

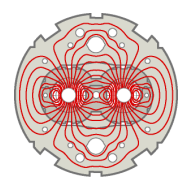
LHC Performance Workshop - Chamonix, 24-28 January, 2011
Session 2 -Shutdown 2012

Work Organisation for Splice Consolidation

Francesco Bertinelli - TE/MS

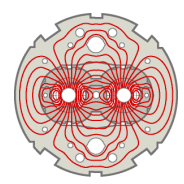
24 January, 2011 (15 minutes + 10 minutes discussion)

- Are there other systematic splice / circuit defects?
- Magnets / interconnects work organisation for shutdown
- Do we have the necessary resources?
- How long will the shutdown take?
- Cost?



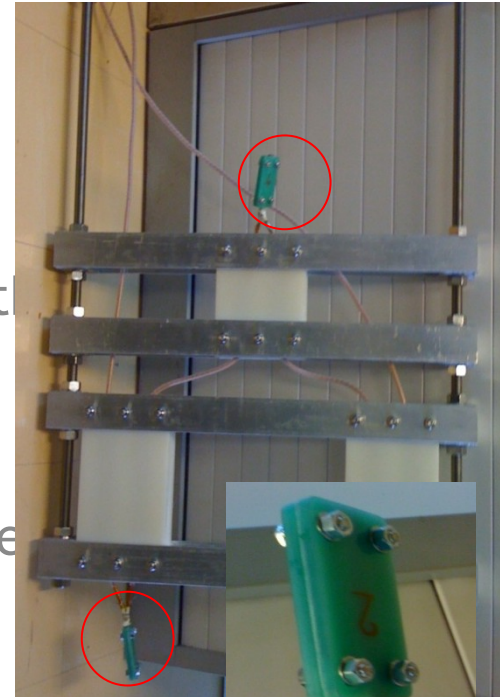
LHC Splices Task Force

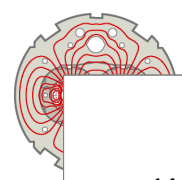
- Membership: F. Bertinelli, N. Catalan Lasheras, P. Fessia, C. Garion, S. Mathot, A. Perin, C. Scheuerlein, S. Sgobba, H. Ten Kate, J.-P. Tock, A. Verweij, G. Willering
- 35 meetings, documented in www.cern.ch/LHCsplices
- work priorities:
 - Design of 13 kA main interconnection splice consolidation (see P. Fessia)
 - 6 kA praying hands splices
 - Overall risk assessment of splices
- “1st” Splice Review (J. Strait / Fermilab, D. Bresson / Alstom, G. Ganetis / BNL, T. Ogitsu / KEK, F. Savary / ITER, P. Vedrine / Saclay), 18-22 October 2010
 - 2nd Review (was) planned for September 2011 (Production Readiness)
- Work organised within Group structure (TE-MSD and TE-MPE): ⇒ to be followed up ...
- End of Task Force? June 2011



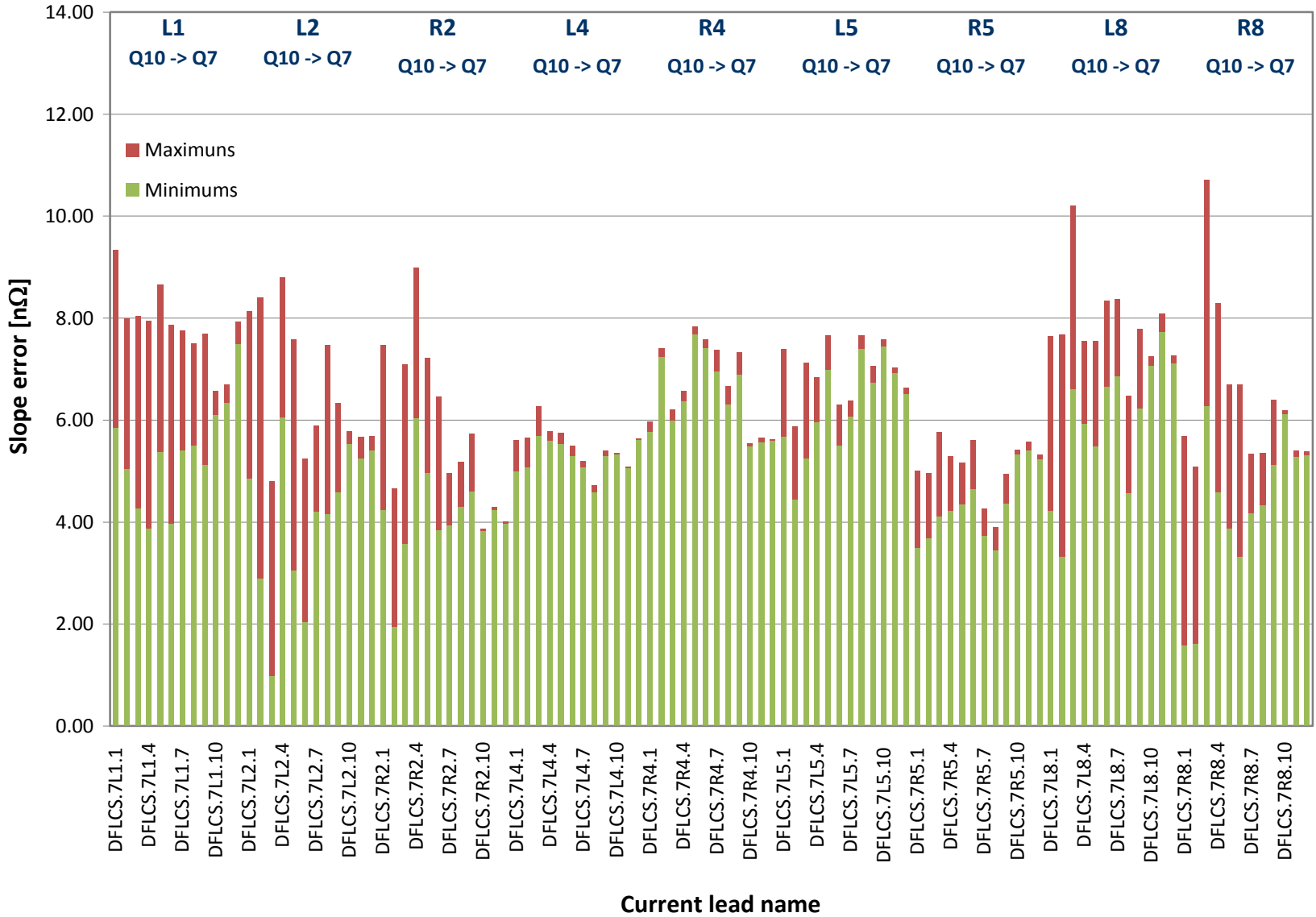
6 kA praying hands splices

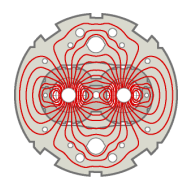
- Detailed electrical schematics done (types and number of splices)
- **Mapping measurements** of splice resistances at cold in the tunnel (during Technical Stops, ongoing)
 - average splice resistance **1.14 nΩ, no outliers**
- Review and collection of existing documentation
- **Fatigue testing** at cold in Block4
 - 3 samples in series
 - 12 000 cycles to 9 kA, then 12 000 cycles to 6 kA with
 - microscopic examination of solder
 - **no deterioration** of splice resistance (1.9 - 2.9 nΩ)
- Planned upgrade of 6 kA QPS (will allow monitoring of se
- Plan for partial inspections during long shutdown
- keep present design
 - **“issue has been laid to rest”** (Splice Review)





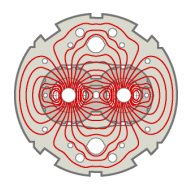
Min. / Max. splice resistance for each measurement





Overall risk assessment of splices

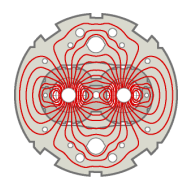
- Sextupole spool circuit assessment (H. ten Kate)
- Octupole spool circuit assessment (D. Tommasini)
 - identified issues and started actions, ongoing **but needing resources**:
 - Prepare detailed electrical schematics (N. Catalan Lasheras, ...)
 - Model electrical circuits (A. Verweij, E. Ravaioli ...)
 - Simulate hot spot temperatures after quenches (A. Verweij, A. Perin)
 - Re-evaluate peak voltage levels at operation (N. Catalan Lasheras)
 - ...
- MB circuit inventory of singularities (R. Principe)
 - assessment is useful, needs integrated approach. **H. ten Kate given mandate** (Sept. 2010) to guide and co-ordinate pool of “magnet experts” for the overall risk assessment: recommend practical actions, finish by May-June 2011.
 - **no obvious showstoppers, but cannot exclude necessary actions** once the risk assessment is completed (e.g. spiders?)



Overall risk assessment of splices

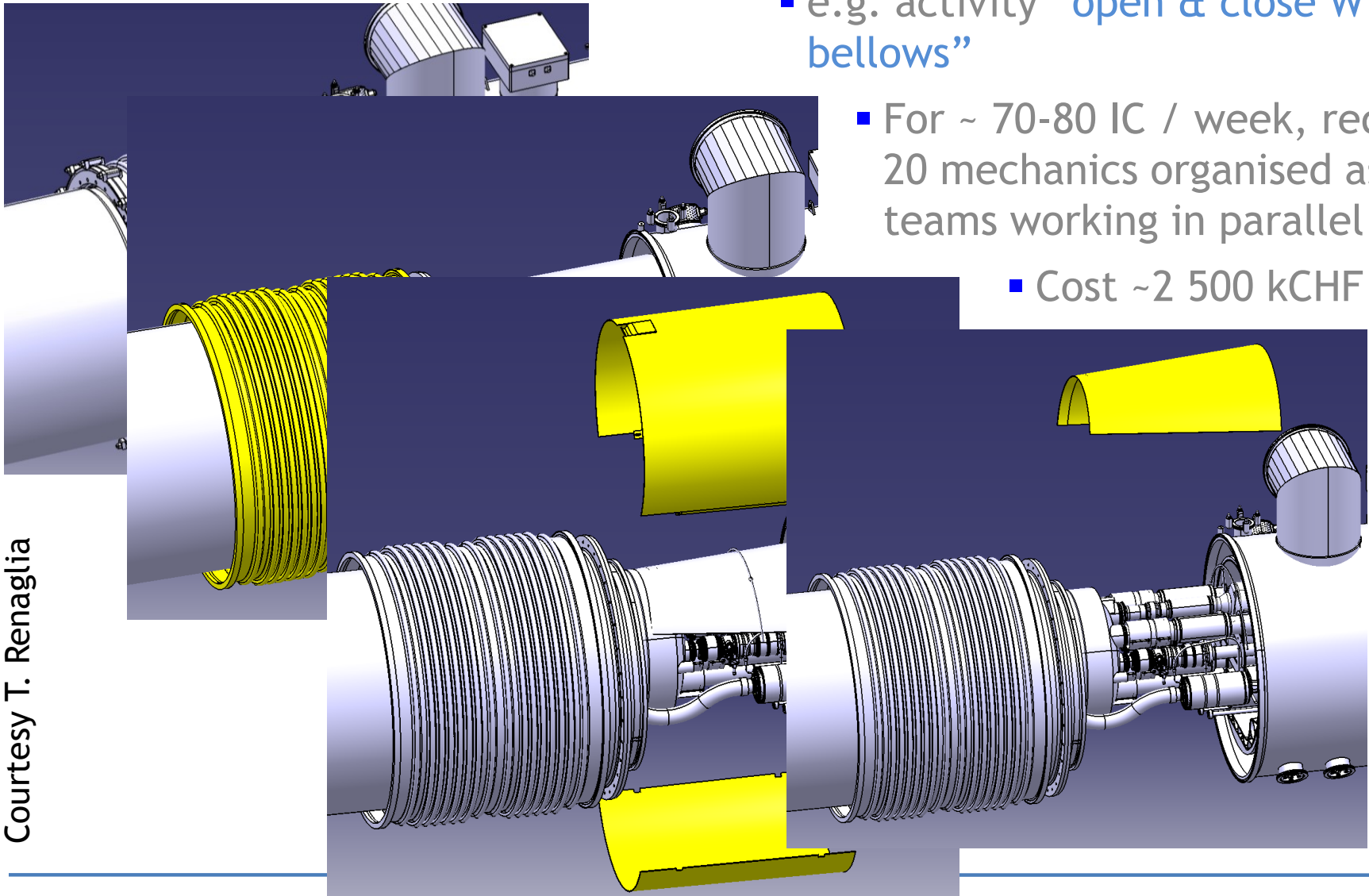
- Schedule for 1st screening reports in the coming months
 - Thursday morning 25 Nov 10: MB (R. Principe)
 - Thursday morning 09 Dec 10: MCD (D. Tommasini)
 - Thursday morning 13 Jan 11: MCB, MCBC and MCBY (S. Russenschuck)
 - Thursday morning 10 Feb 11: MQT, MQS and MQTL (M. Bednarek)
 - Thursday morning 24 Feb 11: MS, MO and MSS (M. Modena)
 - Thursday morning 10 Mar 11: MQ quads (R. Principe)
 - Thursday morning 24 Mar 11: Inner triplets and correctors (N. Catalan Lasheras)
 - Thursday morning 07 Apr 11: 6kA stand alone magnets (G. De Rijk)



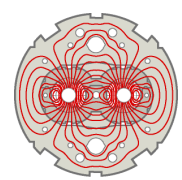


IC “train” - splice consolidation activities

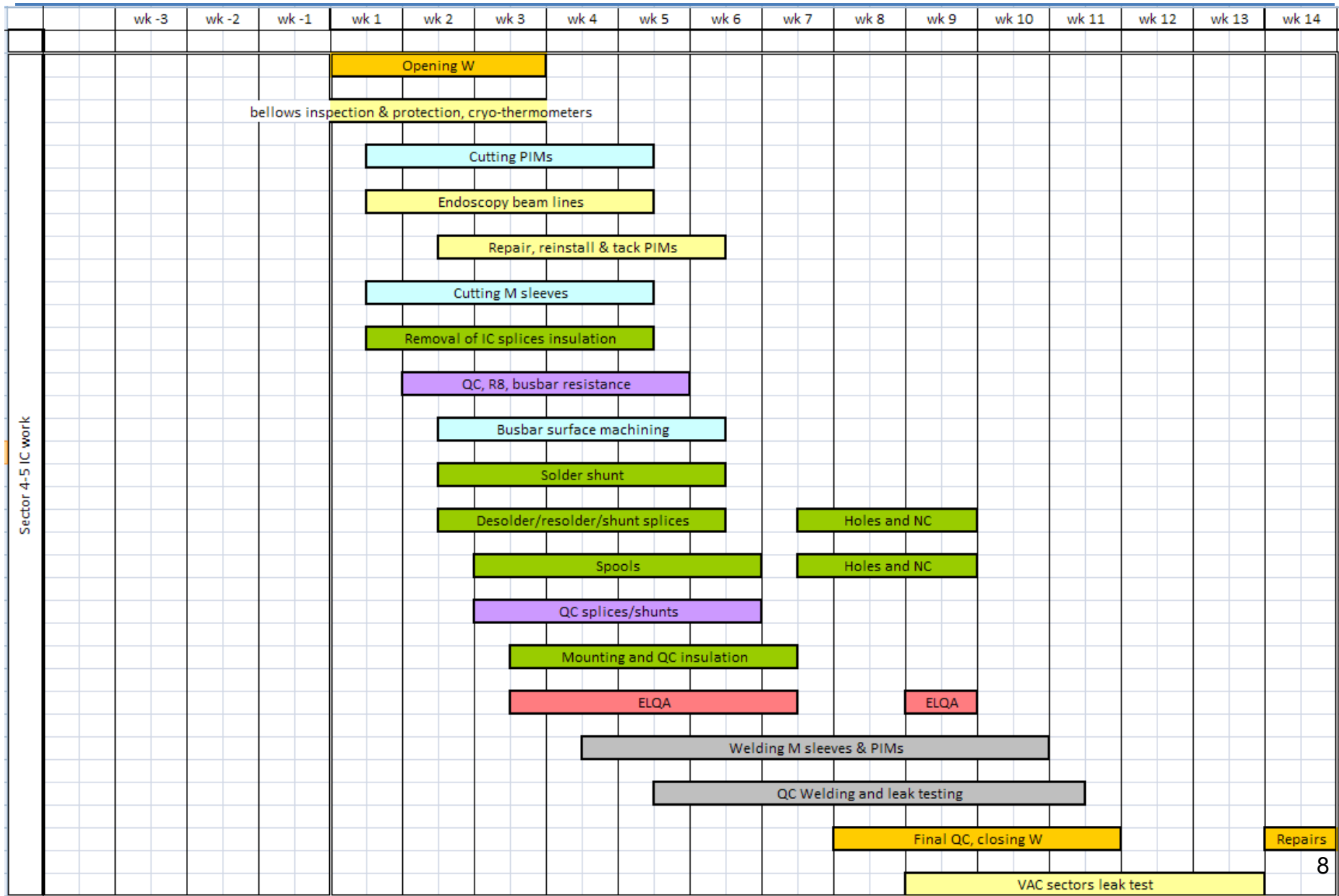
- e.g. activity “open & close W bellows”
- For ~ 70-80 IC / week, requires 20 mechanics organised as 7-8 teams working in parallel
- Cost ~2 500 kCHF

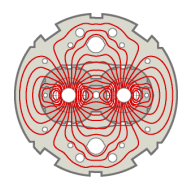


Courtesy T. Renaglia



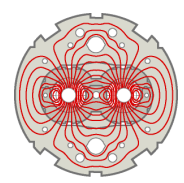
Schedule for splice consolidation “train”





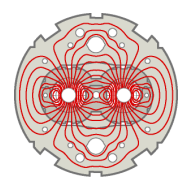
Schedule for IC “train” work

- At 50 IC / week for critical activities
- “IC train work” 12 months, defined as “from first W open to last W closed”
- Assuming:
 - Work sequentially through adjacent sectors, starting at Point 4, clockwise
 - No contingency included (learning, holidays ...)
 - No RP limitations, no access limitations (cryogenics, testing, ...), no coactivity limitations (transport ...)
 - **2 shifts** (6h to 15h and 12h to 21h), Monday to Friday, 40 h / week (FSU contracts)
 - Special Intervention Team (SIT) will intervene before the “train” arrives to re-connect
 - To be integrated within overall shutdown planning



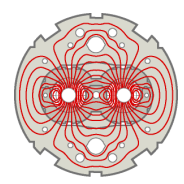
Other activities before and after “train”

- Beam OFF ⇒
 - Dedicated electrical testing at cold (see M. Pojer, N. Catalan Lasheras)
 - Survey <100K
 - Start warm-up
 - Vacuum characterisation, leak testing and localisation (see P. Cruikshank)
 - RP checks
 - RF ball test for PIMs
 - Disconnect BLM, survey wires, QPS wiring
 - open first W
- Close last W⇒
 - RF ball test for PIMs
 - Reconnect BLM, survey wires, QPS wiring
 - Start cool-down
 - Electrical testing
 - Survey measure and smoothing <100K (~4 weeks per sector)
 - HWC
 - Beam ON

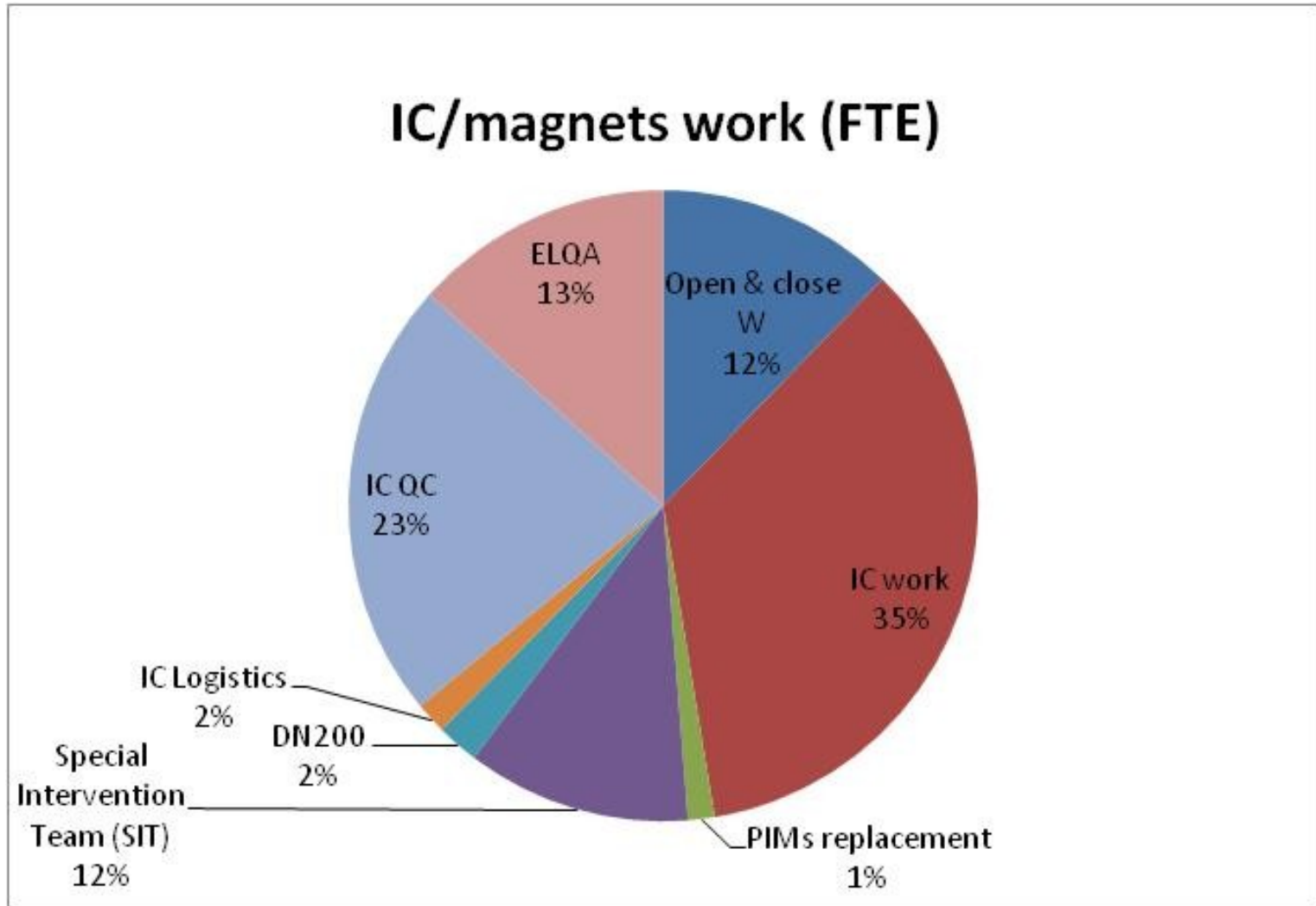


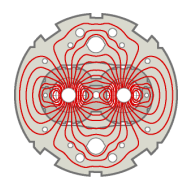
Needed resources for IC/magnet work

| Activity | Identified, trained | Identified, but need training | Missing resources | Comment |
|---|---------------------|-------------------------------|-------------------|---|
| Opening and closing W | | 8 | 20 | TE-MSC-MNC, FSUs task oriented, Dubna Project Associates |
| Bellows inspection & protection, endosc | 5 | 3 | | TE-VSC, Krakow Project Associates |
| Repair, reinstall & tack PIMs | incl. | | 2 | TE-VSC, FSUs |
| Orbital machining M sleeves and PIMs | 3 | 3 | 5 | FSUs |
| Busbar copper surfacing machining | | 7 | | TE-MSC-MNC |
| Electrical connections | 8 | 9 | 3 | FSUs, further CERN contribution? |
| QC electrical connections | 4 | 13 | | TE-MSC-SCD, BE-OP |
| ELQA | 13 | 10 | | Krakow Project Associates |
| TIG welding M sleeves and PIMs | 6 | | 9 | EN-MME and S146 contract |
| QC Welding | | 2 | 4 | EN-MME, external contract, BE-OP |
| QC closing W | | 4 | | TE-MSC-MNC, BE-OP |
| Other | 5 | | 5 | logistics, coordination, overall QA: further CERN contribution? |
| DN200 | 7 | 1 | | Dubna Project Associates |
| Special Intervention IC Team | 7 | 4 | 9 | TE-EPC, FSUs, further CERN contribution? |
| Total | 58 | 64 | 57 | |
| | | 179 | | |



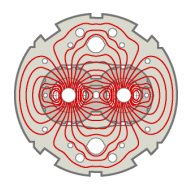
Needed resources for IC/magnet work





Available resources

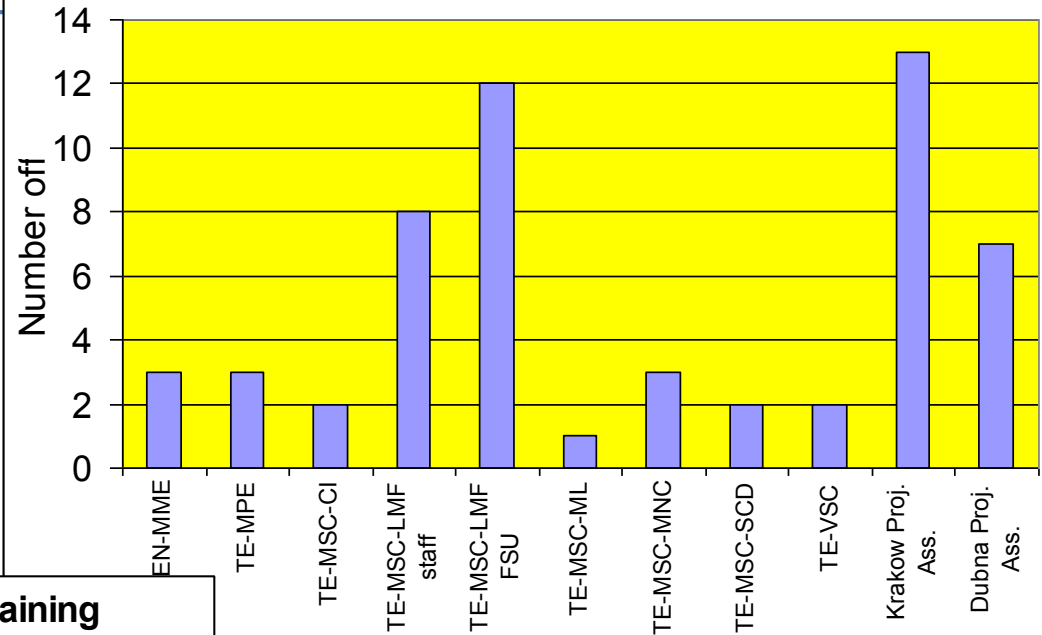
- Current estimate for IC/magnet work (IC train, SIT, DN200):
 - **~200 persons needed** (was ~130 in Chamonix 2010 !)
- ~1/3 are identified (but not all at CERN) and experienced: core team from TE (including FSUs!), EN-MME, Krakow, Dubna
- After several discussion in 2010, identified ~1/3 as special contributions:
 - TE-MS-C-MNC (if injectors stopped and no issues with maintenance)
 - BE-OP (if injectors stopped),
 - TE-EPC
 - Krakow
- **Still missing ~1/3, mainly mechanics**: ongoing discussions with PH-DT, BE-RF, but unrealistic to expect further Project Associates (Dubna, Protvino)
- The balance 50-50 (experienced to new) for critical activities is already lost, resulting in **increase in quality and follow-up risk**
- Possibilities:
 - Accept to **increase duration of shutdown by 2-4 months**
 - **Recruit 5-10 additional FSUs in the next months**, train and integrate them to ongoing work (collimators, welding, busbars, ...)



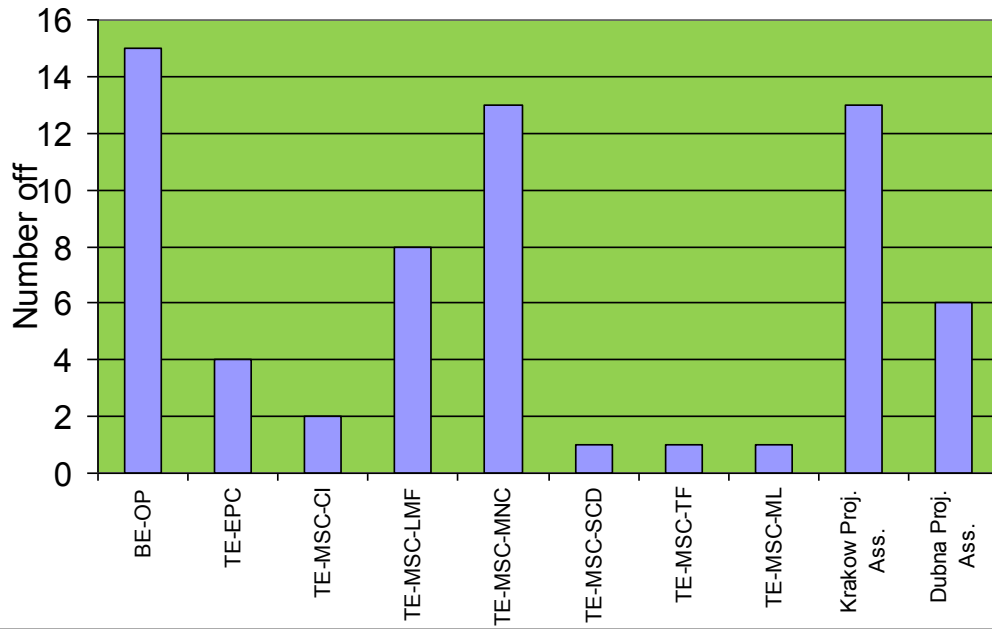
Available resources

Detailed work to identify names

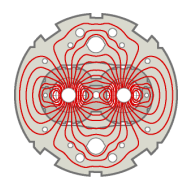
IC work resources: identified, trained



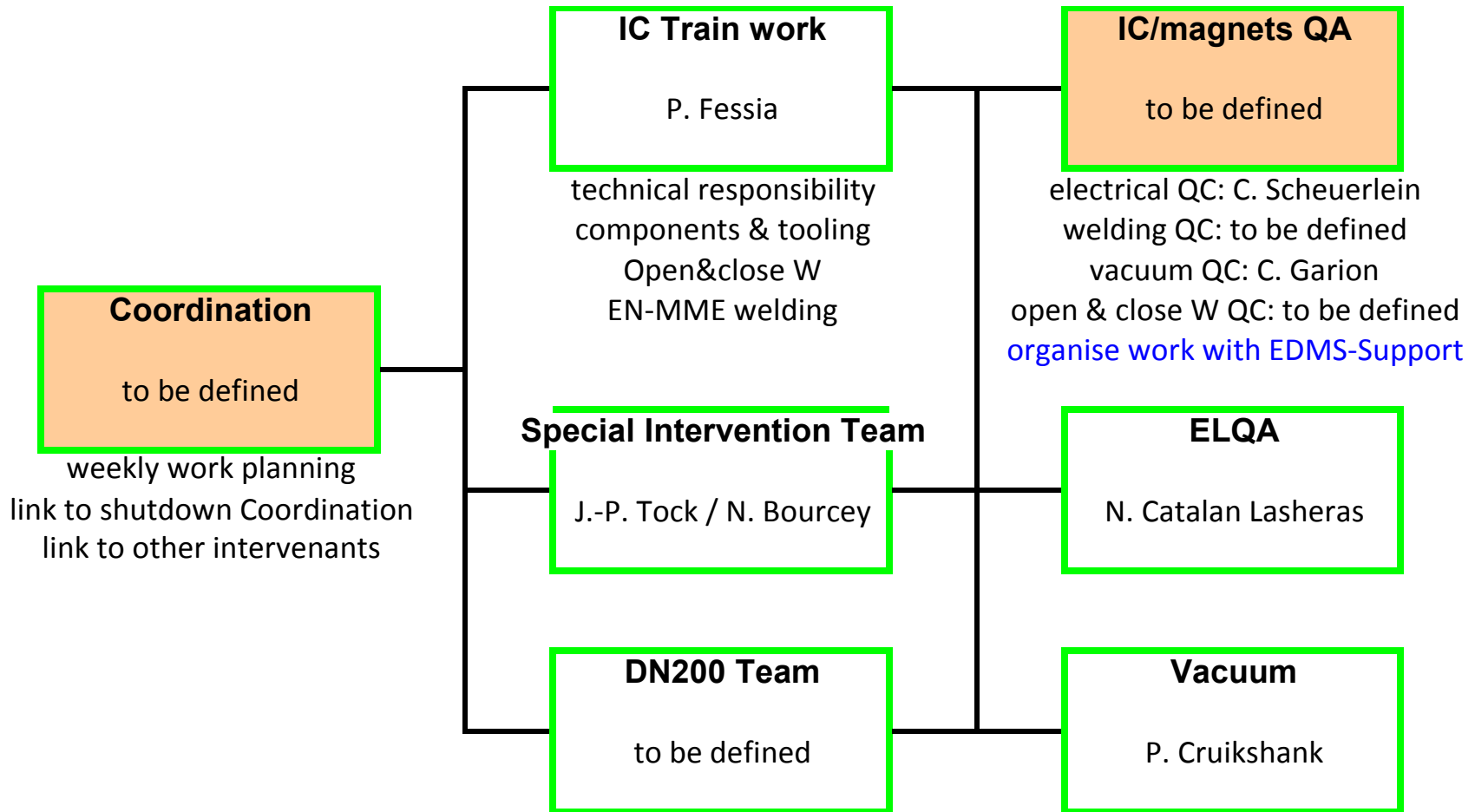
IC work resources: identified, need training



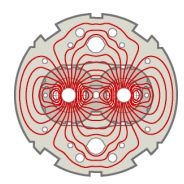
Thanks for support!



IC/magnet work organisation

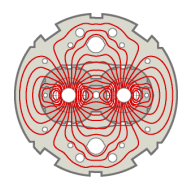


Requires discussion, key roles still to be filled



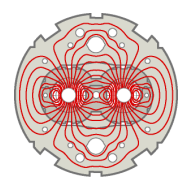
Cost estimates (kCHF)

| | Chamonix 2010 | Chamonix 2011 | Comments |
|------------------------------|--|---------------|--|
| Splice consolidation (99117) | 2 000 (development 2010 and 2011) 14 445 | 17 500 | Copper surfacing, larger teams, save on QC (BE-OP) |
| ELQA | 4 800 | 2 850 | 1 shift only |
| Vacuum | 1 755 | 2 600 | PIMs and QC |
| CRG | 400 | 400 | |
| Special Team | - | 2 600 | |
| Total | 23 400 | 26 000 | |



Conclusions i/ii

- ✓ Are there other systematic splice / circuit defects?
 - we should know by June 2011 with the end of the Task Force risk assessment: currently no major showstoppers
- ✓ Magnets / interconnects work organisation for shutdown
 - IC train, Special Intervention Team, DN200 Team
 - Some key roles still to be covered (QA, coordination)
- ✓ Do we have the necessary resources?
 - No, Still missing 1/3, mainly mechanics
 - Efforts to identify additional resources has been done, unrealistic to expect further contribution as Project Associates



Conclusions ii/ii

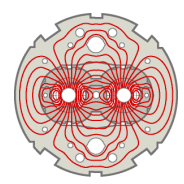
- Injectors stop would free valuable resources: conditions and priorities to be clarified
- Recruit 5-10 FSUs now and start integration and training

✓ How long will the shutdown take?

- defined as “IC train work” could be 12 months, but more realistic to consider 2-4 months extra

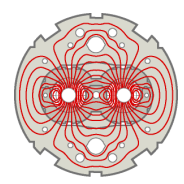
✓ Cost?

- splice consolidation “IC train”: 23 MCHF
- Special Intervention Team: 3 MCHF



Thanks for your attention

Acknowledgement: work, discussions, experience of Interconnections Teams, LHC Splices Task Force and many others



Supporting slides

