

E19 STATUS REPORT

- HIGH-RESOLUTION SEARCH FOR
THETA+ PENTAQUARK IN $\pi^-p \rightarrow K^-X$ REACTIONS -

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for the E19 collaboration

J-PARC PAC, 16th. July 2010

Outline

- Introduction
 - Motivation : Past Experiment KEK-PS E522
 - Goal of the E19 experiment
- Current Status
 - Result of the detector commissioning
 - Spectrometer performance
- Beamtime Request for the autumn runs

Production Mechanism

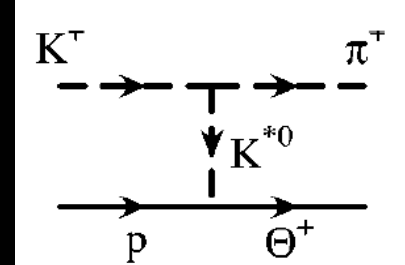
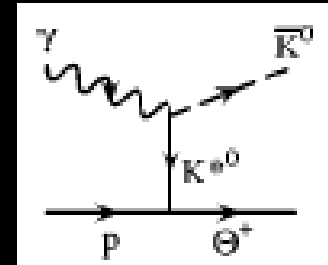
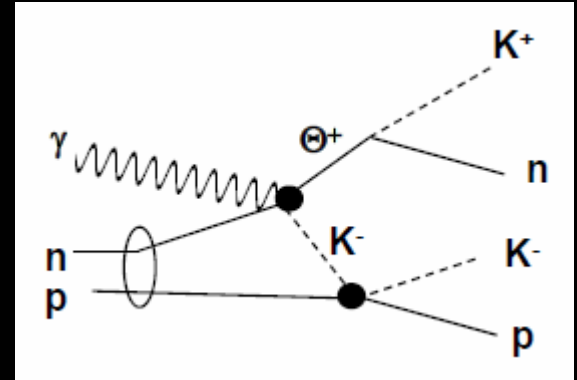
CLAS-d	$\gamma d \rightarrow p K^- K^+(n)$	U.L. $\sim 3\text{nb}$ for γn
LEPS	$\gamma C \rightarrow K^- K^+(n)$	4.6σ

not inconsistent with each other:
strong angle / energy dependence.

CLAS-p	$\gamma p \rightarrow K^0 K N$	U.L. 0.8nb
E559	$K^+ p \rightarrow p^+ X$	U.L. $3.5 \mu\text{b/sr}$

it implies a very small coupling to K^* .

$$g_{NK^*\Theta^+} \sim 0$$

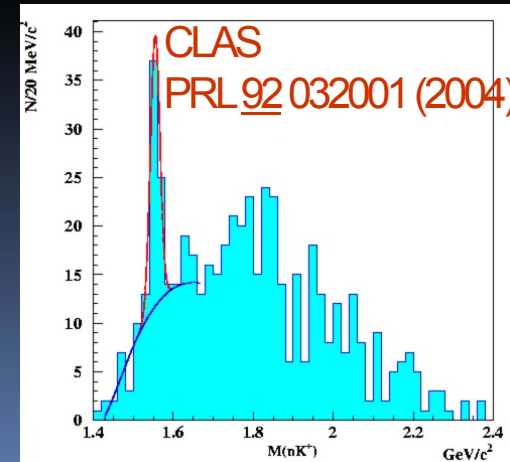
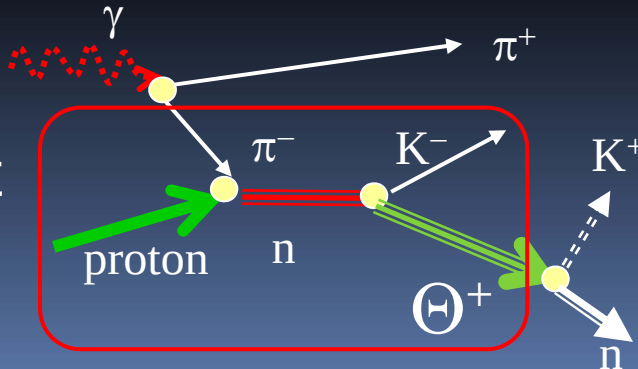


Θ^+ production in π induced reaction

$$\sigma(\pi p \rightarrow K^- \Theta^+) \propto \Gamma_{\Theta^+}$$

$\rightarrow$ could be significant

$$\text{cf: } \gamma p \rightarrow \pi^+ K^- K^+ (n)$$



KEK-PS E522 experiment

- search for Θ^+ via $\pi^- p \rightarrow K^- X$
 - K2 beamline + KURAMA
- beam momentum : 1.87, 1.92 GeV/c
- target : Polyethylene
- intensity : $3.3 \times 10^5 \pi^-$ /spill
- beam time : 32 x 2 hours
- Mass resolution : 13.4 MeV(FWHM)

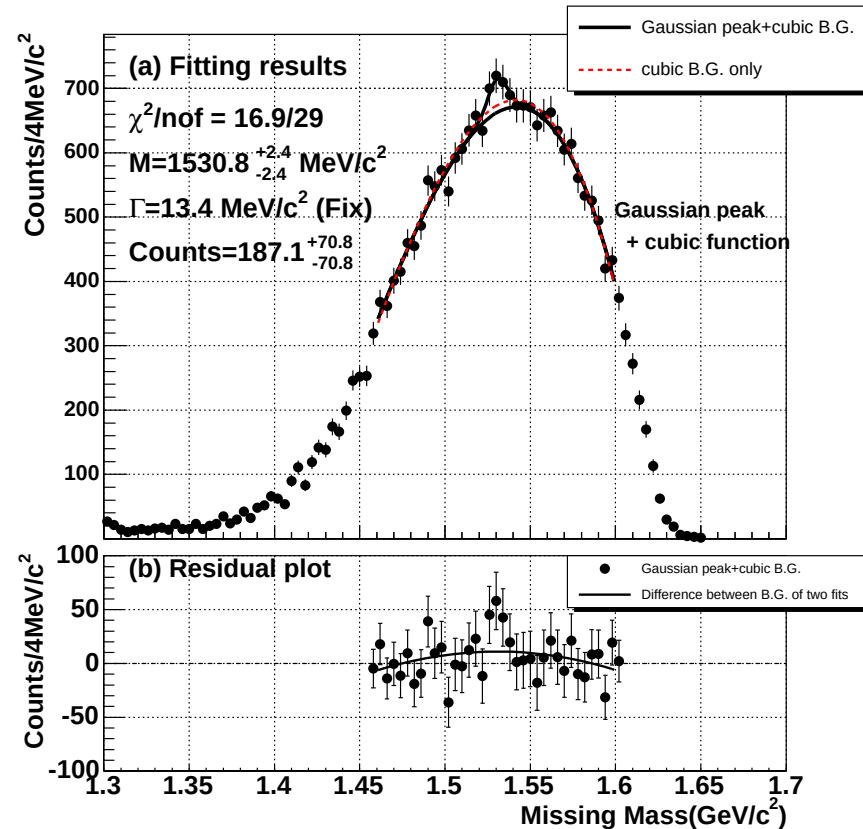
a bump was observed
at $M = 1530.8 \text{ MeV}/c^2$
only at $p_\pi = 1.92 \text{ GeV}/c$

but : $S/N = 2.5\sigma$

upper limit : $d\sigma/d\Omega < 2.9 \mu\text{b}/\text{sr}$

if exist

$p_\pi = 1.92 \text{ GeV}/c$



K. Miwa et al. PLB635,72(2006)

$d\sigma/d\Omega = 1.9 \mu\text{b}/\text{sr}$ (lab)

J-PARC E19 experiment

- ▣ $\pi^- + p \rightarrow K^- + \Theta^+$ at K1.8 + SKS
for $p_\pi = (1.87, 1.92, 1.97 \text{ GeV}/c)$
- ▣ target : liquid H_2 , $0.86 \text{ g}/\text{cm}^2$
- ▣ beam intensity : $10^7/\text{spill}$
- ▣ beam time : 160 hours
($\rightarrow \sim 60$ times larger yield)

SKS :

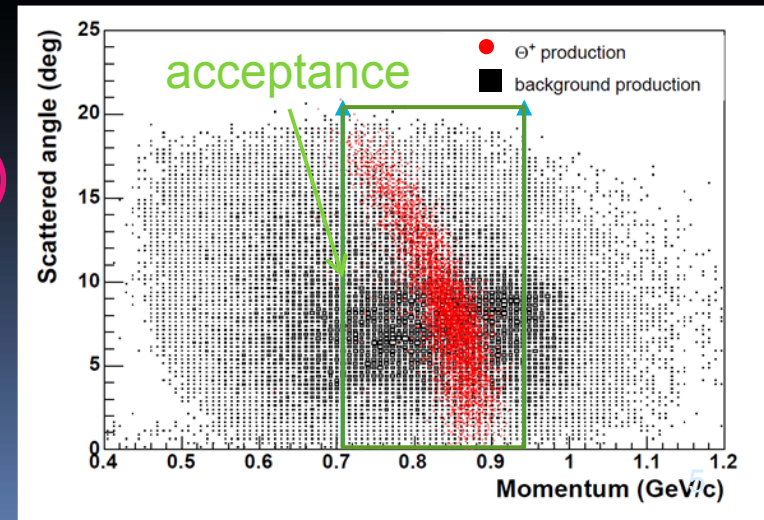
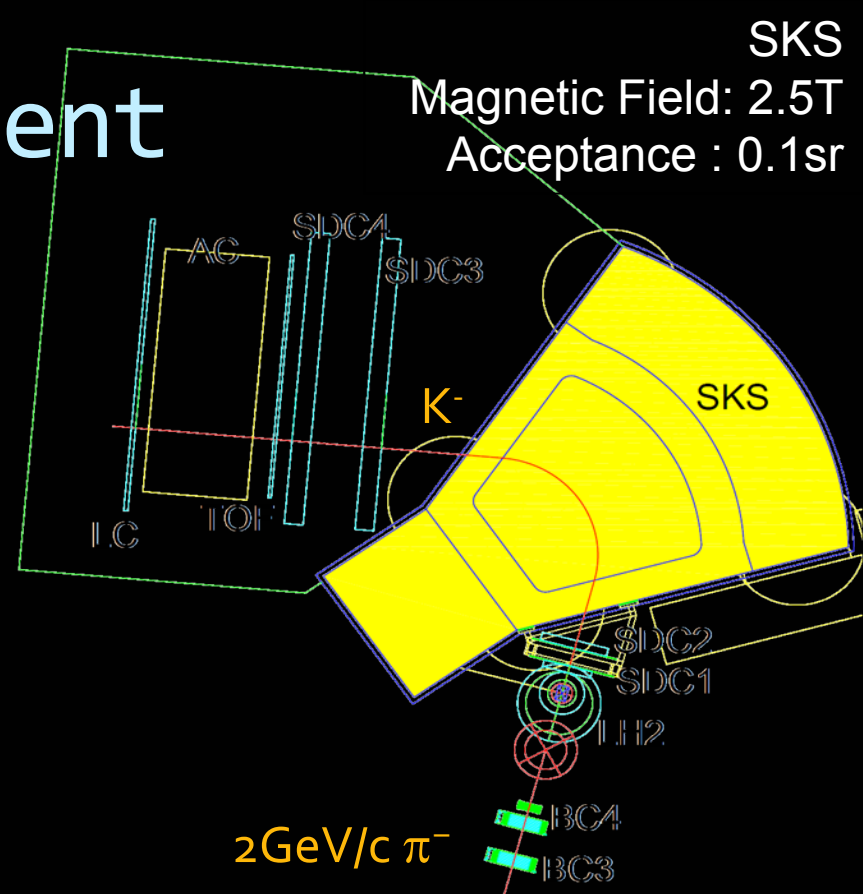
large acceptance

$dp/p \sim 0.2\%$ @ $1 \text{ GeV}/c$

(~ 5 times better than KURAMA)

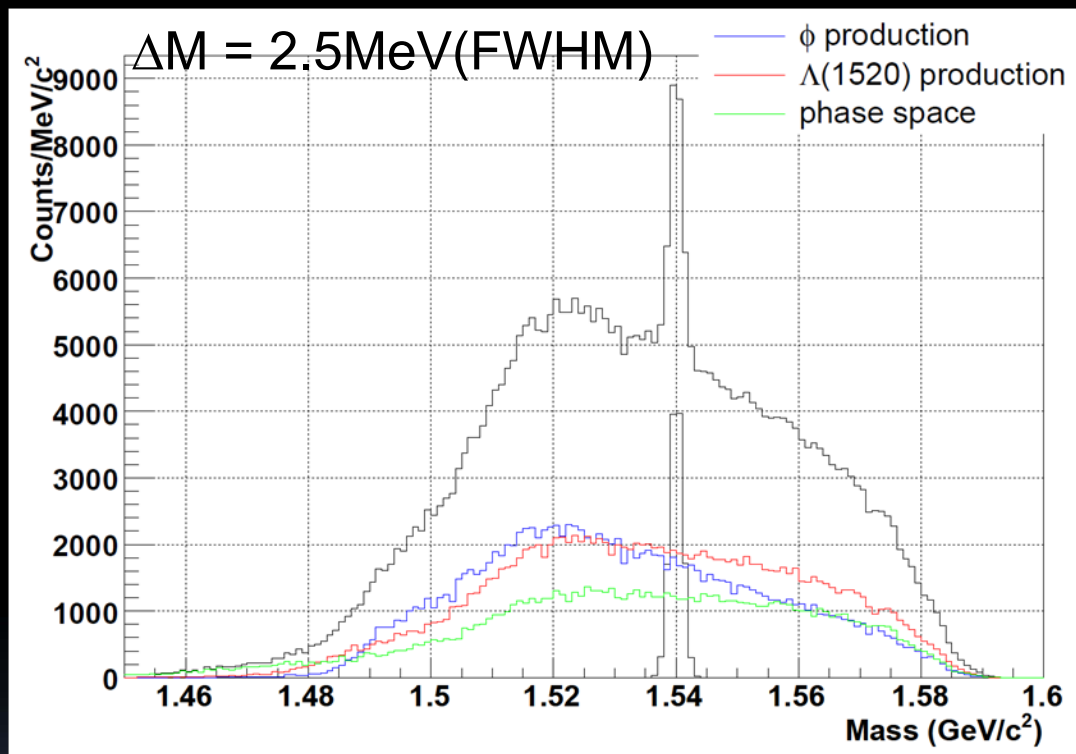
$\Delta M = 2.5 \text{ MeV FWHM}$

ideal for Θ^+ detection



Expected Missing Mass Spectrum

assuming $d\sigma/d\Omega = 1.9\mu\text{b/sr}$ (lab)



we aim to;

- confirm Θ^+ with high statistics
- study momentum dependence of cross section

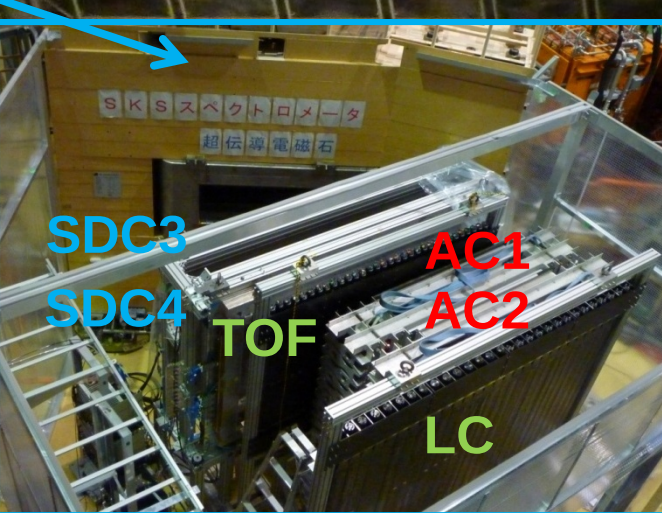
Background sources

ϕ	$\phi n \rightarrow K^+K^-n$	$30.0 \pm 8.0 \mu\text{b}$
Λ	$\Lambda(1520)K^0 \rightarrow K^-K^0p$	$20.8 \pm 5.0 \mu\text{b}$
phase space	K^-KN	$26 \mu\text{b}$

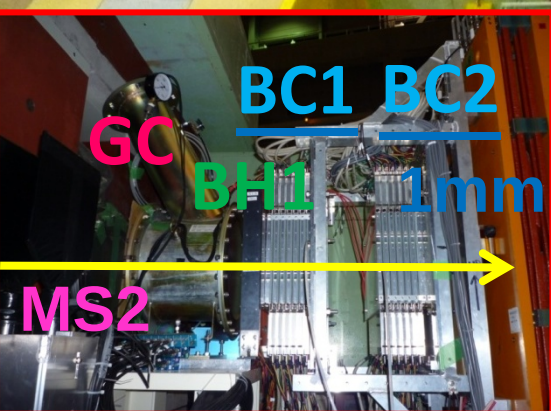
Data Summary (Oct. 2009-Feb. 2010)

- Construction of Spectrometer was completed on Oct. 2009
- First secondary beam 22nd Oct. 2009
- Detector commissioning 36 hours
- Beamline tuning
 - ▣ tuning for pion beam 25 hours
 - ▣ tuning for Kaon beam 5 hours
- Calibration run
 - ▣ beam through : $p=0.65\sim0.8\text{GeV}/c$ 9 hours
 - ▣ π^-p elastic scattering at $p=0.5\text{GeV}/c$ 6 hours
 - ▣ $\pi^-p \rightarrow K^+\Sigma^-$ reaction at $p=1.25\text{GeV}/c$ 30 + 23 hours
 - ▣ empty target 3 hours

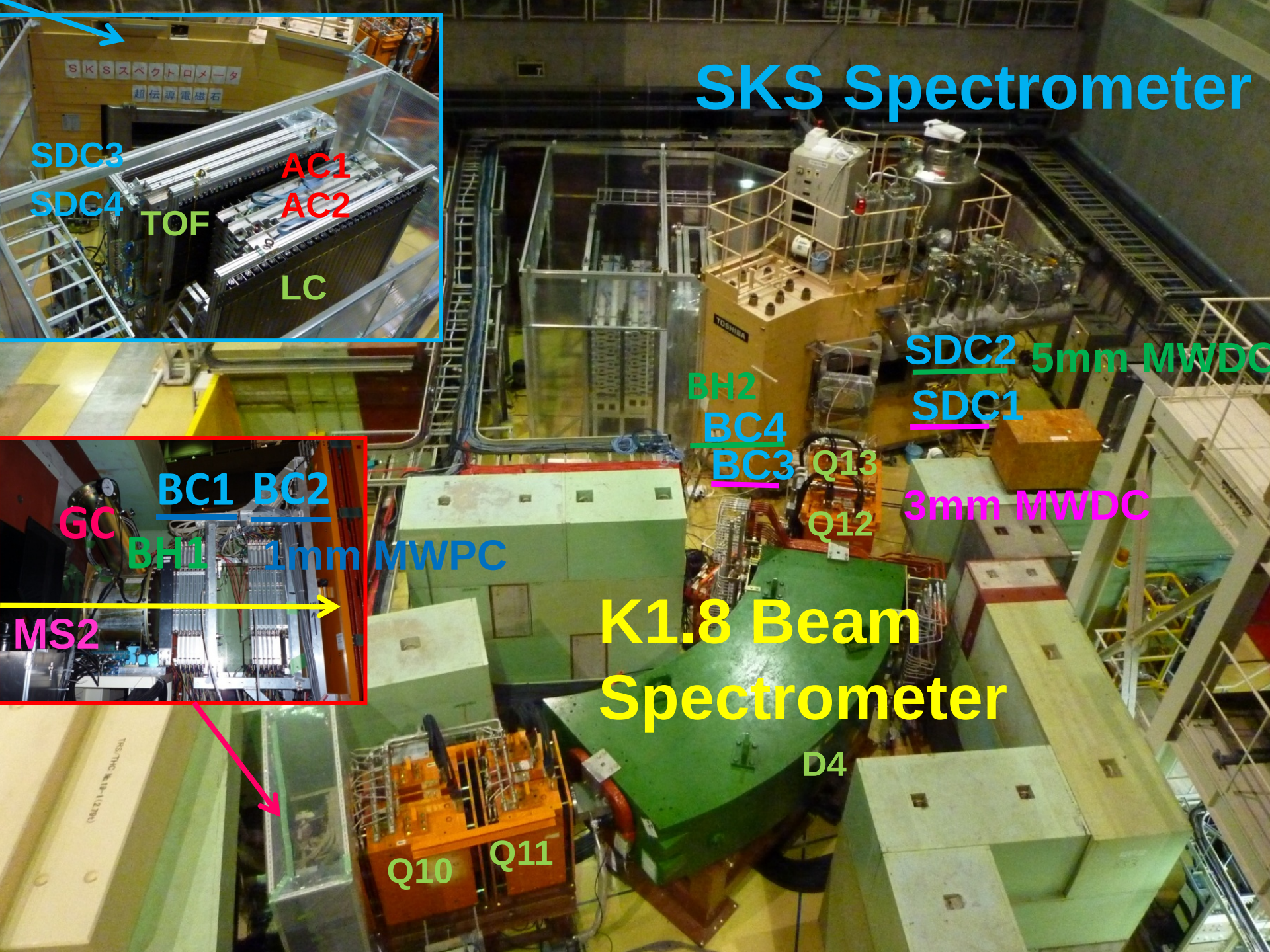
In total, 137 hours (=5.4 days)



SKS Spectrometer



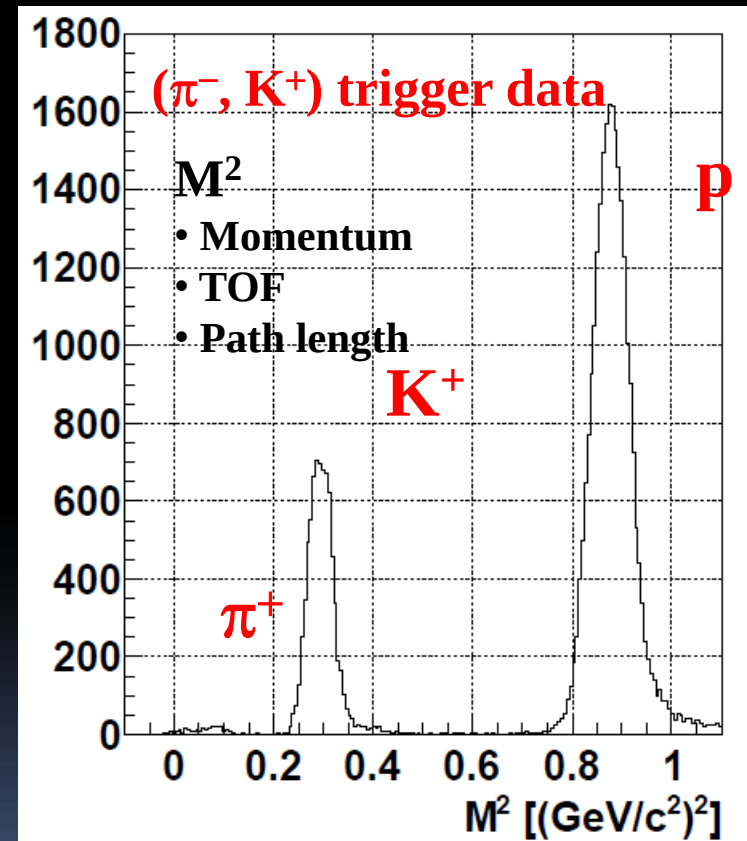
K1.8 Beam Spectrometer



Detector Performance

- SKS magnet
 - successfully operated up to 2.5 T at 400 A.
- Tracking Chambers
 - resolution $\sim 250\mu\text{m}$
 - efficiencies
 - beam tracking : $\sim 95\%$
 - SKS tracking : 92%
- Particle Identification
 - AC & LC efficiency : 99%
 - TOF efficiency : 98%
 - TOF resolution : 122 ps

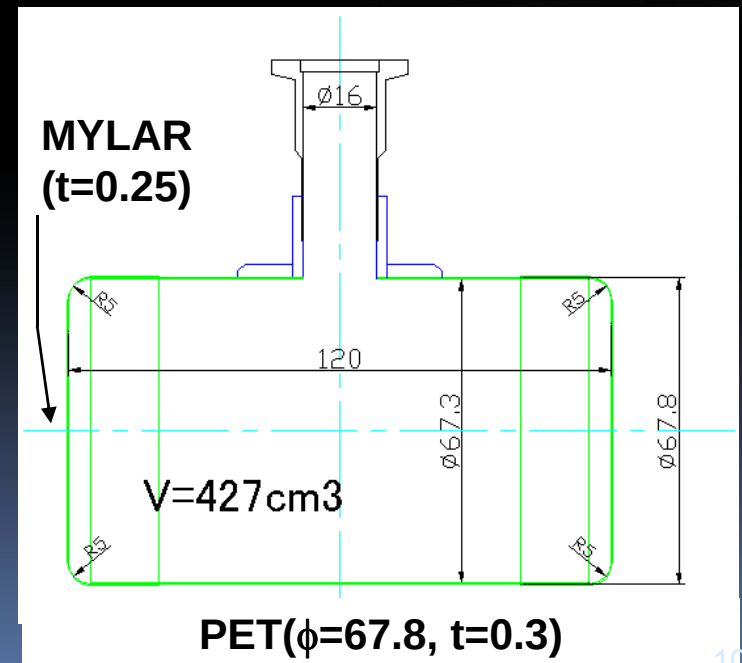
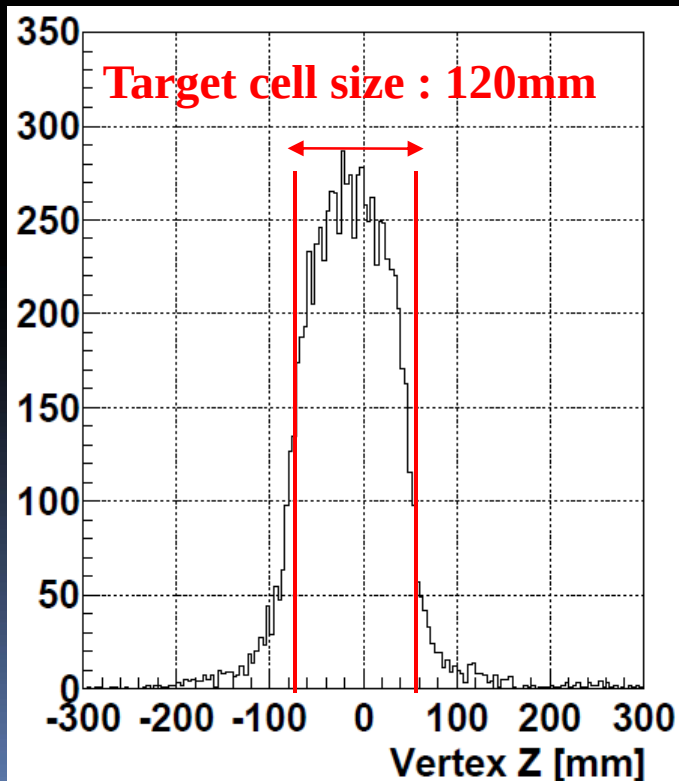
M^2 spectrum of scattered particles



Required performance has been achieved.

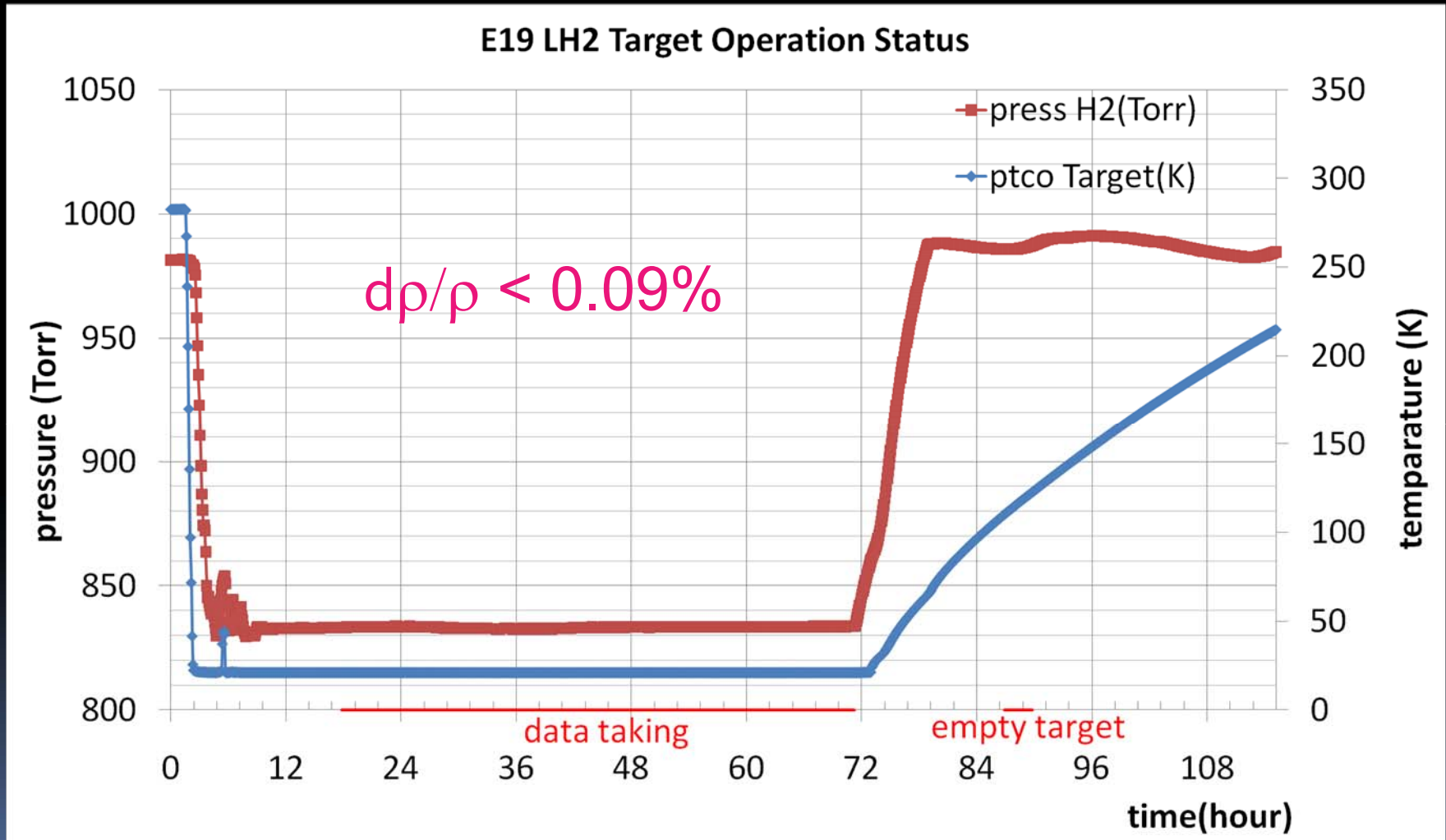
Liquid Hydrogen Target

- continuous-flow Liquid Helium Cryostat
- key to suppress background
& eliminate Fermi motion effect
- thickness : 0.86g/cm^2
- safely operated for 3days



Operation Result of LH2 Target

18th – 22nd, Feb. 2010



Spectrometer Performance

Σ^- production was studied
in $p(\pi^-, K^+)\Sigma^-$ @1.25 GeV/c

- on Target: Liq-H₂(0.86 g/cm²)
- 750k π /spill x 20 hours

Yield : 8.5k
consistent with the estimation
-> overall efficiency is OK.

Measured Mass Resolution :

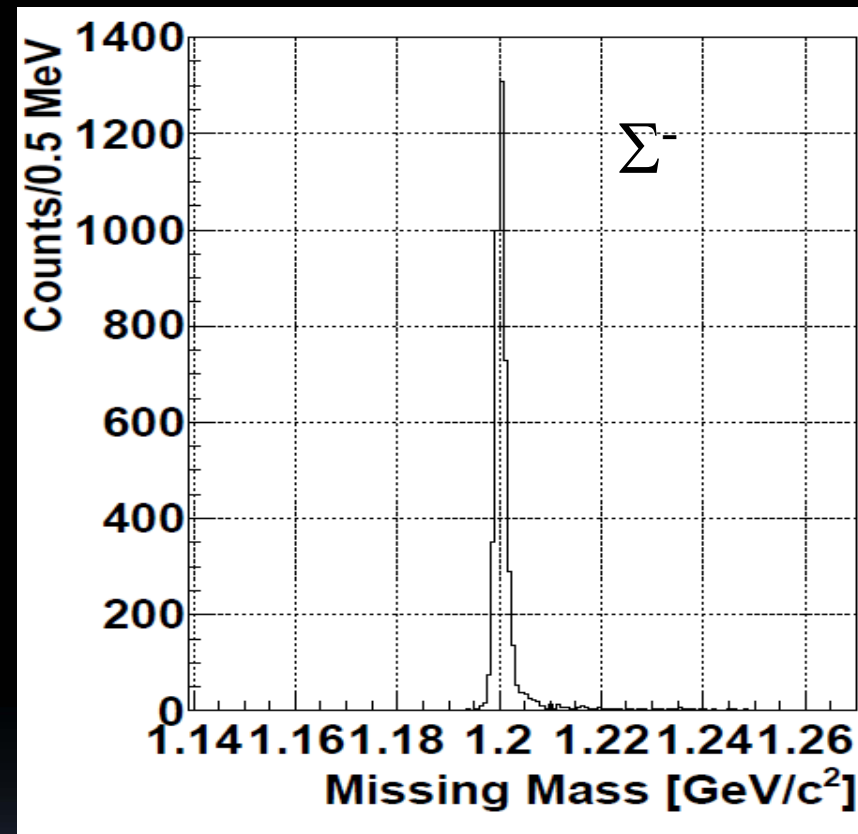
$\Delta M = 1.66 \pm 0.05$ MeV (FWHM)

$\Delta p_{SKS} = 3.3$ MeV/c (FWHM) at 0.7 GeV/c

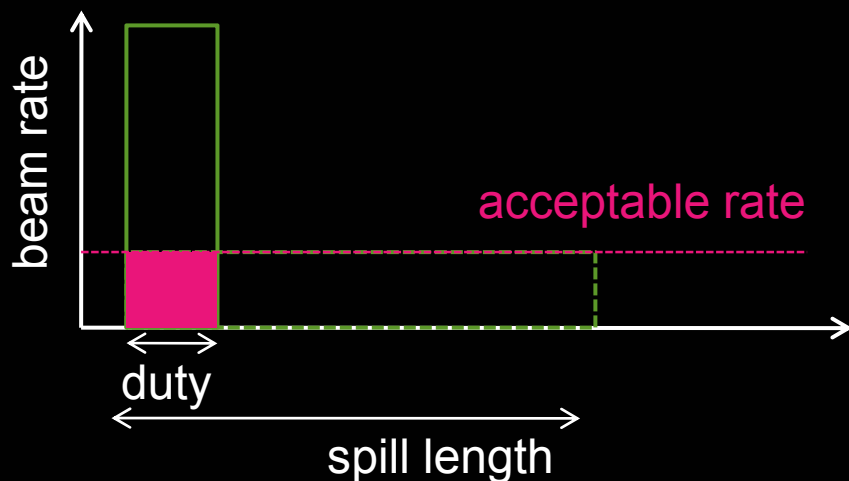
($M = 1.201$ GeV [$M_{PDG} = 1.1974$ GeV])

ready for E19!

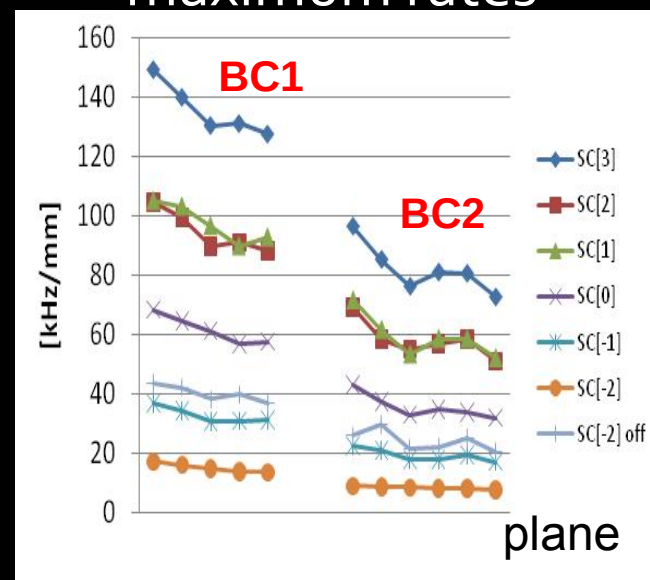
for $p(\pi^-, K^-)\Theta^+$ @1.92 GeV/c : $\Delta M \sim 1.8$ MeV (FWHM)



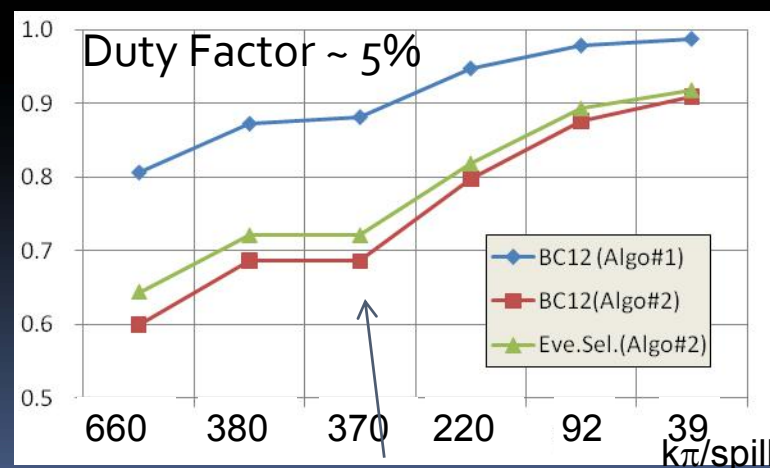
Duty Factor & Beam Rate



maximum rates



analysis efficiency



corresponds 0.75M π /spill w/ duty of 10%

We reported at the last PAC;

- duty factor : 7.5%
- acceptable beam intensity : 500k π /spill

On Feb. 2010

- duty factor was improved to 10%
- acceptable intensity : 750k π /spill
- * upstream counter rate = 1.2M/spill
- 1.2M/(1.8sec*10%) ~ 7MHz
- close to the limit of 10MHz

Beamtime Request

acceptable beam intensity is NOT limited by beam power but **duty factor** (4kW is enough to have 10M π /6 sec.).

- at proposal : $10^7 \pi / 4\text{sec} \times 7 \text{ days} = 1.44 \times 10^{12} \pi$ on target in total
- w/ 750k π /6sec $\rightarrow$ 133 days *44 days for each $p_\pi=(1.87,1.92,1.97\text{GeV}/c)$

Step 1:

needs 6 days to confirm Θ^+ with 10σ at $p_{\text{beam}} = 1.92 \text{ GeV}/c$ assuming 10% duty factor.

Step 2:

needs ~40 days if the duty factor is 30% to reach the expected sensitivity & study momentum dependence

additionally we request for the autumn run;

- ▣ detector commissioning : 2.5 days
- ▣ calibration data
 - $p(\pi^-, K^+)\Sigma^-$ at 1.35GeV/c (400A) : 1.5 day
 - empty target : 1 day



in total,
11 days

Summary

- We are ready to start physics run this autumn.
 - Detector Performance
 - efficiencies, acceptance & high rate capability are OK.
 - Spectrometer performance
 - achieved good resolution measured in Σ^- production.
- We request;
 - 6 + 5 days to confirm Θ^+ existence with 10σ in the coming autumn run.
 - ~ 40 days to achieve the approved beamtime expecting a duty factor of 30%.

BACK UP

e/π Ratio Dependence on Ni/Pt Targets

/spill	Ni		Pt	
	-1.92GeV/c	-1.25GeV/c	-1.92GeV/c	-1.25GeV/c
π	729k	301k	634k	995k
e	155k	172k	39.8k	143k
BH ₁	1140k	692k	889k	1.565M
e/π	0.213	0.573	0.062	0.144
π/BH_1	0.64	0.43	0.71	0.64
Beam Power	1.2kW	0.67kW	1.2kW	1.2kW

at 1.92GeV,

- we can accept 10% more beam π with Pt target.
- electron contamination is not severe.

Time Structure – Run30 –

