



Project Management at CERN

Lessons Learned from the LHC Project

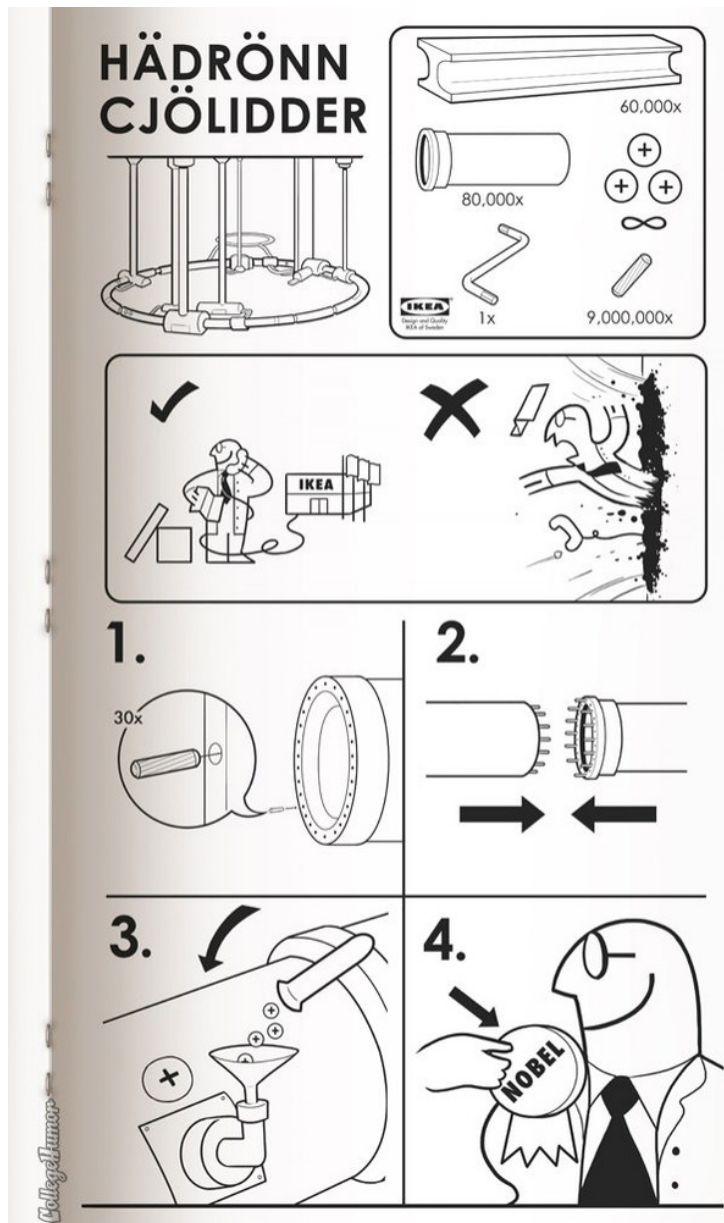
Pierre Bonnal

Office of the Director for Accelerators and Technology
CERN, European Laboratory for Particle Physics, Geneva, Switzerland

on behalf of the **members** of the **DAT's Projects Support Office**

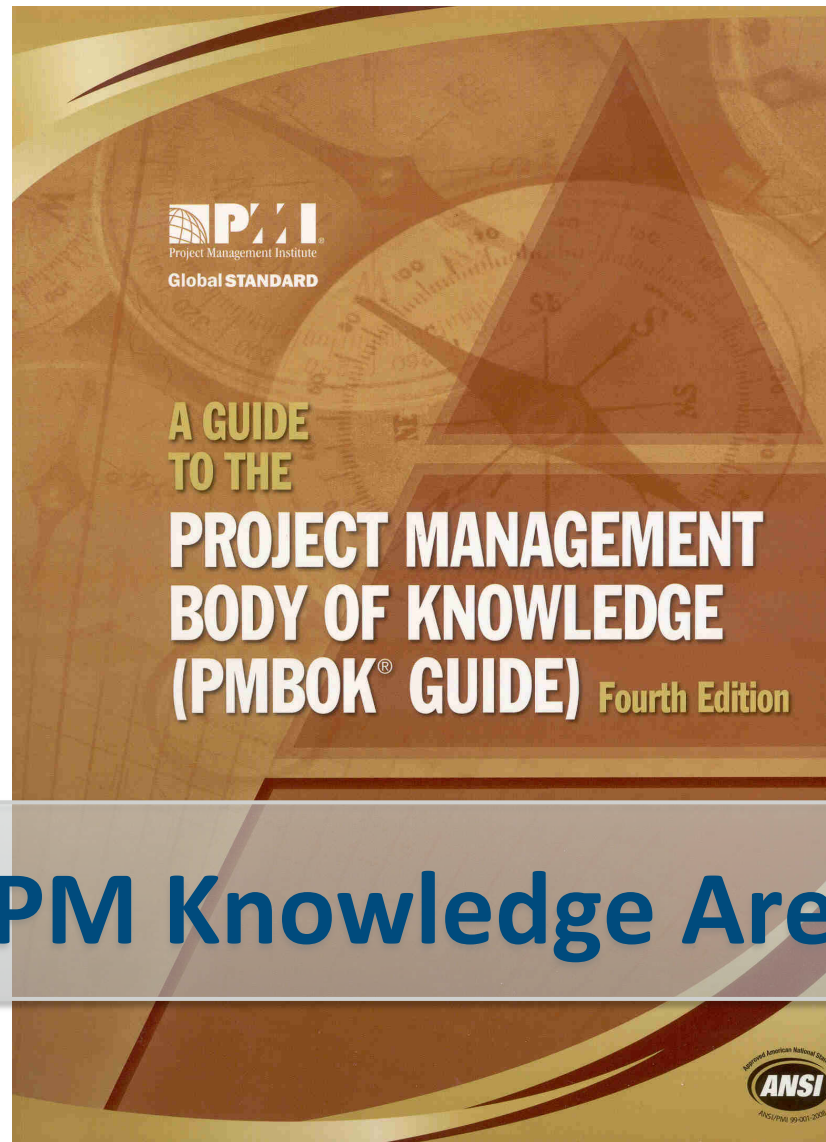
seminar given at ESS, Lund, Sweden – 15th March 2011

Agenda



- CERN and the LHC Project at a glance
- The Project Management framework of the LHC Project
 - What was set-up
 - How it worked
 - What are we* promoting.

* CERN DAT's Projects Support Office



9 PM Knowledge Areas

CERN and the LHC Project

at a glance



Created in 1954 (under the auspices of UNESCO)
20 Member States + some observers
CHF 1 billion annual budget
Near Geneva, Switzerland
Across the FR-CH border
10'000 people

“The Organization shall provide for collaboration among European States in nuclear research of a pure scientific and fundamental character (...). The Organization shall have no concern with work for military requirements and the results of its experimental and theoretical work shall be published or otherwise made generally available”.



accelerators

LHC
+ 7 Detectors

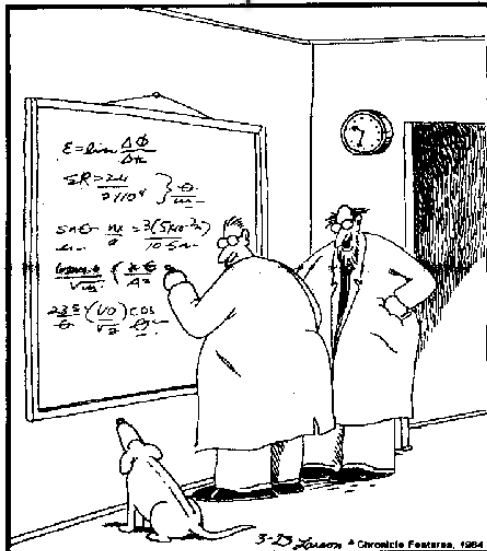
detectors

SPS
+ North Exp. Areas
CNGS

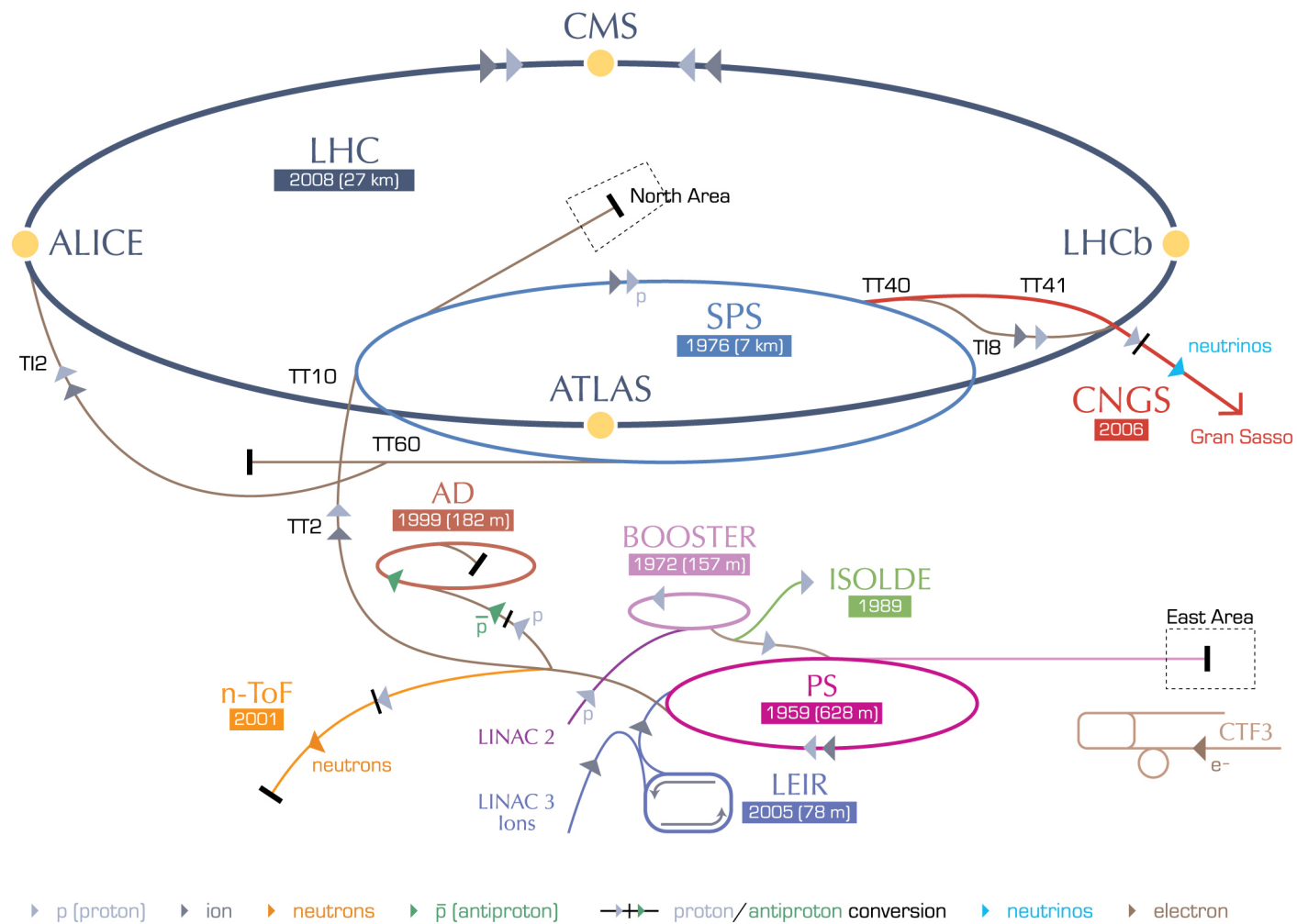
computers

PS Complex
& East Exp. Areas
ISOLDE

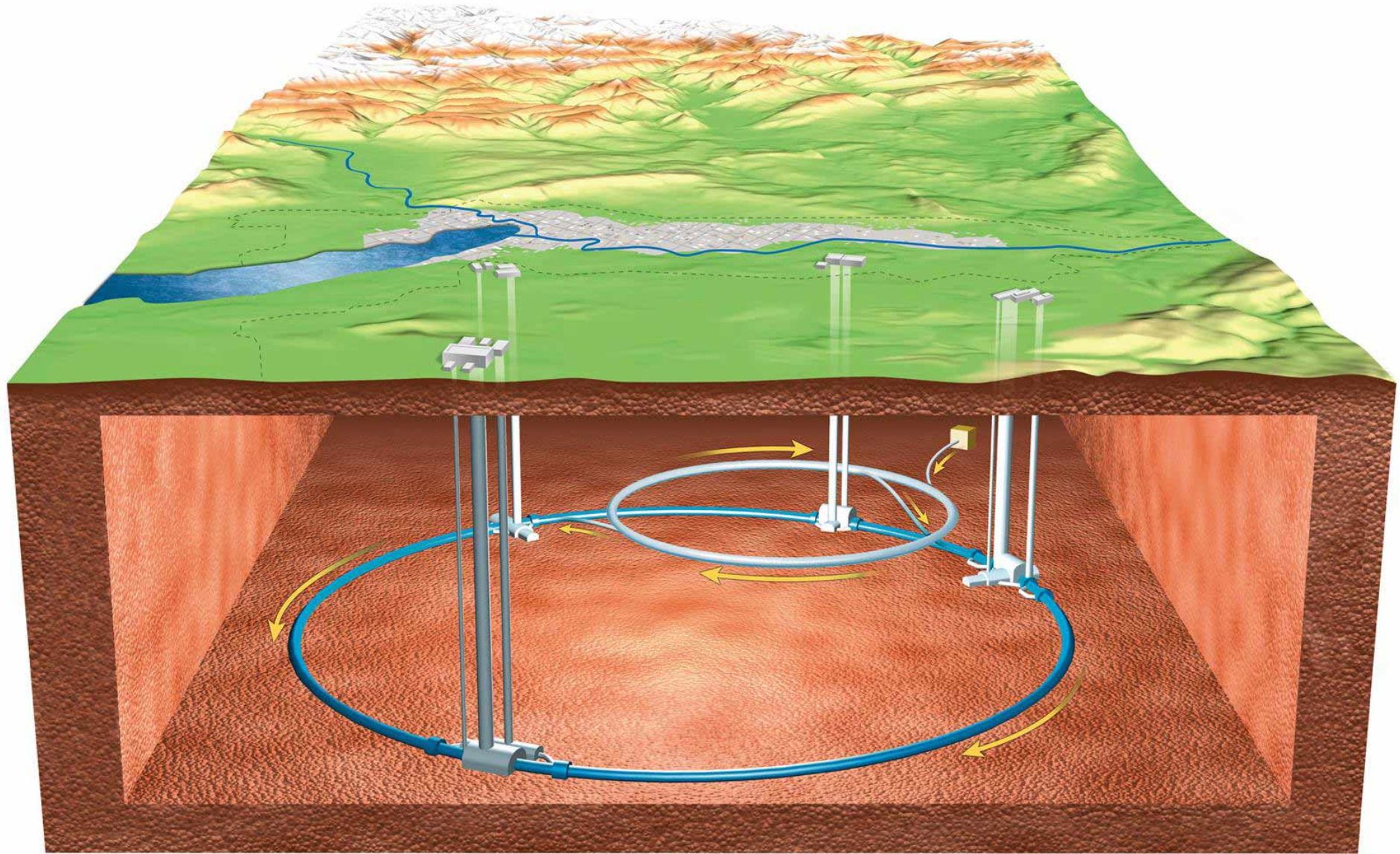
Linear Colliders



And a few theoreticians



LHC Large Hadron Collider SPS Super Proton Synchrotron PS Proton Synchrotron
 AD Antiproton Decelerator CTF3 Clic Test Facility CNGS Cern Neutrinos to Gran Sasso ISOLDE Isotope Separator OnLine DEvice
 LEIR Low Energy Ion Ring LINAC LINear ACcelerator n-ToF Neutrons Time Of Flight





proton synchrotron

Input interpretation:

Proton Synchrotron

Basic properties:

type	synchrotron
institution	European Organization for Nuclear Research
dates	1959 to present

Configuration:

shape	circular
length	600 meters
radius	95.5 meters

Beam characteristics:

accelerated particles

Computed by **Wolfram Mathematica**



super proton synchrotron

Input interpretation:

SppS (Super Proton Synchrotron)

Basic properties:

type	hadron collider
institution	European Organization for Nuclear Research
experiments	UA1 UA2
dates	1981 to 1986

Configuration:

shape	circular
length	6.9 km (kilometers)
radius	1.1 km (kilometers)

Beam characteristics:

accelerated particles

Computed by **Wolfram Mathematica**



large hadron collider

Input interpretation:

LHC (Large Hadron Collider)

Basic properties:

type	hadron collider
institution	European Organization for Nuclear Research
experiments	ALICE ATLAS CMS LHCb LHCf TOTEM
dates	2008 to present

Configuration:

shape	circular
length	26.659 km (kilometers)
radius	4.24 km (kilometers)

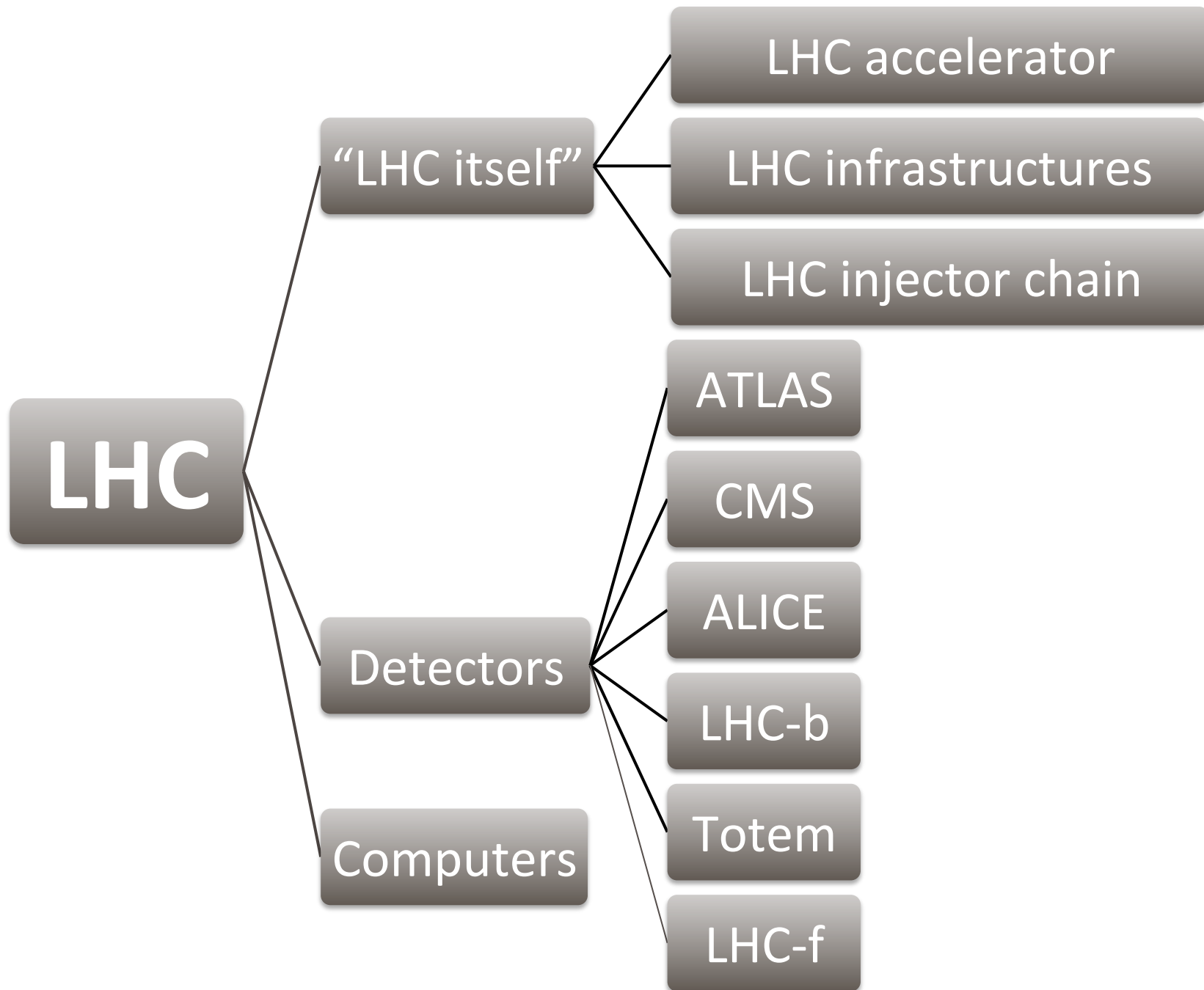
Beam characteristics:

accelerated particles	p	7 TeV (teraelectronvolts)
	p	7 TeV (teraelectronvolts)
center-of-mass energy		14 TeV (teraelectronvolts)

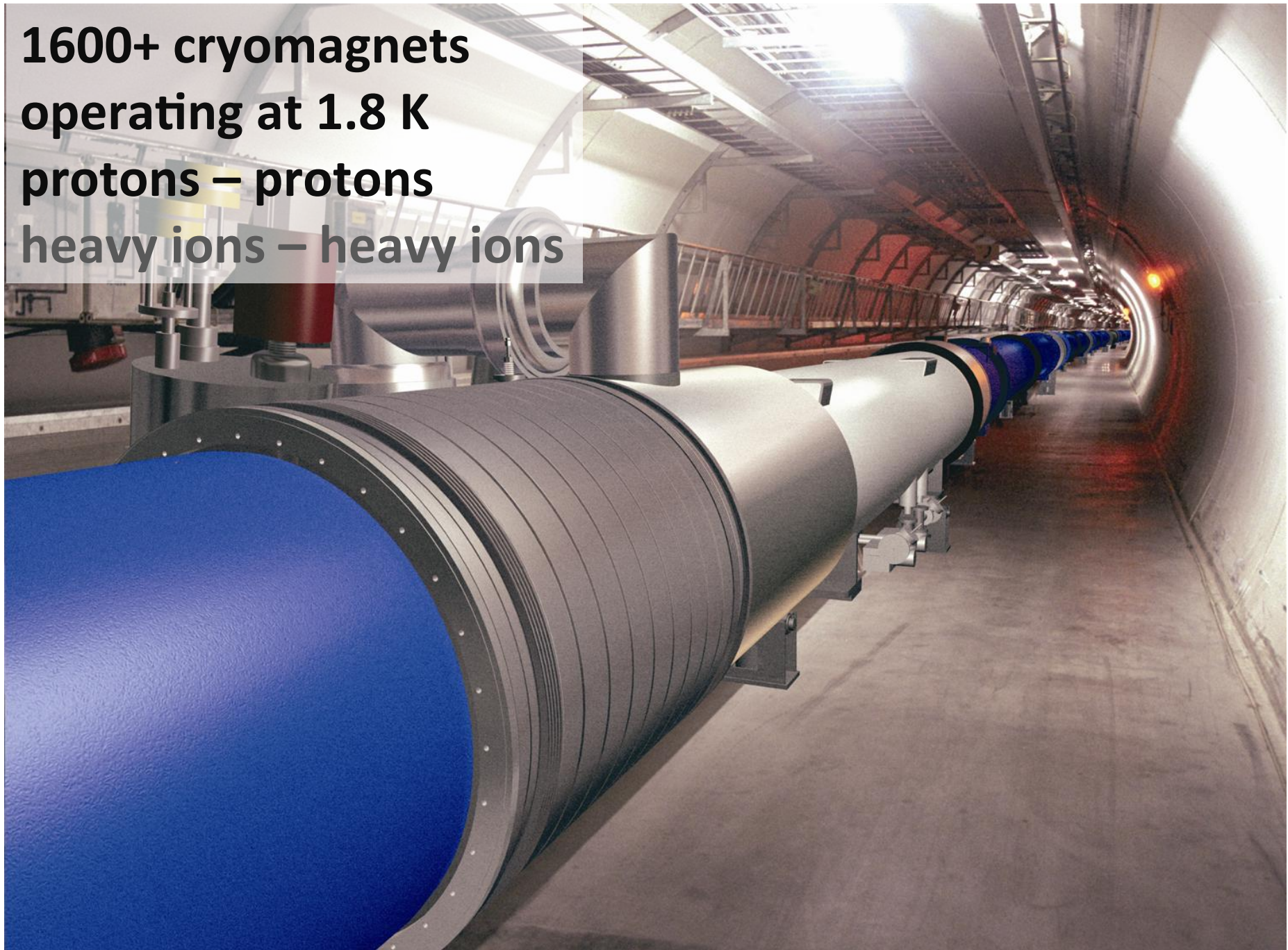
Computed by **Wolfram Mathematica**

[Source information »](#)

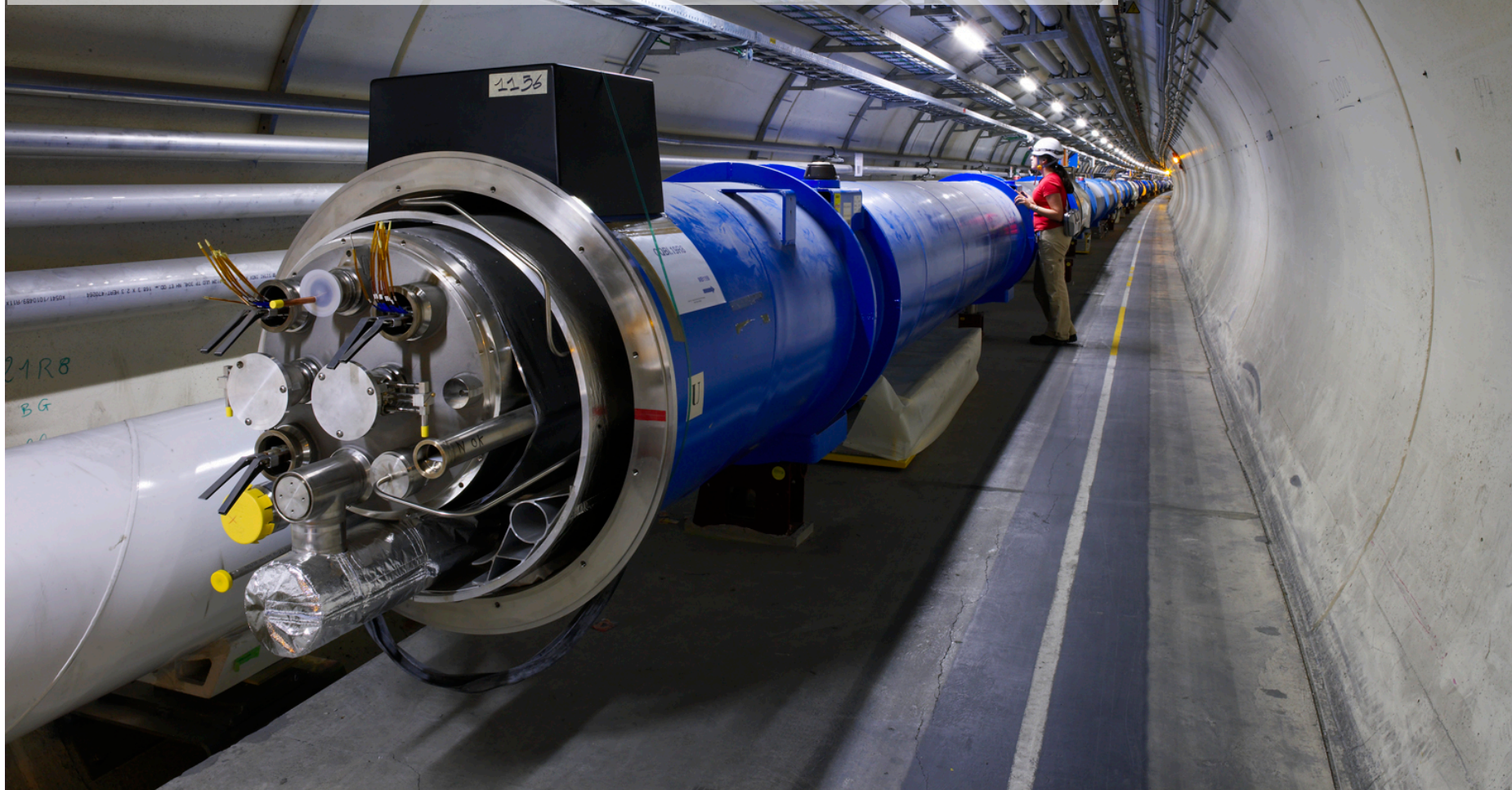
Download as: [PDF](#) | [Live Mathematica](#)

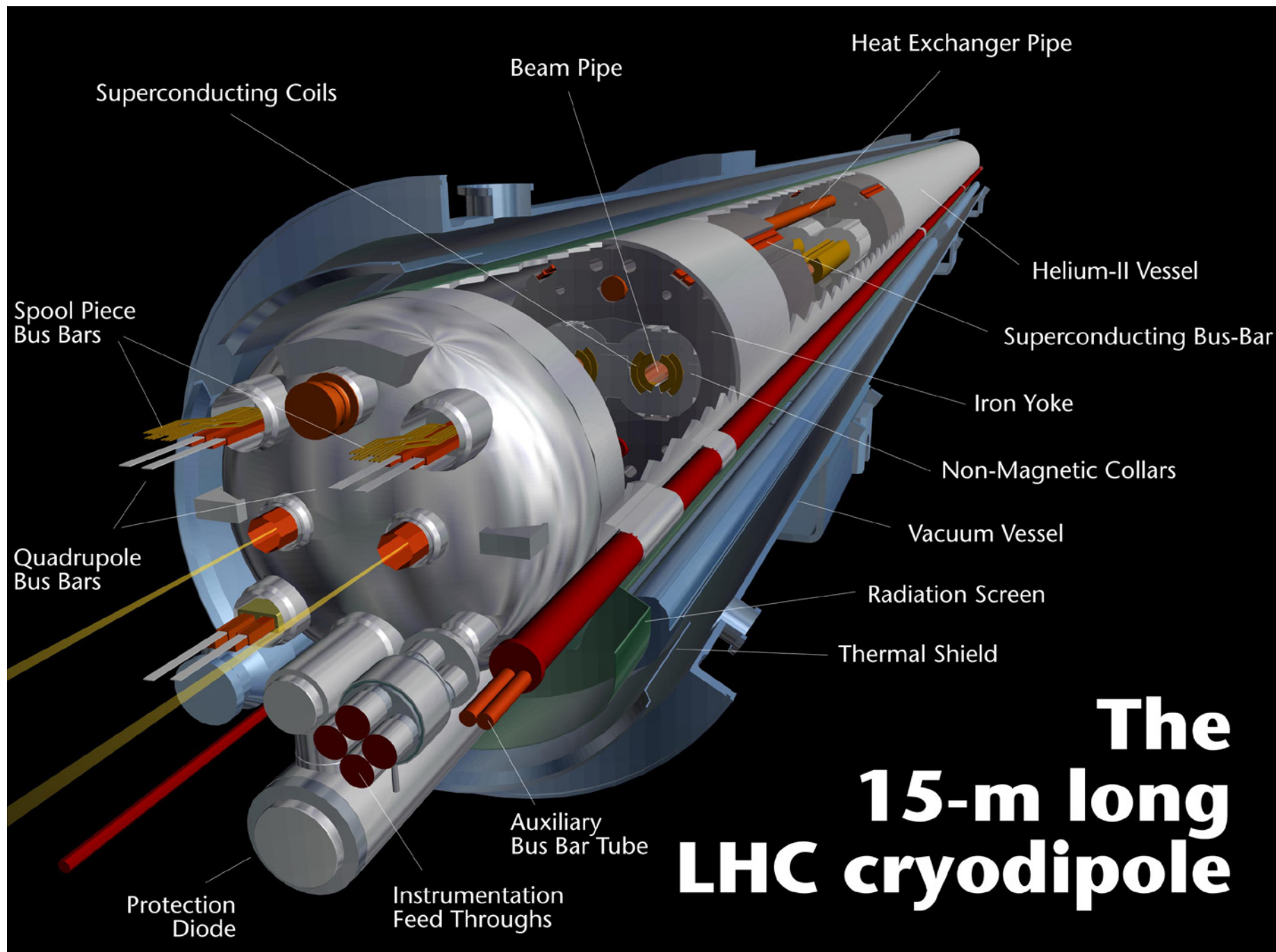


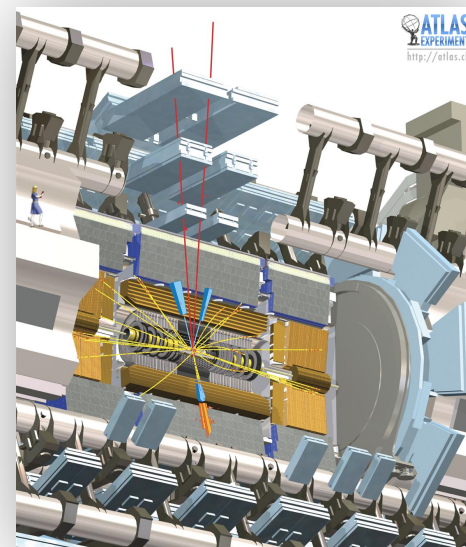
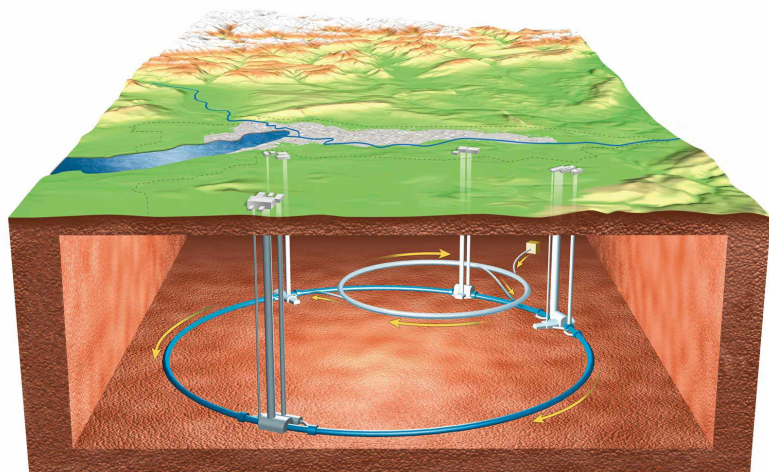
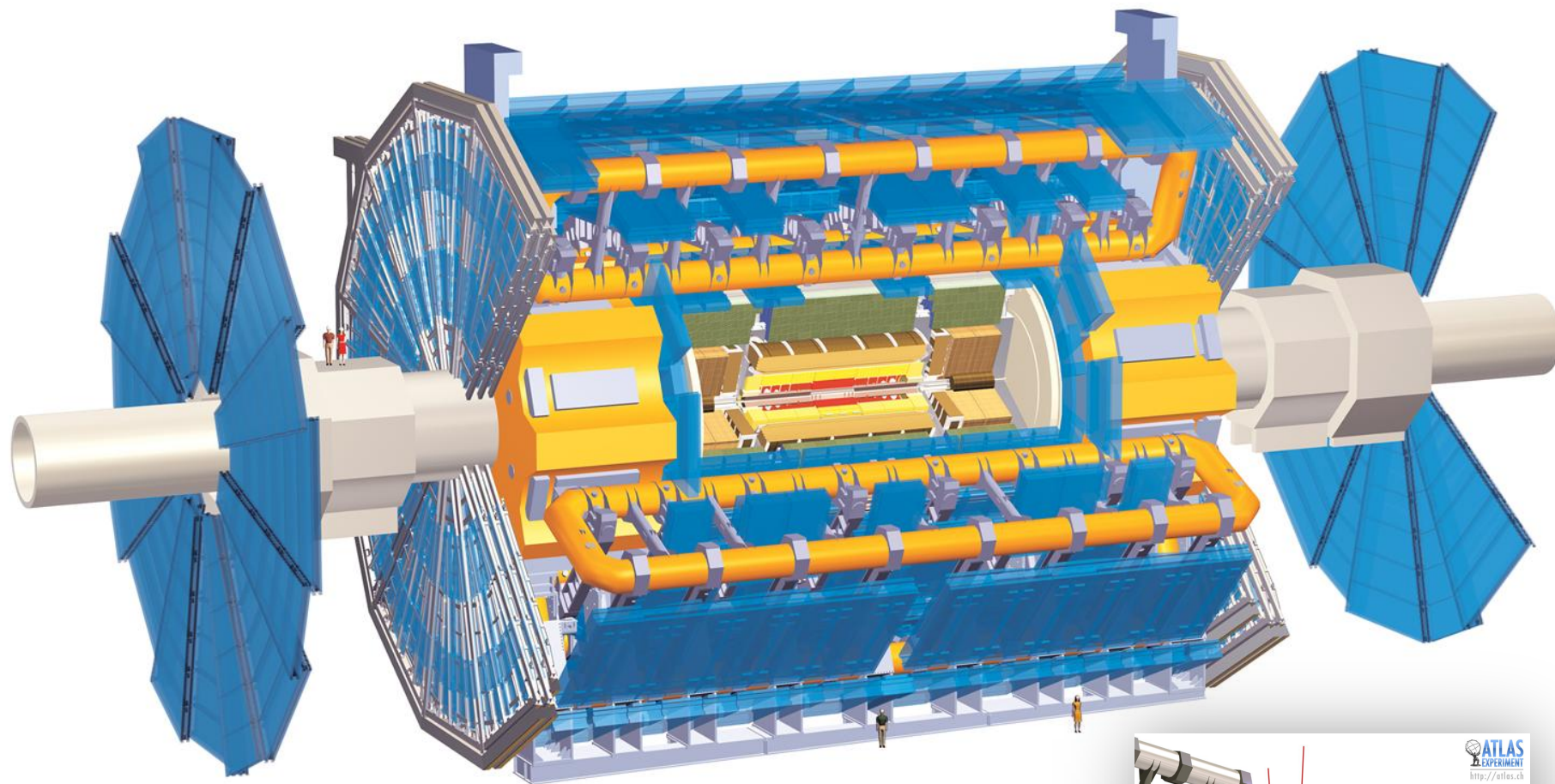
**1600+ cryomagnets
operating at 1.8 K
protons – protons
heavy ions – heavy ions**

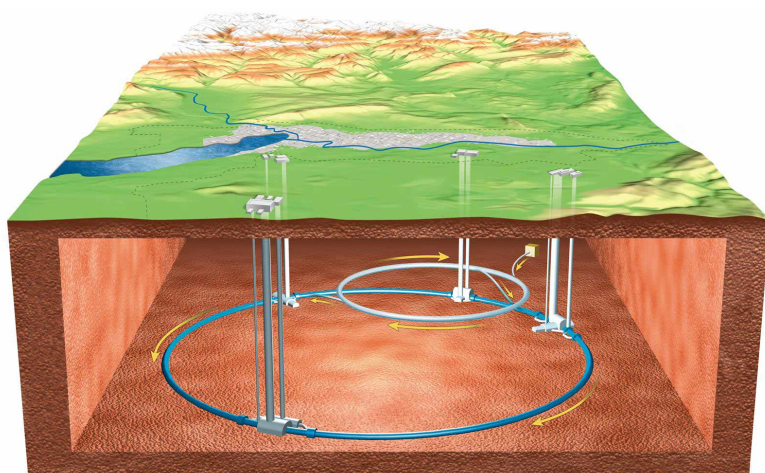
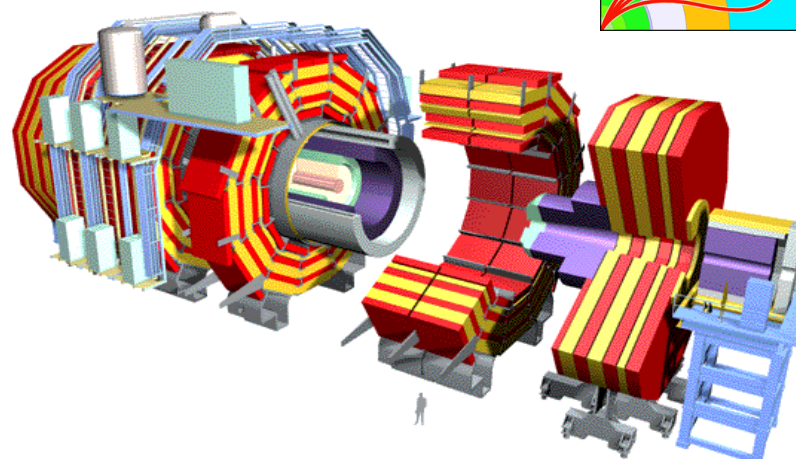
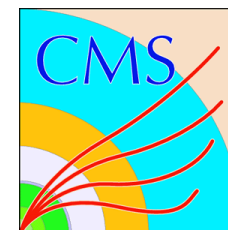
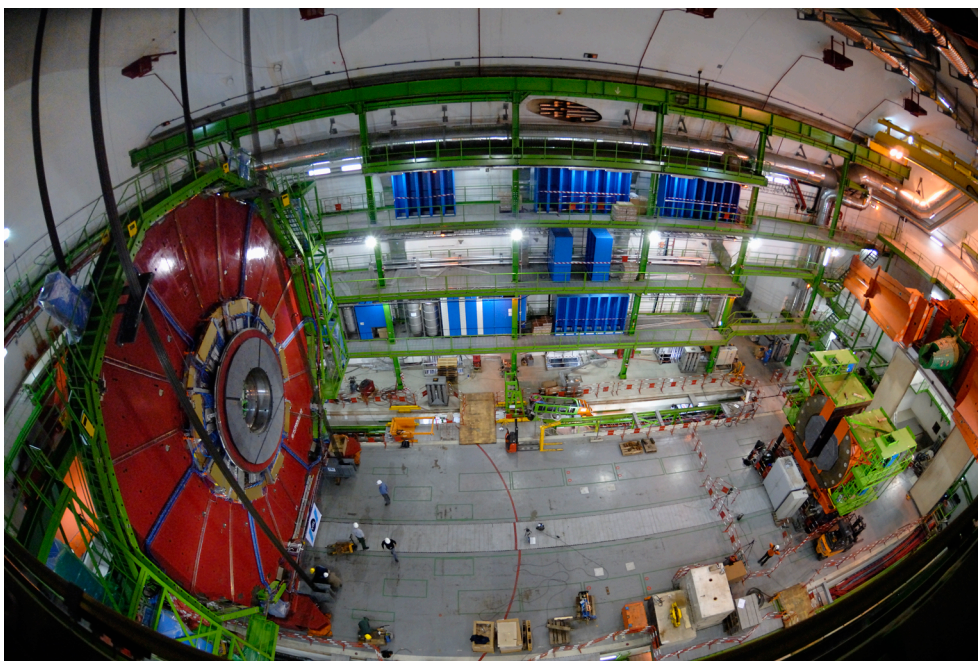


LHC Front-End Project launched in 1984
LHC Project approved in 1994
First circulating beams in 2008
Final Project Cost = CHF 6+ billion









http://lcg.web.cern.ch/LCG/public/default.htm

lhc project grid

Samhain Imbolc Beltaine Lughnasad Telaranha

LCG Worldwide LHC Computing

Home LHC GridFest CERN the WLCG Office



15 Pbytes \div 4 Gbytes = 3.75 million DVDs / year

$3.75 \times 10^6 \times \frac{1}{8} \text{ in.} = 0.47 \times 10^6 \text{ in.} \approx 40'000 \text{ feet}$

a pile that is 30% higher than Mount Everest!

The Large Hadron Collider at CERN near Geneva is the largest scientific instrument on the planet. When it begins operations, it will produce roughly 15 Pbytes (15 million Gbytes) of data annually, which thousands of scientists around the world will access and analyse.

The mission of the **WLCG** project is to build and maintain the computing infrastructure for the LHC that will use the LHC.

The data from the LHC, coming from all over the globe, according to the WLCG, will be recorded on tape. After initial processing at the LHC, the data will be sent to Tier-1 centres, large storage capacity and high-speed networks.

The Tier-1 centres will be distributed around the world, each consisting of one or more large data centres.

computing

can I get involved?

ed Projects

& Tier2 partners

Components

er information



The Construction of the LHC with a few pictures

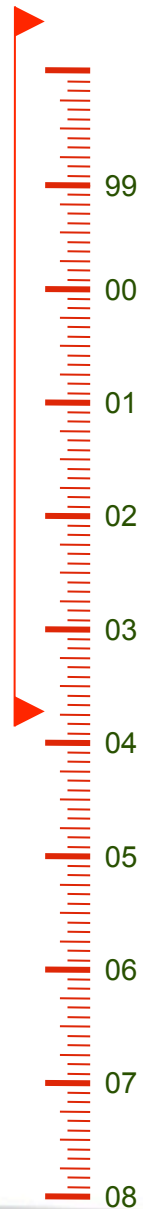
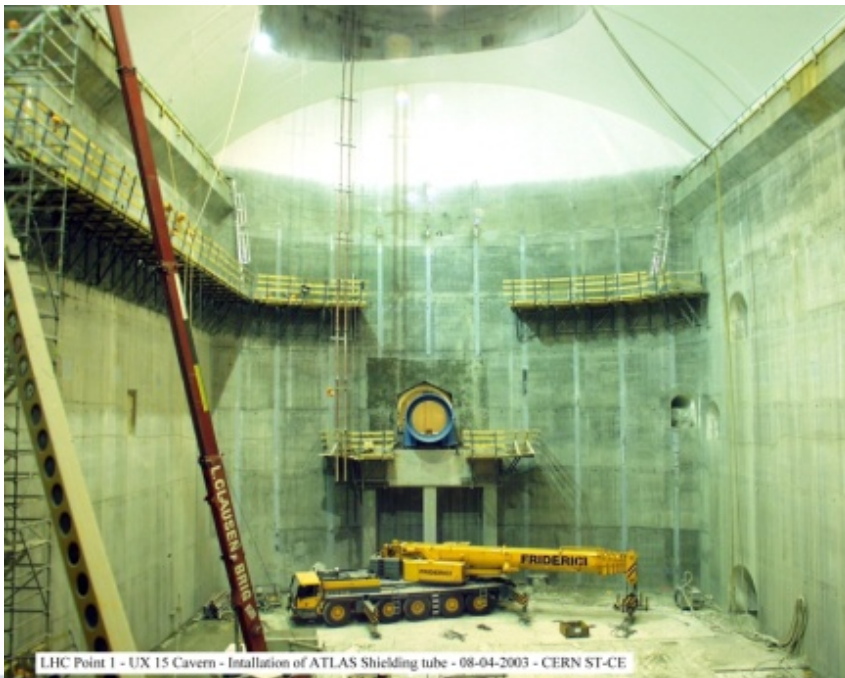
Thanks to **Katy Foraz** for providing the slides

90 main industrial contracts



Civil Engineering

- 4 main contracts
- Issues :
modification of the scope
35-hours law in France



Cryogenics

- 5 cryogenic islands installed/modified
- Cryogenic line: one contract
- Started in June 2003, but stopped July '04 – Nov. '04



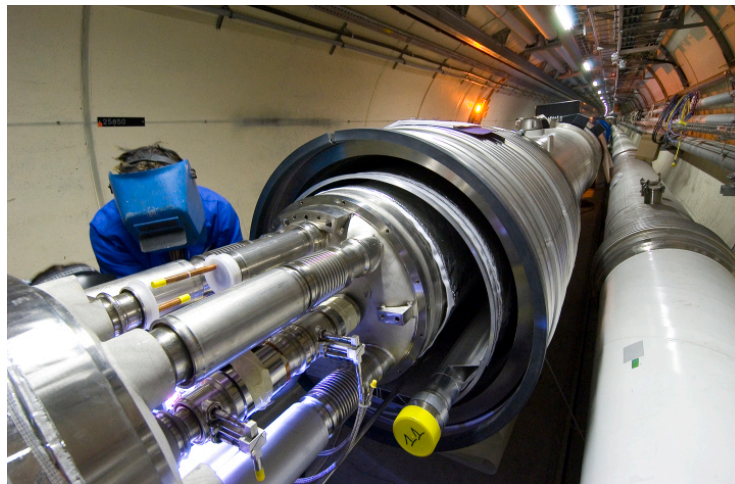
Impact of cryogenics distribution line delay



Superconducting magnets installation

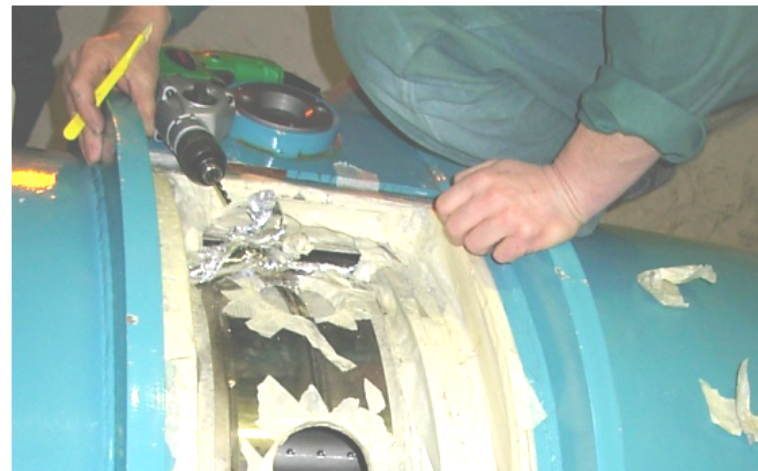
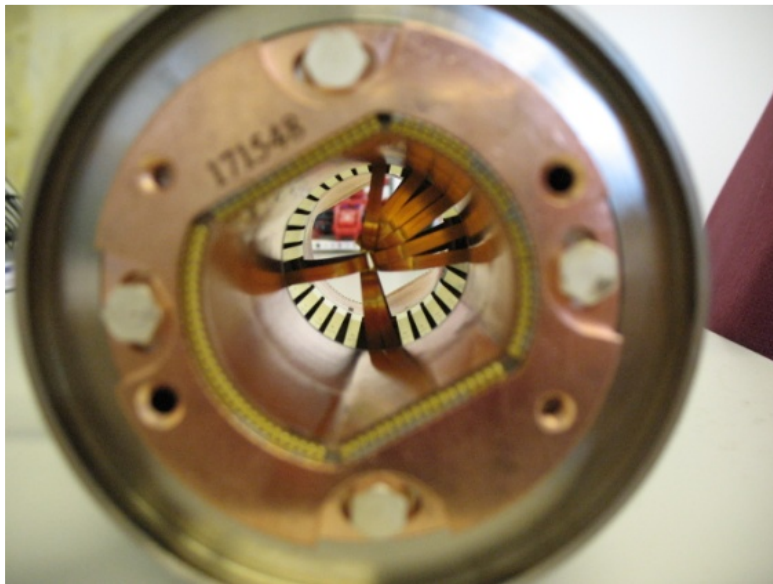
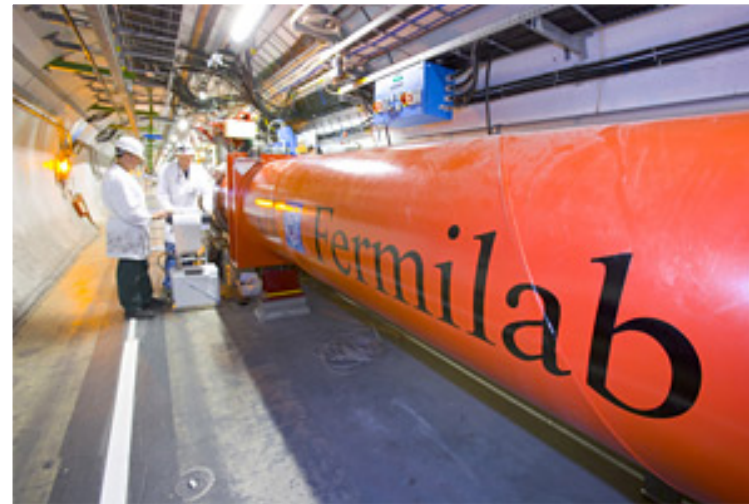


Installing dipoles...



Interconnections of magnets

**Task
forces set
up quickly**

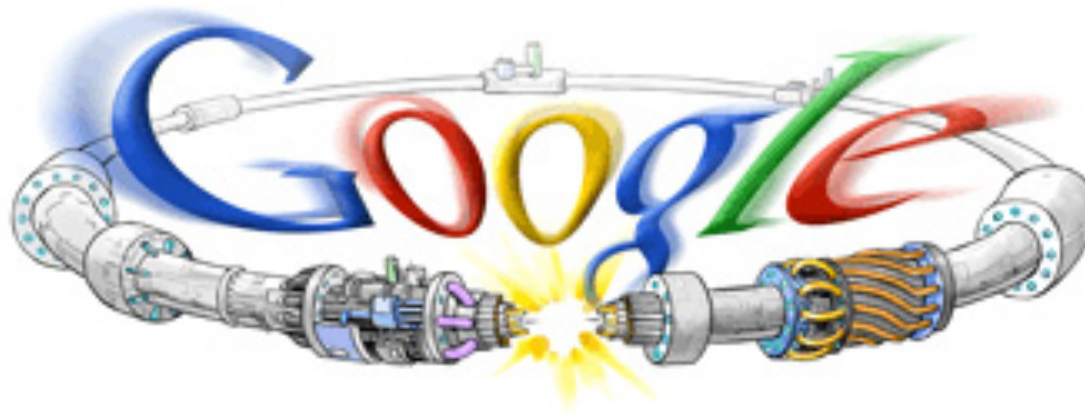


Hardware Commissioning

Painful start with low Mean Time Before Failure and high Mean Time Between Recovery, but debugging was essential, and systematic errors corrected.



September 10th 2008

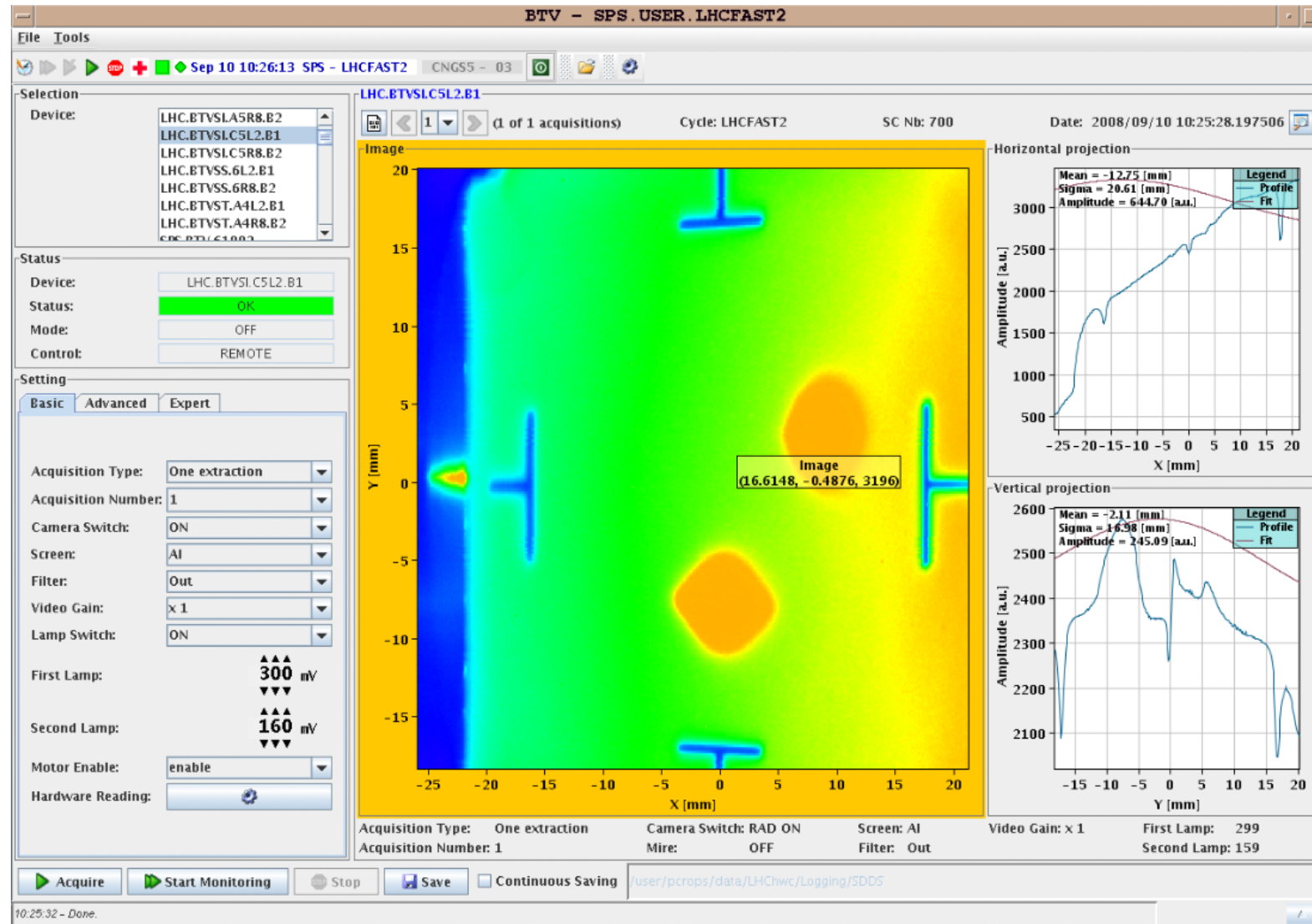


I guess you understand why...

Google Search

I'm Feeling Lucky

September 10th 2008







PMBoK Area #1: Project Integration Management

Project Integration Management includes the activities needed to identify, define, combine, unify and coordinate the various project management activities.

- ***Project Charter*** (i.e. *Project Mission Statement*) ✓
- ***Project Management Plan*** ✓
 - “LHC Project QAP and Project Organization”
 - with appendices: 4 cm thick!
- **Integrated Change Control** mechanism ✓
 - “Engineering Change Requests / Orders”
- **Coordination Forums:** LHC-TC, MARIC, TCC, LEMIC... ✓

PMBoK Area #2: Project Scope Management

Project Scope Management includes the activities needed to identify the work required, and only the work required to complete the project.

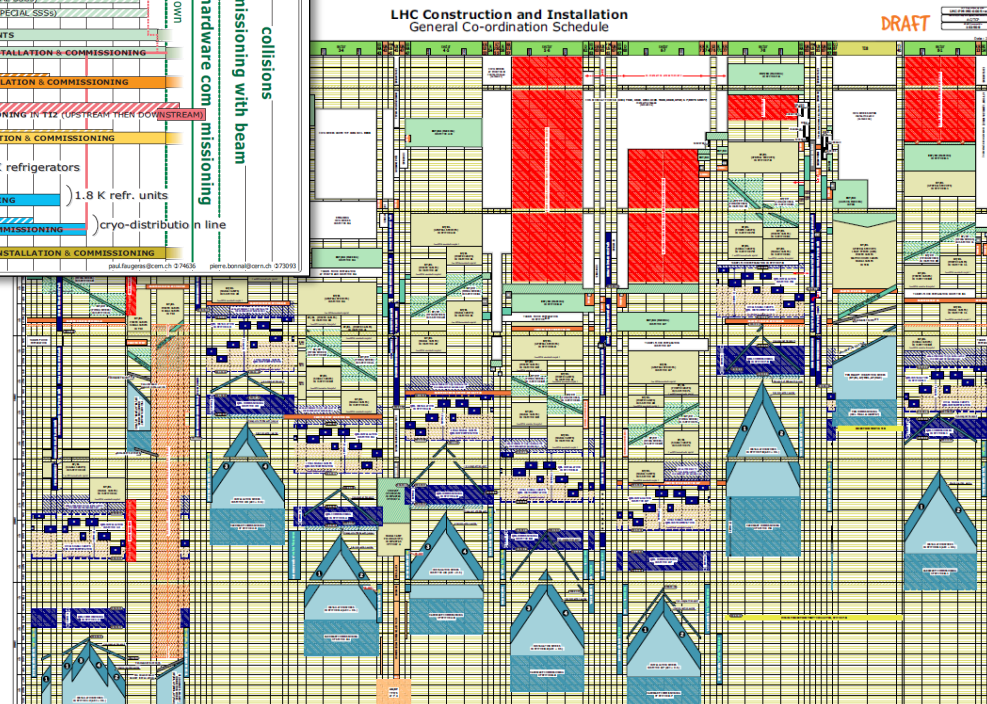
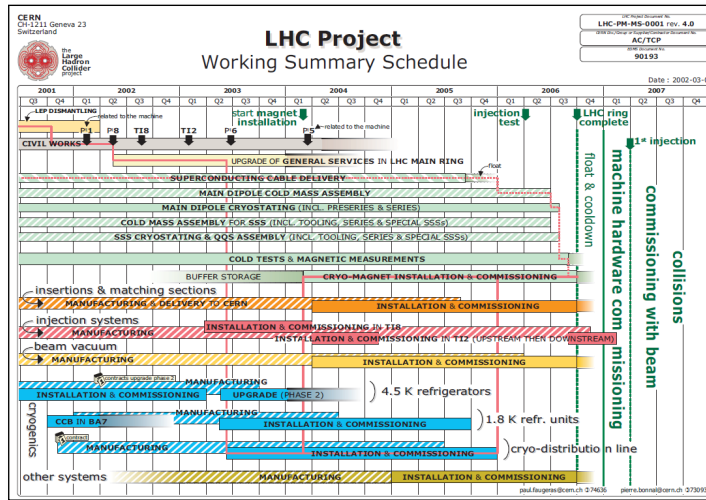
- **Work Breakdown Structure**  then  **PPT-EVM**
 - 1994–2001: not according to state of the art practices
(budget/cost planning  technical planning & scheduling)
 - 2002–2008: embedded in the **LHC Project Control System**
 - Certainly too detailed: 12'000+ Work Units
- **Project Reviews** (LHC Cost & Schedule Review Committee) 

PMBok Area #3: Project Time Management

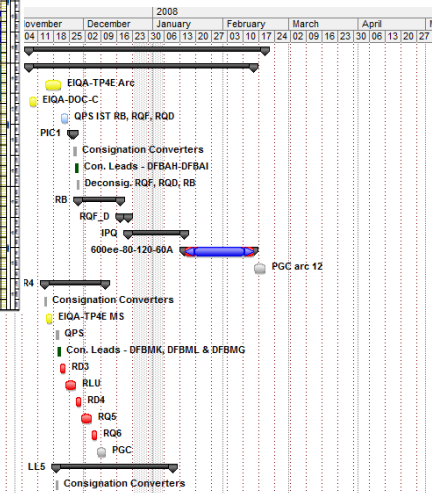
Project Time Management includes the activities needed to manage timely completion of the project..

- ***Project Master Schedule*** ✓
- ***Project Co-ordination Schedules*** ✓
 - Engineering and manufacturing activities: at group level, then embedded in the **LHC Project Control System**
 - Construction, installation and HW/beam commissioning: centralized, but 2 systems & CPM partially implemented
- ***Project Detailed Schedules*** 🚧 / ✓
 - Relative freedom: some used systematically MS Project, others draw Gantt charts: no consolidation possible!

3 levels of planning & scheduling






38	EIQA-TP4E MS	2.5 days	14/11/07	16/11/07	ELQA	38
39	QPS	1 day	19/11/07	19/11/07	QPS_EE_Field	39
40	Con. Leads - DFBMK, DF	0.5 days	20/11/07	20/11/07	MEL	40
41	RD3	2.5 days	20/11/07	22/11/07	Front.Front QPS_EE_PC_ccc.PIC	41
42	RLU	2.5 days	23/11/07	27/11/07	Front.Front QPS_EE_PC_ccc.PIC	42
43	RD4	2.5 days	27/11/07	29/11/07	Front.Front QPS_EE_PC_ccc.PIC	43
44	RD5	2.5 days	30/11/07	04/12/07	Front.Front QPS_EE_PC_ccc.PIC	44
45	RD6	2.5 days	04/12/07	06/12/07	Front.Front QPS_EE_PC_ccc.PIC	45
46	PGC	2 days	07/12/07	10/12/07	Front.Front QPS_EE_PC_ccc.PIC	46
47	LL5	28 days	19/11/07	09/01/08		47
48	Consignment Converters	0.5 days	19/11/07	19/11/07	PC_field	48



PMBoK Area #4: Project Cost Management

Project Cost Management includes the activities involved in estimating, budgeting and controlling costs so that the project can be completed within the approved budget.

- **Project Cost Estimate / Budget Breakdown**  then 
 - 1994–2001: not according to state of the art practices
(budget/cost planning  technical planning & scheduling)
 - 2002–2008: quite better (**EVM oriented**), but still not according to state of the art practices: e.g. no **PM Reserve!**

CERN's EVMS | *Project audit of 2001*

- **18% overspend** announcement ... only
- Technical Coordinator → *“the project is behind schedule”*
- Project Administrator → *“the project is under-running”*
- LHC PM Team: not in position to demonstrate that the project could be completed within allocated budget!

Member States asked CERN Management and the LHC Project Management to set up a formal Project Control System

CERN's EVMS | *The key requirements*

- **EVM-based** project control system
- **Deliverable-oriented** physical progress monitoring
- Interfaced to CERN's **accounting systems**,
to get accurate information on actual costs
- Interfaced to CERN's **contract management system**
- Interfaced to CERN's **human resource** system
- Handle **in-kind contributions**
- **Web-based**
- Excel spreadsheets to interact with DBs
- activity scheduling & time-control reporting engines delayed

LHC Project EVMS | *Weak points*

LHC Project EVMS introduced while AC = CHF 1 billion!!

- “**Granularity**” between breakdown structures
→ consolidations difficult to handle
- Too many activities: **12’000+ activities**
- “Varying granularity” of activities:
 - from a few **kCHF** to several **MCHF**
 - from a few **weeks** to several **months**
- Project Engineers planned too optimistically
...to **obtain budget** (it’s easier to carry over)
- Weak integration with schedule networks



LHC Project EVMS | *Lessons learned*

- Design the WBS so that no. of planned activities < 500
- Breakdown depth → no responsibility ambiguity
- Use the *Work Package vs. Planned Package* feature
- Constrain the **size** of the activities so that:
 - 80% of the budget of the activities in range **0.2% – 2%**
E.g. a \$1M 50'000 p·hrs → \$2k – \$20k and 100 p·hrs – 1000 p·hrs
 - Activity duration < **10% project duration** and **3 months**
 - No. of level-of-effort activities < 5% of no. of activities

LHC Project EVMS | *Strong points*

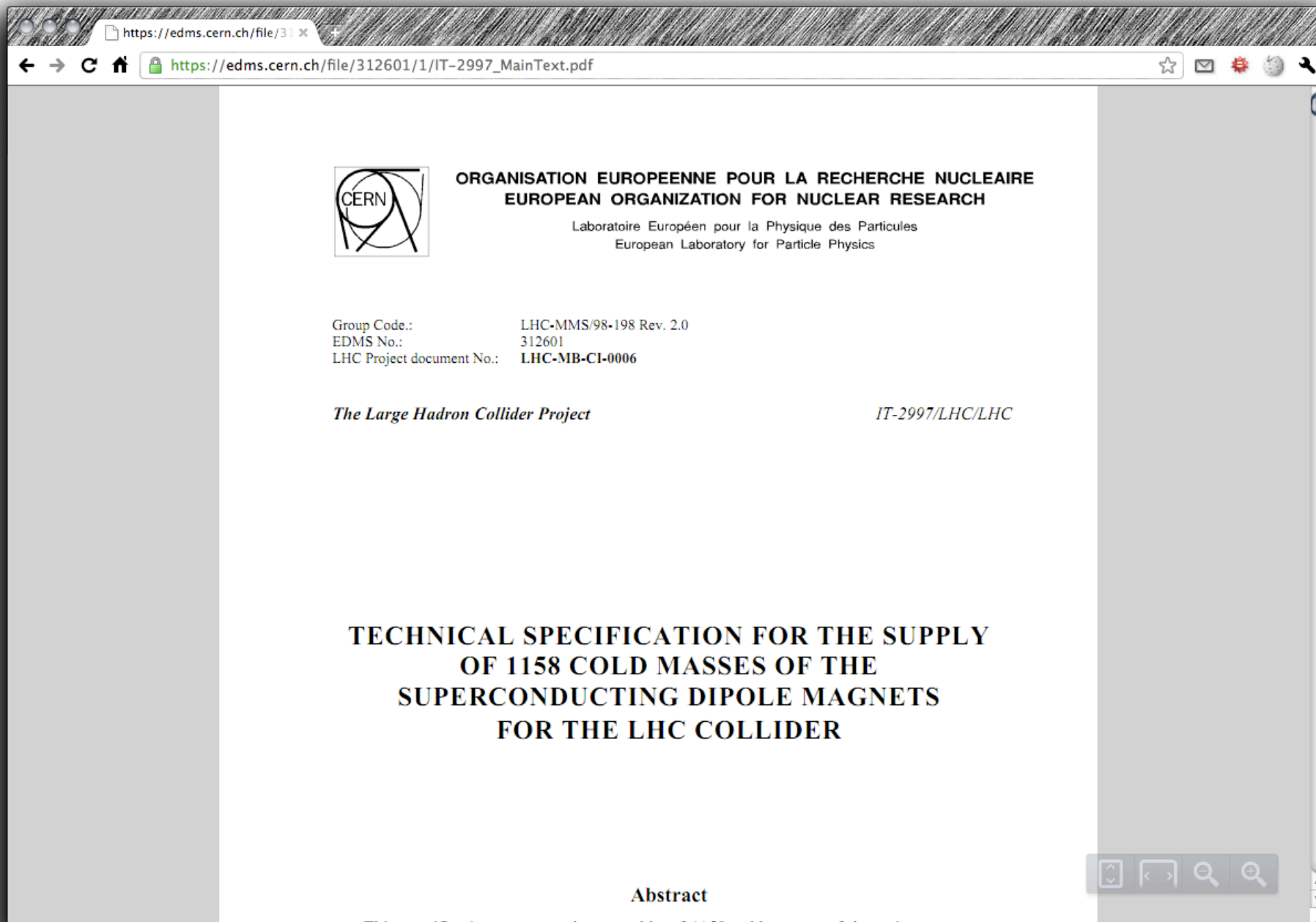
- Tailored tools:
 - Excel interface to interact with databases very appreciated
 - strongly integrated with corporate databases
- Deliverable-oriented approach revealed to be efficient
- “AC = EV rule” for in-kind contribution worked well
- Contributed to cost consciousness at all levels
- Change of culture inside the organization
- **Regain confidence of CERN's Member States**



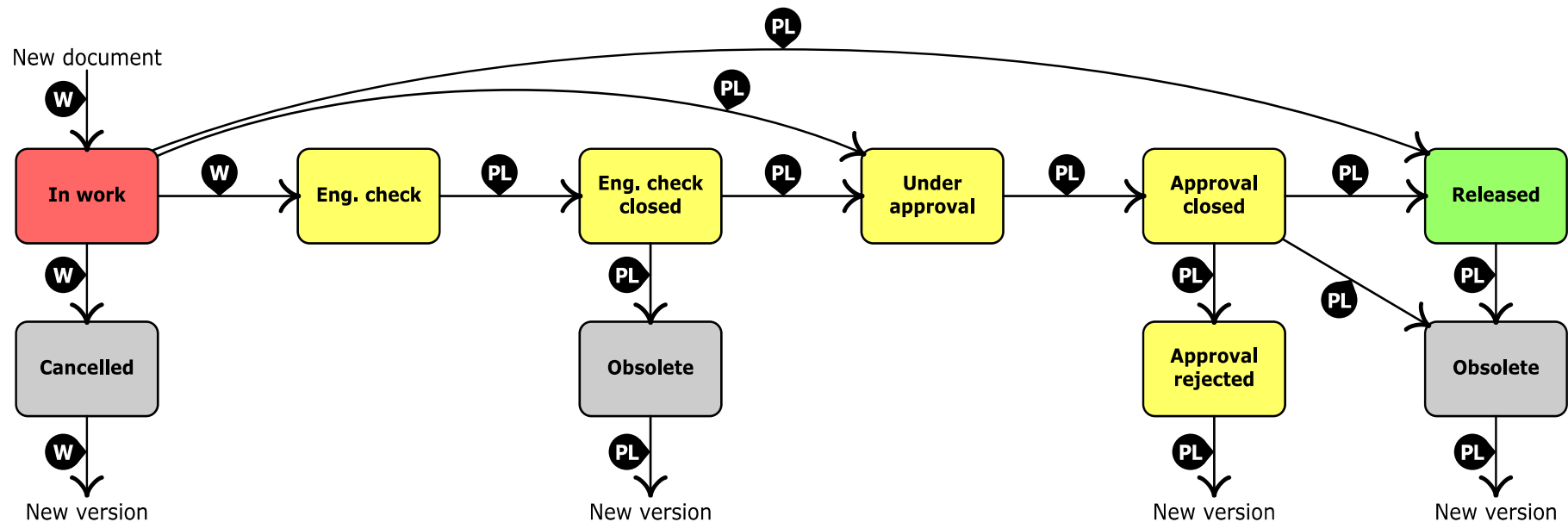
PMBok Area #5: Project Quality Management

Project Quality Management includes the activities that determine quality policies, objectives and responsibilities so that the project will satisfy the needs for which it was undertaken.

- ***Project Management Plan*** ✓
- **Engineering Data Management System (EDMS)** ✓
- **Manufacturing & Test Folder (MTF)** ✓
- **Quality Audit** framework:
 - not systematic, but well achieved on outsourced activities ✓
 - not run on activities performed by CERN ✗
 - not foreseen as such in the LHC Project QAP ✗



Document Lifecycle in EDMS



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PMBok Area #6: Project HR Management

Project Human Resource Management includes the processes that organize, manage, and lead the project team. The project team is comprised of the people with assigned roles and responsibilities for completing the project.

- ***Human Resource Plan***  and 
 - embedded in CERN Human Resource Management
 - not formally achieved as expected by PM Best Practices
- ***Organization Breakdown Structure (OBS)*** 
 - “LHC Project QAP and Project Organization”



PMBoK Area #7: Project Comm' Management

Project Communication Management includes the processes required to ensure timely and appropriate generation, collection, distribution, storage, retrieval, and ultimate disposition of project information.

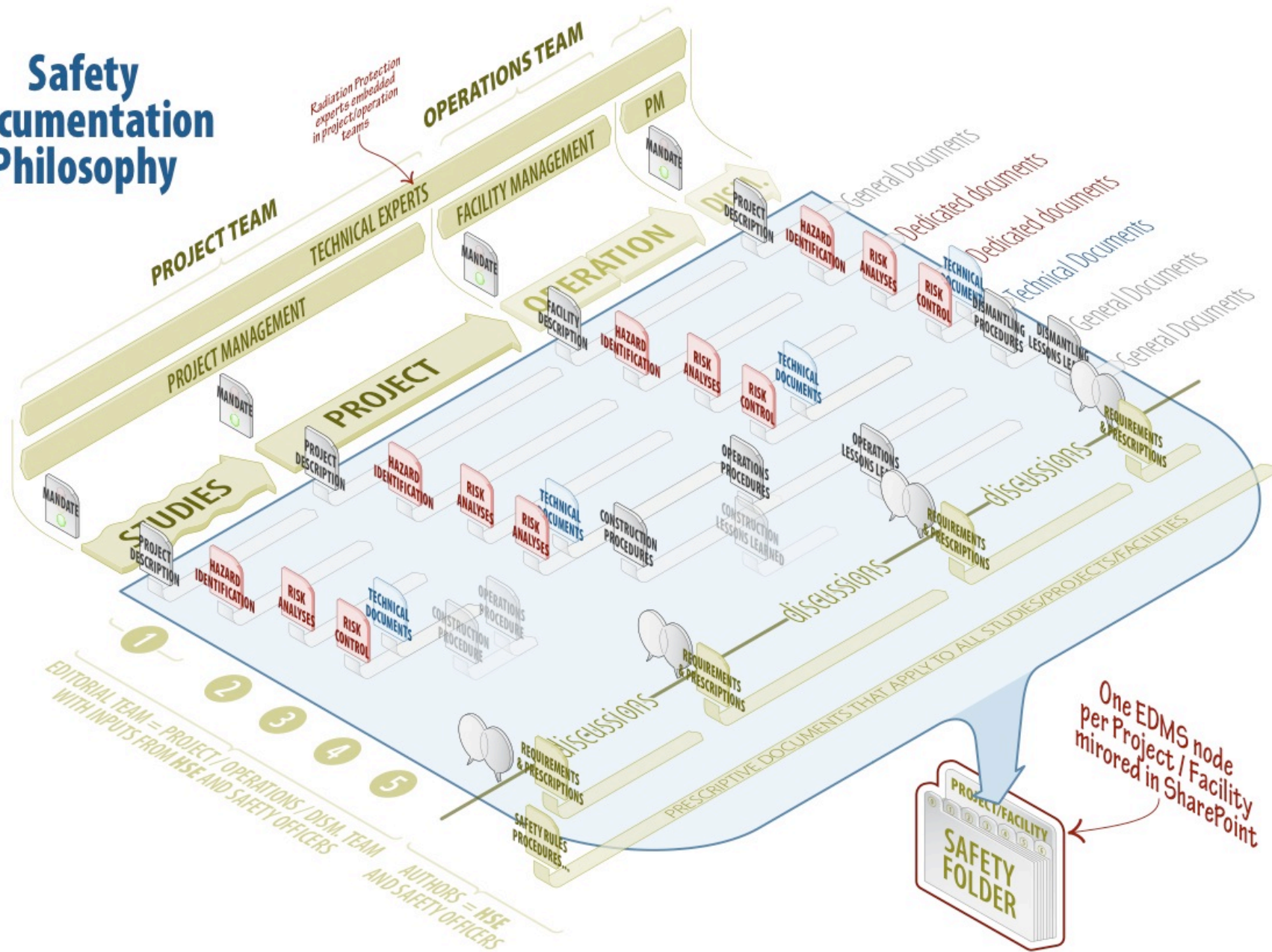
- ***Project Communication Plan*** ✓
 - “LHC Project QAP and Project Organization”
- ***Project Reports*** ✓
 - twice a year to the CERN Governing Bodies
 - more often to various Steering or Advisory Committees
 - as from 2003, EVM Progress Reports
 - publications in journals and talks at conferences

PMBok Area #8: Project Risk Management

Project Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, and monitoring and control on a project.

- ***Project Risk Management Plan*** X
- ***Project Risk Register***  and X
 - one initiative in 2002–2004 to identify risks associated with Supply Contracts
- ***Project Contingency Plans*** X
- ***Risk Analysis*** 
- **Safety Documentation:** written by a task force in 2005–2007!

Safety Documentation Philosophy



PMBoK Area #9: Project Procurement Management


Project Procurement Management includes the processes necessary to purchase or acquire products, services, or results needed from outside the project team. It also includes the contract management and change control processes required to develop and administer contracts or purchase orders issued by authorized project team members.

- ***Project Procurement Plan*** ✓
 - appended to “LHC Project QAP and Project Organization”
 - templates for Technical Descriptions and Specifications
- **Specification Committee** mechanism
- Propagation of Engineering Changes, not straightforward.

Some physics results! It works!



Summary : Lessons learned

- Choose the right tool: **activities + deliverables**
 - off-the-shelf PM Information Systems?
 - no  between cost, schedule, risks, proc.
- Stick to a **PM Standard** (e.g. PMBoK + ANSI #748)
- Be **systematic** for building the PBS, WBS, for identifying activities, for scheduling...
- Promote that PM information is to be shared
- Prefer a framework that is **deliverable-oriented**
- Consider “rolling-wave planning & scheduling”

Thank you.