Theoretical and experimental investigation on resolution of optical transition radiation transverse beam profile monitor.

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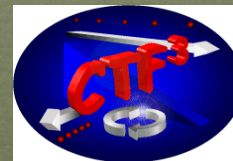KEK ATF
S. Boogert, P. Karataev
JAI at RHUL
L. Nevay
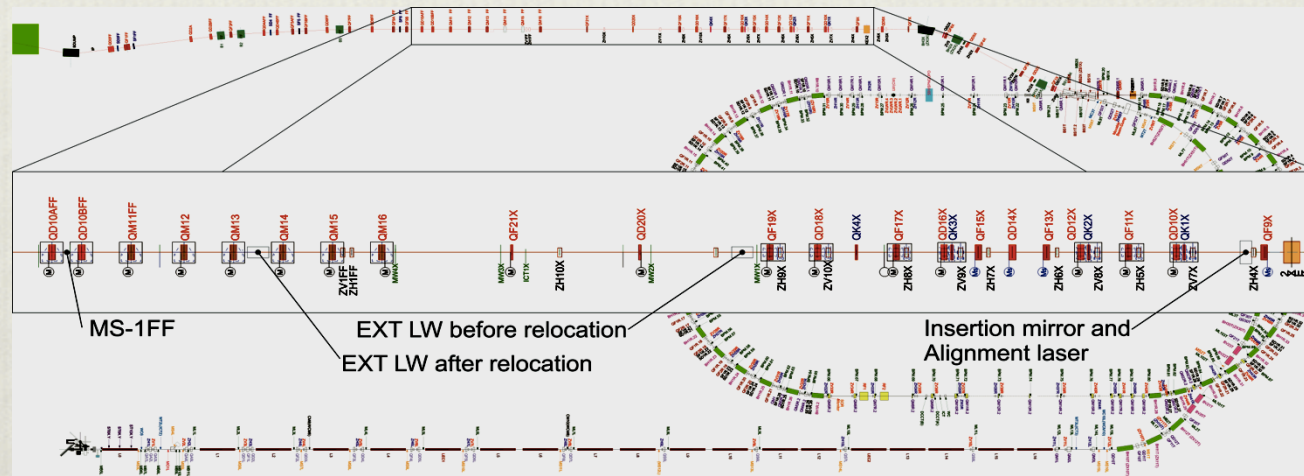JAI at Oxford
T. Lefevre, E. Bravin, B. Bolzon
CERN CTF3

Outline

The aim is to develop a simulation tool for optimization of OTR monitor systems for small-to-large beam size diagnostics
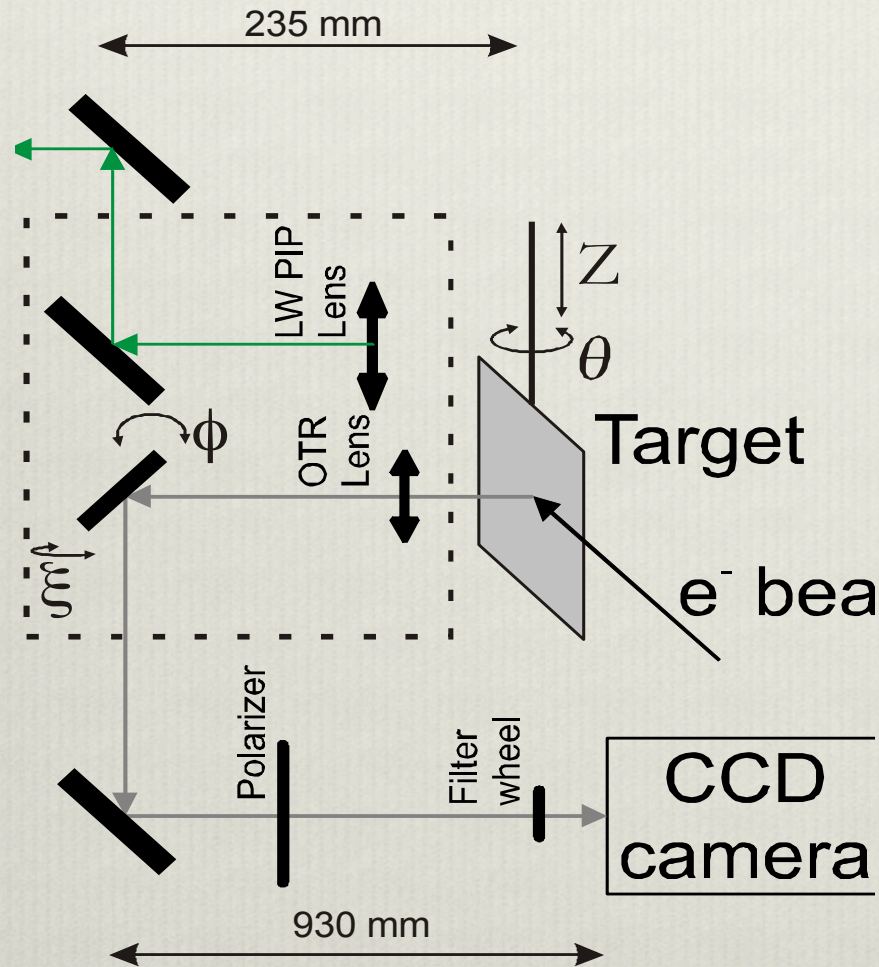
- ❖ Introduction and overview

- ❖ Beam time summary

- ❖ Resent results

- ❖ Future improvements and prospects

- ❖ Summary

Introduction and overview

❖ Initial setup spring 2009

❖ Observation of OTR PSF end of 2009

❖ e-optics verification, monitor commisioning 2009 – 2012
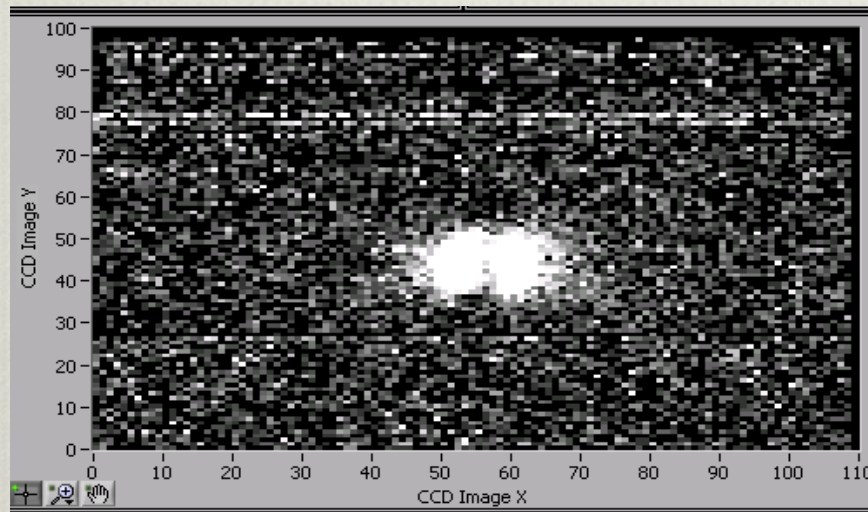
❖ EXT LW cross-checking ~ spring 2012

Setup overview

❖ CCD :

  ❖ SBIG ST 8300 MT

  ❖ ~ 50% Q.E. @ 550nm

  ❖ 5.4 um/pixel

❖ Lens (tested since 2009)

  ❖ 50mm f=120mm

  ❖ 30mm f=120mm

  ❖ 30mm f=120 achromat

  ❖ 12.6mm f=100mm

OTR images

OTR image @ previous location

OTR image @ current location

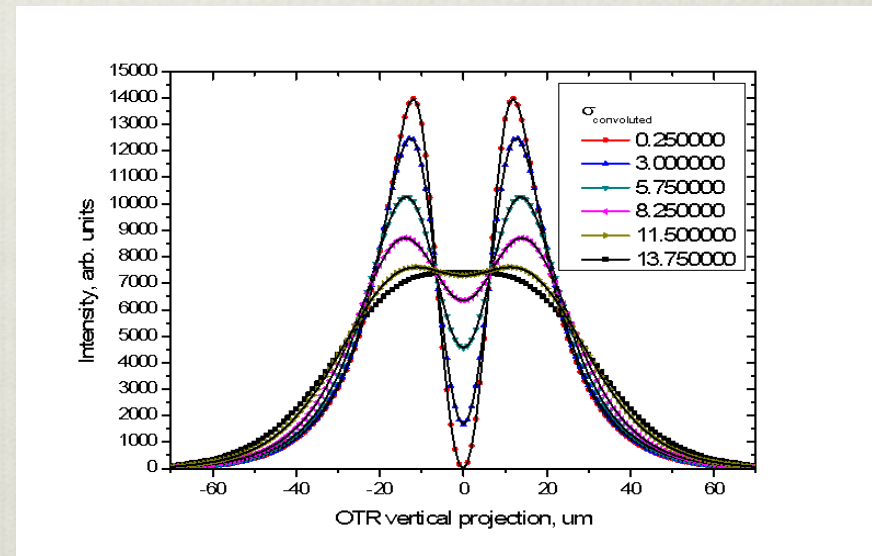14th ATF TB/SGC Meeting
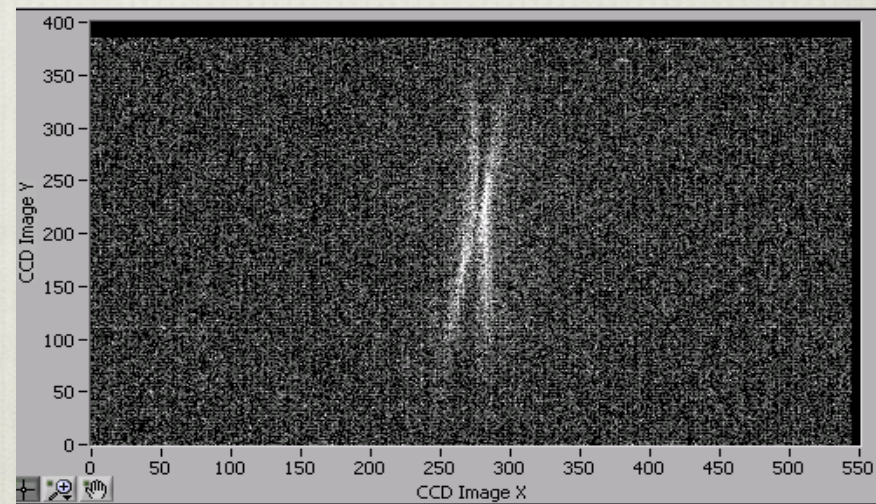
Beam size effect on OTR

"Usual" OTR image
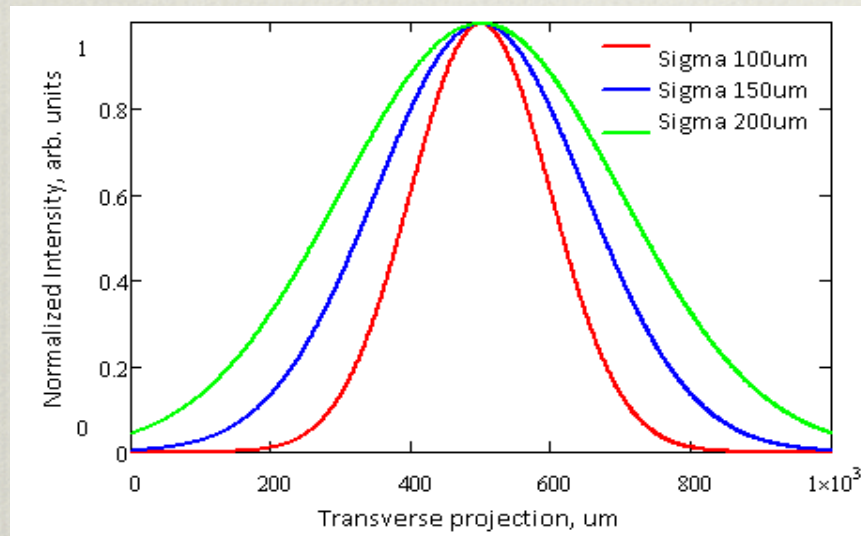
OTR vertical polarization component, for sigma < ~15 um

OTR PSF-like Fit function

$$f(x) = a + \frac{b}{1 + \left[c(x - \Delta x)\right]^4}\left[1 - e^{-2c^2\sigma^2}\cos\left[c(x - \Delta x)\right]\right]$$

a	143.034 +/- 80.2691
b	60440.8 +/- 175.643
c	0.0807 +/- 0.00165
Δx	543.838 +/- 0.18656
σ	2.36213 +/- 0.59153

Here *a*, *b*, c, σ, and Δx are free parameters of the fit function;
- *a* is the vertical offset of the distribution with respect to zero.
- *b* is responsible for the amplitude of the distribution;
- c is responsible for the distribution width;
- σ is the smoothing parameter dominantly defined by the beam size;
- Δx is the horizontal offset of the distribution with respect to zero.

$$\Delta f(x) = \sqrt{\sum \left(f(x)\right)_i^2 \cdot \Delta_i^2}$$
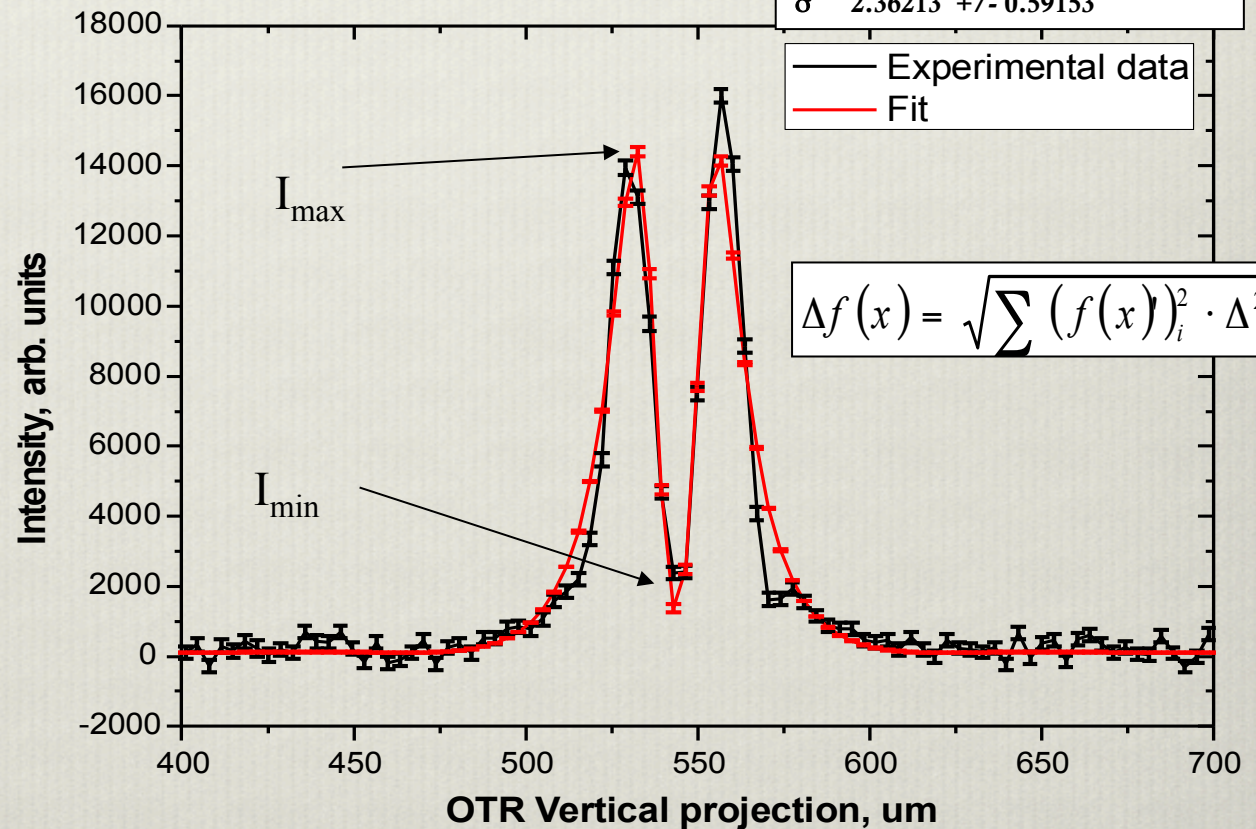
Beam time summary

- ❖ OTR dedicated shifts

    - ❖ 3/8, 3/15, 4/11, 6/5

    - ❖ System developments

        - ❖ Focusing

        - ❖ Additional scans

- ❖ Tuning for EXT LW

    - ❖ 4/12, 4/13, 4/18, 4/25, 5/18, 5/21, 5/22, 5/24, 6/15

    - ❖ Routine e-beam diagnostics

    - ❖ Cross-checking

Focusing

16.0 mm	16.2 mm	16.4 mm	16.6 mm	16.8 mm
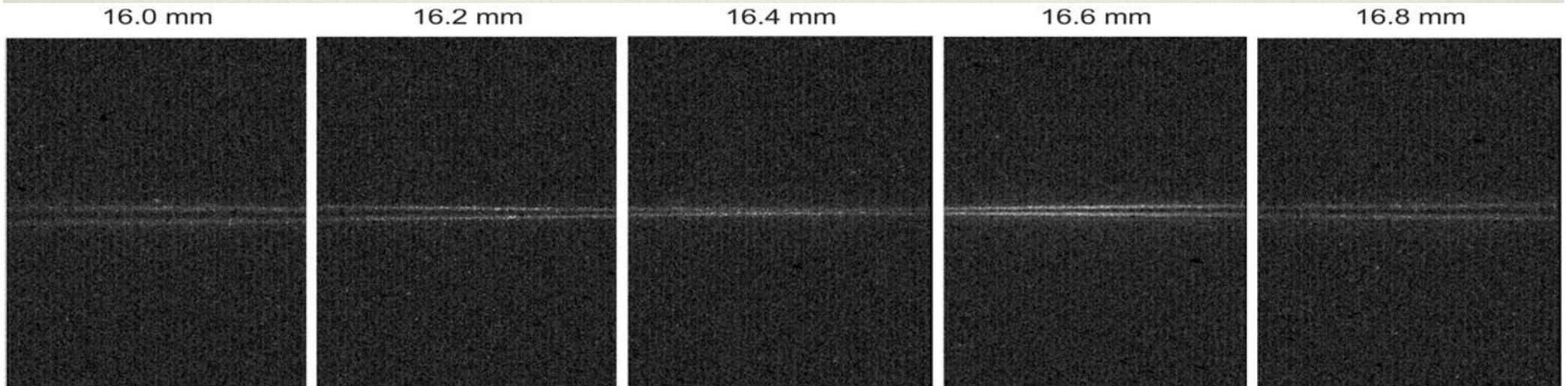
❖ Images are consistent with the optical model

❖ Large horizontal beam size makes possible very fast focusing

Polarizer angular scan

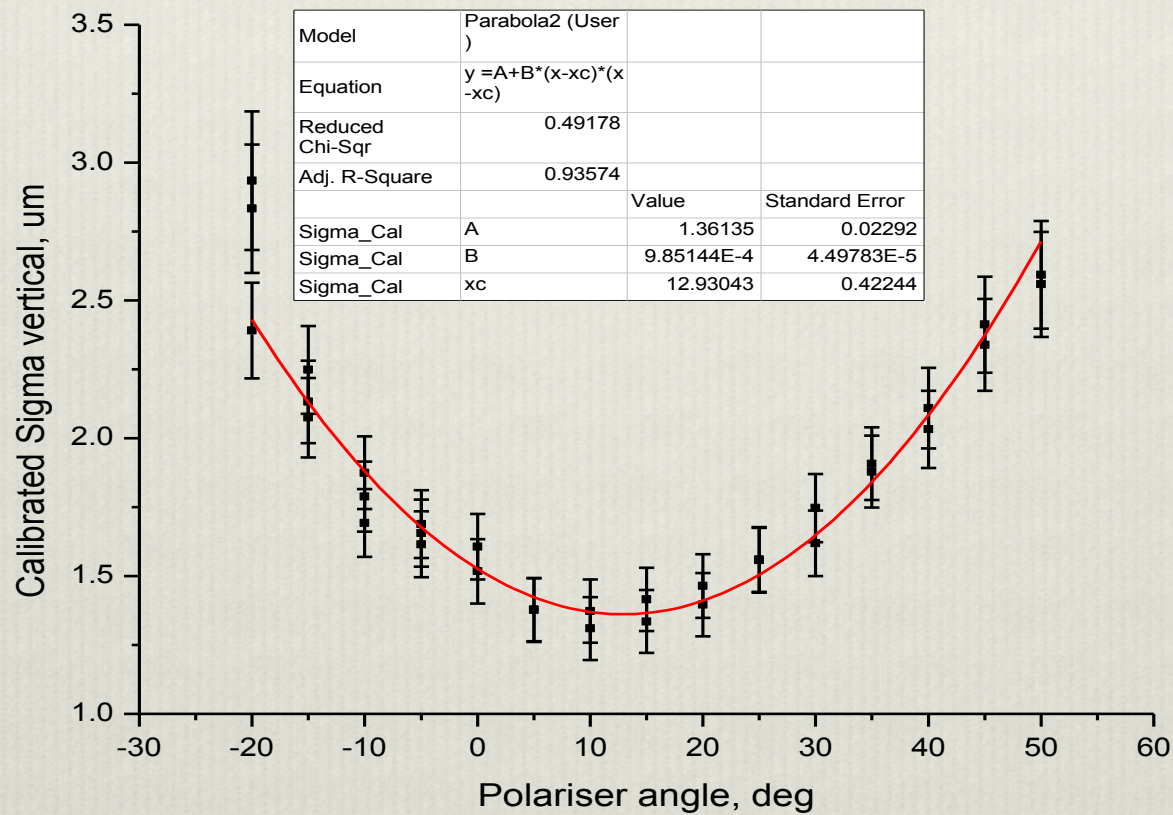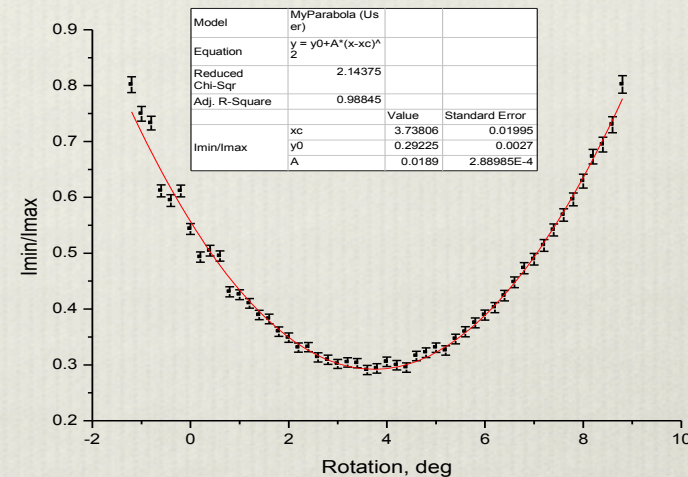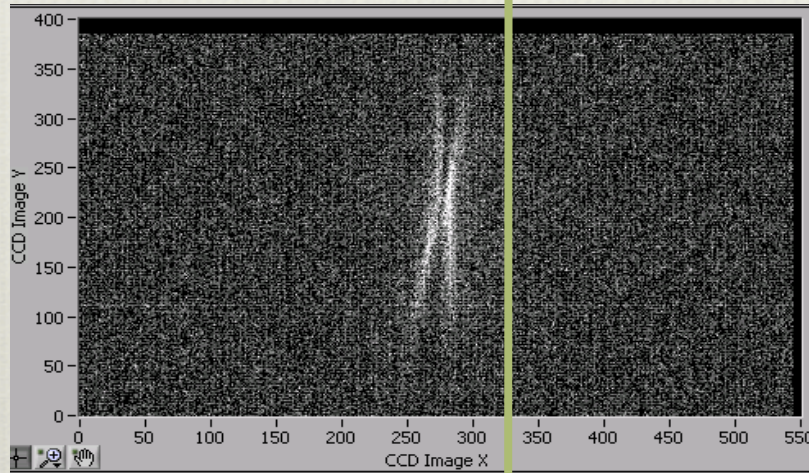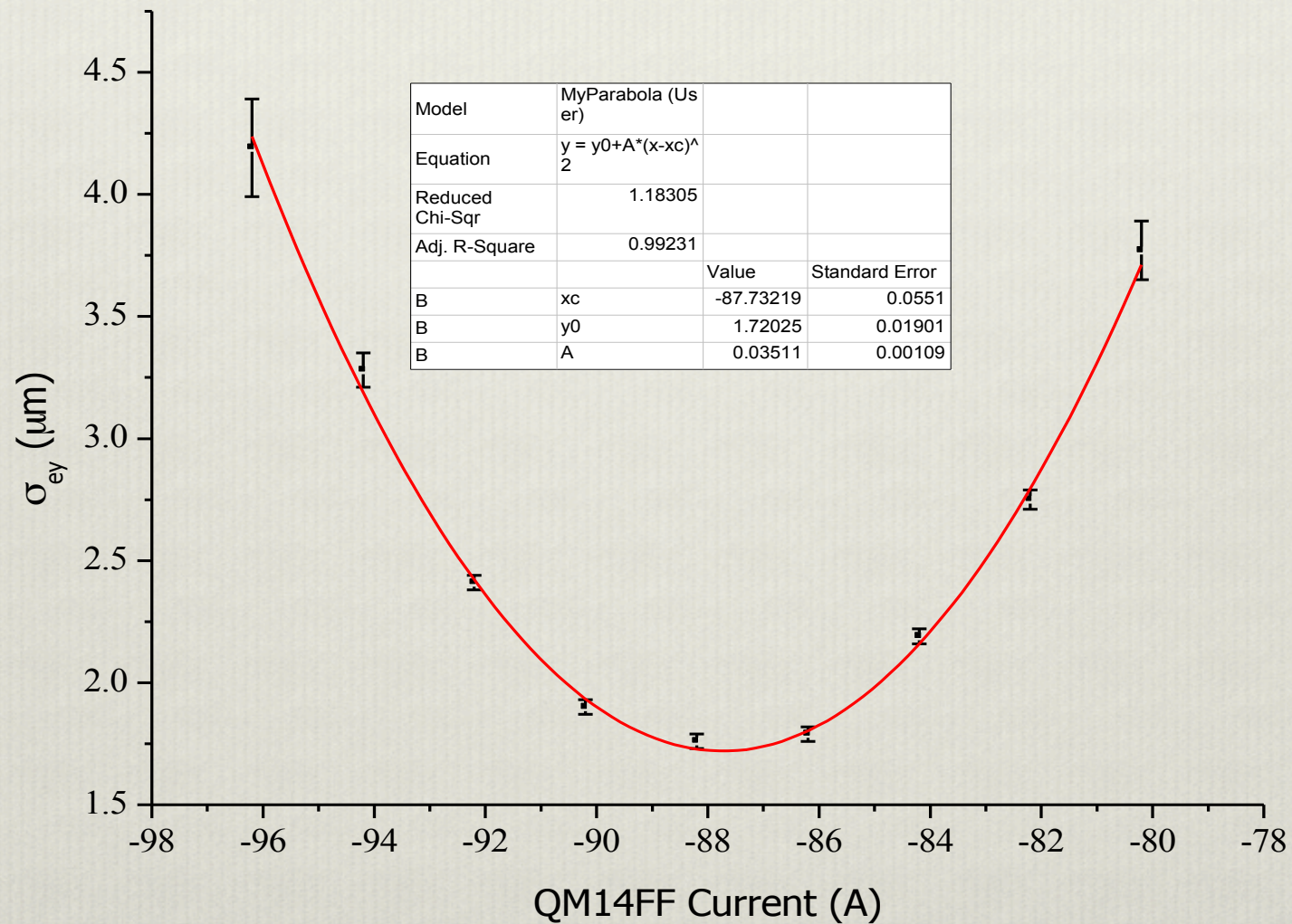| Model	Parabola2 (User)		
Equation	y =A+B*(x-xc)*(x -xc)		
Reduced Chi-Sqr	0.49178		
Adj. R-Square	0.93574		
		Value	Standard Error
Sigma_Cal	A	1.36135	0.02292
Sigma_Cal	B	9.85144E-4	4.49783E-5
Sigma_Cal	xc	12.93043	0.42244

Image rotation analysis

- ❖ Many images were analyzed, rotation is always around 4 deg.

- ❖ Removes the optical path misalignment effect.

Best scan example

| Model	MyParabola (User)		
Equation	y = y0+A*(x-xc)^2		
Reduced Chi-Sqr	1.18305		
Adj. R-Square	0.99231		
		Value	Standard Error
B	xc	-87.73219	0.0551
B	y0	1.72025	0.01901
B	A	0.03511	0.00109

Future improvements and prospects

- ❖ Optical line re-arrangement

- ❖ Multi-elements microscope simulation is ongoing

- ❖ New OTR PSF-like Fit function

- ❖ Lens Light-Based-Alignment

- ❖ ATF-2 postIP relocation possibility

Optical line re-arrangement
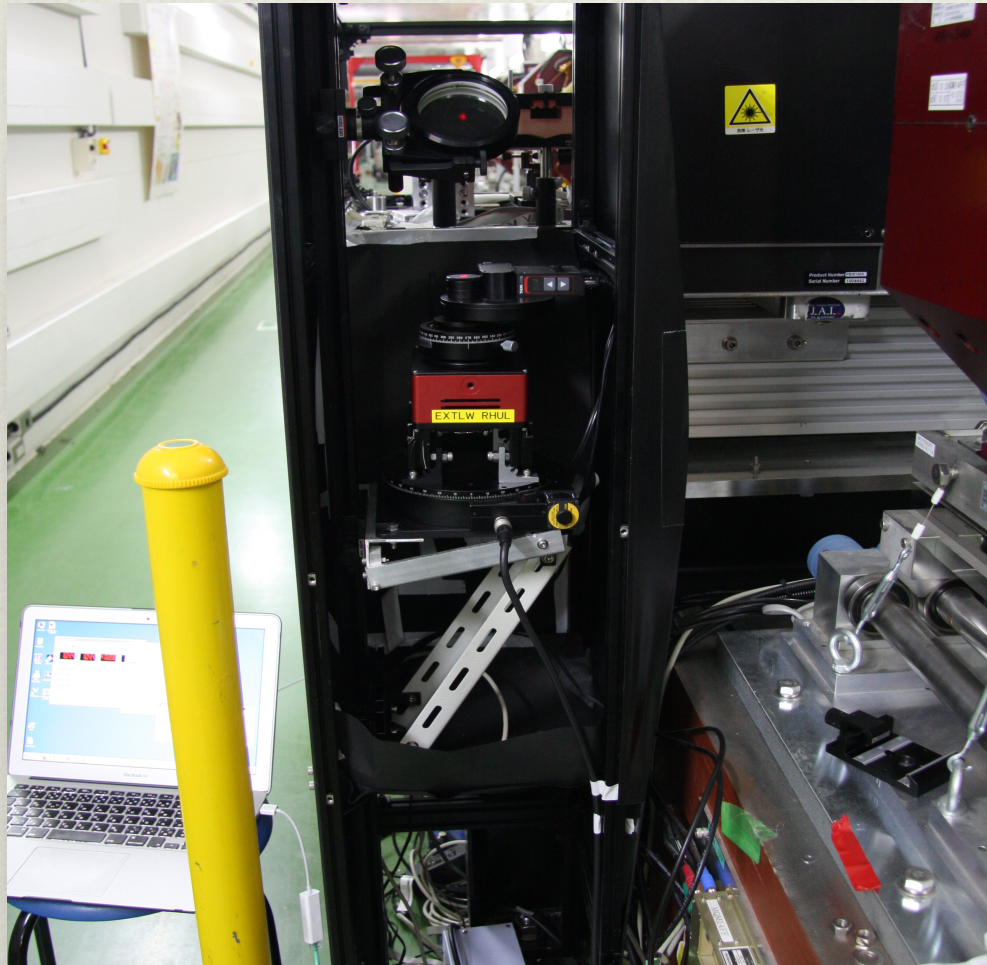
❖ Before

   ❖ Polarizer (in rotation base)

   ❖ Filter wheel (motor.)

   ❖ CCD

❖ Now

   ❖ Filter wheel (motor.)

   ❖ Polarizer (manual)

   ❖ CCD

   ❖ Rotation base

New OTR PSF-like Fit function

$$f(x) = a + \frac{b}{1 + \left[c(x - \Delta x) \right]^4} \left[1 - e^{-2 c^2 \sigma^2} \cos\left[c(x - \Delta x) \right] \right]$$

❖ Provides a better fit around two-lobe distribution dip

❖ Must define limits of a new variable parameter

❖ Need to check/change calibration, including calibration fit? and error propagation (effectively repeat all analysis study)
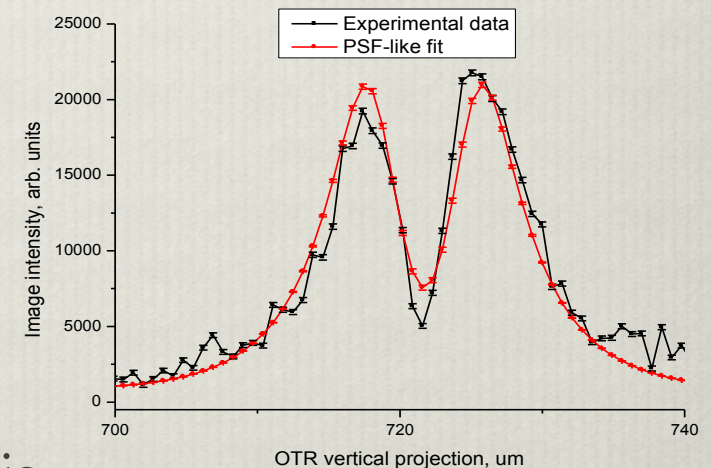
Summary

- ❖ Many improvements has been introduced

- ❖ Routine EXT LW cross-check is achieved

- ❖ More work on analysis and simulations is required

- ❖ Relocation to ATF-2 PIP region: possibility is under consideration. More details will be given at 15th ATF TB/ SGC Meeting