

# XLZD Simulations Software Task Force

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# Taskforce introduction

**Review the XLZD simulation tools and platforms, in particular for the upcoming XLZD design phase:**

- What tools are in place to meet near-term goals (3-6 months to 1-2 years) to evaluate the first round of design considerations?
- Is a broad array of tools appropriate, or does it create chaotic approaches and spread resources too thin? i.e., there are multiple consumers: WG1 science studies, Requirements TF, and now the “L2” groups spinning up.
- Where are the tools hosted and accessed? What resources are in place and what resources are missing? Overall, what do you recommend is the evolution path to “full and final” simulation package(s)?
  - (NB: Data structure and analysis pipeline is beyond the scope of this charge.)

Input(s):

**Background:** U238, Th232, K40, 85mKr, 37Ar, etc

**Signal:** WIMP SI & SD, EFT, Inelastic DM, etc

Full Model Chain

BACCARAT + Optics

Particle Generators

Geant4 Particle Tracking

Energy Deposits

{Vol, PID, E, x, y, z}

G4S1Light

(Clustering,  
NEST gives  
S1 photons)

G4S2Light

(S2 map gives  
S2 photons  
from electrons)

BACCARAT output (PMT hits)

MCTruth Files (Photon stream)

DER (Detector Electronics Response)

DER Output (DAQ-like file)

LZAP Processing

Output:  
LZAP RQ File

Fast (Parametric) Model Chain

BACCARAT + E-Only

Particle Generators

Geant4 Particle Tracking

Energy Deposits

{Vol, PID, E, x, y, z}

Deposit ROOT File

**LZLAMA Processing**  
(Using parametric models  
for detector response and  
signal reconstruction)



Particle propagation

PMT hits

$PMT \#, \theta, t, E_{kin}$

LXe/GXe deposits

$dE, x, y, z, t, NR/ER, \dots$

Quanta generation

$x, y, z, t, n_e$

$x, y, z, t, n_y$

S2 photons  
generation

$x'_e, y'_e, t'_e,$   
 $n_y$

S2 photons  
propagation

S1 photons  
propagation

PMT hits  
 $PMT \#, t$

Photosensor  
acceptances

Signal  
digitization

Data-like waveforms  
 $PMT \#, t, amplitude$

Geant4 MC

fuse



**XENON**  
MONTE CARLO



## Overview of simulation packages currently used in XLZD context

Group	Working Group 1	Requirements Task Force	XLZD-UK
<b>Simulation packages</b>	<b>RAT - specifically RATPAC2</b> <ul style="list-style-type: none"> <li>Integration of existing packages: BACCARAT or XLZD Sandbox geometry, Tray, FlameNEST/Alea</li> </ul>	<b>ALEA &amp; FlameNEST</b> <ul style="list-style-type: none"> <li>Existing packages from XENON and LZ</li> </ul>	<b>XLZD-Sandbox:</b> <ul style="list-style-type: none"> <li>Advanced geometry</li> <li>Same physics lists as BACCARAT (LZ GEANT4 simulation)</li> </ul>
<b>Description</b>	Geant4 simulation with a wrapper that allows a common database from which several packages within the simulation/analysis chain pull from. Developed in SNO & KamLAND	FlameNEST is here not only used as inference tool but also for simulation with light collection map from XLZD BACCARAT and neutron simulations from XLZD-Sandbox	Standalone Geant4 simulation emerged from XenonFutures and now used for design studies in UK pre-construction project.
<b>Status</b>	XLZD-BACCARAT & XLZD-Sandbox geometry implemented. Proof of concept that Tray can be used within the framework.	Working packages adapted for XLZD. Producing results	Advanced: Working + some validation done. In a state to be used for simulations
<b>Links</b>	<a href="#">RATPAC Documentation</a> <a href="#">Samantha's presentation (04/2025)</a> <a href="#">Kian's presentation (09/2025)</a> <a href="#">GitHub</a>	<a href="#">Taskforce slides</a> <a href="#">Flamedisx XLZD - GitHub</a>	<a href="#">Documentation</a> <a href="#">GitLab</a>

# Task Force Plan

- Gather input from:
  - Developers and simulation experts
  - Different working groups (WG1, WBS 1.11, Requirements TF)
  - Please let us know, if you/someone in your group should be part of this consultation process.
- Bring all information together and develop recommendations to ensure short term results and long-term sustainability of efforts
- Timeline: develop recommendations over the next few months