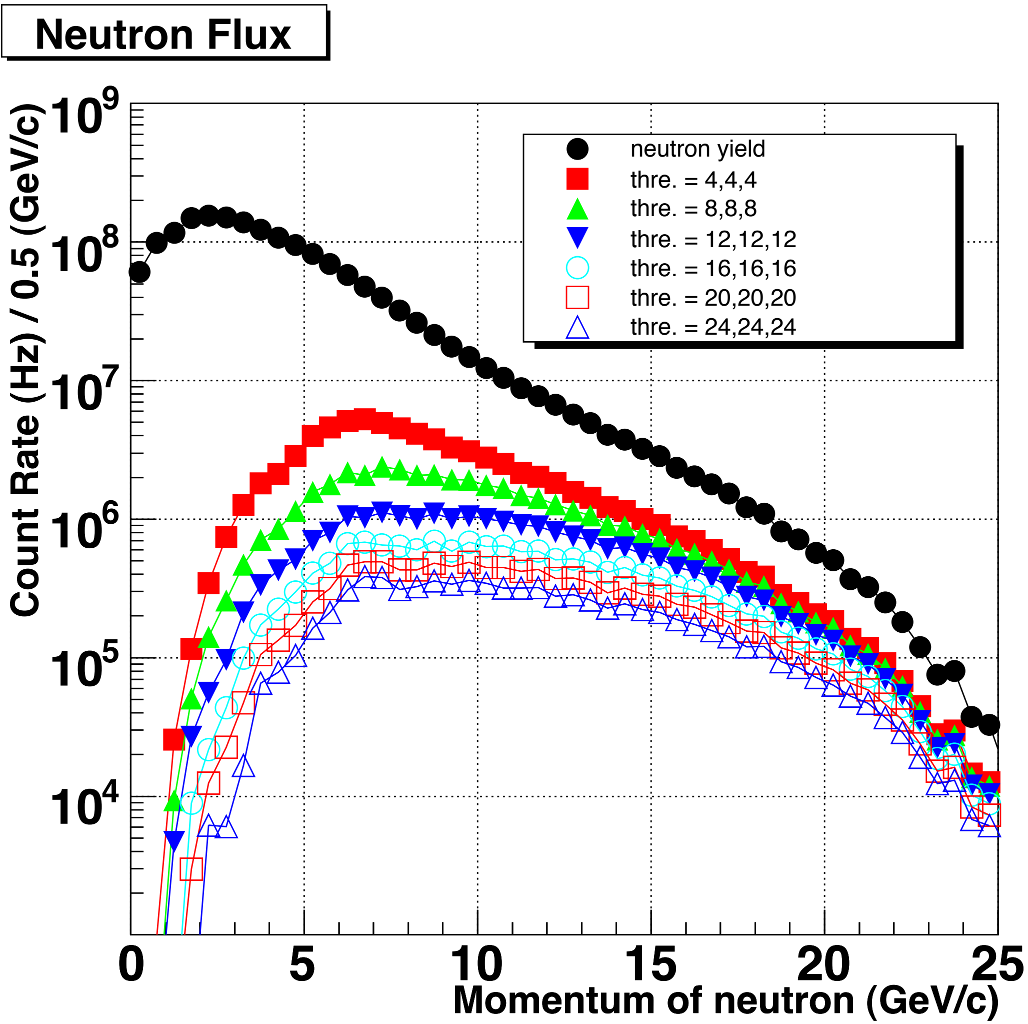
Step 2: 5 deg, 50m (one study)

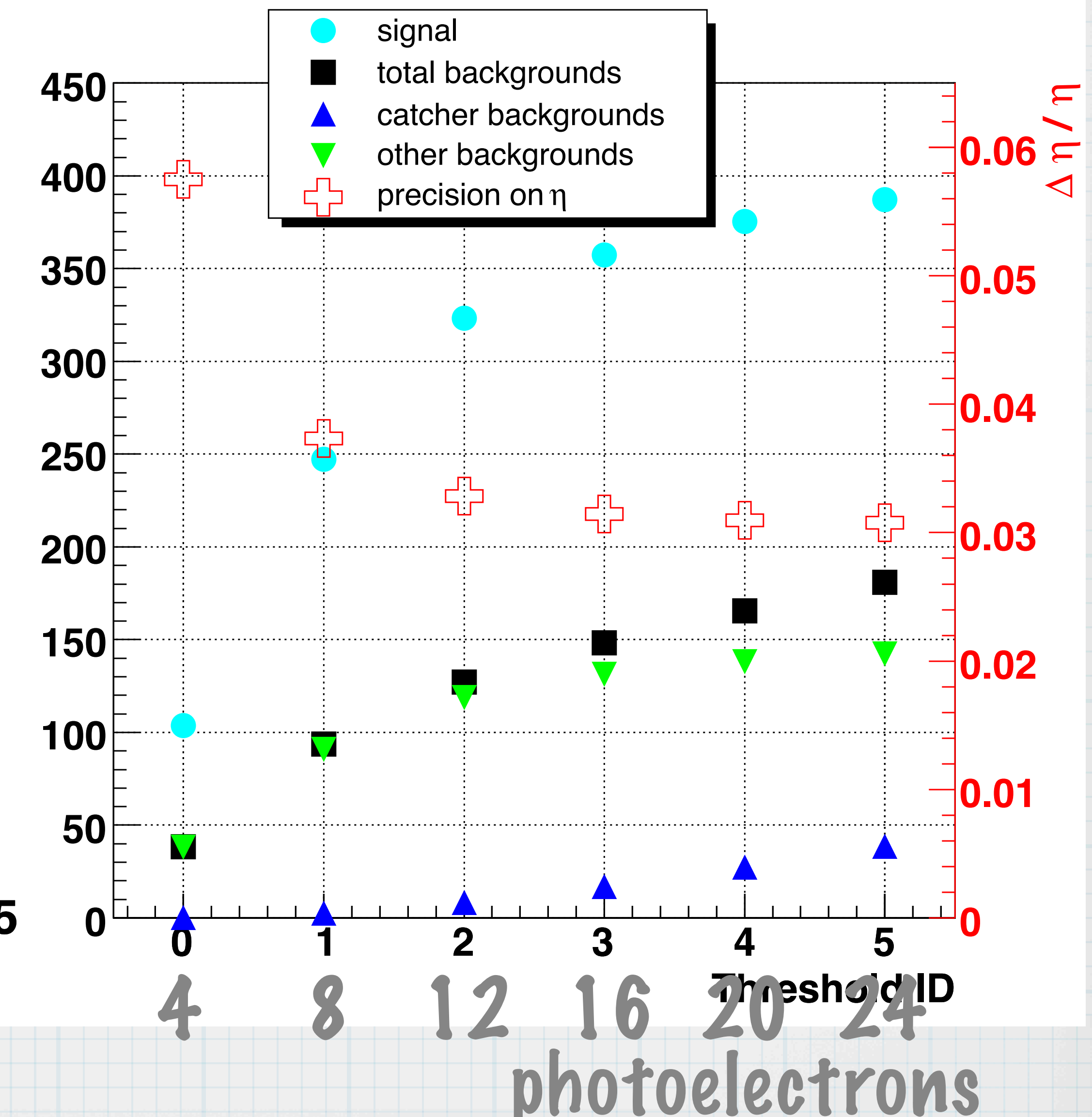
* 390 signal evts / $3x10^7$sec @ full intensity
* S/N=2.1





Step 2: BA rate, thr.



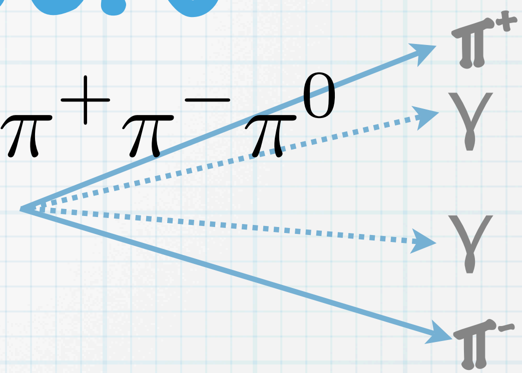


Studying ...

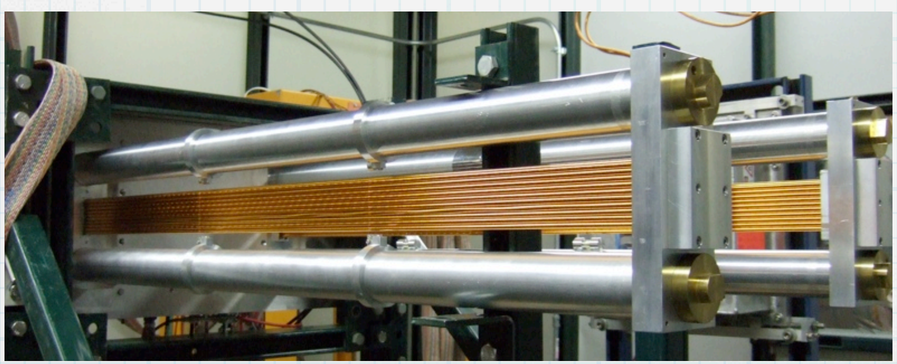
* Background sources and rates
* Photon veto inefficiency
* Veto in the neutral beam
* Collimation scheme
* Tracking w/straw chambers
* Photon angle measurement
* DAQ scheme
* --> Proposal by end of April !

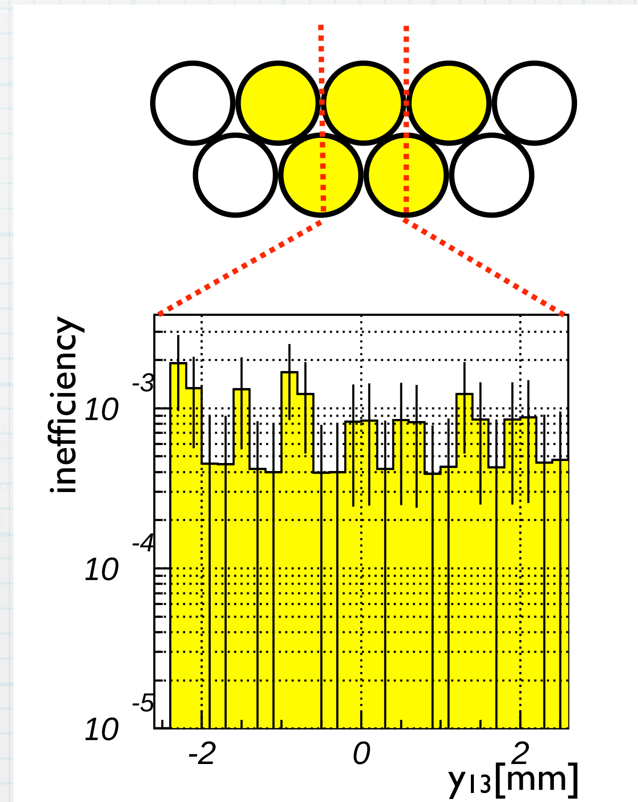
Straw Chambers

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



- Use it as a charged veto, and a tracking device to calibrate CsI
- Tested 5mmΦ, 1m long prototype at Fermilab

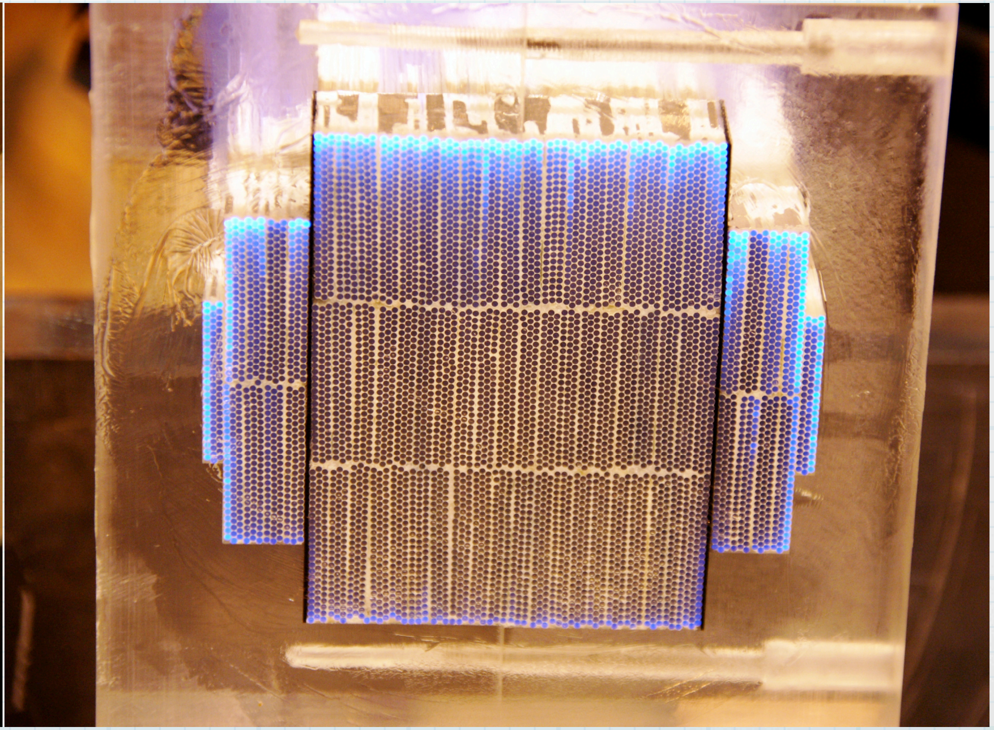




- $(7.7 \pm 1.1) \times 10^{-4}$ inefficiency w/2 layers

Spaghetti detector R&D

* Detect fused photons
* Measure photon angle



Beam test at SPring8

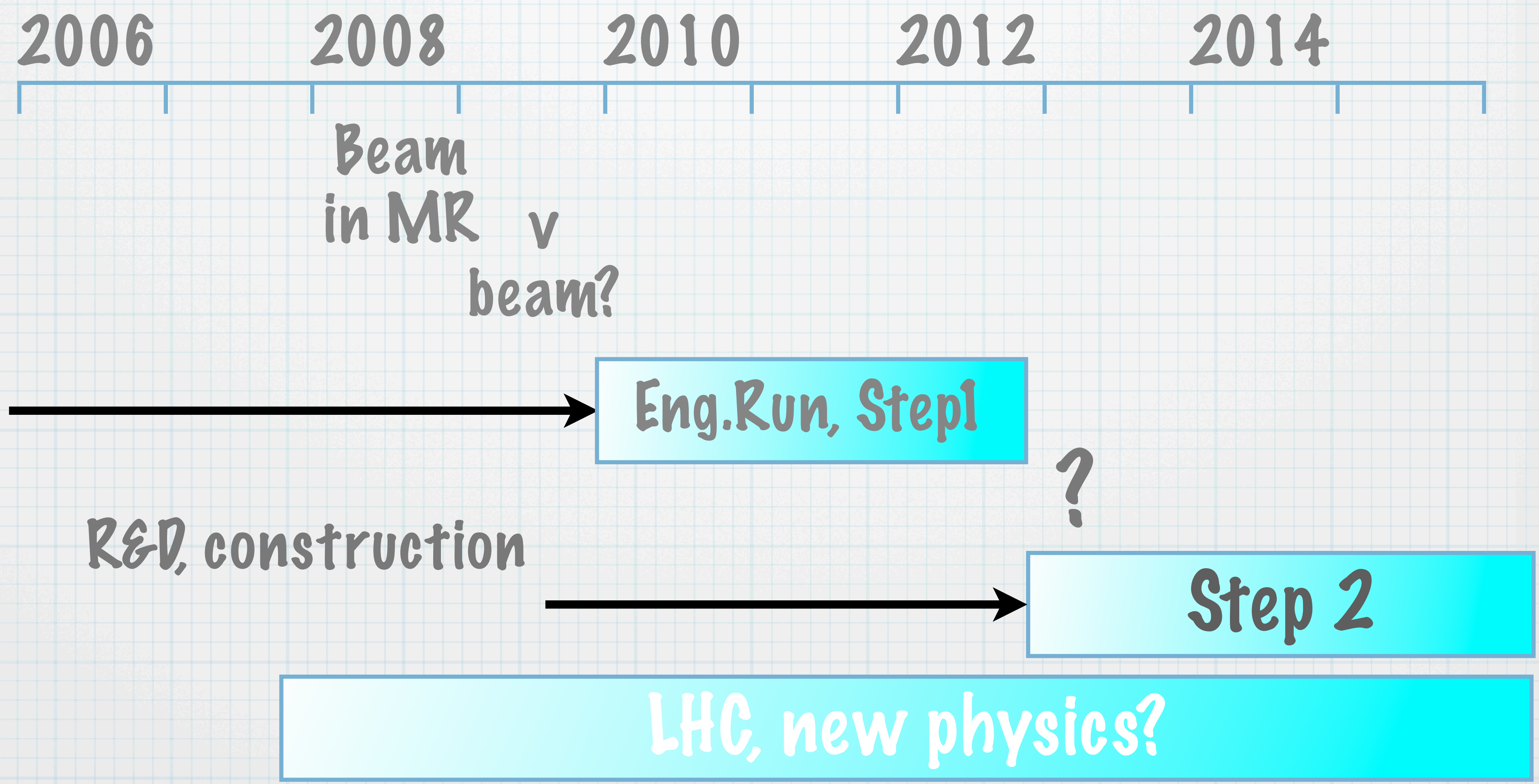
Trigger/DAQ

* Record waveform behind PMT for double hit isolation and low noise
* Level 1: Etot, 2γ, veto, ... -> 200kHz
* Level 2: clustering etc. w/FPGA -> 20kHz
* Online trig: ->3kHz
* 30kB/evt; <30MB/sec>

Proposal

* due by the end of April
* trying to finalize design parameters, etc.
* PAC in mid 2006

The next 10 years



Summary

- Step by step approach
- Step 1: Use modified E391a detector for studying and the first observation
- Step 2: New large detector for >100 signal events
- Proposal by end of April
- Looking for collaborators