AXEL

A Xenon ElectroLuminescence detector

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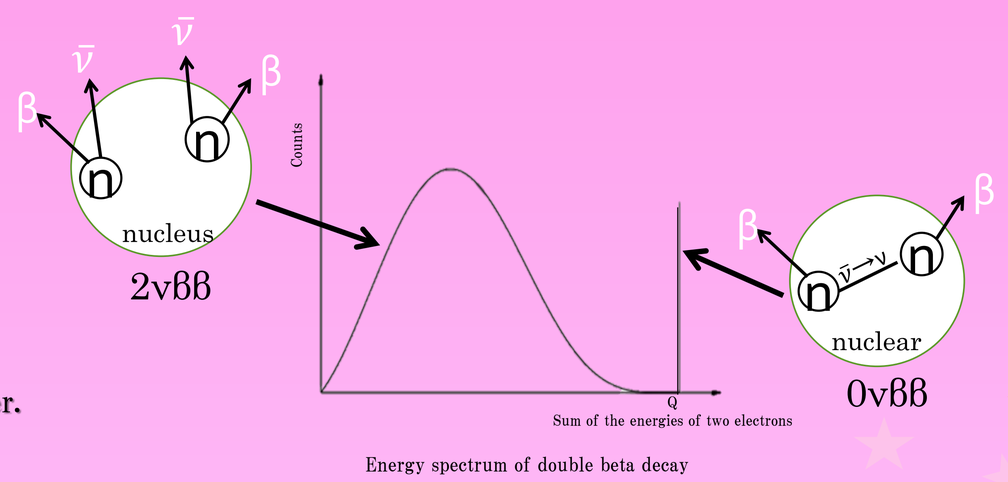
0νββ decay

Neutrino is very mysterious particle.

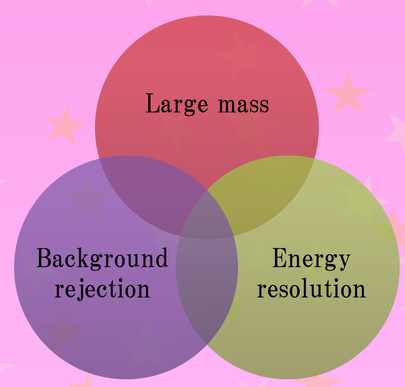
Ordering of the neutrino masses
Whether neutrino is Majorana or not?
Why neutrino is so light?
Is neutrino origin of the matter-dominant universe?

0νββ decay is the key to solve these questions!
- 0νββ occurs if neutrino is a Majorana particle.
- The lifetime is sensitive to the neutrino mass eigenstates order.



Energy spectrum of double beta decay

★Three integrant to discover 0νββ

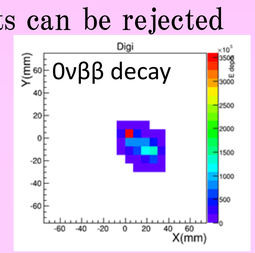


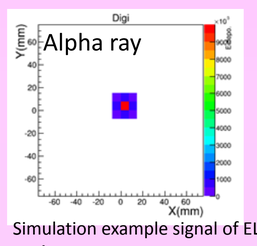
What's AXEL?

We are developing high pressure Xe gas TPC to discover 0νββ from ^{136}Xe (Q=2.48MeV).

Feature

★ Good energy resolution : 0.5%(FWHM@2.46MeV)
-> Using proportional scintillation mode
★ Large mass
-> 1 ton enriched high pressure gas xenon (^{136}Xe)
★ Background rejection
-> 7.5 mm pitch tracking with ELCC
-> Compton gamma events and alpha-decay events can be rejected

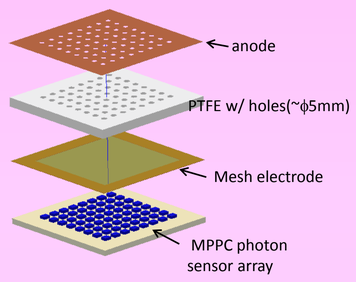


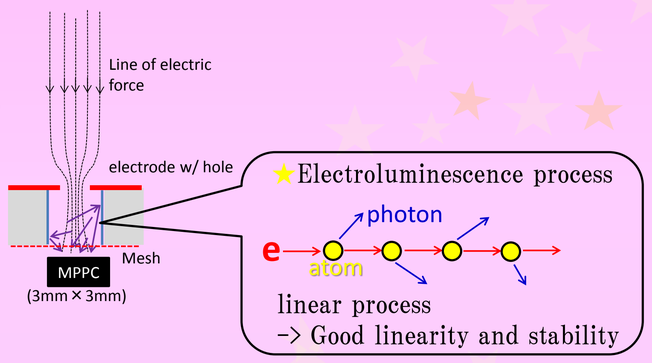


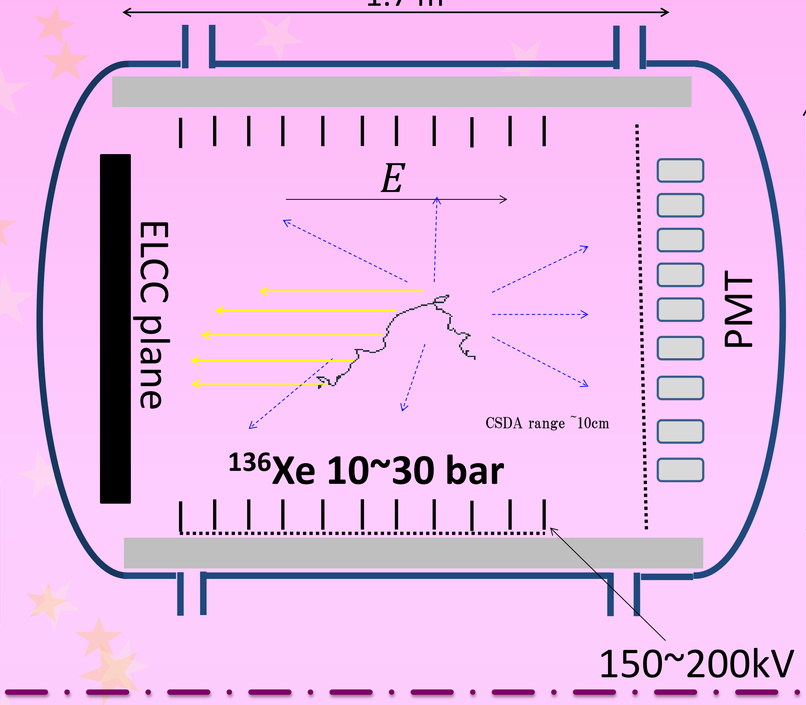
Simulation example signal of ELCC

ELCC (Electroluminescence Light Collection Cell)

★ Ionization electrons are collected into cells and produce ELs
★ Less dependence on event position
★ It is easy to extend to large area due to solid structure
Our original idea!



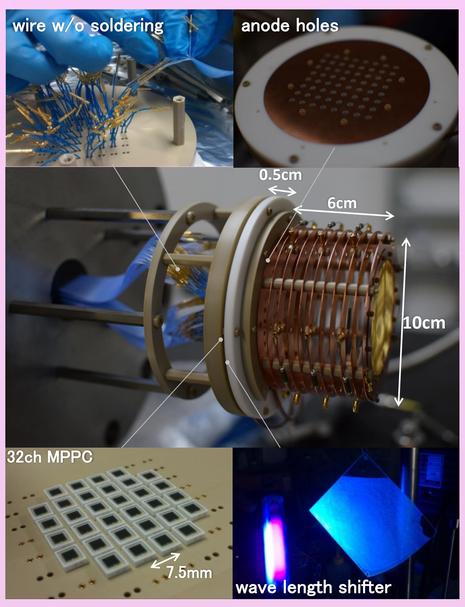




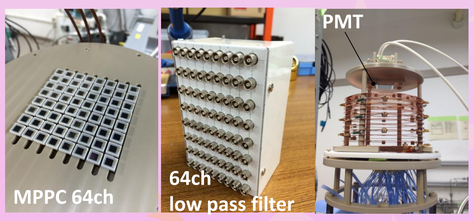
R&D status

Prototype Chamber

★Prototype chamber with 32ch MPPC and 4 bar Xe gas.



Now, we are upgrading to 64ch.



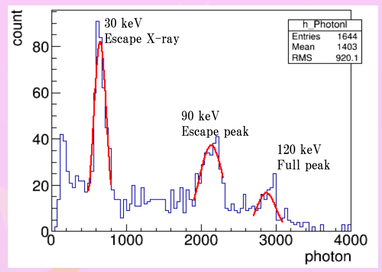
★Energy measurement using ^{57}Co gamma source and 4 bar Xe gas.

- ~3 % energy resolution at Q-value (converted by $\sqrt{E}$).
  But it is not sufficient.

-> Possible solutions.
- replace current MPPC+WLS with VUV sensitive MPPC.
- larger fiducial volume with 64ch MPPCs
- install PMT to detect t_0 signal. (scintillation light)

-> Now, upgrading.

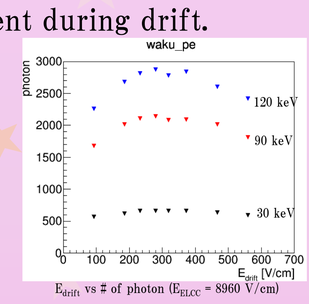
Energy	30 keV	90 keV	120 keV
FWHM	30.6 %	17.8 %	10.5 %
FWHM@Q-value (converted by $\sqrt{E}$)	3.4 %	3.4 %	2.3 %



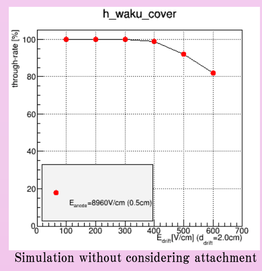
Energy spectrum of ^{57}Co gamma ray source

★ Gain dependence to E_{drift}.

- High electric field
  -> worse efficiency of ionization electrons collection, consistent with electric field calculation.
- Low electric field
  -> electron attachment during drift.



E_{drift} vs # of photon (E_{ELCC} = 8960 V/cm)



Simulation without considering attachment

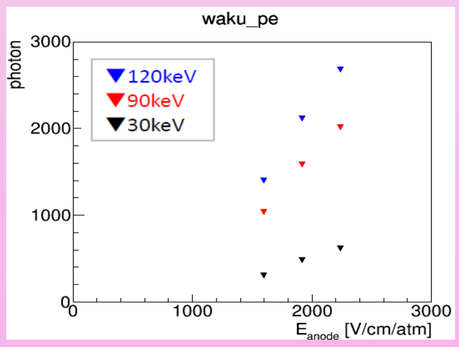
★ Gain dependence to E_{ELCC}

- The number of EL photons

$$dN_{photon}/dz = 70(E/p-1.0)p$$

noble gas detector
ISBN: 978-3-527-40597-8

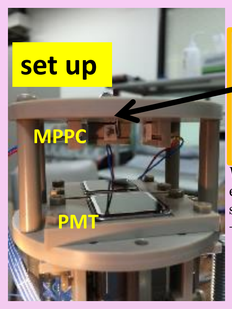
-> qualitatively as expected.

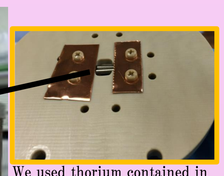


We will achieve 0.5%(FWHM) with upgraded detector!

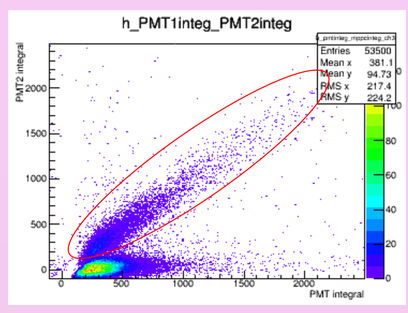
Measurement of MPPC's basic properties

★ PDE of VUV sensitive MPPC (developed by Hamamatsu photonics)
- Motivation
  - PDE is very important basic performance.
  - want to measure PDE for UV lights from high pressure Xe gas.
- Experiment
  - mini chamber filled with high pressure Xe gas up to 10 bar.
  - VUV-MPPC detect scintillation light from α (UV-PMT as a reference).
- Current status
  - succeeded to detect scintillation photons by MPPC
  - now, we are evaluating systematic errors due to geometry.

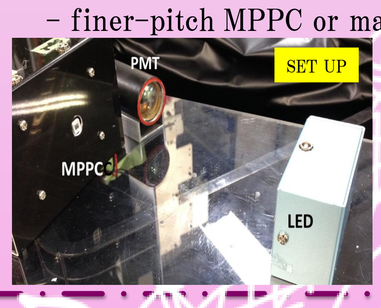


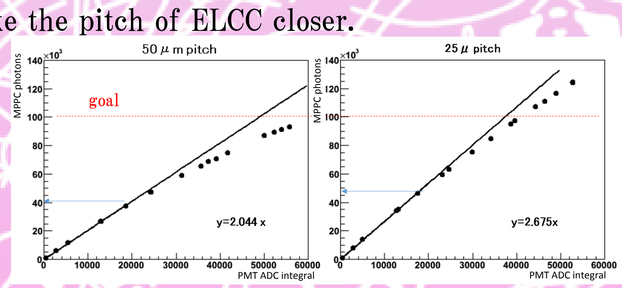


We used thorium contained in electrode for welding as alpha source.
-> Activity is very low.
and
Energy spectrum is continuous.



★ Linearity of MPPC
- Motivation
  - linearity is very important to obtain high energy resolution.
  - in our case, many photons (~10^5) may come in long time (~5usec).
- Experiment
  - using LED light and comparing PMT.
- Current status
  - linearity is OK up to ~$4*10^4$ photons/5us (50 μm-pitch, 3,600pixels)
    ~$5*10^4$ photons/5us (25 μm-pitcu, 14,400pixels)
  -> non-linearity observed.
- Solutions
  - finer-pitch MPPC or make the pitch of ELCC closer.





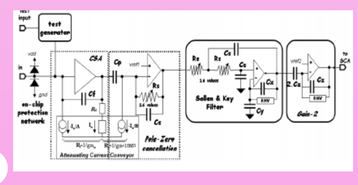
Future plan

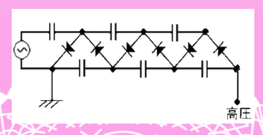
For upsizing

★ Developing readout module
- we have to readout huge amount of MPPC waveform signal.
  -> we'll develop electronics for readout based on ASIC chip.

★ High voltage supply & monitor
- More than 100 kV is required to drift electrons between 1 m distance.
  -> option is a Cockcroft-Walton's high-voltage supply.
  -> All elements are in the high-pressure vessel
  charging is done when data taking is off.
  -> want to develop voltage monitor.

★ Gas purity
- Impurities badly reduce scintillation light and drift electrons.
  -> we have to construct gas purification and circulation system.
  -> And we have to choose materials which have little outgas.





1 ton scale !!!
202X-
MPPC ~50000ch

World record!!
201X-
MPPC ~4000ch

2015- Next step
MPPC 64ch

Find new Physics!