JPS meeting Mar.'02
@ Ritsumeikan Univ.

Liquid Xe calorimeter beam test for the $\mu \rightarrow e\gamma$ search experiment

$\mu \rightarrow e\gamma$ 崩壊探索実験用液体 Xe カロリメータの γ ビームテスト

by
Hajime Nishiguchi @ ICEPP , Univ. of Tokyo

西口　創 @ 東大ＩＣＥＰＰ

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

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

Outline

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- Our plan

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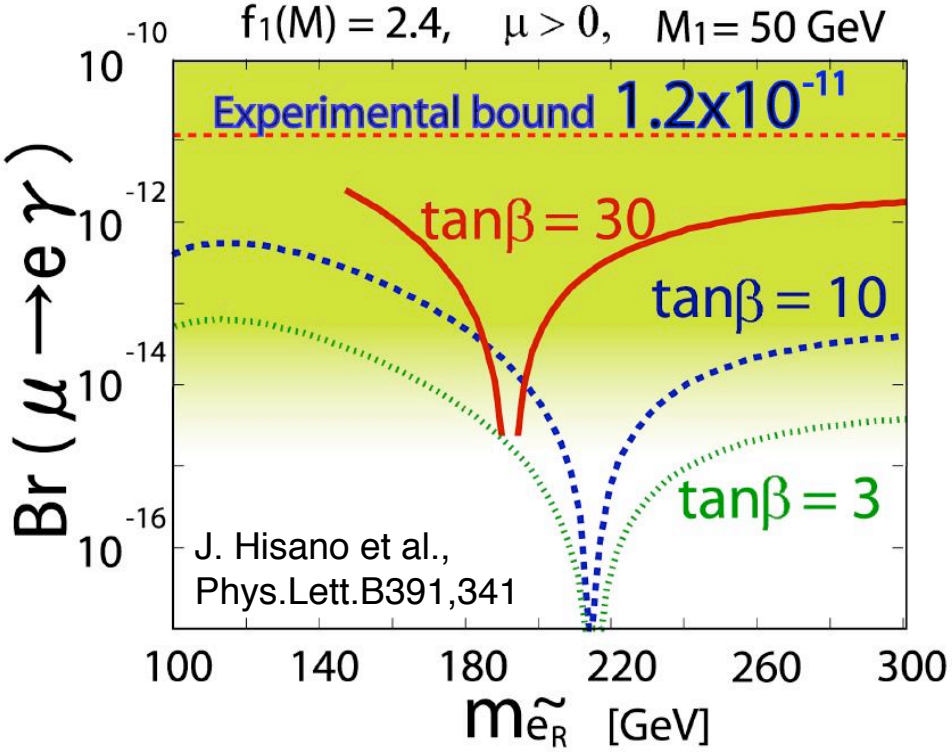
➢ Related topics
25pXA-2 (小曽根健嗣, *et al.*)
25pXA-3 (澤田龍, *et al.*)

I. Introduction

μ → e γ search experiment

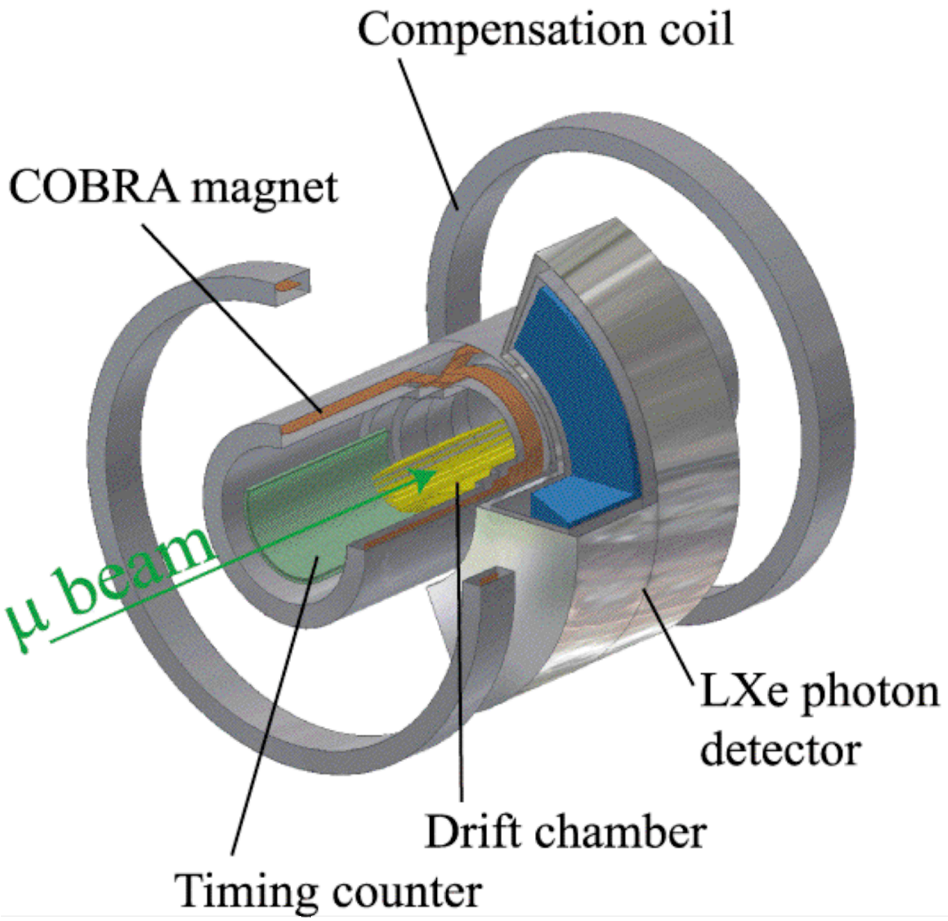
- **μ → e γ decay ?**
  - 'μ → e νν' ~ 100% (in SM)
  - 'μ → e γ' violates Lepton Flavor Conservation !
  - SUSY-GUT models predict Br(μ → e γ)=10^{-11}~10^{-14}



- Sensitive to physics beyond the SM !
- New experiment with a sensitivity of BR~10^{-14} planned at PSI

I. Introduction

Our plan



- 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/physics run will start in 2003**

Collaboration

Tokyo-ICEPP
Waseda , KEK

PSI

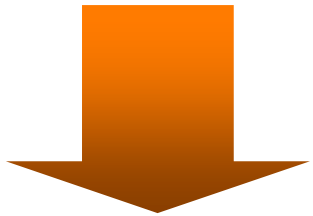
INFN-Pisa

BINP-Novosibirsk

II. Liquid Xenon Calorimeter

Requirement on the γ detector

Very Small Branching Ratio

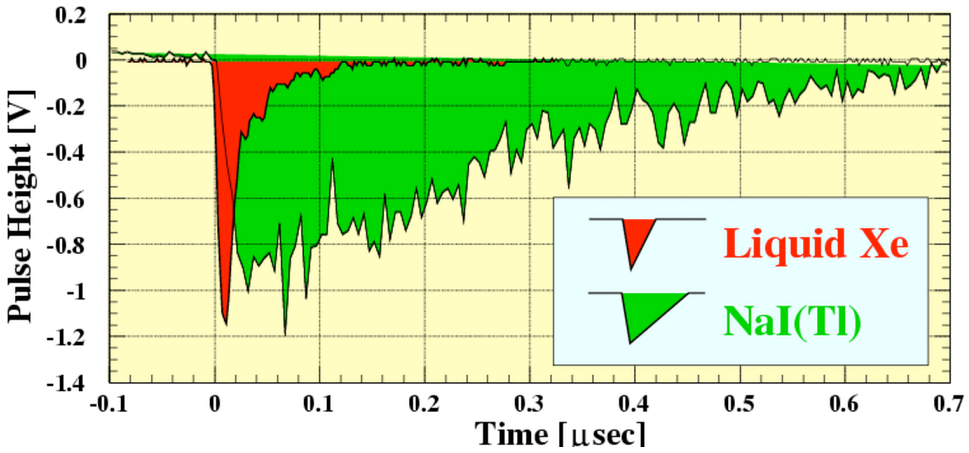


- Good Energy Resolution (<1%)
- Good Position Resolution (~2mm)
- Good Timing Resolution (~50psec)

II. Liquid Xenon Calorimeter

Why Xenon ?

- High light yield (75% of NaI(Tl))
  - ➢ Good Resolutions
- Fast Signal
  - ➢ Reduce pileups
- Spatial uniform response
  - ➢ No need for segmentation

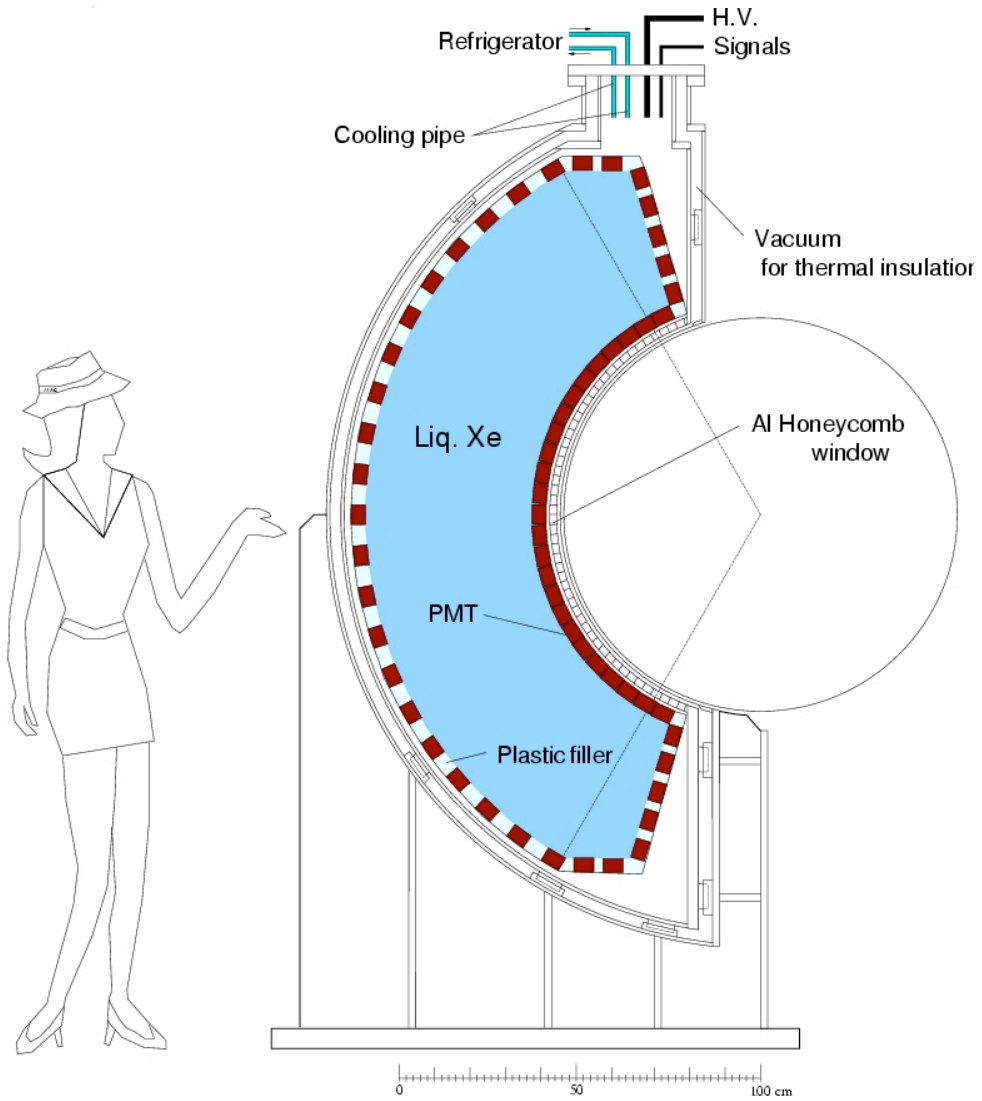


Properties of Liquid Xenon

Mass number	131.29
Density	3.0 g/cm^3
Boiling and melting points	165 K, 161 K
Energy per scintillation photon	24 eV
Radiation length	2.77 cm
Decay time	4.2 nsec (fast) 22 nsec (slow) 45 nsec (recombi.)
Scintillation light wave length	175 nm
Refractive index	1.57

II. Liquid Xenon Calorimeter

Final detector plan



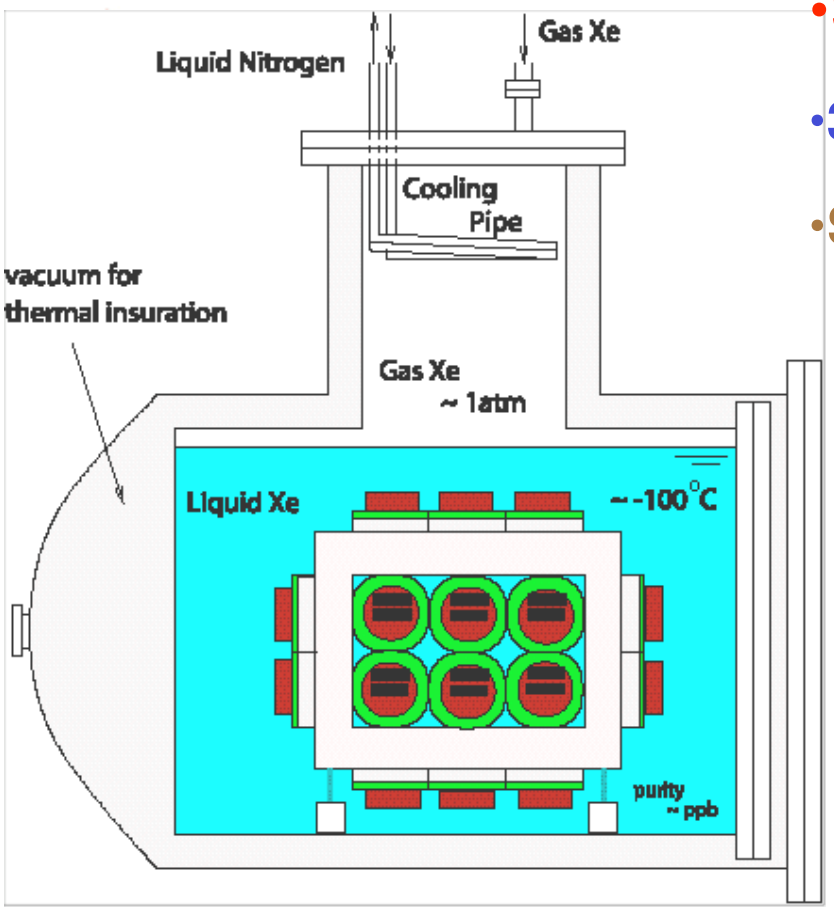
Detector design

- Active volume of Liquid Xe : **800 liter**
- Scintillation light is collected by ~ **800 PMTs** immersed in Liquid Xenon .
- Effective coverage (front) **~ 43.2 %**

➢ Design work is running now .

II. Liquid Xenon Calorimeter

Prototype detectors

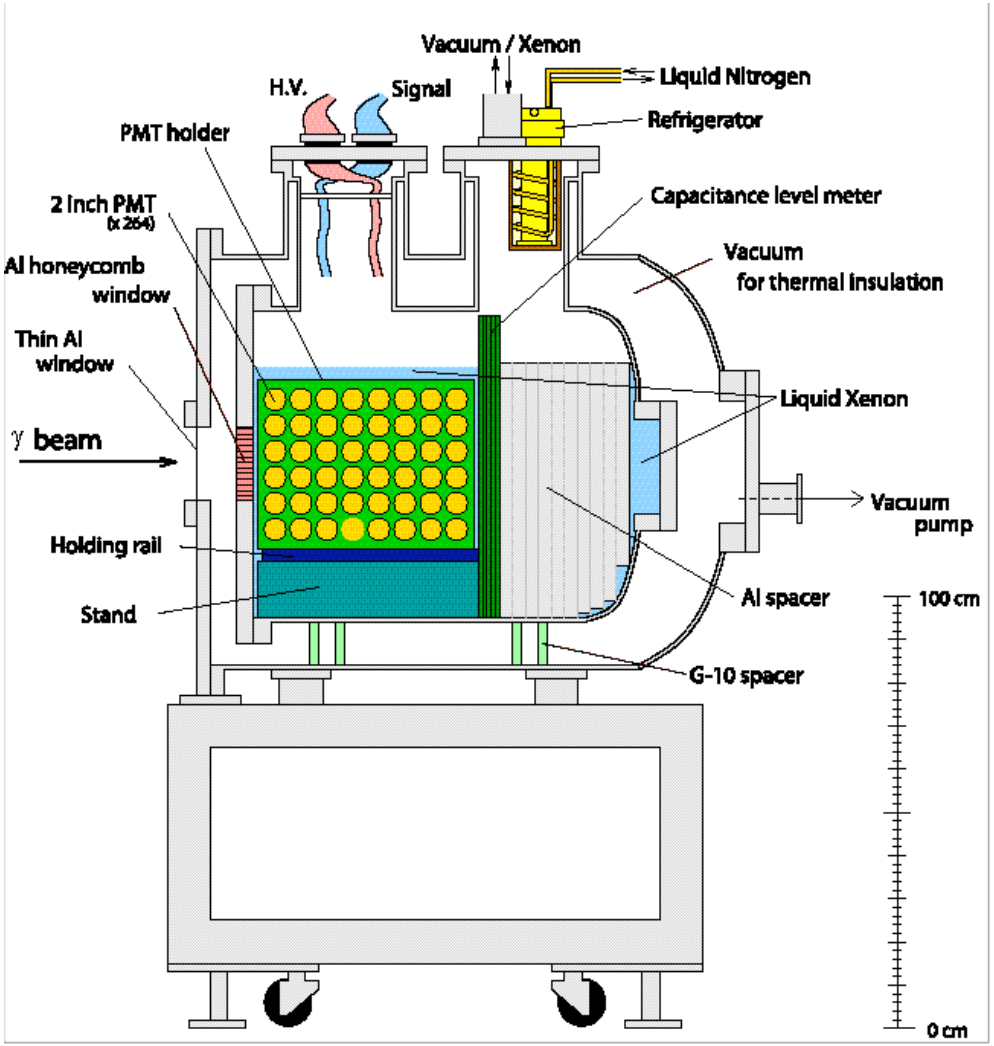


- **Small prototype detector**
- **32 PMTs & 2.3 Liter Liquid Xe**
- **Study performed with RI source 0.3 ~ 2 MeV , and extrapolations from the results implied excellent resolutions for 52.8MeV γ from μ→e γ**

Has to be verified with larger detector for higher energy γ rays

II. Liquid Xenon Calorimeter

Large prototype detector



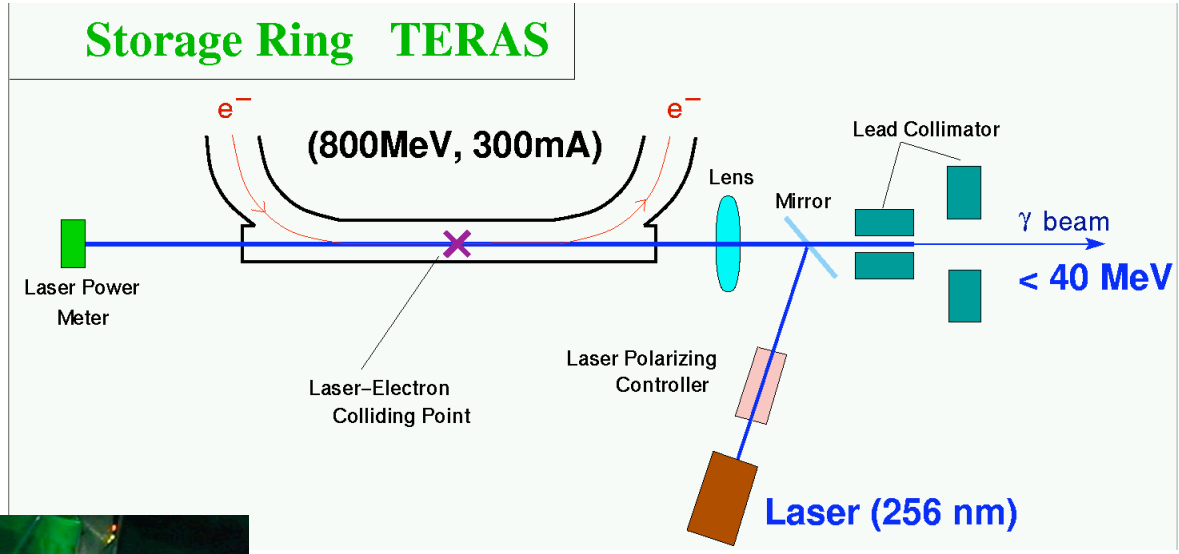
- 228 PMTs
- 125 Liter Liquid Xenon
- Beam test for 40 MeV γ

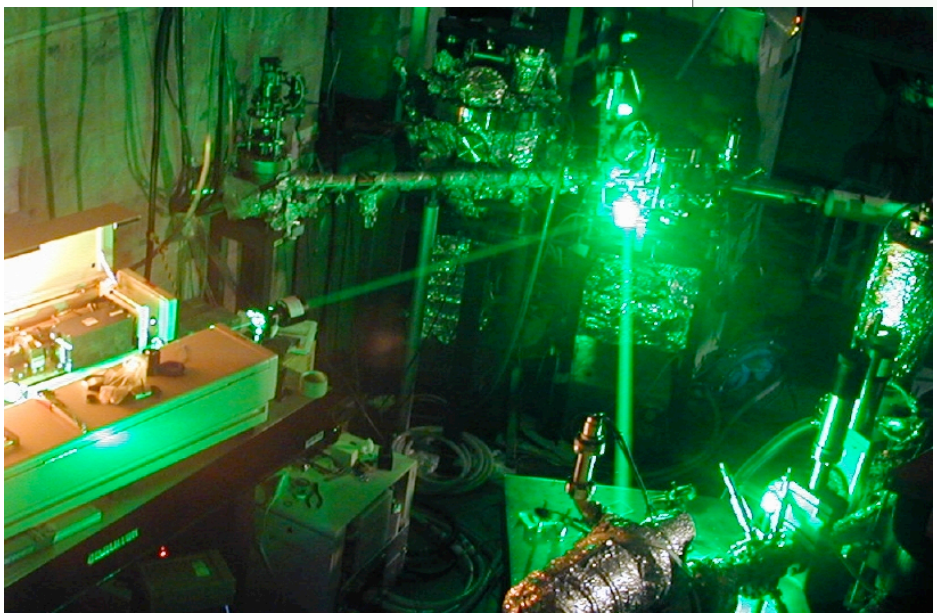
III. γ beam test

Overview

γ beam test has been performed @ AIST (08/Feb – 01/Mar)

National Institute of
Advanced Industrial Science & Technology





40 MeV γ beam obtained from Laser Compton Scattering

- Related topic
  26pWK-2 (大垣英明 @ AIST, *et al*

III. γ beam test

Purpose

- Performance test with high energy γ
  (Energy-, position-, time resolutions)
- Check of cryogenics
  and other detector components
- Check of stability of detector operation

III. γ beam test

Beam test outline

February													
08	09	10	11	12	13	14	15	16	17	18	19	20	21
KEK to AIST	Set Up	evacuating					Pre-cooling		Purification and Liquefaction			Beam ON	

February							March						
22	23	24	25	26	27	28	01	02	03	04	05	06	07
Accelerator trouble, DAQ using Cosmic ray				Beam ON				Xenon recovery		Wait for temp. rising			AIST to KEK

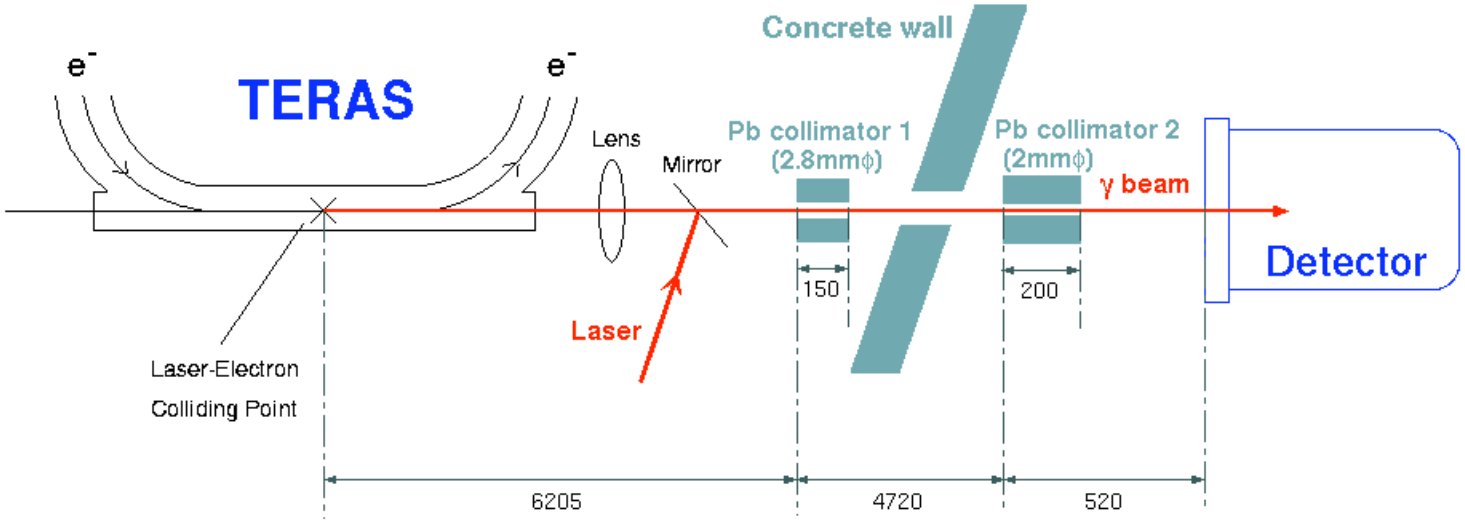
All detector components have been working successfully during full term of this beam test !!

(Refrigerator , LN2 system , DAQ system , HV supply …)

III. γ beam test

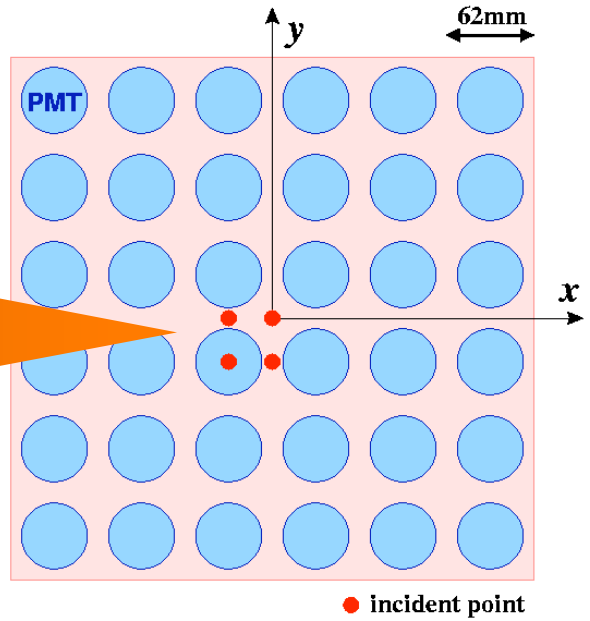
DAQ

Detector arrangement



Photon beam is collimated by 2 collimators , and incident center of detector window .

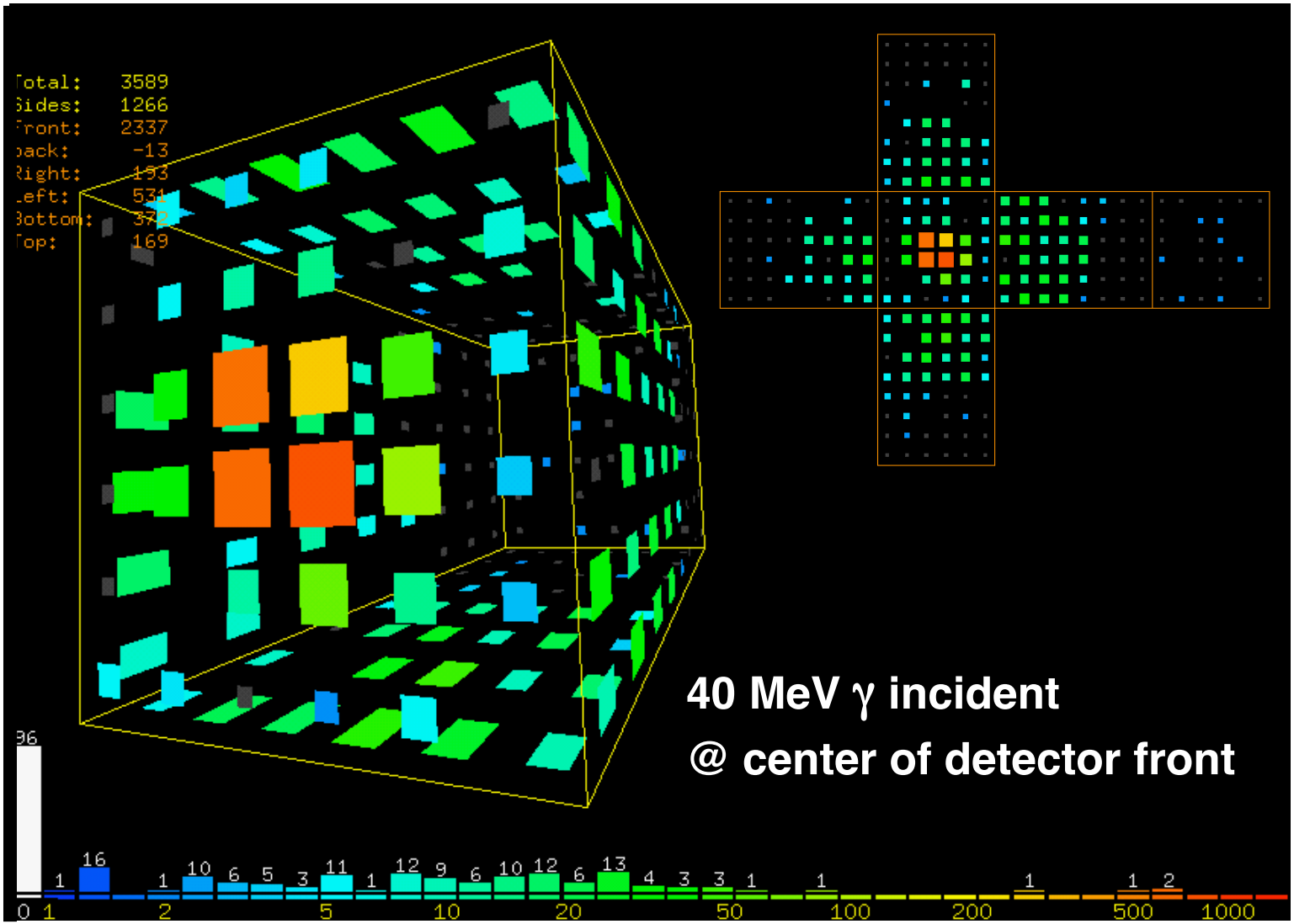
40 MeV γ



Position scan of the detector , vertically & horizontally

III. γ beam test

Typical event



III. γ beam test

Analysis for position measurement

Offline calibration

↓

Rough event selection by total energy

↓

Select PMT region by the light distribution @ front wall

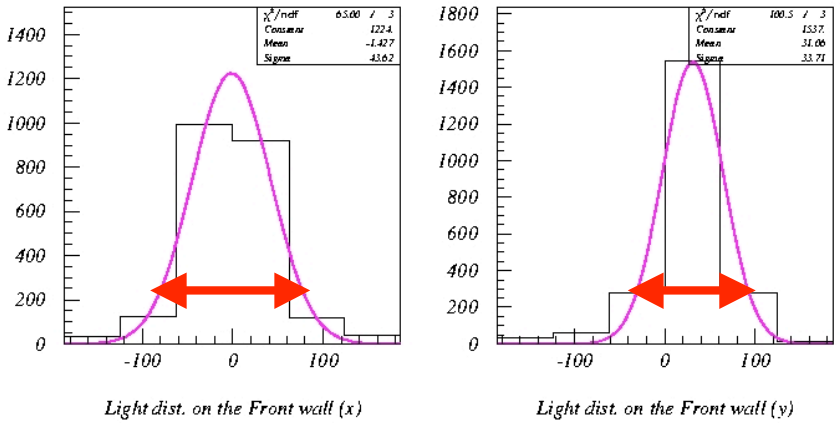
↓

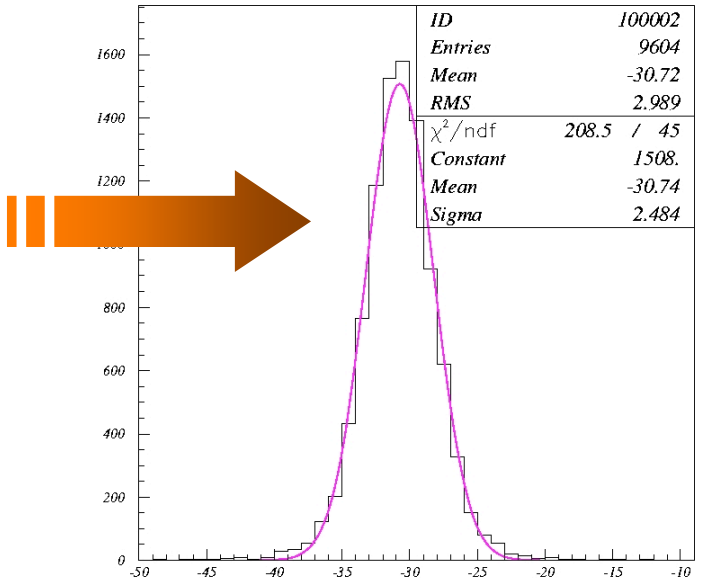
Position reconstruct by weighted mean using PMTs in the region decided previous

↓

Fit the distribution by Gaussian and deduct the beam spread

Light distribution @ front wall

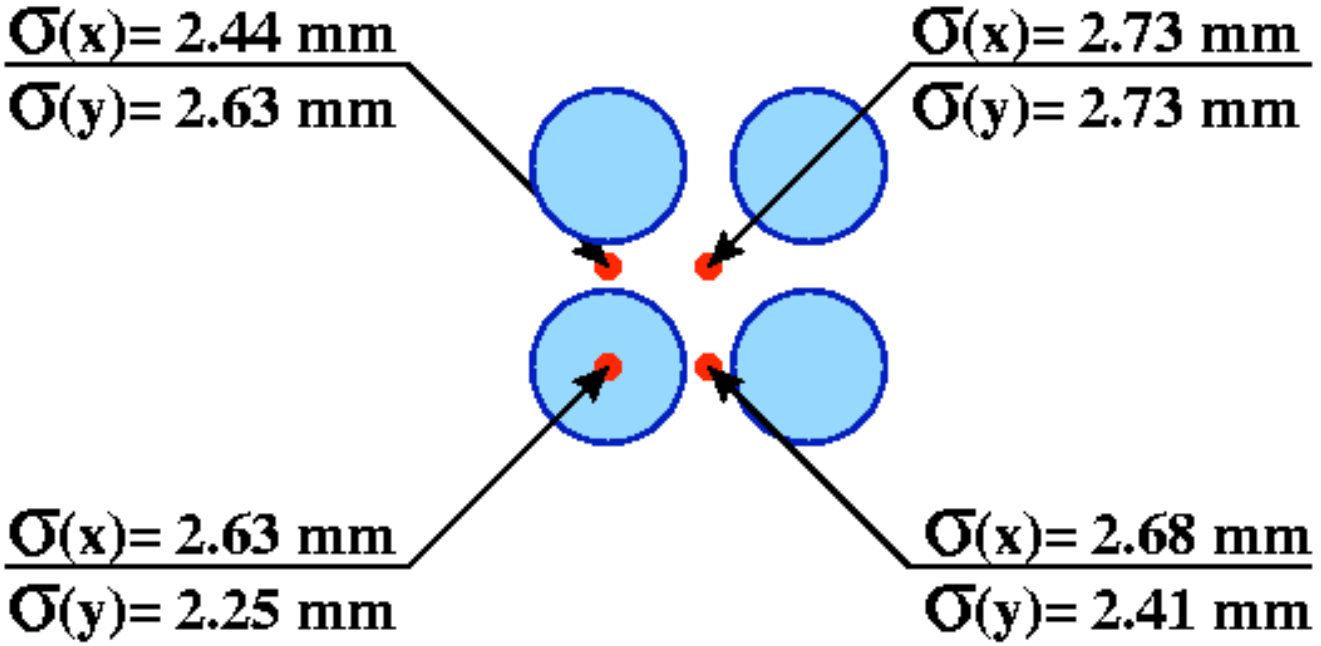




III. γ beam test

Position resolution

Results (preliminary!)



Position resolution ; 2.3 ~ 2.7 mm !!

IV. Summary

- We plan the new $\mu \rightarrow e\gamma$ search experiment @ PSI and R&Ds are progressing now .
- We performed the γ beam test using prototype liquid xenon calorimeter @ AIST (08/Feb.~07/Mar.) .
- We could check the all components , Very good !!
- Analyzing now !
- Position resolution estimation (preliminary) : 2-3mm