計画研究A01「多重ストレンジネスのバリオン間相互作用」研究紹介と報告

高橋俊行（KEK）

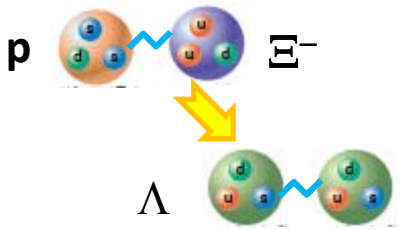
第２回ウィンタースクール・研究会

Outline

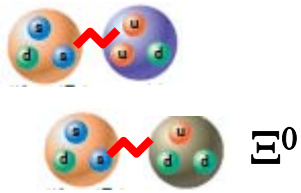
- Introduction
  - •Project of Group-A01
  - • (Previous studies on S=-2 system)
- Motivation and status of each experiment
  - •E07 (Emulsion exp.)
  - •E42 (H search by HypTPC)

A01 Bryon-baryon interaction with multi-straneness

ΞN→ΛΛ Int.



ΞN Int.

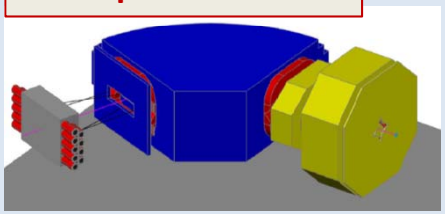


ΛΛ Int.

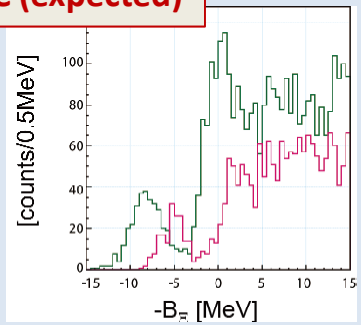
High density region of EOS

Spectroscopy of Ξ-Nucleus

S-2S Spectrometer



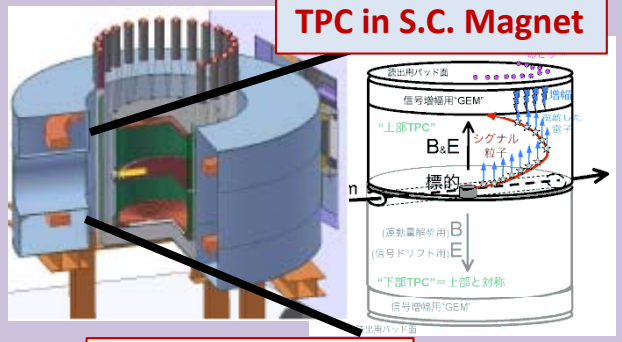
$^{12}_{\Xi}$C (expected)



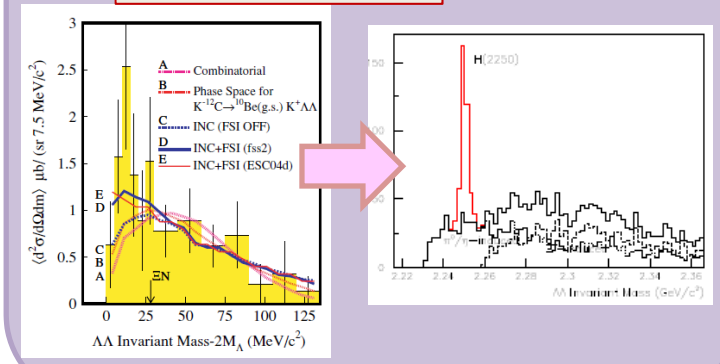
永江（特別推進）

ΛΛ corereton with L.A. Hyperon Spectrometer

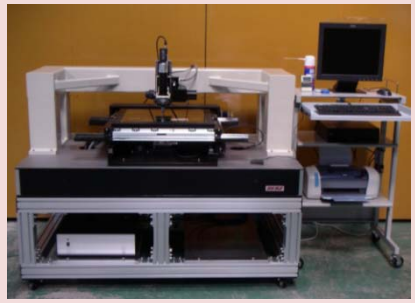
TPC in S.C. Magnet

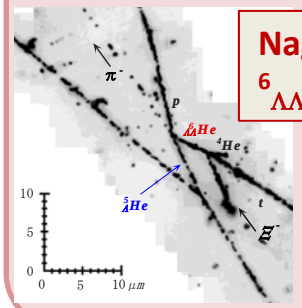


ΛΛ Invariant mass



Emulsion Exp.
＋Automatic Scaninng

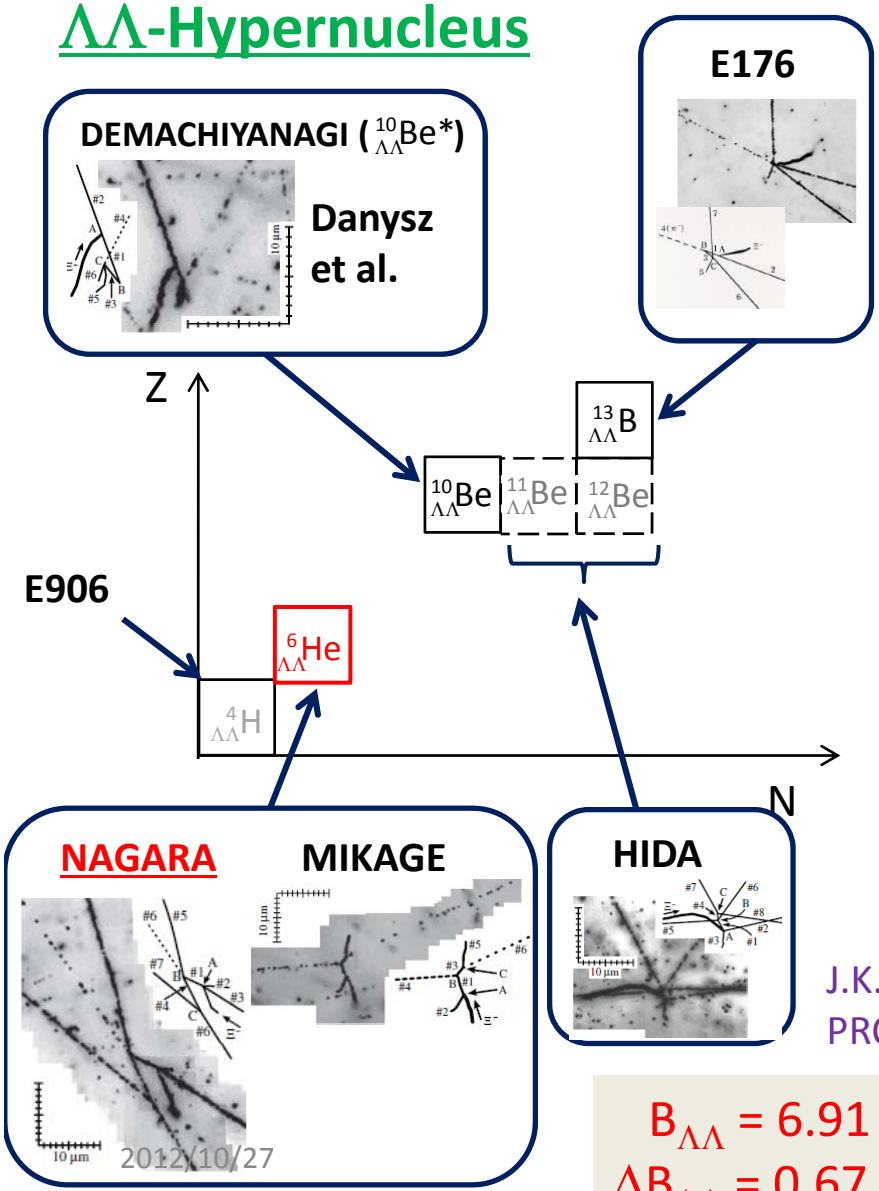




Nagara Event
$^{6}_{\Lambda\Lambda}$He

Information on S=−2 System, so far (1)

ΛΛ-Hypernucleus

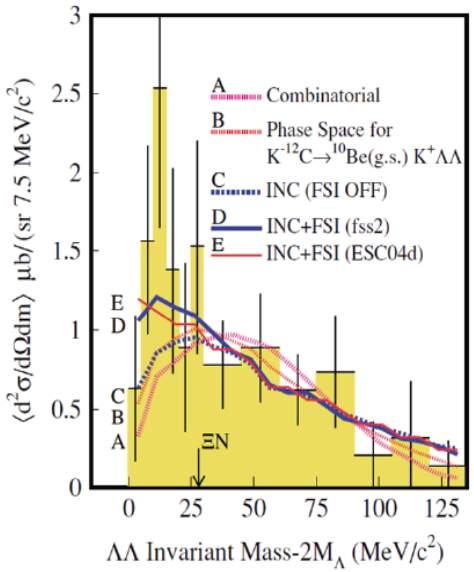


H-particle , ΛΛ-invariant mass

KEK-E522

Resonance *H* ?

C.J.Yoon et al.
PRC75(2007)022201(R)



Y. Nara et. al, Nucl. Phys. A 614(1997)433.
A. Ohnishi, et al, Nucl. Phys. A670(2000)297c, A684(2001)595, A691(2001),242c;Few-Body Syst. Suppl. 12 (2000), 367

$m_H \geqq 2223.7$ MeV/c²
(7MeV window for bound *H*)

J.K. Ahn et al.
PRC 88 (2013) 014003

$B_{\Lambda\Lambda} = 6.91 \pm 0.16$ MeV
$\Delta B_{\Lambda\Lambda} = 0.67 \pm 0.17$ MeV

weakly attractive

Information on S=−2 System, so far (2)

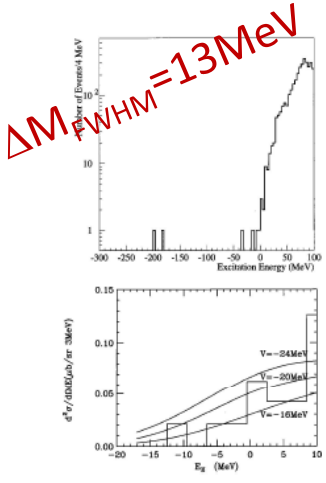
Ξ-Nucleus Missing mass spectroscopy of $^{12}C(K^-,K^+)^{12}_{\Xi}Be$

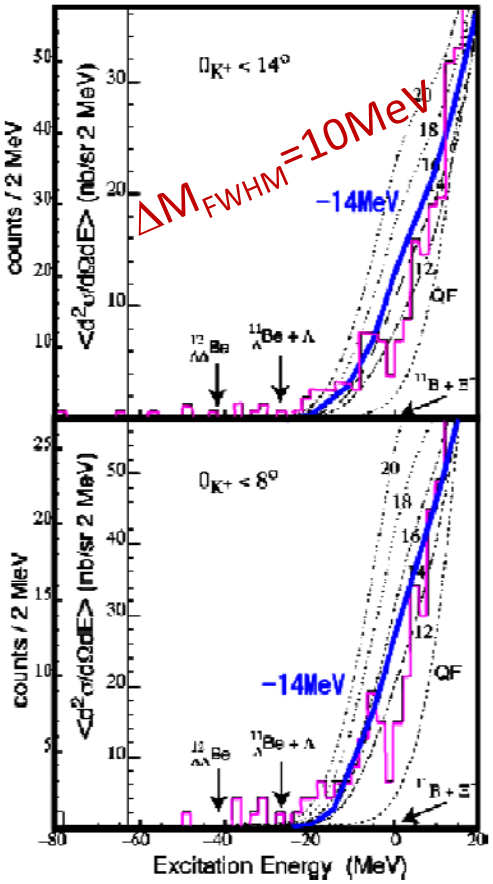
No clear peak was observed...,

Spectrum shape suggests attractive potential for Ξ.

KEK E224

T.Fukuda et. al,
PRC58(1998)1306





BNL AGS E885

U_{Ξ}=-14 MeV

P.Khaustov et. al,
PRC61(2000)054603

−20 < E < 0 MeV	89±14 nb/sr θ< 8° 42± 5 nb/sr θ<14°

Twin Λ hypernuclei from Ξ⁻ capture

A.Ichikawa et. al, Phys.Lett.B500(2001)37

$\Xi^- + {}^{14}N \rightarrow {}^{5}_{\Lambda}He + {}^{5}_{\Lambda}He + {}^{4}He + n$

B_{Ξ}=−2.6±1.2 MeV

Motivation of J-PARC E07 (Emulsion Exp.)

- Detection of double hypernuclei by new hybrid method
  - 10 times' statistics of E373 ⇔ 10^4 Ξ^- stop
    10^2 double hypernuclei
    ~10 identified nuclides
  - Nuclear (A) dependence of $\Lambda\Lambda$ binding energy
  - H-dibaryon !?
  - Ξ-N interaction via twin Λ hypernclei

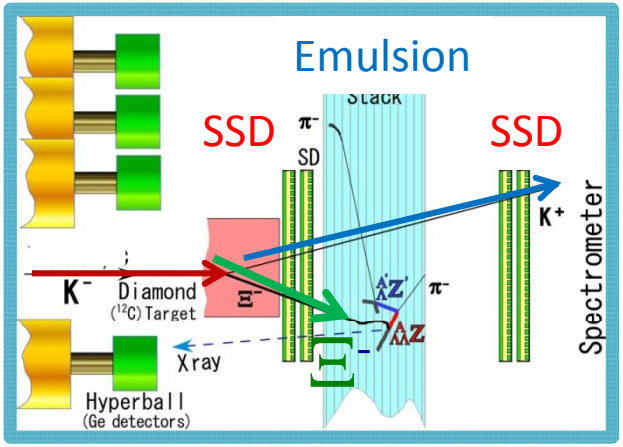
  ⇒ needs to develop new emulsion analysis methods
  Umehara (Poster), J.Yoshida (Talk)
- X-rays from Ξ-atom (Ag/Br) tagged by the emulsion
  - Ξ-Nucleus potential in the surface region
    ⇔ Spectroscopy of Ξ-hypernuclei

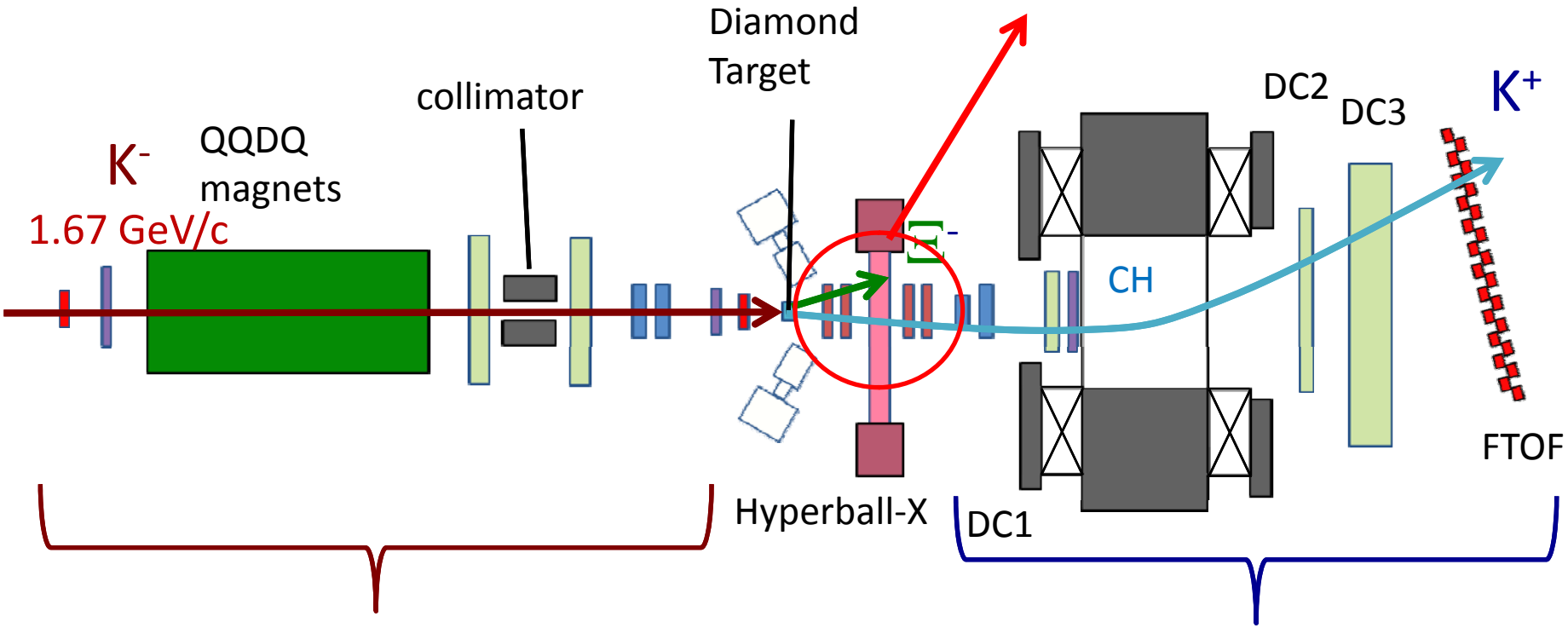
Effects of J-PARC Hadron Accident

- Construction of K1.1BL and relocation of SKS to K1.1 from K1.8 (planned in 2013 summer) were postponed.
  - Beam time of E07 (at K1.8) will be delayed by 1.5-2 years
    - Detector setup 2013 autumn → 2015 summer or later
    - Beam irradiation 2014.3 → 2016.1 or later
  - Run plan will be discussed in the next PAC (2015 May)
- User activities at J-PARC has been restricted.

E07 Setup

K1.8 Beam Line @J-PARC

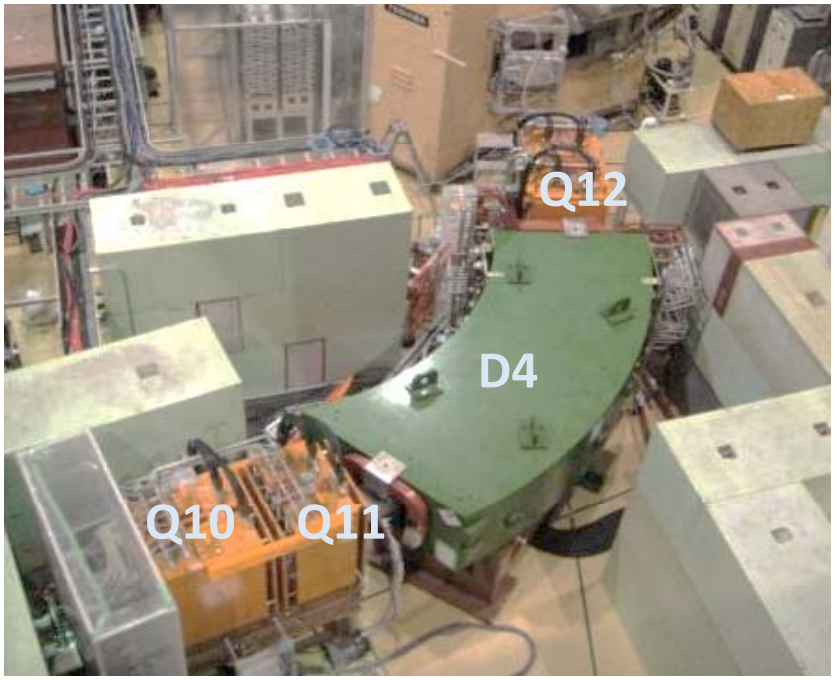


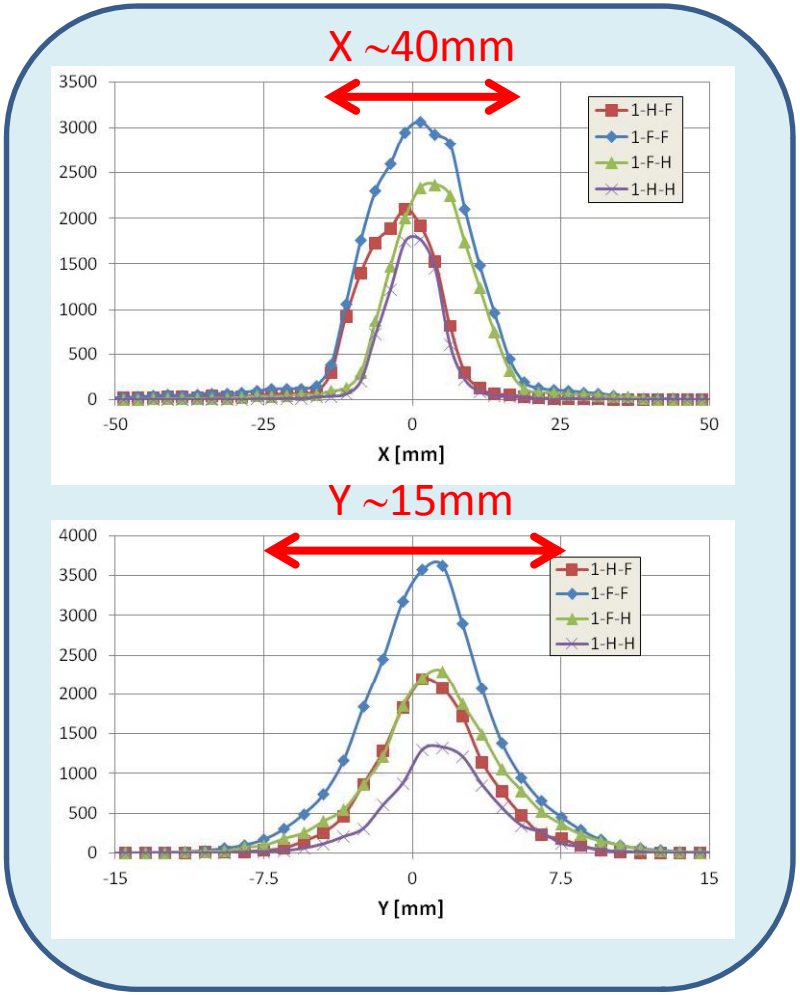


K^- beam & B.S.

remove Q13 & install collimator

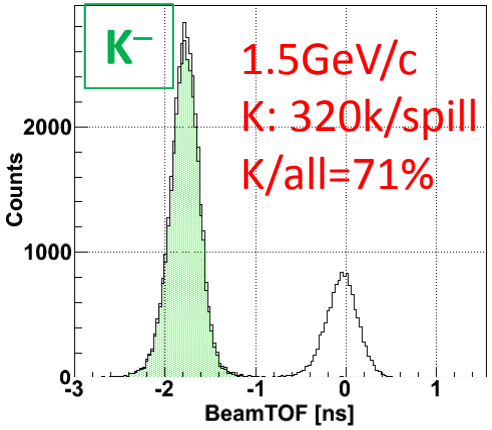
⇒ BL is shorten by 50cm

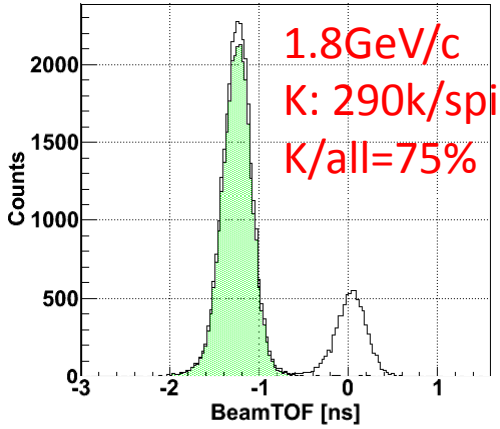




E13 commissioning at 20kW

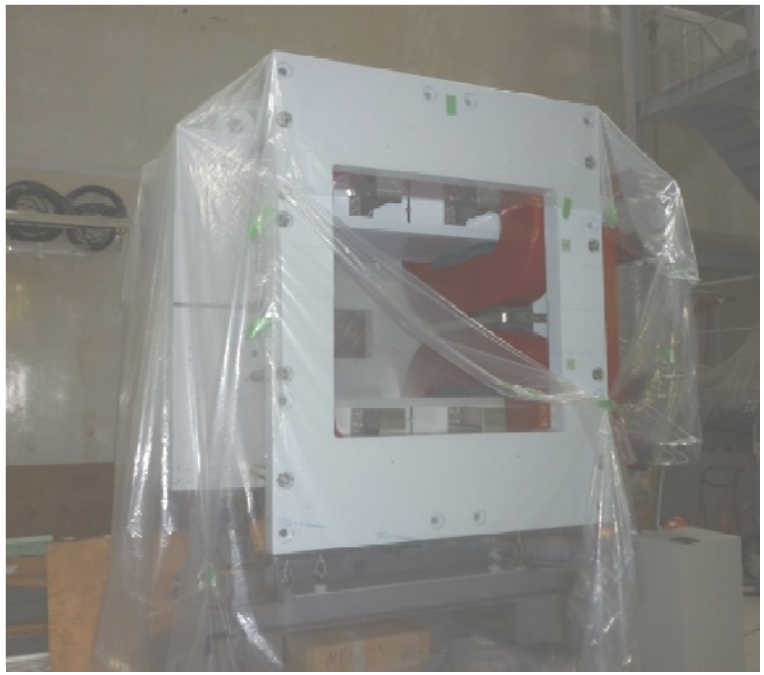
ESS1/ESS2 = ±250kV (max ± 375kV)





KURAMA spectrometer

KURAMA magnet
(from downstream)



gap: 50cm → 80cm (x 1.25)
to compensate the reduction
of emulsion (2.6 t → 2.1 t)

Downstream drift chambers

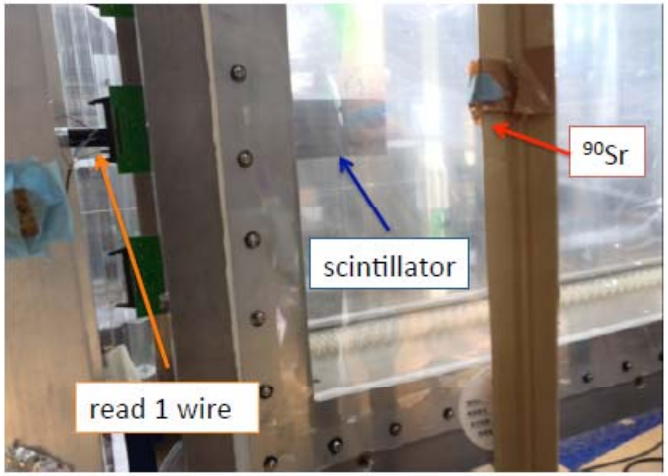
DC2 (KL chamber)
1185 x 1185 mm^2
XX'YY'
9mm spacing

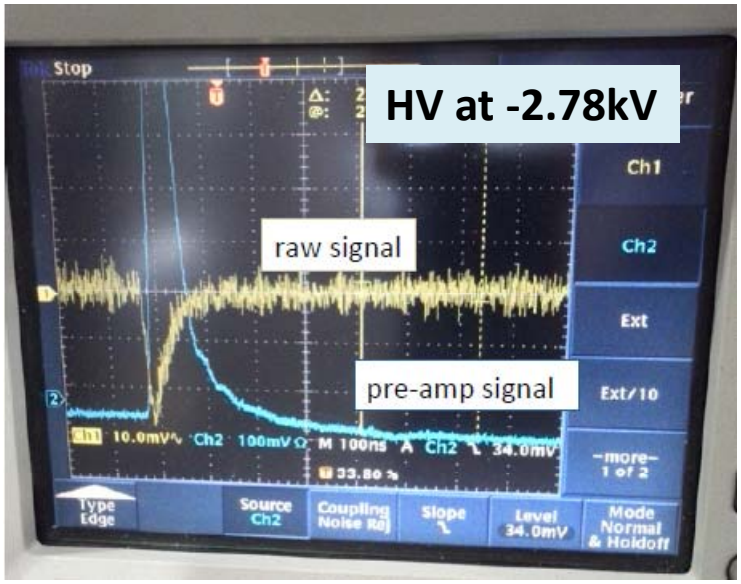
DC3 (AIDA chamber)
1900 x 1280 mm^2
XX'YY'
20 mm spacing

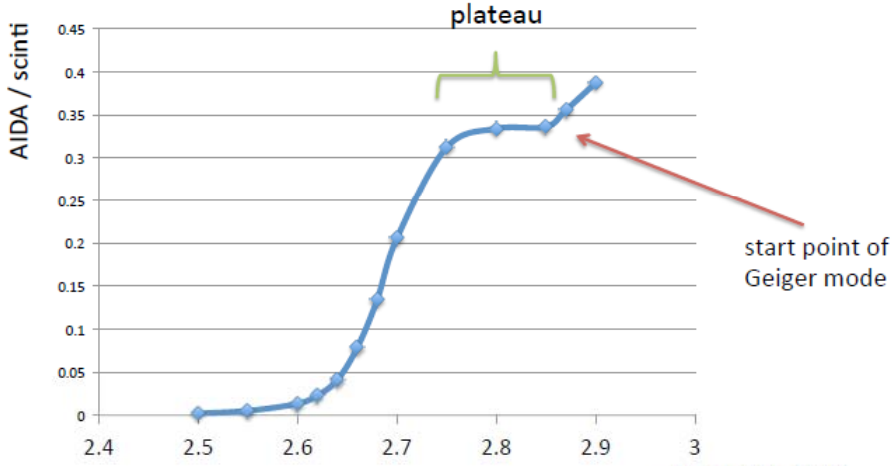
Test of AIDA chamber (1)

Ekawa (Kyoto)

Plateau curve by single wire measurement







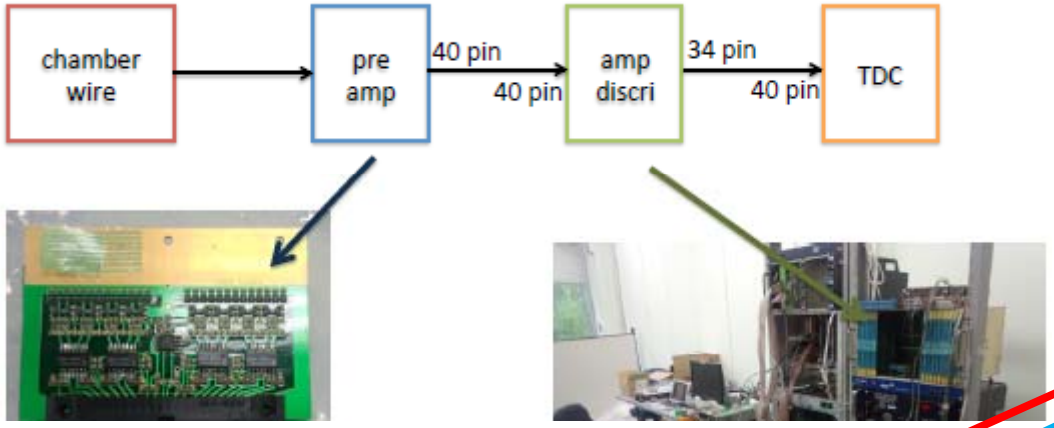
.8 kV is good.

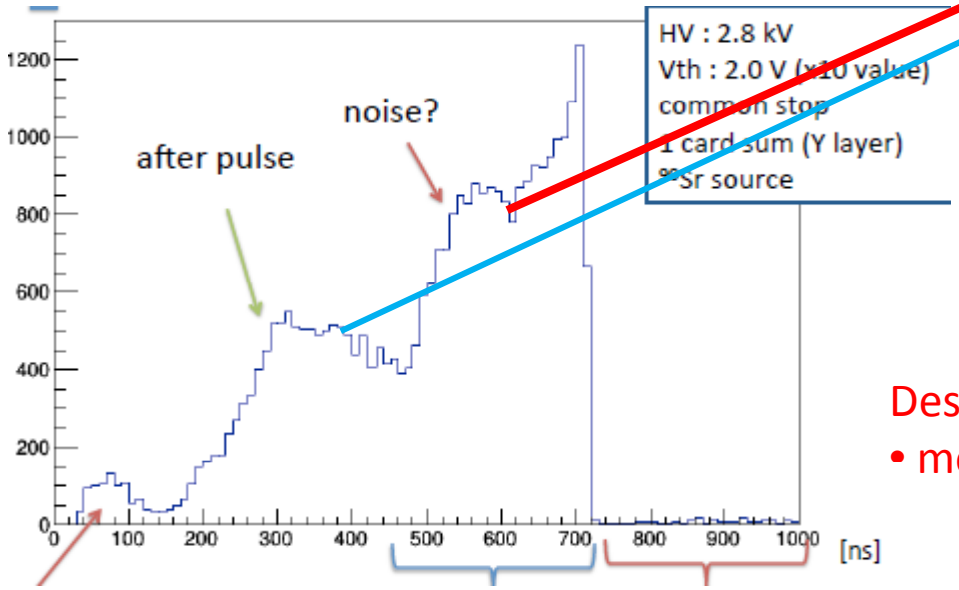
-2.8kV is enough

Test of AIDA chamber (2)

Ekawa (Kyoto)

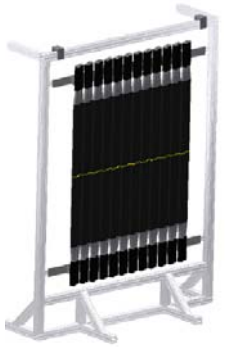
16 channels (1 card) readout using TDC (DAQ)





Problems
- after pulse
- noise reduction

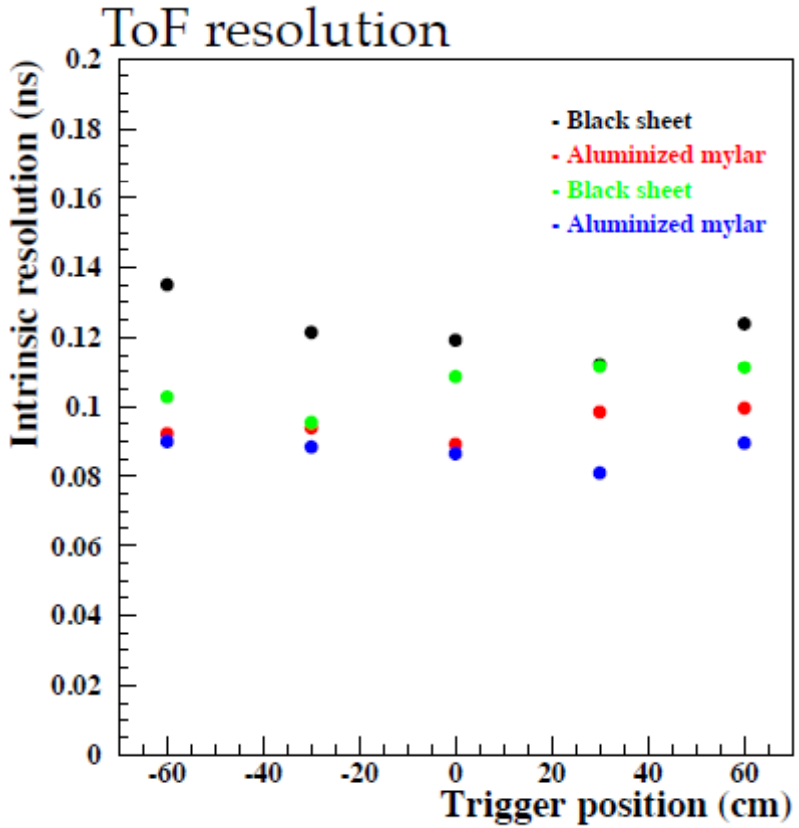
Design of the supporting frames is underway
- movable system for the access of upstream



Forward Time Of Flight wall Assembly began

Hwang (JAEA)

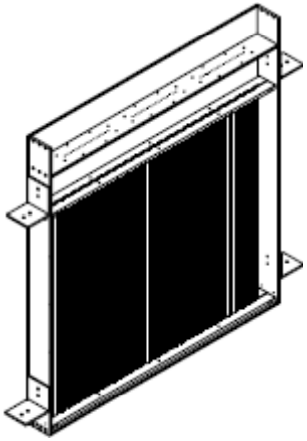
Wrapping material dependence

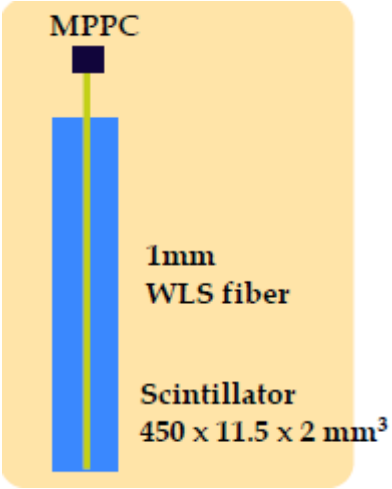


σ < 100ps with Aluminized mylar

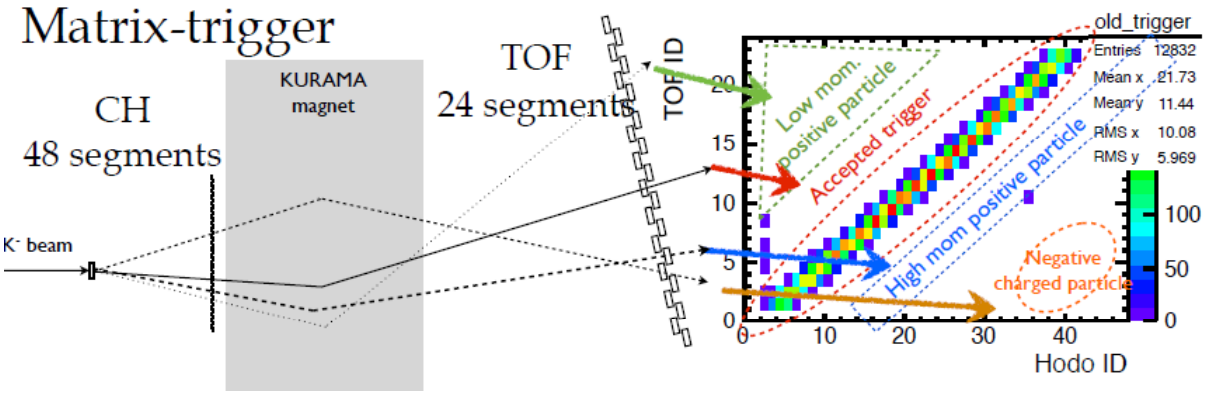
Charge Hodoscope (CH) & Matrix/Mass Triggers to reduce trigger rates

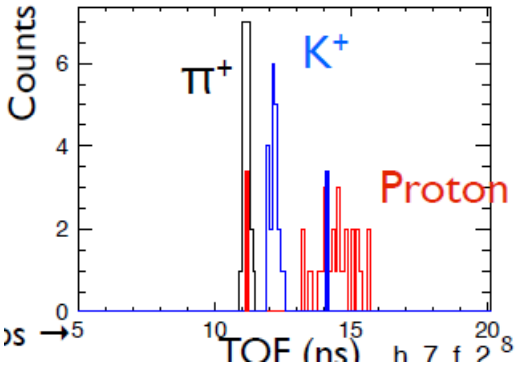
Hwang (JAEA)





- 48 segments
- WLS fiber + MPPC R.O.
- 10.5mm spacing
- 458 x 400 mm^2 eff. area





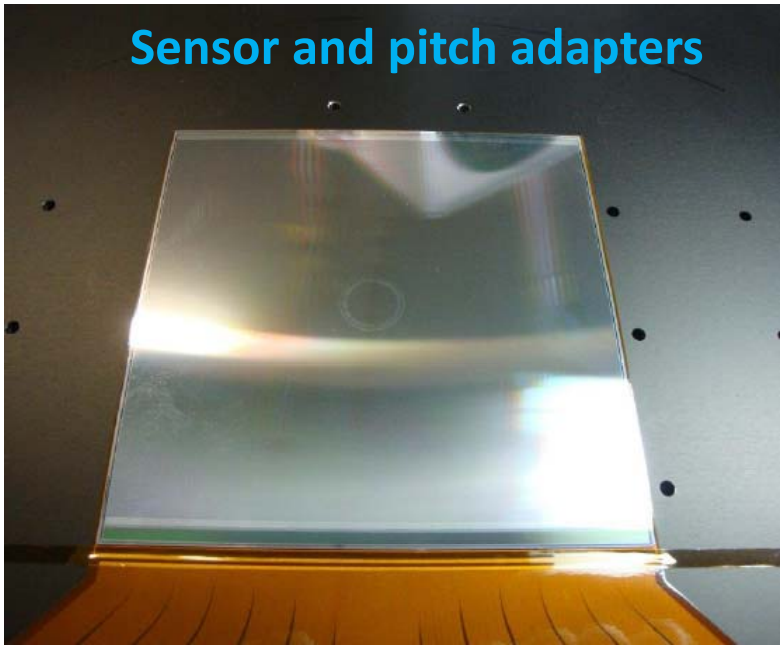
SSD

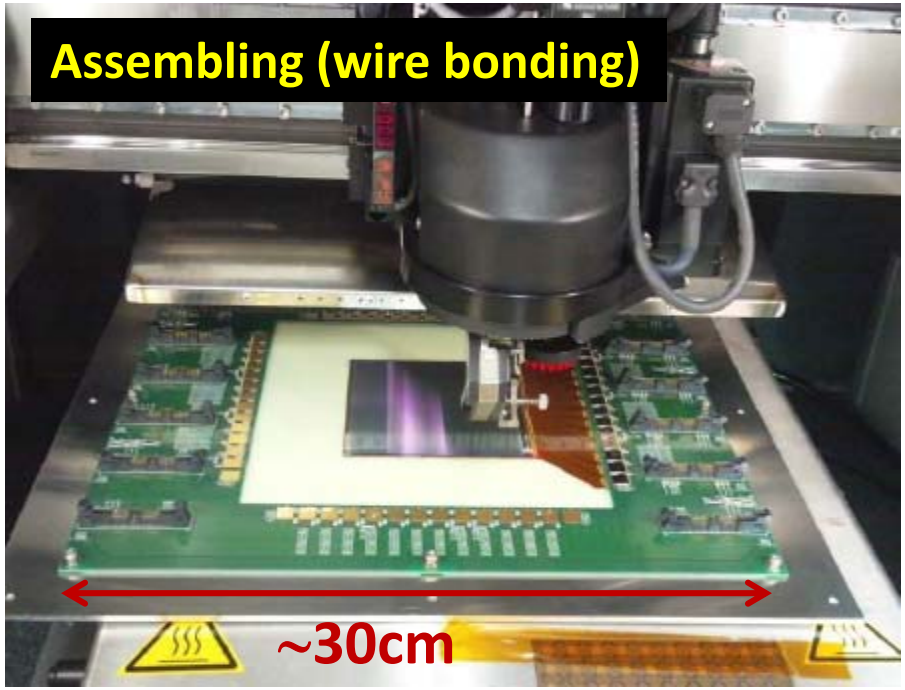
Watabe(Nagoya), Kiuchi(JAEA),J.Lee,Tanida(Soeul)

Sensor (Hamamatsu)
- single-side 50μm pitch
- N-bulk with 320μm thickness
- 90 x 90 mm^2

Configuration
- XYXY stacks at up- and down-stream of the emulsion
- 77x77 mm^2 eff. area
- 1536/1792 ch./layer R.O.
- APV front-end for DAQ

ΔX ~20μm ,$\Delta X'$ <20mrad
good enough for guide of automatic tracking in the emulsion

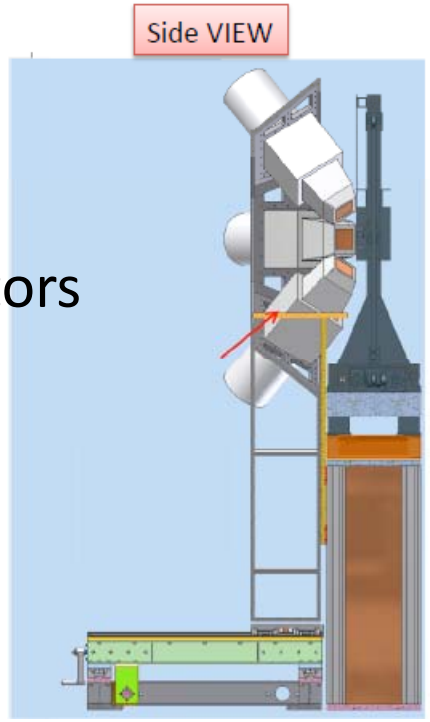


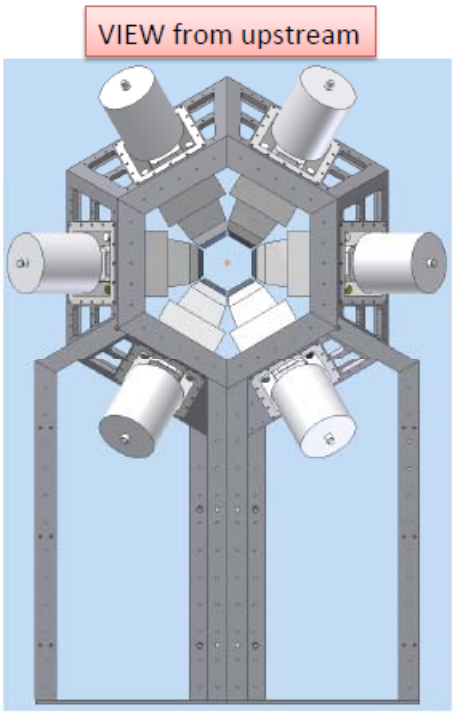


Hyperball-X

Hosomi(JAEA), Tohoku-group

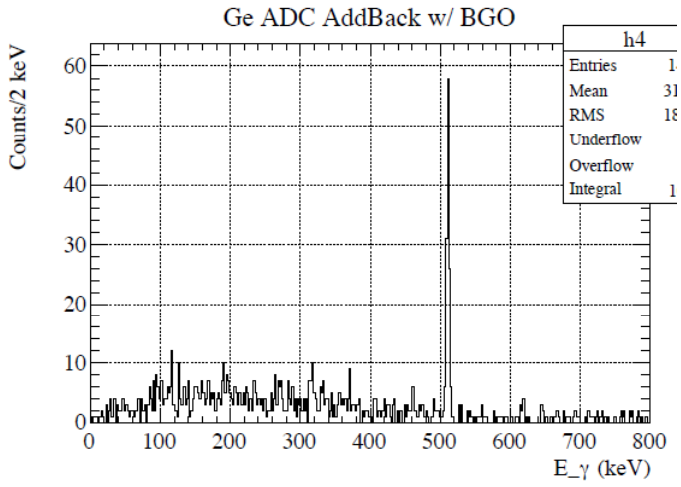
- 6 units of clover-type Ge detectors
- 1 unit has 4 crystals
- BGO for B.G. (π^0 & Compton) suppressor
- ~3% photo-peak efficiency at 350keV



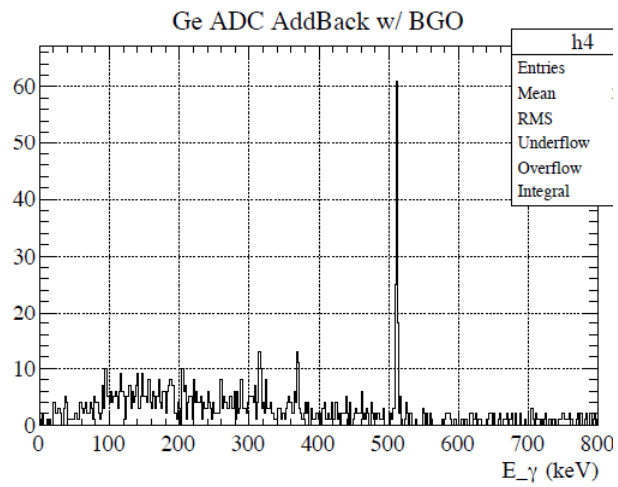


Simulation

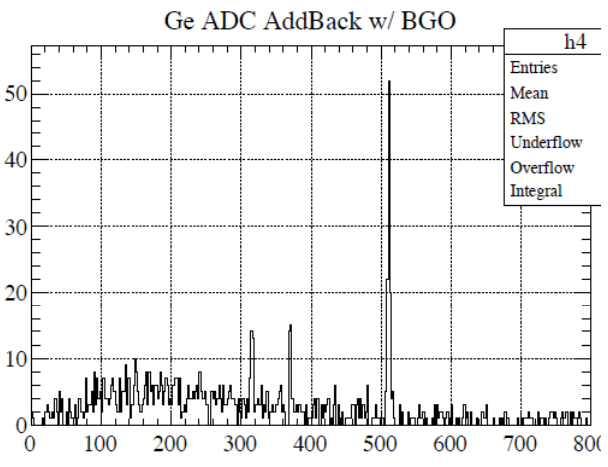
PΞ = 0.3



PΞ = 0.45



PΞ = 0.6



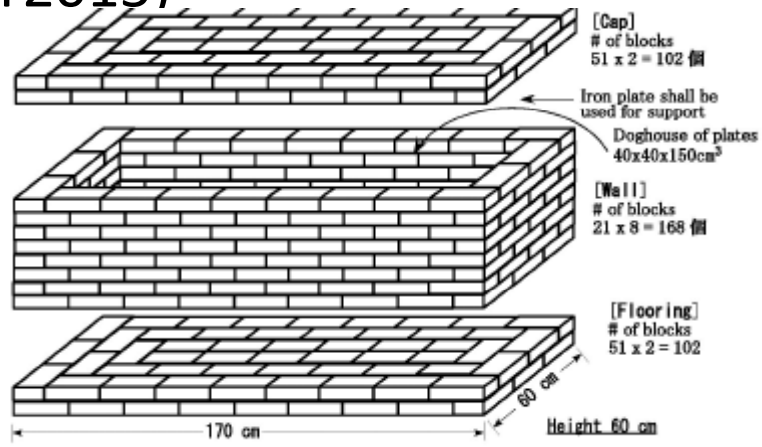
Emulsion

Nakazawa, Yoshida,Umehara, Kinbara, Mishina, Kyaw, ... (Gifu)
Toho-Univ. group

- Emulsion gel of 2.1 t was purchased.
- The first 240kg was arrived on Dec.6 (Gifu-U)
- Emulsion plate making has just begun
  10 days for 144 plates (34.5 x 35.0 cm^2)
  will be finished by end of March

Produced emulsion plates are stored
in the box of Lead blocks
at Kamioka-Mine until beam irradiation (JFY2015)
in order to avoid irradiation of cosmic-rays
and Compton electrons.

Box making was done on Dec. 24.



Summary (E07)

- E07 aims to collect 10 times' statistics of double hypernucleus of the previous experiment
  - A-dependence of $\Lambda\Lambda$ binding energy
  - ΞN interaction from twin hypernuclei /
    X-ray measurement from Ξ-atoms
- Schedule will be delayed by 1.5-2 years due to the Accident.
- However, construction of the detectors and emulsion is gradually underway.

Status of H-dibaryon Search Experiment at J-PARC (E42)

Hiroyuki Sako (JAEA)
for J-PARC E42 Collaboration

Outline

- Introduction
- TPC design
- R&D Status
- Summary

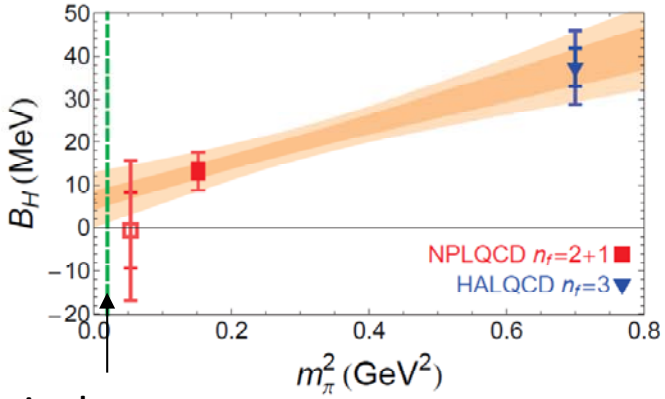
Search for H-dibaryon

Most stable and compact 6-quark state (*uuddss*)

Lattice-QCD calculations

Binding energy : -13 ~ +7 MeV

H may be slightly bound or unbound



Physical π mass

Experimental search

- Peaks observed

by KEK-E224, E522

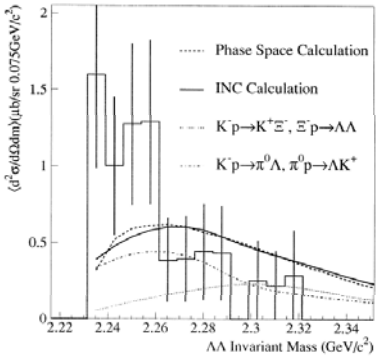
around ΛΛ mass threshold

  - Indication of H?
  - Statistics not enough

High statistics experiment

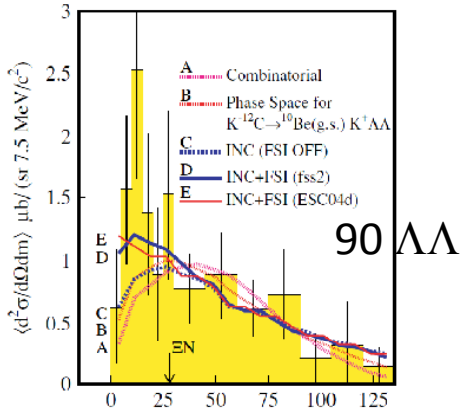
at J-PARC

KEK-E224



m-2m$_\Lambda$(MeV/c^2)

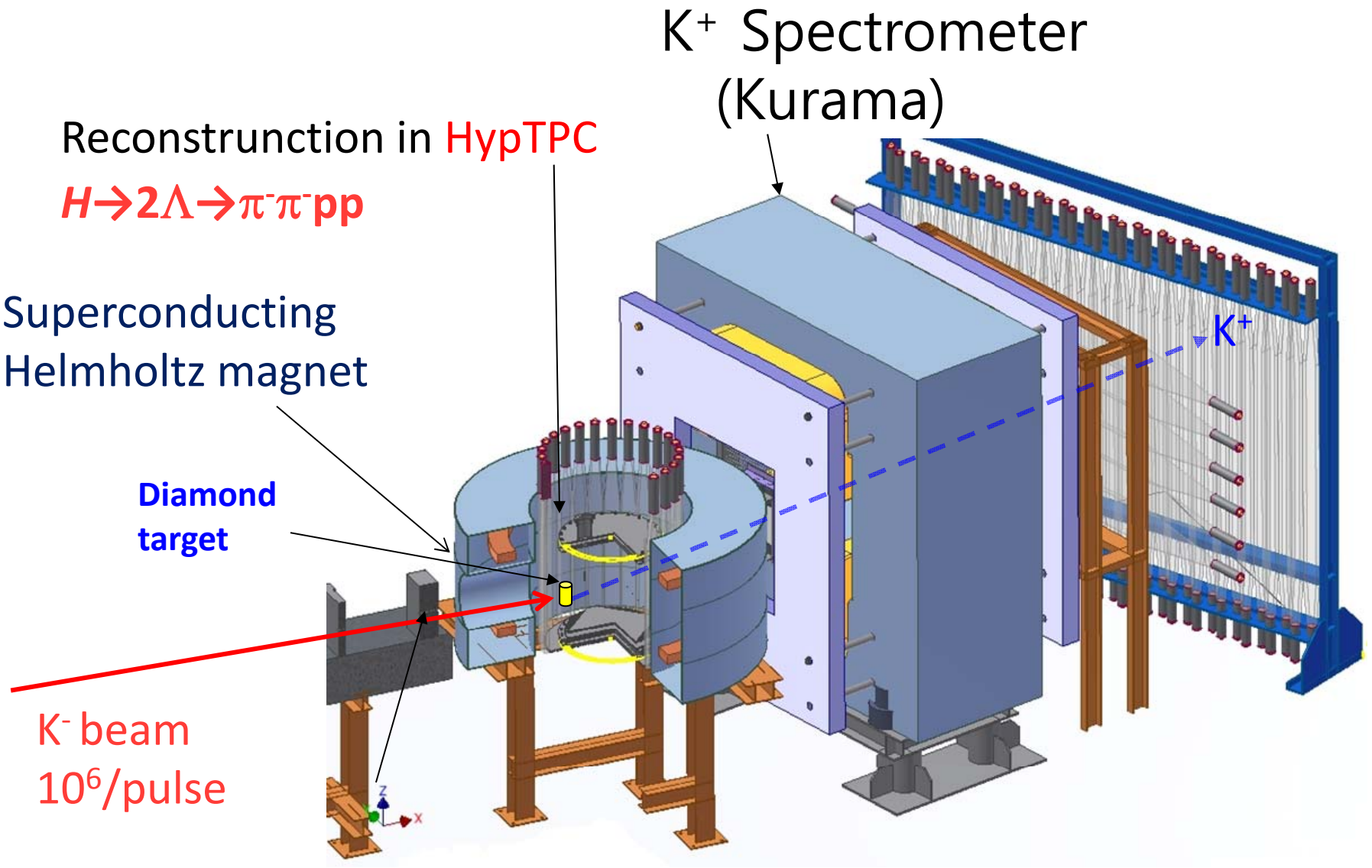
KEK-E522



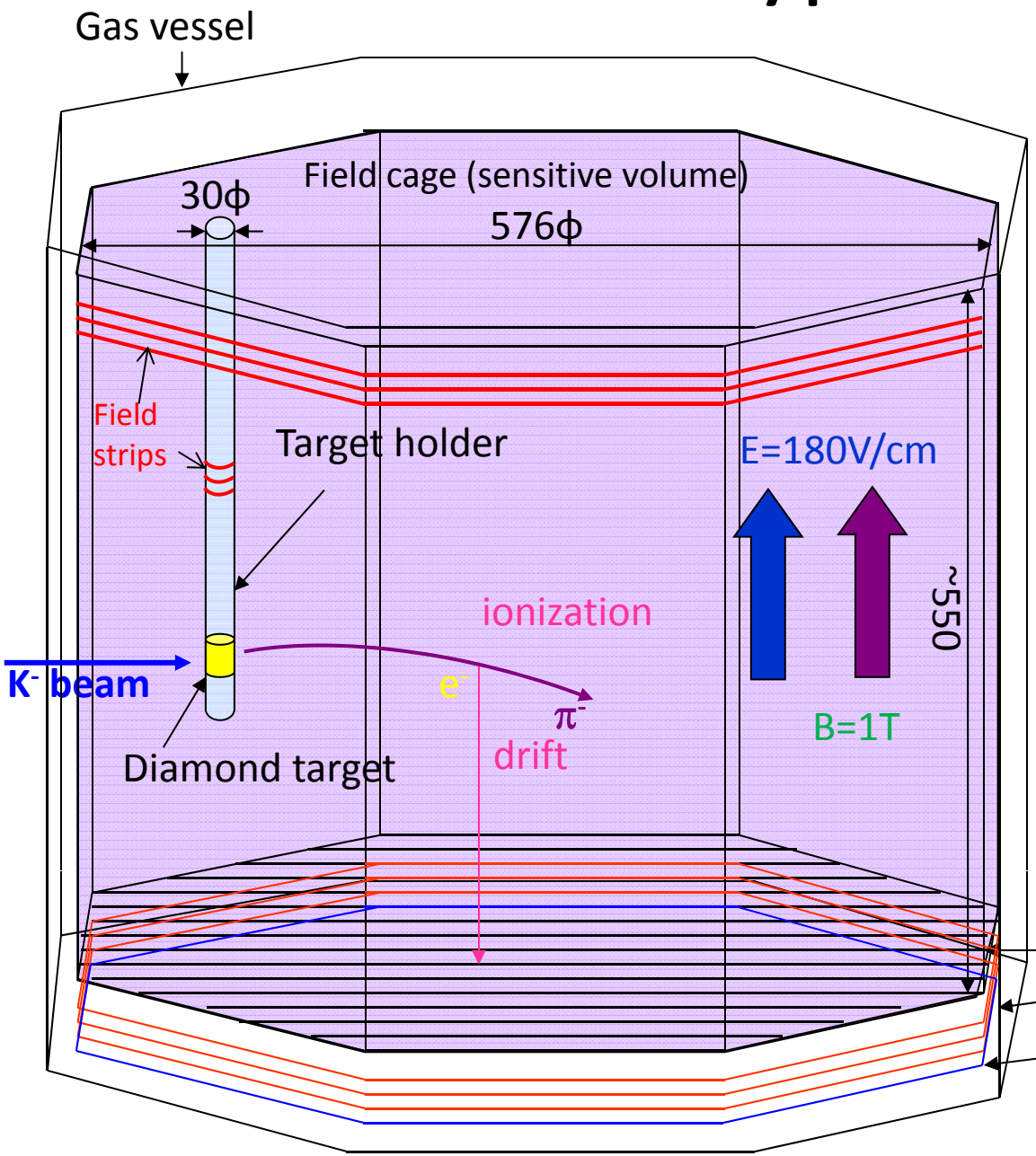
m-2m$_\Lambda$(MeV/c^2)

J-PARC E42

Search for H-dibaryon in $^{12}C(K^-,K^+)X$ at 1.6 GeV/c

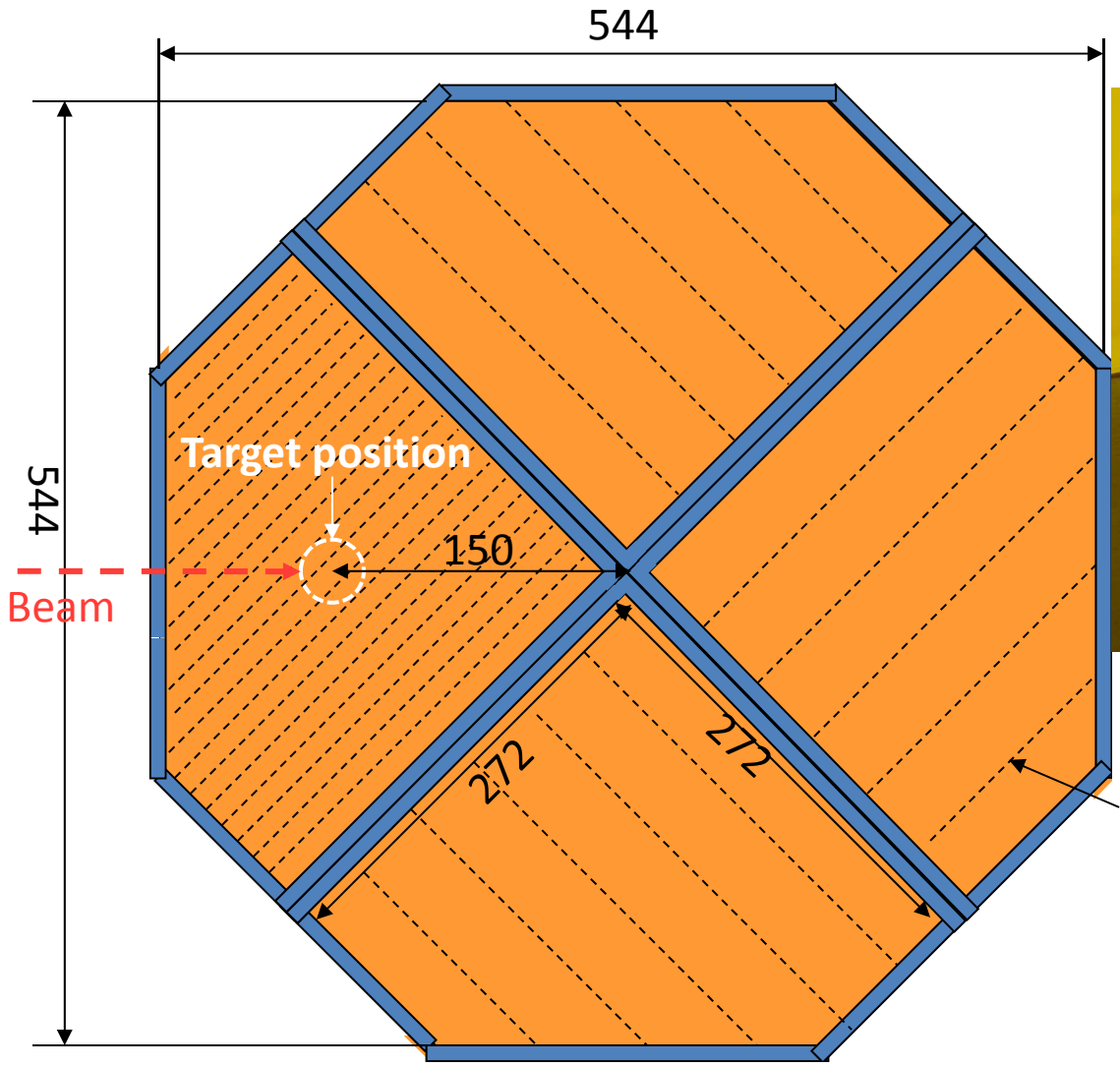


HypTPC

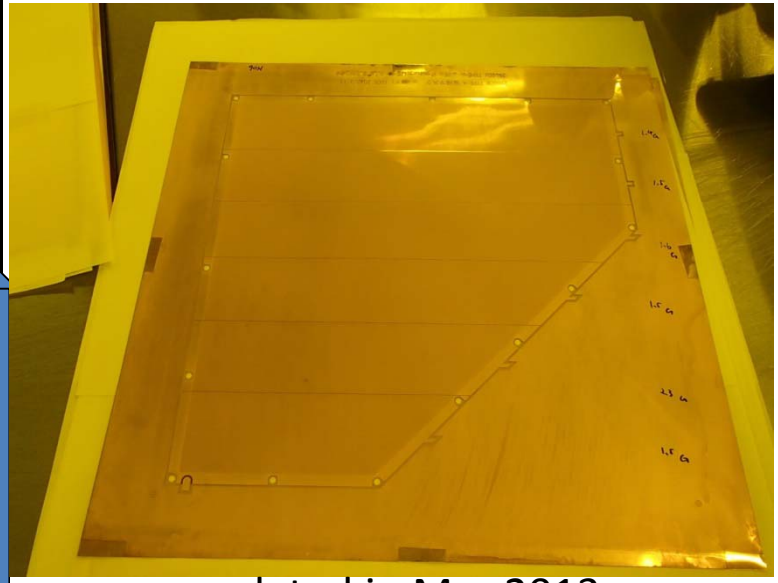


- Octagonal prism shape field cage
  576(ϕ) x550(h)
- Cylindrical target holder
- Gas
  P-10 (Ar-CH_4(90:10))
- Vertical magnetic and drift field

GEMs



- 4 GEMs (277x277mm^2)
- 3-layer GEM (50μm+50μm+100μm)



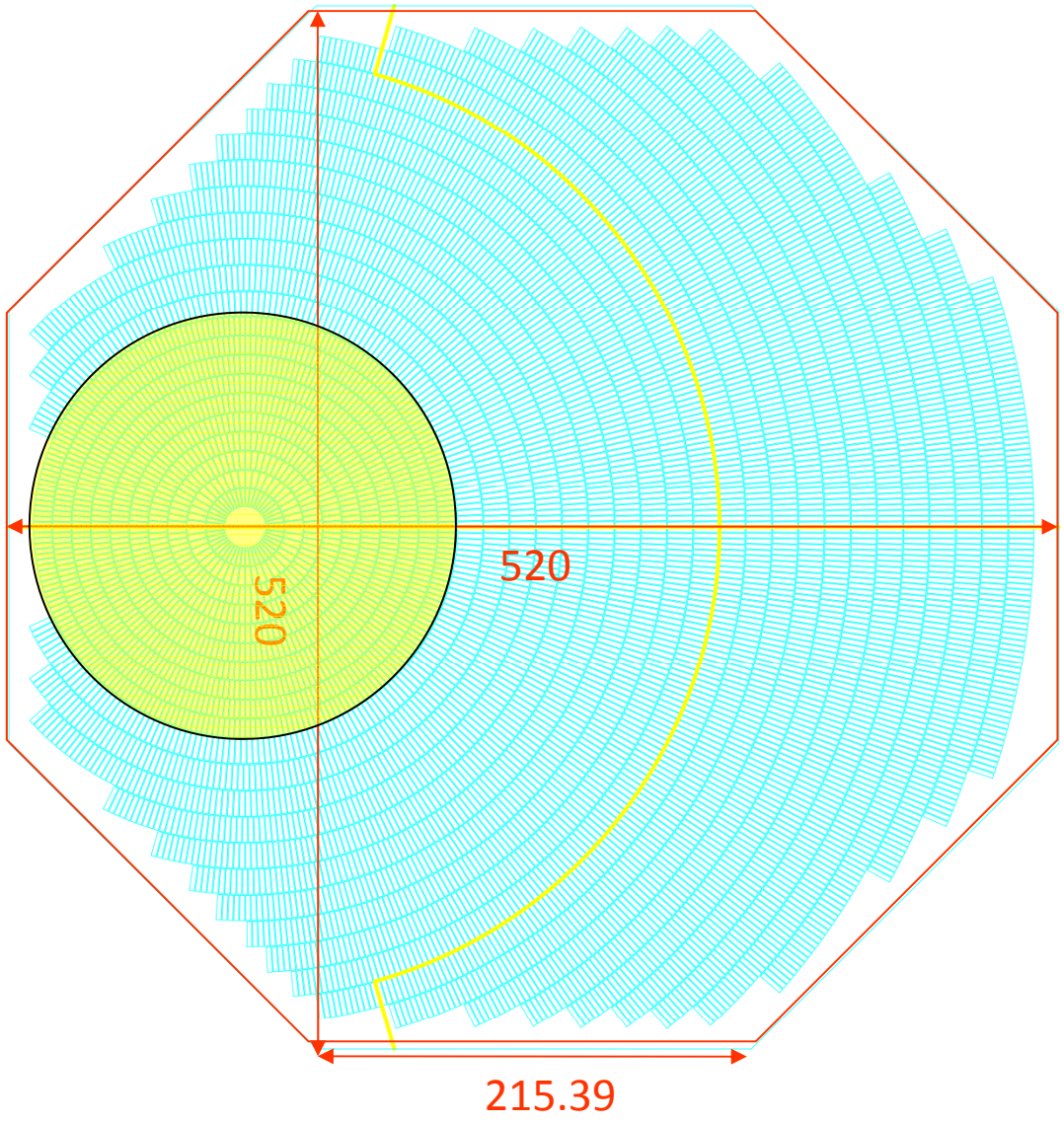
completed in Mar 2013

Electrode division

- 12.5 mm width (20 div.) 1 sheet
- 41mm width (6 div.) 3 sheets

- Suppress discharge rate
- Minimize acceptance reduction in case an electrode is broken

Readout pads



No. of plane = 32

Pad size

2-2.5 x 10-12.5mm^2

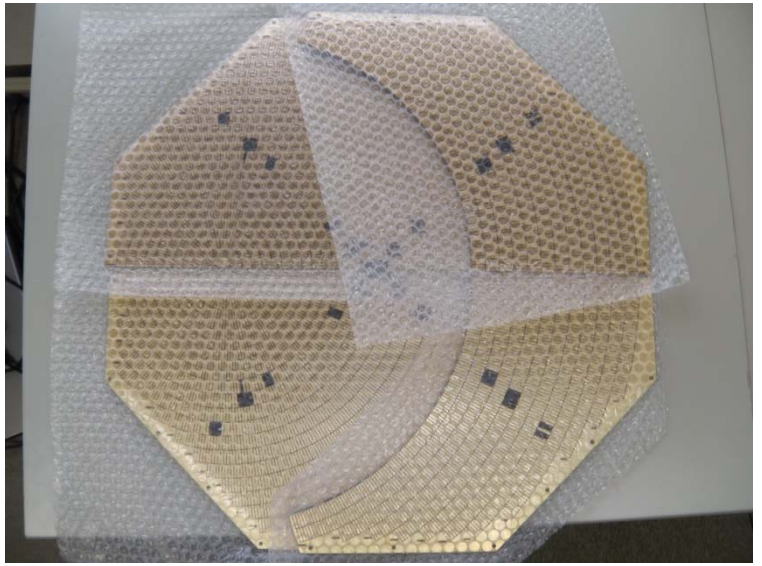
Total no. of pad = 5768

Average charge sharing

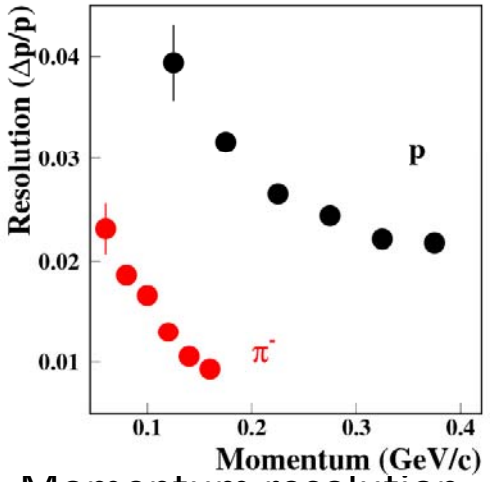
~ 3 pads / hit

Horizontal position resolution at B=1T< 300μm

Completed in Mar2013



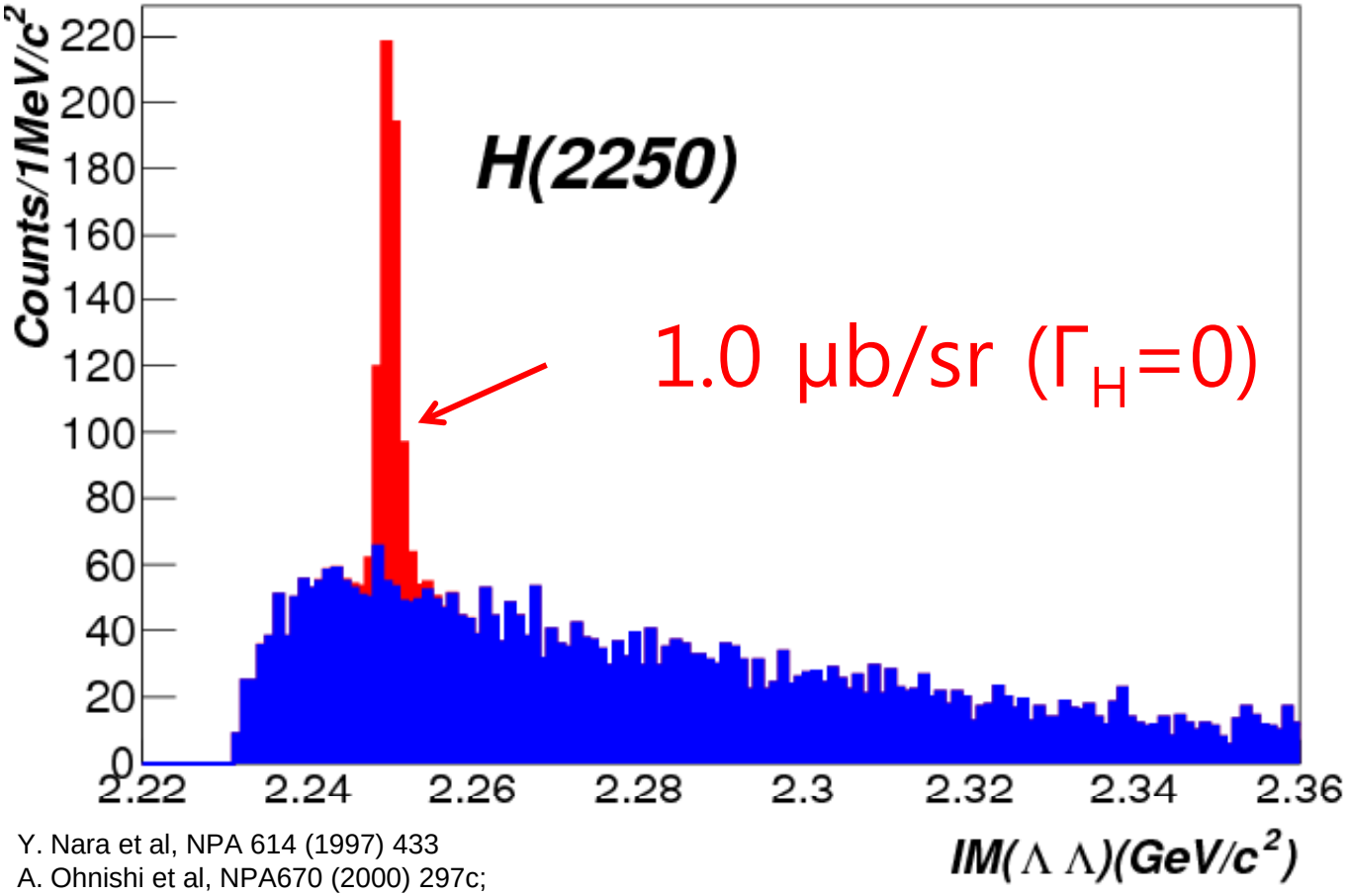
Simulated H-dibaryon mass spectrum



Momentum resolution
π : 0.8-2.3%
p : 2.2-4.0%

Invariant mass resolution
~1.5 MeV/c^2

11000 ΛΛ events
and 1440 H-dibaryons
in 33-day experiment



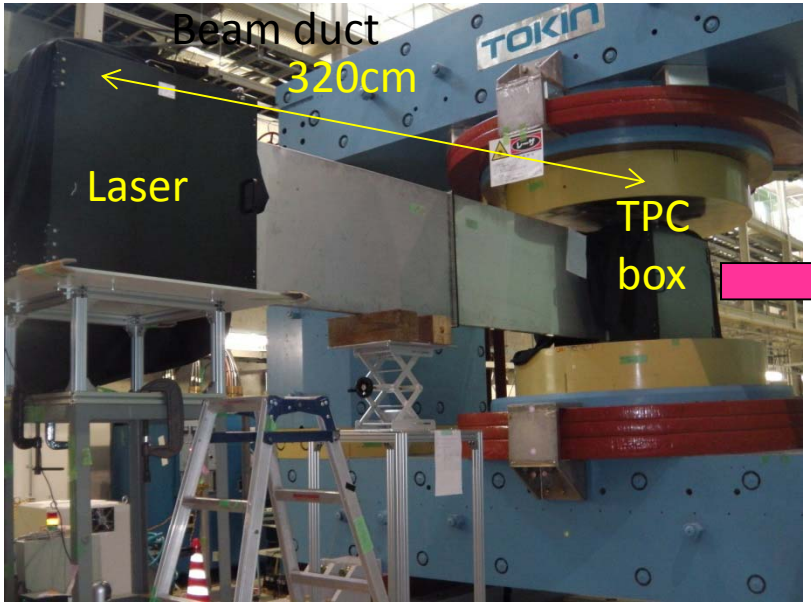
Y. Nara et al, NPA 614 (1997) 433
A. Ohnishi et al, NPA670 (2000) 297c;
Few-body Syst. Suppl. 12 (2000) 367;
NPA684(2001),595;NPA691(2001) 242c.

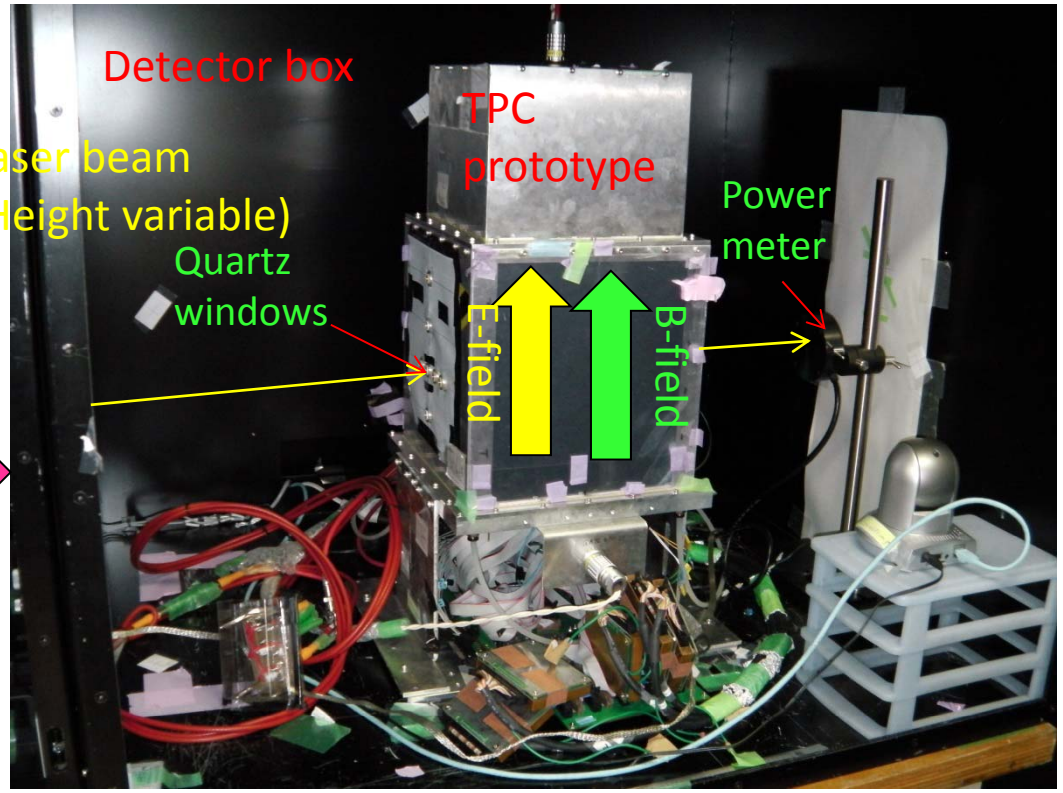
J.K. Ahn PAC meeting, Jul. 2012

Test with UV laser with B-field (J-PARC, Apr 2013)

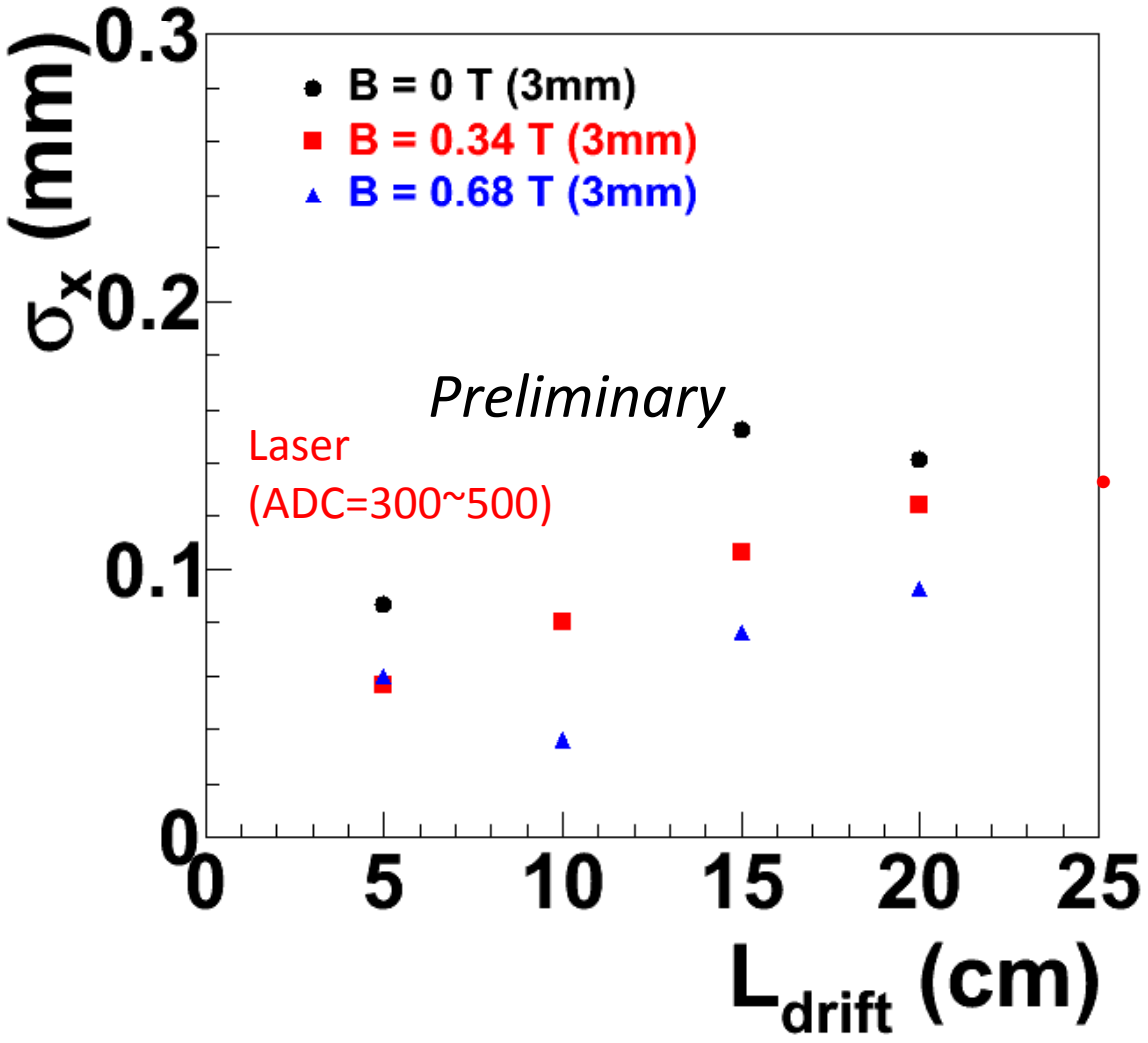
- YAG laser 266nm
- Energy 0-15mJ/pulse, 10Hz

FM cycrotron magnet
B<=0.7T, gap=90cm





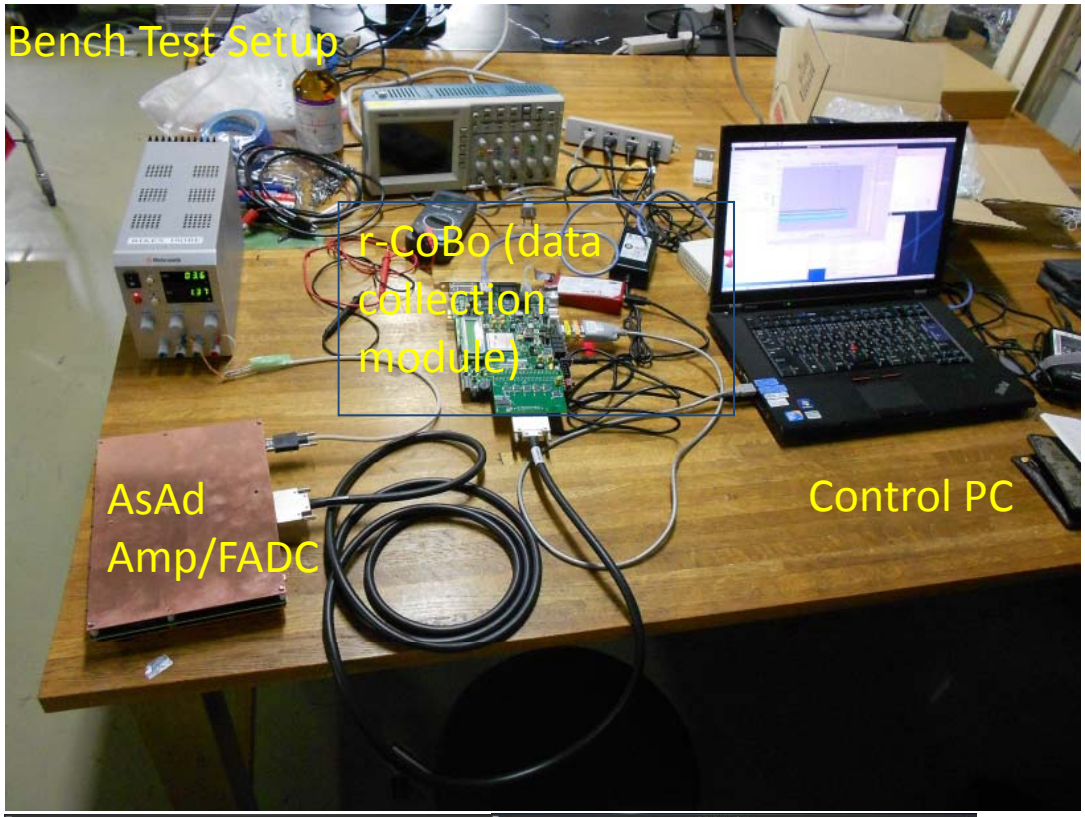
Horizontal resolutions with B-field

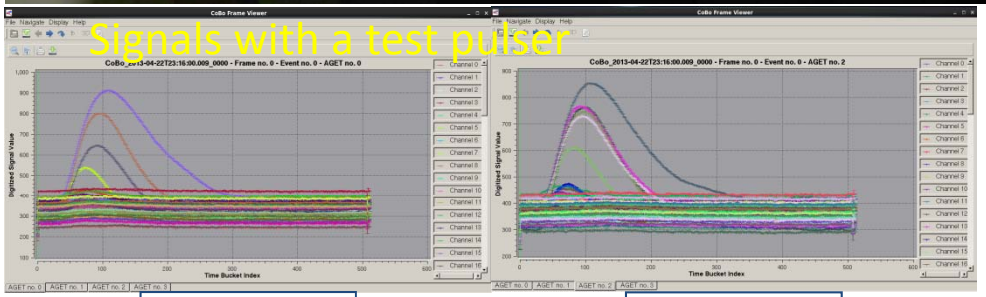


- Horizontal position resolutions improve by 40-50% from B=0 to 0.7 T

Development of TPC Electronics

GET (General Electronics for TPC)





AGET0

AGET2

- Developed by Saclay, GANIL, IRFU, CENBG (France) MSU (USA)
- Optimized for TPC
  Variable gain/polarity,
  FADC frequency
- Adopted by Samurai-TPC, ACTAR TPC,ATTPC, MINOS

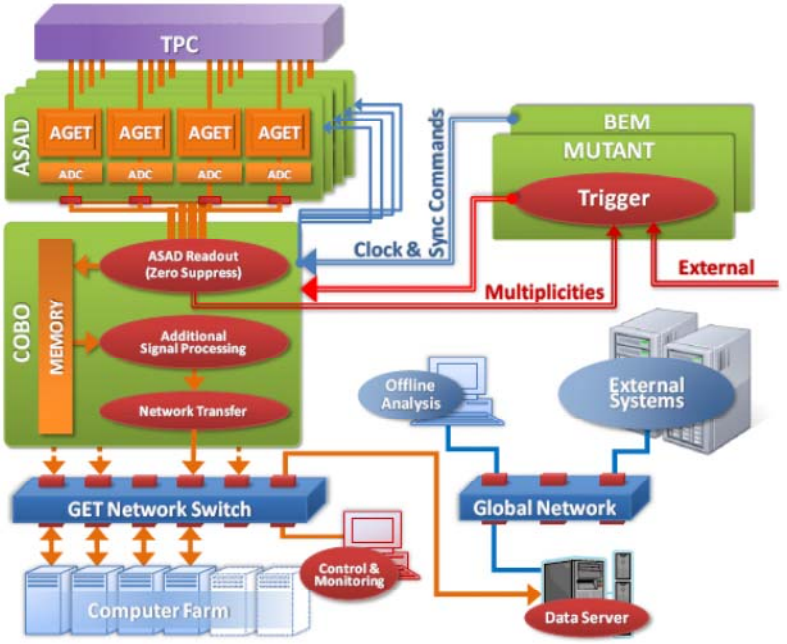
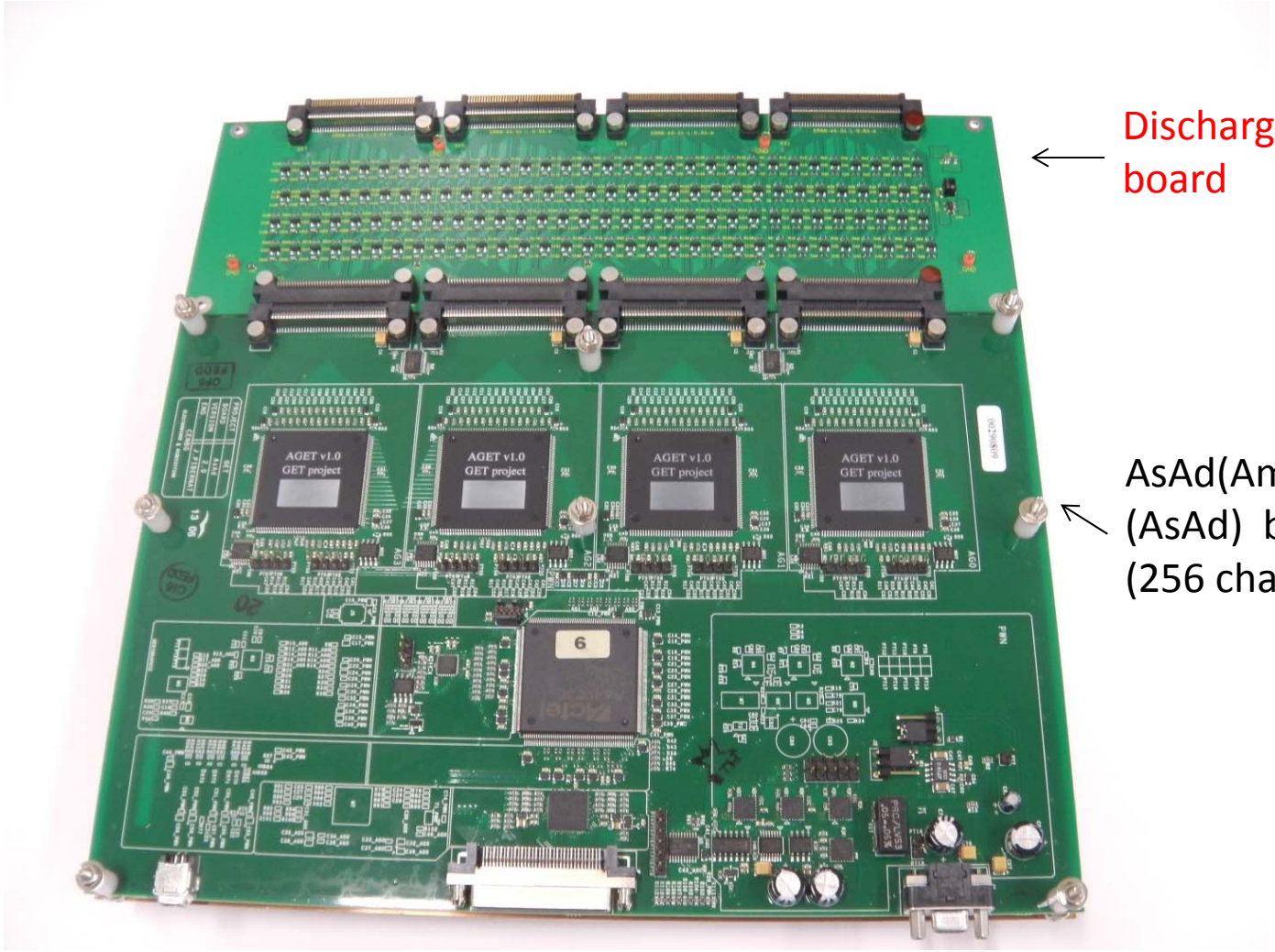


Fig. 1: Global view of the GET electronic.

Development of discharge protection board



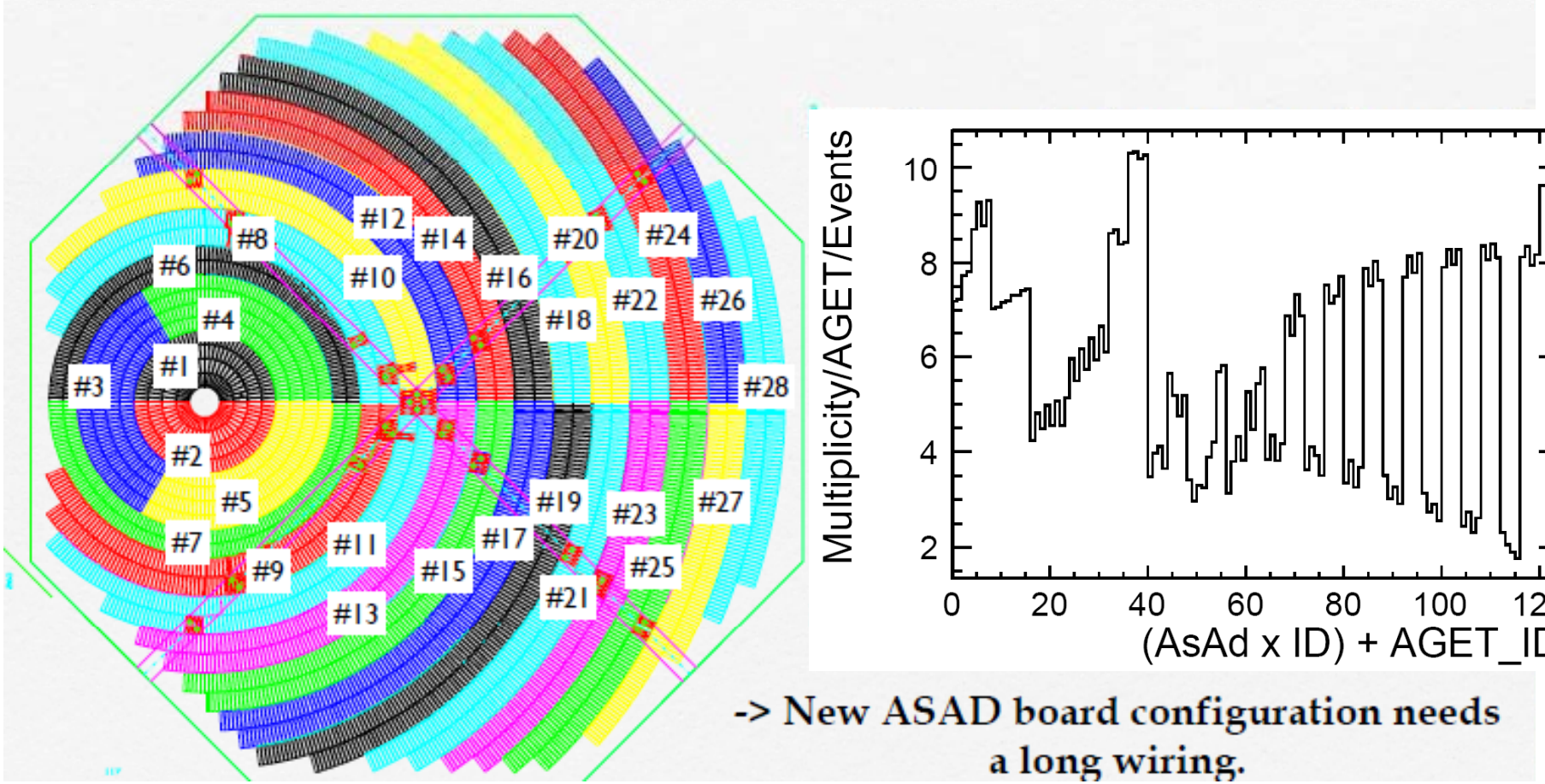
Discharge protection board

AsAd(Ampifier/FADC (AsAd) board) (256 channels)

Pad⇔AsAd mapping to optimize of DAQ speed

- Minimize the maximum multiplicity/AGET ~ 10

→ AD conversion time ~ 250 μsec → 1kHz (K^-,K^+) triggers



Summary (Hyp-TPC E42)

- We have been developing a TPC for J-PARC E42
  - High rate operation:
    - GEM and gating grid wires
  - Large H decay event acceptance:
    - A cylindrical target holder inside TPC drift volume
- Position resolutions improved by 40% at 0.7 T with a UV laser in a prototype TPC as expected

Schedules

Mar 2014-	Test of TPC2 (final TPC)
	GEM gain and stability against discharge
Jun 2014	Build field cage and target holder
Jul 2014-	Full system tests with GET electronics
Mar 2015	Goal completion
2014-2015	Construction of S.C. Helmholtz magnet

backup

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Proposal for 50 GeV Proton Synchrotron

Search for H-Dibaryon with a Large Acceptance Hyperon Spectrometer

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