Optics in TI2/8 and virtual beta*

J. Wenninger

Acknowledgments to S. Redaelli and G. Muller as co-founders and developers for ‘β* system’ in LHC, J. Wozniak for SIS technical support.

SIS β* for LHC ring

- For each IR we select 2 PCs (1 of R1, 1 of R2) such that the ratio I_1/I_2 is a monotonous function of β*.
  - Reference data is a table of current ratios versus β*.
  - This table applies only for one squeeze type. The current tables do not work for ATS pre-squeeze, and even less so for the real ATS squeeze (→ would have to include at least 2 PCs more).
- SIS monitors the PCs, reconstructs β*, sends the β* values (one per IP) to the SMP system which feeds it into the LHC MTG.
  - This is not a ***real*** measurement of β* at the IP !
- Beta* values are received by collimator FECs through the timing card and are used in combination with a β* gap limit for interlocking (TCTs only).

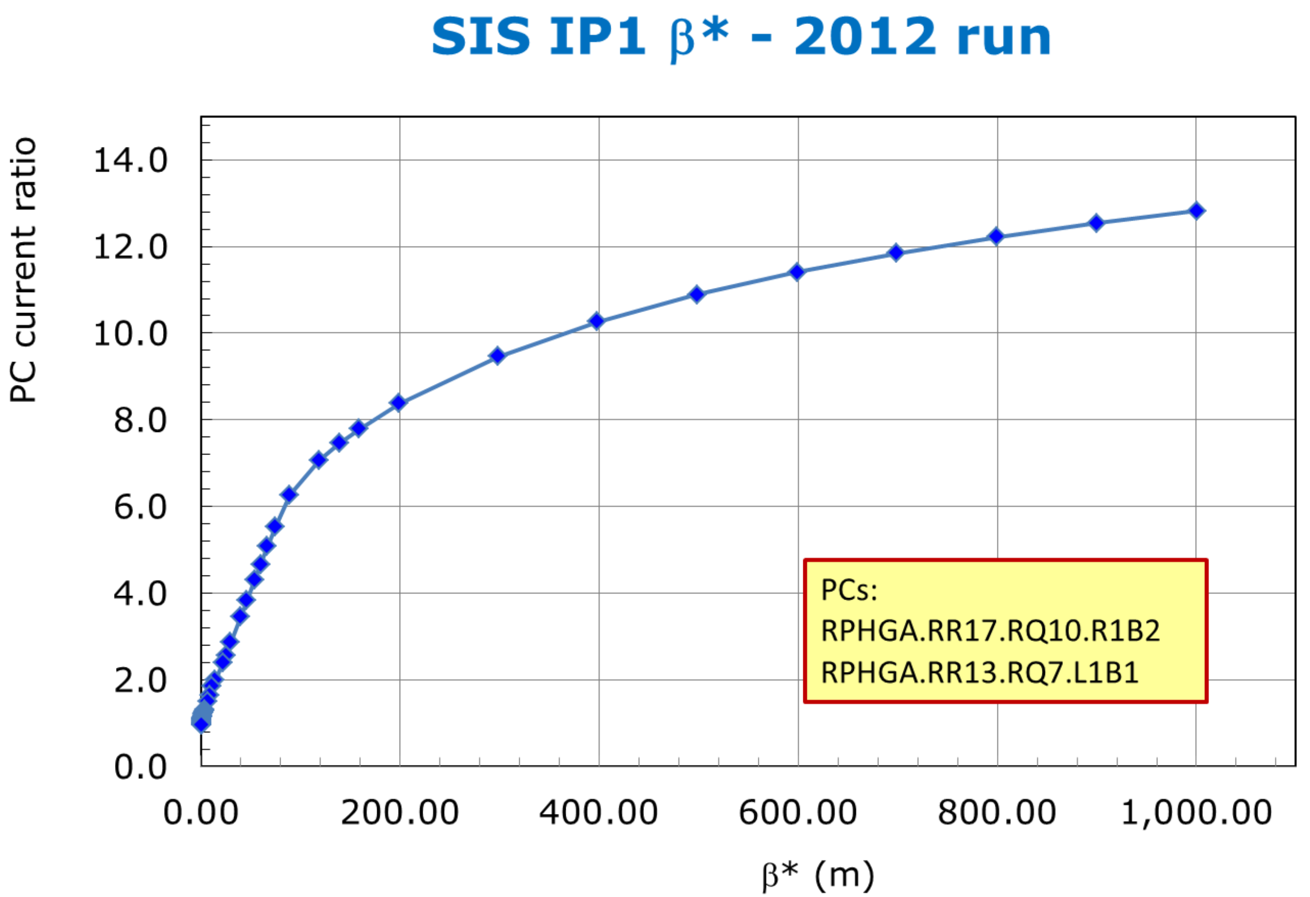
PC selection – run I

- The following PC pairs were used for run I.
  - Selected a long time ago by Stefano Redaelli.
  - Q10 – Q7 for IR1+5.
  - Q5 – Q7 for IR2+IR8.
  - A small JAVA program by Gabriel Muller is used to compute the current ratio versus β^* from selected LSA BP settings.

IP	PC no 1	PC no 2
1	RPHGA.RR17.RQ10.R1B2	RPHGA.RR13.RQ7.L1B1
2	RPHH.UA23.RQ5.L2B1	RPHGA.UA27.RQ7.R2B2
5	RPHGA.RR57.RQ10.R5B2	RPHGA.RR53.RQ7.L5B1
8	RPHGB.UA83.RQ5.L8B1	RPHGA.UA87.RQ7.R8B2

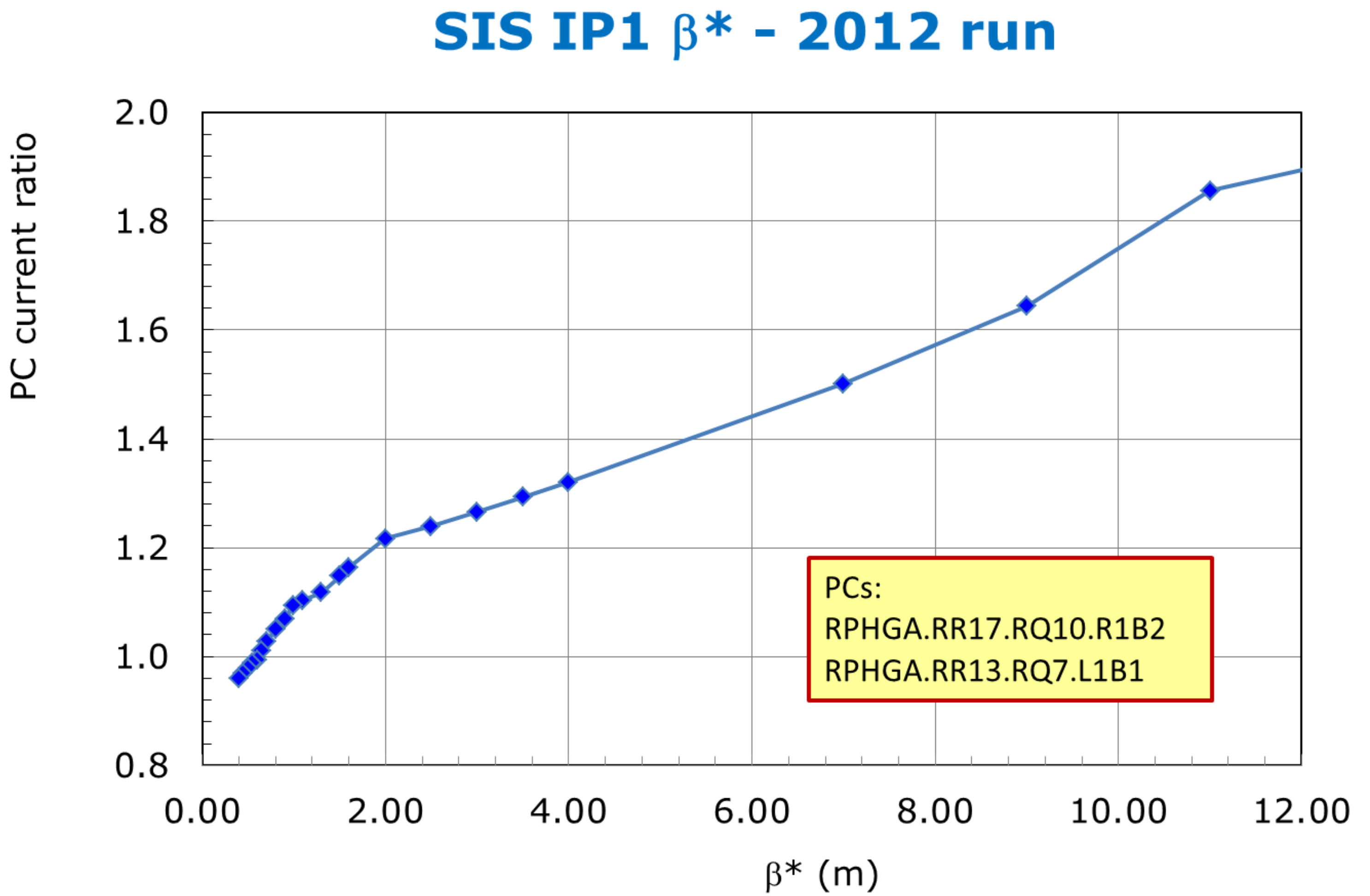
Example : IP1 – 2012 run

- Full range of table 0.4 m → 1000 m.
  - Non-linearities in the magnet transfer functions are neglected – sufficient for our purpose.



Example : IP1 – 2012 run

- Zoom into range 0.4 m to 11 m.



Limitations and post LS1 changes

- The tables PC-ratio-β^* are stored inside the SIS project.
  - Very safe (only experts can change).
  - Does not work for ATS – neither pre-squeeze not squeeze.
- After LS1 the idea is to move the tables to LSA settings (MCS) – one set for each hypercycle.
  - Possible to store different settings for ATS pre-squeeze.
- To be able to cover the pure ATS squeeze, a second table must be added for IR1 and IR5.
  - PCs in IR4+IR6 for IR5 squeeze, in IR2 and IR8 for IR1 squeeze.
  - Adapt the IR2 and IR8 pairs not to be perturbed by ATS squeeze.

Transfer lines

- Since the injection collimators have similar FEC software (β^* limits can be activated), the idea is to extend the ring concept to them.
- There is no β^* in the TL's, but one could define an artificial 'virtual' β^* for a TL optics and re-use the SIS-SMP-MTG chain.
  - Proposal would be to use the LSA optics ID (unique) as β^*.
  - This would at the same time provide a logging of the TL optics in Timber !
  - We need 2 additional timing event – telegram pairs in the LHC.

TL optics and virtual β* concept

- For each TL optics, store ALL (rather than just 2) quad currents as critical settings in LSA settings. To each optics associate a unique virtual β*.
  - Must be stored on the BP that contains the TCDI settings.
  - In same BP store also the virtual β* limits for TCDI.
  - Alternative is to pick 2 quads like in ring – to be evaluated.
- SIS reads the reference settings and compares them to the published extraction currents (every cycle).
  - If in tolerance publish virtual β* value associated to optics.
  - If not in tolerance publish 0 → interlock.
- On TCDI side read β* from MTG and check if in limit.
  - Fully data driven system.

Remarks

- TCDI settings, virtual β* limits and TL optics (quad) references are stored together in a single BP.
  - If the wrong BP is used, the SIS interlock will fail (unless the optics happens to match, but then it is OK).
- We re-use the existing concepts. New items:
  - reference settings for TL quads + virtual β*,
  - β* limits for TCDIs,
  - SIS code for the logic,
  - Timing event/telegram pair (I hope that there is room for another 2 telegrams…).

Some use cases

- Case 1: SPS operates with a single cycle configured for fast extraction.
  - For every cycle SIS checks the currents and publishes β*.
  - Please note that β* is published AFTER the cycle. In case of cycle change, the FIRST time a cycle is executed the β* comes from an older cycle.
    - Not easy to get around that unless everything is done closer to HW.
  - If the cycle has a TL optics that matches, β* comes out correctly.
  - If the TL optics does not match, β* is 0.

Some use cases

- Case 2: SPS operates with more than one cycle configured for fast extraction (fast extraction timing events are present), and one cycle has ‘wrong’ settings (for example a Hiradmat cycle).
  - After a good LHC cycle, β^* published ok.
  - After the ‘bad’ cycle, β^* published is 0.
  - Here β^* oscillates between 0 and the correct value. Extraction does not work, a bit unstable situation.
  - The publication of ‘0’ could be suppressed by a check of the SPS USER destination – publish only on cycles for LHC.
    - Prevents ‘0’ publication, but depend on extra info. To be decided.