AXEL

-A Xenon Electro Luminescence detector -

High Density Xenon gas TPC for double beta decay search and direction sensitive dark matter search

- References are from “Noble Gas Detectors” unless otherwise noted.

Double Beta decay candidates

	abound(%)	$\tau(2\nu\beta\beta)$ yr	Q(keV)	Q^5/1E16	$Q^5 x \tau(2\nu\beta\beta)$/1E36	
48Ca	0.187	3.9E+19	4271	142.12	55.4	enrichment difficult
76Ge	7.8	1.7E+21	2039	3.52	59.9	
82Se	9.2	9.6E+19	2995	24.10	**23.1**	
96Zr	2.8	2.0E+19	3350	42.19	8.4	
100Mo	9.6	7.1E+18	3034	25.71	**1.8**	
110Pd	11.8		2013	3.31		
116Cd	7.5	2.8E+19	2802	17.27	4.8	
124Sn	5.64		2228	5.49		
130Te	34.5	7.6E+20	2529	10.35	78.6	
136Xe	8.9	2.2E+21	2479	9.36	**208.8**	
150Nd	5.6	9.2E+18	3367	43.27	4.0	enrichment difficult

* $\tau(2\nu\beta\beta) \propto Q^{11}$, $\tau(0\nu\beta\beta) \propto Q^5$

^{136}Xe

- Xenon production rate
  - 5000-7000m^3/yr ~50ton in 1998.
- 2x10^6 kton exists in air
- Enrichment is relatively easy.

	Density at 0℃,1atm (g/L)	Liquid Density (g/cm3)	Melting point(K)	Boiling point(K)
He	0.1786	0.145	-	4.22
Ne	0.9002	1.2	24.56	27.07
Ar	1.784	1.398	88.80	87.30
Kr	3.749	2.413	115.79	119.93
Xe	5.894	3.053	161.4	165.03

Energy resolution

- Statistical limit
  - W-value 21.5 eV, Fano factor<0.17
    - → 0.29%(FWHM)@2.48MeV (0.55%(FWHM)@662keV)
- At higher density, energy resolution becomes worse. → reject liquid option.

A. Bolotnikov, B. Ramsey / Nucl. Instr. and Meth. in Phys. Res. A 396 (1997) 360–370

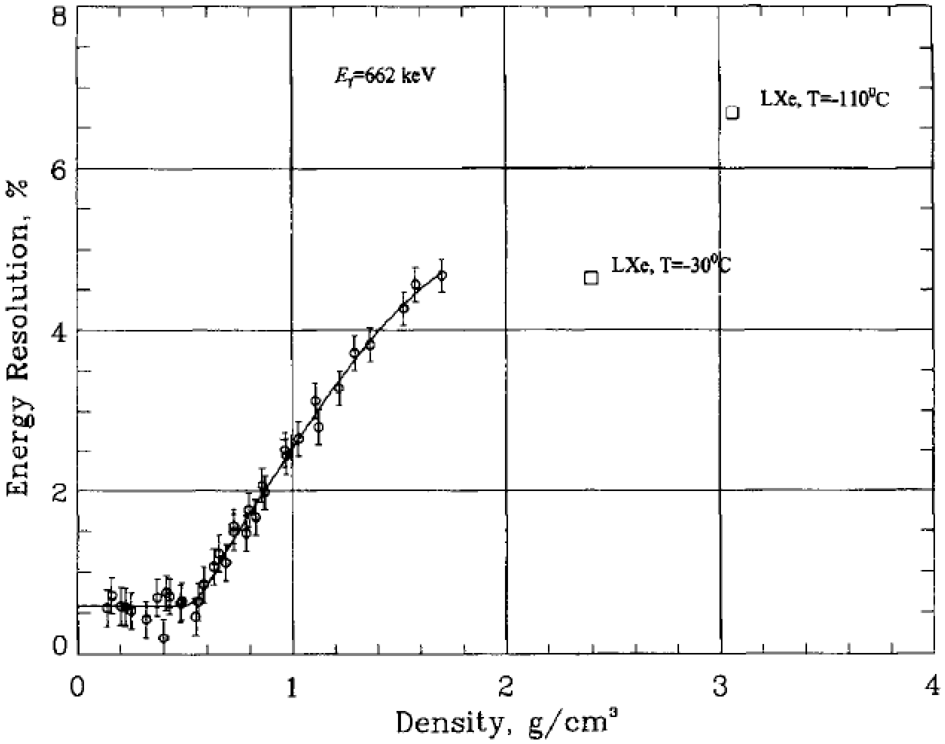


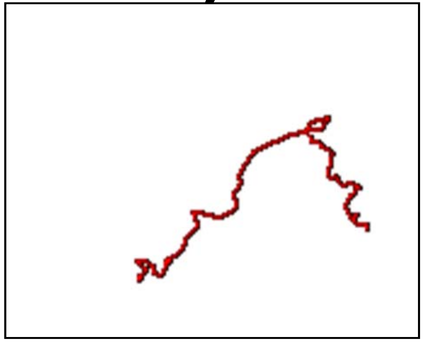
Fig. 5. Density dependencies of the intrinsic energy resolution (%FWHM) measured for 662 keV gamma-rays.

High density (15~30 x STP)

High pressure

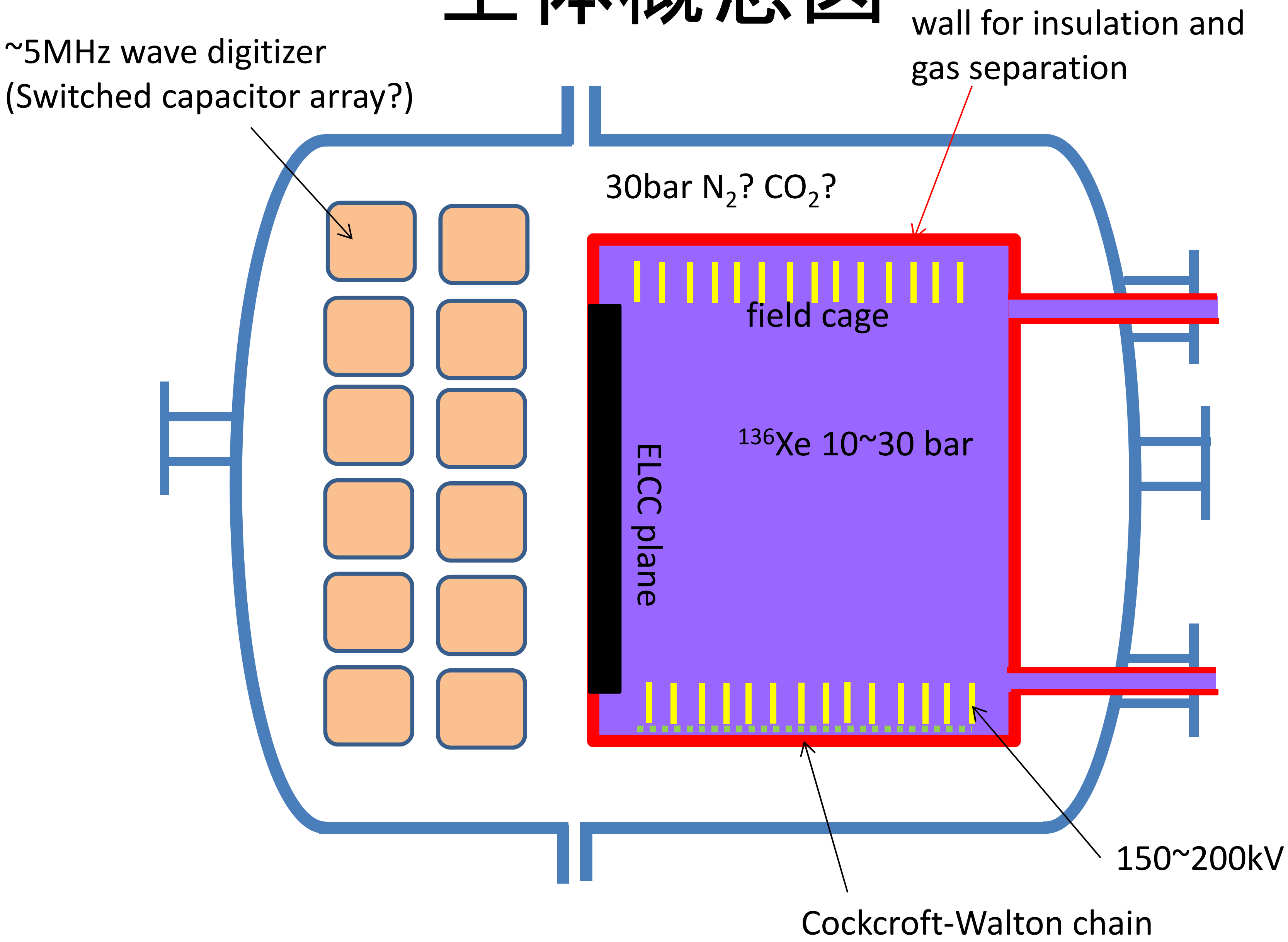
- Need pressure vessel including feed through
- Need photo detector operatable at high pressure

我々のBaseline design(目標)



- 1 ton enriched ^{136}Xe gas (not liquid)
- At 15~30 times higher density than STP
  - ρ = 0.088~0.18g/cm^3
  - e.g. ϕ2mx1.7m(H) cylinder at 0.18 g/cm^3
- Use proportional scintillation mode (Electroluminescence) for energy measurement
  - Energy resolution goal < 0.5%(FWHM)
  - Ultraviolet photon(~170n) detection by MPPC
- Tracking as TPC
  - Range(2.5MeV e) ~ 210 cm at STP
  - T_0 by primary scintillation signal
  - Sample 15~20 points using pads. 5~7.5mm spacing→5.5x10^4~1.2x10^5 ch
  - Purpose is to identify two blobs at track ends. → distinguish from α's and γ's.
  - Electric field for drift : ~1.5kV/cm@30bar →drift velocity ~1m/ms
- Energy measurement by ELCC(see next pages)

全体概念図


wall for insulation and gas separation
~5MHz wave digitizer (Switched capacitor array?)
30bar N_2? CO_2?
field cage
^{136}Xe 10~30 bar
ELCC plane
150~200kV
Cockcroft-Walton chain

Milestones

- MPPC 64チャンネル、10気圧検出器を製作し1.3MeVガンマ線の測定で原理証明
  - このための開発要素、盛りだくさん。
- 来年度以降の目標は
  - キセノン10気圧 9kg検出器

    ↓
  - 30気圧 27kg検出器で世界記録更新

    ↓
  - 30気圧1トン検出器で発見！

Scintillation

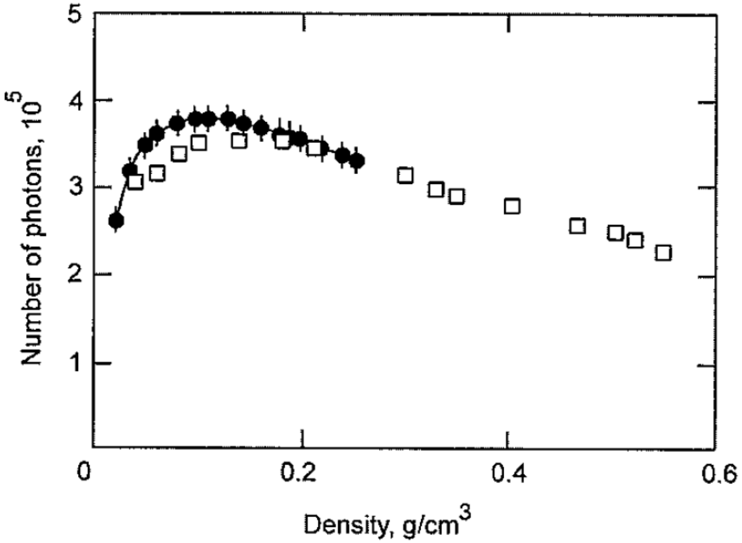


Fig. 3.38 Dependence of light output of scintillations excited by alpha particles on the density of high-pressure xenon: open squares represent data of Bolotnikov and Ramsey [33], closed circles represent data of Kobayashi et al. [198]. Redrawn from [198].

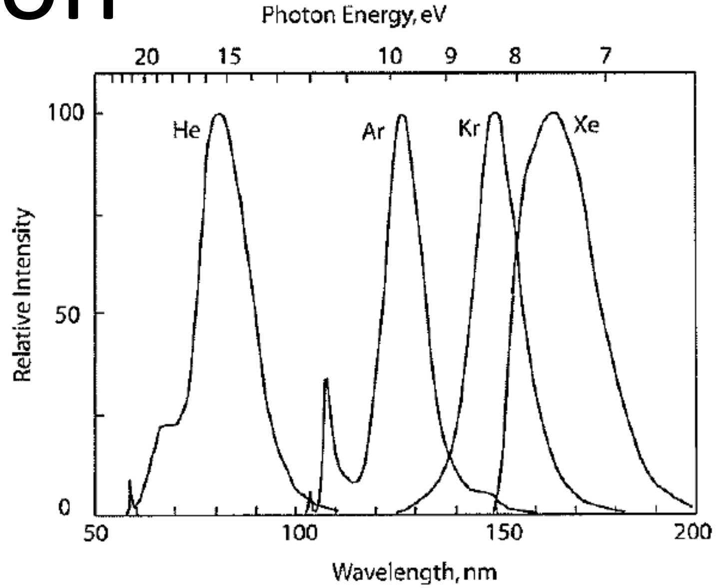
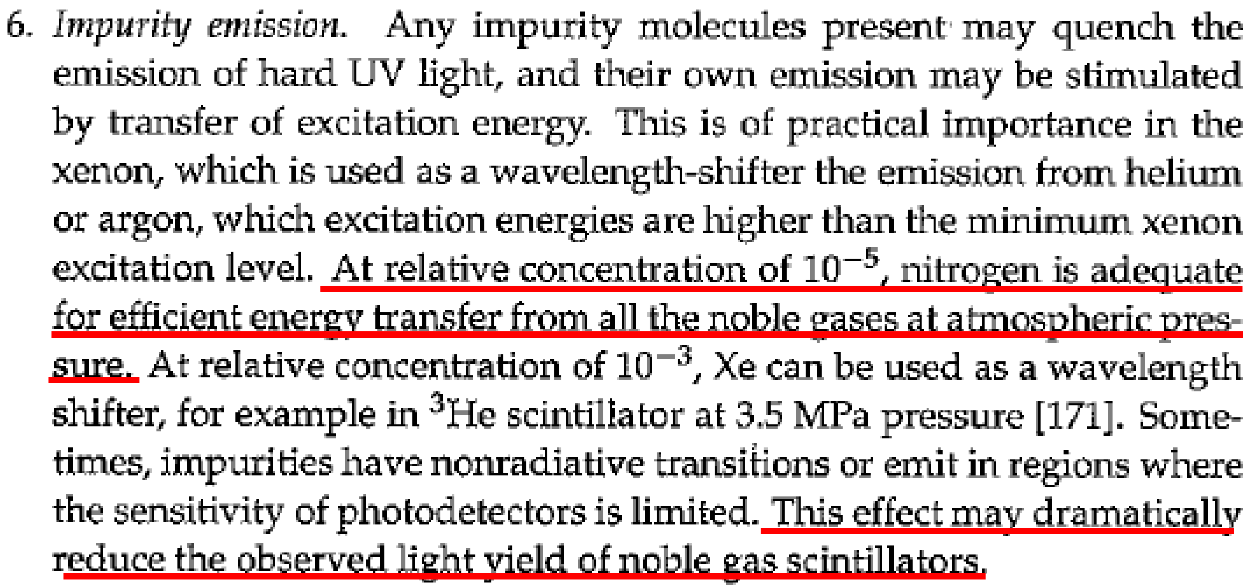


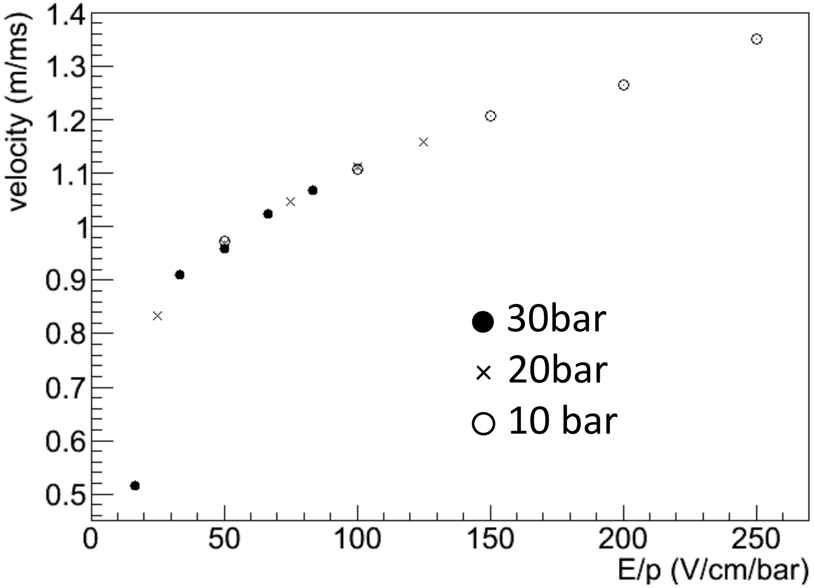
Fig. 3.27 Noble gas continua of helium, argon, krypton, and xenon normalized to the same intensity of the maximum. Redrawn from [176].



6. *Impurity emission.* Any impurity molecules present may quench the emission of hard UV light, and their own emission may be stimulated by transfer of excitation energy. This is of practical importance in the xenon, which is used as a wavelength-shifter the emission from helium or argon, which excitation energies are higher than the minimum xenon excitation level. At relative concentration of 10^{-5}, nitrogen is adequate for efficient energy transfer from all the noble gases at atmospheric pressure. At relative concentration of 10^{-3}, Xe can be used as a wavelength shifter, for example in ^{3}He scintillator at 3.5 MPa pressure [171]. Sometimes, impurities have nonradiative transitions or emit in regions where the sensitivity of photodetectors is limited. This effect may dramatically reduce the observed light yield of noble gas scintillators.

What is the influence on scintillation from N_2 or H_2 addition?

Electric Field and electron drift



@ E=1.5kV/cm, p=30 bar

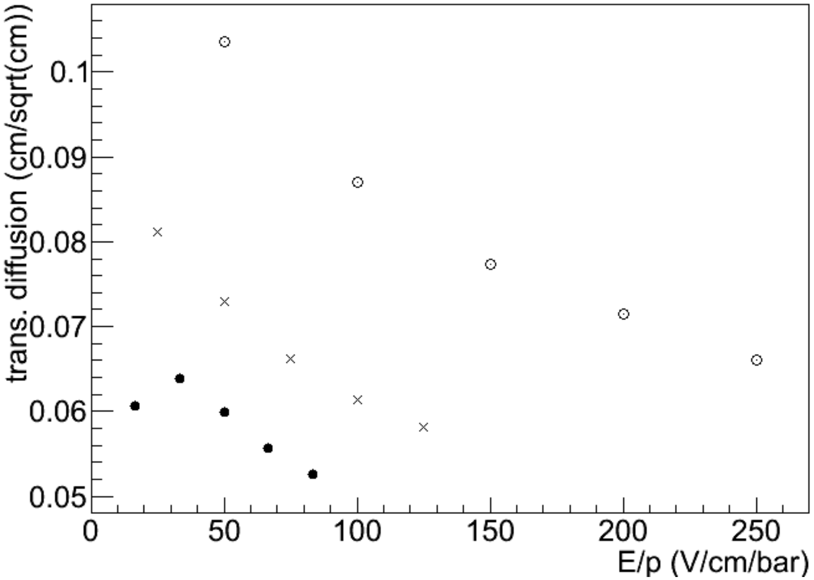
Drift velocity 0.96m/ms

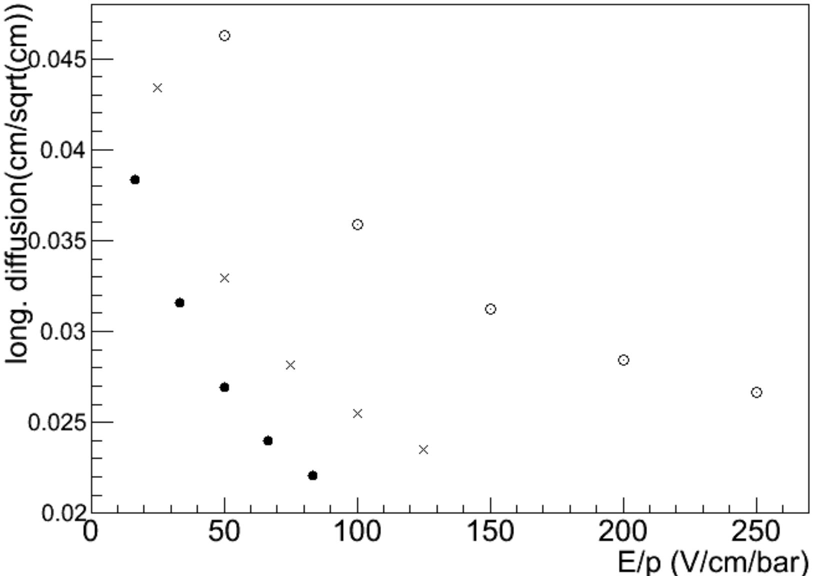
- Possibly add H_2, N_2 or He to increase the drift velocity.
  - It will also reduce diffusion.
  - It will also reduce light yield

diffusion after 1m drift

- transverse : 6mm
- longitudinal : 2.7mm

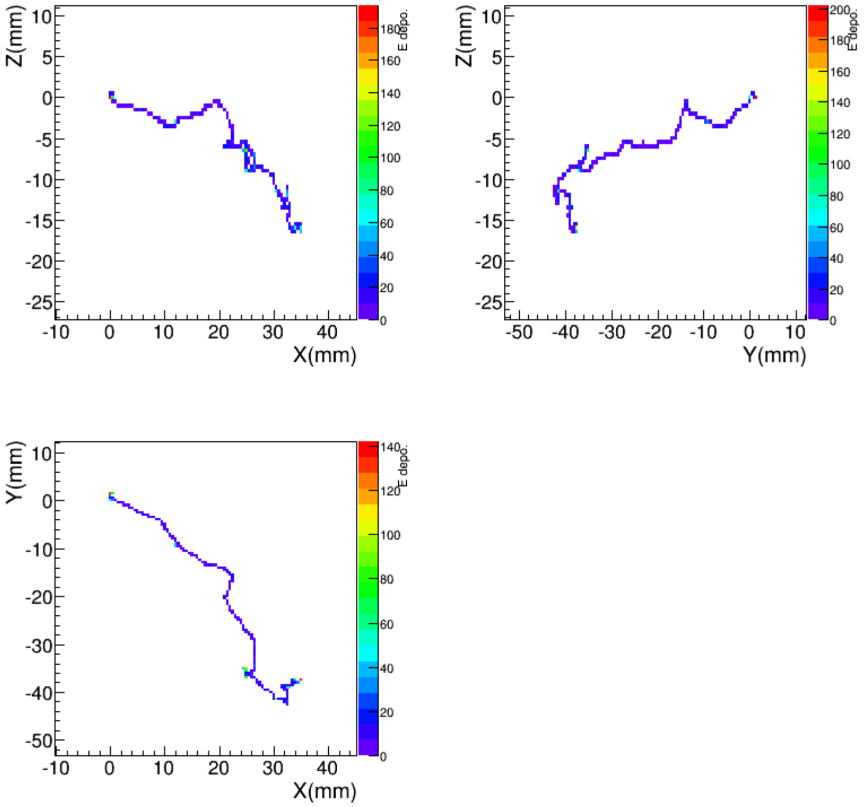
MAGBOLTZ calculation



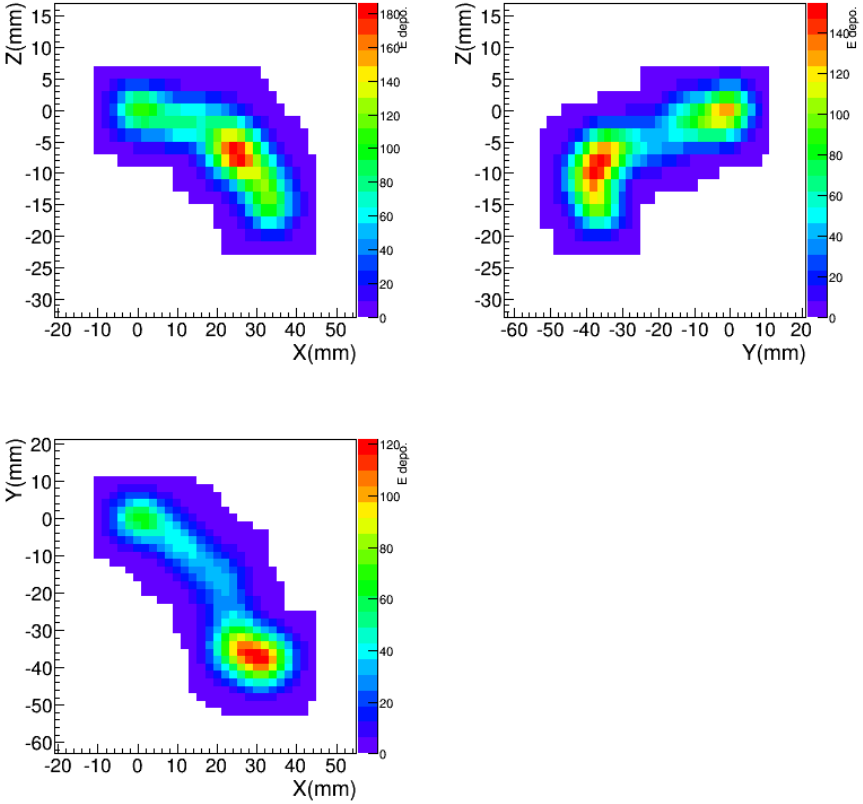


simulation example 1

initial ionization distribution



after 1m drift



Electroluminescence

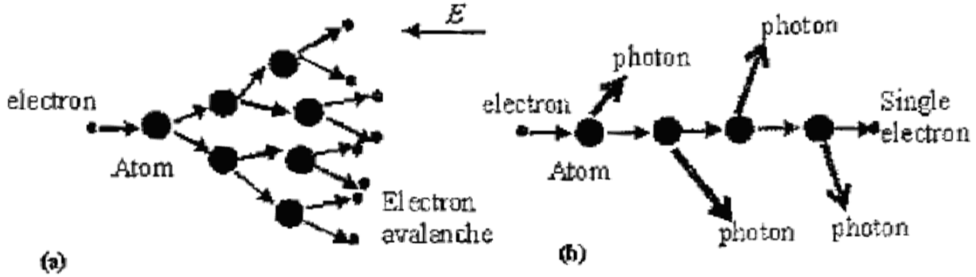


Fig. 6.2 Amplification process in gas detectors with gas gain (a) and electroluminescence (b) or proportional scintillation.

Good and stable linearity are expected because

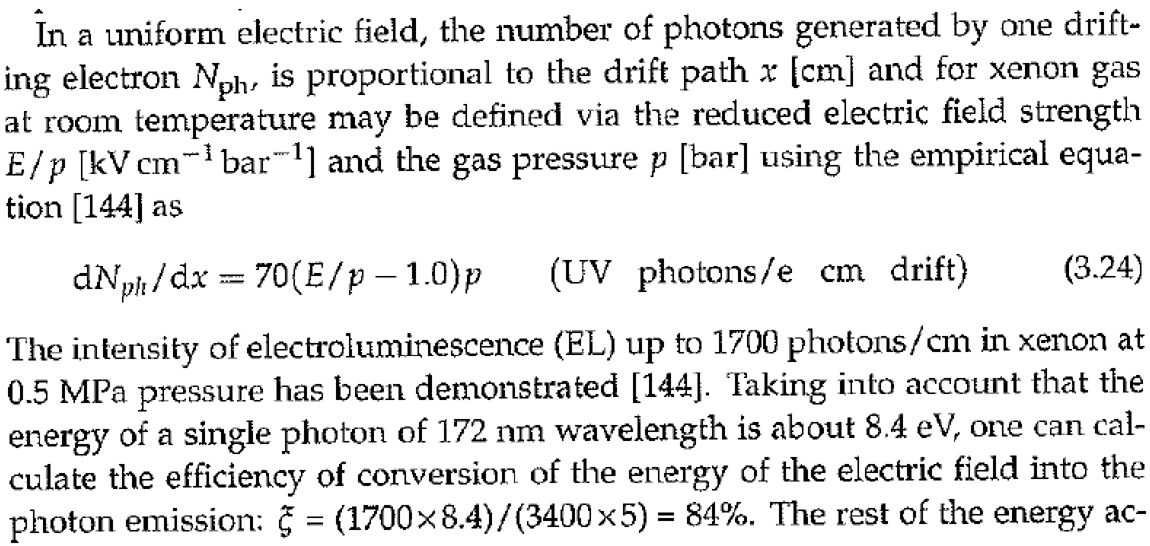
- A linear amplification process.

  c.f. Electron multiplication process is exponential process.
- The number of produced photons is proportional to the voltage drop rather than to the field strength.
  - Insensitive to the capacitance change by microphonic vibration

To keep original resolution determined by career generation,

- $\varepsilon \Upsilon > 1/F$ ($\varepsilon > 5\%$ for 400 photons/e)

  c.f. usually <1%



In a uniform electric field, the number of photons generated by one drifting electron N_{ph}, is proportional to the drift path x [cm] and for xenon gas at room temperature may be defined via the reduced electric field strength E/p [kV cm^{-1} bar^{-1}] and the gas pressure p [bar] using the empirical equation [144] as

$$dN_{ph}/dx = 70(E/p - 1.0)p \qquad \text{(UV photons/e cm drift)} \qquad (3.24)$$

The intensity of electroluminescence (EL) up to 1700 photons/cm in xenon at 0.5 MPa pressure has been demonstrated [144]. Taking into account that the energy of a single photon of 172 nm wavelength is about 8.4 eV, one can calculate the efficiency of conversion of the energy of the electric field into the photon emission: $\xi = (1700\times8.4)/(3400\times5) = 84\%$. The rest of the energy ac-

w/ 5 mm gap
To get 200 (400) photons,
18 (21) kV@30atm.
7.9 (11) kV@10atm.
3.4 (6.2) kV@1atm.

w/ 4 mm gap
To get 200 (400) photons,
4.9 (7.7) kV@5atm.
3.3(6.1) kV@1atm.

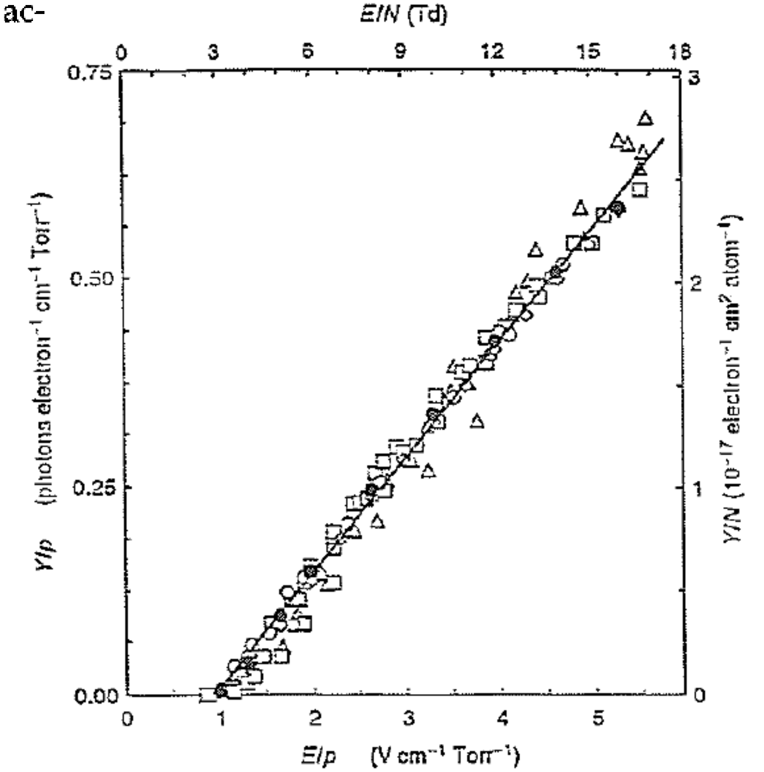
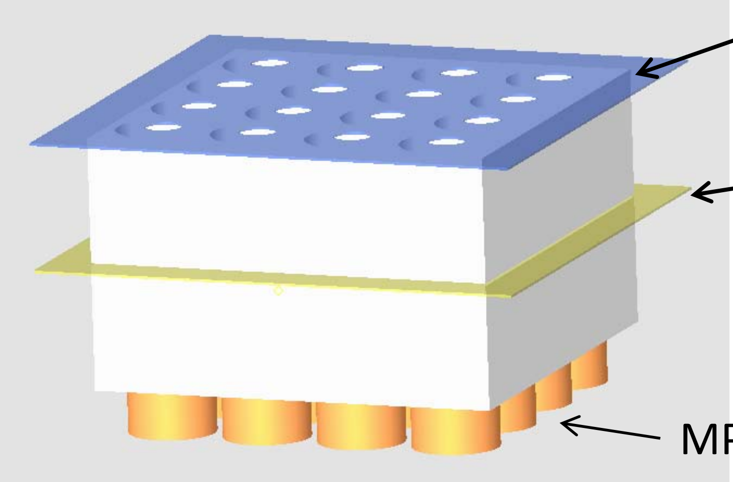


Fig. 3.17 Reduced light output of electroluminescence of xenon gas at 293 K temperature and normal pressure as a function of the reduced electric field strength (compilation of experimental and computer simulation data by Conde [143]).

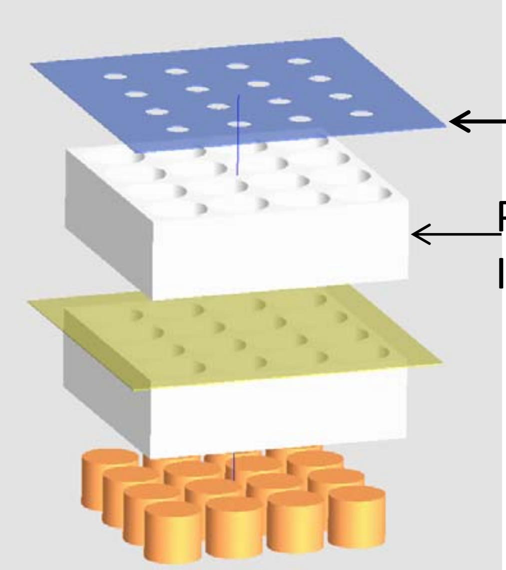
Readout by Electroluminescence light collection cell (ELCC)



anode

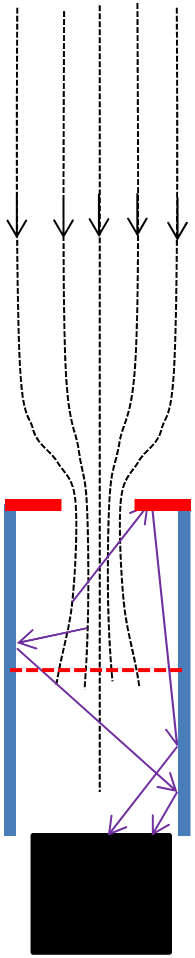
Mesh electrode

MPPC



Mirror surface in the opposite face.

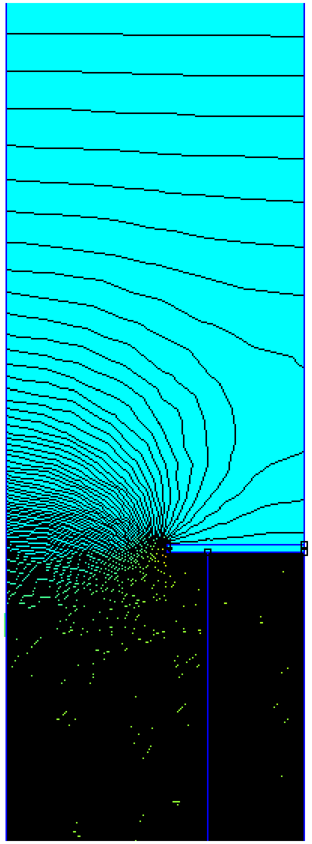
PTFE w/ holes(~ϕ5mm)
Inner surface may be coated w/ WLS.

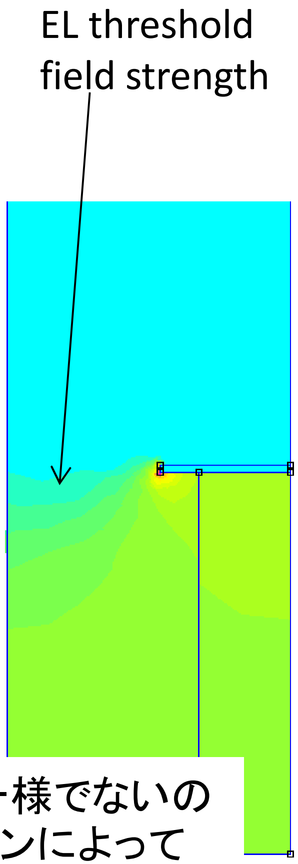


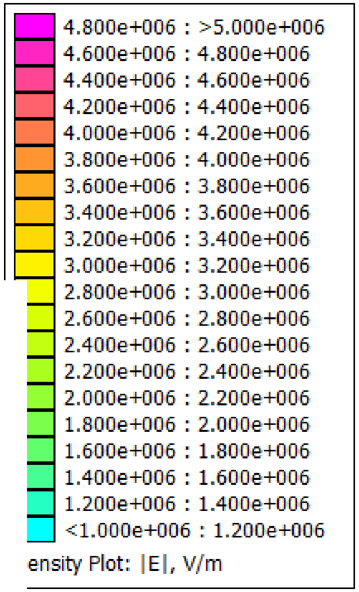
Line of electrical force

UV photons by electroluminescence are (converted to visible light,)reflected and detected by MPPC.
MPPC input window may be coated w/ WLS.

Electric Field in ELCC

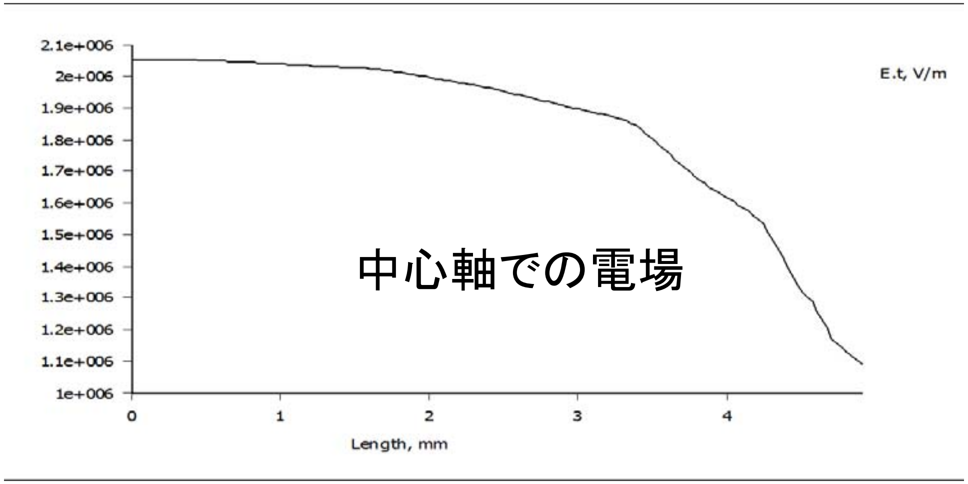






10気圧の場合。
アノードの穴はφ4。
PTFEの穴はφ5。
anodeは10.5kV
ドリフト電場は
500V/cm

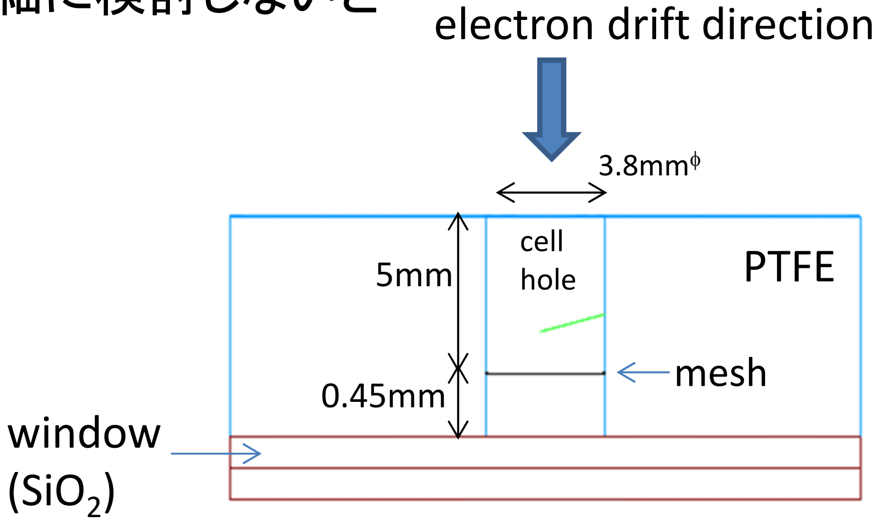
電場の強さが場所によって一様でないので、EL光が電子のドリフトラインによってばらつく可能性がある。
詳細なシミュレーションをしたいが、どういうツールがある？
(FEMMでscriptを書いて電場マップを作り、geant4?)



中心軸での電場

ELCC light collection efficiency

- by Geant4. cell内で光を一様発生
- PTFEについては、波長175nm以下での反射が観測されていない。175nm以上では反射率は>55%とされているので、平均反射率として11%を仮定。
- 収集効率は12.9% （これに、光検出器のefficiencyを掛ける必要あり。)
- ギャップを長くすれば、EL gainは十分に稼げるが、電圧は高くなる。wavelength shifterを塗って可視光にしてしまう手もある。どちらが良いかは、詳細に検討しないとわからない。



MPPCに対する要求

EL光

- 全光量は~1e6 photons.(ELで10倍増幅した場合)
- MPPC1個での瞬間最大光量は1e3phtons/50ns
- 3mm角、ピクセルピッチ10μm(ピクセル数9e4)からピクセルピッチ25μm(ピクセル数1.4e4)のMPPC
- 保護膜なしのタイプで紫外光を直接検出するか、WLSで可視光に変換するか。

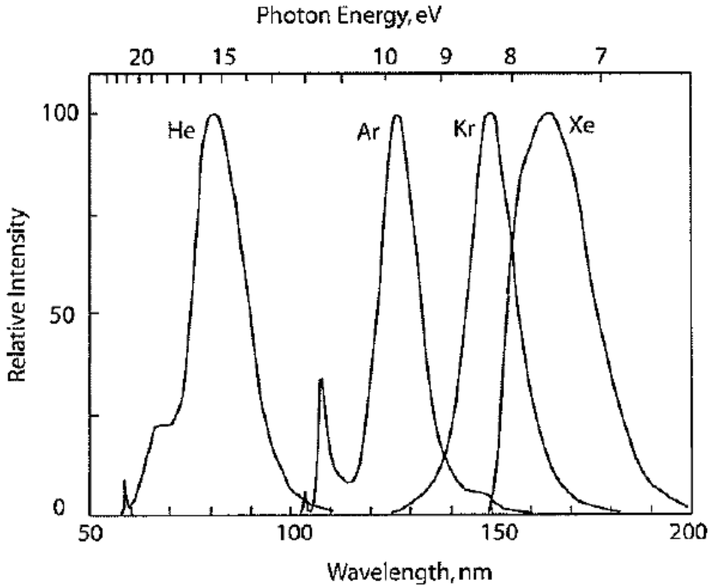
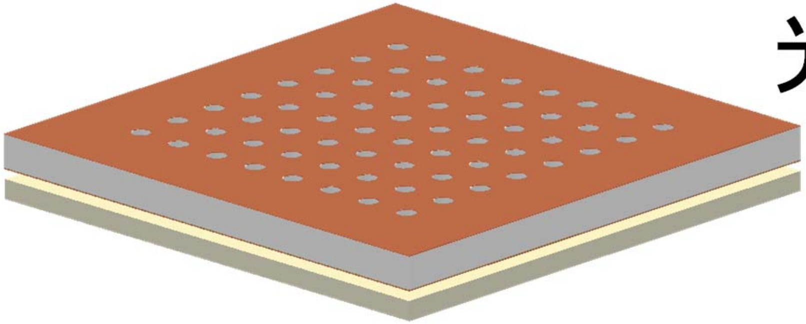


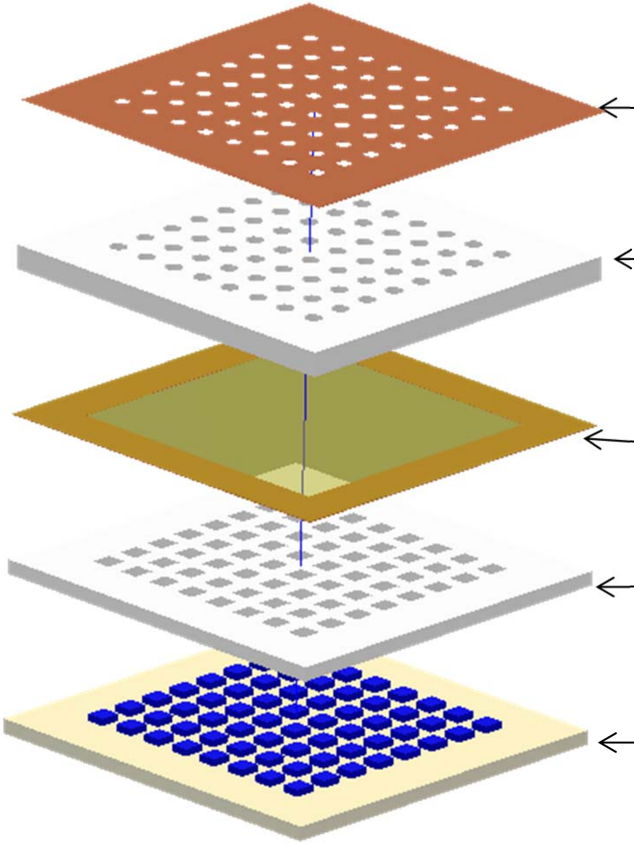
Fig. 3.27 Noble gas continua of helium, argon, krypton, and xenon normalized to the same intensity of the maximum. Redrawn from [176].

"Noble Gas Detectors"より
[176] R.E.Huffman, J.C.Larrabee and Y.Tanaka, Appl. Opt. 4, 1581-1588 (1965)

光収集セル(ELCC)の構造



- 電極1と電極2の間に高電圧がかかる。
  電極2はGND



電極1 無酸素銅
厚さ~100μm

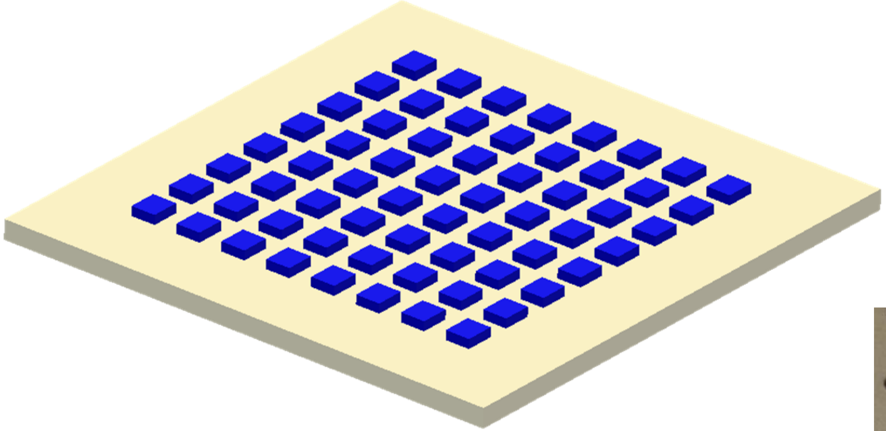
PTFE(テフロン) (紫外光の反射材の役割)
厚さ5mm

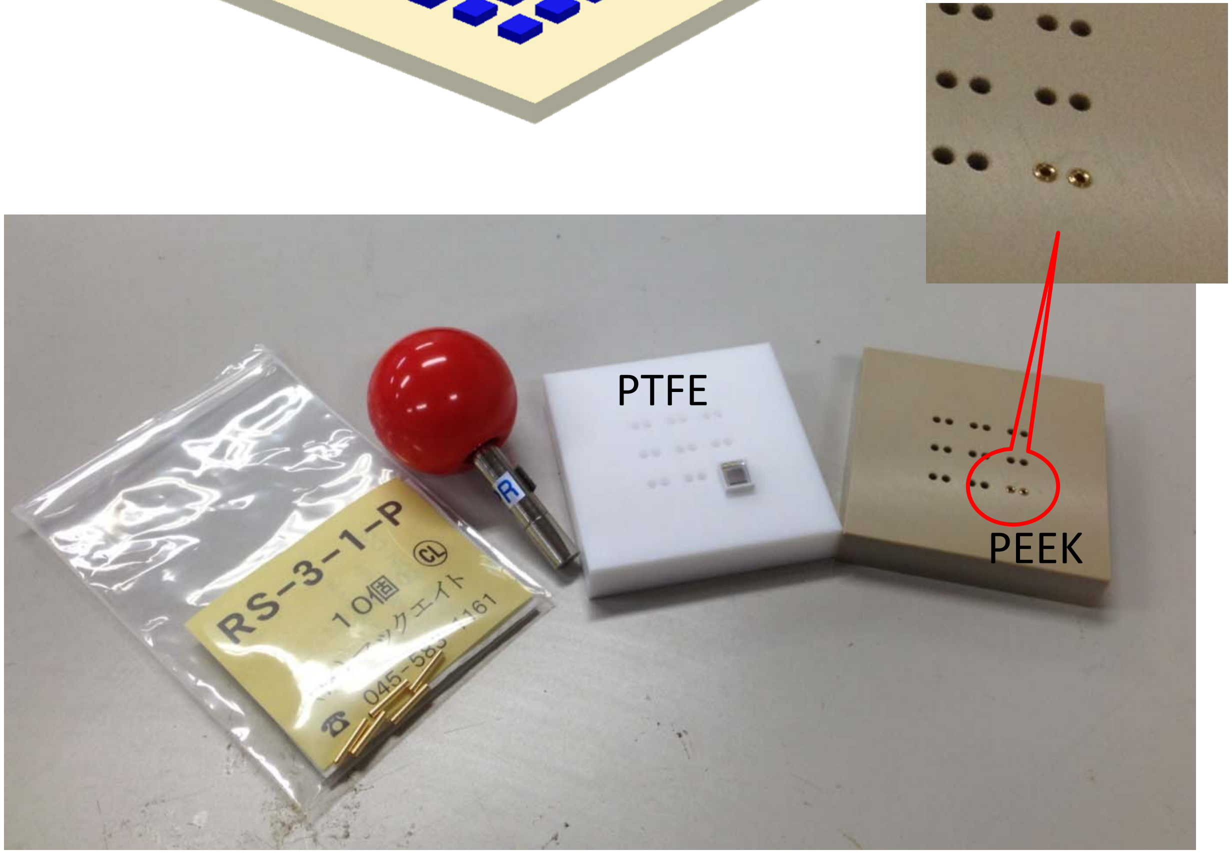
電極2 メッシュ

PTFE(テフロン) (紫外光の反射材の役割)
厚さ2mm?
MPPCが入り込むような穴が開いている。

MPPC plane
3mm角MPPCを7.5mmピッチで並べる

MPPC plane





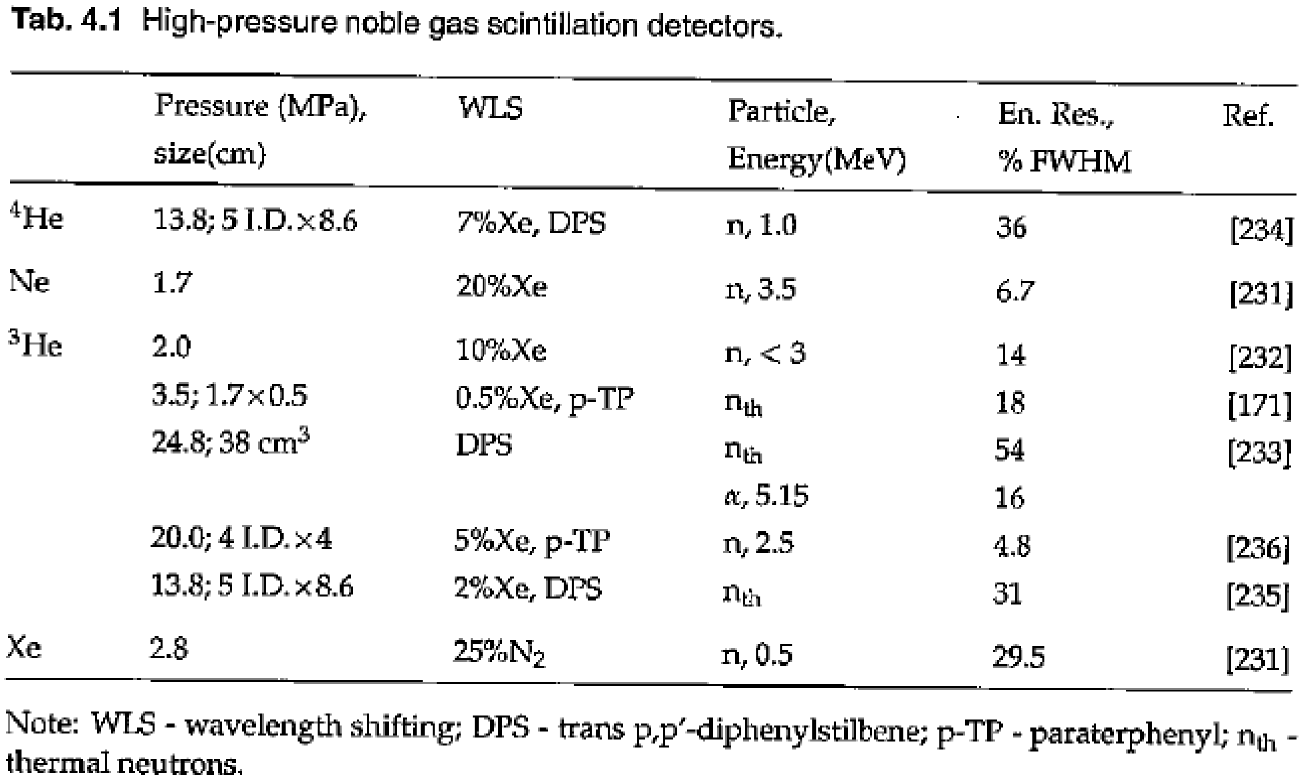
プラスチックの板に両方向中継ソケットを差し込む。
ソケットの表側にMPPC、片側にケーブルを圧着したピンを差し込む。
PTFEだと、MPPCを抜くときに、ソケットが板から抜けてしまった。

primary scintillation to determine t_0

- 全光量
  - Ws = 76eV (from NEXT CDR) → 32,300 photons
- Tracking planeでのlight yield
  - 2mϕx1.7mHの円柱で両側にtracking planeがあると仮定 → planeのacceptance 17.5%x2
  - ELCC開口率

    2mmϕ, 5mm spacingだと12.6%
  - PDE 20%と仮定
  - 32,300*0.175*2*0.126 *0.2 = 284 p.e.
  - ELCCの開口穴半径を3mmϕにすると、639p.e.
- これを全MPPC(>1e5 ch)の和として検出するのは難しい。(dark currentと区別がつかない)
- 低温にしてMPPCのdark rateを下げるか高圧化で動作するPMTが必要。

Wavelength shifter



Tab. 4.1 High-pressure noble gas scintillation detectors.

	Pressure (MPa), size(cm)	WLS	Particle, Energy(MeV)	En. Res., % FWHM	Ref.
^{4}He	13.8; 5 I.D.×8.6	7%Xe, DPS	n, 1.0	36	[234]
Ne	1.7	20%Xe	n, 3.5	6.7	[231]
^{3}He	2.0	10%Xe	n, < 3	14	[232]
	3.5; 1.7×0.5	0.5%Xe, p-TP	n_{th}	18	[171]
	24.8; 38 cm^3	DPS	n_{th}	54	[233]
			α, 5.15	16	
	20.0; 4 I.D.×4	5%Xe, p-TP	n, 2.5	4.8	[236]
	13.8; 5 I.D.×8.6	2%Xe, DPS	n_{th}	31	[235]
Xe	2.8	25%N_2	n, 0.5	29.5	[231]

Note: WLS - wavelength shifting; DPS - trans p,p′-diphenylstilbene; p-TP - paraterphenyl; n_{th} - thermal neutrons.

- Acrylic tube coated with a thin layer of polysterene doped with organic fluor TPB (tetraphenyl butadiene) (p.114)
- N_2 output peak 340nm

8.5.2.1 **Wavelength Shifters Dissolved in Noble Gases**

One of the first wavelength shifters used with noble gas scintillators was a gas admixture of nitrogen. For example, Grün and Schopper [228] used argon in mixture with 2% of nitrogen in their development of a detector for triggering of cloud chambers. The addition of a small amount of nitrogen to noble gases enhances the light emission in the blue range. At earlier studies it was concluded that nitrogen acts as a simple fluorescent converter. However, the nitrogen also acts as the quenching agent: its addition to the noble gas results in decreasing the absolute scintillation efficiency. For example, Northrop and Nobles [13] observed that there is a reduction in the practical light output of a xenon gas scintillator, used with solid wavelength shifter, when nitrogen is added. The efficiency is reduced by about 1/3 by addition of 10% of nitrogen or hydrogen. The latter is often used in high-pressure xenon detectors to increase the drift velocity of electrons. Another undesirable feature of nitrogen is the introduction of a slower component of decay time. For example, the addition of 10^{-4} N_2 introduces in argon scintillator a component with decay time of 0.5 μs, which accounts for 75% of the total photon emission [170]; the decay time reduces with an increase in the concentration of nitrogen, however, this reduces the total light yield. From all these facts, one can conclude

8.5.2.2 Solid Wavelength Shifters

A number of solid wavelength shifters deposited onto optical elements such as windows and mirrors have been considered including *trans*-stilbene, tetraphenylbutadiene (TPB), sodium salicylate, p-quaterphenyl, diphenylstilbene, and p-terphenyl (see, for example, McKinsey et al. [429] and references therein). The last one was found to be the best one to be used with xenon and xenon-containing gas mixtures from the point of view of high quantum efficiency (> 90% according to Belogurov et al. [144]), low hydroscopic, chemical inertness, and exclusive radiation hardness. Emission and absorption spectra of p-terphenyl are presented in Fig. 8.10.

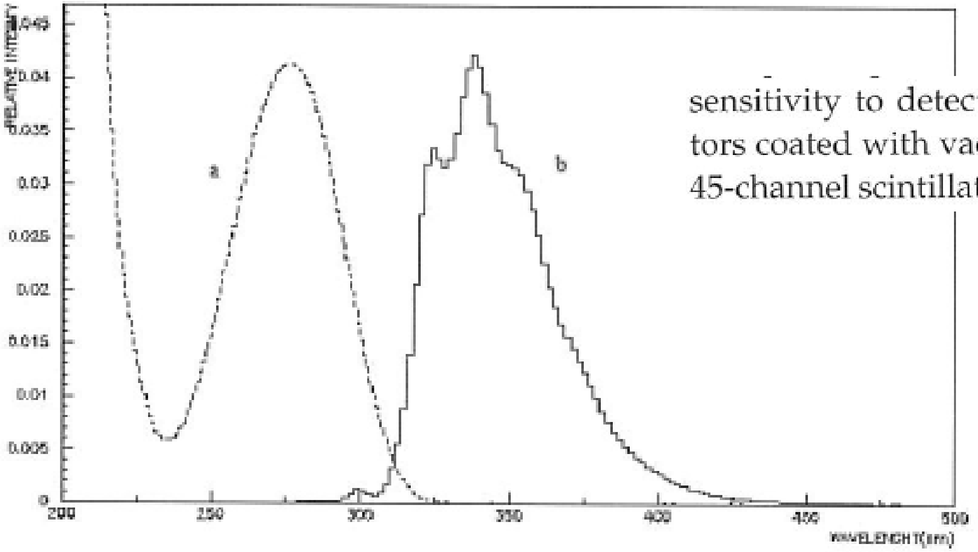


Fig. 8.10 (a) Absorption and (b) emission spectra of p-terphenyl [407].

sensitivity to detection of Cherenkov light [431]. Aluminized Mylar reflectors coated with vacuum deposited p-TP have been used in construction of a 45-channel scintillation LXe/LKr electromagnetic calorimeter (see Chapter 4).

The p-terphenyl is reported to have a short decay time of 2–5 ns and widely used as a scintillating dye in plastic scintillators. Kumar and Datta [430] com-

Wavelength shifter –p-terphenly

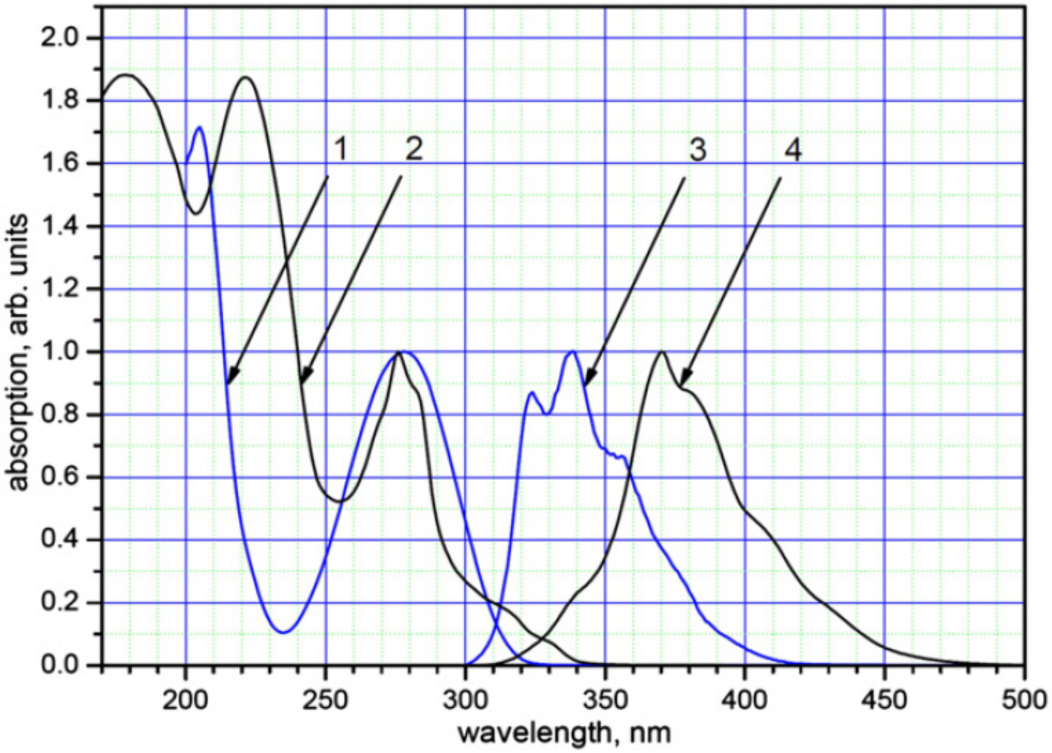
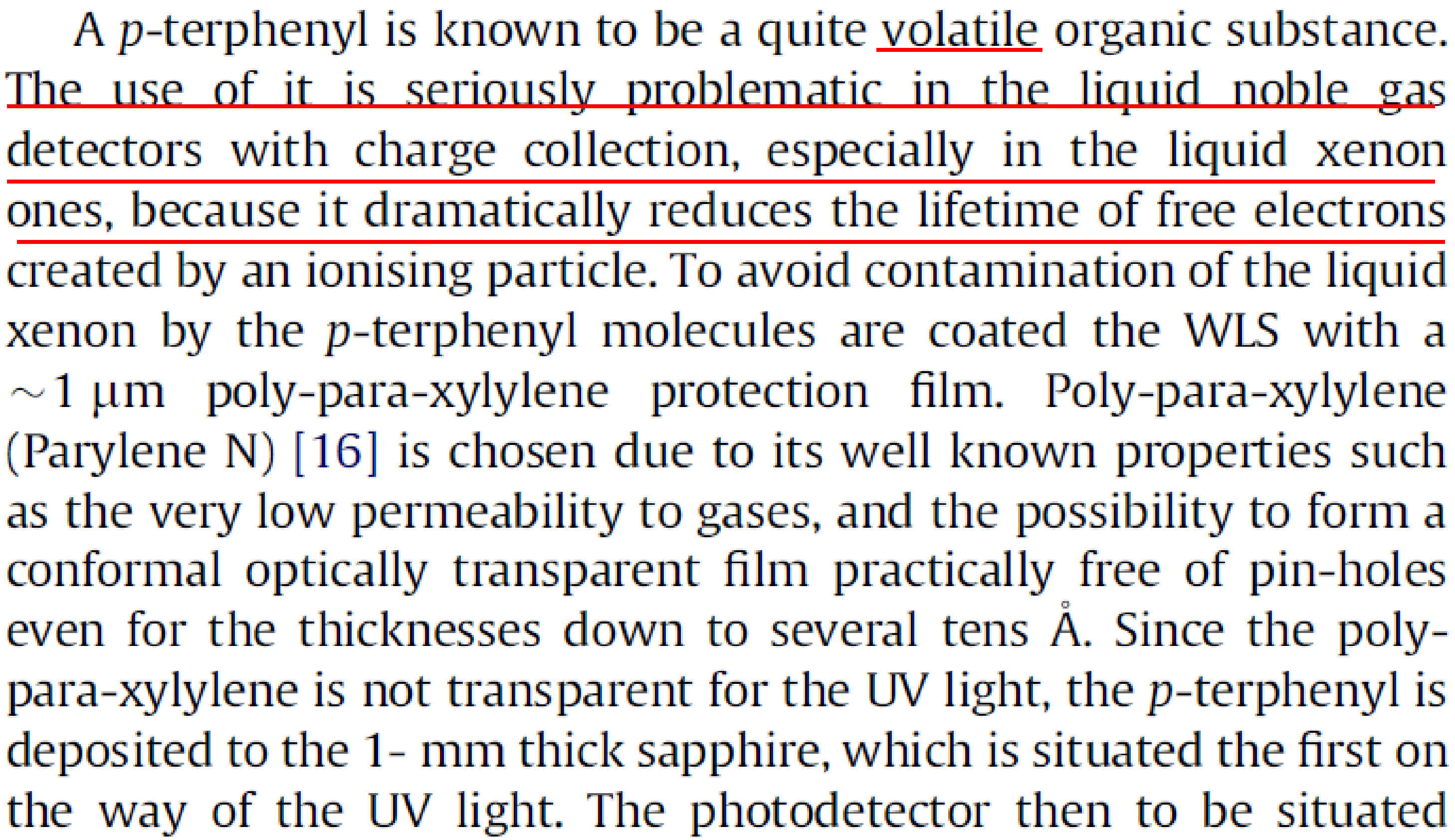


Fig. 1. Absorption and emission spectra of *p*-terphenyl. 1 – *p*-terphenyl in solvent, absorption, 2 – polycrystalline *p*-terphenyl, absorption, 3 – *p*-terphenyl in solvent, emission, 4 – polycrystalline *p*-terphenyl, emission.

D.Yu.Akimov et. al, “Development of VUV wavelength shifter for the use with a visible light photodetector in noble gas filled detectors”
http://dx.doi.org/10.1016/j.nima.2011.12.036

D.Yu. Akimov, et al., Nucl. Instr. & Meth. A (2011),
doi:10.1016/ j.nima.2011.12.036

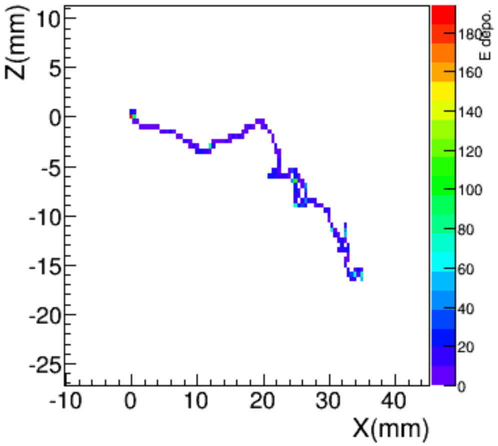


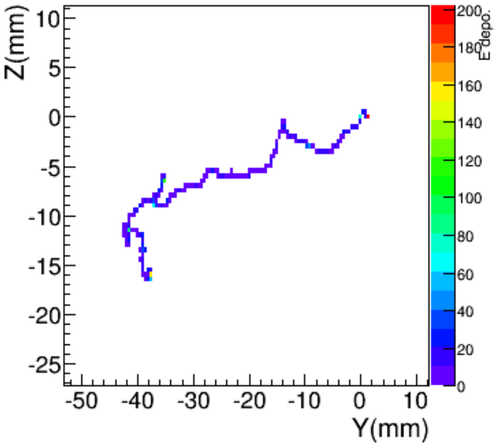
A *p*-terphenyl is known to be a quite volatile organic substance. The use of it is seriously problematic in the liquid noble gas detectors with charge collection, especially in the liquid xenon ones, because it dramatically reduces the lifetime of free electrons created by an ionising particle. To avoid contamination of the liquid xenon by the *p*-terphenyl molecules are coated the WLS with a ~1 μm poly-para-xylylene protection film. Poly-para-xylylene (Parylene N) [16] is chosen due to its well known properties such as the very low permeability to gases, and the possibility to form a conformal optically transparent film practically free of pin-holes even for the thicknesses down to several tens Å. Since the poly-para-xylylene is not transparent for the UV light, the *p*-terphenyl is deposited to the 1- mm thick sapphire, which is situated the first on the way of the UV light. The photodetector then to be situated

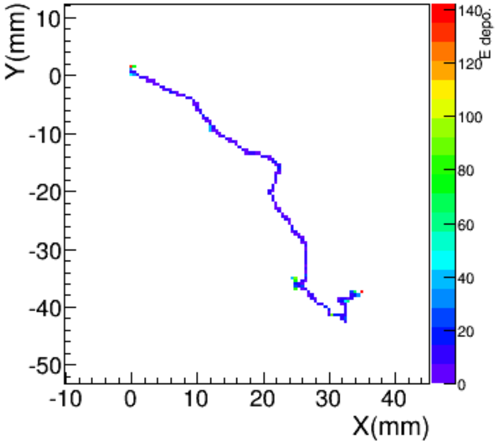
TPB (tetraphenyl butadiene) coating

- http://microboone-docdb.fnal.gov/cgi-bin/ShowDocument?docid=1006
- “Environmental Effects on TPB Wavelength-Shifting Coatings”, C.S. Chiu et.al, JINST 7 (2012) P07007
  - a TPB solution consisting of a 1:1:43 ratio by mass of PS to TPB to toluene. Each acrylic plate required three coatings of the TPB solution. This has been measured to have about 50% of the efficiency of the evaporative coating.
  - the harmful effect of certain wavelengths of light on the degradation of 50% TPB-PS chemical TPB coatings and isolated the most damaging wavelength range to the UV spectrum. On the other hand, we have seen that humidity does not play a significant role in long run plate degradation.
- Additional info. From the top document
  - Above 33%, the TPB will crystallize out of solution.
  - Adding ethanol to this mixture breaks up the surface tension, making the coating look smooth and uniform
  - Plates are wiped after coating to remove any loose TPB, after which they do not degrade further and are very resilient

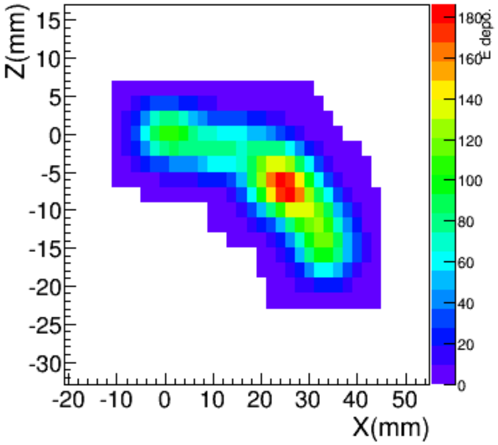
simulation example 1
row track

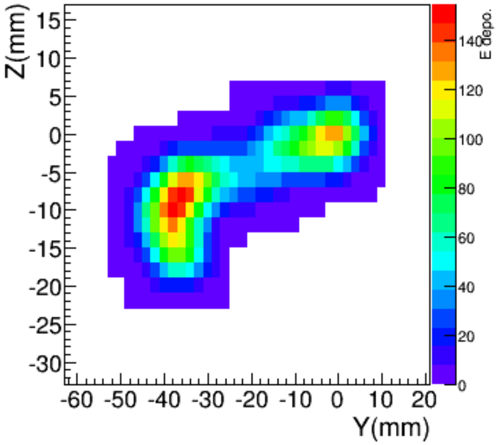


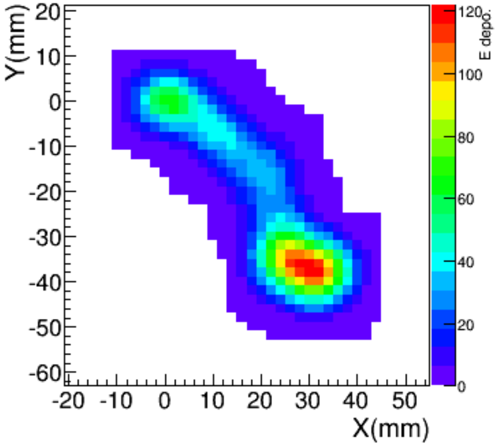




simulation example 1
diffusion after 1m drift

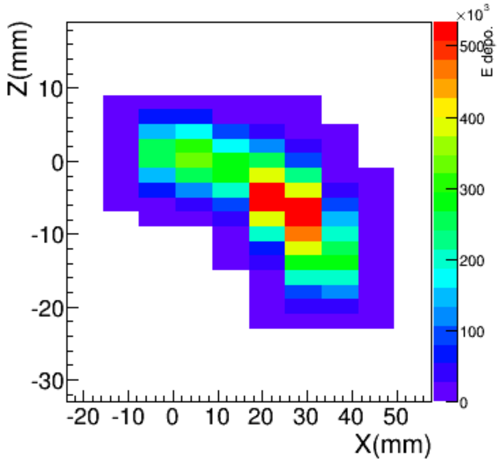


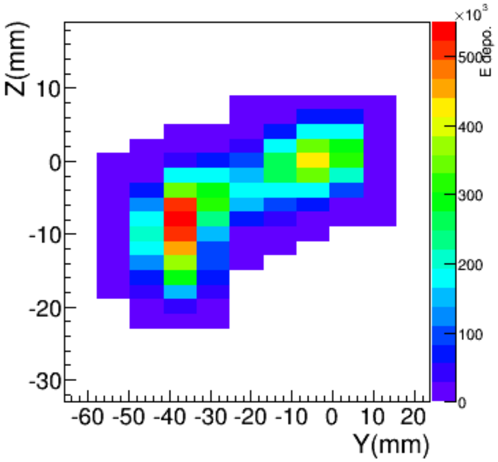


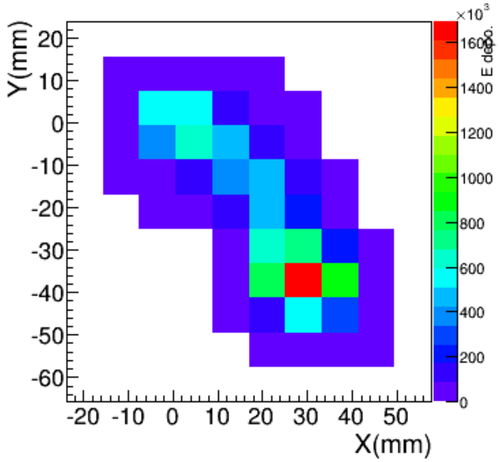


simulation example 1

segmentation (7.5mm in x or y and 2mm in z)

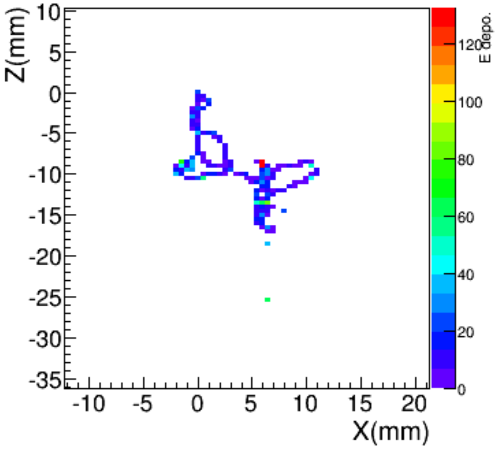


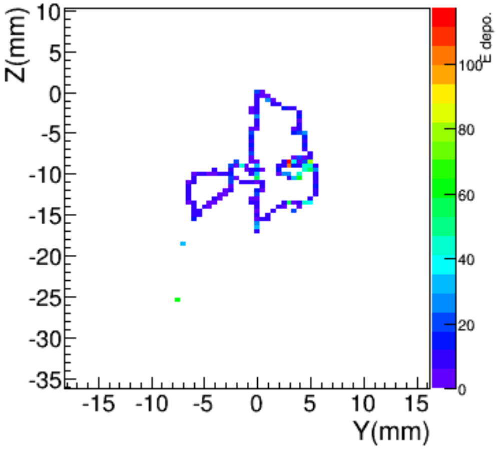


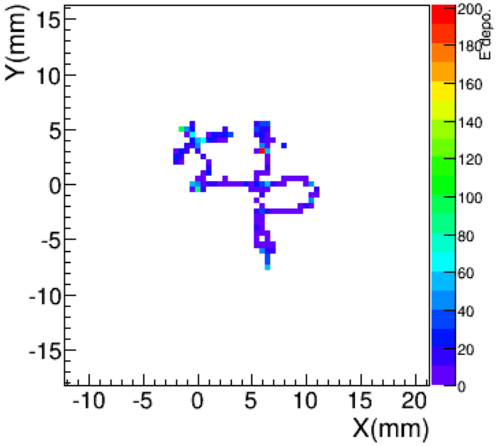


z marginalized by ELCC generation time(4μs)

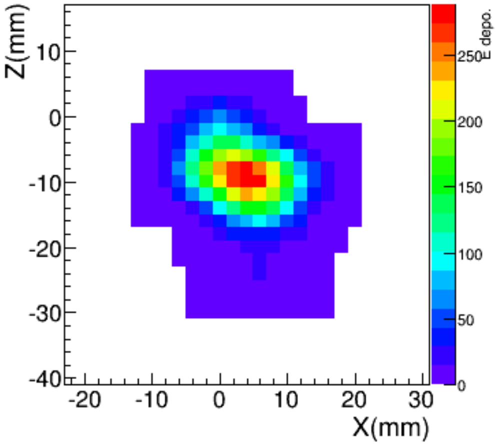
simulation example 2
row track

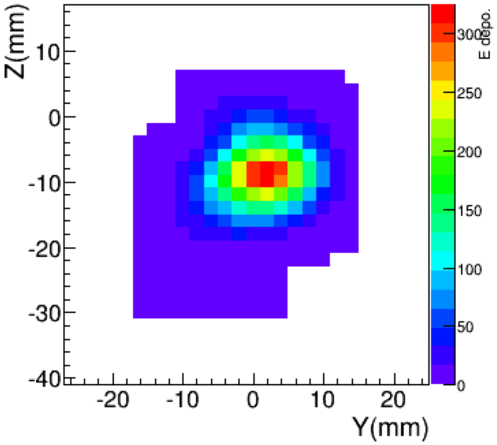


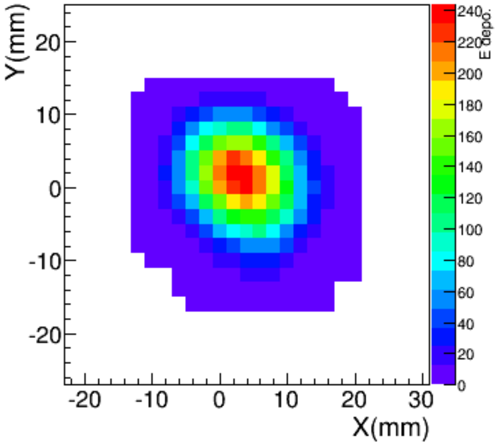




simulation example 2
diffusion after 1m drift

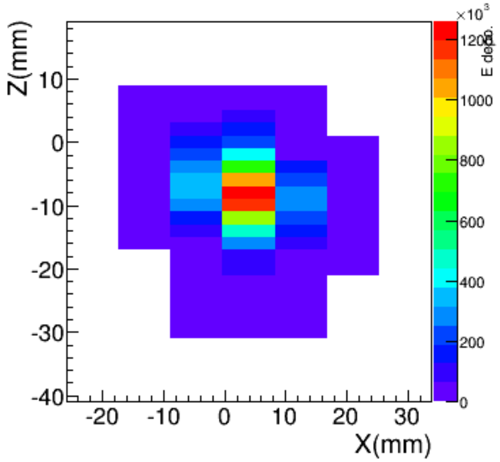


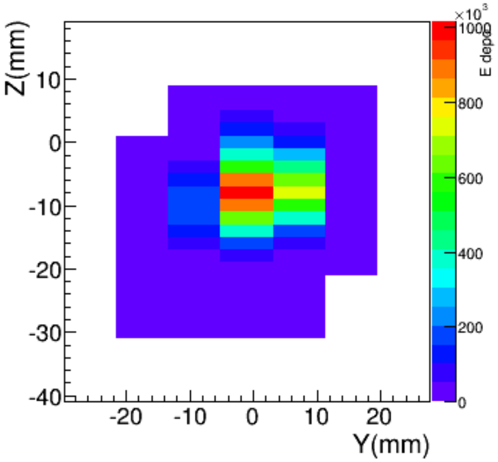


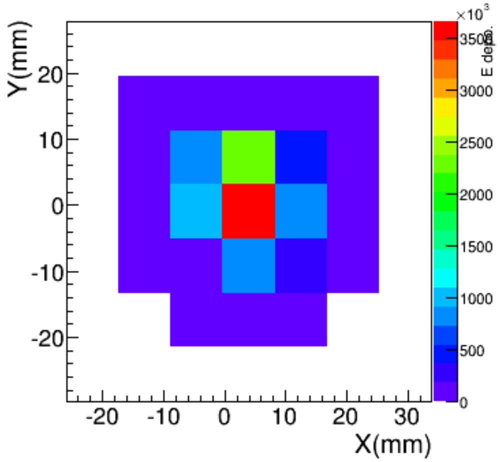


simulation example 2

segmentation (7.5mm in x or y and 2mm in z)



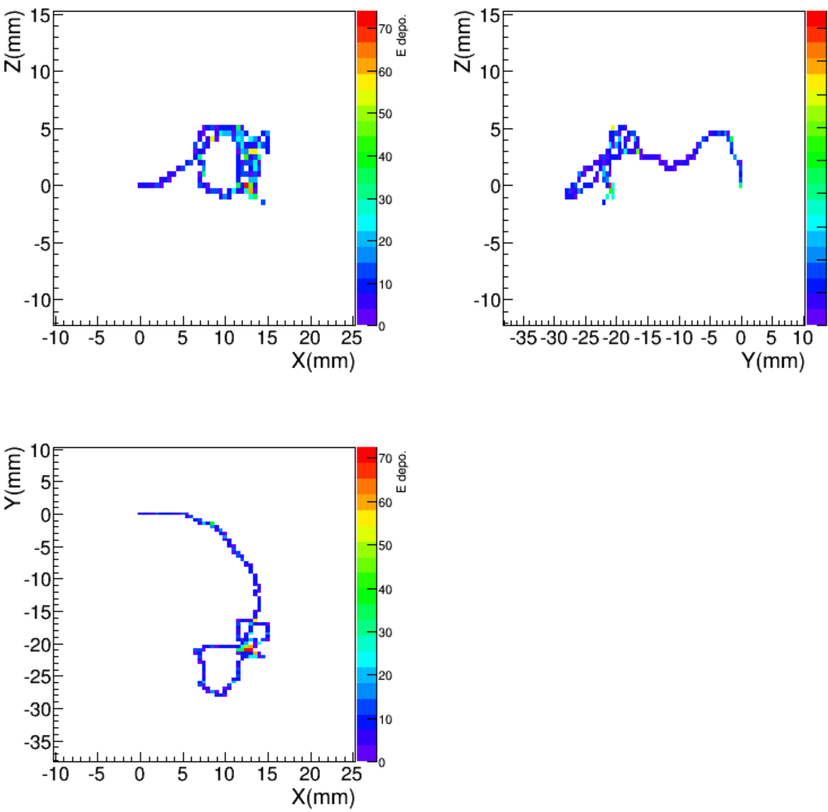




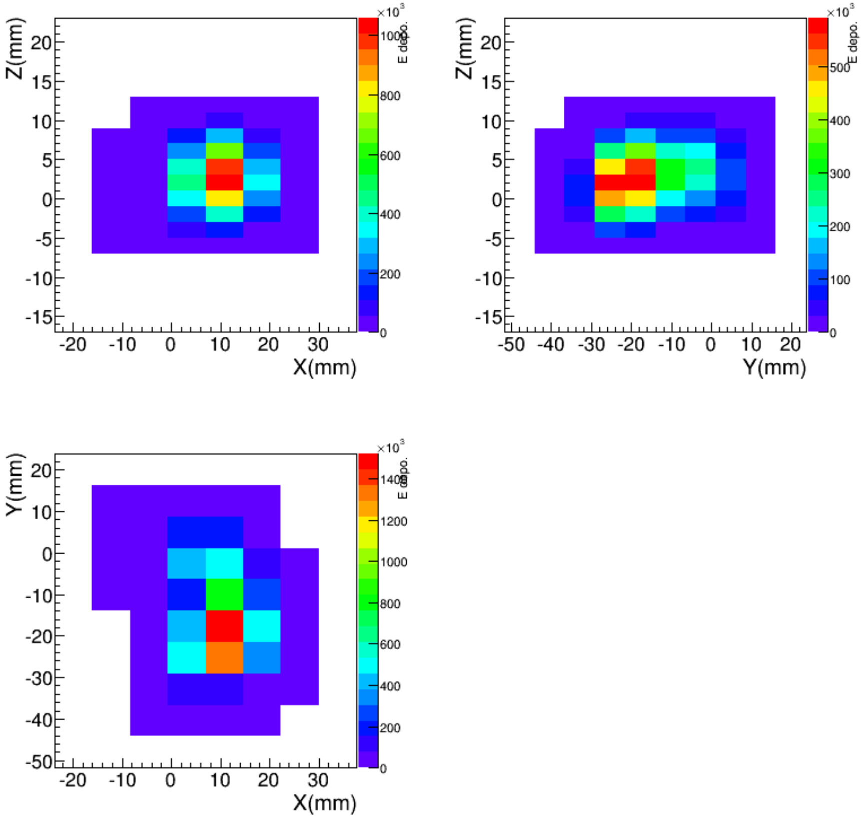
z marginalized by
ELCC generation
time(4μs)

2.5MeV electron example1

row track

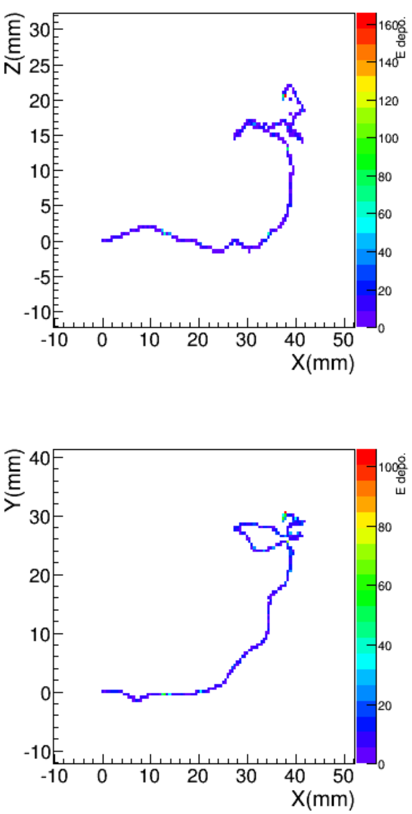


detected track

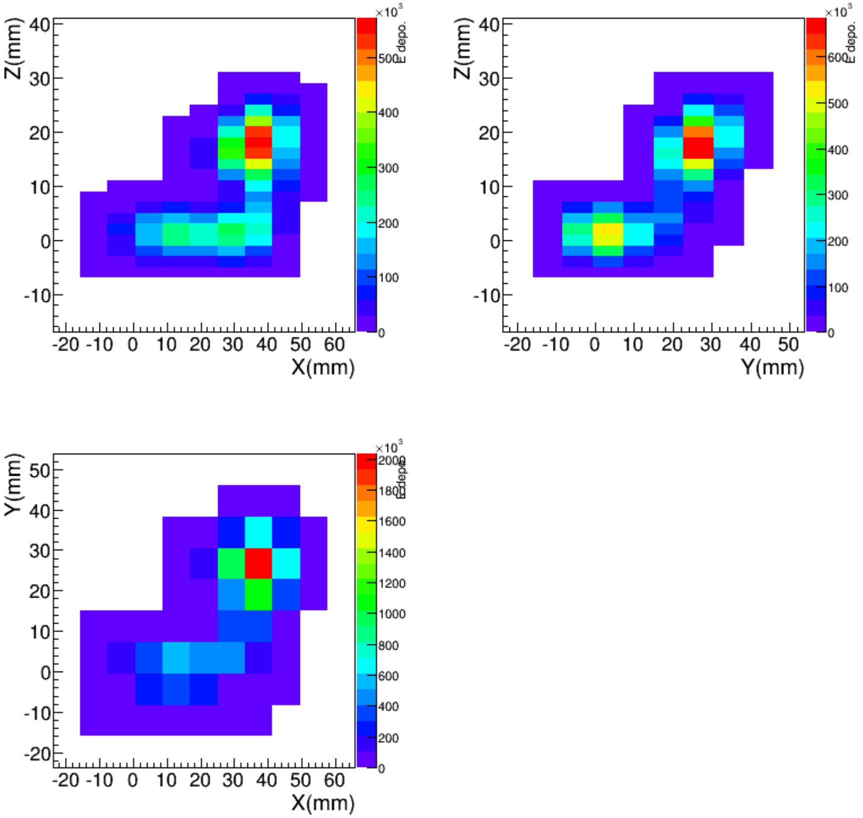


2.5MeV electron example2

row track

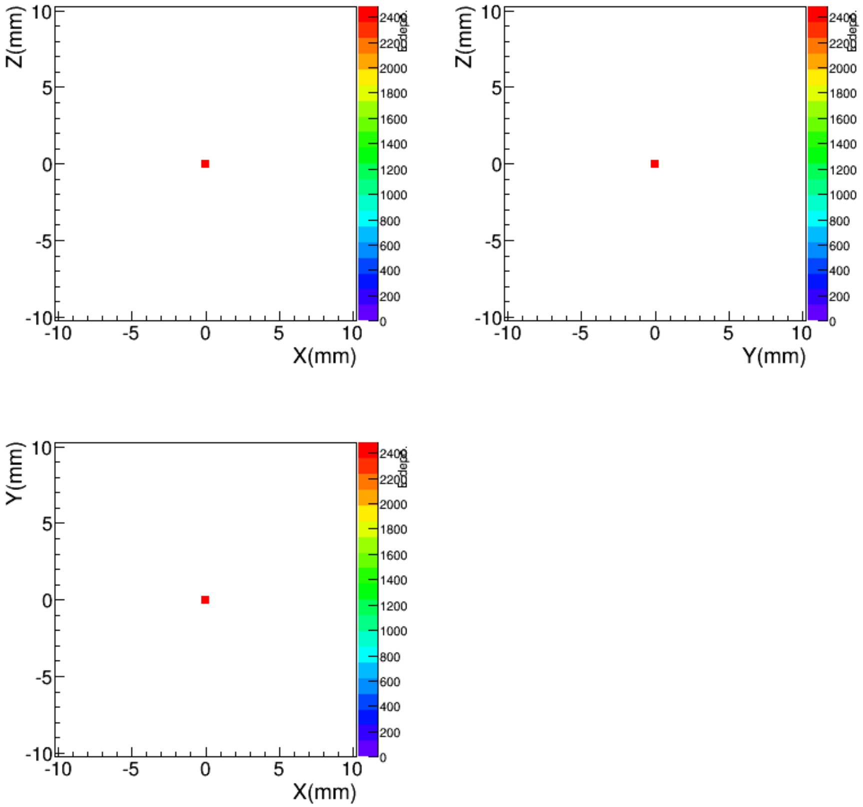


detected track

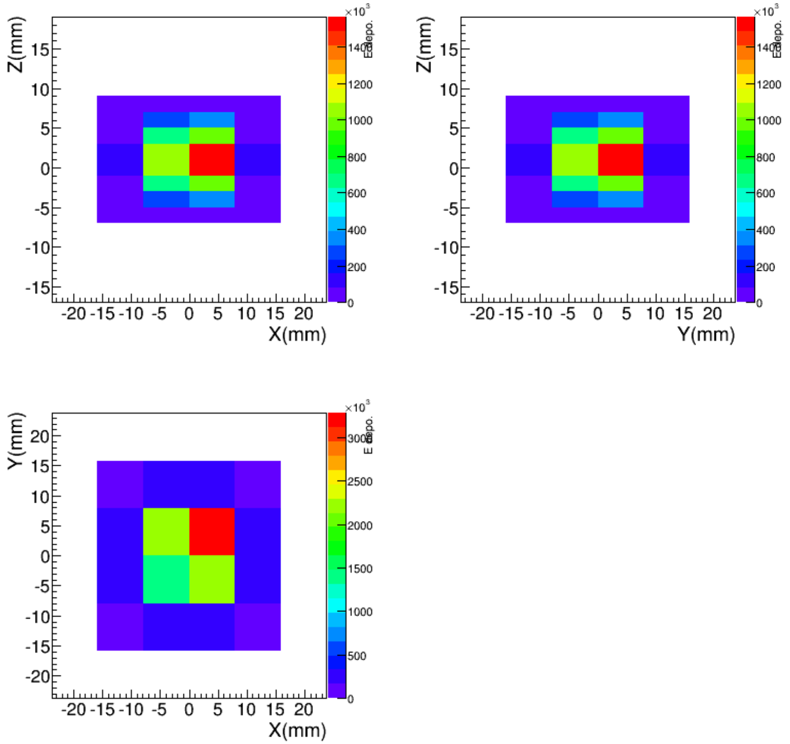


2.5MeV alpha example

row track



detected track



note that scale is very different from electron cases.

trackイメージにより

- α backgroundは良く落とせそう
- γ backgroundで、ちょうど2.5MeVで光電吸収したような事象は、すべて落とすことは難しい

(コンプトン散乱等、複数の場所で電子を出すような事象は、落とせる)

Back ground

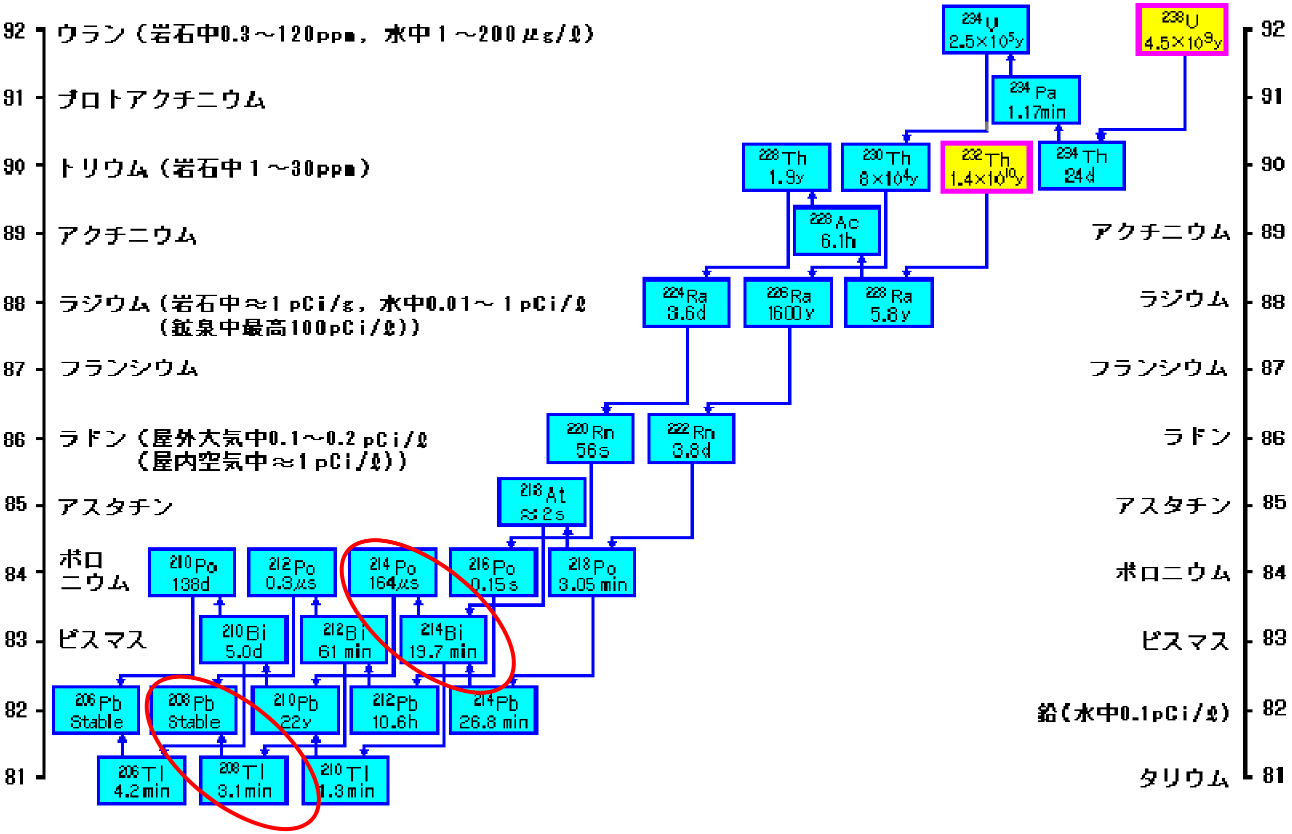
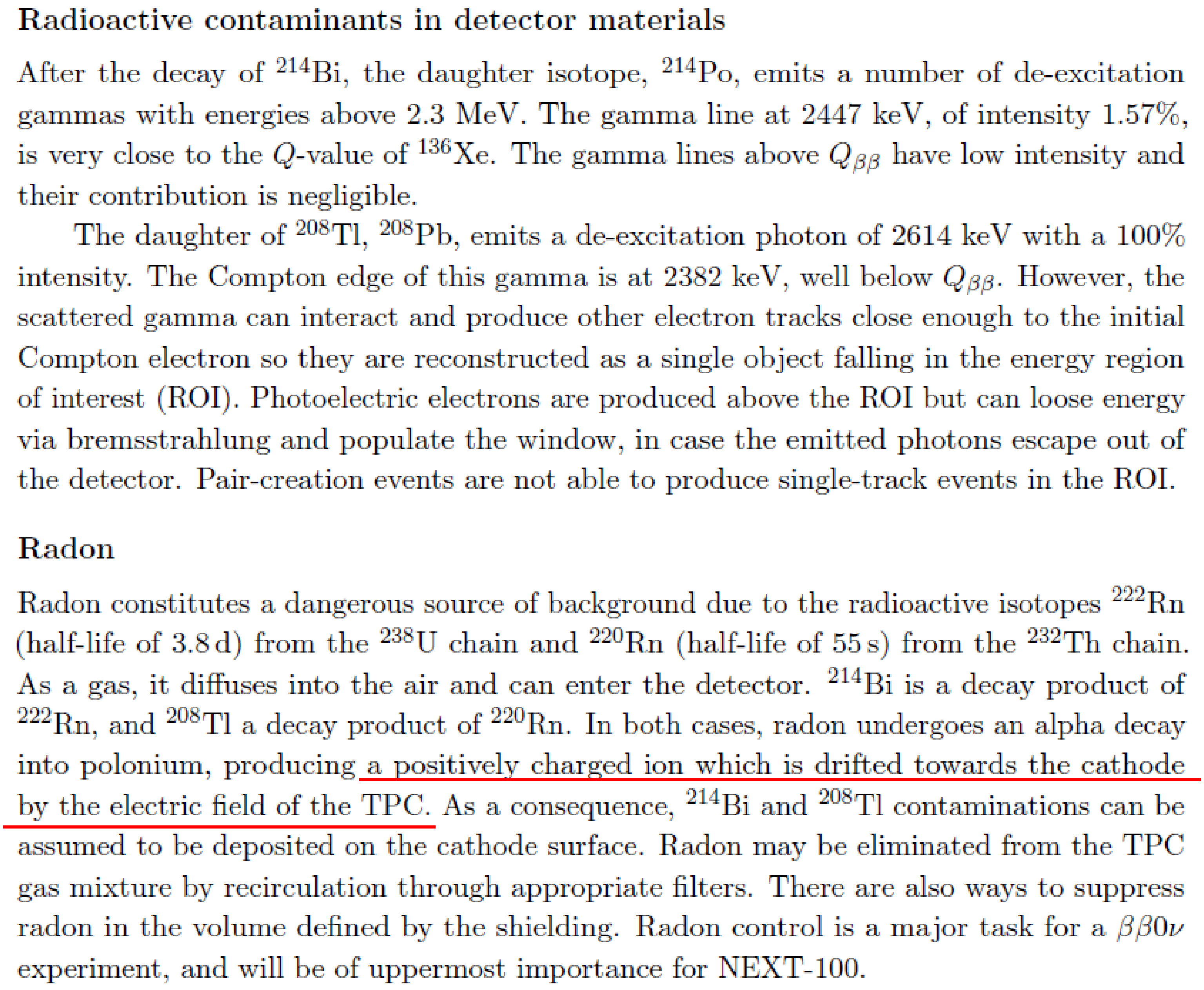


図6　ウラン238とトリウム232の崩壊系列

［出典］W. マーシャル（編）・加藤和明（監訳）：放射線とその応用－上、筑摩書房（1987.7）、p36



Radioactive contaminants in detector materials

After the decay of ^{214}Bi, the daughter isotope, ^{214}Po, emits a number of de-excitation gammas with energies above 2.3 MeV. The gamma line at 2447 keV, of intensity 1.57%, is very close to the Q-value of ^{136}Xe. The gamma lines above $Q_{\beta\beta}$ have low intensity and their contribution is negligible.

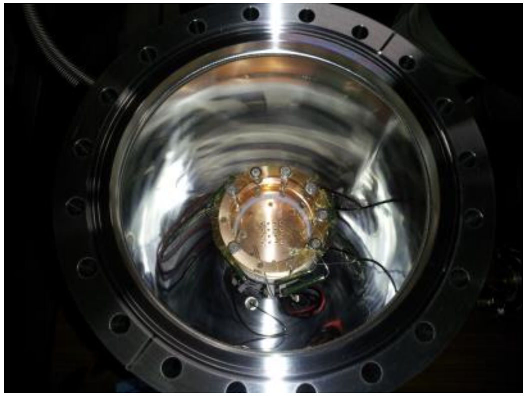
The daughter of ^{208}Tl, ^{208}Pb, emits a de-excitation photon of 2614 keV with a 100% intensity. The Compton edge of this gamma is at 2382 keV, well below $Q_{\beta\beta}$. However, the scattered gamma can interact and produce other electron tracks close enough to the initial Compton electron so they are reconstructed as a single object falling in the energy region of interest (ROI). Photoelectric electrons are produced above the ROI but can loose energy via bremsstrahlung and populate the window, in case the emitted photons escape out of the detector. Pair-creation events are not able to produce single-track events in the ROI.

Radon

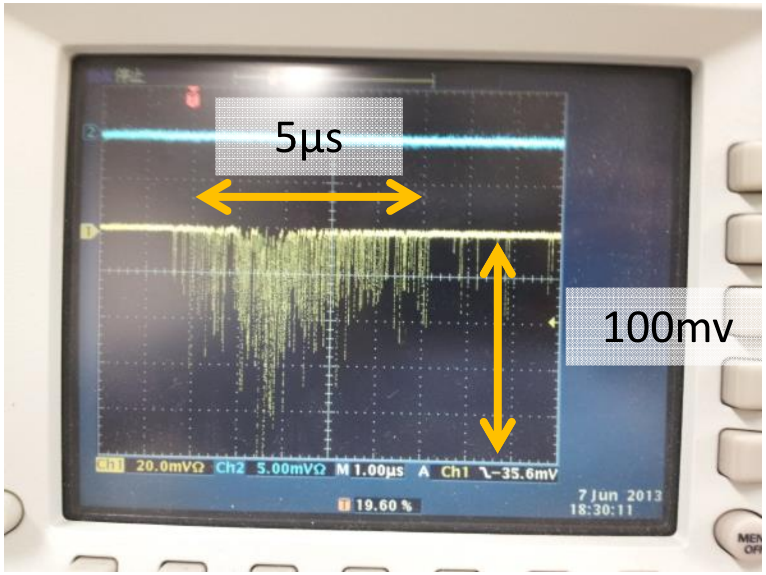
Radon constitutes a dangerous source of background due to the radioactive isotopes ^{222}Rn (half-life of 3.8 d) from the ^{238}U chain and ^{220}Rn (half-life of 55 s) from the ^{232}Th chain. As a gas, it diffuses into the air and can enter the detector. ^{214}Bi is a decay product of ^{222}Rn, and ^{208}Tl a decay product of ^{220}Rn. In both cases, radon undergoes an alpha decay into polonium, producing a positively charged ion which is drifted towards the cathode by the electric field of the TPC. As a consequence, ^{214}Bi and ^{208}Tl contaminations can be assumed to be deposited on the cathode surface. Radon may be eliminated from the TPC gas mixture by recirculation through appropriate filters. There are also ways to suppress radon in the volume defined by the shielding. Radon control is a major task for a $\beta\beta0\nu$ experiment, and will be of uppermost importance for NEXT-100.

J.J.Gomez-Cadenas et.al, “Present status and future perspectives of the NEXT experiment”, arXiv:1307.3914

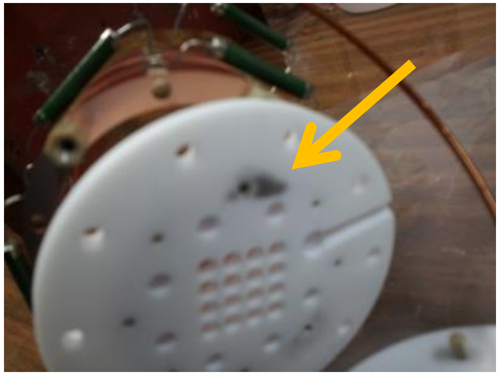
ELCC ver0



ELCC ver0
読み出しには
1 inch PMTにwave length shifter(TPB)を塗布して使用



EL信号観測に成功！
光量が少ないため、PMTのパルス(~20ns)が重なって針のような信号に見えている。



ELCCでの放電

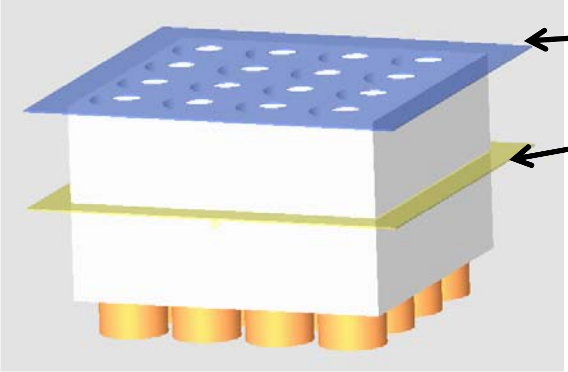
フィードスルーでの放電

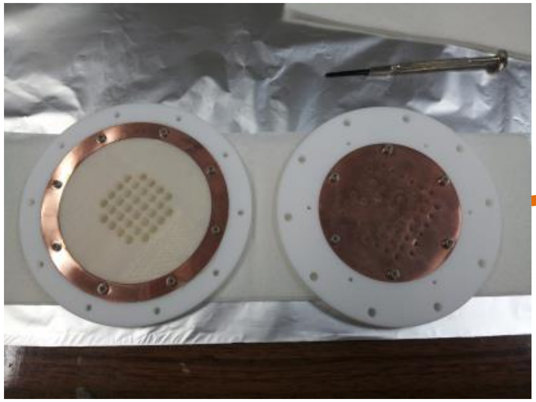
- 問題点
  - フィードスルー、ELCCのギャップ間で放電
  - 低電圧運用(ELCCのギャップ4mmで3kV)、電子の収集効率が悪いことによる光量不足

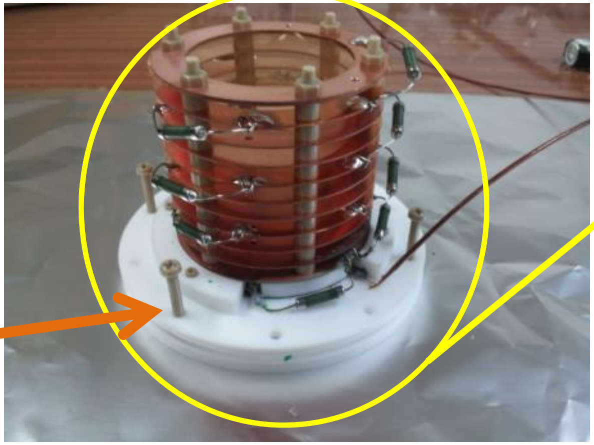
→ ver1で改善へ

ELCC ver1

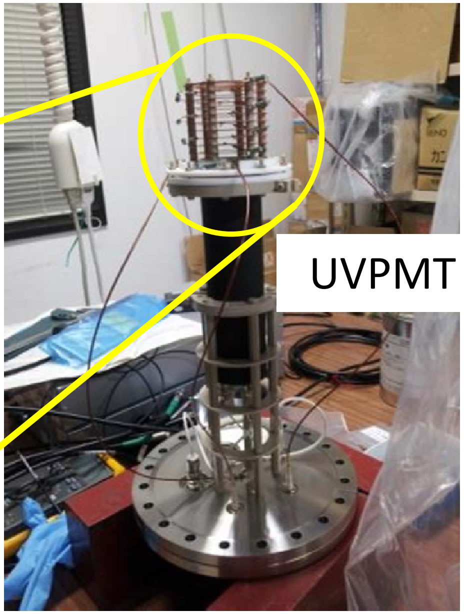
- 読み出しにはUVPMT(浜ホト H3178)を用いた。





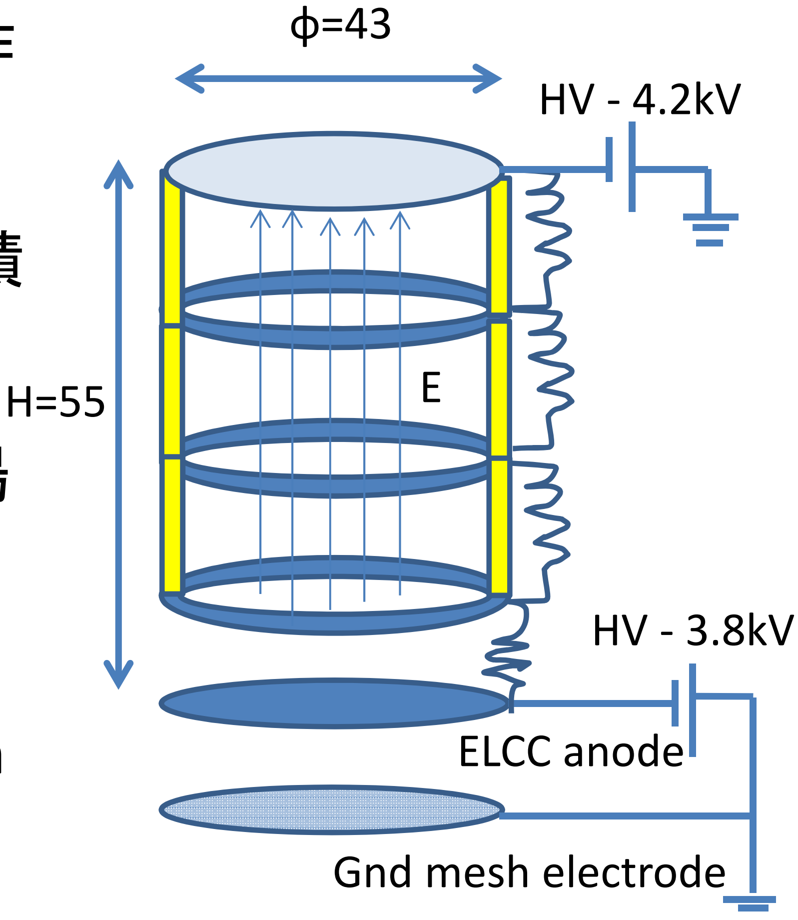


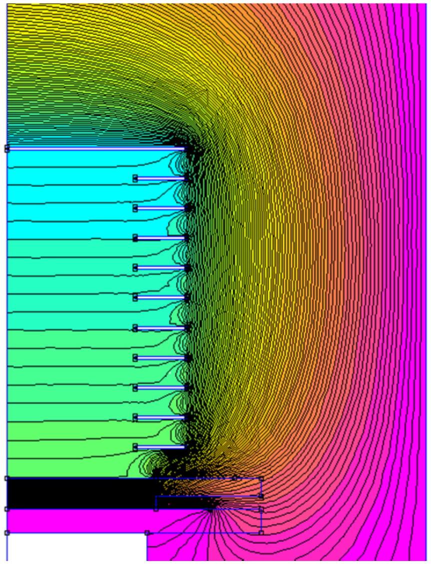
ELCCと
フィールドケージ



フィールドケージ

- 電離した電子をELCCに導く電場を作る。
- 銅のリング(x11)を積み、抵抗分割する。
- z方向に一様な電場を構成する。
- 電子がdriftする領域はφ=43,H=55mm
- 有効領域は28×28×55mm



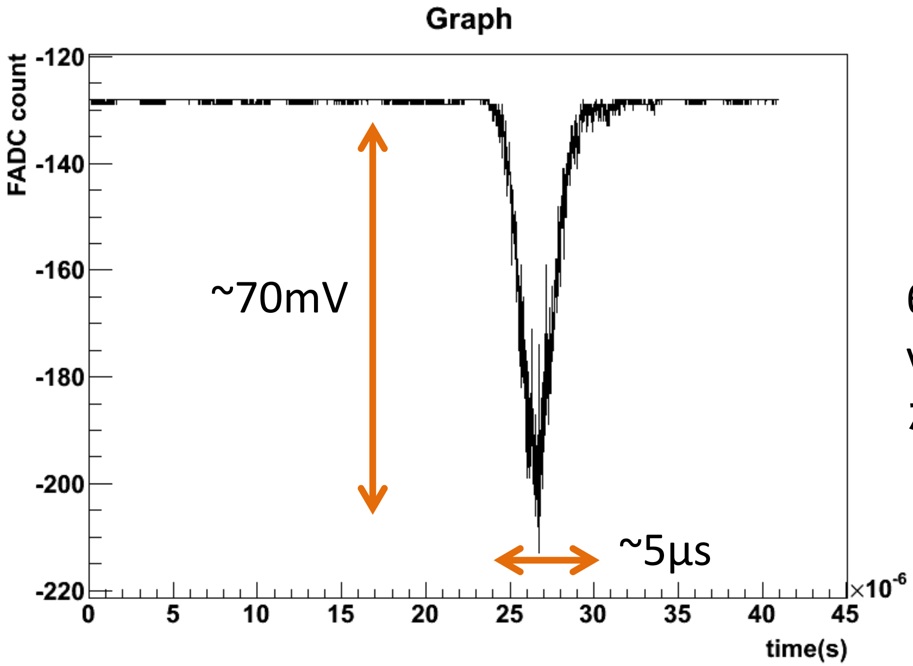


FEMMによる電場計算

ELCC信号例

- 読み出しには100MHz FADC(CAEN V1724)を使用

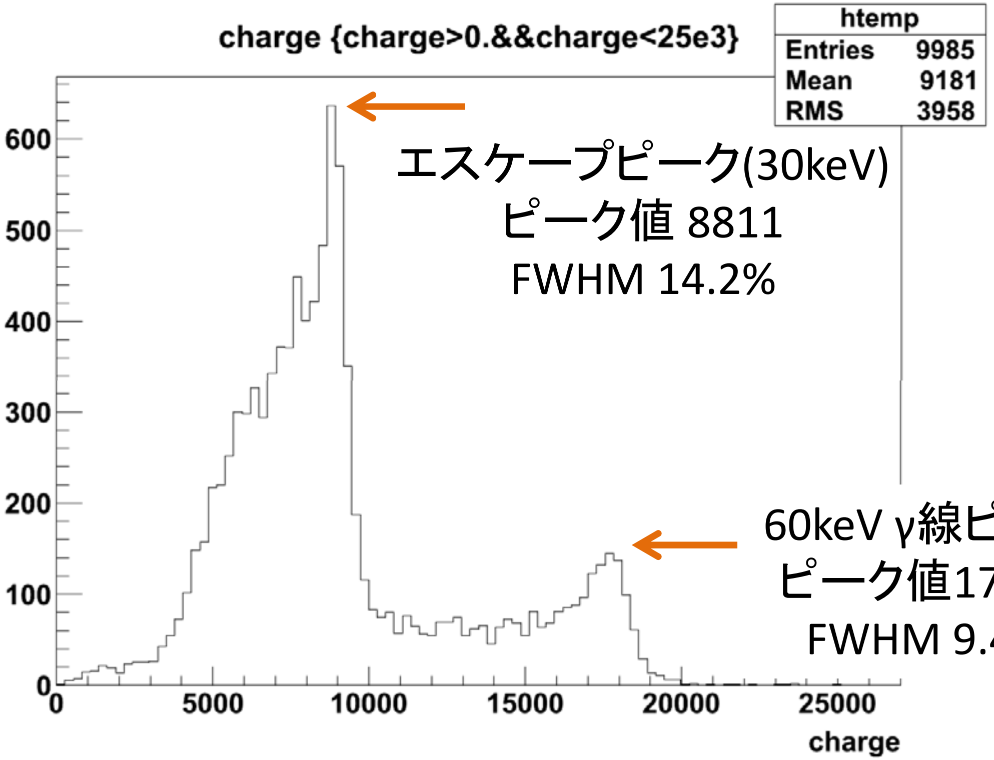
- フィールドケージ内での電離電子のz方向の広がり(~1cm)に対して、ドリフト速度が~1×10^5cm/sなので、信号幅は~10μs程度と予想される。



60keVγ線の信号
ver0に比べて、光量が増えている

光量分布

- 2個のピークが見られる。-> 60keVピークとエスケープピーク（後述）
- 低値側に裾を引いているのはELCCの有効領域から漏れ出した電子の信号が失われたからであると考えられる。
- ピークの右側だけを用いてFWHMを概算評価した。

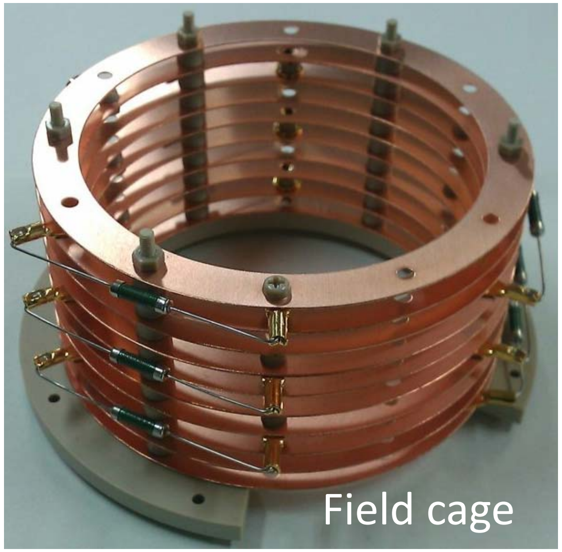


エスケープピーク(30keV)
ピーク値 8811
FWHM 14.2%

60keV γ線ピーク
ピーク値17590
FWHM 9.4%

Ver.3

- 1 MPa chamber
  - JIS配管
  - ガスケットにu-tightsealを採用 (helicoflexと同じようなメタルシール)
  - フィードスルーは、テフロンケーブルをエポキシモールド　(TECSAM)
- MPPC plane (up to 64 channel)
- under construction


Field cage

Xeの純度

- PMT、ELCCからのアウトガス、フィードスルーのついたフランジからのリークにより、Xeの純度が悪化している可能性がある。

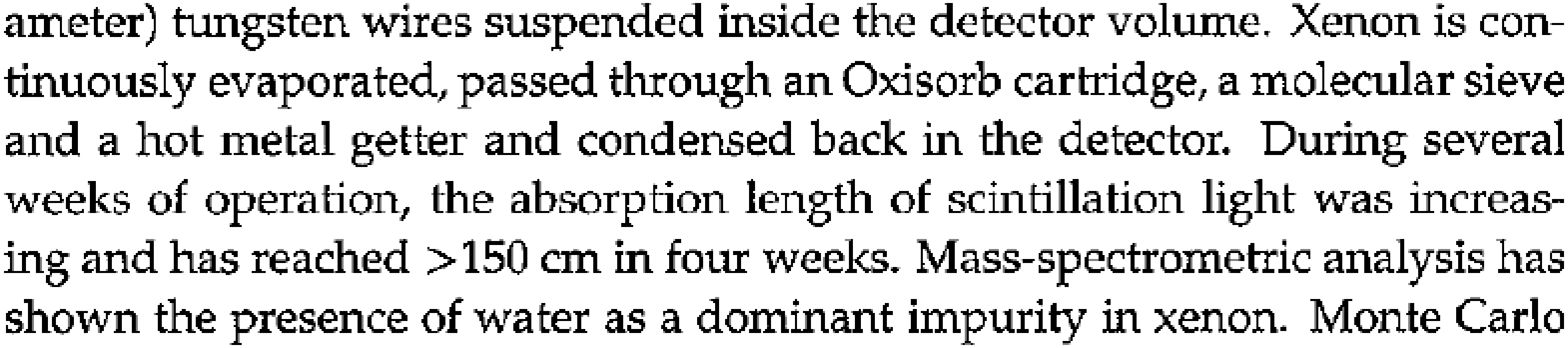
- 純度悪化による光量の減少
  - 電離電子の不純物ガスへの付着
  - Xe励起状態のクエンチ

    $Xe_2^* + M \rightarrow 2Xe + M$

- 純度モニターの手法
  - Xe不純物によるdrift速度の変化（ELCC信号時間幅）を使う？

Gas purification

MEG prototype



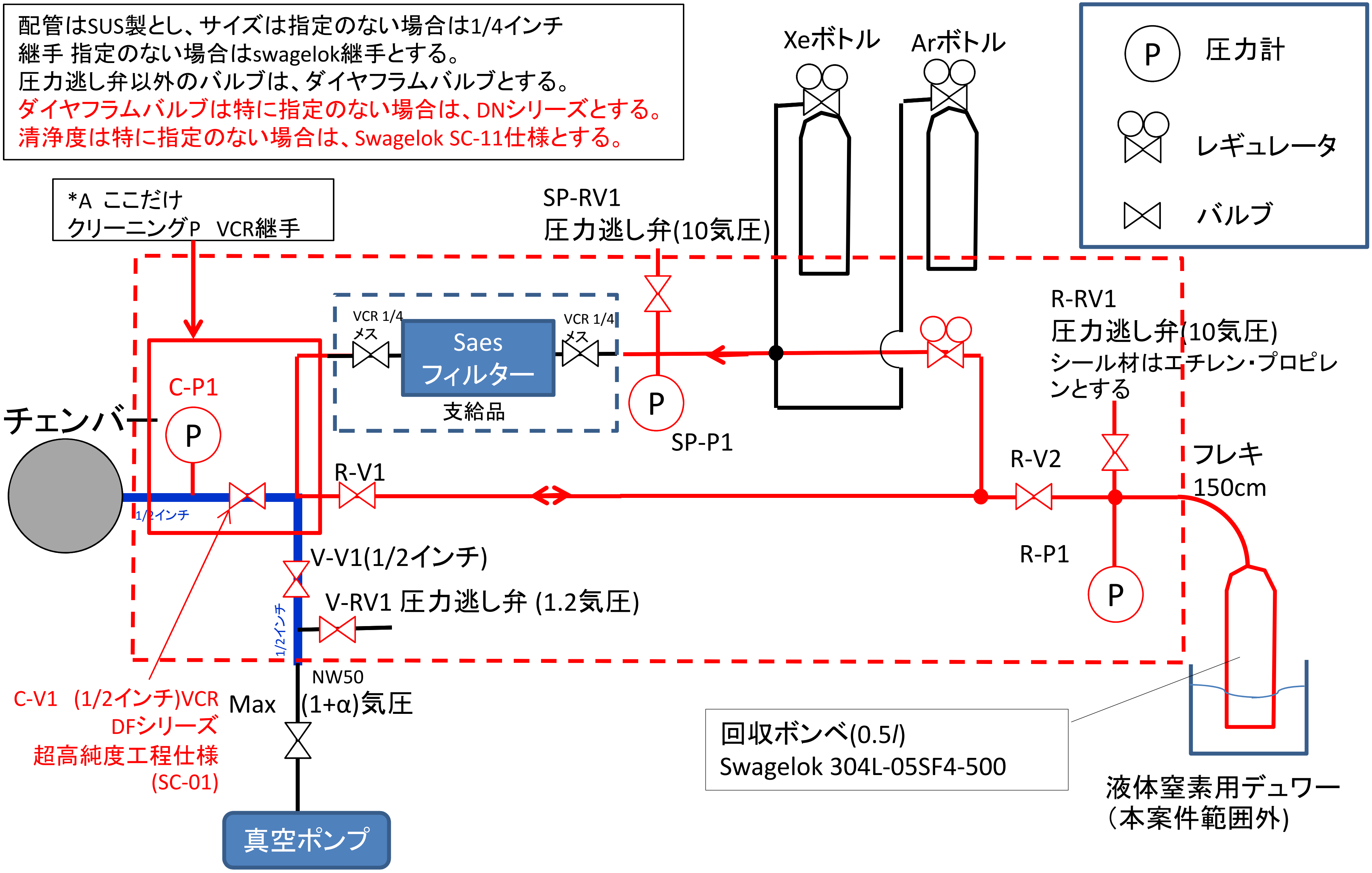
ameter) tungsten wires suspended inside the detector volume. Xenon is continuously evaporated, passed through an Oxisorb cartridge, a molecular sieve and a hot metal getter and condensed back in the detector. During several weeks of operation, the absorption length of scintillation light was increasing and has reached >150 cm in four weeks. Mass-spectrometric analysis has shown the presence of water as a dominant impurity in xenon. Monte Carlo

高圧のキセノンを循環できるか？ 純度を保つためには、金属ベローズポンプか。ただし、高圧のものがなかなか見つからない。循環させなくても、ゲッターやモレキュラーシーブをつないでおくだけではダメか？

ガスの再利用

- キセノンが高いので、液体窒素で再収集することを考えている。
- が、常温に戻したときに10気圧以上になると高圧ガス製造装置になる可能性があり、ずっと冷やしていないといけない。。。
- お金があれば、冷凍庫を買う？　チェンバーをもう1個買う方が安いか。

配管はSUS製とし、サイズは指定のない場合は1/4インチ
継手 指定のない場合はswagelok継手とする。
圧力逃し弁以外のバルブは、ダイヤフラムバルブとする。
ダイヤフラムバルブは特に指定のない場合は、DNシリーズとする。
清浄度は特に指定のない場合は、Swagelok SC-11仕様とする。



P	圧力計
🝓	レギュレータ
⋈	バルブ

*A ここだけ
クリーニングP VCR継手

SP-RV1
圧力逃し弁(10気圧)

Xeボトル

Arボトル

R-RV1
圧力逃し弁(10気圧)
シール材はエチレン・プロピレンとする

VCR 1/4
メス

Saes
フィルター
支給品

VCR 1/4
メス

SP-P1

C-P1

チェンバー

1/2インチ

R-V1

R-V2

フレキ
150cm

V-V1(1/2インチ)

R-P1

V-RV1 圧力逃し弁 (1.2気圧)

1/2インチ

NW50

C-V1 (1/2インチ)VCR
DFシリーズ
超高純度工程仕様
(SC-01)

Max (1+α)気圧

回収ボンベ(0.5*l*)
Swagelok 304L-05SF4-500

液体窒素用デュワー
(本案件範囲外)

真空ポンプ

圧力計 : 圧力範囲は-1気圧から12気圧
バルブ : V-V1のみ流量調整(ベローズ)。その他は開閉(ダイヤフラム)。

HV power supply

- 高電圧を容器の外からかけると、フィードスルーの耐圧が問題になるため、液体Arではコッククロフトウォルトン電源が検討されている。
  - 測定中は、AC入力を切る。電圧のモニターができない。Liq Arではノイズが問題だがEL読み出しでもだめか？
- 10気圧プロトタイプ
  - ドリフト電場 500V/cm
    - フィールドゲージはv2と同じ(ギャップ5.5mmx10段) → 275V/gap x 10段
  - EL電場 7.9~11kV　@ 5mmギャップ
  - total max 13.75kV
  - これならば、コッククロフトウオルトンではなく、15kV耐圧のフィードスルーを2個使うべき。(+抵抗分割)
- 30気圧本番
  - ELCC電場 21kVまたはもっと。
  - ドリフト電場 1.5kV/cm。例えば、高さが1.7メートルだと255kV、コッククロフトウォルトンを使うメリットあり。

高耐圧絶縁トランス

ELTR－30K2型
DC30kV重畳用の高耐圧絶縁トランスです。
小型ION源重畳用です。

電圧　：　1φ　100:100　50／60Hz
耐電圧　：　WV　DC30kV
容量　：　300VA
入力線　：　3Pプラグ線　3m　1本
出力線　：　DC30kVシリコン線
出力部　：　2連3PACコンセント　2個

Direction sensitive dark matter search

- Extend the idea by D.R.Nygren, “Columnar recombination: a tool for nuclear recoil directional sensitivity in a xenon-based direct detection WIMP search”
- Our plan is to investigate the possibility of operation under magnetic field. → Enhance the recombination for the track parallel to the field
- To keep O(eV) electron curvature < O(10)μm, hi field (>1T) is necessary