CLHCP 2017 at Nanjing (2017.12.22-24)

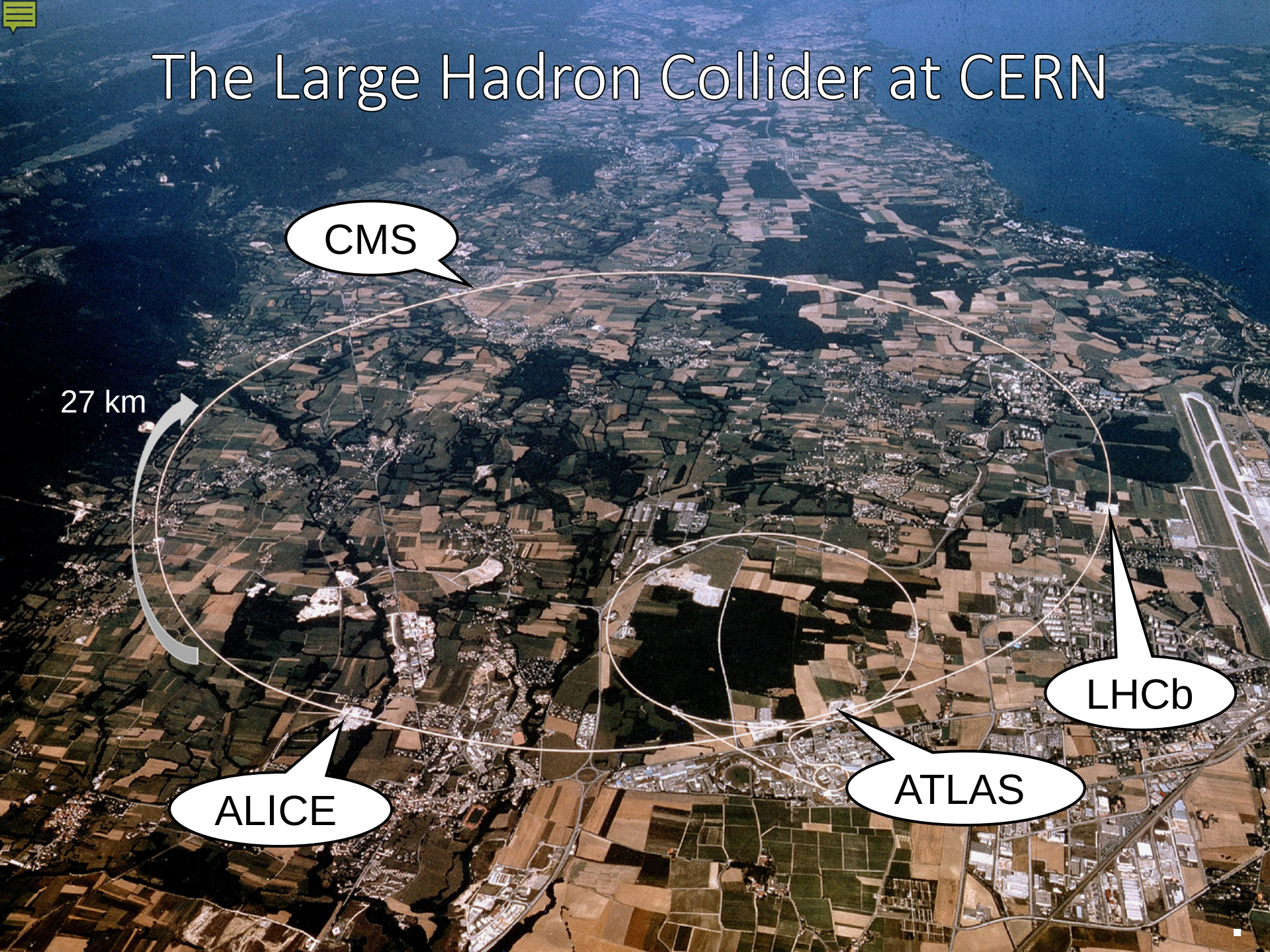
ATLAS Phase II Update

- Inner tracking: silicon strip detector ----Xin Shi et al
- Thin gap muon trigger RPC ----Yongjie Sun

Yuzhen Yang
2017.12.29

Special Topic

The Large Hadron Collider at CERN



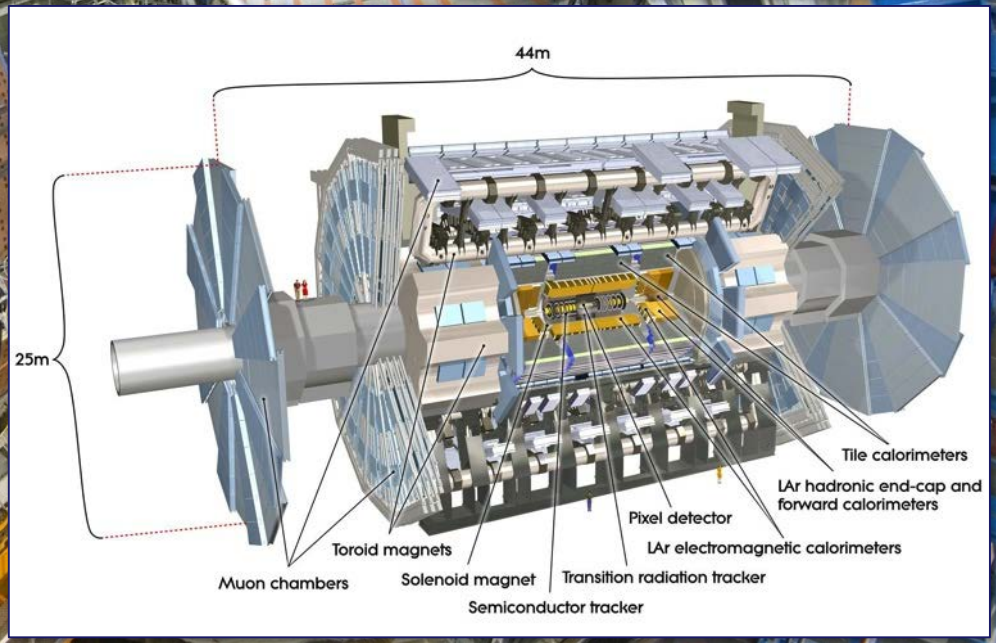
LHC Point 1: The ATLAS Experiment

The ATLAS Collaboration

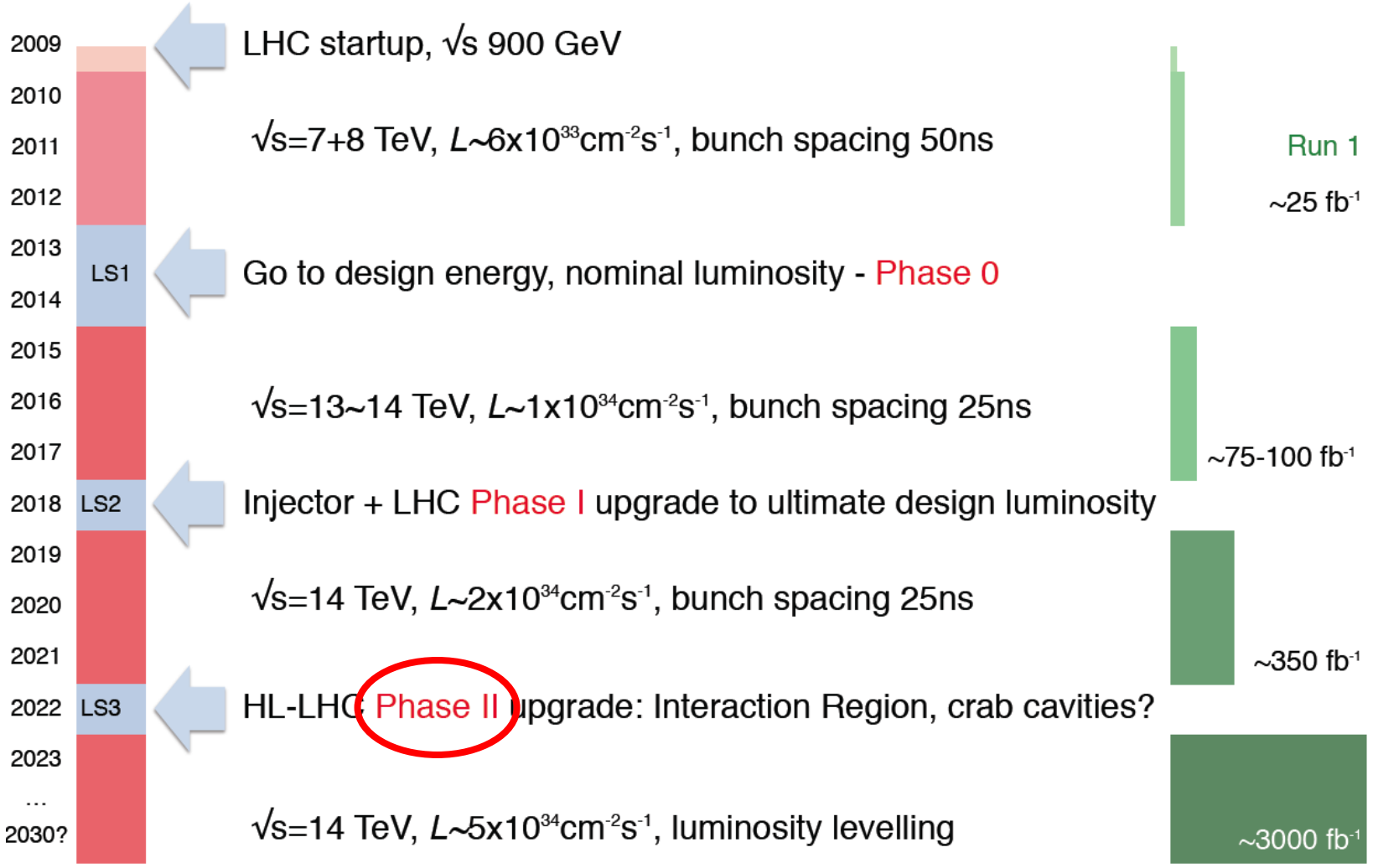
3000 Members

177 Institutes

38 Countries



LHC to HL-LHC


2009
2010
2011
2012
2013
LS1
2014
2015
2016
2017
2018
LS2
2019
2020
2021
2022
LS3
2023
…
2030?
LHC startup, √s 900 GeV
√s=7+8 TeV, L~6x10³³cm⁻²s⁻¹, bunch spacing 50ns
Go to design energy, nominal luminosity - Phase 0
√s=13~14 TeV, L~1x10³⁴cm⁻²s⁻¹, bunch spacing 25ns
Injector + LHC Phase I upgrade to ultimate design luminosity
√s=14 TeV, L~2x10³⁴cm⁻²s⁻¹, bunch spacing 25ns
HL-LHC Phase II upgrade: Interaction Region, crab cavities?
√s=14 TeV, L~5x10³⁴cm⁻²s⁻¹, luminosity levelling
Run 1
~25 fb⁻¹
~75-100 fb⁻¹
~350 fb⁻¹
~3000 fb⁻¹

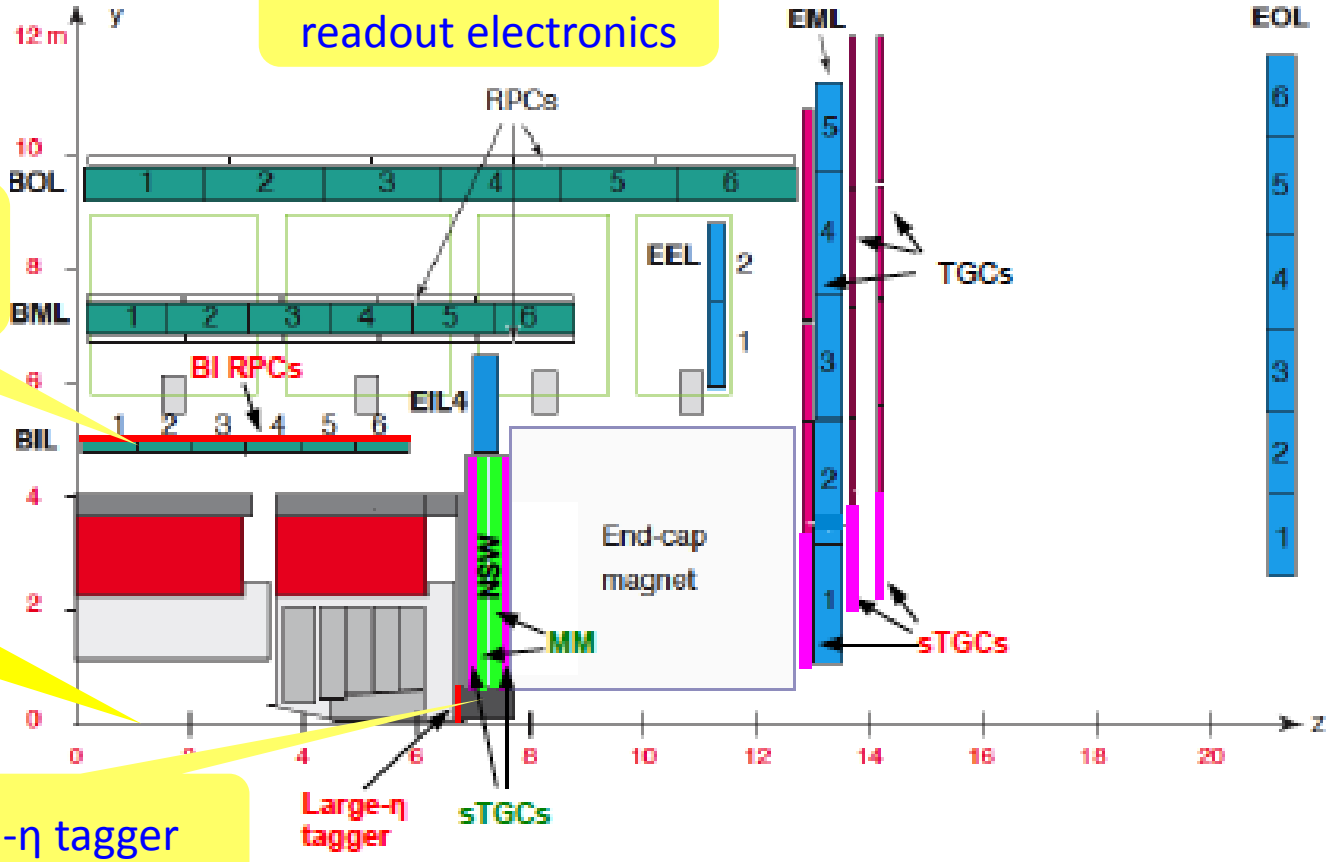
ATLAS Phase-II upgrade

Front-end and readout electronics

Thin gap muon trigger RPC

Inner tracker (ITk)

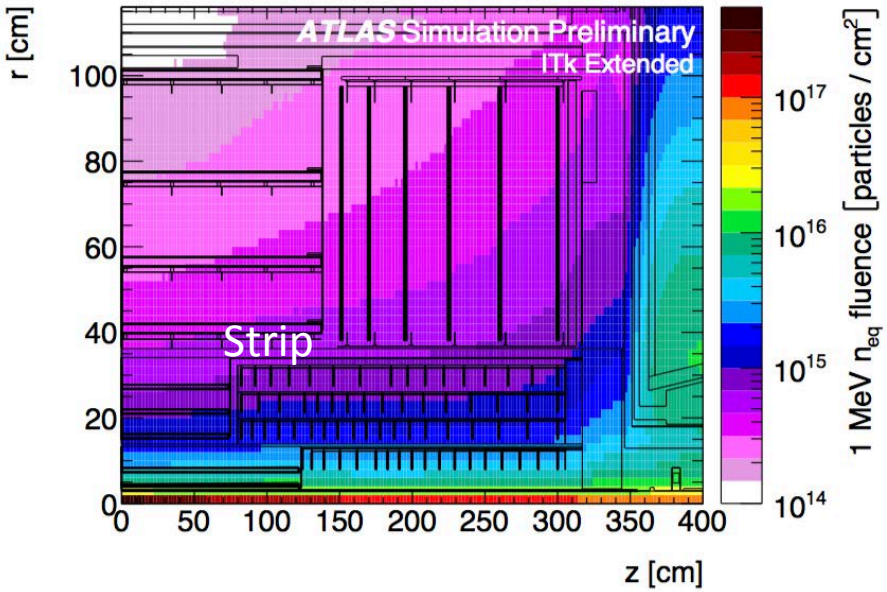
High-η tagger



ATLAS ITk Upgrade

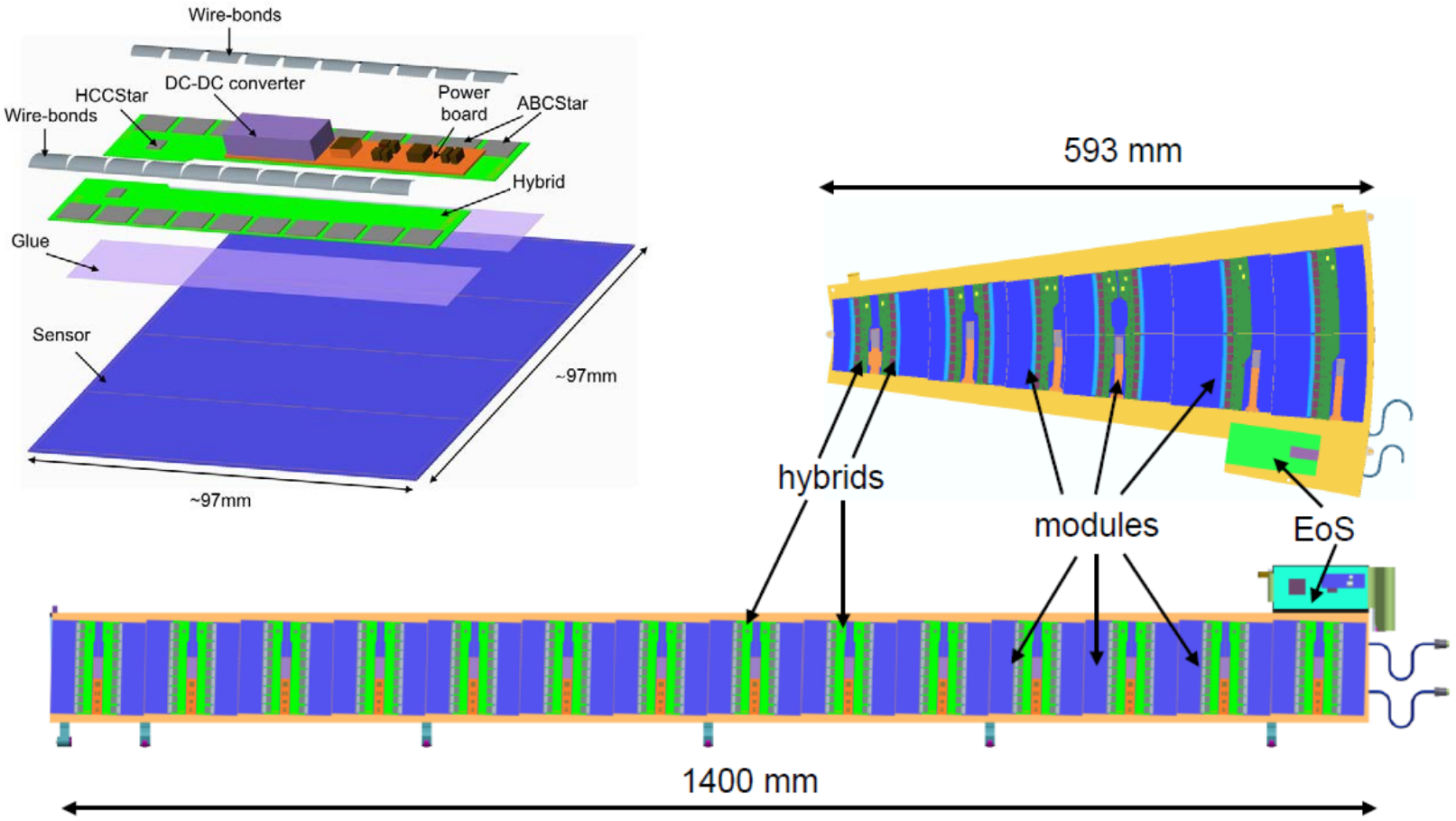
- ATLAS Detector upgrade for the LHC high luminosity upgrade, all silicon tracking device

Layer	Radius [mm]	Maximal Fluence [n_{eq}/cm^2]	Maximal Dose [MRad]
Strips			
Long Strips	762	4.2×10^{14}	10.7
Short Strips	405	8.1×10^{14}	35.7
End-cap	385	1.2×10^{15}	50.4
Pixels			
Layer 0	39	2.25×10^{16}	1710
Layer 1	75	0.82×10^{16}	715
Layer 2	155	0.25×10^{16}	148
Layer 3	213	0.12×10^{16}	96
Layer 4	271	0.12×10^{16}	61
End-cap	80	0.67×10^{16}	687



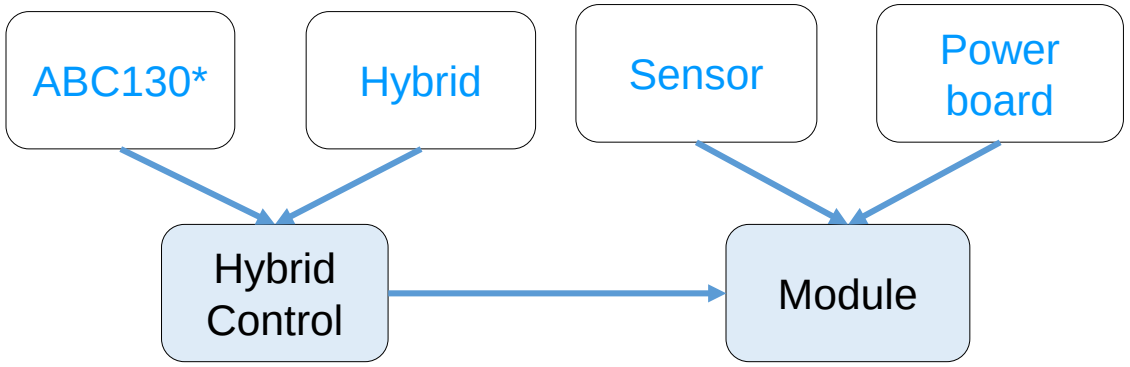
ITk Silicon Strip Detector Concept

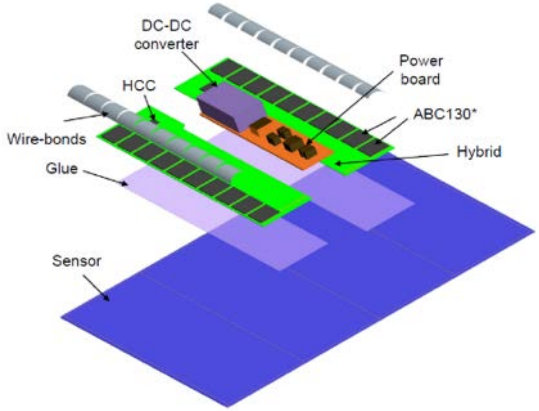
- Stave/Petal + Mechanics Supported Silicon Modules



Assembly and tests of barrel modules

- Produce 50 working modules during pre-production





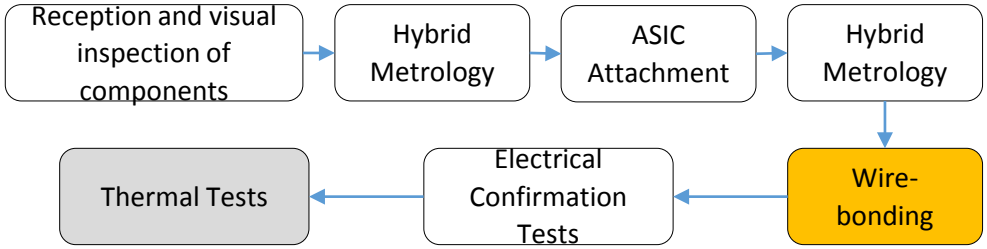
Silicon Strip Detector Module

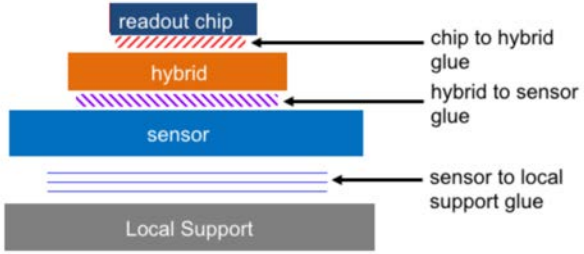
- Silicon Sensor + Hybrid PCB (with Readout ASICs and control chips) + Power board + Glue and Wire-bonds

Quality Control

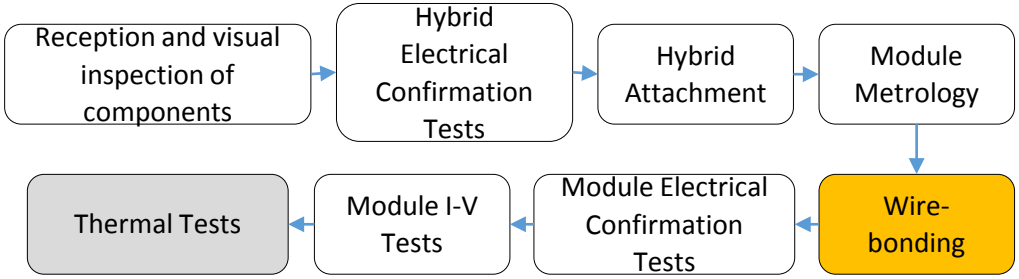
- Based on the prototype study, along with the current ATLAS SCT detector experience, improve the quality control (QC) of module production process

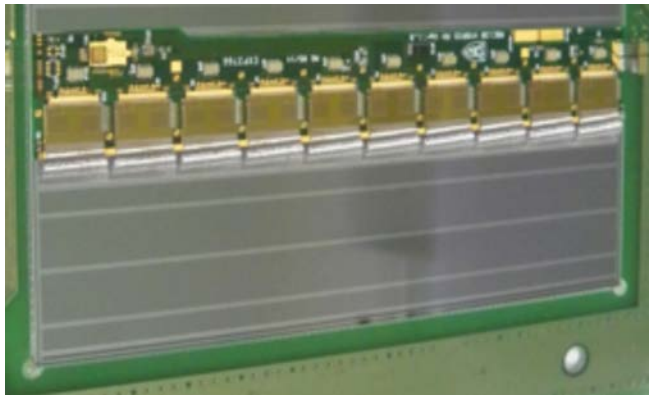
Control board QC





Detector Module QC





R&D on high performance RPC for the ATLAS Phase-II upgrade

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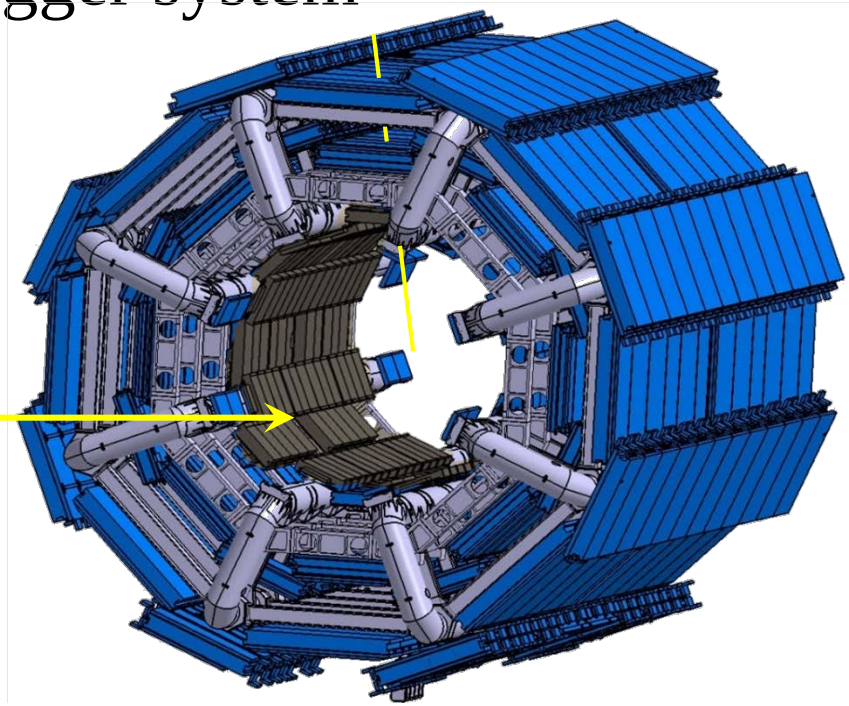
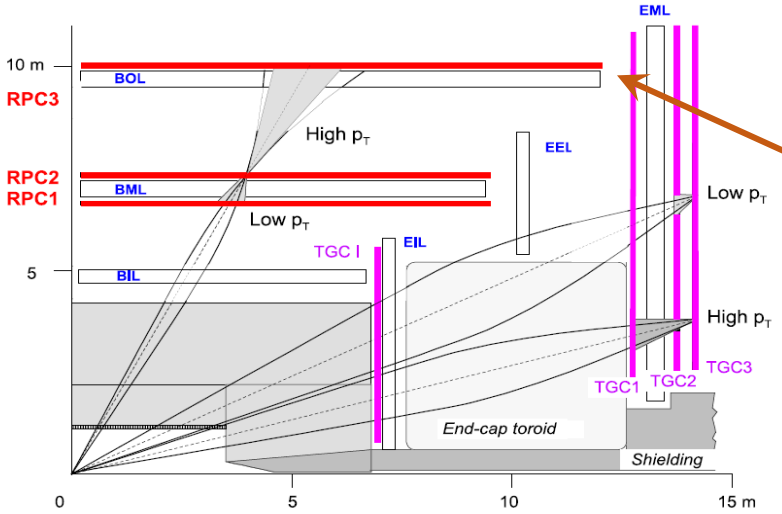
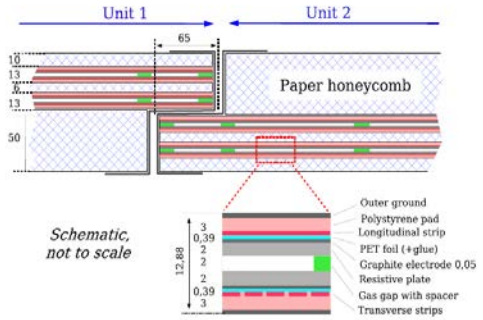
Current ATLAS RPC muon trigger system

- 6 layers RPC (BM and BO), measure η&ϕ position on each layer.
- OUTER LAYER (BO) for High p_T trigger
- MIDDLE LAYER (BM) for Low p_T trigger
- NO RPC on INNER LAYER (BI)）





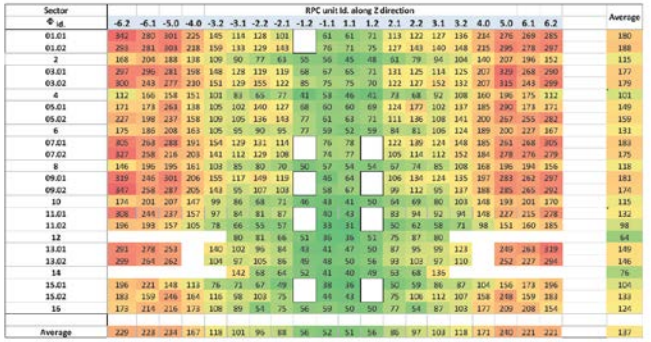


The main problems of current RPC

➢ Longevity:

- Designed for work under 1×10^{34} $cm^{-2}s^{-1}$@14TeV for 10 years, corresponding to integrate charge of 0.3 C/cm^2
- Reach the life time at HL-LHC
- Can only work under lower voltage with detection efficiency lost of 15%-35%

$L=7\times10^{34}cm^{-2}s^{-1}$@14TeV

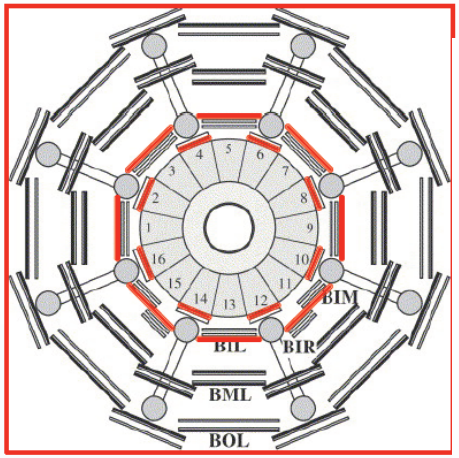


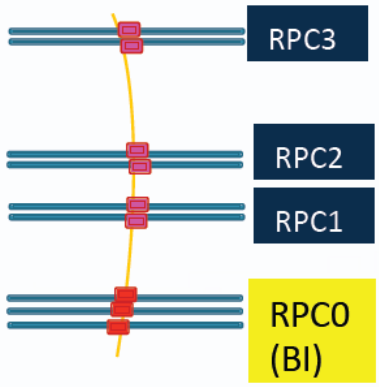
➢ The rate capability:

- Under HL-LHC, the extrapolated rate on RPC will be an order of magnitude higher, ~300Hz/cm^2

➢ Basic solution:

- Add 3 BI RPC layers
- Rate: ~ kHz/cm^2, work 10 years for HL-LHC
- With higher spatial and time resolution for muon tracking and bunch crossing ID
- Close most of the acceptance holes





The basic requirements

- Higher rate capability: ~ kHz/cm^2
- Longer longevity: 10 years of HL-LHC
- Higher spatial resolution: ~ mm
- Higher time resolution: ~0.5ns

Current RPC detector:

- 2 mm gas gap, with avalanche mode → 1 mm
- Work voltage: 4.8 kV/mm → ~2.7 kV
- Charge: 30 pC/count
- Rate: 100 Hz/cm^2
- Time resolution: 1.1 ns → 0.5 ns
- Strip pitch: 26-35 mm
- FEE: GaAs technology → Si BJT → SiGe
- Gas component: Freon, Iso-butane, SF6

Main challenges

- More sensitive, high signal-to-noise ratio, fast, low power consumption Front End Electronics
- New materials for a thinner and more rigid chamber structure
- Increasing the signal-to-noise ratio by optimizing the gas gap and readout panel structure
- Optimizing the detector parameters for maximizing spatial and time resolution, thus momentum resolution, and track-to-track separation.
- Looking for new environment friendly gas mixture.