High Lumi LHC - WP8
Collider Experiments Interface

LCU meeting
09 July 2009

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- <u>HL-LHC WP8 COLLIDER-EXPERIMENTS INTERFACE</u> aims at evaluate :

_ Constraints on beam pipe design for various options for the high luminosity insertions
_ Take into account physics requirements at IP
_ The fluence, dose rate & activation to be expected
_ The backgrounds and particle fluence induced in detectors region for various operation modes

  ➔ Coherent plan, finding the best compromise between both sides (experiments/machine)
        <u>coordinators : H. Burkhardt – D. Lacarrere</u>

- <u>1st Workshop Collider-Experiments Interface was held on the 30th November 2012</u> :

_ Morning session : "desiderata" from the LHC experiments
_ Afternoon session : dedicated to to the technical requirements from the machine side
        link : **https://indico.cern.ch/conferenceDisplay.py?confId=214361**

Aperture changes (Example IP1)

• New optics require aperture upgrades
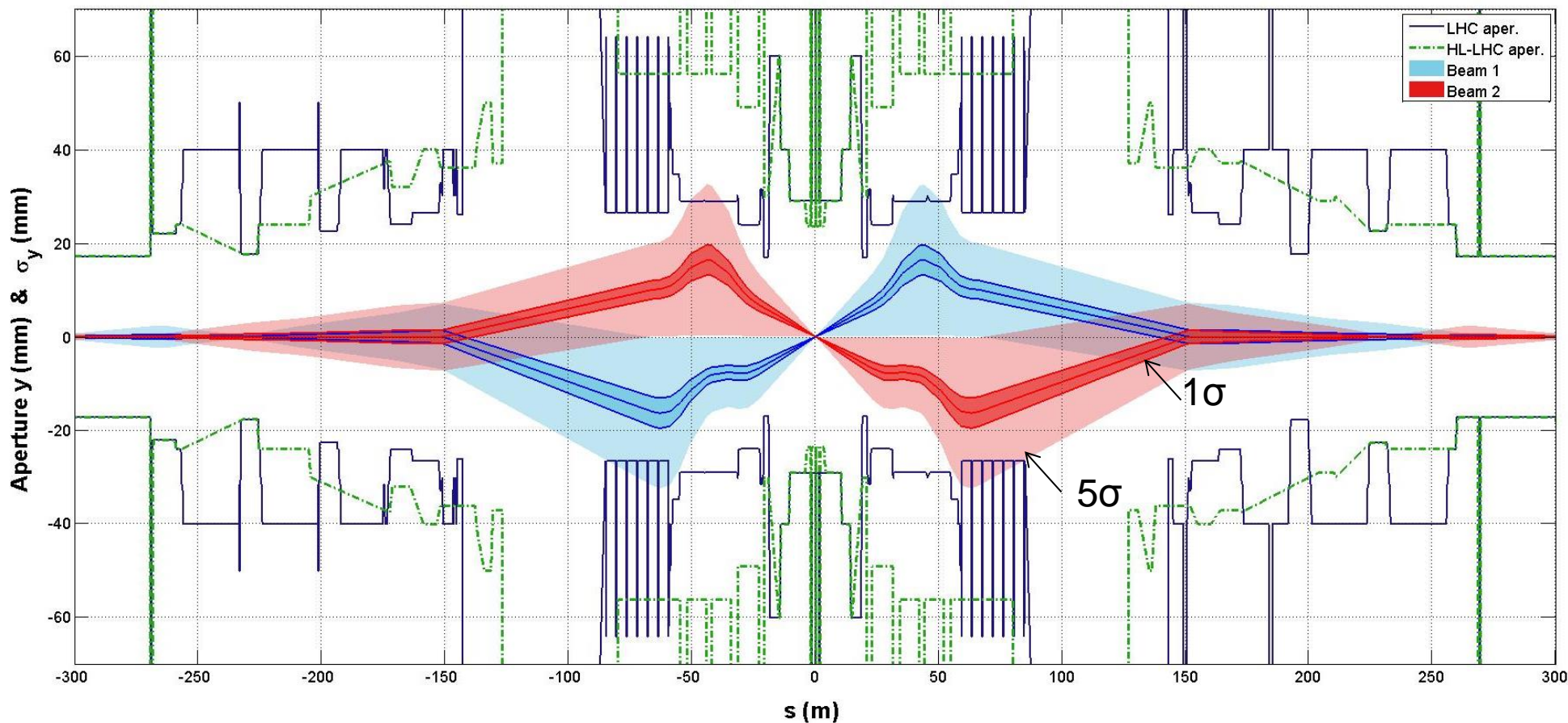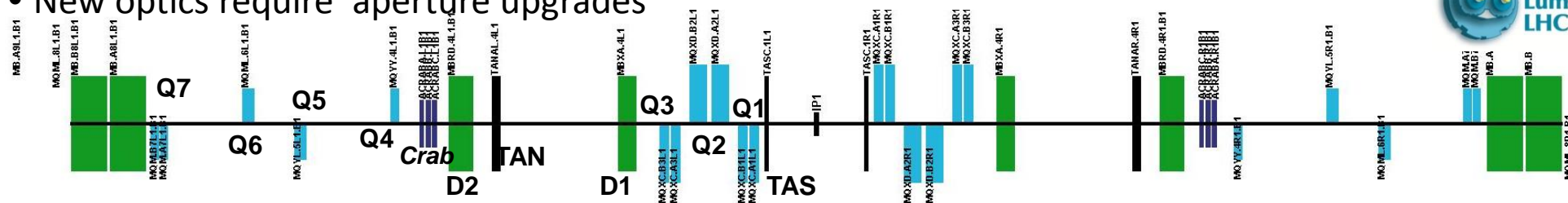
Example : IP1 Vertical plan , On collision – HL LHC optics and aperture changes- 7 TeV- ε_n=3.75 µm.rad - β*=0.15 m (round)

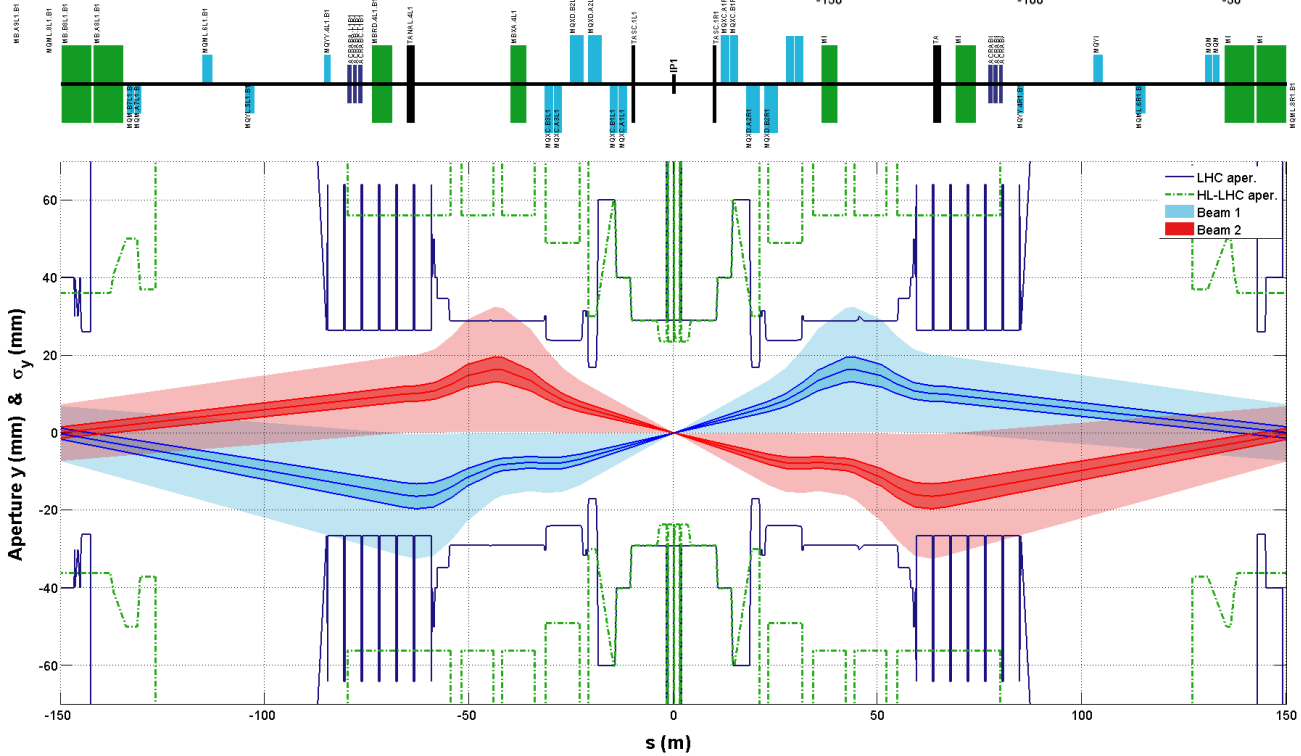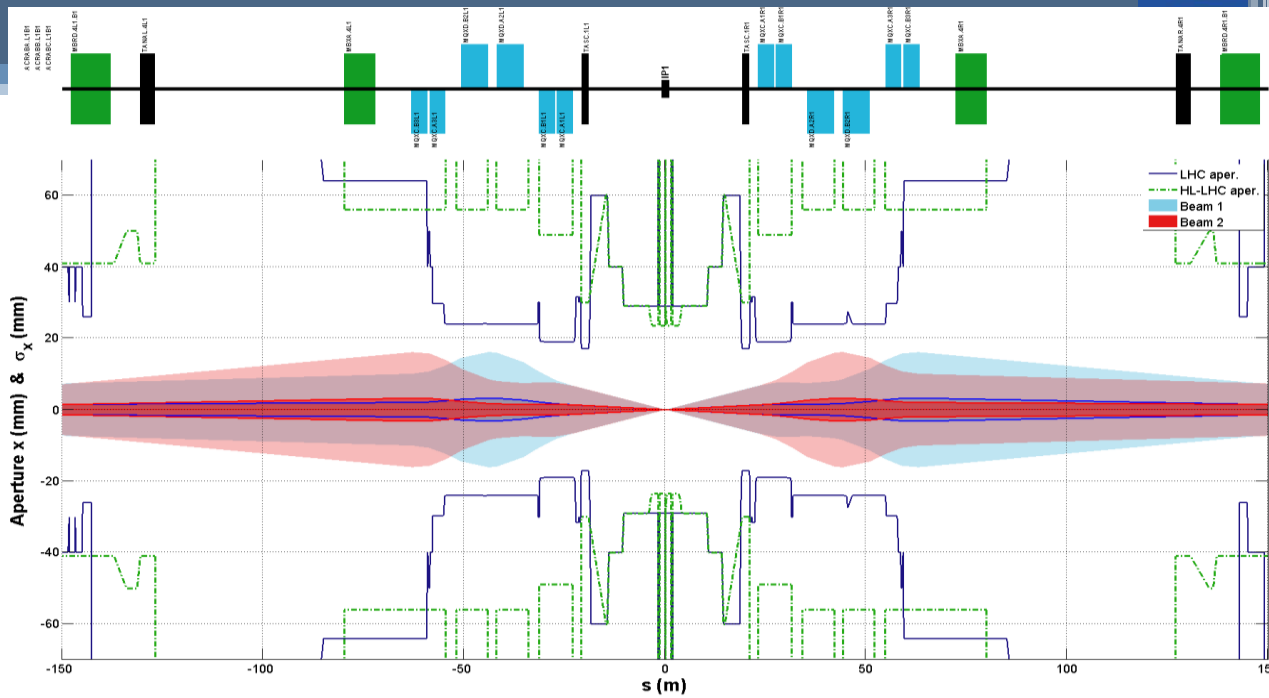**IR 1**

ZOOM
Horizontal and vertical plan
@ IP1
Beam envelope :
1σ & 5σ

Collision optics
-7 TeV-
- ε_n=3.75 μm.rad -
- β*=0.15 m –
- Round beam

Pipes diameter reduction
Ø 58mm -> Ø 47 mm

IR 5

ZOOM
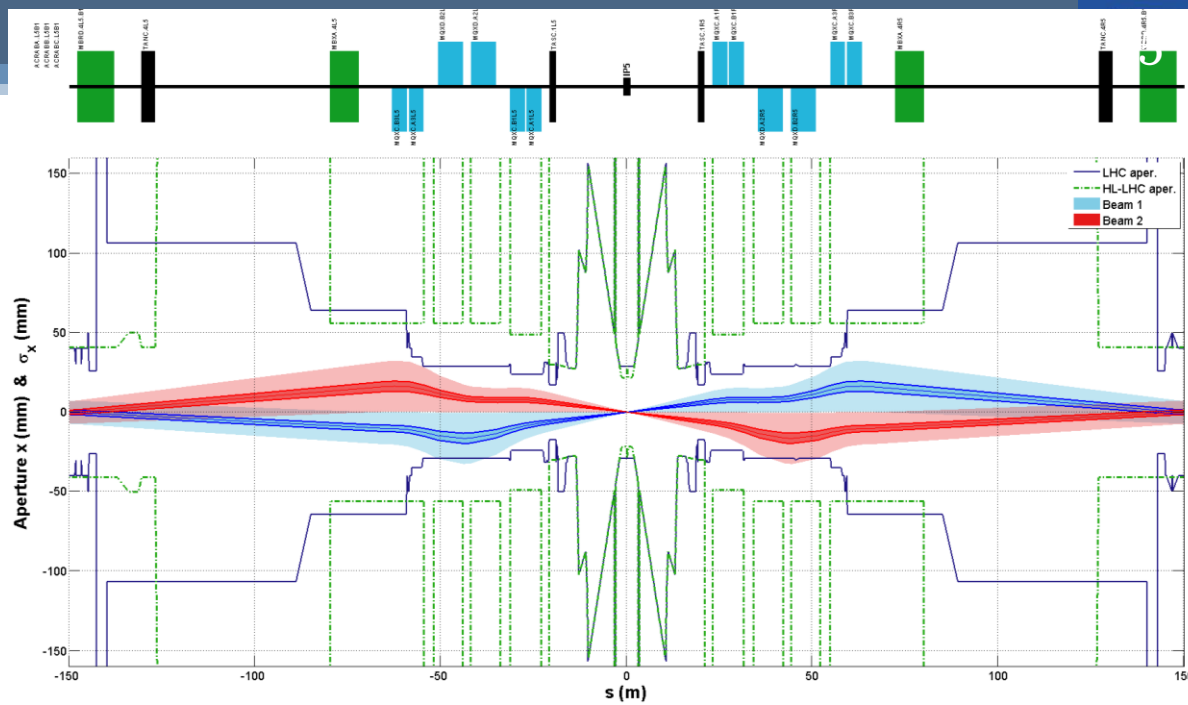Horizontal and vertical plan
@ IP5
Beam envelope :
1σ & 5σ
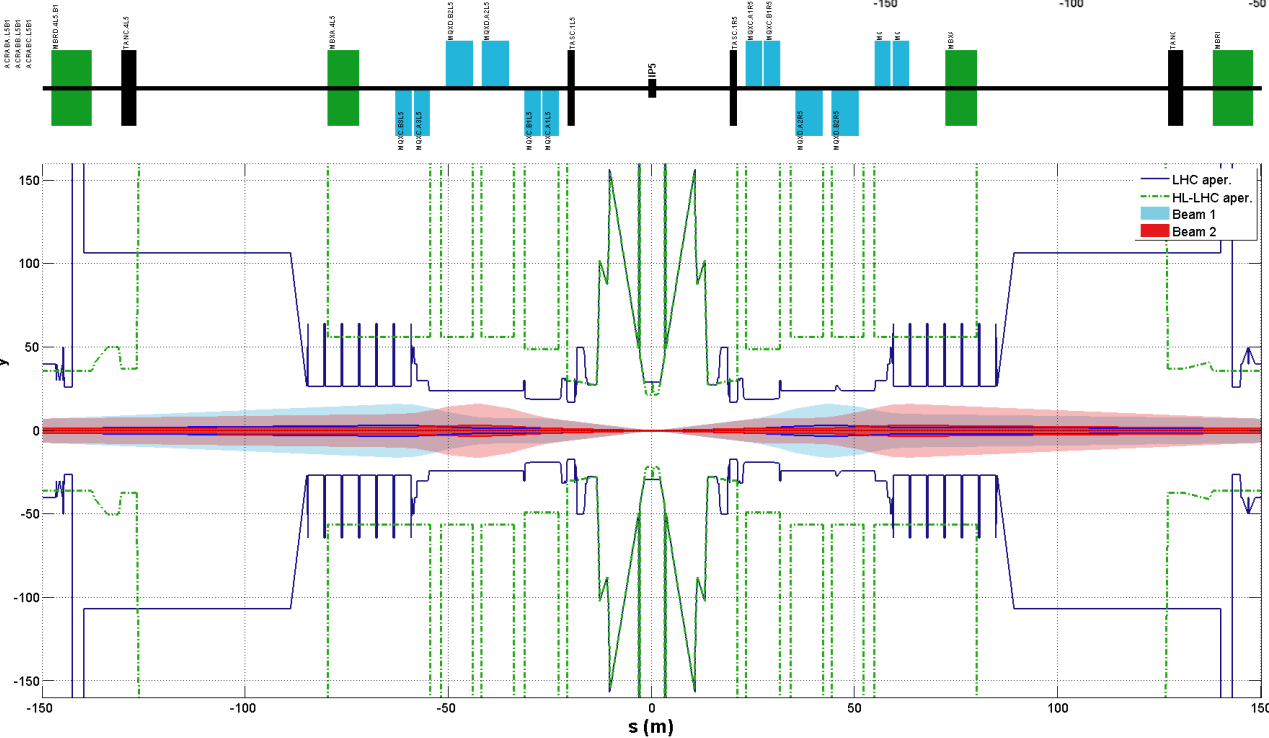
Collision optics
-7TeV-
- ε_n=3.75 µm.rad -
- β*=0.15 m -
Round beam

Pipes diameter reduction
Ø 58 mm -> Ø 43.4 mm

Key point

→ What will be the consequences of the aperture changes for HL-LHC in terms of background, radiation and protection of the central detector regions.

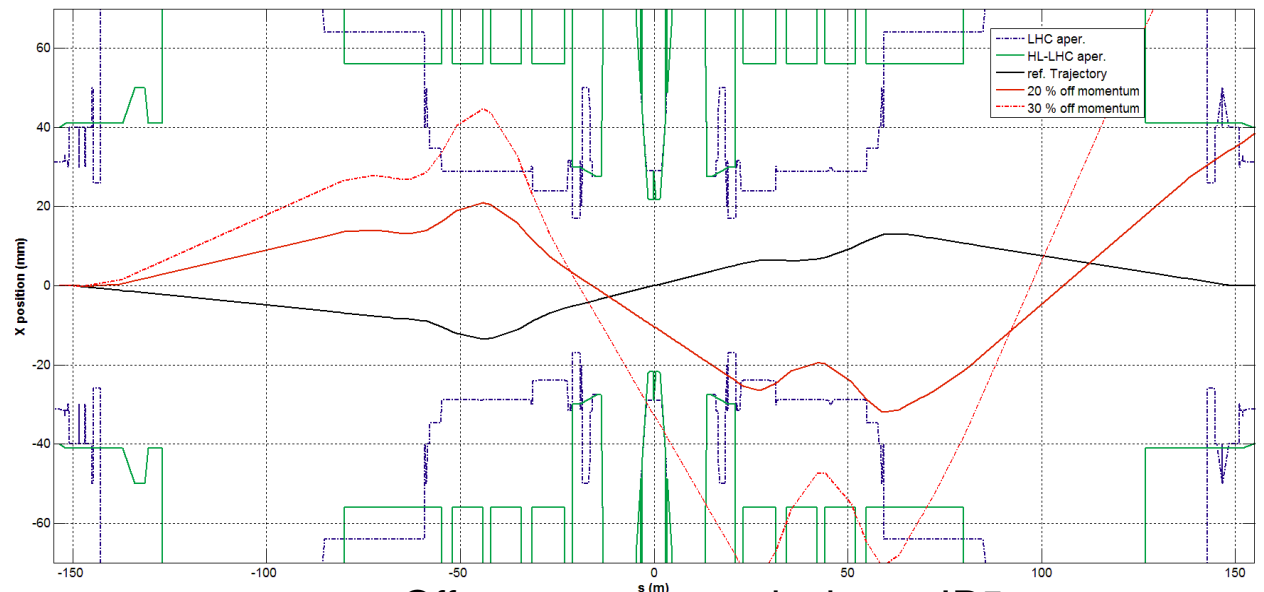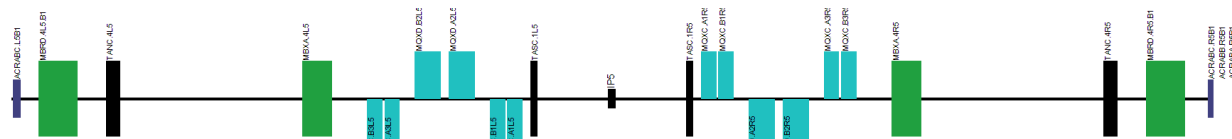_ TAS and triplets Opened whereas detector chamber reduced

- **Background issues :**

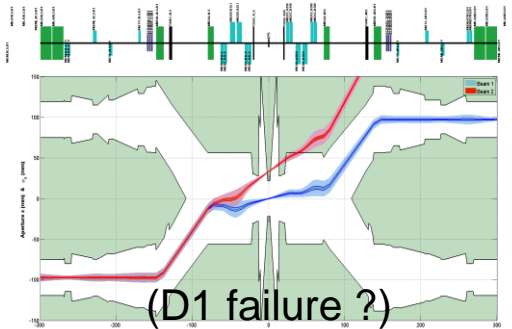   Beam gas scattering – showers from TCT – IR cross-talk …

- **Machine protection issues and possible failure scenarios :**

- Crab cavity failure scenarios ◄
- Dump failures : asynchronous beam dump
- UFOs
- Beam-beam kick missing
- Fast vacuum valves
- (D1 failure scenarios)

- (…)

(D1 failure ?)

Off-momentum particules at IP5.

Crab cavity failures

- Failure of the crab cavity (quench, RF power supply, LLRF & strong phase shift)

Order of magnitude : 5.3° phase change in 1 turn at IP5 ➔ particles at ± 2.4 σ_z displacement of 2.1 σ_x after 5 turns.
(*Tobias Baer et al. IPAC2012, MOPPC003*)

- Need 3 turns to dump the beam after the cavity failure is detected : So what happen to the beam halo during those 3 turns ?

- Tracking simulations using SixTrack (*with Bruce Yee Rendon BE/ABP, PhD*)

-> *Crab cavity modeled and installed (IP5 and IP1) in the SixTrack optics file thanks to Bruce*
-> one can change the voltage and the phase of any crab cavity at IP1 and IP5
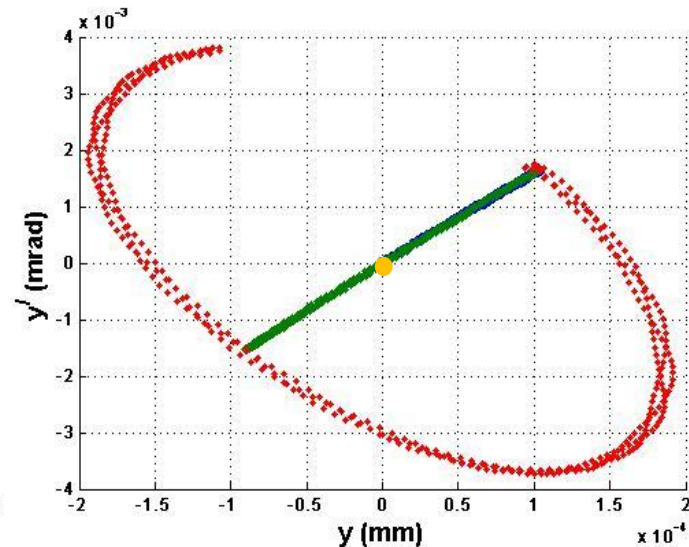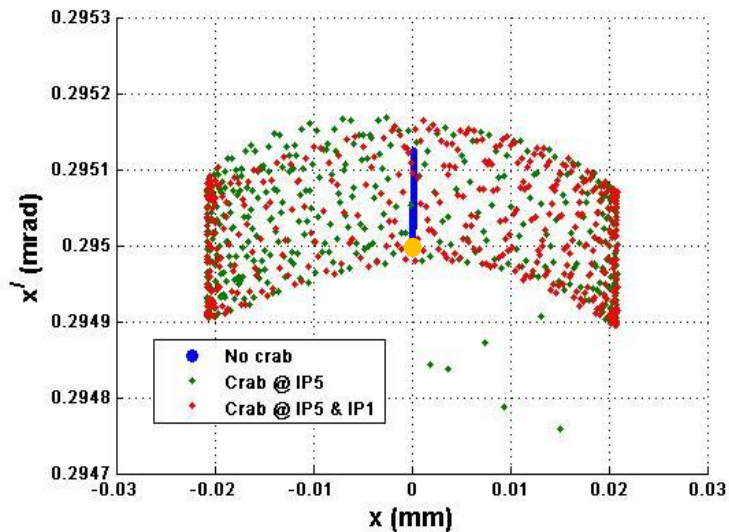-> Beam distribution settings (and collimation settings) are in progress

- 1st Goal : study the worst case (probably not fully realistic)
        -> Failure in 1 turn of the Voltage (from nominal to 0)
        -> Failure in 1 turn of the Phase control (from 0 to ±90°)
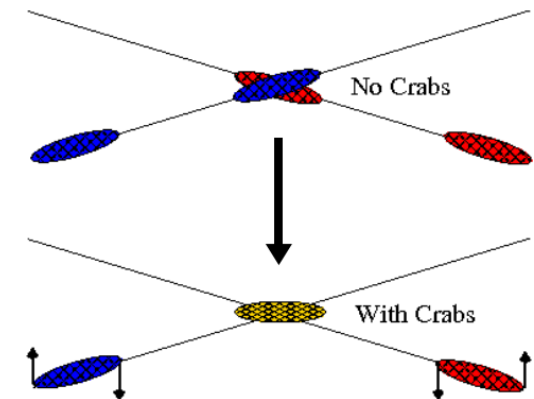
Tracking check @ IP5
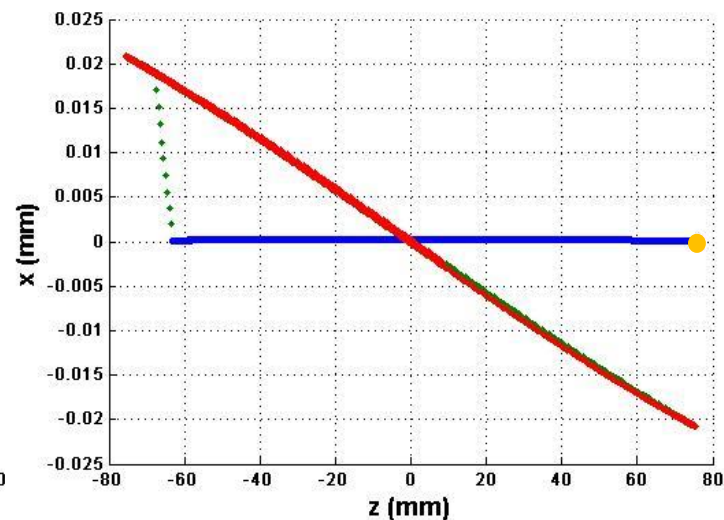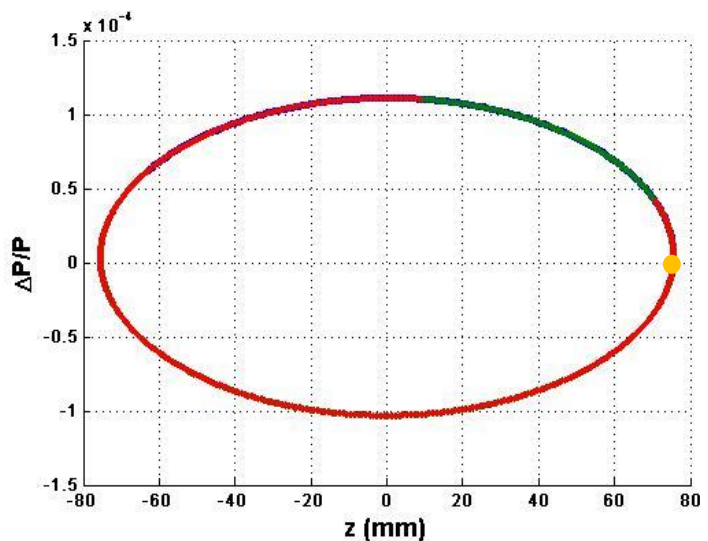
- 1 particle at 1 σ_z = 75.5 mm
- 1000 turns :
  - 1-> 200 t : no crab
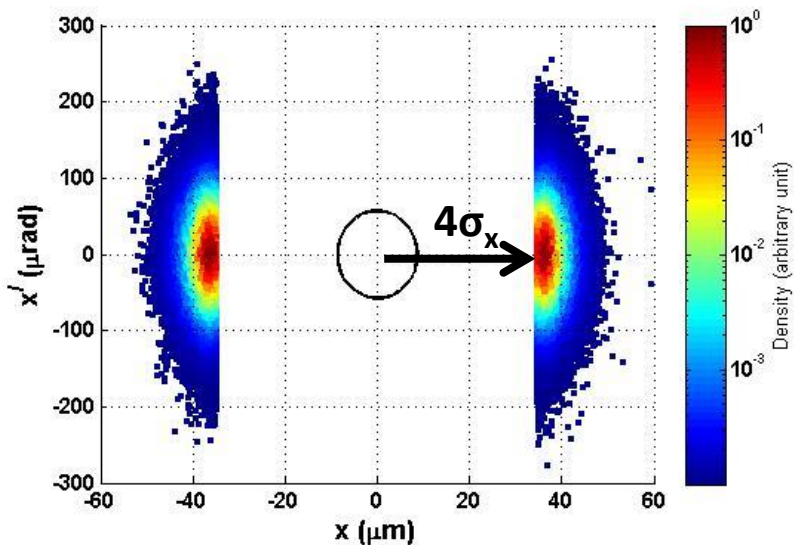 - 200 -> 600 t : Crab @ IP5
  - 600 -> 1000 t : Crab @ IP5 + IP1

Optics configuration
- SLHCV3.1b
- On collision @ 7 TeV
- β*=0.15 m

Multipart simulations : looking for a starting point

4σ$_x$

Beam :

_ **Beam 1**
_ **6.4 10^6 particles**
_ **ε$_n$=3.75 µm.rad**
_ **Gaussian distributions**
_ **Cut at 4 σ$_x$ (ie. 6.3 10^{-3} % of the total beam)**
_ **σ$_z$ = 75.5mm; ΔP/P = 1.14 10^{-4}**

Optics config :

_ SLHCV3.1b @ 7 TeV
_ collision for every IP
_ β*=0.15 m @ IP1 & IP5
_ crossing angle : 590 µrad

Collimators settings:

Coll. setting	σ
TCP IR7	6.
TCSG IR7	7.
TCLA IR7	10.
TCP IR3	12.
TCSG IR3	15.6
TCLA IR3	17.6

Coll. setting	σ
TCLP	open
TCLI	open
TCSTCDQ IR6	7.5
TCDQ IR6	8.
TDI	open
TCT IR1/5	8.3
TCT IR2/8	30.

A Marsili et al.
Collimation cleaning with ATS optics for HL-LHC
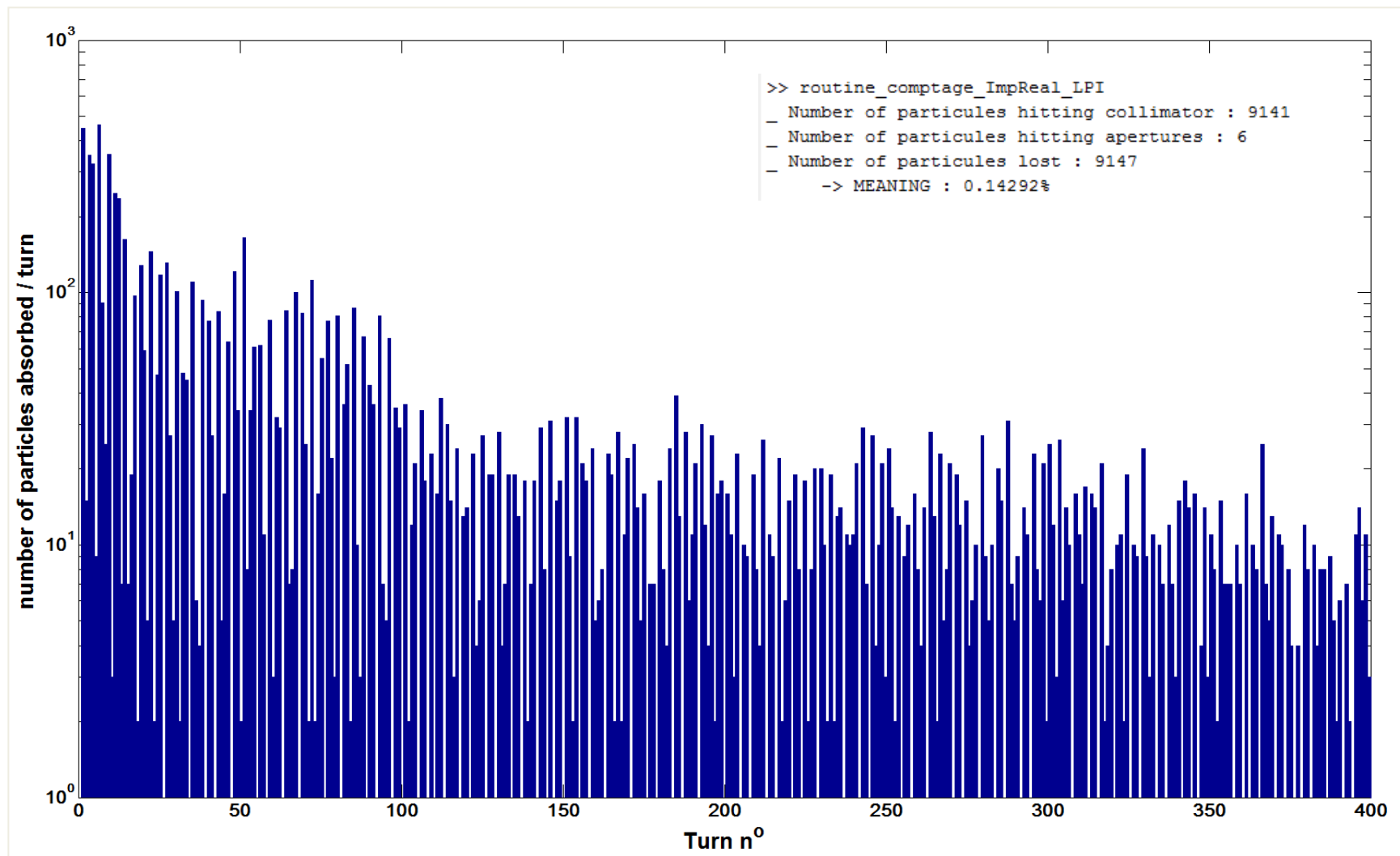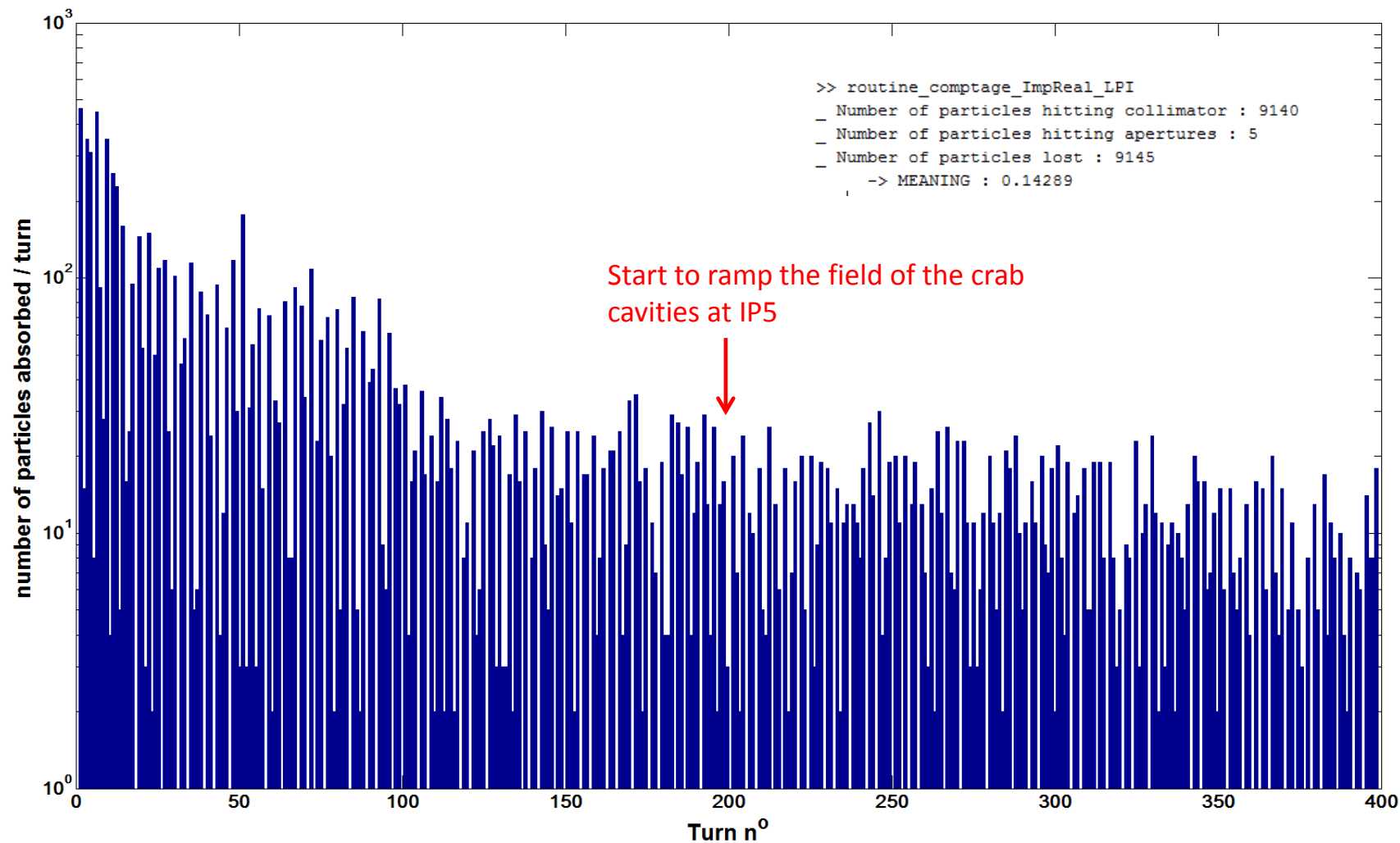*Collimation Review, 2013/30/05*
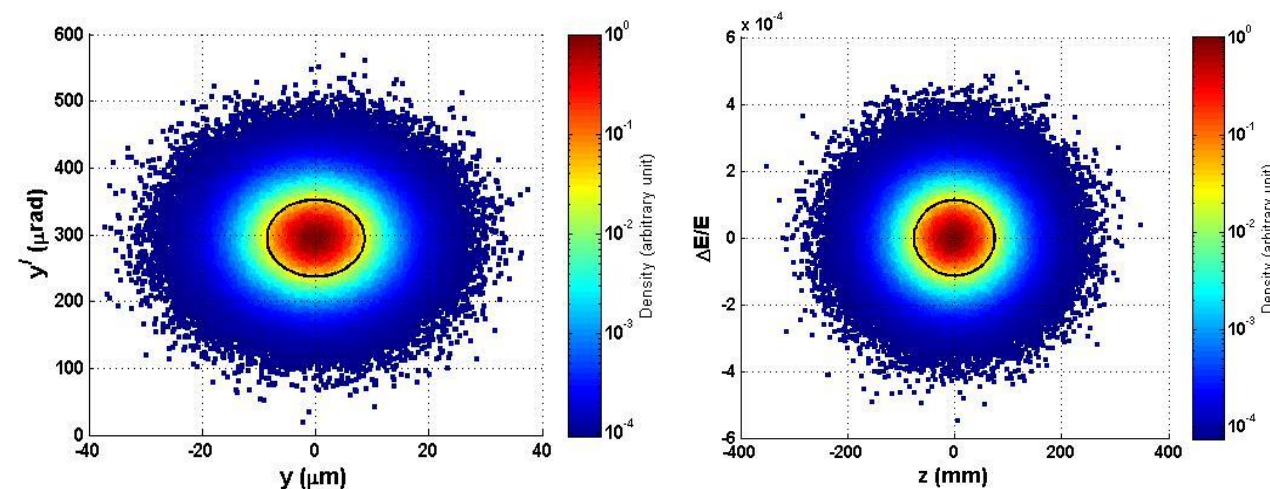
Apertures in SixTrack
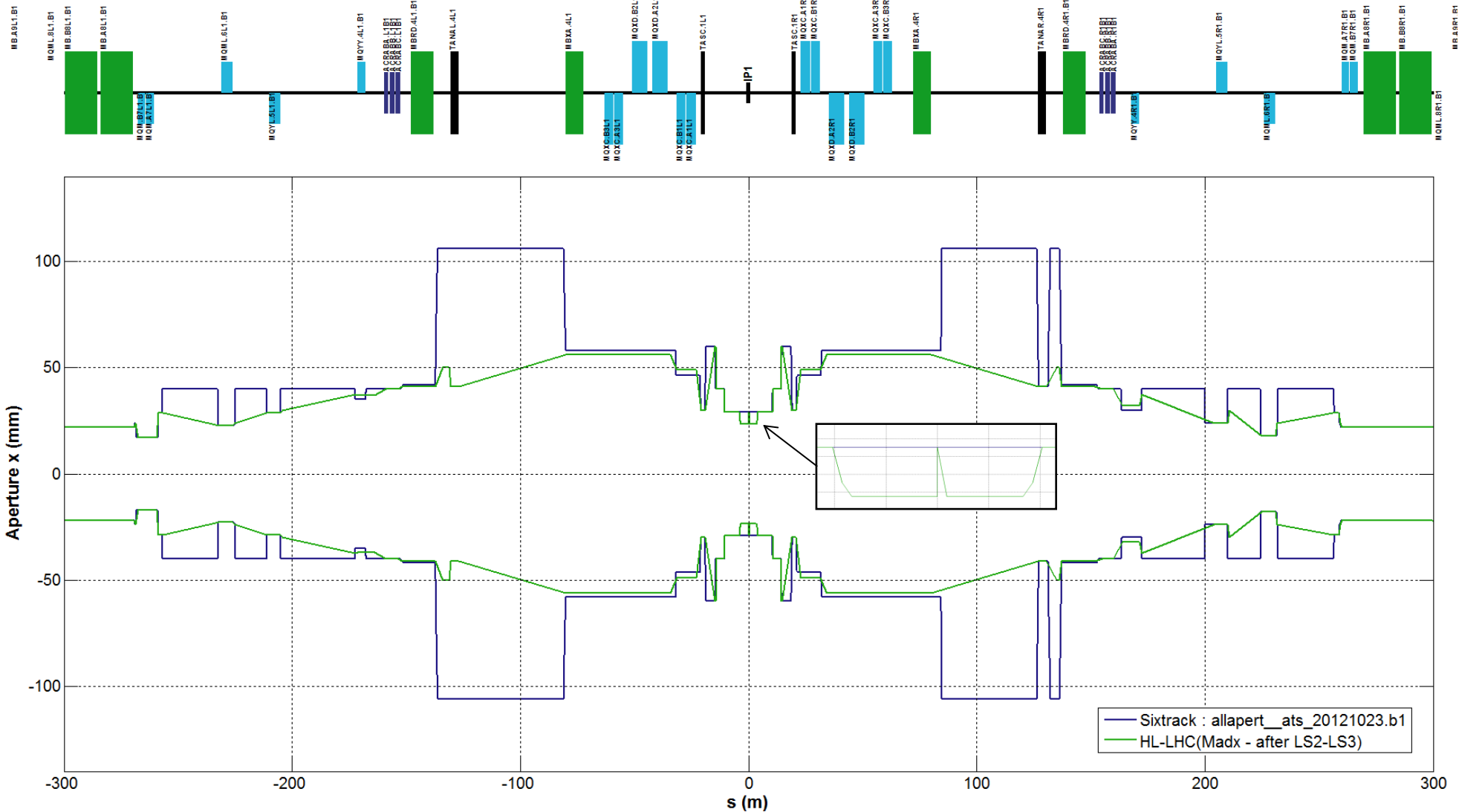
Preliminary results

A first test : _ we track 6.4 millions particules for 400 turns

_ *All the crab cavities are switched off*


```
>> routine_comptage_ImpReal_LPI
_ Number of particules hitting collimator : 9141
_ Number of particules hitting apertures : 6
_ Number of particules lost : 9147
      -> MEANING : 0.14292%
```

Preliminary results

A first test : _ we track 6.4 millions particules for 400 turns

_ *crab cavities switched ON at IP5*


```
>> routine_comptage_ImpReal_LPI
_ Number of particles hitting collimator : 9140
_ Number of particles hitting apertures : 5
_ Number of particles lost : 9145
    -> MEANING : 0.14289
```

Start to ramp the field of the crab cavities at IP5

Conclusion & last remarks

- Crab simulation with SixTrack
    - _ Can simulate failures at IP1 and IP5
    - _ Working to find the best initial conditions
    - _ Need apertures updates in the SixTrack file : *allapert_ats_20121023.b1*
    - _ *Survey file* needs updates, because we need to start simulations somewhere else than IP1
    - _ First simulate worst case scenarios.

- Apertures around the IPs
    - _ Triplets apertures increased
    - _ We consider the worst case : which is keeping the reduced beam pipes diameters at IPs
    - _ TAS aperture is likely increased from Ø34 mm to Ø60 mm

- Asynchronous beam dump is also an import issue

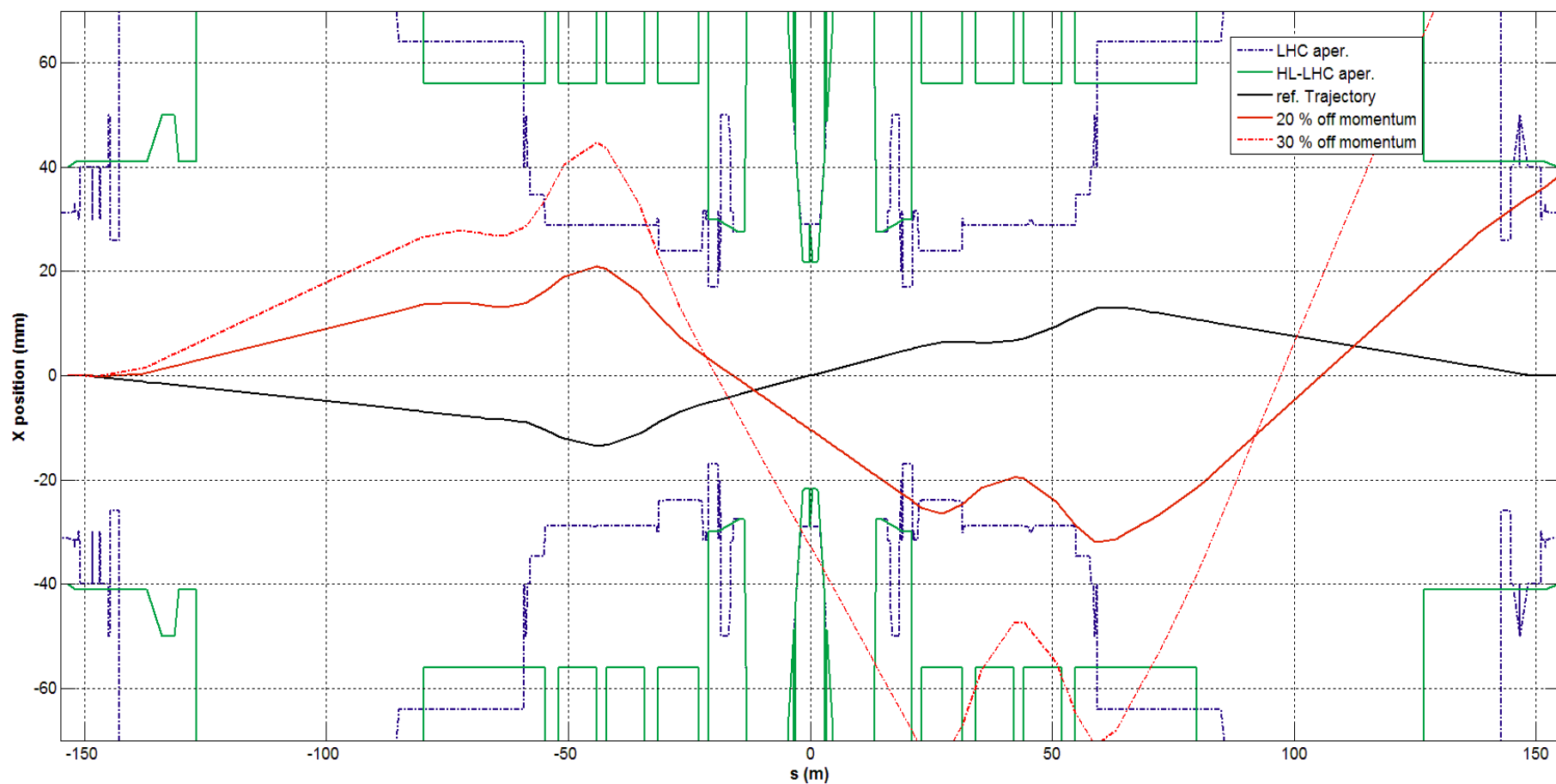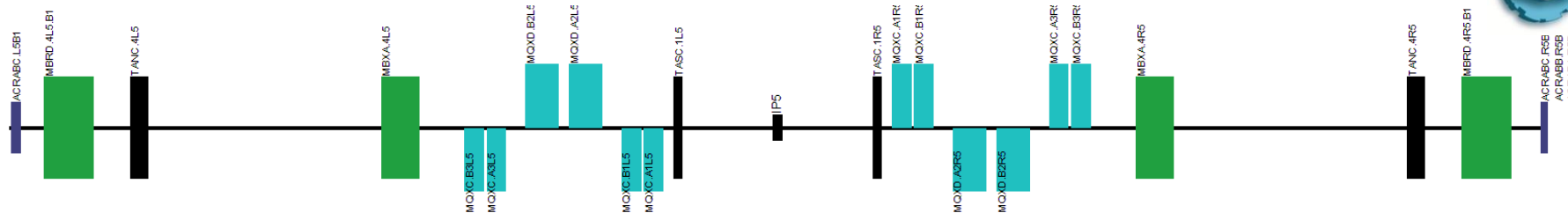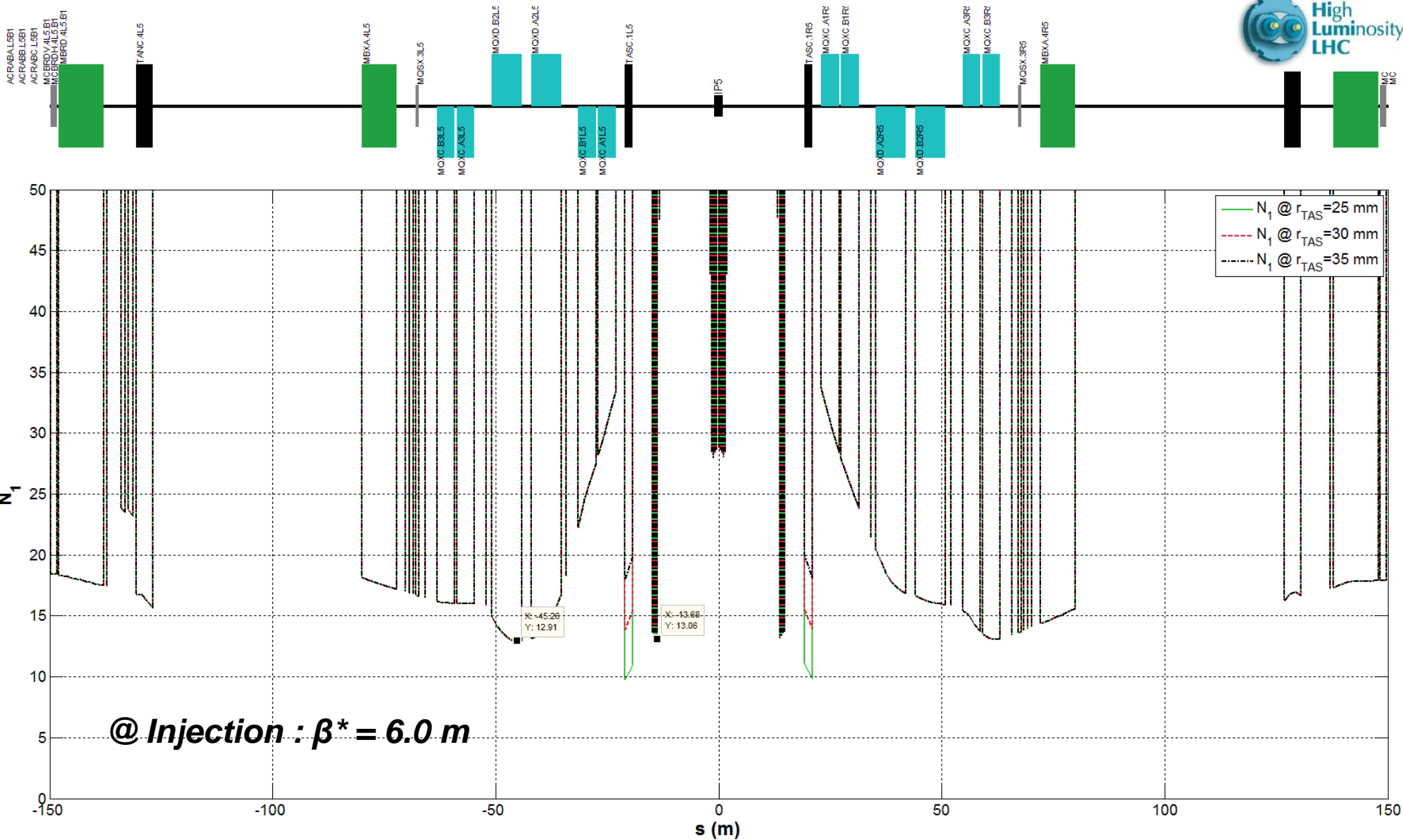- UFOs close to iPs need to be explore as well.

THANK YOU

Additional slides

LCU meeting

F.B.

Example D1 failure

LBS#47 F. Bouly
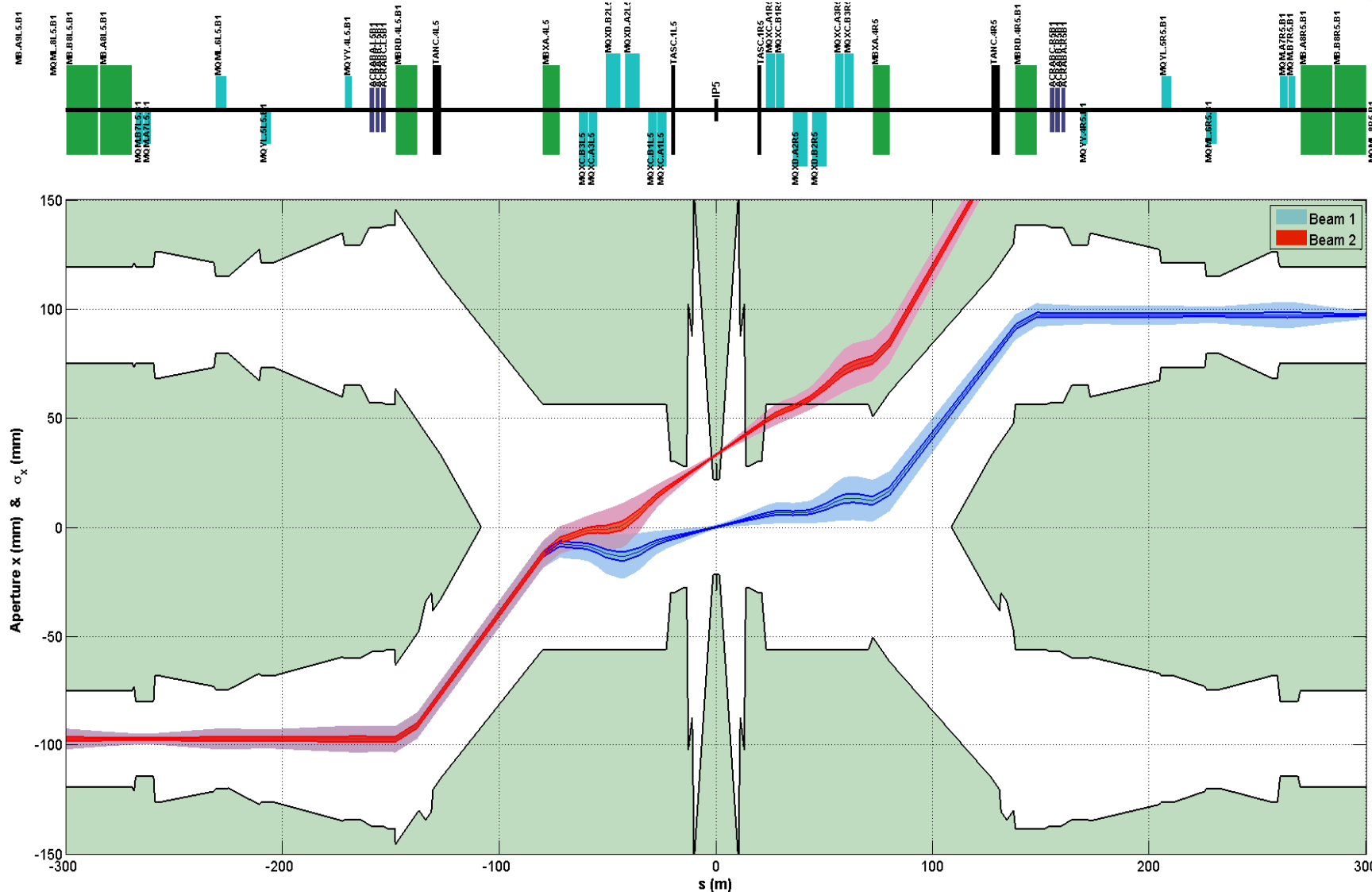
Example off momentum at injection

N1 for different TAS apertures- Beam 1- IP5

@ *Injection : β* = 6.0 m*

N1 for different TAS apertures- Beam 1- IP5

collision : $\beta^* = 0.15$ m