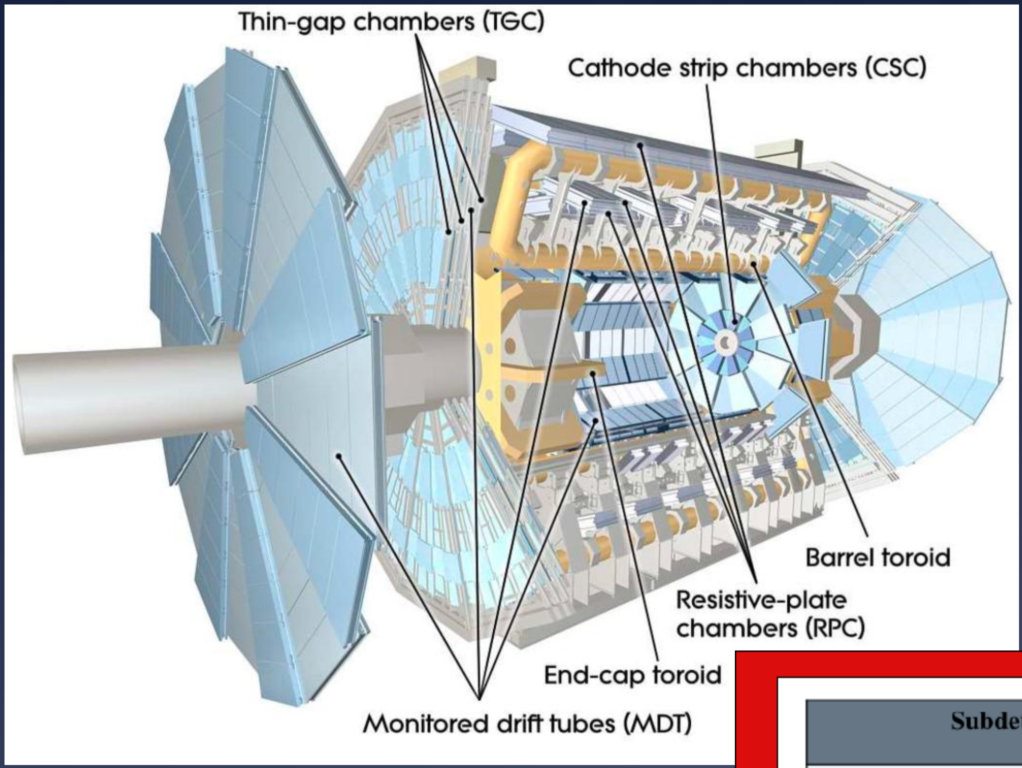
ATLAS detector upgrades



ATLAS off to a good start – the detector is performing very well.

This talk is about the changes needed in ATLAS during the next 10-12 years as LHC moves towards design, ultimate and high luminosity around 2020

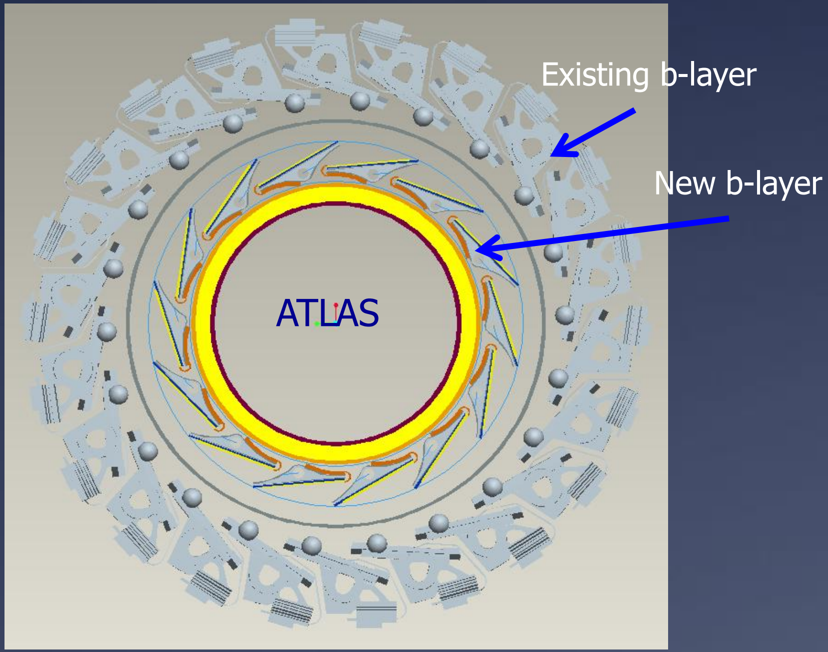
Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.5%
SCT Silicon Strips	6.3 M	99.3%
TRT Transition Radiation Tracker	350 k	98.0%
LAr EM Calorimeter	170 k	98.5%
Tile calorimeter	9800	97.3%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
LVL1 Calo trigger	7160	99.8%
LVL1 Muon RPC trigger	370 k	99.7%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.7%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.3%
TGC Endcap Muon Chambers	320 k	98.8%

Shutdown 2012

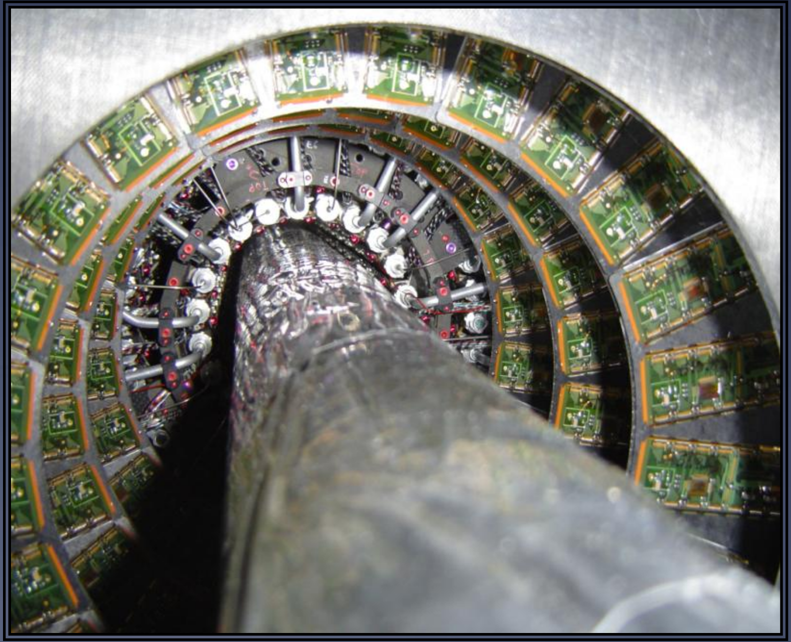
- The main activity is to exchange the external beam pipes with light material one, this will require to break the vacuum and have a big opening
- The other main activity is to install and operate a redundant ID evaporative cooling plan
- We will finish the EE installation, if not already done
- We will fix bugs and consolidate the detector and its infrastructure (calo LVPS, OTxs, ……)

Preparing for 2015 – IBL

- Improves ATLAS vertexing
- Backup in case of problems with current B-layers
- TDR being prepared (in mature state)
  - Focus on performance and simulation studies and documentation



Add new b-layer around a smaller beam pipe, stave structure, 160 MHz readout, CO_2 cooling

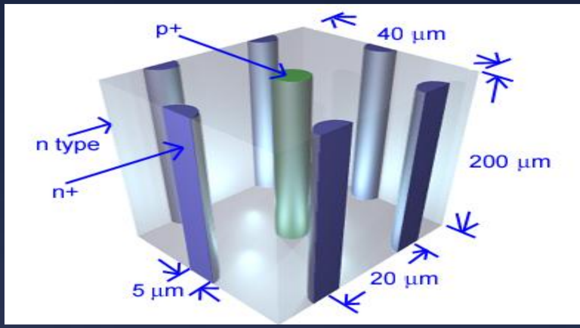


Some key components

Today oxygenated N on N sensors are used in some of the most critical areas of the LHC detectors.

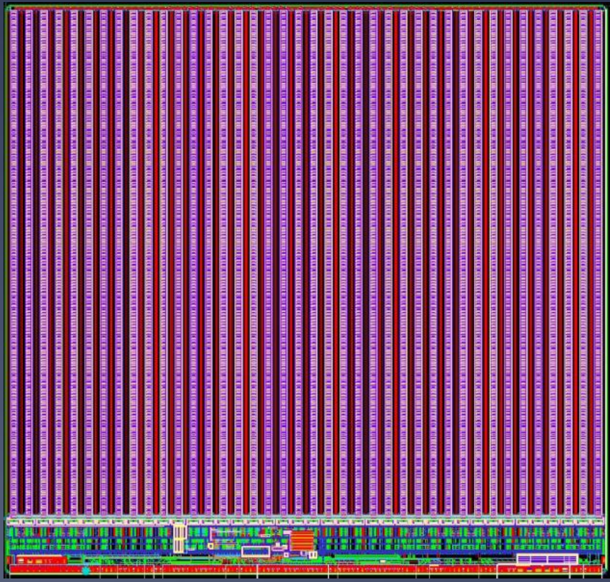
For IBL:

- **Planar**
  - N-in-N conservative edge
  - N-in-N slim edge & Thin n-in-p
- **3D**
  - Active edge sensors preferred and in production at all 3D fabs
  - Double sided 3D also in production as backup
- **Diamond**
  - Polycrystalline CVD diamond sensors available from DDL and II-VI (total ~ 20)



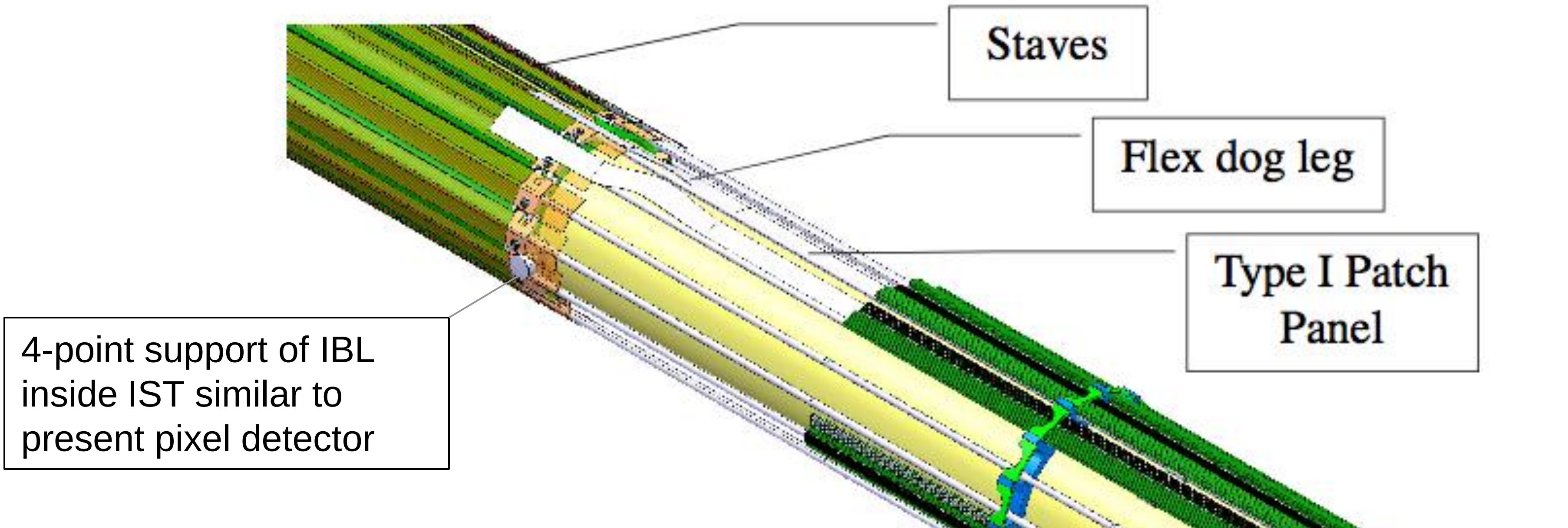
The FE-I4 integrated circuit contains readout circuitry for 26 880 hybrid pixels arranged in 80 columns on 250 mm pitch 15 by 336 rows on 50 mm pitch (0.13 um technology)

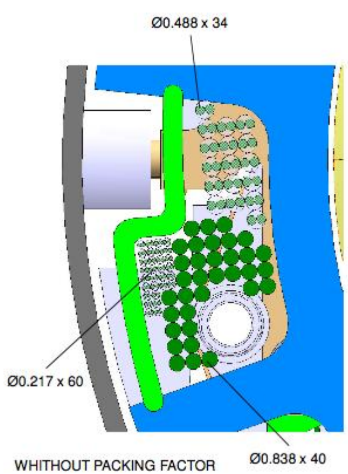
Modules assembled on staves

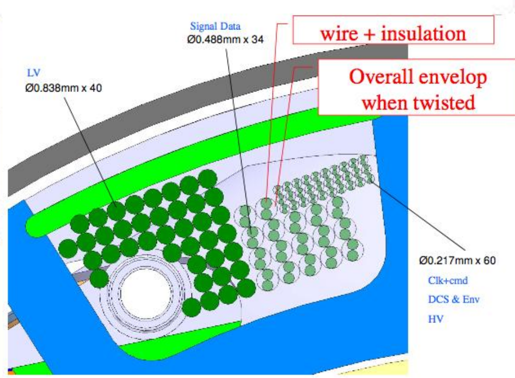


Stave support and integration with services

Integrate type 1 services to EoS and staves on module supports

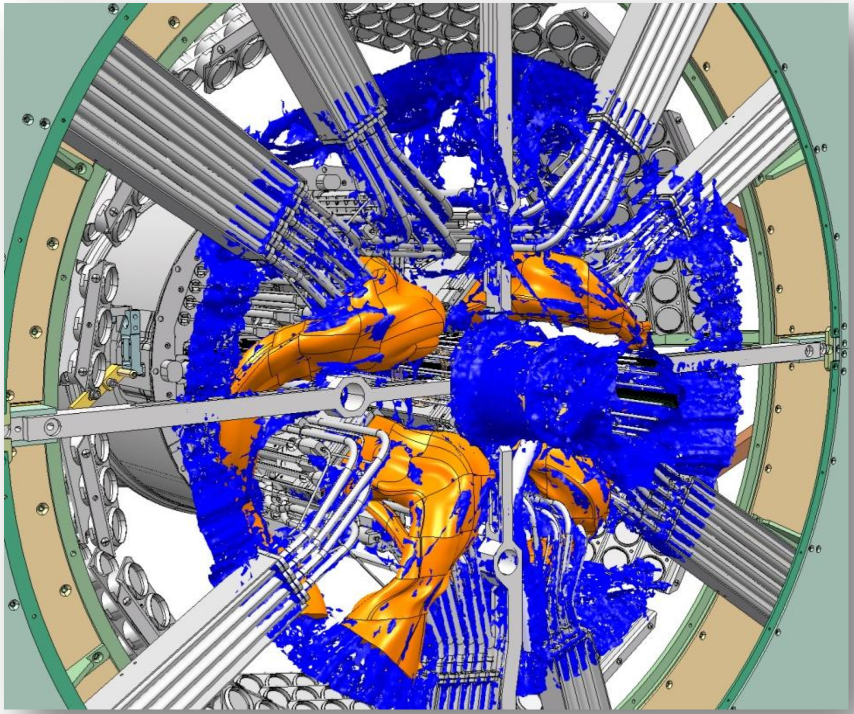


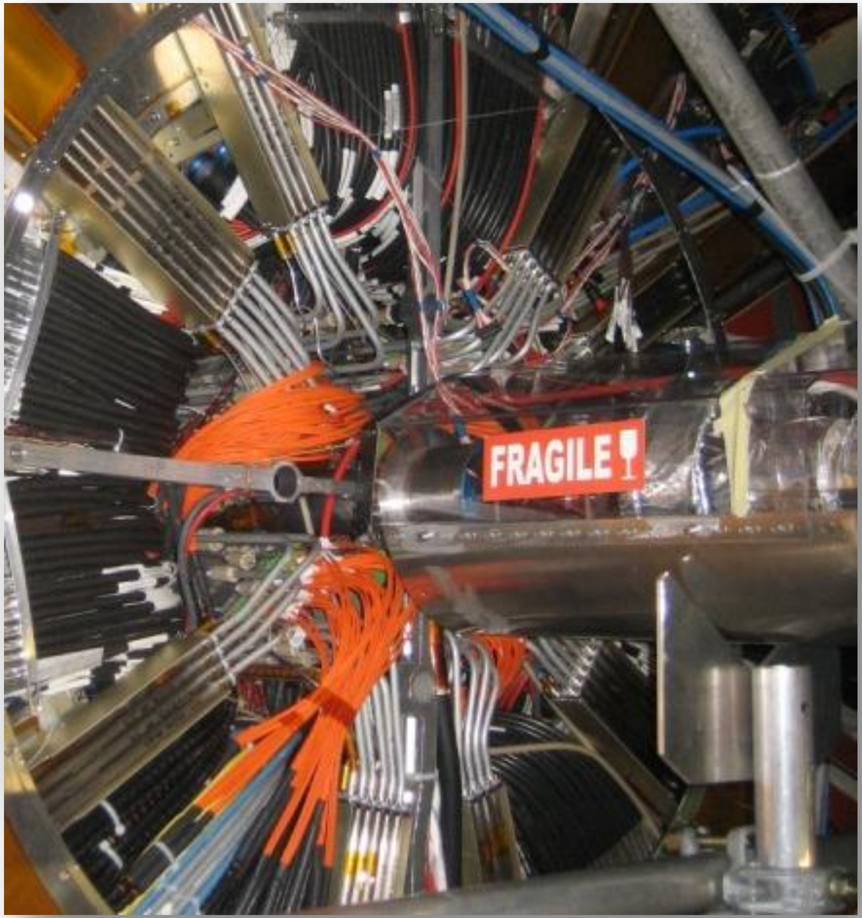




Space and service routing in PP1 area

Main goal: understand the available space for IBL services based on drawings and surface scans





Timescales

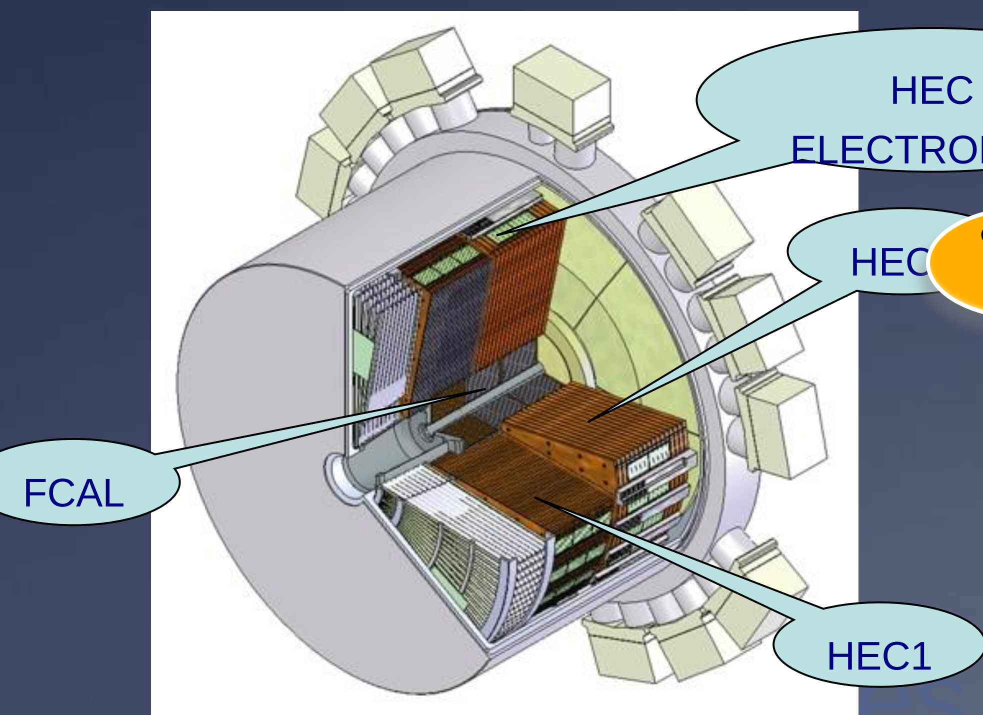
- For HL-LHC a new ID is needed to deal with both increased instantaneous and integrated luminosity (2020)
- There are several key projects that are needed for HL-LHC, but that can give significant benefits – and would be more easy to implement – if they are prepared and installed before
- We are therefore considered how these projects can be moved from R&D towards implementation and will need to understand better the machine plan in the period 2015-2020 concerning shutdowns
  - Examples are muon system improvements, new electronics for calorimeters and muons, improvements in the forward detector systems and shielding …
  - An important additional motivation is to reach the trigger performance as needed for HL, but that can benefit ATLAS also before HL is reached

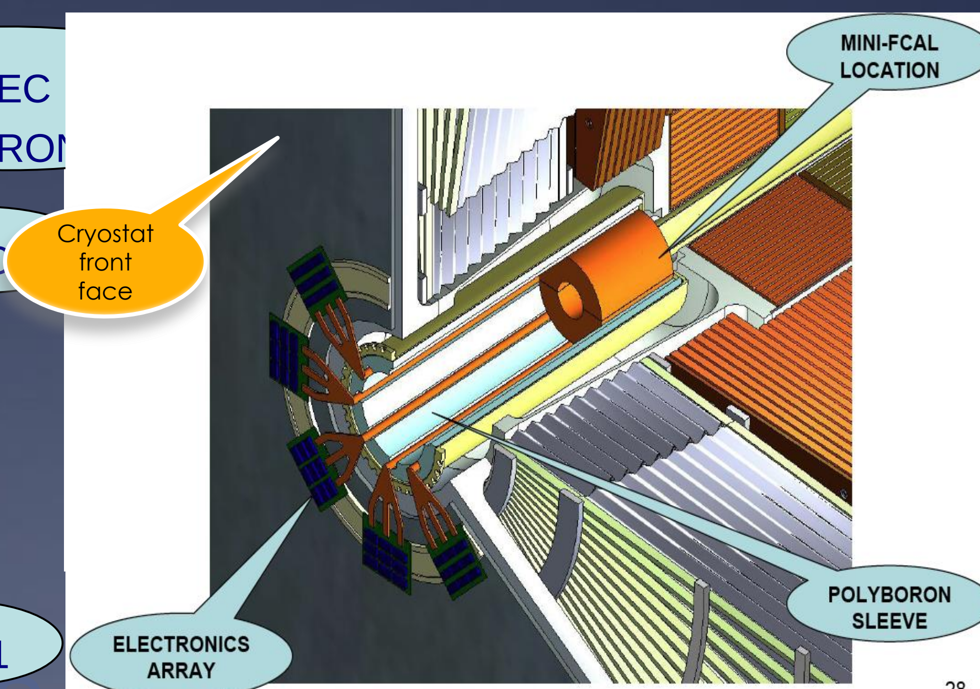
Trigger improvements

- Various projects being pursued:
  - New hardware tracks finder (FTK) to supply L2 with good seed (proposal being reviewed))
  - Combining trigger objects at L1 and topological "analysis"
  - Full granularity readout of the calorimeter (requires new electronics)
  - Changes in muon systems (small wheels), studies of an MDT based trigger, and changes in electronics
  - Increased L1 latency to allow more processing (can only befit fully when a new ID is installed)
  - A track trigger
  - Upgrades of HLT farms
- Some of these changes are linked to possibilities that open when electronics changes are made (increased granularity, improved resolution and increased latency)

Calorimeters

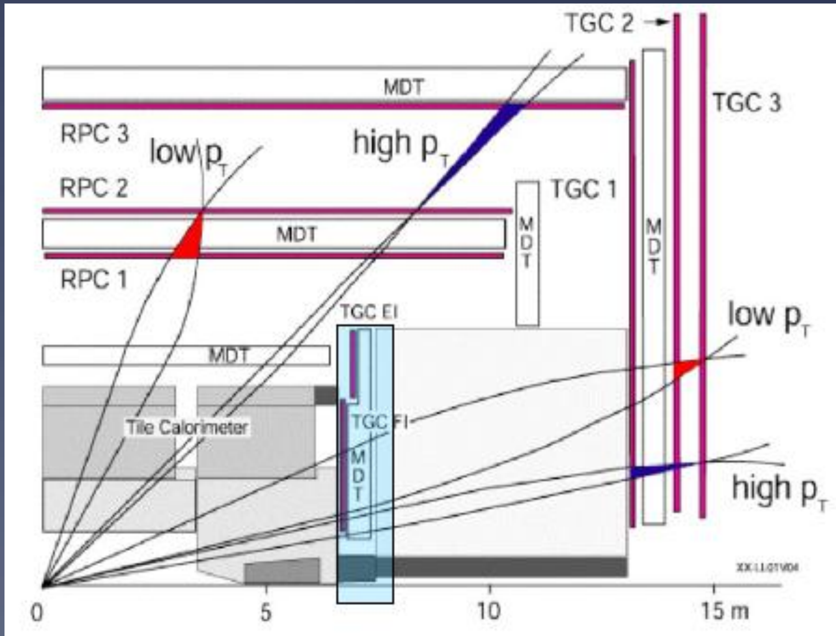
- Electronics changes being foreseen – for better performance and granularity
  - Trigger improvements might give a strong motivation for electronics changes
- Forward calorimetry in particular might suffer from radiation effects
- ATLAS forward LAr calorimeter:
  - Boiling of LAr, ion build up between electrodes, voltage drop over HV resistor
  - Studies underway; If these show action is needed, two solutions considered:
    - Warm calorimeter in front of current calorimeter (Cu/Diamond)
    - Open cryostat, insert new FCAL with smaller gaps and more cooling



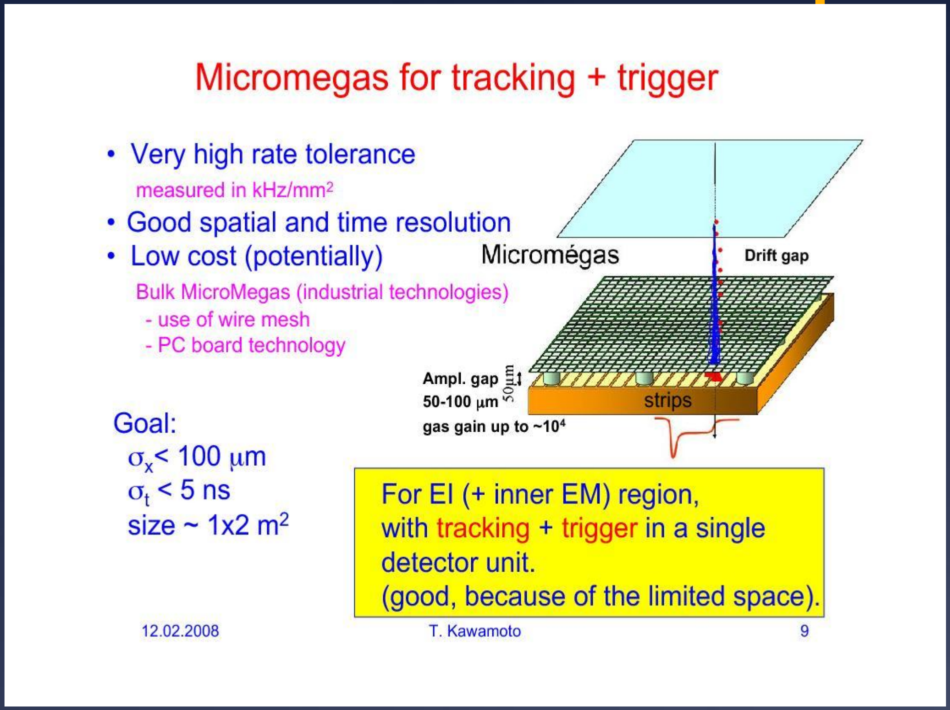


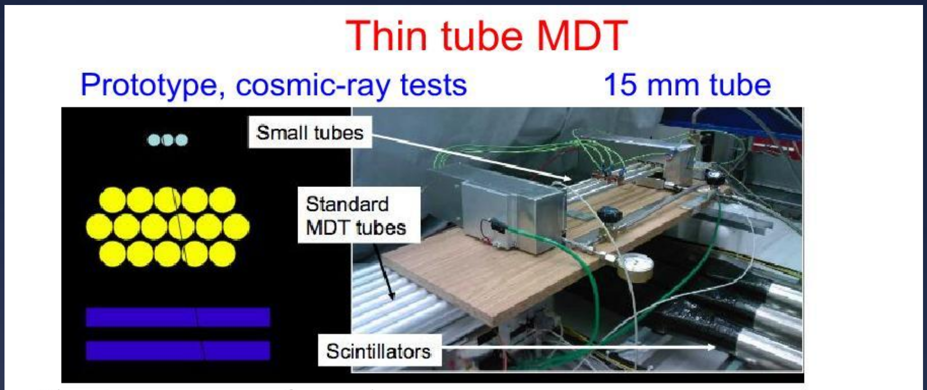
Muon changes

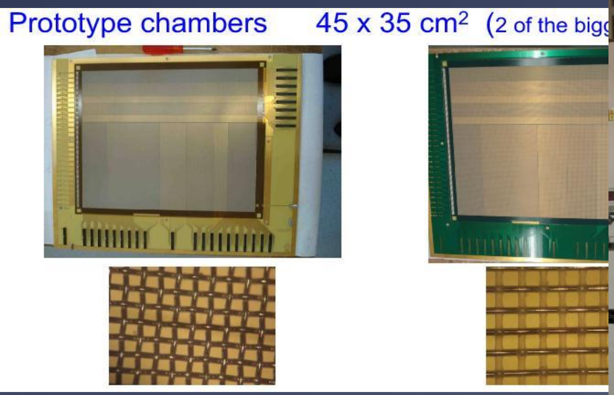
- New small wheels, recover staged CSCs with new detector technologies
- New electronics for trigger improvements
- Considering bringing MDT into trigger
- Improved shielding



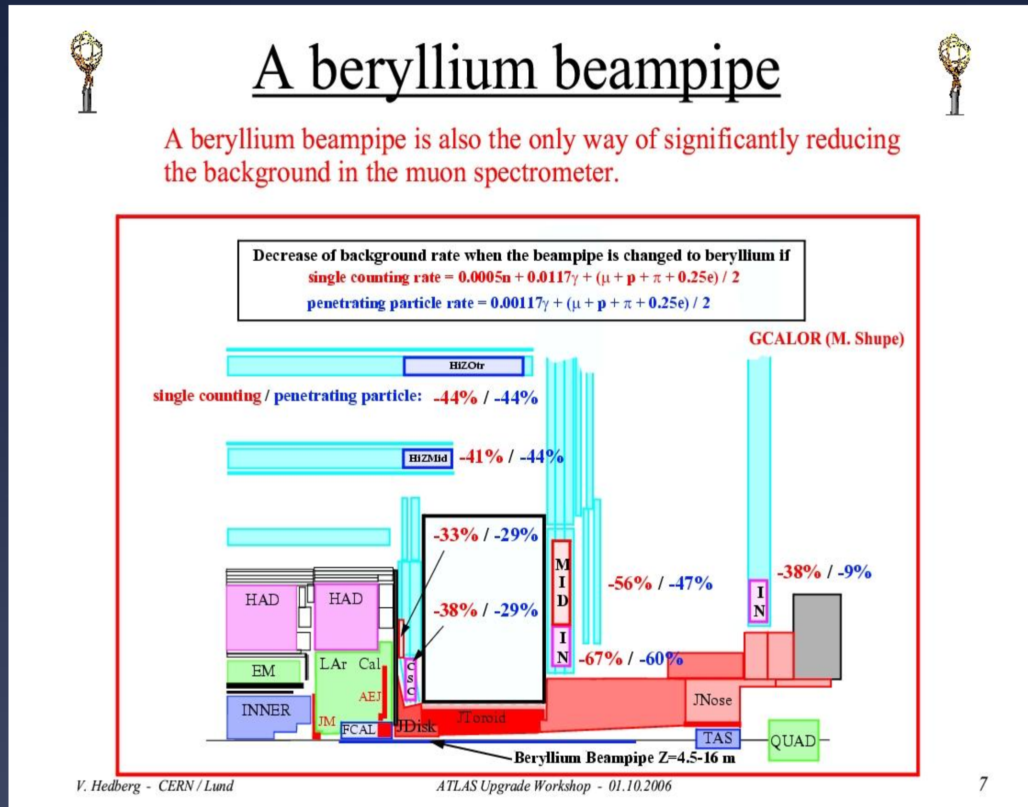
Muons - example of chamber R&D







Beam-pipe and shielding

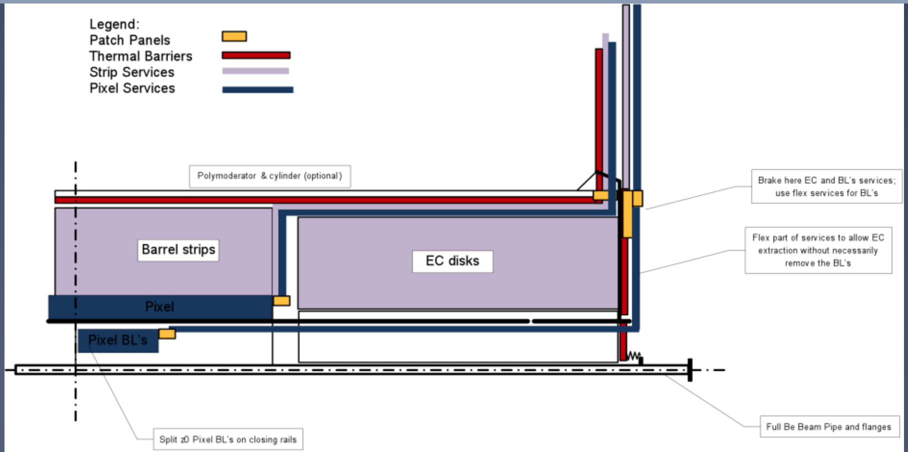


- All-Be beam pipe reduces muon BG considerably
  - Expensive beampipe, but **much** cheaper than new muon chambers

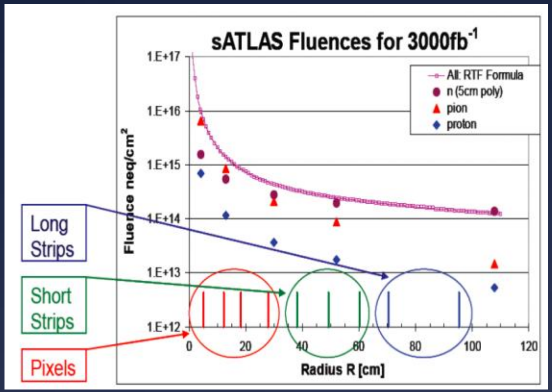
ID replacement for HL-LHC 2020

- Critical parts are the sensors, ASICs and system engineering (mechanics, power, cooling, assembly, etc)
- To develop and buy silicon sensors for several hundreds of m^2 silicon sensors, with finer granularity than for LHC, is not an easy task, for example;
  - Extend previous studies from LHC to SLHC fluence – large irradiation programs needed
  - Extend previous studies to include n-on-p (can operate not fully depleted after irradiation)
  - Study biasing, guard rings, isolation methods, substrate variations
- In ATLAS a new readout ASIC (ABCDN-25) has been produced and is being used (SCT system is based on DMILL ASIC). Next steps will be in 0.13 or 0.09 technologies

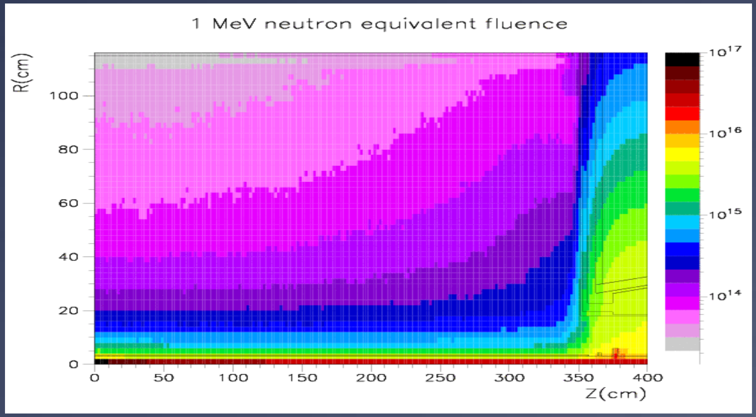
Also for the ID one can consider to – but it is difficult – to make it such that barrel, EC and PIXEL systems are individual units, allowing at least some access in case of problems, and also some flexibility in installation

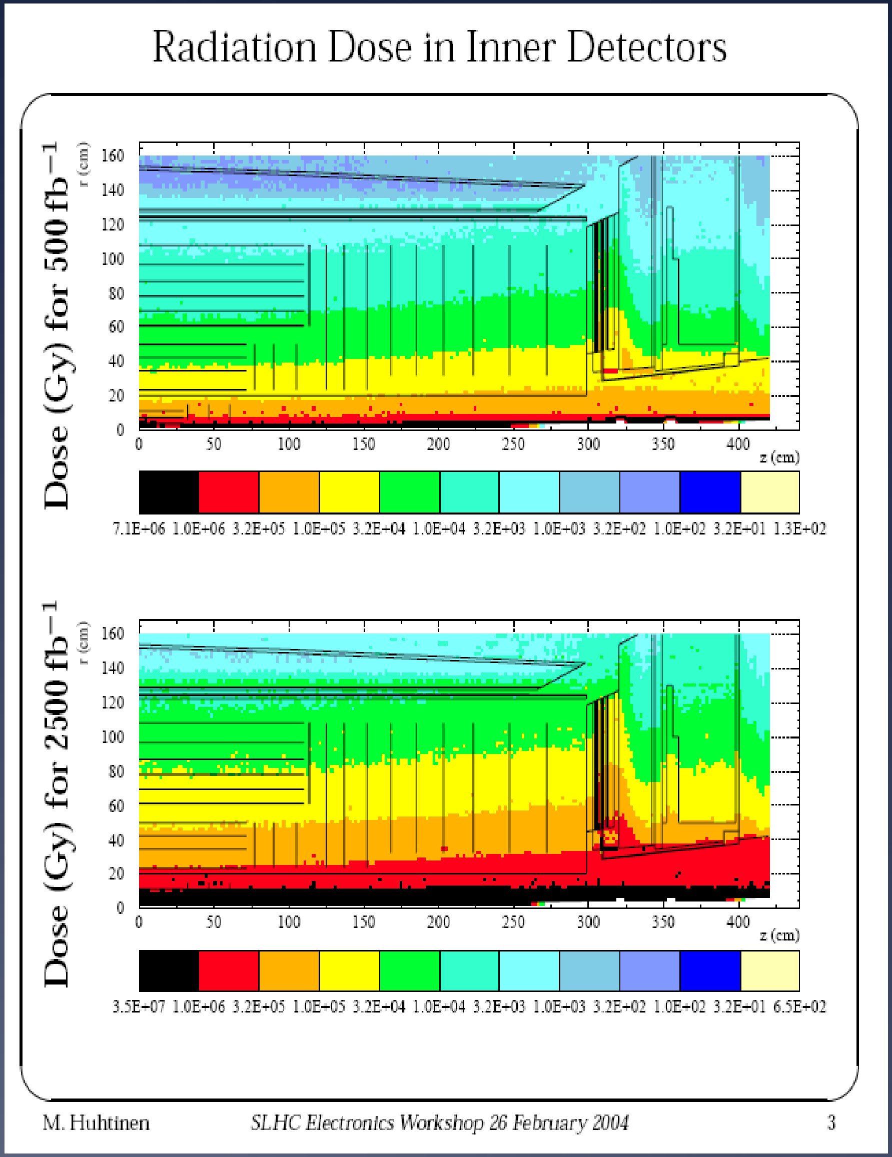


What are the conditions at HL-LHC?

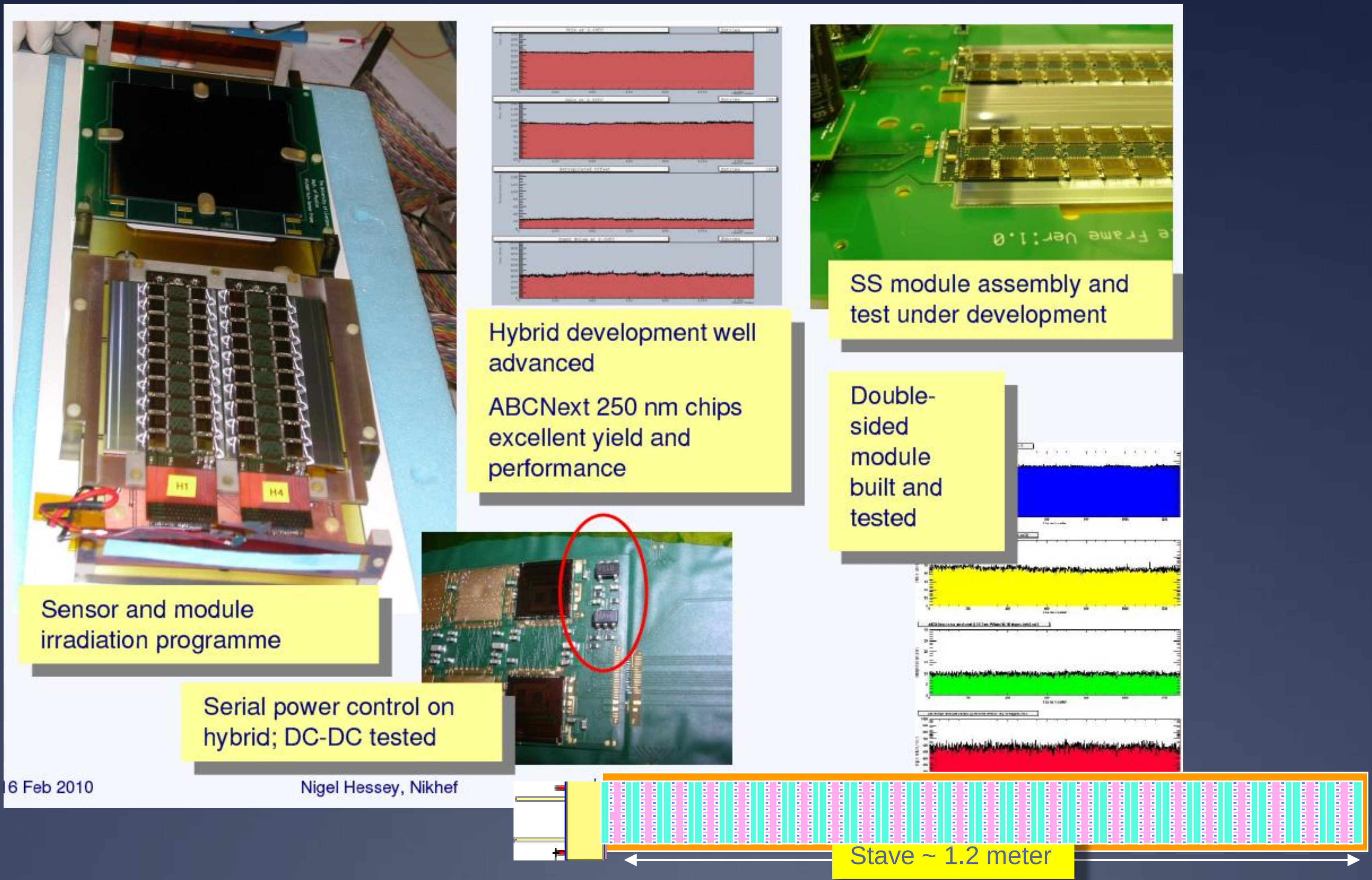


- Want to survive at least 3000 fb^{-1} data taking
- B-layer at 37 mm:
  - >10^{16} 1 MeV n-equivalent non-ionising
  - Few 10s of MGray





Various silicon strip tracker developments



Summary

- The ATLAS detector changes foreseen over the coming 10 years are substantial
- Main focus are ID, electronics and trigger changes, and in the forward direction
  - The ID replacement is needed due to radiation damage
  - Electronics and Trigger changes (for L1) allow ATLAS to maintain its performance at HL-LHC
  - Generally there is a broader focus on detector performance, not only on replacing parts that are expected to fail due to radiation or luminosity increases
- Upgrade construction projects are being formed, with a clear upgrade deliverable, as we go along, the IBL is the first example