J-PARC E16 Status & Plan

Proposal title :
Electron pair spectrometer at the J-PARC 50 GeV PS to explore the chiral symmetry in QCD

Satoshi Yokkaichi
(RIKEN Nishina Center)

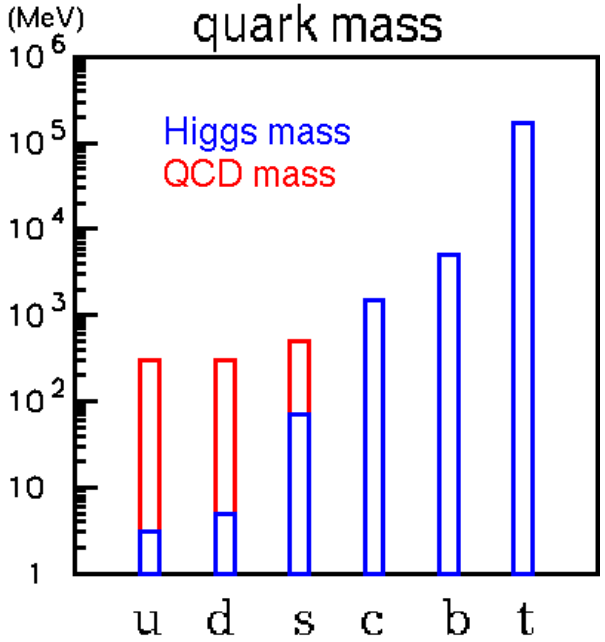
- physics motivation
- experiment
- detector development
- schedule
- summary and requests to KEK

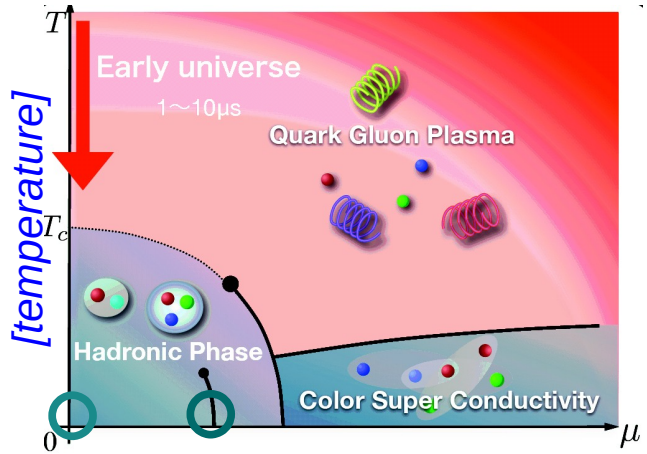
Collaboration

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



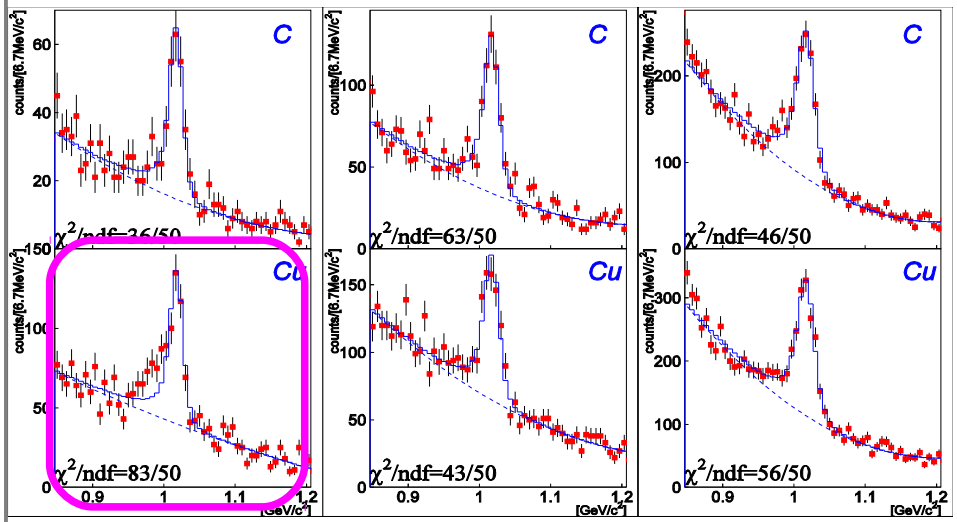


vacuum normal [density]
nuclear density

J-PARC E16 experiment

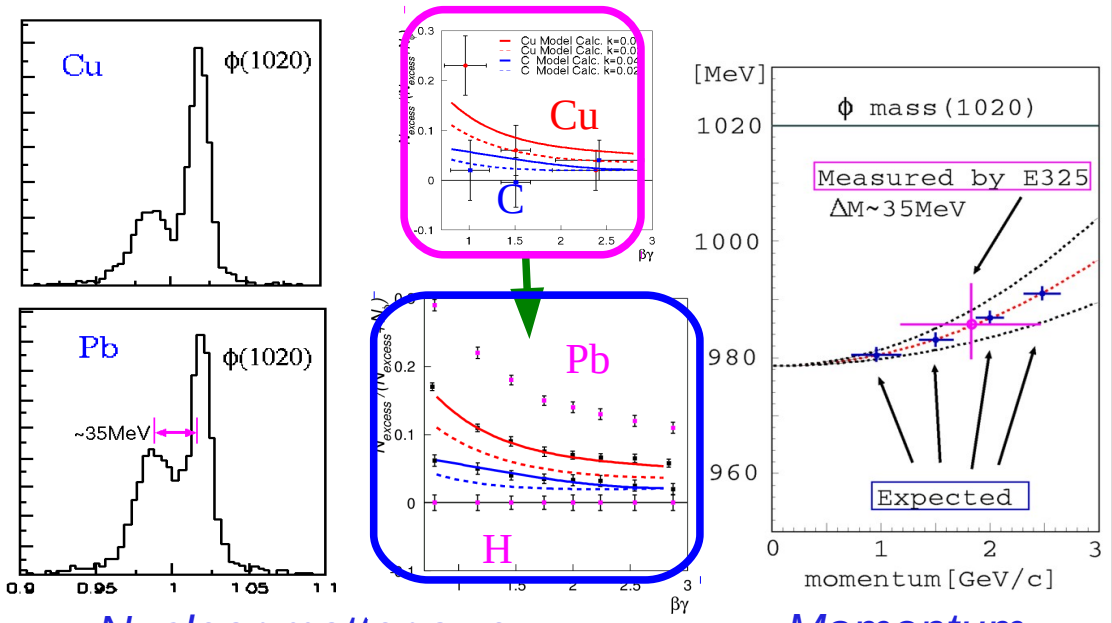
- Measure the vector-meson mass modification in nuclei systematically with the e^+e^- invariant mass spectrum
- A 30 GeV primary proton beam (10^{10}/spill) / 5 weeks of physics run to collect ~10^5 $\phi \rightarrow e^+e^-$ for each target (CH2/C/Cu/Pb) : E325 x 100
- confirm the E325 results, and provide new information as the matter size dependence and the 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

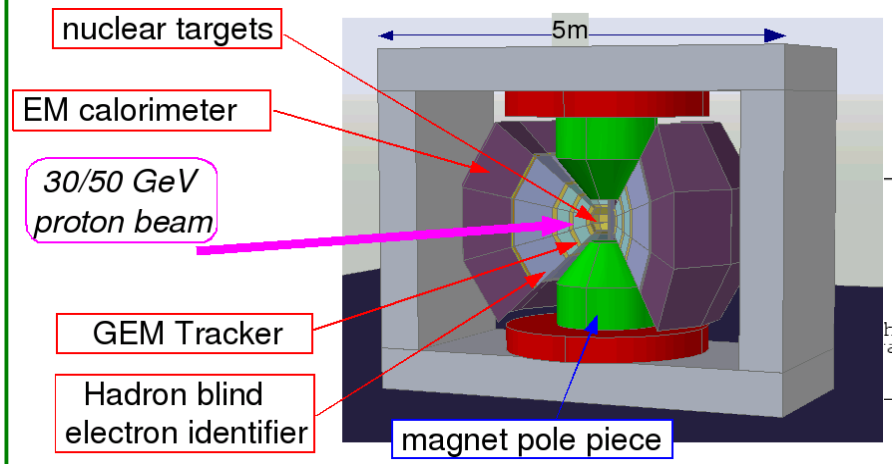


Nuclear matter size dependence & *Momentum dependence* of mass modification are measured

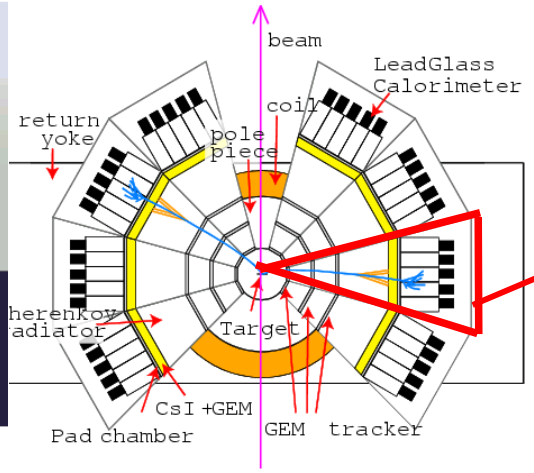
To collect high statistics

- 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.

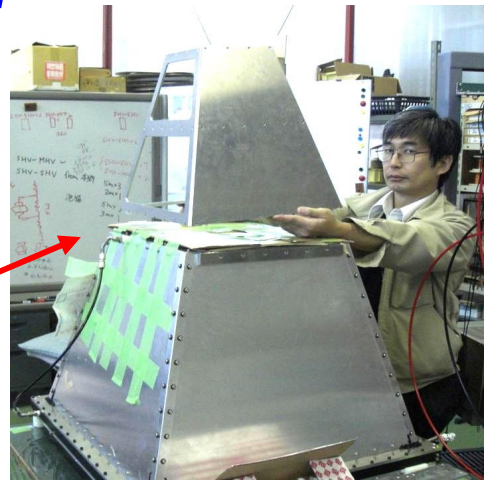
Proposed Spectrometer



Plan View



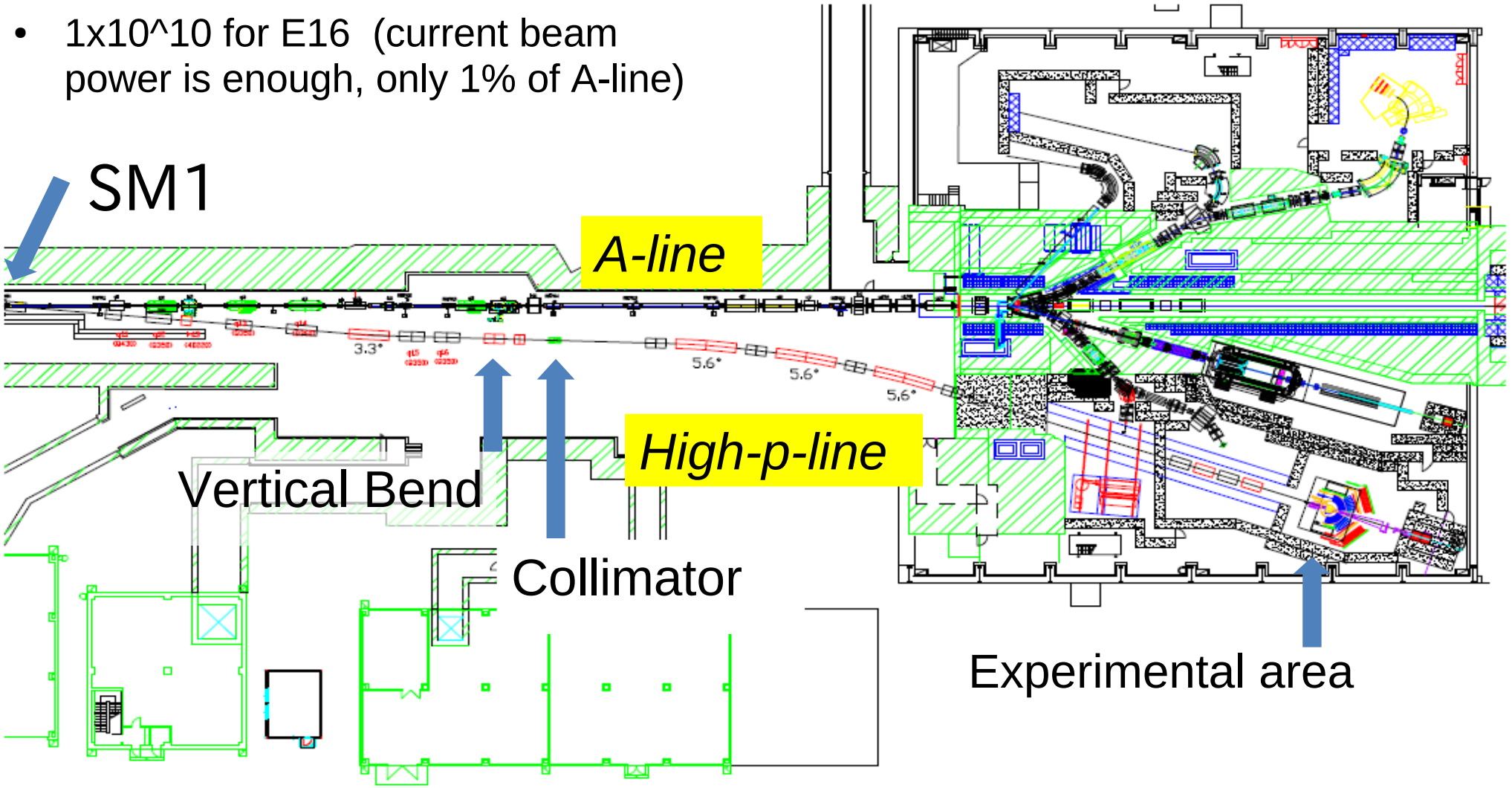
Prototype Module



26 detector modules

High-p line in the Hadron hall

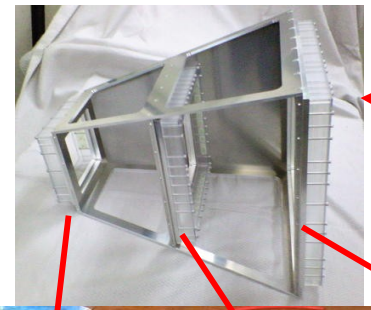
- 1x10^10 for E16 (current beam power is enough, only 1% of A-line)

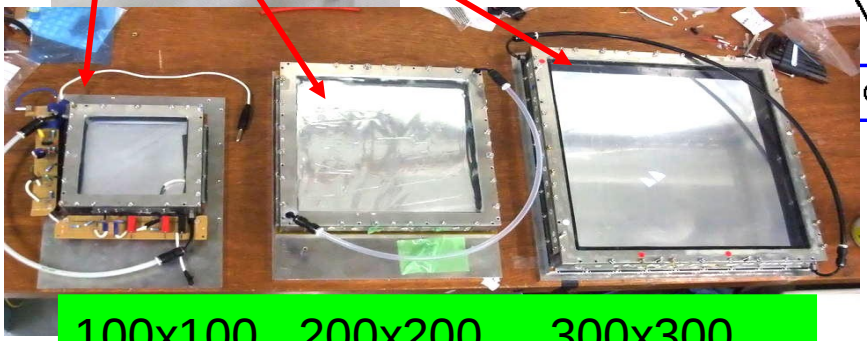


- A three-years plan of the construction : budget has been requested by KEK

Beam test results of prototype detectors

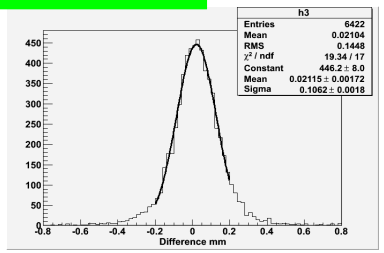
GEM Tracker



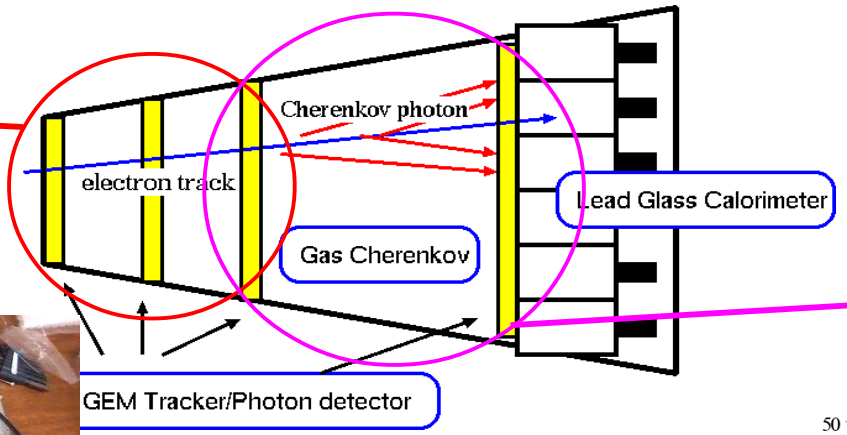


100x100 200x200 300x300

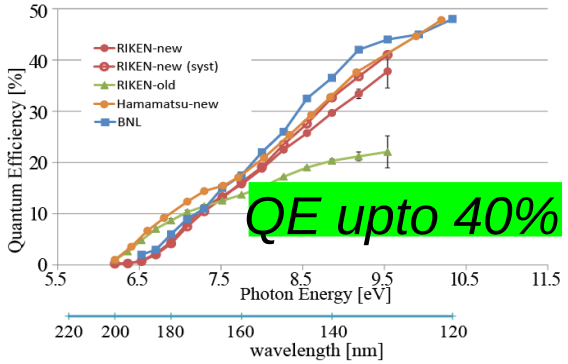
Required position resolution (~100μm) is achieved



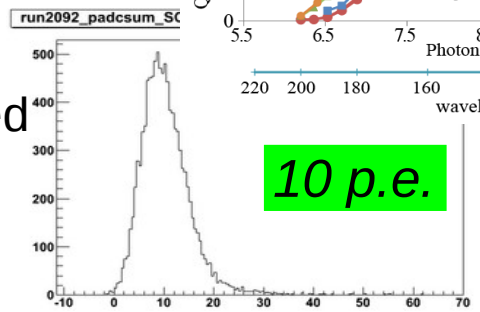
HBD (Hadron-Blind Cherenkov detector)



UV Cherenkov photons are detected with CsI-evaporated LCP-GEM and CF_4 gas



QE upto 40%



10 p.e.

- Large size (300x300mm) PI- and LCP-GEM are successfully worked for a electron beam
  - Stability for a pion beam should be checked.
- GEM Tracker is successfully worked.
- Improvement of the photo-detection efficiency of HBD is on going

Schedule

•2007: stage1 approval

•2008-2010 : development of prototype detectors w/ Grant-in-Aid(2007-8, 2009-13)

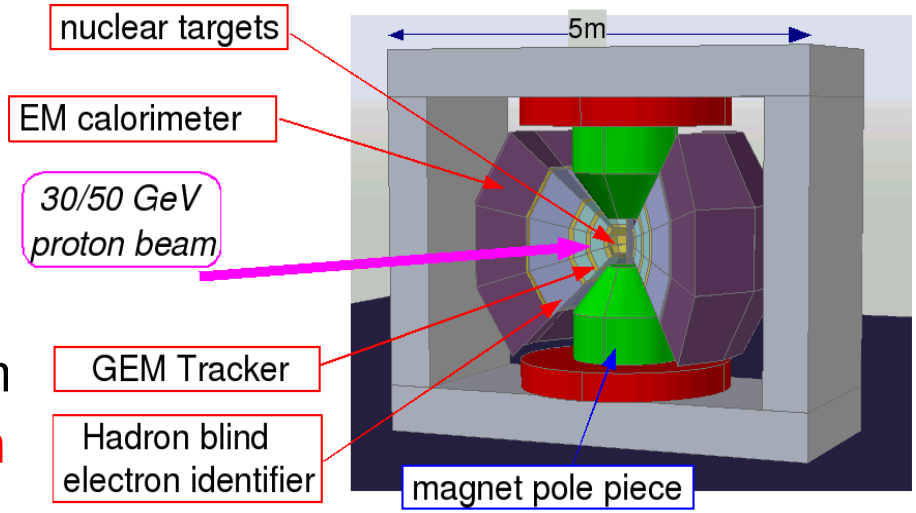
•2011 : additional parts of the spectrometer magnet , R/O circuit development

- 1st module of production type (GT and HBD)
  - test using pion beam @ J-PARC

•2012 : magnet re-construction

- all the detectors are installed in the magnet

- production of the detectors/circuits



•2013 : staged goal of the spectrometer construction (w/ 8 detector modules) : ready for the beam

- (beam power is enough for 10^10 /spill at High-p)

•2014-15 : production of detector modules (depending on the budget)

Schedule

					1	2	3	4	5	6	7	8	9	10	
		理研2期					理研3期					理研4期			
JFY		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
		H20	H21	H22	H23	H24	H25	H26	H27	H28	H29	H30	H31	H32	
J-PARC hadron		0	1	2	3	4	5	6	7	8	9	10	11	12	
RJC plan						1	1	2	3	4	5	1	2	3	
BNL MOU															
RHIC PHENIX		8	9	10	11	12	13	14	15	16					
sPHENIX										1?	2	3	4	5	
ePHENIX															
eRHIC															
LHC ALICE				1	2	3	4	5	6	7	8	9	10	11	
GSI FAIR											1	2	3	4	
HADES run												0?	1	2	
High-p line						→	1	2	3	1	2	3	4	5	
E16 construction															
E16 run								→	0	1	2	3			
new hadron (Grant-in-Aid)			1	2	3	4	5								

This year(JFY)

Schedule

					1	2	3	4	5	6	7	8	9	10
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E16 construction														
E16 run									0	1	2	3		
new hadron (Grant-in-Aid)			1	2	3	4	5							

This year(JFY)

possibly compete with HADES/FAIR

Summary

- Investigation of the hadron spectral modification in nuclear matter is a study of the nature of QCD vacuum
  - A 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
  - Staged Goal of construction : the end of JFY 2013
- Requests to KEK : see Next

Current requests to KEK

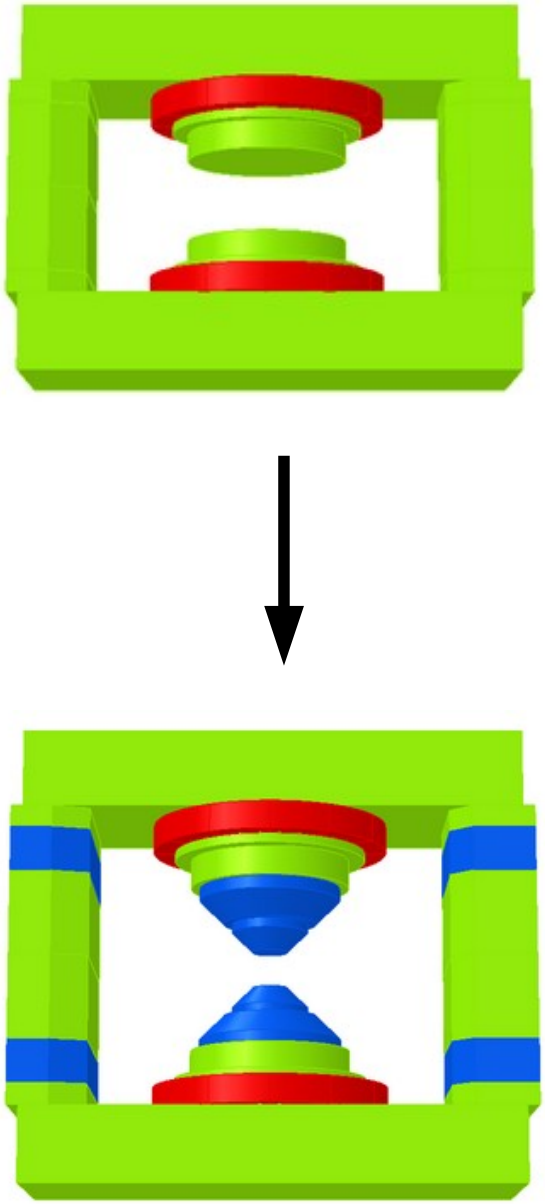
- Test experiment at K1.1BR using a pion beam
  - stability of GEM and HBD response for the pion beam
  - proposal is already submitted. Coming May or June is preferable.
- Spectrometer Magnet construction in JFY2012
  - FM magnet re-construction with new parts.
  - detector installation in the magnet in JFY2013
-
- Early start of the construction of the High-p line.
  - We can start a commissioning in JFY2014
  - Accelerating of the High-p construction is welcome

Backup slides...

-

Spectrometer Magnet re-construction

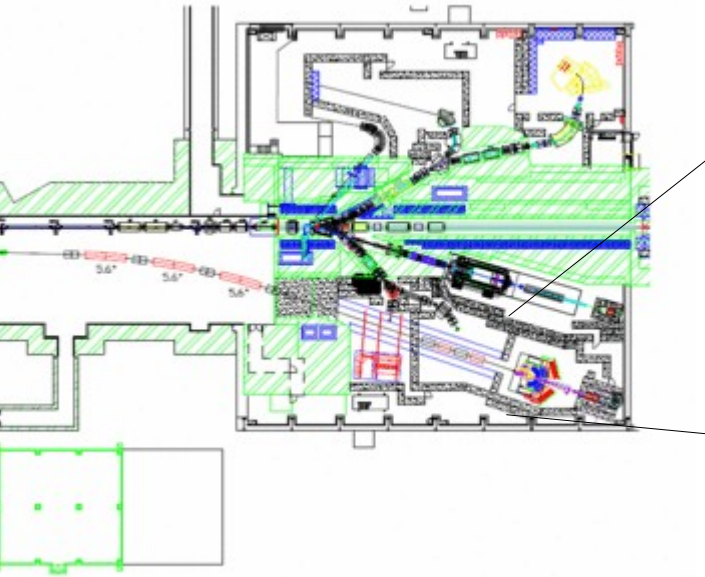
- FM magnet (used by KEK-PS E325)
  - additional poles and yokes
    - larger acceptance/stronger field
  - decompose -> proper location on the High-p line -> re-construction with new parts
  - a pit (digging of the floor concrete) is required under the magnet
    - cannot be managed by Grant-in-Aid : at least, 'overhead' of grants should be used.
  - 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



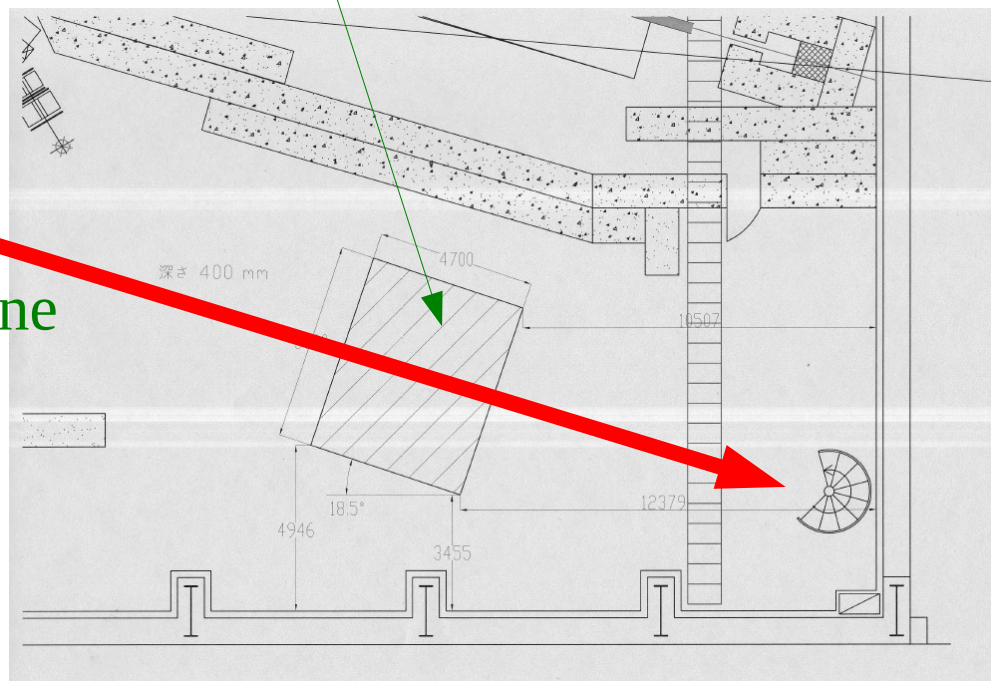
Floor digging for the spectrometer magnet

- make a pit on the floor at the magnet position on the planned High-p line

pit size: 4.7m x 5.9m x 40cm (depth)

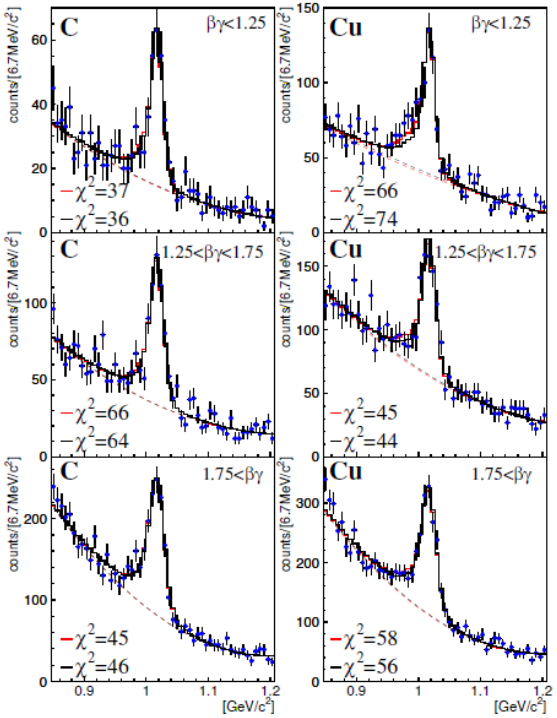


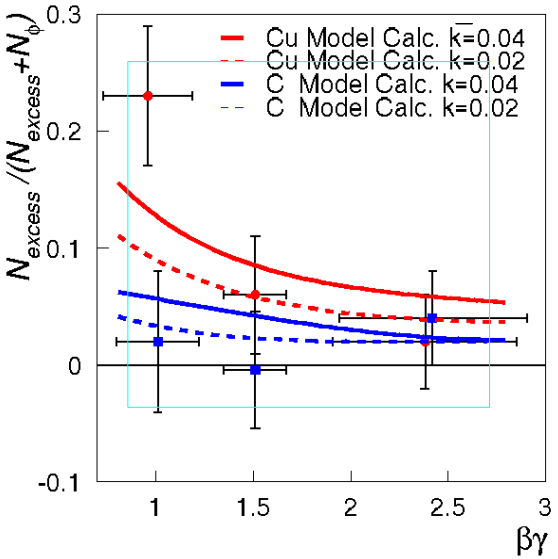
beam line



dispersion relation (mass VS momentum)

- prediction for ϕ by S.H.Lee(p<1GeV/c)
- current E325 analysis neglects the dispersion (limited by the statistics)





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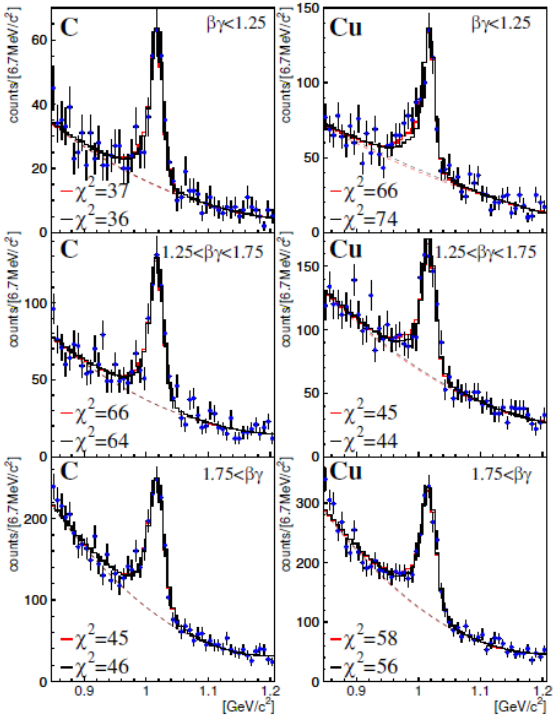

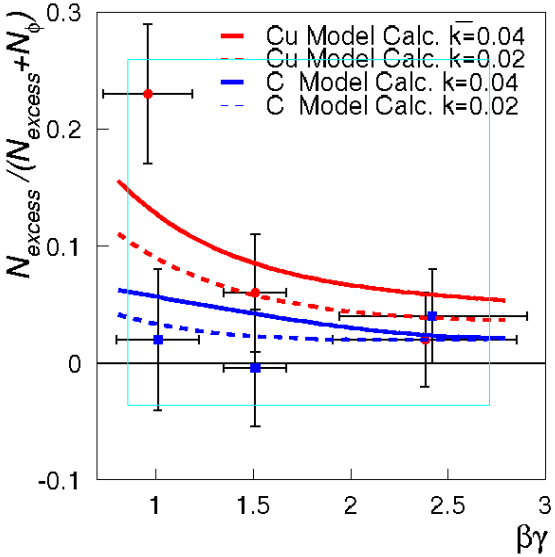

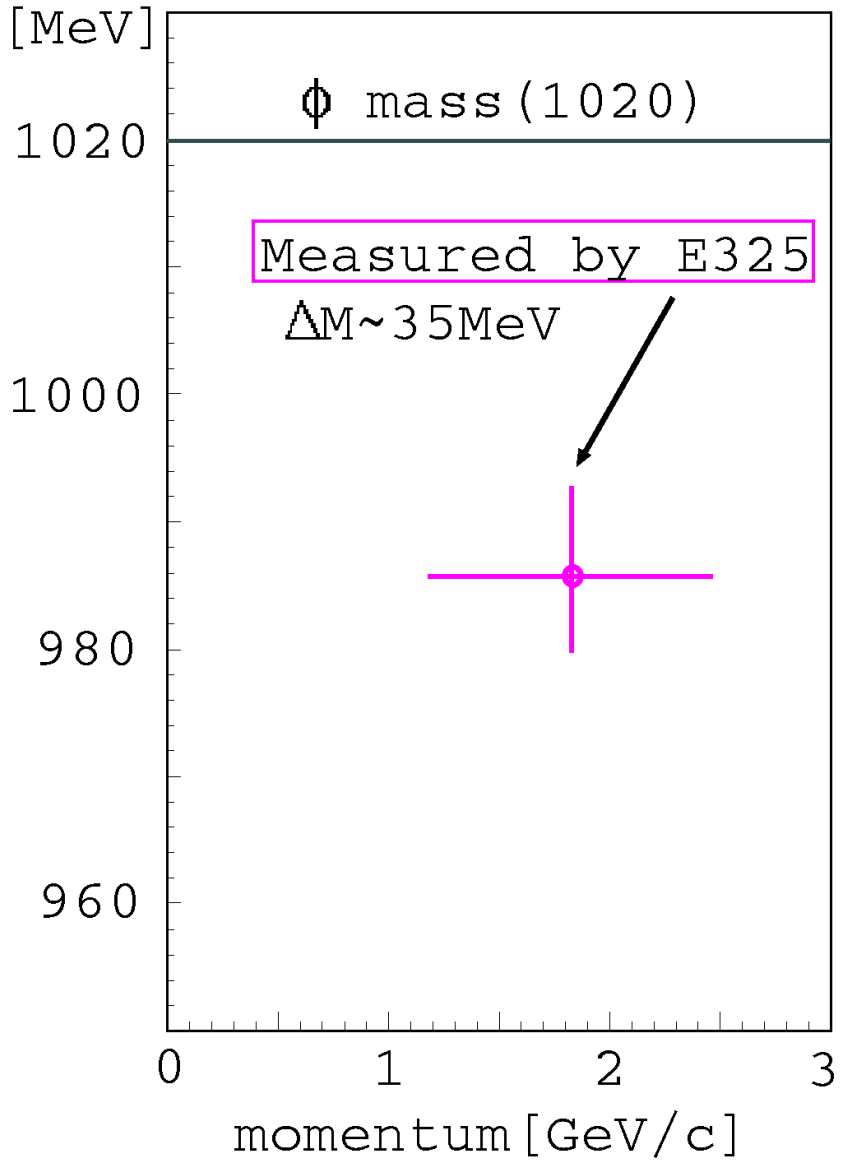

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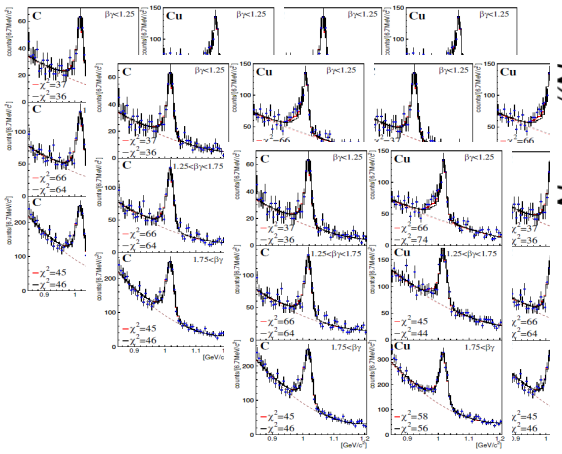
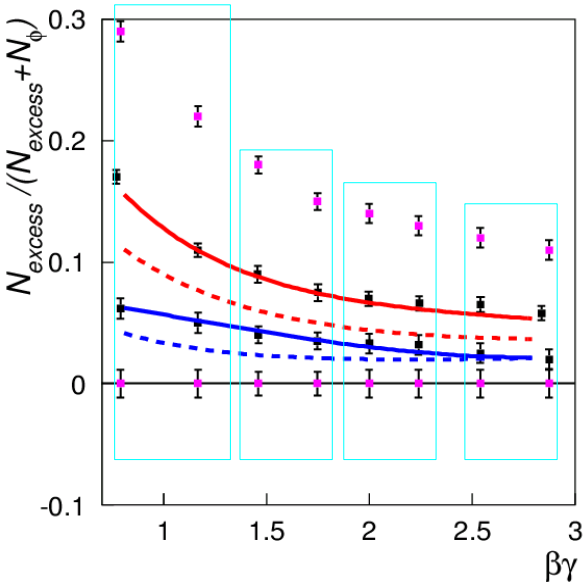
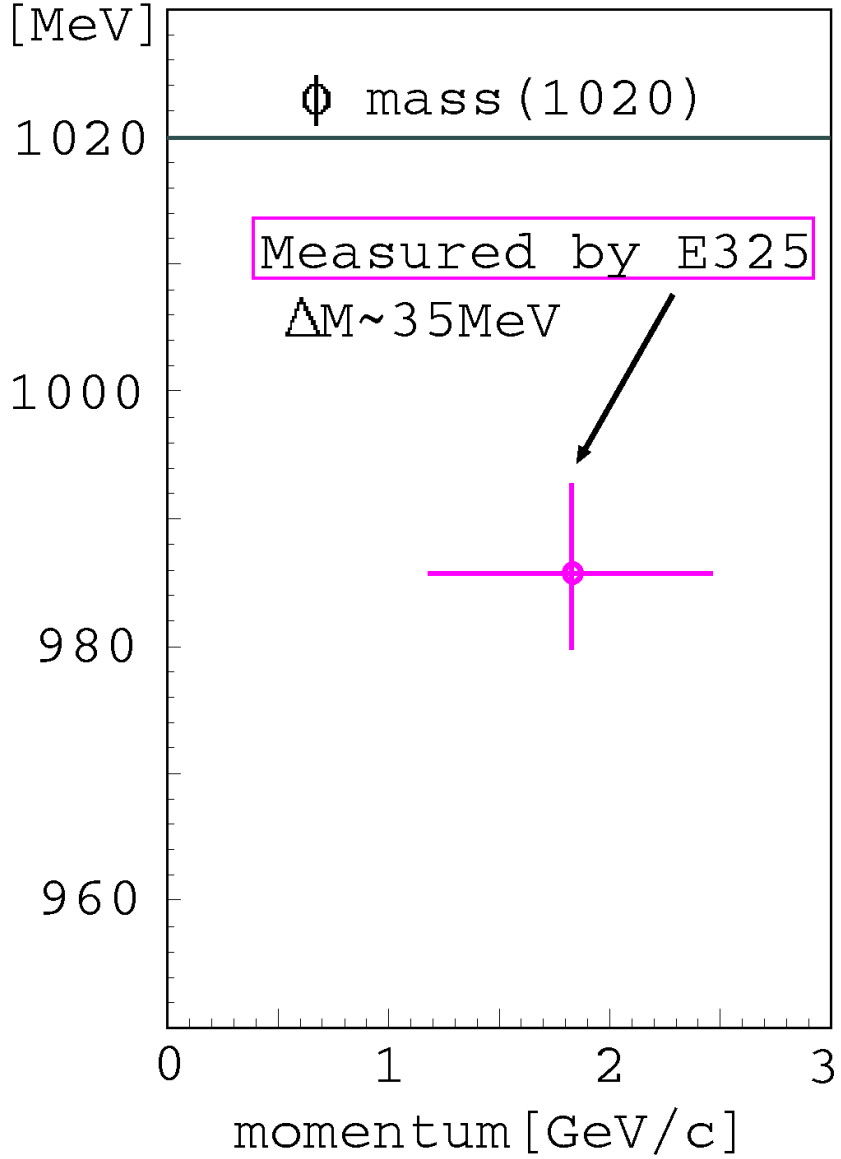
- fit with common shift parameter $k_1(p)$, to all nuclear targets in each momentum bin







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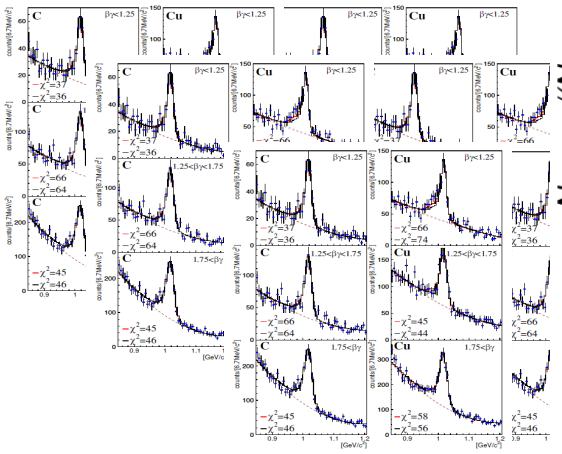
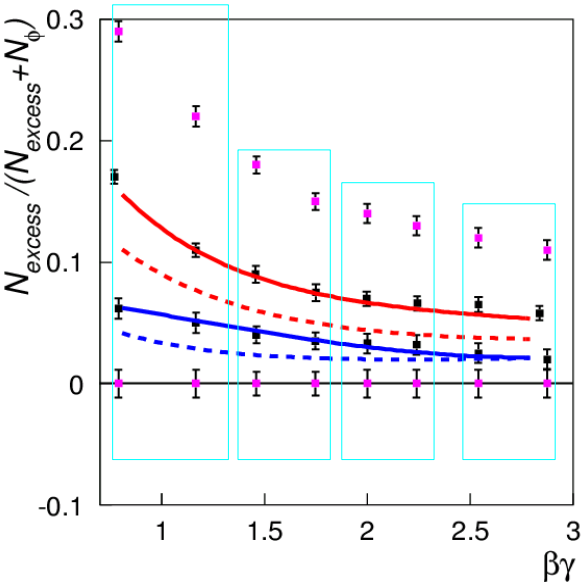
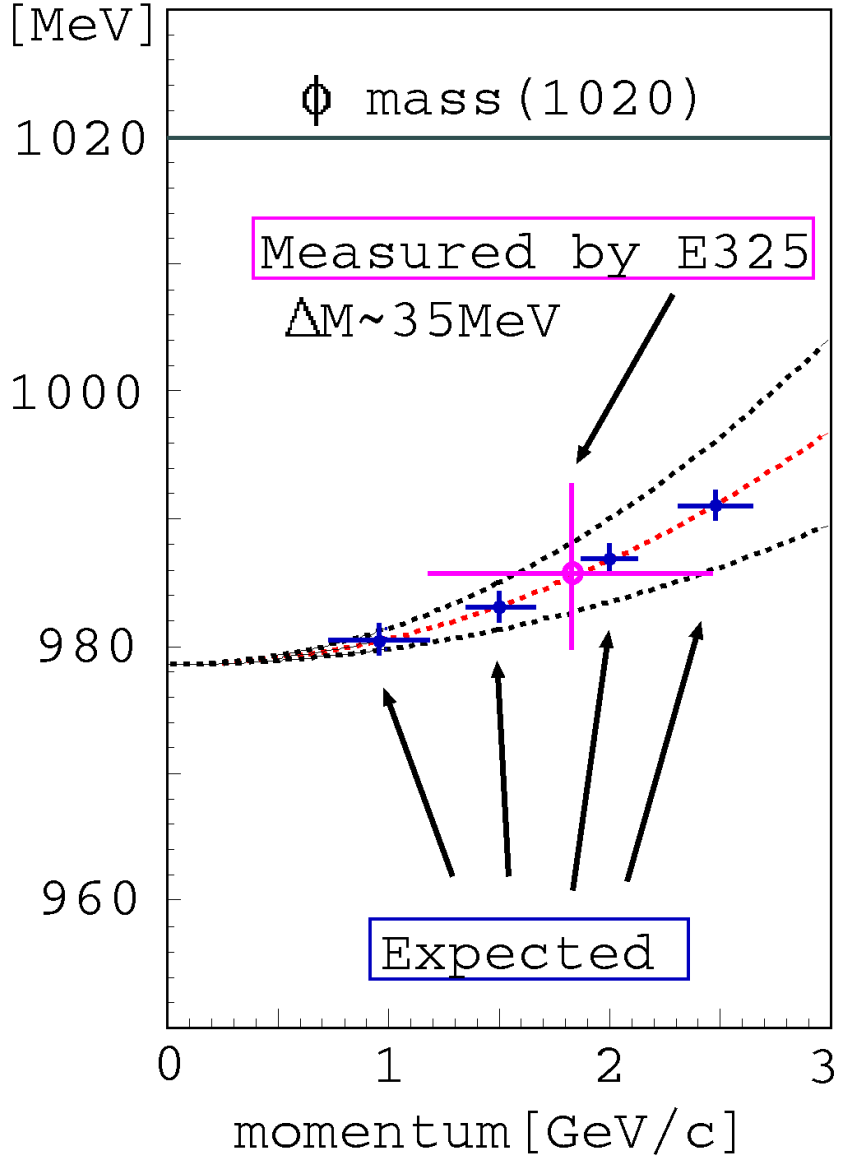


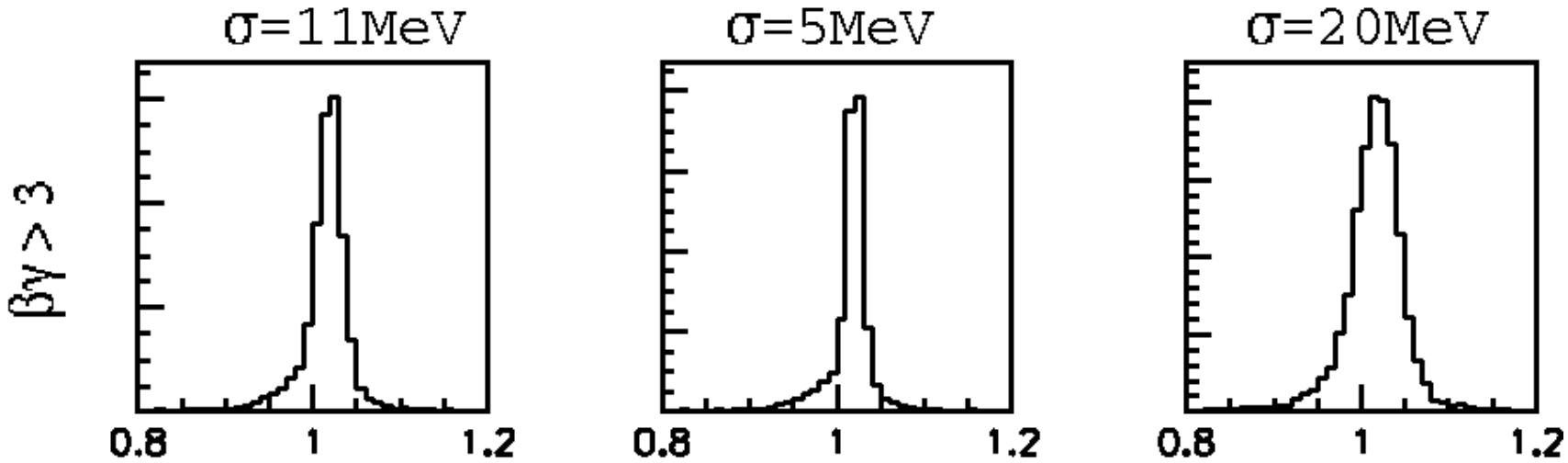




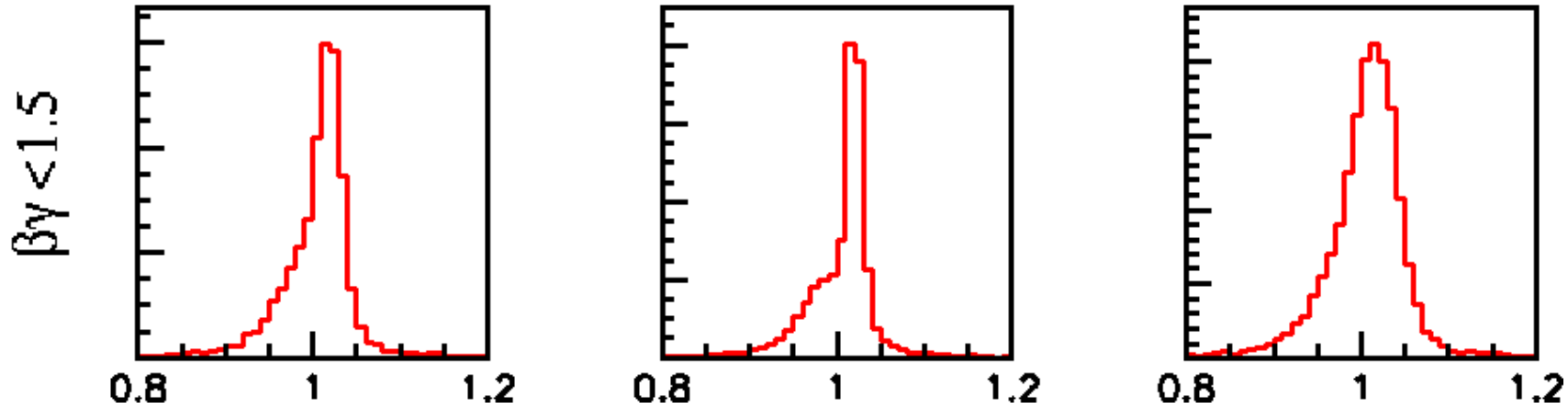
mass resolution requirement

- mass resolution should be kept less than ~10MeV

Fast



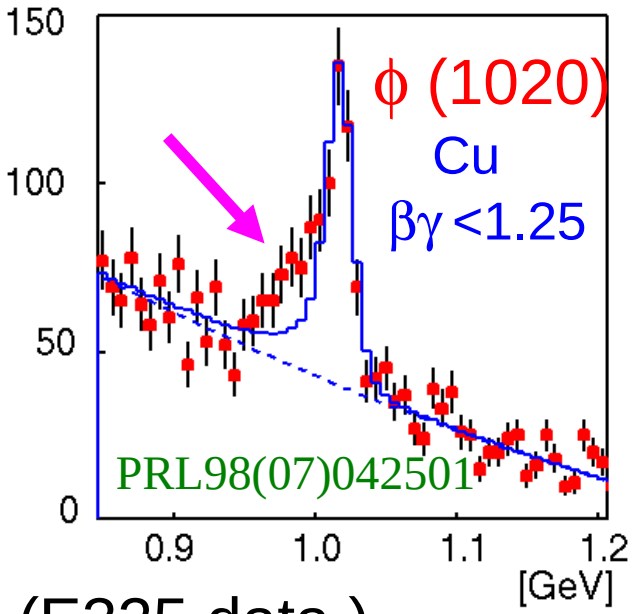
Slow



(model calc. for the Cu target)

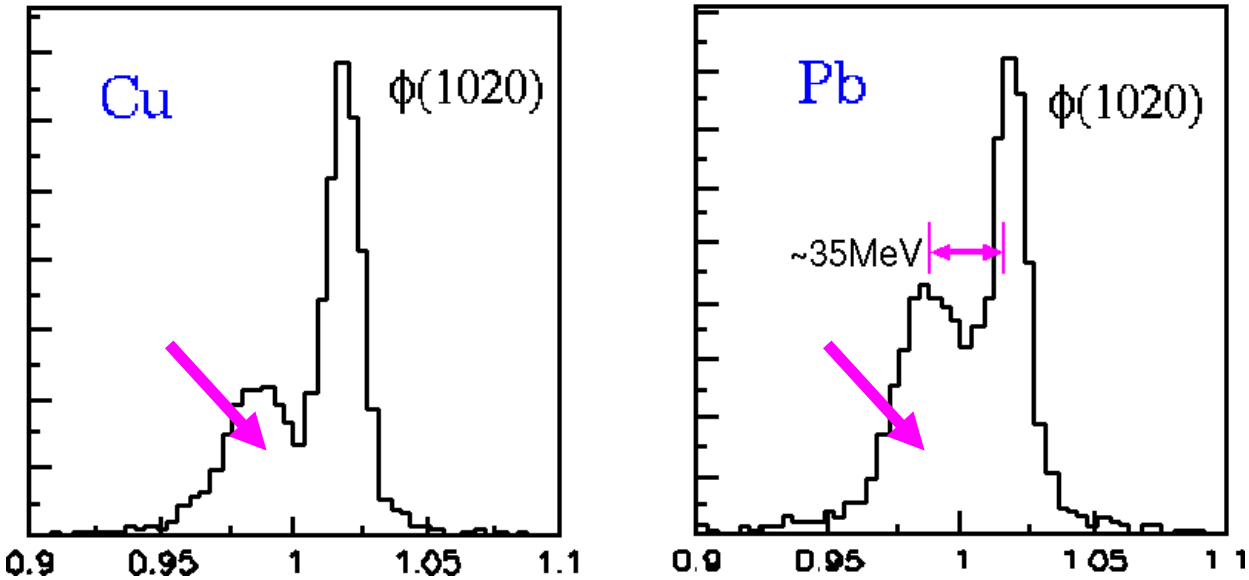
mass resolution requirement

- mass resolution should be kept less than ~10MeV
- Very ideal case : very slow mesons w/ best mass resolution:



(E325 data)

βγ<0.5, σ=5 MeV



(model calc.)