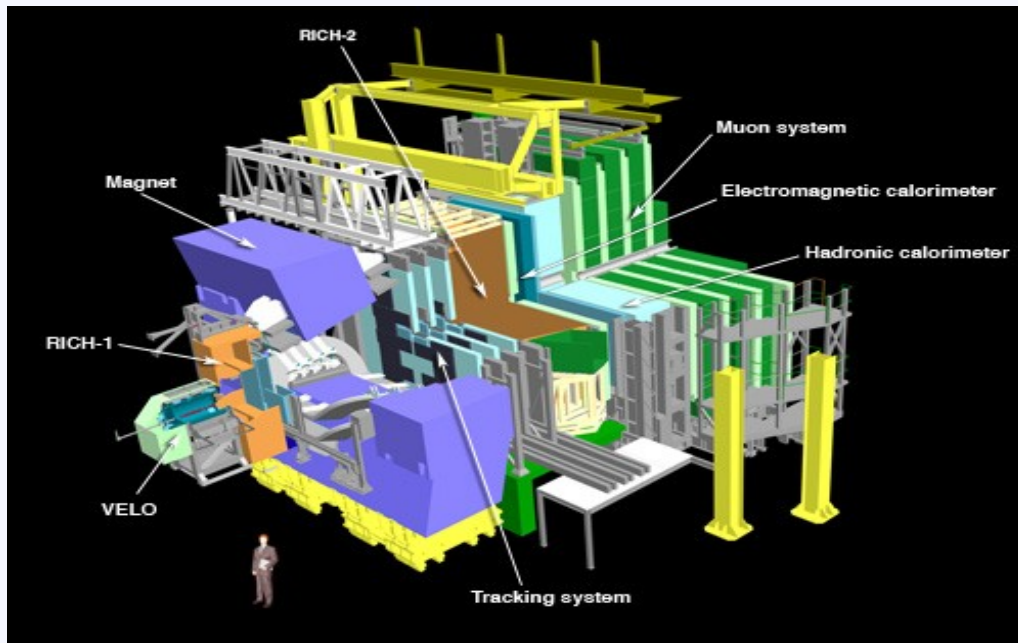
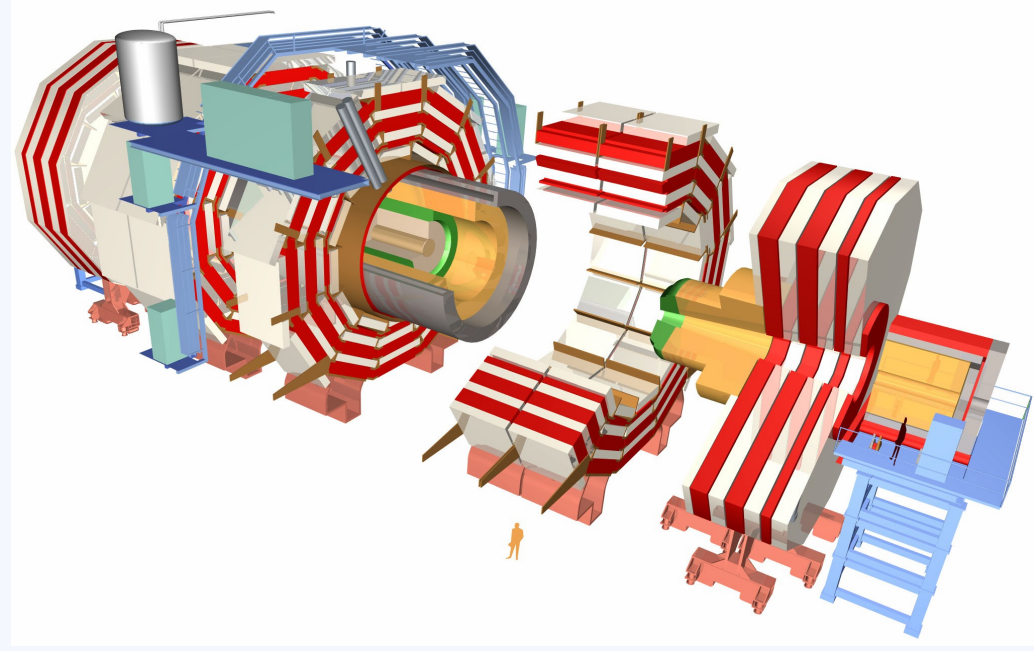
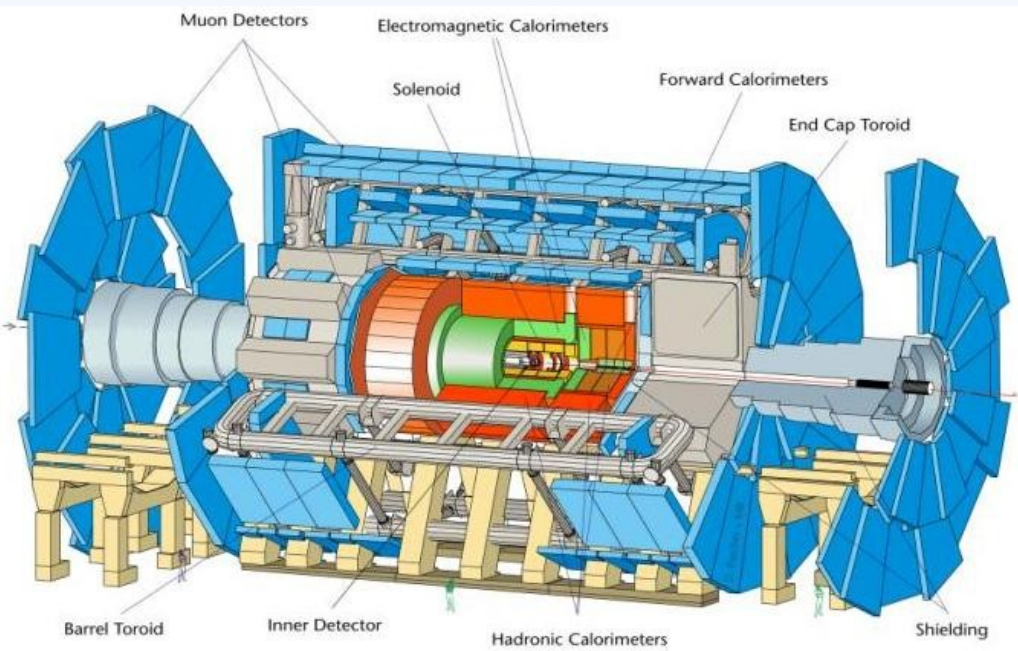


Status of LHC Experiments' Upgrade Projects



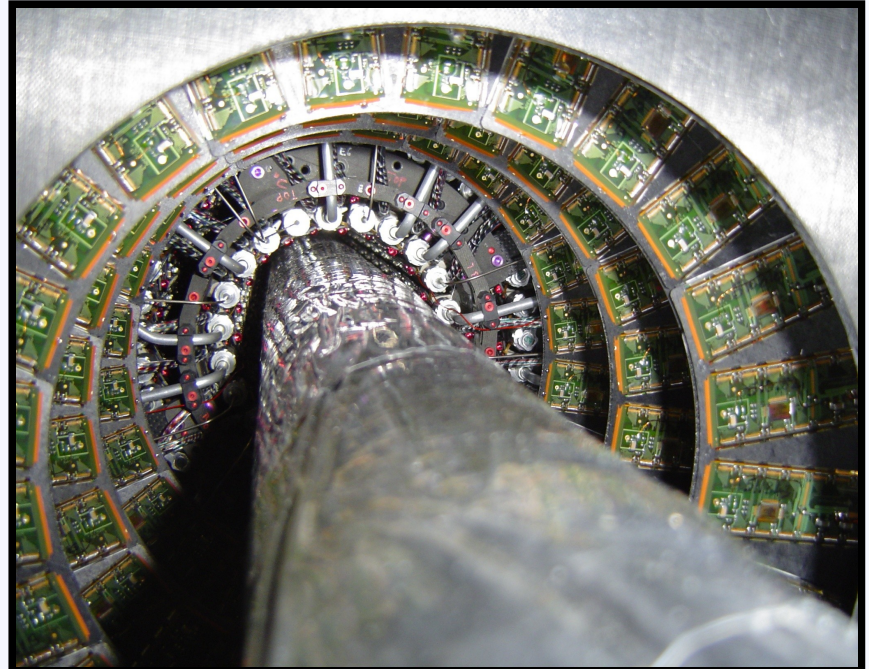
Goals
Current Understanding of
Changes Needed
Triggers
Organisation
Schedule

Upgrade Goals

- ◆ Physics goals as discussed by James Wells
 - ◆ Mixture of detailed measurements to understand what is found at LHC, and extending searches for new physics
 - ◆ We do not know now exactly what the emphasis will be, but we do know it needs current detector performance to be maintained to cover all possibilities
- ◆ Phase-I luminosity around $3 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ which means 75 events per BC at ATLAS and CMS; and 550 fb^{-1} delivered
- ◆ Phase-II luminosity $10 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ or more, and 300 – 400 collisions (or $> \sim 75$ with luminosity levelling) per bunch crossing – very challenging to the detectors
- ◆ Independantly of machine upgrade, the inner trackers of both ATLAS and CMS will need replacing due to radiation damage
- ◆ LHCb does not use full LHC luminosity, and certainly not sLHC. But would like to increase luminosity from 2×10^{32} to 2×10^{33} , coupled with better efficiency for B-decay modes in order to get substantially larger data set

Phase-1 detector changes

- ▶ CMS will replace the entire pixel detector with a new one (4 layers).
- ▶ ATLAS will insert one new pixel layer, inside the current pixel detector - “IBL Project”
 - ▶ These new detectors are needed because of radiation damage to the innermost layers, and to cope with the higher track rates
- ▶ Both experiments will complete staged muon chambers, necessary for the high rates at Phase-I
- ▶ Trigger-DAQ continuously evolves to cope with the data rate



Phase-II Detector Changes - ATLAS

◆ Muon System:

- ◆ Large uncertainty factor 5 means we do not know how much of muon system needs replacing: Just forward region or nearly everything?
- ◆ R&D Projects on-going for the technology choice: New high-rate TGCs, micromegas, small-diameter MDT

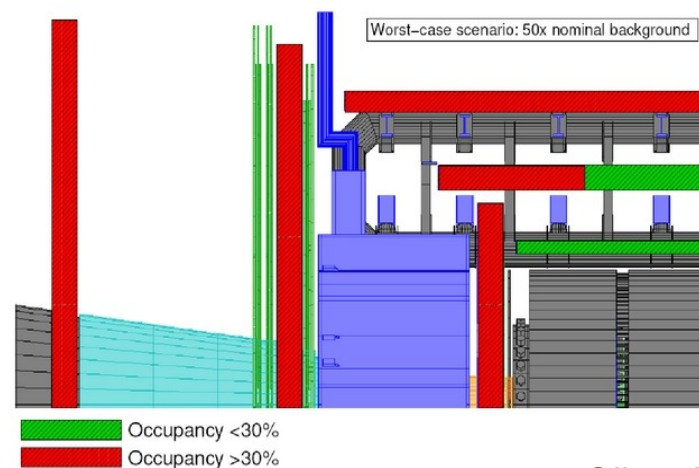
Limitations – occupancies of the chambers



At least half of the chambers in the inner end-cap disk would have to be replaced by chambers with higher high rate capability.

If safety factor not needed

Limitations – occupancies of the chambers



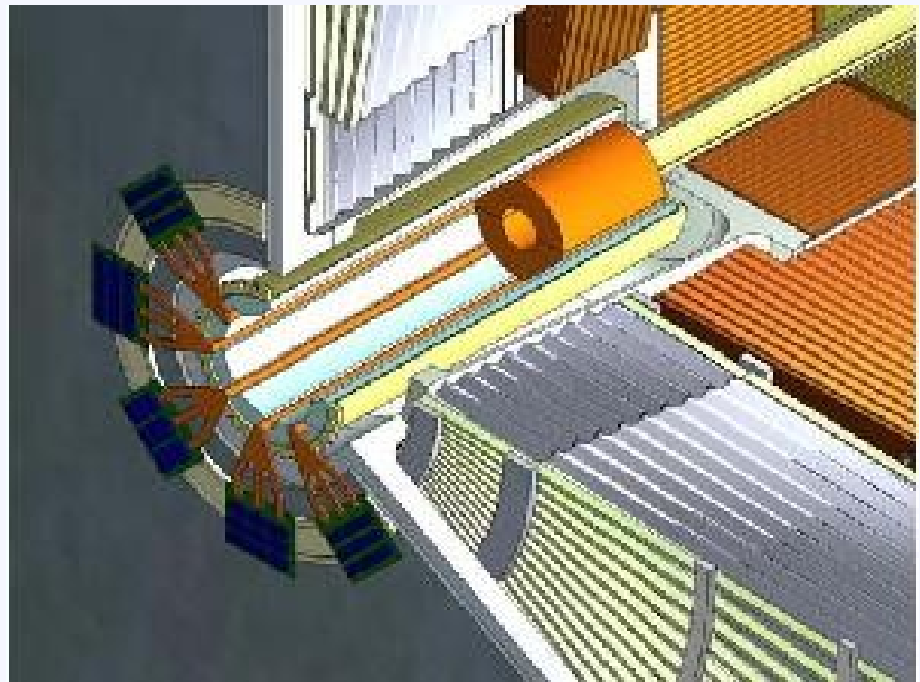
Almost all chamber would have to be replaced.

Oliver Kortner

...Worst case

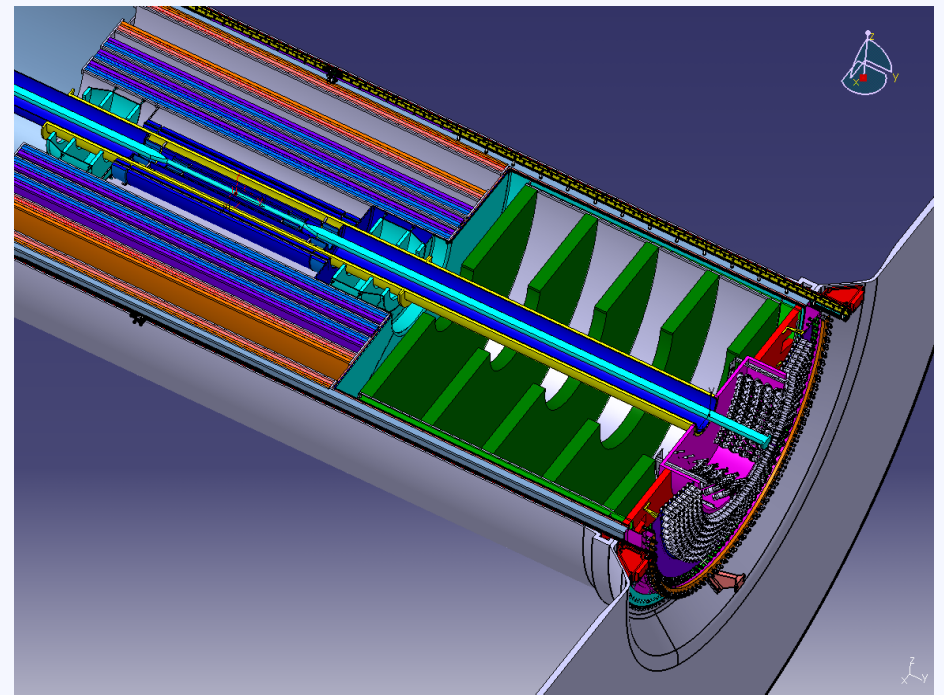
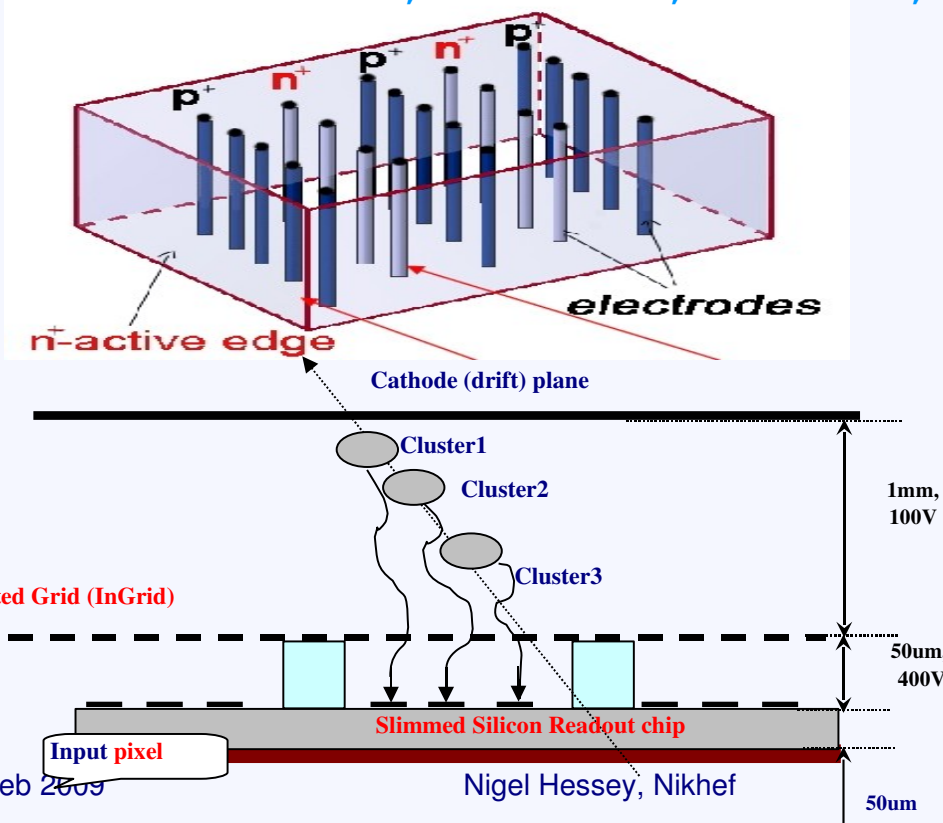
ATLAS Calorimeters

- ▶ Tiles and most of LAr calorimeter detectors perform well at sLHC
- ▶ But electronics and power supplies need replacing
 - ▶ New readout scheme, with all data moved to counting room at 40 MHz
 - ▶ More flexibility in trigger
- ▶ Several possible problems of the small forward-most LAr known as FCAL, under study at Protvino testbeam:
 - ▶ (Fluctuating) HV drop
 - ▶ High Ion build up in gaps between electrodes
 - ▶ Heating causing boiling
- ▶ Two solutions considered:
 - ▶ Mini-FCAL in front
 - ▶ Replace FCAL
 - ▶ Major work in the pit
 - ▶ Can fit in the 18 month SD



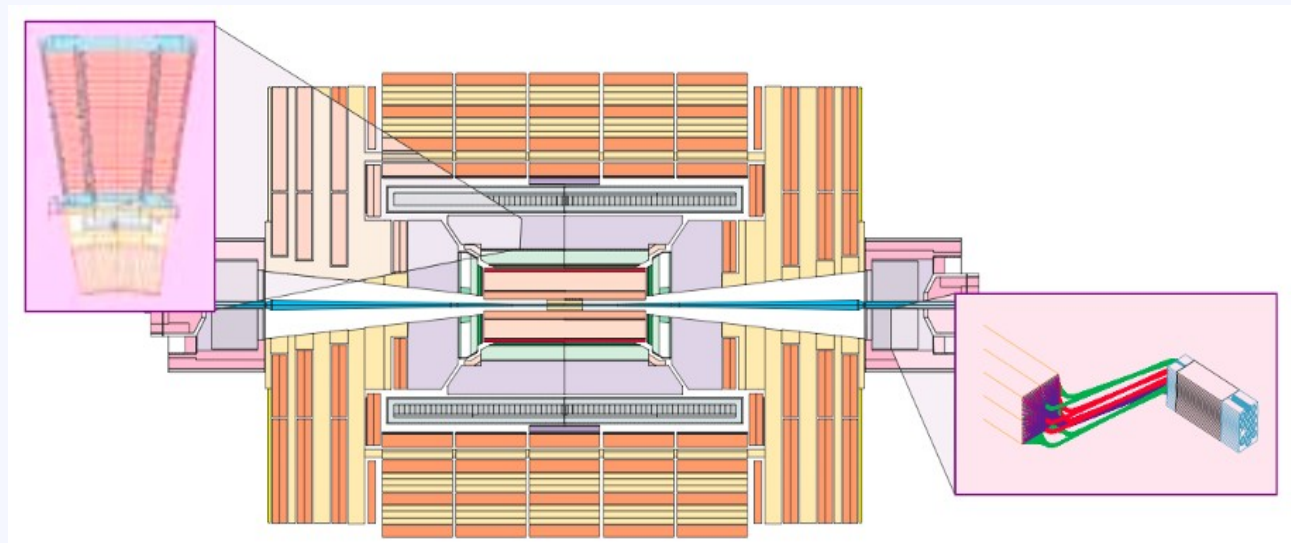
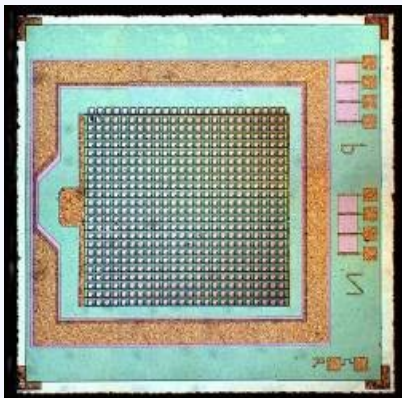
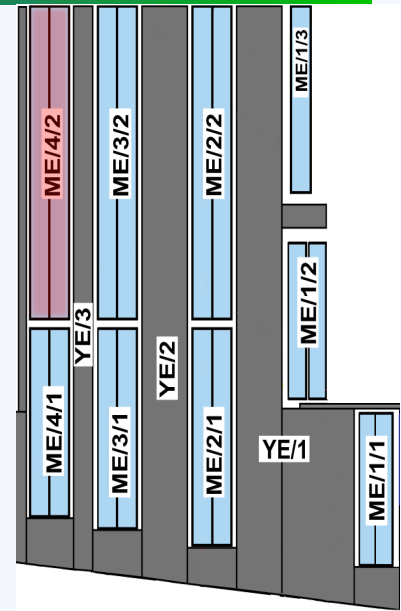
ATLAS Inner Detector

- ◆ All new; higher granularity to keep occupancy low at the very high rates of sLHC
 - ◆ All silicon (no more TRT)
 - ◆ Layout Task Force starting to accelerate convergence on working layout
- ◆ New technologies being investigated for inner-most layers, where the non-ionising dose can reach 2.5×10^{16} 1-MeV n_{eq}/cm^2
 - ◆ Planar-silicon, 3D silicon, diamond, and Gossip (gas pixel detector)



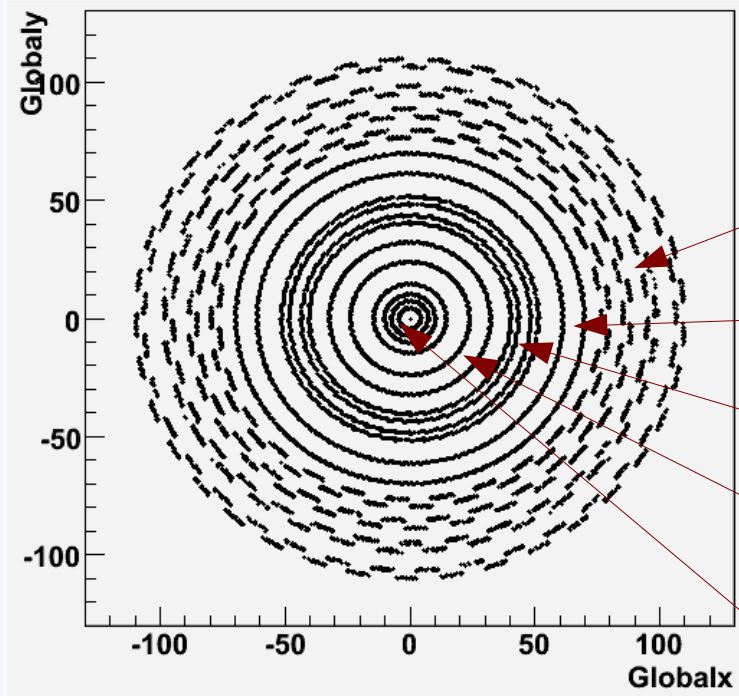
CMS Phase-II Changes

- ◆ Muon system largely OK after Phase-I completion – well shielded with iron return
 - ◆ Need to see backgrounds to confirm; possibly $\eta > 2$ need changing, or limit trigger region to this
 - ◆ But will replace electronics
- ◆ Calorimeters
 - ◆ Mostly OK - few towers blacked by sLHC (tower 1 ~ 4 % of original light output; tower 2 ~23%)
 - ◆ Consider replacing hybrid photo-diodes (barrel and endcap) and photomultipliers (forward) with SiPM
 - ◆ Good performance, and removes tails to high energy from PM discharges



CMS Inner Tracker

- ◆ Replace completely
- ◆ Various layouts under evaluation
- ◆ Level-1 track trigger very important
- ◆ Advances in powering: settle on DC-DC baseline



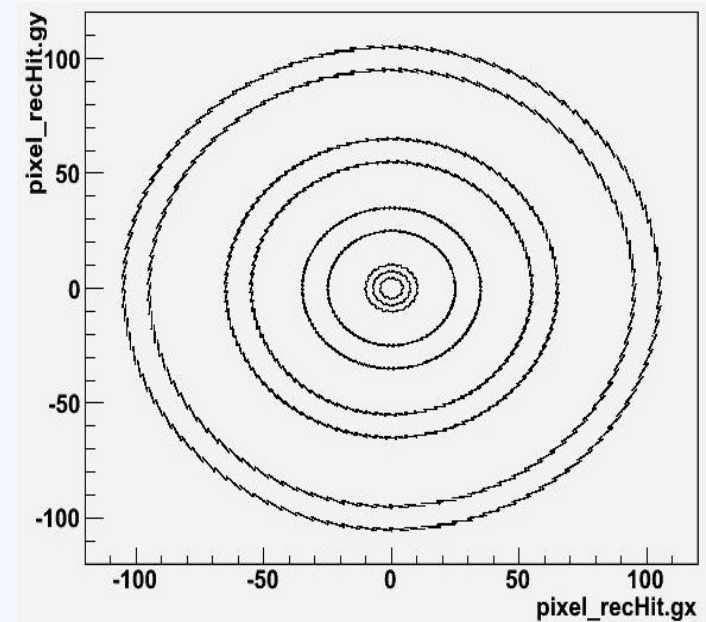
4 TOB short strips

2 TOB strixels

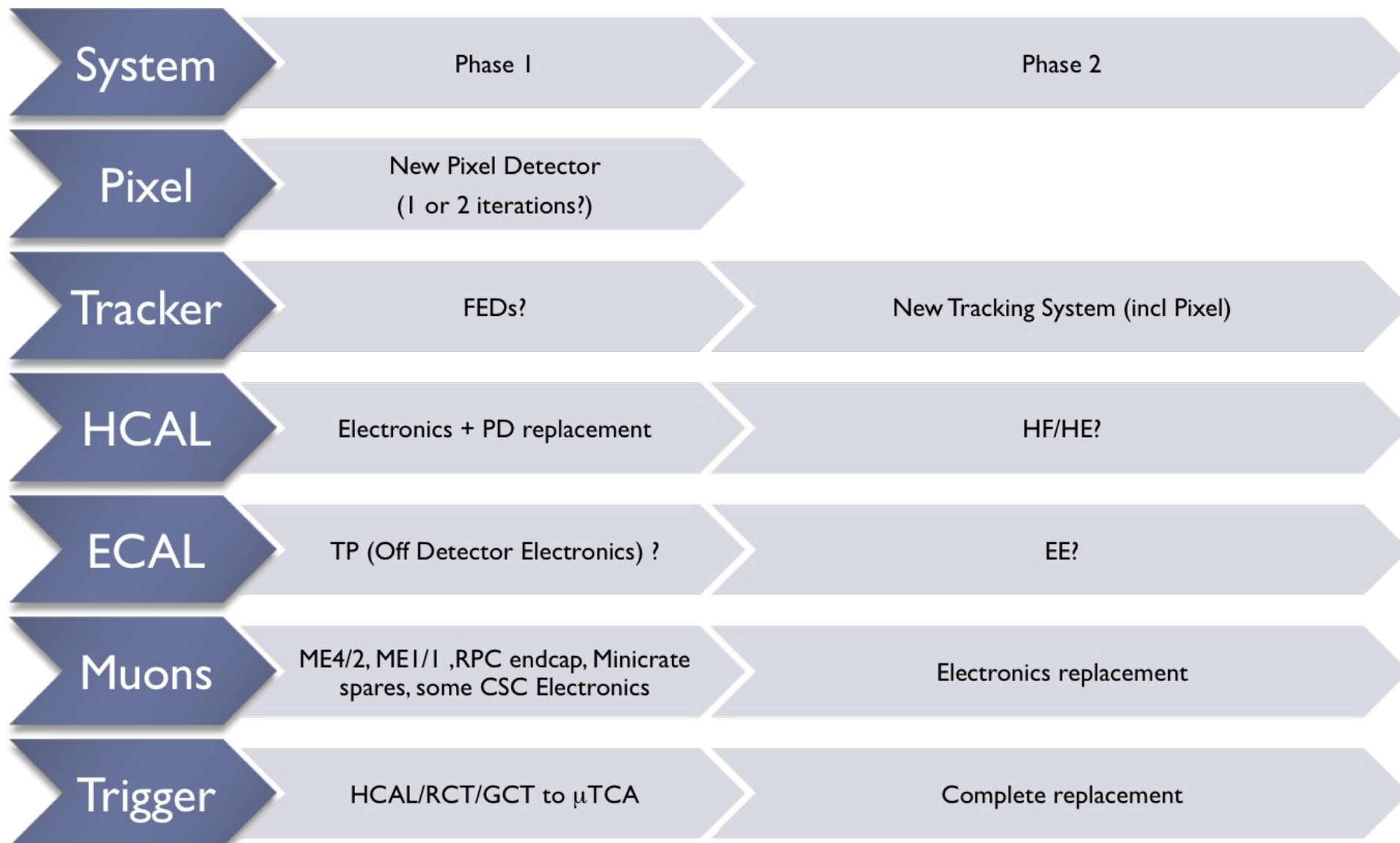
2 TIB short strips

2 TIB strixels

4 inner pixels

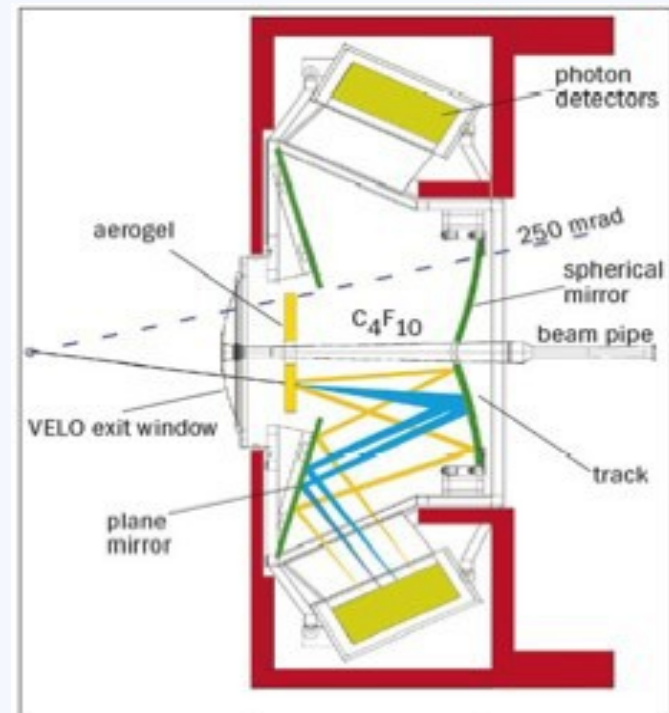
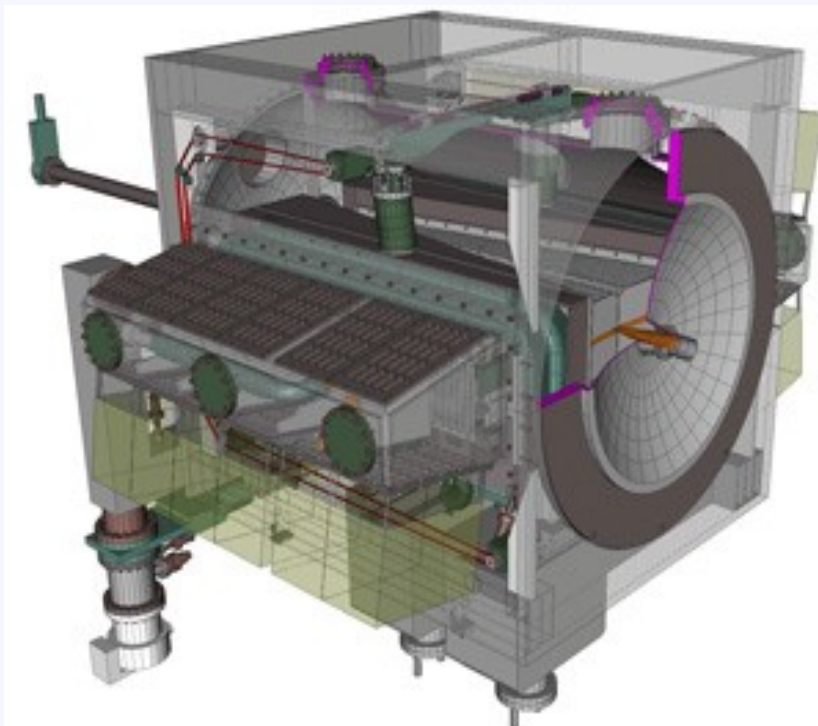


CMS Upgrade Scope Summary



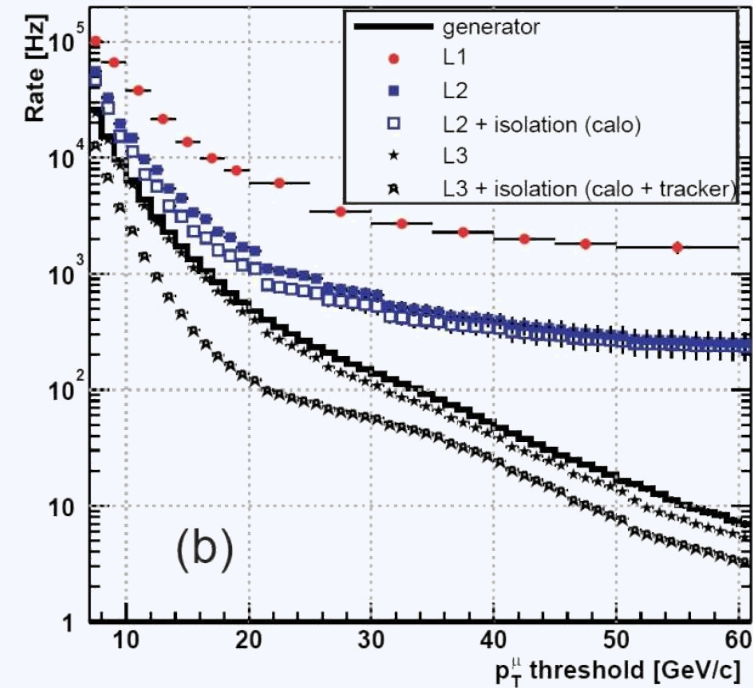
LHCb Changes

- Read out all detectors at beam crossing rate of 40 MHz, in order to have all detector information available for trigger
- Upgrade Vertex Detector, trackers, RICH in order take into account higher rates and improve performance
- Increase event output rate from 2 kHz \Rightarrow 20 kHz

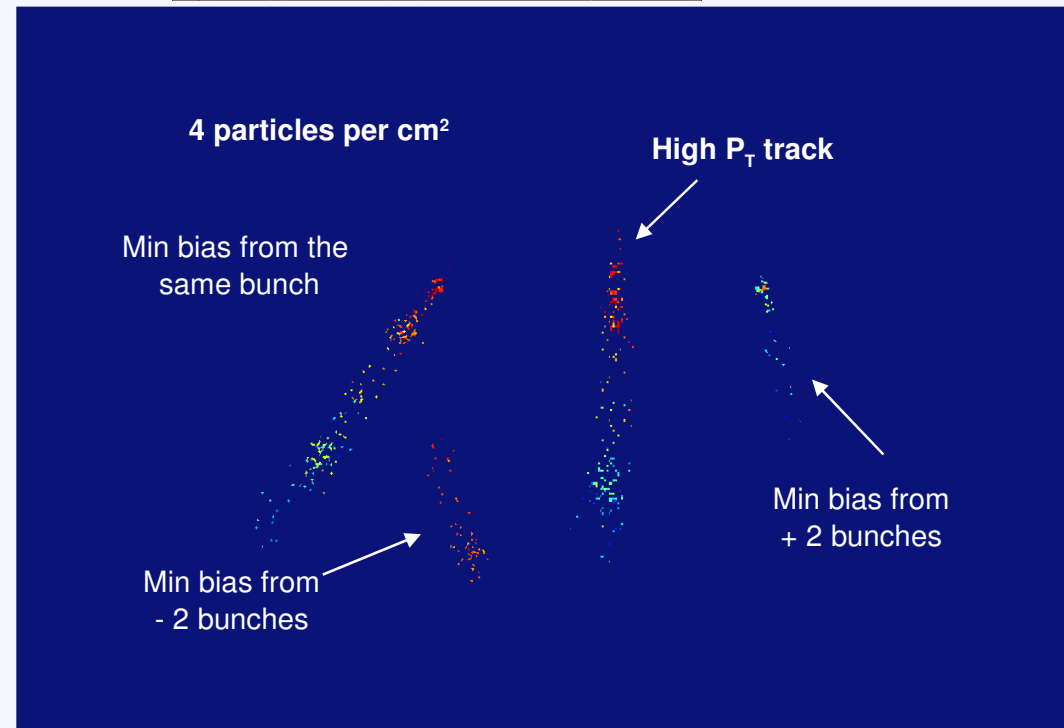
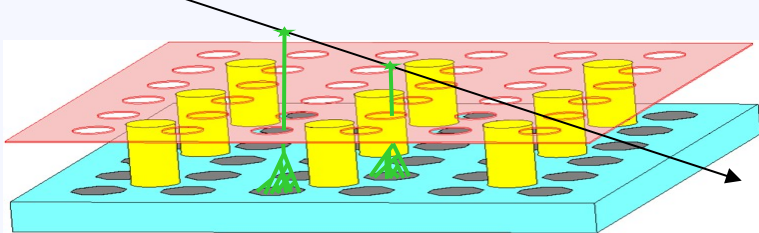
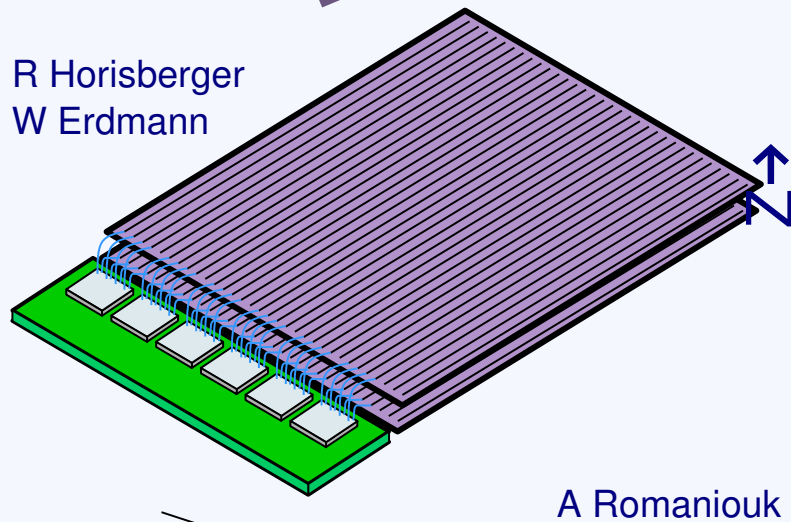
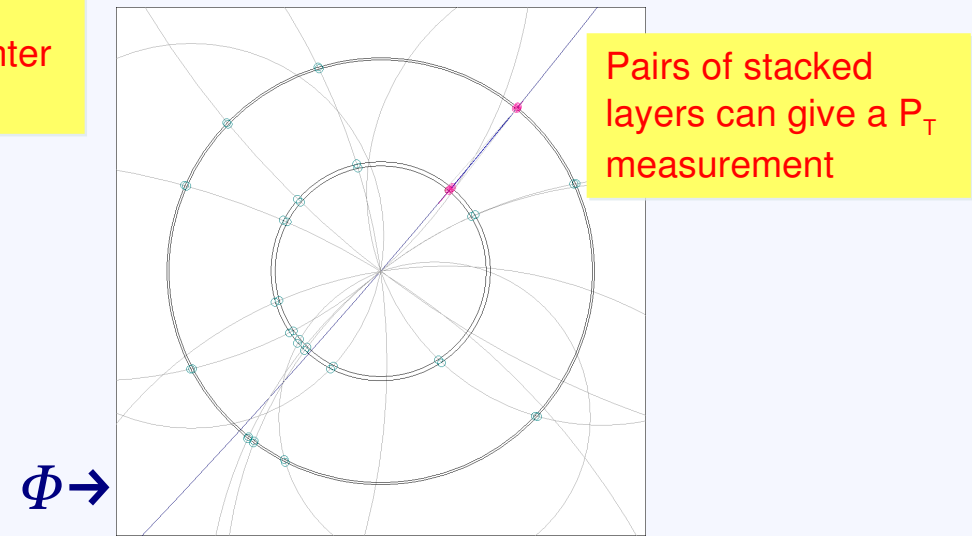
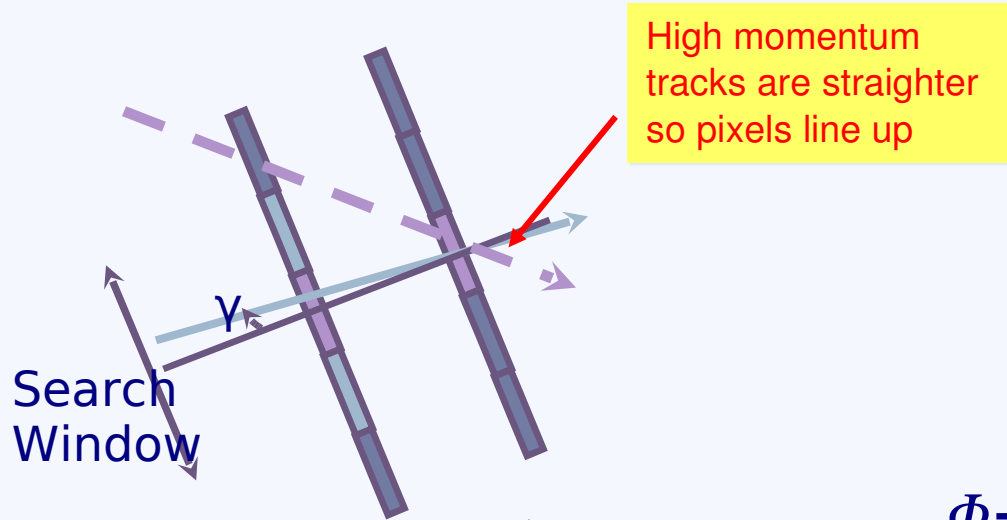


Triggers

- ◆ LHCb will move all data off-detector at 40 MHz allowing a big increase in flexibility, and increase event storage rate 10 fold
- ◆ If ATLAS and CMS keep trigger accept rates the same at each level:
 - ◆ Need to accept ~ 10 x byte rate
 - ◆ And reject 10 times more events
 - ◆ Can reduce rates by raising thresholds, but this cuts into physics channels (e.g. SUSY decay chains give many low energy particles)
 - ◆ At both experiments, muon LVL1 trigger rate \sim constant above $p_T = 20$ GeV/c
 - ◆ CMS: cannot improve – limited BL2 and iron field
 - ◆ Rely on developing track-trigger at LVL1
 - ◆ Plan on totally new trigger scheme at sLHC
 - ◆ ATLAS: can in principle improve
 - ◆ New higher resolution trigger chambers – various ideas
 - ◆ Need to globally optimise the trigger
 - ◆ Is a track trigger at LVL1 possible, necessary, and optimal for ATLAS?



Track triggers



Organisation

◆ LHCb

◆ Upgrade Leaders Group established

- ◆ Coordinators Sheldon Stone and Hans Dijkstra
- ◆ Members from each detector sub-group, including trigger and online; plus physics

◆ Simulation group set up

◆ R&D Project proposals starting

◆ ATLAS

◆ Upgrade Steering Group since long ago

- ◆ Management, system reps, TDAQ, Physics, ...

◆ Project Office

- ◆ Part of Technical Coordination
- ◆ Includes Review Office

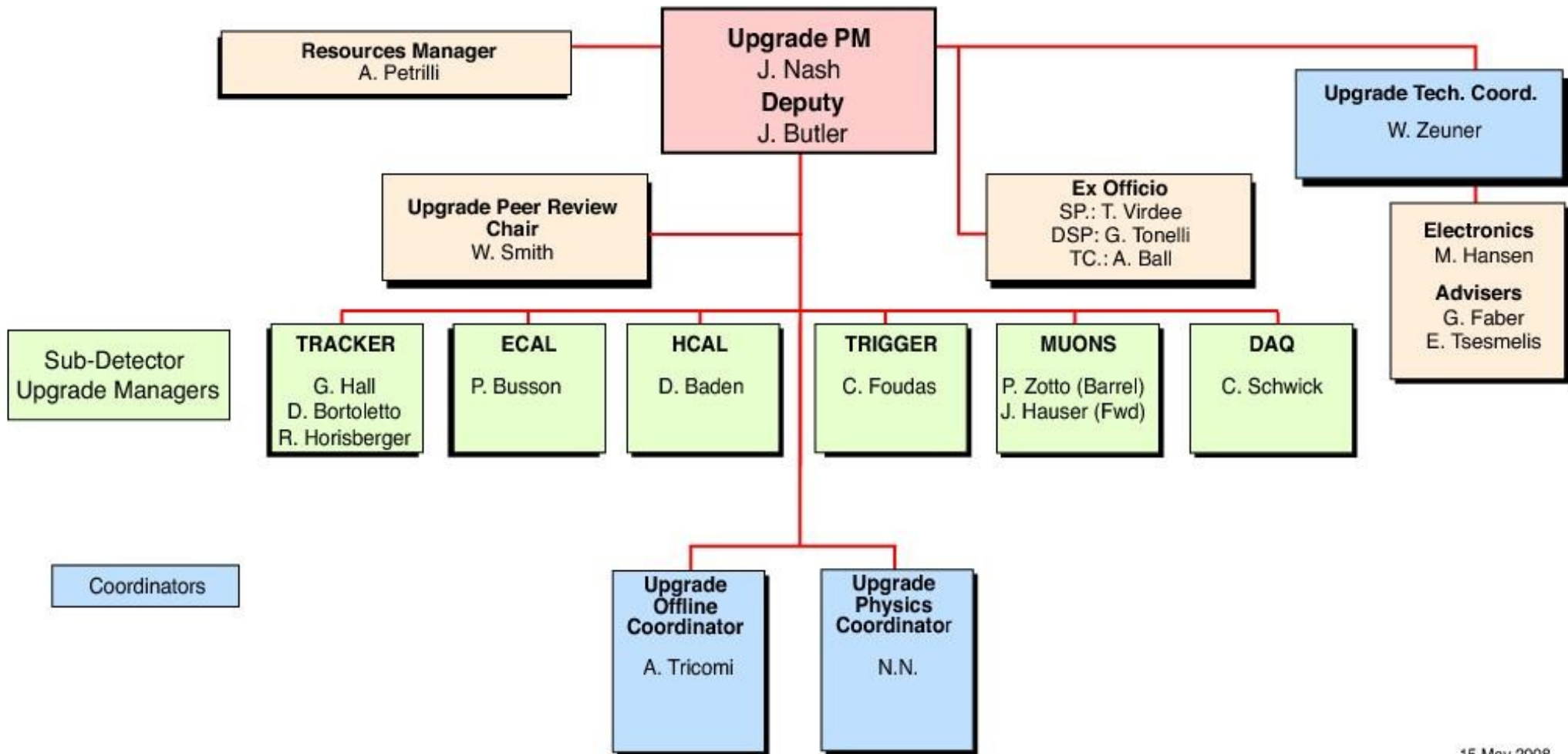
- ◆ Reorganisation in progress to move from R&D projects to more systematic project organisation

◆ Large core of interest, with sub-system workshops and now two ATLAS-wide workshops per year (one on-going now)

◆ Large set of R&D Proposals underway (~33 at some stage)

Organisation - CMS

CMS Upgrade Project



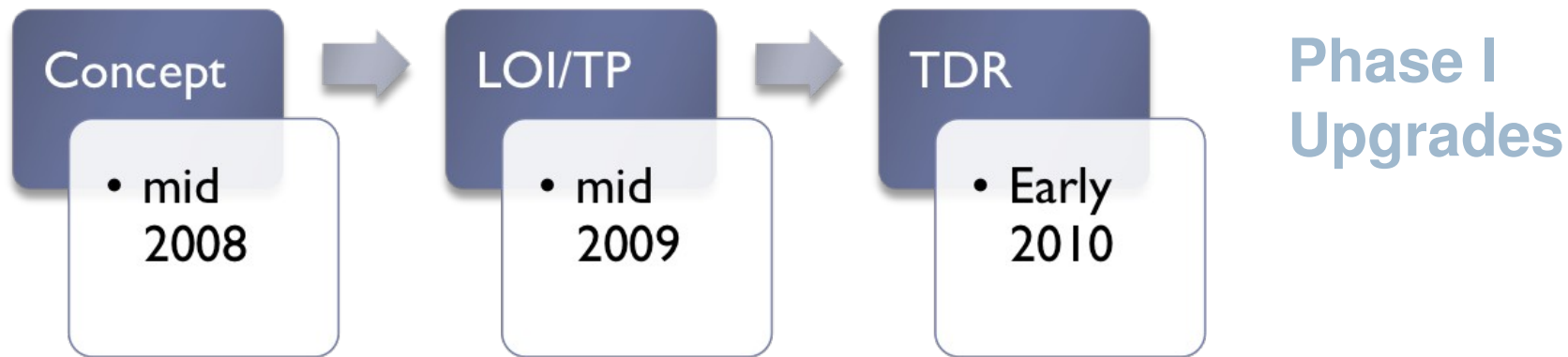
15 May 2008

◆ R&D Proposals: ~26 so far

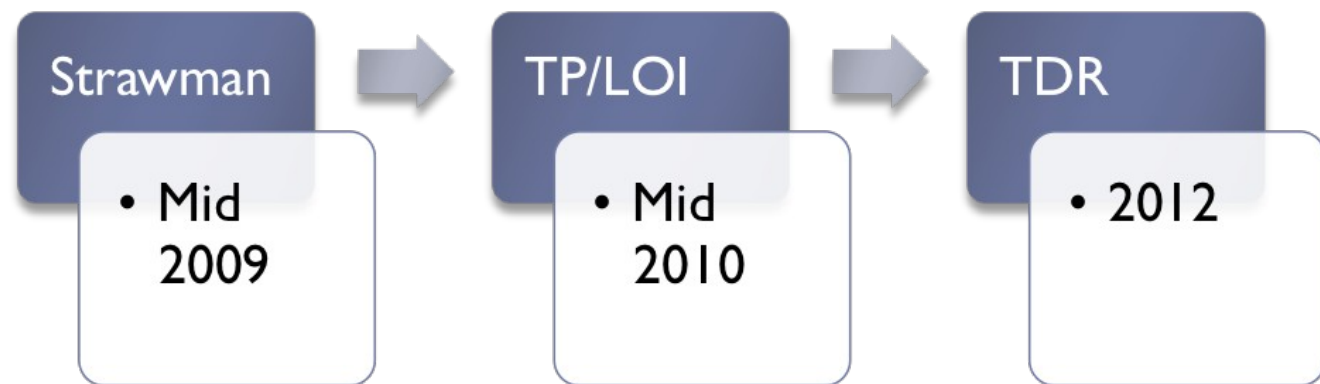
ATLAS Documents Schedule

- ◆ Prepare Phase-I TDR for new B-layer ~next 12 months
- ◆ Prepare Lol for Phase-II ~next 12 months
 - ◆ Define the project scope, see institute interests; send to LHCC
- ◆ Prepare Technical Proposal on same timescale as machine prepares for sLHC approval (2011-12)
 - ◆ This is the document on which we would ask for approval of ATLAS Phase-II Upgrade
 - ◆ May contain options and open questions
- ◆ Technical Design Reports system by system, when designs settled
- ◆ Both ATLAS and CMS need to absorb the impact of the LHC schedule post Chamonix on the LHC Phase-I and Phase-II upgrade schedules

CMS Documents Schedule



Phase 2 Upgrades



Summary

- ◆ ATLAS, CMS and LHCb have major detector upgrade programs underway
- ◆ Basic organisation is in place and evolving
- ◆ Understanding of the scope of upgrades advances, with still some uncertainties, to be evaluated in next couple of years for approval
- ◆ More understanding the LHC, Phase-I and Phase-II machine upgrades needed