



# S44: High Energy Physics Big Data and the ATLAS experiment with a hands-on tutorial - 1

Data Science School Göttingen on 21.07.2017  
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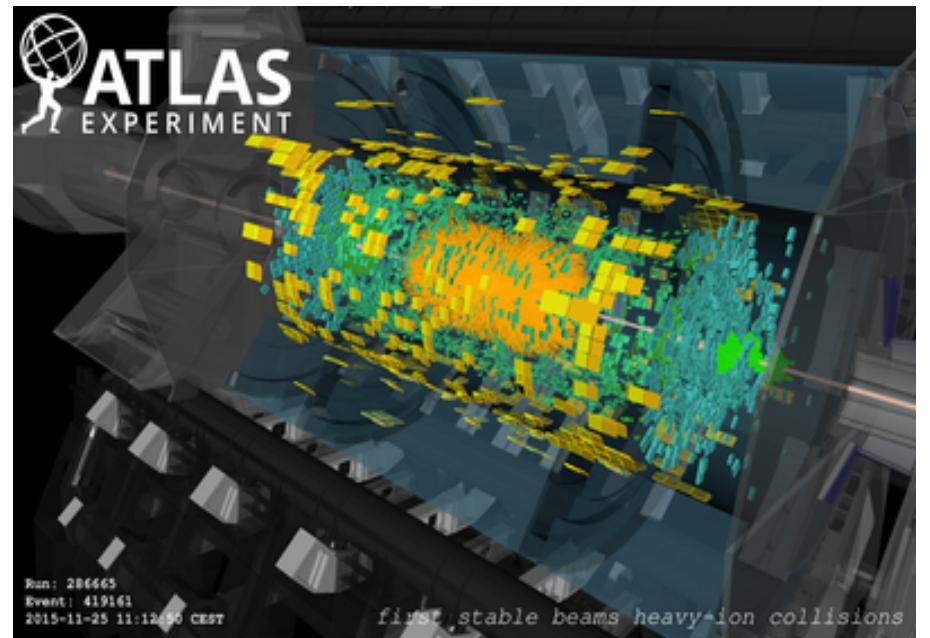
# Overview of Introduction (45 mins)

- **Introduction to ATLAS data analysis model**
  - What are the LHC experiments?
  - The ATLAS detector
  - Inner Detector
  - Basic Physics
  - ATLAS Grid computing and WLCG resources
  - Data flow in ATLAS
  - Basis of data analysis in high energy physics
  - Event Data Model (EDM) in ATLAS
  - Basis of data analysis
  - Basic tools: ATLAS CLI and CVMFS
- **ATLAS Metadata Interface (AMI)**
- **Rucio (ATLAS Data Management System)**
- **Introduction to World LHC Computing Grid (WLCG)**
- **PanDA (ATLAS Job Management System)**

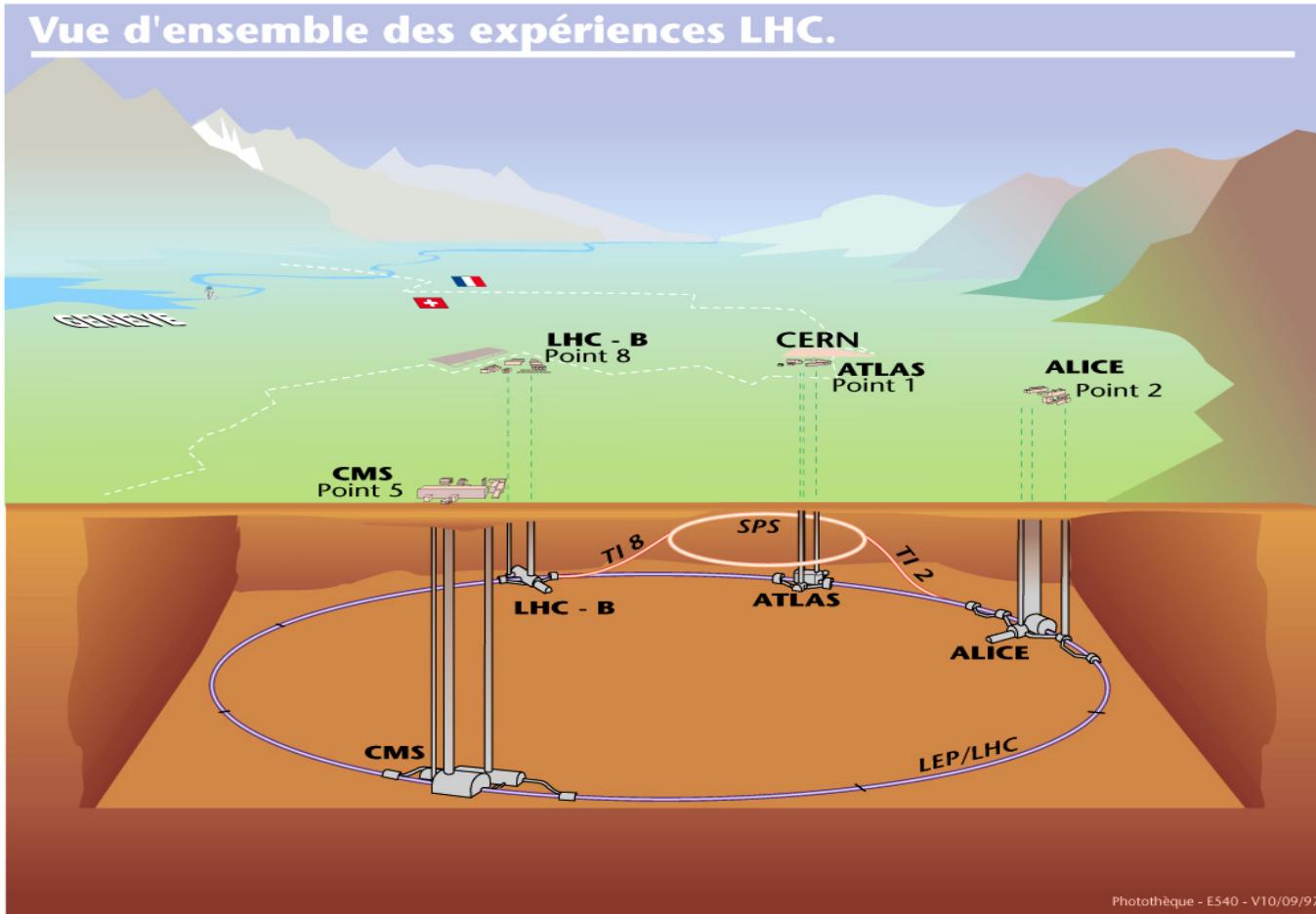
# Overview of Hands-on (30-40 mins)

- Let's start Hands-on
  - Your Grid environments
  - Hello World AMI (ATLAS Metadata Interface)
  - Hello World Athena job
  - Hello World PyRoot
    - Plot of electron Pt distribution
  - Hello World prun Grid job
  - Hello World PyRoot Grid job

# Introduction to ATLAS data analysis model



# What are the LHC experiments? - 1



The biggest hadron collier on this planet

- Hadron-Hadron collisions in TeV scale (14TeV in 2018)
- 100m below ground
- 27km circular ring
- The world largest distributed computing platform across 36 countries
- 4 main experiments (ATLAS, CMS, Alice and LHCb)
- **Already not super easy!**

Expectations

- New physics
- Understanding of early universe and fundamental laws
  - Validation of many theoretical models

# What are the LHC experiments? - 2

- New discovery was announced by ATLAS and CMS in 2012
  - *Higgs boson* (was expected by Standard Model)
  - Nobel prize 2013



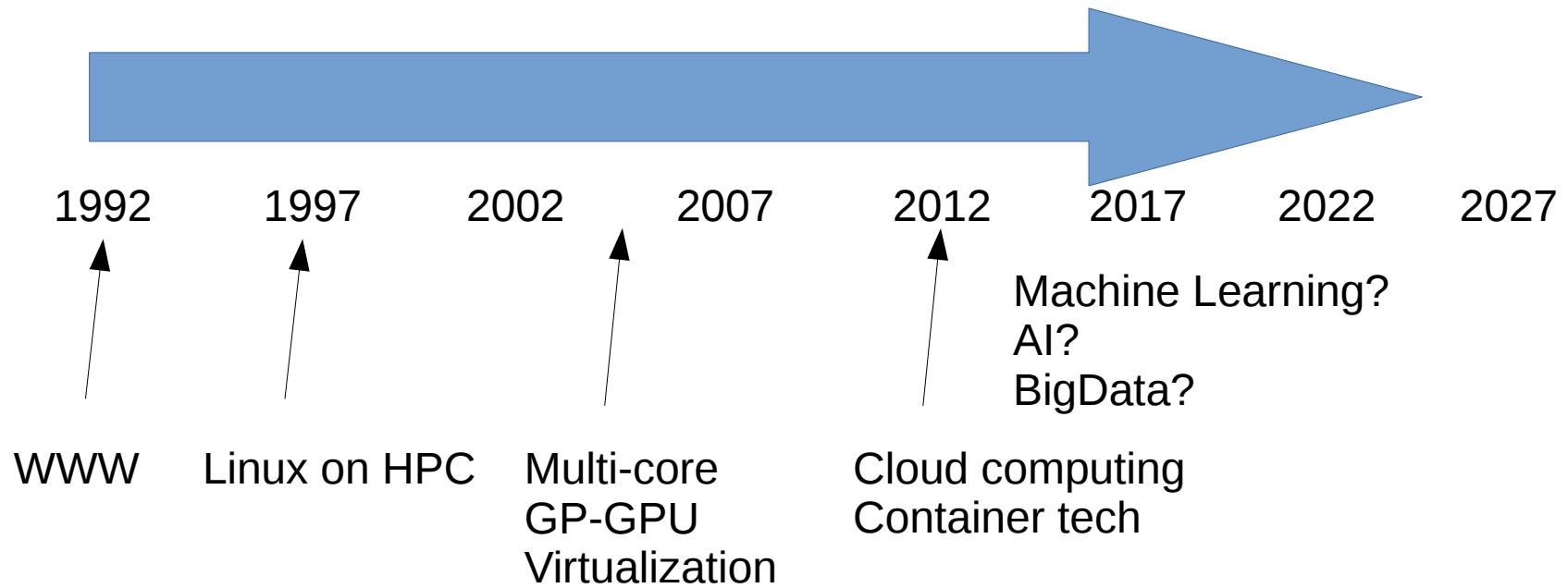
# What are the LHC experiments? - 3

## Standard Model of Elementary Particles

three generations of matter (fermions)					
	I	II	III		
mass	$\approx 2.4 \text{ MeV}/c^2$	$\approx 1.275 \text{ GeV}/c^2$	$\approx 172.44 \text{ GeV}/c^2$	0	
charge	2/3	2/3	2/3	0	
spin	1/2	1/2	1/2	1	
QUARKS	u up	c charm	t top	g gluon	Higgs
	$\approx 4.8 \text{ MeV}/c^2$	$\approx 95 \text{ MeV}/c^2$	$\approx 4.18 \text{ GeV}/c^2$	0	
	d down	s strange	b bottom	0	
LEPTONS	e electron	$\mu$ muon	$\tau$ tau	$\gamma$ photon	Z boson
	$\approx 0.511 \text{ MeV}/c^2$	$\approx 105.67 \text{ MeV}/c^2$	$\approx 1.7768 \text{ GeV}/c^2$	0	
	-1	-1	-1	1	
	1/2	1/2	1/2		
GAUGE BOSONS	$\nu_e$ electron neutrino	$\nu_\mu$ muon neutrino	$\nu_\tau$ tau neutrino	$\nu_W$ W boson	Z boson
	$<2.2 \text{ eV}/c^2$	$<1.7 \text{ MeV}/c^2$	$<15.5 \text{ MeV}/c^2$	$\approx 80.39 \text{ GeV}/c^2$	
	0	0	0	$\pm 1$	
	1/2	1/2	1/2	1	
SCALAR BOSONS					This

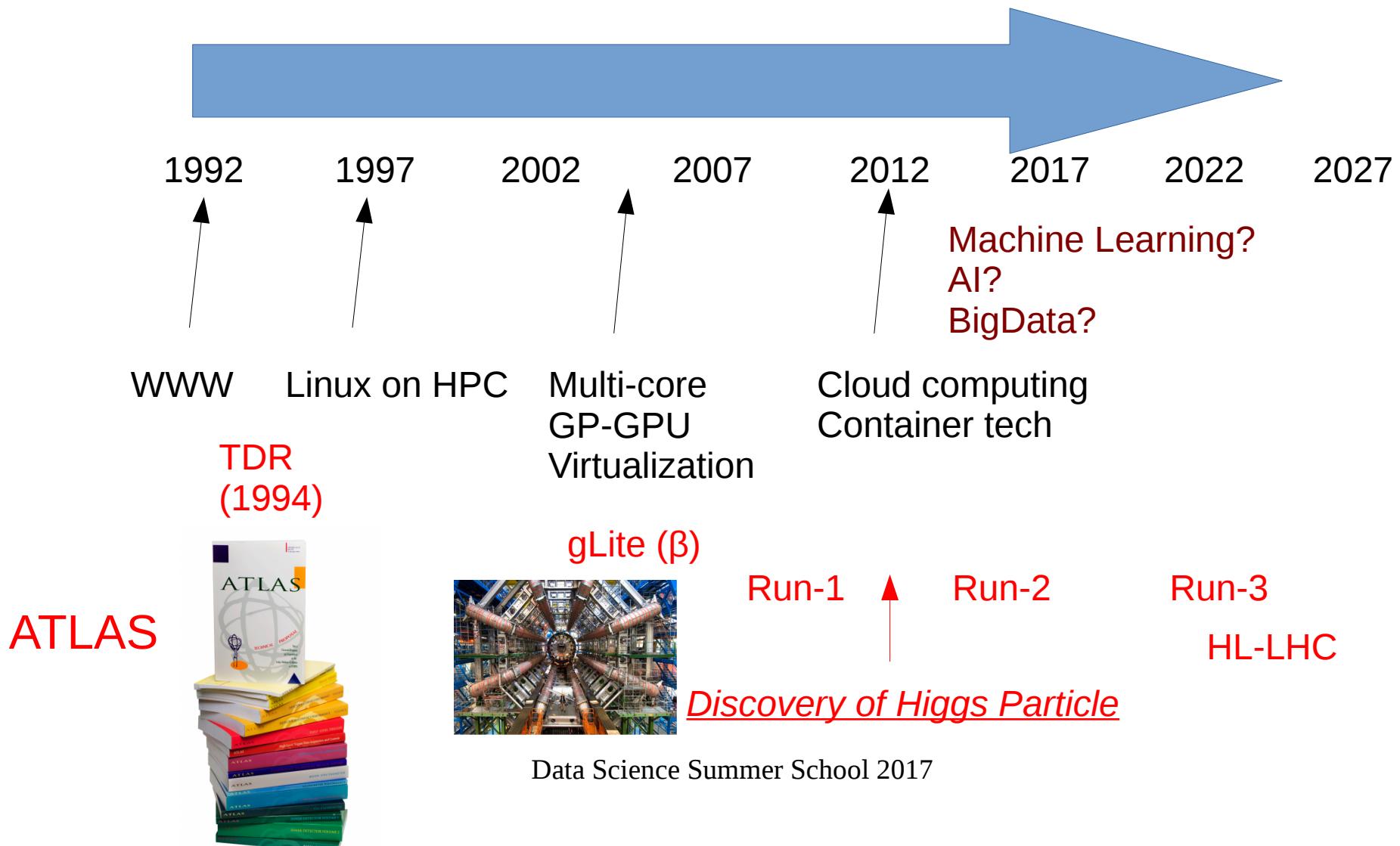
# What are the LHC experiments? - 4

- Has continued since 1992



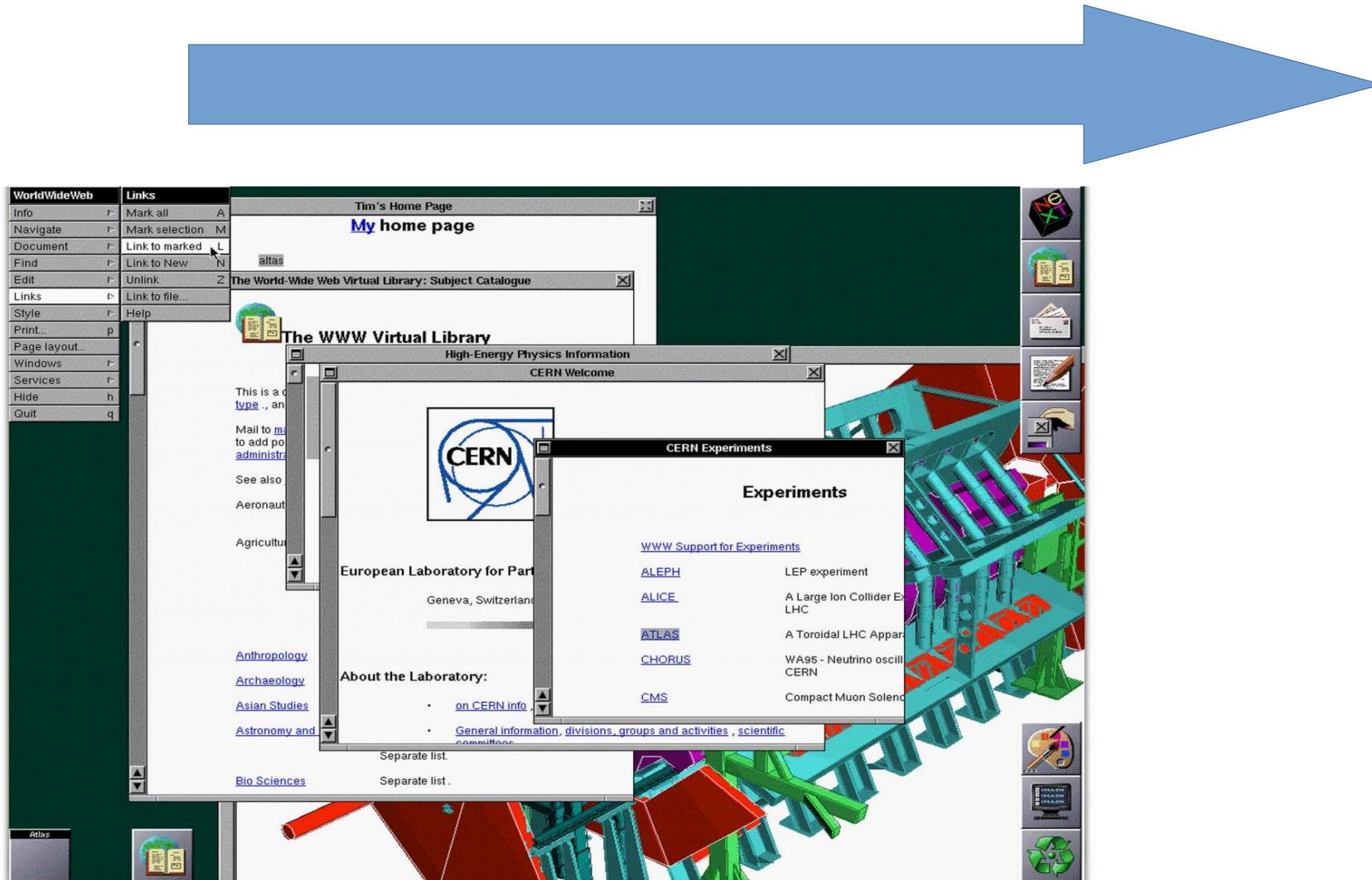
# What are the LHC experiments? - 4

- Has continued since 1992



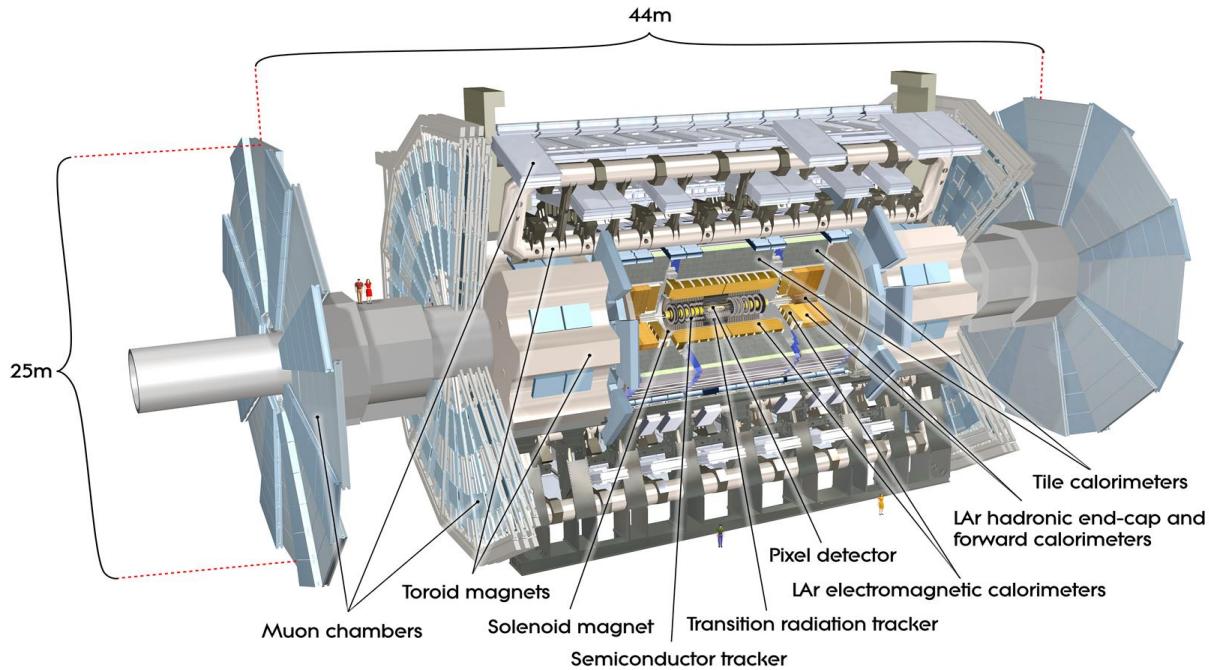
# What are the LHC experiments? - 4

- Has continued since 1992



Screenshot of the original NeXT web browser in 1993 (Image: Berners-Lee/CERN)

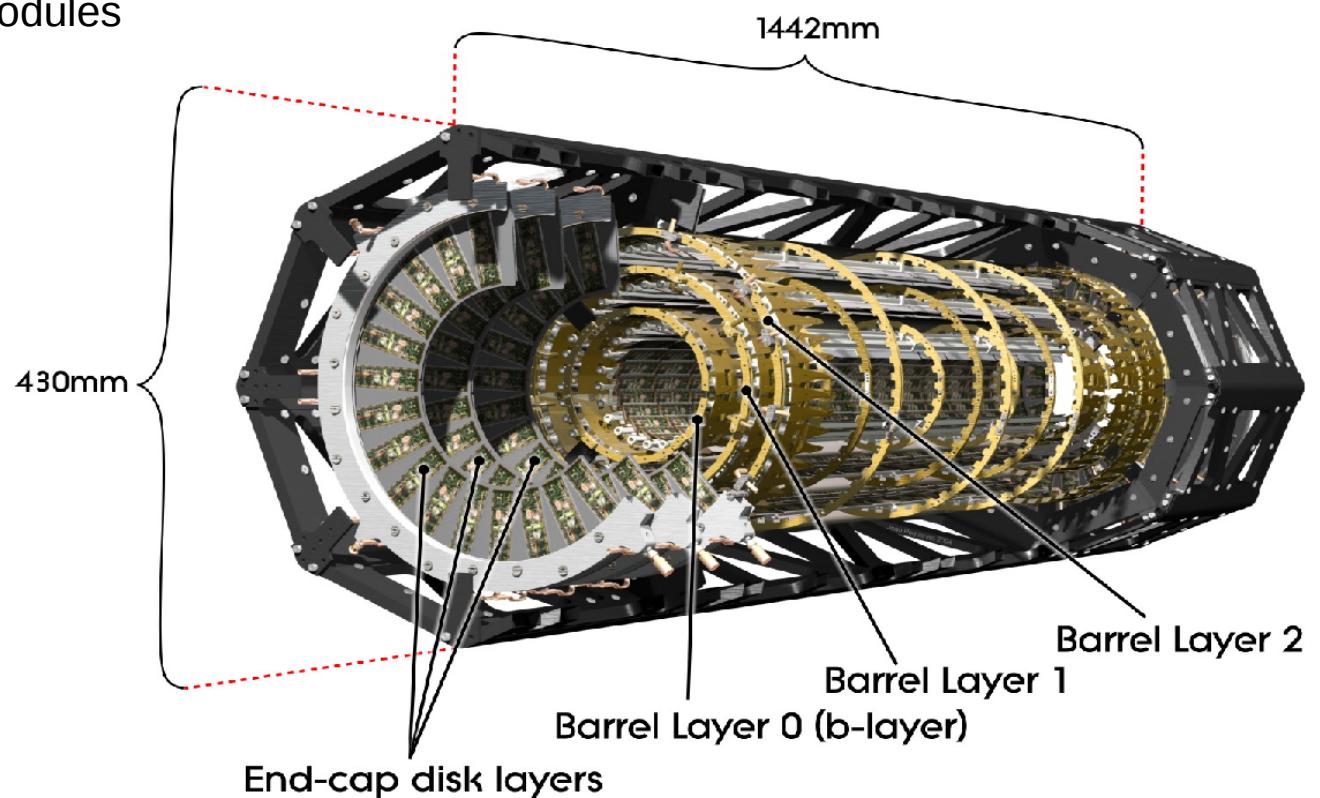
# The ATLAS detector



- General-purpose HEP experiment
  - Reconstruction of outgoing particles from proton-proton collisions at 13TeV
  - pp-rate: 40MHz
  - Length: 46m, Height 25m, Weight 7kt, B-field 4T

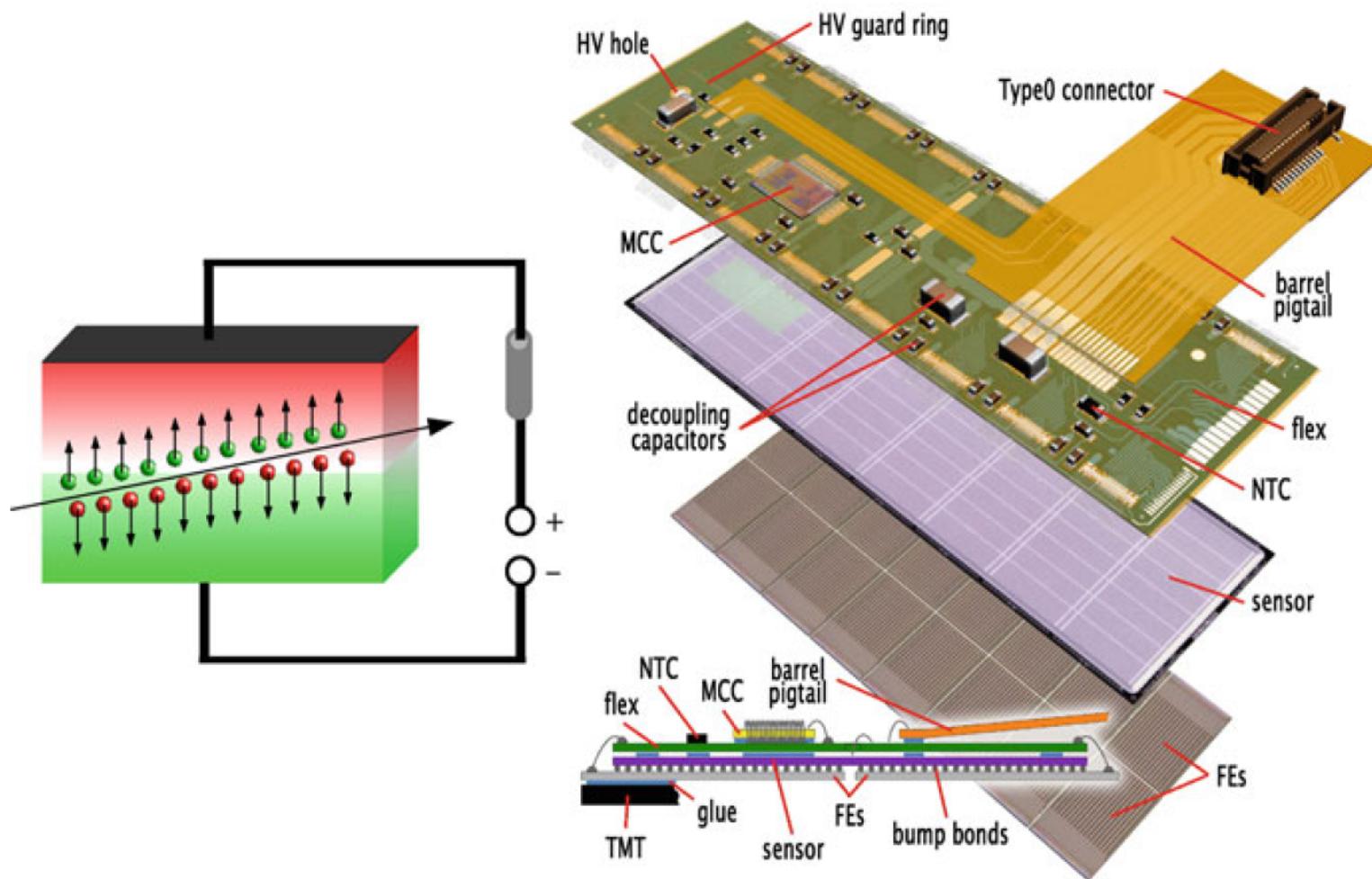
# Inner Pixel Detector - 1

- 80 million pixels (80 million channels). Area  $1.7\text{m}^2$ . 15 kW power consumption
- Barrel has 1,744 modules ( $10\text{cm}^2$ ) with 46,080 readout channels per module
- Pixel size  $50 \times 400\mu\text{m}^2$ . Resolution  $14 \times 115\mu\text{m}^2$
- Three Pixel disks (in each endcap) have 6.6 million channels
- 3 barrel layers: 1,456 modules
- 3 disks in each end-cap: 288 modules

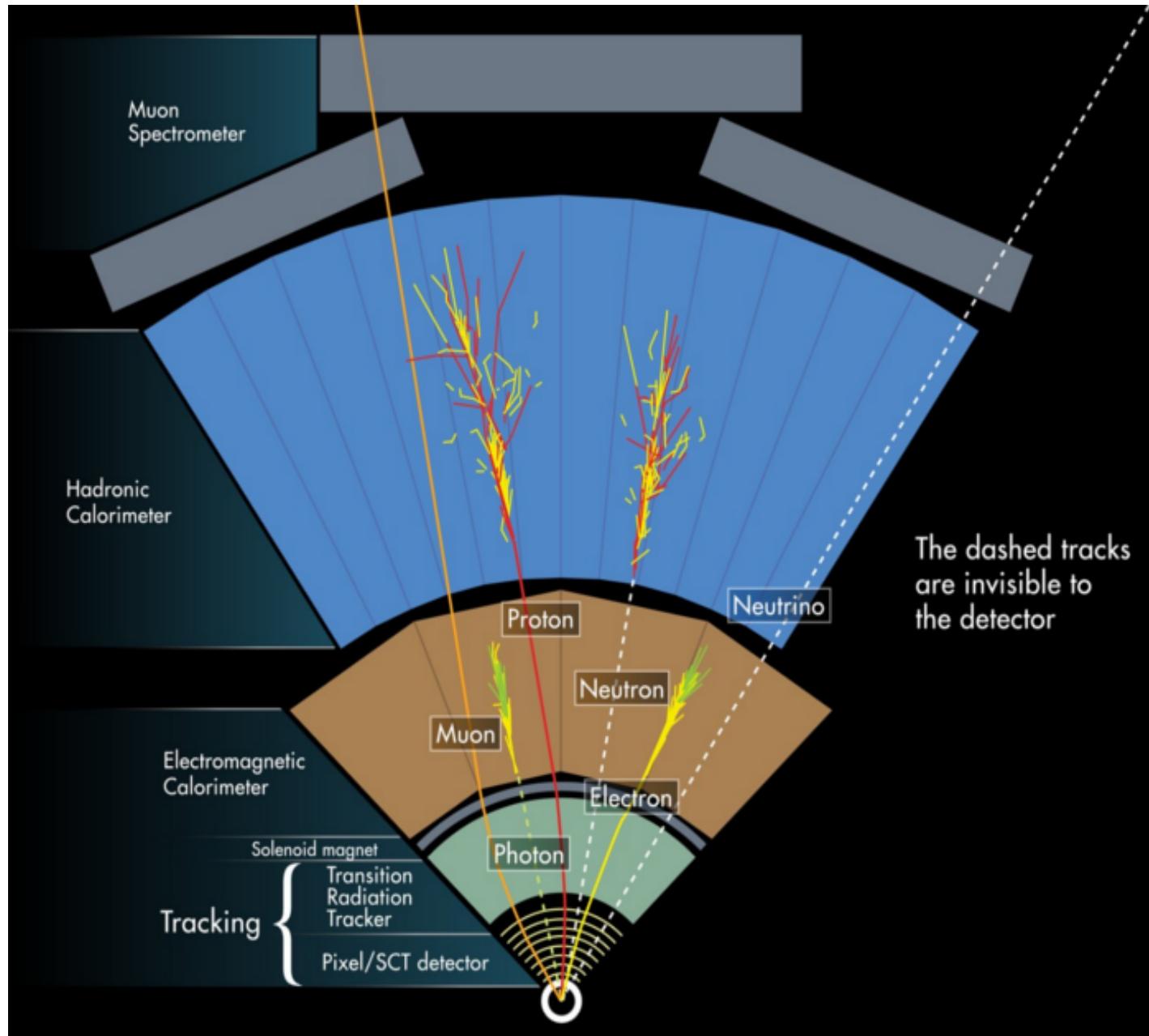


# Inner pixel detector - 2

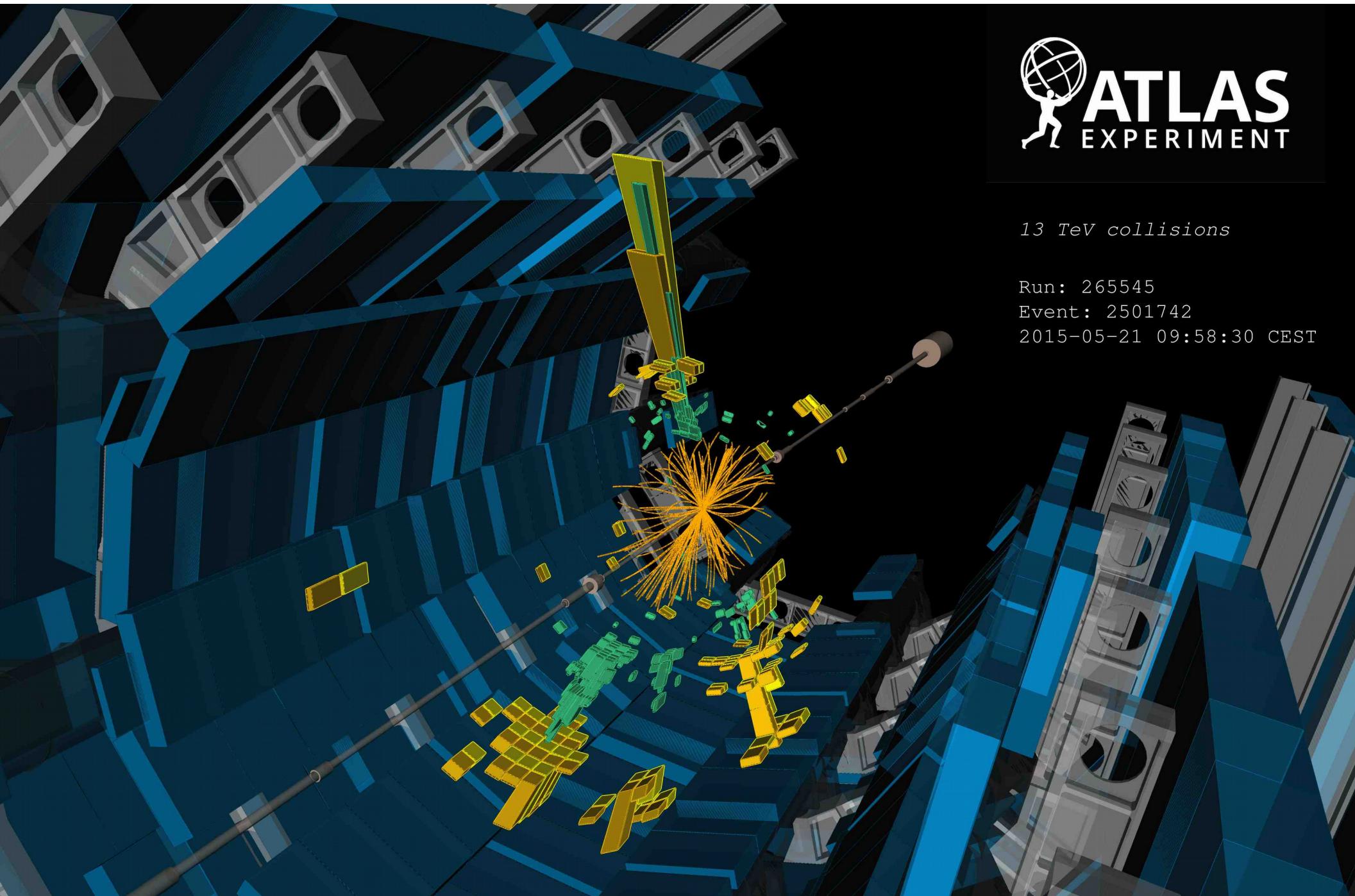
- Works like (very complicated) CCD camera



# Silicon Tracker & Trigger - 2



# One event



13 TeV collisions

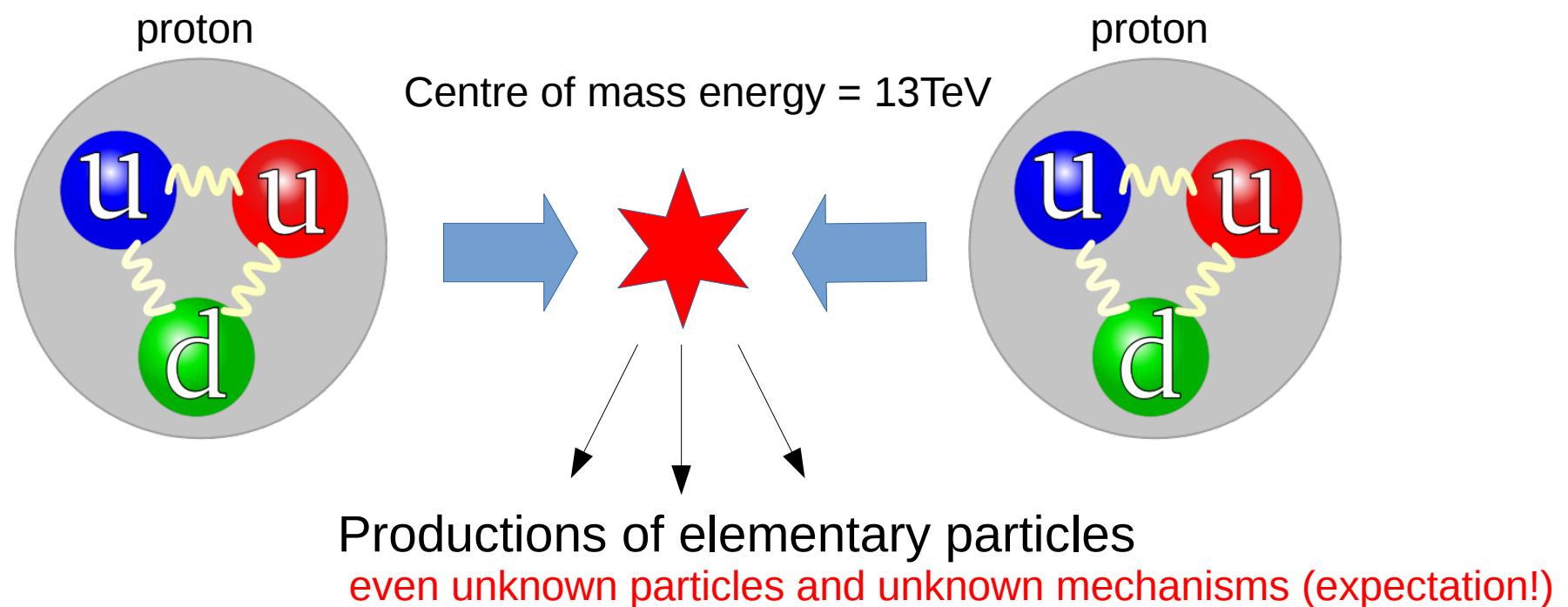
Run: 265545

Event: 2501742

2015-05-21 09:58:30 CEST

# Basic Physics - 1

- Proton-Proton (Hadron-Hadron) Collisions
  - Proton = 2 Up quarks, 1 Down quark bound by Gluons (strong force)



# Basic Physics - 2

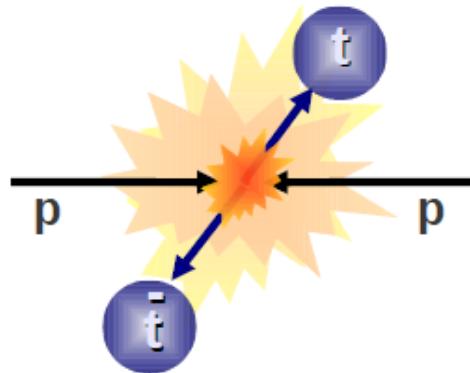
- Production of Teilchenzoo (particle zoo)



# Basic Physics - 3

- For example, Top-Quark production

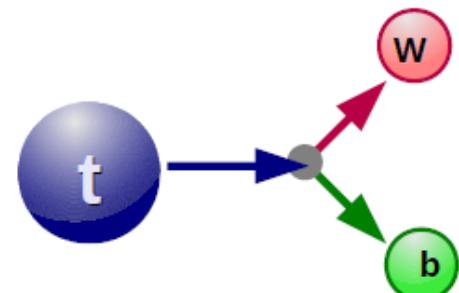
## Production:



## Intrinsic properties:



## Decay:



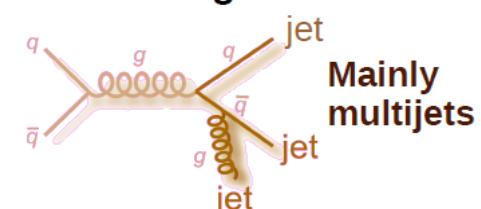
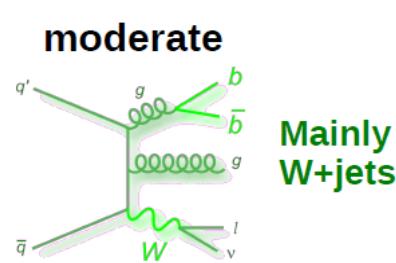
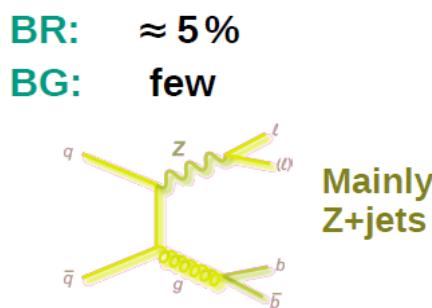
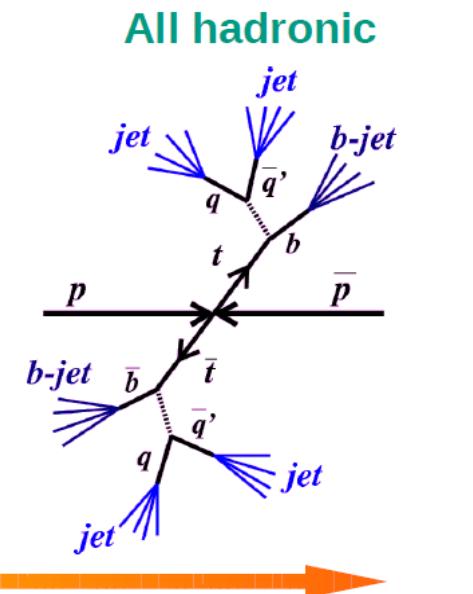
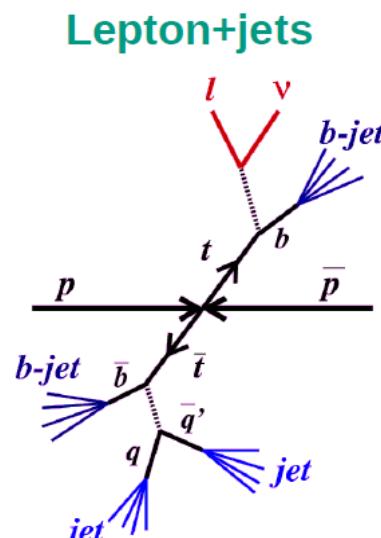
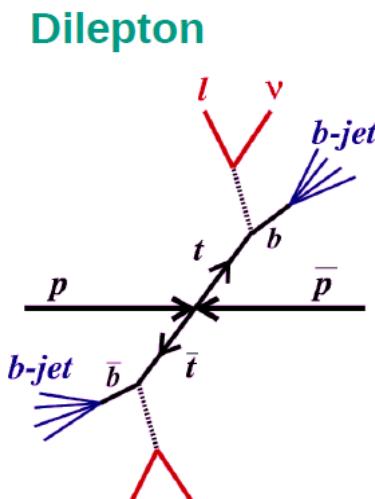
- Production rate of different processes (*strong and EW*)
- Differential distributions
- New production mechanisms

- Top quark mass  $\rightarrow$  constraints on Higgs mass
- Charge
- Lifetime

- Decay channels (*SM and new*)
- Couplings

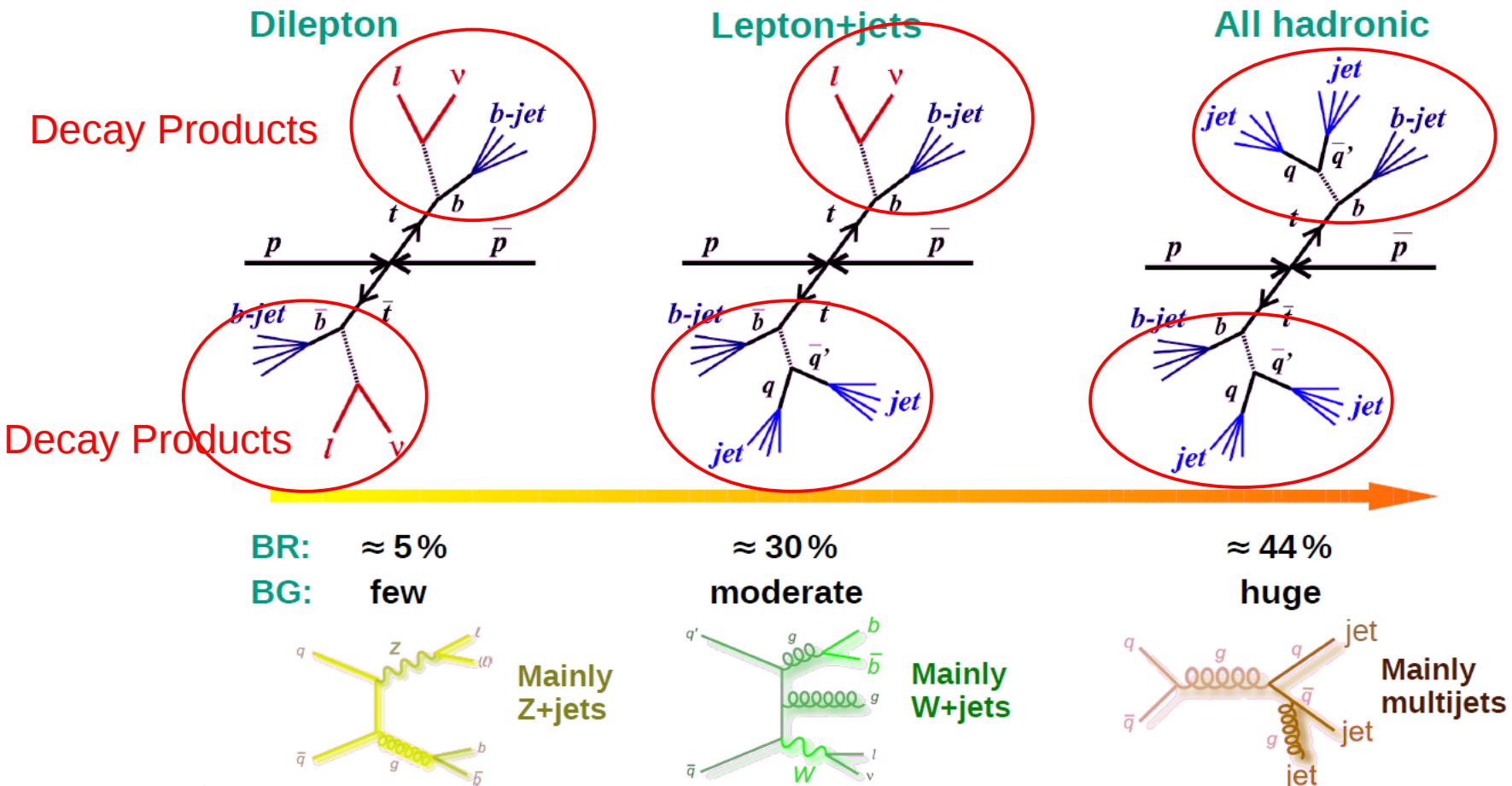
# Basic Physics - 4

- For example, Top-Quark production
  - Event signatures



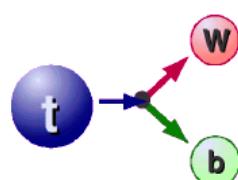
# Basic Physics - 5

- For example, Top-Quark production
  - Event signatures



# Basic Physics - 6

- For example, Top-Quark production
  - Decay products

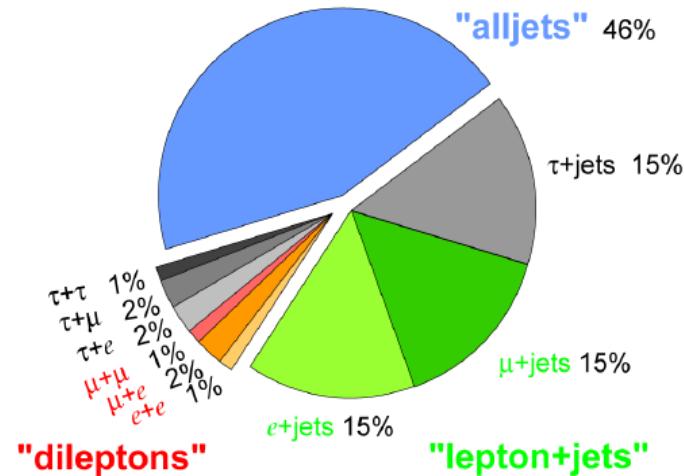


SM:

$$t \rightarrow b W \approx 100\%$$

Decay of top quark pairs

$\bar{c}s$	electron+jets	muon+jets	tau+jets	all-hadronic
$\bar{u}d$				
$-\tau$	$e\tau$	$\mu\tau$	$\tau\tau$	tau+jets
$-\mu$	$e\mu$	$\mu\tau$	$\mu\tau$	muon+jets
$-e$	$e\mu$	$e\mu$	$e\tau$	electron+jets
$W$ decay	$e^+$	$\mu^+$	$\tau^+$	$u\bar{d}$
				$c\bar{s}$



**"lepton+jets"-channel:**  
( $e+\text{jets}$  and  $\mu+\text{jets}$ )

- Moderate background
- Relative high branching ratio (~30%)

# ATLAS Grid computing and WLCG resources - 1

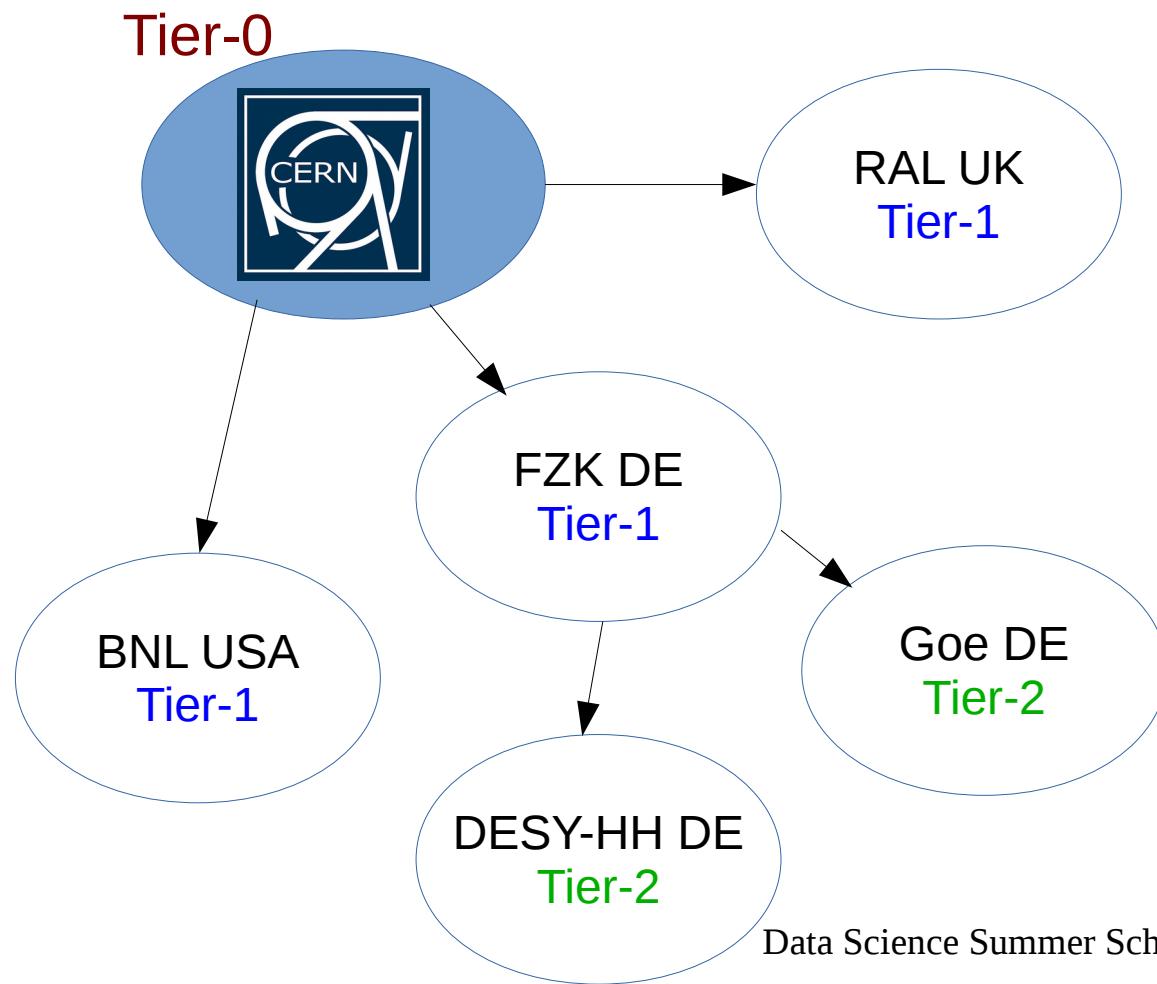
- World LHC Computing Grid (WLCG)
  - The most sophisticated data-taking & analysis system ever built for science, providing near real-time access to LHC data
  - 2 million computing jobs per day
  - 42 countries
  - 170 computing centres



# ATLAS Grid computing and WLCG resources - 2

- LHC multi-tier structure

- WLCG = Worldwide LHC Computing Grid



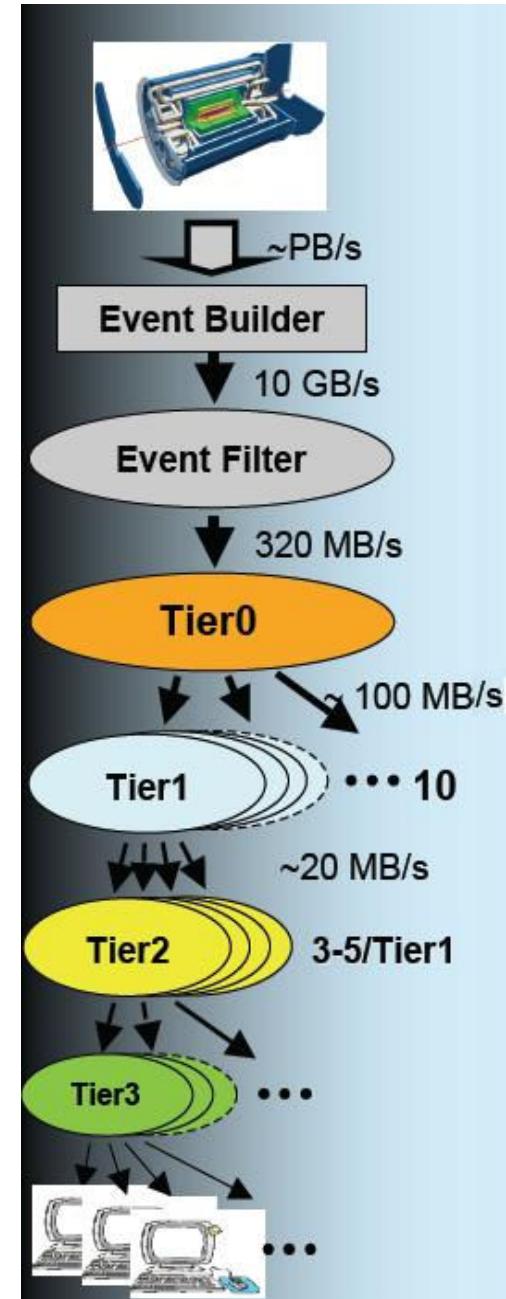
**Tier-0:** Raw data, Data store (in tape), Pre-processing, Reconstruction

**Tier-1:** National LCG-Centre, faster network connections and larger storage spaces (e.g. Tape), MC production, user analysis, etc.

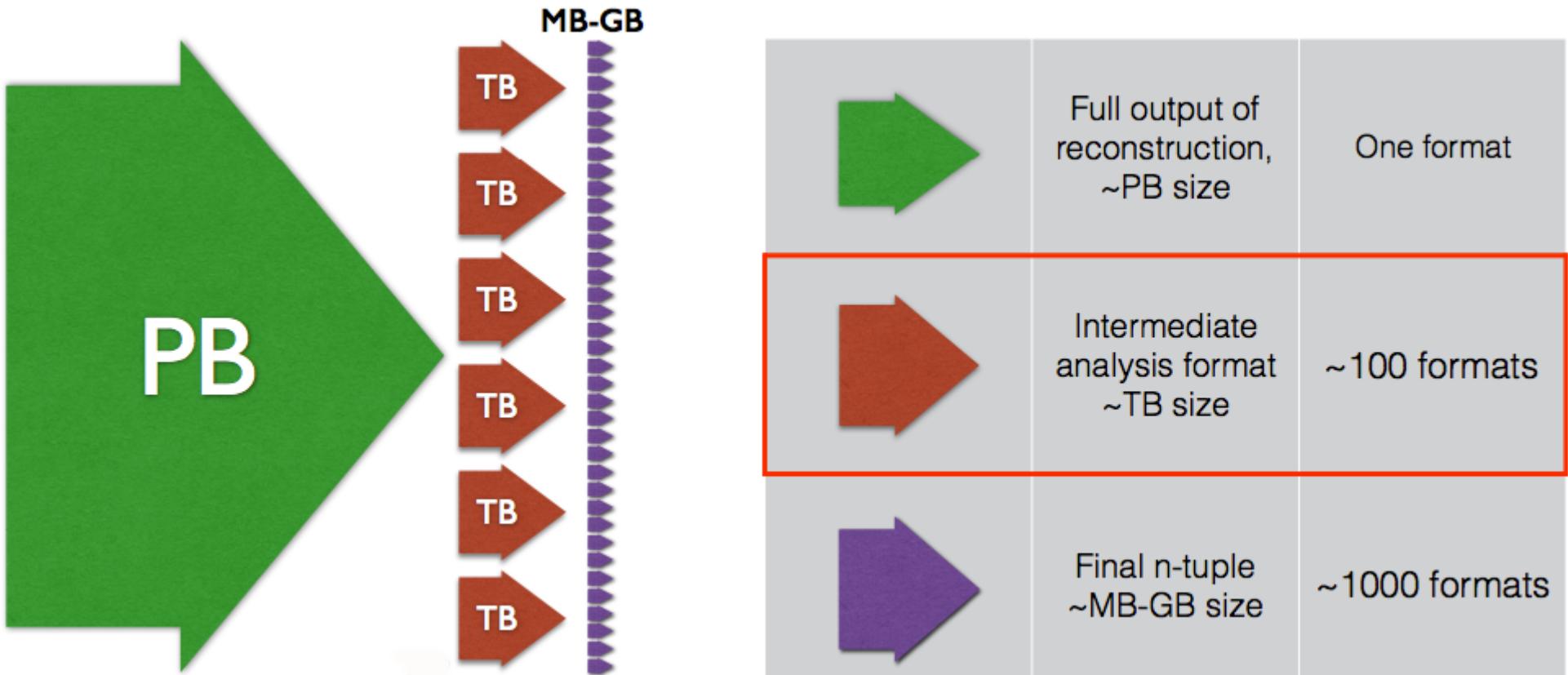
**Tier-2:** University or Facility level computing sites. MC production, user analysis, etc.

# Data flow in ATLAS

- **RAW** = about 2 MB/event
  - Original data at **Tier-0** (ATLAS detector)
  - Complete replica distributed among all **Tier-1s**
- **ESD (Event Summary Data)** = 1 MB/event
  - ESDs produced by primary at **Tier-1s**
  - Globally 2 copies on disk
- **AOD (Analysis Object Data)** = 0.2 MB/event
  - Completely replicated at each **Tier-1**
  - Partially replicated to **Tier-2s** so as to have a complete set in the **Tier-2s** associated to each national **Tier-1**
  - Every **Tier-2** specifies which datasets are most interesting for their reference community; the rest are distributed according to capacity
- **TAG (Event Level Metadata Tags)** = 1 kB/event
  - TAG files or databases are replicated to all **Tier-1s** (Root/Oracle)
  - Partial replicas of the TAG are distributed to **Tier-2s** as Root files
  - Each **Tier-2** have all TAGs that correspond to the AODs stored



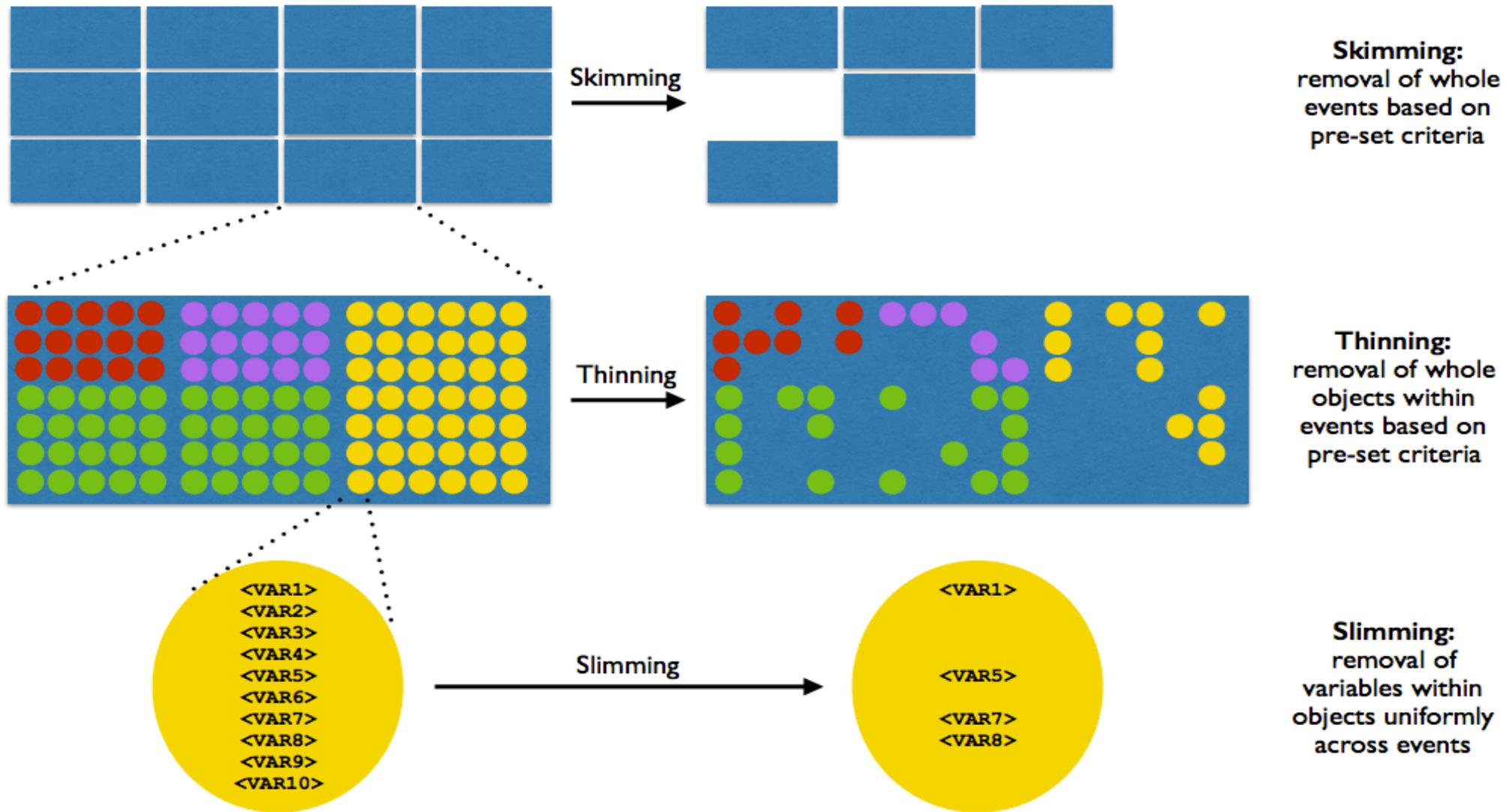
# Event Data Model (EDM) in ATLAS



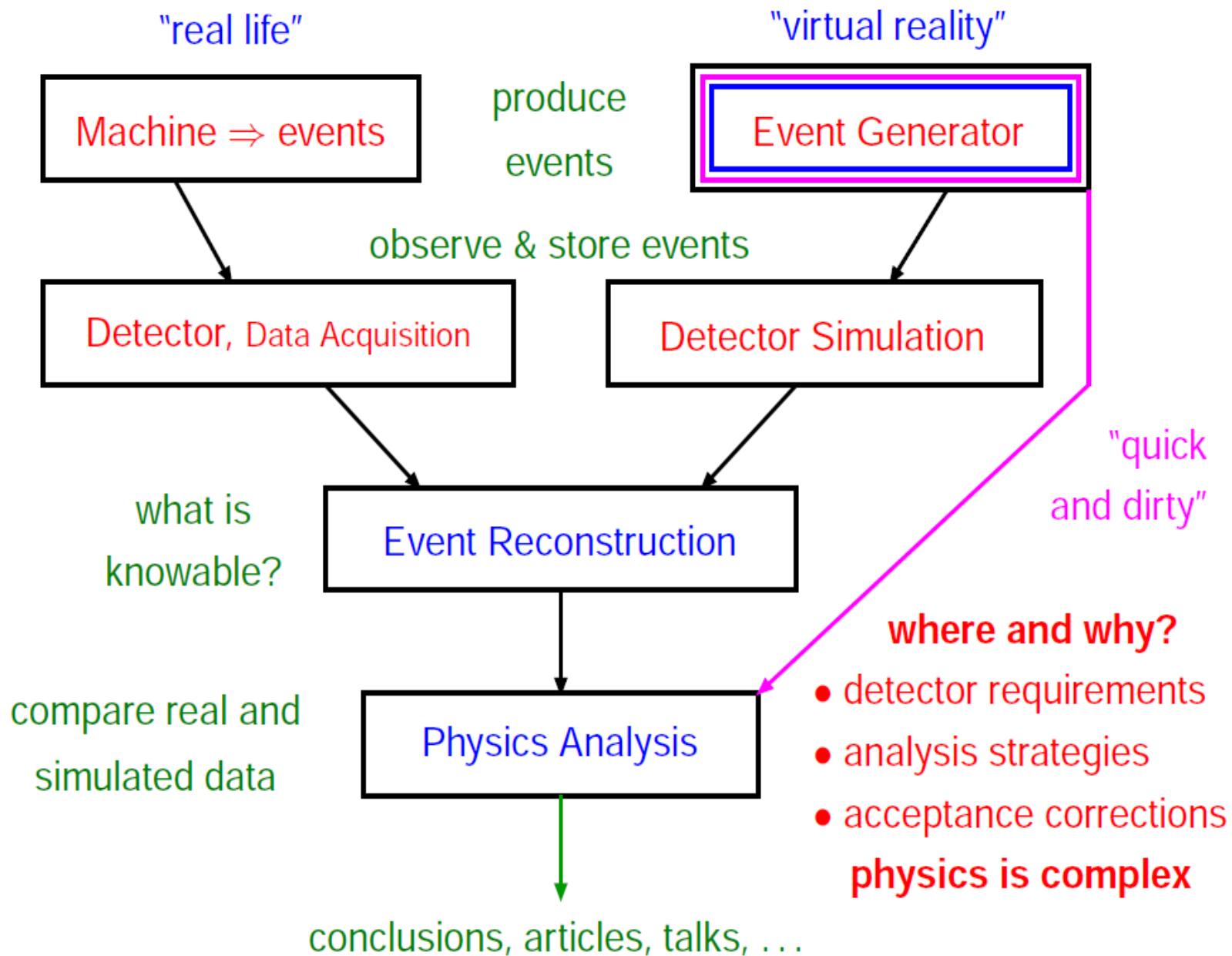
- AODs are still huge, so need to have manageable size of data → Derived AOD (DAOD)
- Derivation framework in Athena (ATLAS software framework)
- Each analysis group use own derivation framework

# Event Data Model (EDM) in ATLAS

- Size reduction (= selection of events, particles and parameters)



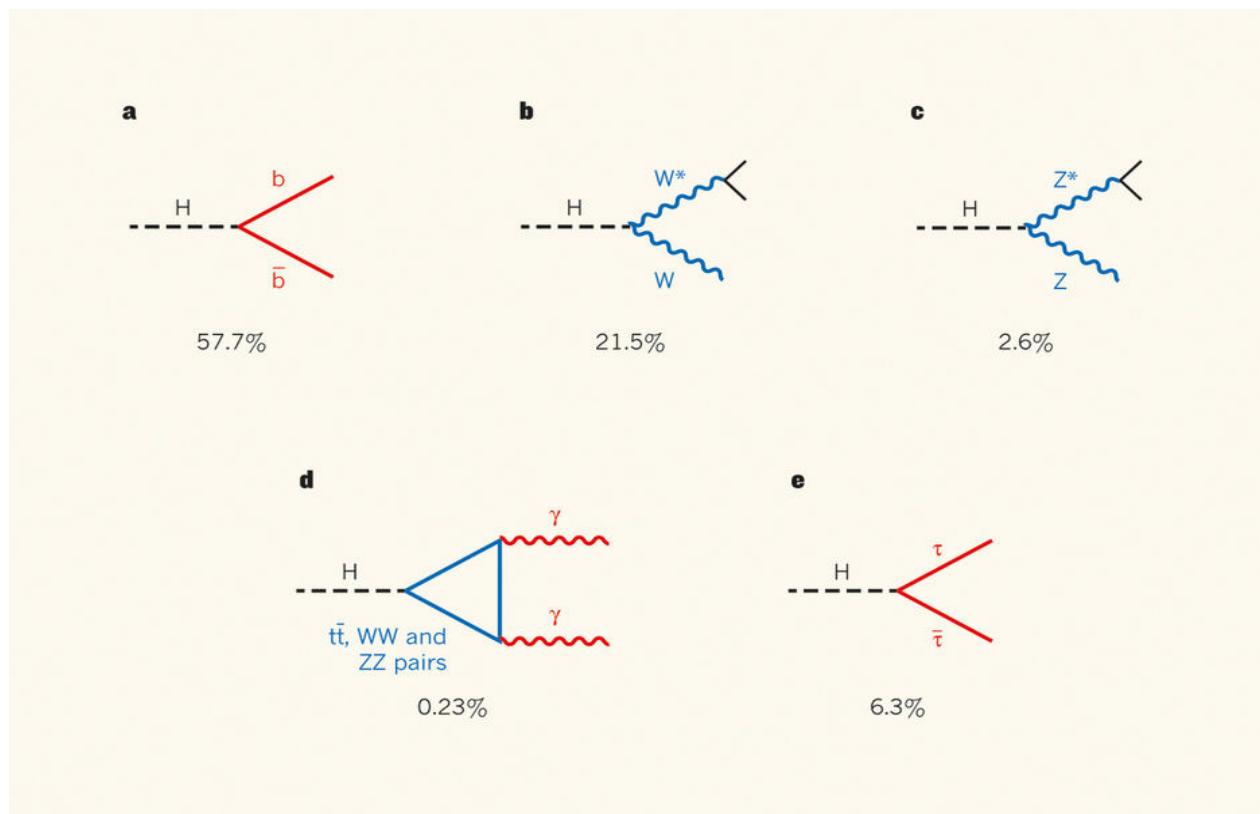
# Basis of data analysis - 1



# Basis of data analysis - 2

- Higgs decay channel

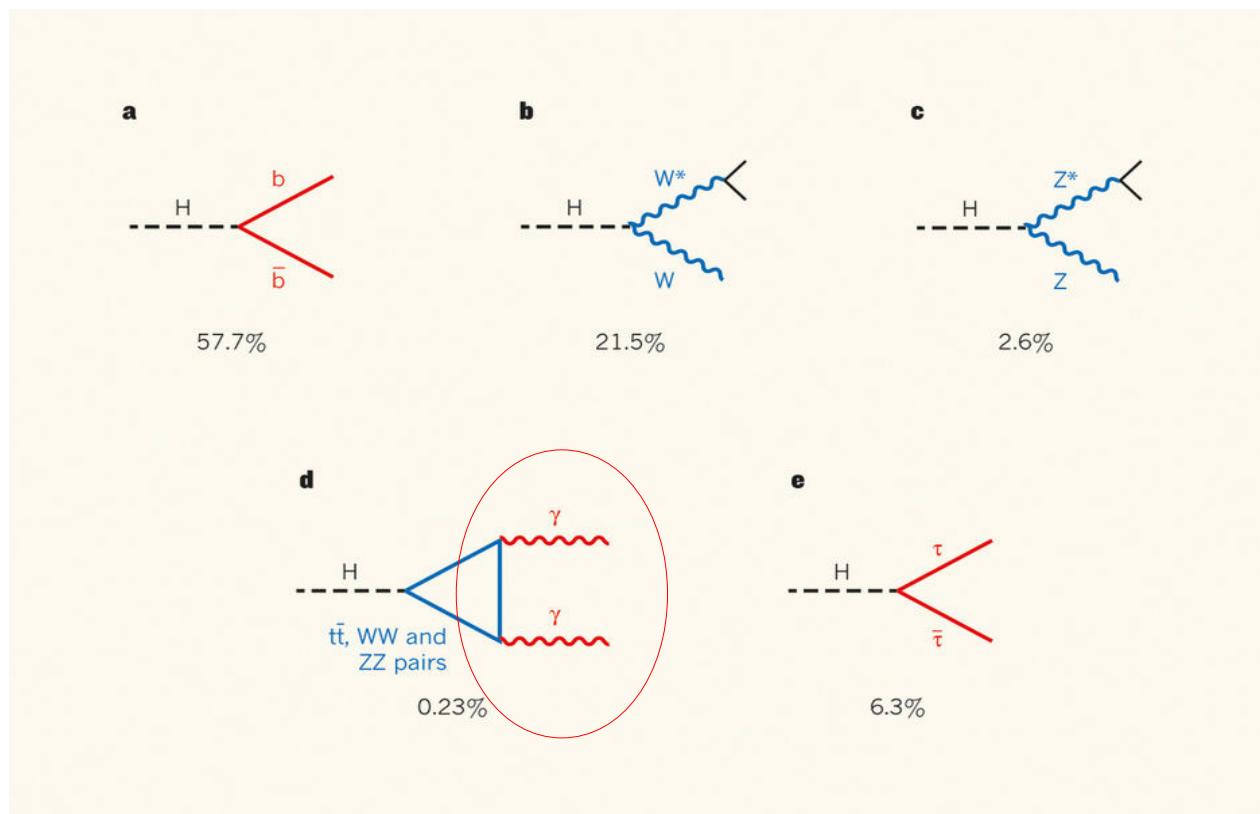
- 1 EUR  $\rightarrow$  50 + 50 cent
- 1 EUR  $\rightarrow$  50 + 20 + 10 cent
- 1 EUR  $\rightarrow$  20 + 20 + 20 + 20 + 20 cent
- 1 EUR  $\rightarrow$  50 + 20 + 10 + 10 + 10 cent



# Basis of data analysis - 2

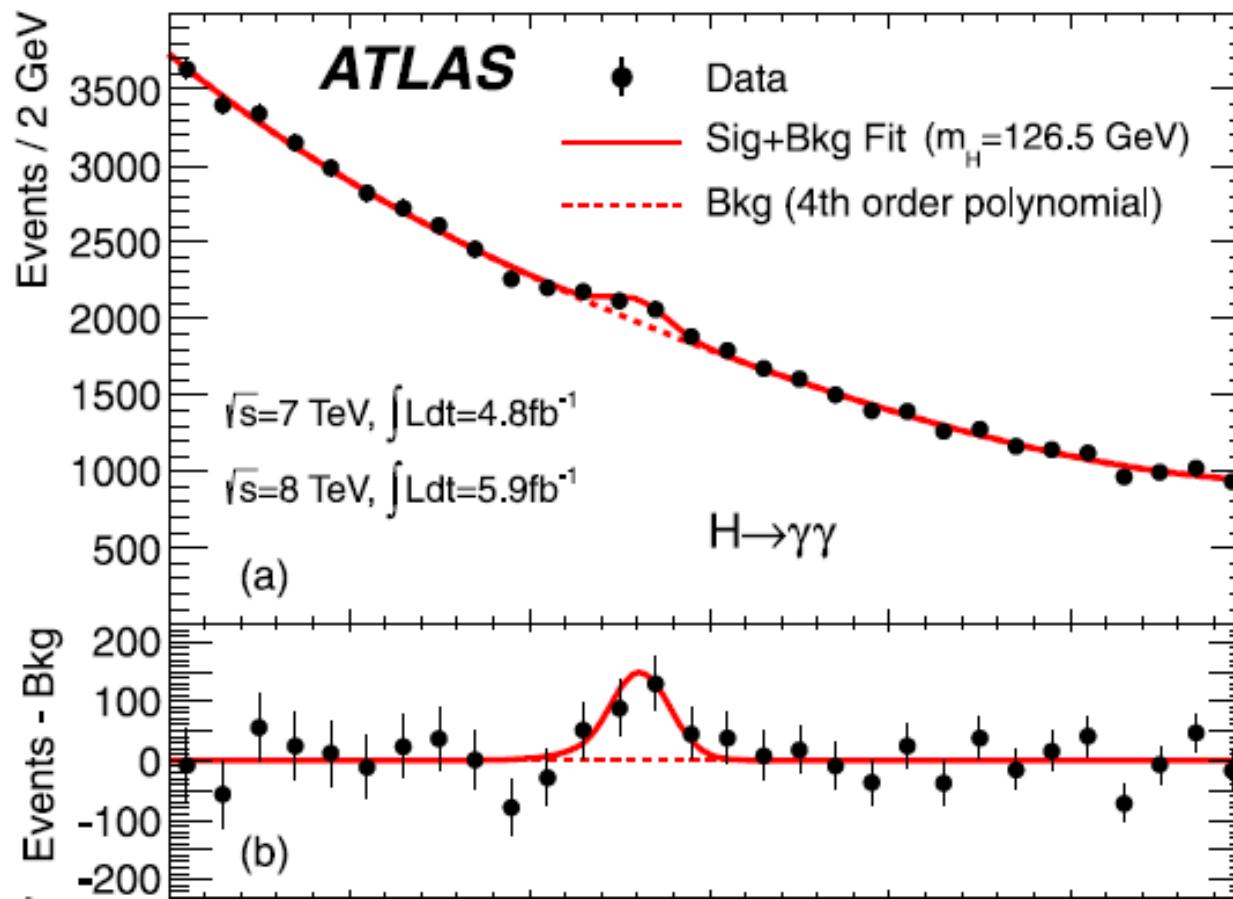
- Higgs decay channel

- 1 EUR  $\rightarrow$  50 + 50 cent
- 1 EUR  $\rightarrow$  50 + 20 + 10 cent
- 1 EUR  $\rightarrow$  20 + 20 + 20 + 20 + 20 cent
- 1 EUR  $\rightarrow$  50 + 20 + 10 + 10 + 10 cent



# Basis of data analysis - 3

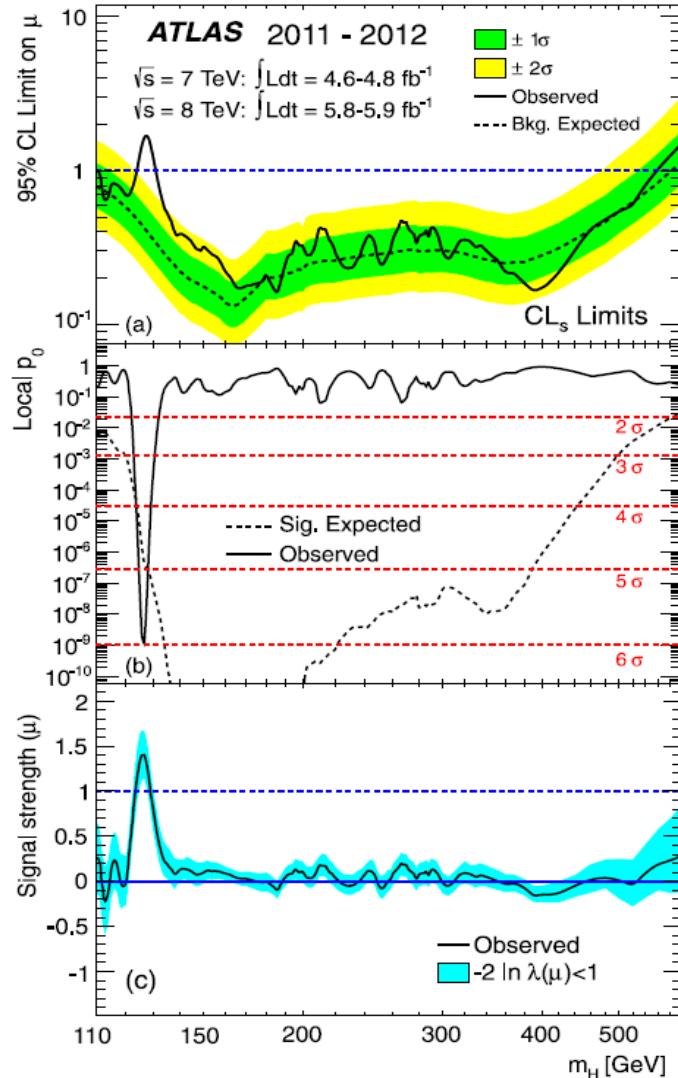
- Atlas Collaboration. "Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC." arXiv preprint arXiv:1207.7214 (2012).



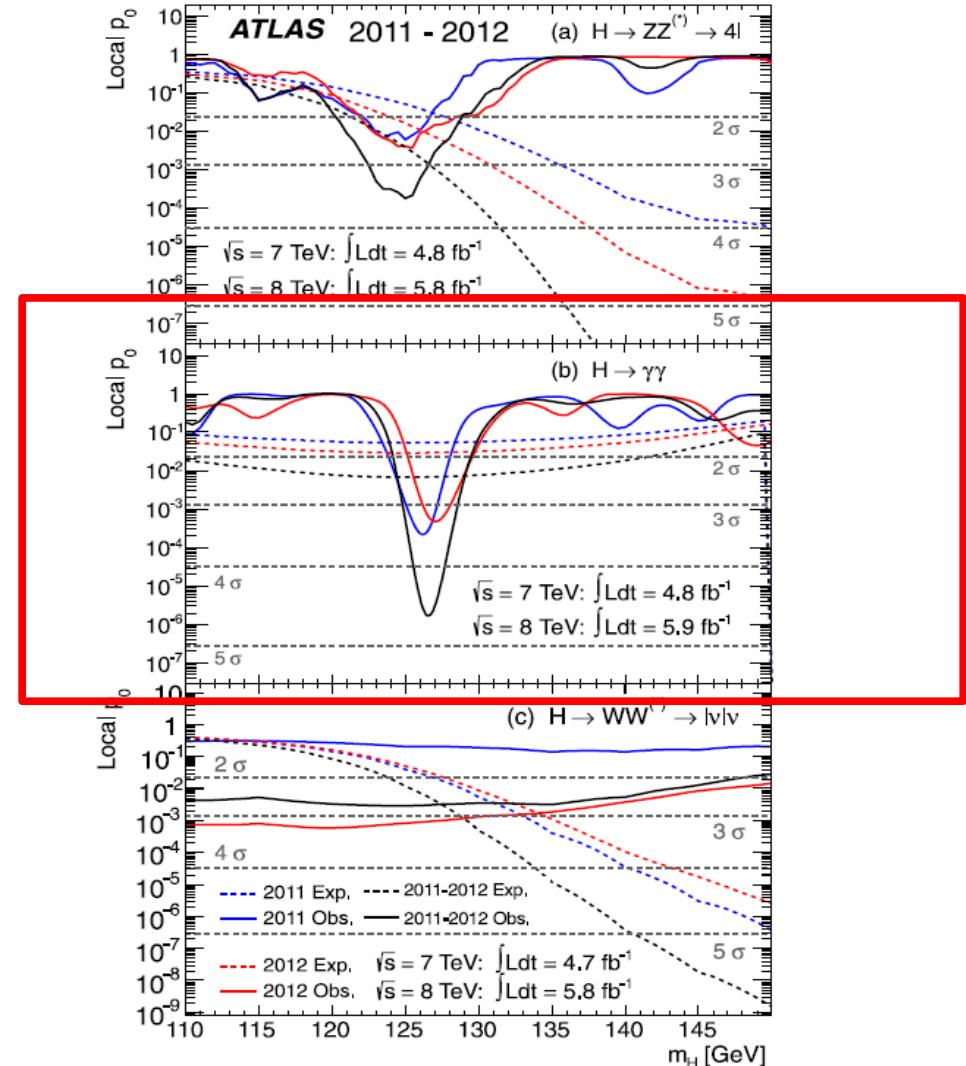
# Basis of data analysis - 4

ATLAS Collaboration / Physics Letters B 716 (2012) 1–29

13



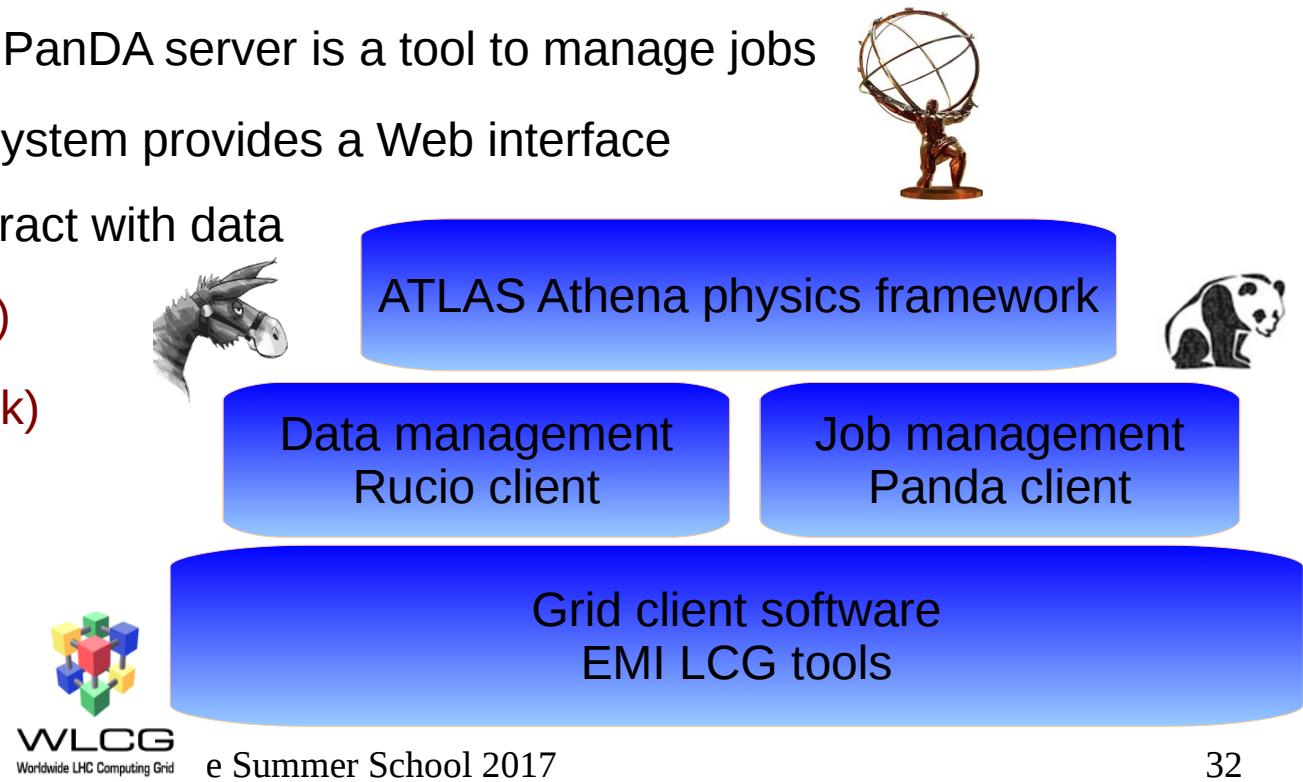
**Fig. 7.** Combined search results: (a) The observed (solid) 95% CL limits on the signal strength as a function of  $m_H$  and the expectation (dashed) under the background-only hypothesis. The dark and light shaded bands show the  $\pm 1\sigma$  and  $\pm 2\sigma$  uncertainties on the background-only expectation. (b) The observed (solid) local  $p_0$  as a



**Fig. 8.** The observed local  $p_0$  as a function of the hypothesised Higgs boson mass for the (a)  $H \rightarrow ZZ^{(*)} \rightarrow 4\ell$ , (b)  $H \rightarrow \gamma\gamma$  and (c)  $H \rightarrow WW^{(*)} \rightarrow l\bar{l}v\bar{v}$  channels. The dashed curves show the expected local  $p_0$  under the hypothesis of a SM Higgs boson signal at that mass. Results are shown separately for the  $\sqrt{s} = 7 \text{ TeV}$  data (dark blue in the web version), the  $\sqrt{s} = 8 \text{ TeV}$  data (light red in the web version)

# Basic Tools: ATLAS CLI and CVMFS

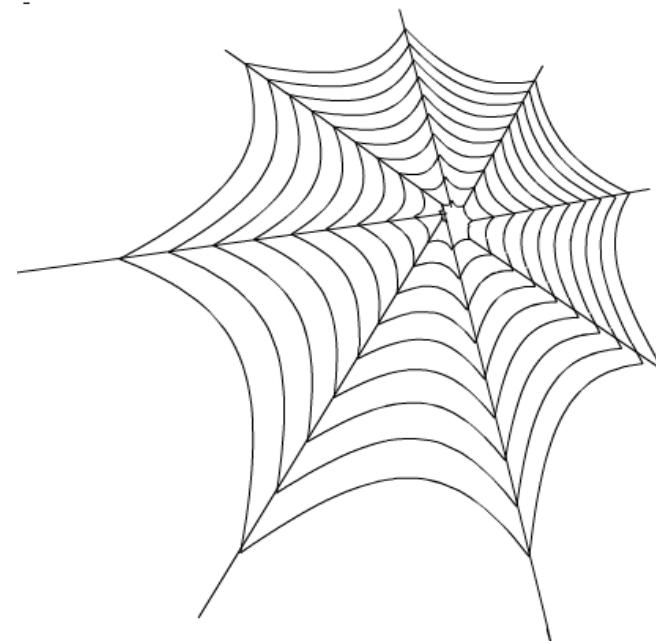
- Grid client software originally supported by *European Middleware Initiative (EMI)*
- CVMFS is a remote repository using FUSE file system
  - e.g. /cvmfs/atlas.cern.ch → A repository of all client software we need
  - Internally using HTTP → Need of network access
- PanDA client using ATLAS PanDA server is a tool to manage jobs
  - BigPanda monitoring system provides a Web interface
- Rucio client is a tool to interact with data
- ATLAS framework (Athena)
- ROOT (c++ HEP framework)



# CVMFS (CERN VM File-System)

- Before CVMFS
  - Problems of distribution of common High Energy Physics software environments
  - Needed to build every software release in every university/facility
- After CVMFS
  - Everything is centrally managed/updated
  - Nightly build is also available
  - Nothing to do (e.g. build of every update) in local PCs / Clusters
  - Using general http proxy system like Squid → less network access and robust

# ATLAS Metadata Interface (AMI)

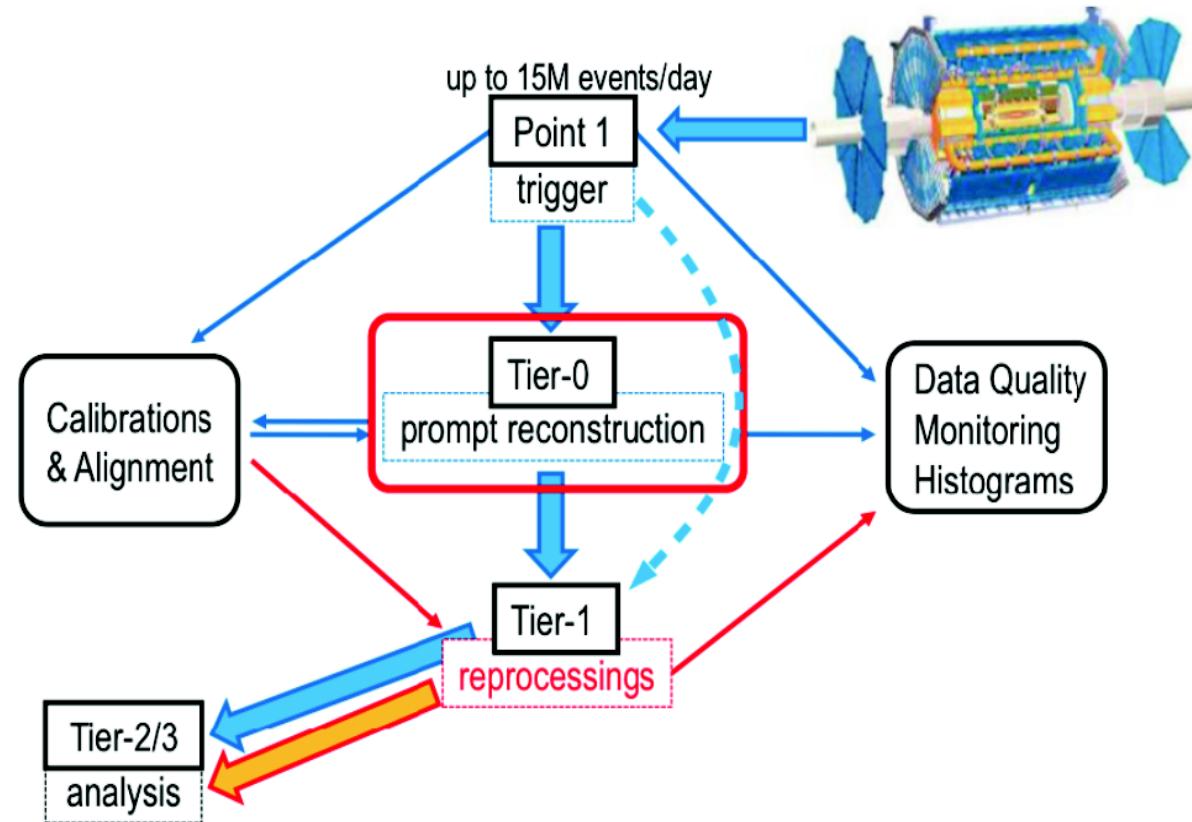


# AMI (ATLAS Metadata Interface)

- **Metadata = Data of Data (Description of data)**
- Key of ATLAS Data Life Cycle Management
- On each step of data reconstruction in ATLAS, AMI Tags are generated
  - ATLAS data set, metadata link
    - Size and origin of dataset
    - File, number of events
    - Software parameter (AMI Tags)
    - MC parameter (PDF, generator, cross section, etc)
    - Lost files and Lumi blocks
    - Link to other applications (COMA, Rucio)
    - Data period
      - Luminosity, Trigger, Data of RAW data creation etc
  - Special Interface
    - AMI-Tags
      - Software Configuration Parameters
    - AMI-Glance
      - Data + Publication
    - Definition of data periods
    - Definition of physics containers
    - Reprocessing campaigns
    - Event count comparator

# ATLAS Dataset - 2

- Tier-0
  - RAW is produced
  - Prompt data reconstruction
- ProdSys2
  - MC + Reprocessing
  - PanDA, JEDI, DEFT
- Distribution of dataset
  - Rucio



# ATLAS Dataset - 3

- Data reconstruction → Example : x353 = AMI tag
  - `Reco_tf.py —AMI=x353 --inputBSFile=tier0_RawData.data`
- Reprocessing Campaign
  - After improvement of ATLAS software or framework, often huge reconstruction jobs can run
    - The campaign require many computing resources
    - As a result, many different versions of AOD (Analysis Object Data)
      - Derivation framework: AOD → Derived AOD
      - About 1% size of original AOD
      - Selection of particular event, parameter etc
      - Different configurations, software and conditions

# ATLAS Dataset - 4

- Dataset = Collection of files
  - Collision data (data) and Monte Carlo (mc)

## Data:

project tag:  
2012 pp data  
8 TeV      Run number      stream      merged files      Data type:  
data12\_8TeV.00209980.physics\_Egamma.merge.AOD.f476\_m1223  
  
AMI tag describes configuration of  
each step (Tier-0 bulk reconstruction **f**,  
file merging **m**)

## Simulation:

project tag: MC DSID  
"mc12" setup      unique #  
8 TeV      for process      "human-readable" description of MC sample      merged files      Data type:  
mc12\_8TeV.119353.MadGraphPythia\_AUET2BCTEQ6L1\_ttbarW.merge.NTUP\_SMWZ.  
e1352\_s1499\_s1504\_r3658\_r3549\_p1328/  
  
AMI tag describes configuration of  
each step (evt generation **e**, full simulation **s**,  
reconstruction **r**, D3PD creation **p**)  
/: is a "container" (points to other datasets)

# AMI WebUI - 1

Datasets / Dataset Browser

Search Form 1: data12\_001-real\_data

1 dataset 1075 records

Query :dataset.amiStatus='VALID' AND (dataset.dataType like 'AOD') AND (dataset.streamName like 'physics\_MinBias')

more fields +	logicalDatasetName ▾ Q	nFiles ▾ Q	totalEvents ▾ Q	totalSize ▾ Q	runNumber ▾ Q	period ▾ Q
<a href="#">details</a>	data12_8TeV.00200804.physics_MinBias.merge.AOD.r4644_p1517 DQ2 - Provenance - GANGA export	18 182	585918 11645642	68.699 GB	200804 COMA Report - Periods - Run_Summary - Run_Query - DAQ_Config	A1 more Info - COMA - All Runs
<a href="#">details</a>	data12_8TeV.00200805.physics_MinBias.merge.AOD.r4644_p1517 DQ2 - Provenance - GANGA export	2	54277	1.881 GB	200805 COMA Report - Periods - Run_Summary - Run_Query - DAQ_Config	A2 more Info - COMA - All Runs
<a href="#">details</a>	data12_8TeV.00200841.physics_MinBias.merge.AOD.r4644_p1517 DQ2 - Provenance - GANGA export	4	186265	20.177 GB	200841 COMA Report - Periods - Run_Summary - Run_Query - DAQ_Config	A3 more Info - COMA - All Runs
<a href="#">details</a>	data12_8TeV.00200842.physics_MinBias.merge.AOD.r4644_p1517 DQ2 - Provenance - GANGA export	4	194266	17.213 GB	200842 COMA Report - Periods - Run_Summary - Run_Query - DAQ_Config	A3 more Info - COMA - All Runs
<a href="#">details</a>	data12_8TeV.00200863.physics_MinBias.merge.AOD.r4644_p1517 DQ2 - Provenance - GANGA export	4	99639	15.288 GB	200863 COMA Report - Periods - Run_Summary - Run_Query - DAQ_Config	A3 more Info - COMA - All Runs
<a href="#">details</a>	data12_8TeV.00200913.physics_MinBias.merge.AOD.r4644_p1517 DQ2 - Provenance - GANGA export	4	120898	16.403 GB	200913 COMA Report - Periods - Run_Summary - Run_Query - DAQ_Config	A3 more Info - COMA - All Runs
<a href="#">details</a>	data12_8TeV.00200928.physics_MinBias.merge.AOD.r4644_p1517 DQ2 - Provenance - GANGA export	2	47551	7.145 GB	200928 COMA Report - Periods - Run_Summary - Run_Query - DAQ_Config	A4 more Info - COMA - All Runs
<a href="#">details</a>	data12_8TeV.00200965.physics_MinBias.merge.AOD.r4644_p1517 DQ2 - Provenance - GANGA export	8	290279	36.652 GB	200965 COMA Report - Periods - Run_Summary - Run_Query - DAQ_Config	A4 more Info - COMA - All Runs
<a href="#">details</a>	data12_8TeV.00200982.physics_MinBias.merge.AOD.r4644_p1517 DQ2 - Provenance - GANGA export	2	40071	7.092 GB	200982	A4

1: number of results  
2: default order, more recent first

3: query clauses  
4: +/- fields  
5,6: filter,calculator

7: conversion of units  
8: group by, order by tools

# AMI WebUI - 2

Element's information		Children elements	
logicalDatasetName	mc14_8TeV.129173.Pythia8_AU2CTEQ6L1_gammajet_DP140.merge.AOD.e1146_s1896_s1912_r5591_r5625 RucioInfo Provenance - Campaigns - GANGA export - Series	dataset_extra	4 Records
physicistResponsible	c.gwenlan1@physics.ox.ac.uk	dataset_keywords	5 Records
nFiles	200	dataset_comment	No records found
totalEvents	999500	files	200 Records
totalSize	672.801 GB	jobOptions	No records found
dataType	AOD	prodsys_task	1 Records
prodsysStatus	ALL EVENTS AVAILABLE	field	approx_crossSection
ECMEnergy	8000	value	5 1.2217E+02
physicsComment		field	approx_GenFiltEff
PDF	CTEQ6L1 - LO with LO alpha_s	value	9.6932E-04
version	e1146_s1896_s1912_r5591_r5625 Datasets - Config_Tag	field	autoConfiguration
AtlasRelease	19.0.3	value	['everything']
crossSection	122.170 nb 2 Report an error - Jira issues	field	postInclude
Trans	1: provenance & rucio 2: JIRA link for X section pbs	value	[RecJobTransforms/UseFrontier.py]
data		3: click for list of files 4: detail of prodsys task 5: cross section	

# Rucio (ATLAS Data Management System)

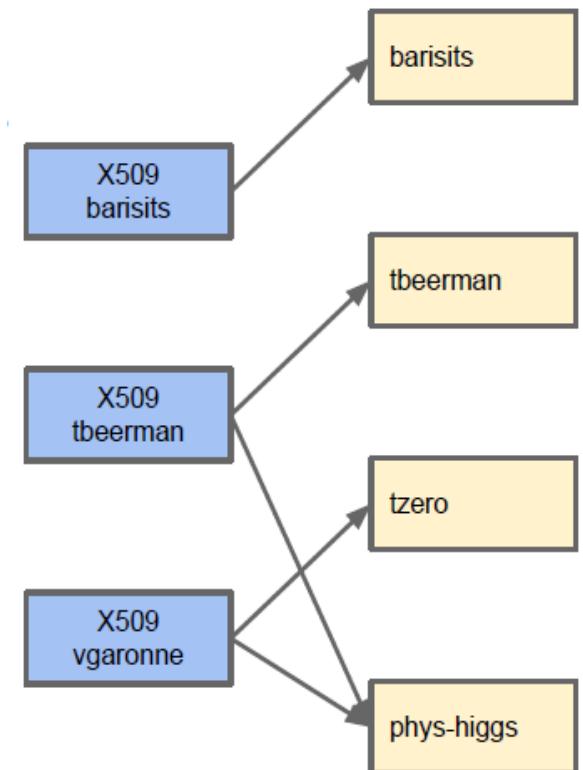


# Basic concepts - 1

- Data Management System for Run-2 in ATLAS distributed computing system
  - Used to download outputs of Grid jobs, moving data and searching for them
- Rucio CLI tools from CVMFS
  - Web interface provides similar functionality

# Basic concepts - 2

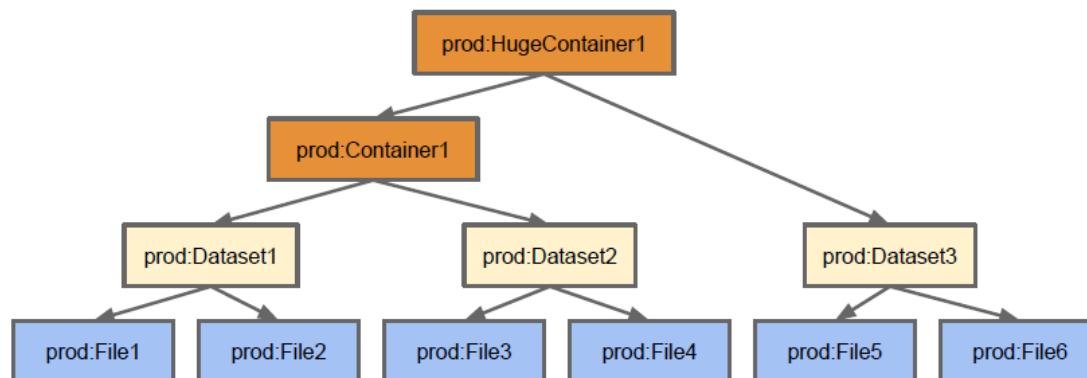
- Accounts
  - A Rucio Account can represent users, groups (phys-susy) or activities (panda, tzero)
  - Quota and permissions are associated to an account
  - One can connect to a Rucio account using X509 certificates/proxies, Kerberos
  - One credential can be used to map to different accounts.



# Basic concepts - 3

- Rucio namespace

- 3 types of Data Identifiers (DIDs): File, Datasets, Containers.
  - Dataset: Collection of Files
  - Containers: Collection of Datasets or Containers
- The namespace is divided using scopes. A name is unique within a scope but can be used in other scopes. A DID is identified by a scope and a name



# Hands-on exercise

## list DIDs

- A data Identifier is found by name and scope

```
## To list all DIDs within a scope
```

```
rucio list-dids user.gkawamur:*
```

SCOPE:NAME	[DID TYPE]
user.gkawamur:user.gkawamur.pruntest_7168.log	CONTAINER
user.gkawamur:user.gkawamur.tut.helloworldathena.test.log	CONTAINER
user.gkawamur:user.gkawamur.20160323144306.1.log	CONTAINER
user.gkawamur:user.gkawamur.tutorial.grid.deriv.test1.log	CONTAINER
user.gkawamur:user.gkawamur.pruntest_14222.log	CONTAINER

```
## Using filters (search)
```

```
rucio list-dids data16_13TeV:* --filter type=DATASET,datatype=AOD
```

SCOPE:NAME	[DID TYPE]	
data16_13TeV:data16_13TeV.00293572.physics_CosmicCalo.merge.AOD.x387_m1554		DATASET
data16_13TeV:data16_13TeV.00297447.physics_Standby.merge.AOD.x416_m1583		DATASET
data16_13TeV:data16_13TeV.00297041.physics_Main.merge.AOD.f686_m1583		DATASET
data16_13TeV:data16_13TeV.00297041.physics_CosmicCalo.merge.AOD.f686_m1583		DATASET
data16_13TeV:data16_13TeV.00297041.physics_ZeroBias.merge.AOD.f686_m1583		DATASET

# Hands-on exercise

## show metadata

### ## Showing metadata of a dataset

```
rucio get-metadata data16_13TeV:data16_13TeV.00303819.physics_Main.merge.AOD.f716_m1620
```

```
purge_replicas: None
campaign: None
is_new: None
is_open: False
closed_at: 2016-07-18 07:39:44
deleted_at: None
availability: AVAILABLE
eol_at: None
guid: None
panda_id: None
provenance: None
accessed_at: 2016-09-19 22:00:22
version: f716_m1620
scope: data16_13TeV
hidden: False
md5: None
events: 25475721
adler32: None
complete: None
lumiblocknr: None
monotonic: False
updated_at: 2016-09-19 22:00:42
obsolete: False
transient: None
did_type: DATASET
suppressed: True
expired_at: None
stream_name: physics_Main
account: tzero
run_number: 303819
name: data16_13TeV.00303819.physics_Main.merge.AOD.f716_m1620
task_id: None
datatype: AOD
created_at: 2016-07-17 04:17:53
bytes: 6462688464808
project: data16_13TeV
length: 2595
prod_step: merge
phys_group: None
```

# Hands-on exercise

## list replicas

### ## Listing dataset replicas

```
rucio list-dataset-relicas data16_13TeV:data16_13TeV.00303819.physics_Main.merge.AOD.f716_m1620
```

```
DATASET: data16_13TeV:data16_13TeV.00303819.physics_Main.merge.AOD.f716_m1620
```

RSE	FOUND	TOTAL
CERN-PROD_TZDISK	2567	2595
GRIF-LPNHE_DATADISK	2595	2595
IN2P3-CC_DATADISK	2595	2595
CERN-PROD_DERIVED	2595	2595

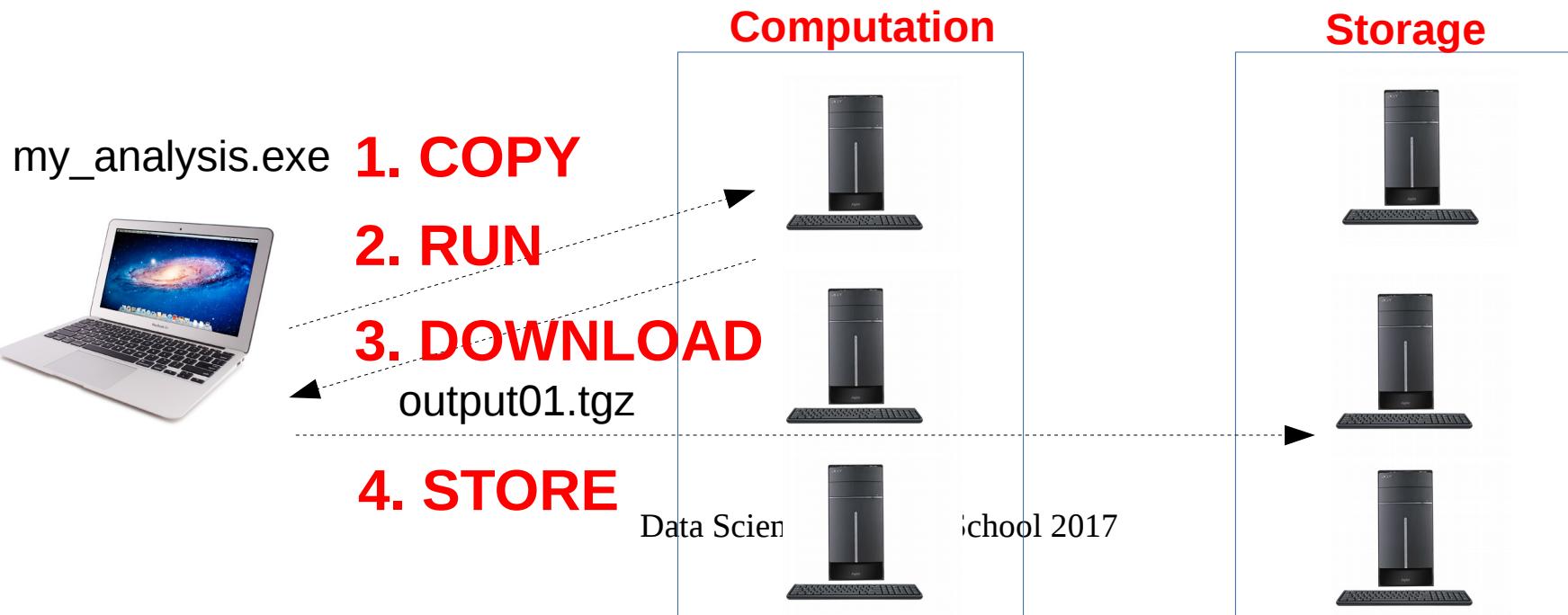
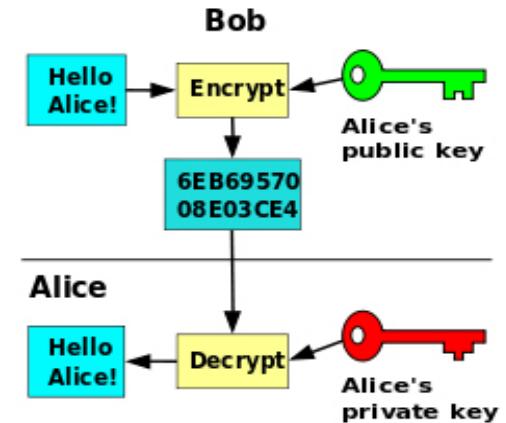
# Introduction to World LHC Computing Grid



# Concepts - 1

- How it works (*without Grid*)
  - Only PKI by openssl -> a simplest way

```
$ scp my_analysis.exe computer01:~/  
$ ssh computer01 “~/myprogram.exe run 01”  
$ scp computer01:output01.tgz ./output01.tgz  
$ scp output01.tgz storage02:output01.tgz
```



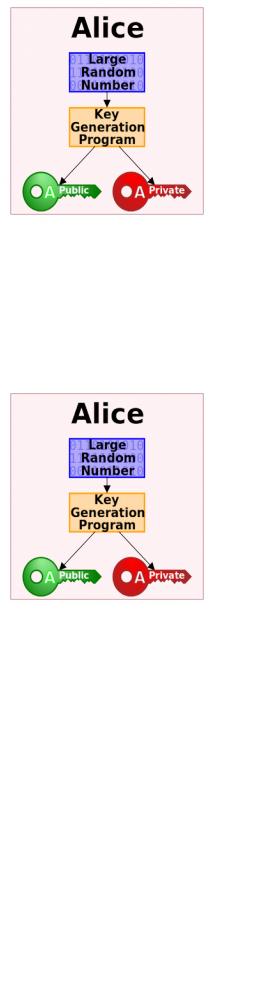
# Concepts - 2

- How it works (*with Grid*)
  - Need of basic stuffs
    - Security policy based on PKI
    - Working with many users (physicists)
    - Recognition of users in affiliation, organization and experiment
    - Control of Job allocation
    - Control of storage space allocation and data replication
    - Control among geographically distributed computers
    - Interface of local computing infrastructures
    - Tree-like information search for computing clusters
      - E.g. like Domain Name Server
    - End user tools to make life easy



# Concepts - 3

- Then, hierarchical signatures

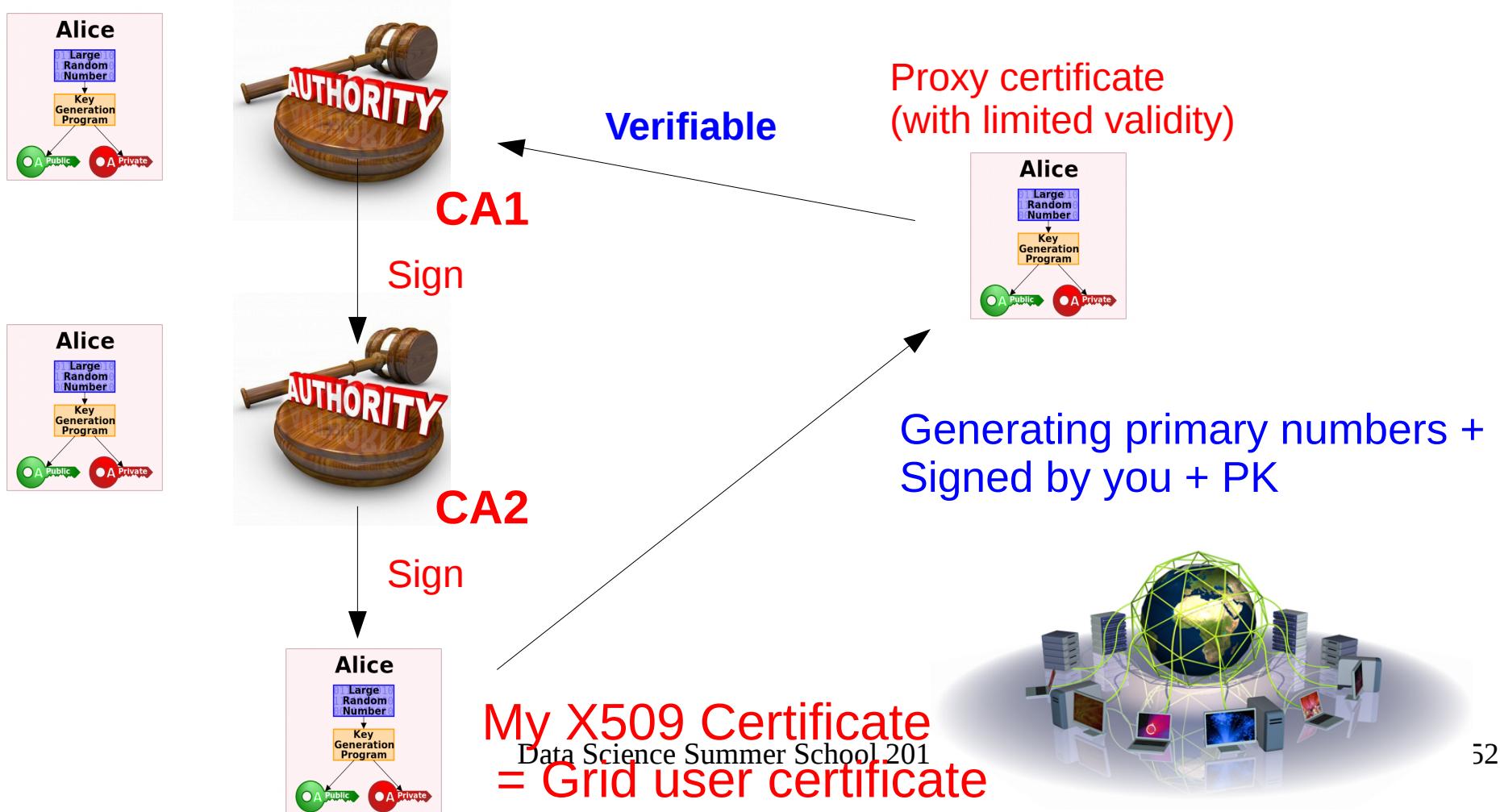


My X509 Certificate  
Data Science Summer School 2011  
= Grid user certificate



# Concepts - 4

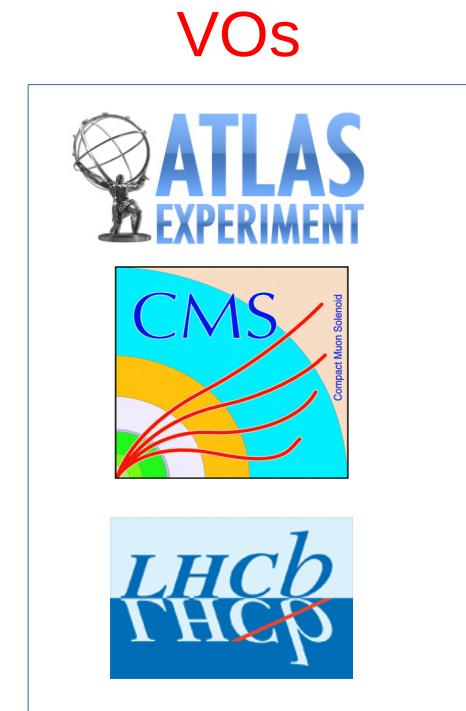
- Generating a new certificate = proxy certificate



# Concepts - 5

- Virtual Organization (VO), VOMS
  - VOMS extends a certificate with a VO

## Certificate Authority



# Concepts - 6

- A similar analogy
  - Authenticated and authorized for your tasks

Certificate Authority



↓  
Sign



User certificate

↓  
Sign



Proxy certificate  
= a limited copy of your certificate

Controlled



Authentication  
= who you are?

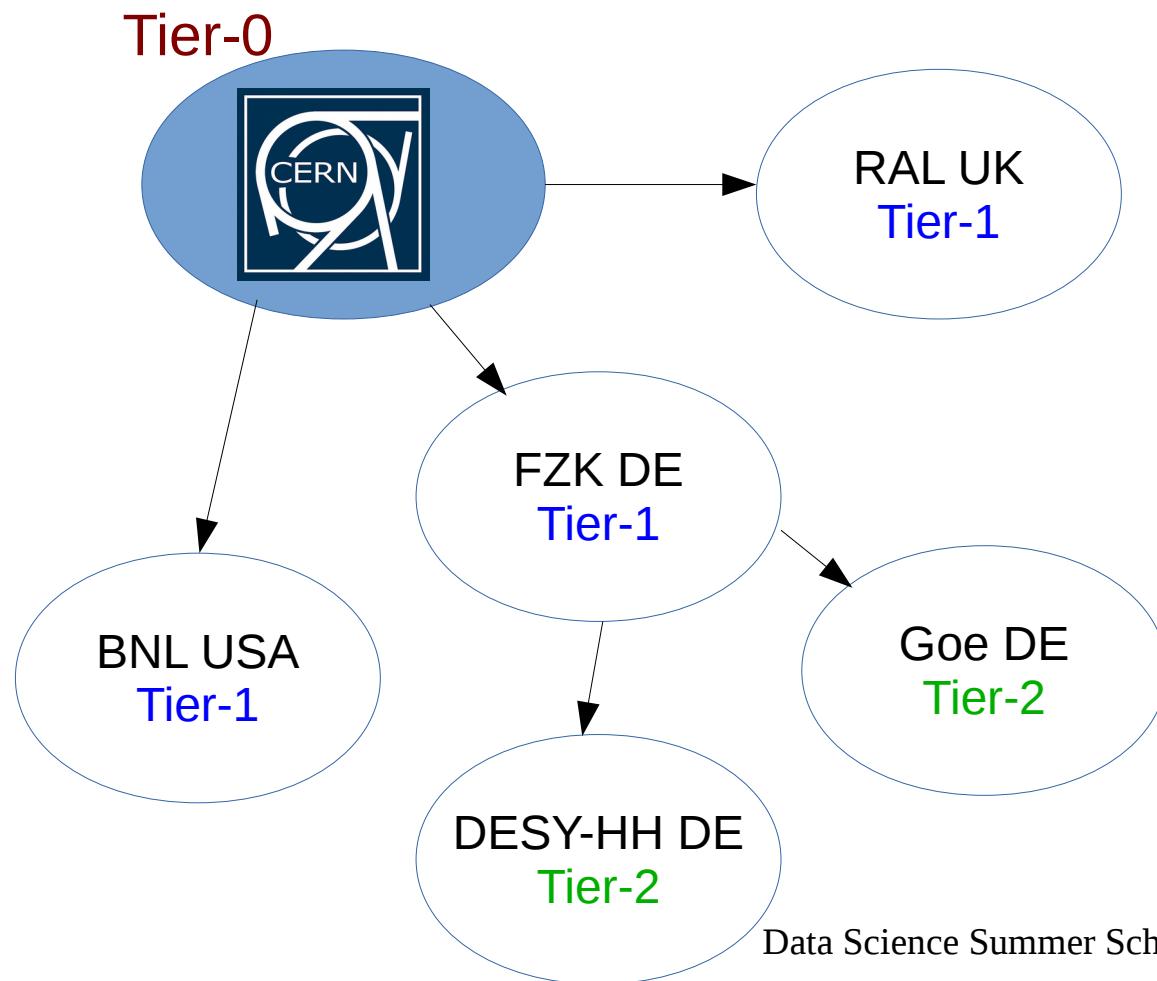


Authorization  
= can enter a new land (Grid)



# ATLAS Grid job - 1

- LHC multi-tier structure
  - WLCG = Worldwide LHC Computing Grid



**Tier-0:** Raw data, Data store (in tape), Pre-processing, Reconstruction

**Tier-1:** National LCG-Centre, faster network connections and larger storage spaces (e.g. Tape), MC production, user analysis, etc.

**Tier-2:** University or Facility level computing sites. MC production, user analysis, etc.

# ATLAS Grid job - 1

- FZK Tier-1



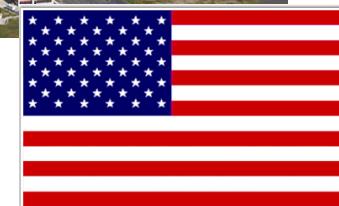
Forschungszentrum Karlsruhe  
in der Helmholtz-Gemeinschaft



- BNL Tier-1



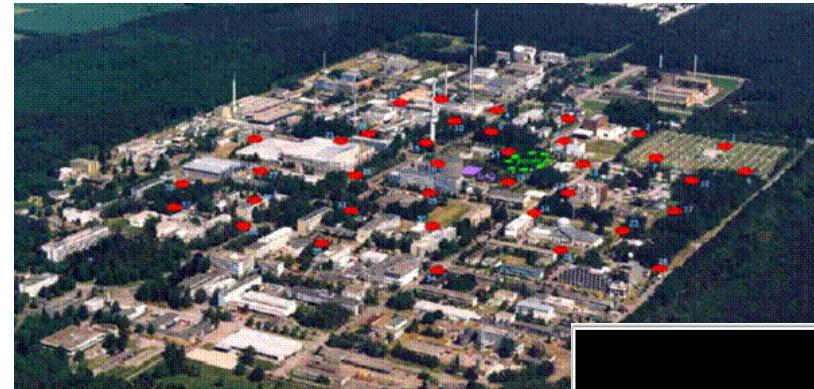
017



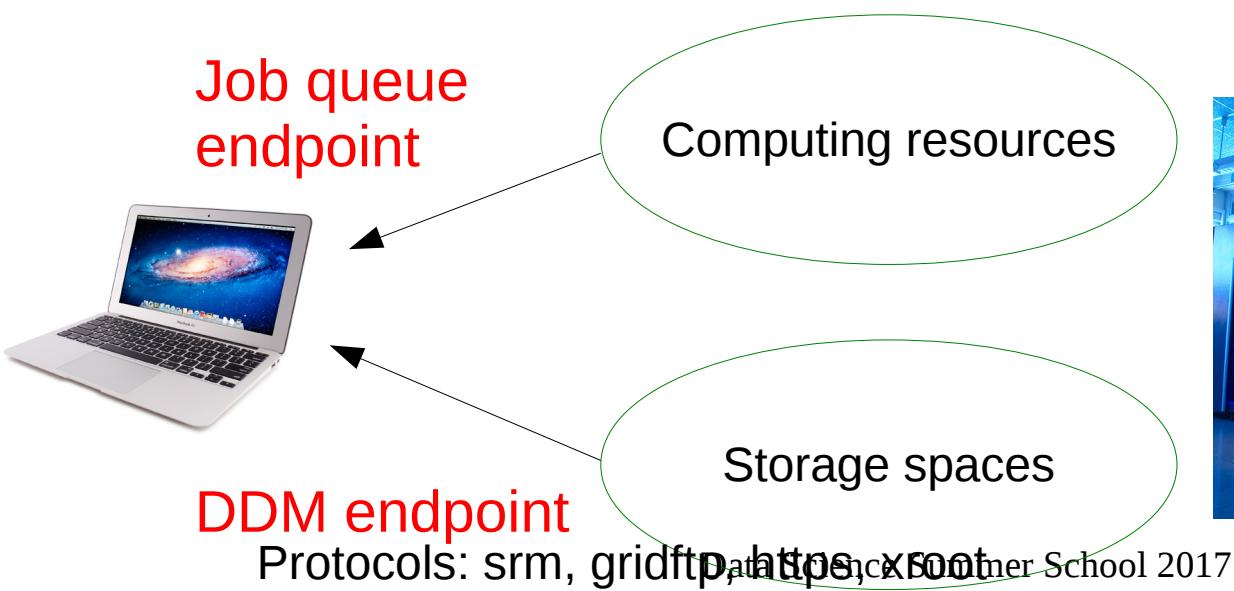
56

# ATLAS Grid job - 1

- FZK Tier-1



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DDM = Distributed Data Management

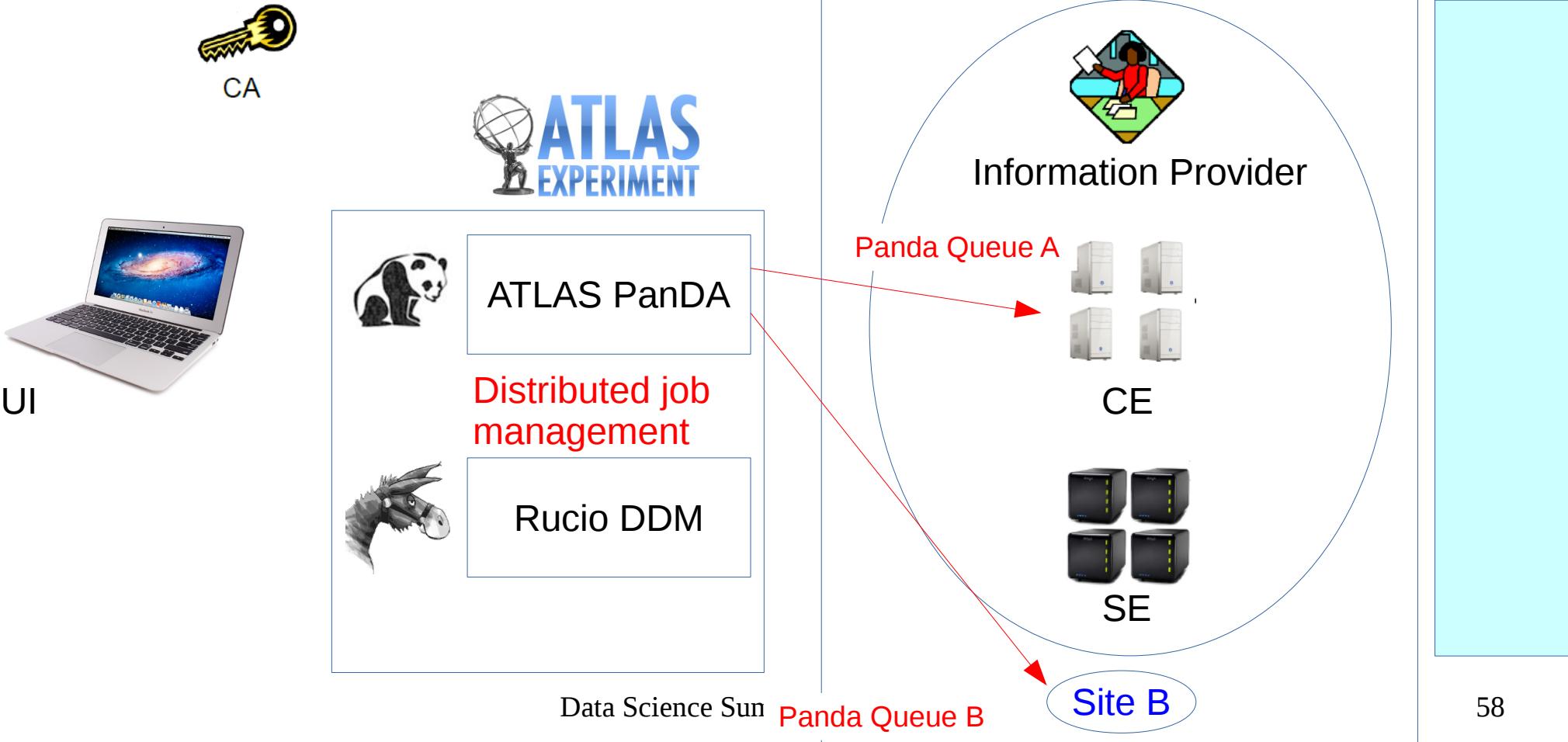
# ATLAS Grid job - 2



**WLCG**  
Worldwide LHC Computing Grid

Job  
Status

- How do they work?



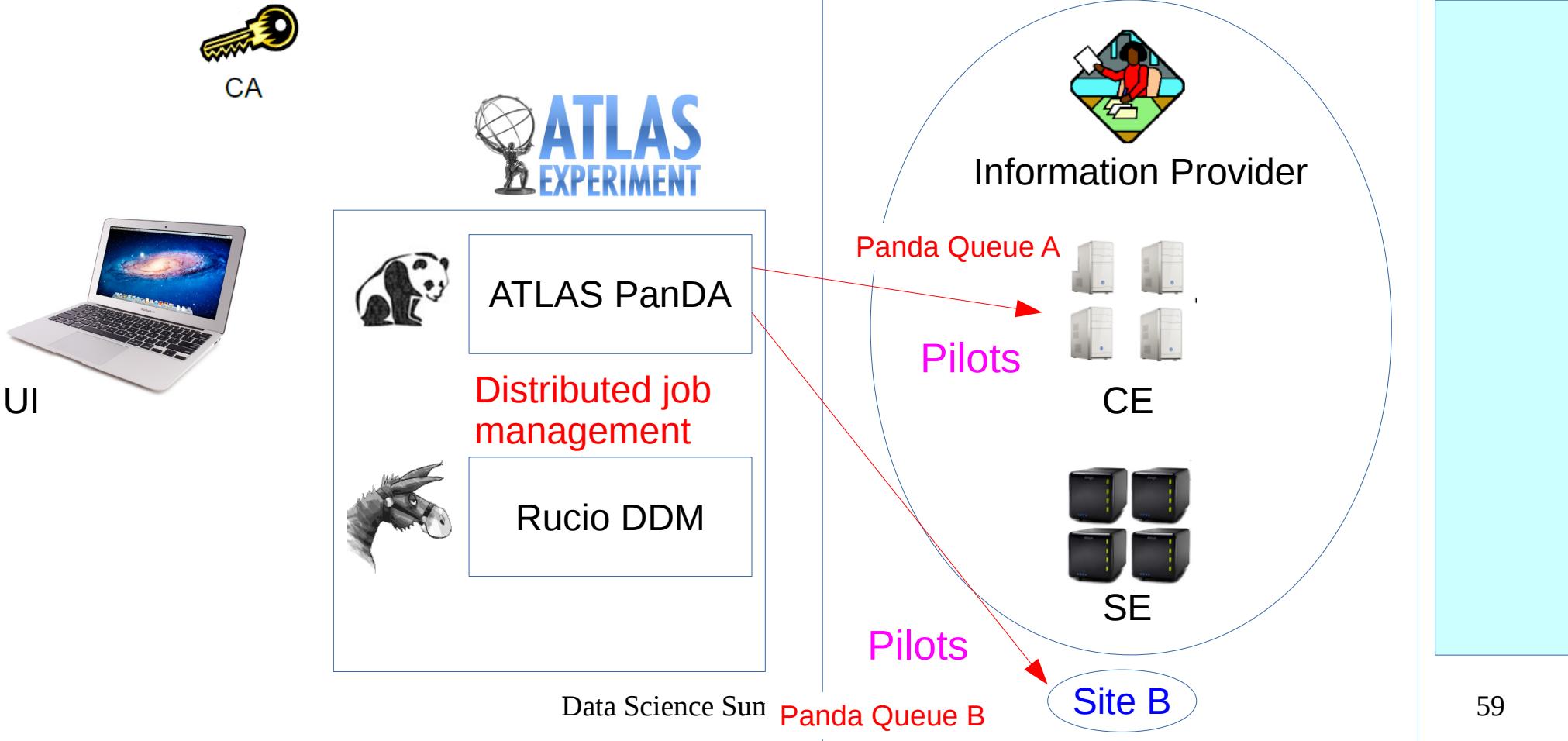
# ATLAS Grid job - 3



**WLCG**  
Worldwide LHC Computing Grid

Job  
Status

- How do they work?

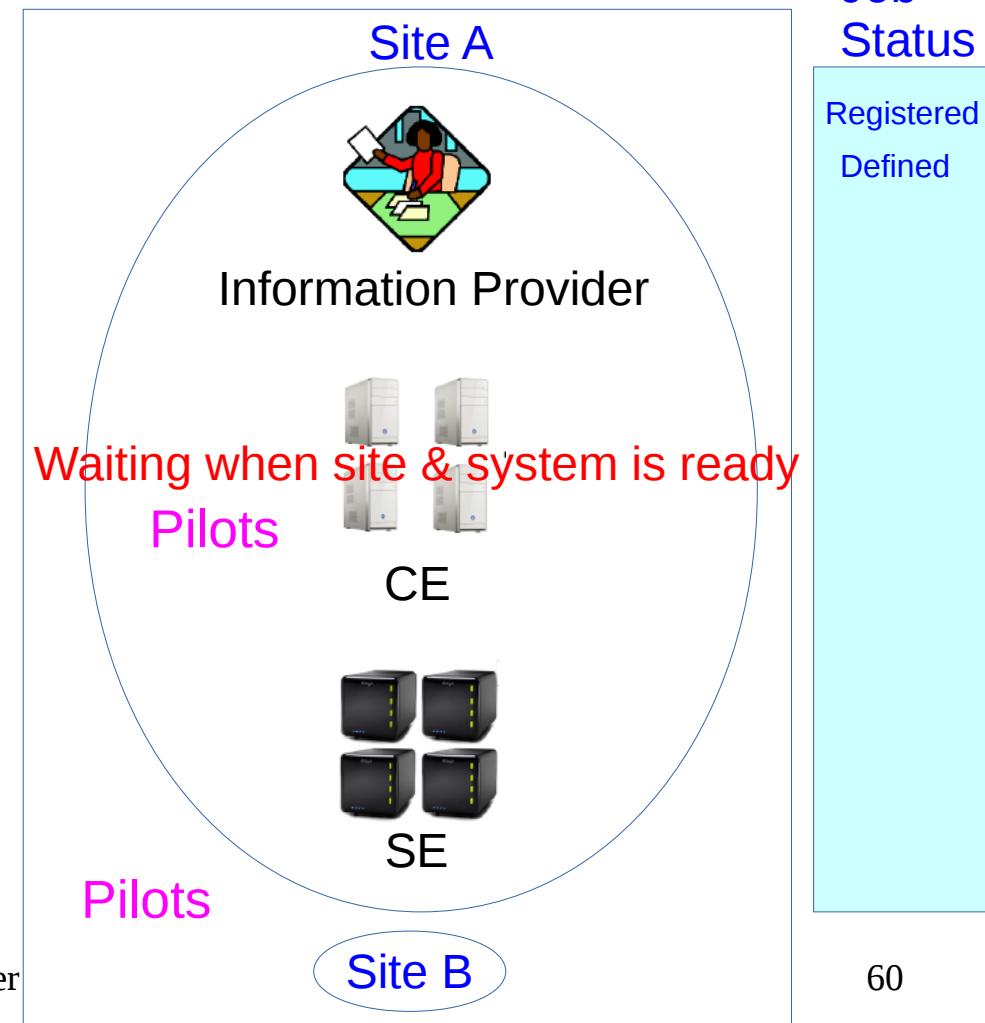
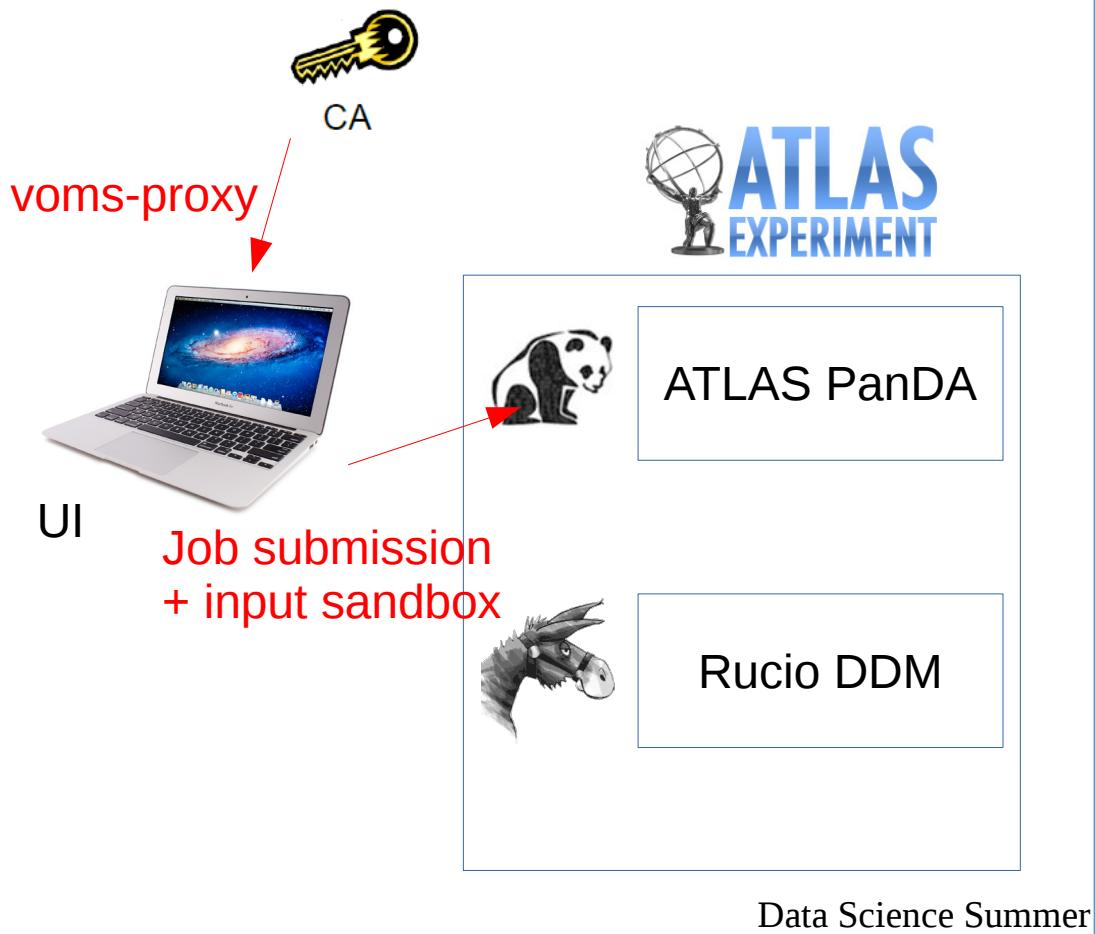


# ATLAS Grid job - 4



**WLCG**  
Worldwide LHC Computing Grid

- How do they work?

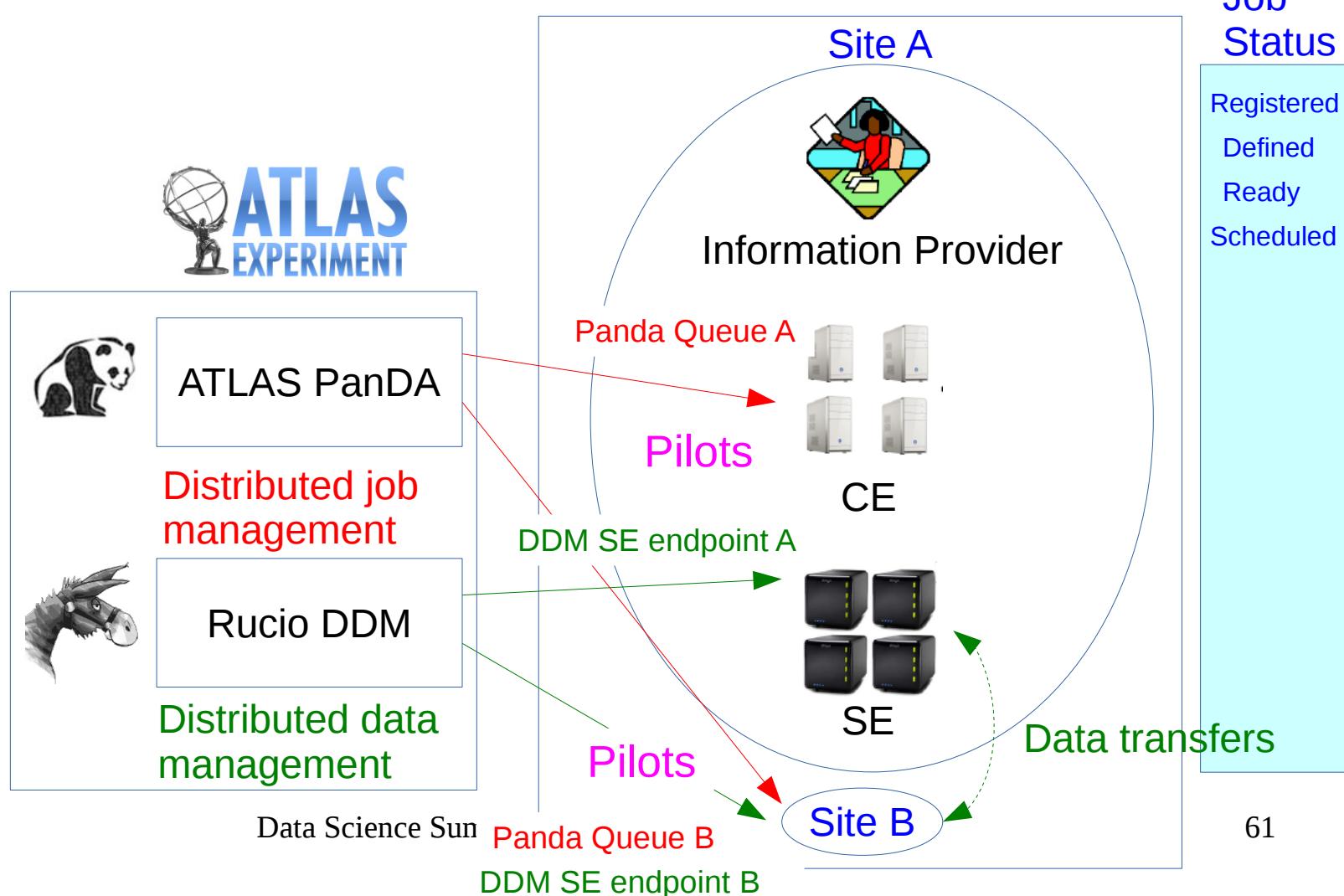


# ATLAS Grid job - 5



**WLCG**  
Worldwide LHC Computing Grid

- How do they work?

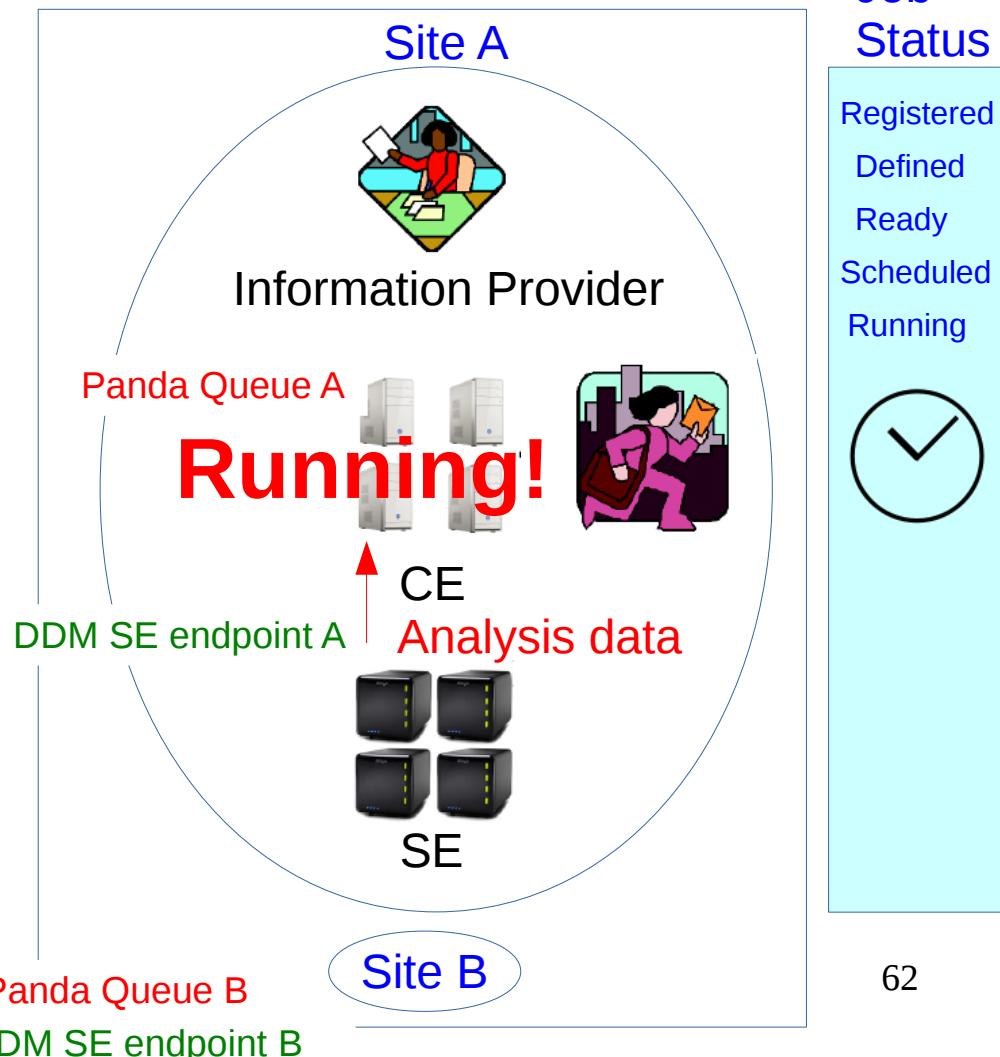
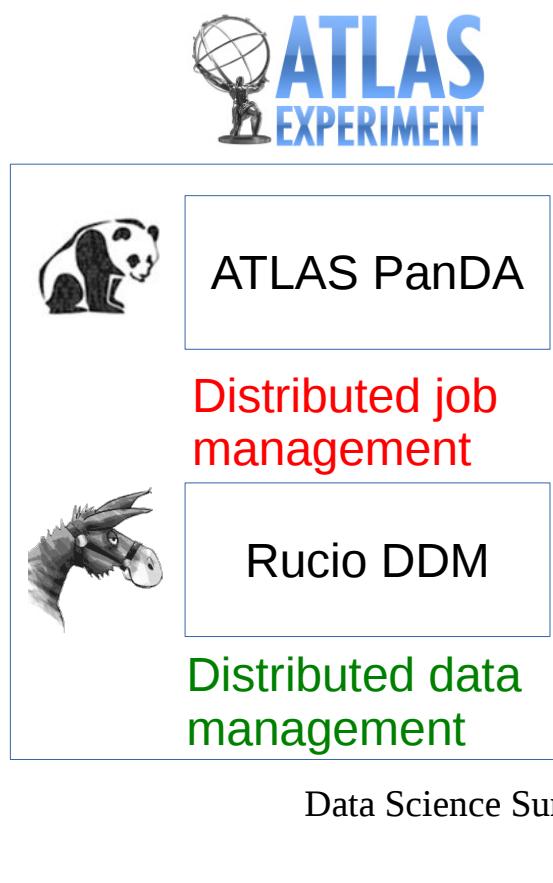


# ATLAS Grid job - 6



**WLCG**  
Worldwide LHC Computing Grid

- How do they work?

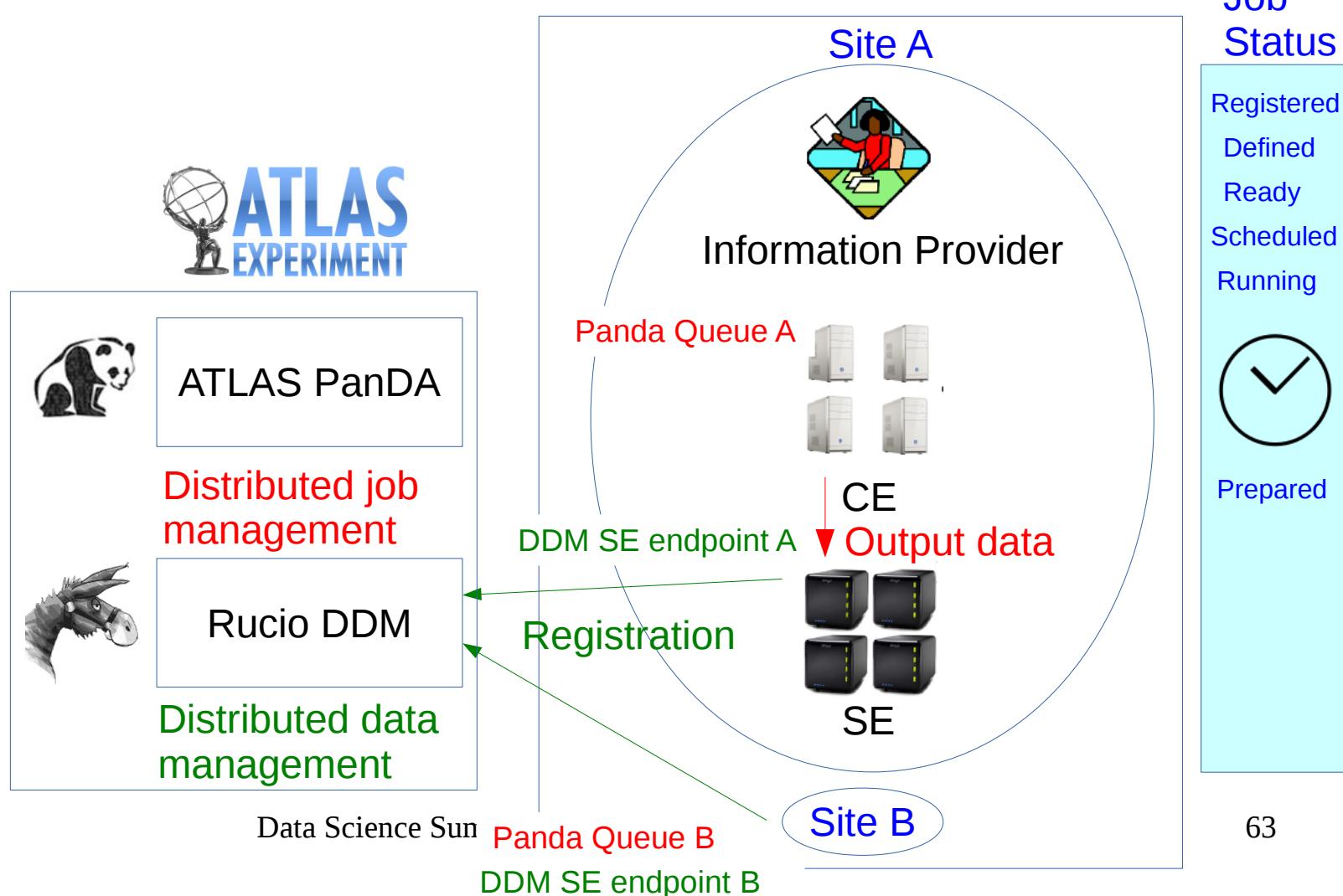


# ATLAS Grid job - 7



**WLCG**  
Worldwide LHC Computing Grid

- How do they work?

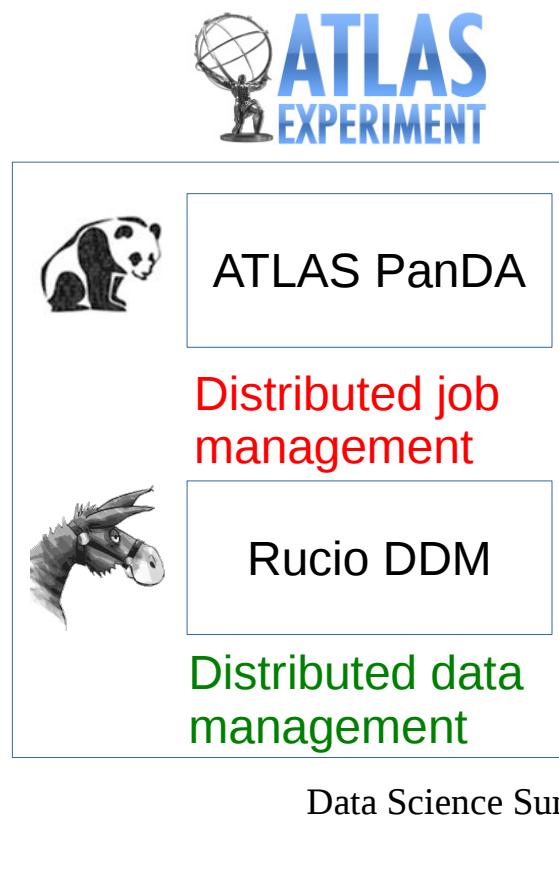


# ATLAS Grid job - 8

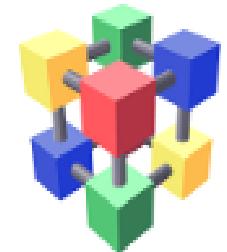


**WLCG**  
Worldwide LHC Computing Grid

- How do they work?



# PanDA (ATLAS Job Management System)



**WLCG**  
Worldwide LHC Computing Grid

# Monitoring PanDA jobs (1/5)

Go to: <http://bigpanda.cern.ch> and enter your jediTTaskID

here →

The dashboard displays three stacked bar charts showing the number of slots of running jobs. The left chart covers 24 hours from 2014-10-06 09:00 to 2014-10-07 09:11 UTC. The middle chart covers 7 days from 2014-09-30 to 2014-10-07. The right chart covers 29 days from 2014-09-07 to 2014-10-07. The charts are color-coded by location: CERN (blue), NL (orange), EG (green), EU (red), and T0 (yellow). A legend at the bottom of each chart shows these colors.

**Search**

PanDA job ID or name  Submit

Batch ID  Submit

Task ID  Submit

Task name  Submit

**News**

- 20140923: Job pages directly link to object store based log tarballs
- 20140913: Link DEFT request page from task list and detail pages
- 20140912: On task page highlight input containers, hide datasets by default
- 20140911: Task name search supports wildcarding
- 20140911: Show wait time, duration for jobs not yet running, completed
- 20140818: Job attempt# off for user page, JEDI jobs. Not meaningful in JEDI.
- 20140818: Task attribute summary added to user page
- 20140817: Output container list added to task detail page
- 20140817: Support clarified. Use DAST list, as ever, for dist analysis support

# Monitoring PanDA jobs (2/5)

Task is running

bigpanda.cern.ch/task/?jeditaskid=4212437&display\_limit=200

ATLAS PanDA monitor Dashboards Tasks Jobs Errors Users Sites Incidents Search Prodsys Services VO Help Generated 2014-10-07 09:34 UTC

Task 4212437: user.nozturk.pruntest/

Task ID	Jobset	Type	WorkingGroup	User	Task status	Ninputfiles	finished	failed	Created	Modified	Cores	Priority	Parent
4212437	15168	anal		Nurcan Ozturk	running	1	0 (0%)	0 (0%)	2014-10-07 09:33	10-07 09:33	1	1000	

States of jobs in this task [Show jobs](#)

defined	waiting	pending	assigned	throttled	activated	sent	starting	running	holding	transferring	finished	failed	cancelled	merging
1								1						

Jump to [job parameters](#), [task parameters](#)

View: [job list \(access to job details and logs\)](#) [child tasks](#) [prodsys task page](#) [brokerage logger](#) [JEDI action logger](#) [error summary](#)

Output containers

[user.nozturk.pruntest.log/](#)

4 datasets, show/hide by type: [all](#) [lib\(1\)](#) [log\(1\)](#) [pseudo\\_input\(1\)](#) [tmp\\_log\(1\)](#)

Dataset, container name	Type	Stream	State	Status	Nfiles	Created	Modified

Job parameters

"

# Monitoring PanDA jobs (3/5)

Task is done

Screenshot of the ATLAS PanDA monitor interface showing a completed task.

**Task ID:** 4212437 | **User:** Nurcan Ozturk | **Status:** done | **Ninputfiles:** 1 | **finished:** 1 (100%) | **failed:** 0 (0%)

**States of jobs in this task:** defined, waiting, pending, assigned, throttled, activated, sent, starting, running, holding, transferring, finished, failed, cancelled, merging. (The 'finished' state has a value of 2, indicated by a red arrow.)

**Jump to job parameters, task parameters**

**View:** job list (access to job details and logs) | child tasks | prodsys task page | brokerage logger | JEDI action logger | error summary

**Output containers:** user.nozturk.pruntest.log/ (indicated by a red arrow)

**4 datasets, show/hide by type:** all lib(1) log(1) pseudo\_input(1) tmpl\_log(1)

Dataset, container name	Type	Stream	State	Status	Nfiles	Created	Modified
-------------------------	------	--------	-------	--------	--------	---------	----------

# Monitoring PanDA jobs (4/5)

Task details, list of jobs. Click on “PanDA ID” to go to the job details, job log files

click 

Job list Sort by Pandaid, ascending mod time, descending mod time, priority, attemptnr											
PanDA ID Attempt#	Owner Group	Task ID	Transformation	Status	Created	Time to start d:h:m:s	Duration d:h:m:s	Mod	Cloud Site	Priority	Job info
2280470784 Attempt 1	Nurcan Ozturk	4212437	runGen-00-00-02	finished	2014-10-07 09:33	0:06:28	0:0:01:04	10-07 09:49	ES ANALY_IFAE	1000	
	Job name: user.nozturk.pruntest/ #1 Datasets:										
2280470783 Attempt 0	Nurcan Ozturk	4212437	buildGen-00-00-01	finished	2014-10-07 09:33	0:00:16	0:0:01:04	10-07 09:40	ES ANALY_IFAE	2000	
	Job name: user.nozturk.pruntest/ #0 Datasets: Out: panda.1007093351.25596.lib._4212437										

 run job: runs the job at the grid site

 build job: recreates the athena environment at the grid site

# Monitoring PanDA jobs (5/5)

## How to find job log files

Screenshot of the ATLAS PanDA monitor interface showing job details for PanDA job 2280470784.

Job details for PanDA job 2280470784 (Generated 2014-10-07 10:52 UTC)

PandaID	Owner	TaskID	Status	Created	Time to start d:h:m:s	Duration d:h:m:s	Modified	Cloud Site	Priority
2280470784	Nurcan Ozturk	4212437	finished	2014-10-07 09:33	0:0:06:28	0:0:01:04	10-07 09:49	ES ANALY_IFAE	1000

Job name: [user.nozturk.pruntest/](#) type: panda-client-0.5.30-jedi-run transformation: runGen-00-00-02

Datasets:

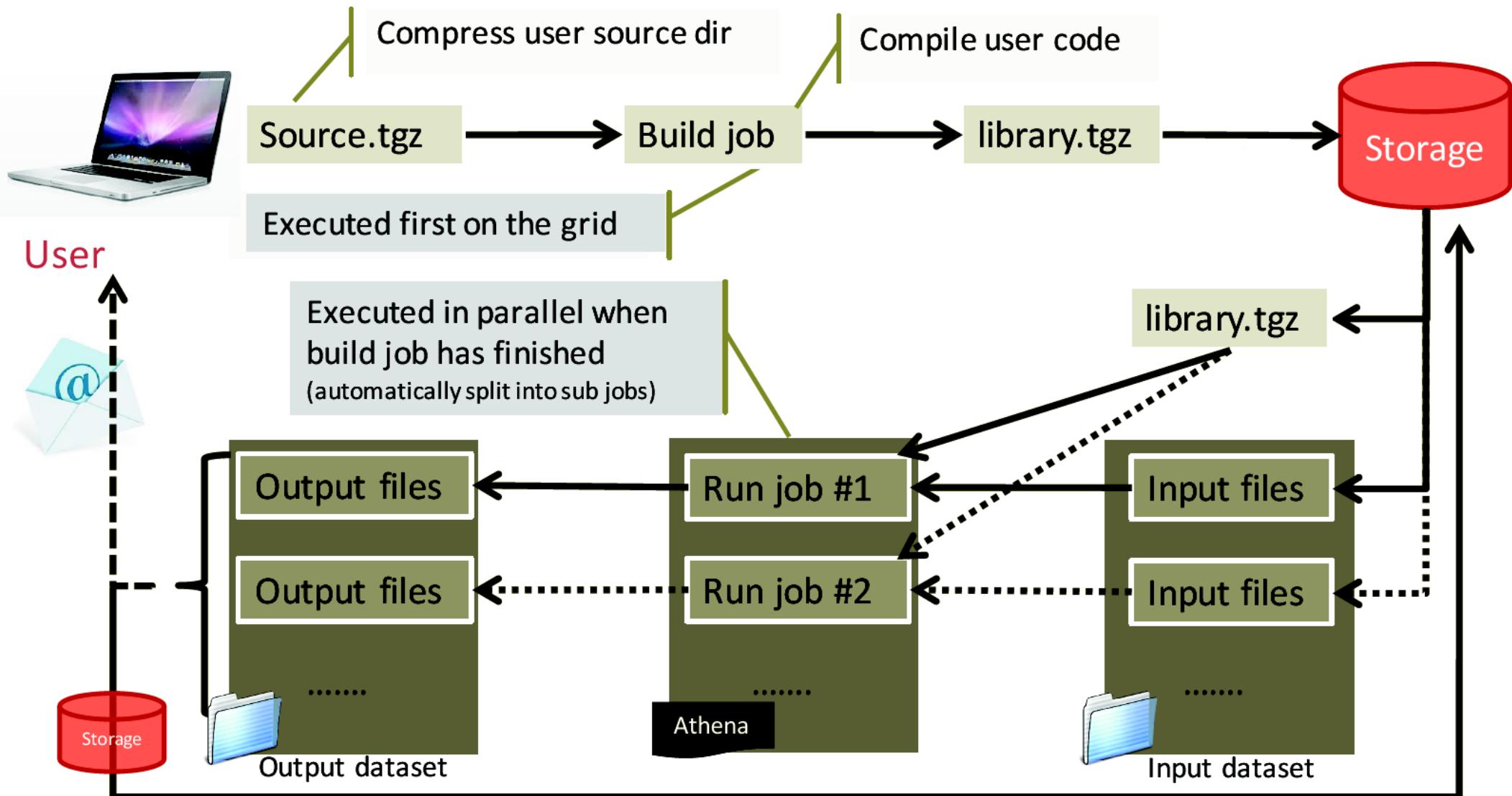
Job information logfiles pilot job stdout, stderr, batch log logger records child jobs

Jobset 15168

check athena\_stdout.txt (for pathena)/prun\_stdout.txt (for prun) and pilotlog.txt (all commands issued by the pilot) from this link

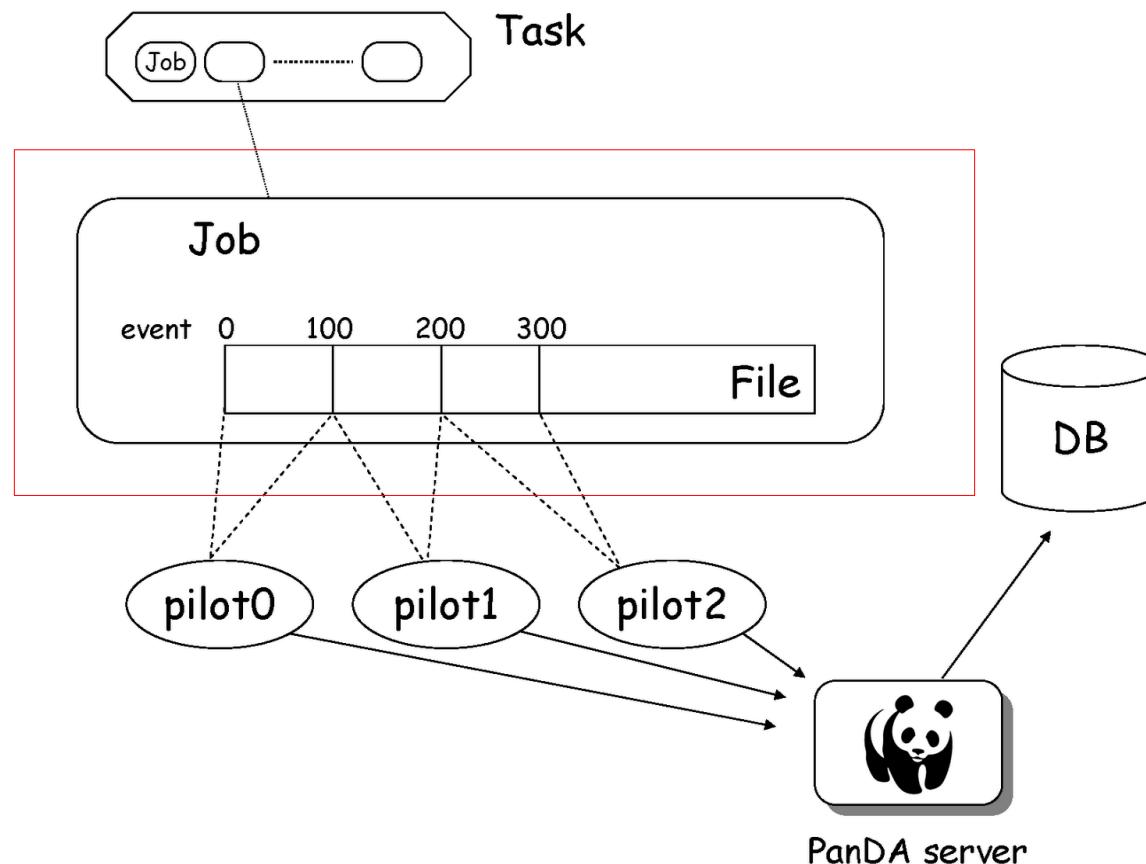
5 job files						
Filename (Type)	Scope	Size (MB)	Status	Attempt (max)	Dataset	
<a href="#">panda.1007093351.25596.lib._4212437.241508507.lib.tgz</a> (input)	panda	0	ready		<a href="#">panda.1007093351.25596.lib._4212437</a> (dispatch block: <a href="#">panda.1007093351.25596.lib._4212437</a> )	
<a href="#">user.nozturk.pruntest.log.4212437.000001.log.tgz</a> (log)	user.nozturk	0	finished		<a href="#">user.nozturk.pruntest.log.6779086</a>	
<a href="#">user.nozturk.pruntest.log.4212437.000001.log.tgz</a> (log)	user.nozturk	0	ready		<a href="#">user.nozturk.pruntest.log/</a> (destination block: <a href="#">sub0186192010</a> )	
pseudo_lfn (pseudo_input)		0	finished		<a href="#">pseudo_dataset</a>	
pseudo_lfn (pseudo_input)		0	unknown		<a href="#">pseudo_dataset</a>	

# Build job & Run job



# Event level processing

- Task (calculation) can be split by evenl level handler
  - Event Level Handler can generate basic pilot jobs according to events in given file(s)



Let's start your hands-on exercise!  
To be continued...

# Backup

# RucioUI (WebUI R2D2)



# RucioUI

- Move data between RSEs, use Rucio replication rules
- Such request can be generated by CLI and UI
- The UI tool is *the Rucio Rule Definition Droid (R2D2)*  
<https://rucio-ui.cern.ch/r2d2>
- Basic need: X509 certificate in your browser



ATLAS Rucio UI    Monitoring ▾    Data Transfers (R2D2) ▾    Reports ▾    pattern OR name OR rule id    Search    Using account: gkawamur ▾    Other Monitoring ▾    Help ▾

You are here: Rucio Rule Definition Droid - List Rules    Rucio Version ( WebUI / Server ): 1.8.0 / 1.8.0

### Rules

New request

Account	RSE	State	Activity	Interval
gkawamur	RSE		User Subscriptions	14 days

Show 10 entries    Search:

Name	Account	RSE Expression	Creation Date	State	Locks OK	Locks Replicating	Locks Stuck
No data available in table							

Name	Account	RSE Expression	Creation Date	State	Locks OK	Locks Replicating	Locks Stuck

Showing 0 to 0 of 0 entries    Previous    Next

[delete rule](#)

[download as JSON](#)

# RucioUI: Select DIDs - 1

- Data transfers (R2D2) → Request new rule

ATLAS Rucio UI   Monitoring ▾   Data Transfers (R2D2) ▾   Reports ▾   pattern OR name OR rule id   Search   Using account: gkawamur ▾   Other Monitoring ▾   Help ▾

You are here: Rucio Rule Definition Droid -

If you are new to this interface, click [here](#) to take the [tour](#).

Approve rules

If you find any errors or have suggestions for improvements for this interface please report it to [Jira](#).

Your input will be saved until you submit it. If you want to clear the form please click [here](#).

1. Select Data Identifiers (DIDs)

DID Pattern Search   List of DIDs

Please start by entering a DID or DID wildcard and search for either containers or datasets. Then select the requested DIDs. Please do not use a trailing '/' for containers.

Data pattern: panda.0323093918.103961.lib\_7993599   Search    Container    Dataset

Show: 10   Filter:

entries

Name
panda.0323093918.103961.lib_7993599

Official dataset:  
data15\_13TeV.00266904.physics\_Main.merge.DAOD\_SUSY1.  
f594\_m1435\_p2361\_tid05608871\_00

User dataset:  
user.jdoe:my.dataset.1

Enter if you have a dataset list

Wild card query by Rucio expression

# RucioUI: Select DIDs - 2

- E.g. a wild card pattern
  - “data15\_13TeV.\*.physics\_Main.merge.DAOD\_SUSY1.\*”

Your input will be saved until you submit it. If you want to clear the form please click [here](#).

**1. Select Data Identifiers (DIDs)**

DID Pattern Search List of DIDs

Please start by entering a DID or DID wildcard and search for either containers or datasets. Then select the requested DIDs. Please do not use a trailing '/' for containers.

Data pattern    Container  Dataset

Show  Filter:

entries

Name	
data15_13TeV.00266904.physics_Main.merge.DAOD_SUSY1.f594_m1435_p2361_tid05608871_00	
data15_13TeV.00266904.physics_Main.merge.DAOD_SUSY1.r6944_p2410_p2425_tid06685122_00	
data15_13TeV.00266904.physics_Main.merge.DAOD_SUSY1.r6944_p2410_p2540_tid07869001_00	
data15_13TeV.00266904.physics_Main.merge.DAOD_SUSY1.r7600_p2521_p2614_tid08133087_00	
data15_13TeV.00266919.physics_Main.merge.DAOD_SUSY1.r6944_p2410_p2425_tid06685125_00	
data15_13TeV.00266919.physics_Main.merge.DAOD_SUSY1.r6944_p2410_p2540_tid07869009_00	
data15_13TeV.00266919.physics_Main.merge.DAOD_SUSY1.r7600_p2521_p2614_tid08133105_00	
data15_13TeV.00267073.physics_Main.merge.DAOD_SUSY1.f594_m1435_p2361_tid05629722_00	
data15_13TeV.00267073.physics_Main.merge.DAOD_SUSY1.r6943_p2410_p2425_tid06685128_00	
data15_13TeV.00267073.physics_Main.merge.DAOD_SUSY1.r6943_p2410_p2540_tid07869016_00	

Name

Showing 1 to 10 of 524 entries

Previous  2 3 4 5 ... 53 Next

**Select the DIDs you want to replicate**

**Data Identifiers and Scope**

Files, datasets and containers share the same naming convention, which is composed of two strings: the scope and the name, separated by a colon. The combination of scope and name is called a data identifier (DID).

The scope is used to divide the name space into several, separate sub spaces for production and individual users. User scope always start with 'user.' followed by the account name.

By default users can read from all scopes but only write into their own one. Only privileged accounts have the right to write into multiple scopes including production scopes like mc15\_13TeV.

Examples:

Official dataset:  
data15\_13TeV.00266904.physics\_Main.merge.DAOD\_SUSY1.  
f594\_m1435\_p2361\_tid05608871\_00

**metadata**

User dataset:  
user.jdoe:my.dataset.1

# RucioUI: Select DIDs - 3

- Metadata

data15_13TeV.00266904.physics_Main.merge.DAOD_SUSY1.f594_m1435_p2361_tid05608871_00	
accessed_at	Mon, 14 Sep 2015 04:34:53 UTC
account	panda
availability	AVAILABLE
closed_at	Mon, 24 Aug 2015 14:33:30 UTC
created_at	Sun, 07 Jun 2015 10:09:59 UTC
datatype	DAOD_SUSY1
did_type	DATASET
events	10593
filesize	237.94 MB
hidden	false
is_open	false
length	7
monotonic	false
name	data15_13TeV.00266904.physics_Main.merge.DAOD_SUSY1.f594_m1435_p2361_tid05608871_00
obsolete	false
prod_step	merge
project	data15_13TeV
run_number	266904
scope	data15_13TeV
stream_name	physics_Main
suppressed	true
task_id	5608871
updated_at	Mon, 14 Sep 2015 06:35:06 UTC
version	f594_m1435_p2361

# RucioUI: select a RSE - 1

- Find your destination space

**2. Select Rucio Storage Elements (RSEs)**

Please enter an RSE or an RSE expression.

RSE (expression)	BNL-OSG2_SCRATCHDISK	Check Quota
------------------	----------------------	-------------

RSE	Remaining Quota	Total Quota
BNL-OSG2_SCRATCHDISK	45.47 TB	45.47 TB

Name	Remaining Quota	Total Quota
------	-----------------	-------------

If you have quota the table will show your total and remaining quota

**Continue**

**2. Select Rucio Storage Elements (RSEs)**

Please enter an RSE or an RSE expression.

RSE (expression)	BNL-OSG2_DATADISK	Check Quota
------------------	-------------------	-------------

You have no quota for this RSE. If you really want to create a rule for this RSE you can continue and create a manual request, which you will have to send to DDM support.

**Continue**

If you have no quota use either have to switch to an account which has quota or you can ask for approval

# RucioUI: select a RSE - 2

- SCRATCHDISKs in Germany
  - cloud=DE&type=SCRATCHDISK

2. Select Rucio Storage Elements (RSEs)

Please enter an RSE or an RSE expression.

RSE (expression)  Check Quota

**RSE expression (e.g. to Göttingen)**

List of RSEs

RSE	Remaining Quota	Total Quota
CSCS-LCG2_SCRATCHDISK	20 TB	20 TB
CYFRONET-LCG2_SCRATCHDISK	11 TB	11 TB
DESY_IH_SCRATCHDISK	30.68 TB	30.68 TB
DESY-ZN_SCRATCHDISK	25 TB	25 TB
FMPHI-UNIBA_SCRATCHDISK	11 TB	11 TB
FZK-LCG2_SCRATCHDISK	50 TB	50 TB
GOEGRID_SCRATCHDISK	25 TB	25 TB
HEPHY-UIBK_SCRATCHDISK	1.65 TB	1.65 TB
IEPAS-KOSICE_SCRATCHDISK	14.29 TB	14.29 TB
LRZ-LMU_SCRATCHDISK	26.91 TB	26.91 TB
MPPMU_SCRATCHDISK	20 TB	20 TB
PRAGUELCG2_SCRATCHDISK	20.4 TB	20.4 TB
PSNC_SCRATCHDISK	2.2 TB	2.2 TB
TUDRESDEN-ZIH_SCRATCHDISK	4.26 TB	4.26 TB
UNI-FREIBURG_SCRATCHDISK	32.5 TB	32.5 TB
UNI-SIEGEN-HEP_SCRATCHDISK	50 GB	50 GB
WUPPERTALPROD_SCRATCHDISK	22.55 TB	22.55 TB

Total size of selected DIDs: 237.94 MB

Name	Remaining Quota	Total Quota
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Continue

# RucioUI: select options

**3. Options**

Please select/enter your wanted options and then submit your rule request.

Grouping  
 All  Dataset  None

Lifetime (in days). Leave empty for infinite lifetime.  
15

Copies  
1

Comment  
For ATLAS-D

Create sample

Asynchronous Mode

Number of files

Continue

A grouping definition of how the replica will be distributed

Use if you select files randomly

# Rucio UI: Transfer status

- Go to top page and see your transfer activity
  - <https://rucio-ui.cern.ch/r2d2>

The screenshot shows the ATLAS Rucio UI interface for monitoring rules backlog. At the top, there's a navigation bar with links for ATLAS Rucio UI, Monitoring, Data Transfers (R2D2), Reports, and Help. A search bar is also present. Below the navigation, it says "You are here: Rules Backlog Monitoring" and "Rucio Version ( WebUI / Server ): 1.8.0 / 1.8.0".

The main area is titled "Rules" and contains a table of transfer activities. The columns include Account, Activity, Endpoint, State, Age, and Load. A search bar is located at the bottom right of the table.

Account	Activity	Endpoint	State	Age	Load
gkawamur	Activity	RSE	Done	younger than 12 hours	Load

Below the table, there's a section for "Rules" with filters for Data Type, Project, and Stream, and a "Get Link" button. A search bar is also present here.

Name	Endpoint	State	Creation Date	Data Type	Project	Stream	Version	OK	Replicating	Stuck
data16_13TeV.00309640.express_express.recon.E_SD.f750	CERN-PROD_DATADISK	Done	Sun, 02 Oct 2016 20:23:55 UTC	ESD	data16_13TeV	express_express	0	956	0	0
data16_13TeV.00309640.physics_Late.recon.ESD.f750	SLACRDXD_DATADISK	Done	Sun, 02 Oct 2016 20:59:14 UTC	ESD	data16_13TeV	physics_Late	0	955	0	0
data16_13TeV.00309640.physics_Late.recon.ESD.f750	BNL-OSG2_DATADISK	Done	Sun, 02 Oct 2016 20:59:14 UTC	ESD	data16_13TeV	physics_Late	0	955	0	0
data16_13TeV.00309640.debugrec_hlt.merge.AOD.g53_f750_m1689	CERN-PROD_DATADISK	Done	Sun, 02 Oct 2016 21:01:47 UTC	AOD	data16_13TeV	debugrec_hlt	0	1	0	0
data16_13TeV.00309640.debugrec_hlt.merge.AOD.g53_f750_m1689	INFN-T1_DATADISK	Done	Sun, 02 Oct 2016 21:01:47 UTC	AOD	data16_13TeV	debugrec_hlt	0	1	0	0
data16_13TeV.00309640.debugrec_hlt.merge.AOD.g53_f750_m1689	UNI-FREIBURG_DATADISK	Done	Sun, 02 Oct 2016 21:01:48 UTC	AOD	data16_13TeV	debugrec_hlt	0	1	0	0
data16_13TeV.00309640.physics_Late.merge.AOD.f750_m1689	RAL-LCG2_DATADISK	Done	Sun, 02 Oct 2016 23:08:55 UTC	AOD	data16_13TeV	physics_Late	0	96	0	0
data16_13TeV.00309640.physics_Late.merge.AOD.f750_m1689	UKI-NORTHGRID-LANCS-HEP_DATADISK	Done	Sun, 02 Oct 2016 23:08:55 UTC	AOD	data16_13TeV	physics_Late	0	96	0	0