

SAC, 13-4-2023

at as he as by

Radboud University

ATLAS F. Filthaut

- Group
- Physics highlights
- Upgrade activities



NIKHEF ATLAS GROUP























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9 postdocs



PHD THESIS DEFENSES IN 2022-2023

Alice Alfonsi (3/22): A tale of a new generation -Searching for dimuon decays of the higgs boson with the ATLAS detector



Marko Stamenkovic (3/22): Charming Higgs bosons: Constraint on the Higgs-charm coupling from a search for Higgs boson decays to charm quarks with the ATLAS detector Marc de Beurs (3/22): A top portal to new physics



Michiel Veen (3/23): A Look Into the Heart of the Standard Model: Searching for Heavy Higgs Bosons and Constraining the Higgs Boson Width via Its Offshell Production

On average, 4-5 defenses / year since 2019

Brian Moser (3/22): The Beauty and the Boost: a Higgs Boson Tale - Measurements of Higgs Boson Production at High Energy in Decays to Bottom Quarks and Their Interpretations with the ATLAS Experiment at the LHC

(2022 ATLAS Thesis Prize; cum laude)









ATLAS WORKSHOPS / MEETINGS IN THE NETHERLANDS



HGTD Week (RU, 6/22)

Upcoming: Top group WS (5/23)



Exotics group Workshop (9/22)



ITk mechanics Workshop (3/23)





Flavour Tagging Workshop (10/22)



CURRENT LEADERSHIP POSITIONS IN ATLAS

PHYSICS

Physics coordinator: P. Ferrari Exotics group convener: F. Dias Top-quark mass/properties convener: C. Nellist $H \rightarrow WW$ convener: R. Hayes Statistics committee: L. Brenner, W. Verkerke

COLLABORATION

CB Chair Advisory Group: W. Verkerke Early Career Scientist Board: H. Arnold

DETECTOR

ITk Strip Global Structure Activity Coordinator: M. Vreeswijk HGTD Institute Board chair: F. Filthaut HGTD DAQ coordinator: M. Wu HGTD electronics coordinator : F. Filthaut





NIKHEF ATLAS PHYSICS AMBITIONS

LS2	LHC Run-3 (300 fb ⁻¹)
	2022
	Higgs and 2nd generation fermions (µ
	Precision Higgs property measuremen
	Higgs self-couplings (di-Higgs, single i
	Dibosons (WW scattering, anomalous
đ	Anomalous couplings in top, top qua
	Data-driven and ML-driven searches f



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RECENT PHYSICS HIGHLIGHTS







t-channel single-topquark polarization





The Higgs boson's 10th anniversary



Higgs boson self-coupling constraints from single and double-Higgs production

1148 papers submitted to date (246 since 1/20)



UPGRADE CONTRIBUTIONS





MUON NEW SMALL WHEEL

L1 µ trigger rate dominated by fake (forward) muons; tracking degradation due to occupancy





NSW:

- Small-strip TGC (trigger): 8 layers
- MicroMegas (precision tracking): 8 layers

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- **B & T sensor system**
- **FELIX DAQ system**
- Implementation in simulation software



Status:

- LS2 extension has made it possible to install both New Small Wheels in ATLAS before the start of Run 3
- NSW µ triggers commissioned in 2022, expected to be deployed in 2023

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Integration in tracking ongoing





NIKHEF AND PHASE 2 MUON SYSTEM

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1.0.0

RASNIK alignment system modernized & adapted to more confined space



- Radiation hard electronics, compatible with existing readout
- New lenses & LEDs



$ELMB \rightarrow ELMB2$:

- Monitoring of T & B sensors
- Radiation tolerant controllers
- No longer needed for configuration of FE electronics

Radiation tests successful, procurement done (Nikhef + CERN)



Include MDT chambers in hardware trigger: replace mezzanine boards on all ~1000 chambers

About to be ordered



DAQ: FRONT END LINK EXCHANGE

FELIX: flexible, modular, universal DAQ system for event data, timing and trigger control



SKIP CUSTOM HARDWARE LAYER OF RODS





- Phase 1: NSW (ready for 1 MHz readout), BIS7/8 RPC, LAr and L1Calo
- Phase 2: use FELIX throughout ATLAS ullet

DETECTORS LINK DIRECTLY TO FELIX

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- **Felix firmware** (F. Schreuder f/w coordinator)
- Felix software (M. Dönszelmann s/w coordinator)

phase 1





FELIX STATUS

Phase 1

Scope: 105 FELIX cards (+ 184 as spares & for test stands) Status: 286 cards delivered, 4 with problems

Successfully used for readout of newly installed detectors & trigger systems

Phase 2

Scope: 639 FELIX cards

Challenge: 10 times higher readout rates \rightarrow upgraded system

- Ongoing f/w R&D at Nikhef (incorporating lessons learned from Phase-1 deployment)
- Mezzanine card for evaluation of 25 GB/s links Status:
- Q1 2022: Preliminary Design Review
- Versal (XCVM1802) based FLX-182 card: minor update of prototype FLX-181; expected to satisfy known requirements, but keep exploring other FPGA alternatives
- h/w review end 2023



Top level Phase-2 f/w organization



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INNER TRACKER STRIP END-CAP

Ever increasing pile-up and radiation will necessitate a new all-silicon tracker in ATLAS by 2027



 \rightarrow 165 m² of silicon, \rightarrow 2 end-caps & barrel

Provide carbon fiber support structure for both end-caps, including cooling & electrical services

• Assemble a full Strip end-cap of the new ITk tracker



SUPPORT STRUCTURE

Mechanical precision:

- petal wheels: ~ 300 µm
- local: ~ 50 μ m

First end-cap structure (EC1) ready, but

- some rework needed (petal envelope changed)
- support beams & bulkhead not yet delivered

EC2 being prepared

Petal insertion tooling and thermal enclosure (for cold tests) converged on, in collaboration with DESY



SERVICES

Cooling manifolds produced at Nikhef







Electrical patch panels procured by Nikhef Electrical cabling in collaboration with IFIC/Valencia





TIMELINE OF THE STRIP ENDCAP

Work at Nikhef



EC2 for Nikhef

- ATLAS ITk project delayed by > 1 year
- EC1 contingency • reduced to 3 months







HIGH-GRANULARITY TIMING DETECTOR



Poor (~ mm) *z* resolution for forward tracks



- 15×15-pad sensors,
- ALTIROC asic:



improved track/jet & jet/interaction association

 $1.3 \times 1.3 \text{ mm}^2 \text{ LGAD pads}$ 4 measurement layers, 8032 2-sensor modules Time Of Arrival (20 ps bins) Time Over Threshold (120 ps bins)





NIKHEF & HGTD

Nikhef joined end 2020: modest investment in initial detector, exploiting experience with FELIX anticipate larger participation in upgrade for improved radiation hardness & later ITk upgrade (connected to FASTER programme & Roadmap proposal – see next slide)

Nikhef responsibilities:

- DAQ software
- DAQ for detector certification
- Coordination (DAQ, electronics)

Also participating in DAQ activities @ CERN Demonstrator, test beam (& data analysis) Full Demonstrator test at end of 2023





LONGER-TERM AMBITIONS

Physics opportunities

- Higgs physics
 - Rich precision Higgs program in many production and decay modes
 - Higgs self-coupling in reach (for SM Higgs, possibly earlier for BSM Higgs)
- All high-p_T physics
 - Improved forward tracking (ITk/HGTD) improves sensitivity to all vector-boson fusion processes
 - Boosted and high- p_T tail events will continue to push BSM sensitivity boundaries (statistics limited)

Technical Challenges

- Dense pileup (200 collisions per bunch crossing) requires novel fast-timing tracking detectors
- Exponential increase of computing time in reconstruction (presently foreseen resources insufficient)

Ambition (FASTER ENW-XL grant and part of NWO Roadmap proposal)

- LS3 and beyond (R&D in Roadmap): novel tracking algorithms and approaches (including h/w acceleration)
- LS4 (R&D and construction in Roadmap): HGTD upgrade using more radiation-hard LGADs
- LS5 (R&D in Roadmap): Replacement of two innermost ITk barrel layers equipped with precise timing



OUTLOOK



Physics:

Wrapping up Run-2 analysis, started Run-3 analysis Focus on Higgs physics but room for other measurements (top, EW) and searches (e.g. anomalies)

Upgrade contributions:

Phase-2 contributions fully funded; significant progress despite difficult conditions (Covid) Beyond Phase 2, focus on broader use of precision timing (HGTD + 4D tracking) In parallel, increasing focus on improved tracking (with/without precision timing)

Funding:

Group has been successful recently with incidental funding: Personal grants (2 VIDI grants) + university-paid (start-up) positions NWO ENW-XL Higgs programme (7 PhD + 3 PD) + ENW-XL FASTER R&D programme (1-2 PhDs ~ related to ATLAS) Absence of long-term funding presents a risk for exploitation of ATLAS physics potential

Group outing in Groenlo, June 2022

