Case study - conceptual design of a hadron collider

Design a hadron-hadron collider as a top-factory

**Fundamental requirement:**

Produce $1.0 \cdot 10^6$ events with top-quarks per year

- Make a green field design
- Be creative! (but be prepared to defend your design and sell it to your colleagues)
- If you are uncertain or need additional information: ask

Main tutors and contact persons F. Tecker and W. Herr
Beam quality:

Pile up should not be more than 2 per bunch crossing

If you choose $pp$ or $p\bar{p}$ take a total cross section $\approx 100$ mb (weak energy dependence)

Assume top quark mass $175$ GeV/$c^2$, the top production cross section as a function of $\sqrt{s}$ (measurement and model) should be taken from the attached figure (for the energy of your choice).

Momentum spread $\Delta p / p \leq 0.3 \cdot 10^{-4}$. Bunch length not larger than 0.1 m

Technical constraints:

The length of the machine (whatever type) must not exceed 30 km

Optimistic 80% effective running time, i.e. for luminosity production

Total beam energy should not exceed 0.5 GJ and total beam current $\leq 1$ A

Dipole magnets (if any) are normal conducting (with maximum field of 1.8 T)

Think about a possible injector chain consistent with your design
Hints for this exercise:

- Prepare a conceptual design for the collider with a realistic parameter set, i.e.
  - Basic parameters: machine and particle type, beam energy, geometry (1 or 2 rings, what are the implications?)
  - Luminosity (assume constant during operation, levelled), intensity, number of bunches, required emittance
  - Optics considerations: propose realistic optics parameters and contemplate about a lattice
  - Collective effects: space charge, beam-beam (keep below maximum value)
  - RF frequency, estimate r.m.s. bunch length, transition energy, ramping time
  - Synchrotron radiation, i.e. energy loss etc.

- Propose the necessary injector chain (multi-stage system)
  - The concept and design will be driven by the parameters of the collider
- Type of accelerator and parameters (size, injection, extraction energies, field, RF and harmonic numbers), discuss superconducting versus normal conducting technology for the magnets.
top production cross section

proton-proton
proton-antiproton