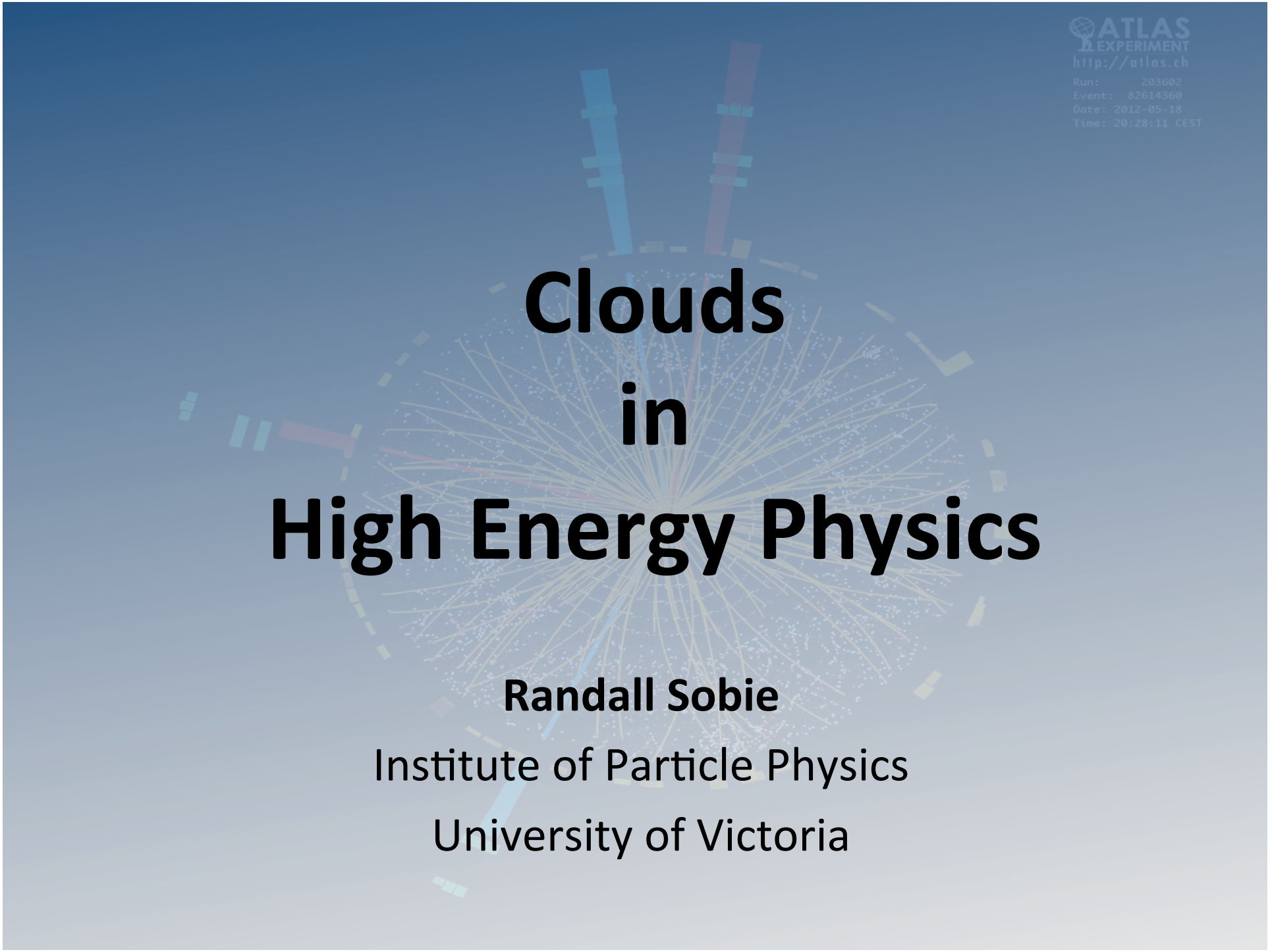


Clouds in High Energy Physics

Randall Sobie

Institute of Particle Physics

University of Victoria

High Energy Physics

(Particle Physics)

The area of physics that studies the fundamental particles of nature and their interactions.

Accelerators

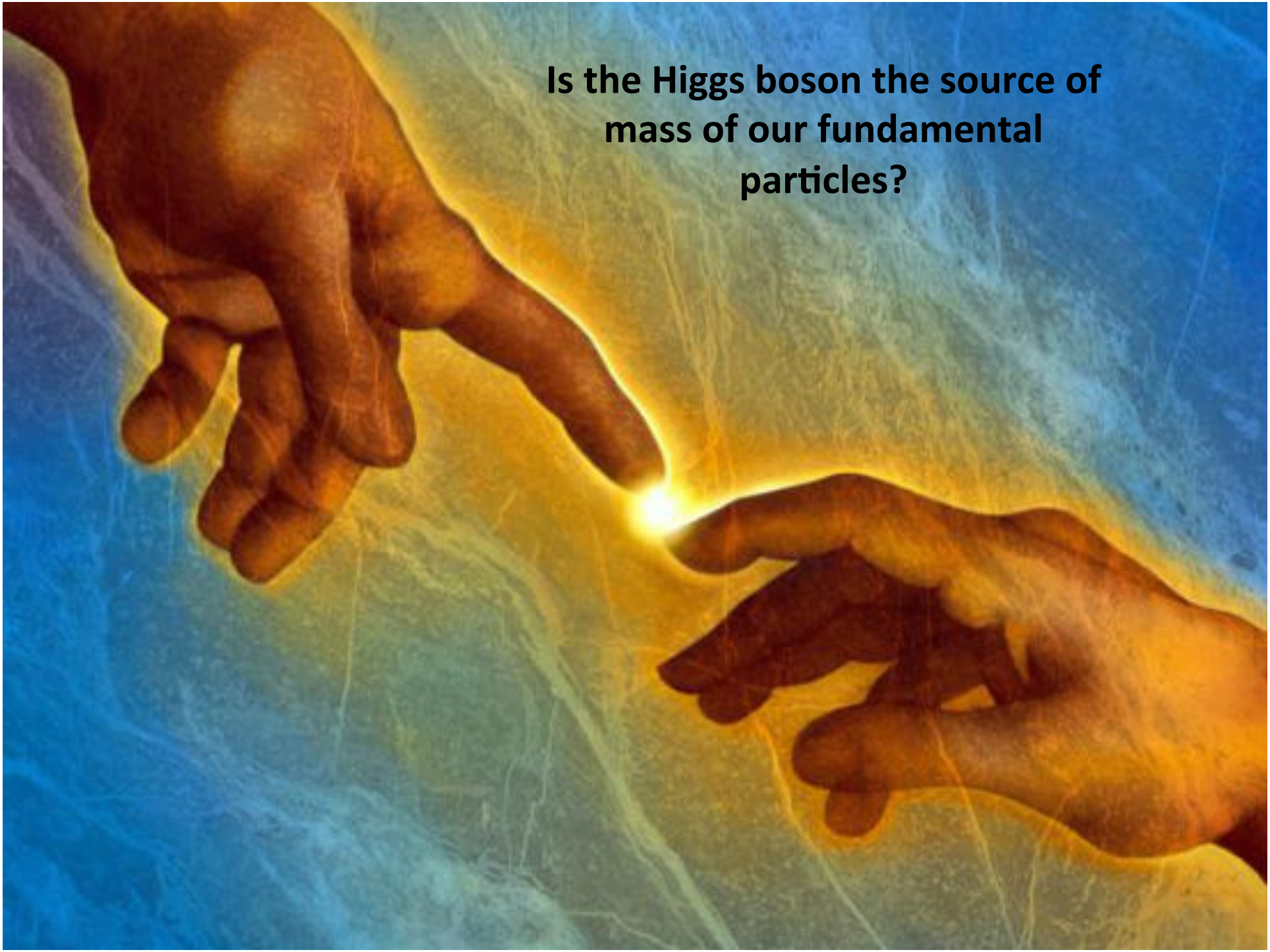
SLAC Linear Accelerator

Underground labs

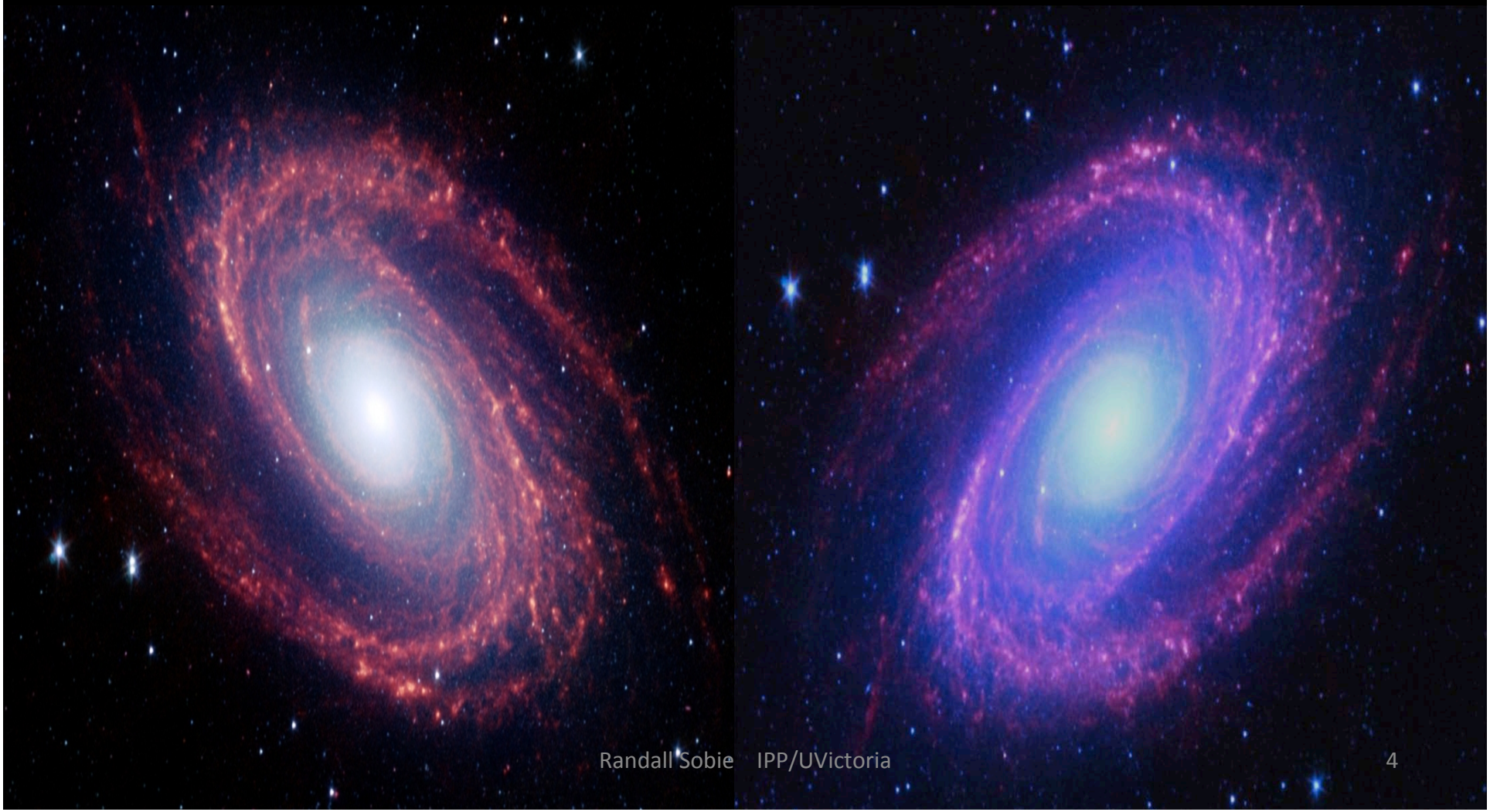
Sudbury Solar Neutrino Detector

Orbiting labs

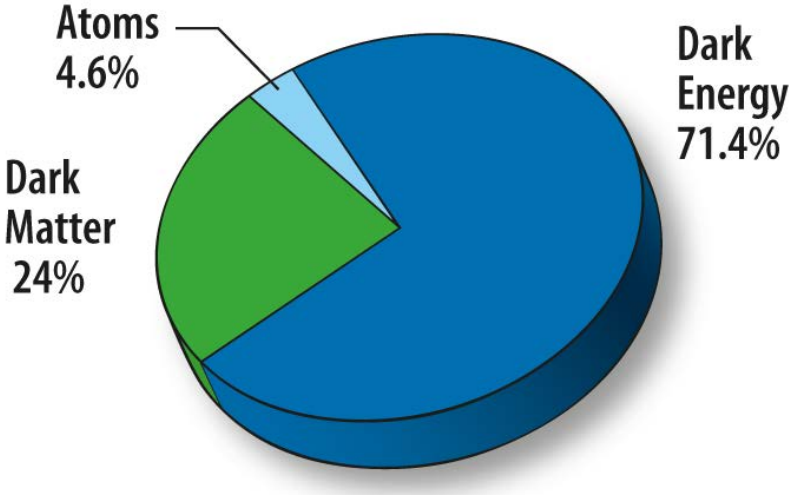
Alpha Magnetic Spectrometer
Space Station


Is the Higgs boson the source of mass of our fundamental particles?

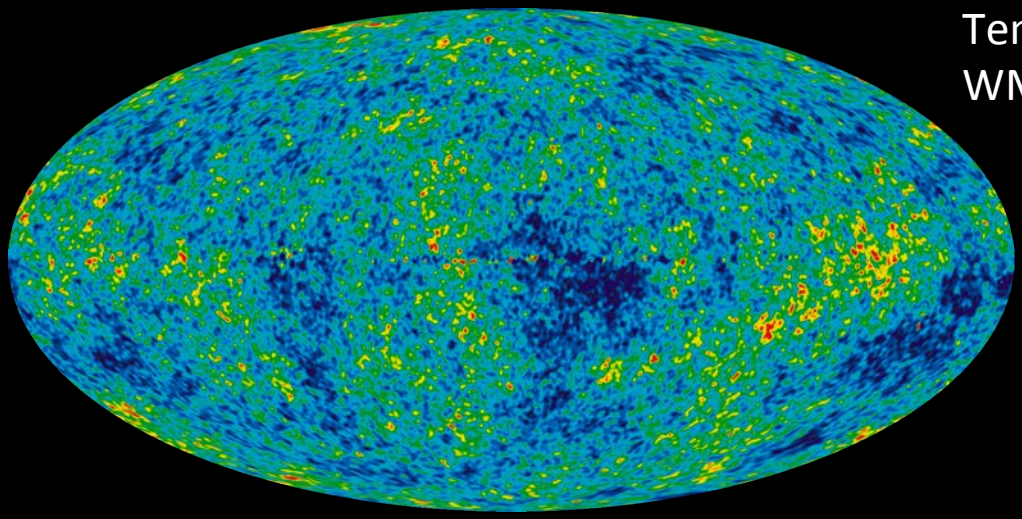
Why is the universe made of matter and not equal amounts of matter/antimatter?



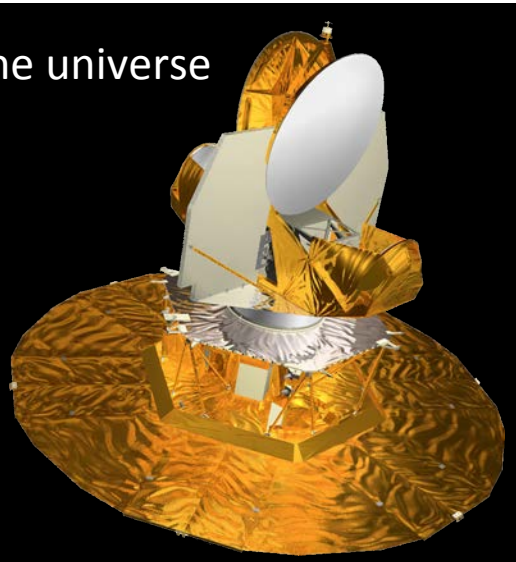
What is origin of Dark Matter and Dark Energy?



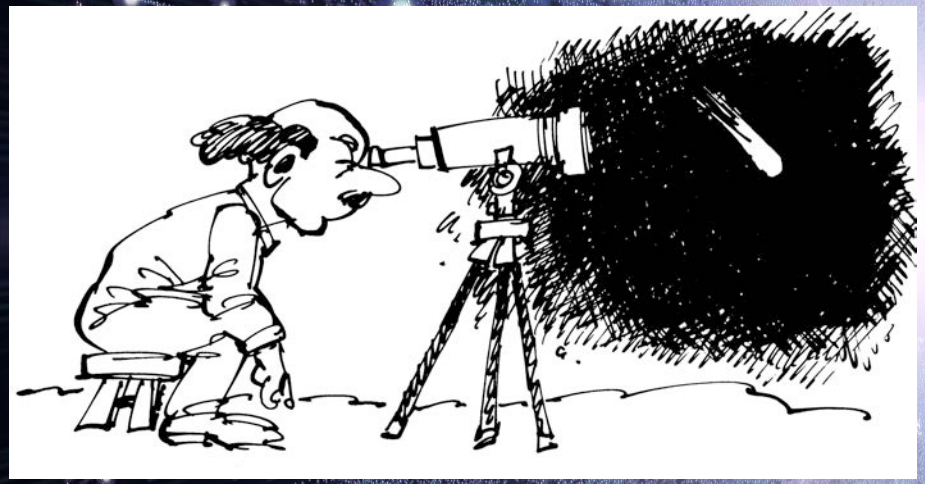
We do not know the composition of 95% of the universe



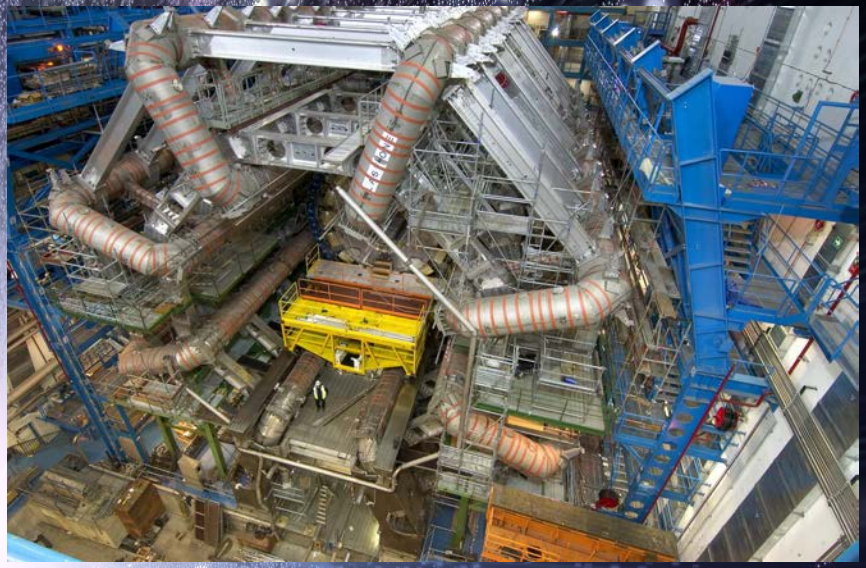
Temperature of the universe
WMAP satellite



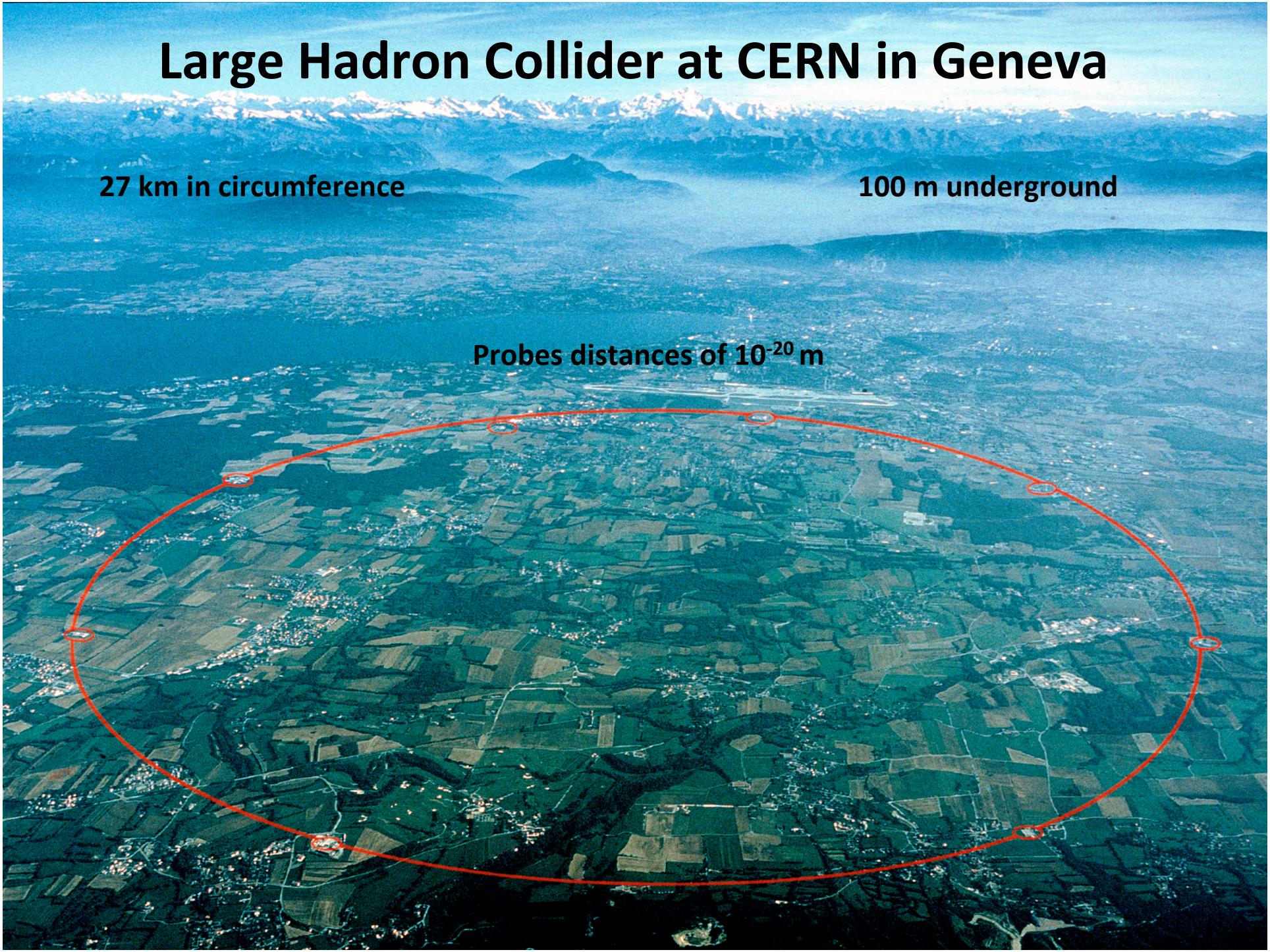
Understanding our World



Understanding our World



Large Hadron Collider at CERN in Geneva

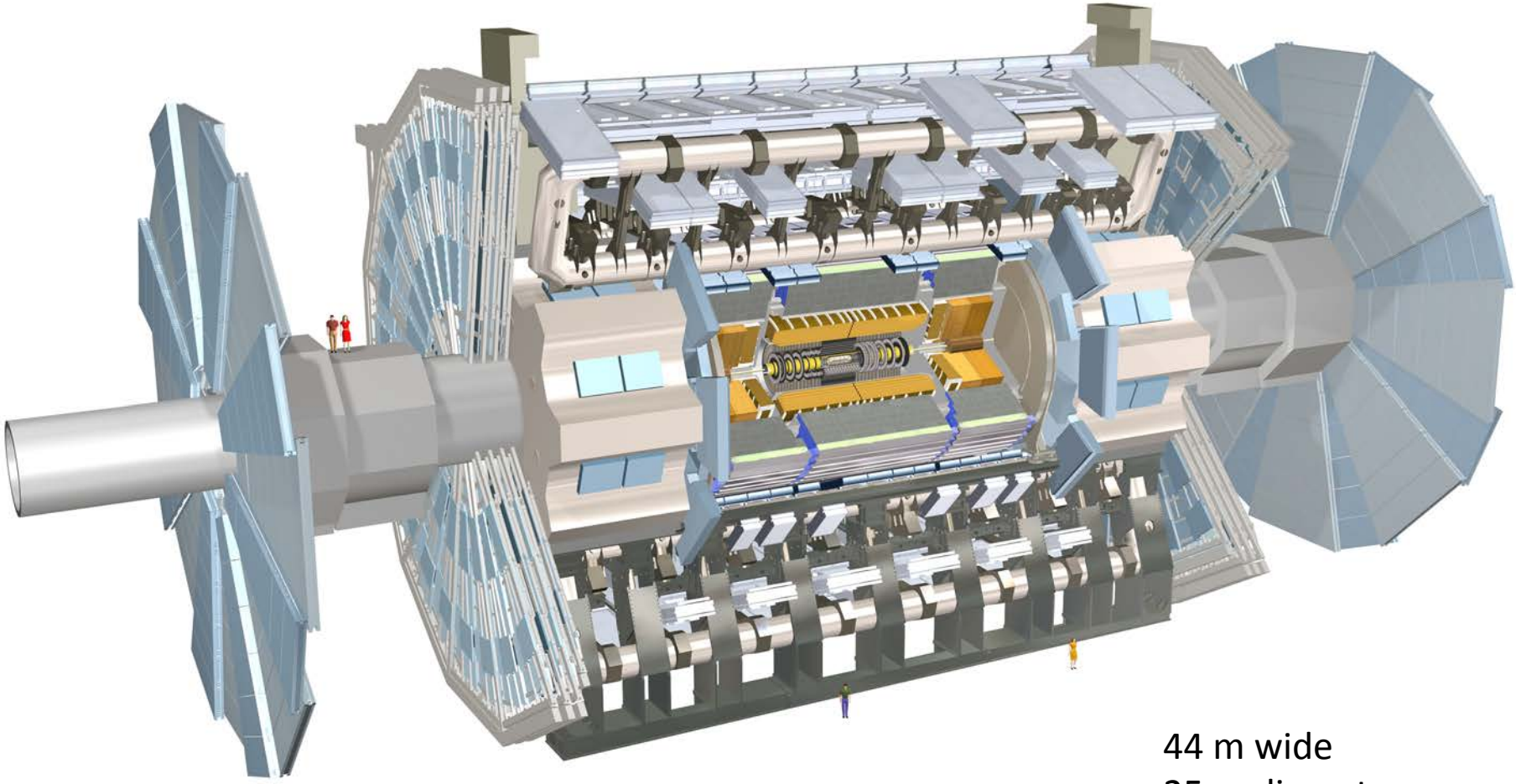


Large Hadron Collider at CERN in Geneva

27 km in circumference

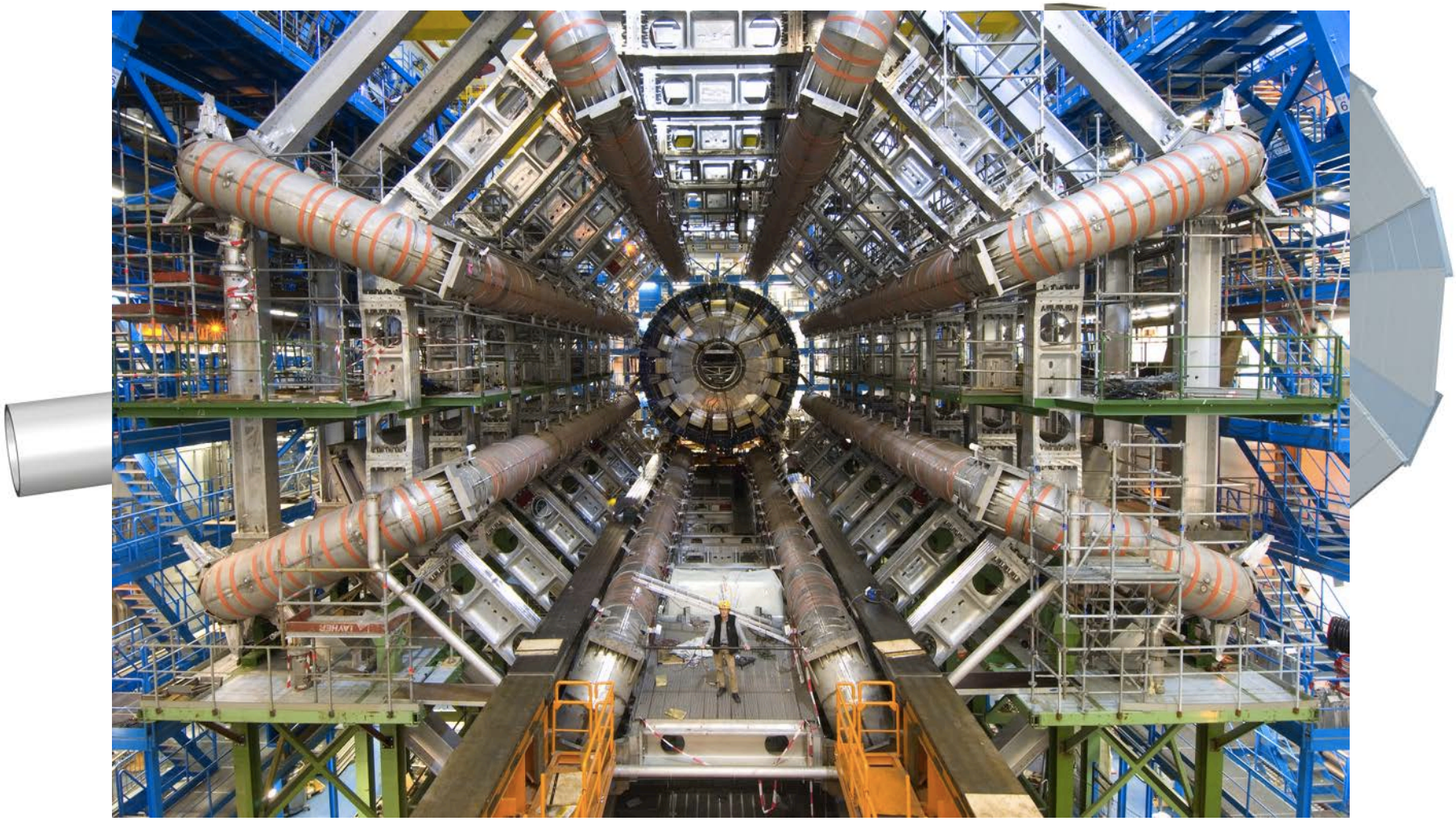
100 m underground

ATLAS Detector

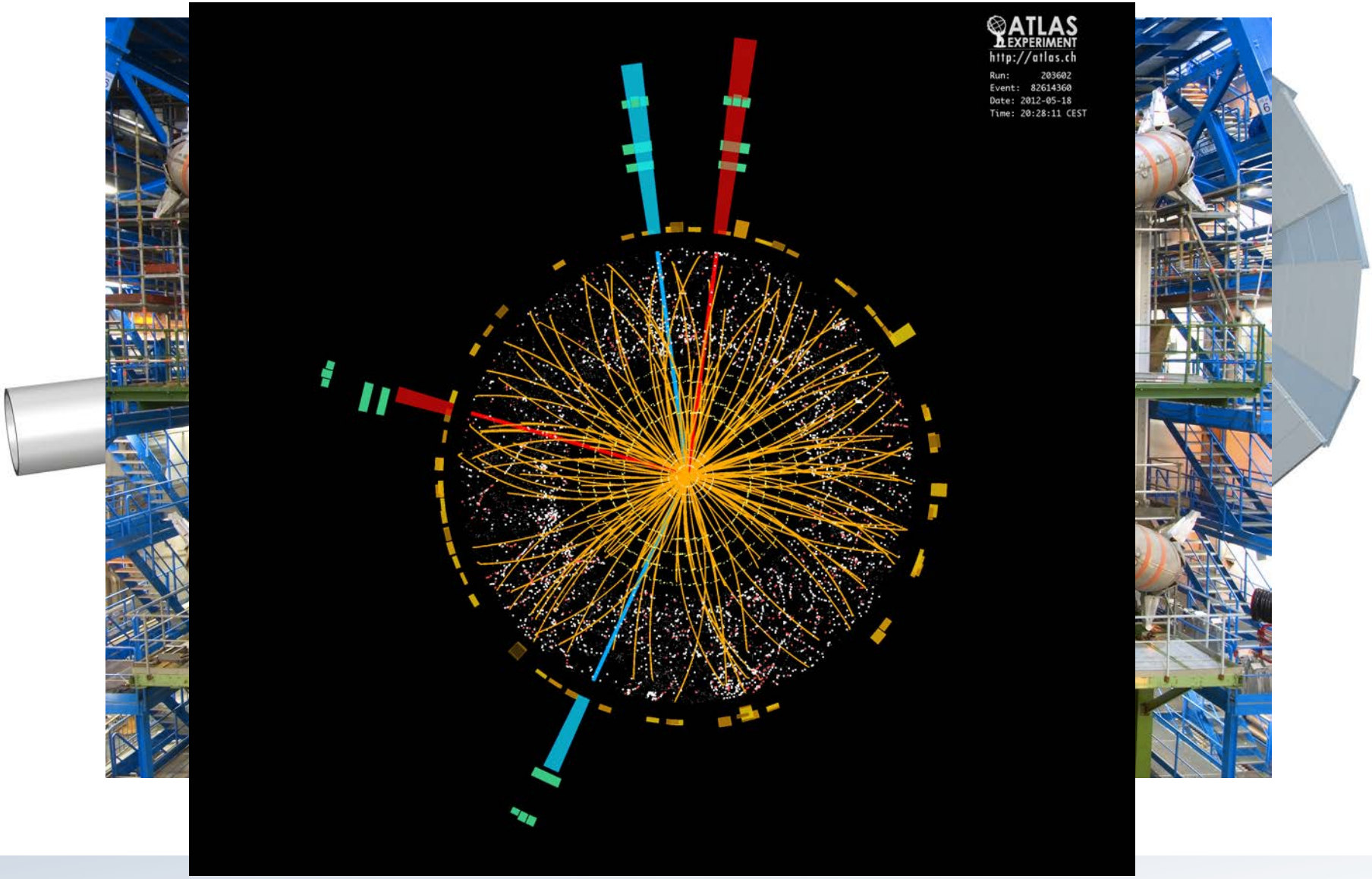


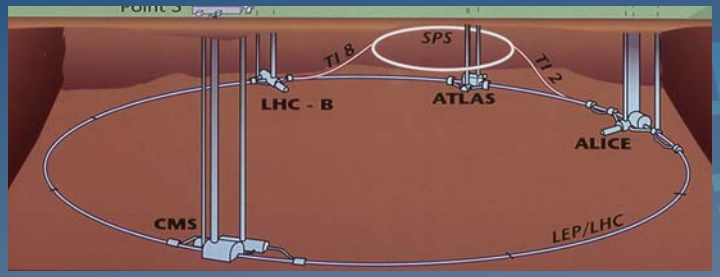
44 m wide
25 m diameter

ATLAS Detector

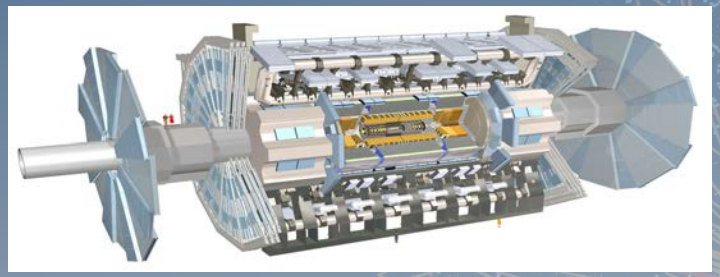


ATLAS Detector





40 million collisions per second

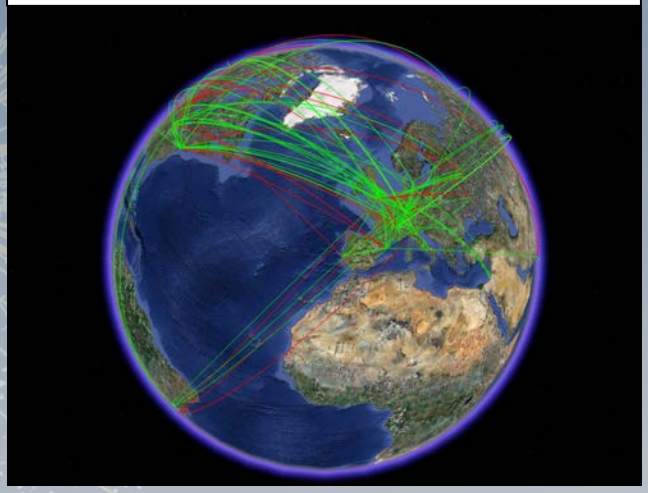


100,000 collisions selected

200 events per second

WLCG Computing Grid
CERN Tier 0
10 Tier1 sites
60+ Tier2 sites

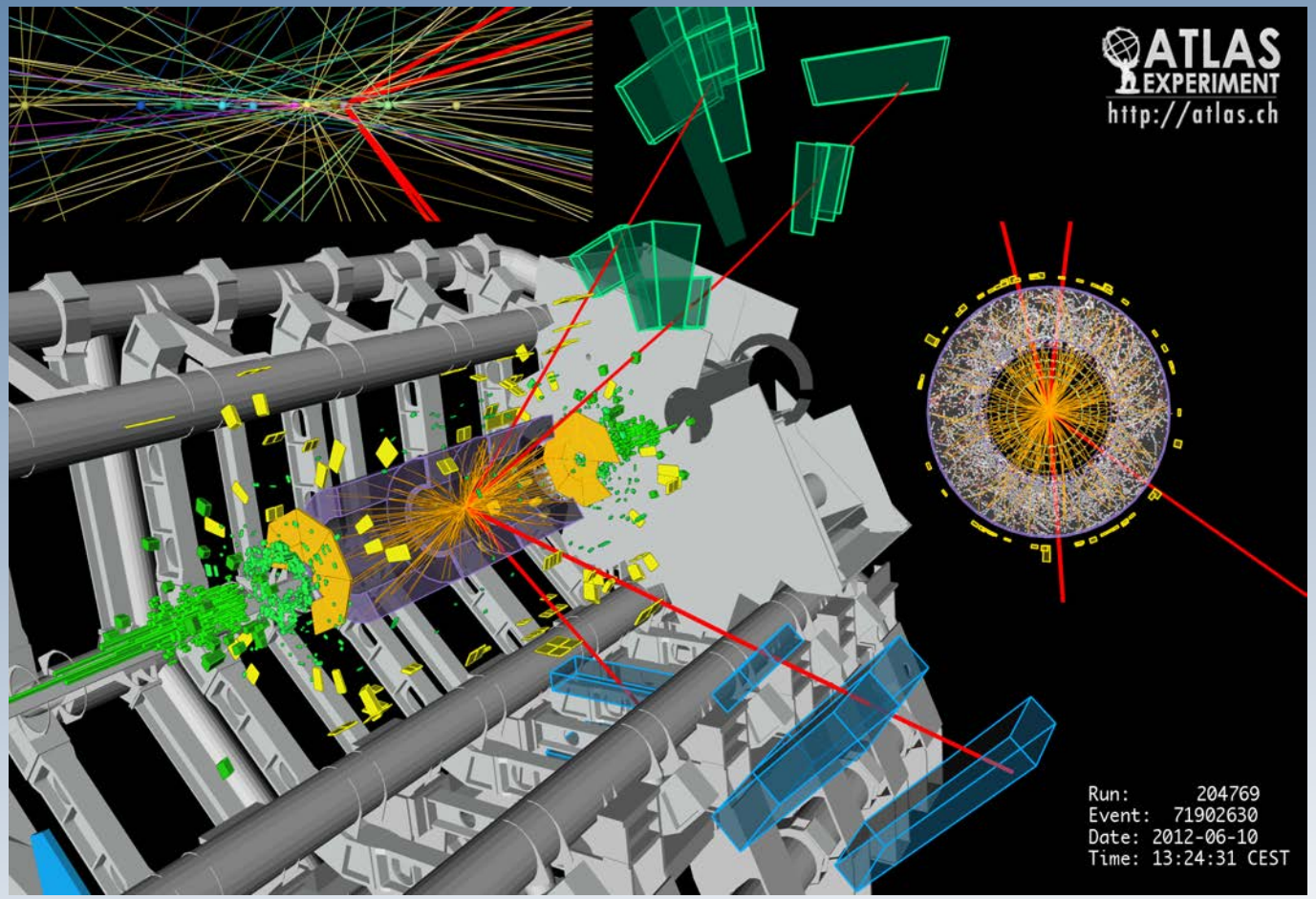
140 PB data



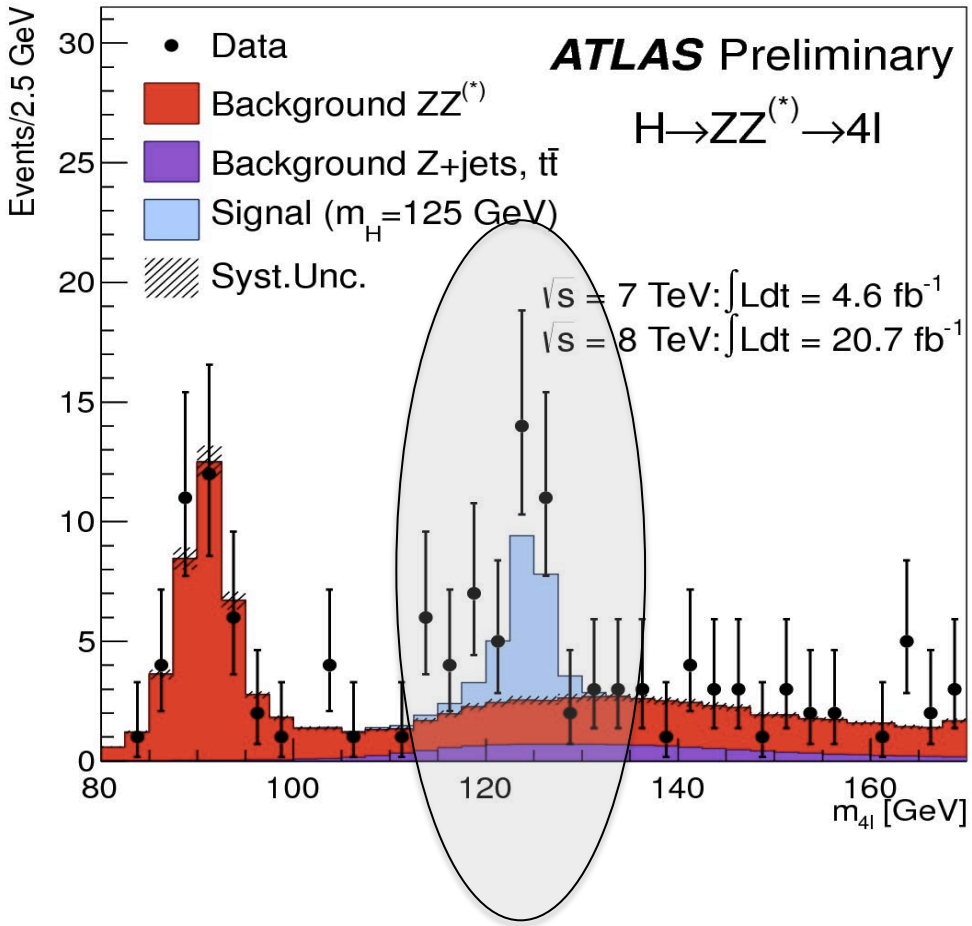
Higgs Discovery in 2012

The ATLAS and CMS experiments see evidence for a Higgs-like particle

Picture shows an event where the Higgs candidate decays to 4 electron-like particles



Search for Higgs decays to 4 "leptons" (electrons or muons)



Number of candidates (vertical axis)

Mass of the candidates (horizontal axis)

We observe an excess of candidates with a mass of 125 proton-masses

Also observed in the CMS experiment

The New York Times

Science

July 4, 2012

WORLD | U.S. | N.Y. / REGION | BUSINESS | TECHNOLOGY | SCIENCE | HEALTH | SPORTS | OPINION

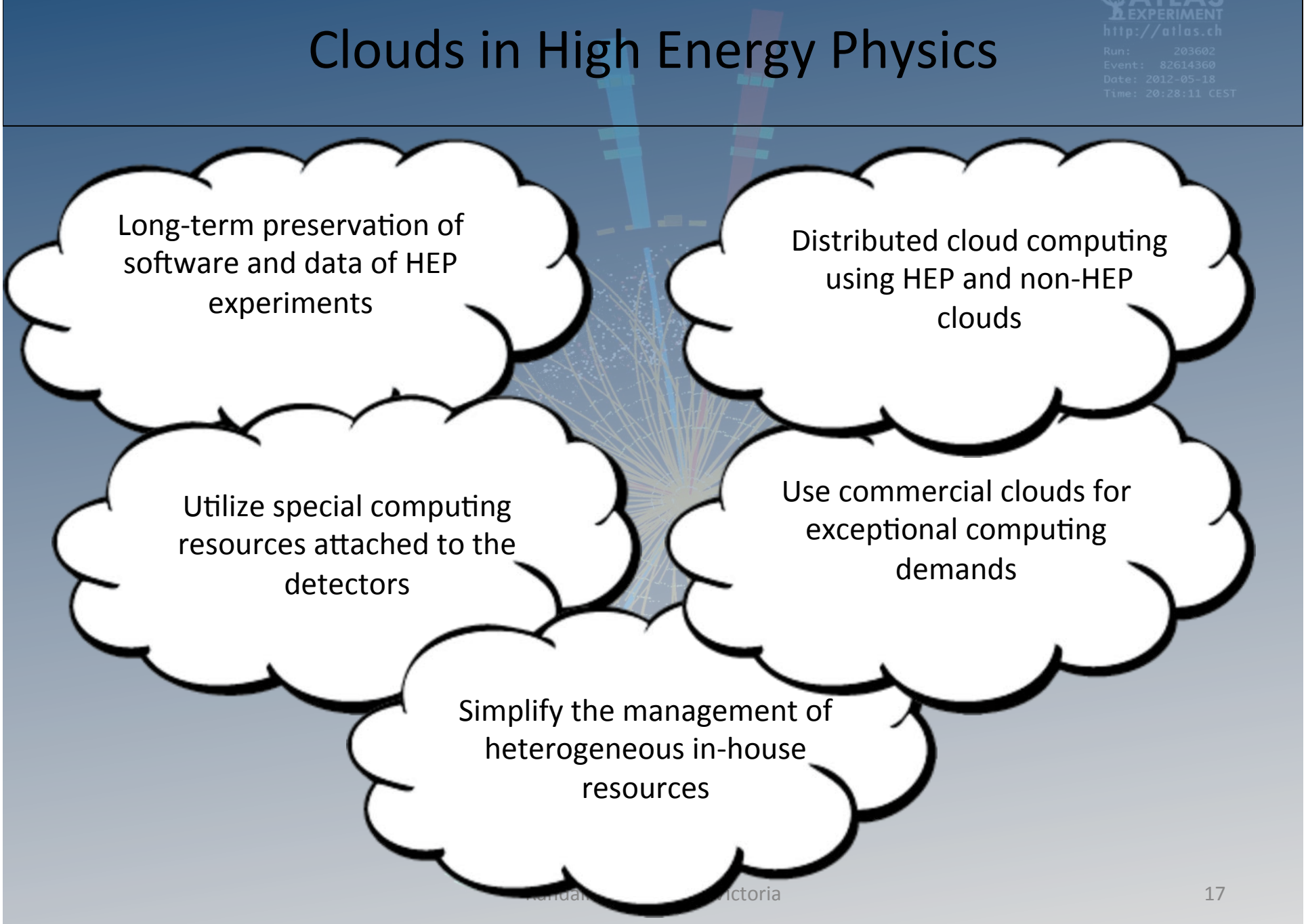
ENVIRONMENT | SPACE & COSMOS

Physicists Find Elusive Particle Seen as Key to Universe

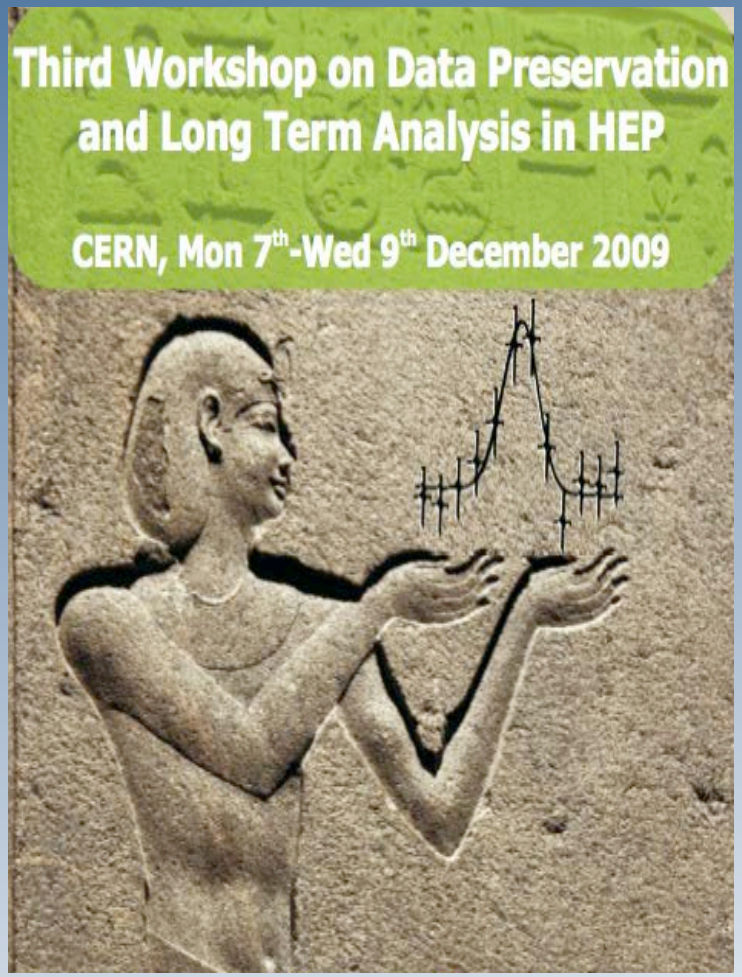
Pool photo by Denis Balibouse

Scientists in Geneva on Wednesday applauded the discovery of a subatomic particle that looks like the Higgs boson.

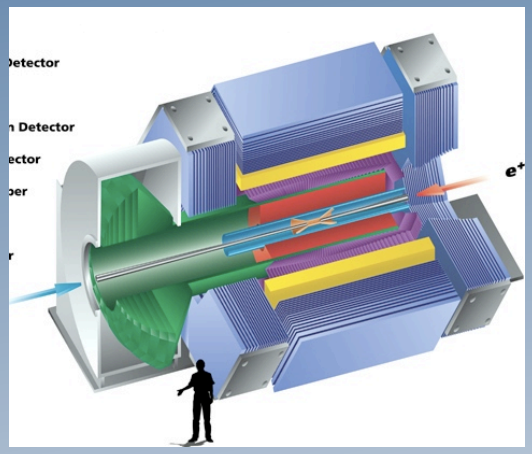
Clouds in High Energy Physics



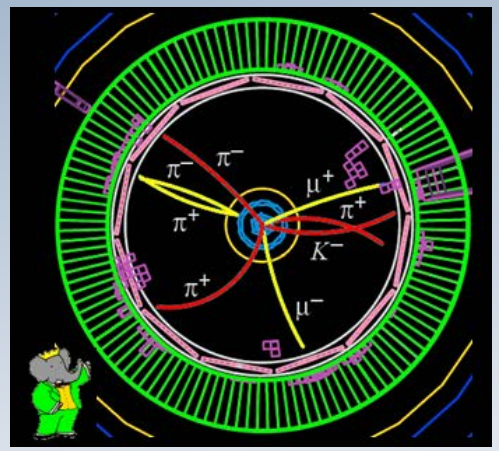
Using Clouds for Data Preservation



SLAC Linear Accelerator



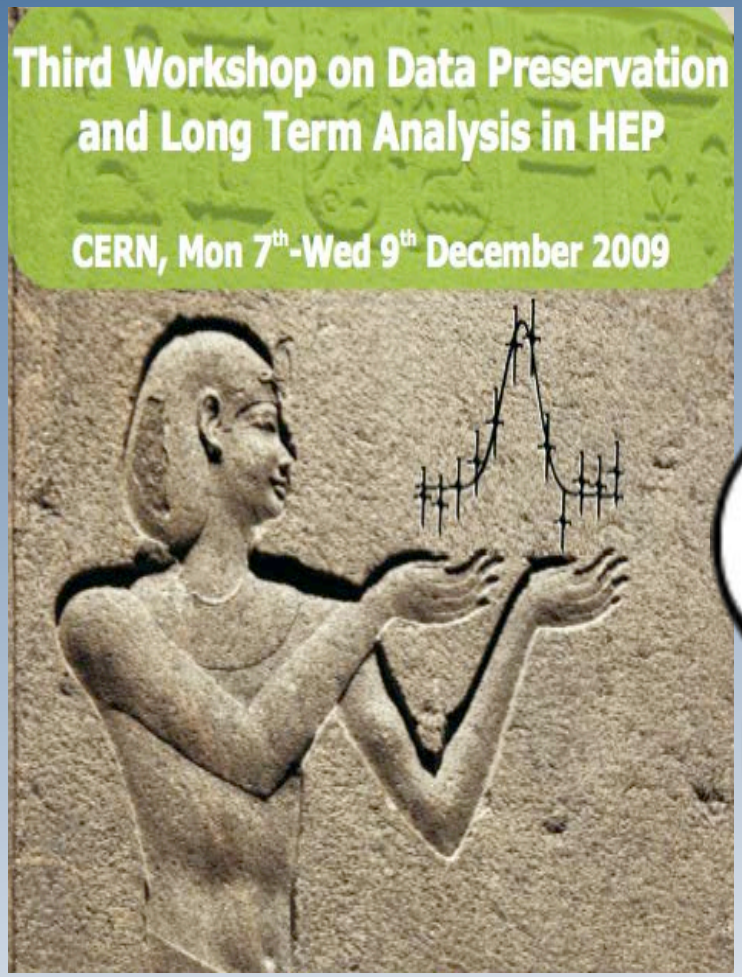
BaBar Detector

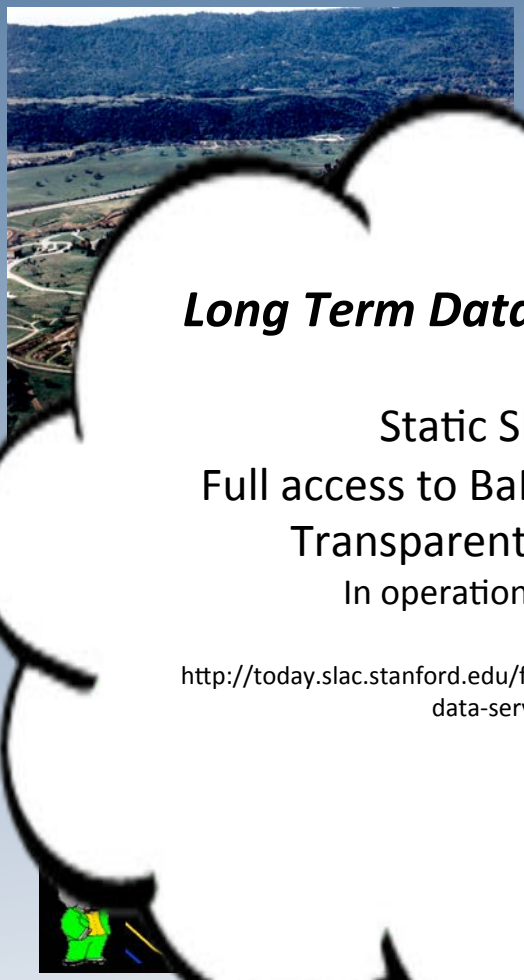


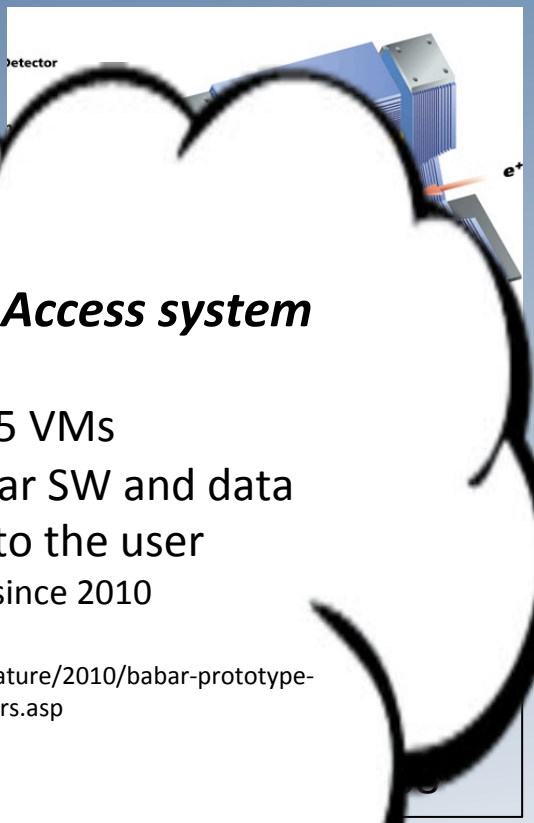
Electron-positron collision

BaBar experiment stopped recording electron-positron collisions in 2008

Using Clouds for Data Preservation







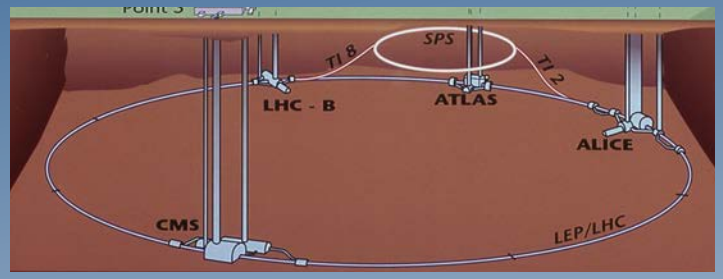
Long Term Data Access system

Static SL5 VMs
Full access to BaBar SW and data
Transparent to the user
In operation since 2010

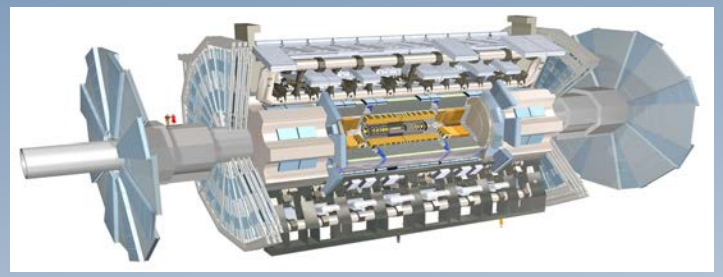
http://today.slac.stanford.edu/feature/2010/babar-prototype-data-servers.asp

Electron-p… co…

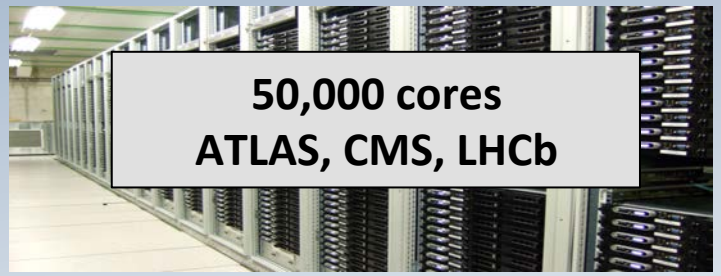
ATLAS/CMS High Level Trigger Clouds



40 million collisions per second



100,000 collisions selected



200 events per second

HLT Farms

These systems are used in real-time when there is colliding beams

The aim is to use the resources during the idle periods for other purposes

Enabled as private OpenStack clouds

See talk by Toni Perez
Wednesday 1100

Private and commercial clouds

Ibex @ CERN (J. van Eldik, T. Bell, B.Moreira)

OpenStack cloud with 5000 cores
Provide batch services and cloud services

HEP using Amazon, Google, Rackspace and others

Star Experiment at RHIC (Brookhaven NL)
Belle Experiment at KEK (Japan)
ATLAS Experiment

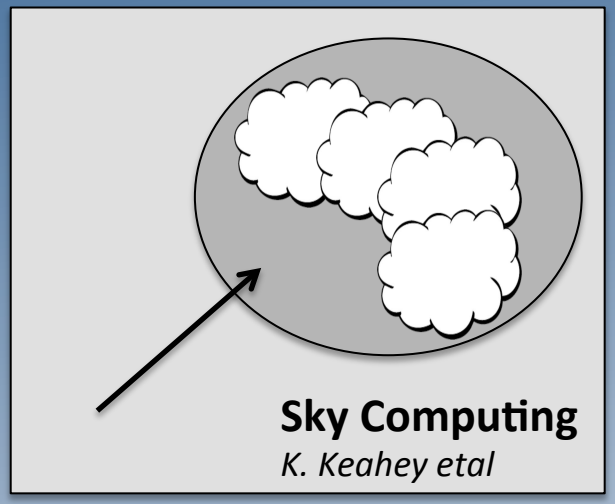
Commercial clouds used for exceptional low I/O demands

Challenges: identity management, API compatibility, VM configuration and network connectivity

Costs are higher than our private resources

Distributed cloud computing

Grid of Clouds



Sky Computing
K. Keahey etal

Seamlessly use multiple, heterogeneous IaaS clouds for batch workloads

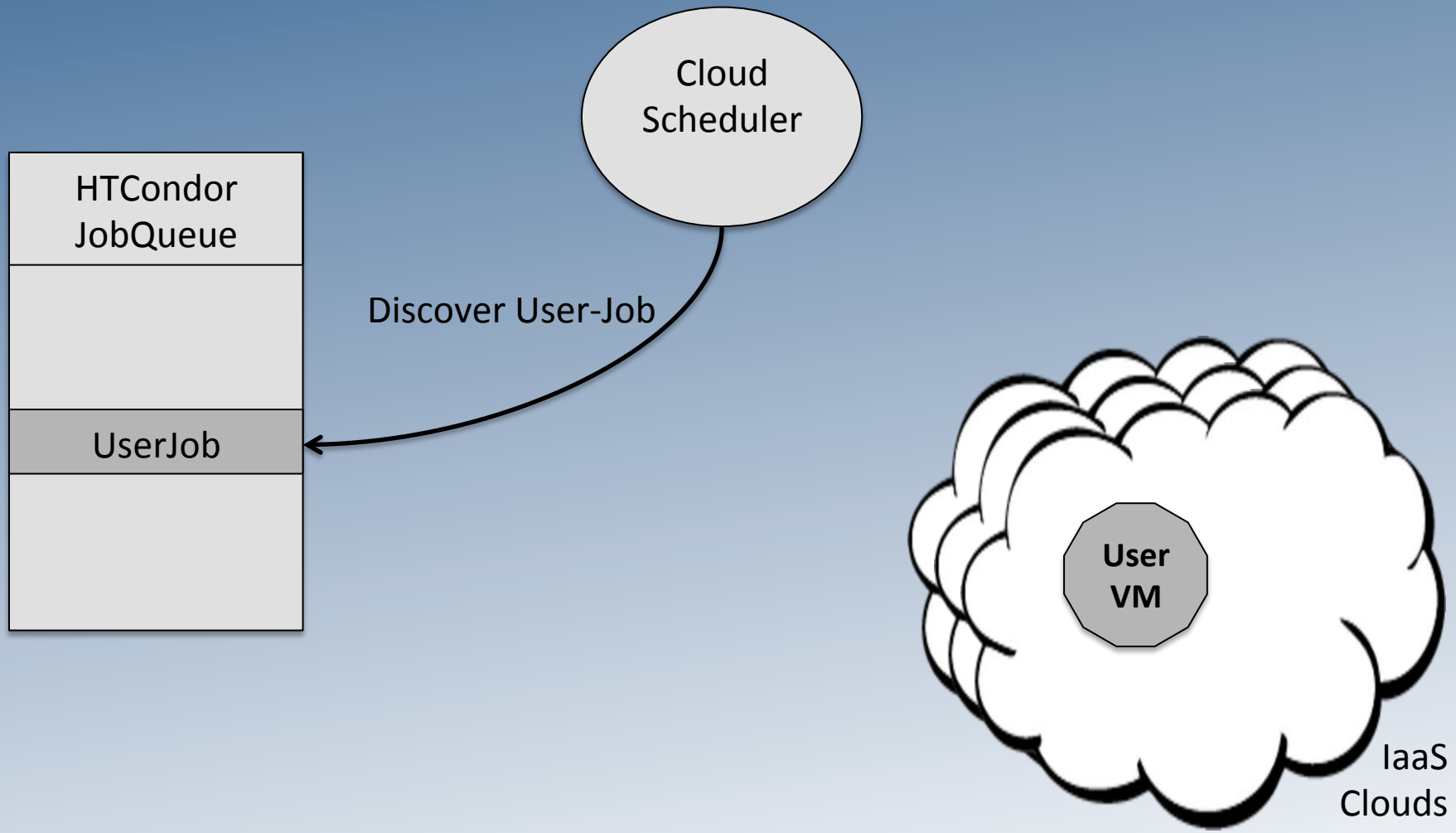
Use dedicated HEP and non-HEP opportunistic resources

Independent of the IaaS cloud type

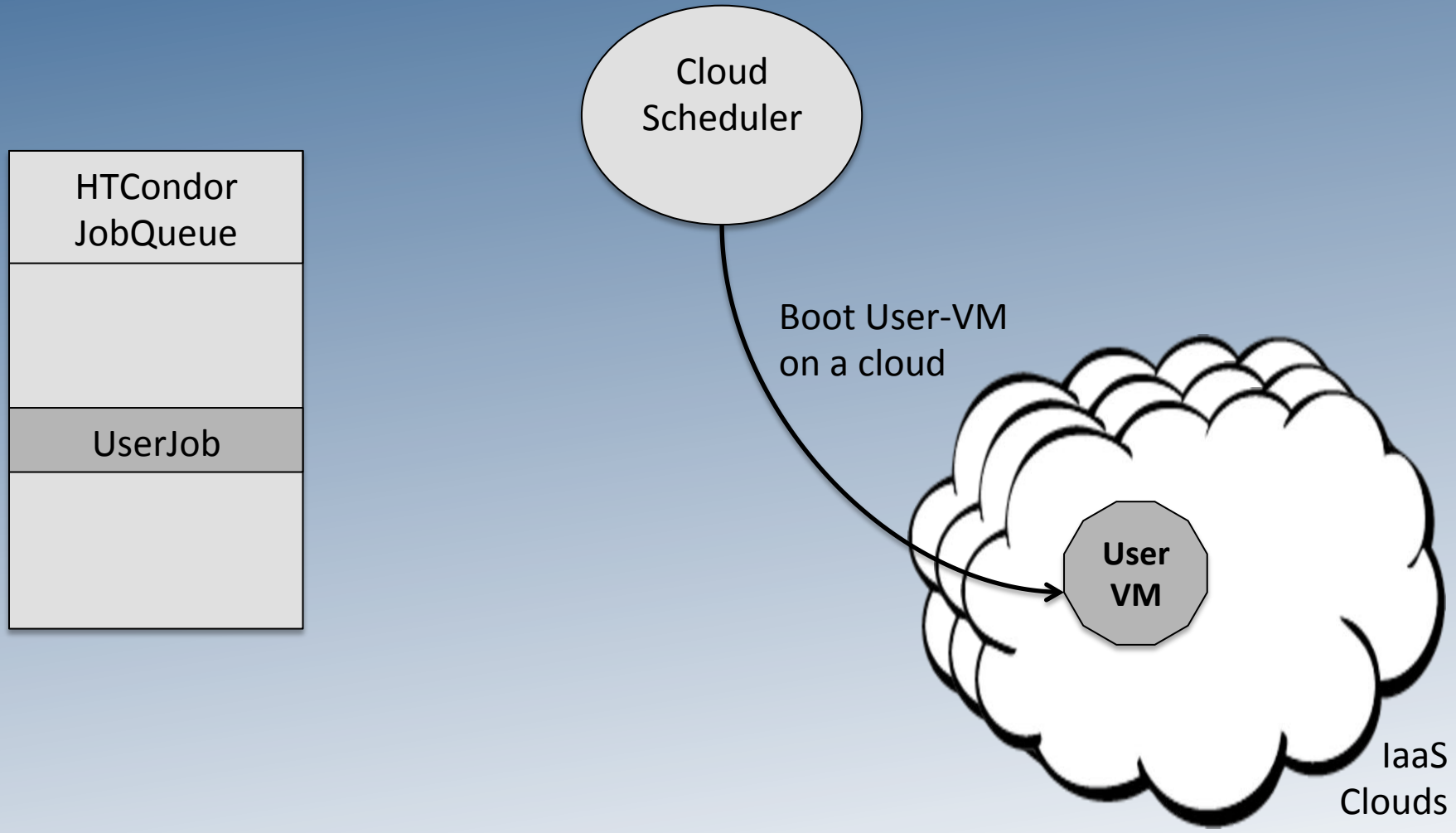
Removes any application requirements from remote site

Support multiple projects

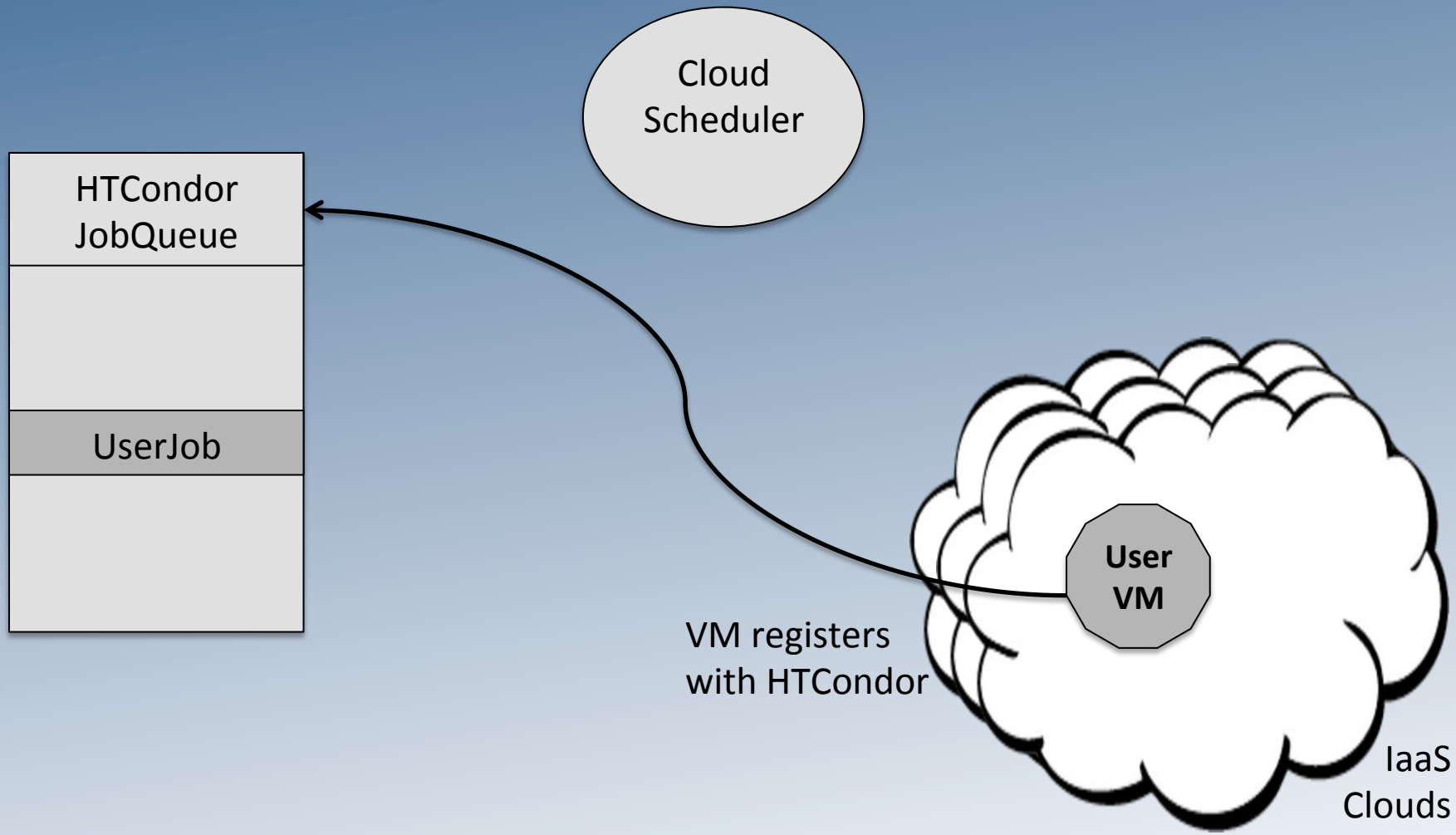
Distributed cloud overview



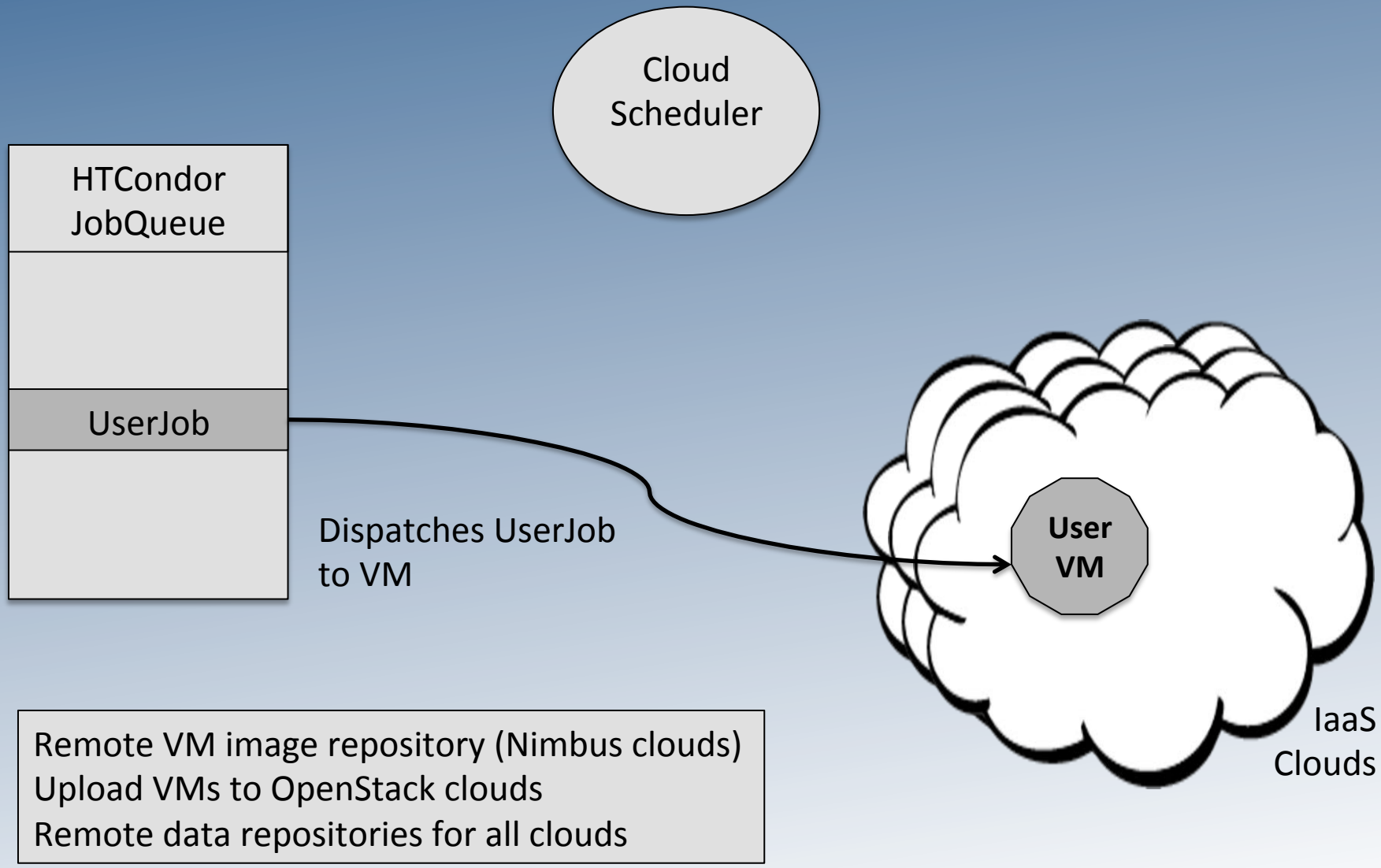
Distributed cloud overview



Distributed cloud overview

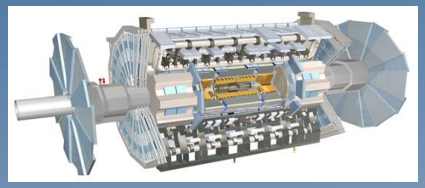


Distributed cloud overview



Remote VM image repository (Nimbus clouds)
Upload VMs to OpenStack clouds
Remote data repositories for all clouds

Distributed cloud status



The Canadian Astronomy Data Centre

If you have used CADC facilities for your research, please include the following acknowledgment:
This research used the facilities of the Canadian Astronomy Data Centre
operated by the National Research Council of Canada with the support of the Canadian Space Agency.

Operational since Nov 2011

Approximately 250K jobs
(Astronomy 500K jobs)

Using 10 clouds for ATLAS jobs
500-1000 simultaneous jobs
12 hour jobs

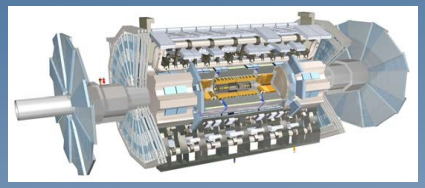
ATLAS jobs submitted from CERN

Nimbus
Victoria(3)
Ottawa
FG Chicago
FG SanDiego
FG Florida

OpenStack
Melbourne
CERN
Edmonton
Oxford

Amazon EC2
Google GCE

Distributed cloud status



April 9 2013
8 clouds
100-120 8-core VMs

The Canadian Astronomy Data Centre

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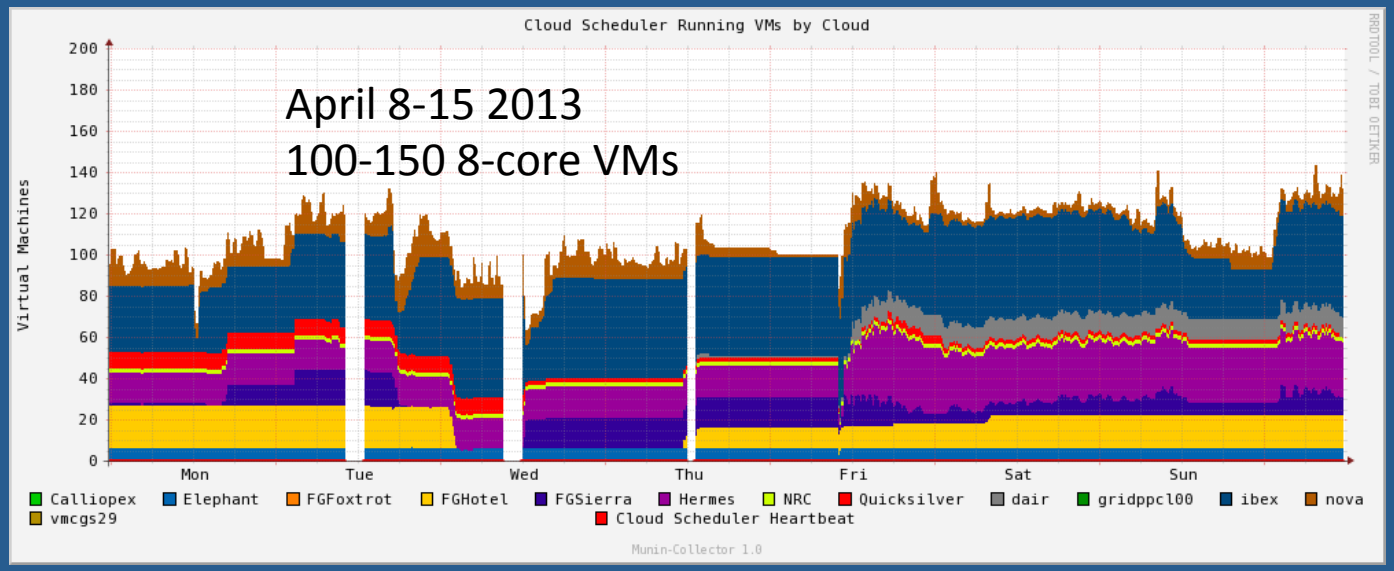
Nimbus
Victoria(3)
Ottawa
FG Chicago
FG SanDiego
FG Florida



Melbourne
CERN--Ibex
CANARIE
WG-Victoria
NRC-Ottawa
Victoria
FG-San Diego
FG-Chicago
Victoria

Technology innovation for new science

We see ourselves as integrators rather than developers of cloud technology

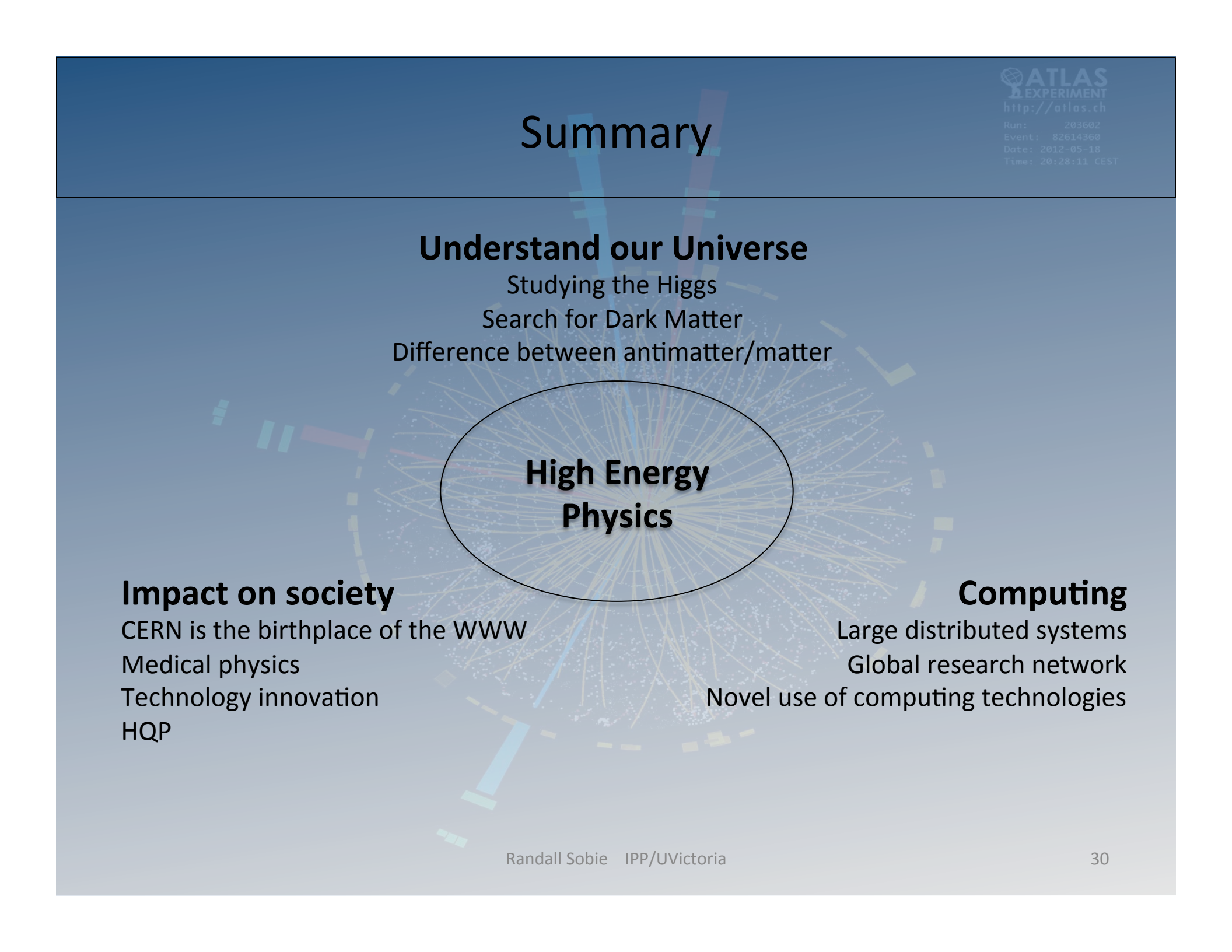
openstack™

The OpenStack developer community can help us

Common authentication
Centralized VM image storage
Consistent meta-data
Unique cloud names

Simplify the integration of OpenStack clouds for us

Summary



Understand our Universe

Studying the Higgs
Search for Dark Matter
Difference between antimatter/matter

High Energy Physics

Impact on society

CERN is the birthplace of the WWW
Medical physics
Technology innovation
HQP

Computing

Large distributed systems
Global research network
Novel use of computing technologies

Acknowledgements

Contact information: rsobie@uvic.ca

Web sites: http://rjs.phys.uvic.ca/
http://heprc.phys.uvic.ca/home/