General tutorial Budapest - problem and outline

1 Concept and Objective

Contrary to traditional tutorials, this approach should lead to a more practical and research oriented learning process which cannot be acquired during lectures alone. This concept should function as a mixture of discussions between students and lecturers, team work, brainstorming, input from lectures and other material the participants can find, e.g. in the available literature. It is closer to the everyday working practices and it pursues an approach increasingly being adopted by universities.

As in real life, the big picture should be formed from the pieces of a puzzle and the ideas of the participants, i.e. the relevant questions should come from the participants themselves. Developing some creativity and to retain and/or discard ideas should be part of this learning process.

2 Exercise

An experiment on particle physics requires particle interactions using a particle accelerator with the following requirements and constraints:

E_{cms} **= 50 TeV**

Desired luminosity $L \approx 10^{35}\ cm^{-2}s^{-1}$

Maximum magnetic field for any type of magnet 10 T

Maximum length of the machine must not exceed 100 km

Total beam energy should not exceed 1 GJ

Relative momentum spread should be smaller than $\frac{\Delta p}{p} \leq 1.0 \cdot 10^{-4}$

To avoid a significant loss of luminosity and time resolution, the r.m.s. bunch length should not exceed 0.1 m

The exercise: Develop a (technically realistic) concept for the necessary accelerator complex

- **Prepare a conceptual proposal and a realistic parameter set for the high energy machine**
  - **Devise the parameters fulfilling the requirements and constraints**

    Needed: circumference, bending field and radius, number of bunches, particles per bunch, beam size at interaction point (suggest emittance and β^***), RF frequency and harmonic number, do you expect to cross transition energy ?**
  - **Discuss beam dynamics issues:**

    optics considerations,

    collective effects (space charge, beam-beam),

    synchrotron radiation (hint: How large is the synchrotron radiation power and the power loss per meter in the bending magnets ? Is that acceptable ?)

    Estimate the maximum longitudinal emittance
- **Propose the necessary injector chain (multi-stage system)**
  - **The concept and design will be driven by the parameters of the high energy machine**

- **The number of stages should be kept as small as possible to avoid degradation of the beams during the transfer. Hint: the ratio between injection and extraction energies should not exceed 20, but may be significantly lower**
- **Type of accelerator and parameters (size, injection, extraction energies, field, RF and harmonic numbers), discuss superconducting versus normal conducting technology for the magnets.**