Slice emittance measurements with Transverse Deflecting Structure

1nC bunch:

- **Beam optics**
- **TDS calibration**
- **Measurement results**
- **Longitudinal resolution**

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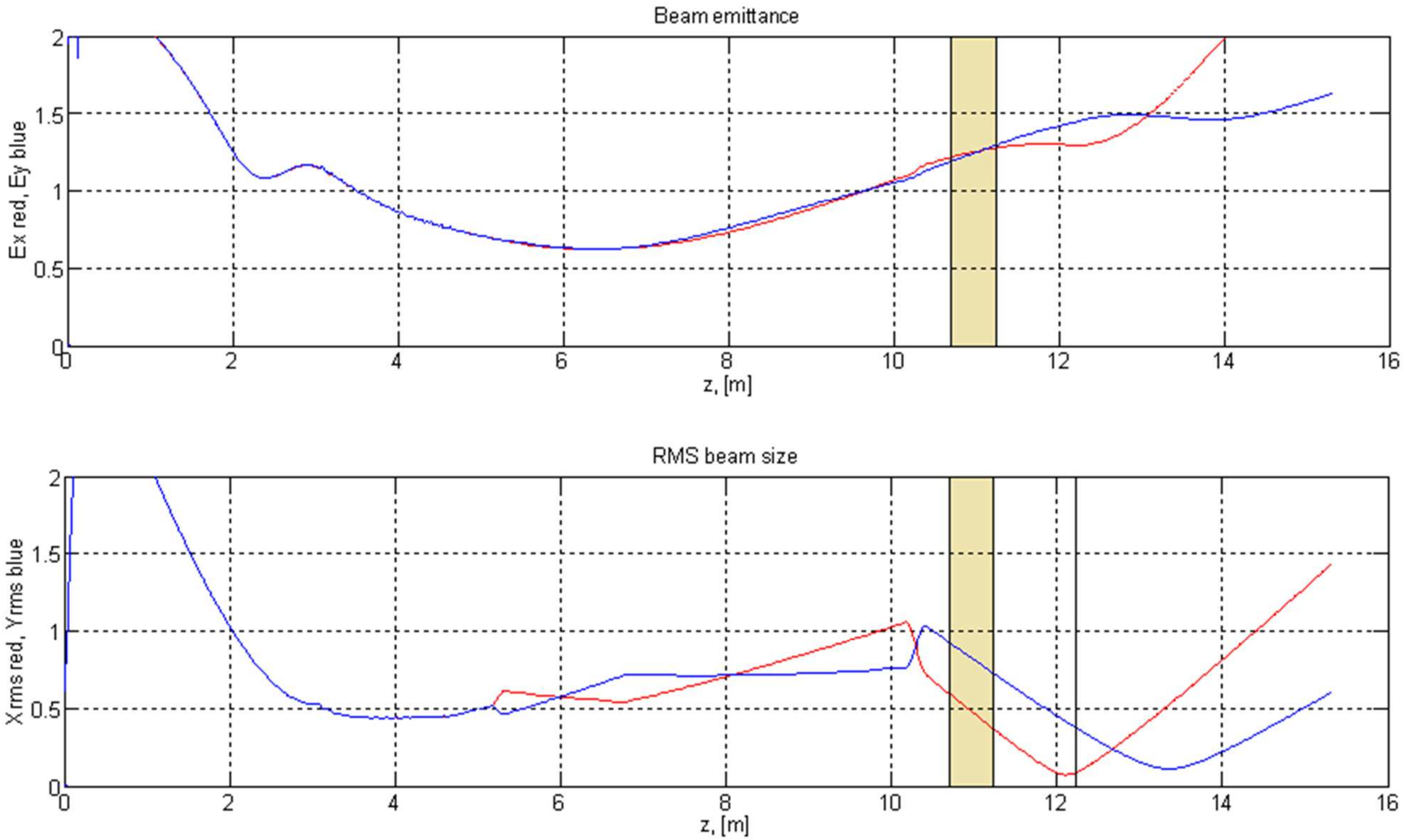
PITZ physics seminar
Zeuthen, February, 2012

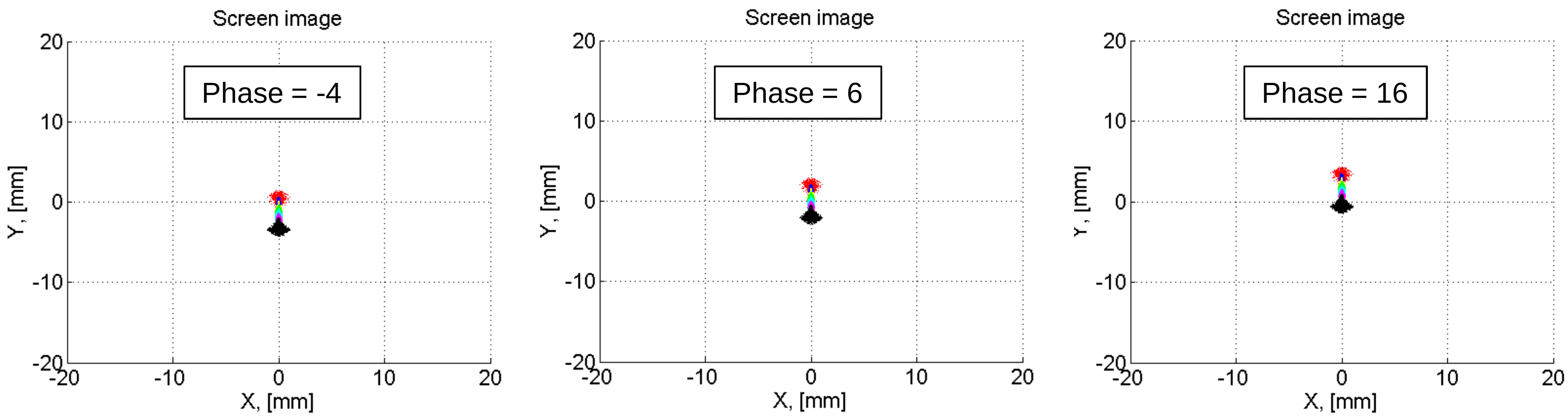
HELMHOLTZ | GEMEINSCHAFT

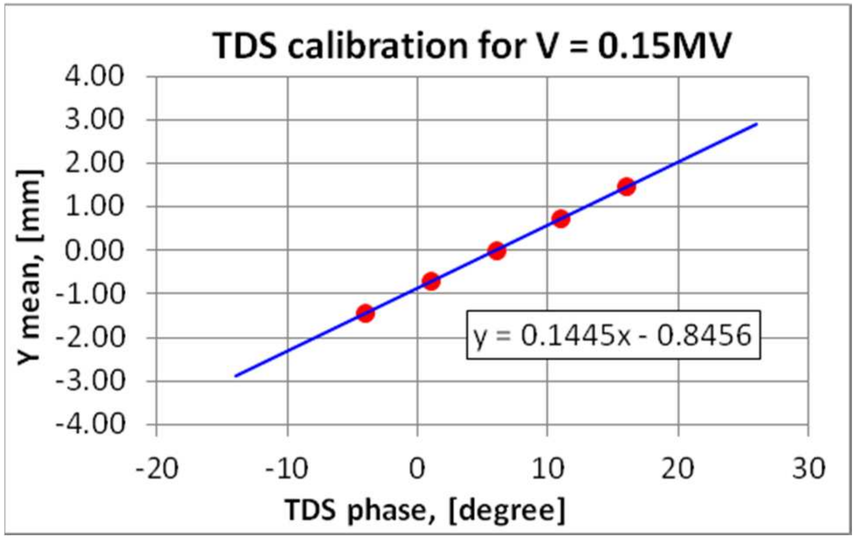
DESY

Beam optics, ASTRA simulation, 1nC



TDS calibration at PST.Scr1, 1nC bunch charge



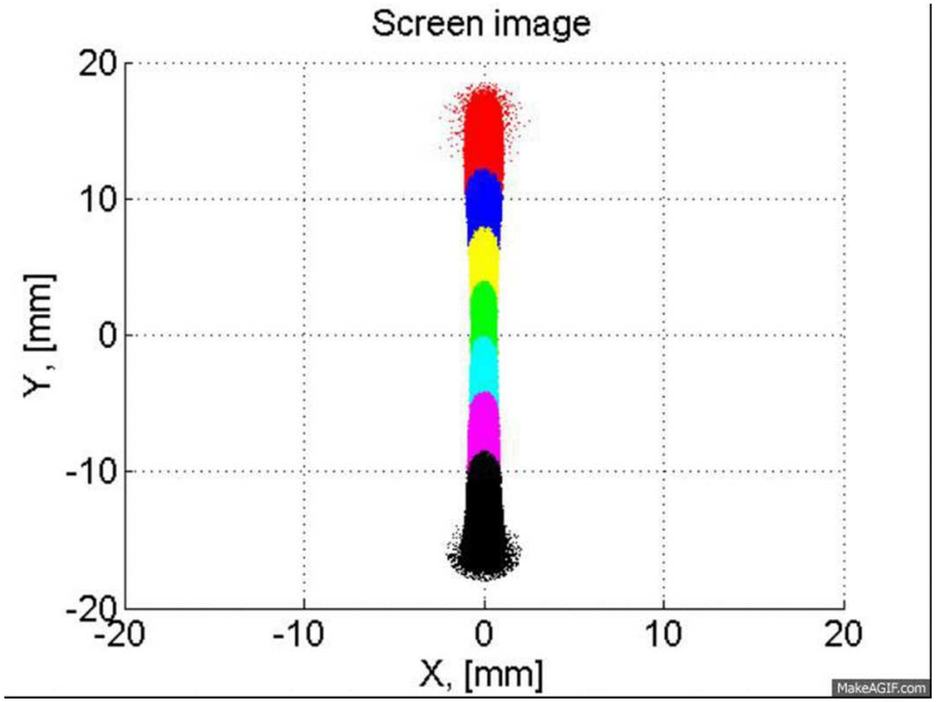


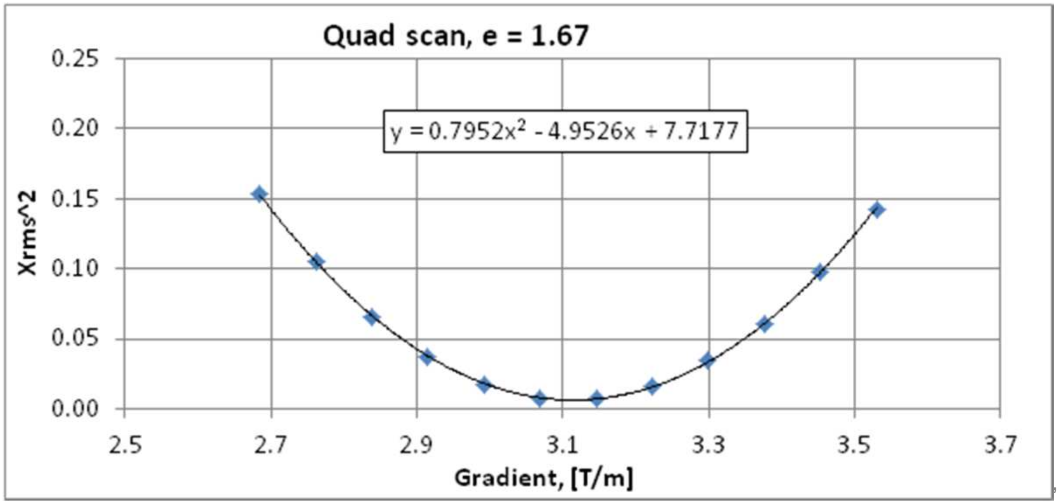
$$S = \frac{K_1 \cdot 360 \cdot f}{\beta \cdot c} = 0.5121$$

$$S(0.6MV) = 2.083$$

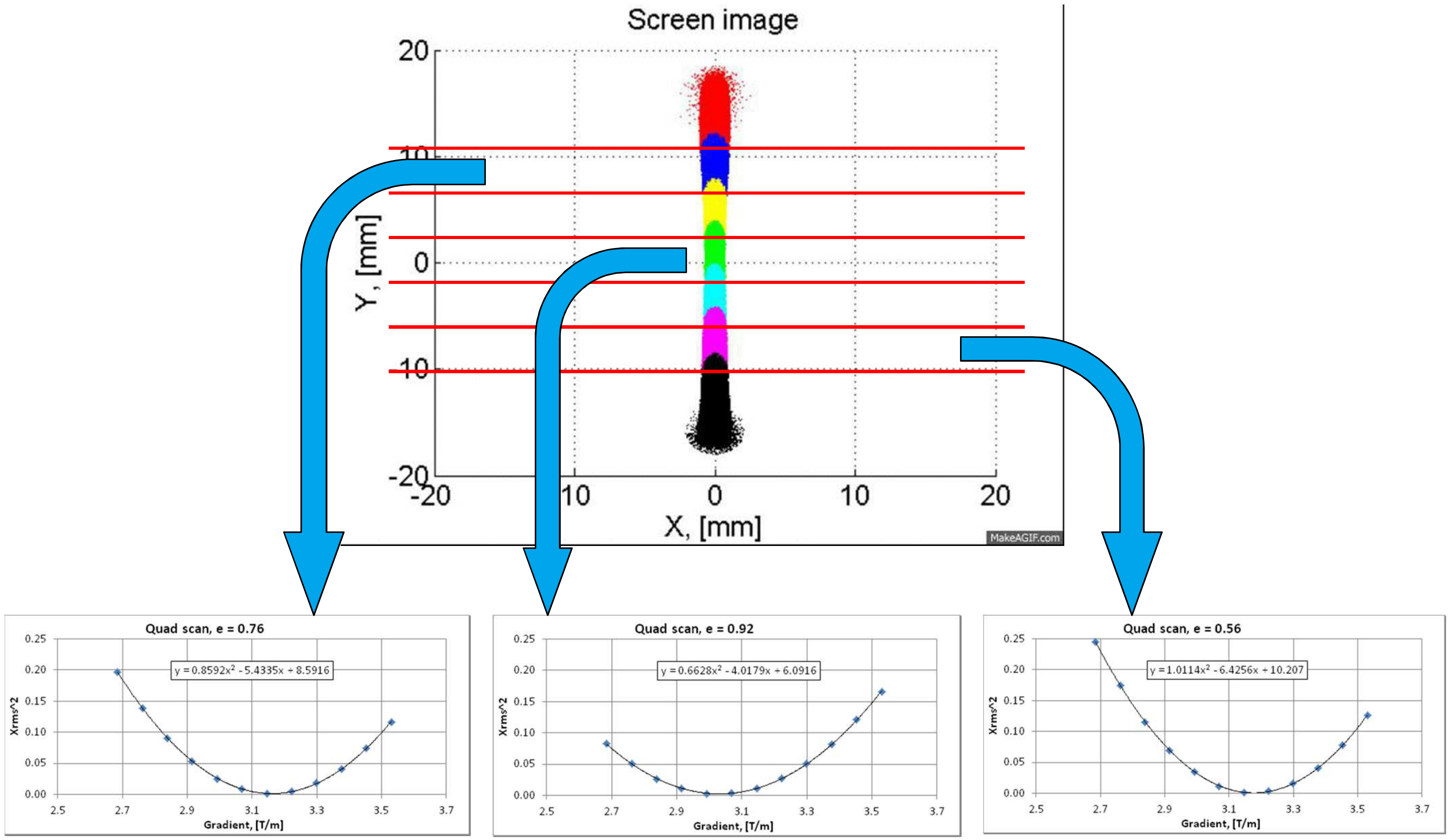
$$S(1.2MV) = 4.165$$

Quad scan (H1.Q6) with TDS deflecting voltage 1.2 MV.

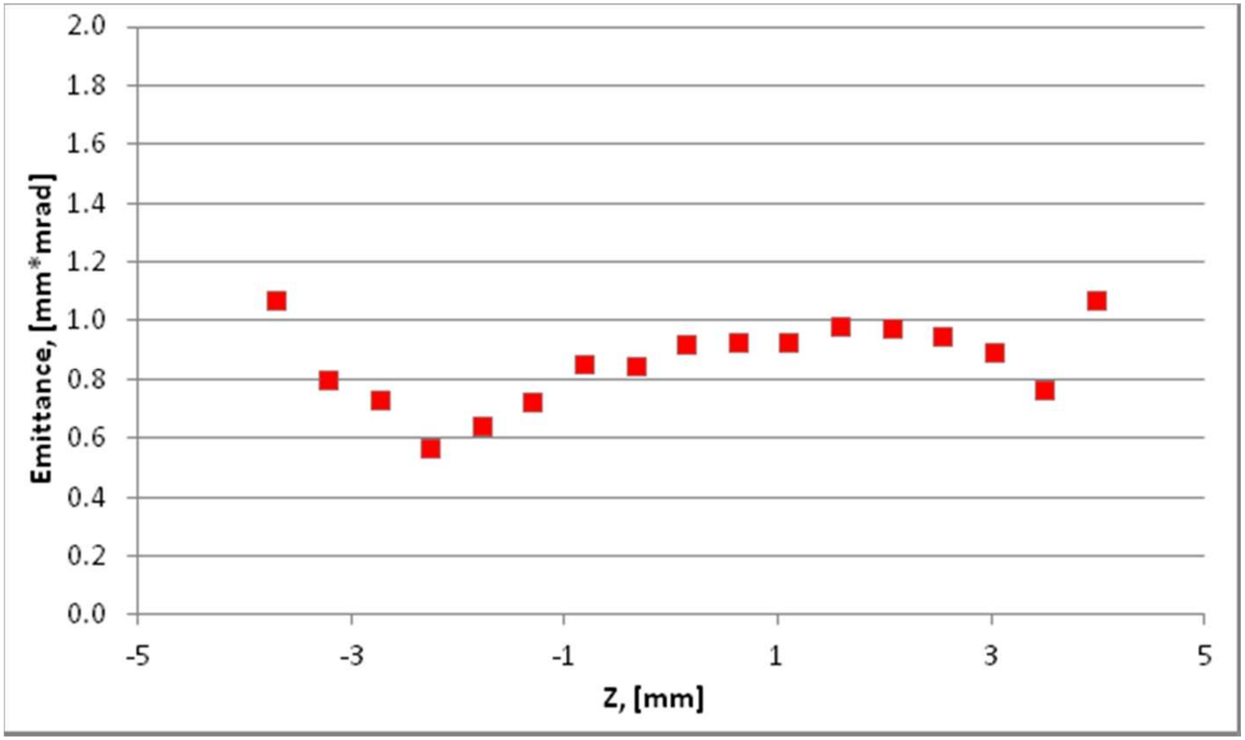




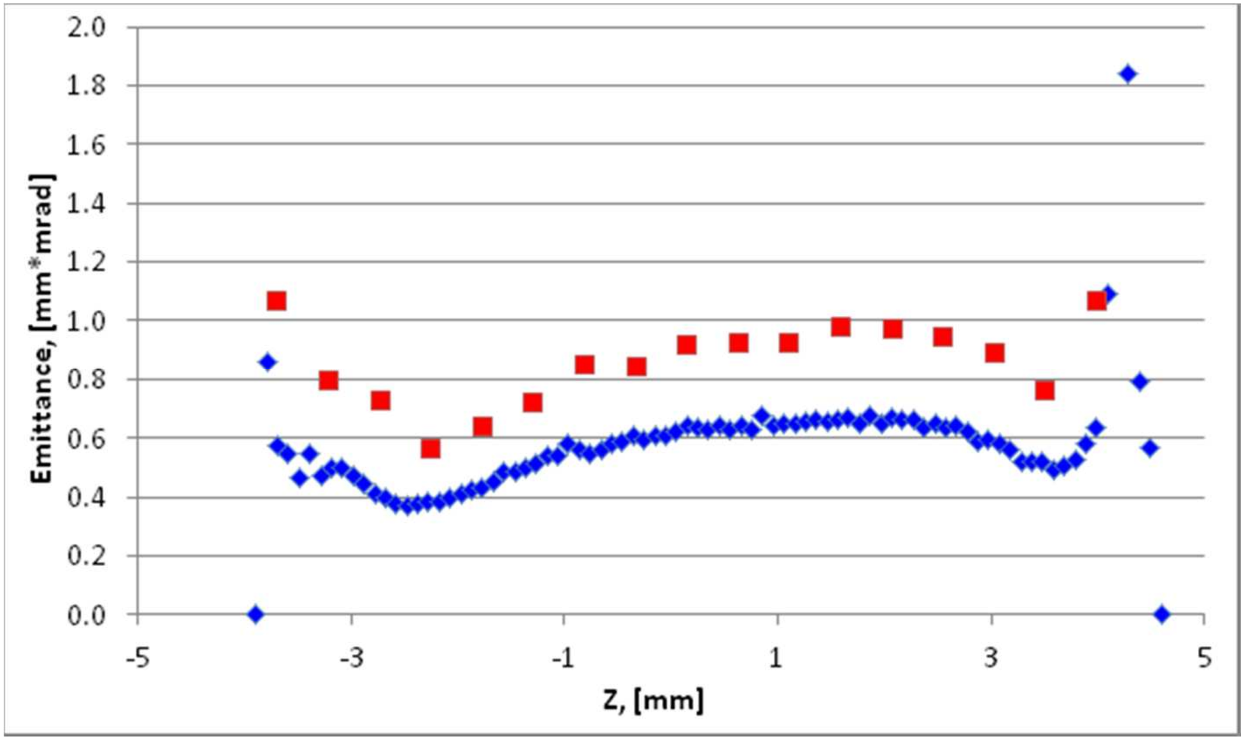
Quad scan (H1.Q6) with TDS deflecting voltage 1.2 MV.



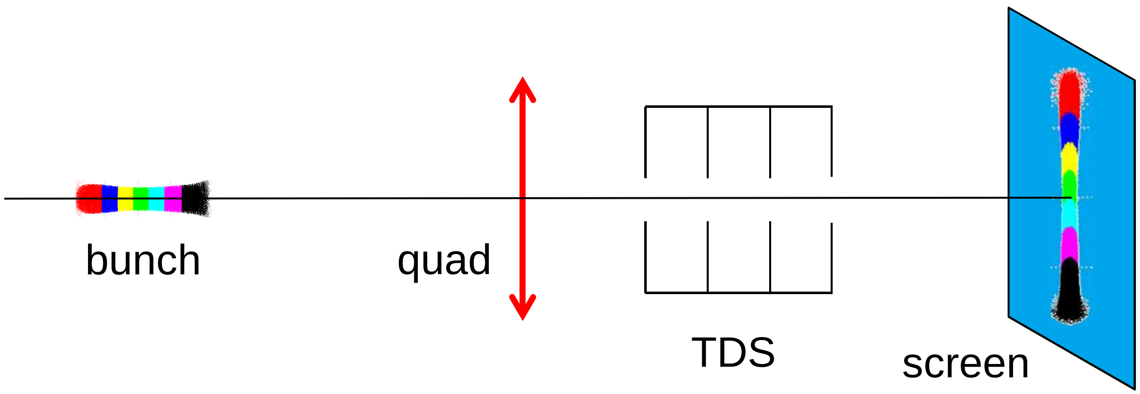
Quad scan summary



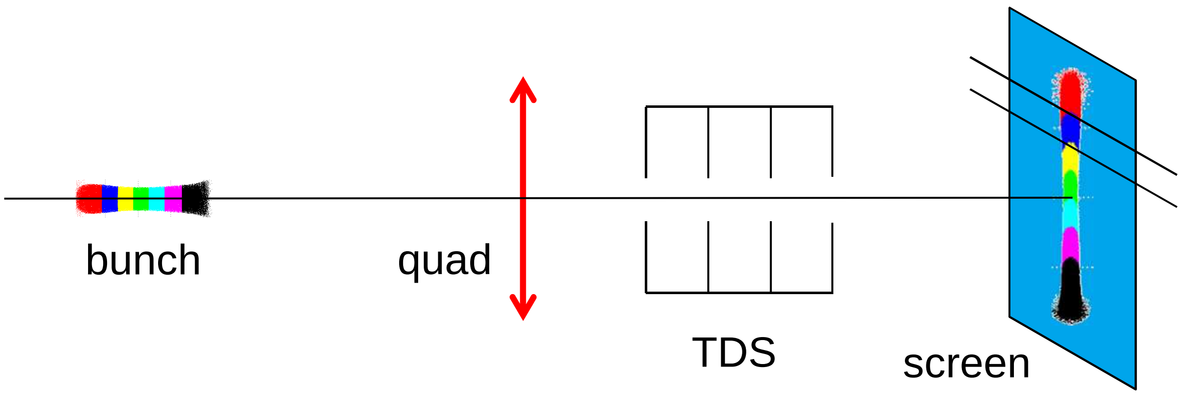
Quad scan summary, compare results

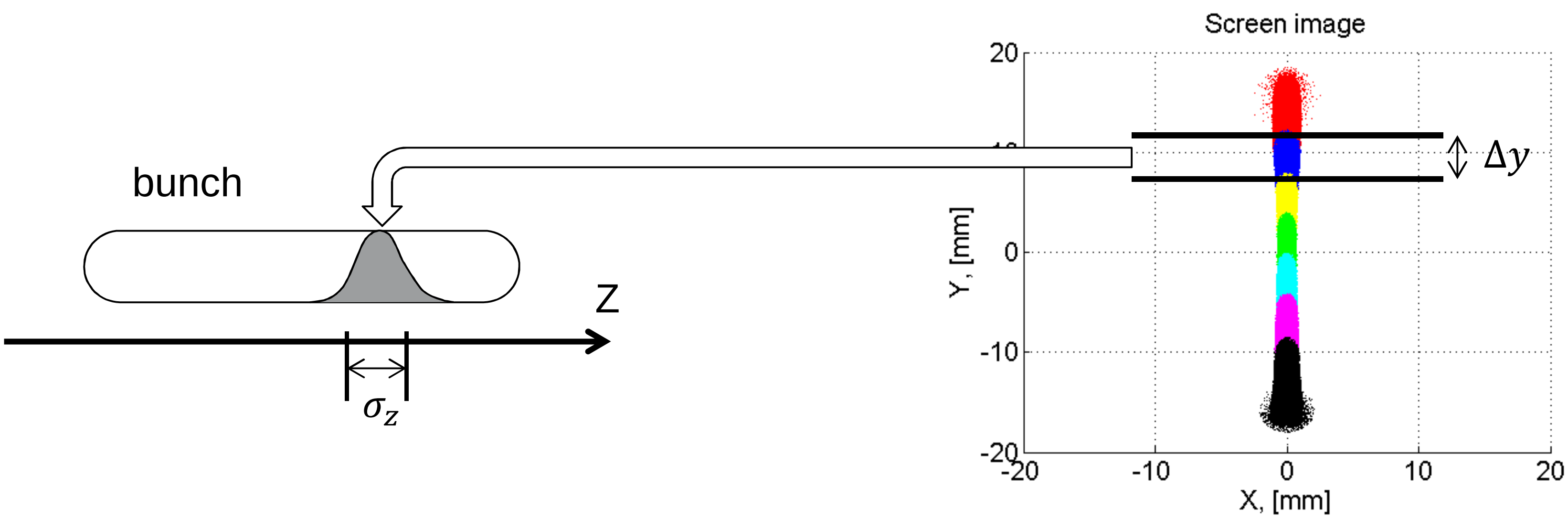


Longitudinal resolution

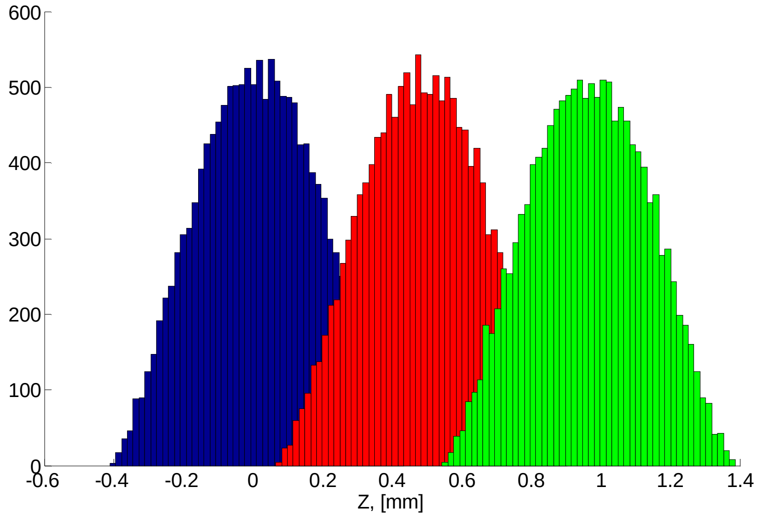


Longitudinal resolution

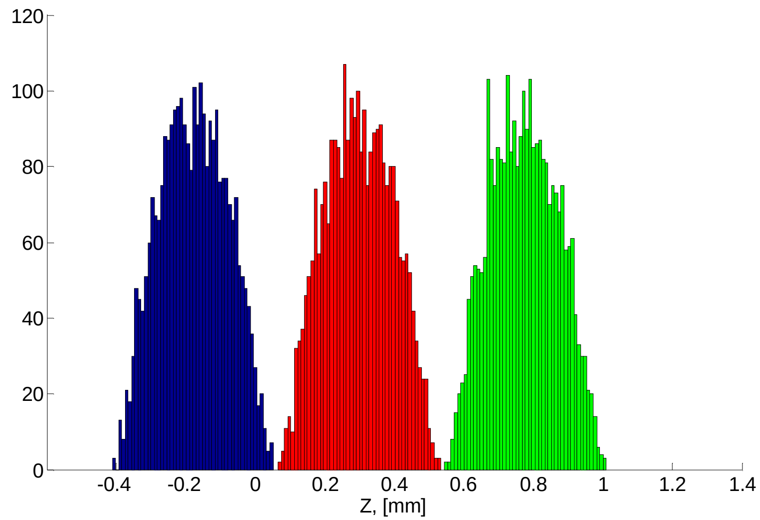




Longitudinal resolution



Vertical cut $\Delta y = 2$mm
Distance between slice centers – 2mm
Slice RMS length $\sigma_z = 0.17$mm



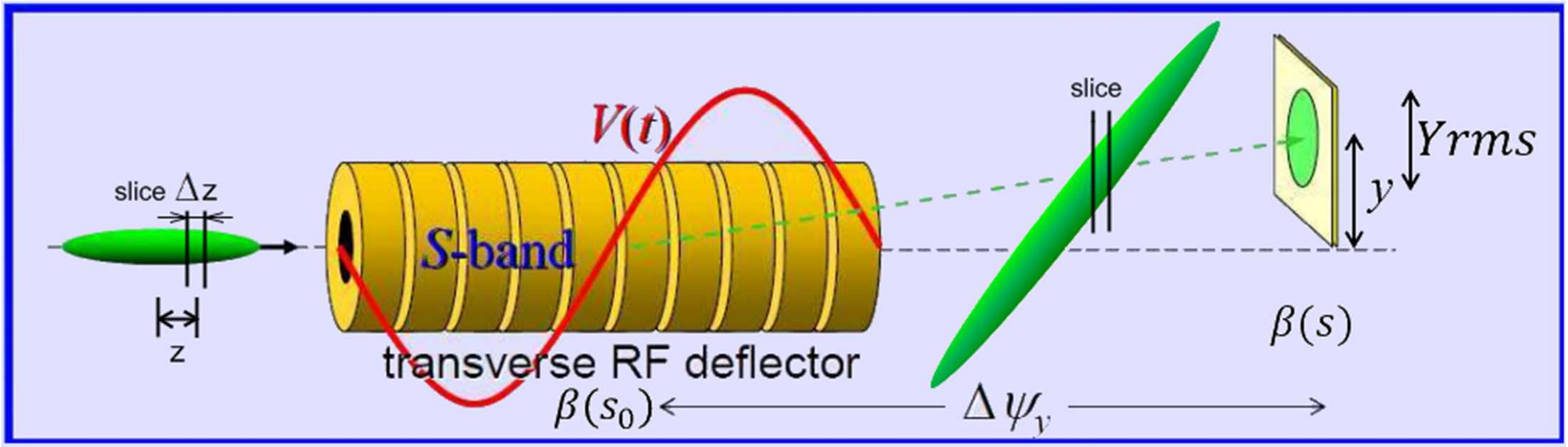
Vertical cut $\Delta y = 0.4$mm
Distance between slice centers – 2mm
Slice RMS length $\sigma_z = 0.09$mm

Conclusion

- Slice emittance measurement simulation done in ASTRA for 1nC bunch charge
- Simulated results are in good agreement to what was expected.
- Achieved longitudinal resolution is about 0.1mm* (RMS), which give us about 80 slices per bunch.

*if for gauss distribution RMS = 0.1mm then FWHM = 0.24mm

TDS resolution



$$S = \sqrt{\beta(s) \cdot \beta(s_0)} \cdot \sin(\Delta\psi_y) \cdot \frac{eV_0 k}{pc} \qquad (1)$$

$$\sigma_z = \frac{\sigma_y}{S} \qquad (2)$$

TDS resolution

$$\sigma_z = \frac{\sqrt{\varepsilon}}{\sqrt{\beta(s_0)}} \cdot \frac{pc}{eV_0 k} = \frac{\varepsilon}{\sigma_y(s_0)} \cdot \frac{\gamma mc^2}{eV_0 k} = \frac{\varepsilon_N}{\sigma_y(s_0)} \cdot \frac{mc^2}{eV_0 k}, \quad (3)$$

$$k = \frac{2\pi f}{c}$$

PITZ:

$$\sigma_z = \frac{0.4 \cdot 10^{-6} m \cdot rad}{800 \cdot 10^{-6} m} \cdot \frac{0.5\ MeV}{1.2\ MeV \cdot 63\ m^{-1}} = 3.4 \cdot 10^{-6} m, \text{or } 11 \text{ fs}$$

TDS induced slice energy spread

$$\sigma_\delta = \frac{eV_0 k}{p_0 c}\sigma_y(s_0), \qquad (4)$$

where $\delta = \frac{\Delta p}{p}$.

PITZ: $$\sigma_\delta = \frac{1.2\ MeV \cdot 63\ m^{-1}}{23\ MeV} \cdot 800 \cdot 10^{-6} m = 2.6 \cdot 10^{-3}\ \ or\ 60\ keV$$

Longitudinal phase space and bunch slices at 5.0m