Preparation for the LHC data on the Swiss ATLAS grid

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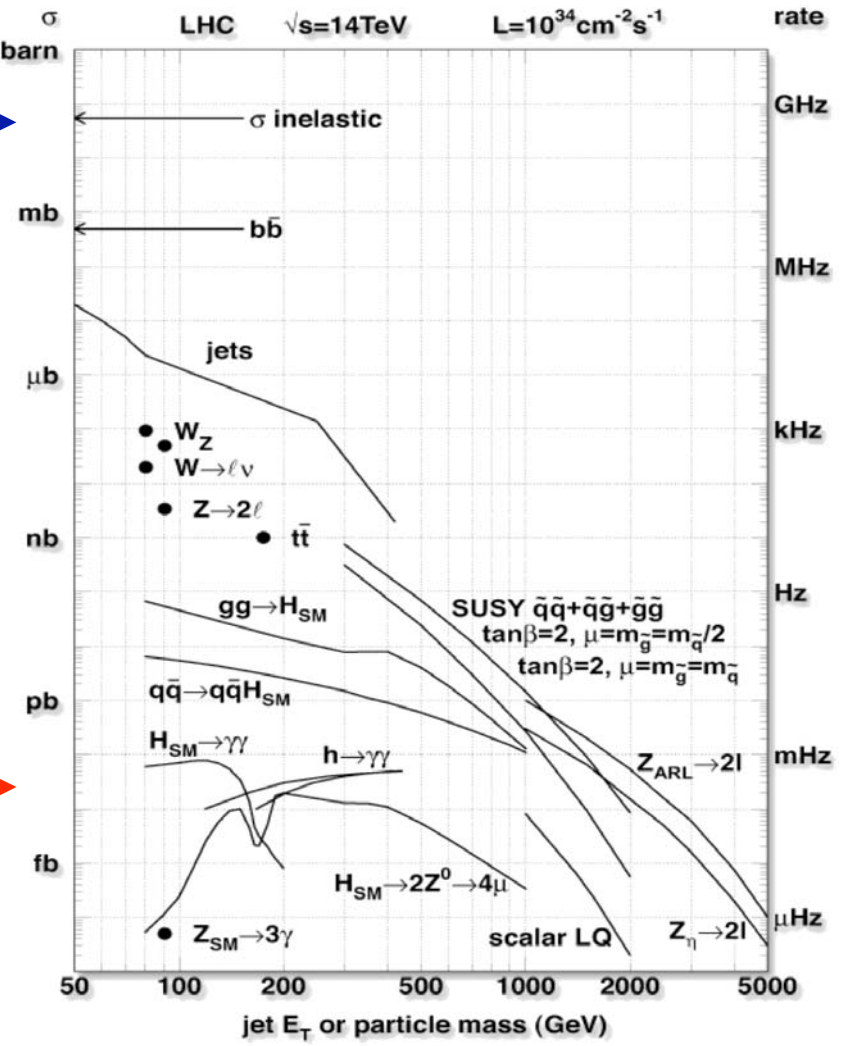
- requirements of physics at the LHC
- global grid computing for the LHC experiments
- Swiss ATLAS grid
- current status and issues

Requirements of the LHC physics

pp collisions

Interesting processes, which may give hints of "new physics", will be rare!

new physics (?)



Probability

Volume of the recorded data

- Data of one in 200’000 collisions is recorded.
- ATLAS will record 200 “events”/s, i.e. 320 MB/s.
- We estimate 3 PB ($3*10^{15}$ B) per year
  - you would need 850’000 DVDs (4 km on shelves)
  - or 6300 large disks (500 GB in 2007)
- The above is for ATLAS. The four LHC experiments together will generate 15 PB per year, counting derived data formats

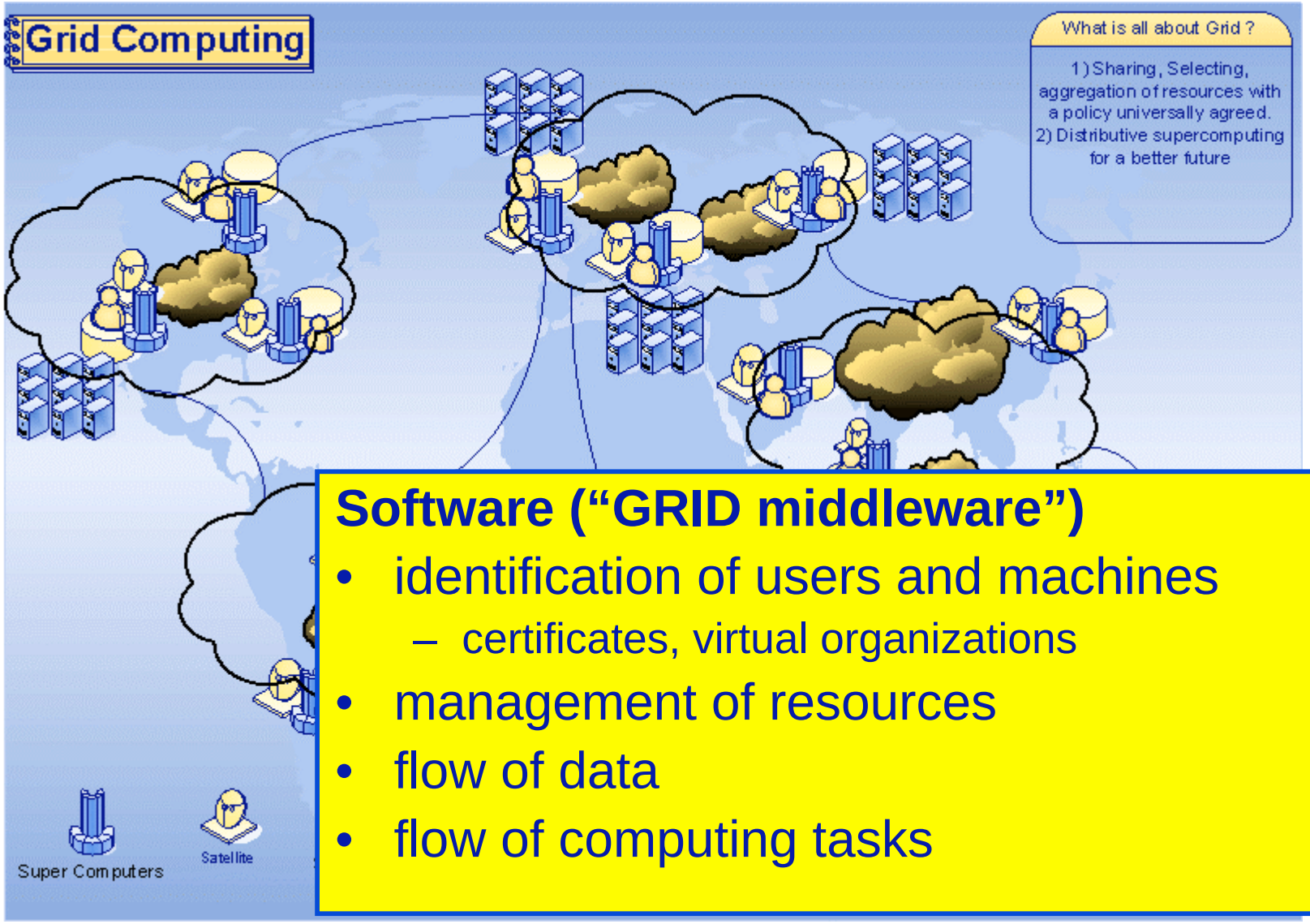
“Trivially parallel” processing of the “event data”
– no need of fast connections between CPU

Global collaboration to analyze the data

Grid as a solution (under construction)

- Internet and WWW give global access to information.
- **GRID is making computing resources (storage and CPU power) available globally.**
- Name and history
  - The term Grid is an analogy to international electric power networks.
  - The “fathers” are Ian Foster, Carl Kesselman, Steve Tueck (project Globus, Chicago, 1997, basis of all current work)
- By necessity particle physicists are pioneers in the deployment and use of Grid systems.

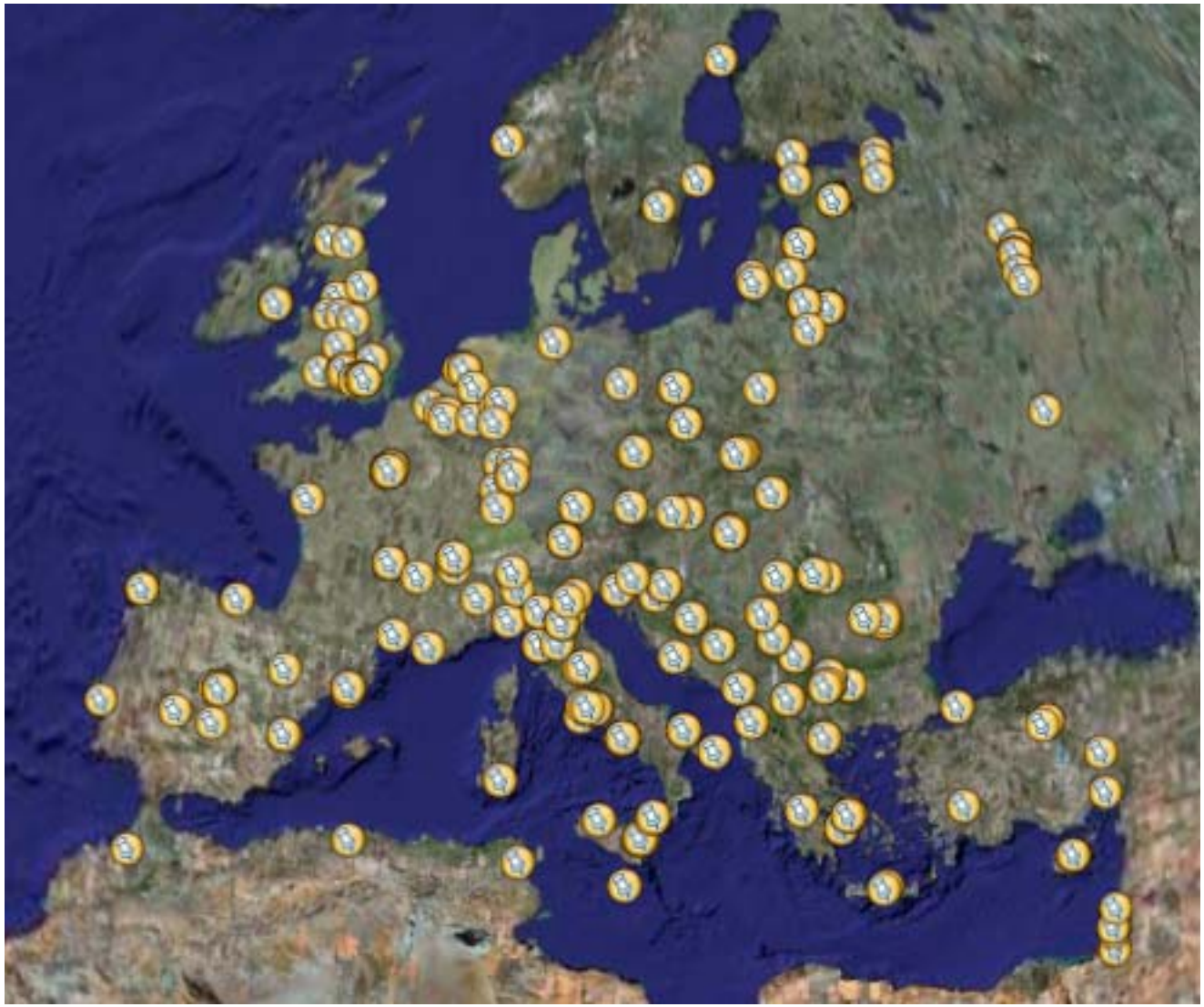
Grid as a concept



Software ("GRID middleware")

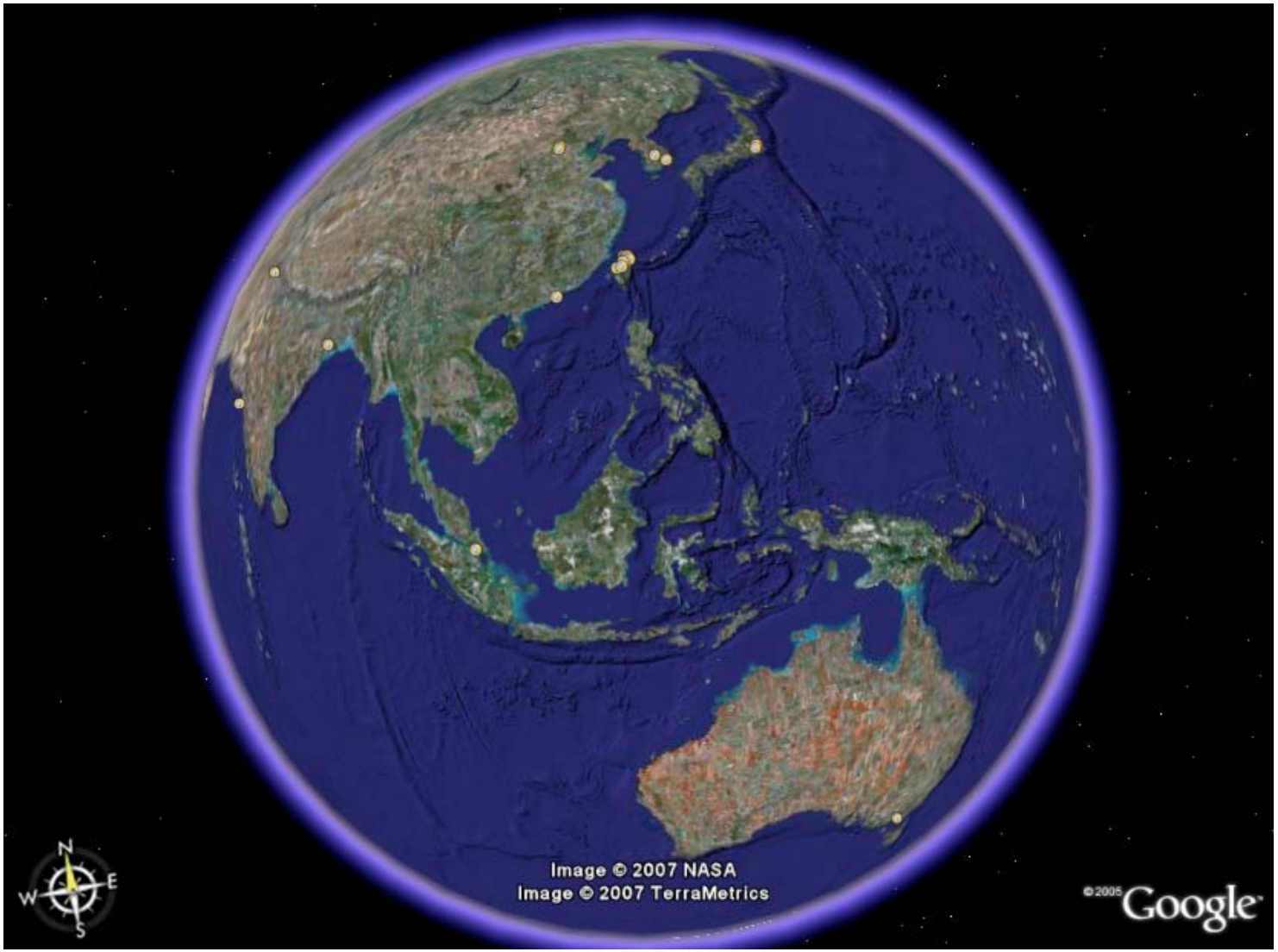
- identification of users and machines
  - certificates, virtual organizations
- management of resources
- flow of data
- flow of computing tasks

Grid as a reality in Europe

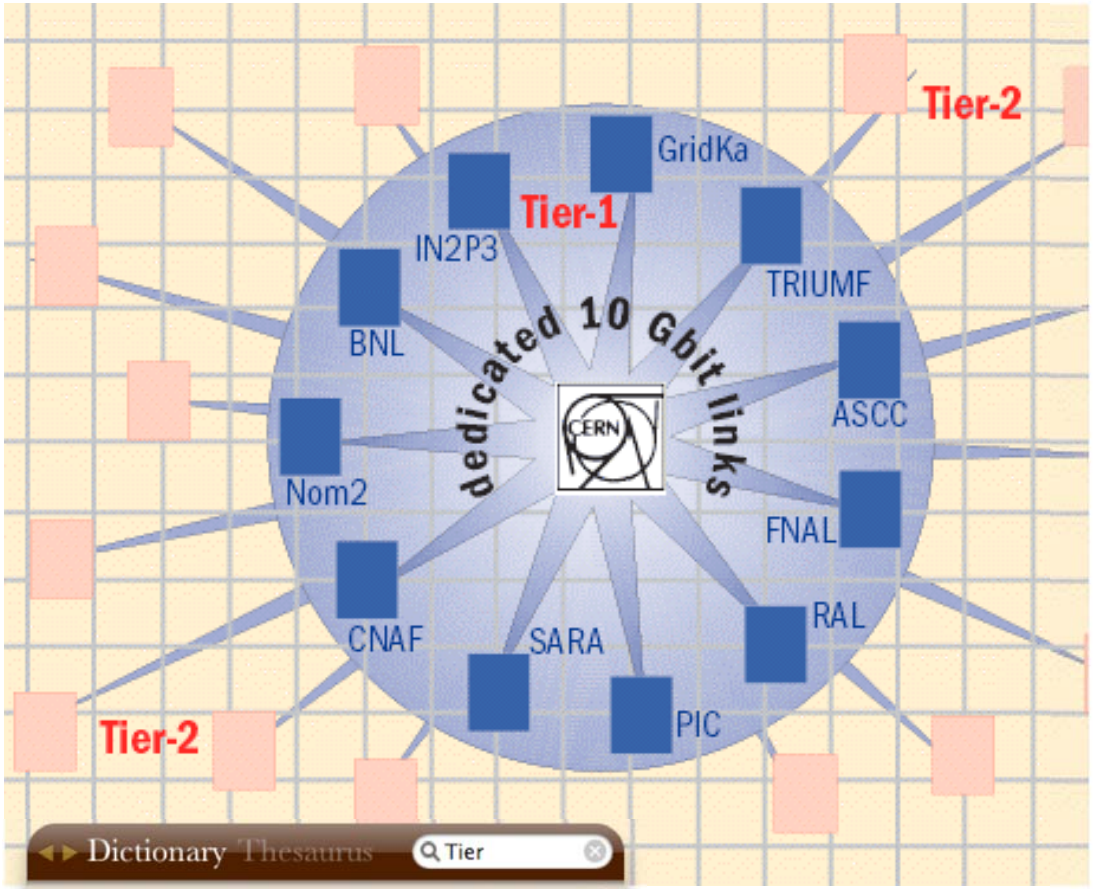


in North America

in Asia and Australia



Computing for the LHC experiments



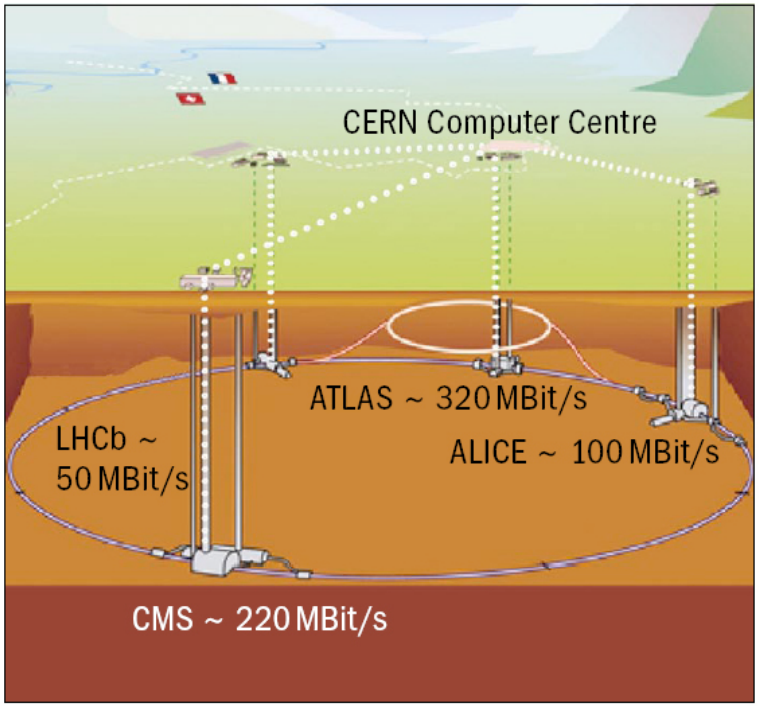
Tier-0 at CERN

Tier-1 a large computer center (11 work for LHC, none in Switzerland) (work with Karlsruhe)

Tier-2 a regional center, e.g. CSCS in Manno (Ti).

Tier-3 at an institute (not shown)

Tier-0 at the CERN Computer Centre



“Scientific Linux CERN”

Swiss Tier-2 cluster at CSCS

Phase-A installed in Dec 07

(225 TB, ~800 kSI2k, 400 cores)

Centro Svizzero di Calcolo Scientifico
Manno, Ticino

Super-computers, e.g. for meteorology

More recently also Cluster computing and Grid

For the three LHC experiments in which Swiss groups participate

- **CMS**
- **ATLAS**
- **LHCb**

Swiss Institute of Particle Physics

Complete System Phase A operational since Jan 2008

LABORATORIUM FÜR HOCHENERGIEPHYSIK
LHEP
UNIVERSITÄT BERN

ATLAS Tier-3 in Berne

Two clusters with NorduGrid front ends in production since 2005

- **One shared and operated by "Informatik Dienste UniBE".**
- **Another smaller cluster owned and operated by the LHEP**

Size

~130 cores for ATLAS (~200 in 2009).
~ 33 TB disk (end of 2008 44 TB).

Usage

~ 120 000 Wall Time Hours in 2006.
~ 170 000 Wall Time Hours in 2007.
~ 40 000 Wall Time Hours in Jan+Feb 2008.

started by C.Häberli in 2005
now done by S.Haug and C.Topfel

ATLAS Tier-3 in Geneva

- a Grid site since 2005
- evolving towards 1st data
  - more hardware in Summer 2007
  - more security/redundancy
- a local computing facility for the Geneva group
  - development and testing of trigger code
  - analysis, interactive or in batch
- free CPU cycles used for ATLAS Monte Carlo production
- current size
  - 61 machines, 188 CPU, 75 TB
  - this the hardware we will use for 1st ATLAS data this Summer

Swiss ATLAS Grid clusters

ATLAS Grid Monitor

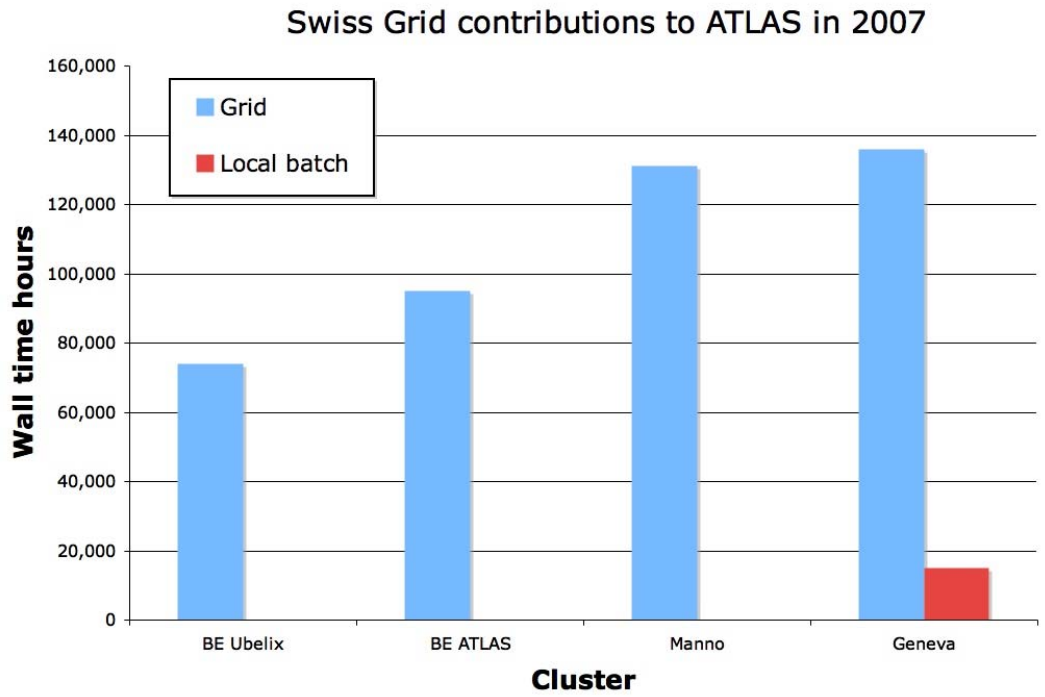
2008-03-26 CET 10:45:24

Processes: Grid Local

Country	Site	CPUs	Load (processes: Grid+local)	Queueing
Denmark	Benedict - Aalborg pr>	56	31+23	8+7
	Steno (DCSC/KU)	111	12+295	1+3047
Norway	EPF (UiO/FI)	22	15+3	3+0
	Hyperion (UiO/USIT)	196	4+158	1+52
	Norgrid@NTNU	38	0+13	0+0
	Titan A (UiO/USIT)	2352	284+1553	4+0
Slovenia	SiGNET	200	199+1	36+0
Sweden	Hive (Swegrid, C3SE)	101	100+1	2+5
Switzerland	Bern ATLAS T3 Cluster	24	20+0	2+0
	Bern UBELIX T3 Cluster	512	96+363	23+76
	Geneva ATLAS dev	80	60+0	4+0
	Geneva ATLAS prod	71	60+0	1+0
	Manno PHOENIX T2	443	0+333	0+4
TOTAL	*13 sites*	*4206*	*881 + 2743*	*85 + 3191*

- T3 in Berne and Geneva are NorduGrid (an easier way for a University group)
- T2 in Manno in NorduGrid and LCG
- Different roles: T2 is mostly for the Collaboration, T3 is mainly for us

Swiss grid for ATLAS



Not a large part of ATLAS computing done on the grid in 2007, below 1%.
(no T1 in Switzerland, T2 getting hardware by the end of 2007).

The resources we have are kept “in production”.

This is a valuable experience.

Ongoing work

- **keeping the systems in production**
  - Monte Carlo simulations of ATLAS, development of offline and trigger software
- **adding more hardware later this year**
- **consolidation, making the setups uniform and more reliable**
- **adding functionality**
  - tools to run multiple jobs, tools for interactive use of many CPUs
- **University groups (BE+GE) working closer together with our T2 in Manno and with our T1 at Karlsruhe**
- **data transfer exercises**
  - moving data has often been unreliable in the past
  - "Full Dress Rehearsal" of ATLAS Computing Feb-May 2008

ATLAS grid working group
of the
Swiss National Grid Association

contact: Sigve Haug, Uni BE

S. Haug, C. Topfel — S. Gadomski, ? — P. Kunszt, ?

SWING: **Swiss National Grid Association**.
http://www.swing-grid.ch

Summary

- ATLAS (and other LHC experiments) need to look for processes that are rare. High intensity of collisions and a lot of data to process.
  - The data is reduced by 5 to 6 orders of magnitude in real time, before recording. ATLAS will record one collision in 200'000.
  - This still leaves several PB of data to analyze every year.
- Plan to use grid developments, organize a global analysis of the data on that basis. A hierarchy of collaborating computer centers is in place.
- **The computing infrastructure is being developed. We use it as much as possible for Monte Carlo simulations.**
- **First confrontation with real data expected this Summer!**
- **It will take a lot more effort to have a reliable service.**

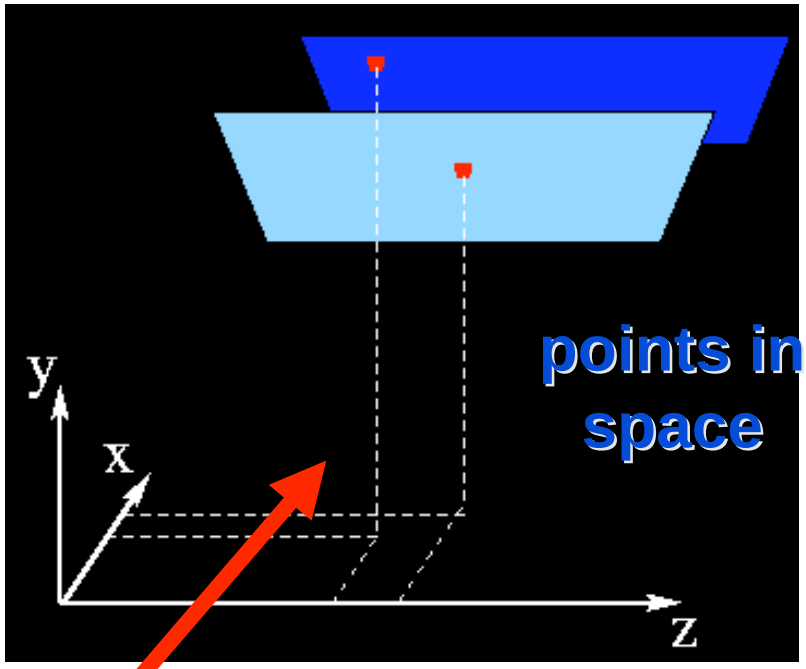
backup slides

Data analysis

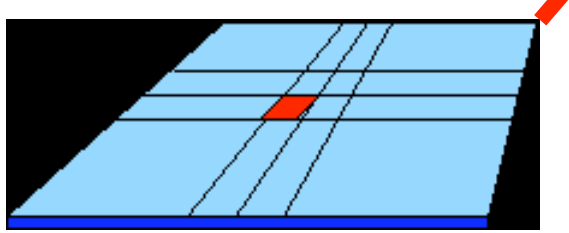
first steps

```
0155200 00000001 0100000d 00000002
0155220 00000cc6 dd1234dd 000001d6
0155240 02040000 00012100 00000000
0155260 00000000 00000000 00000001
0155300 00000004 0000001d 00000cc6
0155320 00000000 ee1234ee 00000009
0155340 00002200 00000000 0000001d
0155360 00000000 00000000 27004000
0160000 d2b1d2b1 d2b9d2b1 d5c1d5f9
0160720 c844d6c0 da044000 00000096
0160740 00000002 0000[illegible]1b8 00000001
0160760 00000004 0000[illegible]01f 00000760
```

“raw” data from the electronics

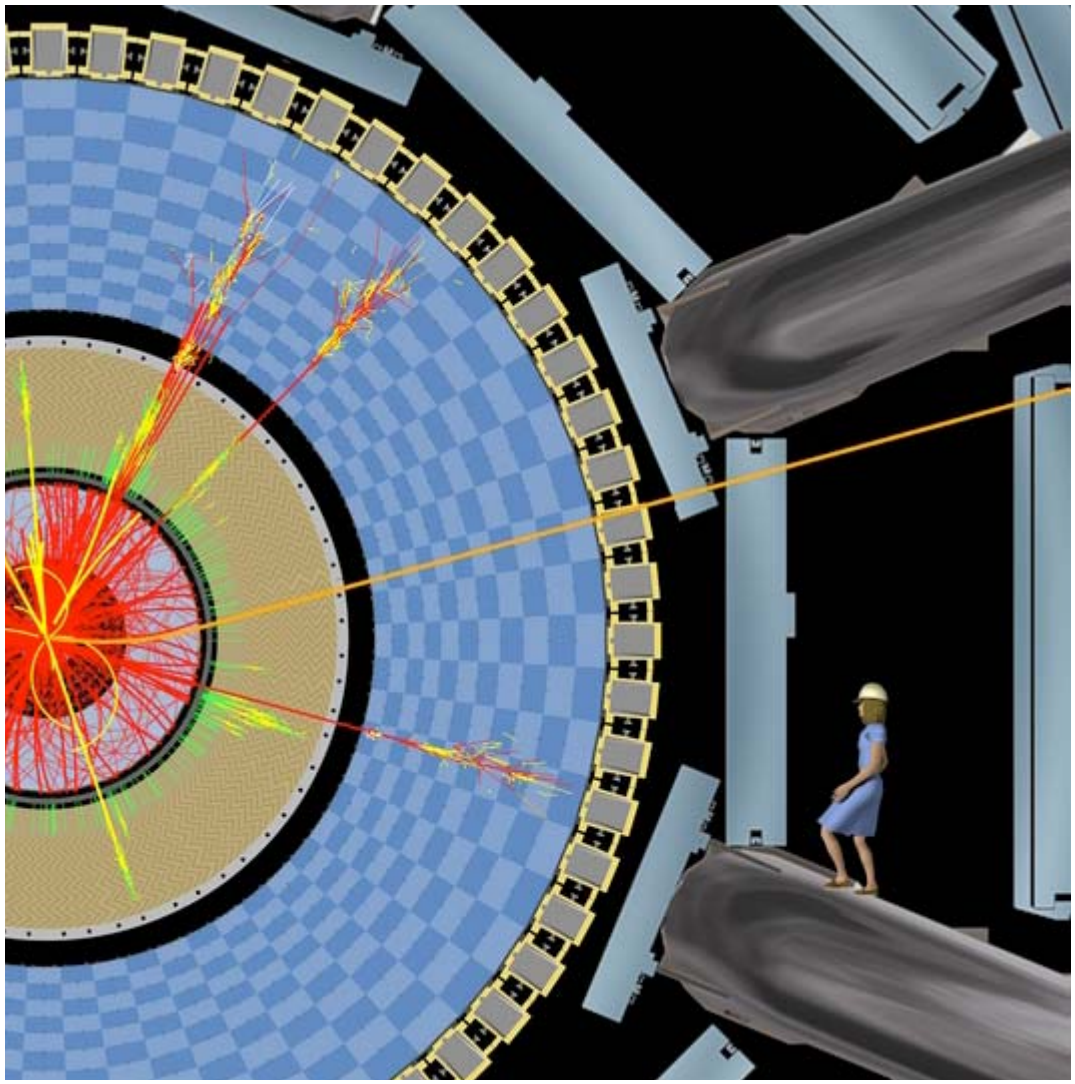


points in space



data points local to a detector

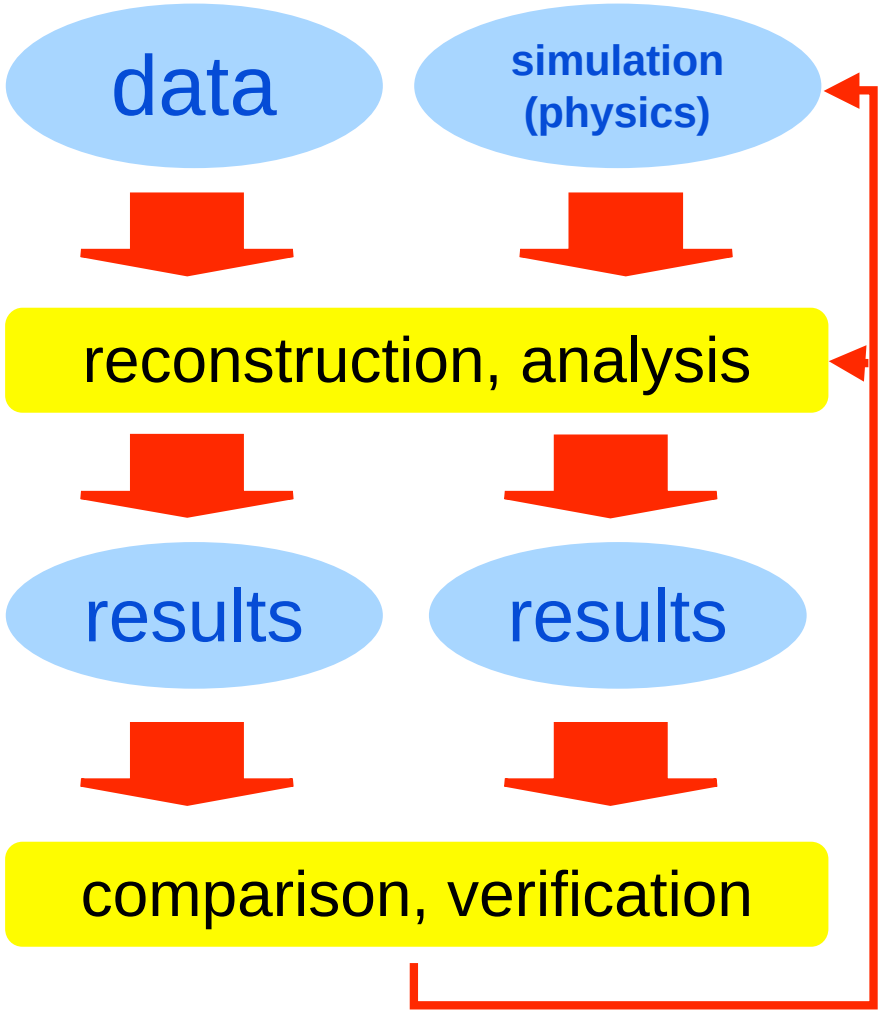
Data analysis, next steps



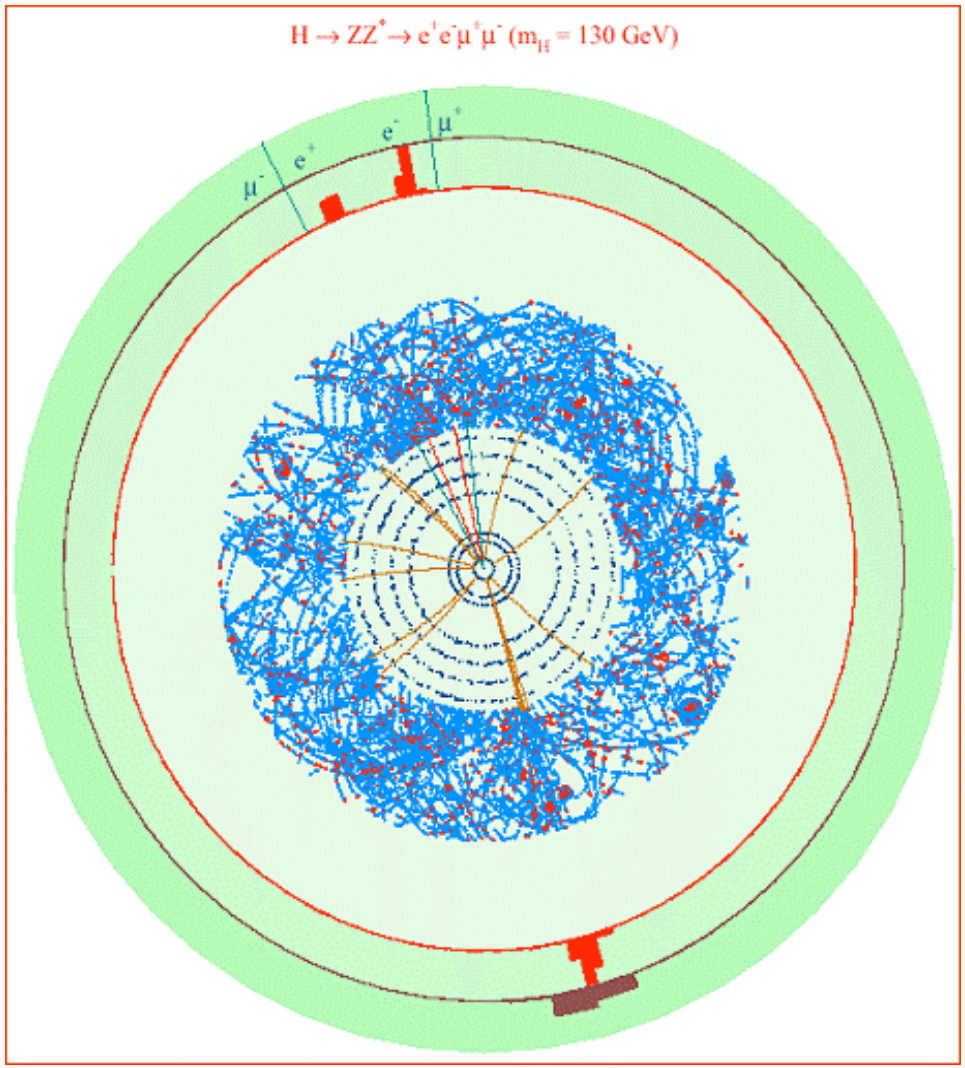
- reconstruction of tracks and energy deposits
- identification of particles (muons, electrons, jets of hadrons

Analysis and simulation

- **an iterative process**
- **understanding of detector and physics takes years**
- **comparison of simulation and data is repeated until agreement is found**

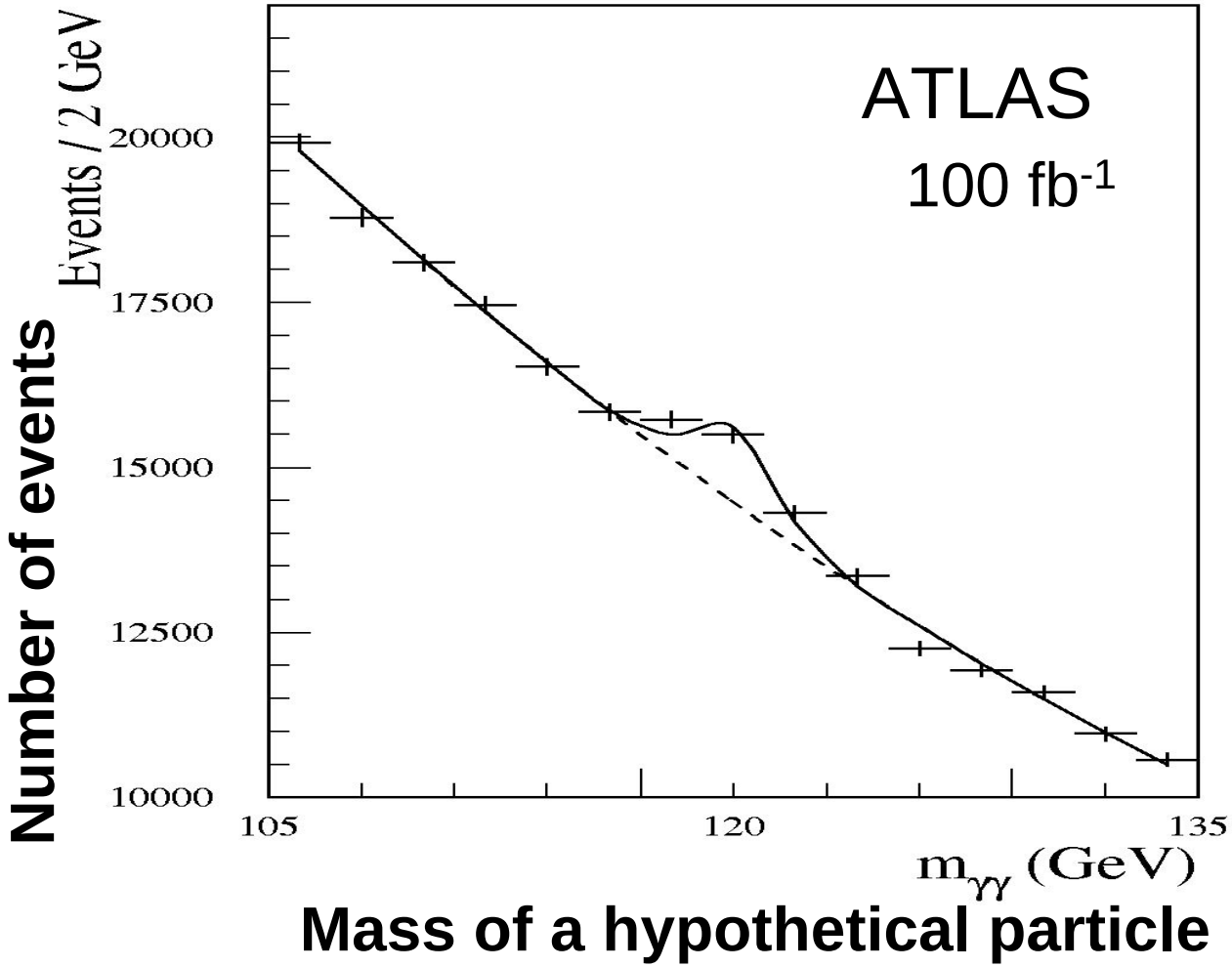


Simulation



- one bunch crossing in ATLAS
- one Higgs boson
- 25 proton-proton interactions
- 750 charged tracks

One “event” is not decisive



expected (hypothetical) signal of a Higgs particle ($H \rightarrow \gamma\gamma$) after several years of data taking