

# UPGRADE SCENARIO ONE: WORK EFFORT

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- Heat load and radiation damage
- 11 T collimators
- SC link for matching sections in IR1 and IR5
- Beam-beam Long Range compensator wire (LRBB)



# SCENARIO: HOW TO REACH THE TARGET

- PIC
  - Wide aperture magnets from Q1 to D1 to allow lower  $\beta * \rightarrow$  new TAS
  - New cryoplant able to withstand heat load of full upgrade
- US1
  - No change in TAS-D2–Q4, whose aperture will limit β\*, so integrated luminosity is increased through beam intensity
  - 11 T collimators
  - Long Range Beam-Beam compensating wires (LRBB)
    - To allow compensate beam-beam effect, and reduce the crossing angle
      - R&D needed to prove the efficiency of this hardware
- US2
  - New matching sections removing the aperture bottleneck → β\* is an additional source of performance

	β*	Peak lumi	Int. lumi	
	(m)	$(cm^{-2} s^{-1})$	$(fb^{-1})$	
PIC	20/40	3.0E+34	1000	
US1	20/40	5.0E+34	2000	
US2	15/15 or 7.5/30	5.0E+34	3000	



# MAIN FEATURES OF USI SCENARIO

Scenario	β*	Bunch pop.	Emittance	Peak lumi	Int. lumi
	(cm)	(adim)	(mm mrad)	$cm^{-2} s^{-1}$	$fb^{-1}$
PIC	20/40	1.4E+11	2.2E+00	3.0E+34	1000
US1	20/40	1.9E+11	2.6E+00	5.0E+34	2000
US2	15/15 or 7.5/30	2.2E+11	2.5E+00	5.0E+34	3000

- Beta\*  $\rightarrow$  optics
- Peak luminosity  $\rightarrow$  heat load
- Integrated luminosity → radiation damage
- US1 features
  - Same optics of PIC
  - Improvement w.r.t. PIC is given by more protons
  - Same peak lumi of US2, similar heat loads from lumi debris
    - But smaller heat loads due to beam w.r.t. US2



- Q: is it possible to intercept the shower of particles by shielding with reasonable thickness (i.e. mm)
- A: YES [see works by the Fluka team, F. Cerutti et al.]
- Q: Is the magnetic field playing a relevant role?
- A: YES
  - The screen needs to be inside the magnet and needs aperture



Energy deposition in the triplet with and without magnetic field [F. Cerutti, E. Wildner, et al.]



- The Q1 D1 part is designed to have 25 MGy after 3000 fb<sup>-1</sup>
  - This is done thanks to wide aperture and shielding [see P. Fessia talk]
  - So we will be below 20 MGy



Peak dose (for 3000 fb<sup>-1</sup>) and peak power (for peak lumi 5 × 10<sup>34</sup> cm<sup>-2</sup> s<sup>-1</sup>) [L. Esposito, F. Cerutti, IPAC 2013]

[R. Kersevan] Upgrade scenario one - 6

Beam screeen sketch

**Tungsten inserts** 



- For the rest of the matching section we scale the results of 0 the baseline
  - Baseline peak dose is 2 MGy (average), 4 MGy (local) for 500 fb<sup>-1</sup> ٠
  - So one will reach 16 MGy for 2000 fb<sup>-1</sup>



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### HEAT LOADS

- (i) Total cryogenic power
  - Assume as in PIC to withstand 5 × 10<sup>34</sup> cm<sup>-2</sup> s<sup>-1</sup> peak lumi (target of full upgrade) about 700 W on the triplet, 600 W on the beam screen
  - US1 has same peak lumi, so same situation
- (ii) Local increase in temperature due to the thermal impedances of the components and the distance to the heat sink: two issues
  - Δt in the coil, to avoid reducing too much the margin of the superconductor (below 0.2 K)
    - With peak 5 × 10<sup>34</sup> cm<sup>-2</sup> s<sup>-1</sup> the peak heat load on the coil is 2 mW/cm<sup>3</sup> as in the LHC baseline (see next slide), so this is not an issue
  - Δt in the beam screen, to avoid degassing (below 10 K) this is a delicate issue
    - Design work of the beam screen is ongoing



# HEAT LOADS

- (ii) Local increase in temperature (cont'd)
  - Q1-D1 is designed for US2, so we have margin (2 mW/cm<sup>3</sup> expected, limit at 4 mW/cm<sup>3</sup>)
  - In the matching section rescaling the baseline results gives about 1.5 mW/cm<sup>3</sup> (baseline multiplied by 5) → ok





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# COLLIMATORS

- The plan for collimation in the next years is strongly dependent on the first results of operation at 7 TeV
  [S. Redaelli]
  - So it is difficult to make a guess, but we must have a baseline
- With these caveat, for US1 we foresee installation of additional collimators in IR7 IR1 IR5
  - 11 T technology used to make space
  - 10 units needed: 20 magnets (5.5 m long) plus 10 collimators
  - Same hardware used in IP2 for the PIC cost ~65 MChf



11 T dipole [M. Karppinen, S. Zlobin et al.]



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### COLLIMATORS

### • Position in IR7



IR7 layout [R. Bruce, S. Readelli, collimation team]



# CRYOGENICS REMINDER

- Two critical areas:
  - Point 4, need of separating RF from magnets
  - Point 1 and 5, need of separating triplet from arcs
  - As usual in these systems, margin matters
    - Both included in PIC [see P. Fessia talk], so ok for US1



Temperature along the arc for the three scenario [L. Tavian]



# SUPERCONDUCTING LINK

Aim: move power converters of matching sections from • tunnel to surface

#### Superconducting Links at P1 and P5 **Matching Sections and Arc**

- Two Superconducting Links per point from surface to underground areas – for powering of MSs
- Two Superconducting Links per point from surface to underground areas – for powering of arcs
- > Need for civil engineering to be verified
- R&D Combined with development of system for Triplets  $\rightarrow$  Test of full system (DFB and SC Link) in 2015
- Installation in LHC during LS3 (2022) or LS2 (2018)
- Procurement of series to be started by end 2015 for integration during LS2
- Synergy with triplet sc link A. Ballarino, October 2012
- Technology: possibly MgB<sub>2</sub>
- Cost: ~20 MChf



Cross-section of link for triplets [A. Ballarino]



### BEAM BEAM LONG RANGE WIRE COMPENSATOR

- Idea: use a current to cancel the longe range beam-beam effect and close crossing angle
- Initial proposal based on CERN-SL-2001-048-BI [J. P. Koutchouk]



- Experimented on RHIC and SPS, but not yet in a collider
  - In RHIC: you can spoil a beam with this
  - In SPS: a wire can compensate another wire
- A proof of principle in the LHC is needed



### BEAM BEAM LONG RANGE WIRE COMPENSATOR

- Proof of principle
  - Timing: between LS1 and LS2, 1-2 years of operation needed
  - Postion: between D1 and D2
    - Proposal to insert it in collimators, but difficult to integrate without breaking collimator hierarcy





### BEAM BEAM LONG RANGE WIRE COMPENSATOR

- Based on the results of the proof of principle in ~2016 run, baseline for HL-LHC can be defined
- What we know already
  - 4 BBLR needed
  - Location: as close as possible to D1
  - There are some delicate technical points
    - Radiation resistance, hot place full of neutrons
    - Compatibility with flat beams to be proved
    - Integration as usual, evil is in details
- Plan and cost
  - Time scale for conceptual design, engineering and construction: ~4 years (fits with HL-LHC schedule)
  - Cost order of magnitude ~10 MChf



- We presented the upgrade scenario one work effort
  - Same peak lumi as US2 (heat loads), and 2/3 of data (radiation damage) many unknowns to be seen with 7 TeV operation
  - New triplet/D1 as defined for PIC allows to swallow larger heat loads, and radiation damage
  - Matching section becomes a bottelneck for β\* (not lower than 30 cm), but can swallow heat load and radiation damage
  - Scenario relies on ability to increase beam intensity
- Work effort
  - Collimators in IR7, IR1, IR5
  - Superconductive link for matching sections in IR1 and IR5
  - Beam-beam long range wire compensator needed
    - New piece of hardware, not yet proved for LHC
    - Proof of principle for the LHC in ~2017