WP 3 - Co-ordination of the experimental upgrades – ATLAS

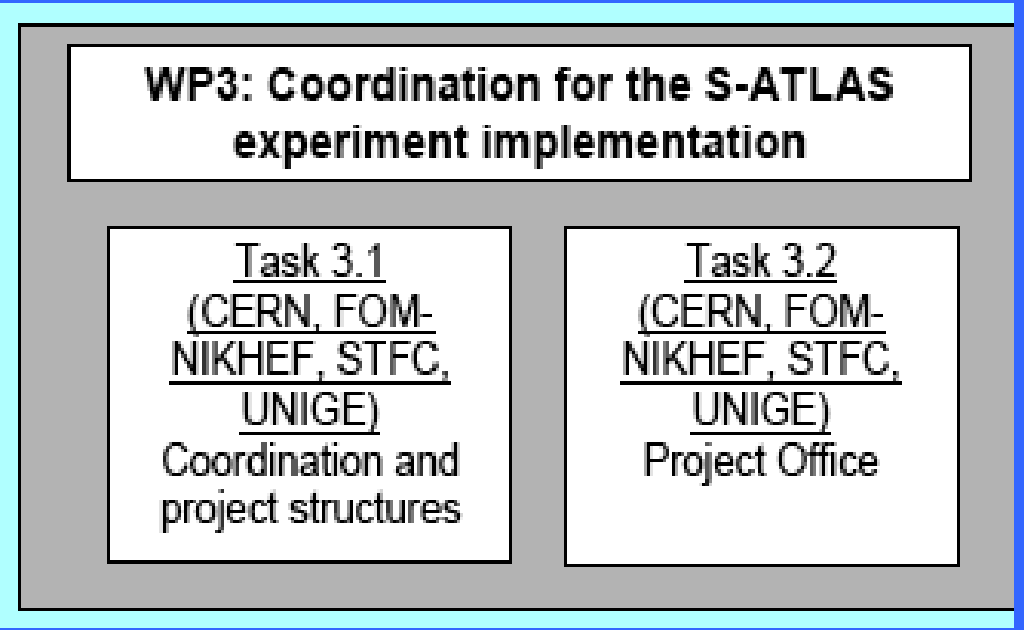
Status of Documents
Organisation Improvements
Meetings held
Some progress highlights
LHC Schedule Considerations

WP Goals

- The main significance of the work-package
  - Outlines a timescale for the equivalents of
    - Letter of Intent (LoI)
      - To LHC Committee; request TP
    - Technical Proposal (TP)
    - Initial Memorandum of Understanding (MoU) for the ATLAS upgrade
      - Intended contributions of institutes
  - Change the perspective of having a LHC detector lifetime of 10 years, to a long term project running well beyond 2020 and having to deal with a substantially higher luminosity than foreseen in the original design
  - Brings some extra resources into the coordination of this work
- The WP is written to cover both phase I and II, however some of the items above are not achievable for phase II by April 2011 ….

Detector work

- Establish the formal structures needed for the ATLAS upgrade construction project, and through Technical Documentation, Cost and Schedule planning, establish an initial MoU for the Upgrade Construction.
- Establish a Project Office to address the critical technical integration and coordination issues of the new detectors, and the technical and managerial tools needed for the project planning and follow up.
- In addition WP5 contains an experimental component (40%) and WP8 addresses a real R&D concern for SLHC detectors (powering)



Tasks 3.1-2 Already done

Deliverables task 3.1	Description	Nature	Delivery date
3.1.1	Project management structure and review office for R&D phase in place	O, R	M06
3.1.2	Establish the initial Memorandum of Understanding for the upgrade	R	M36
3.1.3	Develop detailed cost books for the upgrade including the installation phase	R	M36

Deliverables task 3.2	Description	Nature	Delivery date
3.2.1	Document the technical scope of the upgrade including an initial cost-estimate	R	M24
3.2.2	Schedule for the upgraded detector parts and for the S-ATLAS installation	R	M32
3.2.3	Technical documentation, drawing and CAD information for the existing experiment and the upgraded elements	R	M36

Milestones	Description	Nature	Expected date
3.1	Schedule for the R&D phase	R	M09
3.2	Upgrade project structures adapted to the implementation phase	O, R	M24

What are the key timescales/issues?

- Phase 1 - ~2015
  - What detector elements will need replacement/modification
    - New pixel B-layer around smaller beam-pipe, all inside the envelope of the current PIXEL system: “Insertable B-Layer, IBL”
    - TDAQ improvements
    - Some muon chambers and completion of shielding
    - Possible mini-FCAL to (actively) shield LAr FCAL
- Phase 2 - ~2020
  - What detector elements will need replacement?
    - Whole Inner Tracker
    - Probably FCAL
    - New trigger elements, with 6 – 9 microsecond L1 latency
    - Timescales uncertain, but a new ID requires 8+ years

Tasks 3.1-2 Next steps

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Documents in preparation

- IBL TDR
  - Substantial amount written; initial review by ~dozen experts
- IBL MoU
  - Many discussions, kick off in St Genis meeting July 2009
  - Most issues settled (not all); institutes broadly agreed on contributions
- LoI for sLHC
  - Several chapters written; could be ready by May
  - Propose to continue despite schedule uncertainties, and then select contents according to what we decide to do

Organisation

- PO --> Open meetings, Joint with USG
  - All players present, much more efficient technical discussions
  - Open to all: very important to give all players a say
  - Allows input on things we are not aware of
- USG Enlarged
  - IBL rep plus separate Pixel rep
  - Germany now represented
  - French representation under discussion
- IBL: approved project
  - Project Leader (PL)
  - Technical Coordinator (TC)
  - Management Board
  - Sub-groups
  - Functioning well

New B-layer (IBL)

Current B-layer will become inefficient (max. bandwidth exceeded in front-end chips; radiation damage) at Phase-I

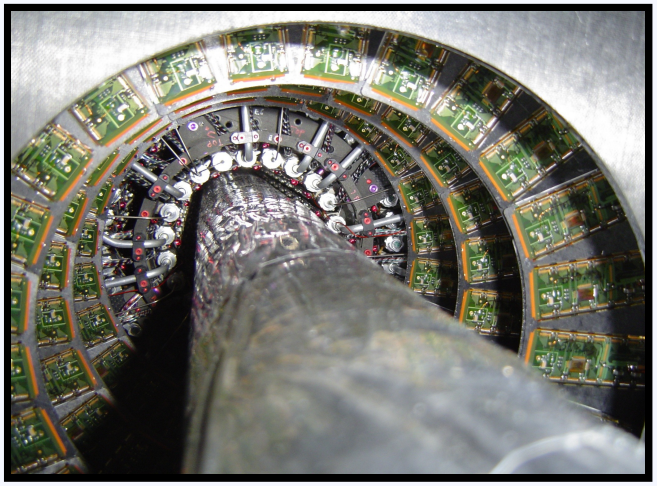
Cannot replace in a one-year shutdown; instead, insert a new layer inside the current one

Requires smaller beam-pipe to make space; agreed now with machine; 29 mm radius --> 25 mm.

Improves the vertexing performance because of proximity to beam

New FE-I4 chips allow higher rate (130 nm CMOS, per-pixel memory only read-out if L1 trigger)

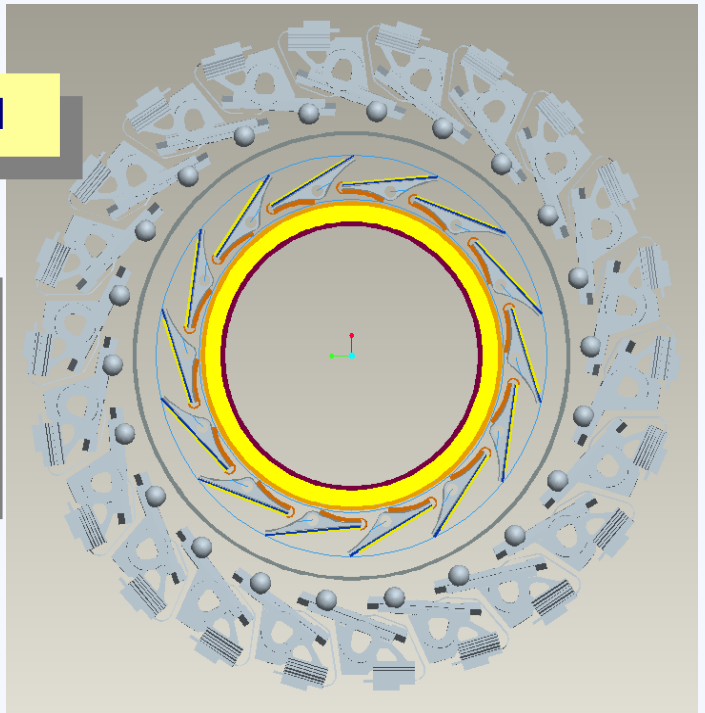
Submission of prototype chip very soon



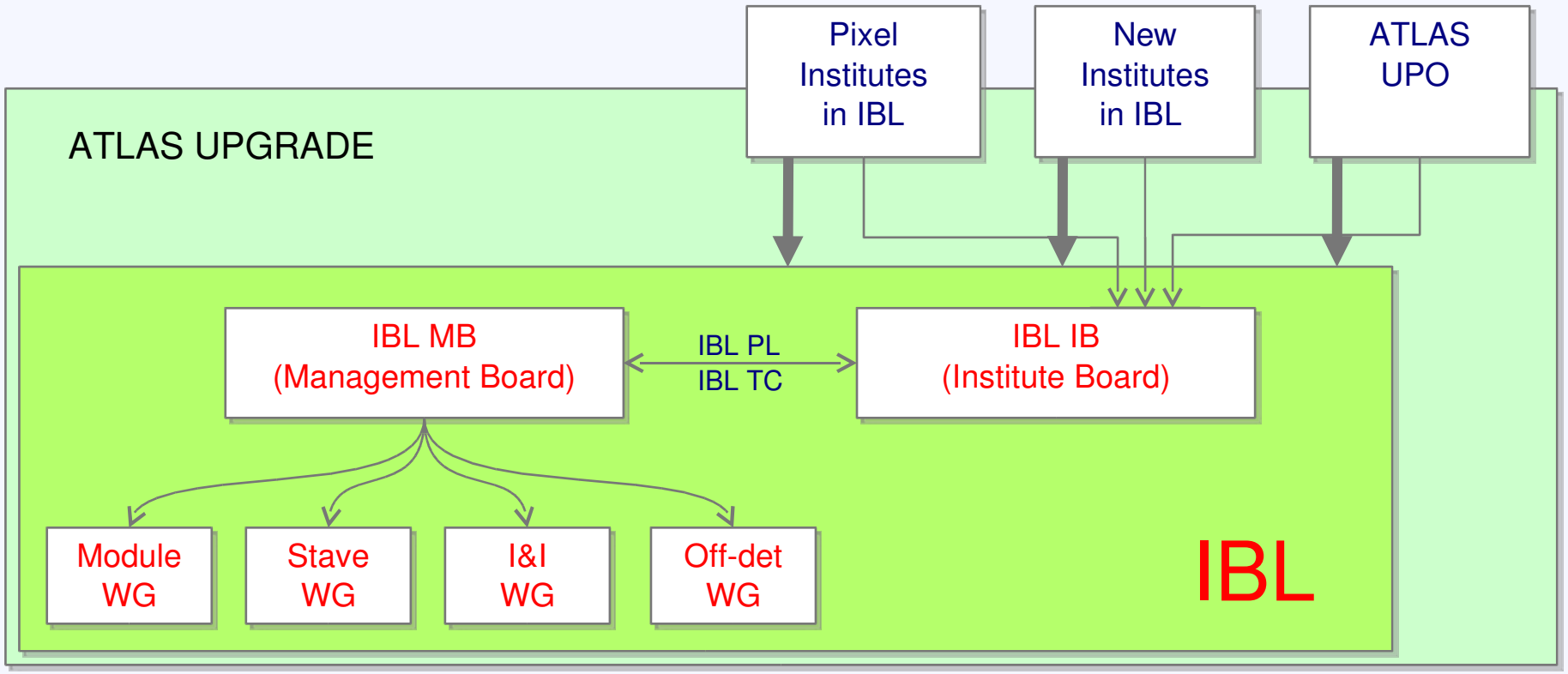
Current beampipe and pixel detector; space is tight!

New layer inside the old

Several sensors considered: planar Si (thinned or not, n-in-n, n-in-p) 3D; diamond



IBL Organisation

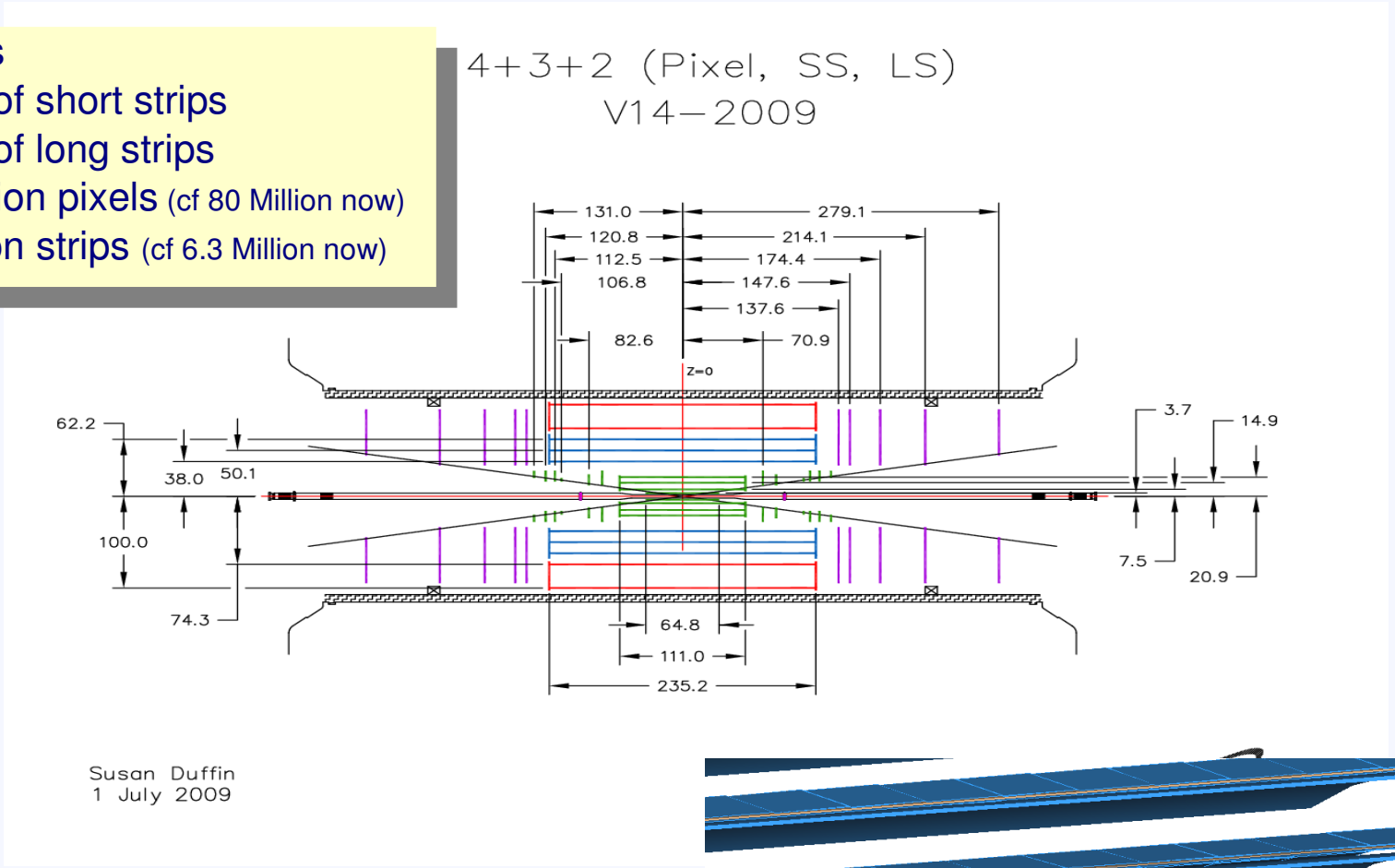


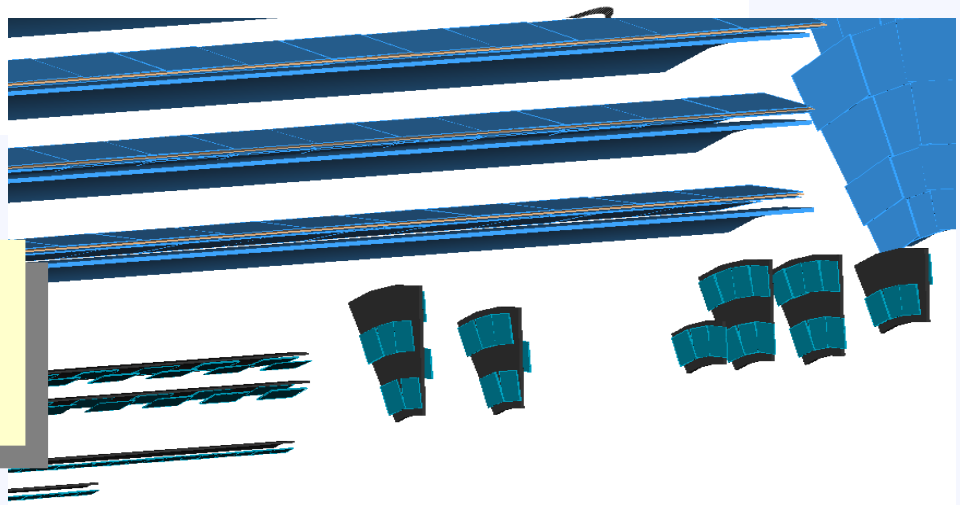
Organisation (cont.)

- Inner Tracker
  - Extra pixel person brought in to cover sLHC Pixels
  - Strips: Strengthened with one new person
  - Strips structure in place, but still some key positions not really covered
  - Pixels more focussed on IBL
  - Working on an Inner Tracker Management Board

Strawman Layout of New ATLAS Inner Tracker

4 layers of pixels
3 double-layers of short strips
2 double-layers of long strips
Approx. 400 Million pixels (cf 80 Million now)
Approx. 45 Million strips (cf 6.3 Million now)

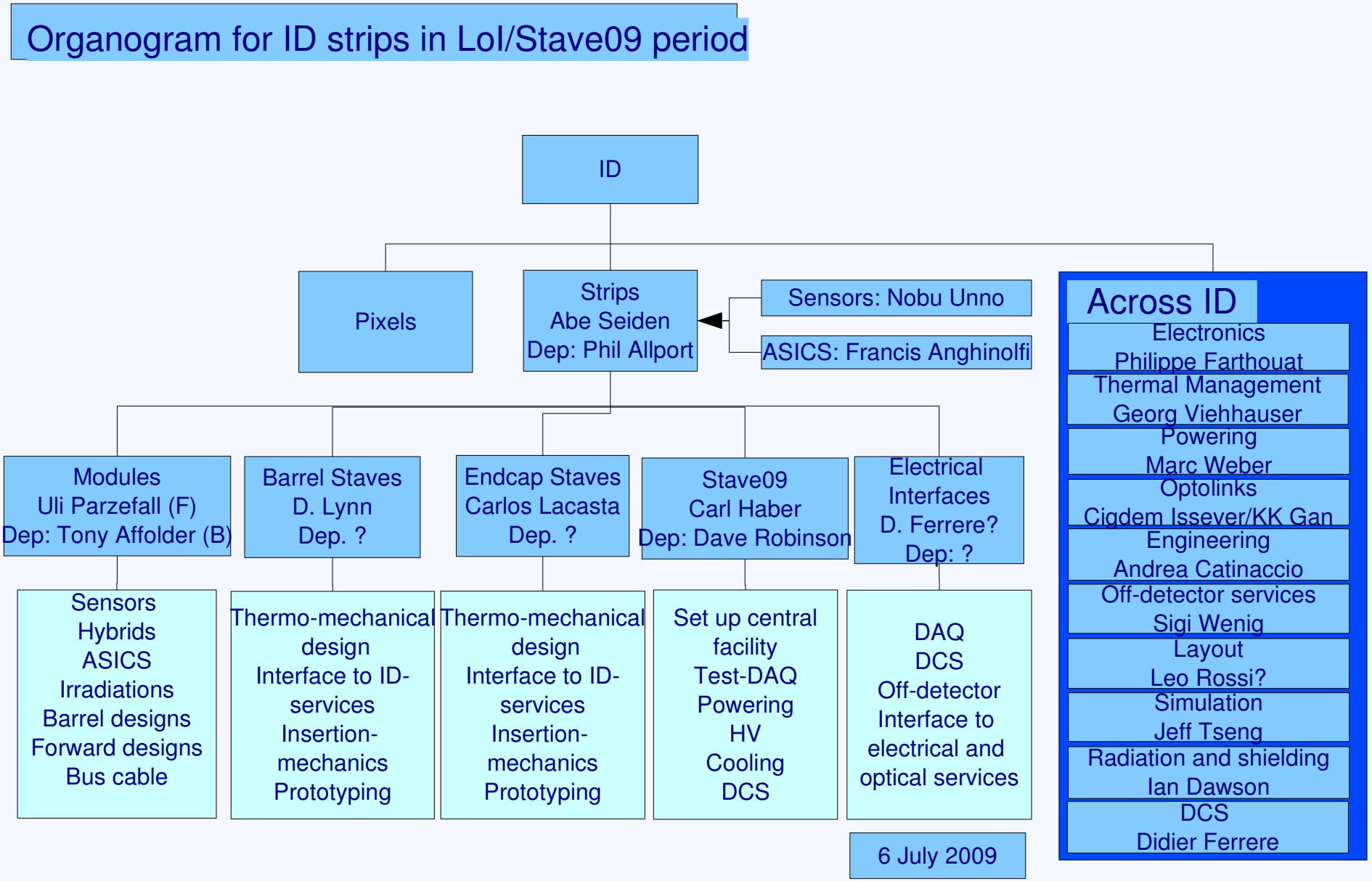




Being implemented in Geant, including realistic services, to study performance and look at optimisations

ID Organisation

- (Some names out of date)



Meetings

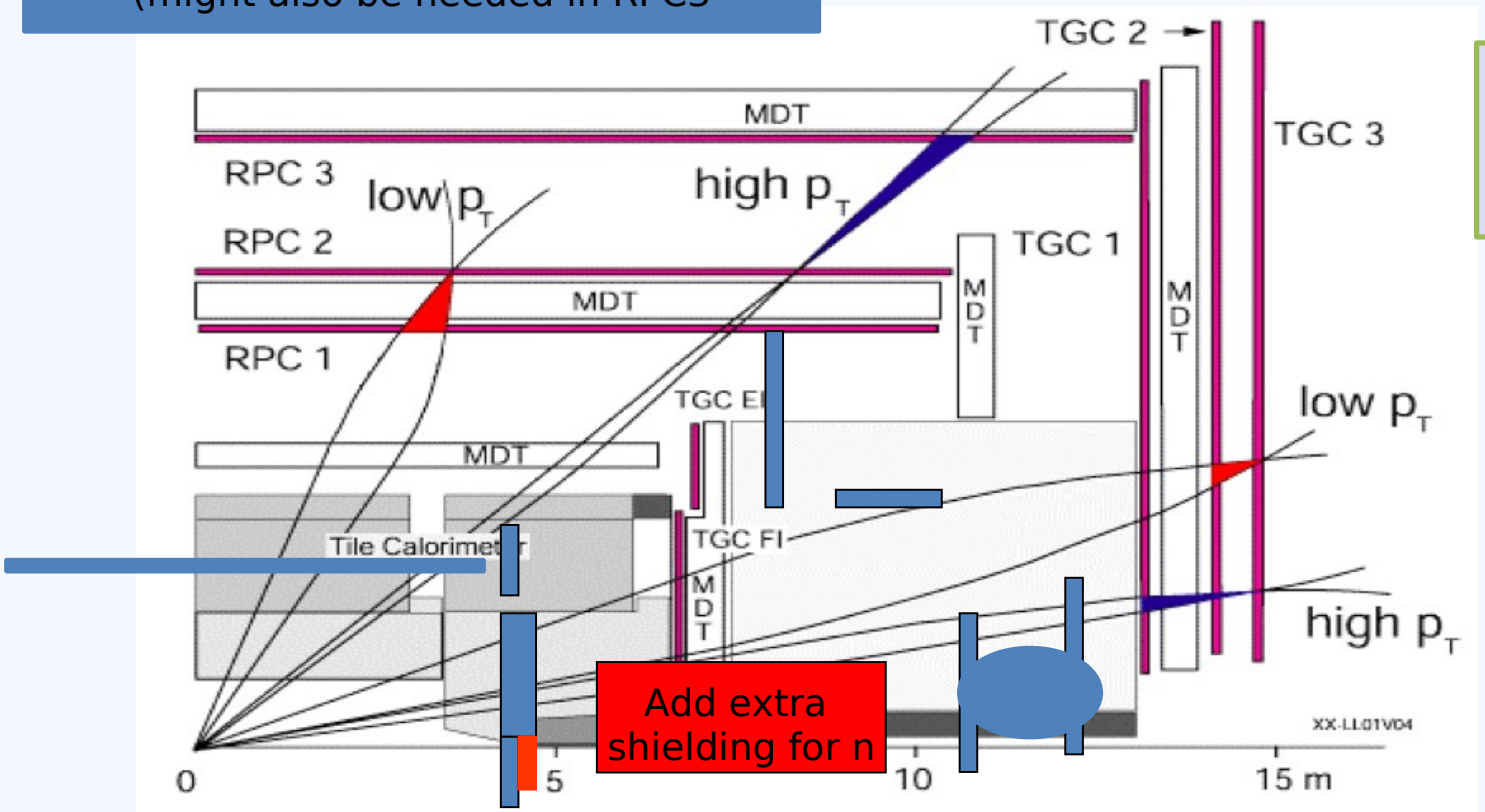
- Two ATLAS Upgrade Weeks held in 2009
  - Well attended
  - Good exchange of information
  - Especially useful for bringing e.g. TDAQ, Calo, Muon and Track Trigger together
  - But also allowing technical discussions at detailed level in parallel sessions
- Next AUW at DESY in April
  - Apart from usual needs, two aims:
  - Help get DESY integrated in Upgrade
  - Build up team spirit, get away from distractions at CERN to encourage everyone to look at Upgrade as a whole, not just their own system

Some Highlights 2009

- Muon trigger performance and how to improve is better understood
- LAr mini-FCAL:
  - Monte Carlo studies underway, concept “complete”, need is better understood – maybe necessary long before sLHC
- Track Trigger
  - ATLAS can go a different path to CMS, with significant advantages
- FE-I4 pixel readout chip for IBL reviewed; heading for production
- Strip modules
  - Both stave and super-module concept advancing
  - ABCNext chip a big success
  - Module noise performance excellent

MUON Upgrade for sLHC

Add extra doublet with mm resolution (might also be needed in RPC3



Might need to add a Doublet of Trigger ch. To improve L1 in low BdL region

Replace very forward chambers for higher resolution and rate capabilities

Replace Small-Wheel chambers for high rate tracking and triggering
Many R&D projects ongoing
Replacement extent depends on cavern background (large uncertainty)

Possible new warm calorimeter

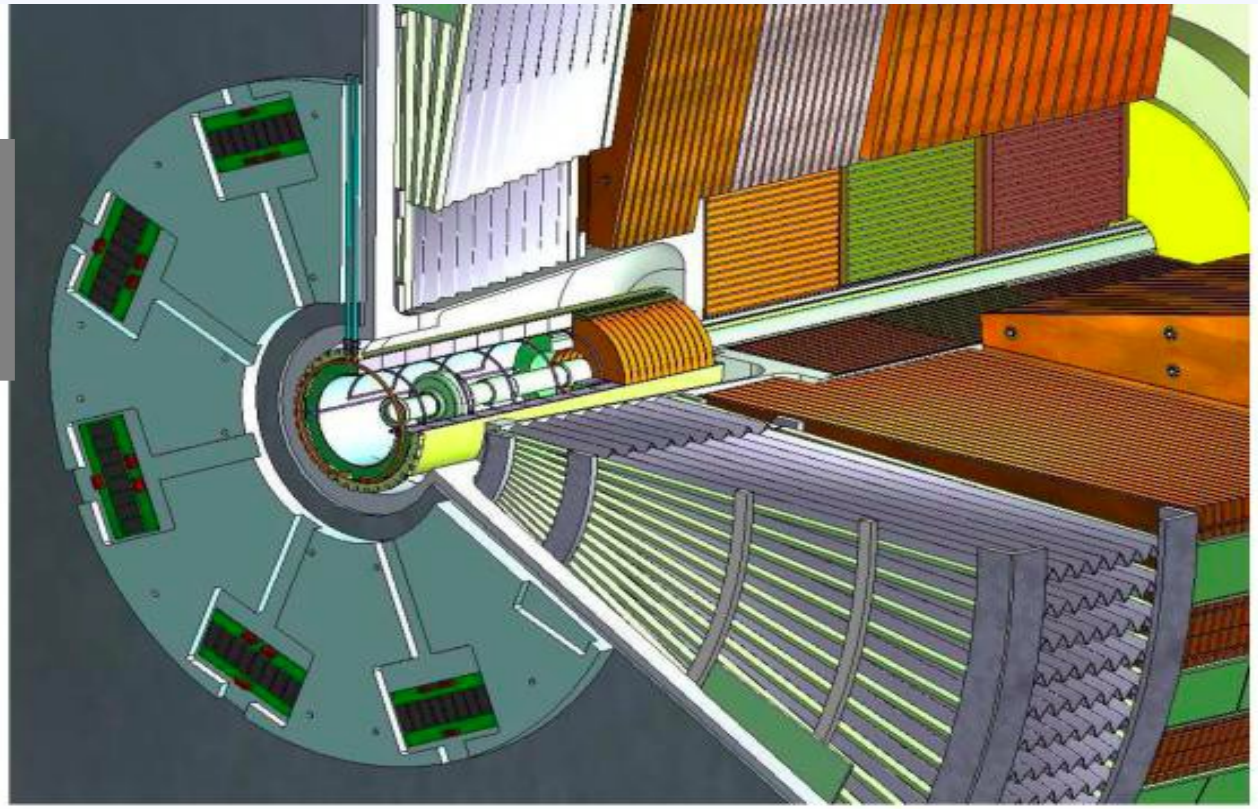
The LAr FCAL extends to pseudorapidity η = 4.9, with very high particle fluxes

Ar^+ ion build up and (fluctuating) voltage drop across HV resistors will deteriorate performance; need studies to see how much.

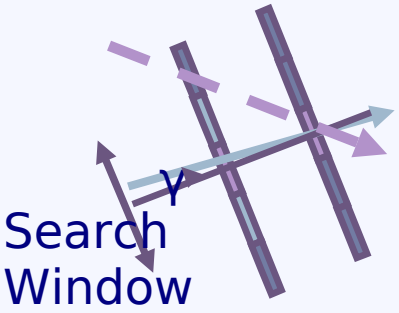
If needed, we can insert a miniature warm calorimeter just in front of the current FCAL

It absorbs the e.m. jet component, halving the energy deposit in the FCAL

Cu absorbers, diamond sensors: very rad-hard, highly segmented readout. Placed in alcove around beam-pipe.

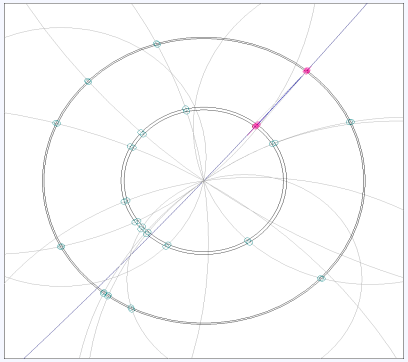


Track Trigger at L1



High momentum tracks are straighter so pixels line up

Pairs of stacked layers can give a P_T measurement



Several ideas for implementing a track trigger at L1. Wanted: high-PT (~20 GeV) leptons.

CMS need to identify electrons early so leans towards paired pixel planes

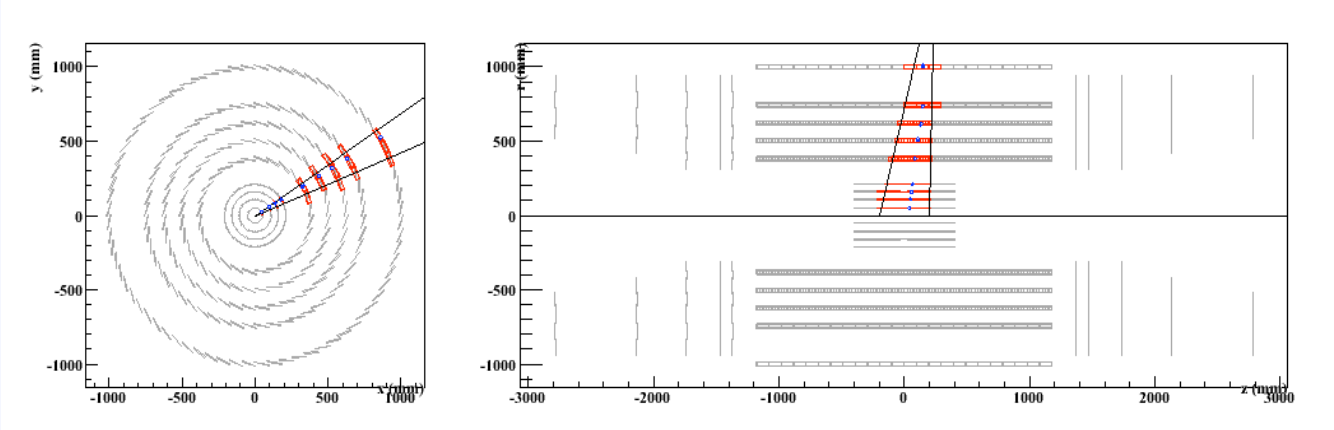
ATLAS EM calo has good identification, allowing another approach:

Calorimeter or muon system identifies a candidate high-PT lepton and gives region-of-interest

Inner tracker modules in that region are read-out, and hardware track finders confirm presence of track with matching momentum

RoI is a few % of modules so small increase in bandwidth needs --> very little increase in material

Needs additional data stream in FE chip and a lot more study, but encouraging so far



Schedule Issues

- Chamonix – 1 week of intense discussion, often controversial reflecting uncertainties and different levels of optimism for a complicated machine
- Near term plan fixed, 3.5+3.5 TeV for 18-24 months (~1 /fb) then long (15 month?) shutdown to prepare machine for “7 TeV” (probably about 6.5+6.5)
- Is it unreasonable to imagine an SPS and Linac4 able to deliver Ultimate current to the LHC; new IR Quads able to take 3 10^{34}, with Crabs allowing you to use the full benefit of the smaller β^* (potential 4 x 10^{34}, too much for quads and current ATLAS) but then use luminosity levelling at ~2.5 10^{34} for significant integrated luminosity per year (150 fb^{-1} /year?)
- If we come near that, then quite soon after we need new Inner Tracker
- And beyond: Nb Sn quadrupoles + higher LHC current for ~4 10^{34} level and ~300 fb^{-1}/year --> 3000 fb^{-1} by 2030
- Hope for a positive statement this afternoon in the Chamonix summary

After Chamonix... Re-assess needs in view of new schedule

- Continue with IBL – it improves ATLAS, Linac4 is still on schedule, organisation is up and running
- We have a large list of tasks needed (consolidation, de-staging, repairs, completion of shielding, ...) and upgrades that are beneficial
- Bring some improvements into separate projects modelled on the IBL organisation – some suggestions:
  - TDAQ, mini-FCAL, Muon chambers (CSC region...), shielding, ...
  - Time scale to suit, but typically before/around 2017
  - If they improve ATLAS performance or robustness, we should do them – it is more important to extract maximum benefit out of reduced luminosity
  - Base our milestone documents, organisation, and planning on these
- Inner Tracker and FCAL replacement
  - Needs some thought. Need to understand confusion, try to get a resonable date estimate, but could be much later.
  - Brainstorm if any ID improvements beyond IBL are possible
    - Entire pixel, Si strips in C-wheel area, endcaps...

Summary

- WP3 is well aligned to ATLAS Upgrade Project
- First deliverable and milestones passed; rest ontheir way
- Next milestones linked to TDR for IBL/Phase-I, and LoI for phase-II
  - On their way
- Need to reflect on implications of Chamonix
  - Particle physics needs a commitment to high integrated luminosity in a reasonable time
    - 3000 fb^{-1} by ~2030
  - Without a machine vision, we will not keep momentum up to develop the detectors. ID >~8 year lead time.