NMX Key Technical Choices – Meeting Requirements

EUROPEAN SPALLATION SOURCE

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NMX Tollgate 2 Review

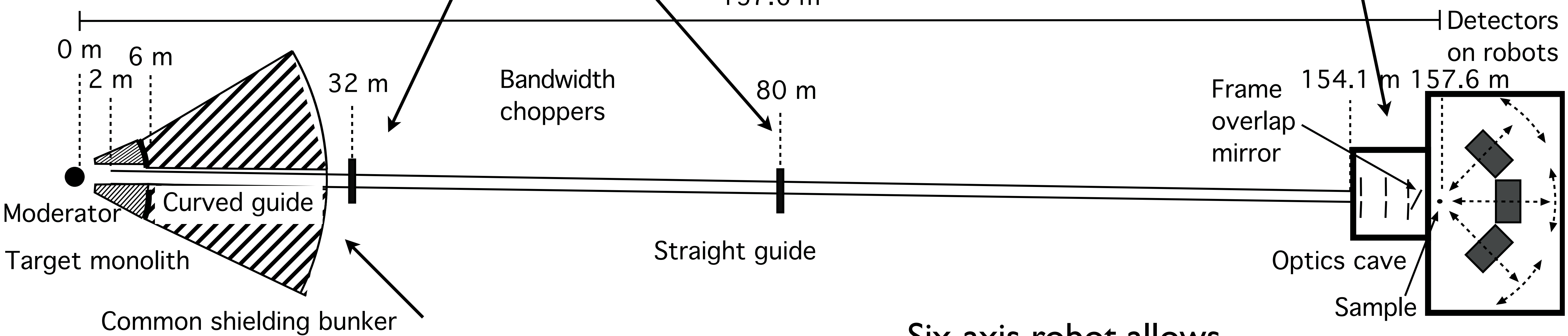
2014-12-11

NMX – A quasi-Laue time-of-flight diffractometer with high **q**-resolution

Adjustable opening chopper allows flexible bandwidth selection.

Collimation section giving flexibility in beam size and divergence

Cold moderator



1.74 Å wavelength band (1.8-3.55 Å)

m=1 is sufficient on three sides, m=2.2 for curving

Six-axis robot allows selecting crystal orientation

Three 60 x 60 cm detectors with 0.2 mm spatial resolution
Variable sample-detector distance (0.2-1.0 m)
Variable 2θ angle (0-110°)

- Match beam size to sample size (max 5 x 5 mm)
- Match beam divergence to sample mosaicity (max. ±0.2°)
- Maximize (useful) flux at sample!

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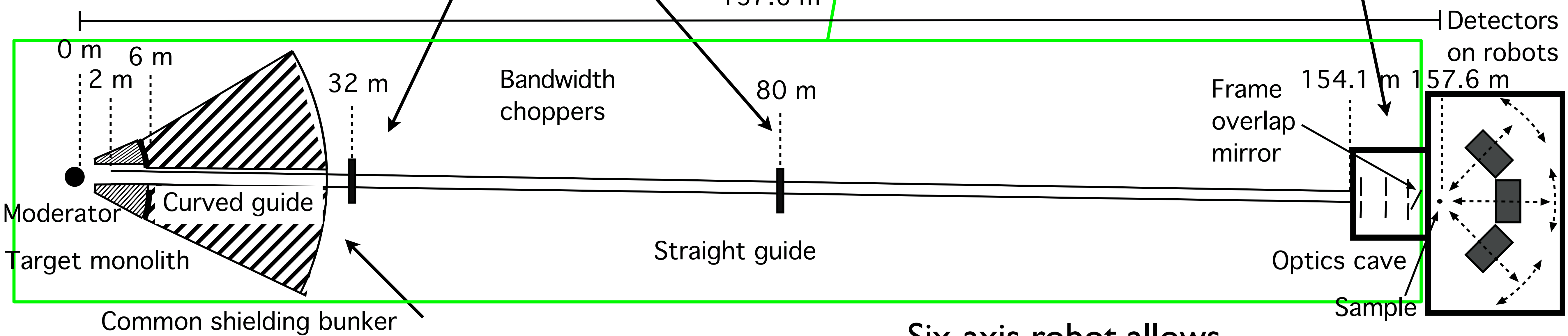

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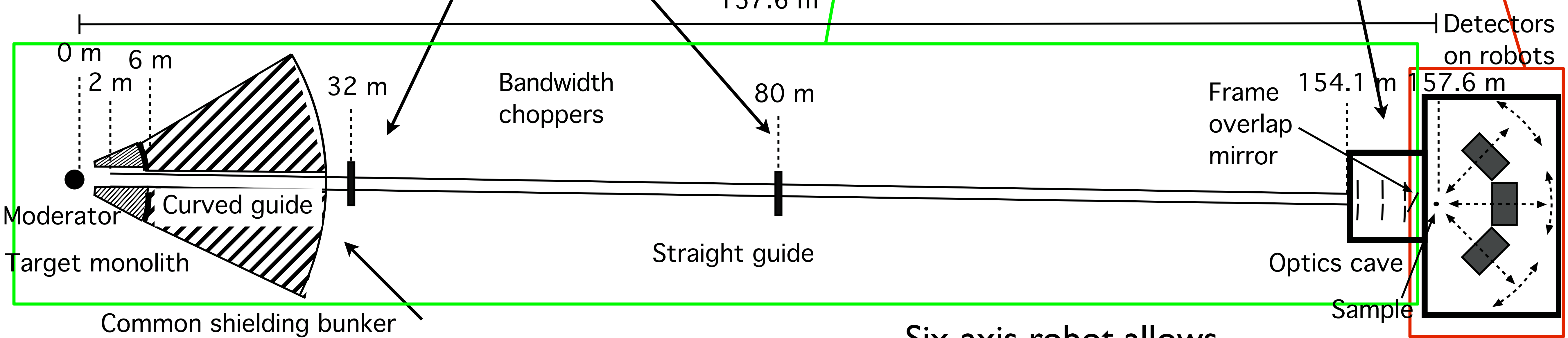

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BTS Subsystem Requirements

Functional requirements

1. Wavelength resolution

1.1. The BTS shall transport from the moderator a beam of neutrons to the sample at a distance that leads to a maximal wavelength uncertainty of 5% ($\Delta\lambda/\lambda$) for the detected neutrons using the full ESS pulse

1.2. Rationale: A moderate wavelength resolution allows the full pulse to be used while conserving the advantage of TOF for the S/B (see 13.6.4 (5))

1.3. Verification: Measurement of the pulse length at sample

2. Beam size

2.1. The BTS shall transport from the moderator to the sample a beam of neutrons with maximum size (full width half maximum) of 5 ± 0.1 mm and minimum size of 0.2 ± 0.02 mm.

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→ ±0.1 K temperature stability

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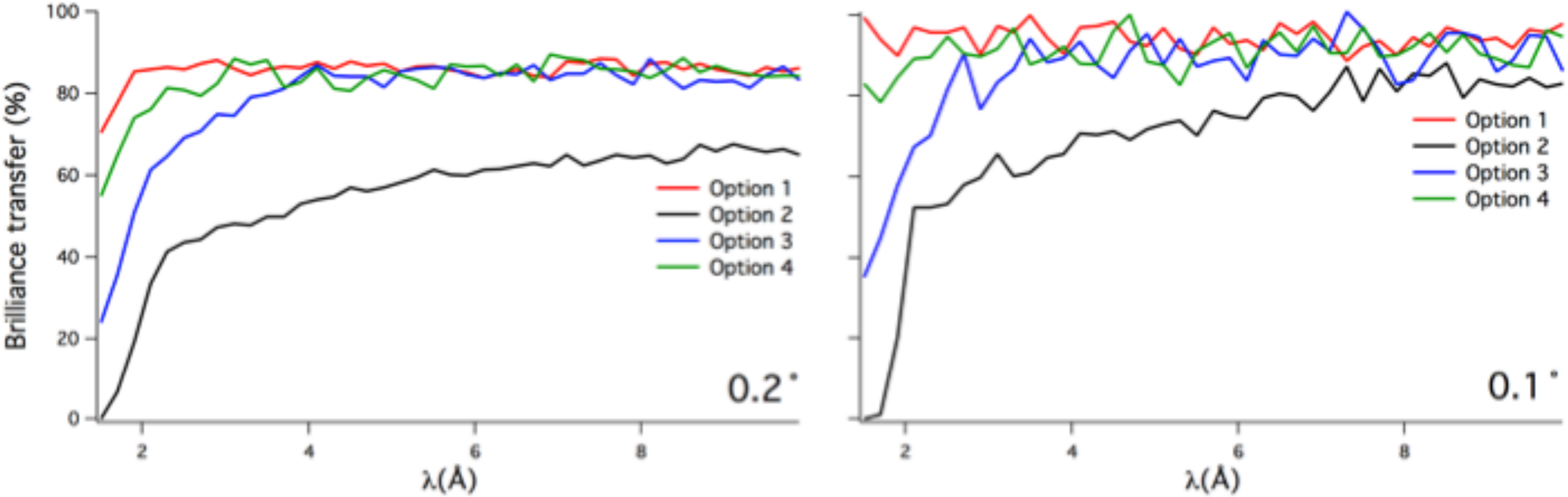
Optics options – performance

Damian Martin Rodriguez



Option 1: Curved in all the guide length

Option 2: Double Bounce mirror

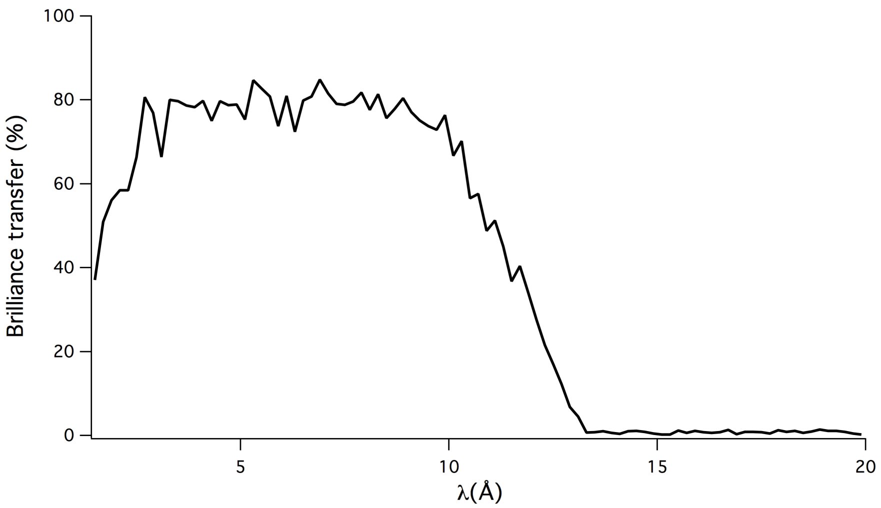
Option 3: Curved inside the bunker

Option 4: Curved inside bunker, optimised for maximum brilliance transfer at 2Å

Optics overview

Damian Martin Rodriguez

Curved inside bunker, optimised for maximum brilliance transfer at 2Å



- Monolith insert horizontally straight, vertically tapers from 31 mm to 46 mm, m =2 horizontal, m = 1 vertical
- 1.2 km curvature radius within bunker
- m = 2.2 on the curve, otherwise m = 1
- Line of sight lost at 31.5 m from the moderator
- Straight guide up to 154.1 m from the moderator, m = 1
- Frame overlap mirror for λ > 10 Å

Optics concept choice – pros

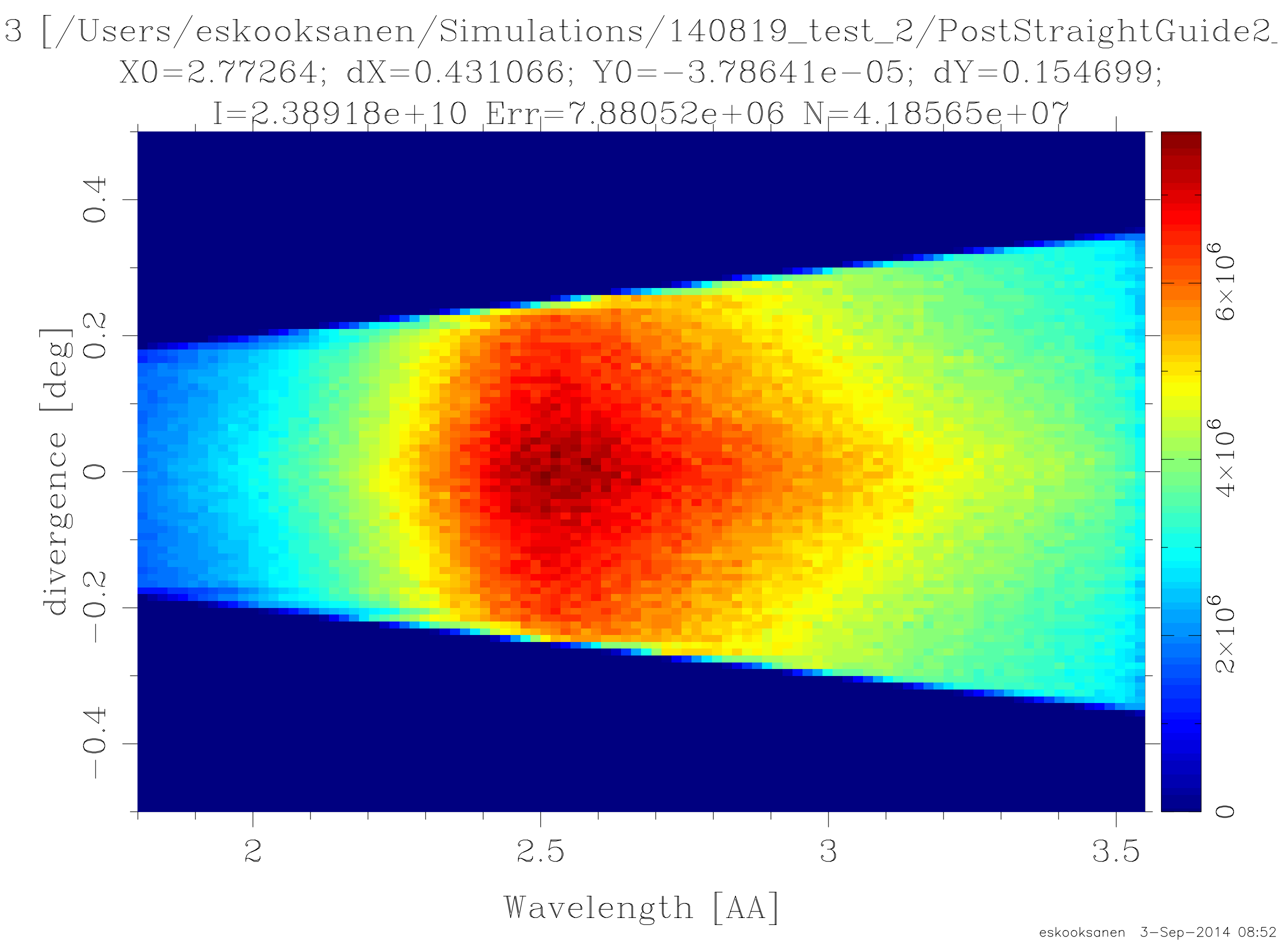
Damian Martin Rodriguez

Option 4: Curved inside bunker, optimised for maximum brilliance transfer at 2Å

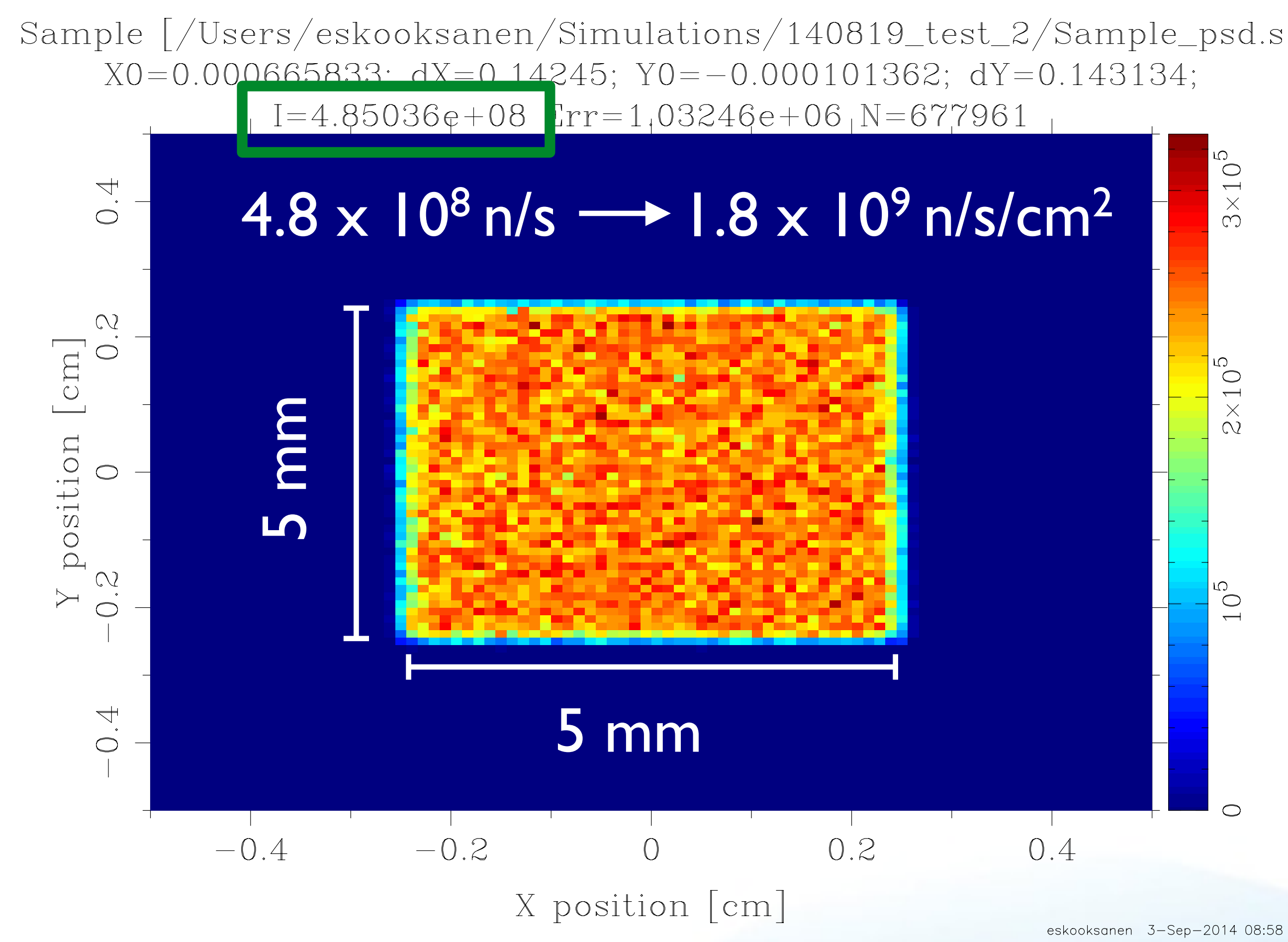
- Acceptable performance for ±0.2° divergence at < 2 Å
- Good performance all round for ±0.1° divergence – this range is more typical for experiments
- Loss of line-of-sight almost within bunker – lower shielding cost & easier component maintenance
- Deflects the beam far enough from the sector centreline to allow two beams to be extracted from the same beamport

Chosen concept – verification

Divergence vs. wavelength at the end of the guide



Beam profile at sample



Choppers

Design drivers

- Choppers are for wavelength selection
- Width and position of wavelength band have to be adjustable
- Transmission has priority
- Frame overlap should be suppressed
- Penumbra should be minimized
- Avoid choppers in bunker

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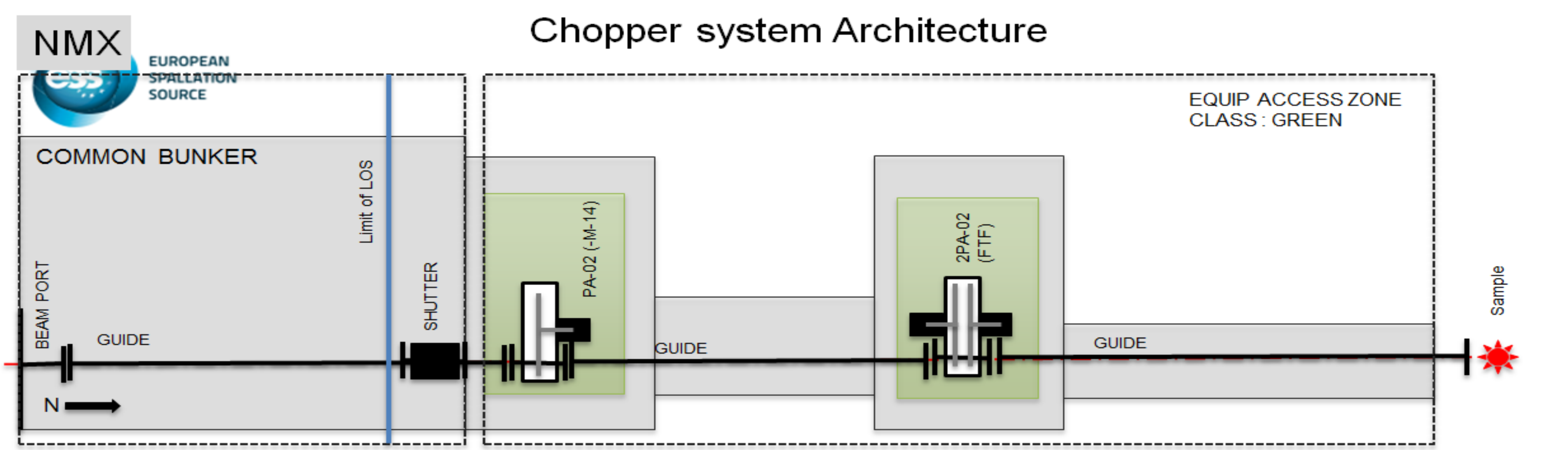
Change of phase and variable openings

Chopper or mirror

Choppers

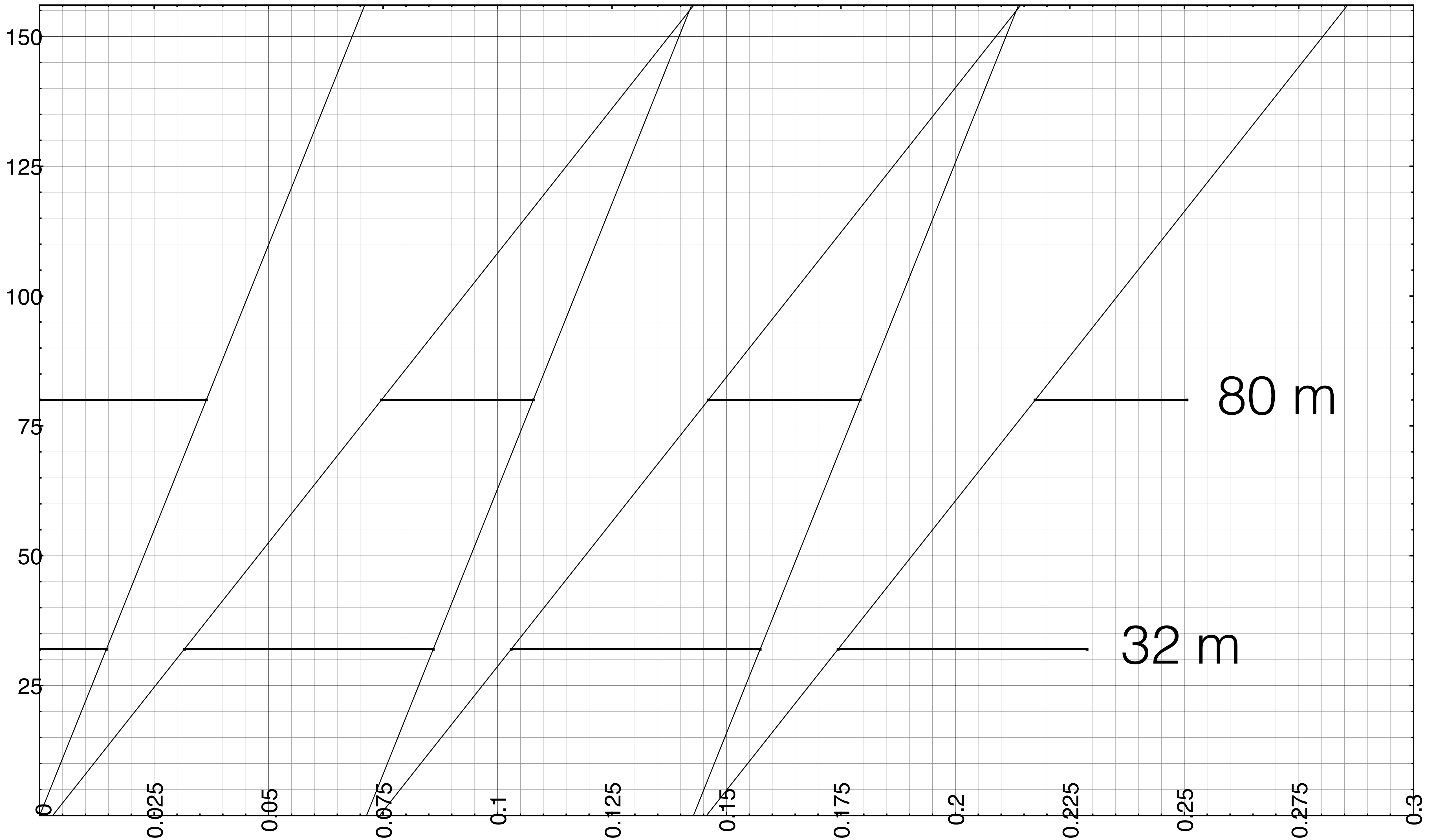


L	31,5	31,7	32	80	156
#			1	2-3	

- 3 chopper axis (2 assemblies)
- 1 single chopper axis
- 1 co-rotating double disc chopper
- 2 pits

Choppers

Bandwidth selection



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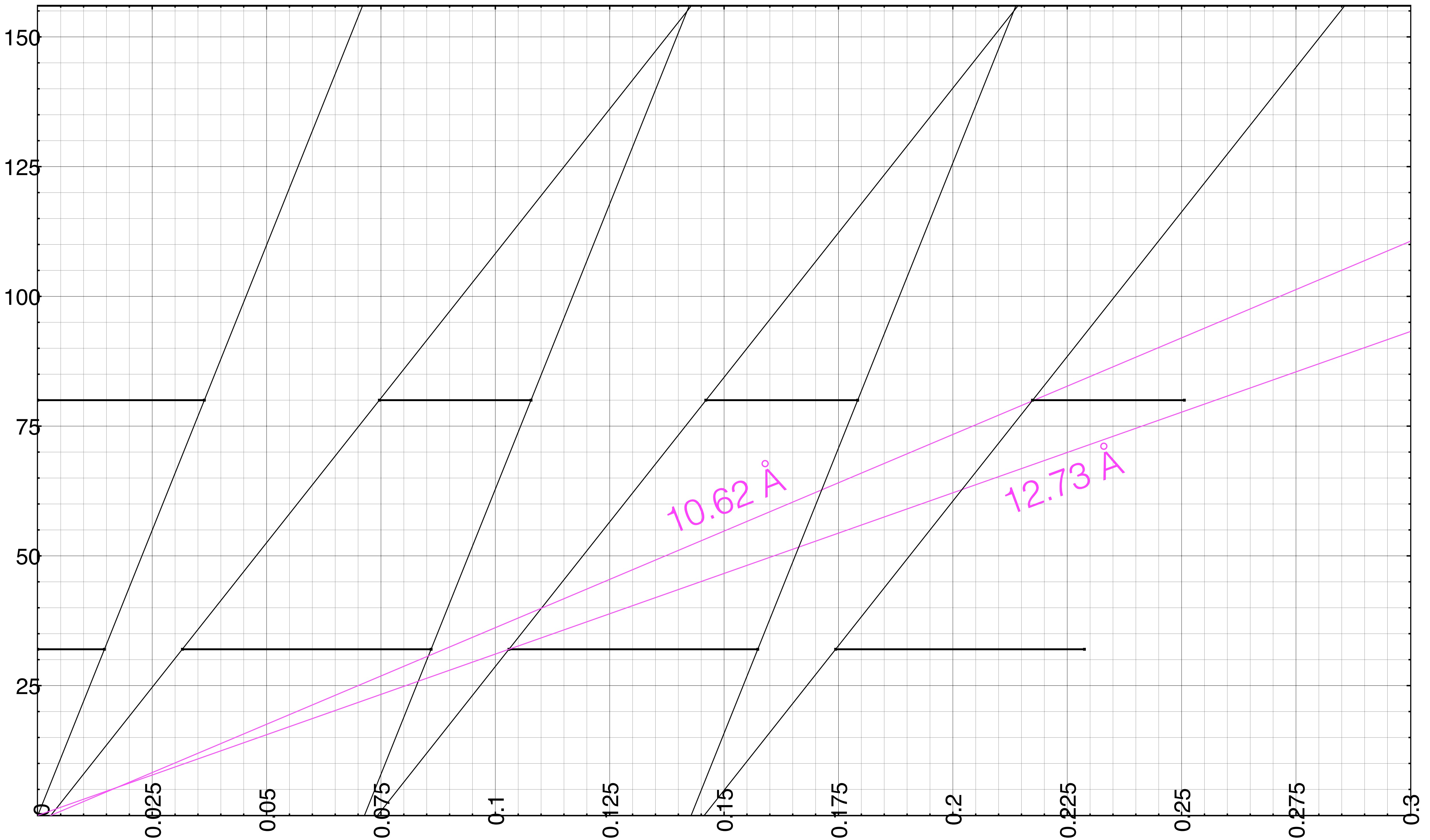
Choppers

Frame overlap suppression



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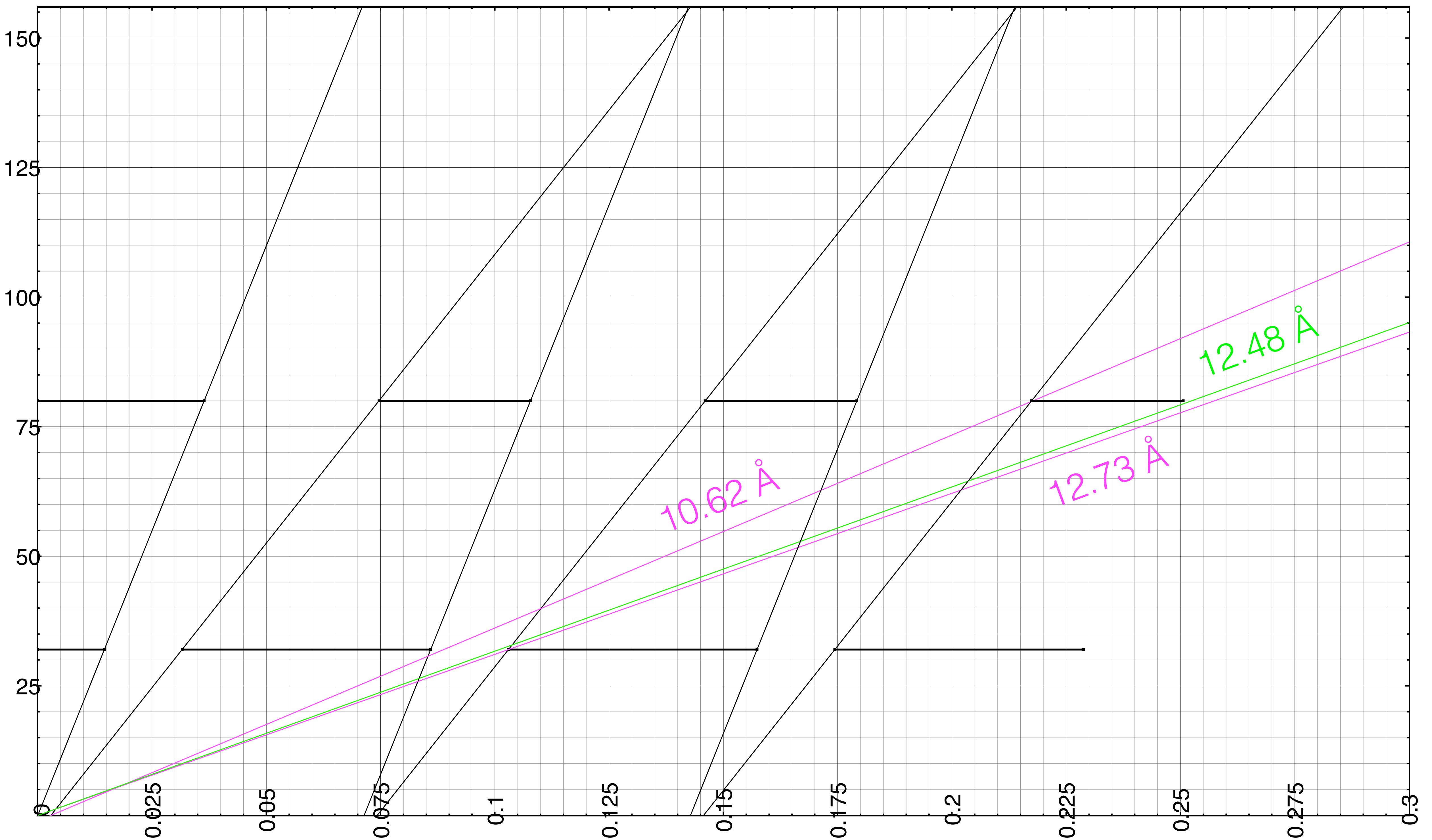

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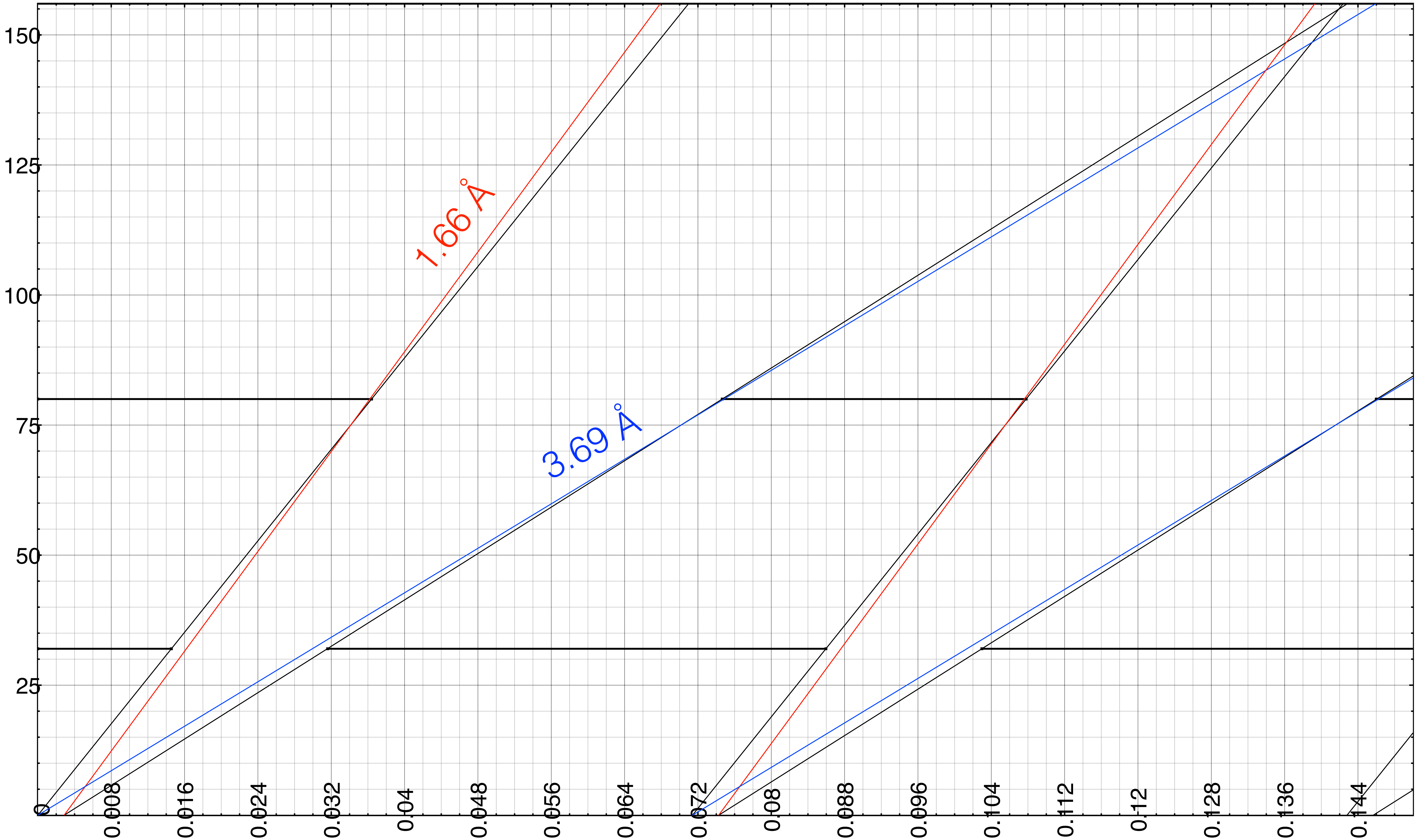
Choppers – Penumbra



1.8-3.55 Å nominal bandpass

Esko Oksanen, European Spallation Source

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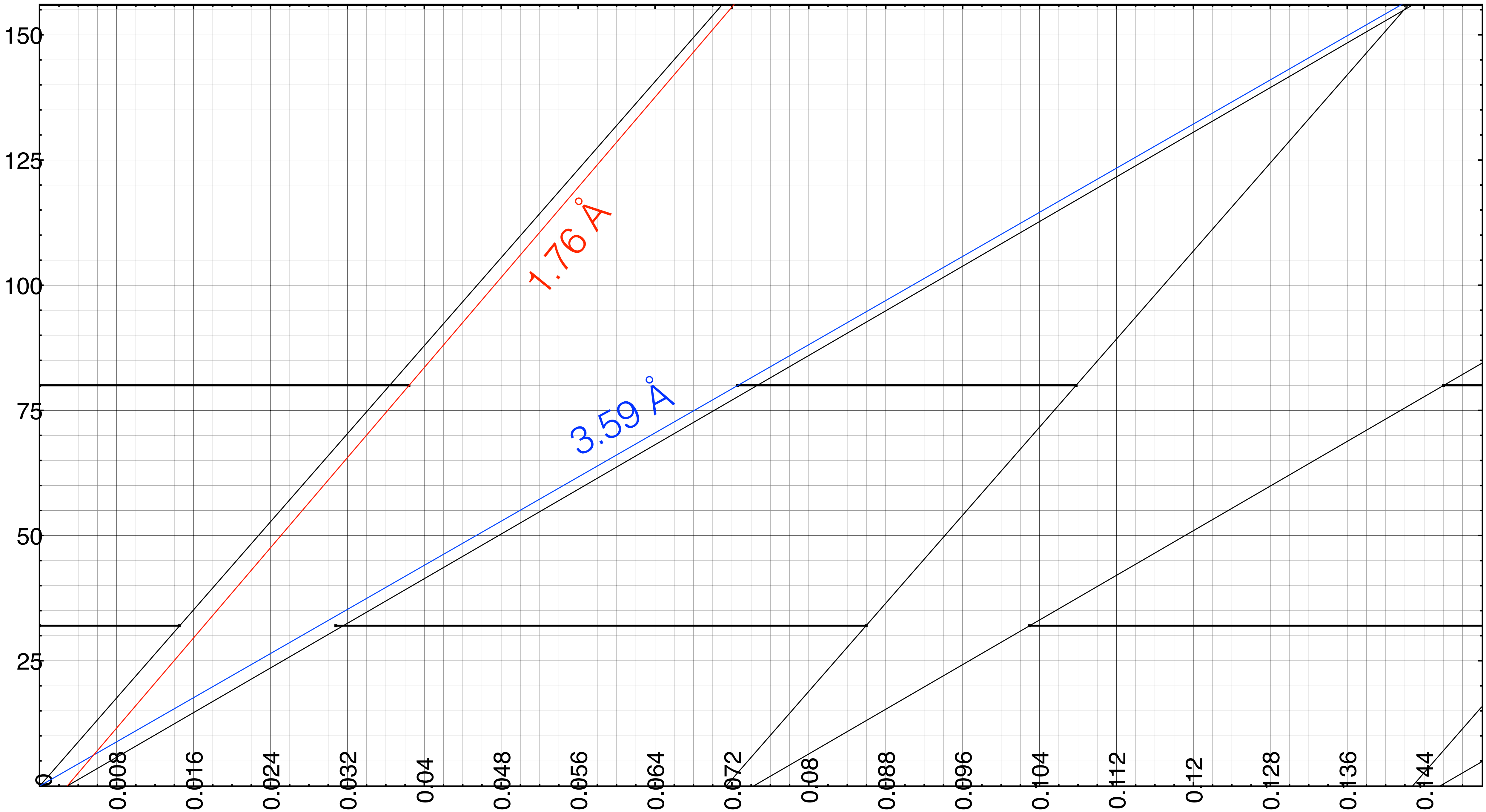
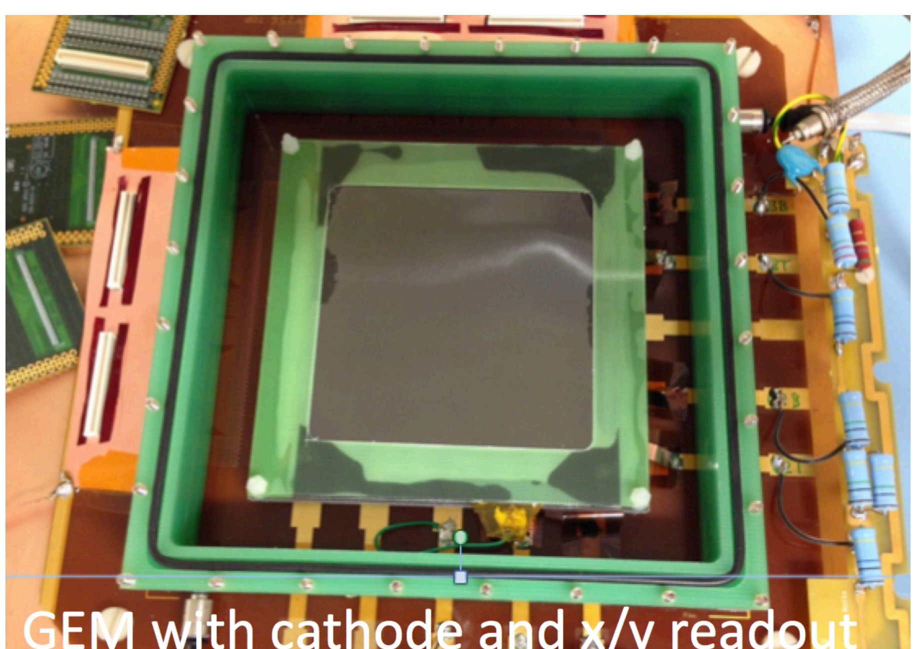
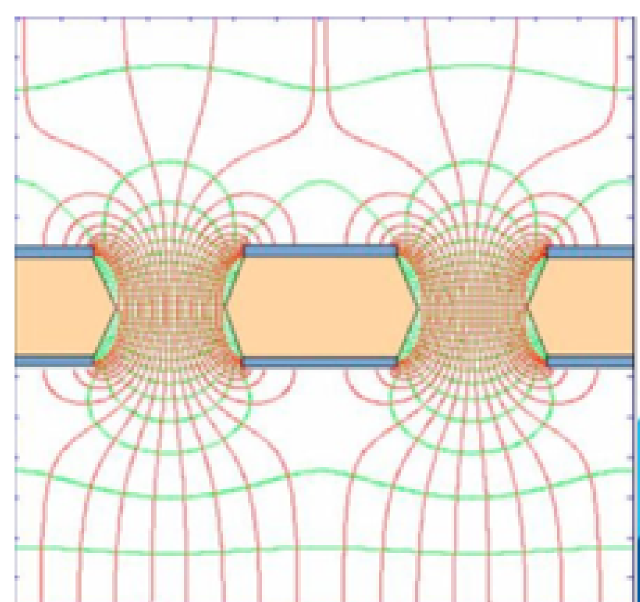


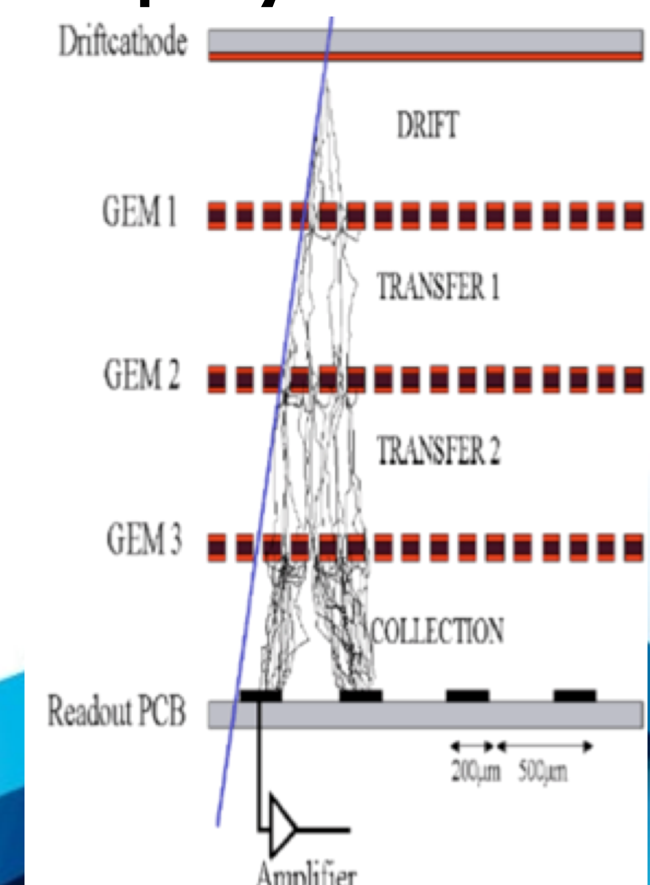
1.9-3.45 Å nominal bandpass

Detectors – technological risk and mitigation strategy

- R&D required to reach 0.2 mm spatial resolution with reasonable area and efficiency
- Gd coated micropattern (GEM) detectors promising – prototypes developed at CERN
- GEM detectors widely used in particle physics
- Large areas readily available

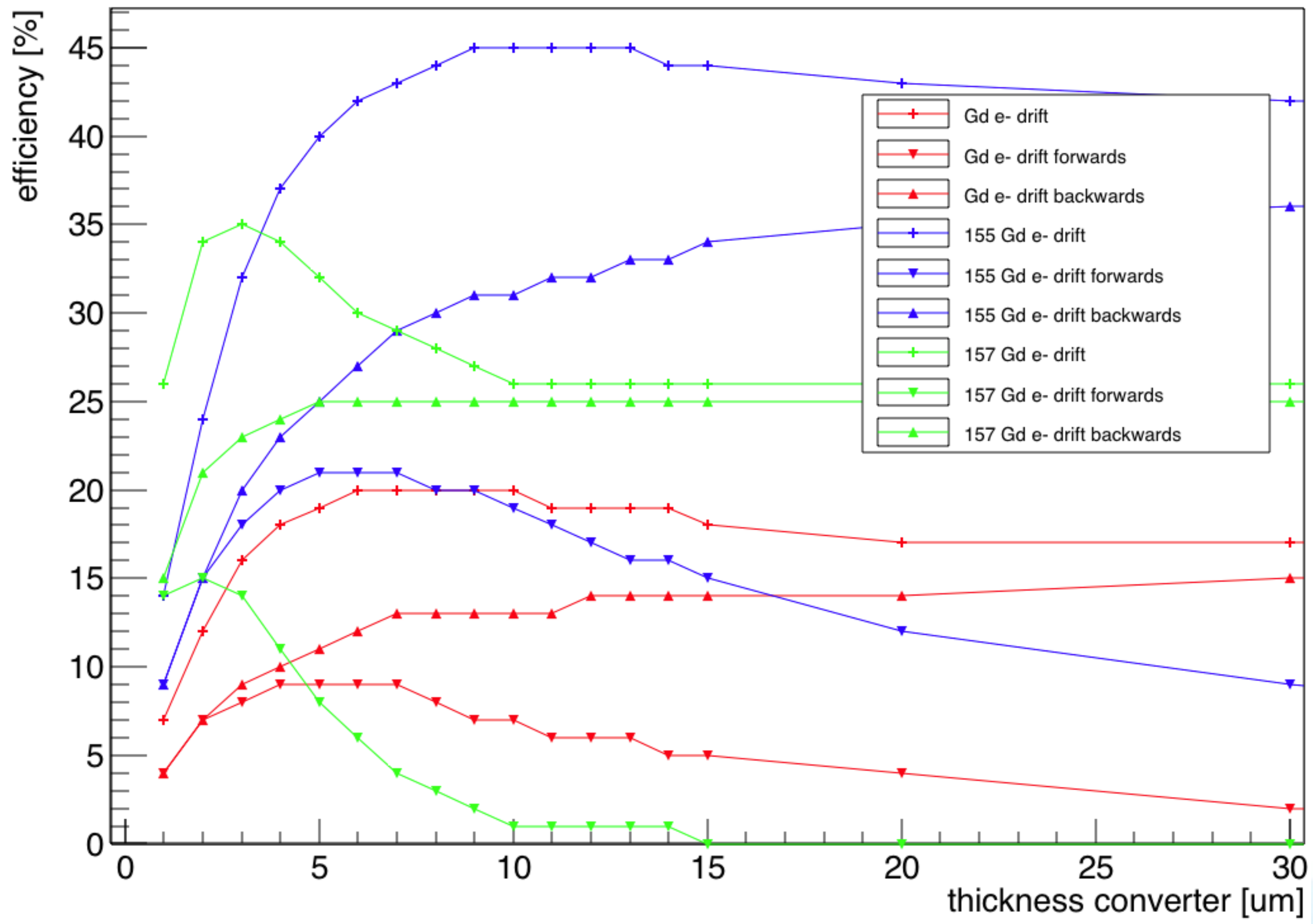




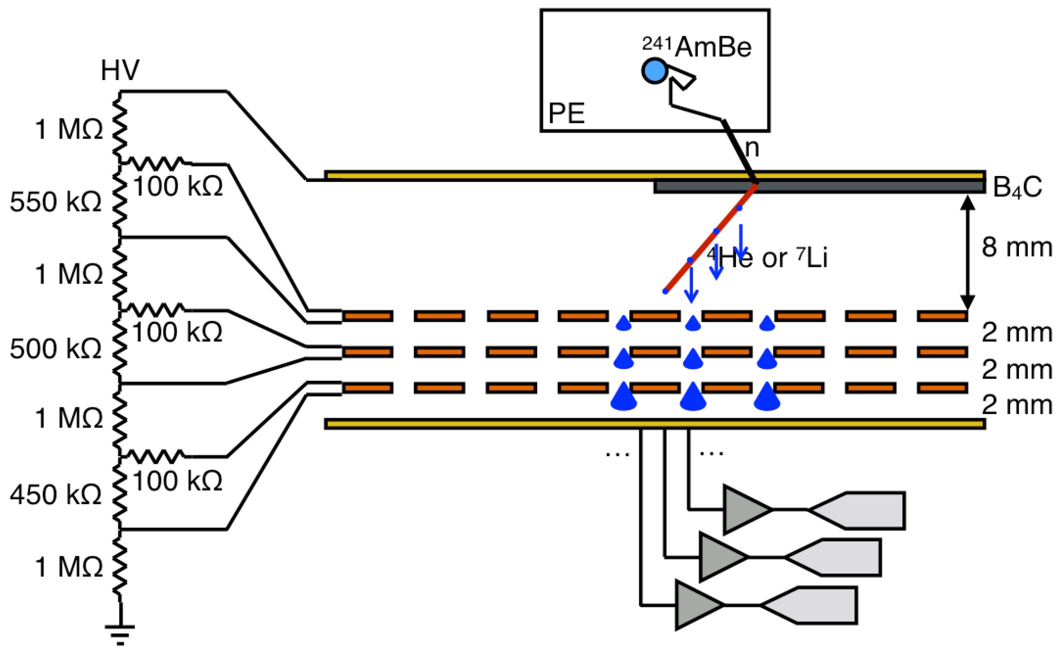


How detect neutrons with a GEM?

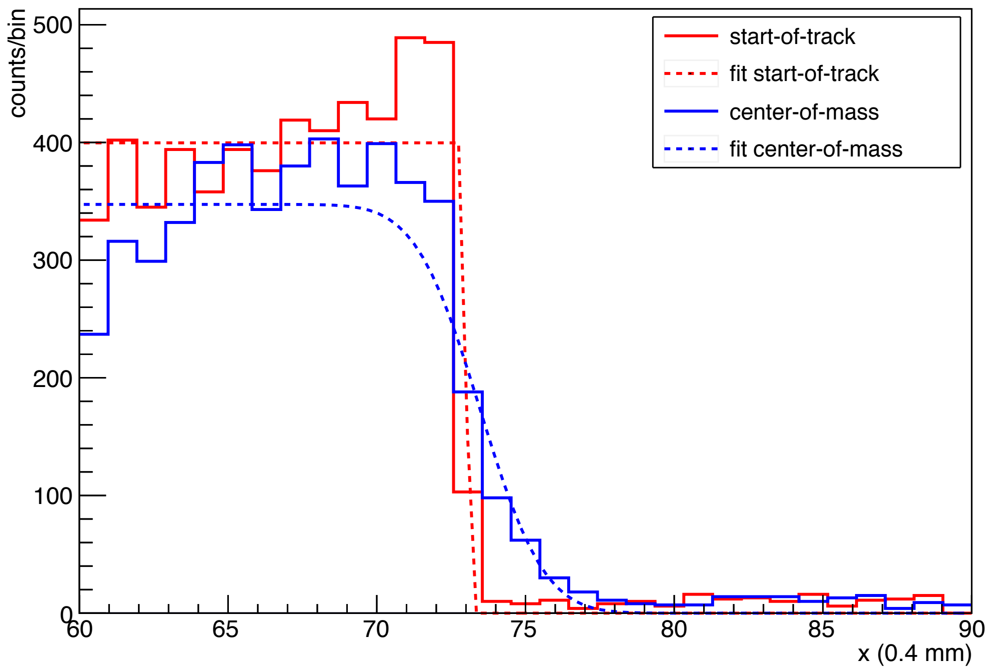
- Neutron converter on cathode
- ^{10}B has been demonstrated to deliver spatial resolution, but low efficiency
- Gd has much higher absorption cross section, but conversion electrons are more difficult to detect
- Enriched ^{155}Gd would improve efficiency significantly



Spatial resolution – μTPC



(a)



(b)

- Spatial resolution of < 100 μm was achieved with a ^{10}B–GEM
- Based on the μTPC concept (algoritms from CERN)

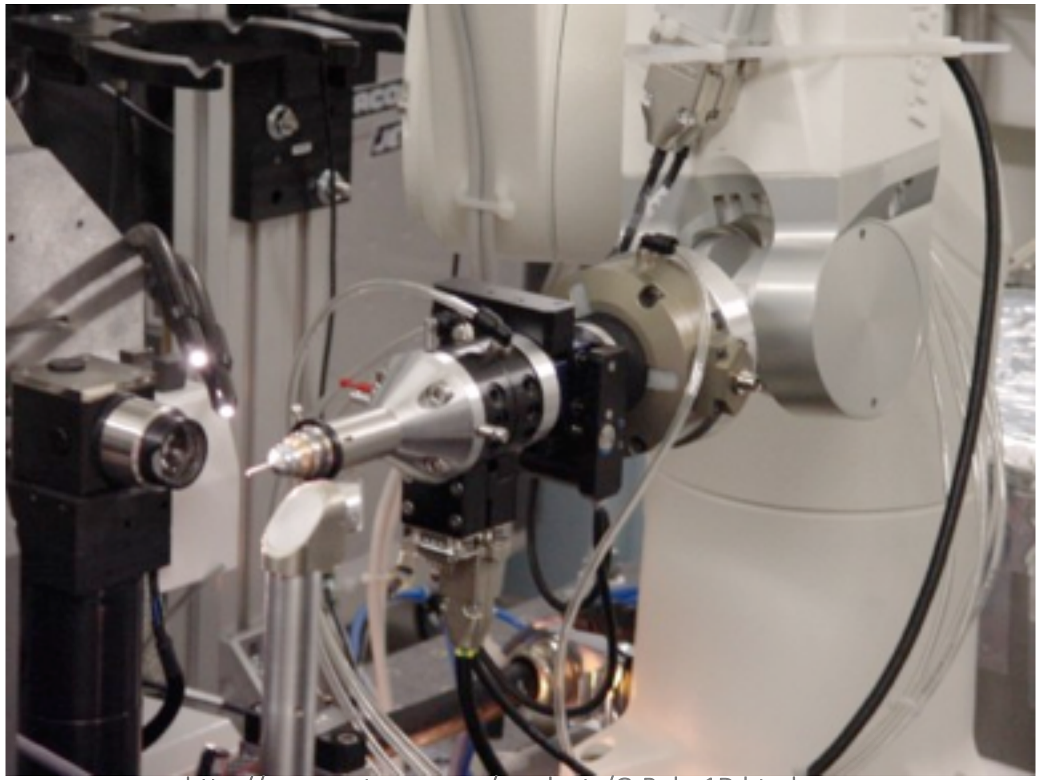
Backup options

- ^{10}B-GEM has been demonstrated, but efficiency is low
- Anger cameras not affordable
- ^{3}He filled MSGCs could be a last resort with reduced area and compromised resolution

Sample positioner

Robotic goniometer

- Six axis industrial robotic arm
- Slim profile
- Tool change.
- Stereoscopic cameras
- Sphere of confusion R< 0.03 mm
- Following error < 6 mdeg

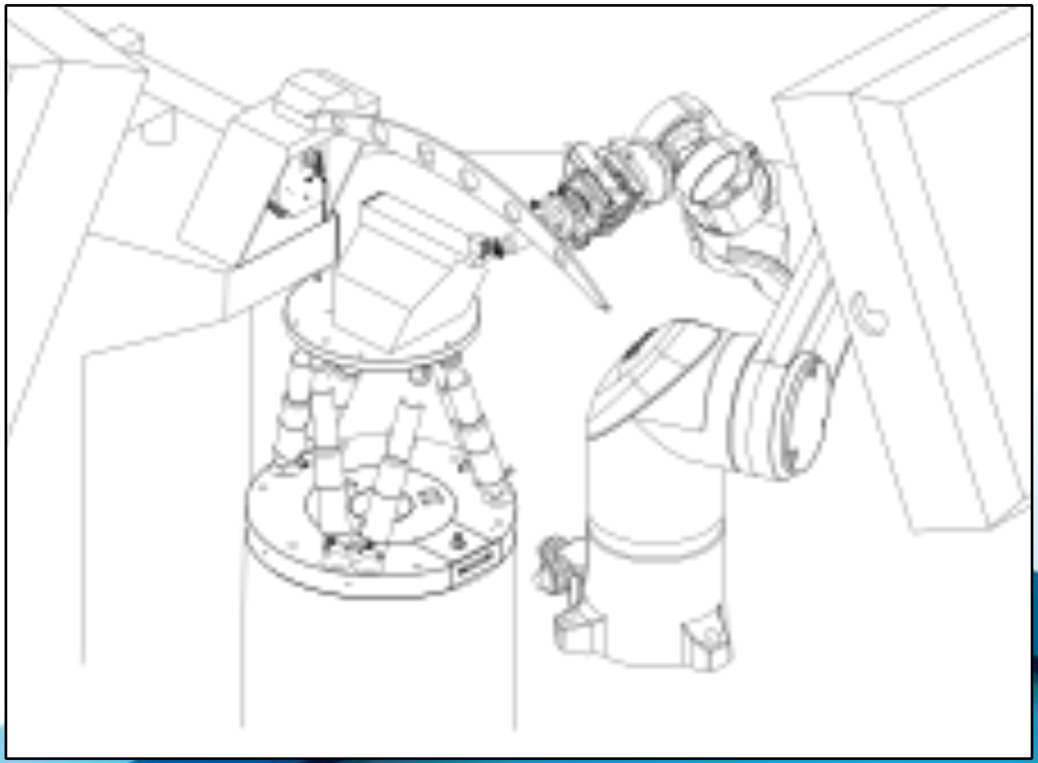


http://www.natx-ray.com/products/G-Rob_1D.html

Benefits

- Three clicks sample centering.
- Neutron beam imaging at sample.
- Multiple sample interfaces on tool changer.

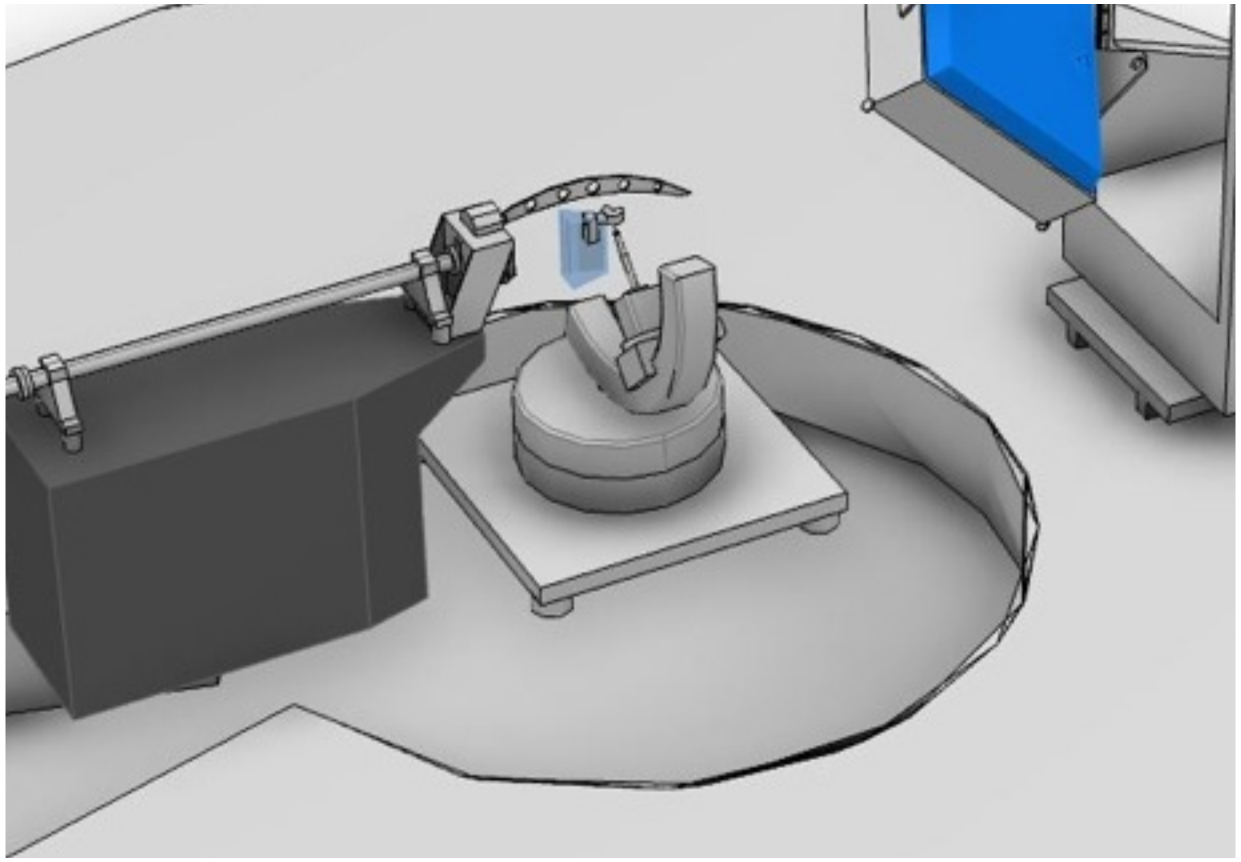
Robotic goniometer allows choice of sample rotation axis direction



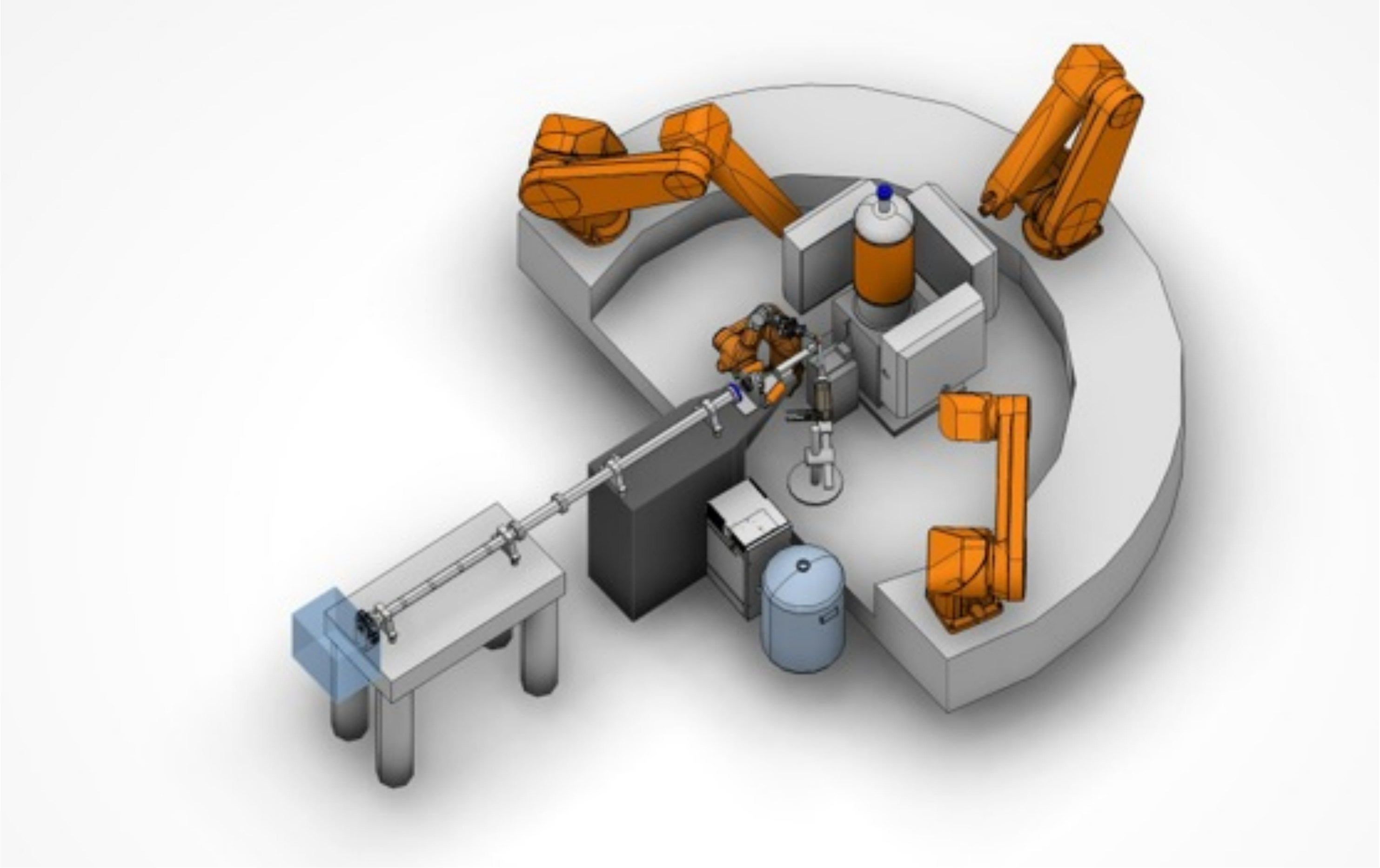
Sample positioner – backup

Conventional goniometer

- Custom solution – could be built in-house
- Bulky with limited access to upper hemisphere
- Small cost difference to robotic option – more integration required



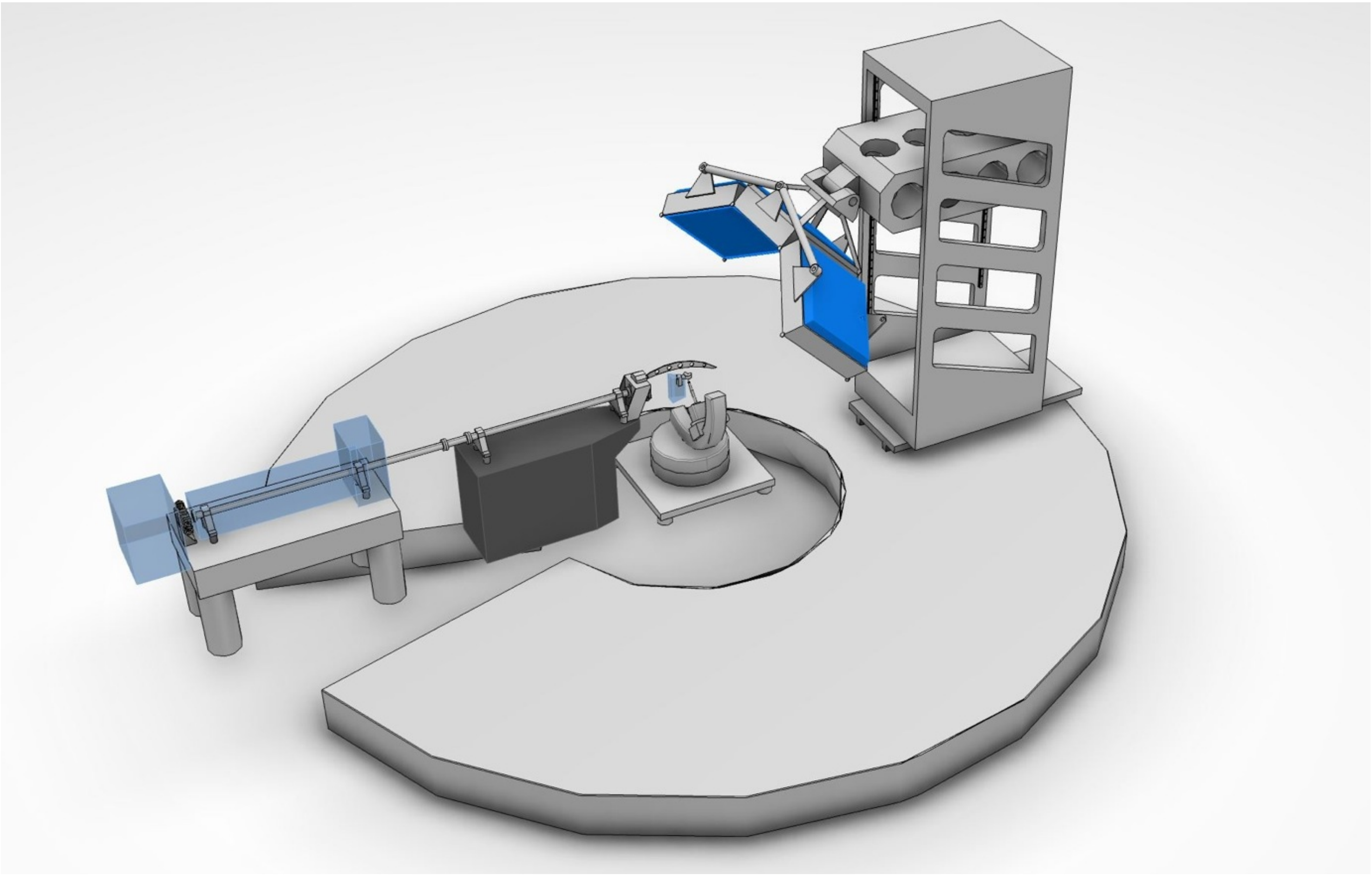
Detector positioners – robotic option



Three 60 x 60 cm detectors with 0.2 mm spatial resolution
Sample-detector distance (0.2-1.0 m) and 2θ angle (0-110°) variable

- Solid angle coverage can be traded for unit cell size
- Allows an alternative sample position for bulky sample environments

Detector positioners – linear mechanics option



Three 60 x 60 cm detectors with 0.2 mm spatial resolution
Sample-detector distance (0.2-1.0 m) and 2θ angle (0-110°) variable

- Could be implemented in-house
- < 20% cost difference to robotic option
- Limited flexibility with bulky sample environments

Questions?