J-PARC PAC
2009/03/06 KEK

E17 and E15 at K1.8BR beam line: Status Report

RIKEN Nishina Center, Japan

Haruhiko Outa

for J-PARC E15/E17 Collaboration

The J-PARC E15/E17 Collaboration

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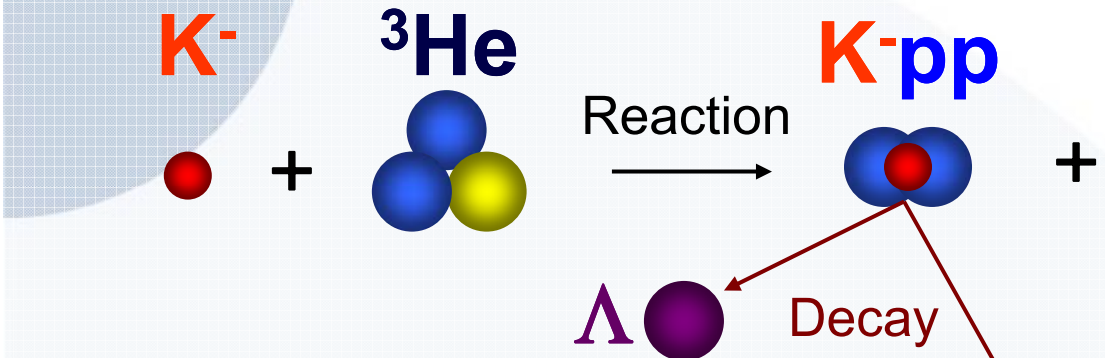
RIKEN[1], RCNP[2], Victoria Univ.[3], SNU[4], SMI[5], INFN-Torino[6], Univ. of Torino[7], TUS[8], LNF-INFN[9], Osaka Univ.[10], Kyoto Univ.[11], Tokyo Tech[12], Osaka E.C. Univ.[13], Univ. of Tokyo[14], KEK[15], Tech. Munich Univ.[16], INAF-IFSI[17]

Outline

- E15/E17 experiments
- K1.8BR beam status (2009 Feb.)
- Preparation status
- Summary

1. E15/E17 experiment

J-PARC E15 (Search for K⁻-pp deeply-bound kaonic nuclear state)



Missing mass spectroscopy

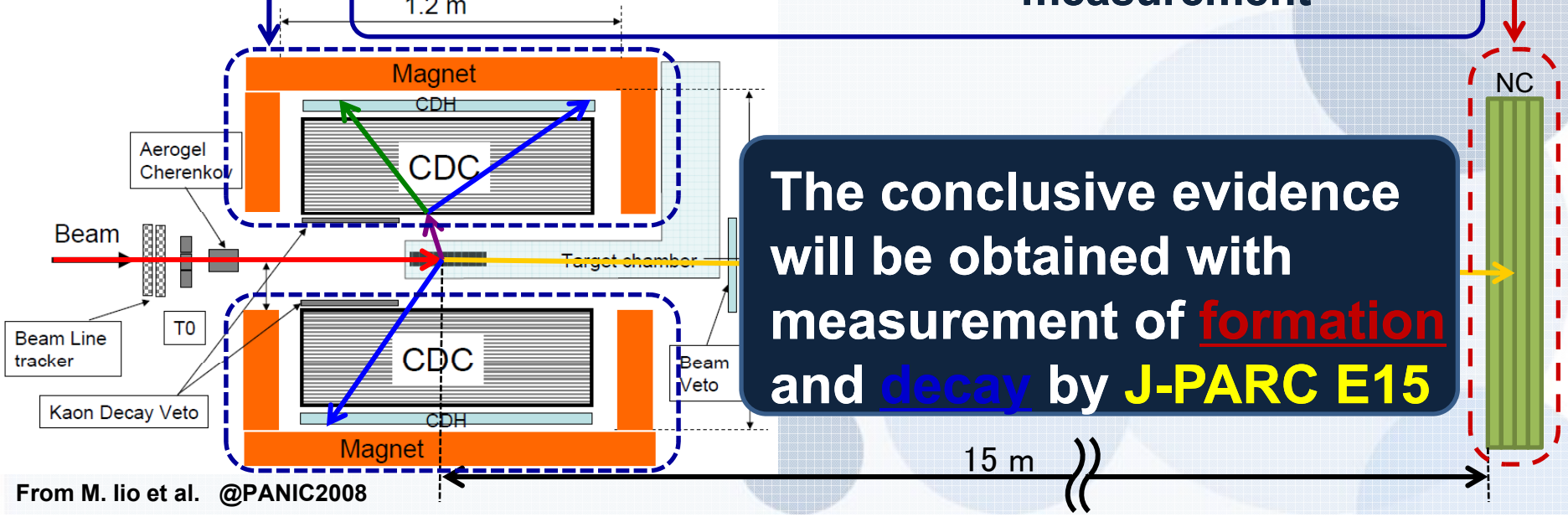
n

K⁻pp search with TOF measurement of neutron

Invariant mass reconstruction

K⁻pp search with decay particles measurement

From M. Iio et al, @PANIC2008



The conclusive evidence will be obtained with measurement of formation and decay by J-PARC E15

From M. Iio et al. @PANIC2008

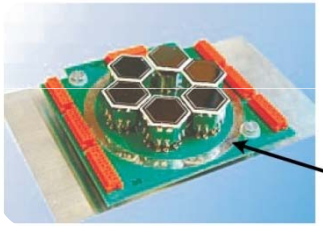
J-PARC E17 (Precision Spectroscopy of K^--^{3}He 3d → 2p x-rays)

For determination the *2p* level shift with precision of a few eV

(E570 equivalent)

Silicon Drift Detector (SDD)

for **high-resolution** x-ray energy measurement



190eV@ 6.4keV

SiLi(Past exp.) **x2**

KETEK VITUS SDD array

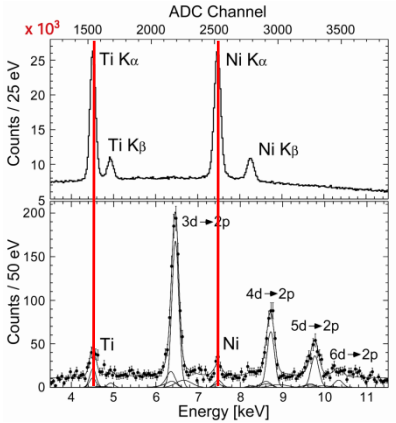
Fiducial volume cut

for **kaons stopping point measurement** with drift chambers for

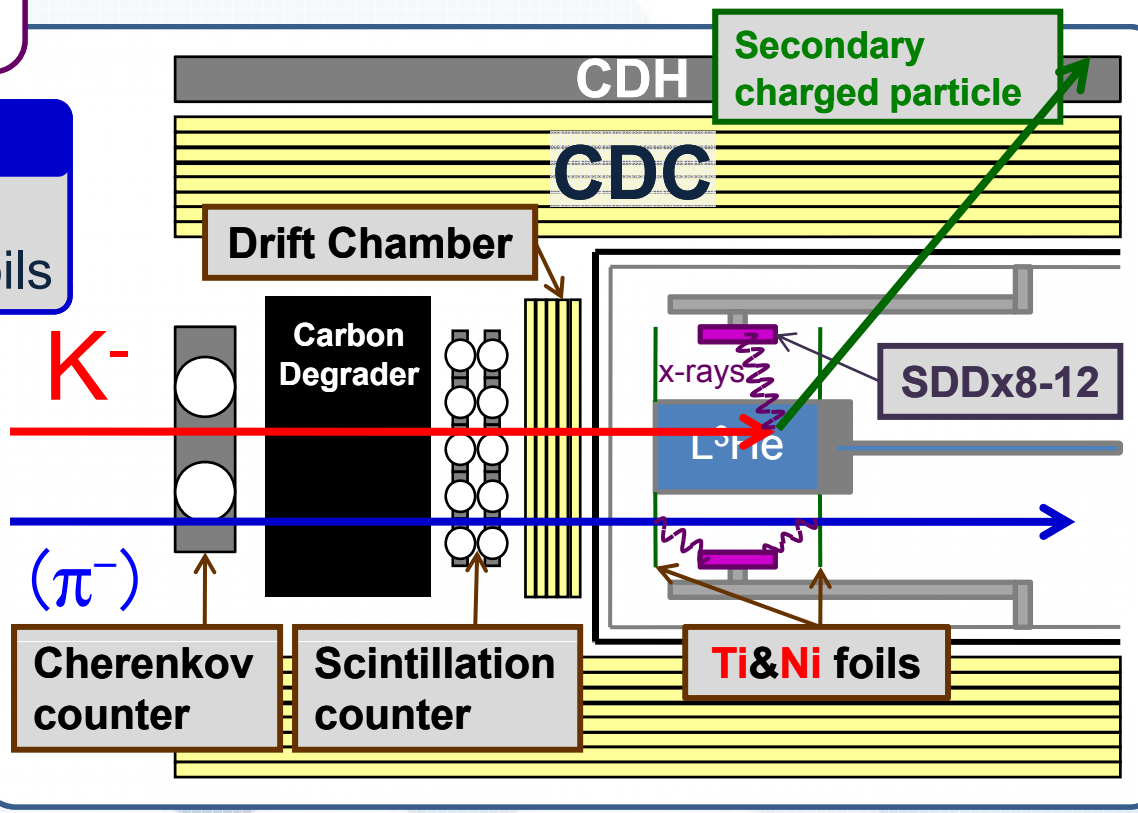
- Incident Kaons (BLC)
- Secondary charged particles (CDC)

In-beam energy calibration

using fluorescence x-rays from titanium and nickel foils



Channel to Energy Conversion



From M. Iio et al. @PANIC2008

Beam time requested in proposals

- E15 (K-pp state search)

  2 weeks commissioning +

  5.5 weeks at K1.8BR full intensity w/ T1 target

  (1500 kw*week for 1000 K-pp identification)

- E17 (K- 3He atom 3d→2p X-ray)

  10 days commissioning +

  5 weeks at K1.8BR 10% intensity w/ T1 target

  (135 kw*week to reach E570-equivalent statistics)

- K1.8BR Beam tuning time is NOT included

2. K1.8BR tuning "started"

- K1.8BR beam line detectors
- Results of February tuning

Beam Line Momentum Measurement

VI→FF

$x'(FF) = -0.88x(VI) + 0.044\theta\,(VI) + 3.53\delta$

$\rightarrow \delta = (x' + 0.88x + 0.044\theta) / 3.53$

$\rightarrow \Delta\delta = \sqrt{((\Delta x')^2 + (0.88\Delta x)^2 + (0.044\Delta\theta)^2)} / 3.53$

$\rightarrow \Delta\delta \sim 0.01\%$ for $\Delta x \sim \Delta x' \sim 0.02$cm , $\Delta\theta \sim 0.7$mrad

D4out/Q8out→FF

$x'(FF) = 0.04x + 0.22\theta + 1.70\delta$

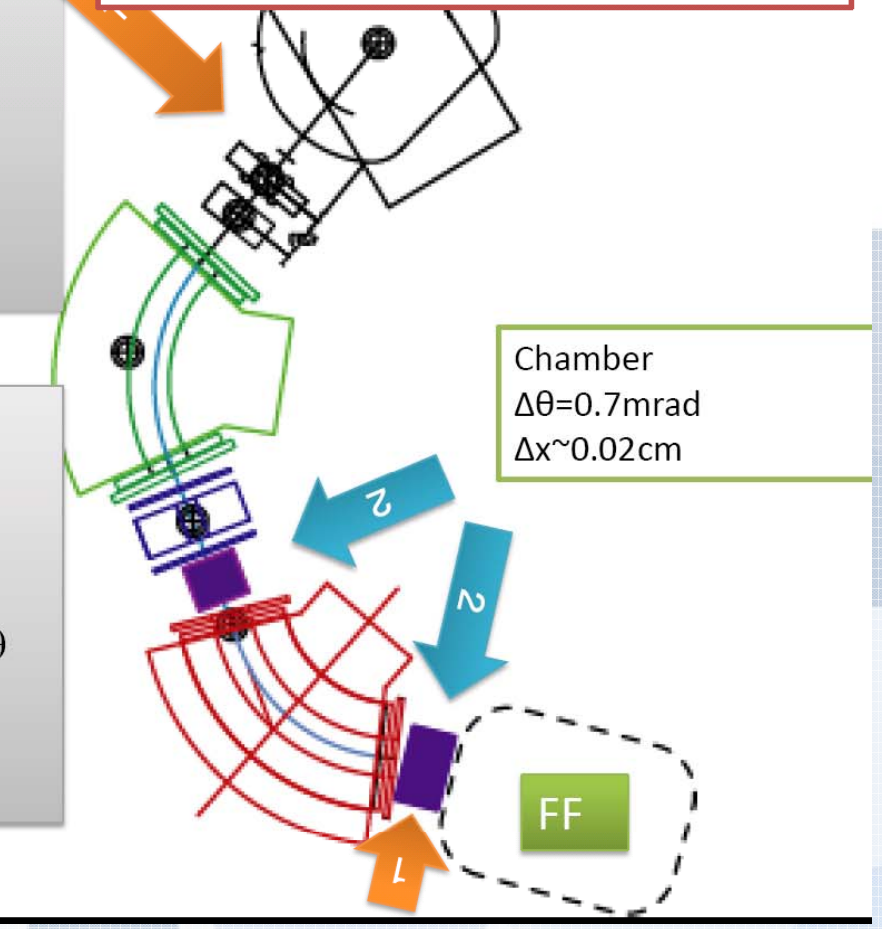
$\rightarrow \delta = (x' - 0.04x - 0.22\theta) / 1.70$

$\rightarrow \Delta\delta \sim (0.22\Delta\theta) / 1.70 \sim 0.13\Delta\theta$

$\rightarrow \Delta\delta \sim \sim 0.1\%(1.0$ MeV/c) for $\Delta\theta \sim 0.7$mrad

T.Suzuki(University of Tokyo)
2008/6/30

運動量測定
2組のChamber の配置



Beam Line Spectrometer

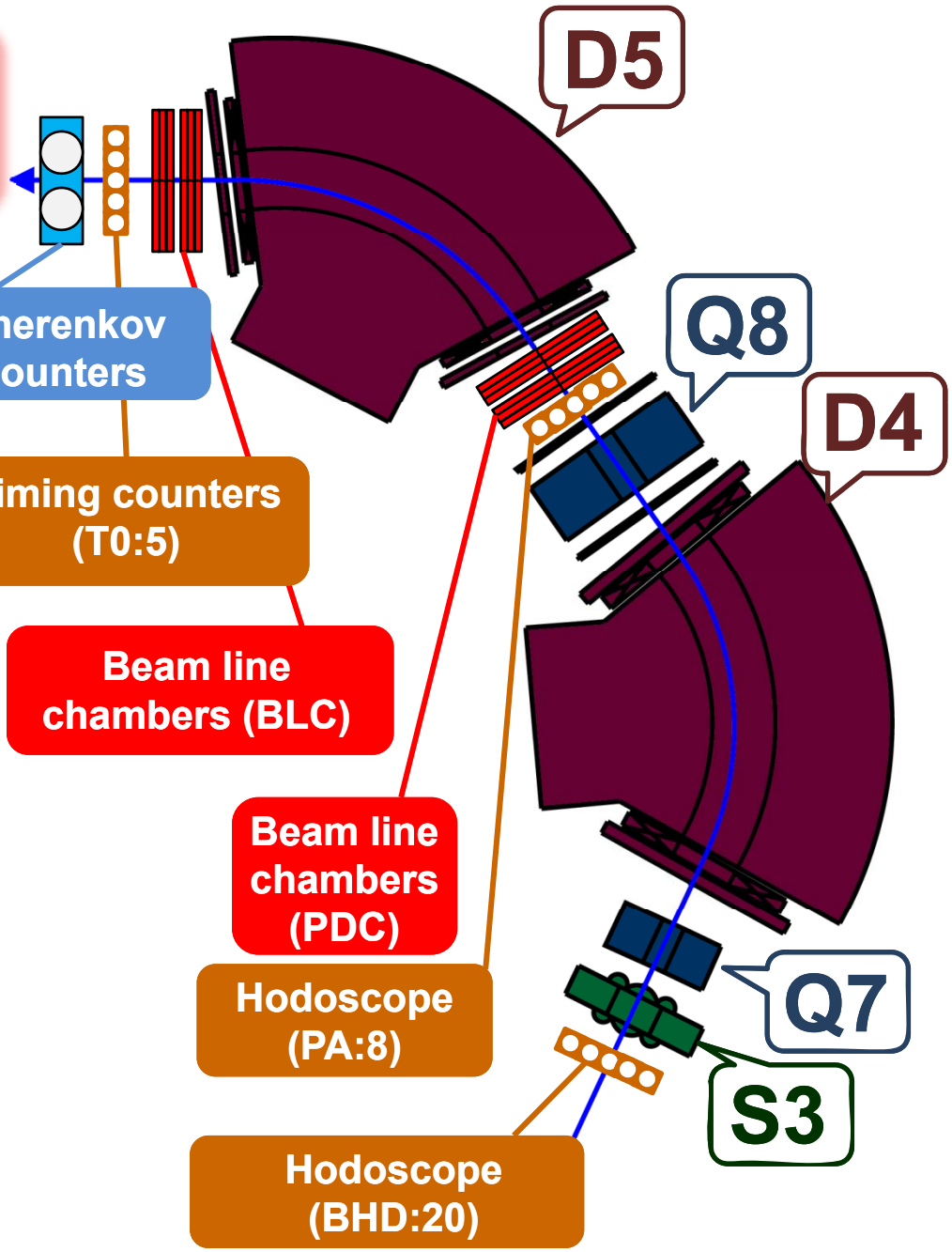
First beam !!
(February. 2009)

Beam Tuning Plan

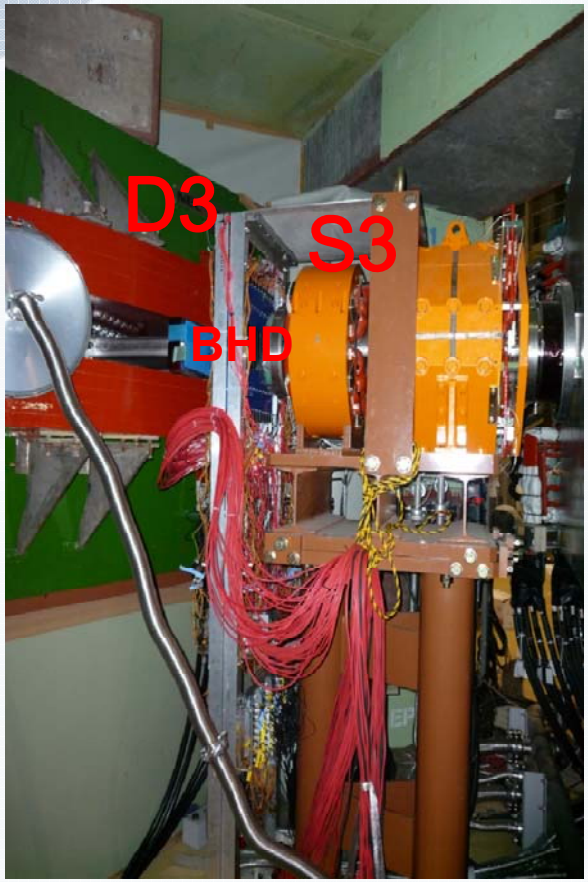
Start from 1.1GeV/c unseparated
For E15 (in-flight)
1) 1.0 GeV/c K+/- beam tuning
2) Momentum measurement by TOF

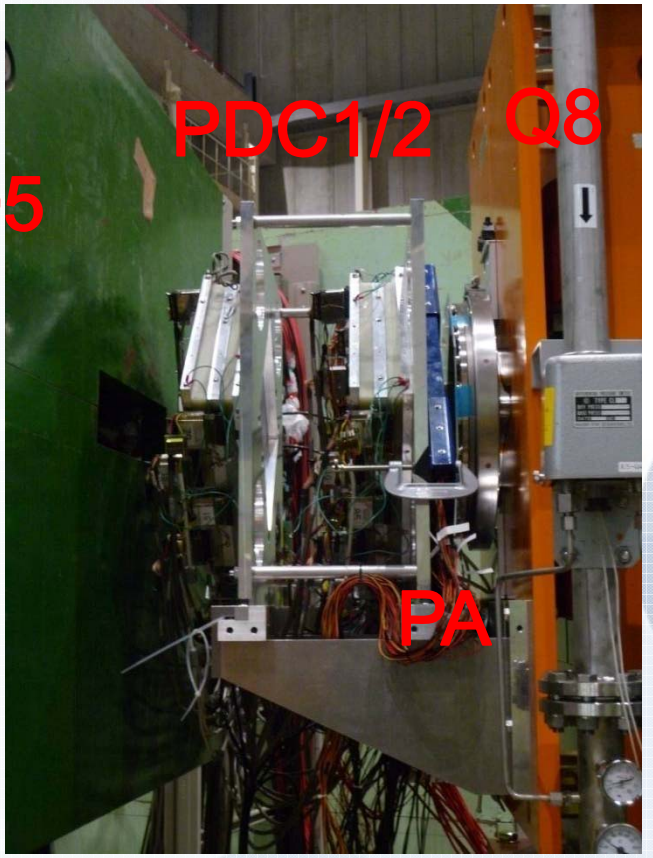
For E17 (Stop)
3) 0.7 GeV/c K+/- beam tuning
4) Momentum measurement by TOF
5) Range measurement

- **Installation of the beam line detectors is completed.**
- **Beam line tuning "started"**

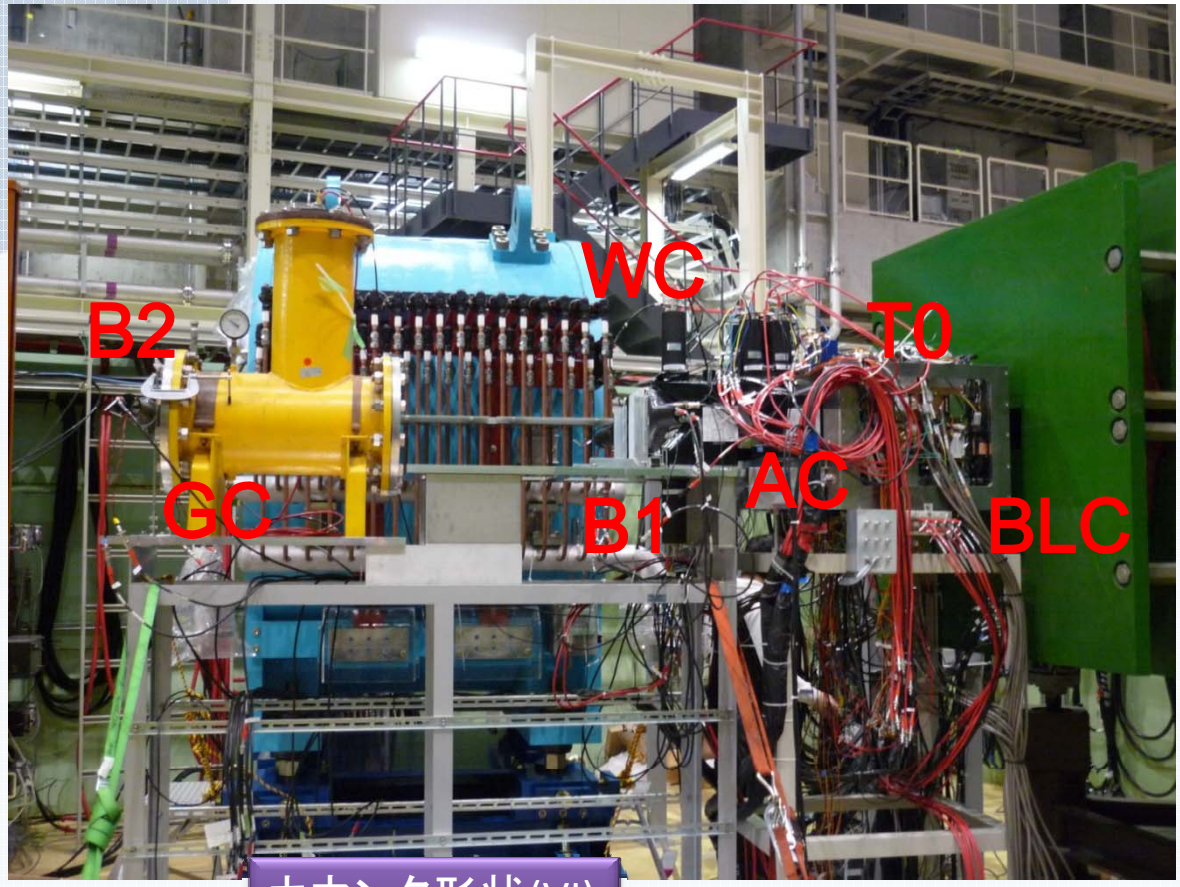


Beam Line Detector Installation -1

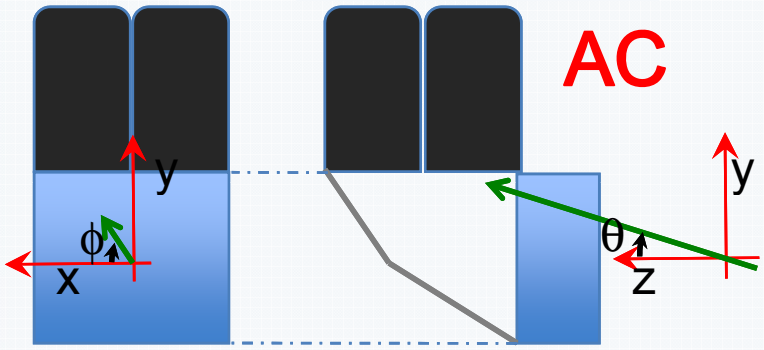




Beam Line Detector Installation -2



カウンタ形状(VI)

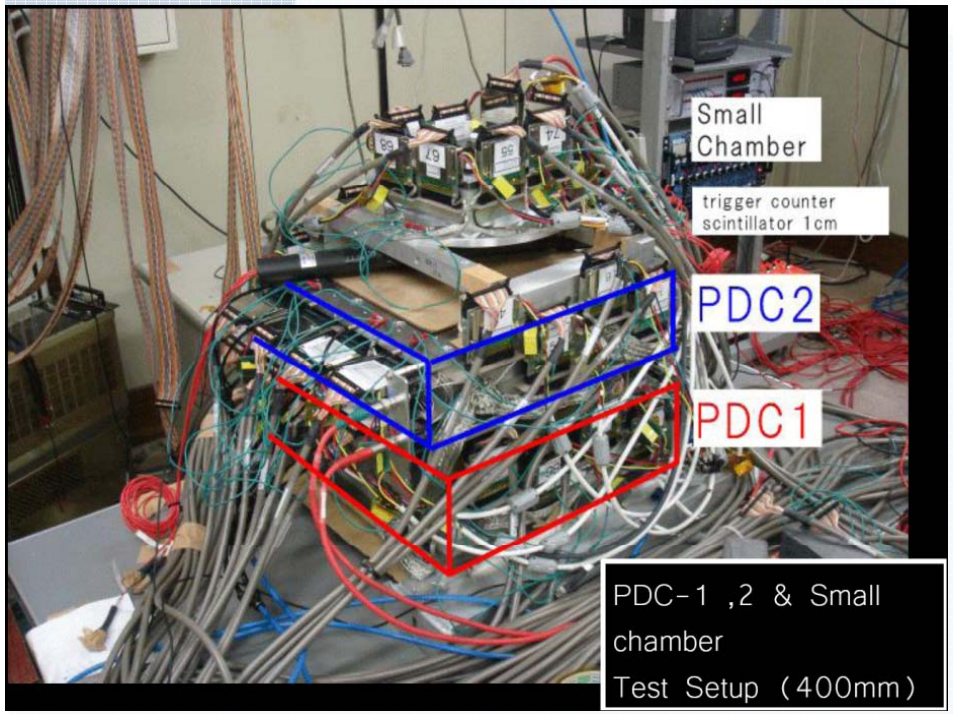


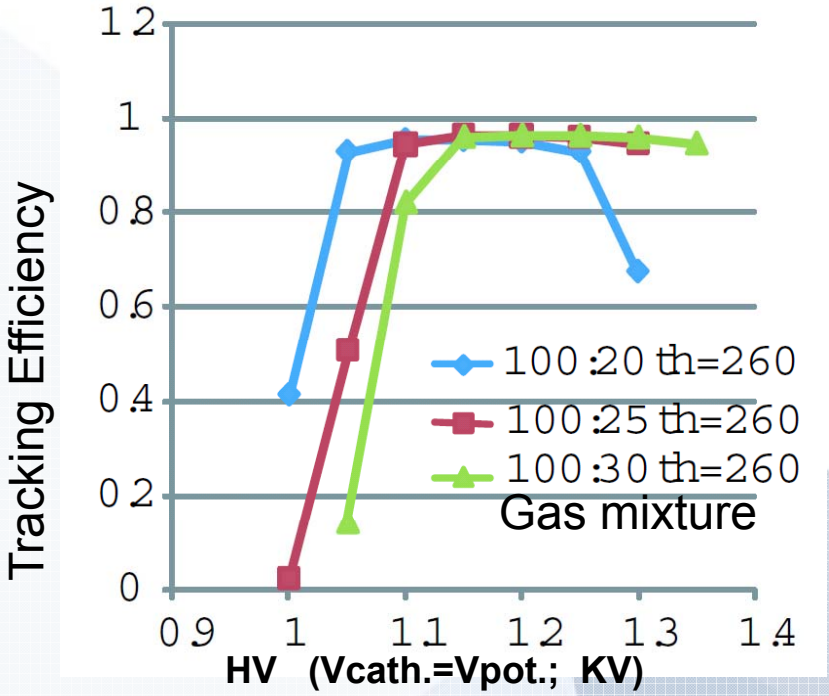
Threshold-type Cherenkov

GC	e	π	K	p
AC	e	π	K	p
WC	e	π	K	p

Particle Identification with only scalar counts

Beam Line Chamber Performance





Fujiwara, beam line subgroup

Resolution

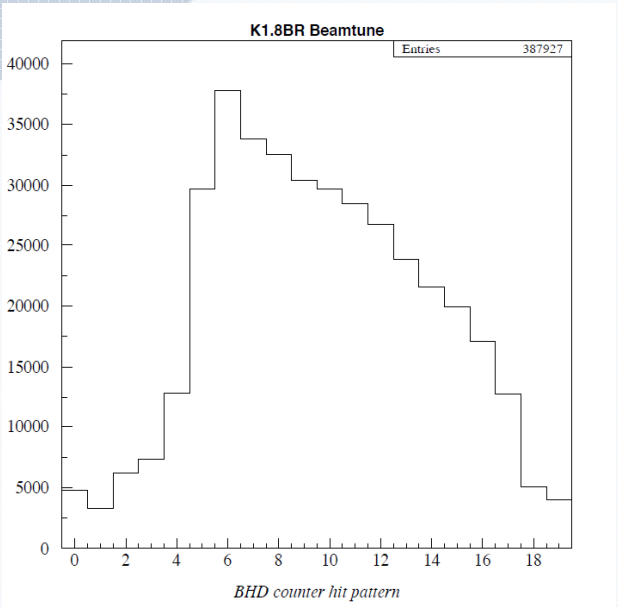
σ～ 300μm (for β-source)

σ～ 190μm (for cosmic ray)

All the 1024wires (32-planes) working fine from the "first shot" of Feb. beam

Beam profile measurements

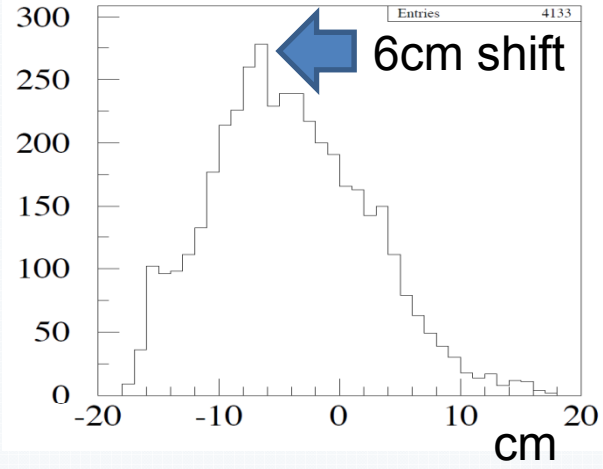
Beam profile at D3-out seen from upstream

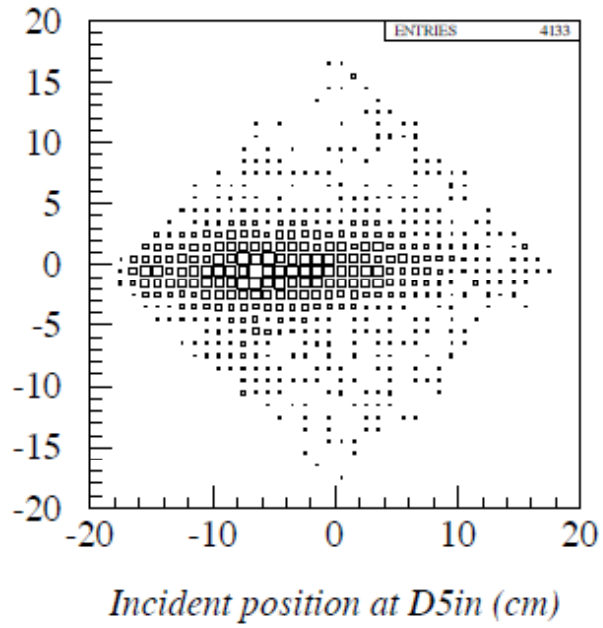


1counter
= 2cm width

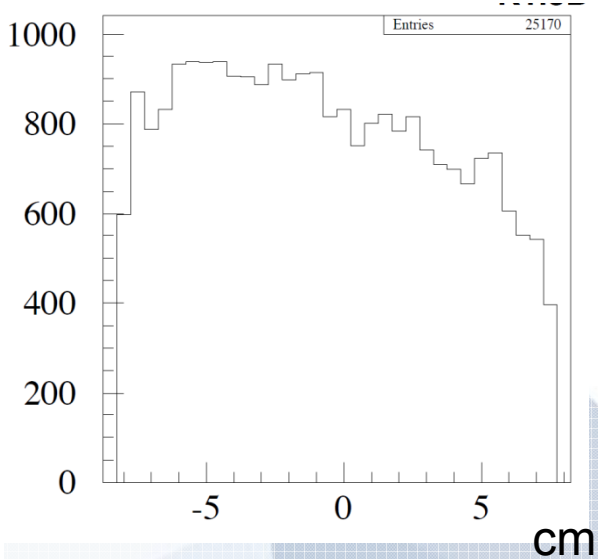
The same unseparated beam run snapshots: Trigger≡BHD × PA × T0

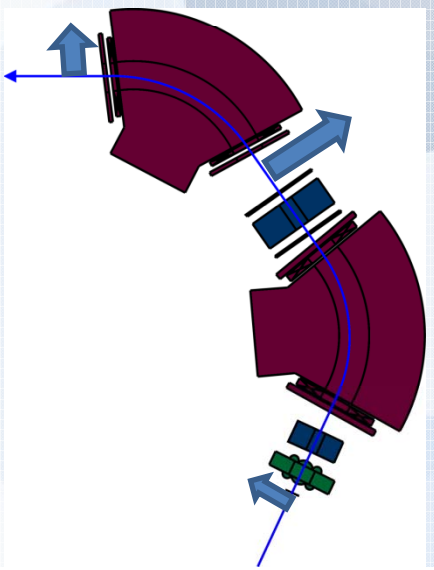
Beam profile at D4-out seen from downstream



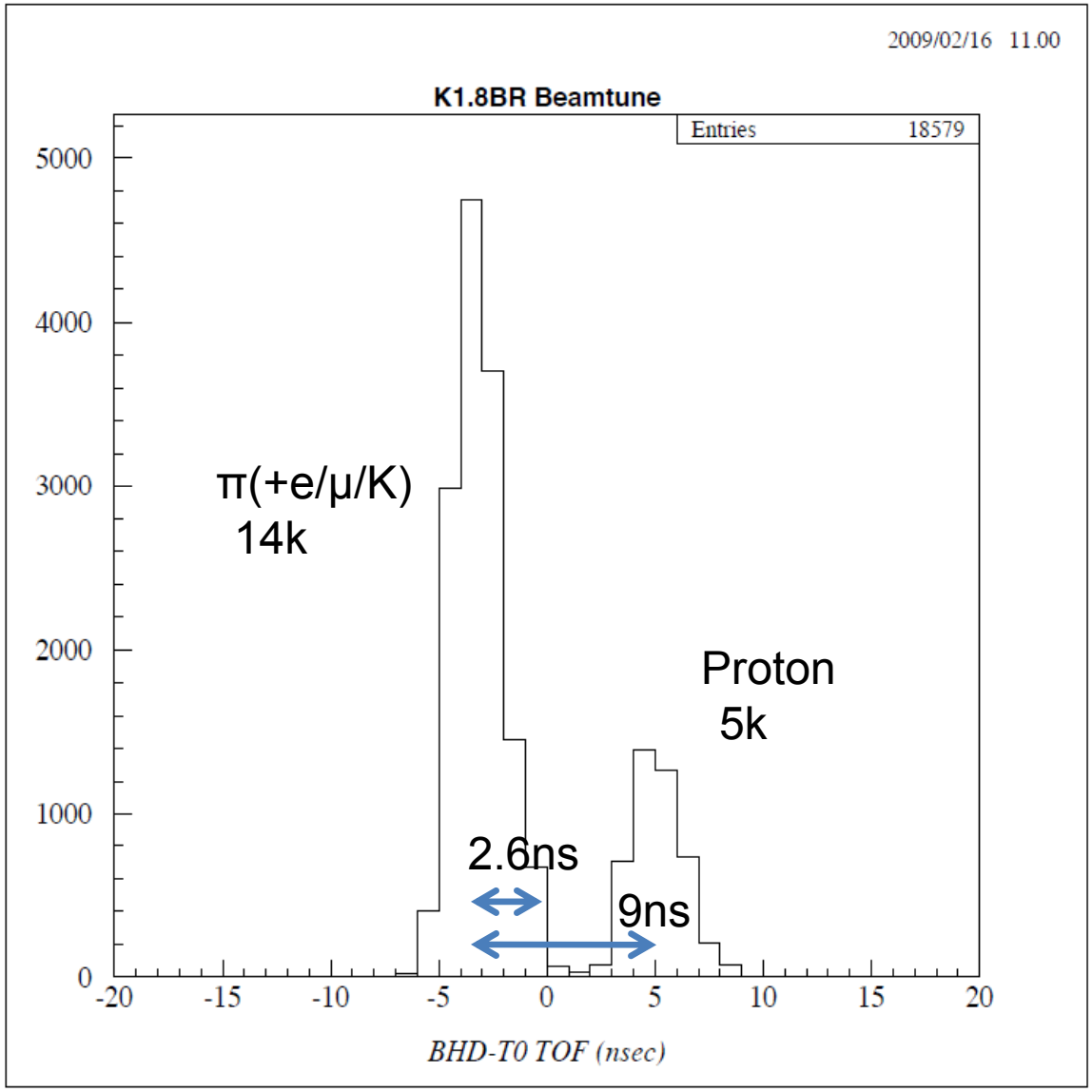


Beam profile at D5-out seen from downstream





π(+ μ/e) / proton separation with 1.1GeV/c beam



2009/02/15

Online TOF spectrum
NO offset correction
NO ADC correction

Flight path = 7.7m
Momentum 1.1GeV/c

Multiplicity=1
(only ¼ of data !!
@30K/spill)

Primary 0.1×10^{12}

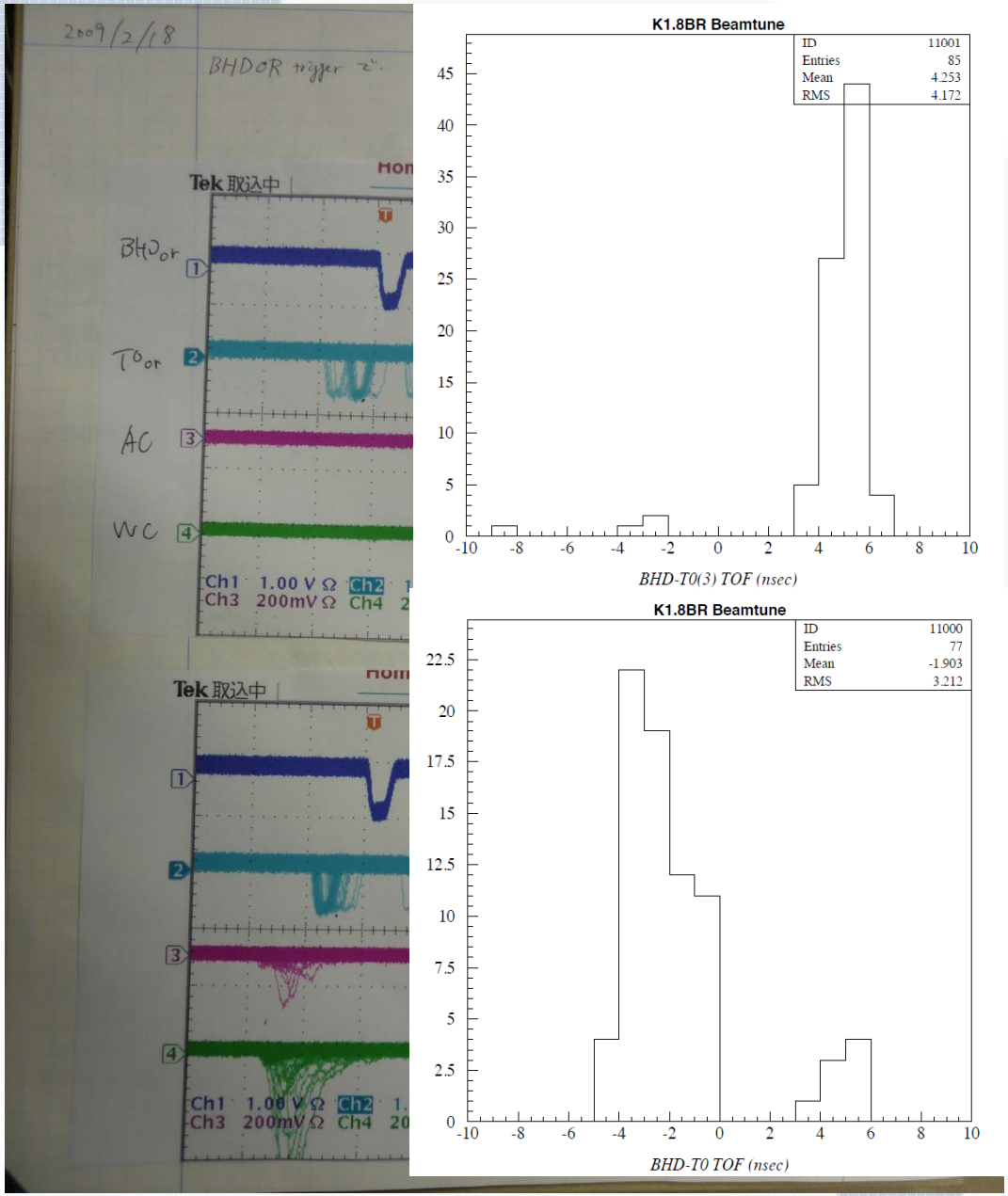
RF-On ; Slit full open

Separator OFF
(**unseparated beam)**

N(K+)～1/300 N(π+)

π(+e+μ) / proton separation

2009/02/18



CM=280
@Proton

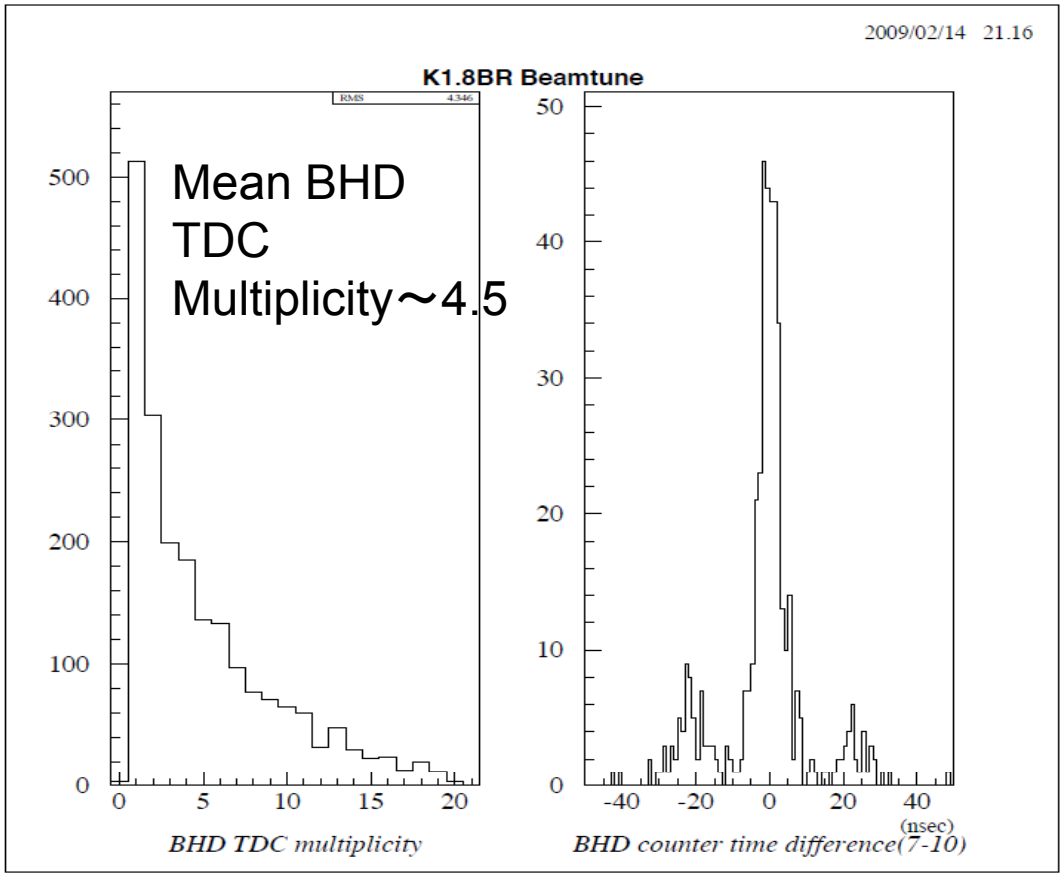
N(π) < N(p)

CM=220
@Pion

N(π) > N(p)

Accelerator stop just after the inspection on 19th.

micro/macro-structure of beam



- **Heavy microstructure**
  even after RF-Off (debunched) condition
  Multiplicity =3.5
  w/ slit full open
- **Limited usable time**
  Feb. Run total shot# used by exp. group
  ～ 4000
  --- Less than 1 shift including commission time of trigger /DAQ tuning

100 ns ←→ 4 hits
1/25 ns = 40 MHz?

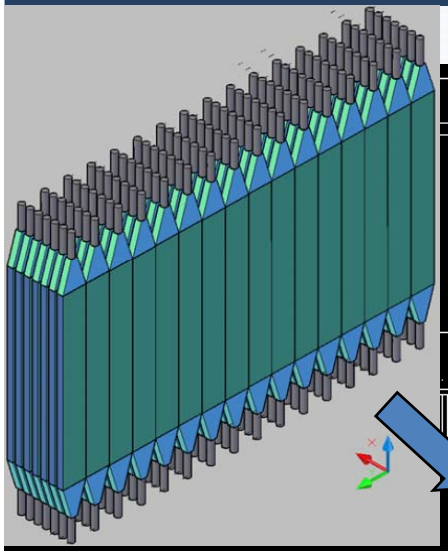
!!

BDH single rate
2-30K/shot (0.1sec)
～2-300KHz

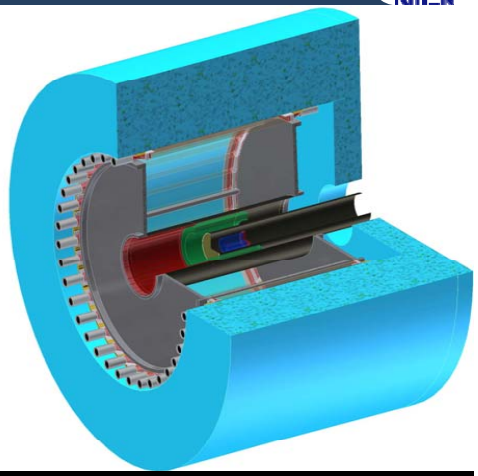
"Continuous" "DC"-beam extraction is important to start beam tuning

3. Preparation Status

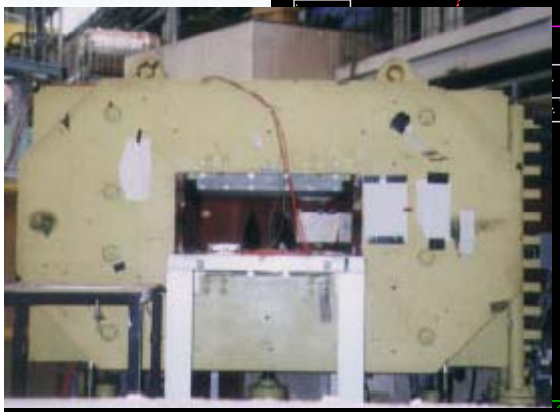
J-PARC E15/E17 Setup



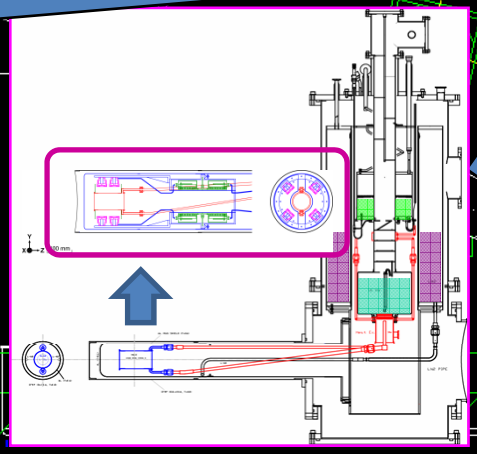
Neutron Counter



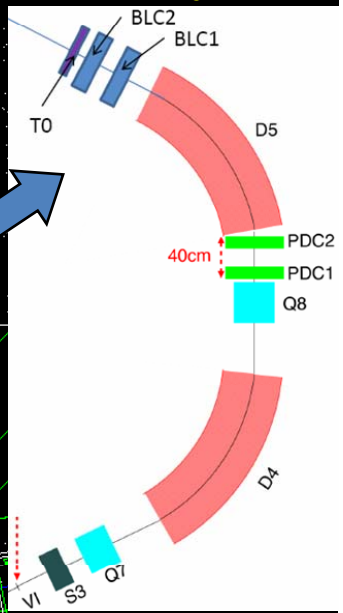
Cylindrical Detector System



Kaon beam sweeper



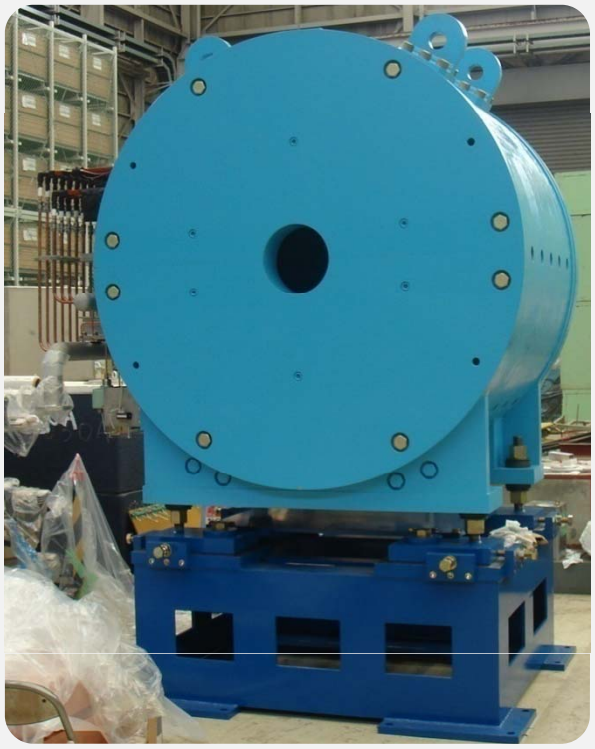
LHe-3 Target & SDDs



Beam Line Spectrometer

Cylindrical Detector System (CDS)

Solenoid Magnet



Max magnetic field: **0.7 T**

- **Now the CDC commissioning is started at J-PARC**
- **The complete CDS will be installed soon**

Cylindrical Drift Chamber (CDC)

Size:
ID=300 mm, OD=1060 mm, L=950 mm

Read-out : **1816 ch**

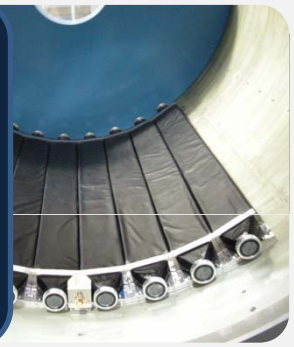
Drift length: ~9 mm (hexagonal)

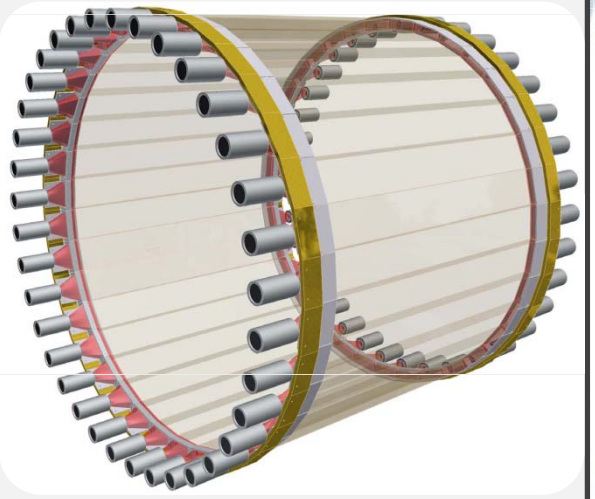
Layer: 15 (7 super layers)
A(3)U(2)V(2)A(2)U(2)V(2)A(2)

Hodoscope Counter (CDH)

Plastic Scintillator Size:
99x30x700 mm^3 (WxTxL)

Configuration: 36 modules



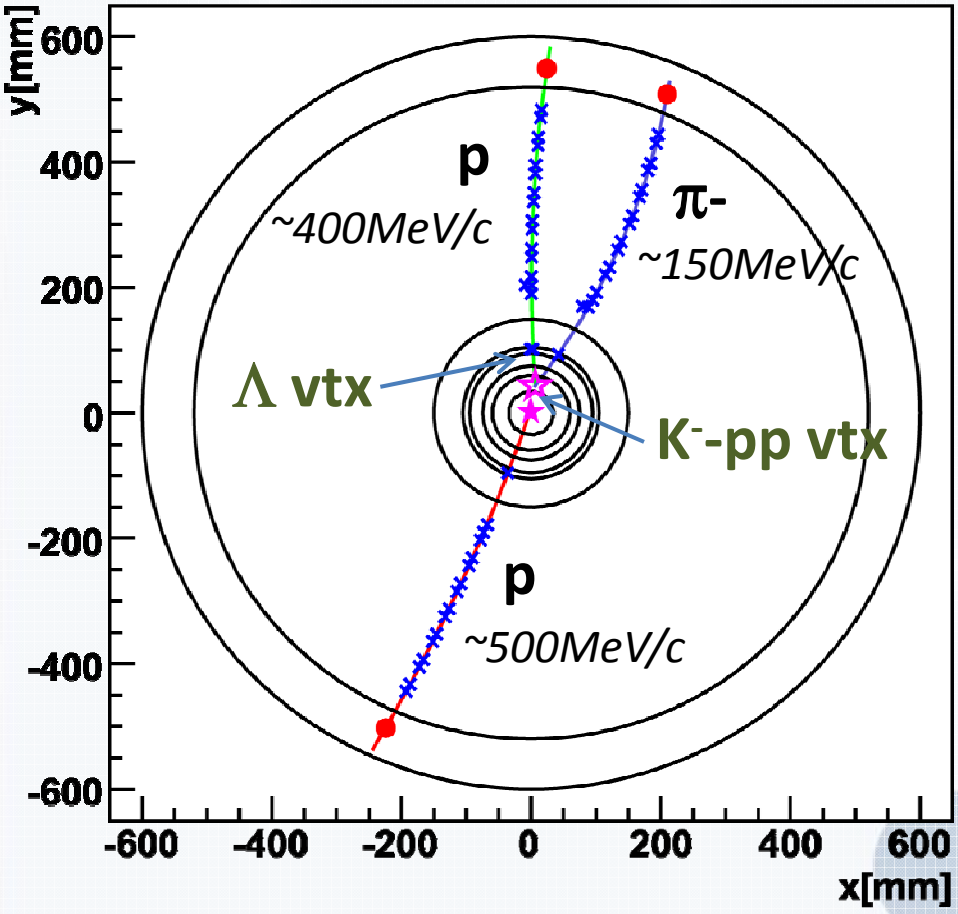


Expected Kinematics for K^--pp Decay

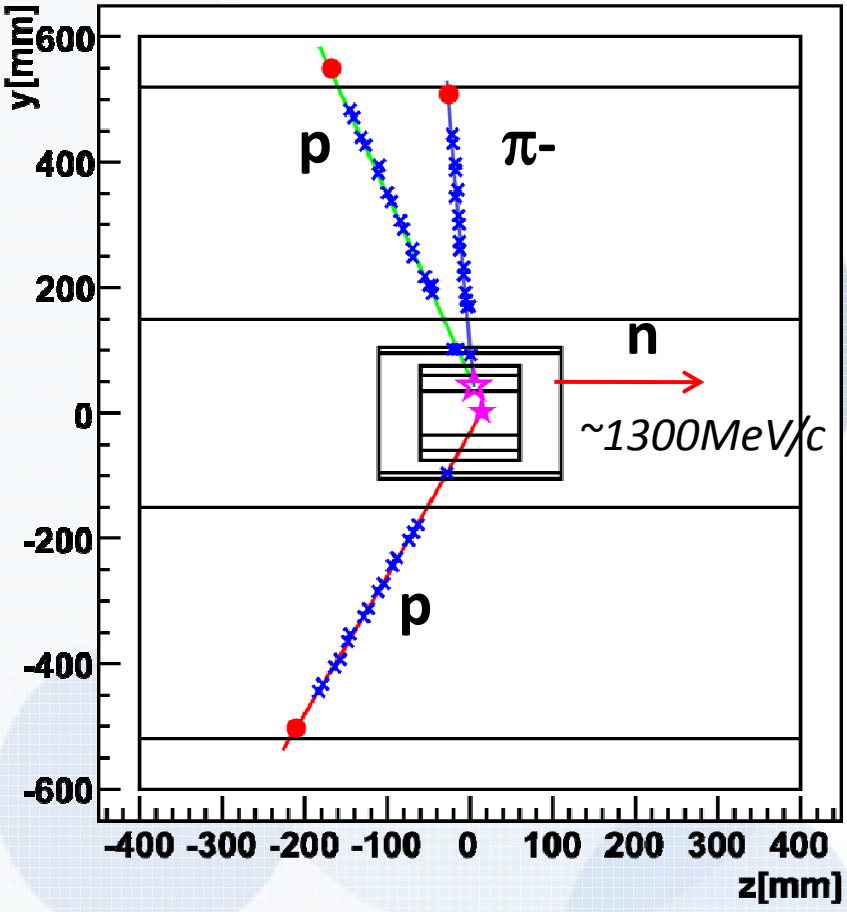
- **Binding energy = 100MeV/c^2**
- **Isotropic decay of K^--pp with forward neutron**

Simulation (Geant4)

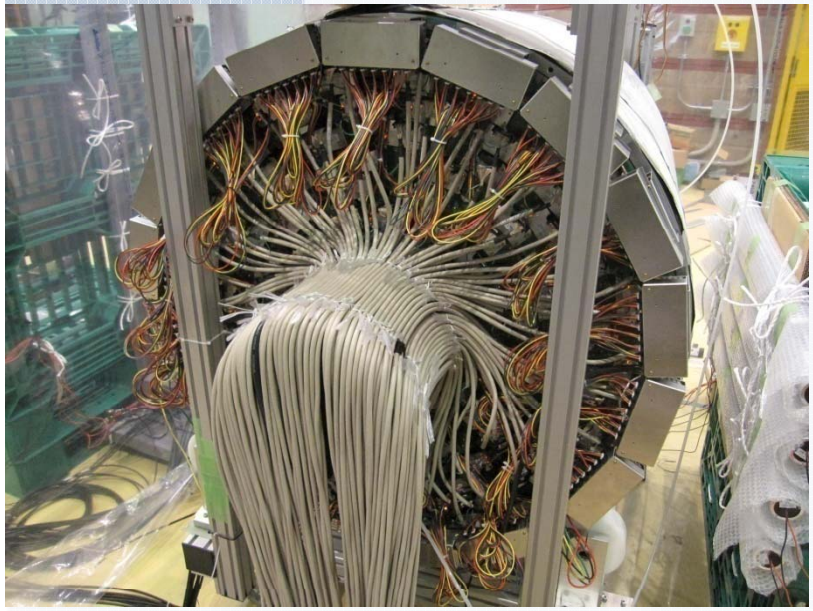
CDS xy-plane

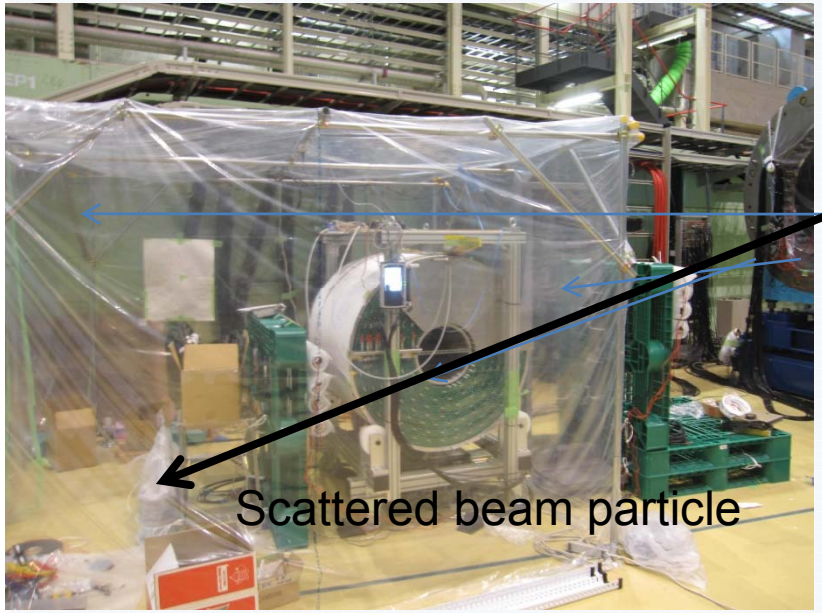


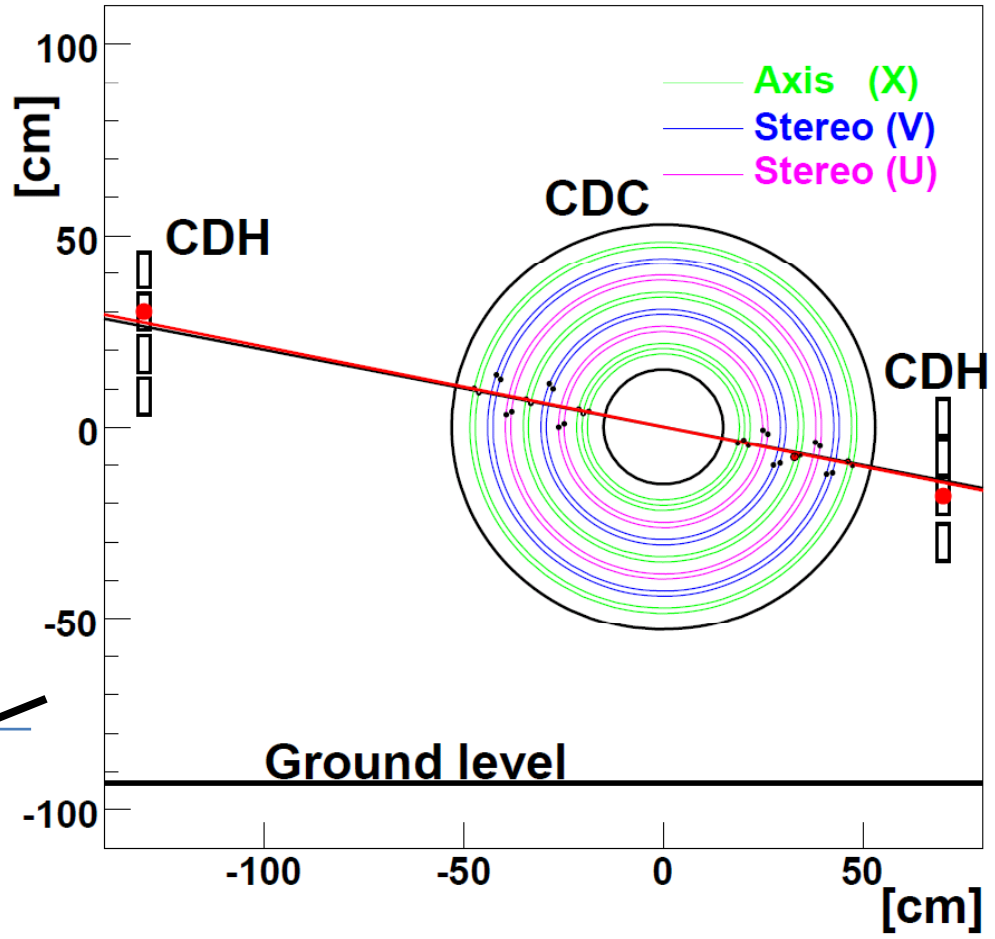
CDS zy-plane



CDC "typical" event display with J-PARC beam



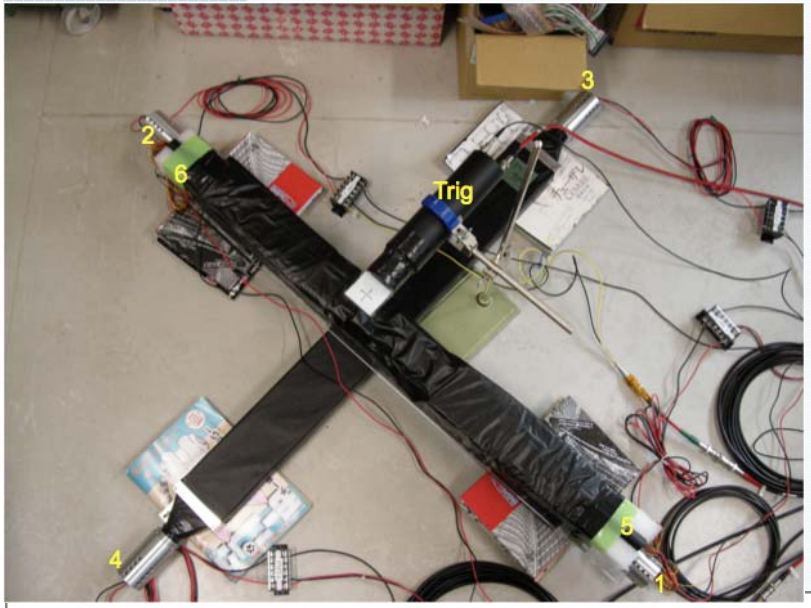


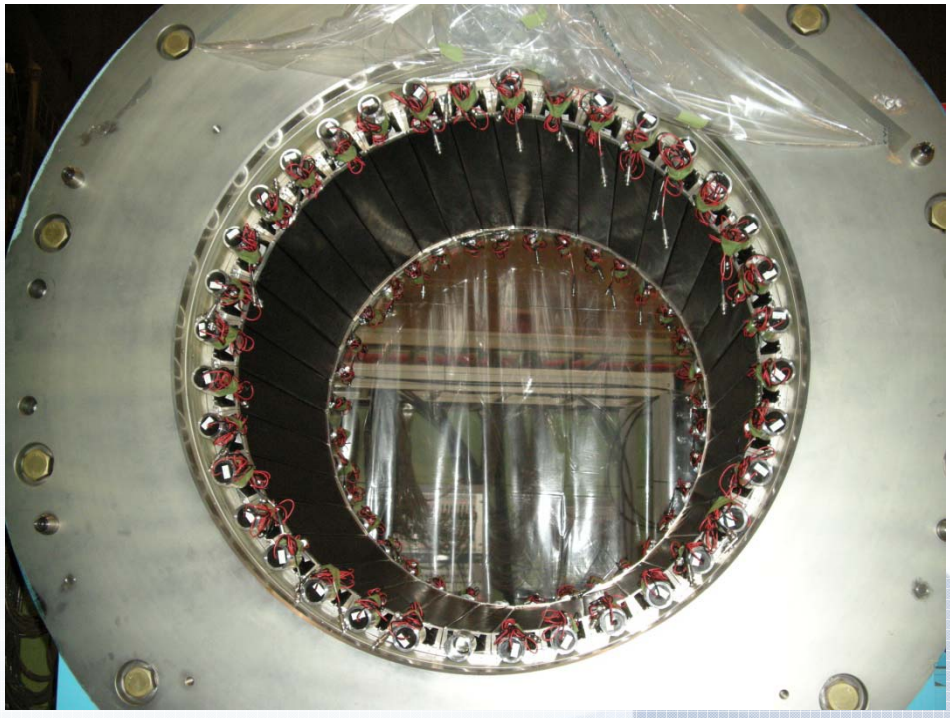


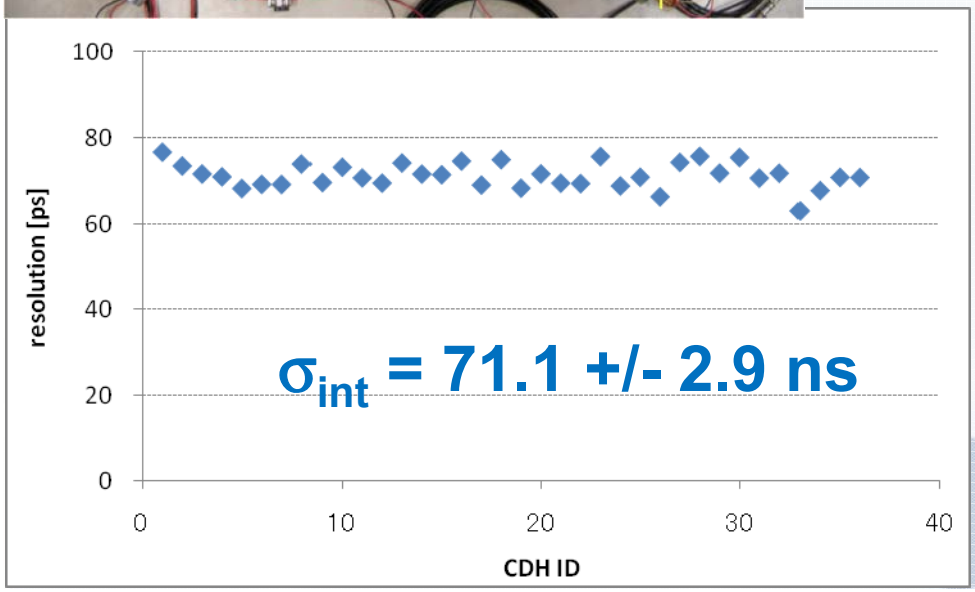
K. Tsukada, CDC subgroup

CDH resolution check

Trig:H6410
CDH:H8409 **Cosmic-ray test**







All the units ready and installed

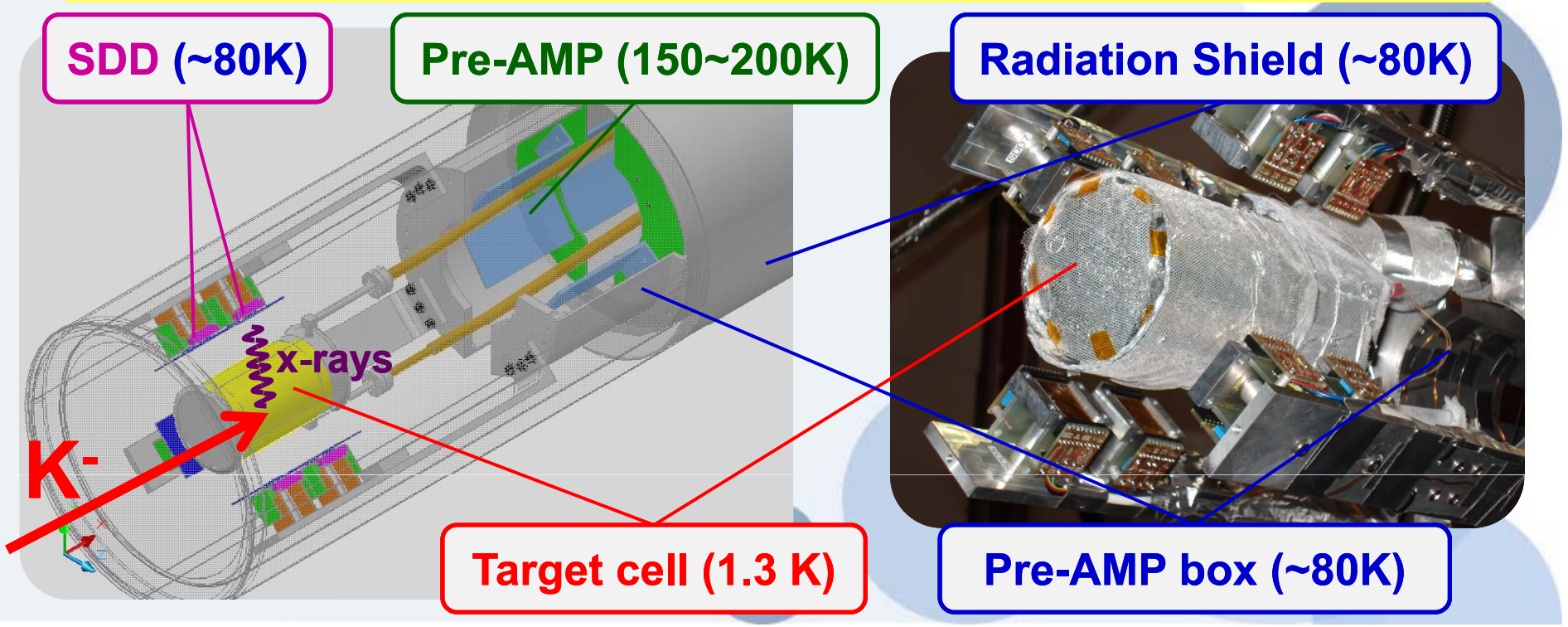
Tokuda and Sakuma, CDC subgroup

E17 Liq. He-3Target

Cryogenic system is ready

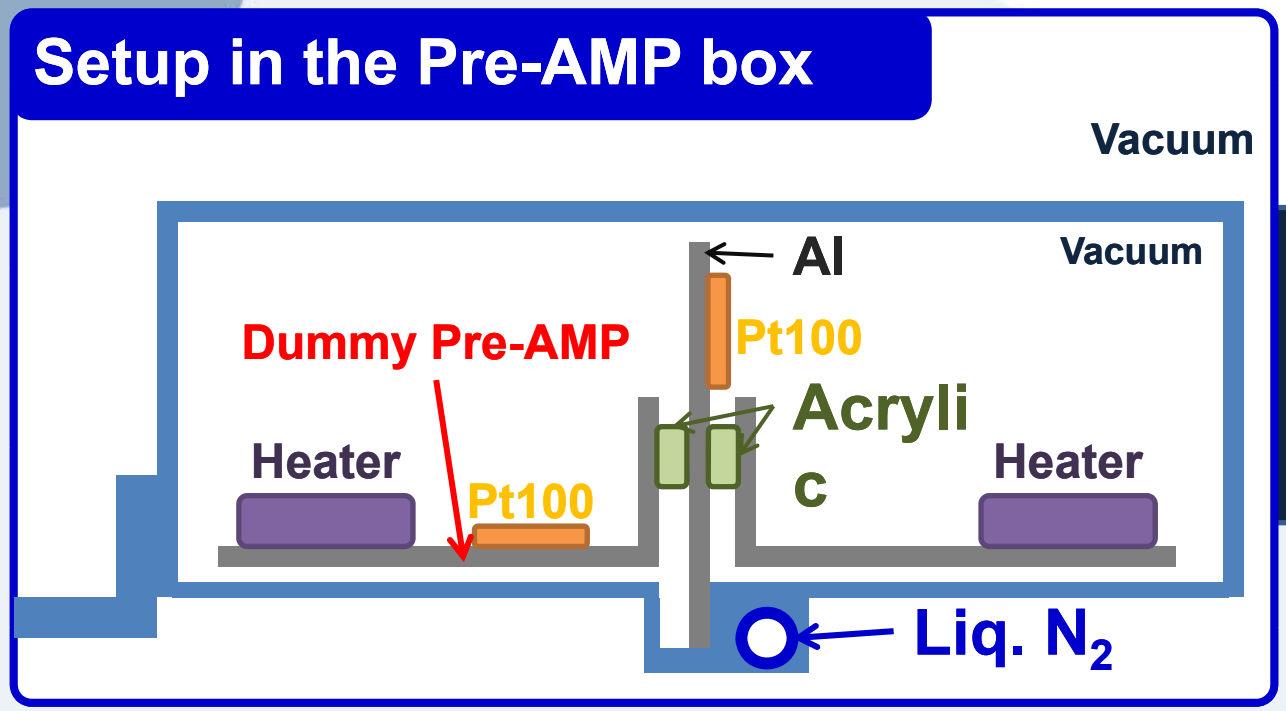
Temperature in the Target Cell	1.3 K
Pressure in the Target Cell	33 hPa
Liq. ^{4}He Consumption	45 L/day
Heat Load to the 1K Parts	0.19 W

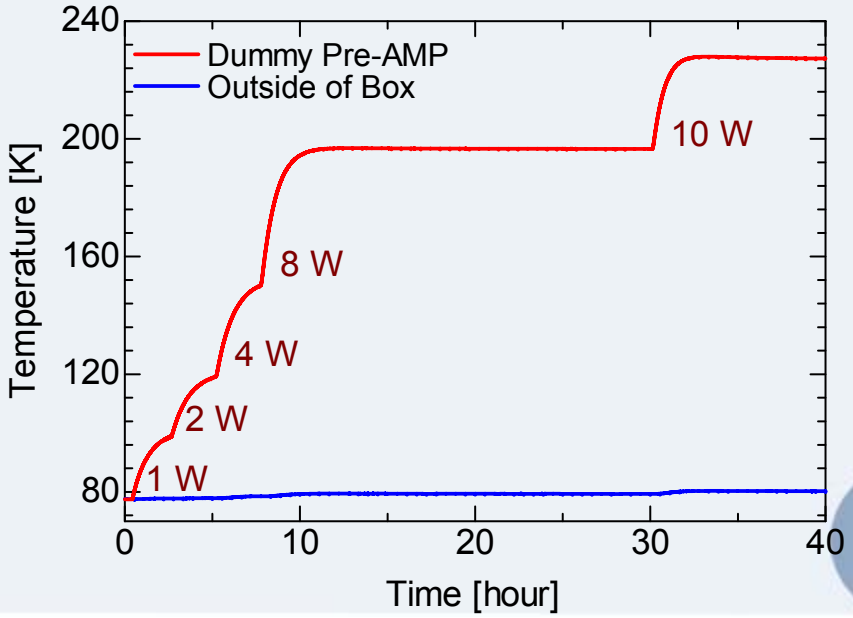
▼▼▼ SDD support work / Pre-AMP test ▼▼▼



Heat load test

Setup in the Pre-AMP box





The temperature around the target cell was kept 80 K under heat load (10W, 230 K) at Pre-AMP position.

Iio, Sato, Ishimoto; target group

R&D of Target Cell

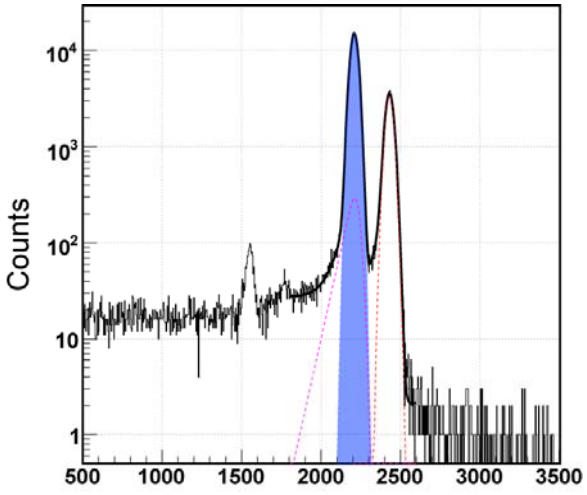
- Pressure Tight (>1atm)
- Impurity-free (Fe, Cu,..)
- High Radiolucency @6.3 keV

Pure Titanium
MICTRON

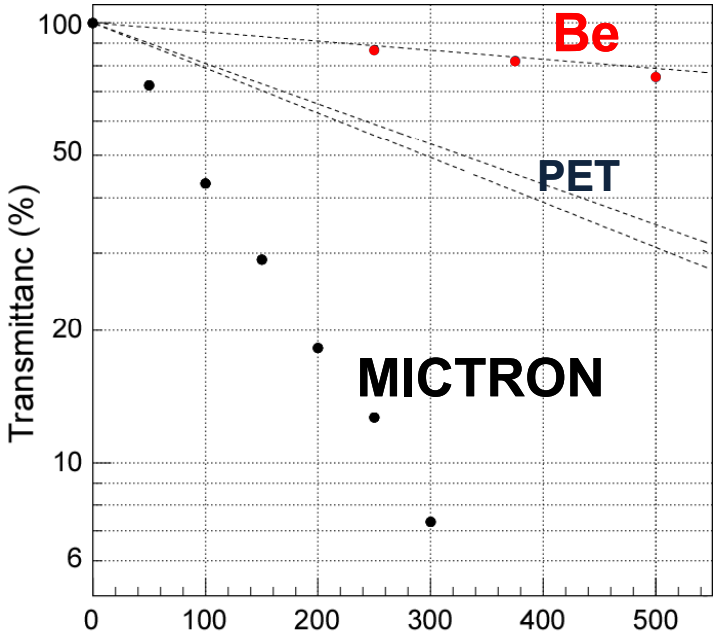
X-ray transmittance measurement

SDD test bench

SDD ADC spectrum w/ ^{55}Fe



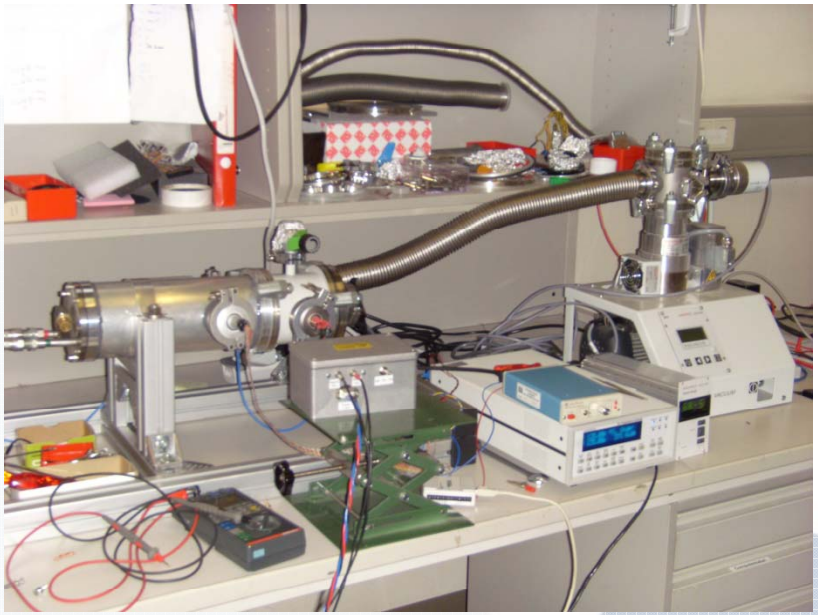
Thickness VS Transmittance



Unexpected poor transmittance of MICTRON

We decided to adopt Beryllium (BRUSHWELLMAN, purity > 99.0%)

Progress in Vienna

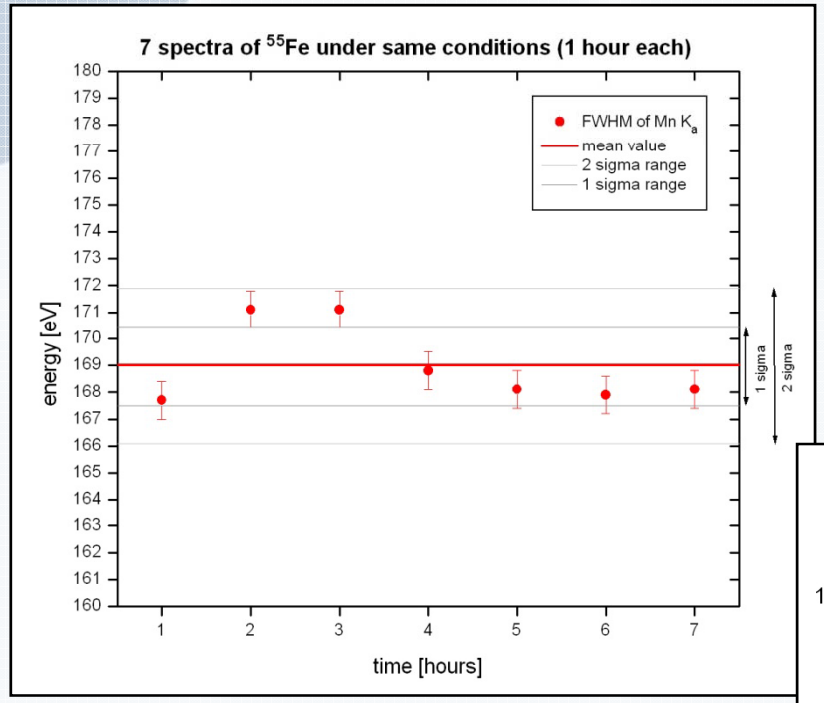


• New test apparatus: temperature on SDD can be varied between 100 and 200K, temperature on Preamp between 150 and 300K.

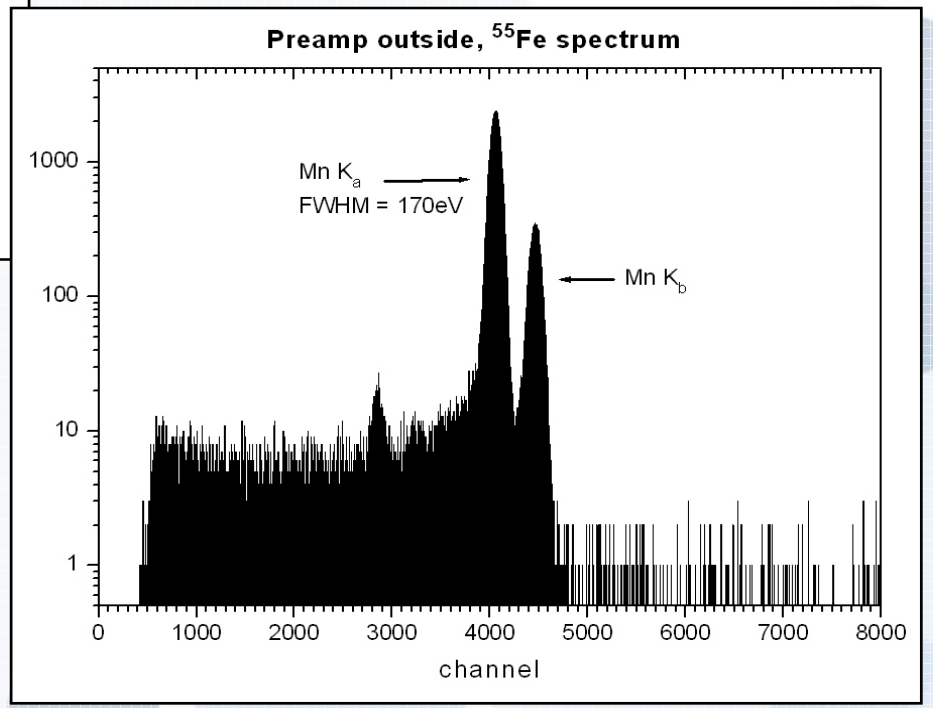
• Preamp outside the vacuum chamber (T=295K): Preamp was mounted outside the chamber, spectra were taken under several conditions: different voltages on Preamp and SDD (for optimization) and different temperatures

•Preamp inside (T=150K–300K): After finding optimum conditions the preamp was mounted inside the device. Measurements at different adjustments are performed now.

Preamp outside

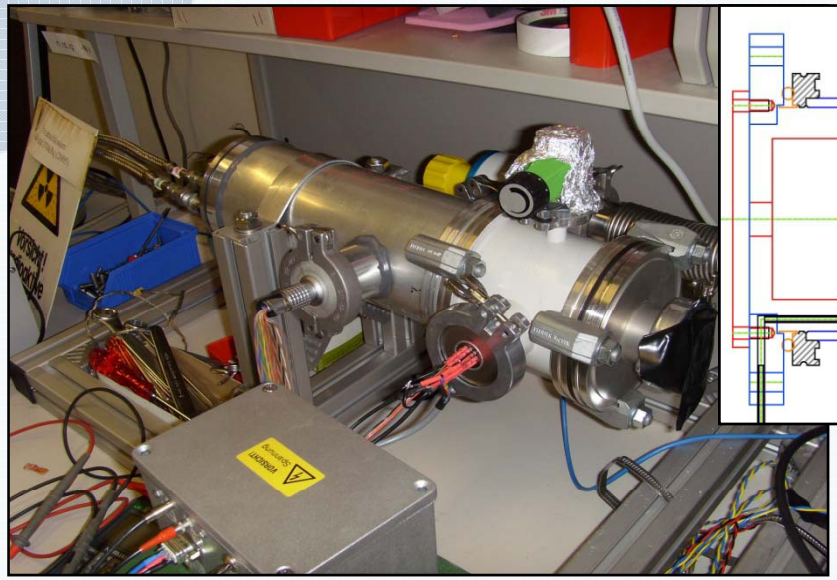


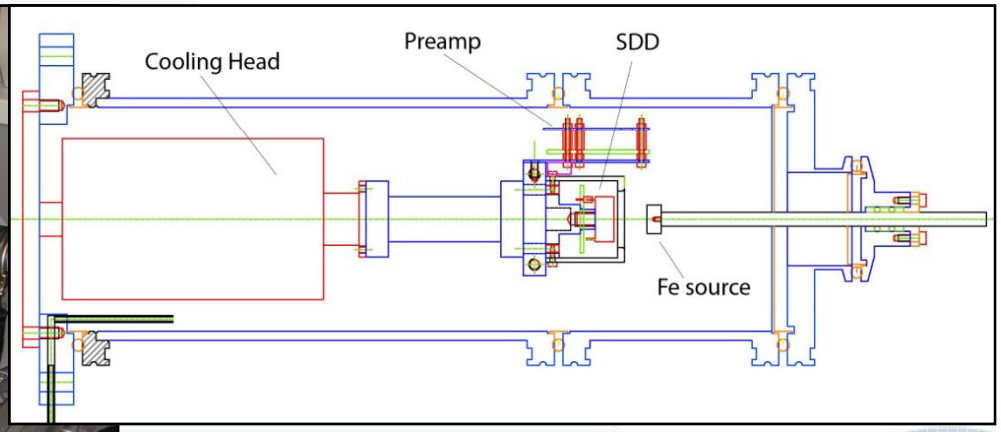
Measurements - performed with the Preamp outside the device - delivered a good and reproducible energy resolution of about 170eV at 5.9keV.

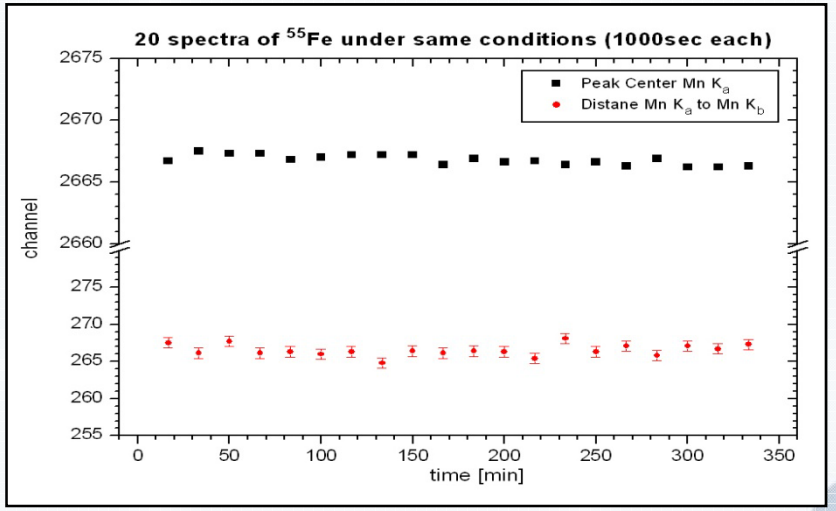


Above the energy resolution of 7 spectra, taken under same conditions, are shown.
On the right hand one can see a typical Fe-55 spectrum which we took with the SDD (Ketek).

Preamp inside





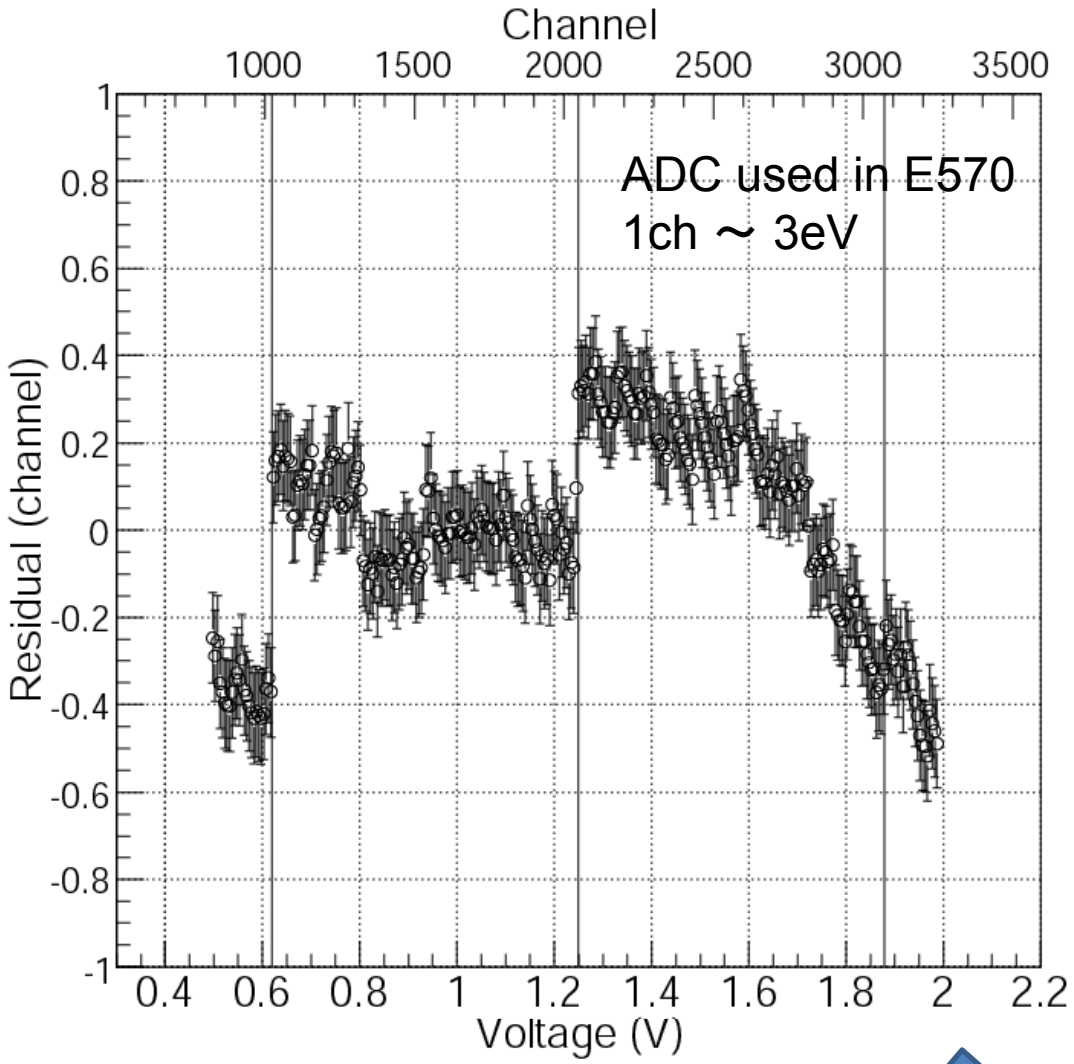


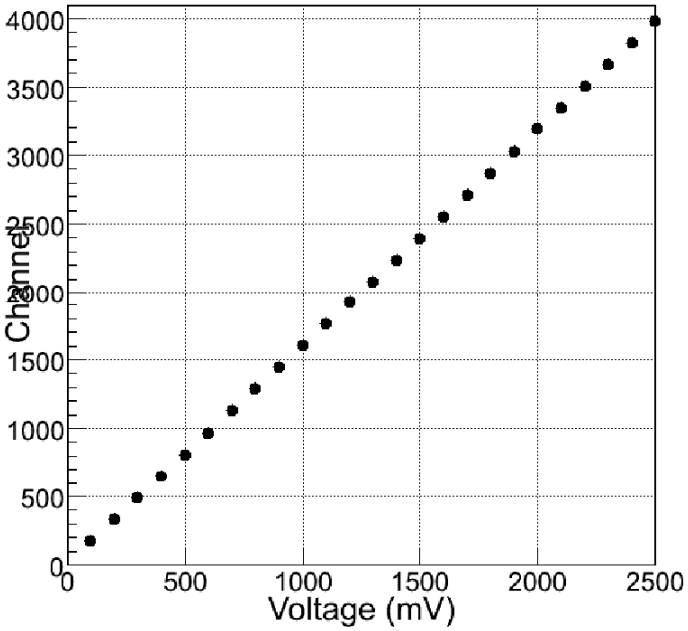
Above, a picture and a sketch of the current test setup in Vienna.
The measurements are under way, but preliminary results show that stable conditions are already reached, as presented in the graph on the left.
Further optimization studies on the energy resolution with the Preamp inside are done now.

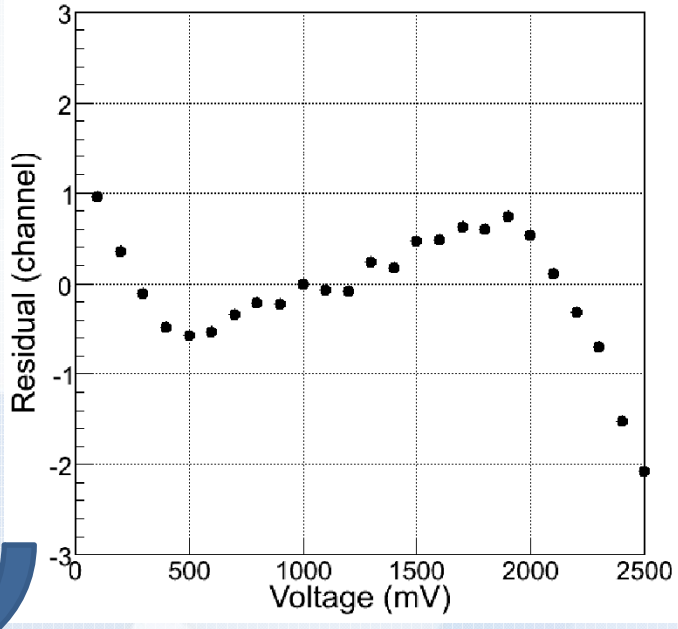
SDD assembly

E17: To reduce systematic error …

Differential Non-linearity test of ADC







M. Sato, Target/SDD subgroup

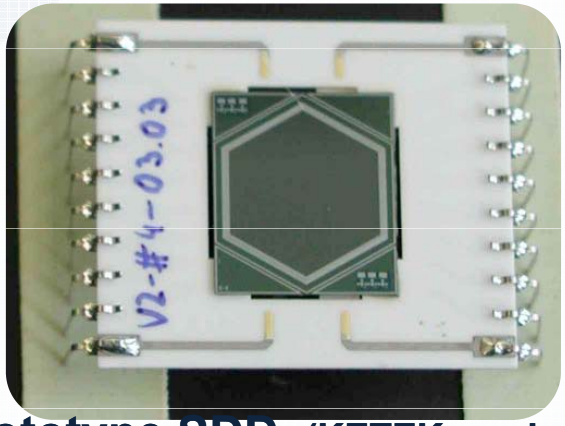
4. Summary and run plan

- We started K1.8BR tuning w/ very severe beam condition.
- All the detectors for E17 will be ready well before next run (scheduled from Oct./Nov. ?): E15 downstream parts going-on.
- Need approximately one month with continuous and "countable" beam for E17+E15 beam tuning @ 1.0/0.7GeV/c K+/- and stopping range adjustment. No strong requirement for intensity for tuning.
- To install target/SDD and CDS roll-in, we need at least one month intermission after beam tuned.
- We want to "start" production run of E17 in FY2009.
  To reach to the final statistics we need 135KW*week with T1 target, but to "see" KHe3 X-peak will be possible with limited injection. It is important for us to see healthy status of all the system.
- Possible thick target (e.g. 50% Pt) option during limited primary proton intensity will be desirable for us for E17 production run. But we need 30KW*week(T1-equivalet) or so to start in FY2009.

Spare Slides

Silicon

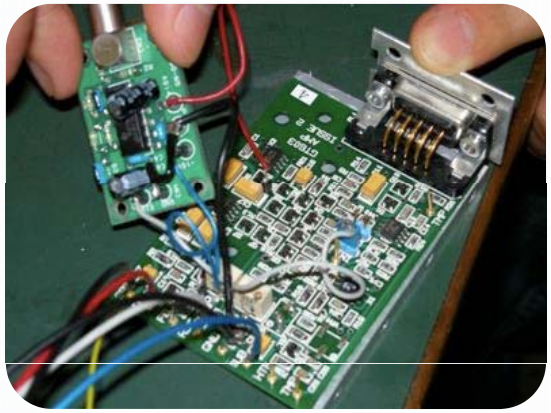
This page may be replaced if I got some new items from SMI



Prototype SDD (KETEK products)

Effective area: 100 mm^2

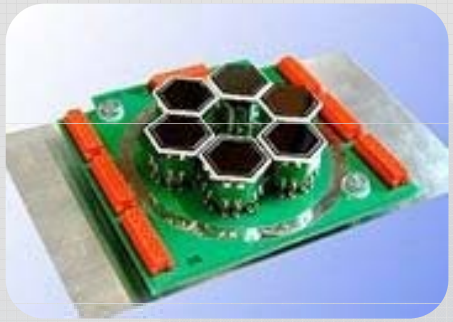
Energy resolution: 190 eV @6.4 keV



Preamp (KETEK products)

New-type SDD
(KETEK products)

Accumulable

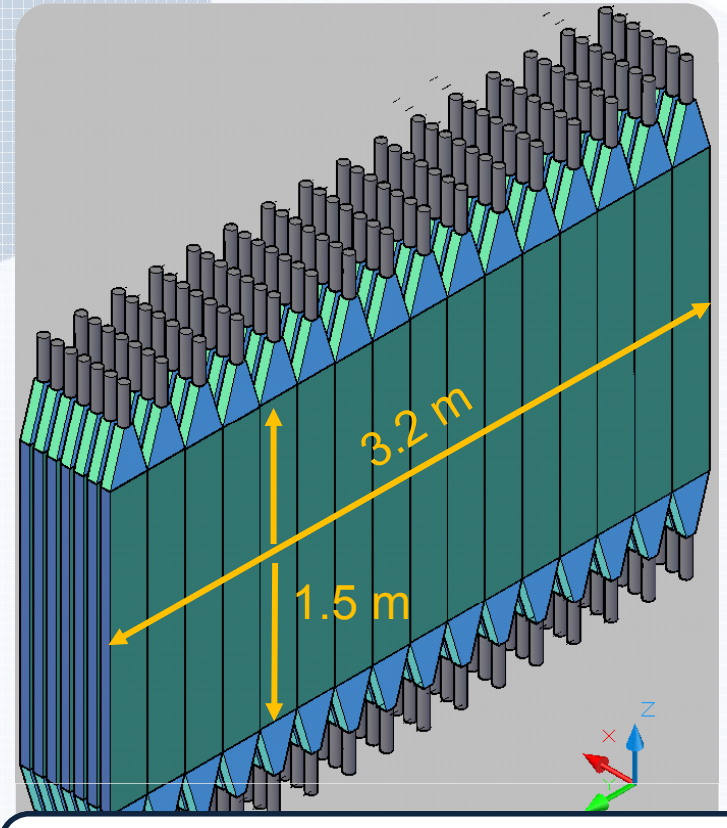


KETEK VITUS SDD array

New compact type preamp will be adopted.

Contribution by SMI group

Neutron Counters



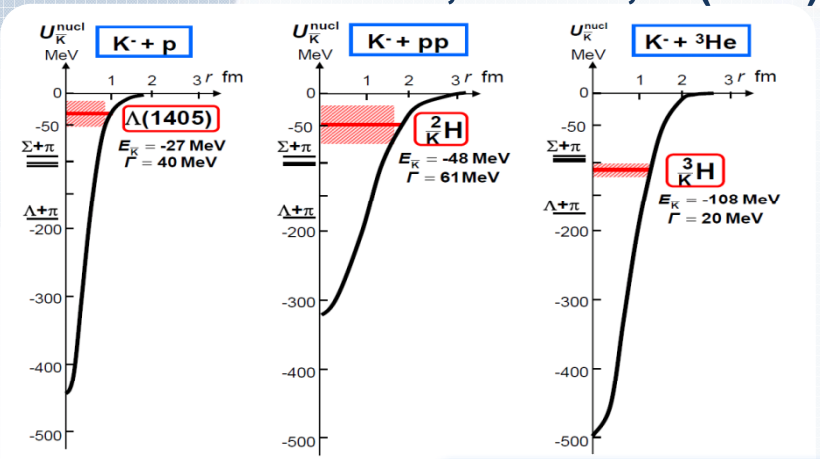
20x5x150 cm^3 Plastic Scintillator
Configuration : 16 (wide) x 7 (depth)
Surface area : 3.2m X 1.5m

20MeV FWHM resolution expected for K-pp w/ σ=150ps resolution, 15m flight path

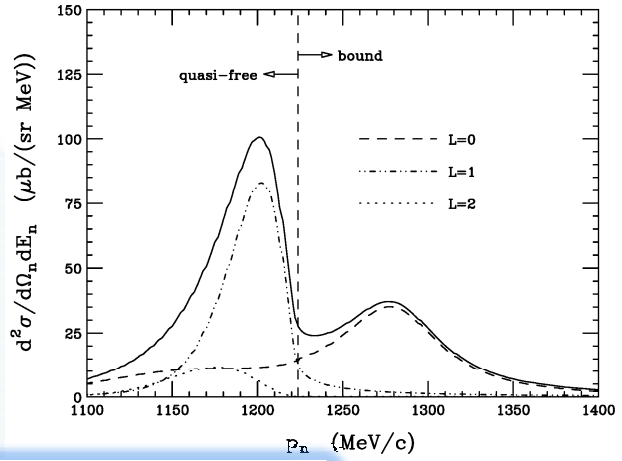
From M. Iio et al. @PANIC2008

Deeply-bound Kaonic Nuclei

Y.Akaishi & T.Yamazaki, PLB535, 70(2002).



Koike, Harada PLB652, 262 (2007).DWIA



Recent theoretical progress (K^--pp)

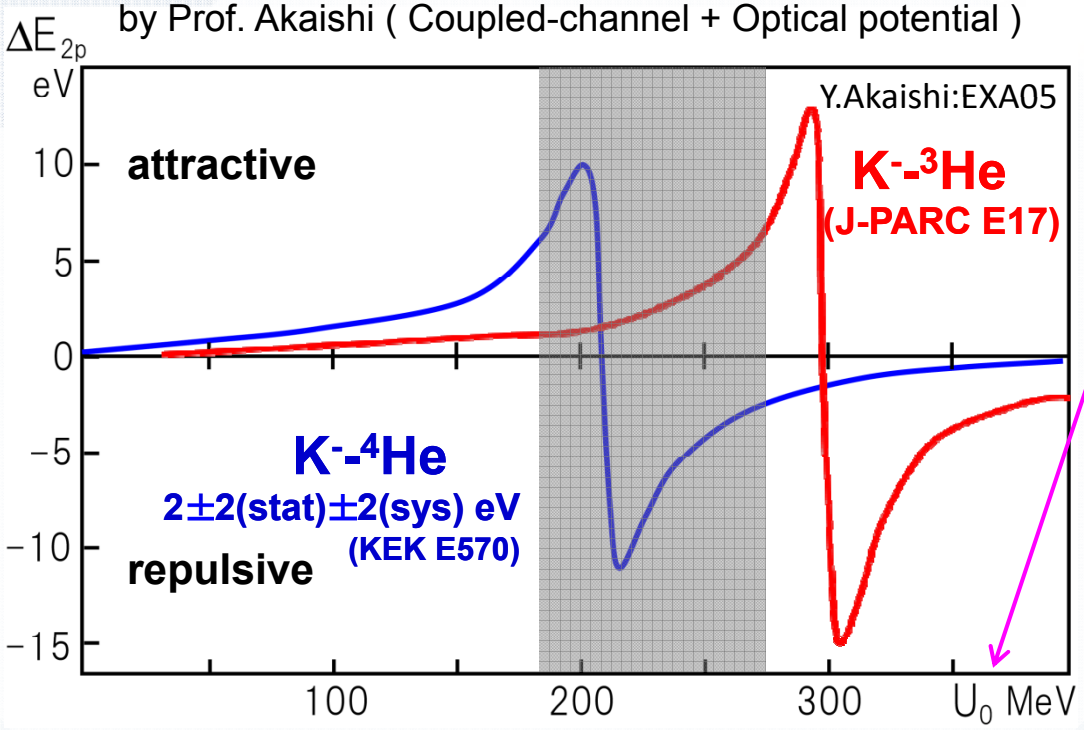
	method	B. E.	Width
Akaishi, Yamazaki PLB535(2002) 70	ATMS	48 MeV	61 MeV
K. Swe Mynt, Akaihi APFB05	Gaussian base Rearrangement-channel		
Iva nuc			
Do YK			
Ike HY			
Arai, Yasui, Oka JPS06-2	Λ*N model	87 MeV	
Shevechenko, Gal, Mares nucl-yh/0610022	Faddeev	55-70 MeV	95-110 MeV

- Kaonic Nuclei really **exist** ?
- The binding energy is **deep** or **shallow** ?
- The width is **narrow** or **wide** ?

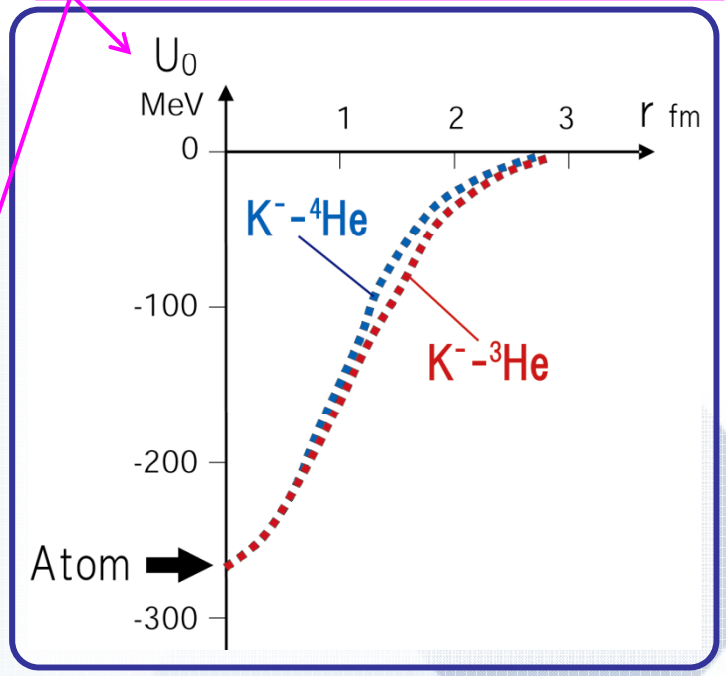
From M. Iio et al, @PANIC2008

Experimental Research of Kaonic Atoms

Calculation results of the strong interaction induced 2p level shift
by Prof. Akaishi (Coupled-channel + Optical potential)



U_0: Real part of the K^--He strong interaction potential



Precise measurement both of K^--^{3}He and K^--^{4}He

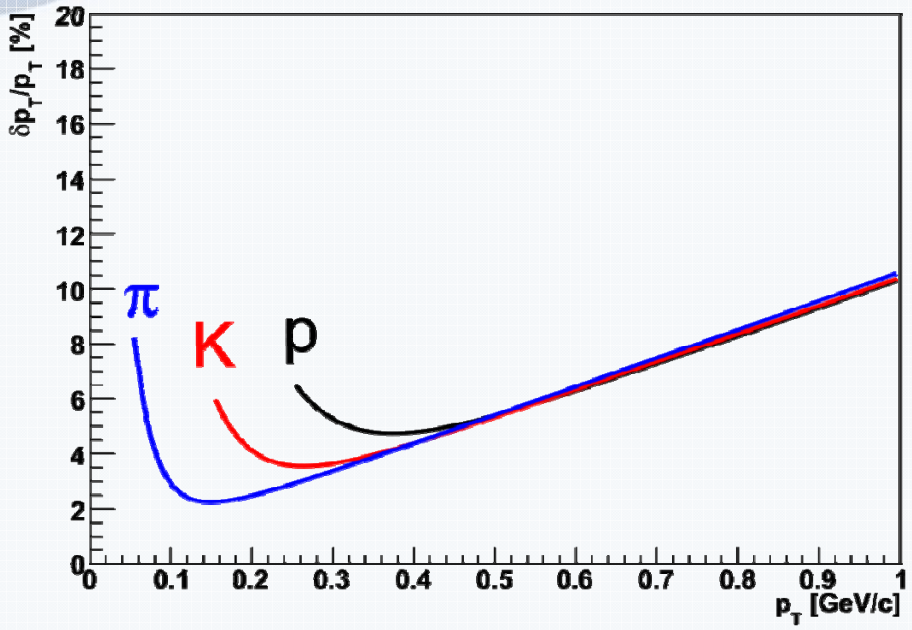
- **Isospin-dependent K^--N Strong-interaction at the low energy limit**
- **Existence of the Deeply-bound Kaonic Nuclear State**

From M. Iio et al. @PANIC2008

Expected Spectrometer Performance II

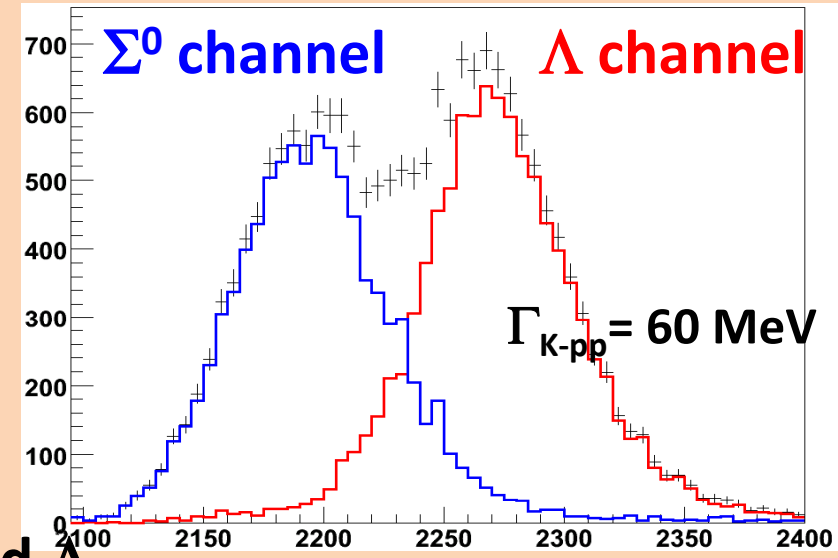
Calculated using Geant4

momentum resolution for π, K, p



we can distinguish the two non-mesonic decay modes for K⁻-pp

- K-pp → Λp → pπ-p
- K-pp → Σ^0p → γΛp → γpπ-p



Invariant mass resolution for K⁻-pp and Λ

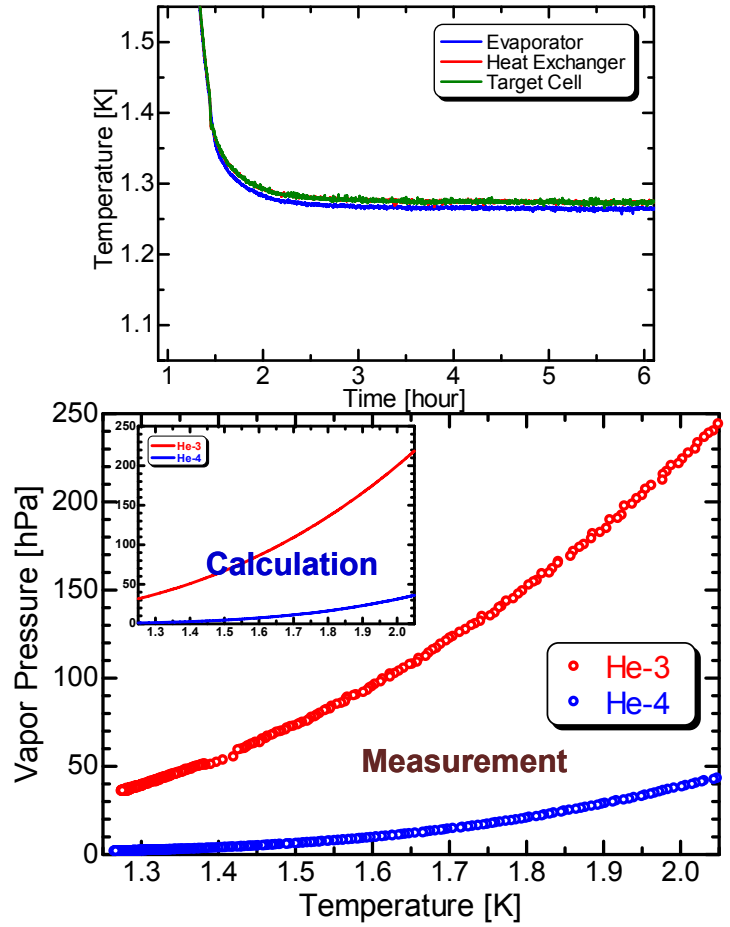
mass resolution	K-pp→Λp	Λ→pπ−
w/o chamber-resolution	5.8 MeV/c²	1.6MeV/c²
w/ chamber-resolution	**18.7MeV/c²**	**2.5MeV/c²**

Liquid ^{3}He Target for E15

Development of the ^{3}He cooling system was completed !

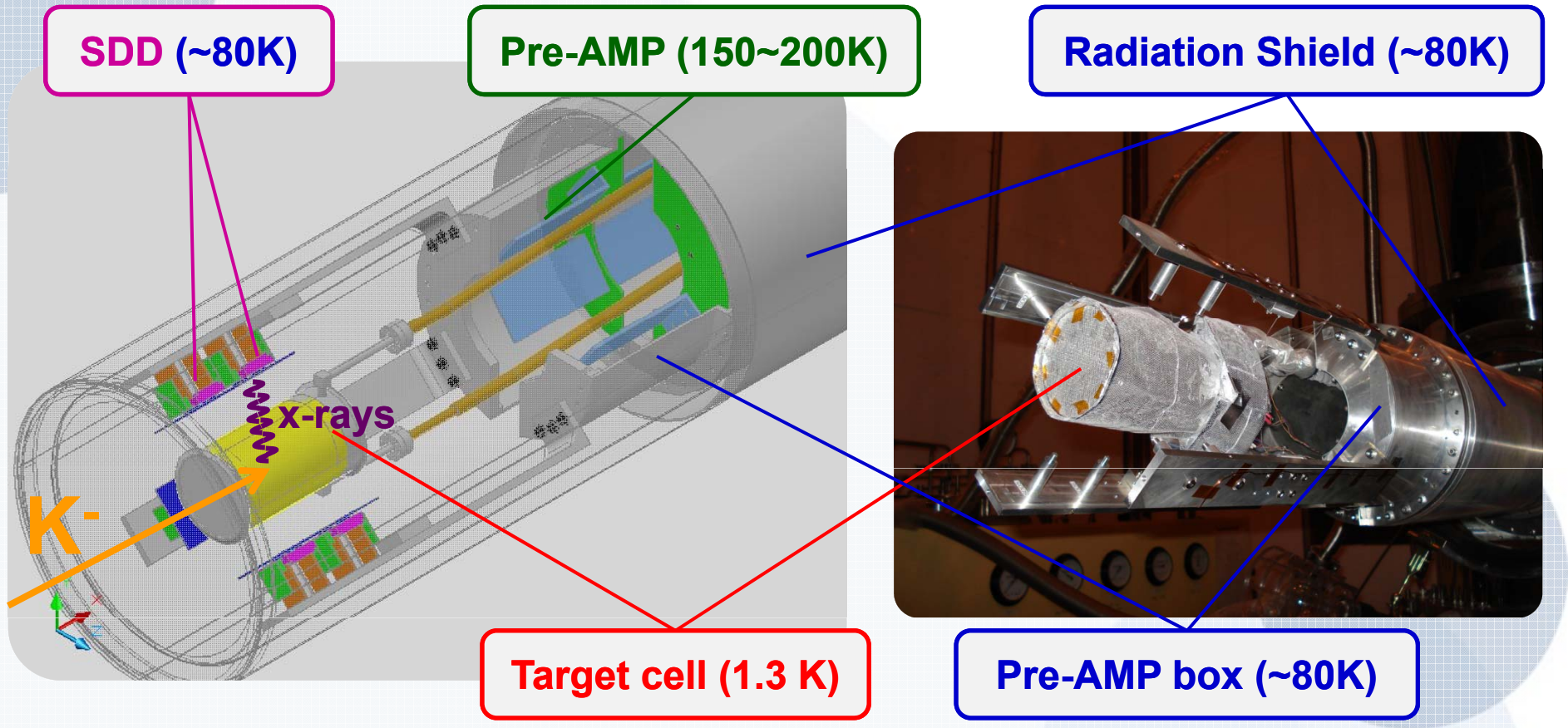
R&D for installation of the x-ray detection device to inside the target system

Cooling test with 200L ^{3}He gas



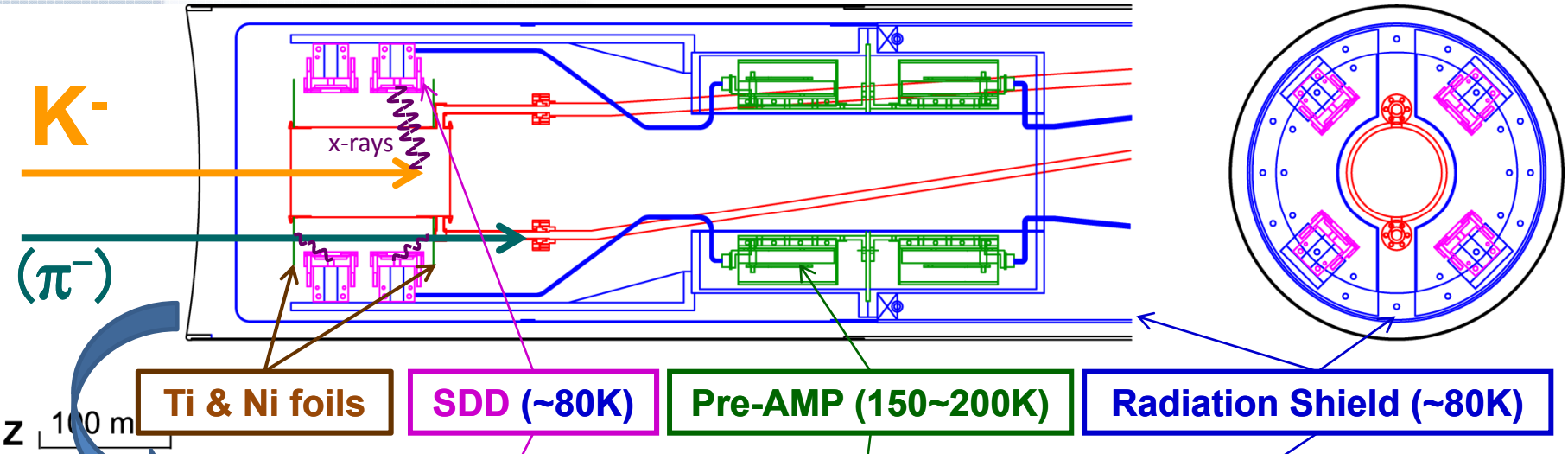
Temperature in the Target Cell	1.3 K
Pressure in the Target Cell	33 hPa
Liq. ^{4}He Consumption	45 L/day
Heat Load to the 1K Parts	0.19 W

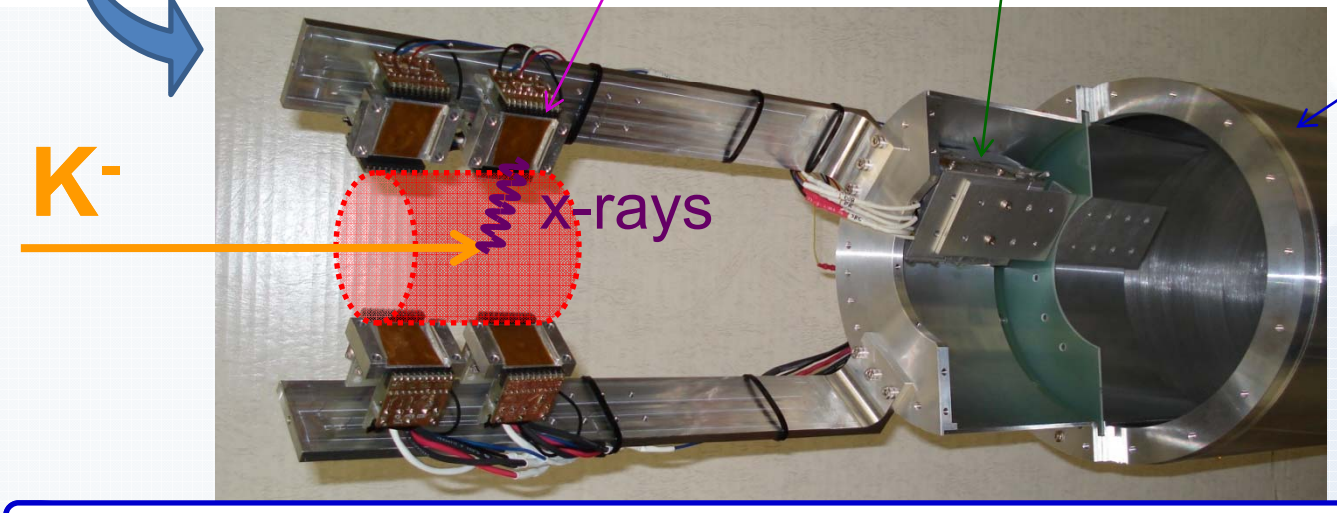
LHe-3 target upgrading for E17



- Design of the upgrading parts are almost completed.
- Now Cooling test is started.
- The target will be installed by the end of March, 2009.

Liquid ^{3}He Target for E17





Things to do

- Fabrication CFRP vacuum chamber and radiation shield
- R&D of the support of the SDDs and Preamps
  (for reducing of the heat load from the preamps)
- Development of the target cell