ハドロン反応によるペンタクォーク探索実験にむけて

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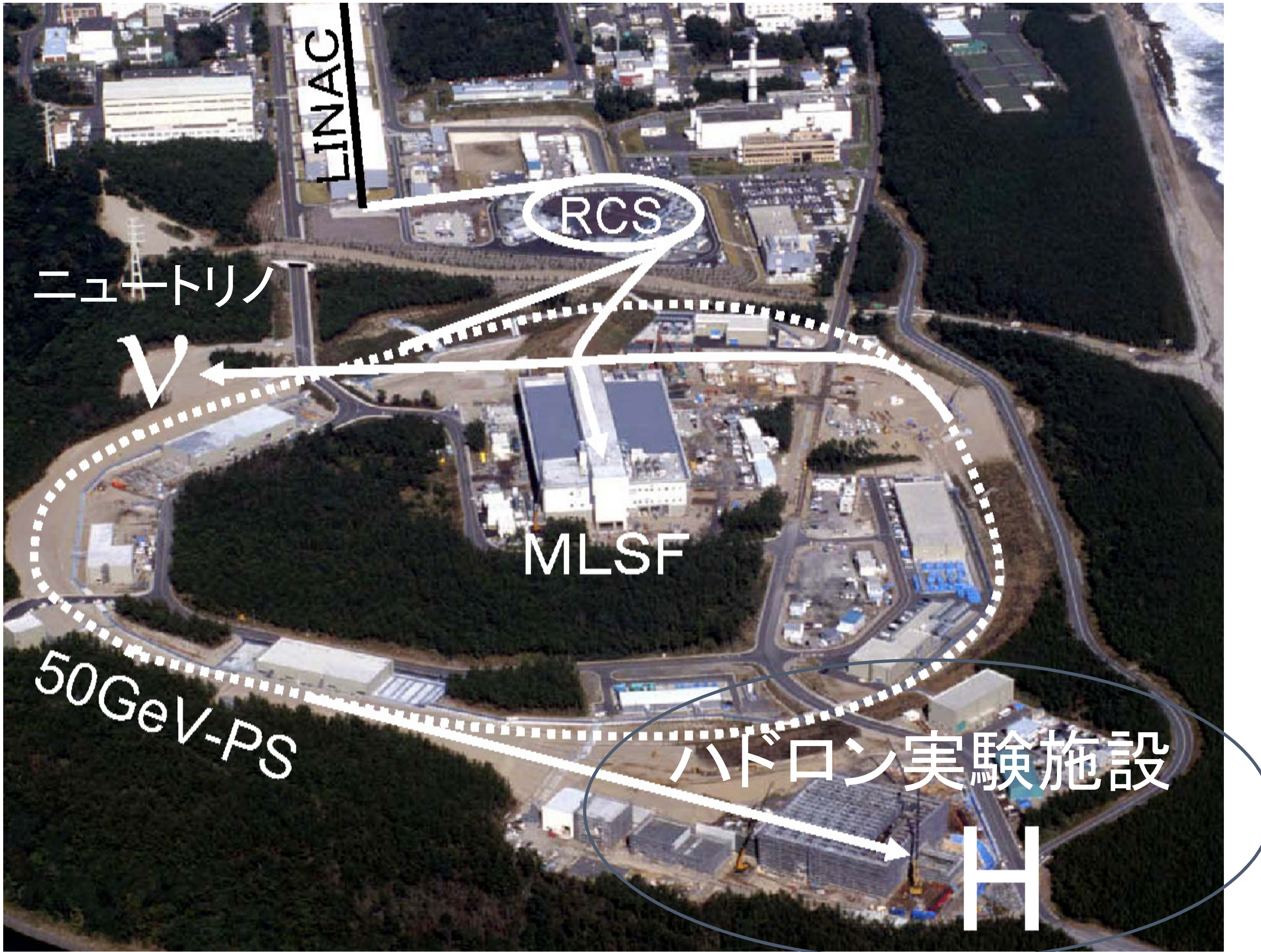
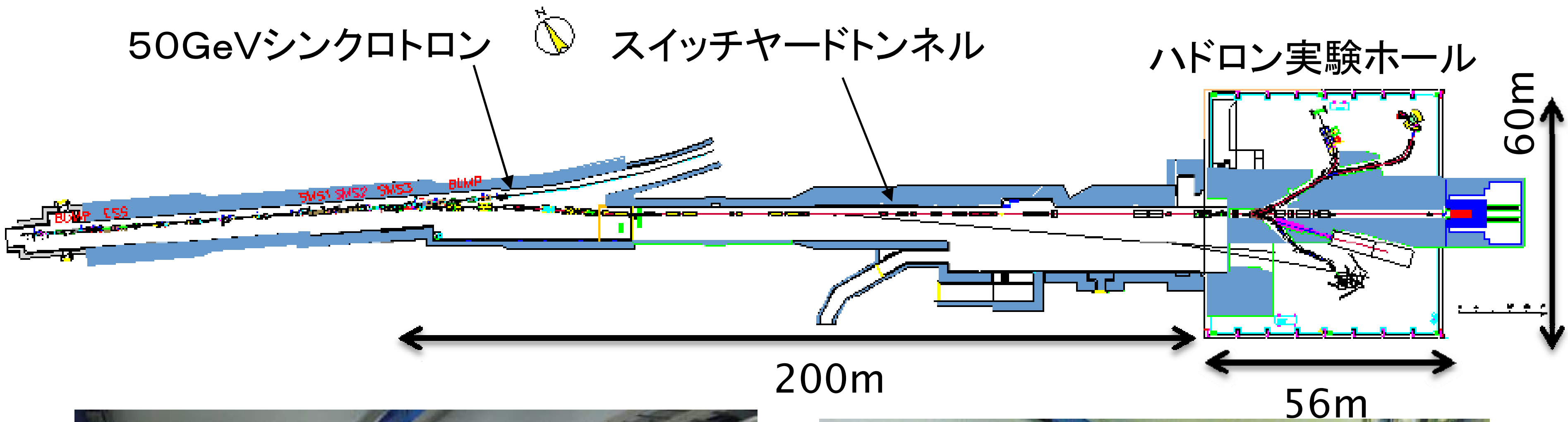
  - Physics Motivation
  - Past experiments at KEK-PS
  - J-PARC E19 experiment : $\pi^- p \rightarrow K^- X$
  - Future Plan
    - LOI: formation process $KN \rightarrow \Theta^+$: settle the situation
    - LOI: Θ^+ hypernuclei
    - other pentaquarks, tetraquarks
  - Current Status of K1.8 beamline

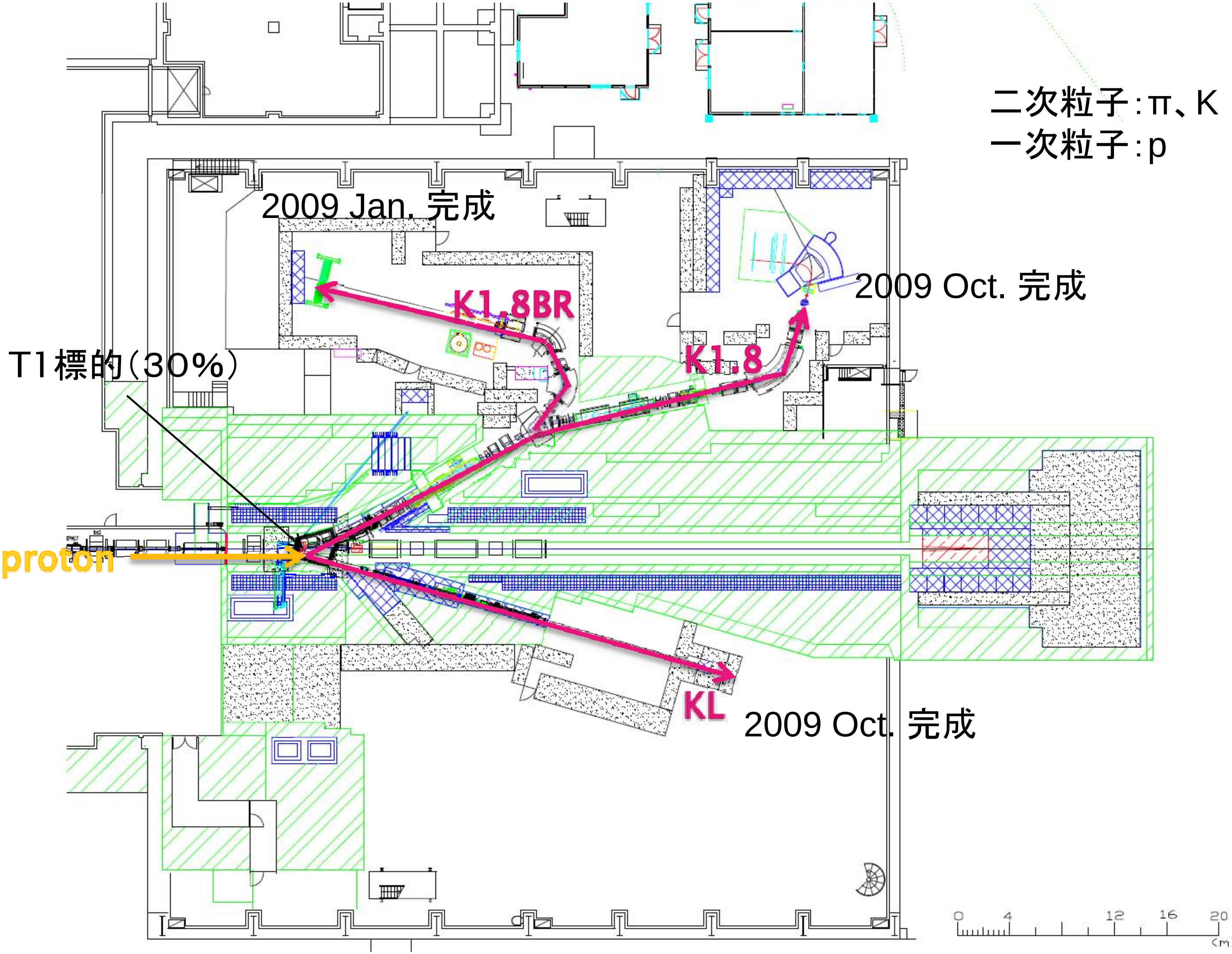
J-PARC　鳥瞰図



50GeVリングからハドロン実験施設へ

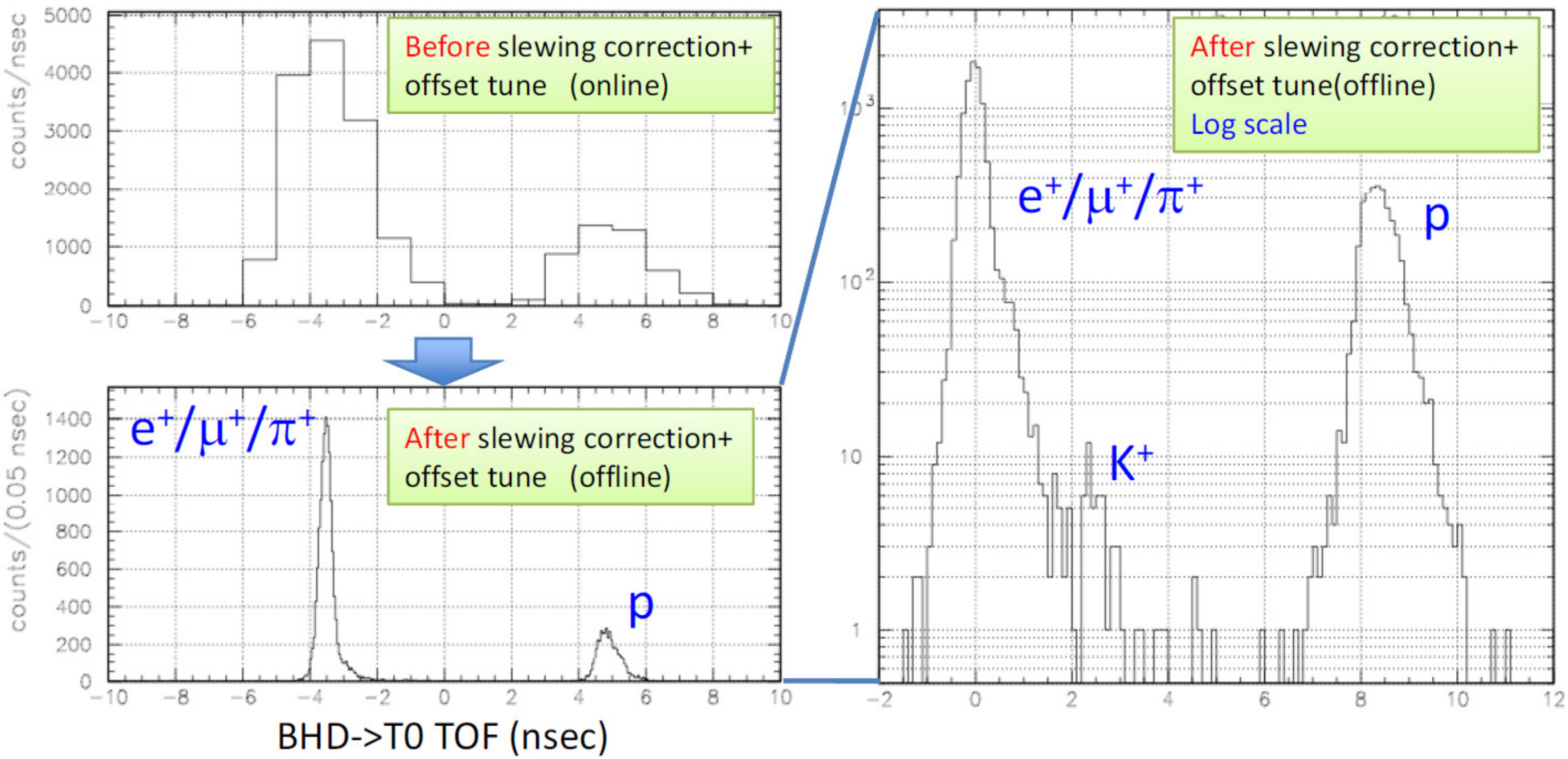


ハドロン実験施設(2009年12月現在)



Beamline Tuning @K1.8BR 2009/2

K^+の同定

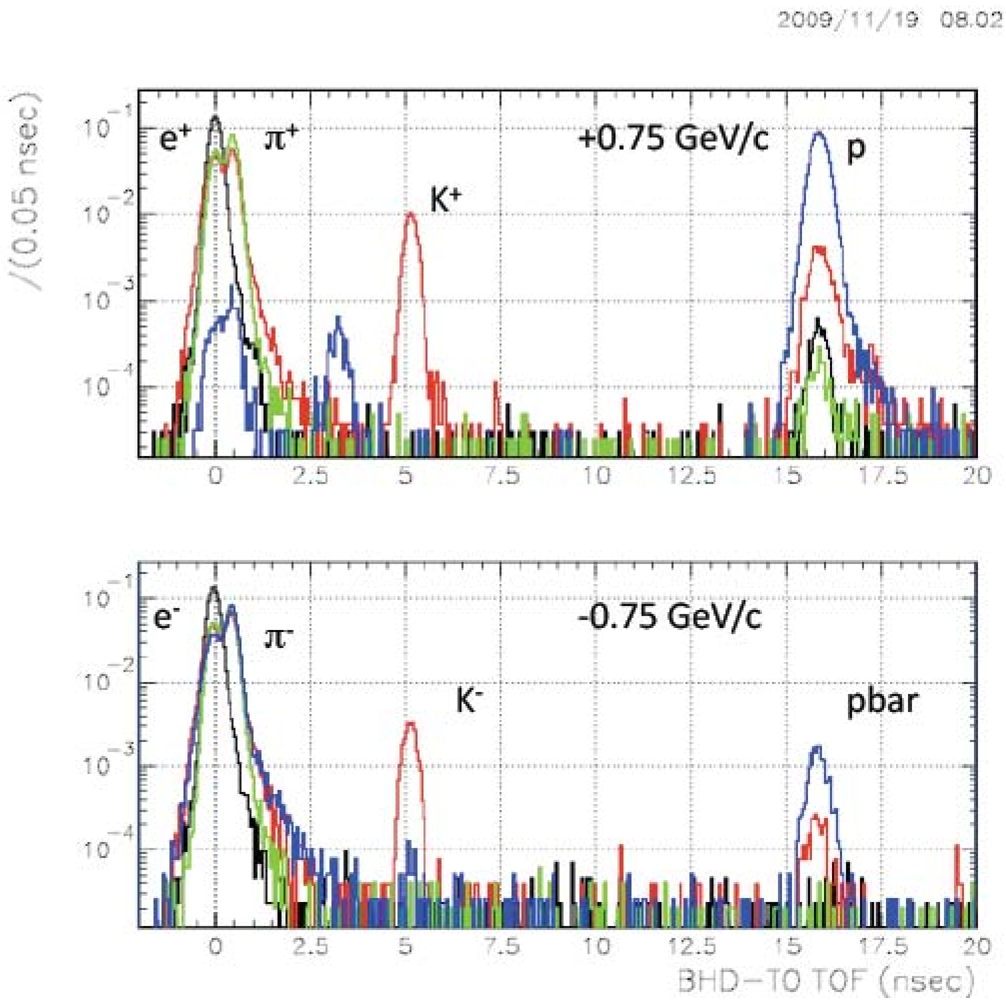


π-KのTOF差~ 2.4 nsec (計算値 2.3 nsec @1.1 GeV/c)

$e^+ + \mu^+ + \pi^+ : K^+$ ~ 9000:40 ($\pi^+:K^+$の計算値~540:1 @1.0GeV/c)

=> BHD->T0のTOFスペクトル上にK^+を同定

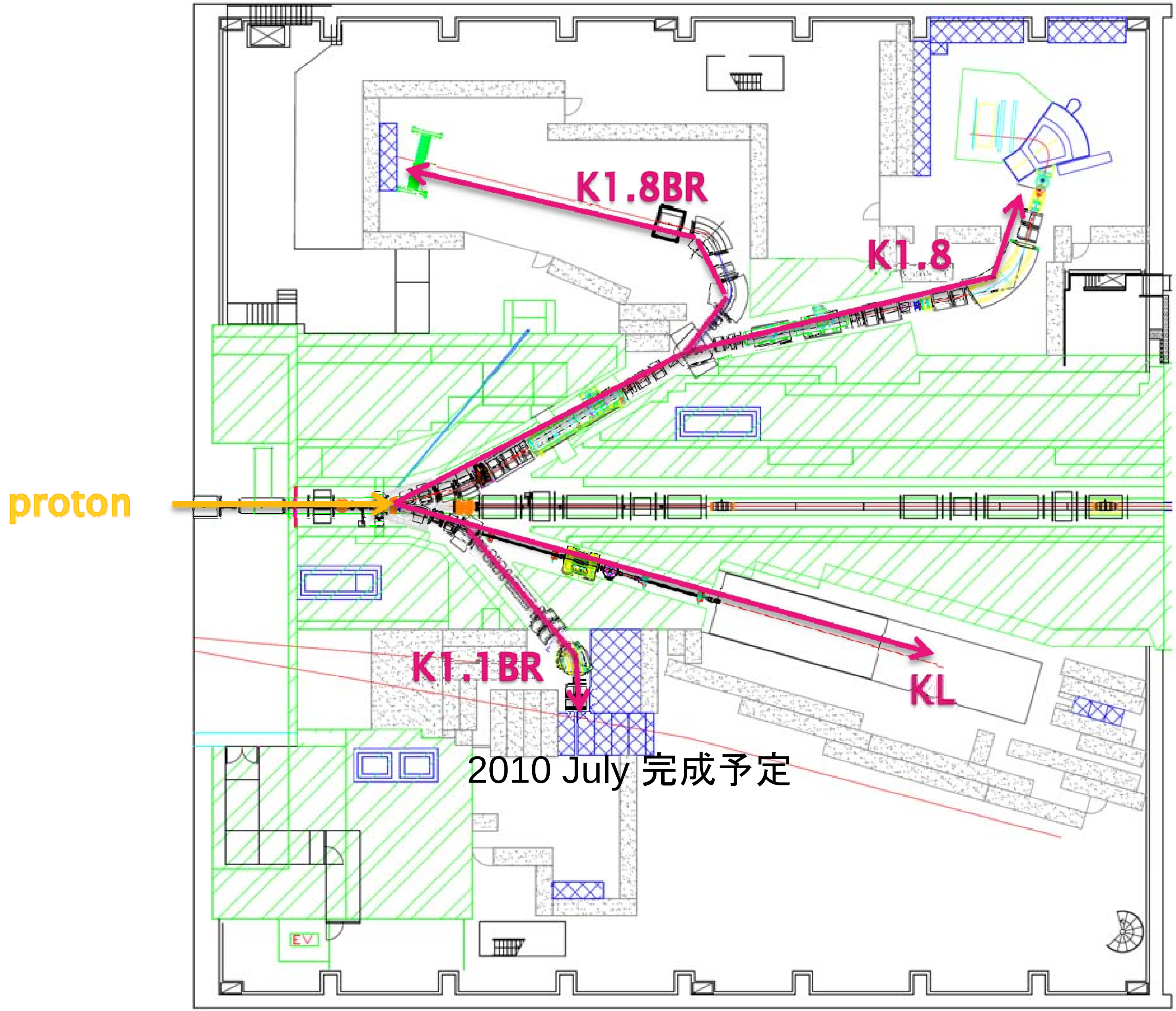
K1.8BRのrun#27のビーム利用(11/14、11/15、11/19)



- ✓11/14及び15は+-0.75 GeV/c、ESS offで"e"/"K"/"π"/"p"のオンライントリガーを構築、KトリガーにおいてはESS offのビームのK/π比を100倍以上改善することが出来た。
- ✓11/19にはCherenov検出器の調整用の大統計データを4時間取得した。

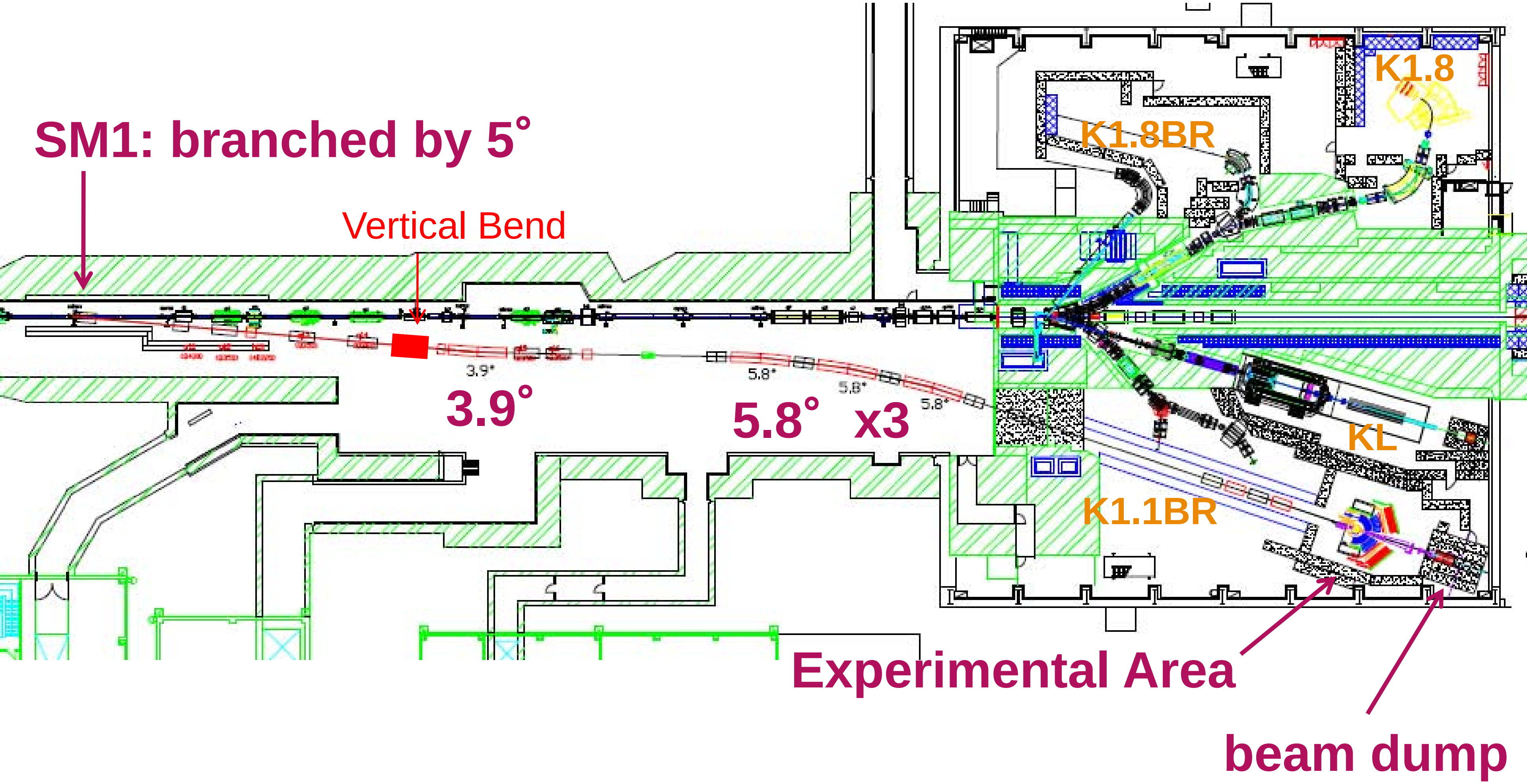
7×10^{10} pppのビーム強度においてはK^+/K^-の個数はそれぞれショット当りで全スリット開状態で**30/7**個であることが確定したため**調整を進行するためには、さらなるビーム強度が必須。**

ハドロン実験施設(2010年度)



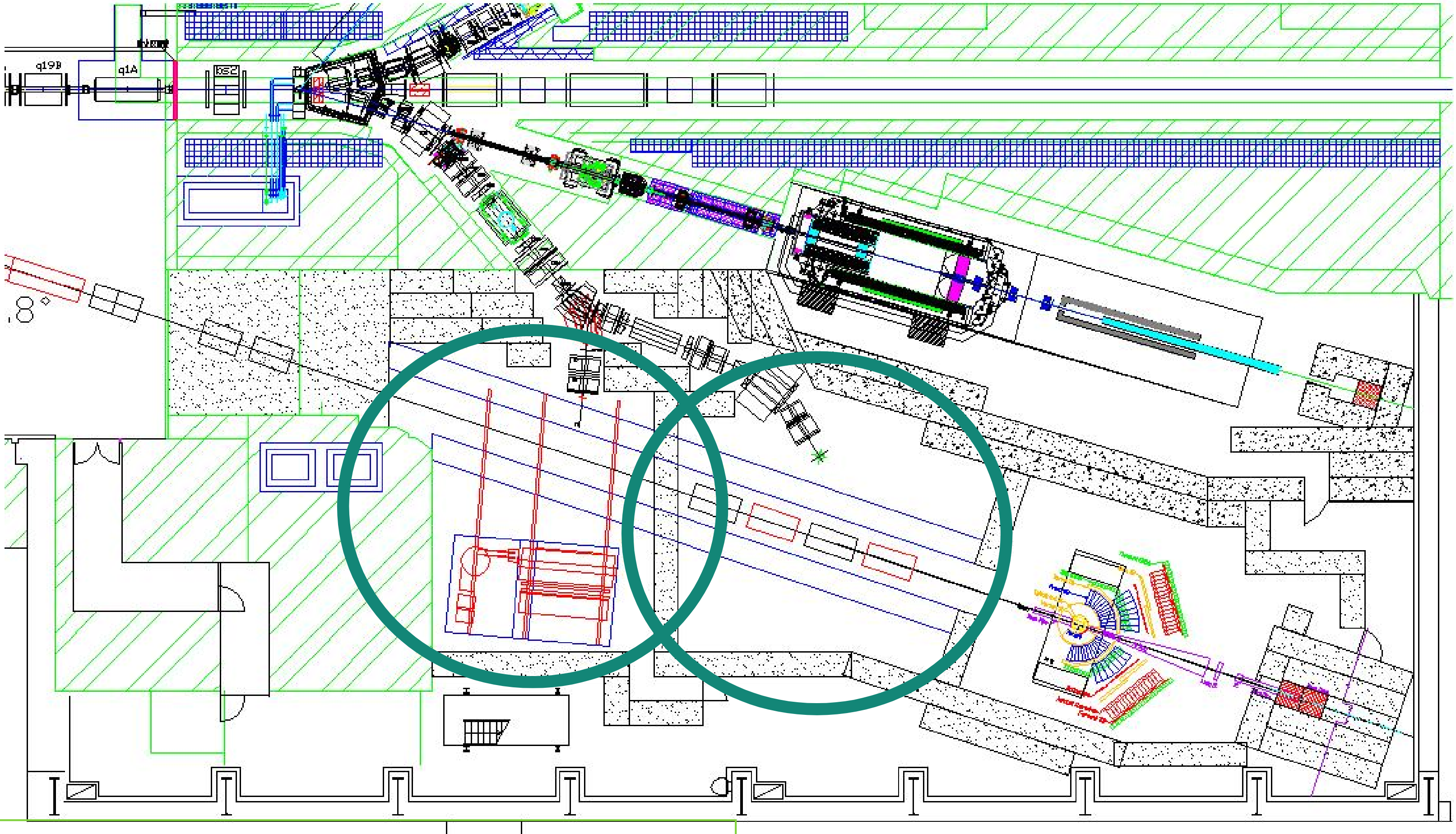
2010 July 完成予定

Location of E16 : High-momentum beam line



Beam dump and shields are for 10^{10} protons/s

Coexistence with K1.1 and K1.1BR



- Removable experimental apparatus
- No Q magnet in K1.1BR Area
  → 2~3 weeks to switch

It will take 2~3 months to switch K1.1 and High-p line.

----J-PARC PAC Approval summary after the 6th meeting ---

	(Co-) Spokespersons	Affiliation	Title of the experiment	Approval status (PAC recommendation)	Slow line priority		Beamline
					Day1?	Day1 Priority	
E15	M.Iwasaki, T.Nagae	RIKEN, KEK	A Search for deeply-bound kaonic nuclear states by in-flight 3He(K-, n) reaction	Stage 2	Day1		K1.8BR
E17	R.Hayano, H.Outa	U. Tokyo, RIKEN	Precision spectroscopy of Kaonic 3He 3d->2p X-rays	Stage 2	Day1		K1.8BR
E03	K.Tanida	Kyoto U	Measurement of X rays from Ξ− Atom	Stage 2			K1.8
E05	T.Nagae	KEK	Spectroscopic Study of Ξ-Hypernucleus, 12 ΞBe, via the 12C(K-, K+) Reaction	Stage 2	Day1	1	K1.8
E07	K.Imai, K.Nakazawa, H.Tamura	Kyoto U., Gifu U., Tohoku U.	Systematic Study of Double Strangeness System with an Emulsion-counter Hybrid Method	Stage 2			K1.8
E08	A.Krutenkova	ITEP	Pion double charge exchange on oxygen at J-PARC	Stage 1			K1.8
E10	A. Sakaguchi, T. Fukuda	Osaka U	Production of Neutron-Rich Lambda-Hypernuclei with the Double Charge-Exchange Reaction (Revised from Initial P10)	Stage 2			K1.8
E13	T.Tamura	Tohoku U.	Gamma-ray spectroscopy of light hypernuclei	Stage 2	Day1	2	K1.8
E18	H.Bhang, H.Outa, H.Park	SNU, RIKEN, KRISS	Coincidence Measurement of the Weak Decay of 12 ΛC and the three-body weak interaction process	Stage 1			K1.8
E19	M.Naruki	RIKEN	High-resolution Search for Θ+ Pentaquark in π -p -> K-X Reactions	Stage 2	Day1		K1.8
E22	S. Ajimura, A.Sakaguchi	Osaka U	Exclusive Study on the Lambda-N Weak Interaction in A=4 Lambda-Hypernuclei (Revised from Initial P10)	Stage 1			K1.8
E27	T. Nagae	Kyoto U.	Search for a nuclear Kbar bound state K-pp in the d(p+,K+) reaction	Stage 1			K1.8
E14	T.Yamanaka	Osaka University	Proposal for KL -> π0 ν ν-bar Experiment at J-PARC	Stage 2			KL
E06	J.Imazato	KEK	Measurement of T-violating Transverse Muon Polarization in K+ -> π0 μ + ν Decays	Stage 1			K1.1BR
E16	S.Yokkaichi	RIKEN	Electron pair spectrometer at the J-PARC 50-GeV PS to explore the chiral symmetry in QCD	Stage 1			High pt

Beam Requests from Stage-2 Experiments

30 GeV, 9μA = 270 kW, 2 x 10^{14} protons/3.6s

K1.8 (SKS)

		Beam Power [kW]	Period [days]	Protons on Target
E03	X rays from Ξ^- Atom	270	33	**1.6 x 10^{20}**
E05	Ξ-Hypernucleus	270	28	**1.4 x 10^{20}**
E07	Double Strangeness with Emulsion	56	25	**2.5 x 10^{19}**
E10	Λ-Hypernuclei	3.2	42	**2.4 x 10^{18}**
E13	Gamma-ray spectroscopy of light hypernuclei	270	42	**2.0 x 10^{20}**
E19	Θ^+ Pentaquark	3.2	14	**8.1 x 10^{17}**

Beam Requests from Stage-2 Experiments

30 GeV, 9μA = 270 kW, 2 x 10^{14} protons/3.6s

K1.8BR

		Beam Power [kW]	Period [days]	Protons on Target
E17	Kaonic 3He	270	3.5	**1.7 x 10^{19}**
E15	deeply bound kaonic nucleus	270	28	**1.4 x 10^{20}**

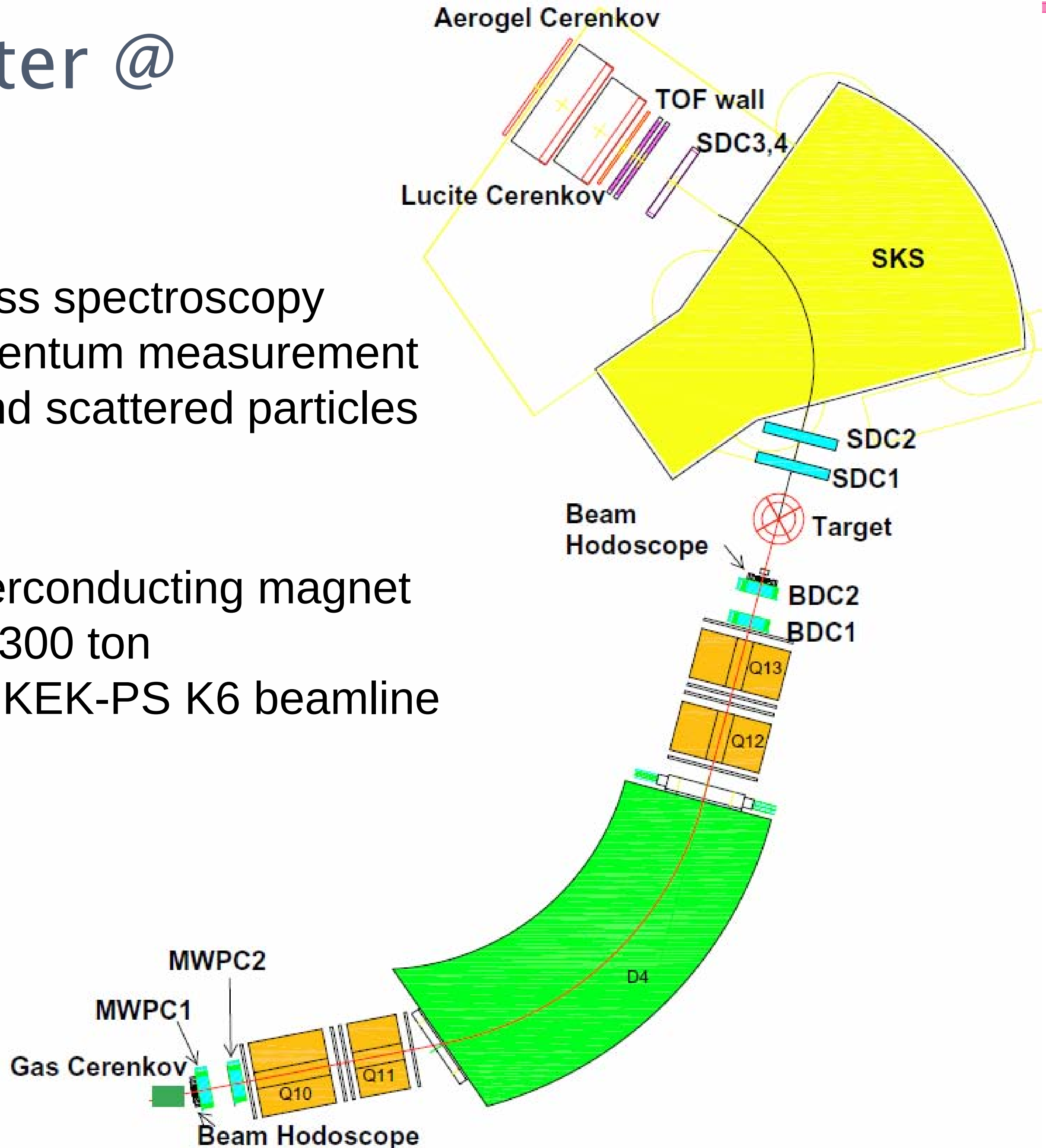
KL

		Beam Power [kW]	Period [days]	Protons on Target
E14	Kaon Rare Decay	270	350	**1.7 x 10^{21}**

Spectrometer @ K1.8

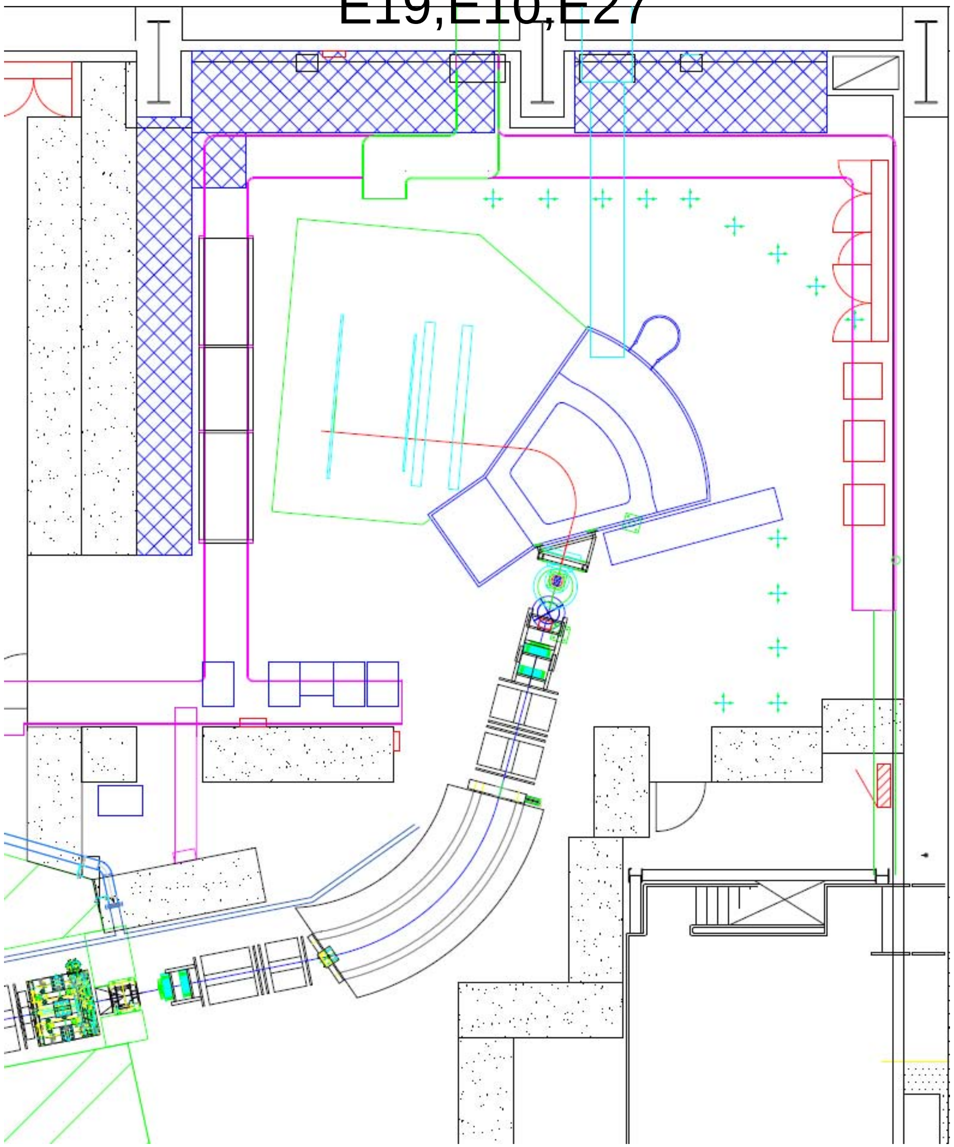
- missing mass spectroscopy
- PID & momentum measurement for beam and scattered particles

- SKS: superconducting magnet
  weight: 300 ton
  used at KEK-PS K6 beamline



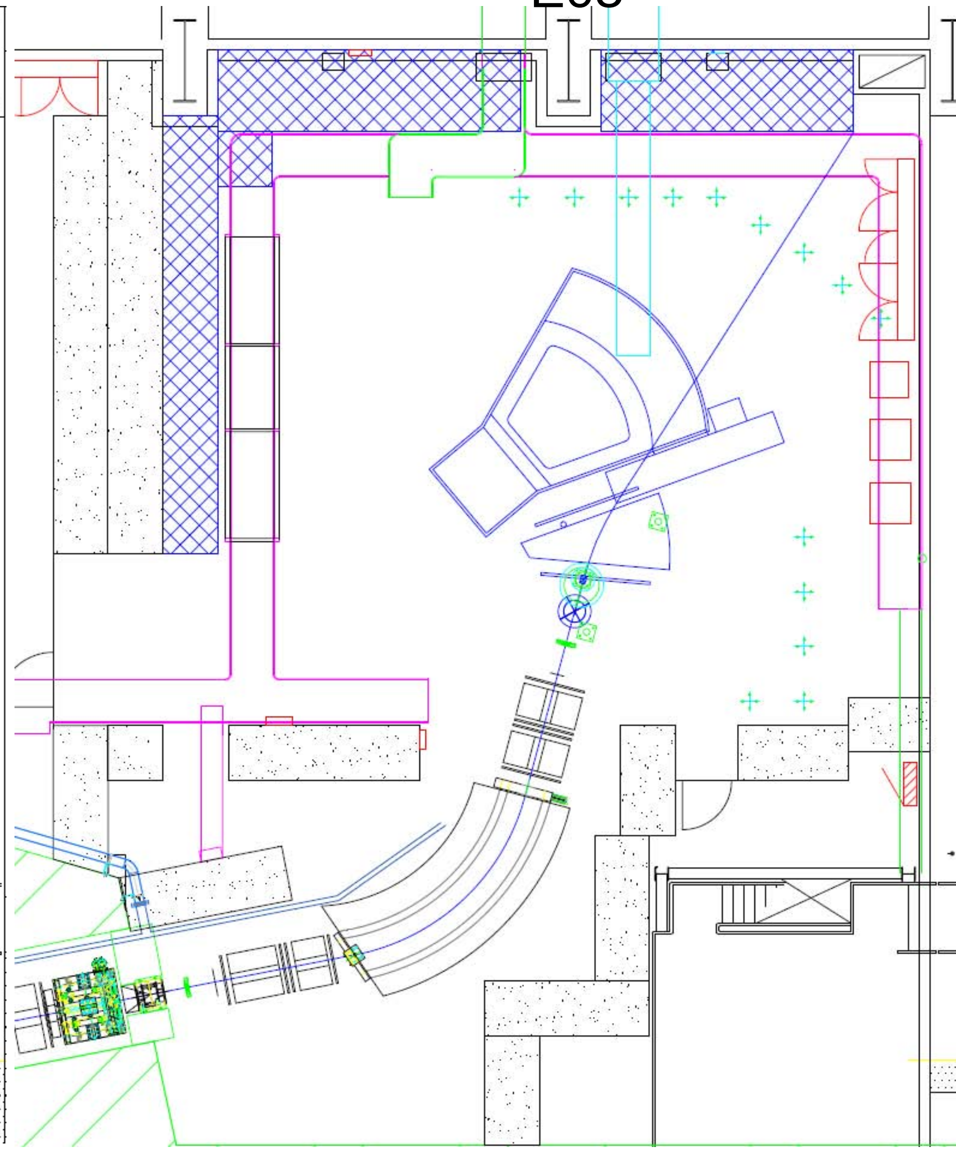
SKS0

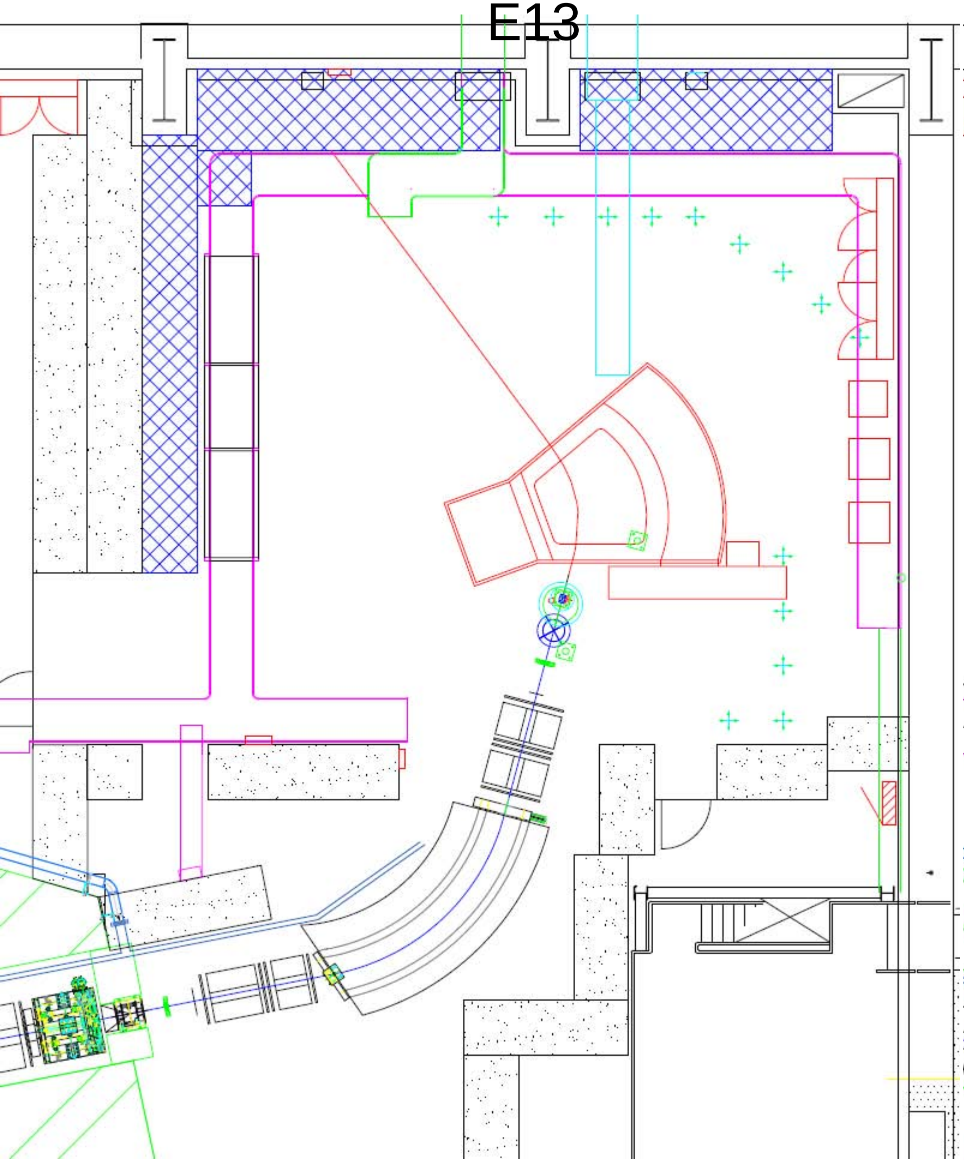
E19,E10,E27

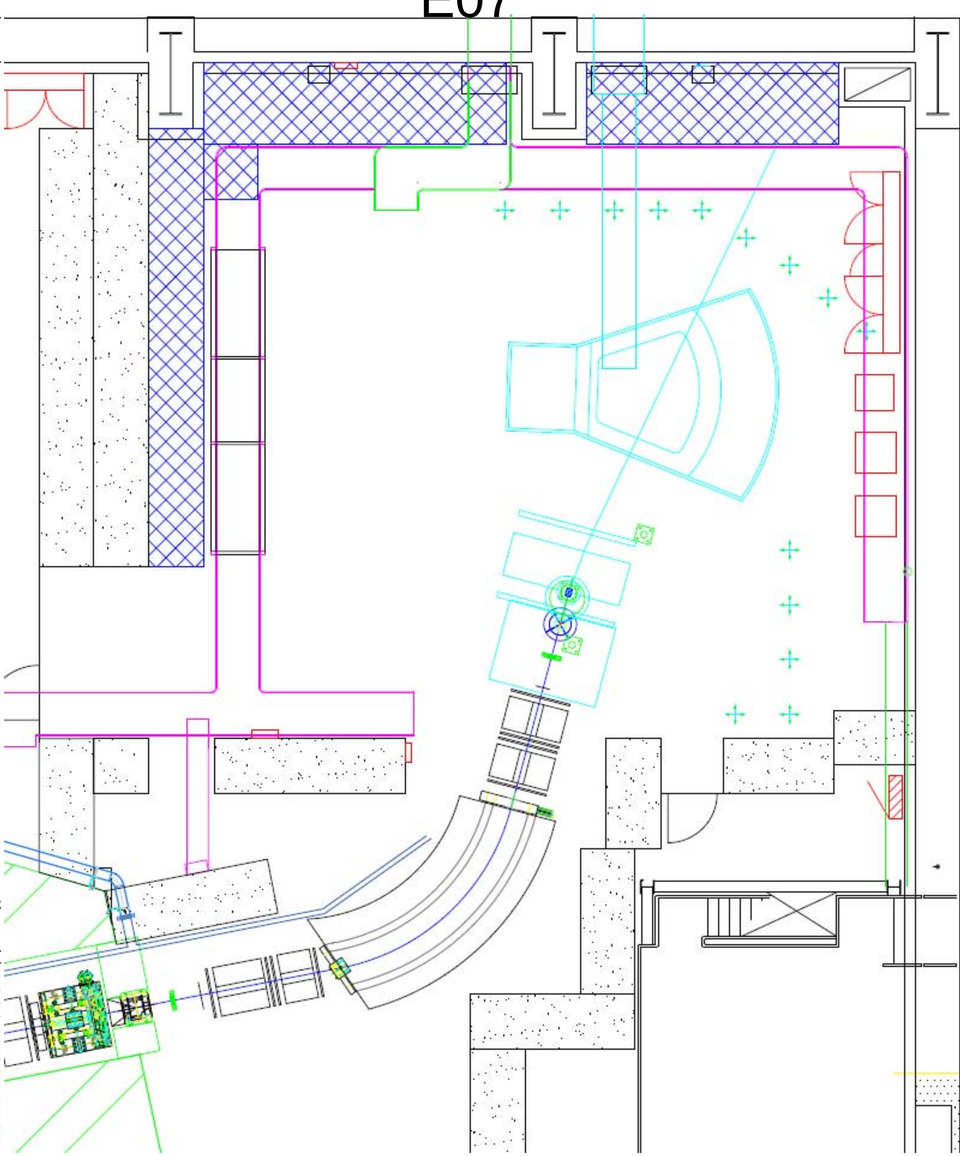


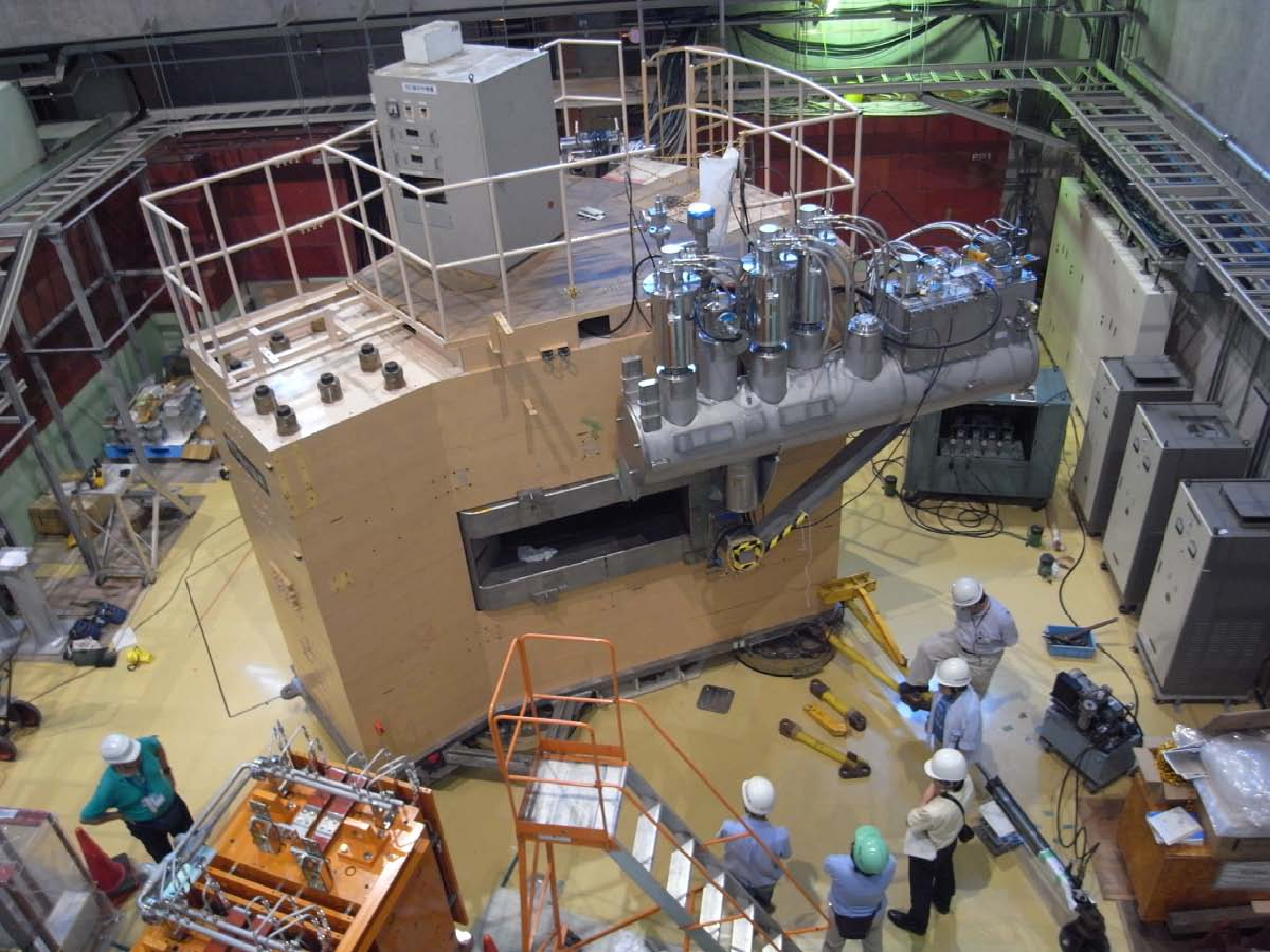
SKS-Plus

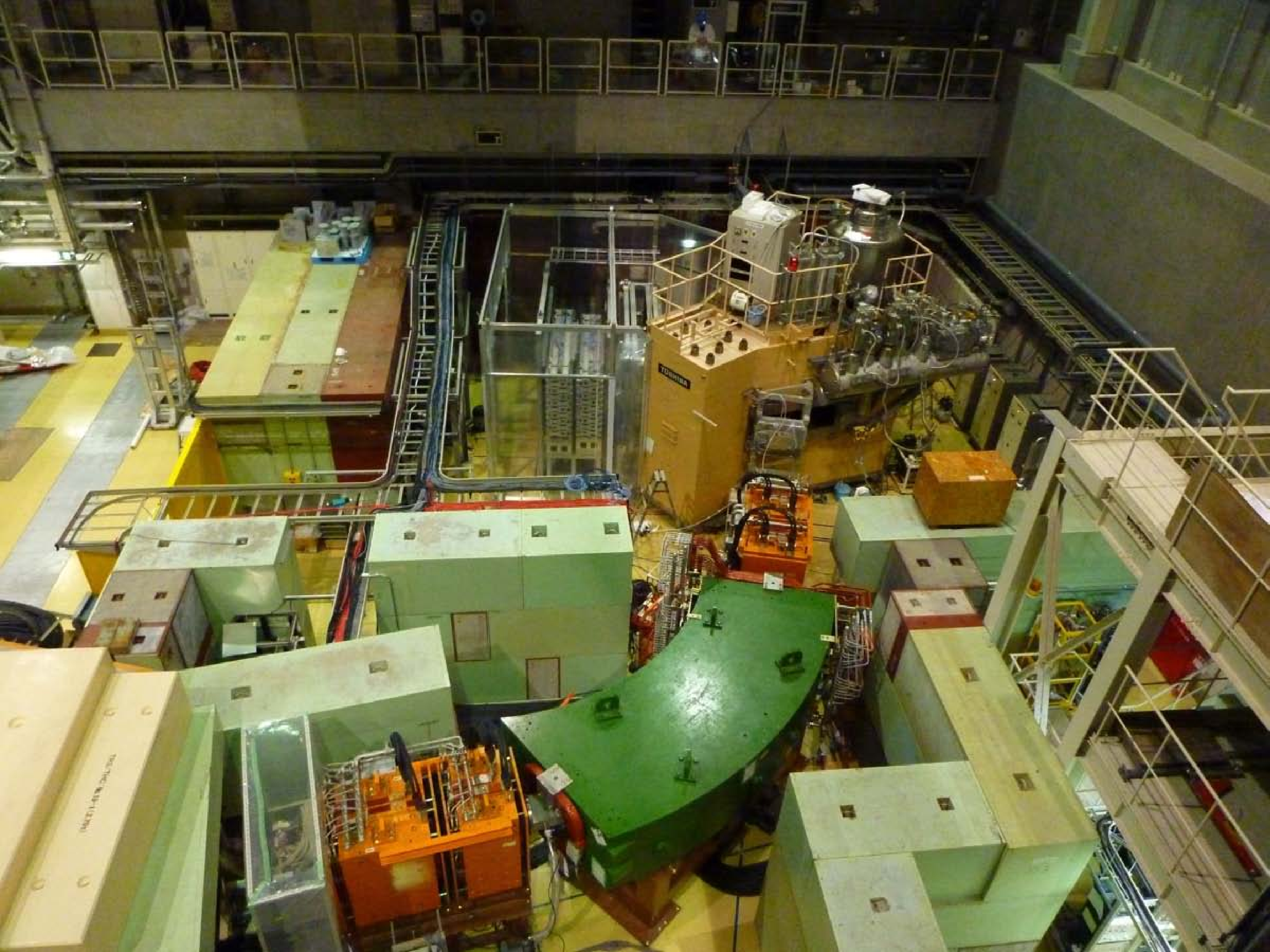
E05



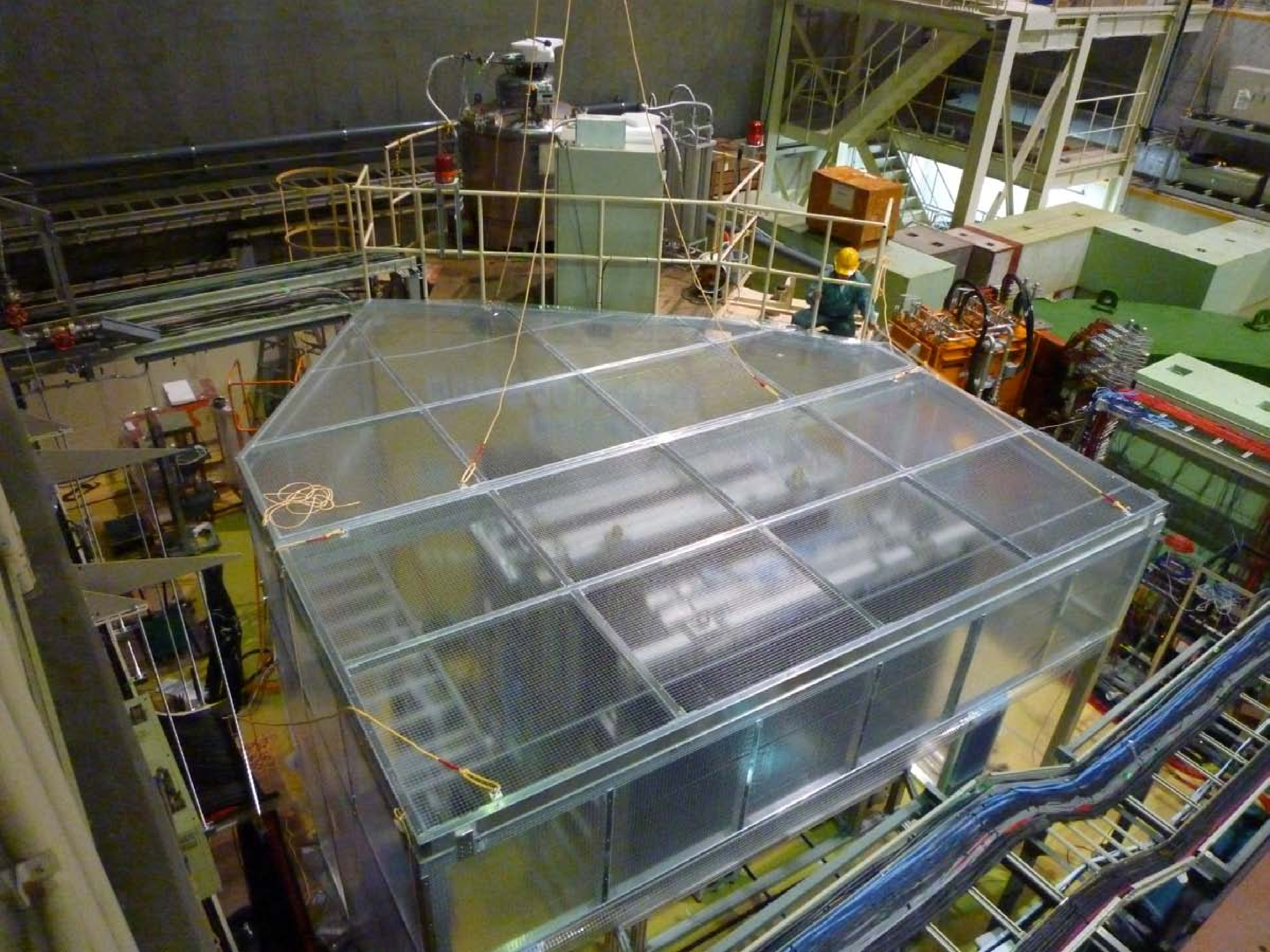

SKS-Minus
E13


KURAMA
E07




TOSHIBA


SKSスペクトロメータ
超伝導電磁石

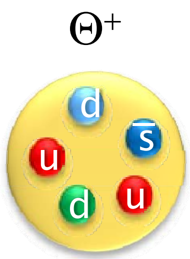


E19 experiment

What is Pentaquark?

✦Irreducible 5 quark state

contain an anti-quark different in flavor than the 4 quarks

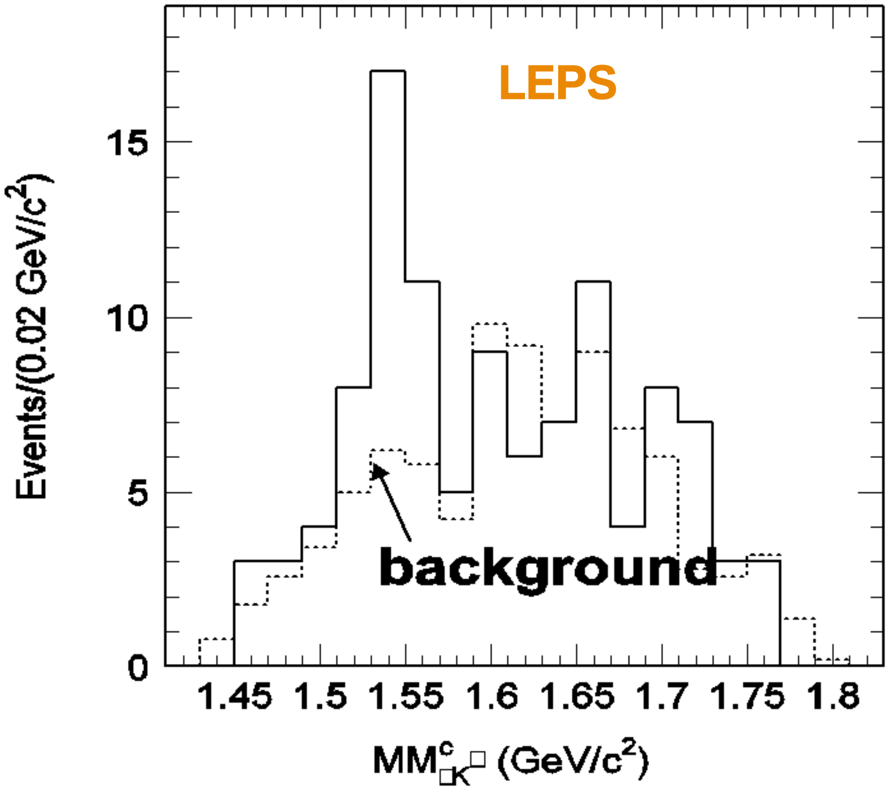


The Θ^+ : $uudd\bar{s}$

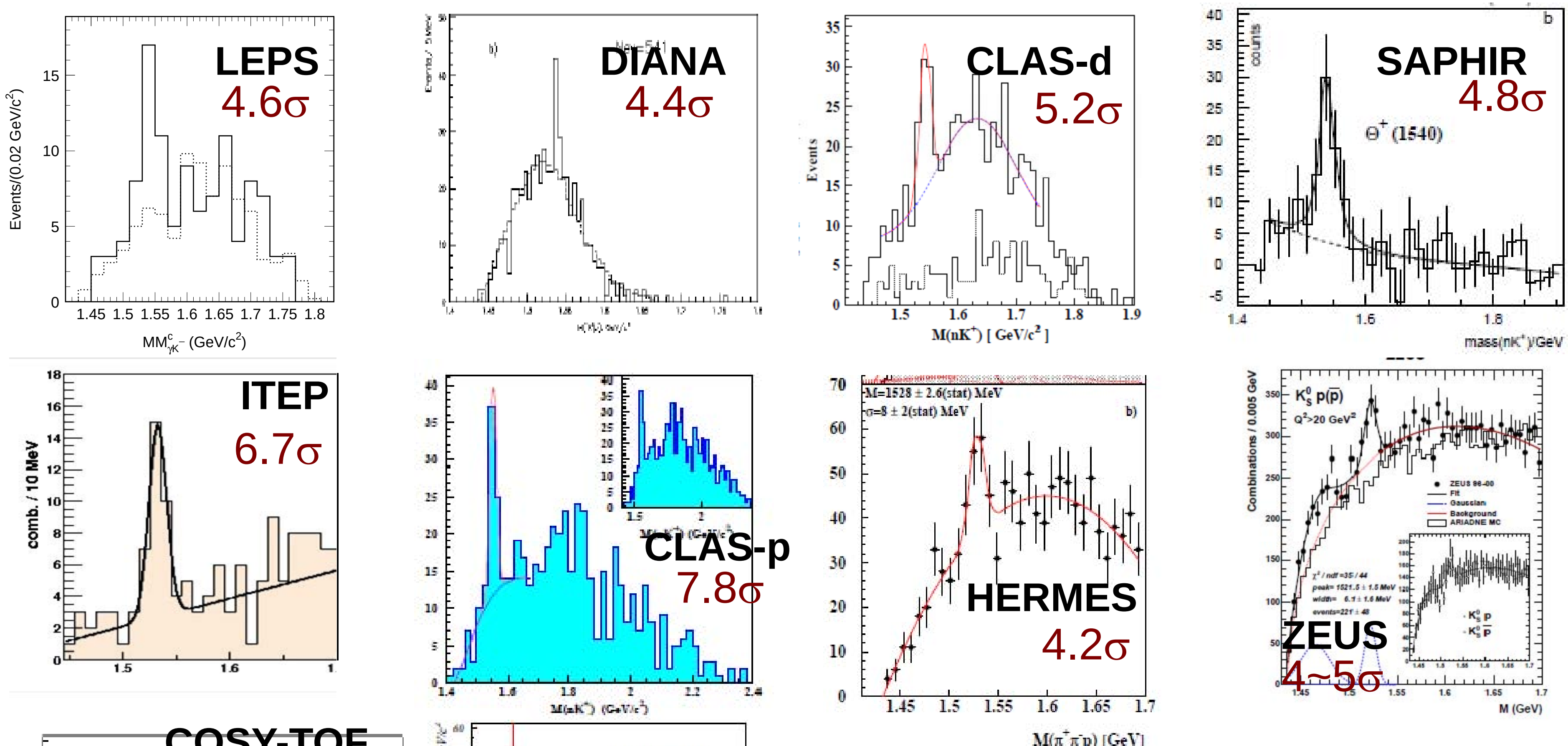
Baryon number = 1/3 + 1/3 + 1/3 + 1/3 - 1/3 = 1

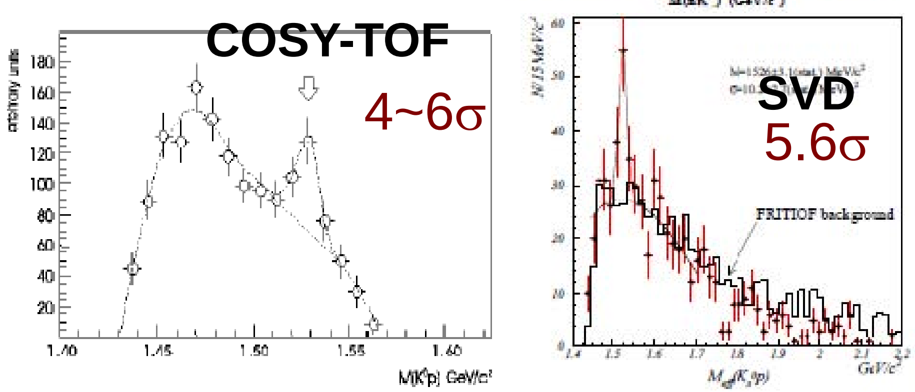
Strangeness = 0 + 0 + 0 + 0 + 1 = +1

- LEPS at Spring-8 ('03)
  - $\gamma n \rightarrow K^- \Theta^+ \rightarrow K^- K^+ n$
  - M=1540±10 MeV
  - Γ<25 MeV



Positive Results



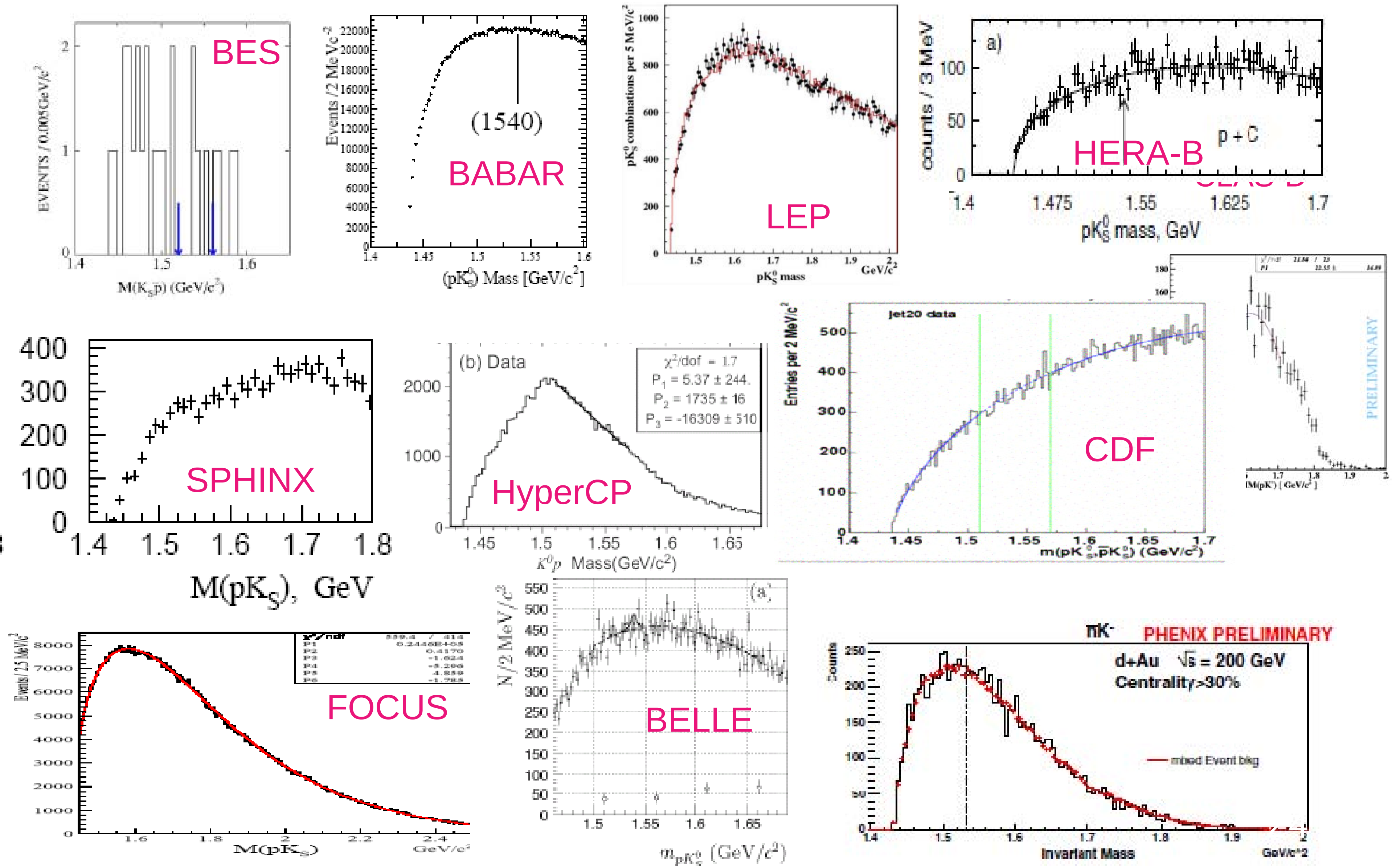


Experiments with positive evidence

Better statistics is needed

(significance ~ 5σ)

Negative Results



Negative Results

Exp.	$\sqrt{s}(E_{beam})$	Reaction	Upper Limit
BES	3.7GeV	$e^+e^- \rightarrow J/\psi \rightarrow \Theta\Theta$	$< 1.1 \times 10^{-5}$ B.R.
BaBar	10.58GeV	$e^+e^- \rightarrow \Upsilon(4S) \rightarrow pK^0X$	$< 1.0 \times 10^{-4}$ B.R.
Belle	11GeV	$e^+e^- \rightarrow BB \rightarrow ppK^0X$	$< 2.3 \times 10^{-7}$ B.R.
LEP	198GeV	$e^+e^- \rightarrow Z \rightarrow pK^0X$	$< 6.2 \times 10^{-4}$ B.R.
HERA-B	41.6GeV	$pA \rightarrow K^0pX$	$< 0.02 \times \Lambda^*$
SPHINX	11.5GeV	$pC \rightarrow K^0\Theta^+X$	$< 0.1 \times \Lambda^*$
HyperCP	(800GeV)	$pCu \rightarrow K^0pX$	$< 0.3\%$ K^0p
CDF	1.96TeV	$pp \rightarrow K^0pX$	$< 0.03 \times \Lambda^*$
FOCUS	~300GeV	$\gamma BeO \rightarrow K^0pX$	$< 0.02 \times \Sigma^*$
Belle	(~0.6GeV)	$K^+A \rightarrow pK^0_s$	$\Gamma < 0.64$ MeV
PHENIX	200GeV	$Au + Au \rightarrow K^-nX$	-
BaBar	9.4GeV	$eBe \rightarrow K^0pX$	-
CLAS-d	0.8-3.6GeV	$\gamma d \rightarrow pK^-K^+(n)$	3nb for γn
CLAS-p	<3.8GeV	$\gamma p \rightarrow K^oKN$	0.8nb

Positive Results

Exp.	Energy($\sqrt{s}$)	Reaction	Mass	Width	σ	
LEPS	≤2.4GeV	$\gamma C \to K^- K^+(n)$	1540 ± 10	< 25	4.6	*
DIANA	≤750MeV/c	$K^+ Xe \to K^0 p X$	1539 ± 2	< 9	4.4	*Belle
CLAS-d	1.58-3.8GeV	$\gamma d \to p K^- K^+(n)$	1542 ± 5	< 21	5.2	
SAPHIR	≤2.8GeV	$\gamma p \to K^0 K^+(n)$	1540 ± 6	< 25	4.8	
ITEP	40GeV	$\nu A \to K^0 p X$	1533 ± 5	< 20	6.7	
CLAS-p	3-5.47GeV	$\gamma p \to \pi^+ K^- K^+(n)$	1555 ± 10	< 26	7.8	?
HERMES	27.6GeV	$e^+ d \to K^0 p X$	1528 ± 3	13 ± 9	4.2	?
ZEUS	(300,318GeV)	$e^+ p \to e' K^0 p X$	1522 ± 3	8 ± 4	4~5	
COSY	2.95GeV/c	$pp \to K^0 p \Sigma^+$	1530 ± 5	< 18	4-6	*
SVD	70GeV/c	$pA \to K^0 p X$	1526 ± 5	< 24	5.6	

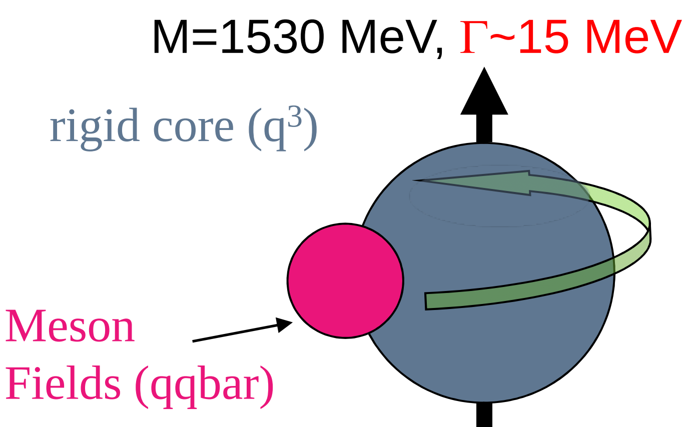
BaBar	(10.58GeV)	$eBe \to K^0 p X$
CLAS-d	0.8-3.6GeV	$\gamma d \to p K^- K^+(n)$
CLAS-p	<3.8GeV	$\gamma p \to K^0 K N$

negative results challenging the above positive results.

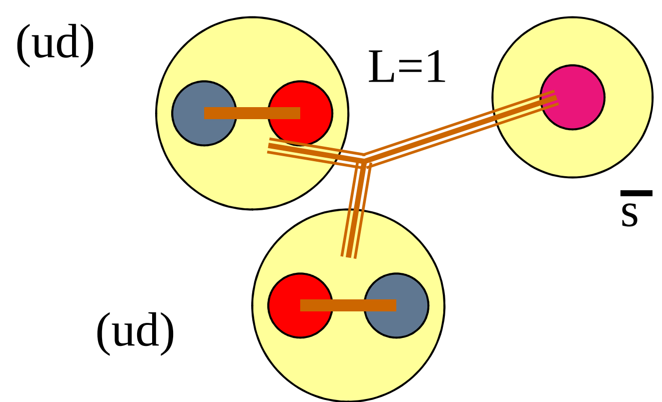
これまでに何が分かったか？

- narrow width ~ 1MeV
- production mechanism
  - nosignal
    - CLAS $\gamma p \rightarrow K^- K N$
    - KEK–PS E559
      - coupling to K*N is small
  - still survive
    - LEPS $\gamma d \rightarrow K^+ K^- X$
      - vs. CLAS γd → produced at forward angles. S=3/2?
    - CLAS $\gamma p \rightarrow \pi^+ K^- K^+ n$
    - DIANA KXe→pKs^0

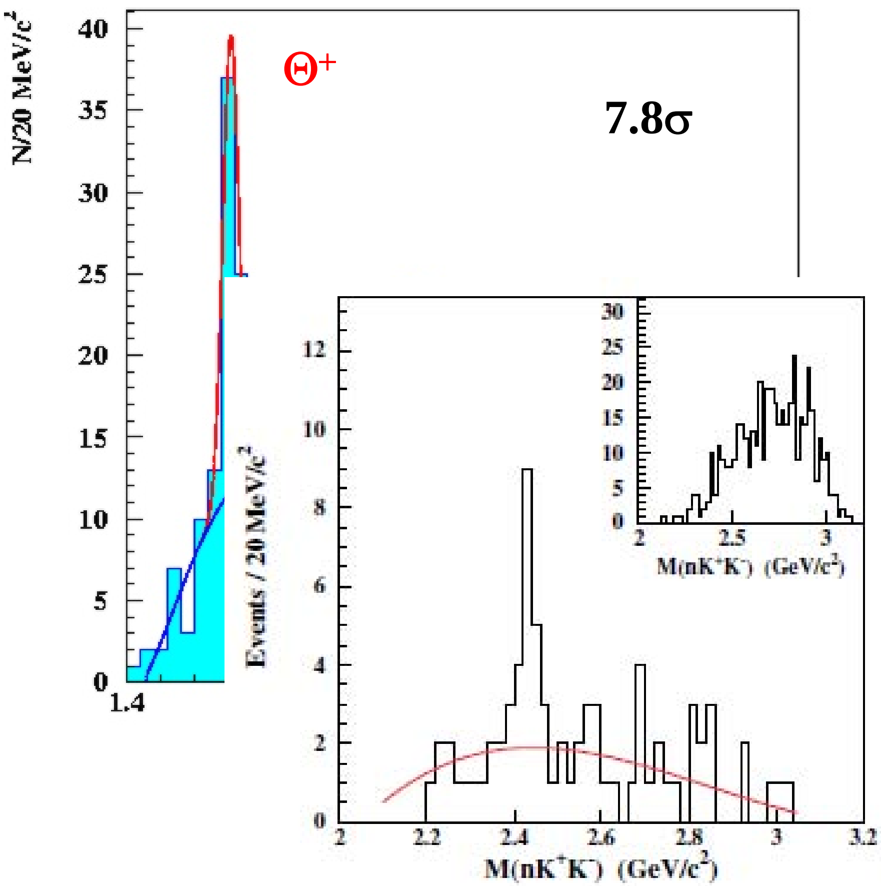
Chiral soliton model: Diakonov et al.



Quark description: Jaffe, Wilczek

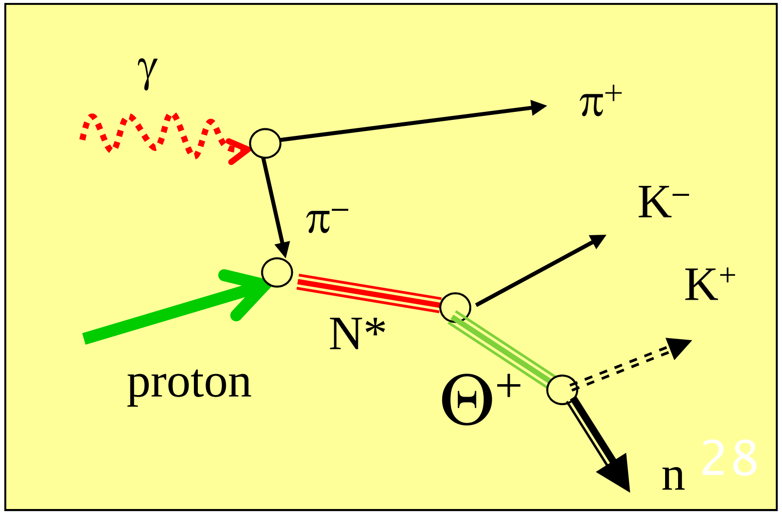


"Best" Positive Evidence



Eγ ~ 3.2 – 5.47 GeV

- $\gamma\, p \rightarrow \pi^{+} K^{-} K^{+} (n)$
  - CLAS: V. Kubarovsky *et al.* PRL <u>92</u> 032001 (2004)
  - Combined analysis of all CLAS data on protons for Eγ <5.5 GeV
  - Cuts: forward π^+, backward K^+
  - indications of production from heavy N*(2420)



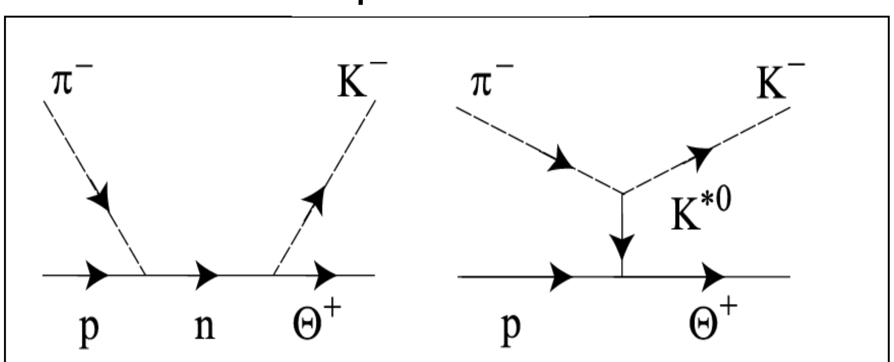
Θ^+ Search in hadronic reactions

- ✓ show the narrow pentaquark really exist (or not).
  — with high statistics.
- ✓ determine the width
  the width appears to be very narrow. ~ 1MeV
  – the mass resolution is the key: SKS
- ✓ spin and parity

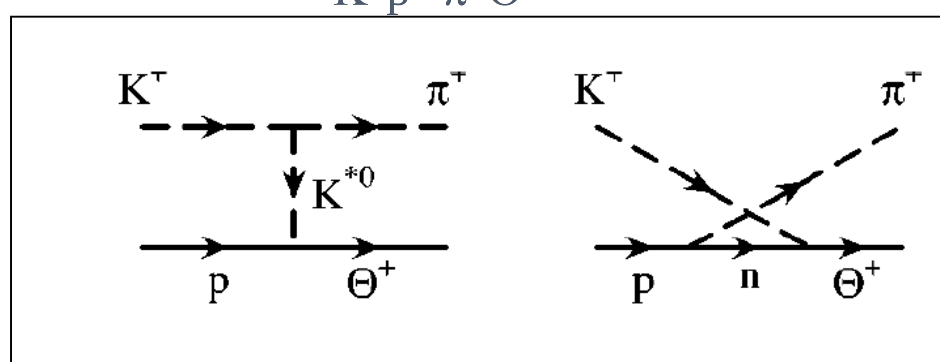
meson induced reactions @ J-PARC

the possible production mechanism will be investigated in the following reactions.

$\pi^- p \rightarrow K^- \Theta^+$



$K^+ p \rightarrow \pi^+ \Theta^+$



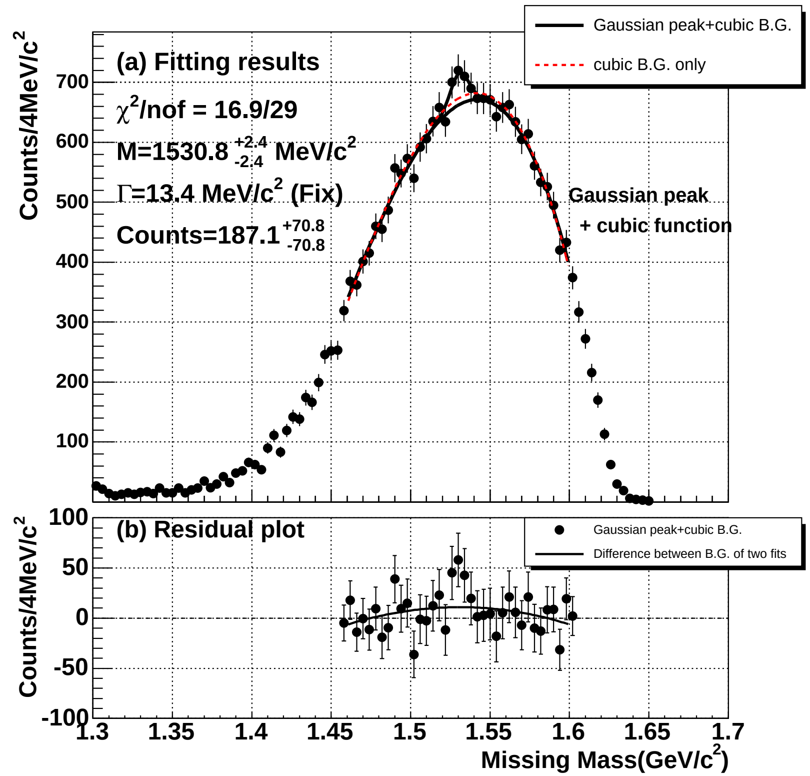
KEK-PS E522 experiment

- Θ^+ search via $\pi^- p \rightarrow K^- X$ reaction
  - K2 beamline + KURAMA
- beam momentum : 1.87, 1.92 GeV/c
- target : Polyethylene
- intensity : 3.3 X 10^5 π^- /spill
- net beam time : 32 hours for each momentum → ~ 7 X 10^9 π^-
- Mass resolution : 13.4MeV(FWHM)

a bump was observed
at M =1530.8MeV/c2
at p_π=1.92 GeV/c
but : S/N = 2.5σ
upper limit : $d\sigma/d\Omega < 2.9 \mu b/sr$

if exist

p_π=1.92 GeV/c

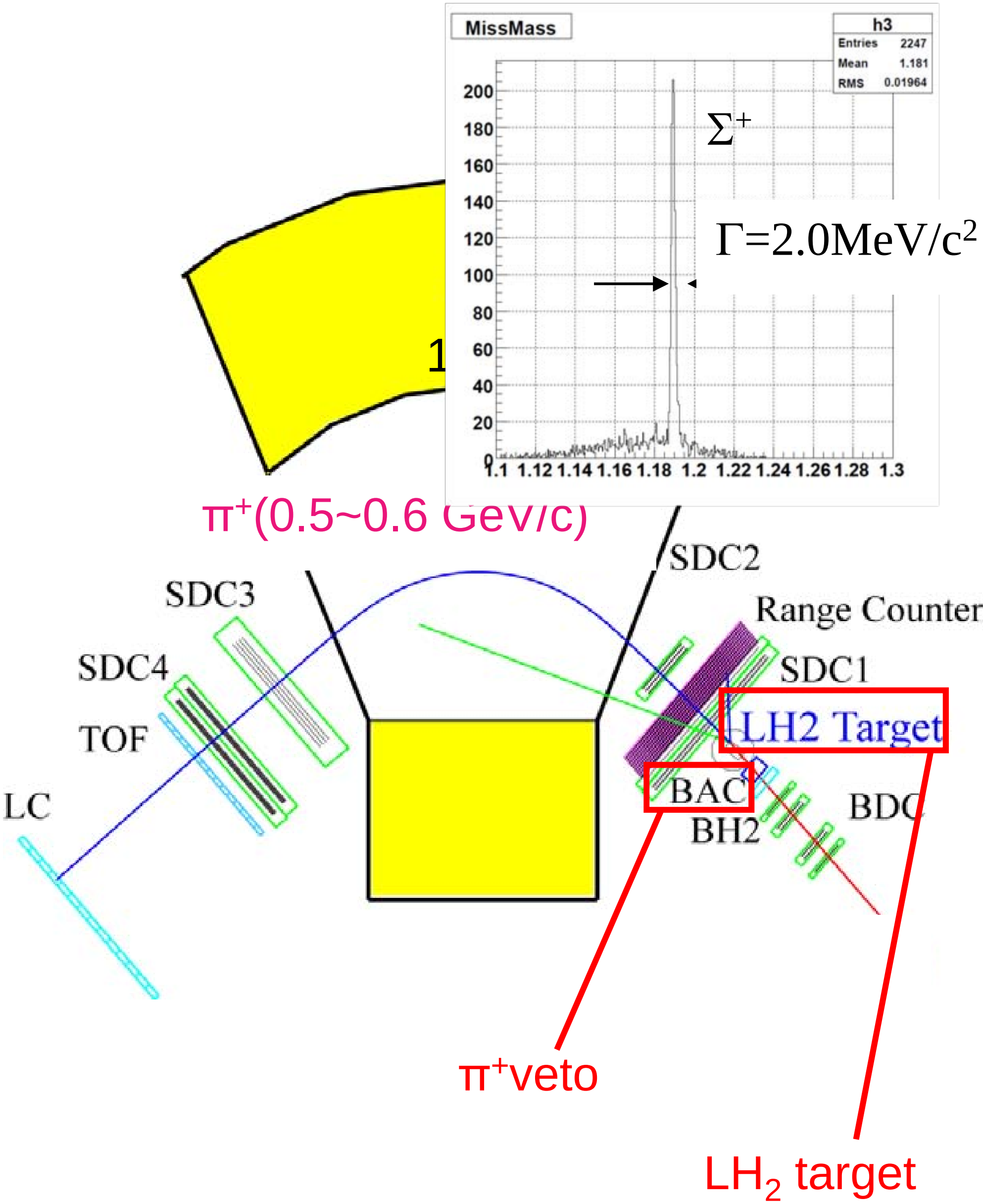


$d\sigma/d\Omega = 1.9 \ \mu b/sr$

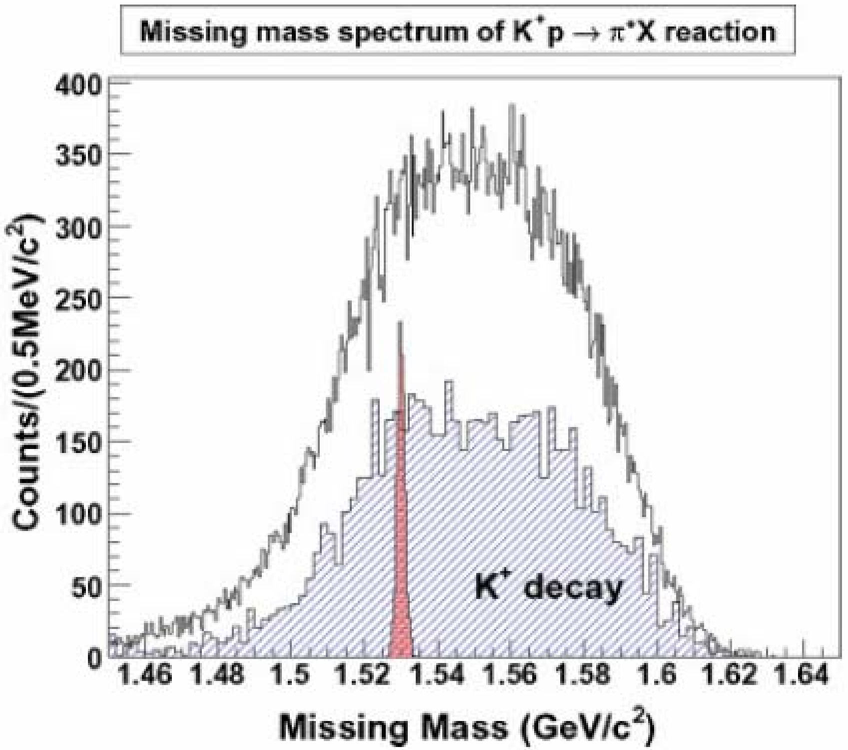
$\rightarrow \sigma_{tot} = 2.9 \ \mu b$

KEK-PS E559 : $K^+p \to \pi^+\Theta^+$

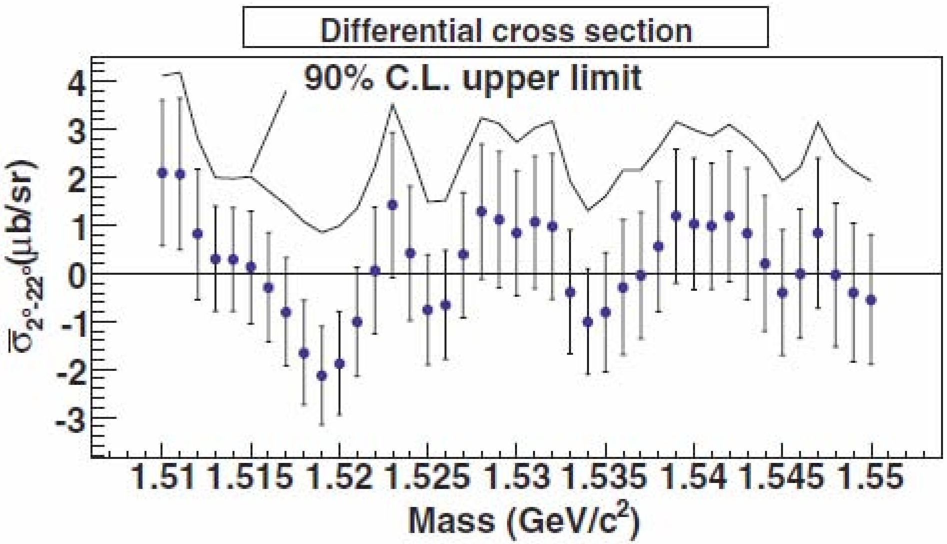
- Θ^+ search via $K^+p \to \pi^+X$ reaction
  - K6 beam line + SKS spectrometer
- Excellent missing mass resolution
  - 2.4MeV (FWHM) expected
  - Checked by $\pi^+p \to K^+\Sigma^+$
- Decay event suppression
  - Rejection of 3 body decay of K^+ is crucial
  - Large acceptance chamber
  - Range Counter



Missing Mass spectrum (K$^+$p→π$^+$X)



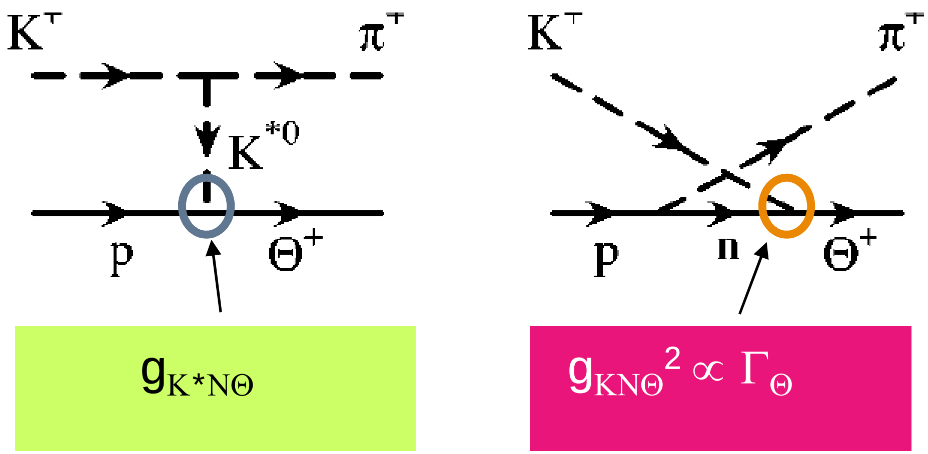
K. Miwa et al. PRC77(08)045203

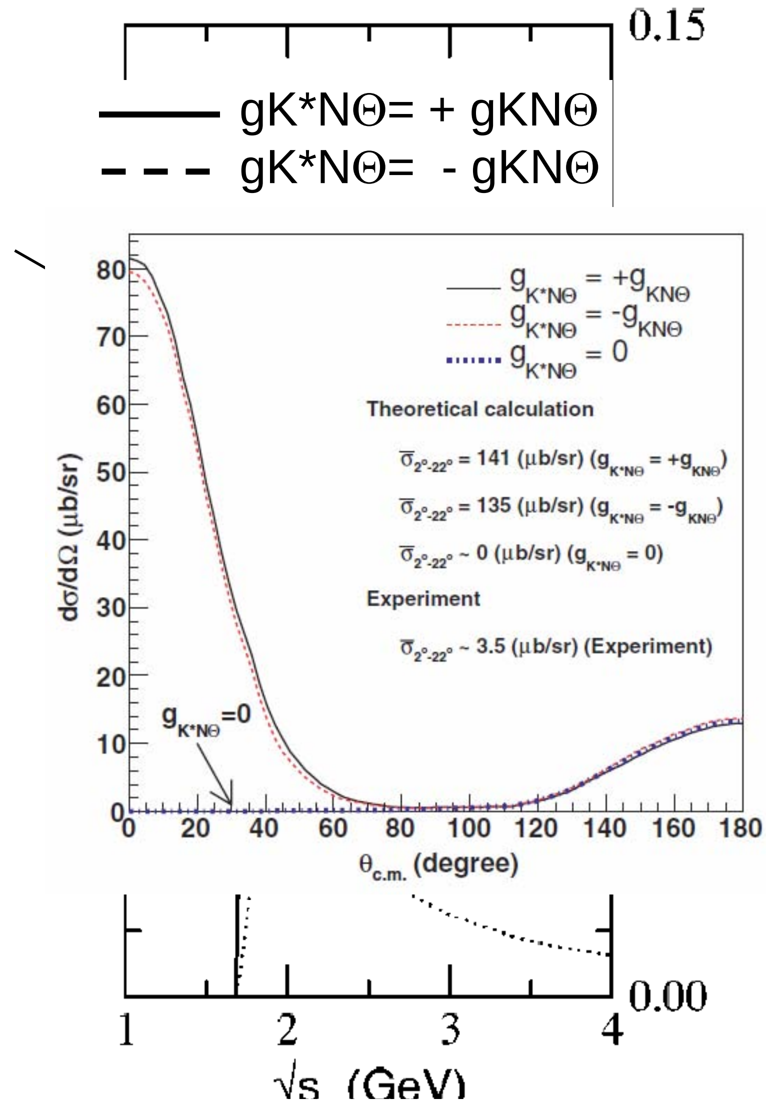


red : expected Θ$^+$ peak assuming 50μb

No significant peak is observed.
upper limit of differential cross section < 3.5 μb/sr at 90% C.L.

Impact on Θ^+ production mechanism



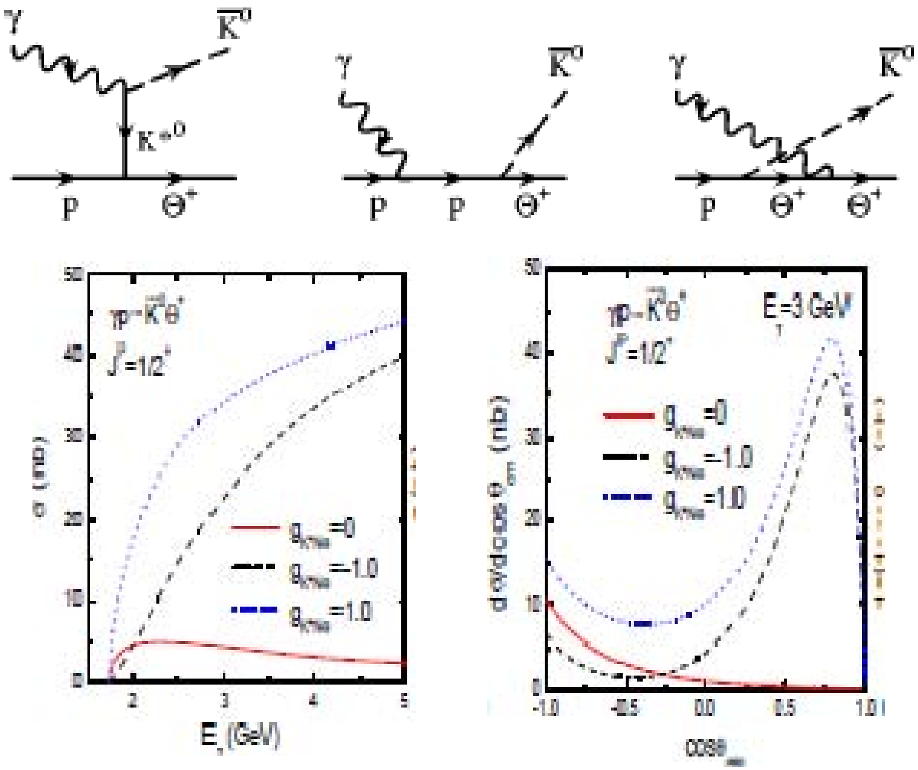


- if $g_{K^*N\Theta} \sim 0$,
  - (K^+,π^+) reaction → u-channel backward peaking
  - (π^-,K^-) reaction → s-channel

CLAS proton data $\gamma p \to K^0 K N$

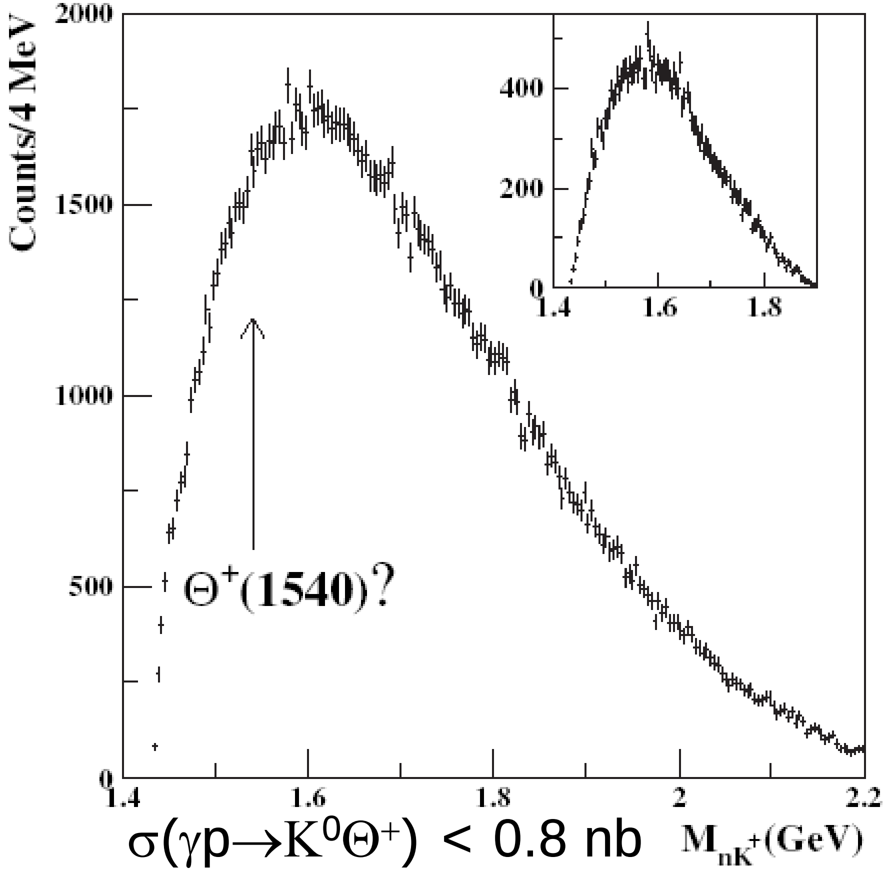
Y. Oh et al. PRD 69, 074016

CLAS DATA : $\gamma p \to K^0\Theta^+$



C. M. Ko and W. Liu, nucl-th/0410068
Γ ~ 1MeV

PRL 96, 042001 (2006)



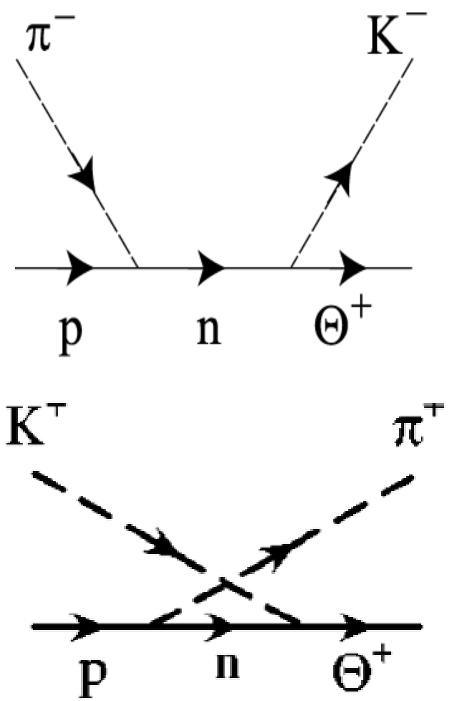
$\sigma(\gamma p \to K^0\Theta^+)$ < 0.8 nb

The result puts a very stringent limit on a possible production mechanism of the Θ^+; it implies a very small coupling to K*.

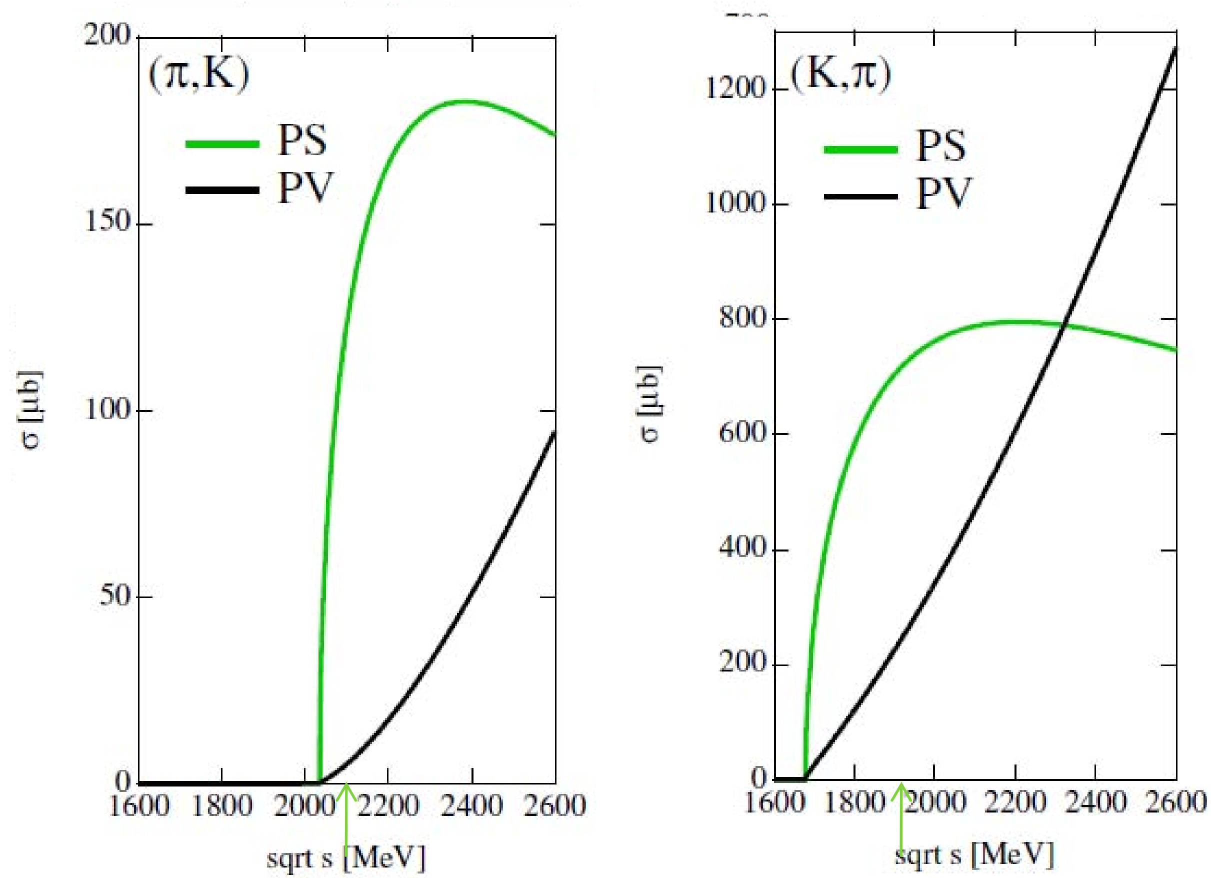
$g_{NK^*\Theta+}$ ~ 0

$\sigma(\pi^- p \to K^- \Theta^+)$ & $\sigma(K^+ p \to \pi^+ \Theta^+)$: Born APPROX.

T. Hyodo, priv. comm



$\Gamma_\Theta = 1$MeV



$g_{KN\Theta}^2 \propto \Gamma_\Theta$

→cross section ∝ width

	$P_{lab} = 1.92$ GeV		$P_{lab} = 1.2$ GeV	
	$\pi^- p \to K^- \Theta^+$ PS	$\pi^- p \to K^- \Theta^+$ PV	$K^+ p \to \pi^+ \Theta^+$ PS	$K^+ p \to \pi^+ \Theta^+$ PV
without form factor	63 [μb]	4.9 [μb]	55 [μb]	1.0 [μb]
F_s, $\Lambda_s = 500$ MeV	4.2 [μb]	0.33 [μb]	9.4 [μb]	0.17 [μb]
F_c, $\Lambda_c = 1800$ MeV	2.4 [μb]	0.19 [μb]	38 [μb]	0.71 [μb]

cf. PS: Oh et al., PRD69(04)014009

PV: Ko, Lee & Park, PLB611(05)87

J-PARC E19 experiment

- Day-I experiment : Sep. 2009 ~
- K1.8 beamline + SKS spectrometer
- natural expansion of E522 ($\pi p \rightarrow KX$@KEK-PS)
- ~5 times better resolution : ~ 2.5MeV FWHM with SKS
  - 10 times better S/N
- 100 times larger yield : 1.2 X 10^4 Θ^+ with 20 shifts

- momentum dependence of cross section

  p_π=(1.87,1.92,1.97GeV/c)

– Goal –

confirm Θ^+ existence with high statistics

Collaboration

KEK	M. Naruki, S. Ishimoto, T. Maruta, N. Saito, Y. Sato, S. Sawada and M. Sekimoto
Kyoto Univ.	S. Dairaku, K. Imai, Y. Nakatsugawa, K. Tanida, H. Fujioka
Osaka Univ.	S. Ajimura
RIKEN	M. Niiyama
Tohoku Univ.	H. Fujimura, K. Miwa, H. Tamura
Univ. of Tokyo	D. Nakajima and T.N. Takahashi

Experimental Method

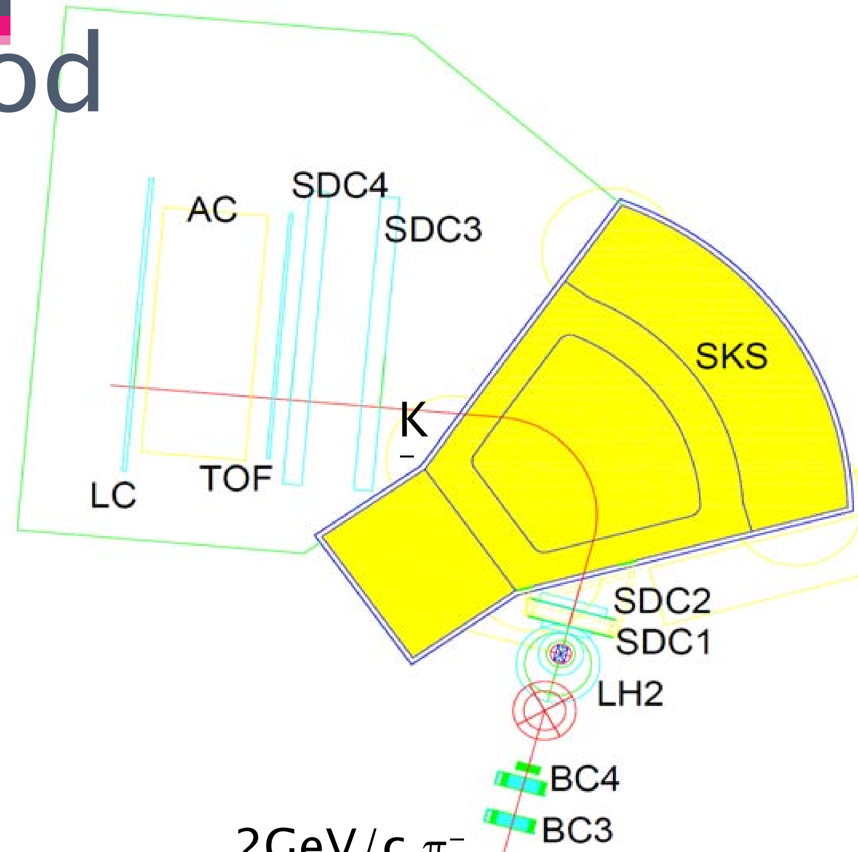
K1.8 beam line + SKS

2GeV/c $\pi^- + p \rightarrow K^- + \Theta^+$
target : liquid H_2, reuse E559's

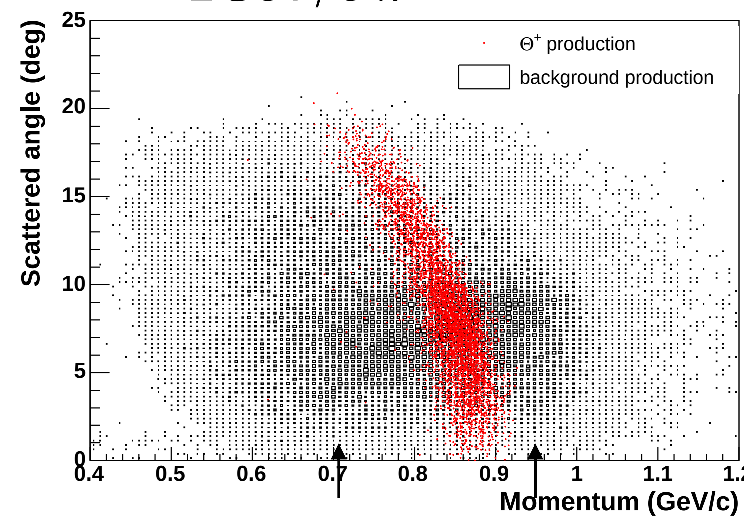
K^- : scattered angle $\leq 40°$
momentum < 0.9 GeV/c

SKS : momentum coverage : 0.7–0.95GeV/c
angle coverage $\leq 20°$
$p_{scattered}$ up to ~ 1.1 GeV/c
dp/p ~ 0.2% @ 1GeV/c
(~5 times better than KURAMA)

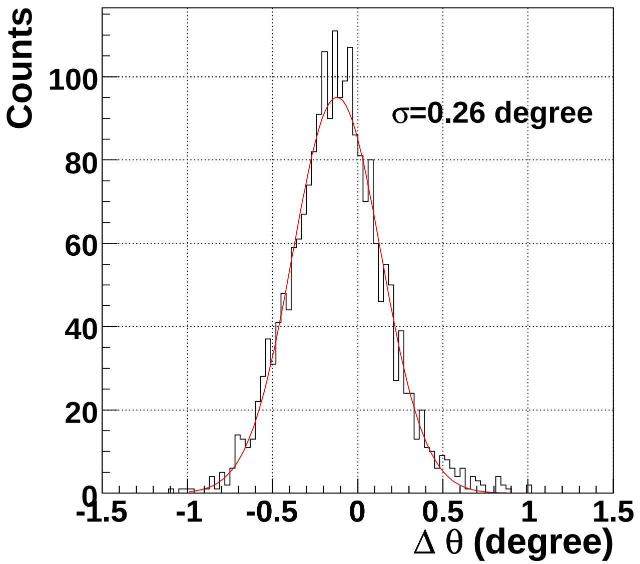
ideal for Θ^+ detection

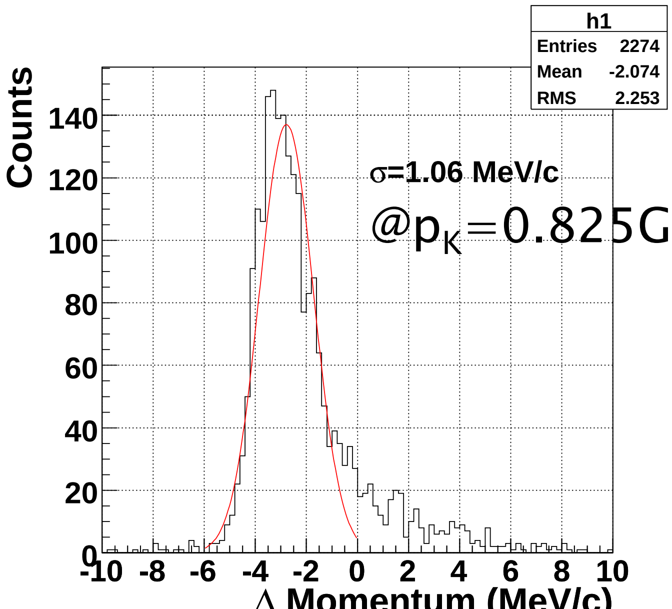


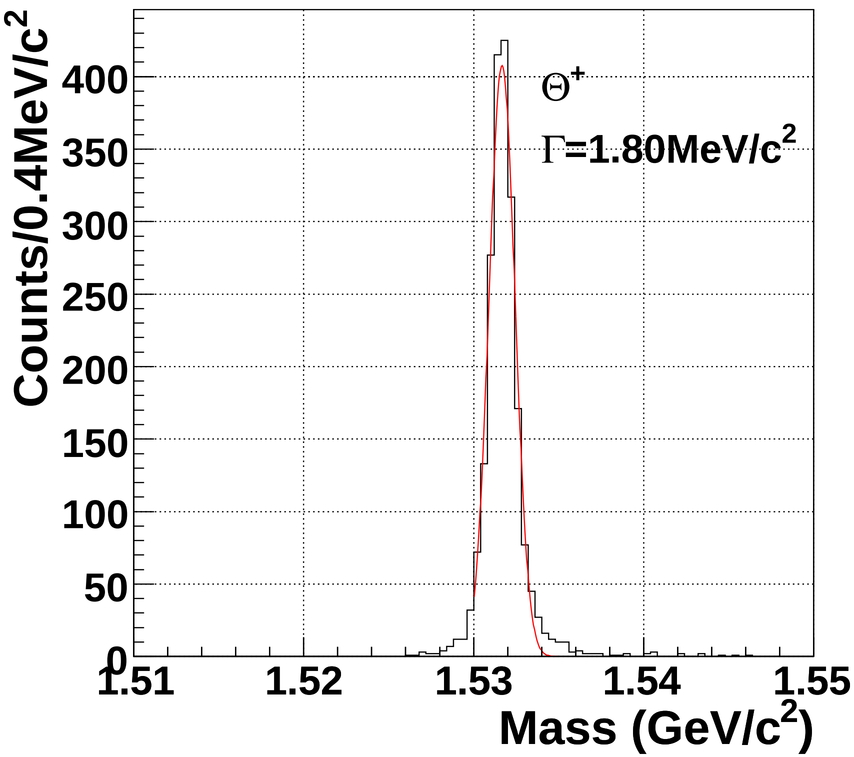
2GeV/c π^-



Missing Mass Resolution







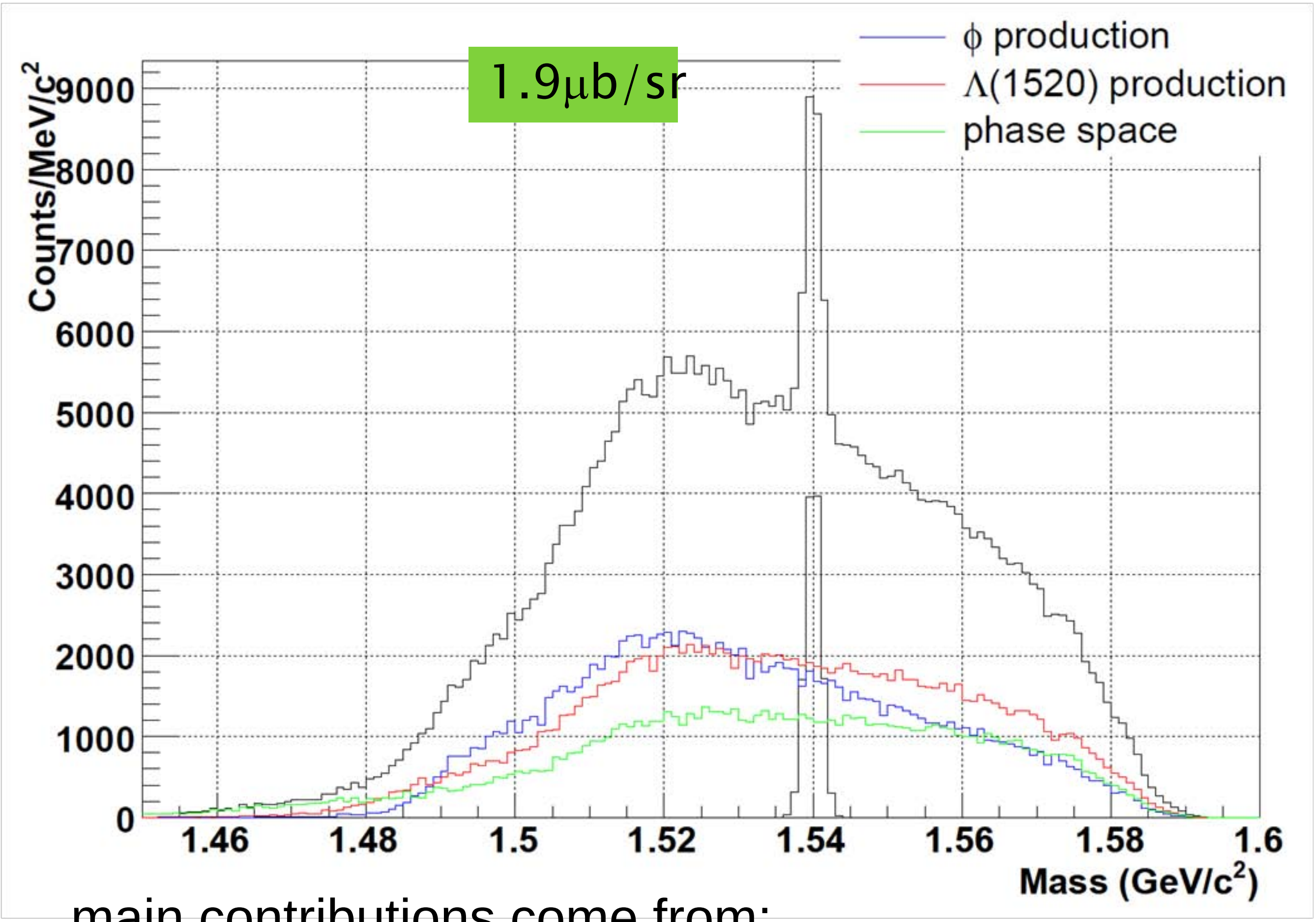
ΔM = 1.8 MeV (FWHM sim.)

$\sigma_\theta = 0.26^\circ$

$dp_K/p_K = 0.096 \times p\% + 0.092\%$

$dp_{beam}/p_{beam} = 1.4 \times 10^{-4}$ @ 1 GeV/c

Expected Missing mass SPECTRUM



significance :
62σ assuming
$\Gamma < 2\text{MeV}$
$\sigma = 1.9\mu b$

main contributions come from;

ϕ :	$\phi n \rightarrow K^+K^-n$	$30.0\pm8.0\ \mu b$
Λ :	$\Lambda(1520)K^0 \rightarrow K^-K^0p$	$20.8\pm5.0\ \mu b$
phase space :	K^-KN	$26\ \mu b$

Expected Yield & Sensitivity

- yield
  - beam pions :160 hours beam time → 4.8×10^{11} π for each p_π
  - SKS acceptance : 0.1 sr
  - analysis efficiency : 50%
  - K decay : 50% ← TOF 4.7m
  - 1.9μb/sr @ p_π=1.92GeV/c ← E522

→ 1.2×10^4 events

- background
  - 0.8 μb/sr/MeV @ 1.530MeV for proton target ← E522
  - momentum flat

→ 5.0×10^3 counts/MeV

statistics	sensitivity
62σ $\Gamma < 2$ MeV	75nb/sr $\Gamma < 2$ MeV

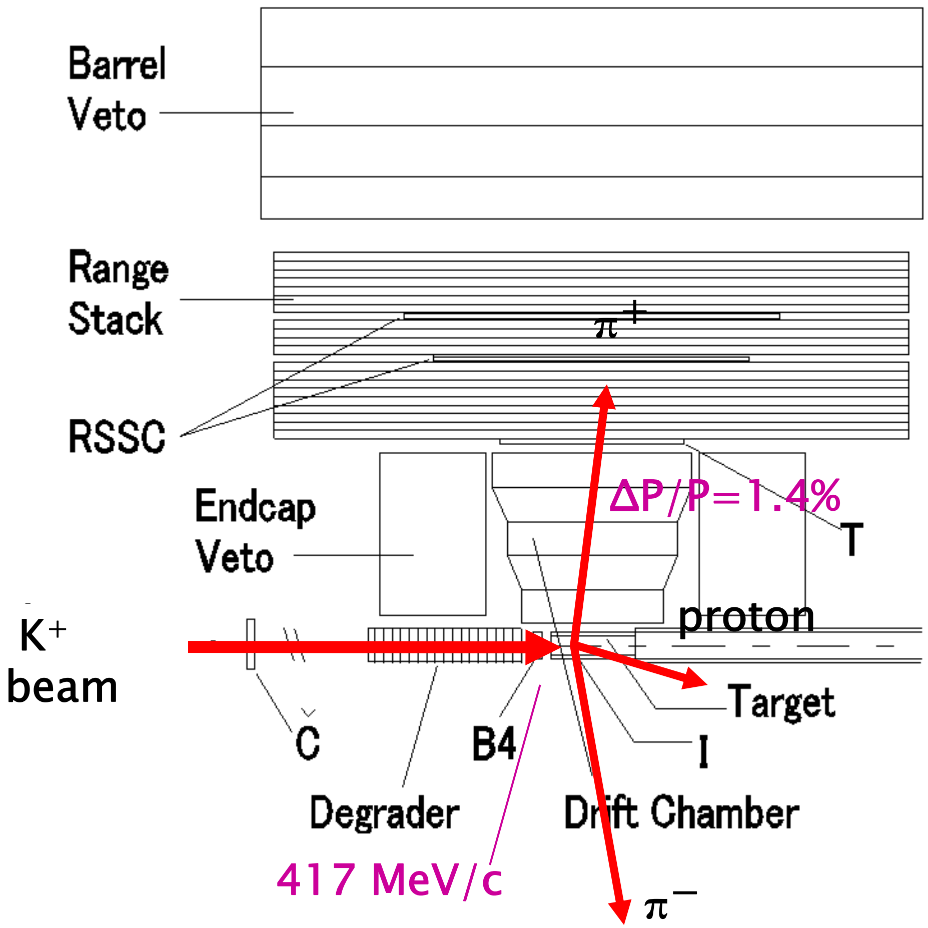
cf. 340nb/sr Γ=1MeV (Born approx.)
→ Γ<0.22MeV

P09-LoI: Letter of Intent for Study of Exotic Hadrons with *S*=+1 and Rare Decay $K^+ \rightarrow \pi^+ \nu\nu$ with Low-momentum Kaon Beam at J-PARC

T. Nakano et al.

Search for Θ^+ in formation reaction

- $K^+ n \rightarrow \Theta^+ \rightarrow K_S^0 p \rightarrow \pi^+ \pi^- p$
  P(K^+)=417 (442) MeV/c
  for M=1.53 (1.54) GeV/c^2
  → K0.8 beamline w/ degrader
- Target
  - LD_2 target
    - mass resolution ~ 3MeV
    - yield : 15/mb/spill (K:3X10^4/spill)
  - active target
    - mass resolution ~6MeV
    - yield : 200/mb/spill
- π^+, π^-, & proton detection with 4π spectrometer



Search for Θ^+ in formation reaction

- determine width from cross section
  - $\sigma(E) = (\pi/4k^2)\, \Gamma^2/\{(E-m)^2+\Gamma^2/4\}$
  - $\sigma_{tot} = 26.4 \times \Gamma$ mb/MeV
- spin measurement
  - decay angular distribution : 1 or $1+3\cos^2\theta$?

will be answer the question;

Θ^+ exists or not

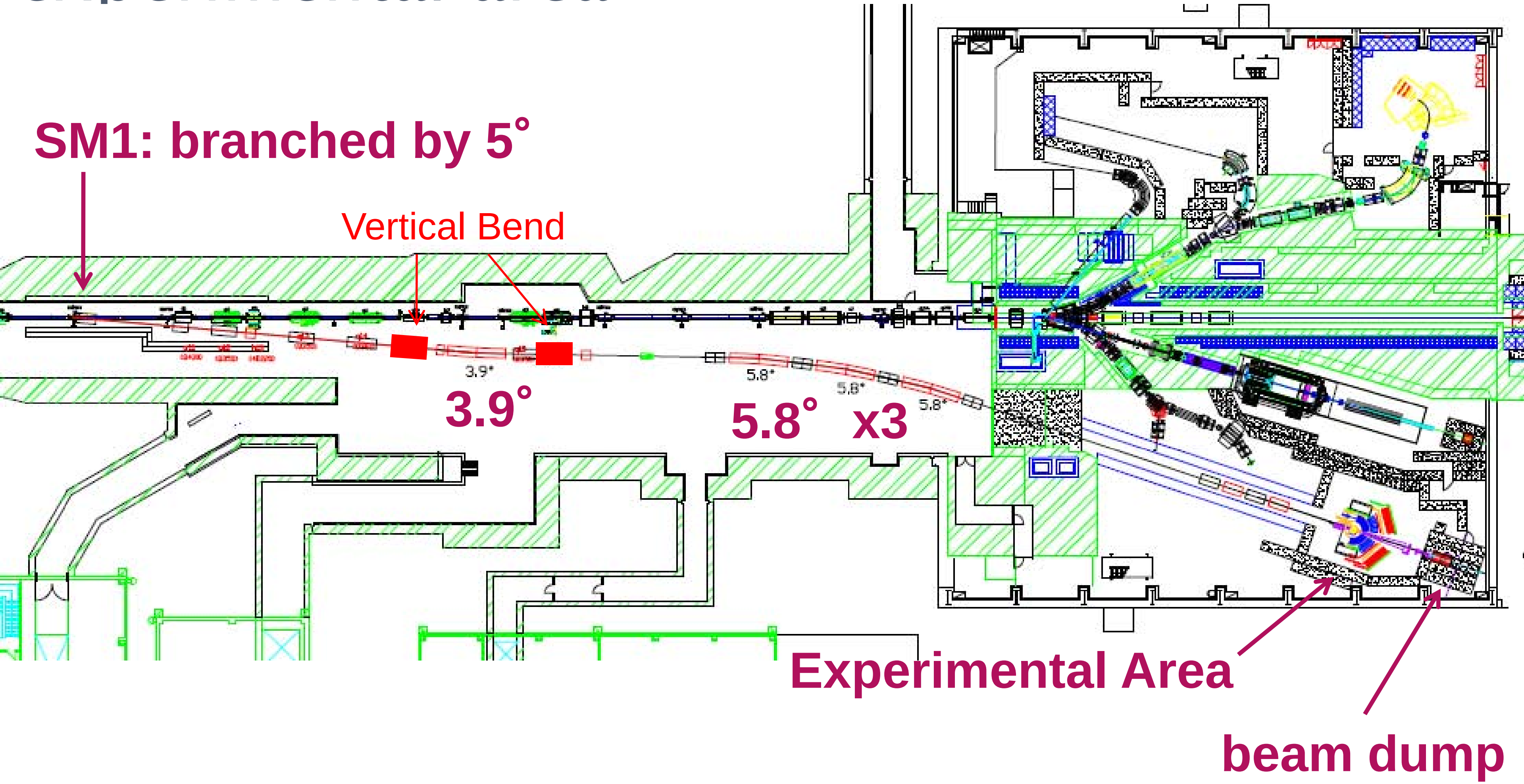
how far we can restrict the width

spin ½ or 3/2

In FUTURE…

- other pentaquarks: cascade $\Xi_5^{--}(1862)$, charmed $\Theta^0_c(3100)$
  - $K^- n \rightarrow \Xi^{--} K^+$, $p_{th}=2.4GeV$
  - $pp \rightarrow pp\Theta^0_c X$, $p_{th}=12.3GeV$
- tetraquark: $\mathscr{Q}^+(udss)$, Θ^+ "family"
  - Y. KANADA-En'yo et. al. : $J^p=1^+$, $M=1.4GeV$, $\Gamma=20\sim50MeV$, $\mathscr{Q}^+ \rightarrow K^+ K^+ \pi^-$
  - Burns et al. : $J^p=1^-$, $M=1.6GeV$, $\Gamma<100MeV$
  - Karliner & Lipkin : $J^p=0^+$
    - $K^+ p \rightarrow K^+ p \mathscr{Q}^+ X$ $p_{th}=3.7GeV$
    - $K^+ p \rightarrow \Lambda \mathscr{Q}^+ X$ $p_{th}=2.8GeV$
    - $K^+ p \rightarrow \Sigma^+ \mathscr{Q}^+$ $p_{th}=3GeV$

A Design of High-p beam line and experimental area



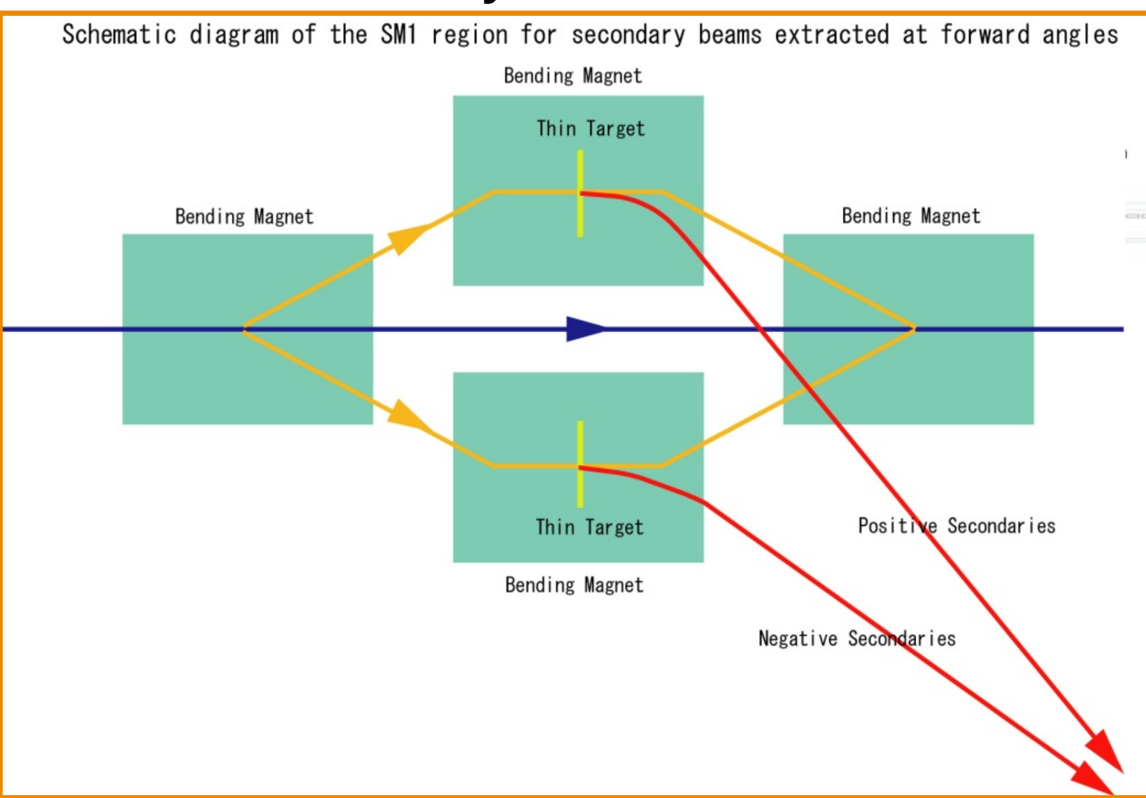
Beam dump and shields are for 10^{10} protons/s

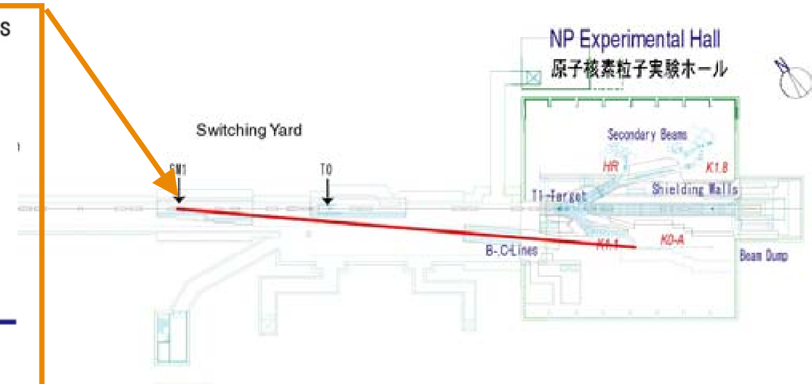
Beam line height : 2.0 m or 2.5 m

Production Target at SM1

- Secondary Beams:
  - Use a thin (2% = 15kW loss) target at SM1
  - Collect them at forward angles
  - Transport them for ~120m

Schematic Layout around SM1





Shielding of the switching yard has been designed to accommodate the loss at SM1

Expected Secondary Beam Intensity

	p (GeV/c)	Yield at SM1	Yield at 120m
p+	5	3.4E7	**2.2E7**
p+	10	1.0E7	**8.1E6**
p-	5	2.5E7	**1.6E7**
p-	10	6.1E6	**4.9E6**
K+	5	3.1E6	**1.3E5**
K+	10	1.4E6	**2.8E5**
K-	5	1.5E6	**6.0E4**
K-	10	3.3E5	**6.8E4**
p bar	5	2.7E5	**2.7E5**
p bar	10	5.5E4	**5.5E4**

30 GeV proton

2% target

beam intensity :
10^{14} protons

Production Angle :
4 degree

$(\Delta p/p)\Delta\Omega$:
0.2 msr%

Sanford-Wang formula

strategy

- beamline tuning
  - optics for K (p=1.8GeV/c)
  - optics for π (p=2GeV/c, 1.05GeV/c)
- spectrometer performance
  - $^{12}C(\pi+,K+)^{12}{}_{\Lambda}C$@1.05GeV/c
- E19
  - πp->KX@1.87,1.92,1.97GeV/c

K1.8 Beamlines

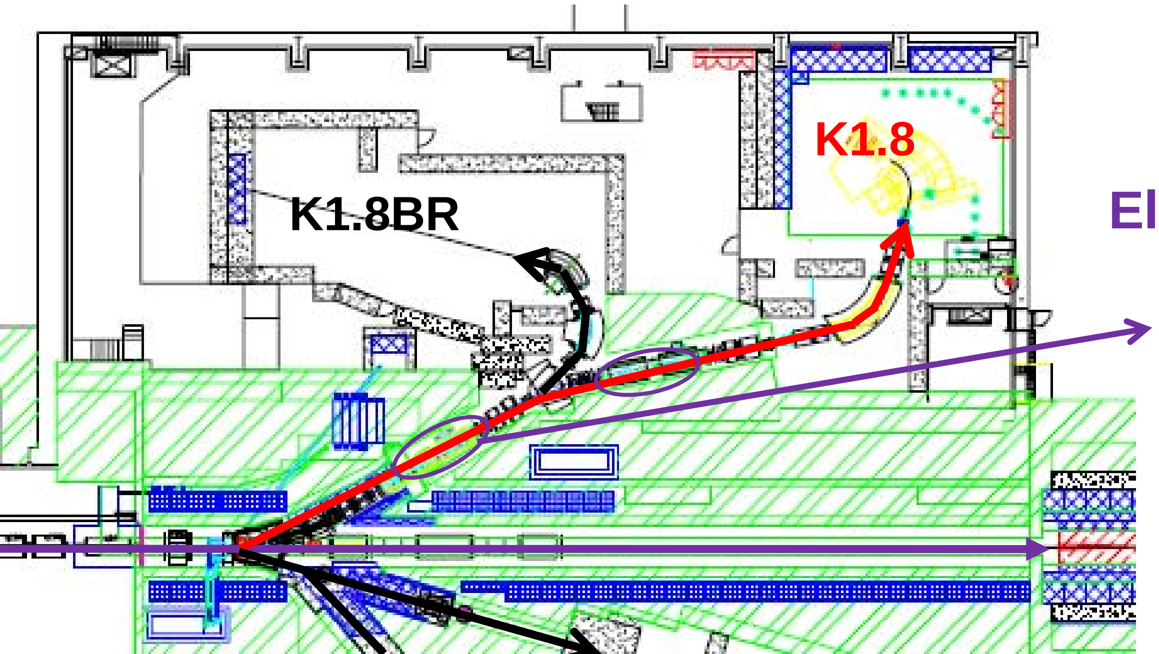
	750kW	270kW
Primary proton beam	50 GeV-15μA	30 GeV-9μA
Length (m)	45.853	
Acceptance (msr.%)	1.4	
$K^-(\pi)$ intensity (ppp) @1.8 GeV/c	6.6E+06	1.4E+06
@1.5 GeV/c	2.7E+06	0.54E+06
@1.1 GeV/c	0.38E+06	0.08E+06
Electrostatic separators	750kV/10cm, 6m×2	
Single rate @ MS2 @ 1.8 GeV/c	＞33E+06	＞8E+06
$K^-/(\pi^-+\mu^-)$ @ FF @ 1.8 GeV/c	4	3.5
X/Y(rms) size @ FF (mm)	19.8/3.2	

P_{max} = 2.0 GeV/c

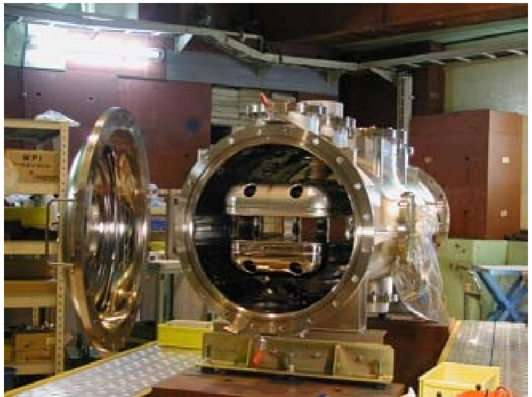
Double stages of E.S. Separators

High-resolution beam spectrometer

Suitable for S=–2 Spectroscopy



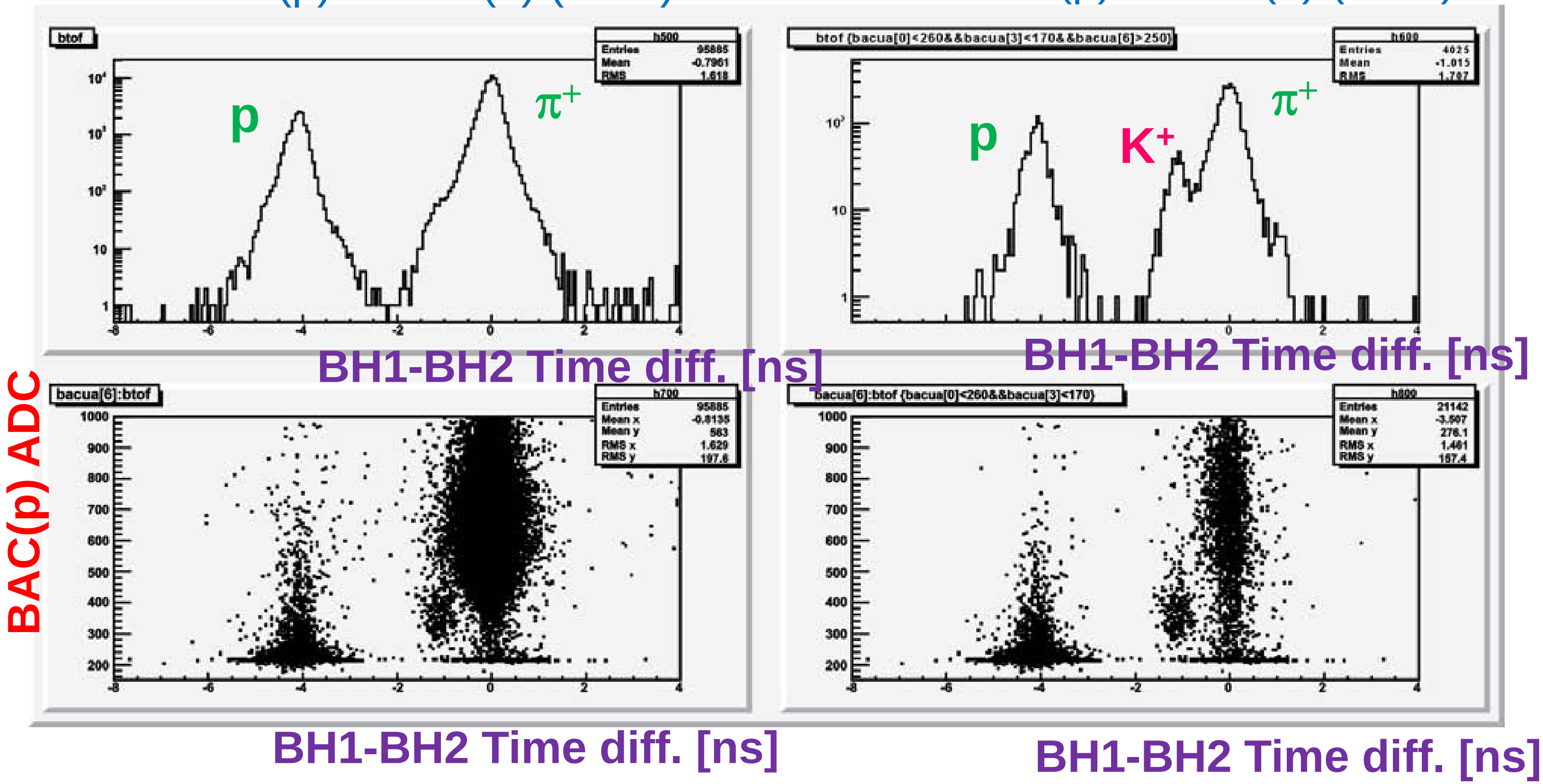
Electro-static Separator (new)



Beam Particles @+1.8GeV/c (unsep.) by BH1xBH2xGC_bar Triggers

Nov.18

w/o BAC(p) & BAC(π) (ADC) cuts   w/ BAC(p) & BAC(π) (ADC) cuts



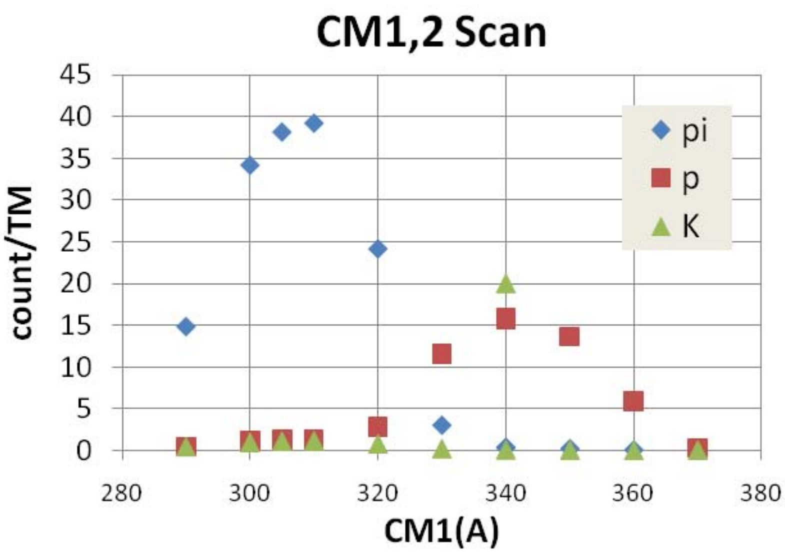
Pion suppression factor ~1/50 by BAC

No multiplicity selection
No pulse height correction

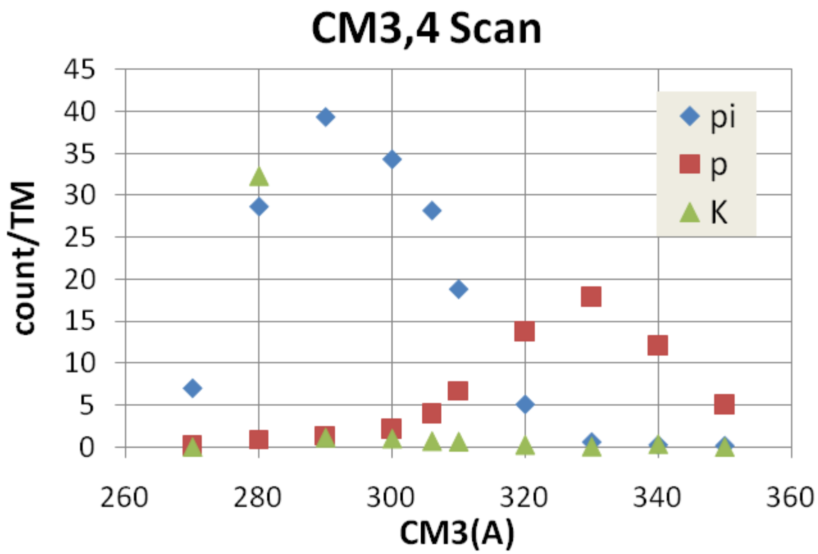
CM Scan

Nov.25

ES1=+-200kV, ES2=0



ES1=0kV, ES2=+-200kV



pi:305A (CM1)
p: 340A (CM1)

CM1=324A for K

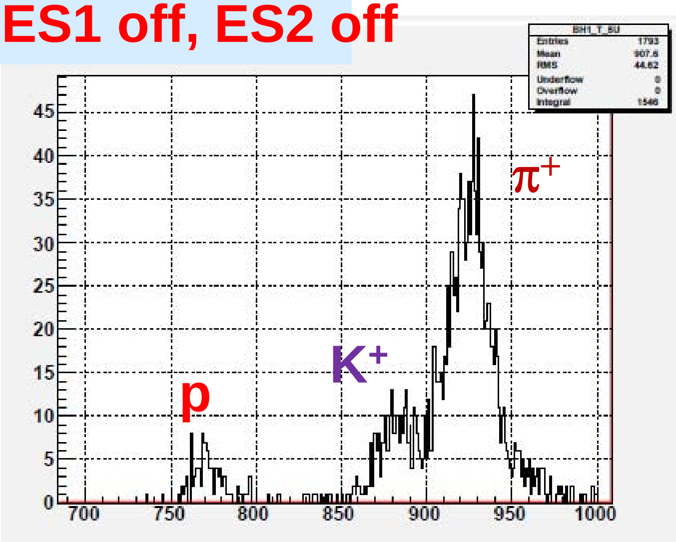
pi: 290A
p: 330A

CM3=306A for K

Beam TOF with “Kaon” Trigger

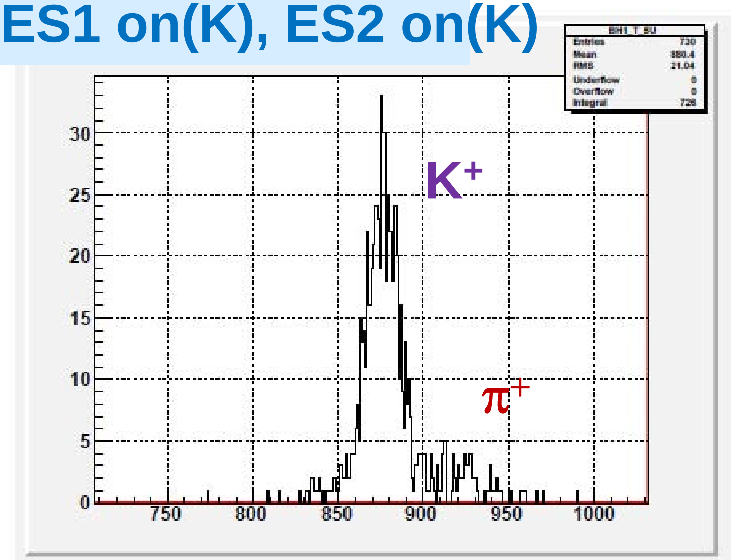
Nov.25

ES1 off, ES2 off



ES1 on, ES2 off

ES1 on(K), ES2 on(K)



ES1 off, ES2 on

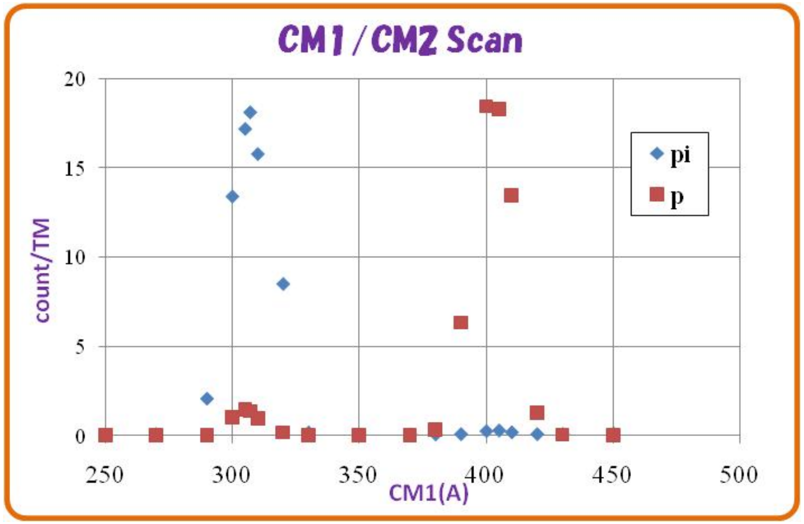
CM Scan

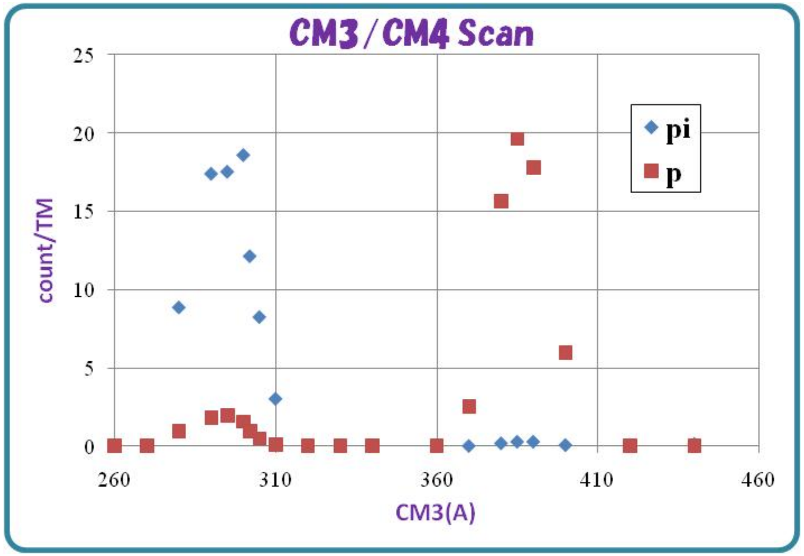
Dec.15

Slit Condition:
- IFH ±100mm
- IFV -1mm/+3mm
- Mom +174.9/-179.8
- MS1 ±2.35mm
- MS2 ±2.5mm

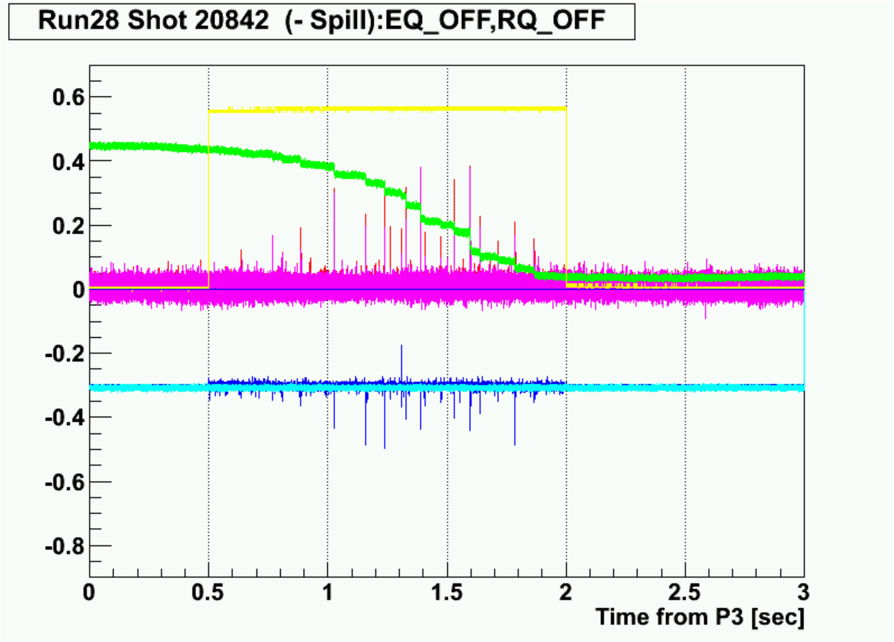
→

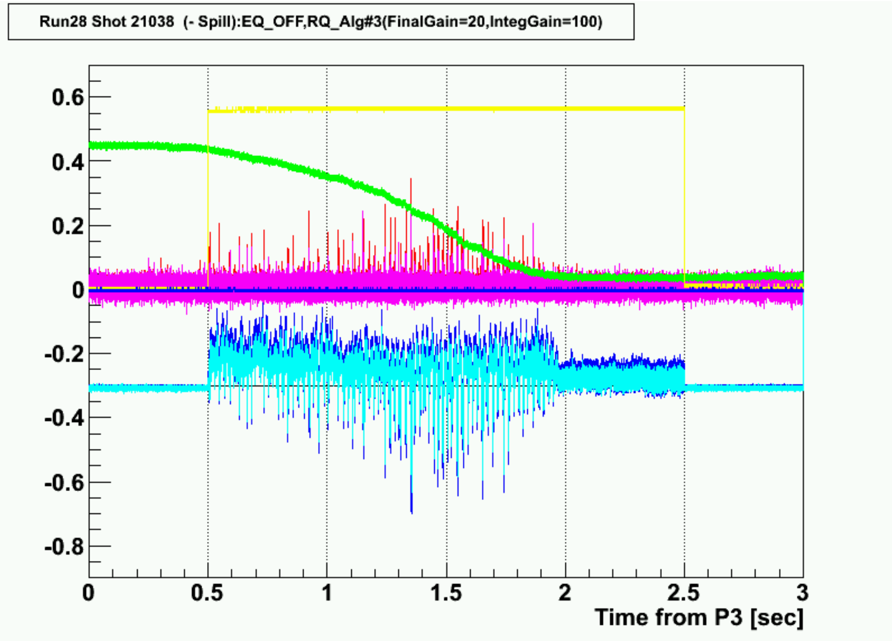
CM1=307A
CM2=287A
CM3=300A
CM4=300A





Spill Structure

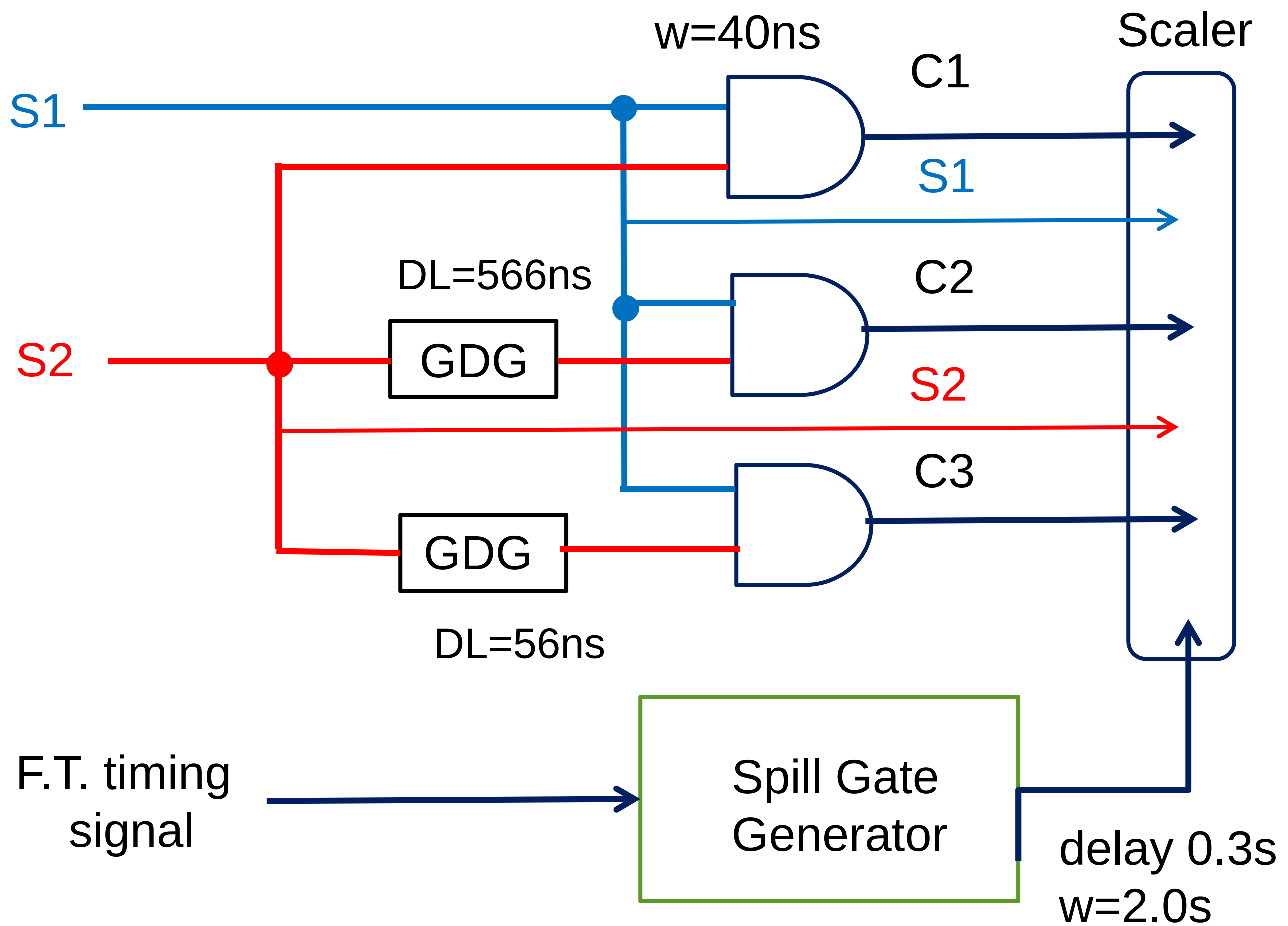




差分信号（Xn = Ref-Spill）そのまま出力
赤、桃：スピル信号反転表示
青：RQ指令値（DSP out）
水色：RQ電流モニタ値

figures from
A. Kiyomichi

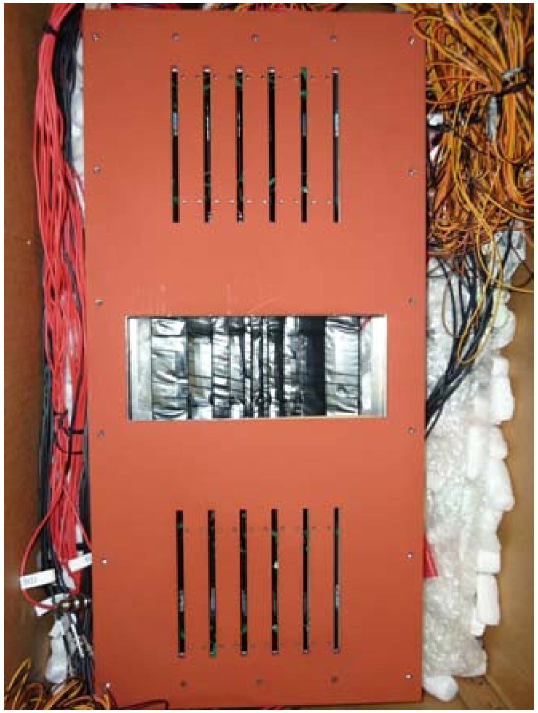
Micro-Structure Monitor



S1, S2は、BH1の隣り合わない Segmentから選ぶ

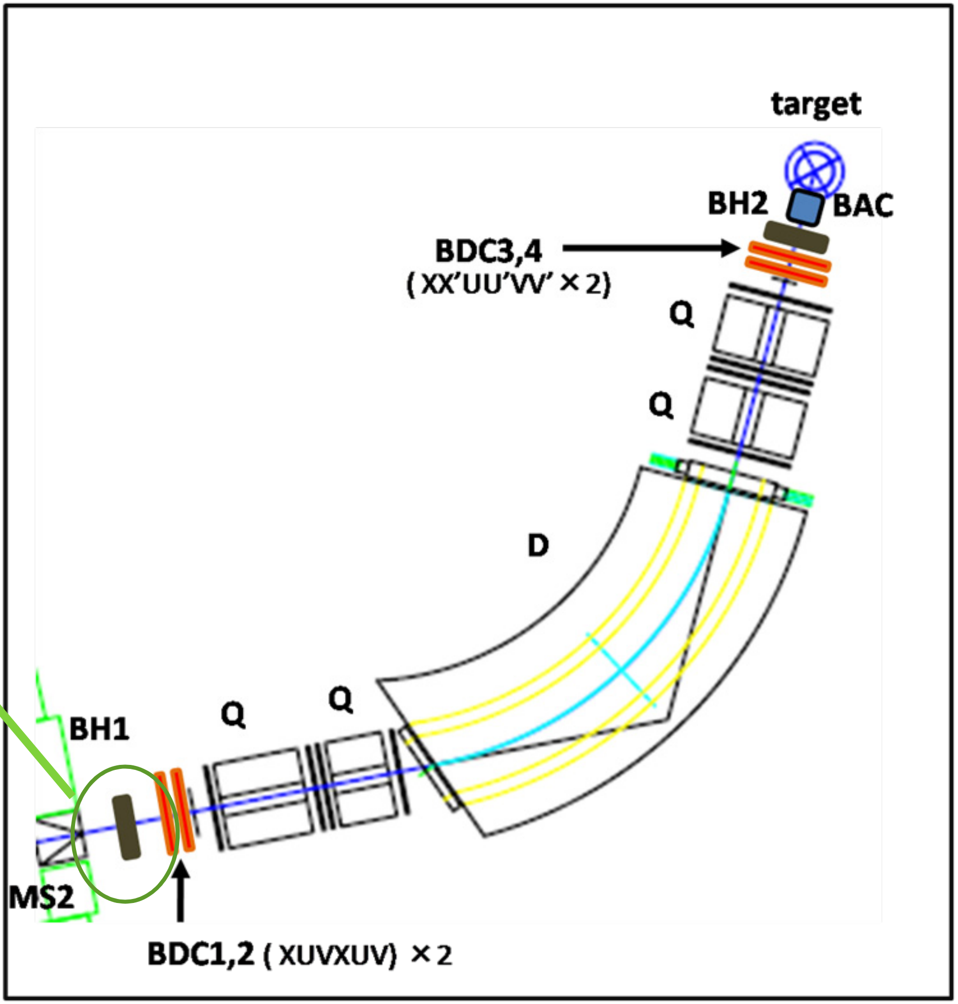
BH1#3, #5, #7, #9

BH1　最上流の検出器



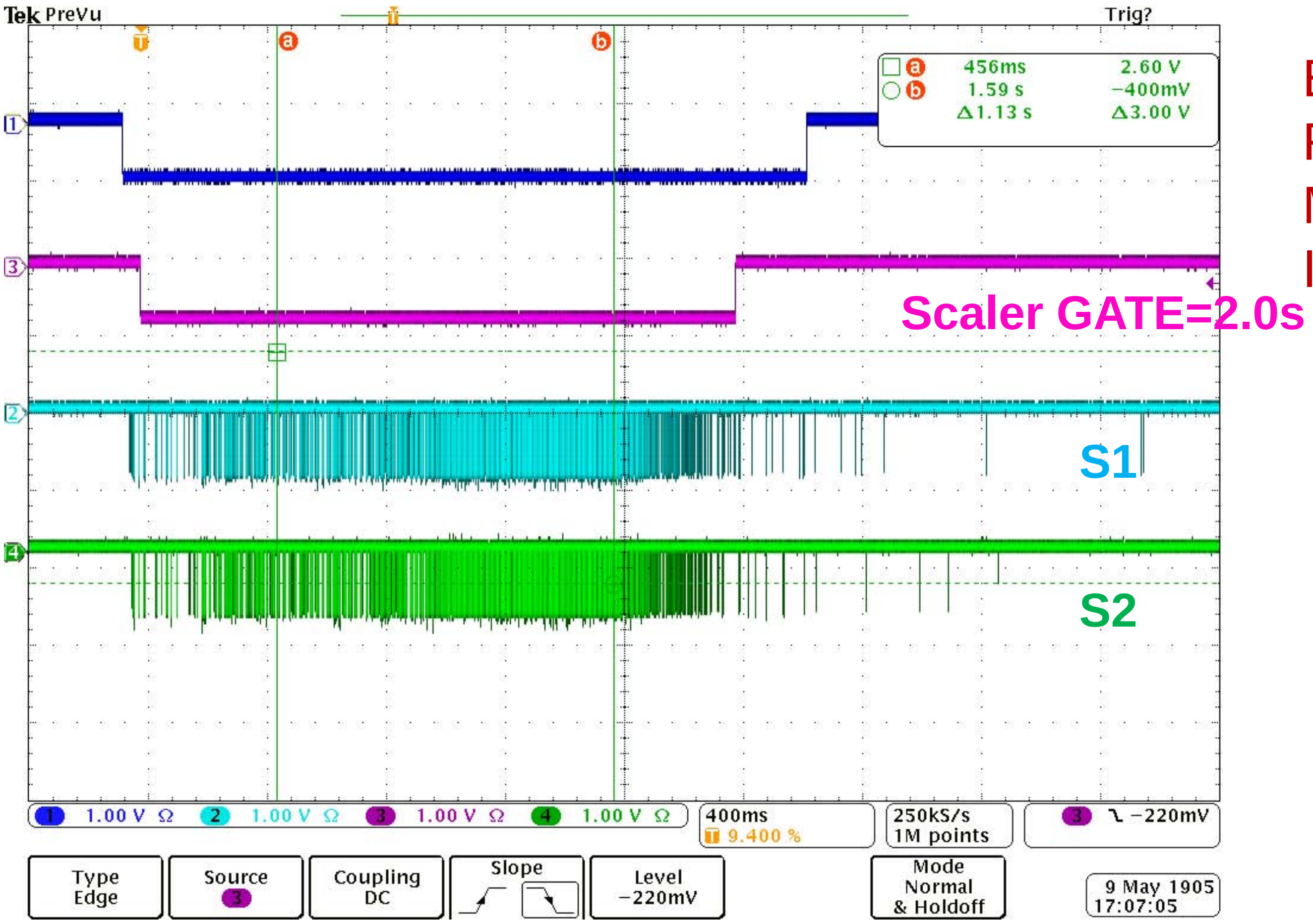
Seg#5,#7, #3, #9を使用

2 segments not neighbor
(with adequate rates)



Logic signal (NIM) after Discriminator and Mean-timer

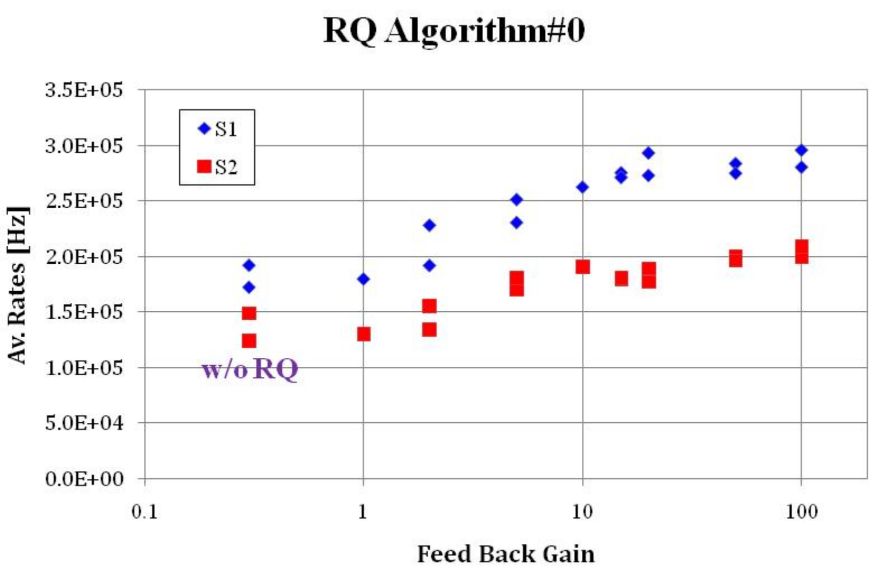
Shot#21025

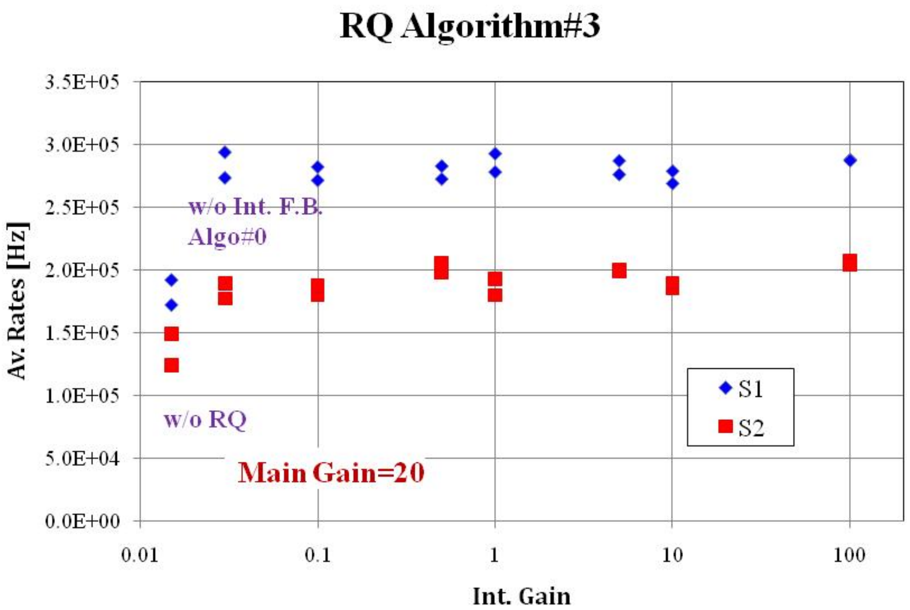


EQ off
RQ Algorithm#3
Main Gain = 20
Int. Gain = 100

Scalerの数え落とし？

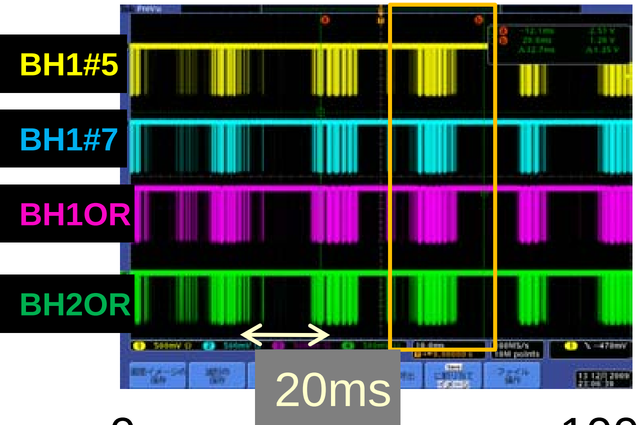
80 MHz Visual Scalerで測定



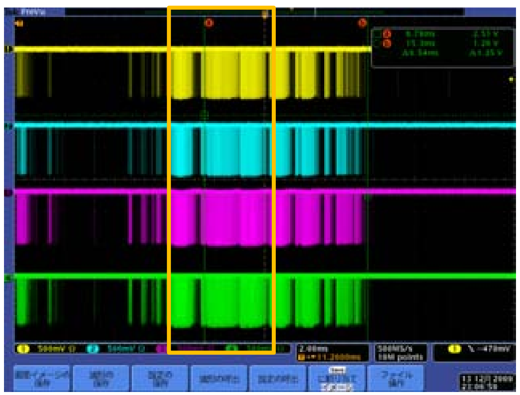


MR陽子数は~4x10^11で同じはずなのにScaler Count数は大きく違う。
Main Gain 20 以下では特にAverage Ratesの減少が顕著

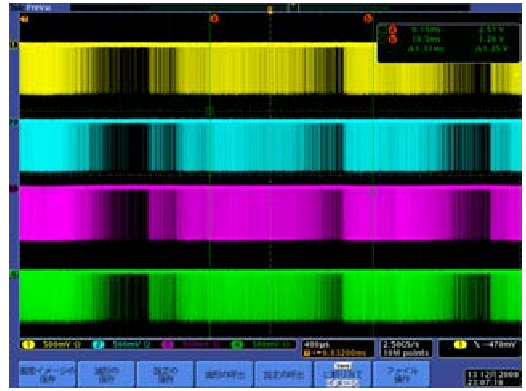
22:30ごろ（Algo#3のどれか）の信号



0ms 100ms

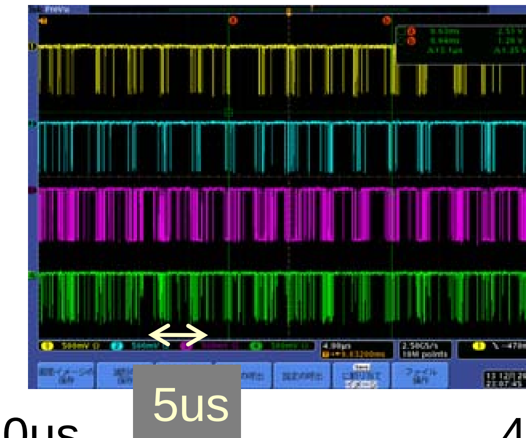


0ms 20ms



0ms 4ms

0us 400us

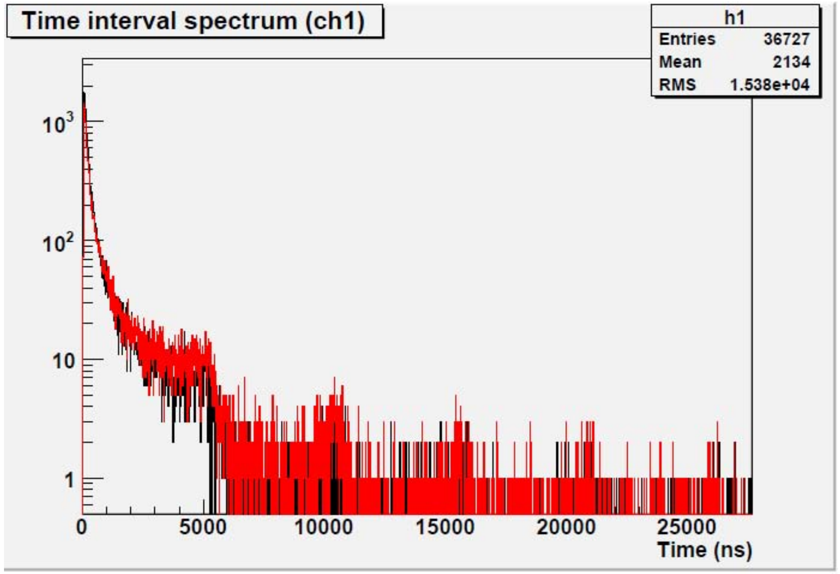


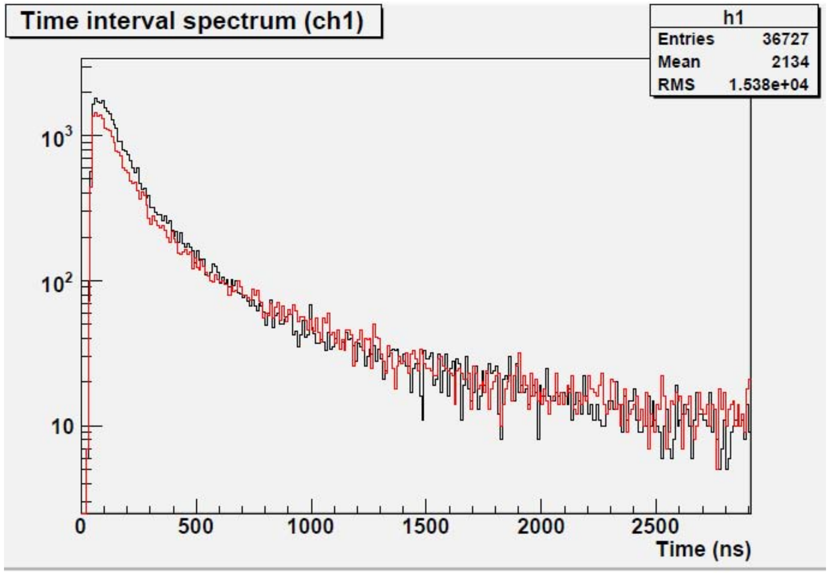
0us 40us

0us 2us

BH1ORはPile-upしている

BH1#5信号間隔のスペクトル





5usの構造

赤:23:10ごろ
黒:Algorithm#3

BH1のHit Patternからは、
Rate(#3) ～Rate(#9) = 0.5xRate(#3)～0.5xRate(#5)
と推定される。

数え落としの原因!?

- Coincidence OutのSignal幅　100nsであった。
  - 10nsに変更する
- Singleの幅、BH1からのそのまま　30ns
  - これ以上狭くするのは、Double Pulseの問題で難しい
- Coincidence Inputの幅　40ns(Coin. W 78ns)
  - 今後必要なら狭くするが、当面様子を見る

Scalerでの数え落としというより、それ以前の回路系でのPile-upが主原因。

- EQ,RQ ONでは、粒子数カウントと粒子比率がコンシステント(KEK-PS K6での経験値と)となった。@4x10^11ppp w/pt target
  - w/o EQ,RQ BH1:0.8MHz, BH2:0.6M, pi:0.38M e:0.054M
  - w/　EQ,RQ BH1:1.3MHz, BH2:0.8M, pi:0.63M e:0.061M

(preliminary)

Summary

- J–PARC E19 searches for Θ^+ in $\pi^- p \rightarrow K^- \Theta^+$ raction
  - K1.8 beamline + SKS is ideal for Θ^+
  - significance ~60σ, sensitivity ~75nb/sr
  - with mass resolution of 2.5MeV(FWHM)
- Current Status
  - just starting the beamline tuning
  - the problem is the microstructure