ATLAS Upgrade Projects

Comments on physics goals

Need for Upgrade

ATLAS Detector - changes needed

Organisation, R&D projects

Schedule, length of shutdown

Comments on physics motivation

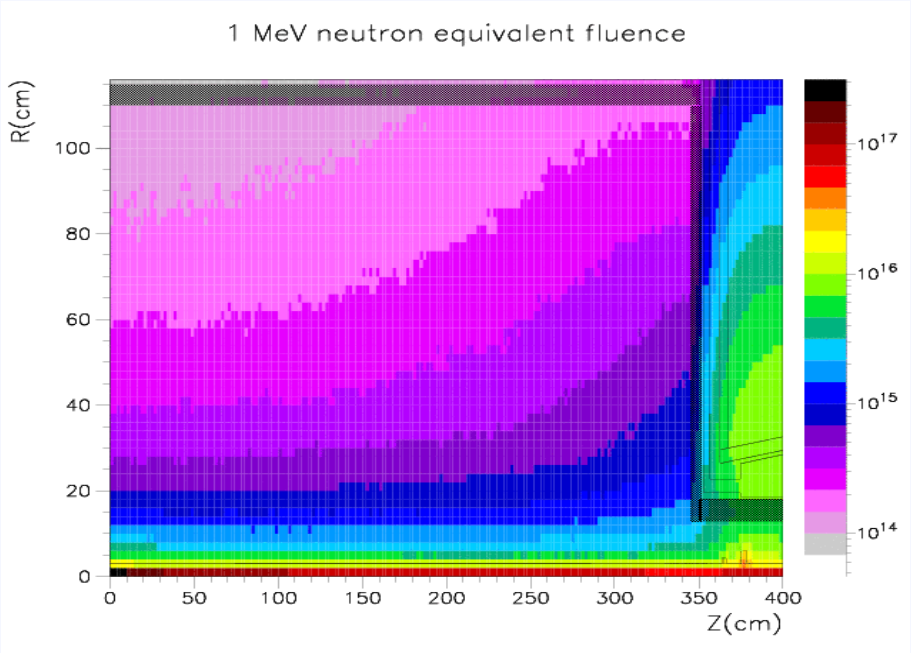
- Covered in previous talks
- Best to look at talk by Michelangelo Mangano in SLHC-PP kick off meeting and references he gives
  - http://indico.cern.ch/conferenceOtherViews.py?view=standard&confId=29254
- Most studies so far are based on premise the upgraded detector performs as well at sLHC as current Atlas does at LHC
  - Need considerable simulation effort to be more realistic
  - Need to get data from LHC to understand the current performance
- Physics goals depend on what early data reveals
  - Need results from LHC
- Expectation is to record ~3000 fb-1 each experiment for substantially better statistical precision and discovery reach

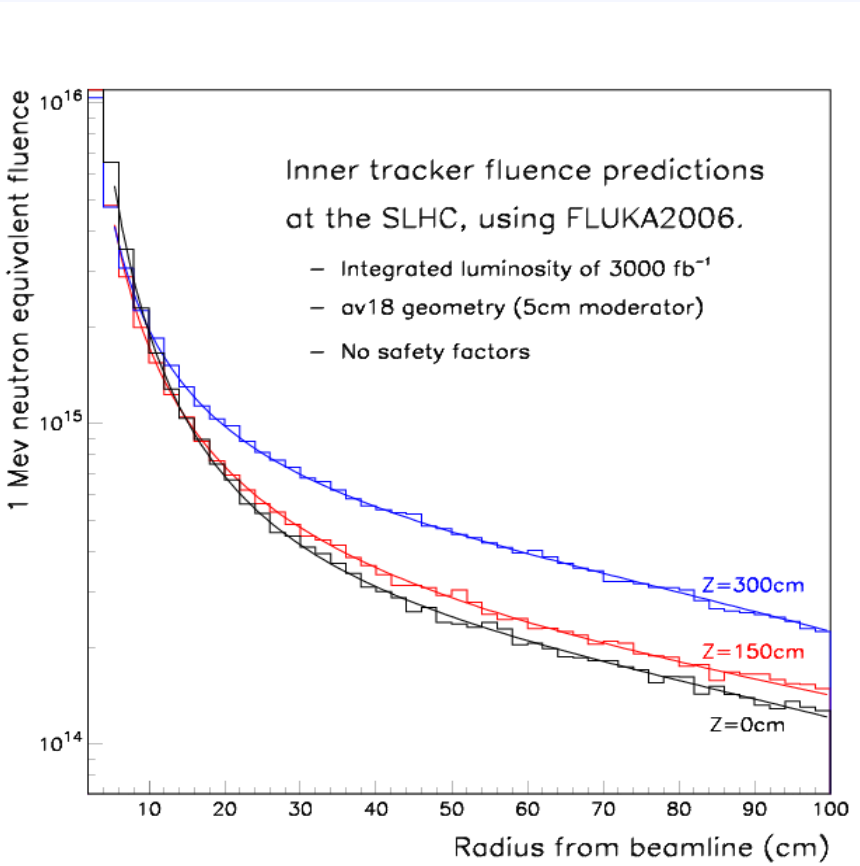
Need for Atlas to upgrade

- Peak luminosity
  - Current detectors have limits on the peak luminosity they can handle
    - Pixel readout:
      - OK up to 2.10^{34} cm^{-2} s^{-1} ; efficiency suffers at 3.10^{34}; poor b-layer performance at 4.10^{34}
    - TRT occupancy gets high already at 2.10^{34} cm^{-2} s^{-1}
    - Muons designed with safety factor 5, so depends on how much of this is `used up' at nominal
- Integrated luminosity
  - Some detectors will suffer significant radiation damage:
    - Pixel b-layer will need replacement before sLHC (2013 or soon after)
    - Rest of ID will need replacement @ 730 fb^{-1} ~ coincides with sLHC
    - Calorimeters need new electronics long before end of sLHC
- Error bars
  - After 5 years steady running, you need 15 years at same rate to halve an error bar
- Others
  - Improved technology, other repairs, ...

Radiation Background

- The background will be challenging
- Shielding is already ~close to optimal
  - Expect backgrounds to be ~10x LHC
- But some improvements possible
  - e.g. 5 cm polymoderator on cryostat wall (Ian Dawson Fluka studies)
  - Be beampipe





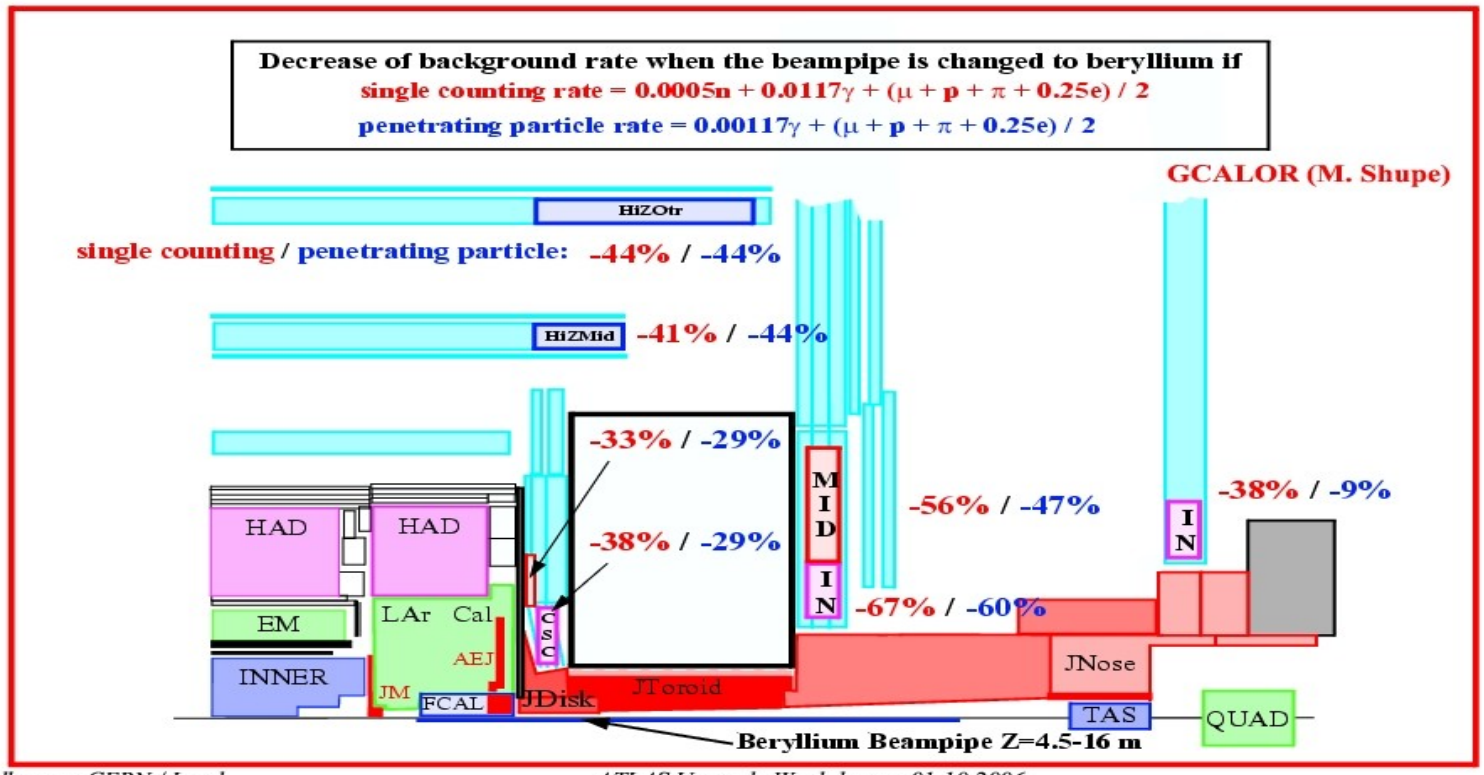
ATLAS Changes: overview

- Pixel b-layer: ~2013 or soon after
- Whole inner tracker for sLHC
- Calorimeters
  - New readout electronics
  - Possibly new forward detectors
- Muons - depends on backgrounds
  - At least new forward chambers
  - Better shielding
  - All-Be beam pipe in the hall
- TDAQ
  - Several possibilities for improvement
  - Aim is to keep trigger accept rates constant at each level
    - (so rejecting 10 times as much, and writing ~10 times as many bytes)

Berillium beam pipe

A beryllium beampipe

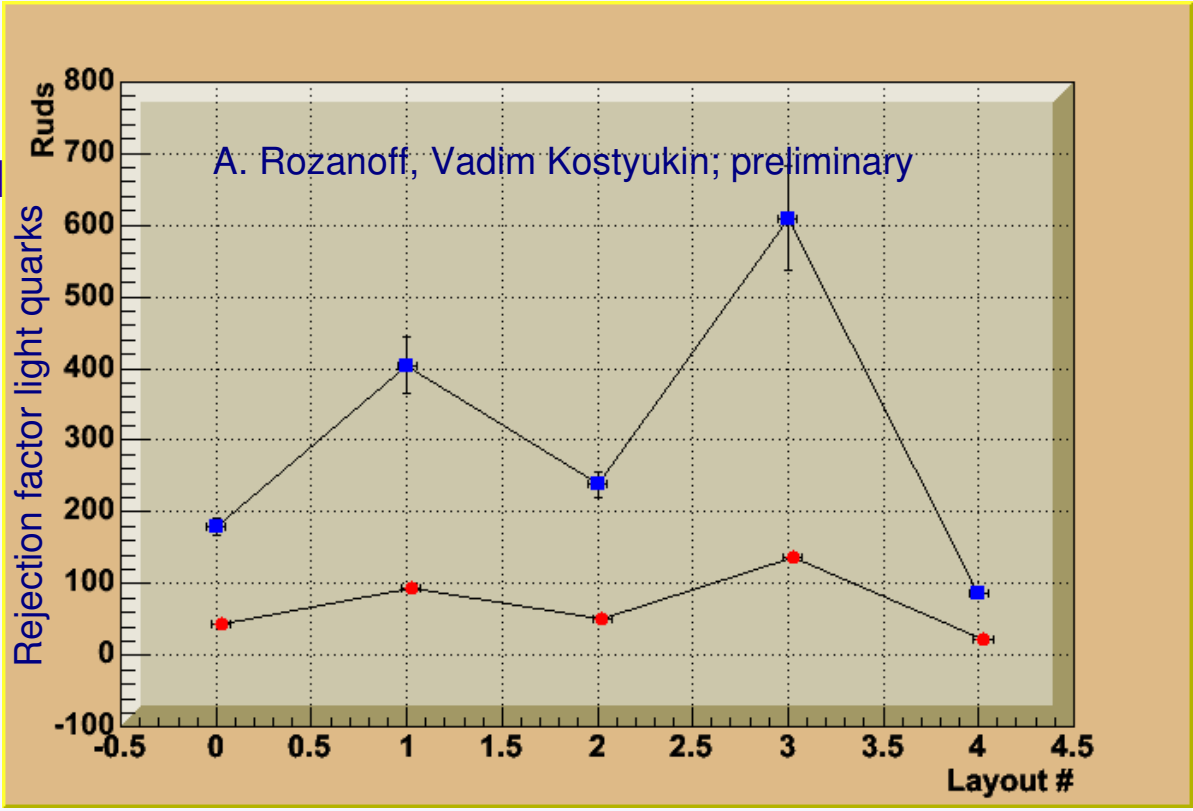
A beryllium beampipe is also the only way of significantly reducing the background in the muon spectrometer.



- Reduces rate up to a factor 3
- No other shielding option had a big effect
- Expensive? No - much cheaper than new muon chambers

Pixel b-layer

- We have realised past ~12 months that replacing the b-layer cannot be done in a normal shutdown
- B-layer task force (BLTF) set up to investigate the options
- It is clear the b-layer cannot be guaranteed to be functioning after 2013, and certainly not up to the time of full inner tracker startup
- Looking at possibilities for rapid replacement of beam pipe itself, and of inserting a new b-layer, inside the old one.
- Preliminary studies with new technology predict good performance



b-inserted as 4-layer R=3.5 cm

b-replaced

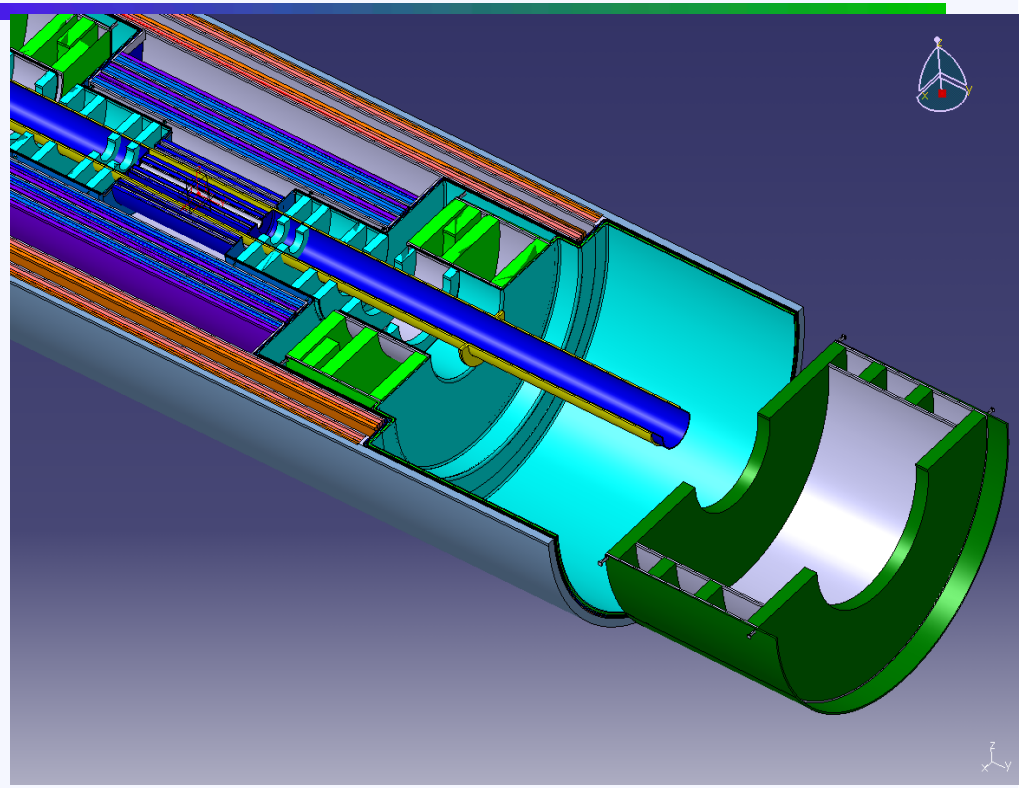
2-old layers

ATLAS

2-layers R=3.5 cm and 8 cm

New Inner Tracker

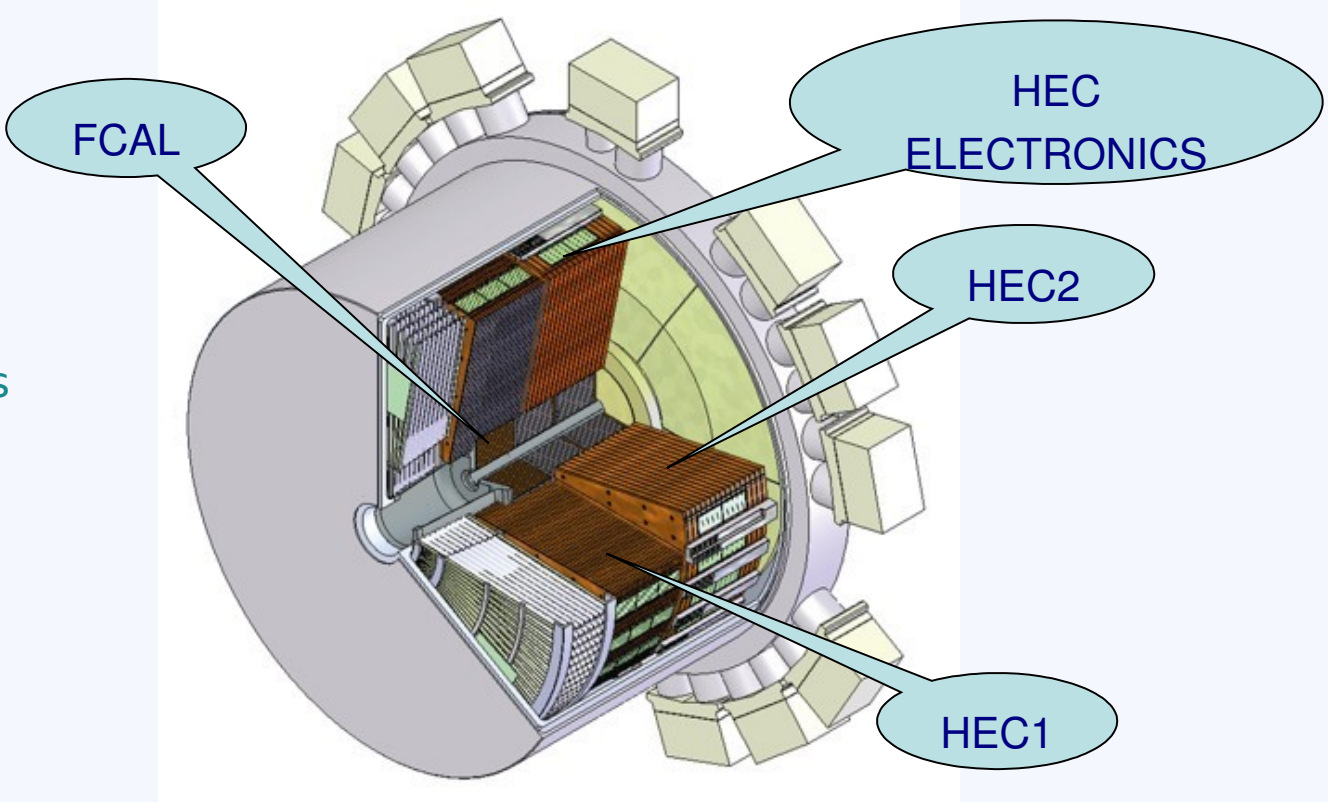
- ID needs complete replacement
  - Radiation damage limit 730 fb^{-1}
  - Peak luminosity limit ~3.10^{34}
    - Pixels, TRT
  - All Si tracker proposed
    - 4 layers pixels
    - 3 layers short strips (~25 mm)
      - Keep occupancy down
    - 2 layers long strips (~100 mm)
    - Aim is max. 1 % occupancy
    - Illustration is “projective barrel”
      - Currently moving to fixed length barrel
  - Look at other b-layer technologies
    - 3D, diamond, thin-Si, gas (Gossip)
  - Strips and pixel covered in more detail this afternoon

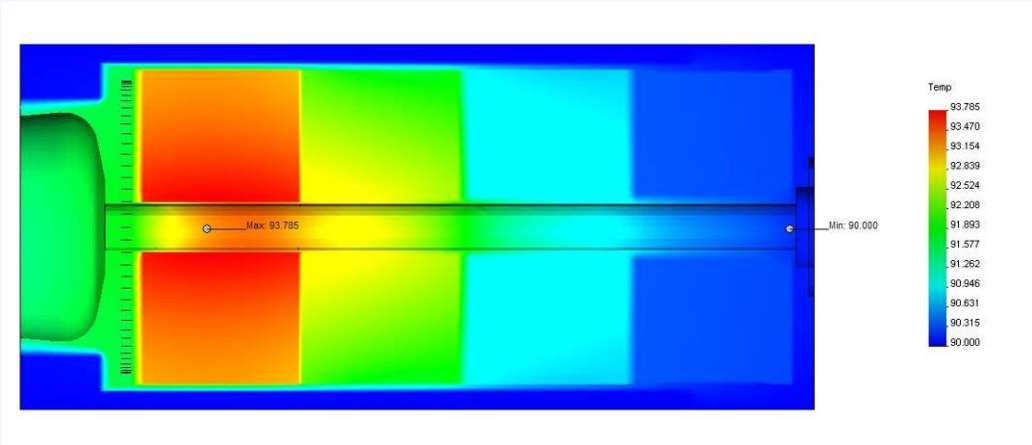


Many changes needed: new sensors; serial/dc-dc powering; CO2 cooling?; readout architecture, data multiplexing; front end ASICs; material - tends to increase due to smaller granularity; innovate to keep minimum.
Very short time scale for assembly, especially considering how long the current ID took.

LAr

- Will replace most readout electronics
  - Readout all data and make trigger off-detector?
    - Several R&D projects to investigate this possibility
- Endcaps:
  - Highest rates occur in the FCAL
  - Possible problems:
    - Boiling of liquid Ar?
    - Charge build up
    - Voltage drop over HV resistor

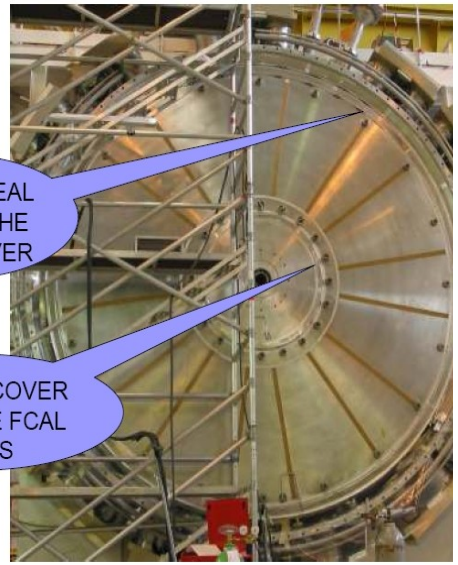




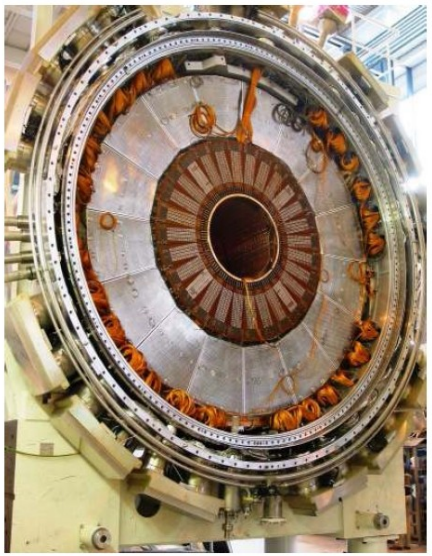
LAr (cont)

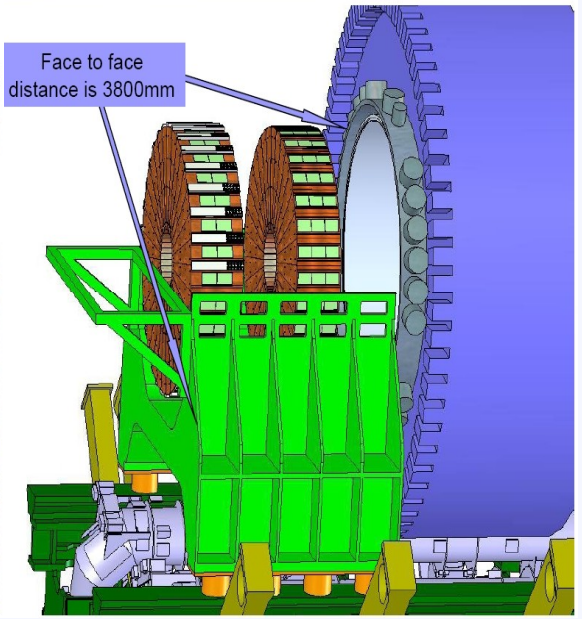
- May need to open up FCAL
  - Replace with ready-made new FCAL with better cooling, smaller gap
    - Avoid boiling Ar, reduce ion build up etc.
  - Replace HEC electronics in cryostat
  - Further improvements investigated for in-pit work

END CAP WITH WARM COVER REMOV



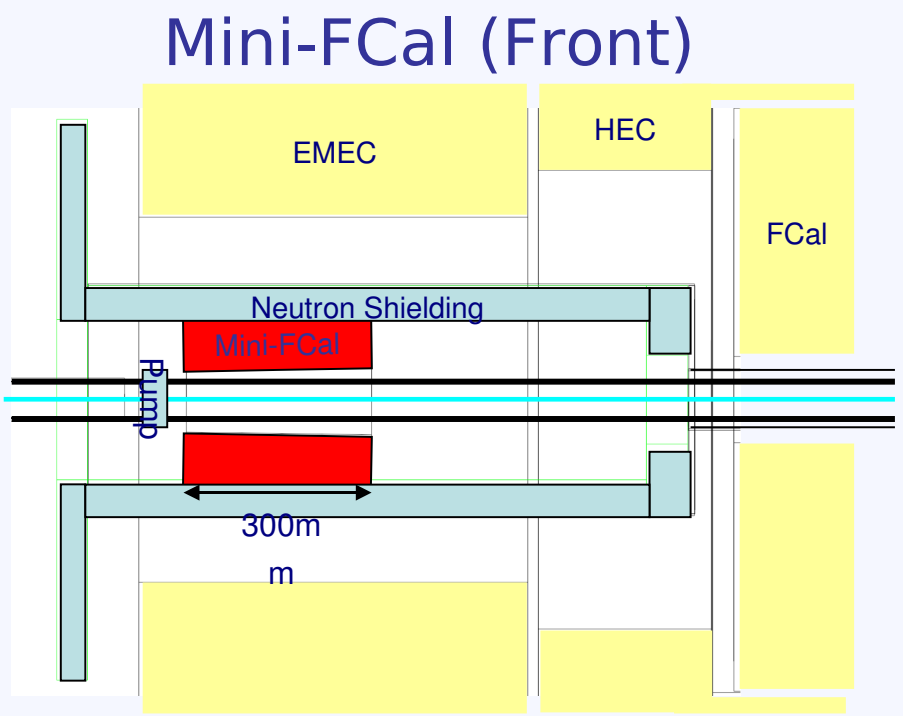
REMOVE COLD COVER TO EXPOSE REAR FACE OF HEC2





LAr: Warm cal?

- Possibility under investigation to insert a new small calorimeter in front of the FCAL
- It reduces heat flux and ionisation by factor ~2 (e.m. component)
- Could remove the necessity to open up
- Testbeam studies ongoing at Protvino to see where the limits are - see talk this afternoon

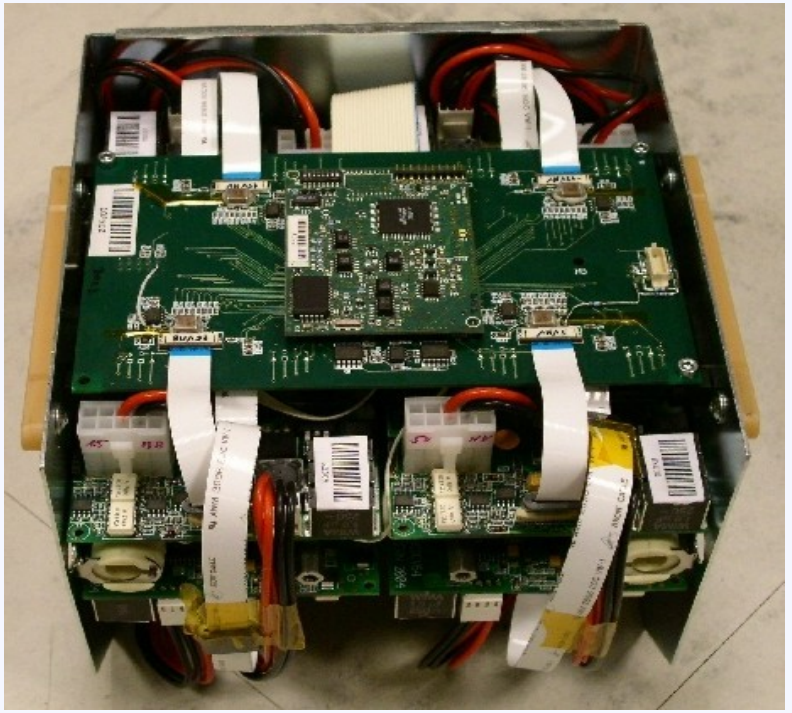


Tiles

- Tiles, fibres, PM: expected to survive
  - Small decrease in performance after 7 years LHC running
  - Even at the end of sLHC running they will be working fine - though worst regions may have significantly less light
  - So do not expect major detector parts to be changed (only Crack scintillator)
- Readout Electronics: rad hardness, maintainance, trigger needs - all benefit from new readout
  - Further studies of rad-hardness needed
  - Also advantages of reading out all data apparent - to be studied (R&D proposals)
  - Conclusion may well be to replace most of FE electronics
  - RODs: new trigger schemes or readout all data will require changes to RODs

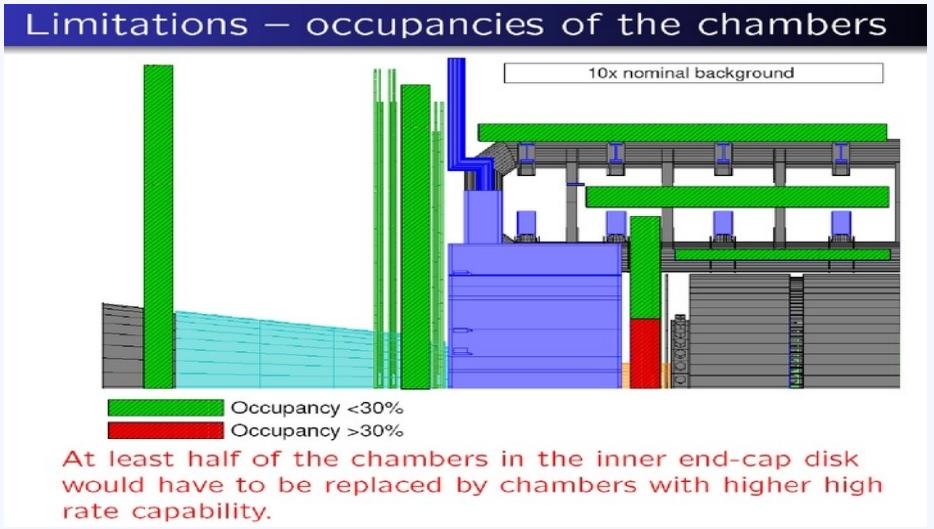
Tiles (cont.)

- Power Supplies:
  - Low voltage supplies insufficiently rad-hard (die in first year of sLHC) and expensive to maintain after 10 years, plus hope of better performance if replaced
    - Expect to replace all for sLHC
    - Long lead time (7 years?) so need to start soon
  - Local HV for PMT's may be rad-hard enough; needs to be studied

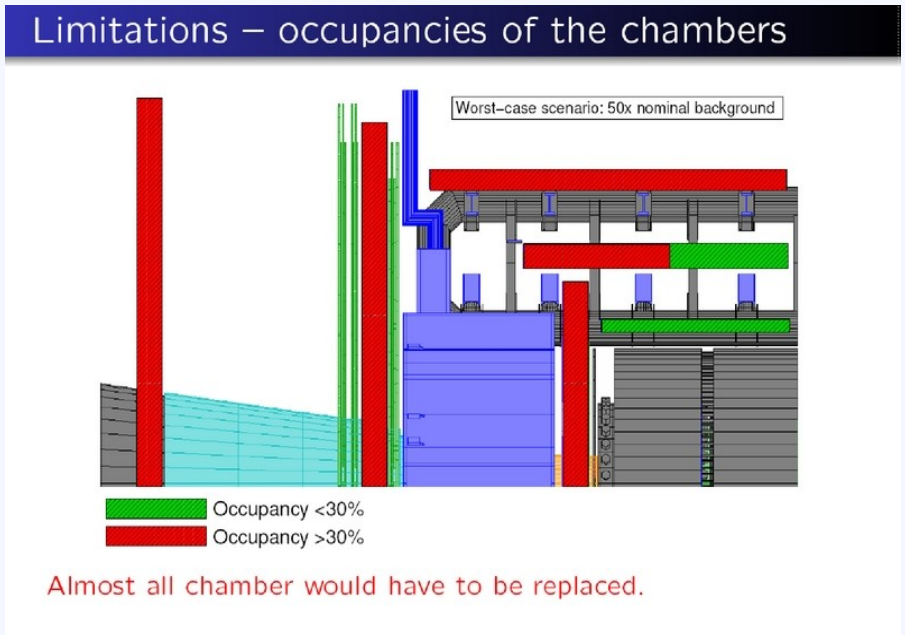


Muons

- Muon background rate uncertain:
  - Find out soon!
  - Allowed safety factor 5
  - If not needed, then most muon chambers can cope with sLHC rates
  - Will need to replace chambers in forward region
  - R&D underway to select technologies
  - Some (micromegas and TGC) carry out both trigger and precision measurements simultaneously
    - Leave more space for better shielding
  - Be beam-pipe also very important



If safety factor not needed

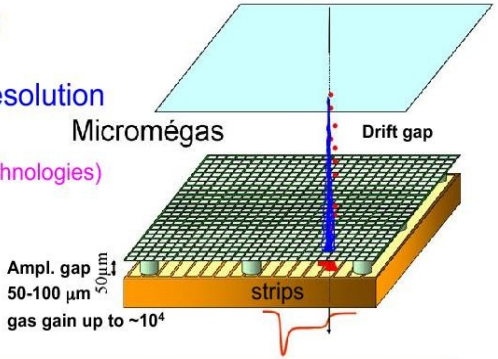


...Worst case

Muons - example of chamber R&D

Micromegas for tracking + trigger

- Very high rate tolerance
  measured in kHz/mm²
- Good spatial and time resolution
- Low cost (potentially)
  Bulk MicroMegas (industrial technologies)
  - use of wire mesh
  - PC board technology

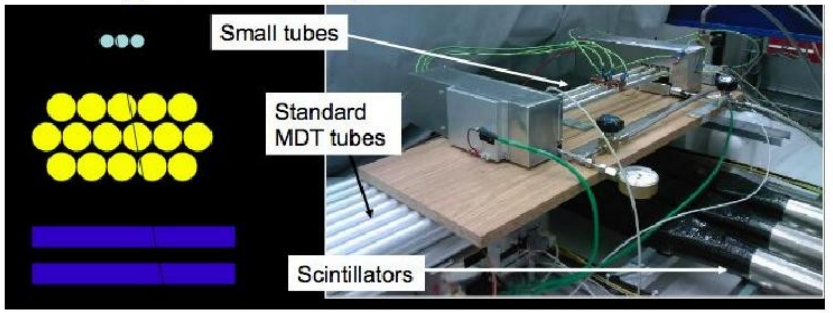


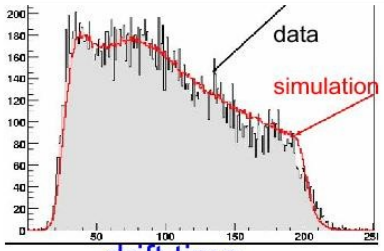
Goal:
$\sigma_x < 100\ \mu m$
$\sigma_t < 5$ ns
size ~ 1x2 m²

For EI (+ inner EM) region,
with tracking + trigger in a single detector unit.
(good, because of the limited space).

Thin tube MDT

Prototype, cosmic-ray tests 15 mm tube

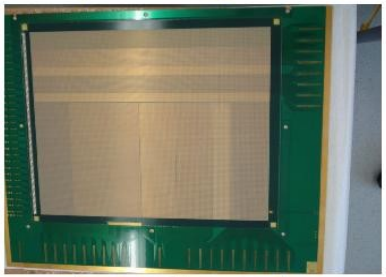


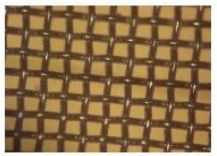


Outlook

- 15 mm tube : x10 higher limit
- Cosmic ray test results promising
- Further tests at GIF planned in 2008

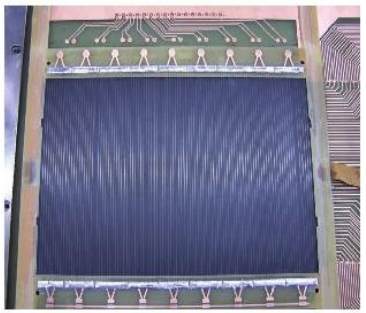
Prototype chambers 45 x 35 cm² (2 of the biggest MMs ever made)



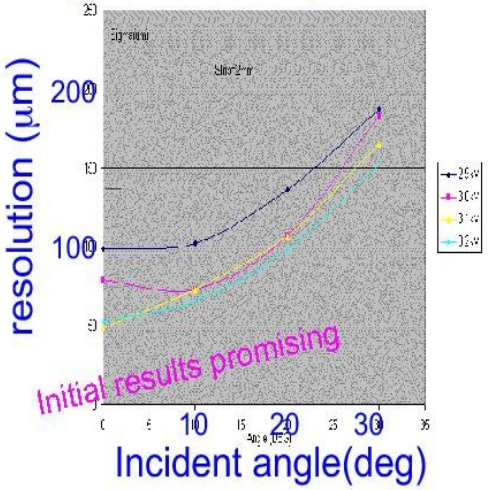


TGC for tracking + trigger

Prototype chambers tested at T9 (Oct/Nov. 2007)



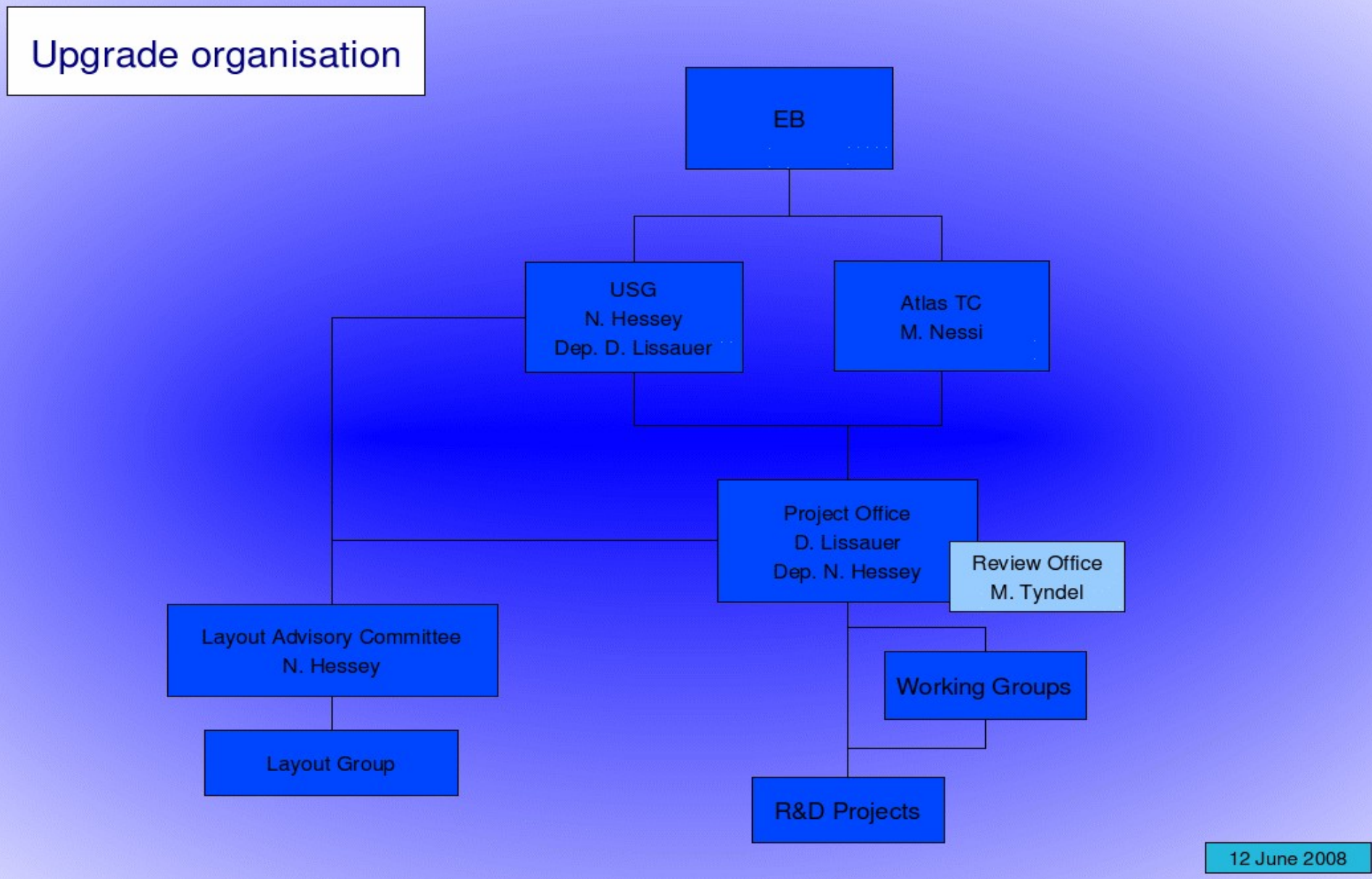
1.5mm and 2 mm strip
Charge readout



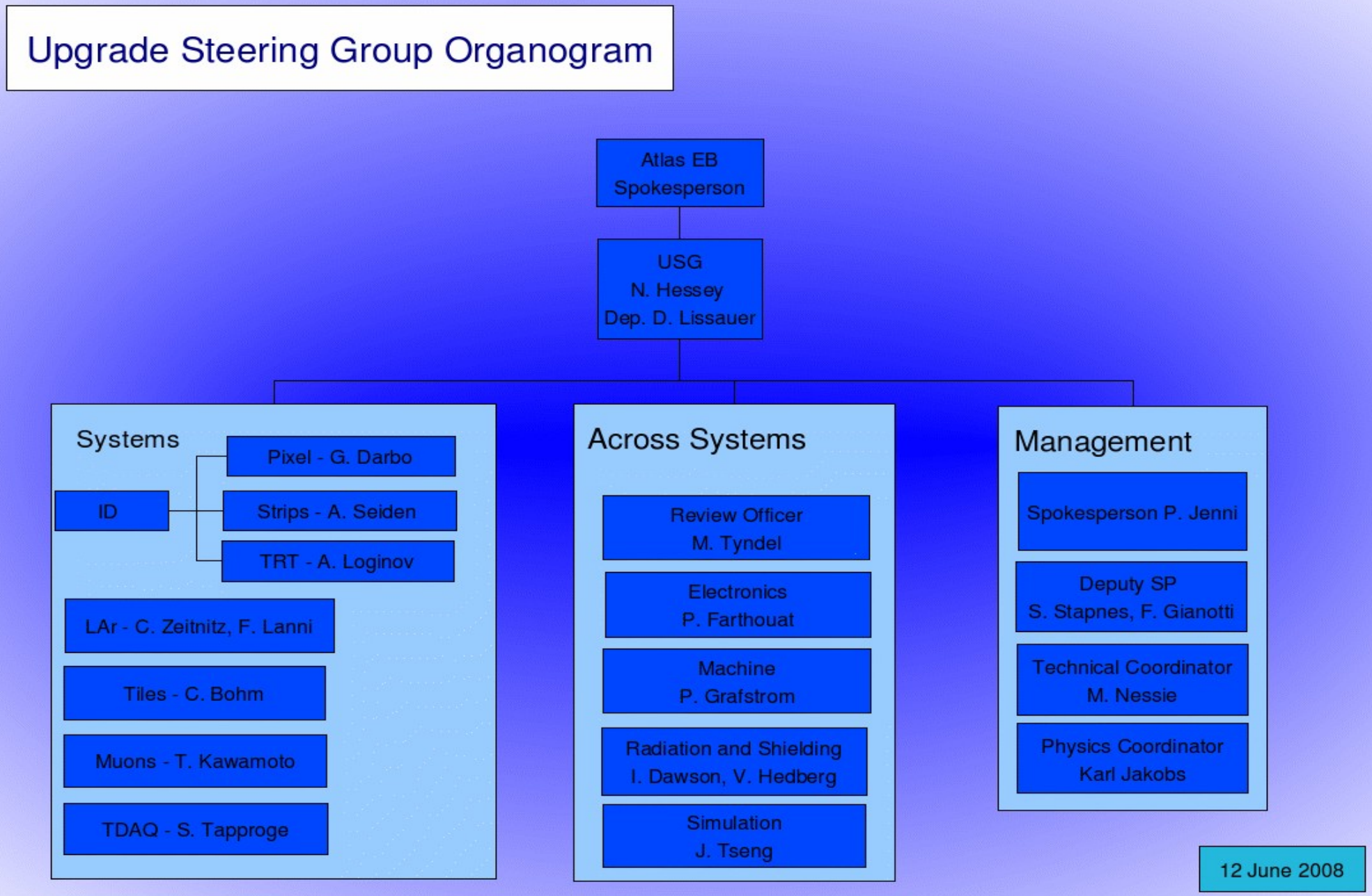
TDAQ

- Baseline is to maintain trigger rates at the different levels
  - That means rejecting 10 x as many events in the same time
  - Writing ~10x as much data
- Look into various possibilities:
  - Higher LVL1 latency
  - Higher LVL1 rate - very difficult
  - Fast track trigger with associative memory (FTK) - listen in on LVL1 readout
  - Combining trigger objects (“topological trigger”)
  - Level 1 track trigger looks very challenging
  - As mentioned, calorimeters may read all data giving more trigger flexibility
  - Need to study trigger rates as function of Pt and pile-up:
    - How well will current schemes work?
    - Need experience with current set-up

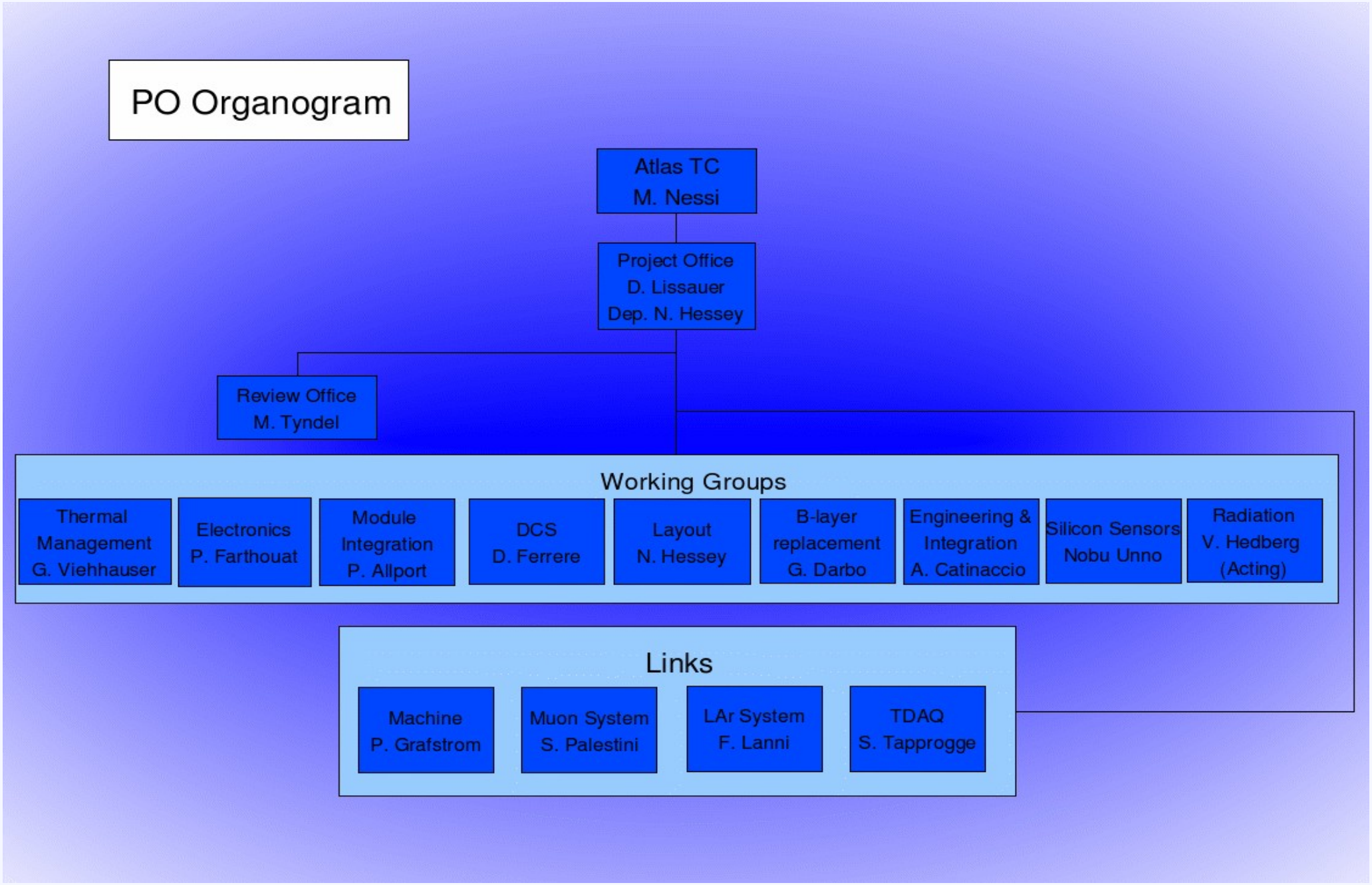
Organisation - overall



Organisation - Steering Group



Organisation - Project office and review office



R&D Projects

- Impressive list of R&D projects underway
  - 29 proposals or LoI's
  - 14 fully approved
  - 1 not for ATLAS
  - Rest at various stages (mostly EoI)
- See web:

  http://atlas.web.cern.ch/Atlas/GROUPS/UPGRADES/proposalSummary.xhtml
- Approval can help obtaining funding - funding agencies know it is relevant
  - But they need a coherent picture of needs, timing etc.

Short name (click for full proposal)	Title	Principle contacts	Status 30/06/08
Opto	Radiation Test Programme for the ATLAS Opto-Electronic Readout System for the SLHC for ATLAS upgrades	Cigdem Issever	Approved by EB
Staves	Development and Integration of Modular Assemblies with Reduced Services for the ATLAS Silicon Strip Tracking Layers	C. Haber, M. Gilchriese	Approved by EB
ABCNext	Proposal to develop ABC-Next, a readout ASIC for the S-ATLAS Silicon Tracker Module Design	F. Anghinolfi, W. Dabrowski	Approved by EB
Radiation BG	Radiation background benchmarking at the LHC and simulations for an ATLAS upgrade at the SLHC	Ian Dawson	Approved by EB
n-in-p sensors	Development of non-inverting Silicon strip detectors for the ATLAS ID upgrade	Hartmut Sadrozinski	Approved by EB
SiGe chips	Evaluation of Silicon-Germanium (SiGe) Bipolar Technologies for Use in an Upgraded ATLAS Detector	Alex Grillo, S. Rescia	Approved by EB
3D Sensors	Development, Testing, and Industrialization of 3D Active-Edge Silicon Radiation Sensors with Extreme Radiation Hardness: Results, Plans	Sherwood Parker now Cinzia Da Via	Approved by EB
Modules	Research towards the Module and Services Structure Design for the ATLAS Inner Tracker at the Super LHC	Nobu Unno	Approved by EB
Powering	Research and Development of power distribution schemes for the ATLAS Silicon Tracker Upgrade	Marc Weber	Approved by EB
Segmented Stra	R&D of segmented straw tracker detector for the ATLAS Inner Detector Upgrade	Vladimir Peshekhonov	Not approved as ATLAS relevant
Gossip	R&D proposal to develop the gaseous pixel detector Gossip for the ATLAS Inner Tracker at the Super LHC	H van der Graaf	Full proposal requested
SoS	Expression of Interest: Evaluations on the Silicon on Sapphire 0.25 micron technology for ASIC developments in the ATLAS electronics readout upgrade	Jingbo Ye	Approved by EB
Thin pixels	R&D on thin pixel sensors and a novel interconnection technology for 3D integration of sensors and electronics	H-G. Moser	Approved by EB
Muon Micromeg	R&D project on micropattern muon chambers	V. Polychronakos, J. Wotschack	Approved by EB
TGC	R&D on optimizing a detector based on TGC technology to provide tracking and trigger capabilities in the MUON Small-Wheel region at SLHC	G. Mikenberg	Proposal received by USG
MDT Readout	Upgrade of the MDT Readout Chain for the SLHC	R. Richter	Expression of Interest received
MDT Gas	R&D for gas mixtures for the MDT detectors of the Muon Spectrometer	P. Branchini	Expression of Interest received
Selective readou	Upgrade of the MDT Electronics for SLHC using Selective Readout	R. Richter	Expression of Interest received
High rate MDT	R&D on Precision Drift-Tube Detectors for Very High Background Rates at SLHC	R. Richter	Expression of Interest received
Diamond	Diamond Pixel Modules for the High Luminosity ATLAS Inner Detector Upgrade	M. Mikkuz	Approved by EB
ID Alignment	ID Alignment Using the Silicon Sensors	H. Kroha	Expression of Interest received
Fast Track Trigg	FTK, a hardware track finder	M. Shochet	Approved by EB
Versatile Link	The Versatile Link Common Project	Francois Vasey	Sent to CB for comments
LAr FE Electron	R&D Towards the Replacement of the Liquid Argon Calorimeter Front End Electronics for the sLHC	G. Brooijmans	EoI Received
LAr Optolink	R and D of a radiation resistant high speed optical link for the ATLAS Liquid Argon Calorimeter readout	Jingbo Ye	EoI Received
LAr ROD	Research and Development of Readout Driver (ROD) for the upgrade of the Liquid Argon Calorimeter Front-End Readout	Hucheng Chen	EoI Received
FCAL cold	Development of new ATLAS Forward Calorimeters for the Upgrade	J. Rutherfoord	EoI Received
LVL1-Calo	ATLAS Level-1 Calorimeter Trigger Upgrade	N. Gee	EoI Received
Tile-Electronics	Tile Calorimeter Electronics for the sLHC	C. Bohm	EoI Received

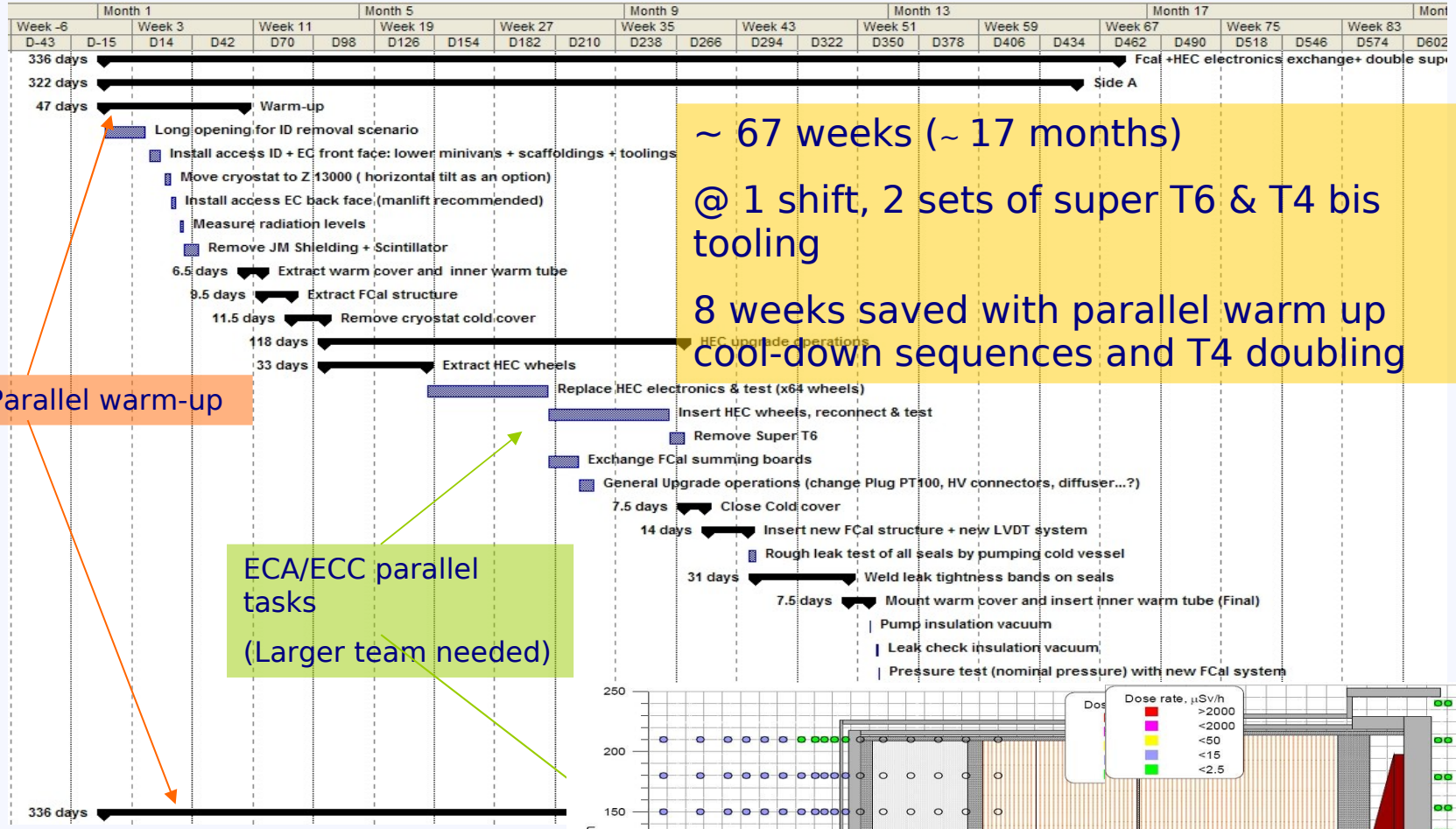
Towards Atlas Upgrade approval

- R&D groups hopefully will grow into the collaborations that build the upgrade
- As shown by Steinar, we need LoI, TP/TDR, Core cost document, MoU etc.
  - WP3 of SLHC-PP project
  - Needs a lot more work
    - Propose series of “ATLAS Upgrade Weeks” starting next year to spur this on
      - At CERN, working and decision making meetings
      - Parallel (systems) and plenary sessions
- Schedule:
  - Aim to be ready for the earliest possible date things might be needed
    - 2015?
  - Need to know and understand machine expectations to fix this
  - Have to limit R&D and choices to meet tight schedule, especially Inner Tracker
    - e.g. with more time, cheaper pixels may be possible allowing more layers (and less strips).
  - Important to be coherent with LHC and CMS

Length of shutdown

- We plan to carry out the installation of all new detectors with only one year of lost beam
  - With slightly longer shutdowns either side, we aim at 18 months
  - This we believe can be achieved - with different ways of doing things
    - e.g. LAr FCAL in the pit
    - New inner tracker fully assembled above ground and installed as one piece
      - It fits (just)
  - Implies considerable re-use of services
    - Especially ID - many services are under muon chambers
    - Complicates and may limit some options
  - LAr is also challenging, but we believe it can be done
    - Needs investment:
      - Cooling/warm-up in parallel
      - Double up tooling, new designs
    - Need to check interferences with muon, ID etc. work
    - Need to study radiation levels - goes for all installation work

Pit work...



~ 67 weeks (~ 17 months)

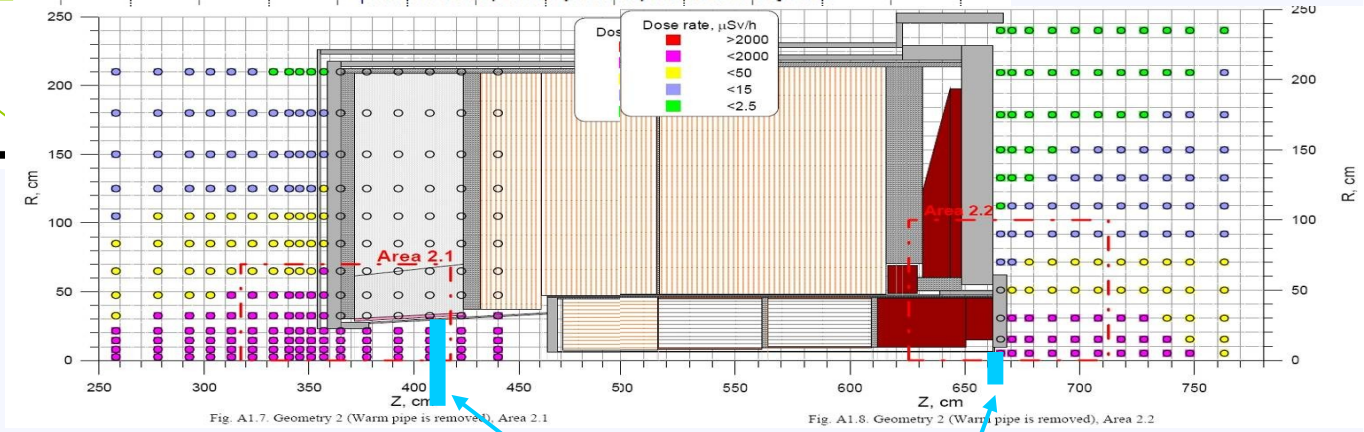
@ 1 shift, 2 sets of super T6 & T4 bis tooling

8 weeks saved with parallel warm up cool-down sequences and T4 doubling

Parallel warm-up

ECA/ECC parallel tasks

(Larger team needed)



Temporary shielding disks

Summary

- A lot has started for the ATLAS Upgrade plans
  - Currently aiming to install in 2015 - as earliest it could possibly be needed
- There is a long way to go
- We need an agreed schedule with machine and CMS
  - Only one year of shutdown, same year for everyone
- It is very important to get experience with the current detector before freezing choices
  - But then we will have very little time to implement the designs

More info

(Some of) Physics motivation