液体Xe検出器によるダークマター探索

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現状

神岡坑内での徹底した安全の確立・・・・ 準備中

- KHK規格の遵守

  キセノン高圧容器の製作　　12月末納品予定

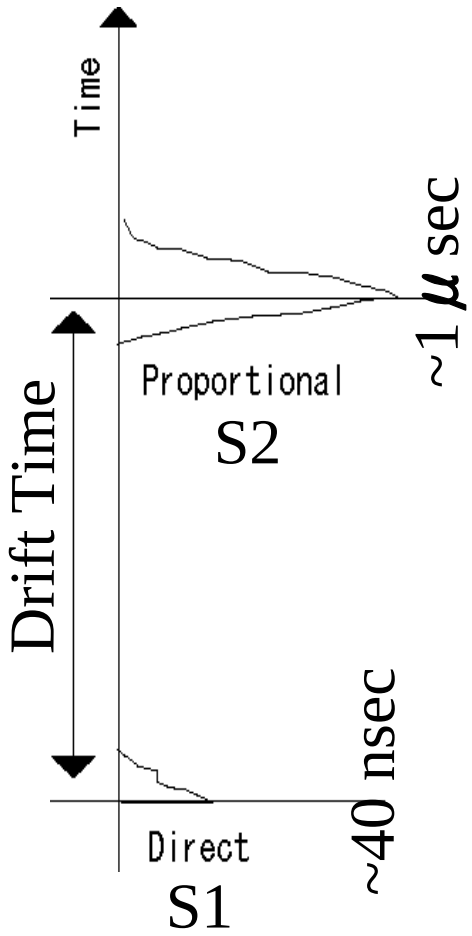
  1.95atm.の破裂盤の設置　　ready

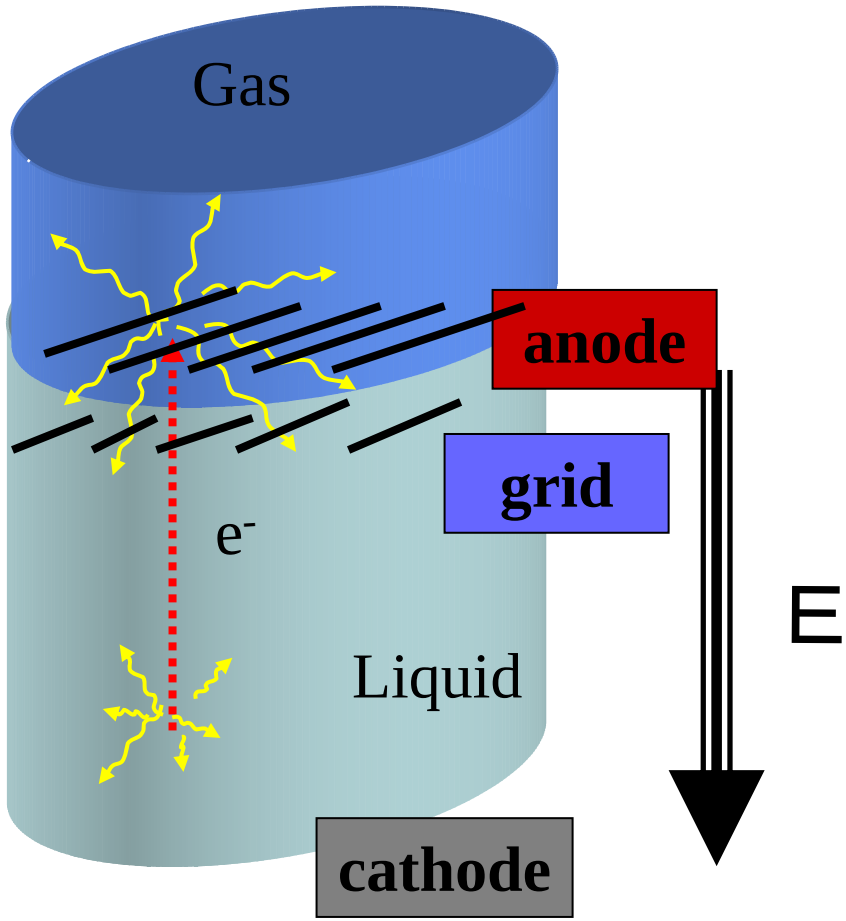
- マンパワーの増強……7〜8人程度のfull time workerが必要

  求むcollaborator!

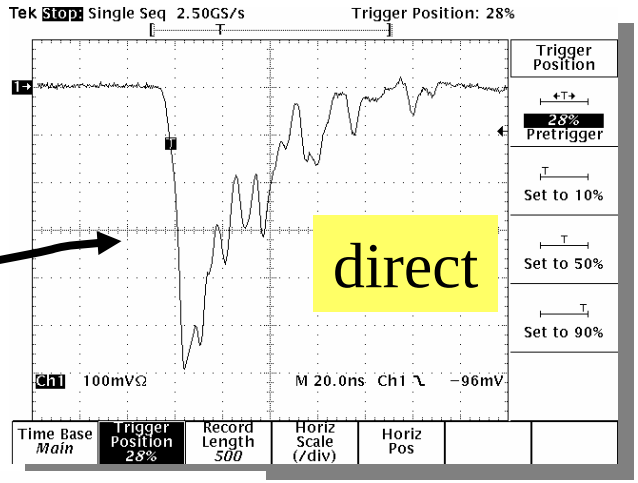
来春から実験開始予定

W- phase Xe Detector (Direct & proportional scintillation)

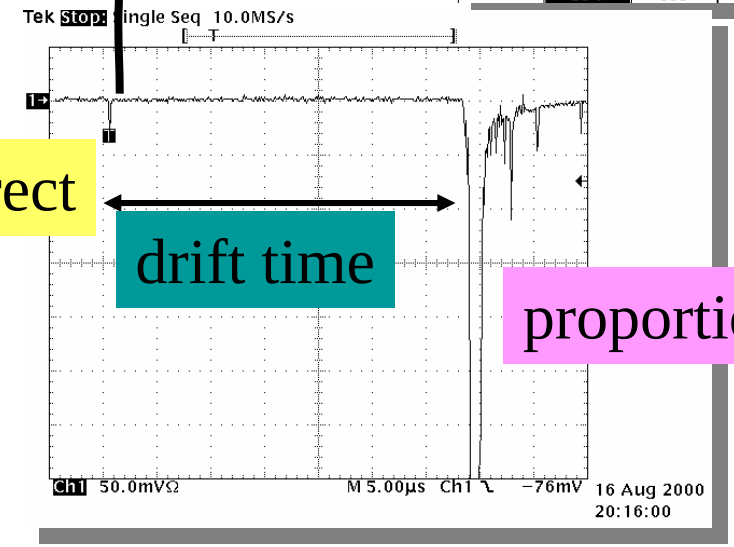


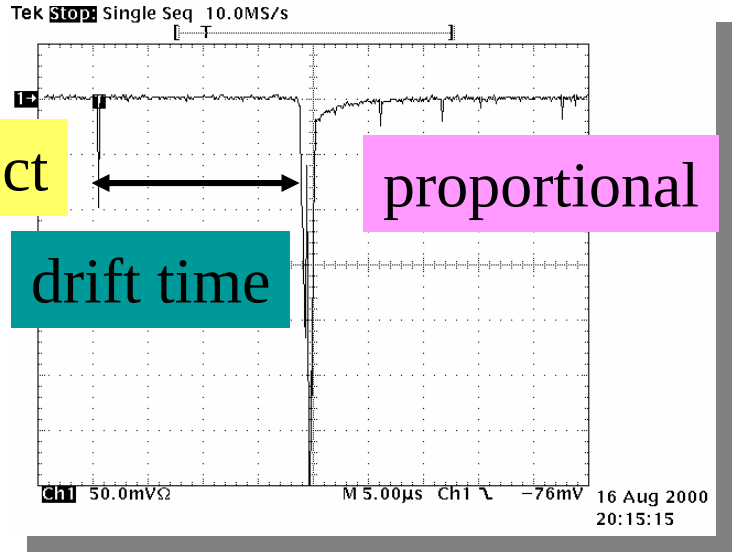


•Signal from Double Phase Xe

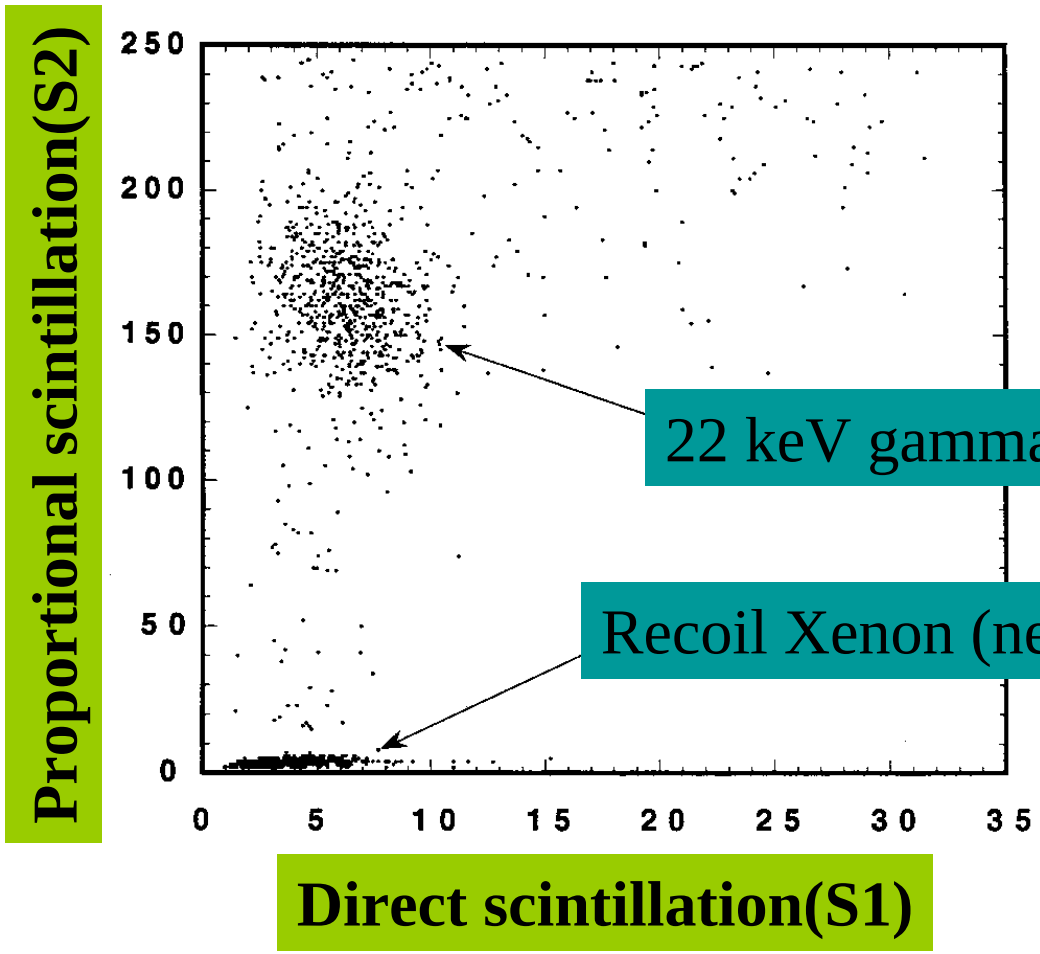


42000photon/MeV
Decay time 45nsec





•Recoil / γ ray Separation

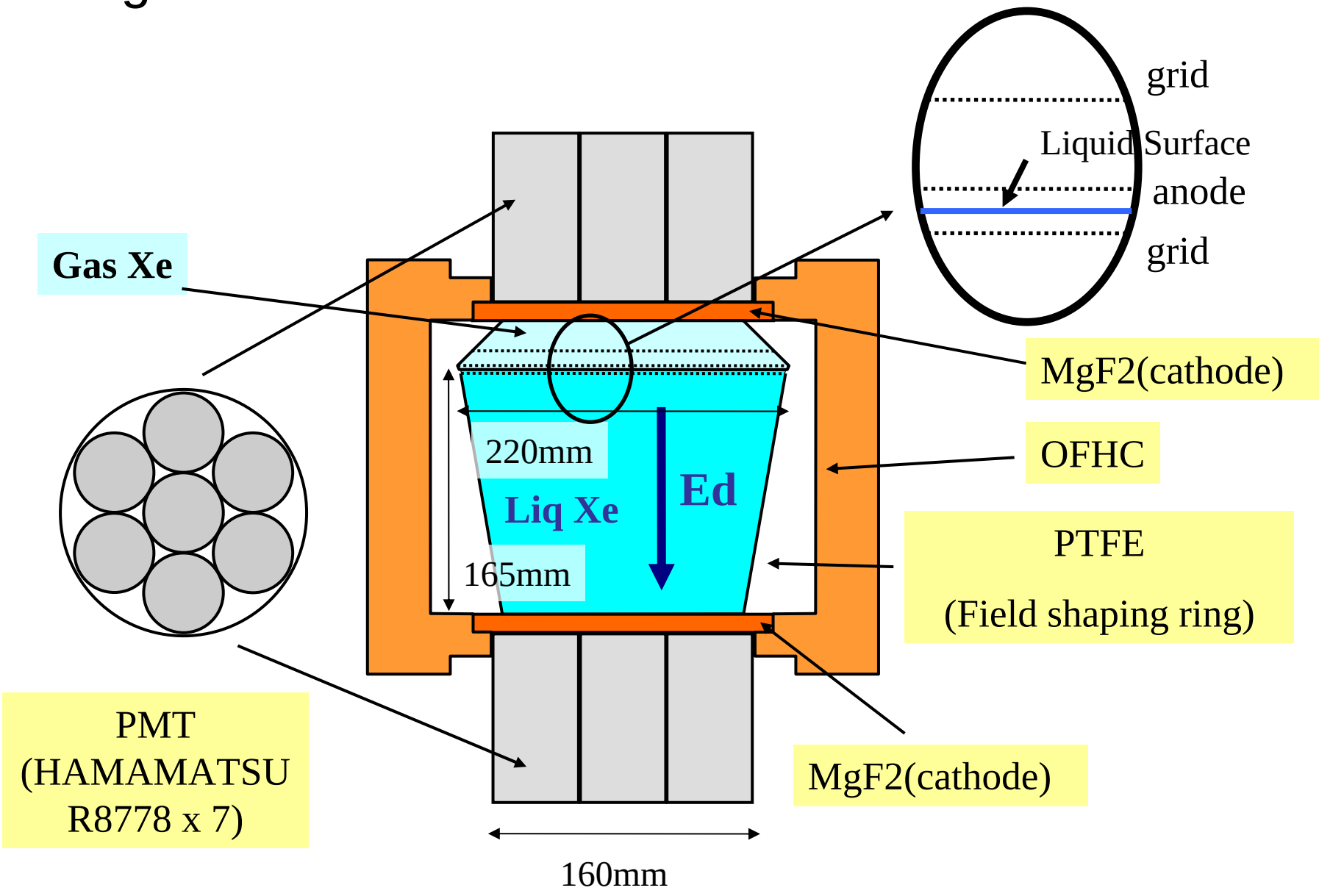


>99% γ ray rejection

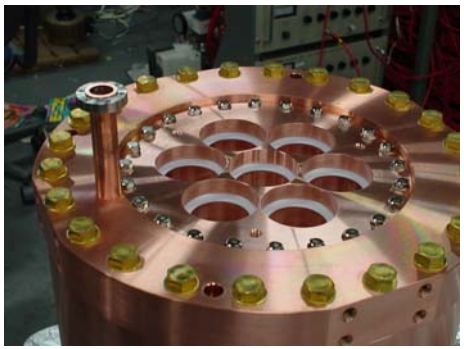
22 keV gamma ray S1 ≪ S2

Recoil Xenon (neutron source) S1 > S2 ∽ 0

15 kg Double Phase Xe Detector

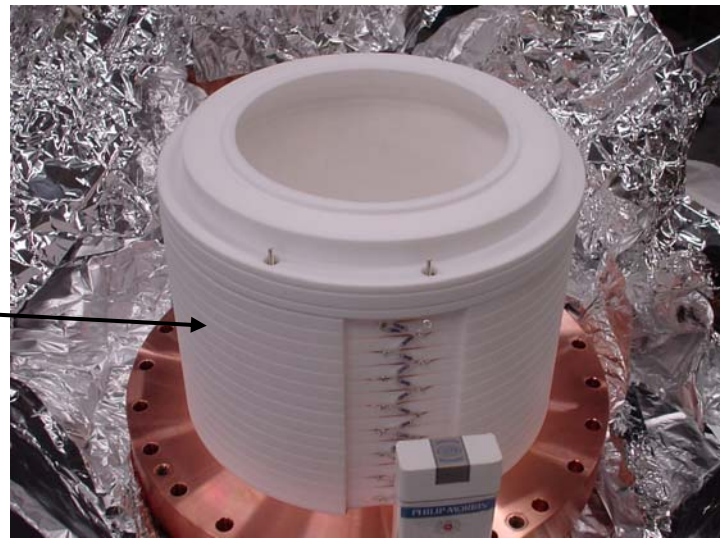


15kg Chamber Construction

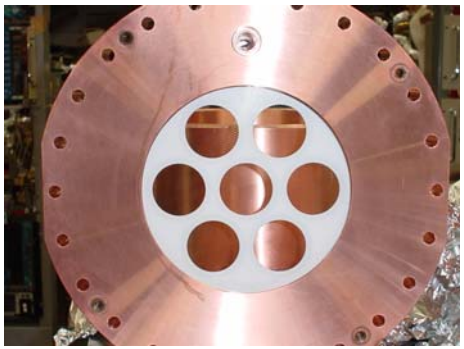


Anode - Grid Set

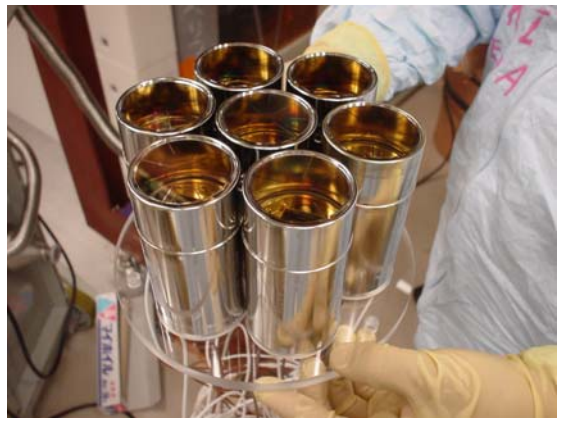
PTFE
Field Shaping Ring



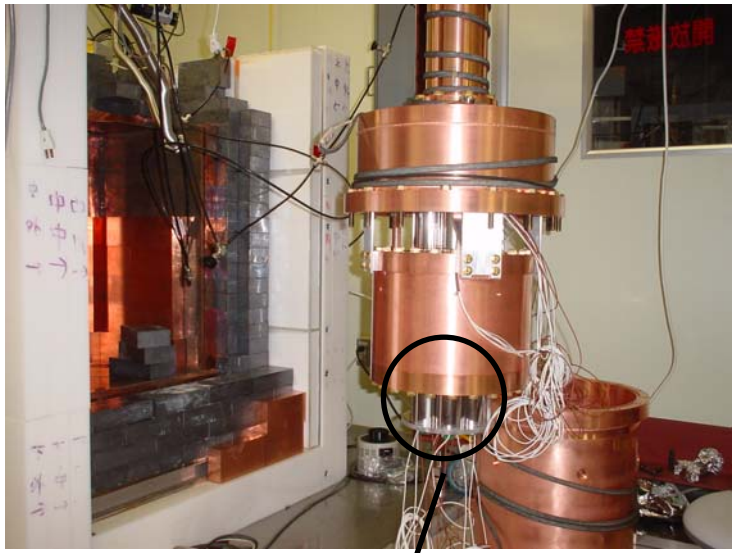
PMT

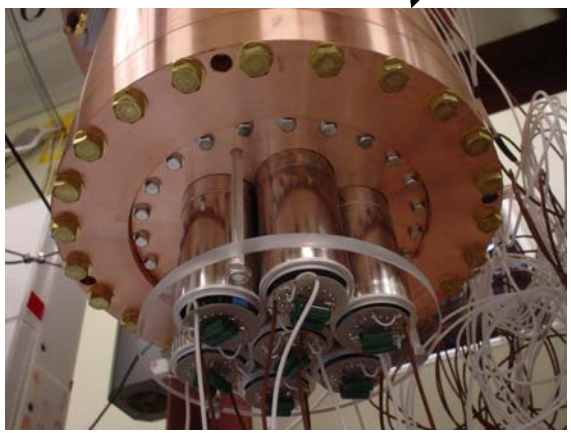


MgF2 Window
(Cathode:gold coated mesh)



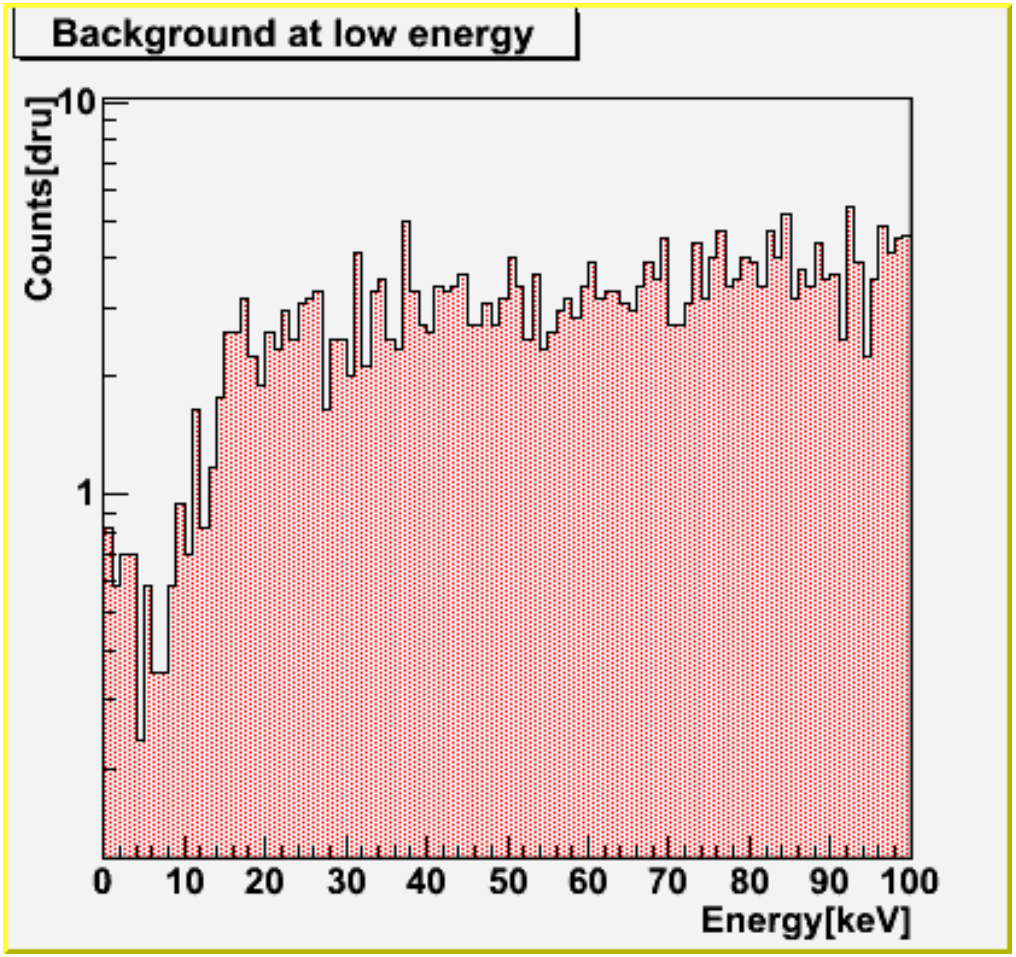
15 kg Chamber Construction





Shield

Background at low energy(without rejection)



Condition

Discrimination level:
3 mV→ about 0.4 pe
Coincidence: more than 3 hits
Coincidence width: 40 ns
Live time = 0.5 days
PMT gain: about $1.0*10^7$

Rejectionにより2〜3桁下げる

R&Dの現状と計画

Wave form analysis

ZEPLIN I experiment
電場なし

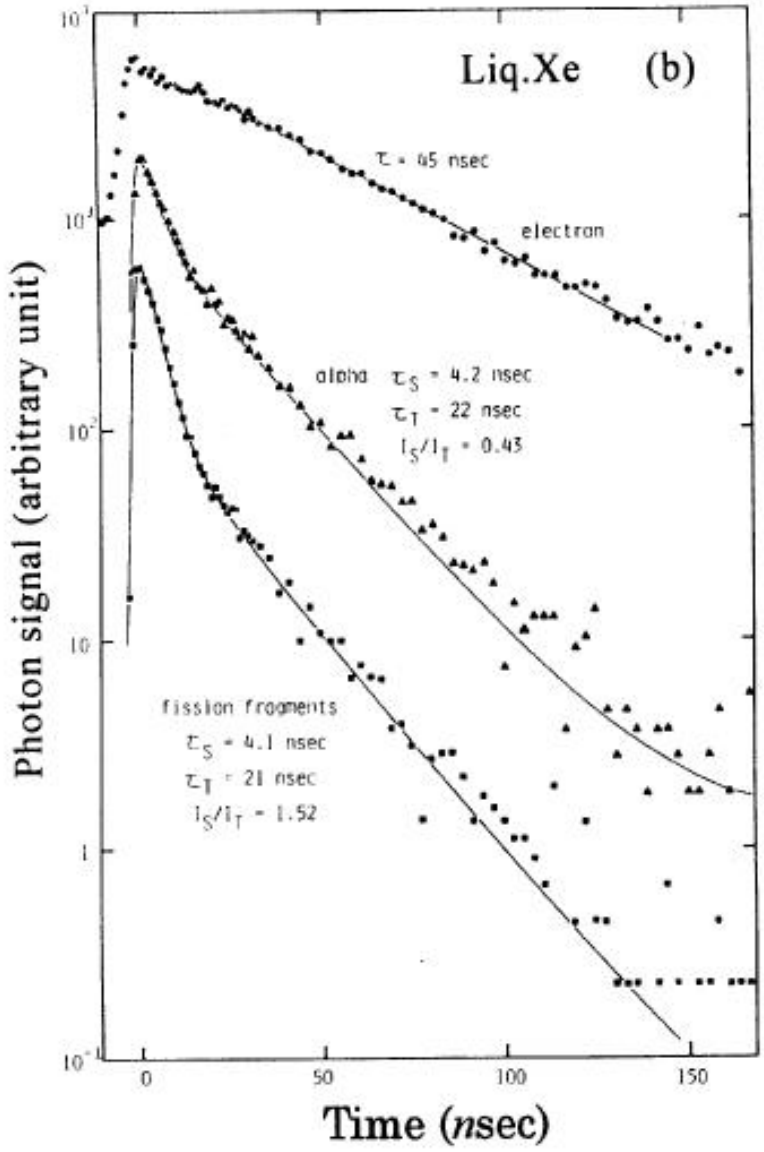
非常に良い結果が得られた！

↓

電場を印加した状態でのWFAは
うまくいくのか？

↓

テスト実験を準備中



3D-double phase xenon detector

If we have pure xenon which is free from radioactive impurities, proportional scintillation is very useful.

Multi-purpose detector

WIMPs
^{136}Xe double β decay
pp ^{7}Be solar ν

Low energy detection by 3D-double phase detector in Underground

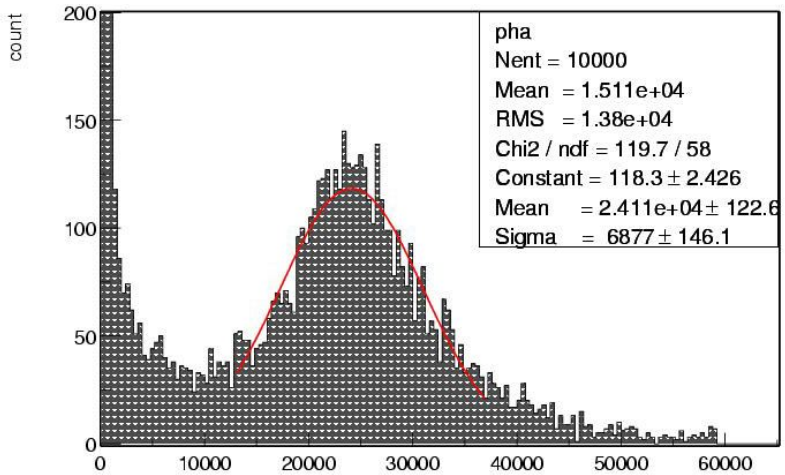
Low background environments → Shielding, Detector

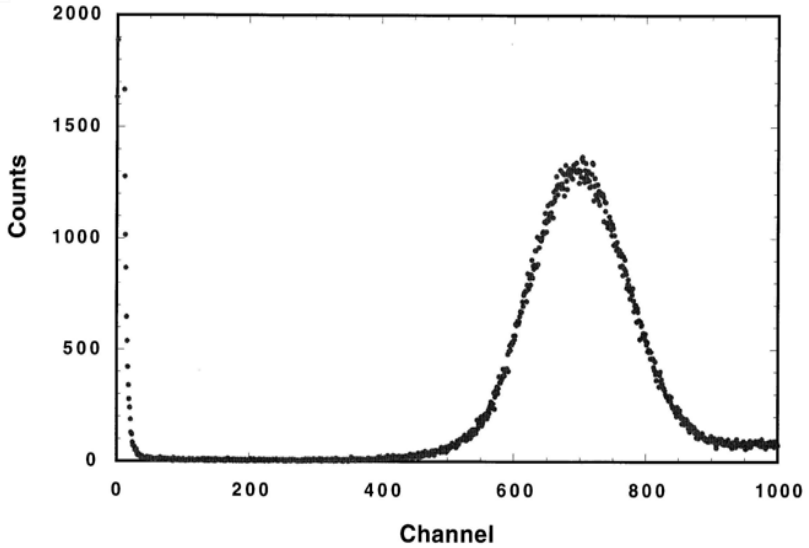
WIMPs	$0\nu\beta\beta$ decay	pp, ^{7}Be solar ν
low Eth ∽few keV	energy resolution	low Eth
large mass	γ / β ID	huge mass ∽10 ton
particle ID		real time
		self-shielding
		particle ID (WIMPs, neutrons,)

Proportional scintillation

Energy spectrum for low energy γ rays

Low energy threshold for pp ^{7}Be solar ν ⟶ < few keV





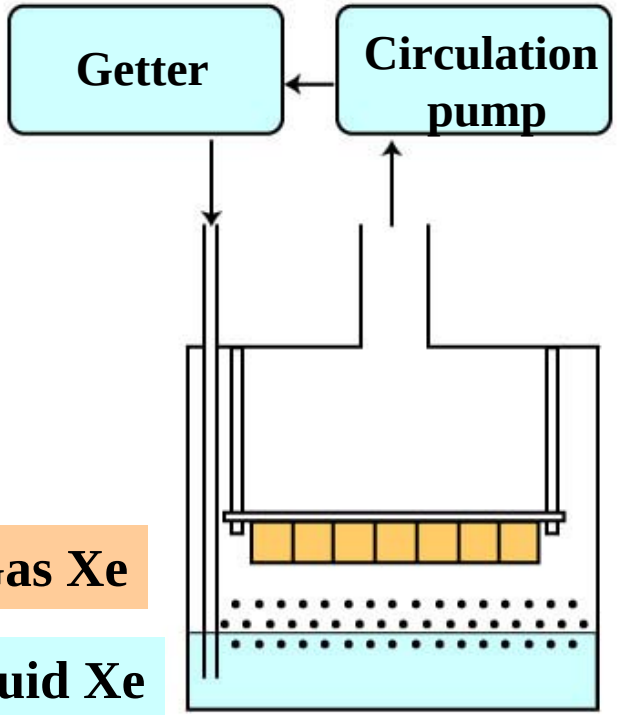
5.9 keV γ ray from ^{55}Fe

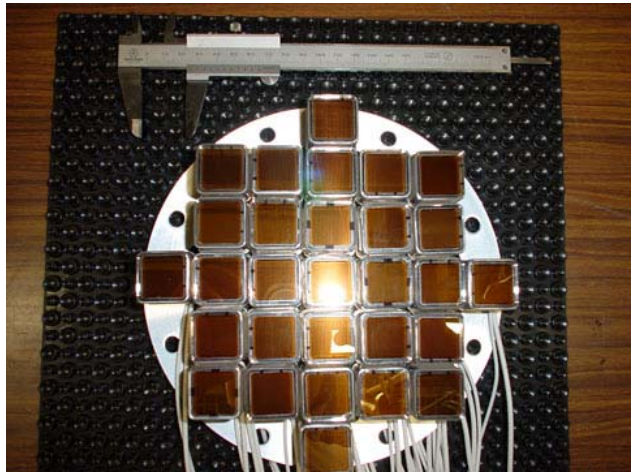
22 keV γ ray from ^{109}Cd

✓Independent of detector size

3D W-phase test chamber

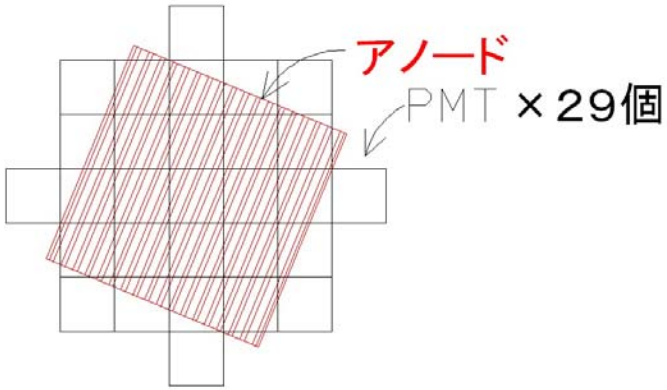
Recirculation purification

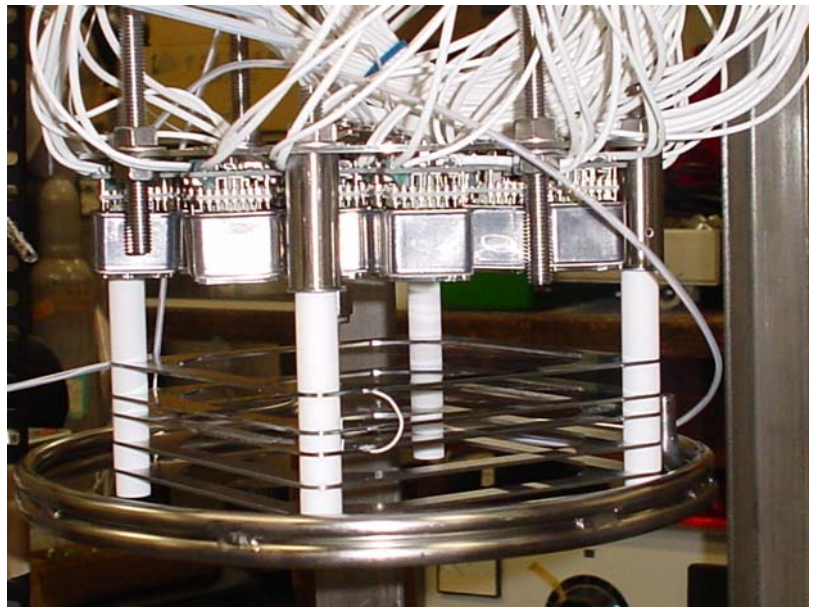




PMT: Hamamatsu R5900-06

- **1inch square type x 29**
- **QE ∽ 20%**
- **Work in LXe Temp.**
- **Gain 10^7**

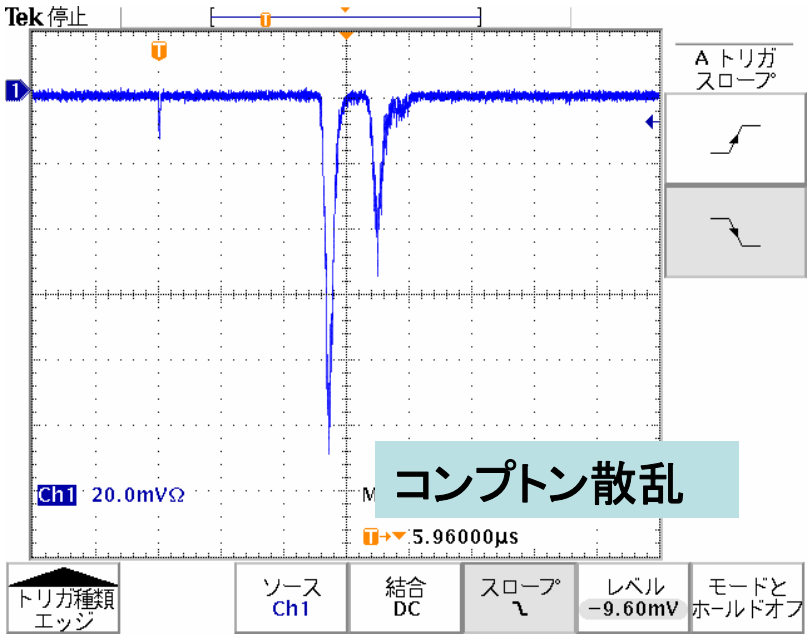




•3次元位置検出

•Z方向

Δz ＝ drift time ×drift velocity



コンプトン散乱

数100μmの位置分解能

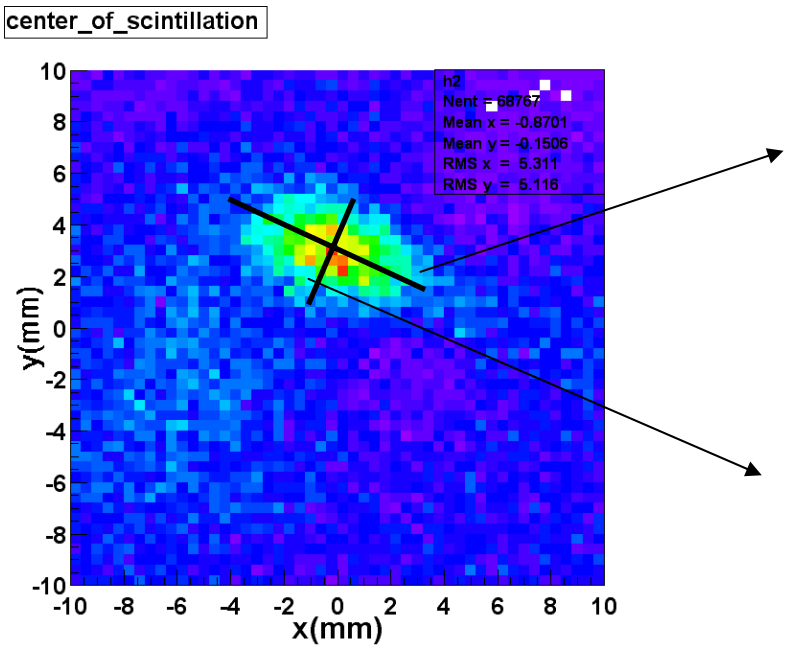
•X－Y方向

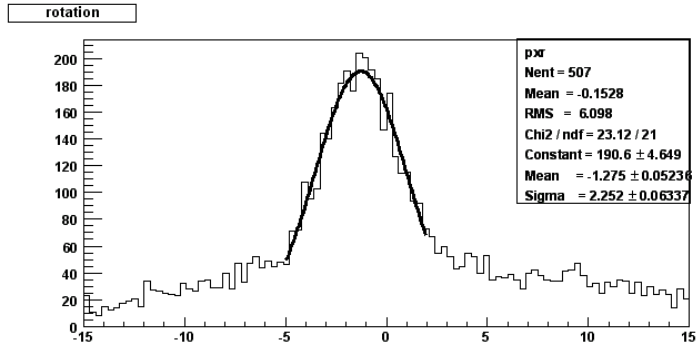
Proportional Scintillationを29個のPMTで見ることにより光量重心を求める

$$\vec{G} = \frac{\sum n_i \vec{x}_i}{\sum n_i}$$

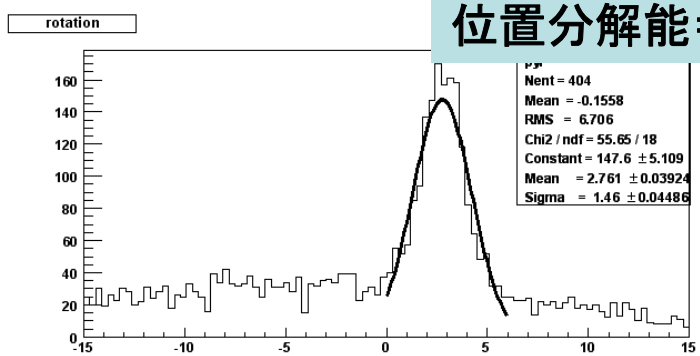
どの程度の位置分解能が得られるのか検証する必要がある。

•x-y位置分解能の方向依存性

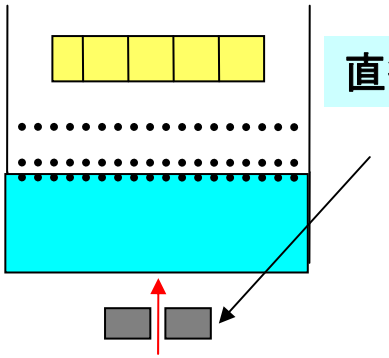




位置分解能＝2.8mm

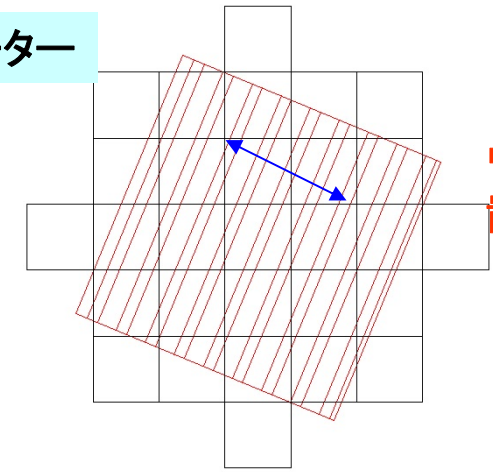


位置分解能＝1.6mm



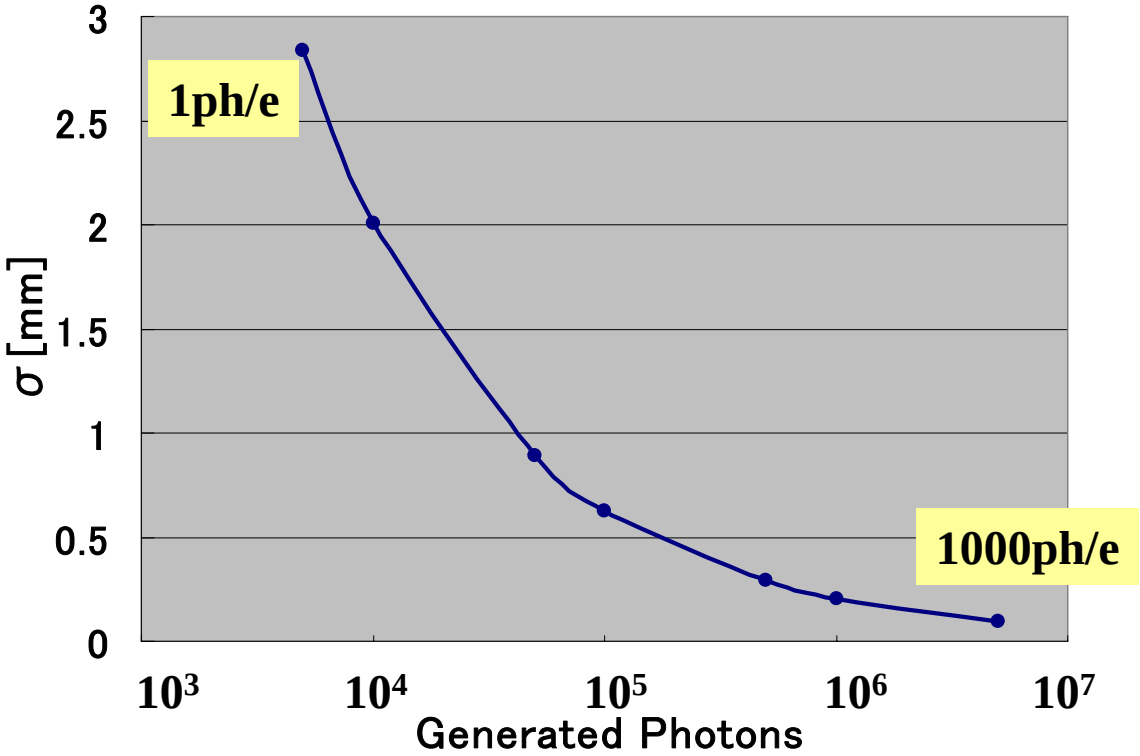
直径3mmのコリメーター

中心付近に^{57}Coを照射



ワイヤーに対して垂直方向は位置分解能が悪くなってしまう。

Position resolution(x,y)



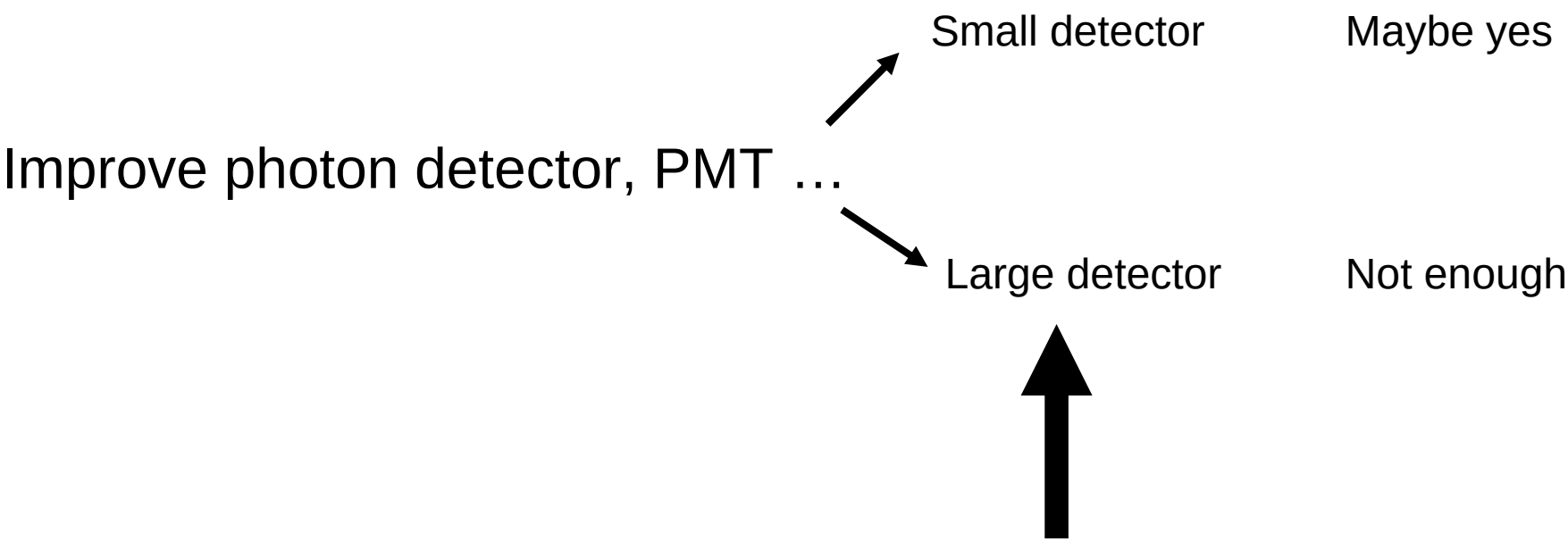
Simulation
(for 100 keV electron)

- **Distance between PMT and anode: 3 cm**
- **proportional scintillation :1 mm Gaussian**
- **Collection of electrons :60%**
- **PMT Coverage : 20%**
- **QE : 5%**

✓ σ_{xy} < 1 mm will be possible by good adjustment of PMTs
✓Use multi -anode PMTs for double β decay experiment

What is the most important in the future?

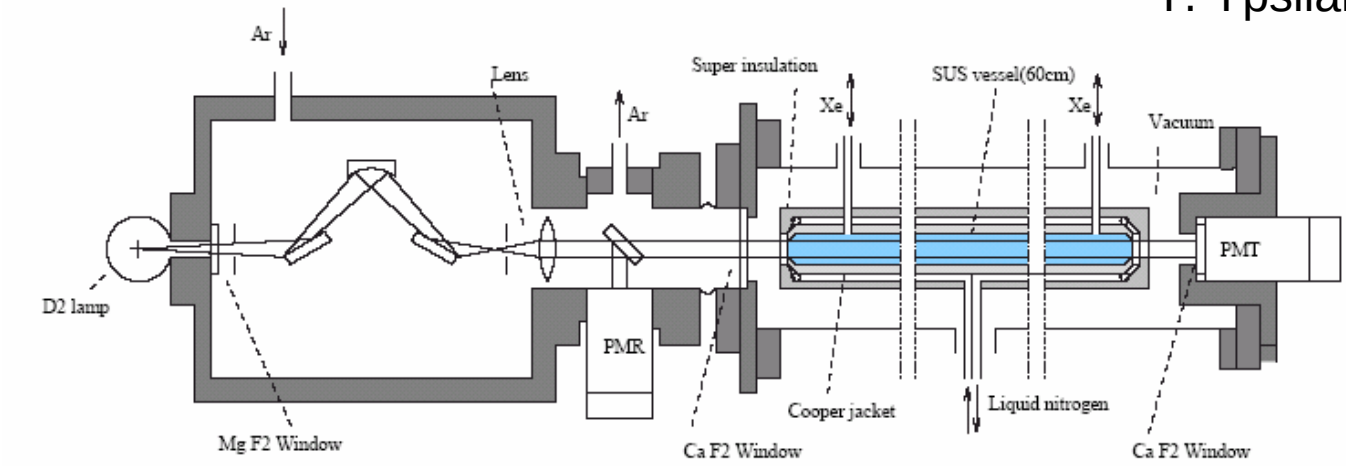
How to collect photon effectively?

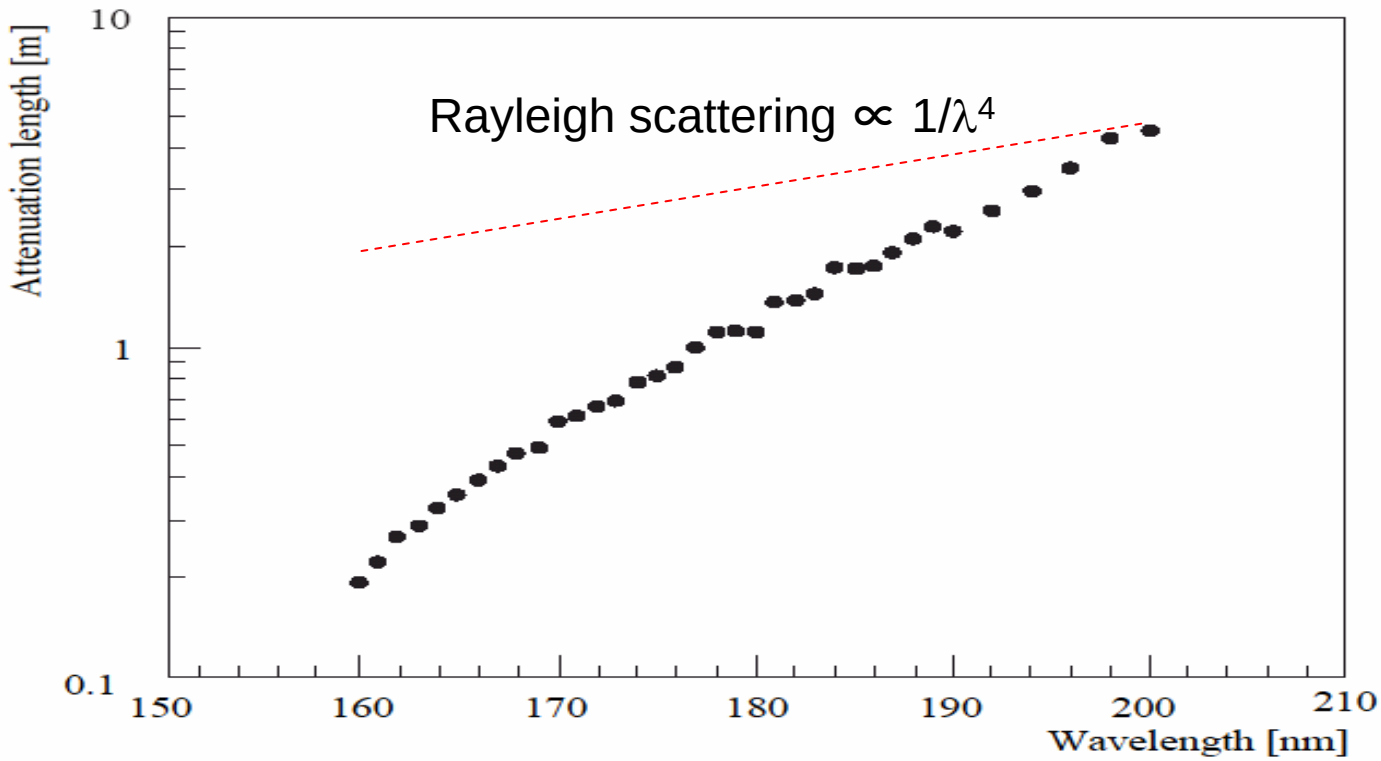


The best is to find a gaseous wave length shifter

Attenuation length vs Wavelength(λ)

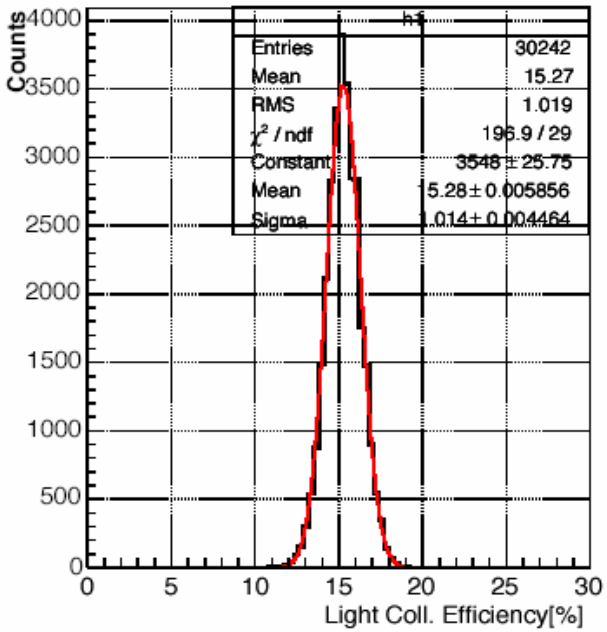
T. Ypsilantis et al.('95)





Light collection efficiency

15 kg W-phase detector



Refractance
MgF2 : 1.45
quartz : 1.56
LXe : 1.60

λ = 175 nm

Reflectance for PTFE : 0.90
Absorption length of LXe : 1 m
Scattering length : 40 cm

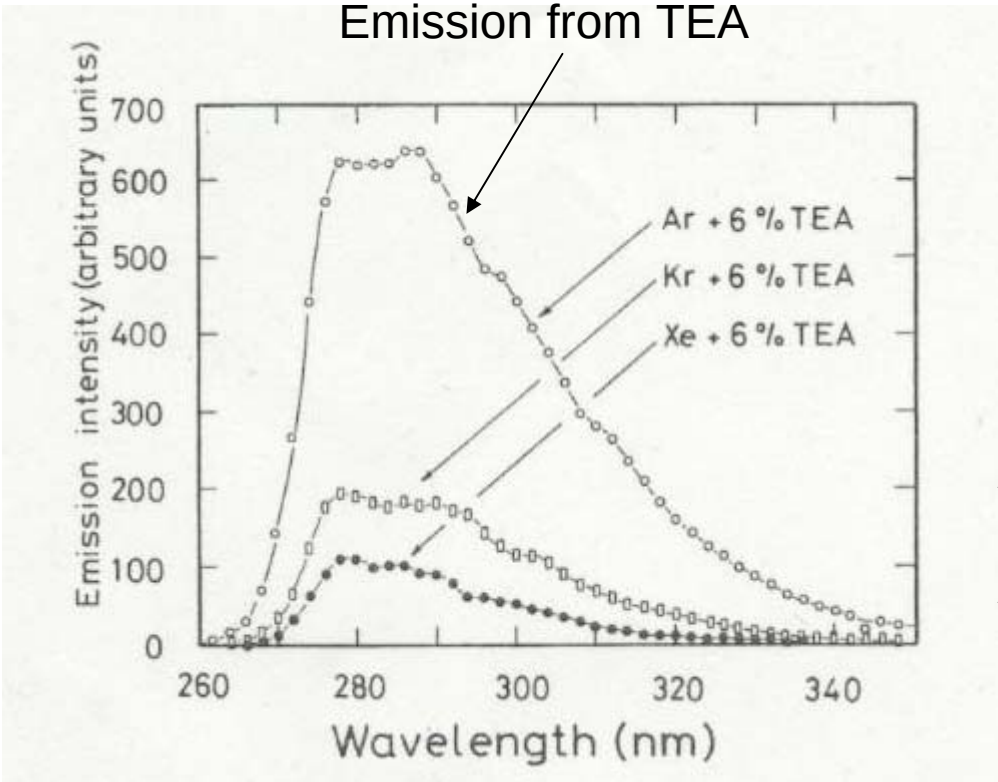
15.3 %
1.75 pe/keV
(QE:25%)

λ = 350 nm

Reflectance for PTFE : ∽ 0.99
Absorption length of LXe : ∽ 20 m
Scattering length : ∽ 3m

∽ 80 %
∽ 8 pe/keV

TEA doped rare gas experiment



M.SUZUKI et al. (1987)

$Ar^* + Ar + Ar \rightarrow Ar_2^* + Ar$

$Ar_2^* \rightarrow Ar + Ar + h\nu(VUV)$

Competitive process

$h\nu(VUV) + TEA \rightarrow TEA^*$

$Ar_2^* + TEA \rightarrow Ar + Ar + TEA^*$

$h\nu(VUV) + TEA \rightarrow TEA^+ + e$

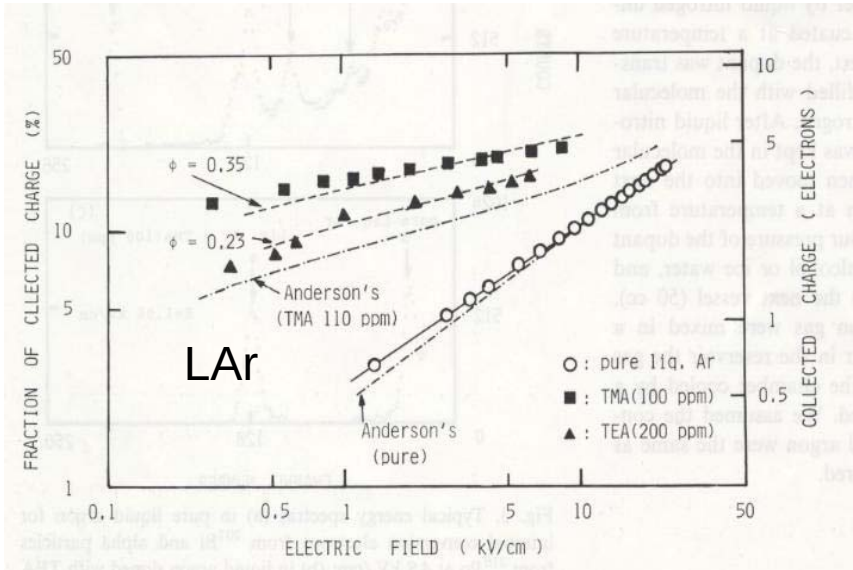
$Ar_2^* + TEA \rightarrow Ar + Ar + TEA^+ + e$

Is it possible to apply to liquid phase?

Photo ionization effect was observed for both liquid.

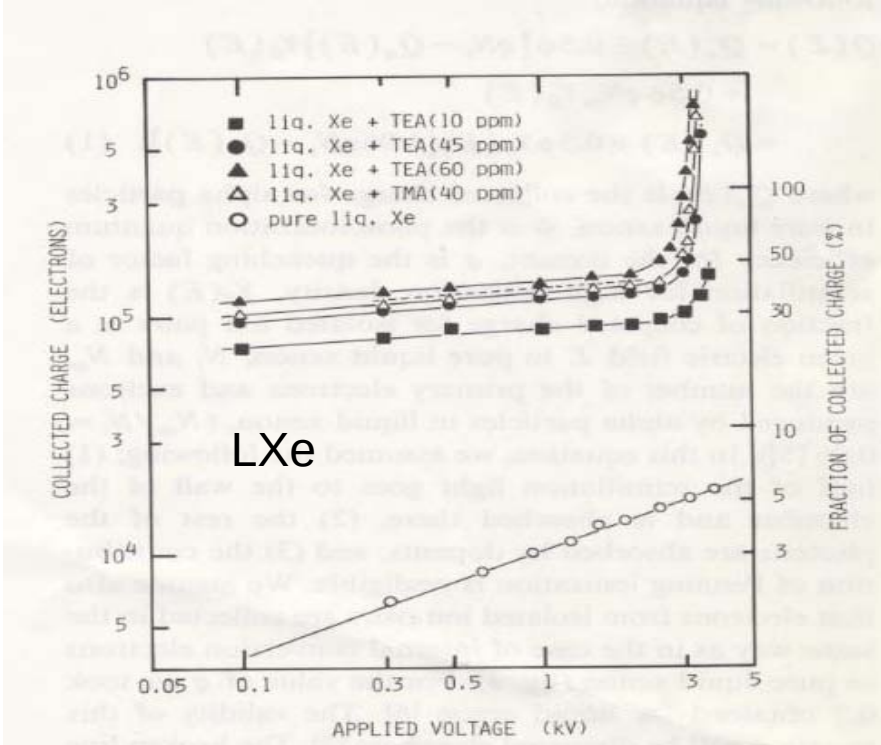
$h\nu(VUV) + TEA \rightarrow TEA^+ + e$
$(Ar_2^* + TEA \rightarrow Ar + Ar + TEA^+ + e)$

QE = 0.23



$h\nu(VUV) + TEA \rightarrow TEA^+ + e$
$(Xe_2^* + TEA \rightarrow Xe + Xe + TEA^+ + e)$

QE ∽ 1



Nobody check visible(UV) light yet!
Excitation process should be occurred.
Especially to LAr because of small QE.

End