Studies for the injection with open Front-ends

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Summary

- **Objectives**
  - Reduction of thermal load variations on beamline components
- **Safety aspects**
  - Prevent the injection of electrons into a beam line
  - Control of dose rates outside optics hutches
- **Operational aspects**
  - Gating of data acquisition
  - Keep all ID gaps closed except in-vacuum IDs
  - Minimising the duration on injections
- **Conclusions**

Injection of electrons into a beam line

- **Concern: 1 injector pulse $\Rightarrow$ 1 mSv behind the hutch**
- **Reasons:**

1) **Bad tuning of the Storage Ring**
   - The injected beam is inside the SR acceptance. The behaviour of lost particles is the same as for injected beam
2) **Hardware failure**
   - In case of hardware failure (magnet, steerer...) there is no difference between injected and stored particles

In both cases, the injected beam behaves similarly to the stored beam. The presence of stored beam before injection guarantees a tuning for which no electron can enter the beamline.

Injection of electrons into a beam line

3) Mistuning/Failure of an injection element

- Fast elements: their tuning can vary from one shot to the next

4) Mistuning of the injector

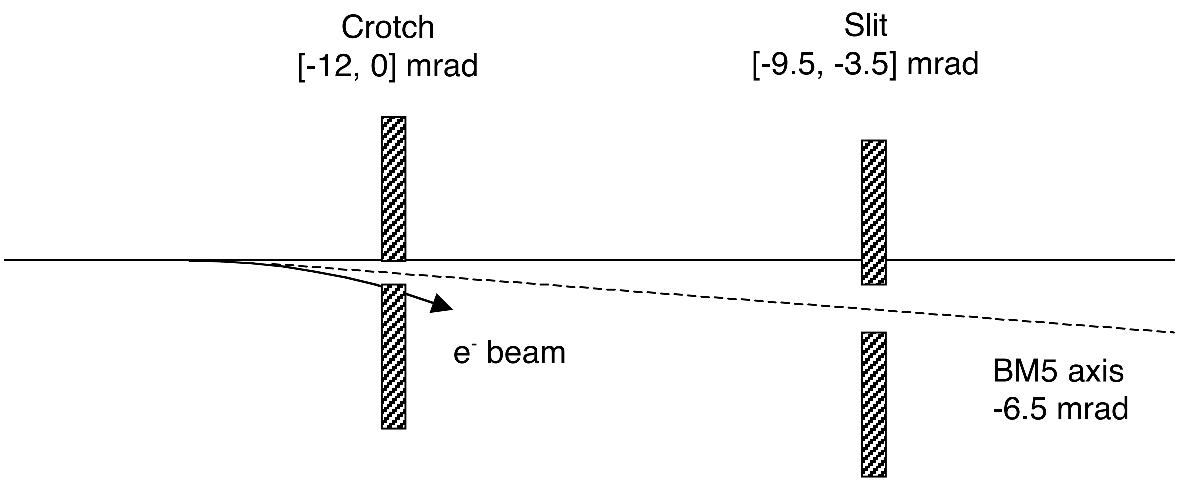
- This appears as a wrong emittance at the injection point or a wrong energy

Both cases can be studied together by tracking backwards all particles entering the 1st front-end after the injection region.

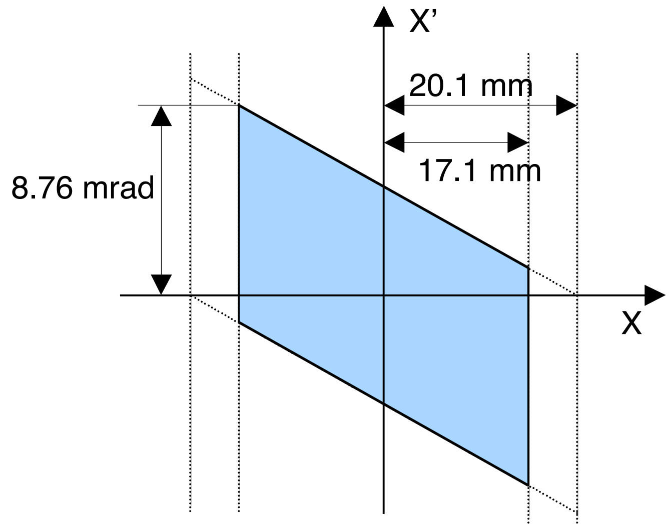
If any case they all hit the vacuum chamber wall before reaching the injection straight section, we can ensure that no injected particle can reach this front-end, or any other front-end, whatever the tuning of the injection is.

Acceptance of BM5 beamline

- **The beamline acceptance is defined by 2 slits**



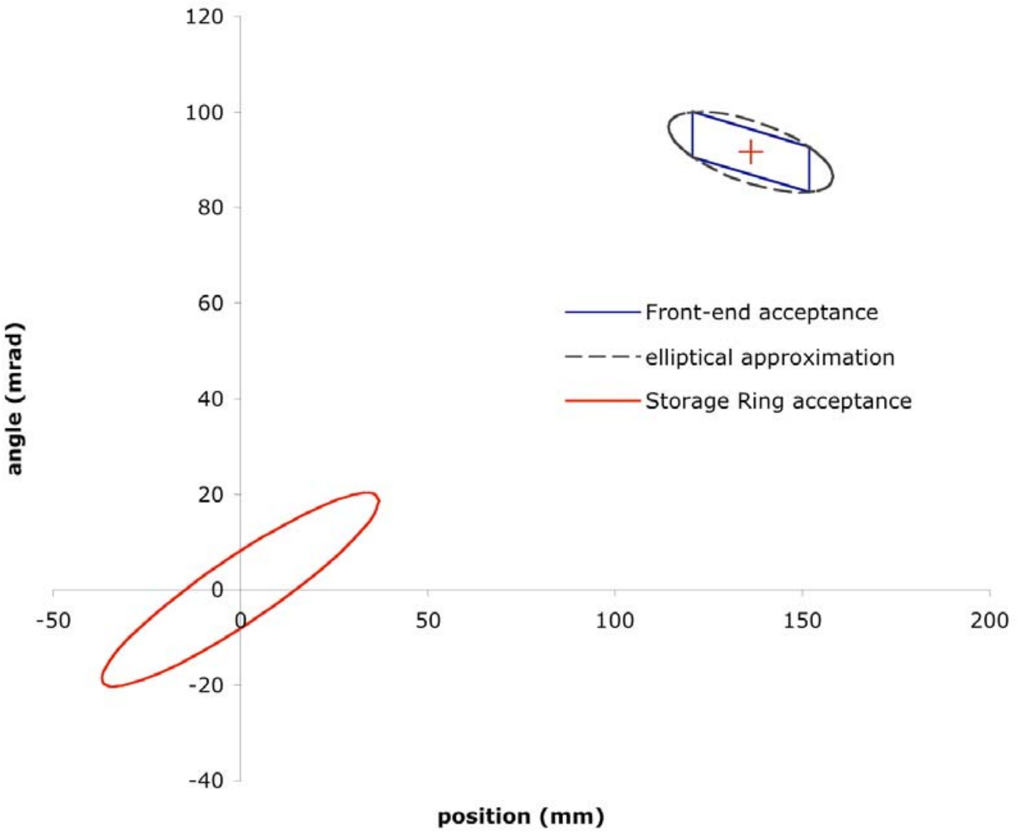
Absorber geometry



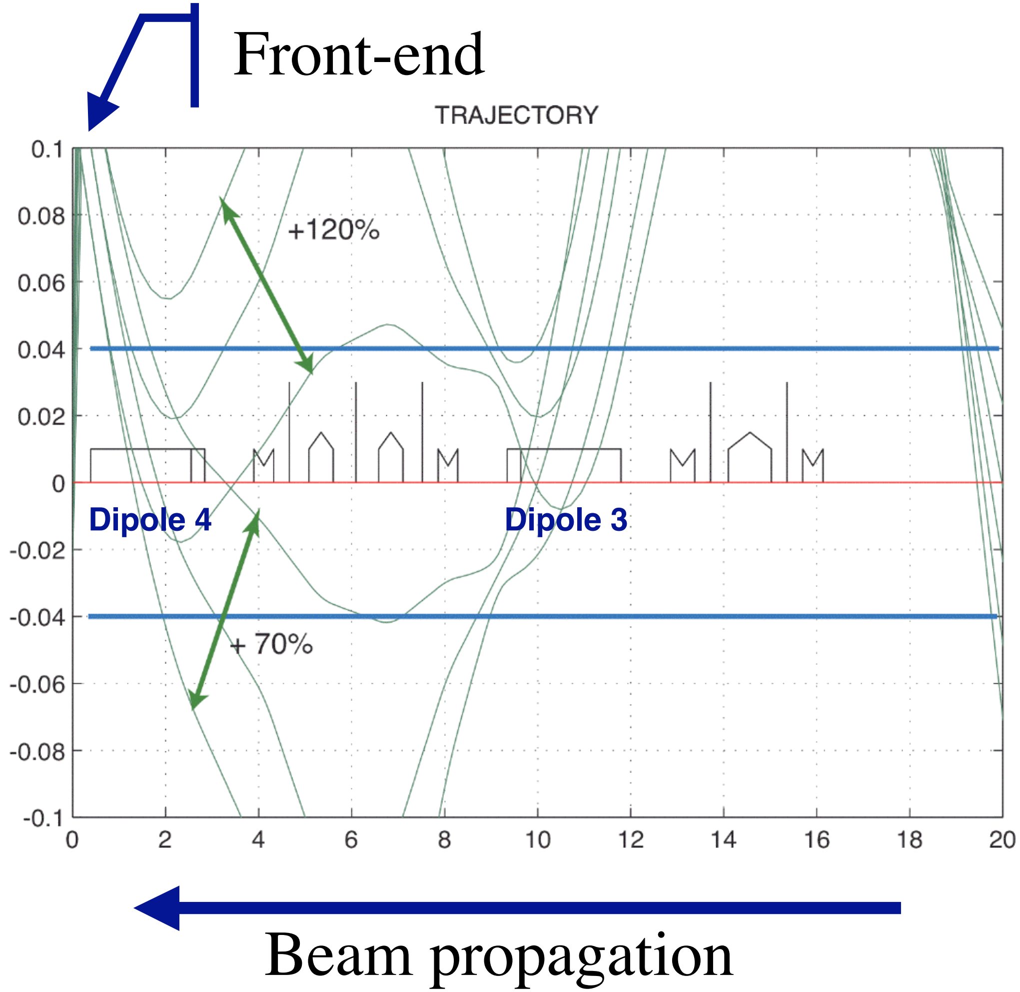
Acceptance at the 1st absorber

Acceptance of BM5 in the SR frame

- **The nominal deviation in the dipole is**
  - 98 mrad for the stored beam
  - 6.5 mrad for the beamline
- **The beamline acceptance is separated from the SR acceptance by more then 60 mrad**
- **All energies must be studied**



1st order transport



Particles entering the beamline must be off-momentum.

To emerge from the previous dipole, their energy deviation must be between +70% and +120%

Particles cannot come from upstream the previous dipole

Additional considerations

- **For large angles and energy deviation, linear optics is inadequate.**
  - Geometrical transport in the dipole
  - Scaled quadrupole strengths
  - ⇒ Even safer
- **Effect of sextupoles and steerers**
  - Negligible
- **Variation of BM5 acceptance**
  - Each front-end can be tuned between 0 and -12 mrad
- **In all cases, particles entering the beam line cannot cross 2 dipoles. There are 4 dipoles between injection and BM5**

Control of dose rates

- **Concern: scraping effect of low-gap chambers**
- **Study of losses during injection**
  - Ionisation chamber inside an optics hutch
  - Ionisation chamber+ neutron monitor outside the hutch
  - Measurements on both ID and BM front-end
  - Measurements for full refills (0 to 200 mA)
    - Nominal conditions
    - Protection scraper more closed: injection efficiency decreases, local losses decrease
    - All scrapers open: injection efficiency increases, local losses increase
    - All scrapers open+coupling correction off: local losses dramatically increased

Control of dose rates

- **Regulation (Euratom/9629)**
  - Dose limit for non-exposed workers < 1 mSv/y
  - Interpreted as $\int$dose over 4 hours < 2 μSv
- **Results: for one 50 mA top-up**
  - Nominal conditions: 0.03 μSv
  - Worst conditions : 0.64 μSv
- **Normal operation: one 50mA top-up every 12 hours**
- **In few bunch modes, the bunch cleaning does not induce significant losses**

Interlock system

- **Injection permission:**
  - I > 5 mA <u>OR</u> all front-end closed
  - Installation of a dedicated current monitor
- **Open front-end permission**
  - Acting on each beamline
  - Integrated dose over 4h < 2 μSv
  - Installation of 43 dedicated ionisation chambers
  - Alarm in control room if dose > 75% of the limit

Radiation monitor close to the hutch of a beamline

Operational aspects

- **Experiment gating:**
  - An injection countdown allows to schedule data acquisition before injection
- **ID gaps**
  - At the moment, only in-vacuum undulators are partially open to avoid demagnetisation (8 mm)
  - This can be reconsidered in the future depending on long-term studies
- **Injection studies**
  - Keep high injection efficiency (100%)
  - Reduce injection time
- **Few bunch modes: we are studying the bunch cleaning in the booster**

Conclusions

- **Modification done without any significant change on the SR or injector**
- **Extremely positive feedback from all beamlines**
  - Thermal variations on normal refills have almost disappeared
  - Some beamlines are using the beam during injection to perform long scans
- **We keep the injection scheduling as it was**
  - Every 12 hours in multibunch
- **Not a single closure resulting from excessive dose rate**
  - Small contribution of injections to the total integrated dose