Project C01 summary

Experimental study on the origin of mass due to the breaking of chiral symmetry

Vector meson measurements in nuclei

Satoshi Yokkaichi
(RIKEN Nishina Center)

- C01 organization
- physics motivation and the experiment J-PARC E16
- progress in JFY2012
- outlook

C01 organization 2012

JFY2012

延與 (研究代表者)

(研究分担者)		(研究分担者)		(研究分担者)	
F	小沢	F	四日市	F	武藤 (磁石)
(D3	渡辺(トラッカー))	PD	青木(HBD)	F	関本(GEM全般)
D2/JRA	小松(トラッカー)	PD	荒巻(LG)		
M2	中井(回路)	PD	高橋(回路)		
M2	菅野(HBD)	PD	川間(回路・ソフト)		
M1	渋川(トラッカー)				
M1	小原(GEMトリガ)				
U-Tokyo/KEK		RIKEN		KEK	

J-PARC E16 Collaboration

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CNS, U-Tokyo H. Hamagaki
Hiroshima-U K. Shigaki JASRI A. Kiyomichi

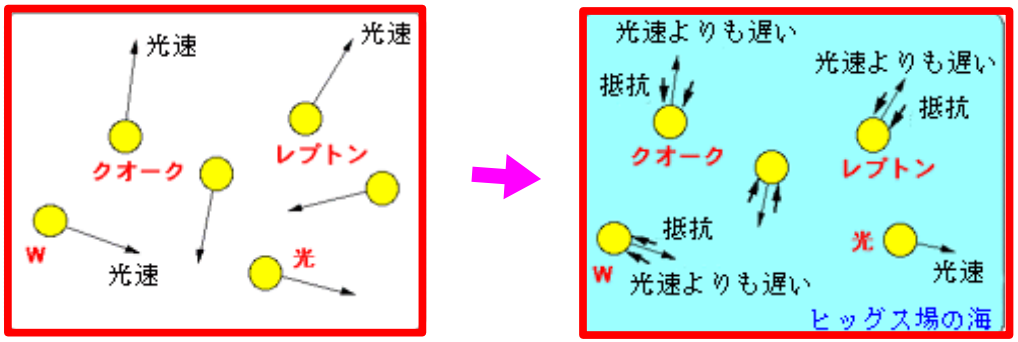
Origin of Mass (Higgs)

Big Bang — 10p[sec]/1P[K]

quark mass — 0 MeV — 3 MeV

"resistance" — Higgs condensate

schematic diagram of vacuum



- Origin of lepton and quark mass: Higgs

Origin of Mass (QCD)

Big Bang — 10p[sec]/1P[K] — 100μ[sec]/1T[K]

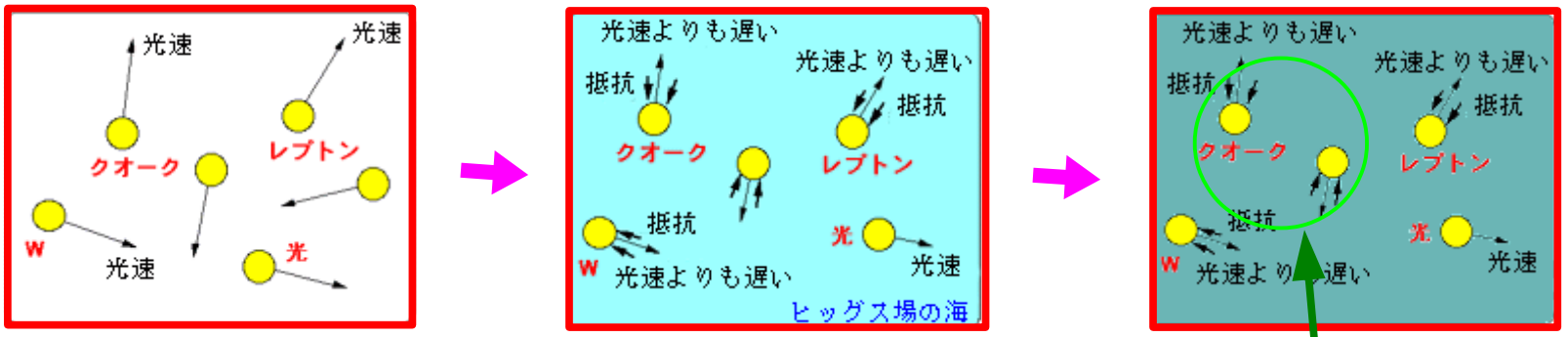
quark mass
"resistance"

0 MeV

3 MeV
Higgs condensate

300MeV
chiral condensate $\langle \bar{q}q \rangle$

schematic diagram of vacuum



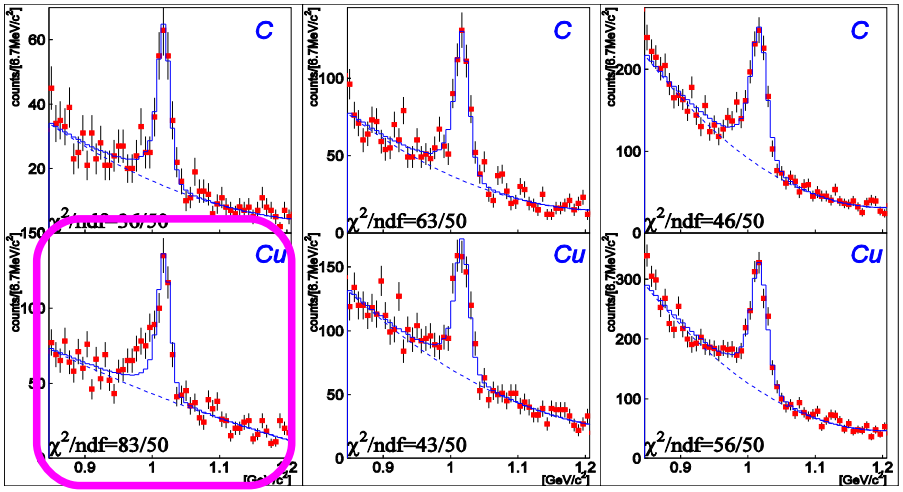
quark confinement : generation of hadrons (nucleon and mesons)

- Origin of lepton and quark mass: Higgs
- Origin of quark and hadron mass : spontaneous breaking of chiral symmetry, originally proposed by Nambu
  - Hadron mass could be modified in hot/dense matter, because of the chiral symmetry restoration is expected in such matter

J-PARC E16 experiment

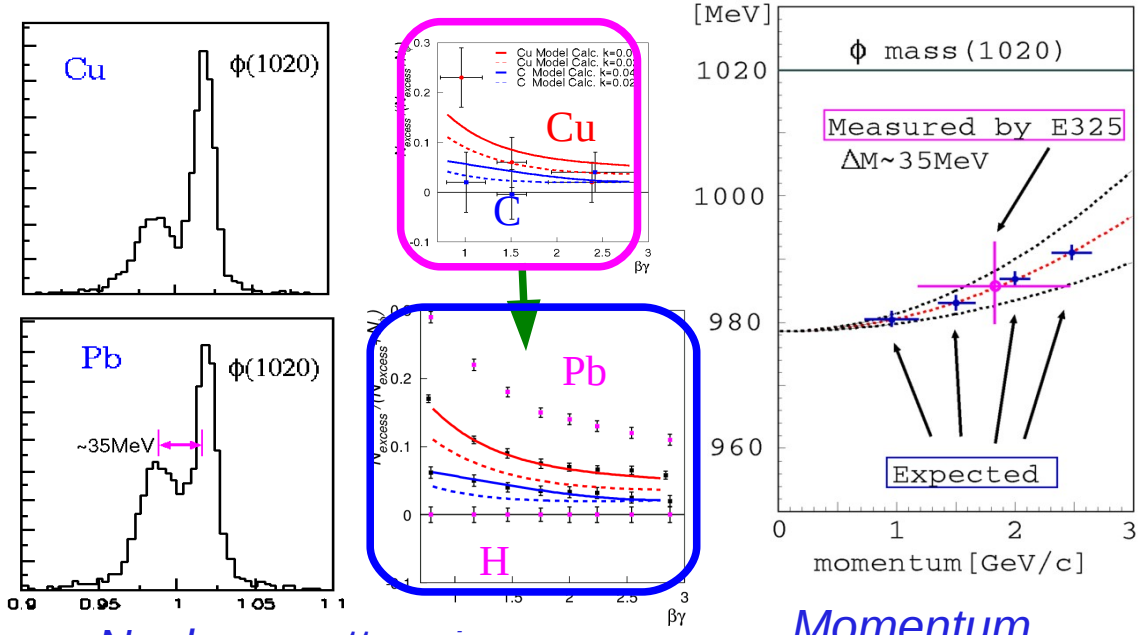
- Measure the vector-meson mass modification in nuclei systematically with the e^+e^- invariant mass spectrum
- A 30 GeV primary proton beam (10^{10}/spill) / 5 weeks of physics run to collect ~10^5 $\phi \rightarrow e^+e^-$ for each target
- confirm the E325 results, and provide new information as the matter size/momentum dependence of modification

Precedent exp.(KEK-PS E325)



ϕ–mass is modified in large nuclei for slowly moving mesons... consistent with the prediction based on the QCD sum rule

Proposed exp. E16



Nuclear matter size dependence & *Momentum dependence* of mass modification are measured

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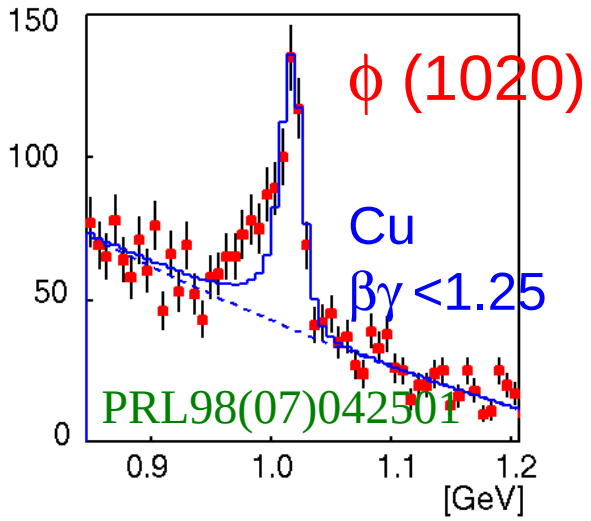

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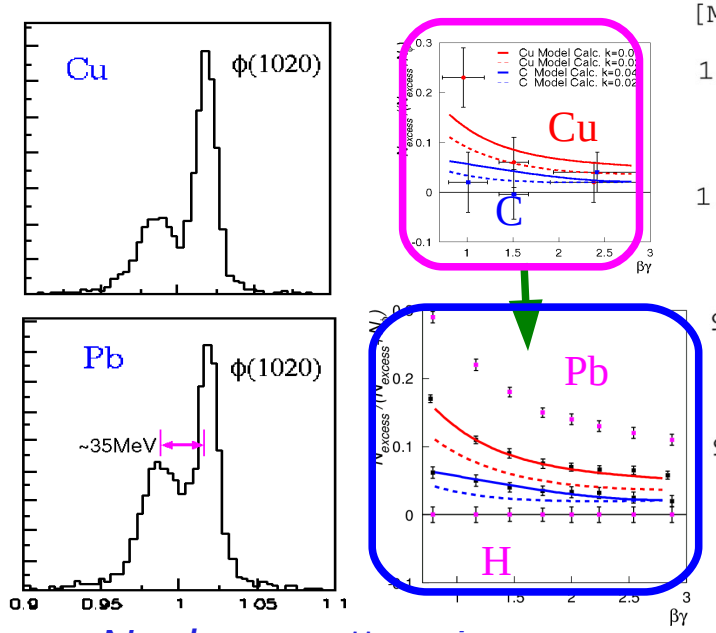
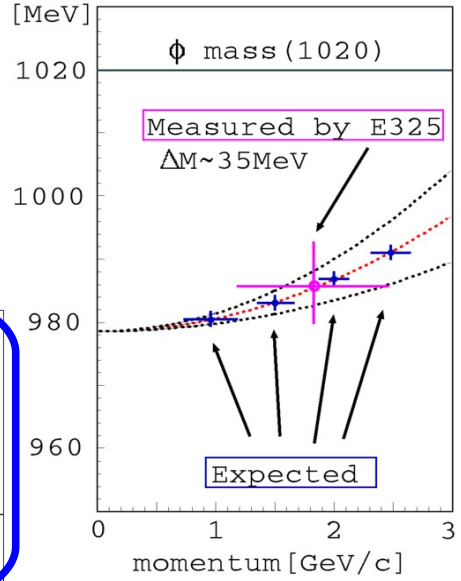


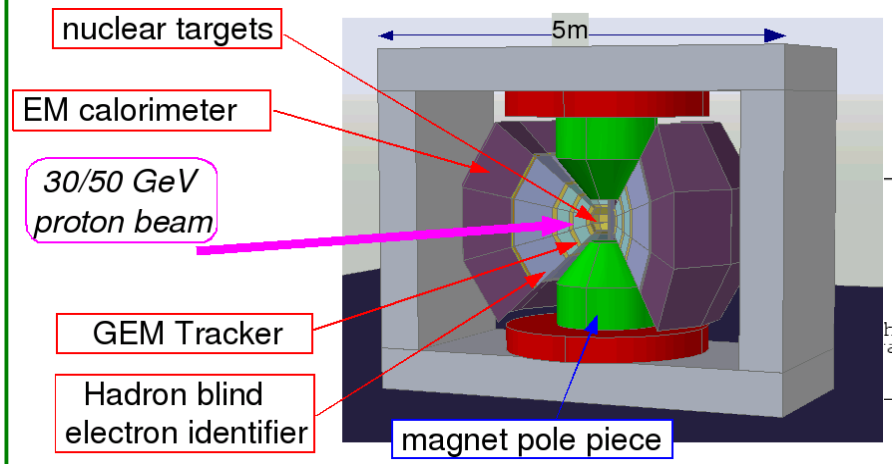


Nuclear matter size dependence & *Momentum dependence* of mass modification are measured

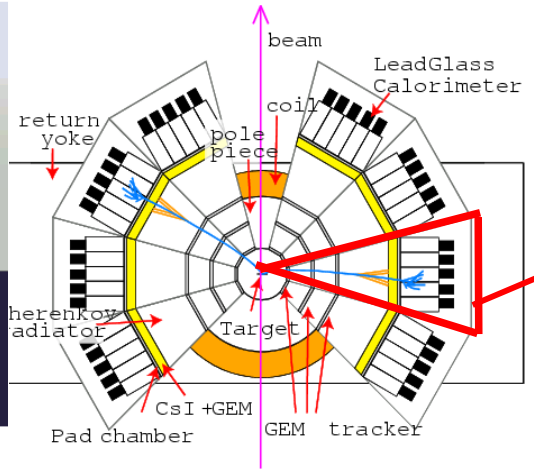
To collect high statistics

- For the statistics 100 times as large as E325, a new spectrometer and a primary beam in the High-p line are required.
  - To cover larger acceptance : x~ 5
  - Higher energy beam (12 → 30/50 GeV) : x ~2 of production
  - Higher intensity beam ($10^9 \rightarrow 10^{10}$ /spill (1sec)) : x 10 (→ 10MHz interaction on targets)
  - to cope with the high rate, new detectors (GEM Tracker & HBD) are required.

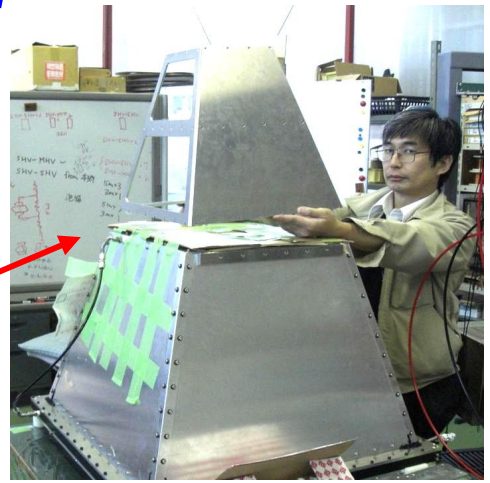
Proposed Spectrometer



Plan View

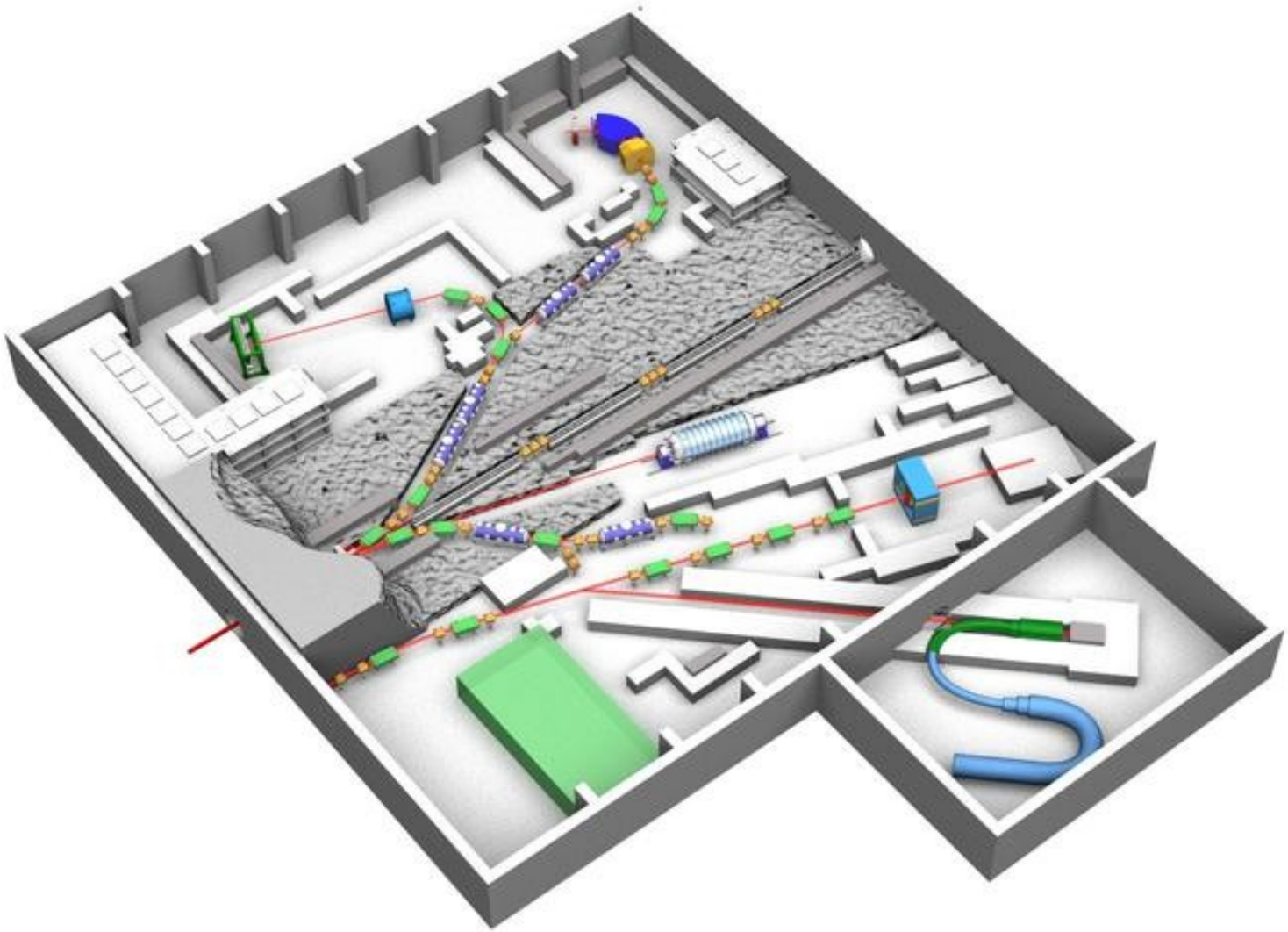


Prototype Module



26 detector modules

High-p line in the Hadron hall



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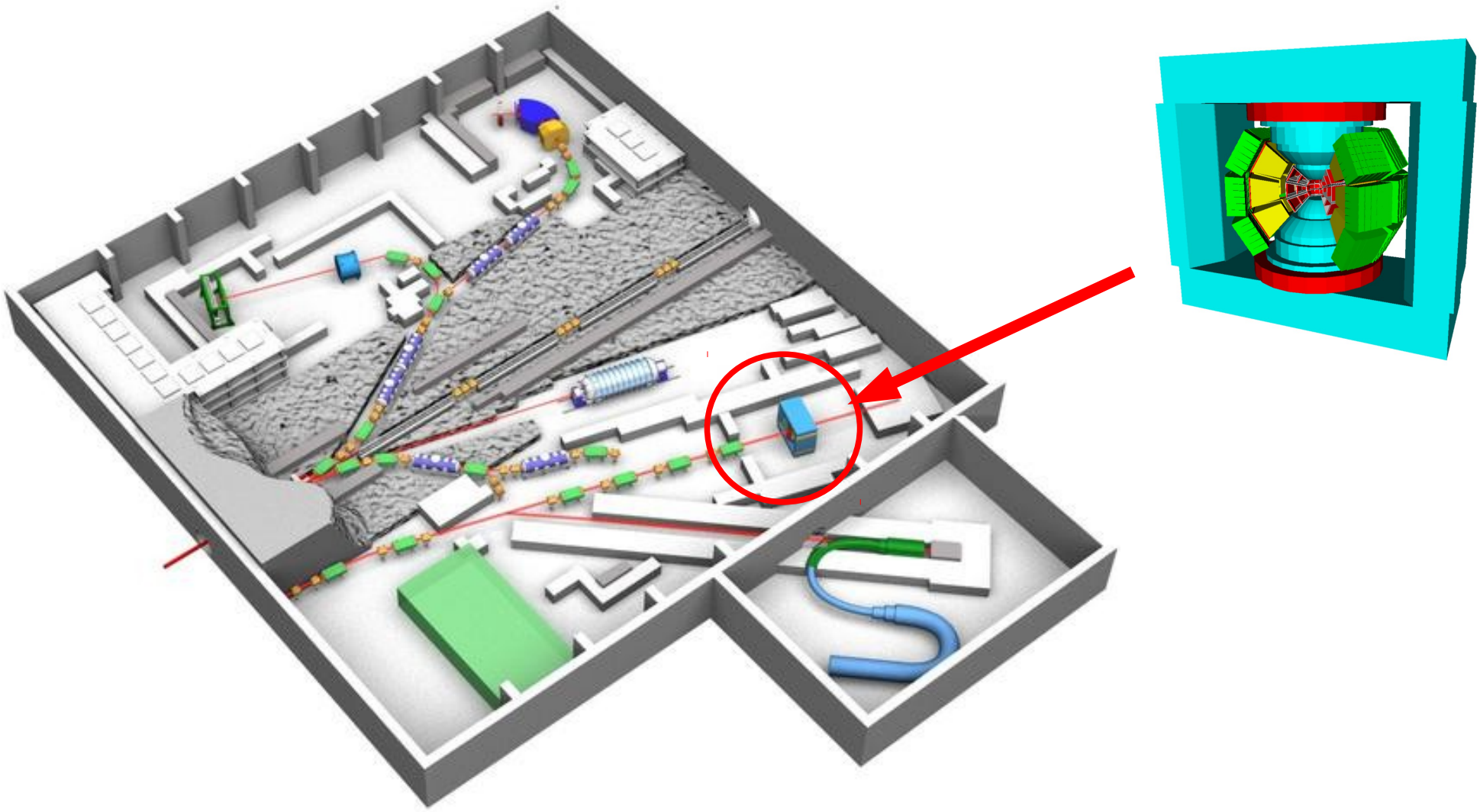

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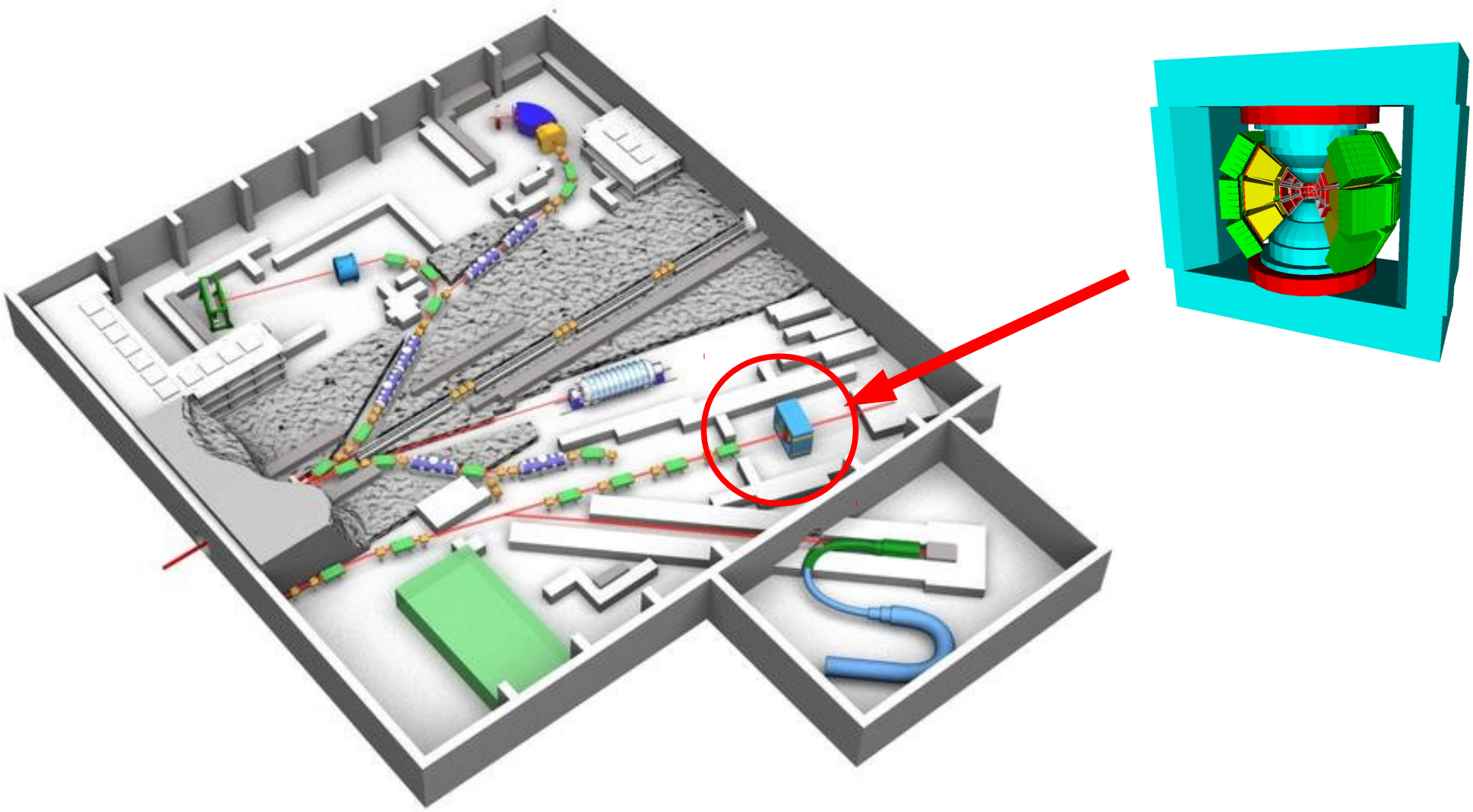


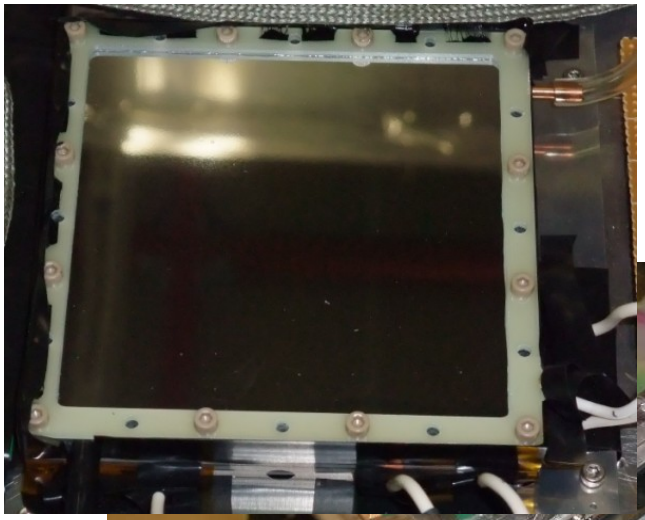
- budget requested by KEK to MEXT : finally funded
  - thanks to KEK staffs, and this grand-in-aid

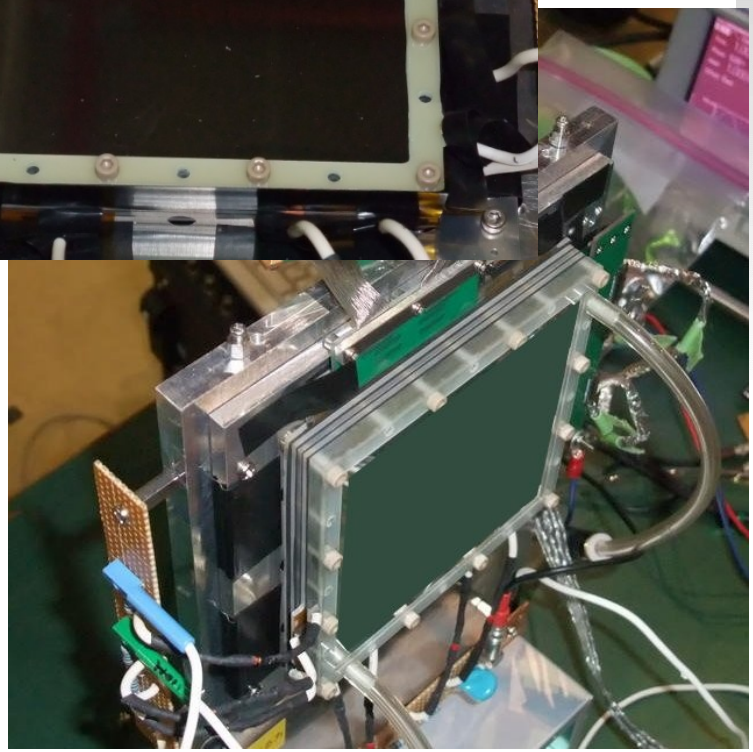
Progress in JFY 2012 (after the previous WS)

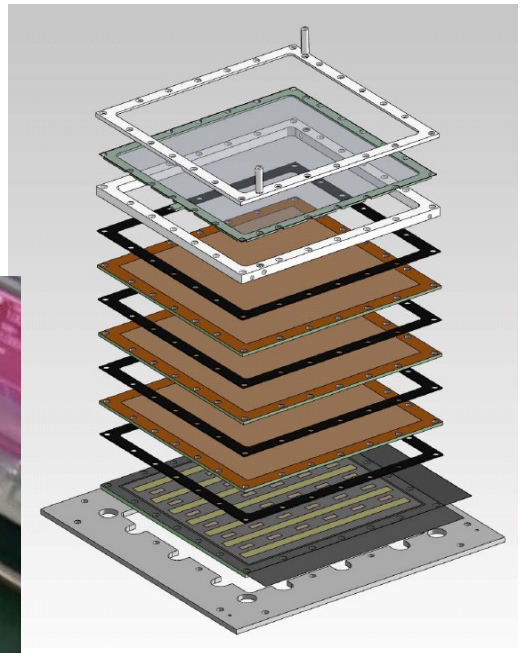
- R/O Circuit → Takahashi's Talk, (Takahashi, Nakai, Kawama)
  - 1st version of preamp board for GEM detectors are tested w/ beam.
  - trigger modules from Belle-II , LG-FEM prototype
- LG → Aramaki's Talk (Aramaki, Sekimoto)
  - All LG is in hand. A few samples are tested w/ beam.
- Spectrometer Magnet (Muto, Ozawa)
  - Coil is delivered in Sep. / Pit is dug in Feb.
- HBD (Aoki, Kanno)
  - improvement of # p.e. and pion rejection factor
- GEM Tracker
  - trigger signal from the 3rd foil (Obara)
  - 1st version of the support frame is delivered in Mar. (Shibukawa)
  - 1st production type of 200mm and 300mm is delivered in Mar.(Komatsu)

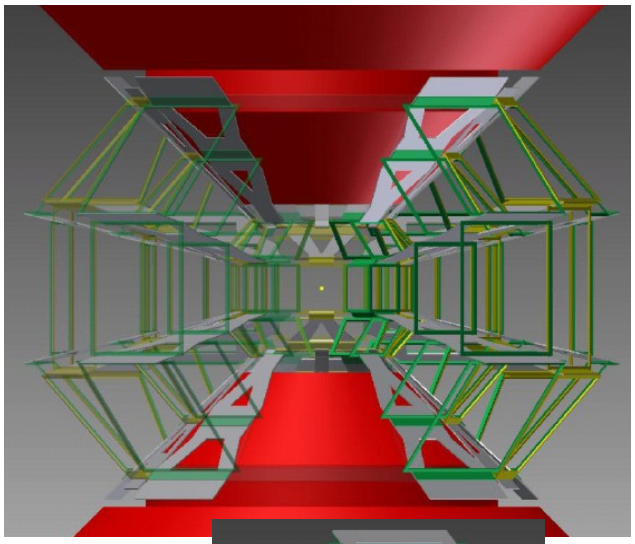
E16 GEM Tracker

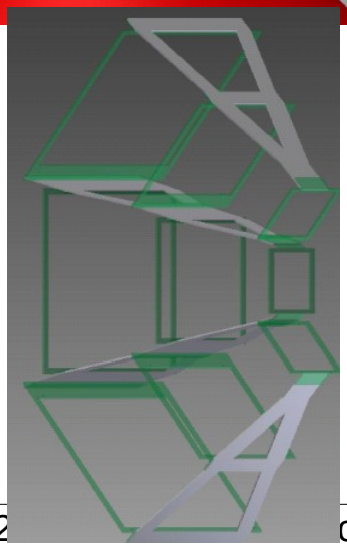
- 1st production type (100x100mm)
  - beam test at LEPS (2011) & J-PARC(2012)
  - trigger signal from the 3rd GEM foil
- Support frame made by CFRP
  - prototype is delivered in Mar.







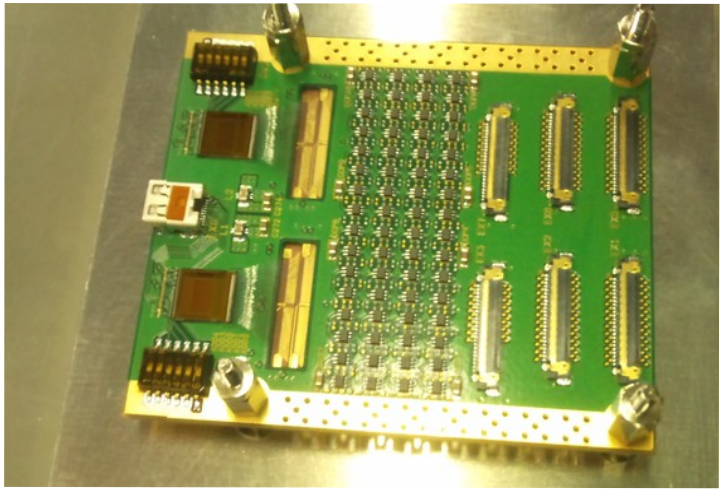




managed by
Y.Komatsu, Y.Obara, &
T.Shibukawa

preamp board for GEM

- preamp board for GEM (68mm x 58mm)
  - with APV25 (CERN ASIC)
  - position resolution is improved via S/N improvement



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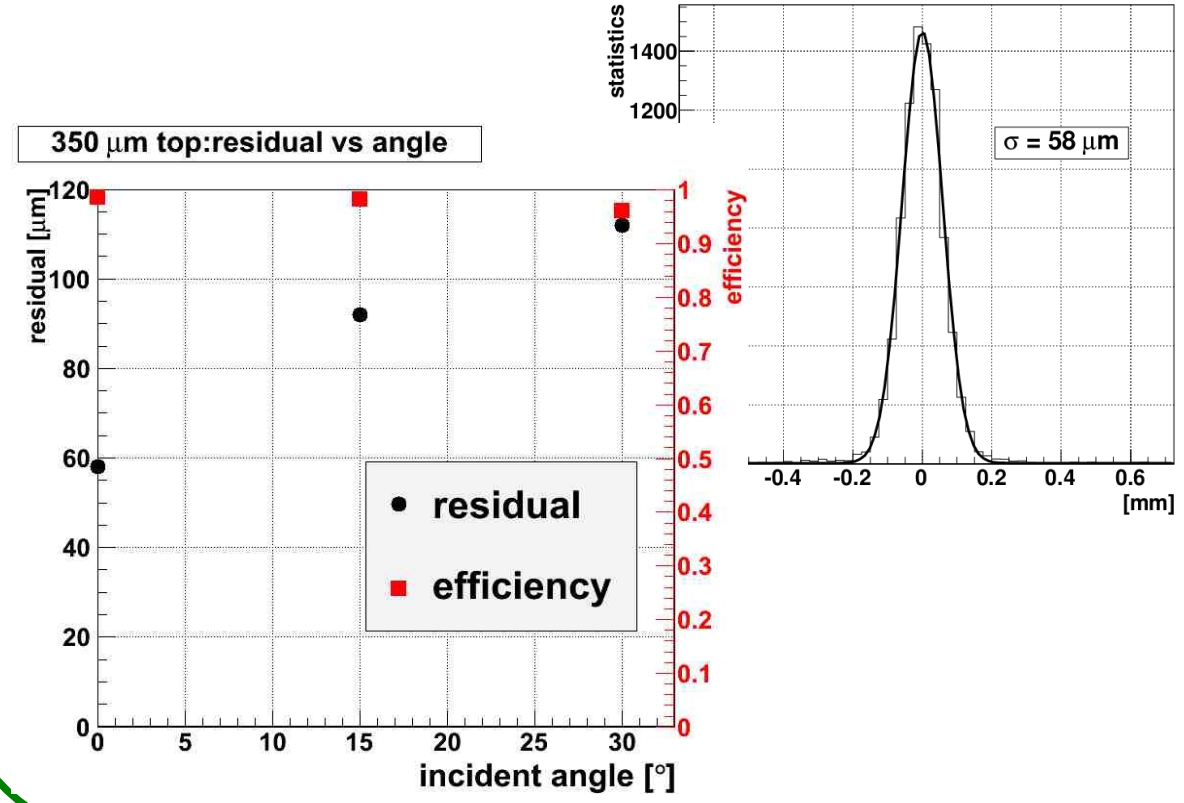
W.Nakai & T.N.Takahashi

- GEM Tracker (1st production type) is tested with the new preamp board at J-PARC K1.1BR

2012 Dec.

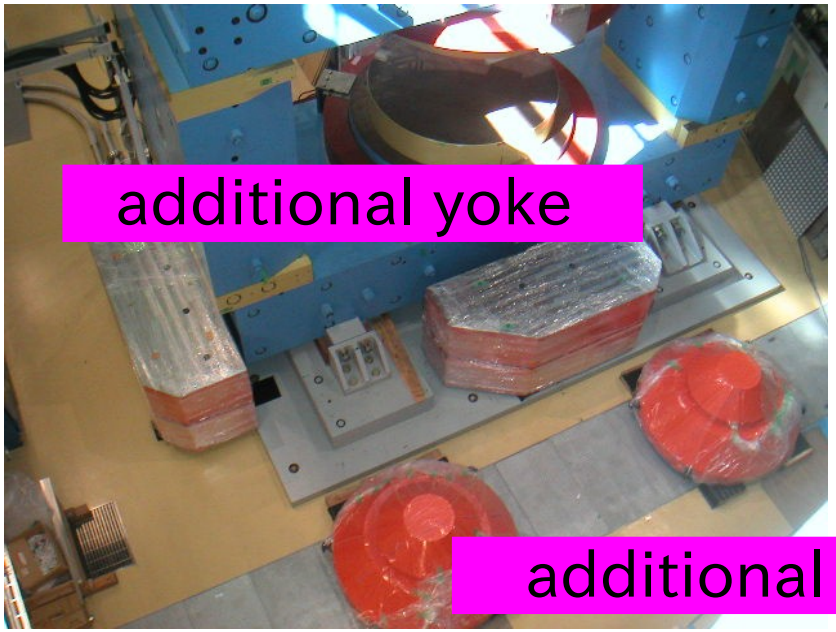


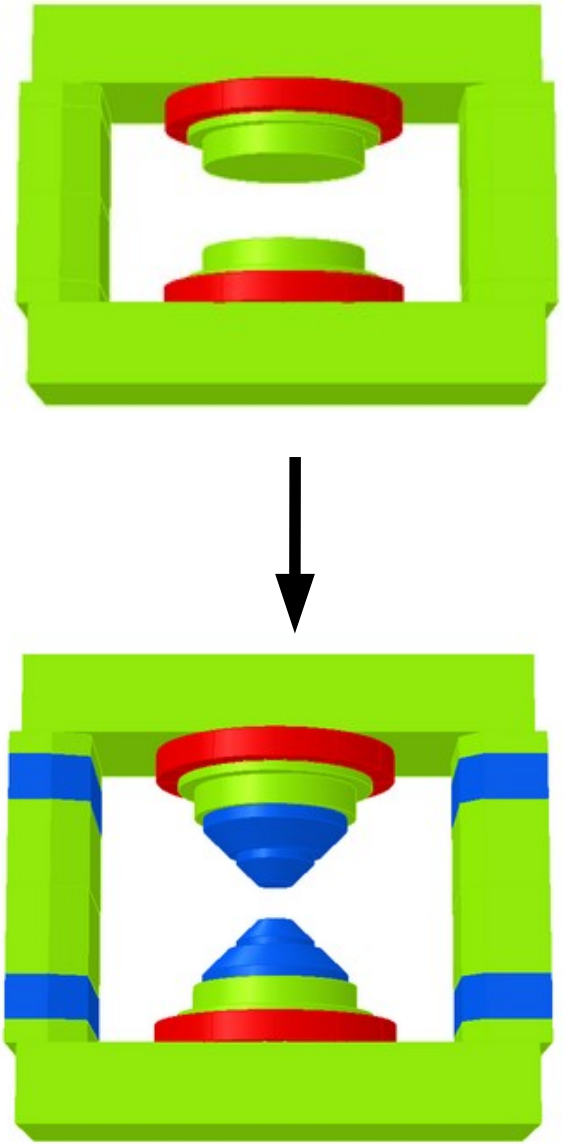
Lead Glass from TOPAZ / E362

17 frames were decomposed
at KEK warehouse
by Y. Aramaki & S. Sekimoto

Spectrometer Magnet

delivered in 2012
(managed by R. Muto)

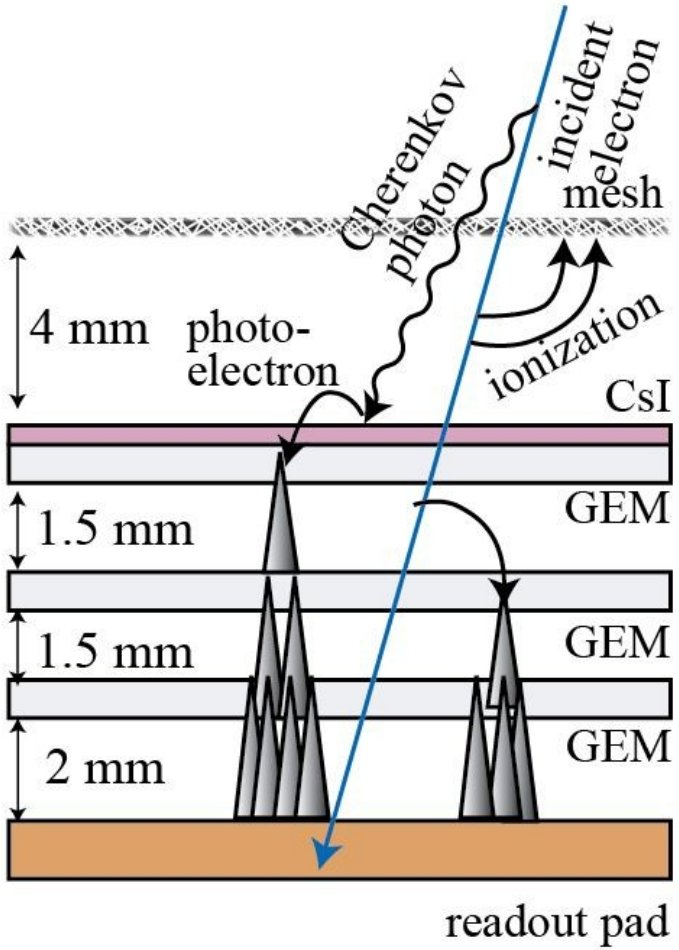




HBD (Hadron Blind Detector)

- Threshold type Gas Cherenkov, using CF_4
  - developed thanks to Weizmann/Stony Brook
  - Ionized electrons are collected by mesh
    - photoelectrons are amplified by 3 stages
    - ionized electrons are amp. by only last 2 stages

      → can detect only particles with cherenkov photons.
      - (1/100 of pion rejection)
  - GEM : LCP t=100um double stack
  - CsI evaporation by Hamamatsu & RIKEN
  - QE improved at RIKEN
    - 10 photoelectrons detected (cf. PHENIX ~20 p.e.) as of 2011
- Test @ J-PARC in 2012: w/ pion beam
  - pion rejection factor measured for the first time
  - stability for the hadron-beam environment



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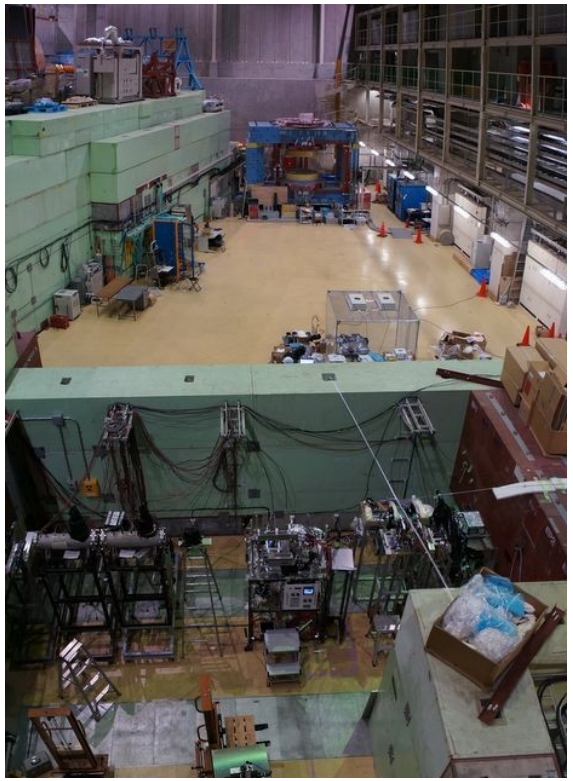
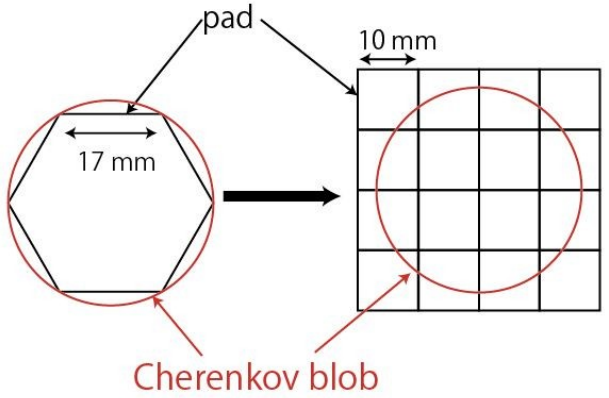
HBD (Hadron Blind Detector)



- Test @ J-PARC K1.1BR in 2012/Jun (T43)
  - #p.e. improvement : 10 → 13
    - QE and HV config. optimization
    - however, still less than that of PHENIX
  - LCP-GEM double stack is unstable in the hadron beam environment

- Test @ J-PARC K1.1BR in 2013/Jan (T47)
  - PI-GEM triple stack is stable, even for CF_4
  - pion rejection is improved with a higher gain of new PI-GEM and smaller-size readout pad
    - measure the distribution of the charge

    → pion rejection factor 100 with e-efficiency 70% achieved, same level as PHENIX, in spite of the less #p.e.



- Should be checked using 300-PI-GEM in 2013/June.

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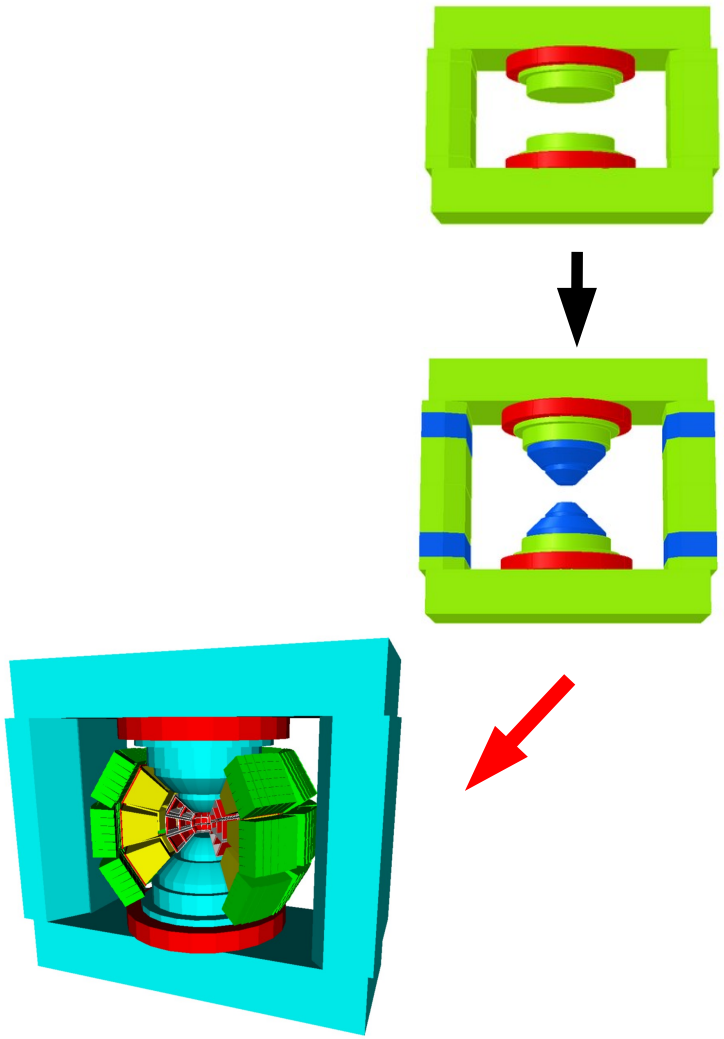
Schedule

- 2007: stage1 approval
- 2008-2011 : detector R&D
- JFY2012 :
  - Test exp (T43/T47) at J-PARC
    - GEM stabilty and HBD response for pion beam
    - GEM R/O circuit
- 2013 Jan : High-p construction budget is approved
- In the Hadron hall schedule table, we are assinged
  - 2014 Nov-2015 Jan : magnet reconstruction
  - 2015 Feb-Aug : detector installation in the magnet
  - 2016 Jan-Mar : detector commissioning
-



Summary

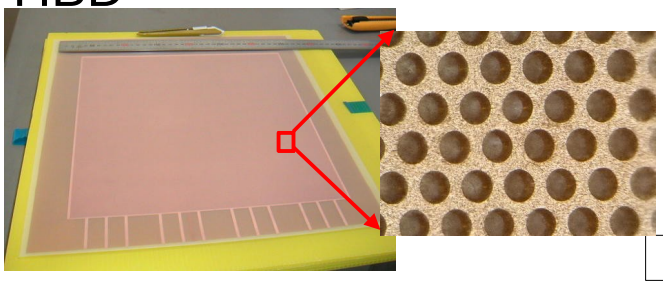
- Investigation of the hadron spectral modification in nuclear matter is a study of the nature of QCD vacuum
  - major origin of hadron mass is the spontaneous breaking of chiral symmetry and the spectral modification could be a signal of the chiral restoration
  - Spectral modification of hadrons is observed in hot (HI collisions) and dense (nuclei) matter in the dilepton invariant mass spectra
  - but discussion is not converged : chiral restoration or not
- J-PARC E16 will measure the vector meson modification in nuclei with the ee decay channel, using 30GeV primary proton beam.
  - confirm the observation by KEK-PS E325 and provide more precise information of the mass modification
  - preparation is underway with this Grant-in-Aid
  - Staged Goal of construction : 8 modules out of 26

Backup slides...

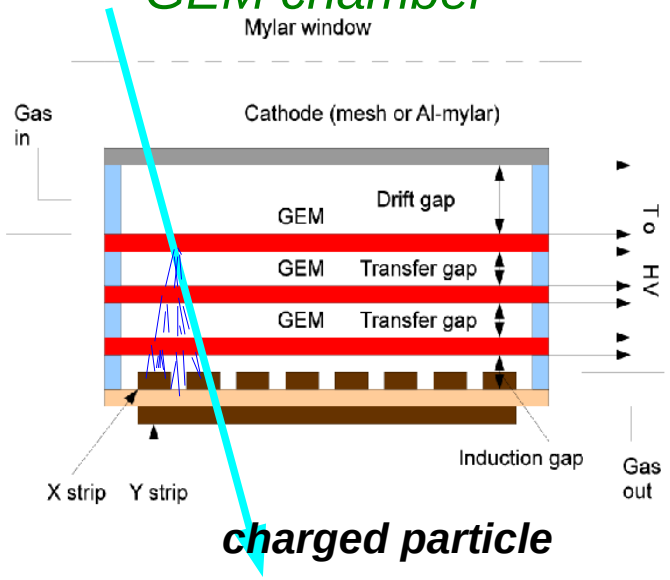
-

Detector R&D

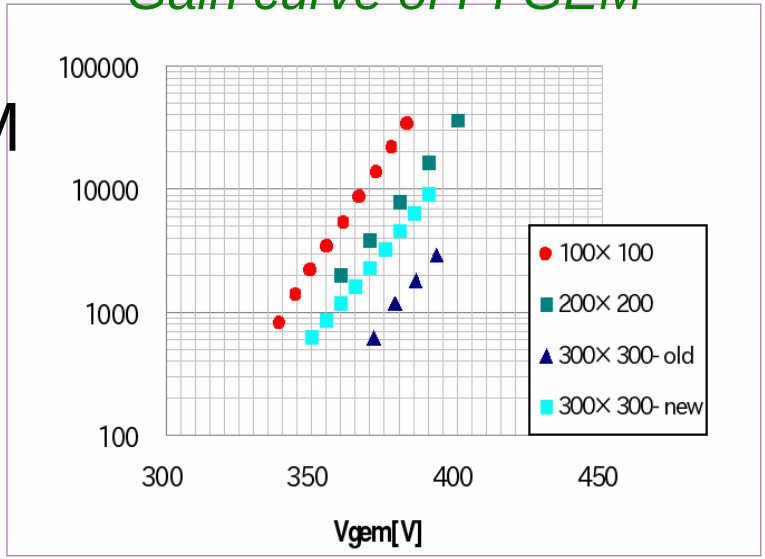
- GEM Tracker to cope with the high rate
  - Ar+CO_2(70:30)
  - angled injection, 2D readout,etc.
  - required position resolution 100um is achieved for angled tracks w/ FADC R/O
- Hadron Blind Detector to trigger the electrons
  - CsI photocathode, CF_4 gas purity, etc.
  -
- Domestic Large size (300mmx300mm) GEM
  - kapton (Polyimide, PI) t=50um for GT
  - LCP , t=100 um for HBD



GEM chamber



Gain curve of PI GEM



Spectrometer Magnet re-construction

- FM magnet (used by KEK-PS E325)
  - additional poles and yokes
    - larger acceptance/stronger field
  - decompose -> proper location on the High-p line
    -> re-construction with new parts
  - a pit (digging of the floor concrete) is required under the magnet
  - takes 6-8 months
    - scheduling of the area and overhead crane usage
  - by the end of JFY2012
- detector installation in JFY2013
  - all the detectors are installed in the Magnet