Status of the positron beam line at MAMI (X1)

2023.10.05

Ground plan of MAMI

Harmonic Douple Sided Microtron: 1.6 GeV

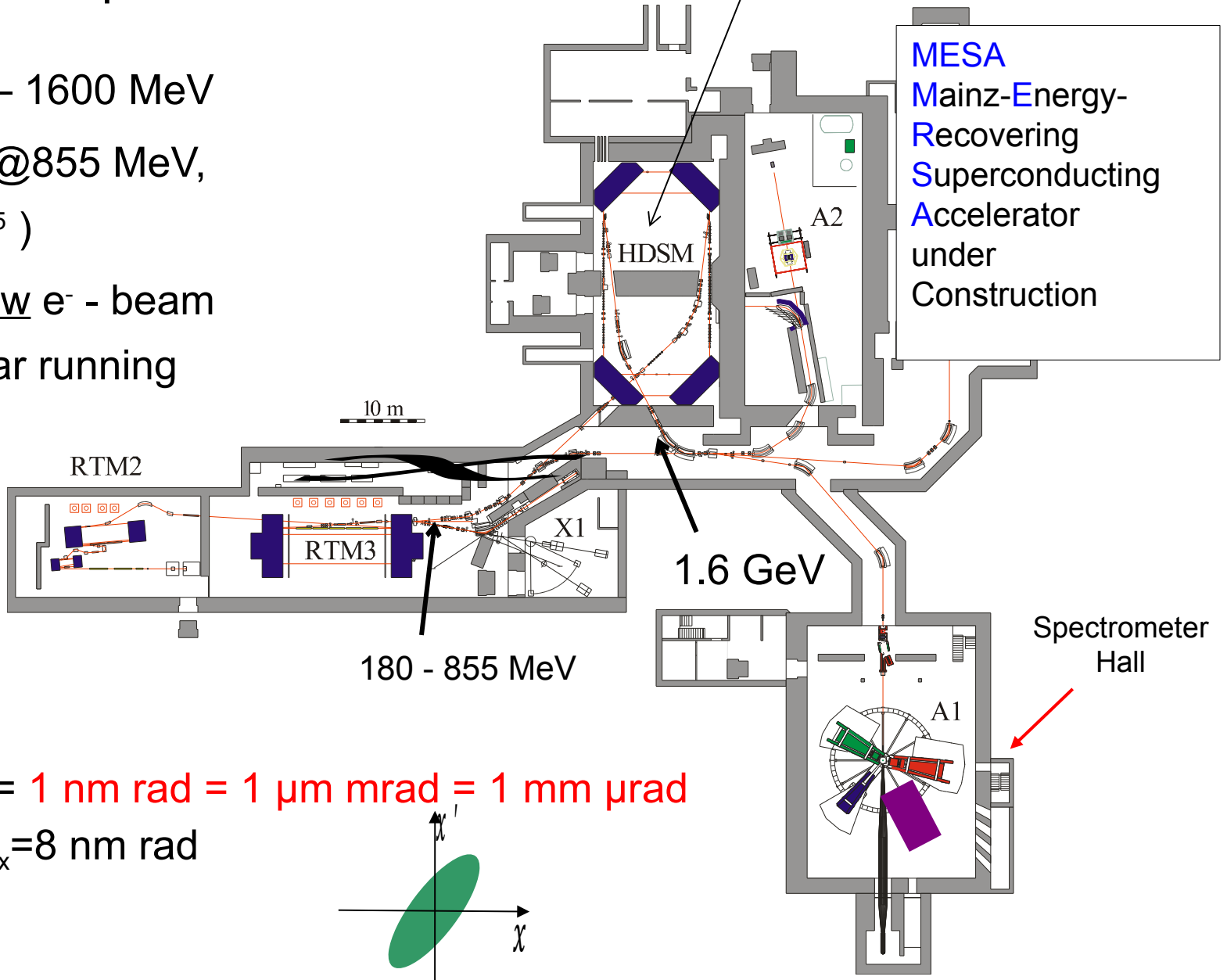
E= 180 MeV – 1600 MeV

ΔE = 13 keV @855 MeV,

$\Delta E/E = (2 \cdot 10^{-5})$

max. 100μA cw e^- - beam

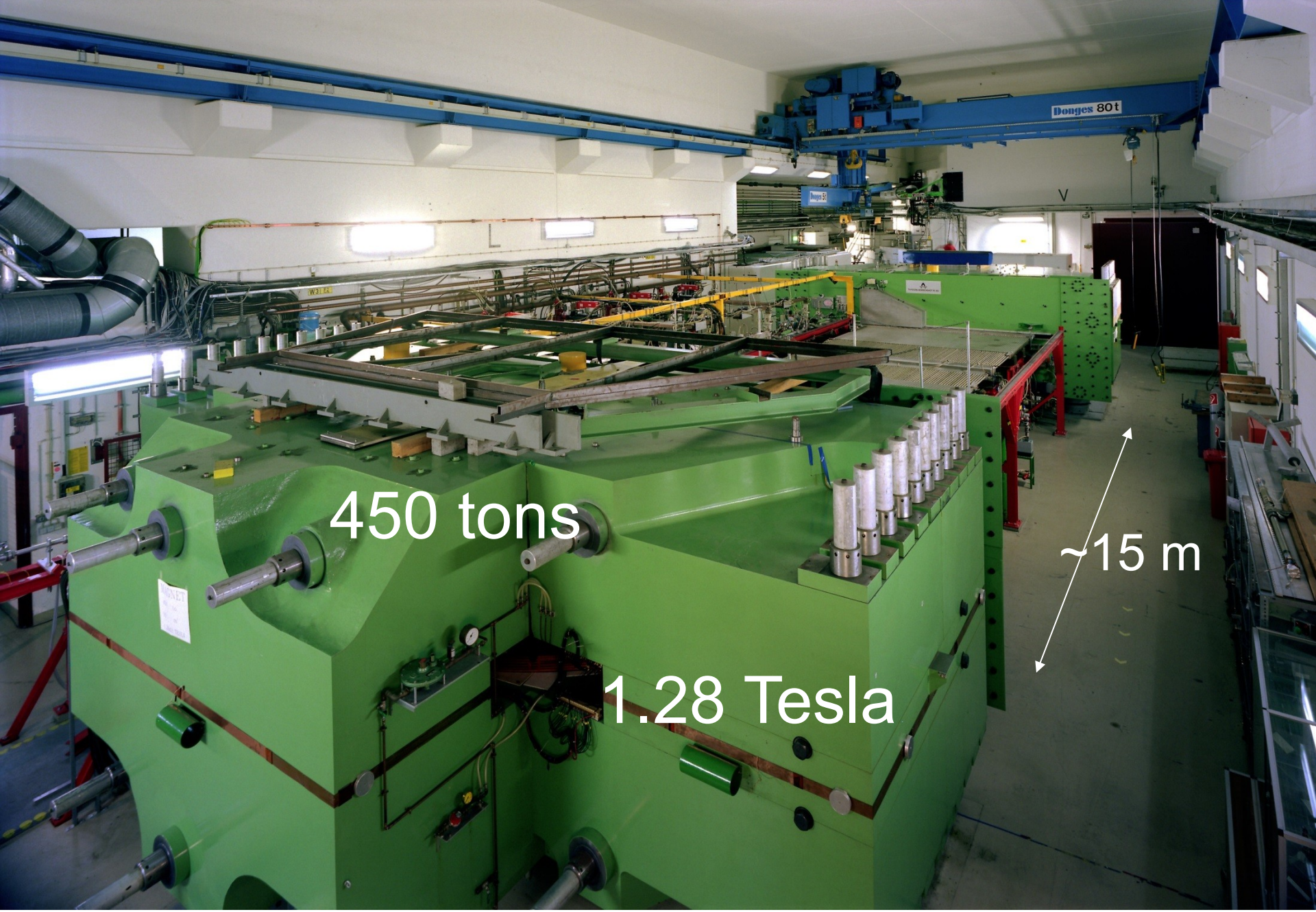
~ 7000 h / year running

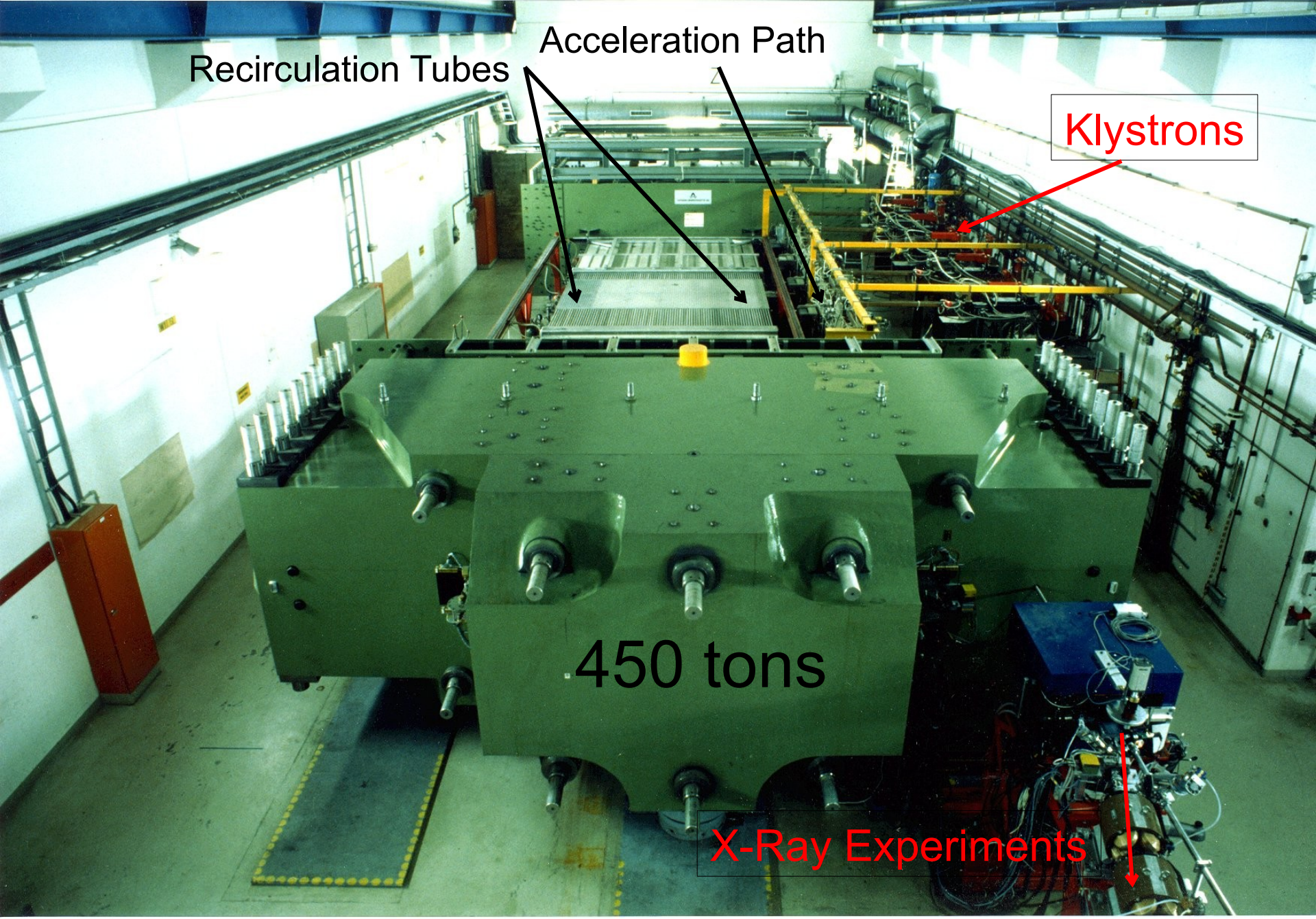


Emittance:

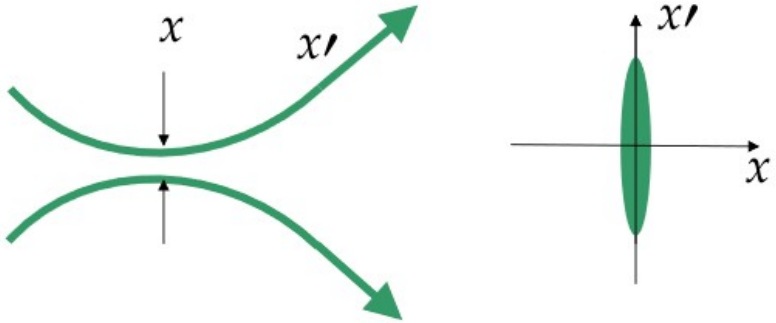
Vertical : ε_y= 1 nm rad = 1 μm mrad = 1 mm μrad

Horizontal: ε_x=8 nm rad


Donges 80t
450 tons
~15 m
1.28 Tesla


Recirculation Tubes
Acceleration Path
Klystrons
450 tons
X-Ray Experiments

High quality Positron beam @ MAMI



vertical

MAMI: $\varepsilon_x = x \cdot x' = 1\ mm \cdot \mu rad = 10\ \mu m \cdot 0.1 mrad$

Emittance $\varepsilon_x = x \cdot x' = \frac{F}{\pi} = const$

Thin target for Positron production

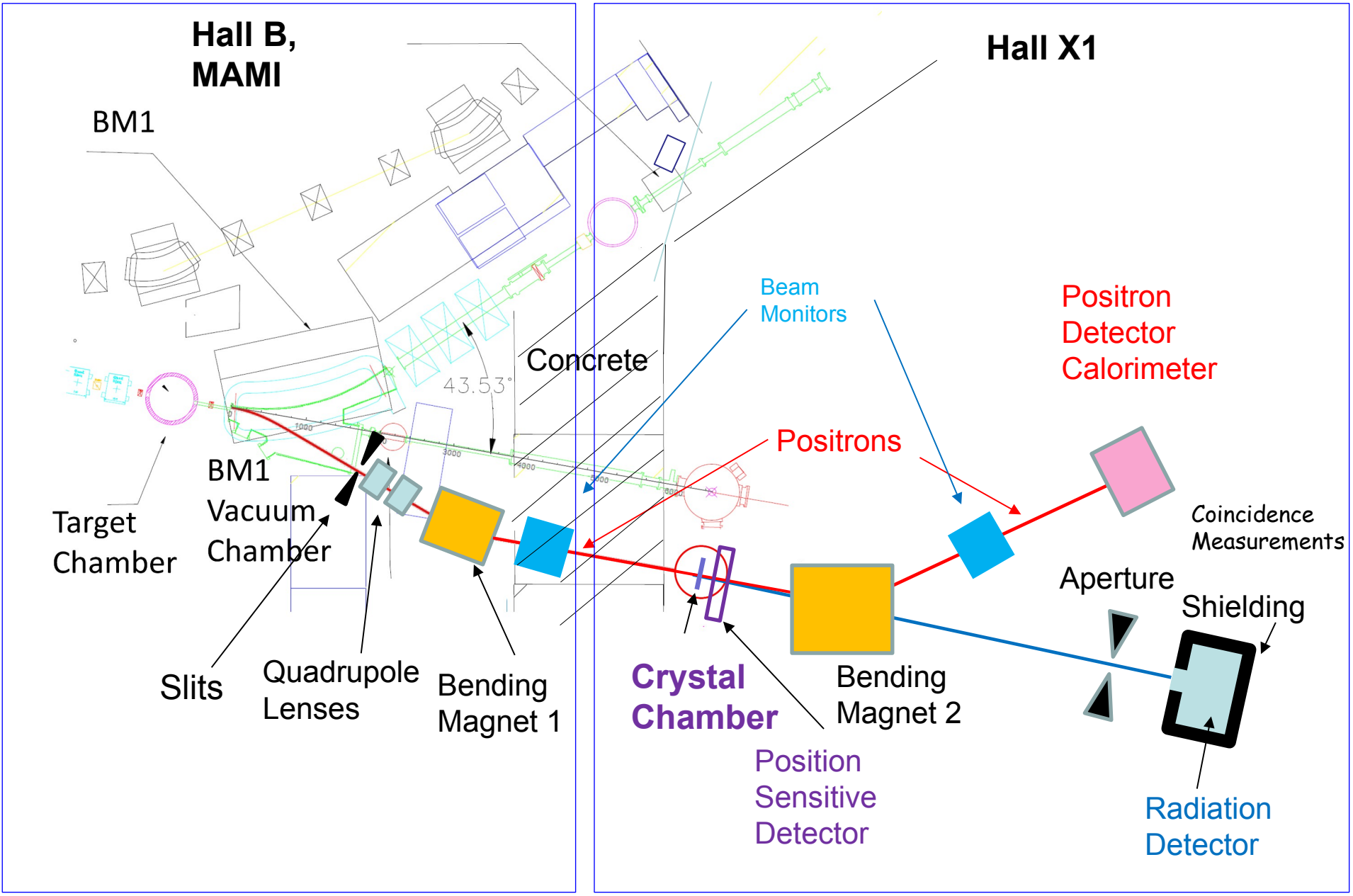
$10\ \mu m\ \ W \rightarrow Scattering\ \sigma_S = 0.94$ mrad

$\sigma_p = \cong \frac{1}{\gamma} = 1$ mrad @500MeV

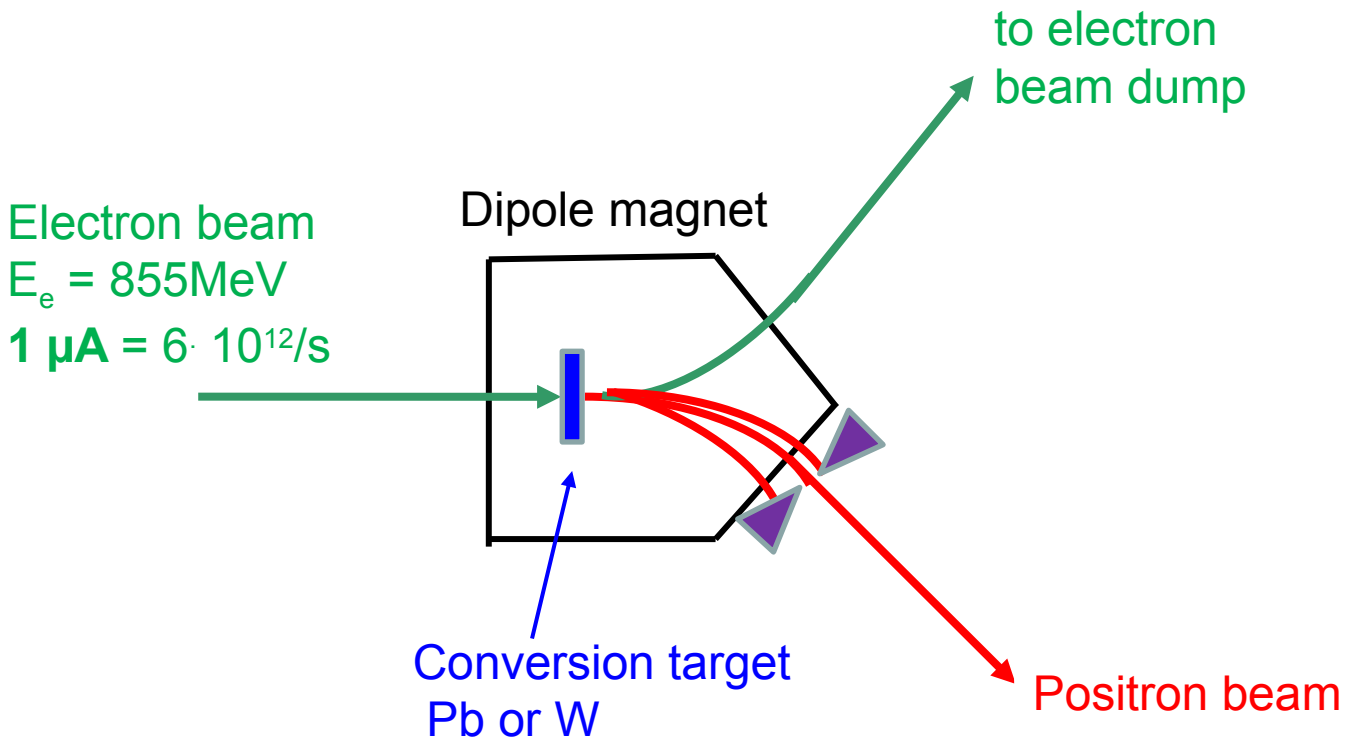
Emittance of Positrons:

$\varepsilon_{e+} = 10\ \mu m \cdot 1.4\ mrad = 1mm \cdot 0.014\ mrad$

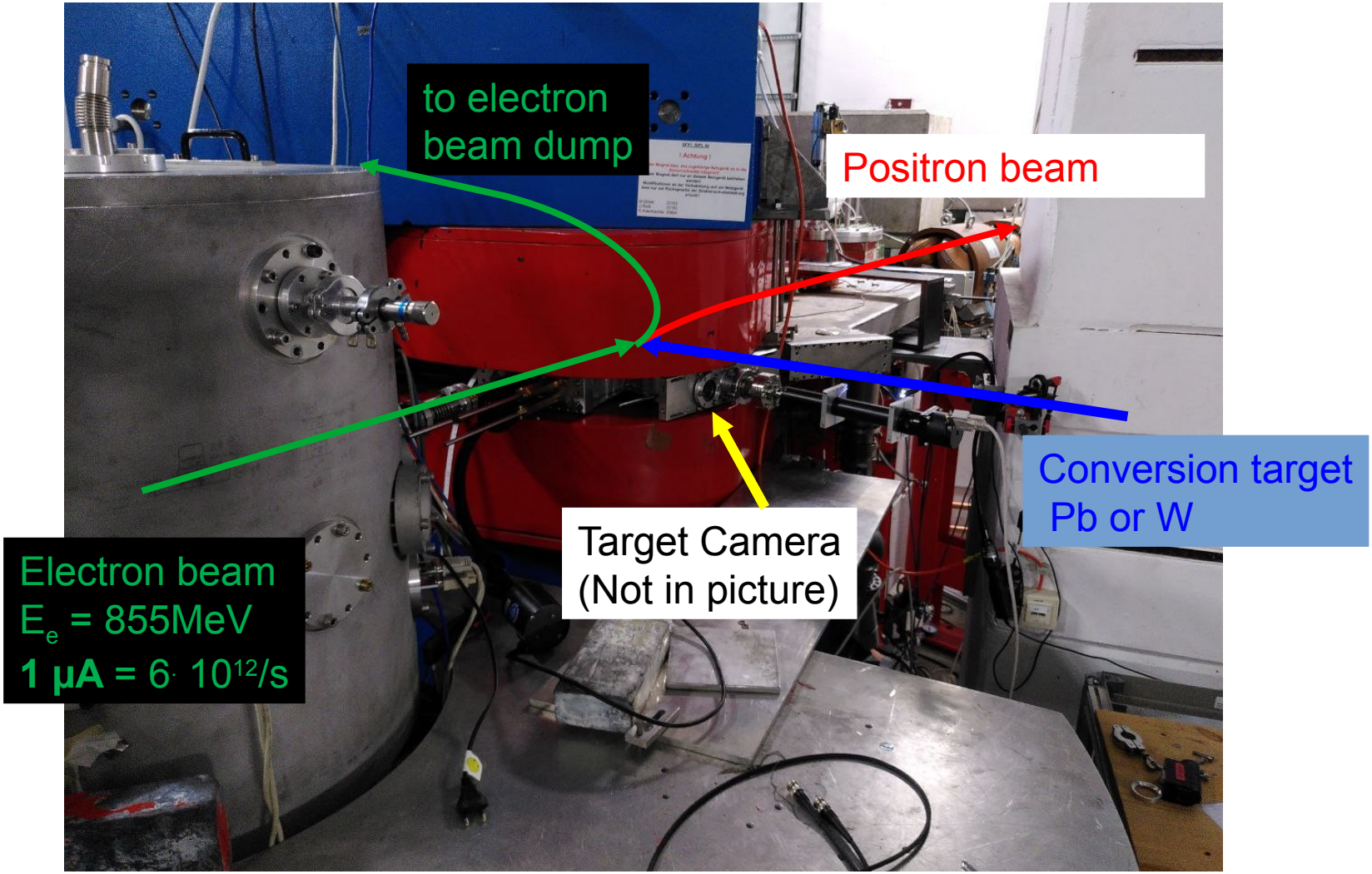
Overview Positron production



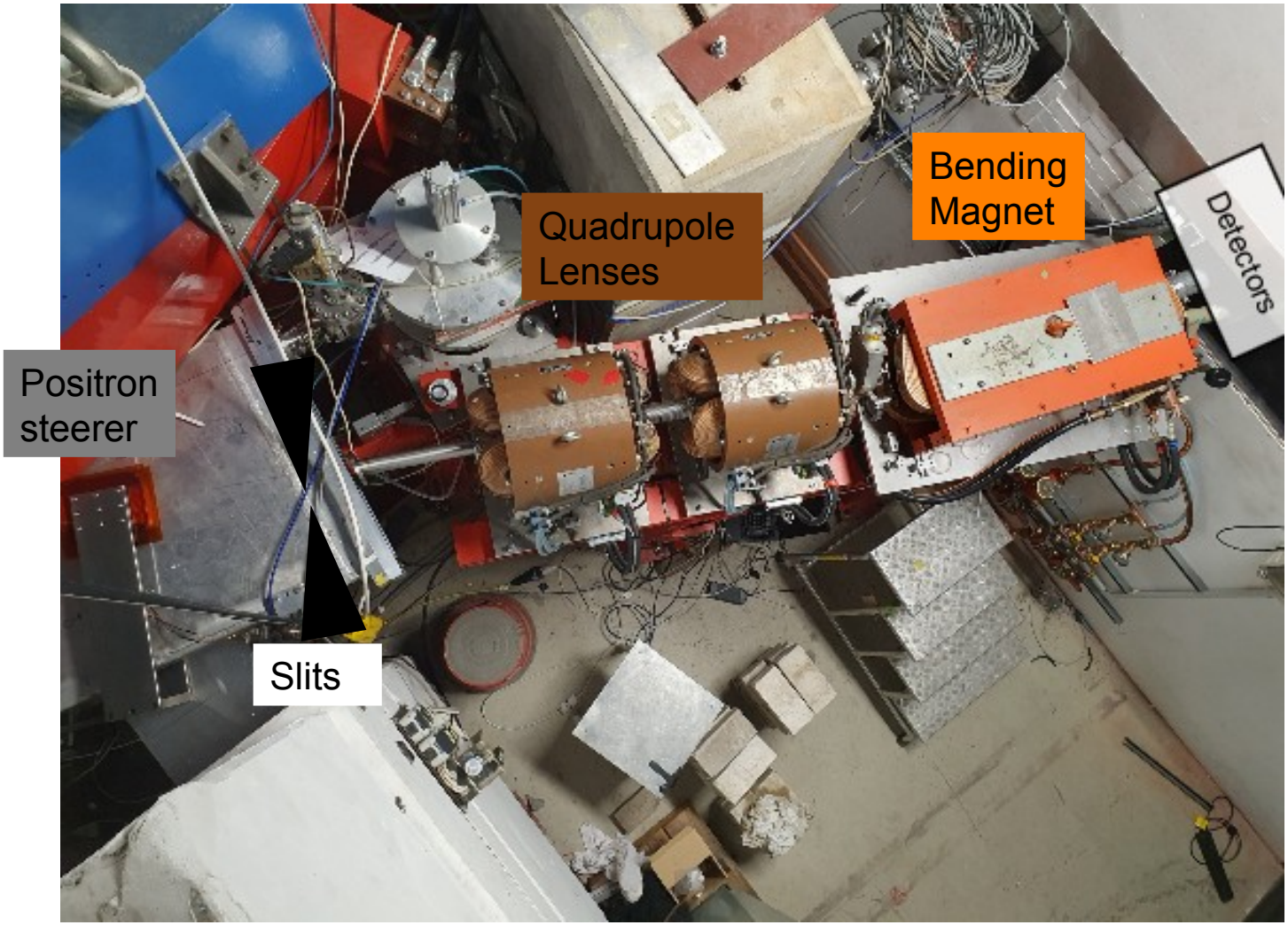
Pair production with the MAMI beam in combination with a monochromator



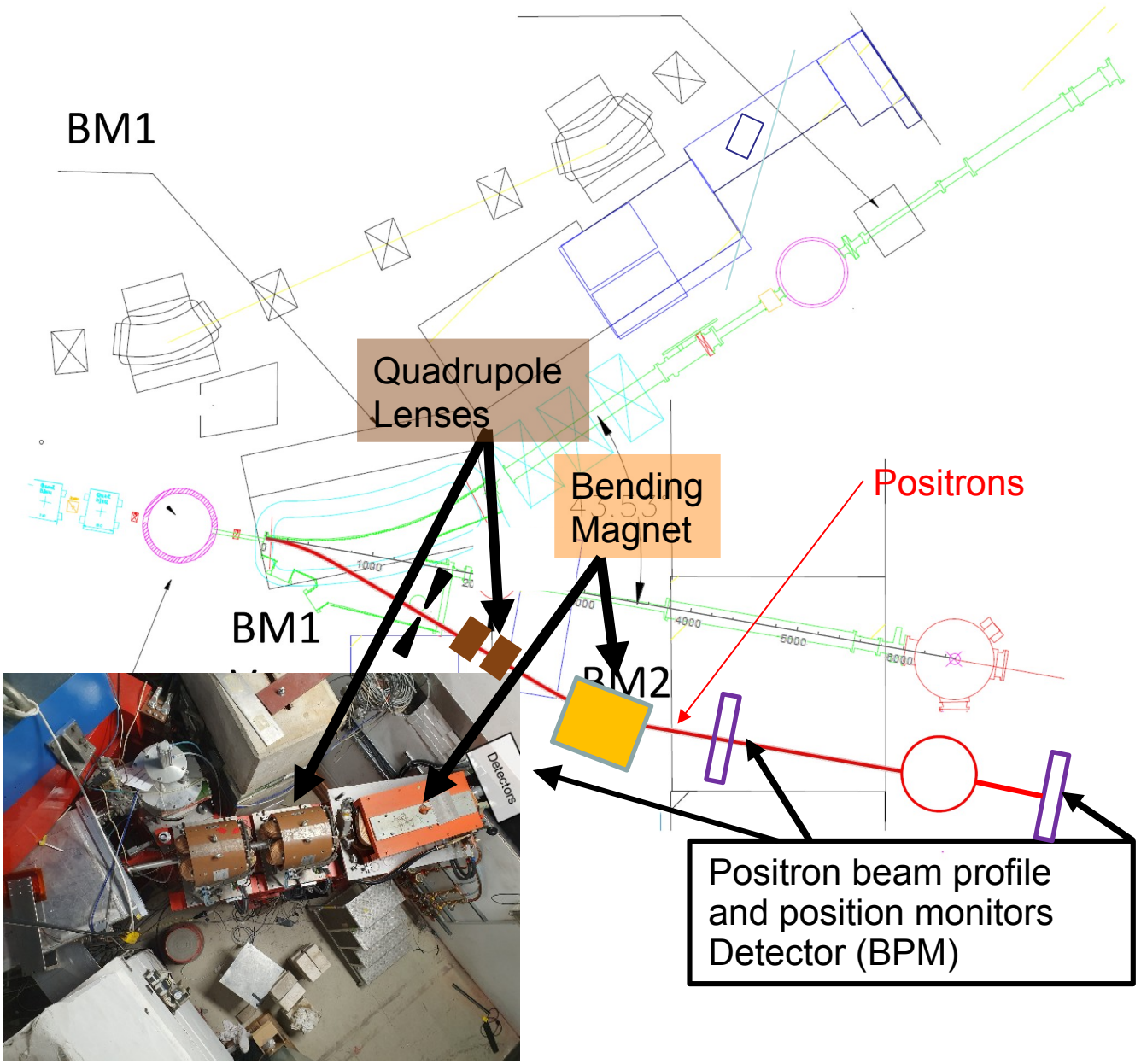
Pair production with the MAMI beam in combination with a monochromator



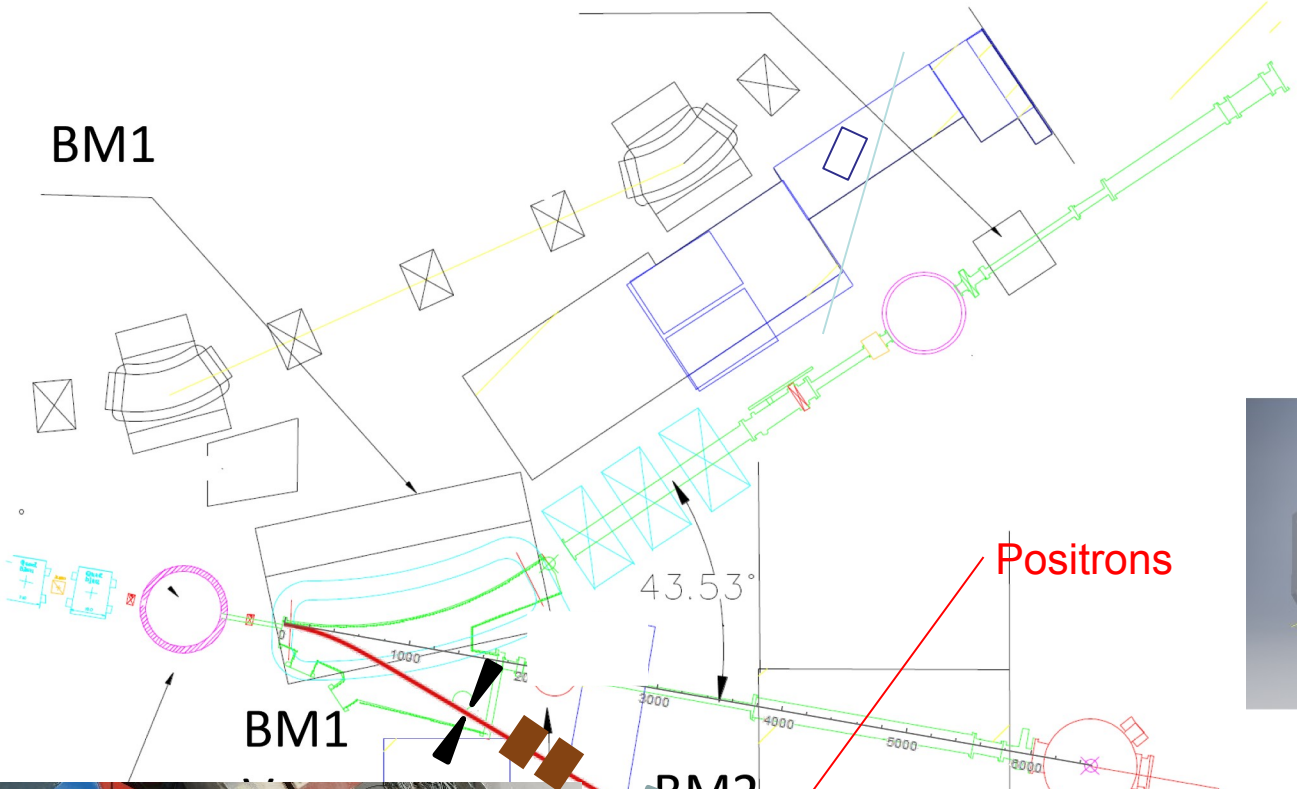
Pair production with the MAMI beam in combination with a monochromator

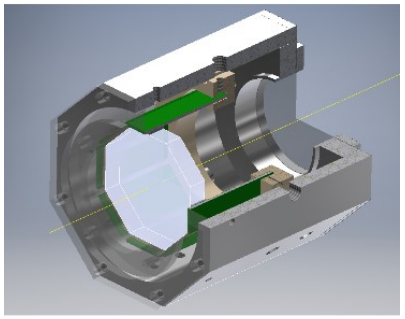


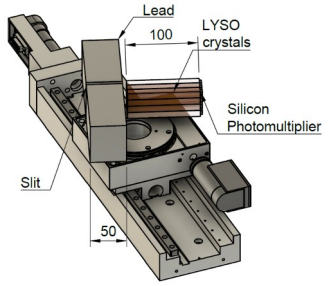
Overview Positron production



Overview Positron production



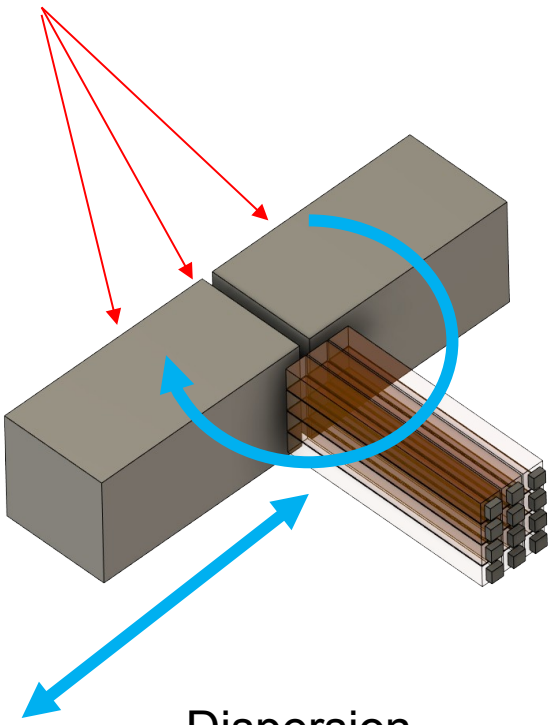




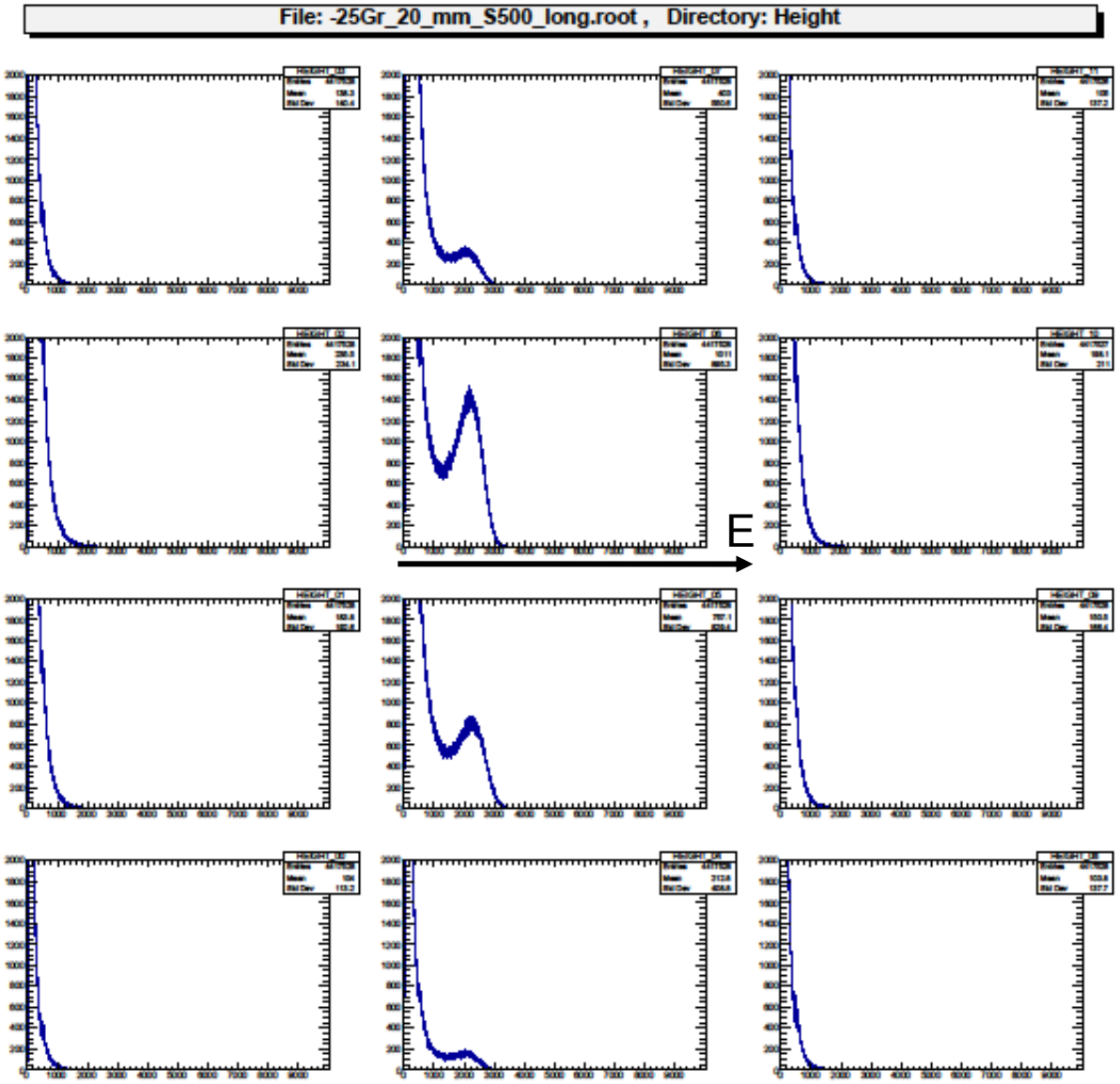
Positron beam profile
and position monitors
Detector (BPM)

Positron Spectra

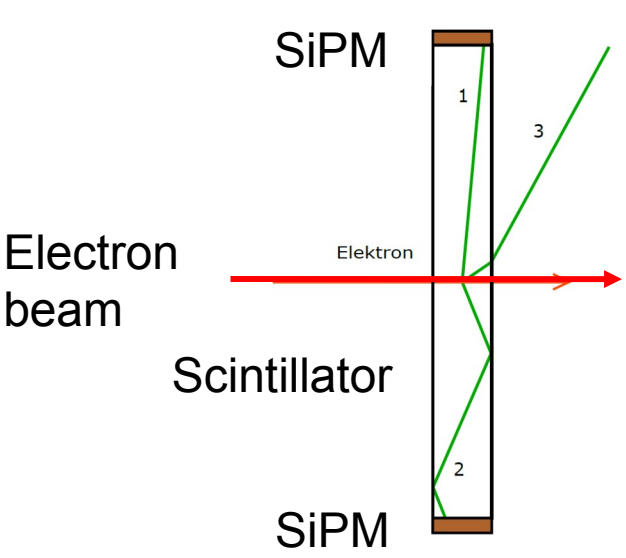
Positrons from
Conversion Target

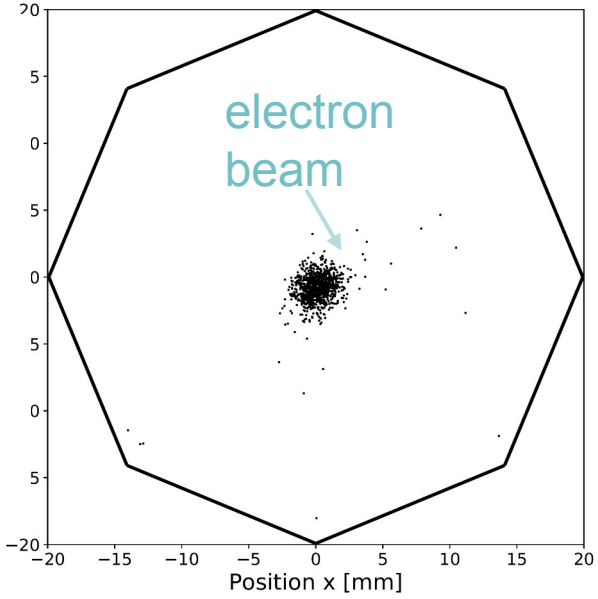


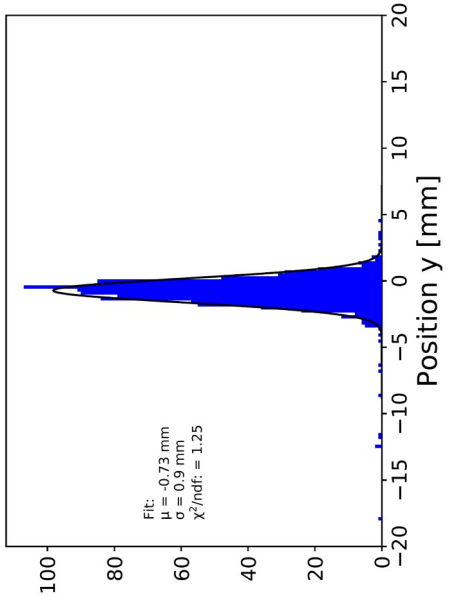
Dispersion
Direction

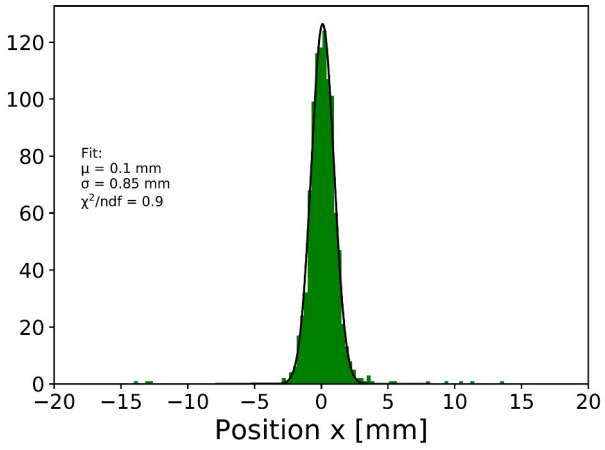


Beam Monitoring



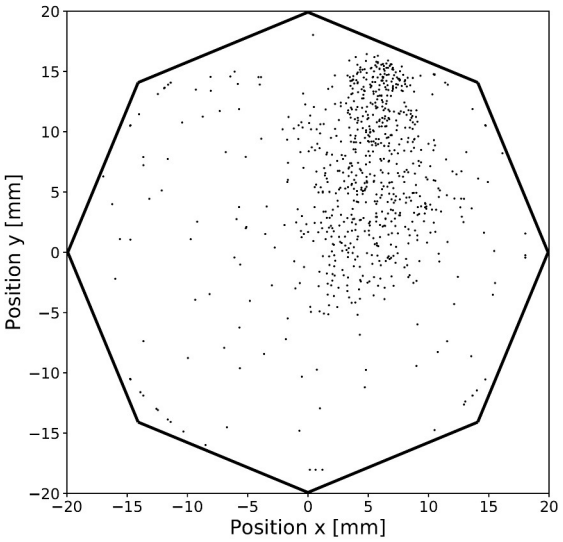




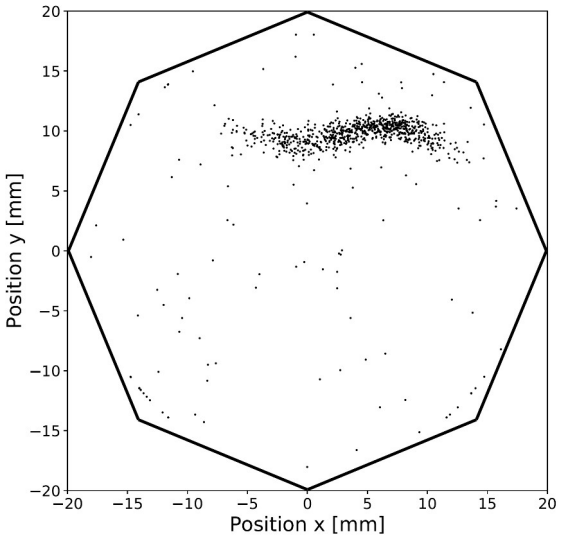


Beam profile measurements
Variation of Quadrupoles

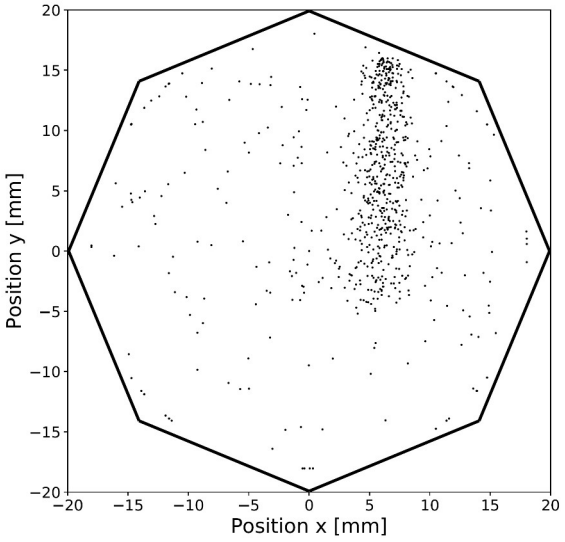
Q1 = 6 A
Q2 = 5 A



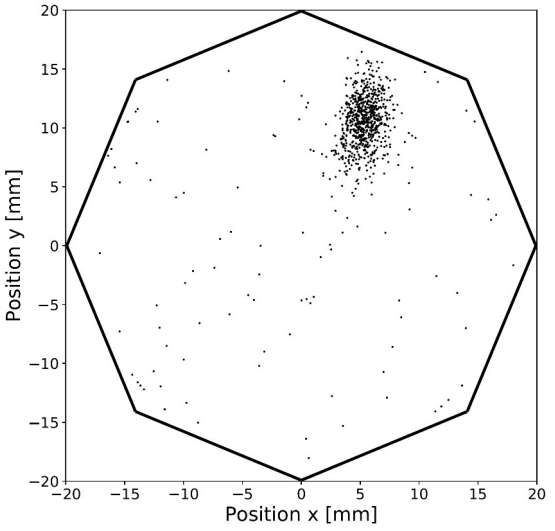
Q1 = 16 A
Q2 = 5 A



Q1 = 2 A
Q2 = 10 A

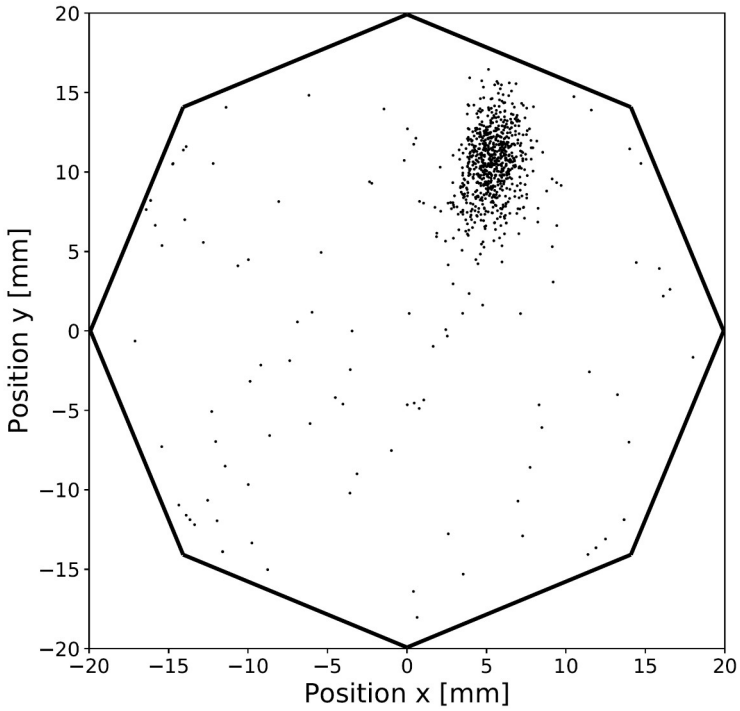


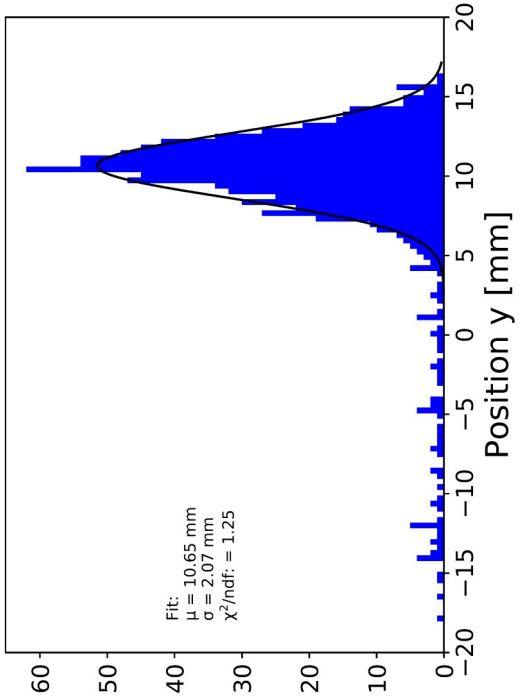
Q1 = 20 A
Q2 = 20 A

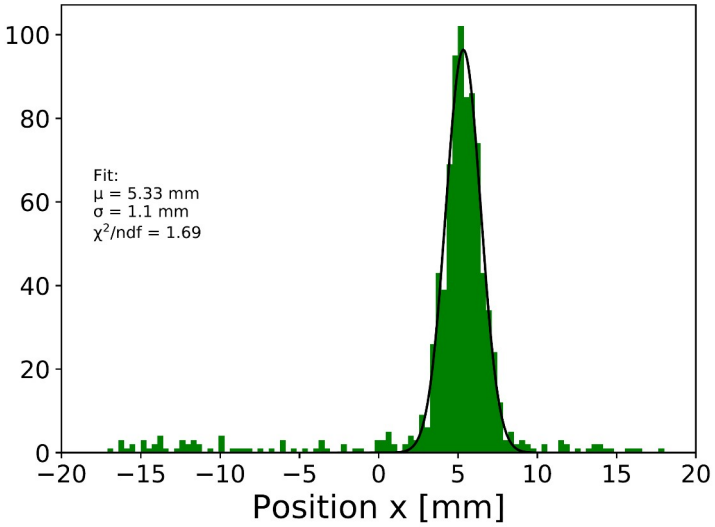


Beam profile measurements

Q1 = 20 A
Q2 = 20 A

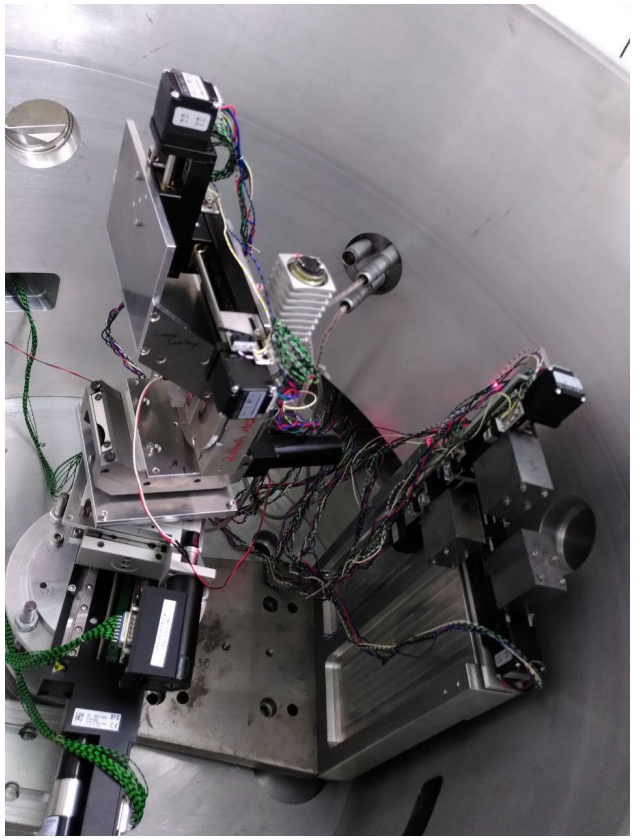


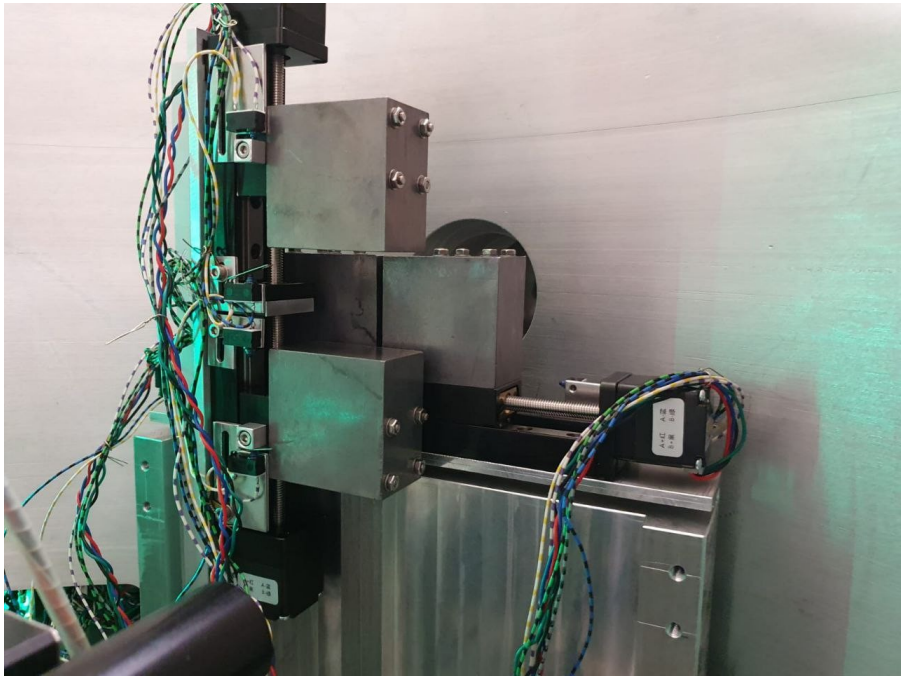




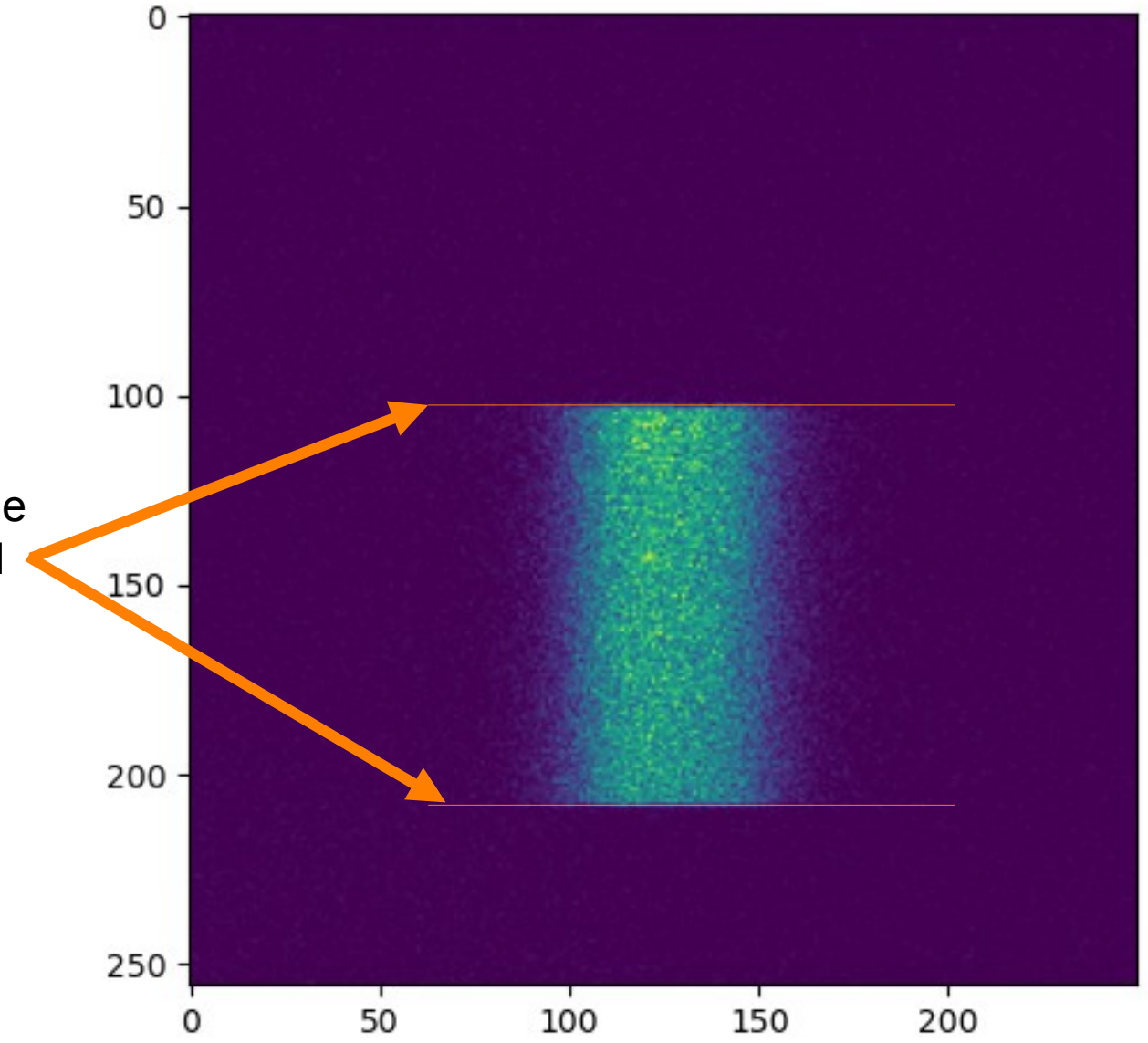
Setting up the crystal chamber and the goniometer

Setting up the crystal chamber and the goniometer



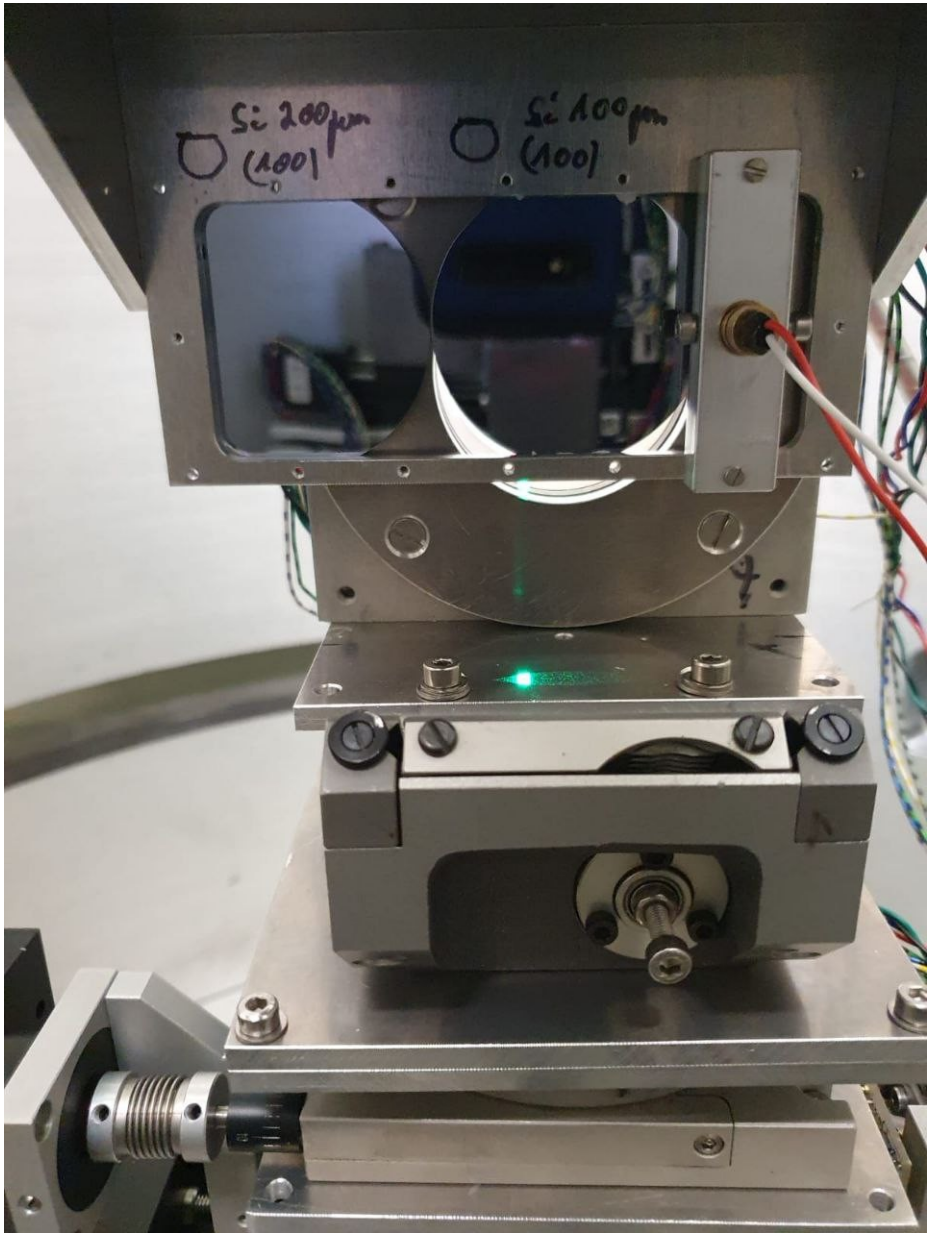


Vignetted positron beam after the chamber

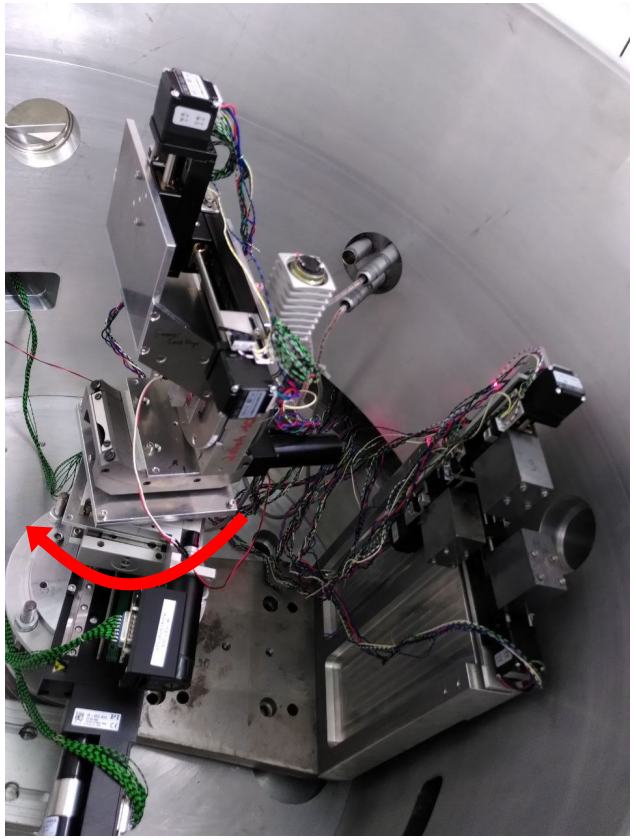


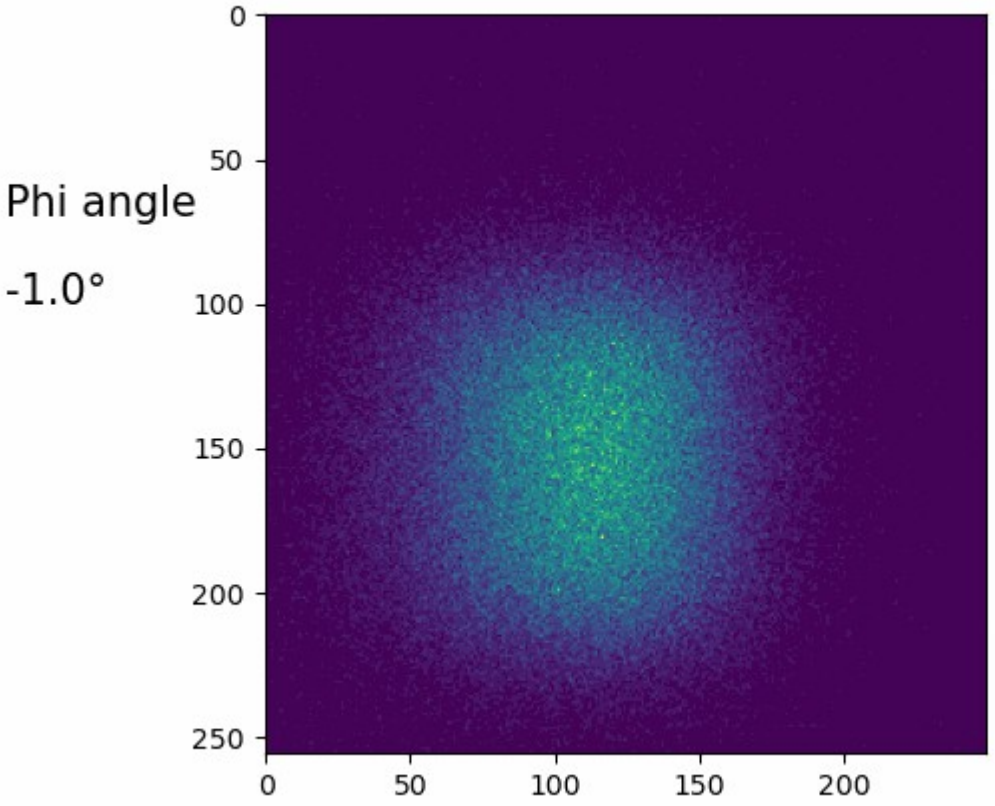
Edges due to vertical aperture

Inserting the Silicon crystals (100)

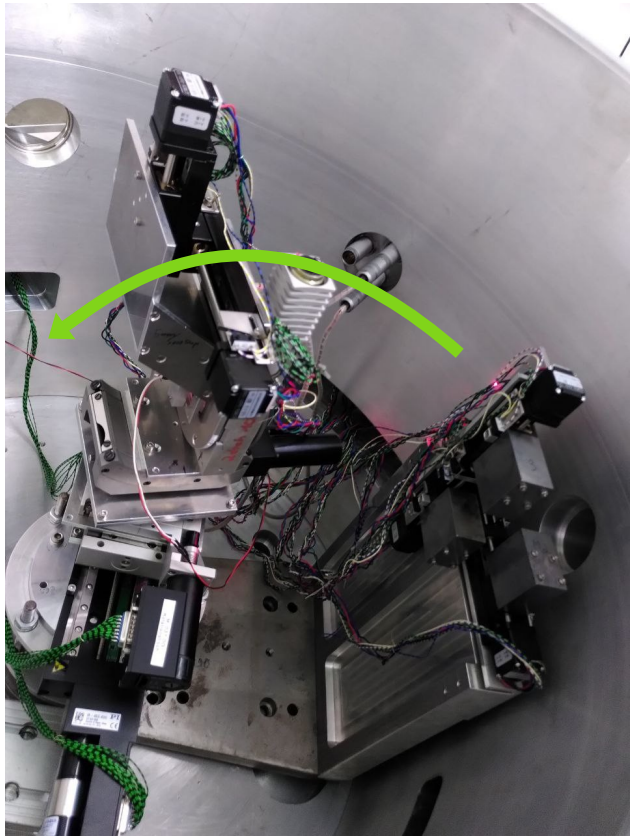


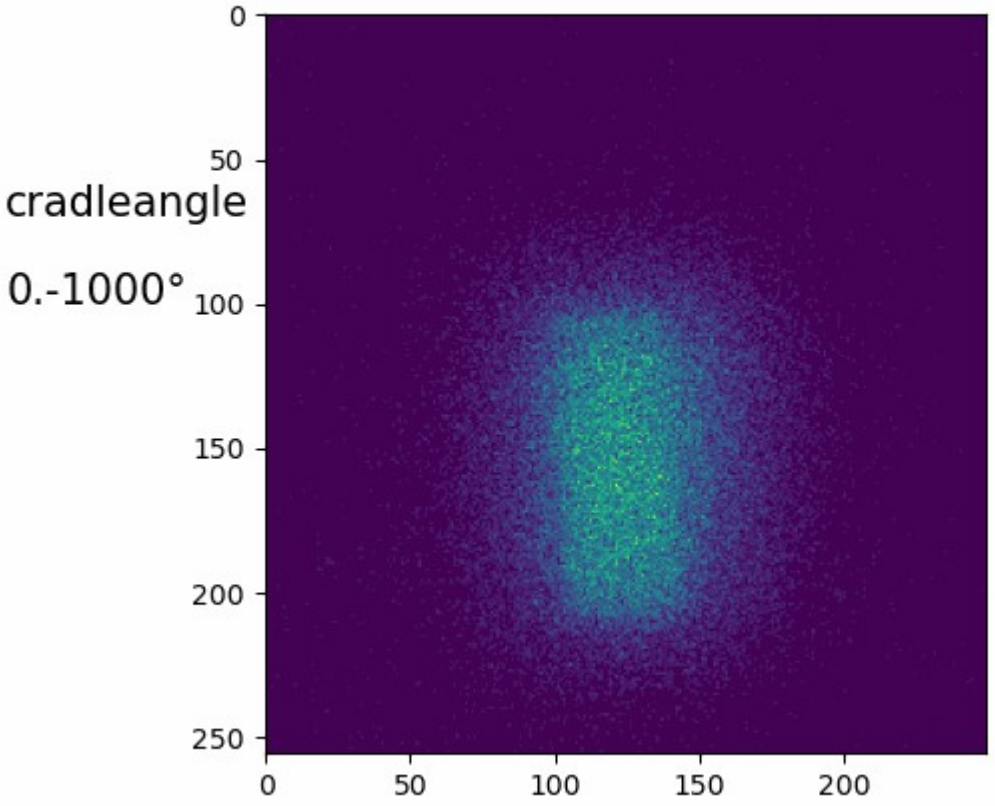
Searching for crystal planes



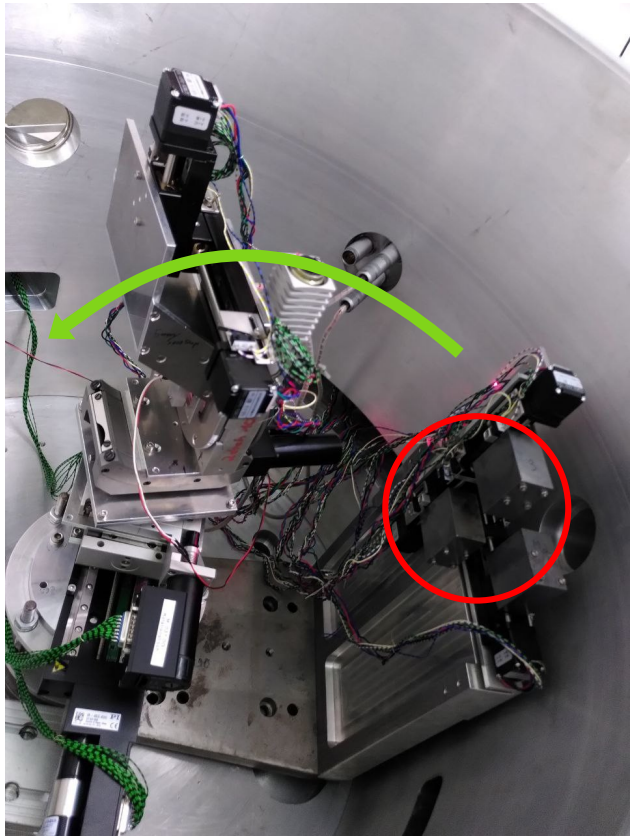


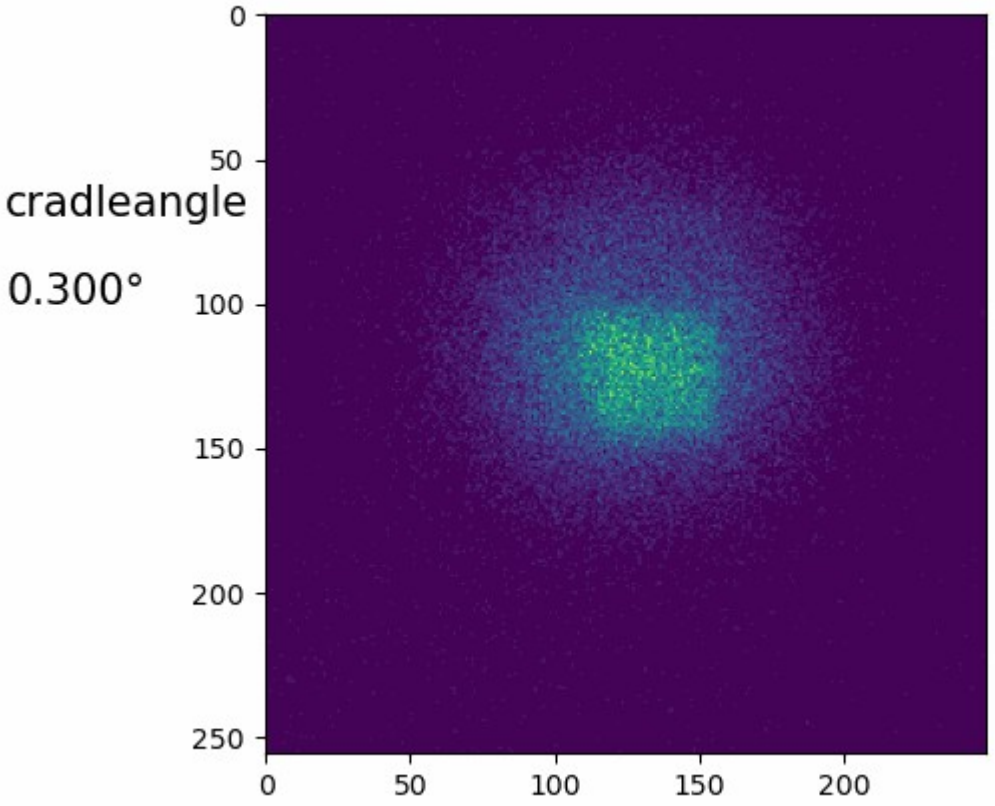
Searching for crystal planes





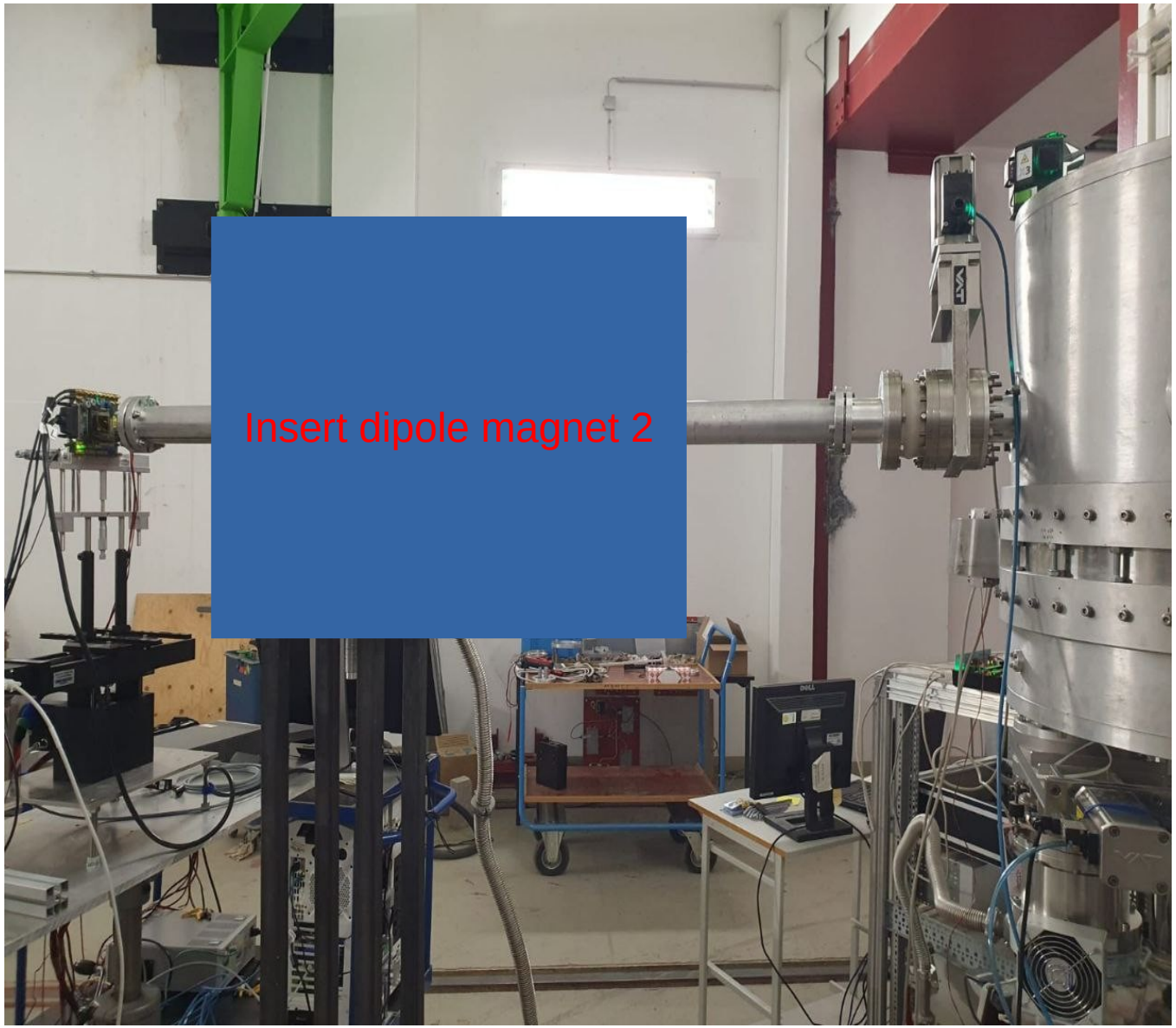
Searching for crystal planes



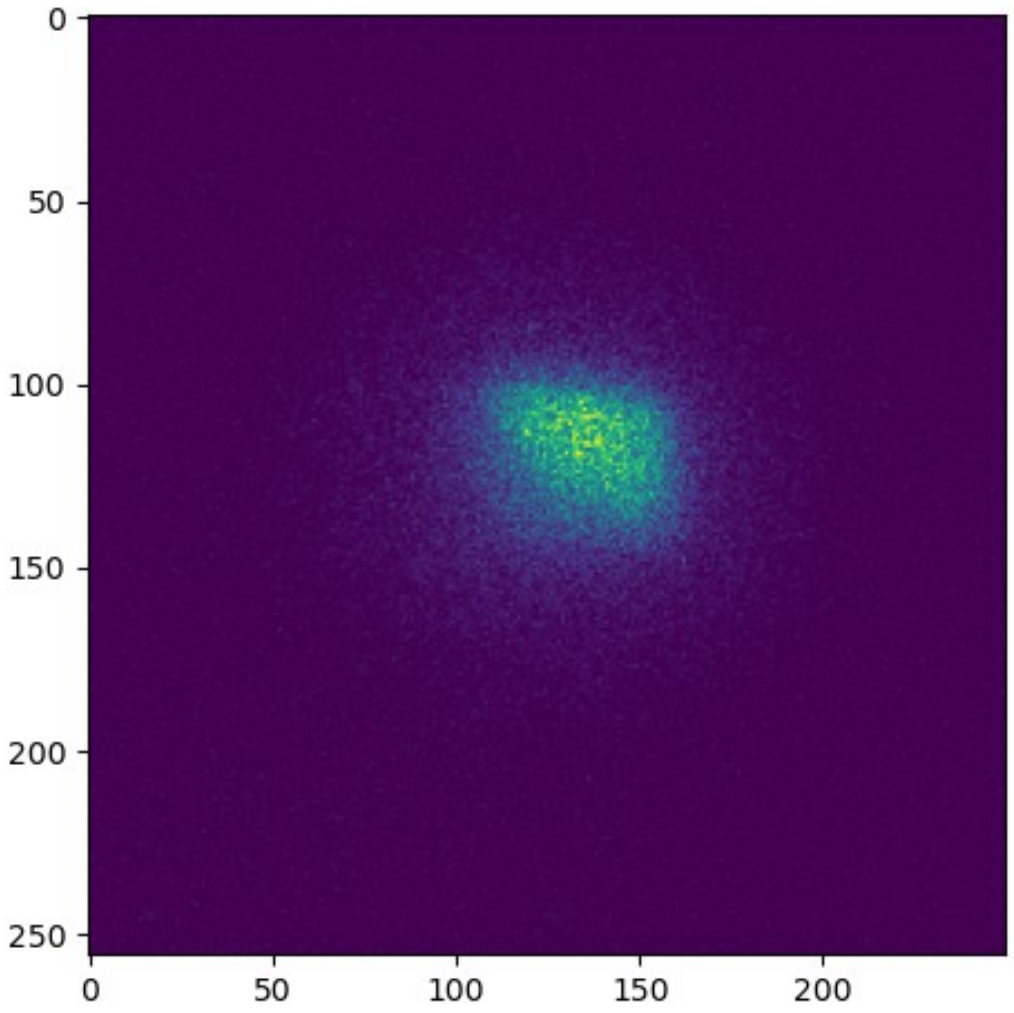


Next steps

Next steps

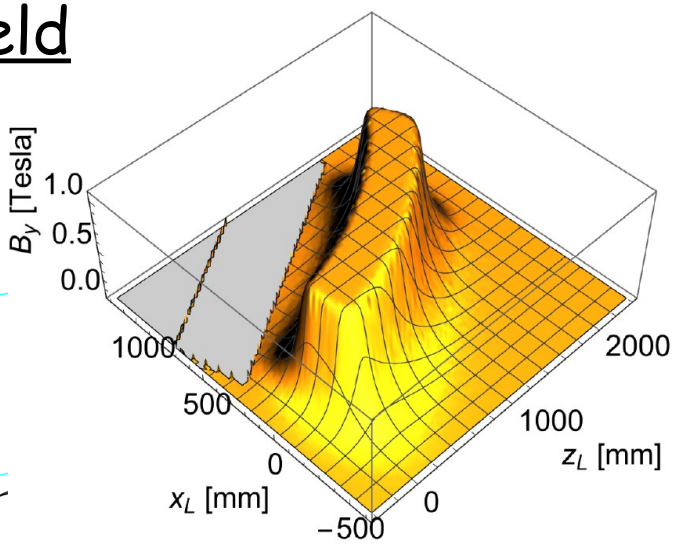


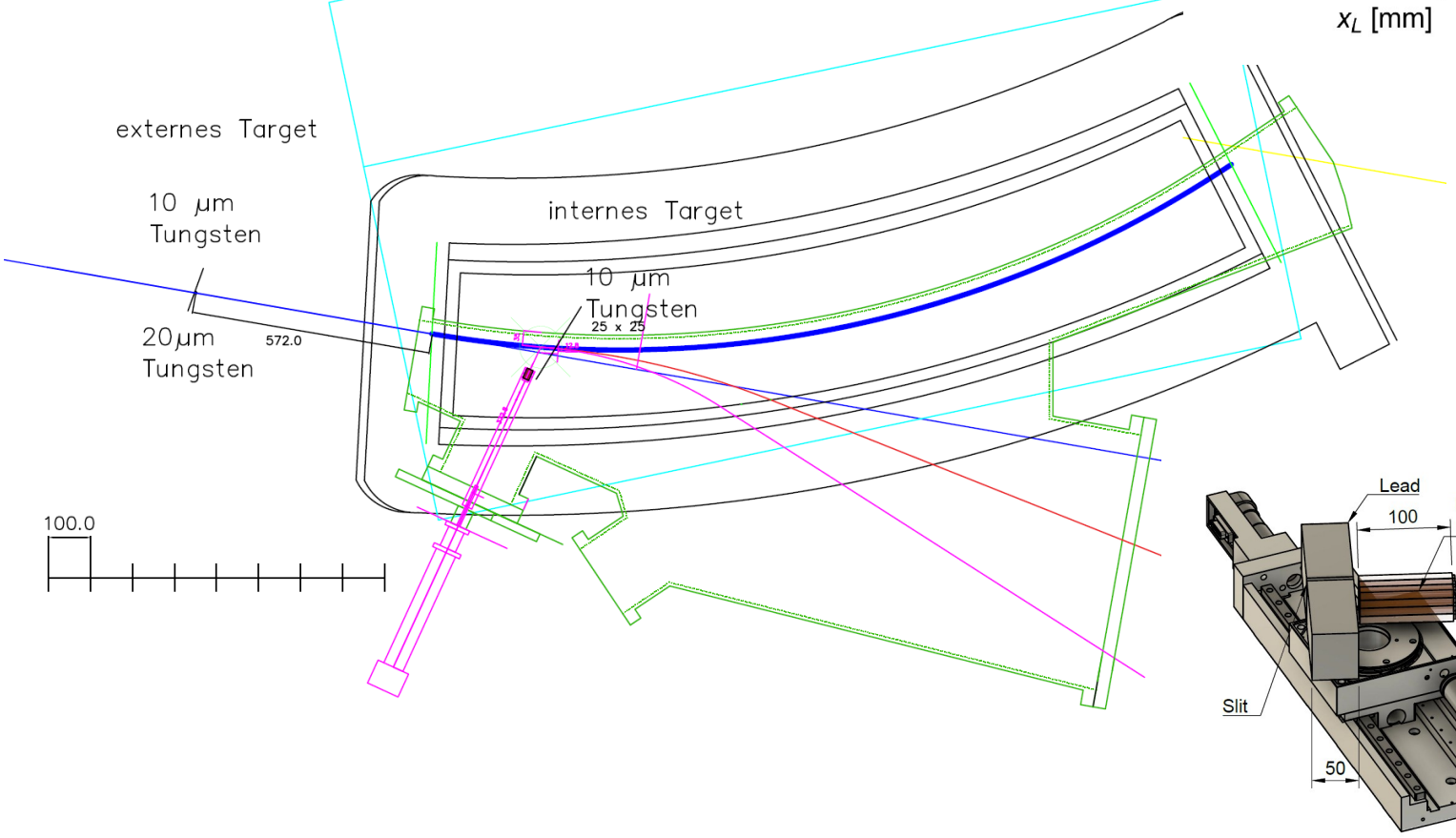
Thank you for your attention



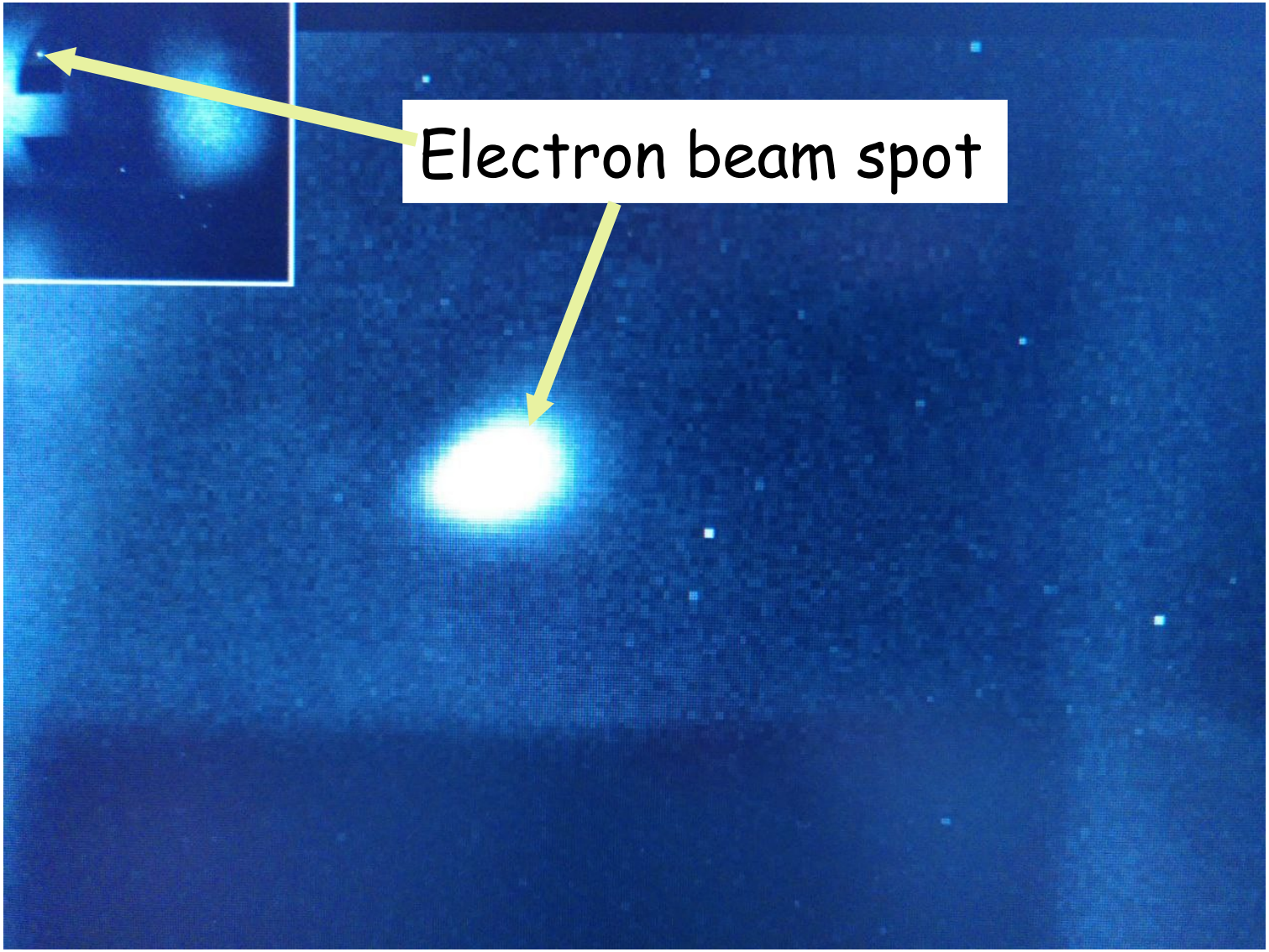
Experimental verification of Positron yield

Calculation and measuring
of the magnetic field of
bending mgnet BM1

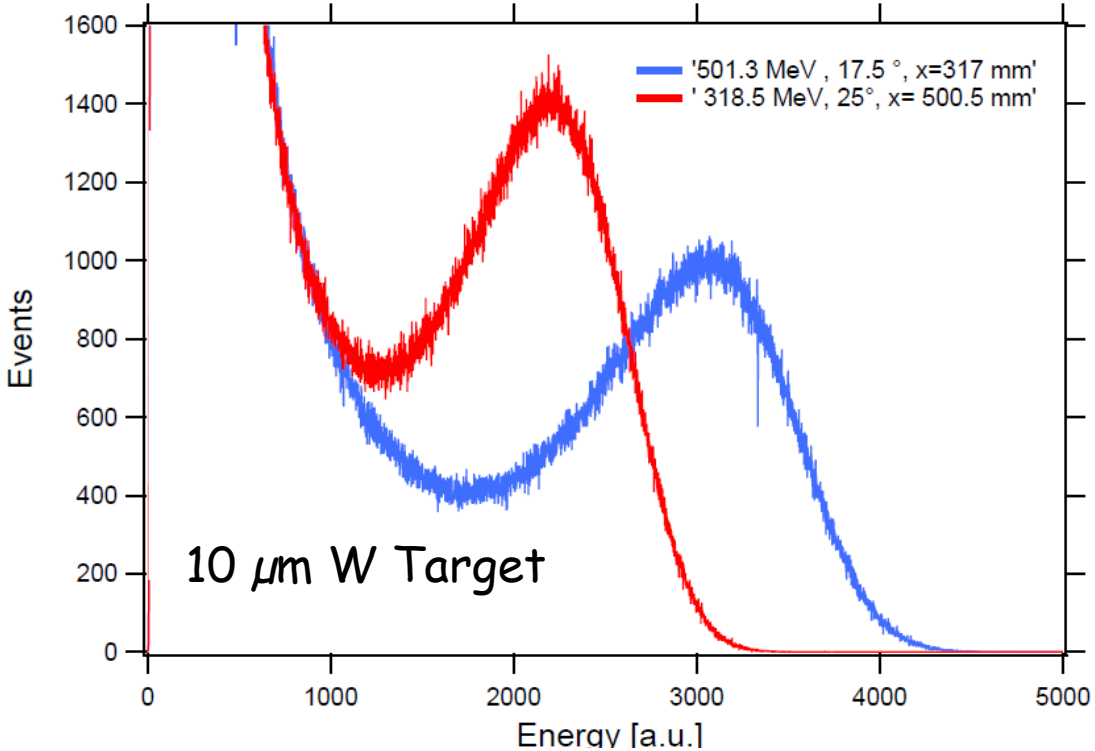




Pair production with the MAMI beam in combination with a monochromator



Energy Spectra

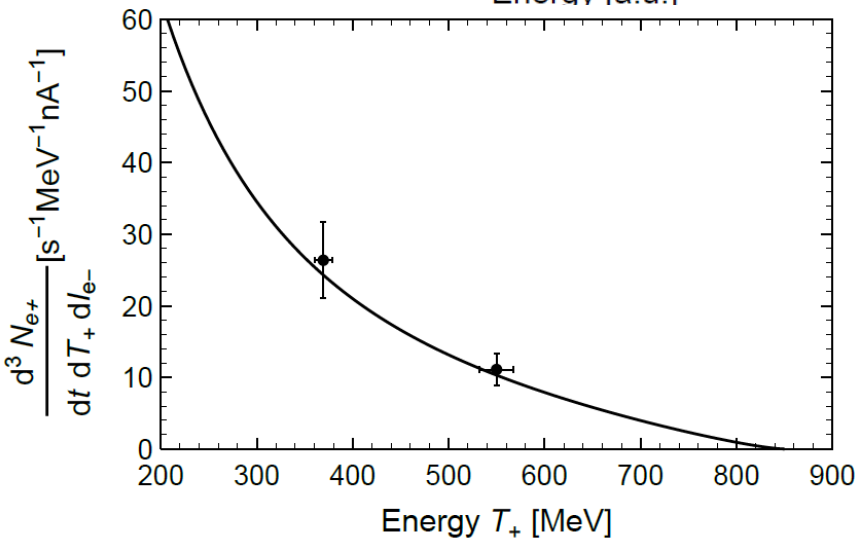


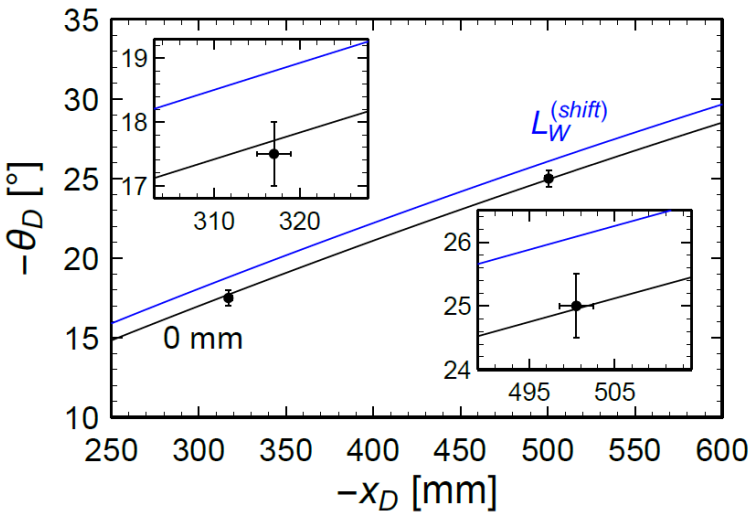
Red: 318.5 MeV

$$32\frac{1}{s\cdot nA\cdot MeV}$$

Blue: 501 MeV

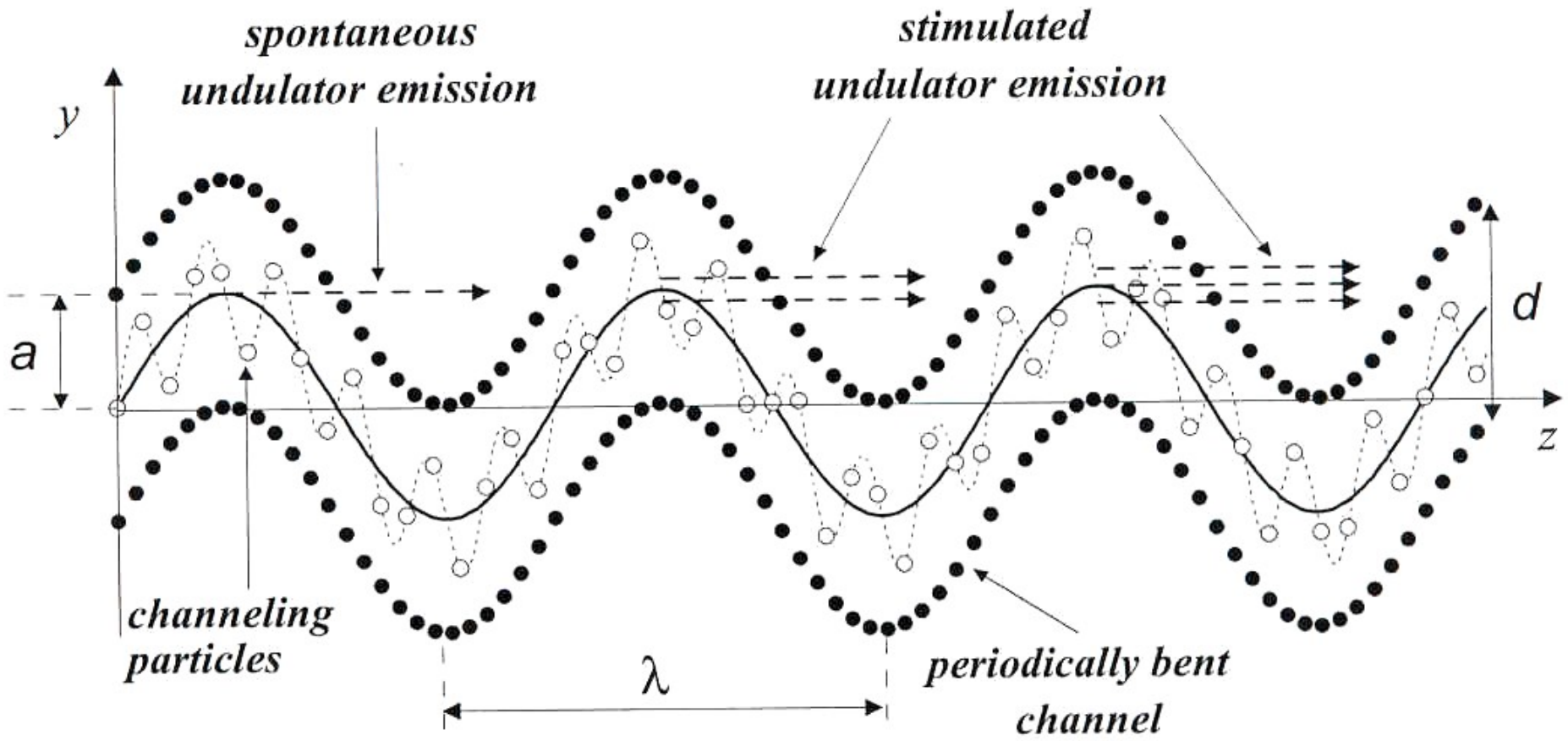
$$10\frac{1}{s\cdot nA\cdot MeV}$$



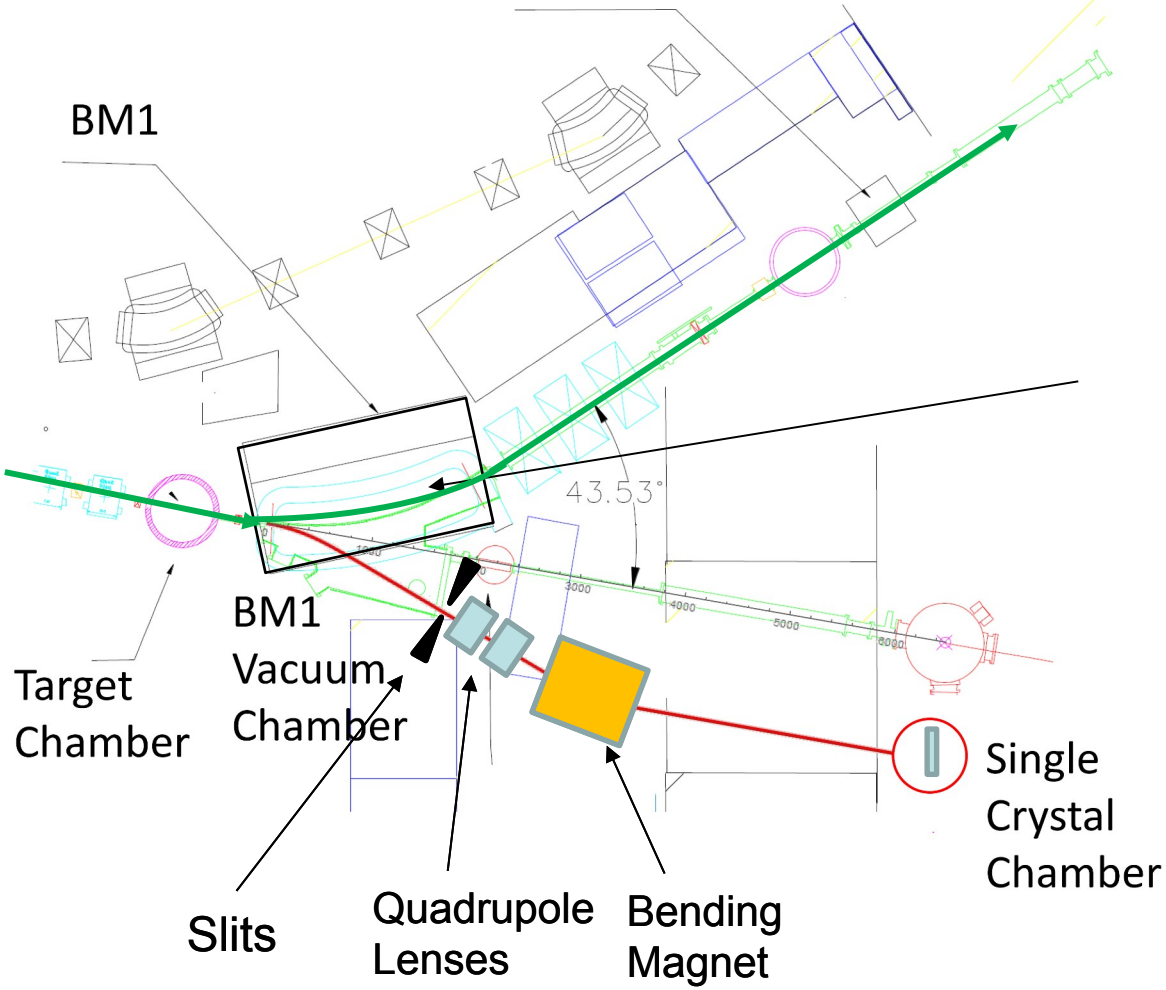


Undulator Radiation at Positron/Electron Channeling in a Single Crystal

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



Beam transport calculations

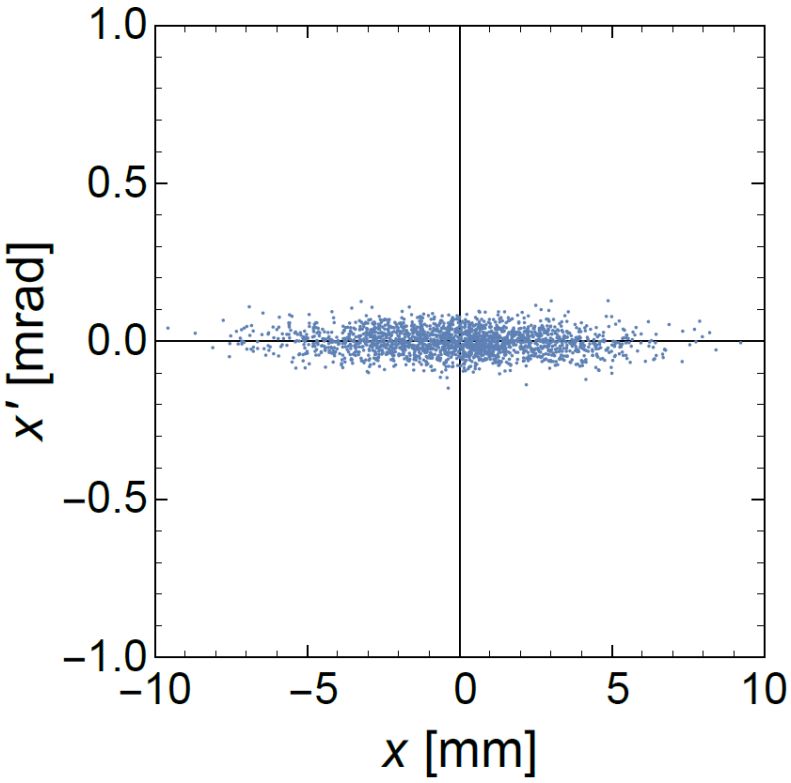


H. Backe et al., Eur. Phys. J. D (2022) 76:150

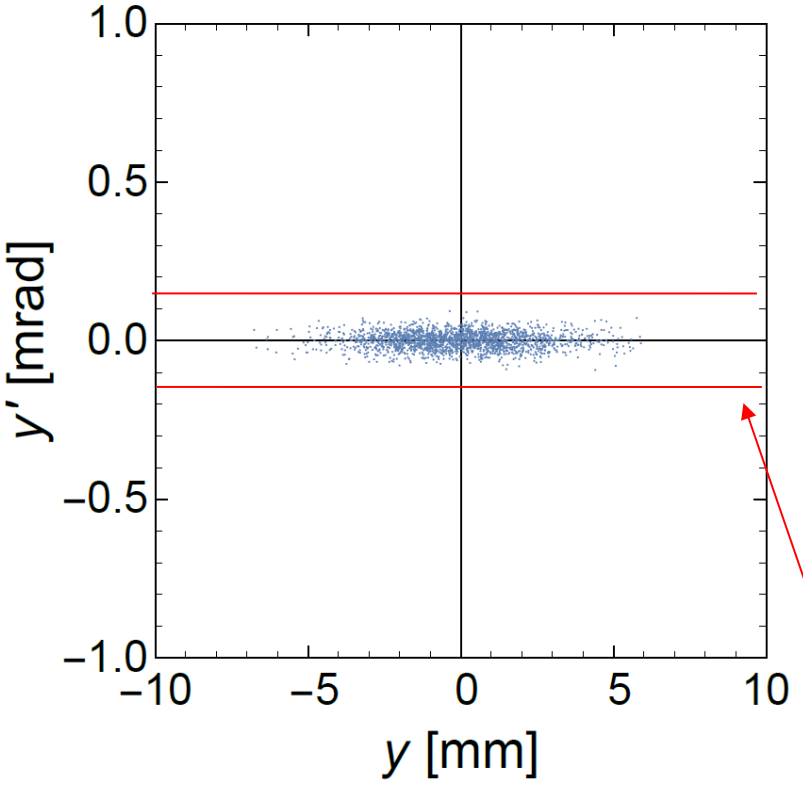
Phase space @crystal chamber

$\Delta \frac{p}{p} = 0$ $\theta Positrons \ \frac{0.8}{\gamma}$ $\frac{\theta Scat}{2} = 0.47\, mrad$ 10 μm W 2000 positrons

Phase space horizontal



Phase space vertical



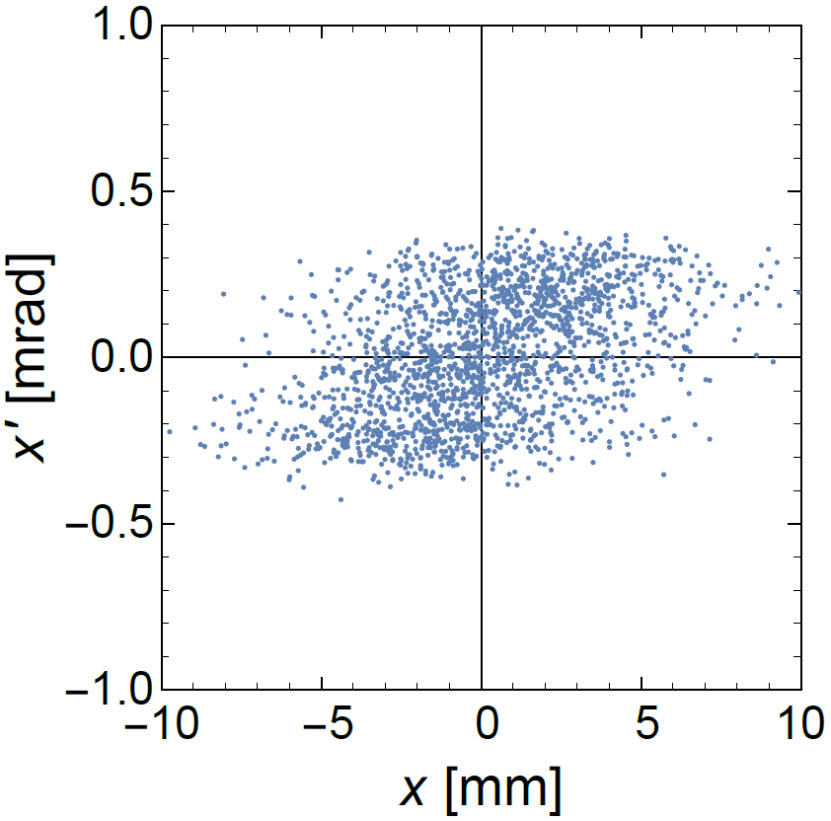
Planar channeling positrons

Phase space @crystal chamber

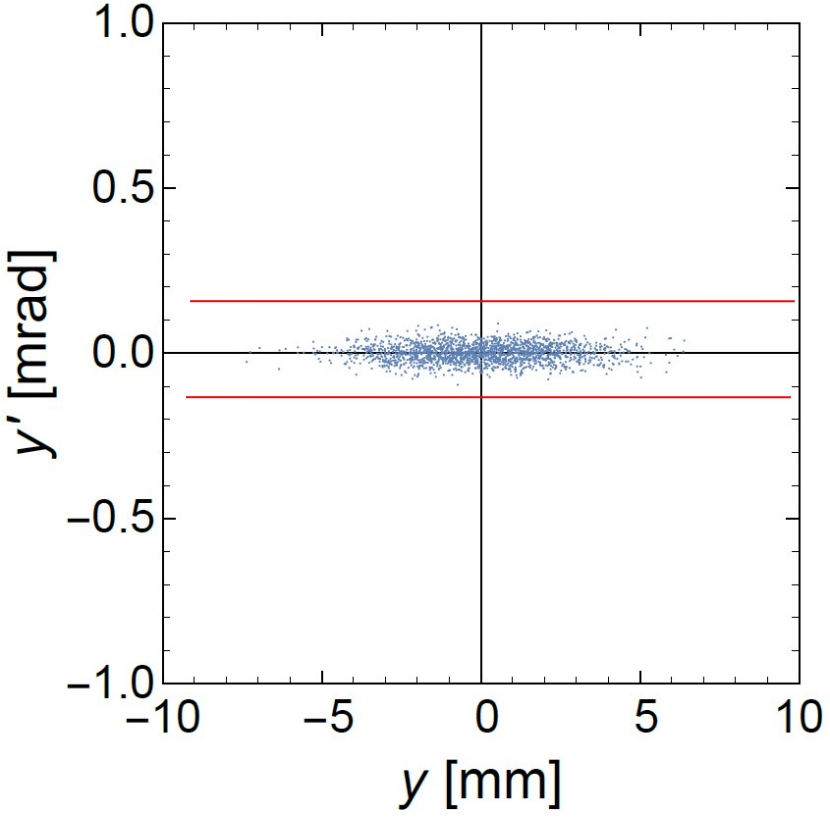
$$\Delta\frac{p}{p} = \pm 0{,}83 \cdot 10^{-3} \langle ¿ \rangle \frac{1\,MeV}{500\,MeV} \qquad \theta\,Positrons\ \frac{0.8}{\gamma} \qquad \frac{\theta\,Scat}{2} = 0.47\,mrad$$

10 μm W

Phase space horizontal



Phase space vertical

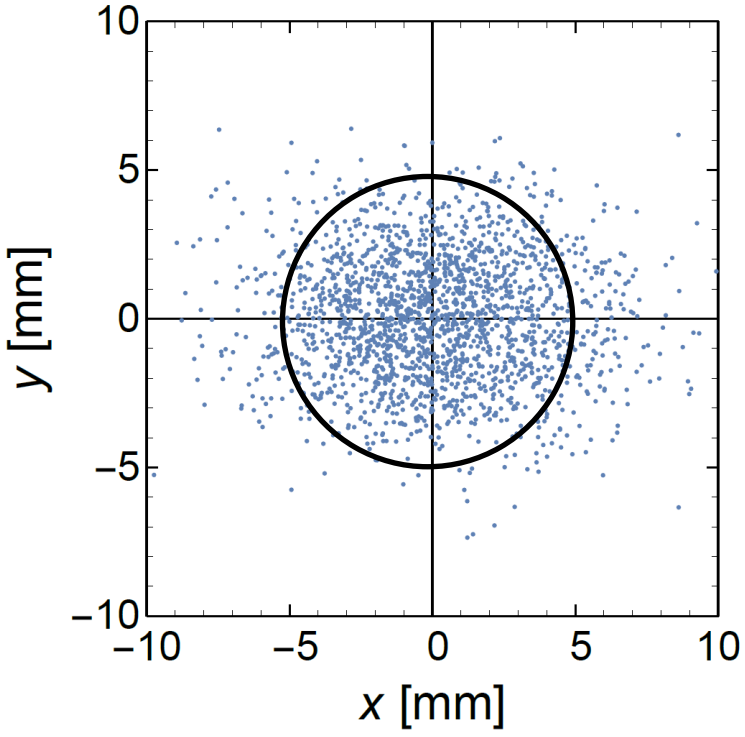


2000 positrons

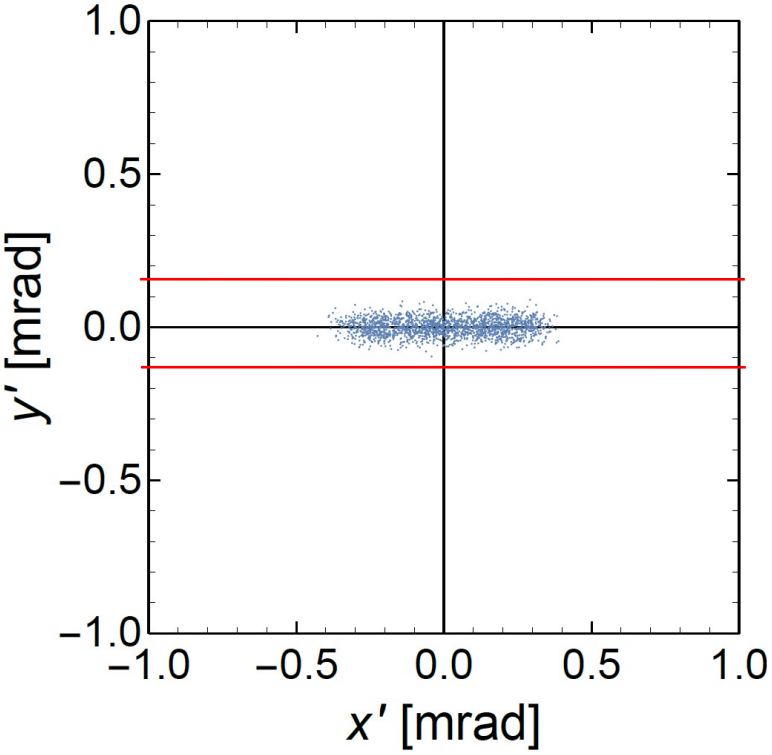
Beam spot size and divergence @crystal chamber

$\Delta \frac{p}{p} = \pm 0{,}83 \cdot 10^{-3} \langle ¿ \rangle \frac{1\ MeV}{500\ MeV}$ $\theta Positrons \frac{0.8}{\gamma}$ $\frac{\theta Scat}{2} = 0.47\ mrad$ 10 μm W

Beam spot size



Divergence



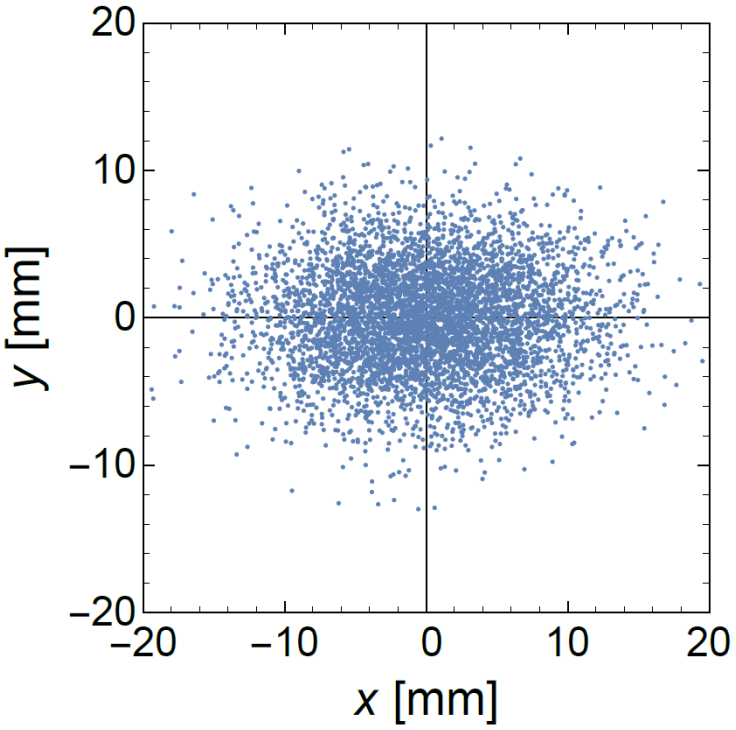
85% accepted in a diameter of 10 mm

Beam spot size and divergence @crystal chamber

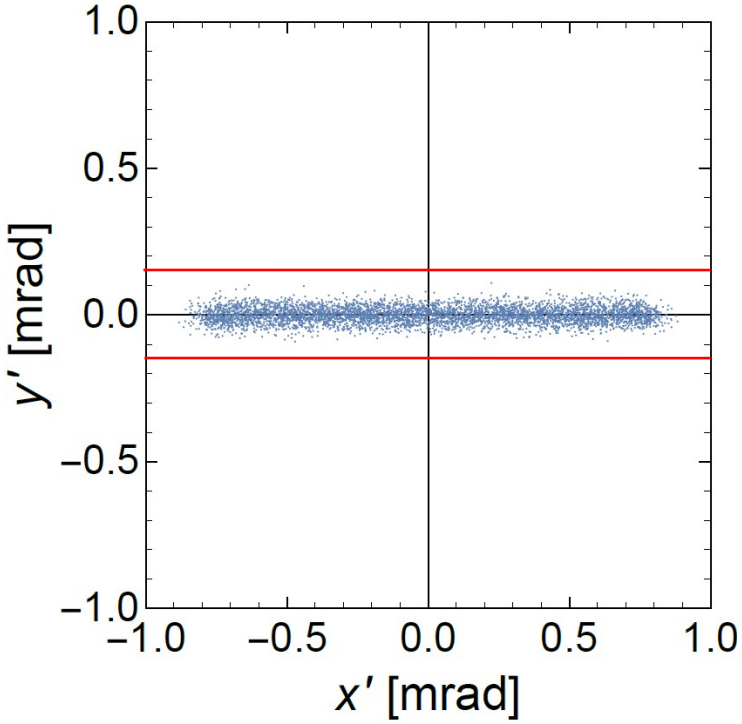
$$\Delta\frac{p}{p} = \pm 0{,}83 \cdot 10^{-3} \langle ¿ \rangle \frac{1\ MeV}{500\ MeV} \qquad \theta\ Positrons\ \frac{0.8}{\gamma} \qquad \frac{\theta\ Scat}{2} = 0.47\ mrad$$

50 µm W

Beam spot size

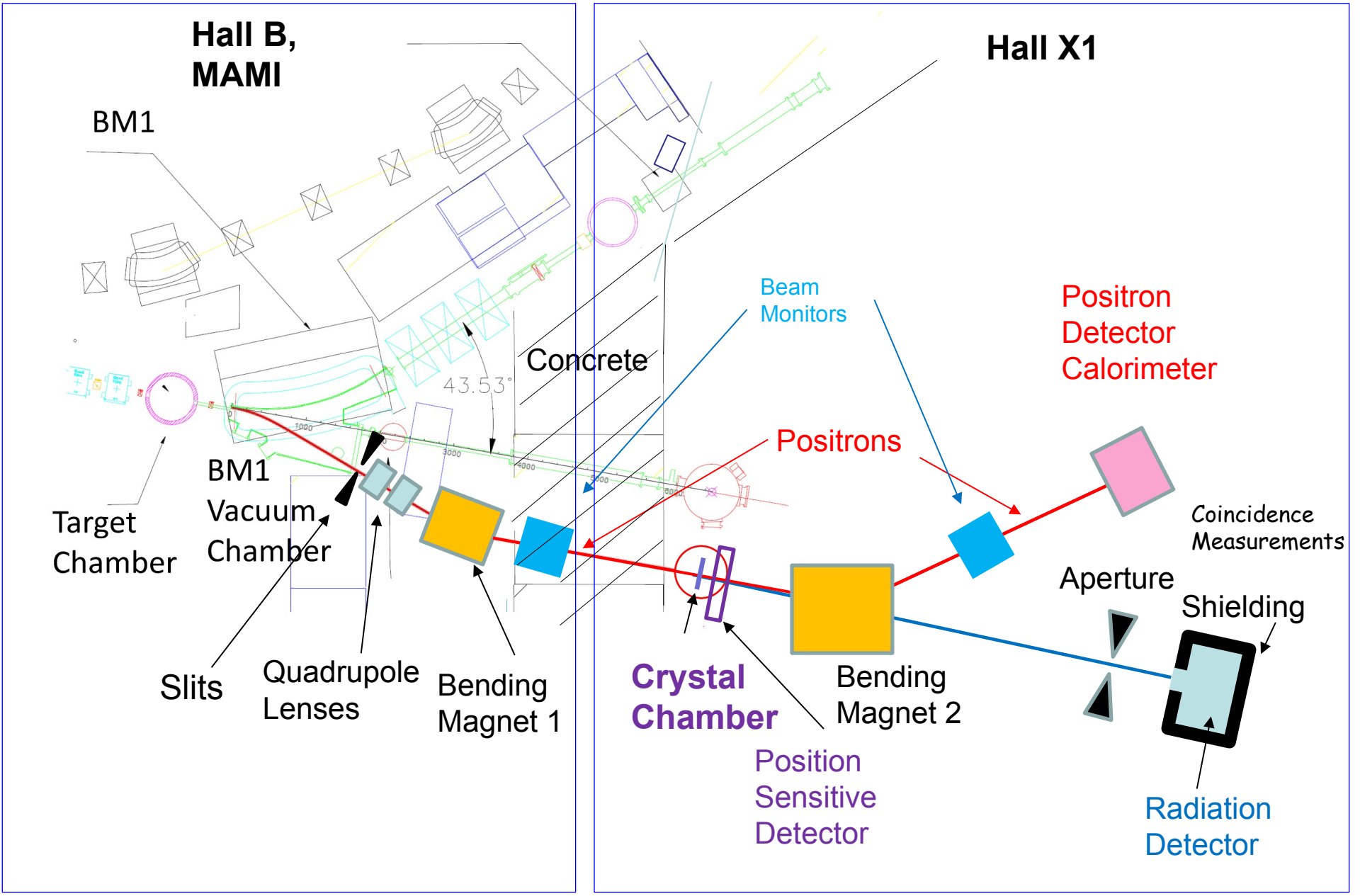


Divergence



Thickness variation of W-Target (<50µm) no influence on the angular distribution
Significant on the beam spot size
Limit for maximum electron beam current is ~ 1 - 2 µA

Overview Positron production



Next Steps

- Optimization calculation for the beam spot size
- Alignment of the beam line
- Test of a position sensitive detector
  (MuPix HV-MAPS chip, 80μm resolution, 100μm thickness, 1 x 2 cm^2)
- Design of the magnet 2
- Background measurements in hall X1 @ high e^- beam current
- Installation of the crystal chamber and rest of the beam line

Conclusion and Outlook

First planned experiments with positrons

- Channeling radiation, thickness variation
- Dechanneling length, transition rates
- Undulator radiation, (old crystals)
- Deflection in bent crystals ('Ferrara setup')

Calculations with realistic beam parameters for these experiments are in progress (H. Backe)

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