# Injecting into ThomX ring with an off-axis dipole

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# Hypothesis

- Septum and kickers will not be available before few months (a year?) → would like to be able to check the ring status (magnets polarity, orbit, Fabry-Perot cavity,…) before that
- Could use a spare ThomX ring dipole as a septum to inject. Without kickers the beam can still make a few turns, provided the field of the dipole does not perturb the “stored” beam

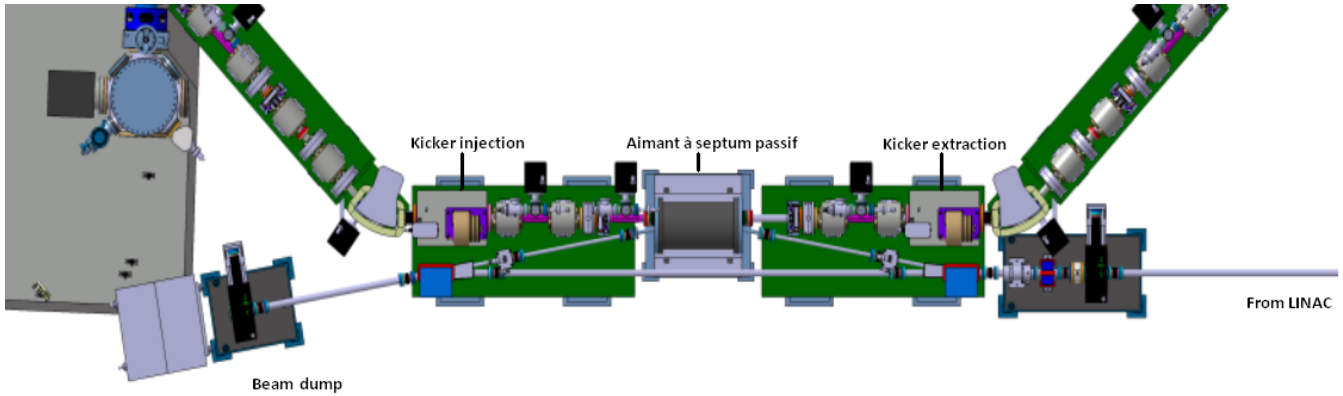
# Design conditions

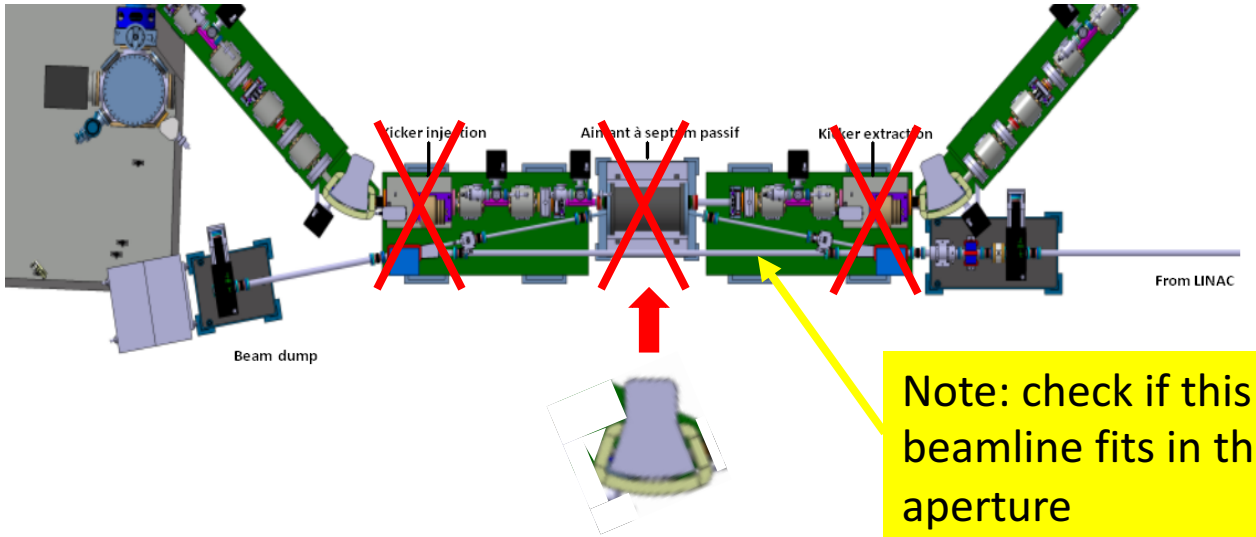
- Design injection is on-axis with septum and kickers
- Design septum deviation = 160 mrad = 9.17 deg
- Kickers are designed for 15 mrad kick
- ThomX dipole deflects 45 deg on-axis
- Ring correctors can give 5 mrad max kick each
- Ring beam pipe aperture is ±2 cm

# Dipole vs septum

- Use a ring dipole mounted off-axis to have the needed lower field and space for the injection beamline
- On-axis injection will not work if we have a dipole instead of a septum and a kicker
- Need to inject a little off-axis and correct the injected beam orbit with the horizontal ring correctors
- The “stored” beam needs to see “zero” field in order not to be kicked out at the second turn
- Dipole field should be very weak compare to design ring field → inject beam on the field slope

# Layout


Kicker injection
Aimant à septum passif
Kicker extraction
From LINAC
Beam dump


From LINAC
Beam dump
Note: check if this beamline fits in the dipole aperture

# ThomX dipole

- Data from dipole #9, measured $B_y$ as a function of X for a 263 A excitation current corresponding to 0.6 T (C. Vallerand)

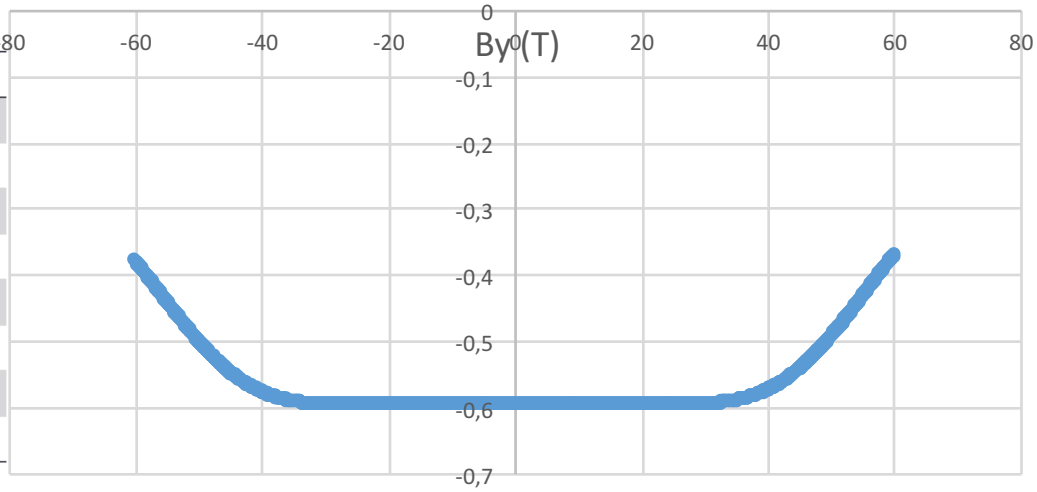
Deflection angle:

$\theta$ [rad] = $BL_t/(B\rho)$ = 0.3 $BL_t/E$ [T m/GeV]

| Beam Energy (GeV) | B r (T m) | L (m) | q (rad) | B (T) | |
|---|---|---|---|---|---|
| 50 | 0.16666667 | 0.2764 | 0.7854 | 0.4735 | Ring dipole set |
| 50 | 0.16666667 | 0.2764 | 0.160 | 0.0965 | Injection dipole set |

Need to know radial aperture of dipole

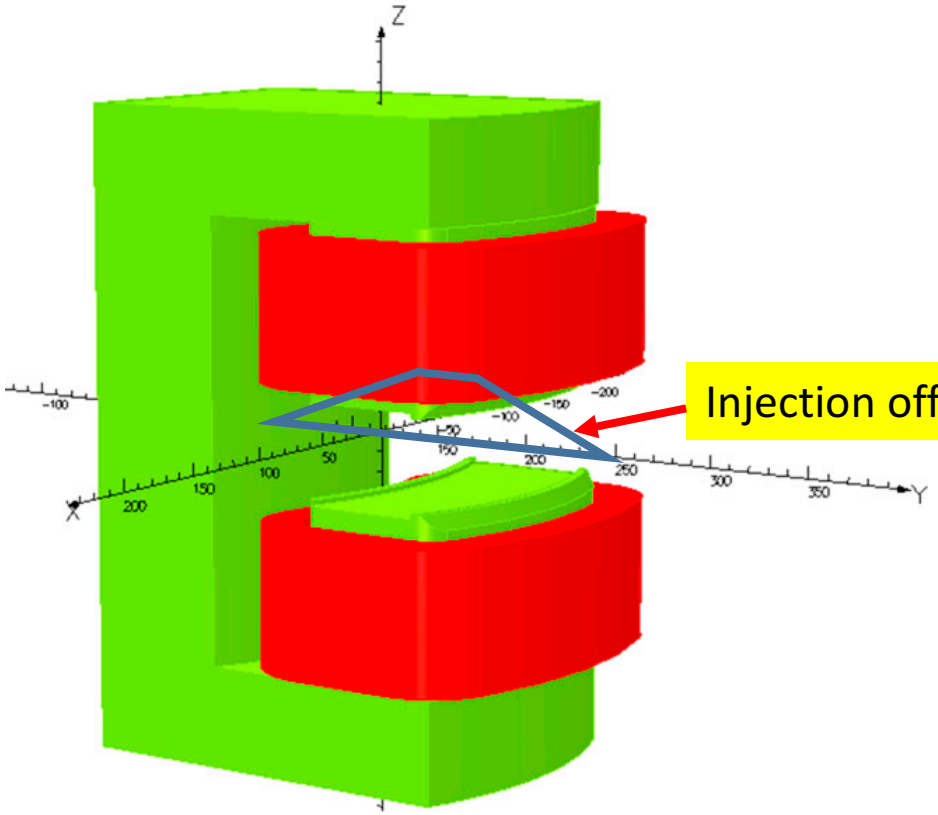
| Features of dipoles | |
|---|---|
| Quantity | 14 + 1 (pre-serie) |
| Radius of curvature | 352 mm |
| Main field $B_0$ | 0.7 Tesla |
| Gap | 42 mm |
| Good field region | +/- 20mm |
| Integral of field | 184.59 mT.m |
| Current max. | 275 Amp |
| Beam energy | from 50 to 70 MeV |

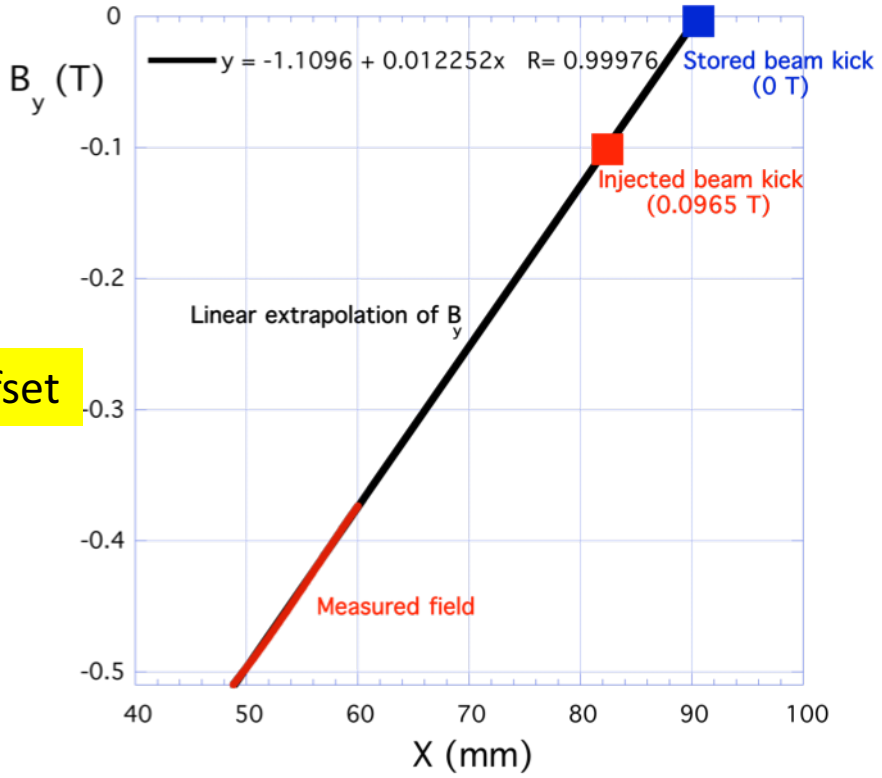


# Extrapolation at low field

- Linear extrapolation of the measured $B_y$ field along the X coordinated performed in order to find the X position suitable to get a 160 mrad kick:
  - 83 mm from dipole center: field deflection = 160 mrad
  - 90.5 mm from dipole center: field = 0
- Install the dipole displaced by 90.5 mm (no field on stored beam axis), inject the incoming beam with a -7.5 mm offset to get the required kick
- $B_y$ drops steeply, the kick will strongly depend on the position and energy of the injected beam !

# Example

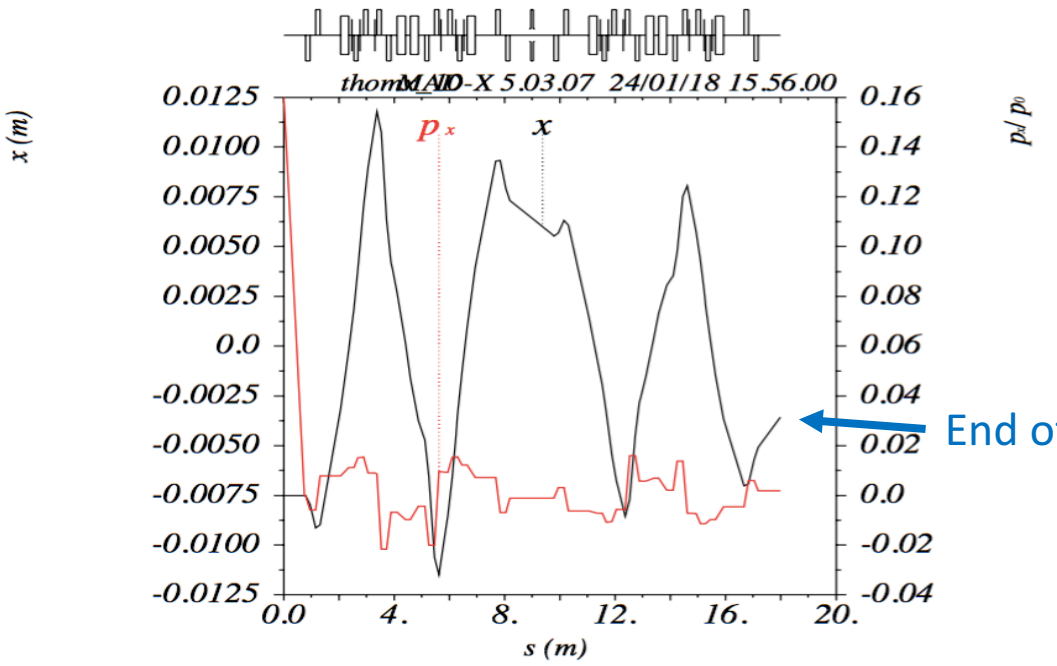



Not real dipole !

# One turn tracking

- One turn orbit:
  - injection angle = 160 mrad,
  - injection offset = -7.5 mm (on the outside of ring)
  - deflection by dipole = -160 mrad
- Orbit is contained in ±12 mm → inside beam pipe aperture

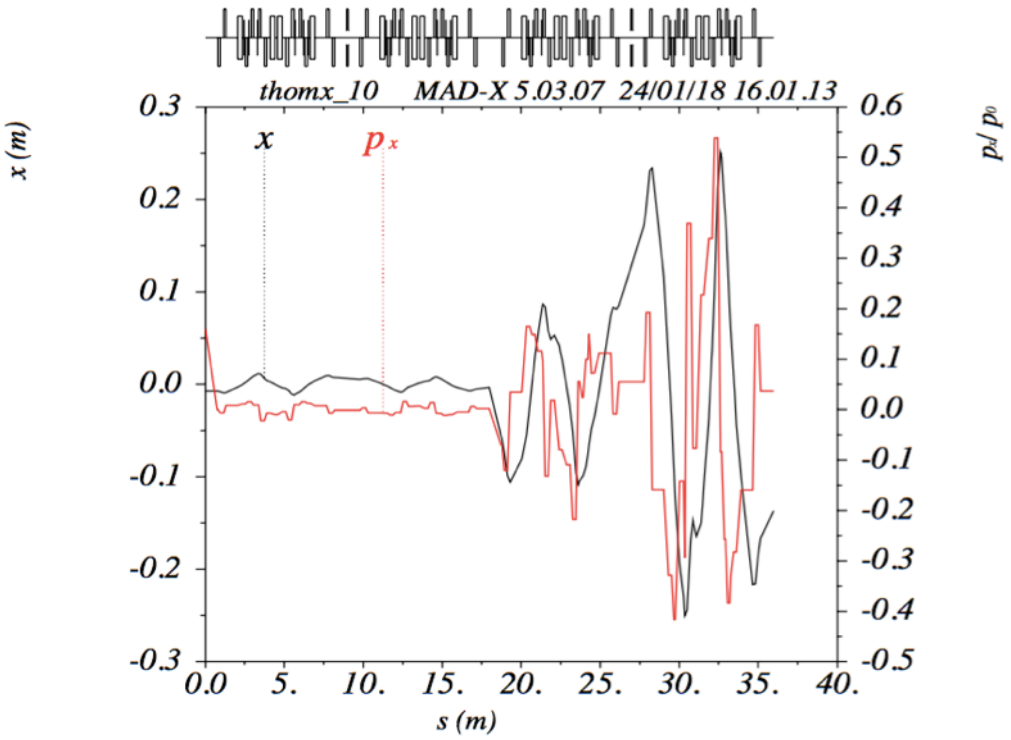



End of 1 turn: x = 3.5 mm

# More than one turn?

- With a dipole to provide the injection kick, the beam will feel a kick on the second turn, depending on its position so it will start to oscillate outside the beam pipe
- At the end of the first turn beam is still off-axis by 3.5 mm, this means that it experiences a 72 mrad kick
- 2-turns tracking with initial kick of 160 mrad and second turn kick of 72 mrad (all other correctors set to zero): bad (see next slide)
- Need to be able to correct the one-turn orbit to be zero at the injection point → orbit bump at injection?
- Correction of residual injection closed orbit with only 5 mrad correctors possible?

# Two-turns, two kicks




Injection angle = -160 mrad, injection x =-7.5 mm, second turn kick = -72 mrad, orbit ±25 cm → need correction or bump at injection point

# Conclusions/to-do list

- A displaced ring dipole could provide the kick for the injection at first turn
- One turn is ok, if orbit can be corrected at injection point, to cross the zero field region, more turns would be easy
- Should check magnet clearance for beam pipes, space, supporting girder,…
- Tracking with incoming beam errors needed
- Beam pipe replacing septum and kickers ones needed