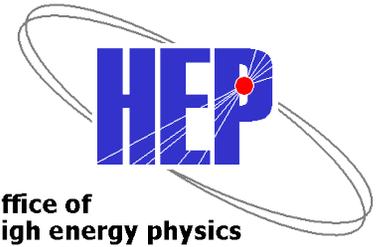




U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science



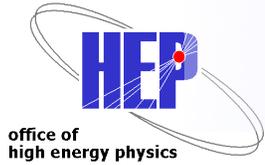
# ATLAS Detector Upgrade Project

Simona Rolli

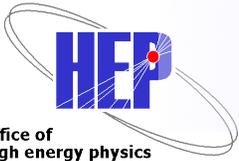
DOE Office of Science

Office of High Energy Physics

# Outline



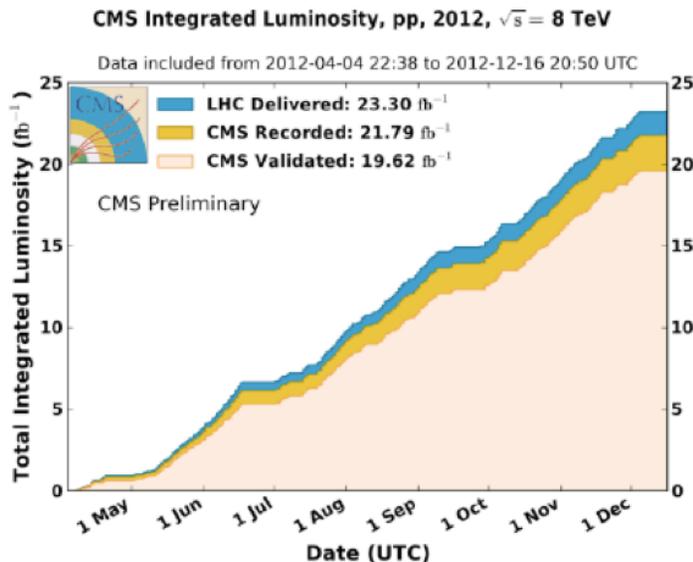
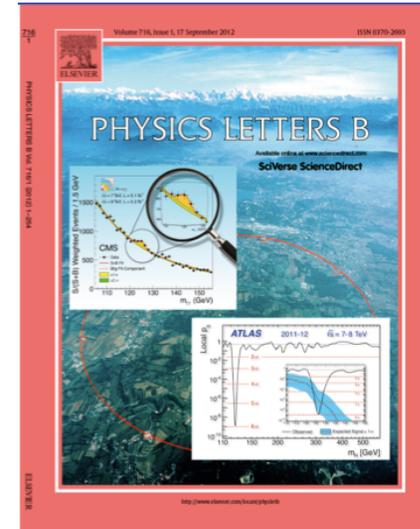
- The Energy Frontier at the LHC
  - Current Program
  - LHC Roadmap
- ATLAS Detectors Upgrades
- Project approval
  - CERN, DOE, NSF...
- DOE Process and this review



# The Energy Frontier Program at the LHC

## 2009-2012 Run I (7-8 TeV)

- > 250 publications/experiment
- Expect > 100 more on Run I data
- 25 fb<sup>-1</sup> of 7+8 TeV pp data
- Higgs boson found!
  - Looks like SM at first glance
- Stringent limits set on physics beyond the SM
- Many precise measurements of SM processes



8/21/13

**2013-2014: LS1** : repair splices in LHC magnets; detector maintenance and consolidation, upgrades and repairs

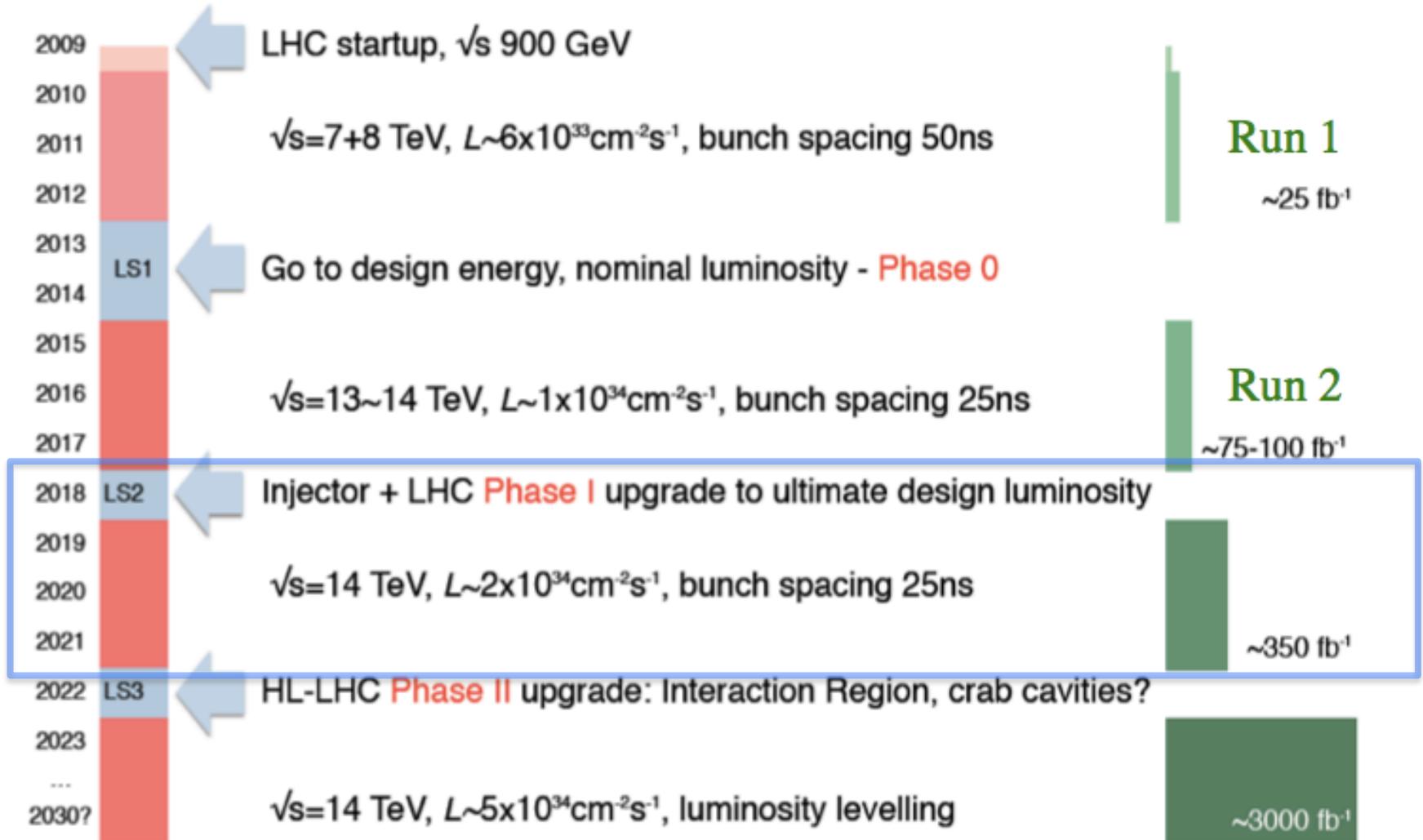
**2015 -2017(18): Run II** 13~14 TeV

- Ramp up luminosity to nominal ( $2 \times 10^{34}$  by LS2, higher after LS2)
- Higgs Precision Measurements;
- Renewed focus on new physics
  - What will 13~14 TeV running tell about BSM physics?

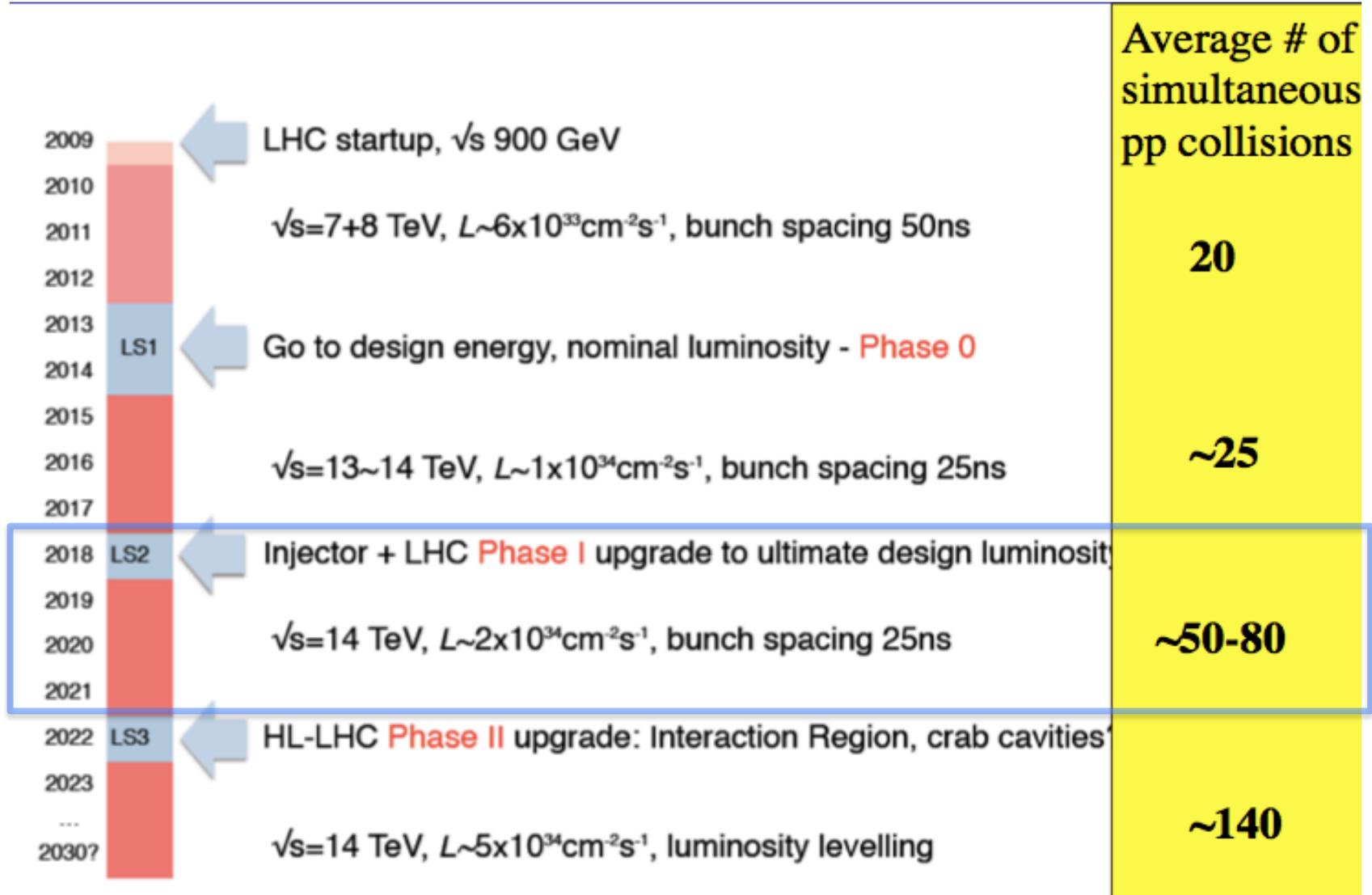
ATLAS Detector Upgrade CD-1 Review, Fermilab, August 28, 2013

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# LHC Roadmap



# LHC Roadmap

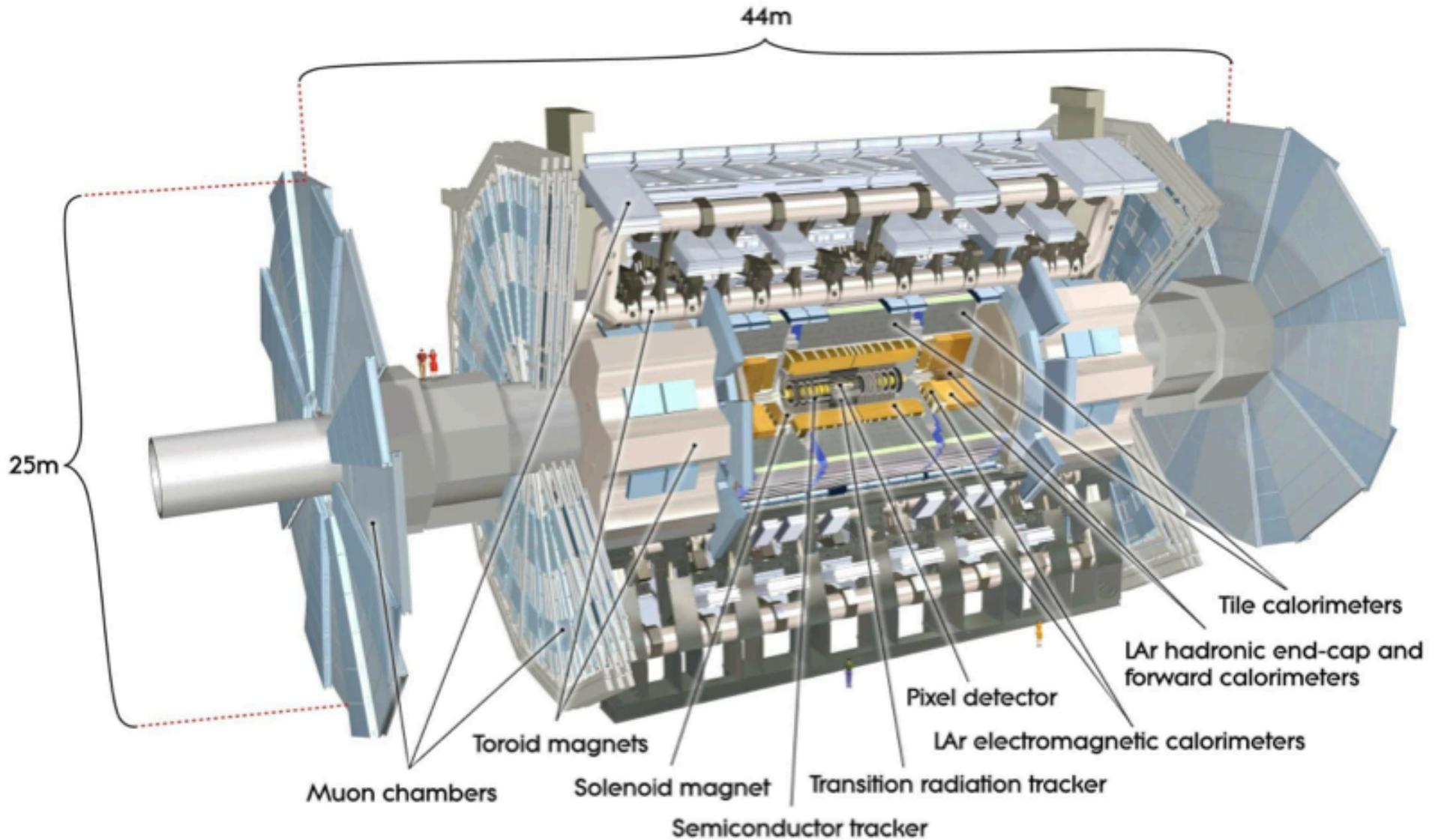


# Detectors Upgrades

- Detectors will need to be upgraded to be able to cope with higher luminosity, e.g.
  - Improve trigger capabilities
    - better discriminate the desired signal events from background as early as possible in trigger decision
- Upgrade and/or replace detectors as they e.g.
  - Cannot handle higher rate due to bandwidth limitations
  - Suffer from radiation damage making them less efficient



# The ATLAS Detector



# ATLAS Upgrade Roadmap

## Phase-0

- 4<sup>th</sup> Si Pixel layer (IBL)
- Complete muon coverage
- Repairs (TRT, LAr and Tile)
- New beampipe and infrastructure updates

## Phase-I

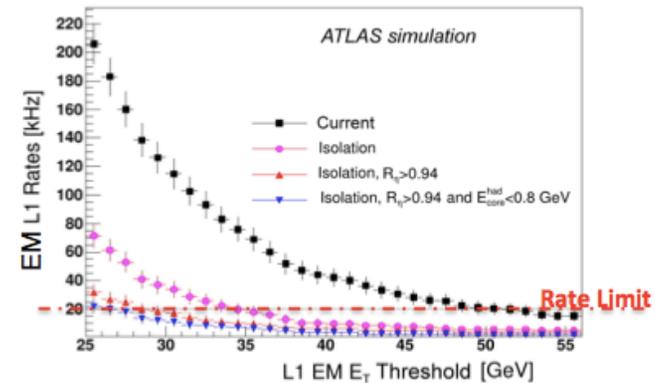
- Fast Track Trigger (FTK)
- Muon New Small Wheel (NSW)
- LAr cal. electronics

## Phase-II

- New pixel and strip tracker
- Calorimeter
- Muon system
- Trigger system
- Computing
- ...

Phase 1 Central theme:

need trigger thresholds near  $pT = 20$  GeV

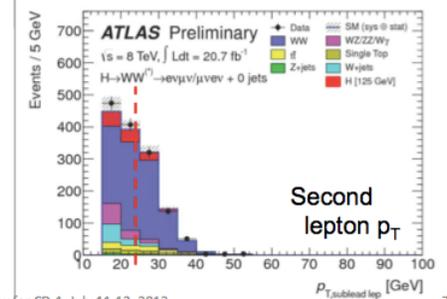
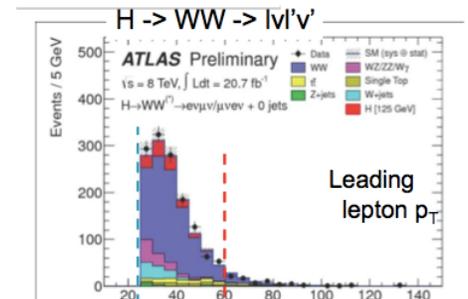
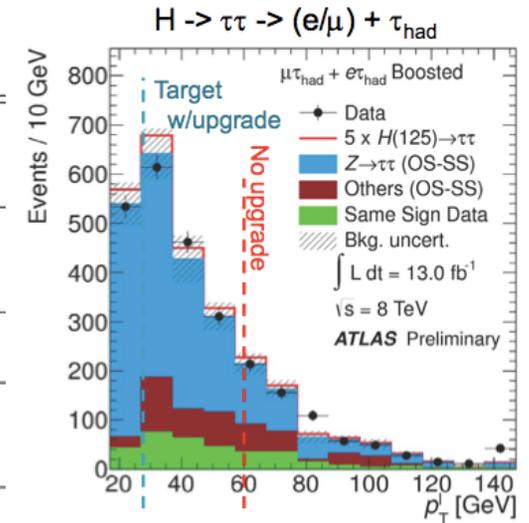


**Rough benchmark:** Without upgrades, changing thresholds in order to contain rates results in ~ 50% loss of efficiency for events triggered on massive-object, single-lepton decay. Impacts W, WH, ttbar, top, SUSY, ...

# Significance of the ATLAS Upgrade Project

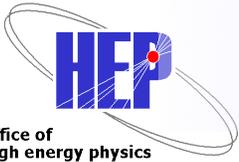
Possible trigger list (100 kHz total)

L1 Item	Equivalent Offline $p_T$ (GeV)	Level-1 Trigger Rates in kHz		
		Predicted (data)	With pile-up (MC)	Unique (no pile-up)
$e/\gamma$				
EM50H	60	4.9	4.9	2.3
EM80	100	2.2	2.2	0.0
2EM20H	2x25	3.4	3.7	2.4
$\mu$				
MU20 ( $\eta < 1.9$ )	25	32.3	32.3	30.1
2MU11	2x13	6.4	10.0	5.9
$e+\mu$				
EM20H_MU10	25, 12	1.9	5.0	0.7
2EM11H_MU10	2x15, 12	0.7	2.5	0.2
EM11H_2MU6	15, 2x6	0.7	2.4	0.2
$\tau$				
TAU80	180	5.4	10.2	0.1
2TAU40	2x100	8.1	8.1	3.0
2TAU15I_3J20	2x45, 60(jet)	8.8	13.5	3.8
2TAU15I_EM20H_3J20	40, 25, 60(jet)	3.4	4.6	0.0
TAU15I_MU15	40, 20	3.0	4.8	0.9
TAU20I_XE40_3J20	50, 90, 60(jet)	1.4	4.1	0.1
$j$				
J100	250	7.3	7.3	0.9
4J20	Nx60	2.4	4.6	0.6
J75_XE40	200,150	7.0	8.6	2.4
XE80	200	8.7	13.1	0.4
Others	L1 Topo	20	12	20.0
Totals	<b>Bandwidth limited total</b>	90.0	100.0	



# US Role

- US has made critical contributions to LHC machine
  - E.g. Inner Triplet magnets
- US is single biggest collaborator in ATLAS
  - ATLAS: 583 US authors (20% of total)
    - 175 US graduate students
- US Contributions
  - Major contributions to design, construction and operation of most subdetectors
  - Major impact on physics analyses
  - Leadership in all areas
- US is actively participating in the upgrades
  - US groups have played a leading role in developing the relevant ATLAS upgrades, and have been intimately involved in the decision-making process.
  - Joint Effort with NSF



# ATLAS Proposal/Project Approval

**CERN:** LHCC approved the LOI in March 2012

Technical Design Reports (TDRs) will be completed for all of the upgrade systems and approved by the LHC Committee by the Fall of 2013.

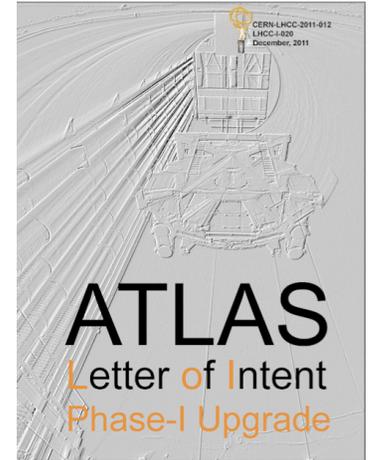
Agreement on the US scope – technology choices and roles and responsibilities – have been reached with the relevant ATLAS collaborating institutions.

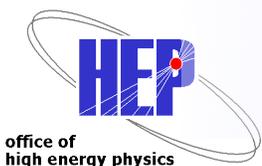
## **US DOE:**

- CD0 now approved
- Plan/goal for moving forward
  - CD-0, Approve Mission Need FY12
  - CD-1, Approve Alternative Selection and Cost Range FY13
  - CD-2, Approve Performance Baseline FY14
  - CD-3, Approve Start of Construction FY14
  - CD-4, Approve Project Completion FY19

## **US NSF**

- Proposal for new “mid-range” Cooperative Agreement submitted in June





# Current Status

## CD-0: Mission Need ( Sept 2012)

The ATLAS Detector needs upgrades to handle the expected increased data rates  
 This initiative will allow the High Energy Physics (HEP) program to continue the forefront exploration of the Energy Frontier at the world's premier collider accelerator.

*Total Project Cost Range: \$22-\$34 Millions*

## CD-1: Approve Alternative Selection and Cost Range ( September 2013)

Conceptual Design Maturity and Alternative Analysis

Scope & WBS

Cost, Schedule and Risk Estimate

Project Management Organization and E&SH

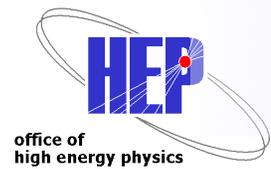
*Current Funding Guidance:*

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	Total
FY 2014 PRB Integrated funding	1,500	7,500	15,250	24,750	33,250	
<b>FY 2014 PRB TPC</b>	<b>1,500</b>	<b>6,000</b>	<b>7,750</b>	<b>9,500</b>	<b>8,500</b>	<b>33,250</b>
OPC	1,500	6,000				7,500
TEC			7,750	9,500	8,500	25,750

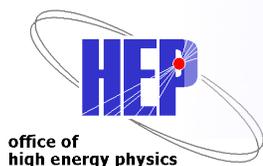
# This Review

Will need to assess that:

- The conceptual design is sound and likely to meet the MIE technical performance requirements
- The project scope is sufficiently defined to support preliminary cost and schedule estimates.
- Cost and Schedule estimates are credible and realistic
- Scope, Cost and Schedule Contingency is adequately estimated
- CD-1 prerequisite documentation has been provided and is complete
- A capable project management team is in place and ES&H is being integrated in the design.
- Roadmap to CD-2 developed and progress to be reported at IPT and other project meetings



# Backup



# HEP Mission

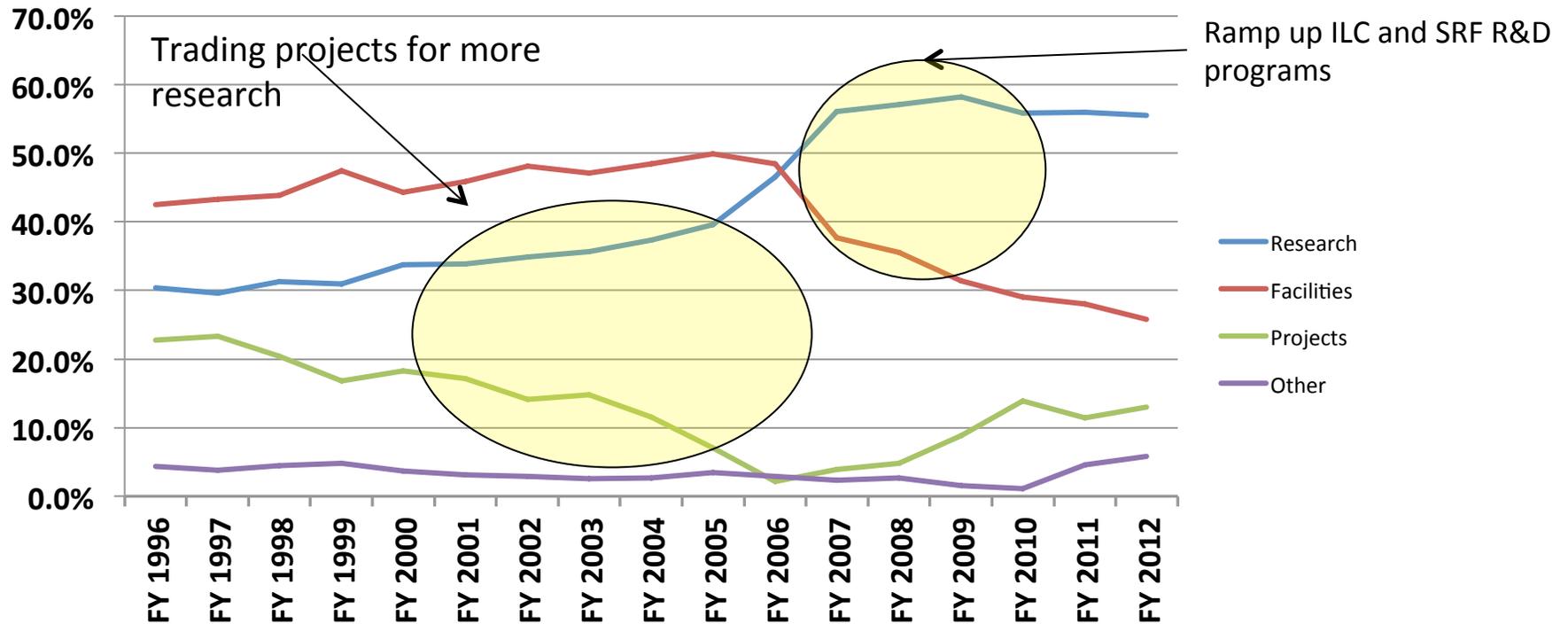
- **HEP's Mission:** To explore the most fundamental questions about the nature of the universe at the Cosmic, Intensity, and Energy Frontiers of scientific discovery, and to develop the tools and instrumentation that expand that research
- **HEP seeks answers to Big Questions:**
  - How does mass originate?
  - Why is the world matter and not anti-matter?
  - What is dark energy? Dark matter?
  - Do all the forces become one and on what scale?
  - What are the origins of the Universe?
- HEP offers high-impact research opportunities for small-scale collaborations at the Cosmic and Intensity Frontiers to full-blown international collaborations at the Energy Frontier.

# The HEP Game Plan

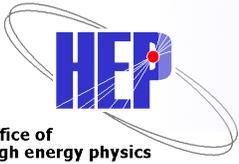
- 2008 P5 Recommendations
  - Three Frontiers
    - US one of the leaders in Energy and Cosmic
      - LHC & LHC Upgrades; Dark Matter & Dark Energy
    - US the leader in Intensity
      - Neutrino and Kaon/Muon programs
    - Strategic Program in Accelerator R&D
      - Society return...
- The HEP budget plan puts in place a comprehensive program across the three frontiers.
  - In five years,
    - NOvA, Belle-II, g-2 will be running on the Intensity Frontier.
    - Mu2e will be in commissioning preparing for first data.
    - The CMS and ATLAS detector upgrades will be installed at CERN.
    - DES will have completed its science program and new mid-scale spectroscopic instrument and DM-G2 should begin operation
    - The two big initiatives, LSST and LBNE, will be well underway.



# Recent Funding Trends



- In the late 90's the fraction of the budget devoted to projects was about 20%.
- Progress in many fields require new investments to produce new capabilities.
- The projects started in 2006 are coming to completion.
- New investments are needed to continue US leadership in well defined research areas.
- Possibilities for future funding growth are weak. Must make do with what we have.



# FY14 Budget

- FY2014 budget philosophy was to enable new world-leading HEP capabilities in the U.S. through investments on all three frontiers
  - **Accomplished through ramp-down of existing Projects and Research**
  - **When we were not able to fully implement this approach, converted planned project funds to R&D: Research  $\Rightarrow$  ~~Projects~~  $\rightarrow$  Research**
    - Therefore, the FY14 Request shows *increases* for Research that are due to this added R&D “bump”, while Construction/project funding is only slightly increased
    - In the interim (since submission of FY14 Request), actual FY13 Research funding also increased because of inability to get projects started
    - Initial FY14 plan for Research will be down more than the originally advertised 2-3% relative to FY13
- Impact of these actions:
  - Several new efforts are delayed: LBNE, **LHC detector upgrades**, 2<sup>nd</sup> Generation Dark Matter detectors
  - US leadership/partnership capabilities will be challenged by others
  - **Workforce reductions at universities and labs**
- Key areas in FY2014 Request
  - **Maintaining forward progress on new projects via Construction and Research funding lines**

# ATLAS Upgrade Project Description

- The [Liquid Argon Calorimeter Trigger Readout Upgrade \(LAr\)](#) introduces higher transverse and longitudinal granularity at the trigger level, as well as increased precision of the information sent to the L1 processors, in order to lower rates while maintaining high signal efficiency.
  - More finely grained computation of lateral and longitudinal electromagnetic shower shapes,
  - Better determination of jet energies and missing transverse energy
  - U.S. deliverables include upgrades to both on- and off-detector components of the liquid argon calorimeter electronics.
- The [New Muon Small Wheel Upgrade \(nSW\)](#) will provide an additional trigger plane to measure the vector of the forward muon track to high precision.
  - Enhanced background discrimination and forward muon momentum resolution,
  - The U.S. contributions focus on deliverables to enable the triggering, readout capability and mechanical alignment of this system.
- The [Trigger and Data Acquisition systems \(TDAQ\)](#) upgrades center around hardware to facilitate input to and output from the new L1 trigger systems as well as firmware related to this hardware and to trigger algorithms.
  - Topological event information at L1.
  - The U.S. deliverables for the TDAQ project focus on upgrades to the hardware and firmware that will increase the bandwidth capability and enhance the overall functionality of this system