OTR Monitors and Emittance Measurements

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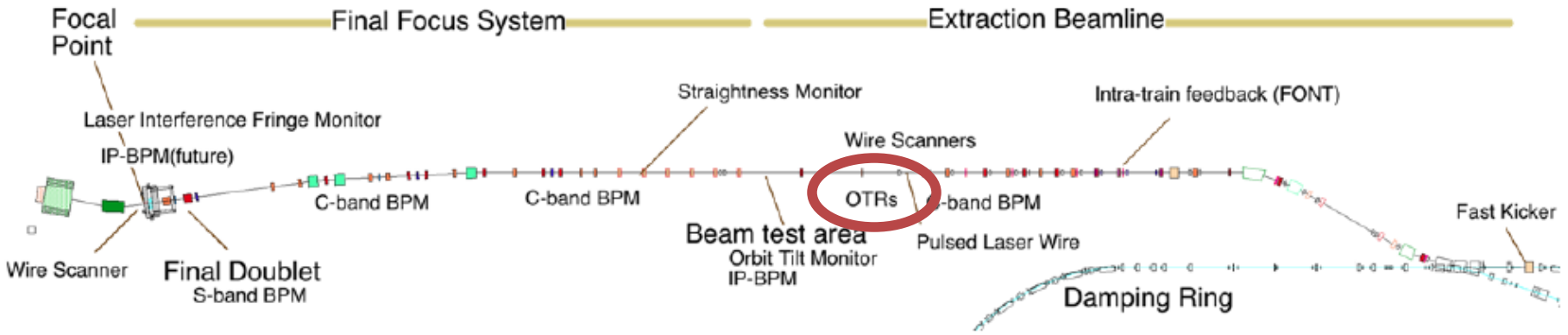
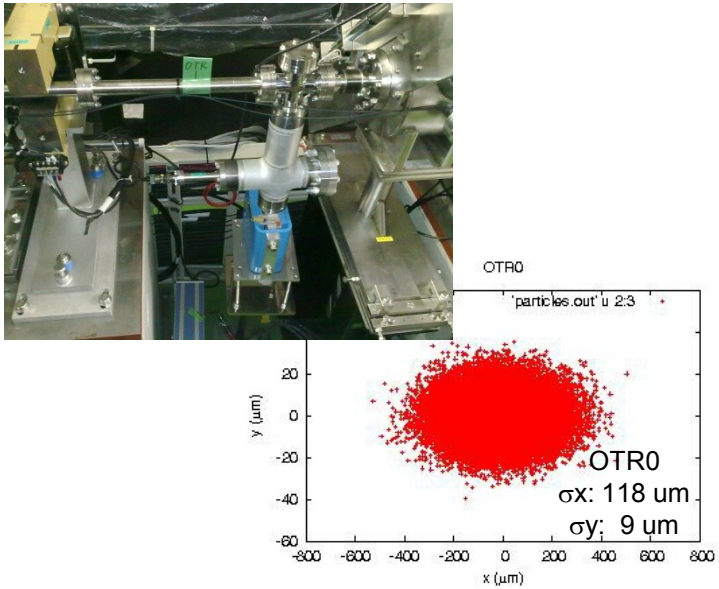
Multi-OTR System Overview





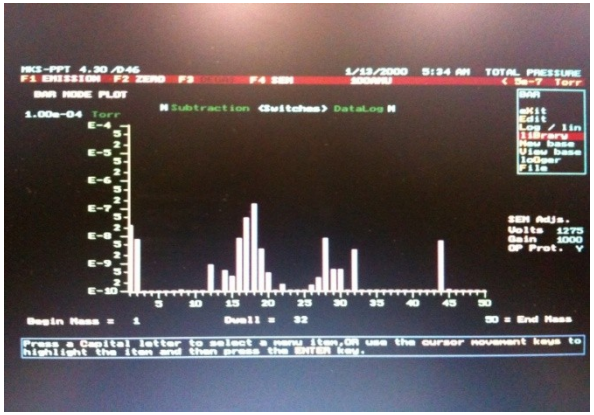
- The multi-OTR system of **4 OTR monitor** installed in the zero-dispersion part of EXT line
- **Fast emittance measurements** with high statistics
- Design based on existing OTR1X with improved features and we will get **2um resolution**
- **Installed near WS** for comparison and confirmation of OTR as a beam emittance diagnostic device

Multi-OTR System February 2010: H/W Tests

Assembling and **first tests** at SLAC and IFIC labs after fabrication

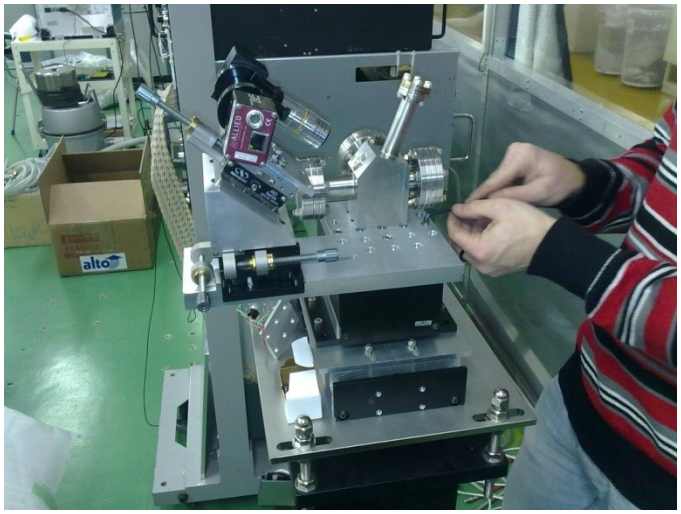
Vacuum test made at SLAC

without OTR

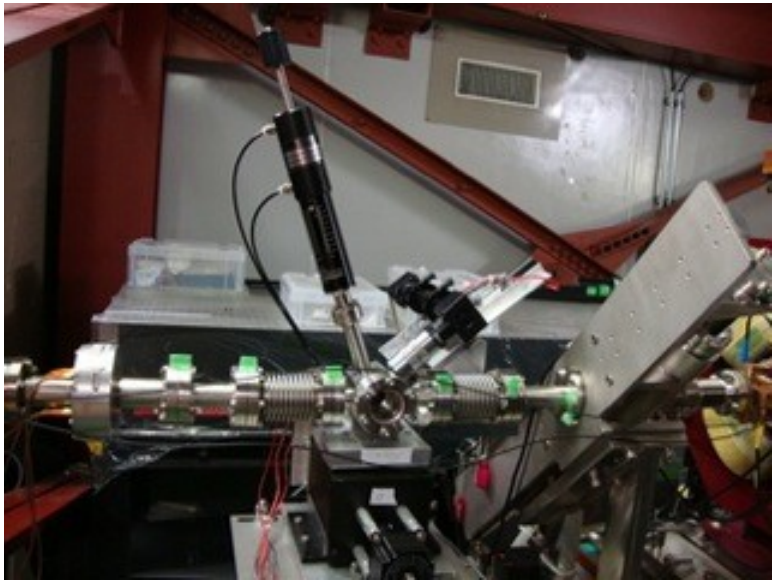


with OTR

Multi-OTR System April / May 2010: H/W Installation

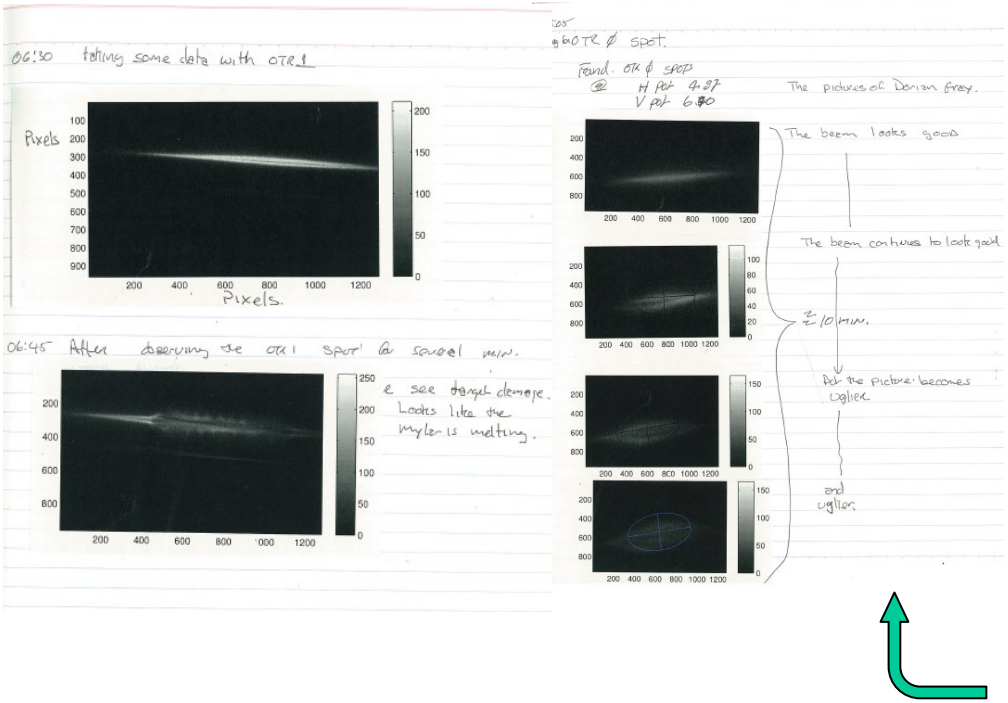


April: All **4 OTRs were assembled** at ATF clean room



May: All **4 OTRs installed** in the EXT line

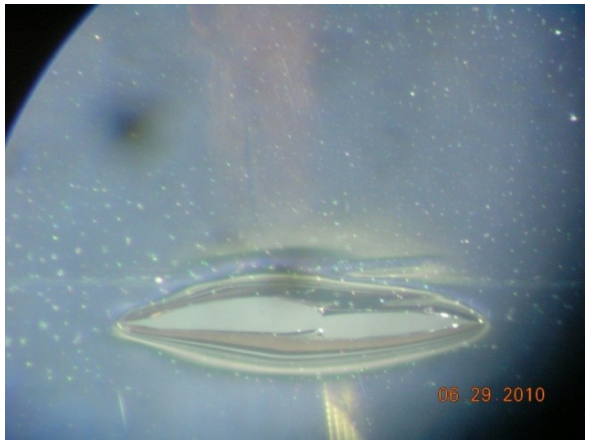
Multi-OTR System June 2010: First Measurements



- Exercise and **calibration** of vertical and horizontal **movers** and read-back **potentiometers**

- Tests of 4 OTRs during beam time: beam seen but 3 **targets** (nitrocellulose coated aluminum) **were damaged** (4×10^9 e^- per pulse)

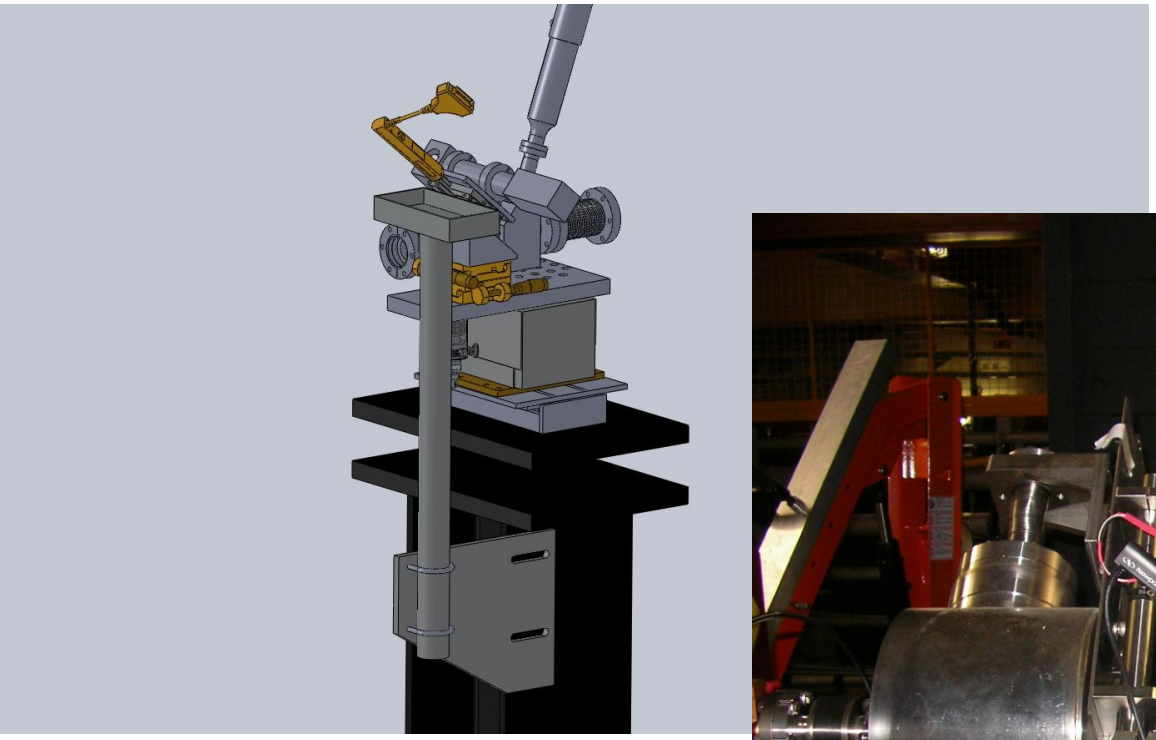
- CCD **Cameras** suffer from **radiation**, some pixel are dead.

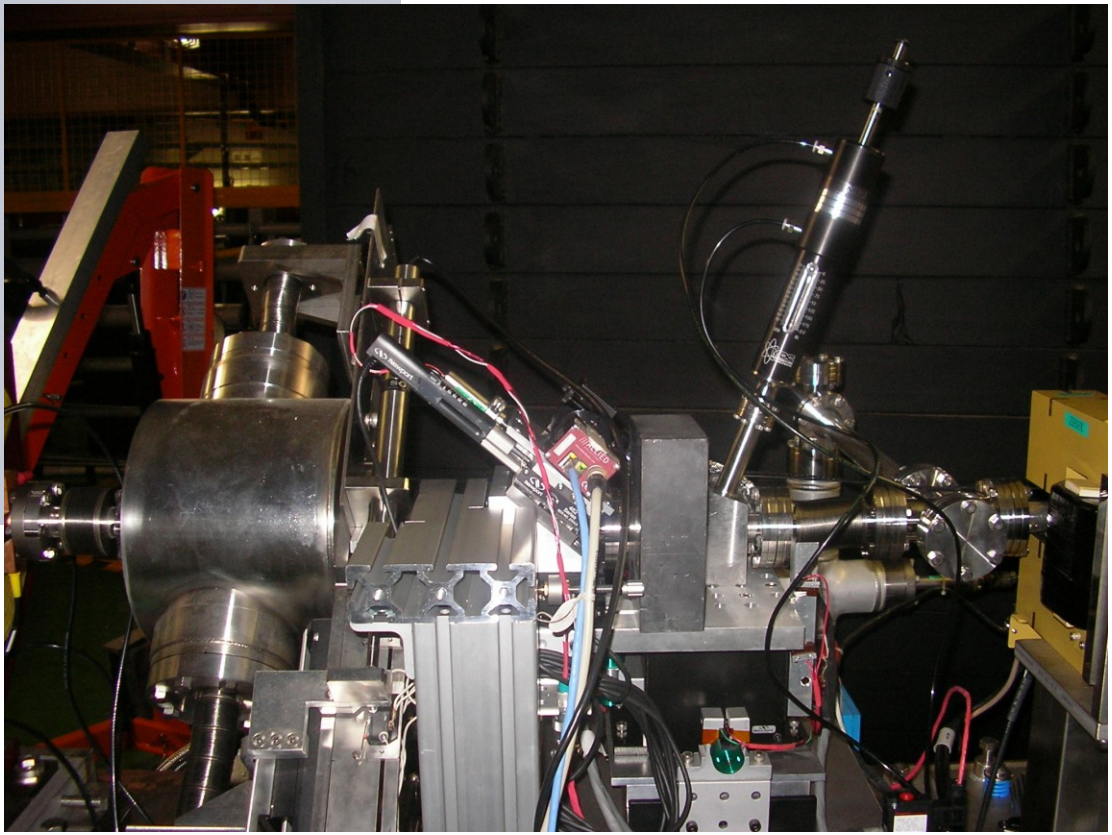


Damaged target

Multi-OTR System

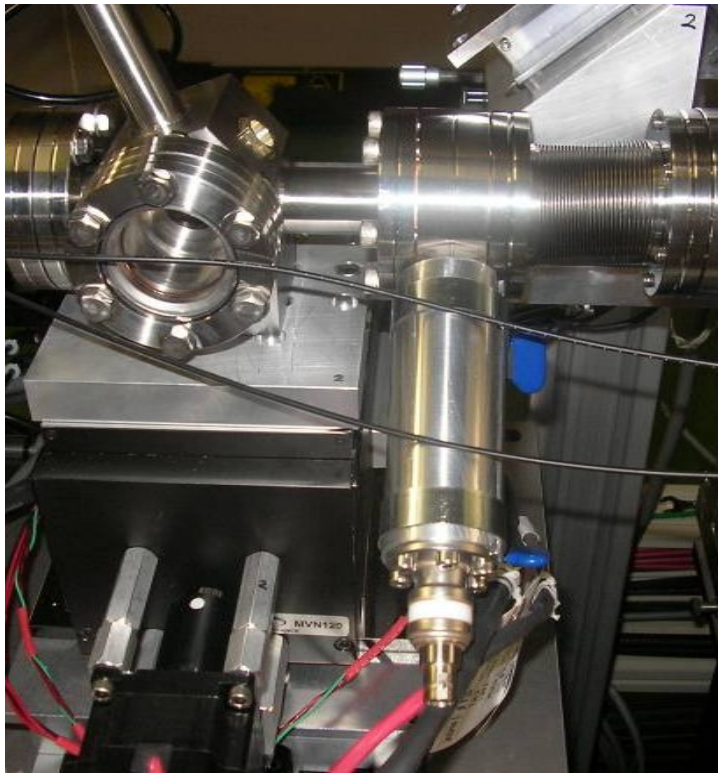
November 2010: Installation of cameras protection



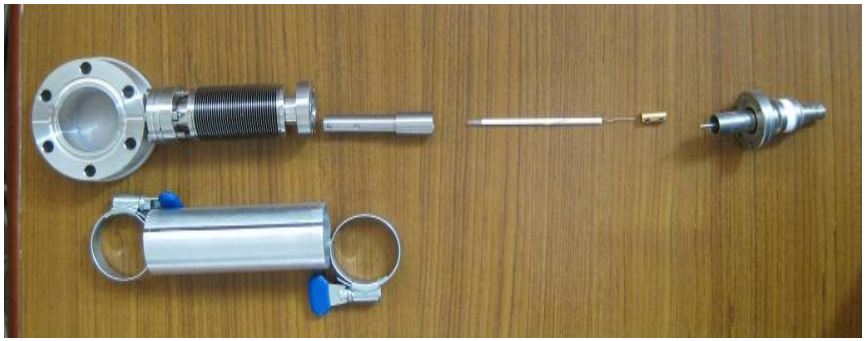


Lead blocks has been added to protect cameras from the radiation

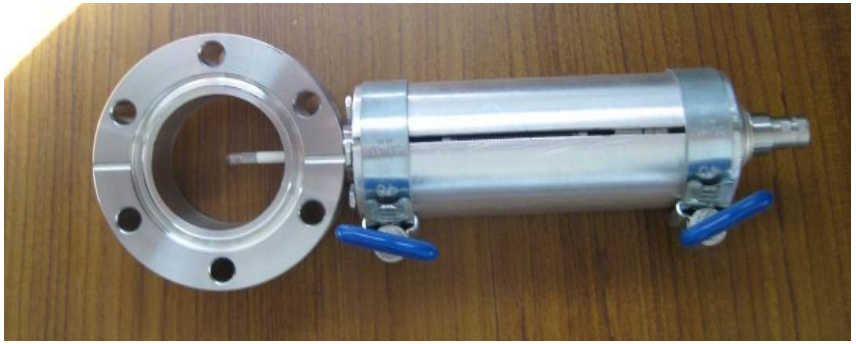
Multi-OTR System November 2010: Installation of calibration setup



Illuminators were **installed** to facilitate calibrating tasks by **lighting** the **target** from the **beam direction**

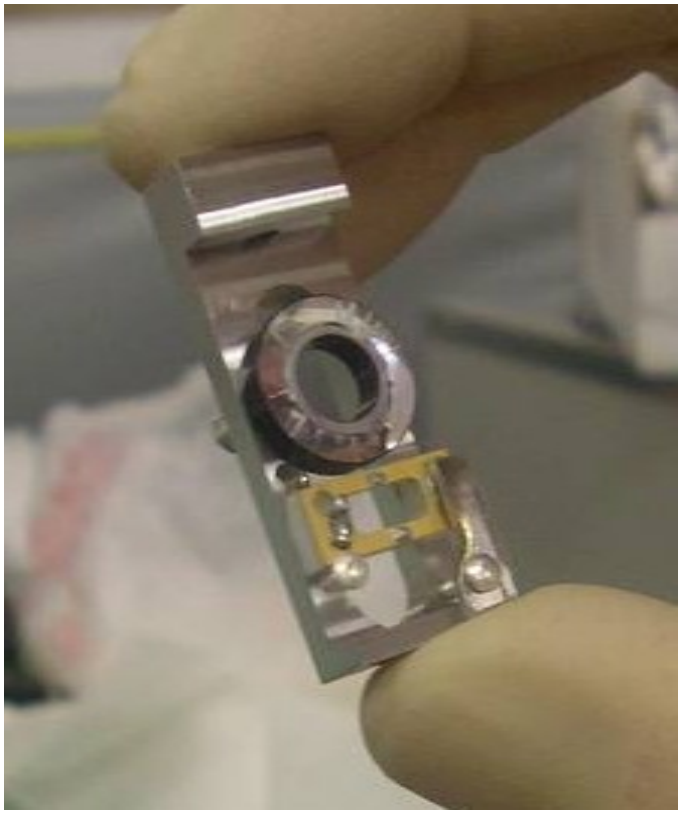


BNC feedthrough, copper connector, ceramic tube with bulb, SS tube (ceramic tube holder), bellow and flange with port.



Aluminium tube and clamp to hold the bellow

Multi-OTR System November 2010: New targets installed and tested

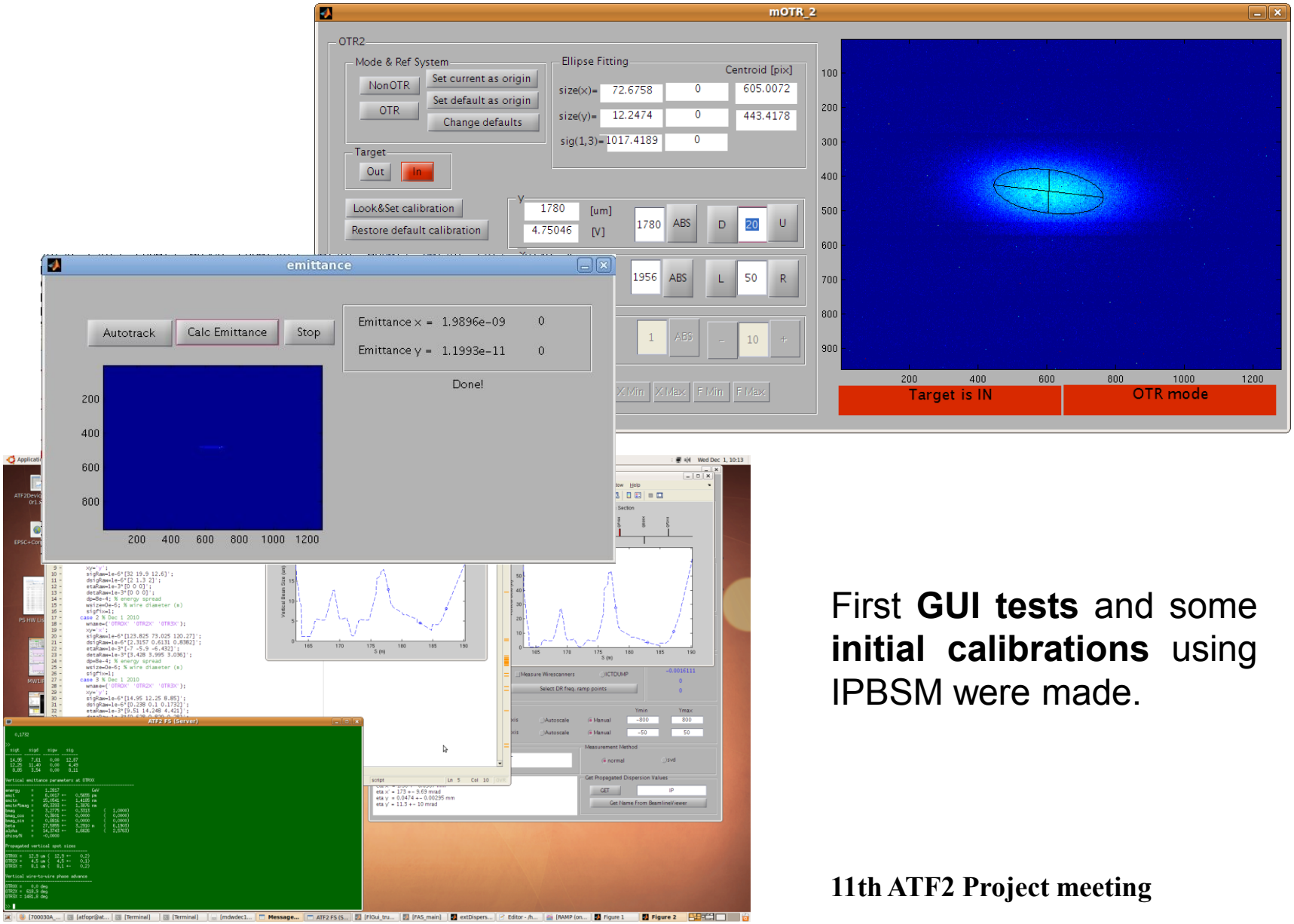


New targets could **stand the beam currents** for several minutes without being damaged

Two **new targets** were installed, two made with **aluminium and** two with **aluminized kapton**. Besides, together with all them were installed the **wire targets, made with 4 wire**, one horizontal, one vertical and two tilted.

Multi-OTR System

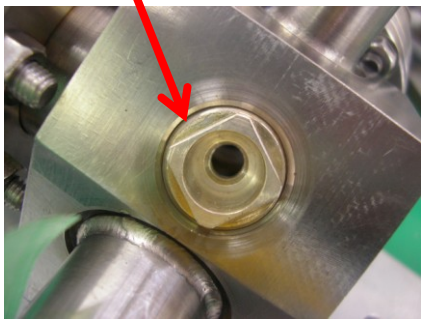
November 2010: First calibration of vertical scale and first software test

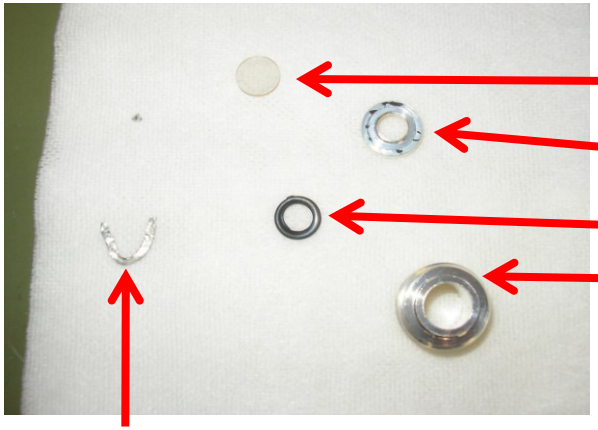


First **GUI tests** and some **initial calibrations** using IPBSM were made.

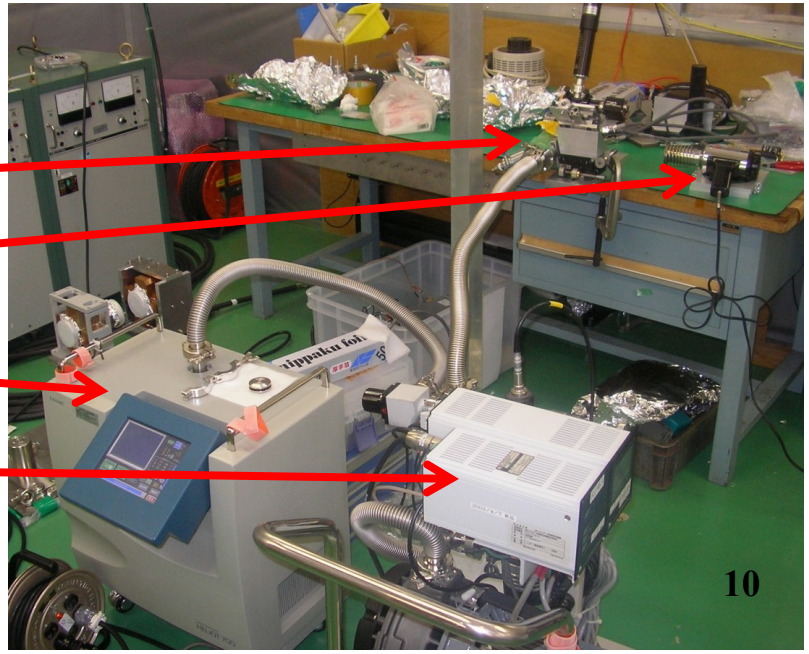
Multi-OTR System December 2010: Vacuum leak repaired

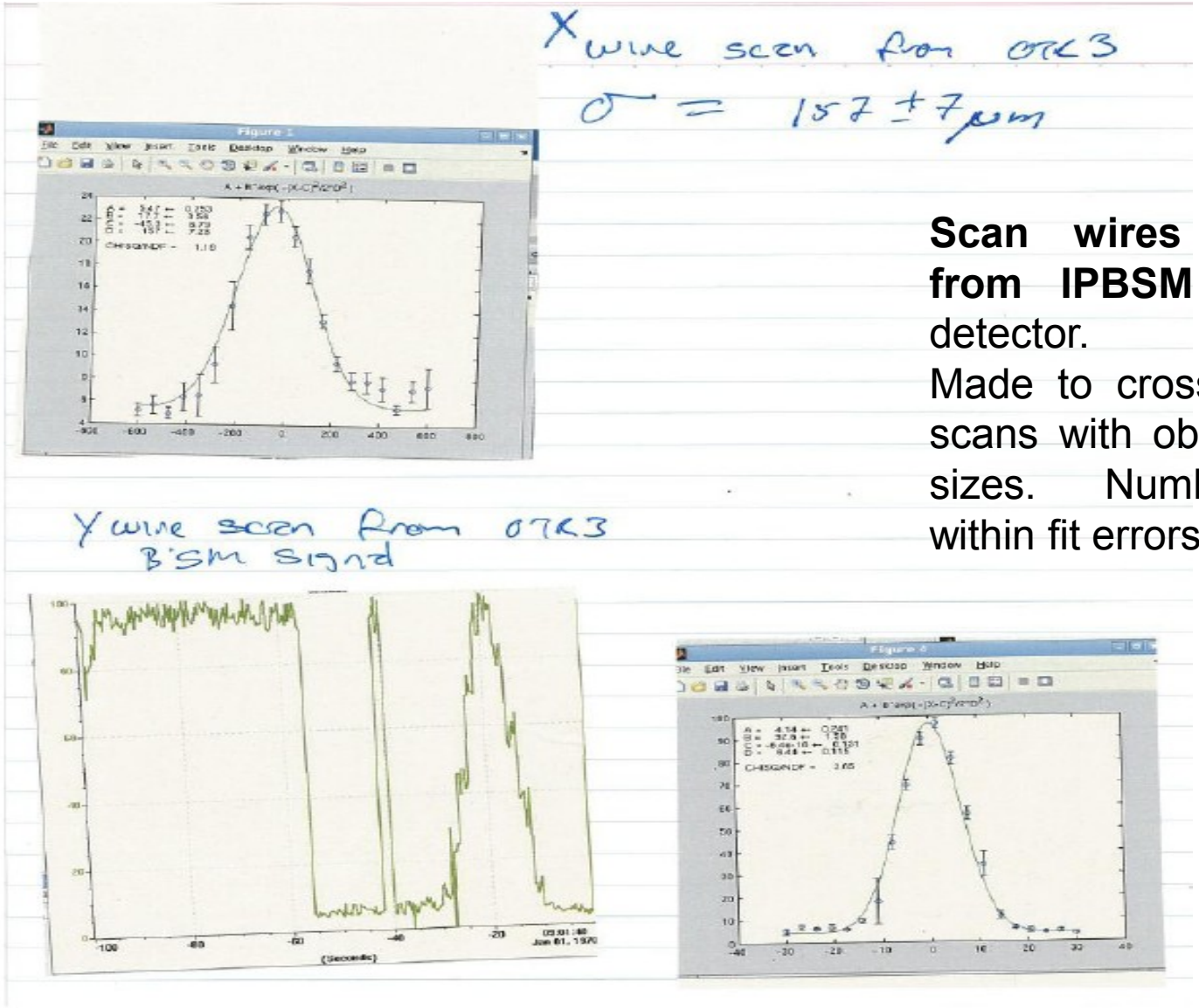
Leak in the camera window





Important **vacuum leak** in the camera window of OTR2 was **repaired** by changing the indium washer



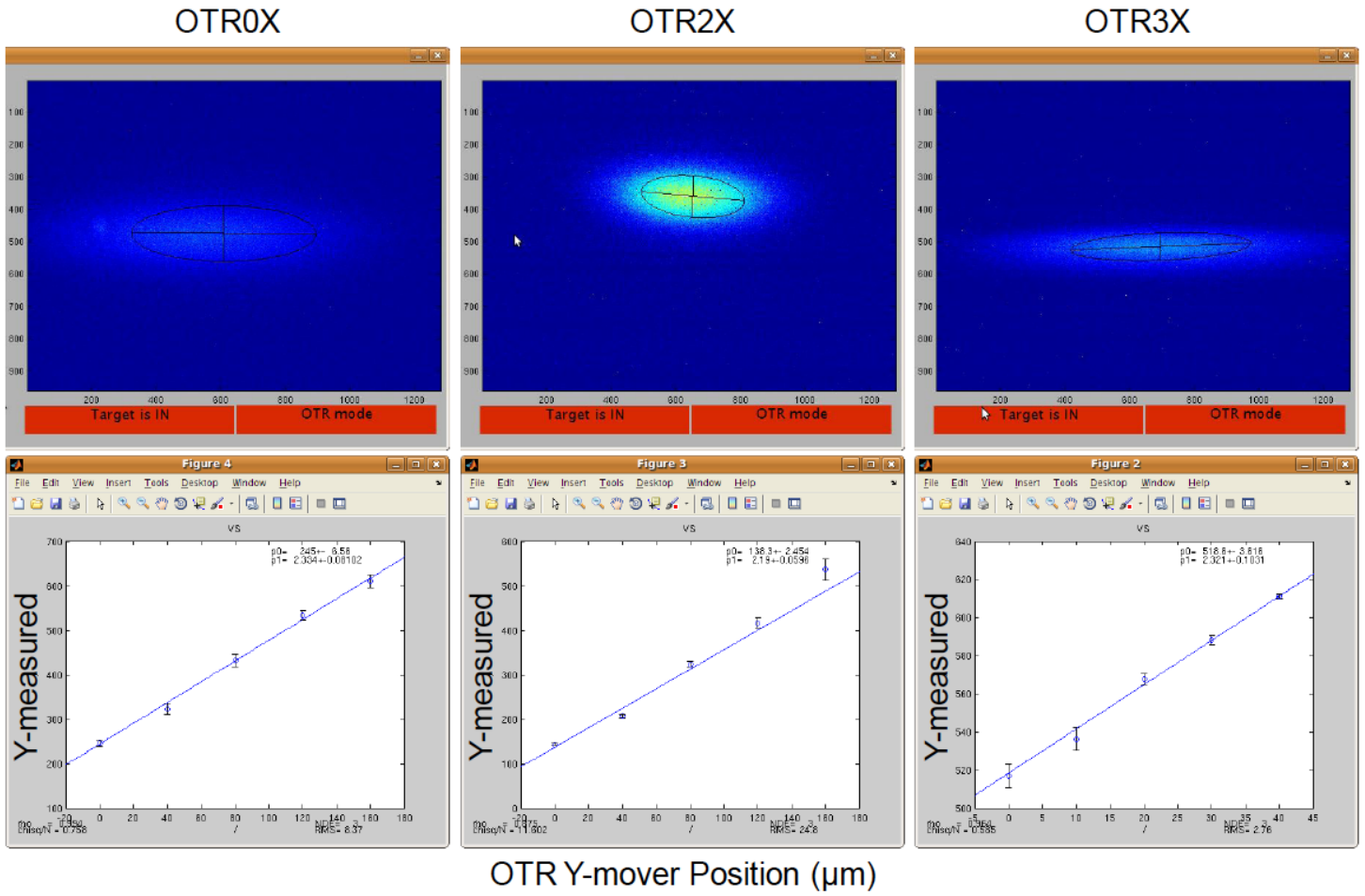


Scan wires vs. signal from IPBSM background detector.

Made to cross check wire scans with observed beam sizes. Numbers agree within fit errors.

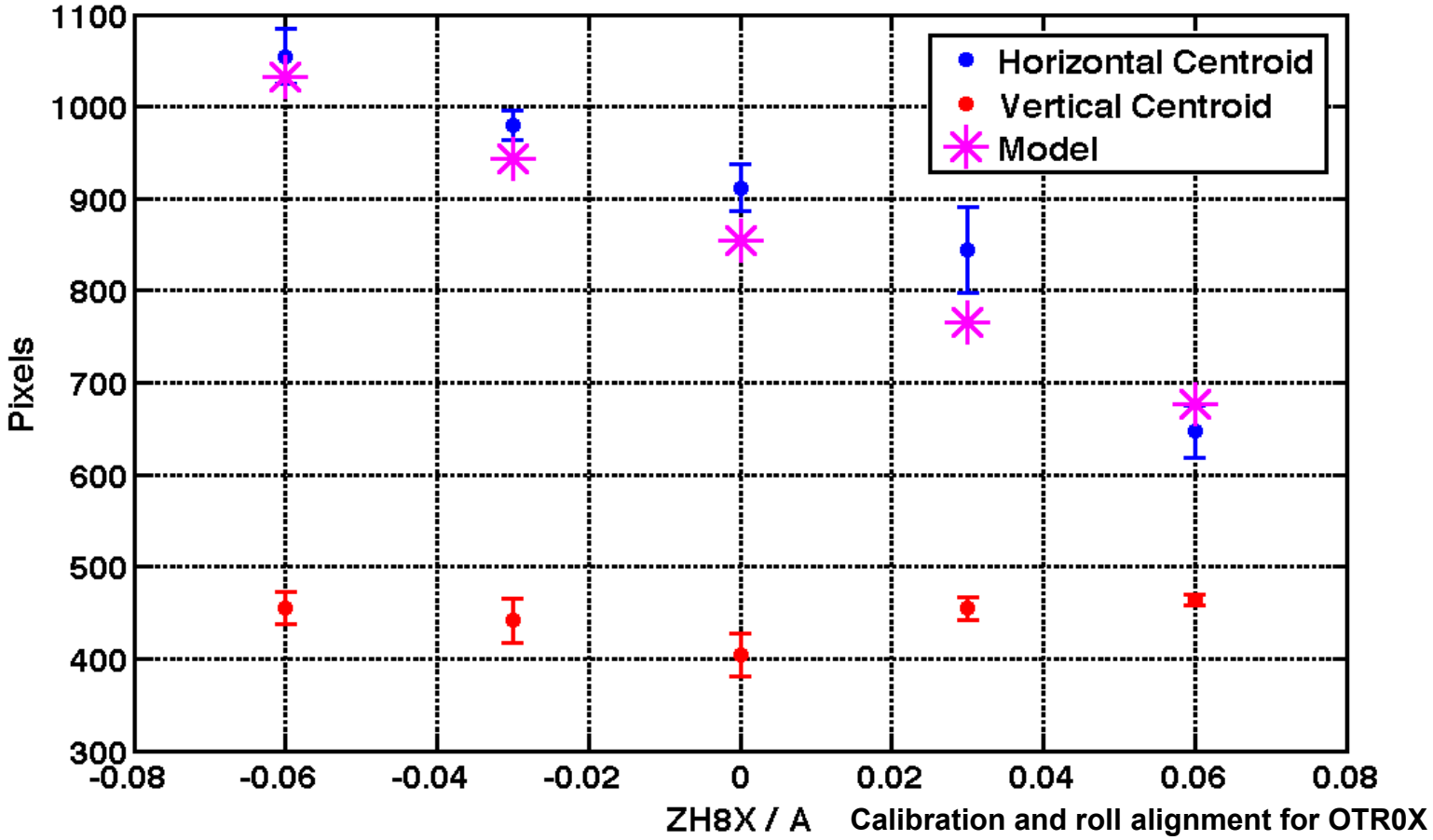
Multi-OTR System

December 2010: Vertical scale calibration



Vertical scale calibration done by scanning the vertical mover stage and recording the motion of the observed beam centroid. Thus the vertical calibration factor um/pixel is obtained.

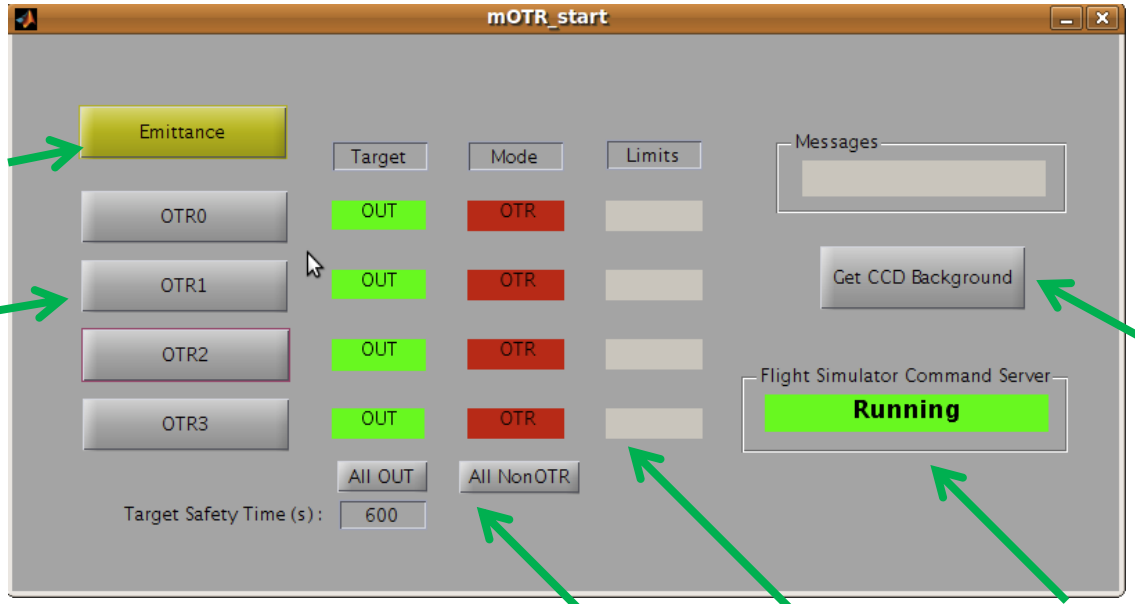
December 2010: OTR0x calibration test and roll alignment



To test the **calibration** an **upstream corrector is scanned** and the response in observed the OTR. To test **roll alignment (of the OTR CCDs)** we have to look for **no motion in the opposite plane**.

- **OTR sofware** is an standalone compiled executable from **Matlab**.
- Some functions like **emittance calculation** or beam finder need the Flight Simulator running.
- OTR status reported and displayed on global **ATF alarm panel** showing **OTR actuator status**.
- All useful **data is stored in EPICS** PVs and archived in the EPICS archival system.

Main start panel



Emittance calculation (next slides)

Single OTR panel (next slides)

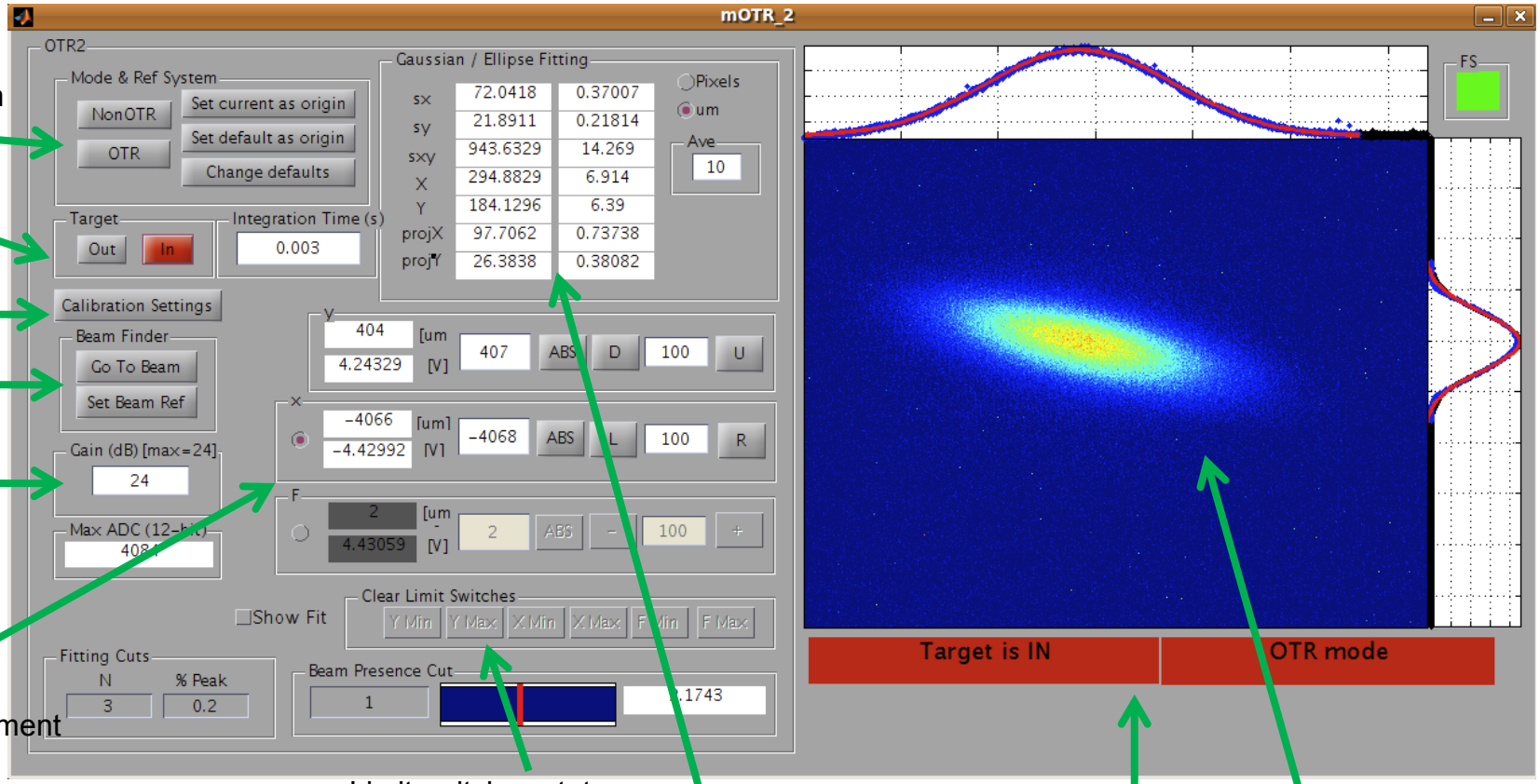
Get CCD Background

Flight simulator Status

Some machine status

Some protection controls

Single OTR panel



Working mode & Reference system

Target control

Calibrations

Beam finder

CCD Gain

Position & movement of the movers

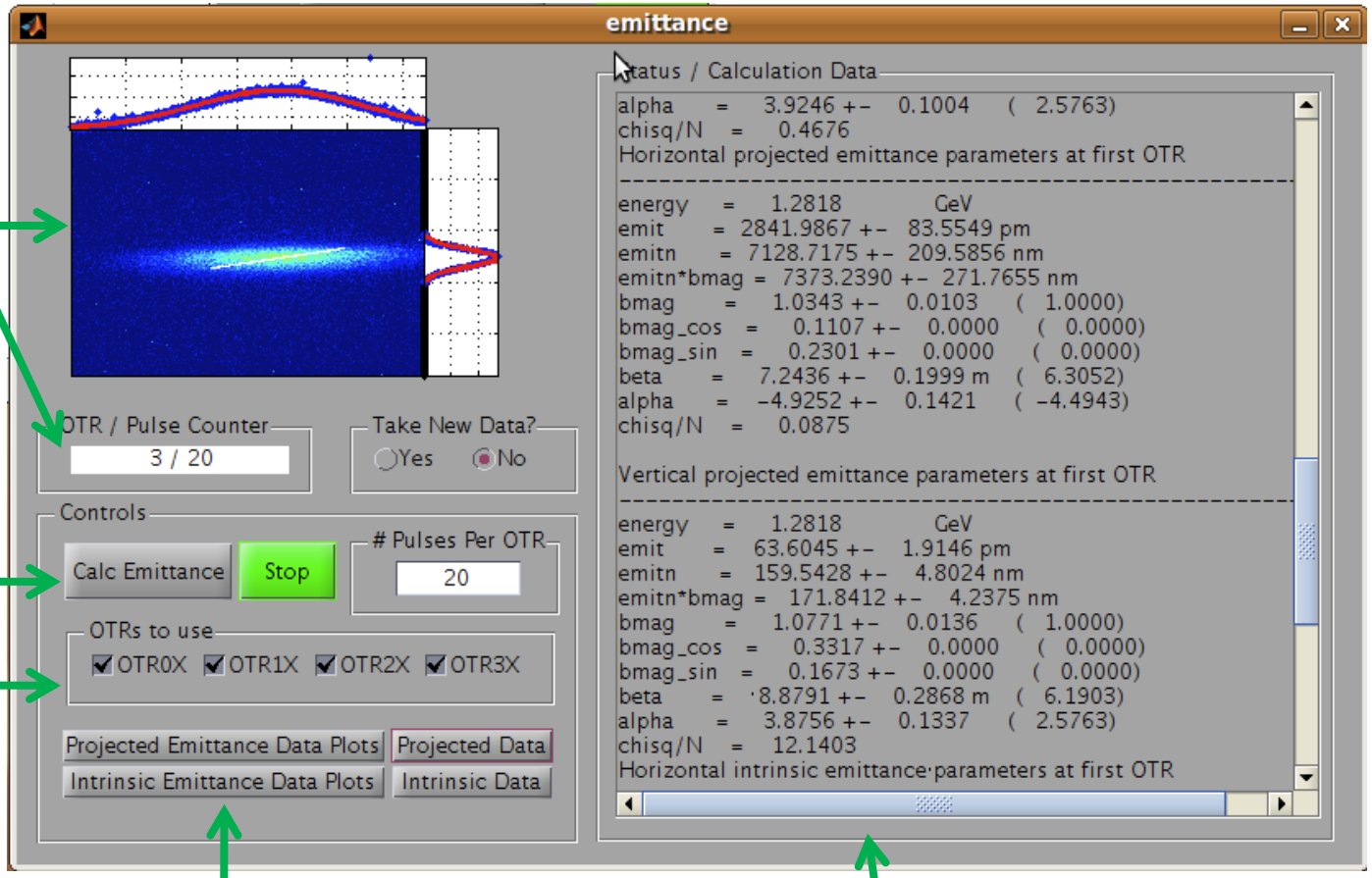
Limit switches status

Ellipse fitting and analysis

Machine status

CCD image and beam fitting

Emittance panel



Current OTR info

Start/stop emittance procedure

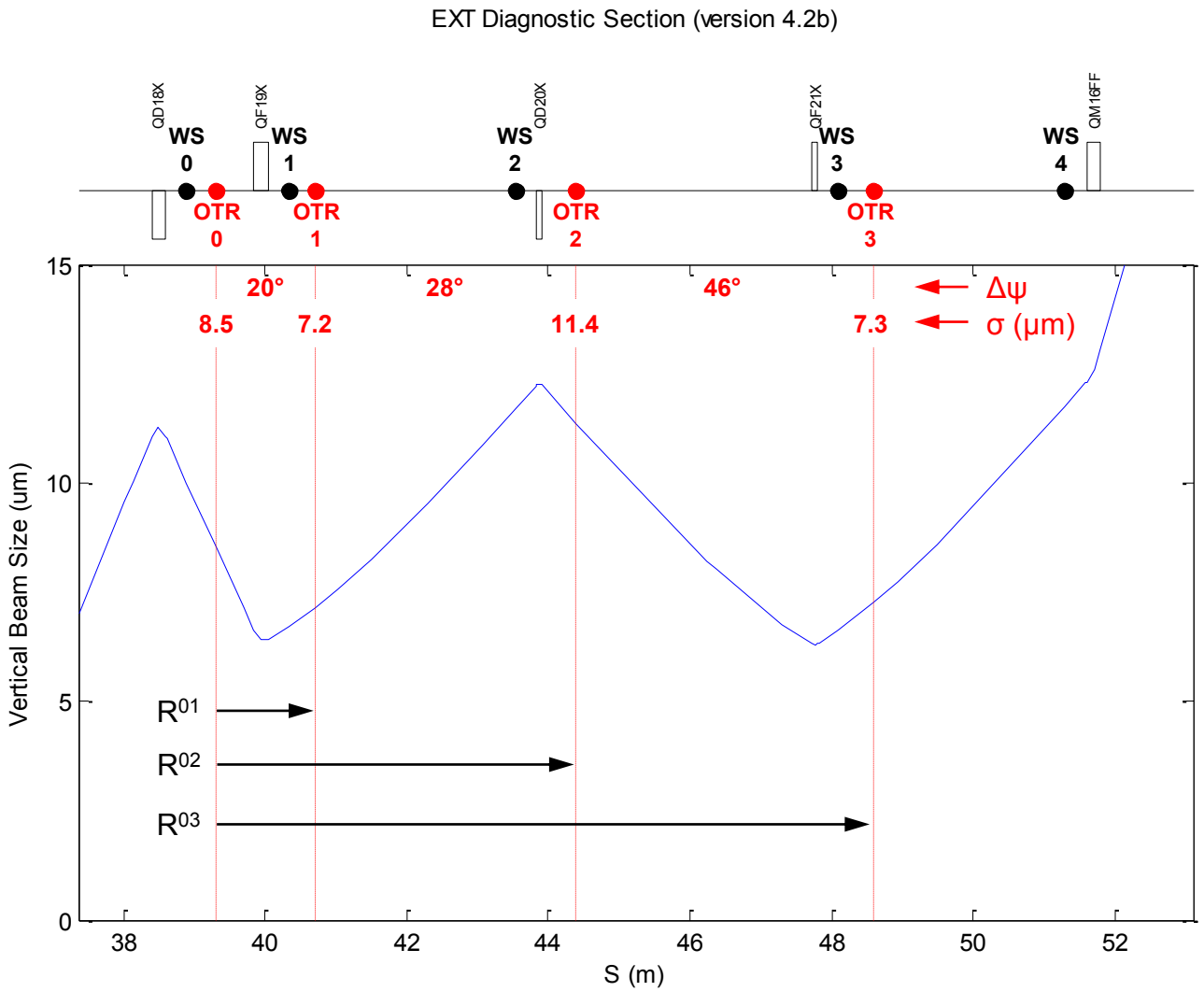
Number of OTR to be used

Data analysis and plots

Calculation data

Multi-OTR System

December 2010: 2D Emittance reconstruction algorithm



$$\sigma = \begin{bmatrix} \sigma_{33} & \sigma_{34} \\ \sigma_{43} & \sigma_{44} \end{bmatrix}, \sigma_{34} = \sigma_{43}$$

$$\sigma^{n} = \left(R^{0n}\right)\sigma^{0}\left(R^{0n}\right)^{T}$$

$$A\vec{x} = b$$

$$\vec{x} = \begin{bmatrix} \sigma_{33} & \sigma_{43}^{0} & \sigma_{44}^{0} \end{bmatrix}^{T}$$

$$\vec{b} = \begin{bmatrix} \sigma_{33}^{0} & \sigma_{33}^{1} & \sigma_{33}^{2} & \sigma_{33}^{3} \end{bmatrix}^{T}$$

$$A = \begin{bmatrix} 1 & 0 & 0 \\ \left(R_{33}^{01}\right)^{2} & 2R_{33}^{01}R_{34}^{01} & \left(R_{34}^{01}\right)^{2} \\ \left(R_{33}^{02}\right)^{2} & 2R_{33}^{02}R_{34}^{02} & \left(R_{34}^{02}\right)^{2} \\ \left(R_{33}^{03}\right)^{2} & 2R_{33}^{03}R_{34}^{03} & \left(R_{34}^{03}\right)^{2} \end{bmatrix}$$

Multi-OTR System

December 2010: 2D Emittance reconstruction algorithm

- **Measure projected OTR beam sizes** σ_n and their **rms errors** $\delta\sigma_n$ (n=0,1,2,3)
  - Gaussian fits to projections
  - statistical rms of measured beam size over N pulses at each OTR
  - correct measured beam sizes for known dispersion (quadrature subtraction)

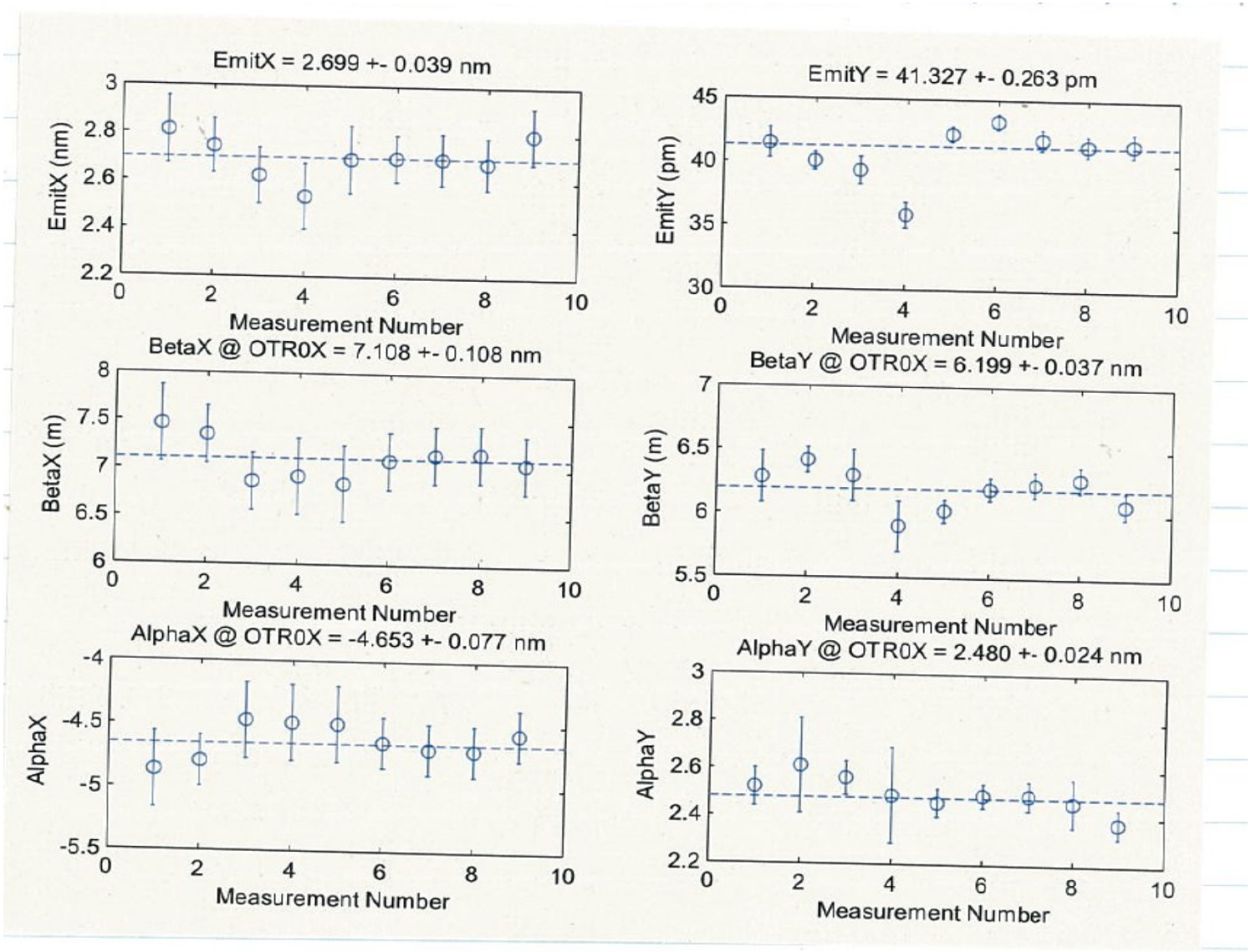
- **Solve 3-parameter linear least-squares problem** Ax = b using all data
  - parameters: σ_{33}, σ_{43}, and σ_{44} at OTR0 (first one)
  - use rms errors and A matrix to compute covariance matrix (T)

- **Compute Emittance, Twiss, BMAG, etc**. from fitted parameters
  - use ∇f and covariance matrix to estimate errors

- **Implemented in Flight Simulator**
  - R-matrices from extant EXT model
  - propagated dispersion values at OTRs from extDispersion package
  - σ_n and $\delta\sigma_n$ at OTRs from OTR emittance measurement package via EPICS (x and y simultaneously)
  - emittance, Twiss, BMAG, etc. computed and displayed (coupling not included)
  - graphics for measured/fitted/projected beam sizes and Twiss parameters

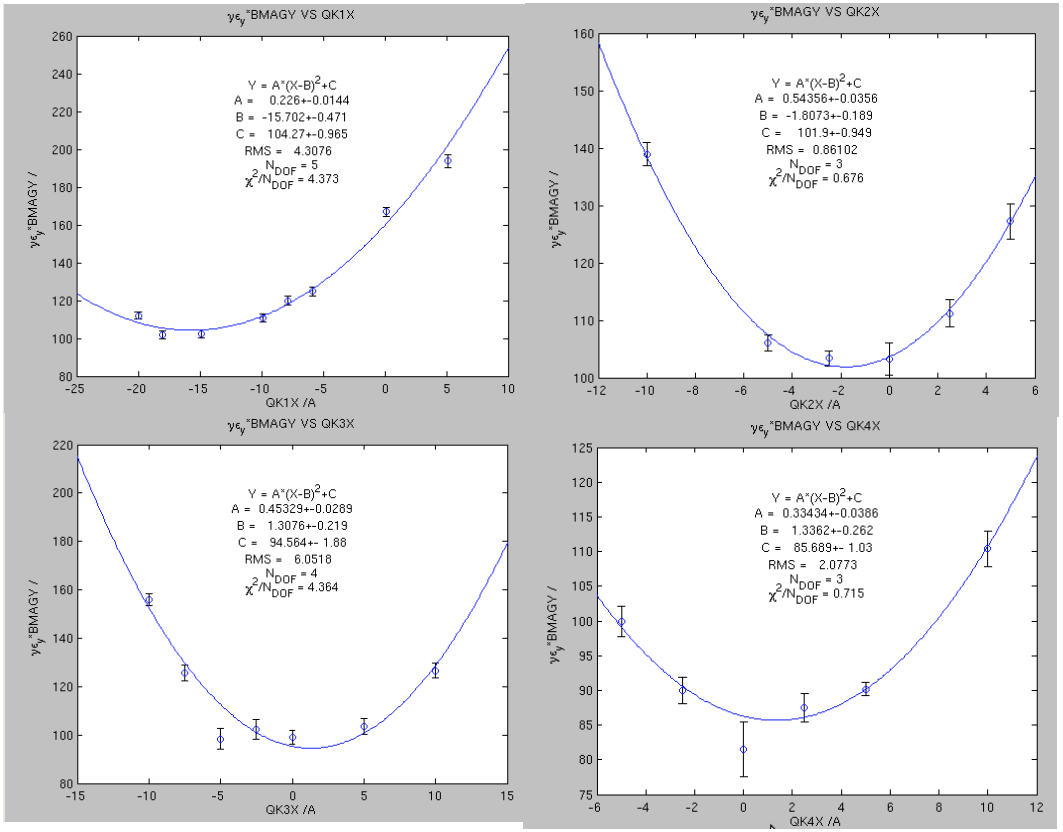
Multi-OTR System

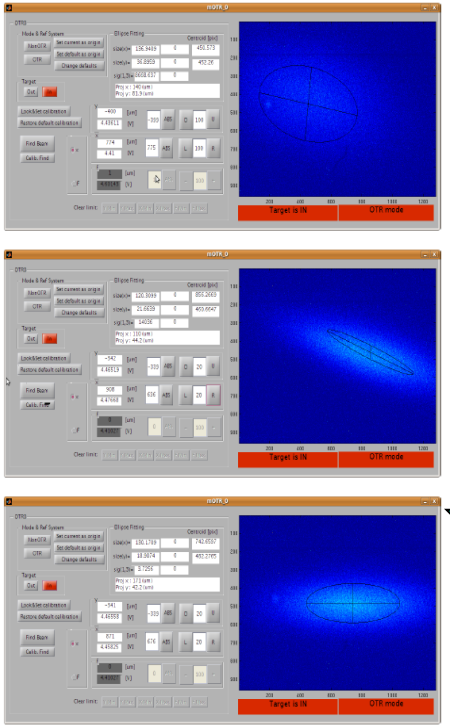
December 2010: Stability Measurement



Multi-OTR System

December 2010: Coupling Correction





OTR0X before corrections

OTR0X after dispersion correction

OTR0X after coupling correction

Coupling correction in the EXT achieved by **scanning each of the 4 EXT skew quads**. For each scan the quantity **(vertical normalised emittance)*BMAGY** is plotted and taken the optimal from a parabolic fit.

Multi-OTR System To do list

•Get the **Beam finder** working.

-Work required on Flight Simulator online orbit fitting

-Work required on OTR software implementation

• Finish **test calibration and roll** for OTR1-3X (no roll means all OTRs in the same coordinate frame and can use ellipse fit tilt with other measurements for the 4D emittance measurement)

•**4D intrinsic emittance** calculation.

-Algorithm development, flight simulator calculation and OTR software implementation.

• Install a **LAN controllable power strip in-tunnel** and build in power cycle controls into the OTR software (CCD cameras can be put into a mode of operation unresponsive to the OTR software and needs to be reset by power cycling the cameras being the power supplies in-tunnel)

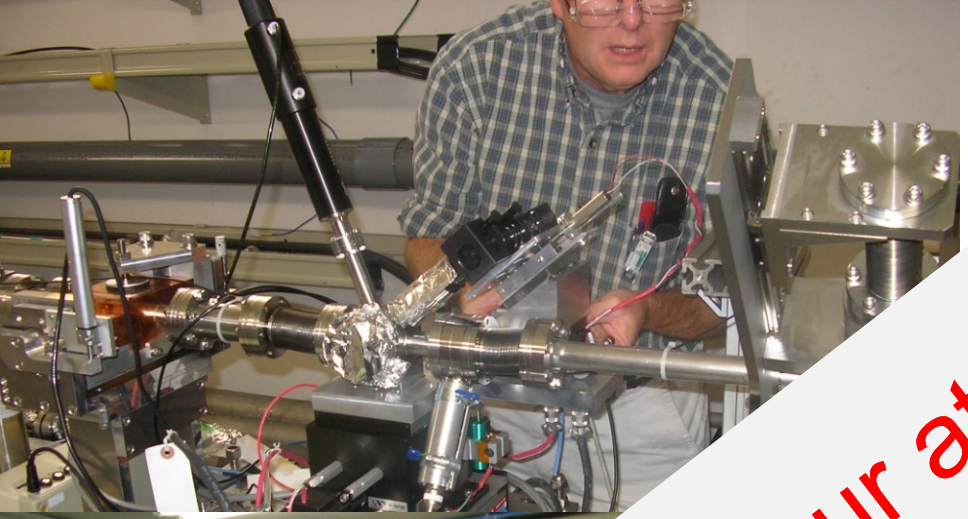
Multi-OTR System To do list

• Provide the capability of doing **automated scans from the emittance GUI** (e.g. Automate the scan QK*X and plot versus emit*BMAG to search the minimum).

• Install **switchable de-magnifier lens** (?)

• **Documentation** (user's guide started)

• Systematic **Measurement campaign during 2011**



Thanks for your attention