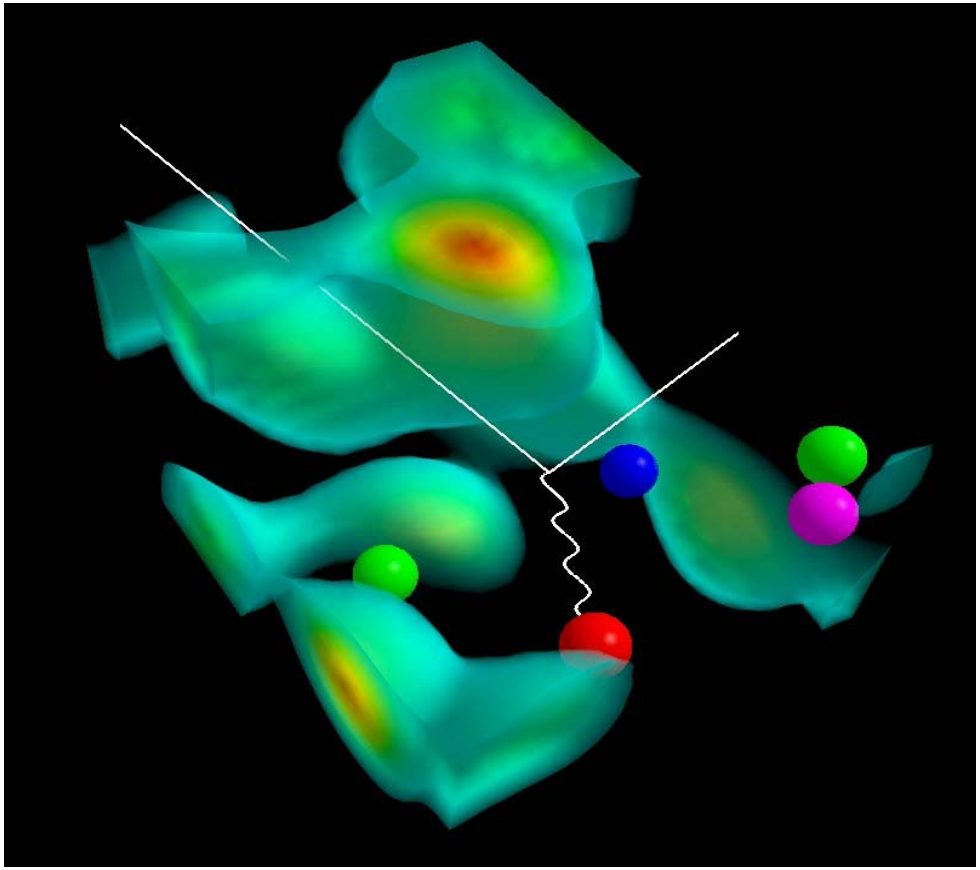
Welcome to Adelaide



Anthony W. Thomas

ANPhA Symposium and Board Meeting
University of Adelaide : August 3rd 2012

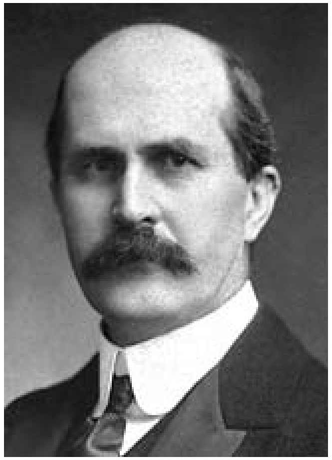
CoEPP
ARC Centre of Excellence for Particle Physics at the Terascale

Australian Government
Australian Research Council

ADELAIDE UNIVERSITY AUSTRALIA

SPECIAL RESEARCH CENTRE FOR THE SUBATOMIC STRUCTURE OF MATTER

The Very Beginning



In Adelaide William Henry Bragg was appointed as Elder Professor of Physics in 1886.

Research aimed at understanding the nature of X-rays – he concluded they were particles

ADELAIDE UNIVERSITY AUSTRALIA

CoEPP ARC Centre of Excellence for Particle Physics at the Terascale

SPECIAL RESEARCH CENTRE FOR THE SUBATOMIC STRUCTURE OF MATTER

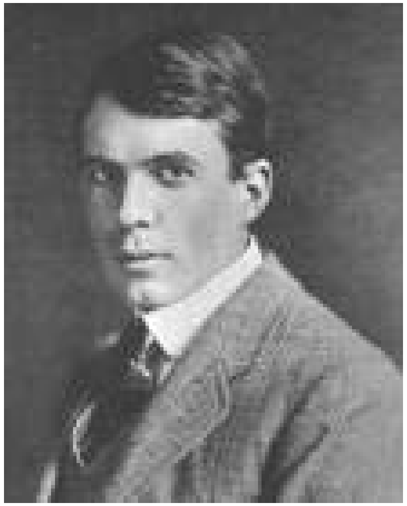
Data eventually forced a re-evaluation

Working with William Lawrence Bragg,

WH was soon forced to re-examine

this and concluded that sometimes X-rays

act like waves and sometimes particles



Only later understood in terms of Quantum Mechanics

A Very Brief History of Subatomic Physics

- **1995: Won national competition to host a National Institute of Theoretical Physics (NITP)**
- **1997: Awarded ARC Special Research Centre for the Subatomic Structure of Matter (CSSM)**
- **2009: CSSM re-invented as C^{2}SSM (Adelaide University's Research Centre for Complex Systems and the Structure of Matter)**
- **2011: Node of the ARC Centre of Excellence for Particle Physics at the Terascale (CoEPP)**
- **Currently more than 40 staff and post-graduate students including experimental participation in ATLAS**

CSSM

- Centre for the Subatomic Structure of Matter formed as an ARC Special Research Centre in 1997

- To understand the quark structure of matter from protons and neutrons to atomic nuclei and neutron stars (pulsars)

- This has made Adelaide a major international player in subatomic physics – leading scientists from around the world come here to work with our staff and students

CoEPP
ARC Centre of Excellence for Particle Physics at the Terascale

ADELAIDE UNIVERSITY
AUSTRALIA

Australian Government
Australian Research Council

SPECIAL RESEARCH CENTRE FOR THE SUBATOMIC STRUCTURE OF MATTER

A few achievements since 1997

- Students:
  - 78 Graduate students 1997+
  - 54 Honours students
  - 46 undergraduates involved in research

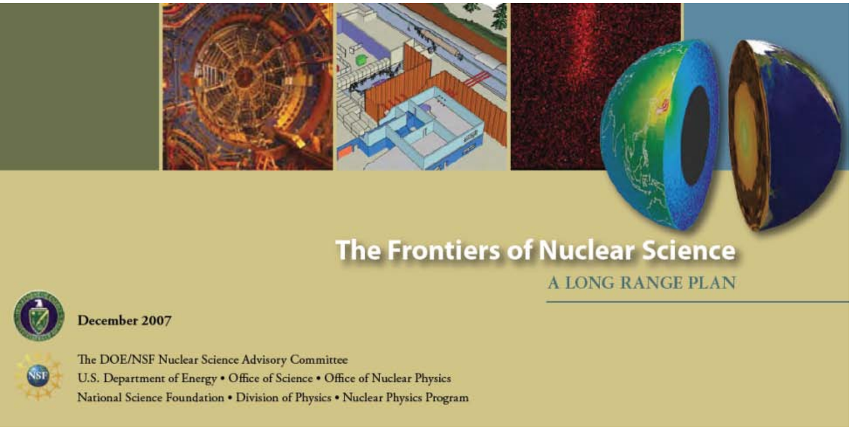
- Workshops:
  - 35 Workshops and Conferences 1997+
  - Including QNP 2000; Symmetries in Subatomic Physics; Light-cone 2005; Pacific Spin 2011; Lattice 2012 and ICHEP (in Melbourne) 2012

- Approx. 370 journal articles with more than

  11,000 citations

Just a few scientific highlights

Quark and Gluon Propagators



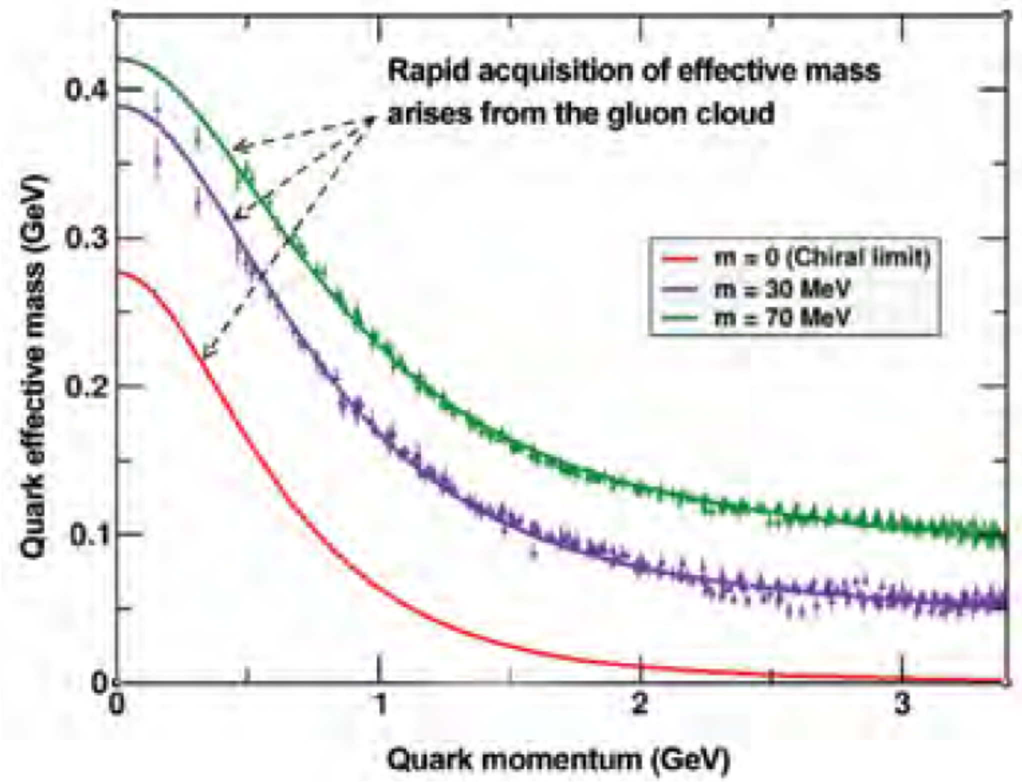
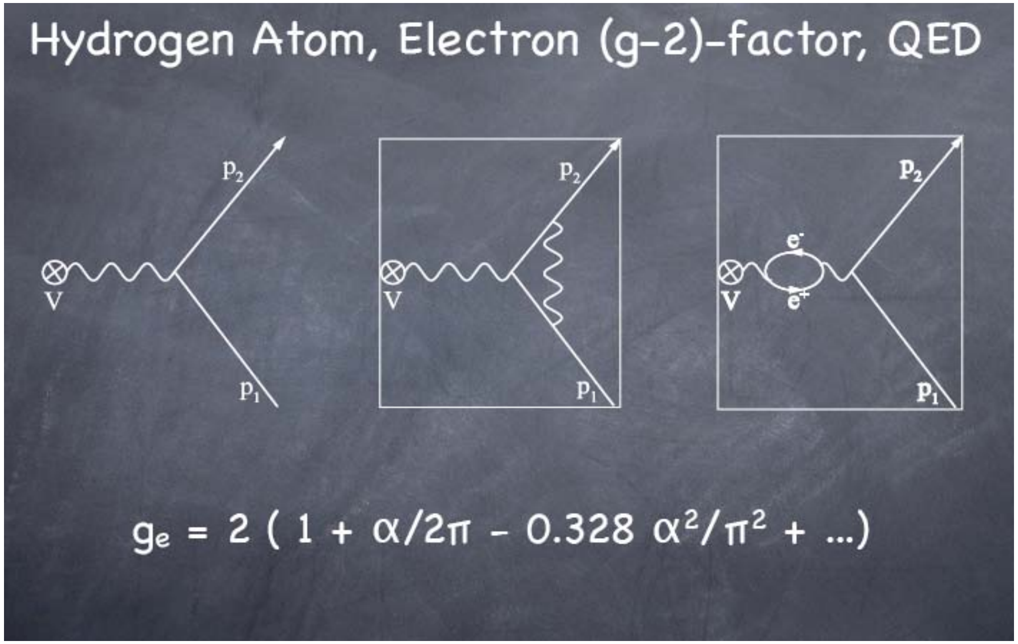
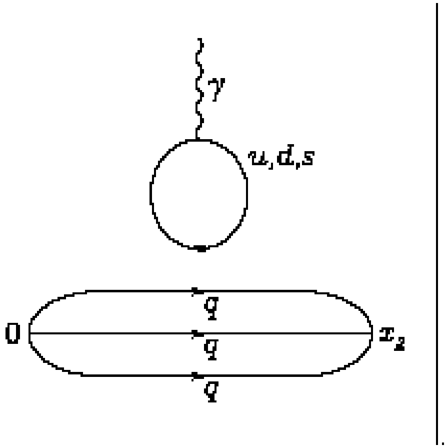


Figure 2.1: Mass from nothing. In QCD a quark's effective mass depends on its momentum. The function describing this can be calculated and is depicted here. Numerical simulations of lattice QCD (data, at two different bare masses) have confirmed model predictions (solid curves) that the vast bulk of the constituent-mass of a light quark comes from a cloud of gluons, that are dragged along by the quark as it propagates. In this way, a quark that appears to be absolutely massless at high energies (m = 0, red curve) acquires a large constituent mass at low energies.

Fundamental Test of Non-Perturbative QCD

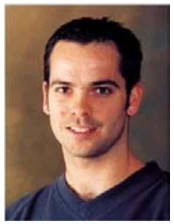
- **Strangeness contribution is a vacuum polarization effect, *analogous to Lamb shift in QED***

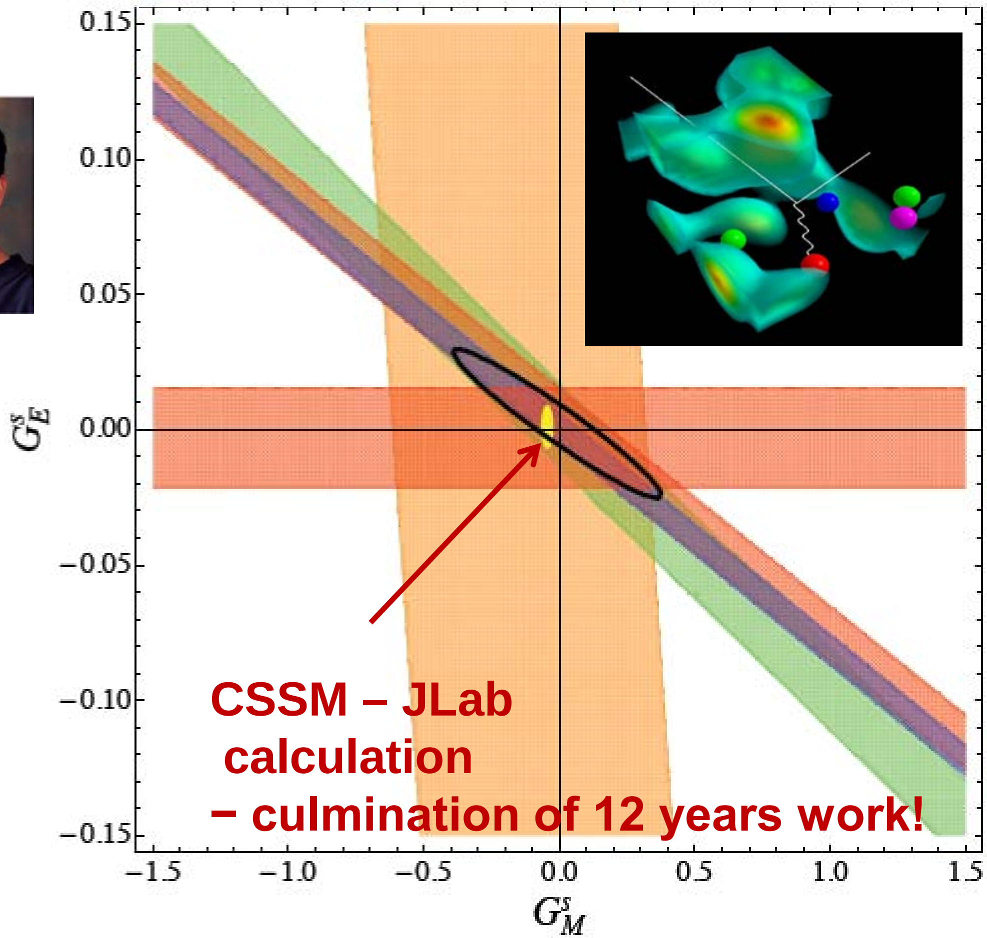




- **It is a fundamental test of QCD at long distances where the force is really *strong***

A unique case : theory 10 times more accurate than data





Experimental program took three major laboratories 20 years!

Thomas Jefferson National Accelerator Facility (JLab)

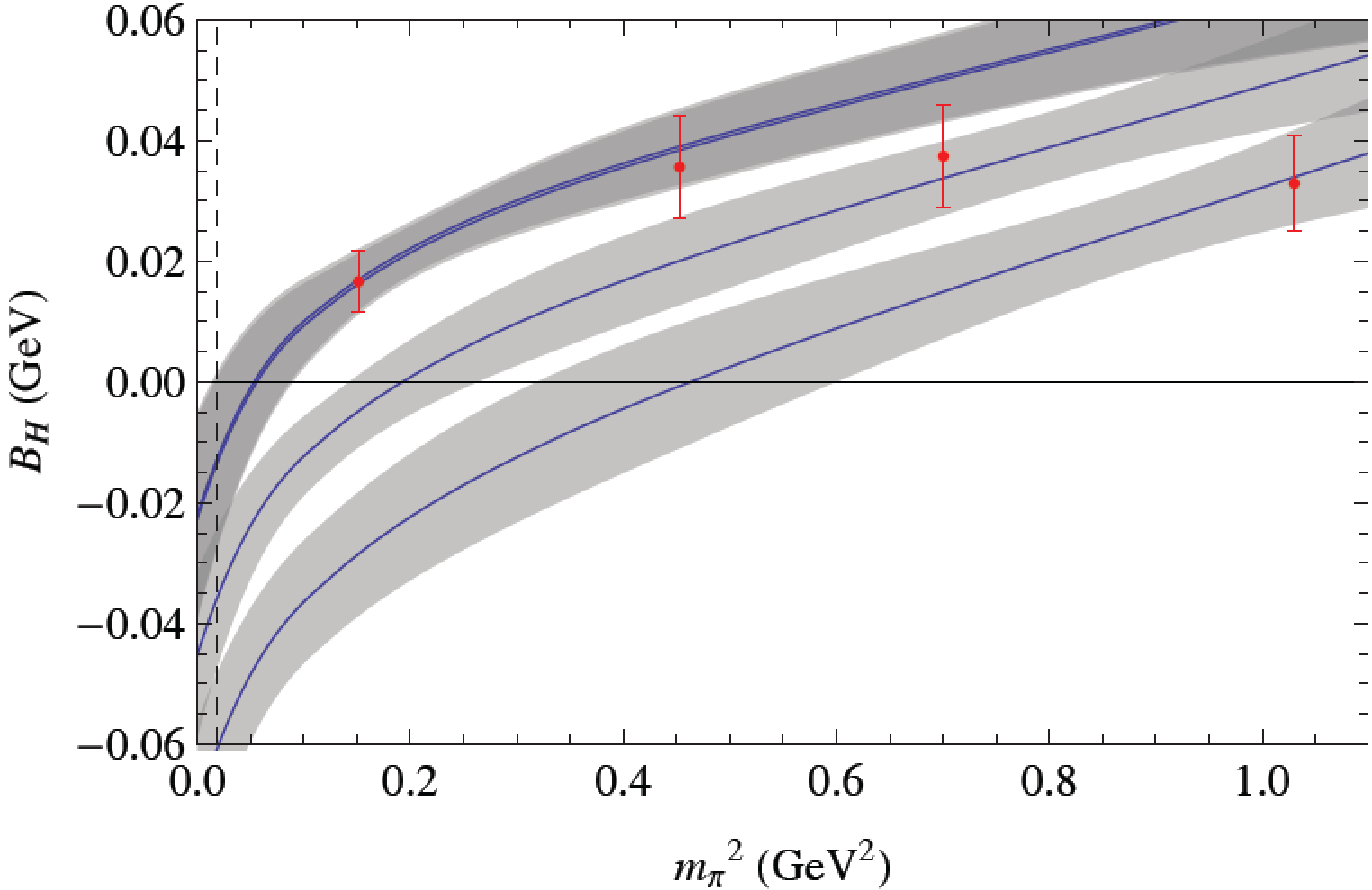
ADELAIDE UNIVERSITY AUSTRALIA

CoEPP ARC Centre of Excellence for Particle Physics at the Terascale

SPECIAL RESEARCH CENTRE FOR THE SUBATOMIC STRUCTURE OF MATTER

Last Strangeness Twist

Using data from NPLQCD & HAL:
find H-dibaryon almost bound – search at J-PARC



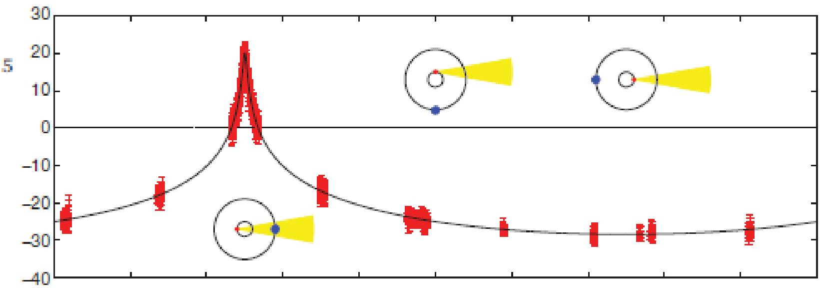
Shanahan, Thomas, Young (June 2011)

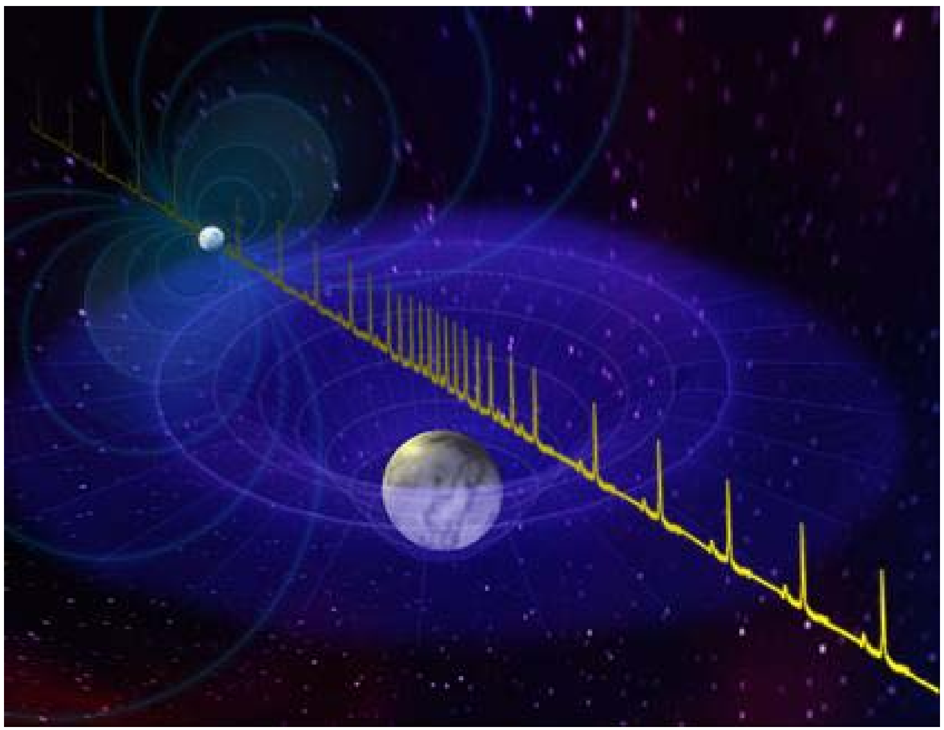
LETTER

doi:10.1038/nature09466

A two-solar-mass neutron star measured using Shapiro delay

P. B. Demorest[1], T. Pennucci[2], S. M. Ransom[1], M. S. E. Roberts[3] & J. W. T. Hessels[4,5]





Report a very accurate pulsar mass much larger than seen before : 1.97 ± 0.04 solar mass

Claim it rules out hyperons (particles with strange quarks)

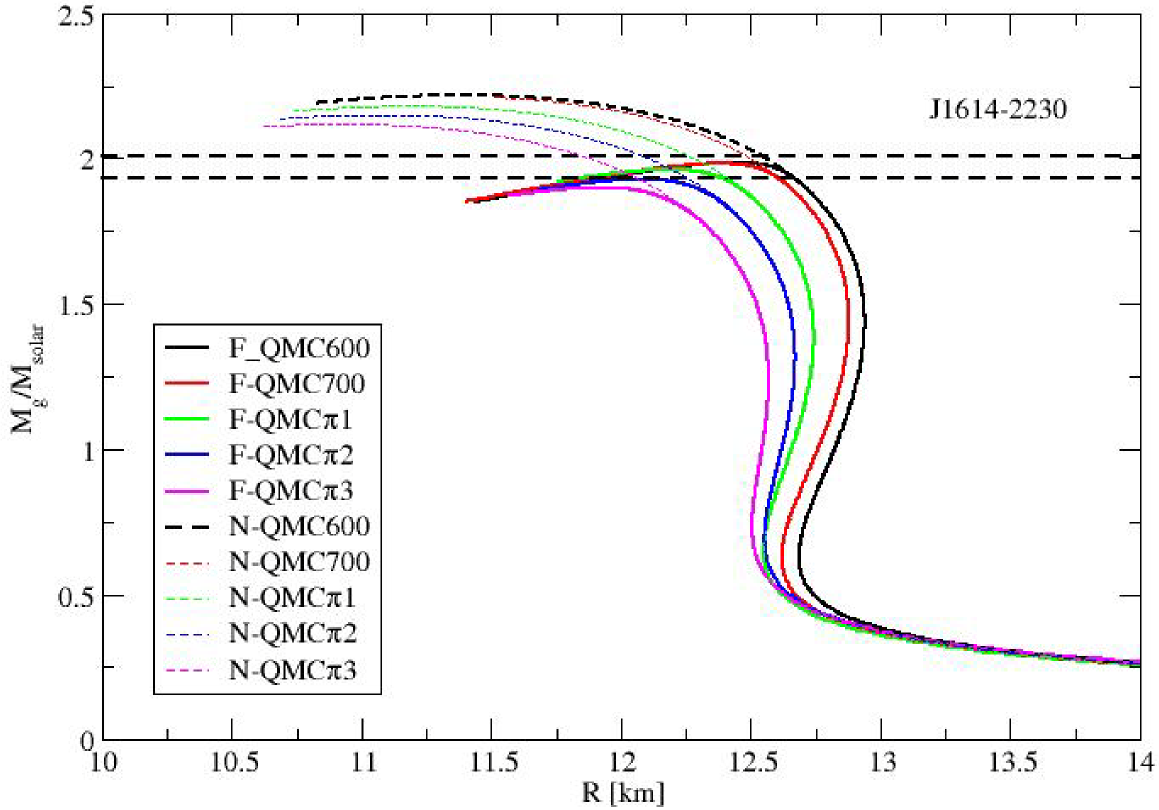
CoEPP
ARC Centre of Excellence for Particle Physics at the Terascale

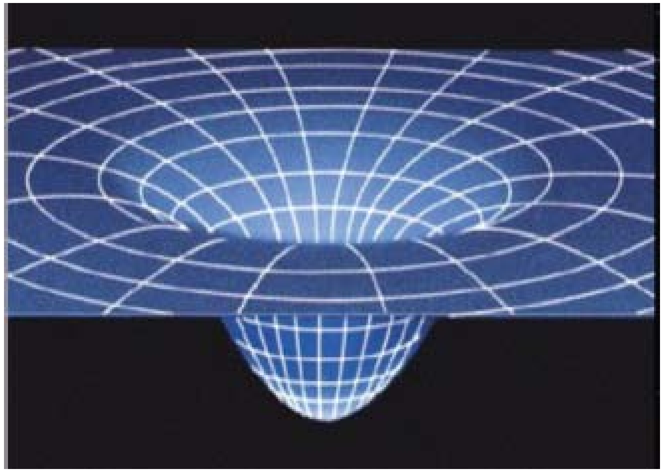
ADELAIDE UNIVERSITY AUSTRALIA

J1614-2230

SPECIAL RESEARCH CENTRE FOR THE SUBATOMIC STRUCTURE OF MATTER

Just 3 years before*....





We conclude that the Demorest et al. result, if confirmed, is very significant for neutron star physics and does indeed rule out all EoS which predict a mass-radius curve that does not intersect the J1614-2230 mass line. However, it does not provide any constraint on the possible `exotic' composition of the high-density neutron star matter.

•Guichon et al., Nucl. Phys. A814 (2008) 66
- result of an on-going collaboration between
CSSM & CEA France with Jirina Stone (Oxford)

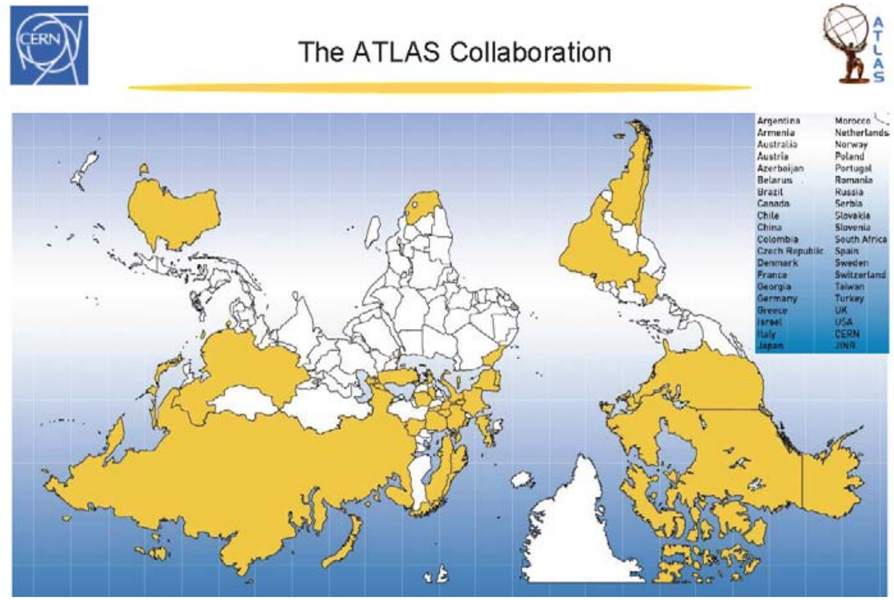
CoEPP ARC Centre of Excellence for Particle Physics at the Terascale

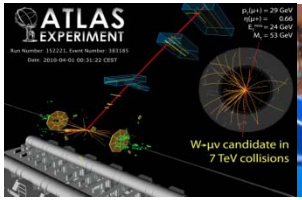
ADELAIDE UNIVERSITY AUSTRALIA

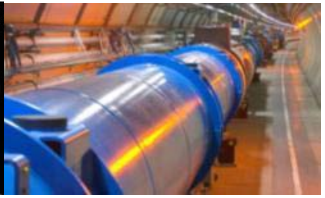
SPECIAL RESEARCH CENTRE FOR THE SUBATOMIC STRUCTURE OF MATTER

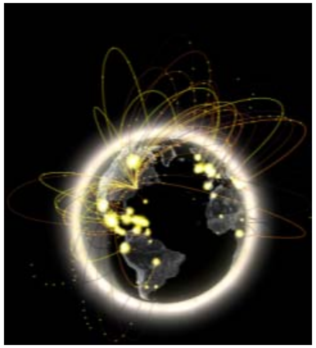
ARC Centre of Excellence for Particle Physics at the Tera-Scale

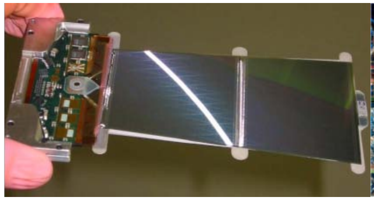
The University of Adelaide
The University of Melbourne
The University of Sydney
Monash University

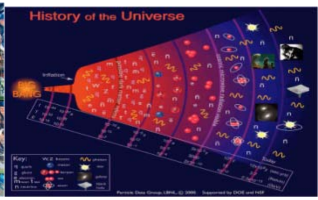








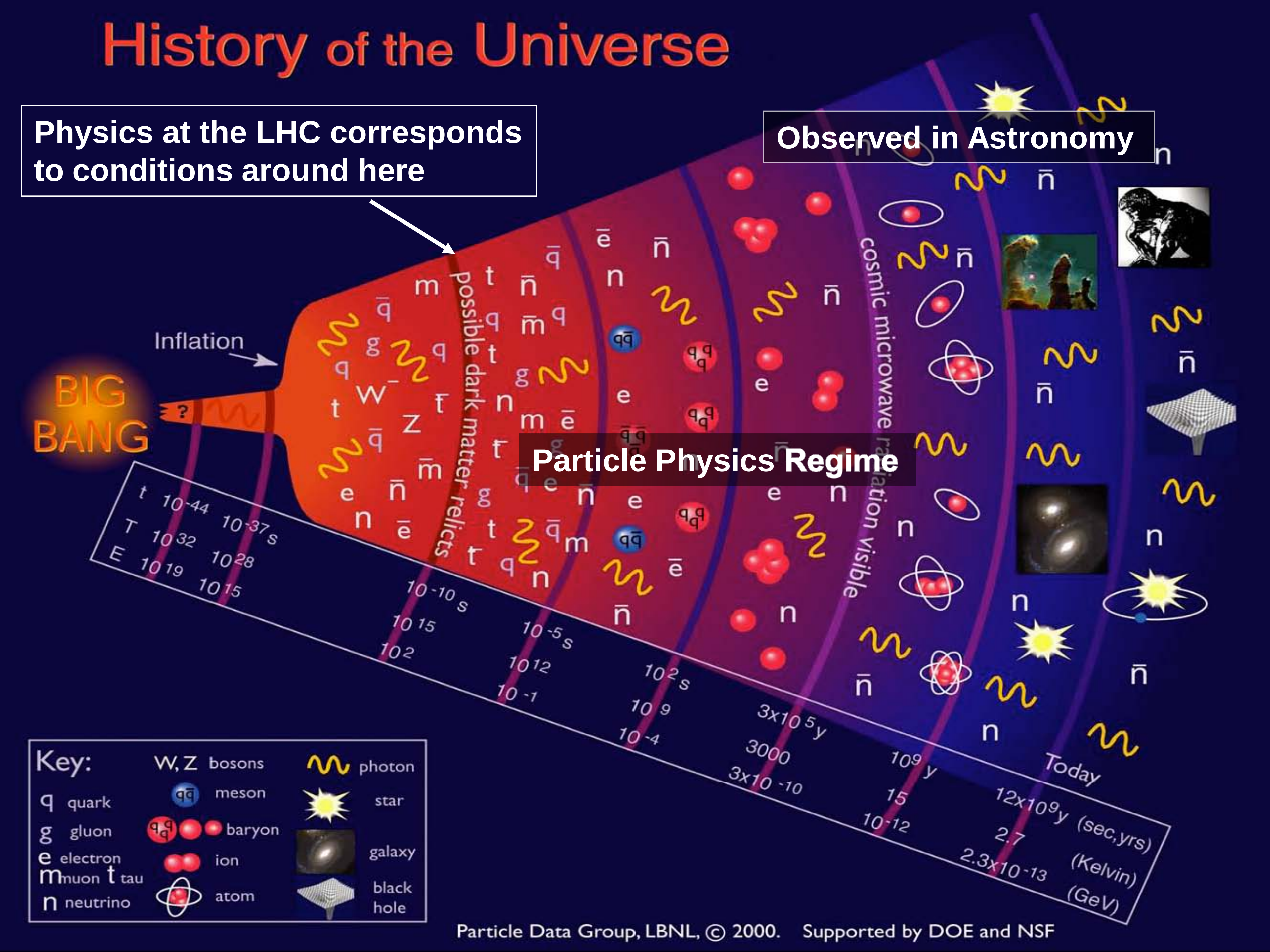




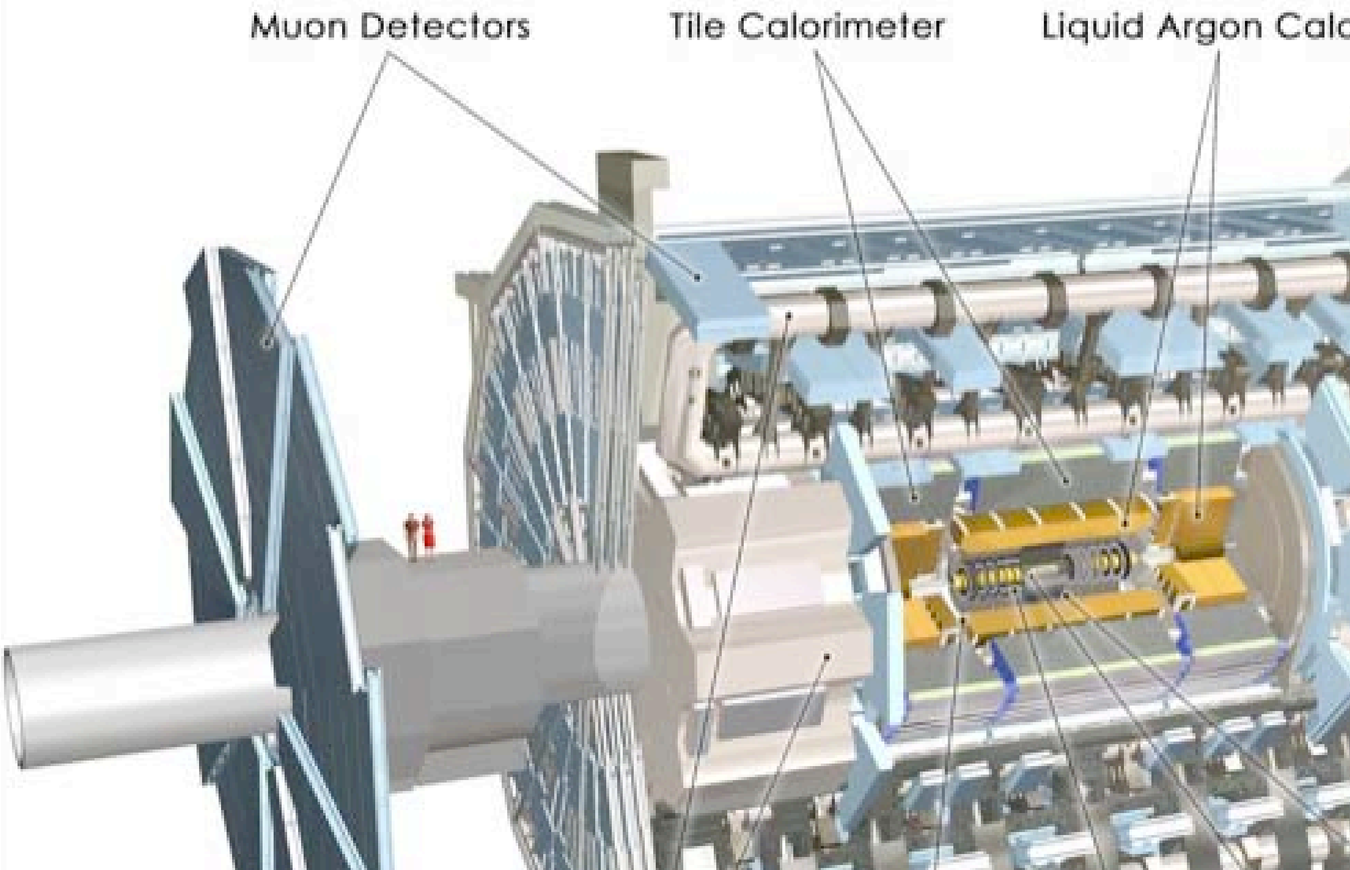
CoEPP
ARC Centre of Excellence for Particle Physics at the Terascale

ADELAIDE UNIVERSITY AUSTRALIA

SPECIAL RESEARCH CENTRE FOR THE SUBATOMIC STRUCTURE OF MATTER



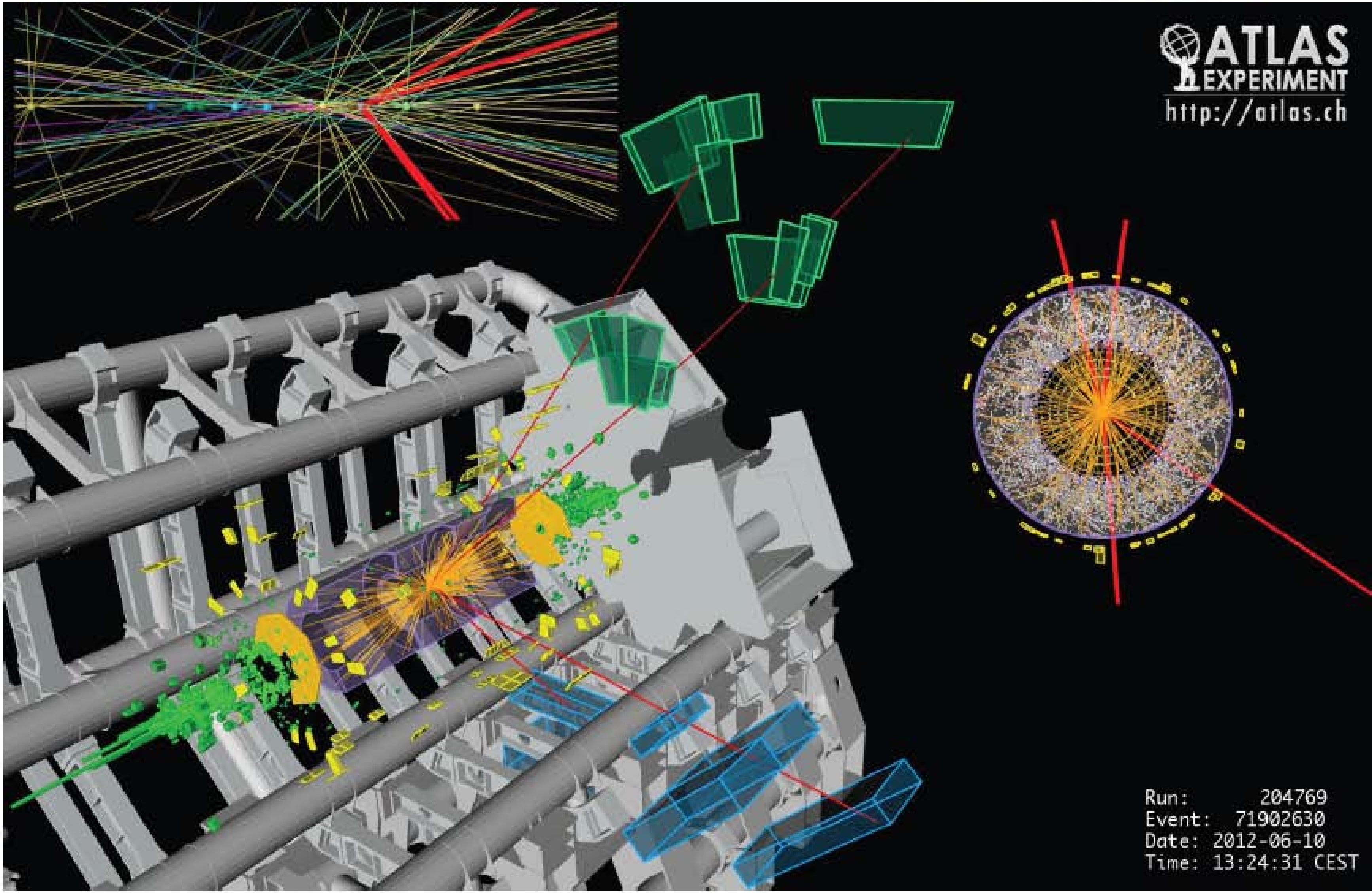
History of the Universe
Physics at the LHC corresponds to conditions around here
Observed in Astronomy
Particle Physics Regime
Inflation
BIG BANG
possible dark matter relicts
cosmic microwave radiation visible
t 10-44 10-37 s
T 10 32 10 28
E 10 19 10 15
10 -10 s
10 15
10 2
10 -5 s
10 12
10 -1
10 2 s
10 9
10 -4
3x10 5 y
3000
3x10 -10
10 9 y
15
10 -12
Today
12x10 9 y (sec,yrs)
2.7 (Kelvin)
2.3x10 -13 (GeV)
Key:
q quark
g gluon
e electron
m muon t tau
n neutrino
W, Z bosons
meson
baryon
ion
atom
photon
star
galaxy
black hole
Particle Data Group, LBNL, © 2000. Supported by DOE and NSF



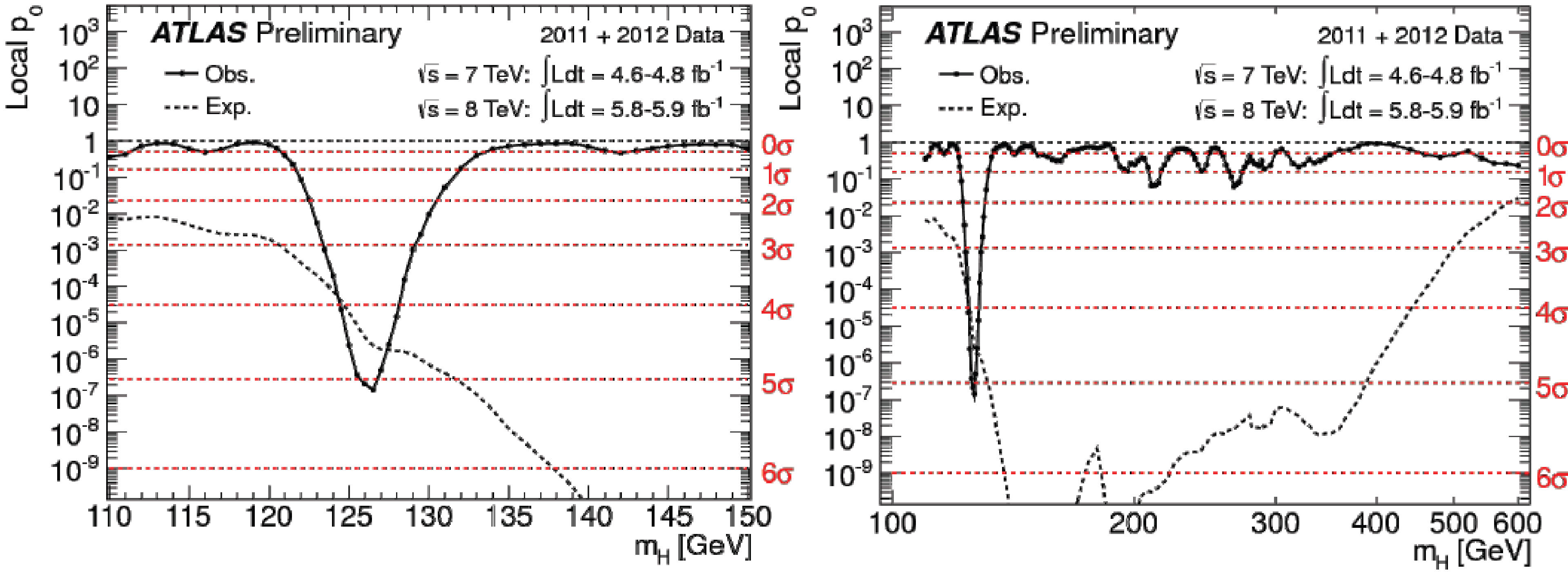
ARC CoE for Particle Physics at the Tera-Scale

SPECIAL RESEARCH CENTRE FOR THE SUBATOMIC STRUCTURE OF MATTER

Event Display: 4μ



Combined search: Compatibility with background



- Smallest p_0 value corresponds to local significance of 5.1σ at m_H=126.5 GeV
  - Expected value if SM Higgs of mass 126.5 GeV exists is 4.6σ
- Significance mildly sensitive to energy scale and resolution systematics (ESS)
  - Important for photons and electrons, negligible for muons
  - ESS estimated to reduce local significance to 5.0σ

Summary

This is a wonderfully challenging and exciting time

The likely discovery of the Higgs boson constitutes the most exciting development in particle physics in almost 30 years

We know enough to realize just how much there must still be to learn

Through the CoEPP and CSSM Adelaide is ideally placed to play a major role in the coming decade and beyond

Event display: 2e2μ