(P17)

Precision spectroscopy of Kaonic Helium 3 3d→2p X-rays

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Collaboration

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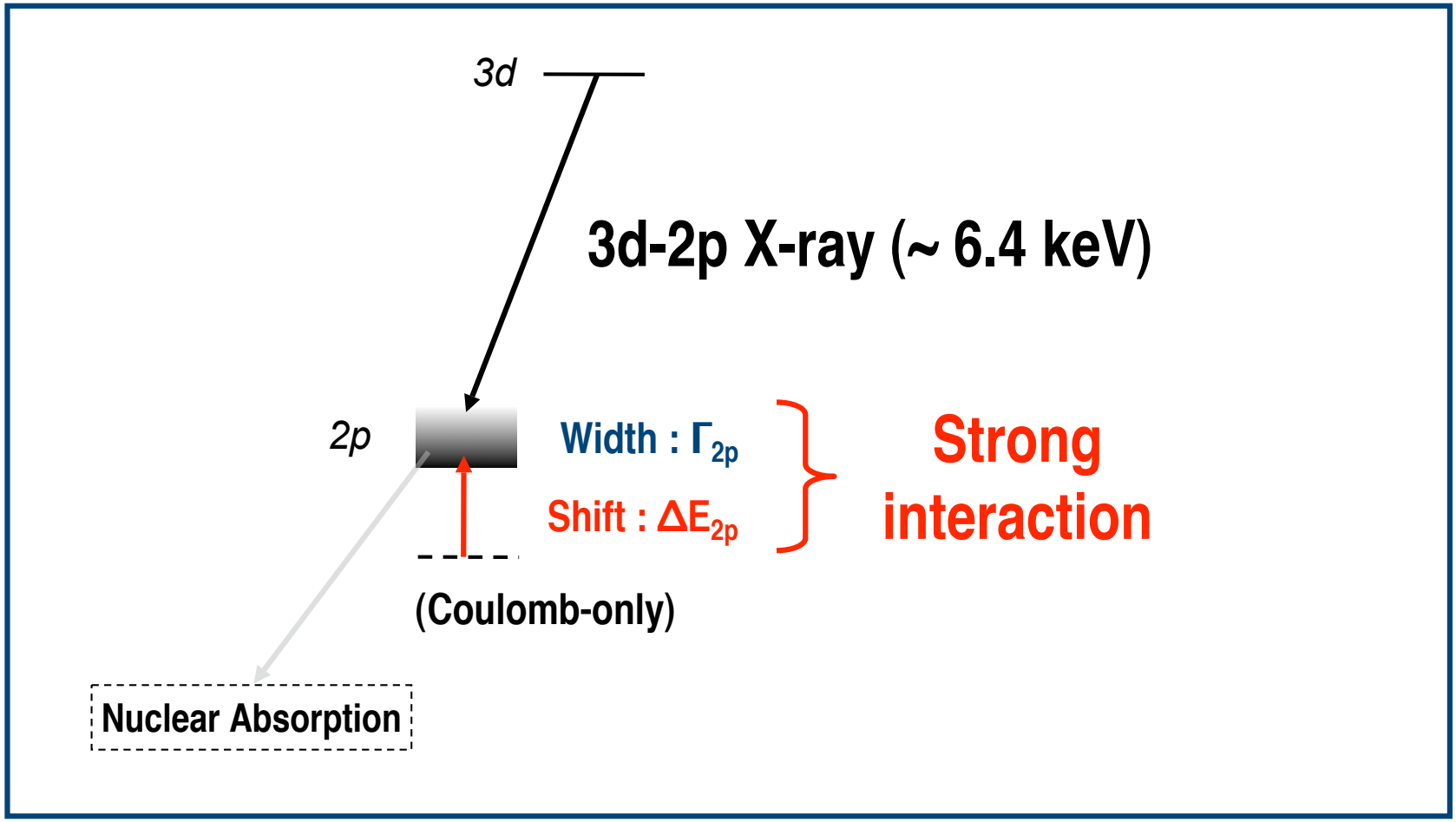
Tokyo Tech[6], Univ. of Tokyo[7], RIKEN[8], KEK[9]

What do we measure?

K^- ^{3}He atom 3d-2p X-ray Energy

Strong-interaction shift (and width)

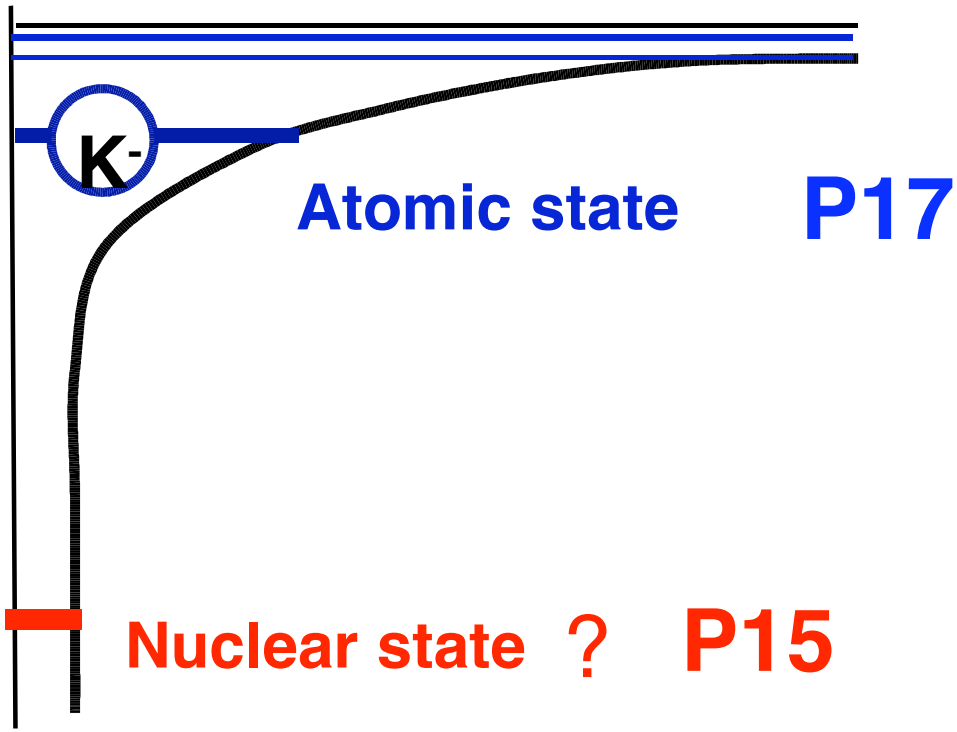


Why kaonic He X-rays?

P17 closely related to P15:

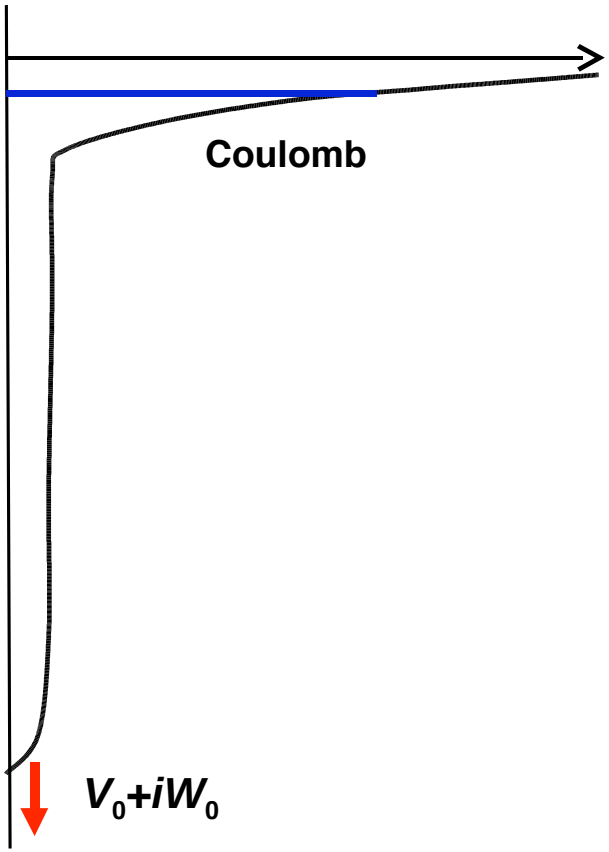
P15: ***A Search for deeply-bound kaonic nuclear states by in-flight ^{3}He(K^-, n) reaction***

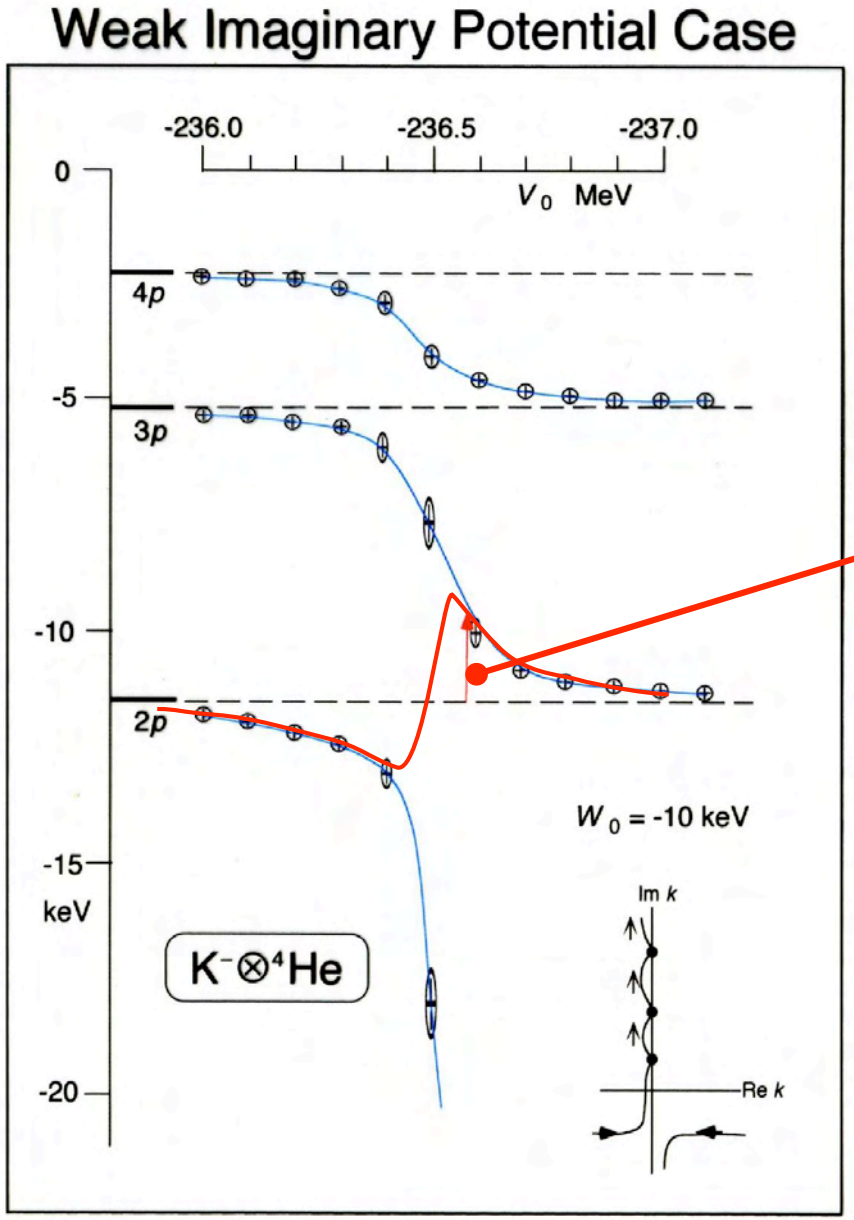
K- nucleus potential deep enough to accommodate the kaonic nuclear state(s)?



note: figure not precise since P17 deals with K^- ^{3}He, while P15 searches K^- pp

Potential depth vs Atomic binding energy(schematic)



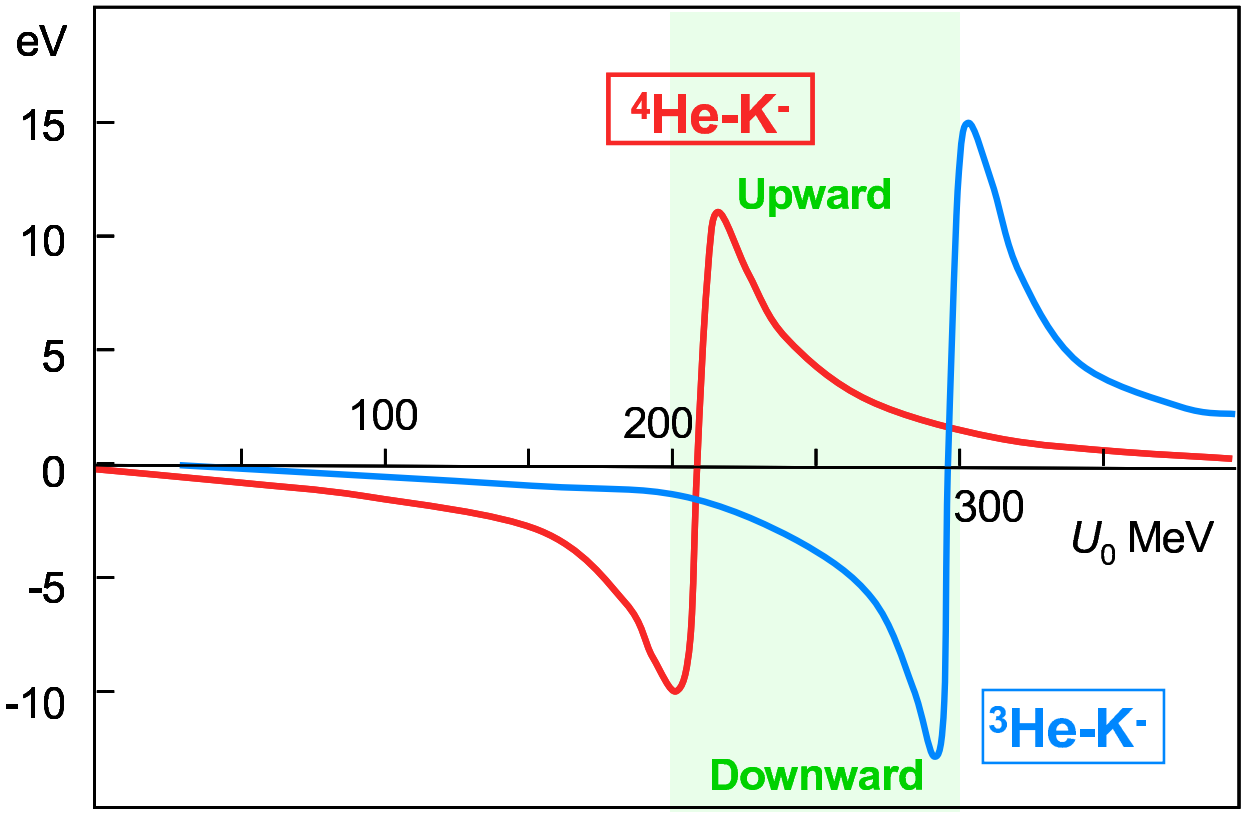


Large shift when a nuclear bound state appears

Akaishi's prediction

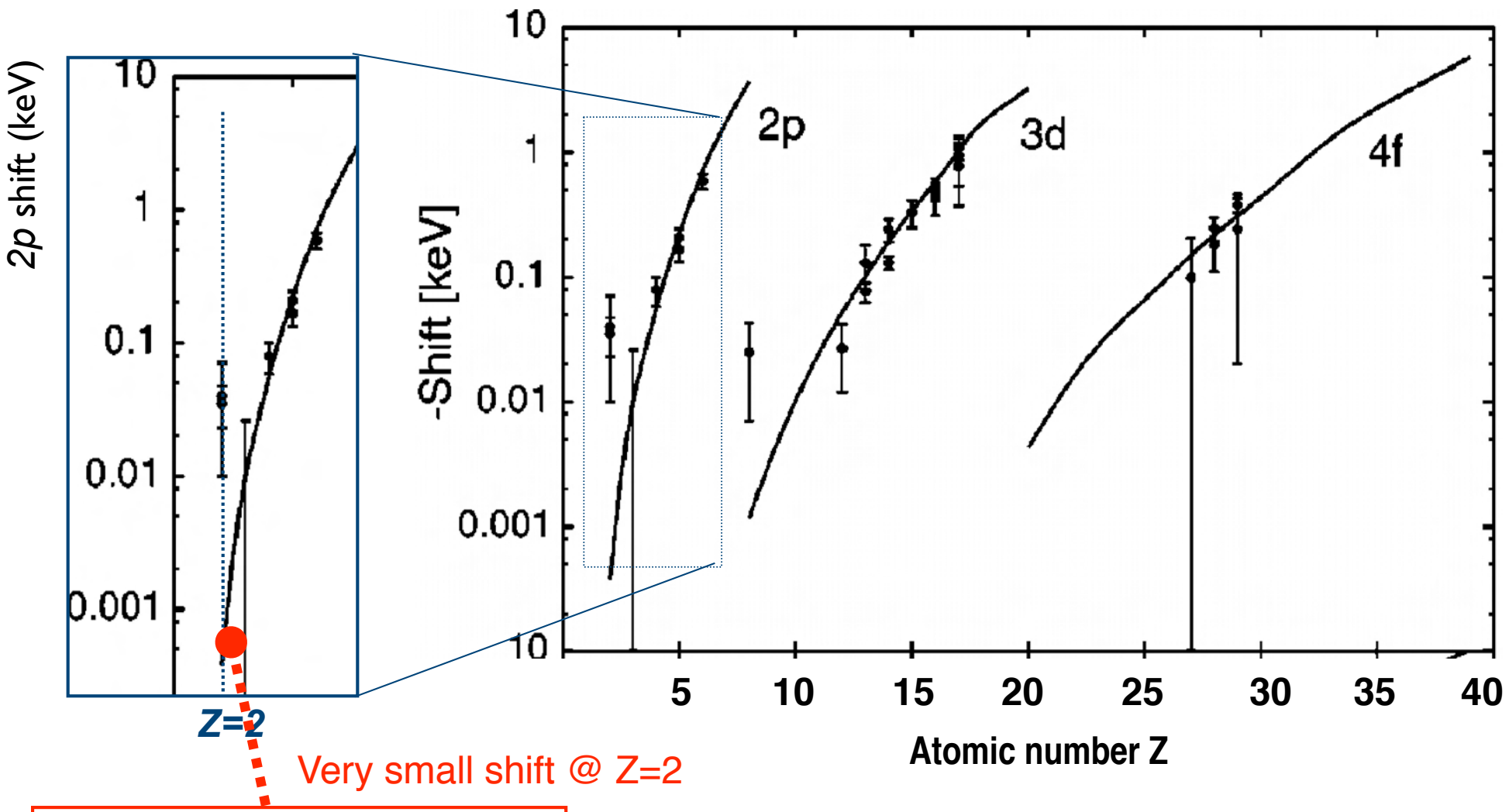
(accommodates kaonic nuclear states)

Upward shift for K^- ^4He
Downward shift for K^- ^3He
I shift I > ~ 5 eV



Akaishi's prediction differs sharply from the K^- - nucleus potential obtained by "Global fit" to the existing K- atom X-ray data

Global fit to existing kaonic X-ray data



Very small shift @ Z=2

(chiral unitary+ optical model):

~0.2eV

S.Hirenzaki, Y.Okumura,
H.Toki, E.Oset, and A.Ramos
Phys. Rev. C 61 055205

and such “shallow” potential cannot
accommodate the kaonic nuclear bound states

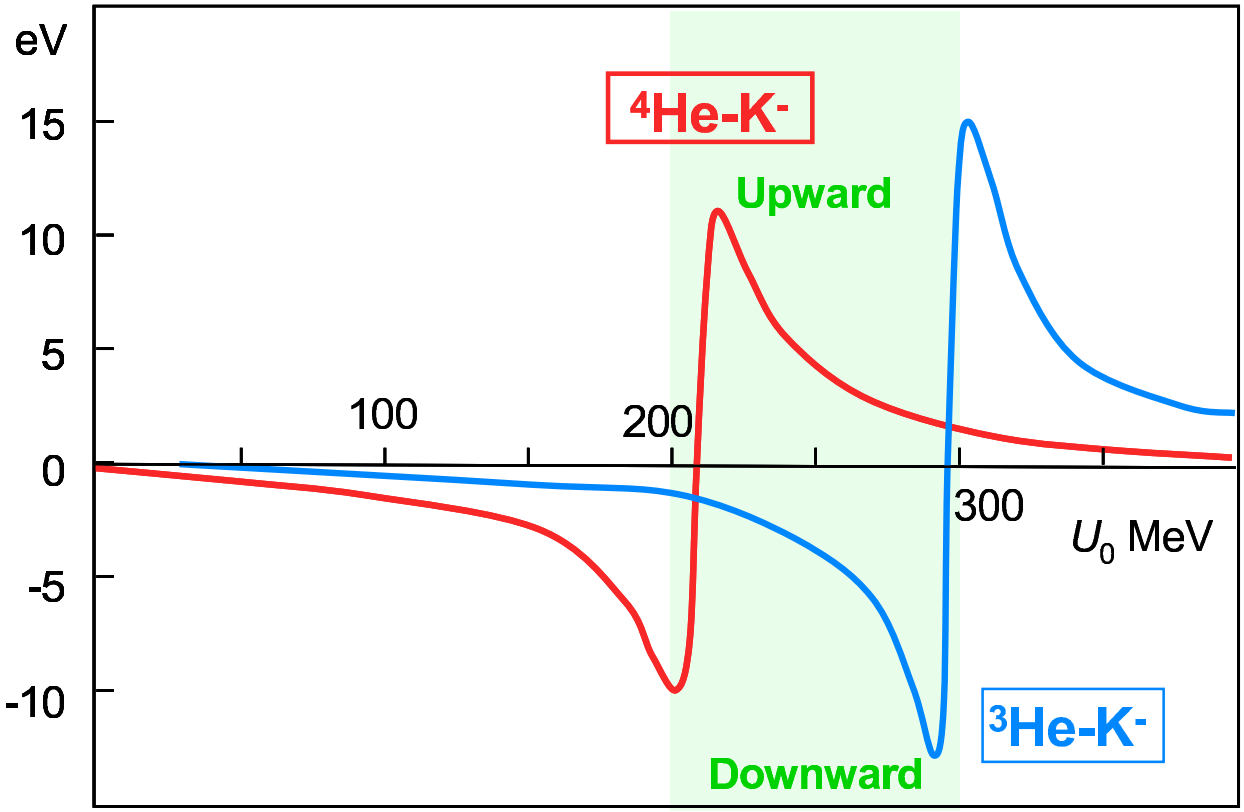
Precise X-ray measurement can tell who is right

KEK PS E570 measured K^- ^4He (Oct, Dec, '05)

measured 3 times before E570, all reporting LARGE (~40 eV) shifts

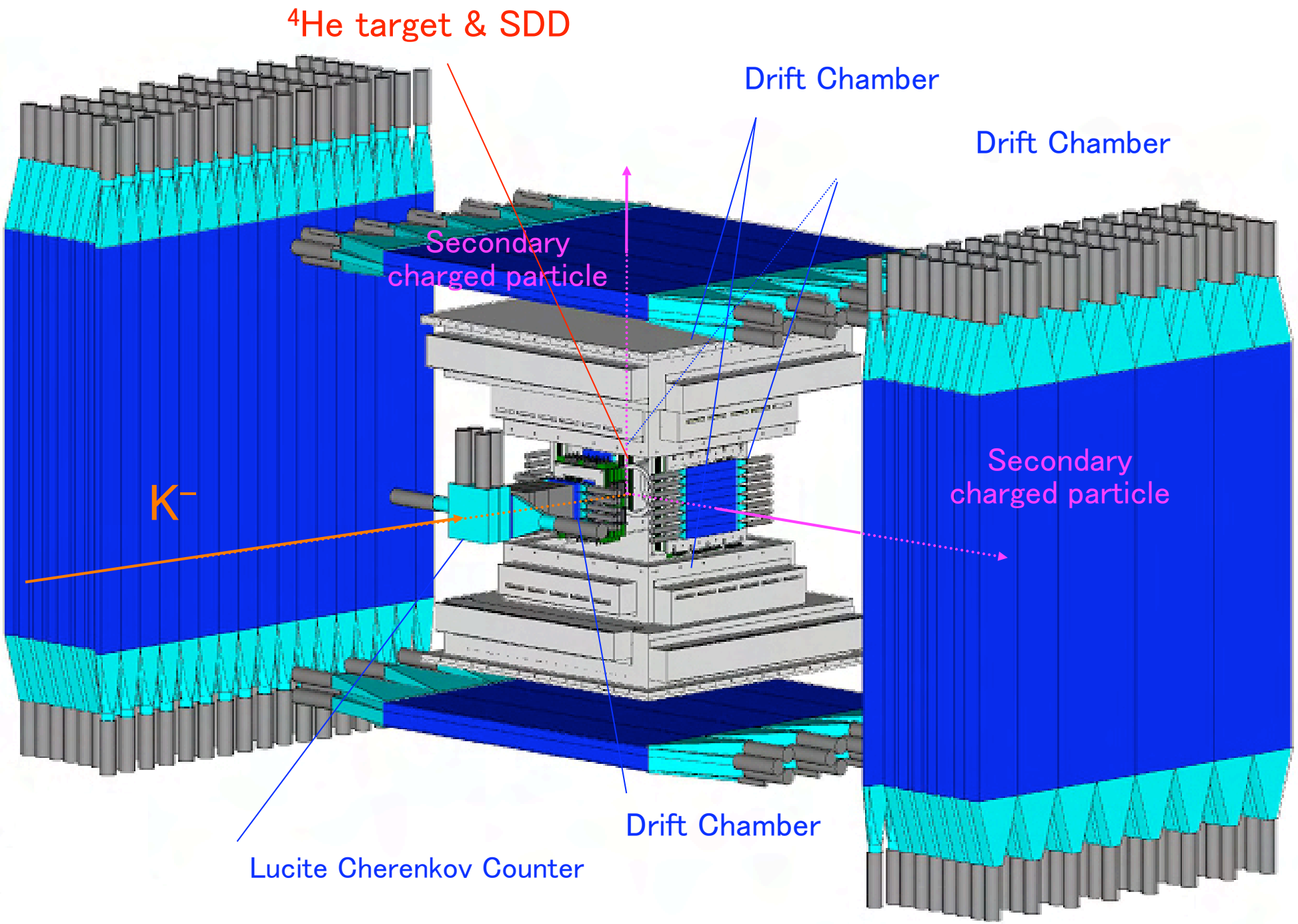
P17 will measure K^- ^3He (J-PARC Day-1)

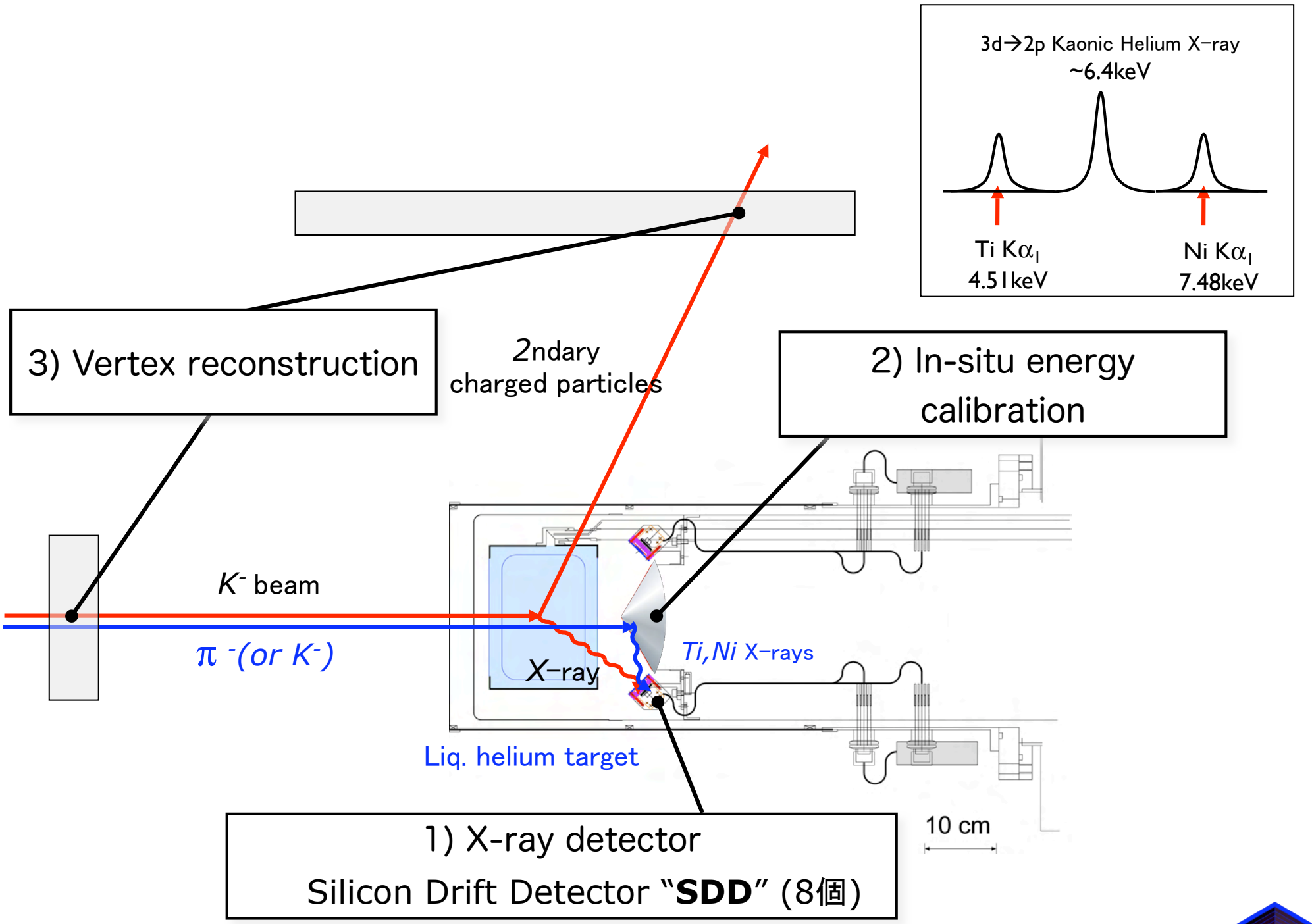
no data available yet



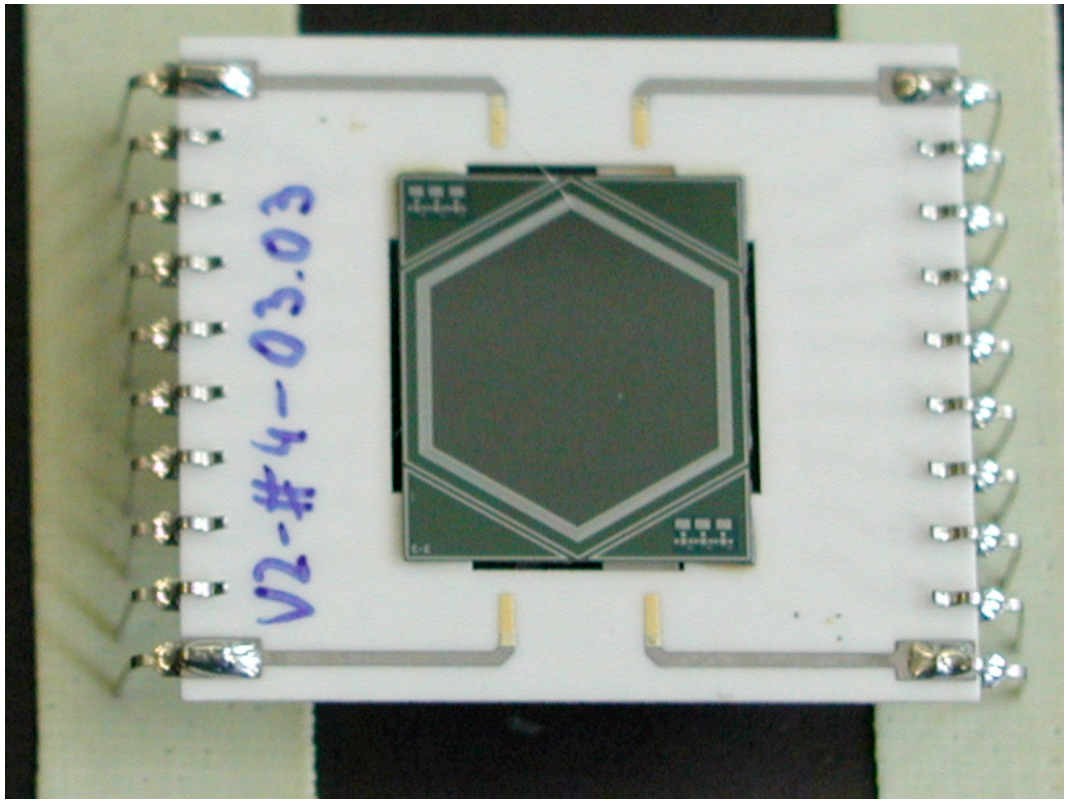
Goal (E570 & P17)
precision ~2 eV

E570


^{4}He target & SDD
Drift Chamber
Drift Chamber
Secondary
charged particle
K^-
Secondary
charged particle
Drift Chamber
Lucite Cherenkov Counter


3d→2p Kaonic Helium X-ray
~6.4keV
Ti Kα1
4.51keV
Ni Kα1
7.48keV
3) Vertex reconstruction
2ndary
charged particles
2) In-situ energy
calibration
K- beam
π -(or K-)
X-ray
Ti,Ni X-rays
Liq. helium target
10 cm
1) X-ray detector
Silicon Drift Detector "SDD" (8個)

E570 SDD (silicon drift detector)

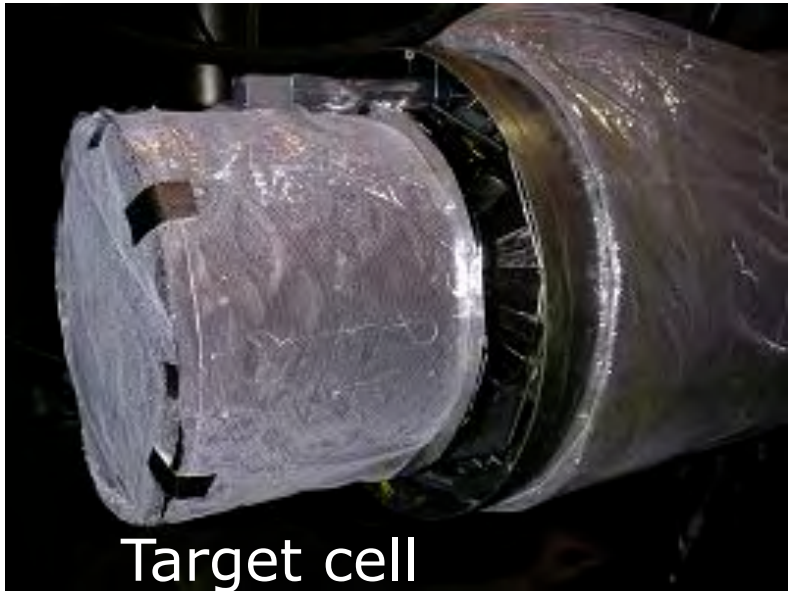


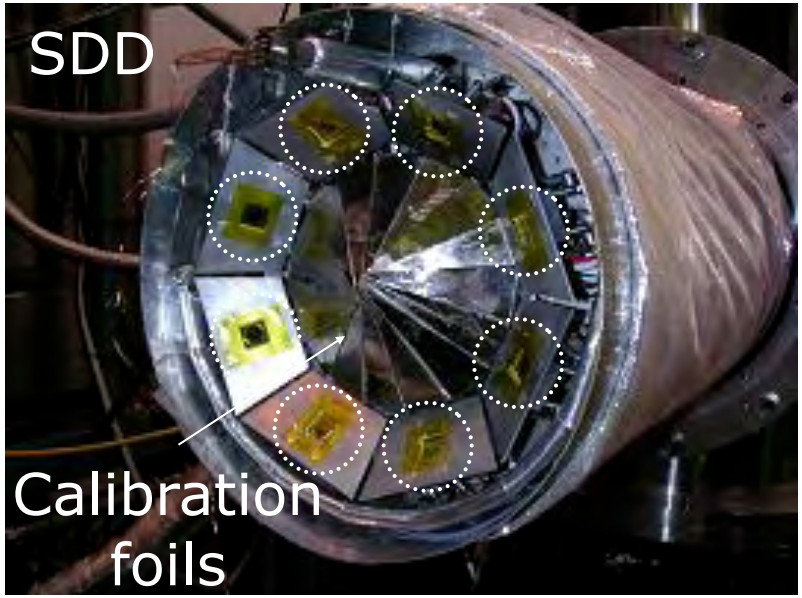
electrons drift to a small anode (small capacitance)

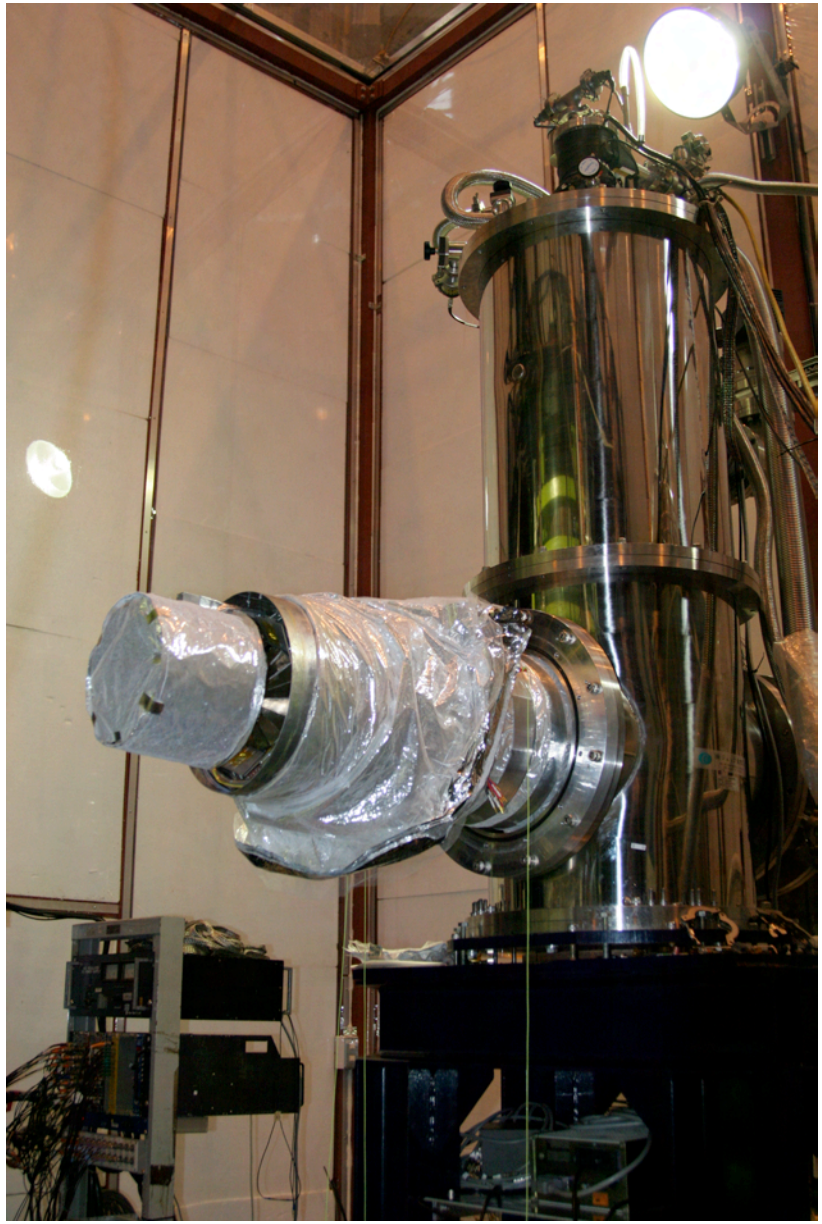
high resolution (185 eV FWHM @ 6.4 keV), large area (100 mm^2)

8 such SDDs used in E570

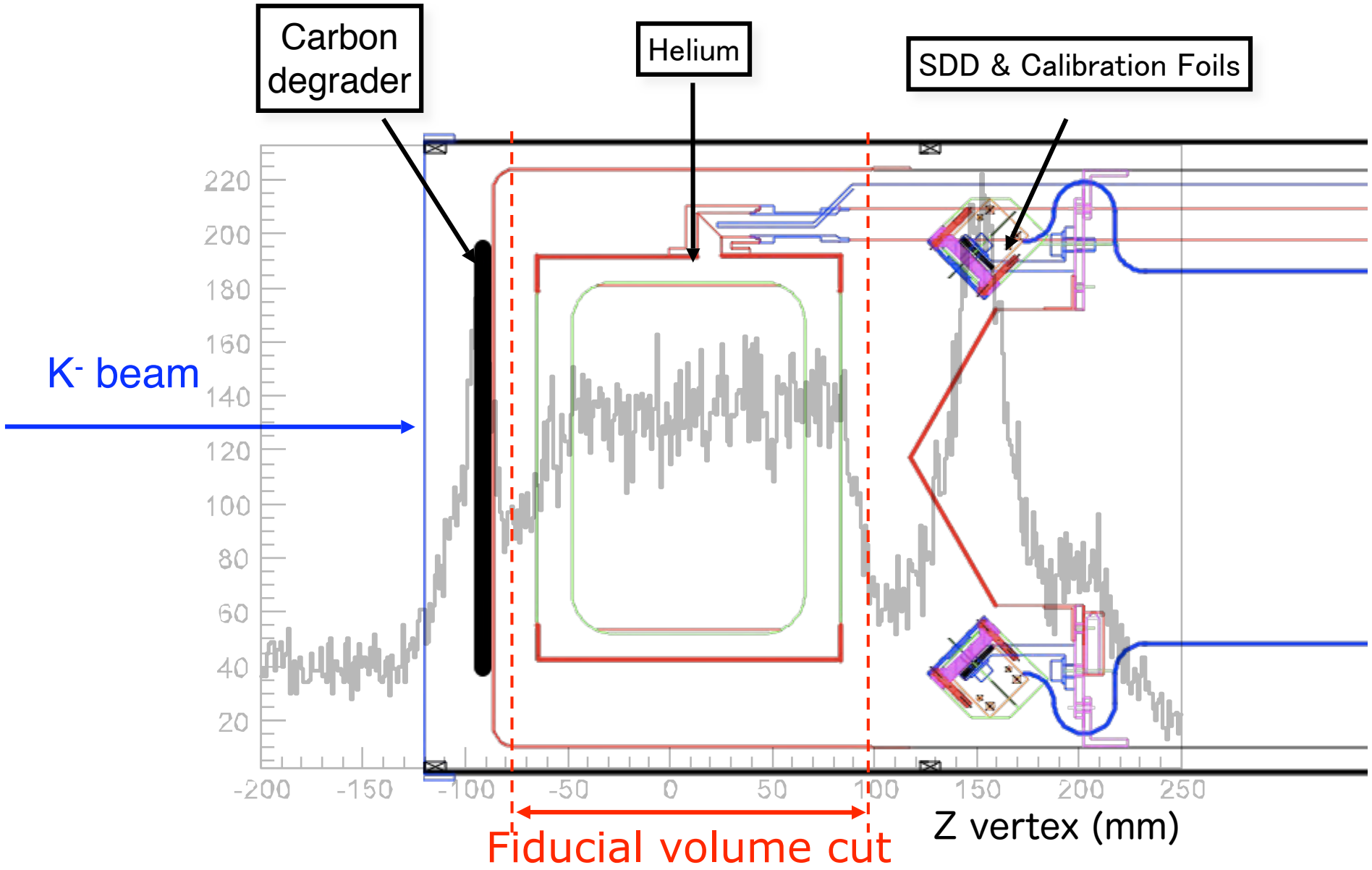
E570 target & X-ray detectors



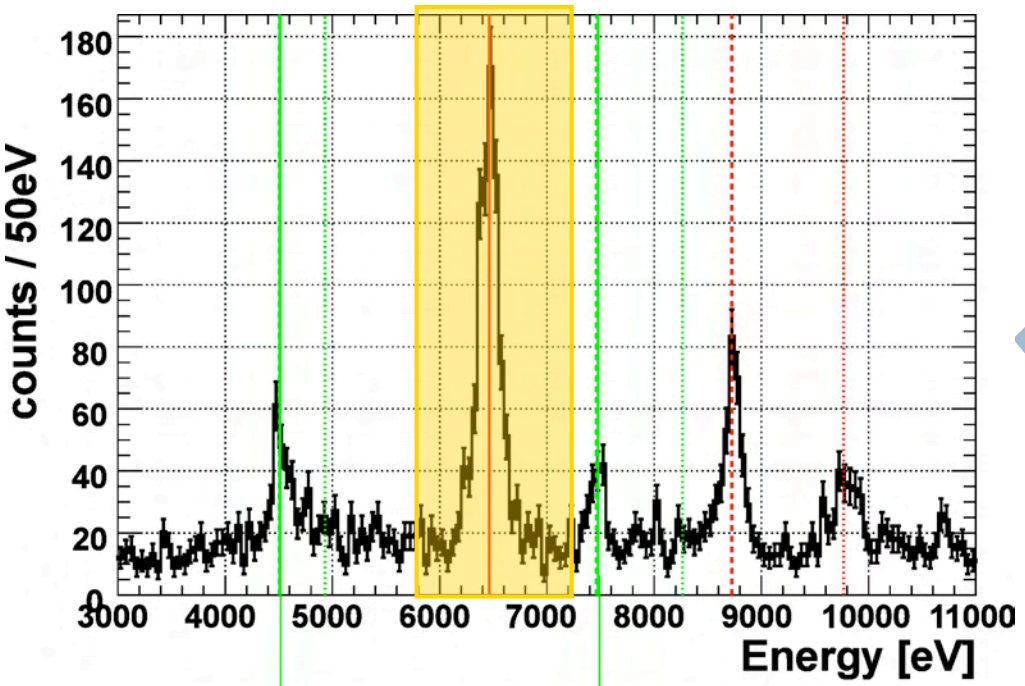


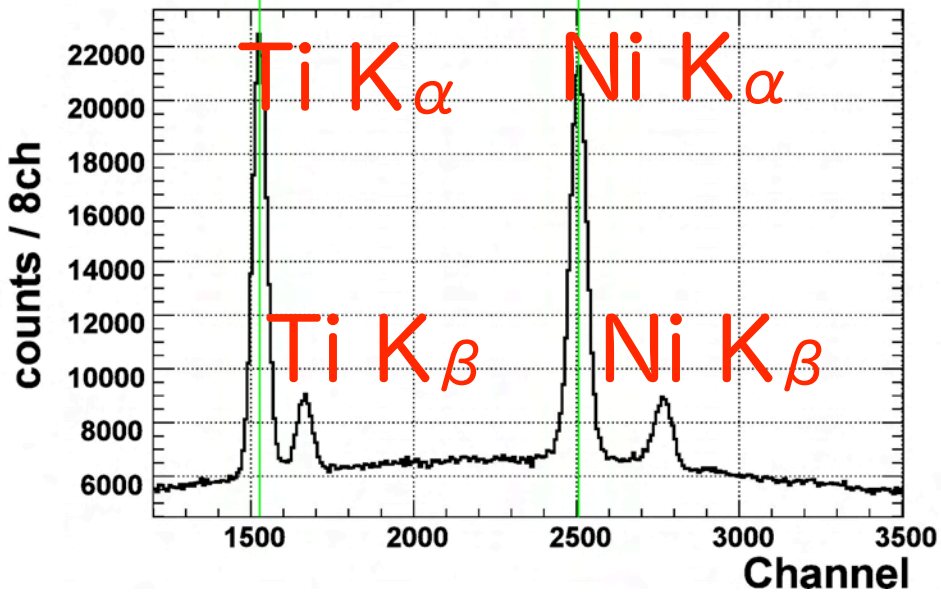


E570 Fiducial selection



E570 in-situ calibration





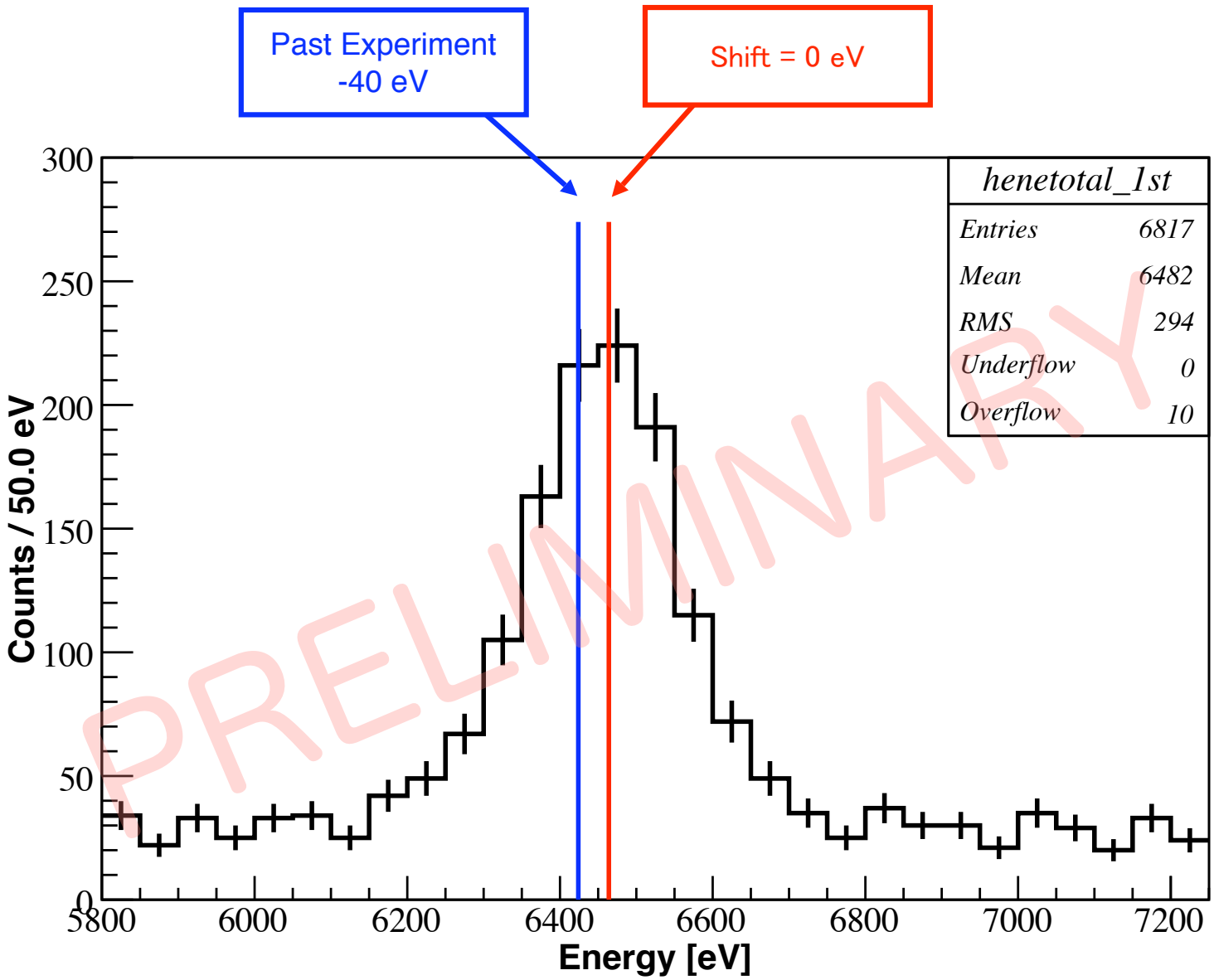
Kaon trigger,
Timing and fiducial cut
(kaonic helium X-ray)

Energy

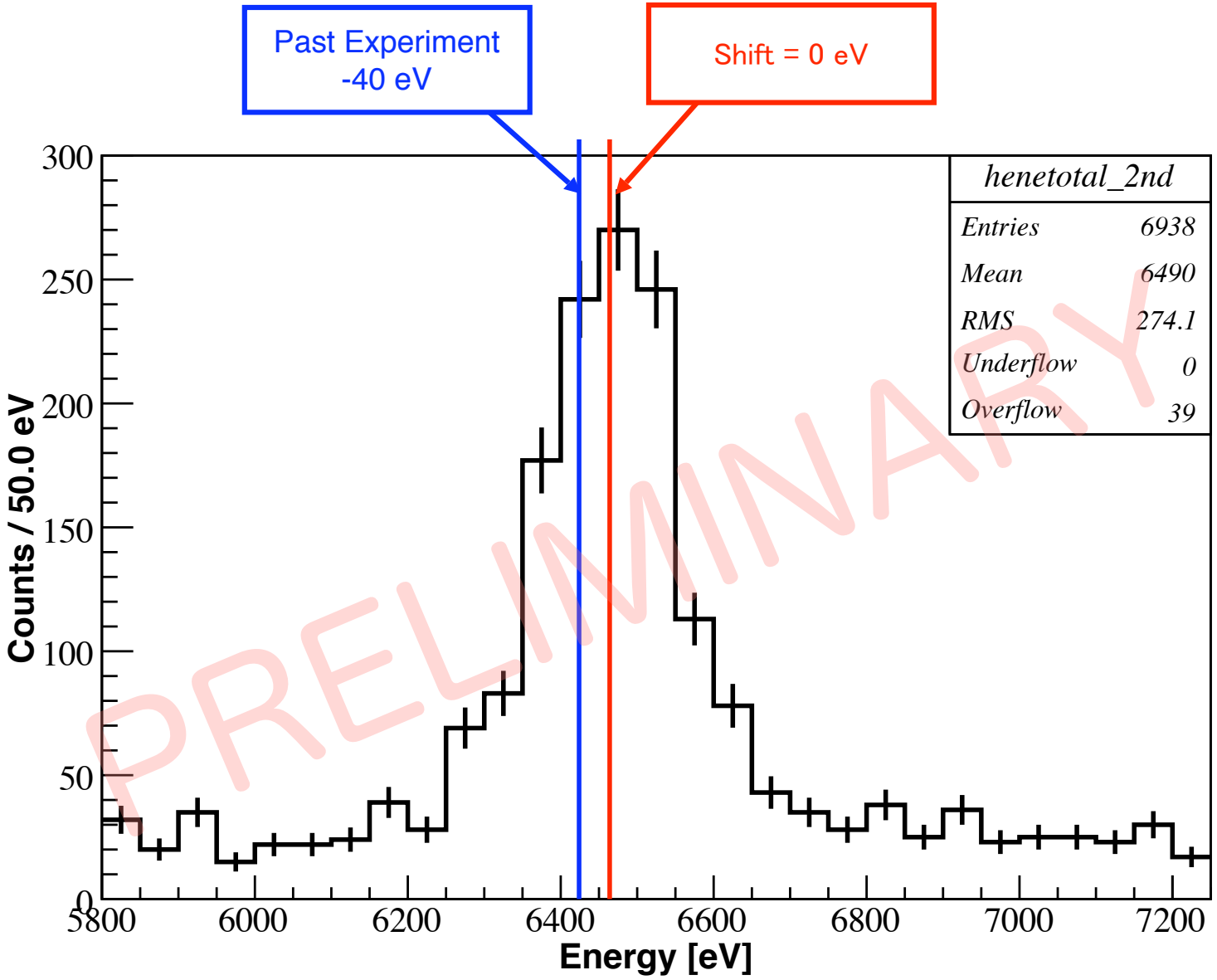
Channel

Self Trigger (calibration peaks)

E570 1st cycle (2005.Oct)



E570 2nd cycle (2005.Dec)



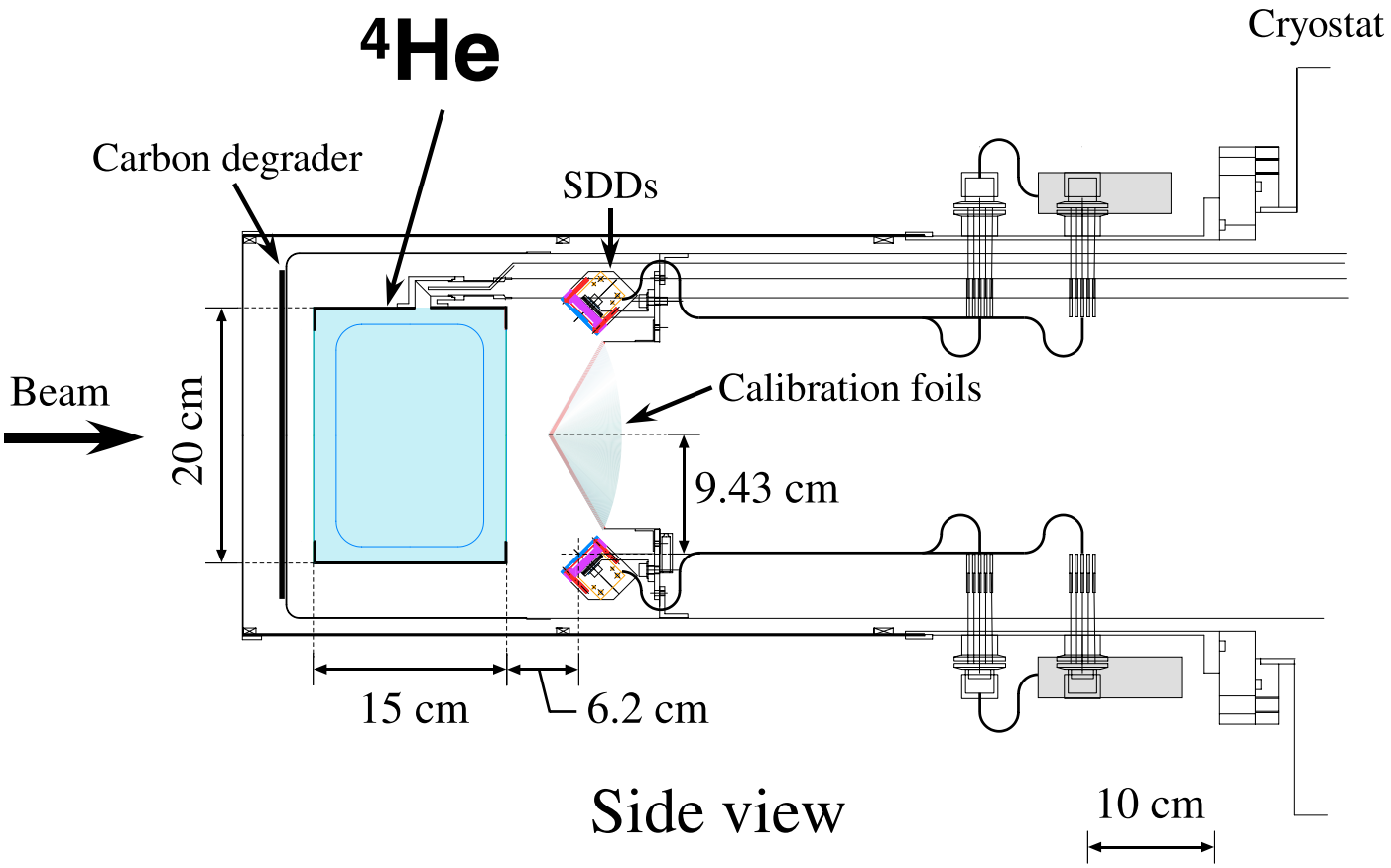
E570 status

- High quality data on ^{4}He accumulated
  - Resolution : 185 eV @6.5keV (SDD)
  - Statistical error : ~ 2 eV, Good S/N ratio (fiducial volume cut)
  - In-situ energy calibration (Ti & Ni X-rays)
- Previous 3 experiments are wrong, shift is likely to be $|\Delta E| \leq 10$ eV
- Now making sure that systematic error < statistical error

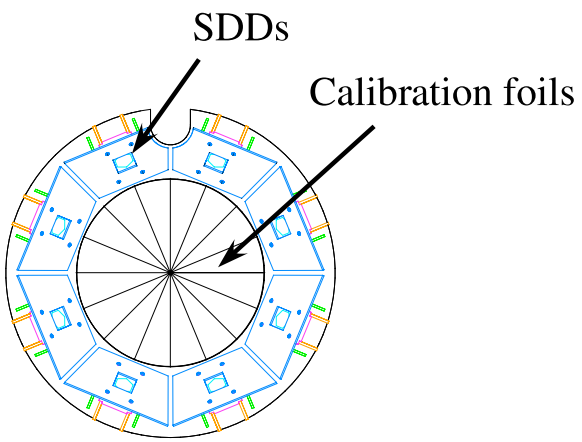
P17 strategy

- SDD, Fiducial cut, in-situ calibration as in E570
- ^{3}He target (mostly common to P15)
- small target volume (10% of E570)
  compensated by Be target window & SDD solid angle (x 3)
- stopped K^- @ K1.8BR
  (K1.8BR not optimized for stopped K^-, but expected yield > E570 @ full intensity)

E570

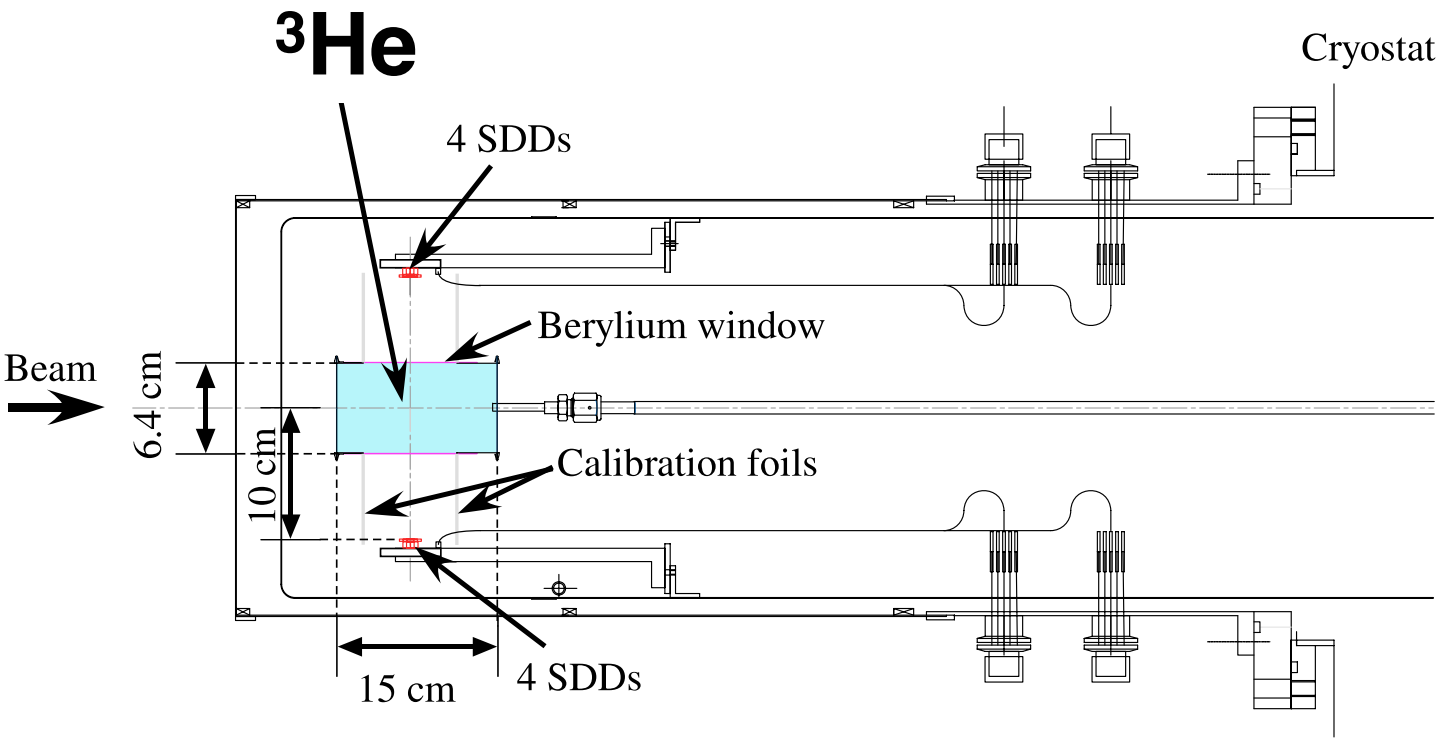


Side view

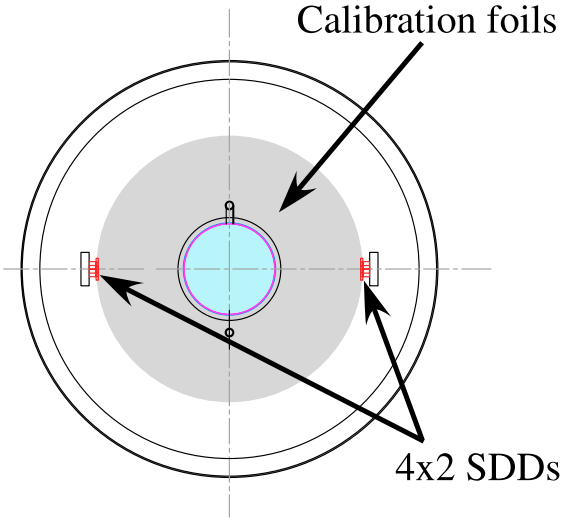


Front view

P17



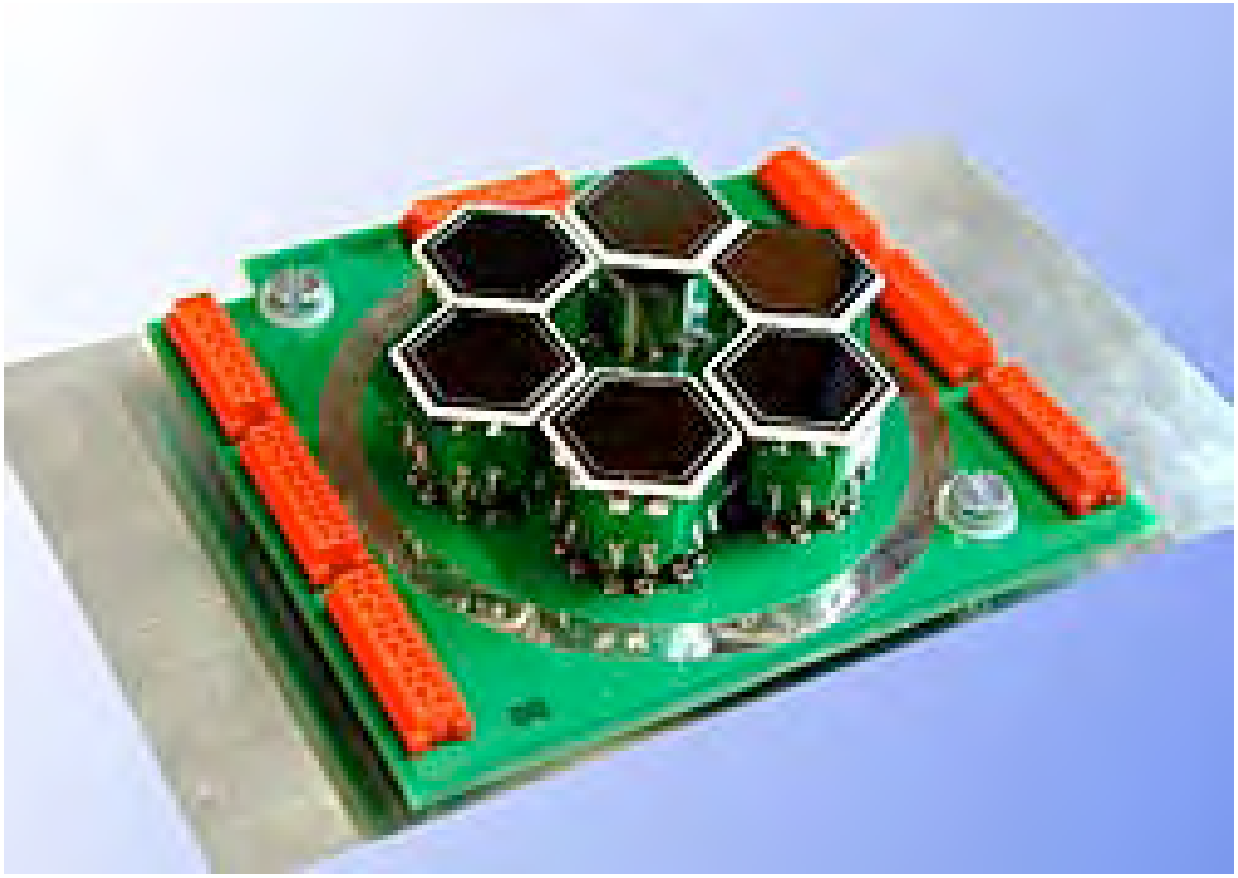
Top view



Front view

smaller target,
side Be window

4-element SDD arrays (x 2)



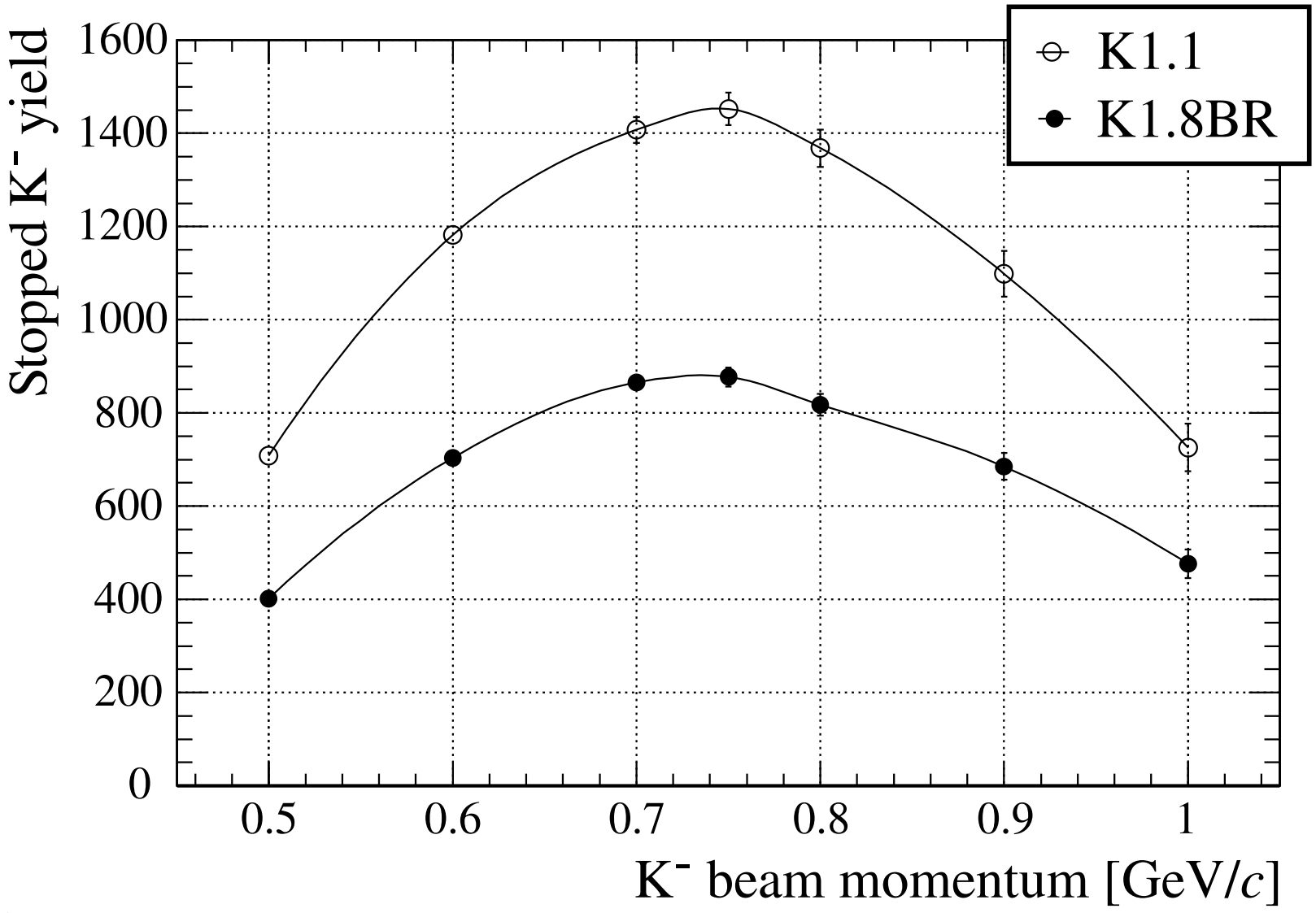
Similar to the array (KETEK 100 mm^2) shown here will be used

Optimum beam momentum: 0.75 GeV/c

E570: ~400 stopped K^- / spill

yield per spill

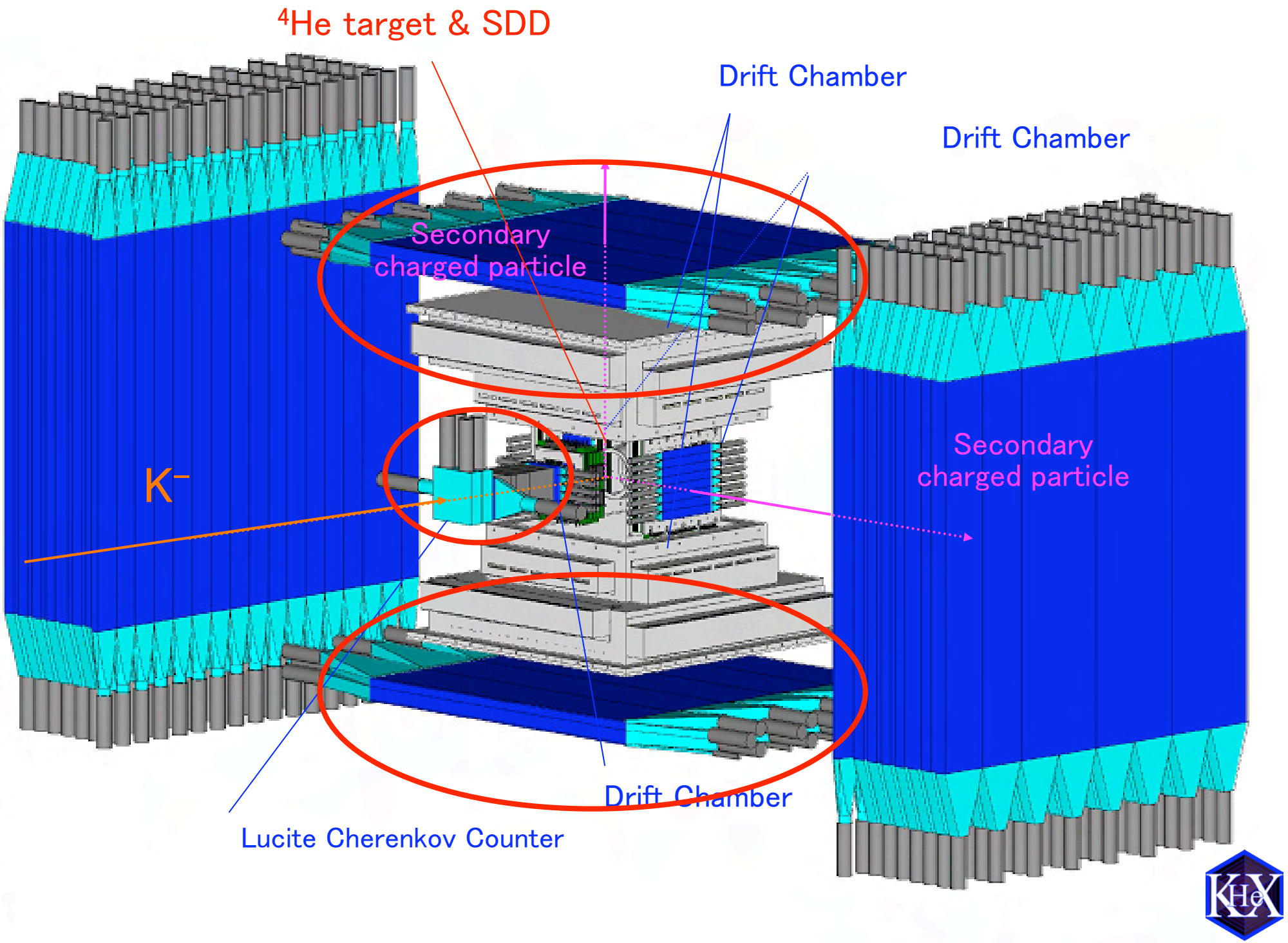
(flat top 0.7s, repetition 3.53s assumed)



Tracking detectors

In the proposal, we said

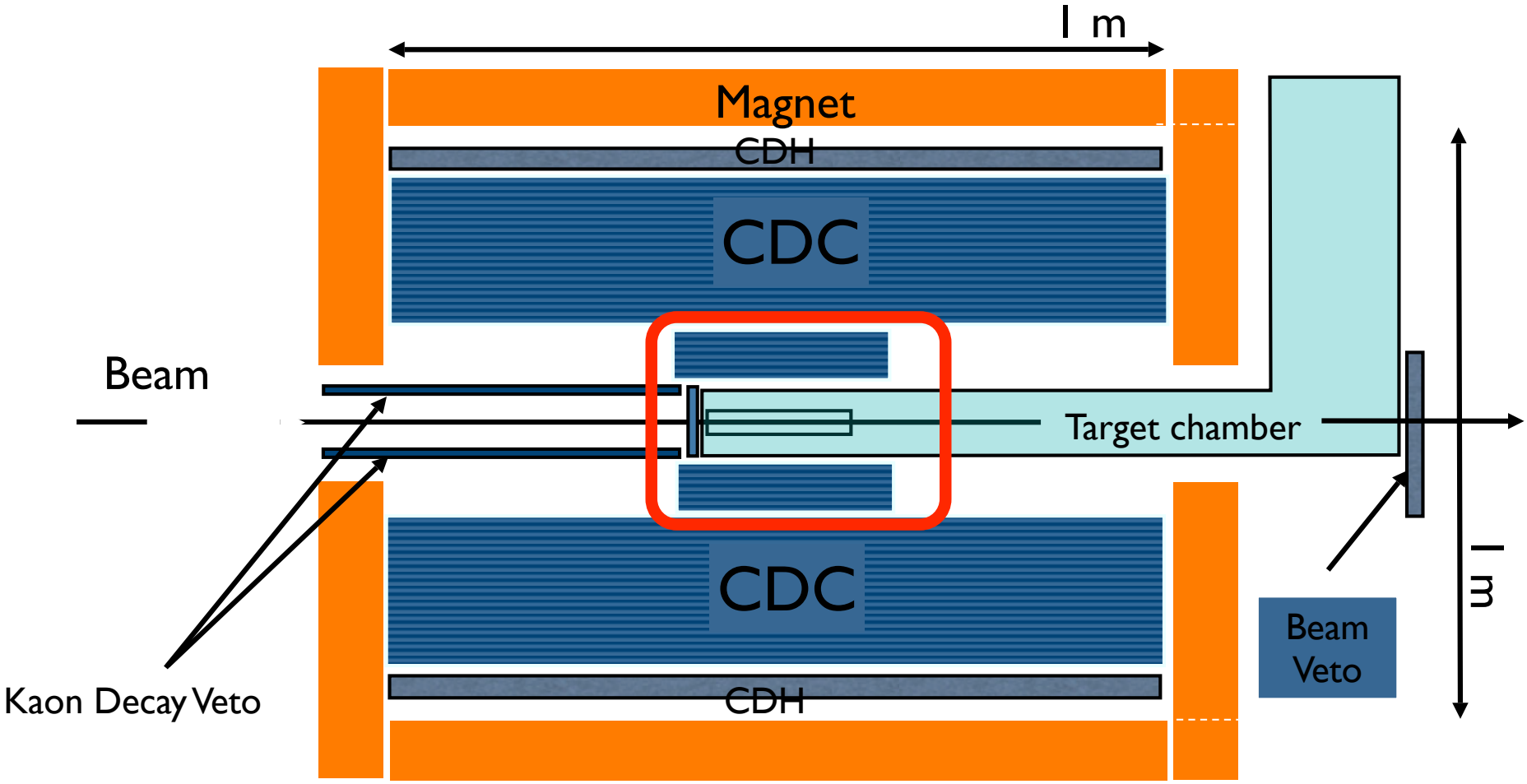
“The beamline tracking counters and chambers, and the “vertex” counters and chambers used in E570 will also be used in the present experiment. ”


^{4}He target & SDD
Drift Chamber
Drift Chamber
Secondary
charged particle
Secondary
charged particle
K$^-$
Drift Chamber
Lucite Cherenkov Counter

Tracking detectors

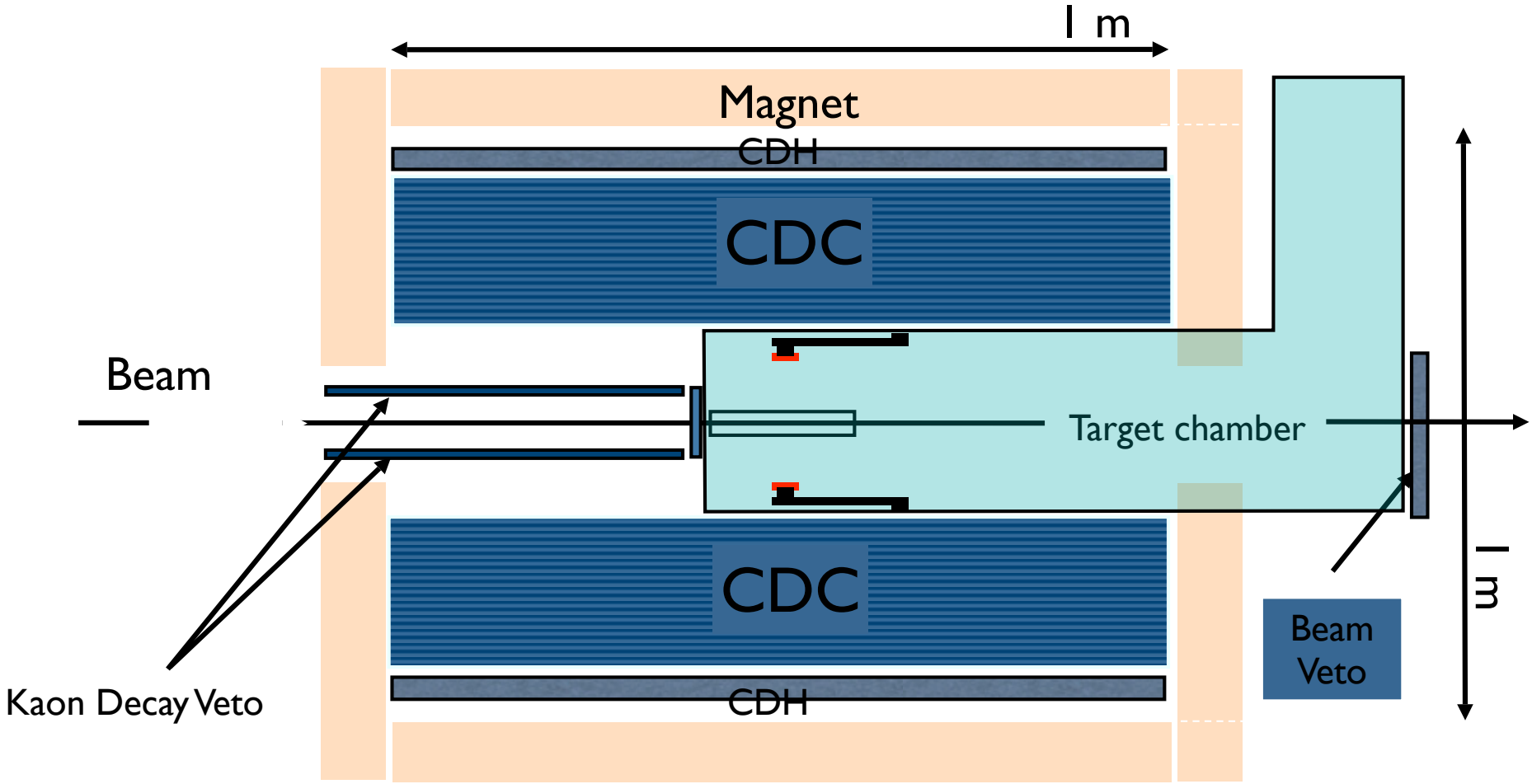
But we will instead use the CDS (Cylindrical Detector System) of P15

Cylindrical Detector System (CDS)



- CDS magnet : Solenoid magnet
- Cylindrical Drift Chamber (CDC)
- Cylindrical Detector Hodoscope (CDH)
- Veto counter : Kaon Decay Veto and Beam Veto

Cylindrical Detector System (CDS)



- Magnet not needed
- Inner tracking chamber removed
- Larger target vacuum vessel
- SDDs placed outside of the beam halo

P17 SUMMARY

Reaction	Stopped K^- + $^3He \rightarrow h\nu$(~6.4 keV) + X
Primary beam	30 GeV, 9 μA proton
Secondary beam	0.75 GeV/c K^-
Beamline	K1.8BR
Target	Liquid ^3He, diameter 6.4cm, length 15 cm (482.5 cm^3)
Detectors	8 x 100 mm^2 SDDs beamline counters & chambers (**P15**) vertex trigger counters & chambers (**P15**)
Beam time	10 days for commissioning +3.5 days at K1.8BR (full intensity) +35 days at K1.8BR (10% intensity)

- P17's physics goal closely related to that of P15
- Precise K^- ^{3}He X-ray shift: crucial information to understand the nature of kaon nuclear bound states
- high-quality physics output: 1 month - even with 10% of the PS intensity
- ideal for the DAY-1 experiment
- share resources with P15 (target, CDS, DAQ and people)
- Makes sense to run P17, and then P15