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 you design and sell it to your colleagues)
- If you are uncertain or need additional information: ask
- Make sure you benefit from lectures, tutors <u>and lecturers</u> (and information you find elsewhere).

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 $\frac{\Delta p}{p} \leq 0.3 \cdot 10^{-4}$. 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

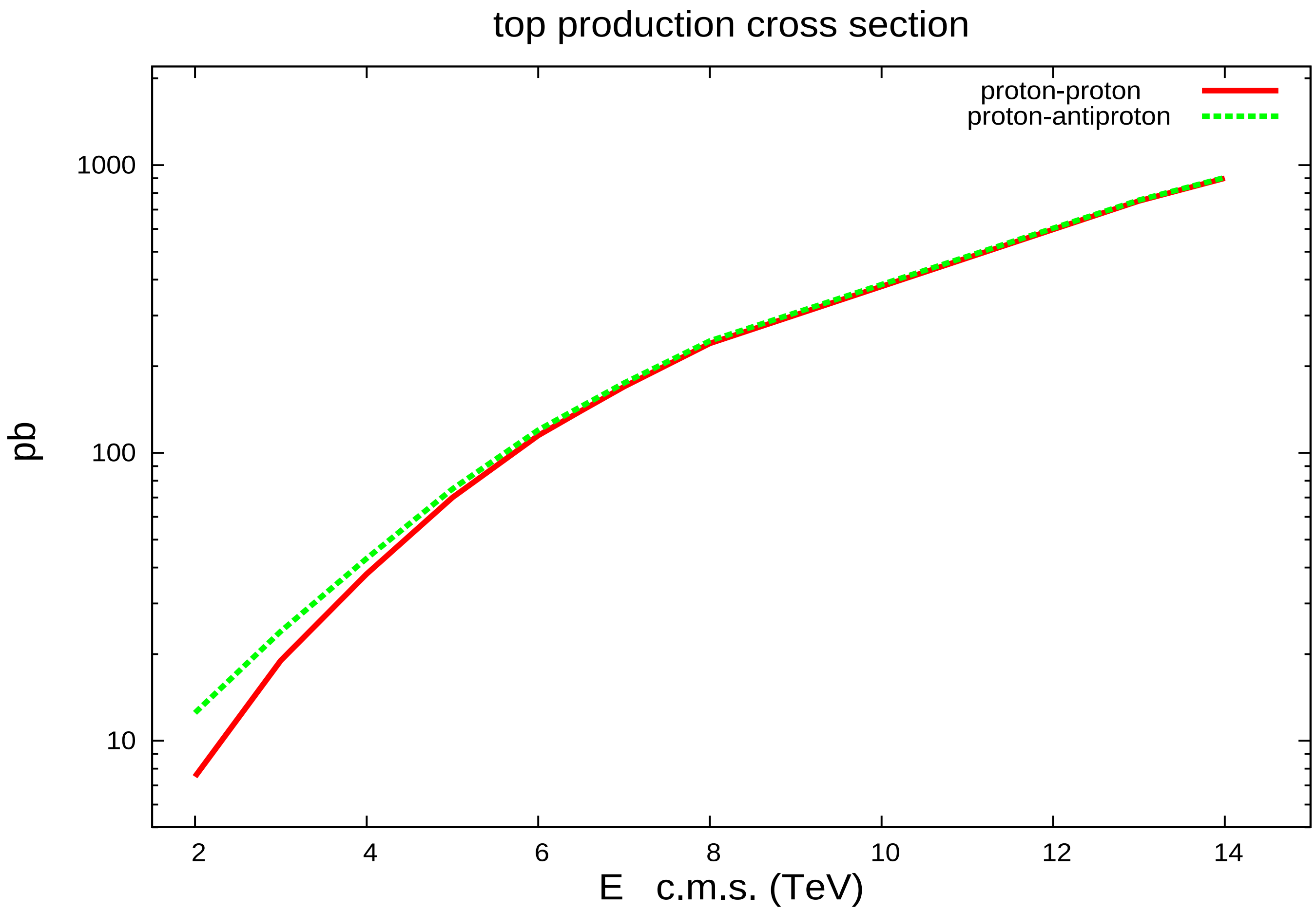
Dipole magnets (if any) are normal conducting (with maximum field of 1.8 T)

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
1000
100
10
pb
2
4
6
8
10
12
14
E c.m.s. (TeV)