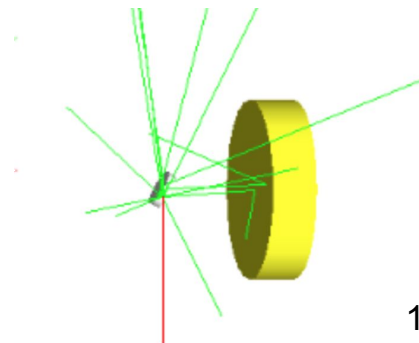
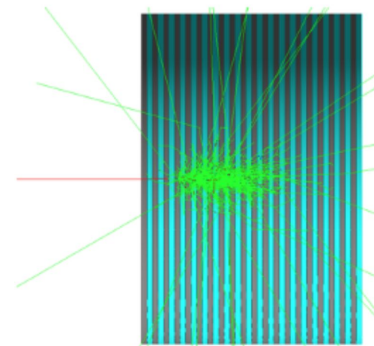




# Competence Centre on Simulation and Big Data

## Highlights - simulation

- Support and maintenance of an Advanced Example in the Geant4 simulation toolkit — a long-standing responsibility of LIP within the collaboration.
- Teaching of advanced detector simulation techniques, integrated into both undergraduate and doctoral curricula.
- Extensive use of the **Virtual Radiation Laboratory (VRLab)** in academic courses, providing flexible hands-on learning in radiation detection and detector performance.



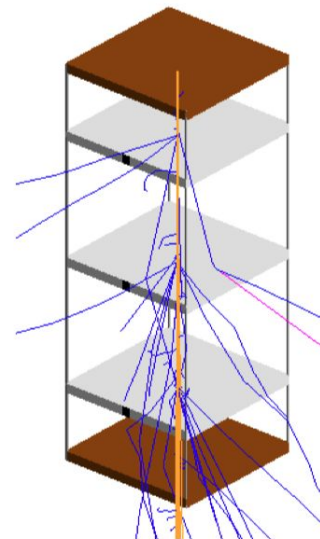


# Competence Centre on Simulation and Big Data

## Highlights - simulation

### VRLab updates and other developments

- New detector materials relevant for crystal scintillators and neutron absorption studies;
- Improved GUI components for setup configuration;
- New “Space Shielding” application for evaluating shielding strategies in space radiation environments.
- Muon hodoscope fully simulated in a PhD-level course, complementing hands-on training with a real detector.

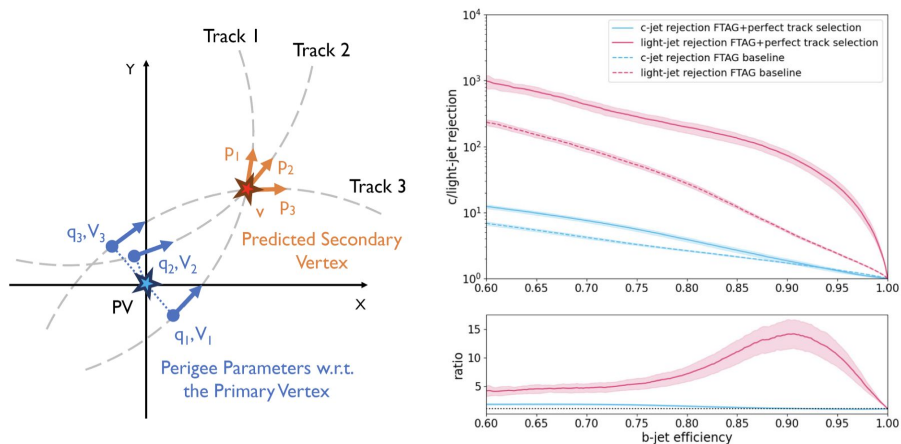




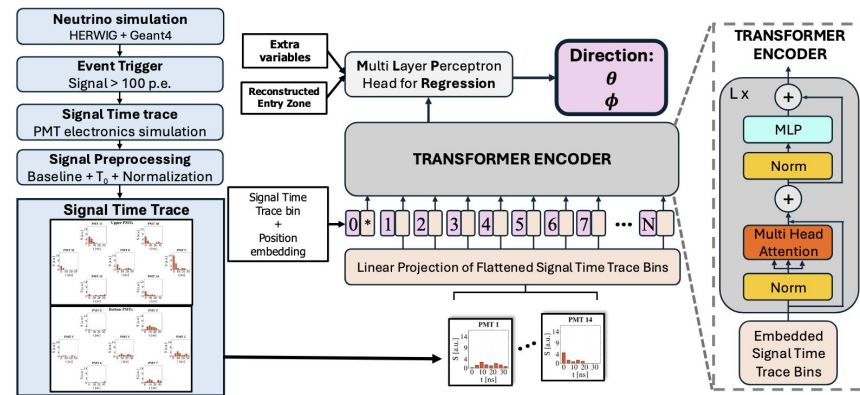
# Competence Centre on Simulation and Big Data

## Highlights - machine learning

### Differentiable vertex fitting for jet flavor tagging



### Transformers for Neutrino Reconstruction in Water-Cherenkov Air Shower Arrays

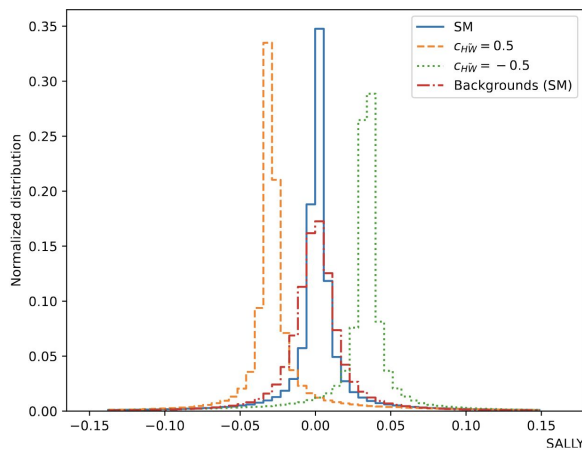




# Competence Centre on Simulation and Big Data

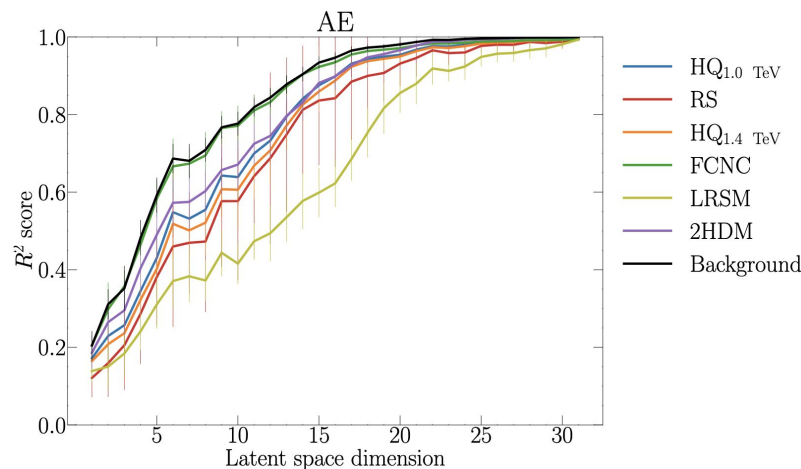
## Highlights - machine learning

Simulation-based inference in  
searches at colliders



JHEP04(2024)014

Sensitivity of anomaly detection in  
searches for unexpected events



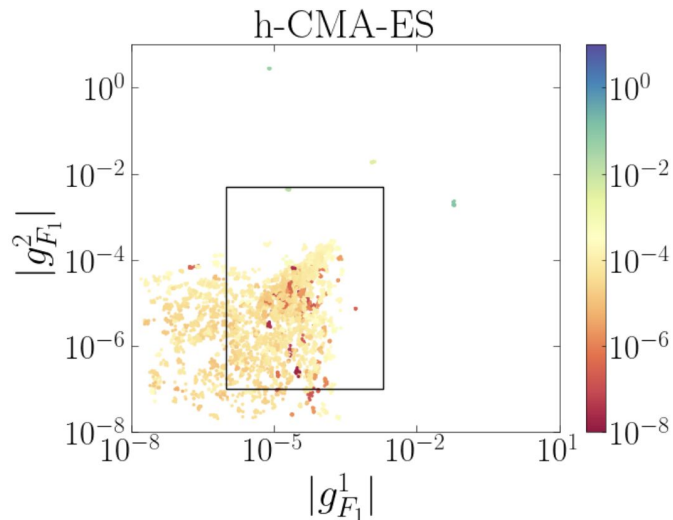
work in progress



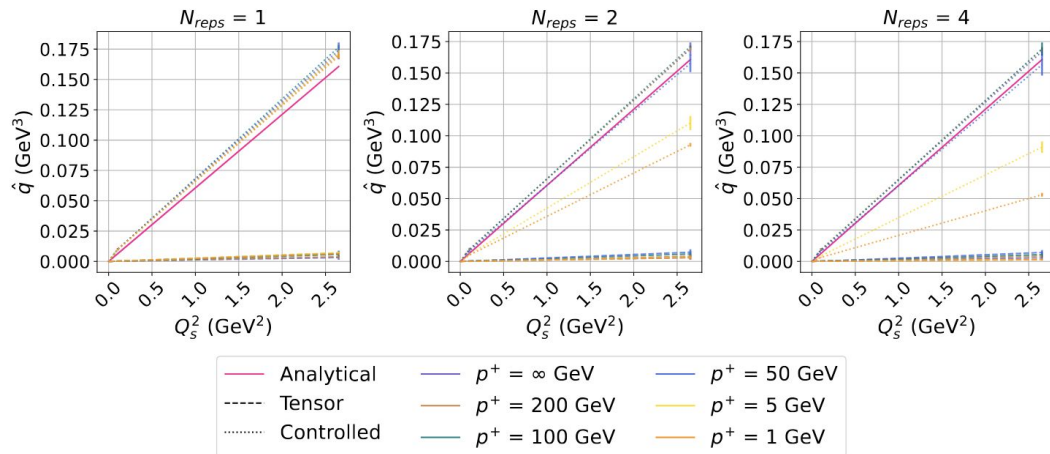
# Competence Centre on Simulation and Big Data

## Highlights - machine learning

Exploring complex parameter space using genetic algorithm



Jet evolution in a quantum computer



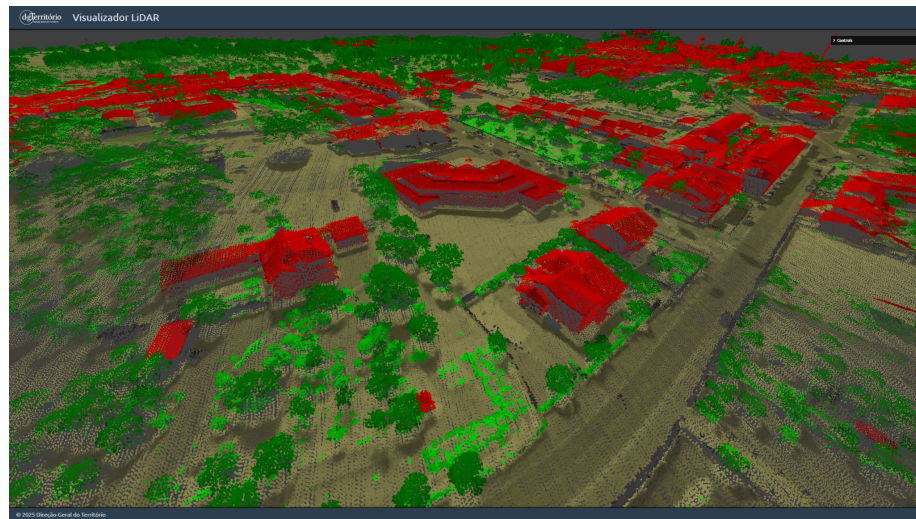
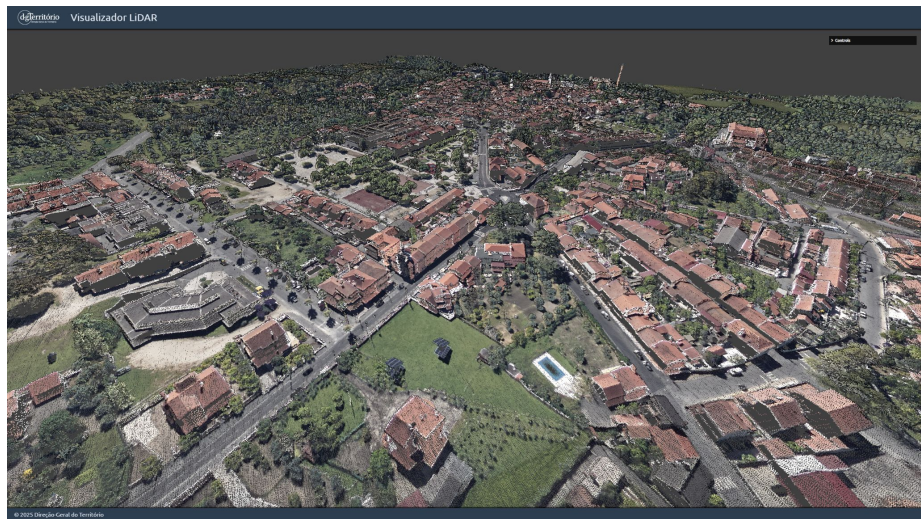
arXiv:2502.03431





# Competence Centre on Simulation and Big Data

## Highlights - DGT / LIDAR (Light Detection and Ranging)

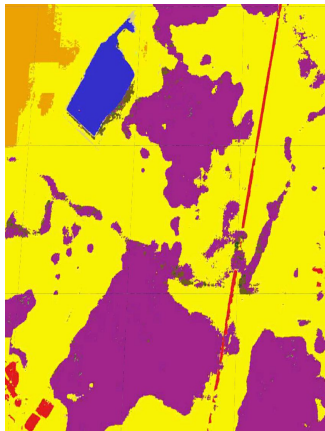




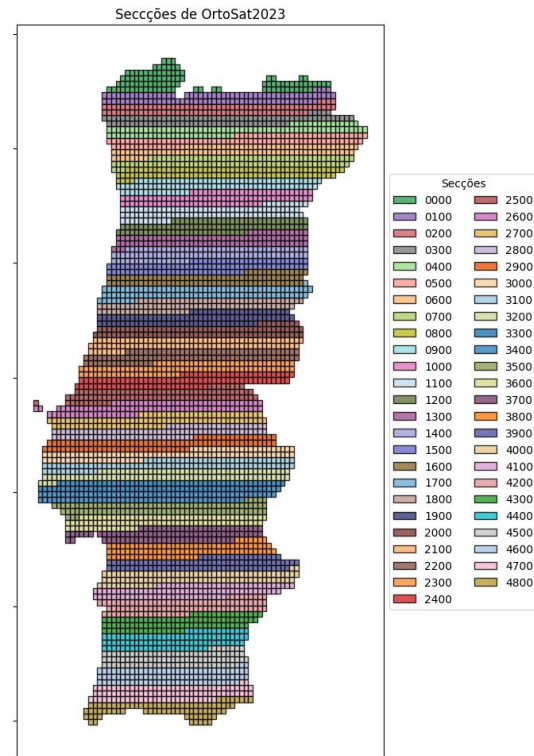
# Competence Centre on Simulation and Big Data

## Highlights - DGT / Land Use Map from Very High Resolution Images

Work in progress



- Using dataset of 30 cm resolution images of continental Portugal taken by Airbus Pléiades Neo (from 2023).
- Image segmentation and classification problem addressed with deep learning with weak supervision (no labels for training).





# Competence Centre on Simulation and Big Data

## SWOT

### Strengths

- Integration in international collaborations (HEP experiments, Geant4 collaboration)
- Diverse team, consolidated by competitive fundings (some secured by the Competence Center)
- Good synergies with the computing team and CNCA

### Weaknesses

- Limited access to GPUs (we are not alone there...)
- We continue to improve the communication between groups, but there is still work to be done

### Opportunities

- The Horizon Europe has a strong focus on Digital Transformation
- The new National Centre for Advanced Computing (evolution of INCD)
- Protocol with DGT opens new perspectives in a strategic area

### Threats

- External services in simulation and big data are highly competitive outside some niche areas