
# ECFA
# About CERN

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# Status of the LHC accelerator - 1

- All sectors have been or are cooled at 1.9 K

- In the commissioning sequence, after cool down of a sector to nominal conditions, follow:

  1. A period of Quality Assurance and Control of all electrical circuits in the arc, then in the LSS and in the inner triplets if appropriate;
  2. A tuning of the cryogenic plant to adapt to and maintain a specific parameters range;
  3. A power test of all circuits, in particular the safety discharge of the magnetic energy, up to a specific level – corresponding to 10 TeV collisions;
  4. When everything has been checked, the sector is handed over to the operators in the control room (CCC).

# Status of the LHC accelerator - 2

- Present status of each sector:
  - Sectors 1-2, 3-4 and 6-7 are in (1), starting (2)
  - Sector 2-3 is in (3)
  - Sector 4-5 is recooled after achieving the whole sequence when the inner triplet at point 5 was under repair
  - Sectors 7-8 and 8-1 have satisfied the whole sequence (sector 7-8 partially twice), including the inner triplets; they are now at 20 K for some maintenance in the cryogenic plants
  - Sector 5-6 has been handed to the operators, after a full testing of magnets at 90% of their nominal performances.

# Status of the LHC accelerator - 3

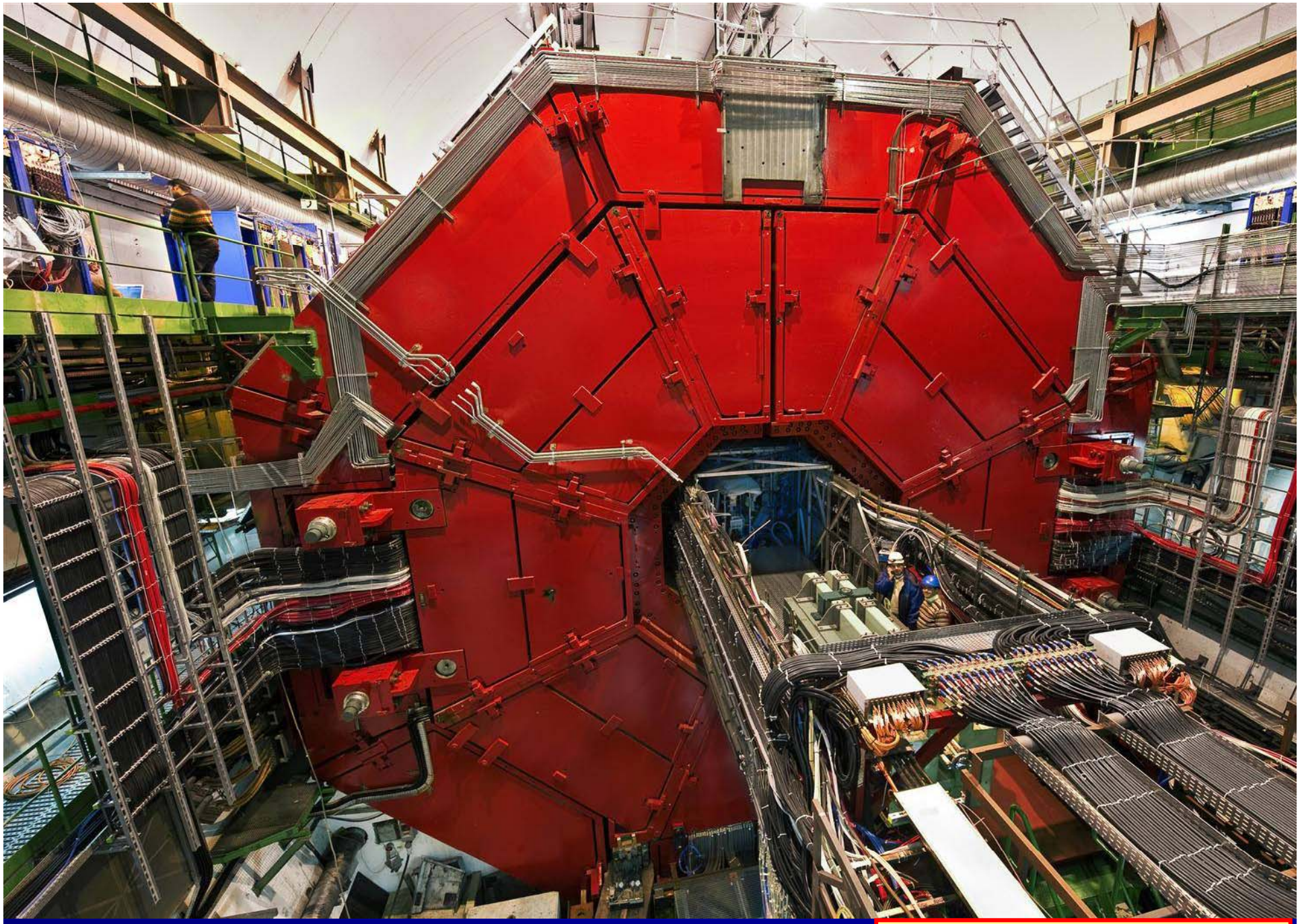
- First dipole magnet tests in 4-5, then in 5-6 at length, have shown the need for an unexpected training of dipoles (from one of the three manufacturers), starting from a field value lower than the 9T achieved during qualifying tests before going into the tunnel.

- Retraining all these magnets in successive discharges at close successive values of the field is time consuming. Decision was made to accept for 2008 collisions an energy limited to 10 TeV, a value achievable with no retraining, which will be done during the end-of-year shutdown.

- The inner triplets have been tested at their full field value – **ouf!**

# Status of LHC experiments and computing - 1 ALICE

- Installation of 2008 detector completed
- Commissioning in progress (cosmics)
- Ready for beam end of July





ALICE Cosmic Data taking

# Status of LHC experiments and computing - 2
# LHCb

- **Magnet**
  Ready for operation

- **VELO**
  Installation completed and commissioning in progress

- **Silicon Tracker**
  TT and IT detectors and electronics installed
  Commissioning in progress

- **Outer Tracker**
  Detector installation completed
  >90% of electronics installed and will be completed before the beam
  ~50% of the aging prevention treatment (heating in-situ) done
  (not a problem for 2008; whole procedure will be completed during shutdown)

- **RICH**
  Installation of RICH-1 has been completed
  Commissioning of RICH-1 and RICH-2 in progress

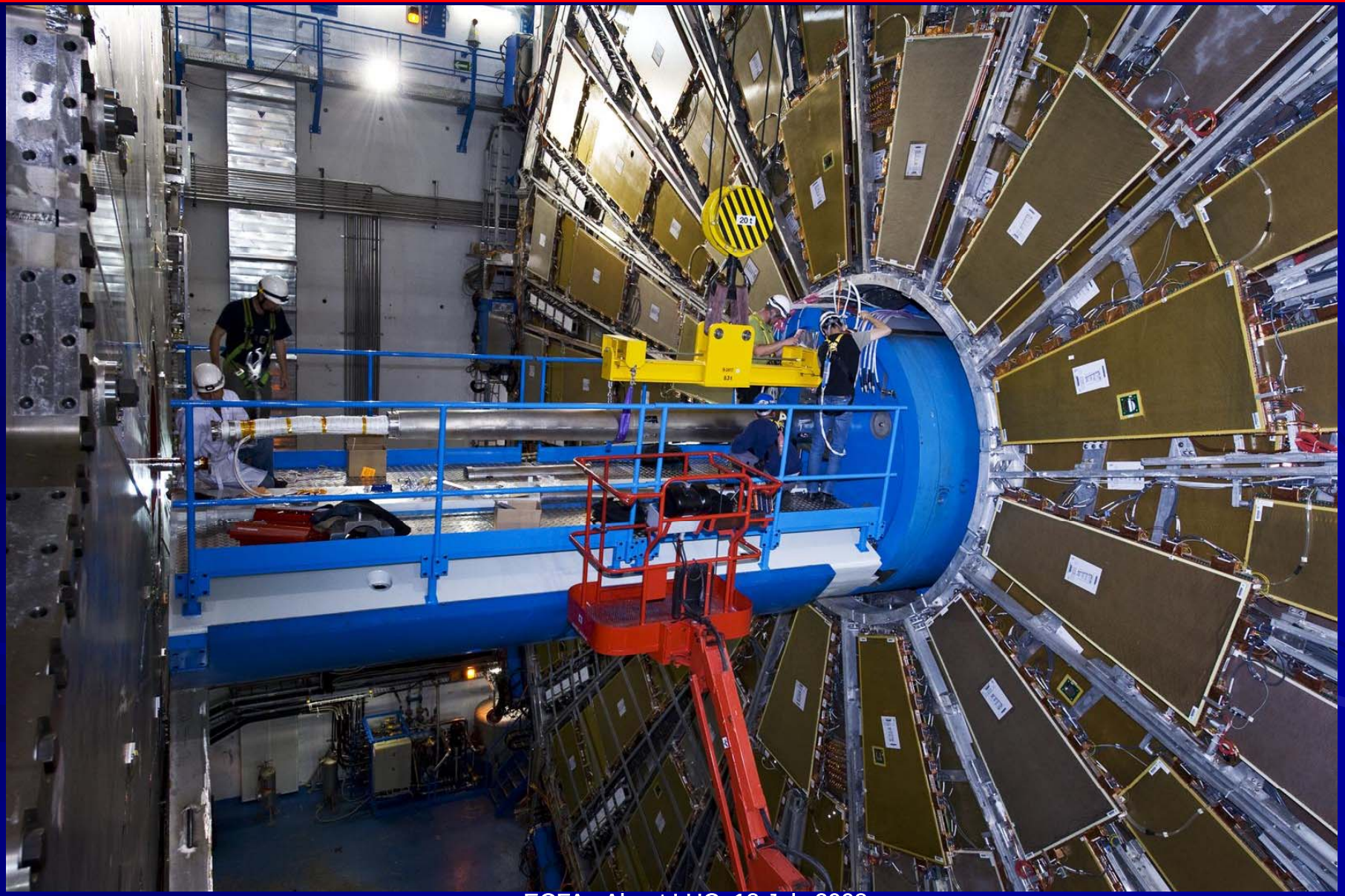
# Status of LHC experiments and computing - 3 LHCb

- **Calorimeter**
  - All systems completely installed
  - Commissioning continuing
- **Muon**
  - Installation of M2 to M5 system completed
  - Commissioning ongoing
  - Installation of M1 in progress (not needed for the 2008 run)
- **Online**
  - All what is needed for the 2008 run installed
- **Level-0 Trigger**
  - Commissioning in progress
  - Calorimeter and muon cosmic triggers in operation
- **HLT and software**
  - Major parts of the physics software had been tested to work with realistic conditions
  - Alignment, calibration and data quality monitoring work progressing well
- **Computing**
  - Data transfer of CCRC08 using FTS was successful

# Status of LHC experiments and computing - 4 ATLAS

- Detector closed
- Repair He leak in ECT-A: done
- Repair cooling system Inner Detector: done, to be commissioned
- Bake-out central part of beam pipe (Pixels): next week
- Commissioning (in particular magnet system): to be completed

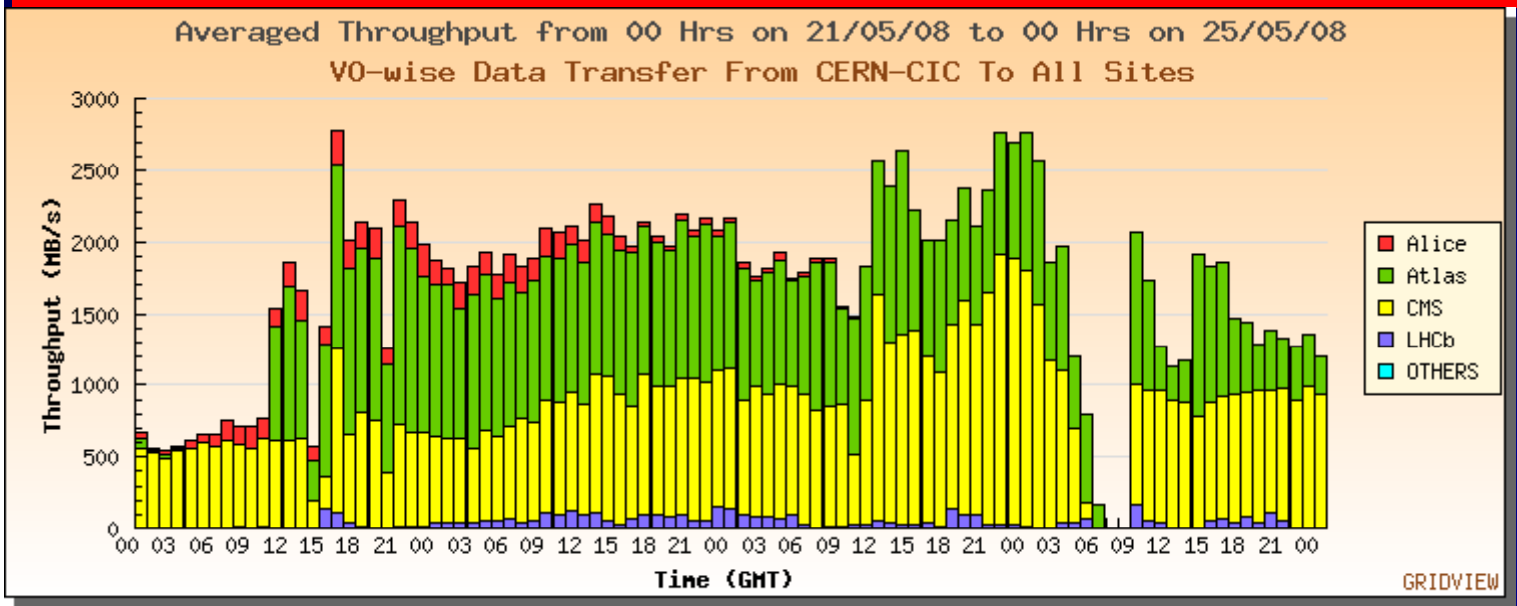
# Closure of ATLAS vacuum sector

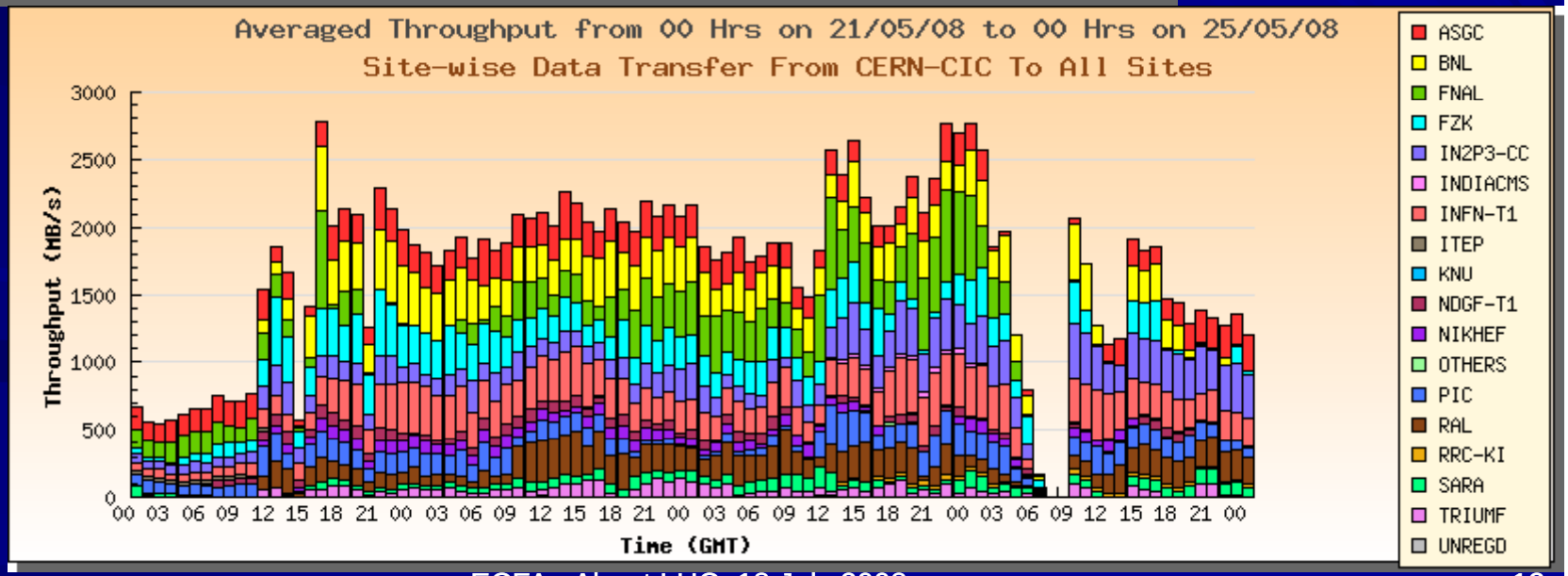


# ATLAS share in Common Computing Readiness Challenge - 5 (CCRC08-2)

- **Very important because it is the only chance to put a realistic service load on the Tier-0 but, more importantly even, on the Tier-1's comparable to data taking conditions**
- **Program**
  - **week 1: Data Distribution Functional Test**
    - **to make sure all files get where we want them to go**
    - **between Tier-0 and Tier-1's, for disk and tape**
  - **week 2: Tier-1 to Tier-1 tests**
    - **similar rates as between Tier-0 and Tier-1**
    - **more difficult to control and monitor centrally**
  - **week 3: Throughput test**
    - **try to maximize throughput but still following the model**
    - **Tier-0 to Tier-1 and Tier-1 to Tier-2**
  - **week 4: *Finale,* all tests together**
    - **also artificial extra load from simulation production**
  - **plus every Friday – Monday detector commissioning data with cosmics**
- **Conclusions**
  - **The data distribution scenario has been tested well beyond the use case for 2008 data taking**
  - **The WLCG infrastructure met the experiments requirements for the CCRC08 test cases**
  - **Still very human intensive exercise**
- **Activity does not stop**
  - **ATLAS will run continuous "heartbeat" transfer exercise to keep the system alive**
  - **in parallel to more detector commissioning data with cosmics**

# Data transfers out of CERN to Tier 1 sites – above by experiment; below by Tier 1
## Target aggregate rate is 1.3GB/s : sustained rate is well above this - 6

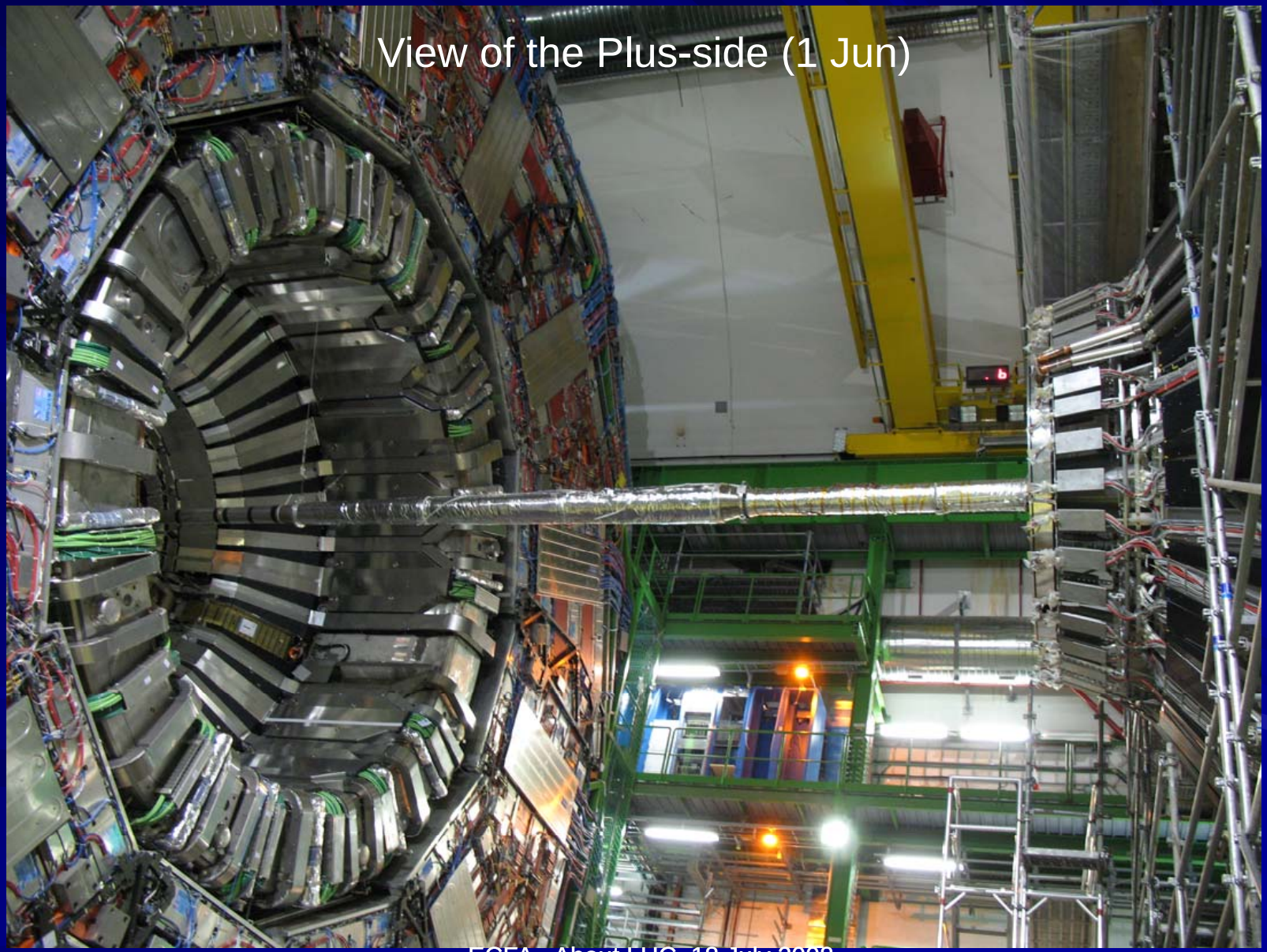


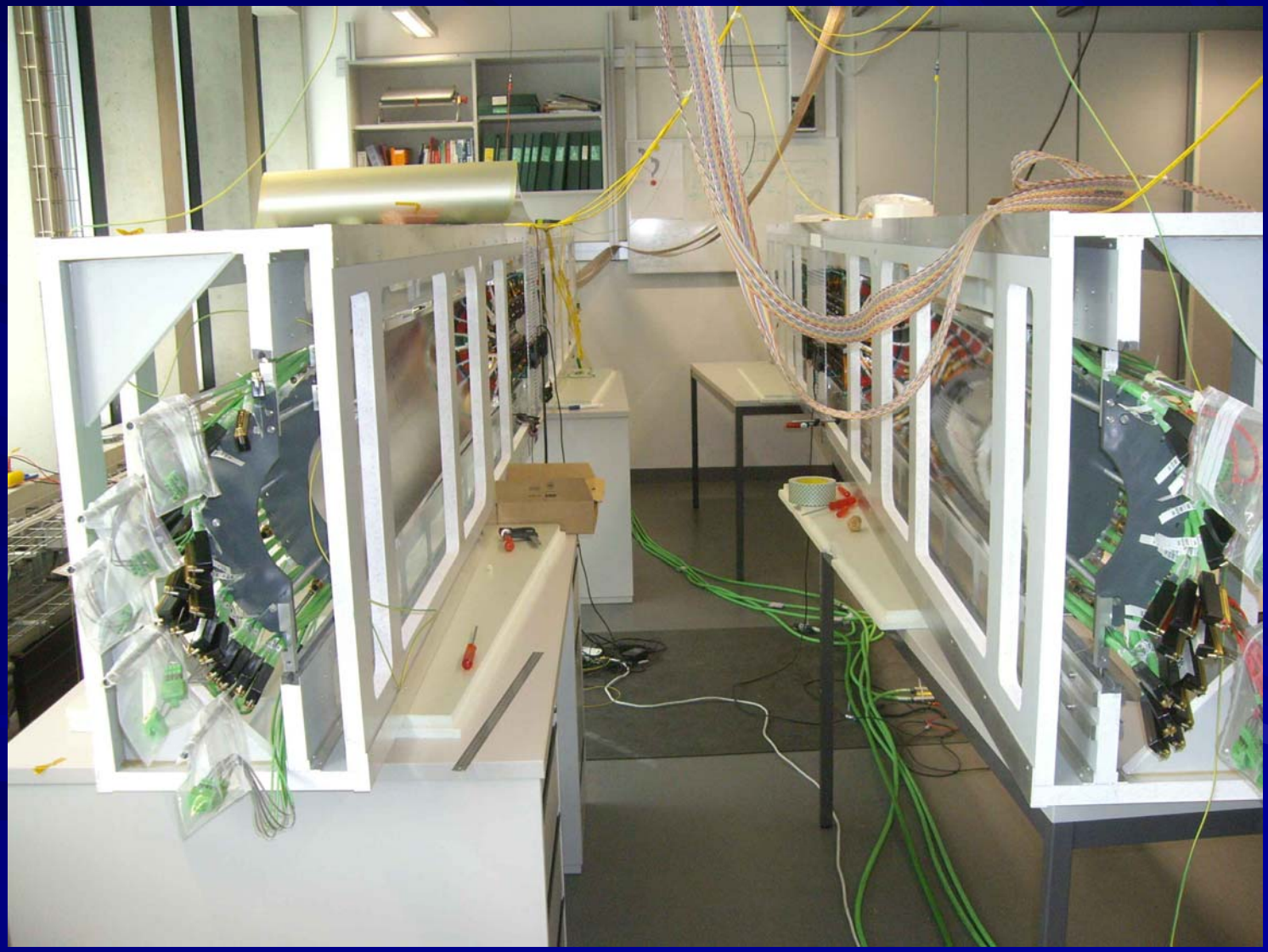
# Status of LHC experiments and computing - 7 CMS

- Tracker commissioning (after repair cooling system): done (but small leaks of coolant)
- Remaining installation tasks: pixel detector;
- End-cap electromagnetic calorimeters: only one or two?
- Magnet test (already tested at the surface): to be completed

# CMS Beam Pipe Installed and Leak Tight



# Finishing Construction: CMS Barrel Pixels

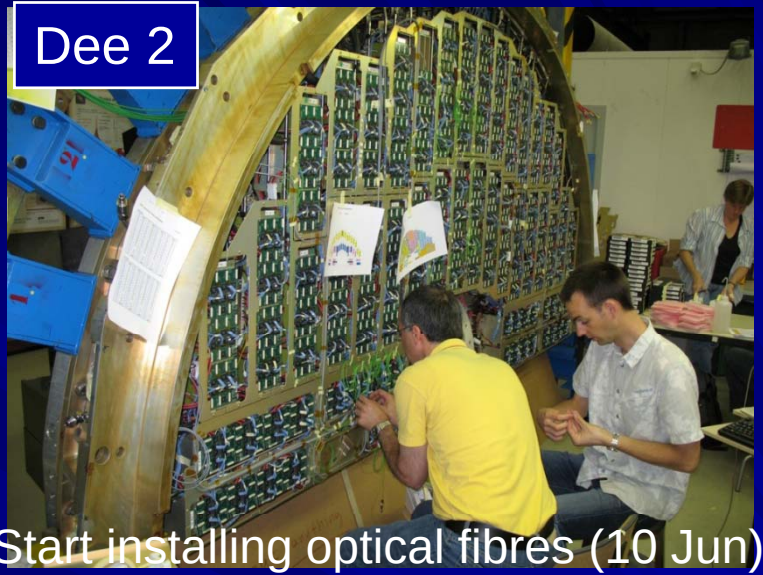


# Finishing Construction: CMS ECAL Endcaps

Dee 1

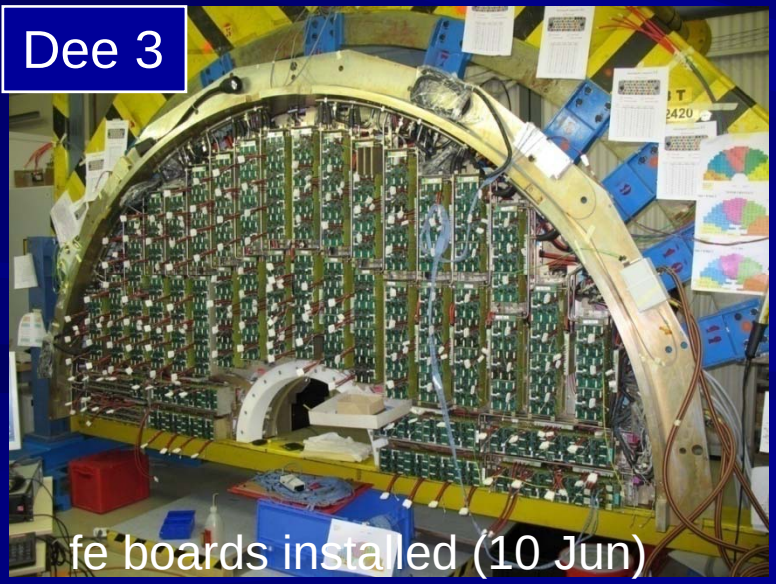
Commissioning (7 Jun)

Dee 2



Start installing optical fibres (10 Jun)

Dee 3



fe boards installed (10 Jun)

Dee 4

All sc mounted (23rd May)

# Conclusions - 8

- The LHC experiments are approaching ‘readiness for beam’ rapidly now
- LHCb by end of July (M1 to be completed later)
- ALICE by the end of July (various modular detectors will be completed later)
- ATLAS: largely ready, but: re-commission SCT cooling; bake out central part of beam pipe; final integrated magnet test → brings us somewhat beyond end of July
- CMS: largely ready, but: re-commission ID cooling; install Pixel detector; install one or two ECAL end cap(s);
  magnet test → brings us somewhat beyond end of July
- The LHC Computing Grid is operational

# ATLAS and CMS strategy toward physics

**Before data taking starts:**

- Strict quality controls of detector construction to meet physics requirements
- Test beams, to understand and calibrate (part of) detector and validate/tune software tools (e.g. Geant4 simulation)
- Detailed simulations of realistic detector "as built and as installed" (including misalignments, material non-uniformities, dead channels, etc.) → test and validate calibration/alignment strategies
- Experiment commissioning with cosmics in the underground cavern

now we are here

**With the first data:**

- Commission/calibrate detector and trigger in situ with known physics events
- "Rediscover" Standard Model, measure it at $\sqrt{s}$ =14 TeV (minimum bias, W, Z, tt, QCD jets, …)
- Validate and tune tools (e.g. MC generators)
- Measure main backgrounds to New Physics (W/Z+jets, tt+jets, QCD multijets,…)

**prepare the road to discoveries …**

# How much data at the beginning ?

| Parameter | Phase A | Phase B | Phase C | Nominal |
|---|---|---|---|---|
| k / no. bunches | 43-156 | 936 | 2808 | 2808 |
| Bunch spacing (ns) | 2021-566 | 75 | 25 | 25 |
| N ($10^{11}$ protons) | 0.4-0.9 | 0.4-0.9 | 0.5 | 1.15 |
| Crossing angle (μrad) | 0 | 250 | 280 | 280 |
| $\sqrt{(\beta^*/\beta^*_{nom})}$ | 2 | $\sqrt{2}$ | 1 | 1 |
| σ* (μm, IR1&5) | 32 | 22 | 16 | 16 |
| L ($cm^{-2}s^{-1}$) | $6x10^{30}$-$10^{32}$ | $10^{32}$-$10^{33}$ | $(1-2)x10^{33}$ | $10^{34}$ |
| Year (June schedule) | 2008 | 2009 | 2009-2010 | > 2010 |
| ∫ Ldt ? | ≤ 100 $pb^{-1}$ | 1-few $fb^{-1}$ | | |

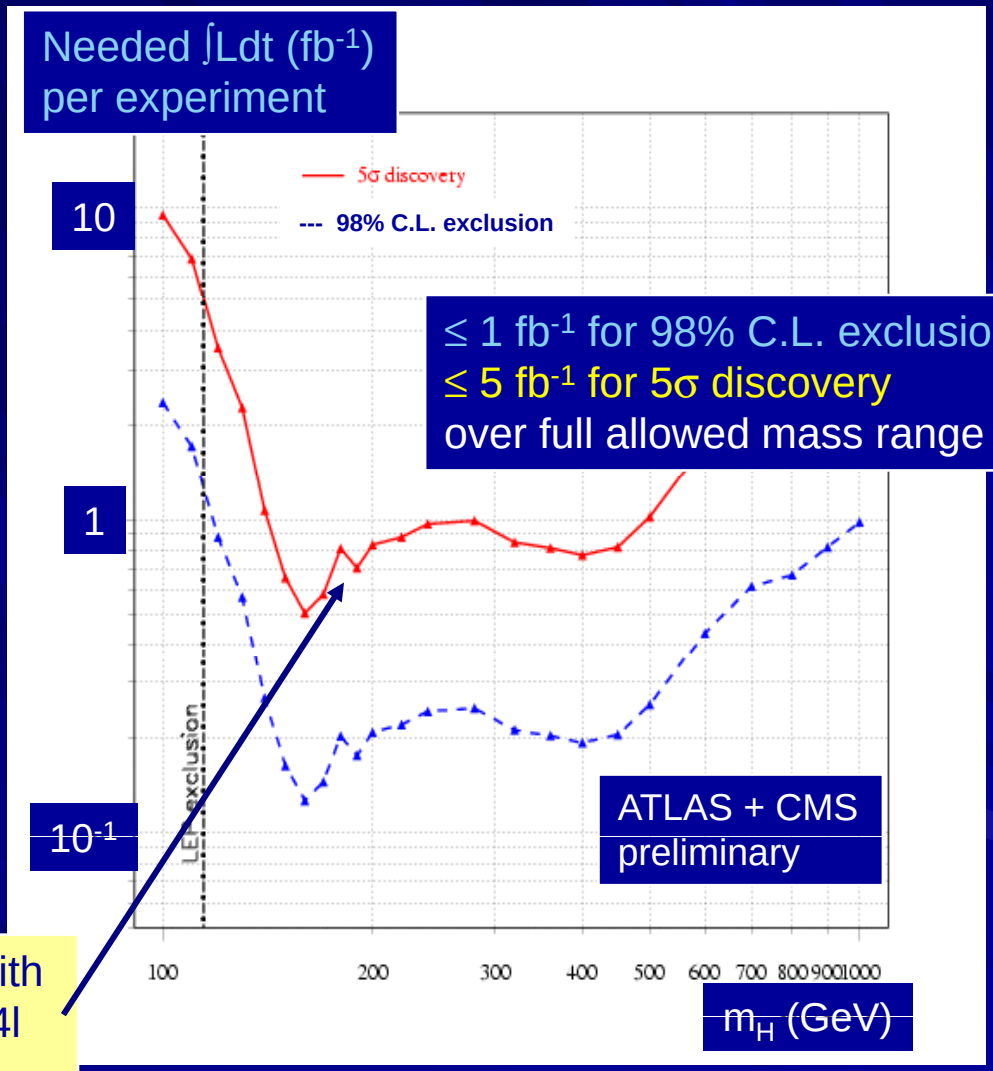
Note: at regime, ~ $6x10^6$ s of pp physics running per year

→ ~ 0.6 $fb^{-1}$ /year if L= $10^{32}$

~ 6 $fb^{-1}$ /year if L= $10^{33}$

~ 60 $fb^{-1}$ /year if L= $10^{34}$

# SM Higgs in ATLAS and CMS



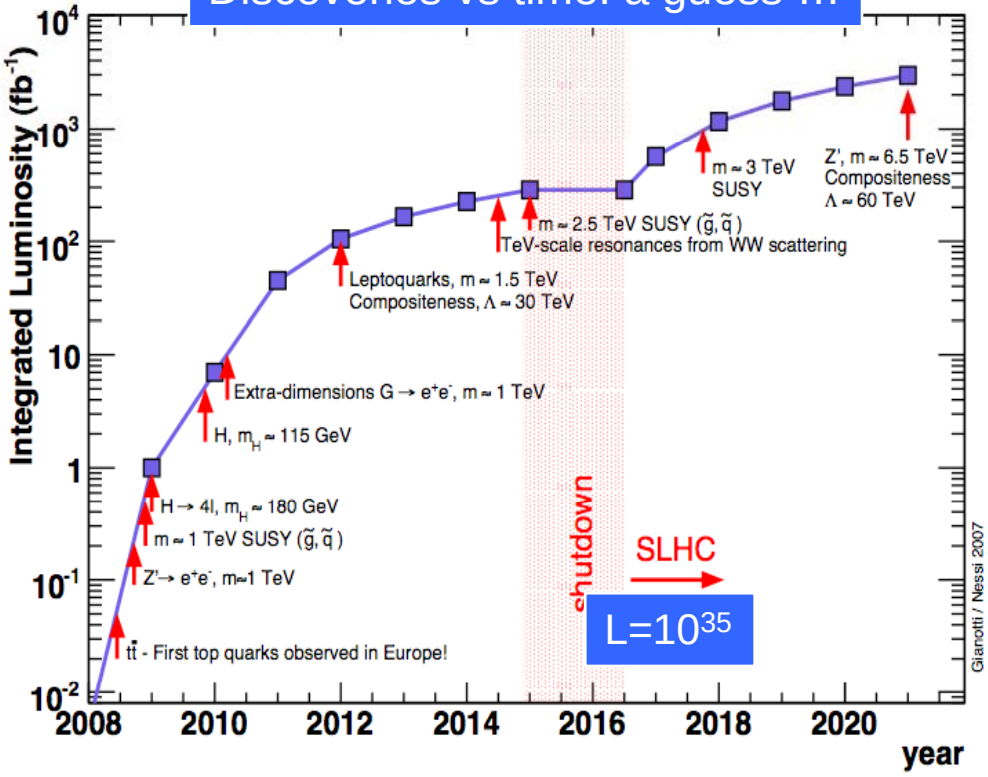

here discovery easier with gold-plated $H \rightarrow ZZ \rightarrow 4l$ $\rightarrow$ **by end 2009 ?**

# With more time and more data, the LHC can discover:

Excited quarks $q^* \rightarrow \gamma q$: up to $m \approx 6$ TeV
Leptoquarks: up to $m \approx 1.5$ TeV
Compositeness: up to $L \approx 40$ TeV
$Z' \rightarrow ll$, jj: up to $m \approx 5$ TeV
$W' \rightarrow l\nu$: up to $m \approx 6$ TeV
etc.... etc….

**Large number of scenarios studied**
**Main conclusions:**
**⇒ LHC direct discovery reach up to m ~ 5-6 TeV**
**⇒ demonstrated detectors sensitivity to many signatures → robustness, ability to cope with unexpected scenarios**

Discoveries vs time: a guess …



# The European Strategy for Particle Physics
# Scientific activities

**In 2006, an ad hoc scientific advisory group has organized the definition of a strategy document.**
**A special meeting of the Council in Lisbon (14 July 2006) has approved unanimously the new European Strategy for Particle Physics**

- **The highest priority is to fully exploit the physics potential of the LHC. Resources for completion of the initial programme have to be secured such that machine and experiments can operate optimally at their design performance.**
- **R&D for machine and detectors has to be vigorously pursued now and centrally organized towards a luminosity upgrade by around 2015.**
- **A coordinated programme should be intensified, to develop the CLIC technology and high performance magnets for future accelerators, and to play a significant role in the study and development of a high-intensity neutrino facility.**
- **There should be a strong well-coordinated European activity, including CERN, through the Global Design Effort, for its design and technical preparation towards the construction decision, to be ready for a new assessment by Council around 2010.**
- **Council will play an active role in promoting a coordinated European participation in a global neutrino programme.**

# Implementing Strategy at CERN - 1

The New Governance for CERN put in place by the Council has led in June 2008 to:

- approval of the proposed strategy for the scientific programme of 2009-2013
- approval of the 2009 budget
- note the budget for the 4 following years

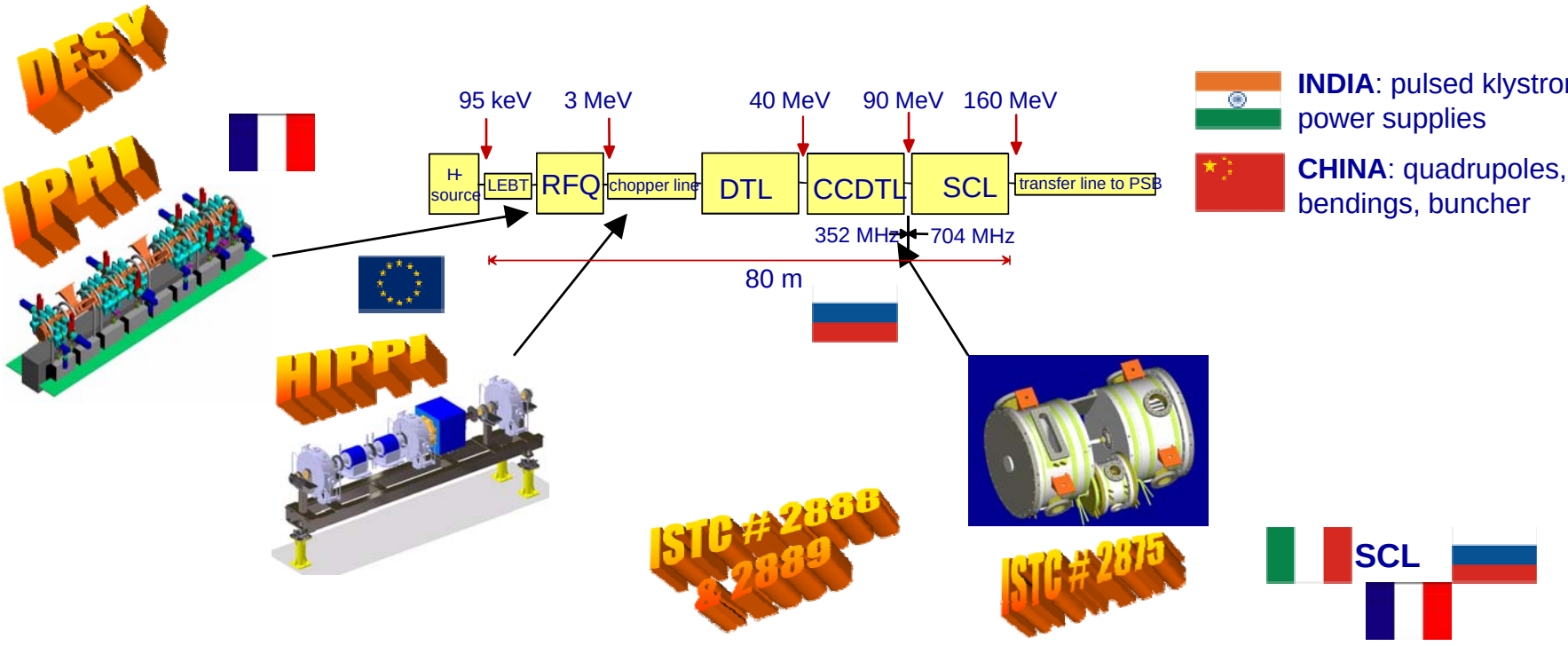
## Details of the Strategy

- to complete the LHC machine and experiments for the optimal operation at design energy and luminosity over the years 2008-2010, including preparation for an increase in computing infrastructure

- to start renovation of the entire injection complex to ensure reliability of LHC operation and prepare for an upgrade of its luminosity by:
  - starting in 2008 construction of Linac 4
  - starting in 2008 replacement of the inner triplets with wide aperture quadrupoles in NbTi at 1.9K
  - starting design of a new SPL and PS2, with the associated qualifying tests

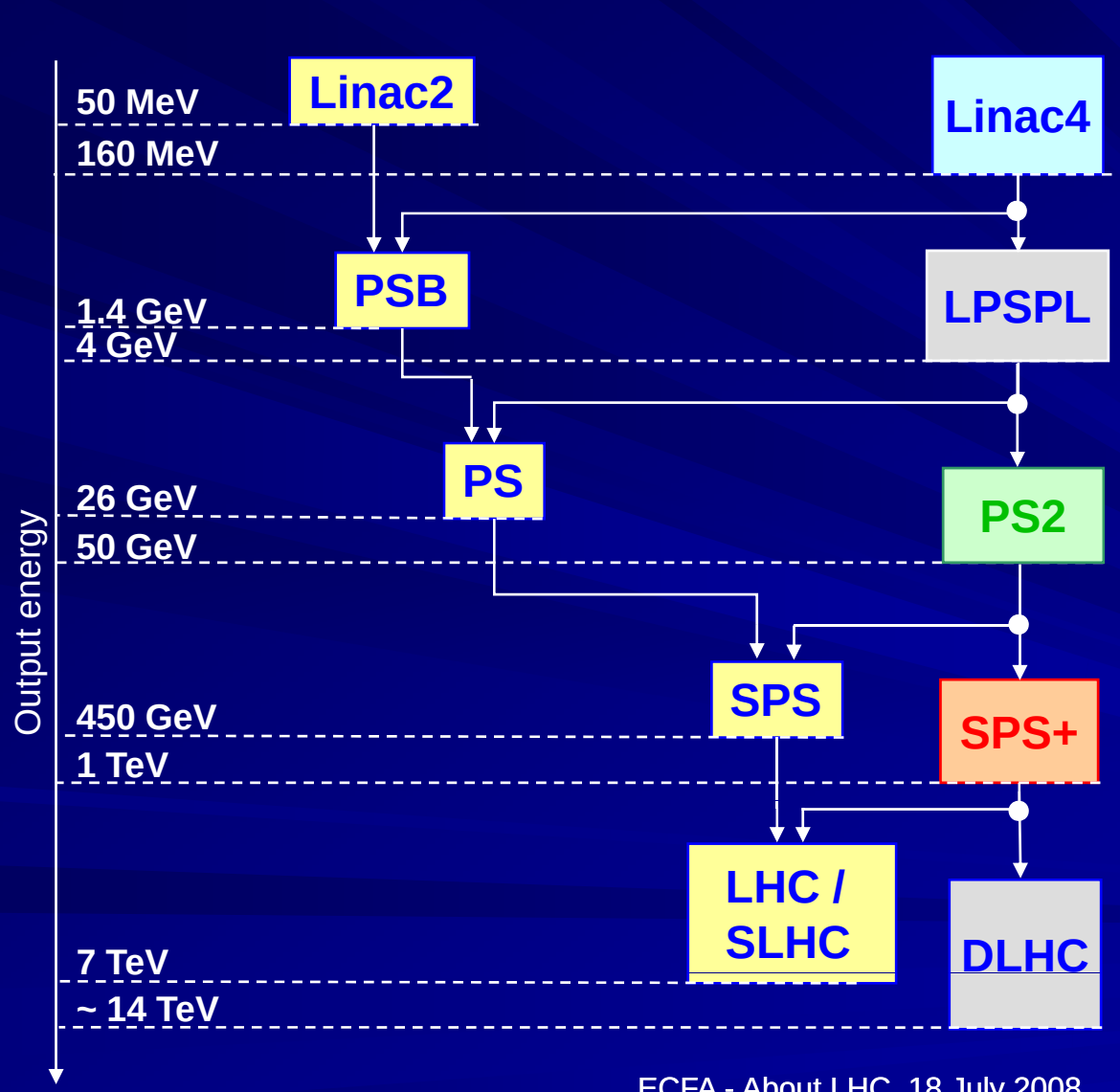
# Linac4: Collaborations for construction

(tentative)



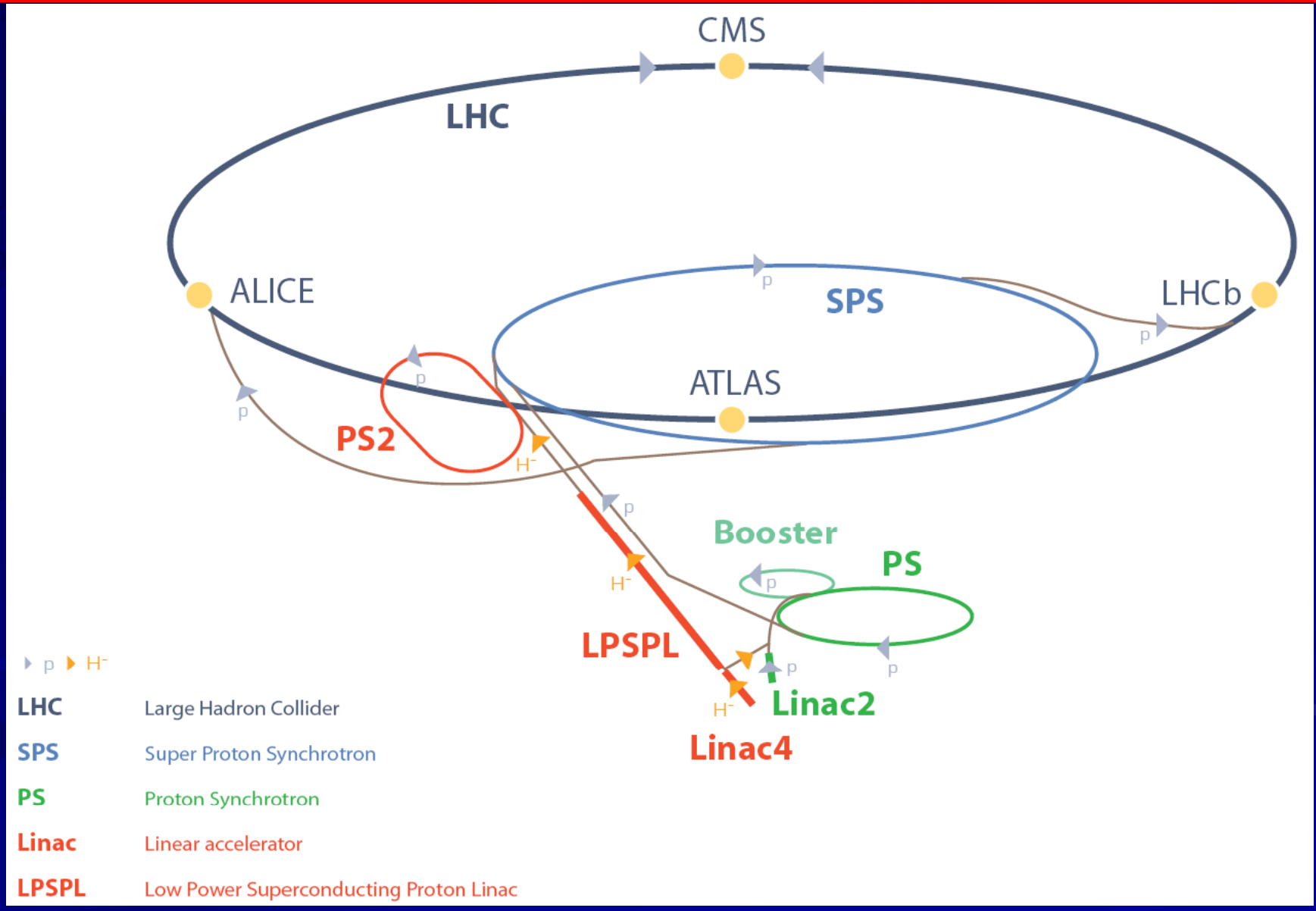

Network of collaborations for the R&D phase, via EU-FP6, CERN-CEA/IN2P3, ISTC, CERN-India and CERN-China agreements.

# Upgrade components

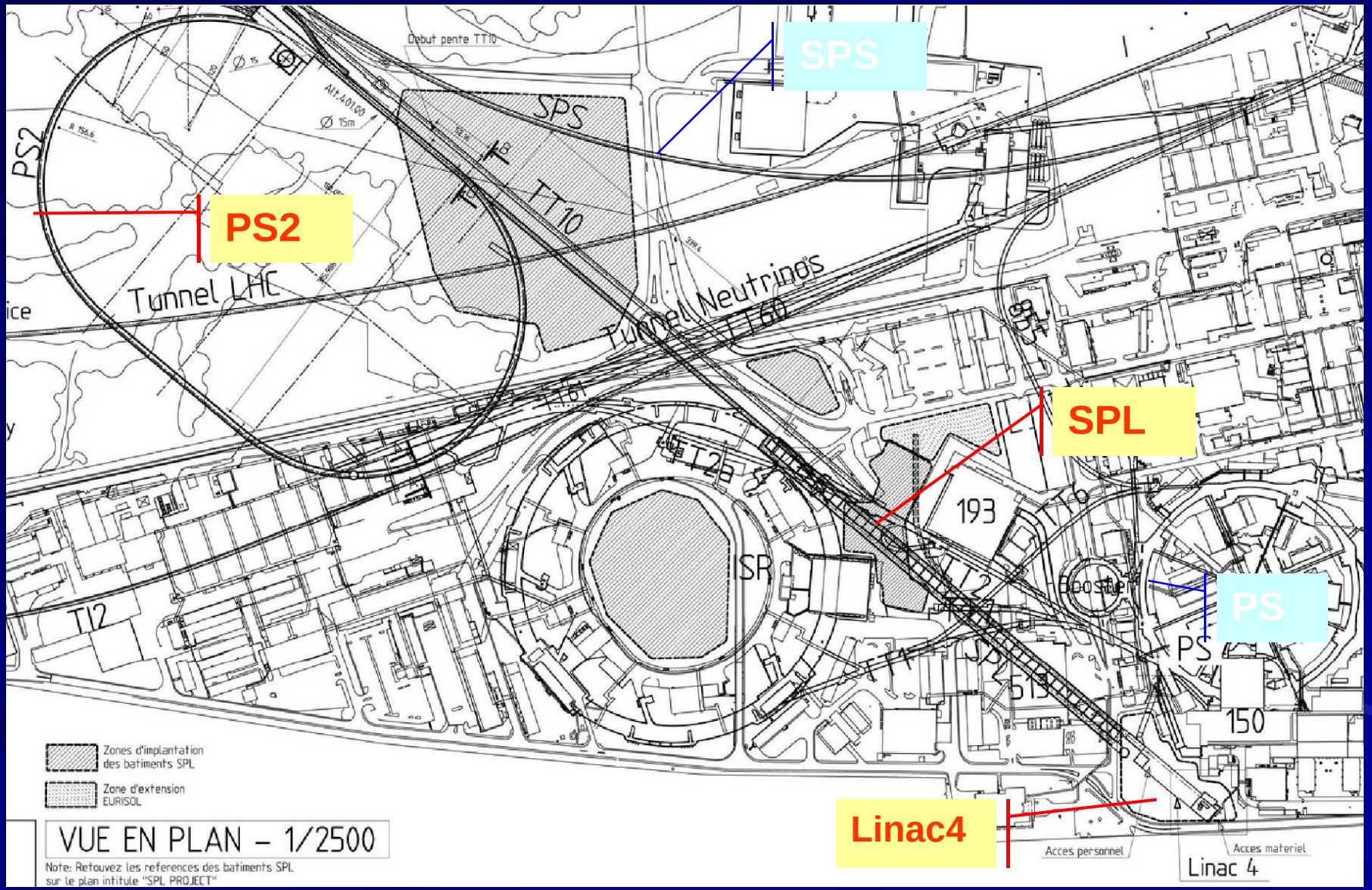



**LPSPL:** Low Power Superconducting Proton Linac (4 GeV)
**PS2:** High Energy PS (~ 5 to 50 GeV – 0.3 Hz)
**SPS+:** Superconducting SPS (50 to1000 GeV)
**SLHC**: "Superluminosity" LHC (up to $10^{35}$ $cm^{-2}s^{-1}$)
**DLHC**: "Double energy" LHC (1 to ~14 TeV)

# LHC and its Injection Lines

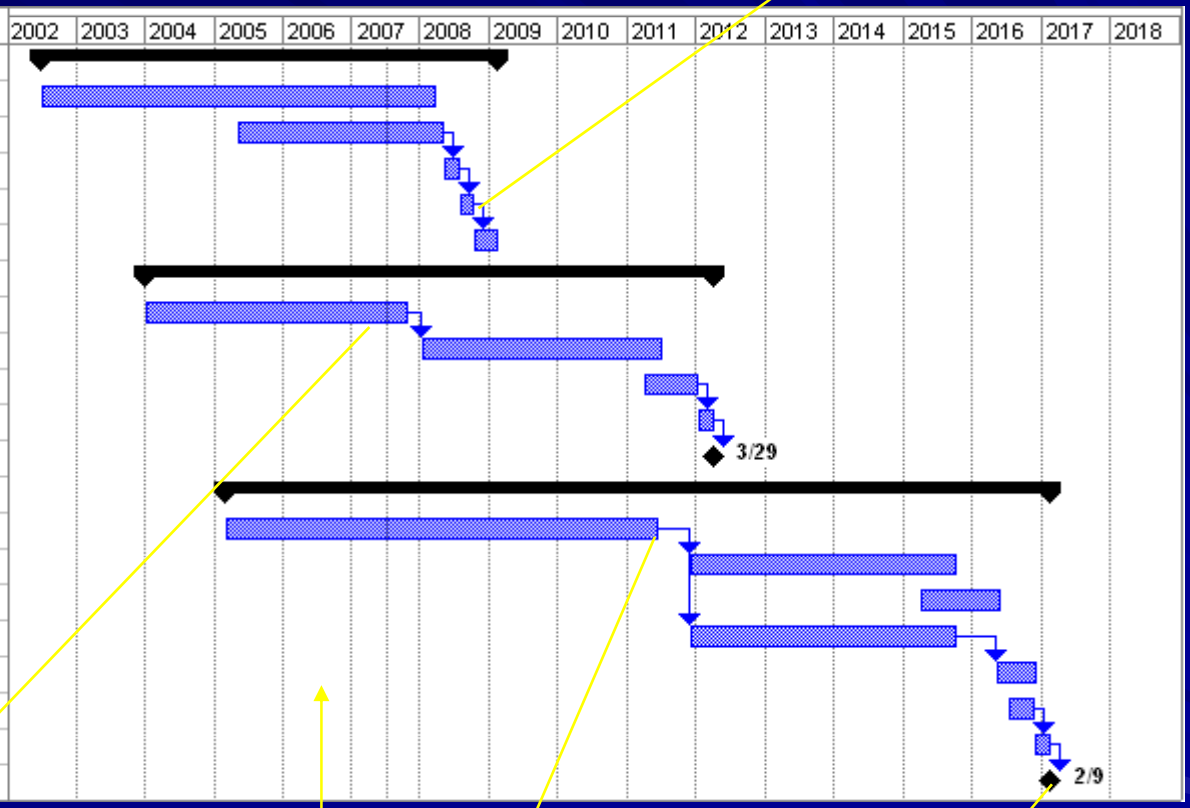


# Layout of the new injectors



# Planning…

| ID | Task Name |
|---|---|
| 1 | **3 MeV Front End** |
| 2 | Design and construction |
| 3 | CERN Installation |
| 4 | Commissioning w/o beam |
| 5 | IPHI RFQ Installation |
| 6 | Commissioning and operation |
| 7 | **LINAC4** |
| 8 | Design refinement |
| 9 | Construction |
| 10 | Linac commissioning |
| 11 | Linac + PSB commissioning |
| 12 | Start for physics |
| 13 | **SPL + PS2** |
| 14 | Design refinement |
| 15 | SPL Construction |
| 16 | SPL beam commissioning |
| 17 | PS2 construction |
| 18 | PS2 beam commissioning |
| 19 | SPS modification |
| 20 | SPS beam commissioning |
| 21 | Start operation for physics |




**3 MeV test place ready**

**Linac4 approval**

CDR 2

**SPL & PS2 approval**

**Start for Physics**

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# Implementing Strategy at CERN - 2

- to prepare for 2016 upgrades of Experiments (ATLAS and CMS), to replace components at their end of life due to radiation damage and to exploit the physics potential of a higher luminosity
- to decide around 2011 on the construction of PS2 and LPSPL, as part of the SLHC programme dedicated to an increase of LHC luminosity up to $10^{35}cm^{-2}s^{-1}$ after 2017
- to pursue actively the qualification of the CLIC acceleration scheme and to contribute to the GDE on the ILC design for systems similar in the two possible lepton colliders (accelerator and detectors)
- to conclude around 2011, according to LHC results, on the competition between CLIC and ILC and on the need of a following TDR for the next lepton collider scheme
- to decide on a significant increase after 2010 for consolidation to refurbish CERN infrastructure including the facilities (ISOLDE, AD, nTOF) dedicated to non-LHC physics

# SLHC experiment upgrades to fully exploit physics potential at luminosity of $10^{35}$ $cm^{-2}sec^{-1}$

**Main challenges:** Up to 400 overlapping events (per bunch collision) and Increased radiation levels

- Need smaller cell sizes in the tracking (occupancy)
- Need low-mass trackers despite larger number of cells ($\Rightarrow$ innovative solutions for on-detector powering and cooling required)
- Need more powerful triggering
- Increased data rates and data volumes (on-detector, DAQ, computing)

**Principal draft upgrade plans for the experiments (ATLAS and CMS) for SLHC Phase 2:**

- Complete replacement of inner tracking detectors
- Redesign of forward regions (including modified shielding)
- Forward muon detector replacements
- New trigger systems with increased selectivity
- Replacement of readout electronics (for some sub-detectors)
- Fully Beryllium beam pipe (ATLAS)

# Concluding remarks

- Projects, R&D, and consolidation only amount to some 11% of CERN resources in 2008-2011 given the need to repay LHC bank loans. They are possible only due to a generous move from Member States to provide for a specific increase of 6% of annual budget during these years
- Only after 2011, after repayment of the loans, can the non-recurrent activities (projects, R&D) increase to healthier share of 37% of the total income
- As far as possible these projects should be built by inviting Member States and Non-Member States to continue and strengthen their previous collaboration on LHC / CLIC and inviting new NMS to join these collaborations

➜ Results from the R&D should be positive and timely to allow the Council to make strategic decisions in 2011

➜ Results from the LHC in physics beyond the Standard Model should allow the Council to decide on the SLHC realization and to conclude on the competition between CLIC and ILC for the next lepton collider scheme according to the needed level of beam energy