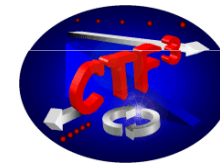# Theoretical and experimental investigation on resolution of optical transition radiation transverse beam profile monitor.

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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
- OTR images
- Beam size effect on OTR
- OTR PSF-like Fit function
- Setup overview
- Reconstructed Quadrupole scans
- Beam size effect on PSF
- Summary

# Introduction and overview

OTR "RMS-based" monitors

- M. Ross et. al. SLAC-PUB-9280, predicted 2um, measured 5.5 um

- T. Mitsuhashi, 8th ATF TB and SGC meeting, "Tele-microscope with apodization and super-resolution for OTR monitor", predicted submicron resolution.

- L. Sukhikh, et. al. "Backward transition radiation in EUV-region as a possible tool for beam diagnostics", NIMA 623 (2010) 567–569. predicted submicron resolution.
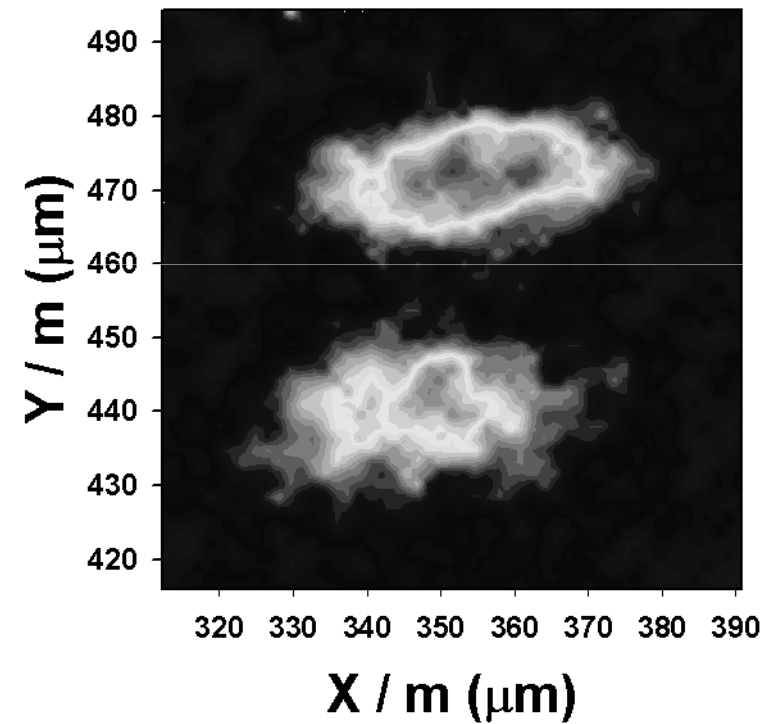
OTR "PSF-based" monitor

- P. Karataev, et.al. "The First Observation of the Point Spread Function of Optical Transition Radiation", PRL **107**, 174801 (2011).

- A. Aryshev, et.al. IPAC-11 WEOBB01, IPAC-10 MOPEA052, RREPS-09: Journal of Physics: Conference Series **236 (2010) 012008**
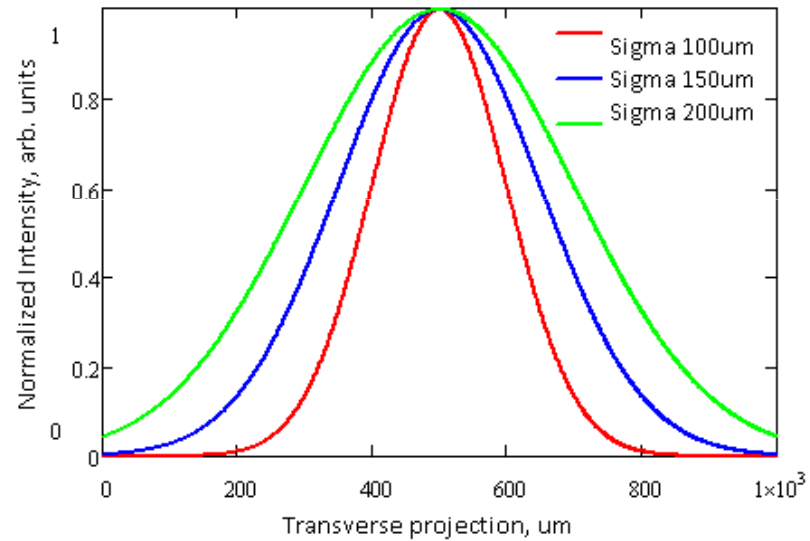
OTR images

"Usual" OTR image
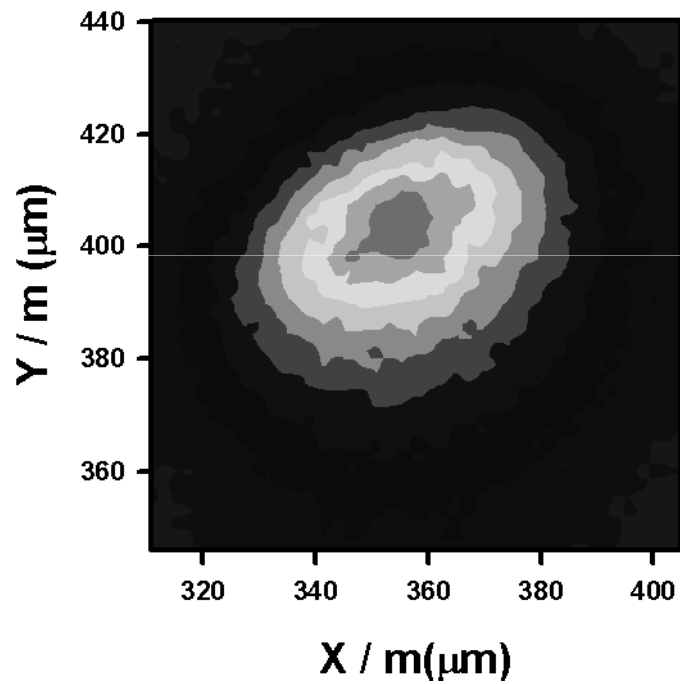
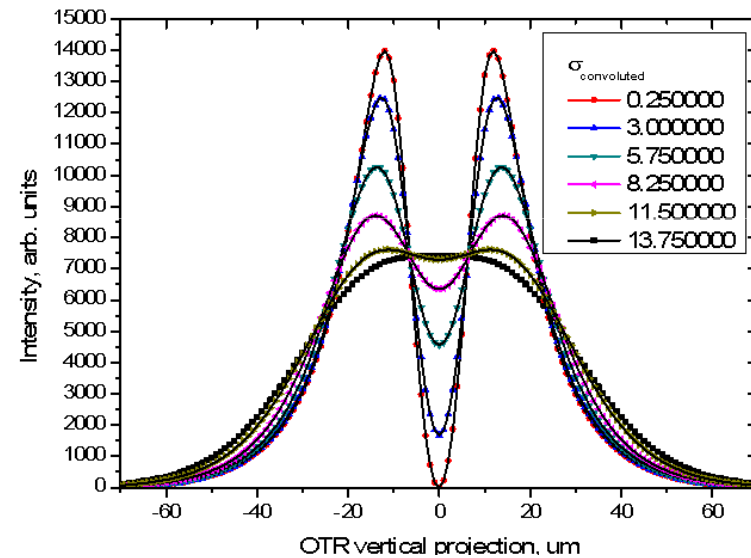OTR vertical polarization component

Beam size effect on OTR

"Usual" OTR image

OTR vertical polarization component, for sigma < ~15 um

OTR PSF-like Fit function

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

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.

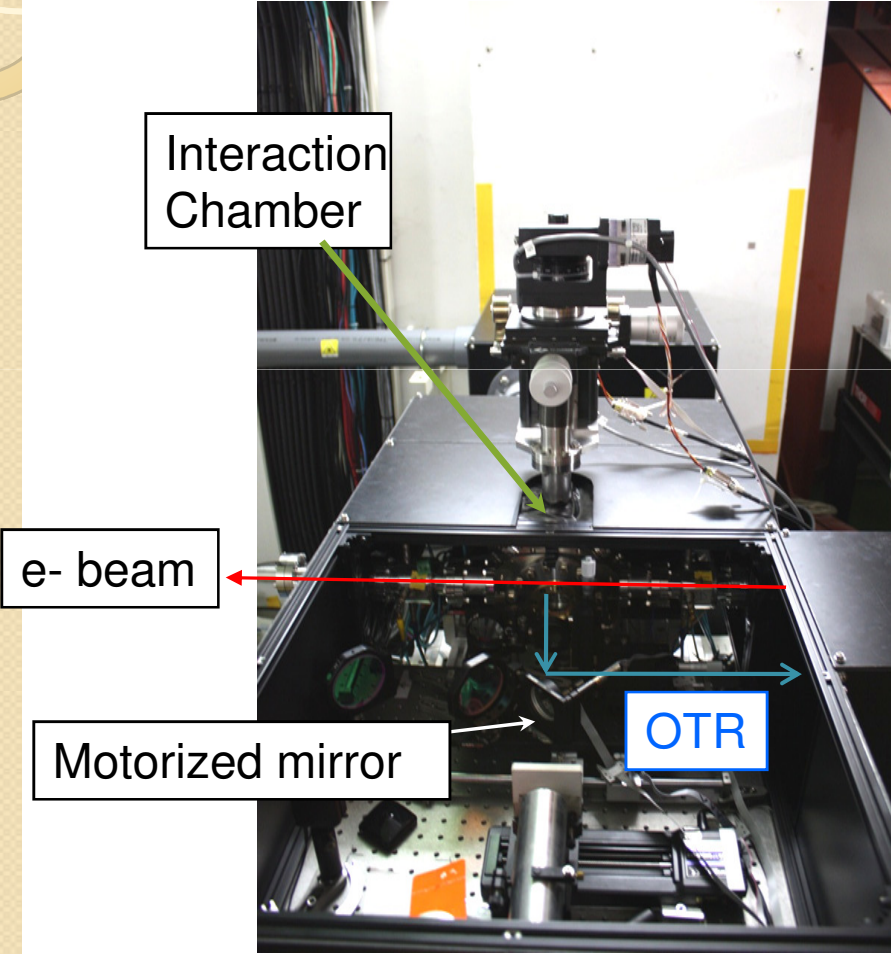$$\Delta f(x) = \sqrt{\sum (f(x)')_i^2 \cdot \Delta_i^2}$$
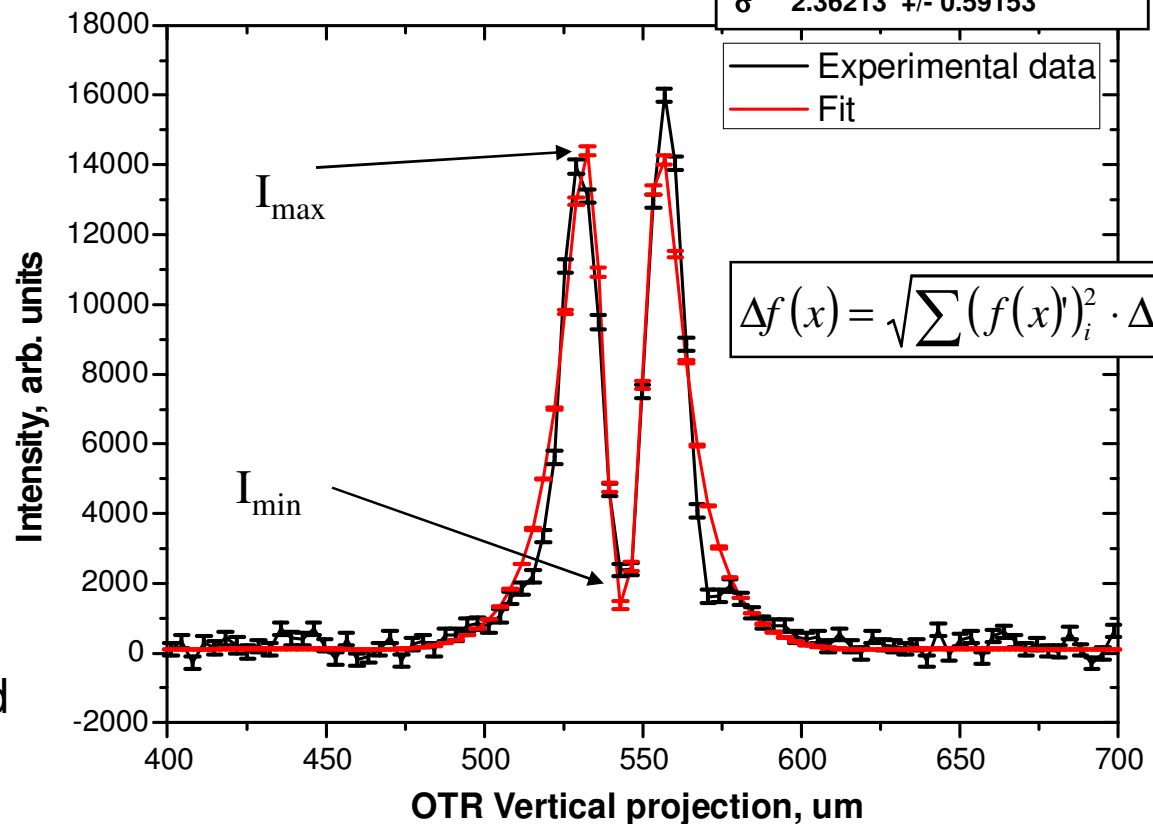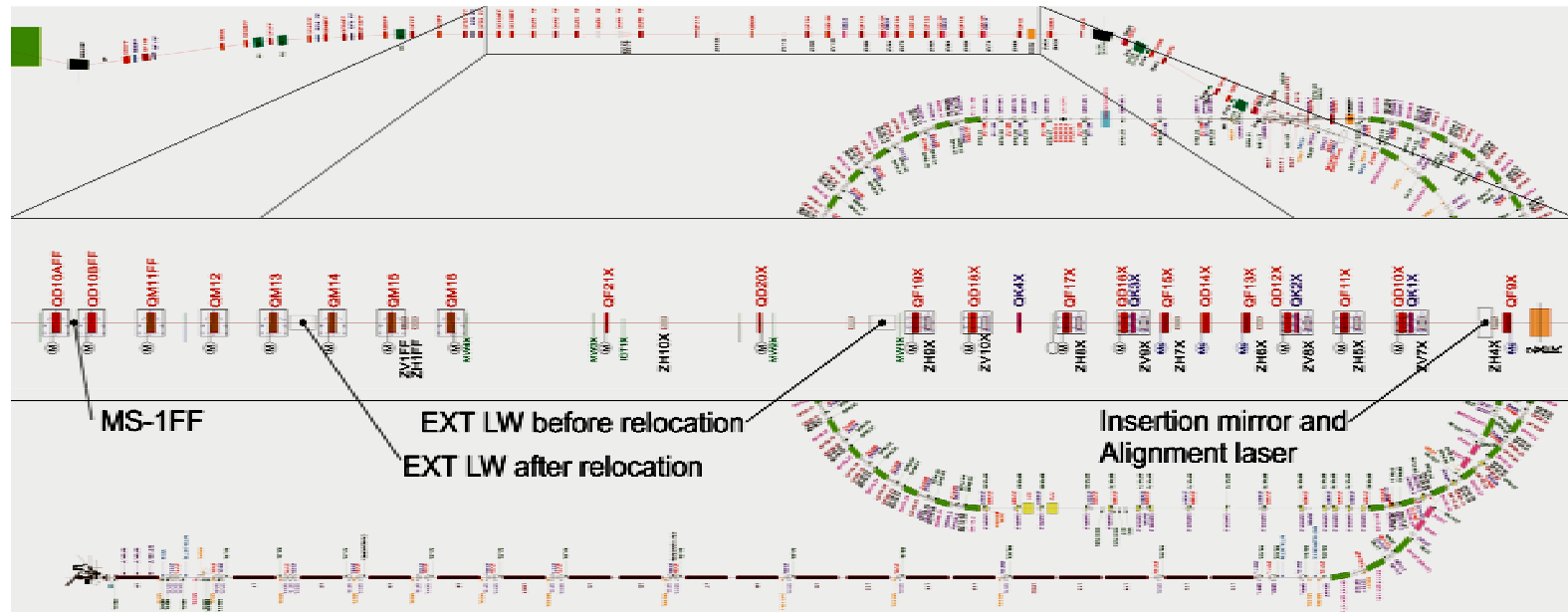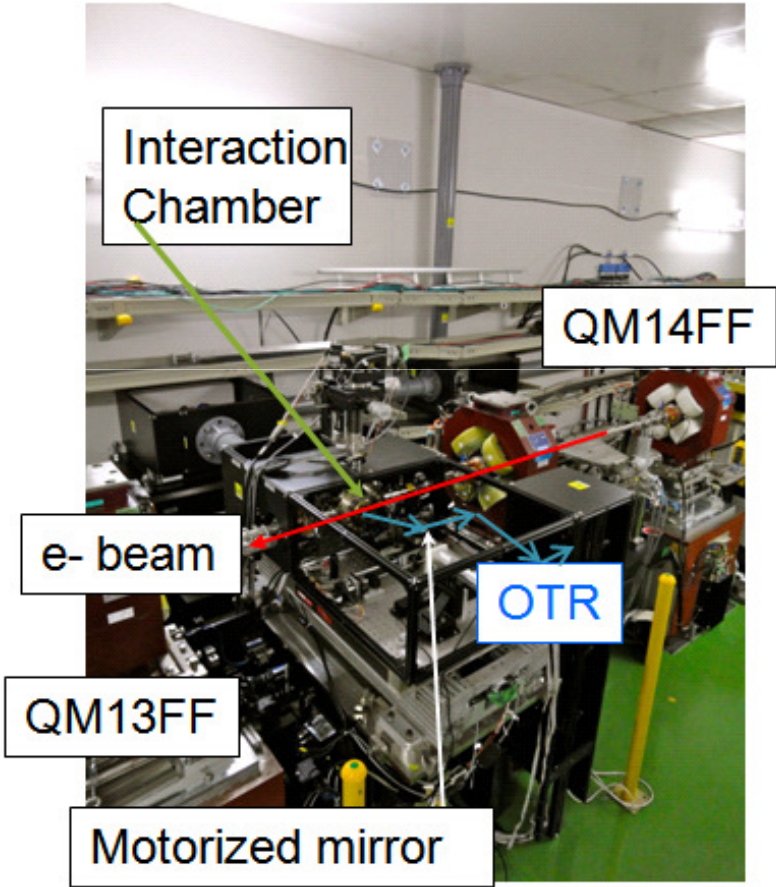
Setup overview

- Initial setup spring 2009
- Observation of OTR PSF end of 2009
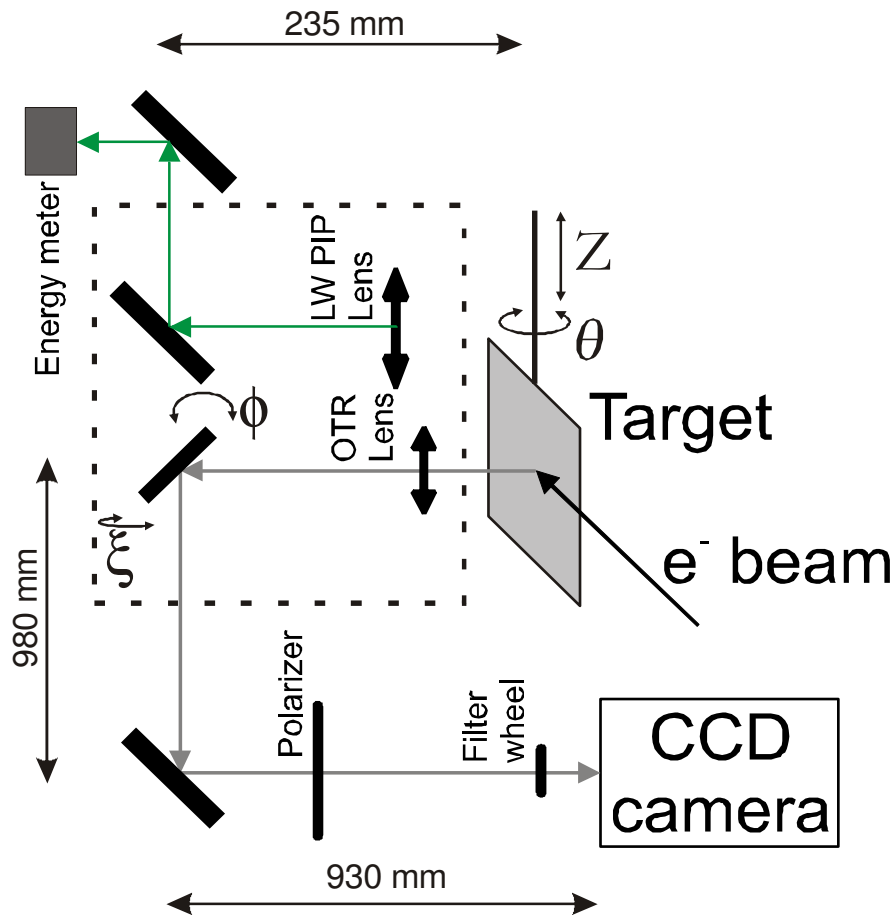- EXT LW optics verification and cross-check 2009 – present
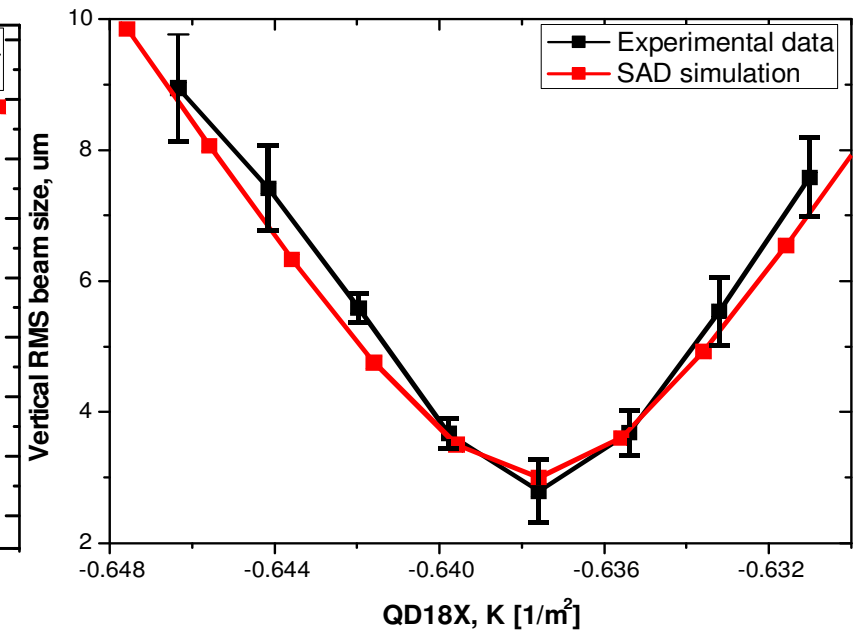
Setup overview
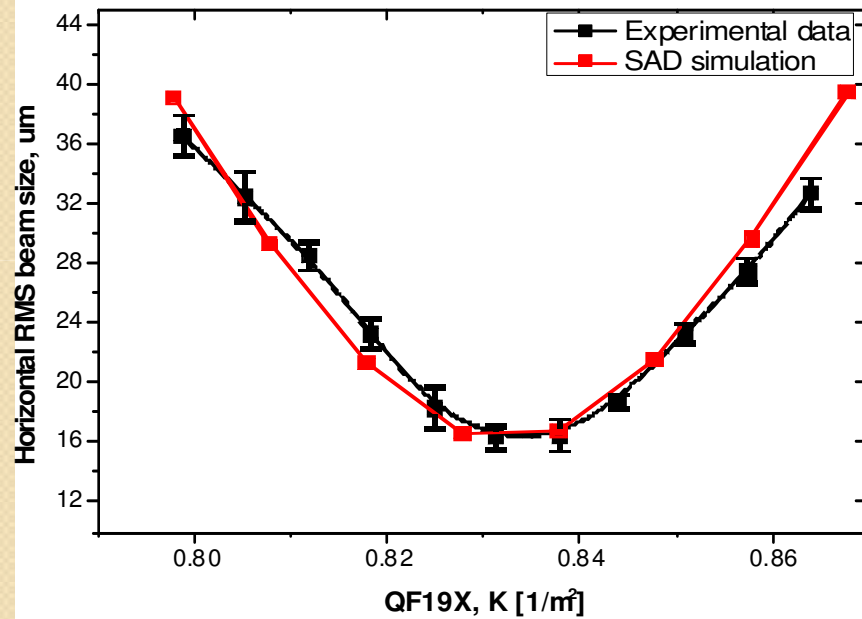
Before relocation

After relocation

Setup overview

- CCD replacement:
Alta E4000
~ 55% Q.E.
7.4 um/pixel
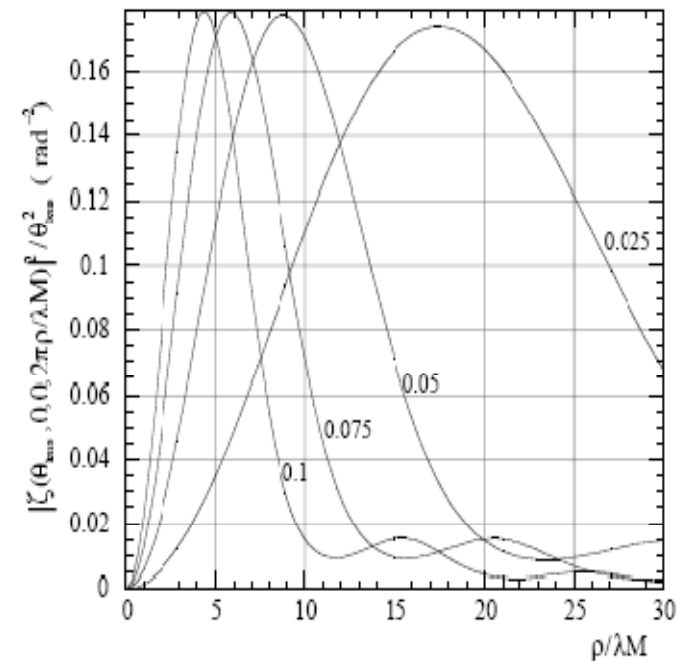
SBIG ST 8300 MT
~ 50% Q.E.
5.4 um/pixel

Reconstructed Q-scans

Phenomena leading to PSF distortion

- Diffraction of OTR tails
- Chromatic aberrations
- Spherical aberrations

for instance, M. Castellano and V.A. Verzilov,
Phys.Rev. ST-AB 1, 062801 (1998)

Summary and conclusion

- Detailed ZEMAX simulation of the optical system will be performed by CERN team.

- Experimental verification of the simulation results at KEK.

- Understanding of practical OTR monitor resolution limitations.

- Optimization of optical system and its tuning.

- Occasional shift requests (2/month on average)