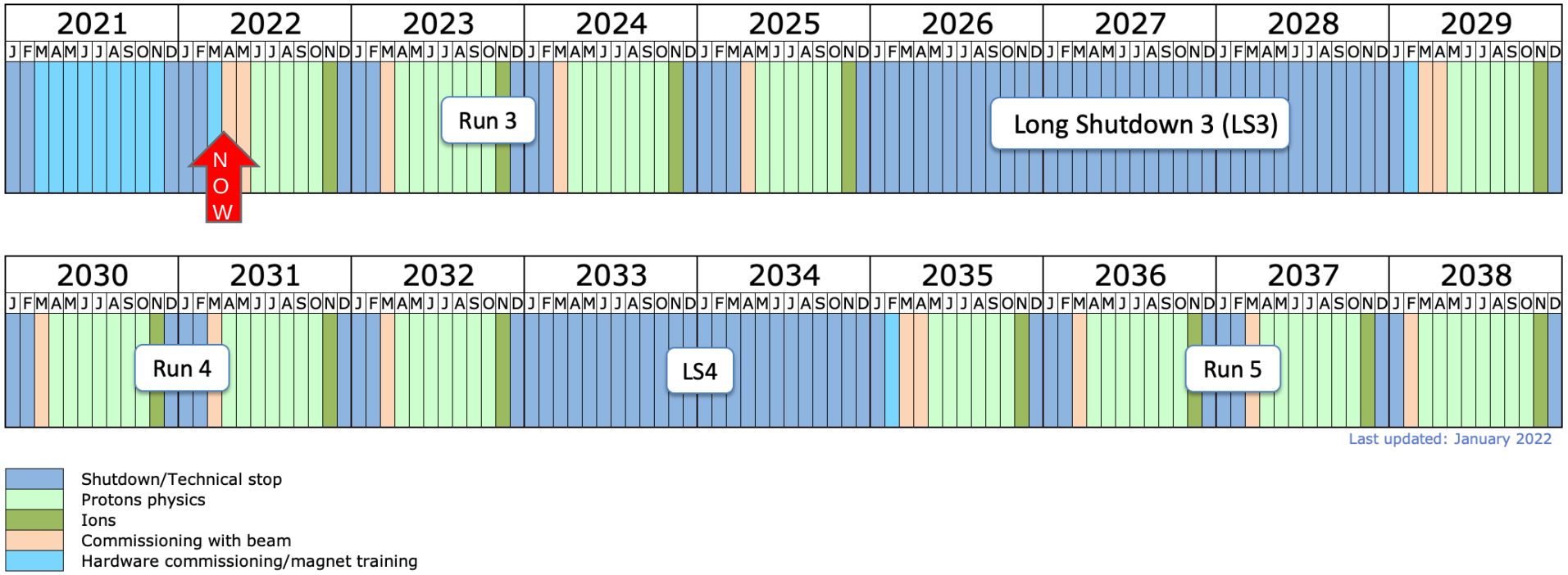
ATLAS 2025-2030

5YP-planning session

2022/04/01

ATLAS Group

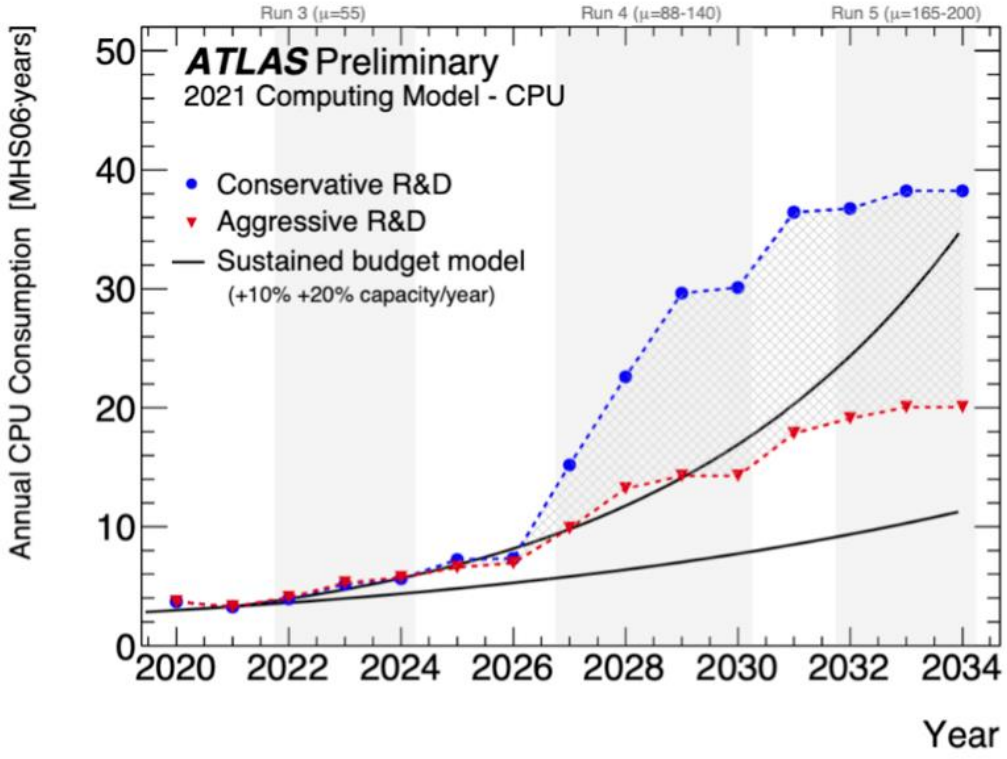
ATLAS & LHC/HL-LHC Schedule



- 2025-2030 covers last year of Run 3, all of LS3, 2 yrs of Run 4
- Priorities for TRIUMF ATLAS group:
  - Complete Phase II upgrades (ITk Strips, LAr electronics)
  - Prepare Tier 1 for 10X data rate
  - Physics analysis program: by end Run 3, dataset almost triples – transition to precision of HL-LHC

Tier-1 Data Centre for HL-LHC

- Significant scale-up for Tier-1 by 2029 HL-LHC start
- 2023 CFI NOI covers expansion to:
  - 50.7k of today's CPU cores (equiv.)
  - 63.4 PB of disk, 170 PB tape
- Covers 1st 2 yrs of HL-LHC
- Operational staff level remains constant



LAr Phase II, Muon NSW Operations

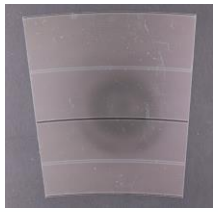
- LAr Hadronic End-Caps are major Canadian / TRIUMF contribution to ATLAS
- Phase-II LAr electronics upgrade production to be complete by 2024; no further upgrade foreseen at this time
- LAr activities in 2025-2030:
  - Operations at CERN
    - Grant-funded personnel
  - Installation, commissioning, calibration, debugging of new electronics
    - Requires time from Leonid, but no other TRIUMF resources
- Muon New Small Wheels are a recent major Canadian / TRIUMF project
- Installed now for Run 3
- Operations at CERN
  - Grant-funded personnel
- No further Canadian muon construction activities foreseen

Main contributions to ITk strip tracker

- **Sensor testing**

(about 2000 (TRIUMF + SFU)

- Visual and electrical testing
- Use of MHESA cleanroom
- 1postdoc, 1 technician, 0.5 engineer (TRIUMF)



- **Module assembly**

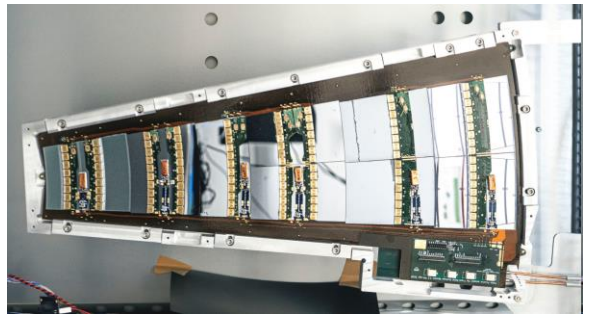
(about 1000 modules at TRIUMF + SFU)

- Assembly and tests
- Use of MHESA cleanroom
- 1 postdoc, 2 technicians, 0.5 engineer (TRIUMF)

- **Petal loading + testing**

(about 100 petals)

- Assembly and tests
- Use of MHESA cleanroom
- 1postdoc, 1 engineer, 1 technician



Technical personnel funded by CFI grant (joint SFU + TRIUMF)

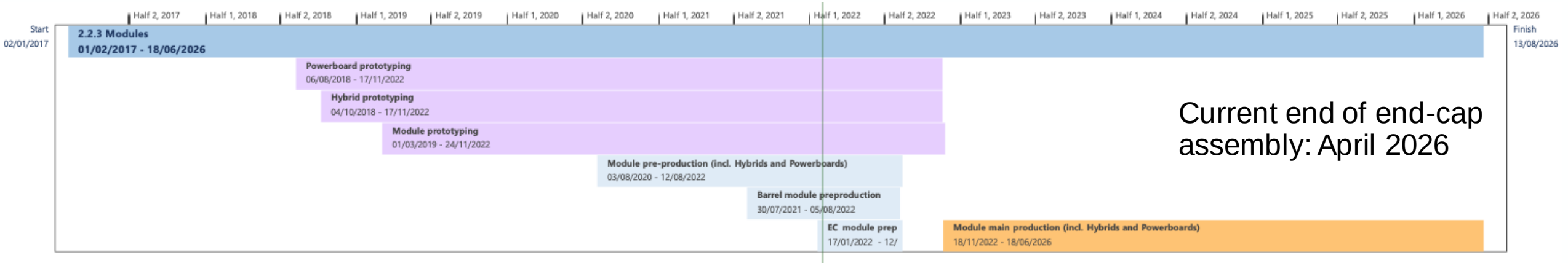
ITk project timeline

- **Sensor testing**
- Completion expected in August 2025
- Afterwards: tests of additional orders

- **Module assembly**
- Completion expected in October 2025
- Afterwards: repairs

- **Petal loading + tests**
- Completion expected in November 2025
- Afterwards: repairs

Schedule recently extended to accommodate accumulated delays

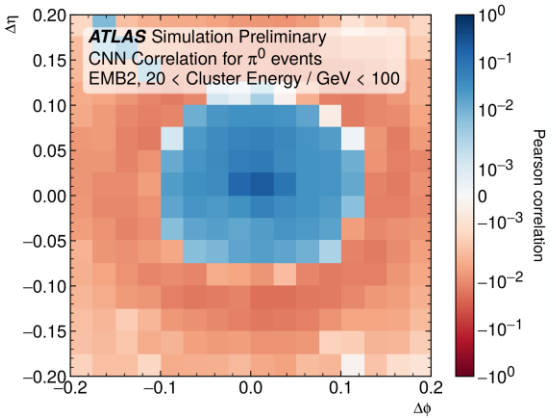


ITk Beyond 2025

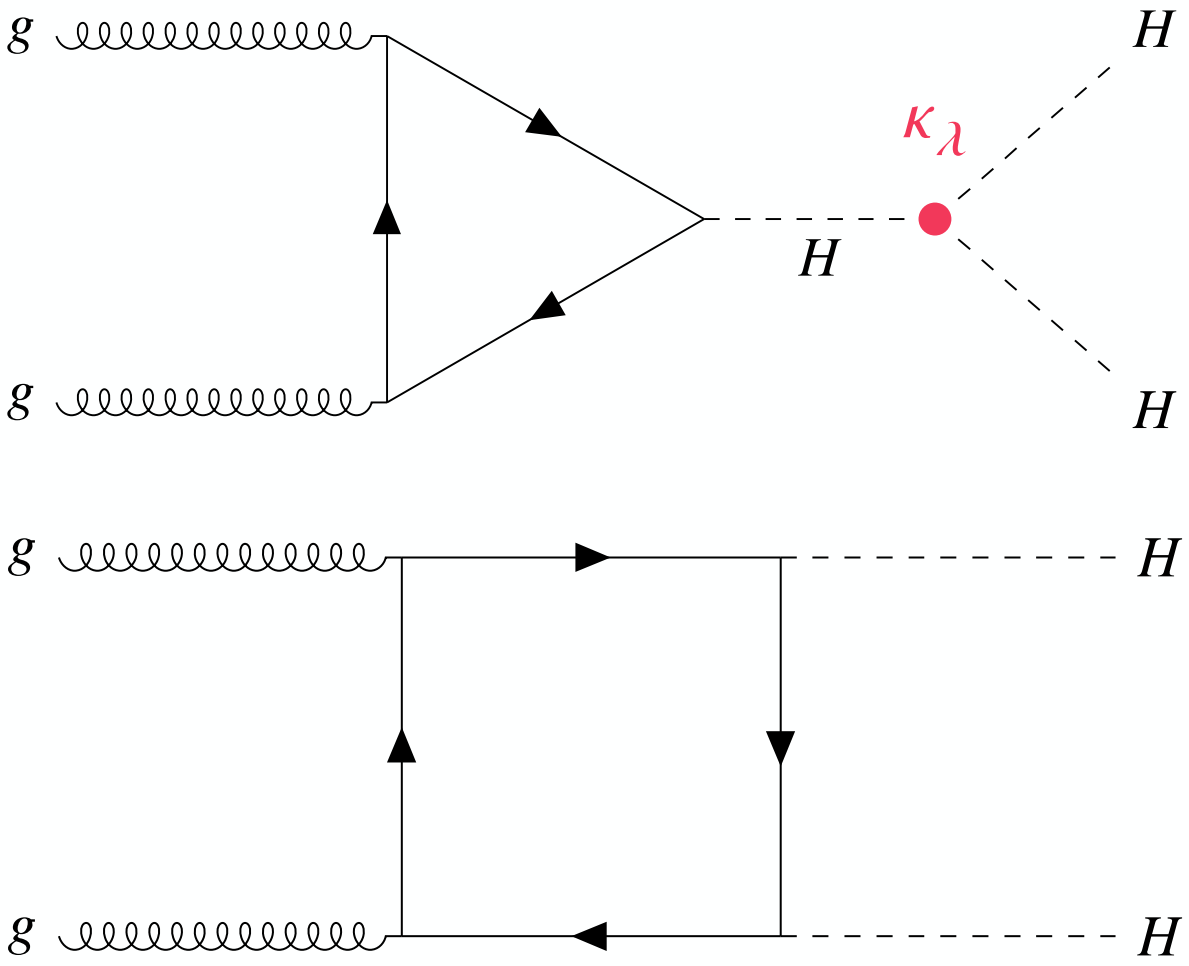
- Potential need for repairs/additional parts, continue to maintain assembly chain
- Anticipate need for follow-up measurements of any observed issues (ABCStar SRAM, ATLAS IBL, …) requiring follow-up measurements using existing test infrastructure (sensors, modules, petals)
- Performance tests of assembled structures (beam tests of full petals, irradiated substructures)
- Support of integration into end-caps/ATLAS detector
- Support operation of the ITk detector during HL-LHC, until 2038 (NSERC operating grant)

ATLAS Physics with Run 3

- Physics with 3x the dataset: huge range of interesting physics options
  - Higgs and SM measurements become more precise
  - Rare signatures (H→μμ) come into focus
  - Ultra-rare signatures (HH) may be observed for the first time!
- Search program also continuing:
  - Higher energy: small cross-section enhancements for BSM
  - New detector capabilities, especially with triggering
    - Huge rate savings from e.g. LAr and NSW Phase-1 upgrades (TRIUMF contribution): trigger can be allocated to new HH, BSM signatures, etc.
- Lots of key ongoing work and innovation in detector performance as well: muon trigger efficiency, JETM calibrations, machine learning for particle flow
  - All critical to make the most of the detector upgrades and new dataset



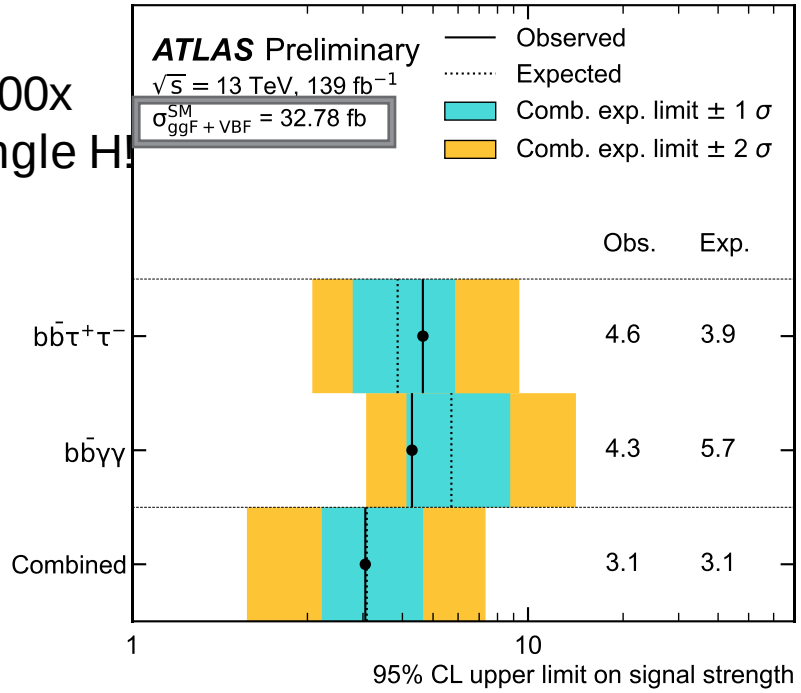
Case Example: Measuring the Higgs Potential

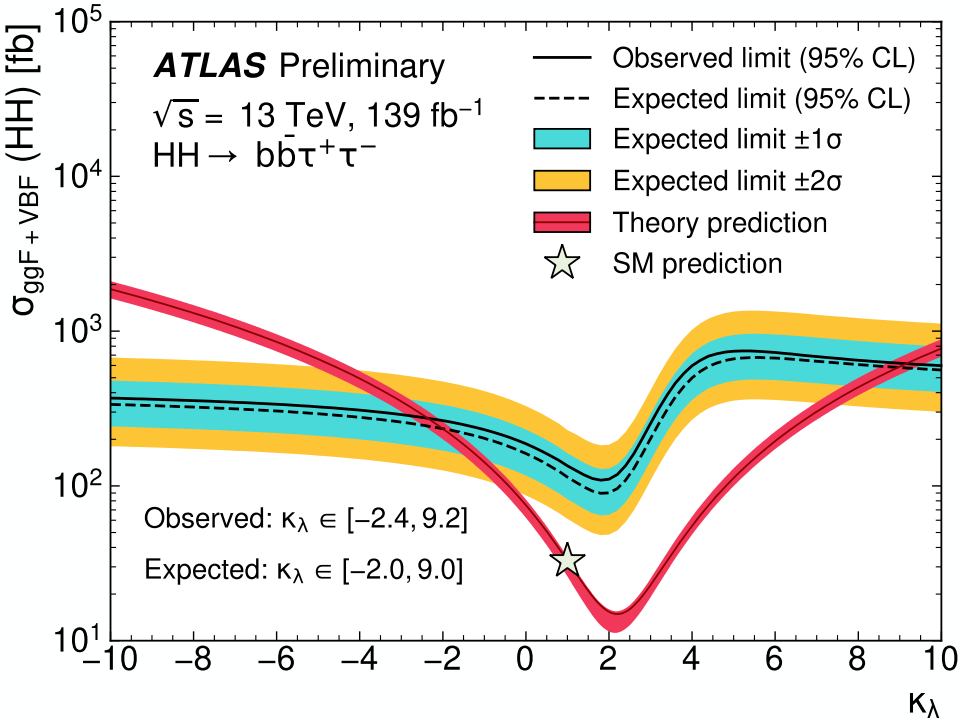


- A flagship analysis for future runs of the LHC: measuring κ_λ by measuring HH production
  - K_λ gives direct information on the Higgs potential: final unknown in SM, with important BSM effects (electroweak baryogenesis, TRIUMF theory expertise)
- Incredibly low cross-section due to destructive interference
  - Larger datasets from Run-3 and HL-LHC enable new sensitivity
  - Measurements here will be leading/competitive until ~FCC-hh!

The Higgs Potential in Run3

Factor of ~1000x lower than single H!





- 3x the dataset– sensitivity to HH down to 1.7x SM?
  - Add more channels and new ideas: down to 1.2x SM?
  - Combine with CMS: down to ~1x SM? 3σ?
  - Potentially evidence of HH before Run-4! Improving prospects for κ_λ for Run-4 and beyond

ATLAS Run 3 – Long Shutdown 3 – Run 4 Transition Period Summary

- ATLAS is now emerging from LS2 and about to start Run 3
  - Marathon to complete Phase-I upgrades (New Small Wheels, LAr)
- Run 3 will be entering final year in 2025
  - Additional dataset expected to be ~double Run 1 + Run 2
  - Several analyses enter precision phase & preparing for LH-LHC
- LS3 very tight installation schedule for Phase-II upgrades
  - Much bigger & more complex than Phase-I upgrades in LS2
  - ITk assembly & installation drives schedule
- Computing requires massive scale-up, both at Tier 1 and on shared resources at DRAC (ex-Compute Canada) sites
- TRIUMF group also has long-standing commitments in Muons (NSW operations…), LAr Calo
- Kind of like now, but: no “Phase-III” upgrades foreseen for LS4…