Status Report on K1.8/SKS Experiments

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K1.8 Exp. Group.

The 9th PAC Meeting on 2010 Jan. 15

- Introduction
- Status of Apparatus
- Available Beam Condition
- Run Plan

Approved Experiments
– K1.8 Beamline –

Stage-2: 5 **2 Day-1 Experiments**
Stage-1: 5

K^- beam: 4
π beam: 6

	Spokesperson	Title	Status	Beam	
E19	M.Naruki SksO	High-resolution search for Θ^+ pentaquark in $\pi^-p \to K^-X$ reactions	Stage-2	π^- (1.87-1.97)	160 hours
E10	A.Sakaguchi SksO	Study on Λ-hypernuclei with the charge-exchange reactions	Stage-2	π^- (1.2)	6 weeks
E13	H.Tamura	Gamma-ray spectroscopy of light hypernuclei SksMinus+HyperBall	Stage-2 Day-1	K^- (1.5)	1000 hours
E07	K.Imai, K.Nakazawa, H.Tamura	Systematic study of double strangeness system with an emulsion-counter hybrid method KURAMA+HyperBall	Stage-2	K^- (1.7)	(150+600) hours
E05	T.Nagae	Spectroscopic study of Ξ-hypernucleus, $^{12}_{\Xi}$Be, via the ^{12}C(K^-,K^+) reaction SksPlus	Stage-2 Day-1	K^- (1.8)	(2+4) weeks
E03	K.Tanida	Measurement of X rays from Ξ^- atom KURAMA+HyperBall	Stage-1	K^- (1.8)	(20+100) shifts
E08	A.Krutenkova	Pion double charge exchange on oxygen at J-PARC SksPlus	Stage-1	π^+ (1.1-2.13)	(3+10) days
E18	H.Bhang, H.Outa, H.Park SksO	Coincidence measurement of the weak decay of 12LC and the three-body weak interaction process	Stage-1	π^+ (1.05)	(28+72) shifts
E22	S.Ajimura, A.Sakaguchi SksO	Exclusive study on the Lambda-N weak interaction in A=4 Lambda-hypernuclei	Stage-1	π^+ (1.1)	4 weeks
E27	T.Nagae SksO	Search for nuclear Kbar bound state K^-pp in the d(π^+,K^+) reaction	Stage-1	π^+(1.5)	40 days

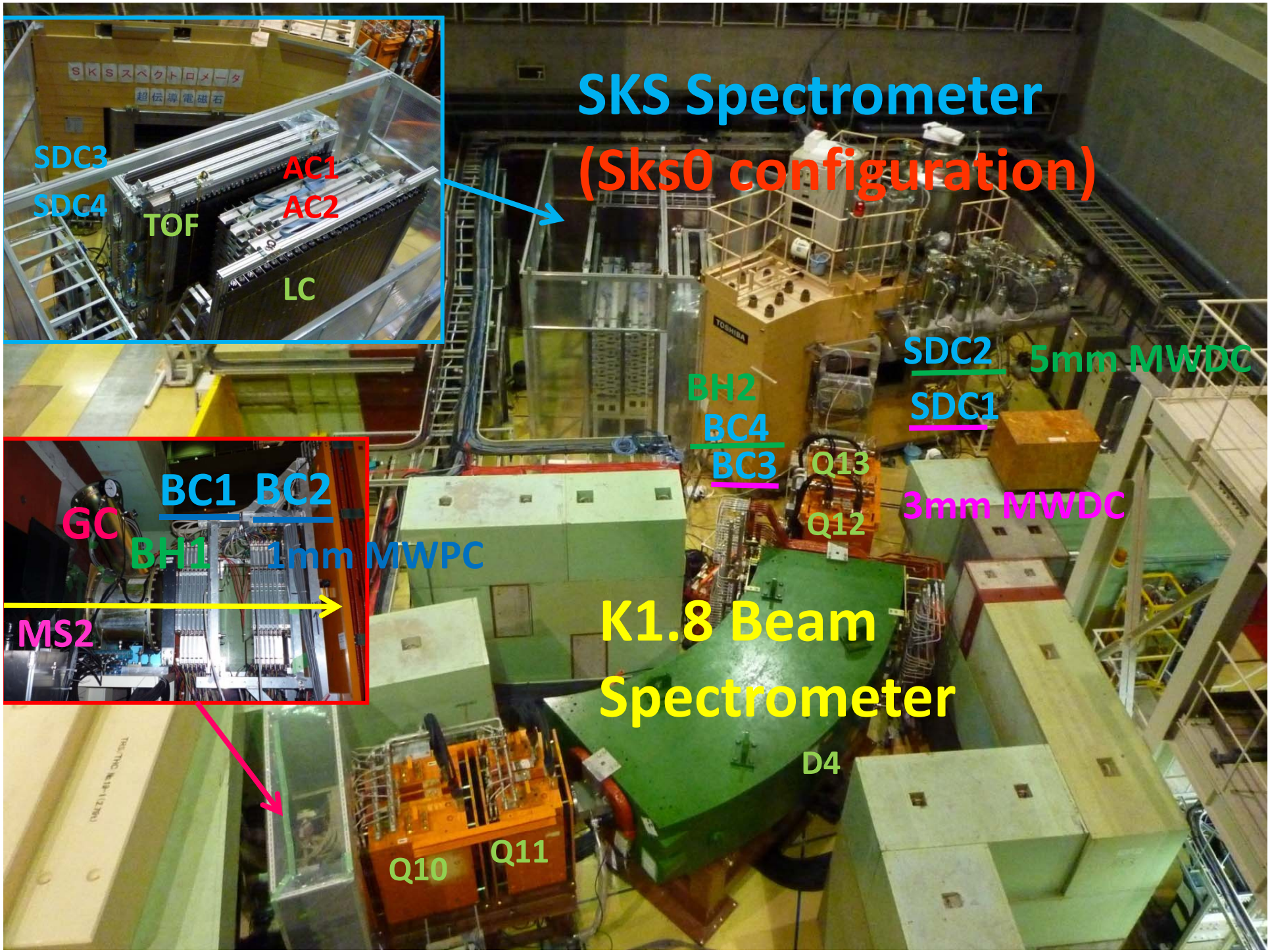
Our Strategy
– explained at 7th PAC Meeting –

After the beamline and spectrometers commissioning, we will start the experiments using pion beam and Sks0 setup.
$^{12}C(\pi^+,K^+)^{12}_{\Lambda}C$ reaction will be measured to check resolution and efficiencies of both Beam and SKS spectrometers.

- Basic studies and tuning of K1.8 and SKS ⟵ **Present**
- $^{12}C(\pi^+,K^+)^{12}_{\Lambda}C$ @ ~1.05GeV/c
  - calibration of the field distribution, optics, etc.
- E19 (π^-p->K^-X@1.87,1.92,1.97GeV/c)
  - 1.4×10^{12} pions on target
- E10 ((π^-,K^+) @1.2GeV/c on ^{6}Li and ^{9}Be)
  - 9.1×10^{12} pions on target

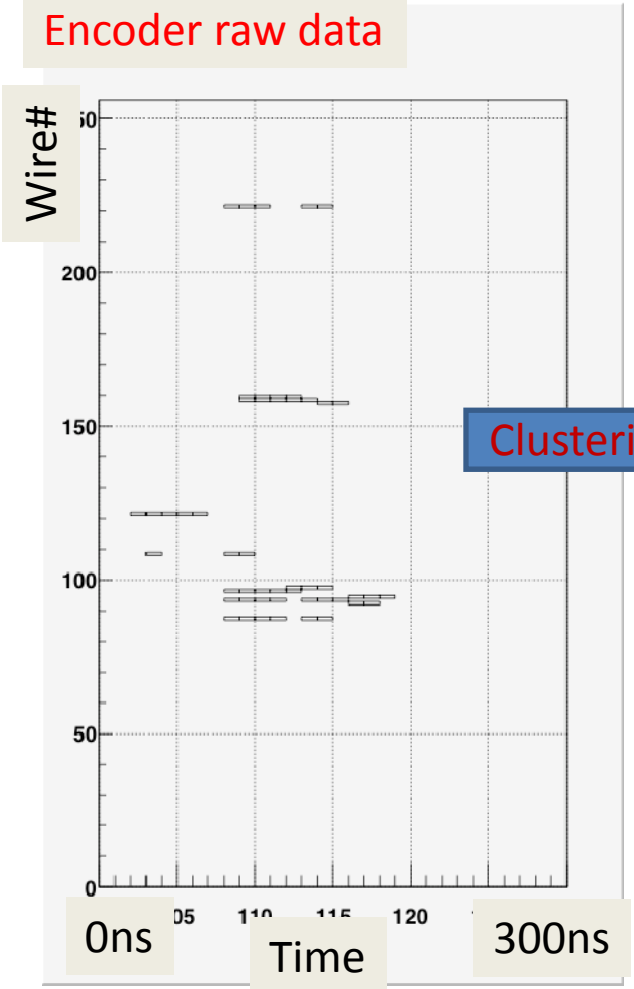
Status of Apparatus

- Spectrometers & Detectors
  - Beamline Chambers MWPC/MWDC
  - Beamline Hodoscope Counters
  - SKS Magnet
  - SKS downstream Chambers
  - SKS Aerogel Cherenkov / TOF
  - Momentum Analysis on Beam Through Data
- K1.8 Beamline
  - Kaons with Electrostatic Separators @ 1.8GeV/c
  - Pion yield .vs. Slit Opening


SKS Spectrometer
(Sks0 configuration)
SDC3
SDC4
TOF
AC1
AC2
LC
BC1
BC2
GC
BH1
1mm MWPC
MS2
BH2
BC4
BC3
SDC2
5mm MWDC
SDC1
Q13
Q12
3mm MWDC
K1.8 Beam
Spectrometer
D4
Q10
Q11

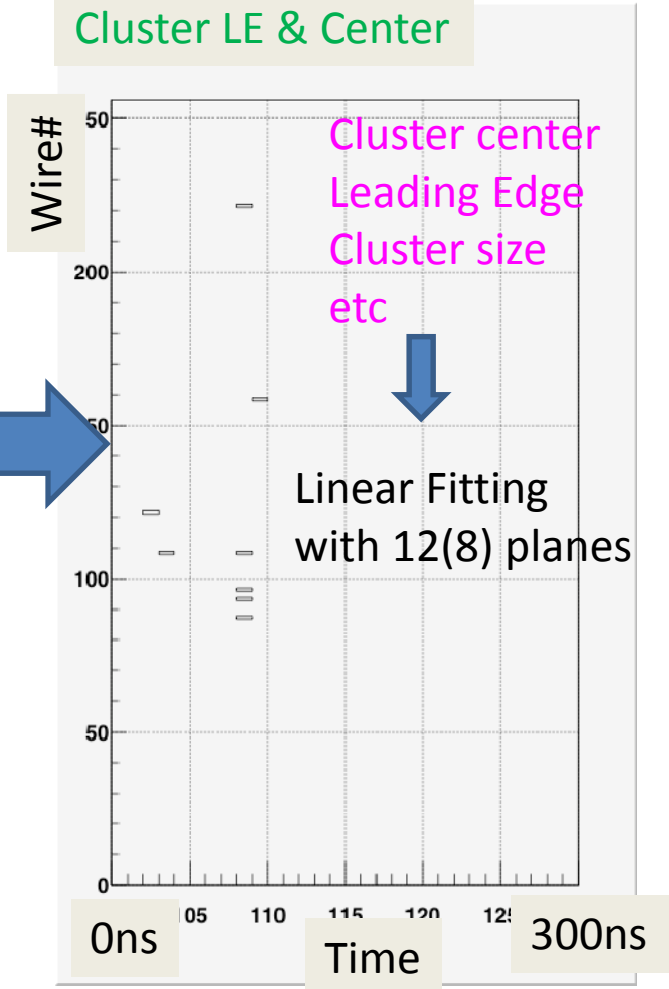
BC1 & 2 – 1mm MWPC –

Encoder raw data



Clustering

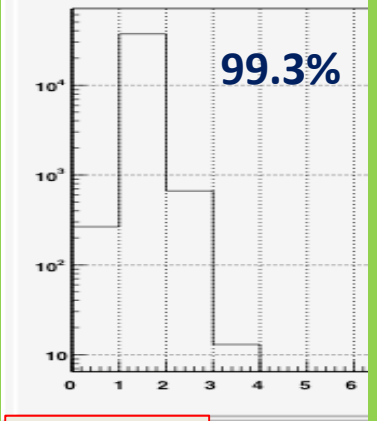
Cluster LE & Center



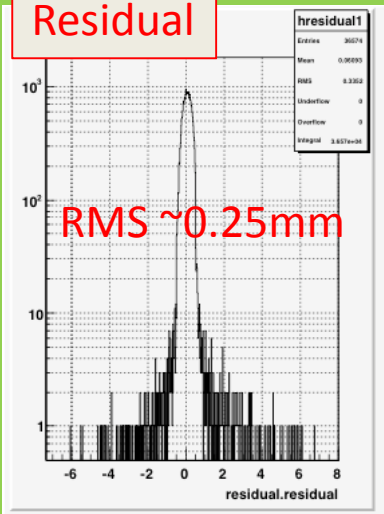
Cluster center
Leading Edge
Cluster size
etc

Linear Fitting
with 12(8) planes

# of tracks



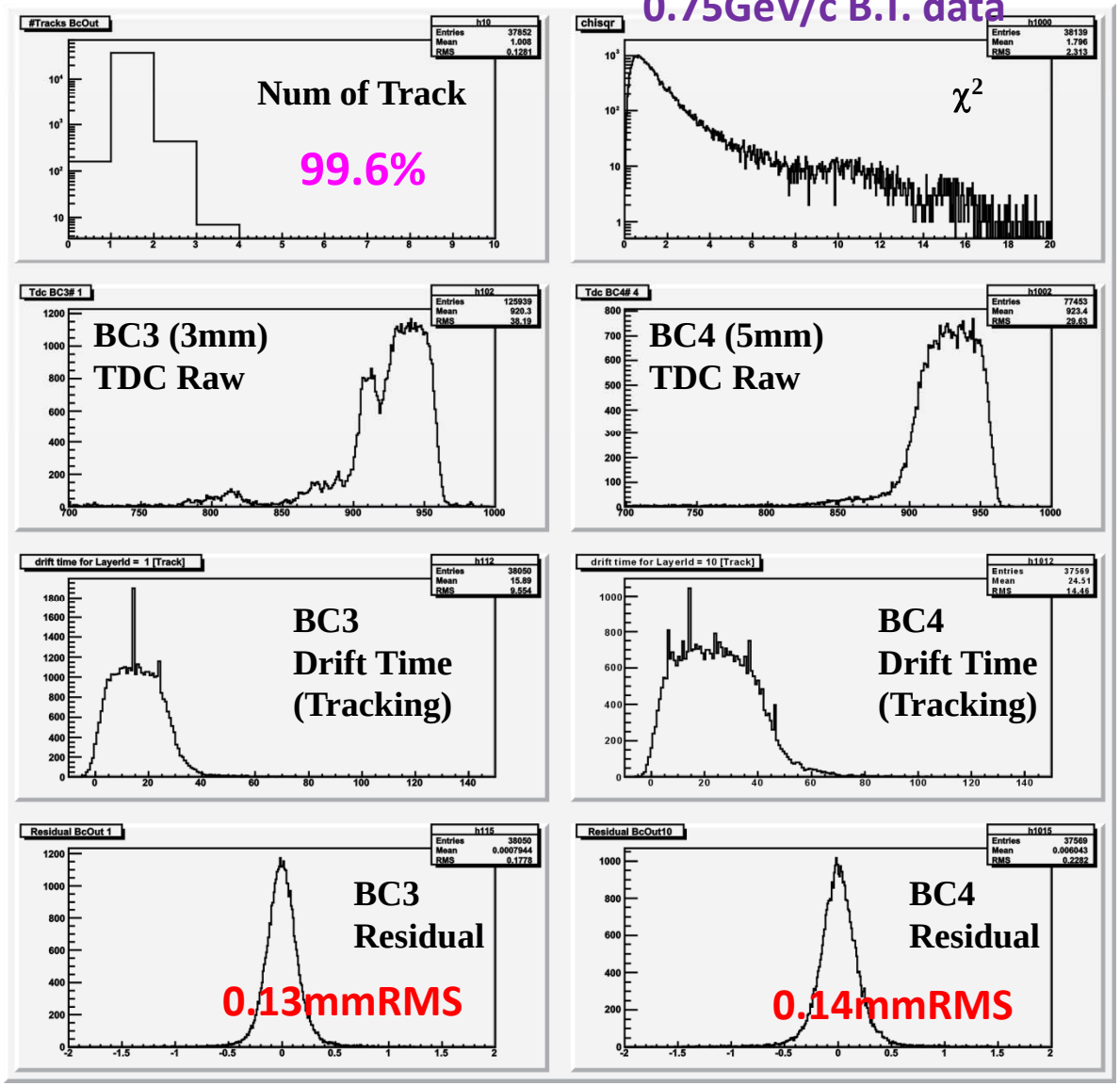
Residual



low intensity data

BC3 & 4 – MWDC –

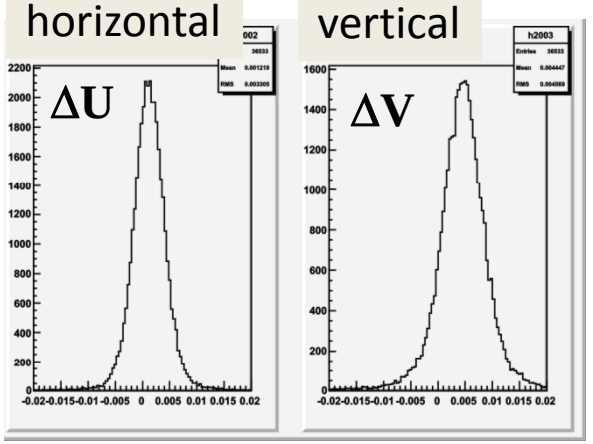
0.75GeV/c B.T. data



SDC1/2 are similar

Angular difference between
BC34 track & SDC12 track

horizontal vertical



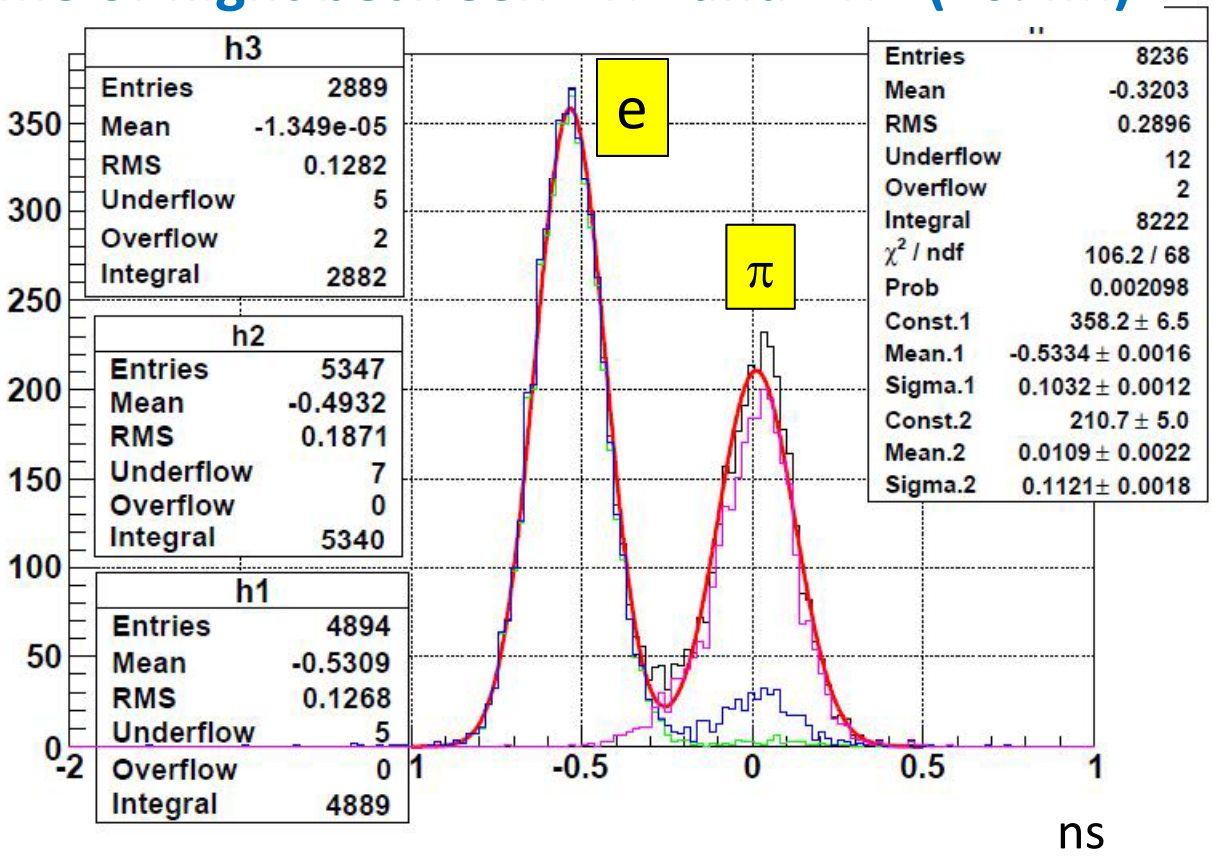
$\sigma_{\Delta U}$: 2.81 mrad
$\sigma_{\Delta V}$: 3.93 mrad

4.83 mrad

E369
$\sigma_{\Delta U}$ = 2.25mrad
$\sigma_{\Delta V}$ = 4.45mrad

Beam Hodoscope Counters (BH1/BH2)

Time of flight between BH1 and BH2 (10.4m)



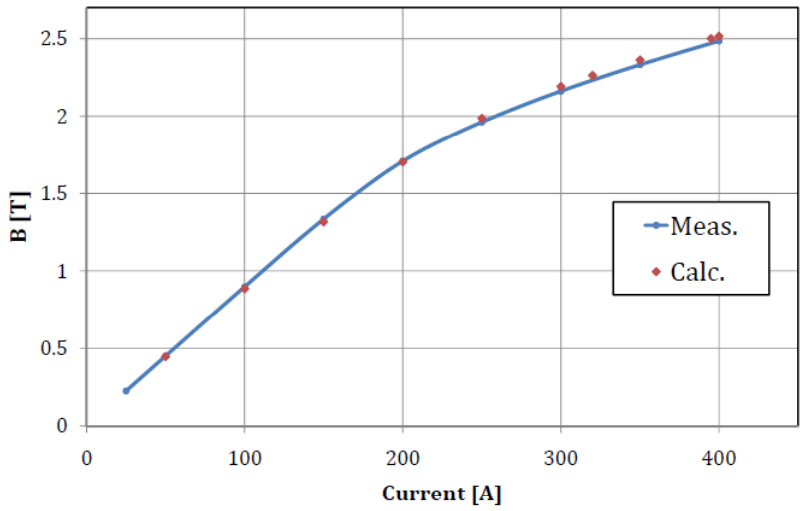
750 MeV/c

σ=100 – 110 ps

good enough to separate $\pi^+/K^+/p$ at 1.8GeV/c

SKS Superconducting Magnet

- Cooling down started on Aug.17
  - Aug.17 – Aug.24 LN_2(2,500L)
  - Aug.28 – Oct.2 LHe(10,000L)
- Stationary state (w/o Excitation)
  - 113kPa in He Vessels
  - 4.35, 4.46, and 4.35K GM-JT cold-head
- Excitation with 400A
  - 41K at HTC current leads (3 GM-JT's)
  - 46.6K at HTC and 116.9kPa after 8hours with 2 GM-JT cryo-coolers



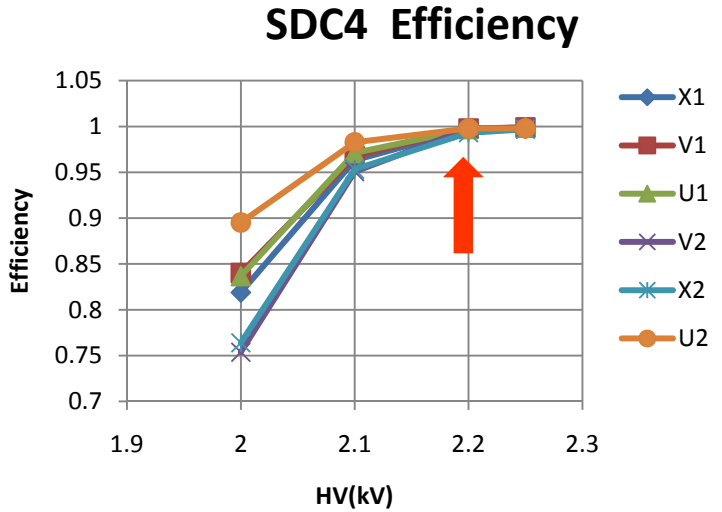
Max. field 2.485T @ 400A

Usually 2 sets of GM-JT cyro-coolers are ON.
Use 3 sets when I>350A more than 1 hours to raise safety

SDC3 & 4

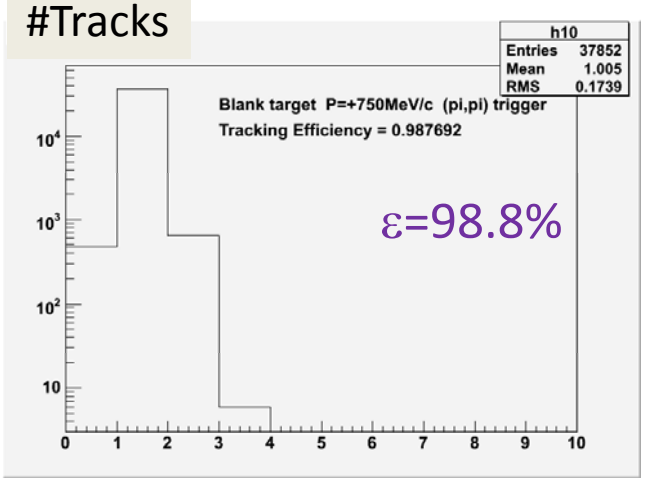
- Large size of 2.14x1.14m^2
- Drift length of ~10mm

HV lines are disconnected to the wires in the region the beam passes through.

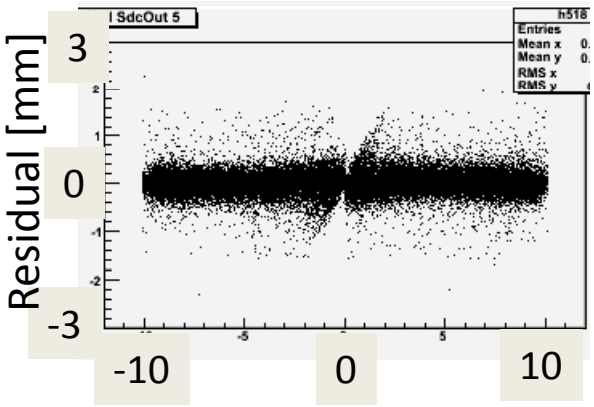


0.75GeV/c Beam Through RUN

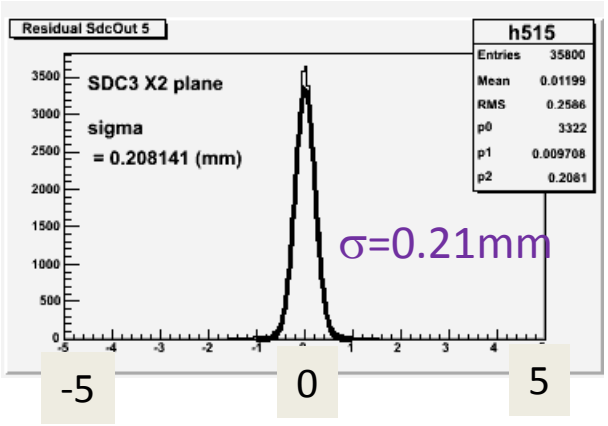
#Tracks



SDC3-X2 plane

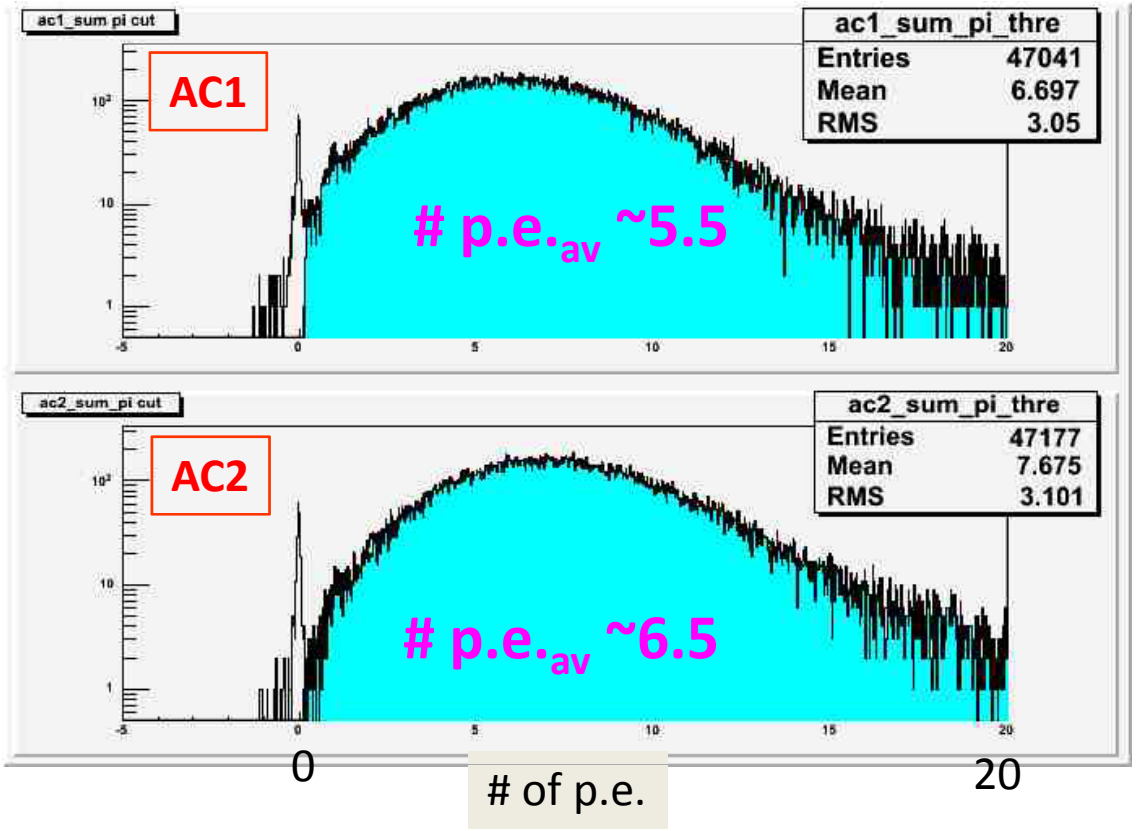


Residual



Aerogel Cherenkov Counter

0.75 GeV/c π^+ Beam



Efficiencies

98.3% (AC1)

99.3% (AC2)

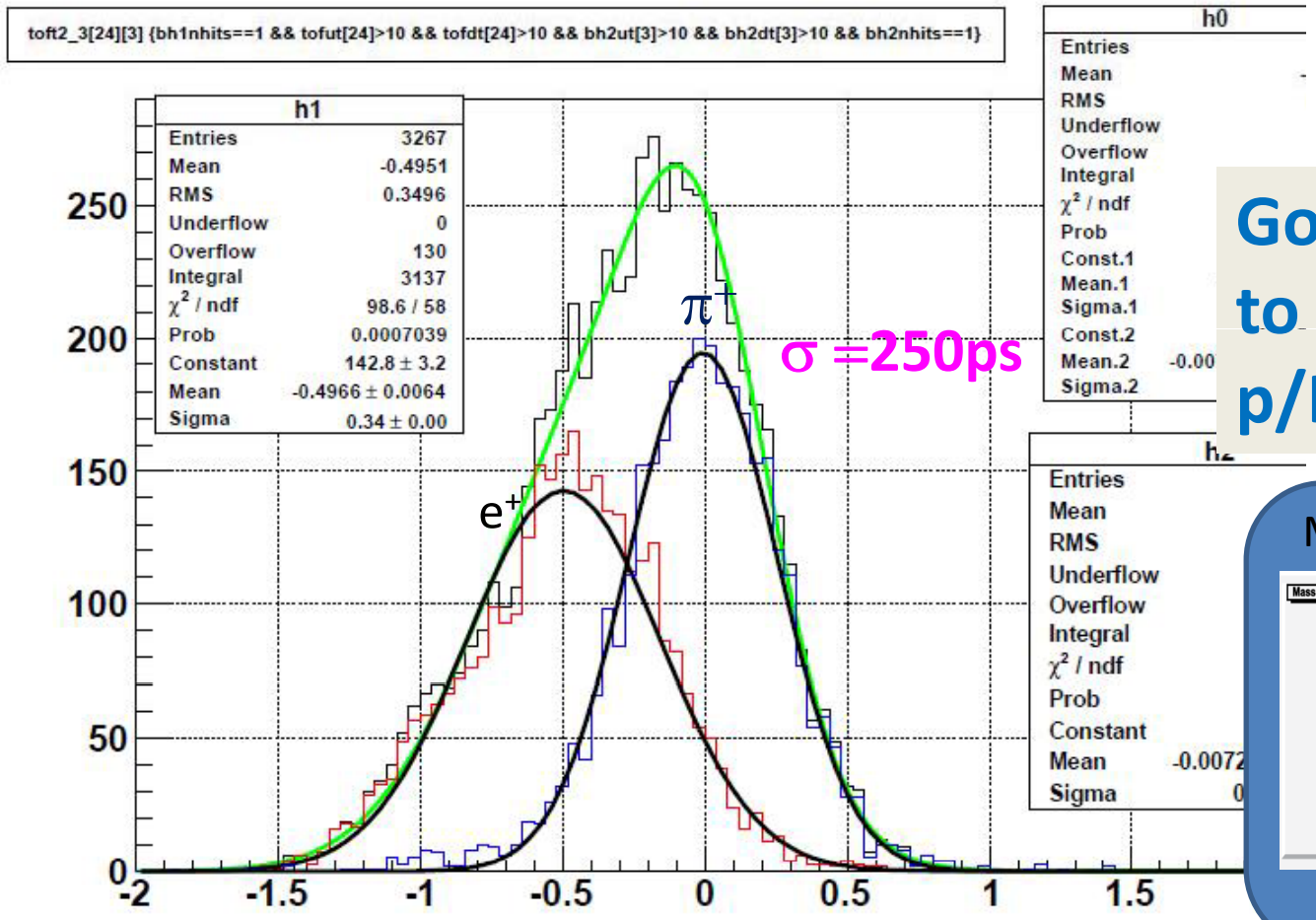
# of p.e. is same as one at E140a (KEK-PS)

~ 6 p.e.

Time Resolution of TOF Counter

BH2-TOF @ 0.75GeV/c B.T.

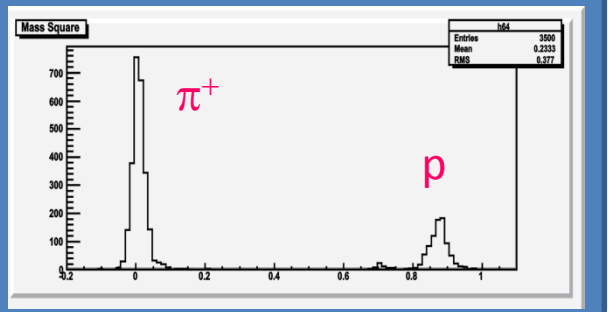
w/o Pulse Height Correction
w/o Path Length Correction



will be improved to 150-200ps

Good enough to discriminate $p/K^+/\pi^+$ in analysis

M^2 after path length corr.



0.75GeV/c B.T.

Momentum Analysis in Both Spectrometers – Beam Through at 0.75GeV/c –

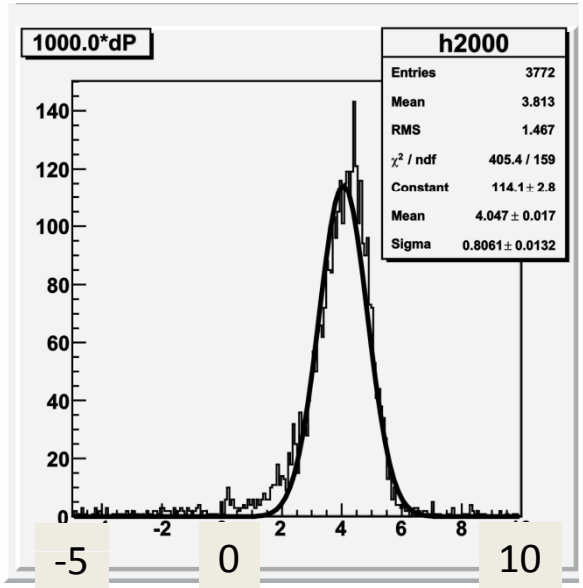
- K18 Beam Spectrometer

  3rd Order Transport Matrix (VI->VO)

- SKS Spectrometer

  Runge-Kutta tracking using the calculated field map

$$\Delta p = p_{SKS} - p_{K18}$$



w/o tuning, optimization, etc ..

1.65 – 1.9MeV/c (FWHM)

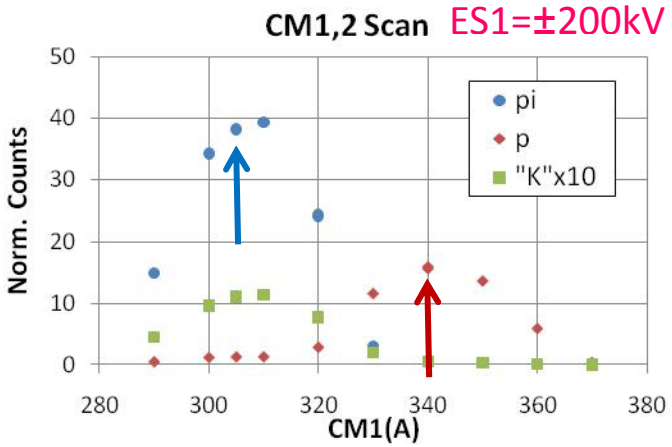
c.f.

1.35MeV/c in E369 (Best)

1.5 MeV/c in E269/E140a (SKS First Exp.)

The Separated Beam Tuning at +1.8GeV/c
– Confirmation of Kaon Enhancement –

K1.8 has double stage of electrostatic separators (ES1 and ES2).

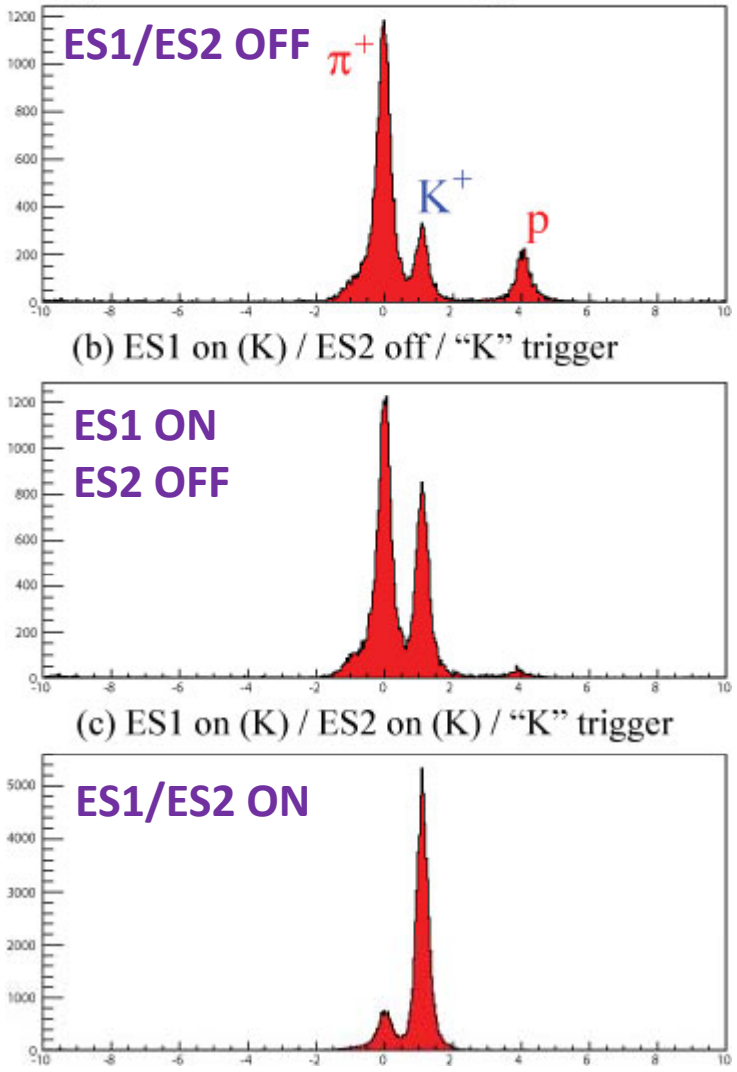


CM1=305A for pion

340A for proton

CM1=324A for kaon

BH1-BH2 ToF in "K" trigger



20.5%

38.5%

83.4%

8% in unbiased trigger

Available Beam Intensity at +1.05GeV/c

$3x10^{11}$ ppp (240W) with Ni target
EQ/RQ operation with 1.5sec extraction length
Separated beam with ES1/ES2= ± 200kV
Mom Slit (H) -179.8/+174.9 mm

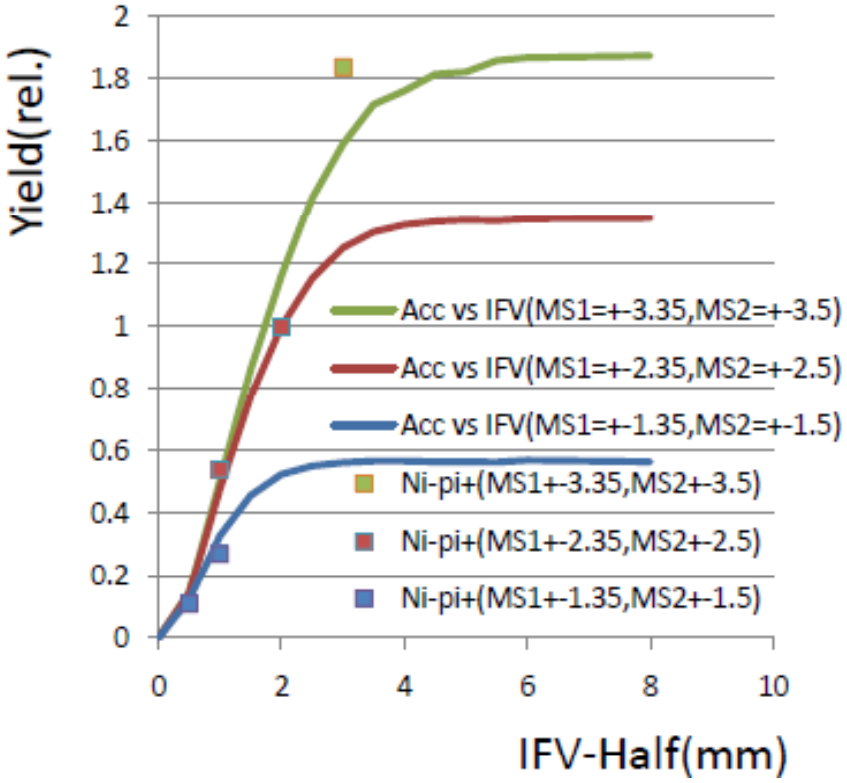
	mm						/1.5sec
	IFH	IFV	MS1	MS2	BH1	BH2	π
SC 3	±130	-2.0/+4.0	±3.35	±3.5	1.82M	1.14M	657k
SC 2	±130	-1.0/+3.0	±2.35	±2.5	929k	539k	378k
SC 1	±100	-1.0/+3.0	±2.35	±2.5	900k	534k	374k
SC -1	±100	0.0/+2.0	±2.35	±2.5	433k	266k	218k
SC -2	±100	0.0/+2.0	±1.35	±1.5	167k	101k	91.9k
SC -3	±100	+0.5/+1.5	±1.35	±1.5	63.7k	41.1k	38.8k
-1.92GeV/c (for E19)							
SC 1	±100	-1.0/+3.0	±2.35	±2.5	1.01M	681k	508k

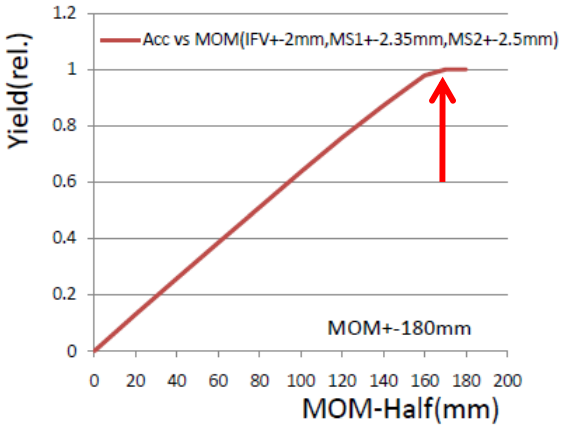
designed for kaon

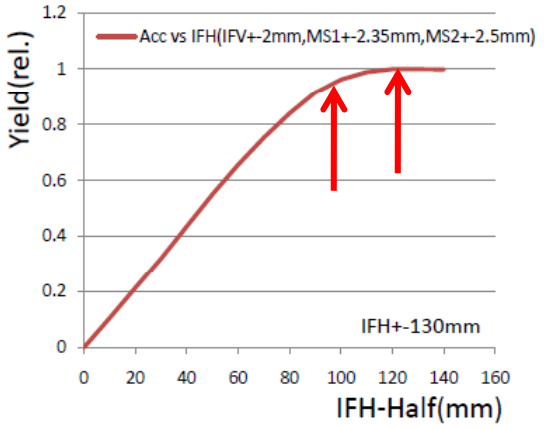
500k/spill pions can be obtained with MR beam of 240W

10M/spill 5kW

Comparison with Turtle Simulation







Beam Intensity & Time Structure

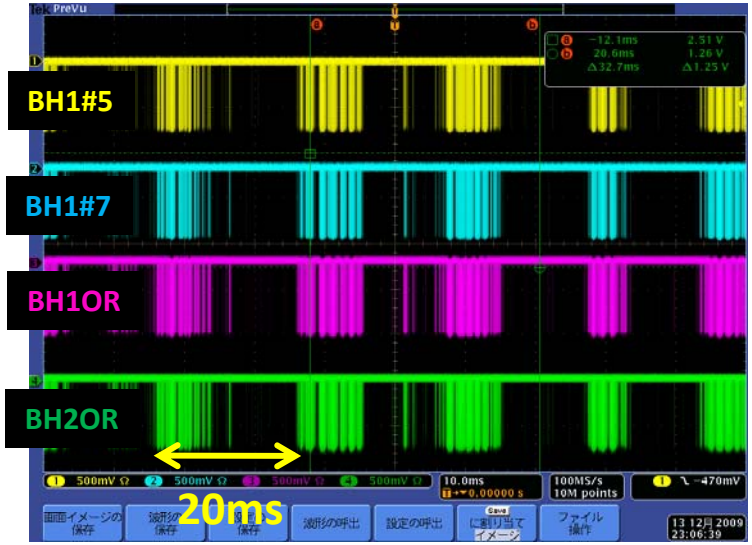
Yield Estimate based on the Available Beam Intensity

Calibration RUN’s

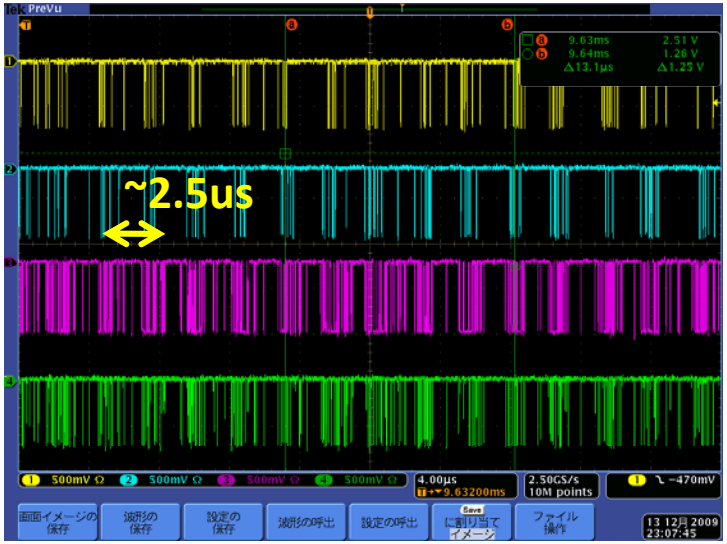
E19

Time Structure of the Beam

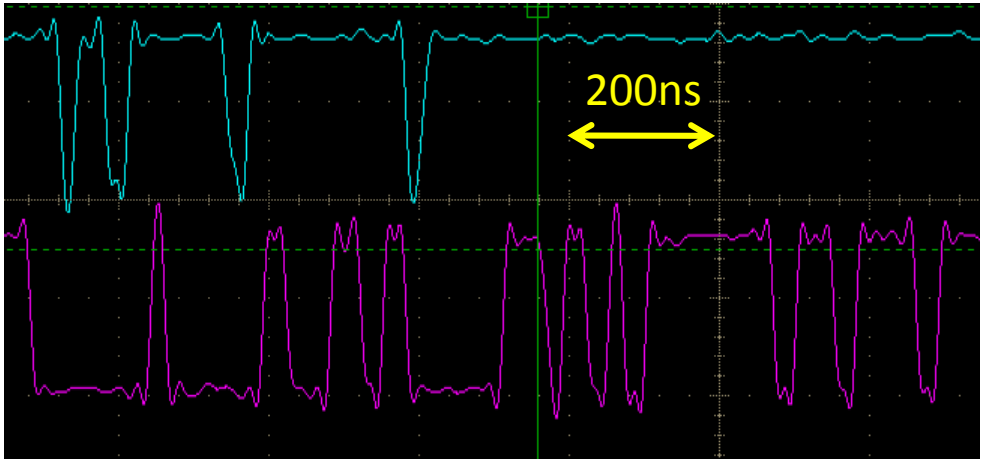
Dec.13
EQ OFF/RQ ON (#3)



0ms 100ms



0us 40us



OR signal was piled-up!

Counts of segment
~500k /2sec gate
Too high (x10)

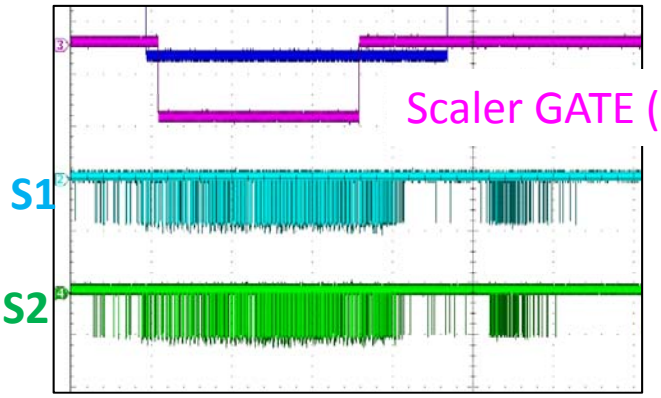
Duty-Factor of the Extracted Beam

Dec.23
EQ ON (1.5s)
RQ ON (#0 Gain=20)

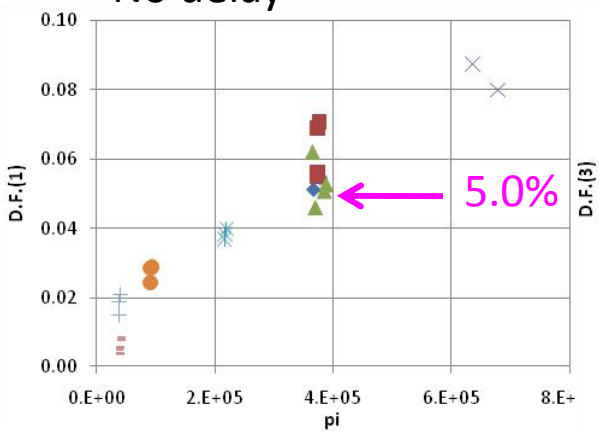
From the accidental coincidence between independent counters (BH1 segments), duty-factor was obtained.

No delay coincidence

Delayed coincidence of 56ns

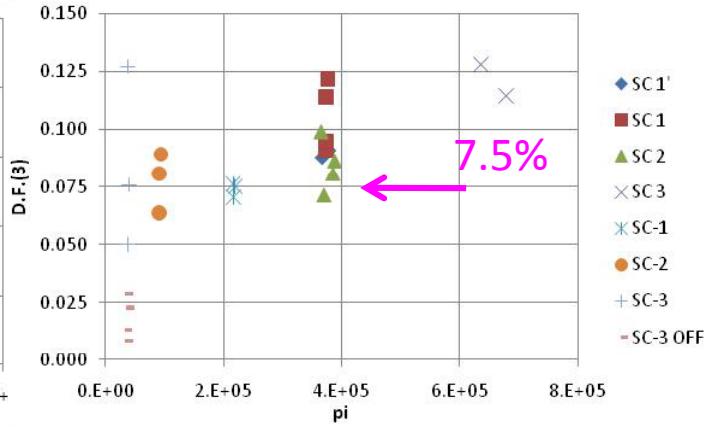


No delay



pion counts

56ns delayed



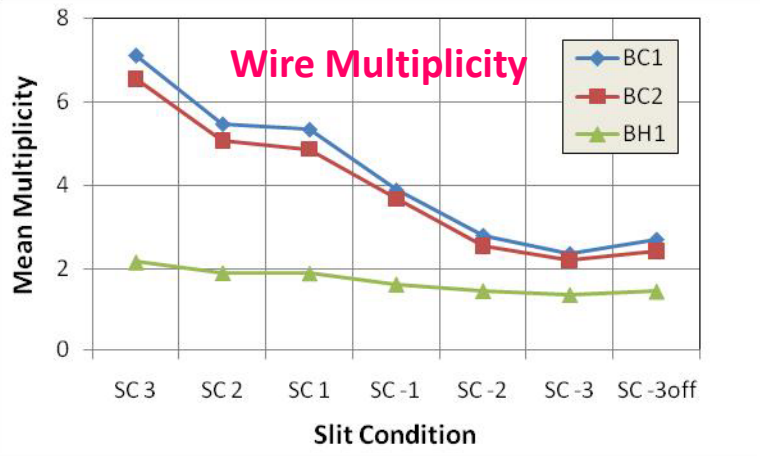
pion counts

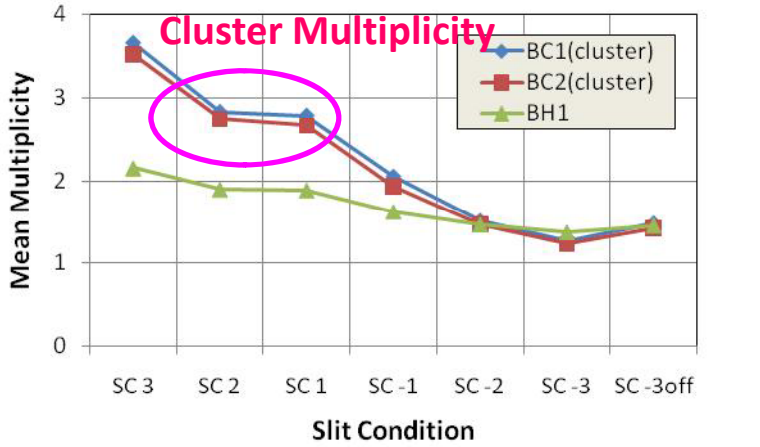
Intensity dependence of “No delay” is not fully understood,
D.F. is estimated to 5-7.5% at the present beam w/ EQ and RQ.

Mean Multiplicity on Beamline Detectors

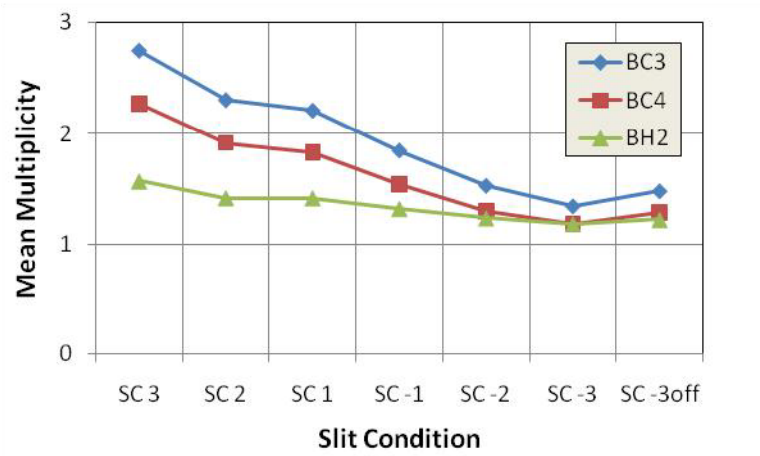
Time window of 300ns for Wire Chambers (BC1-4) and
100ns for Hodoscopes (BH1/2)

B.S. upstream





B.S. downstream



K6 Experience

Mean Mult. < 2.5 @BS upstream

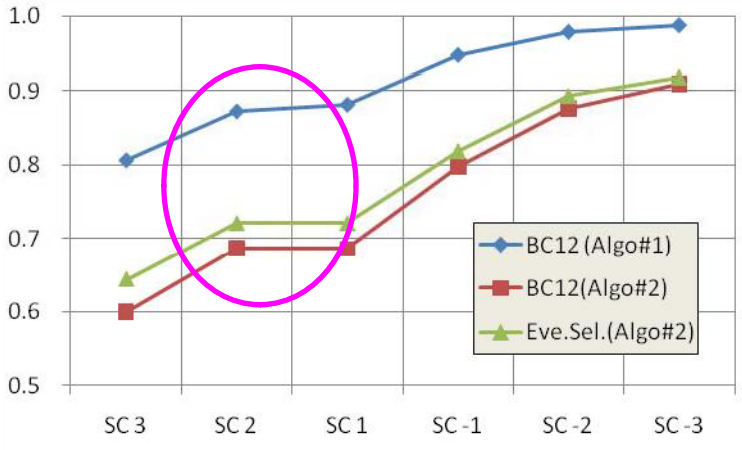
SC 2 / SC 3

350k – 650k/spill beam

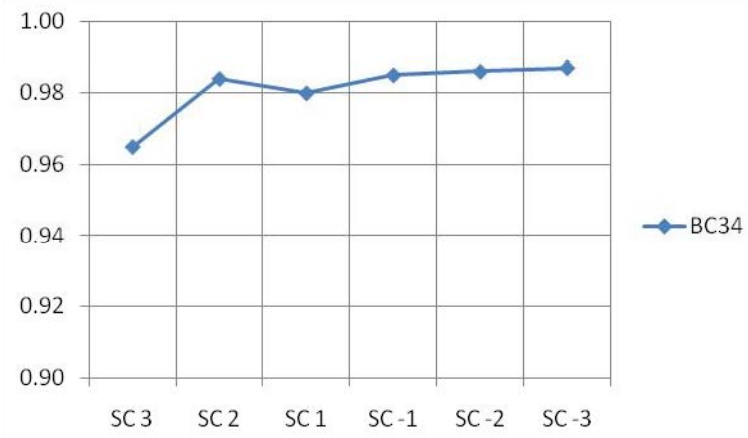
Track Analysis Efficiencies

including “Event Selection Efficiency” to save CPU time/memory etc.

B.S. upstream



B.S. downstream



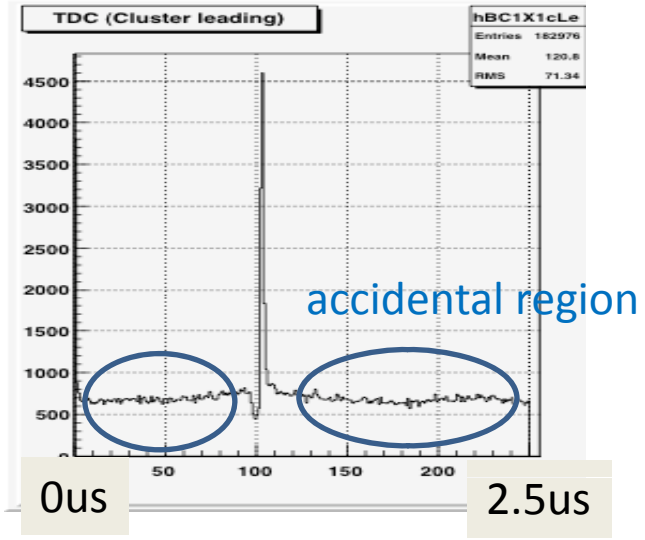
“Event Selection Efficiency” may be improved in future by

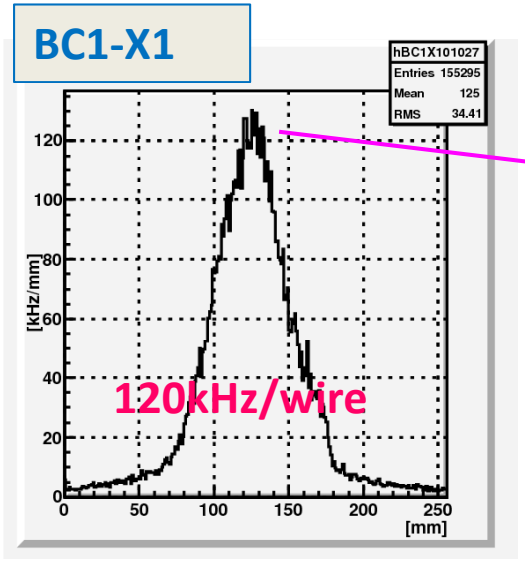
- Optimization of event selection algorism
- Upgrade of CPU power/memory
- etc ..

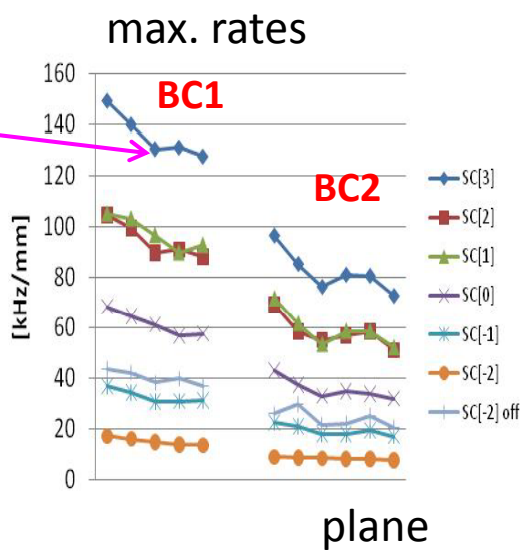
SC 2 / SC 3
350k – 650k/spill beam

Instantaneous Intensity from MWPC Time Spectra

SC 3(657k π^+/spill)







Integration over all wires

–> 8MHz

From BH1 Scaler & Duty-Factor

1.82M/1.5sec/0.05 = 24MHz

From pion Scaler & Duty-Factor

0.66M/1.5sec/0.05 = 8.8MHz

Our expected value at Proposal

200kHz/wire

10MHz in total

Calibration Processes (Resolution Check) – Yield Estimate –

>300 counts for well-separated peak are necessary for check and calibration.

1. $^{12}C(\pi^+,K^+)^{12}_{\Lambda}C_{gs}$ @ 1.05GeV/c — $p(K^+)$: 0.71 – 0.72 GeV/c
2. $p(\pi^-,p)\pi^-$ @ 0.5GeV/c — p(p): 0.70 – 0.73 GeV/c
3. $p(\pi^-,K^+)\Sigma^-$ @1.25 GeV/c — $p(K^+)$: 0.67 – 0.75 GeV/c

a) 5mm Carbon $N_{C12} = 4.26\times10^{-5}$/mb
b) 10mm CH_2 $N_H = 7.9\times10^{-5}$/mb
c) Liq-H_2 (L=12cm) $N_H = 5.1\times10^{-4}$/mb

300k/spill (6sec.) Beam
Analysis efficiency of 0.5
Kaon survival rate of 0.4

	C.S.	Target	Yield	Comments
1	8ub/sr	a	30 / day	15ub/sr at 0 deg.
2	5mb/sr	b	3.5×10^3 / hour	
		c	1.8×10^4 / hour	efficiency of 0.85 from target size
3	40ub/sr	b	800 / 3days	
		c	1500 / day	efficiency of 0.85 from target size

Missing Mass Resolution

1. $^{12}C(\pi^+,K^+)^{12}_{\Lambda}C_{gs}$ @ 1.05GeV/c p(K^+) : 0.71-0.72 GeV/c
2. $p(\pi^-,p)\pi^-$ @ 0.5GeV/c p(p): 0.7-0.73 GeV/c
3. $p(\pi^-,K^+)\Sigma^-$ @1.25 GeV/c p(K^+): 0.67-0.75 GeV/c

$$\Delta M^2 = \left(\frac{\partial M}{\partial p_B}\right)^2 \delta p_B^2 + \left(\frac{\partial M}{\partial p_S}\right)^2 \delta p_S^2 + \left(\frac{\partial M}{\partial \theta}\right)^2 \delta\theta^2 + \Delta E_{strag}^2$$
$$= \Delta_B^2 + \Delta_S^2 + \Delta_\theta^2 + \Delta E_{strag}^2$$

$\Delta p/p$ (BS)=3.3x10^{-4}(FWHM) ⇒ δp_B = 0.35 MeV/c (1.05GeV/c)
0.40 MeV/c (1.25 GeV/c)
0.20 MeV/c (0.5GeV/c)

K6BS & SKS Beam Through (Takahashi D thesis)
$\Delta p/p = (1.58 \pm 0.26)\times 10^{-4}\ p + (0.099 \pm 0.019)\%$ ⇒ δp_S= 1.5 MeV/c@0.7GeV/c

$\delta\theta$=5.0 mrad

@θ=5 deg

	Δ_B		Δ_S		Δ_θ		ΔM
	$\frac{\partial M}{\partial p_B}$	MeV	$\frac{\partial M}{\partial p_S}$	MeV	$\frac{\partial M}{\partial \theta}$	MeV	MeV
1	0.962	0.34	-0.795	1.13	-5.194	0.03	1.24
2	3.470	0.69	-2.822	4.23	-226.9	1.13	4.44
3	0.657	0.26	-0.4889	0.73	-67.73	0.34	0.85

E19 Beamtime Estimate

Proposal

1.44×10^{12} pions on target / 3 incident momenta
10M/spill with 4sec. duration x 160 hours
3-4 times as high (instantaneous) intensity as KEK-PS

KEK-PS 2.5MHz intensity (1.5M/spill with 2.7s duration) D.F.=80%
Ave. multiplicity at the most upstream chamber with 300ns window was 2.5

From multiplicity distribution, 300-500k/spill is the similar intensity as KEK-PS at the present beam w/ EQ/RQ.
D.F. is estimated to 5-7.5% .
500k/spill (6sec.) -> 7.2G/day (1kW MR is enough)

200 days (65 days for one incident momentum)
(Present time-structure)

if the time-structure is drastically improved (x10 D.F.)

20 days using 5M/spill beam (2.5kW MR)

50 days using 2M/spill beam (1kW MR & x4 D.F.)

E19 Beamtime Estimate – continued –

Above beam time is required to carry out fully the proposal goal,

1.2×10^4 Θ^+ in each incident momentum

assumed E522 cross section (1.9ub/sr)

Sensitivity of 75nb/sr

Taking into account of the available intensity and time-structure, we would like to divide into two steps,

Step-1: Confirmation of E522 with 10σ sensitivity at 1.92GeV/c

10 days data-taking with 500kHz/spill beam

If Θ^+ "exists", we can obtain meaningful result.

Step-2: To carry out the proposal value.

3 incident momenta of 1.87, 1.92, and 1.97 GeV/c

with the sensitivity of 75nb/sr.

Our Plan (Revised)

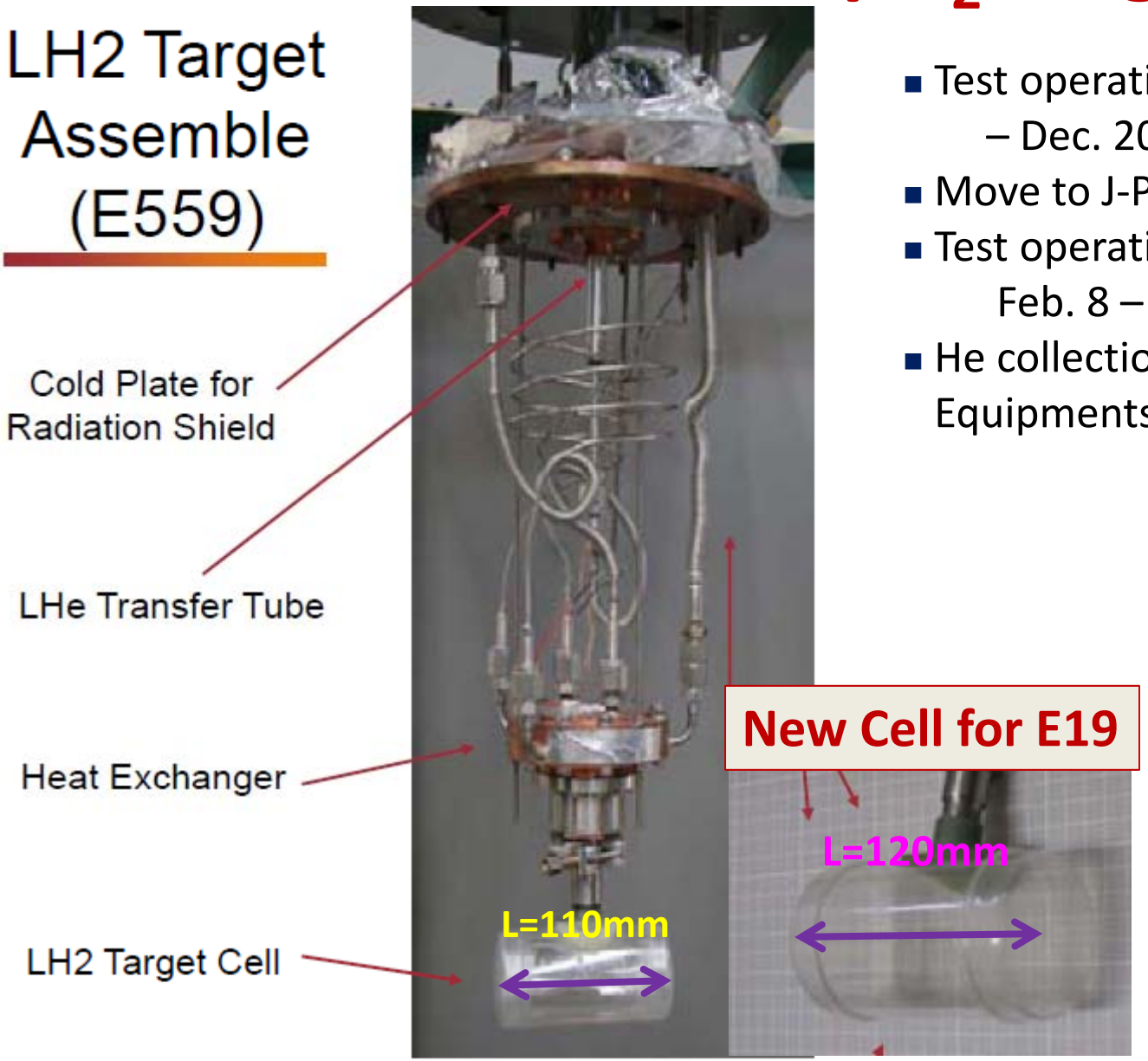
- Resolution check & Calibration (2010 Jan. & Feb.)
  - $\pi^- + p \rightarrow p + \pi^-$ at 0.5 GeV/c with CH_2/Liq-H_2 a few hours
  - $\pi^- + p \rightarrow K^+ + \Sigma^-$ at 1.25 GeV/c with CH_2/Liq-H_2 3/1 days
  - ($^{12}C(\pi^+,K^+)^{12}_{\Lambda}C$ at 1.05 GeV/c) if possible
- E19 ($\pi^- + p \rightarrow K^- + \Theta^+$)
  - Step-1: 10σ at 1.92GeV/c (2010 Autumn) 10 days
  - Step-2: 1.44×10^{12} pions at 1.87, 1.92, 1.97GeV/c
- Other experiments

Starting with 500k/spill intensity, it gradually increases according to the improvements of time-structure of the beam and analysis methods.

Summary

- Experimental apparatus is ready for data-taking.
  - K1.8 beamline — Designed setting is OK for pion
  - SKS spectrometer — Sks0 setup
  - Analyzer — mom. analysis of B.T. data
- Available intensity is limited by time-structure.
  - 500k/spill, spill=1.5s @ the present time-structure
  - 500k/spill pions (>1GeV/c) @240W MR & Ni target
- Running plan
  - Resolution check — **2010 Jan. & Feb.**
  - E19 Step-1 — **2010 Autumn**

Status of Liq-H_2 Target



- Test operations in Tsukuba
  – Dec. 2009
- Move to J-PARC Dec. 24,2009
- Test operation at J-PARC
  Feb. 8 –
- He collection line &
  Equipments for safety are ready