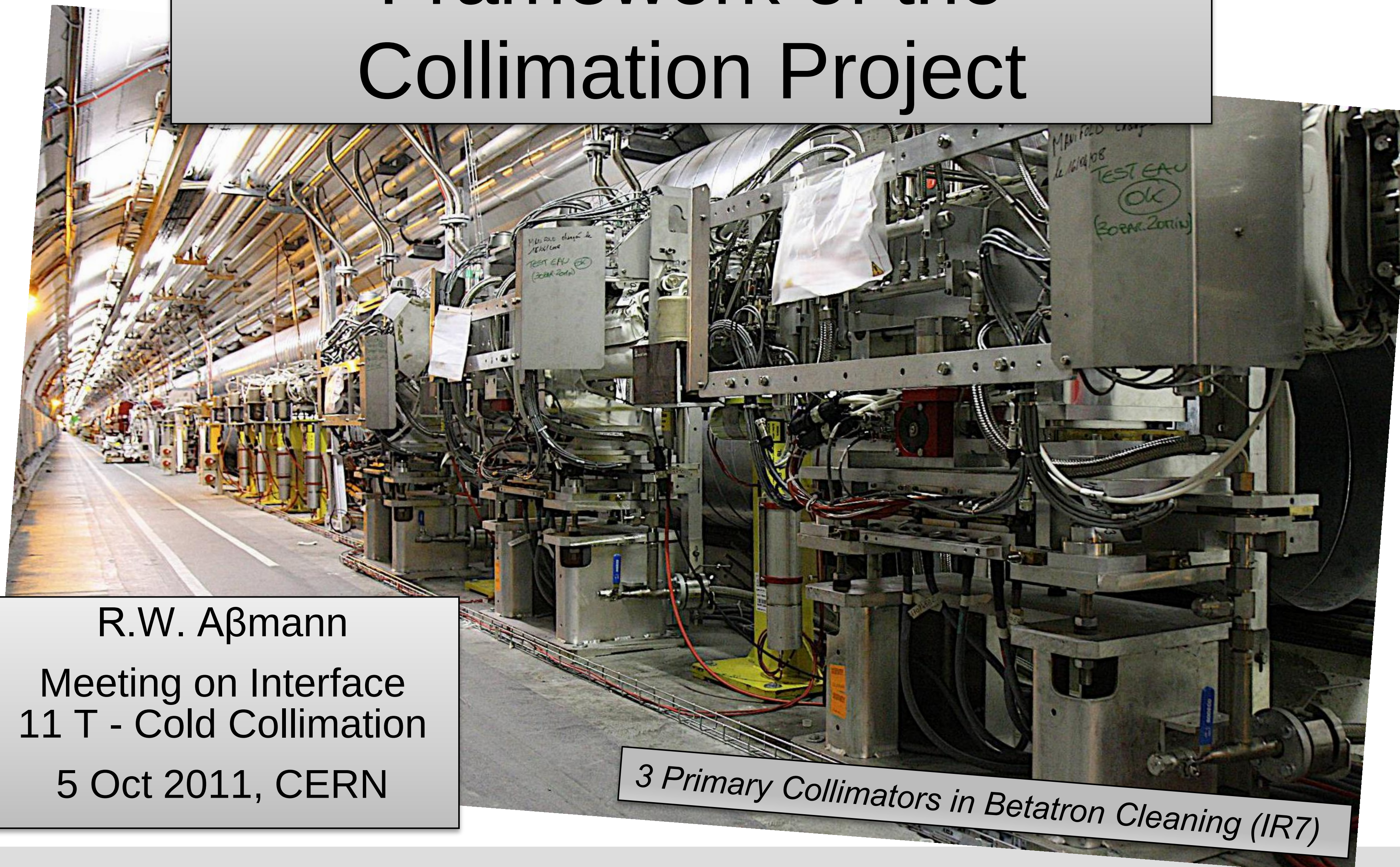
Scope of the Meeting: the Framework of the Collimation Project

LHC Collimation Project CERN



3 Primary Collimators in Betatron Cleaning (IR7)

R.W. Aβmann

Meeting on Interface
11 T - Cold Collimation

5 Oct 2011, CERN

The Collimation Project Team & Close Collaborators

- Results on phase I collimation are outcome of lot of work performed over last 9 years by the following **CERN colleagues**:

O. Aberle, J.P. Bacher, V. Baglin, G. Bellodi, A. Bertarelli, R. Billen, V. Boccone, A.P. Bouzoud, C. Bracco, H. Braun, R. Bruce, F. Burkart, M. Cauchi, J. Coupard, D. Deboy, N. Hilleret, E.B. Holzer, D. Jacquet, J.B. Jeanneret, J.M. Jimenez, M. Jonker, J. Jowett, Y. Kadi, K. Kershaw, G. Kruk, M. Lamont, L. Lari, J. Lendaro, J. Lettry, R. Losito, M. Magistris, A. Masi, M. Mayer, E. Métral, C. Mitifiot, N. Mounet, V. Parma, R. Perret, S. Perrolaz, V. Previtali, C. Rathjen, S. Redaelli, G. Robert-Demolaize, C. Roderick, S. Roesler, A. Rossi, F. Ruggiero, M. Santana, B. Salvachua, R. Schmidt, P. Sievers, M. Sobczak, J.P. Tock, K. Tsoulou, G. Valentino, E. Veyrunes, H. Vincke, V. Vlachoudis, T. Weiler, J. Wenninger, D. Wollmann, …

- Crucial work also performed by **collaborators** at:

EuCARD/ColMat partners (see GSI talk), TRIUMF (D. Kaltchev), IHEP (I. Baishev & team), SLAC (T. Markiewicz & team), FNAL (N. Mokhov & team), BNL (N. Simos, A. Drees & team), Kurchatov (A. Ryazanov & team).

The Last Phase 1 Collimator

LHC Collimation Project

04/10/2011

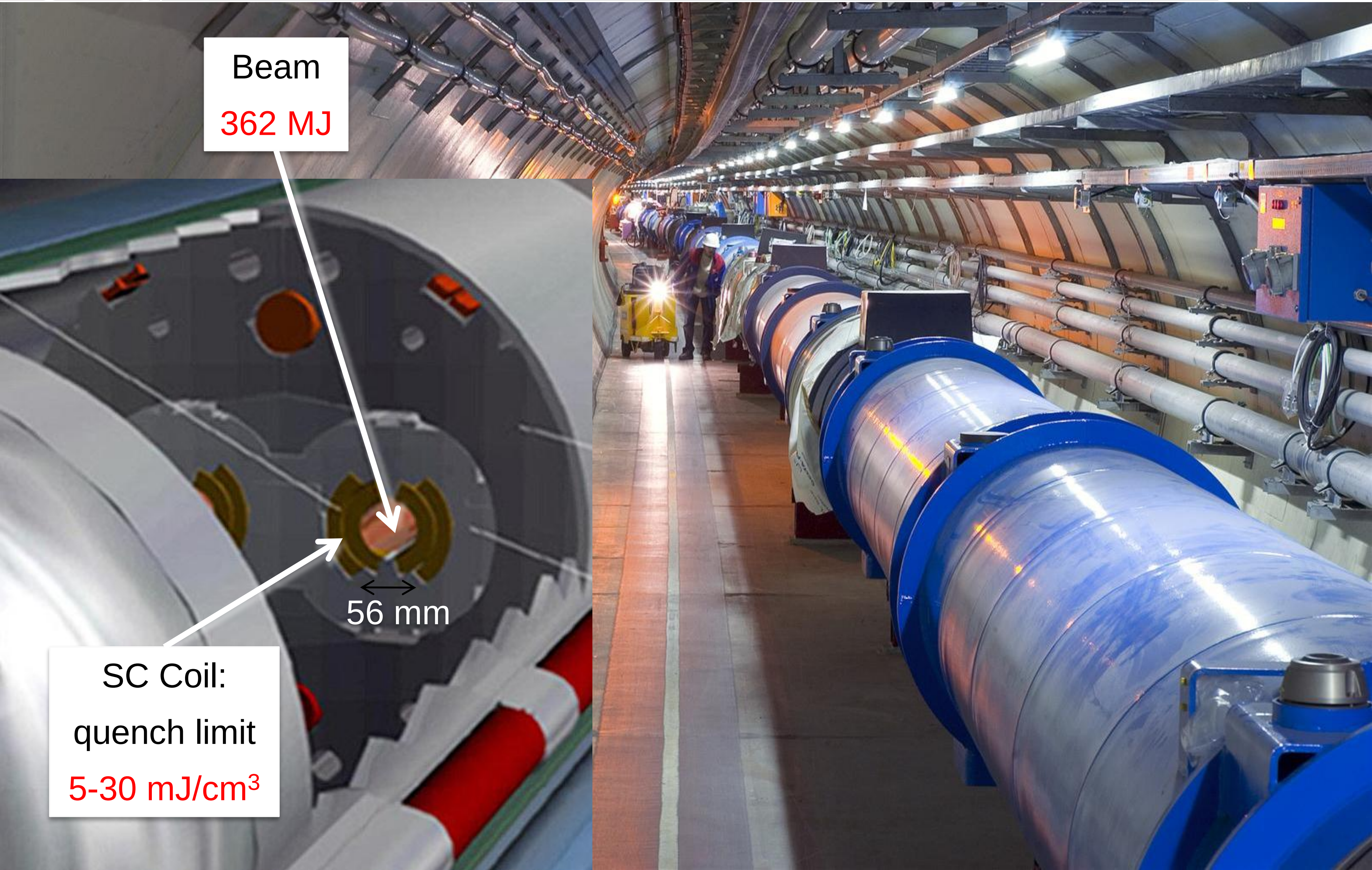
Many PhD‘s & Fellows Related to Collimation

- This challenging topic attracts many excellent students and fellows!
- PHD‘s (some later fellows):
  C. Bracco, M. Brugger, M. Cauchi, A. Dallocchio, D. Deboy, L. Lari, V. Previtali, G. Robert-Demolaize, G. Valentino, ...
- Master students:
  F. Burkart, ...
- Fellows:
  R. Bruce, S. Redaelli, B. Salvachua, T. Weiler, D. Wollmann, FLUKA fellows for collimation, ...

Quench Limit of LHC Super-Conducting Magnets

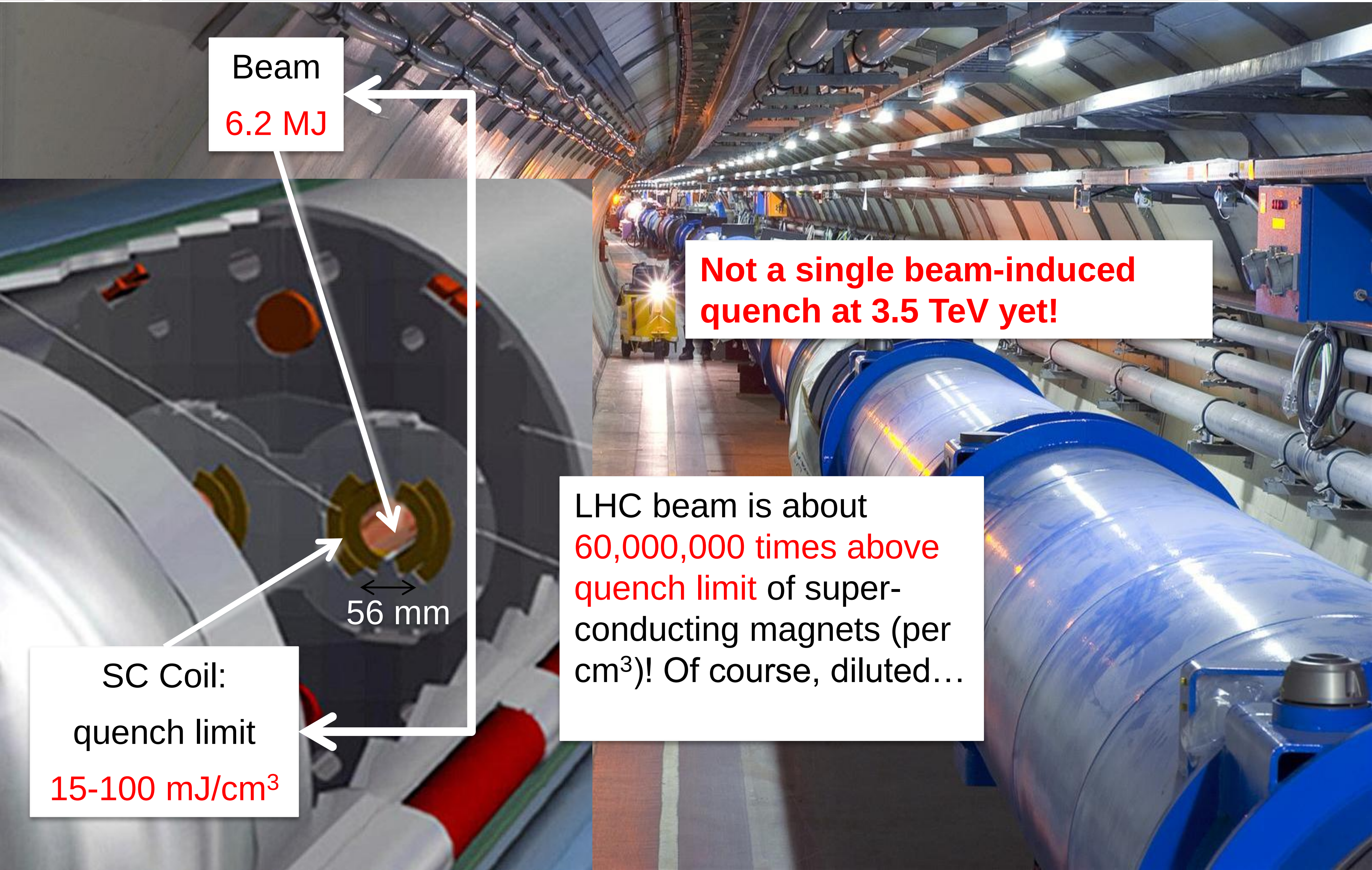
Nominal design at 7 TeV

LHC Collimation Project CERN



Quench Limit of LHC Super-Conducting Magnets

Situation at 3.5 TeV (on September 26, 2010)



Not a single beam-induced quench at 3.5 TeV yet!

LHC beam is about 60,000,000 times above quench limit of super-conducting magnets (per cm^3)! Of course, diluted…

CERN-ATS-Note-2011-042 MD (LHC)

May 24, 2011
Stefano.Redaelli@cern.ch

LHC Collimation Project
CERN

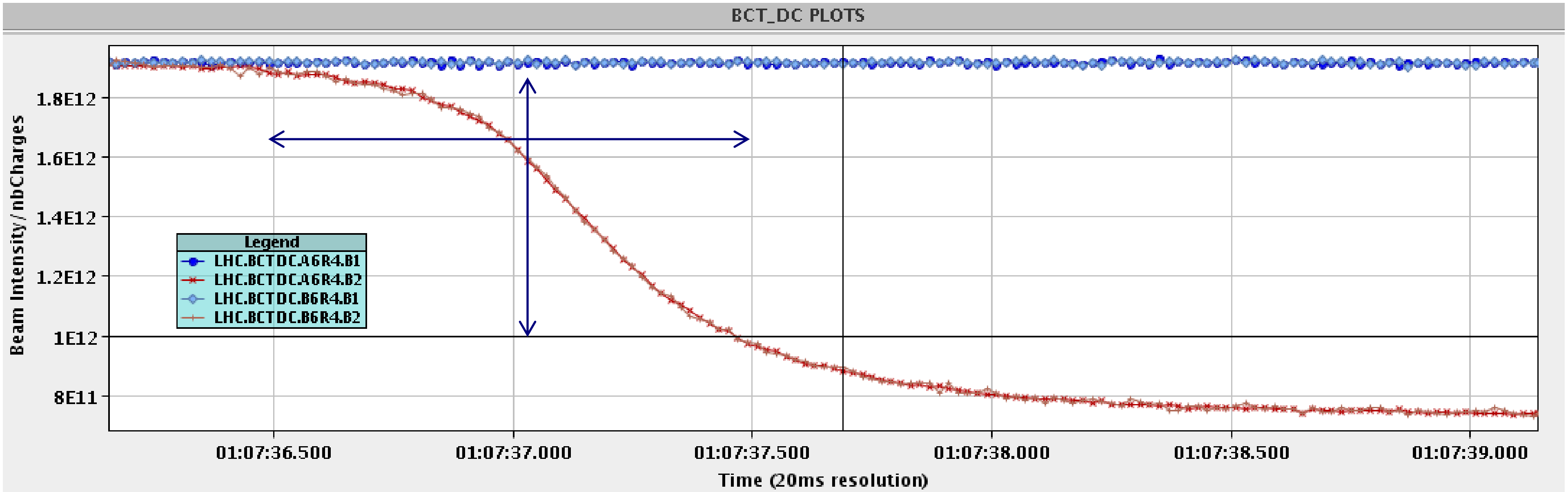
Collimator losses in the DS of IR7 and quench test at 3.5 TeV

R.W. Assmann, R. Bruce, F. Burkart, M. Cauchi, D. Deboy, B. Dehning, E.B. Holzer, E. Nebot del Busto, A. Priebe, S. Redaelli, A. Rossi, R. Schmidt, M. Sapinski, G. Valentino, J. Wenninger, D. Wollmann, M. Zerlauth, CERN, Geneva, Switzerland

Keywords: Collimation, beam losses, quench, dispersion suppressor

16 bunches, 3.5 TeV

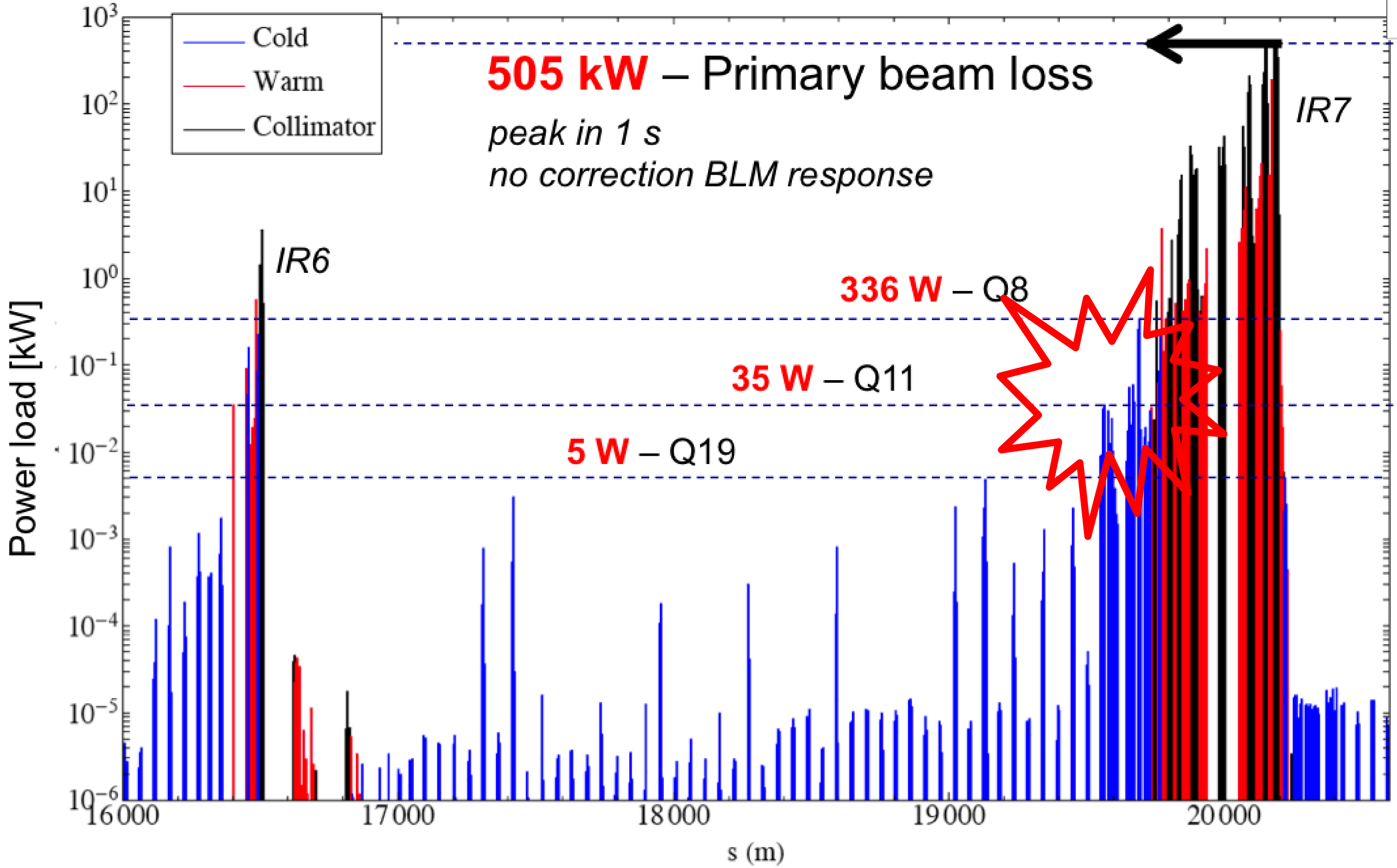
Provoked beam loss: beam blow up on 1/3 resonance



Loss rate:

9e11 p/s @ 3.5 TeV → 505 kW

Leakage into SC Magnets



3.5 TeV operational collimator settings (not best possible)

No quench of any magnet!

CERN-ATS-Note-2011-036 MD

2011-05-24

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LHC Collimation Project
CERN

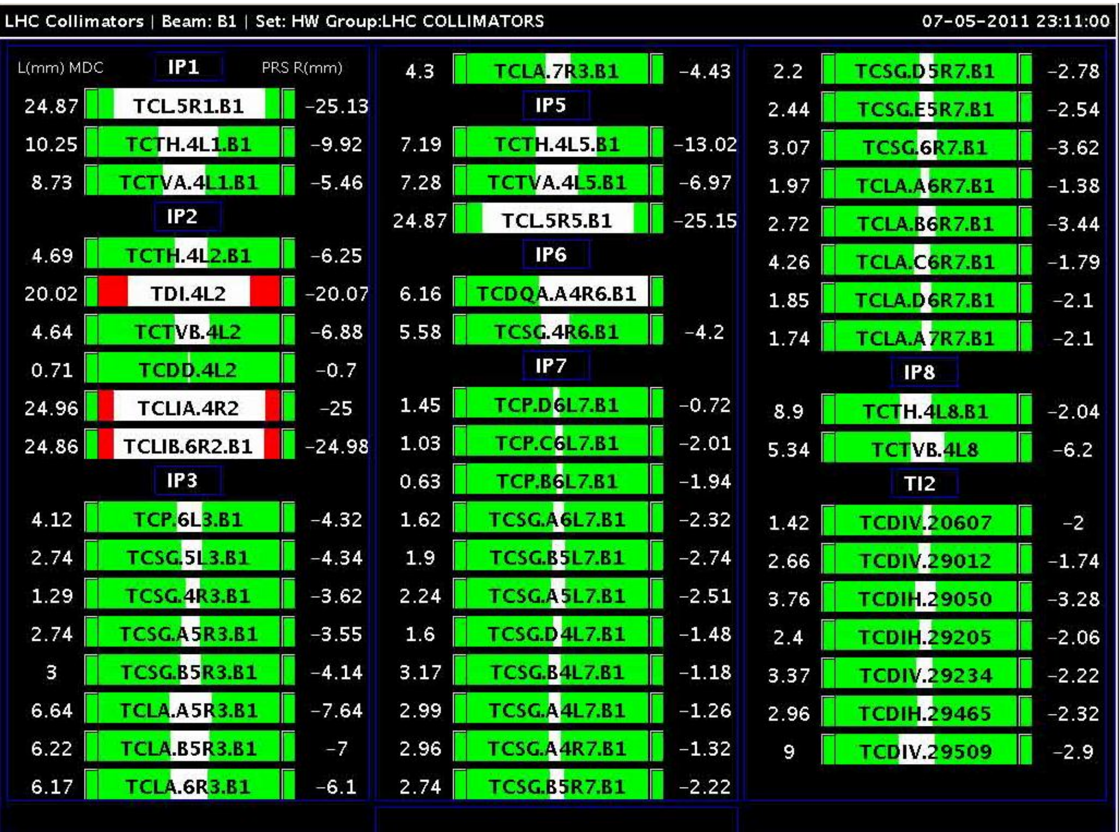
Summary of MD on nominal collimator settings

R.W. Assmann, R. Bruce, F. Burkart, M. Cauchi, D. Deboy, L. Lari, E. Metral, N. Mounet, S. Redaelli, A. Rossi, B. Salvant, G. Valentino, D. Wollmann

Keywords: Collimator settings, collimator impedance

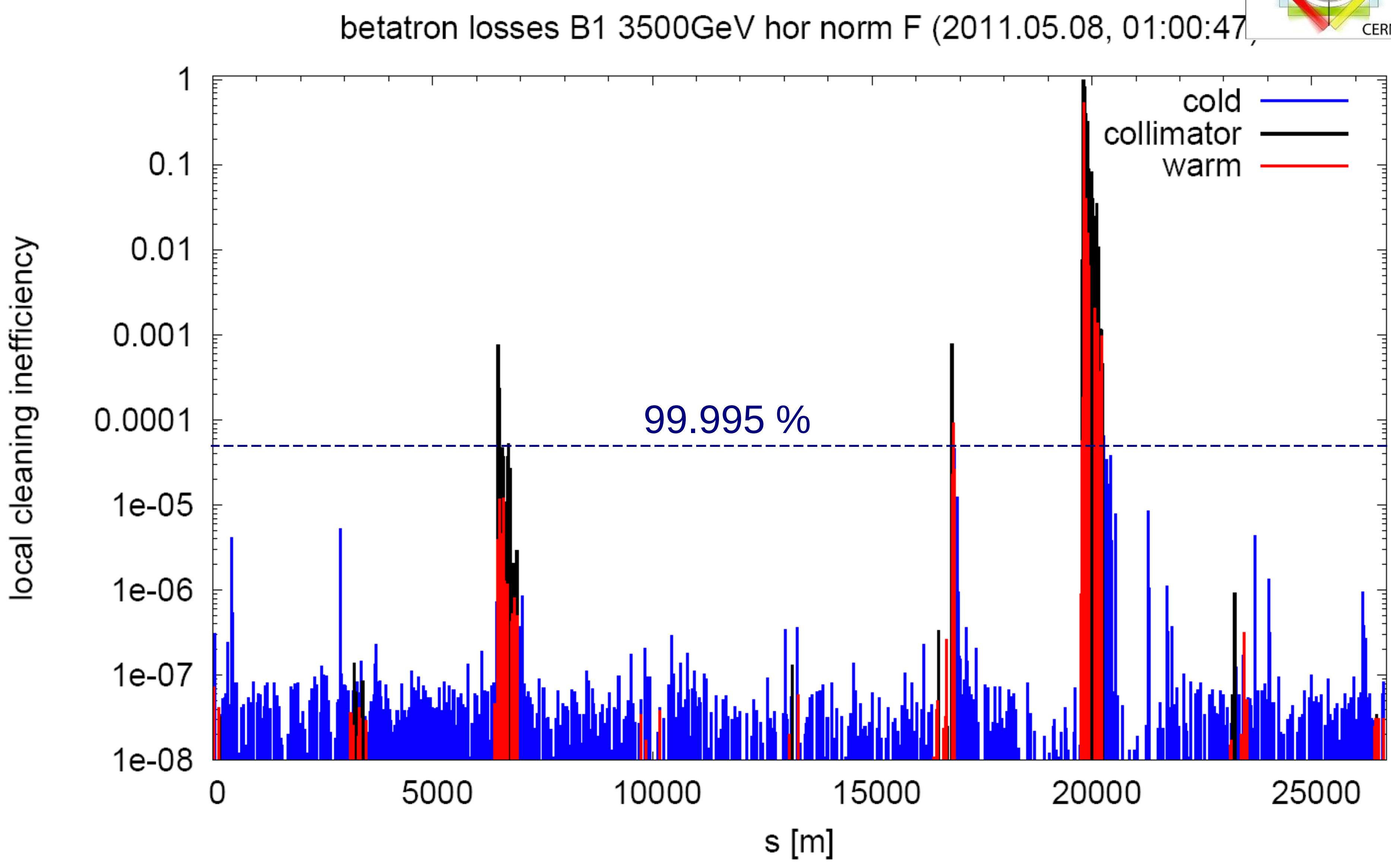
	TCP IR7	TCSG IR7	TCLA IR7	TCSG IR6	TCDQ IR6
2010 settings	5.7	8.5	17.7	9.3	10. - 10.6
Nominal	5.7	6.7	9.7	7.2	7.7
Tight B1	4.0	6.0	8.0	7.0	7.5
Tight B2	4.0	5.0	7.2	6.2	6.7

Settings in nominal beam sigma at 3.5 TeV

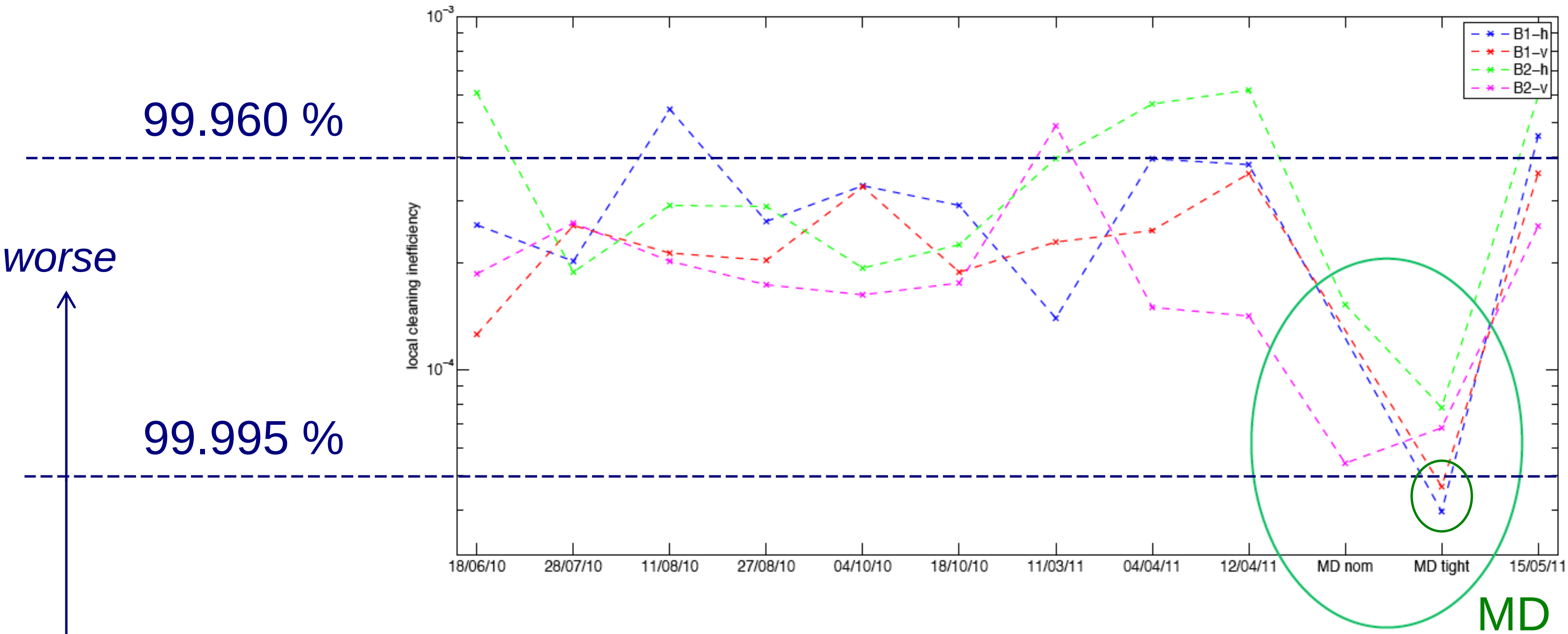


Settings in mm at 3.5 TeV for tightest collimator settings achieved (beam 1)

Observed Losses *(Normalized to Primary Collimat*



(In) Efficiency Reached *(Coll → SC Magnet)*



better

Figure 5: Beam 1 and Beam 2 maximum local cleaning inefficiency in the cold parts of the LHC at 3.5TeV over about one year operation. The results from this MD are contained in the second and third sets of points from the right, where a clear decrease can be observed.

LHC Collimation Status & Outlook

- The LHC collimation problem has been solved for nominal beam:
  - Design goals for nominal intensity and 7+7 TeV beams were demonstrated.
  - Better than design cleaning efficiency was shown.
- In addition gain from lower than specified beam losses.
- Some improvements are ongoing (e.g. minimize collimation setup time):
  - Faster collimation setup with direct feedback from beam loss monitors (2011/12 christmas stop).
  - IR2 collimator move (2011/12 christmas stop).
  - Replacement of IR1/2/5/8 tertiary collimators and IR6 collimators with BPM collimator design → faster setup, lower beta* (long shutdown 1).
  - Radiation measures: remote handling, easy handling, remote survey, ...
  - R&D on low impedance materials (collimation phase 2, for LS2)
  - R&D on new solutions: hollow e-beam lens, crystal coll., non-linear coll.
- On long-term (LS2, performance > nominal) expect to become limited by fundamental losses into LHC dispersion suppressors:
  - Protect dispersion suppressor collimators in IR1/2/3/5/7/8

Work Ahead for DS Collimation Concept

1. Specify cases for collimation (p intensity, ion intensity, lifetimes, p-p luminosity, Pb-Pb luminosity, any other future use cases) for IR1/2/3/5/7/8 independently, including HL-LHC parameters!
2. Define candidate locations for DS collimators, candidate material and candidate jaw length (also 1-sided vs. 2-sided).
3. Define gaps for DS collimators.
4. Simulate collimation efficiency (SixTrack with Collimation) for defined cases. Vary parameters (material, length, gaps).
5. Possibly iterate location until losses for all cases are reliably intercepted (study 1 versus 2 collimators per DS).
6. Once OK for beam losses, define reference case (material, length, gaps, locations). Define power load. Try to have one collimator solution.
7. Calculate energy deposition (FLUKA) and heating for defined cases, including accident cases.
8. Calculate jaw temperature and cooling. Check response to accident cases (ANSYS). Define design reference case.
9. Check impedance and trapped modes (RF simulations).
10. Iterate if necessary.
11. Freeze design.

Collimation Work Organization

- Collimation project management & project meeting
- **Collimation upgrades in DS's and IR's: Studies and specifications**
- **DS upgrade technical feasibility**
- Phase 1 studies and improvements
  - includes BE studies crystal coll, coll with BPM's, hollow e-beam lens
- Collimator design and production

Upgrade Dispersion Suppressors

- Assumed solutions: 11T or IR3-type (magnet movements)
- Scope: IR1, IR2, IR3, IR5, IR7 for proton and ion losses
- DS upgrade specification:
  - Forum: Upgrade specification meeting
  - Mandate: Specify jaw material & length, collimator gaps & precision, collimator locations and power loads, performance improvement
  - Scope: loss simulations, tracking with protons and ions, energy deposition, radiation impact, optics studies, operational studies
  - Runs until specification is provided
- DS upgrade technical feasibility:
  - Forum: Technical integration meeting (V. Parma & J.P. Tock)
  - Mandate: Feasibility of installing cold collimators, housed in cryo-assemblies, in the continuous cryostat during LHC LS2
- Collimator design for dispersion suppressors (warm/cold) → Coll Design Meeting

Conclusion

- The LHC collimation system is very powerful but cannot protect the LHC dispersion-suppressors (long predicted, due to basic physical limits).
- On the long term (for much beyond nominal performance, e.g. for HL-LHC) we will need to protect the dispersion suppressors against losses from collimation insertions and collisions.
- 11T magnets provide an elegant solution to the problem (preferred). Backup solution is the movement of magnets and use of missing dipole space (much less elegant).
- A lot of work is ahead to work out a detailed a solution and to prove that the 11T solution with collimator delivers the required performance:
  - Collimation efficiency and power loads for future requirements (nominal is not enough).
  - Behavior of cold surfaces under power load, cooling, ...
  - Technical feasibility of integration of a long collimator into an 11T assembly.
- Developments must be advanced in parallel to explore all possible issues early. Plan for success.
- We have all the tools and experience to advance this efficiently.

Thank you

... Now more details from Adriana...

DS Upgrade Technical Feasibility

LHC Collimation Project CERN

- **What ?** Feasibility of installing really cold collimators, housed in cryo-assemblies, in the continuous cryostat during LHC LS2, as required by collimation (pt.1, 2, 3, 5 and 7)?
- **Goals**
  - Analyze potential schemes of cold collimators coupled to 11 T magnets;
  - Identify potential show stoppers, either related to the implementation of the layout schemes or related to operational aspects of the associated technical systems (vacuum, cryogenics, machine protection, alignment, etc).
  - Identify potential needs for R&D with its associated effort and timeline.
- **How?** Set-up a Working Group coordinated by MSC-CMI (V.Parma, J.Ph.Tock as alternate), meeting every 2-3 weeks with the following proposed participants by system:
  - Collimators:, EN-MME
  - Vacuum : V Baglin, TE-VSC
  - Cryogenics : R.Van Weelderen, TE-CRG
  - 11 T magnets: M Karppinen TE-MSC
  - Machine Layout & Integration: V.Parma (J.Ph.Tock),TE-MSC
  - HL LHC coordinator : L Rossi (TE-HDO)
  - Collimation project leader or representative
- **Reporting?** to the Collimation Management Meeting. Technical feedback and requests to the specification meeting.