

# WP4: Analysis and Simulation Techniques for Underground Physics Experiments

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# Simplified Layout

## and Initial

Signal Model

Background  
Model

Detector  
Response

Reconstruction

Data Analysis

Phenomenology

### Objectives:

- review all the methods both for simulation and data analysis and compare between them.
- promote the knowledge exchanges
- identify the synergies between experiments
- give the opportunity to people, and specially young people, to present their methods, tools and results

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## FLUX

Halo Model  
Oscillated solar neutrinos  
Core-collapse supernovae  
Neutrinoless double-beta decay  
(...)

## CROSS SECTION

Neutrino Coherent Scattering  
WIMP-nucleus form factor  
Migdal effect  
(...)

PARTICLE GENERATORS

In some areas (e.g. SNEWS2.0) there are attempts to build generators for all experiments, giving the possibility to choose the most appropriate model.

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*The simulation of  
neutrinoless double  
beta decay experiments*

Luigi Pertoldi

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## RADIOACTIVE DECAYS

GEANT4-ENSDF  
(Alpha, neutron) reactions with  
SOURCES, TALYS, etc  
(...)

## COSMIC / COSMOGENICS

GEANT4, FLUKA, CORSIKA, ...

## NEUTRINOS

Neutrino floor, ...

SOFTWARE  
VALIDATION AND  
DISSEMINATION

Review what's already been done and understand what's needed for the future

# Background

Signal Model

*The simulation of  
neutrinoless double  
beta decay experiments*

Luigi Pertoldi

*Neutron background  
simulations for the  
SuperNEMO experiment*

Veronika Palusova

Background  
Model

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*Simulation of  
gamma-ray shower  
after neutron capture*

Gabrielle Soum

*New simulation  
codes (alpha, n)*

Emilio Mendoza

Reconstruction

Data Analysis

*The effect of  
neutron and gamma  
backgrounds in the  
SuperNEMO experiment*

Sam Pratt

*Impact of Nickel Cryostats  
in the nEXO Detector*

Antoine Amy

Phenomenology

# Detector

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PARTICLE TRACKING

GEANT4, FLUKA, ...

RESPONSE MODELS

Ionization, scintillation, phonons,  
Cherenkov (NEST, PARIS, ...)

ELECTRONIC SIMULATION

Well known? It depends on the PHYSICS LIST

CRITICAL:  
atomic physics expertise is needed

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*G4CMP: Condensed Matter Simulations with GEANT4*

Ben LOER

*Detailed GEANT4 Simulation of S2 Photons in XENONnT*

Bernard Andrieu

*Simulation of gamma-ray shower after neutron capture*

Gabrielle Soum

# Reconstruction

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## STANDARD APPROACHES

Position reconstruction (time-of-flight / charge collection, ...)

Particle Identification (Gatti, PSD, time-of-flight, ...)

## MACHINE LEARNING

# Reconstruction

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*Machine learning for LXe TPC analysis*

Sid El Moctar  
Ahmed Maouloud

*Primary electron identification in NEWS-G's S140 SPC*

Francisco Vazquez de Sola

Missing data reconstruction using CNN in the gaseous TPC PandaX-III experiment

Andrii Lobasenko

# Analysis

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Profile Likelihood Ratio (RooFit, R, python-based)

Bayesian Approaches

Alternative Frequentist Approaches (Yellin Method...)

What to use and why?

Can we directly compare results obtained with different approaches?

Should we adopt a reference approach?

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*Distributed computing resources for XENONnT*

Bernard Andrieu

*Xenon Offline Monitoring*

Quentin Pellegrini

Computing Monitoring

We identified and invited experts of Bayesian statistics. They were not available but agreed to give talks in the future.

# Phenomenology

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Theoretical framework to allow comparisons

DM direct search and collider results  
ALPs from different sources  
DBD results vs matrix elements

...

Can we set tighter limits or make the observations more significant by combining multiple results?

Interactions with theoreticians are needed

No talk yet on this subject.  
Because overlapping with WP1 and WP5 ?

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*The Dark Matter Plotter*

Olivier Dadoun

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# Conclusion

In 4 years, we had **a total of 14 talks** from :  
XENONnT, SuperNEMO, nEXO, GERDA/LEGEND, CRAB, PandaX-III, NEWS-G, SaG4n  
(missing experiments, we are seeing you!)

We also organized **one round table** at the beginning of the GDR to discuss  
the needs of the community in the context of this GDR

It confirmed that people were interest in exchanging tools and methods between  
collaborations.

Some ideas were suggested:

- a web site page summarizing all the tools and their configurations  
used by collaborations
- regular online seminars on analysis and simulation tools

... but we did not go further.

Ideas for the future ?