Development of Liquid Xenon TPC for PET Application

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We are developing a liquid xenon (LXe) time projection chamber (TPC). Recently LXe is used in many particle physics experiments thanks to its scintillation characteristics. Basic technologies for handling LXe have been established in those experiments. Because LXe is suited material for gamma-ray detection, it also can be used in medical diagnostic equipments. Our purpose is to investigate the performance of LXe-TPC as a candidate apparatus of the next generation positron emission tomography (PET).

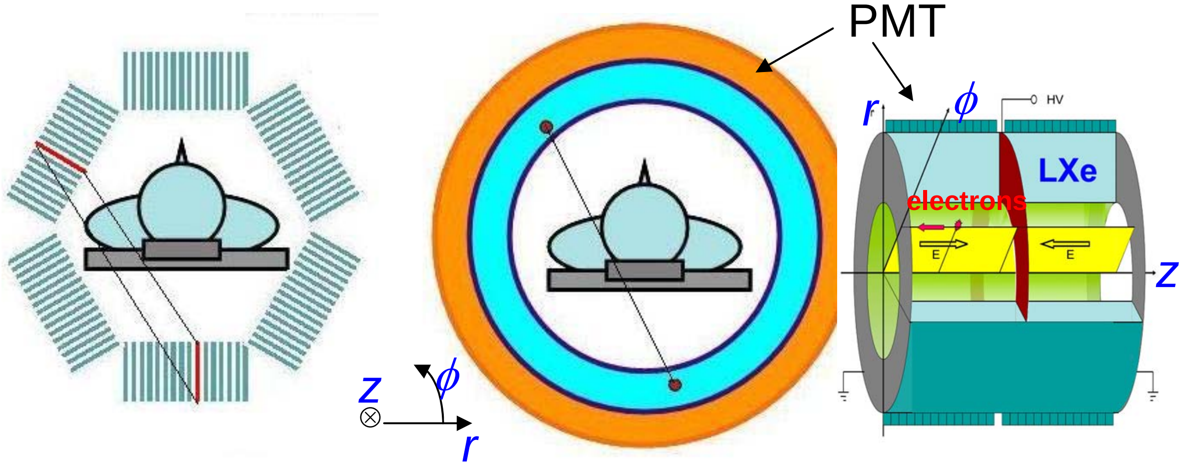


Figure 1: Comparison between present and our-proposed PET
Left: present type with crystal scintillator
Right: LXe type, conversion points are given by point

PET apparatus applied in hospitals and institutes for medical use or research, are equipped with pin-shape crystals (typically 4mm*4mm*2cm).In this configuration the resolution is limited by the size of crystal, and there is no resolution of radial direction so called depth of interaction (DOI). Therefore resolution at near the edge of view area is much worth than center. To improve this, resolution of DOI is must be improved. We are developing liquid xenon TPC, which have properties listed in table 1. In addition, precise event-by-event determination of source location helps to reduce dose for patients. The strategy to detect gamma ray from positron is as follow:

(i) Detecting scintillation light by PMTs, get the time information of interaction and rough position,
(ii) Electrons generated by gamma interaction drift in electric field and are collected on read pads to determine the coordinates (r, ϕ),
(iii) Measuring Time of Flight between two gammas by PMT signals.(LOI ,Line of interaction)

resolution (FWHM)	crysal (typical)	Lxe (expected)	
phi,z position	4	1	[mm]
r position(DOI)	20	1	[mm]
energy	~10%	<10%	
time	a few	<1	[ns]

Table 1: comparison of resolutions
Values of crystal are typical values of existing PETs

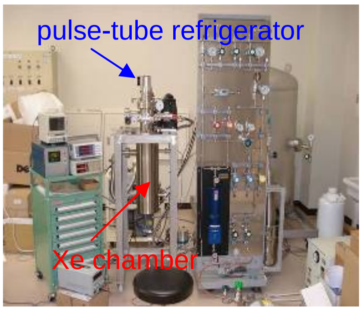
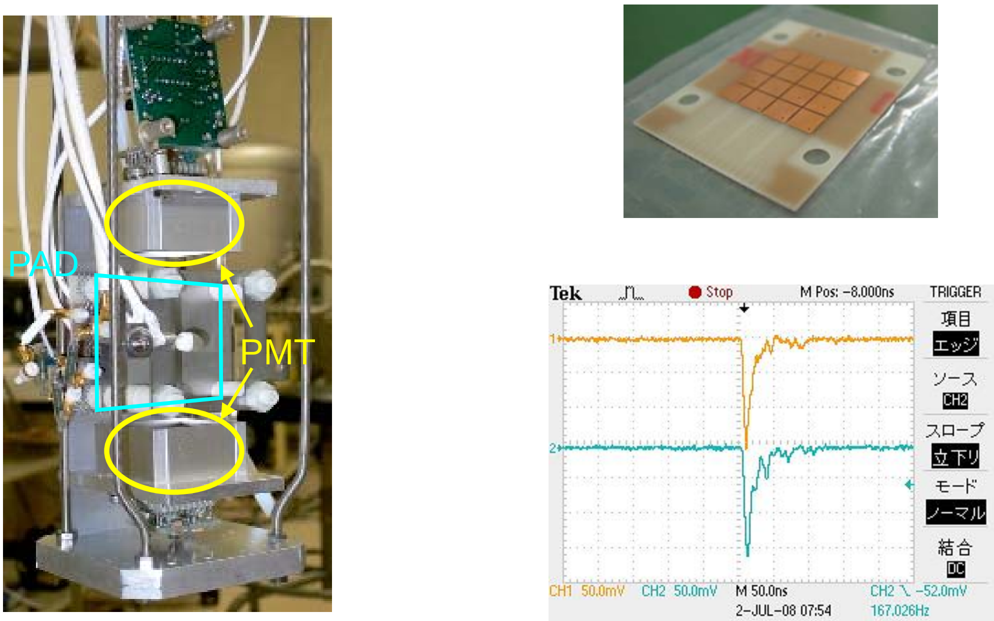


Figure 2: xenon cooling system

Now we are studying the fundamental performance of LXe-TPC using a proto-type installed in xenon system. A picture of the proto type is shown in Figure 3. This TPC consists of cathode plane, field shaping electrodes, a grid and read-out pads printed on a G10 board. Two PMTs are attached to detect VUV scintillation light for trigger and time measurement purposes.

In this presentation, we will describe the detector consept together with test results and status of prototype R&D work.



Figures 3: Proto-type TPC left: aspect of proto-type
right top: read-out pads right bottom: signals from PMTs