Case study - conceptual design of a hadron collider

- **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 and lecturers (and information you find elsewhere).**

For a particle physics experiment design a machine with the specifications:

Fundamental requirement:

Produce 1.0·10^6 events with top-quarks per year (precision tests of standard model)

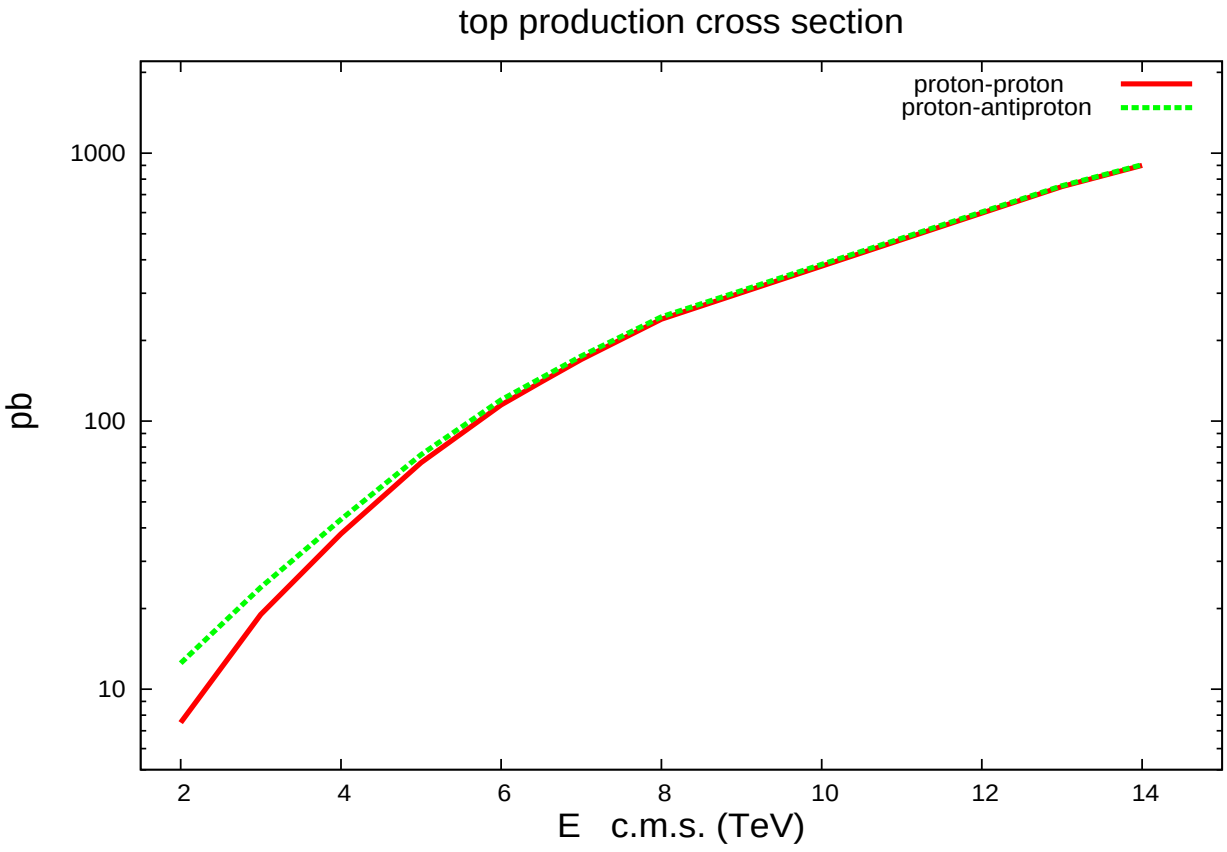
Beam quality:

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

Pile up should not be more than 2 per bunch crossing

Total cross section for pp **or** $p\bar{p}$ **(your choice) collisions ≈ 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 figure below (for the energy of your choice).**



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 smaller than 1 A

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

Think of 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), 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.**