TDS resolution for FLASH and PITZ

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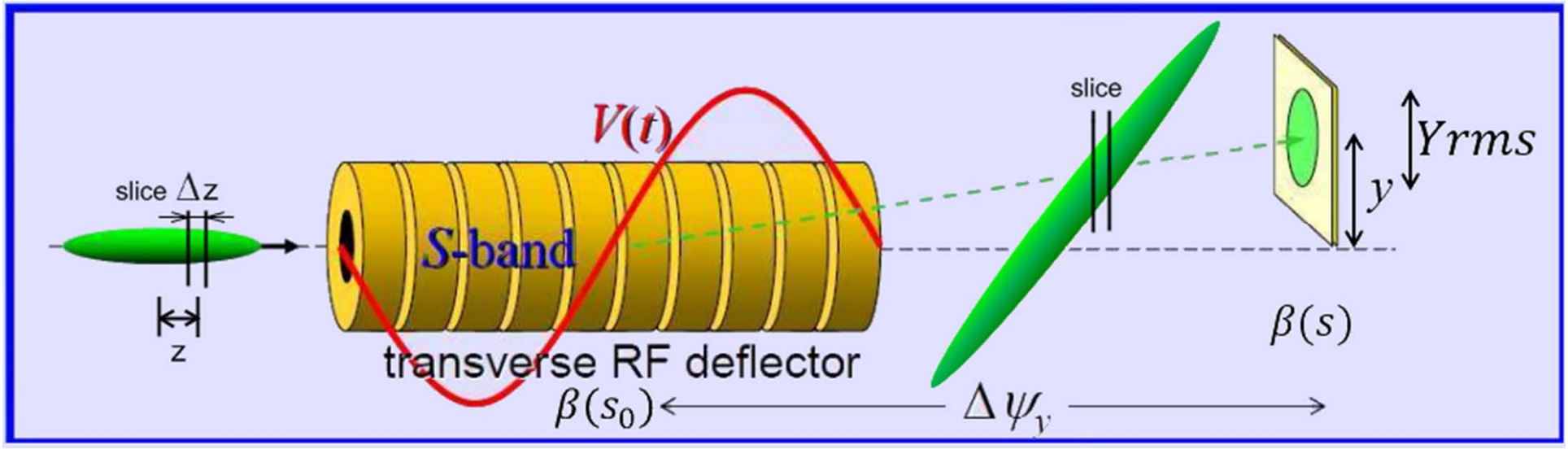
HELMHOLTZ GEMEINSCHAFT

DESY

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

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

FLASH: $$\sigma_z = \frac{1 \cdot 10^{-6} m \cdot rad}{100 \cdot 10^{-6} m} \cdot \frac{0.5\ MeV}{20\ MeV \cdot 63\ m^{-1}} = 4 \cdot 10^{-6} m, \text{ or } 13 \text{ fs}$$

PITZ: $$\sigma_z = \frac{1 \cdot 10^{-6} m \cdot rad}{1000 \cdot 10^{-6} m} \cdot \frac{0.5\ MeV}{1.8\ MeV \cdot 63\ m^{-1}} = 4.4 \cdot 10^{-6} m, \text{ or } 15 \text{ fs}$$

TDS induced slice energy spread

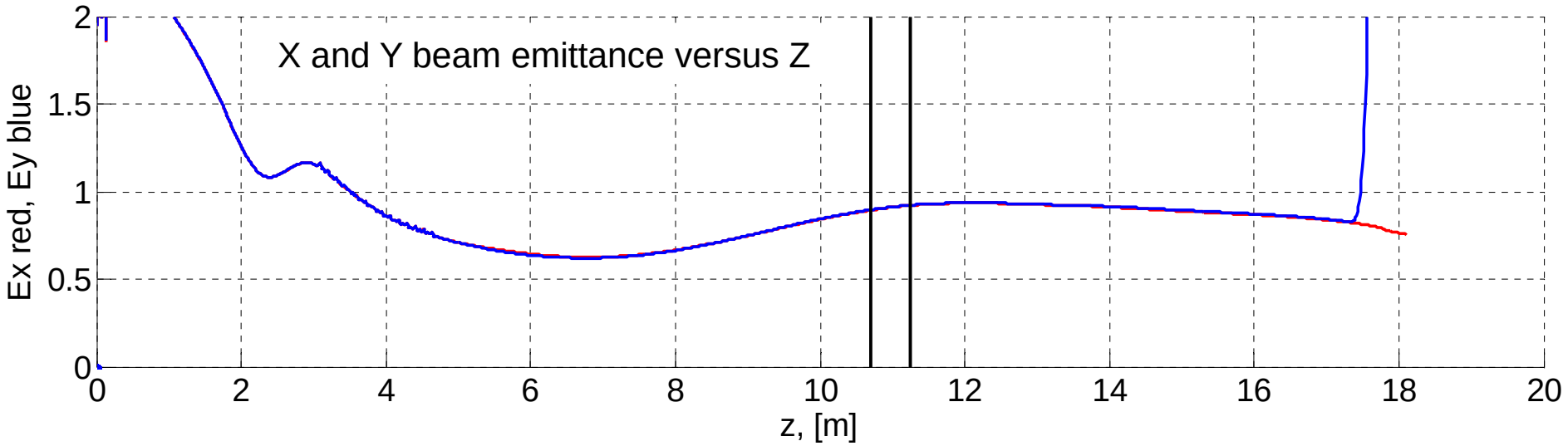
$$\sigma_\delta = \frac{eV_0 k}{p_0 c}\sigma_y(s_0), \qquad (4)$$

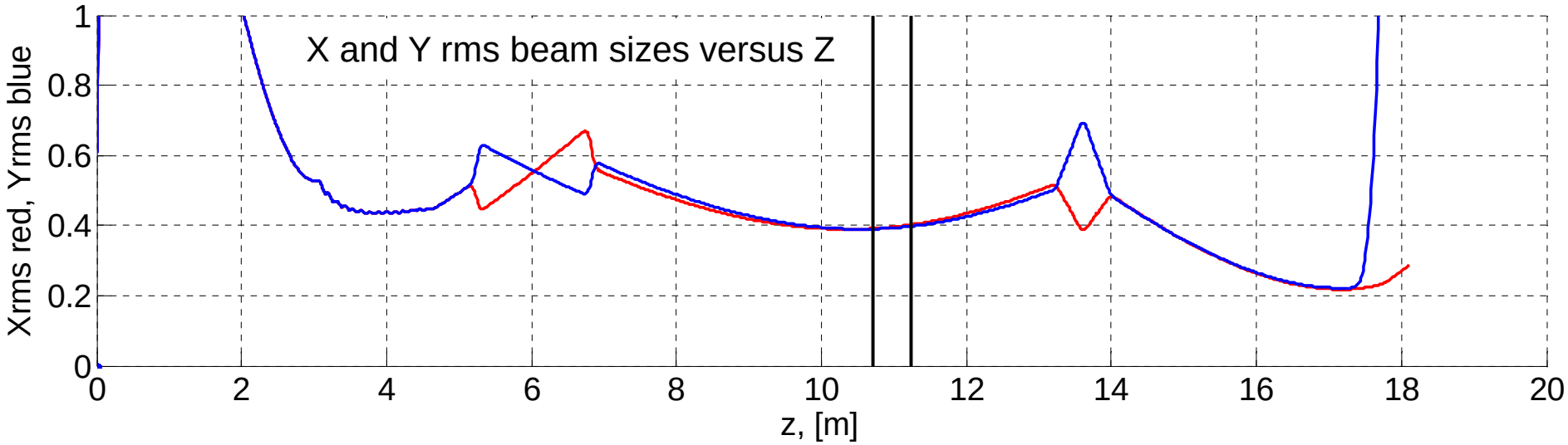
where $\delta = \frac{\Delta p}{p}$.

FLASH: $$\sigma_\delta = \frac{20\ MeV \cdot 63\ m^{-1}}{1200\ MeV} 100 \cdot 10^{-6} m = 10^{-4}\ or\ 120\ keV$$

PITZ: $$\sigma_\delta = \frac{1.8\ MeV \cdot 63\ m^{-1}}{23\ MeV} 1000 \cdot 10^{-6} m = 5 \cdot 10^{-3}\ \ or\ 115\ keV$$

TDS beam optics, emittance and beam size (ASTRA)





Current state of TDS simulation for PITZ

Longitudinal resolution

$$\sigma_z = \frac{\varepsilon_N}{\sigma_y(s_0)} \cdot \frac{mc^2}{eV_0 k}$$

PITZ:

$$\sigma_z = \frac{1 \cdot 10^{-6} m \cdot rad}{400 \cdot 10^{-6} m} \cdot \frac{0.5\ MeV}{0.6\ MeV \cdot 63\ m^{-1}} = 33 \cdot 10^{-6} m, \text{or } 110 \text{ fs}$$

Induced slice energy spread

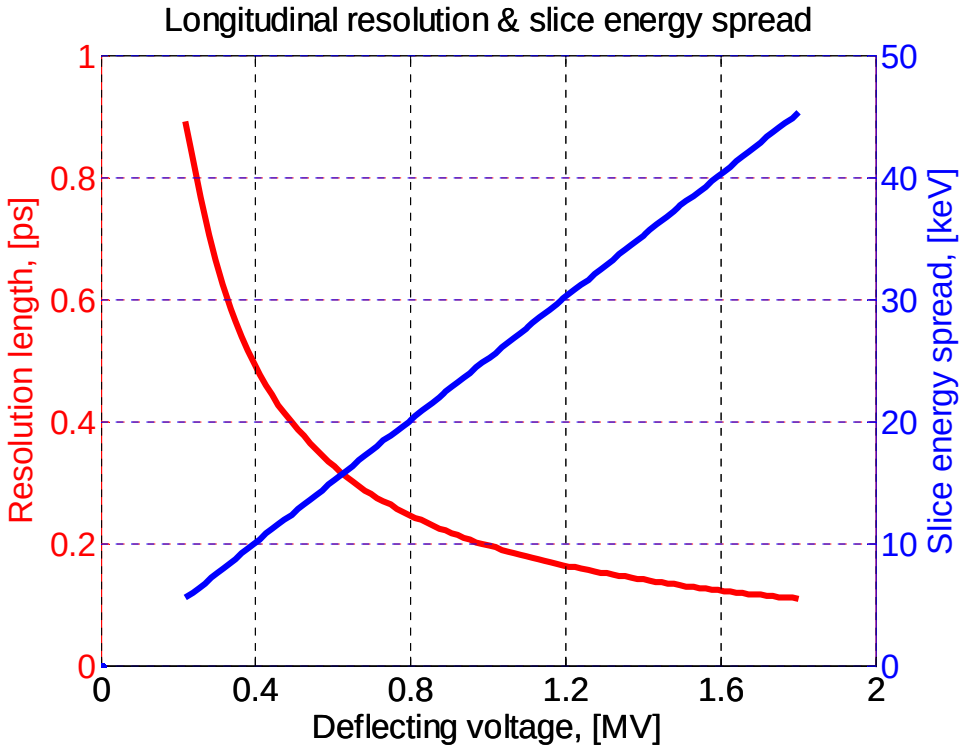
$$\sigma_z = \frac{eV_0 k}{p_0 c} \sigma_y(s_0)$$

PITZ:

$$\sigma_z = \frac{0.6\ MeV \cdot 63\ m^{-1}}{23\ MeV} 400 \cdot 10^{-6} m = 6.5 \cdot 10^{-4}\ \ or\ 15\ keV$$

TDS resolution and induced energy spread

For TDS deflecting voltage 0.6MV parameter S will be about 3.2, and for transverse RMS beam size 0.3 mm at screen (TDS OFF), resolution length will be 0.1 mm or 0.3 ps.

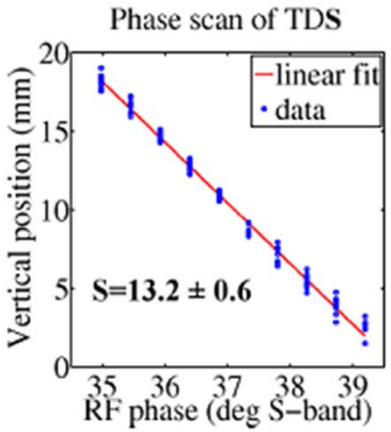


More details in the talk "**Simulation of the PITZ TDS and HEDA2 longitudinal phase space measurement**" for PITZ Collaboration Meeting October 2011: https://pitz.desy.de/meetings/collaboration_meetings/2011_october/index_eng.html

Presented FLASH LOLA resolutions

Christopher Behrens and Christopher Gerth, FLASH Seminar: June 14th, 2011

$$\sigma_\zeta = \frac{\sigma_{y_\beta}(s)}{S(s)}$$



beam size – 70 um ?

Achieved Resolutions (already during commissioning in 2010)

- Time: 18±3 fs at 1200 MeV.
- Rel. Energy: $1.4 \cdot 10^{-4}$ (100 keV) at 700 MeV ⇒ approx. $1.0 \cdot 10^{-4}$ at 1200 MeV.
- Both like expected (slightly better) and in parallel to FEL operation, i.e. no special optics.

Year 2011: achieved 7fs time resolution.