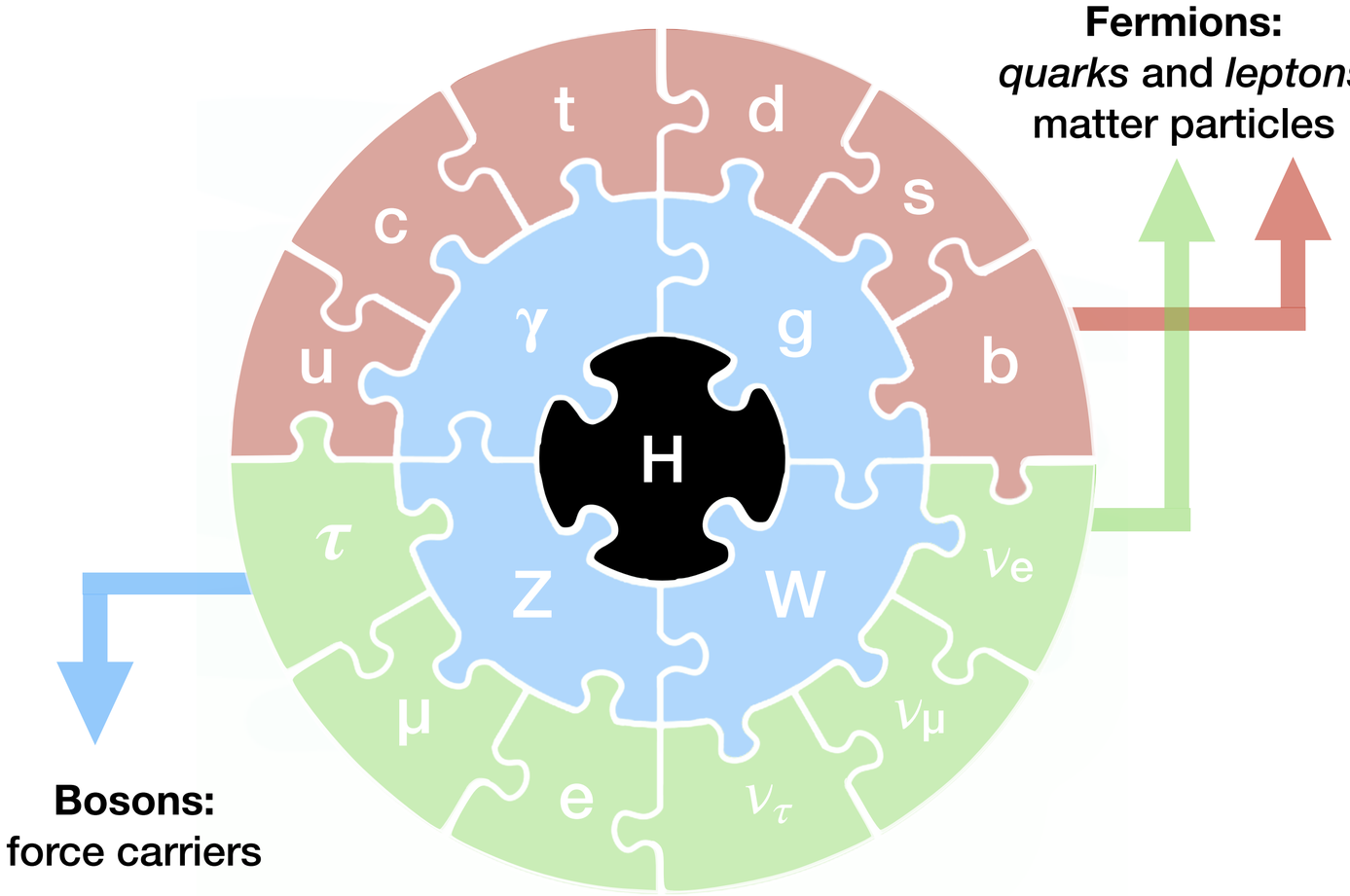
Nikhef

Master Projects in the ATLAS group at Nikhef

University of Amsterdam
Institute of Physics

ATLAS EXPERIMENT

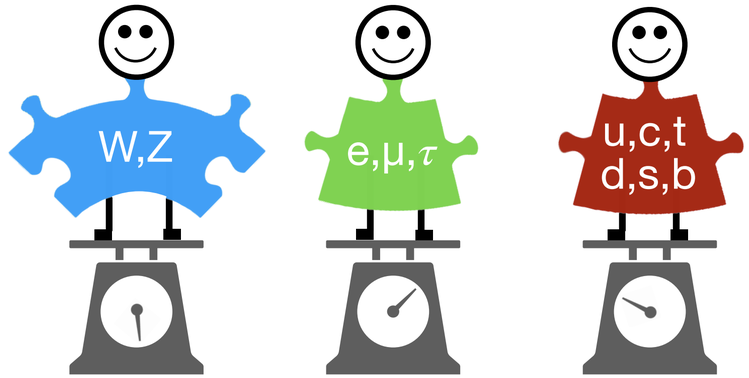
Standard Model of Particle Physics

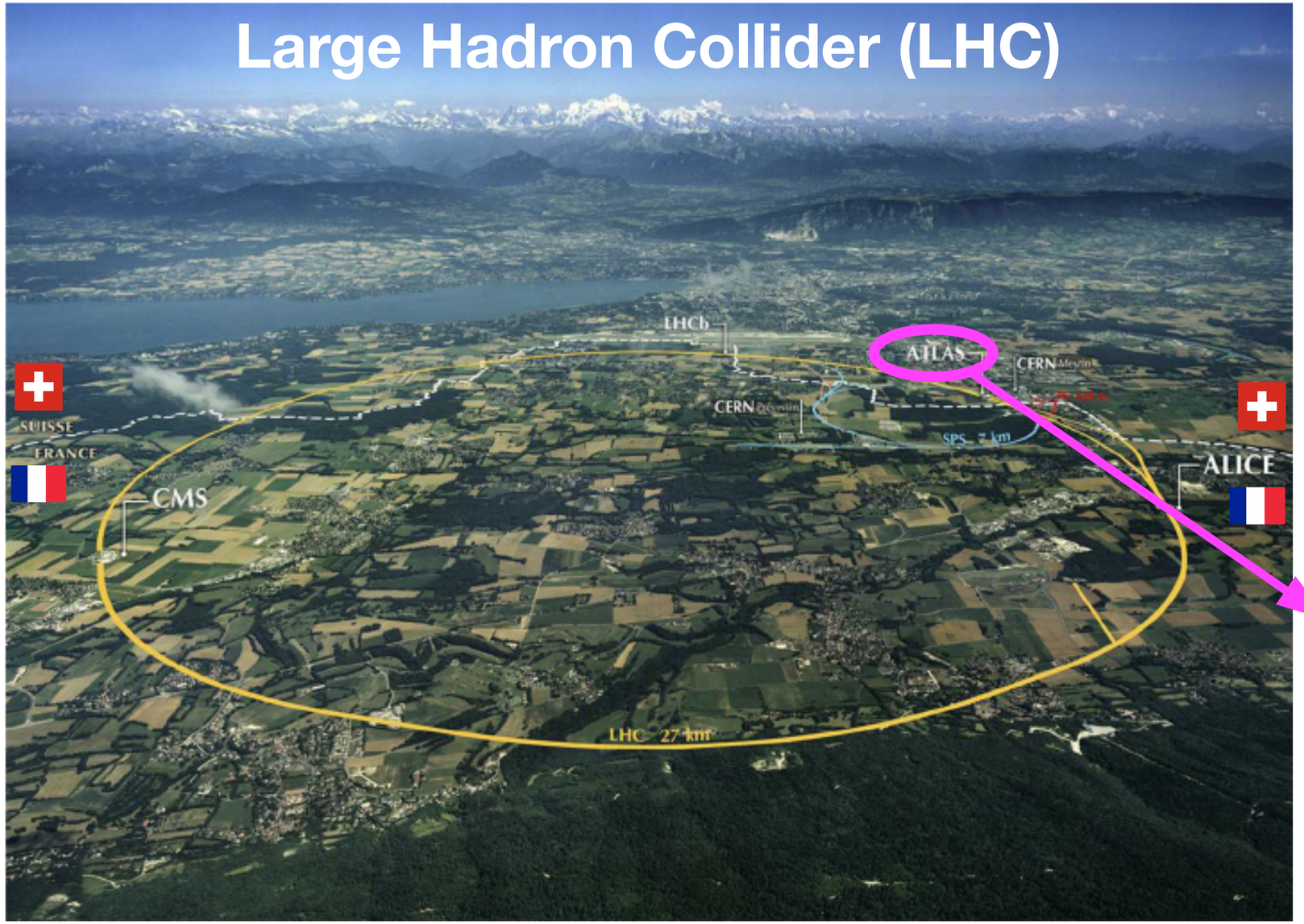


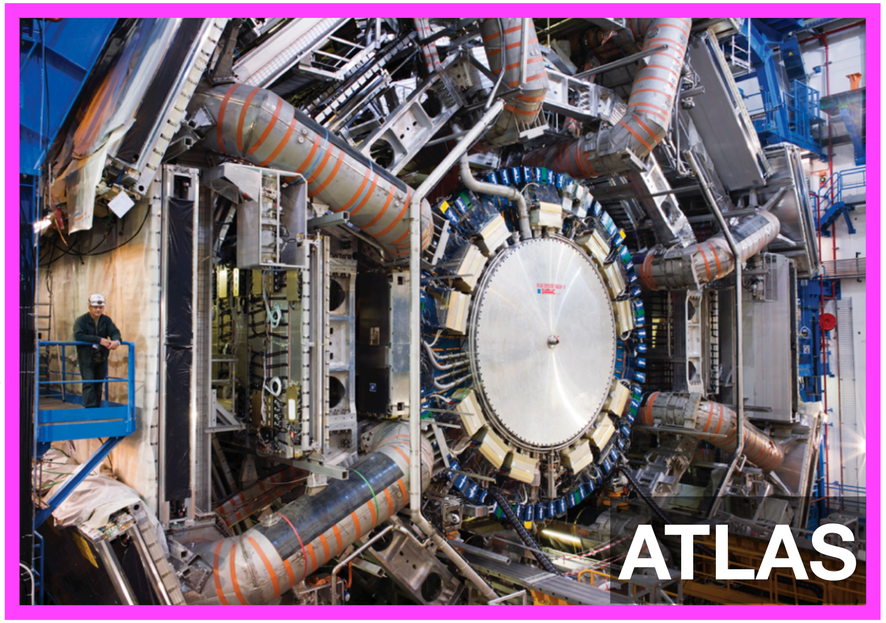
Fermions:
quarks and *leptons*
matter particles

Bosons:
force carriers

Higgs mechanism




Large Hadron Collider (LHC)
LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
CMS
ALICE
LHC 27 km


ATLAS

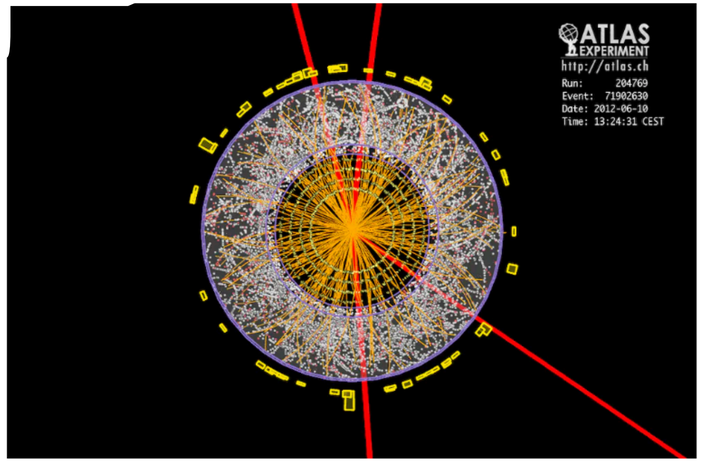
ATLAS Group at Nikhef

- 14 staff (6 UvA faculty members), 8 postdocs, 20 PhD students, 10 MSc students
  - ➡ MSc students are embedded in the group activities and research

Available Projects

Detailed description at https://wiki.nikhef.nl/education/Master_Projects

Charged particle tracking with new machine learning techniques



Main task of ATLAS detector is to capture the trajectories/ tracks from the interactions at the LHC

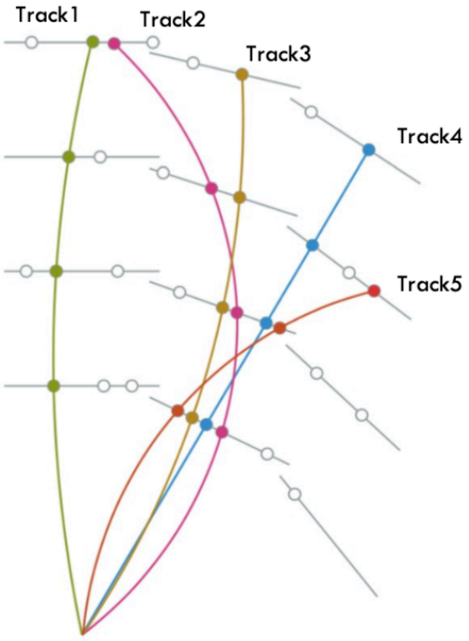
There are hundreds of these tracks in every collision and soon to be thousands!

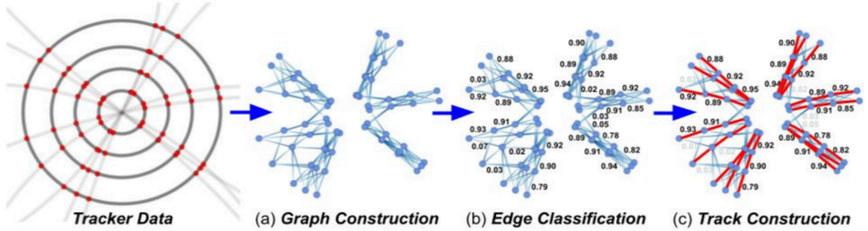
→

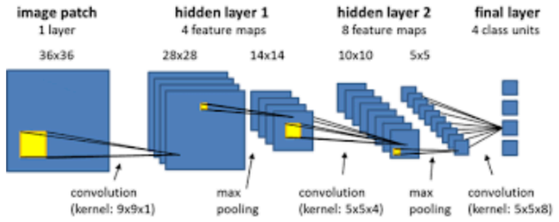
New (Machine Learning) techniques are needed!

In this project we will study performance of the state-of-the-art techniques:

Convolutional Neural Networks
Transformer Networks, …





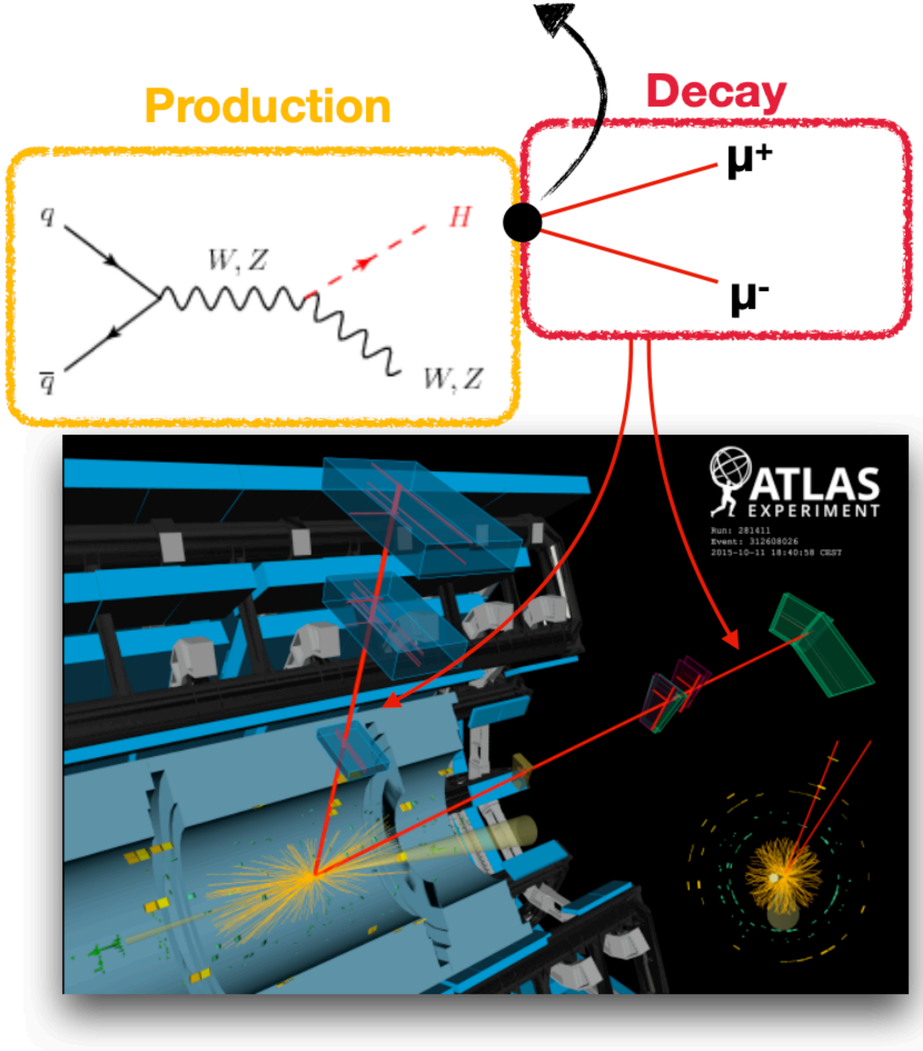


Contact:
z.wolffs@nikhef.nl and
ivo.van.vulpen@nikhef.nl

Machine learning to search for rare Higgs decays

Higgs boson coupling to light fermions of the second generation not yet observed!

- Investigating the Higgs boson coupling to light fermions of the second generation is a major project for LHC data-taking in 2022-2025
- **Higgs boson decay to muons** is the most sensitive channel for probing this coupling
- Project focuses on optimizing event selection for Higgs boson decays to muons in the **associated production with a gauge boson (VH)**
- Advanced **machine learning and deep learning algorithms** will be developed and implemented to distinguish signal events from background processes



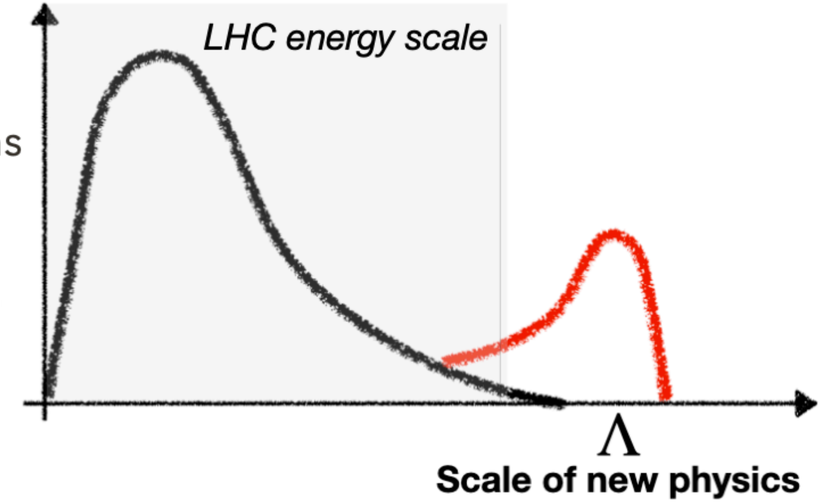
Please contact verkerke@nikhef.nl oliver.rieger@nikhef.nl

Interpretation of LHC data using SMEFT

The **Standard Model Effective Field Theory (SMEFT)** framework provides a systematic approach to test the impact of **new physics** at the energy scale of the LHC through higher-dimensional operators. The interpretation of experimental data using SMEFT requires a particular interest in solving **complex technical challenges**, and **advanced statistical techniques.**

Two projects

1. **Signal and background sensitivity in SMEFT**
   Investigate the impact of SMEFT operators on cross-sections and differential distributions for Higgs signal and background processes
2. **Probing CP-violation in the Higgs sector with SMEFT**
   Investigation of CP-odd SMEFT operators in combined measurements of the Higgs boson

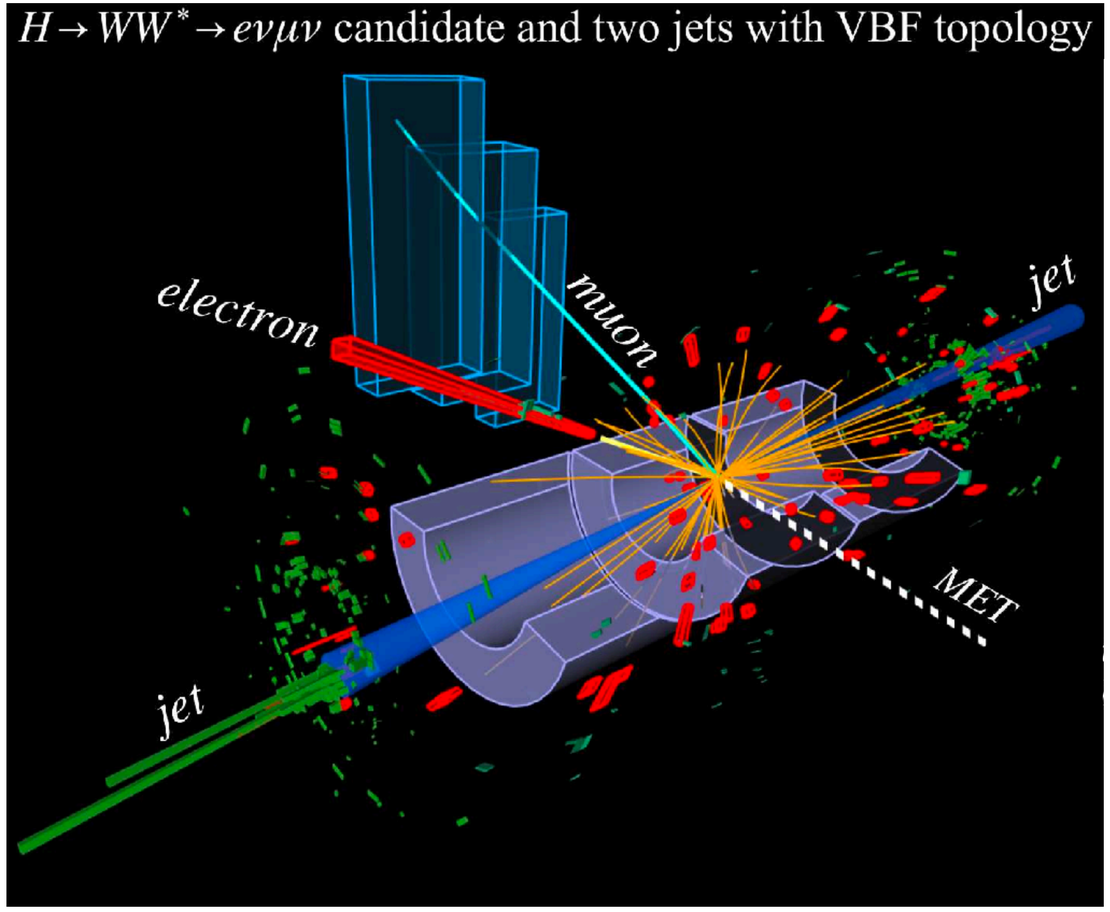


Please contact
verkerke@nikhef.nl,
oliver.rieger@nikhef.nl,
avisibil@nikhef.nl,
lbrenner@nikhef.nl

Studying rare modes of Higgs boson production

- Studying Higgs boson production and decay at the LHC might hold the key for unlocking new information about the physical laws governing our universe.
- Study the **H→WW** decays when the Higgs is produced by vector boson fusion (VBF) plus a photon emission

➡ Feasibility of measurement - not yet observed!

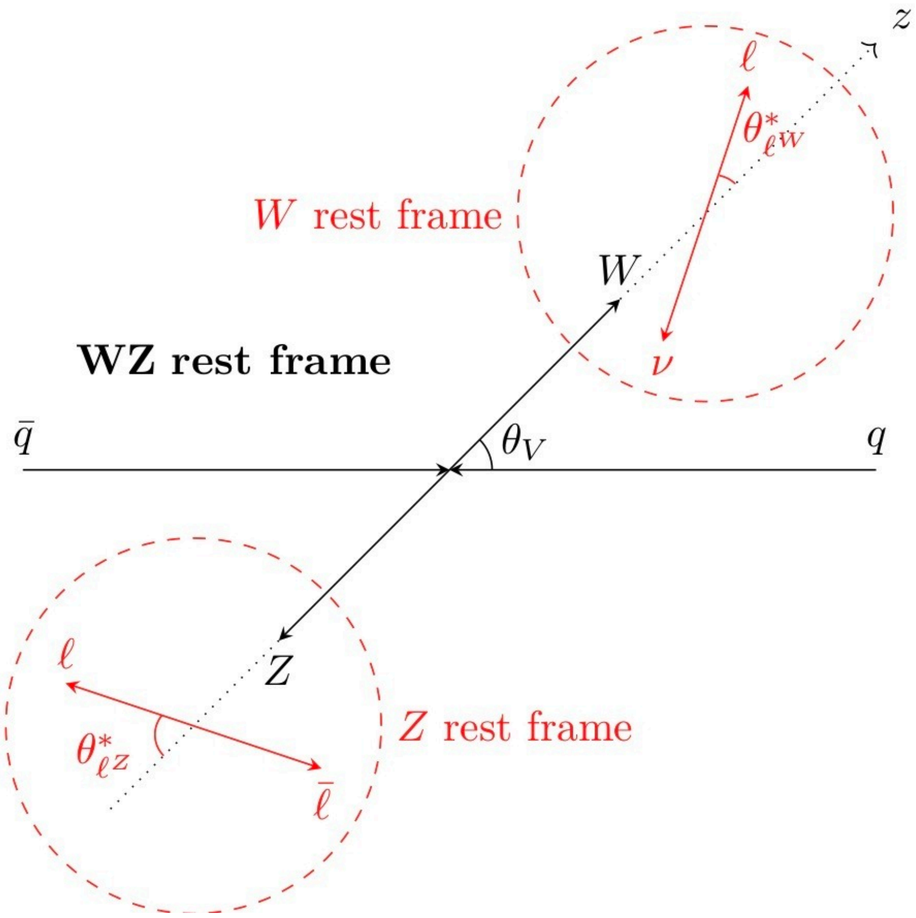


Contact:
rhayes@nikhef.nl and f.dias@nikhef.nl

Exploring triboson polarisation in loop-induced processes

- Studying polarisation of electroweak bosons (W, Z) can give an insight on how the electroweak sector works
- Study the **gg → W⁺W⁻Z** process and the angular separation between its various decay products to explore the helicity polarisation
- Project in the interface between theory and experiment

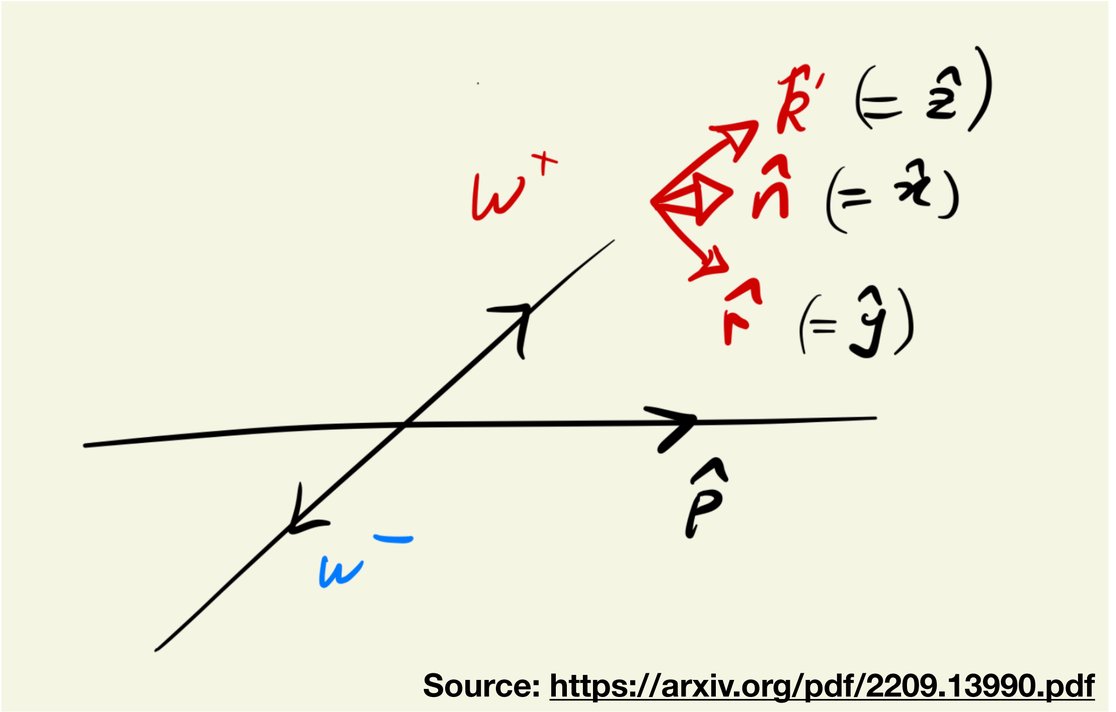
➡ Use MadGraph MC, analysis design and sensitivity with experimental tools



Contact:
f.dias@nikhef.nl

Performing a Bell test in Higgs to di-boson decays

- Test of quantum mechanics and quantum field theory using Higgs boson decays (H→WW)
- Experimental setup to check *"spooky action at a distance"* - quantum entanglement/quantum non-locality
- More on this review article: https://arxiv.org/pdf/2402.07972.pdf



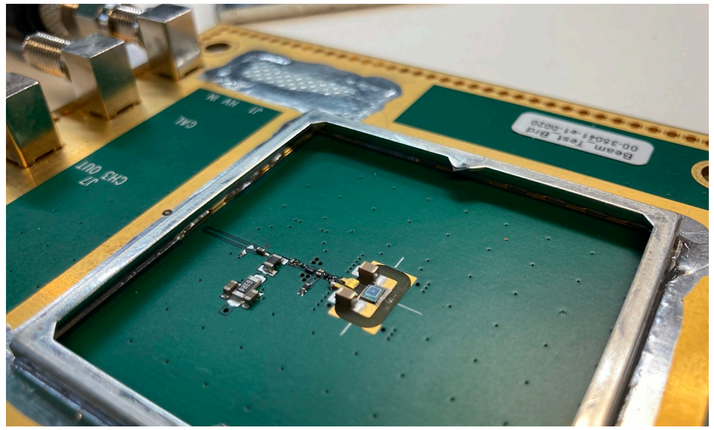
Source: https://arxiv.org/pdf/2209.13990.pdf

Figure 3: Cartoon of the right-handed coordinate axes used for the quantum state tomography of bipartite systems such as W^+W^-. The axes are aligned as indicated (with $\hat{\mathbf{n}} = \hat{\mathbf{x}}$ pointing out of the page), and are each defined in the respective bosons' rest frames. For tomography of other bipartite systems the axes are similarly defined, with the $\hat{z}$ axis parallel to the direction of the first of the two named particles in the bipartite centre-of-mass frame.

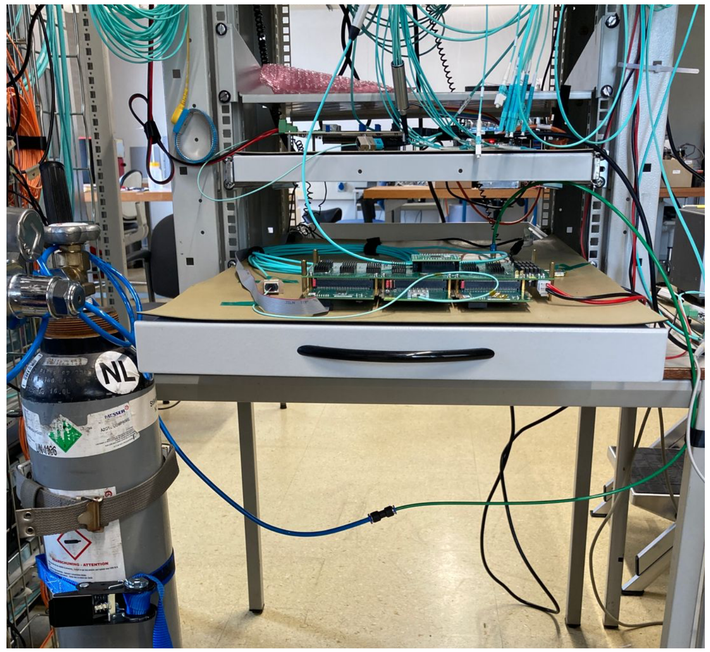
Contact:
peter.kluit@nikhef.nl

A new timing detector - the HGTD

- High-Granularity Timing Detector (HGTD) will allow to know the time (at picosecond level) of tracks from particles crossing the detector: better reconstruction of physics in ATLAS
- Detector currently under construction, projects on:
  - ➡ Study the impact on physics analysis performance (ATLAS/Nikhef)
  - ➡ Test sensors in the lab (ATLAS and R&D/Nikhef)
  - ➡ Precisely simulate/model the silicon avalanche detectors in the Allpix2 framework (ATLAS/Nikhef)



LGAD sensor on a test carrier board



FELIX+HGTD readout

Contact:
hella.snoek@nikhef.nl

Interested? Send us an email!

Detailed description at https://wiki.nikhef.nl/education/Master_Projects