Xe-TMA for high-pressure Time Projection Chambers

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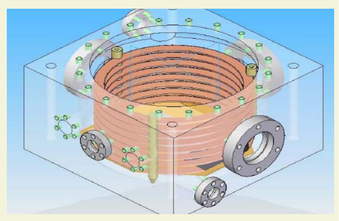
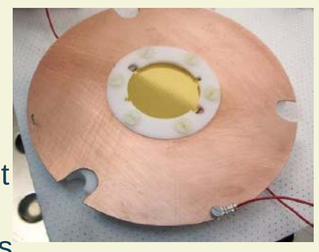
Motivation:

Xenon-Trimethylamine (TMA) constitutes an interesting mixture because it is expected to present significantly lower diffusion than pure Xe, even for very small TMA concentrations. This is a desirable feature for increasing the topological fidelity during the charge collection from extended ionization events originated for instance in active Xe-based Time Projection Chambers (TPCs), as the one constituting the core of the new neutrino-less double beta decay experiment NEXT. At medium-to-high pressures it has been shown, with the help of Micromegas amplifying structures, a very strong gain increase as a function of the TMA concentration, all other operating factors (notably the electric field) being constant. This observation, suggestive of Penning-like energy transfers, is strongly motivated theoretically in virtue of a Nature fine-tuned TMA IP, precisely adjusted to the narrow Xe second continuum (170nm). This fact, together with the known fluorescent behaviour of the TMA molecule have potential to allow surpassing the intrinsic energy resolution in Xe (arising from the Fano factor) while keeping enough scintillation to reconstruct the T_0 of the event [2].
A detailed study of all these aspects requires of different experimental setups and experimental approaches. We present first measurements in literature of the longitudinal diffusion coefficient in TMA mixtures, as obtained with the recently commissioned NEXT-MM system.

Setup

small-size dedicated setup for drift velocity

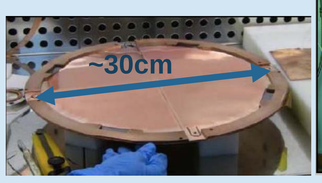




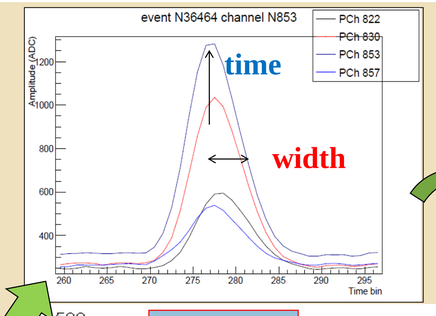
- 2l volume stainless steel vessel
- 1-4 cm adjustable drift.
- 3.5 mm diameter readout area
- Low outgassing materials

38cm-drift pixelated TPC (NEXT-MM)

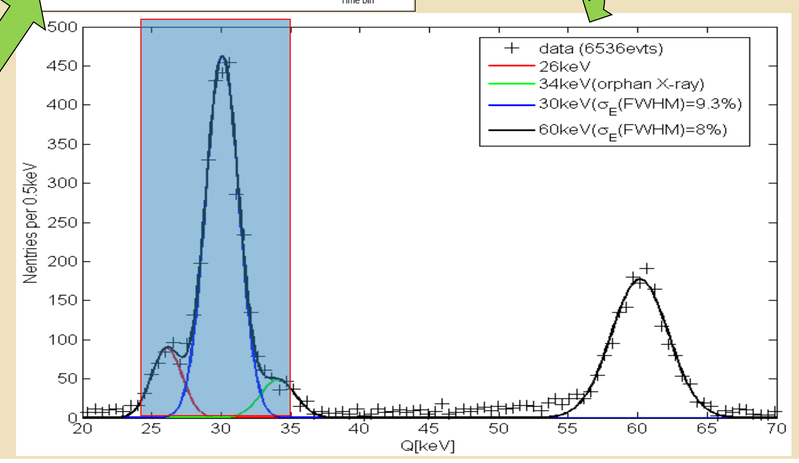
- 1 kg Xe (10 bar) active volume
- 38 cm drift distance
- ~30 cm diameter readout area
- Low outgassing materials
- 4 sectorial microbulk micromegas
- ~1200 pixels independently read

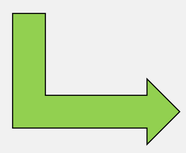


pre-analysis

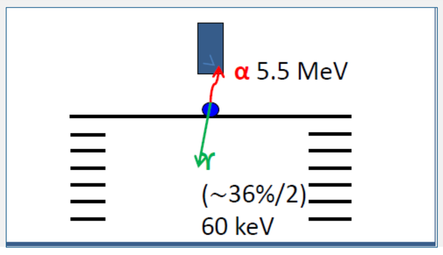


Standard pulse shape analysis based on a gaussian fit



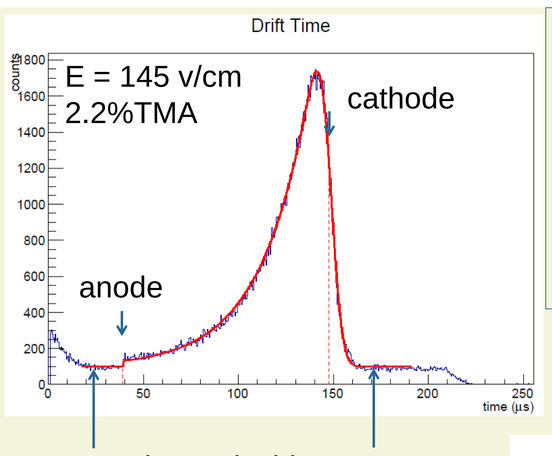


experimental procedure

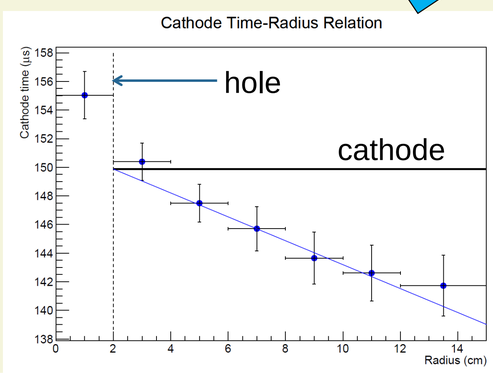


Data taking with ^{241}Am source:
1) α particles of 5.5 MeV → trigger.
2) 33% γ of 59.5 keV in coincidence →detected.
3) *Single-cluster 30keV escape peak used for analysis*

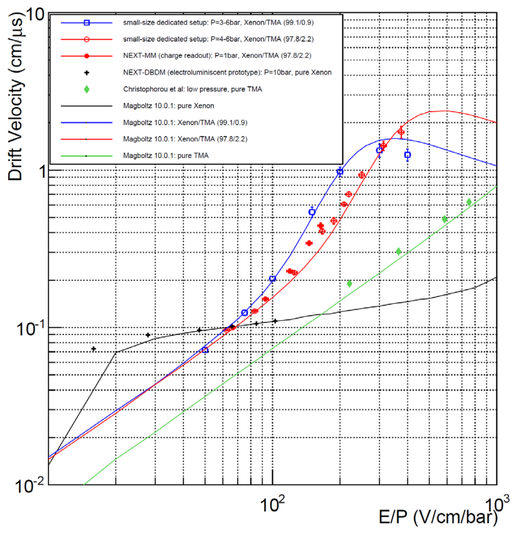
Drift Velocity



- Broadening on the cathode side mainly geometric in origin (source extension, absence of strong collimation, cathode 'shadow').
- Operational parameterization to the convolution of Gaussian and exponential function.

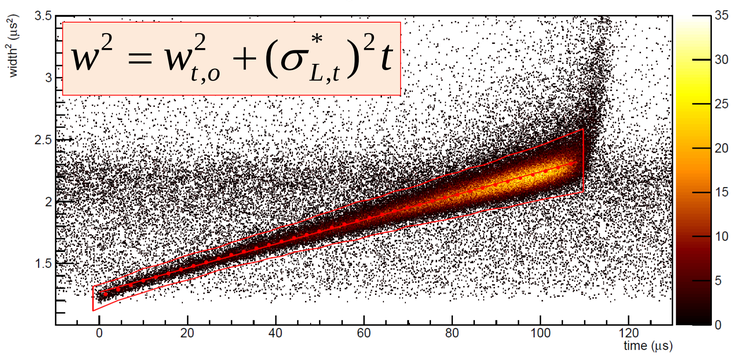


2% correction in NEXT-MM due to absence of collimation and fringe fields near cathode hole

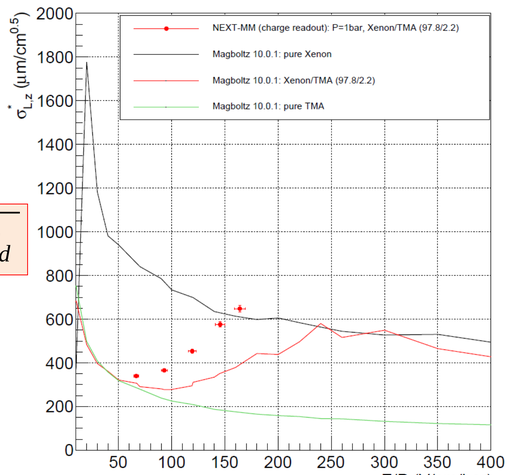


Diffusion

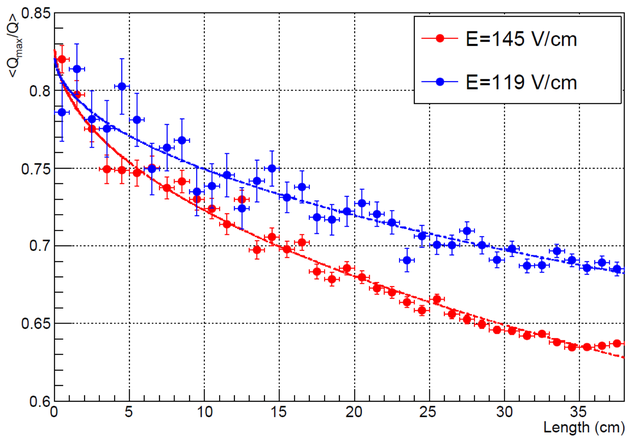
Longitudinal



$\sigma_{L,z}^* = \sigma_{L,t}^* \sqrt{v_d}$

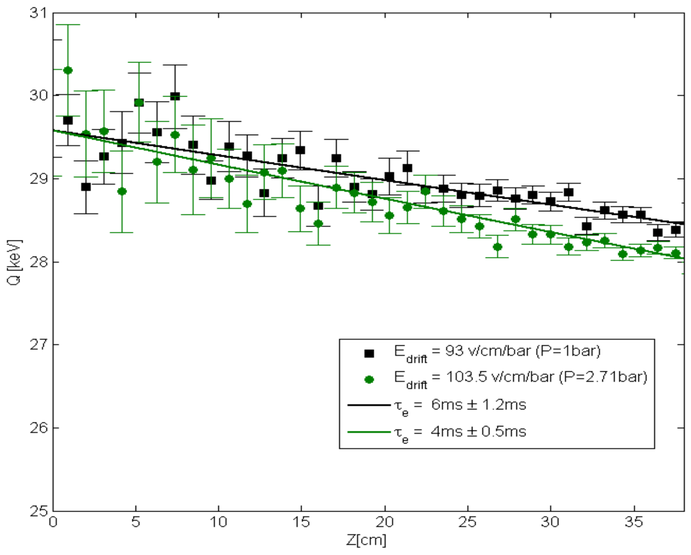


Transversal



Strong dependence of several observables with z due to transverse diffusion! A quantitative estimate more ongoing.

Attachment



- Electron life-time only mildly dependent on system pressure.
- Good prospects for operation at 10bar.

Conclusions

- Xe-TMA presents interesting features for TPC-based experiments in the rare event searched field.
- We have for the first time determined the diffusion coefficient in this type of mixture.
- Magboltz 10.0 does not describe the data, although it captures the trend.
- Electron life-time about 4ms at 2.7bar (still a comfortable value for meter-scale counters), possibly dominated by impurities, and not by TMA.
- We intend to resume these measurements and perform a systematic characterization of this and other mixtures of potential interest for rare event searches.
- Operation up to 10 bar is envisaged.

References

[1] Cebrián S et al. 2013 J. Inst. 8 P01012
[2] Nygren D. 2012 *J. Phys. Conf. Ser.* 309 012006