Status and Plans for the LHC and the Experiments

RRB 40

April 27, 2015

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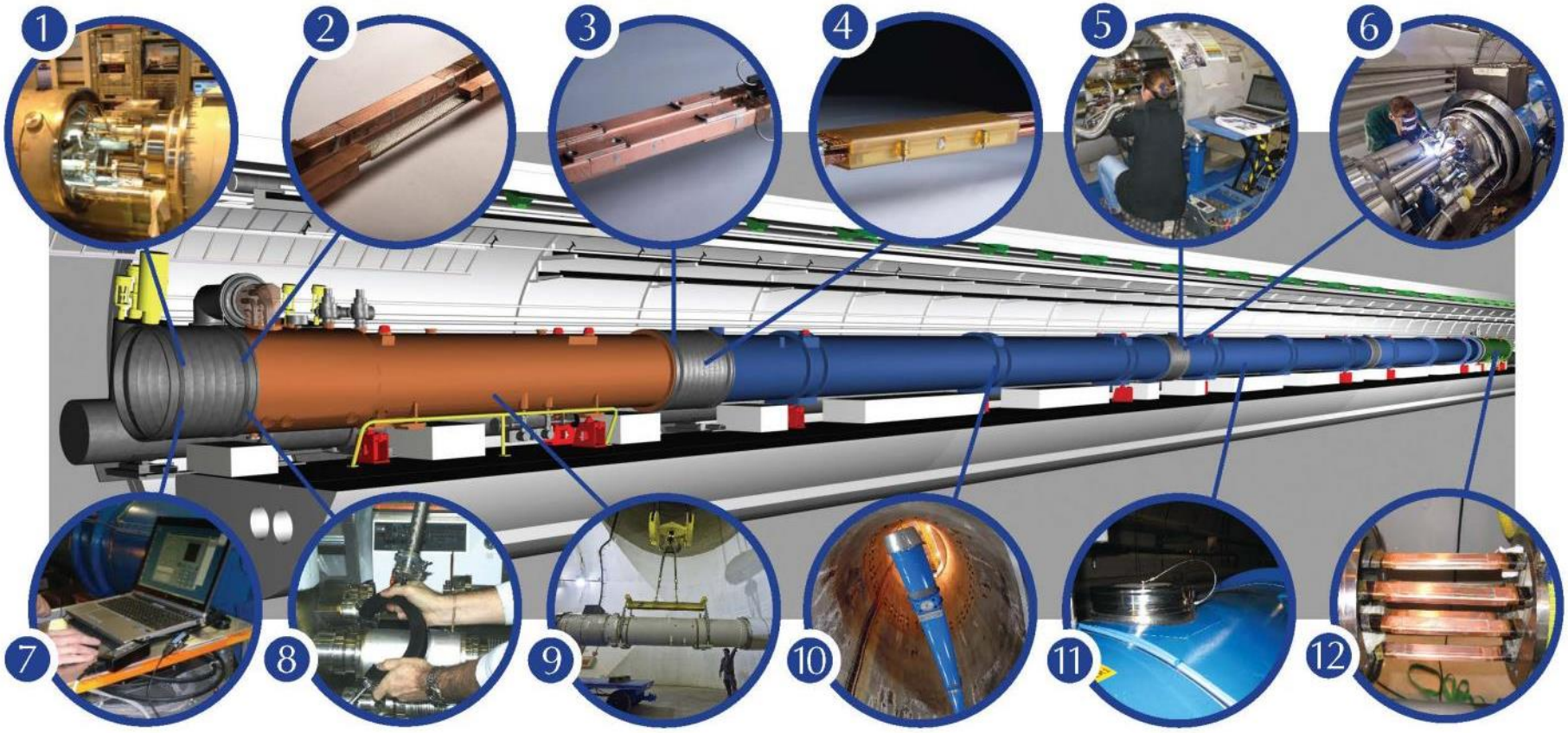
CERN

LS1 completed

- A great success, in terms of safety, quality and schedule
- All systems operational
- LHC commissioning with the beams started
- Experiments are ready for beam.

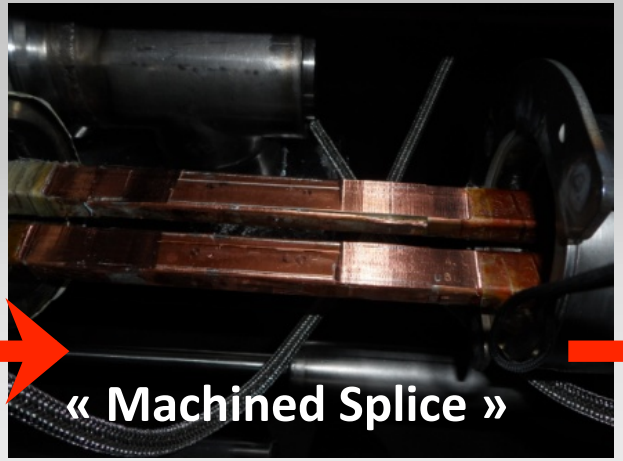
The main 2013-14 LHC consolidations

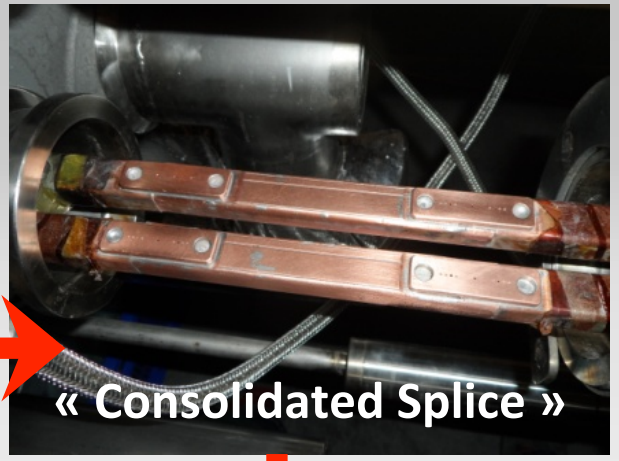
1. 1695 Openings and final reclosures of the interconnections
2. Complete reconstruction of 1500 of these splices
3. Consolidation of the 10170 13kA splices, installing 27 000 shunts
4. Installation of 5000 consolidated electrical insulation systems
5. 300 000 electrical resistance measurements
6. 10170 orbital welding of stainless steel lines

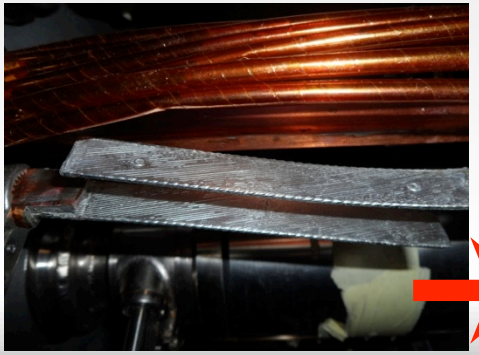


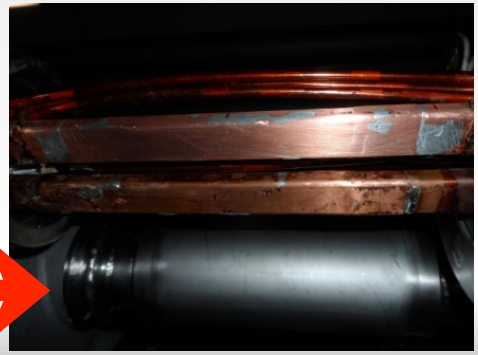
7. 18 000 electrical Quality Assurance tests
8. 10170 leak tightness tests
9. 3 quadrupole magnets to be replaced
10. 15 dipole magnets to be replaced
11. Installation of 612 pressure relief devices to bring the total to 1344
12. Consolidation of the 13 kA circuits in the 16 main electrical feedboxes

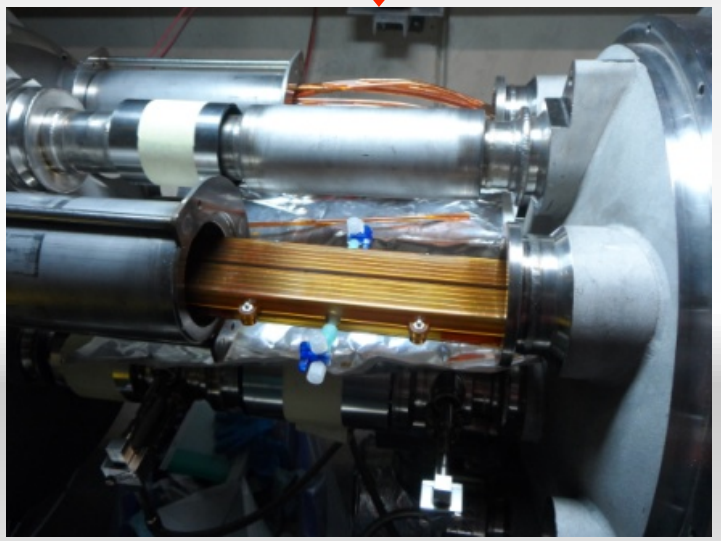

« Old Splice »


« Machined Splice »


« Consolidated Splice »


« Cables »


« New Splice »


« Insulation box »

- Total interconnects in the LHC:
  - 1,695 (10,170 high current splices)
- Number of splices redone: ~3,000 (~ 30%)
- Number of shunts applied: > 27,000

And a lot more besides…

Superconducting Magnets and Circuits Consolidation (SMACC)

Monumental effort

- Over 350 persons involved
- Including preparation: ~1,000,000 working hours
- No serious accidents!

Jean-Philippe Tock

Collaborations with NTUA (Athens), WUT (Wroclaw) and support of DUBNA

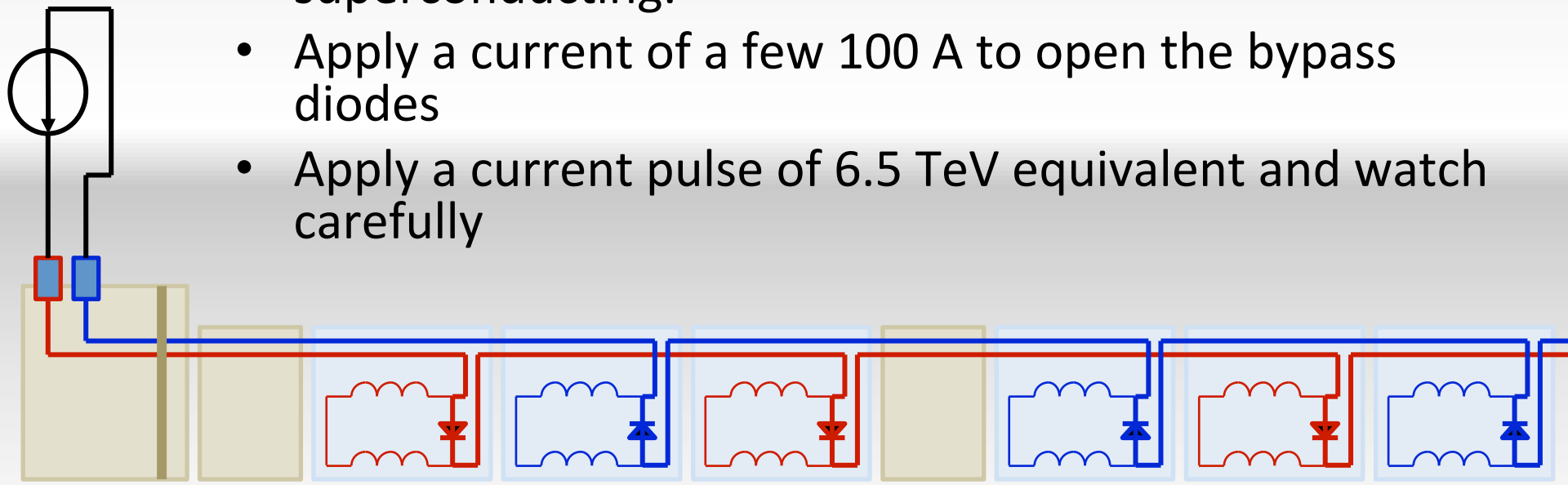
SMACC project : Closure of the last interconnection – 18.06.2014
Activity led by A Musso (TE-MSC)

CSCM (Copper Stabilizer Continuity Measurement)

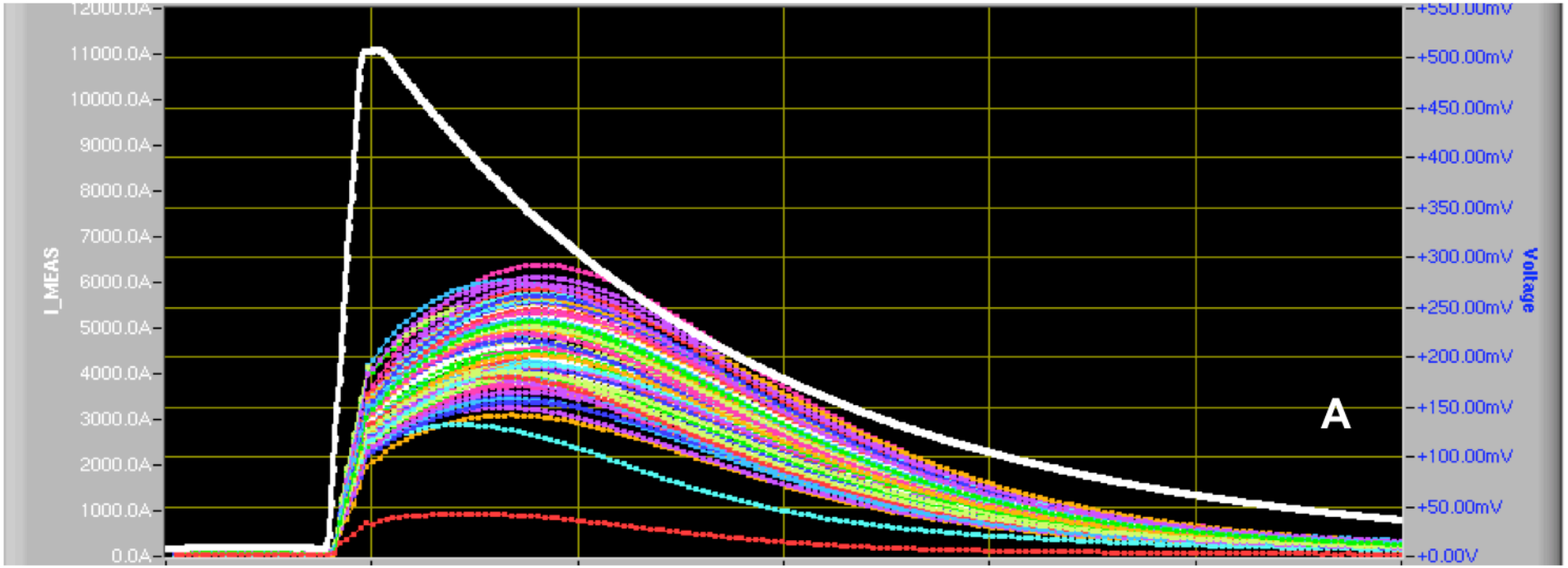
Fully qualify magnet bypass = copper stabilizer of the bus-bar + diode + diode leads

Bypass contains about 3500 connections/joints per sector!

- Connect the two 6 kA/200 V power converters in series
- Stabilize the sector 20 K so the magnets and bus are not superconducting.
- Apply a current of a few 100 A to open the bypass diodes
- Apply a current pulse of 6.5 TeV equivalent and watch carefully



Signals from 11.1 kA run



Conclusion:

- Voltages on the busbars behave as simulated, with a spread due to RRR and length differences. ☺
- There are no outliers! ☺
- All busbar segments (including joints and lyras) are qualified for 6.5 TeV! ☺

From the minutes

- *For the March LHCC meeting in 2015, the LHCC Upgrade Cost Group is preparing a document on the review procedure for the Phase II upgrades during their lifecycle, which will address performance and cost of the entire detector. The overall plans for the upgrades are laid out in comprehensive Letter of Intent (ATLAS) or Technical Proposals (CMS).*
- *In addition the experiments will provide concise **Scoping Documents** for cost scenarios of **200MCHF, 235 MCHF and 275 MCHF** for the September LHCC.*
- *The Scoping Documents will also contain a preliminary assessment of the funding commitments of the Funding Agencies (obtained by the contacts of the experiments with their Funding Agencies).*

From the minutes

- *The LHCC and the UCG will review the Scoping Documents and prepare a recommendation for the October 2015 RRB.*

This procedure was presented to the SPC and reported at the Council meeting of December 8-9 2014.

An update of the process was proposed for the April 2015 RRB.

Phase II Upgrades, a proposal for discussion

- The HL-LHC programme will require significant upgrades of the existing experiments to maintain detector performance in the presence of high radiation damage, increased pile-up, challenging trigger rates.
- The upgraded detectors will have to be installed during the LS3, currently scheduled for two and half years starting at the beginning of 2023. The LHCC and UCG will work in close connection to ensure a timely review of the scientific and technical feasibility as well as of the budget and schedule of the upgrade program.
- Given the significant cost and scope of the Phase-II upgrade program, **a multi-step approval and verification process** is required

The steps

- **In the first step**, the overall scope and cost for the entire upgrade program for each experiment will be defined, with the possibility to maintain different options which may depend on technical issues and/or on funding availability.
- **In the second step**, the detailed technical design reports (TDR) for the various subsystems will be reviewed. These TDRs will naturally come at different times depending on the maturity of the projects, and will be reviewed individually, with the requirement that each fits in the overall approved plan.

The steps

- **In the third step**, the final design and construction readiness of the major detector components will be reviewed. As in the second step, different subsystems, and in some cases also different elements of subsystems, will be ready at different times, and will be reviewed accordingly, with the requirement that they are compatible with the overall construction and installation plan.
- **In the fourth step**, as sub-systems are coming together in the experiment, an operations readiness review should be held to evaluate the capability of the completed detectors to provide the expected performance and mark the end of the Phase-II upgrades construction project.The exact timing, scope, and procedure of the operations readiness review will be defined at a later stage.

Phase II Upgrades, a proposal for discussion

- The entire process will be **driven by the scientific goals of the experiments, captured with the aid of a few detector and physics performance benchmarks**. The benchmarks can be used to gauge the cost-effectiveness of different detector options as well to provide a quantitative assessment of the degree of success of the detector construction. Technical feasibility and suitability will be also part of the LHCC review.

- Detector construction **financial information**, **which will be reviewed by the UCG**, should be provided in the form of an **unescalated CORE cost without contingency denominated in Swiss Francs**, complemented by an indication of **the required work expressed in person-month**, typically separated in various work categories. Specific forms will be provided, as for the Phase-I upgrades, to ease the review and guarantee the uniformity of the information provided. **A risk analysis and estimate of the uncertainties** should also be carried out at each stage of the project.

STEP 1: Approval of preliminary design for the complete set of Phase-II upgrades

The experiment will provide an overall description of the intended upgrade program in the form of a Letter of Intent or Technical Proposal, supplemented by a "Scoping Document" (SD) with the specific goal of exploring different detector scoping options. The combined documentation will contain conceptual designs for all elements of the upgrade, and will include:

- Physics motivation and performance, with a discussion of the optimization of cost vs. capability. In particular it is important to produce good quantitative justification for any detector extension or improvement, for instance in term of solid angle coverage.
- A detailed description of each detector element, supported by R&D or prototyping results

STEP 1 cont.

- Plan and schedule for remaining R&D, prototyping, etc. needed to develop detailed designs, and to determine final cost estimates and schedule.
- Plans for selecting among alternative technical solutions, if any.
- Current estimates of approximate total CORE project costs, manpower, schedule and needed funding profile, in sufficient detail to allow a meaningful review.
- A list of expected Technical Design Reports and an overall plan with milestones and schedule for producing them.
- Options for detector scoping with a total cost in the **approximate range 200–235–275 MCHF** with a discussion of the impact on the physics performance and in particular on the performance benchmarks.

STEP 1 cont.

The experiment will provide a separate, **confidential** document containing a preliminary funding plan with the "money-matrix" expected from the various funding agencies.

The LHCC will review the documentation for technical feasibility and capability to address the science, while the UCG will specifically evaluate cost and schedule.

The LHCC/UCG positive recommendation and approval by the RB, followed by a presentation to the RRB, will allow the experiment to proceed with the process needed to establish a firm budget, schedule and funding profile.

CERN Management will propose to the RRB a reference number for the total CORE cost of the Phase-II upgrades for each experiment.

THANK YOU