HZB Helmholtz Zentrum Berlin

Rolf Follath

RIXS spectrometer designs

- VLS Spectrometer
- Plane Grating Spectrometer

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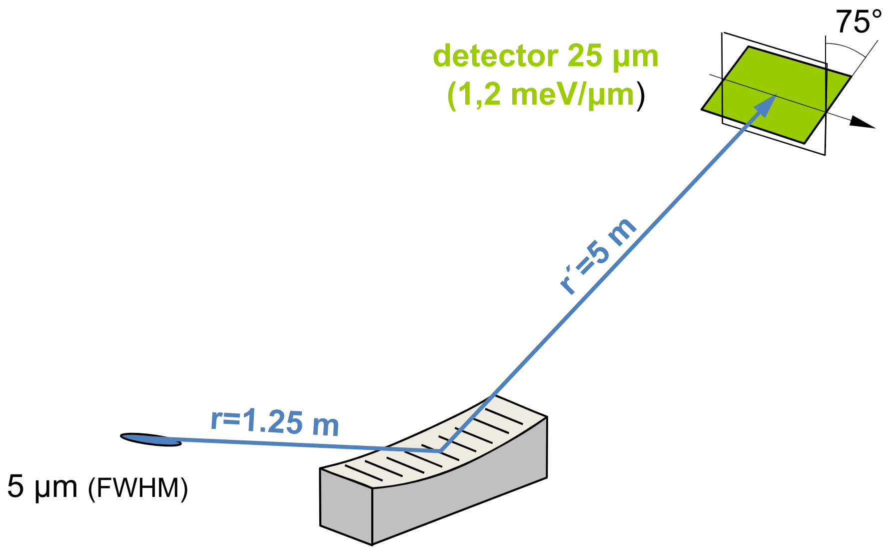
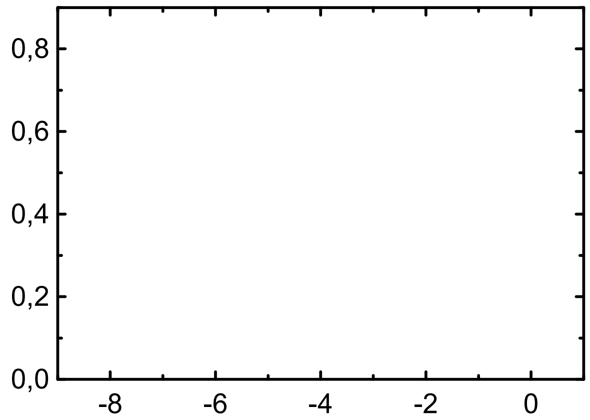
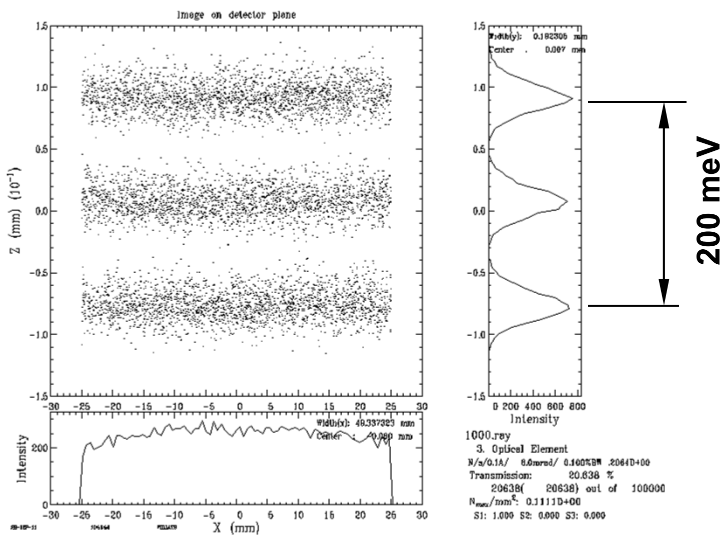
VLS-Spectrometer





R_G = 108 m, L=150 mm
N = 3200 l/mm
v_1 = 2.29e-4 1/mm,
v_2 = 2.07e-8 1/mm^2
σ = 0.25 µrad



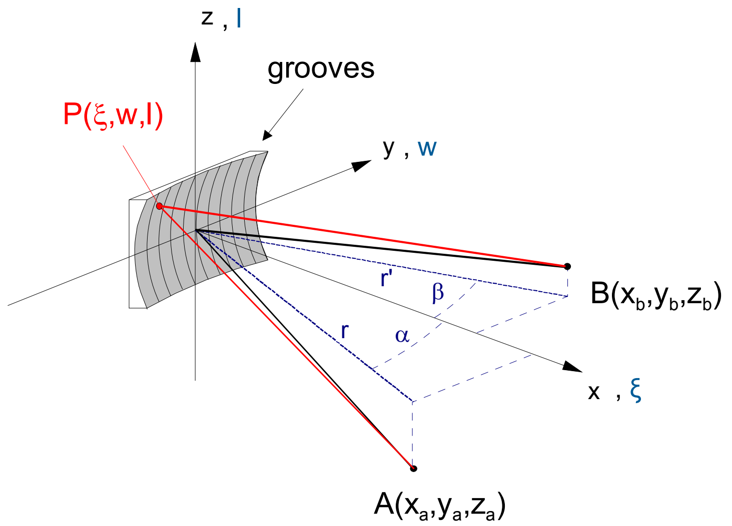
Acceptance : detector x 2 mrad^2

Calculations for detector width of 50 mm

Resolution ≈ 30 meV @ 1000 eV

Design follows SAXES spectrometer at SLS, G. Ghiringelli, Rev. Sci. Instrum. **77**,113108 (2006)

Path function



R: Radius of curvature
r: distance source to grating
r‘: distance grating to detector
α: incident angle
β: diffraction angle

Optical Path function

$$F = \overline{AP} + \overline{PB} + N(w) \cdot \lambda$$

$N(w)$: Number of lines between 0 and w

Taylor expansion of F in the coordinates of the grating surface w,l

$$F = F_{00} + F_{10} w + \tfrac{1}{2} F_{20} w^2 + \tfrac{1}{2} F_{02} l^2 + \tfrac{1}{2} F_{30} w^3 + \tfrac{1}{2} F_{12} w l^2 + \ldots$$

VLS operation parameter

For spherical gratings with variable line separation $d(w) = d_0\left(1 + \upsilon_1 \cdot w + \upsilon_2 \cdot w^2 + \upsilon_3 \cdot w^3 + \dots\right)$

$$F_{10} = m\frac{\lambda}{d_0} - (\sin\alpha + \sin\beta)$$ grating equation

$$F_{20} = \left(\frac{\cos^2\alpha}{r} - \frac{\cos\alpha}{R}\right) + \left(\frac{\cos^2\beta}{r'} - \frac{\cos\beta}{R}\right) - \upsilon_1 m\frac{\lambda}{d_0}$$ meridional focus (xy-plane)

$$F_{30} = \left(\frac{\cos^2\alpha}{r} - \frac{\cos\alpha}{R}\right)\frac{\sin\alpha}{r} + \left(\frac{\cos^2\beta}{r'} - \frac{\cos\beta}{R}\right)\frac{\sin\beta}{r'} + \frac{2}{3}\left(\upsilon_1^2 - \upsilon_2\right) m\frac{\lambda}{d_0}$$ coma

Three conditions to fulfill,

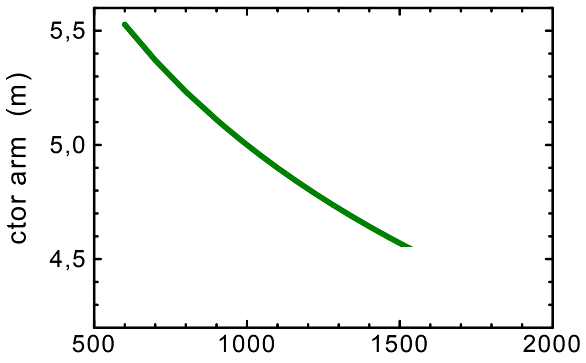
Use two angles **α,β** and **r‘**, the distance betwen grating and detector

Detector angle

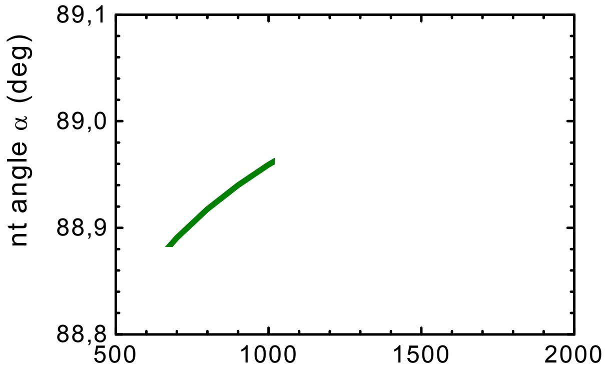
$$\tan\phi = \frac{\cos\beta}{r'\left(\frac{\tan\beta}{R} - \upsilon_1\right) - 2\sin\beta}$$

VLS system settings for α,β, r‘

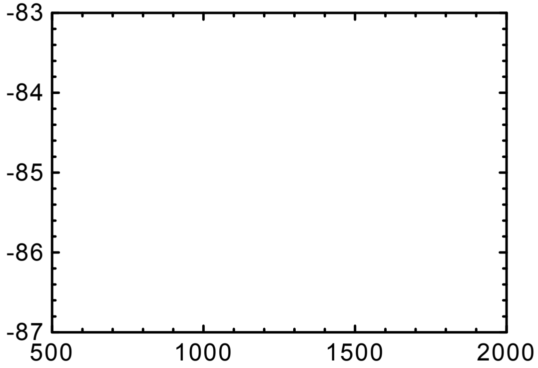
detector arm



entrance angle α

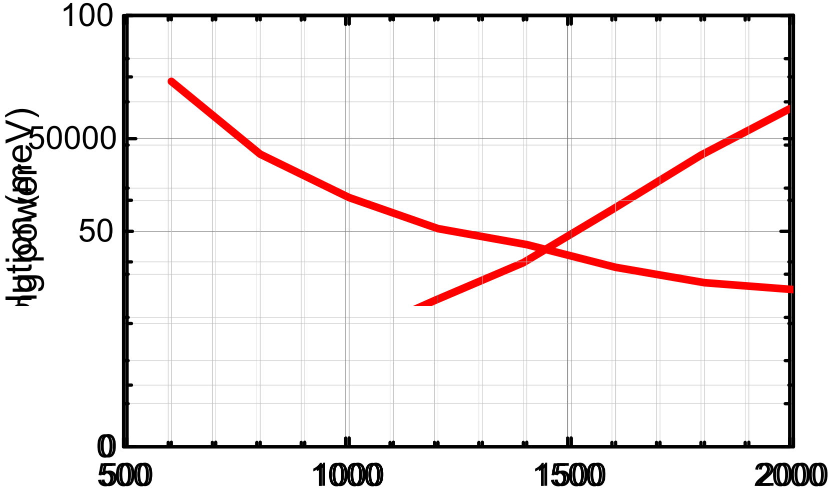


diffraction angle

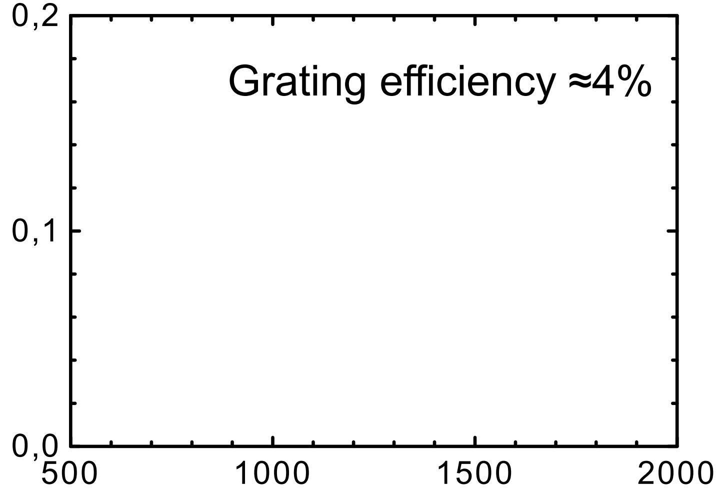


Detector position variation : hor: **1 m**, vert**. 0,8 m**

VLS performance



Effective vert.. acceptance



Hor. acceptance determined by detector

Add horizontally collecting mirror or use grating to focus sagittally

VLS tolerances

Contributions to energy resolution

Energy	**1000 eV**		**(600+10) eV**	
Abberations	1,8 meV	✓	4.4 meV	✓
Slope errors	17 meV		8.3 meV	
Source size	19 meV		8.4 meV	
Total	**26 meV**		**11 meV**	

Limited by source and slope errors

Alignment:

Detector position	+/- 2 mm	30 meV	15 meV
	+/- 4 mm	46 meV	24 meV
Source distance	+/- 2 mm	26 meV	12 meV
	+/- 4 mm	34 meV	16 meV

Alignment on the mm-scale

VLS tolerances

Contributions to spot size on detector

Energy	**1000 eV**	**(600+10) eV**
Abberations	0.4 µm ✓	6 µm ✓
Slope errors	3.7 µm	11.2 µm
Source size	4.2 µm	11.4 µm
Total	**5.6 µm**	**15 µm**

Limited by source and slope errors

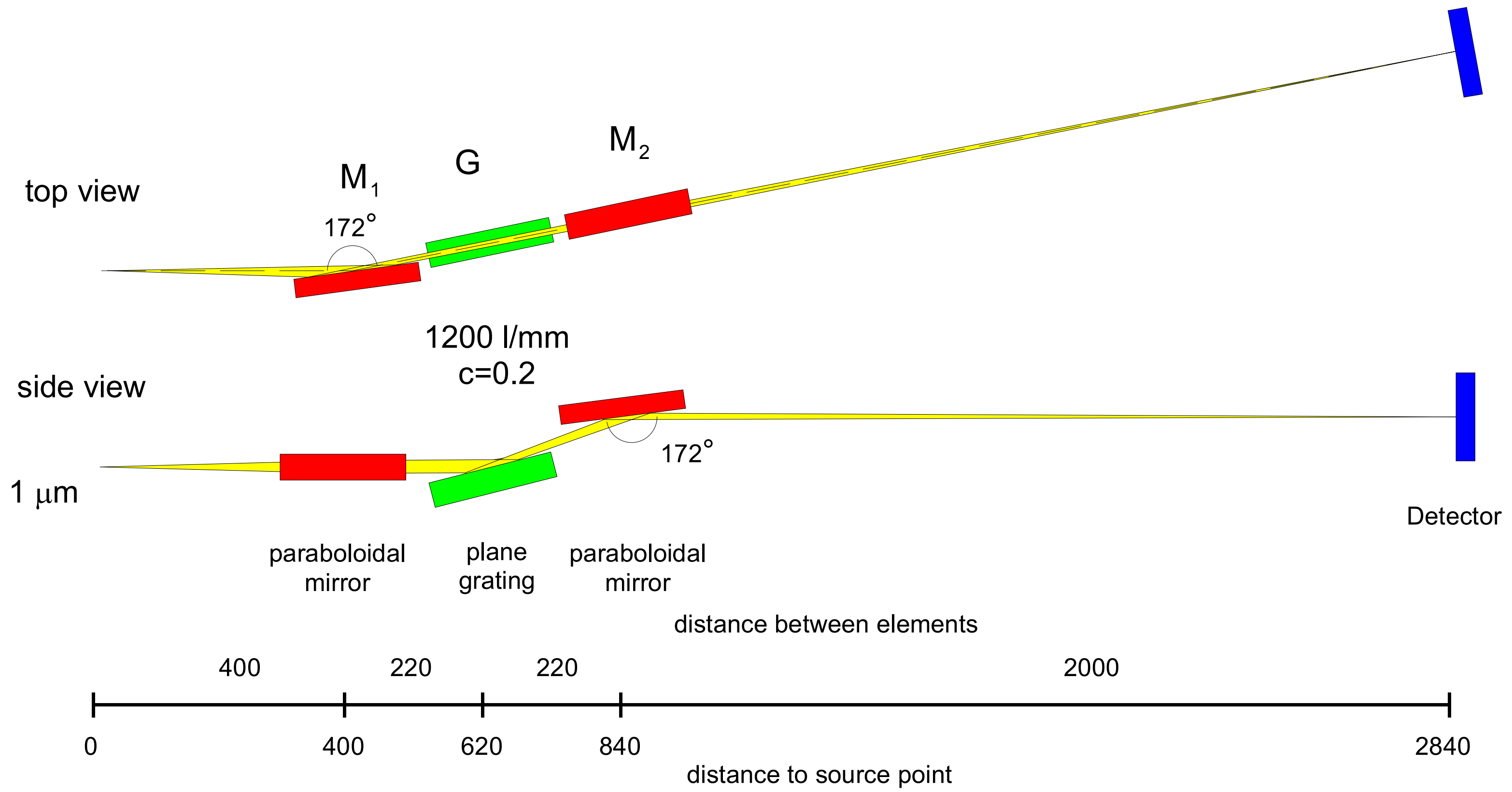
Alignment:		
Detector position +/- 2 mm	6.4 µm	20 µm
+/- 4 mm	10 µm	32 µm
Source distance +/- 2 mm	5.7 µm	16 µm
+/- 4 mm	7.4 µm	22 µm

Alignment on the mm-scale

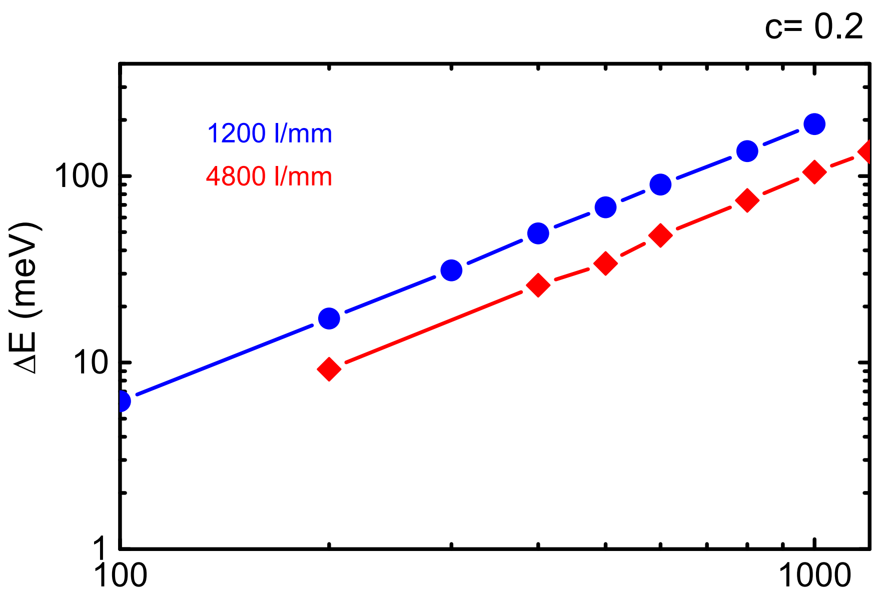
Plane Grating Spectrometer for UE49-SGM at BESSY II

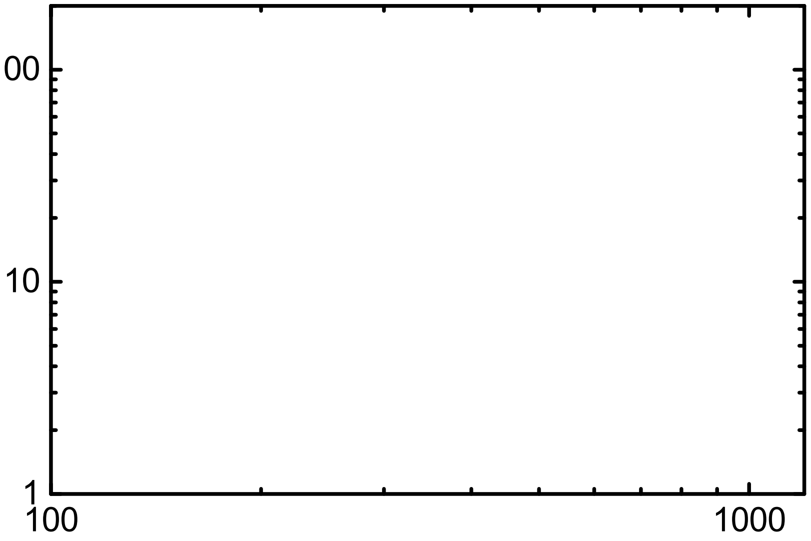
Following an instrument designe by J.Nordgren group*

Modified design for BESSY II



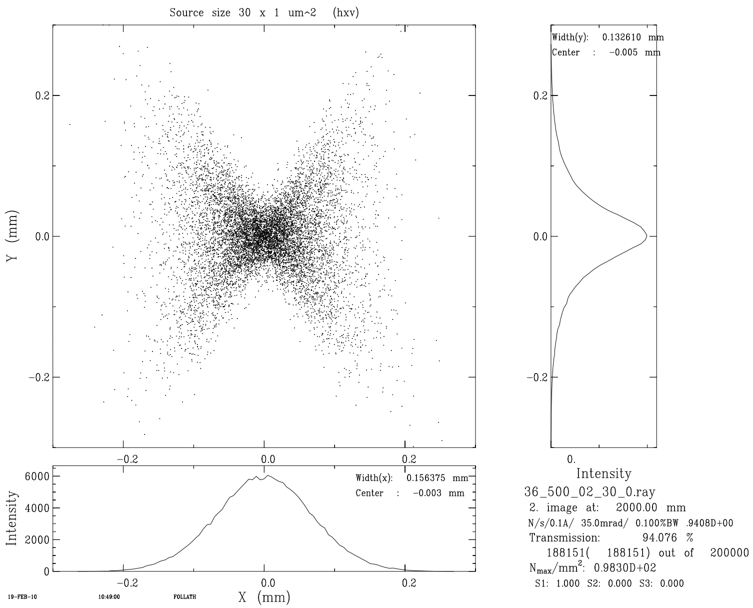
* M. Agaker:Nucl. Instrum. and Methods, A **601** 213 (2009)

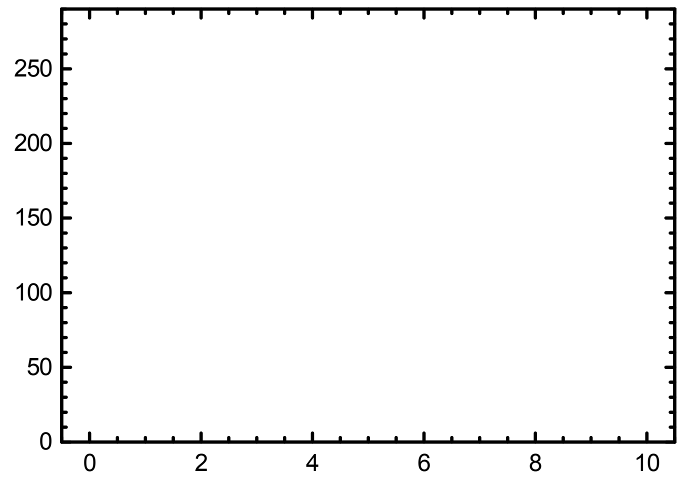


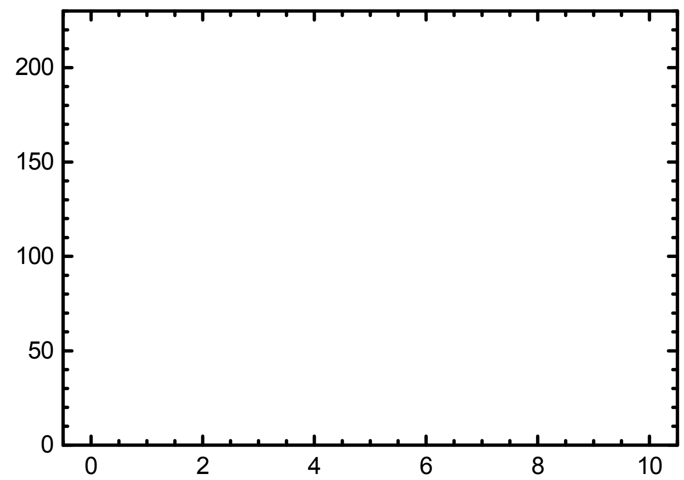


- Effective transmission = Transmission • Geometrical Acceptance
  - Transmission includes reflectance and grating efficiency
  - Geometrical acceptance: 35 mrad x 40 mrad
- Slope errors included
- Source size 1 μm (achieved in Oct. 2011)

Image for source size of 30 x 1 µm

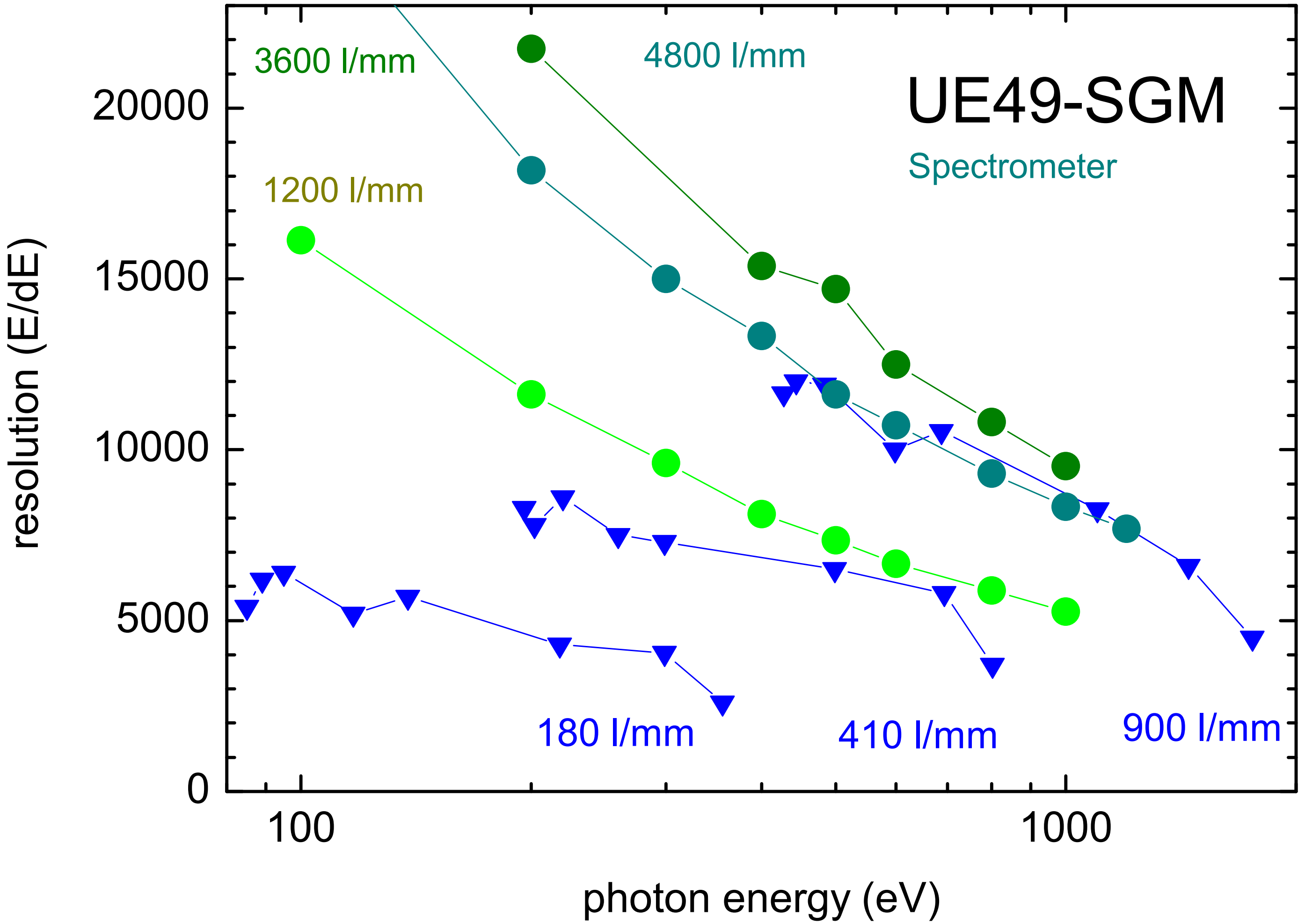






Center part has better resolution
=> apertures?

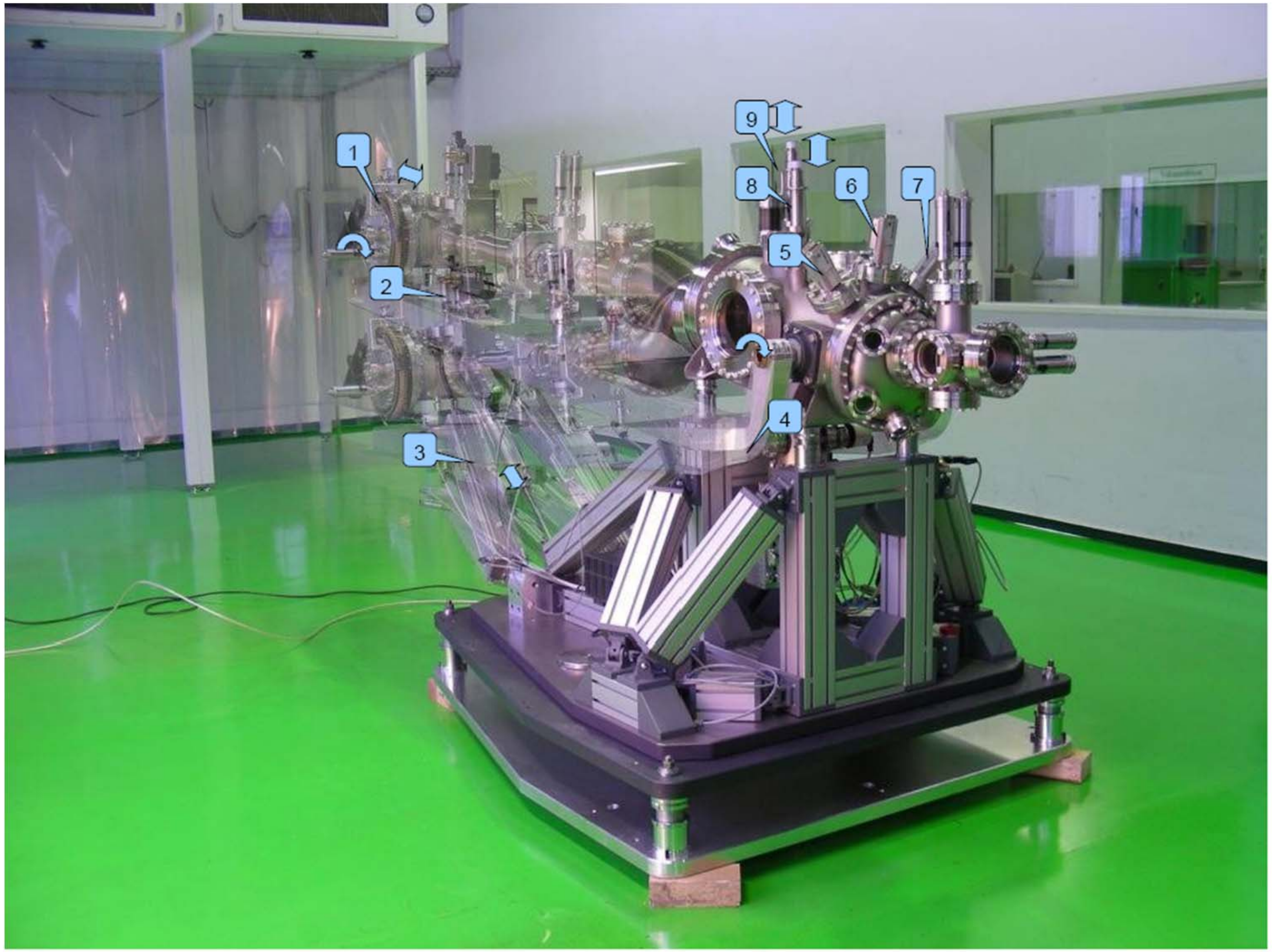
Resolving power Beamline vs. spectromer



▼Beamline
●Fluorescencespectrometer

Beamline in commissioning

mechanic



Thank You