

# The New XUV Optics Beamline at BESSY-II

**Andrey Sokolov**

**HZB** Helmholtz  
Zentrum Berlin

F. Schäfers, F. Senf, M. Mast, J.-S. Schmidt,  
F. Eggenstein, F. Siewert, S. Künstner, A. Erko

**Institute for Nanometre Optics  
and Technology, BESSY-II**



# The new Optics Beamline at BESSY II

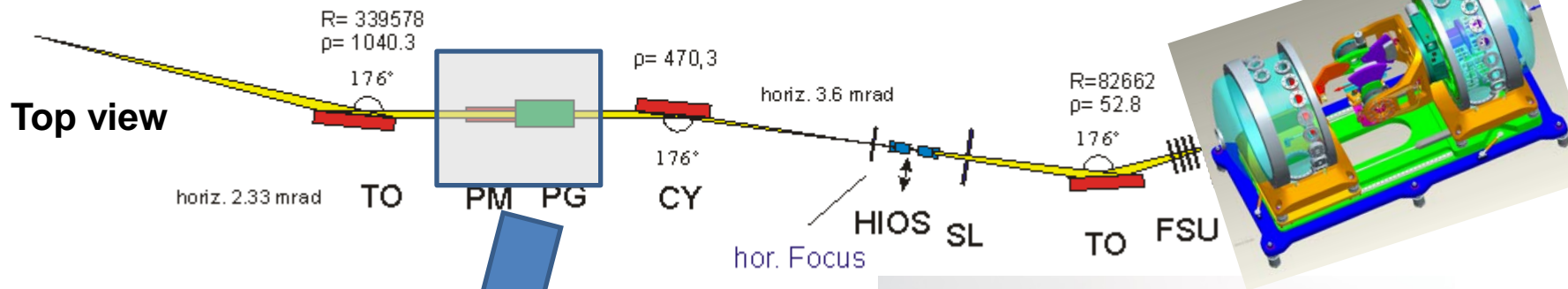
Characterisation of in-house produced gratings and more

## Collimated PGM

- 10 - 2000 eV
- moderate resolution 10.000 (@500 eV)
- polarization linear/elliptical
- higher order light suppression
- low divergence, small spot size

## Reflectometry

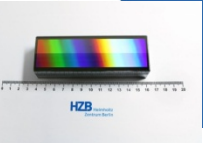
- „at-wavelength“ metrology
- quality control
- in-house R&D
- user operation
- short-term access



**SX-700 Monochromator of 1981**

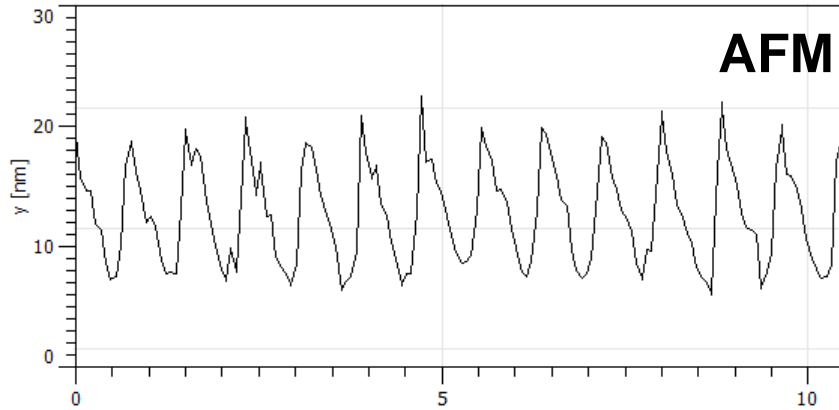
**Replacement of the 33 years old gratings by new ones**



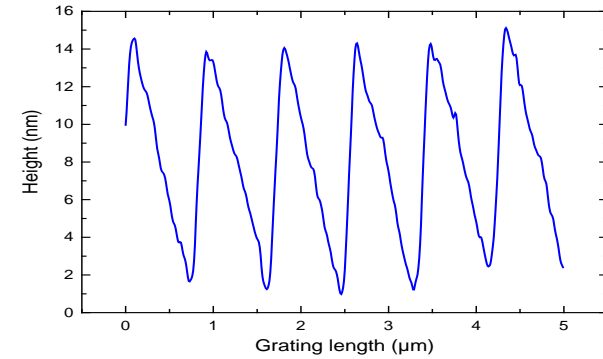


# Grating performance

old grating 1200 l/mm

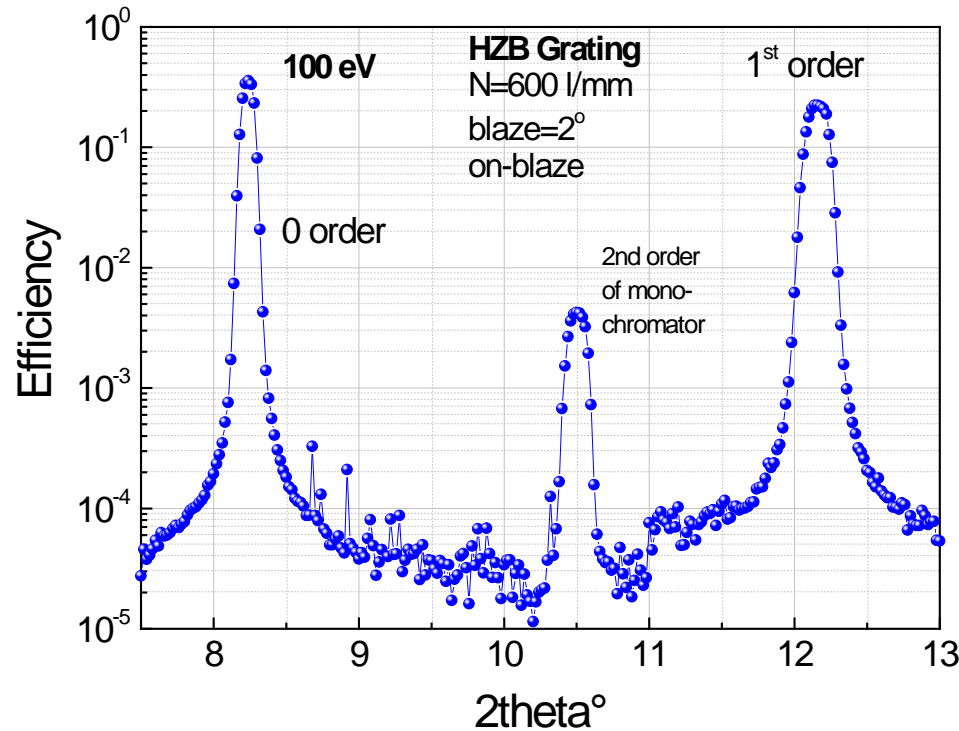


new HZB-grating 1200 l/mm

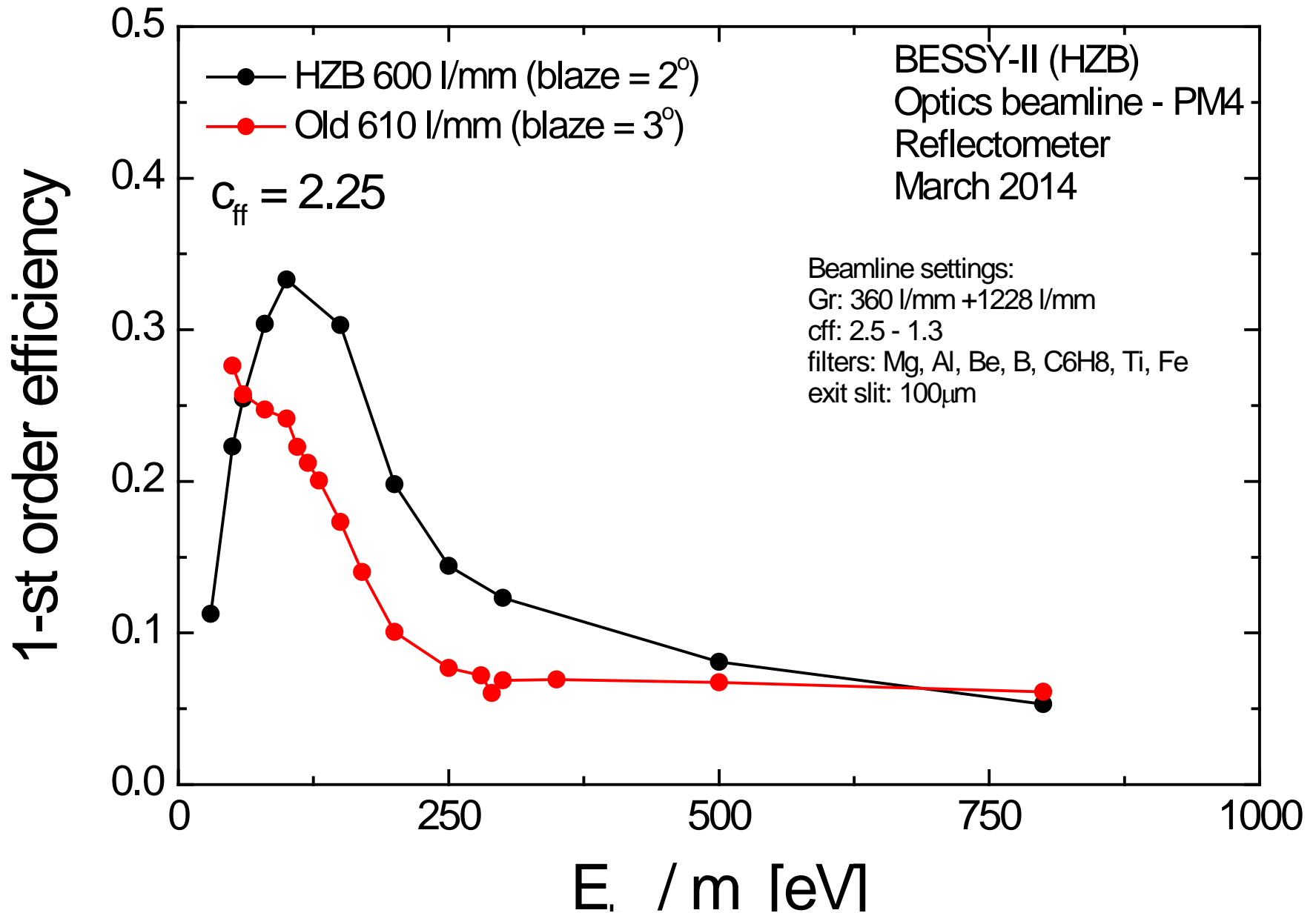


$$\Theta_{\text{blaze}} = 1.1^\circ$$

$$\sigma = 0.3 \text{ nm rms}$$

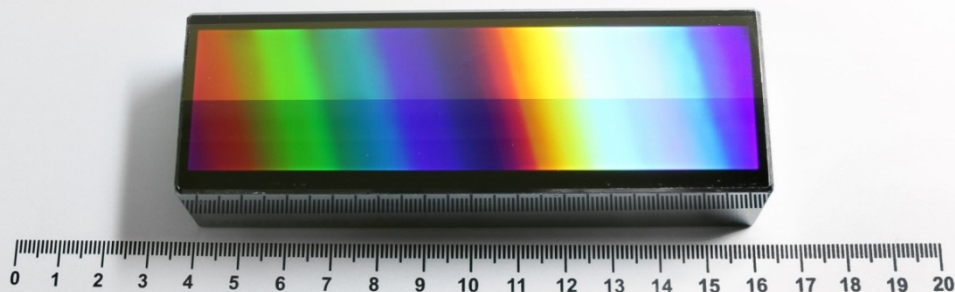


# 600 l/mm – old / new

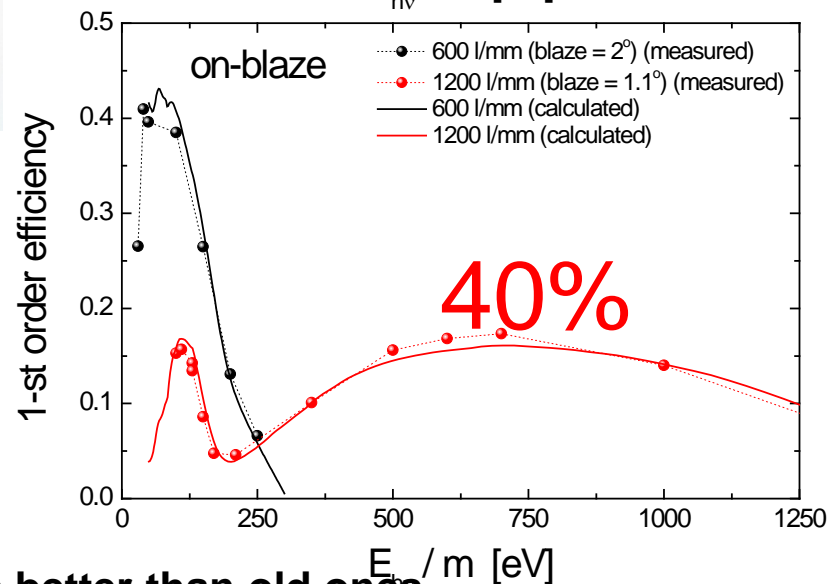
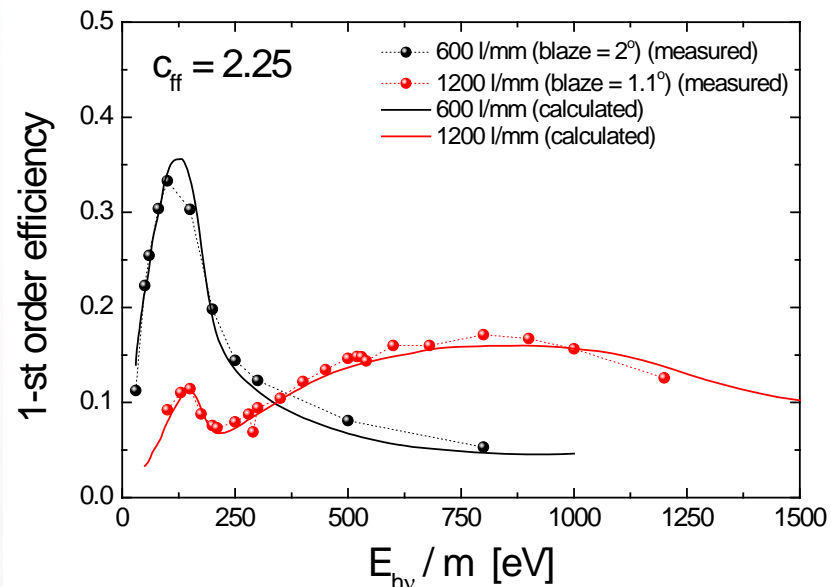


# Metrology on a blazed grating: efficiency

## Technology Center for Precision Optical Gratings (HZB)



**HZB** Helmholtz  
Zentrum Berlin

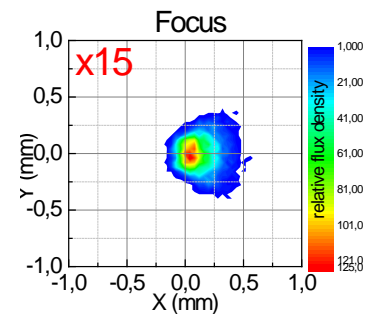
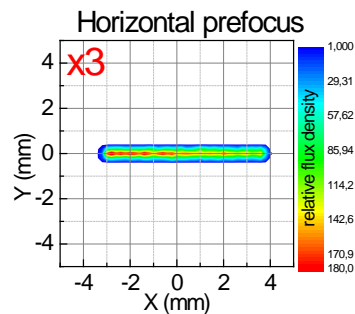
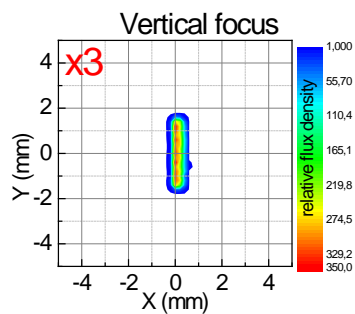
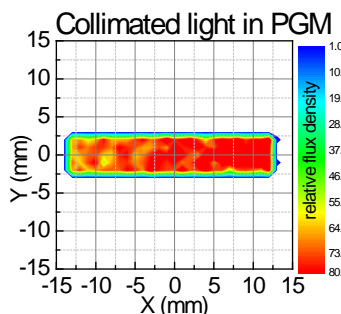
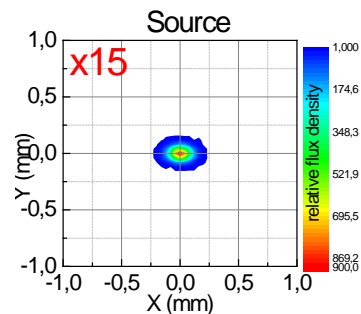
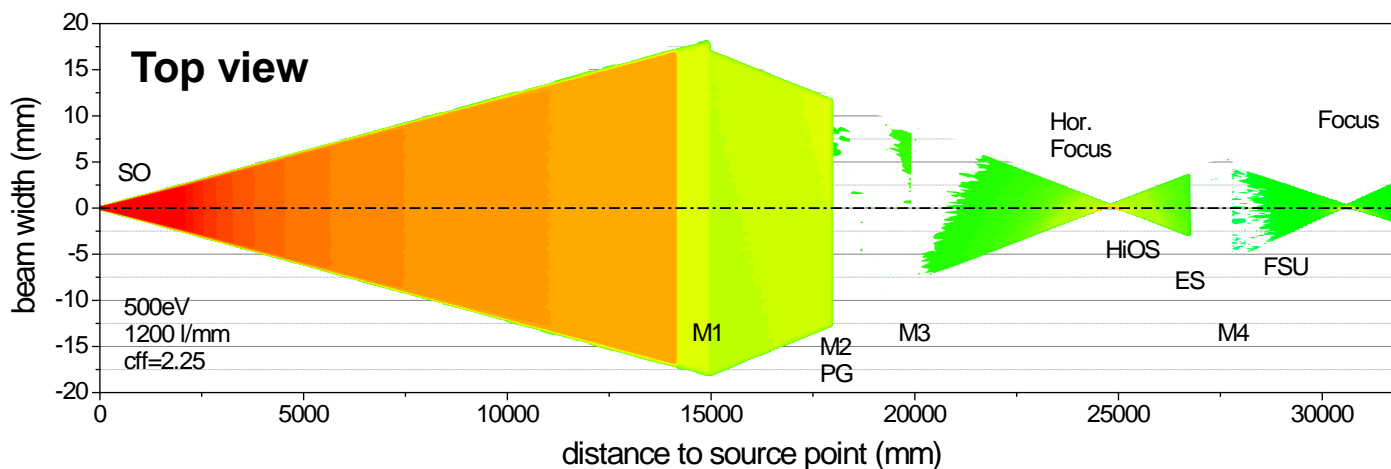
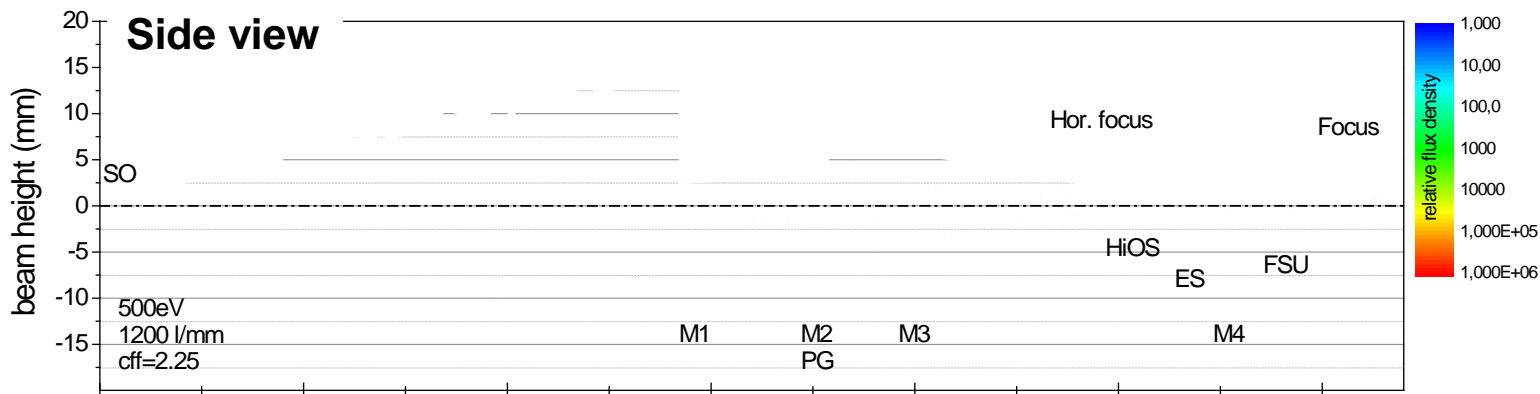


Line density	600 l/mm	1200 l/mm
Blaze angle	2.0°	1.1°
$\sigma$ rms	0.6 nm	0.3 nm
Au-Coating	40 nm	40 nm

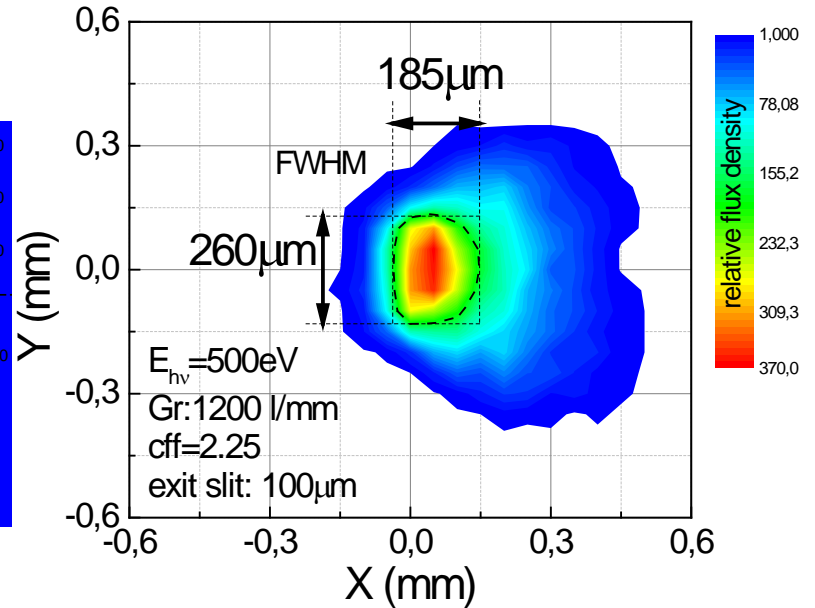
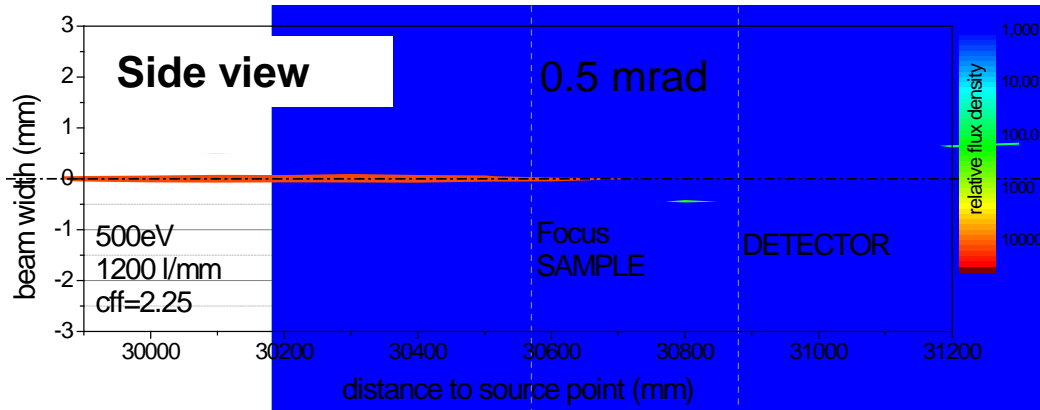
- HZB-grating production is well established now

- gratings are better than old ones (blazeangle, roughness, efficiency, straylight)

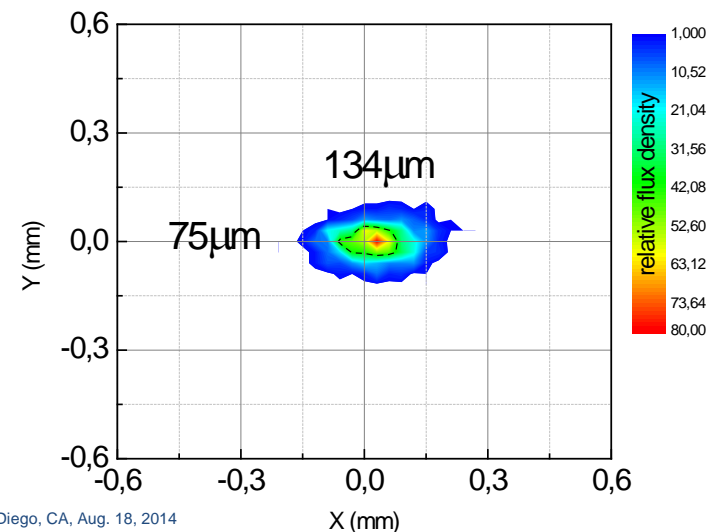
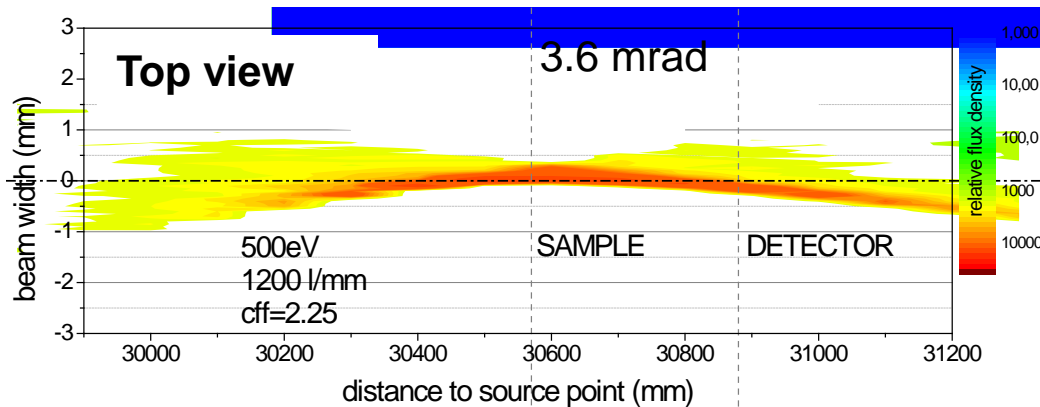
# Beam size and divergence



# Beam size and divergence at the sample



Can be steered by apertures and exit slit

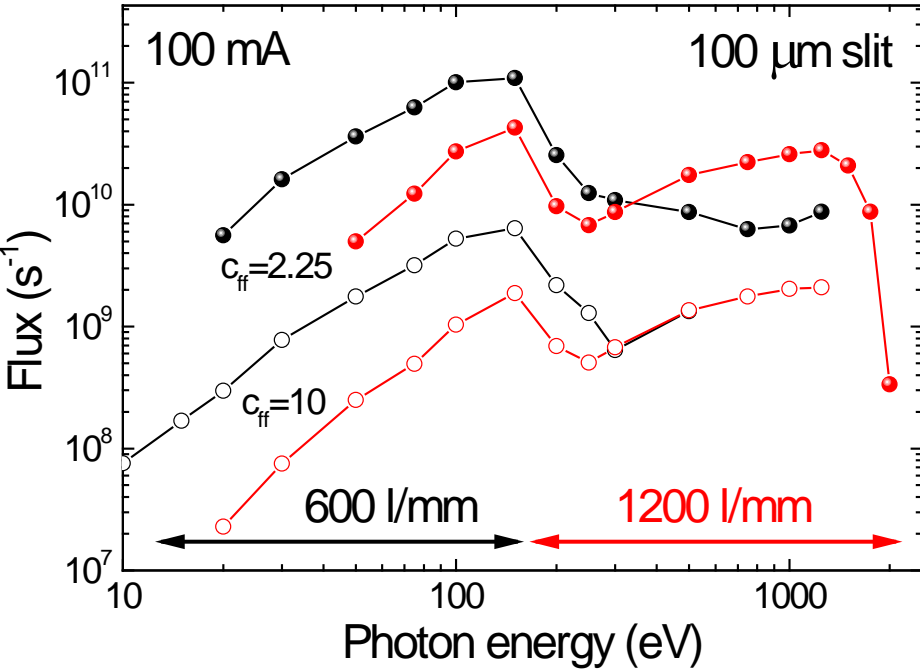


calculated with RAY

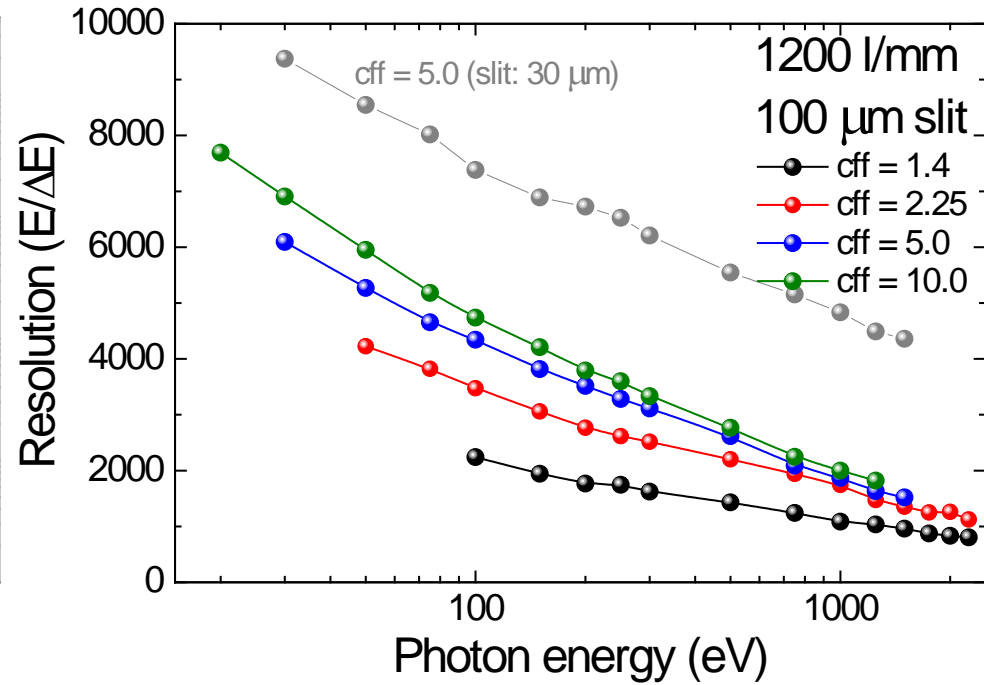


# Flux and resolution

$10^{10} - 10^{11}$  photons/s/100 mA



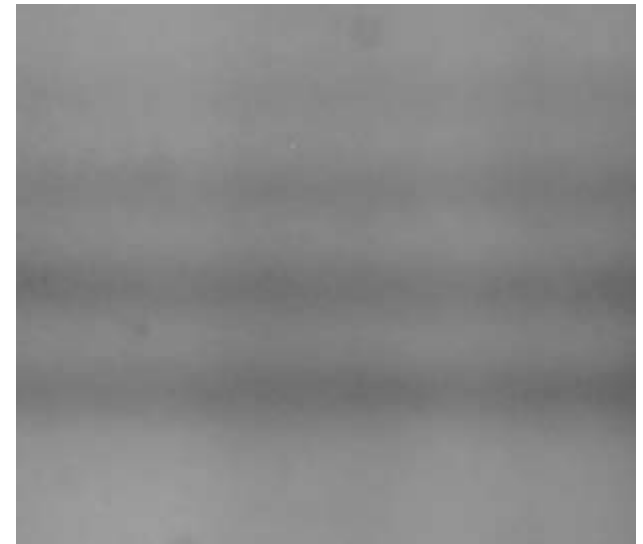
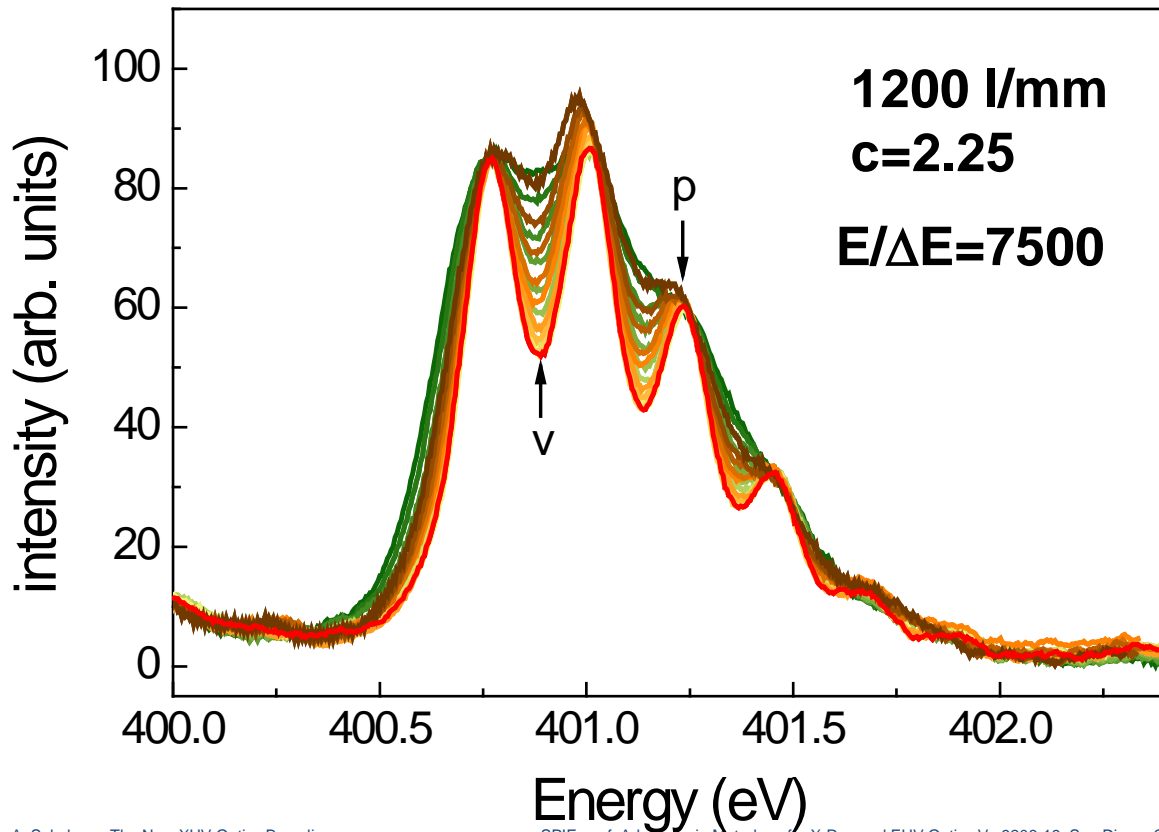
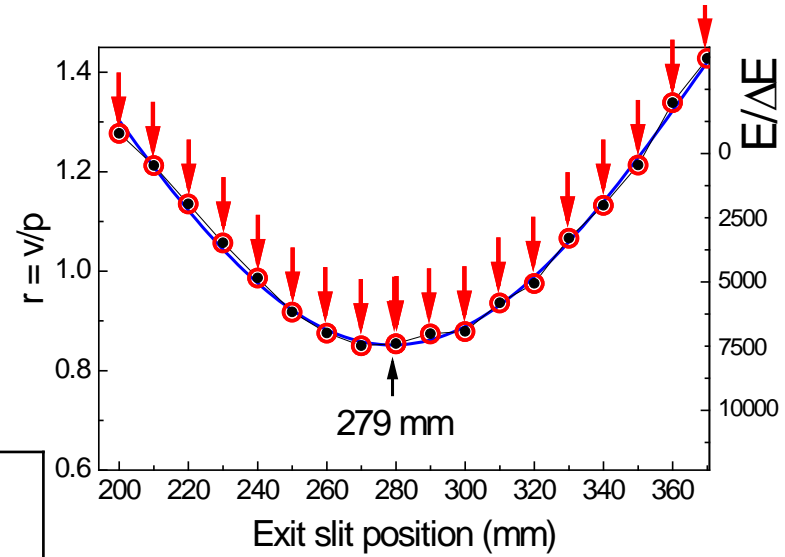
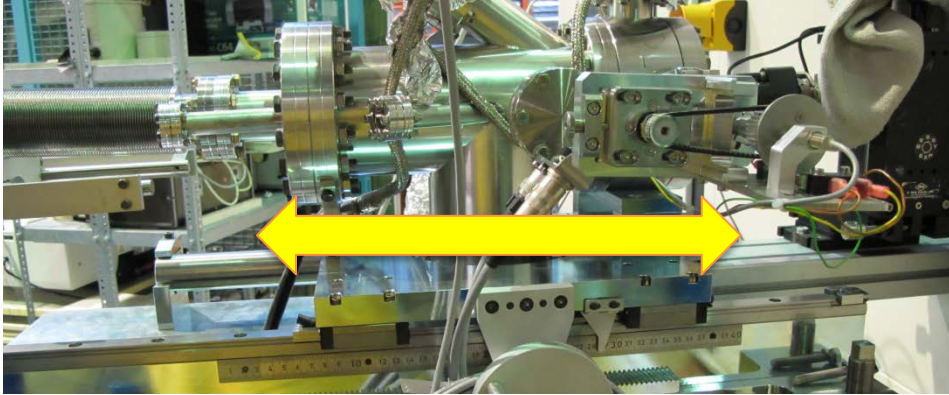
$E/\Delta E=1.000 - 10.000$



Calculations with RAY

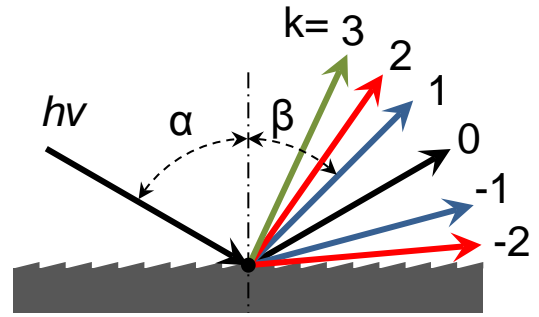


# Energy resolution @ Nitrogen k-edge



# The famous c-factor

$$Nk\lambda = \sin(\alpha) - \sin(\beta)$$



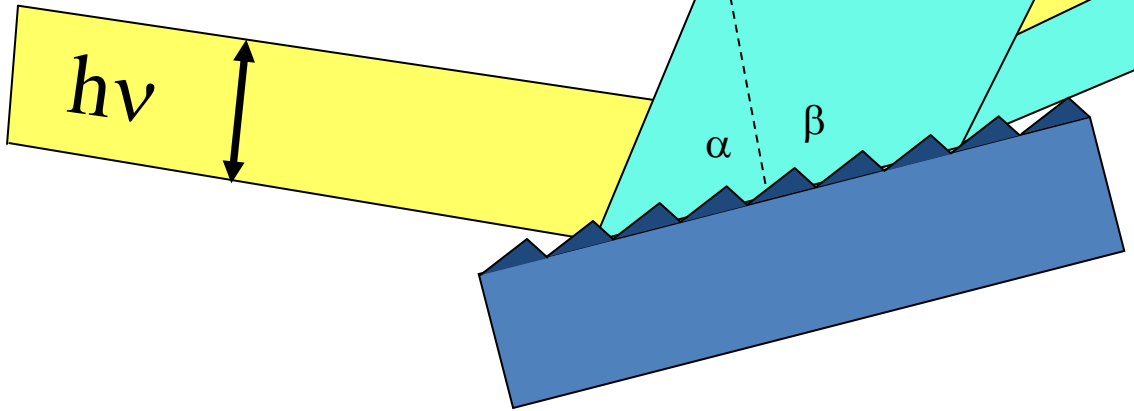
$c > 1$ , inside order,  $n > 0$

$c = 1$  (0-th order)

$c < 1$ , outside order,  $n < 0$

**H. Petersen 1982:**

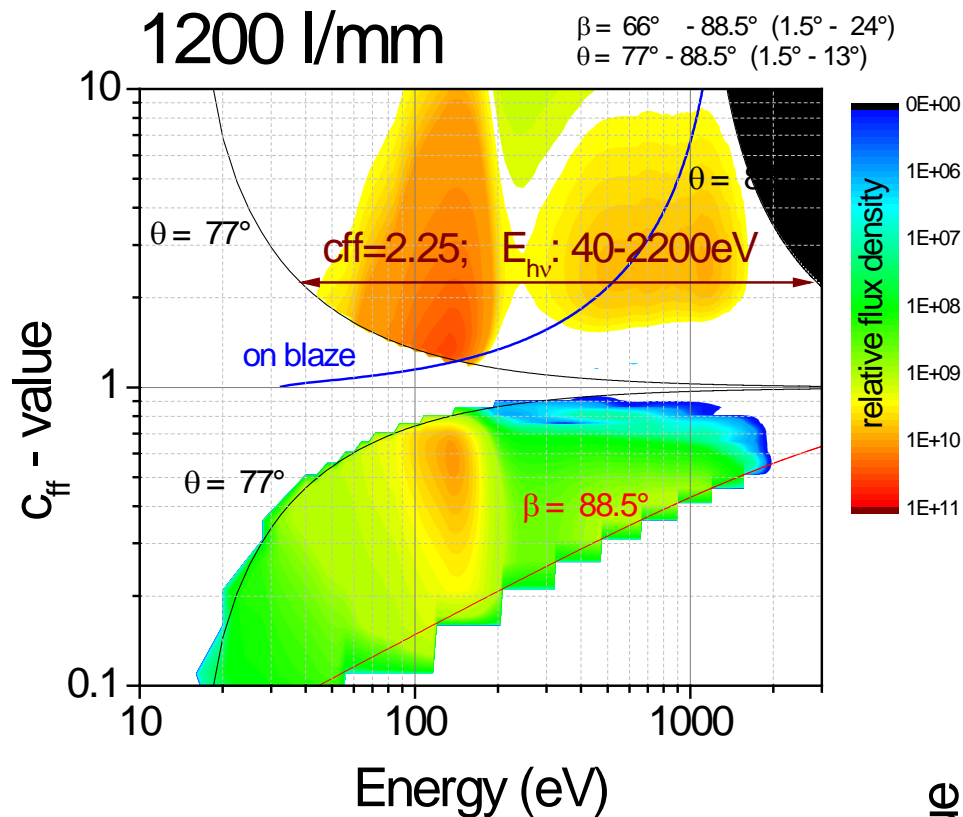
$$c_{ff} = \cos\beta / \cos\alpha$$



**c: magnification**

(asymmetric crystals: b)

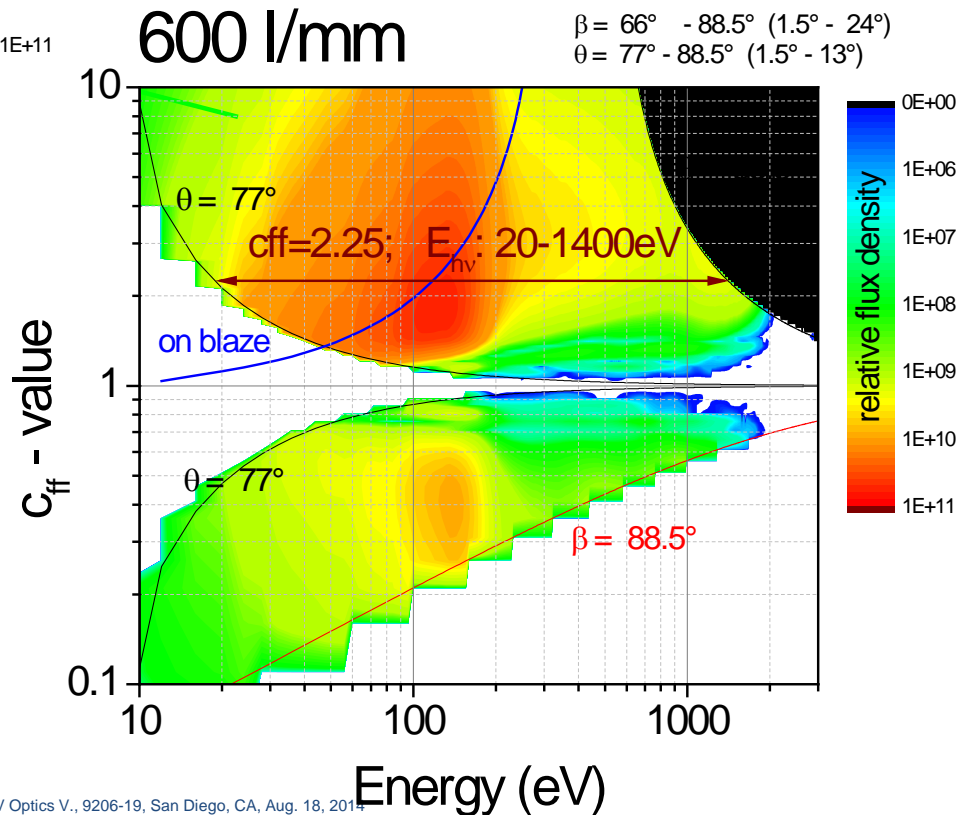
# Working energy range



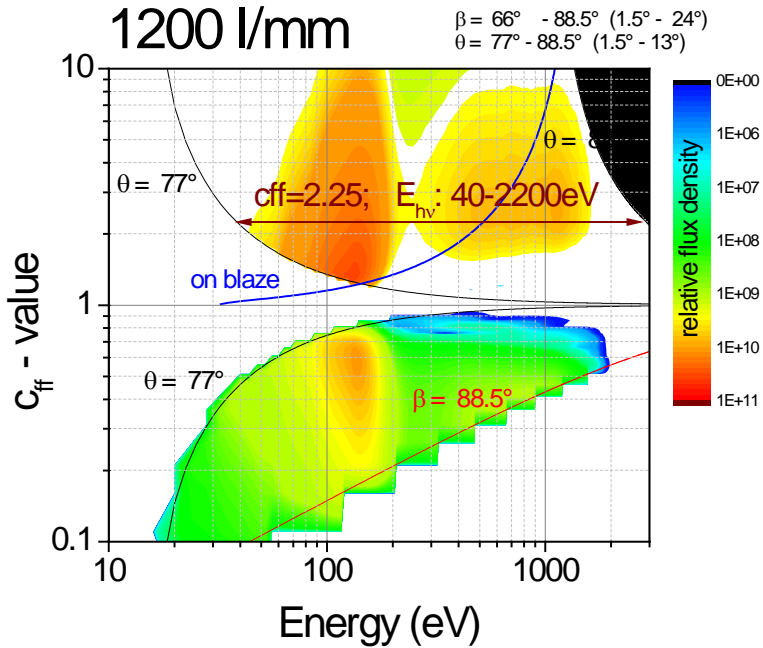
Wide energy range:  
10 eV – 2200 eV

Calculations with REFLEC

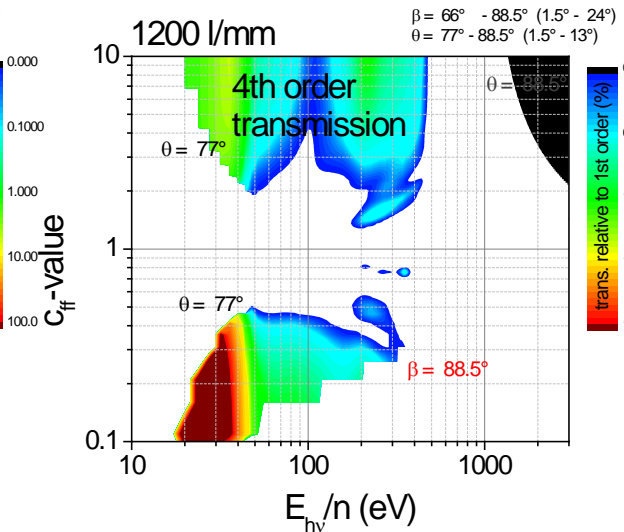
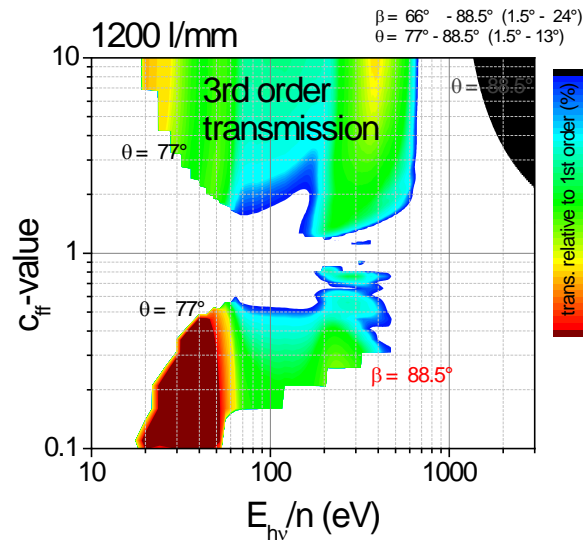
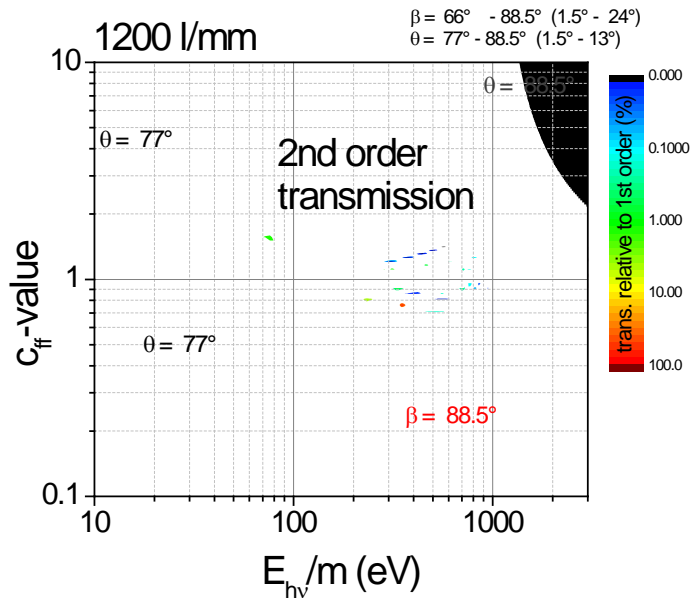
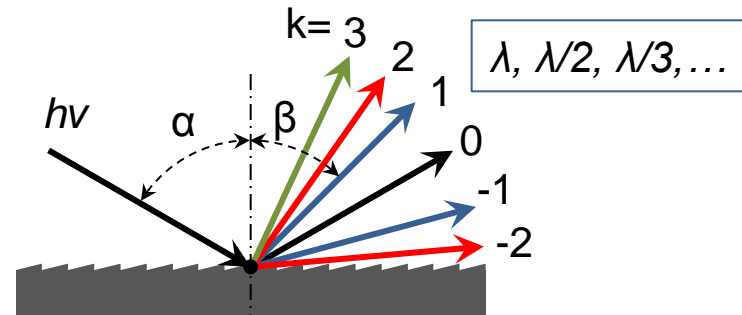
SX700 ZEISS monochromator  
Gratings: **1200 l/mm** and **600 l/mm**



# Higher order transmission



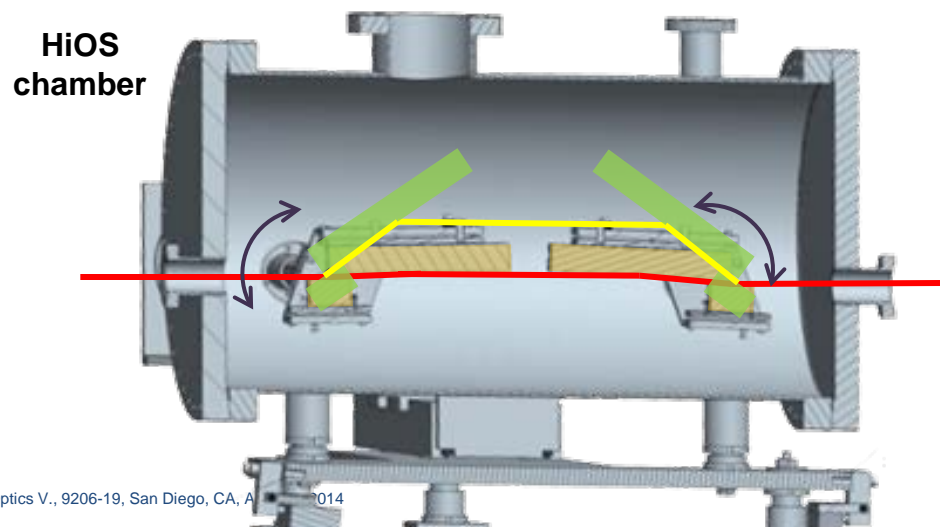
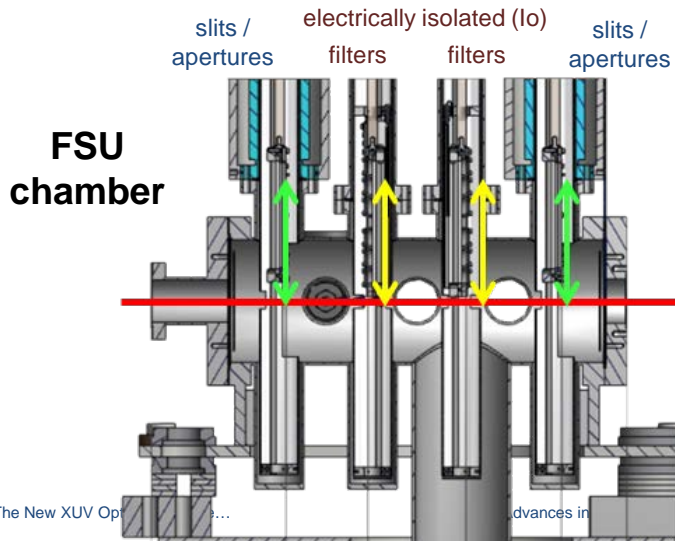
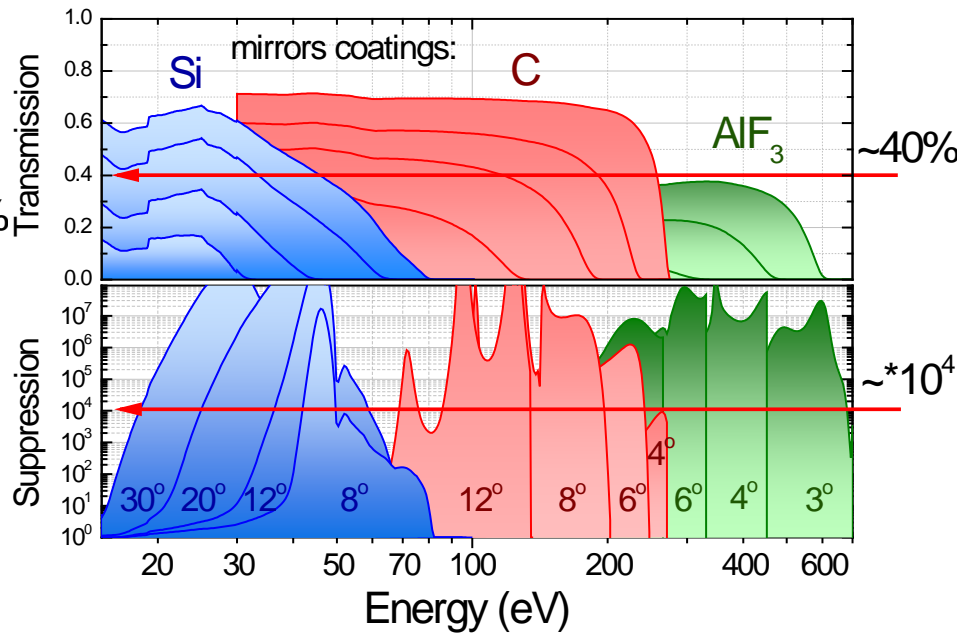
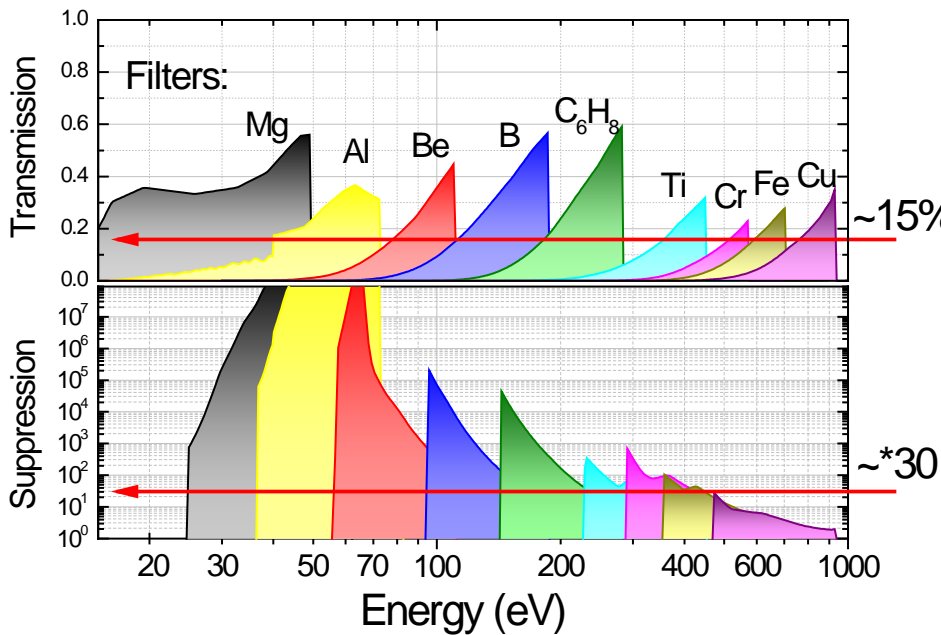
$$Nk\lambda = \sin(\alpha) - \sin(\beta)$$



# Higher order suppression

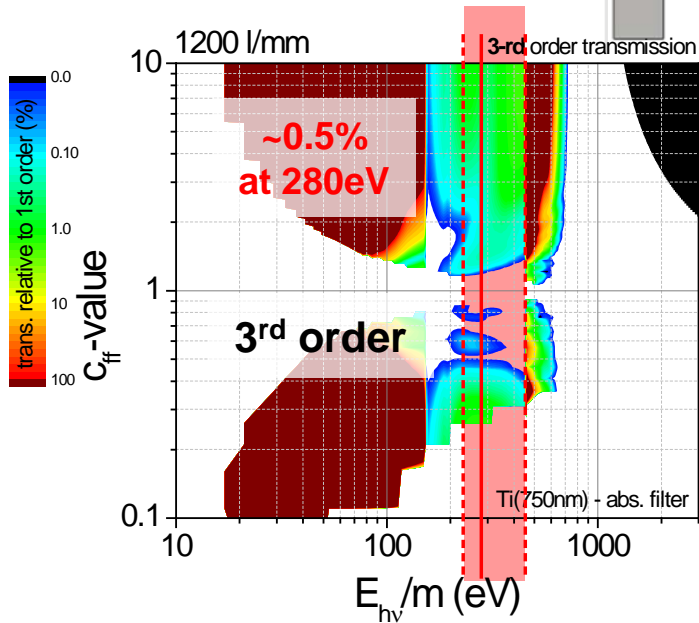
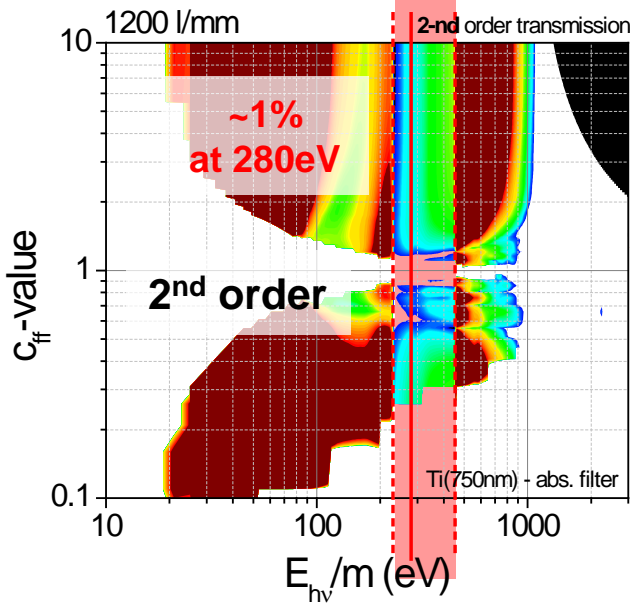
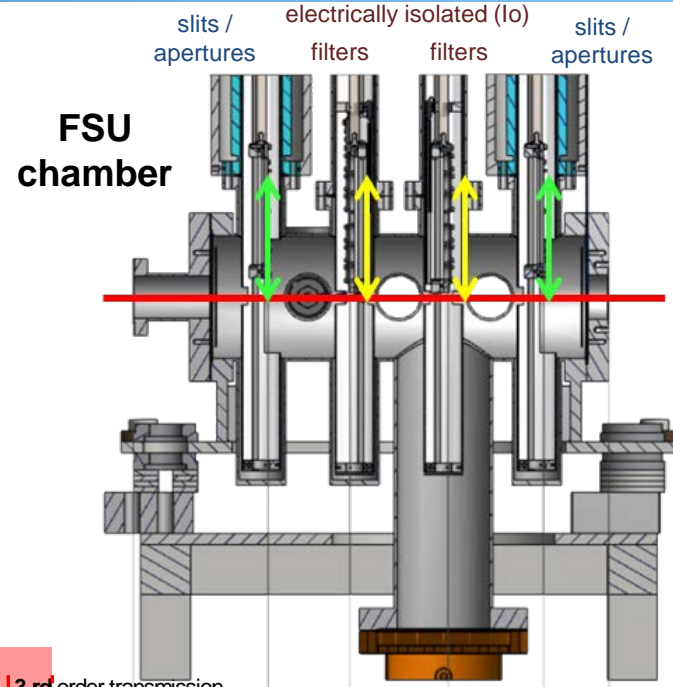
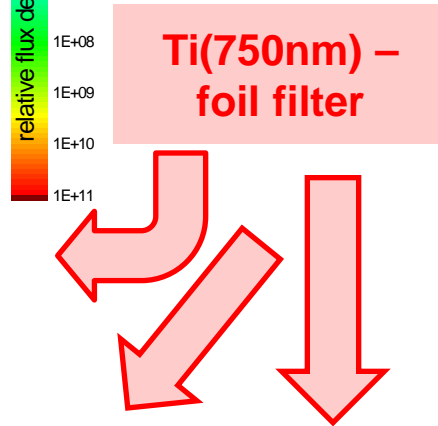
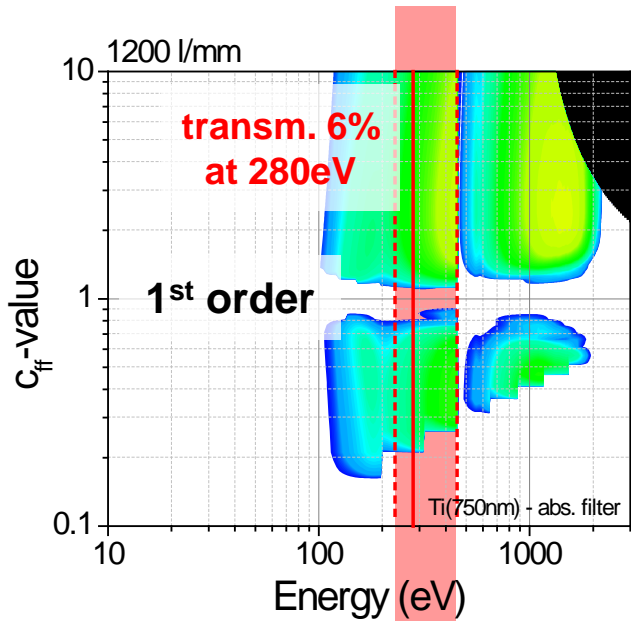
Set of 12 absorption filters

4-mirror system

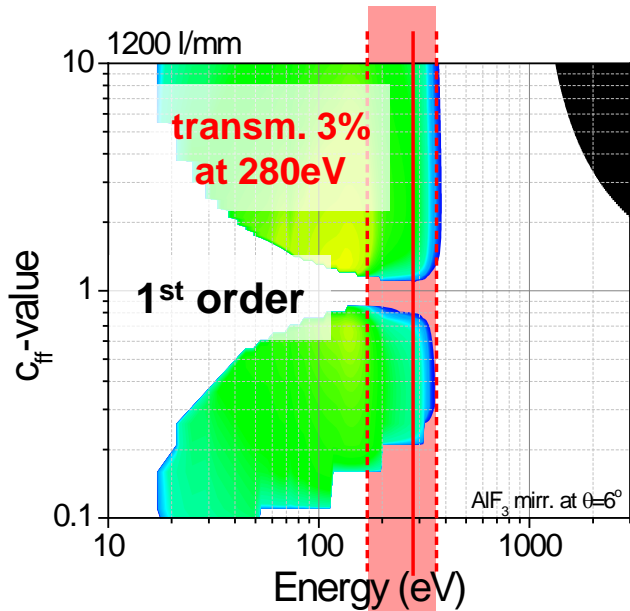




# Higher order suppression for 280 eV using Ti - absorption filter

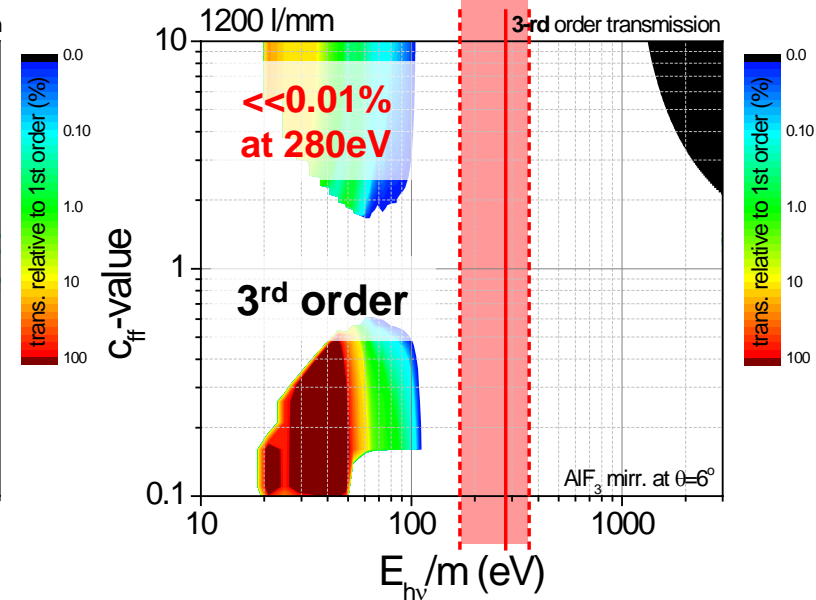
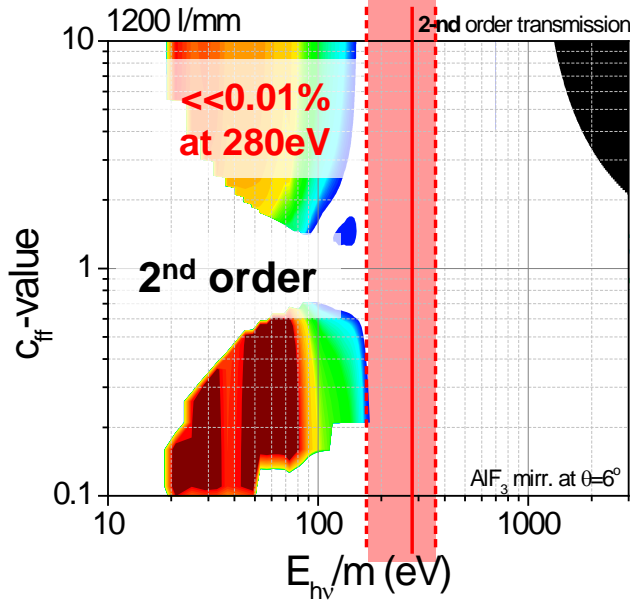
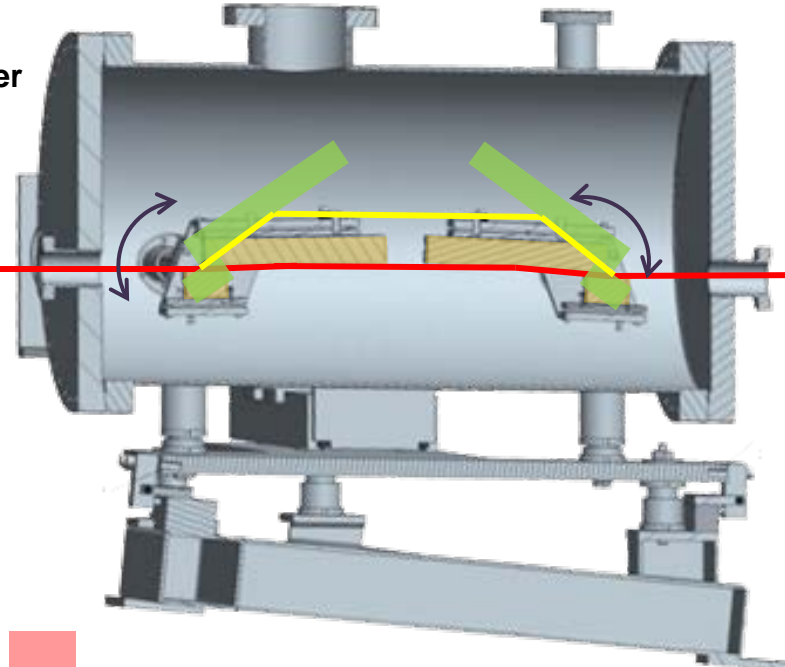


# Higher order suppression for 280eV using HiOS



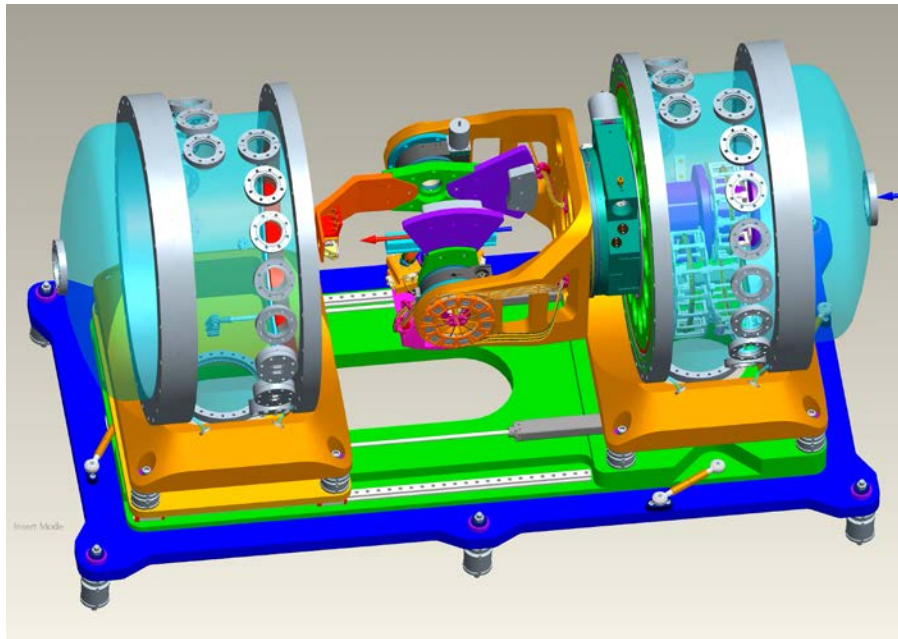
HiOS chamber

AIF<sub>3</sub> coated mirrors at  $\theta=6^\circ$



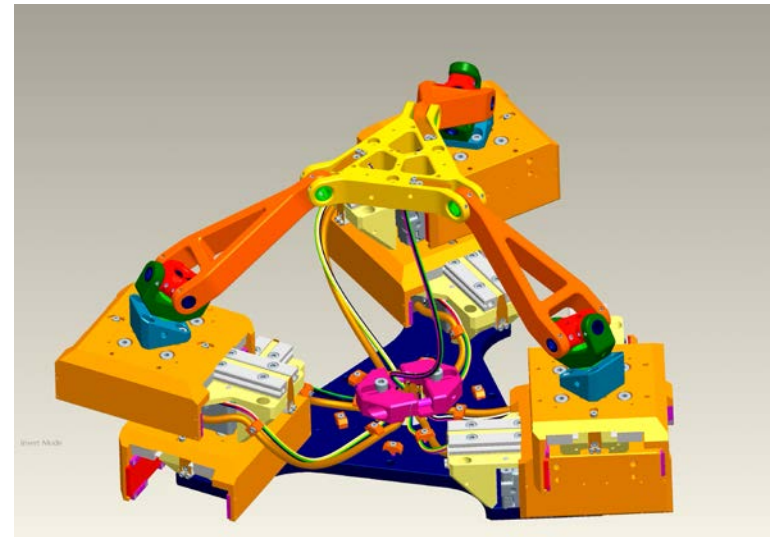


# The endstation: Four circle – six axes UHV-Reflectometer



- Azimuthal 360° rotation: Rs and Rp
- Wide angular range:  $\theta = 0^\circ - \sim 90^\circ$
- Different detectors: photodiodes, channeltron, Kerr (polarisation), ...
- Load-lock for samples:  $< 50 \times 50 \times 10 \text{ mm}^3$

## Tripod unit for sample adjustment



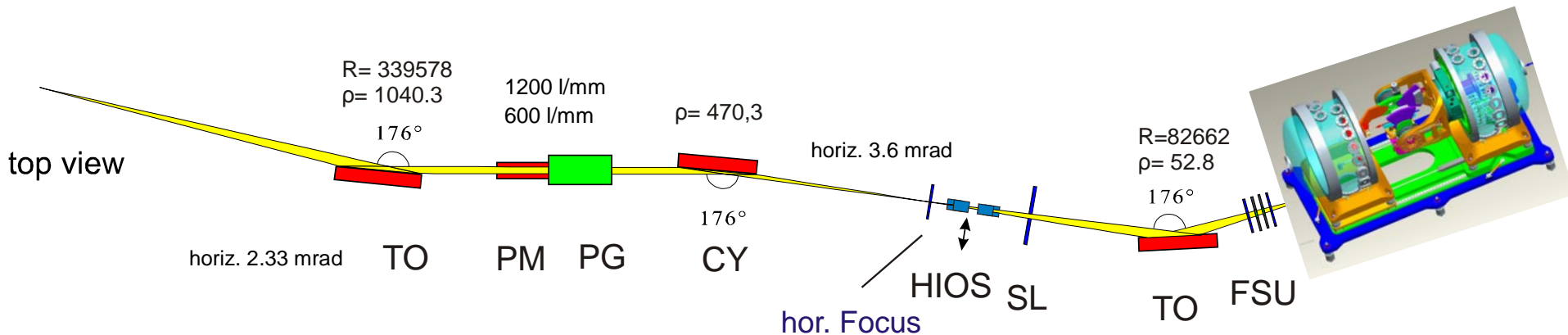
- Six degrees of freedom
- Sample weight: 4 kg
- Sample size:  $300 \times 60 \times 60 \text{ mm}^3$
- Motor resolution: 100 nm / 0.001°
- Max. scan range +/- 15 mm

**Pointing stability: 10  $\mu\text{m}$  / 0.01°**

# Conclusion

- HZB grating production facility is successfully operating
- HZB grating in-situ metrology facility is close to operation
- Attractive XUV Optics Beamline at BESSY-II
- At-wavelength metrology (quality control) of XUV-optics
- Suited for large scale samples
- Measurements at short-term request
- Non-destructive investigation and characterization
- In depth analysis of materials and buried interfaces

**The setup will be open for user operation to the end 2014**



Thank you for attention!