pbar Separator
Septum Non-Linearity

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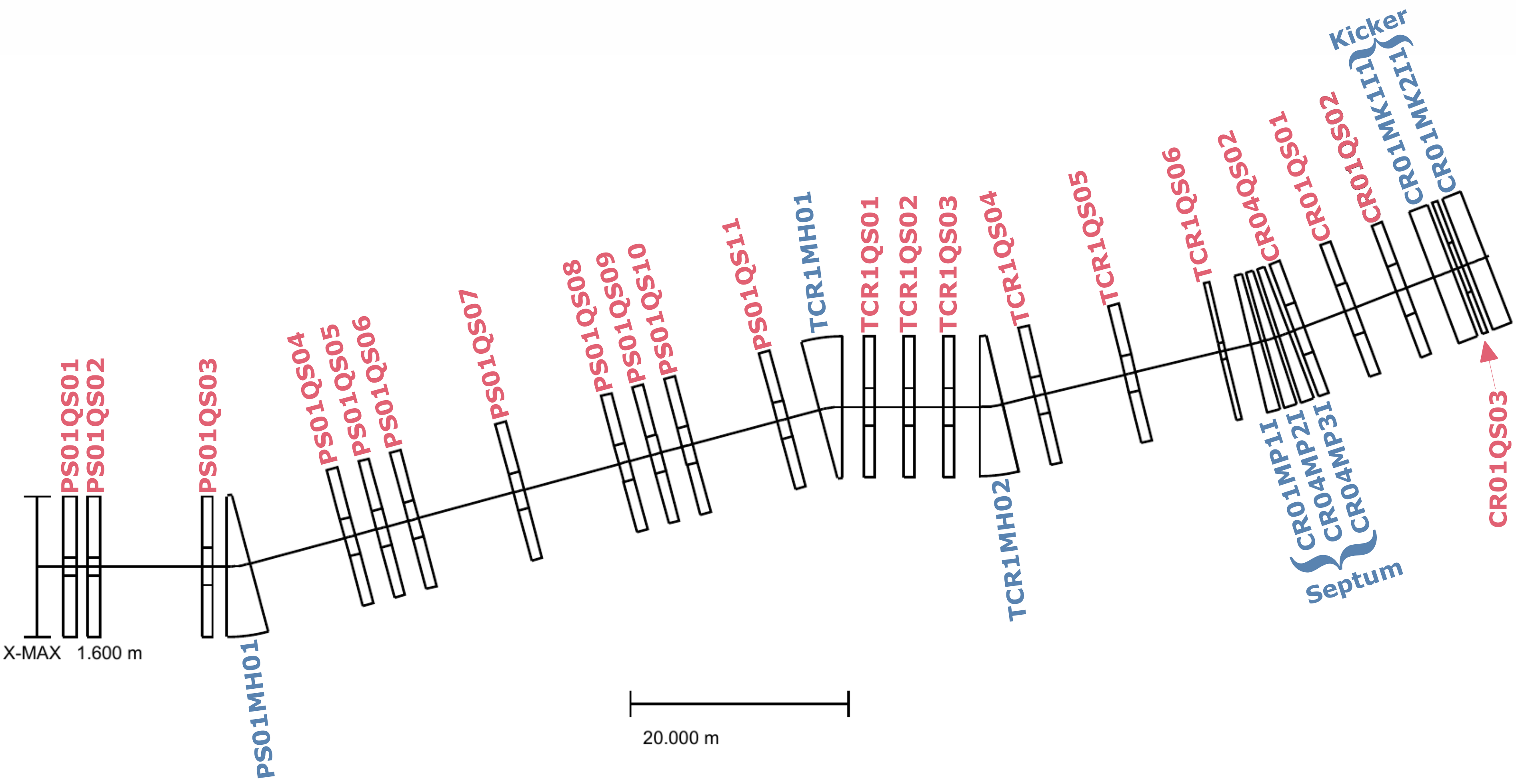
pbar Separator Beamline Overview



Simulation Software

- GICOSY is an ion optics software based on COSY 5.0, developed at the University of Gießen, Germany and still maintained also at GSI (web-docs.gsi.de/~weick/gicosy/). It has been used to assess parameters such as beta and dispersion function, twiss parameters and envelopes and to generate the transfer matrices of the ion optical elements as needed by MOCADI.

- MOCADI is a Monte Carlo simulation software developed and maintained at GSI (web-docs.gsi.de/~weick/mocadi/) which has been used to assess losses using realistic aperture shapes and an initial pbar distribution due to a MARS simulation of pbar generation through proton-target interaction followed by magnetic horn focusing*.

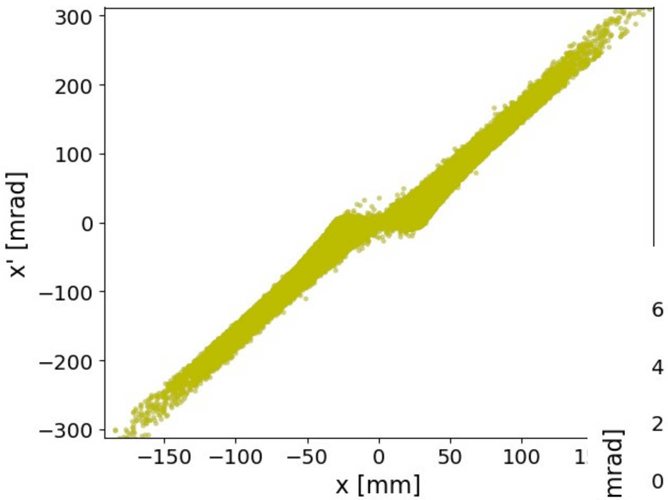
* horn focusing simulated by dedicated software

Remarks on Collimators used in MOCADI

- Collimators are either elementary, i.e. fully absorbing and infinitesimally thin, or composed of elementary ones.
- The horizontal-vertical (HV) collimator placed between the magnetic horn and PS01QS01, the beamline's first quadrupole, is simulated by two identical elementary collimators in 1.6 m distance from each other. The reference HV-collimator has a circular aperture with a 70 mm diameter.
- The horizontal and vertical collimators between PS01QS02 and PS01QS03 and the momentum collimator between PS01QS04 and PS01QS06 are each elementary ones.
- Quadrupole apertures* are simulated as three subsequent elementary collimators: at entrance, in the middle and at exit.
- Dipole apertures* are simulated as two subsequent elementary collimators: at entrance and at exit. **Exception:** the septum dipoles, where there are five elementary collimators per dipole.
- A special phase space collimator is used for assessing losses to be expected due to particles not within the ring's (geometric) acceptance.

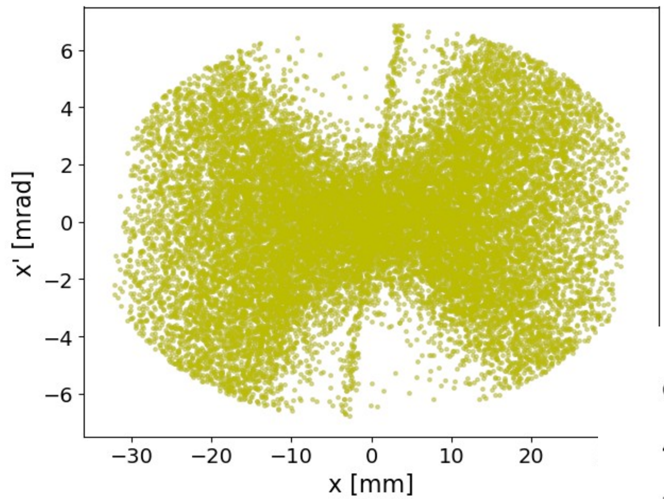
* due to yoke or vacuum chambers

Input Beam Distributions used with MOCADI

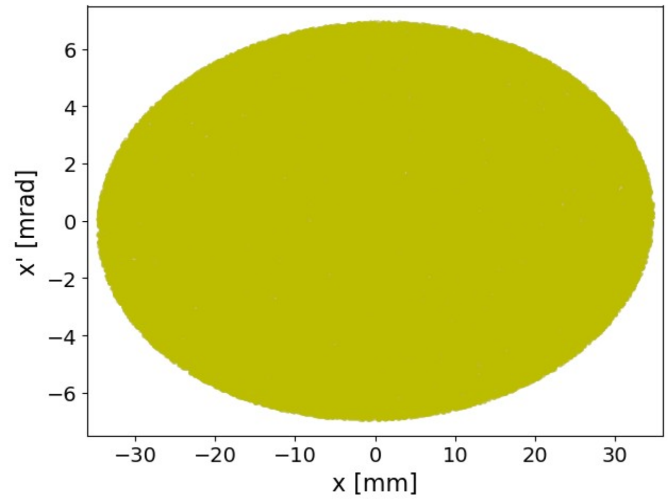


13 Tm ± 10% or 13 Tm ± 3% selection from a MARS generated beam, no acceptance limitation

Acceptance limited, 13 Tm ± 3% selection from a MARS generated beam; in some cases 13 Tm sharp were set for all particles

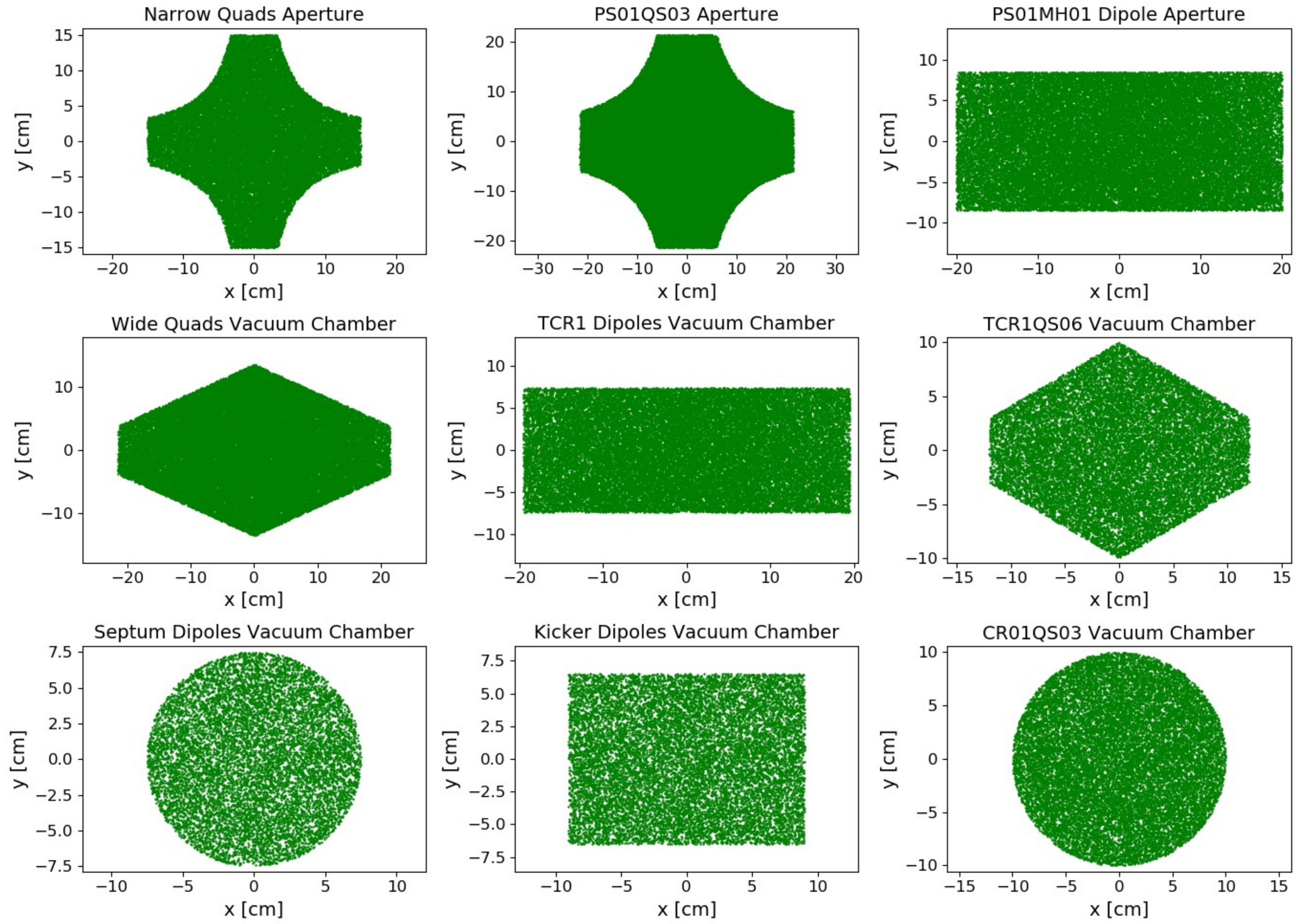


Uniformly distributed, acceptance limited 13 Tm beam

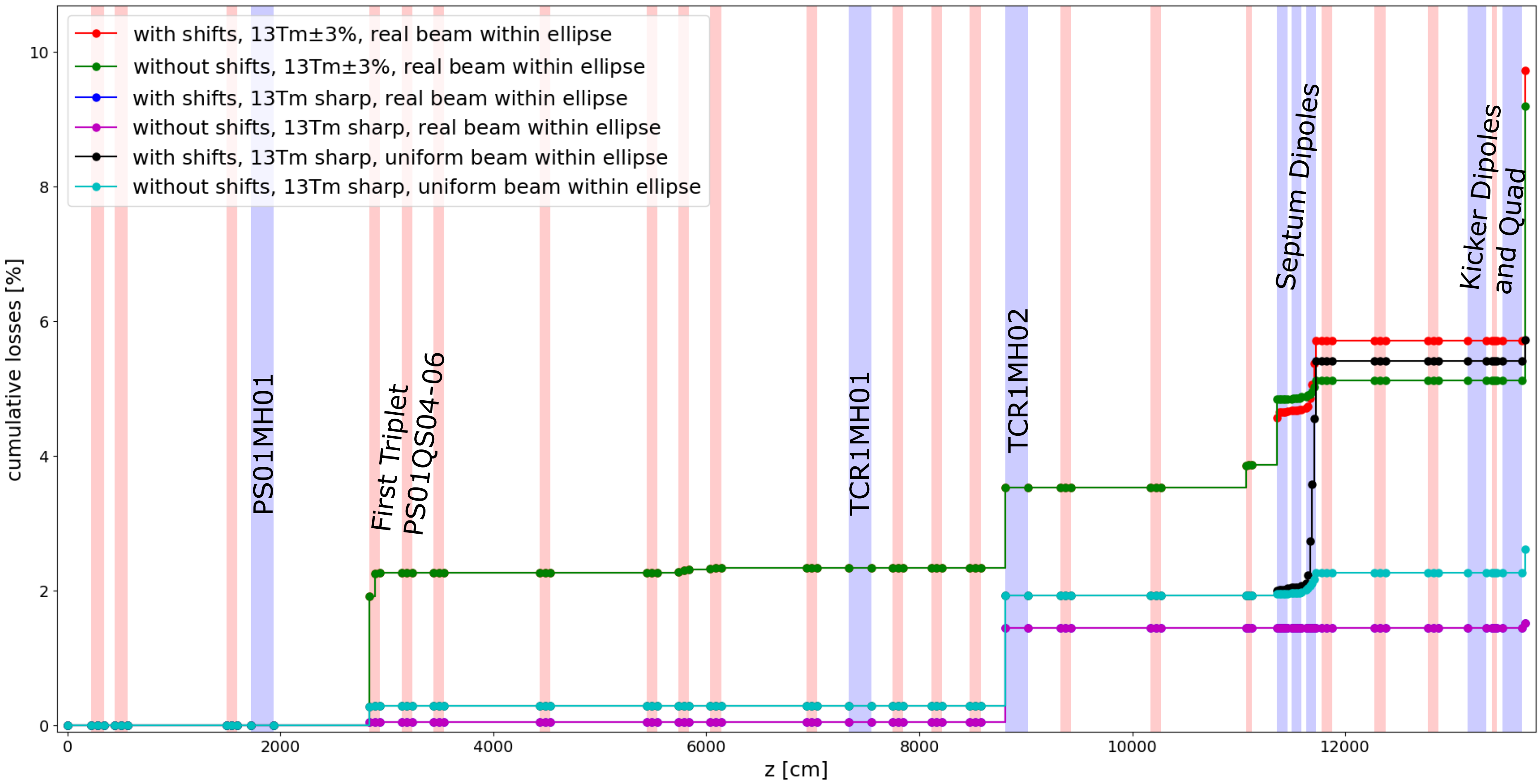


Note: Here acceptance is to be understood as purely geometrical, i.e. as defined by the x-x′ and y-y′ phase space ellipses. The ellipses used for the acceptance limited beams depend on the quad settings and position of the horn's exit plane, since they have to be imaged onto those defining the CR's acceptance.

Reference Apertures used with MOCADI

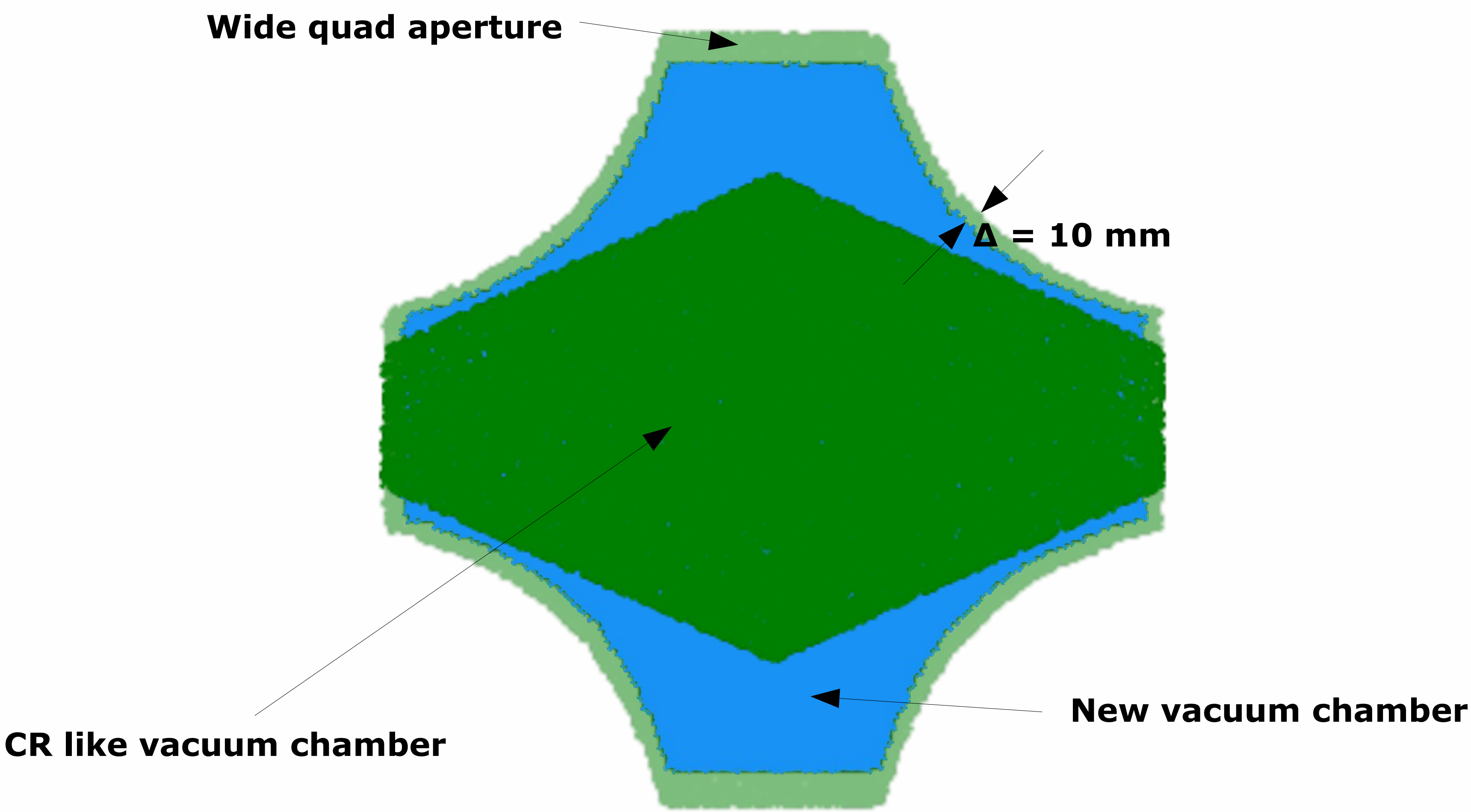


Losses for Different Acceptance Limited Beams

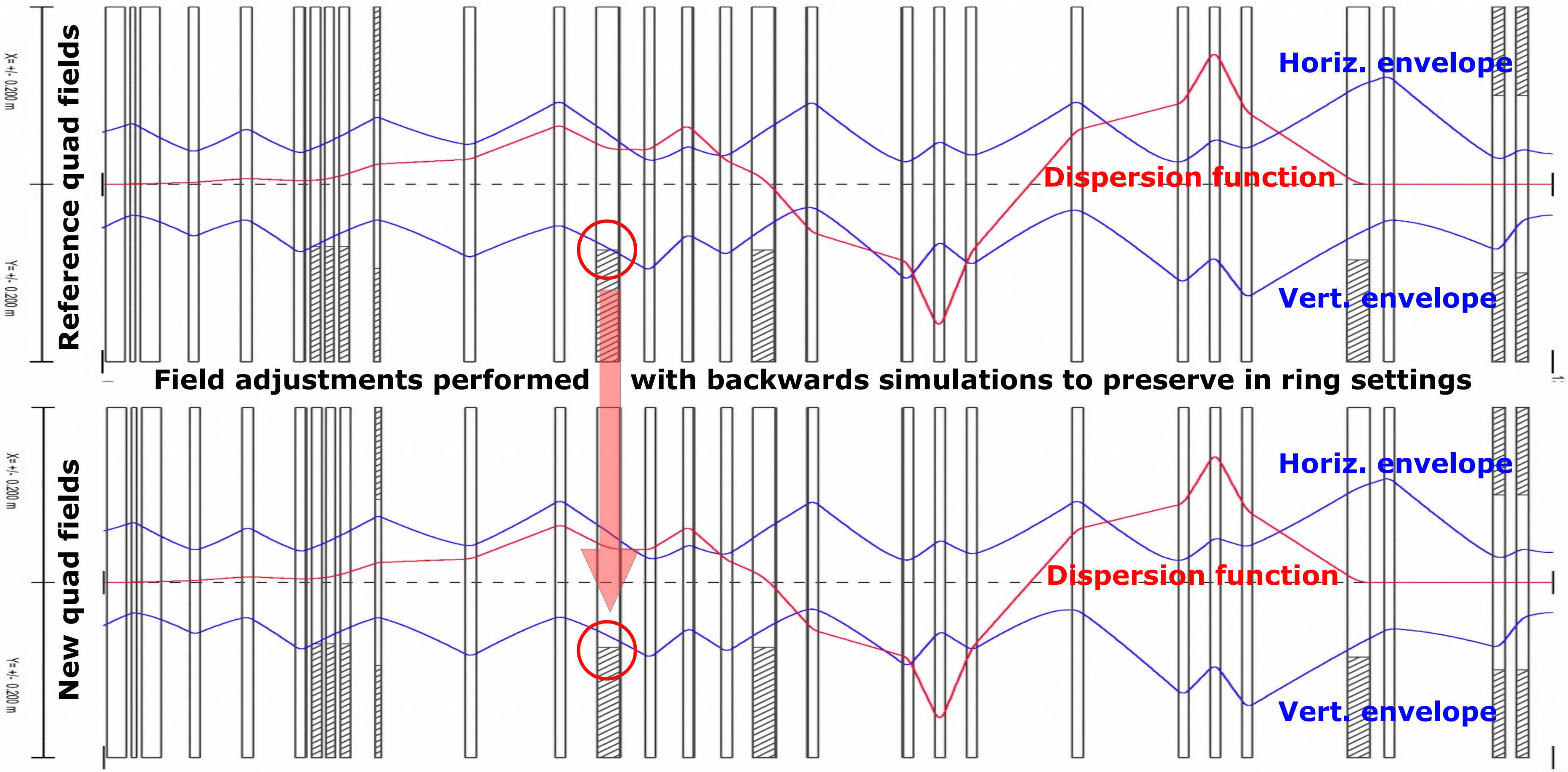


Note: No dedicated collimators used in these simulations

Reducing Losses by Chamber Removal/Modification



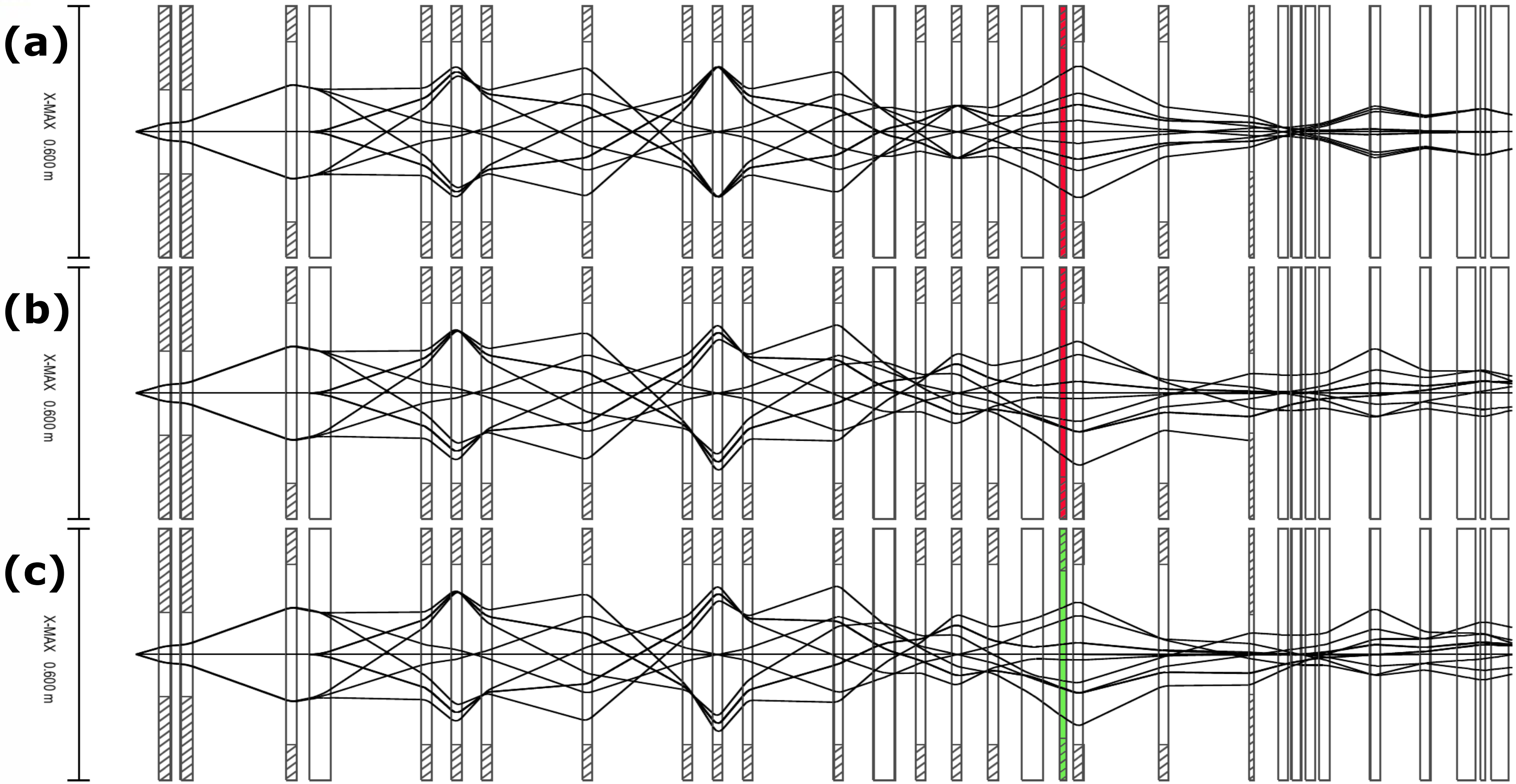
Reducing the Beam Envelope @ TCR1MH02



Field gradients in T/m – only for quads with changes

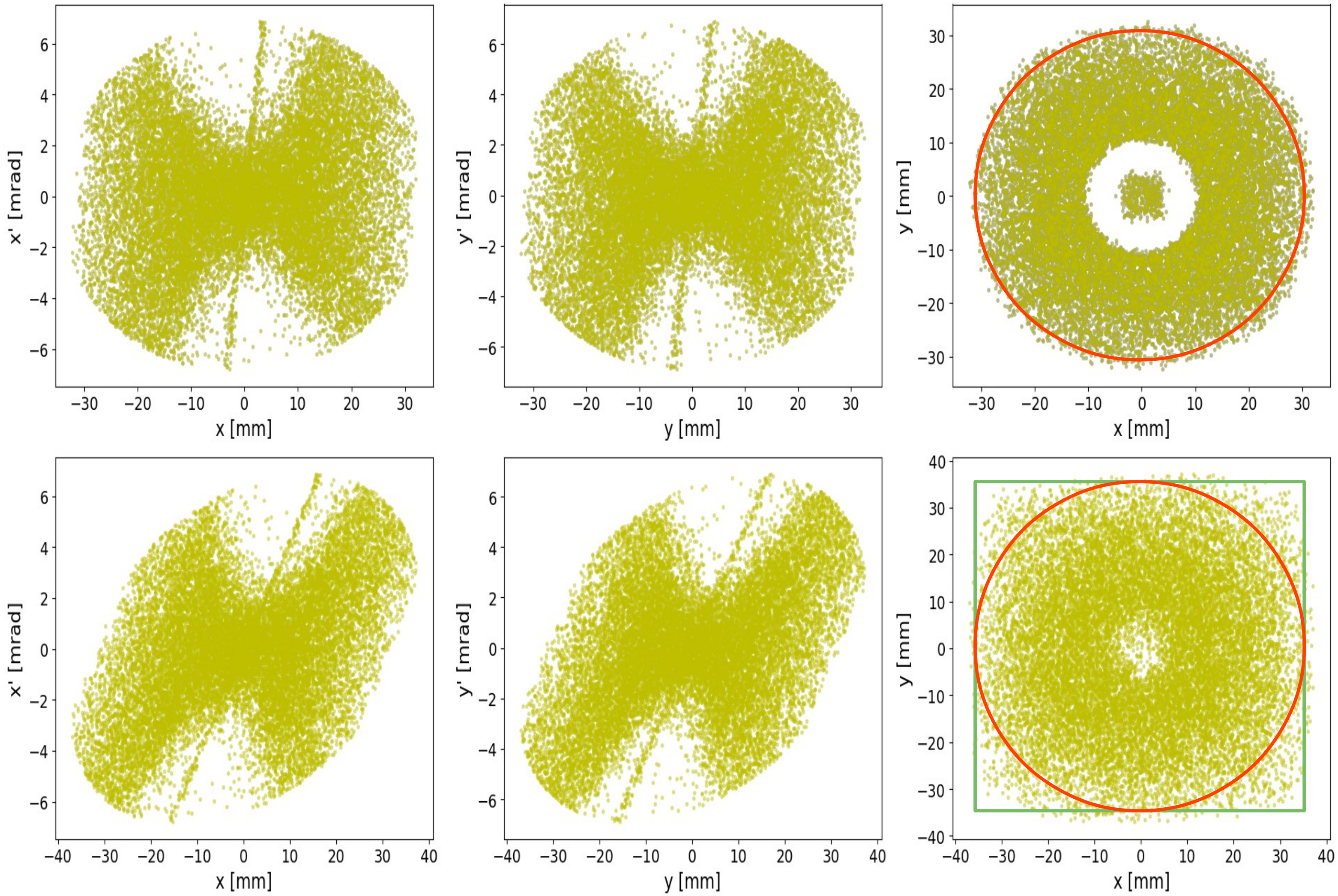
	PS01QS02	PS01QS04	PS01QS05	TCR1QS04	TCR1QS05	TCR1QS06
Reference	-3.24821	-2.40617	3.90601	2.10321	-1.79760	3.93614
New	-2.97	-2.23857	3.84080	2.16377	-1.97023	4.09569

Adding a Sextupole to Reduce Losses in Septum



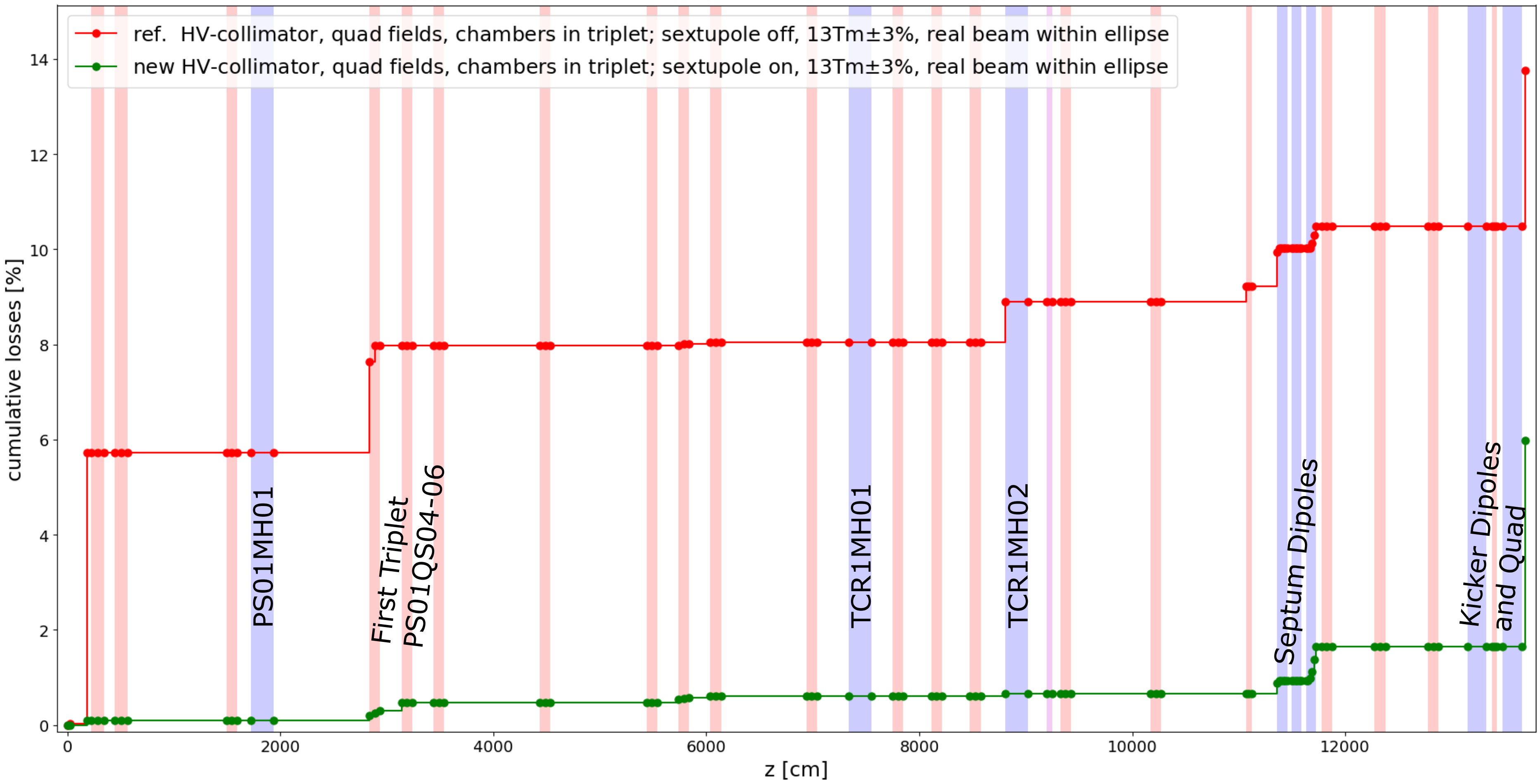
Ray tracing simulations performed with GICOSY. A point source emits along three different directions respectively three rays of different energies, including the reference one. **a)** 1st order simulation, sextupole is **off** (but also irrelevant); **b)** 3rd order simulation, sextupole is **off**; **c)** 3rd order simulation, sextupole is **on**.

Choosing HV-Collimator's Shape and Size

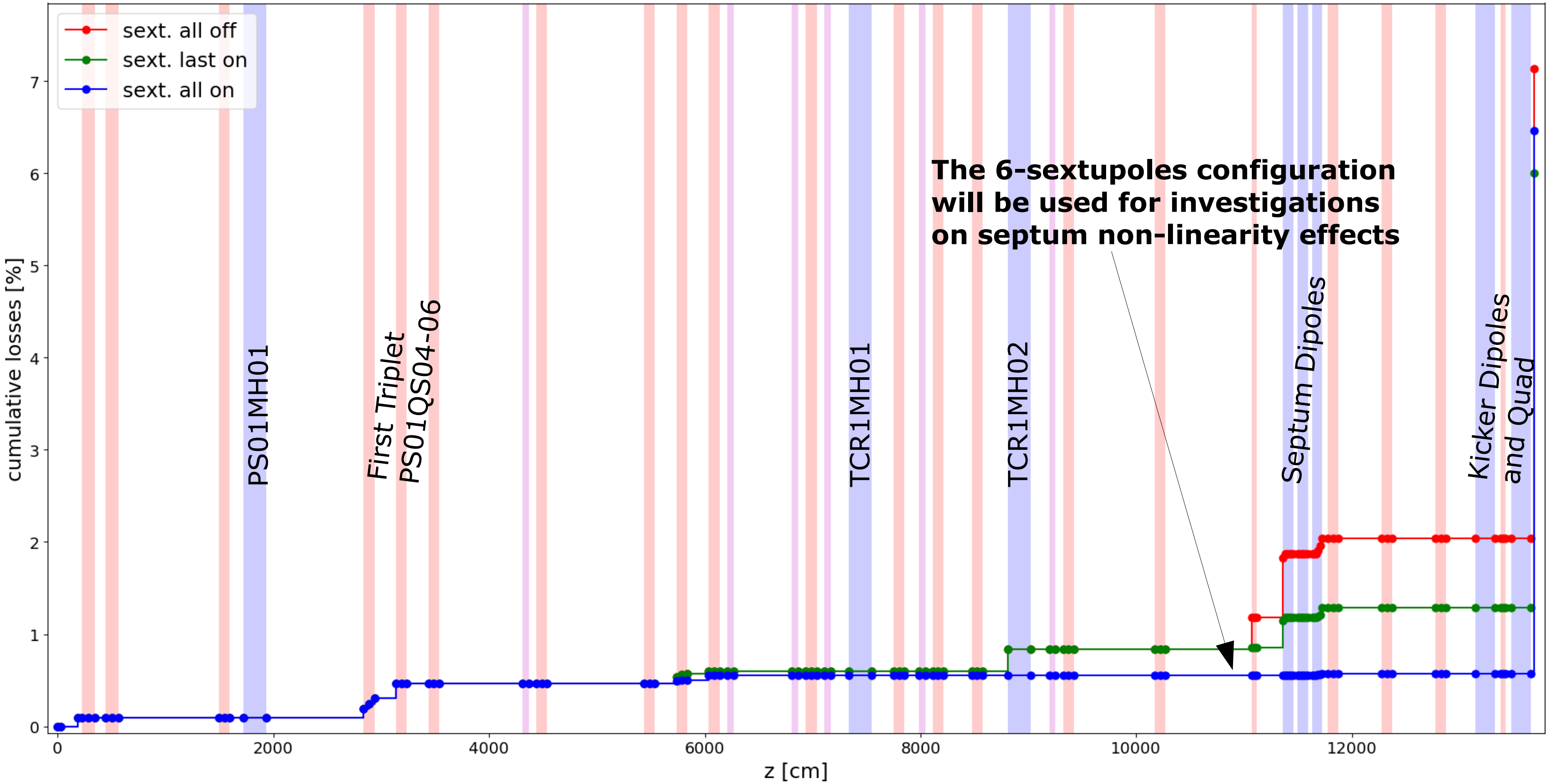


Note: Particle distributions at horn's exit plane (upper graphs) and after a drift to the position of the collimator's exit plane. No collimator used for this simulation!

Losses Comparison: Reference vs. New Set-Up

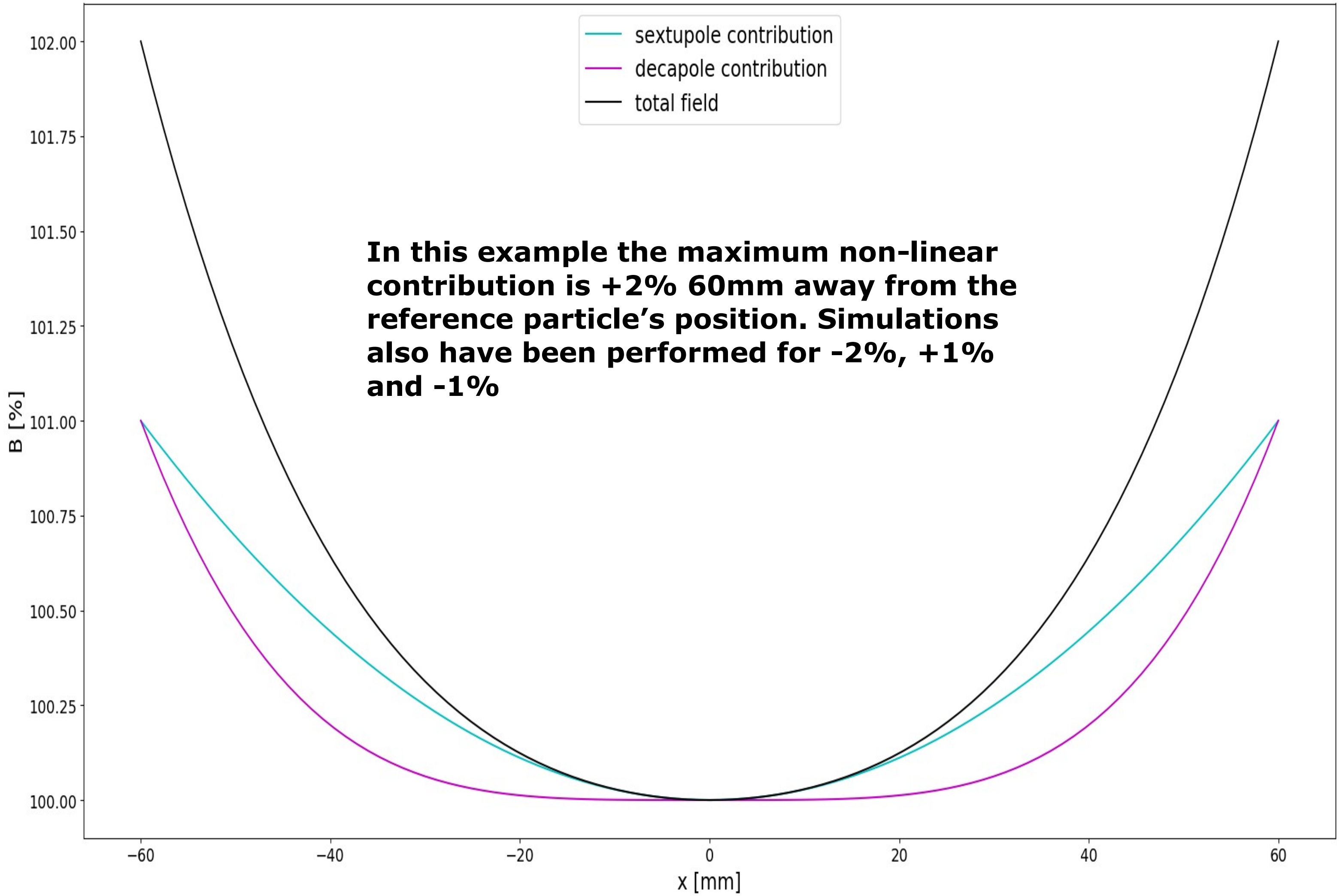


Losses Comparison: 0, 1 or 6 Sextupoles On



Note: Acceptance limited beam used for these simulations

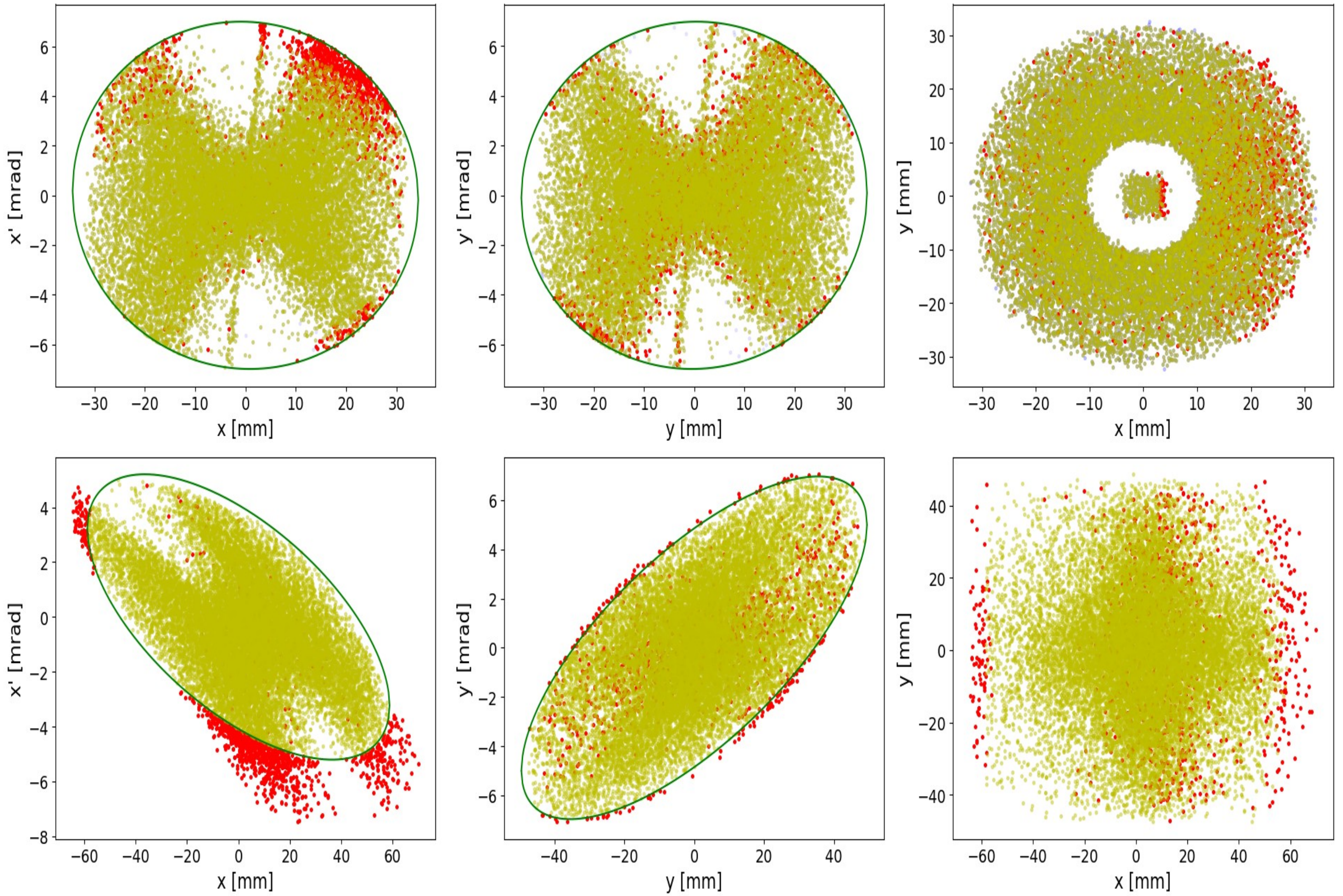
Typical Septum Field Non-Linearity for Simulations



In this example the maximum non-linear contribution is +2% 60mm away from the reference particle's position. Simulations also have been performed for -2%, +1% and -1%

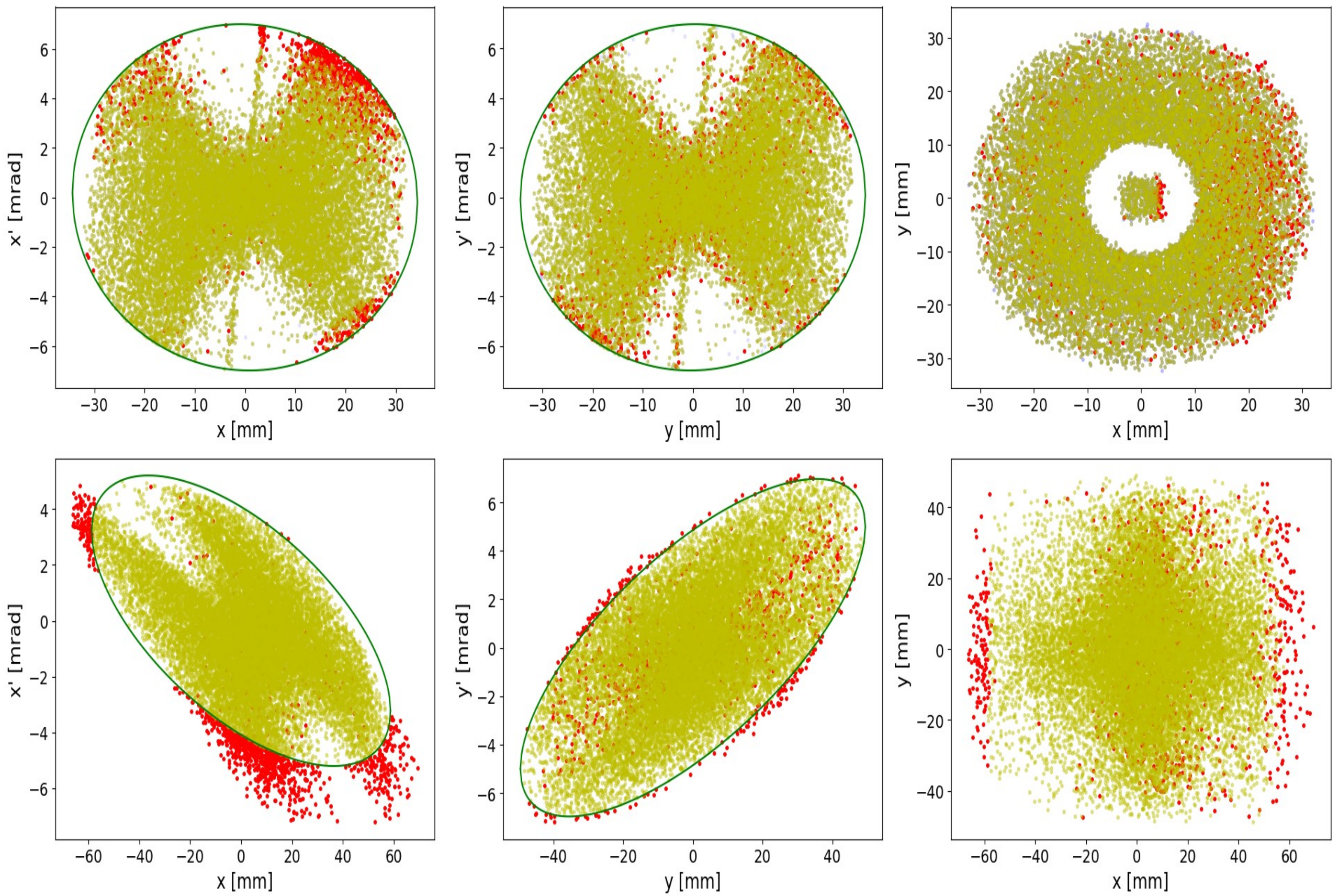
Note: The vertical field component is shown as function of lateral displacement from the reference particle's position within the (horizontal) symmetry plane of the septum.

Phase Space at Input and Output, Ideal Septum



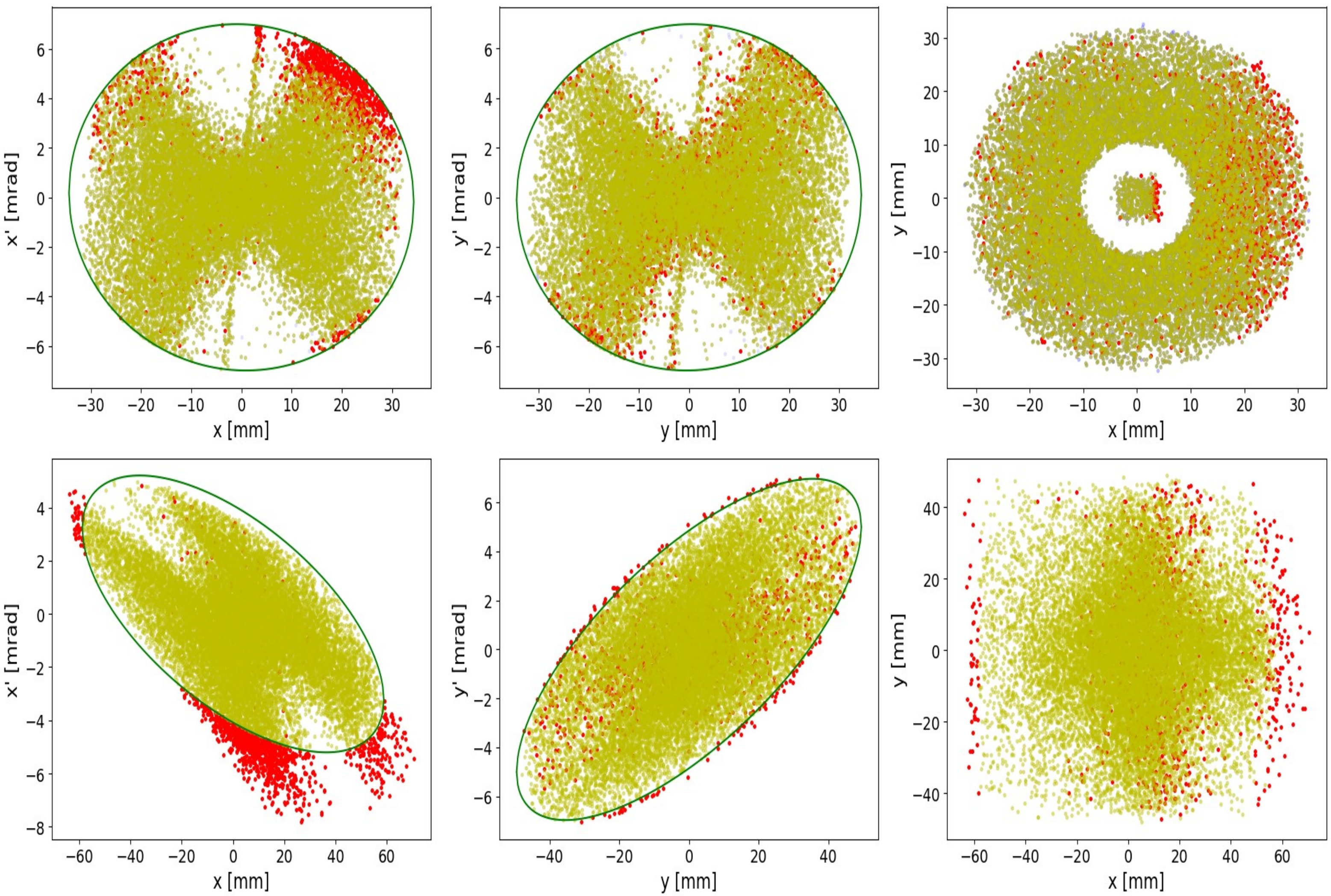
Note: Particle distributions at input (horn's exit plane) are shown in the upper graphs. Particles shown in red would get lost because they don't fit into the CR's acceptance!

Phase Space at Input and Output, -1% Non-Linear Contribution



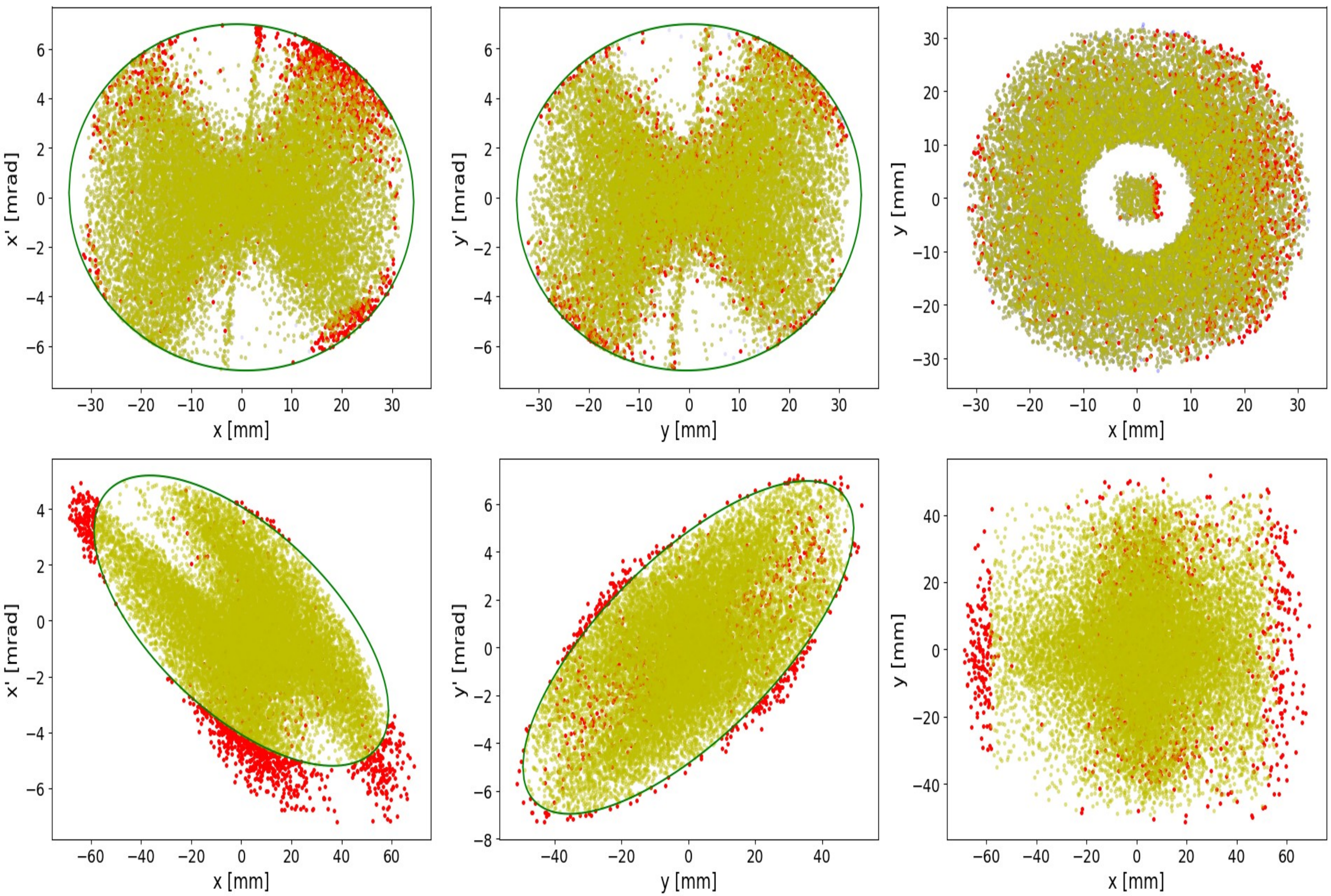
Note: Particle distributions at input (horn's exit plane) are shown in the upper graphs. Particles shown in red would get lost because they don't fit into the CR's acceptance!

Phase Space at Input and Output, +1% Non-Linear Contribution



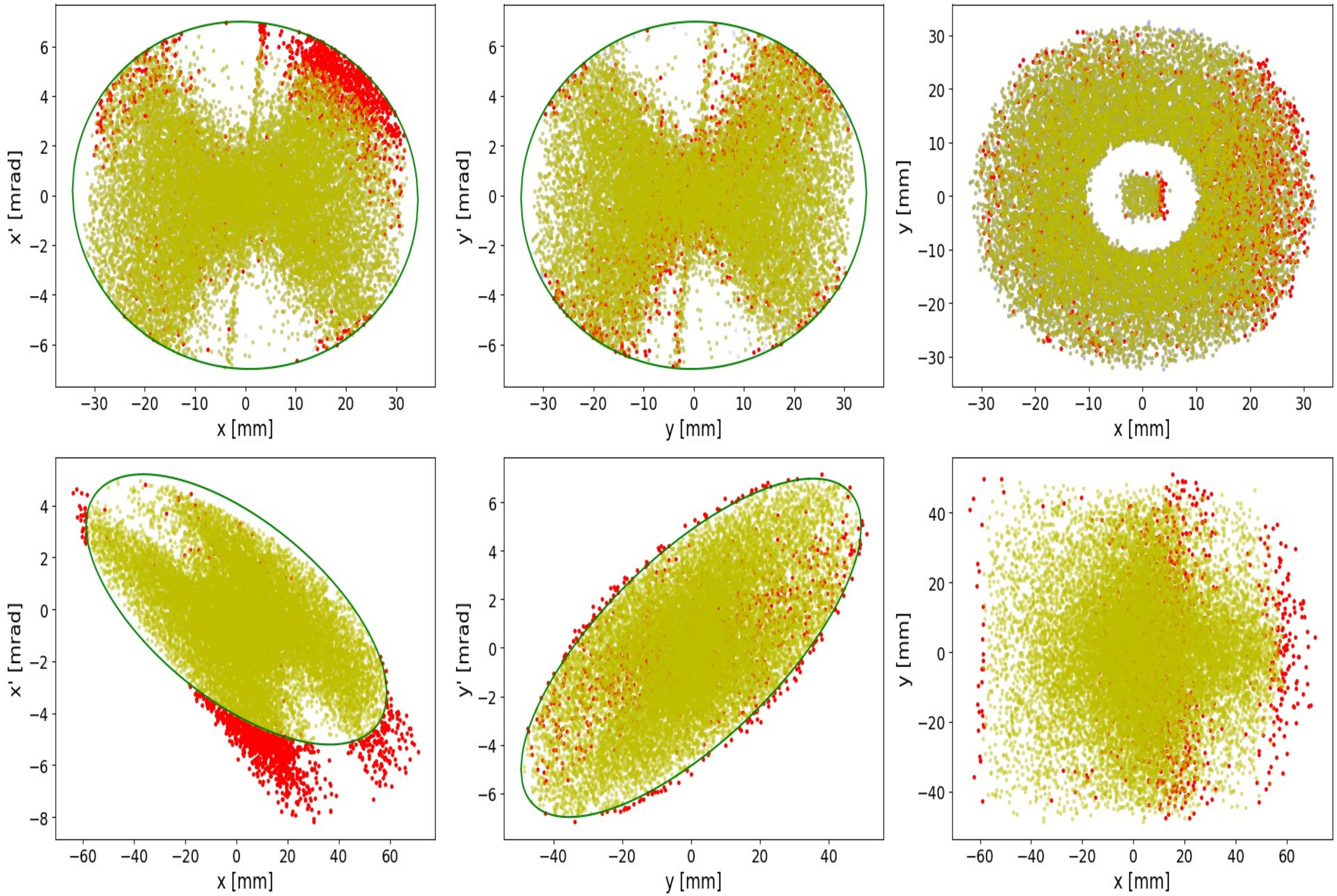
Note: Particle distributions at input (horn's exit plane) are shown in the upper graphs. Particles shown in red would get lost because they don't fit into the CR's acceptance!

Phase Space at Input and Output, -2% Non-Linear Contribution



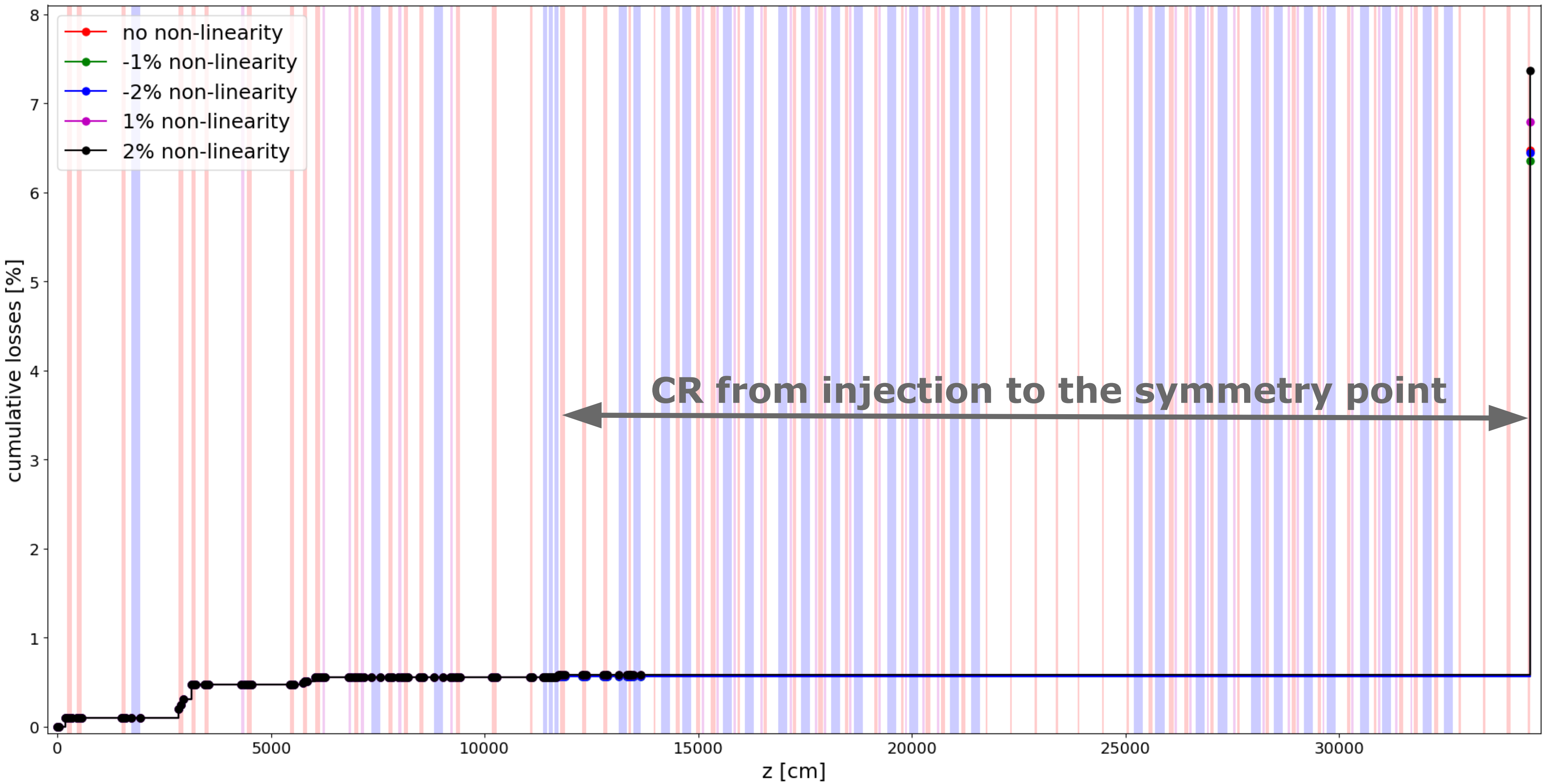
Note: Particle distributions at input (horn's exit plane) are shown in the upper graphs. Particles shown in red would get lost because they don't fit into the CR's acceptance!

Phase Space at Input and Output, +2% Non-Linear Contribution



Note: Particle distributions at input (horn's exit plane) are shown in the upper graphs. Particles shown in red would get lost because they don't fit into the CR's acceptance!

Losses for Different Non-Linear Contributions

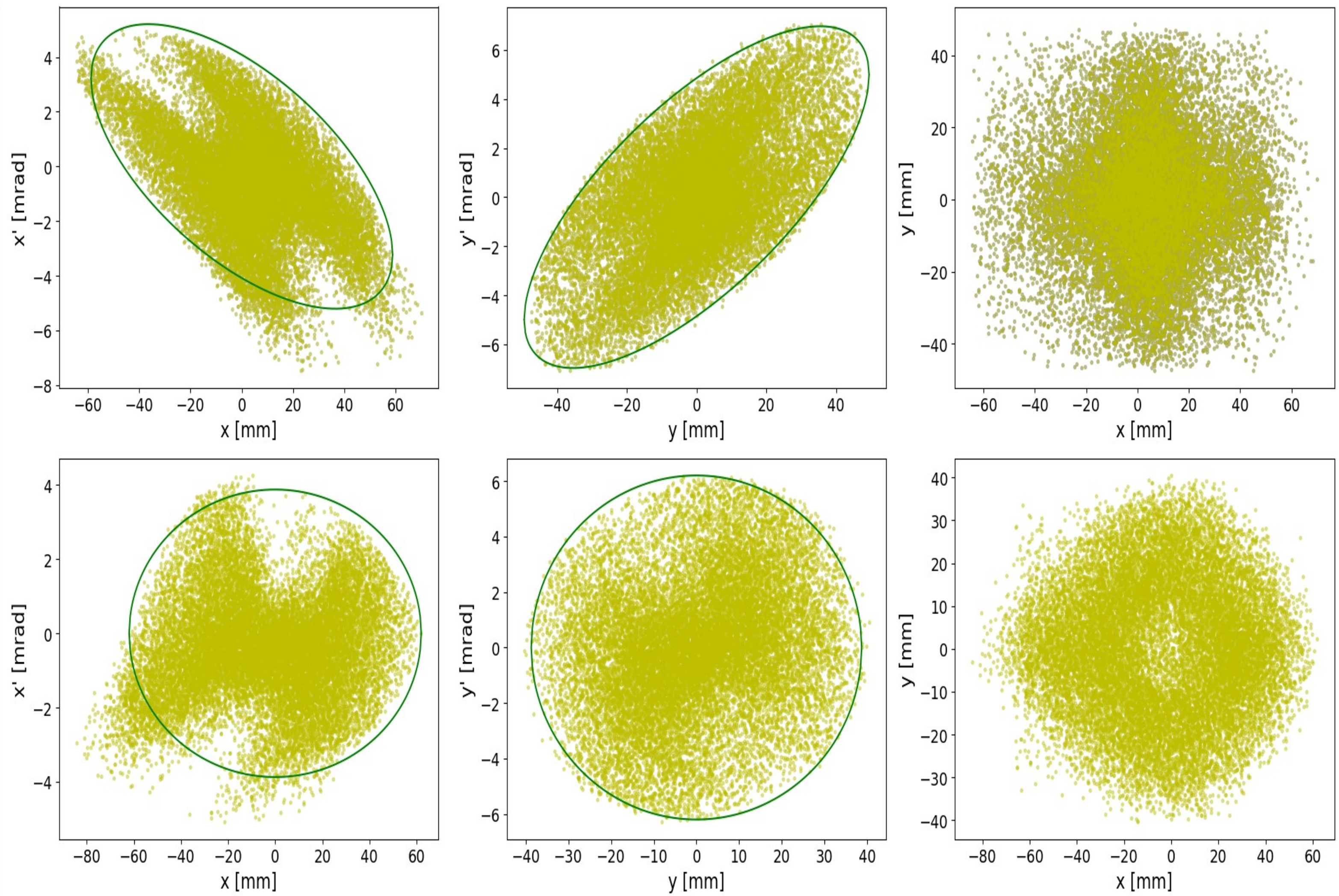


Note: Acceptance limited beam used for these simulations, CR added but without collimators to simulate limiting apertures or non-linear effects.

Final Remarks

- Relatively small changes applied to the reference ion optical set-up may sensibly improve the transmission to the ring.
- Adding sextupoles to the set-up appears to be useful, at least for reducing losses in the septum.
- Non-linear contributions to the field in the septum do not appear to have a strong effect on losses due to beam-acceptance mismatch, **HOWEVER** these are just **PRELIMINARY RESULTS** and simulations with a field closer to reality should be performed.

Phase Space after Injection and at the SP



Note: Particle distributions after injection are shown in the upper graphs.