

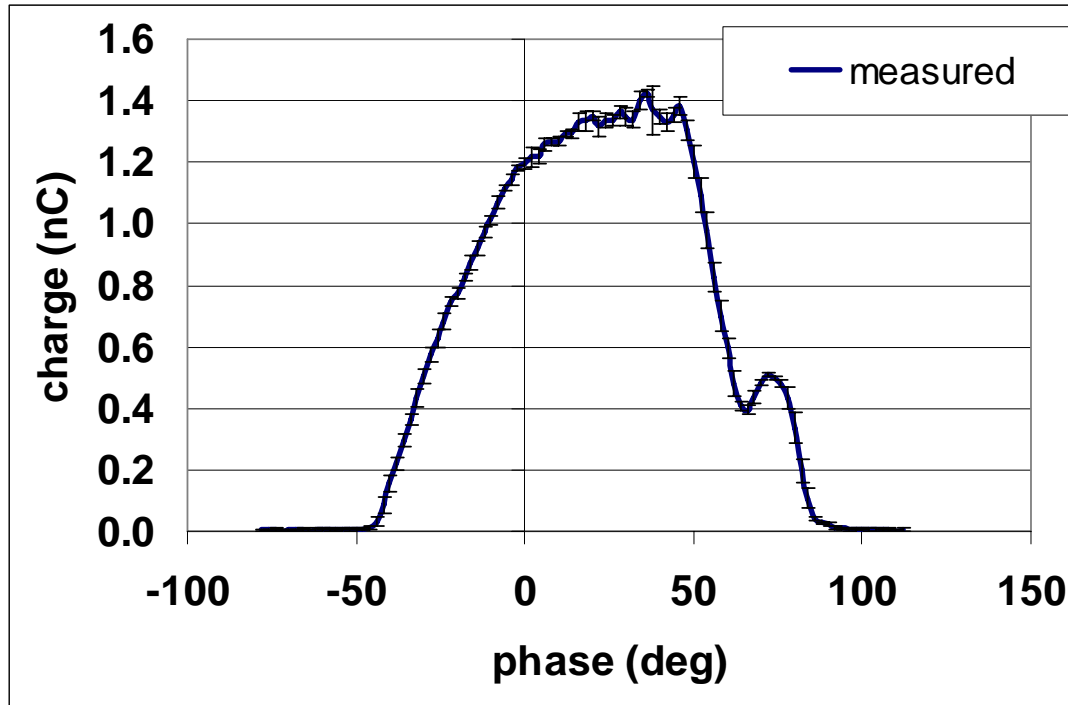
Simulations on the gun benchmark problem

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Future Light Sources

Phase scan simulations



variable parameters :

- laser spot rms size at the cathode
- coefficients Q_0 and A

assumed fixed parameters :

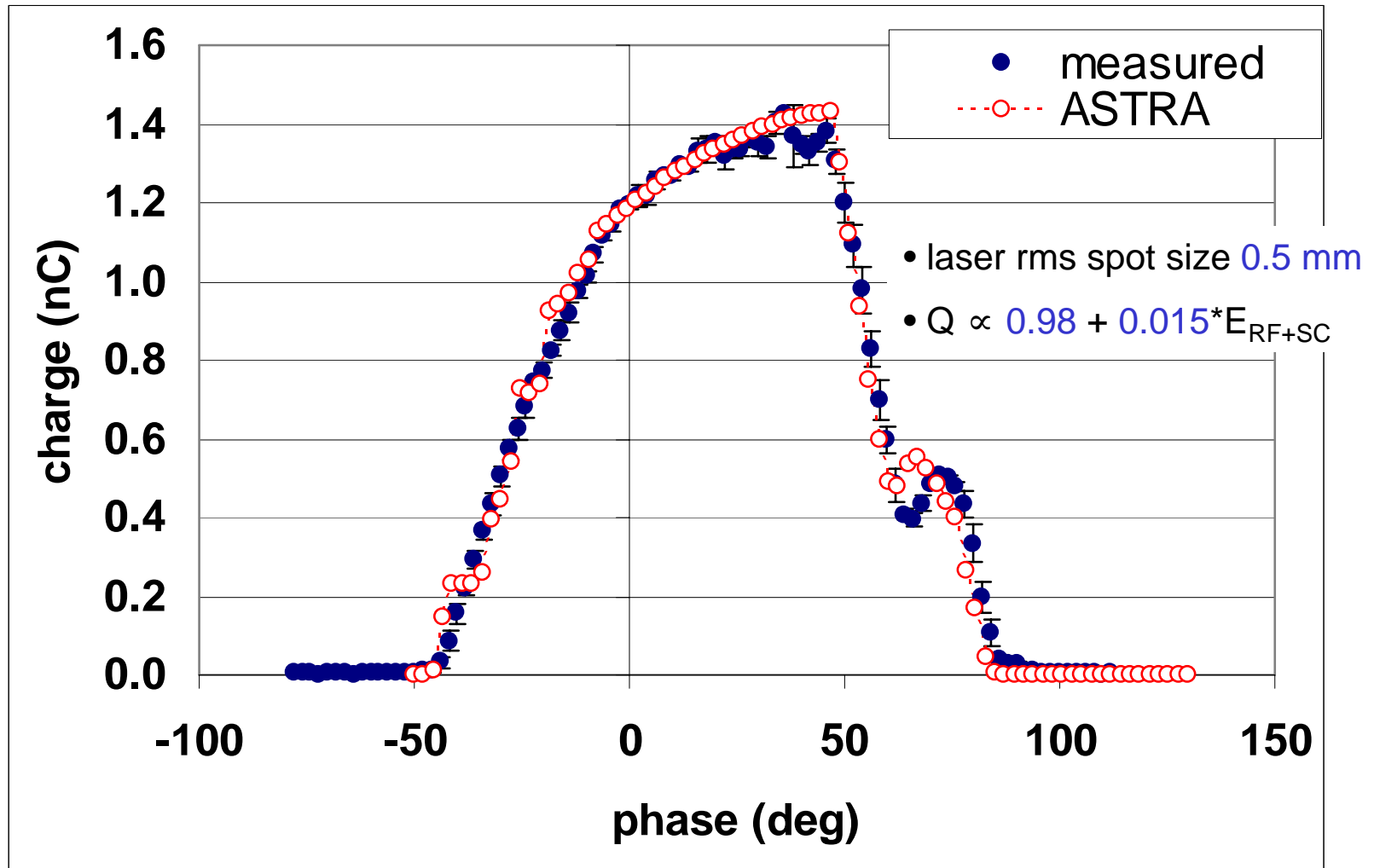
- accelerating gradient 45.8 MV/m
 $\Rightarrow p_{\text{max}} \approx 5.27 \text{ MeV/c}$
- field balance $\text{FB}=1.05$
- **uniform** radial shape of the **laser spot** at the cathode
- laser pulse of **flat-top temporal profile**, with **24 ps FWHM** and **4 ps** rise/fall time

- model of the Schottky effect

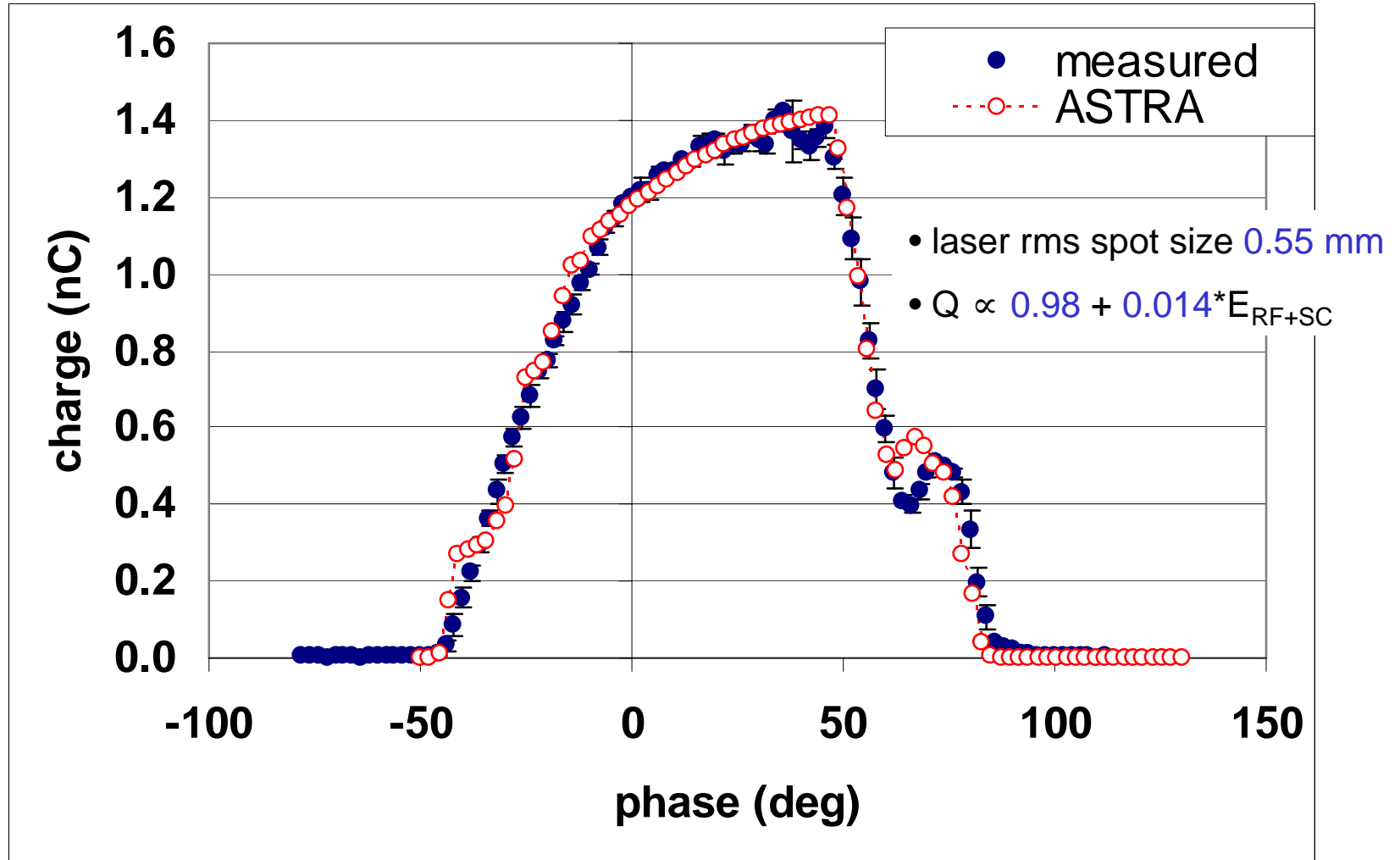
$$Q \propto Q_0 + A * E_{\text{RF+SC}}$$

- solenoid current 320 A

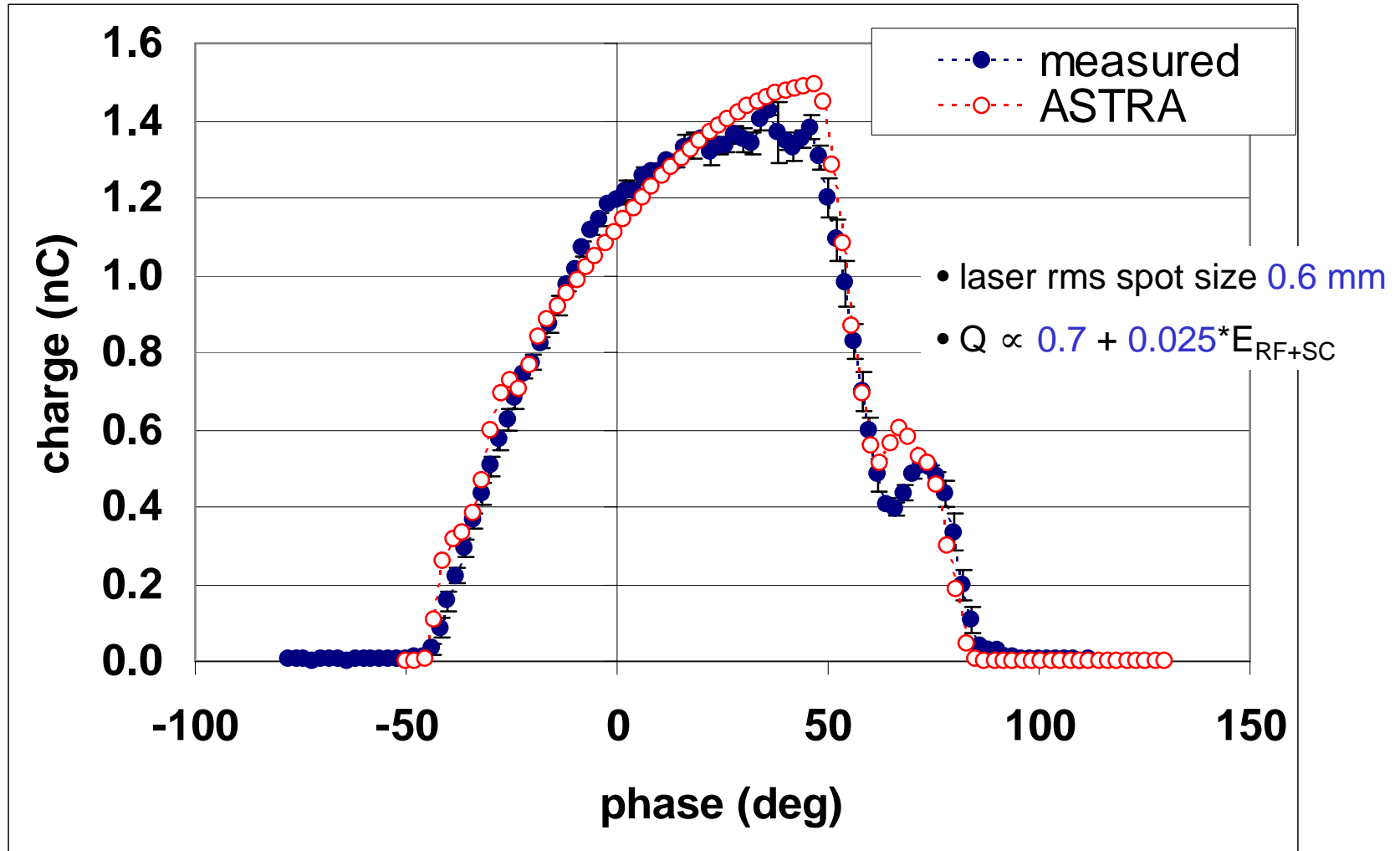
Phase scan simulations



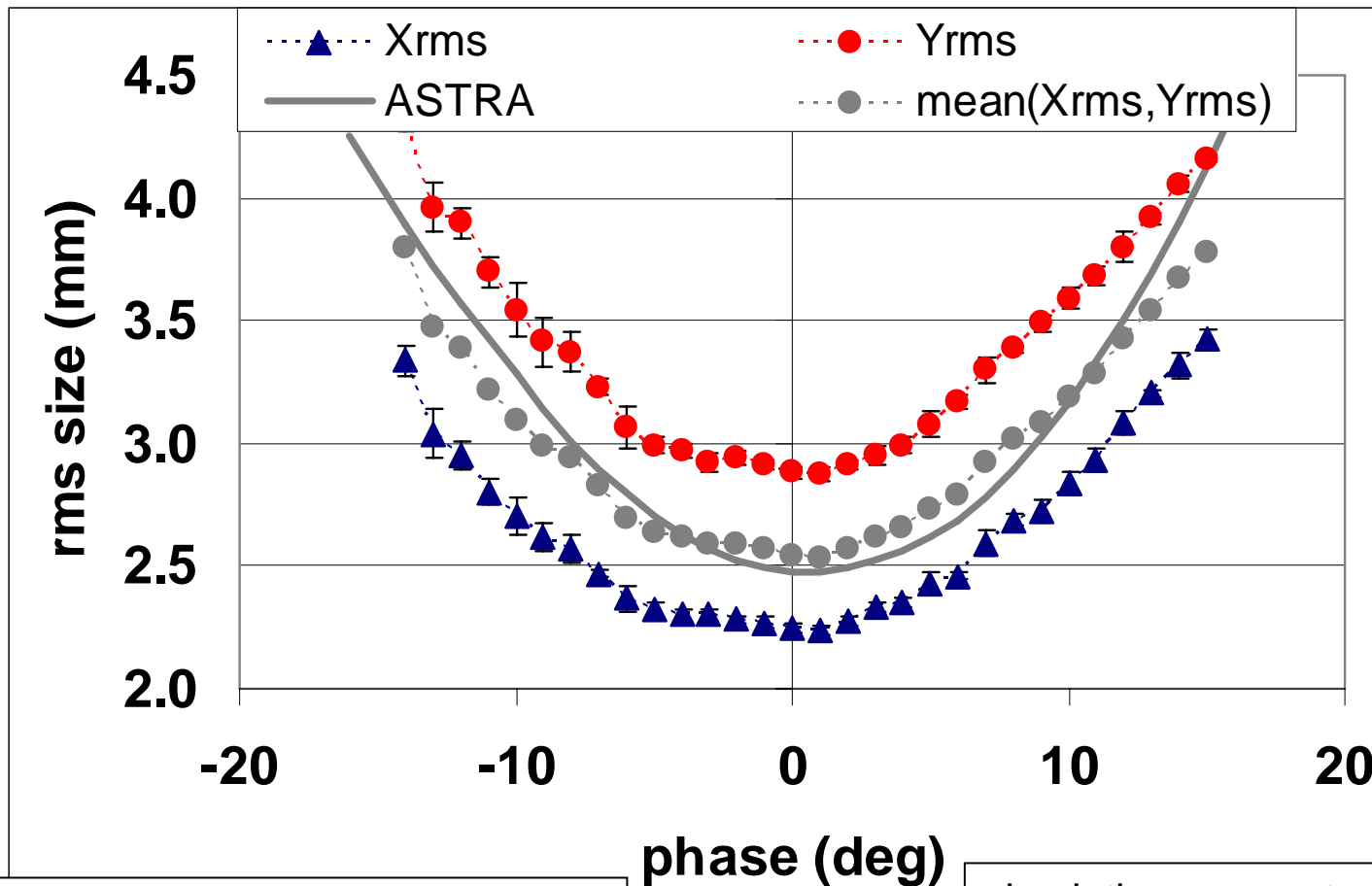
Phase scan simulations



Phase scan simulations



Reference phase check



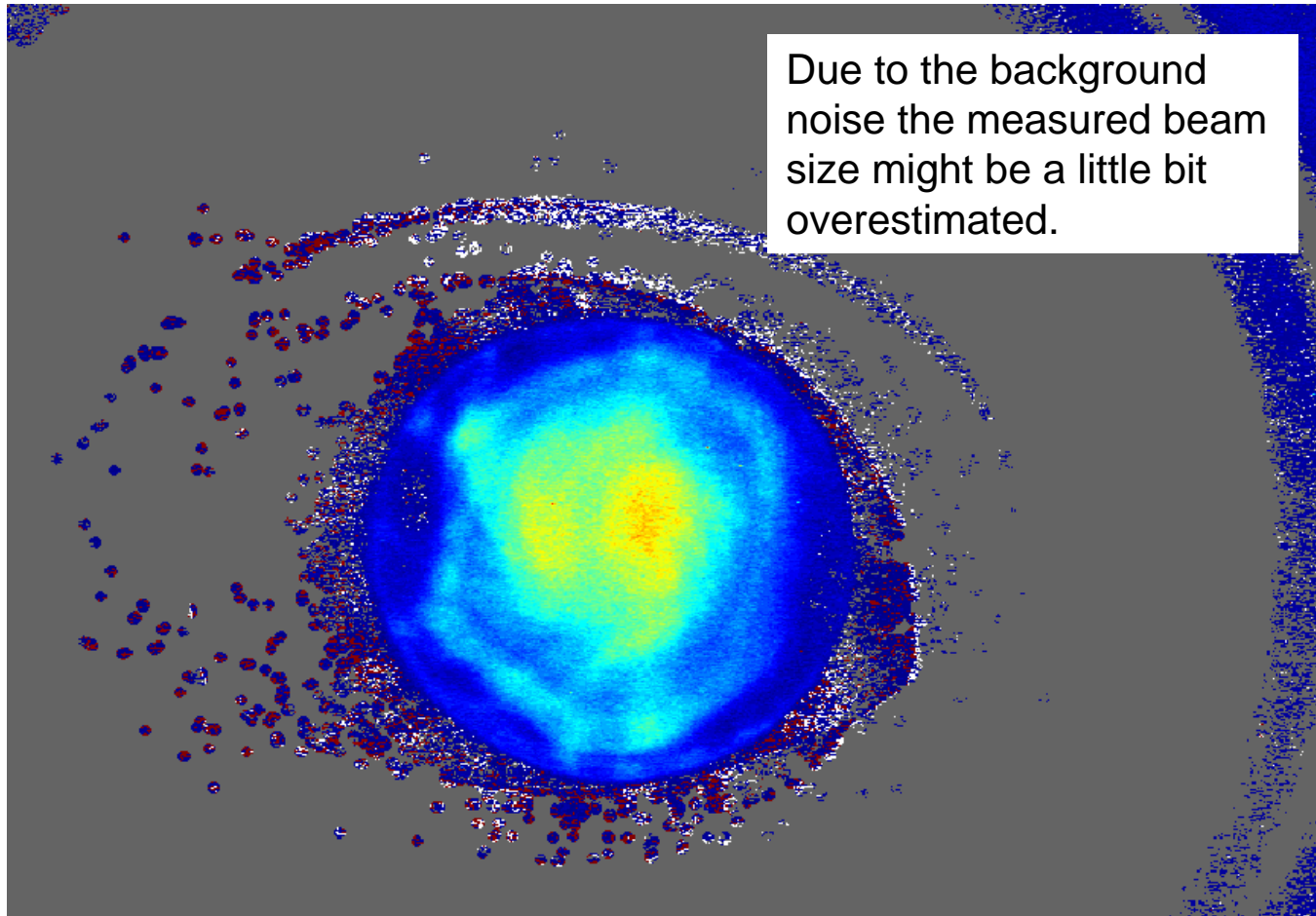
measurement conditions

- laser rms spot size 0.54/0.57 mm
- $I = 320$ A
- laser pulse duration 23 ps FWHM , 3 ps rise/fall time

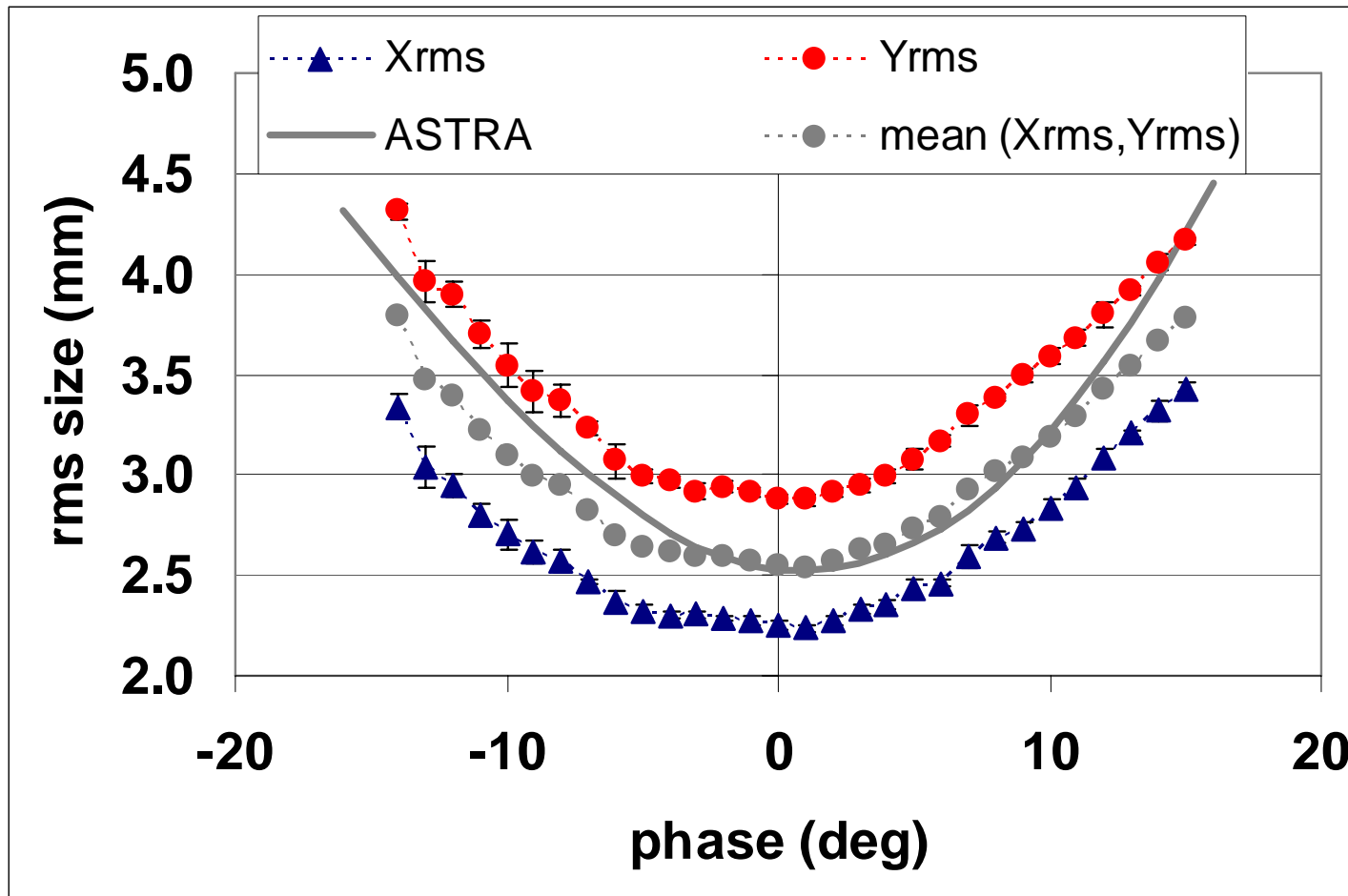
simulation parameters

- laser rms spot size 0.6 mm
- $I = 325$ A
- laser pulse duration 24 ps FWHM , 4 ps rise/fall time

Reference phase check

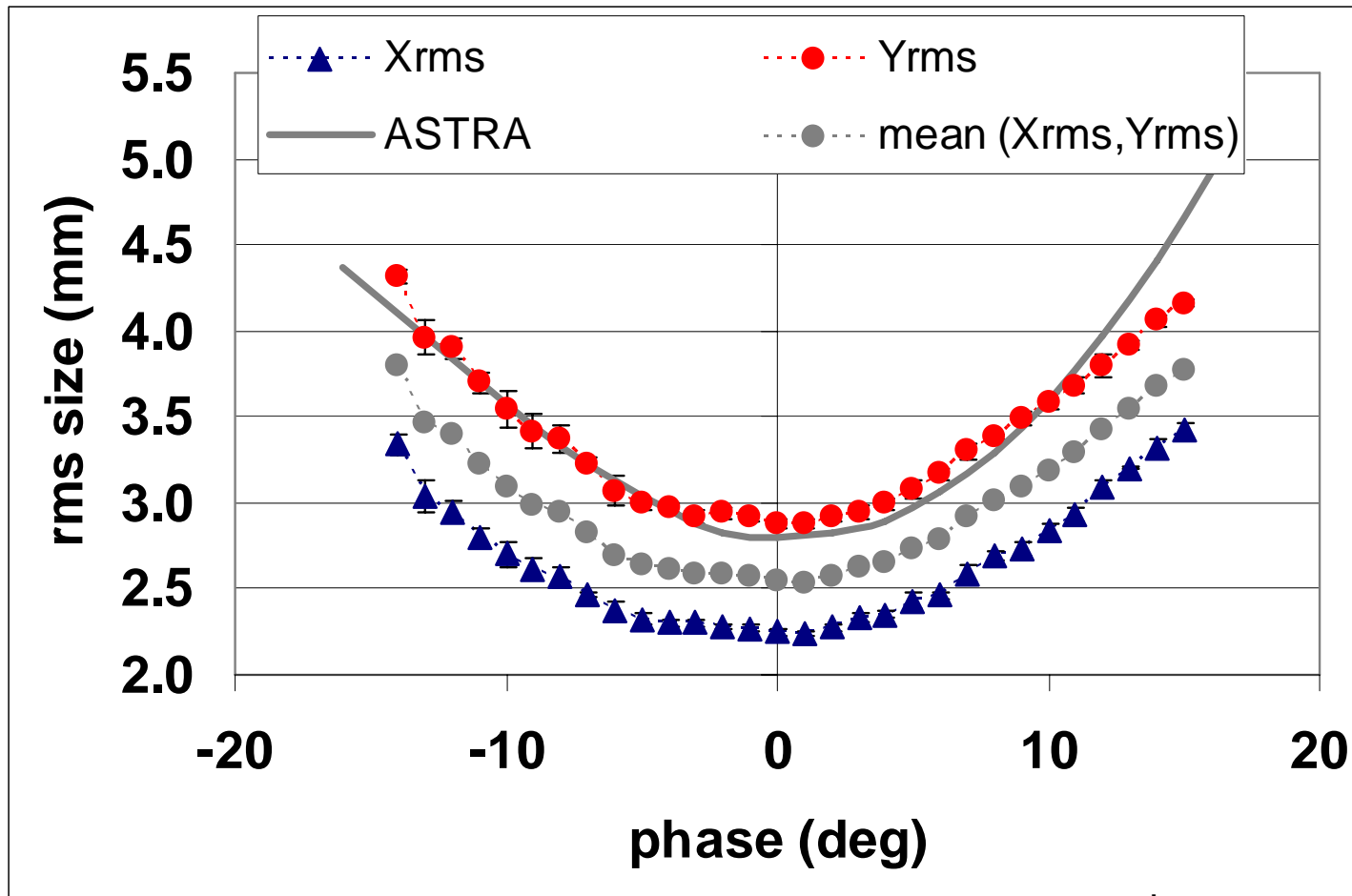


Reference phase check



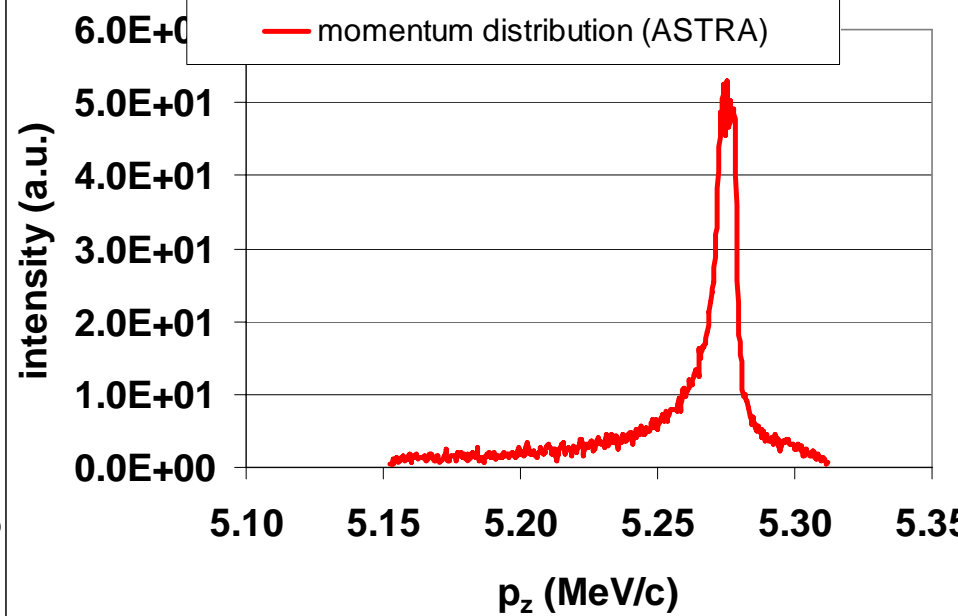
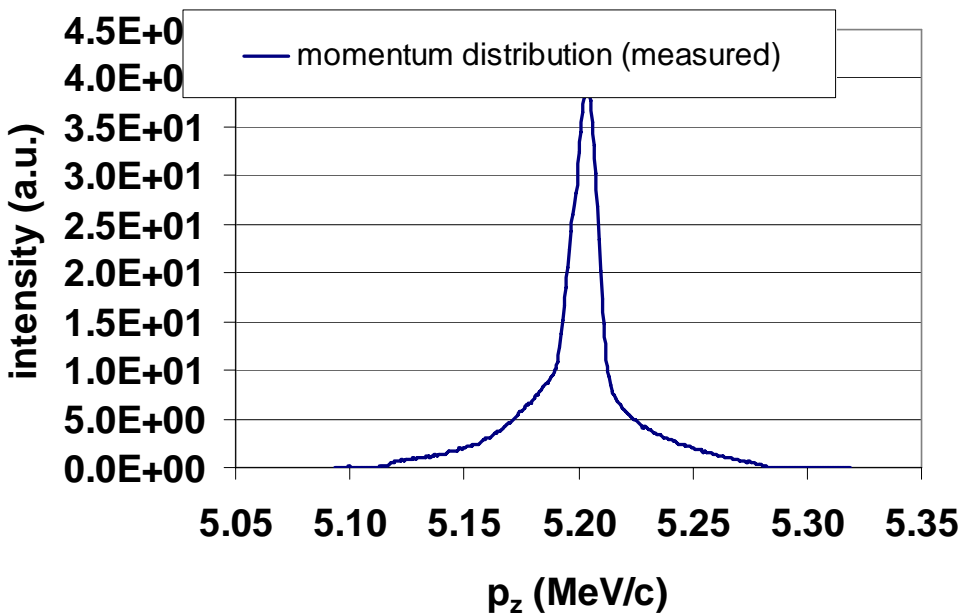
- laser rms spot size 0.55 mm
- $I = 325$ A
- laser pulse duration 24 ps FWHM , 4 ps rise/fall time

Reference phase check



- laser rms spot size 0.50 mm
- $I = 325$ A
- laser pulse duration 24 ps FWHM , 4 ps rise/fall time

Momentum distribution – 5deg



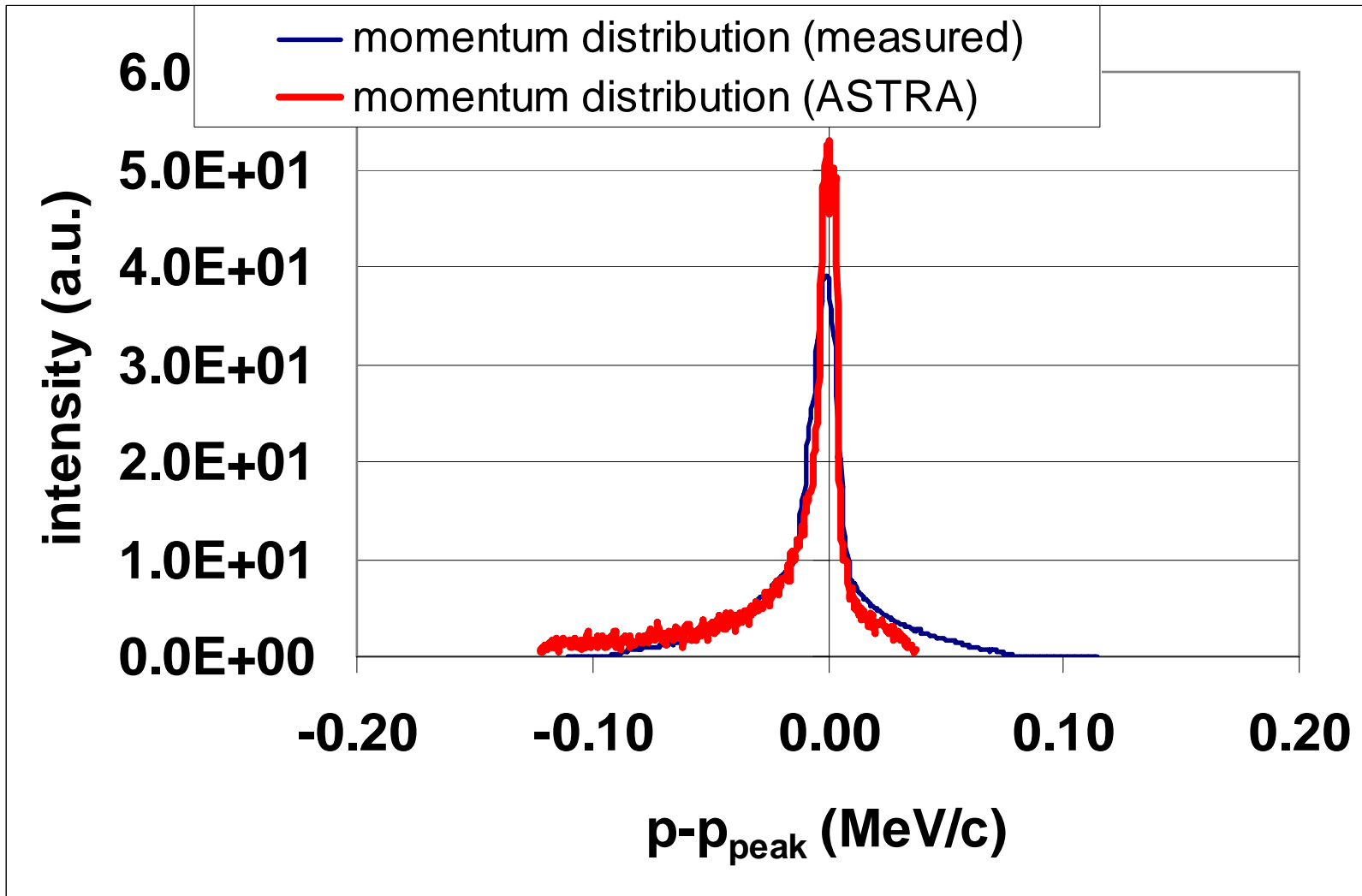
for the measurement

- laser rms spot size 0.54/0/57 mm
- $I = 280$ A
- $Q=1$ nC
- laser pulse duration 23 ps FWHM ,7 ps rise/fall time

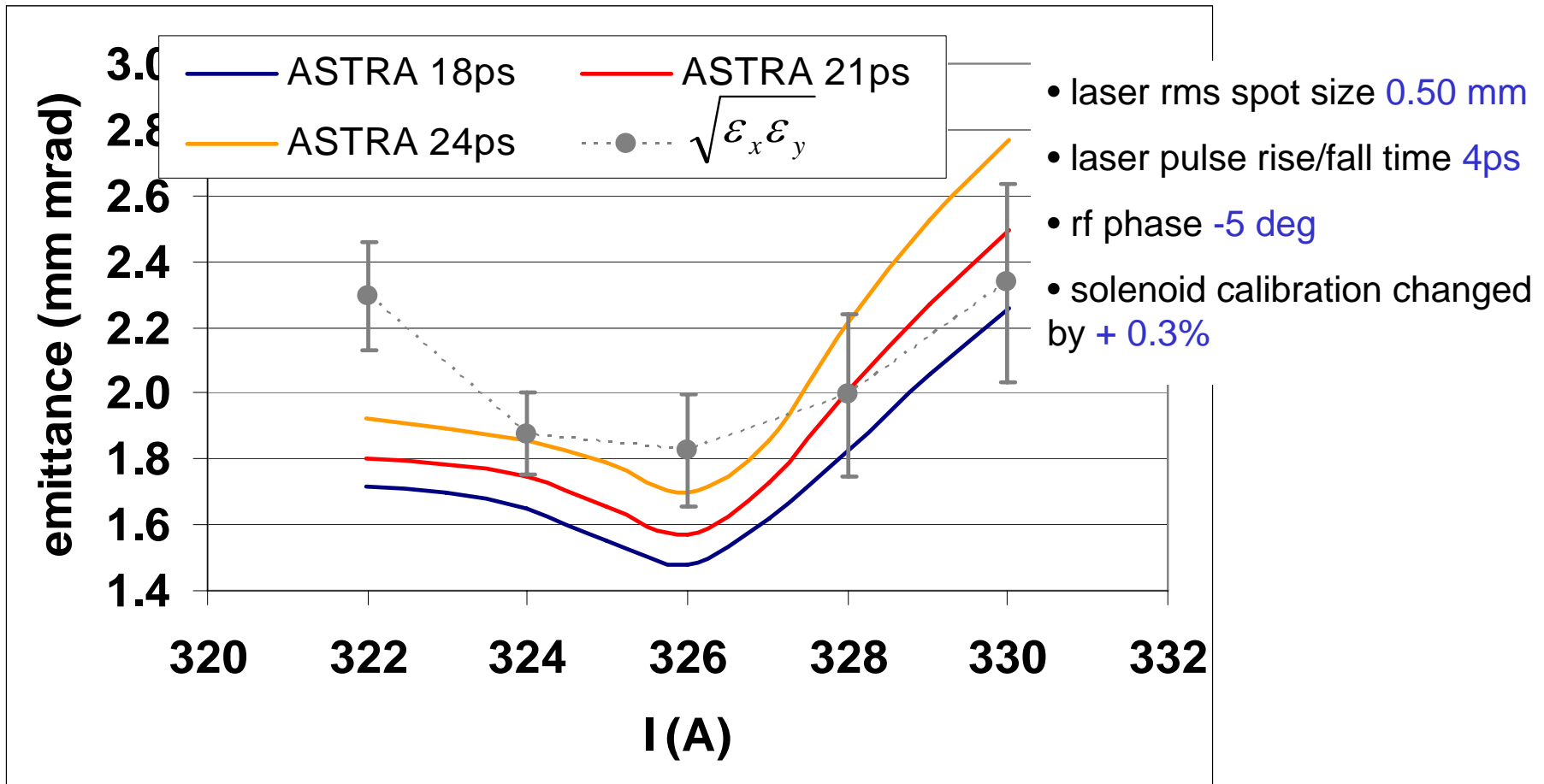
for the simulation

- laser rms spot size 0.55 mm
- $I = 280$ A
- $Q=1$ nC
- laser pulse duration 24 ps FWHM ,4 ps rise/fall time

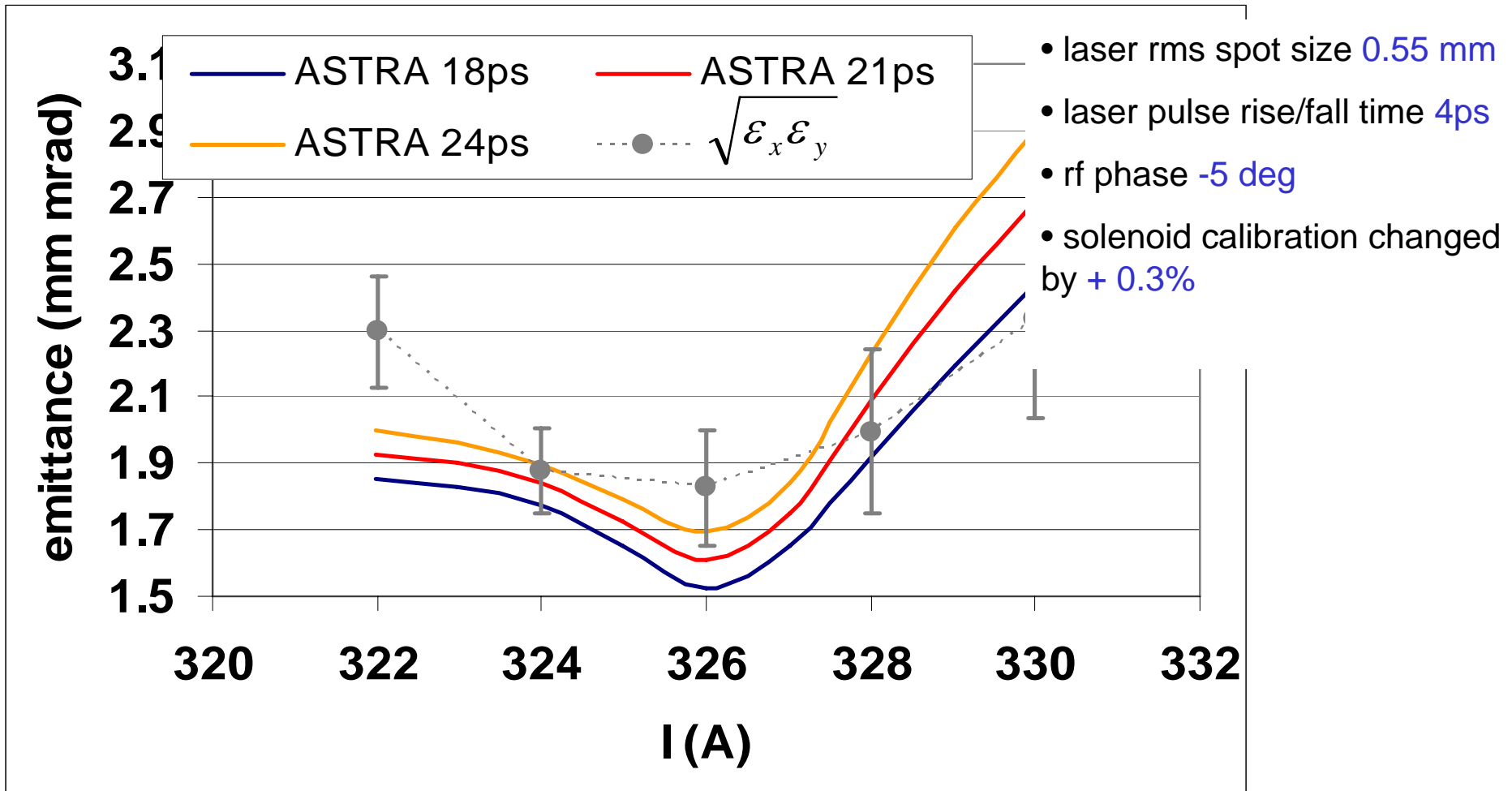
Momentum distribution-5 deg



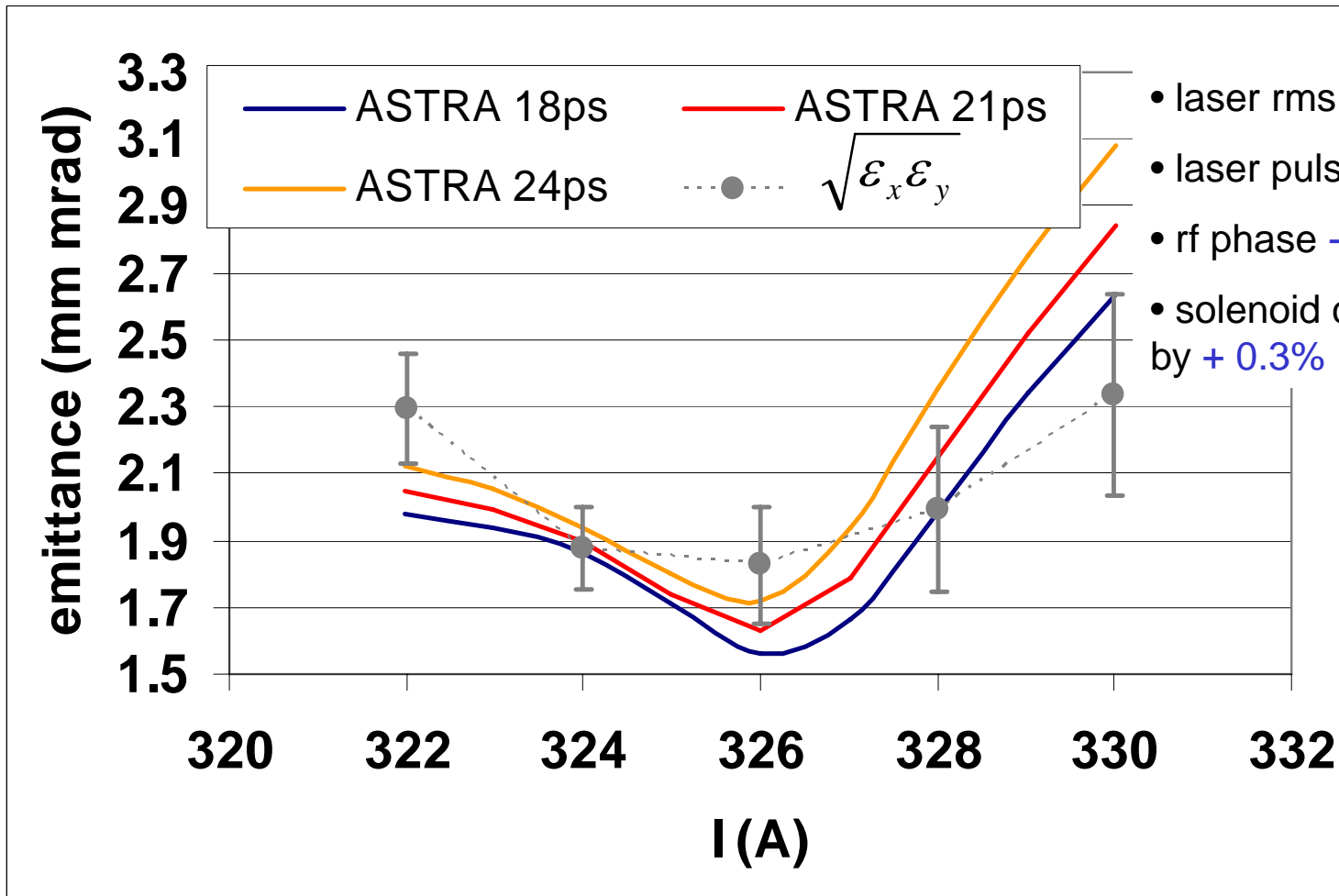
Transverse emittance



Transverse emittance

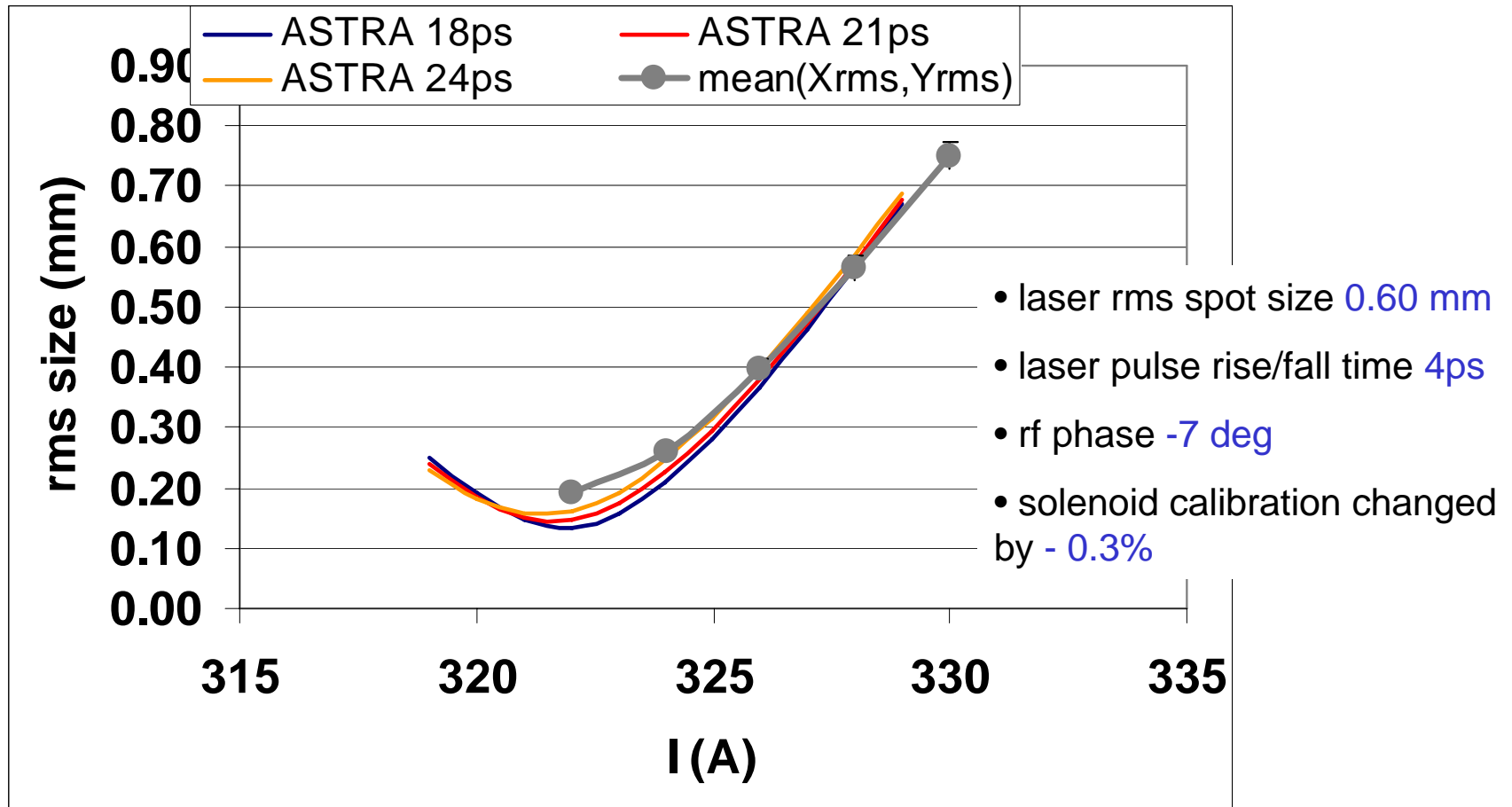


Transverse emittance

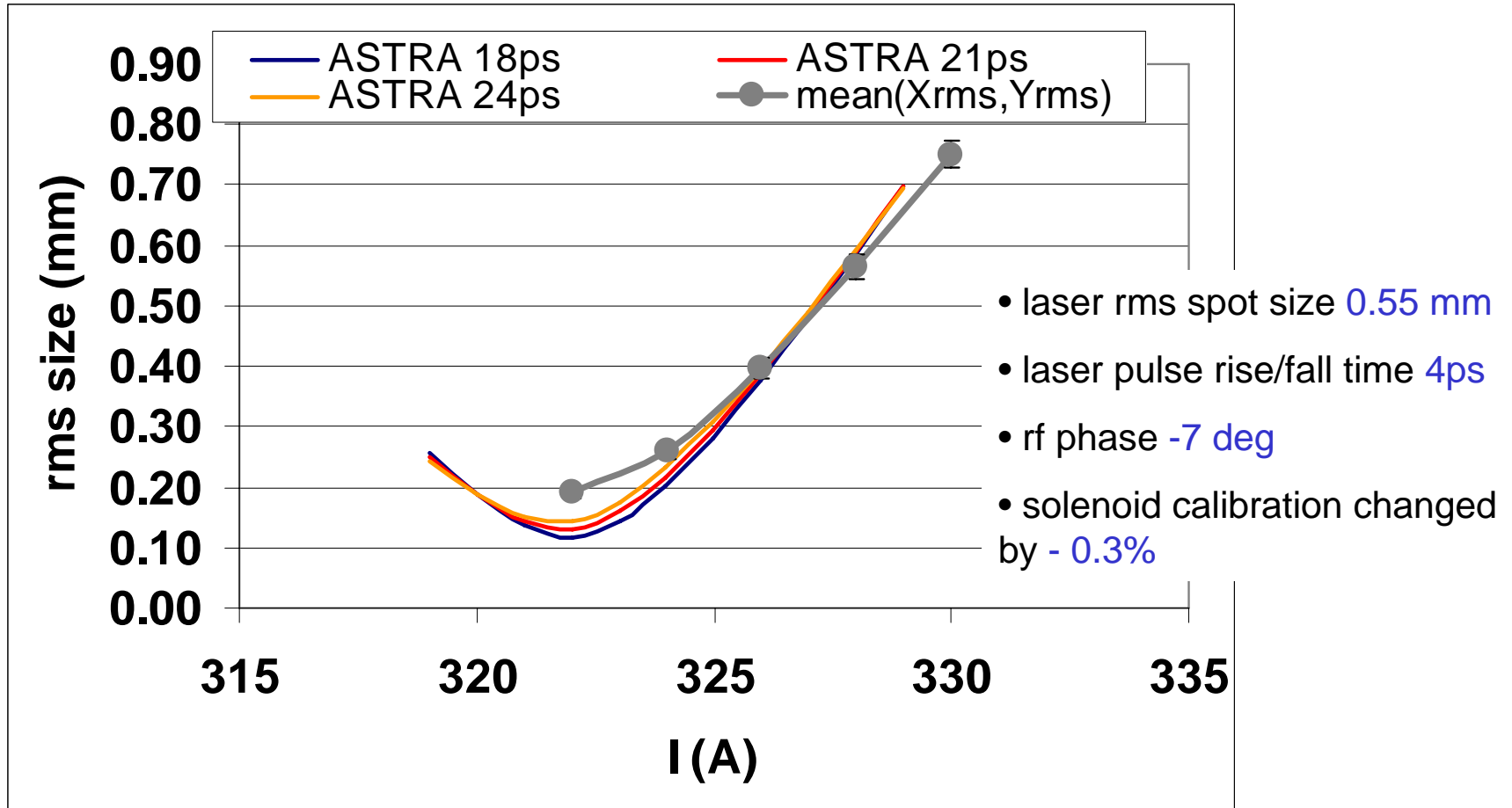


- laser rms spot size 0.60 mm
- laser pulse rise/fall time 4ps
- rf phase -5 deg
- solenoid calibration changed by + 0.3%

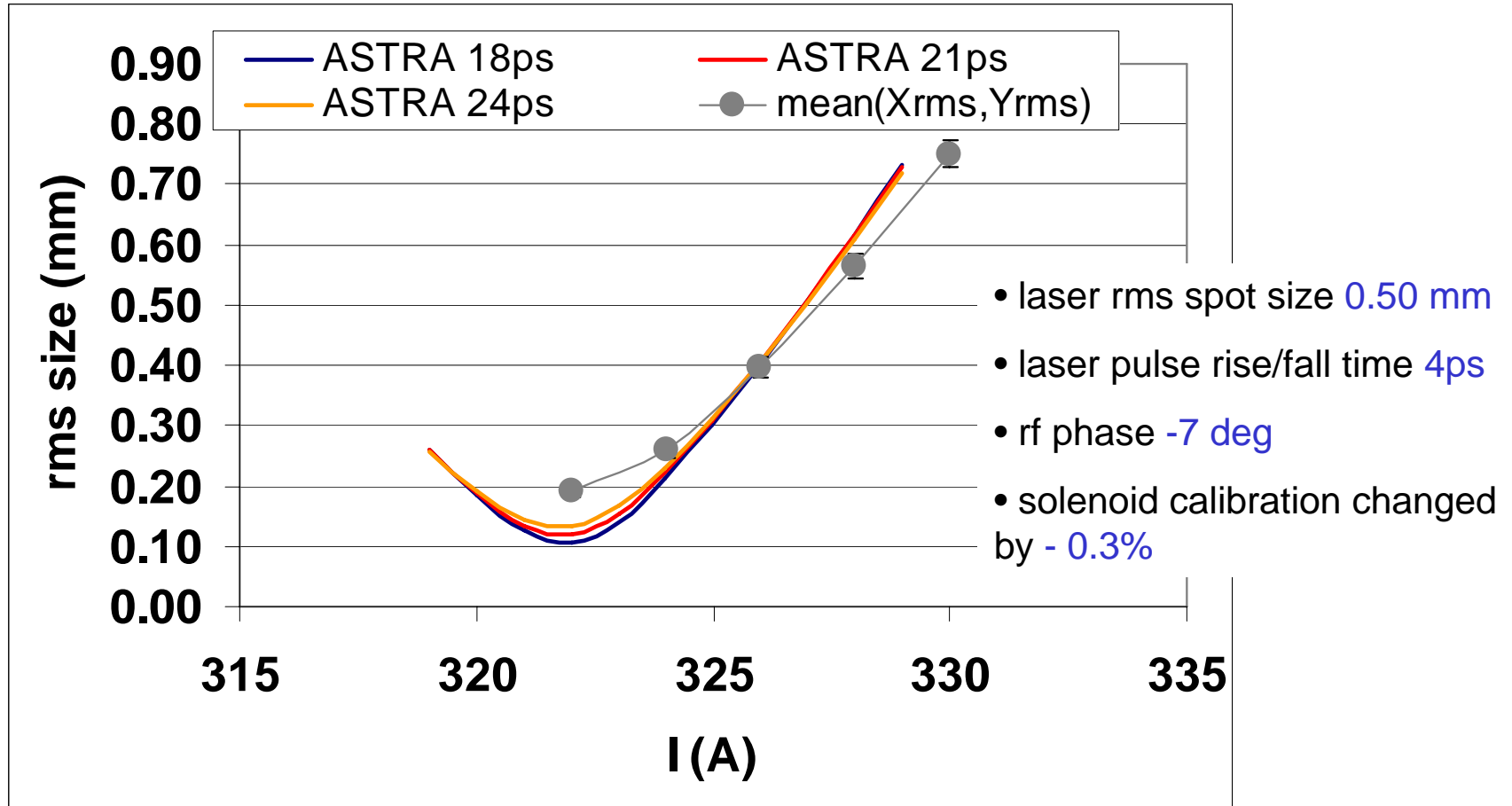
Transverse beam size (Screen 2)



Transverse beam size (Screen 2)



Transverse beam size (Screen 2)



Conclusions

- Simulations on the gun benchmark problem done by variation of a **limited number of parameters** (laser spot size at the cathode, laser pulse length, rf phase, solenoid calibration)
- Considered were the following measurements:
 - charge vs. rf phase
 - reference phase determination
 - momentum distribution
 - transverse emittance
 - rms beam size
- The problem is complex, but a fair agreement between measurements and simulation was obtained.
- Assumed was **2 deg** uncertainty for the rf phase and **~0.5%** uncertainty for the solenoid calibration
- More parameters have to be considered (e.g. electric field balance, rise/fall time of the laser pulse, ...).