Matching of the beam at the entrance of the plasma

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DESY

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Outline

Motivation

- Plasma acceleration allows very compact acceleration.
- But plasma acceleration needs small longitudinal beams.
- Current injectors produce beams much longer beam than required.
- Need create small longitudinal bunches from a long one.
- Can be done using self modulation of the beam within a plasma.
- Need experimental confirmation !

Self Modulation

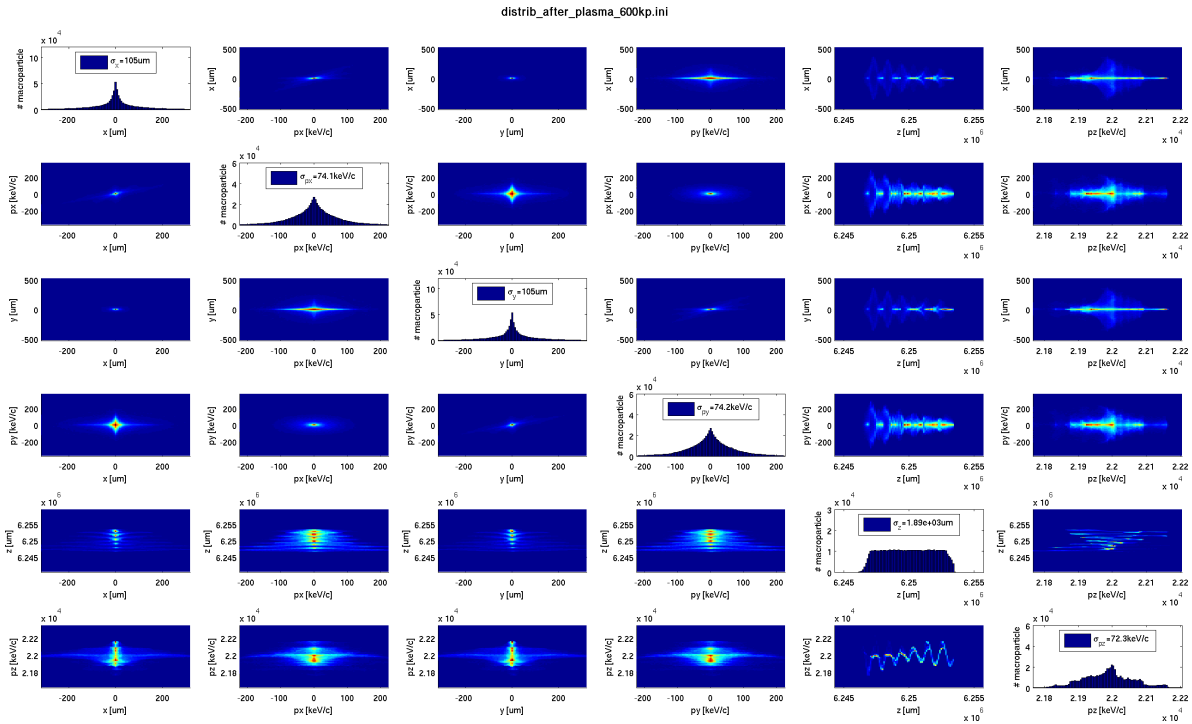
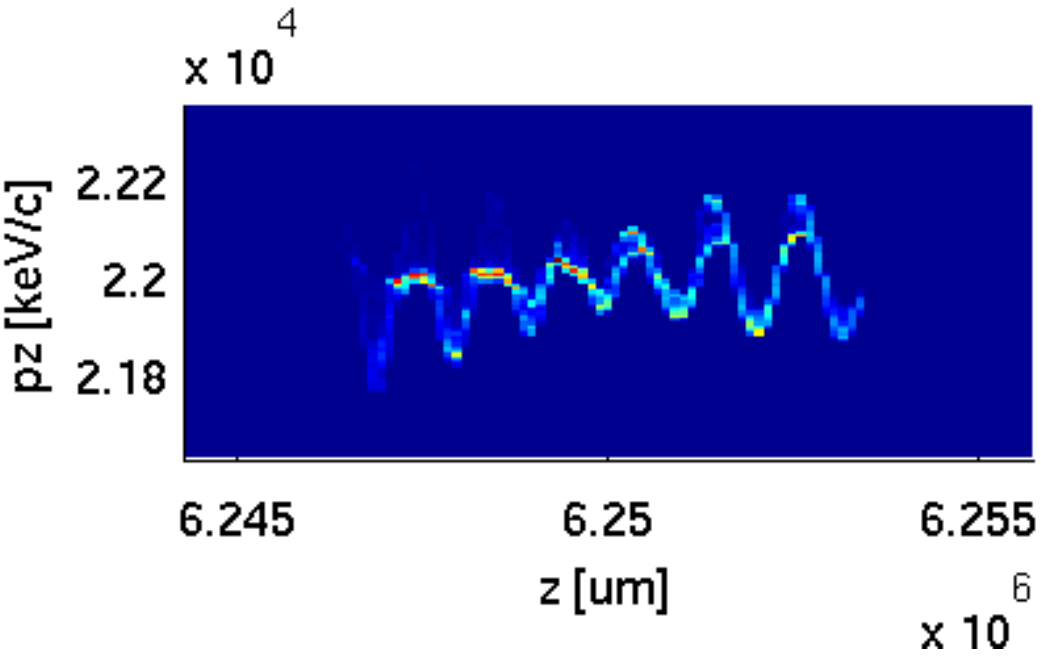


Figure: Simulated phase space after plasma

- Energy is clearly modulated.
- Modulation depends on beam size (smaller $\Leftrightarrow$ larger modulation).

Self Modulation



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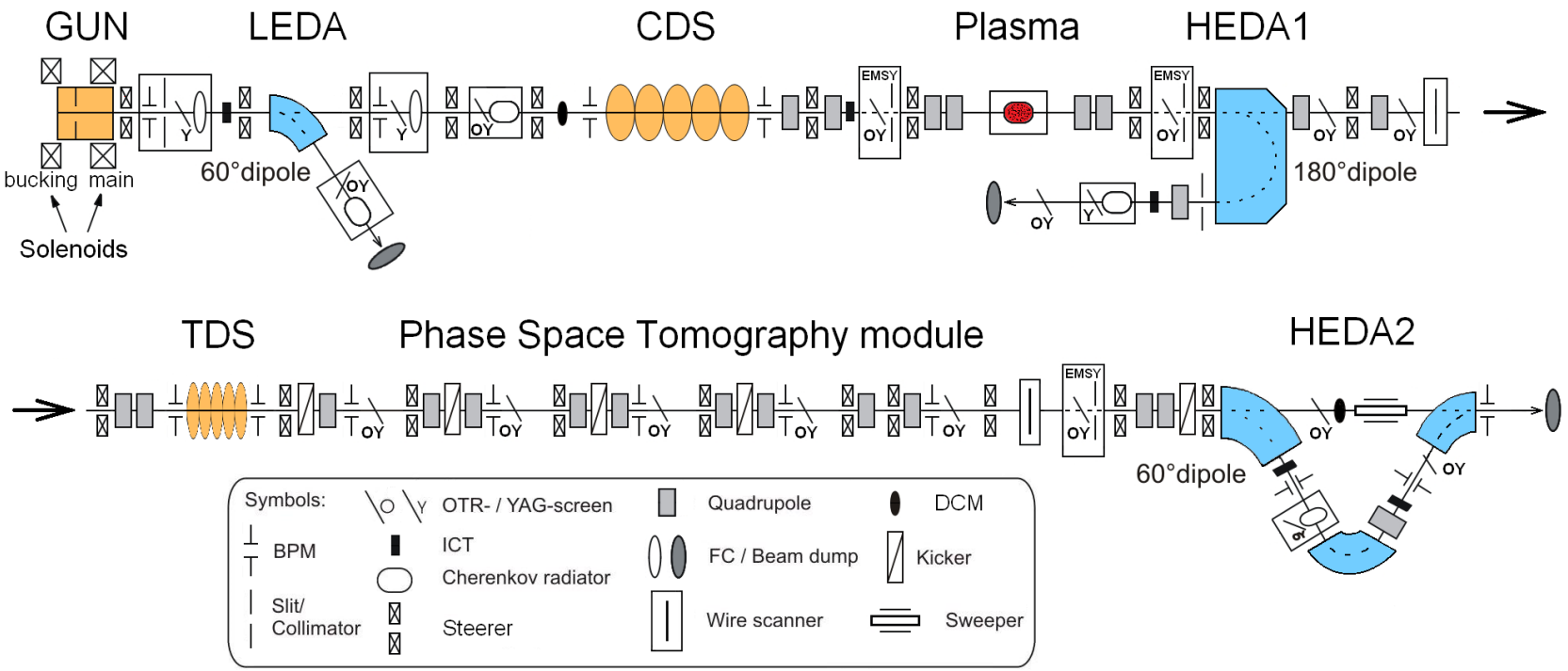
New PITZ Layout



Tracking with Astra to the end of the booster

Optimized for 100pC beam by Martin.
Get Twiss parameters and emittance at the exit of the booster (BOOST.BPM2, $z = 4.61m$)

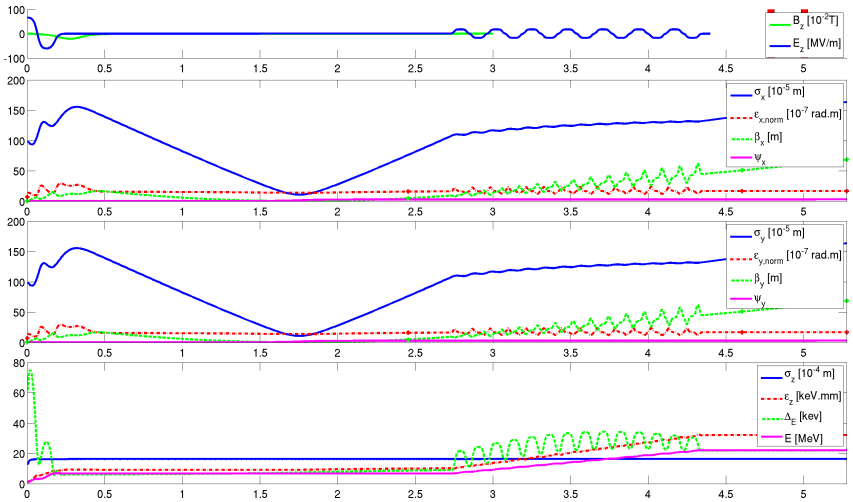


Figure: Twiss from gun to BOOST.BPM2

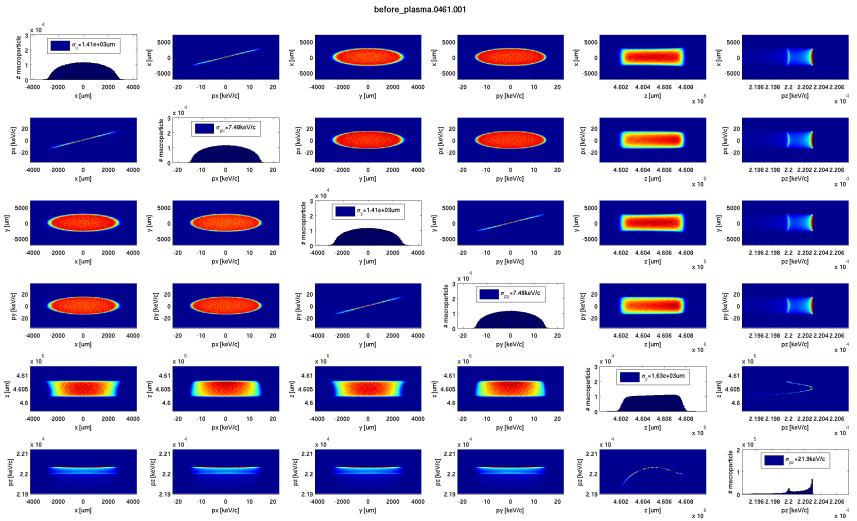


Figure: Phase space at BOOST.BPM2

Matching of quadrupoles strength with MADX

Using Twiss parameters obtained from ASTRA at BOOST.BPM2 as input. Vary:

- HIGH1.Q1 strength.
- HIGH1.Q2 strength.
- HIGH1.Q3 strength.
- HIGH1.Q4 strength.

Constraints :

- $\beta_x < 100m$ and $\beta_y < 100m$ everywhwere.
- matching $\sigma_x = \sigma_y = 50, 60, 70, 80, 90, 100\mu m$ at plasma entrance.

Much faster that doing scan with ASTRA ($< 5min$)

Matching results (50 um case)

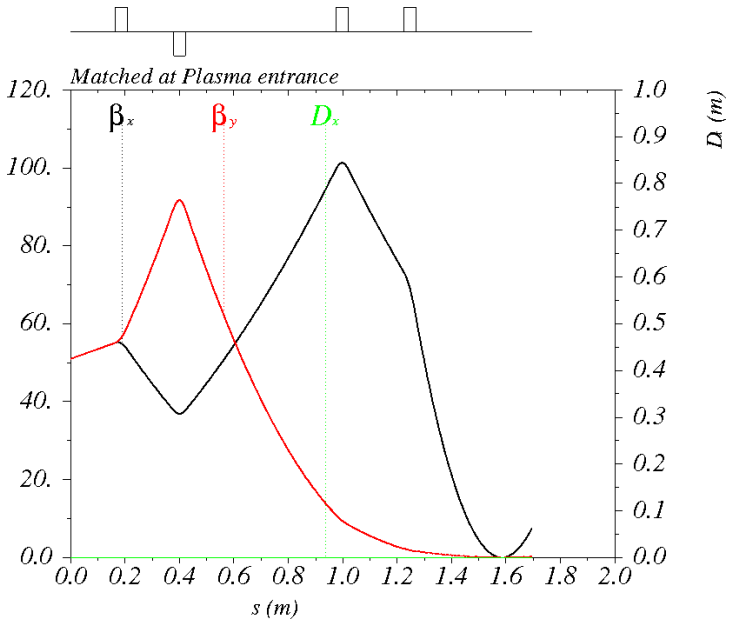


Figure: β from booster to plasma

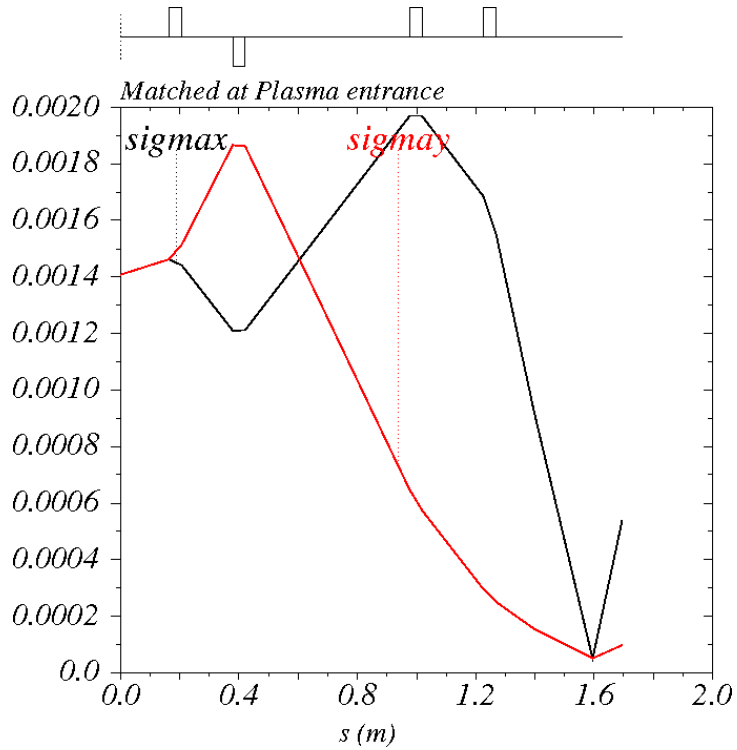


Figure: σ from booster to plasma

Tracking with ASTRA to the plasma foil

Using quadrupoles strength given by MADX, track the beam from BOOST.BPM2 to the foil isolating the plasma cell from vaccum (Z=6.0m).

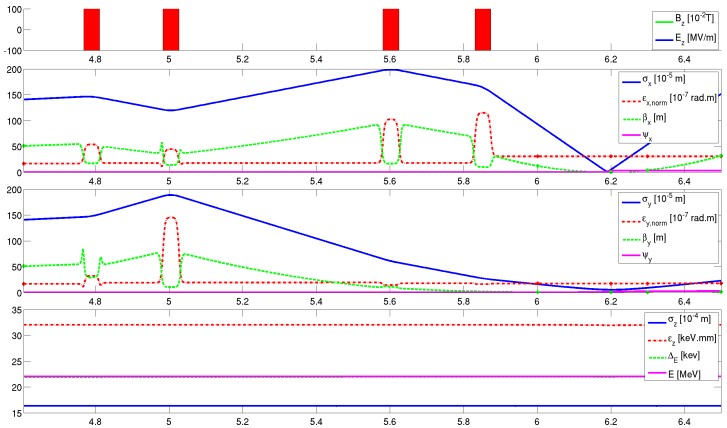


Figure: Twiss from booster to plasma

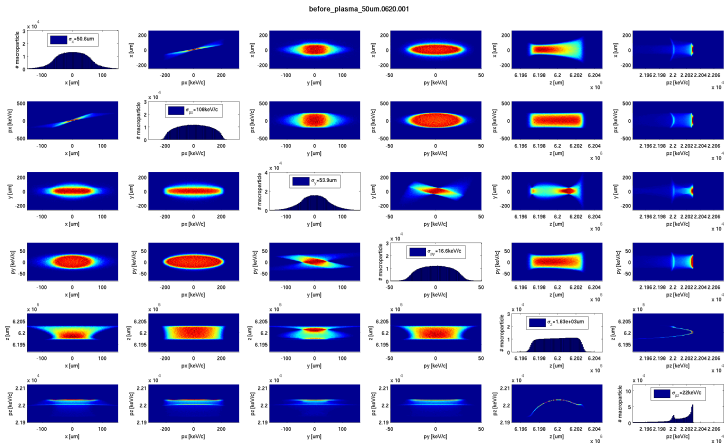


Figure: phase space at plasma entrance (z=6.2m no foil)

scattering of electrons by the foil

Thickness of the foil not decided yet, so several scattering simulated for each case ($0, 0.1, 0.2, 0.3, 0.4, 0.5 mrad$).
Scattering simulated as adding random gaussian angle with specified rms in X and Y to each particles (script from Mikhail).

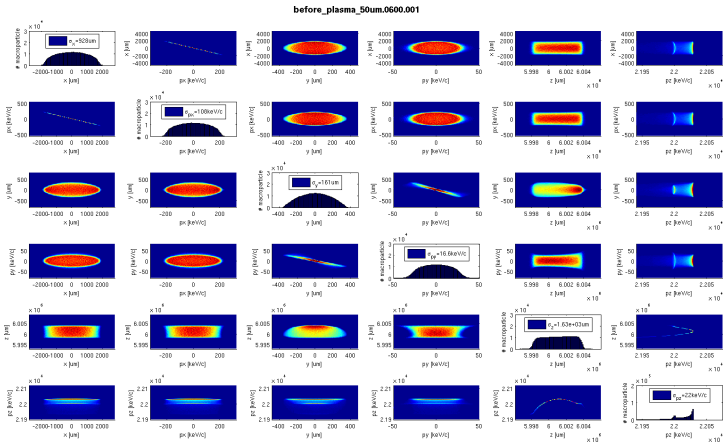


Figure: phase space before the foil

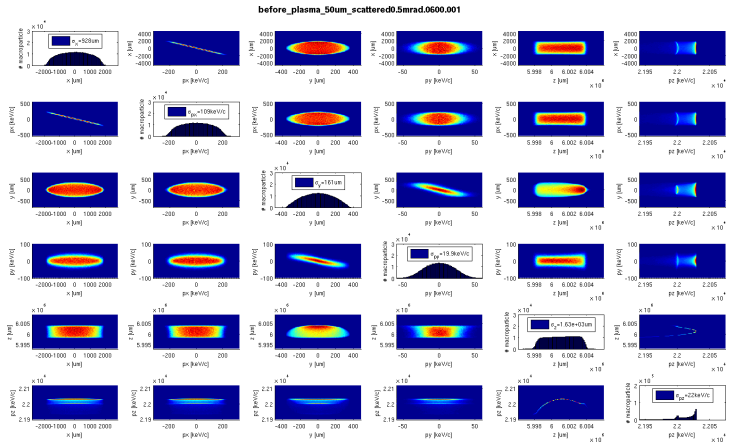


Figure: phase space after 0.5mrad scattering

Tracking with ASTRA from the foil to the plasma entrance

Using the scattered distribution, tracking from the foil to the entrance of the plasma is done with ASTRA.
Just a $20cm$ drift, nothing fancy.

Results: Beam size at the plasma entrance

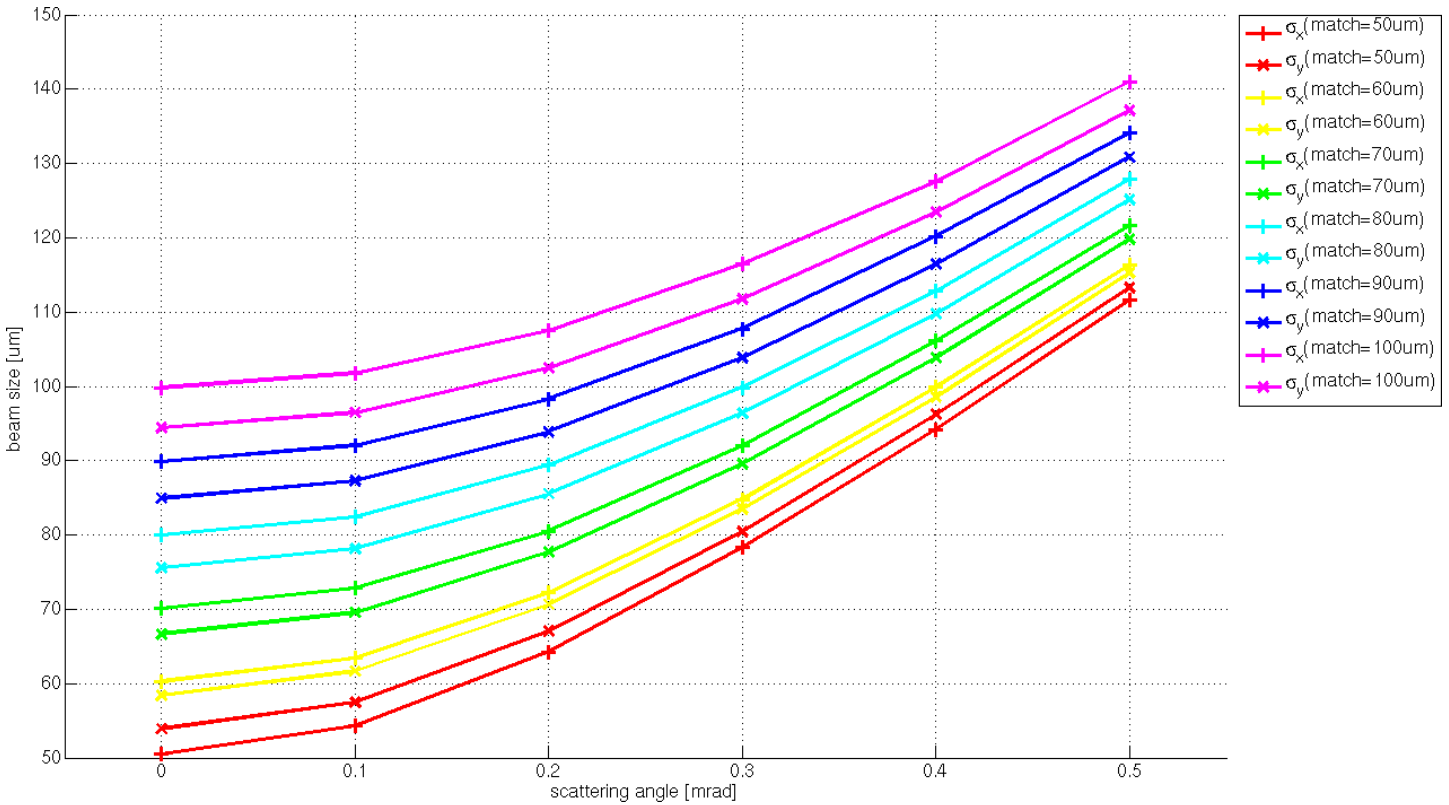


Figure: beam size at plasma entrance function of scattering for different matching conditions

Conclusion and prospects

Conclusions

- Procedure to match PITZ beamline implemented.
- Fast and robust matching possible (using MADX).
- No large deviation found between ASTRA and MADX.
- Chromatic limit seems not reached yet at 50um

Prospects

- Try matching even smaller beam size.
- No screen at the plasma entrance, experimental matching procedure to be defined.
- Matching after the plasma to be studied (for longitudianl measurement with TDS).