Project C01

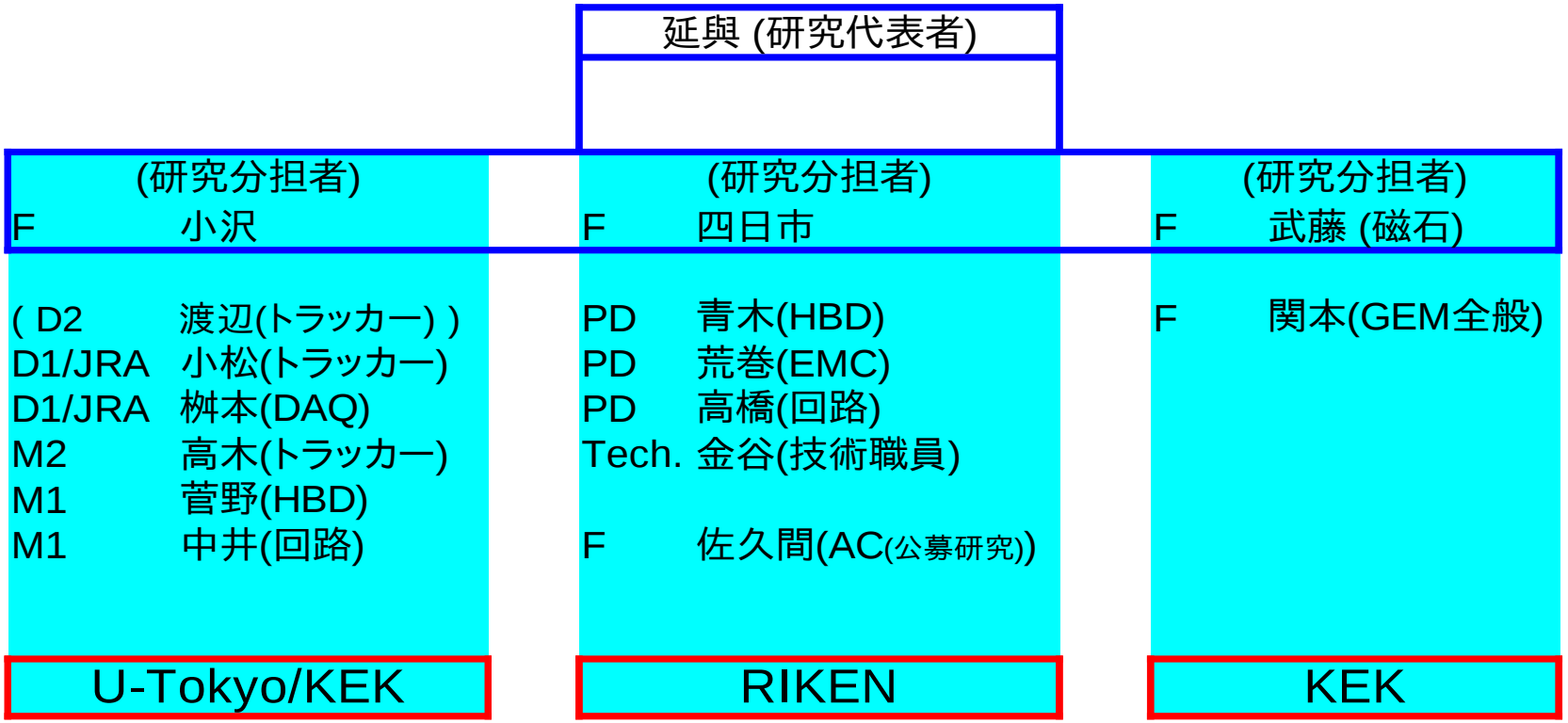
Experimental study on the origin of mass due to the breaking of chiral symmetry

Vector meson measurements in nuclei

Satoshi Yokkaichi
(RIKEN Nishina Center)

- C01 organization
- physics motivation and the experiment J-PARC E16
- progress in JFY2011
- outlook
- summary

C01 organization

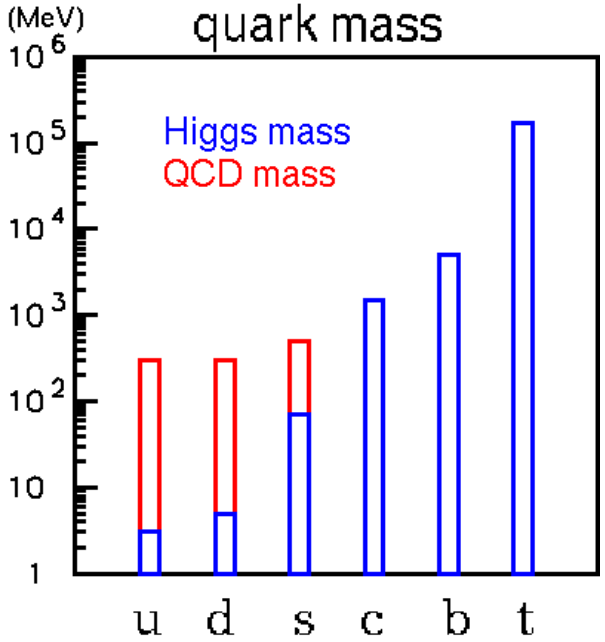


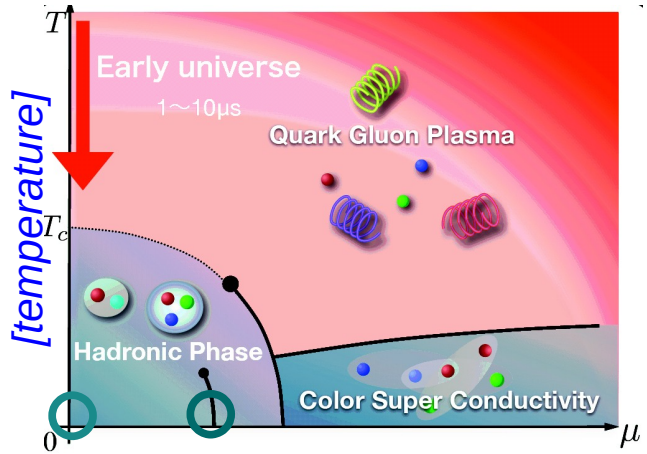
J-PARC E16 Collaboration

RIKEN	S.Yokkaichi, K. Aoki, Y. Aramaki, H. En'yo, J. Kanaya, F. Sakuma, T.N. Takahashi
KEK	K.Ozawa, M. Naruki, R. Muto, S. Sawada, M. Sekimoto
U-Tokyo	Y.S. Watanabe, Y.Komatsu, S.Masumoto, A.Takagi, K.Kanno, W.Nakai
CNS, U-Tokyo	H. Hamagaki
Hiroshima-U	K. Shigaki
JASRI	A. Kiyomichi

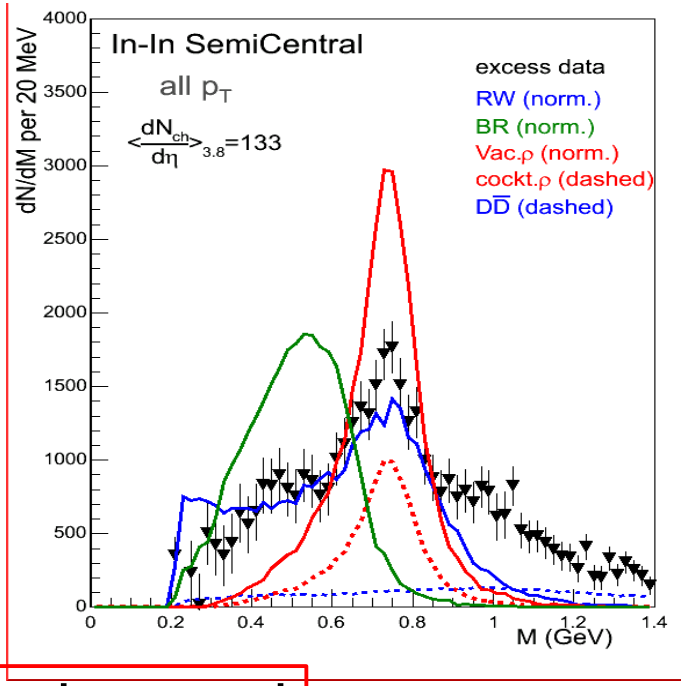
Mass and chiral symmetry in nuclear matter

- Origin of quark and hadron mass : spontaneous breaking of chiral symmetry
- In hot/dense matter, chiral symmetry is expected to be restored
  - hadron spectral modification is also expected
  - many theoretical and experimental approaches
- Hadron modification is observed in many experiments, but the origin is not determined
  - NA60(SPS), PHENIX(RHIC) : ρ and/or low mass
  - CLAS-g7(JLab) : ρ
  - E325(KEK-PS) : ρ/ω, and φ
    - best mass resolution and high statistics
- Next Step ...
  - put an emphasis on φ : not ambiguous like ρ/ω



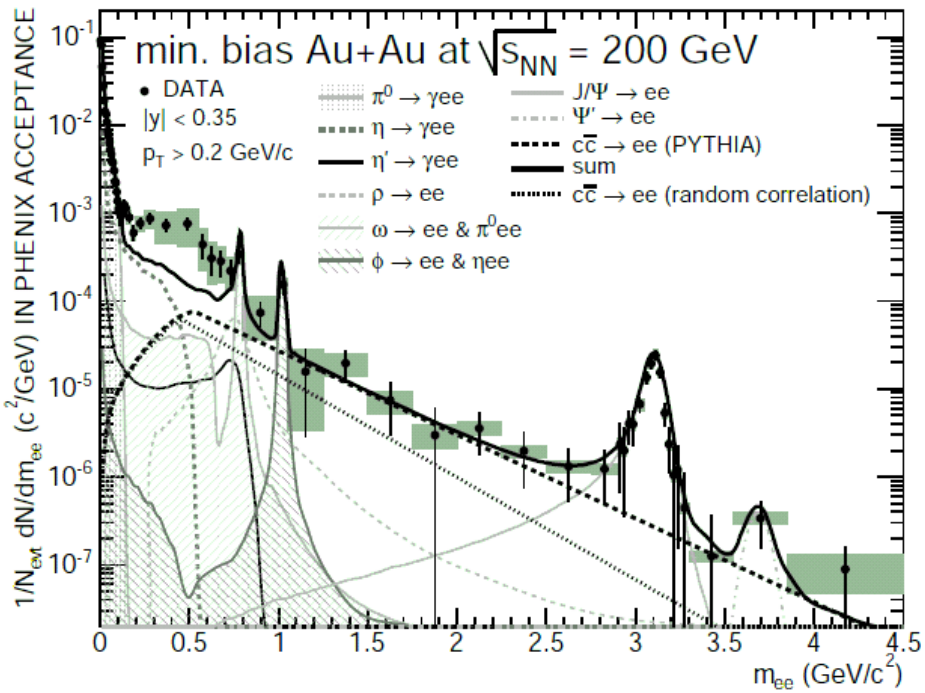


vacuum normal [density]
nuclear density



BKG subtracted

NA60



PHENIX

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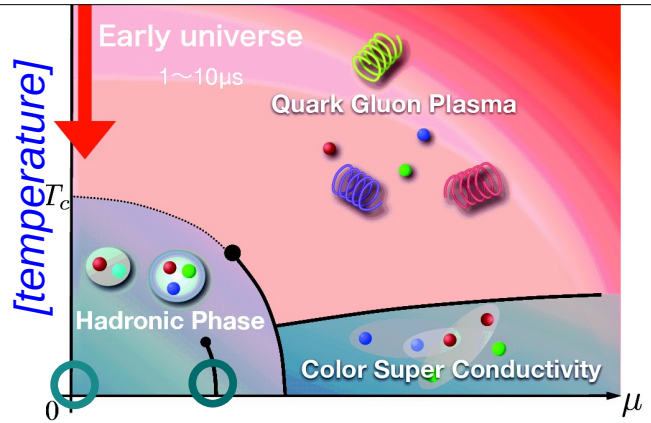

Mass and chiral

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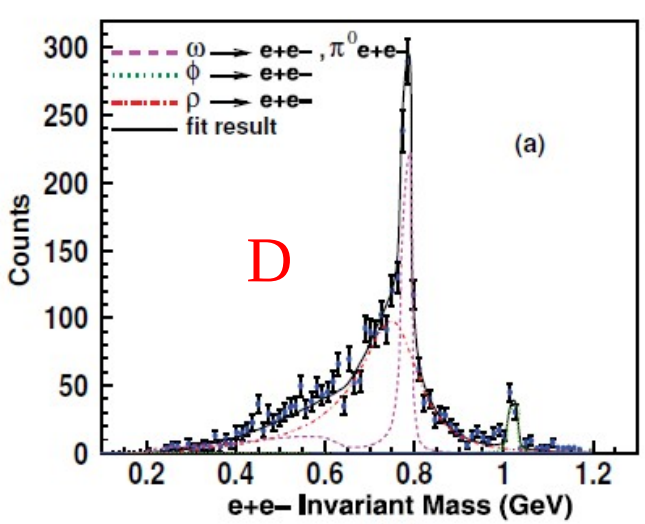
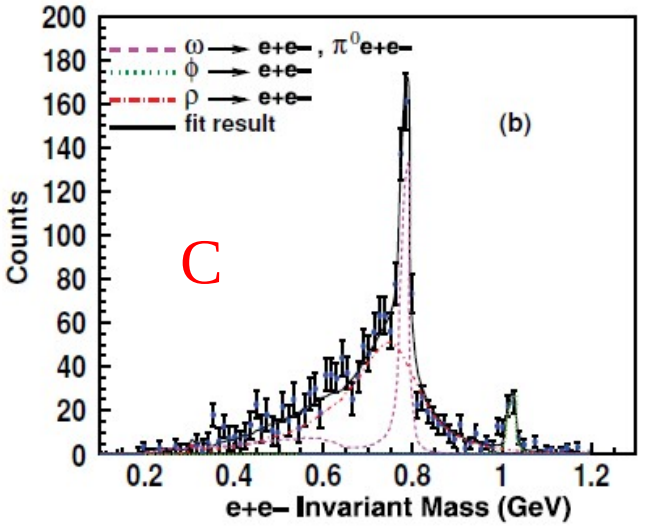
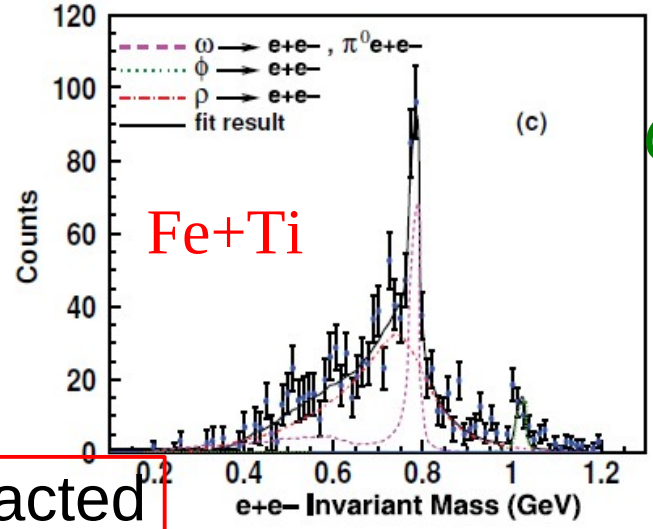
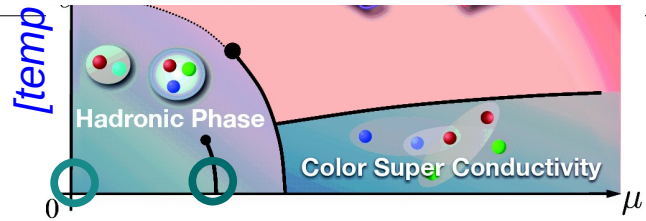






CLAS-g7

BKG subtracted



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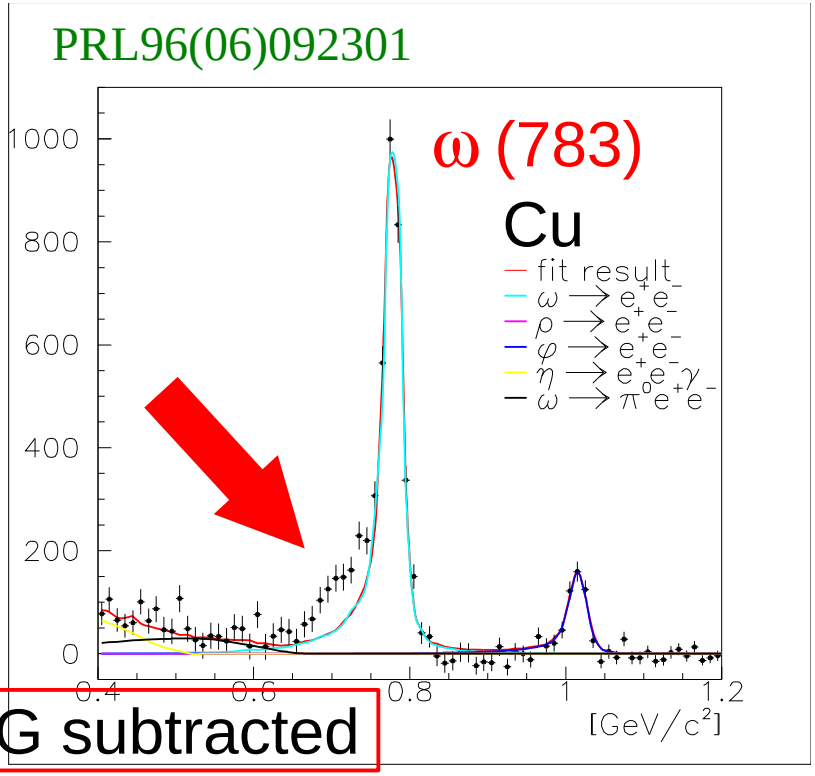
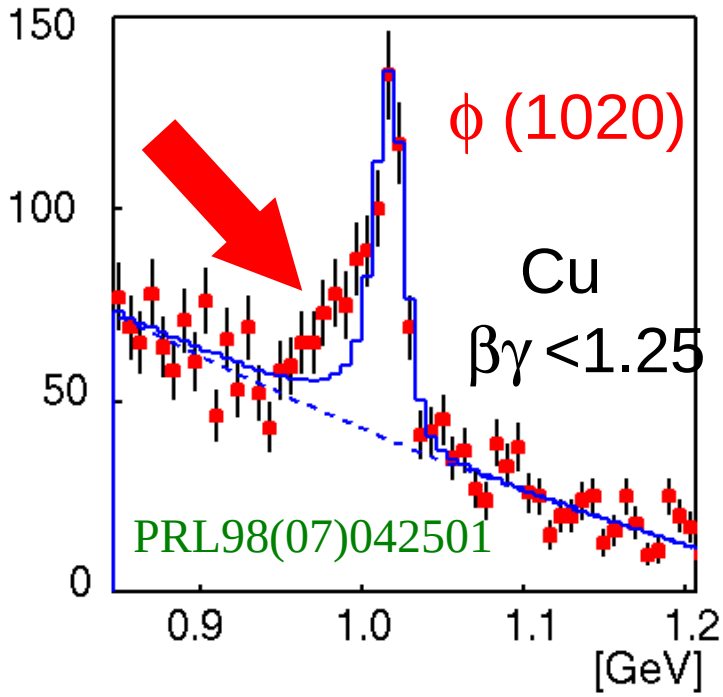


E325



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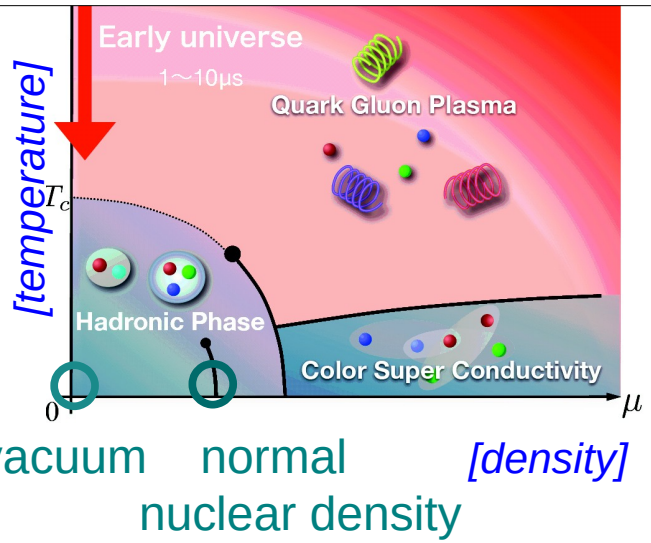
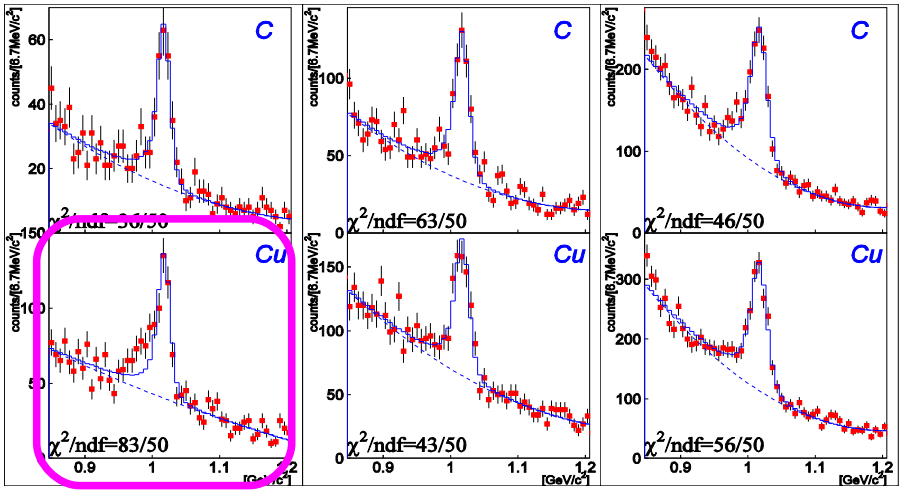


J-PARC E16 experiment

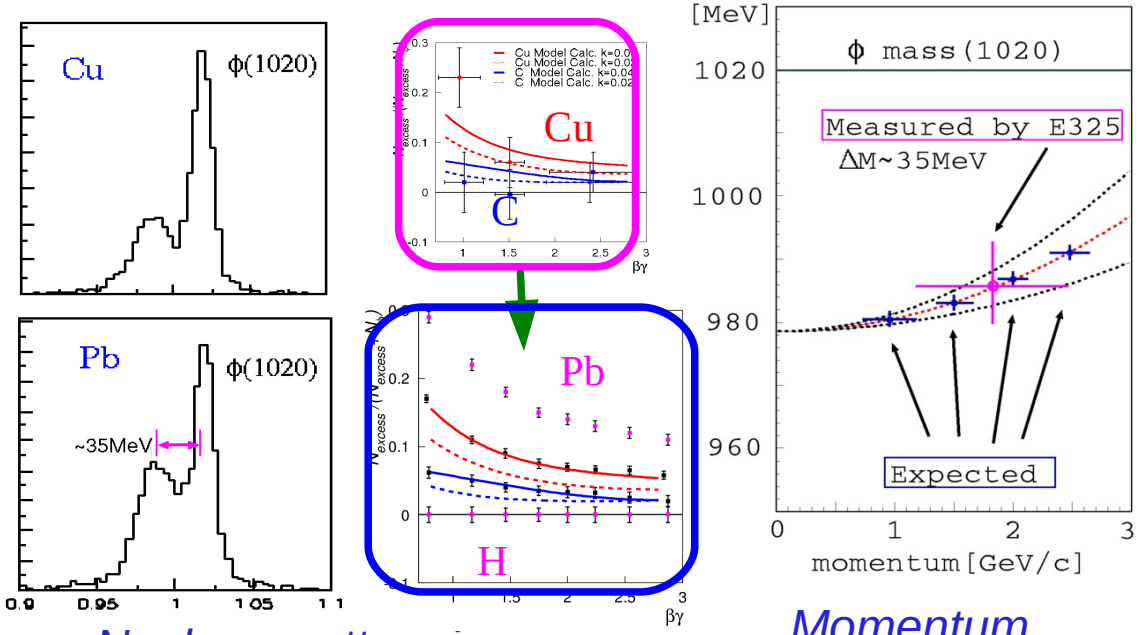
- Measure the vector-meson mass modification in nuclei systematically with the e^+e^- invariant mass spectrum
- A 30 GeV primary proton beam (10^{10}/spill) / 5 weeks of physics run to collect ~10^5 $\phi \rightarrow e^+e^-$ for each target
- confirm the E325 results, and provide new information as the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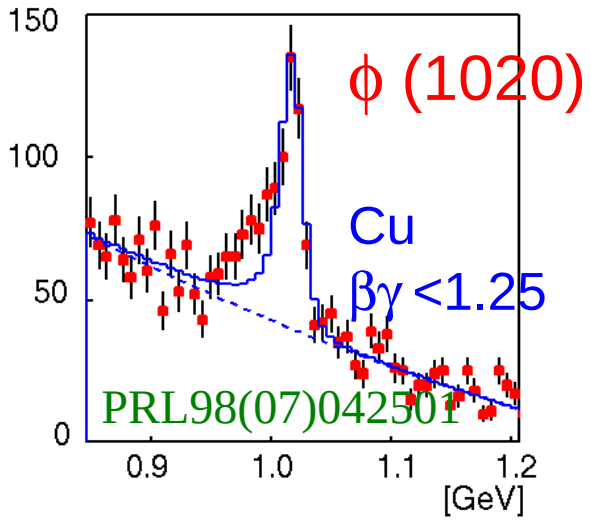

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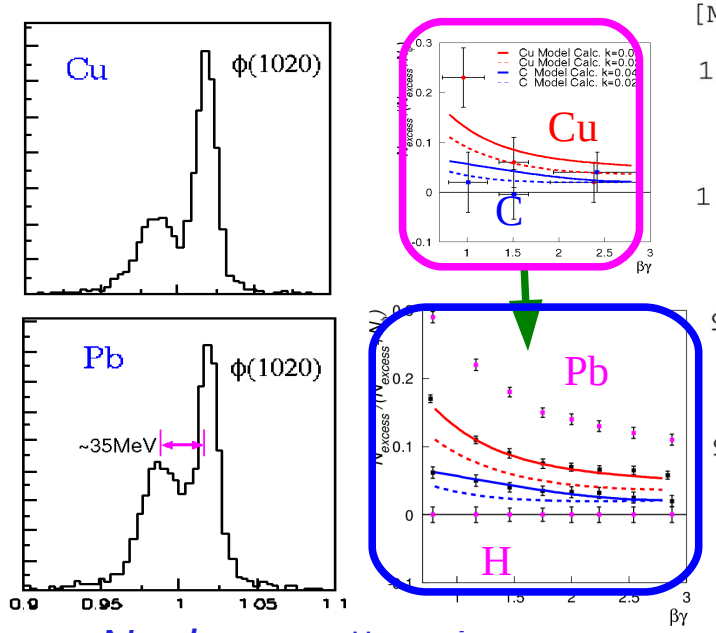
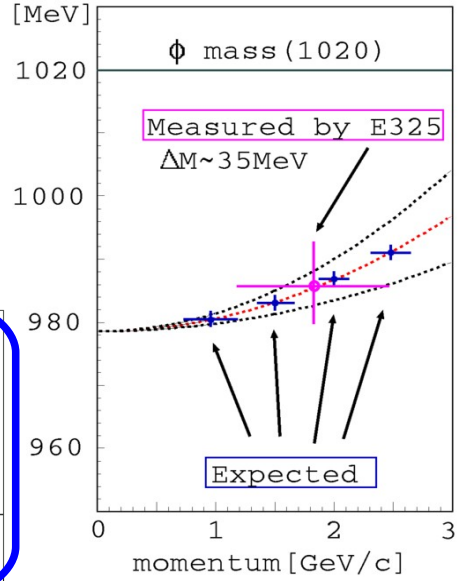


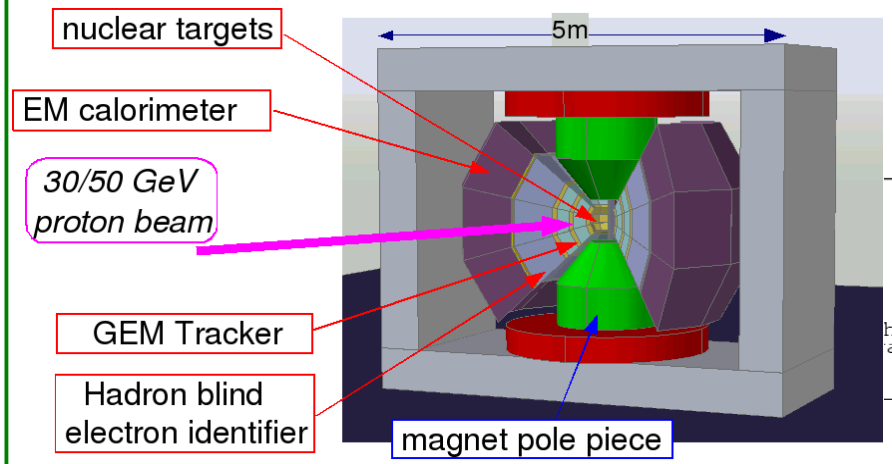


Nuclear matter size dependence & *Momentum dependence* of mass modification are measured

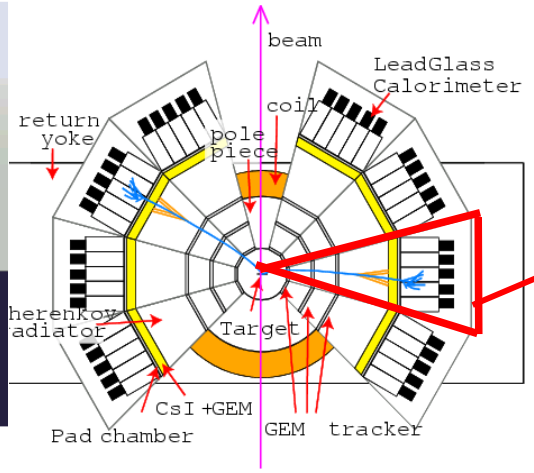
To collect high statistics

- 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.

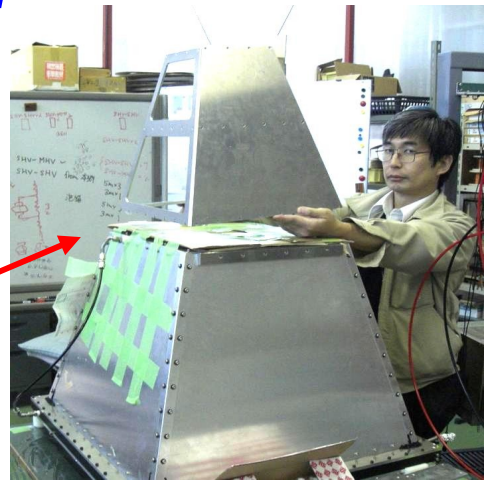
Proposed Spectrometer



Plan View



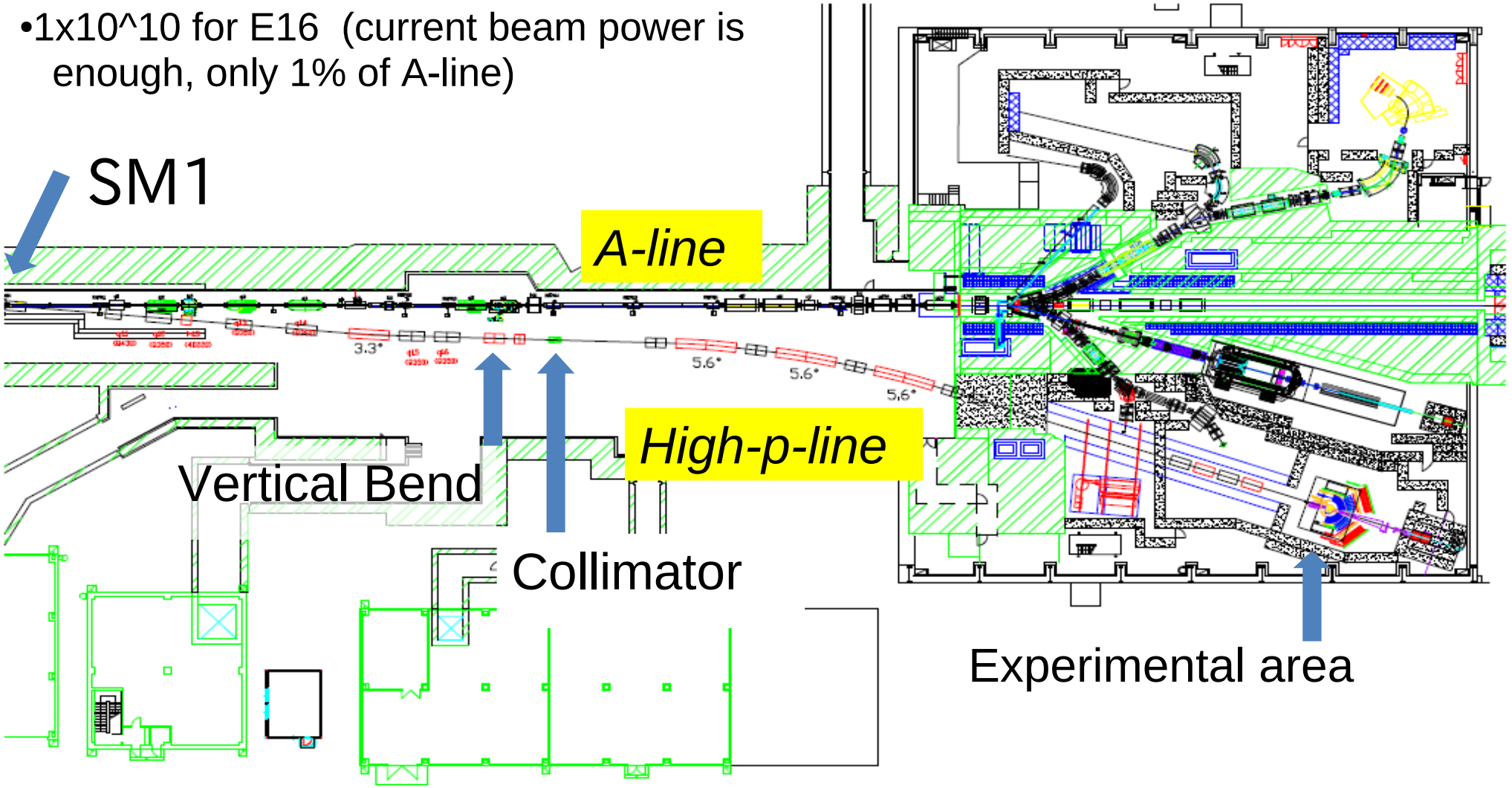
Prototype Module



26 detector modules

High-p line in the Hadron hall to be constructed

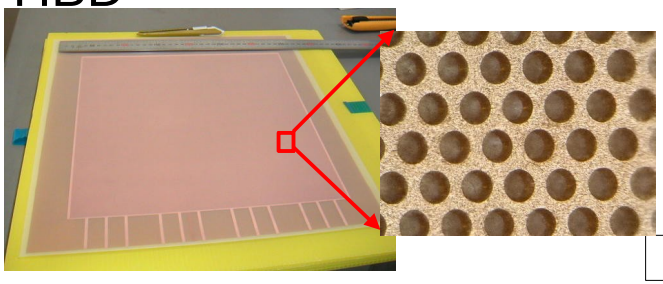
- 1x10^10 for E16 (current beam power is enough, only 1% of A-line)



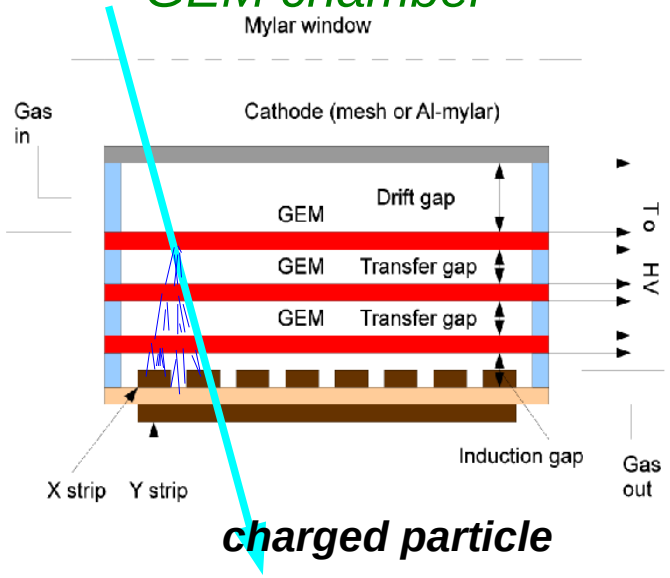
- 3 years plan of the construction : budget requested by KEK to MEXT

Detector R&D

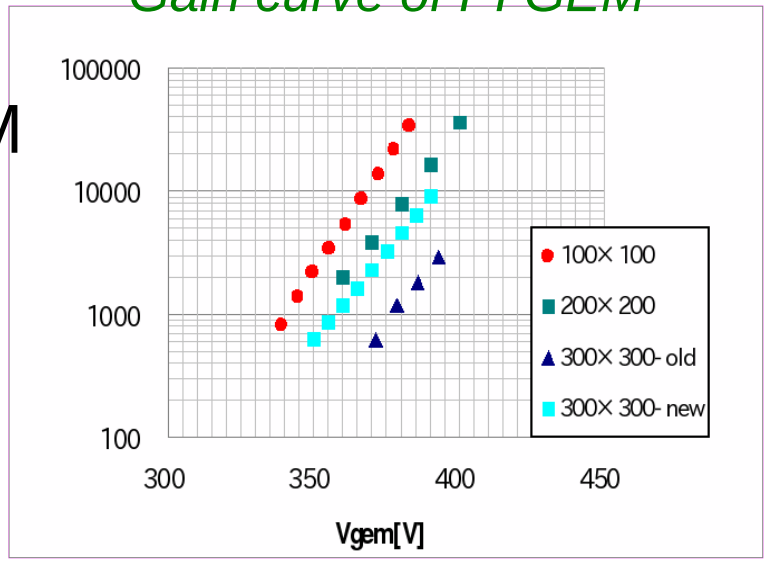
- GEM Tracker to cope with the high rate
  - Ar+CO_2(70:30)
  - angled injection, 2D readout,etc.
  - required position resolution 100um is achieved for angled tracks w/ FADC R/O
- Hadron Blind Detector to trigger the electrons
  - CsI photocathode, CF_4 gas purity, etc.
  - *Next Talk by K. Aoki*
- 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

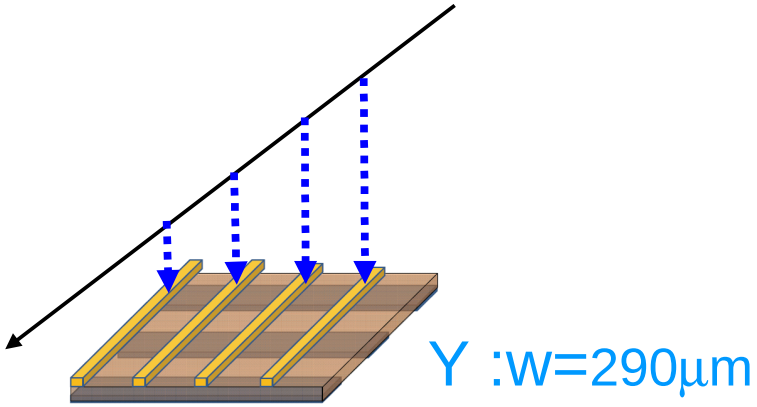


Progress in JFY 2011 (after the previous WS)

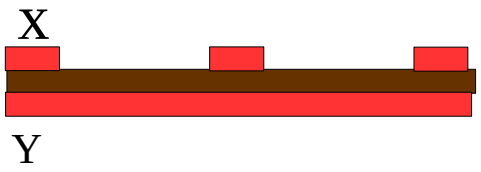
- Beam test at ELPH, Tohoku-U (March), and at LEPS (Oct.)
- GEM Tracker
  - 1st production type (100x100) w/ BVH-type R/O board works well.
  - Total mechanical design is in progress.
- Spectrometer Magnet
  - additional poles and yokes (coil) will be delivered at March (Sept.)
- HBD
  - improvement of #p.e, 1st module of production type, … : *reported by K. Aoki*
- LG
  - design of magnetic shield and the checking of PMT are in progress
- R/O Circuit
  - R&D is just started. some test board/modules were just delivered.
- Budget request for High-p line from KEK to MEXT is rejected
  - Construction cannot start in JFY2012

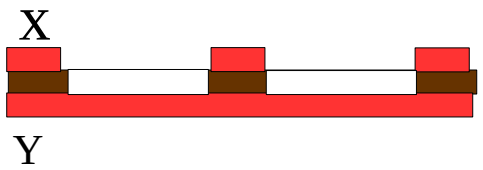
Three types of 2D-R/O board of GEM Tracker

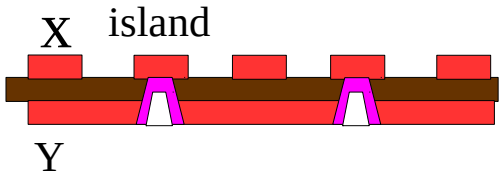
- thin two-dimensional read out board
  - base: t=25 um kapton
  - strip pitch : X: 350 um, Y:350 um
  - required resolution X:100um , Y: 700um
- double side type
  - Y- efficiency is bad (~80%)
- mesh type
  - amplified electrons can reach both X and Y strips by etching-out of base kapton
  - expensive and fragile
- BVH (blind-via-hole) type
  - island electrodes between X strips to transport the electrons to Y strips via holes
  - pitch of Y is changed: 1400um
  - tested in Oct. 2011, works well



X : w=70 μm



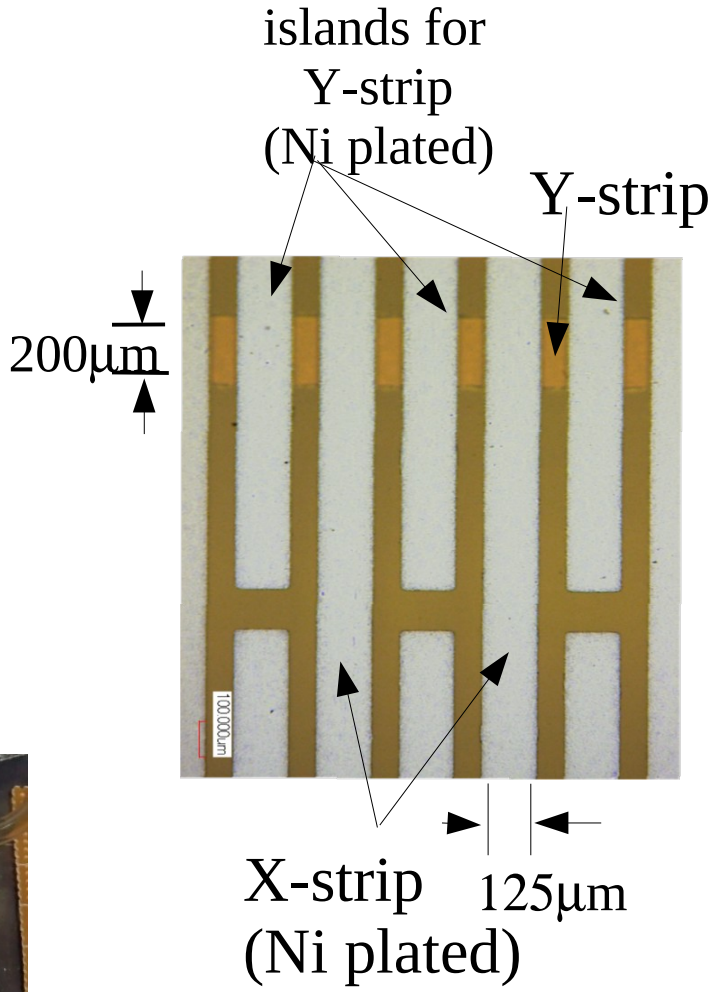


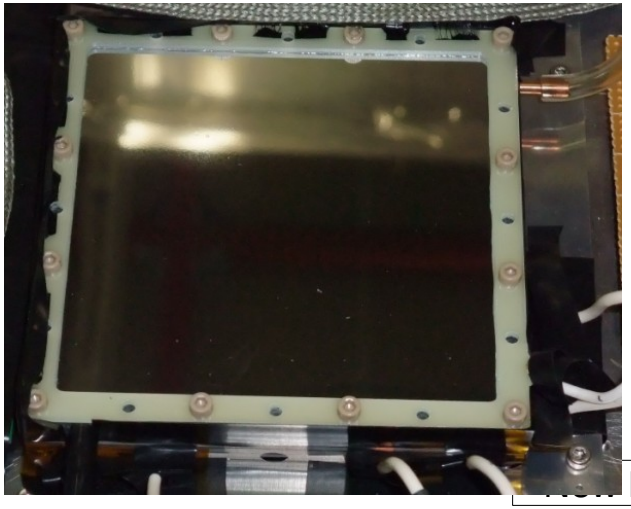


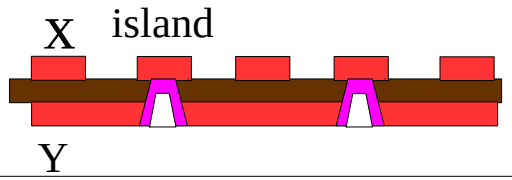
GEM Tracker test @ LEPS

- 1st 100mm x 100mm production type Tracker
  - BVH-type R/O board
  - Al-mylar cathode
  - gastight is kept by the GEM frame, Al-mylar and the R/O board
  - resolution (efficiency) under the gain=5000
    - 105μm (98%) for X
    - 310 μm (93%) for Y : can be improved by gain=10000

BVH type R/O board

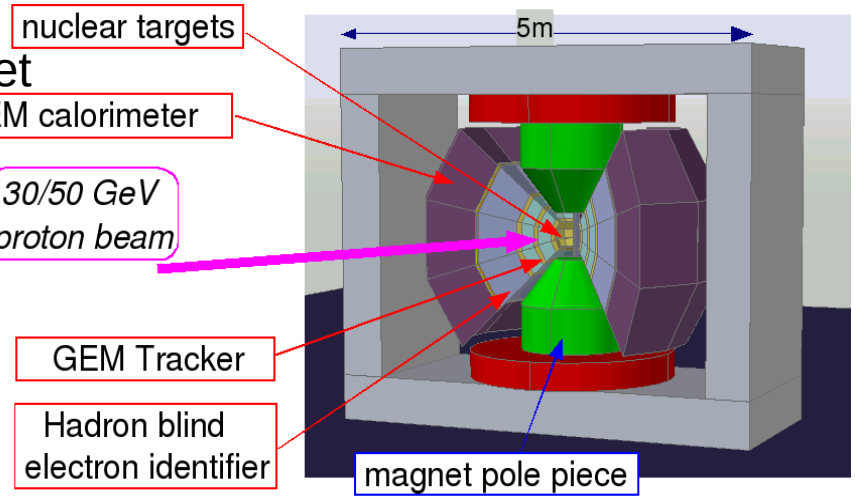






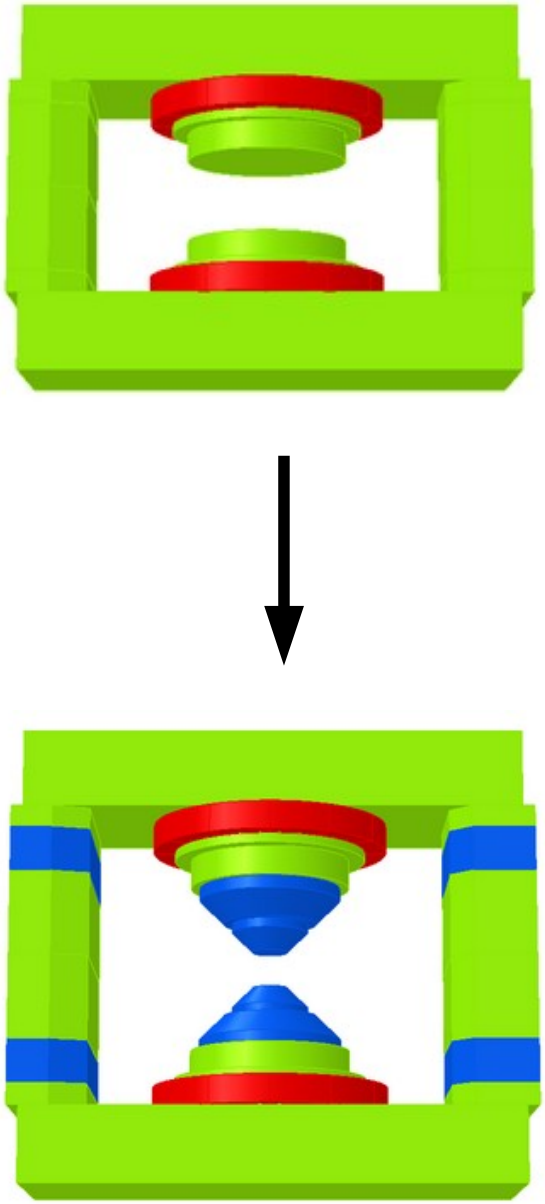
Schedule

- •2007: stage1 approval
- •2008-2010 : development of prototype detectors
- •2011 : additional parts of the spectrometer magnet , R/O circuit development, 1st module of production type (GT and HBD)
- •2012 : magnet re-construction
  - all the detectors should be installed in the magnet
  - Test exp (T43) at J-PARC around June
    - GEM stabilty and HBD response for pion beam
    - GEM Tracker R/O circuit
  - production of the detectors/circuits
- •2013 : staged goal of the spectrometer construction (w/ 8 detector modules) : ready for the beam
- •2014-15 : production of detector modules (depending on the budget)



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



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 : the end of JFY 2013

Backup slides...

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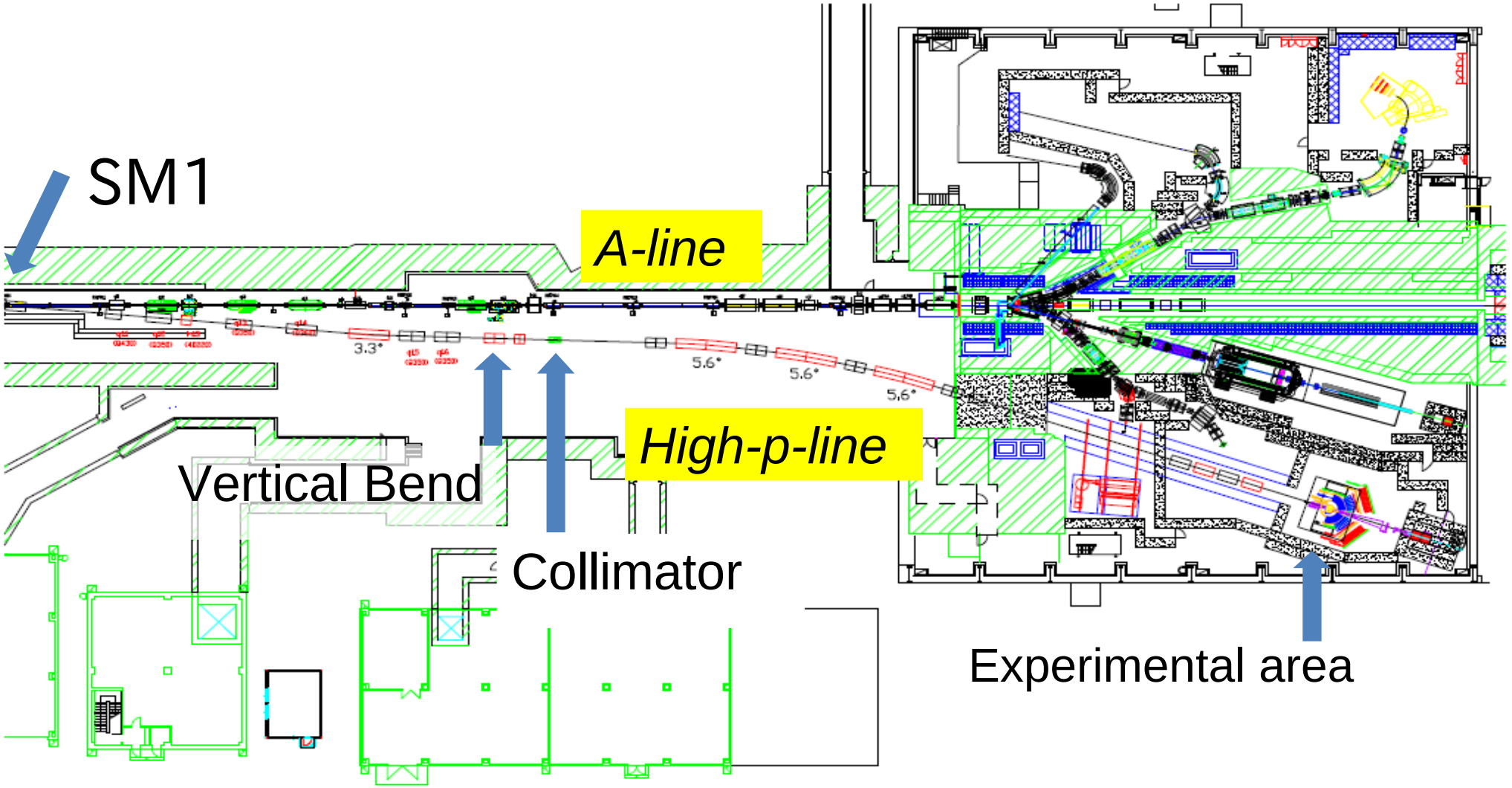
High-p line


SM1
A-line
3.3°
5.6°
5.6°
5.6°
High-p-line
Vertical Bend
Collimator
Experimental area

High-p line