Characterization of the electron transport properties in pure xenon with NEXT-White and study of helium-xenon as a promising alternative

R. Felkai[a], A. Simón[a,b], F. Monrabal[c,d], M. Sorel[a], J.J. Gómez-Cadenas[d,e,a]
on behalf of the NEXT Collaboration

[a] Instituto de Física Corpuscular (IFIC), CSIC & Universitat de València; [b] Ben-Gurion University of the Negev; [c] University of Texas at Arlington
[d] Donostia International Physics Center (DIPC); [e] Basque Foundation for Science

NEUTRINO 2018 Heidelberg 4–9 June

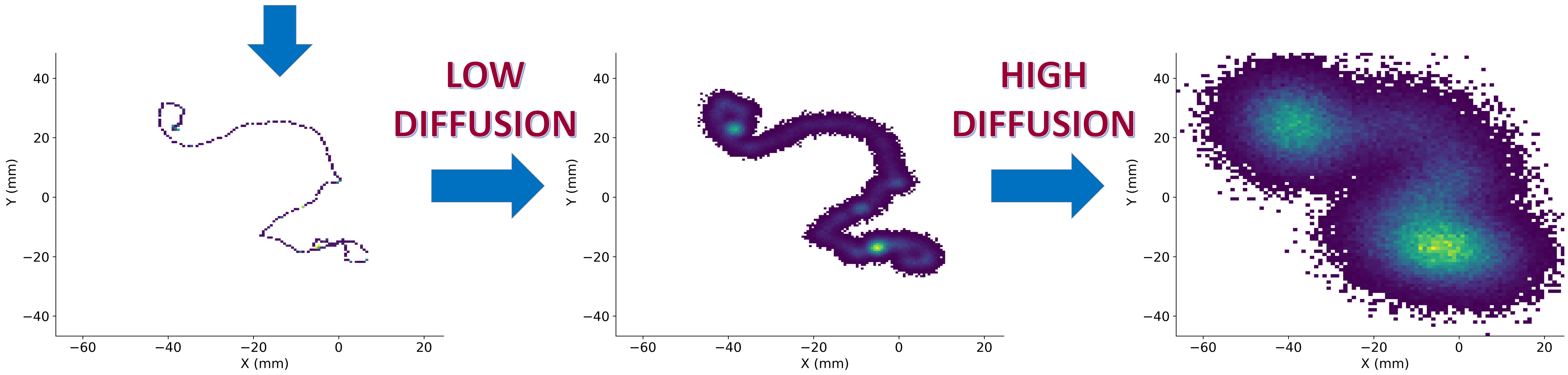
NEXT-White (NEW)

The NEXT experiment searches for neutrinoless double beta decay in ^{136}Xe. Its detector NEW is currently the largest high pressure xenon gas TPC using electroluminescence (EL) as a signal amplification process in the world.
The detector has been successfully operated in Canfranc since October 2016 and is now going through its fourth run.

Topology of events and diffusion

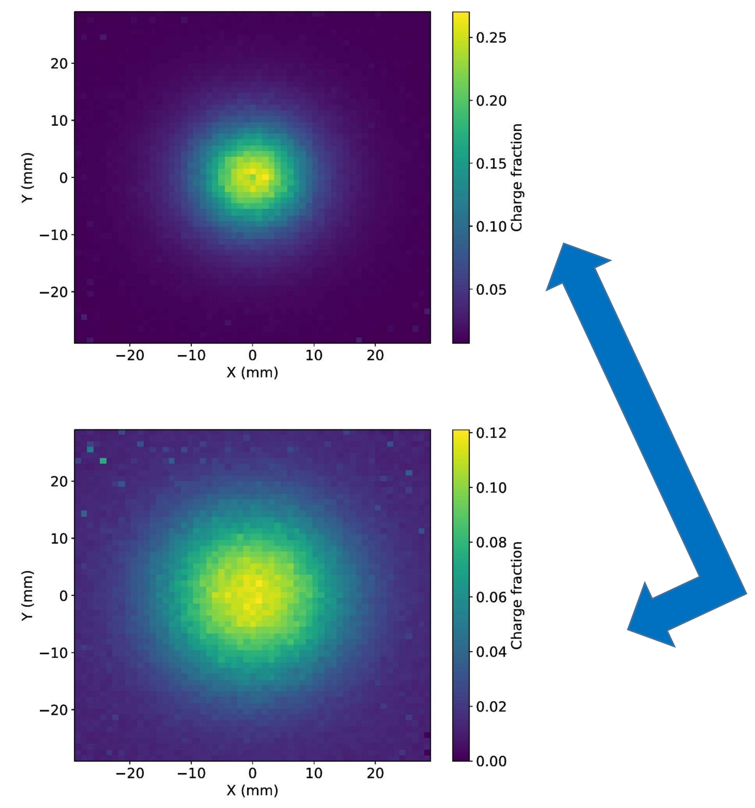
A double beta decay in high pressure xenon leaves one ionization track terminated by two compact areas of higher energy deposition, the so-called blobs. Efficiently rejecting single-blob events is a key feature of the experiment in order to achieve the desired sensitivity.
However in a big enough chamber the diffusion of the secondary electrons moving in pure xenon will smear the topological features of interest such as the blobs.
NEW allowed us to study all the transport properties of the drifting electrons in a large high pressure xenon detector.

0vbb TRUE TRACK



Krypton calibration

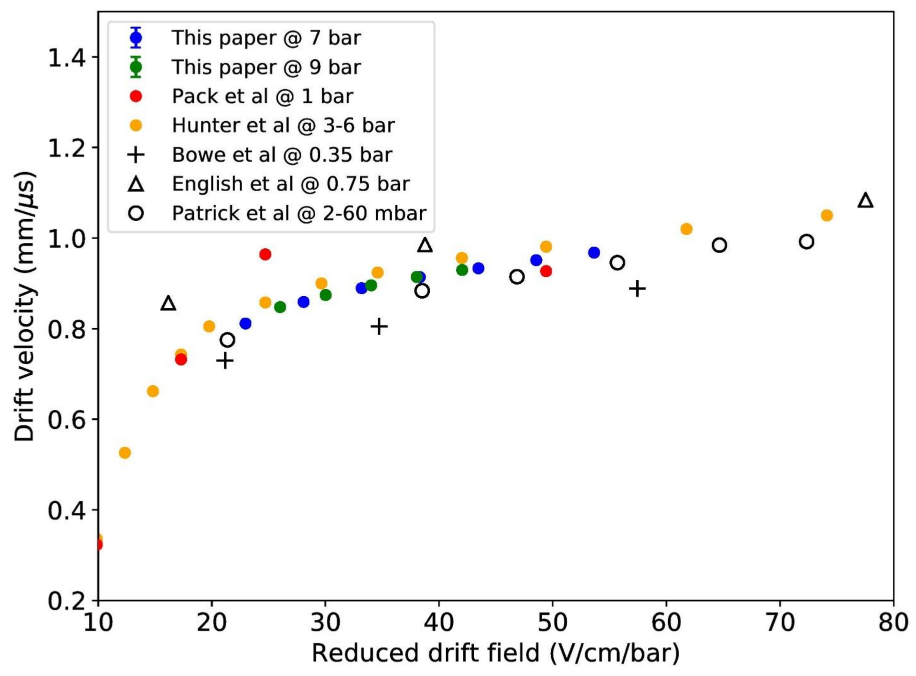
The second run of data taking with NEW was specifically dedicated to calibration using various radioactive sources.
One of those source was ^{83m}Kr producing events of 41.5 keV that are point-like at high pressure. This source provides a dense and uniform distribution of events which could be used to map the detector response and measure the drift properties of electrons in high pressure xenon.



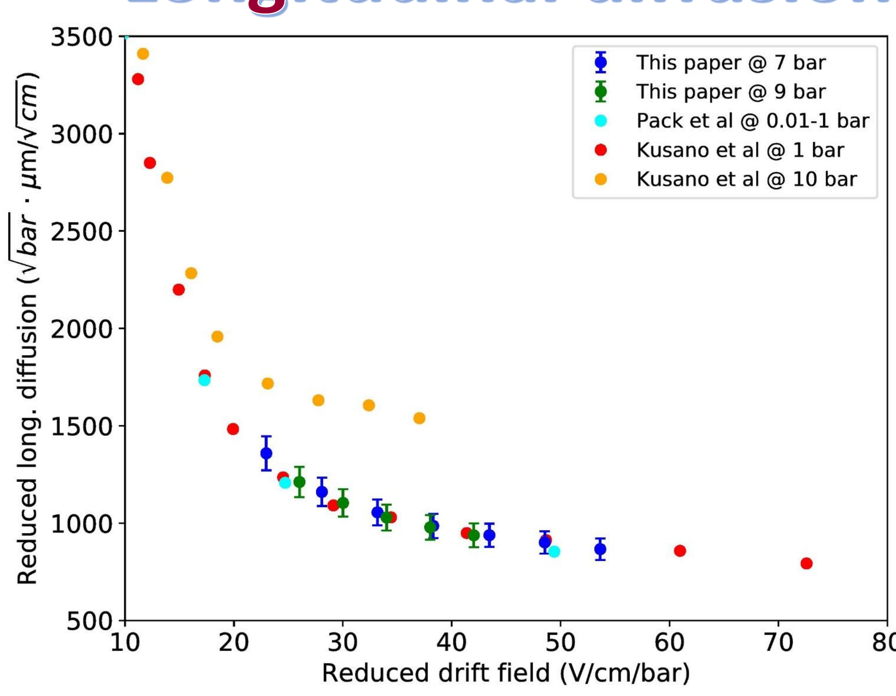
Transport properties in pure xenon

The **drift velocity** is obtained by measuring the drift time from the cathode until the EL region.
The **longitudinal diffusion** coefficient is obtained from studying the shape of the mean EL pulse for different drift time intervals. Each mean waveform is a convolution of the point spread function with a diffusion-induced Gaussian. We produced a linear fit of the variance of this Gaussian versus the drift time of which the slope gives the diffusion coefficient.
The method to obtain the **transverse diffusion** coefficient is the same as the one described above, but this time the mean x-y charge distribution is gathered by the SiPMs of the tracking plane.

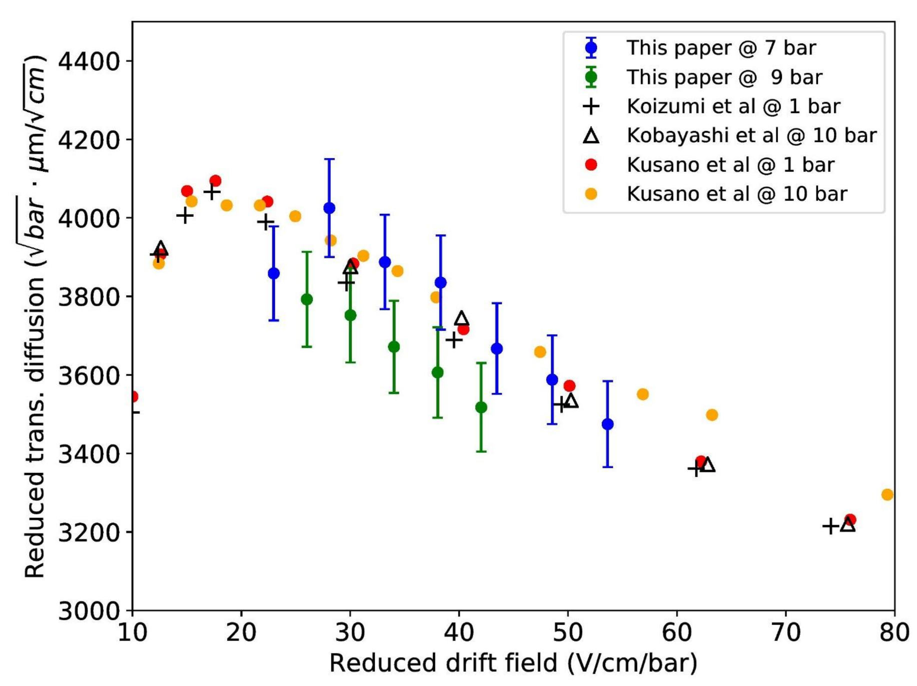
Drift Velocity



Longitudinal diffusion



Transverse diffusion



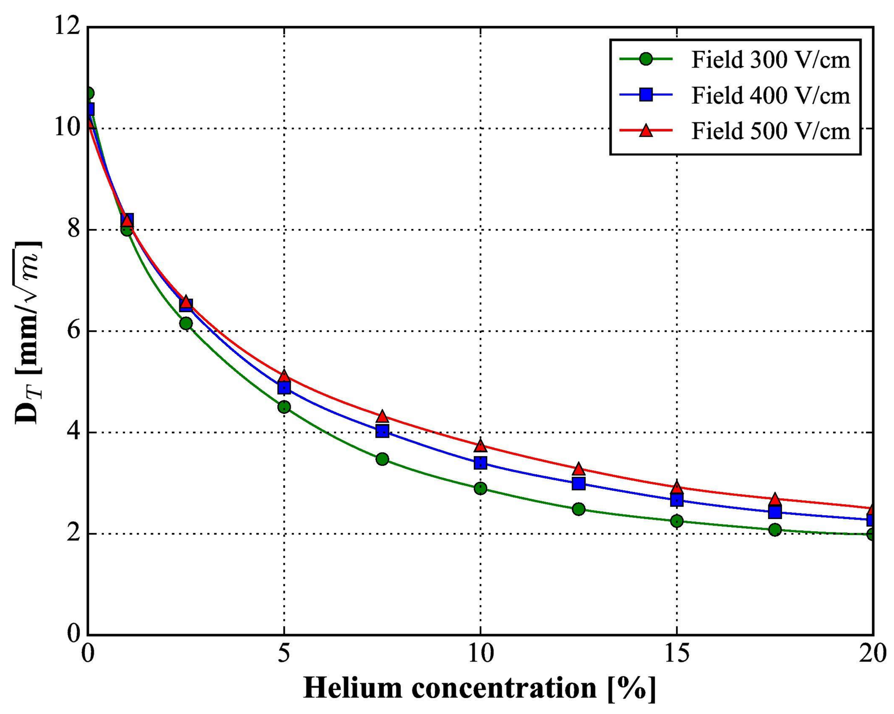
Helium-Xenon gas mixture

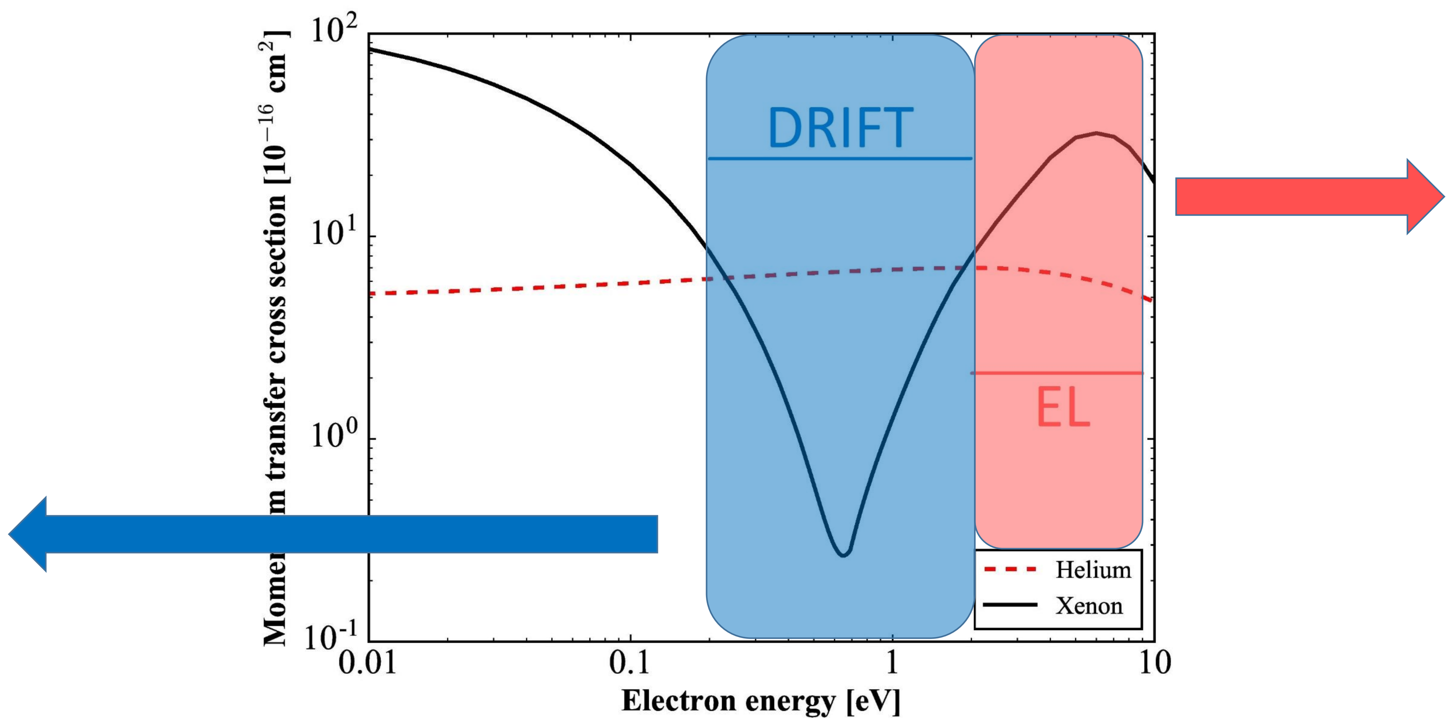
While gaseous xenon is a fantastic medium for calorimetry in 0vbb experiments, its high diffusion is a threat to performing the background rejection based on topological information. One of the major R&D efforts within the collaboration is to study the so-called low diffusion xenon-based gas mixtures.
Our results suggest that a helium-xenon mixture of 15:85 can achieve **low diffusion** while keeping the **good energy resolution** of pure xenon.

Current endeavour

There is a red light blinking in physicists' minds when one wants to operate PMTs in a helium environment. Diffusion of helium through the glass window of PMTs leads to afterpulses even at the atmospheric concentration of helium.
To operate a NEXT type of detector with a helium-xenon gas mixture we suggest shielding the PMTs behind **sapphire windows** sealed by metallic sealants (**Helicoflex**). As these two materials are totally helium-proof, we intend to demonstrate, in the near future, a successful operation of a HeXe EL TPC with the prototype **NEXT-DEMO++** (commissioning currently ongoing).
A TPC fully instrumented with SiPMs is also under investigation within the Collaboration and is another promising possibility that will allow for HeXe operation, simplifying the detector mechanics.

Transverse Diffusion





Light yield