

ATLAS Upgrade

Zdeněk Hubáček for ATLAS CZ Groups

Setkání CZ-HEP komunity

10.1.2022



LHC / HL-LHC Plan



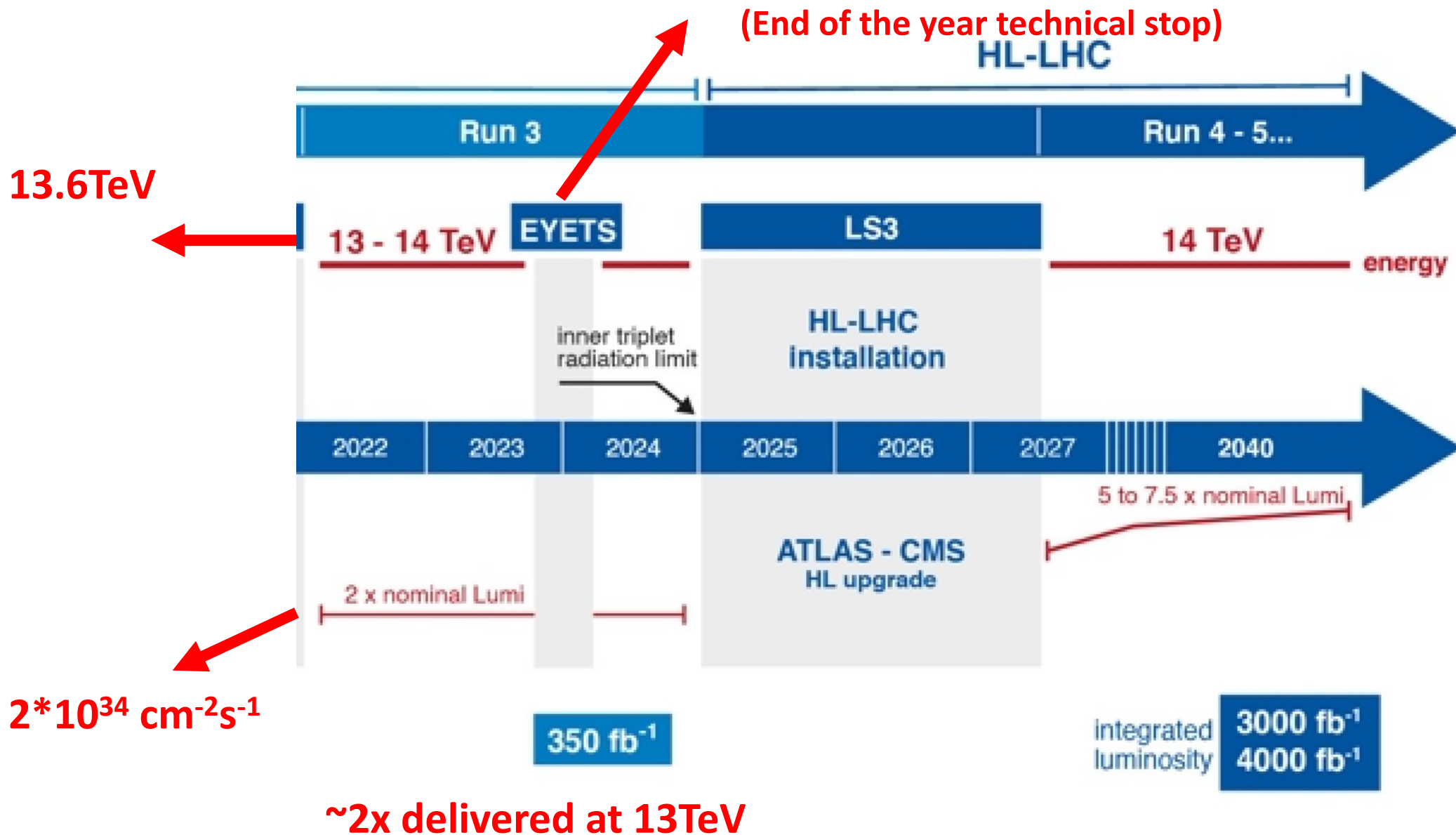
We are here!

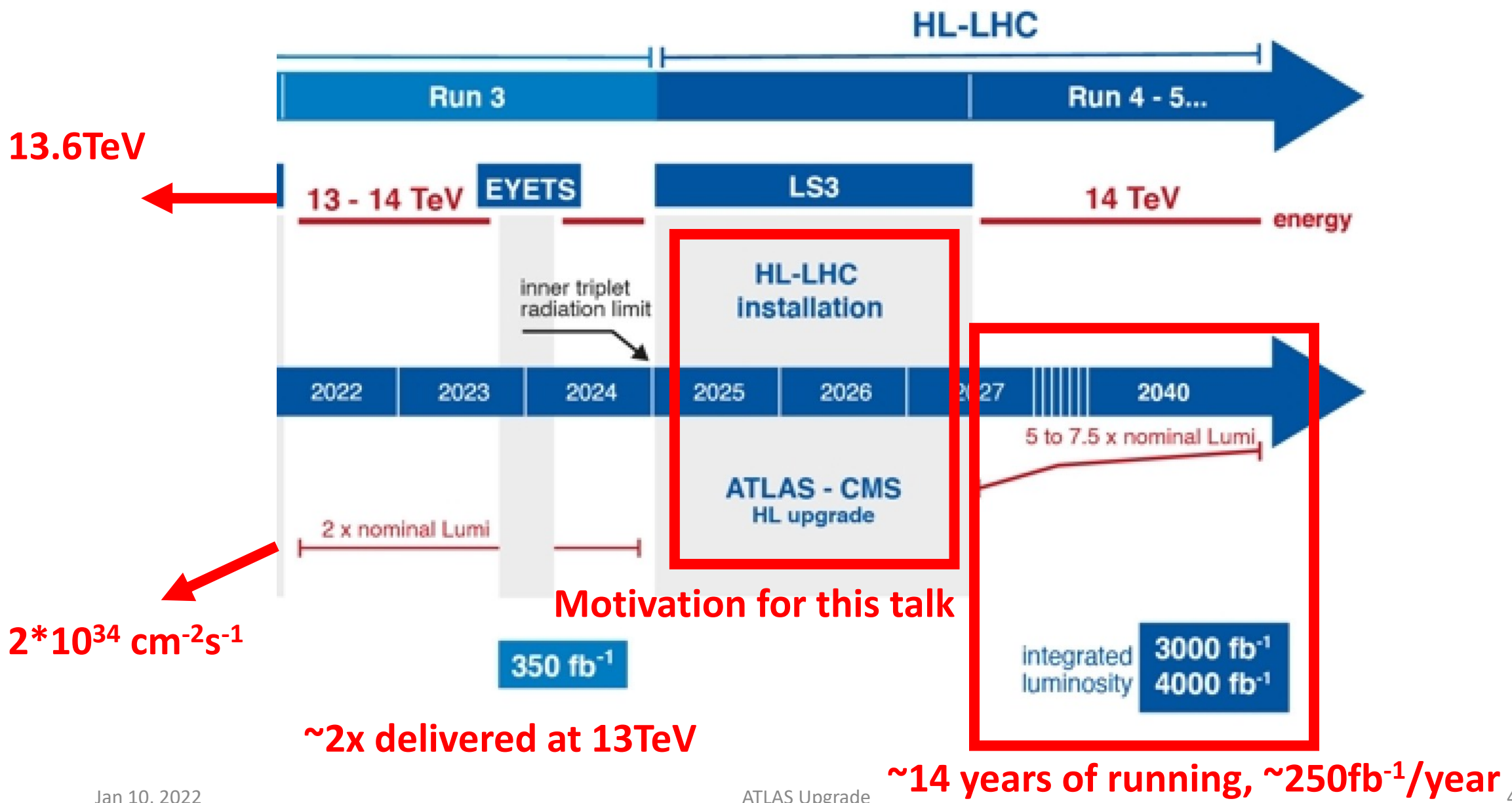
HL-LHC TECHNICAL EQUIPMENT:



HL-LHC CIVIL ENGINEERING:

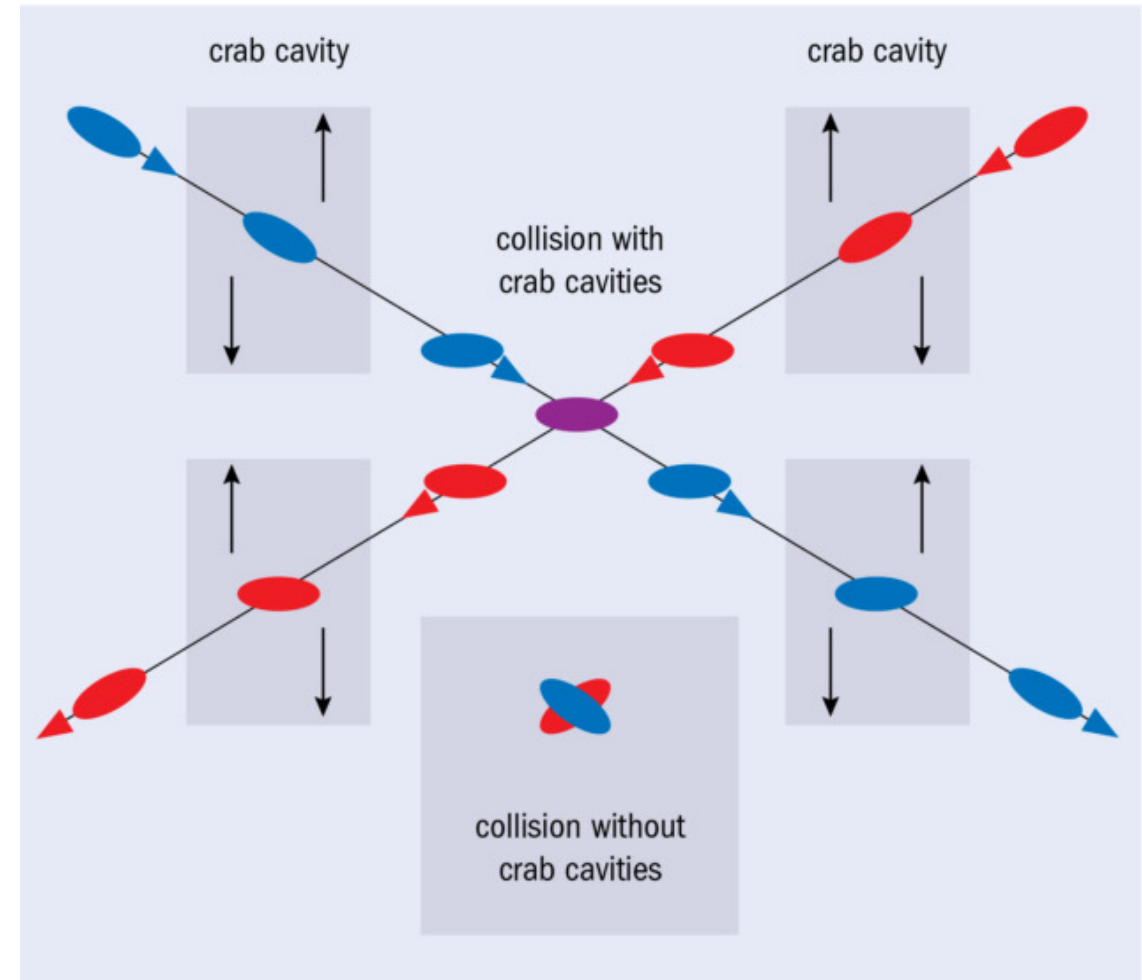






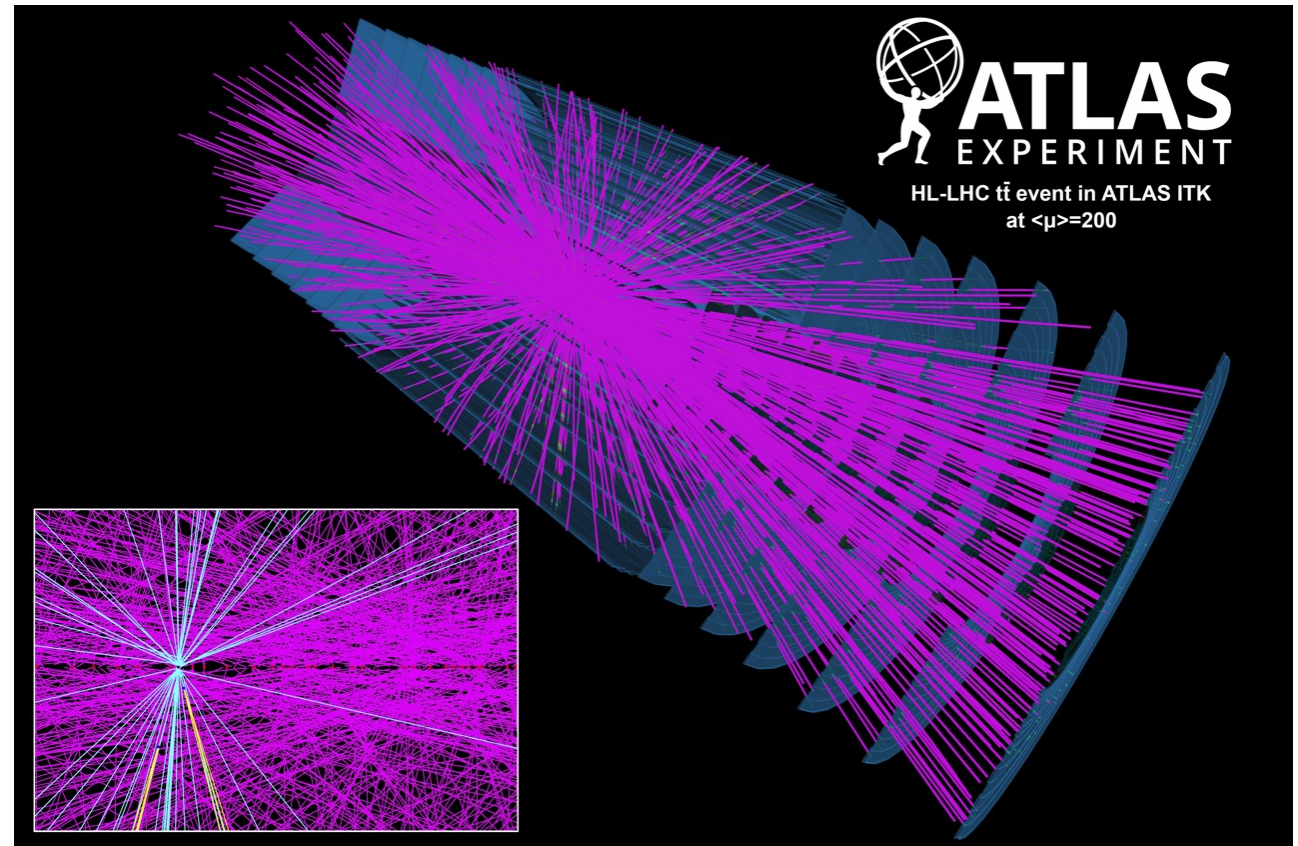
HL-LHC - $5 \cdot 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ Instantaneous Luminosity

- **Upgraded injectors** to increase the beam intensity (number of protons in bunches, NB: ~ 2800 bunches, 25ns apart)
- **Reduced β^*** (accelerator parameter related to the beam size at the interaction point) from 40-55 cm to 15 (10) cm - new inner-triplet magnets 8T \rightarrow 12T
- Larger intensities require larger beam crossing angle to avoid parasitic beam interactions which in turn reduce the luminosity gain \rightarrow new **crab cavities**



ATLAS Upgrade Motivation

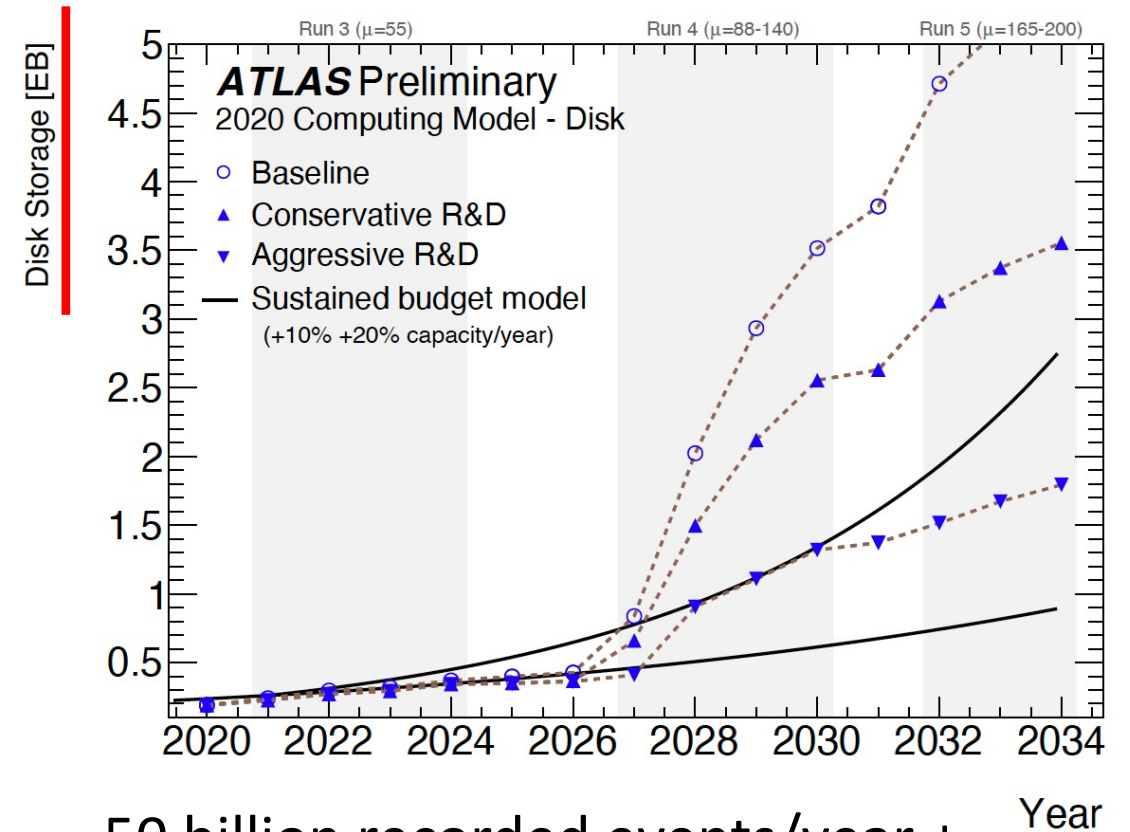
- HL-LHC goals mean larger interaction rates
 - 140 (peak 200+) interactions in the same bunch crossing (**=pileup interactions**)
 - Run2 was 30 (60)



Simulated $t\bar{t}$ event with 200 pileup interactions, purple showing tracks with $p_T > 1\text{GeV}$

ATLAS Upgrade Motivation

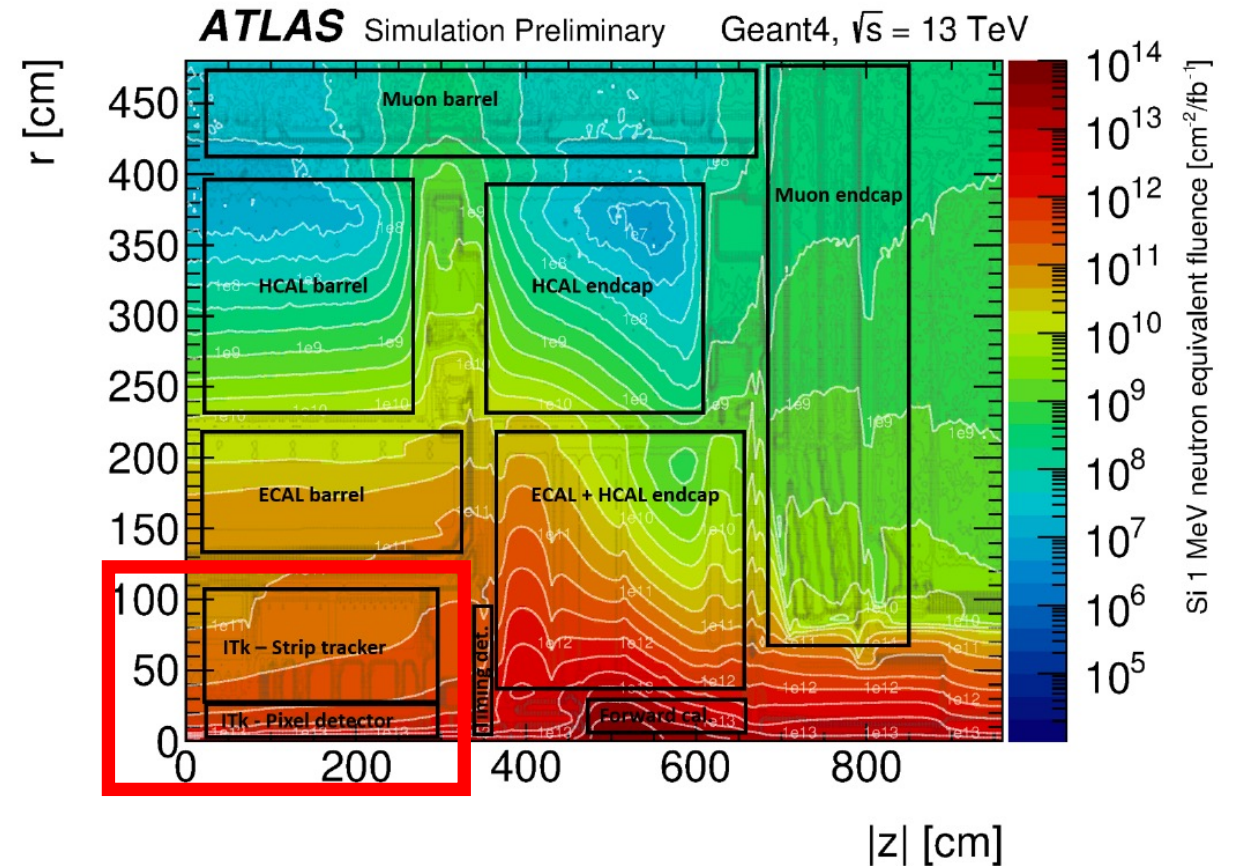
- HL-LHC goals mean larger interaction rates
- Upgrade detector electronics which was not designed for this rate (trigger, calorimeter)
 - So we can record everything we need
 - So we can reconstruct relevant physics objects effectively



50 billion recorded events/year + simulated events

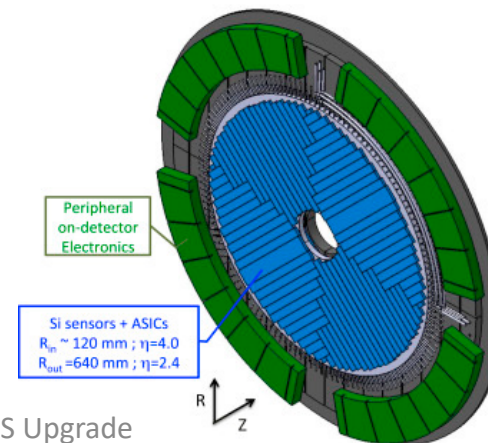
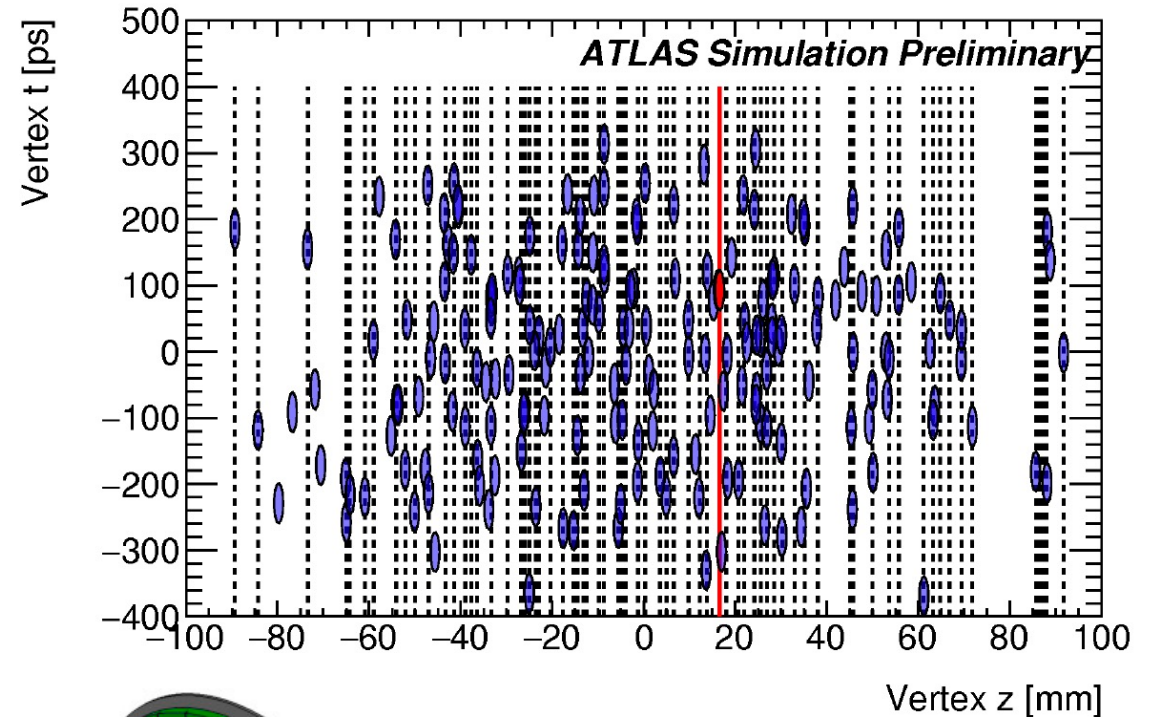
ATLAS Upgrade Motivation

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- Replace **tracking detector** (closest to the beam) with more radiation hard detectors (higher particle intensities)



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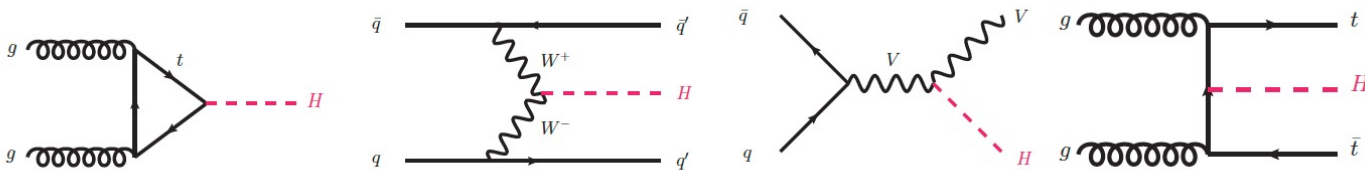
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- Add new detectors in order to possibly filter the pileup interactions – add detectors with **timing information** (High Granularity Timing Detector - **HGTD**)



50 μm thick LGAD silicon sensor, 6.4m² total active area
Timing information with 30ps resolution for tracks $2.4 < |\eta| < 4.0$

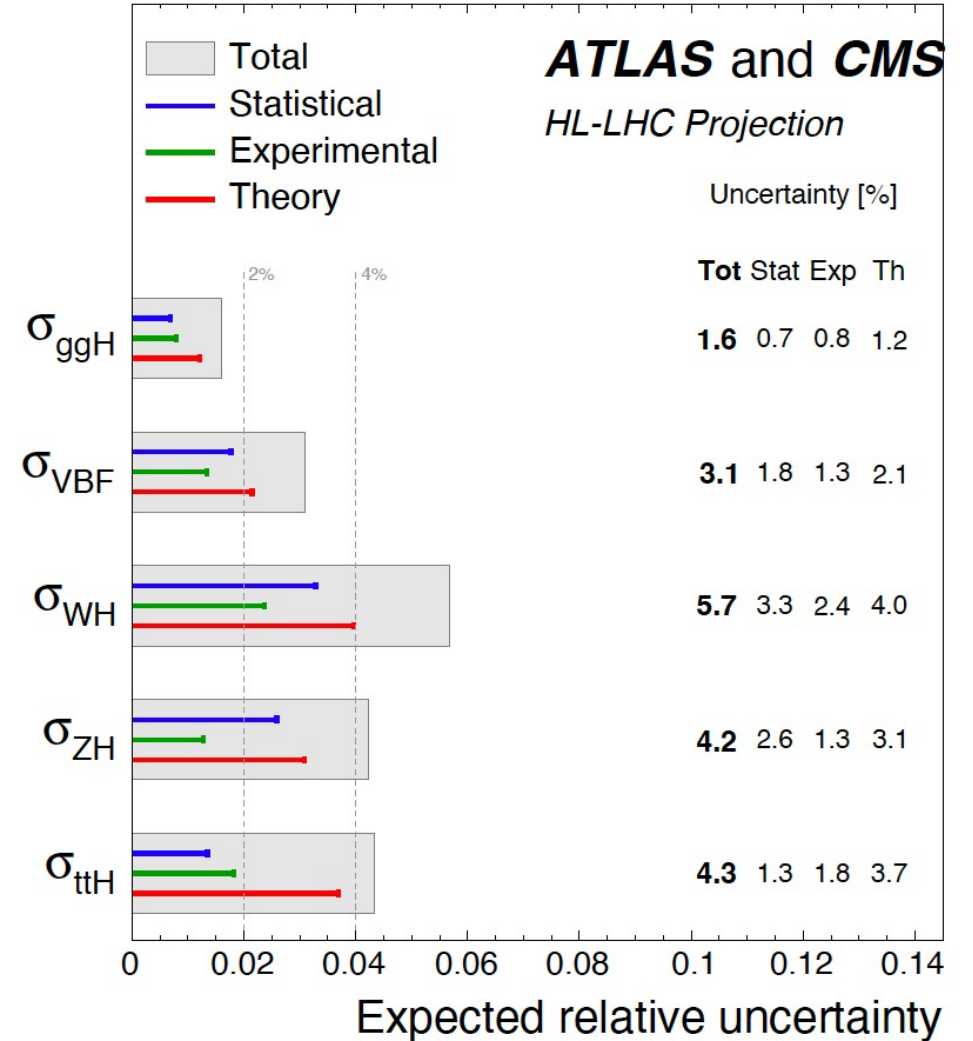
ATLAS Upgrade Physics Motivation

- Higgs factory – about $170 \cdot 10^6$ Higgs bosons will be produced, $\sim 120\text{k}$ Higgs boson pairs
- Compare to $60 \cdot 10^9$ W bosons, $6 \cdot 10^9$ Z bosons, $3 \cdot 10^9$ top quark pairs



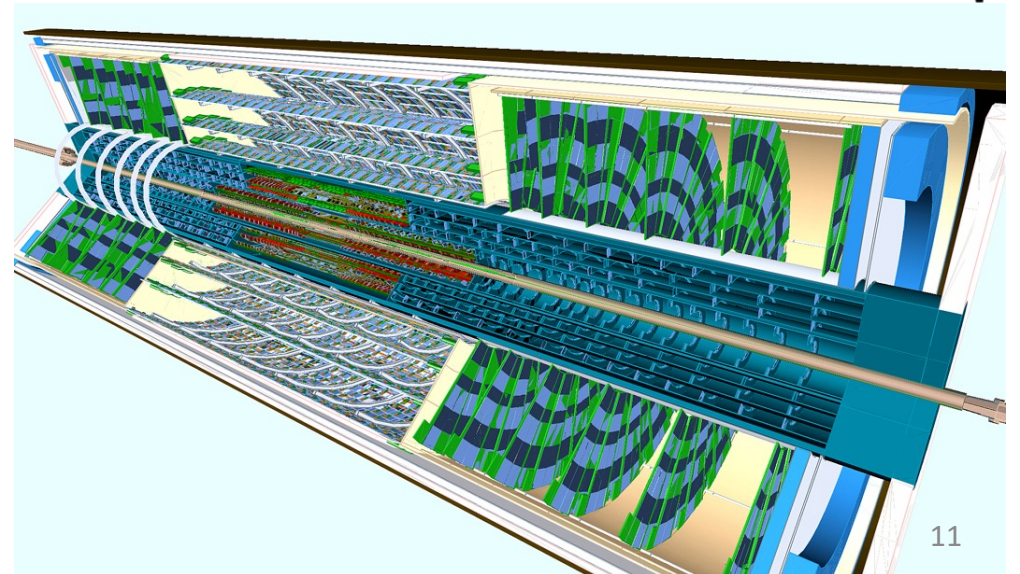
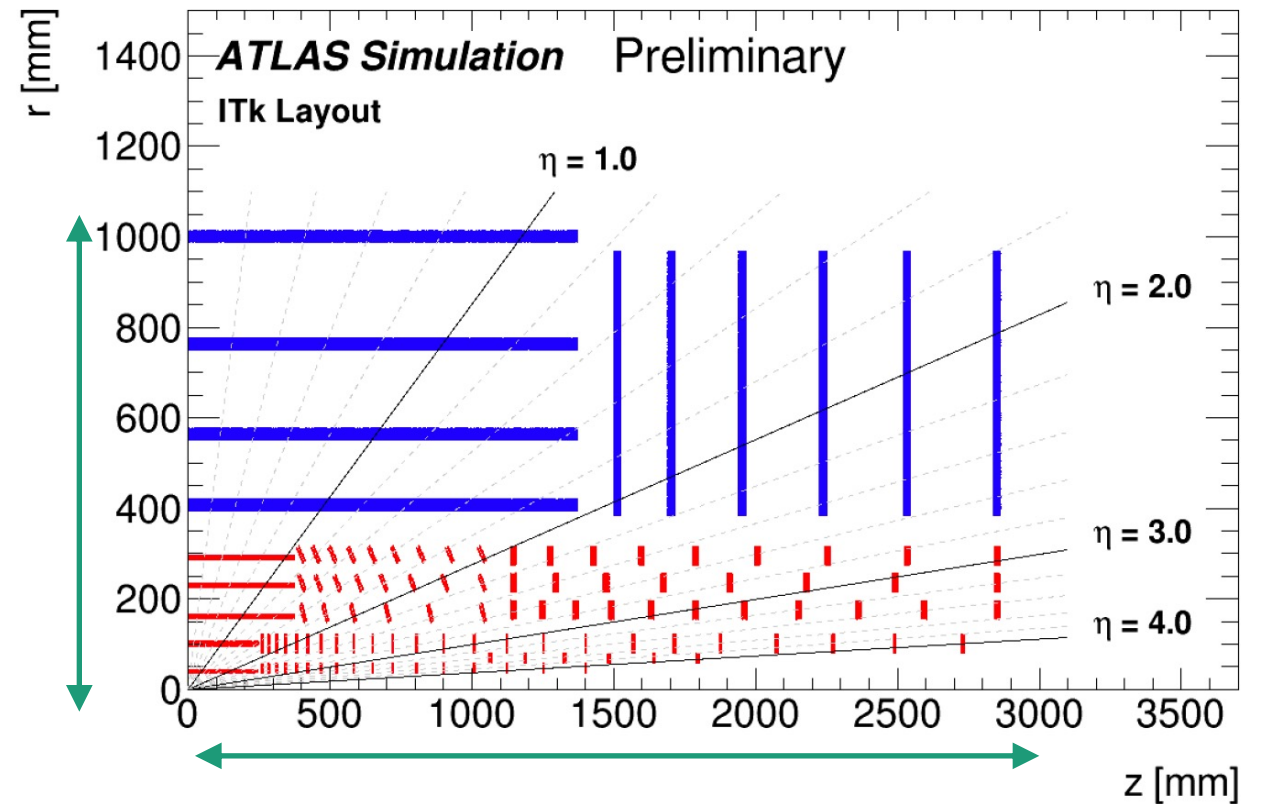
- Searches for any new physics signals beyond the Standard Model

$\sqrt{s} = 14 \text{ TeV}, 3000 \text{ fb}^{-1}$ per experiment



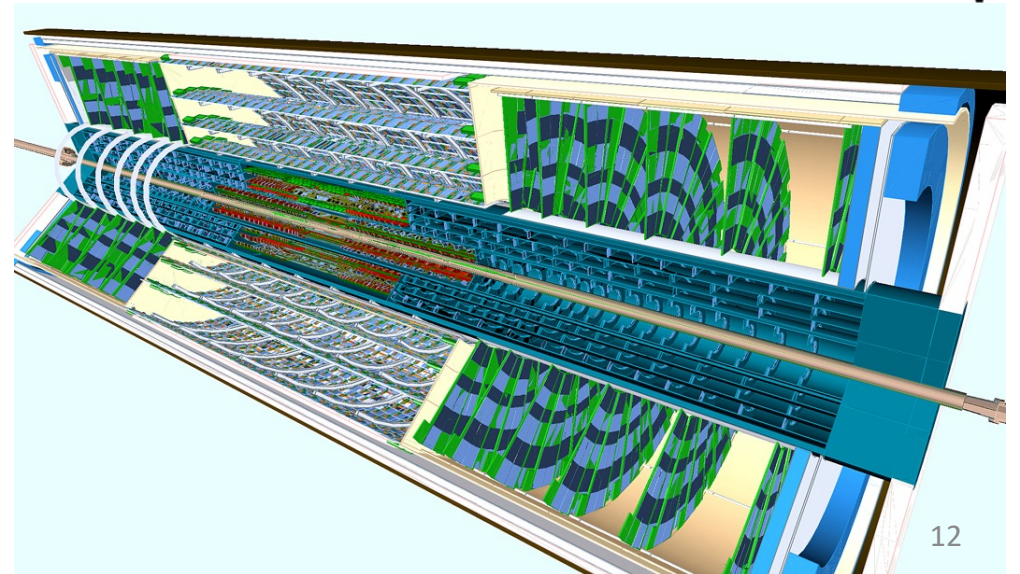
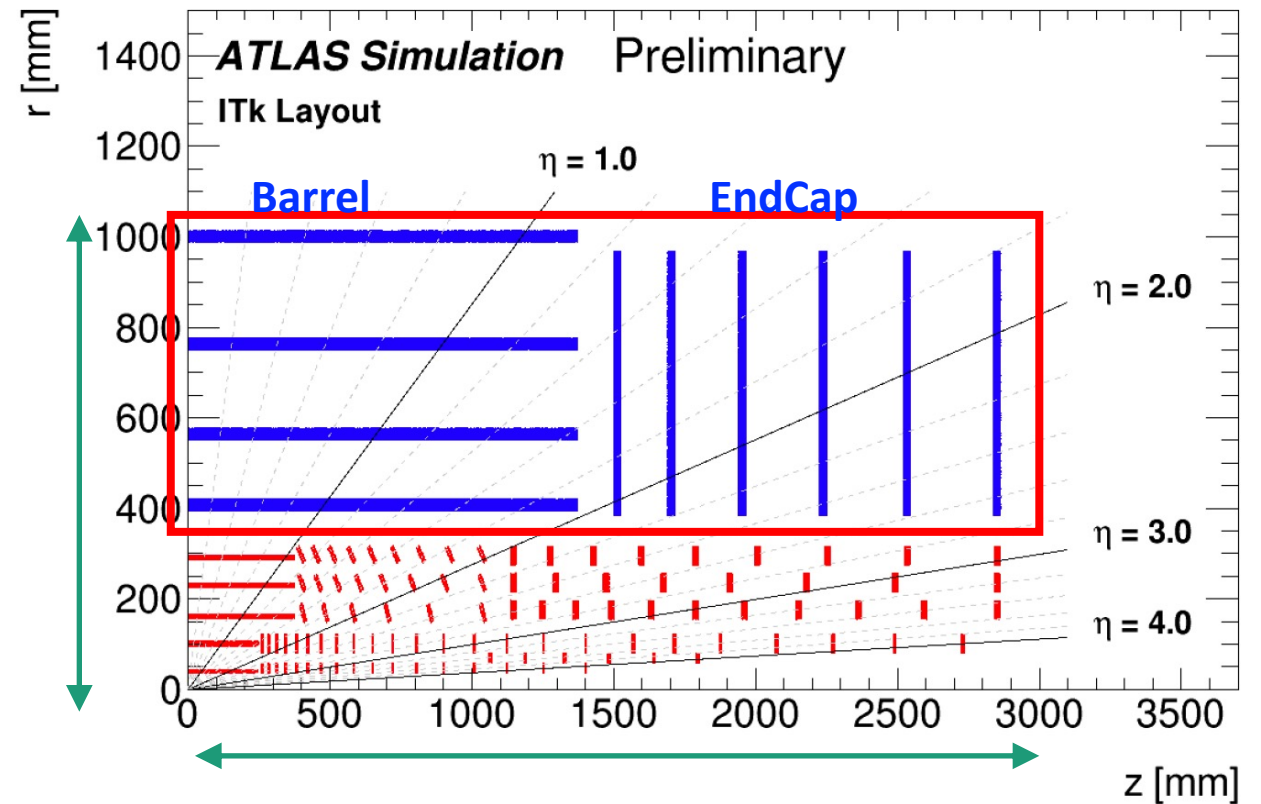
ATLAS Inner Tracker (ITk)

- Current inner detector designed only for 400-800 fb⁻¹
- To be replaced with a new all-silicon tracking detector made of 2 parts
 - **Strip subsystem** $|\eta| < 2.7$
 - **Pixel subsystem** $|\eta| < 4$
 - (extended reach w.r.t to the current detector)
 - Increased granularity
 - Together at least 9 precision hits for track
 - Designed to reduce material budget



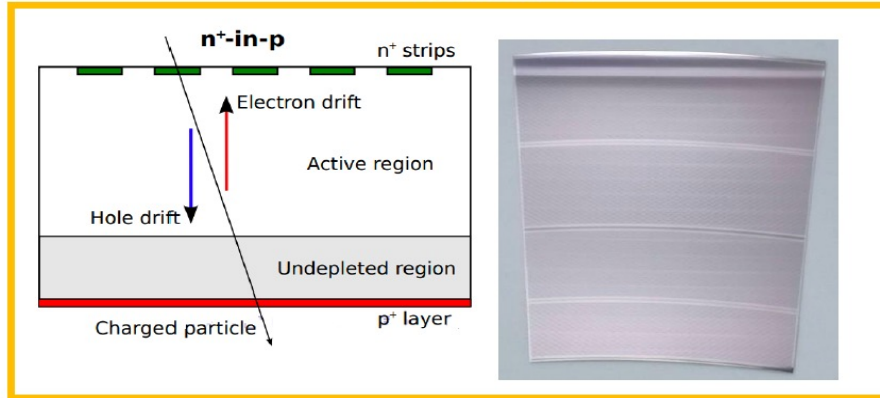
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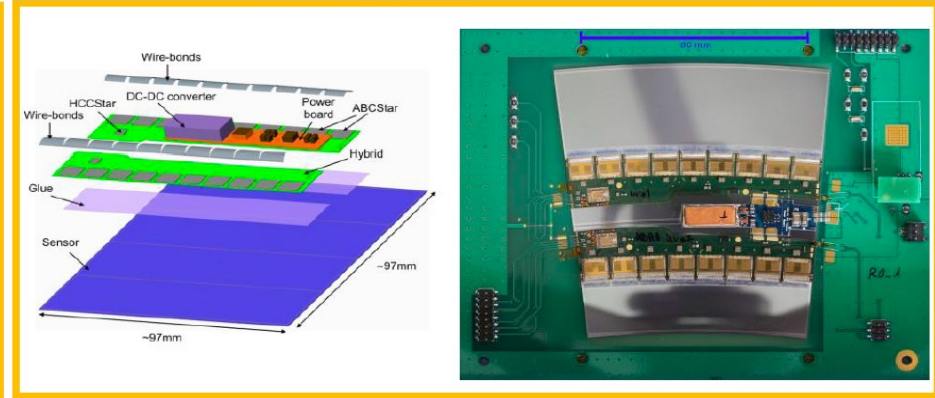


ATLAS ITk Strip Detector

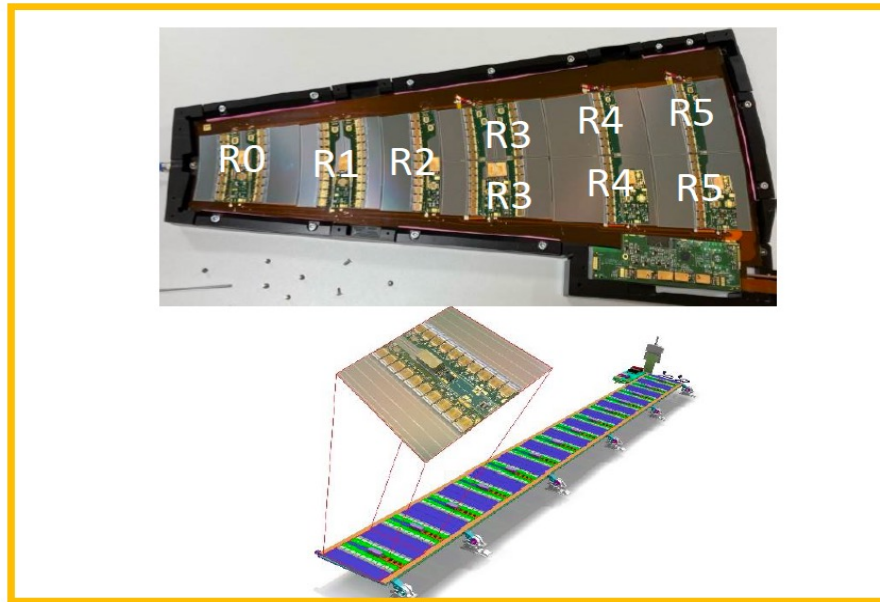
SENSORS



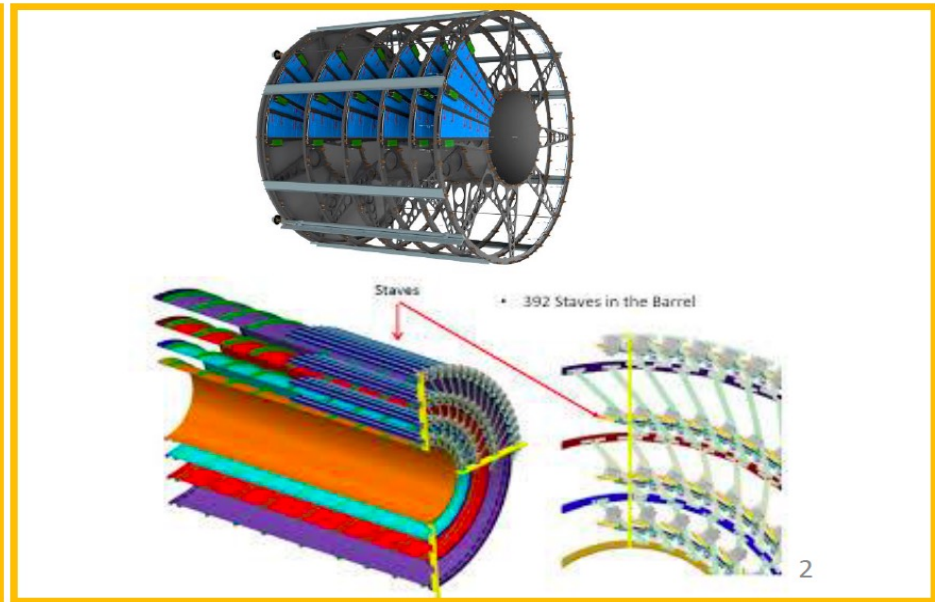
MODULES



LOCAL SUPPORT STRUCTURES

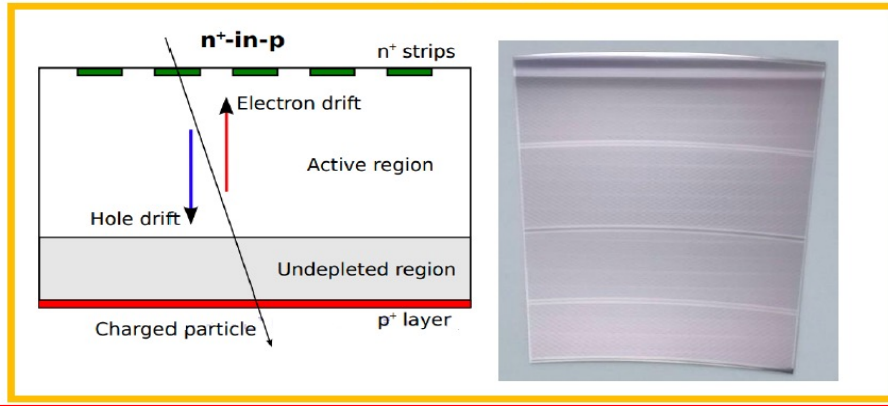


GLOBAL SUPPORT STRUCTURES

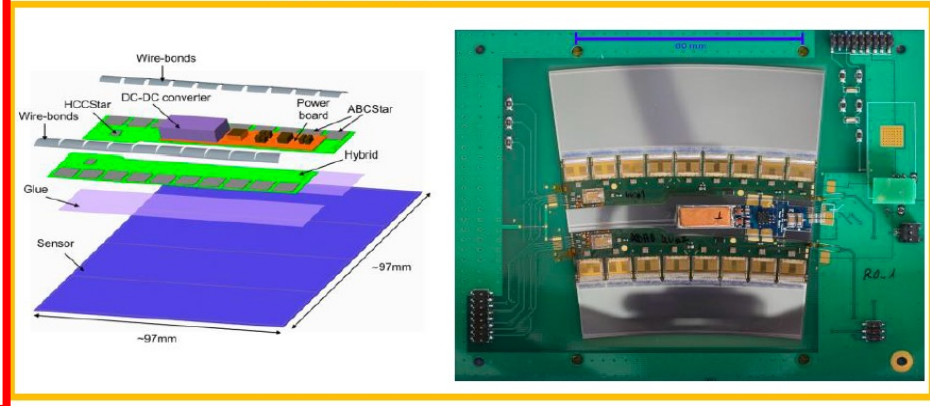


ATLAS ITk Strip Detector

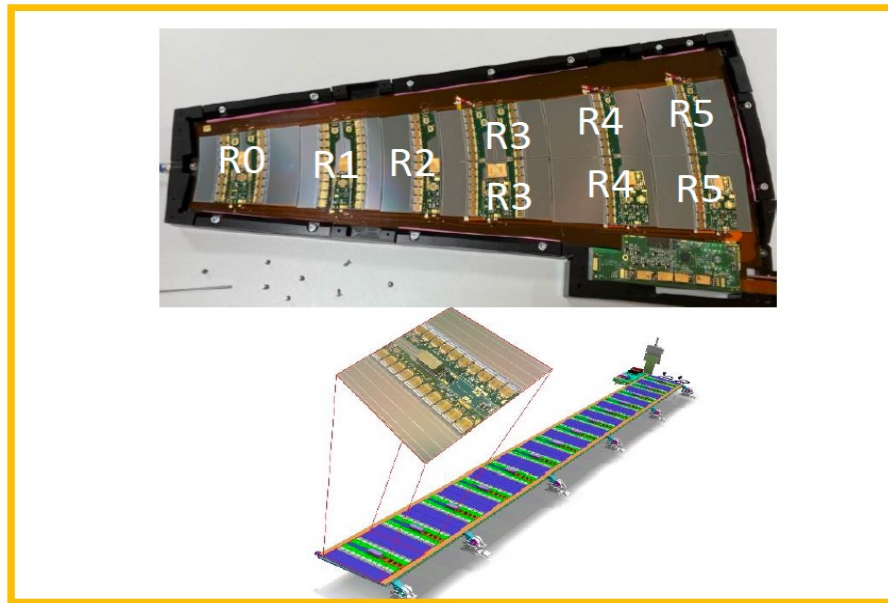
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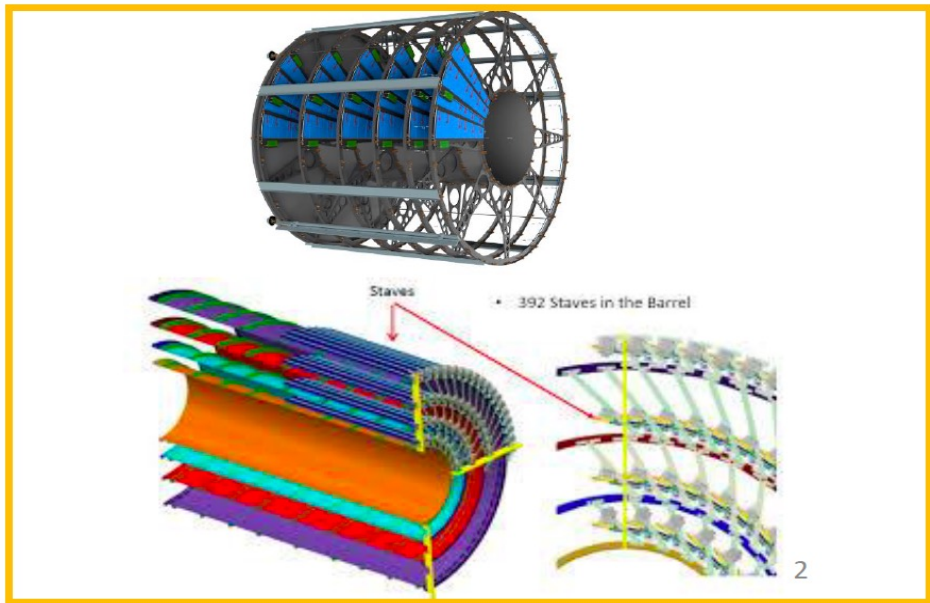
MODULES



LOCAL SUPPORT STRUCTURES



GLOBAL SUPPORT STRUCTURES



ITk Strip Sensor Testing

- Sensor Quality Control (QC) – 4500 (50%) of EndCap sensors will be tested in Prague
- Sensor Quality Assurance (QA)– UJP Praha ^{60}Co γ irradiation
- Largest commitment of Czech groups in ATLAS Upgrade – **13+ FTE in 2021!**

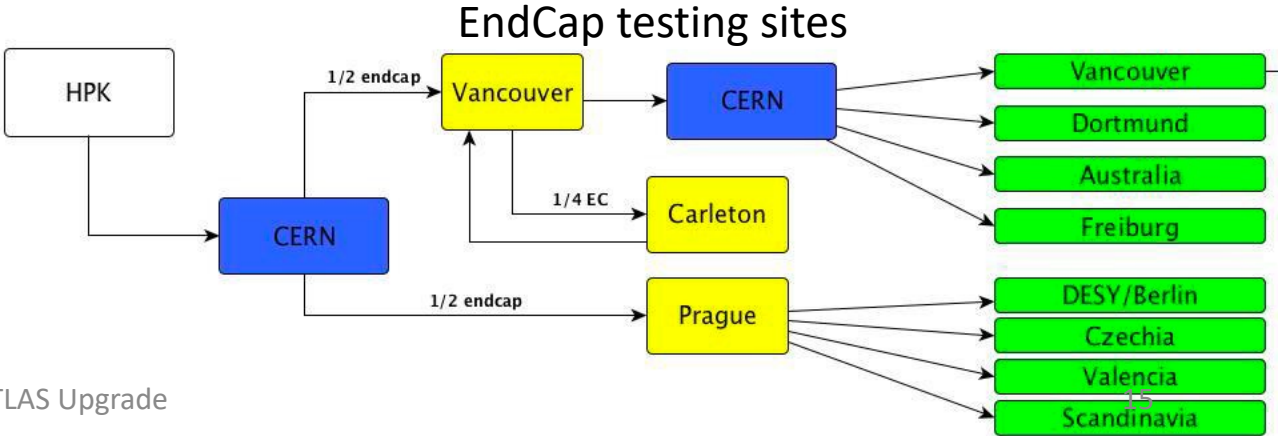


ATLAS COLLABORATION

ANNEX 1: List of Upgrade Institutes and Contact Persons

Institutes by Funding Agency	Institute Short Name
Czech Republic	
Palacký University, RCPTM, Joint Laboratory of Optics, Olomouc	Olomouc
Institute of Physics of the Czech Academy of Sciences, Prague	Prague AS
Czech Technical University in Prague, Prague	Prague CTU
Charles University, Faculty of Mathematics and Physics, Prague	Prague CU

Jan 10, 2022 Physics, Prague



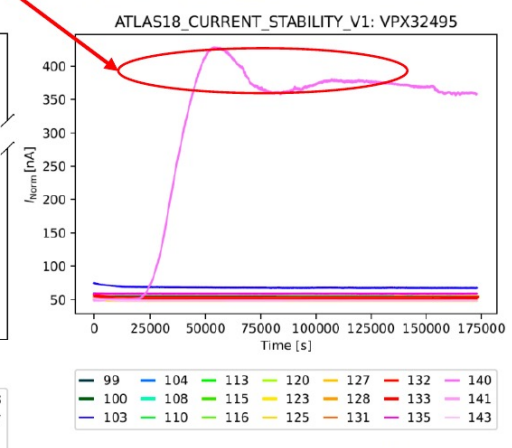
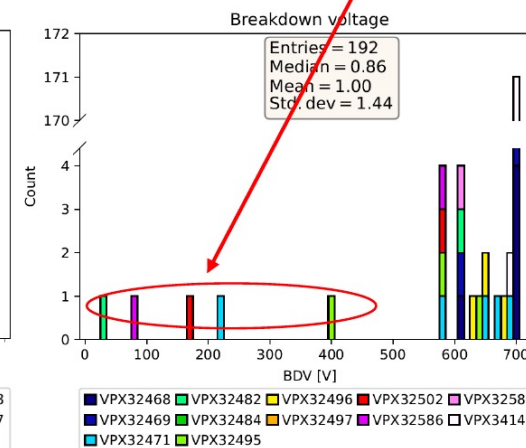
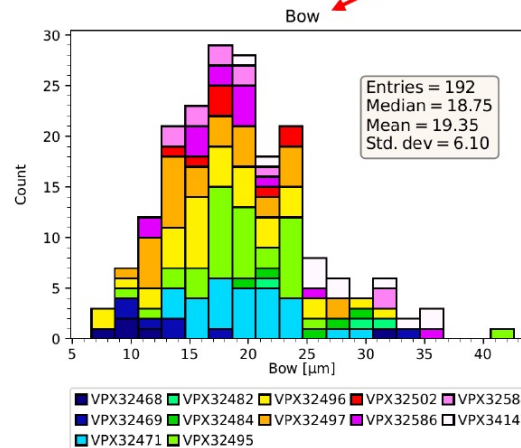
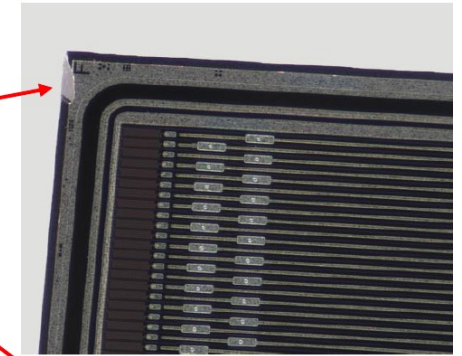
ATLAS Upgrade

ITk Strip Sensor Schedule

- Pre-production – 200 sensors tested in 2020-2021
- 09/2021 IoP received first production batches
- 2021 – 2024 production testing (4500 sensors)

Pre-production test summary at IoP

Basic Summary for Each Test Type			
Test Type	Measured	DBPass	DBFail
ATLAS18_VIS_INSPECTION_V2	192	191	1
ATLAS18_SHAPE_METROLOGY_V1	192	192	0
ATLAS18_MAIN_THICKNESS_V1	192	192	0
ATLAS18_IV_TEST_V1	192	187	5
ATLAS18_CV_TEST_V1	192	192	0
ATLAS18_CURRENT_STABILITY_V1	90	86	4
ATLAS18_FULLSTRIP_STD_V1	40	39	1
ATLAS18_KEKTEST_NEW_V1	0	0	0



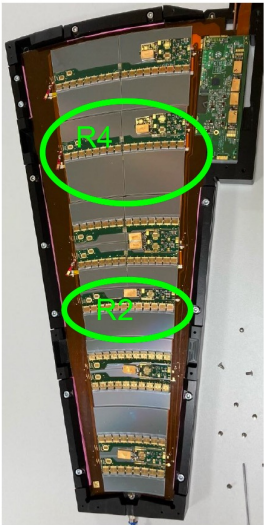
ITk Strip Module Assembly

Czech Module Commitments

9% of EC modules, (approx. 700, R2/R4 designs)

- reception QC (Prague, joint lab@CAS)
- assembly (Argotech, Trutnov)
- wire-bonding (Argotech, Trutnov)
- final QC testing (Prague, lab@CAS)
- shipping (Prague, lab@CAS -> Valencia)

- 2022 – prototyping + production readiness review
- 08/2022-06/2026 – production (approx 340xR2 + 340xR4 modules)



Summary

- HL-LHC instantaneous luminosity $5 \cdot 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ will bring on average 140 interactions in the same bunch crossing
- ATLAS Detector upgrade
- Completely new Inner tracker (ITk)
- Czech contribution to ITk Strip sensor testing and assembly