Chromatic effects in quadrupole scans

Update

A. Mostacci et al., “*Chromatic effects in quadrupole scan emittance measurements”,* PRST-AB 15, 082802 (2012)

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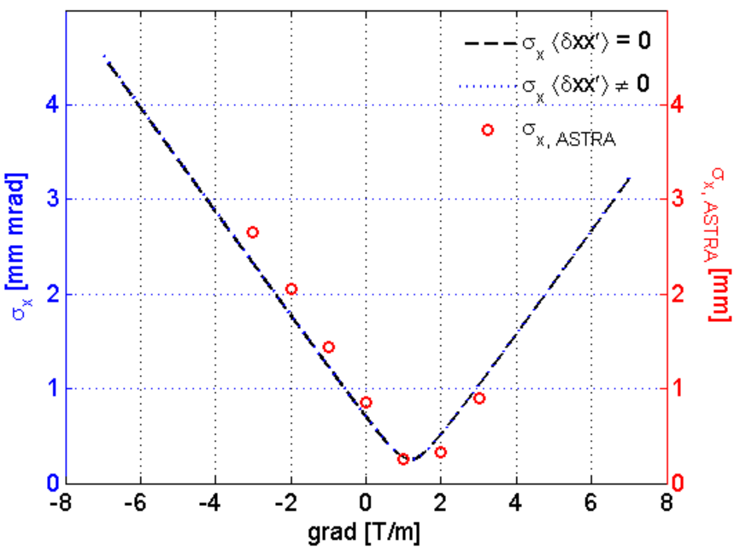
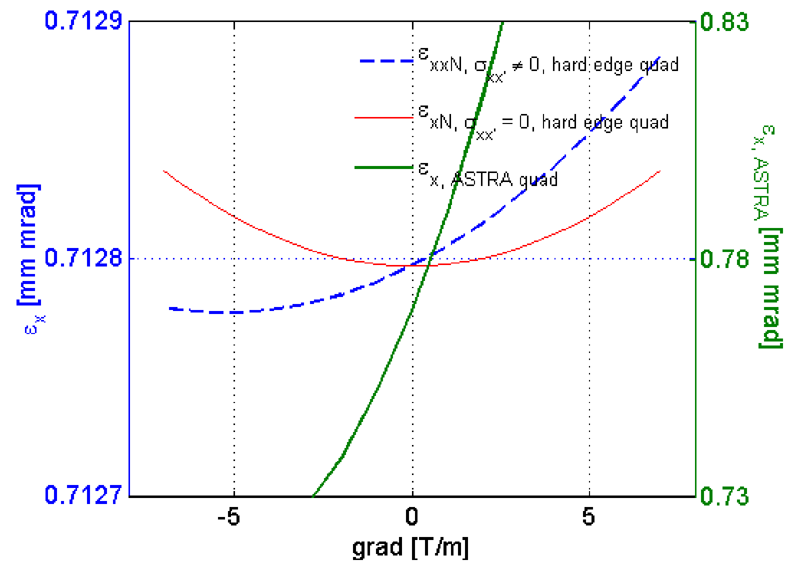
1 nC, smallest emittance Gun#4.1

Case 1: 1 nC, ε_{EMSY1} = 0.7 mm mrad, $\sigma_{x,EMSY1}$= 0.65 mm, p = 24.96 MeV, σ_γ = 0.4 %

Previous talk - plots – wrong.

High1Scr4





$\Delta\varepsilon \sim 0.001$ mm mrad / 0.1 mm mrad

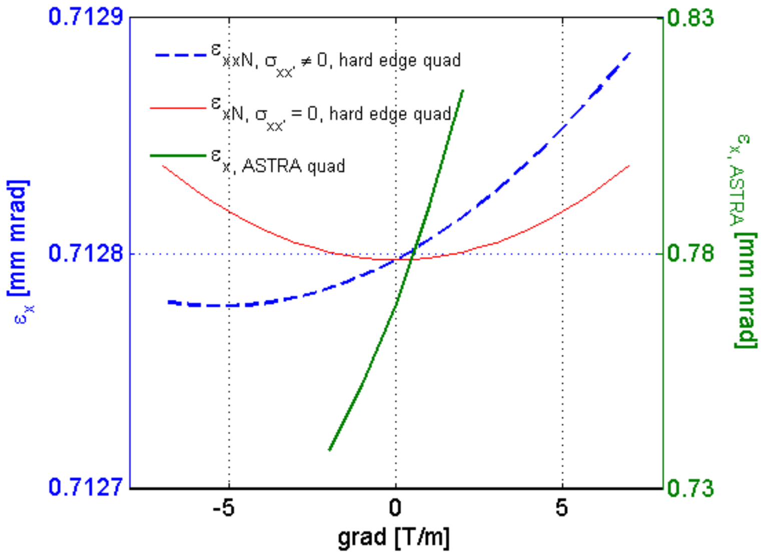
- Space charge excluded in the tracking
- ASTRA:
  - measured quad profile used
  - particles lost on apperture

* Calculated over the full gradient scanning range [-7, 7] T/m

1 nC, smallest emittance Gun#4.1

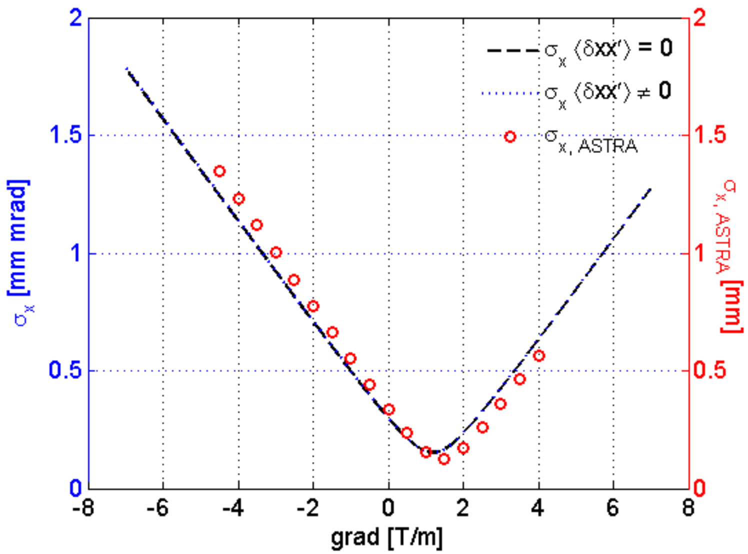
High1Scr5

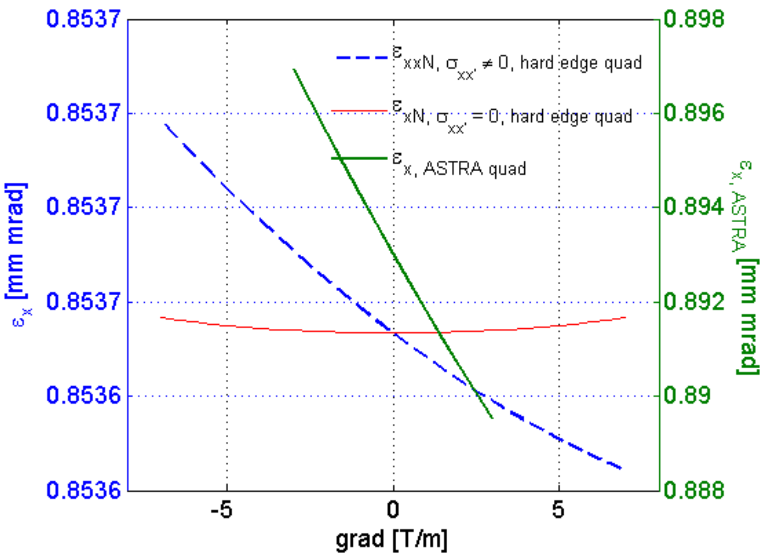
$\Delta\varepsilon \sim 0.0003$ mm mrad / Lost particles



Case 2: $\sigma_{x,\ EMSY1}$ = 0.21 mm, $\varepsilon_{x,\ EMSY1}$ = 0.87 mm mrad

High1Scr4





$\Delta\varepsilon$ = 3e-6 mm mrad* / 0.01 mm mrad

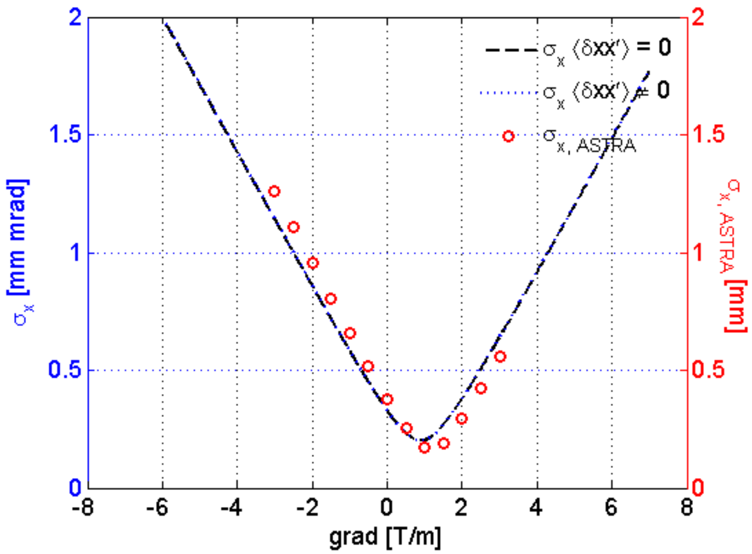
> Smaller Δ than for bigger spot sizes.

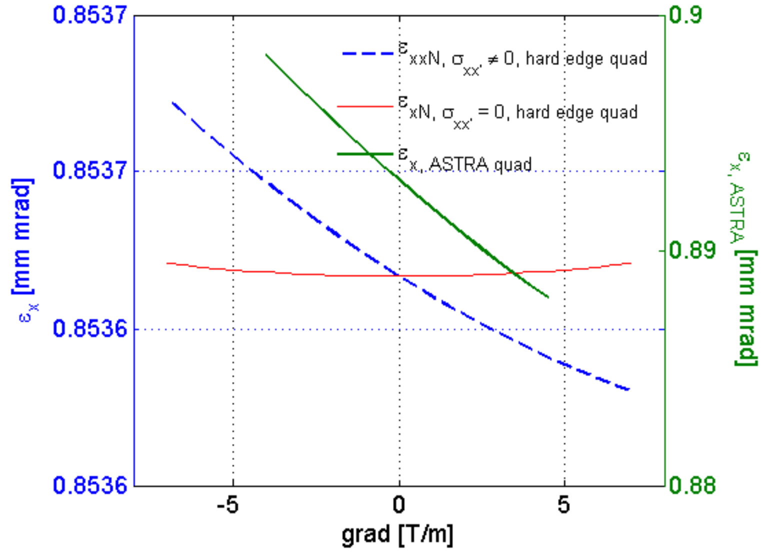
* Calculated over the full gradient scanning range [-7, 7] T/m

Systematic uncertainty – smaller spot size at the quad

Case 2: $\sigma_{x,\ EMSY1}$ = 0.21 mm, $\varepsilon_{x,\ EMSY1}$ = 0.87 mm mrad

High1Scr5



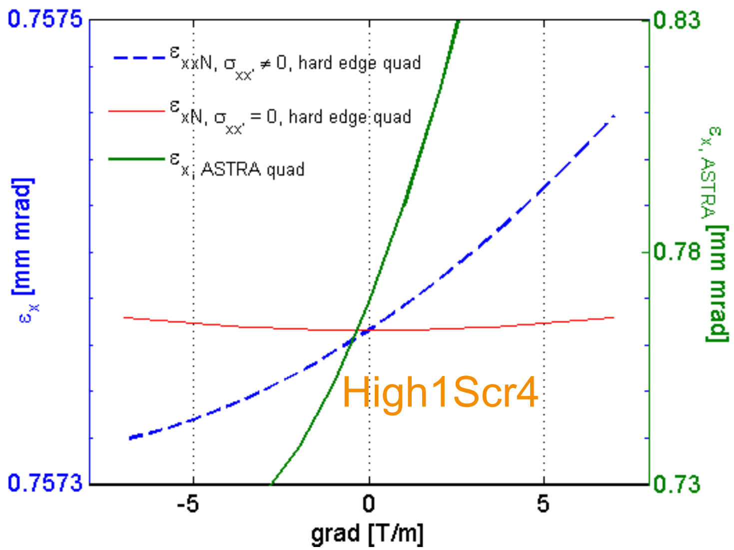


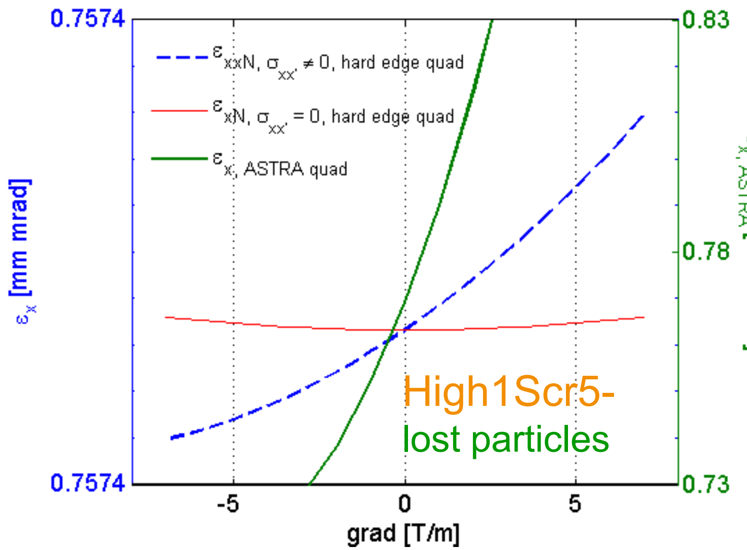
$\Delta\varepsilon$ = 2.2e-5 mm mrad* / Lost particles

* Calculated over the full gradient scanning range [-7, 7] T/m

Quadrupole focusing in advance

- Use High1Q1/2 to focus the beam at the entrance of the quadrupole (**Case 1**)
  - Only one plane possible since small σ_x and $\sigma_{xx'}$ are needed together
    - hard since with the scan σ_y might be bigger than the screen





$\Delta\varepsilon$ = 3e-6 mm mrad* $\Delta\varepsilon$ = 4e-6 mm mrad*

$\Delta\varepsilon$ = 0.07 mm mrad $\Delta\varepsilon$ = 0.07 mm mrad

Somewhat maller Δ than for the bigger spot size.

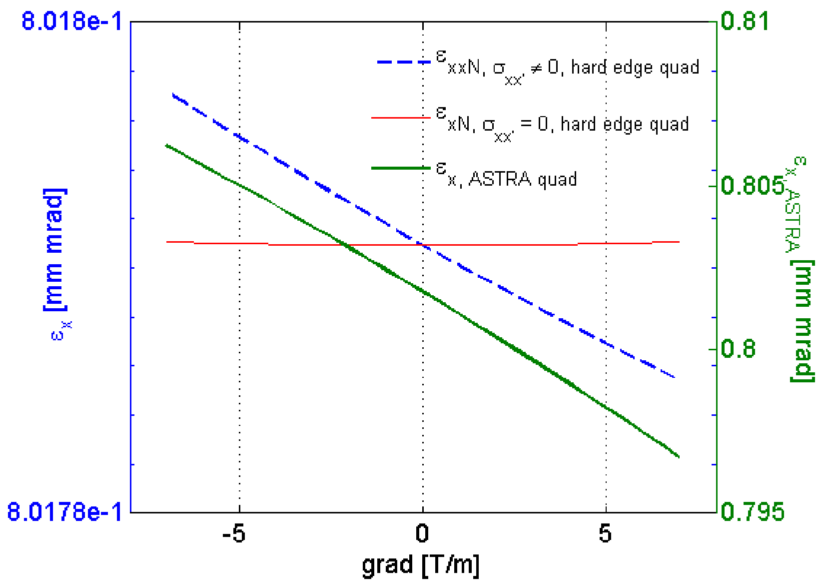
* Calculated over the full gradient scanning range [-7, 7] T/m

Big spot at the entrance of the quad

Case 3: EMSY1: $\varepsilon = 0.82$ mm mrad

$\sigma_{x,\,y}$ = 0.8 mm, in front of High1Q3 → 1.1 mm

Focusing as in the previous slide: control $\sigma_{y'}$, $\sigma_{x'}$, $\sigma_{xx'}$



High1Scr4/5 pretty much the same result for focused beam.

$\Delta\varepsilon$ = 6e-6 mm mrad* / 0.02 mm mrad

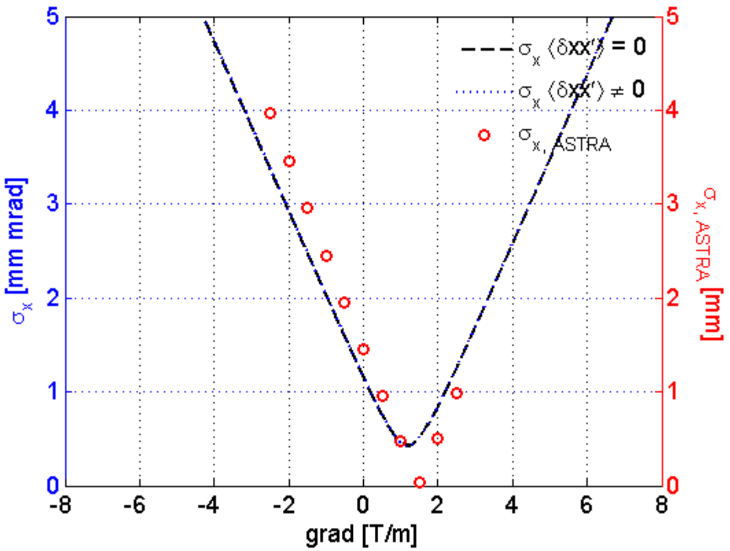
Big spot at the entrance of the quad

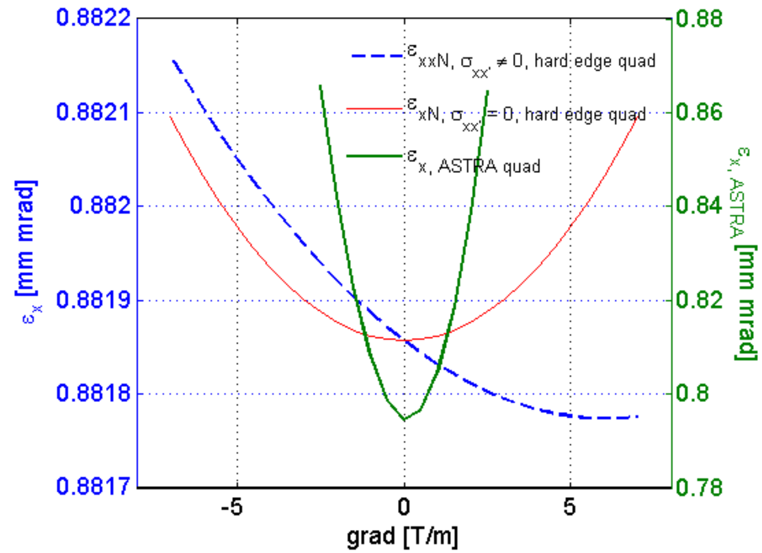
Case 3: EMSY1: $\varepsilon = 0.82$ mm mrad

$\sigma_{x,\,y} = 0.8$ mm, in front of High1Q3 $\rightarrow$ 1.1 mm

No upstream focusing

High1Scr4





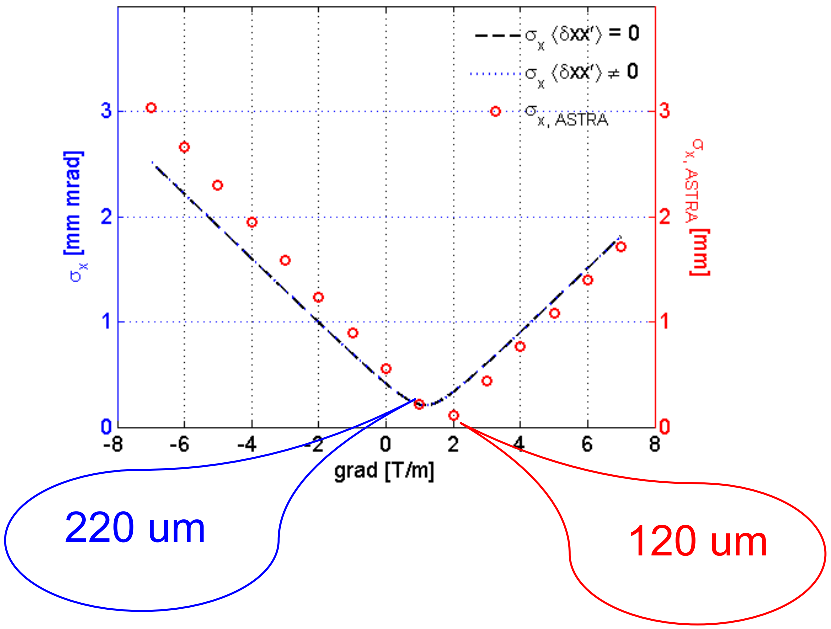
$\Delta\varepsilon = 0.01^*$ / 0.05 mm mrad

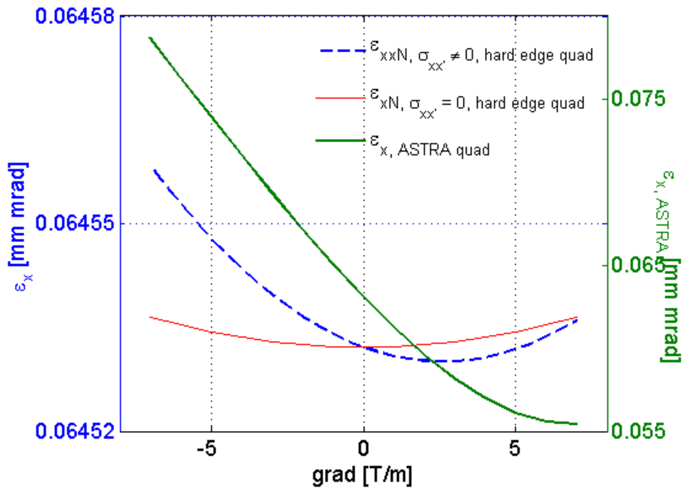
Losing beam downstream High1Scr4.

- Optimised machine settings as in

Krasilnikov et al., “*Experimentally minimized beam emittance from an L-band photoinjector*”, PRST-AB 15, 100701 (2012)

High1Scr4

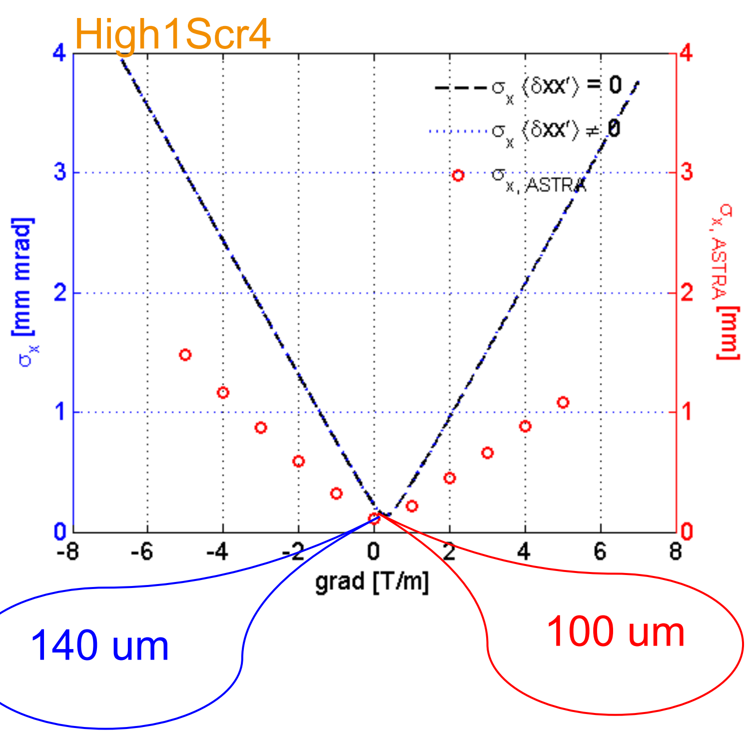


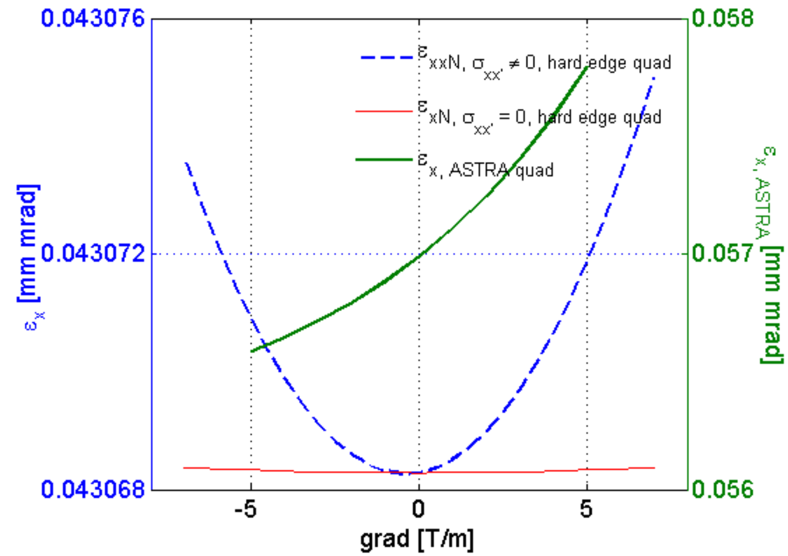


$\Delta\varepsilon$ = 1e-5 mm mrad* / 0.01 mm mrad (14%)

20 pC, no booster

- Settings as in Grygorii Vashchenko, “*Emittance simulation for a different electron bunch charges with upgraded PITZ setup*”, DPG 2013





$\Delta\varepsilon$ = 3e-7 mm mrad* / 0.07 mm mrad (18%)

Final remarks

- Calculated systematic uncertainly much smaller than simulated
  - Discrepancies in the calculated spot sizes
  - Quads – in model hard edge
  - In ASTRA – measured profiles

- Derive mathematical formalism of a smooth quadrupole