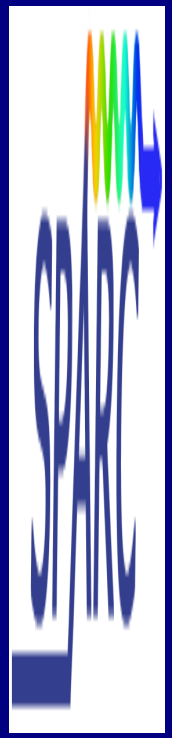
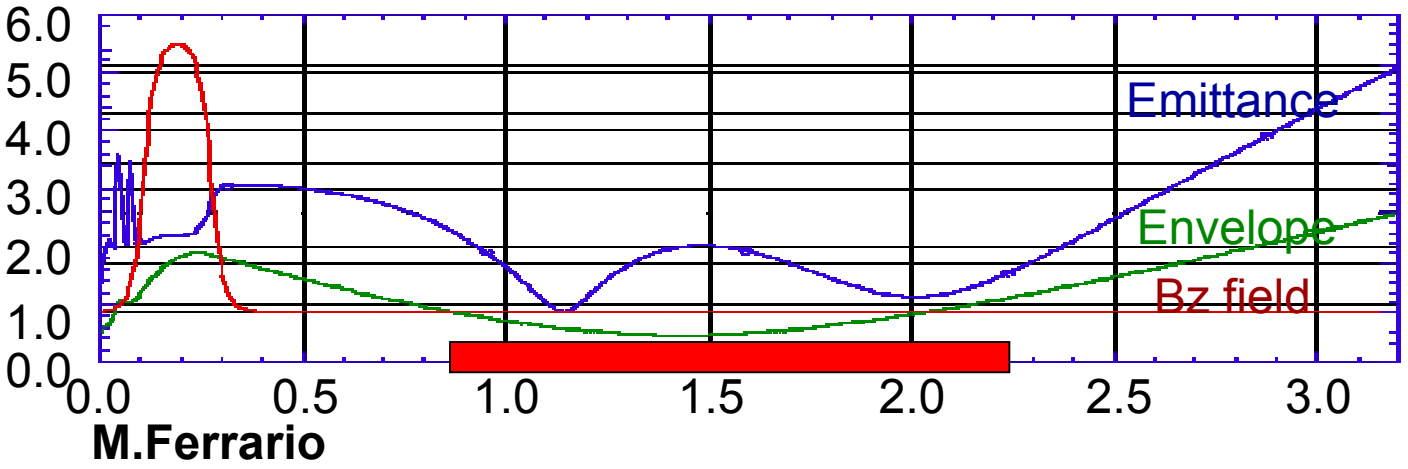


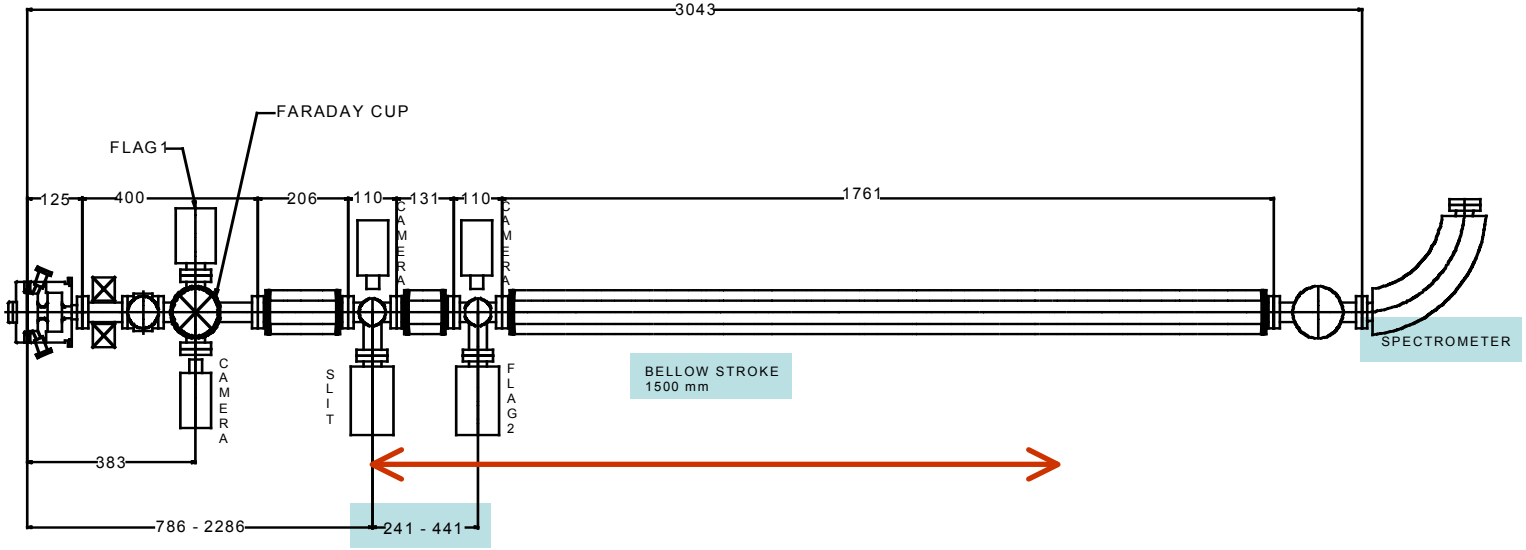
GUN Emittance measurement

Alessandro Cianchi

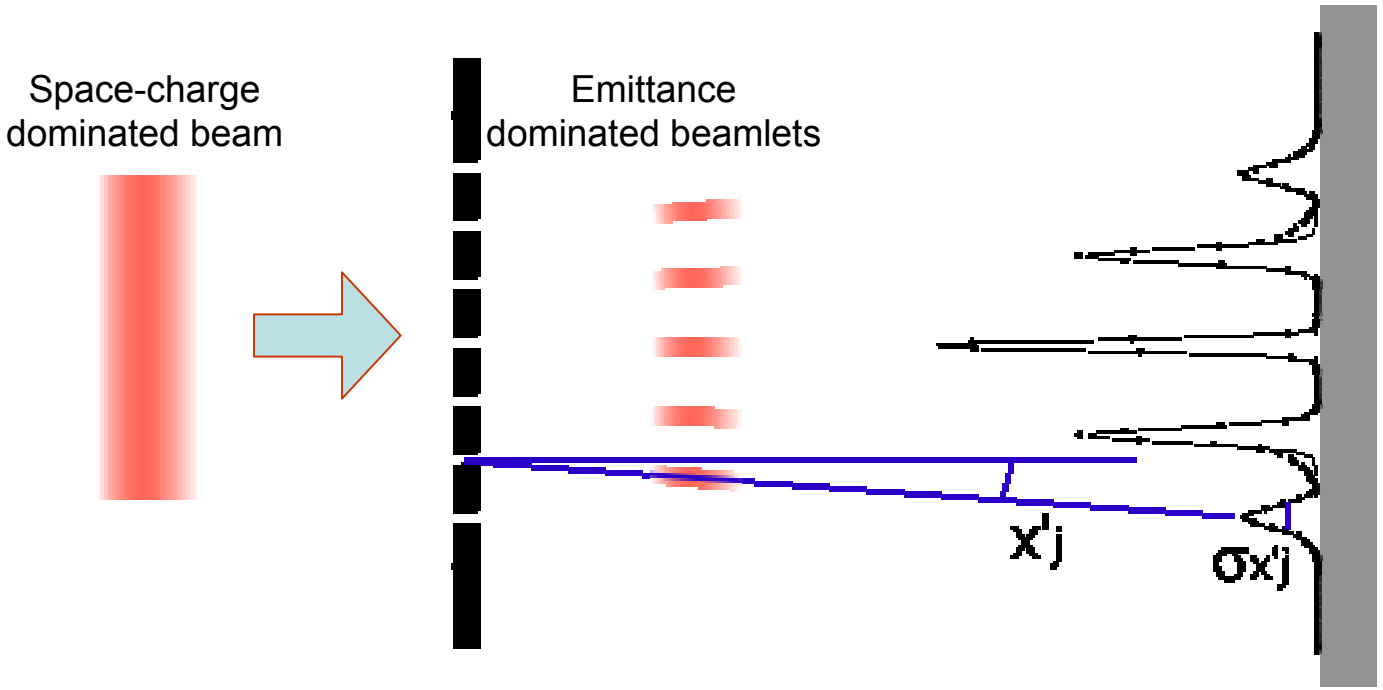
University of Rome "Tor Vergata"
and INFN-RM2
for
Diagnostic Group
In collaboration with the
Beam dynamics group

Measure of the emittance





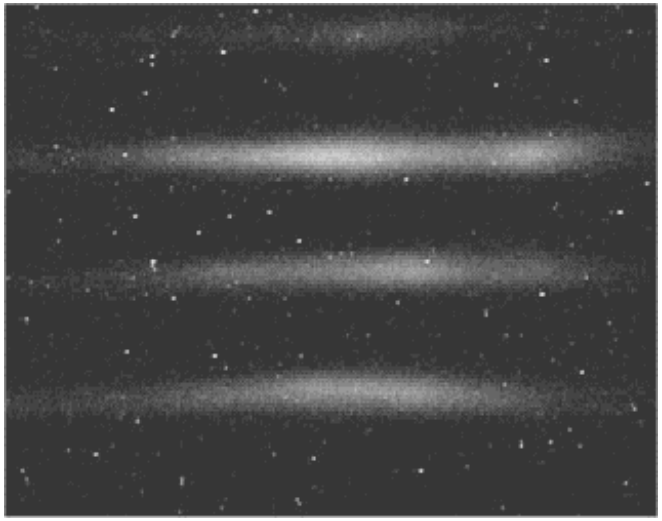
The Pepper Pot method

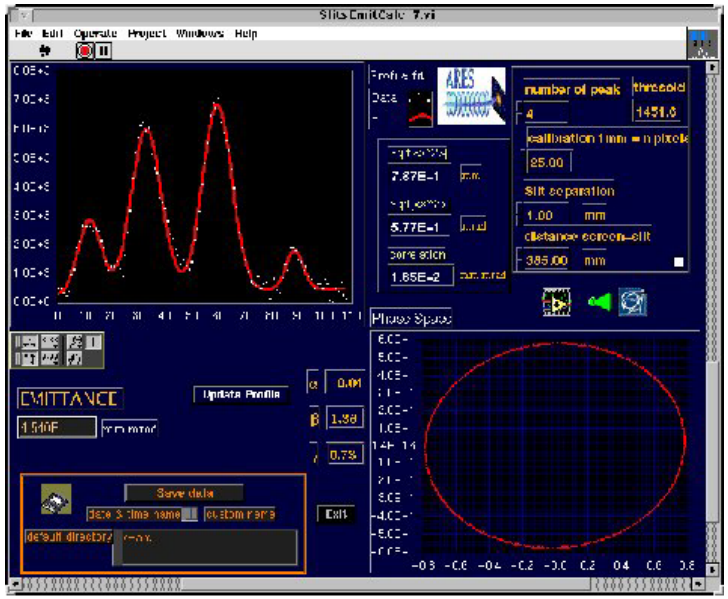


$$\varepsilon_n^2 = \langle x^2 \rangle \langle x'^2 \rangle - \langle x x' \rangle^2$$

$$\approx \frac{1}{N^2}\left\{\left[\sum_{j=1}^{p} n_j \left(x_{sj} - \overline{x}\right)^2\right] \cdot \left[\sum_{j=1}^{p} n_j {\sigma_{x'_j}}^2 + n_j \left(\overline{x'_j} - \overline{x'}\right)^2\right] - \left[\sum_{j=1}^{p} n_j x_{sj} \overline{x'_j} - N \overline{x}\,\overline{x'}\right]^2\right\}$$

Past experience at TTF



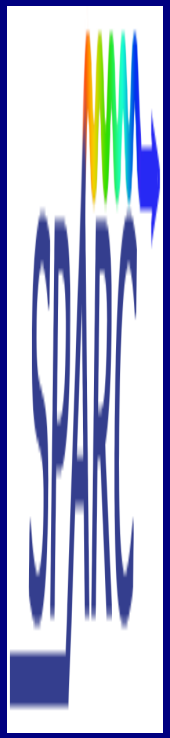


Transverse Phase Space Studies in TTF Photoinjector During Run 00-01. A Comparison between Simulation and Experiment. Ph. Piot, K. Floettman, S. Schreiber, D. Sertore - DESY; A. Cianchi - INFN Frascati; L. Catani - INFN Roma II – TESLA FEL note 2000-04

Emittance measurement at the TTF Photoinjector

Ph. Piot, S. Schreiber,D. Sertore,K.Floettmann, DESY, 22603 Hamburg, Germany, A.Cianchi, INFN Frascati, Italy, L. Catani, INFN Roma II, Italy. Proceedings of PAC 2001

SPARC measure related problems



- Not fixed position :
  - **Different behavior of the beamlets**
  - **Different conditions: from converging to diverging beam**
  - **Different strategy to process and analyze data**

- Small (1-2 mm-mrad) emittance :
  - **High resolution screen (better than 30 μm)**
  - **Aberration free optics**

- Low charge (1 nC but only 10-50 pC after the slits)
  - **Screen that produce enough photons to be detected**
  - **Digital camera with high efficiency and resolution**

Single vs Multi-slits mask

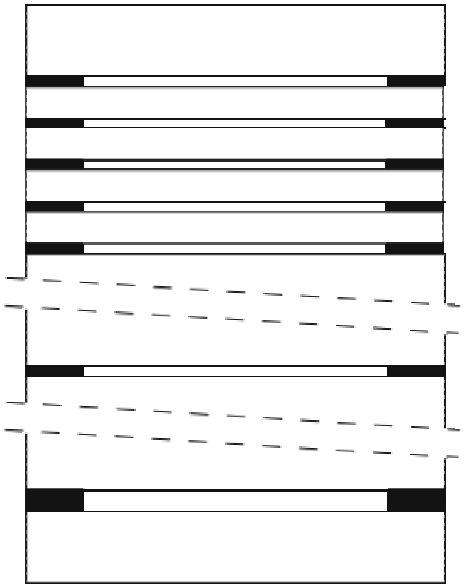
- **Multi slits (fixed distance between slits 500 μm)**
  - ✓ **Single shot measure**
  - ✓ **No overlap means that it is difficult to use in every z position**
  - ✓ **Different beam sizes means that in some z only few slits are visible**
  - ✓ **Uniformity of the slits machining**
- **Single slit (moved across the beam by stepper motor)**
  - ✓ **Better accuracy**
  - ✓ **It is possible to use everywhere**
  - ✓ **Stability of the beam**

Slits Mask

width = 50 μm
step = 500 μm

width = 50 μm

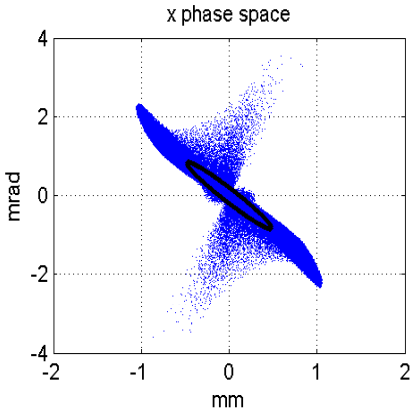
width = 100 μm

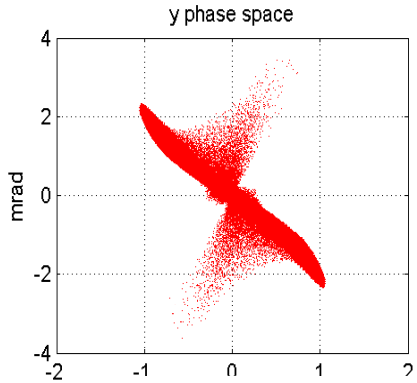


thickness = 2 mm

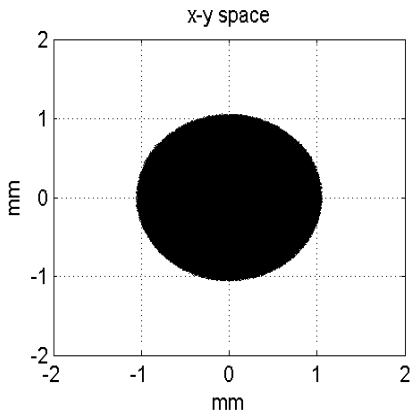
a prototype of a Tungsten multi-slit is under fabrication

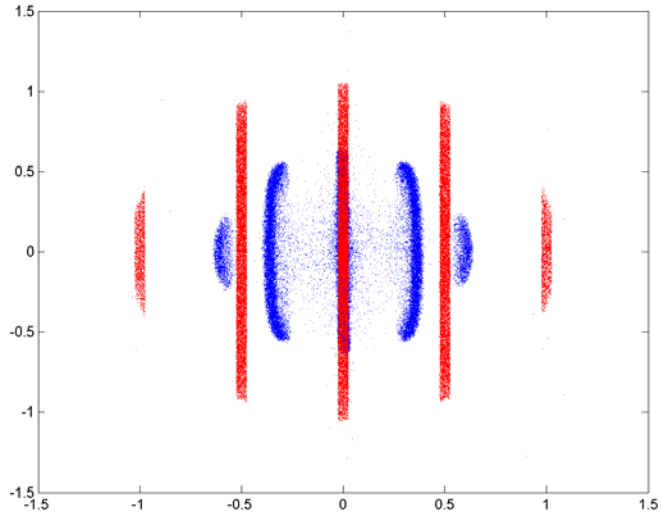
Phase space





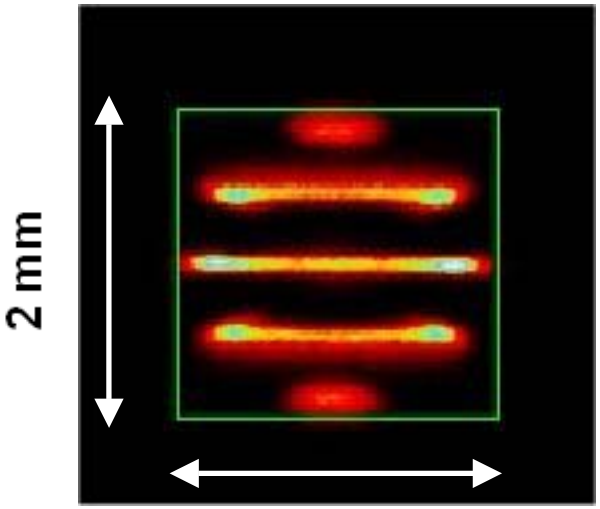
Z=120 cm



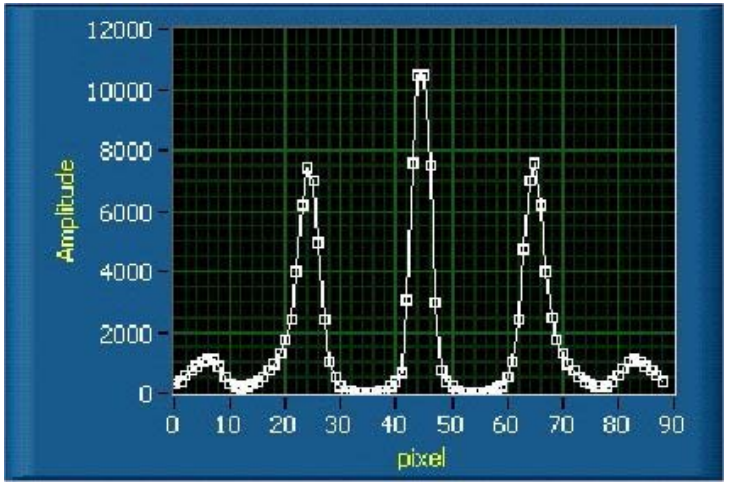


All the Parmela output files used in the simulation comes from *C.Roncivalle (ENEA)*

SPARC case

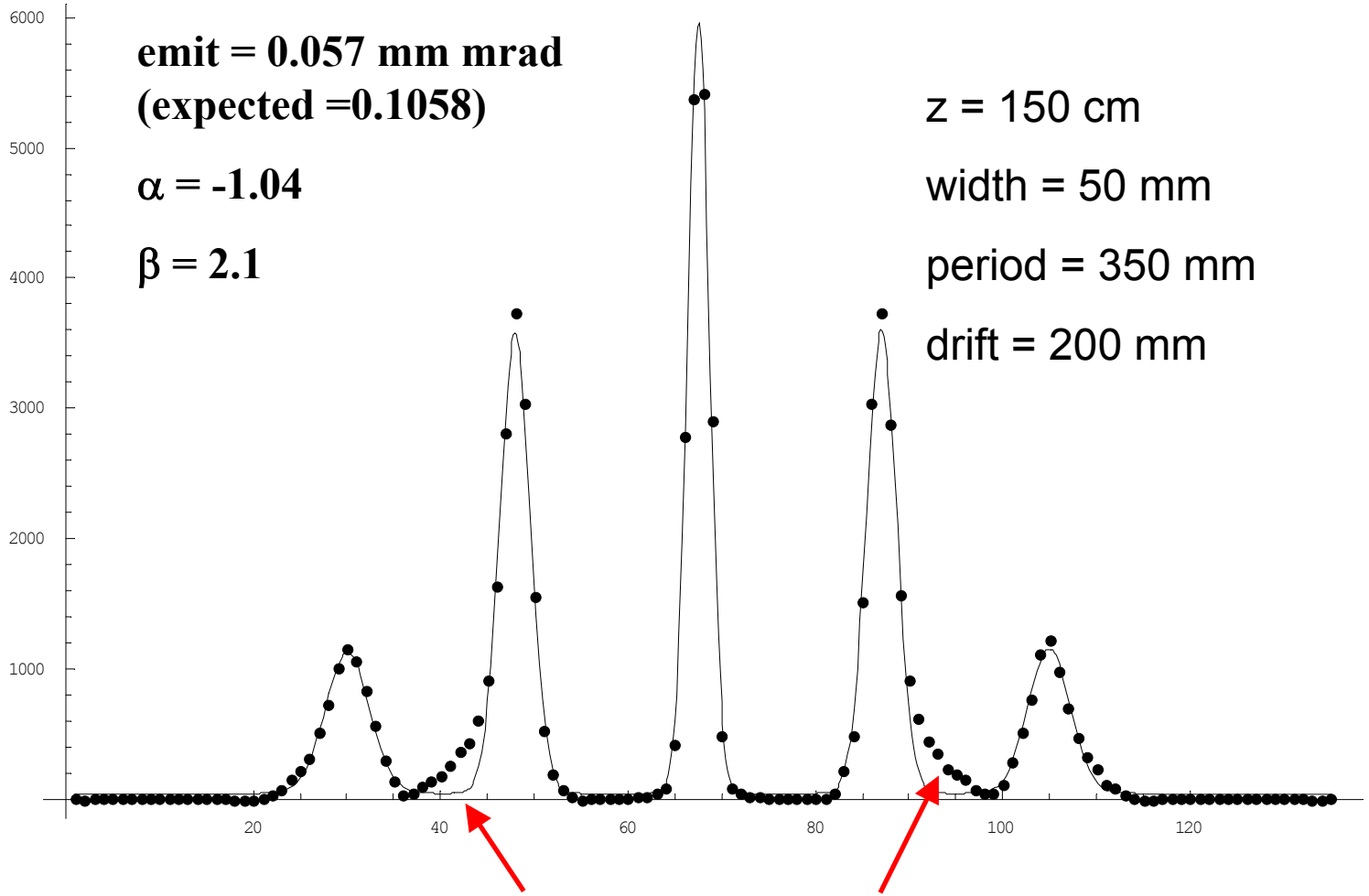


Simulated image



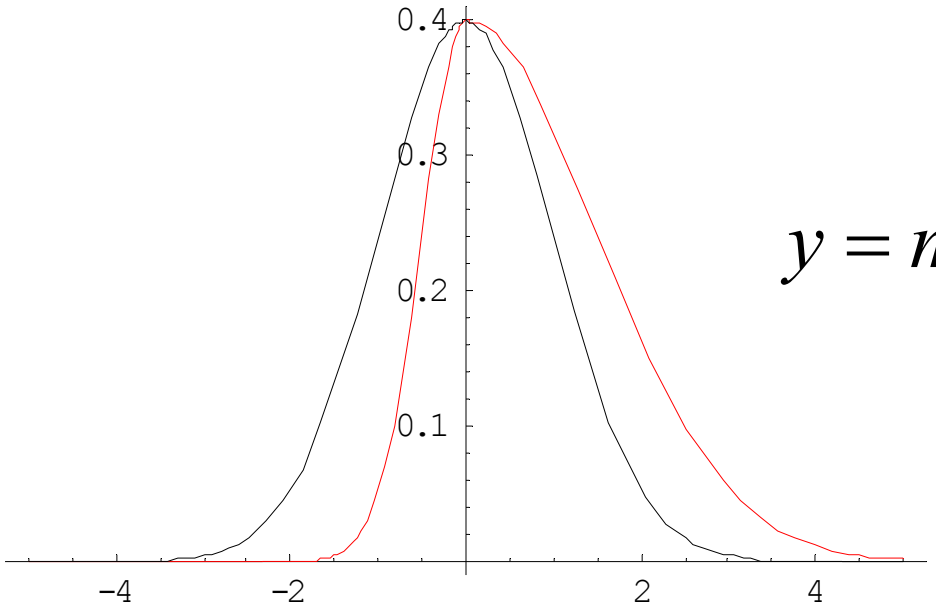
Simulated profile

Gaussian fit



Significant differences respect to a gaussian shape

Asymmetric Gaussian

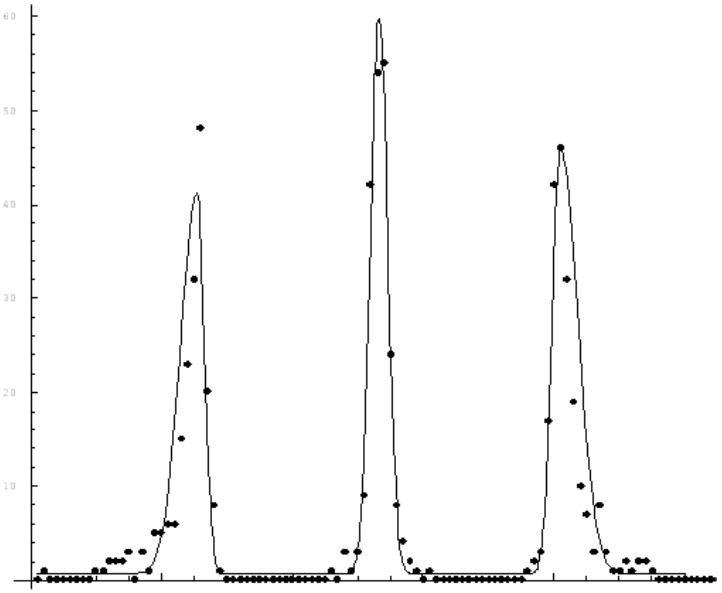


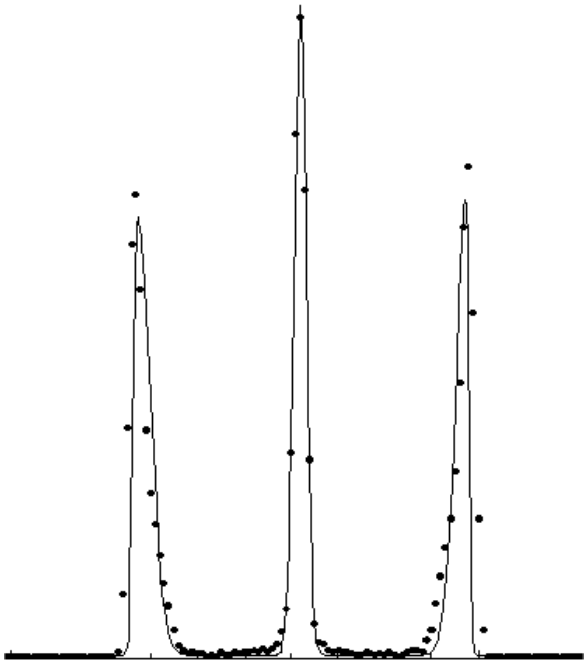
$$y = m_1 e^{-\frac{x^2}{\left(\sqrt{2}\sigma\left(1+sign(x)a\right)\right)^2}}$$

$$x_m = \frac{4\sigma a}{\sqrt{2\pi}}$$

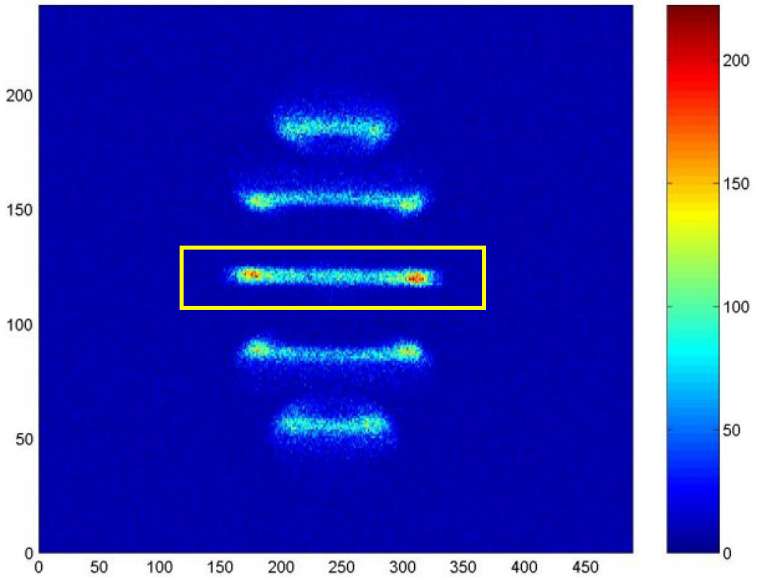
$$\sigma_a = \sigma_0\left(1+0.211\sqrt{a^2}\right)$$

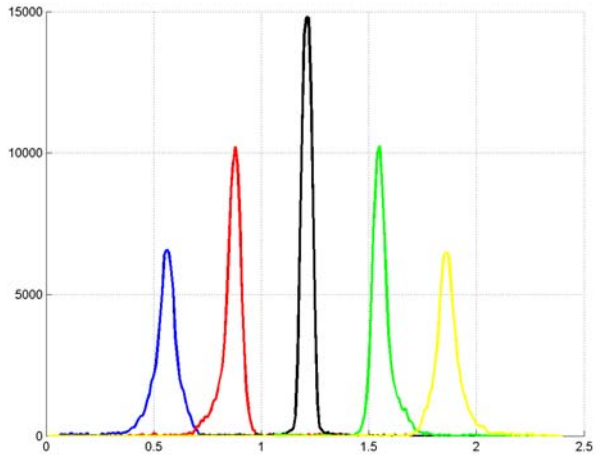
Still not good





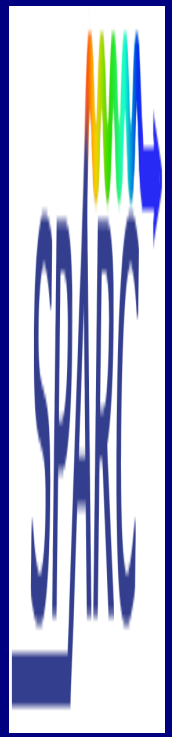
RMS





- Single slit measure
- One by one processing
- Projection, baseline identification, ROI selection, RMS calculation

An example

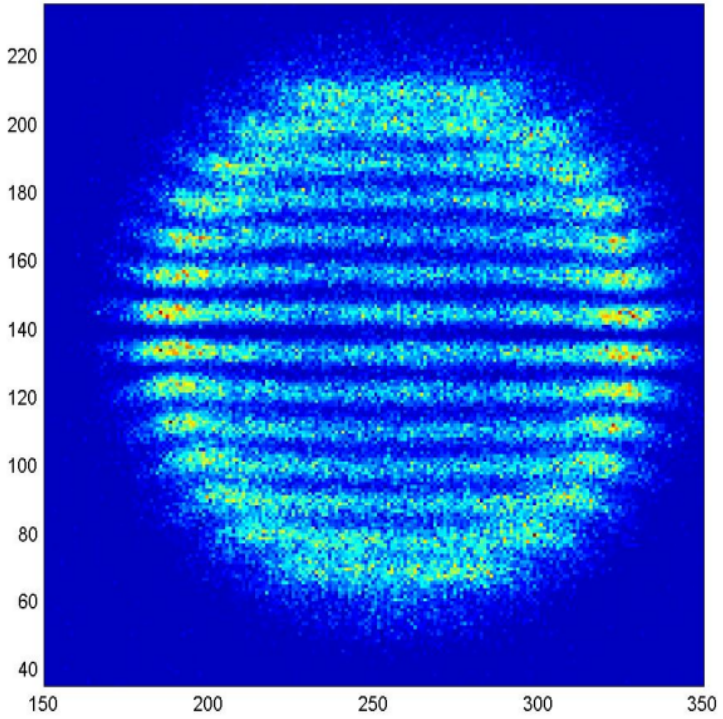


Z=150 cm

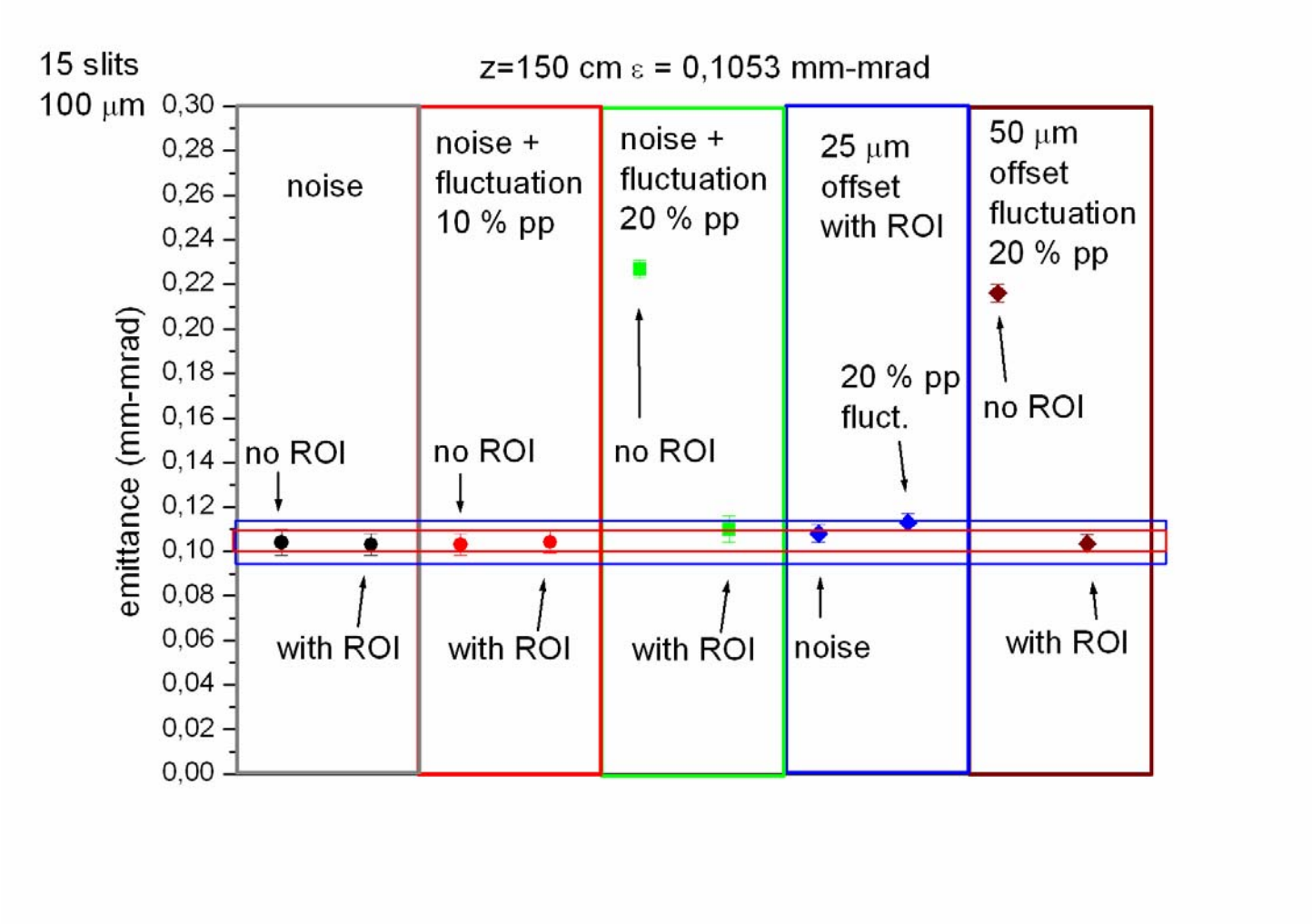
Emit = 0,1053 mm-mrad

15 samples

100 μm spacing



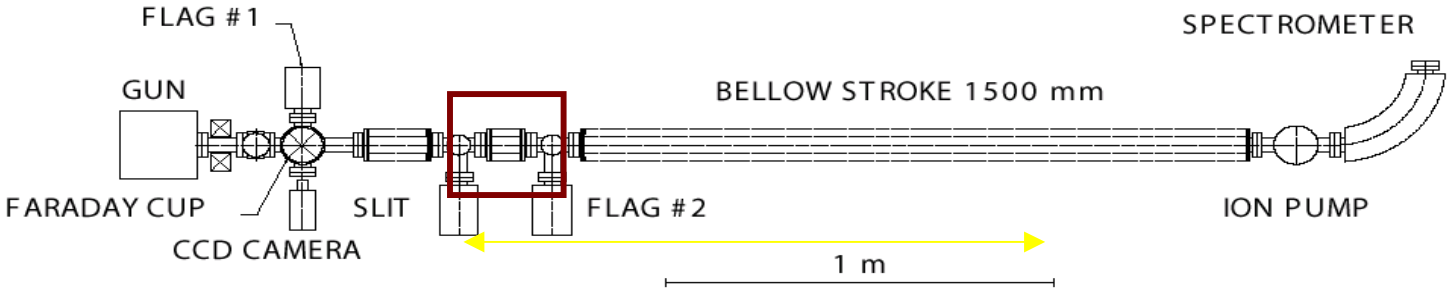
Actual performance

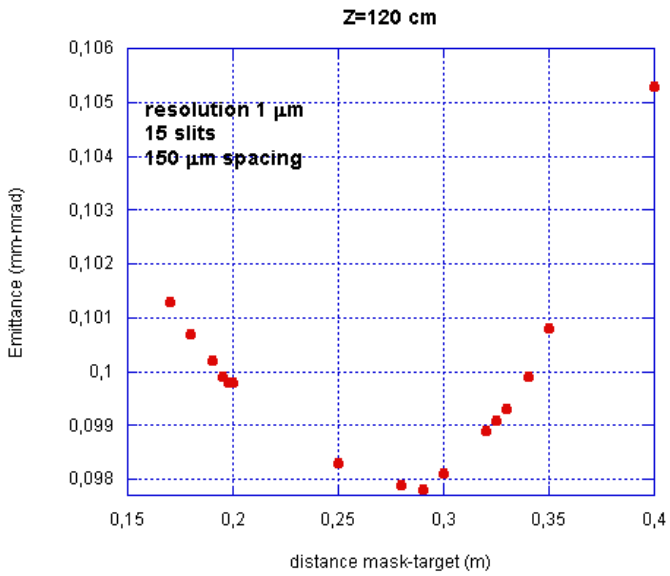


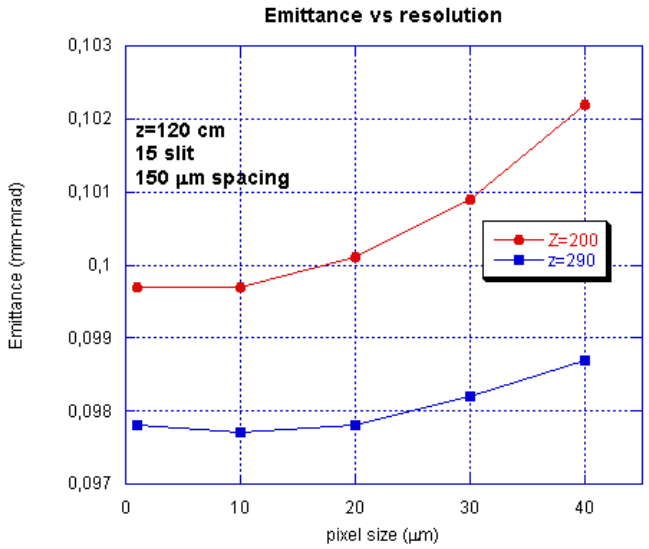
Different approach

- We want to test this method in all the condition
- Different noise and background subtraction used in PITZ
- Average and envelope background
- We want to compare both method
- We are still looking for the possibility to have a fit

Design optimization



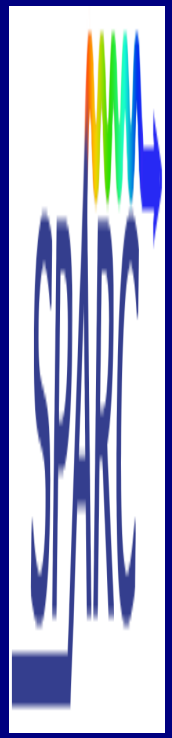




Screen

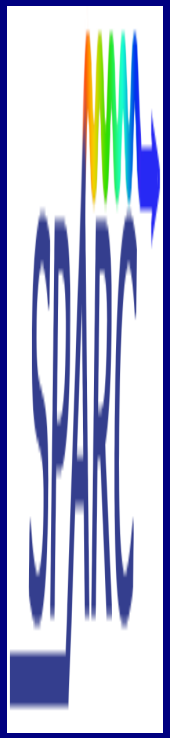
- Main requirements are the linearity and the good photons/electrons ratio
- Alluminated Silicon for production of OTR should be difficult to use, both for geometrical problems and for intensity problems
- So far the use of YAG powder screen seems the best choice (Zeuthen type) but
- A test facility is running in the Dafne BTF to test alternatives: Berillium oxide, and YAG trasparent christal target to reduce depth of field effect with the use of a mirror

Camera



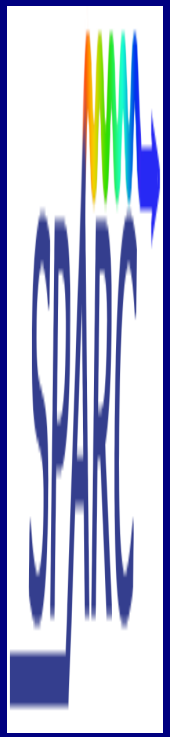
- We use digital camers for TTF 2
- Digitalization in the camera
- Simple cable connection
- Market supported

PITZ



- Several contact points
- Daily experience
- Similar system to measure the emittance
- Good amount of data to process

Future Activities



- Finalization of the mechanical drawing
- Construction of the emittance meter
- improve the understanding of the measurement (by simulations):

  - check for all possible beam conditions

  - define measurement strategies
- test radiators at Dafne BTF (sensitivity, linearity, resolution for YAG, Beryllium Oxide, Cromox)
- share experience with PITZ (DESY/Zeuthen)