J-Parc E14

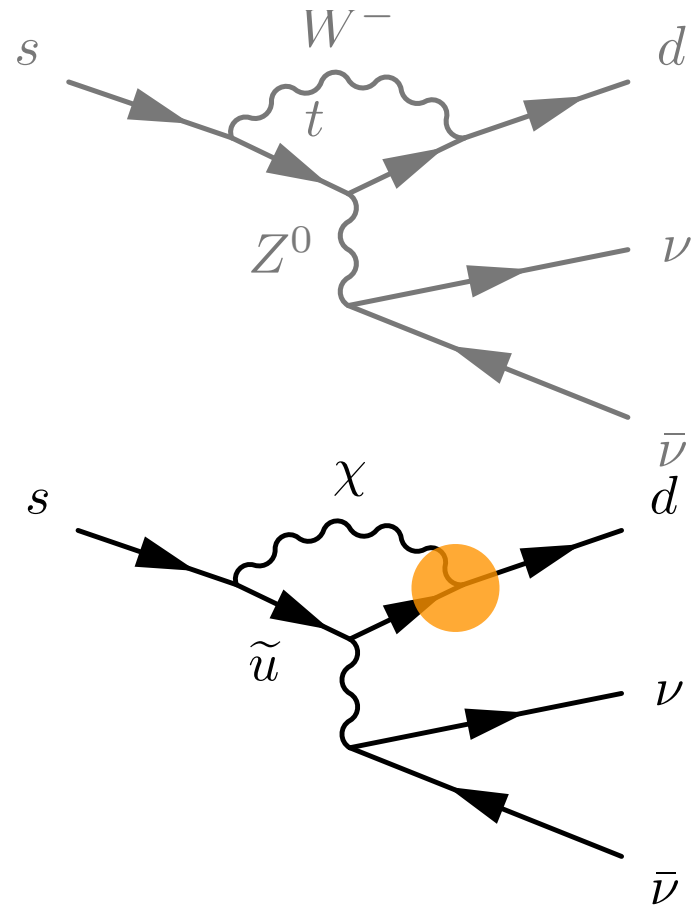
$K_L \to \pi^0 \nu\overline{\nu}$

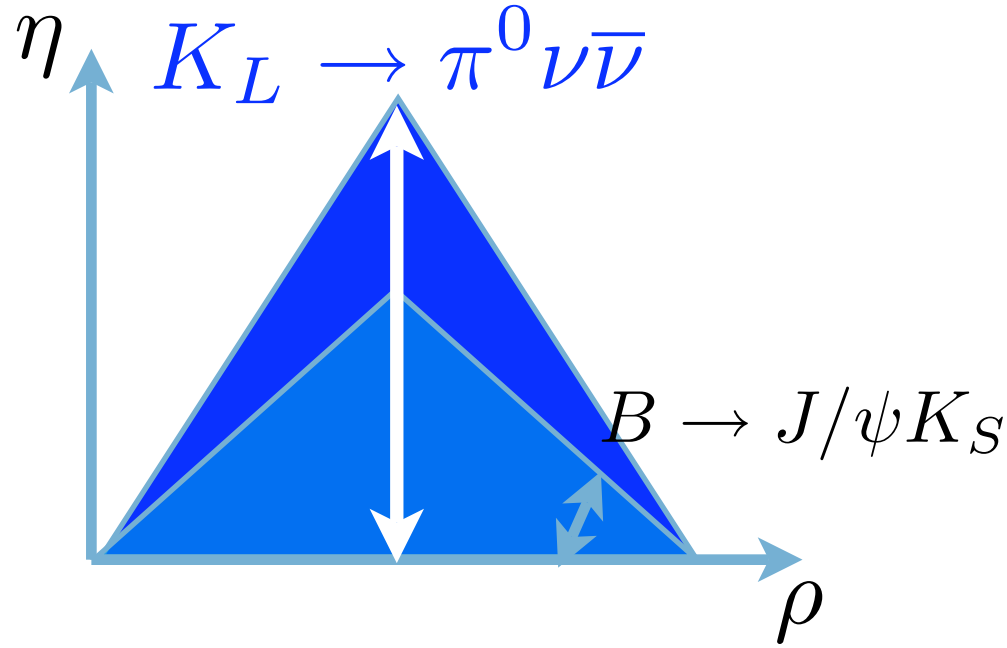
Taku Yamanaka
Osaka Univ.

Jul. 6, 2007
J-Parc PAC @ KEK

J-Parc E14

- Physics
  - Measure the CKM eta and probe new physics beyond the standard model.
- Goals
  - Step 1: First observation of the decay
  - Step 2: Measure BR to <10%





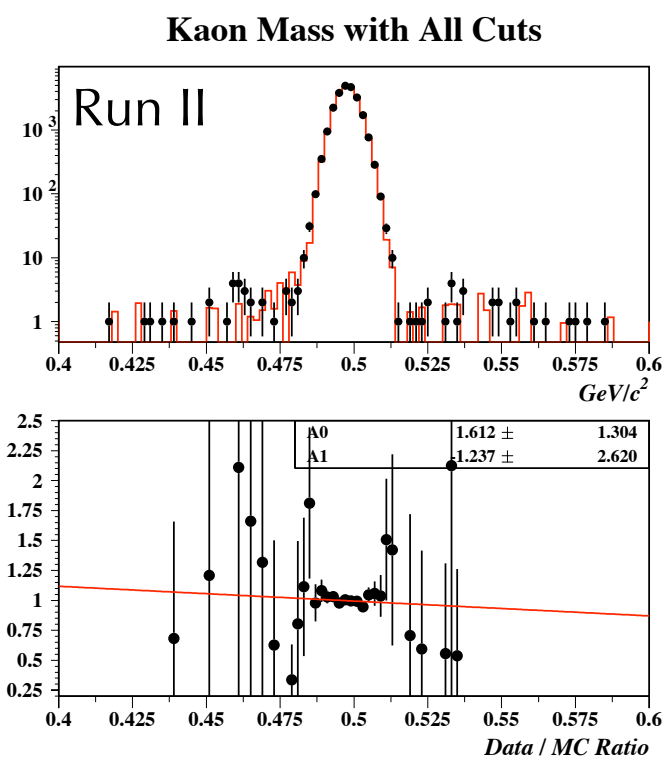
Outline

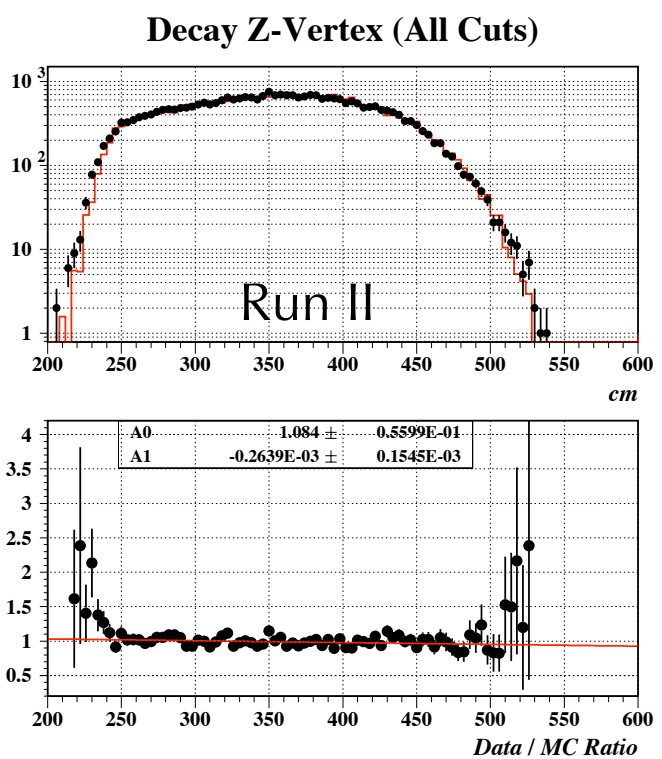
- Status of KEK PS E391a
- Summary of FIFC reports
- Schedule
- Budget and manpower
- Request and Summary

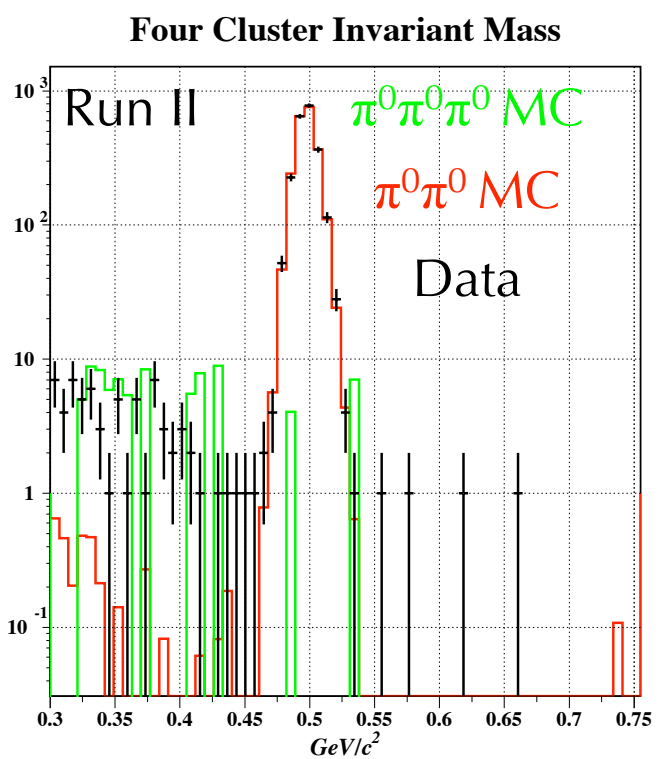
Status of KEK PS E391a Run-2 FULL data sample

K_L decays

- We understand
  - detector performance
  - K_L->3pi0 background under K_L->2pi0

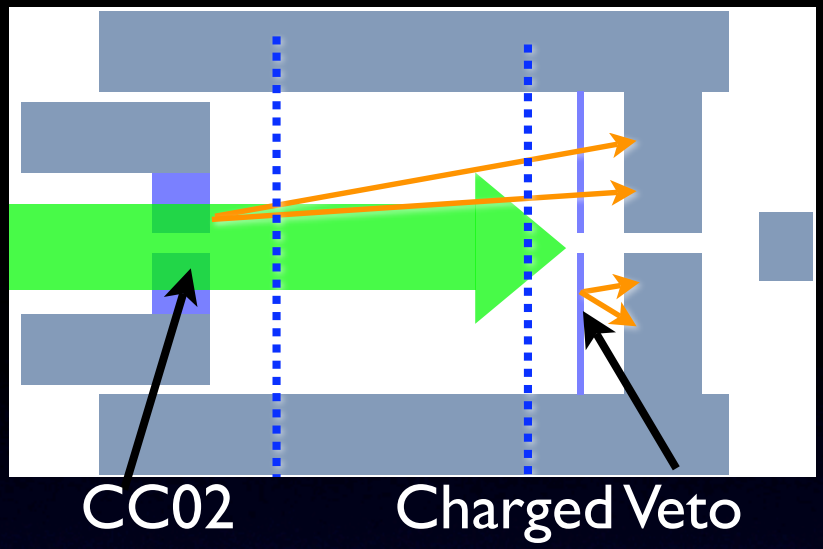


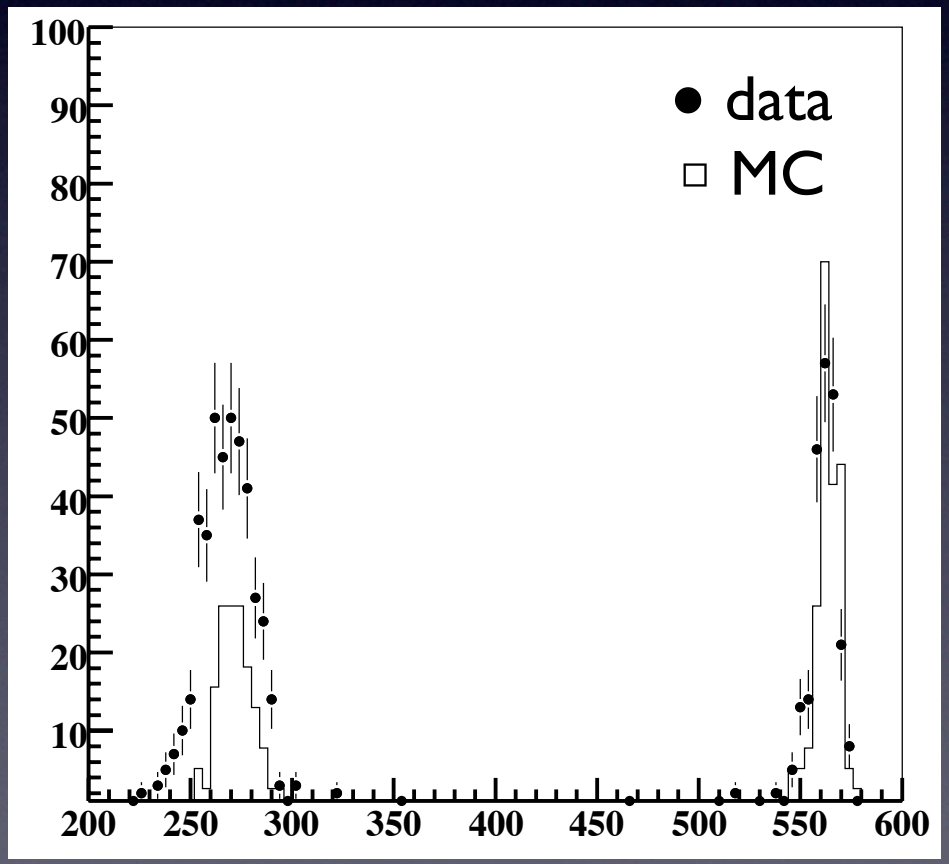


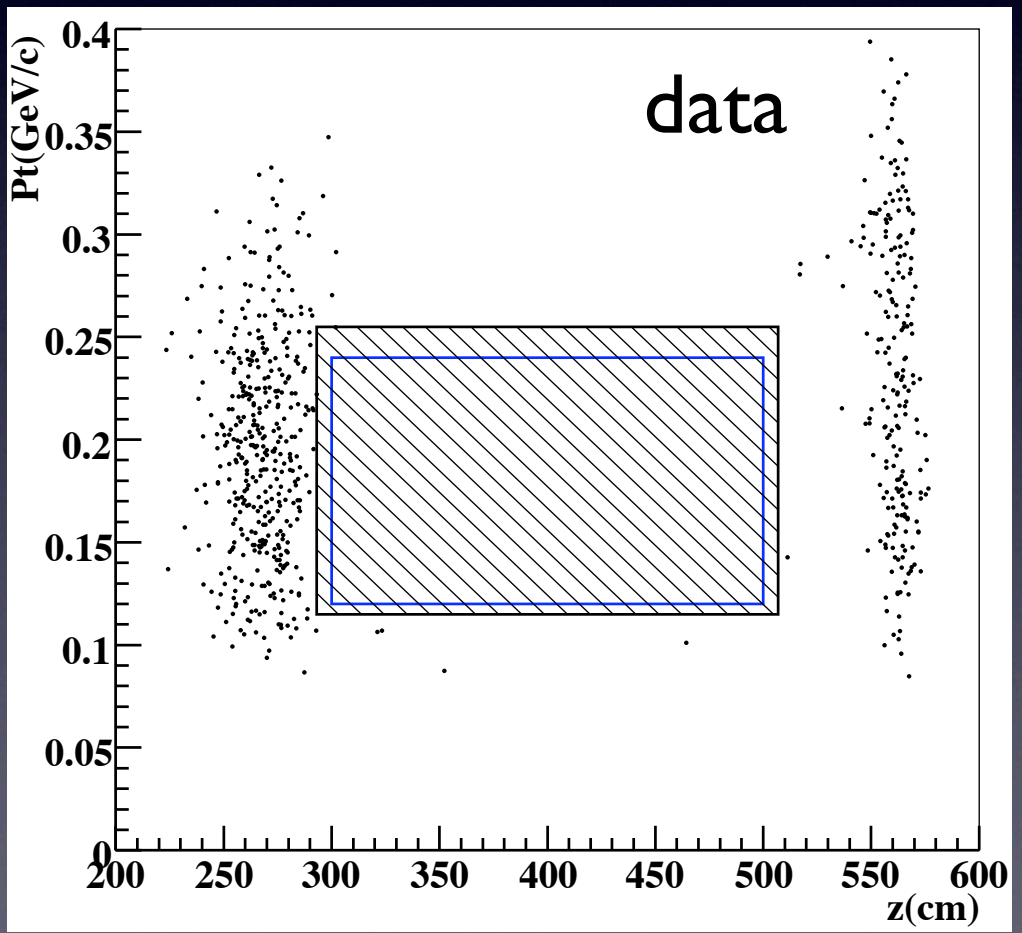


Halo neutron background

- Run 2 full data sample



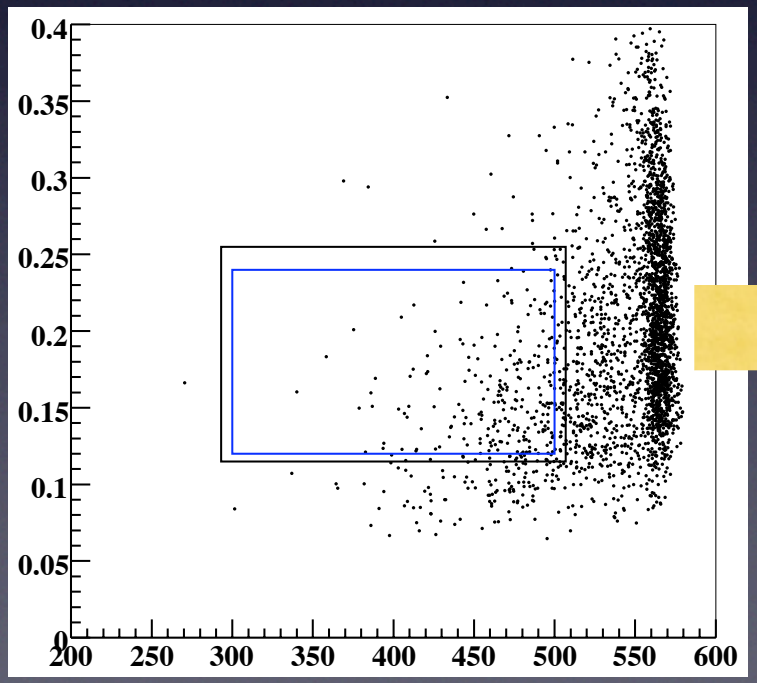


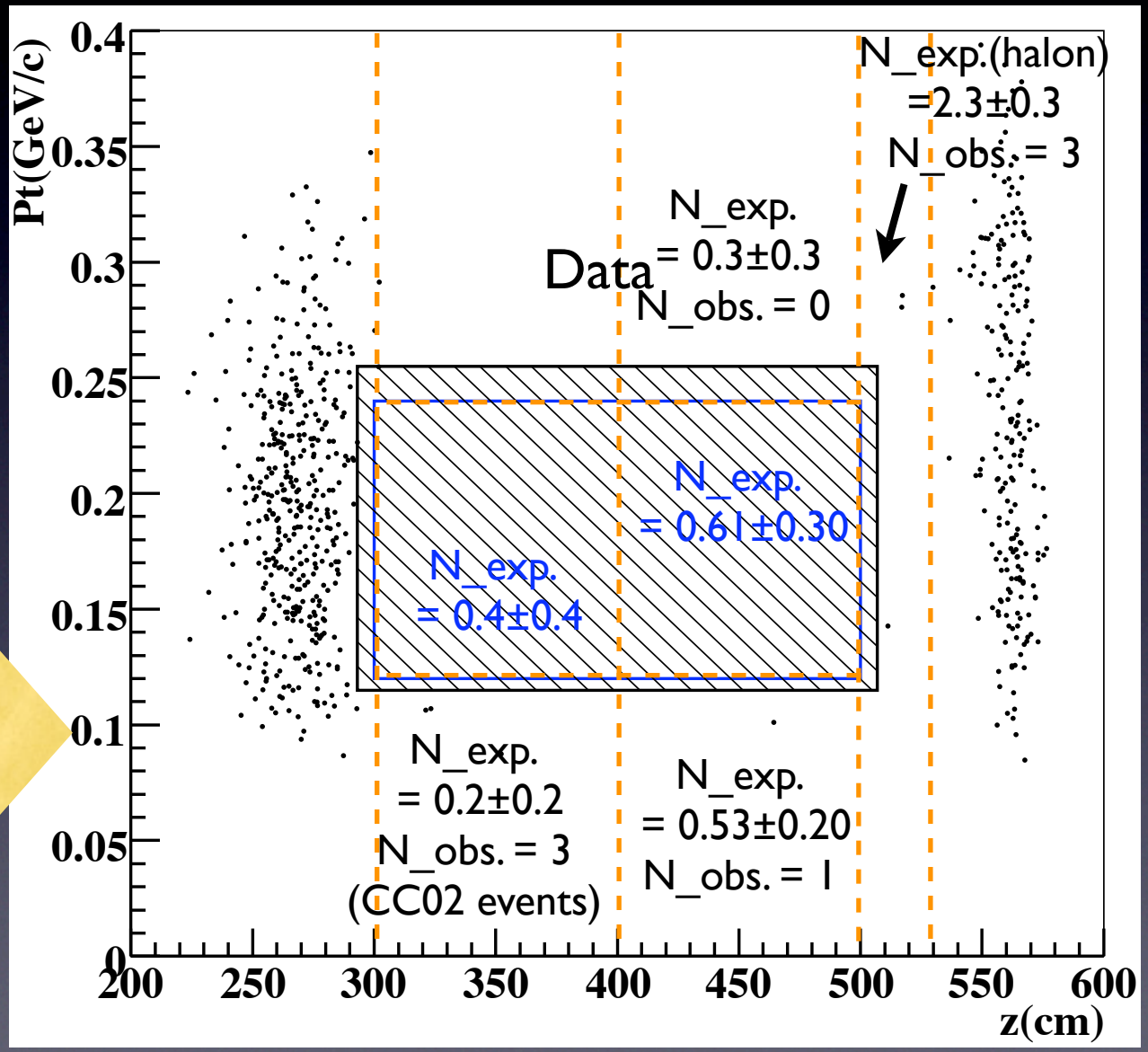


Halo n bkg from downstream

- ~1 event based on bifurcation study

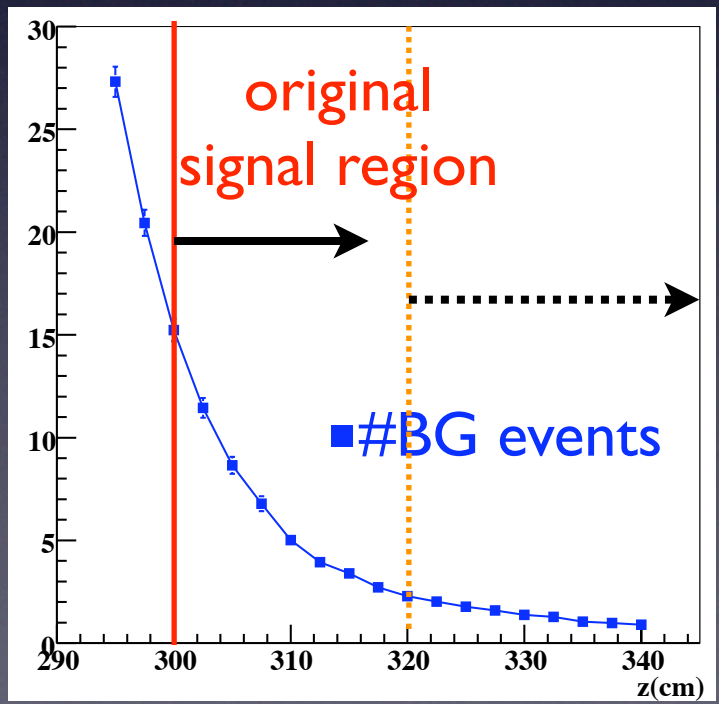
w/o photon veto

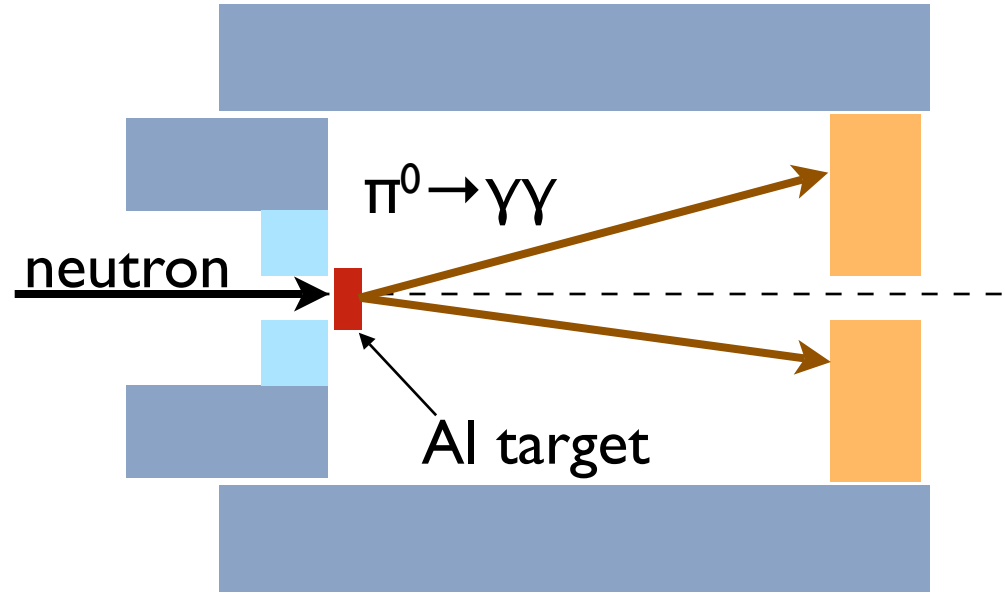


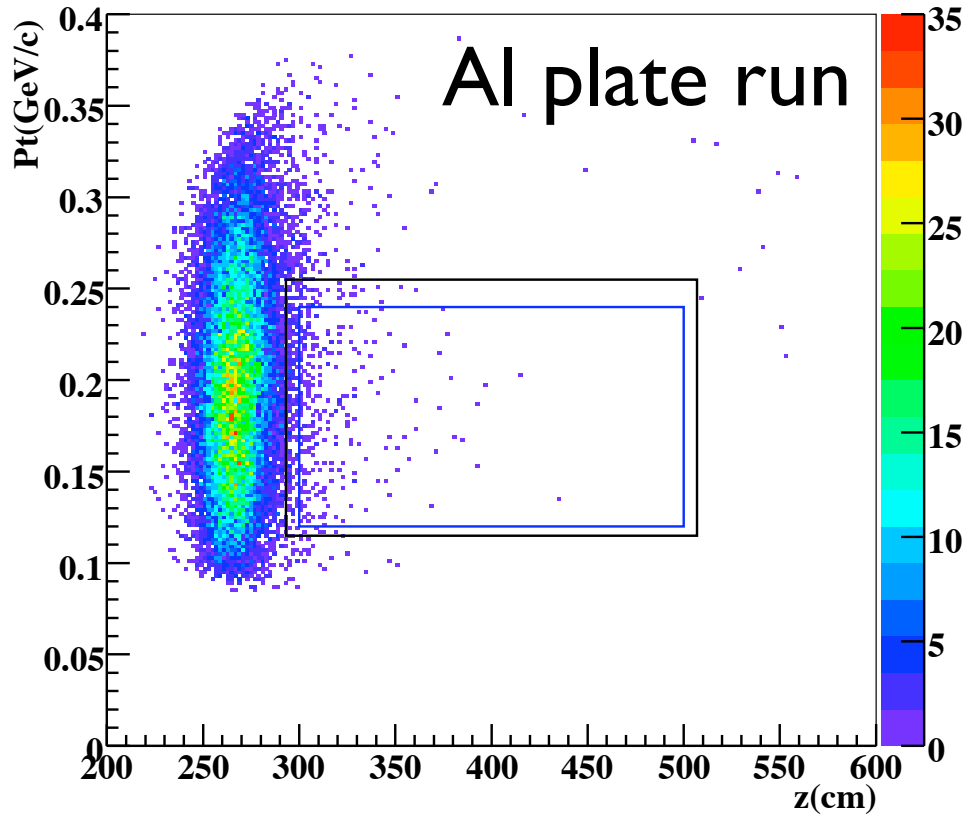


Halo n bkg from upstream

- Use special run w/ Al plate in beam, and used its z shape
- 2.3±0.3 events w/new z cut



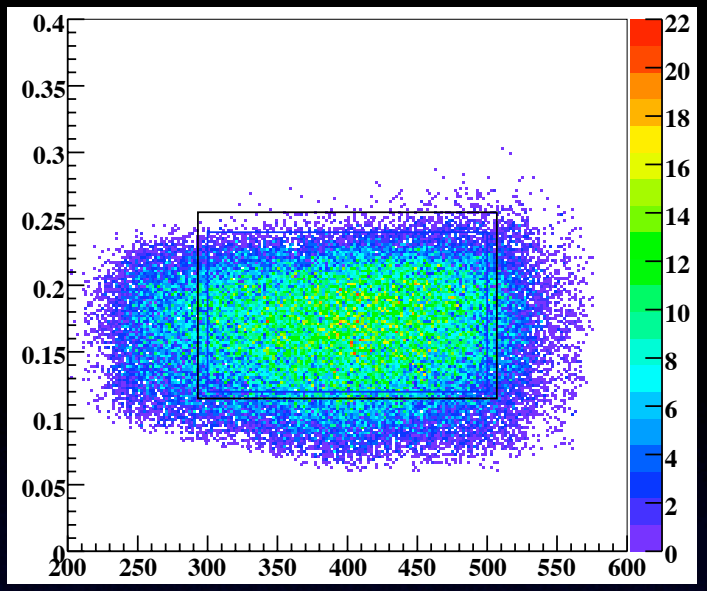


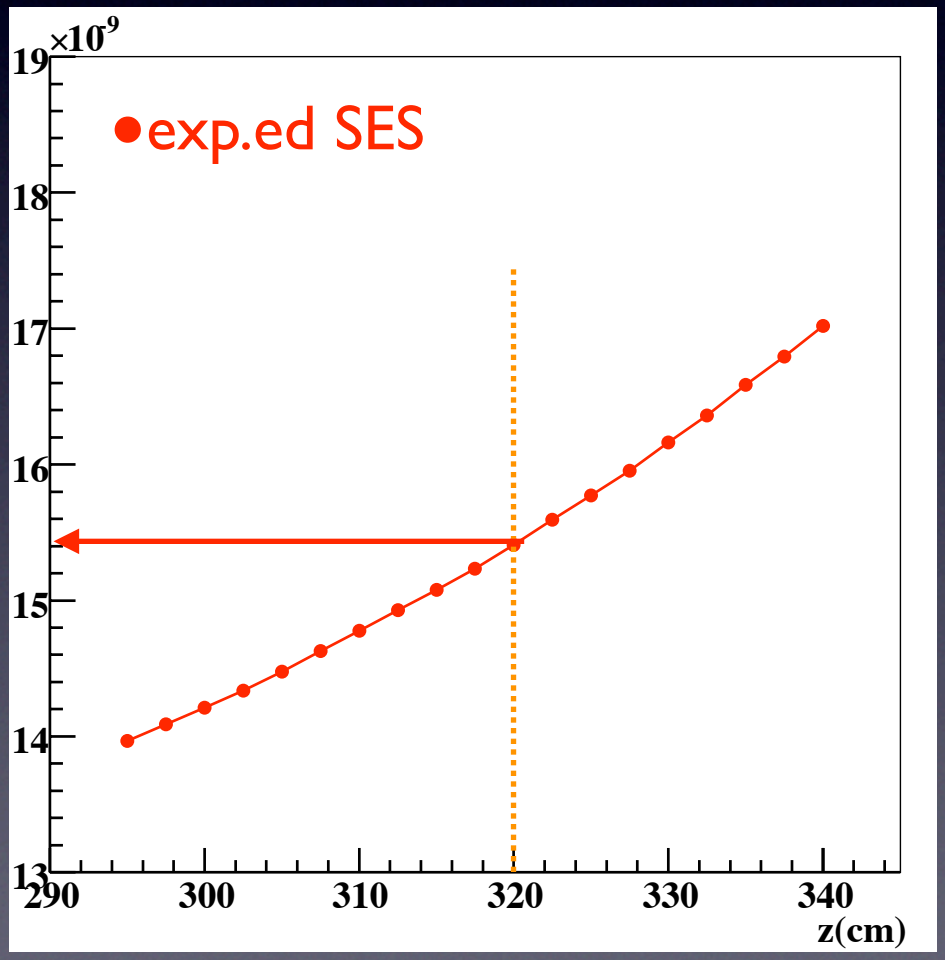


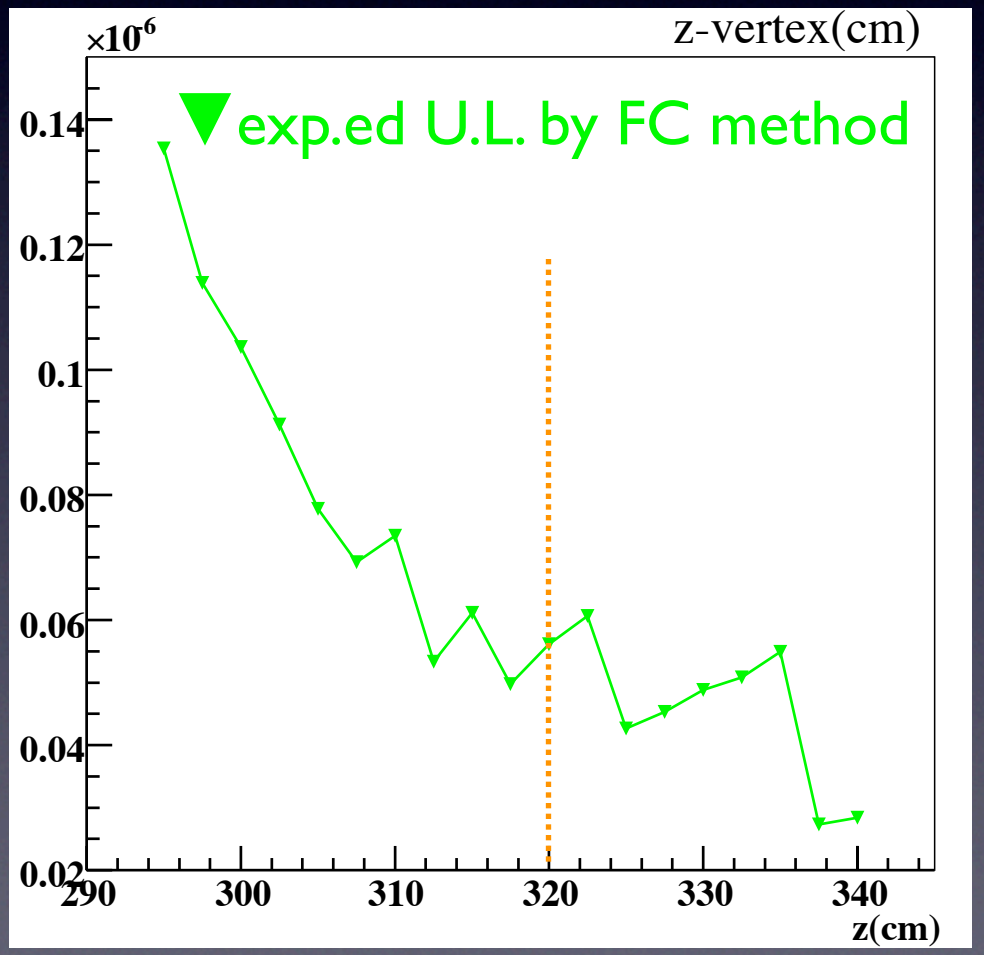
Sensitivity

- single event sensitivity

  ~ 1.54 x 10^{-8} for Run 2

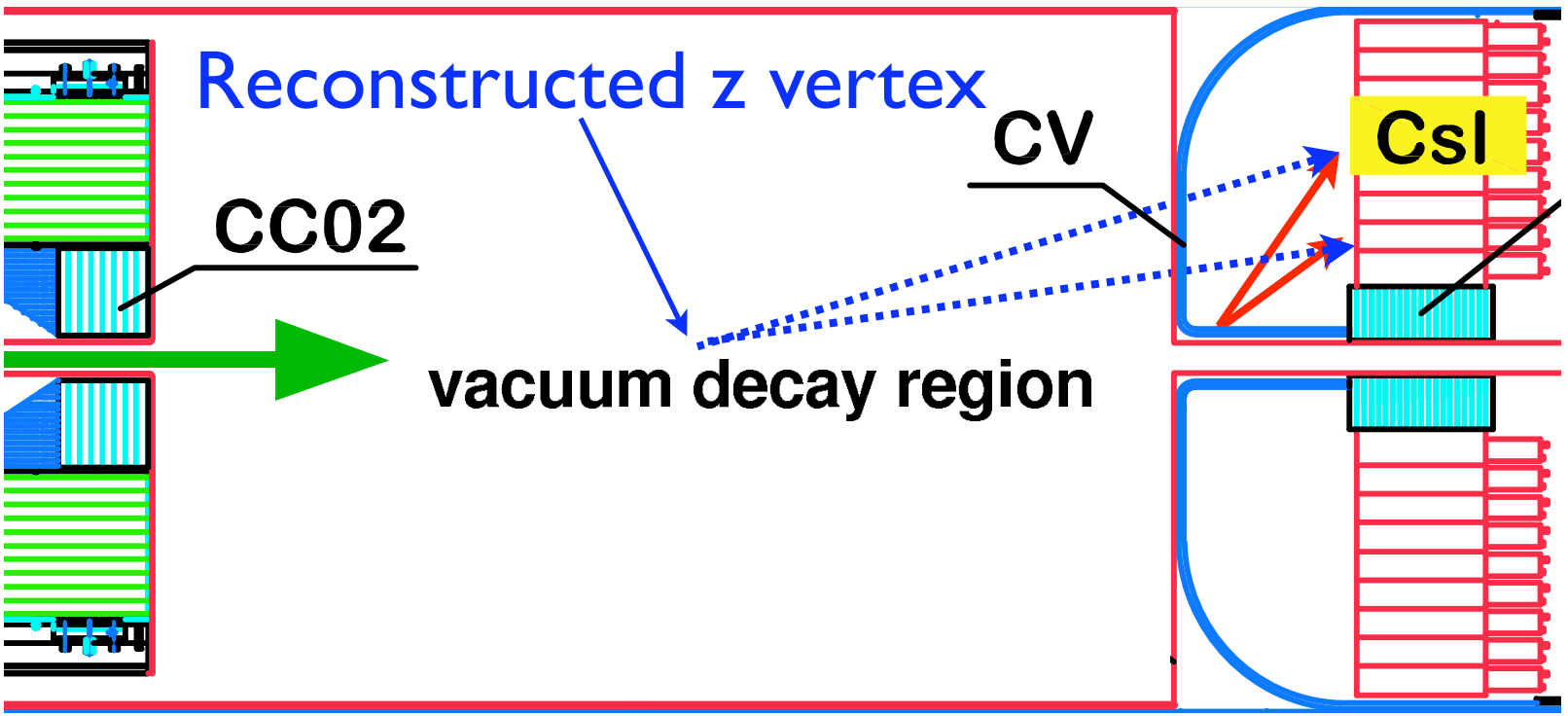






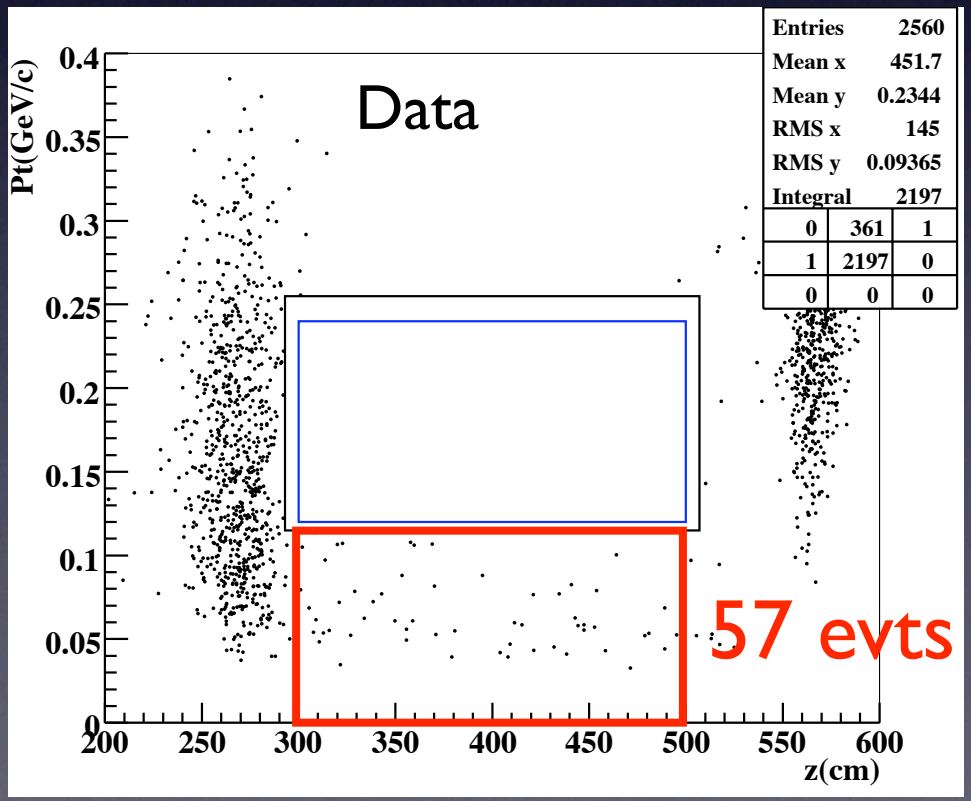
η background?

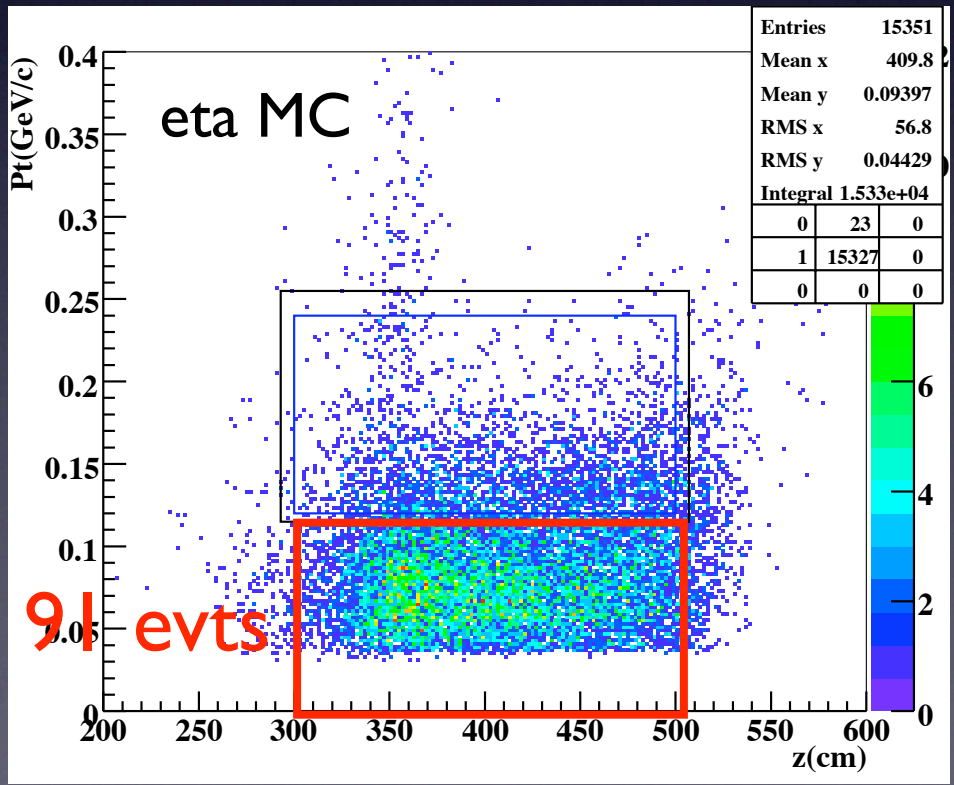
- η (m=548MeV/c^2)→γγ (BR=40%)
- halo neutron + charged veto around the beam produces η?



without R-z cut to enhance eta

- #events in low PT region agrees within <2

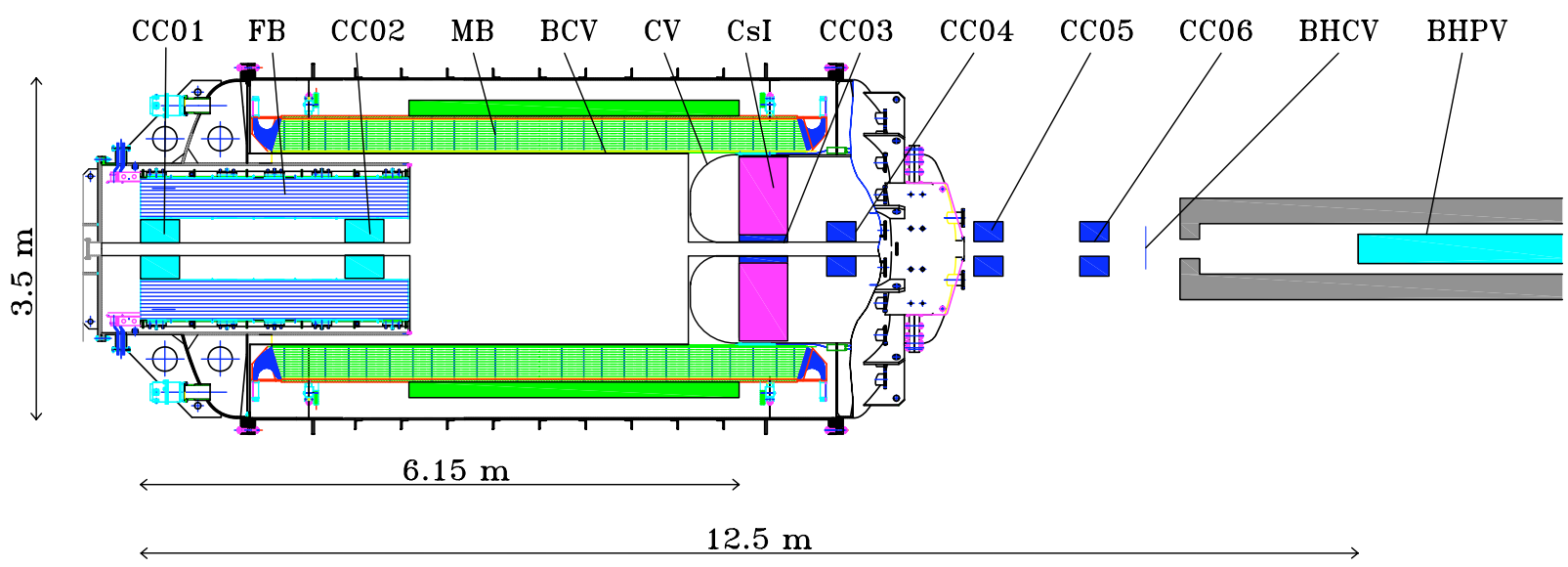




The J-Parc E14

J-Parc E14

- Improved beamline
- CsI: 7x7x30 ==> 2.5x2.5x50 cm^3
- Waveform digitization for rates and cost
- Upgraded veto counters



E14 Basic Strategies

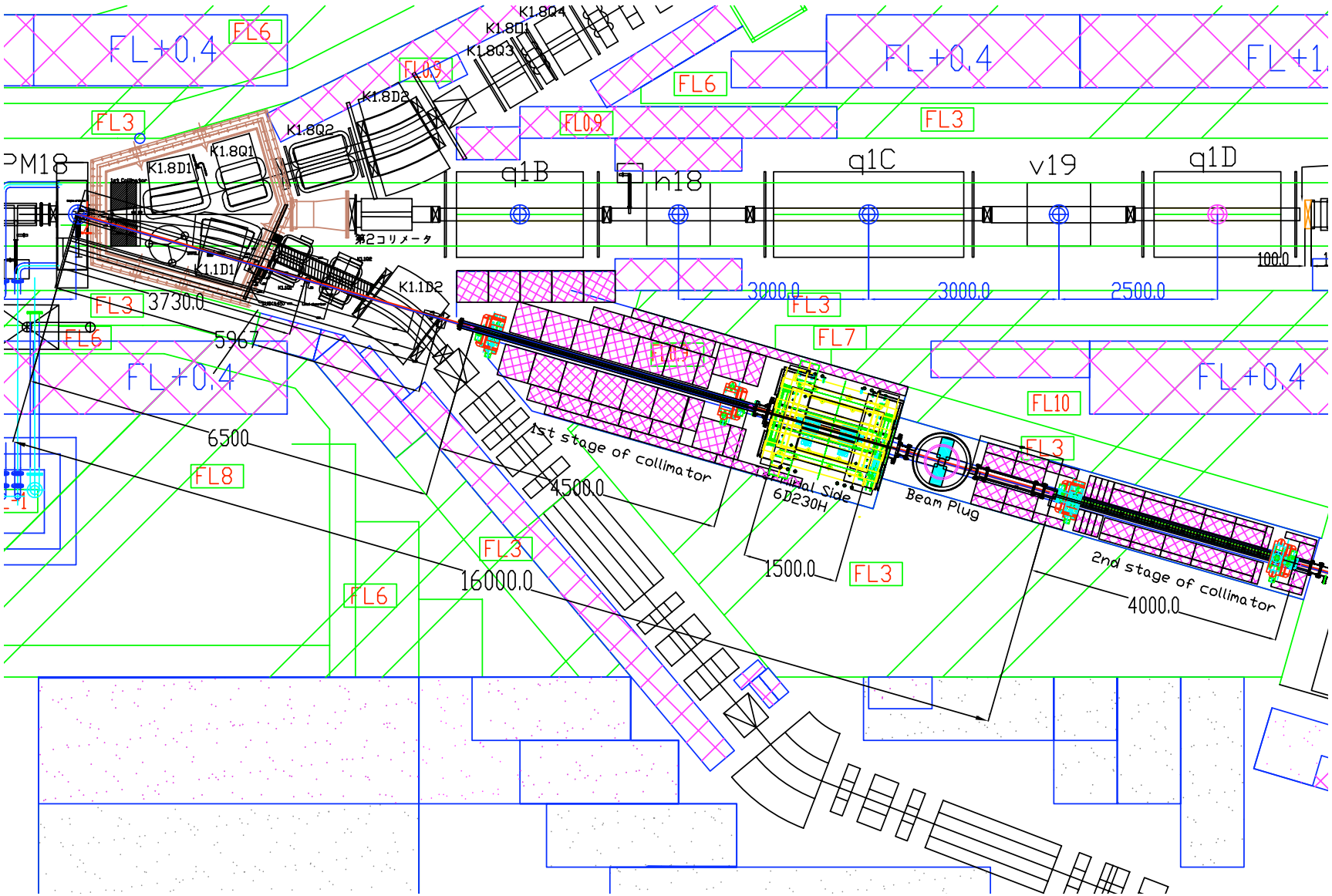
1. Suppress and control backgrounds based on the E391a experience
   1.1. Halo neutron backgrounds
   1.2. KL backgrounds
2. Make detector capable of handling high rates

E14 Strategy 1.1
Suppress halo neutron bkg

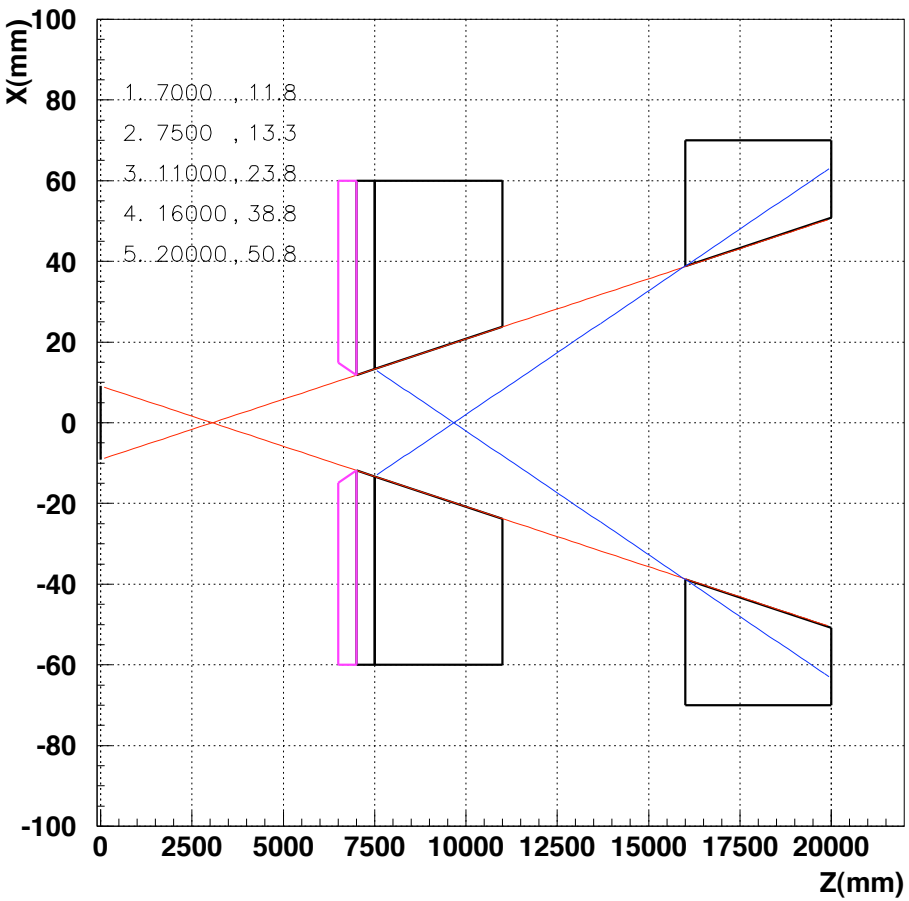
1. Reduce beam halo;
    1. halo n/K_L = halo n/core n (< 10^{-5})

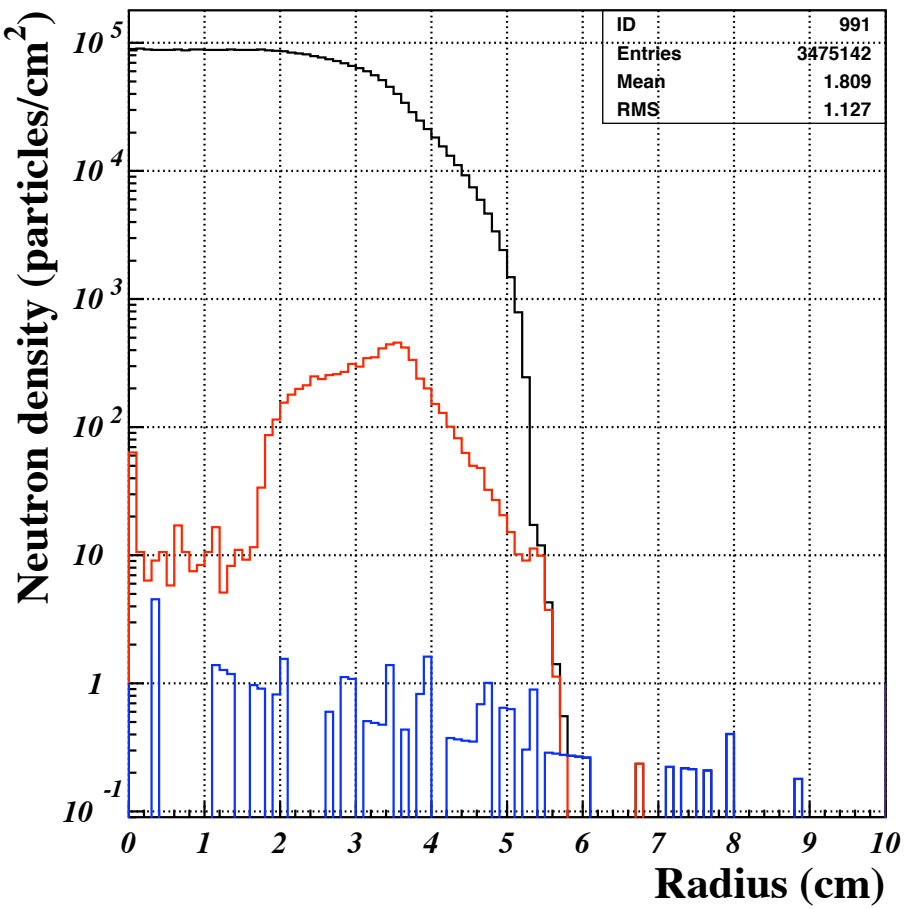
        x core n / K_L (<10)

FIFC: Beamline



I design chosen by quick MC

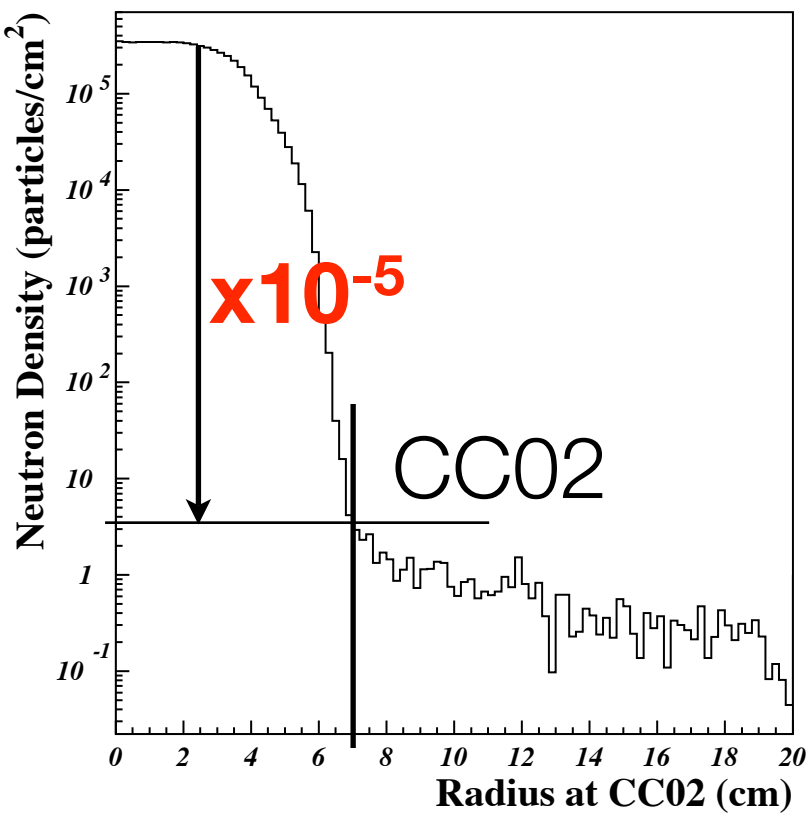




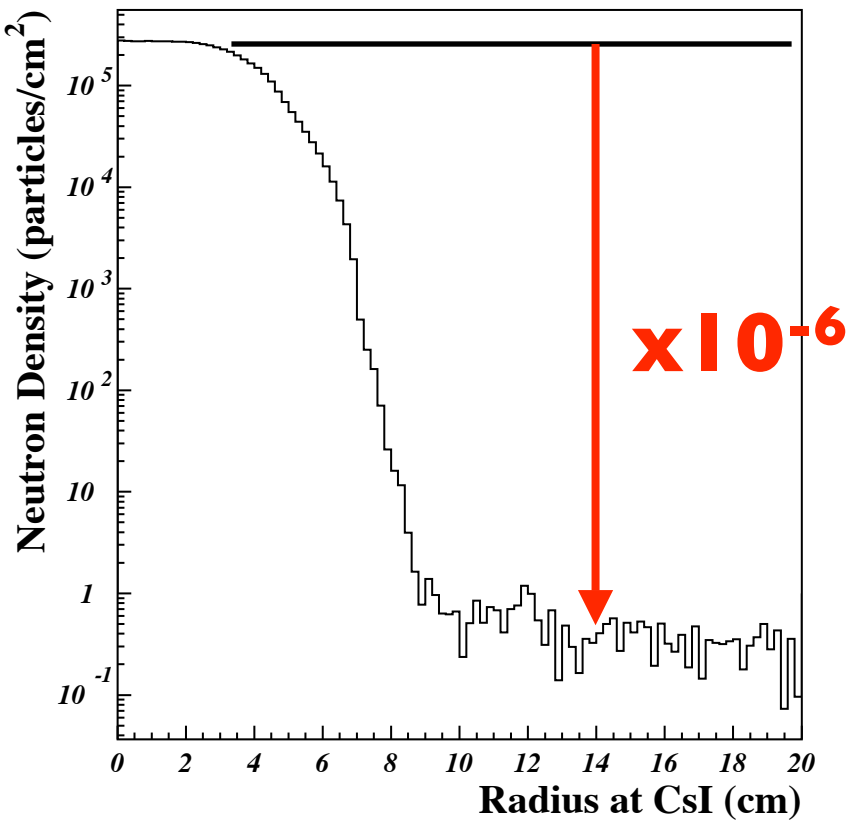
Geant4 simulation for halo neutrons

- 2×10^4 halo neutrons/pulse (2E14)

Neutron profile at CC02



Neutron profile at the CsI



core n / K_L

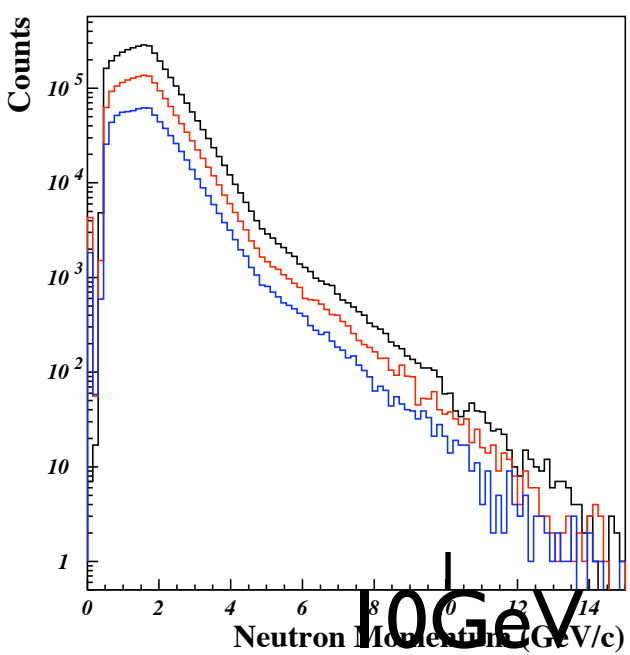
- n / K ~ 7 (T_n > 1GeV); << 40@E391a

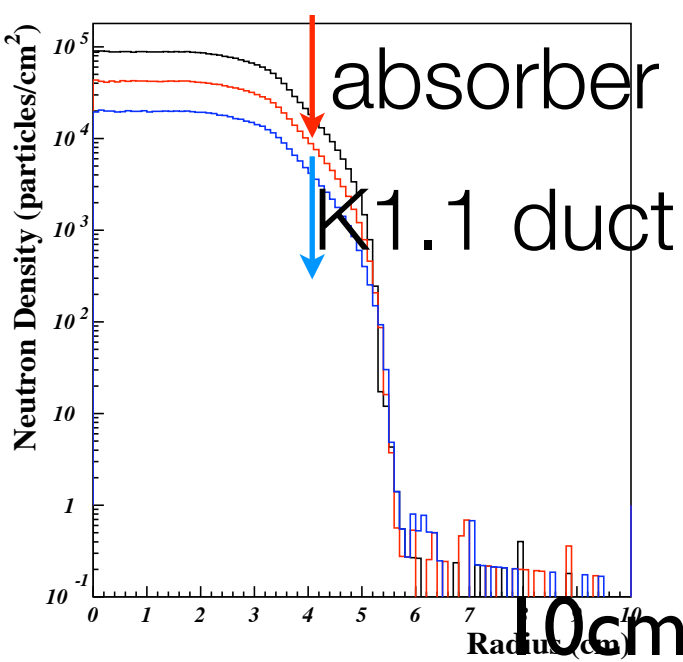
  due to large targeting angle (16deg)

particles	detailed simulation	proposal [1]
K_L	4.6×10^6	8.1×10^6
n ($E_n > 0.1$GeV)	1.4×10^8	3.4×10^8
n ($E_n > 1.0$GeV)	3.0×10^7	6.9×10^7
γ (> 2MeV)	0.9×10^8	4.5×10^8
γ (> 10MeV)	1.3×10^7	6.1×10^7
γ (> 100MeV)	$< 10^6$	$< 10^6$

K1.1 duct

- 5mm thick SUS beam duct for K1.1 does not affect the halo, but reduces the K and n by x1/2.
- Thinner window is necessary



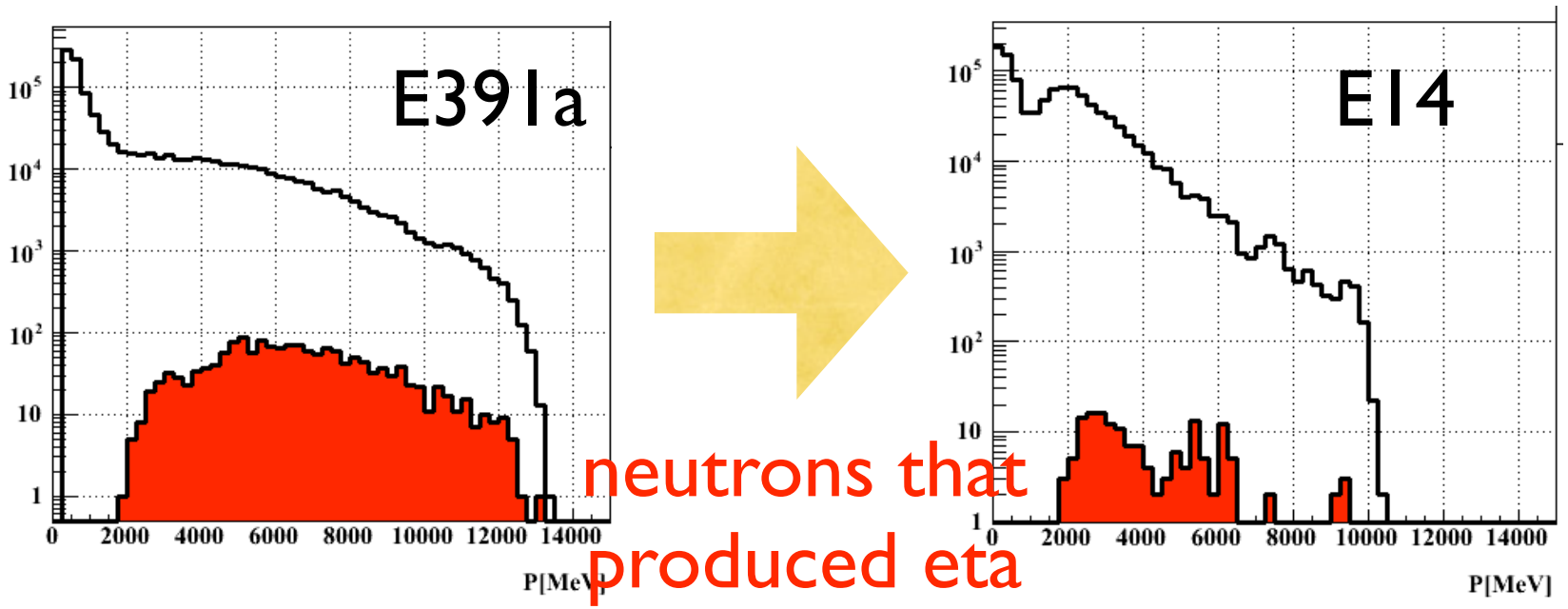


10GeV

10cm

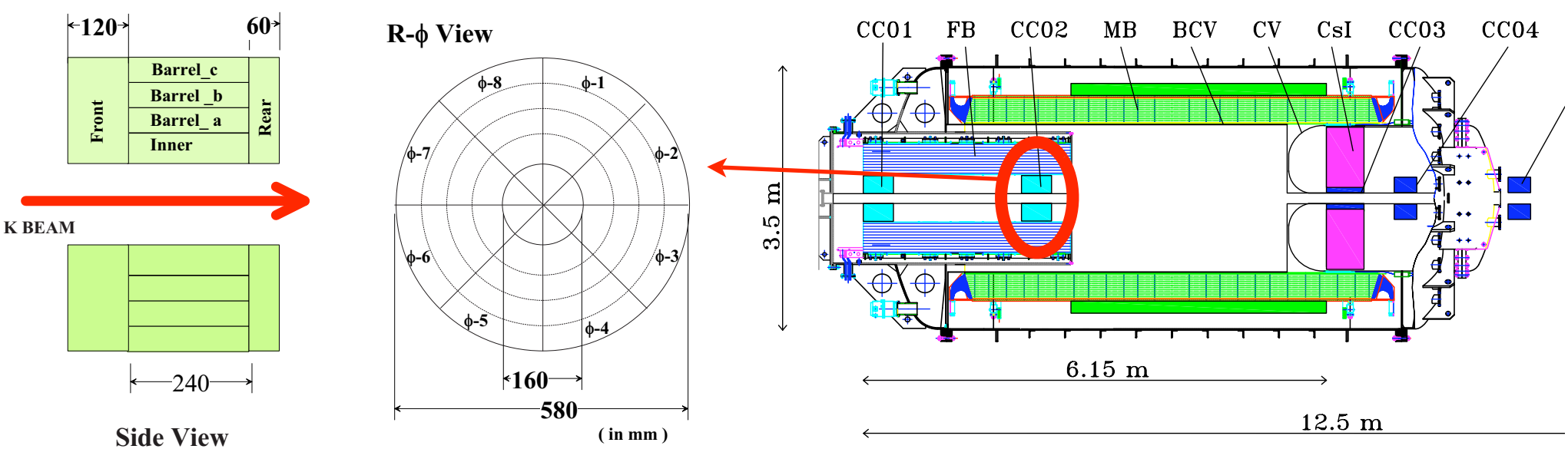
E14 Strategy 1.1
Suppress halo neutron bkg

1. Reduce beam halo; halo/core < 10^{-5}
2. Reduce pi0 and eta production
    1. Lower neutron momentum



E14 Strategy 1.1
Suppress halo neutron bkg

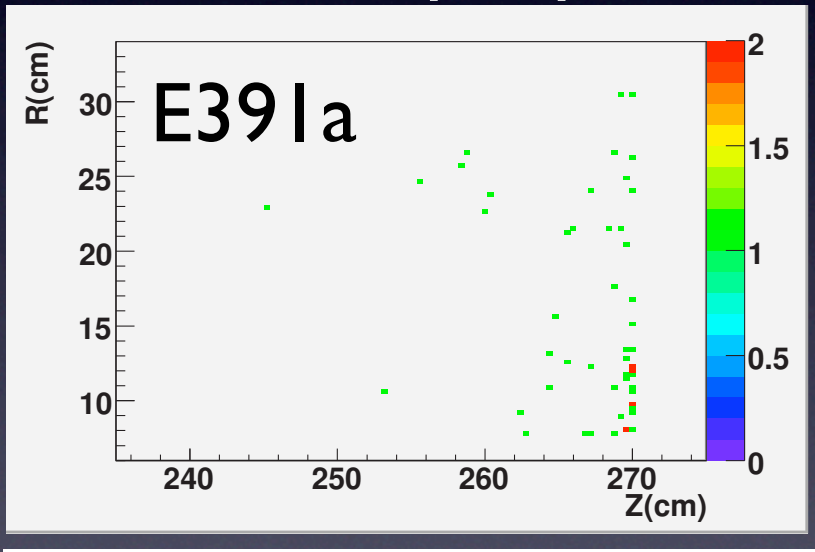
1. Reduce beam halo; halo/core < 10^{-5}
2. Reduce pi0 and eta production
3. Detect halo neutron interaction and veto
    1. Neutron Collar Counter (segmented CsI)

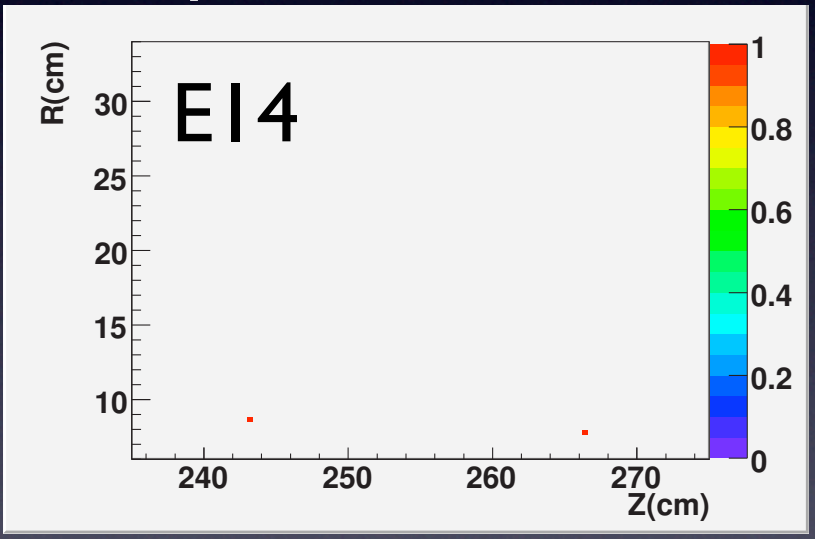


NCC

- Suppresses and vetoes pi0 bkg

pi0 prouduction points



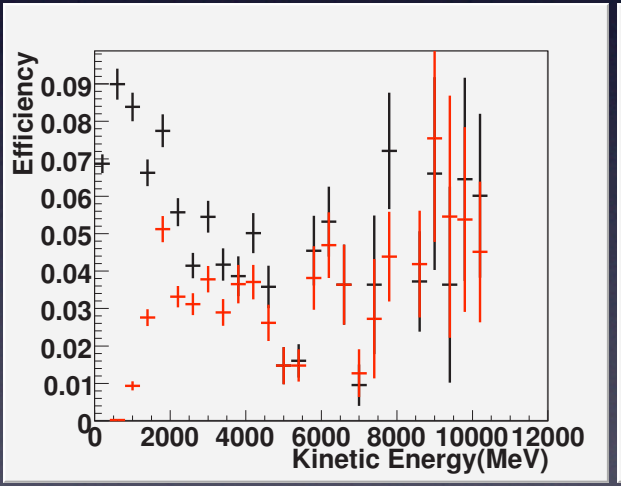


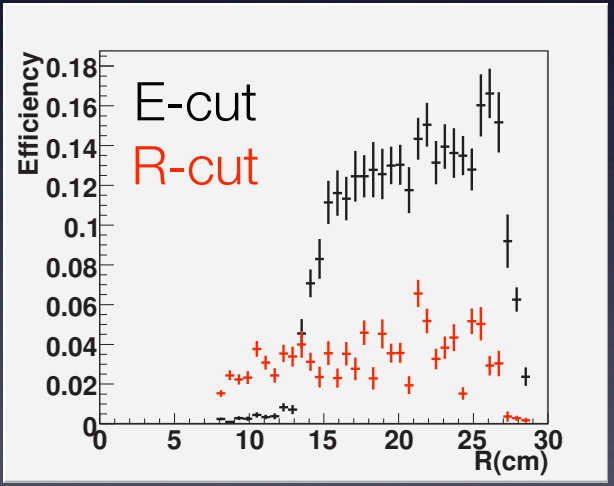
Counter	Generated	π^0 in CAL	After veto	In the signal box
CC02	10^8	6964	55	0.06
NCC2	10^8	869	2	0.001

NCC

- can measure halo neutron profile and energy spectrum

Neutron detection efficiency





Cut set	ϵ_n	ϵ_K	Ratio (ϵ_n/ϵ_K)	K_L contamination
E-cut	6.3%	0.1%	63	5.4%
R-cut	2.9%	0.08%	37	9.2%

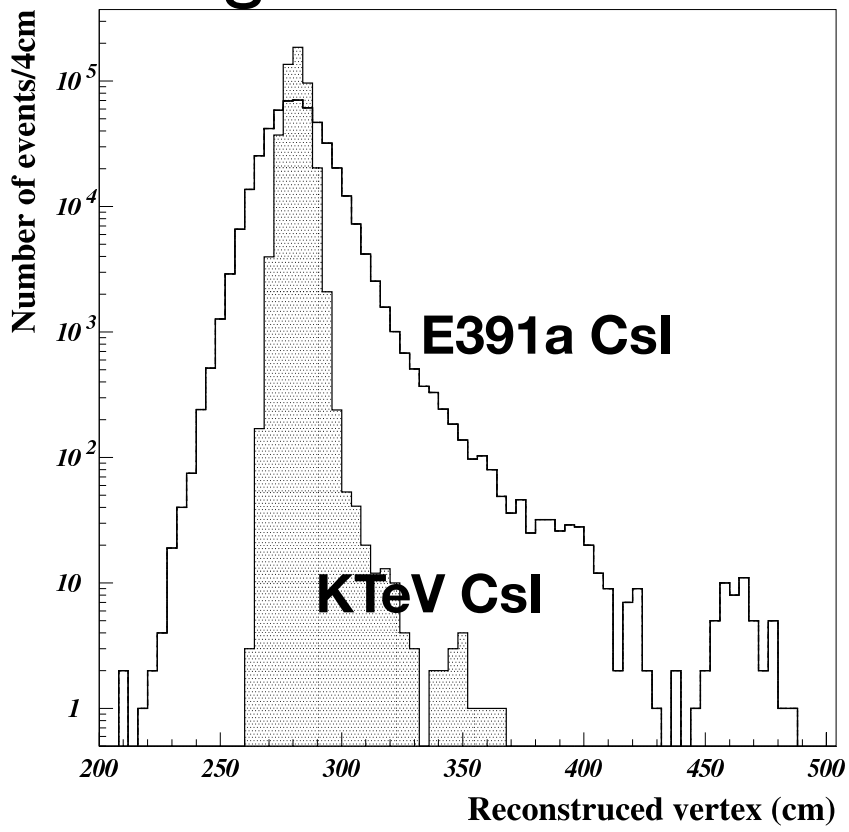
E14 Strategy 1.1
Suppress halo neutron bkg

1. Reduce beam halo; halo/core < 10^{-5}
2. Reduce pi0 and eta production
3. Detect halo neutron interaction and veto
4. Localize background by better calorimeter resolutions

KTeV CsI Calorimeter

- 30cm -> 50cm
  - reduces energy response tail due to shower leakage
- 7cm -> 2.5cm square
  - position resolution 5mm -->1mm

Halo neutron background at CC02



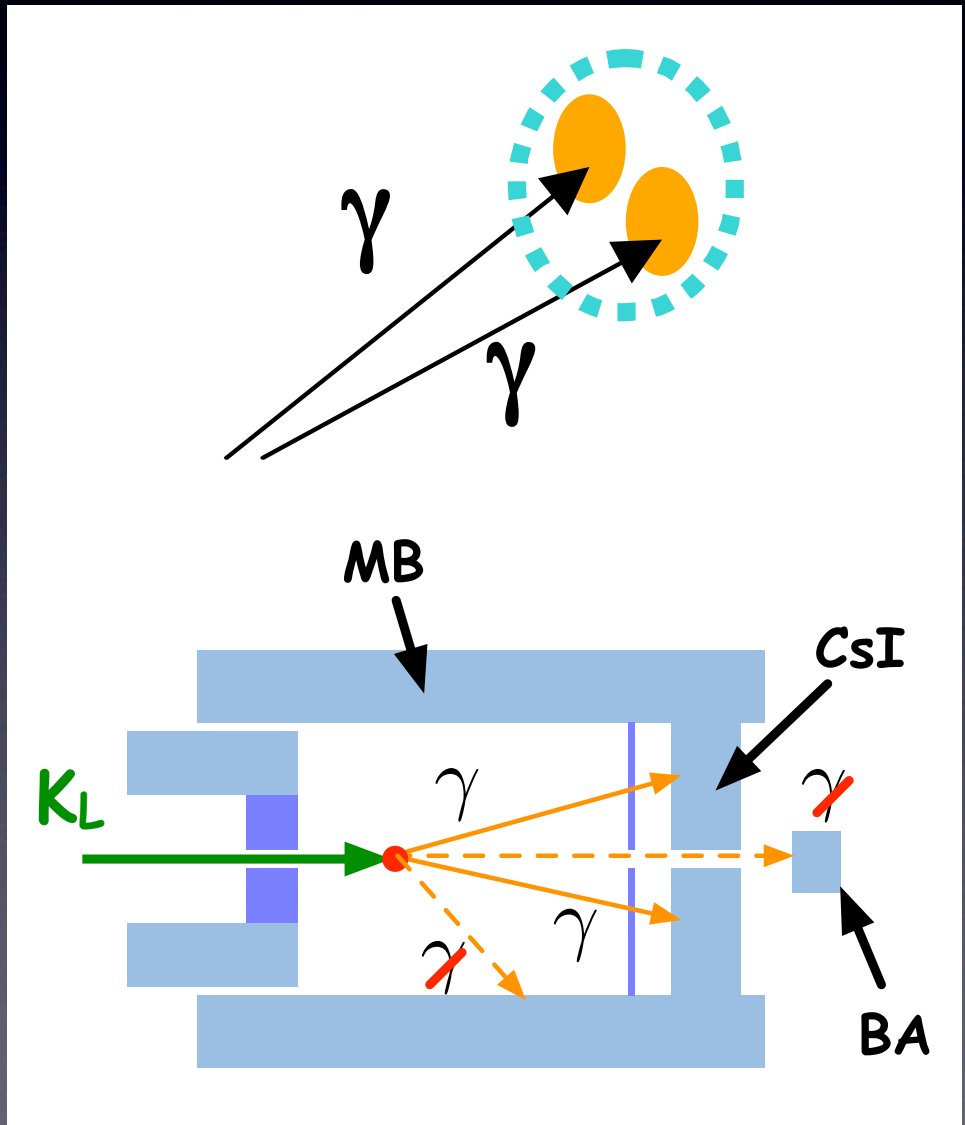
Halo neutron background at E14

- With
  - halo neutron / K_L = 5×10^{-3} (E391a:0.33)
  - low halo neutron momentum
  - CsI resolution
- CC02 bkg 0.07 evts
- eta bkg <O(1) evts, under study

E14 Strategy 1.2
Suppress K_L background

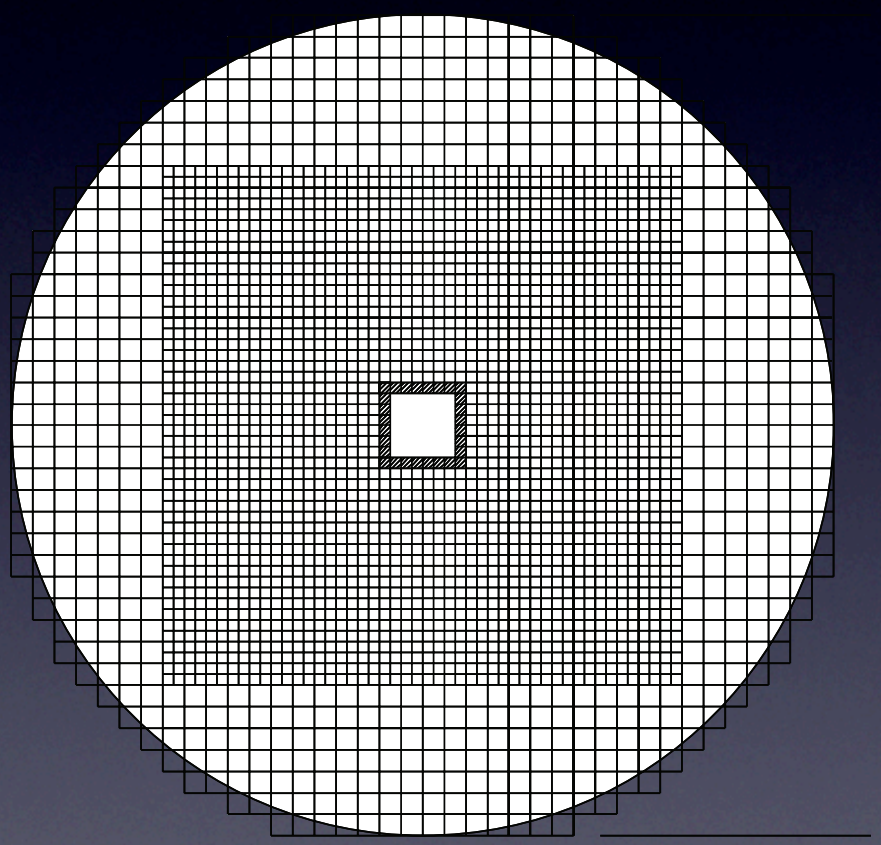
1. Identify fused photon clusters

2. Better veto, especially in the beamline



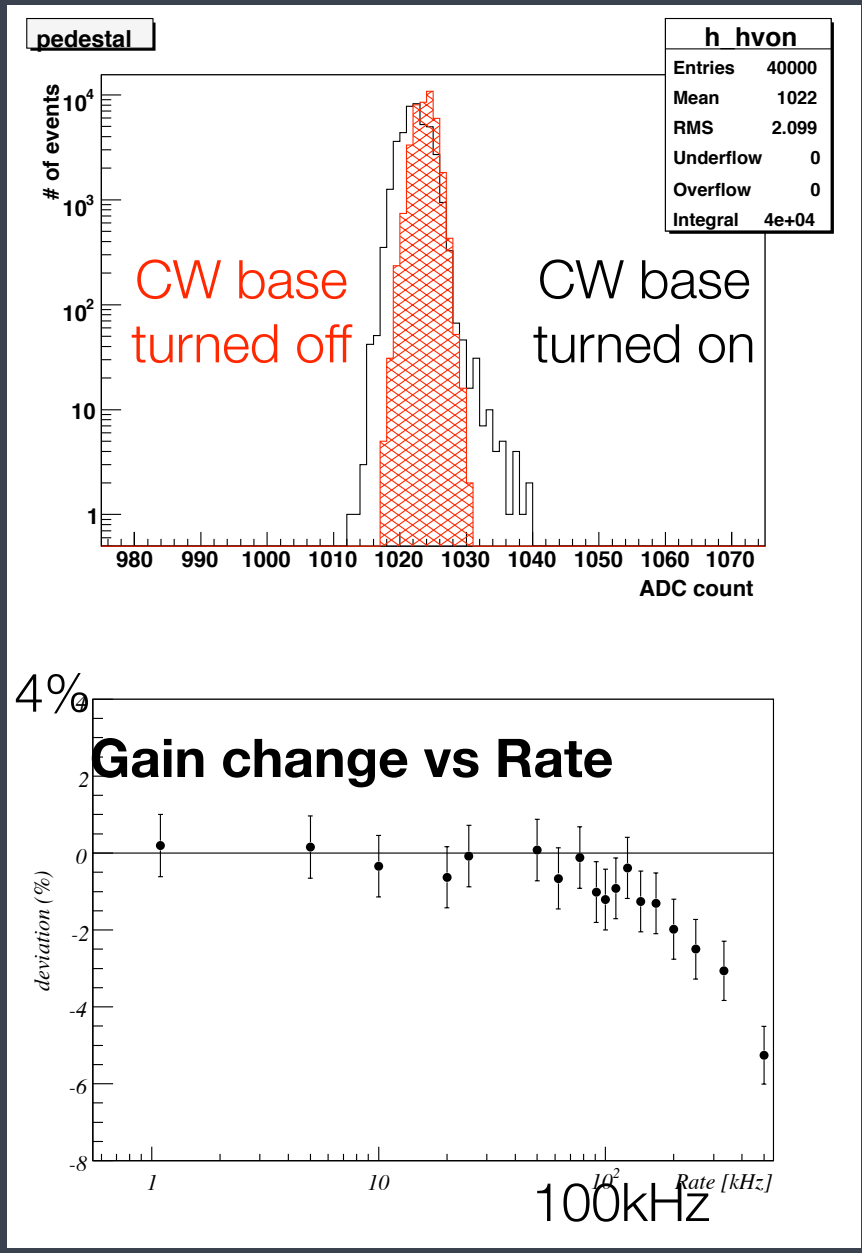
KTeV CsI

- Ownership is transferred from FNAL to Univ. Chicago
- Engineer+technician are preparing for unstacking
- Will start disassembling / shipping in August 2007
- Will test CsI and PMTs at Osaka



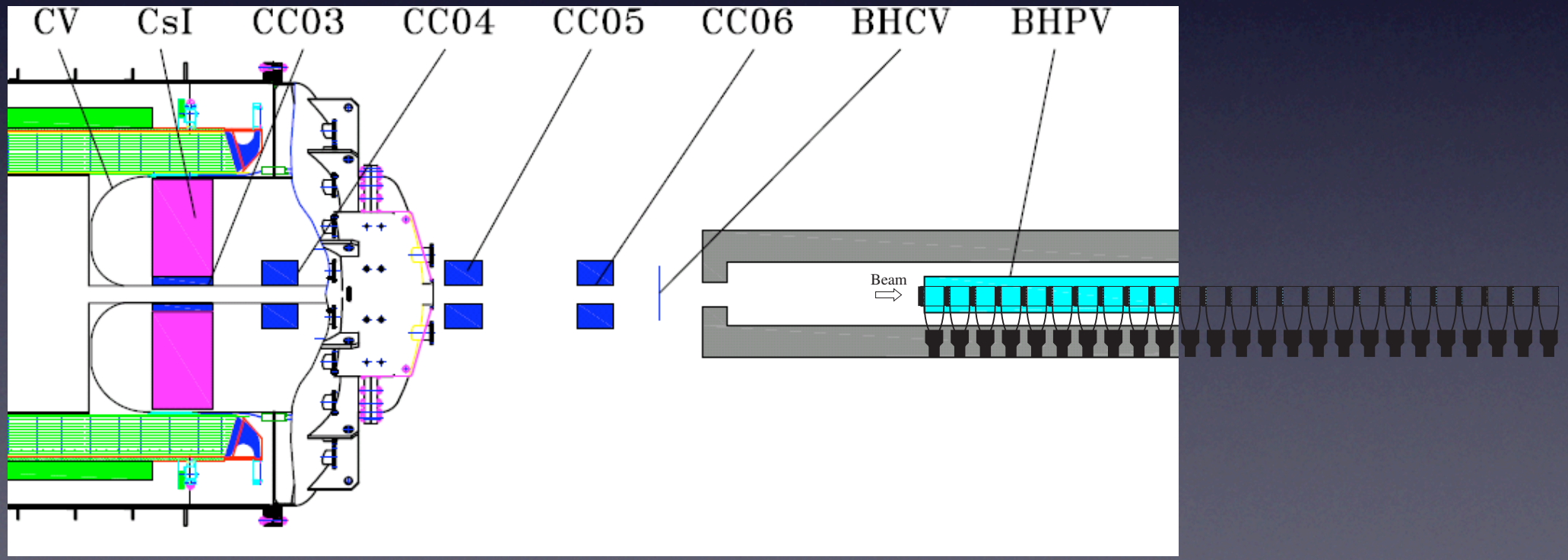
CsI PMT base

- Requirements
  - Minimize the heat and the number of vacuum feed through
  - Low noise (<0.5mV)
- Studying Cockcroft-Walton base
  - ~0.1W, low voltage DC power
  - ZEUS base shows good performance
  - Start designing CW base for KTeV tubes with Matsusada and HPK



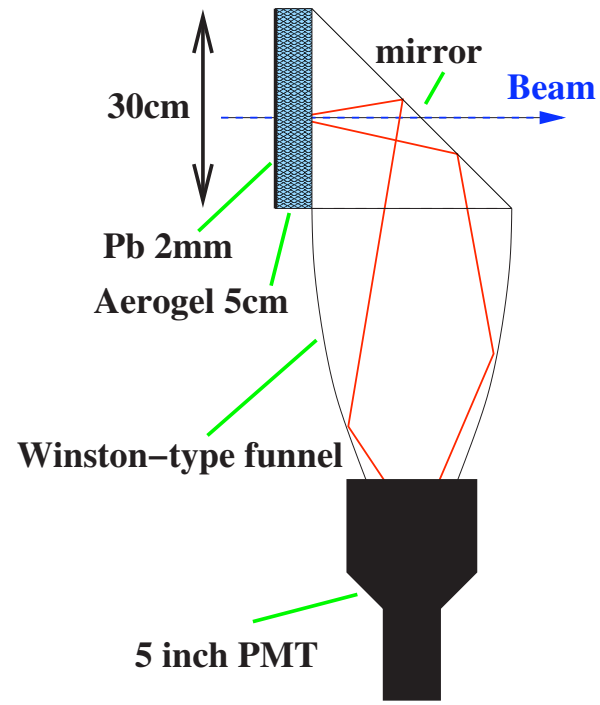
E14 Strategy 1.2
Suppress K_L background

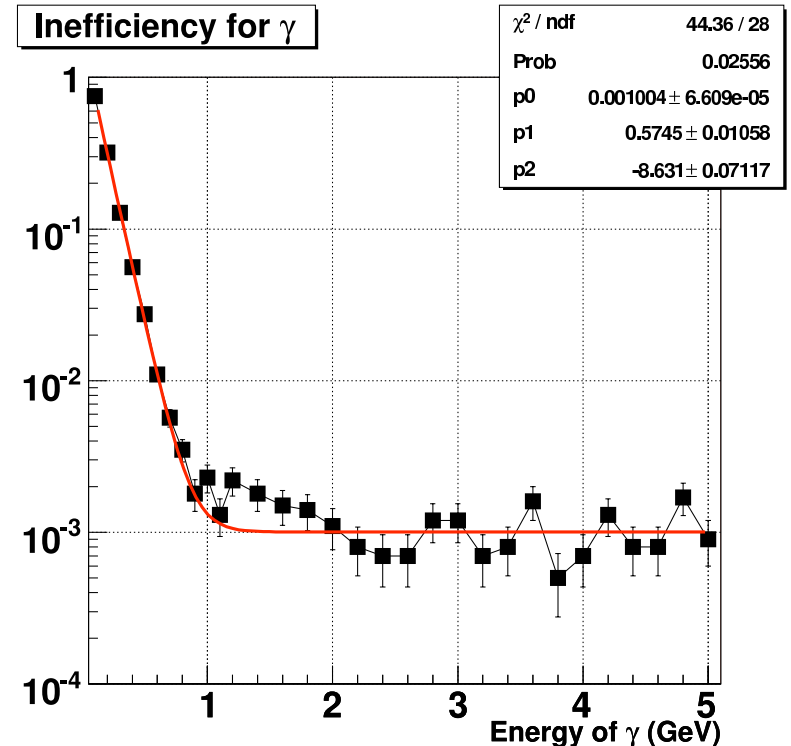
- Longer CsI => suppress punch through
- New photon veto in the beam



Beam Hole Photon Veto

- Insensitive to neutrons: 0.2% @ 2GeV/c
- 10^{-3} photon detection inefficiency @>1GeV
- false hit rate : 2MHz
- Proven by prototype beam tests





K_L bkg @E14

- K_L->2pi0 : 3.65
- K_L->pi+pi-pi0 : 0.93
- K_L->pi e nu : 0.01
- K_L -> 2 gamma : negligible

E14 Basic Strategies

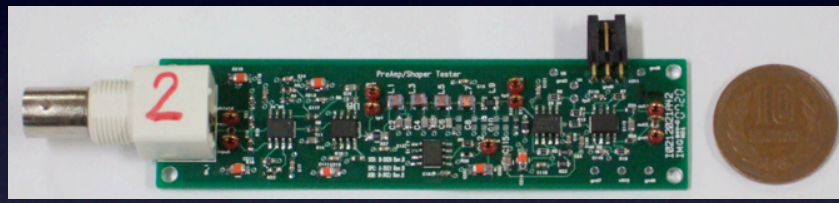
1. Suppress and control backgrounds based on the E391a experience
2. Make detector capable of handling high rates
   - 2.1. BHPV in beam
   - 2.2. Waveform digitization

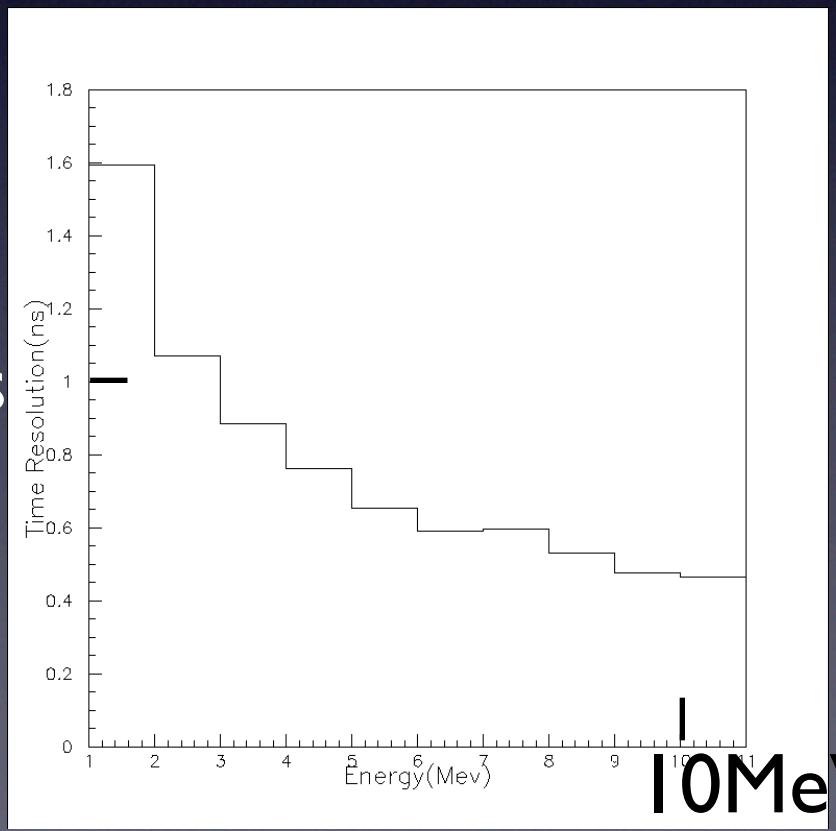
E14 Strategy 2.2
Waveform digitization

- ~3000 (CsI) + ~1000 (others) channels
- Deadtime-less for 250kHz trigger
- Record waveform to isolate a pulse on earlier tail
- 0.3MeV ~ 2GeV, 14bit, 1ns resolution
- and affordable

solution = Gaussian filter + 125MHz 14bit FADC

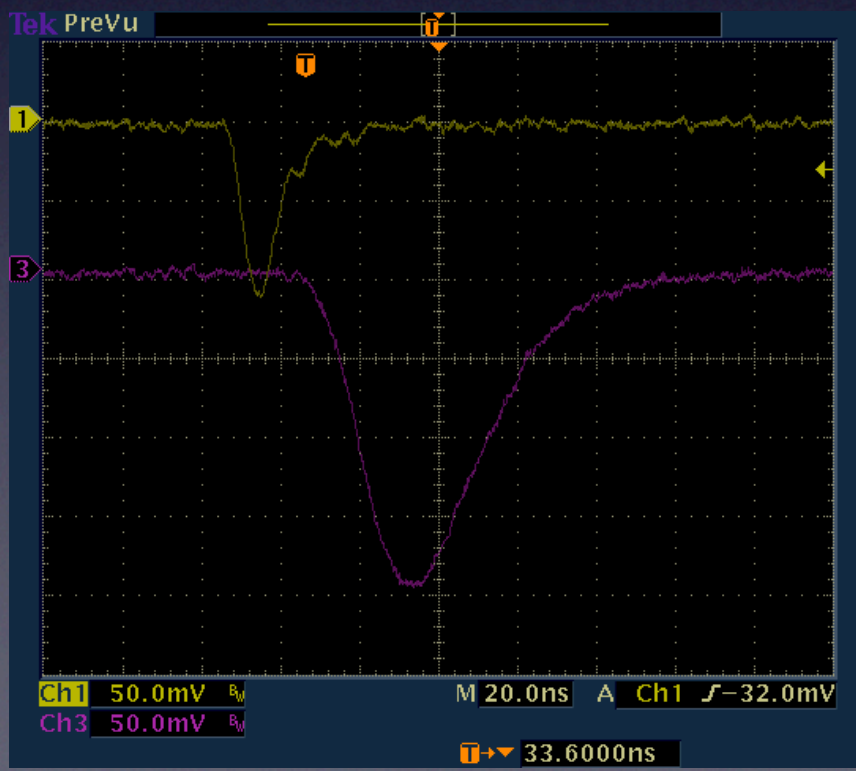
- Δt <0.5ns for E>10MeV





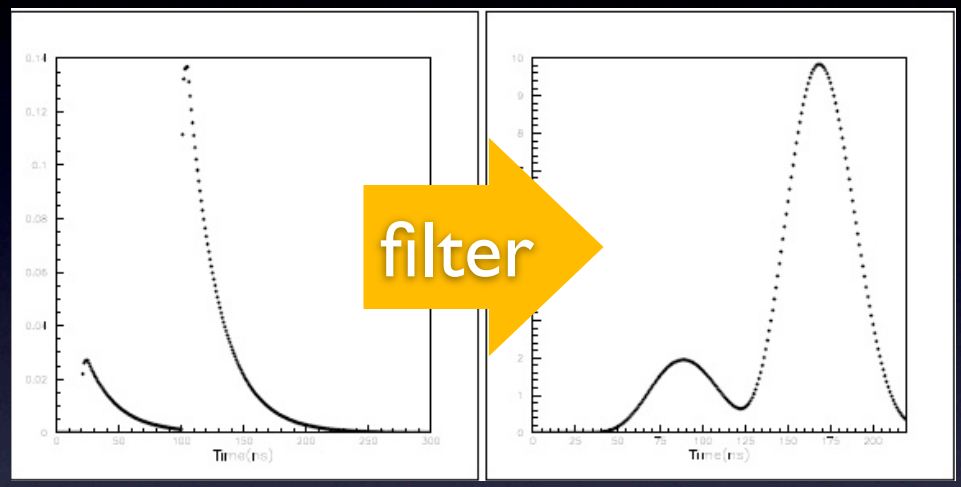
Ins

10MeV



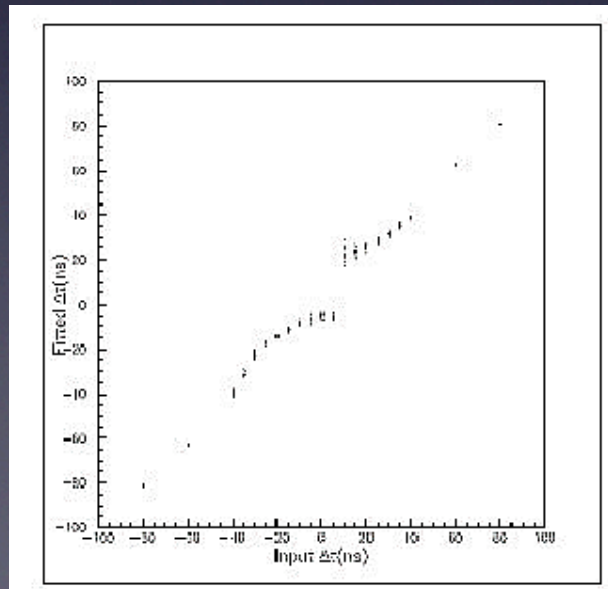
Double pulse resolution

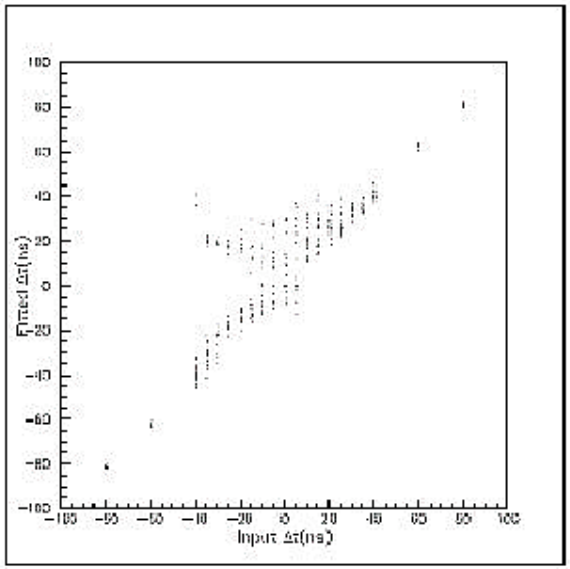
- Can separate >20ns apart 5:1 pulses
- More studies underway



200MeV + 40MeV

10MeV + 2MeV



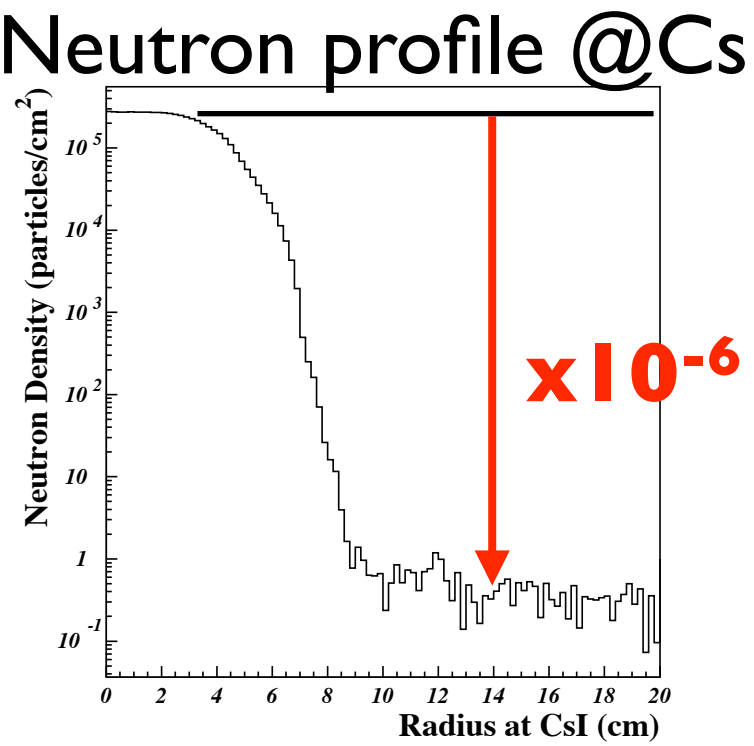


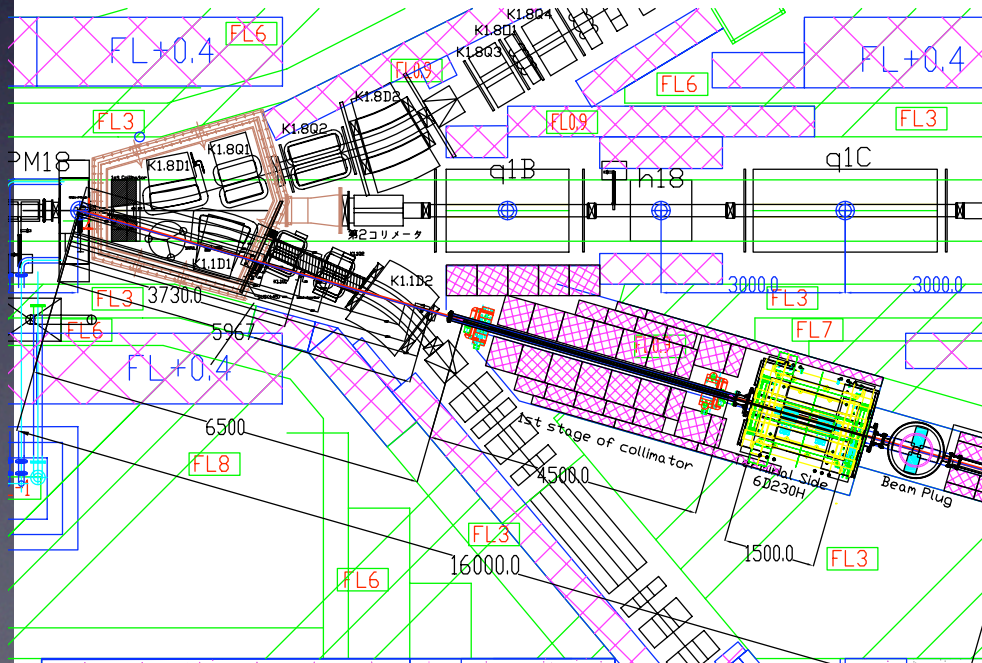
Schedule/Priorities

1. Construct KL beamline and study it in Jan.-Feb. 2009. Should understand halo neutrons
2. Build the CsI calorimeter
3. Mass production of waveform digitizer
4. Main Barrel upgrade, and close vacuum tank
5. Upgrade downstream veto
6. Upgrade upstream veto

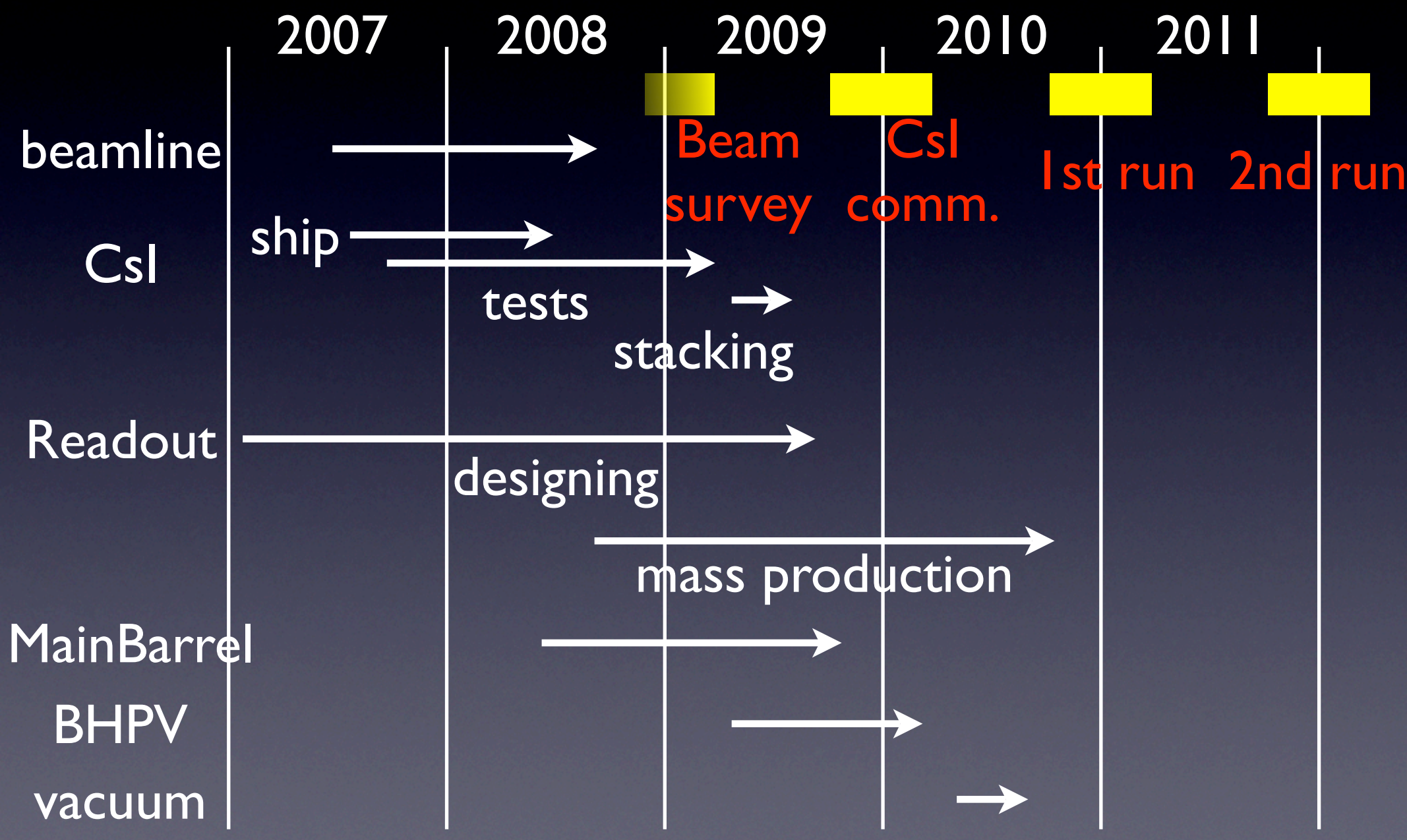
Beamline

- Make sure that the beamline performs as designed.
- Should minimize radiation work. The collimator should be installed before the beam comes





Schedule


2007
2008
2009
2010
2011
beamline
Beam survey
CsI comm.
1st run
2nd run
ship
CsI
tests
stacking
Readout
designing
mass production
MainBarrel
BHPV
vacuum

Budget

Unit: 10^4 yen~$100

	sum	2007	2008	2009	2010	2011
sum	62790	5870	18620	27340	9960	1000
beamline	16330	2830	5400	8100		
CsI	5900	700	4300	900		
readout	14840	1700	2180	9660	1300	
veto	11520		5340	6180		
others	9300	40	300	1400	7560	
RA,travel	4900	600	1100	1100	1100	1000

Funding scenario

Unit: 10^4 yen~$100

	sum	2007	2008	2009	2010	2011
sum	62870	6120	18430	27390	9950	980
Tokutei	27870	5620	10930	6890	3450	980
US/J	2000	500	1000	500		
KEK	22000		3000	16000	3000	
DOE	9000		3000	3000	3000	
G.in Aid	2000		500	1000	500	

Amounts in yellow are allocated

Manpower

Institution	#Physicists (+#in future)	#students (+ #in future)	technicians & engineers (FTE)
Arizona State Univ.	1	0 (+1)	0
Univ. of Chicago	2	2	1.5
Chonbuk National Univ.	1	1 (+1)	0
JINR	3	2 (+2)	0
KEK	4	0	0
Kyoto Univ.	3	4 (+4)	0
Michigan Univ.	1 (+1)	0 (+1)	1∼3
NDA	2	0	0
National Taiwan Univ.	1	2 (+1)	0.25
Osaka Univ.	2	4 (+4)	0
Pusan National Univ.	1	2	0.5
Saga Univ.	2	4	0
Univ. of Seoul	3	2	0
Tbilisi State Univ.	2	0??	0??
Yamagata Univ.	3	2 (+2)	0
Sum	31 (+1)	25 (+14)	3∼6

Many young people

Institution Responsibilities

Institution	tasks
KEK	Beamline, detector construction, MB upgrade
Kyoto	Beam hole Photon and Charged vetoes, NCC2, between CsI PMT and FADC, software, ...
Osaka	CsI & PMT test, calibration system, readout, etc., event builder
Yamagata	Charged veto, MB upgrade, neutron counters for beam survey
Saga	CC03, beamline construction
NDA	CV, CC03
Chicago	Readout electronics, trigger, etc.
Michigan	Trigger/DAQ, CsI PMT base
Arizona State	Beamline MC, software
JINR	CC04, CC05, CC06, calibration, structural analysis
U.Seoul, CNU	beam survey
Pusan	CV, CC03

We ask for a Stage 2 Approval in July

- Reasons
  - Stage 2 Approval is required for starting rad certification process
  - CsI's may not be shipped without Stage 2 Approval (Email from Y. Wah)
  - Funding request to DOE in one month needs Stage 2 Approval
  - Postponing Stage 2 may harm foreign collaborators

Summary

- E391a is very close to opening the box
- Preparations for beamline and detector are going well
- We want to do beam survey in Feb. 2009
- We request a Stage 2 Approval