UiO : Department of Physics
University of Oslo

Tools for Global Collaboration – A quick look at a CERN experiment

Alex Read, High Energy Physics (HEP), Dept. Physics, U. Oslo

16.03.2016

The Research Council of Norway

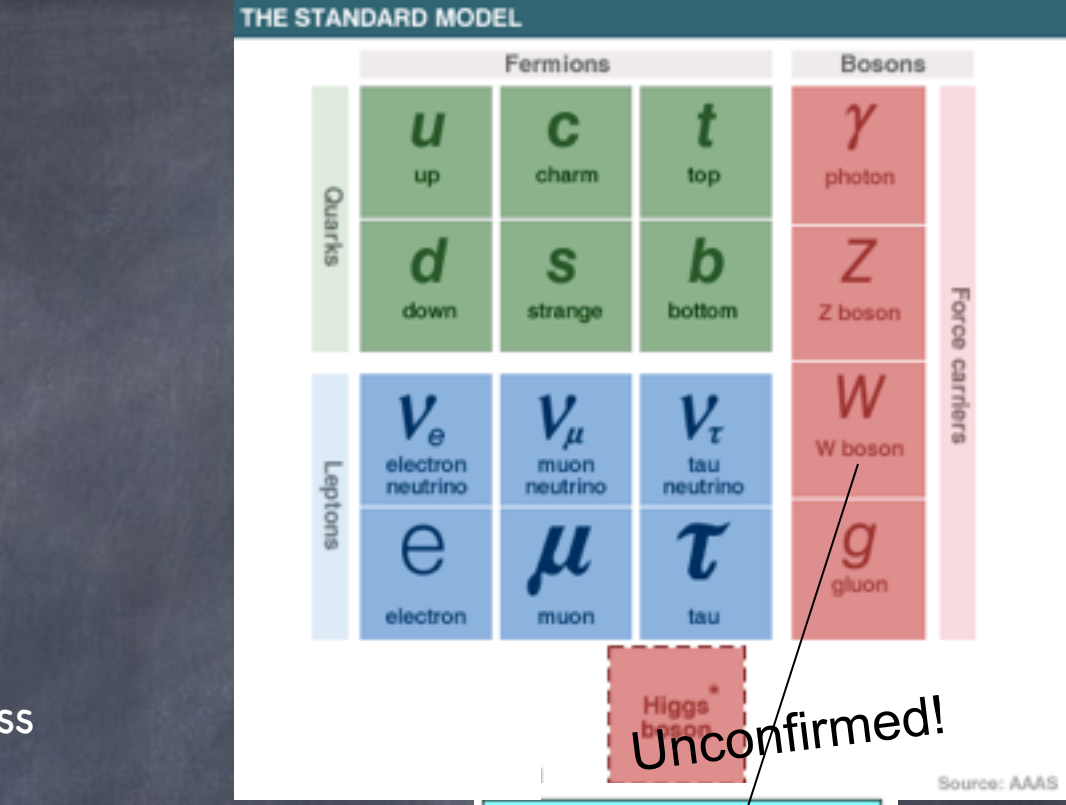
ATLAS EXPERIMENT

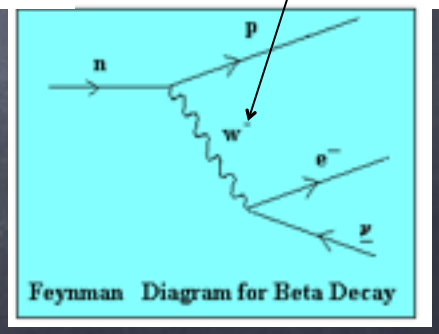
Outline

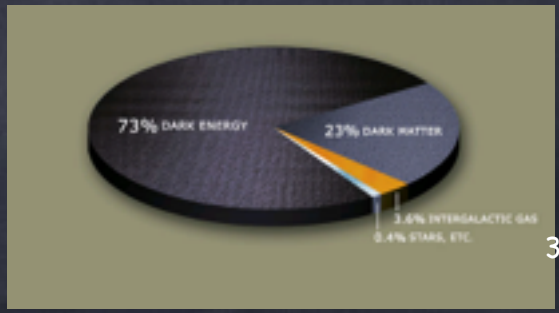
- Particle physics-light primer (LHC, CERN)
- Writing articles 25, 15 years ago
- Digital collaboration tools used by ATLAS experiment (3000+ physicists)
  - Communication
  - Document handing

Before LHC (2010-)...

- Standard Model from 60's+70's works like a dream (almost...)
  - Neutrinos have small mass
  - Separate theory from gravity
  - Higgs not confirmed
  - Many empirical constants
  - Universe is full of dark matter (and energy)





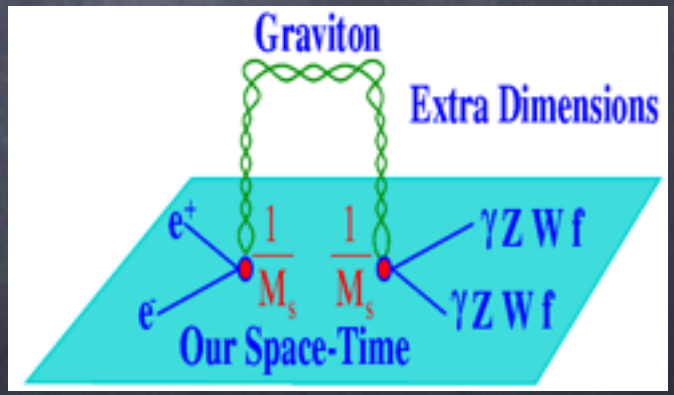


Higgs particle, the missing link of the SM

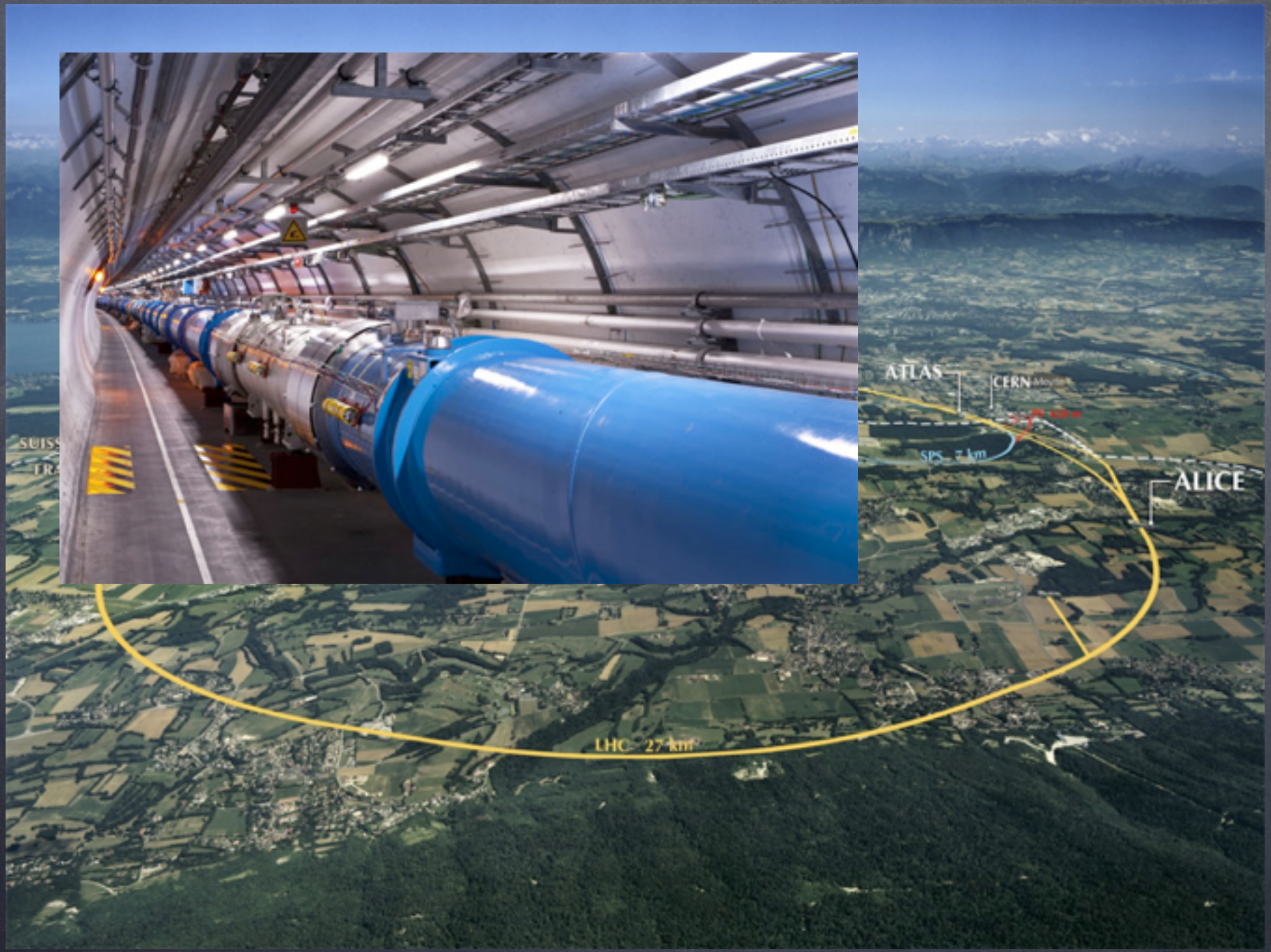
- Higgs particle couples to mass
  - Invented to give mass to fundamental particles, applied to the massive weak bosons W and Z (half a century ago!)
  - Through empirical constants can give mass to SM fermions (electrons, quarks,…) as well (first results confirm this as well!)
- Must be at least 1 massive, spinless particle or theory is misleading/wrong (we found it at the LHC - 2012!)
- Fixes some problems, creates others

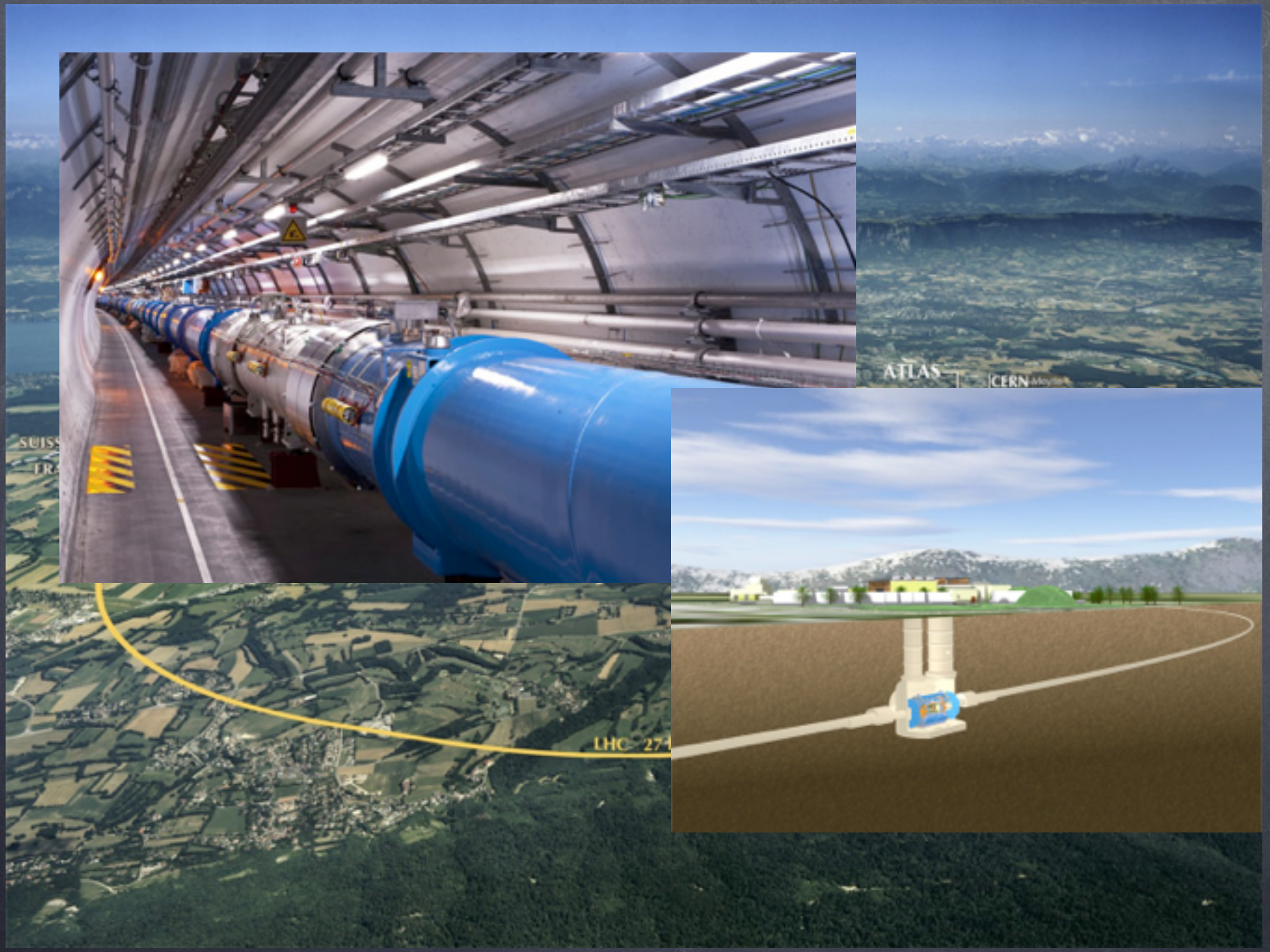
Beyond the Standard Model

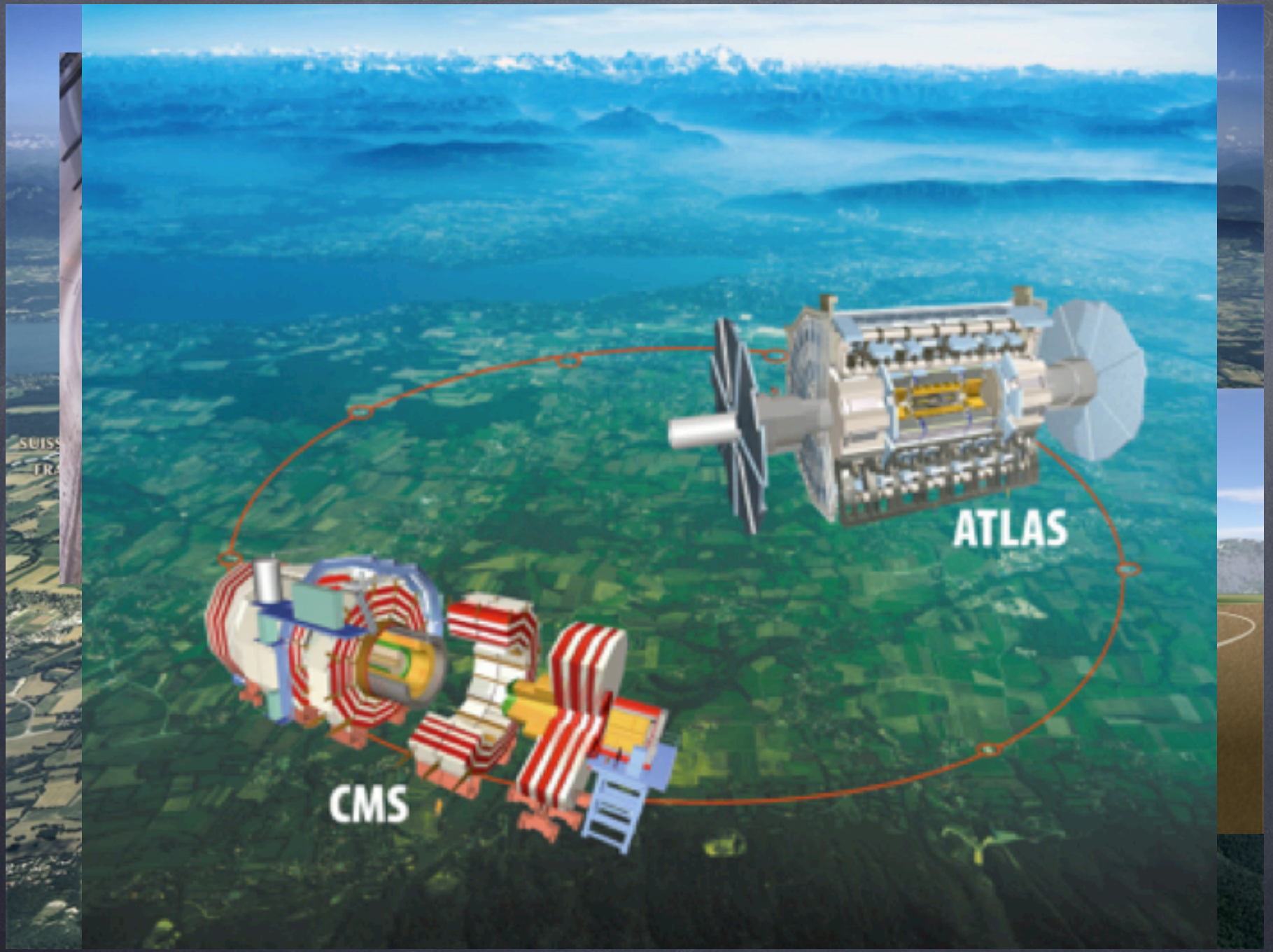
- Is there a (super)symmetry between matter and force, fermions and bosons?
  - If there is, what hides the SUSY partners from us? What breaks the supersymmetry?
- Why is gravity SO much weaker than the other (strong, EM, weak) forces?
  - Gravity leaks into extra dimensions? -> (unstable and harmless) microscopic black holes??
- ~~CP~~, precision measurements, no time to make the full list…



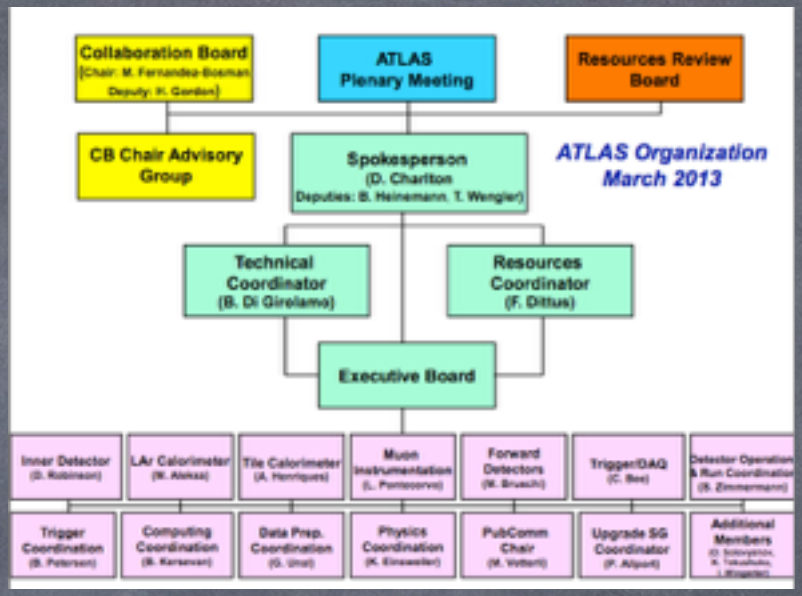

LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
CMS
ALICE
LHC 27 km

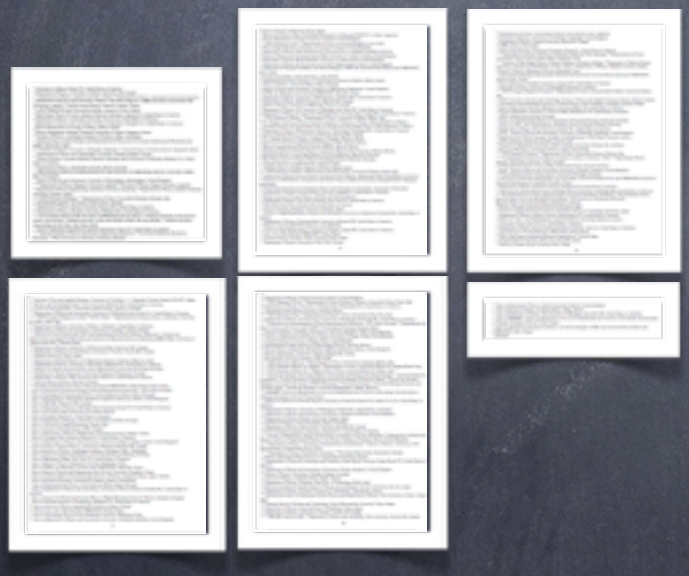

ATLAS
CERN
SPS 7 km
ALICE
LHC 27 km

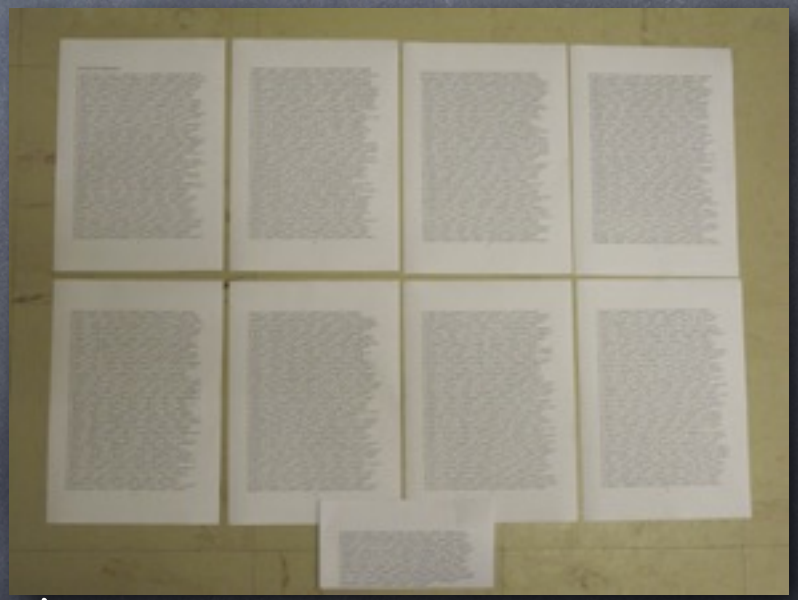

ATLAS
CERN
LHC


ATLAS
CMS


38 Land (2011)
ATLAS
Collaboration





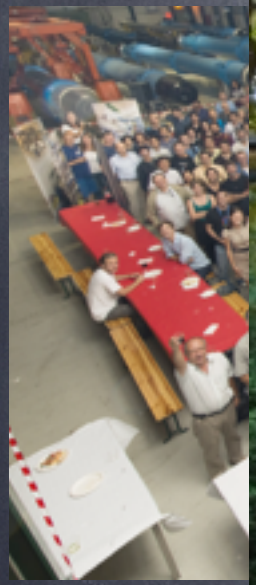


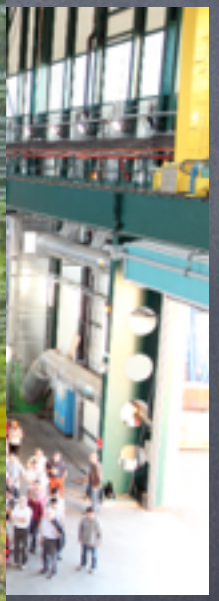
Typisk universiteter og laboratorier (180)

Typisk forfattere (3000)

ATLAS, CMS collaborations

ATLAS, CMS





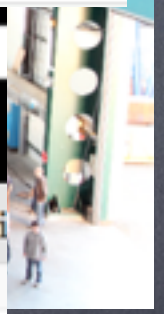
Subatomær fysikk

Forskning | Prosjekter | Kontakt

Eksperimentell partikkelfysikk
Eksperimentell kjernefysikk
Teoretisk partikkelfysikk

ATLAS
ALICE

Faglig ansatte



UiO : Fysisk institutt
Det matematisk-naturvitenskapelige fakultet

Forsiden Fysikk | Forskning | Studier | Livet rundt studiene | Tjenester og verktøy | Om insti

Forskning

Forskergrupper

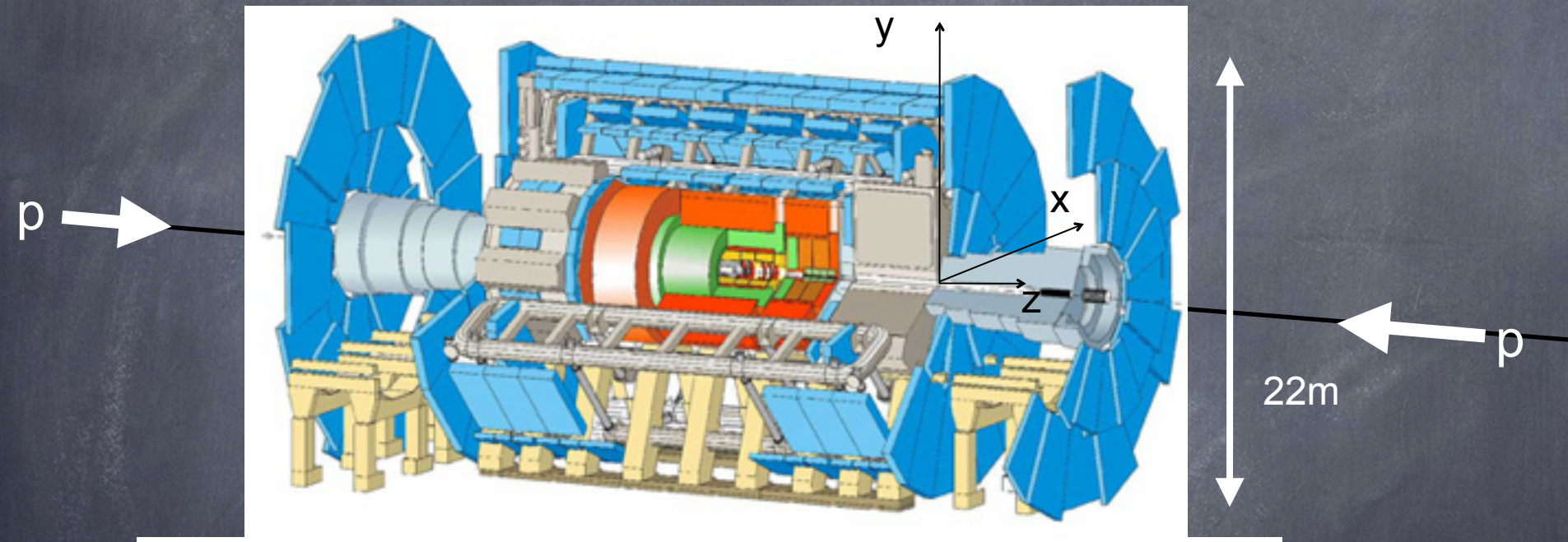
Eksperimentell partikkelfysikk

- Aktuelle saker

Eksperimentell partikkelfysikk

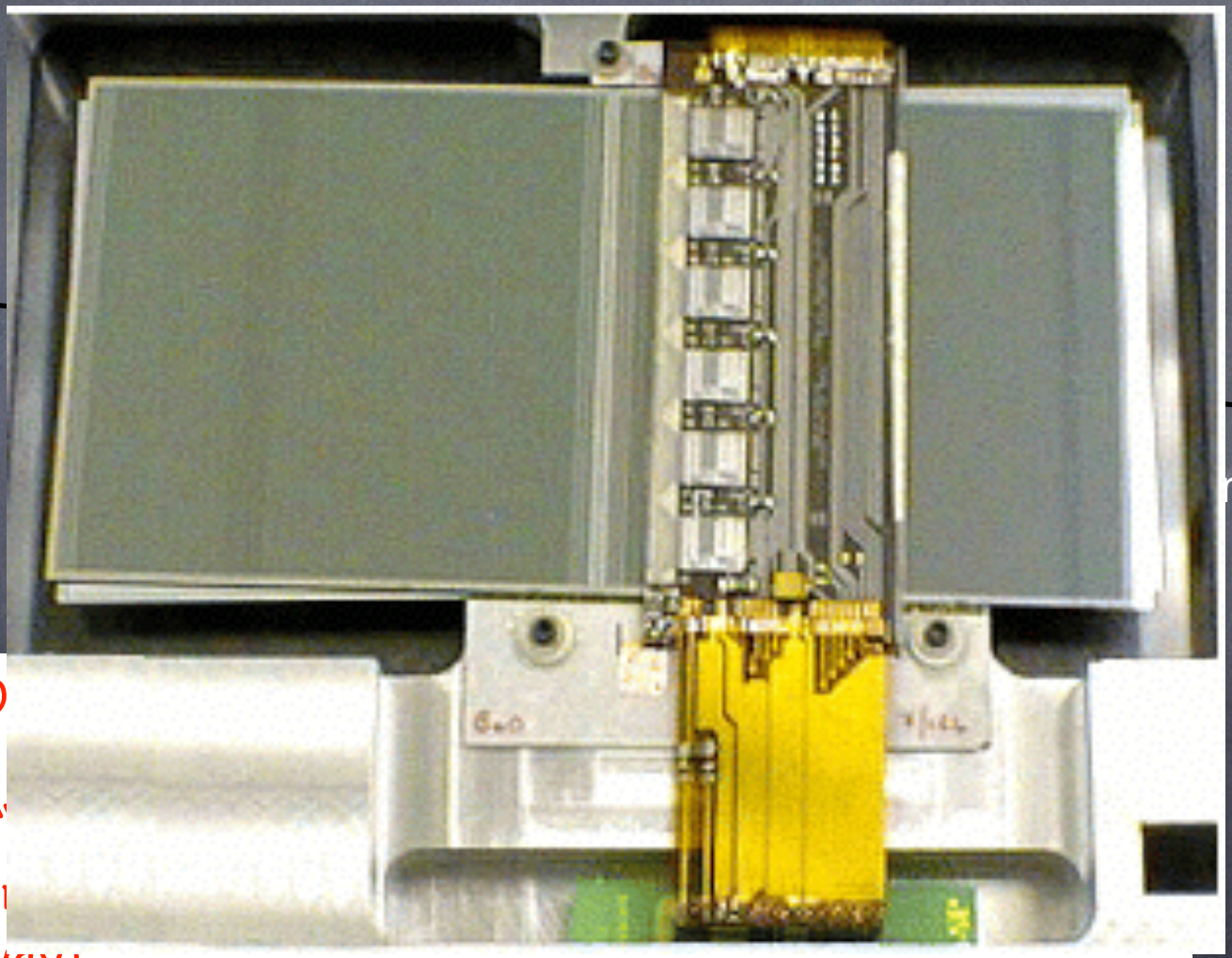
Gruppen for eksperimentell partikkelfysikk (EPF) leter etter naturens minste byggestener og studerer naturens mest grunnleggende krefter. Gruppen deltar i ATLAS-eksperimentet ved The Large Hadron Collider (LHC) ved CERN, og satser sterk på utvikling og bygging av silisium-baserte partikkeldetektorer, utvikling av morgendagens datanettverket (grid), data-analyse og formidling.

ATLAS-experiment - world's largest digital camera - partly "Made in Norway"!



7000 tons (ca. 100 empty Boeing 747 airplanes)
90M 3-D pixels
400 "pictures"/s (discard 20 Mpictures/s)
Several 1000 TB/yr (data storage and analysis also in Norway)

ATLAS-experiment - world's largest digital camera - partly "Made in Norway"!



p

p

m

7000

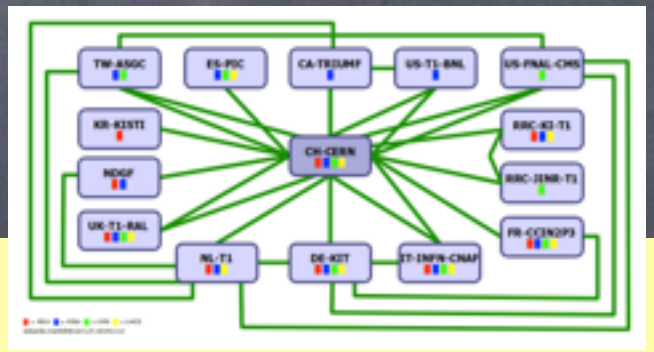
90M

400 "

Sever

Norway)

Scale of the WLCG



Storage:

Sampling rate of raw data 0.1 – 1 GB/s
Total amount of data 10-15 PetaBytes/year

Computing power:

Need for 200.000 of the fastest computers of today

Particle detection

- Detector sees stable particles (e.g. electron, proton, photon and those unstable but with long (enough) lifetime to escape the detector before decay (e.g. muon, charged pi-meson)

→

Particle detection

- Detector sees stable particles (e.g. electron, proton, photon and those unstable but with long (enough) lifetime to escape the detector before decay (e.g. muon, charged pi-meson)
- Highly unstable particles are recognized by their decay products and a characteristic mass $(mc^2)^2=(\sum E)^2-(\sum \vec{p}c)^2$

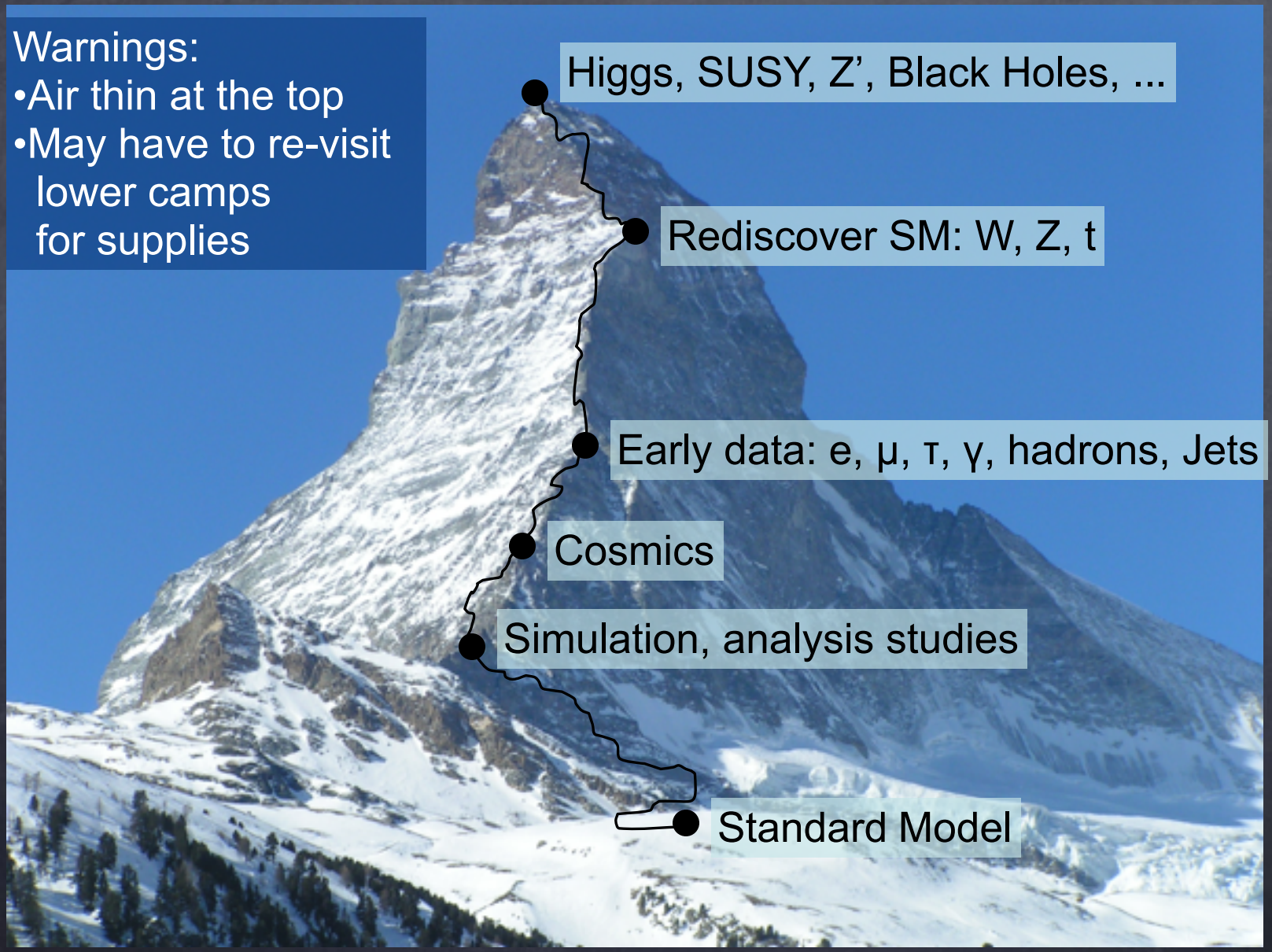
Particle detection

- Detector sees stable particles (e.g. electron, proton, photon and those unstable but with long (enough) lifetime to escape the detector before decay (e.g. muon, charged pi-meson)
- Highly unstable particles are recognized by their decay products and a characteristic mass $(mc^2)^2=(\sum E)^2-(\sum \vec{p}c)^2$
  - e.g. $\Pi^0 \rightarrow \gamma\,\gamma$, $Z \rightarrow e^+e^-$, $H \rightarrow ZZ \rightarrow e^+e^-e^+e^-$

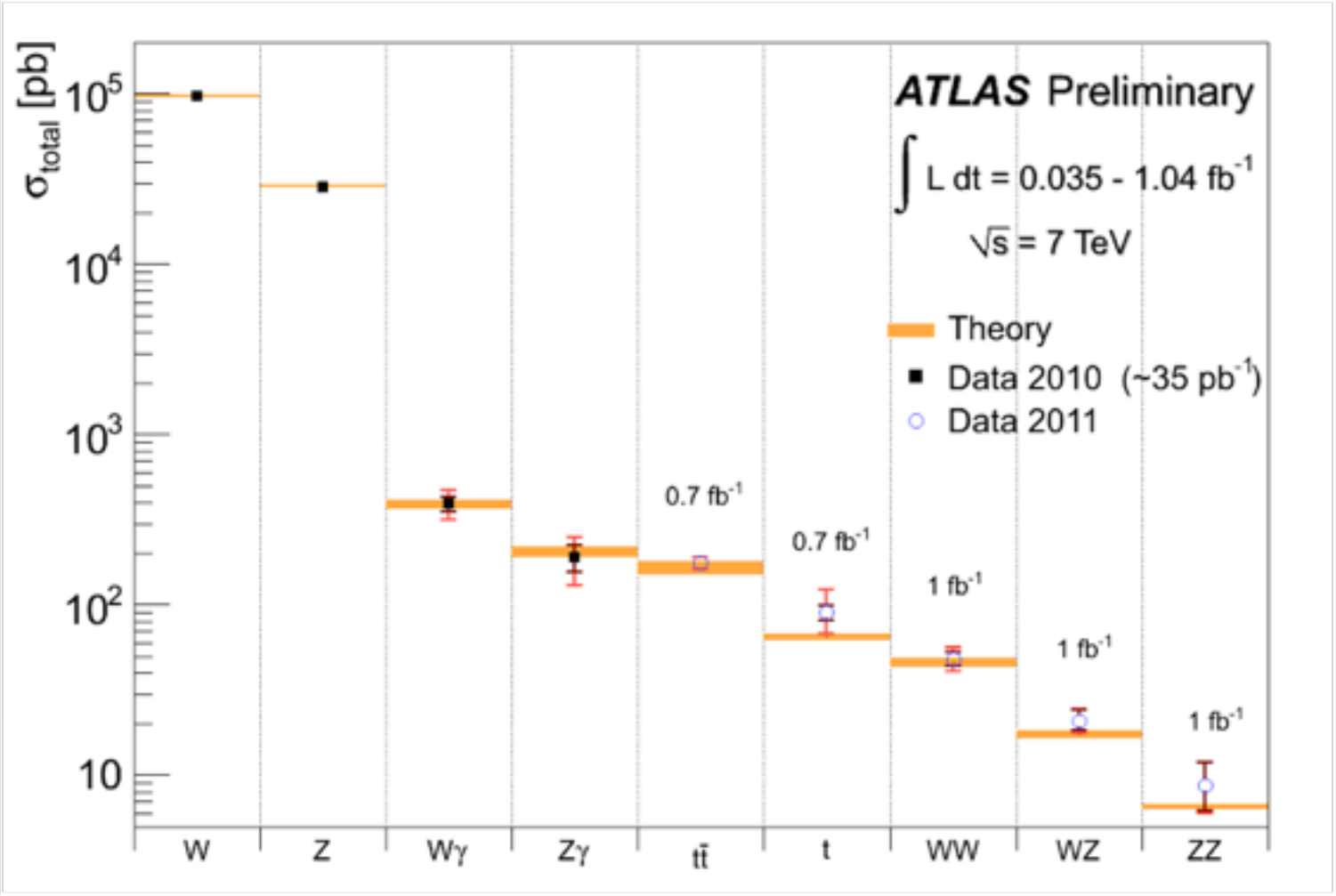
Particle detection

- Detector sees stable particles (e.g. electron, proton, photon and those unstable but with long (enough) lifetime to escape the detector before decay (e.g. muon, charged pi-meson)
- Highly unstable particles are recognized by their decay products and a characteristic mass $(mc^2)^2=(\sum E)^2-(\sum \vec{p}c)^2$
  - e.g. $\Pi^0 \rightarrow \gamma\,\gamma$, $Z \rightarrow e^+e^-$, $H \rightarrow ZZ \rightarrow e^+e^-e^+e^-$
- We "see" the unstable particles the same way you see objects on the other side of the room - something (for you, light) transmits their properties across space.

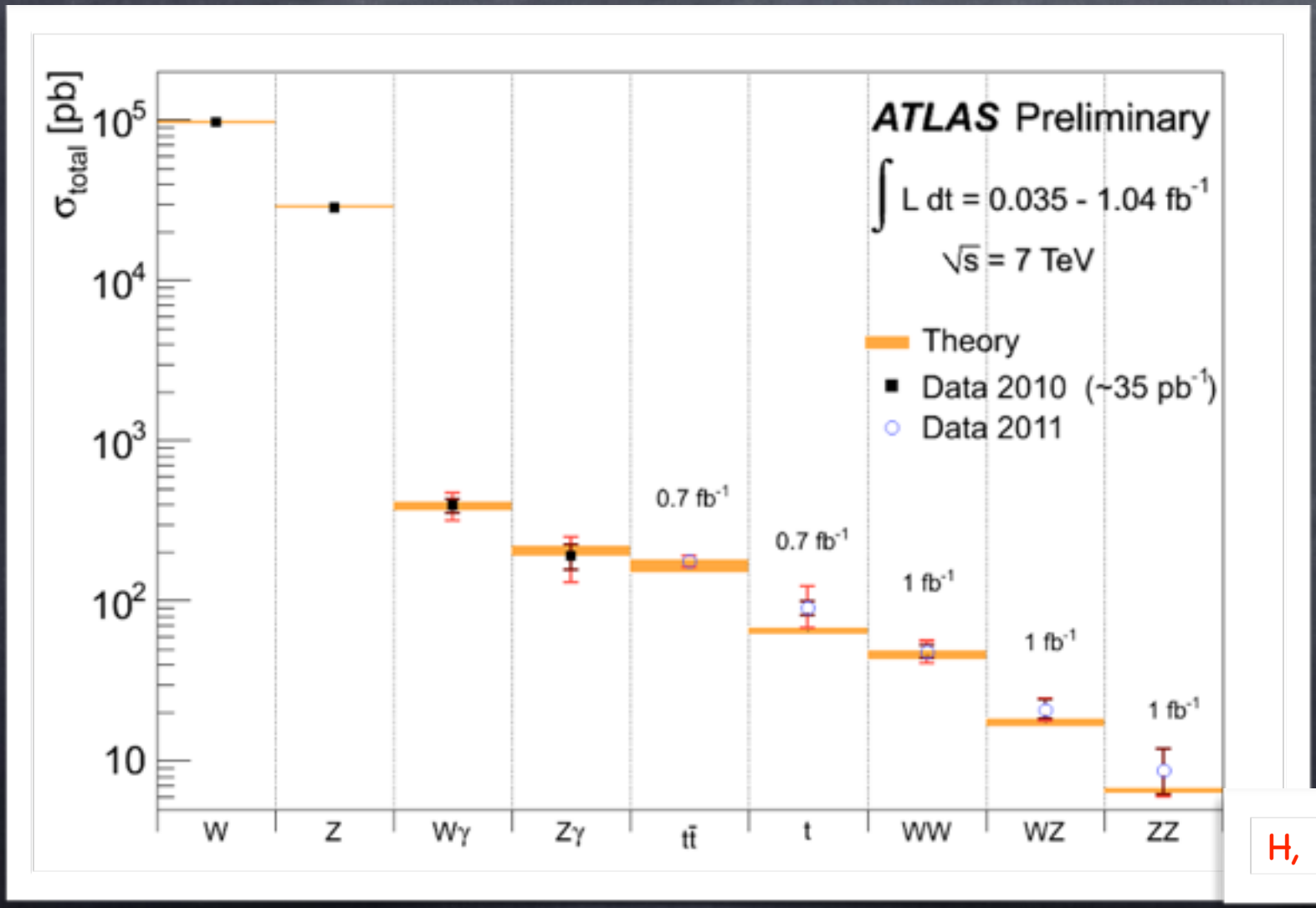
Trail to LHC results



Measurements of Standard Model "candles"



Measurements of Standard Model "candles"



H, HW, HZ?!

- LHC challenge: We looked for about 10,000 Higgs bosons in a million billion proton-proton-collisions

- LHC challenge: We looked for about 10,000 Higgs bosons in a million billion proton-proton-collisions

- LHC challenge: We looked for about 10,000 Higgs bosons in a million billion proton-proton-collisions

Results 4 July (*), 2012

Results 4 July (*), 2012

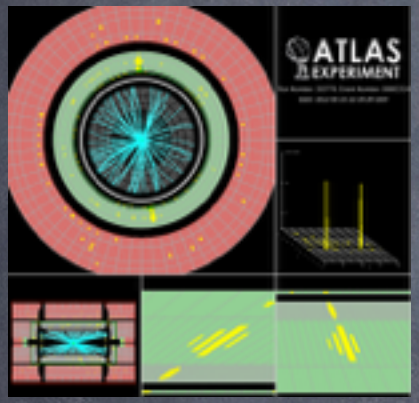


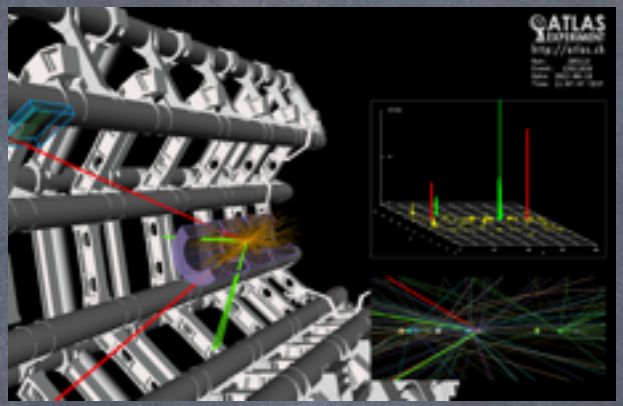
Results 4 July (*), 2012

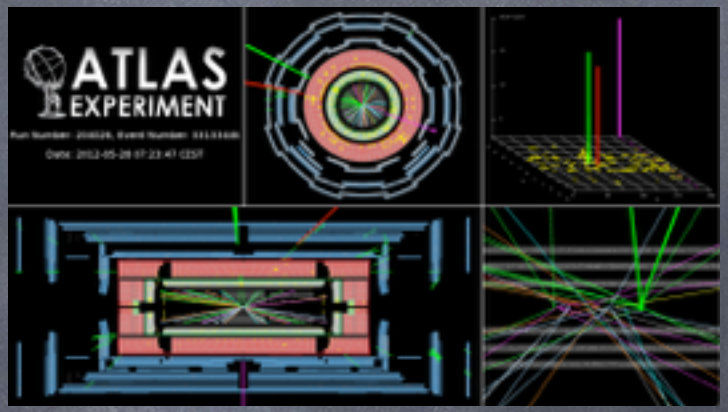
$H \to \gamma\gamma$

$H \to ZZ^* \to (e^+e^-)(\mu^+\mu^-)$

$H \to W^+W^{-(*)} \to e^+\nu_e\mu^-\nu_\mu$





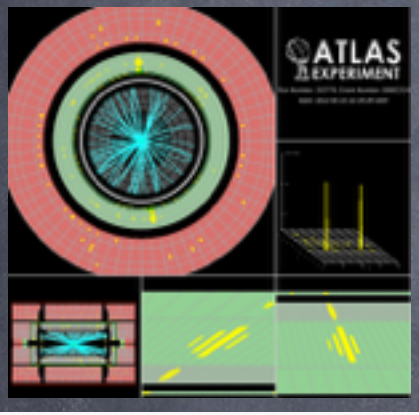


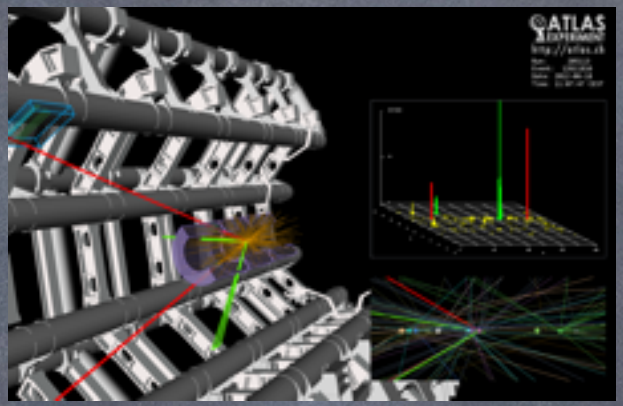
Results 4 July (*), 2012

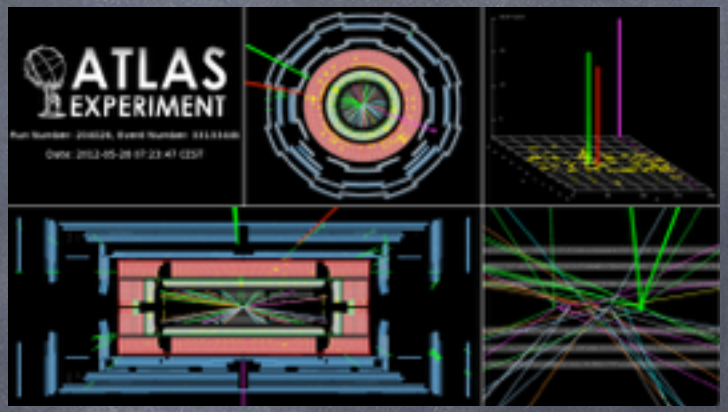
$H \to \gamma\gamma$

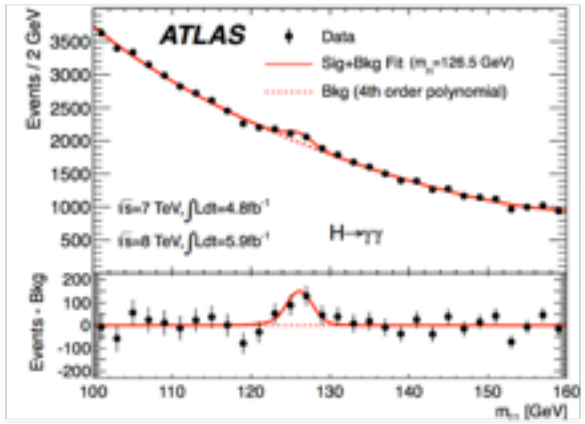
$H \to ZZ^* \to (e^+e^-)(\mu^+\mu^-)$

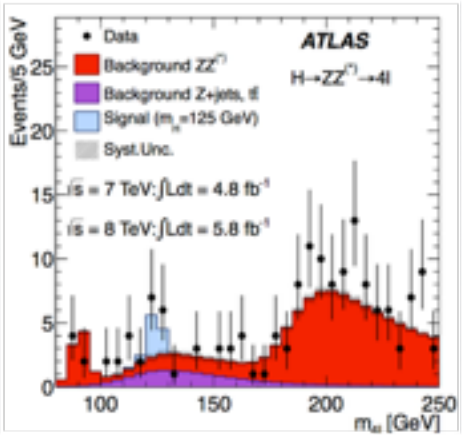
$H \to W^+W^{-(*)} \to e^+\nu_e\mu^-\nu_\mu$

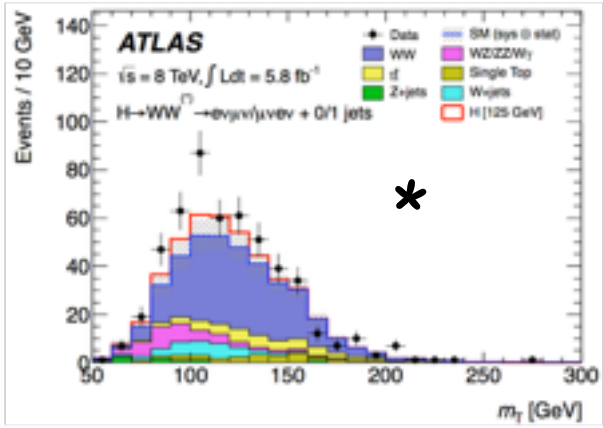




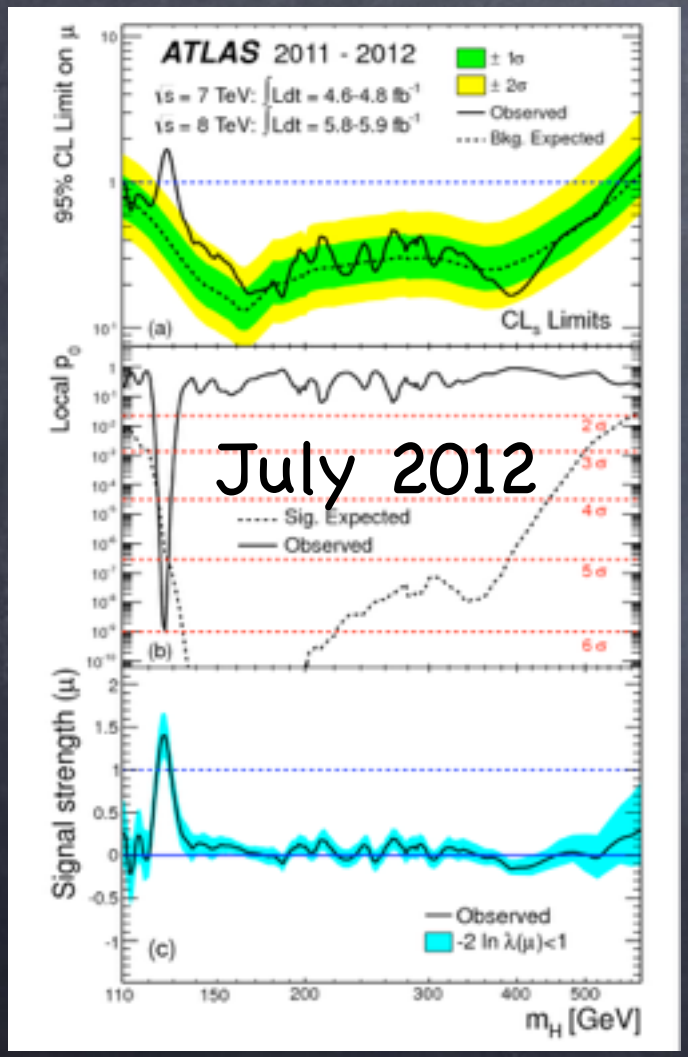


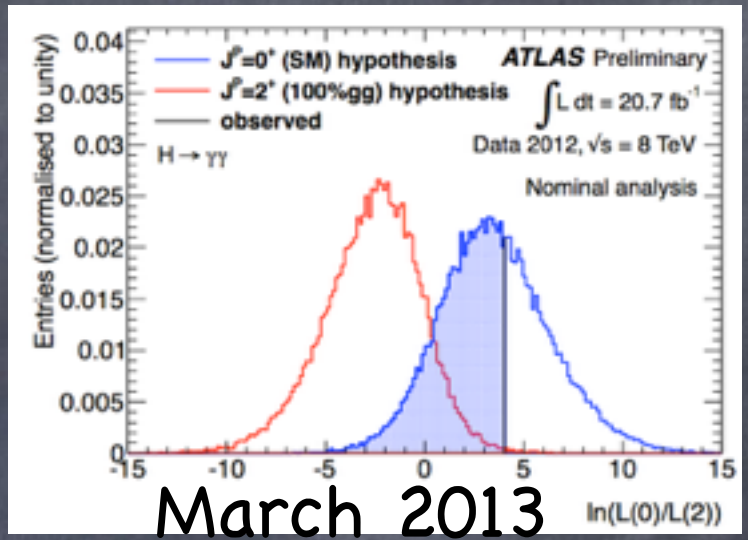


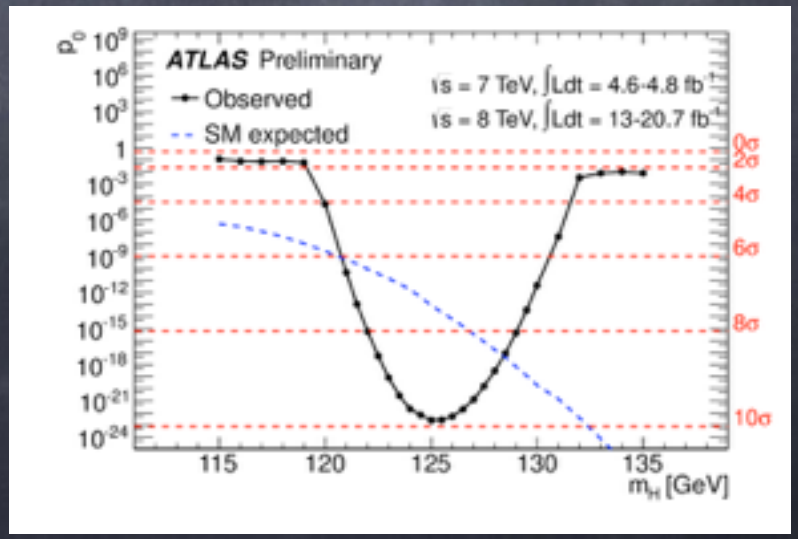




Evidence for the Higgs boson







Significance (evidence) out of this world!

Milky Way. ESO/S. Guisard

Significance (evidence) out of this world!

- Build LHC+ATLAS+CMS **for every star in the universe (ca. 1.000.000.000.000.000.000.000.000)** - about 10 will give false evidence of a discovery

Nobel Symposium on LHC results

from Monday, 13 May 2013 at **12:15** to Friday, 17 May 2013 at **13:15** (E
at **Krusenberg herrgård**
Krusenberg 436, 755 98 Uppsala

Description A "Nobel Symposium on LHC results" will be held in Sweden 13-17 May 2013.

-
-
-

Wednesday, 15 May 2013

09:00 - 12:00 The Higgs Boson

Convener: Fabiola Gianotti (CERN)

09:00 **SM Higgs measurements** *30'*

Speaker: Alexander Read (University of Oslo)

Material: **Slides**

Nobel Symposium on LHC results

from Monday, 13 May 2013 at **12:15** to Friday, 17 May 2013 at **13:15** (E
at **Krusenberg herrgård**
Krusenberg 436, 755 98 Uppsala

Description A "Nobel Symposium on LHC results" will be held in Sweden 13-17 May 2013.

My mission: "Make sure the experimentalists get a share of the Nobel Prize"

Wednesday, 15 May 2013

09:00 - 12:00 The Higgs Boson

Convener: Fabiola Gianotti (CERN)

09:00 **SM Higgs measurements** *30'*

Speaker: Alexander Read (University of Oslo)

Material: **Slides**

Nobel Symposium on LHC results

from Monday, 13 May 2013 at **12:15** to Friday, 17 May 2013 at **13:15** (E
at **Krusenberg herrgård**
Krusenberg 436, 755 98 Uppsala

Description A "Nobel Symposium on LHC results" will be held in Sweden 13-17 May 2013.

My mission: "Make sure the experimentalists get a share of the Nobel Prize"

Wednesday, 15 May 2013

09:00 - 12:00 The Higgs Boson

Convener Fabiola Gianotti (CERN)

09:00 **SM Higgs measurements** *30'*

Speaker: Alexander Read (University of Oslo)

Material: **Slides**

Æresdoktor UiO September, 2014

The Nobel Prize in Physics 2013

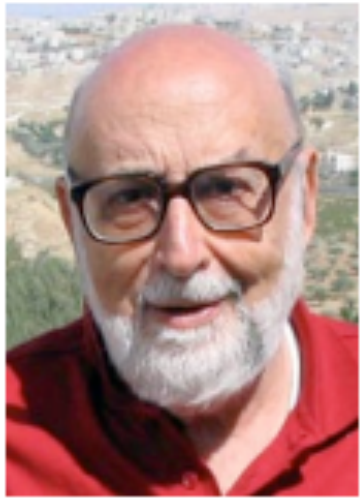


Photo: Pnicolet via Wikimedia Commons

François Englert

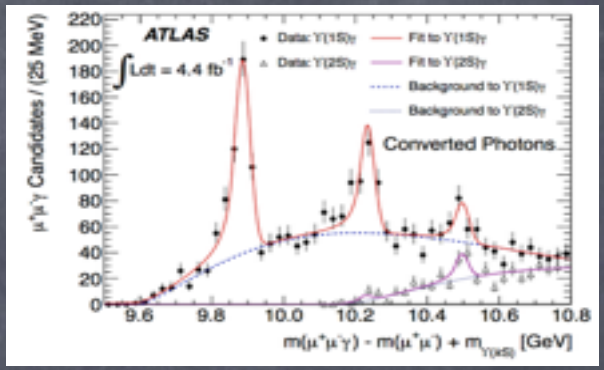
Photo: G-M Greuel via Wikimedia Commons

Peter W. Higgs

The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"*

What is the Higgs boson and why is it important?

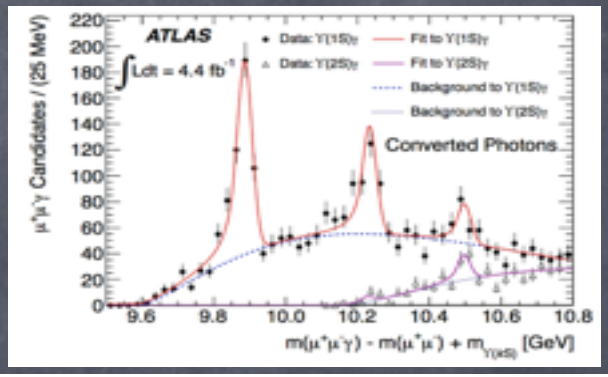
Results so far



- Small amount of data in 2010
- 150x more data in 2011 (7 TeV)
- Another 4-5x in 2012 (8 TeV)
- 273 physics papers so far (Jan. 2014)
  - About 2/week
- Discovered one new (predicted) particle
- Confirmed many previous SM results
- Excluded many speculative models of new physics
- Discovery of a Higgs boson candidate - July 2012
  - Basic properties confirmed in March 2013, we now call it a Higgs boson

Results so far

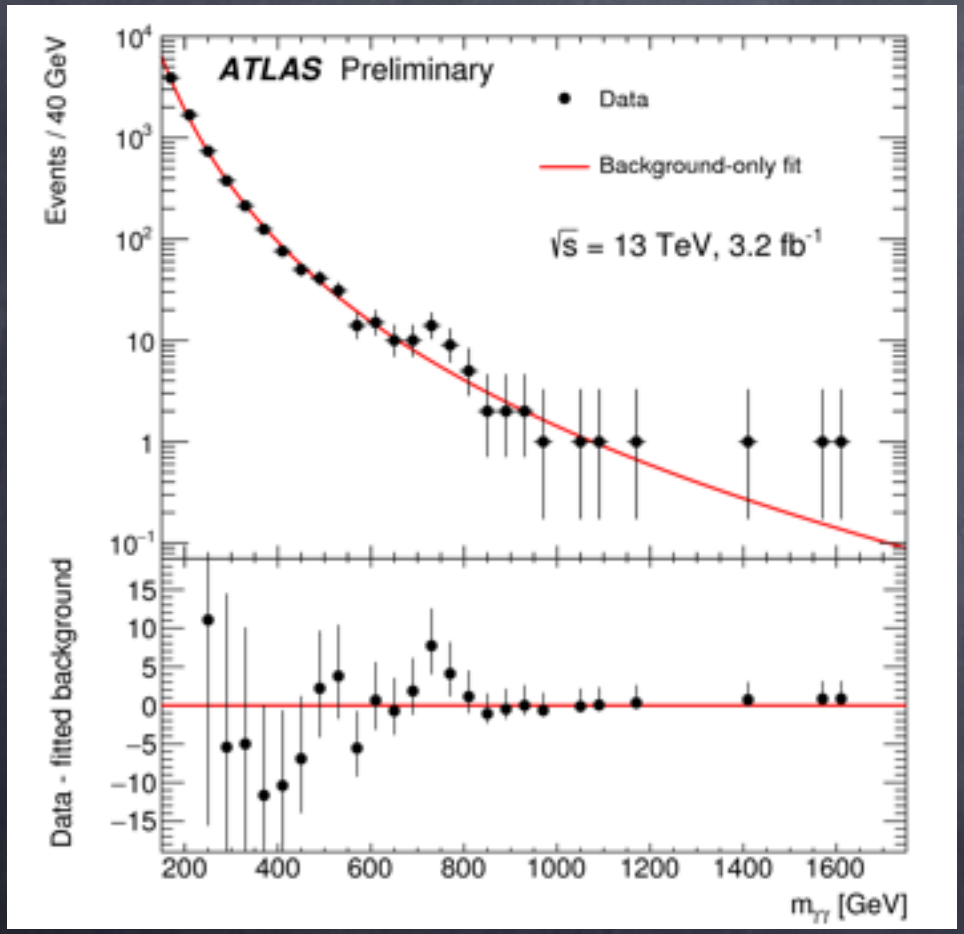
- Small amount of data in 2010
- 150x more data in 2011 (7 TeV)
- Another 4-5x in 2012 (8 TeV)



More than 500 ATLAS papers
ATLAS submitted its 501st paper on Dec. 18th. This includes 496 run-1 papers and 5 run-2 papers. 251 of these papers were searches, 219 measurements and 31 performance papers.

- Discovered one new (predicted) particle
- Confirmed many previous SM results
- Excluded many speculative models of new physics
- Discovery of a Higgs boson candidate - July 2012
  - Basic properties confirmed in March 2013, we now call it a Higgs boson

New discoveries?



- Smaller hint seen by CMS, but at same mass
- You may have seen this in New Scientist and Nature recently
- 200 theory papers since December
- Experimentalists more sceptical…2016 data will confirm/refute

New Scientist 8 March 2016 at 19:35

To: Alexander Lincoln Read

Reply-To: New Scientist

Bigger than the Higgs?

Add us to your address book or Safe List | View this email as a webpage here | Subscribe here

NewScientist

Is this discovery bigger than the Higgs?

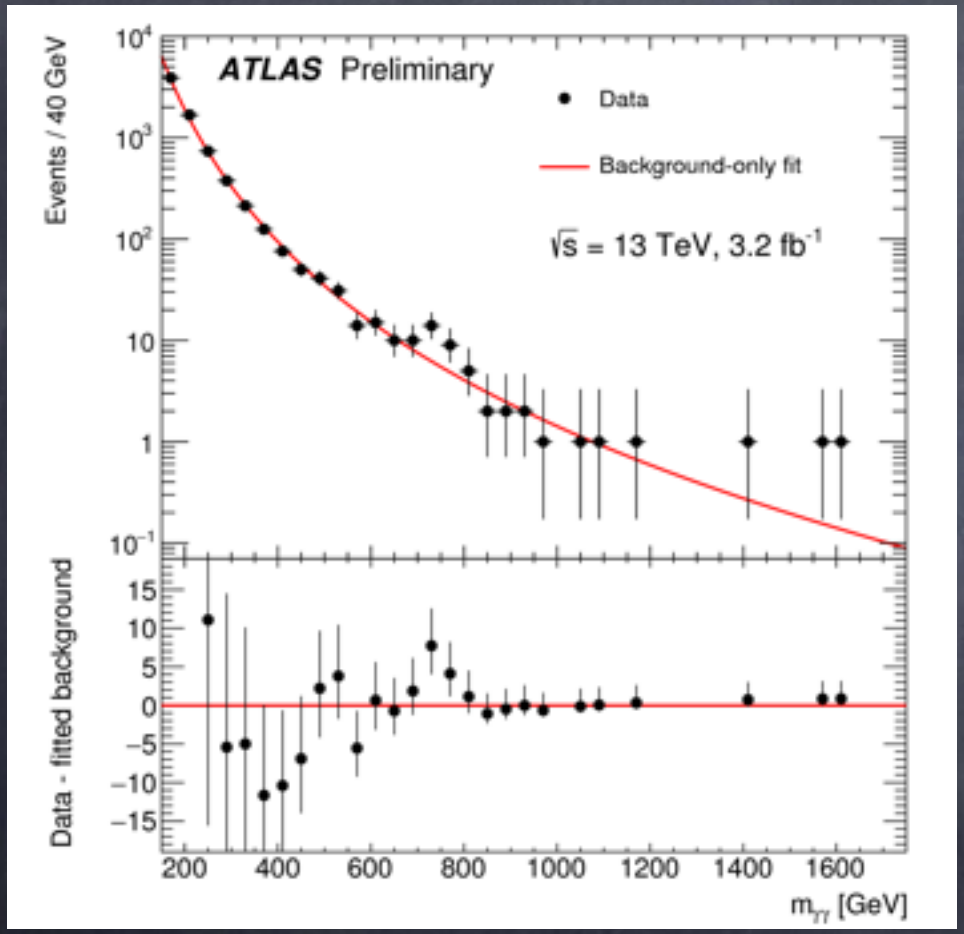
Never mind the Higgs boson or gravitational waves, it looks as if the LHC has found a surprise massive particle that gives a glimpse into a new and better theory of reality. This week *New Scientist* opens a door into an unexplored world.

Also in this week's issue:

- Cancer's penicillin moment: Drugs that unleash the immune system
- Microbe CSI: How to read the air for clues at crime scenes

To read *New Scientist* features, just pick an option below.

New discoveries?



- Smaller hint seen by CMS, but at same mass
- You may have seen this in New Scientist and Nature recently
- 200 theory papers since December
- Experimentalists more sceptical…2016 data will confirm/refute

Working together

The good old days

- My thesis (1981-86) experiment MAC had ~30 authors
  - F2f, telephone, fax, drawing office
  - Data stayed at SLAC (Stanford, CA.)
- My postdoc experiment DELPHI (1986-2002) had ~600 authors
  - Web (made at CERN) from ~1993, before

Selected recent CERN history

- Where http://www... was invented.
  - Part of motivation was roughly "If the LEP experiments discover the Higgs boson, the physicists spread across the world need some efficient way to organize writing the paper."
- Where the Higgs boson was discovered - announced 4 July, 2012.

How to get 3000+ physicists to work together??

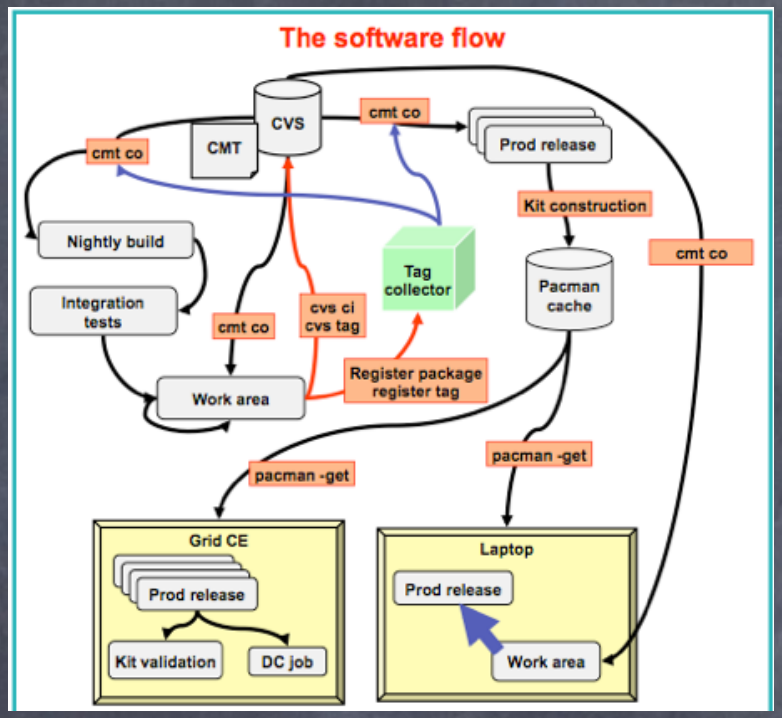
- Portal to ATLAS experiment
- Web: centrally controlled information
- Twiki: public results, community documentation
- eGroups/hypernews/Mailing lists: announcements, offline discussions
- Sharepoint - (n) web-based collaboration (especially documents)
- Audio/visual communication: Skype, Jabber, EVO (phased out), Vidyo
- Code management: svn, CMT
- Publication process: Glance, arXiv ("live"), open access
- Document preparation and repository: CDS
- Meetings: Indico and Doodle
- Calendar: google
- Computing: Cloud storage, Grid (another lecture...)

New things

- More interactive collaborative document editing
  - google docs
  - dropbox
  - pdf annotation
  - overleaf (LaTeX++)


Login
European Organization for Nuclear Research
ATLAS EXPERIMENT
HOT
Collaboration
ATLAS Now
ATLAS Public
CERN
MEETINGS
Detector Operation
Trigger
Computing & Software
Data Preparation
Physics
GENERAL
ATLAS Organization
Management
Organigram
Institutions
Collaboration Board
Executive Board
Committees & Databases
Policy Documents
MoU & Annexes
Policy for External Collaboration
General Information
Documentation & Links
ATLAS e-News
Old Collaboration page
GENERAL NEWS
ATLAS RESULTS
Public Results
ATLAS Event Displays
Conferences & Talks
Analysis Tracking - Papers
Analysis Tracking - Conference Notes
DETECTOR ACTIVITIES
SEARCH & PHONES
Search
Name
SERVICES & TOOLS
SERVICES
EDH
Glance
CET
EVO
CDS
eGroups
Indico
HyperNews
EDMS
Twiki
TOOLS
ATLAS Directory
LHC Member Search
Collaborative Tools

Code management (2000+ packages)



cvs -> svn

- Packages are first created in a work area, registered to the TagCollector and imported to the CVS repository
- Packages are checked out to work area(s)
- Tags are declared to the TagCollector, registered for the *next release*
- Nightly builds take all registered tags for the next release
- Quality checks and Integration tests results are reported to developers (through Web pages)
- Production releases take validated tags
- Distribution kit is automatically constructed from production releases
- Release kits are installed on Grid CE and laptops
- KitValidation jobs are run after installation
- Users may develop packages against installed kits

However, sometimes electronic collaboration is simply not enough ☺