Evaluation of emittance measurements data consistency – PITZ-PoV

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Mini Workshop on

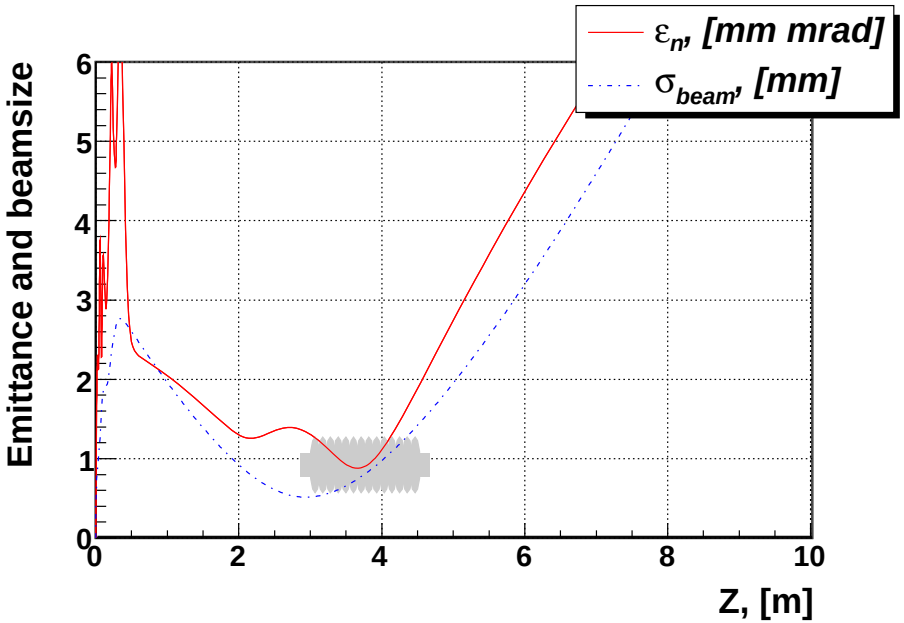
“Characterization of High Brightness Beams”

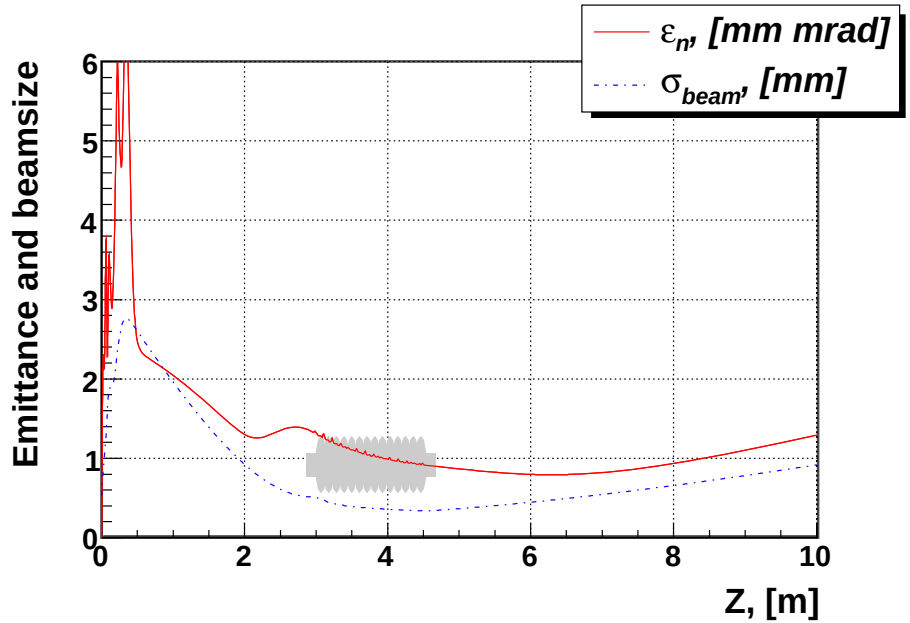
Zeuthen, May 27th, 2008

Featuring

- Motivation
- Emittance measurements at PITZ
  - method
- Criteria for data consistency
  - PPoV
- Discussions

Injector topology





- ASTRA simulation
  - 1 nC (200 kParticles)
  - 2x20x0.48 ps.ps.mm
  - 0.5 eV
  - on-crest phases
  - 283 A
  - 22 MeV
  - 0.76 mm.mrad

Emittance measurement

Single slit mask method

single slit method:

direct measurement

"multi-shot" accumulates jitter

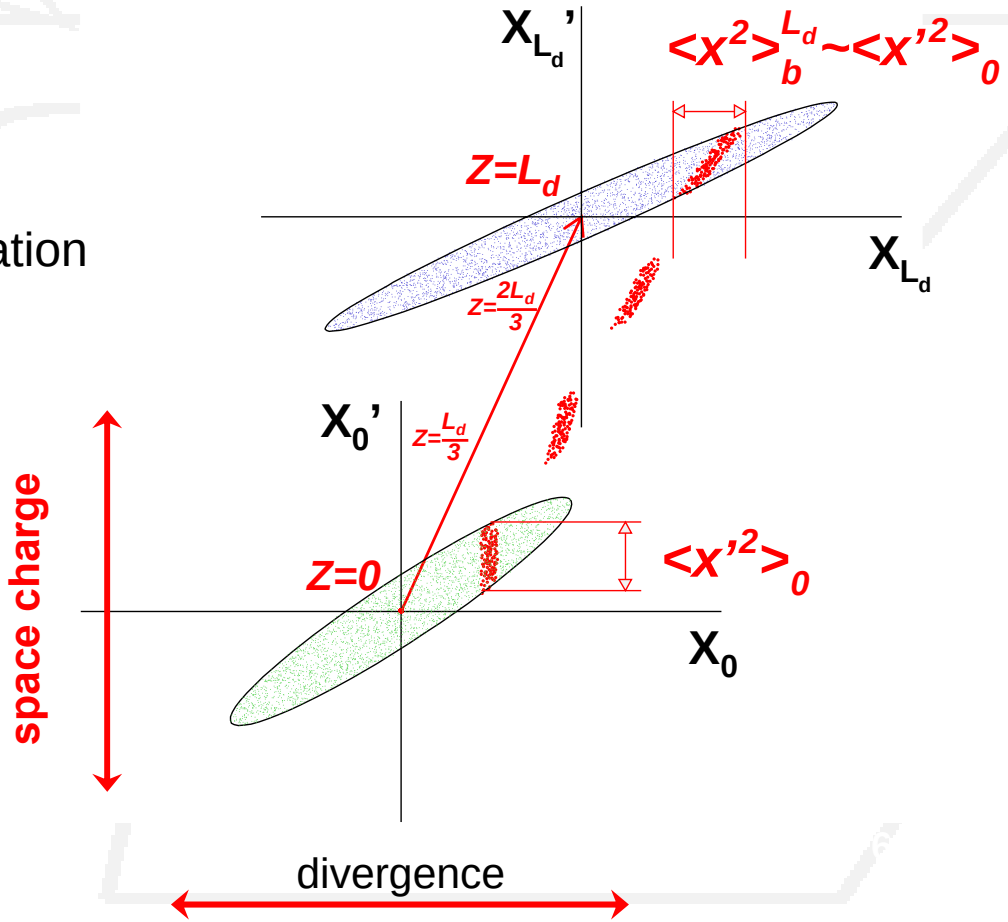
sheared divergence approximation

$$\varepsilon_{x,n} = \beta\gamma \cdot \sqrt{\langle x^2 \rangle \cdot \langle x'^2 \rangle}$$

$$\langle x'^2_i \rangle = \sqrt{\frac{\langle x_b^2 \rangle_i}{L_d^2}}$$

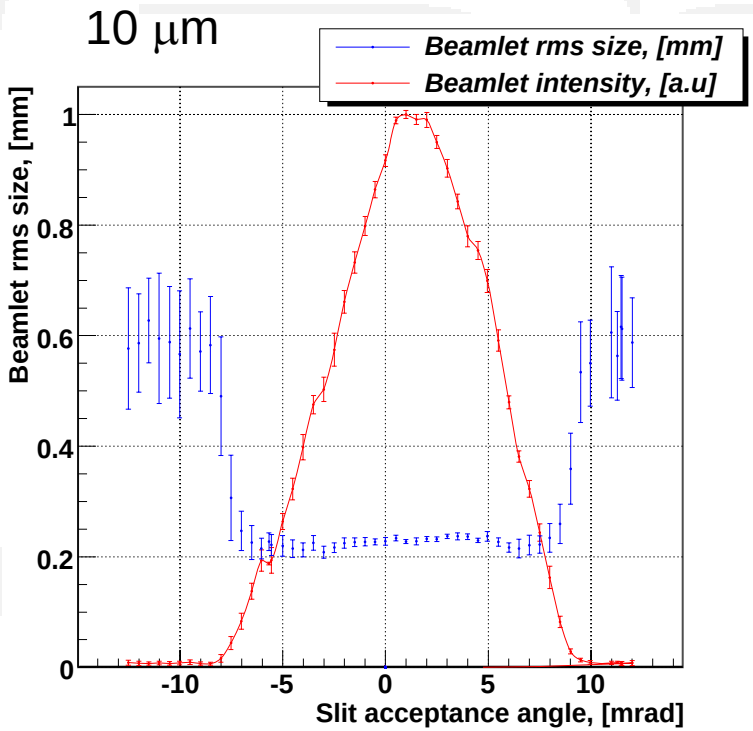
local divergence

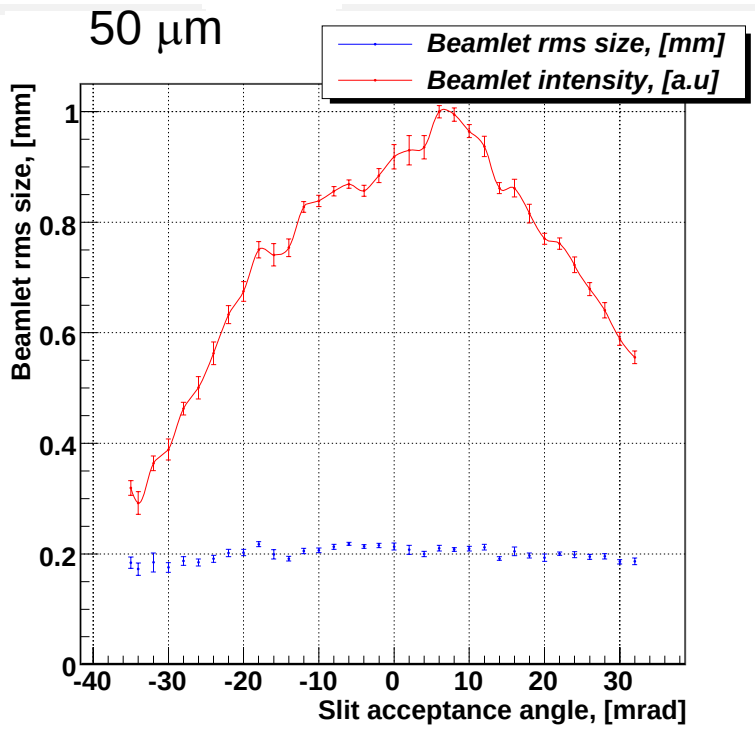
$$\langle x'^2 \rangle = \frac{1}{n} \cdot \sum_{i=1}^{n} w_i \cdot \langle x'^2_i \rangle$$



Reply from yesterday

slit scattering effects





Criteria

- Machine setup and monitoring
- Completeness of data
- Quality of data
  - S_2N
  - instruments
    - amplitude range
    - optical resolution
    - method specifics
  - jitter
- Data treatment

Machine setup and monitoring

- Establishment and control of the main parameters
  - bunch charge
  - RF phases and amplitudes
  - beam momentum and momentum distribution
  - beam trajectory
  - ...
- Fast and reliable procedures

Completeness of data

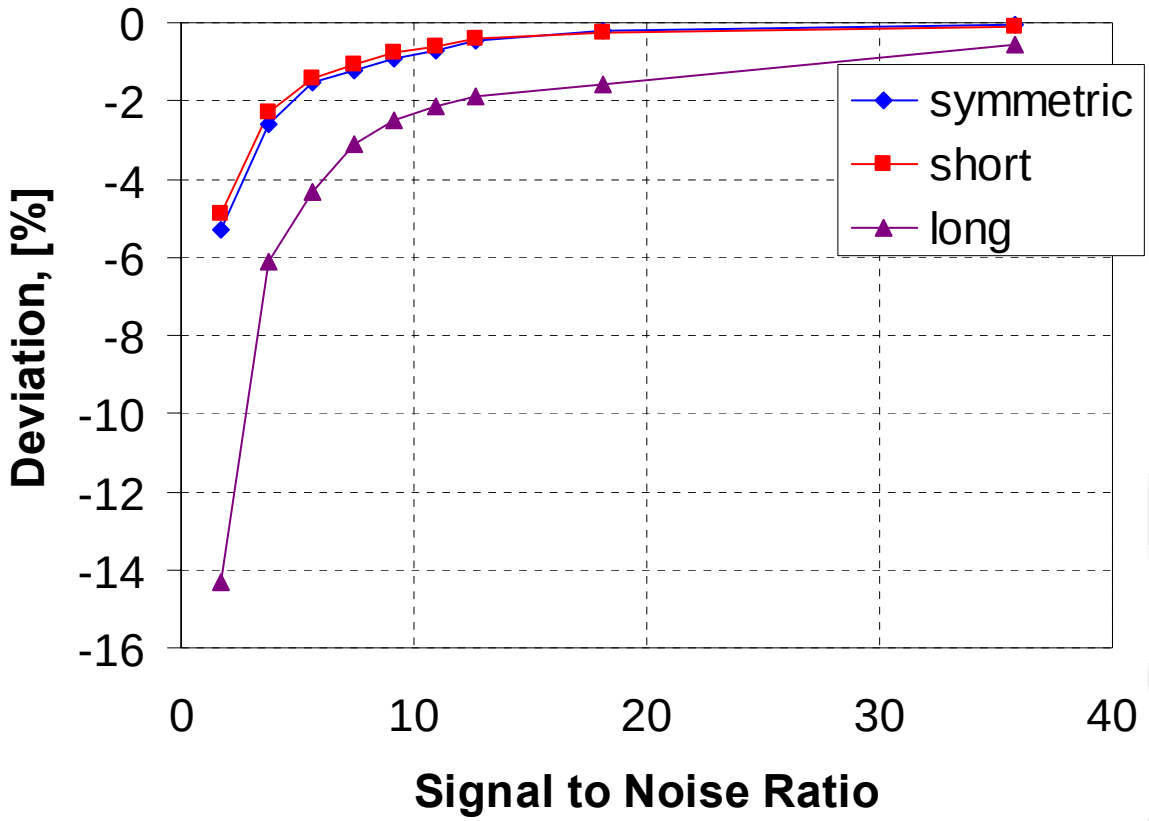
- Beam and beam-let sizes ☺
  - mean momentum and momentum distribution at each possible location (i.e. after gun, etc.)
  - statistical overview
- Auxiliary data
  - phase scans
    - charge vs. gun phase

    (hints on longitudinal laser distro, gradient@cathode etc.)
    - momentum vs. RF phases

    (hint on the field distribution)
  - beam size vs. ***Z***
  - lattice – PS currents
  - cathode laser monitoring
  - Q.E.
  - etc…
- Automation solves most problems
- Data statistics

Quality control

3x sigmask @ Signal to Noise Ratio

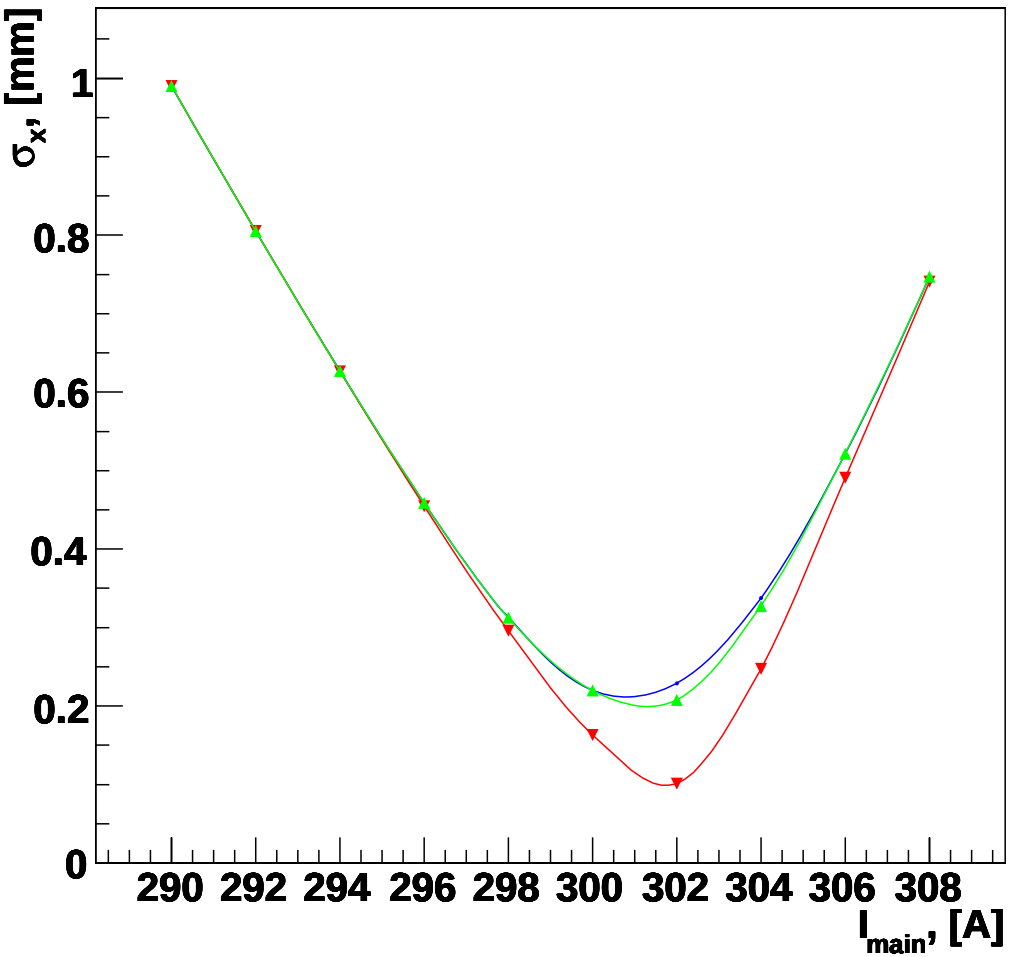


- Gaussian distribution combined with an 12 bit camera background
  - **round** "beam"
  - **short** side of a "beam-let"
  - **long** side of a "beam-let"

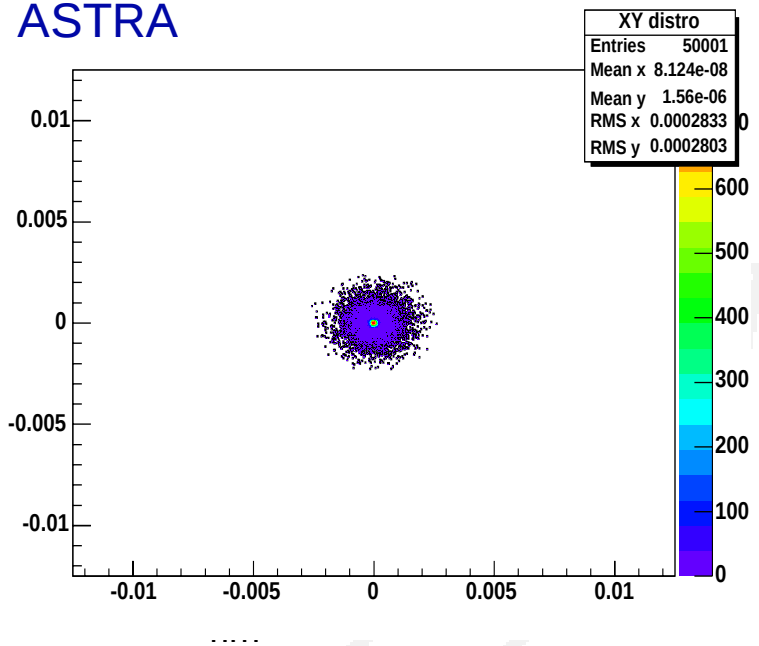
Quality control

instruments – amplitude range (bi

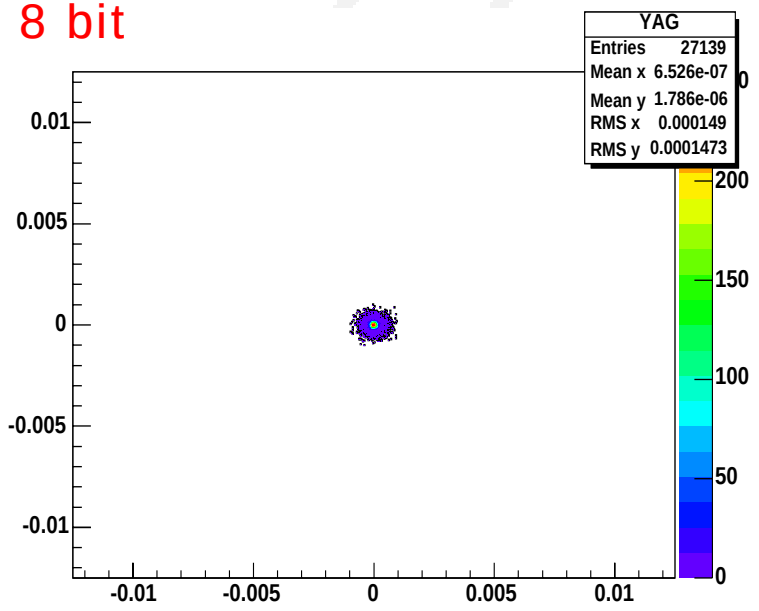
ϕ = 0°



ASTRA



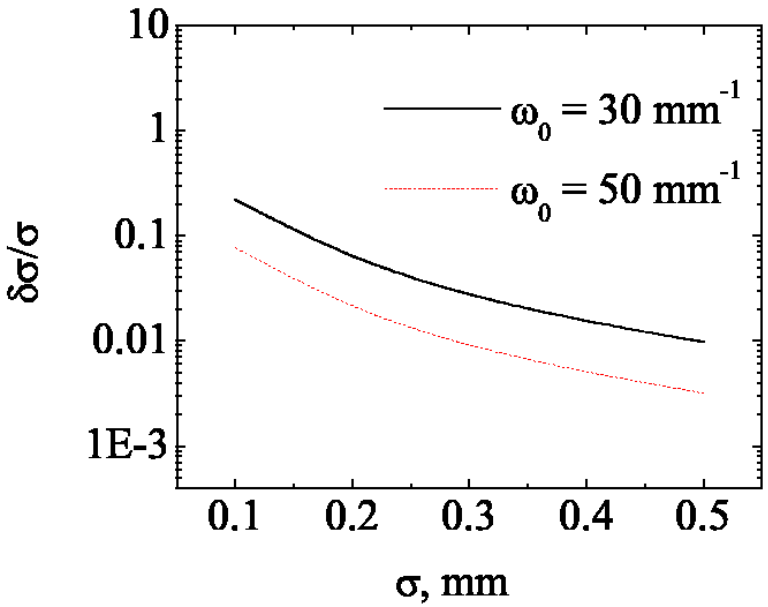
8 bit



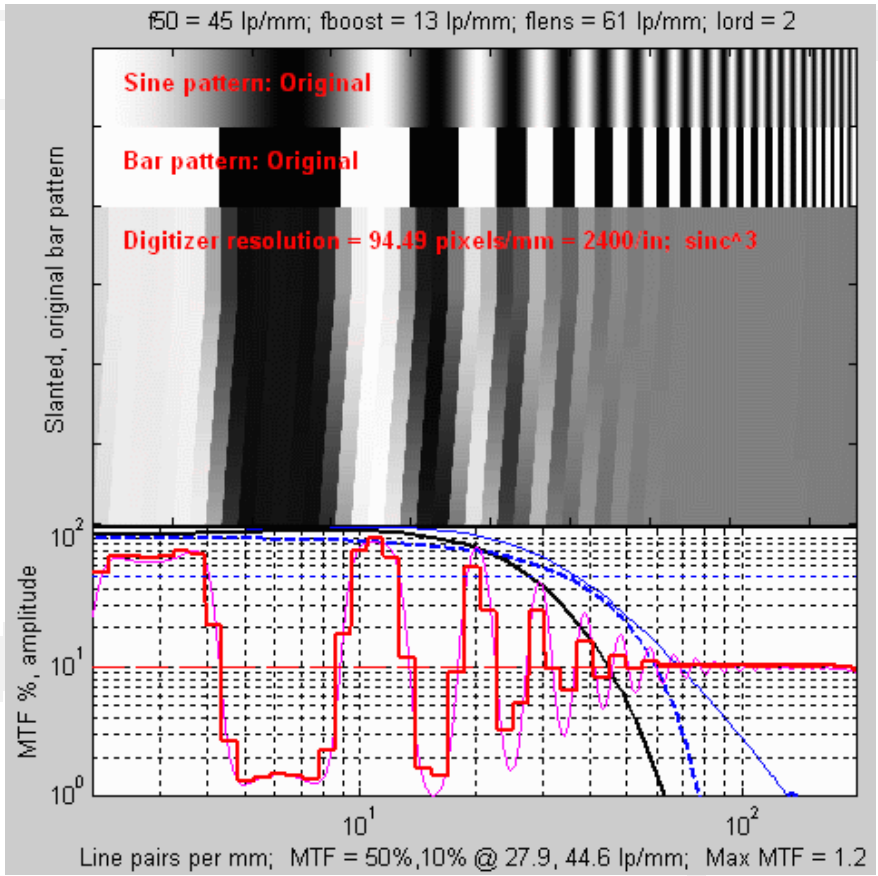
Quality control

instruments – optical contribution

- MTF formalism used
- Uncertainty as a function of beam size



TRANSVERSE BEAMSIZE MEASUREMENT SYSTEMS AT PITZ
R. Spesyvtsev, diploma thesis



http://www.normankoren.com/Tutorials/MTF.html

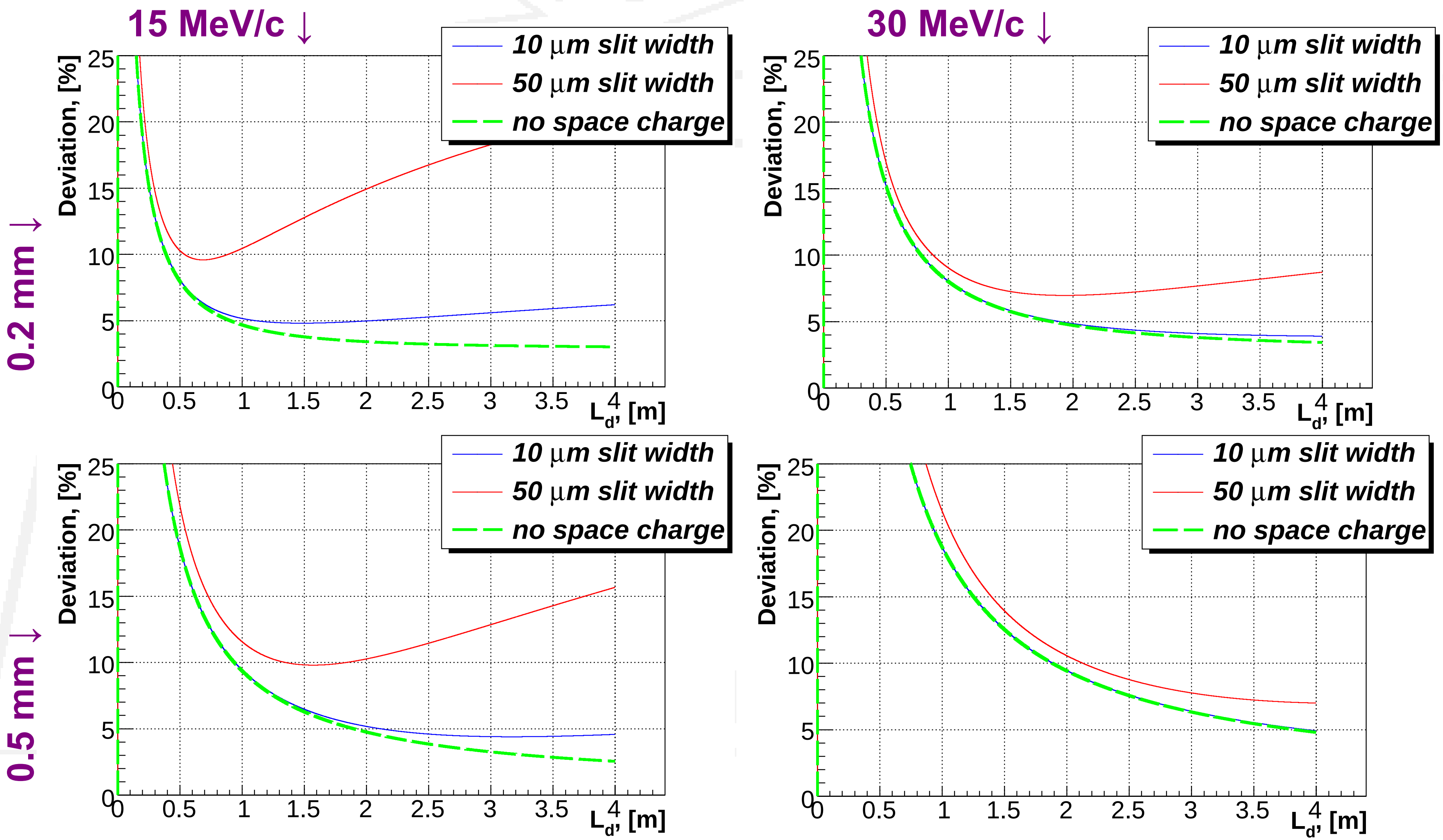
Quality control instruments – method specifics

- Envelope equations for non-symmetric beam
  - Used to calculate the beamlet evolution
  - Estimates the influence of the slit opening due to space charge on the beamlet size
- Uniform distribution used to solve the system

- General parameters:
  - I_p = 50, A
  - γ = 10 .. 60
  - σ_x = 0.2 .. 2, mm
  - σ'_x - scaled such that
  - ε_x = 0.9 mm.mrad

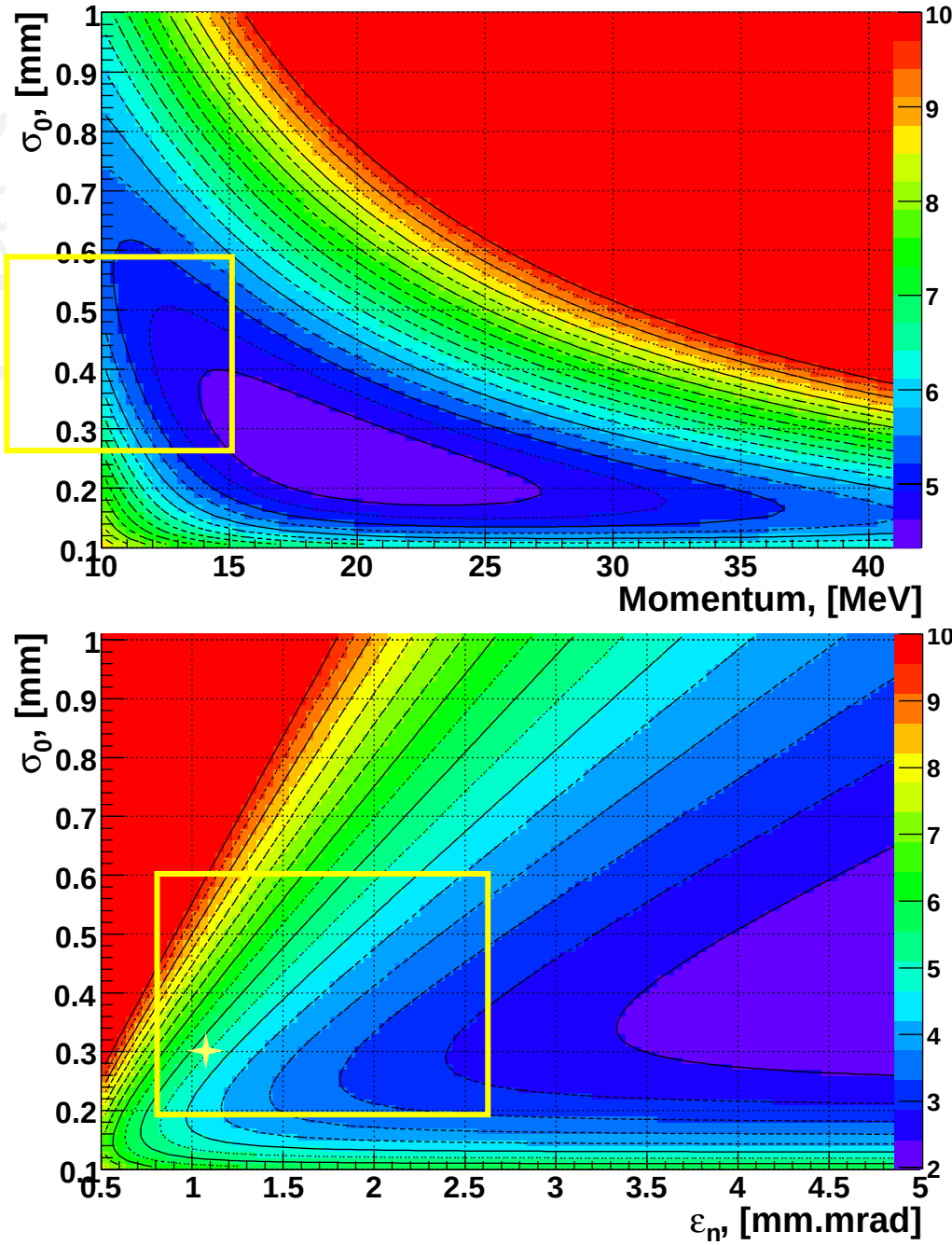
Quality control

instruments – method specifics



Quality control
method specifics

- Single slit method uncertainties
  - as a function of beam momentum and the initial *rms* size, ε_n=0.9 (upper plot)
  - as a function of the initial *rms* size and the emittance
    - mean momentum
      - 15 MeV/c
      - 30 MeV/c
    - slit opening 10 μm
    - L_d = 2 *m*
    - optic resolution 50 *l/mm*



Miscellaneous

- Jitter
  - discussions in talk of MK
- Data treatment variations
  - *sigmask*
  - fit methods
  - rms methods
  - “cut” methods

Conclusions

- Data consistency is affected by numerous factors
  - machine setup and performance
  - data ensemble
  - data treatment
- Higher attention needed during the preparation and execution of emittance measurements
- Automation solve most of the problems
  - but new emerge

Discussions

- ☺

The END

- STOP!
  - don’t click further!!!