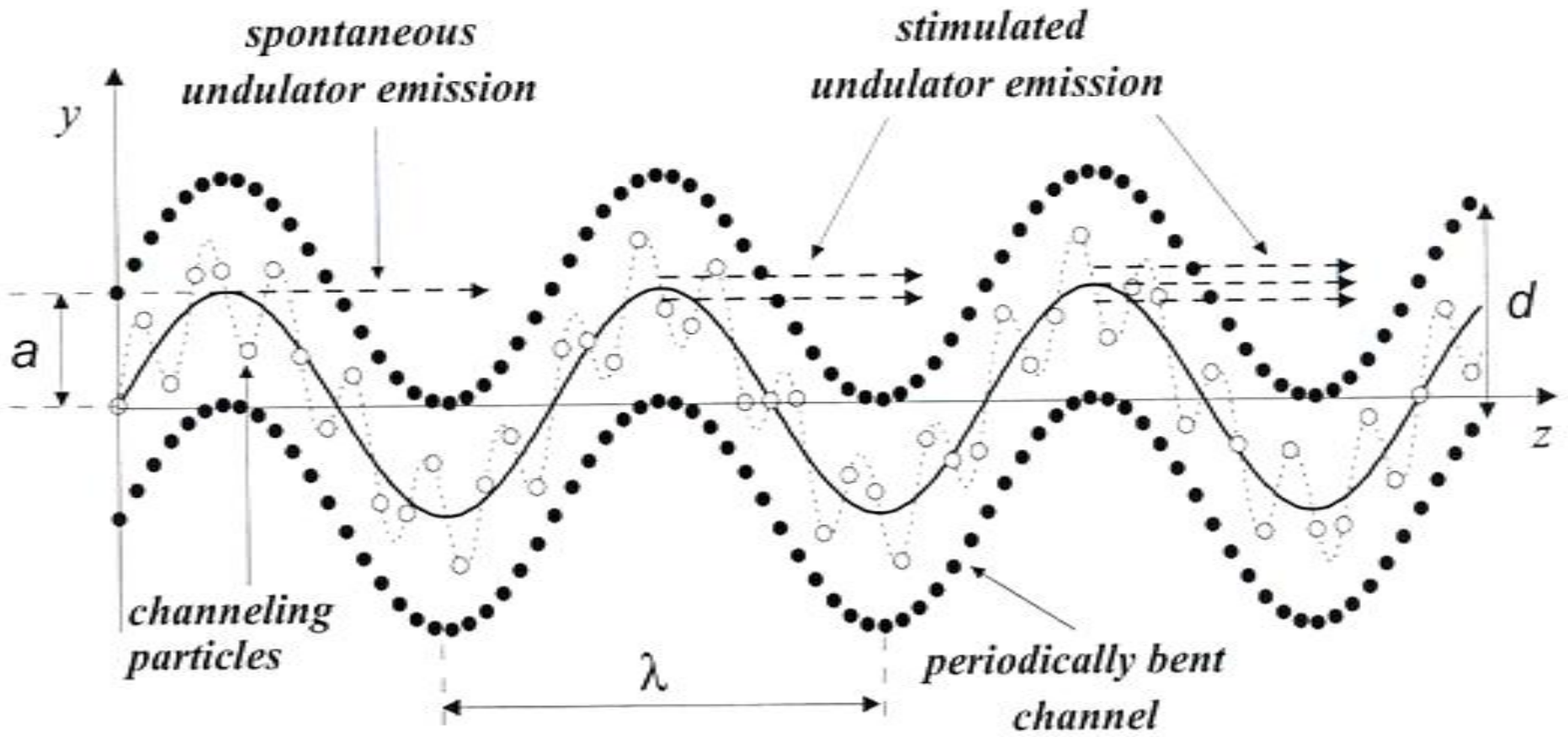
Channeling Experiments with Electrons at the Mainz Microtron MAMI

1. Motivation
2. Channeling Experiments with Positrons @BTF Frascati
3. Channeling Experiments with Electrons @MAMI Mainz
4. Measurements of the Dechanneling Length
5. A Planar Channeling Experiment with Electrons using a Periodic Graded Composition Strained Layer SiGe Target
6. Conclusions

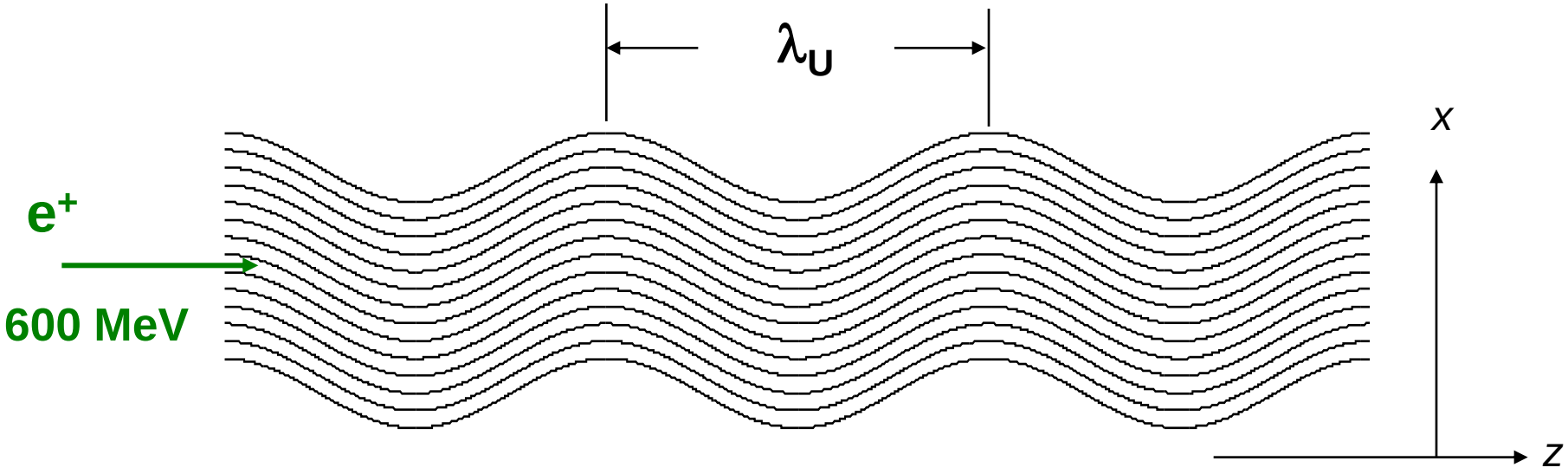
Channeling 2008, Erice, Italy, Oct. 2008
W. Lauth, University of Mainz, Germany

Undulator Radiation at Positron/Electron Channeling in a Single Crystal

A. Solov'yov, A. Korol, W. Greiner *et al.*



Positron Channeling in Si-Undulator Crystal



$$x = A \cdot \cos\left(\frac{2\pi}{\lambda_U} z\right)$$ A = 9 Å, λ_U = 50 µm, N_U = 4

Beam Energy E = 600 MeV, γ = 1175.2

$$K = \gamma \cdot A \cdot \frac{2\pi}{\lambda_U} = 0.133$$

Photon energy

$$\hbar\omega = k \frac{4\pi \cdot \gamma^2 \hbar c}{\lambda_U (1 + K^2/2 + \gamma^2(\theta_x^2 + \theta_y^2))} = 67.9\,\text{keV}$$

at $\theta_x = \theta_y = 0$, and first order $k = 1$

Channeling Experiments with Positrons @BTF Frascati

Beam Test Facility (BTF)

(See Poster Lina Quintieri)

Emittance: $\varepsilon_x = \varepsilon_y =$ **10 mm mrad**

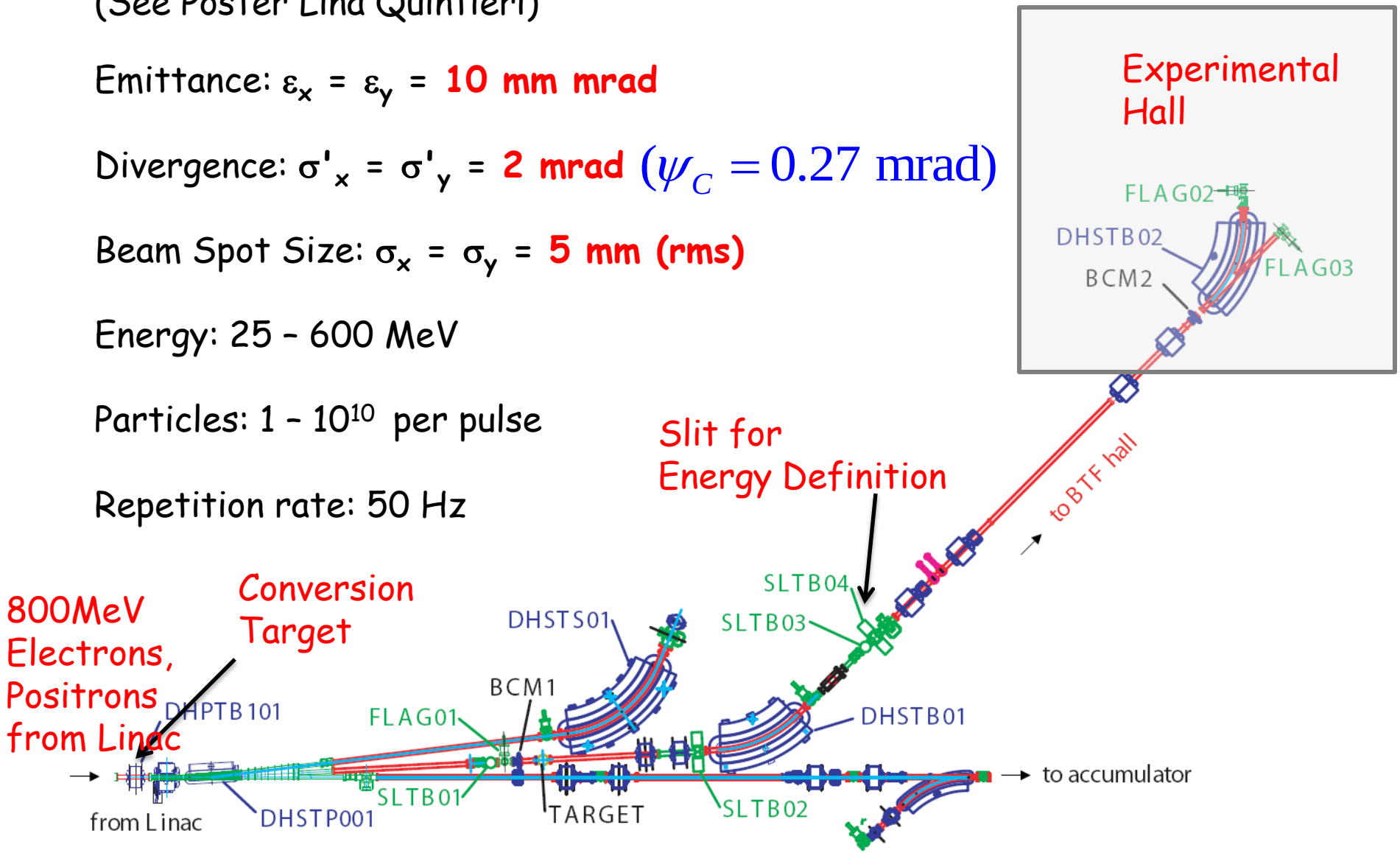
Divergence: $\sigma'_x = \sigma'_y =$ **2 mrad** $(\psi_C = 0.27 \text{ mrad})$

Beam Spot Size: $\sigma_x = \sigma_y =$ **5 mm (rms)**

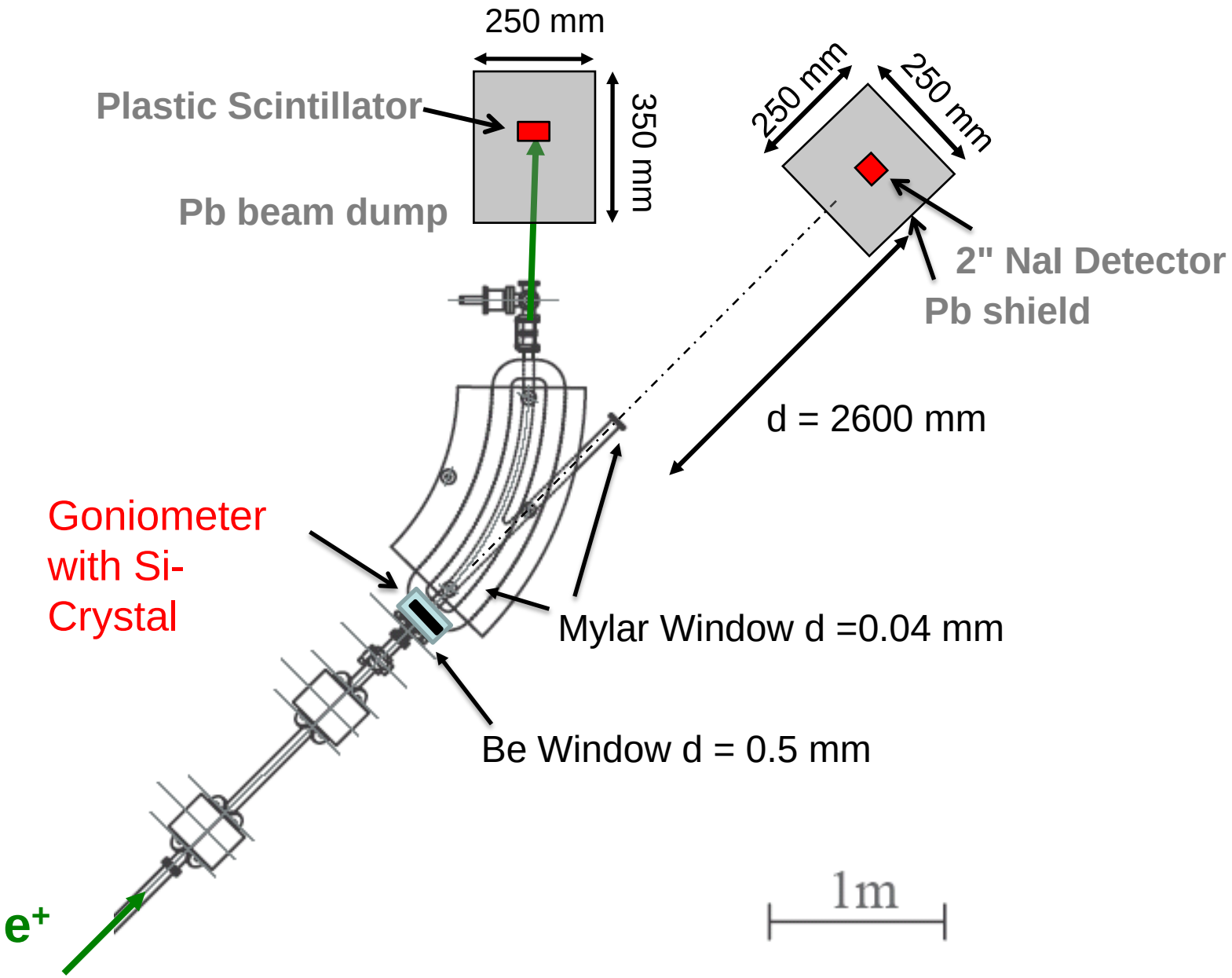
Energy: 25 – 600 MeV

Particles: 1 – 10^{10} per pulse

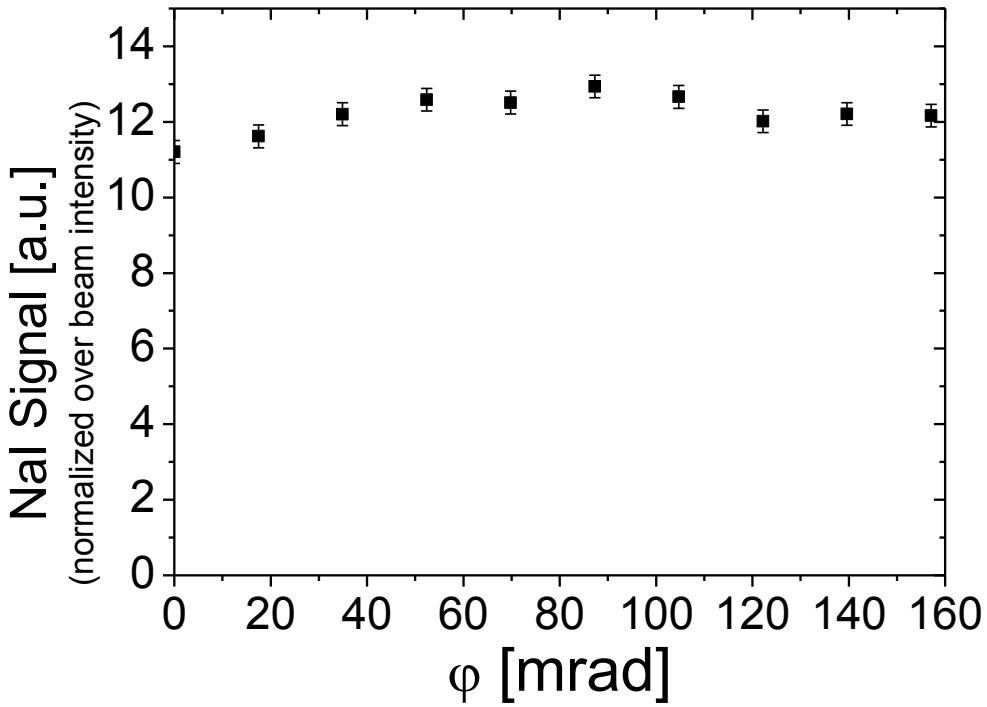
Repetition rate: 50 Hz



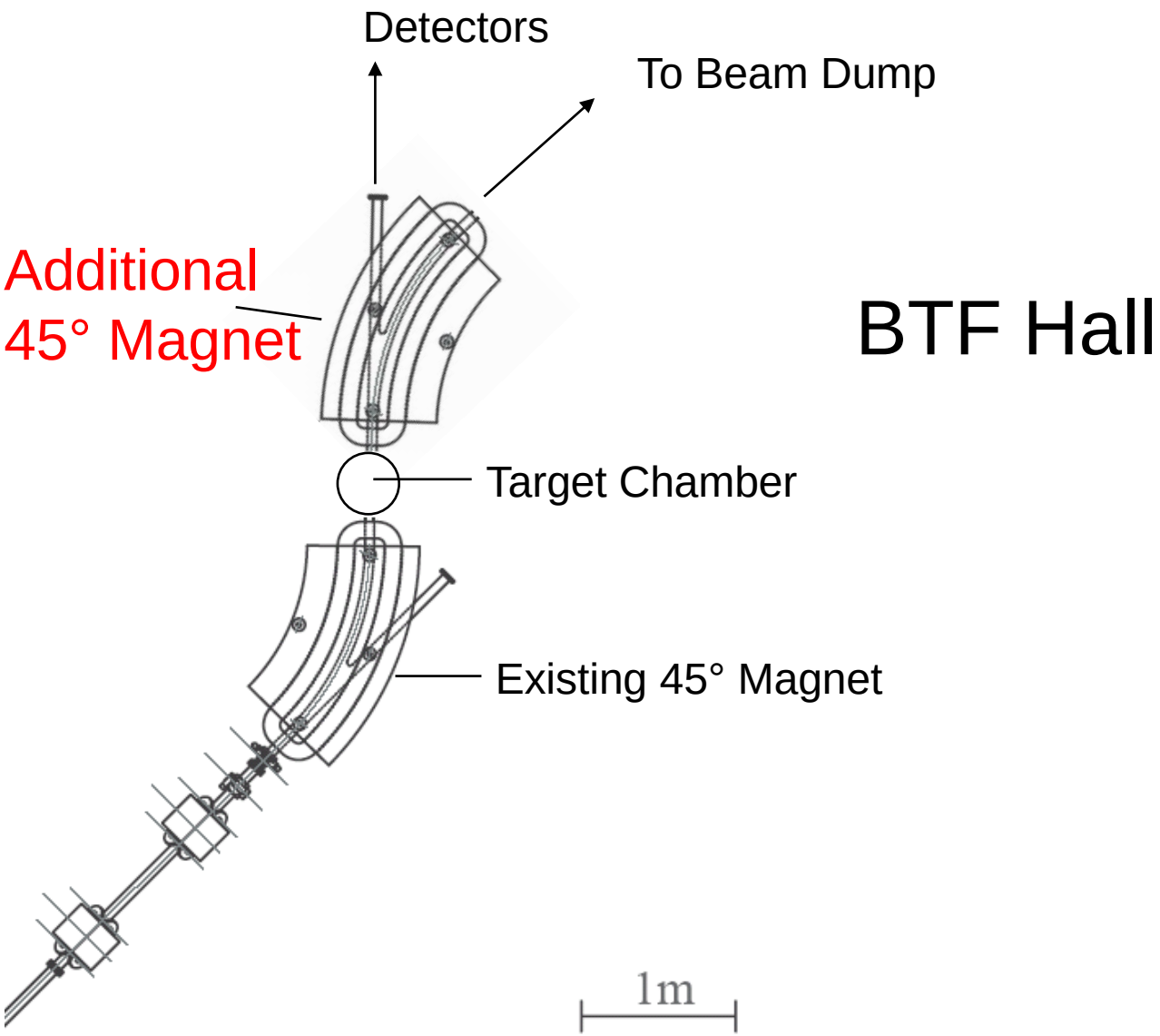
Experimental Setup @ BTF



Experimental Result



Improvement of the Beam line



Experiments with Electrons

Dechanneling Length

The Mainz Microtron MAMI

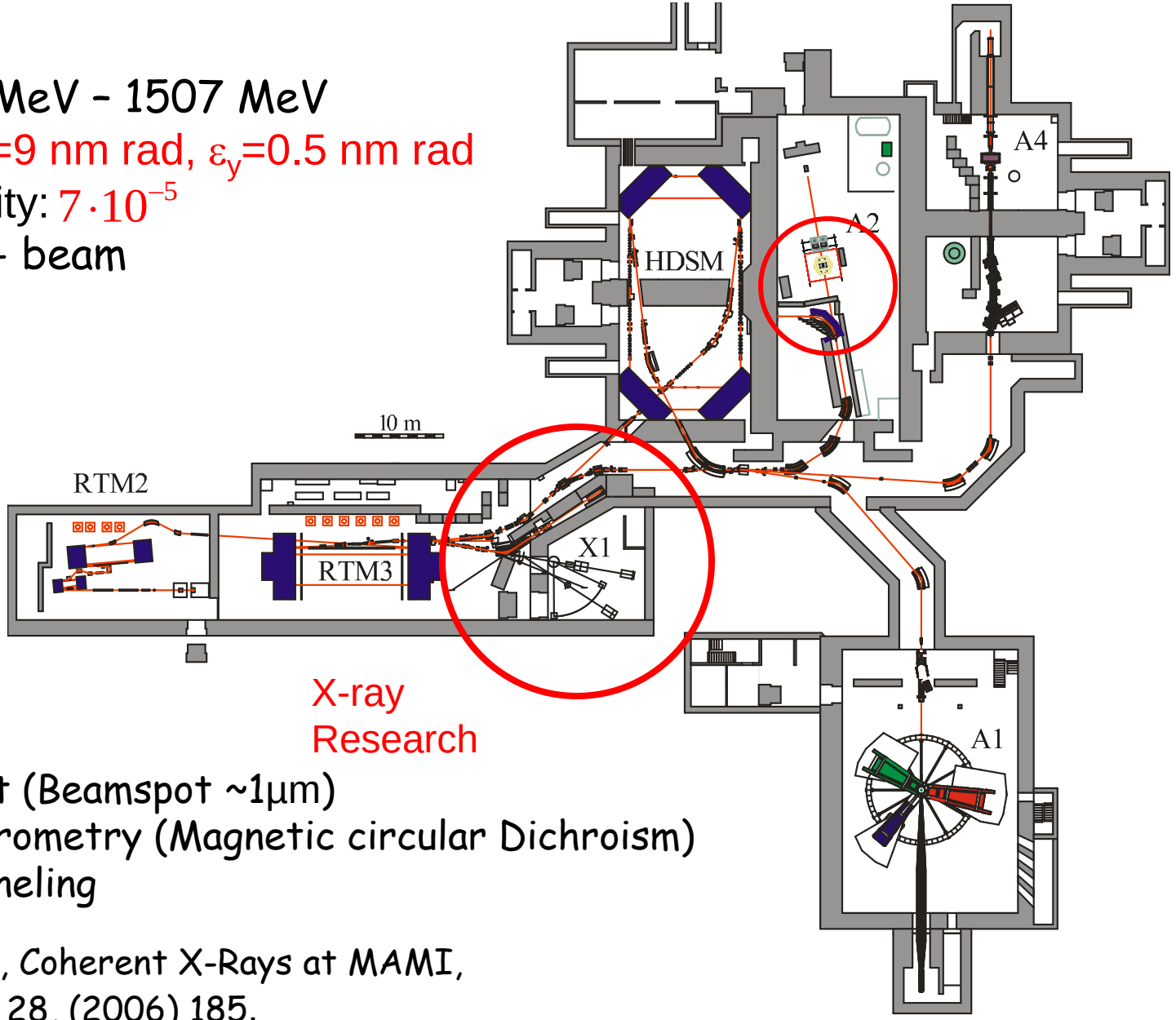
Parameter:

Energy: 180 MeV – 1507 MeV

Emittance ε_x=9 nm rad, ε_y=0.5 nm rad

Energy Stability: $7 \cdot 10^{-5}$

100μA cw e^- - beam



X-ray Research

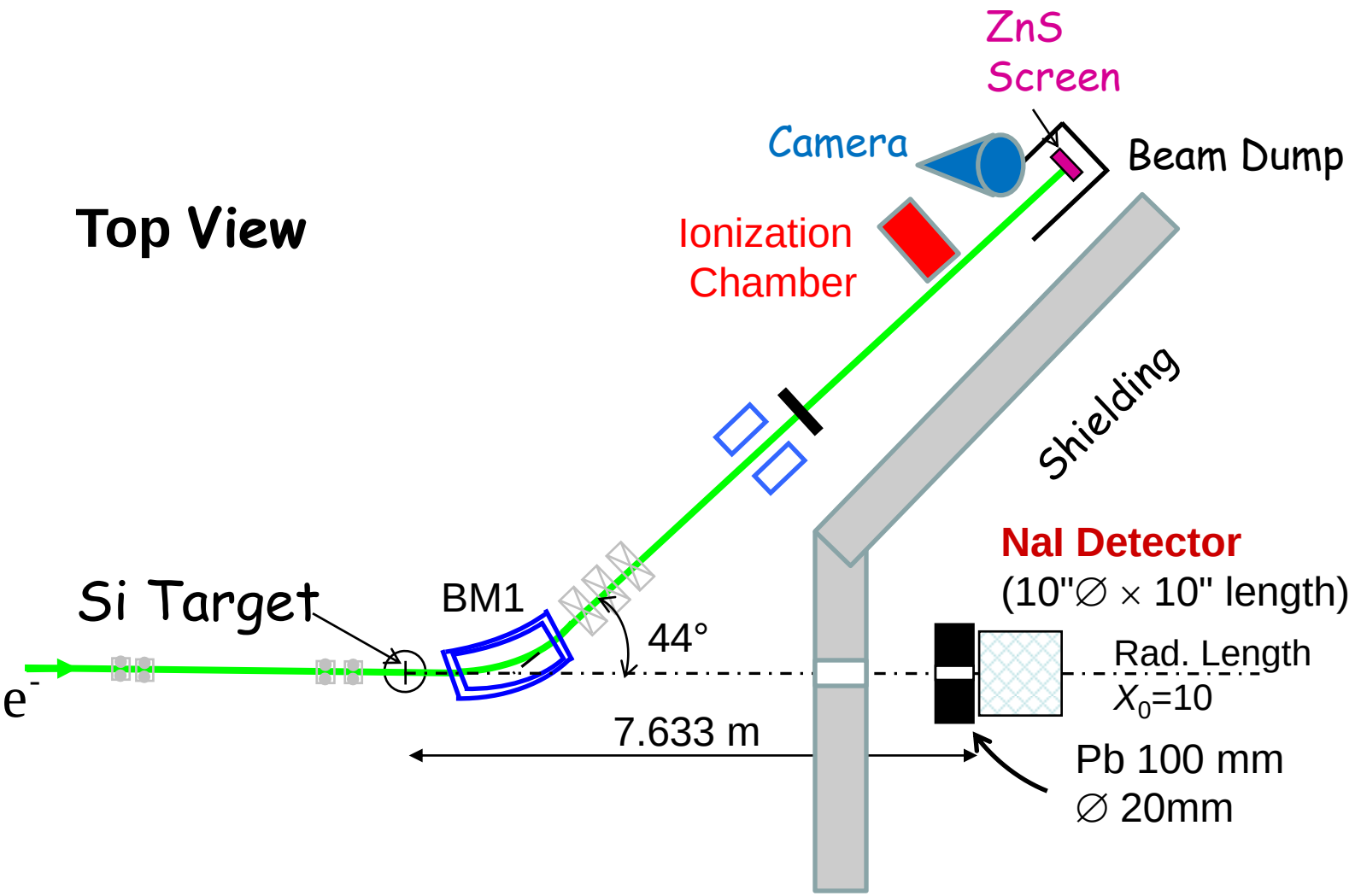
Phase Contrast (Beamspot ~1µm)

X-ray Interferometry (Magnetic circular Dichroism)

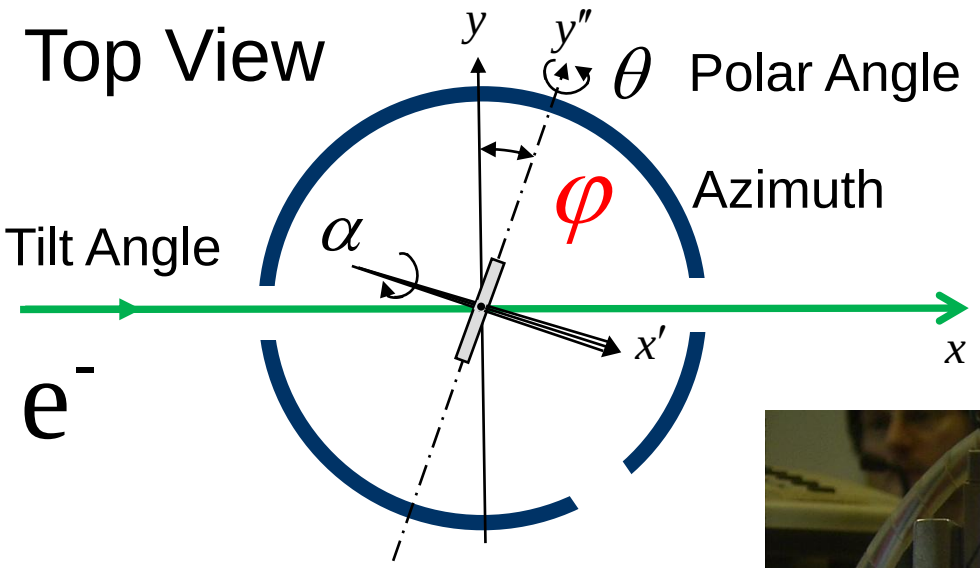
PXR, TR, Channeling

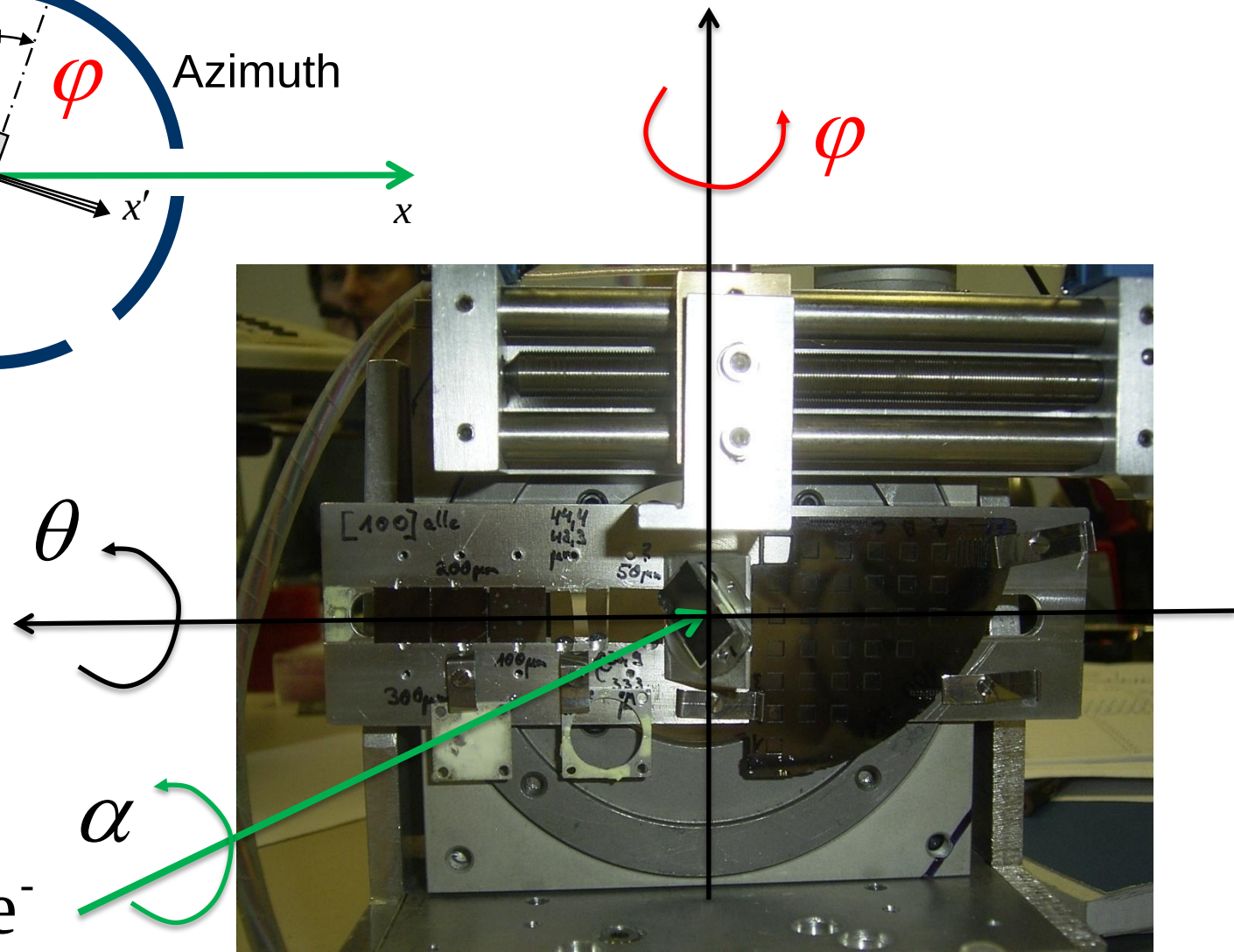
W. Lauth et al., Coherent X-Rays at MAMI, Eur. Phys. J. A 28, (2006) 185.

Experimental Setup (855 MeV e⁻)



Target Setup and Definition of Angles

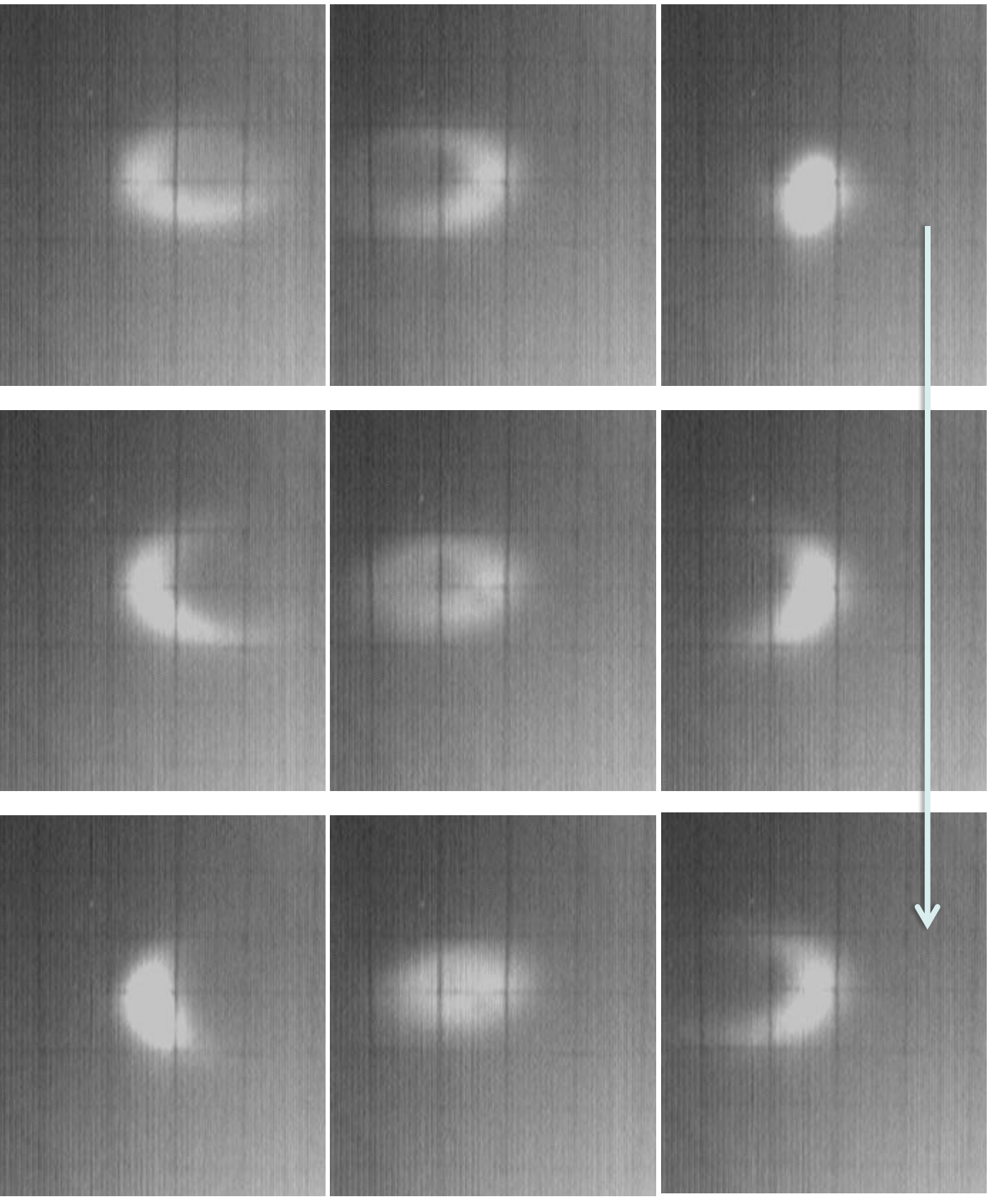




Video of the Beam Spot at the Dump Screen

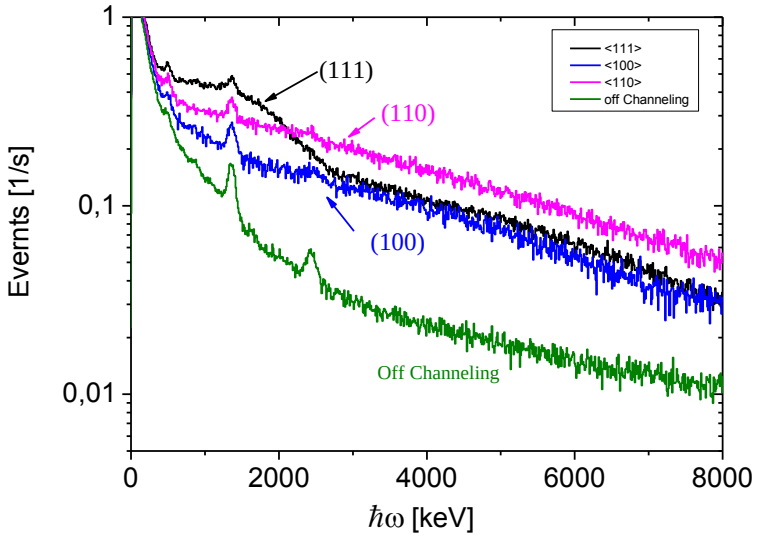
uvs081024-005.AVI

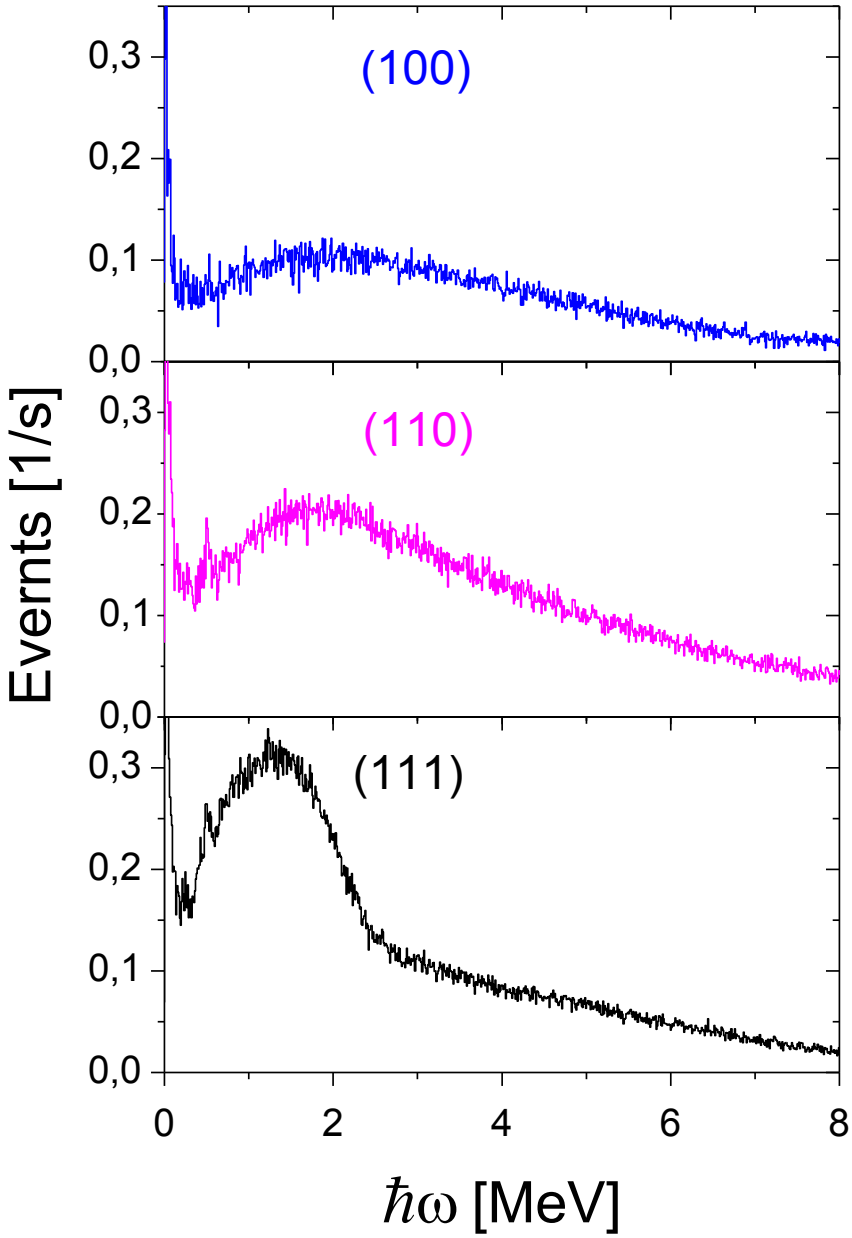
Dumpphotos



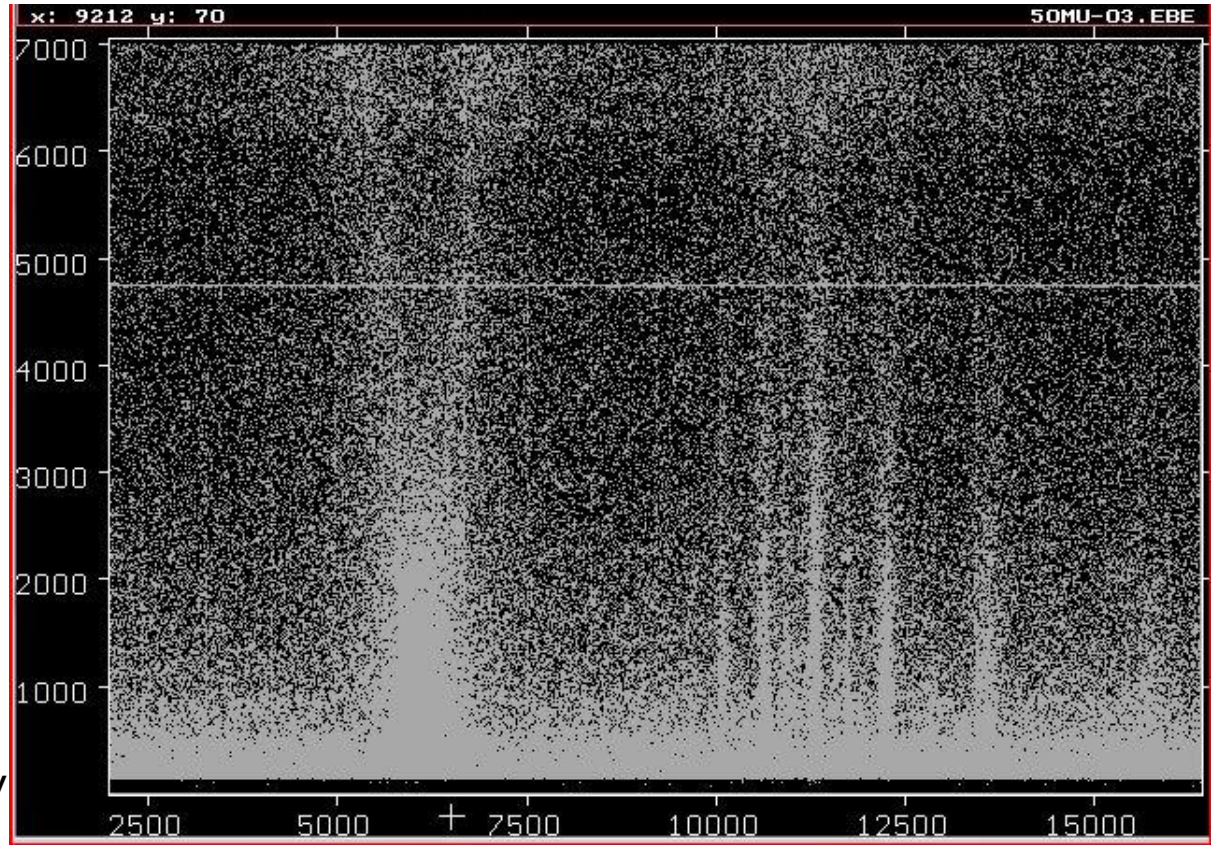
NaI Raw Spectra

174μm Si Crystal





Energy – angle dependence of the radiation

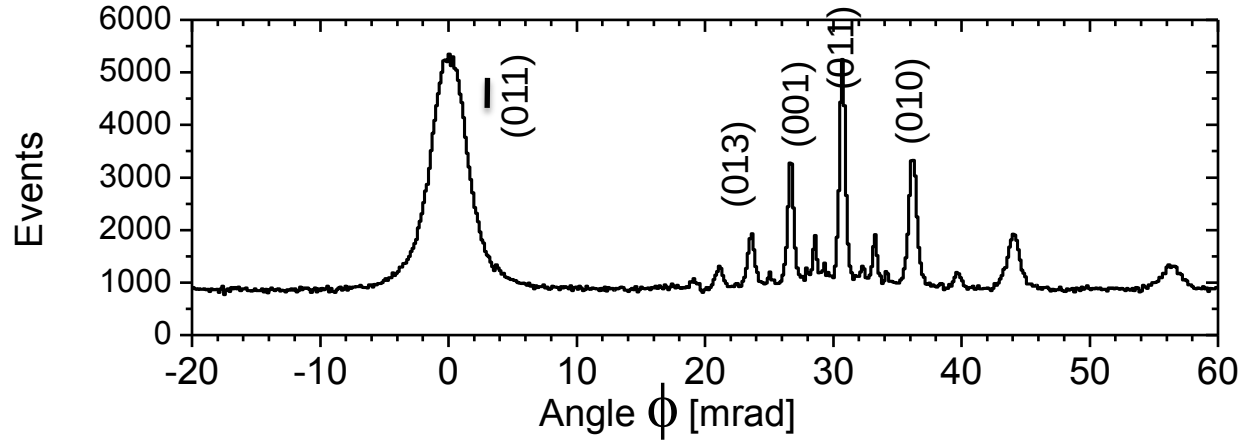


20 E [MeV]

10

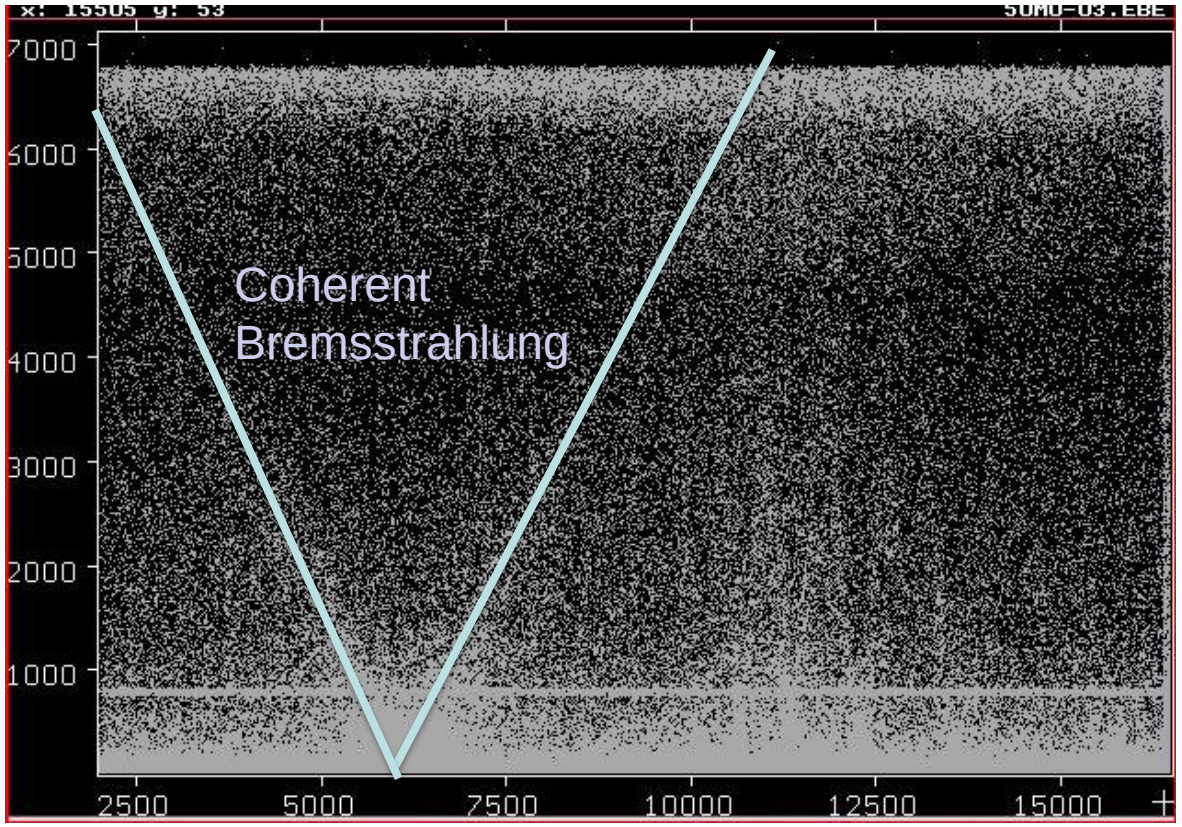
6 MeV

0.6 MeV



Channeling and Quasichanneling

Energy – angle dependence of the radiation

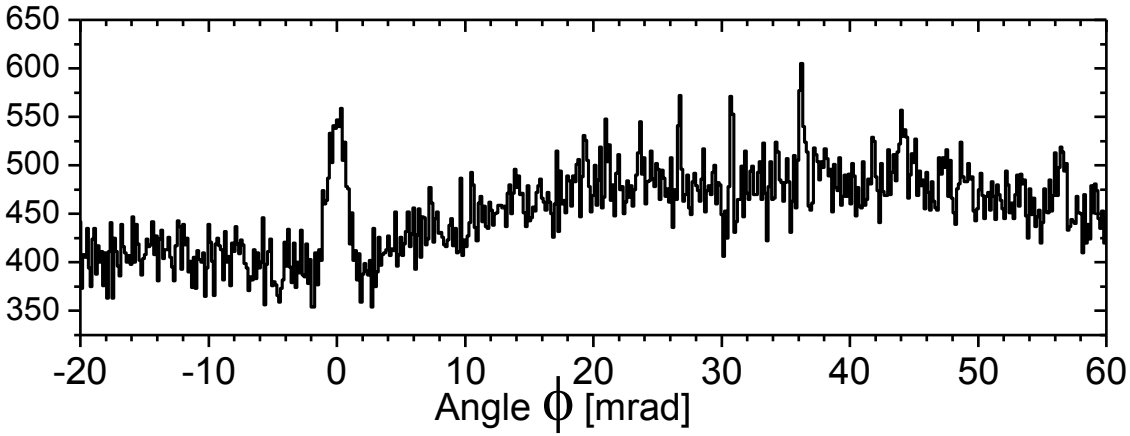


E [MeV]

100

50

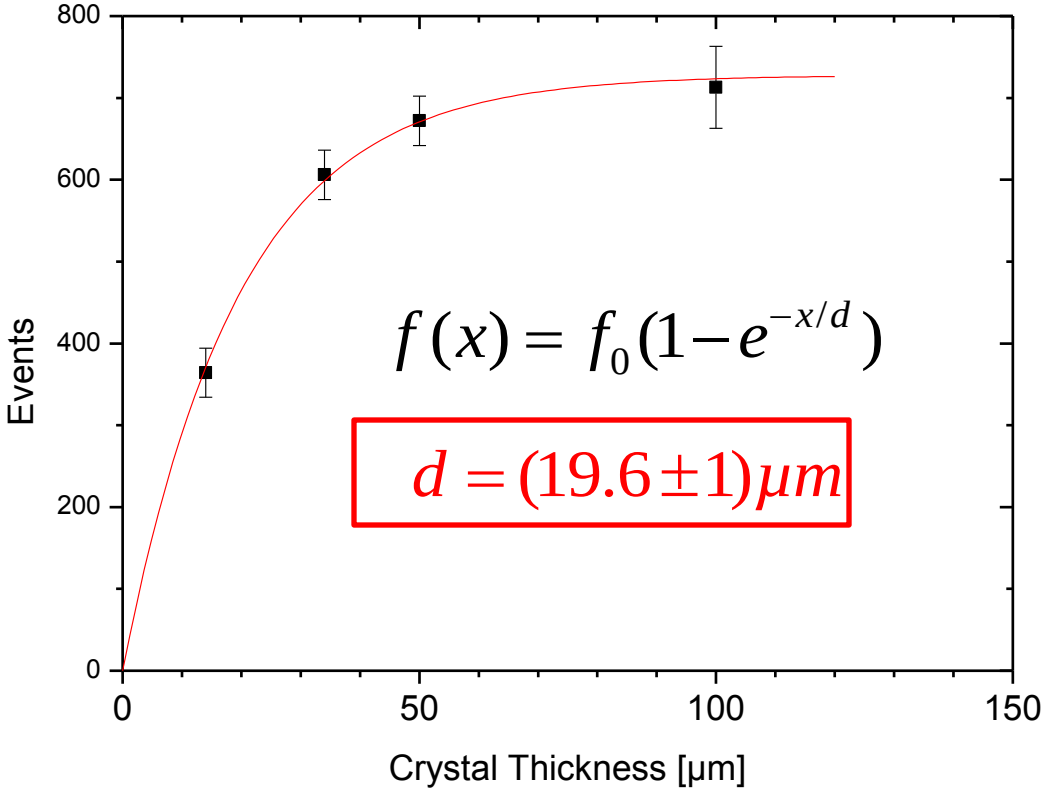
Pulser



High energy
Bremsstrahlung

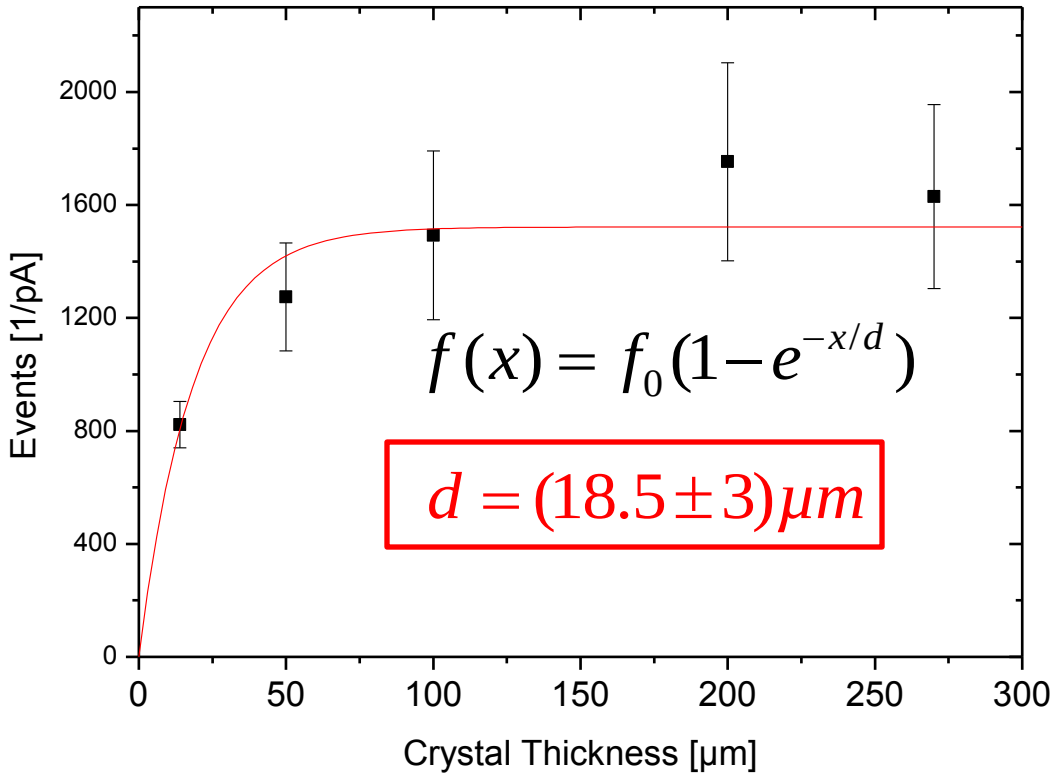
Dechanneling length @ E_e =855 MeV

Photon energy: > 100 MeV (Bremsstrahlung)



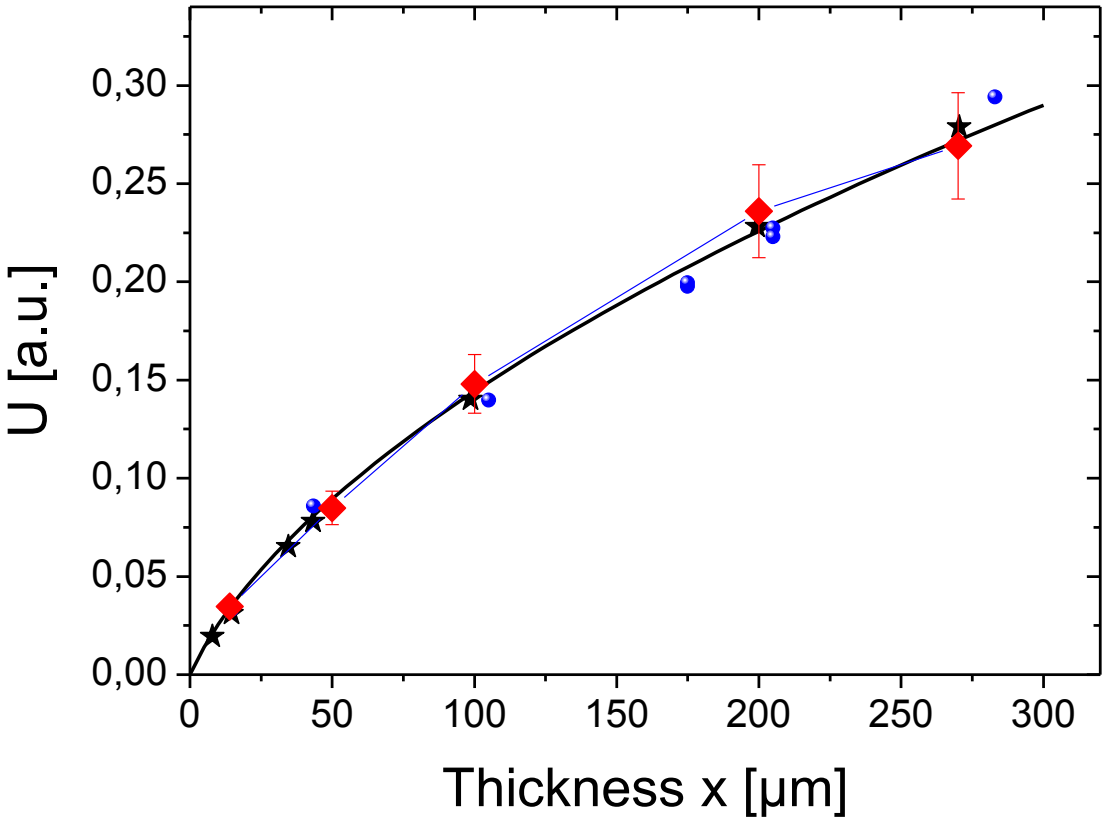
Dechanneling length @ E_e =195 MeV

Photon energy: > 12 MeV (Bremsstrahlung)



Dechanneling length @ E_e =855 MeV

Photon energy: < 5 MeV (Channeling Radiation)



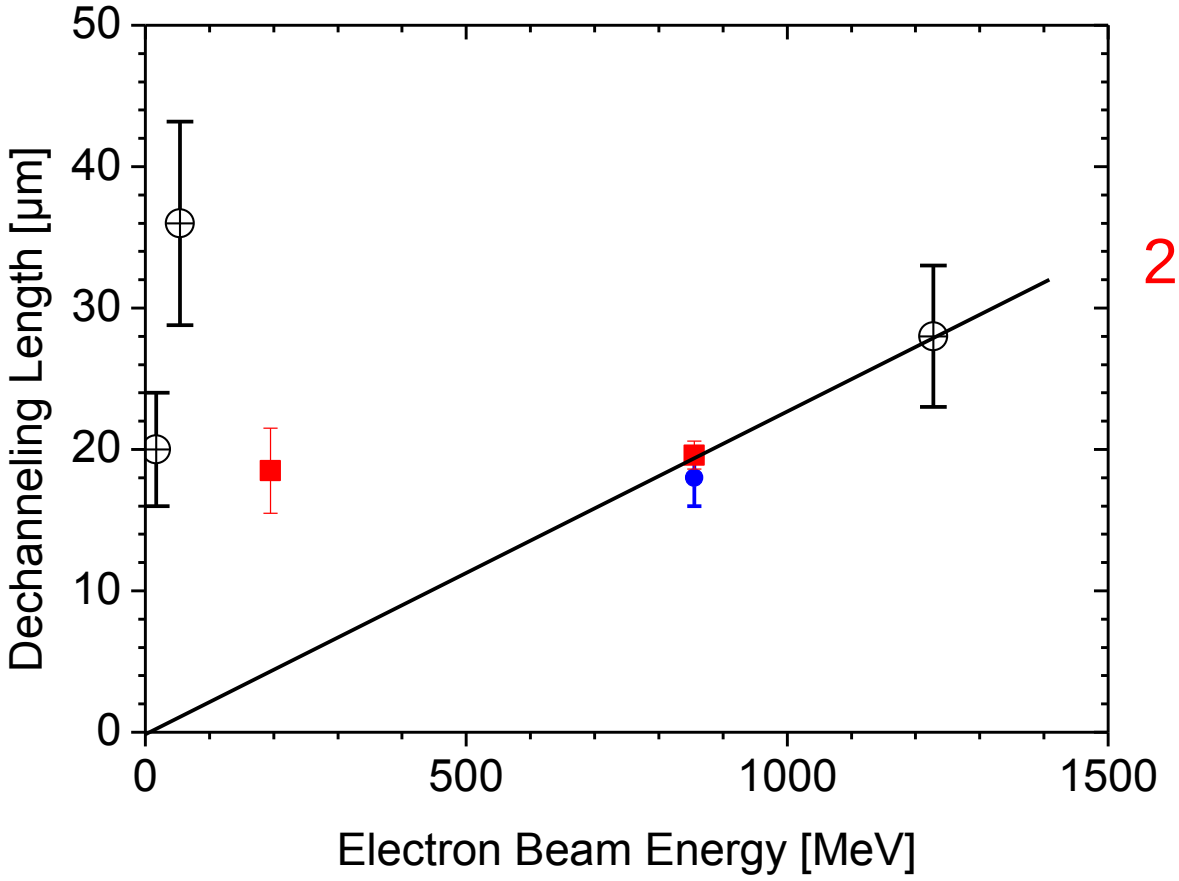
No saturation
Can be explained with channeling / rechanneling processes

Fokker-Planck Equation ->

$d = 18\mu m$

H. Backe et al.
NIM B 266(2008) 3835

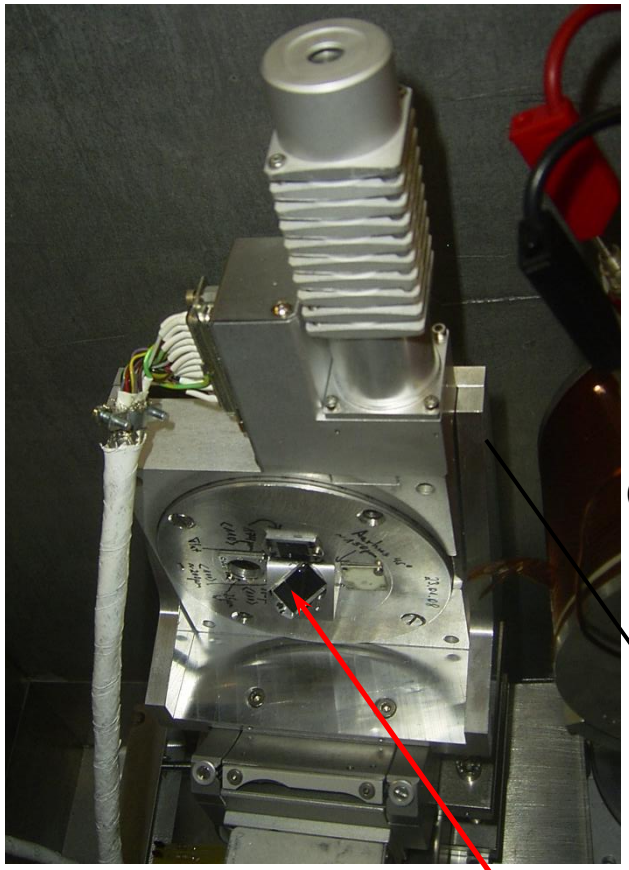
Dechanneling Length versus Electron Energy



21.3 μm/GeV

Channeling with periodically bent crystals

Experimental Setup @1.5GeV



Ionization Chamber

Beam Dump

Top View

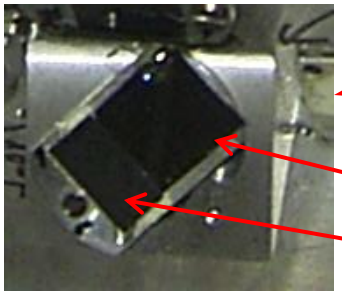
Goniometer

Tagger Magnet

300 Plastic Scintillators

NaI Detector
(10"∅ × 10" length)

e^-



Si-Crystals

Aperture
∅ 3mm

2.7 m

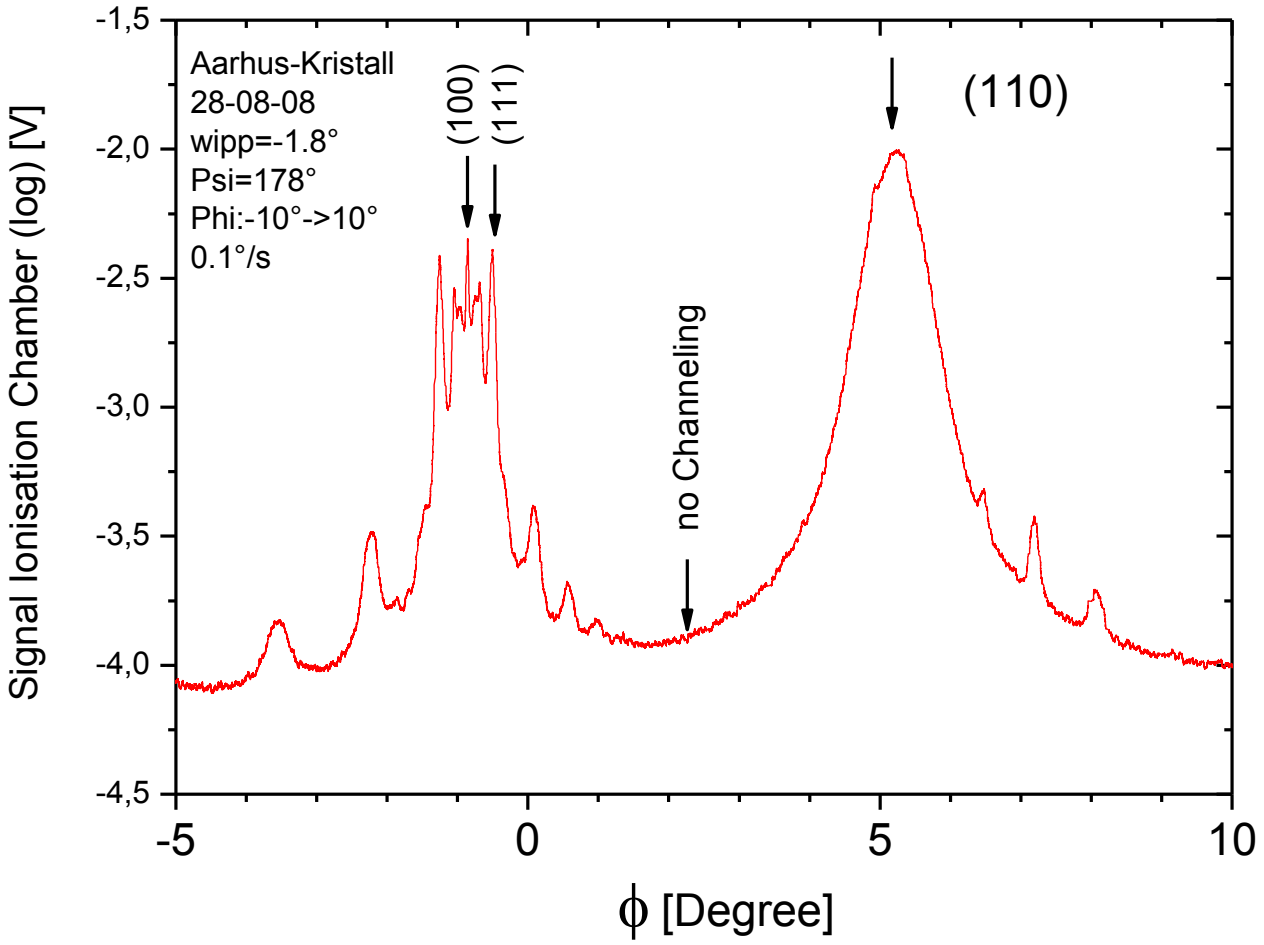
Pb 100 mm
∅ 45mm

Undulating crystal

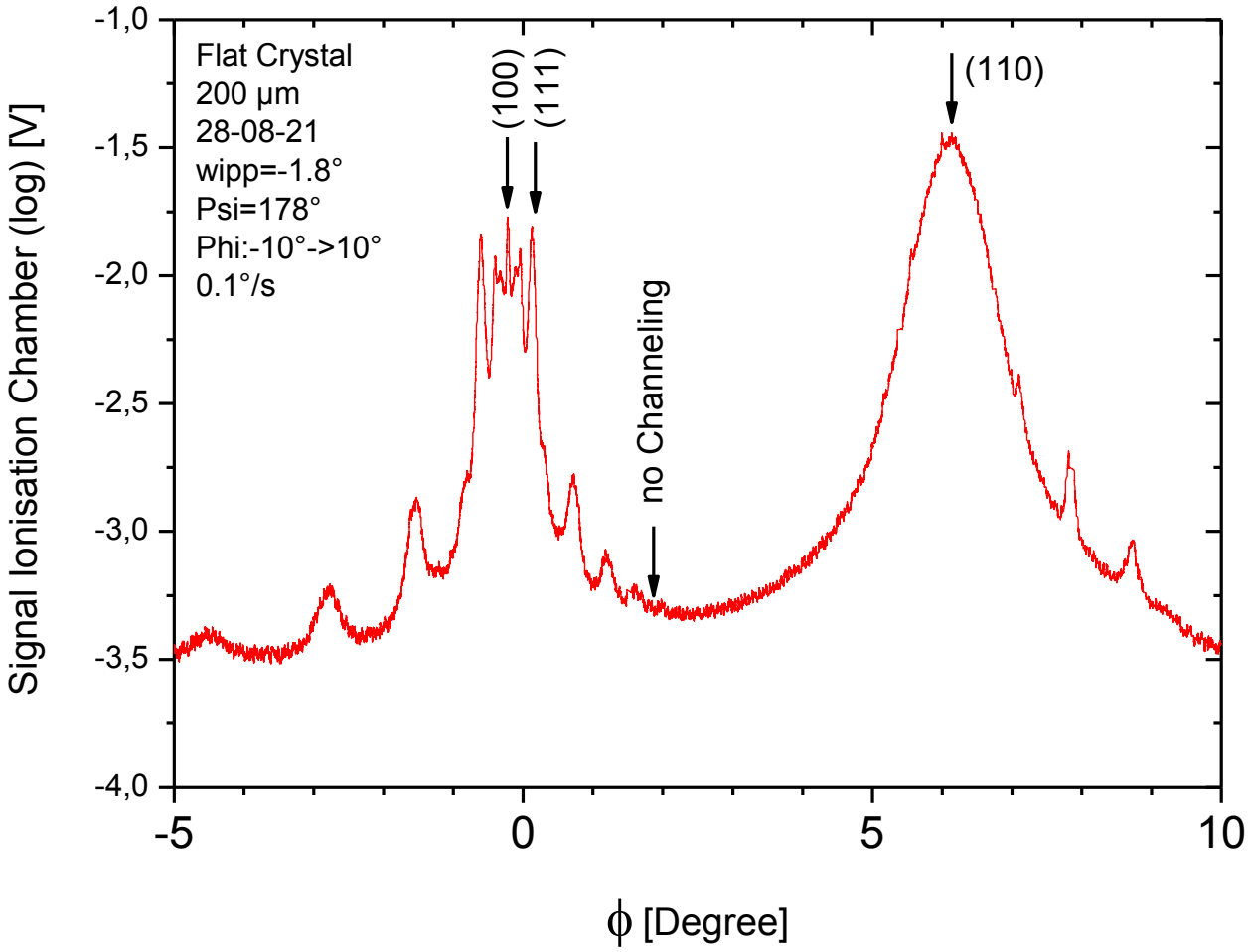
Flat crystal

7.633 m

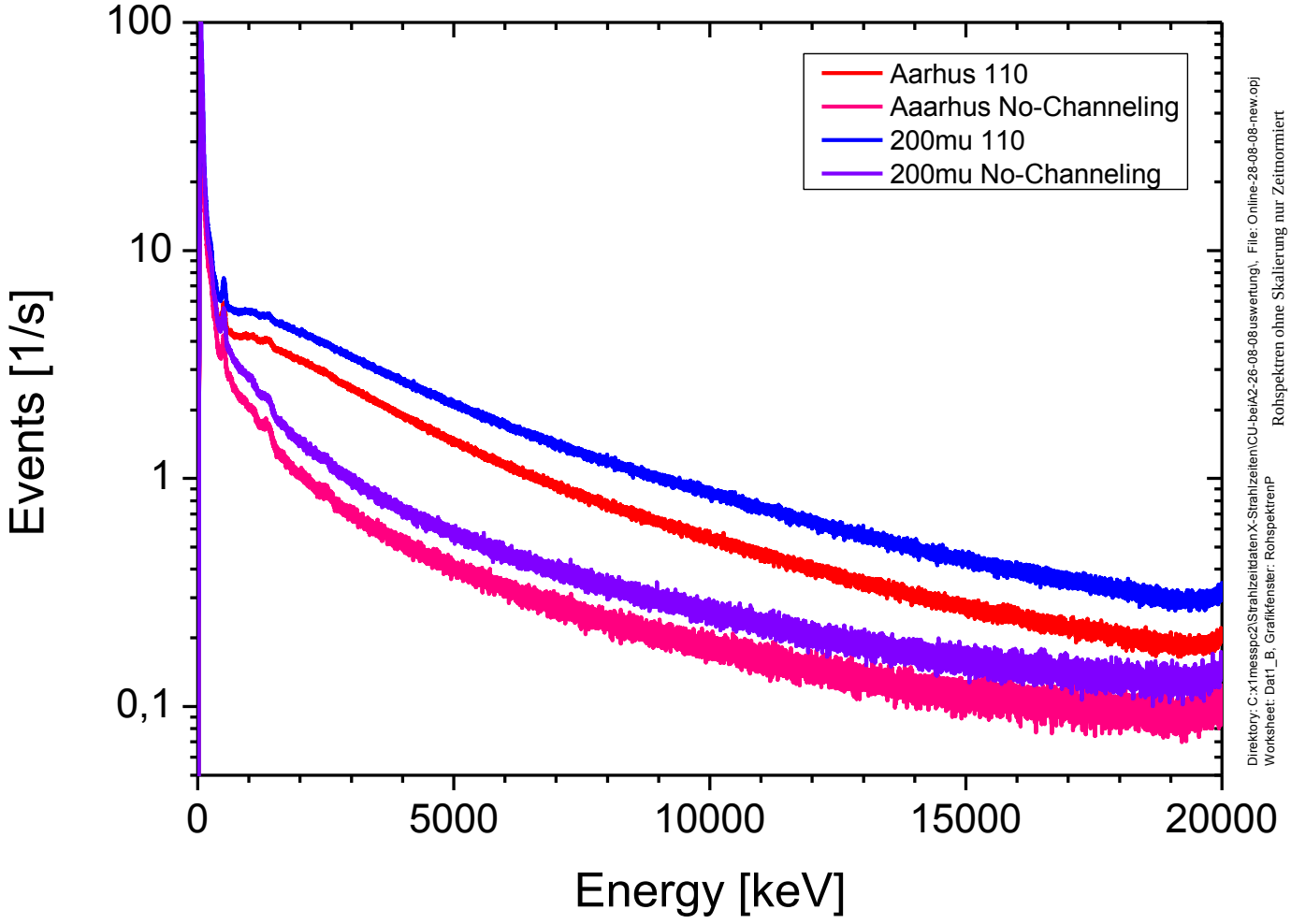
Scan around the vertical axis Φ
Bent crystal



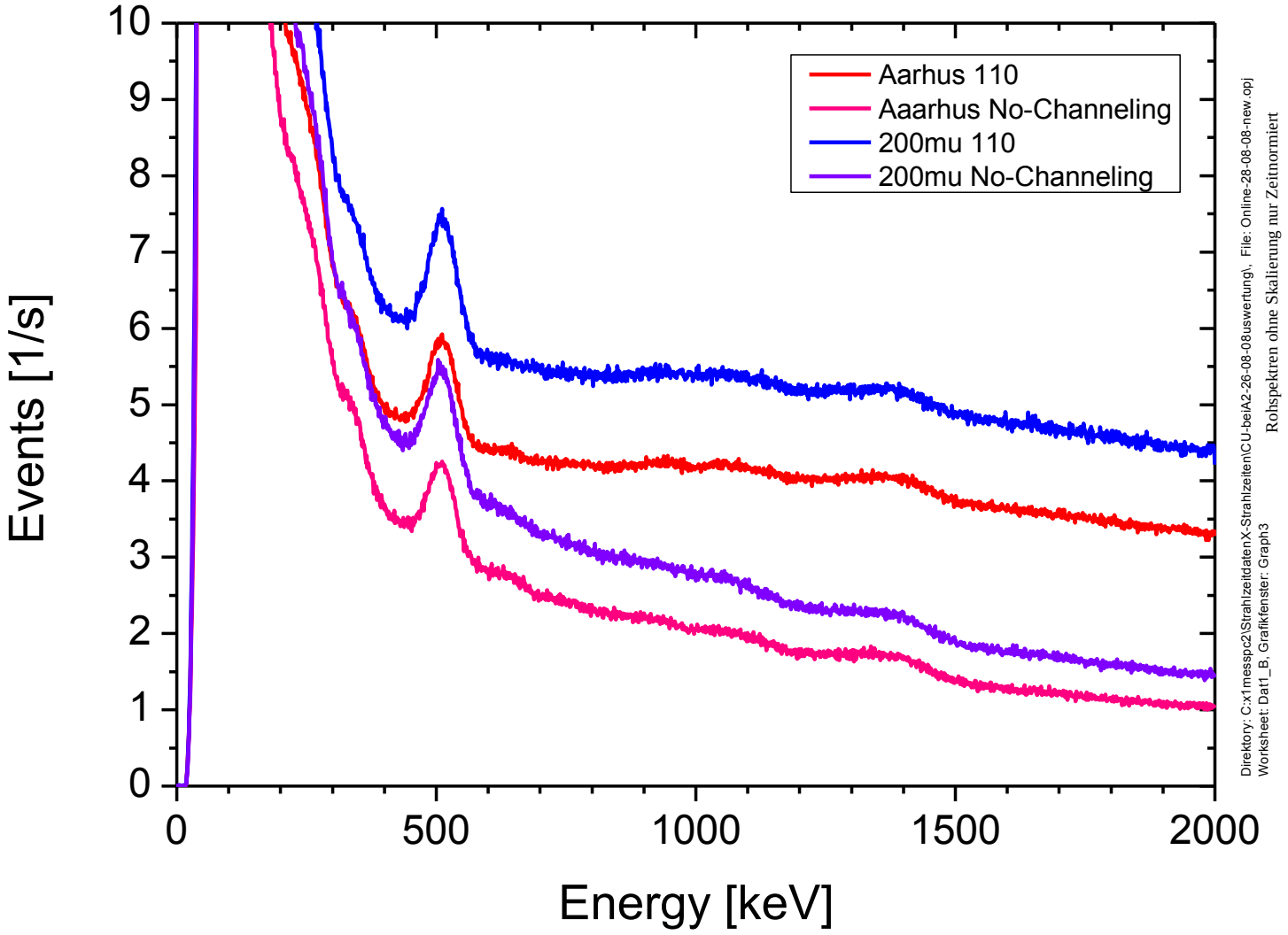
Scan around the vertical axis Φ
Flat crystal



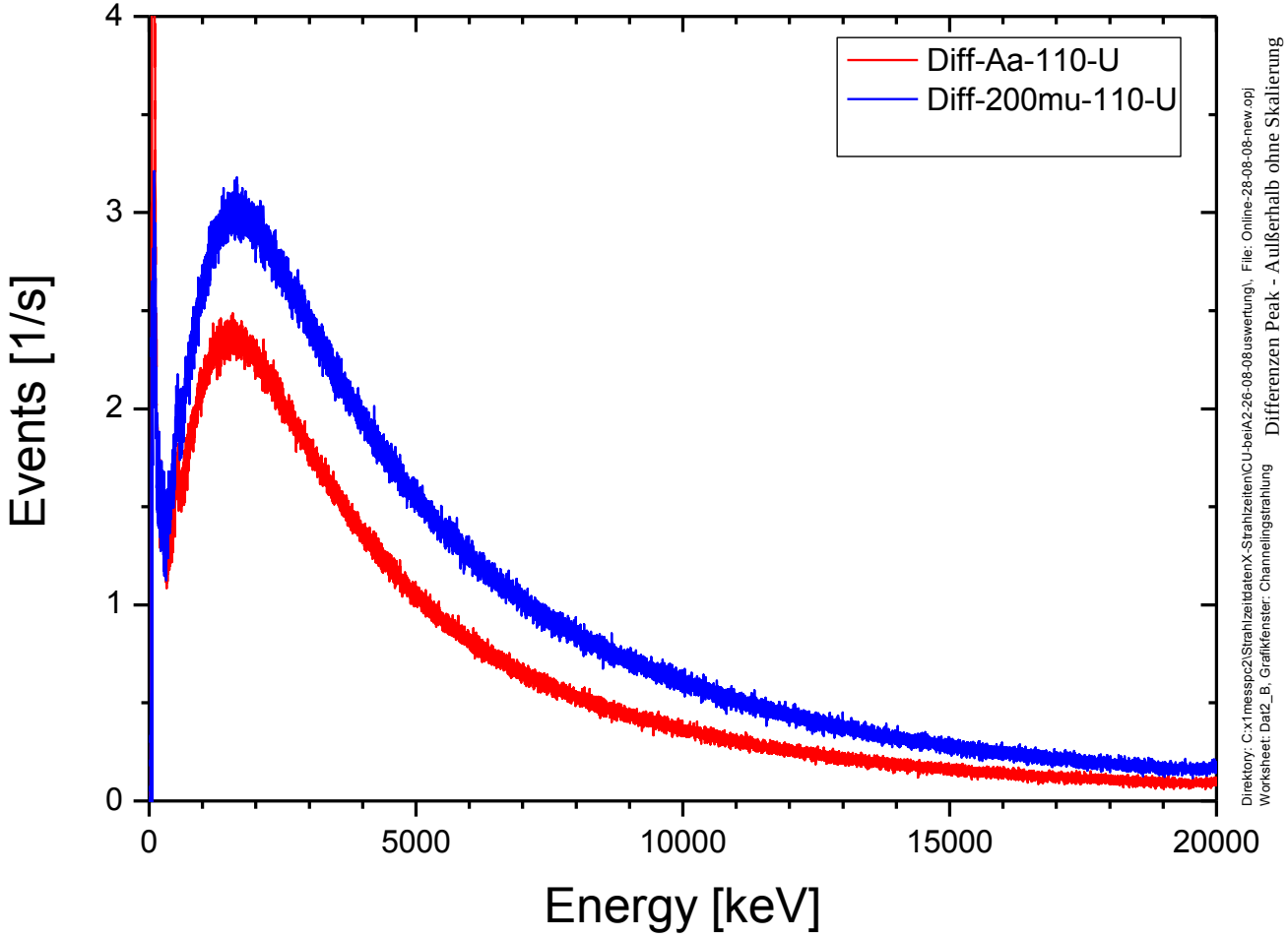
Raw Data


100
10
1
0,1
Events [1/s]
0
5000
10000
15000
20000
Energy [keV]
Aarhus 110
Aaarhus No-Channeling
200mu 110
200mu No-Channeling
Direktory: C:x1messpc2\Strahlzeitdaten\X-Strahlzeiten\CU-bei\A2-26-08-08uswertung\, File: Online-28-08-08-new.opj
Worksheet: Dat1_B, Grafikfenster: RohspektrenP
Rohspektren ohne Skalierung nur Zeitnormiert

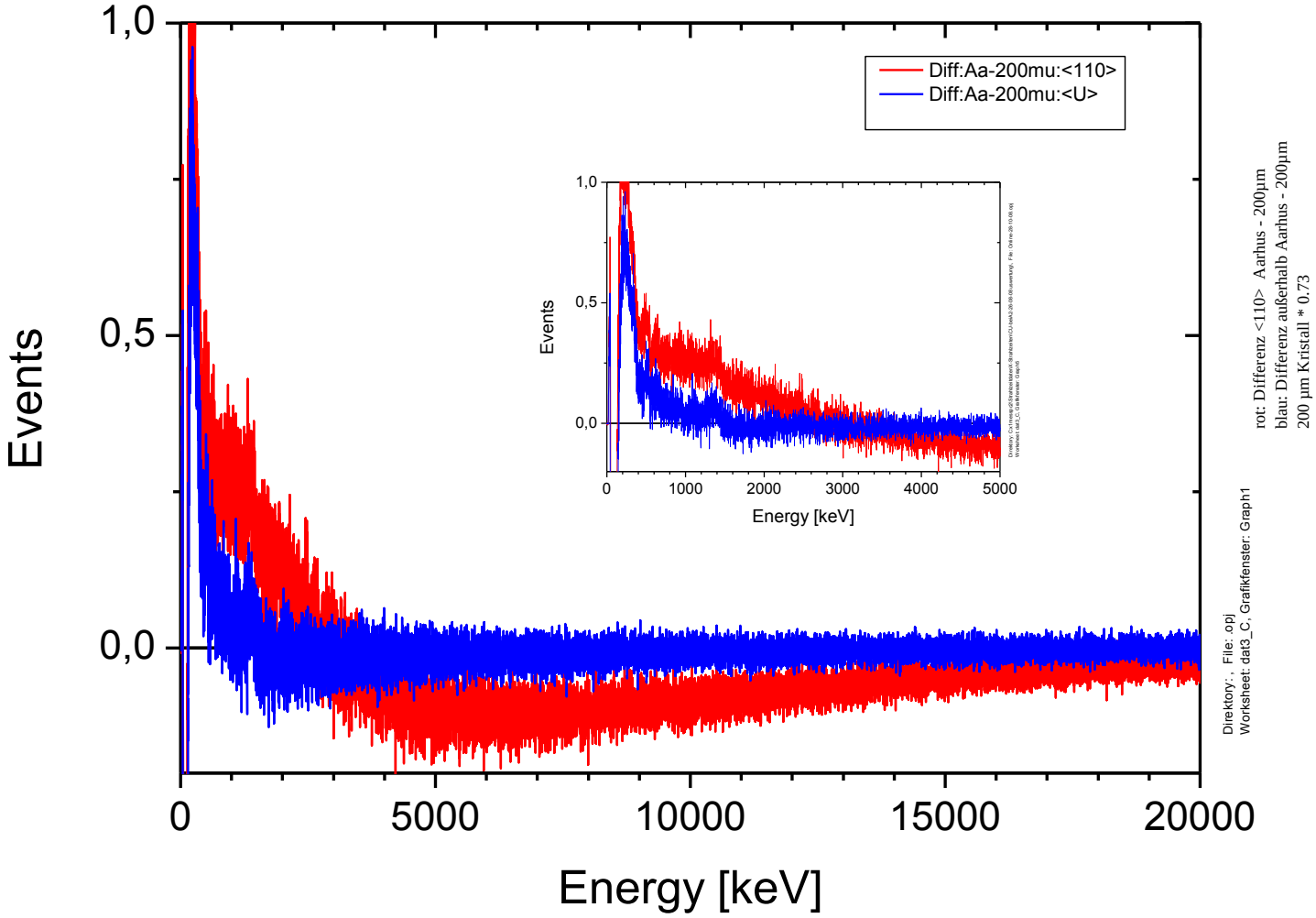
Raw Data


Aarhus 110
Aaarhus No-Channeling
200mu 110
200mu No-Channeling
Events [1/s]
Energy [keV]
0
1
2
3
4
5
6
7
8
9
10
0
500
1000
1500
2000
Direktory: C:x1messpc2\StrahlzeitdatenX-Strahlzeiten\CU-beiA2-26-08-08uswertung\, File: Online-28-08-08-new.opj
Worksheet: Dat1_B, Grafikfenster: Graph3
Rohspektren ohne Skalierung nur Zeitnormiert

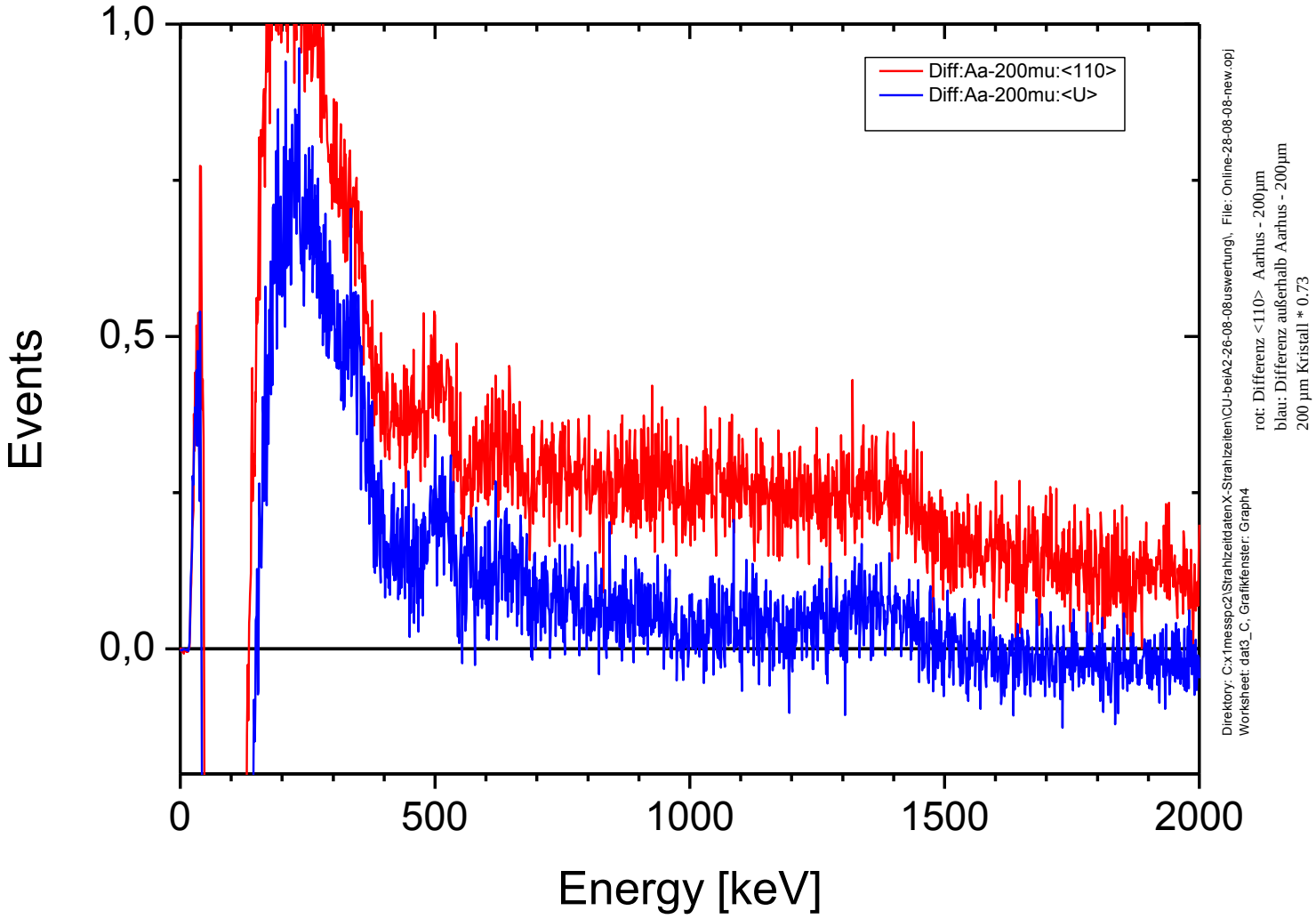
Channeling Spectra (110) Plane



Difference Spectra Bent-Flat



Difference Spectra Bent-Flat



Conclusions

- For Positron channeling a suitable machine is missing (Upgrading of BTF)
- Dechanneling length of Electrons have been measured

  21.3 μm/GeV
- With a 4 period Crystal Undulator an enhancement of radiation has been observed

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