E17 Status

0. About E17
1. Readiness of x-ray detectors and ^{3}He target
2. Status of beam tuning at K1.8BR
3. Beam requirements
4. Near-future schedule
5. Summary

Takatoshi Suzuki (Univ. of Tokyo)

for J-PARC E17 collaboration

J-PARC E17 collaboration

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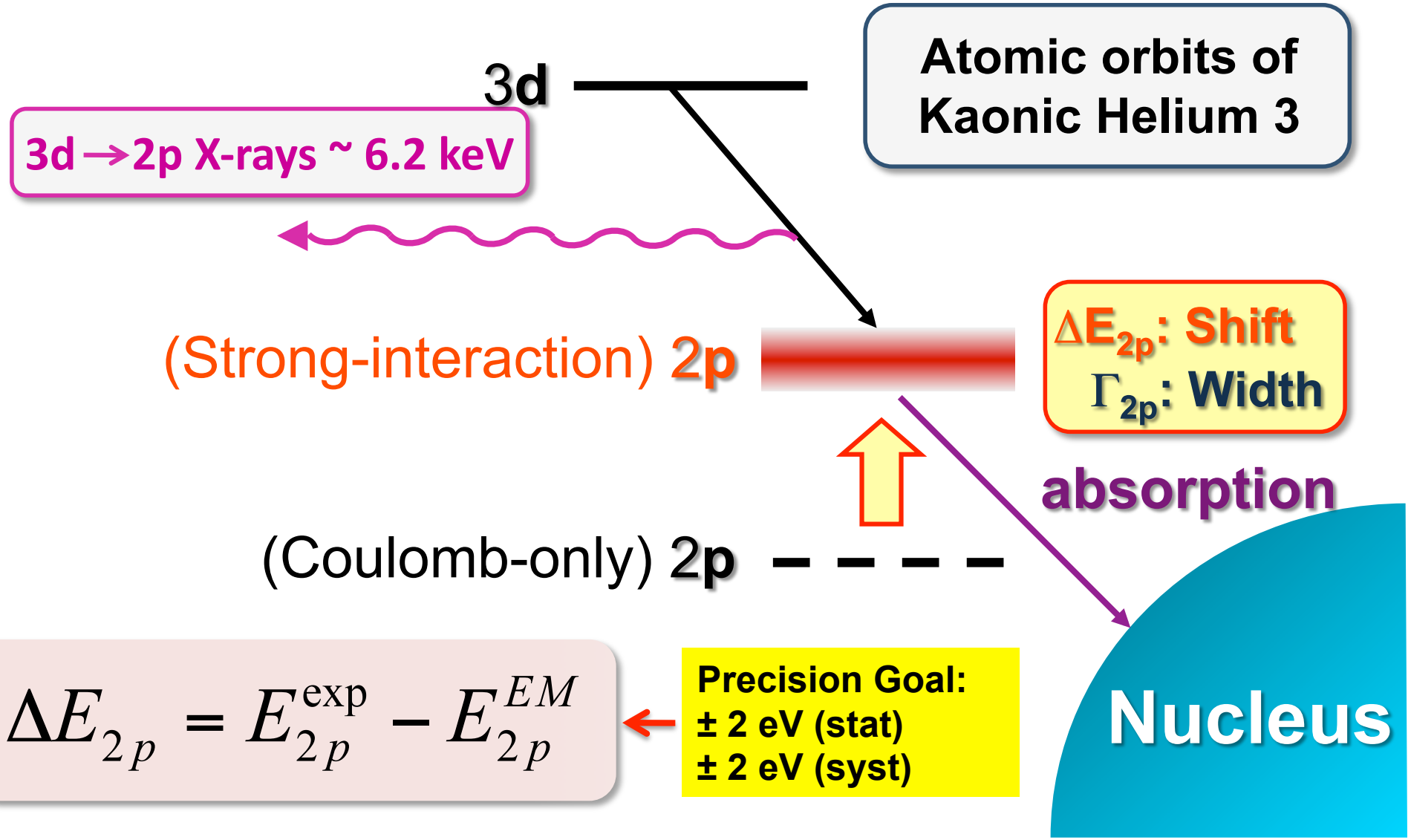
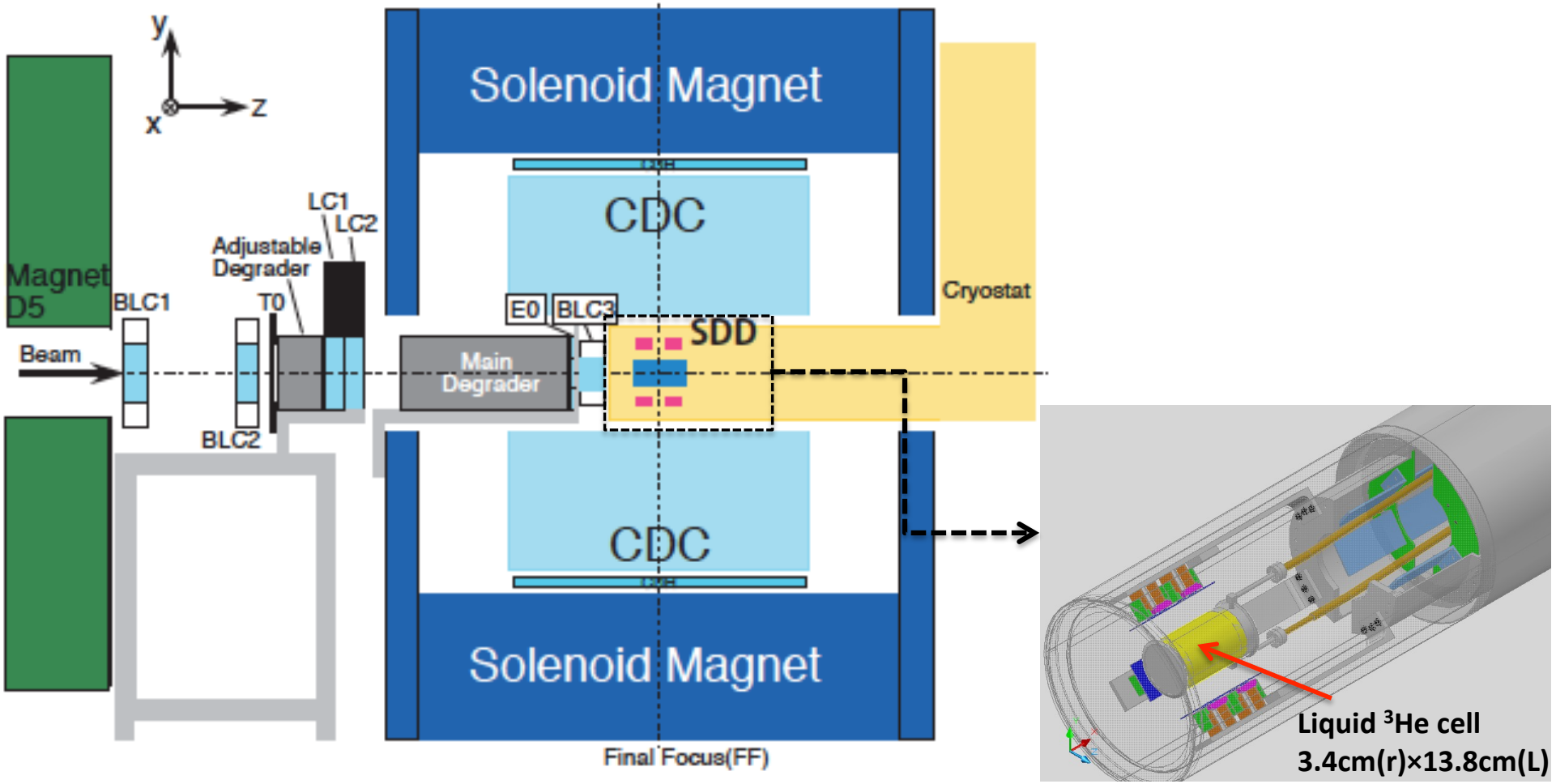
E17:Strong-interaction Shift and Width of Kaonic Helium 3

- **Last orbit of Kaonic atoms is sensitive to K^--nucleus strong-interaction.**



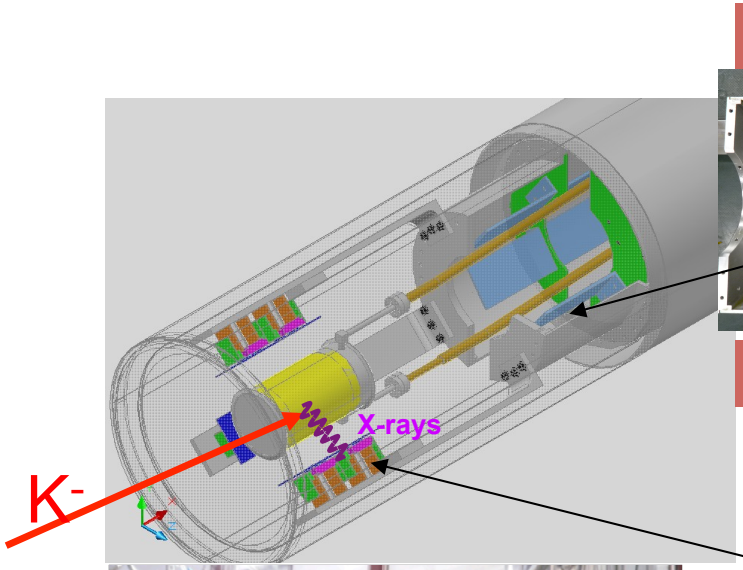
E17 Setup

Beamline / Beam	**K1.8BR / K^- (p_K>0.7 GeV/c, discussed later)**
Target	**Liquid ^{3}He**
X-ray detector	**Silicon Drift Detector (SDD)**
Secondary particle detector	**E15 Cylindrical Drift-chamber System (CDS)**

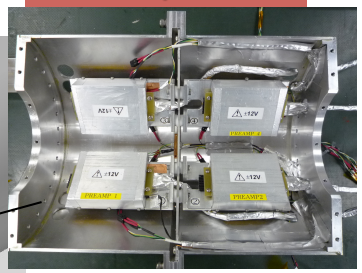


Silicon Drift Detector (SDD) Status

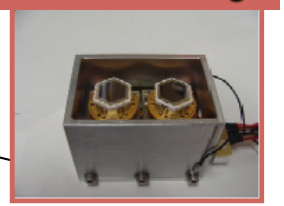
- **SDD installed in the 3He cryostat**
  - **Successfully operated 4 SDDs with preamp inside vacuum**
  - **Cross-talk suppressed**

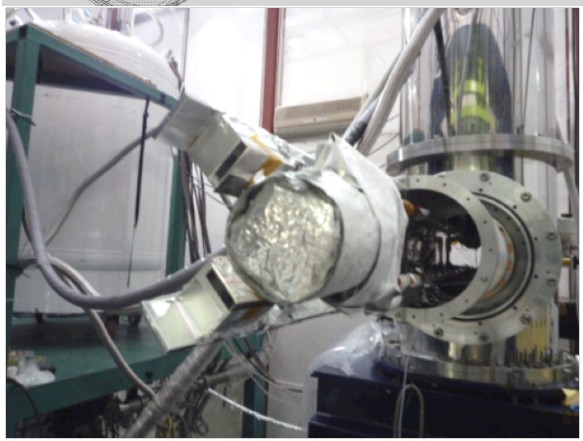


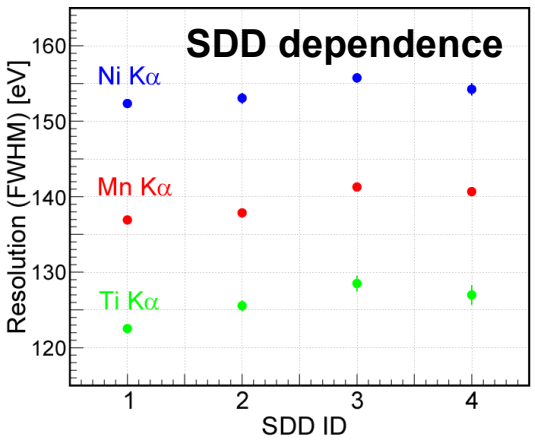
Preamp



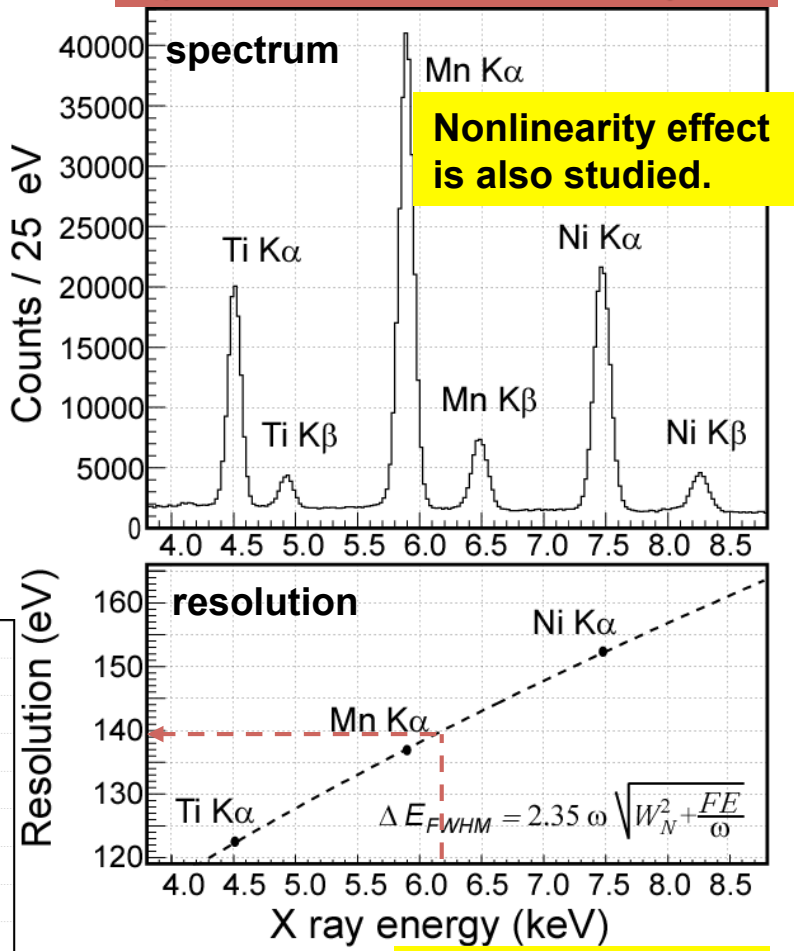
SDD housing







Spectrum w/ fluorescence X-rays



Nonlinearity effect is also studied.

Well-estimated by known formula.

ΔE_{FWHM} ~ 140 eV at K-3He X ray (6.2 keV)

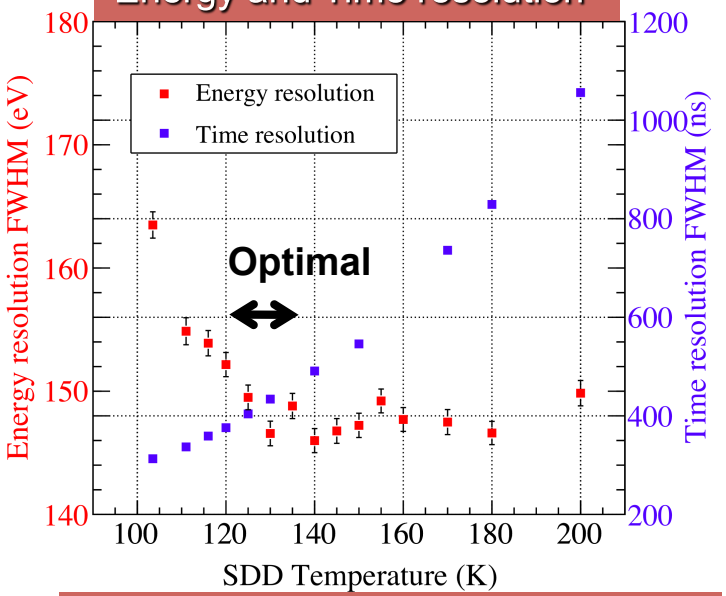
SDD Systematic Study @ Test Bench

To achieve <2eV absolute energy accuracy at 6.2 keV….

- **Optimal temperature/voltage (SDD, preamp.)**
  - Energy resolution
  - Time resolution
- **Pileup rejection**
  - Online: optimization of VETO time after “Reset” & large signals
  - Offline: Flash ADC (in preparation), pre-gate, tail charge
- **Incident-angle**
  - Some parts of response function depend on incident-angle
  - But, the peak position changes at most 0.5 eV

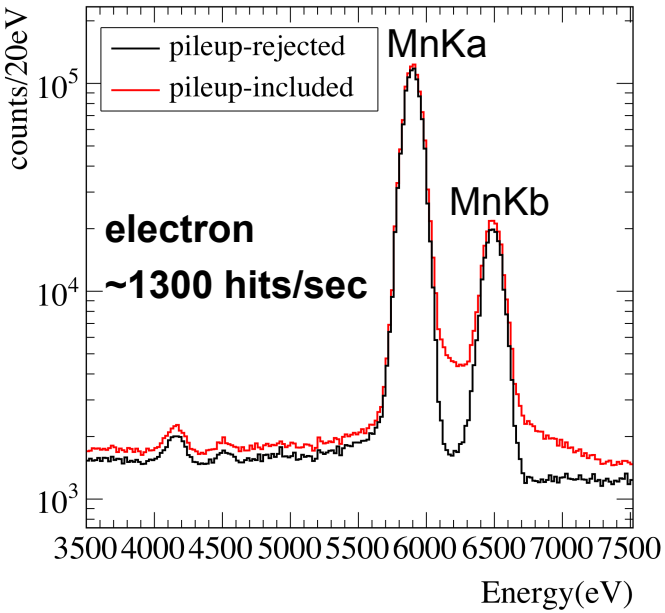
Overall systematic uncertainty is controlled to be 1~2 eV.

Energy and Time resolution

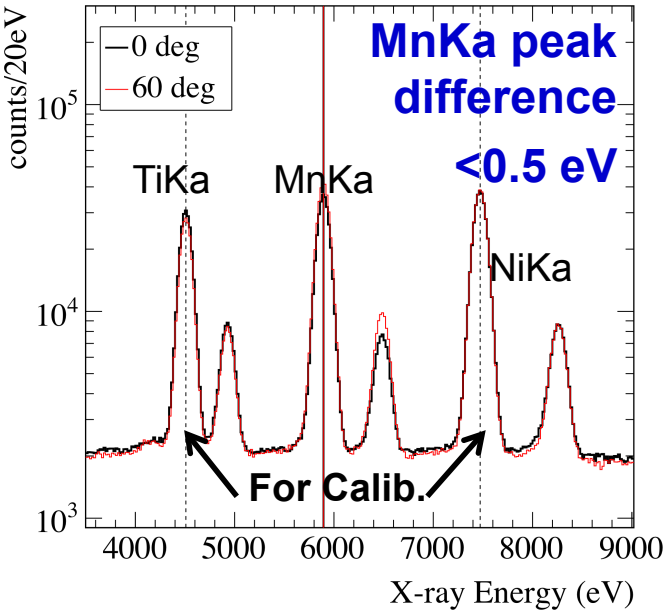


TestBench

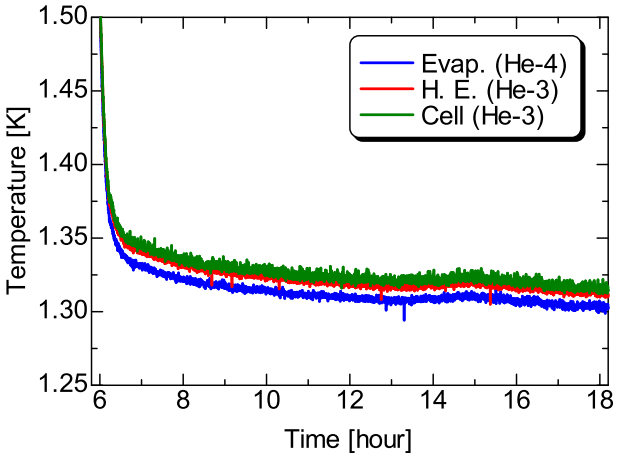
Fe55 Spectrum w/ Sr90 electron

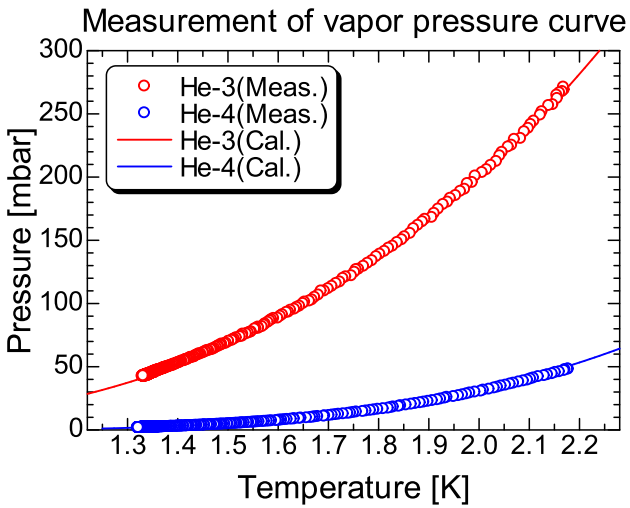


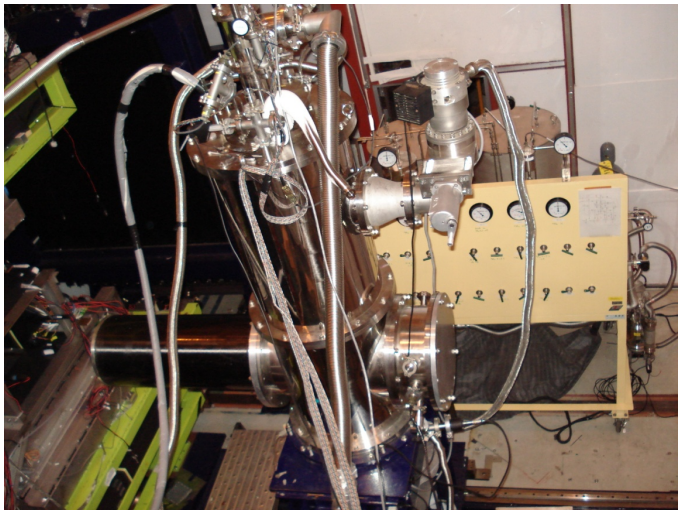
Different Incident-angle Fe55 X-rays

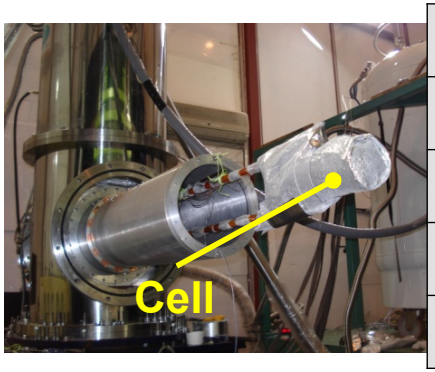


Liquid ^{3}He Target System





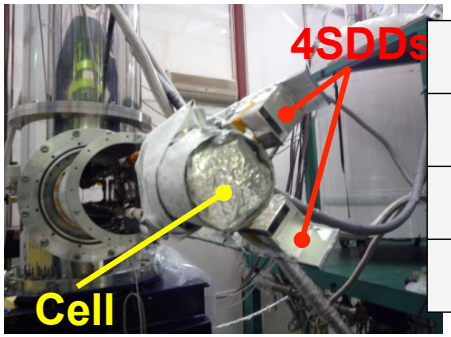




Date: Apr. 2010	J-PARC E15
Temperature in the Target Cell	1.3 K
Pressure in the Target Cell	42 mbar
Liq. ^{4}He Consumption	45 L/day
Heat Load to the 1K Parts	0.18 W

Heat load of 0.08W increased by installing half sets of x-ray detectors (4 SDDs).

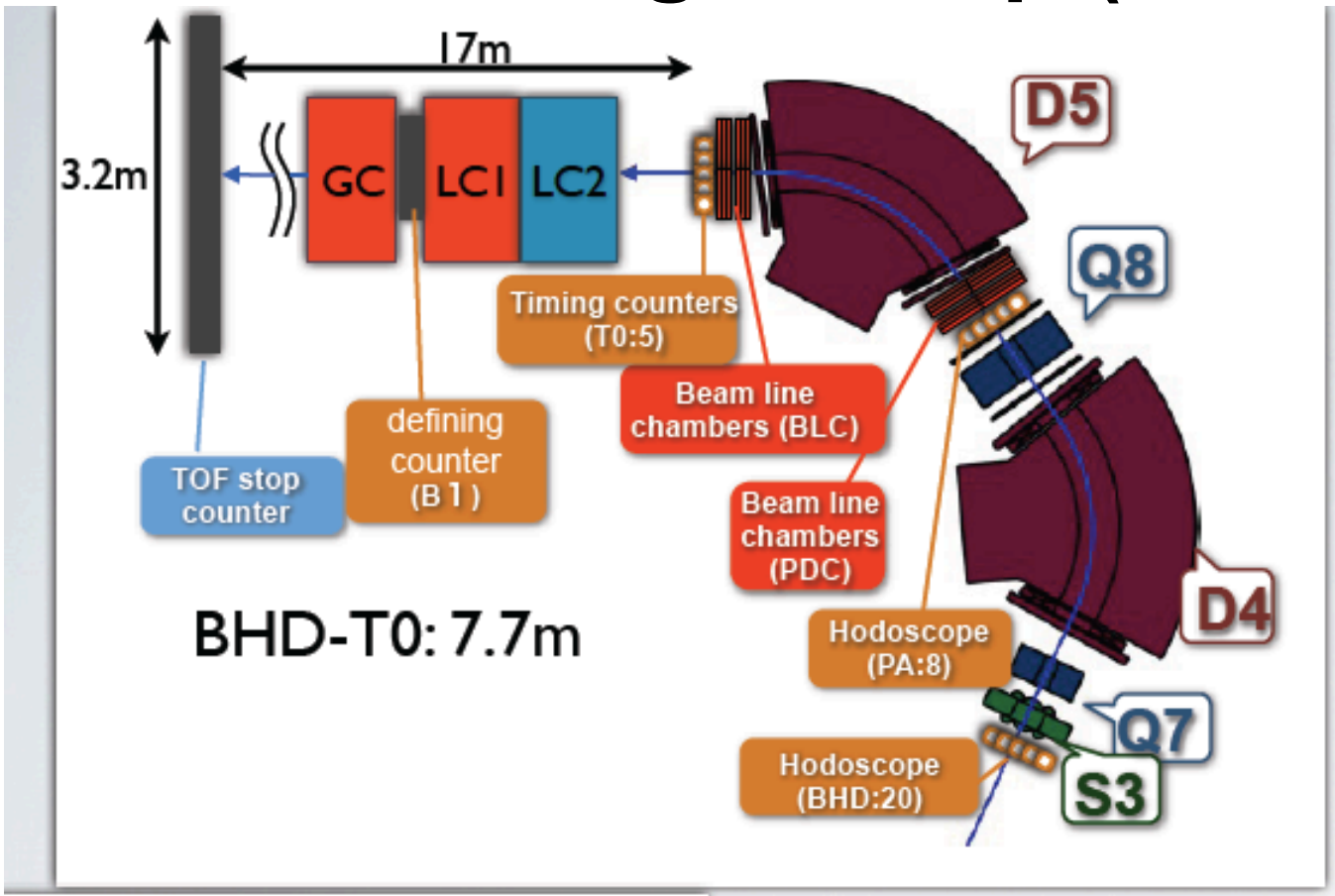
Heat load in 8 SDDs: 0.33 W?



Date: June. 2010	J-PARC E17	KEK E570
Temperature in the Target Cell	1.4 K	1.5 K
Liq. ^{4}He Consumption	65 L/day	120 L/day
Heat Load to the 1K Parts	0.26 W	0.48 W

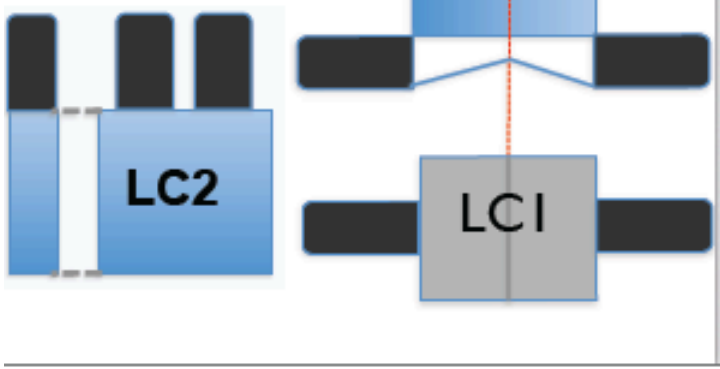
Heat load problem was almost solved

Beam Tuning : Setup (0.7~0.9 GeV/c)



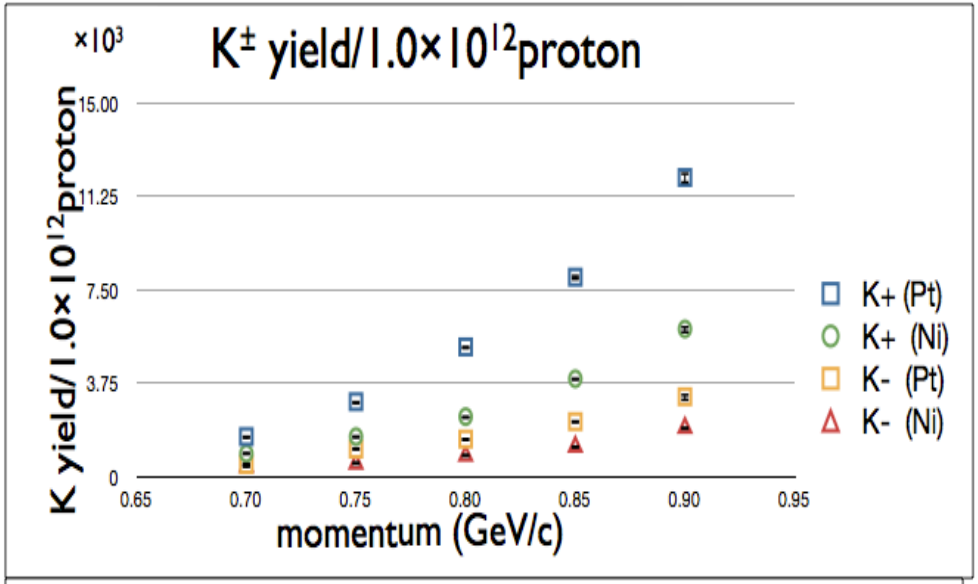
TOF(BHD-T0)
: off-line

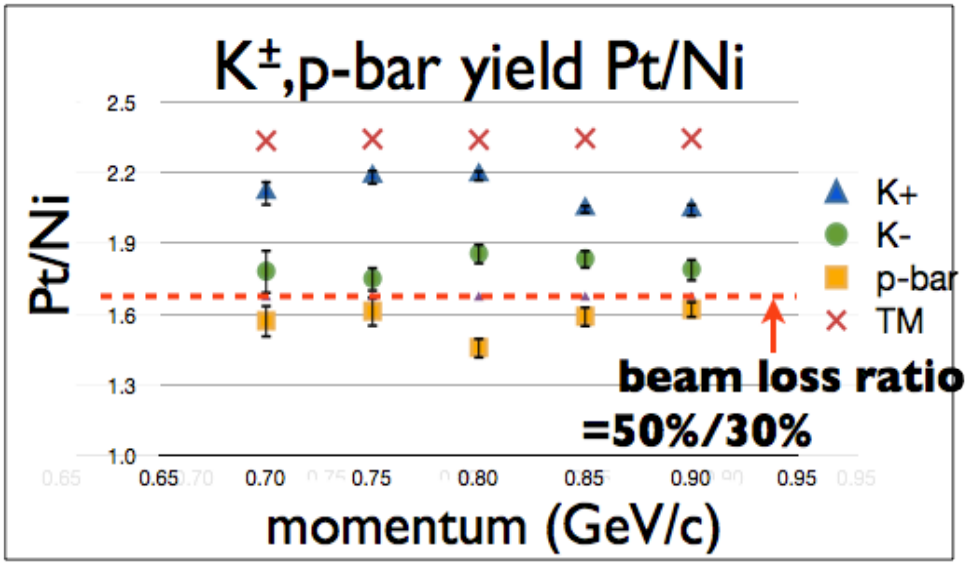
scaler
: on line

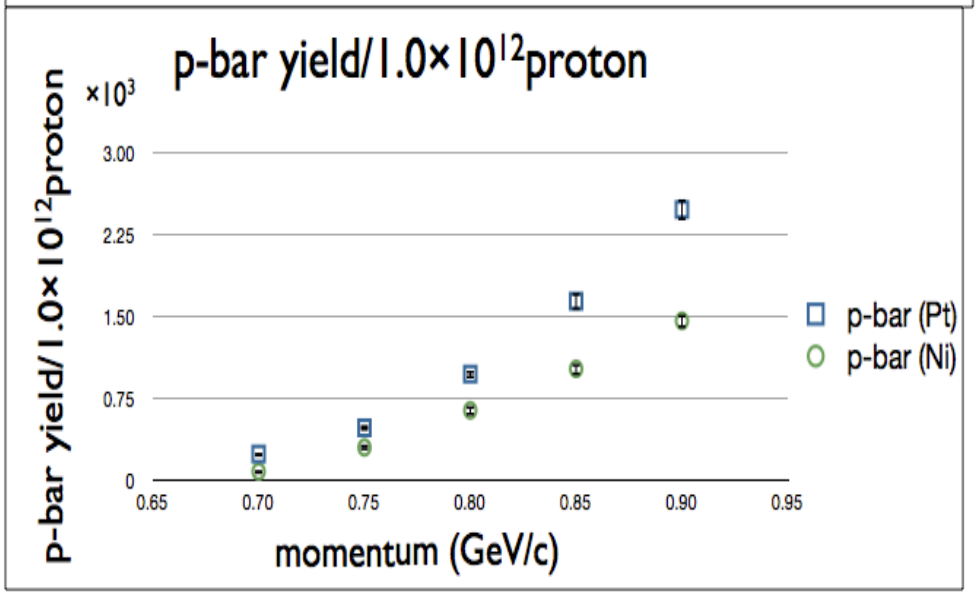


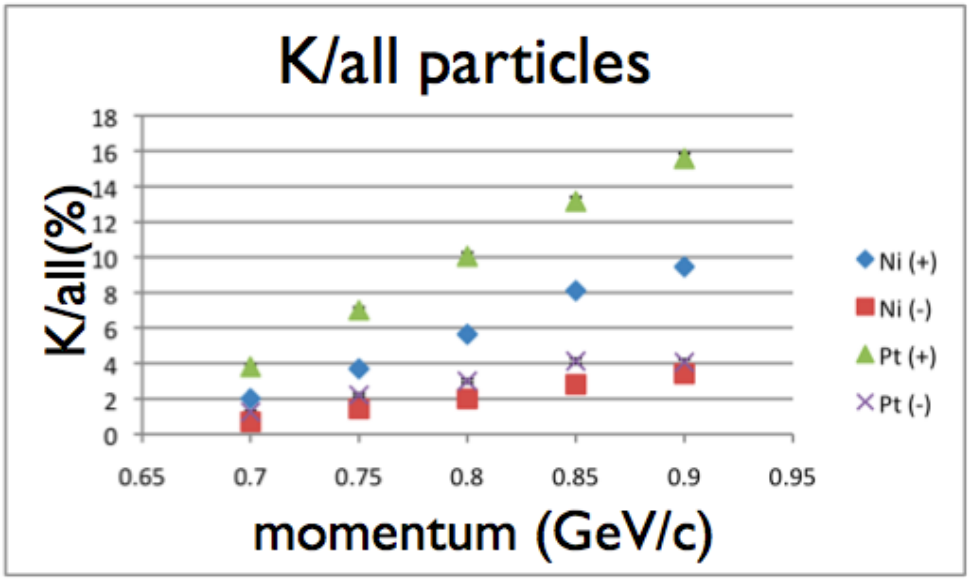
	Gas (0.997<β)	Lucite1 (0.67<β<0.905)	Lucite2 (0.905<β)
e (β=~1)	○	×	○
π (β=0.983)	×	×	○
K (β=0.832)	×	○	×
p (β=0.624)	×	×	×

Beam Tuning: Pt VS. Ni targets





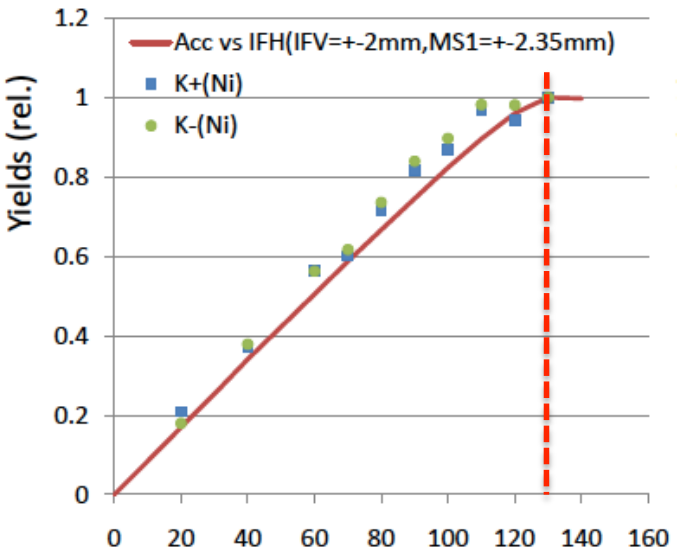




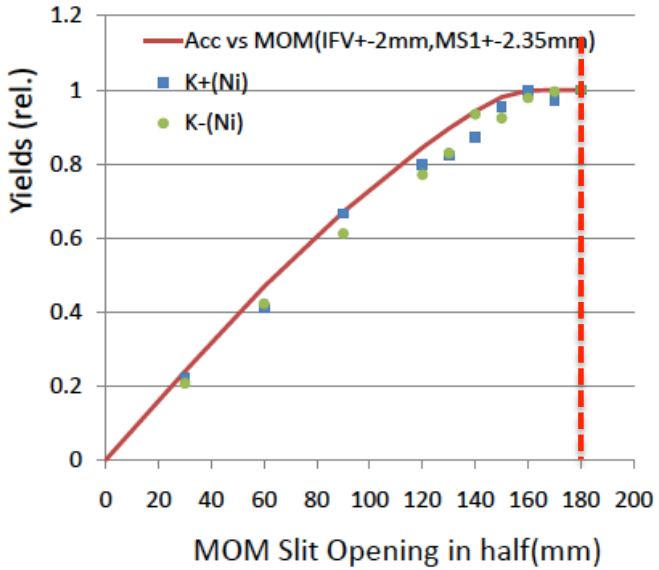
For K±, Pt is better than Ni for both of K/all ratio and yield per primary proton.

Beam Tuning: Slit Openings VS K± Yield

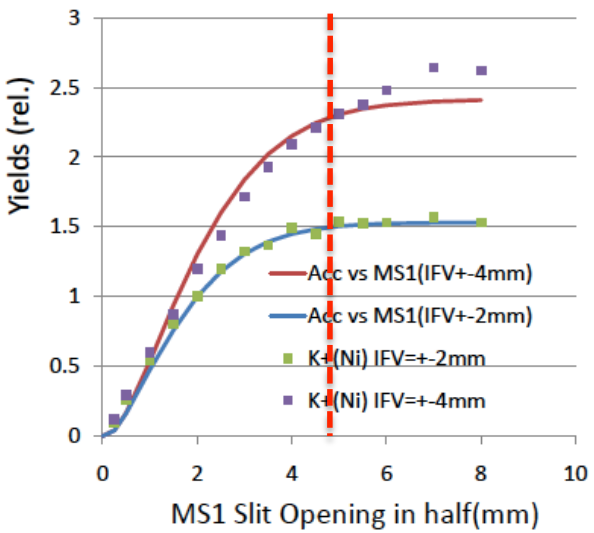
Mes.1 (IFH Slit Opening at IFV=+-2mm, MOM=+-180mm, and MS1=+-2.35mm

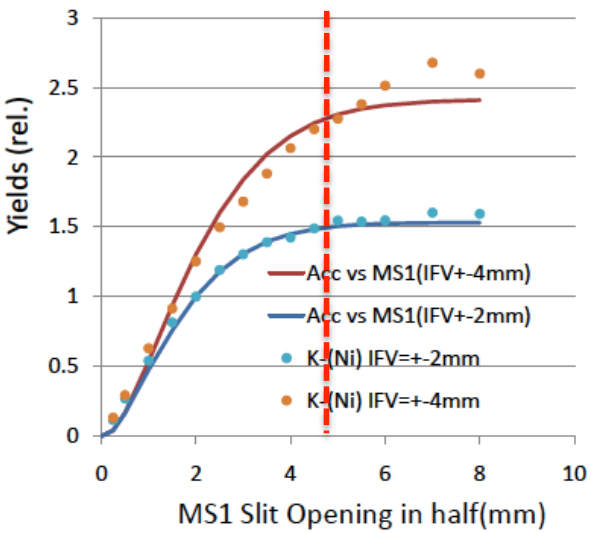


Mes.2 (MOM Slit Opening at IFH=+-130mm, IFV=+-2mm, and MS1=+-2.35mm)

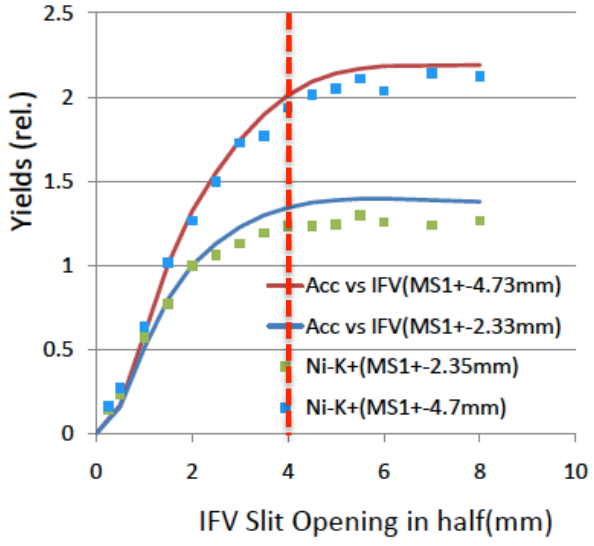


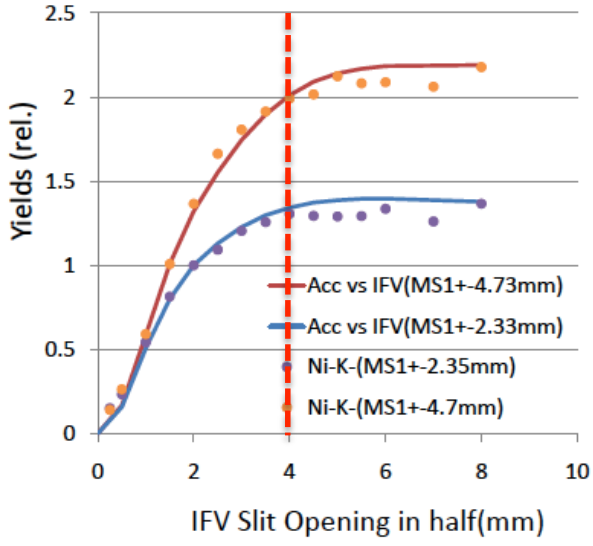
Mes. 3, 4 (Yields vs MS1 Opening for 2 IFV Opening, at IFH=+-130mm and MOM=+-180mm)



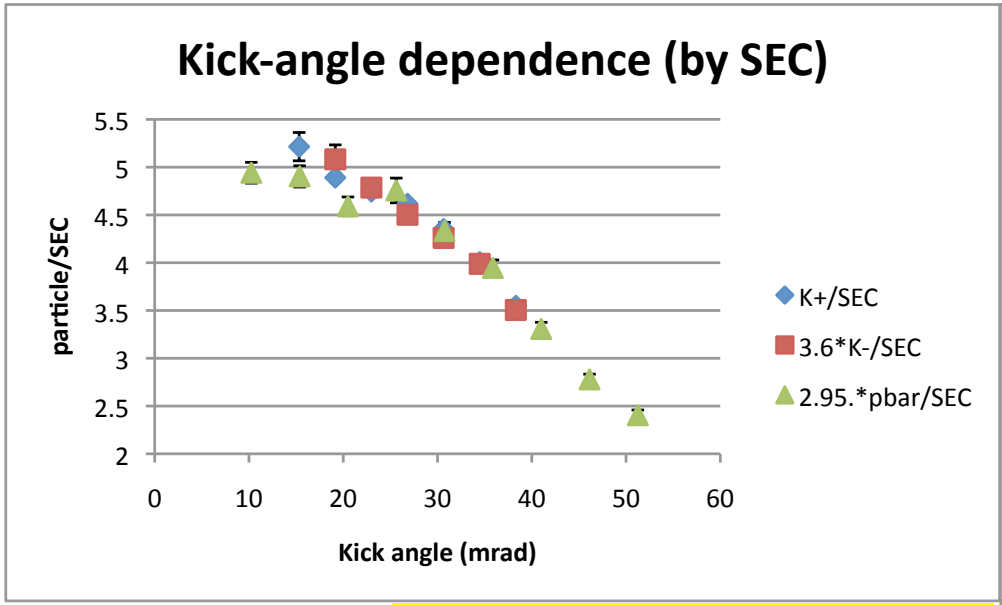


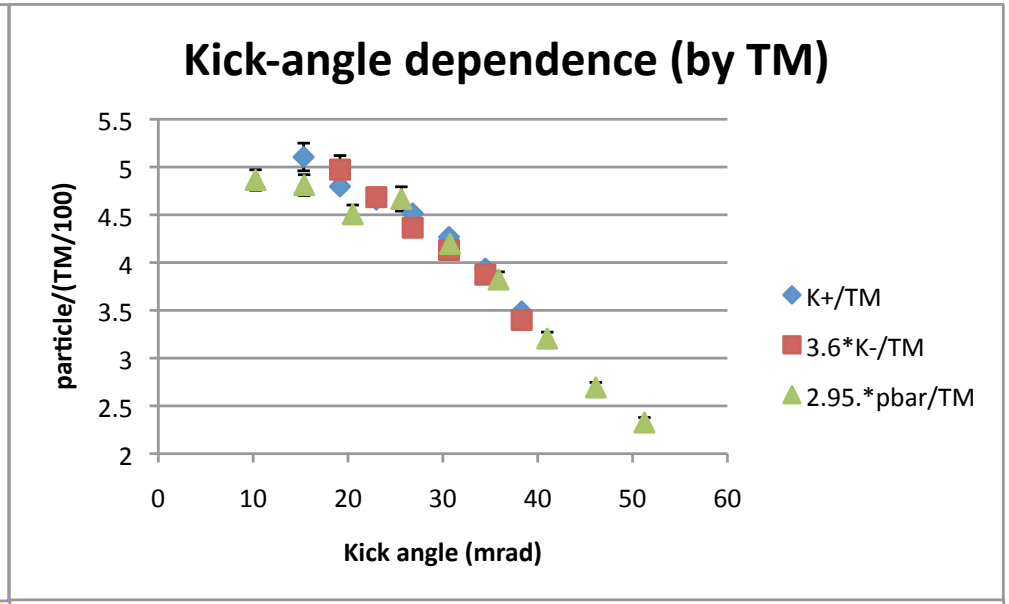
Mes.5,6 (Yield vs IFV Slit Opening for 2 MS1 Opening, at IFH=+-130mm and MOM=+-180mm)





Beam Tuning: Kick-angle VS $K^{\pm}$/pbar Yield



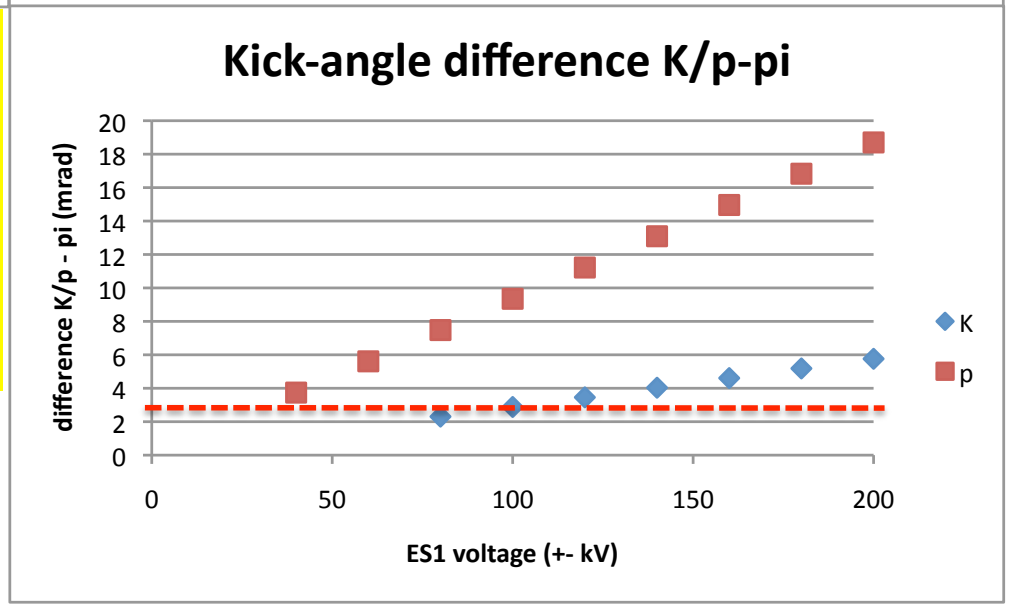


Kick-angle is defined by

$$y' = \frac{eEl}{pc\beta}$$

d :gap of electrodes, 10cm
l : length of ES1, 6m
V : operational voltage
E=V/d
p : particle momentum
βc : particle velocity

Dependences of $K^{\pm}$/pbar yields on it are consistent each other.



1. Acceptance saturates at ~20 mrad.

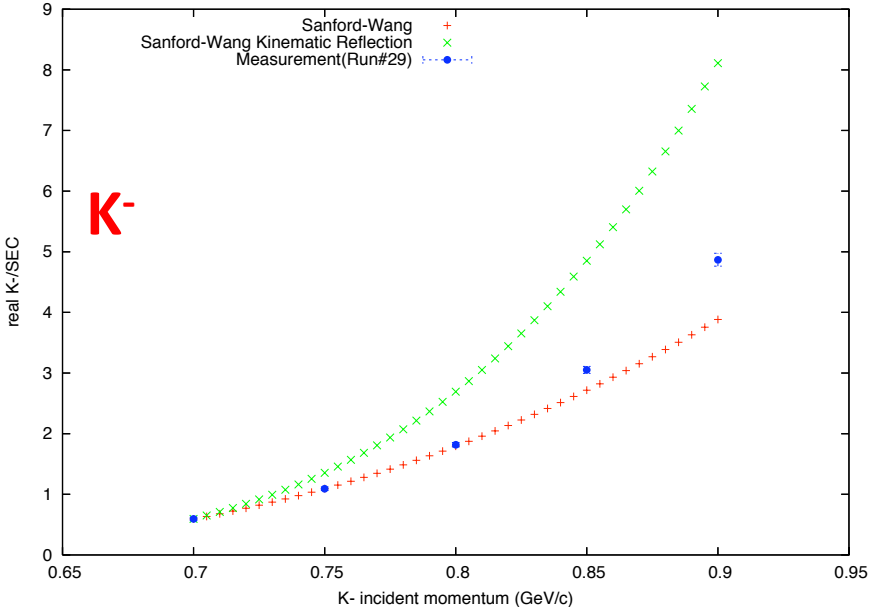
2. $\theta_{K/p}$-θ_{π} difference should be 3 mrad or larger for safe K/p-π/e separation →
Vertical displacement of K/p-π at MS1 should be > **12.5 mm** for MS1 2W(±4.7mm) setting.

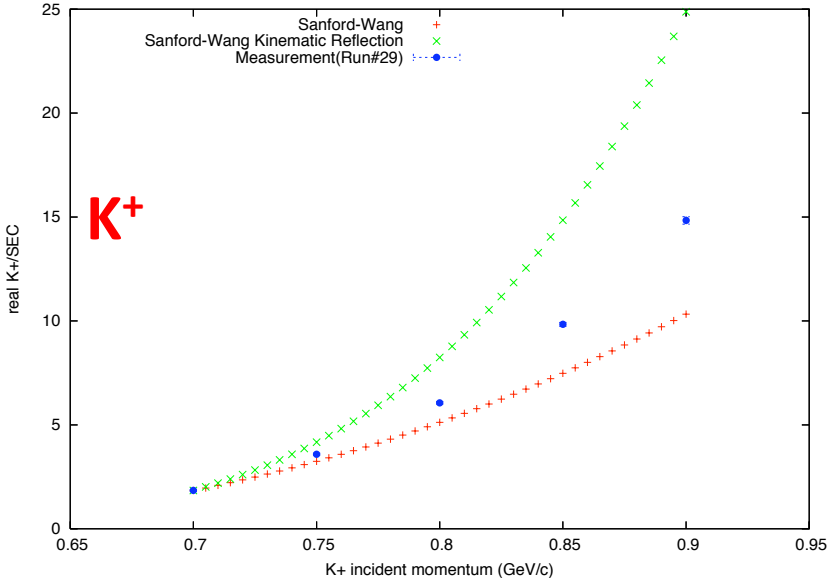
Beam Tuning: Comparison of Momentum Dependence Calculated VS Measured

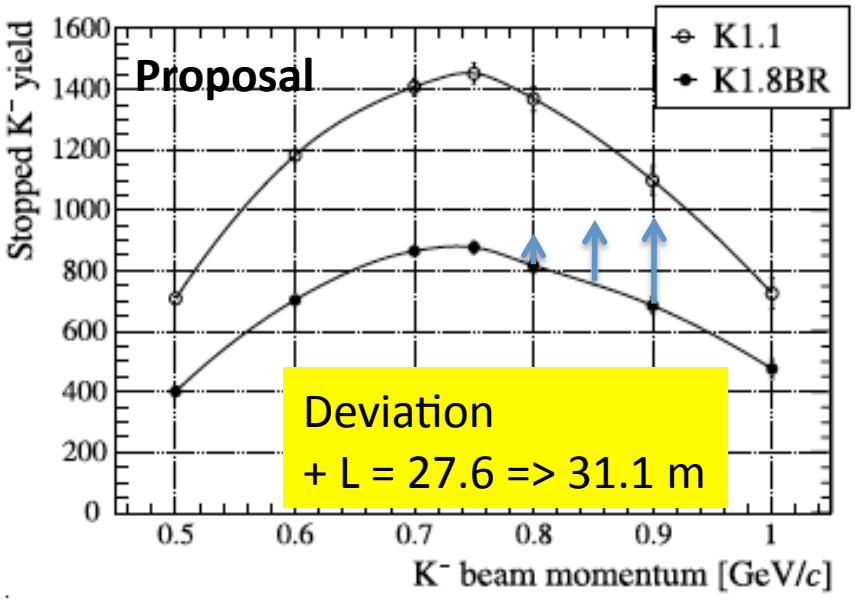
Calculation:

1. Sanford-Wang formula
2. Kinematic reflection w./w.o.
3. Decay factor : exp(-L/βγcτ)
   L=30.7m (T1->B1,31.1-0.4)
4. Kick angle (for V=±200 kV, **measured acc.**)

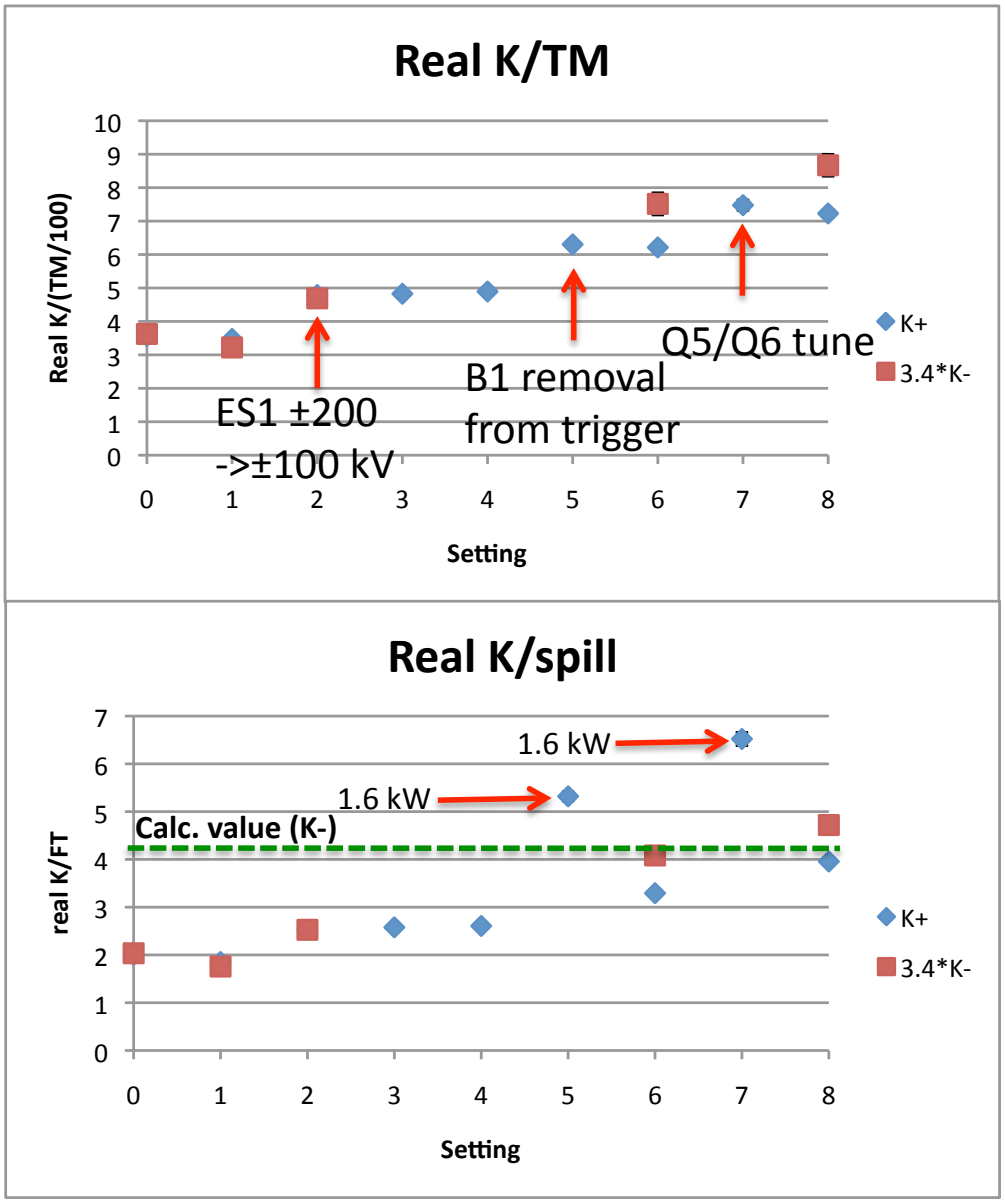
✓ **Real data is in between 2 models.**
✓ **For K^-, simple SW gives better description.**
✓ **Higher momentum is optimum for E17.**







Beam Tuning: Improvement of $K^{\pm}$ yields



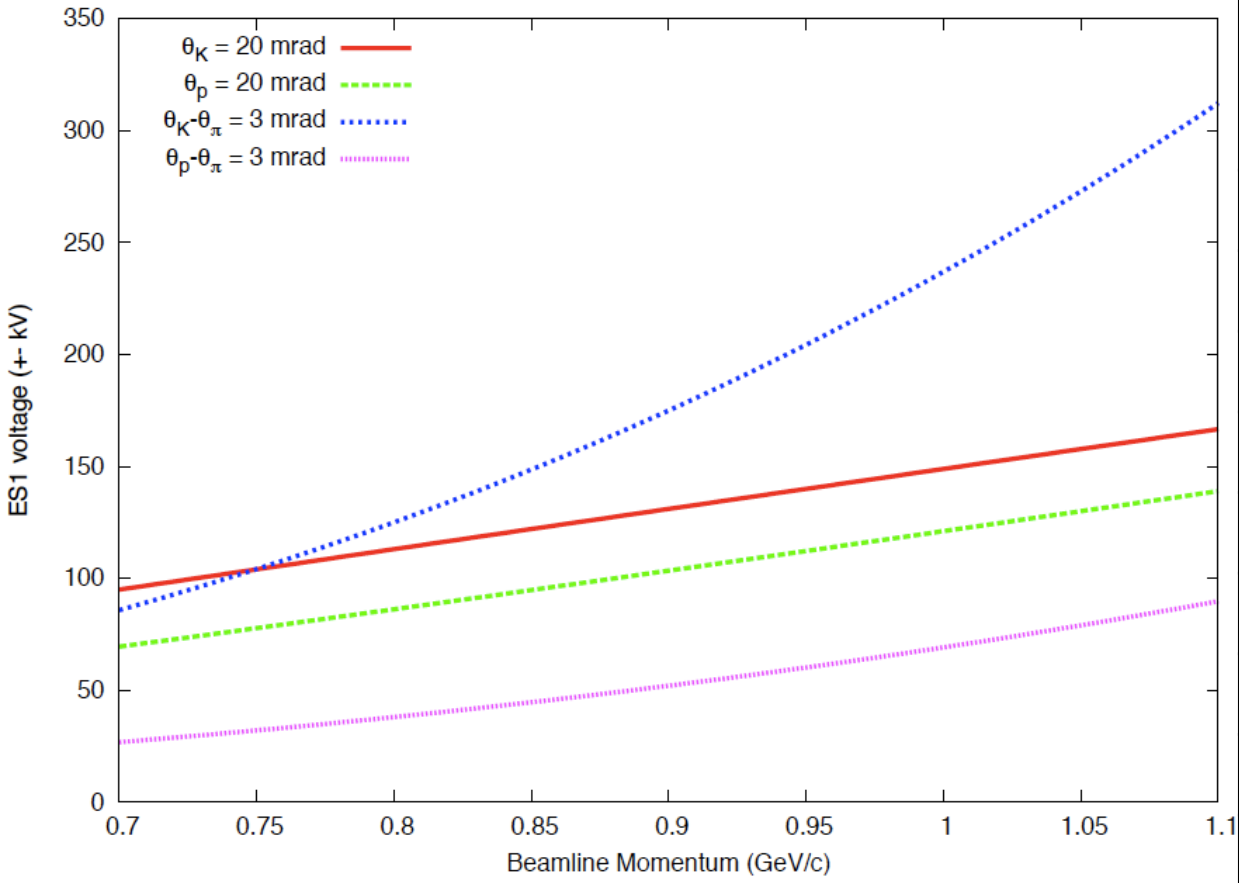
Kaon yield / 1.25 10^{12} ppp ≅ 560 SEC
Ni, "1 kW" for 30 GeV, 0.167 Hz operation
Vertical : 2W, Horizontal :full open
Statistical error only

Setting	K^+ (kilo/pill)	K^- (kilo/spill)
0	2.00±0.03	0.597±0.015
1	1.98±0.02	0.547±0.008
2	2.73±0.02	0.790±0.023
3	2.80±0.02	-
4	2.84±0.02	-
5	3.61±0.07	-
6	3.63±0.07	1.30±0.06
7	4.26±0.09	-
8	4.26±0.07	1.50±0.06

Beam Tuning: Recommended ES1 Voltage

1. $\theta_{K/p}$ < 20 mrad (max acceptance)
2. $\theta_{K/p}$-θ_{π} > 3 mrad (K/p-π/e separation)

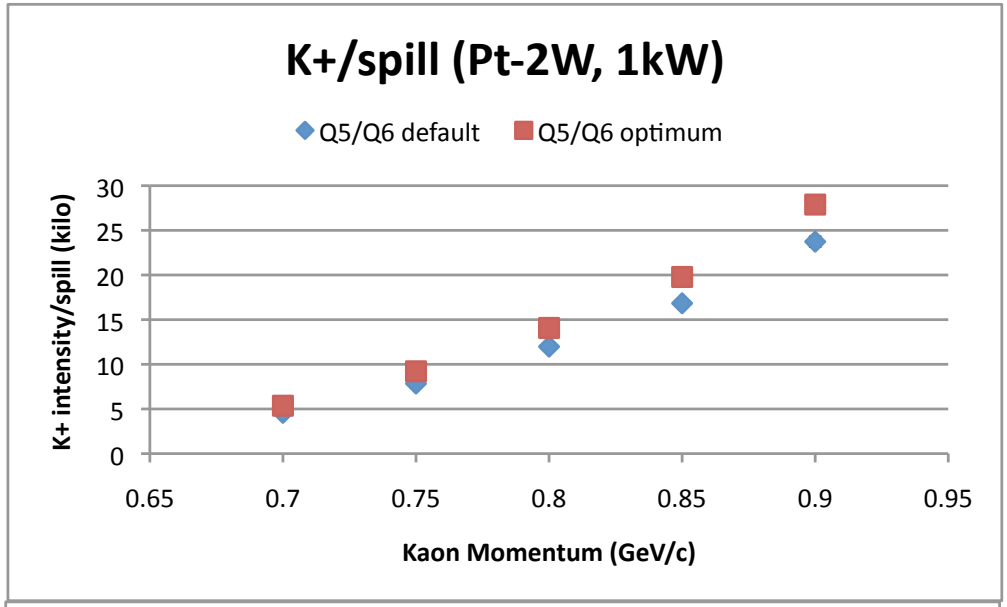
Incompatible at and above 0.80 GeV/c for K.
Condition 2 define the angle and K-yield, and acceptance loss is unavoidable there.

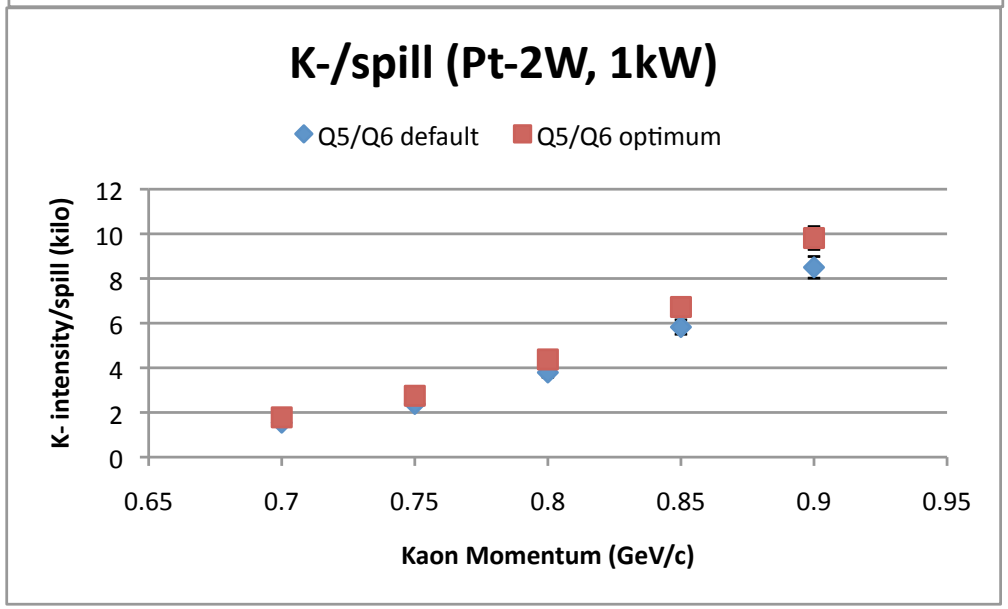


Beamline moment (GeV/c)	Recommended voltage (acceptance max) for K/p yield	Min. voltage required by K/p-π/e separation
0.70	95.3/69.8	85.8/26.8
0.75	104.4/78.0	104.2/32.1
0.80	113.5/86.5	125.0/38.0
0.85	122.5/95.1	148.6/44.6
0.90	131.5/103.8	174.9/52.0
0.95	140.5/112.7	204.3/60.2
1.0	149.4/121.5	236.9/69.1
1.05	158.4/130.5	272.8/79.0
1.10	167.3/139.5	312.2/89.8

✓ **Present operational limit of ±200 kV stands for only up to ~0.9 GeV/c.**
-> Operational limit should be enlarged up to ±320 kV for 1.1 GeV (Max. Mom.) operation.

Beam Tuning : Expected Kaon Yields

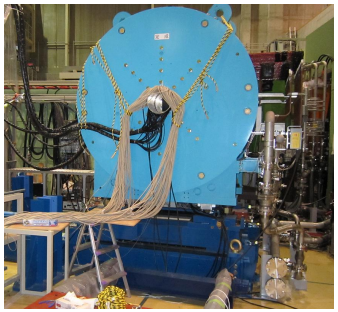




Kaon yield / 1.25 10^{12} ppp ≅ 560 SEC
Pt,"1 kW" for 30 GeV, 0.167 Hz operation
Vertical :2W, Horizontal :full open
Recommended ES1 voltage
Statistical error only

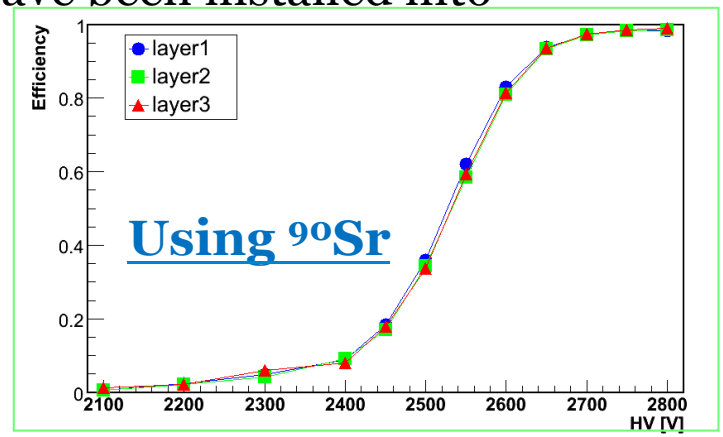
Momentum (GeV/c)	K^+ (kilo/spill)	K^- (kilo/spill)
0.70 (default)	4.56±0.12	1.54±0.09
(optimum)	5.36±0.13	1.78±0.10
0.75	7.85±0.18	2.38±0.13
	9.22±0.19	2.75±0.14
0.80	11.98±0.27	3.79±0.21
	14.07±0.28	4.38±0.22
0.85	16.83±0.37	5.83±0.32
	19.78±0.39	6.72±0.34
0.90	23.73±0.53	8.50±0.48
	27.89±0.57	9.81±0.51

→ **Input for optimum momentum decision.**



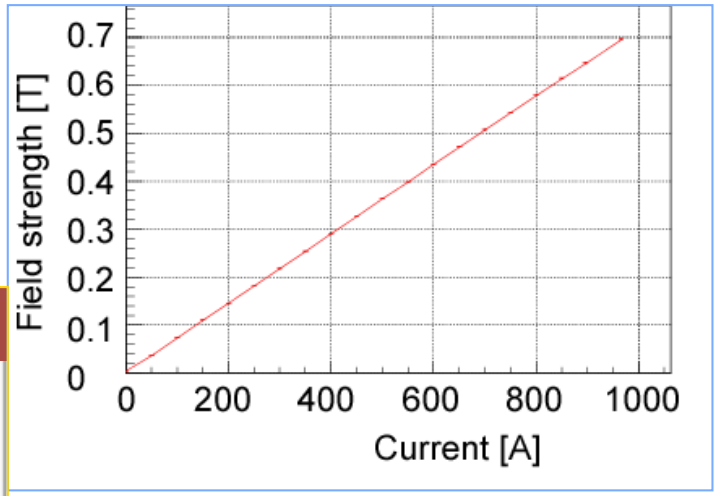
Current Status of CDS

- All of the components(CDC, CDH) have been installed into the solenoid magnet.



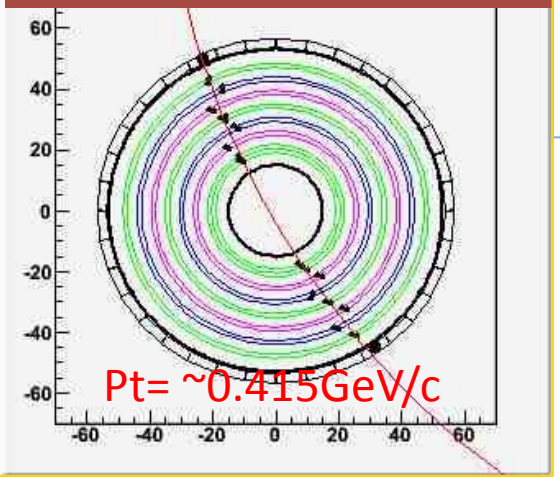
1. Efficiency of CDC was measured using 90Sr source
-> **Efficiency of >99% was achieved for all layers**

2. Excitation test of Solenoid Magnet have been performed in May 2010
-> **Design value (max field : 0.7T) was successfully achieved**

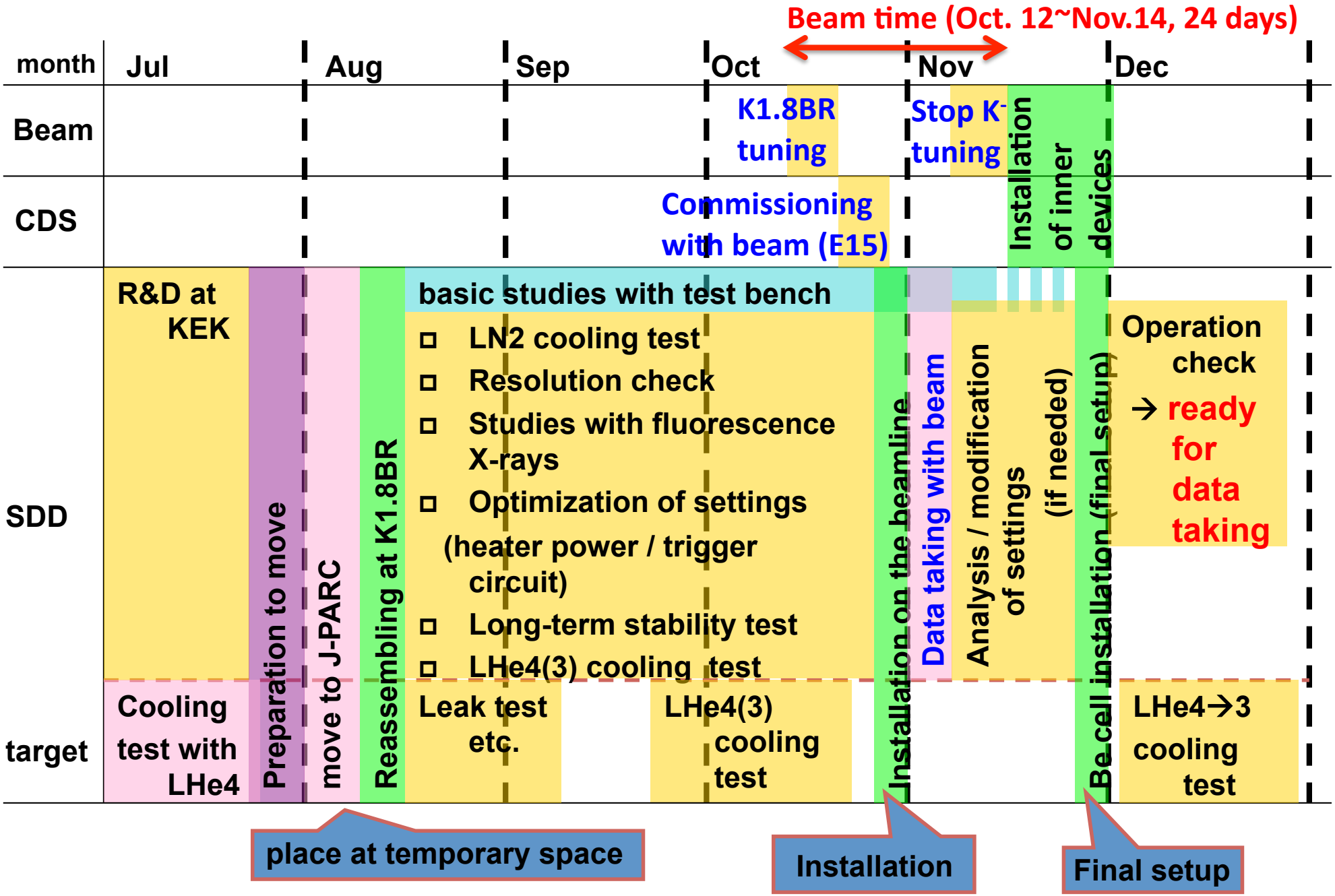


3. We've got CDS Commissioning data with 0.5 T magnetic field. Now ,analysis are under way.

Typical Event Display



Near-Future Schedule (E17-related part)



Beam measurements in this autumn

Oct. ~ Nov. beam time will be devoted to the further beamline commissioning and detector tuning.

Beamline

- ✓ Further Kaon tuning
- ✓ Beam momentum analyze by D5
- ✓ Range measurement to optimize stopped K^- number

CDS

- ✓ (in-flight π^+, p) run
- ✓ (in-flight π^+, p) run with CDS field (E15)
- ✓ (in-flight K^- , K^0_S/Λ) run with CDS filed (E15)

SDD

- ✓ Check of the calibration peaks (yield, S/N ratio, trigger)
- ✓ Rate dependence (response function, live time rate, etc.)

We will be ready to start the physics run by the end of the year 2010.

Beam Requirements (for Physics Run)

Expected L_α x-ray yield, in comparison with KEK E570 result (dashed quantities) :

$$Y(3d \rightarrow 2p) = \frac{N_{stopK^-}}{N'_{stopK^-}} \cdot \frac{\varepsilon_{DAQ}}{\varepsilon'_{DAQ}} \cdot \frac{\varepsilon_X}{\varepsilon'_X} \cdot \frac{\varepsilon_C}{\varepsilon'_C} \times Y'(3d \rightarrow 2p)$$

Ratio of $K^-_{stopped}$

Depending on integrated beam Intensity

DAQ effic. ratio ~ 1.0

x-ray detection effic. ratio= 7.7

Vertex detection effic. ratio = 2.0

Setup dependent term ~ 15.4 times (VS E570)

In order to achieve ΔE_{stat} ≈2 eV (E17 proposal)

$Y(3d\text{->}2p) \approx Y'(3d\text{->}2p) \approx 2\times10^3$ events ($\Delta E_{stat} \sim \sigma_{E=6.2\ keV}/Y^{1/2}$)

$N_{stop\ K^-} = N'_{stop\ K^-}/15.4 \sim 6\times10^6$ ($N'_{stop\ K^-} \sim$ 90M)

K^- beam intensity@750 MeV/c = 1.5 k /spill (1kW - 0.167Hz, Ni)

Stopping Efficiency of K^-: 0.4%-> Number of stopped K^- ≈ 6 /spill.

=> Required spill number: $6\times10^6/6 = 1\times10^6$ (208 shifts ~ 10 weeks)

We require 10 kW•week to achieve the precision goal.

Summary

Preparation status -

- ✓ R&D of SDD at KEK is finished, and possible sources of systematic errors are investigated well. Systematic error for the x-ray energy is now controlled to be 1~2 eV.
- ✓ ^{3}He target is operatable under “E17” mode, and ready for moving to J-PARC together with SDD.
- ✓ K1.8BR Kaon tuning is proceeding rapidly. Pt target is superior than Ni in all aspects. Kaon yield at 0.75 GeV/c agree with calc., but more steeply increase with momentum than expectation. Beamline momentum for physics run may be enlarged from 0.75 GeV/c.

Beam usage of this autumn -

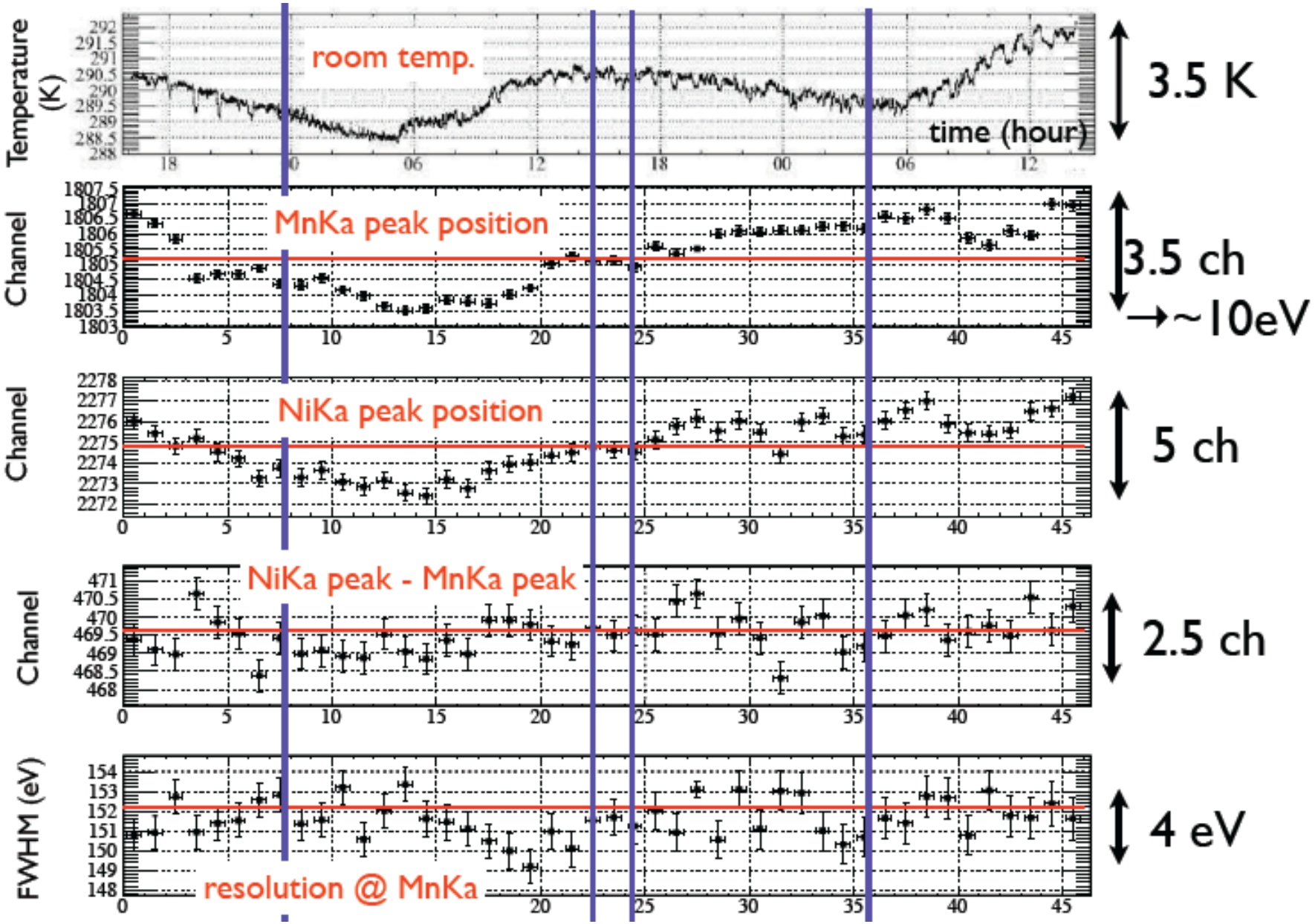
- ✓ Beamline : momentum analyze by D5 / Optimization of stop K^-.
- ✓ CDS : Beam calibration.
- ✓ SDD : Confirmation of calibration peaks / Rate study.

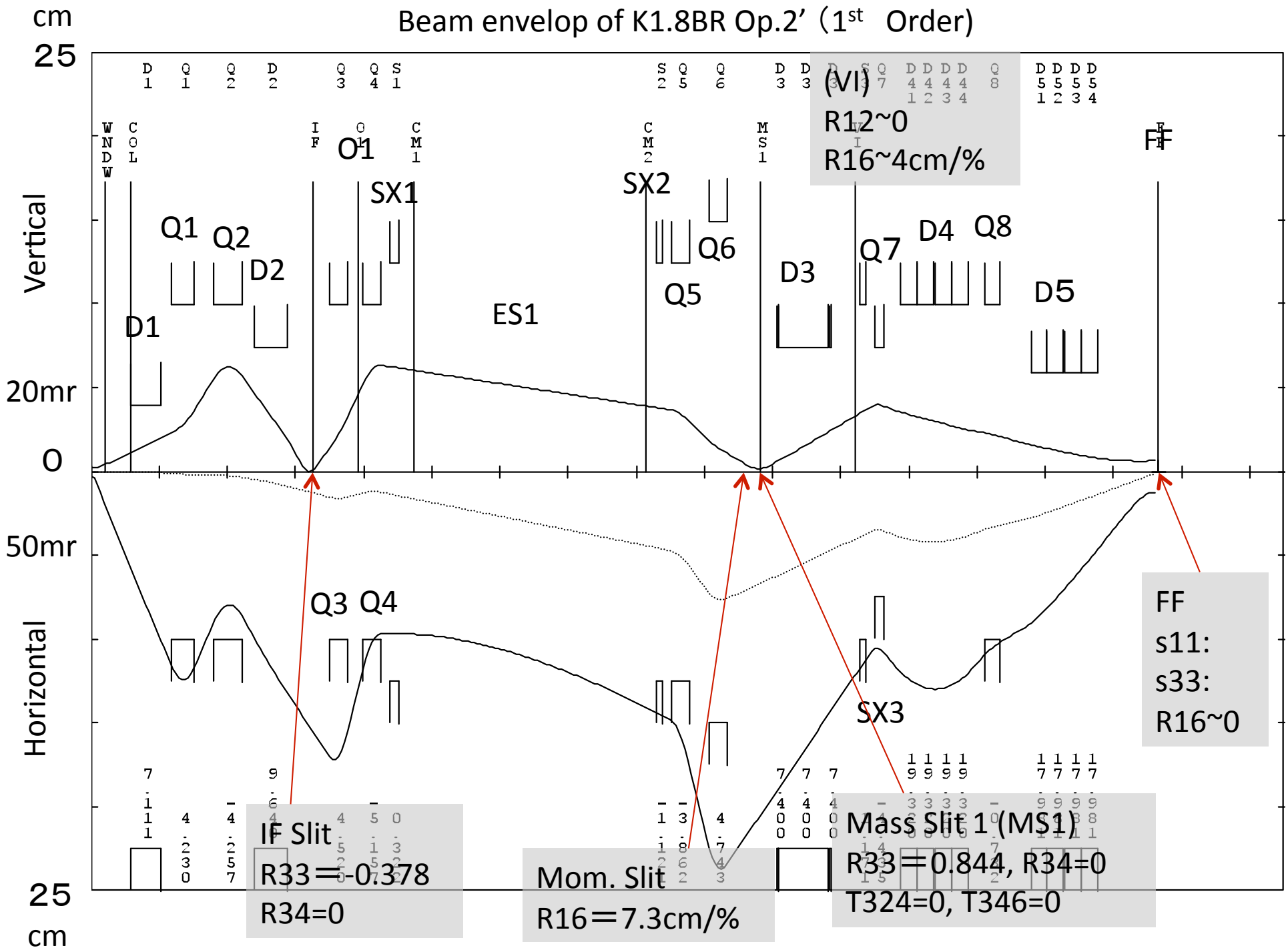
After these measurements, we will be ready to start physics run.

Beam requests

- ✓ We require **10 kW•week** to achieve the statistical uncertainty of 2 eV. with Ni.
- ✓ We requests the usage of Pt, with which higher K/others ratio is realized and integrated primary beam intensity is 1.8~1.9 times reduced.

Long-term stability – peak channel, resolution




Beam envelop of K1.8BR Op.2’（1st Order)
cm
25
Vertical
20mr
0
50mr
Horizontal
25
cm
D1
Q1
Q2
D2
IF
SX1
CM1
ES1
SX2
Q6
Q5
MS1
D3
Q7
D4
Q8
D5
FF
Q3
Q4
SX3
(VI)
R12~0
R16~4cm/%
FF
s11:
s33:
R16~0
IF Slit
R33＝-0.378
R34=0
Mom. Slit
R16＝7.3cm/%
Mass Slit 1 (MS1)
R33＝0.844, R34=0
T324=0, T346=0

Beam Tuning : Settings

Ni target / 30 GeV, 0.167 Hz, 1 kW (1.6 kW only for set 7) / 0.75 GeV/c

Set	Run (+/-)	ES1 (±kV)	CM(A) (+/-)	D5(A)	Q5/Q6 (A)	Acryl plates	Sub. coil short	B1	IF-V center (mm)	M.S. center (mm)
1	972/1001	200	349/354	1230	311/400	on	off	on	1.8	0.2
2	982/991	100	175/178	1230	311/400	on	off	on	1.8	0.2
3	1067/-	100	175/-	1230	311/400	on	on	on	1.8	0.2
4	1071/-	100	175/-	1217.7	311/400	on	on	on	1.8	0.2
5	1074/-	100	173/-	1217.7	311/400	on	on	off	1.8	0.3
6	1136/1149	100	173/177	1217.7	311/400	off	on	off	1.8	0.3
7	1079/-	100	173/-	1217.7	342/480	on	on	off	1.8	0.3
8	1138/1150	100	173/177	1217.7	342/480	off	on	off	1.8	0.3
0	947/928	200	351/355	1230	311/400	on	off	on	2.0	0.0

✔ IF-H/Mom. slit full open, Vertical slits are opened twice the designed value.

✔Set 0 is with similar condition to set 1, but from Run#29.

SIDDHARTHA
M. Cargneli (SMI)
@MENU2010

Fit of Kaonic Helium 3

KHe3
never measured before !

shift = - 1.7 eV
+- 2.7 eV (stat.)
+- 4 eV (syst.)