Laboratoire d'Annecy-le-Vieux de Physique des Particules

Computing physics at High-Luminosity LHC

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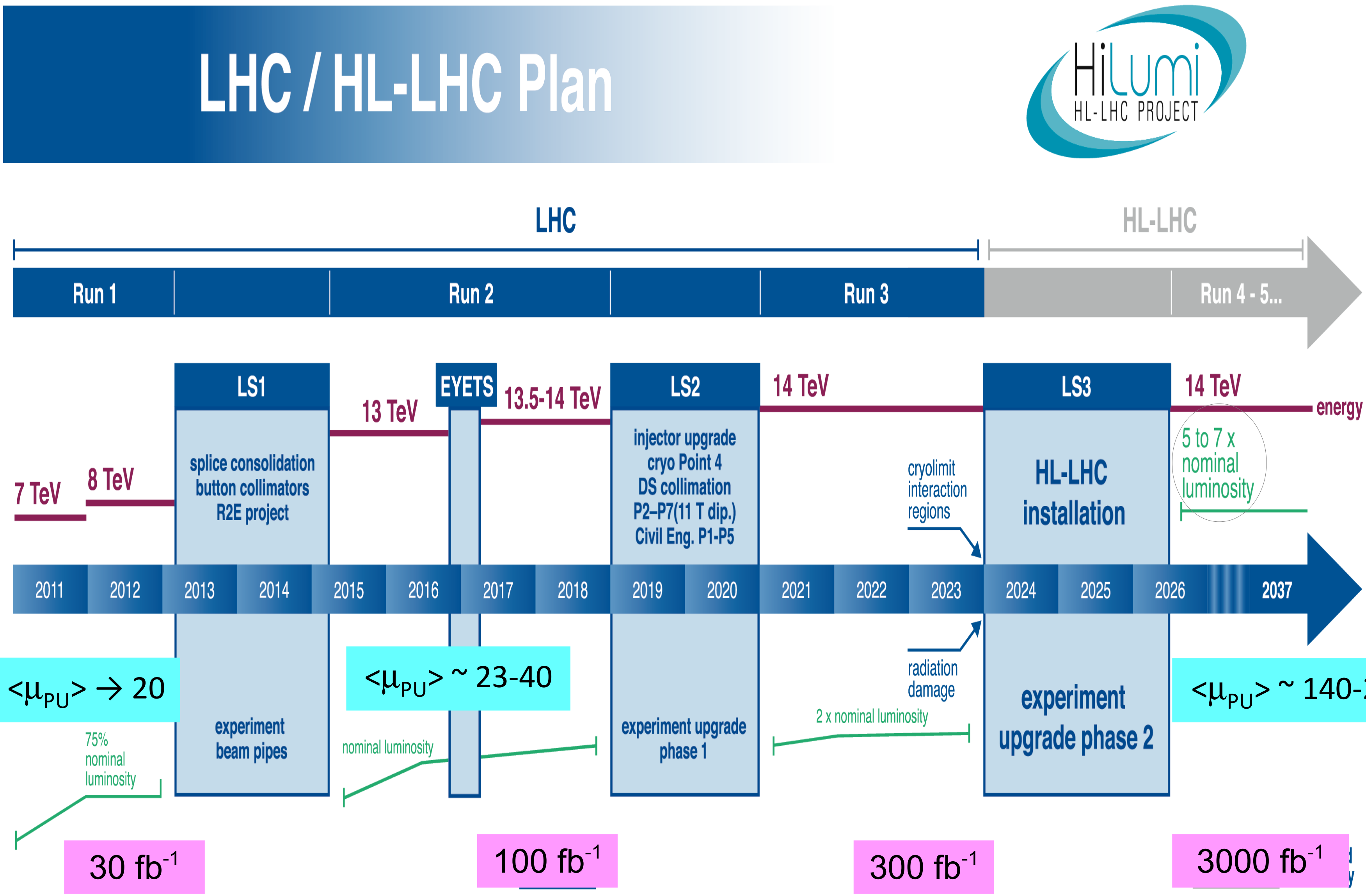
TIM 2017

High Luminosity LHC (2024-2037)



$<\mu_{PU}> \rightarrow 20$

$<\mu_{PU}> \sim 23\text{-}40$

$<\mu_{PU}> \sim 140\text{-}200$

30 fb^{-1}

100 fb^{-1}

300 fb^{-1}

3000 fb^{-1}

High Luminosity LHC goal

- Target : Gain an order of magnitude in integrated luminosity

  compared 300 fb^{-1} at Run-3 (O(50 fb^{-1}) nowdays)

- Physics goal : Search for new physics and better understand of SM

  Precision measurements :

  Factor 10 in luminosity → Factor √10 in statistical precision

  Bias effect ('systematic') critical more often → more studies = more MC

  Very rare decays

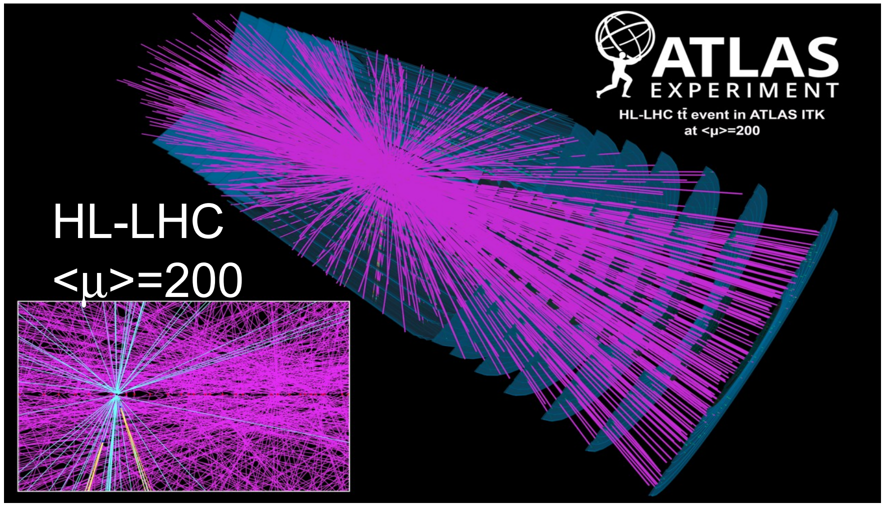
  H → μμ (Decay probability : O(10^{-4}))

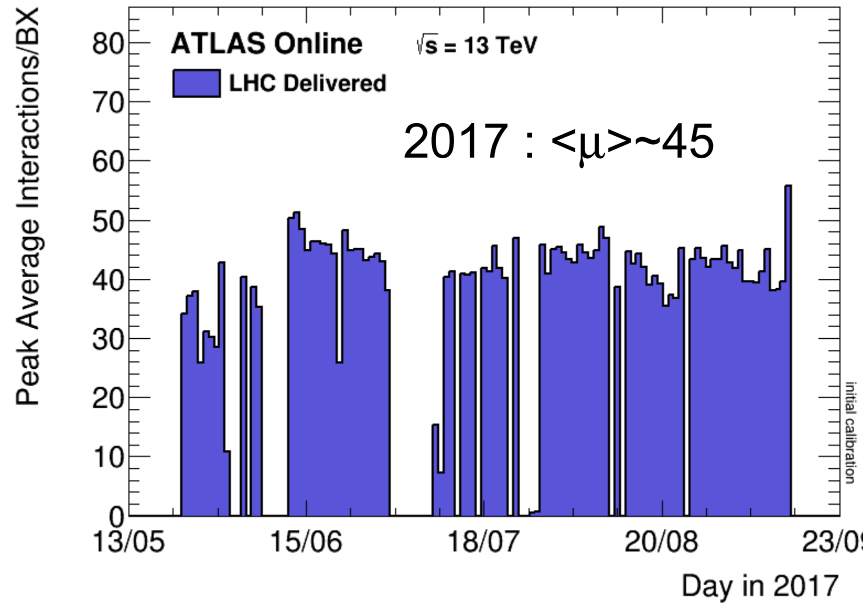
  Double Higgs production → access to

  Higgs self-coupling (first observation expected)

Detector running conditions

High particle density





Detector requirements to maximize benefits from high int. luminosity:

- Replace sub-detector not sustaining integrated radiation dose
- Minimize degradation from pile-up (high granularity,fast timing)
- Improve or maintain current detector performances
- Allow higher event rate to increase trigger acceptance

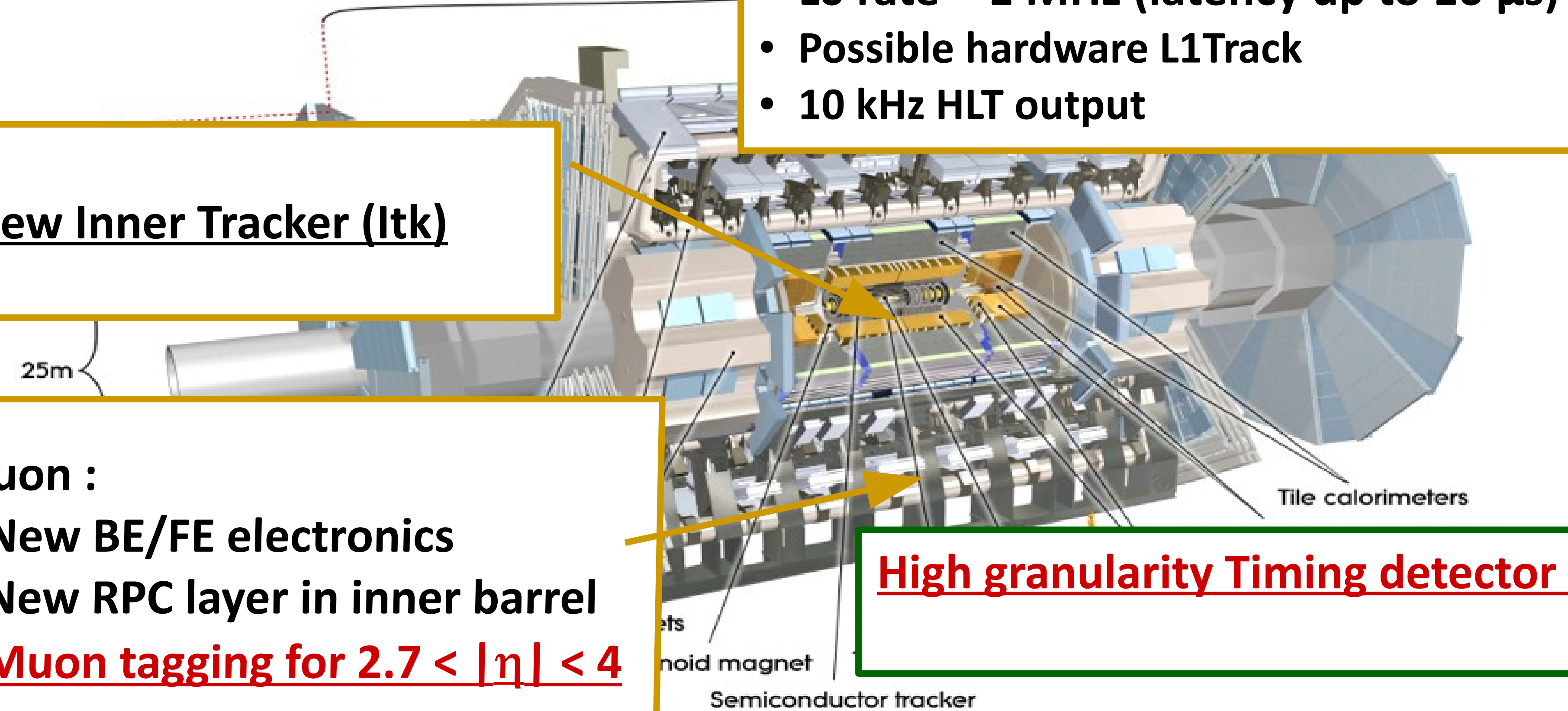
S. Jezequel, TIM17

ATLAS Phase-II detector upgrades

Calorimeters :
- **New BE/FE electronics**

TDAQ :
- **L0 rate ~ 1 MHz (latency up to 10 μs)**
- **Possible hardware L1Track**
- **10 kHz HLT output**

New Inner Tracker (Itk)

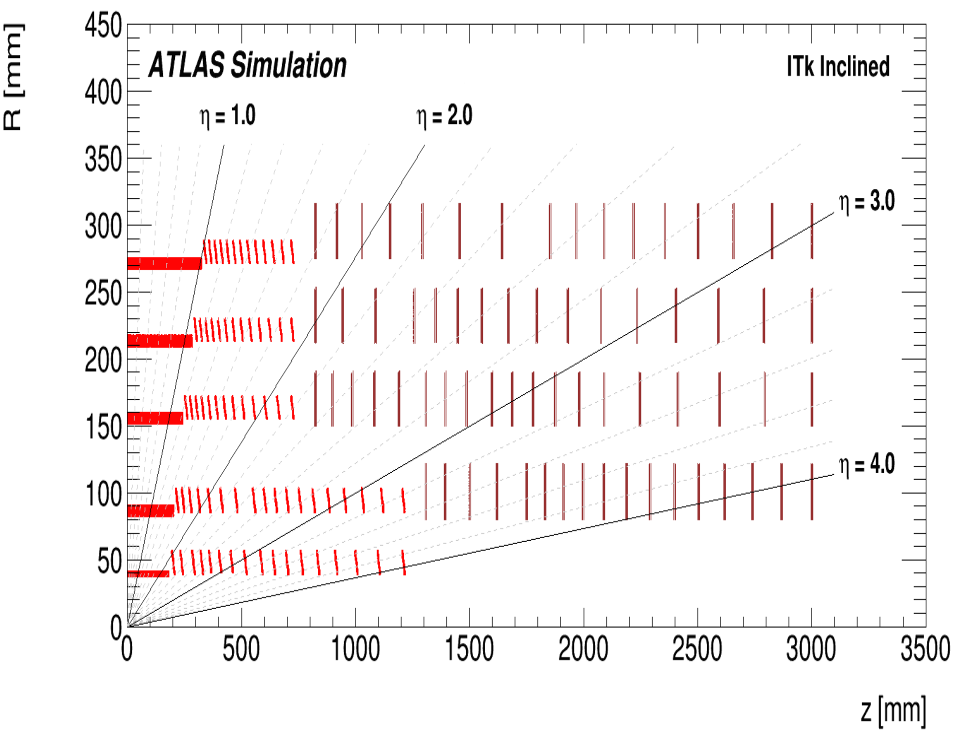


Muon :
- **New BE/FE electronics**
- **New RPC layer in inner barrel**
- **Muon tagging for 2.7 < |η| < 4**

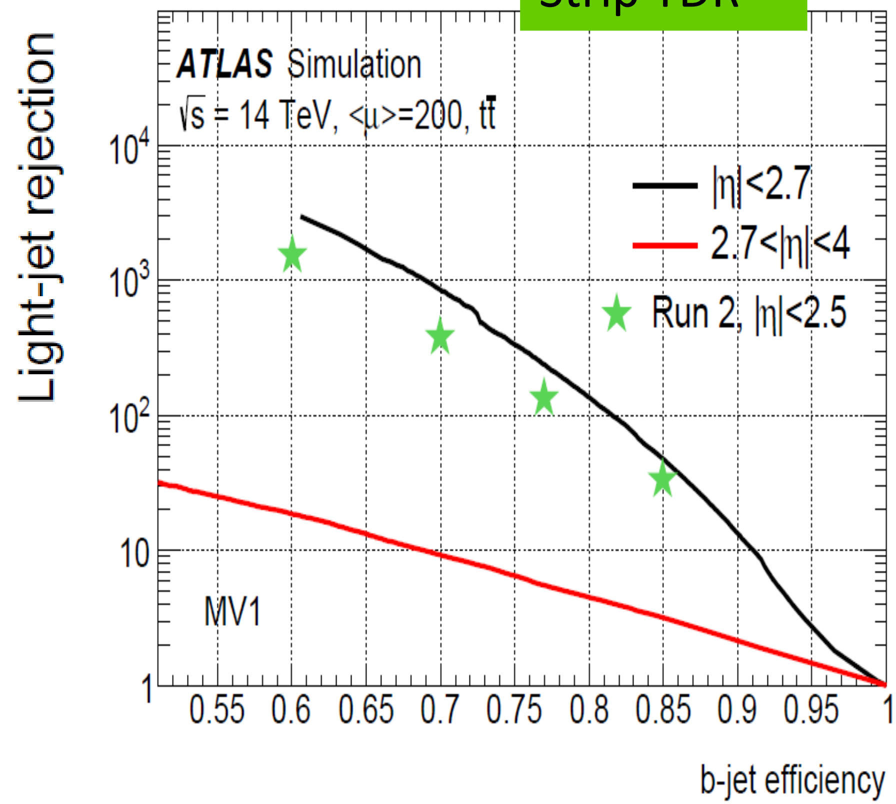
High granularity Timing detector

- **Still under evaluation**
- **New detector**

Detector performances : b-tagging



Strip TDR

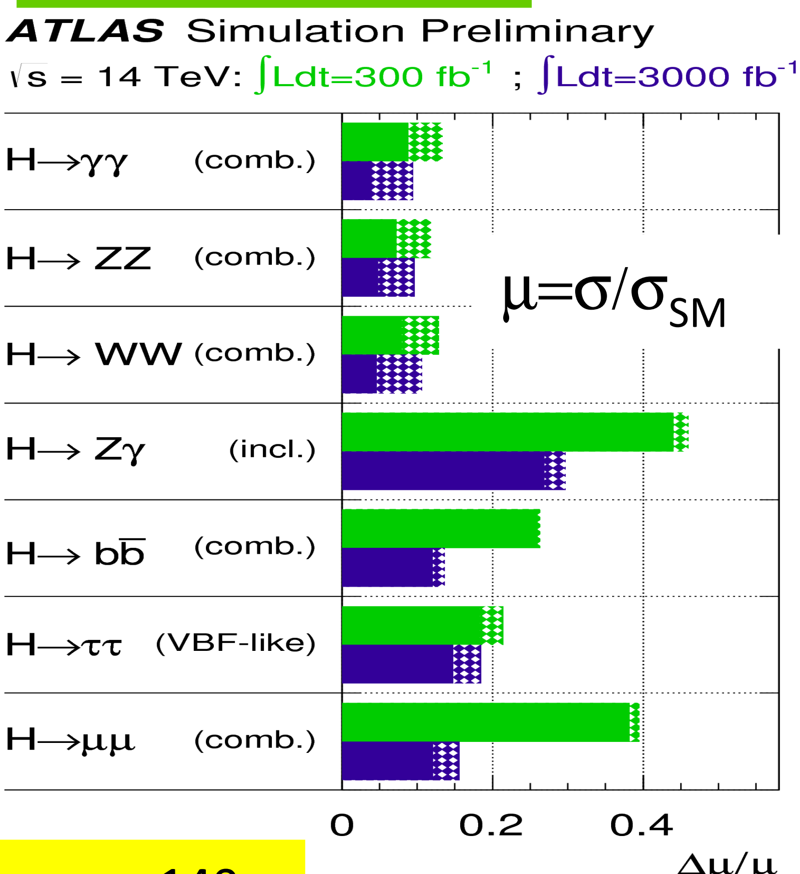


Similar performances as Run-2 for $|\eta| < 2.7$
Significant jet rejection at large η

Results

Higgs branching ratios

ATL-PHYS-PUB-2014-016



$\mu=\sigma/\sigma_{SM}$

$<\mu_{PU}>=140$

Search for HH → bbγγ

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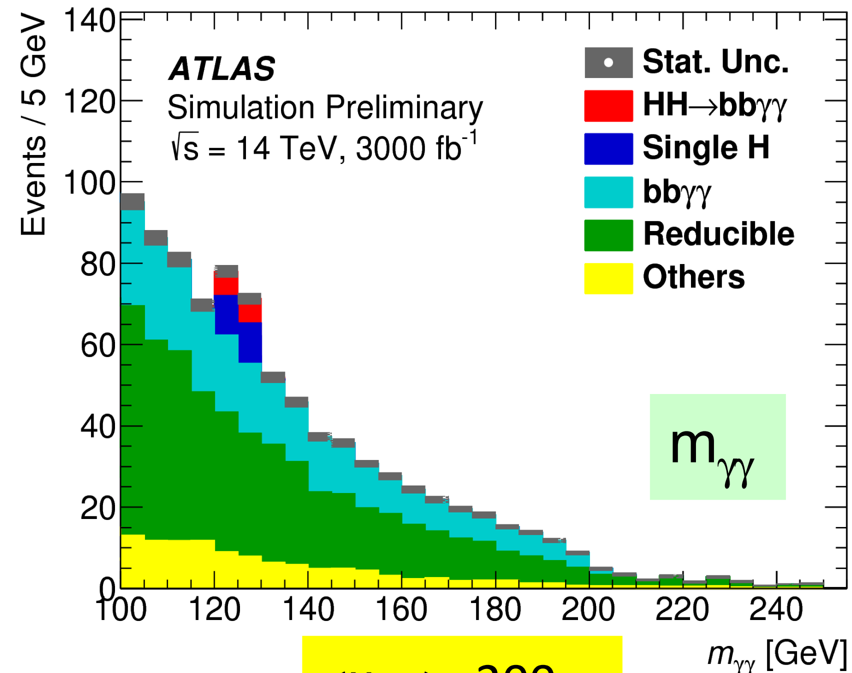


$m_{\gamma\gamma}$

$<\mu_{PU}>=200$

~10 selected signal events with all data

Upgrade Phase-II documents in 2017-2018

	Q1	Q2	Q3	Q4
2017		Muon TDR✔	LAr TDR (✔) Tile TDR (✔) HGTD IDR (✔)	Pixel TDR TDAQ TDR Lumi region Yellow Report Kickoff
2018		Yellow Report workshop?		HL/HE-LHC Yellow Report

- IDR : Initial Design Review (First internal evaluation of detector interest)
- TDR : Technical Design Report (Public document to LHCC + Funding Agencies)
  - Physics benchmarks for each TDR whose goal
    → Quantify and split effects from higher luminosity and detector upgrades

- HE-LHC:FCC magnets in LHC tunnel → $\sqrt{s}$~27 GeV and μ=800 (to be evaluated)

Requested results in 2017 for HL-LHC

- Target in 2017:
  - Optimise detector and analysis cuts to prepare HL-LHC (high-pileup)

    → Detector changes each 6 months (will converge in 2018)
  - Provide list of physics topics accessible at HL-LHC and measurement precision
  - Demonstrate that the huge background samples will be understood

- Reasons to not do simul+digi+reco chain on all events as in Run2 :
  - Detector layout still evolving each 6 months (will converge in 2018)
  - Limitation in ressources : CPU and memory usage (next slide)
  - Precise measurement or rare events :

    → Need to control precisely the background level and shapes

    → require huge number of background events

Current processing for HL-LHC

- Information from **Hector de la Torre** (current responsible for Upgrade Production) comparing Run-2 / HL-LHC (mu=200)

- Simulation
  - No pileup yet
  - Similar CPU per event and memory (PSS per core)

- Digi+Reco
  - Add pileup events to the interesting event
  - Memory : 3.2 – 3.6 GB / core (depends on the number of cores per job) while 1.6 GB/core for Run-2
  - Wallclocktime to process event multiplied by factor 10

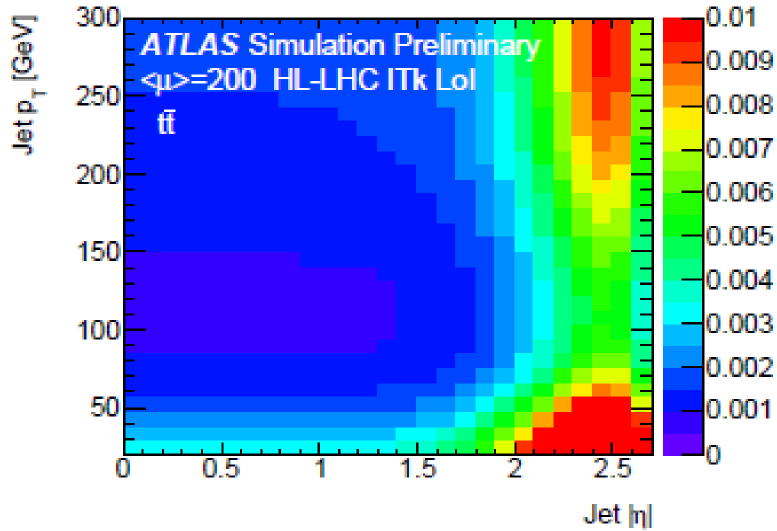
→ Do not do simul+digi+reco chain on all events as in Run2

Current analysis tools for HL-LHC

- Current procedure to produce expected results
  - Fully simulated/reconstructed events :
    - Single particles
    - Benchmark channels for signal/background : H-> $\gamma\gamma$, Z → ee, multijets,...
      - Tasks currently requested

→ Produce efficiency/rejection maps vs (η,Pt) applied on truth events

B-tag efficiency



Pending issue with smearing functions: Control of background systematics

Conclusion

- HL-LHC : More data and MC, more memory, more CPU, ...
- First iteration on analysis results already done at HL-LHC
  - → Basic software (tracking,...) available
  - Still room for CPU usage optimisation (Itk)
- Few items for short term
  - → Switch to release 21 and git
  - → Use premixed PU events
- Pending issues :
  - Fastdigi and fastreco : Will it used ?
- But we are not doing detailed analysis as physicists are used to do
  - Precise measurements requires optimal software/computing resources