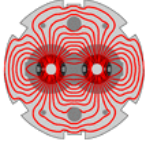


Summary of the session on "Beam Dynamics Issues in HE-LHC"

SR and cryo, e-cloud, impedances, SR damping, IBS, beam-beam, etc

Vladimir Shiltsev, Elias Metral

HE-LHC'10 Workshop

October 14-16 2010, Malta

The goal:

- ***"…This mini-workshop will take a first look at a higher-energy LHC (HE-LHC) with about 16.5 TeV beam energy and 20-T dipole magnets…"***
  - We have put effort to understand potential issues with BD and SR in HE-LHC and to evaluate them
  - Identified some topics for further, more technical study

Feasibility Types

Two Main Themes

- Heat load & cryogenics
  Dimitri DELIKARIS, CERN
- Requirements from the vacuum system
  Jose Miguel JIMENEZ, CERN
- Beam screen issues
  Elias METRAL, CERN
- IBS and cooling at RHIC& HE-LHC active emittance control Wolfram FISCHER, BNL
- Modeling IBS and cooling
  Oliver BOINE-FRANKENHEIM, GSI
- SR damping, IBS, and beam-beam simulations
  Alexander VALISHEV, FNAL
- SR + beam-beam simulations
  Kazuhito OHMI, KEK

Cryo, vacuum and Beam Screen

- **The HE-LHC will be the 1st hardron machine totally dominated by synchrotron radiation**
- x17 SR power compared to LHC: 0.33-5.7W/m
- Optimal temperature of Beam Screen seems to be 40-60 K (vs 4.5-20 K now)
  - Total (SR+image heating+rest) 10W/m
- Optimal temperature of cold mass is 2K (saves ~2T and adds stability to magnetic field)
- Equavalent total cryo capacity is about what LHC has now

Cryo, vacuum and Beam Screen

- **40-60K beam screen becomes more resistive x5.5 plus higher magnetoresistance in 20T will add additional factor ~2**
- Anomalous skin effect negligible
- RW Impedances will be up sqrt (rho)
- … But energy is up x2.4
- Overall conclusion: OK (=should not be a major issue) but further considerations required
- BTW: HTS coating wont work (flux frozen), Al screen as not that advantageous(e-cloud)

Cryo, vacuum and Beam Screen

- **Flux and energy of SR photons will be significantly higher (wrt LHC) that will lead to about 74 (!)-fold increase in the beam-induced pressure rise**
- No silver bullet to solve that problem yet
- Strategy (how to keep things under control):
  - Increase pumping speed with larger slots area
    - ~4% now → 6-7%? (stability)
  - Use TiN or a-C (or smth else?) coating in cold sectors to control e-cloud
  - NEG coating in warms (bakeable to activate)
  - Heavy dependence on vacuum cleaning by SR and e- bombardment and beam scrubbing (by losses) – will take time, start with low N_p/bunch
- Conclusion: at this moment, vacuum does not look as a complete showstopper, but that ‘s something to be concerned of - will need to be reevaluated on base of the LHC experience

“Would be Nice to Have Plan B”

SR damping, IBS and Beam-Beam

- SR damping/fluctuations and effects on beam dynamics are well understood
- IBS theory, and proven models and simulation codes are available
- Initial HE-LHC luminosity evolution simulation are confirmed by others (eg ~0.8 fb-1/day)
- Beam-beam effects are uncertain and predictive power of modeling tools is limited

Word of caution

- Ultimately, the LHC operation will show what kind of bean dynamics phenomena set the most stringent limits on performance – e.g. is that:
  - Instabilities
  - Head-on or/and long range beam-beam effects:
    - Losses not tolerable
    - Emittance blowups
    - Beam luminosity/lifetime
  - Collimation system (in)efficiency
  - External noises, drifts
  - Smth else or combinations
- At the current stage – 1% of the design luminosity – it's too early to draw conclusions and make strong recommendations

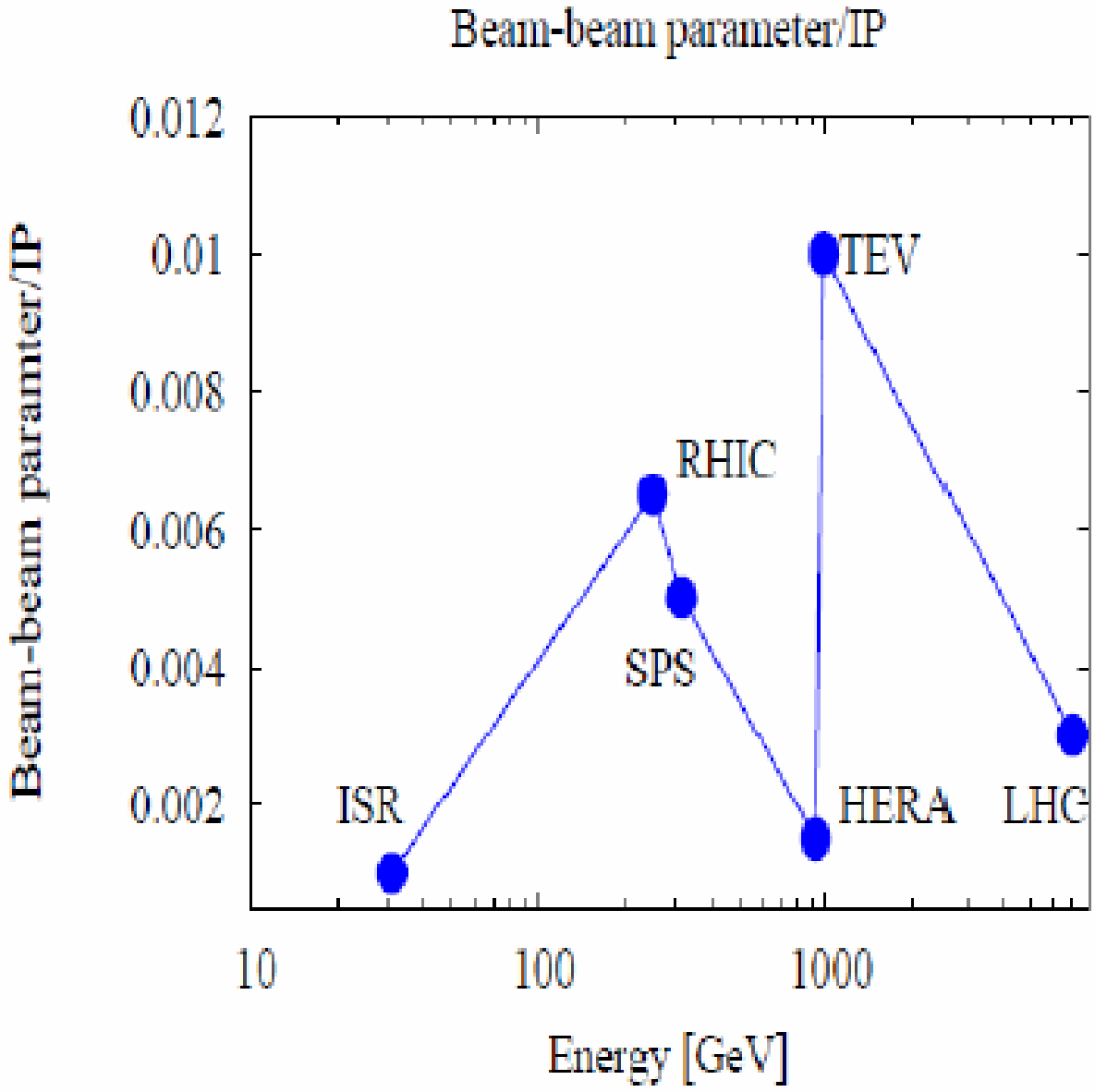
Euphoria Mood: “Sky is the limit”

Spectrum of Opinions on Beam-Beam

- On one hand, in HE-LHC:
  - Luminosity burn up and SR damping will dominate luminosity evolution (integral/day)
  - IBS does not matter ~1%
  - Beam-beam does not matter ~10%

- On the other hand →

So Far Beam-Beam Effects Of Great Importance

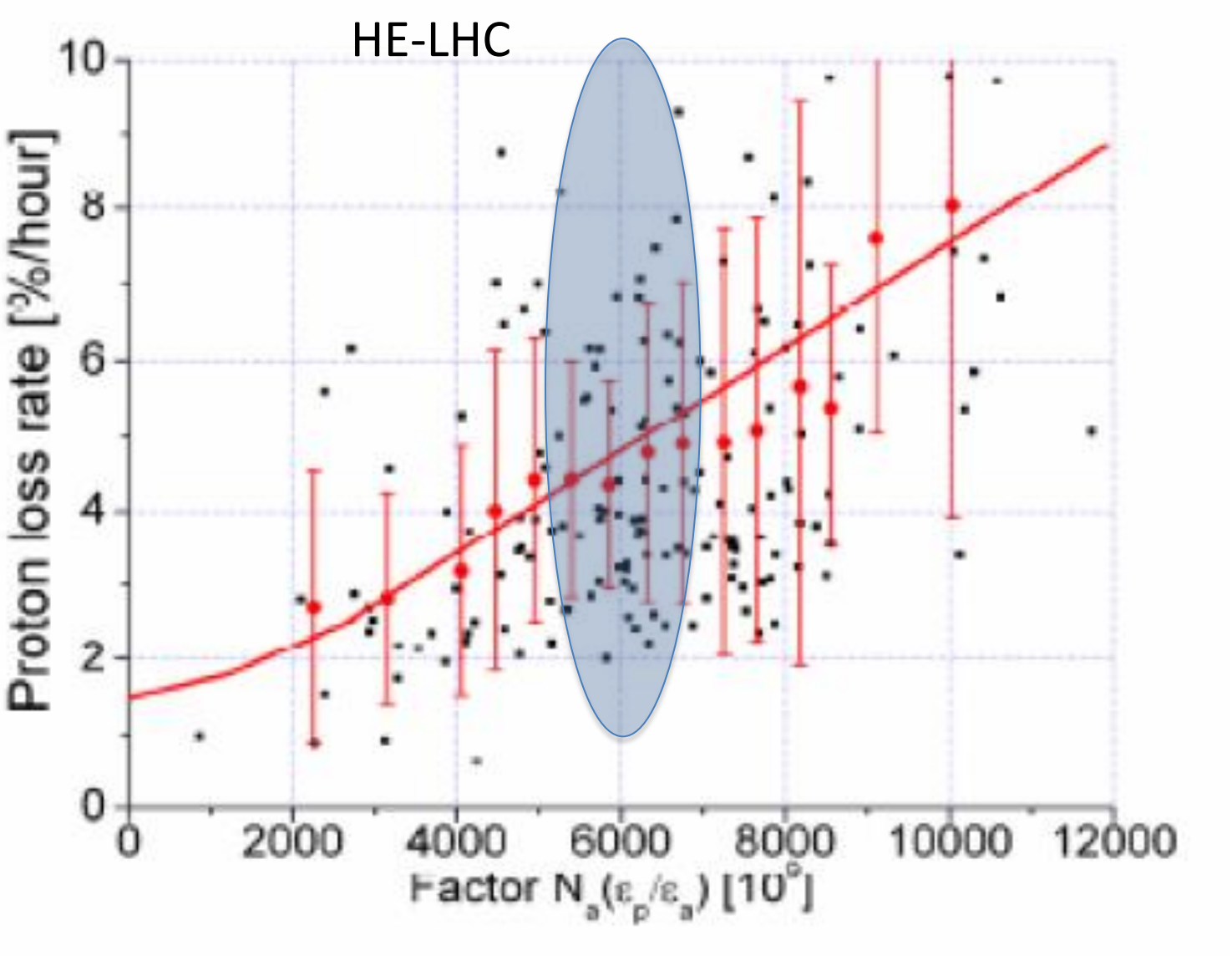


HE-LHC

Importance of Beam-Beam effects

	HeadOn	LongRange
Tevatron	**yes**	**yes**
RHIC	**yes**	n/a
LHC	**?**	**?**

Head-On (weakest) Beam-Beam in Tevatron

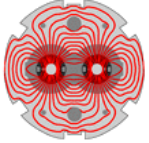


Questions Addressed/Raised

- Does damping/cooling help to increase beam-beam limit:
  - Seemingly “yes” as ksi higher in e+e- machines
  - By how much 1-2 hrs SR damping in HE-LHC helps to increase ksi (can one count on >0.01/IP)?
  - Can even faster cooling help further? Optical Stochastic Cooling gives extra 1 hr , coherent e-cooling 1 min decrements
- Is beam heating needed to stay at the BB-limit or beam-beam can stabilize itself (eg in Tevatron b-b emittance blowup is much faster than 1 hr)

Questions Addressed/Raised

- How effective might be various compensation schemes:
  - Wires
  - Electron lenses
  - Crab waist scheme with flat beams
- How serious are concerns of coherent beam-beam instabilities?
  - Particularly, multi-bunch beam-beam phenomena
- All that is subject of further work/studies



Finally, three things which I see and like so much:

Right Attitude

Beautiful Place

Great People