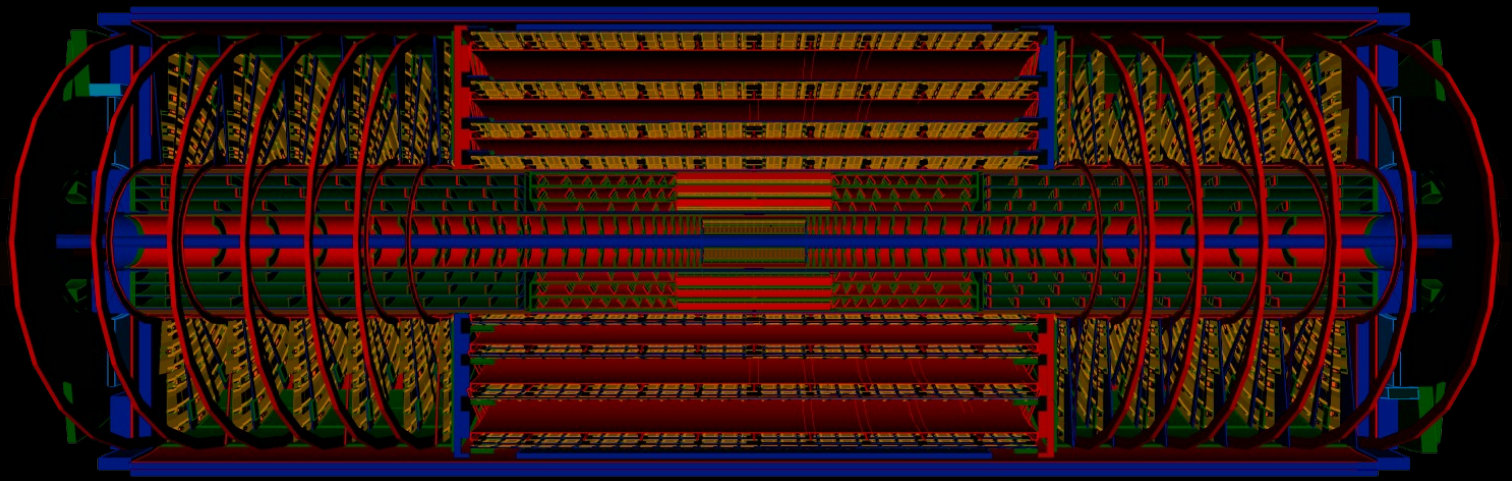
Phil and the ATLAS Upgrade



Dave Charlton
Phil-fest, 27 January 2023

With thanks to Nanni Darbo for many photos!

Pre-history

Even while we were building the ATLAS Inner Detector, Phil had his eyes on building a bigger and better one for the High-Lumi LHC, HL-LHC

E.g. Upgrade Tracker Workshop, Liverpool, 2006
(chaired by Phil)

Pre-history

Even while we were building the ATLAS Inner Detector, Phil had his eyes on building a bigger and better one for the High-Lumi LHC, HL-LHC

E.g. Upgrade Tracker Workshop, Liverpool, 2006
(chaired by Phil)

By early 2009, we'd *almost* started LHC, so we started the ATLAS Upgrade Weeks...

ATLAS Upgrade Week 2009

LHC had started, and stopped – physics yet to come...

ATLAS Upgrade Week

23 Feb 2009, 08:00 → 27 Feb 2009, 12:00 Europe/London

Various CERN Meeting Rooms (CERN)

Nigel Hessey (NIKHEF)

Marzio ***What is new, what has to change ?***

- ✓ We are entering a new phase were the upgrade will be defined as a project, where R&D will need a substantial follow up, where decisions need to be made and where collaboration structures will be formed
- ✓ Today we do not have a clear schedule nor for phase I, nor for phase II. In the next months while the LHC schedule will be confirmed the global picture should emerge

ATLAS Upgrade Week 2009

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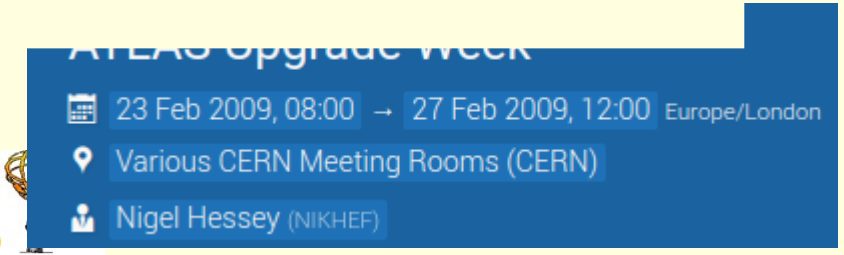

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Frank Zimmermann did try, and suggested

- Phase-I upgrades in 2014 (not yet “LS-n”)
- Phase-II upgrades in 2018/19 (not yet “LS-n+1”)

Before LHC data-taking – it was a hard time to make predictions!

ATLAS Upgrade Week 2009

LHC had started, and stopped – physics yet to come...

ATLAS Upgrade Week

23 Feb 2009, 08:00 → 27 Feb 2009, 12:00 Europe/London

Various CERN Meeting Rooms (CERN)

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FRIDAY, 27 FEBRUARY

Upgrade Organisation — 500/1-001 - Main Auditorium

Machine plans, feedback on LoI structure, schedule (Phase I and II), wrap-up of key issues, work plan towards October AUW.

09:30 **ID strip sensors, modules and its integration (sessions issues)**

Speaker: P Allport (U of Liverpool)

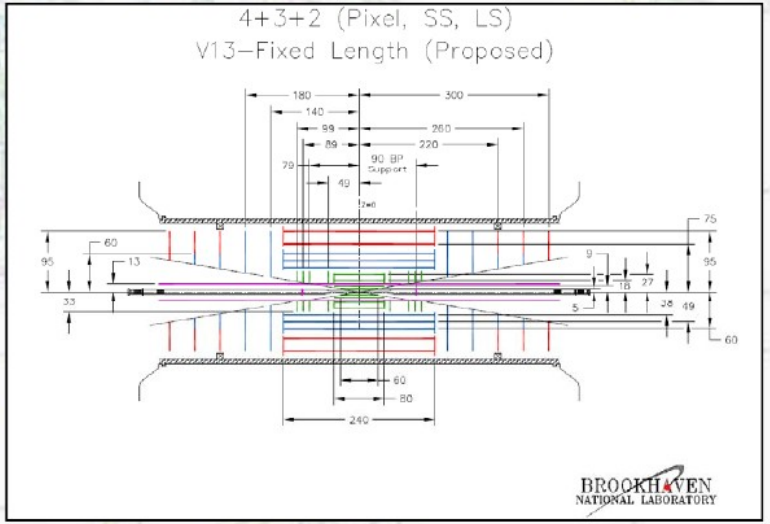
Inner Detector Upgrade Modules and Module Integration Issues

Phil Allport (University of Liverpool)

27/2/09

Upgrade Organisation

- Progress with module components
- First prototype barrel modules
- Barrel stave concept and components
- Inner Detector Upgrade and petals
- Mechanics, power, cooling, DCS, services layout, DAQ
- Conclusions



Already v13 ITk layout…!

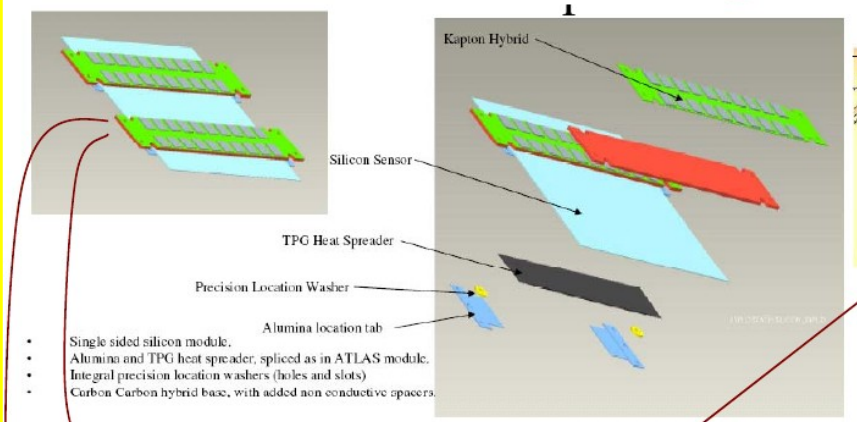
Inner Detector Upgrade Modules and Module Integration Issues

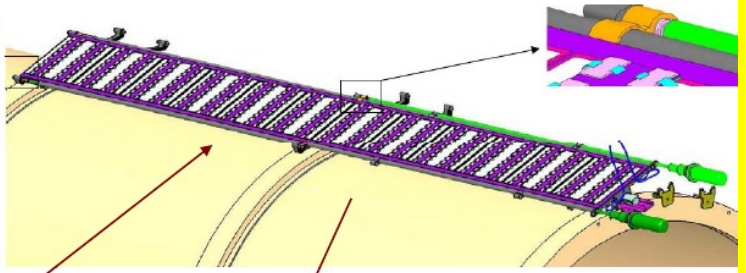
Phil Allport (University of Liverpool)

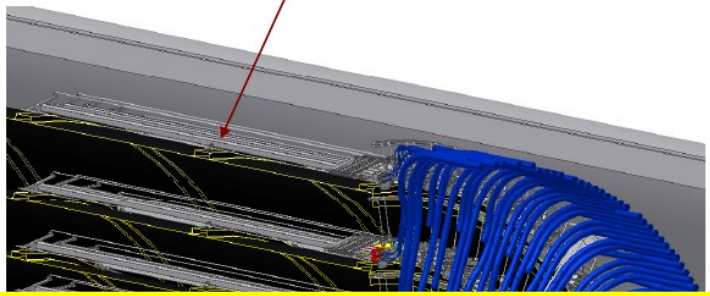
27/2/09

- Progress wi
- First protot
- Barrel stave components
- Inner Detec and petals
- Mechanics, DCS, servic
- Conclusions

ATLAS Tracker Upgrade Module Concept



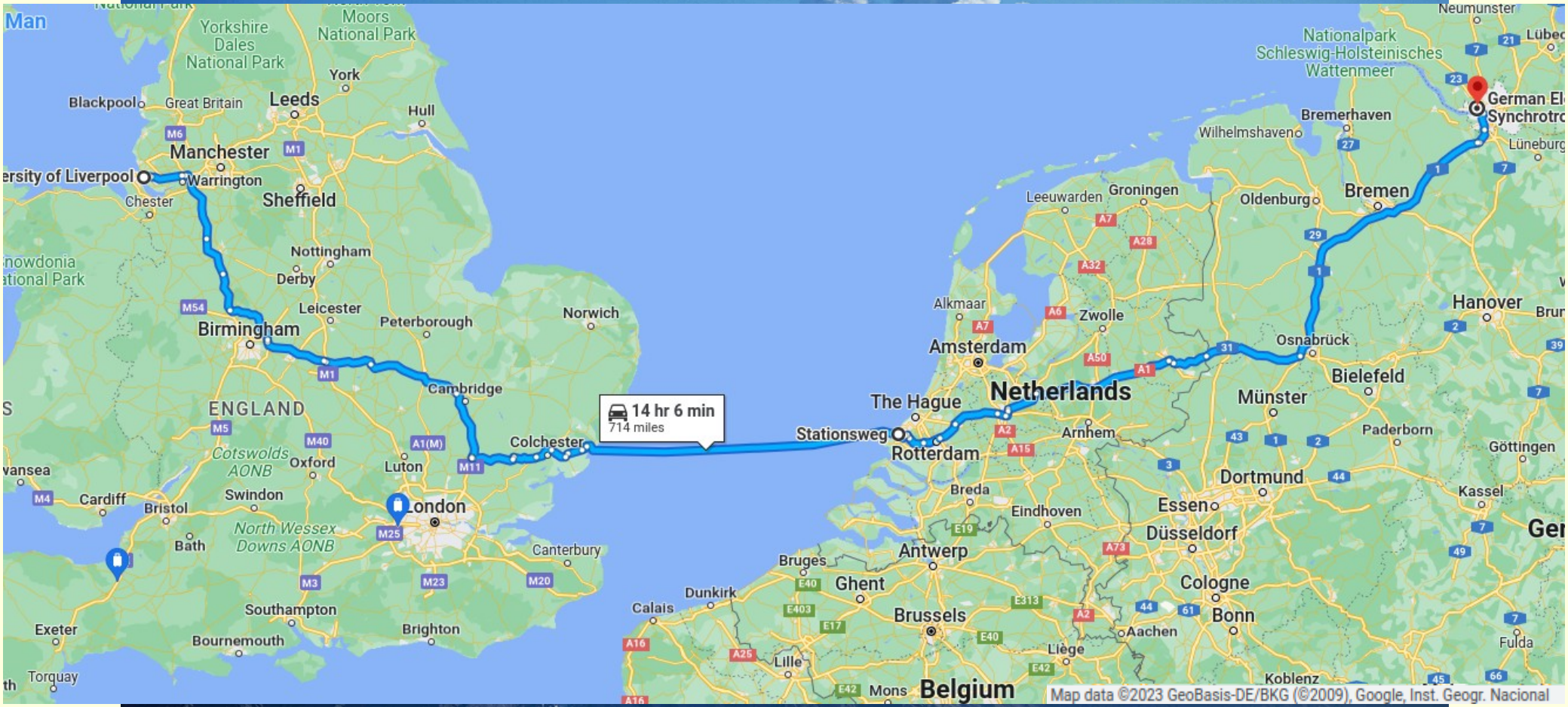




BROOKHAVEN NATIONAL LABORATORY

First ATLAS Upgrade Week away from CERN

You may remember the “environment” at the time...


14 hr 6 min
714 miles
Manchester
Liverpool
Warrington
Chester
Leeds
Sheffield
York
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Nottingham
Derby
Leicester
Birmingham
Peterborough
Norwich
Cambridge
Colchester
ENGLAND
Oxford
Luton
London
Swindon
Bristol
Cardiff
Bath
Southampton
Brighton
Bournemouth
Exeter
Torquay
Canterbury
Stationsweg
The Hague
Rotterdam
Amsterdam
Netherlands
Alkmaar
Zwolle
Arnhem
Breda
Eindhoven
Antwerp
Bruges
Ghent
Brussels
Dunkirk
Calais
Lille
Mons
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Kassel
Göttingen
Fulda
Lüneburg
Neumünster
Nationalpark Schleswig-Holsteinisches Wattenmeer
Map data ©2023 GeoBasis-DE/BKG (©2009), Google, Inst. Geogr. Nacional

The Hardy Few

ATLAS project

ATLAS Upgrade Organization

ATLAS Project Document No:	EDMS Document No:	Created: 29/5/2010	Page: 1 of 11
ATU-ORG-MM-0001	1093133	Modified: 24/10/2010	Rev. No.: 7.1

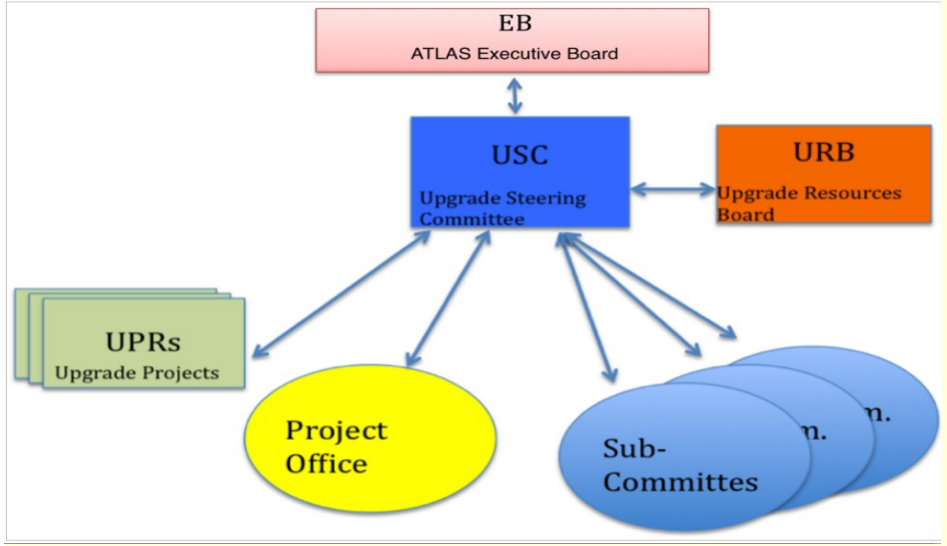
Upgrade Organization

Abstract

The purpose of this document is to guide the implementation of a new organization for the detector upgrade. This organization will cover all phases of the work (phase 0, phase I and phase II) and it will substitute the organization in place today. This document is expected to be revisited as the upgrade programme evolves. Endorsement of this document by the ATLAS Collaboration Board will be requested.

Prepared by:	*Checked by:*	*Approved by:*
Ph.Allport **D.Francis** **G.Herten** **N.Hessey** **F.Lanni** **M.Nessi** **L.Pontecorvo**	**ATLAS EB** **ATLAS Management**	**ATLAS CB**

Distribution List:	*EDMS Approval by:*
ATLAS Collaboration **ATLAS Management**	**M.Nessi**



ATLAS upgrade projects as such started to be set up following this

The start of Phil's transition to "organising" more than "doing" for a few years…?!

March 2011... a good month!

Phil was elected as ATLAS Upgrade Coordinator on 4 March 2011 (to start on 1 March!)

ATLAS Upgrade Week in Oxford, end March 2011

March 2011... a good month!

Phil was elected as ATLAS Upgrade Coordinator on 4 March 2011 (to start on 1 March!)

ATLAS Upgrade Week in Oxford, end March 2011


Pitt Rivers
MUSEUM

There followed an avalanche of documentation...

Scientific Committee Paper

CERN-LHCC-2011-012 ; LHCC-I-020

Letter of Intent for the Phase-I Upgrade of the ATLAS Experiment

Allport, Philip; Nessi, Marzio

CERN. Geneva. The LHC experiments Committee

(Letter of Intent)

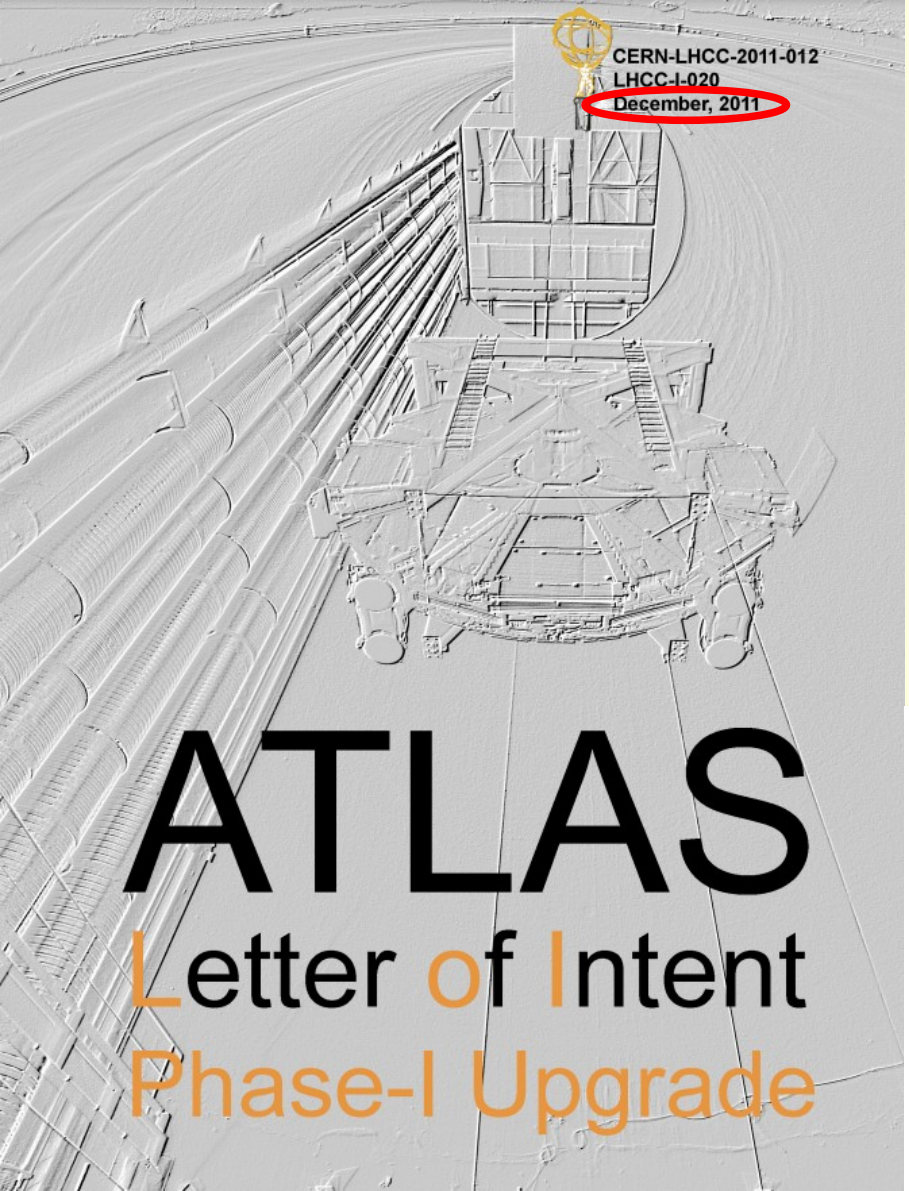
marzio.nessi@cern.ch on 29 Nov 2011

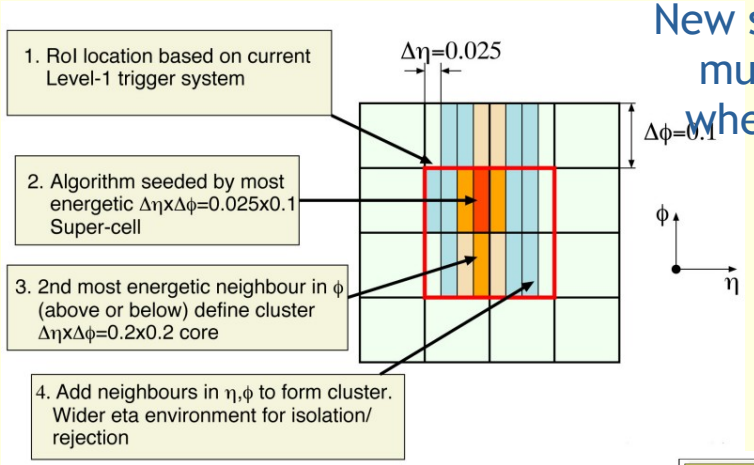
philip.patrick.allport@cern.ch on 17 Jan 2012

Detectors and Experimental Techniques

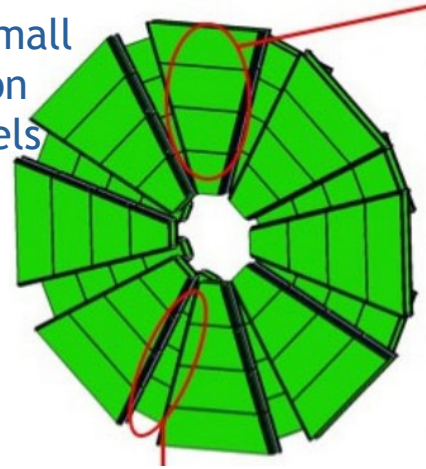
CERN LHC ; ATLAS

After the first successful years of running at the LHC, the ATLAS Collaboration is preparing to fully exploit the unprecedented physics opportunities offered by exploration of a completely new energy domain. This program builds on the excellent LHC accelerator complex performance demonstrated to date. A plan to consolidate and improve the physics capabilities of the current detector over the next decade, targeting the 2018 LHC shutdown as installation milestone, is presented in this Letter of Intent. The document primarily addresses the proposed enhancements to the ATLAS trigger system to cope with luminosities beyond the LHC nominal design value, while retaining the same physics performance. The Phase-I upgrades will allow ATLAS to maintain low pT trigger thresholds for isolated leptons by increasing the granularity of the calorimeters involved in the Level-1 trigger and by introducing new muon trigger and tracking detectors in the forward direction. Precision measurements of the couplings of the Higgs boson, if found in the low mass region, as well as searches for supersymmetric particles in a large region of the SUSY parameter space, rely on the capability of efficiently selecting low pT isolated leptons. Fast accurate tracking information provided near the start of the Level-2 trigger processing will lead to much more effective identification of events with isolated t and b-hadrons, improving the selection of Higgs boson decays and sensitivity to many other physics channels. Finally, a new set of very far forward detectors will enable ATLAS to explore the new diffractive physics domain made accessible by the LHC energies and luminosities, providing an unprecedented sensitivity to large momentum transfer processes.





New small muon wheels



New LAr+L1Calo trigger

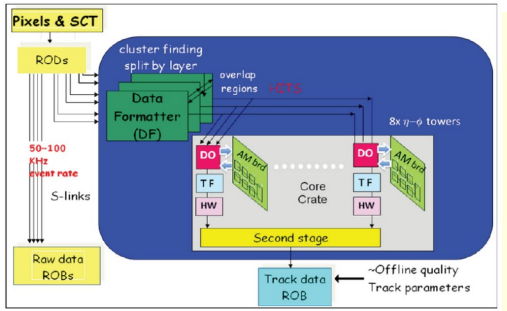
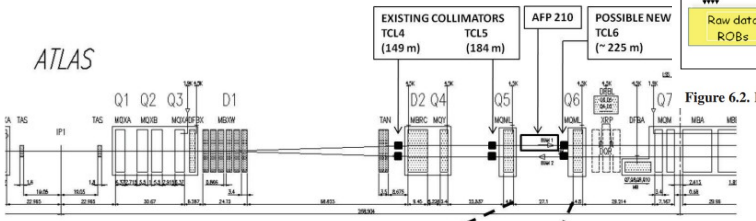
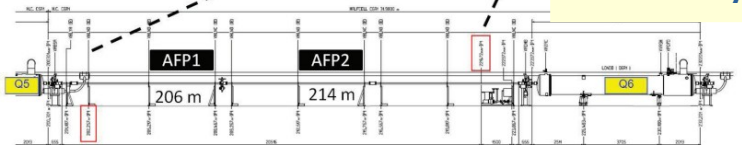


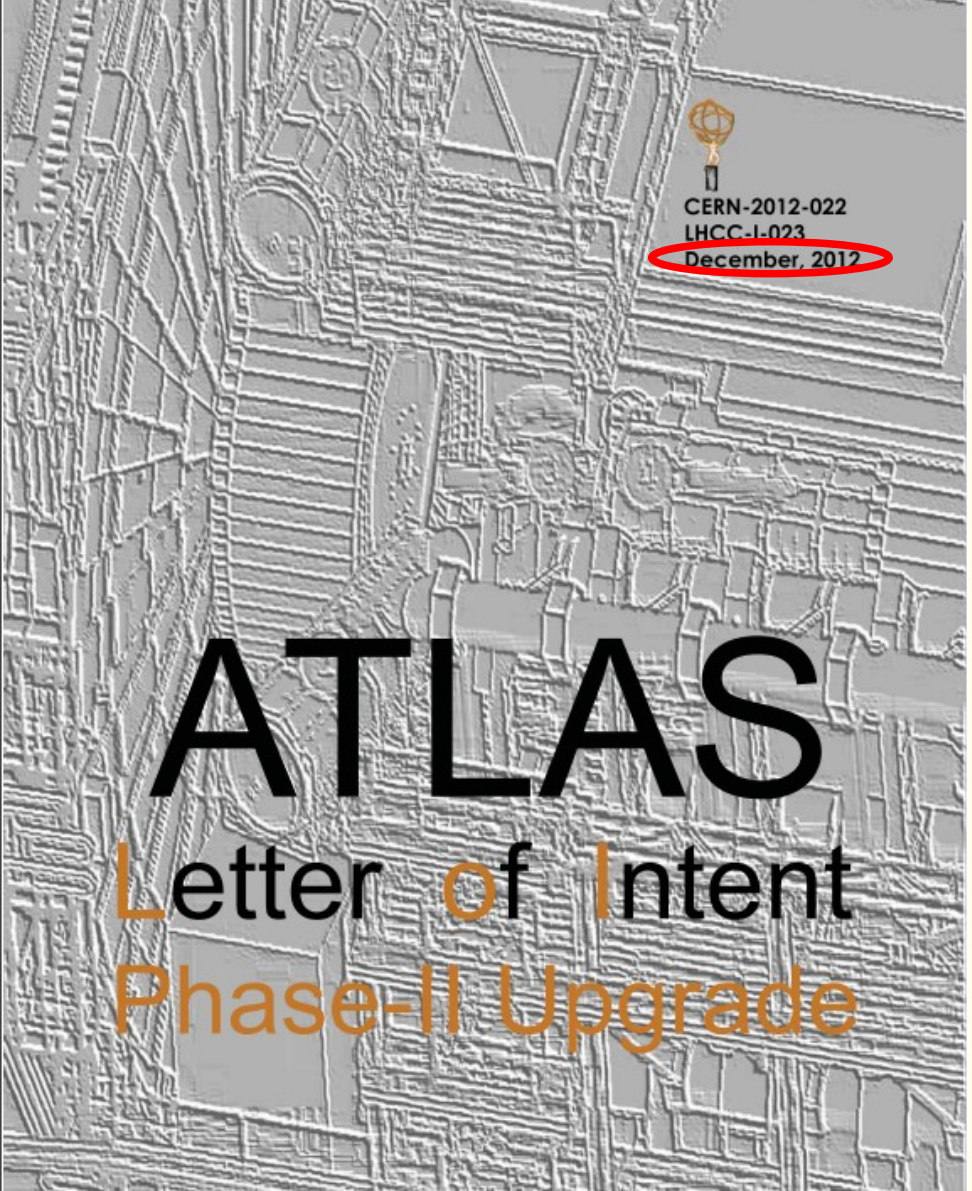
Figure 6.2. Functional sketch of one of 8 FTK core crates plus

FTK



Forward protons, AFP





Letter of Intent for the Phase-II Upgrade of the ATLAS Experiment

ATLAS Collaboration

ABSTRACT:

This Letter of Intent presents a plan for preserving and improving the current detection capabilities of the ATLAS detector to meet the challenges and take advantage of operating at the High Luminosity LHC (HL-LHC). From 2024, the HL-LHC will provide unprecedented pp luminosities to ATLAS, resulting in an additional integrated luminosity of around 2500 fb^{-1} over ten years. This will present a unique opportunity to substantially extend the mass reach in searches for many signatures of new physics, in several cases well into the multi-TeV region, and to significantly extend the study of the properties of the Higgs boson.

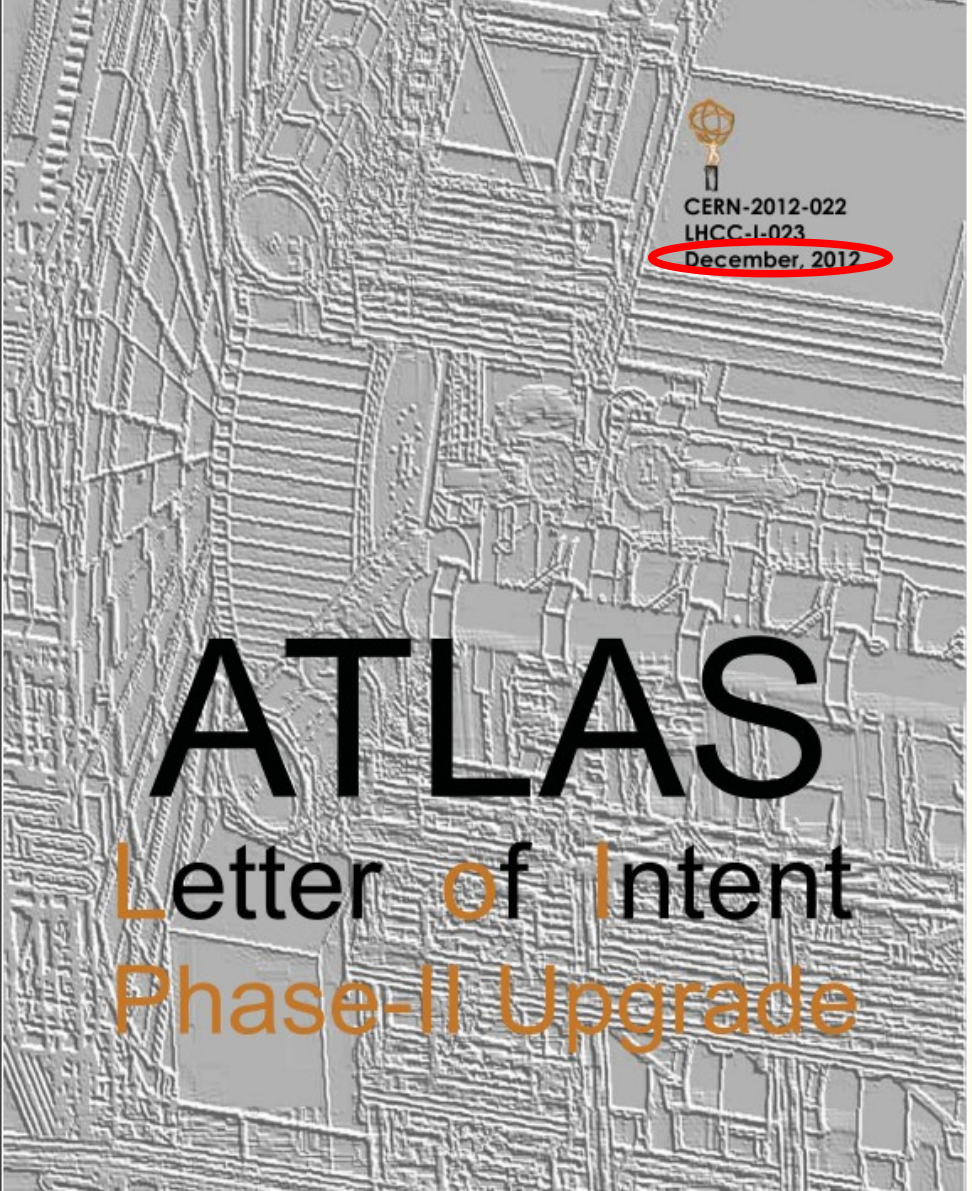
The increased luminosity and the accumulated radiation damage will render the current Inner Tracker no longer suitable for long term operations. It will need to be replaced with a new all-silicon tracker to maintain tracking performance in the high occupancy environment and to cope with the increase of approximately a factor of ten in the total radiation fluence. New technologies are used to ensure that the system can survive this harsh radiation environment and to optimise the material distribution, while the new readout scheme allows the implementation of a track trigger contributing to the improvements in the ATLAS triggering capabilities.

The very high luminosities also present significant challenges to the operation and performance of the rest of the detector systems as well as the trigger; the consequent high number of collisions per crossing will degrade the performance of ATLAS unless the LAr and Tile calorimeters and the Muon Spectrometer readout systems are upgraded. A new trigger architecture will be implemented exploiting the upgrades of the detector readout systems that will maintain and improve the event selection.

The increased luminosity may also degrade the performance of the forward calorimetry. Options for upgrading the hadronic endcap calorimeter readout electronics and the forward calorimeter detector design are being investigated to address the performance degradation, if this proves to be required.

Finally, the computing and software must be upgraded to meet the challenges of the increased luminosity and changes in computer architectures.

KEYWORDS: ATLAS, LHC, HL-LHC, Upgrade, CERN



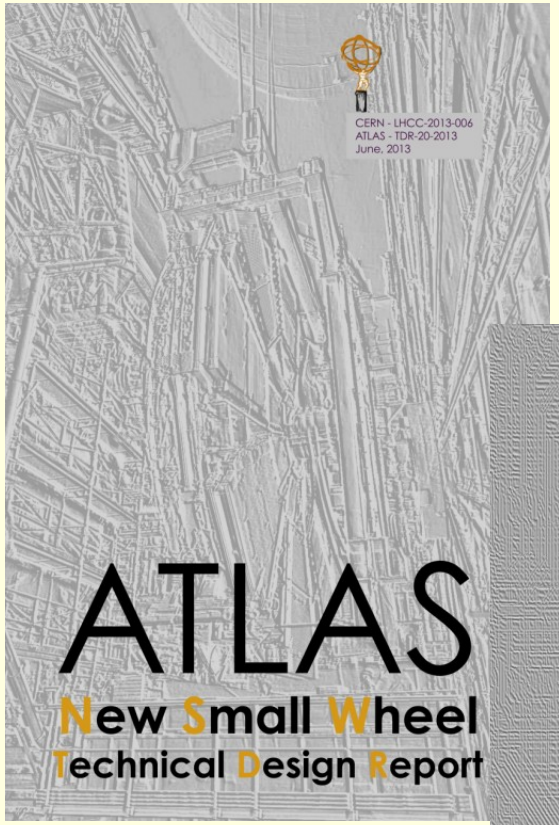
Remarkable accuracy!

	CORE cost (MCHF)	Possible additions		
Total (MCHF)	230.334	45.013	3.047	9.22

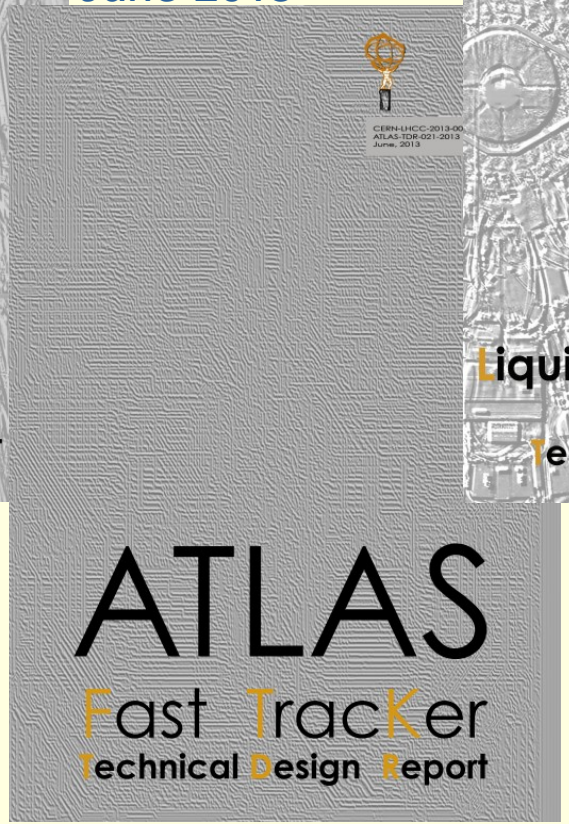
Table 10.18: CORE Cost table

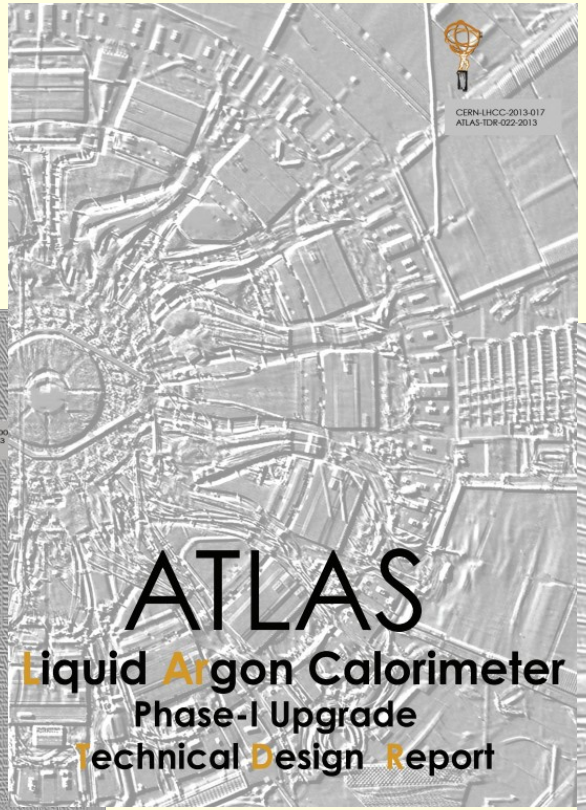
Already in 2012 the total "CORE" (equipment) cost of the Phase-II upgrades was established

Final approved amount, several years later and with a different detailed set of upgrades, was still 275 MCHF

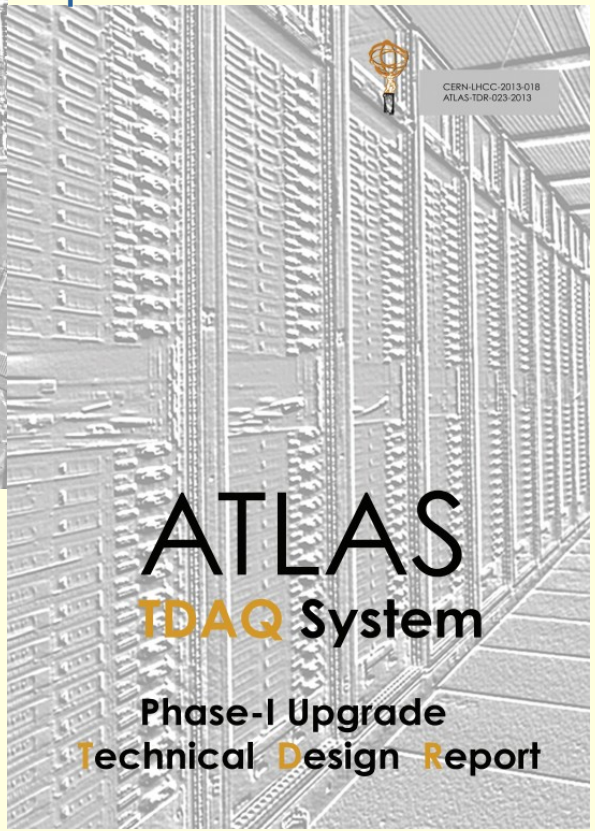


June 2013

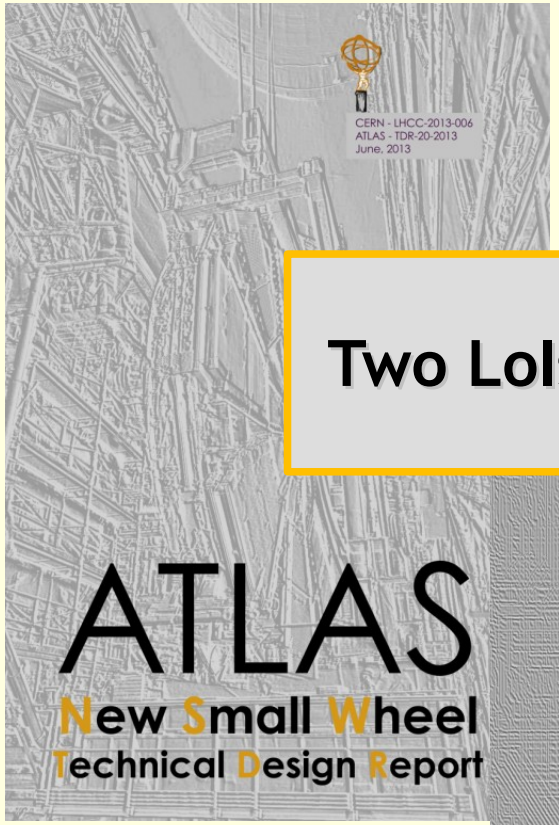


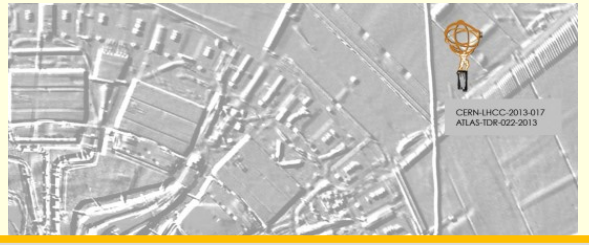


September 2013



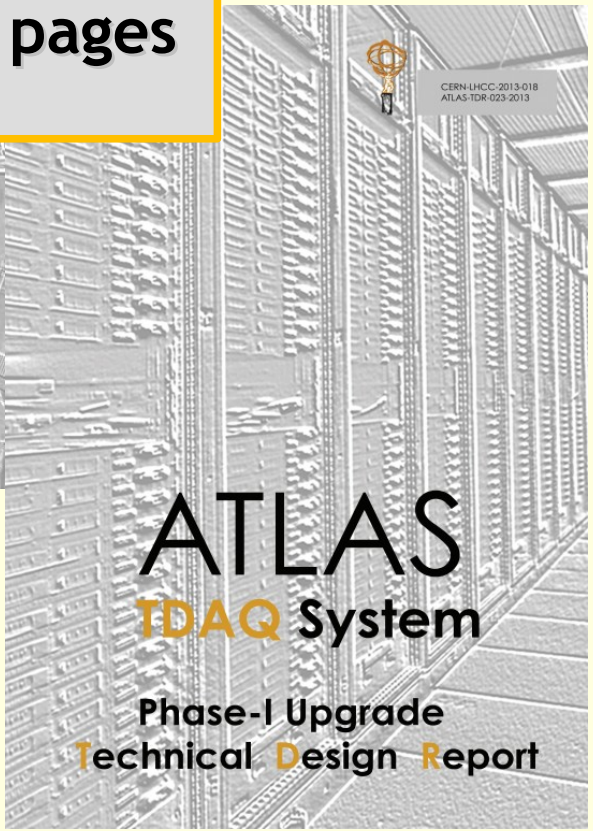
Phase-I TDRs



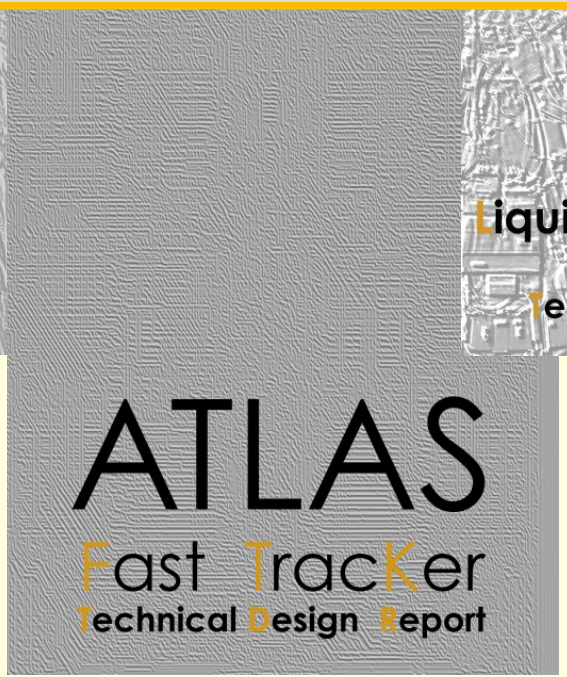


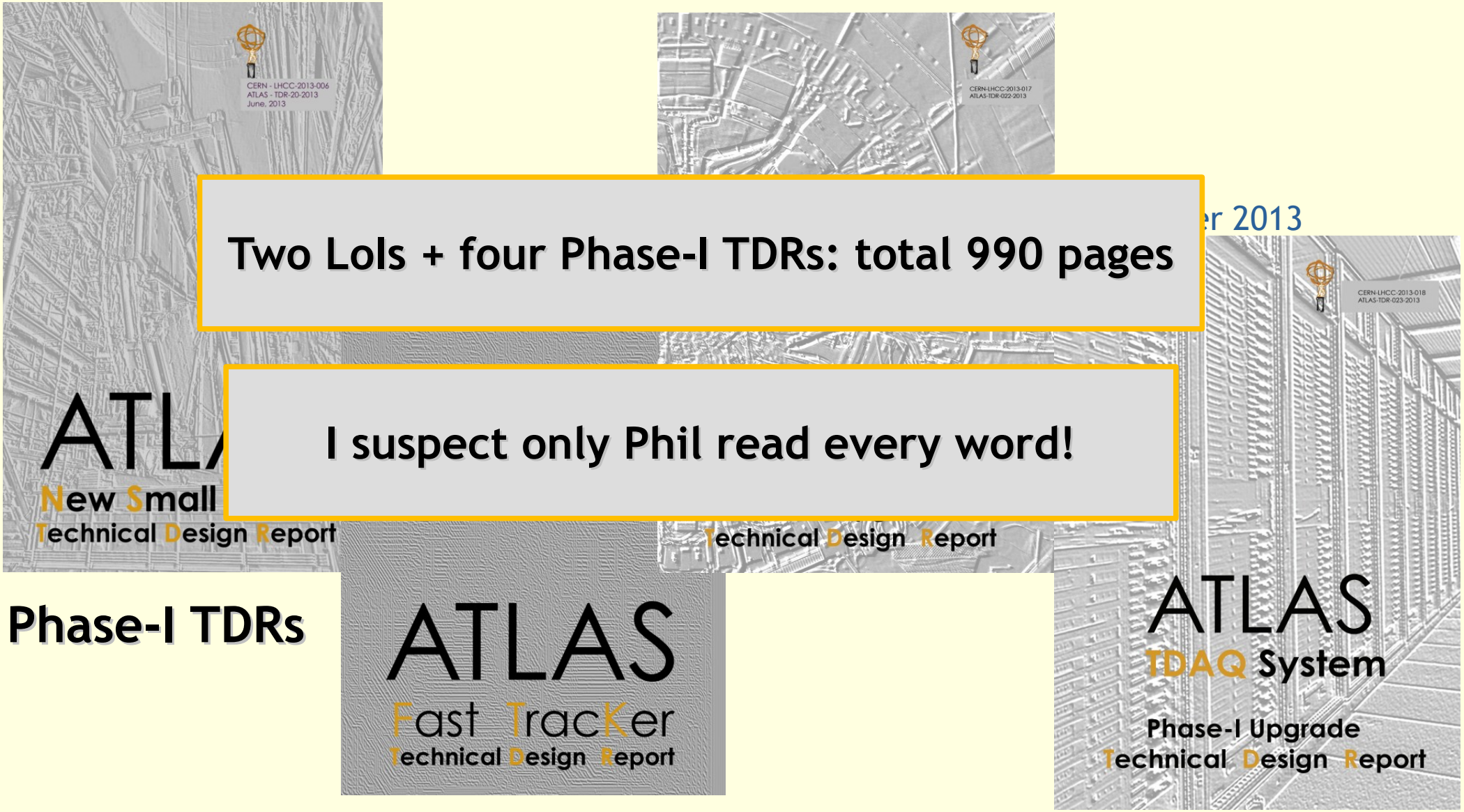
Two LoIs + four Phase-I TDRs: total 990 pages

er 2013



Phase-I TDRs

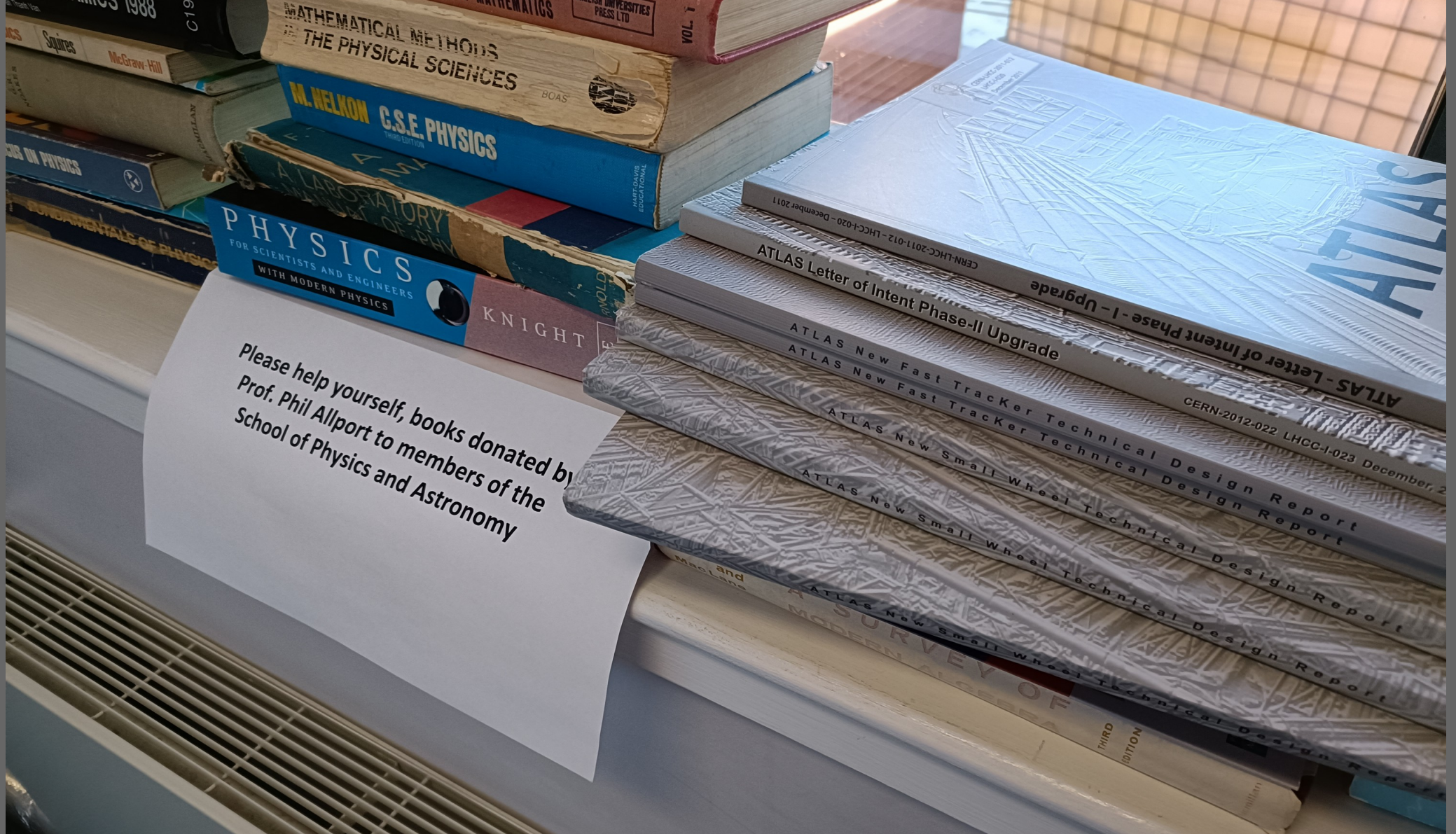




Two LoIs + four Phase-I TDRs: total 990 pages

I suspect only Phil read every word!

Phase-I TDRs


Please help yourself, books donated by
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WITH MODERN PHYSICS
KNIGHT
ATLAS
ATLAS - Letter of Intent Phase-I - Upgrade
CERN-LHCC-2011-012 - LHCC-I-020 - December 2011
ATLAS Letter of Intent Phase-II Upgrade
CERN-2012-022 LHCC-I-023 December
ATLAS New Fast TracKer Technical Design Report
ATLAS New Small Wheel Technical Design Report
A SURVEY OF
THIRD EDITION

October 2013

Building momentum for the HL-LHC upgrades after the 2013 European Strategy Update

ECFA European Committee for Future Accelerators

Why now ?

Update of the European Strategy for Particle Physics adopted 30 May 2013 in a special session of CERN Council at Brussels.

Statement c:

c) The discovery of the Higgs boson is the start of a major programme of work to measure this particle's properties with the highest possible precision for testing the validity of the Standard Model and to search for further new physics at the energy frontier. The LHC is in a unique position to pursue this programme. *Europe's top priority should be the exploitation of the full potential of the LHC, including the high-luminosity upgrade of the machine and detectors with a view to collecting ten times more data than in the initial design, by around 2030. This upgrade programme will also provide further exciting opportunities for the study of flavour physics and the quark-gluon plasma.*

Joachim Mnich

ECFA High Luminosity LHC Experiments Workshop

Physics and technology challenges

1st – 3rd October

Aix-les-Bains

France

https://indico.cern.ch/conferenceDisplay.py?confId=252045

Programme Committee

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A. Ball
S. Bertolucci
P. Campana
D. Charlton
D. Contardo
B. Di Girolamo
P. Giubellino
J. Incandela
P. Jenni
M. Krammer
M. Mangano
S. Myers
B. Schmidt
T. Virdee
H. Wessels

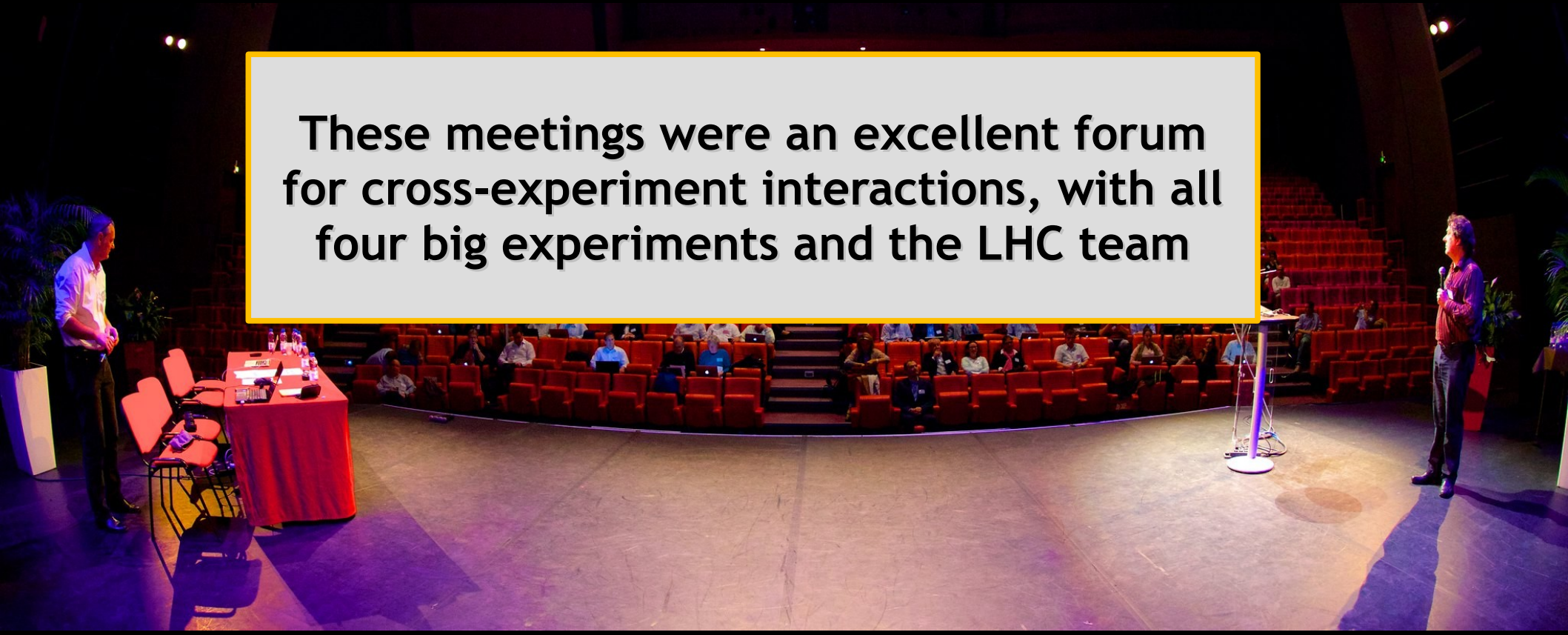
Local Organising Committee

P. Allport, D. Contardo, D. Hudson, C. Potter

Picture Credit: OT Aix-les-Bains / Gilles Lansard

ECFA HL-LHC workshop "Aix-1"

ECFA HL-LHC workshop "Aix-1"



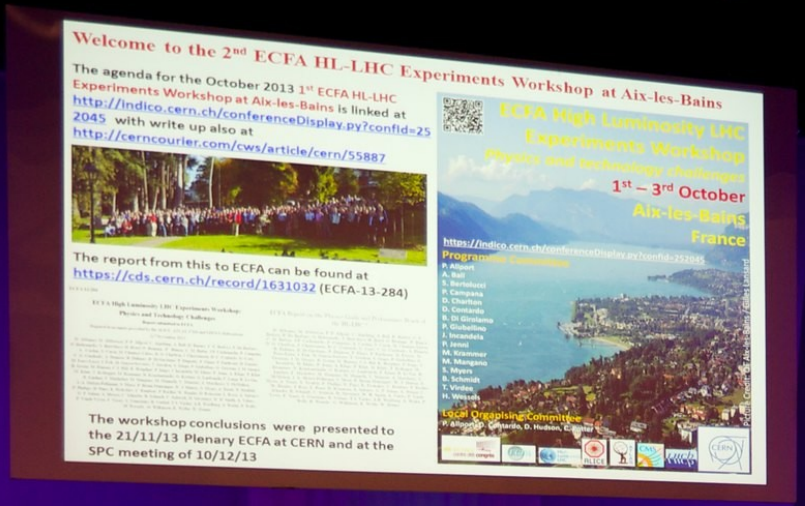
These meetings were an excellent forum for cross-experiment interactions, with all four big experiments and the LHC team

ECFA HL-LHC workshop "Aix-1"


ECFA HL-LHC workshop "Aix-1"


ECFA HL-LHC workshop "Aix-2"

"Aix-2"


Welcome to the 2nd ECFA HL-LHC Experiments Workshop at Aix-les-Bains
The agenda for the October 2013 1st ECFA HL-LHC Experiments Workshop at Aix-les-Bains is linked at http://indico.cern.ch/conferenceDisplay.py?confId=252045 with write up also at http://cerncourier.com/cws/article/cern/55887
The report from this to ECFA can be found at https://cds.cern.ch/record/1631032 (ECFA-13-284)
The workshop conclusions were presented to the 21/11/13 Plenary ECFA at CERN and at the SPC meeting of 10/12/13
ECFA High Luminosity LHC Experiments Workshop
Physics and technology challenges
1st – 3rd October
Aix-les-Bains
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ECFA/13/284

ECFA High Luminosity LHC Experiments Workshop: Physics and Technology Challenges

Report submitted to ECFA

Prepared from inputs provided by the ALICE, ATLAS, CMS and LHCb Collaborations

21st November 2013

D. Abbaneo, M. Abbrescia, P. P. Allport, C. Amelung, A. Ball, D. Barney, C. F. Bedoya, P. De Barbaro, O. Beltramello, S. Bertolucci, H. Borel, O. Bruning , P. Buncic, C. M. Buttar, J.P. Cachemiche, P. Campana, A. Cardini, S. Caron, M. Chamizo Llatas, D. G. Charlton, J. Christiansen, D. C. Contardo, G. Corti, C. G. Cuadrado, A. Dainese, B. Dahmes, B. Di Girolamo, P. Dupieux, P. Elmer, P. Farthouat, D. Ferrere, M. Ferro-Luzzi, I. Fisk, M. Garcia-Sciveres, T. Gershon, S. Giagu, P. Giubellino, G. Graziani, I. M. Gregor, B. Gorini, M. Hansen, C.S. Hill, K. Hoepfner, P. Iengo, J. Incandela, M. Ishino, P. Jenni, A. Kluge, P. Kluit, M. Klute, T. Kollegger, M. Kramm, R. Lindner, F. Machefert, M. I.-A. Melzer-Pellmann, S. Mersi, P. Phillips, D. Pinci, K. Prokofiev, G. P. Salam, A. Sbrizzi, C. Scha, P. Vande Vyvre, F. Vasey, S. Ve, H. We

Yet more paperwork!

1. Introduction

The European Strategy for Particle Physics was published[1] earlier this year and adopted at the special European Strategy Session of CERN Council in Brussels on 30 May 2013. In that document, the priorities are set for European particle physics taking account of the Higgs boson discovery at the LHC in 2012 and of the global energy frontier research landscape. This contains a key message towards the accomplishment of the HL-LHC programme: "*Europe's top priority should be the exploitation of the full potential of the LHC, including the high-luminosity upgrade of the machine and detectors with a view to collecting ten times more data than in the initial design, by around 2030. This upgrade programme will also provide further exciting opportunities for the study of flavour physics and the quark-gluon plasma.*" In this context, the ECFA High Luminosity LHC Experiments Workshop[2] was a first meeting of the four LHC experiments, together with the accelerator and theory communities, to address the challenges of the HL-LHC programme. The meeting held in Aix-les-Bains from 1st to 3rd October, 2013 gathered more than 300 physicists and engineers from these different communities.

ECFA/15/289

ECFA High Luminosity LHC Experiments Workshop: Physics and Technology Developments

Summary submitted to ECFA

M. Abbrescia, A. Affolder, P.P. Allport, E. Anderssen, A. Apyan, O. Arnaez, P. Aspell, A. Ball, S. Bally, I. Bejar Alonso, A. Belloni, O. Beltramello, I. Bergstrom, S. Bertolucci, L. Betev, F. Bordry, P. Braun Munzinger, O. Bruning, H. Burkhardt, J. Buytaert, P. Campana, M. Campbell, T. Camporesi, A. Canepa, A. Cardini, S. Caron, F. Cavallari, D. Charlton, J. Christiansen, P. Clarke, P. Collins, J. Christiansen, D. Contardo, G. Corti, A. Dainese, P. de Barbaro, N. De Bortoli, B. Di Girolamo, P. Dupieux, K. Einsweiler, F. Faccio, P. Farthouat, D. Ferrere, M. Ferro-Luzzi, M. Garcia-Sciveres, C. Gargiulo, T. Gershon, M. Girone, P. Giubellino, P. D. Giugni, V.V. Gligorov, E.W.N. Glover, B. Gorini, T. Grassi, L. Gray, G. Graziani, I. Gregor, A Grillo, C. Grojean, M. Hansen, F. Hartmann, A. Henriques, F. Huegging, P. Iengo, G. Isidori, C. Joram, A. Kluge, M. Klute, N. Konstantinidis, O. Kortner, M. Krammer, Mans, V. Manzari, F. Meijers, Neufeld, A. Nisati, G. Passaleva, u, F. Ronchetti, L. Rossi, R. Rusack, harma, D. Silvermyr, W.H. Smith, ea, V. Vagnoni, P. Vande Vyvre, Weiler, P. Wells, J.P. Wessels, i, W. Zeuner

January 2015

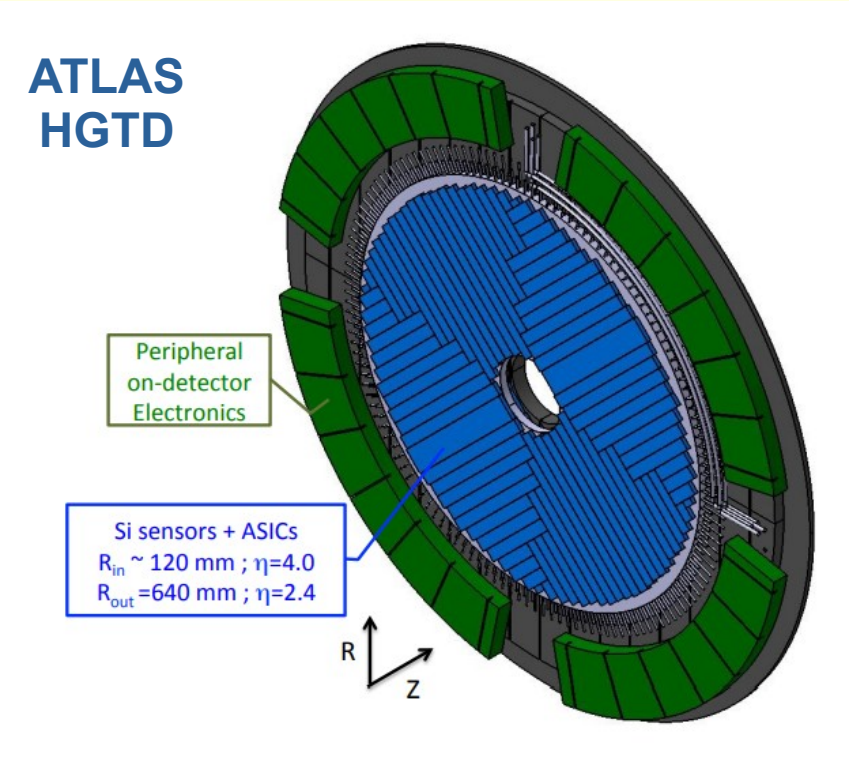
1. Introduction

The 2014 ECFA High Luminosity LHC Experiments Workshop[1] was a second meeting of the four LHC experiments with the accelerator and theory communities. The meeting was held in Aix-les-Bains, from 21st to 23rd October and attracted 250 participants.

This report follows on from the one published after the 2013 workshop[2] (ECFA-13-284, see Ref. (1)) that outlined the major physics goals and the projected performance reach for the High Luminosity LHC (HL-LHC) along with the research and development for upgrading the accelerator and experiments.

5. Timing Devices

At the High-Luminosity-LHC (HL-LHC), about 140-200 concurrent collisions per beam crossing will take place with vertex densities along the beam axis above 1 mm^{-1}. At these densities, some vertices and their associated particles will be merged forming fake jets of high transverse momentum. Moreover, the random overlap of energy deposits from neutral particles (mainly photons), that cannot be tied to any vertex, will deteriorate the calorimeter performance in terms of energy measurement and particle identification, as particles appear to be less isolated. On the other hand, collision vertices also have a time spread of order



A High Luminosity LHC Experiments Workshop: Physics and Technology Developments

Summary submitted to ECFA

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January 2015

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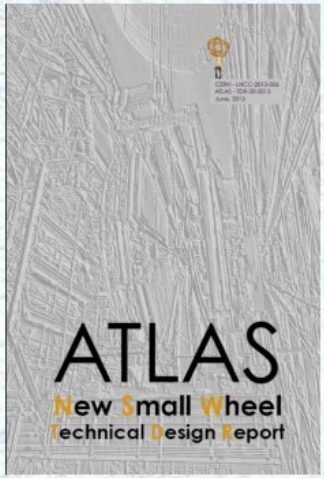
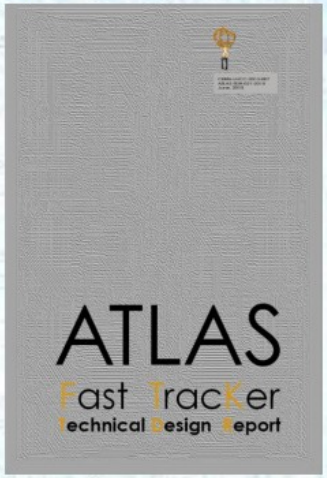
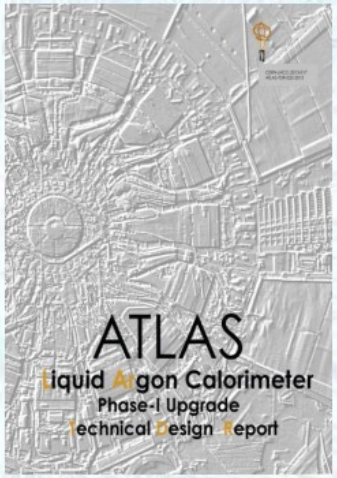
Cementing the Phase-I Programme

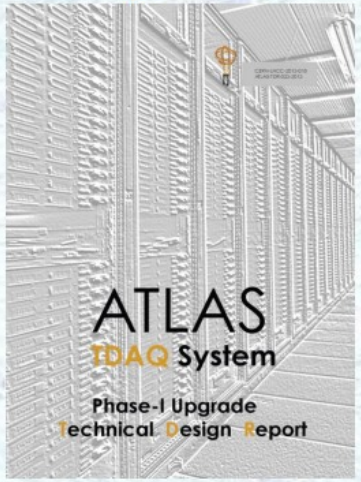
Current Phase-I TDRs and MoUs

In 2013, 4 TDRs for Phase-I construction projects were prepared within ATLAS, approved by the CB and endorsed at the LHCC meeting of 5/12/13









Upgrade Cost Group reports approve all four cost estimates (see http://cds.cern.ch/collection/LHCC%20Public%20Documents?ln=en documents CERN-LHCC-2014-007 **to** CERN-LHCC-2014-010**).**
MoUs https://dfs.cern.ch/dfs/users/d/dittus/public/ATLAS_Upgrade_MoUs/ sent to the DRC-Office on 24/3/14 and annexes printed on 2/4/14

Phil's closeout ATLAS Upgrade Week 2014 (Freiburg)

This gobbledegook says that the Funding Agencies had agreed to pay up...

Freiburg 2014

Freiburg 2014

Just as Phil was completing his four years as Upgrade Coordinator, we were embarking on the next round of approvals, for Phase-II

By far the biggest Phase-II project

For endorsement by the ATLAS Collaboration Board, one week before the end of Phil's term!

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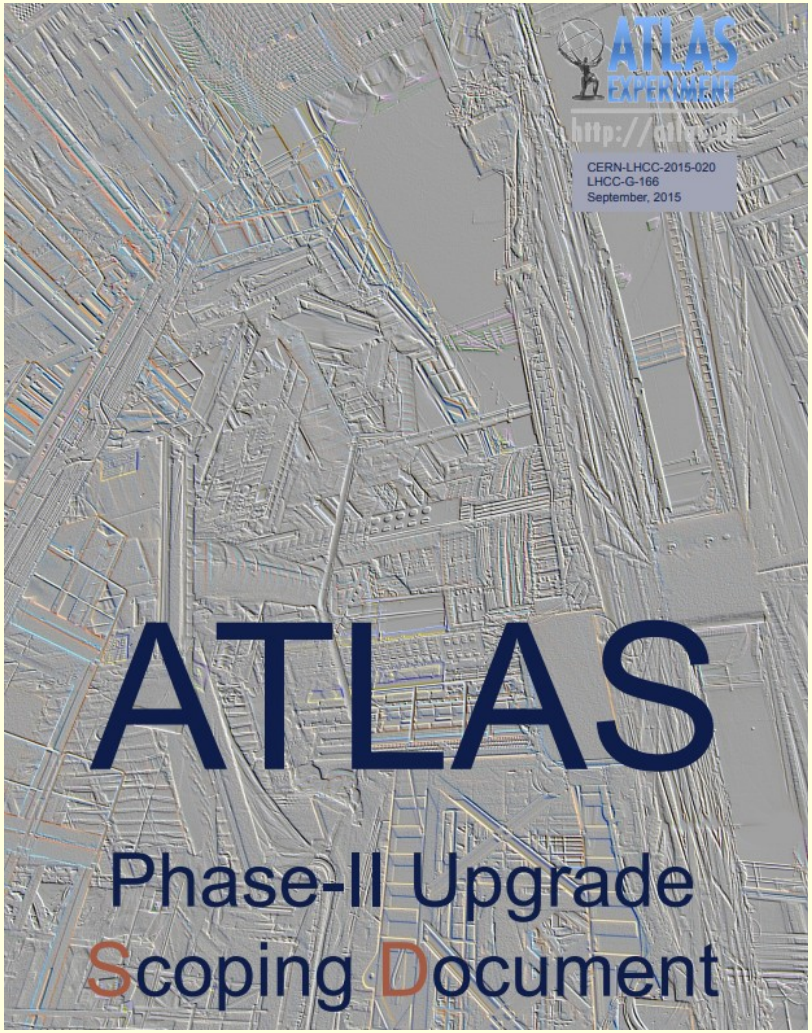
Table 25. Top-level summary of the CORE cost estimates for the Phase-II ATLAS upgrades by detector subsystems (expanded to Level-2 in the WBS).

WBS	Detector system	Reference Detector Total Cost [MCHF]	Middle Scenario Differential Cost [MHCF]	Low Scenario Differential Cost [MCHF]
	ATLAS	**271.04**	**-42.55**	**-71.16**

Remarkably, the CORE cost was the same as in the LoI!



After four years with Phil as Upgrade Coordinator

ATLAS upgrades had gone from a set of R&D projects and clever ideas, to two well-developed programmes

Phase-I
- Fully defined, documented and approved
- Construction well in progress

Phase-II
- Concepts defined and documented, scope established
- Funding Agencies “reconciled” to the cost!

All are big team efforts

… but you led the whole shebang, Phil – thanks so much from us all in ATLAS!

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Phil, your impact on ATLAS' upgrades has been gigantic, and ever thoughtful!

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Long may it continue!

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Bonus(?)


CERN


RECEPTION