

# PS 2GeV Injection – Feasible?

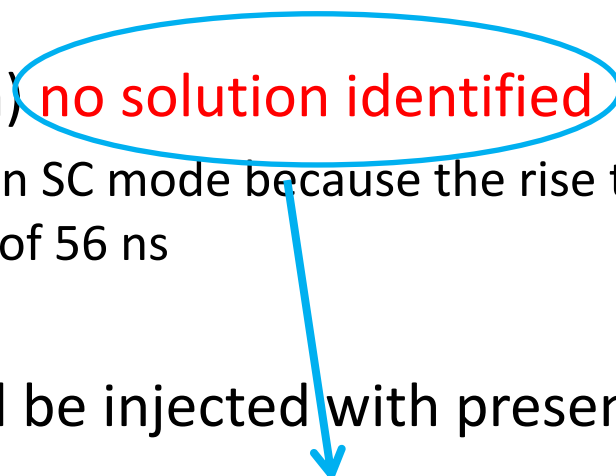
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# Outline

- Situation end 2010
- Requirements for 2 GeV HI beam injection
- SMH42 with integrated bumper
- KFA45 and 53
- Injection region optics
- BT-BTP optics
- Potential scenarios

# Situation End 2010

- 2 GeV LHC beam (3/3  $\mu\text{m}$ ) can be injected with
    - SMH42 rebuilt (including a bumper in the tank)
    - KFA45 in SC mode (required kick strength possible, increased rise time ok for LHC beam)
  - 2 GeV HI beam (12/9  $\mu\text{m}$ ) **no solution identified**
    - KFA45 can't be operated in SC mode because the rise time has to be below the bunch spacing of 56 ns
  - 1.4 GeV HI beam can still be injected with present bump and new septum
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**Study goal:**

What needs to be done to inject also the HI beam at 2 GeV?

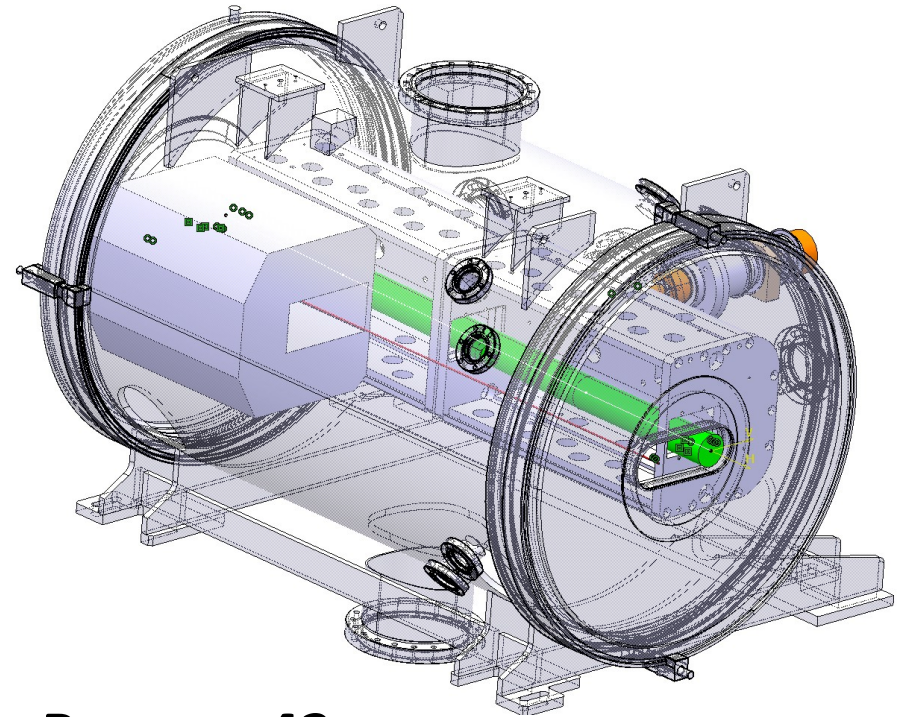
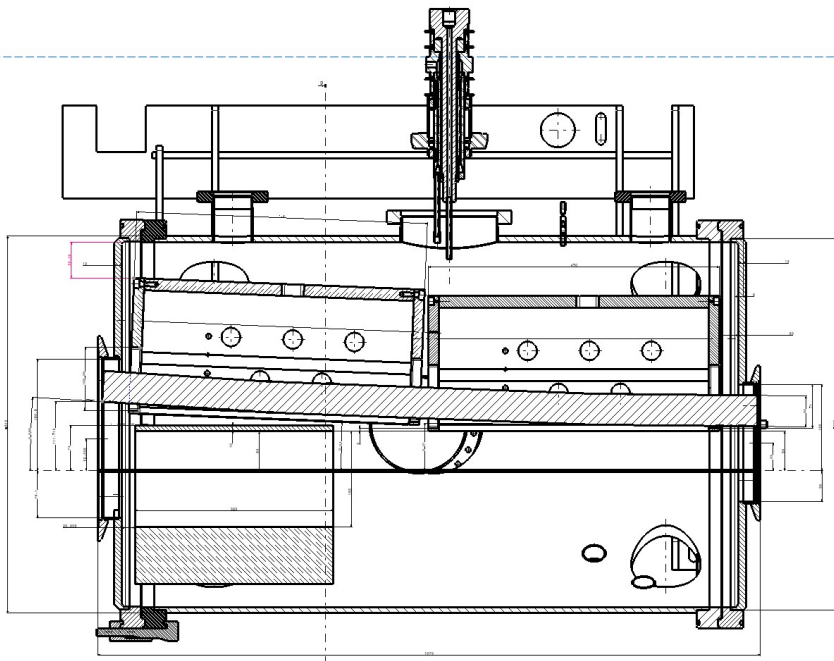
# Requirements for 2 GeV HI beam injection

- Septum and kicker strength increased by 30%  
( $B\rho_{2\text{GeV}}/B\rho_{1.4\text{GeV}}$ )
- Kicker rise time as KFA45 in terminated mode  
(rise/fall: 42/68 ns, 2-98%)
- In view of taking full advantage from Linac4's doubled bunch intensity:
  - Remove aperture bottlenecks in the BT-BTP line
  - Squeeze beam size at injection to reduce present losses at the septum
  - Improve injection bump to reduce continuous losses in the ring while bump is on (faster bumper, reduced bump height)

# SMH42 with bumper

## SMH42:

- $L_m$ : 2 x 400 mm
- Kick: 55 mrad
- Beam acceptance:  
 $v \times h$ : 60 x 70 mm



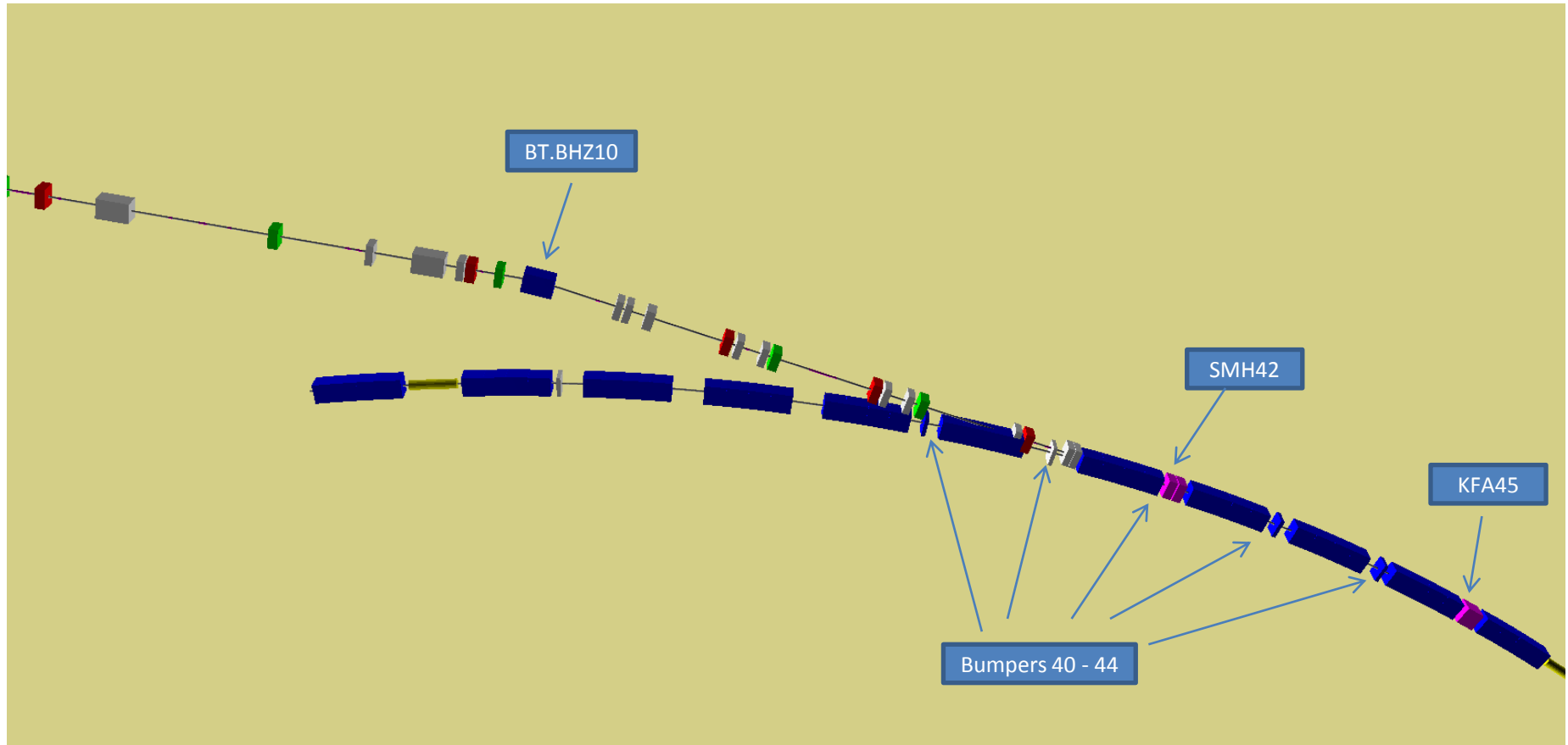
## Bumper 42:

- Under vacuum
- $L_m$ : 260 mm
- Kick: 13 mrad
- Beam acceptance:  
 $v \times h = 70 \times 140$  mm

# KFA45 and 53

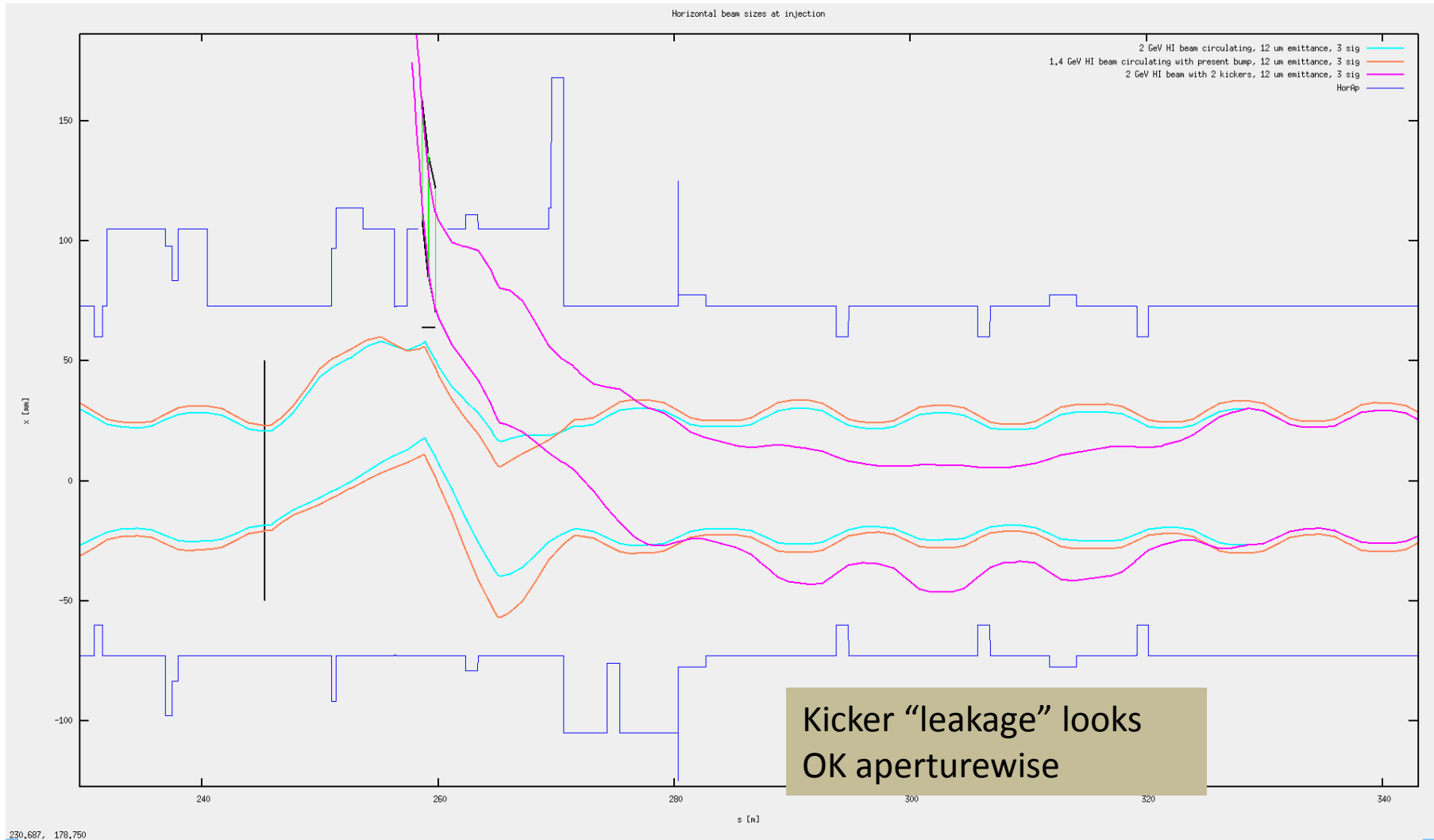
- KFA45: kick cannot be increased keeping the same rise time
- Provide missing kick 180 deg later in SS53
- Luc's calculation for Kicker53:
  - 1.6 mrad with four 25 ohm magnets and four generators operating at 35 kV with RG220 cables
  - Includes 3 mm ceramic plates in the gap
  - The magnets will operate in short-circuit mode
  - Present KFA45 rise/fall times should be kept
  - New dump switches have to be designed
  - Magnets are only 158 mm long – design study needed

# Survey



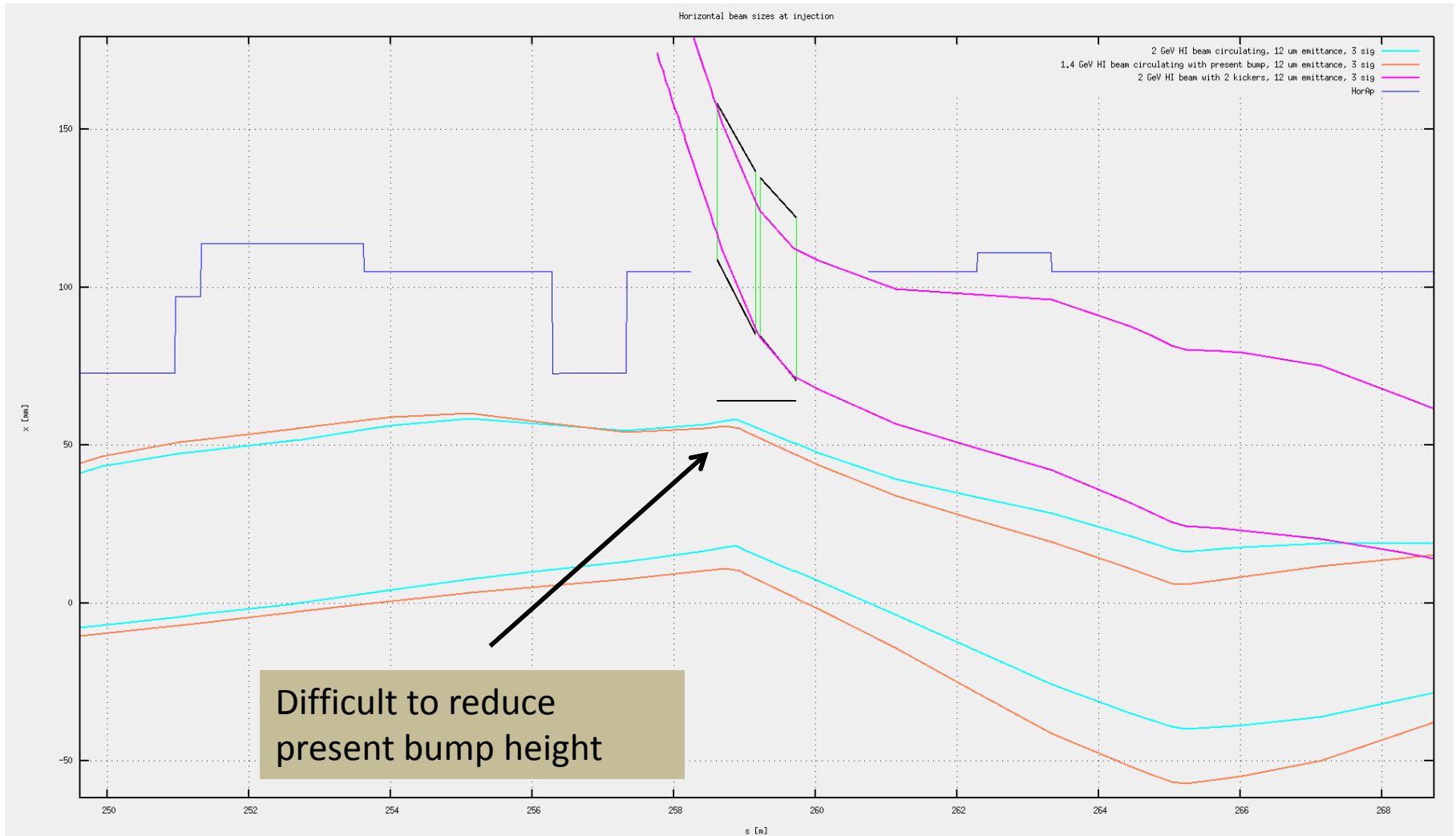
- Angle between BTP line and PS by 0.6 mrad steeper with new septum position - check minimum clearance in 41 magnet and strength limit of switching dipole

# Injection envelopes

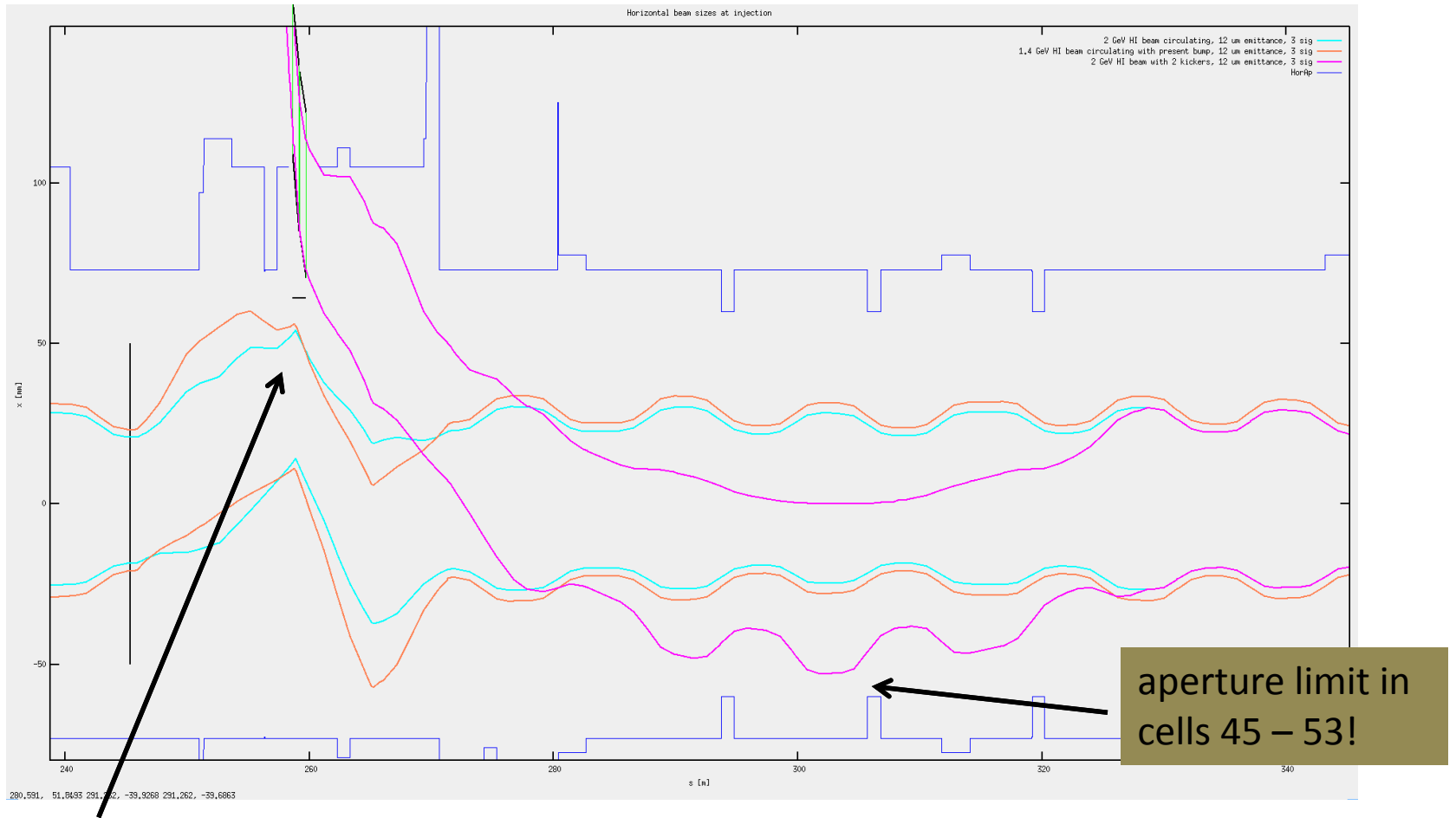




# Injection envelopes



# More kick in SS53



Slight improvement of injection bump possible with increased kick strength in SS53 (12 mT.m instead of 10 mT.m)

# Element strengths

	2 GeV HI beam [mrad]	2 GeV LHC beam [mrad]	Present 1.4 GeV [mrad]
KFA45	3.1	4.3	4.3
KFA53	-1.0	-	-
SMH42	55	55	55
BSM40	3.7	6.7	3.7
BSM41	0.8	-5.2	-
BSM42	-13.0	-9.0	-13.3
BSM43	8.8	11.3	11.1
BSM44	-2.2	-4.6	-4.4



Bumper included in the septum tank – limited to 13 mrad

Values in red are on the HW limit

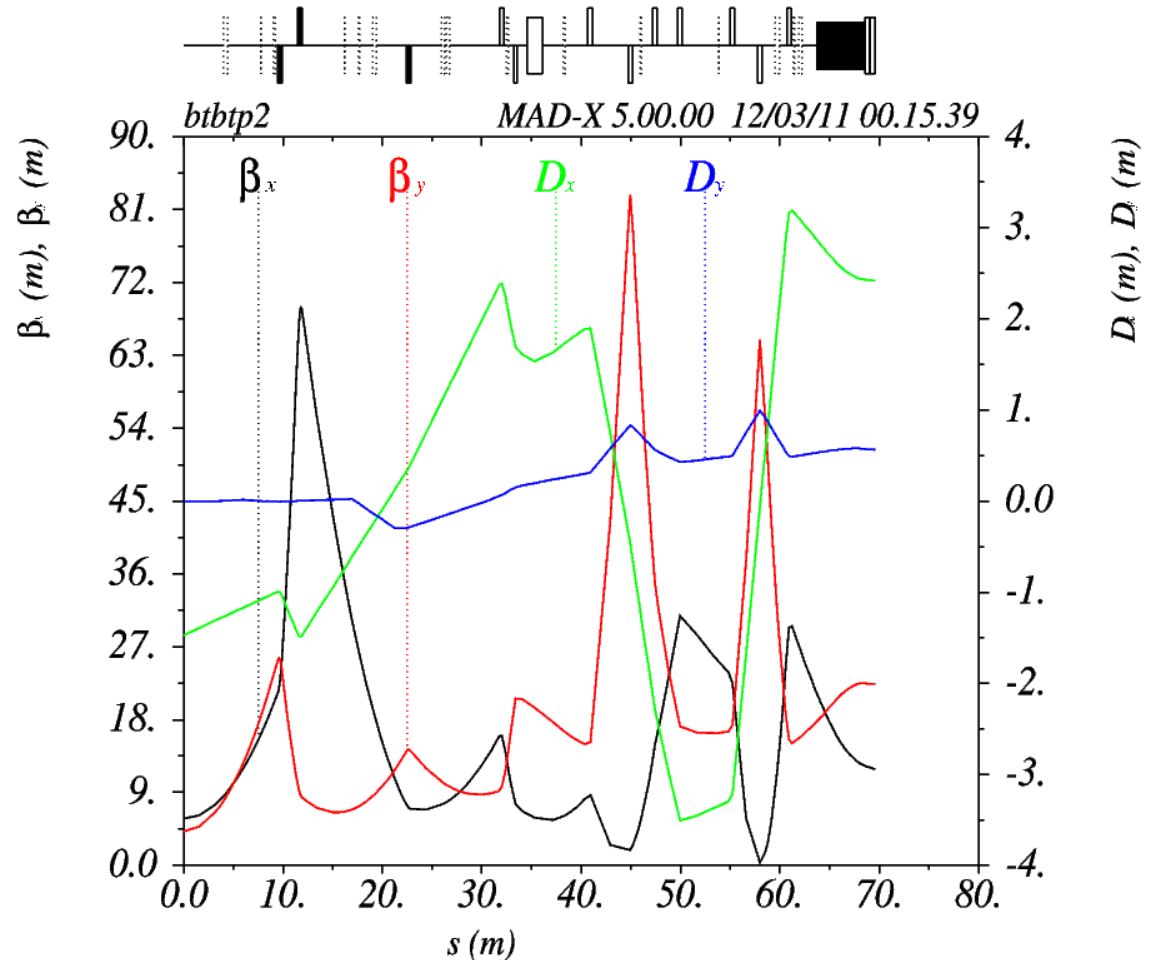
# Required in BT-BTP

- Remove mismatch in horizontal plane for LHC beam for emittance conservation
- Squeeze HI beam into the septum
  - Ideally follow with PS injection optics
  - Or certain mismatch could be accepted (em blow up of 10-20%)
  - However makes life difficult again for continuous losses in inj region
- Reserve space for:
  - Beam stopper at 2 GeV (1.5 m)
  - Collimator for HI beam (1 m)
  - Additional quadrupole
  - Quadrupole, correctors, instrumentation which are presently in the wall
- BT-BHZ10 (switching dipole)...no geom. solution to dump safely the beam in case BHZ is off!
  - Interlock on BHZ10 current
  - Verify if vacuum chamber can withstand at least 2 full intensity shots
  - Fast BLM to monitor failures

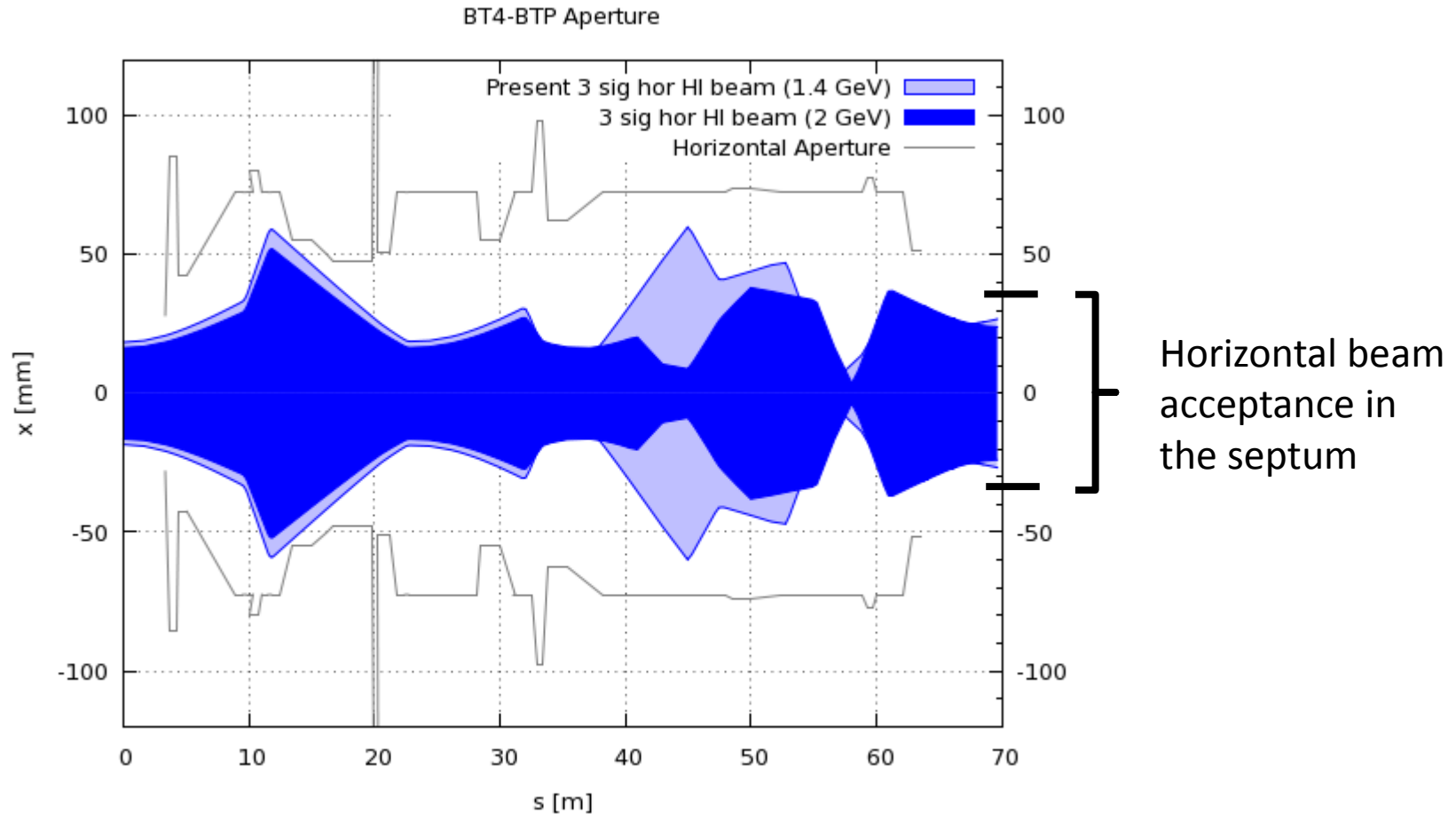
Make  
line  
ppm!

# BTP matched to PS

- BTP optics matched to PS optics in the horizontal plane
- 1 additional quad
- Quad in the wall also used
- Probably possible with one quad less

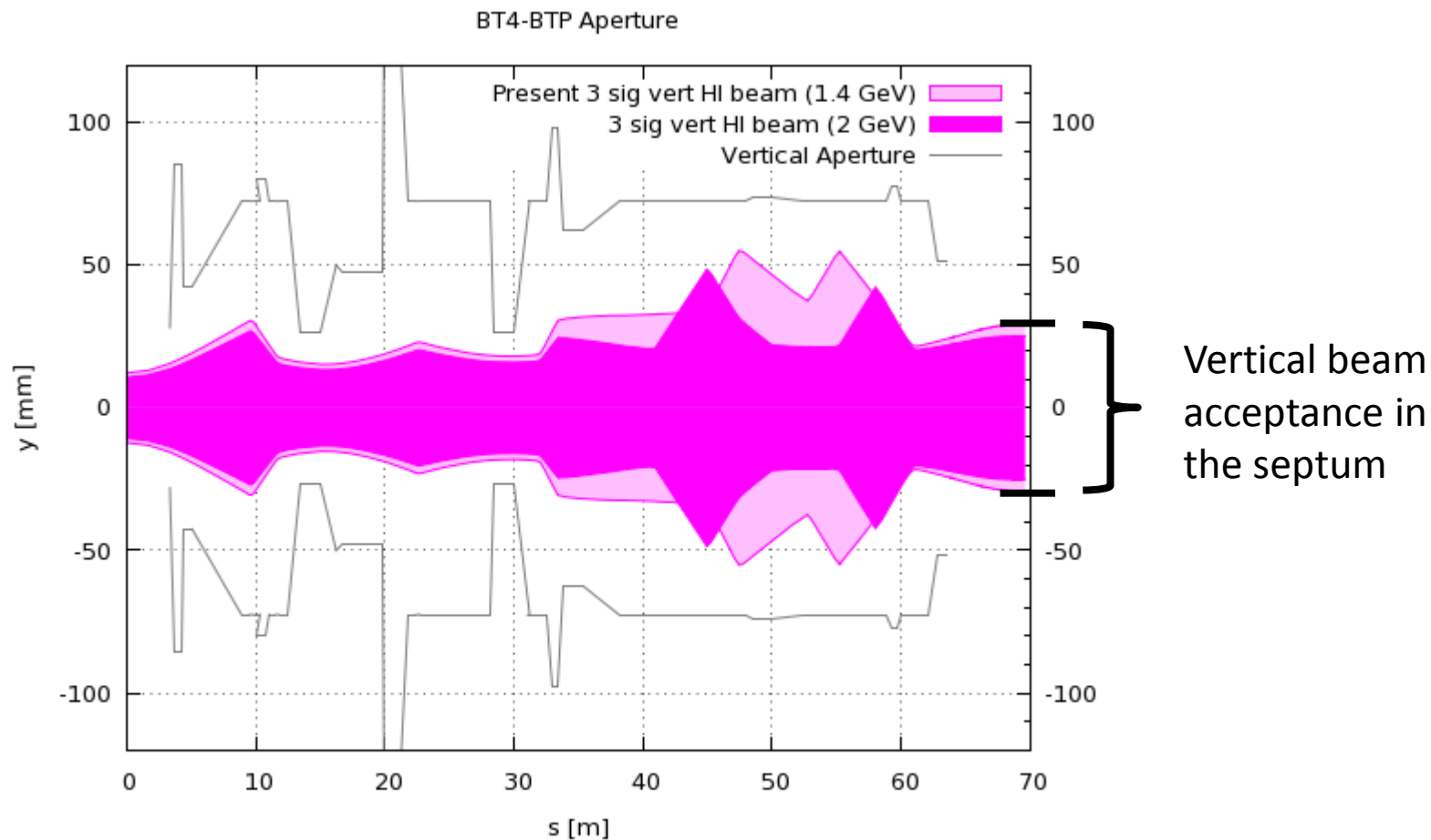


# BT-BTP Aperture



- 3 sig of HI beam in horizontal plane,  $dp/p=1.3e-3$
- BTP optics matched horizontally to PS optics at injection

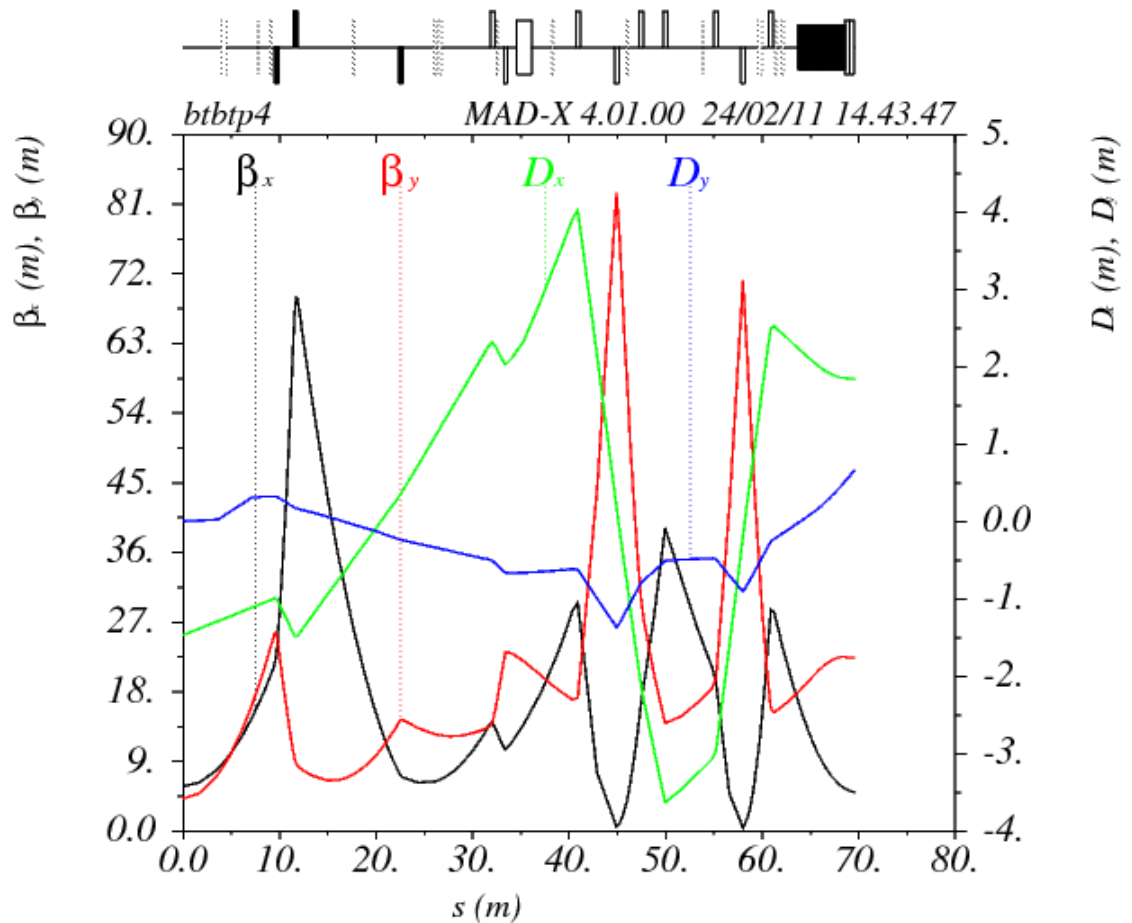
# BT-BTP Aperture



- 3 sig of HI beam in vertical plane,  $dp/p=1.3e-3$
- BTP optics matched horizontally to PS optics at injection

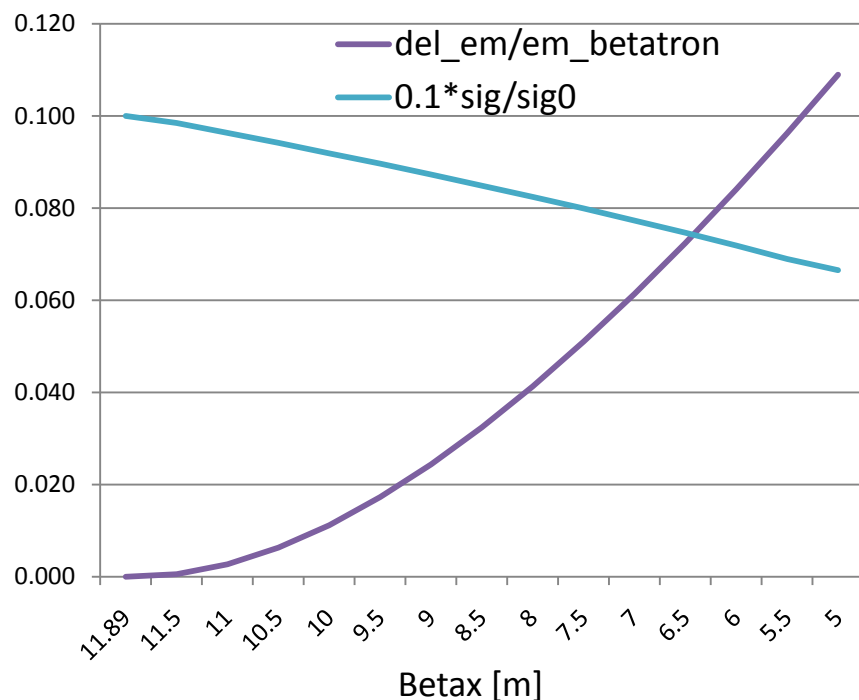
# Flexibility of BTP optics

- Hor. Beta reduced from 11 to 5 m
- Hor. dispersion reduced from 2.42 to 1.8 m
- Angles kept matched
- For the moment only in horizontal plane checked





# Mismatch from squeeze (hor)



- Considering present PS optics
- For PS inj. optics flexibility see Sandra's talk
- Reduce beam size by 1/3
- Betatron mismatch gives 11% emittance blow-up
- Dispersion mismatch gives 1 permille blow-up

Possible to reduce losses at the septum

BUT beam size in the ring will be increased (if PS optics can't follow) and consequently also the continuous losses at the injection bump

# Potential scenarios

- Only LHC at 2 GeV
  - LHC beam injected via KFA45 in SC mode
  - HI beam injected as presently at 1.4 GeV
  - Requires: new SMH42 (with Bumper42), KFA45 in SC mode (dump switches), damper operational (to cure extra 0.1 um emittance growth)
- All beams at (up to) 2 GeV
  - LHC and HI injected via KFA45 in terminated mode with additional Kicker53
  - Requires: new SMH42 (with Bumper42), KFA45 as present, additional kicker in SS53
  - Possibility to inject HI beam at  $\leq 2$  GeV
    - Less kick needed in 45 and 53
    - reduce injection bump height and thereby continuous losses in the ring

# Conclusion

- All assumptions are valid for beams injected from the PS Booster – might change in case of the RCS
- All beam types can be injected at 2 GeV into the PS
- Cost for HI beam at 2 GeV dominated by new Kicker53
- TODOs
  - Decide for scenario
  - Study new kicker
  - Study bumper42 power supply
  - Study optics in injection region and line
  - Check optimum position for collimator
  - Check consequences of potential BT-BHZ10 failures
  - Study space charge