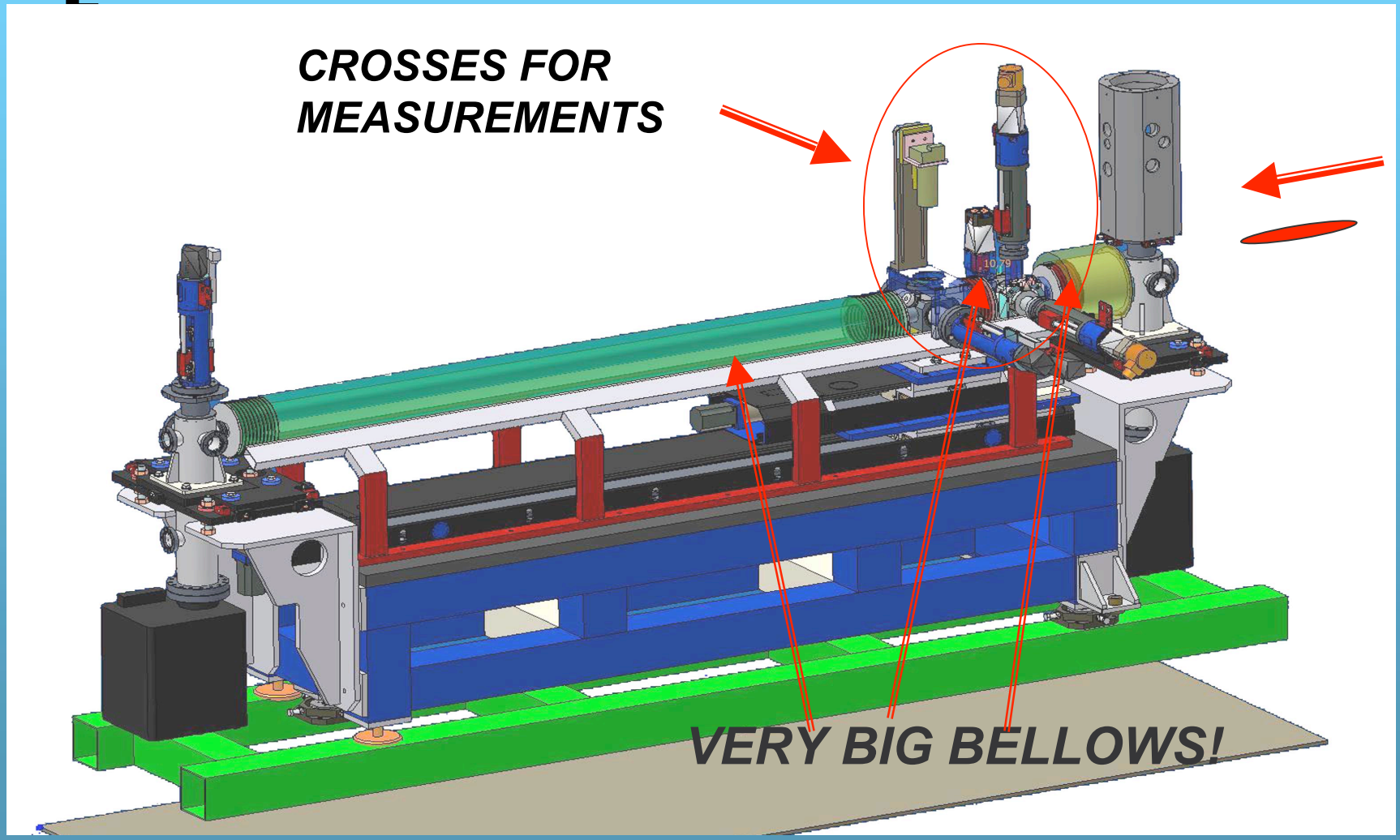
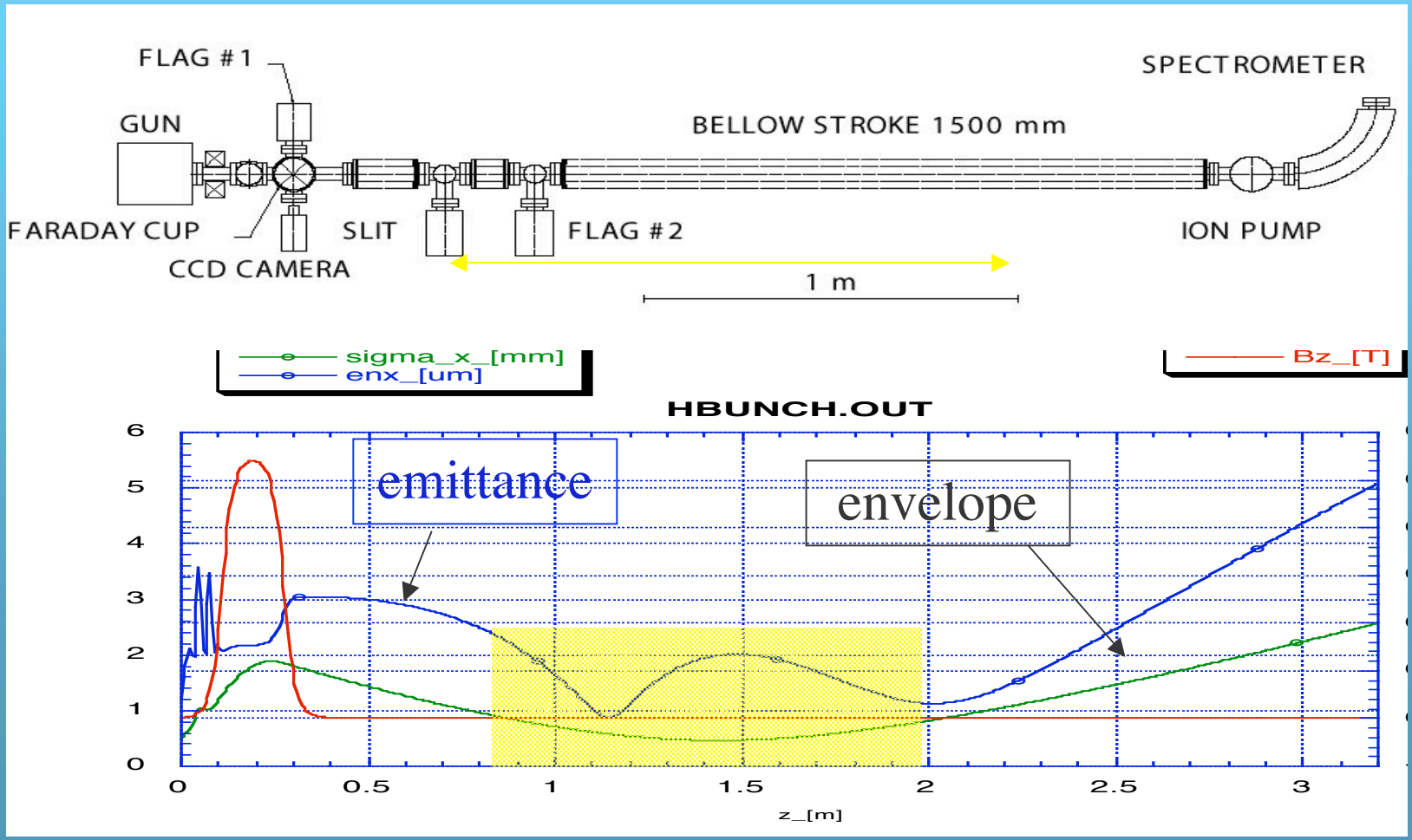
The SPARC movable E-meter and its first measurements at PITZ

Daniele Filippetto
for the SPARC diagnostic and control group

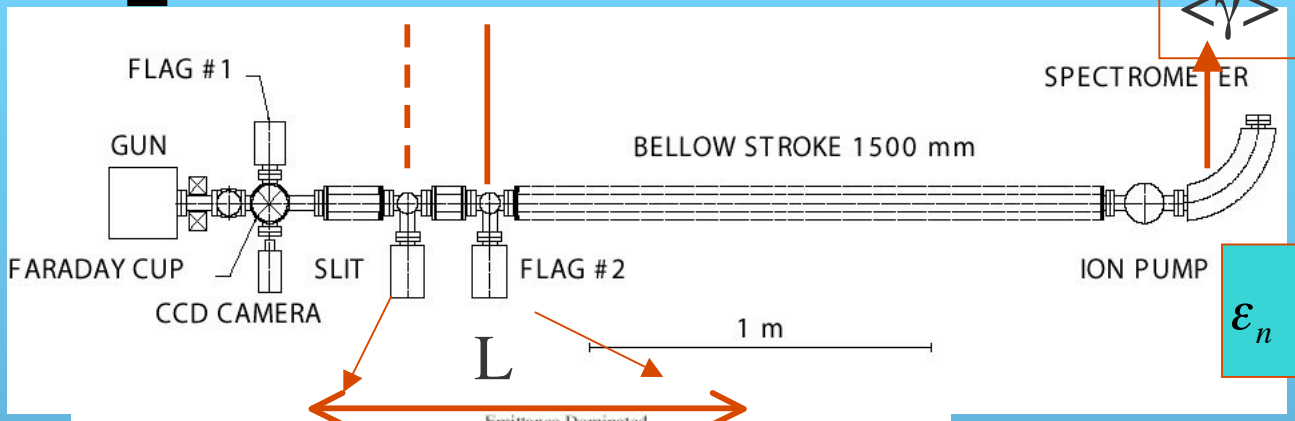
How we did it?



WHAT WE'RE GONNA DO WITH THAT

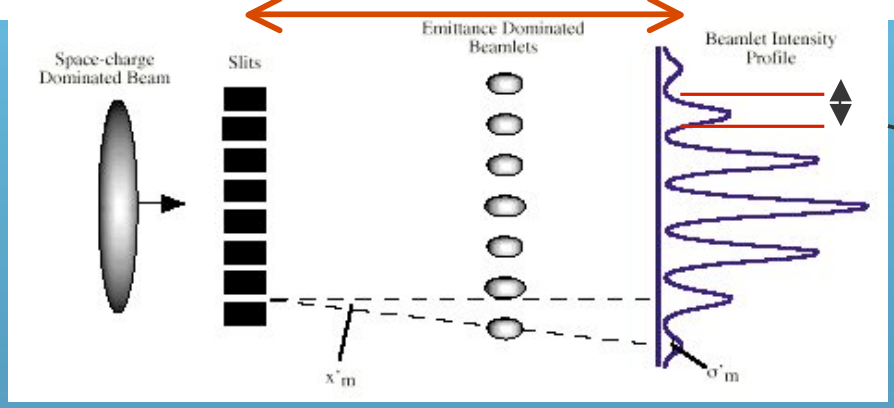


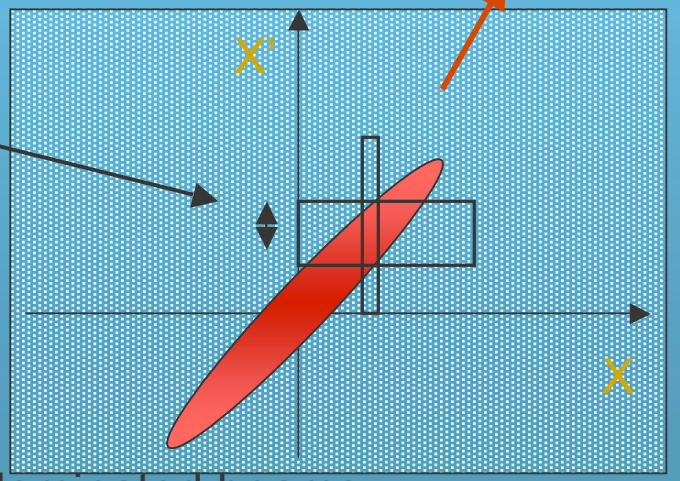
EMITTANCE MEASUREMENTS:



$\langle\gamma\rangle$

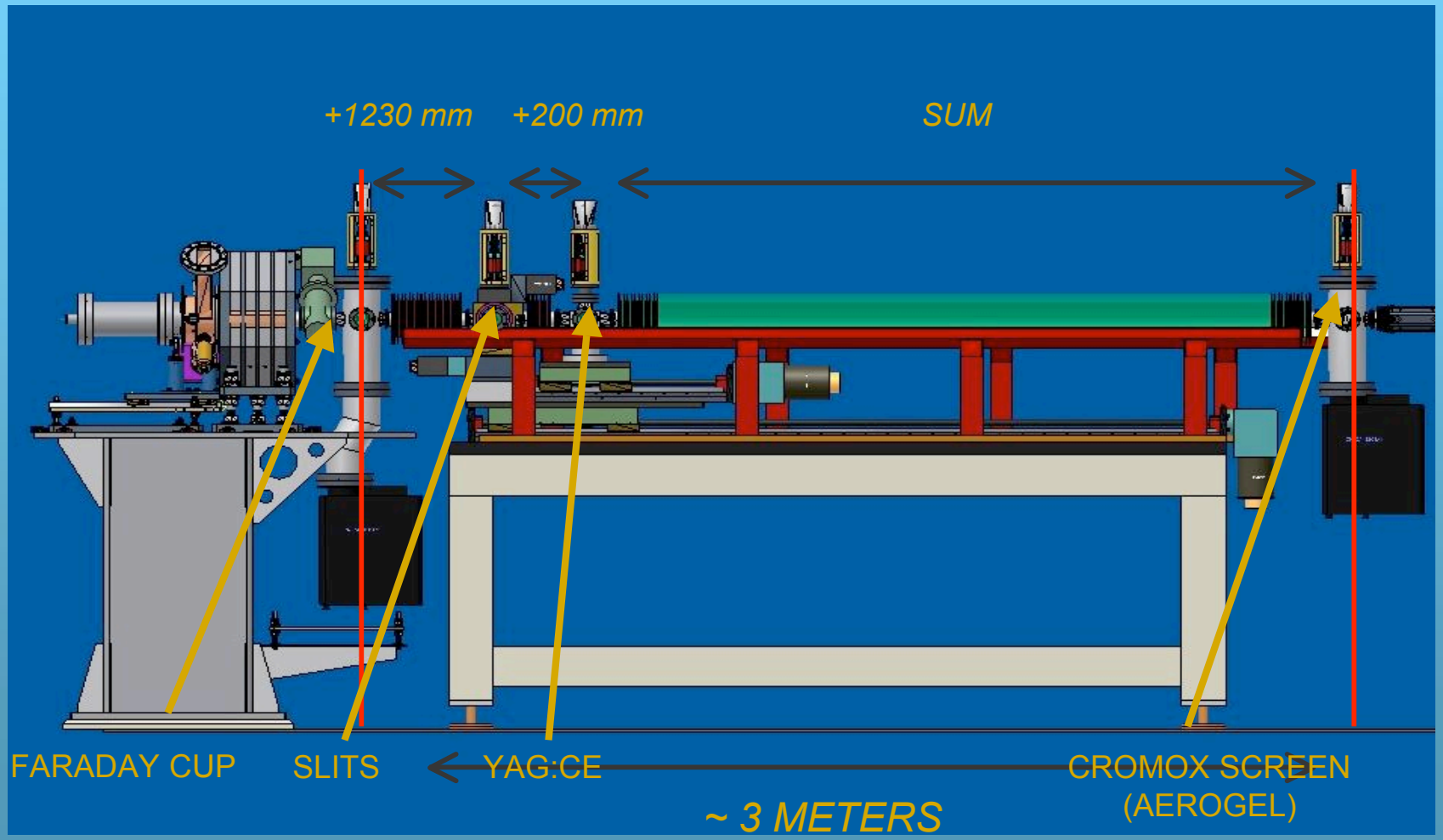
$$\varepsilon_n = \langle\gamma\rangle\sqrt{\langle x^2\rangle\langle (x')^2\rangle - \langle xx'\rangle^2}$$





- It's the only technique you can use in space charge dominated beams.
- We can reconstruct the phase space from the beamlets profile, not just calculate the emittance

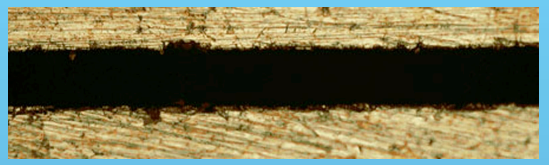
[. . .]


+1230 mm
+200 mm
SUM
FARADAY CUP
SLITS
YAG:CE
CROMOX SCREEN
(AEROGEL)
~ 3 METERS

SLIT MASKS:

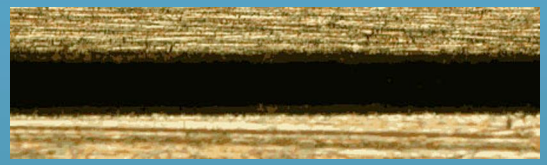
- 2 independent slit masks 90 degrees respect to each other, prepared staking single pieces of 2mm tick tungsten;

- each mask has 2 single slit of 50 and 100 um width, and an array of 7x50 um slits separated by 500um;



- profiles measured were inside tolerances (5%) for 7 of 9 slits;

- Alternative method: PHOTOCHEMICAL MACHINING



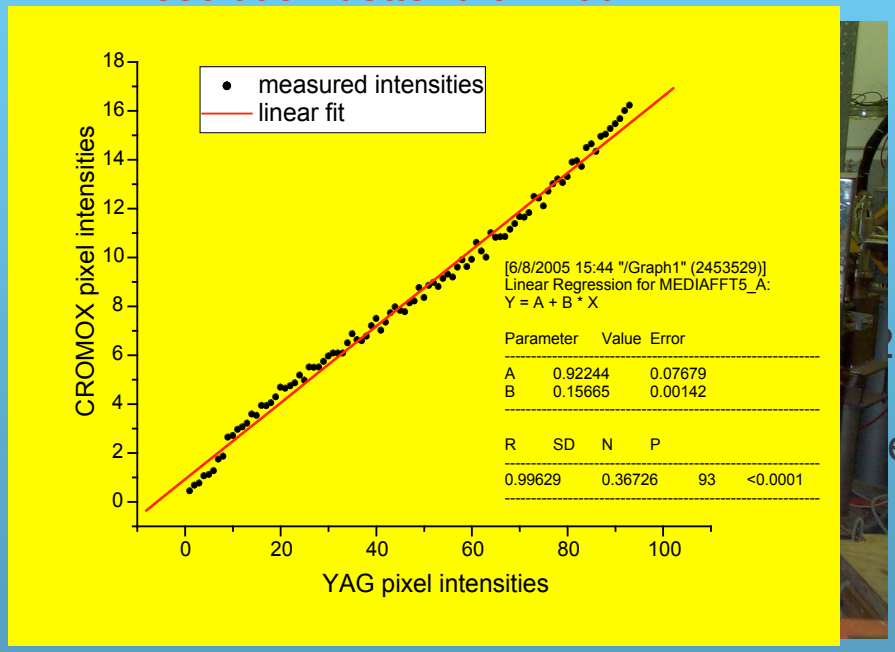
✓ higher uniformity
✓Improved smoothness of edges
✓Eliminates irregularities produced by mechanical stress of material

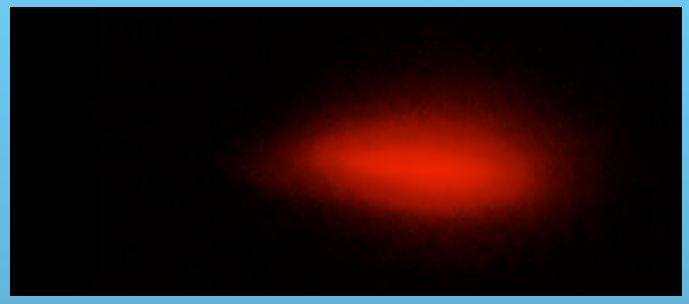
SCREEN FOR IMAGING:

High accuracy is needed in measured transverse beamlet distribution:

- ✓ linear response with SPARC beam intensities
- ✓ resolution better than 20um

CR-OXIDE





2 bit digital camera

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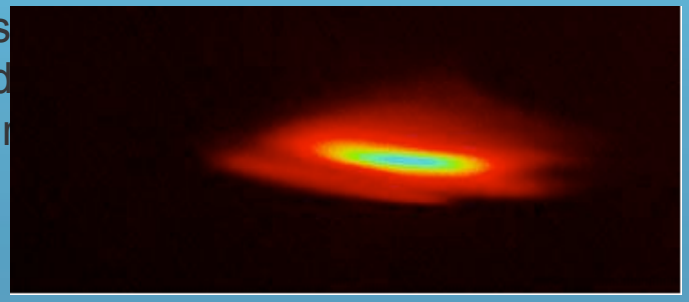
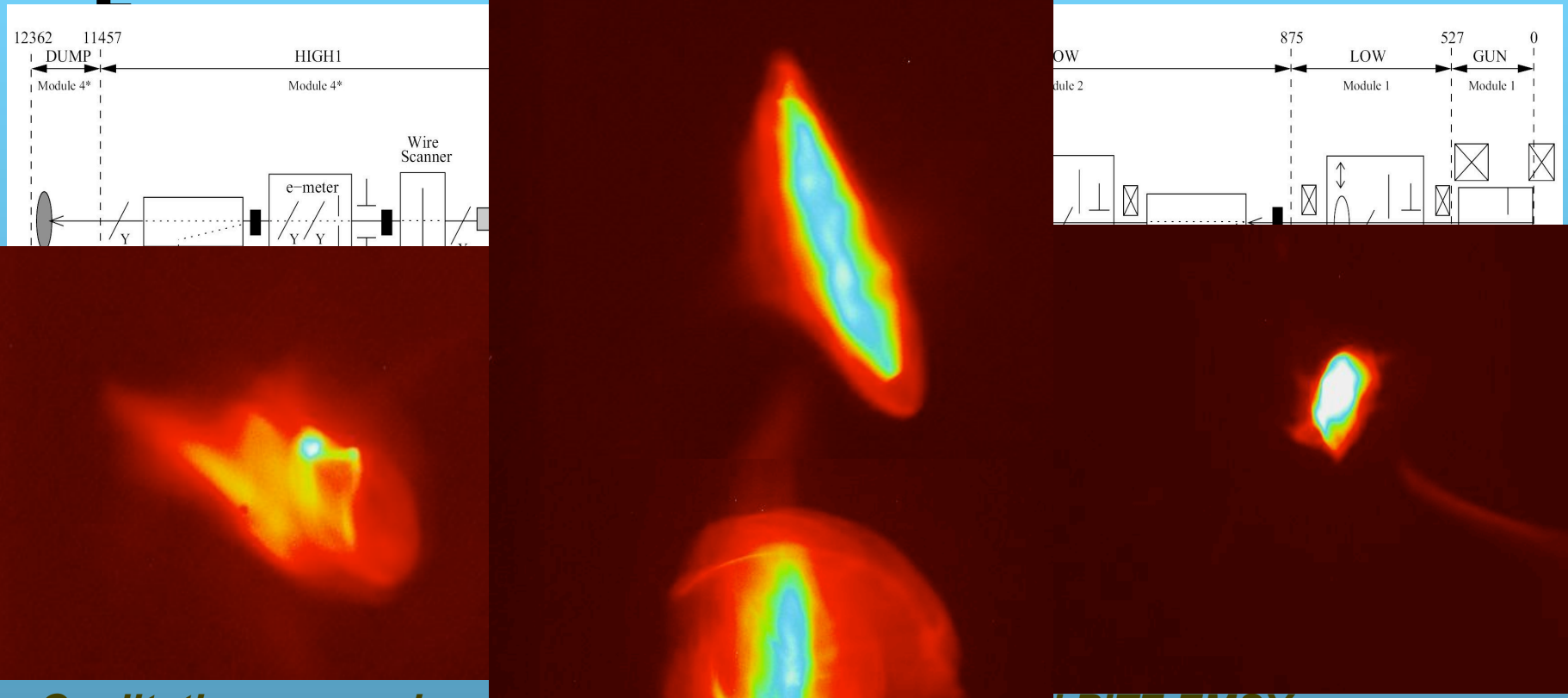


Measurements with different charge densities show:

- higher efficiency
- higher resolution
- linearity

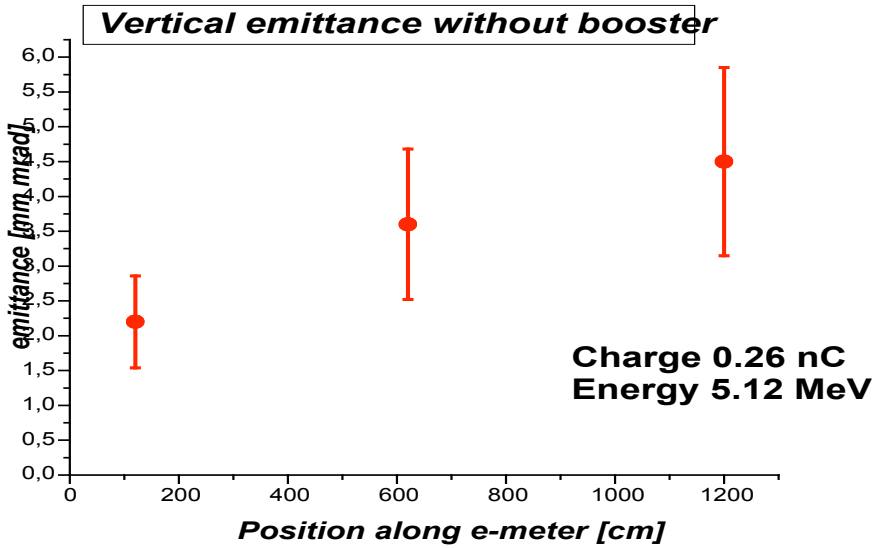
YAG:CE

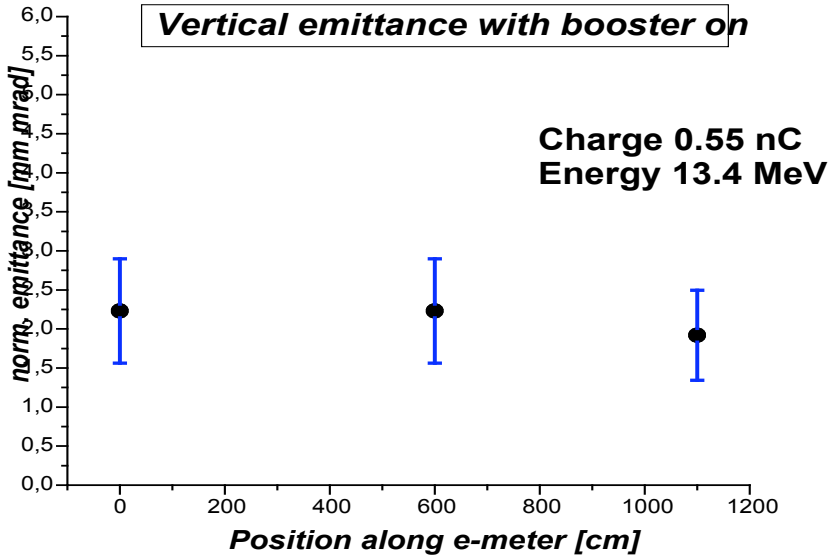
TEST @ PITZ

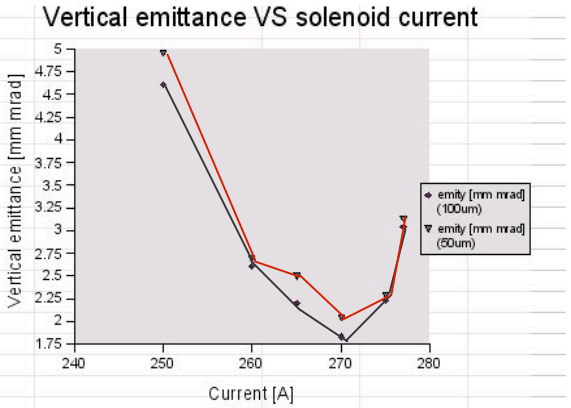


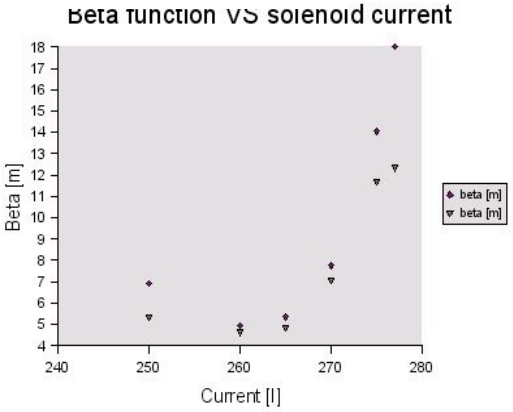
Qualitative comparison ***PITZ EMSY measurements.***
Help PITZ team to work

MEASUREMENTS @ PITZ:









AFTER TESTS:

- Control system and electronics work;
- On-line & off-line image analysis programs adjusted
- Measurements are in agreement with our expectations;
- Simulations on the PITZ line in progress;
- Some problems with errors (not better than 30~35%);

WORKING ON ERRORS:(1)

$$\varepsilon = \sqrt{\langle x^2 \rangle \langle x'^2 \rangle - \langle xx' \rangle^2};$$

$$\Delta\varepsilon = \sqrt{\frac{1}{(2\varepsilon)^2}\left[\left(\langle x^2 \rangle \Delta\langle x^2 \rangle\right)^2 + \left(\langle x'^2 \rangle \Delta\langle x'^2 \rangle\right)^2 + \left(2\langle xx' \rangle \Delta\langle xx' \rangle\right)^2\right]} = \ldots$$

$$\ldots = \varepsilon\delta\sqrt{\frac{1}{2} + \alpha^2 + \frac{3}{2}\alpha^4}$$

Hp:

Relative error is supposed to be equal for all the 3 parameters measured.

$$\Delta\langle x \rangle, \Delta\langle x' \rangle, \Delta\langle xx' \rangle = \delta \cdot \langle x \rangle, \delta \cdot \langle x' \rangle, \delta \cdot \langle xx' \rangle;$$

$$\frac{\Delta\varepsilon}{\varepsilon} \propto \alpha^2 \cdot \delta !!$$

WORKING ON ERRORS:(2)

In order to measure emittance oscillation in SPARC case lower errors are needed (not more than 20%);

$$\frac{\Delta\varepsilon}{\varepsilon} \propto \alpha^2 \cdot \delta$$

δ : comes from either beam fluctuations or mechanical tolerances and data acquisition (8 bit digital images, resolution and magnification of the optical system, precision on measured width of the slits…)

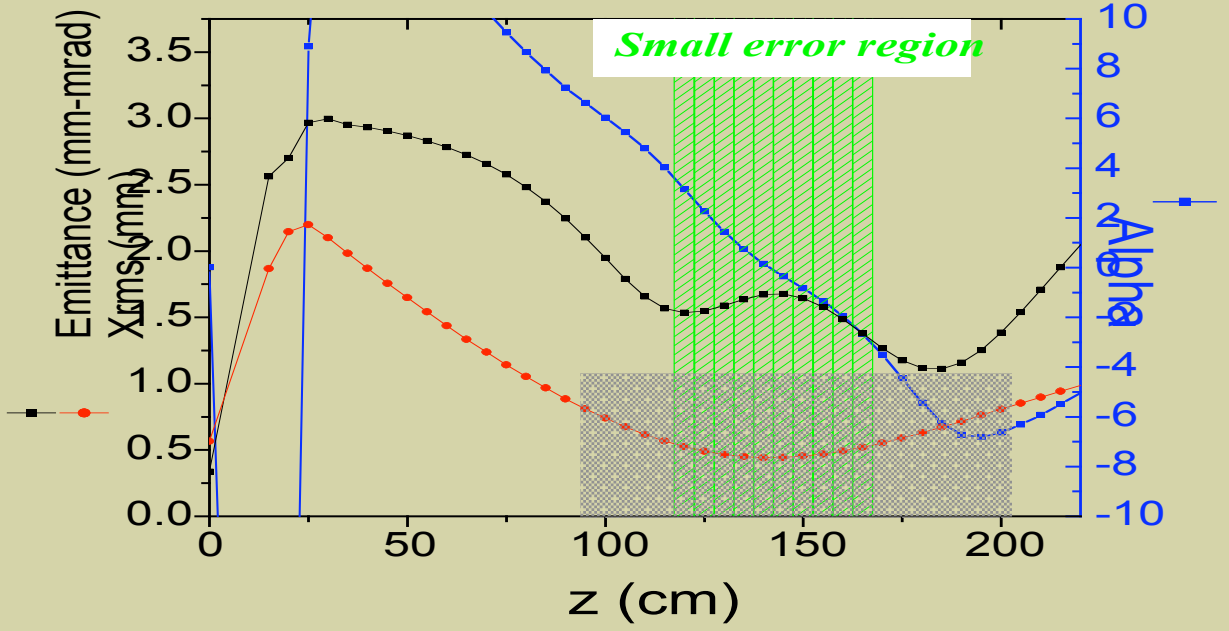
- Increase the magnification up to 1:1 (but the beam has to be small…);
- Up to 12 bit image digitalization;
- Better measurements of the slit width… but

Errors dominated by beam fluctuations: very stable beam and many images for each slit needed.

WORKING ON ERRORS:(3)

α^2 : $\frac{\Delta\varepsilon}{\varepsilon} \propto \alpha^2 \cdot \delta$ $\longrightarrow$ $tipical\,\delta \sim 0.02$ $\xrightarrow{Errors<20\%}$ $|\alpha| \leq 3$

PARMELA



THERE COULD BE SOME PROBLEM AT THE BEGINNING AND AT THE END. SINGLE SHOT MEASUREMENTS WITH MULTISLIT?

CONCLUSIONS:

- Hardware & control system ok;
- PITZ collaboration very useful;
- Results of the first measurements consistent with expectations;

IMPROVEMENTS:

- Decrease errors;
- Try to use single shot emittance measure with multislit array where alpha is too high.