XENONnT physics-driven 6D Surface Background Model

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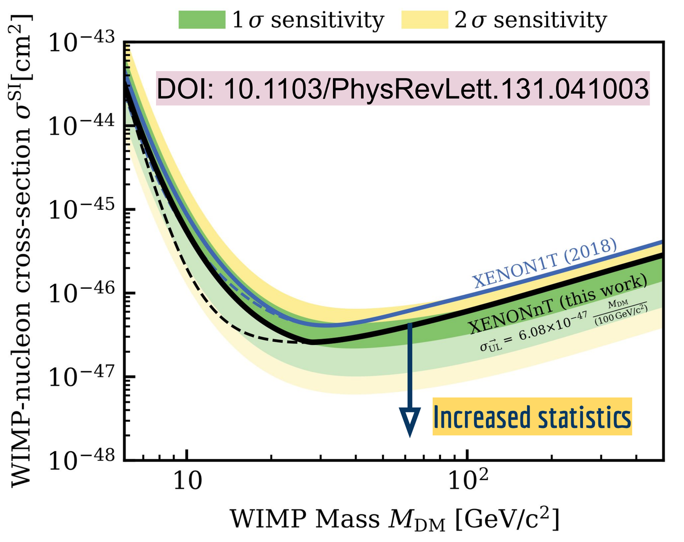
MOTIVATIONS

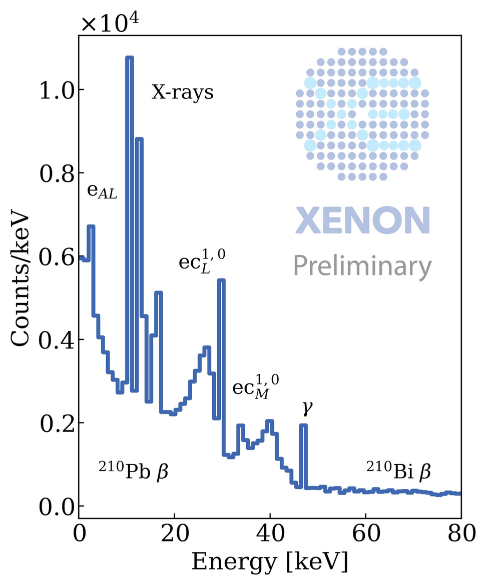
The **XENONnT experiment**, searching for **WIMP** Dark Matter, has already **excluded** a vast region of its parameters space.

To probe **lower** WIMP **cross sections** an **increased statistics** is demanded.

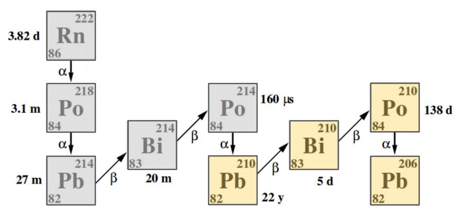
1. Wait more **time** (detector now in data-taking)
2. Improve the **data selection** (extend the fiducial volume FV)



THE PHYSICS INPUTS



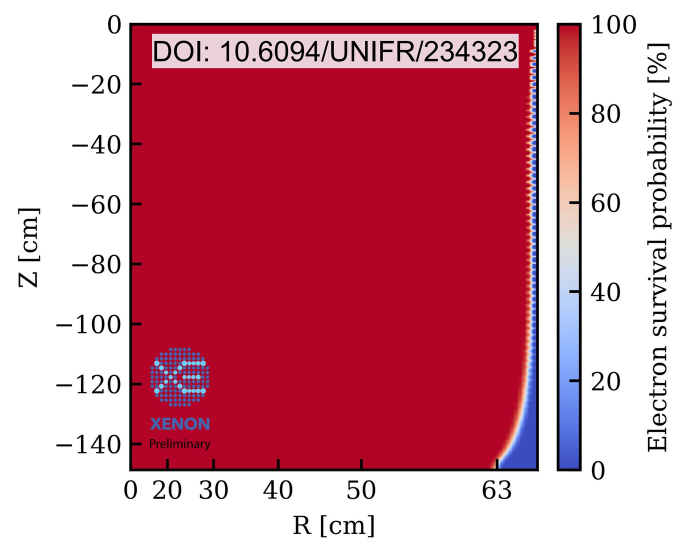
Air-born ^{222}Rn daughters may **plate out** on **Teflon panels** used to optically define the TPC volume.



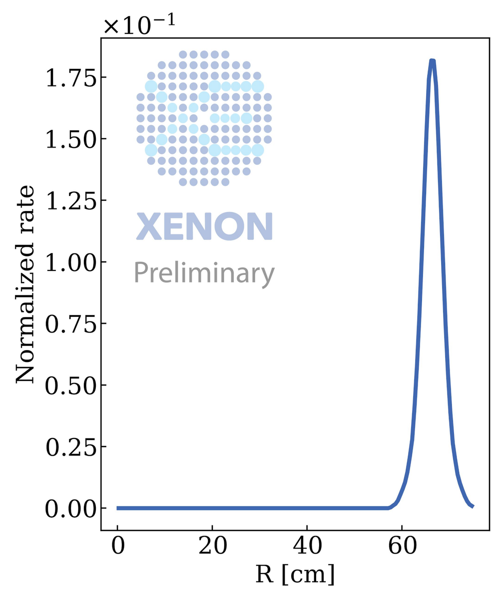
^{210}Pb, due to its **long half life** (22y), constitutes a stable background for WIMP searches. To **model** it we need:

- **^{210}Pb chain energy spectrum** (obtained with **GEANT4**)
- **Electron survival probability** (obtained with **PyCOMes**)

Indeed, **electrons** travelling towards the anode, **may be trapped** by the Teflon panels, due to the **Teflon charge up** phenomenon.



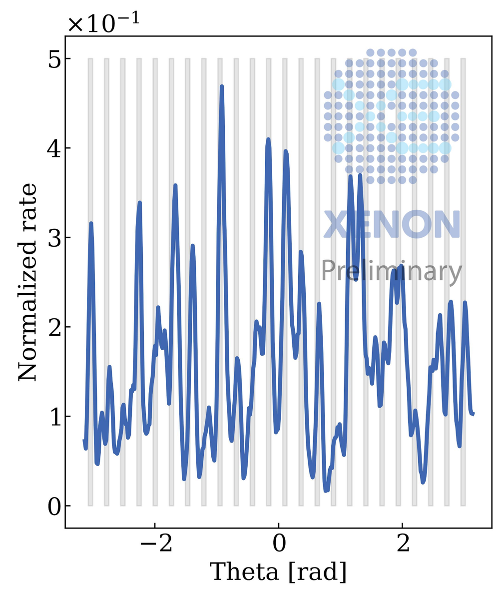
THE SPATIAL INPUTS



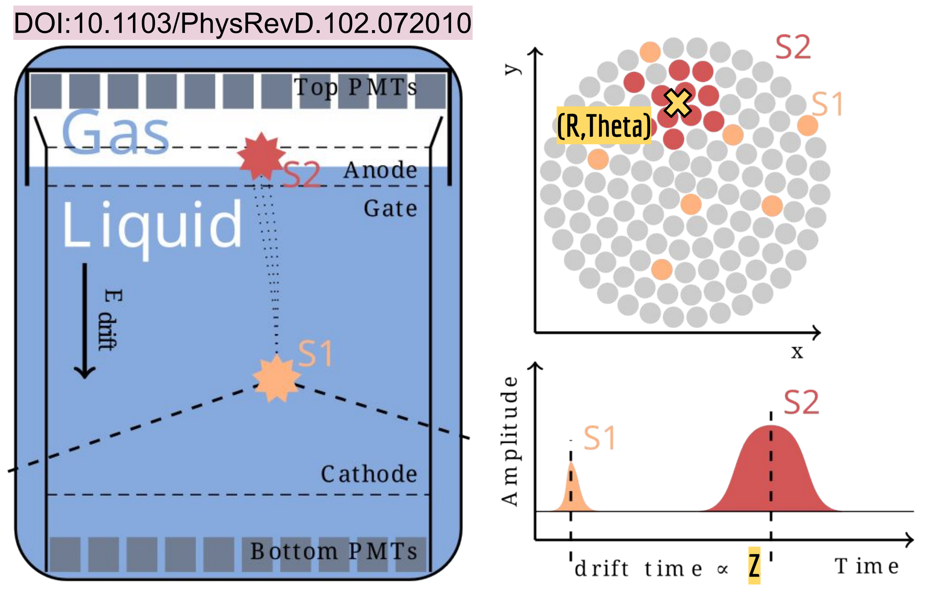
Thanks to the LXe high **stopping-power**, the surface background events are **clustered** in the neighborhood of the TPC borders. However, in terms of contamination level, the **Teflon panels differ from one another**: they have been differently exposed to air. This is evident in the events Theta distribution.

By using the **data-driven R and Theta distributions** and assuming an initial **uniform** z distribution, it is possible to build a good model for this background.

This is fundamental to **design a new (R,Theta,Z) FV cut** and gain statistics.



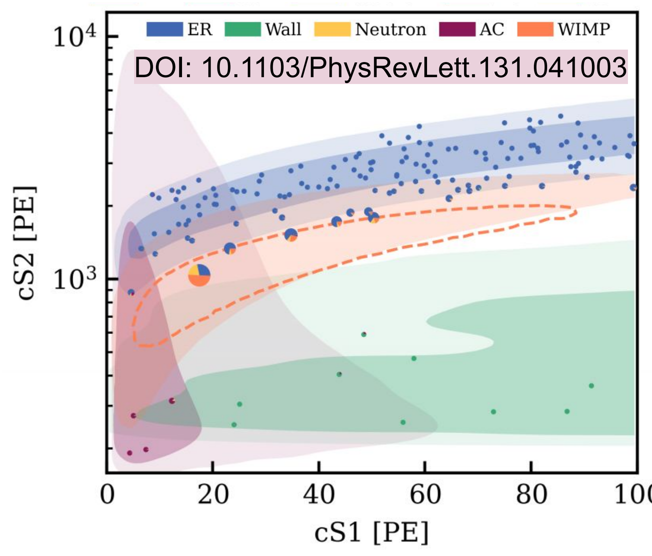
THE OBSERVABLE SPACE



The **XENONnT experiment** features a **double-phase Xenon cylindrical TPC**.

Whenever an event occurs in LXe volume, the deposited energy is split into three different channels:

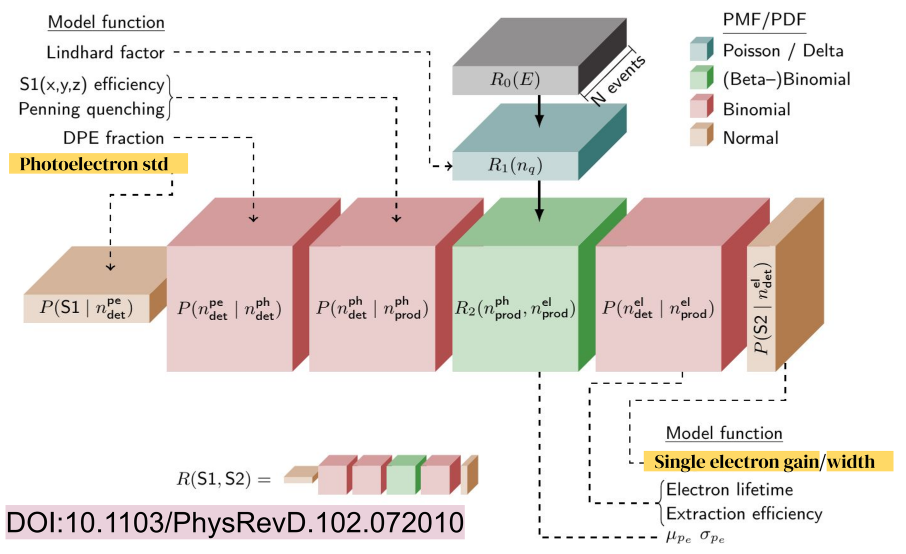
- **Excitation photons** produce the **S1** signal.
- **Ionization electrons** extracted in the GXe give **S2** signal.
- **Heat** is not detected.



On the **s1-s2** plane, it is possible to **discriminate** the WIMP signal-like events from the backgrounds.

The **surface background** (green), is characterized by **lower S2 signals** due to the electrons collection at Teflon panels.

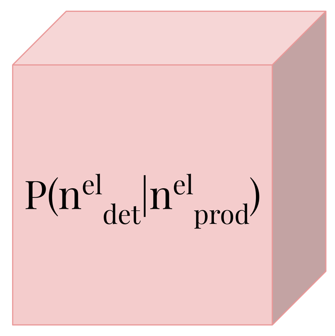
Traditionally, the analysis is performed in the signal **corrected space** and, to reduce the computational time, **only** the r spatial information is used.



With **flamedisx modelling and inference toolkit**, it is instead possible to build a **full dimensional** model for this background, by exploiting blocks representing the **conditional probabilities of the physics processes that build up an event**.

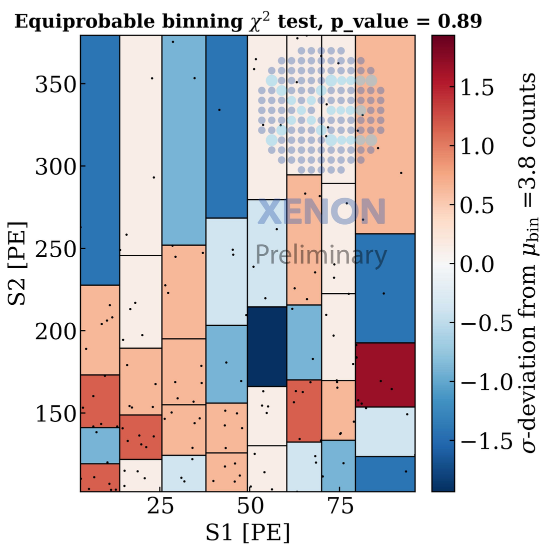
By using the **explicit likelihood fit** it is possible to heavily **reduce the computational costs**.

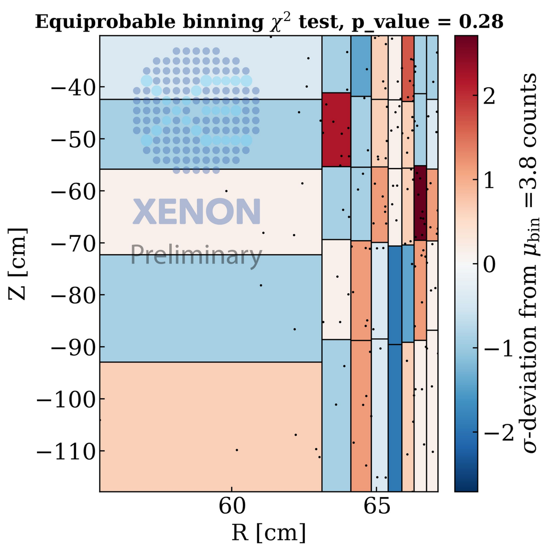
THE SURFACE BACKGROUND MODEL



To reproduce the **reduced S2 values**, the block modeling the **electron detection efficiency** has to be modified to include the **survival probability** map and a nuisance parameter **p0** that **reduces** the nominal **electron lifetime**.

electron_detection_eff = extraction_eff*exp(-drift_time*p0 /e_lifetime)*survival_probability(r,z)



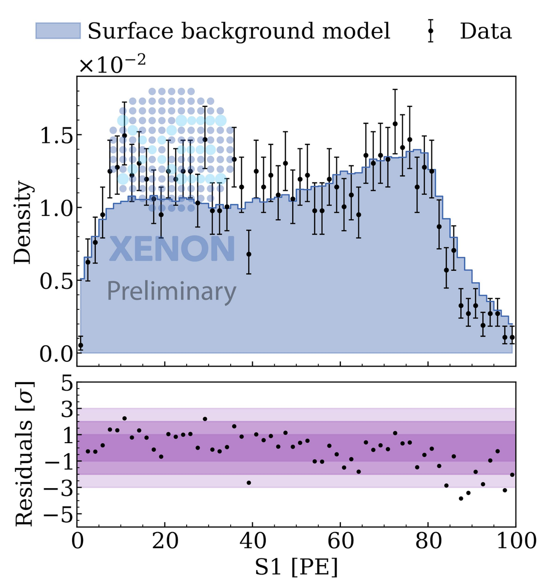


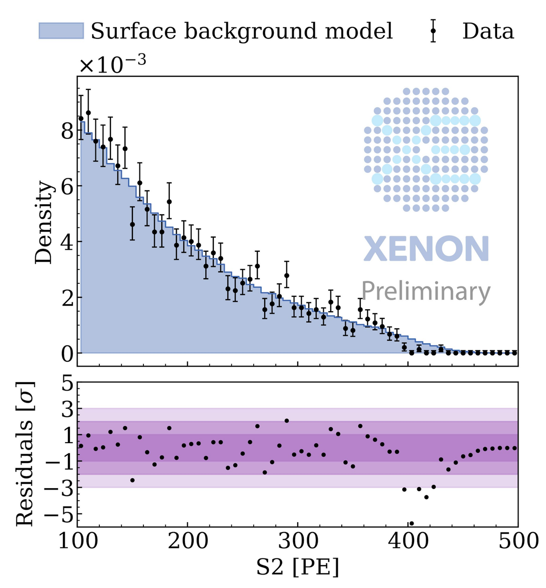
By optimizing the model on a data-set of randomly selected 150 events, we get the following best fit values.

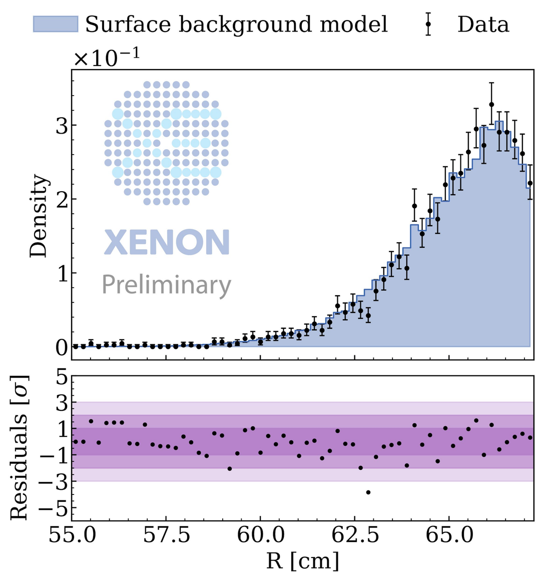
p0: 20.2 ± 0.2
Single electron gain: (4.25 ± 0.07) PE/electrons
Single electron width: (29.1 ± 1.9) PE/electrons
Photoelectron std: (2.3 ± 1.2) PE/PE

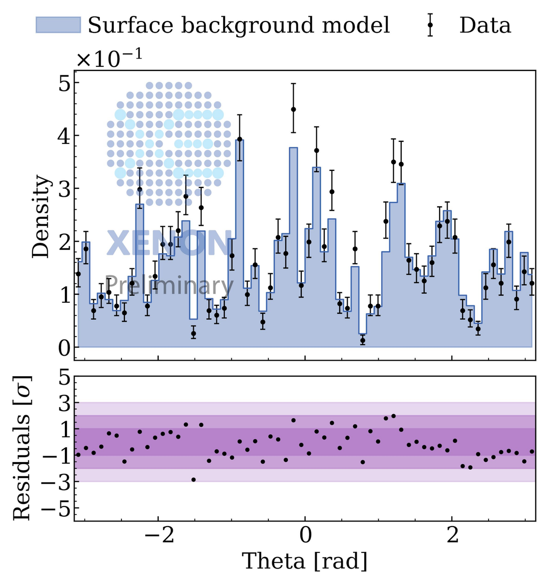
From both **Goodness of Fit tests** and visual matching, we can say the model **agrees** with the data.

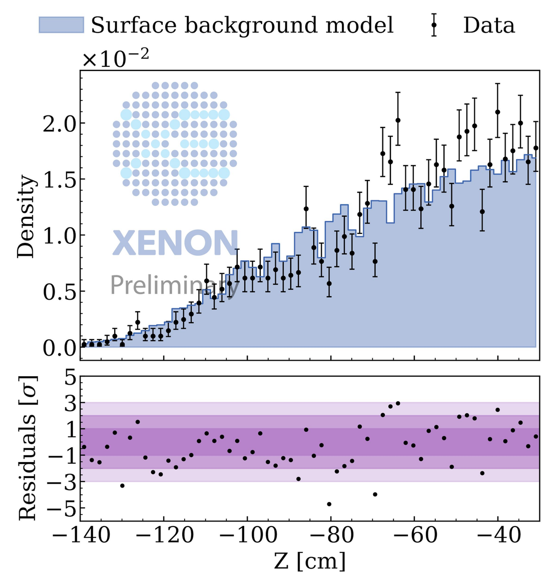
Notice that **s1, s2 and z trends** are determined by the **input Pb210 energy spectrum** and the s2 reduction effect, modeled through the **electron detection efficiency block**.











For further information on this study, please contact
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CONCLUSIONS AND OUTLOOK

XENON Preliminary

Thanks to this study, we **measured the surface background effective activity inside the XENONnT TPC**:

$$A^{effective}_{Pb210chain} = (1.97 \pm 0.11) mBq/m^2$$

In the near future, we will **design an optimized (R,Theta,Z) fiducial volume** and refit, with the flamedisx toolkit, the XENONnT SR0 data for **WIMP searches**.