How do we have to ramp the LHCb spectrometer magnet ?

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Present scenario

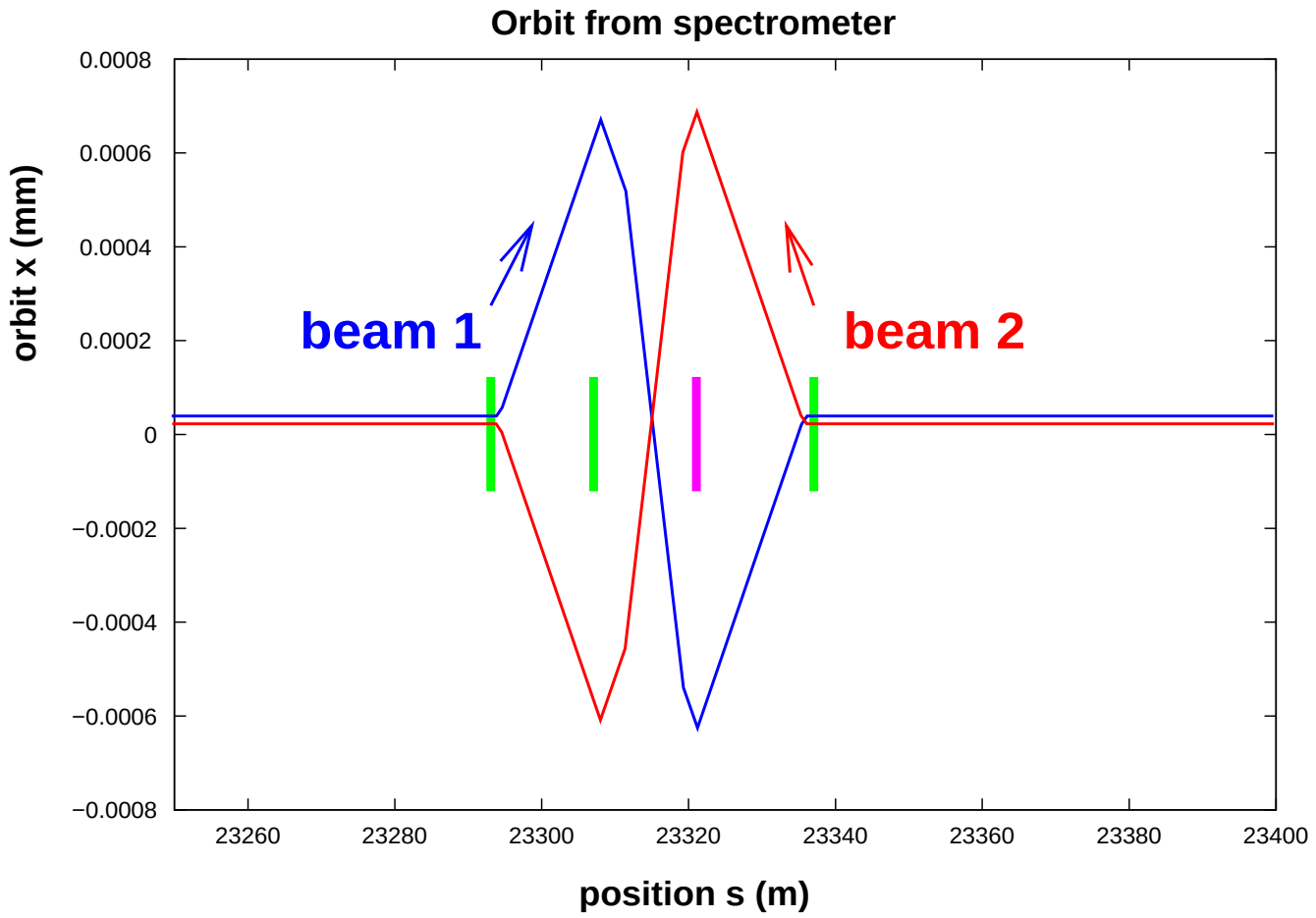
- Spectrometer at 100% field at 7 TeV
- Spectrometer at 450/7000 = 6.4% field at 450 GeV
  - Implies ramping the spectrometer $\propto$ E
- Q: can we go to more than 6.4% field at 450 GeV ??
- Q: can we go to full field for collisions at lower energy ?

Reminder: CHAMONIX 2006

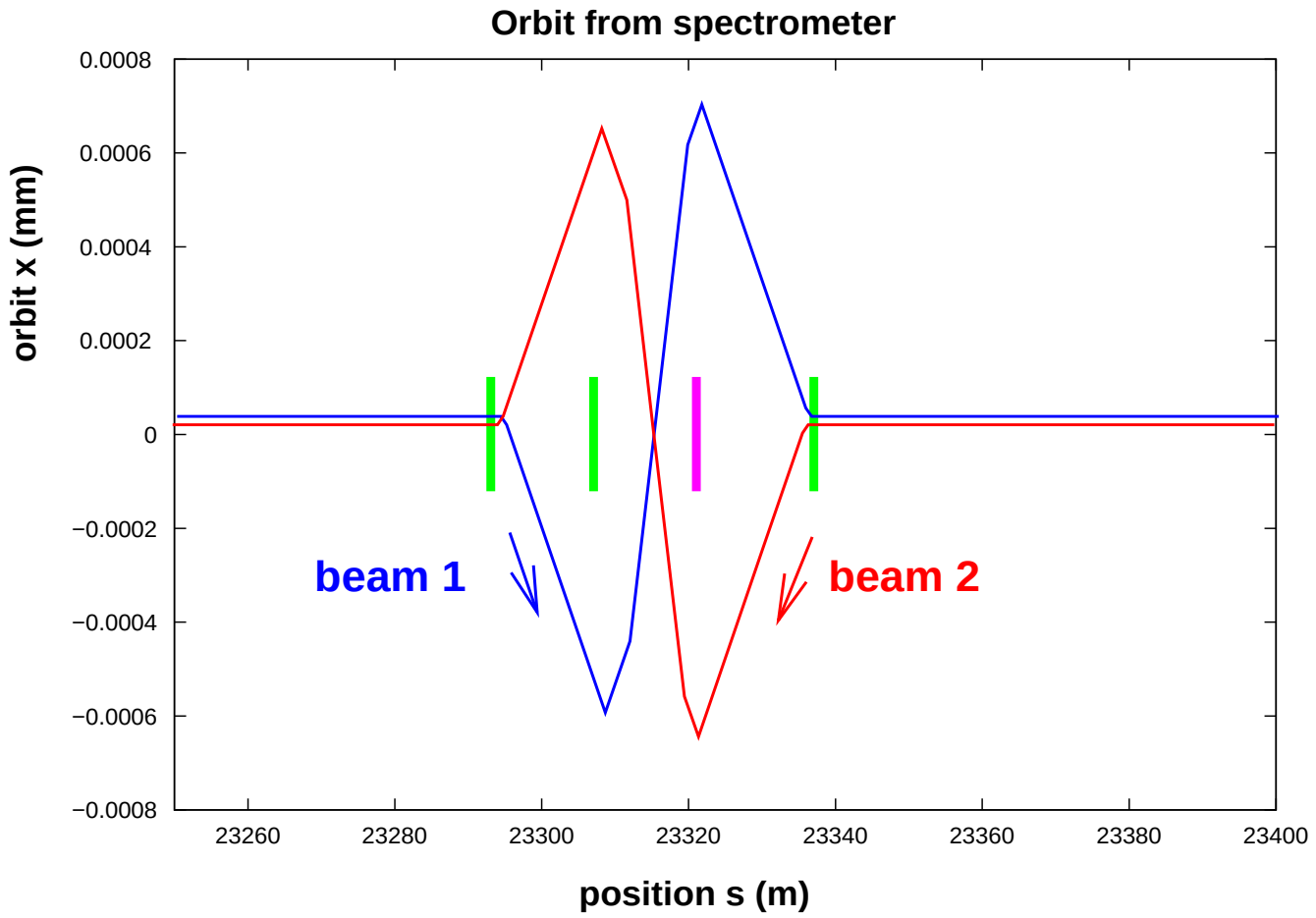
IP8 basic facts:

- Crossing angle in horizontal plane
  - Sign of effective crossing angle fixed (to avoid additional crossings)
  - Sign of external crossing angle fixed
- LHCb spectrometer compensated with 3 magnets
  - Creates (internal) crossing angle
  - Polarity change causes change of sign of (internal) crossing angle → must be overcompensated

Spectrometer(-compensator) bump (⊖) at IP8



Spectrometer(-compensator) bump ($\oplus$) at IP8



Spectrometer field with external angle

- **For $\oplus$: external angle must be larger than spectrometer angle**
- **At top energy: internal crossing angle is $\mp$ 135 μrad**
  - **For polarity ($\ominus$): $\mp$ 65 μrad $\mp$ 135 μrad ($\rightarrow$ $\mp$ 200 μrad)**
  - **For polarity ($\oplus$): $\mp$ 210 μrad $\pm$ 135 μrad ($\rightarrow$ $\mp$ 75 μrad)**
  - **For different polarities: different effective crossing angles (see LHCCWG specification)**
  - **We have a preferred polarity ($\ominus$) for the spectrometer**

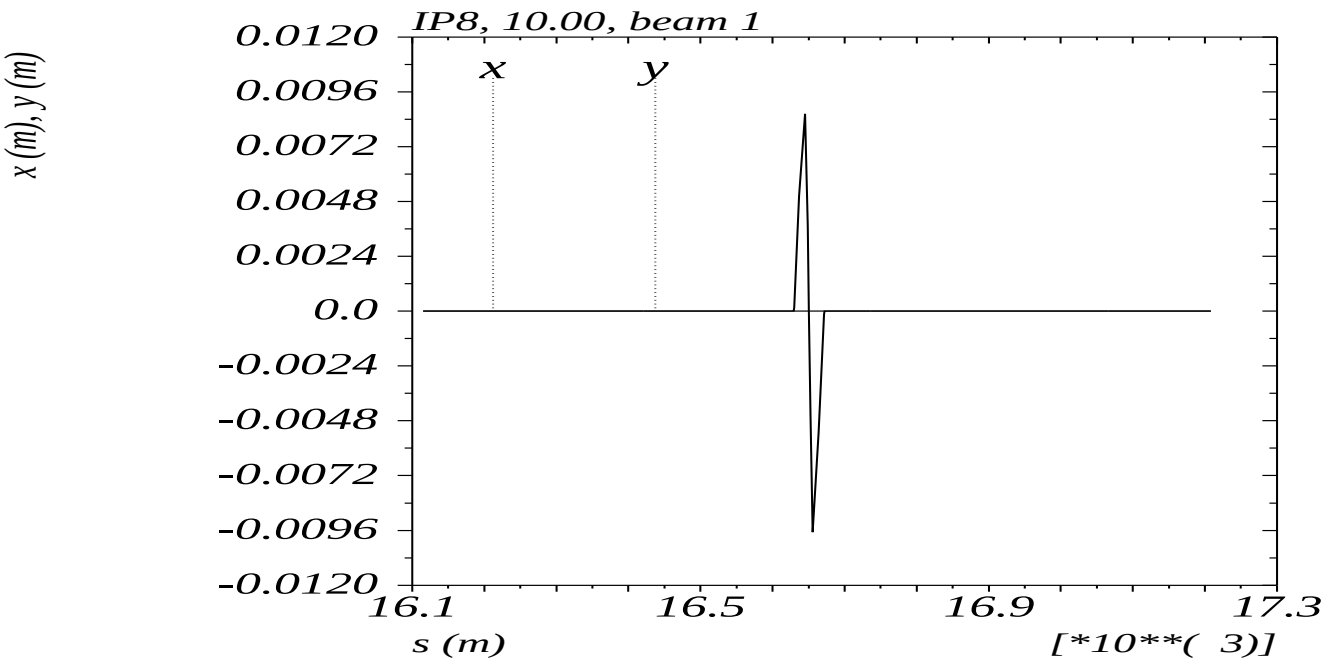
Full spectrometer field at injection

- **At top energy: crossing angle $\mp$ 135 μrad**
- **At injection with ramp: crossing angle $\mp$ 135 μrad**
- **At injection without ramp: crossing angle $\mp$ 2100 μrad**
  - → **For polarity ($\ominus$): maybe difficult**
  - → **For polarity ($\oplus$): is overcompensation possible to avoid additional crossings ?**

Different scenarios

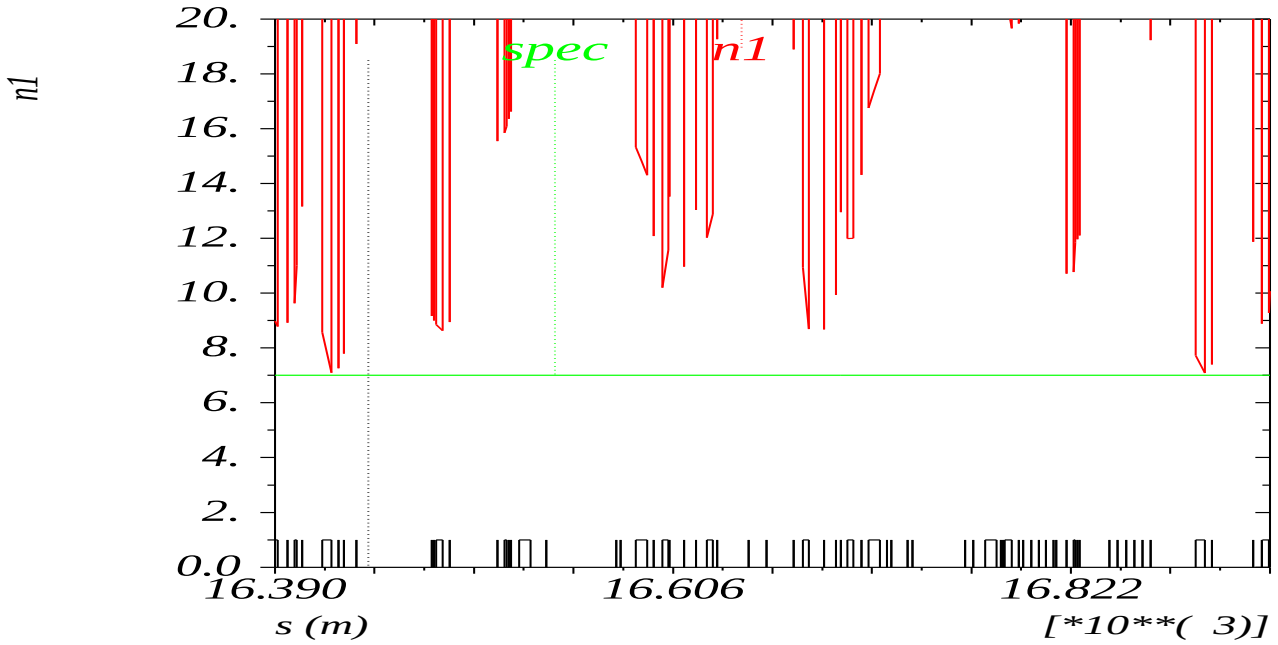
- **Number of bunches:**
  - → **For 43 and 156 bunches: no external angle needed**
  - → **For 75 ns, 50 ns, 25 ns: need the external angle superimposed**
- **Optics:**
  - → **No β^* smaller than 10 m**

Crossing scheme with spectrometer ($\ominus$)



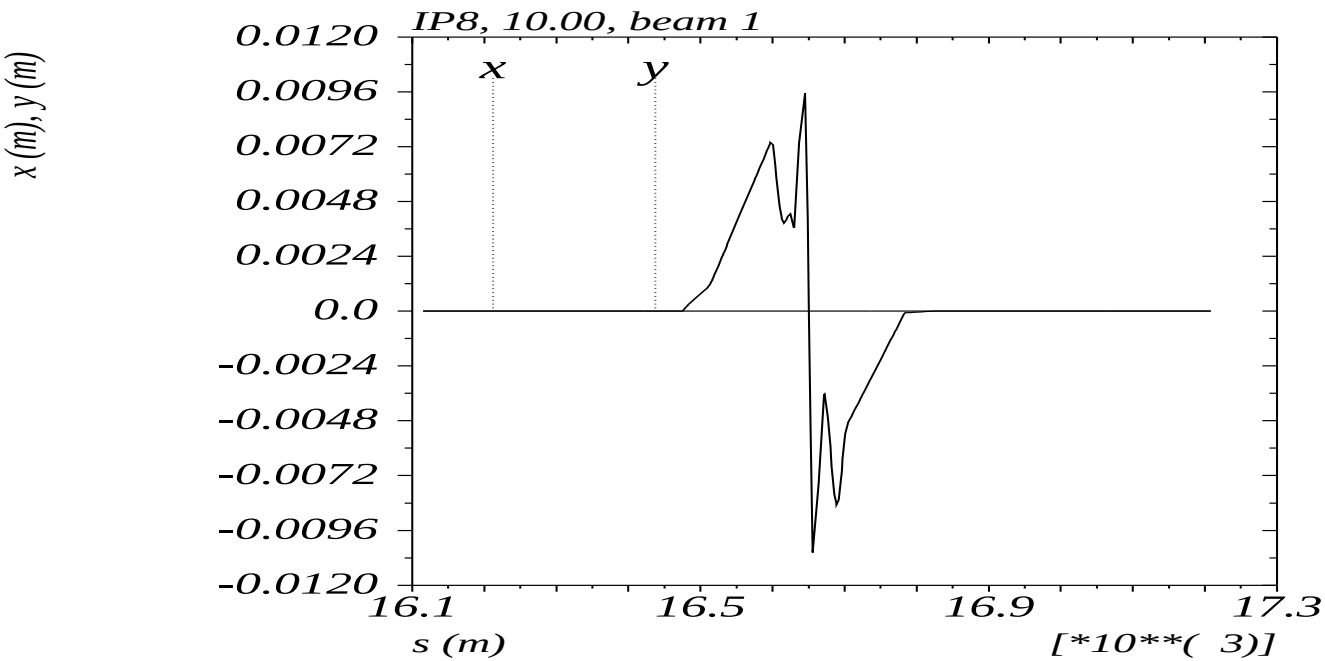
➞ **For 43 and 156 bunches: no external angle**

Crossing scheme with spectrometer ($\ominus$)



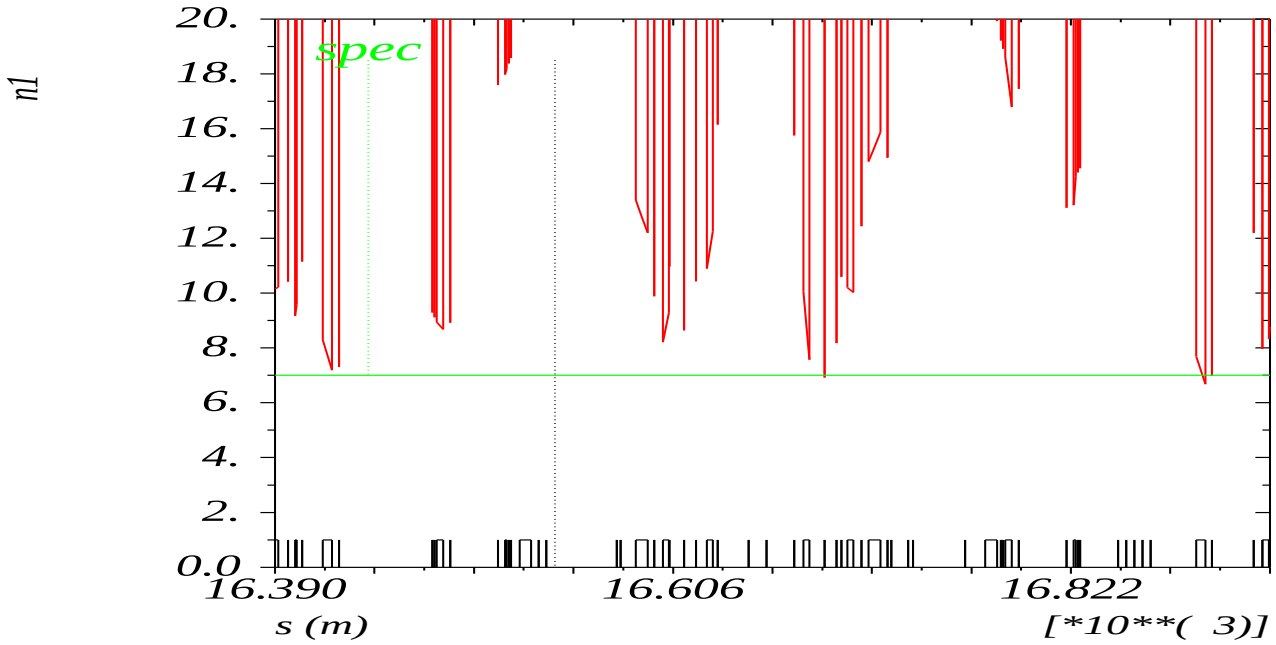
→ For 43 and 156 bunches: no external angle

Crossing scheme with spectrometer ($\ominus$)



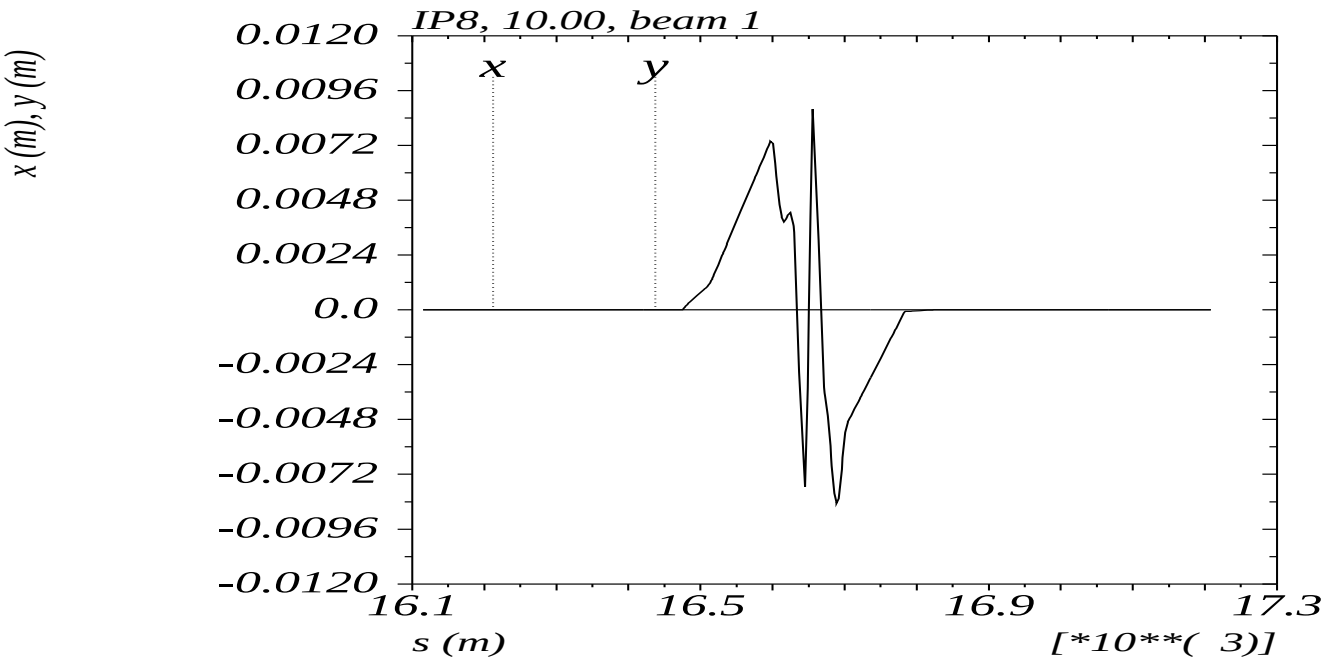
➡ **With $\mp$ 170 μrad external angle: sufficient separation**

Crossing scheme with spectrometer ($\ominus$)



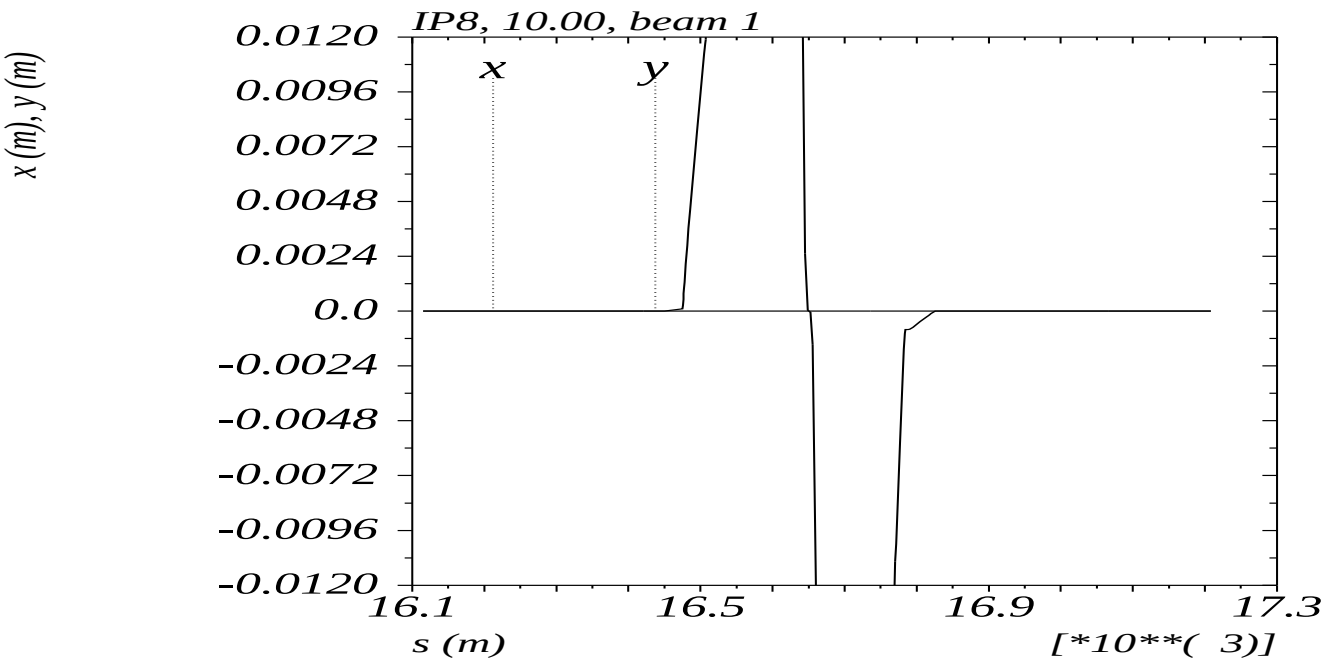
➡ **With $\mp$ 170 μrad external angle: sufficient separation**

Crossing scheme with spectrometer ($\oplus$)



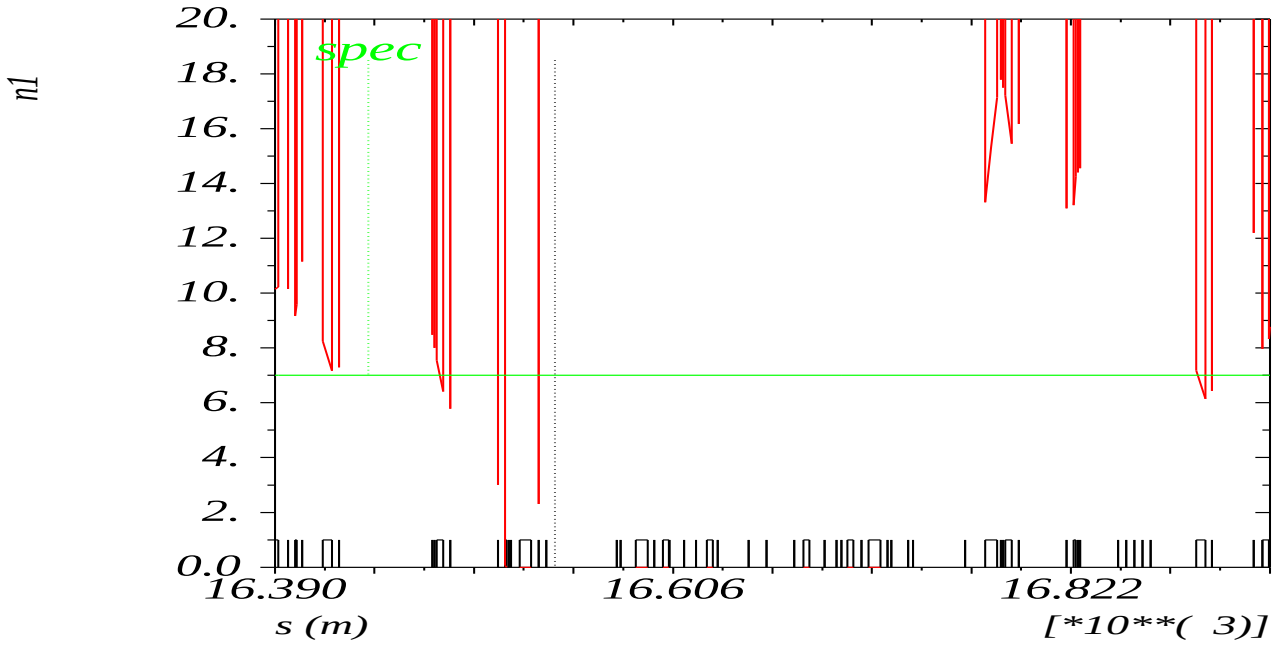
- **With $\mp$ 170 μrad external angle: insufficient separation**
- **Additional crossings to be avoided**

Crossing scheme with spectrometer ($\oplus$)



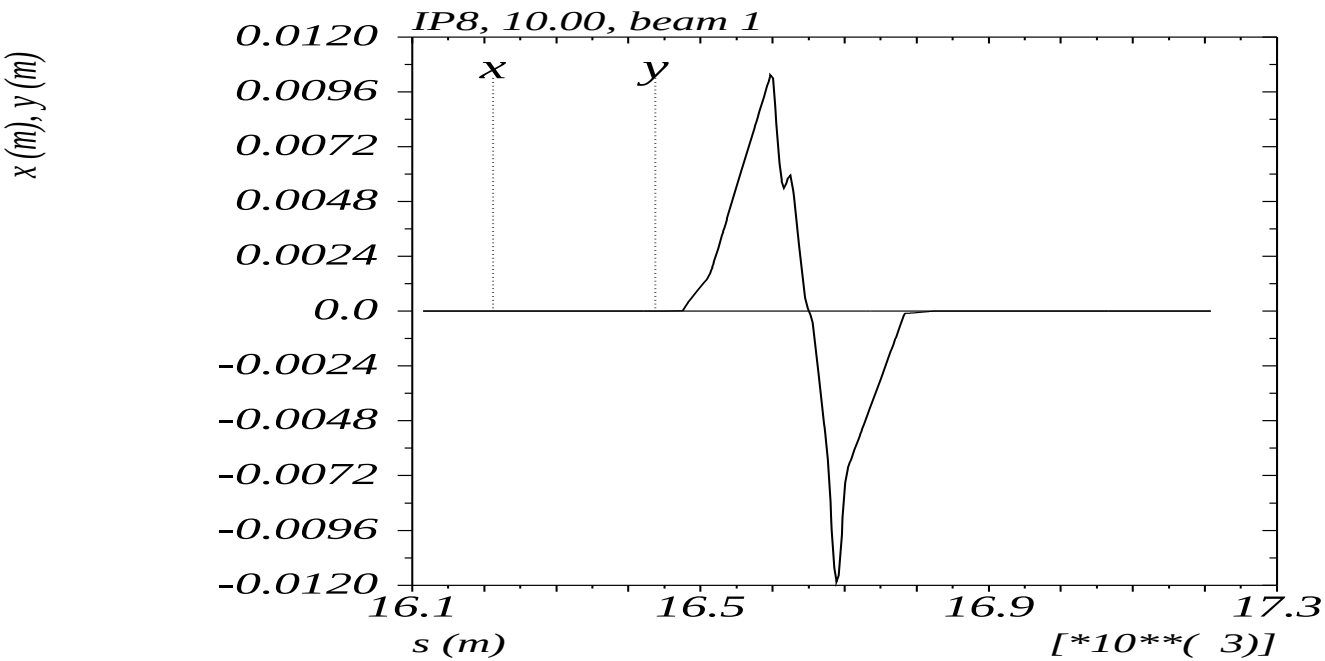
➡ **With very large external angle: sufficient separation**

Crossing scheme with spectrometer ($\oplus$)

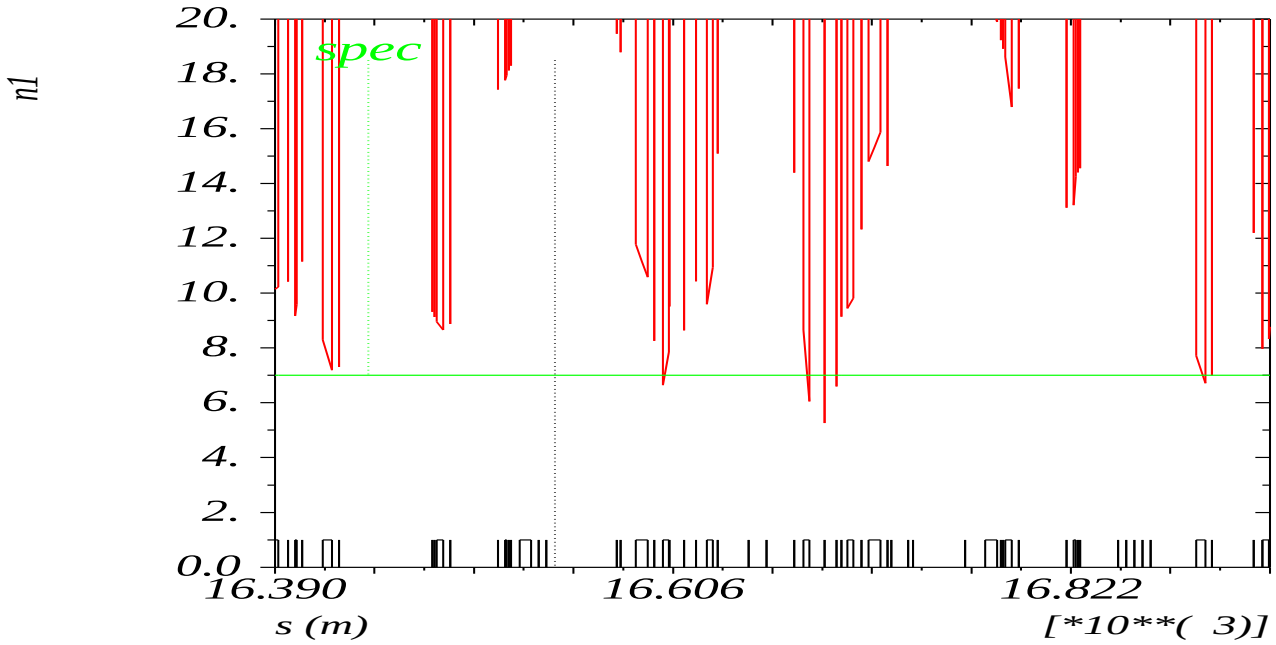


→ With external angle for sufficient separation

Crossing scheme with spectrometer ($\oplus$) at 20%



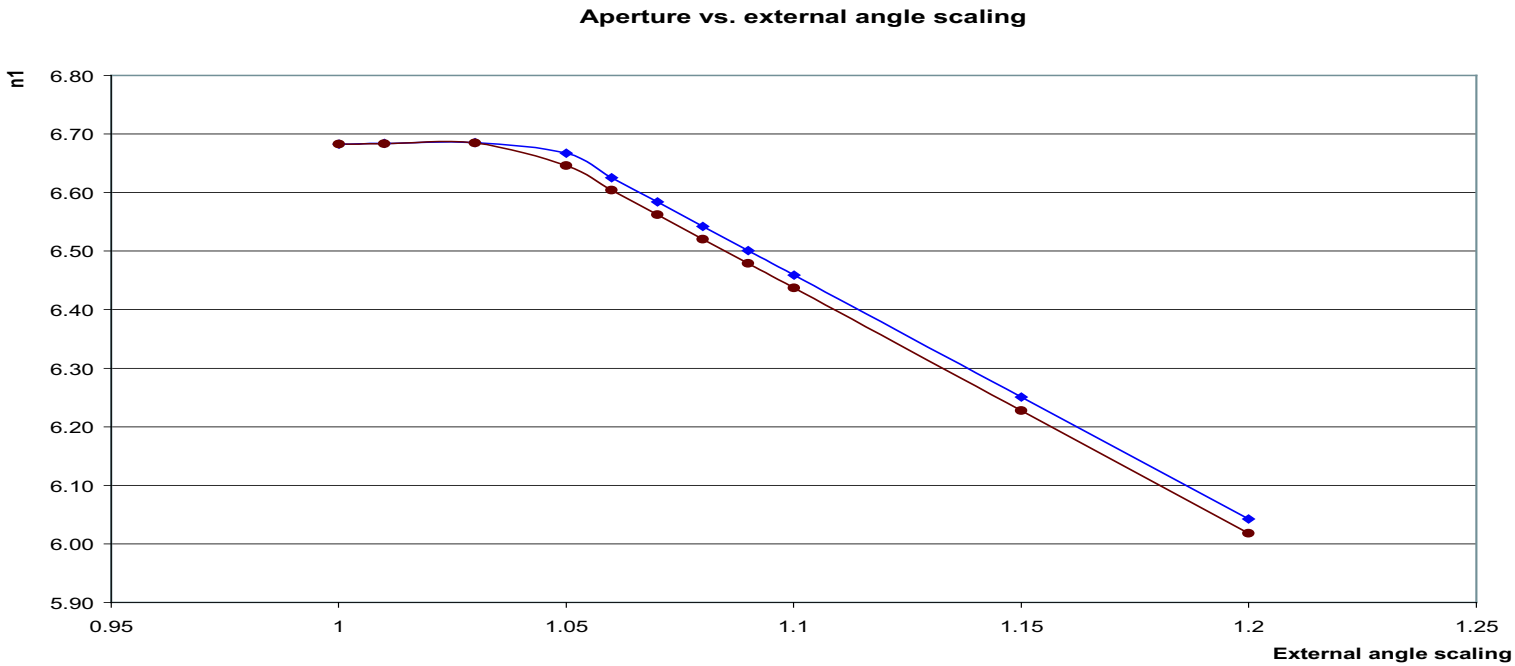
Crossing scheme with spectrometer ($\oplus$) at 20%



Which is the maximum field ?

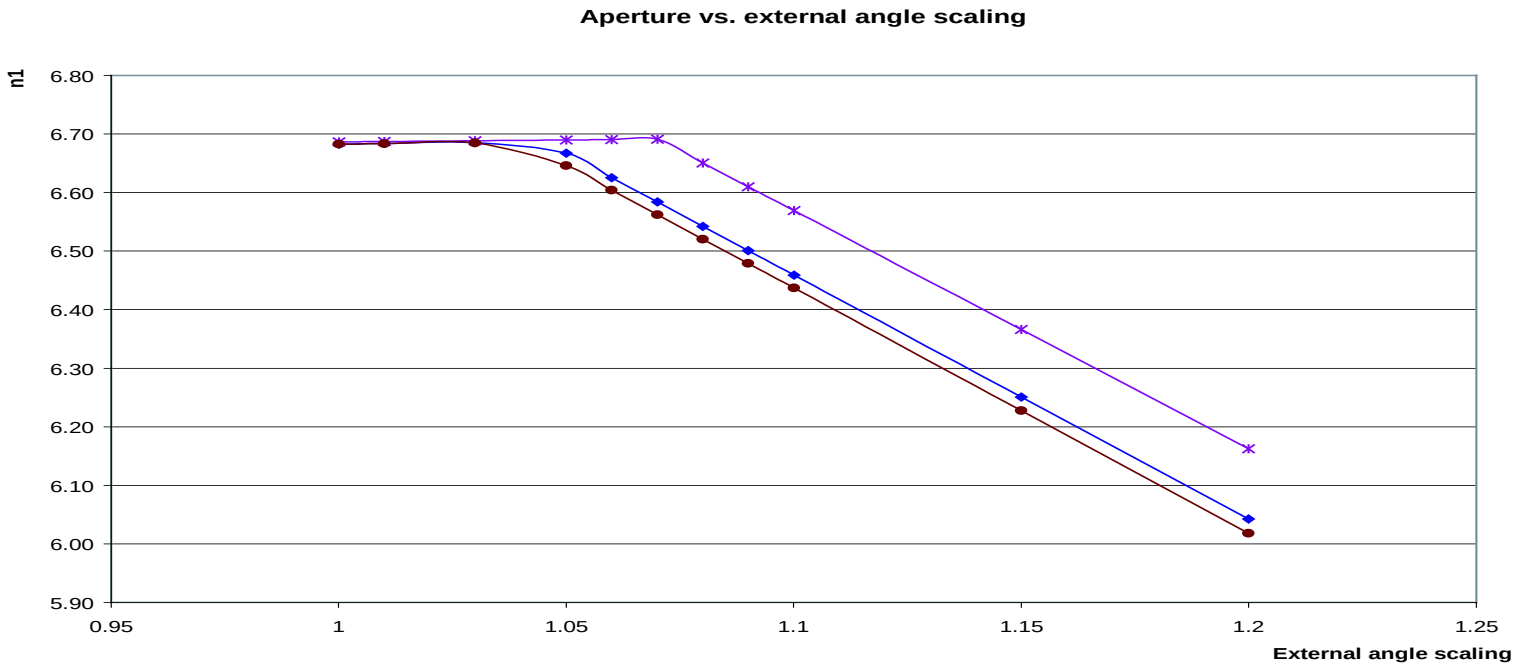
- **Find the maximum field to fulfil aperture requirements**
- **Scan field and compute $n1$**
- **Try to optimize crossing angle to maximize $n1$ in this process**

Minimum $n1$ as function of crossing angle



- External angle scaling of 1.2 corresponds to 8.2% of maximum field

Minimum $n1$ as function of crossing angle

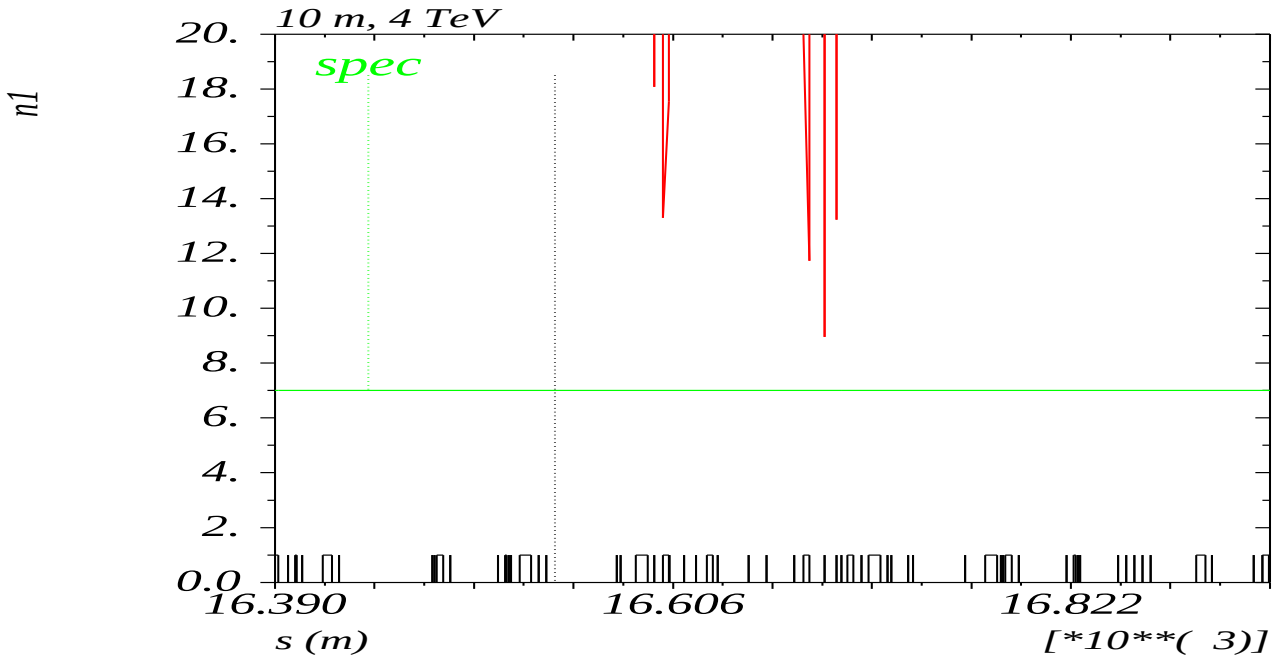


- External angle scaling of 1.2 corresponds to 8.2% of maximum field

Collisions at lower energy

- Collisions at lower energies are discussed ...
- At which energy is the full field possible ?
  - Without crossing angle full field is always possible
  - Depends on β^*, polarity (of course) and number of bunches:

Collisions at lower energy



- 4 TeV, full field spectrometer $\oplus$, $\beta^* = 10$ m

Collisions at lower energy

- At which energy is the full field possible ?
  - Without crossing angle full field is always possible
  - Depends on β^*, polarity (of course) and number of bunches:
  - For β^* 10 m full field possible around 4000 GeV (both polarities)

SUMMARY

- **Working scenarios at injection:**
  - → **No angle, no problem**
  - → **For one polarity full field (probably) feasible**
  - → **For second polarity full field excluded, can maybe go from 6.4% to 7.5%**
- **With $\beta^* = 10$ m collisions at 4 TeV (or more):**
  - → **Full spectrometer field is possible for both polarities**