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γ beam test of the Liquid Xe calorimeter for the MEG experiment

MEG実験用液体 Xe カロリメータのγビームテスト

by
Hajime Nishiguchi @ Univ. of Tokyo

西口　創 @ 東京大学

東大, 早大理工総研[A], 高エ研[B], 阪大[C]
PSI[D], INFN-Pisa[E], BINP-Novosibirsk[F]

大谷航, 小曽根健嗣, 菊池順[A], 久野良孝[C], 澤田龍, 鈴木 聡[A],
寺沢和洋[A], 道家忠義[A], 春山富義[B], 真木晶弘[B], 真下哲郎, 三橋利也,
三原智, 森俊則, 八島純[B], 山口敦史[A], 山下雅樹[A], 吉村浩司[B], 吉村剛史[A]
A.A.Grebenuk[F], D.Grigoriev[F], I.Ioudine[F], D.Nicolo'[E], S.Ritt[D], G.Signorelli[E]

Outline

I. MEG Experiment

- Detector Overview
- Liquid Xenon Calorimeter

II. γ beam test

- γ beam test overview
- Beam test , using γ from LCS
- Beam test , using γ from Nuclear Reaction
- Other topics

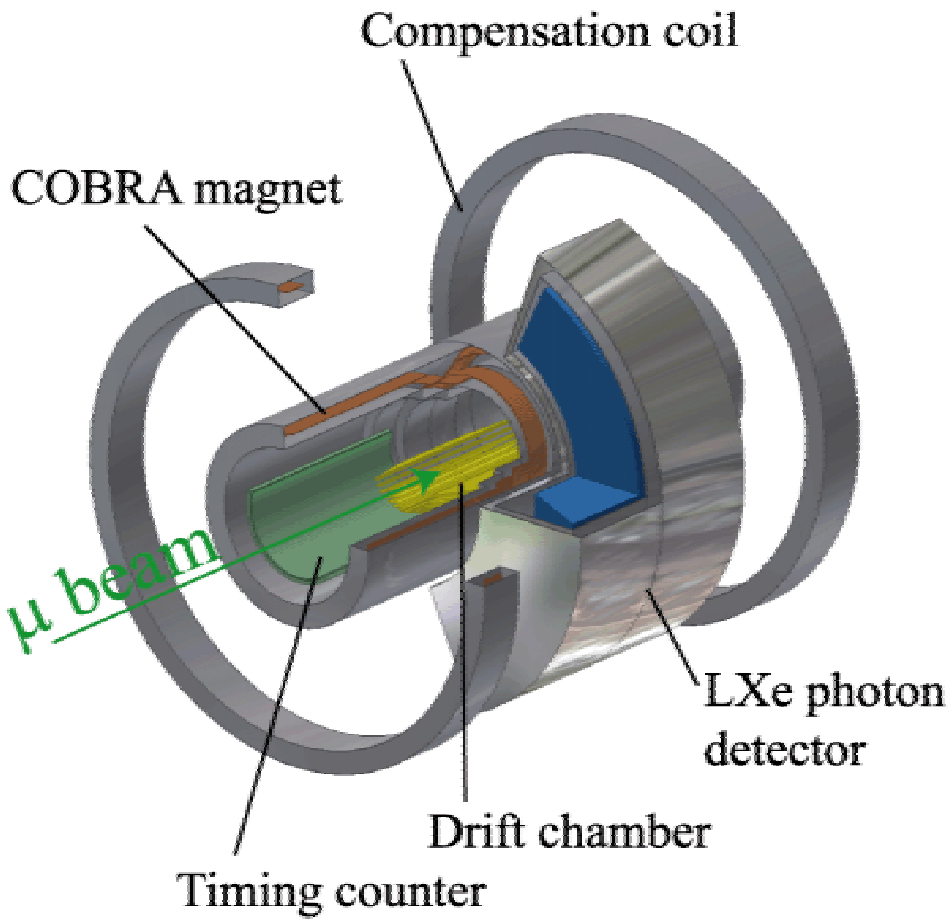
III. Summary

I. MEG experiment

(The search experiment for $\mu \rightarrow e\gamma$ @ PSI)

I. MEG experiment

Detector Overview



- Sensitivity down to BR~10^{-14}
- Most intense DC muon beam at PSI
- Liquid xenon photon detector
- Positron spectrometer with gradient magnetic field
- Thin superconducting magnet
- Positron tracker and timing counter

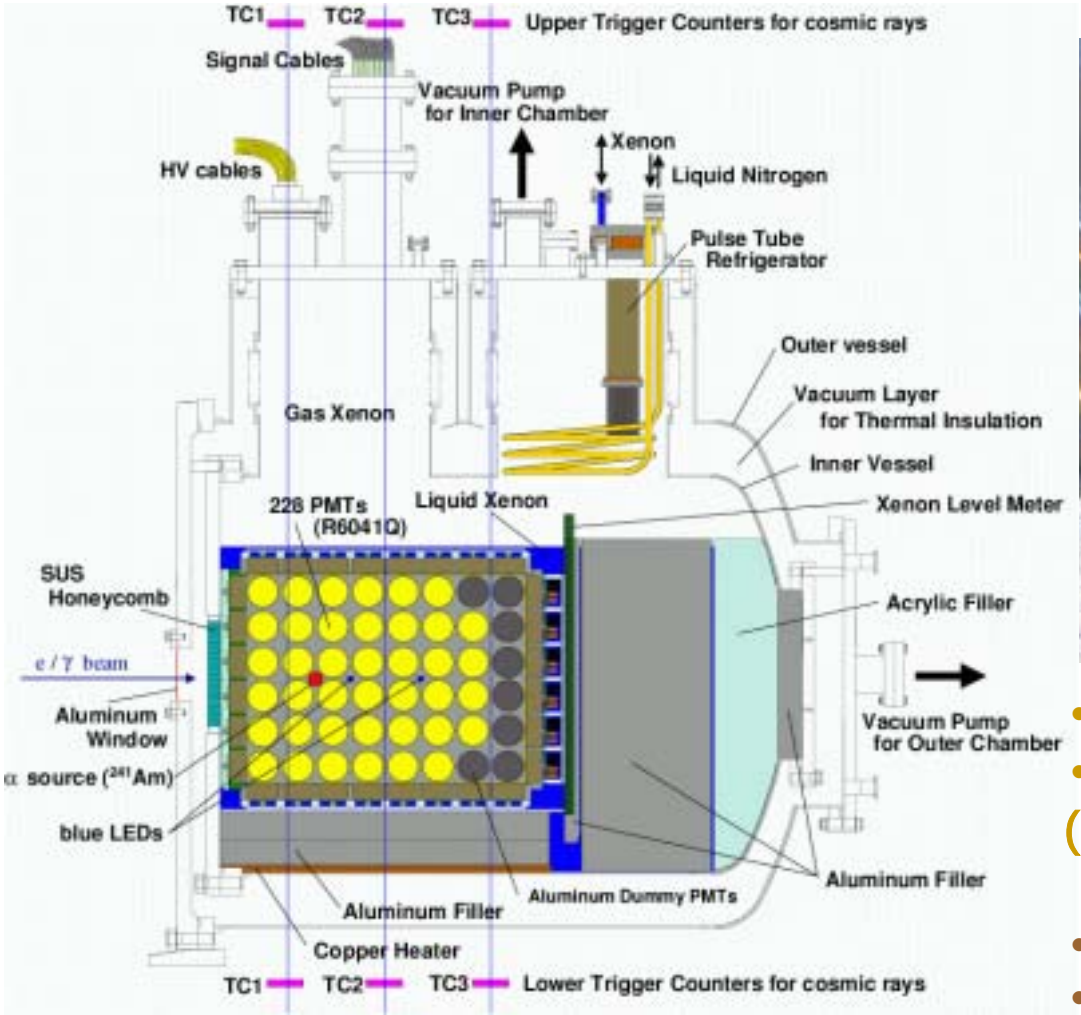
- Engineering run will start in 2004

Collaboration

Tokyo-ICEPP Waseda , KEK | PSI | INFN-Pisa | BINP-Novosibirsk

I. MEG experiment

Prototype detector



- 228 PMTs
- 110 Liter Liquid Xenon
(xenon active volume : 68.6 liter)

- check for the detector operation
- γ beam test up to 40 MeV
- absorption length measurement

II. γ beam test

II. γ beam test

Importance of γ beam

- **Performance test**
  - Check the liquid xenon operation
  - Check the detector components
  - Check the detector stability
  - Check the detector resolution
    (Energy resolution , Position resolution , Timing resolution)
- **Energy calibration**
  - ~50MeV region (signal level)
  - low ~ middle energy region

➢ We want various energy γ beams

II. γ beam test

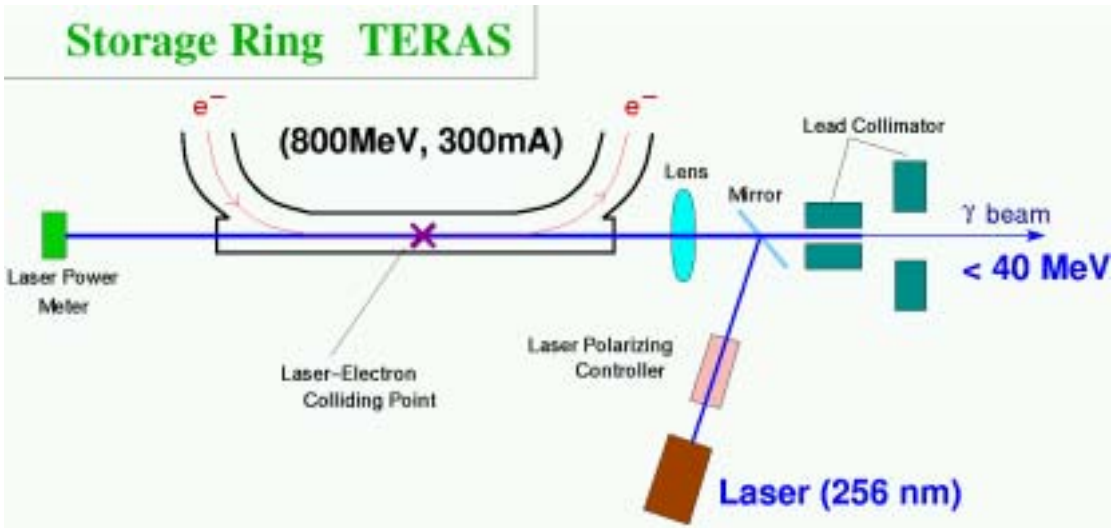
Candidates of the γ source

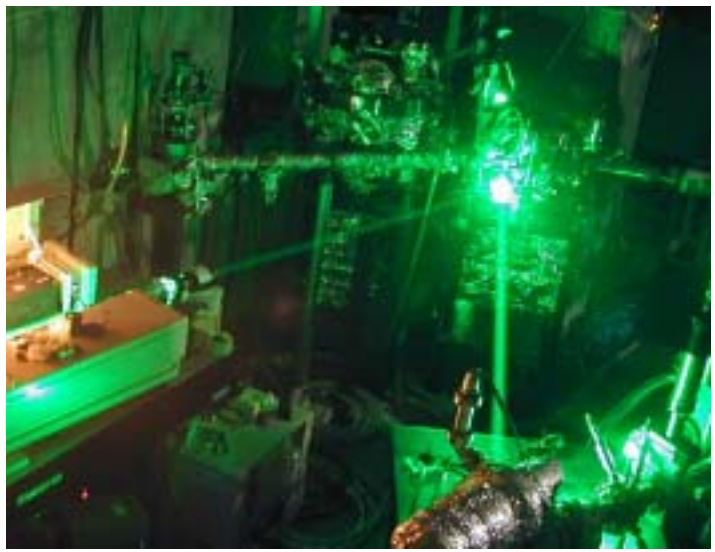
- Using Radio Isotope (~ 5MeV)
  (^{60}Co : 1.33MeV , ^{88}Y : 1.84MeV , Am/Be : 4.43 MeV)
- Using Laser Compton Scattering (20MeV ~ GeV)
  (TERAS @ AIST : 20MeV , 40MeV , and so on ...)
- Using Nuclear Reaction
  - ^{7}Li(p,γ)^{8}Be : 17.6MeV (E_p=440keV , σ~5mb)
  - ^{11}B(p,γ)^{12}C : 22.6MeV (E_p=7.2MeV , σ~120μb)
  - ^{9}Be(^{3}He,γ)^{12}C : 31.2MeV (E_{He}=6.5MeV , σ~1.5μb)

    and so on ...
- Using π^- beam (55 ~ 83 MeV)
  (sharp edge of γ energy from $\pi^- p \rightarrow \pi^0 n$ process)

II. γ beam test

Laser Compton facility , TERAS @ AIST

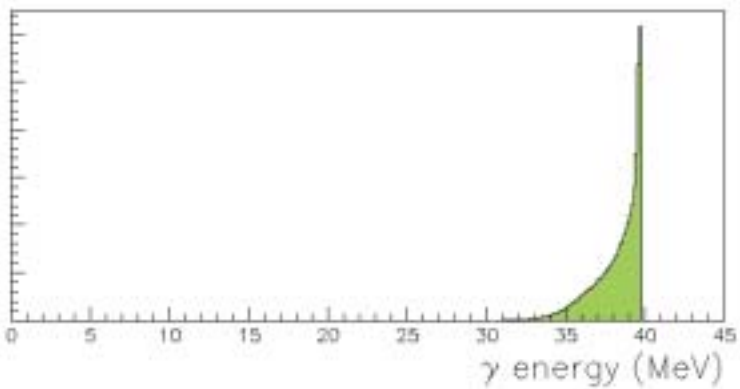




TERAS : Electron storage ring at AIST
(National Institute of Advanced Industrial Science and Technology)
(Old , Electrotechnical Laboratory , Bureau of Electrocommunications)

Laser Compton Scattering facility ;
2nd Laser :20MeV(max) γ beam obtained
4th Laser :40MeV(max) γ beam obtained

γ beam test has been performed



calculated γ beam energy spectrum at TERAS

II. γ beam test

Results , expected performance

Detector operation:

- All components of the detector worked well !

Resolution:

- Energy : **worse** (σ_E = 1.4 ~ 2.0 % expected)
- Position : σ_x = 7.2 ~ 11.8 mm (σ_x = ~ 4 mm expected)

(in FWHM respectively)

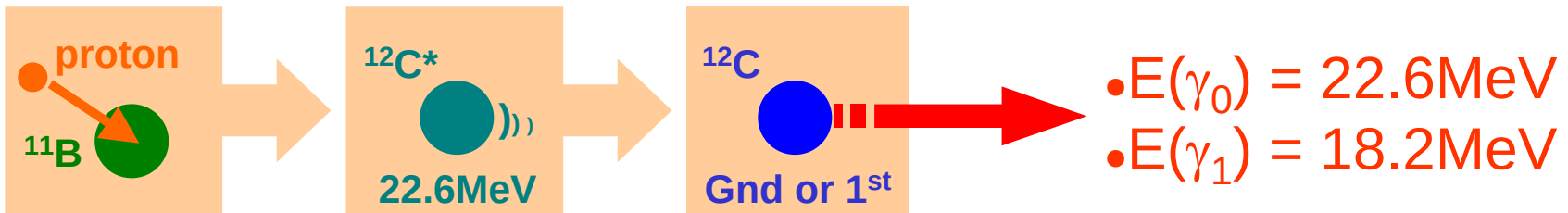
➢ Light absorption problem !!

- Absorption length increased , 7cm → >3 m by Xenon purification
- New γ beam test planed @ TERAS in last October & February
- Unfortunately , accelerator trouble happened again and again !! ☹
- Next γ beam test will be performed in late April .

II. γ beam test

γ from the nuclear reaction

- Using γ beam from the nuclear reaction
- Example ; $^{11}B(p,\gamma)^{12}C$: 22.6MeV (E_p=7.2MeV , σ~120μb)



- Need to check something;
  - Rate
  - Backgrounds
  - Energy spread

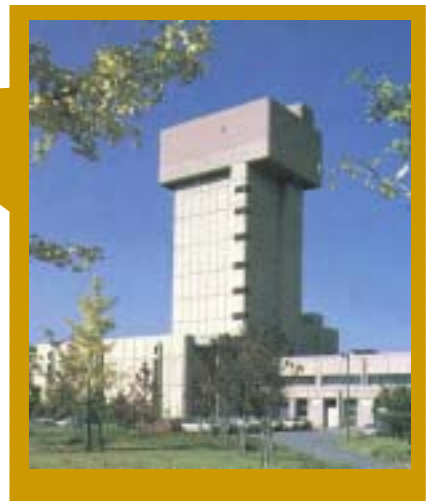
Merits : various channels , easy
Demerits : low rate , backgrounds

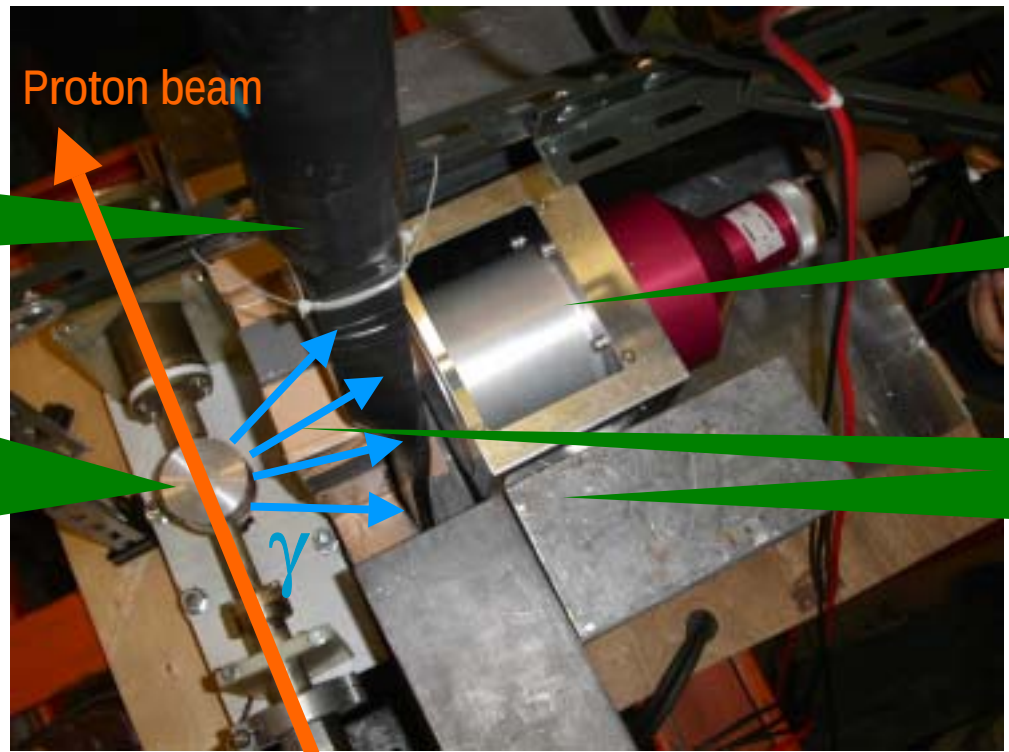
- Test experiment has been performed with NaI @ Tsukuba univ.

II. γ beam test

γ beam test @ UTTAC , Tsukuba univ.

- Proton beam delivered by UTTAC
  (**U**niversity of **T**sukuba : **T**andem **A**ccelerator **C**enter)
- Boron powder target hardened with epoxy resin
- Counter : ϕ5" x ^{t}5" NaI crystal with 5" PMT
  and 4 veto counters (up , right , left and front side)





Veto counter

Scattering Chamber (target inside)

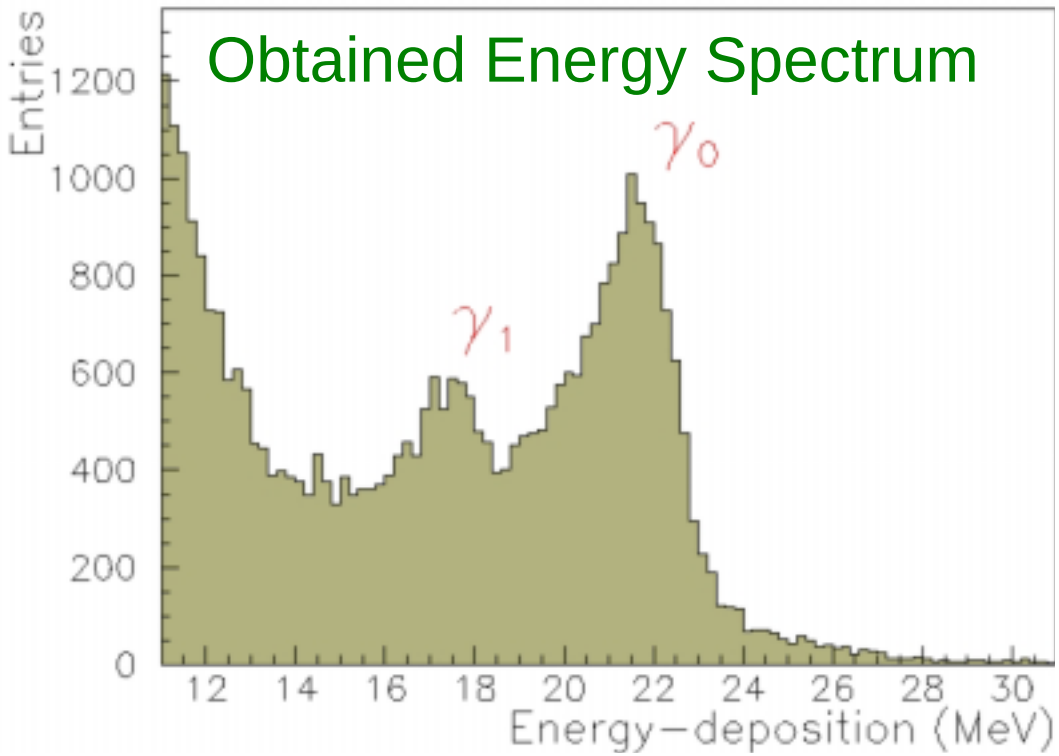
NaI counter

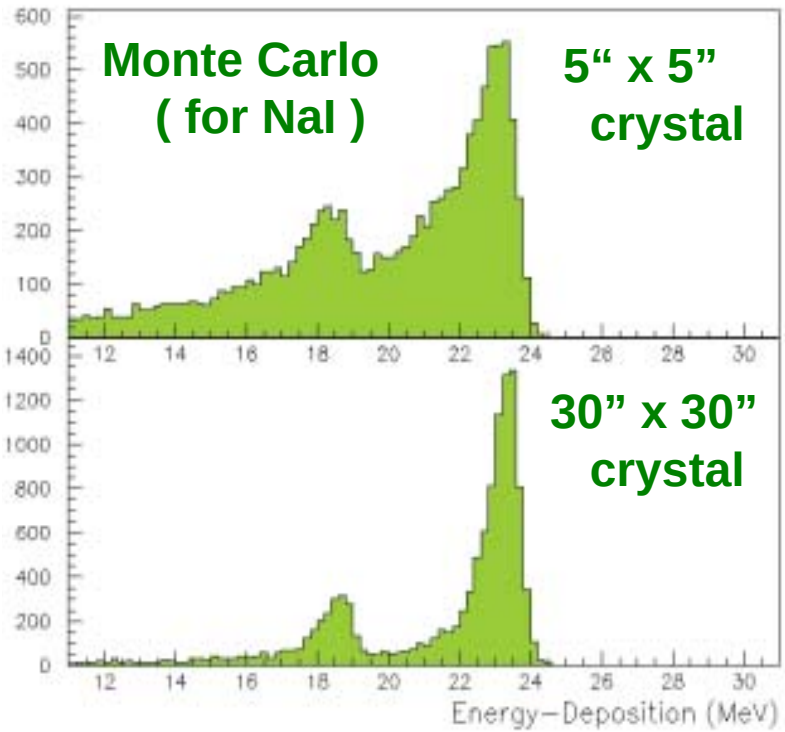
Pb shield and collimator

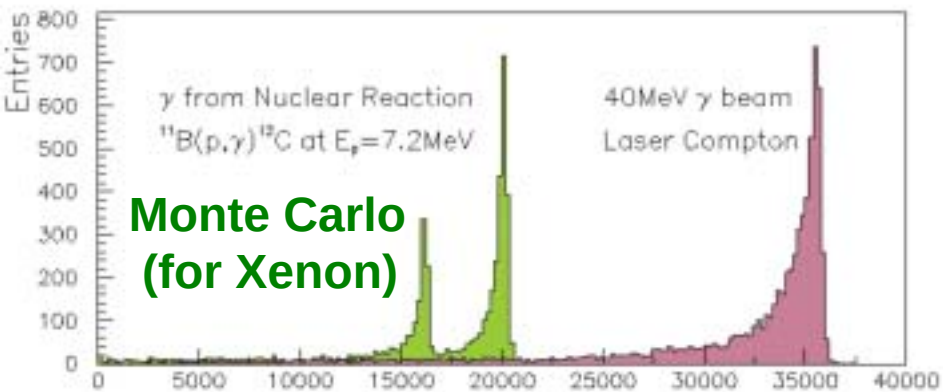
Coverage : 0.13%

II. γ beam test

Results of test experiment , using NaI







Counting rate : ~ 16Hz ☺

predicted rate : ~ 13Hz

Backgrounds rate : 3Hz (0.3Hz after veto)

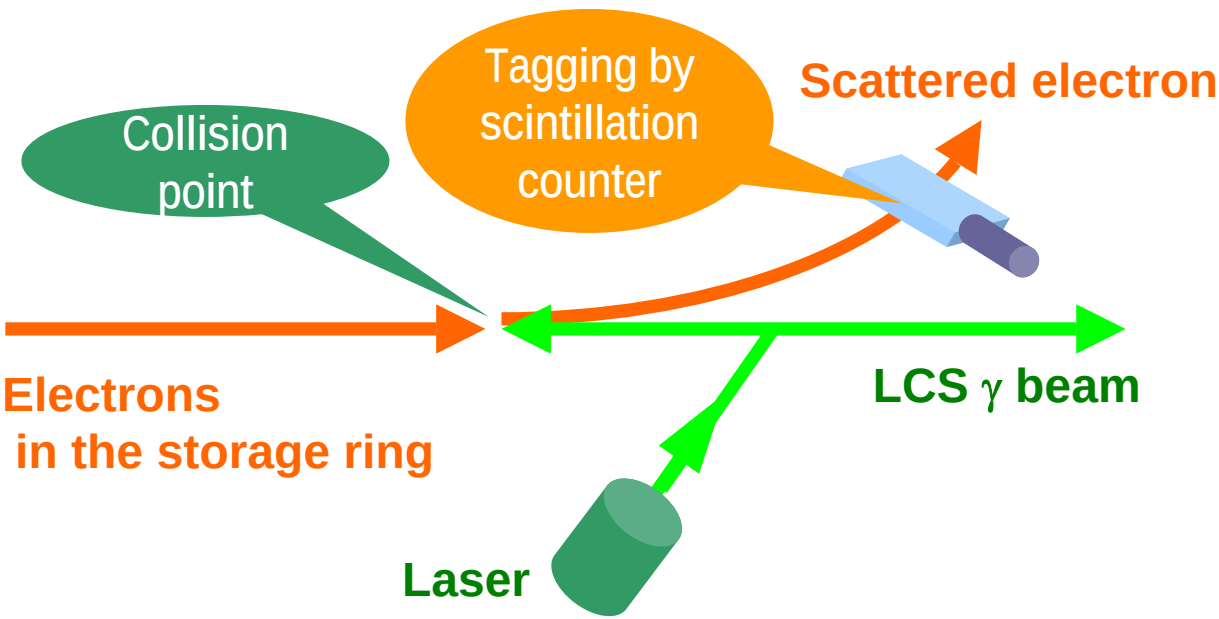
Problems : neutron BGs and other reactions

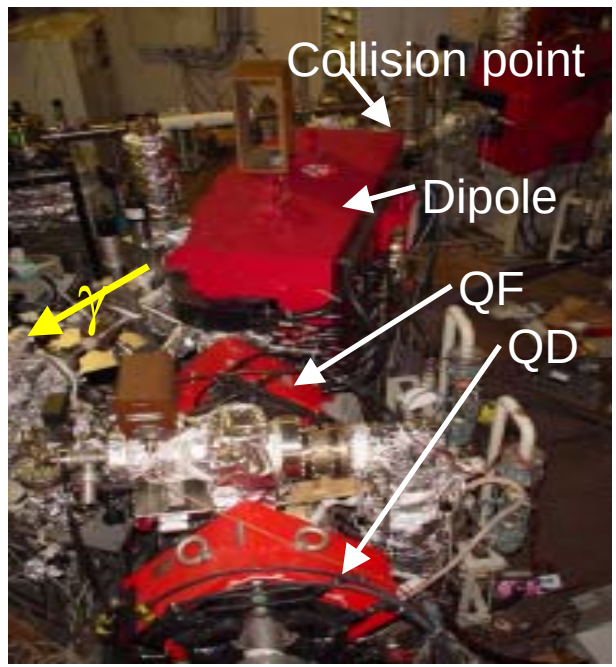
Next step : new target & using Xenon

II. γ beam test

Other candidate

- **Timing resolution :**
  - **We've never measured the timing resolution of the Liquid Xenon detector , using high energy γ beam .**
  - **Tagged γ beam of the Laser Compton Scattering (We plan this test on the next γ beam test @ TERAS)**



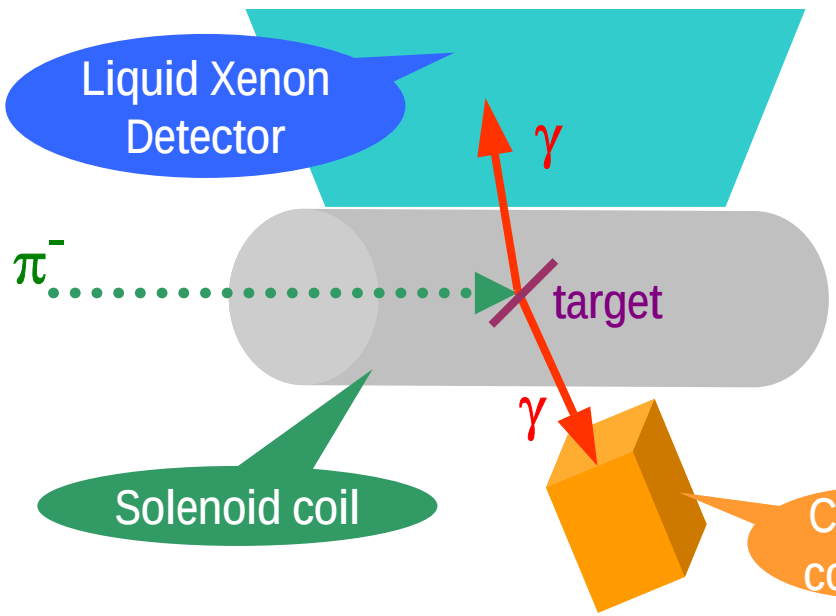


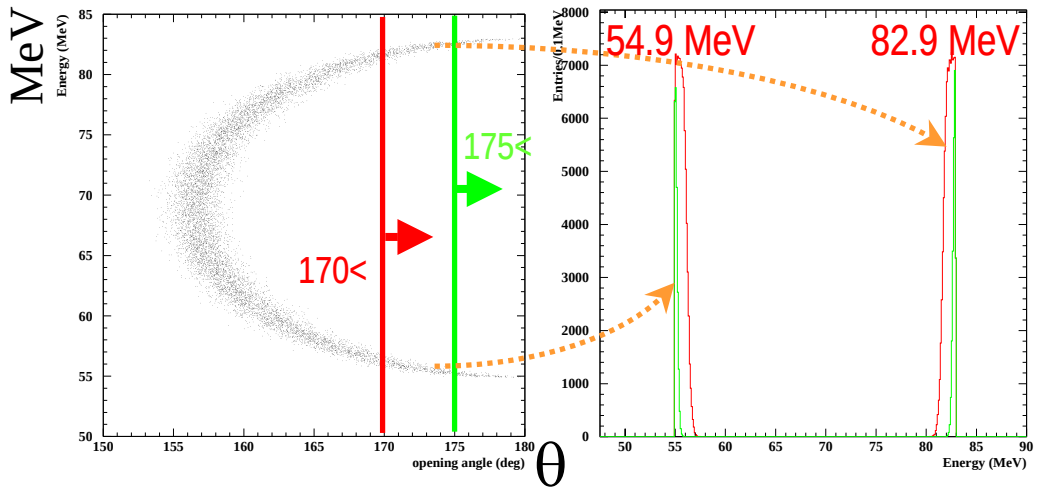
II. γ beam test

Other candidate - cont'd

■ Using π^- beam :

- **We shall also make in-suit calibration runs with π^- beam (using the sharp edges of γ energy from $\pi^- p \rightarrow \pi^0 n$ process)**
- **We plan this test in October @ PSI πE5 beam line**
  (This beam test will be performed by prototype detector)



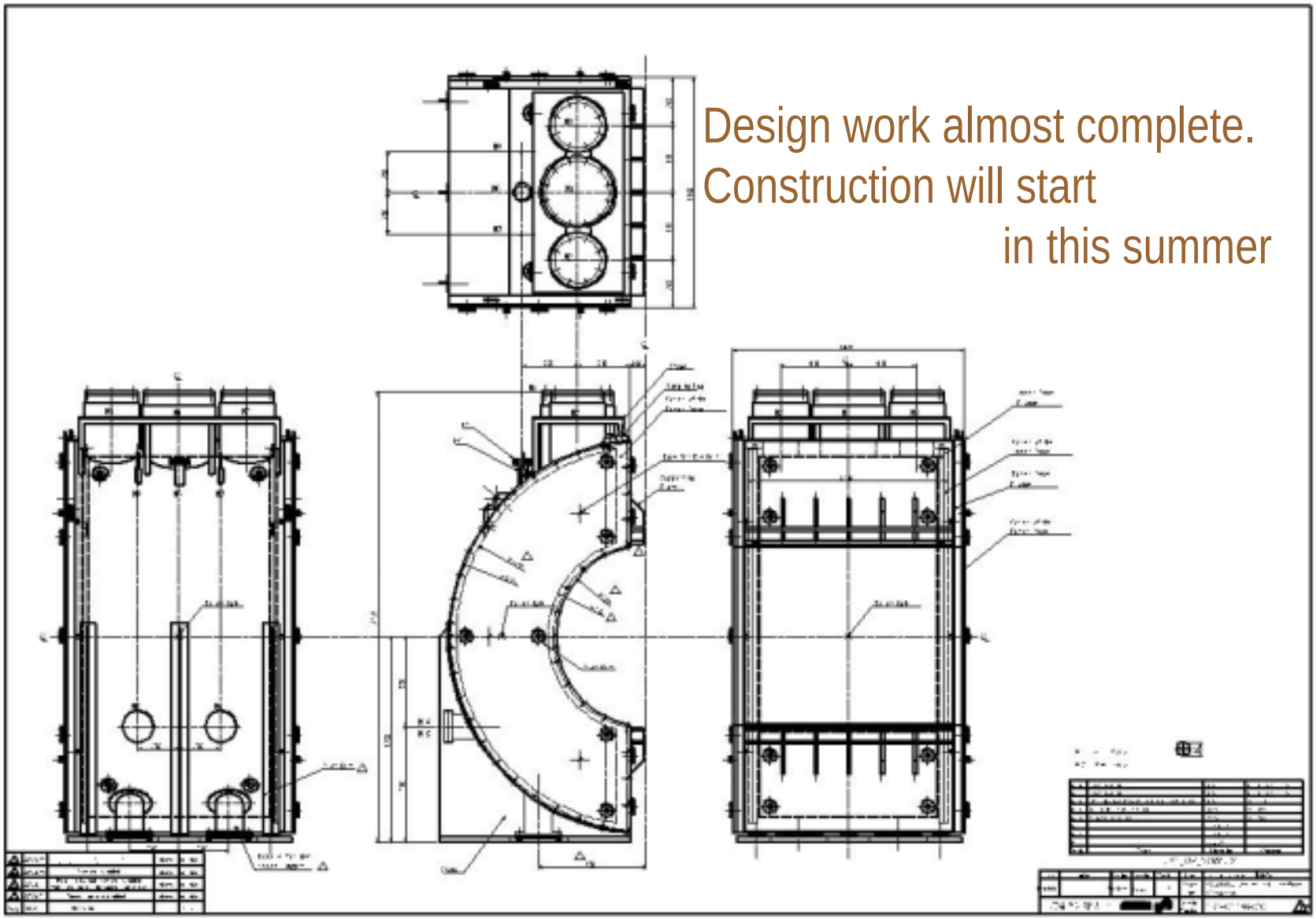


$\pi^0(28\text{MeV}) \rightarrow \gamma\,\gamma$

$54.9\ \text{MeV} < E(\gamma) < 82.9\ \text{MeV}$

EXTRA

Design work on the Final detector



IV. Summary

- We plan the new $\mu \rightarrow e\gamma$ search experiment @ PSI and R&Ds are progressing now.
- Our γ beam test using prototype liquid xenon calorimeter @ TERAS has been suspended because of accelerator trouble , and the next γ beam will be carried out with many improvements in late April.
- We also tested using γ from the nuclear reaction @ UTTAC , and confirmed the γ beam function well.
- We plan some tests ;
  - April : 20 & 40 MeV LCS γ beam test @ TERAS
  - May : nuclear reaction γ beam test @ UTTAC
  - October : $\pi^0 \rightarrow \gamma\gamma$ beam test @ PSI