PRESTO: diffraction on ICONE

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JDN 2023 - Erquy

Pulsed sources

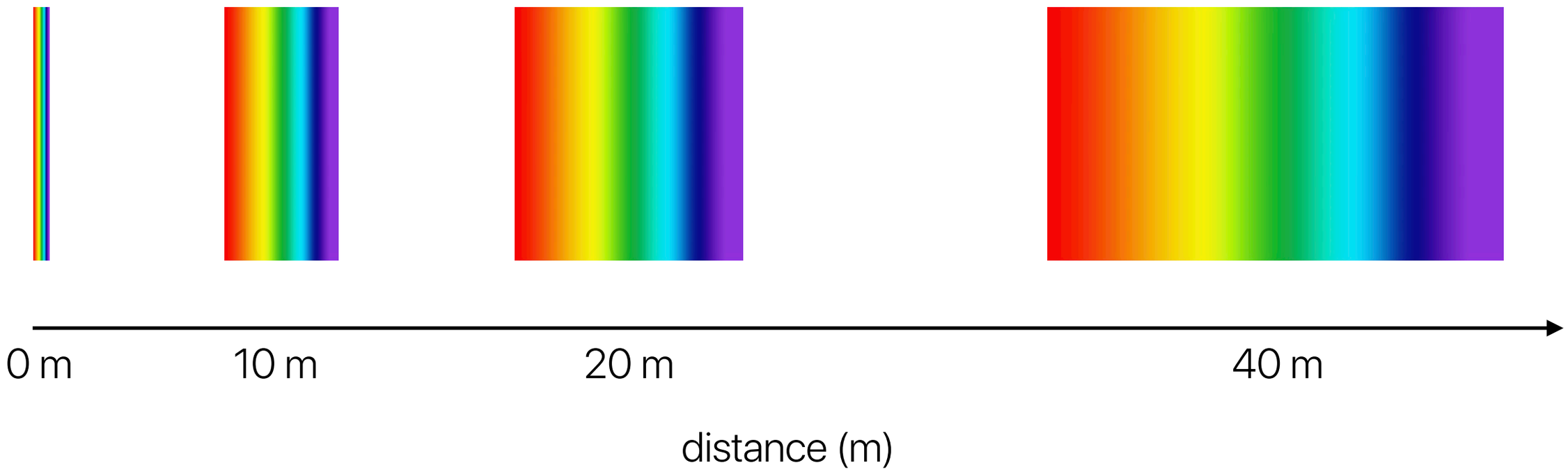
- White beam emitted at given frequency and pulse length.

- 3 main parameters to build an instrument:
  - Frequency: intervals between pulses used to separate wavelengths using neutrons ToF
  - Pulse length: affect Q-resolution
  - Moderator to sample distance strongly impact beam properties at sample position.

- Additional equipment (choppers, slits) used to tailor the beam to specific needs => versatile instruments.

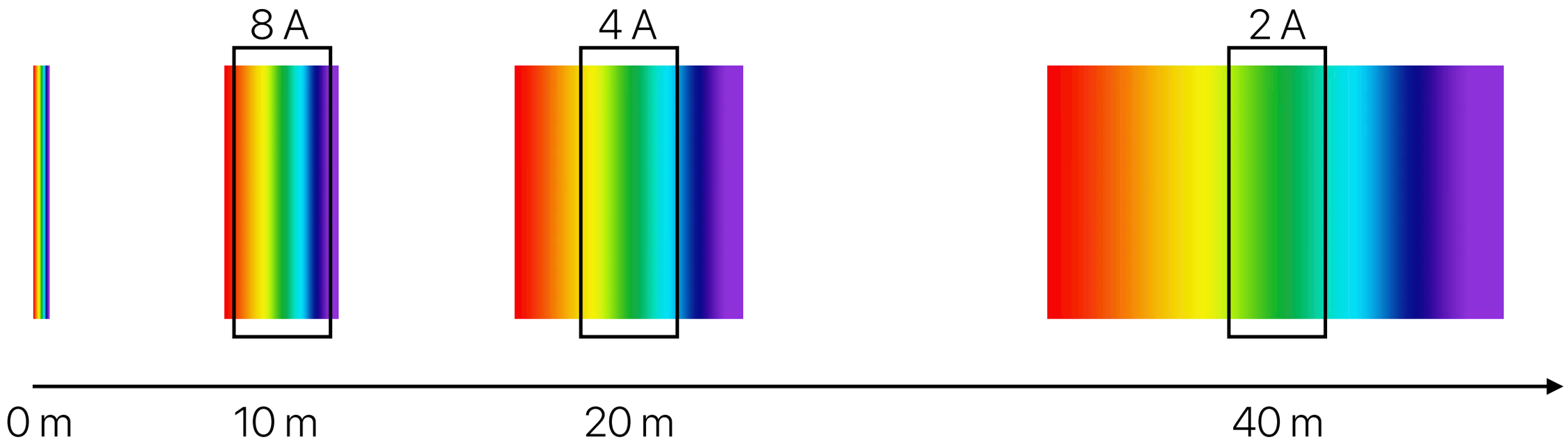
Frequency & distance

- 50 Hz frequency



Frequency & distance

- 50 Hz frequency => 20 ms measurement intervals



$$\Delta\lambda \propto \frac{t_{mes}}{dist}$$

Frequency & distance

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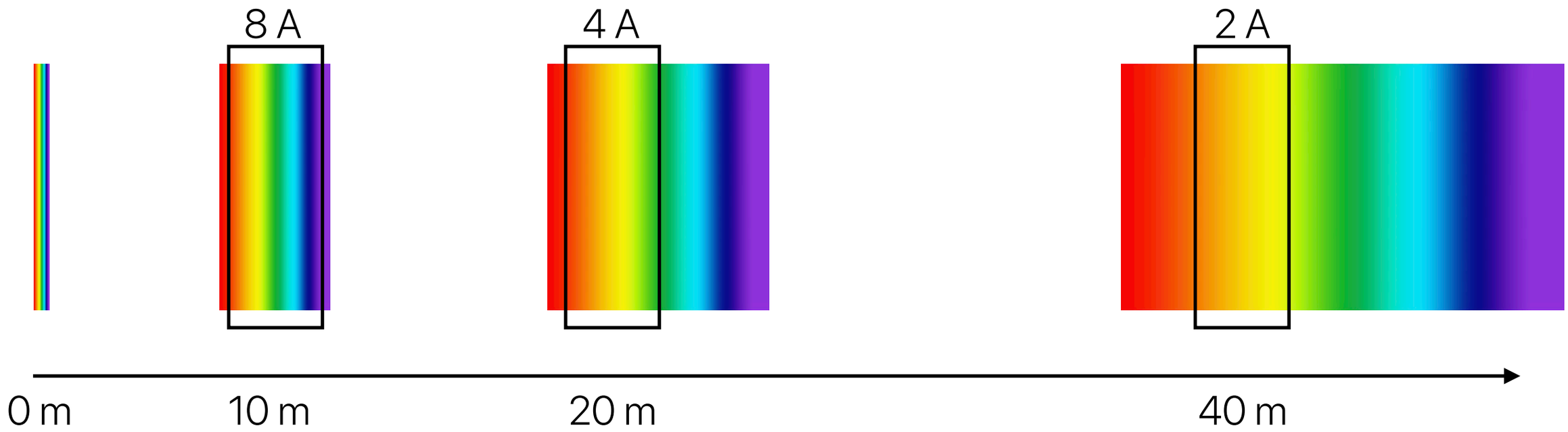
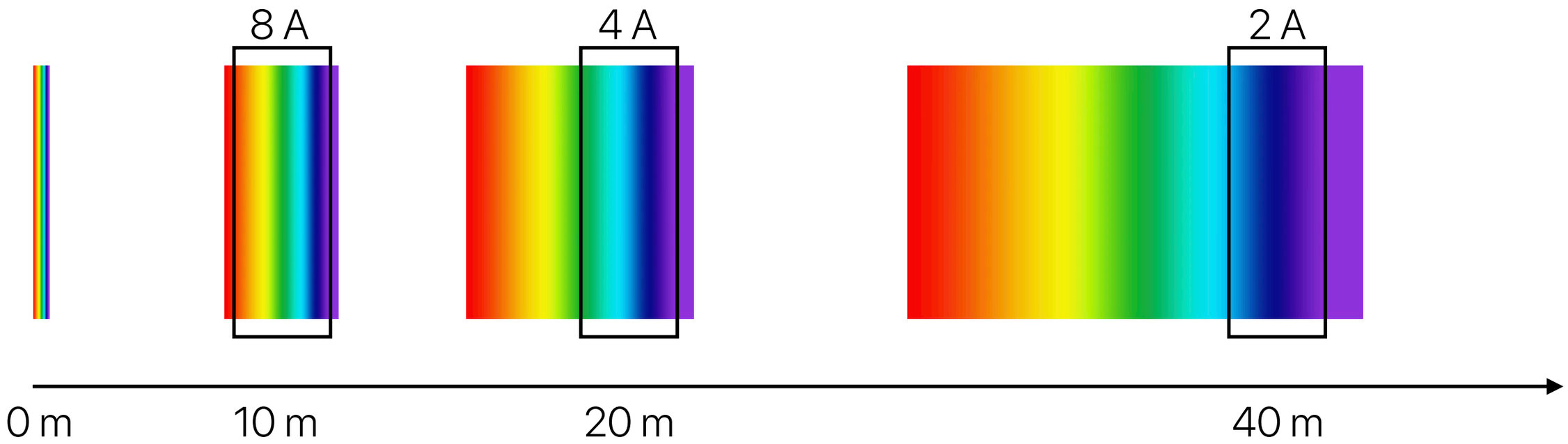


$$\Delta\lambda \propto \frac{t_{mes}}{dist}$$

Band chopper phase to define λ_0

Frequency & distance

- 50 Hz frequency => 20 ms measurement intervals

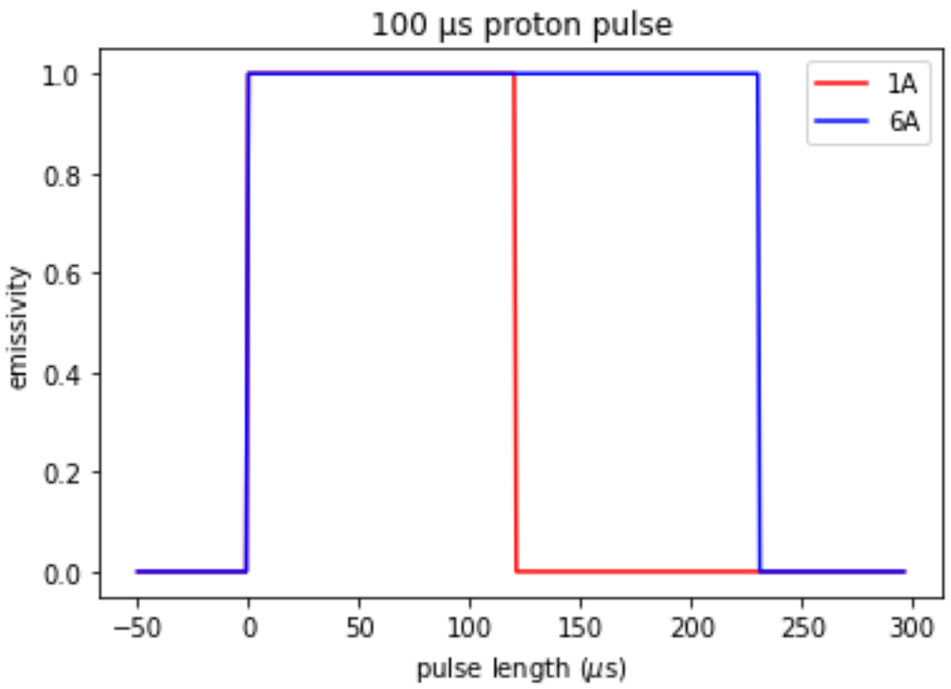


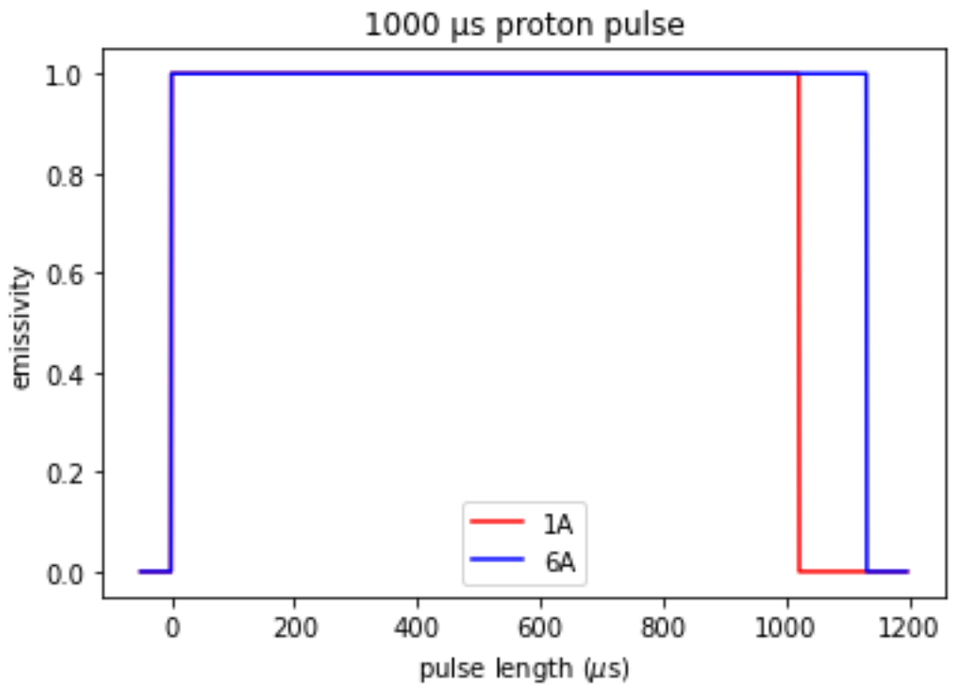
$$\Delta\lambda \propto \frac{t_{mes}}{dist}$$

Band chopper phase to define λ_0

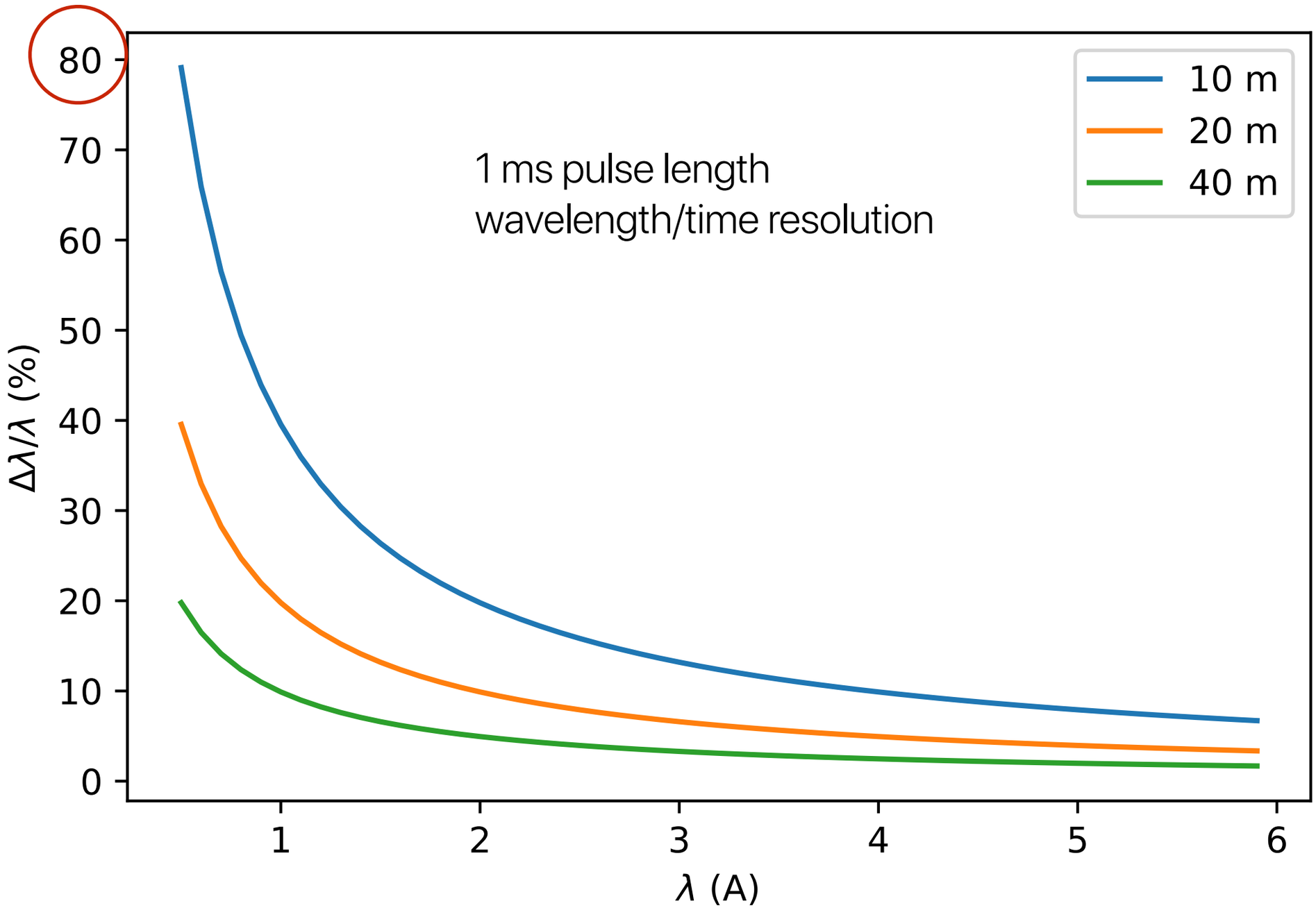
Pulse length

- Pulse length:
  - Proton pulse length
  - Moderation time = neutron moderation through collisions with hydrogen. Mean free path ~3cm => 10-100 µs
  - Very short proton pulses leads to variable neutron pulse length



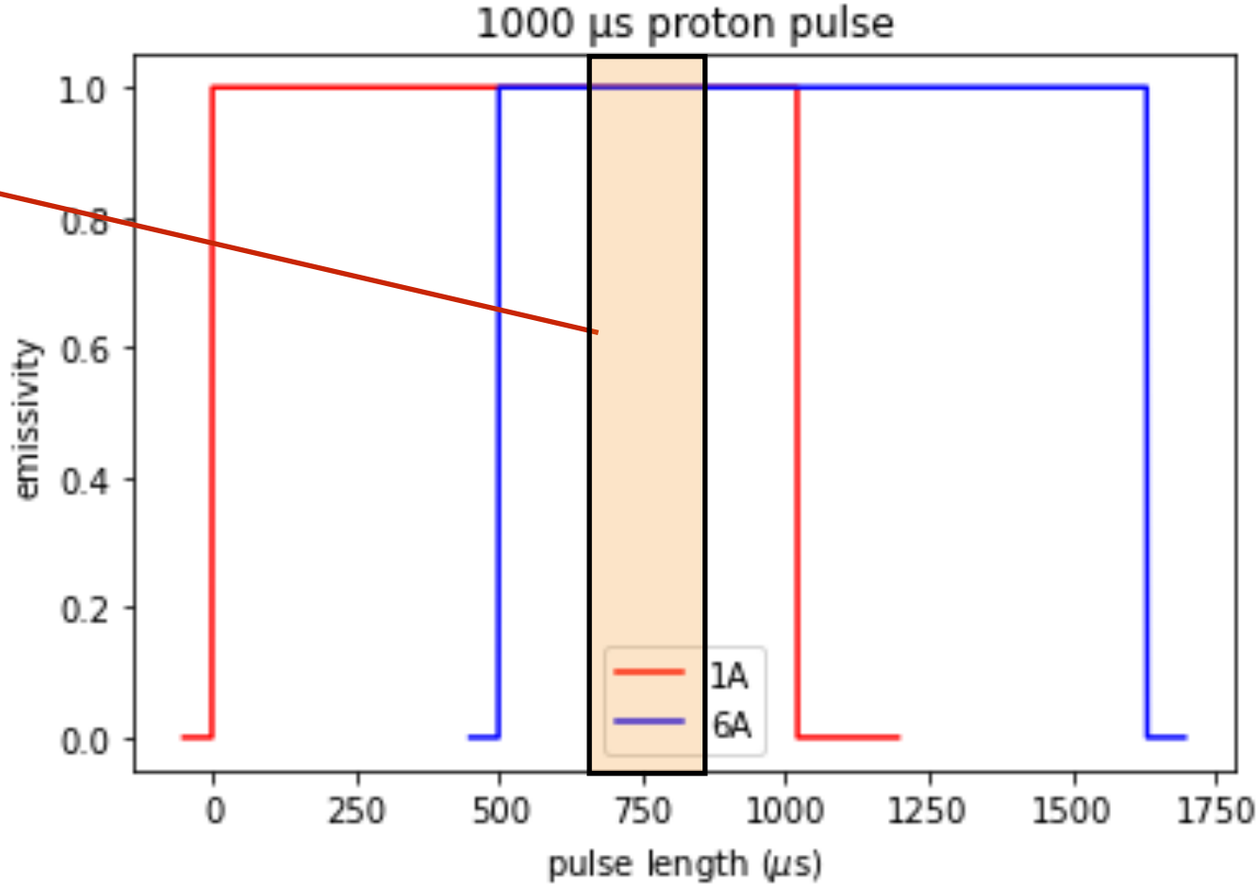


Effect on resolution



Pulse length

- Pulse length:
  - Can be tuned using choppers close to the moderator
  - High speed counter-rotative pulse shaping (150/300 Hz)

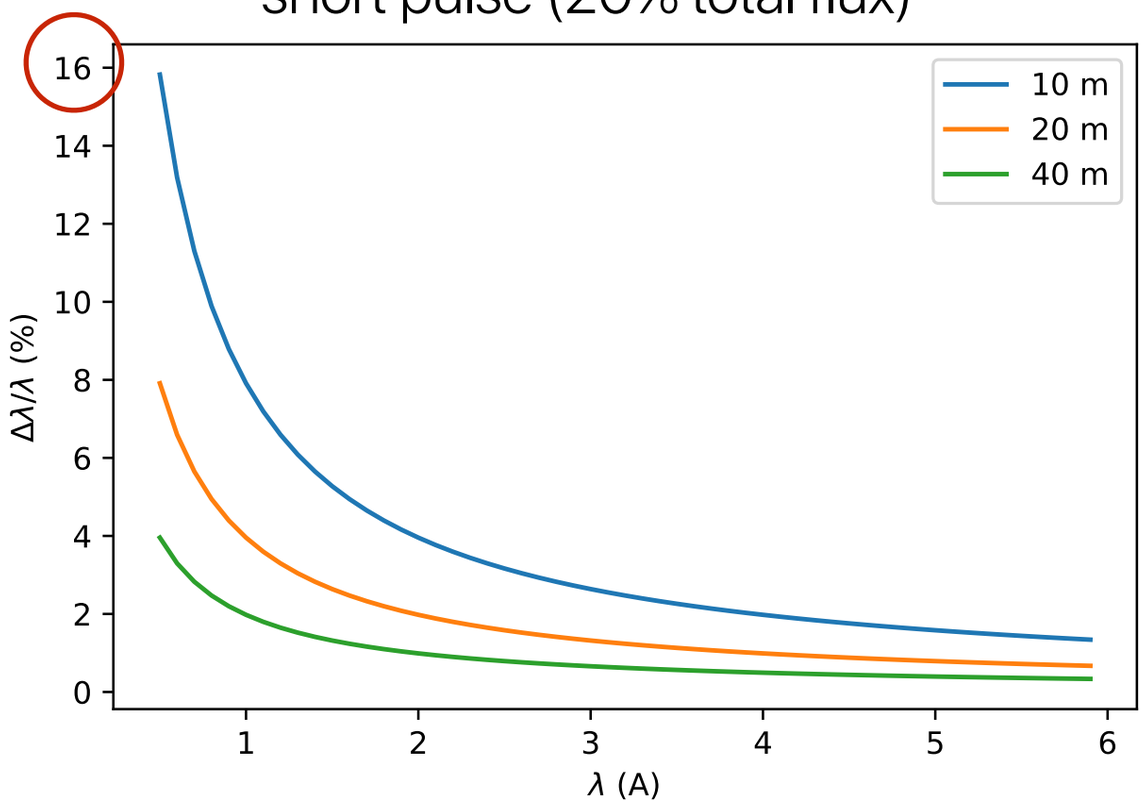


White shortened pulse

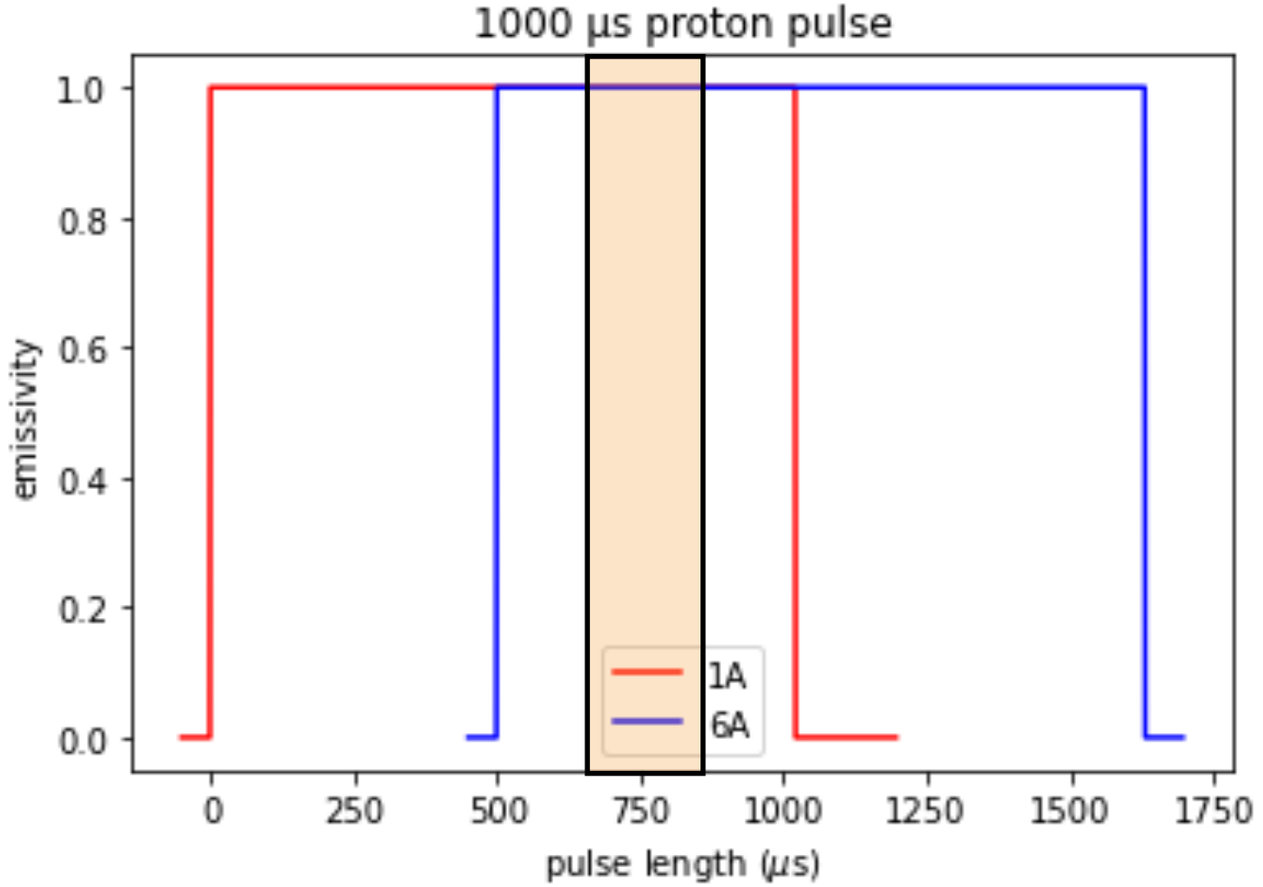
Pulse length

- Pulse length:
  - Can be tuned using choppers close to the moderator
  - High speed counter-rotative pulse shaping (150/300 Hz)

200 µs pulse length
short pulse (20% total flux)



1000 µs proton pulse



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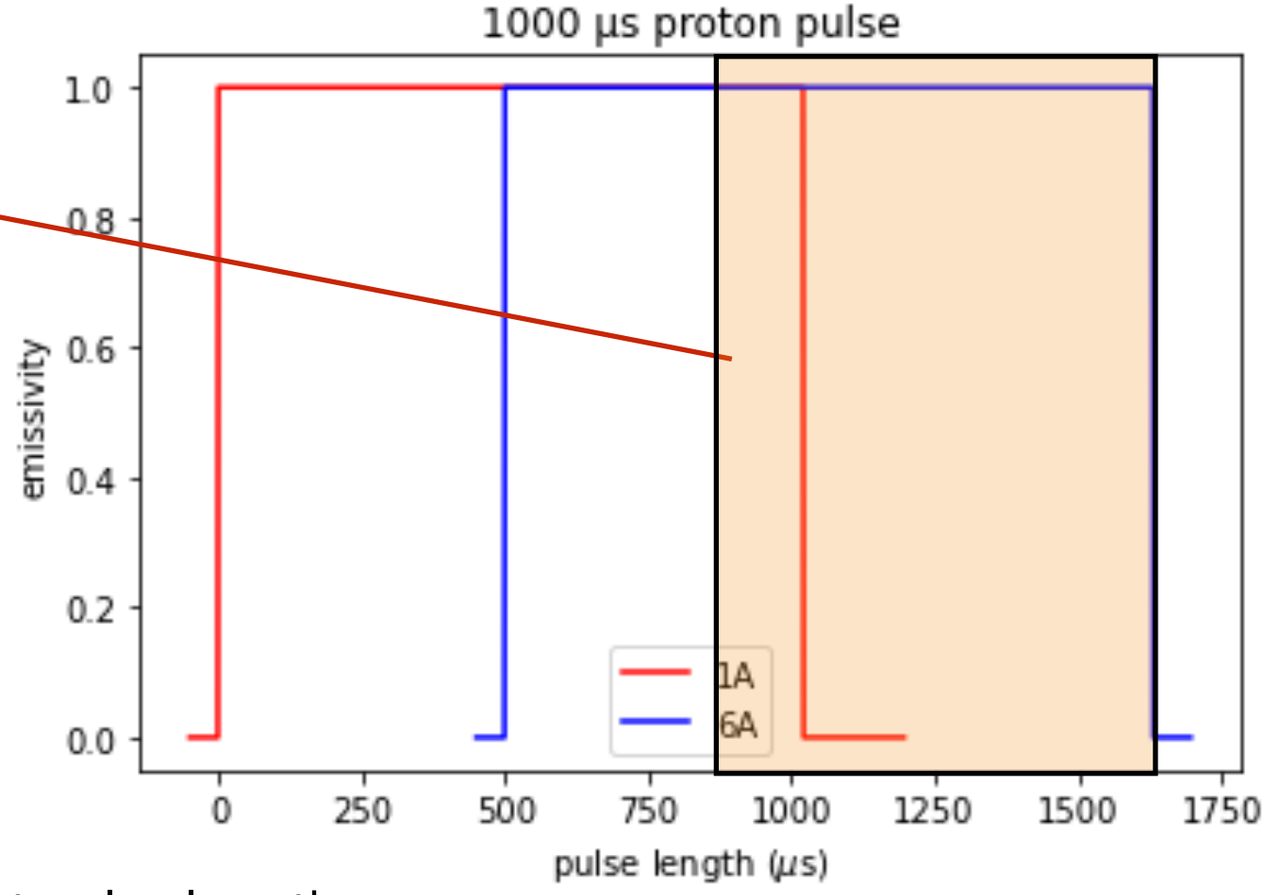
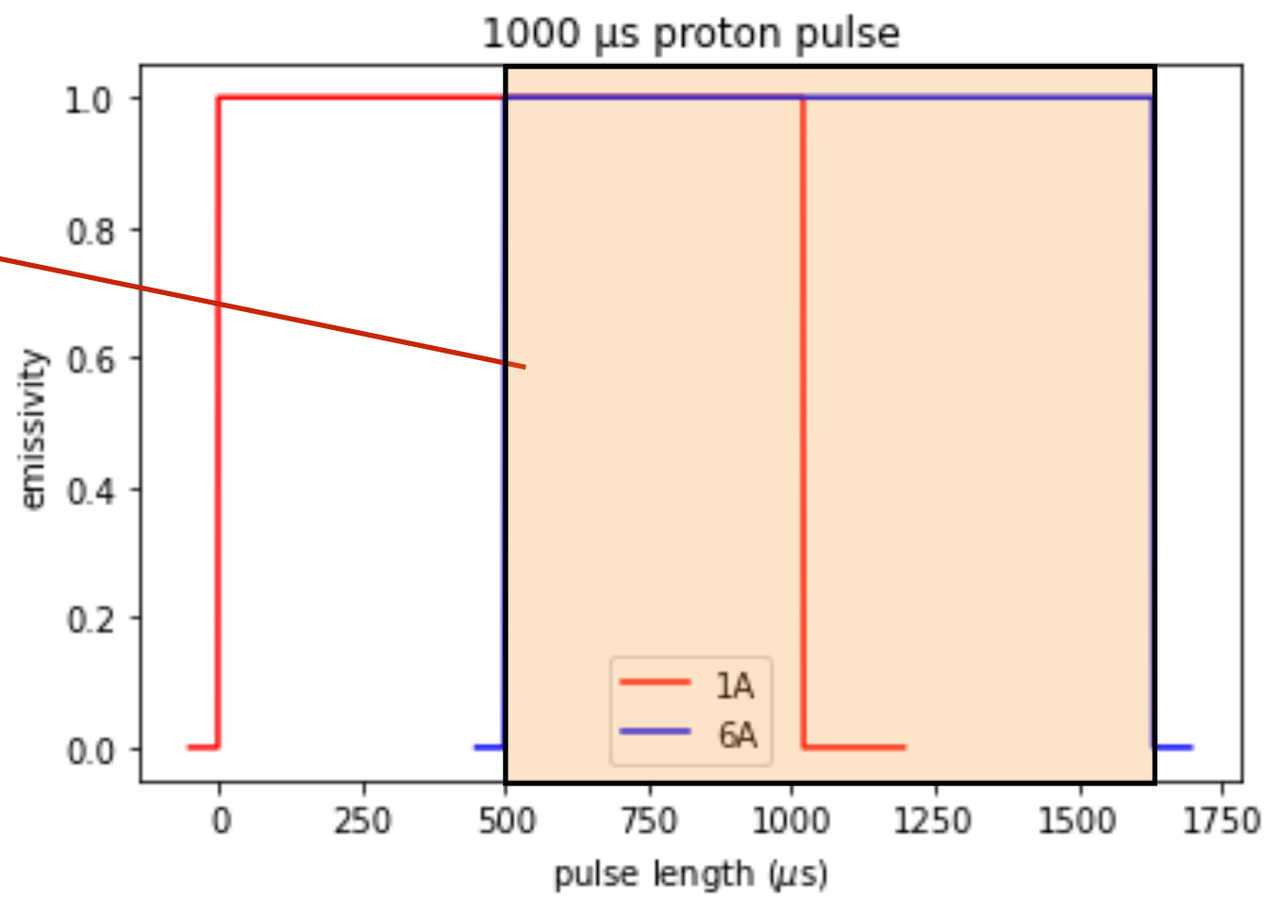


wavelength dependent pulse length
short hot pulse

Pulse length

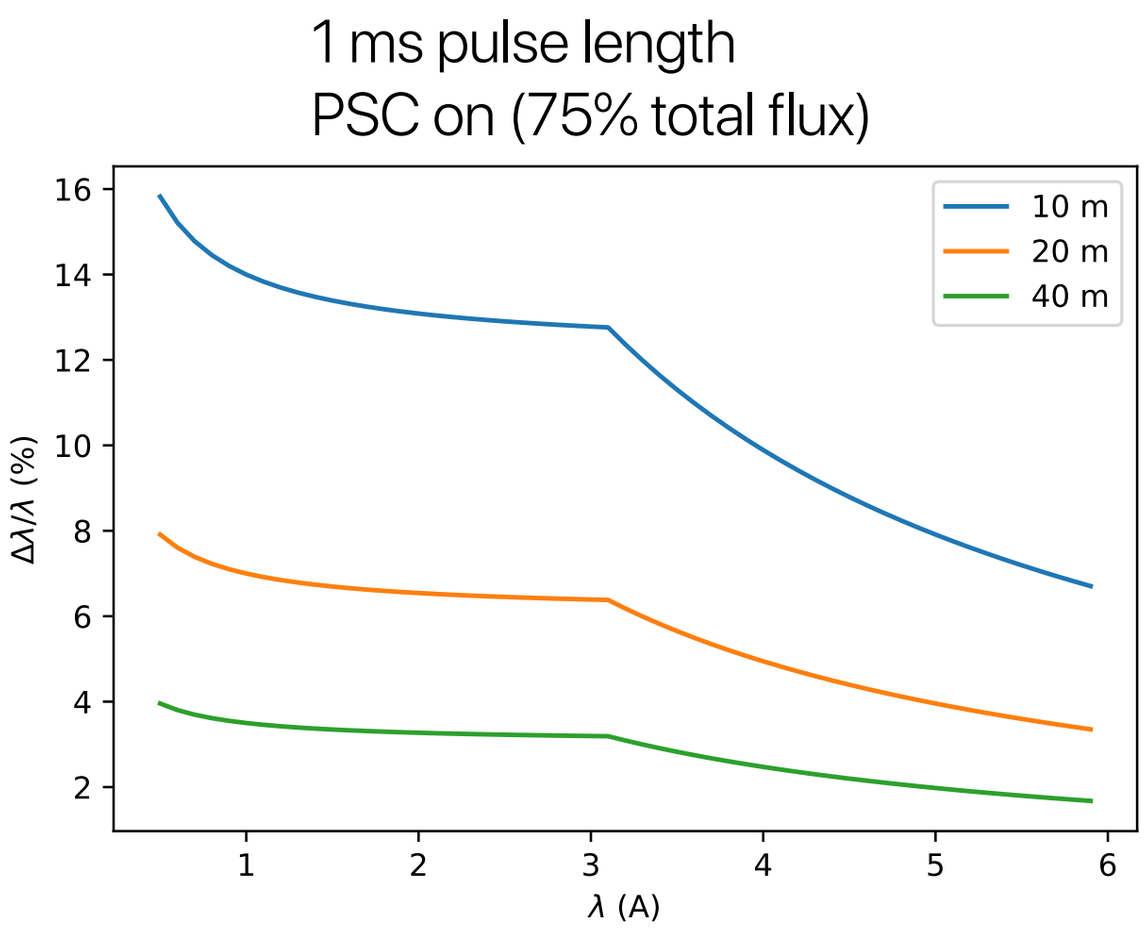
- Pulse length:
  - Can be tuned using choppers close to the moderator
  - High speed counter-rotative pulse shaping (150/300 Hz)

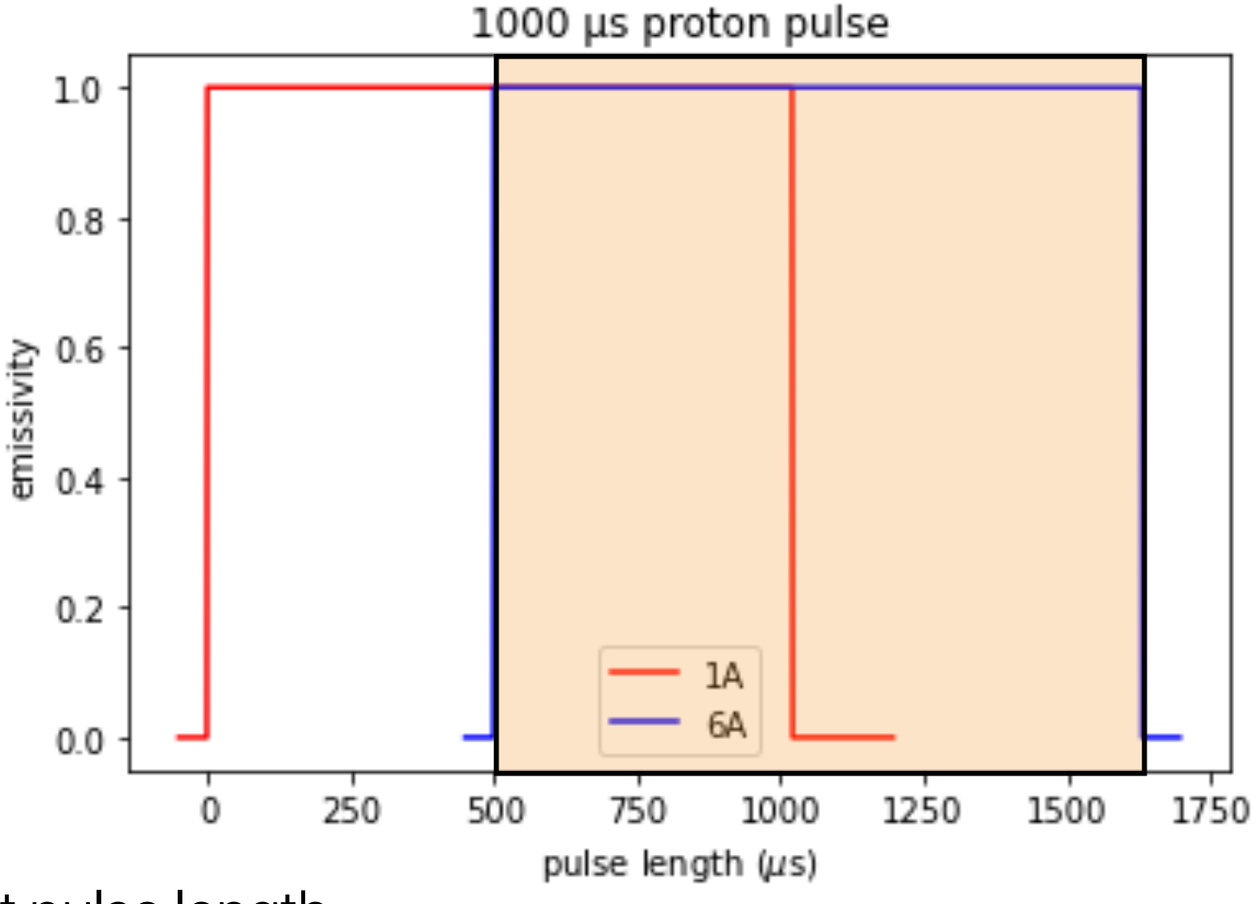


wavelength dependent pulse length
short hot pulse + full cold pulse

Pulse length

- Pulse length:
  - Can be tuned using choppers close to the moderator
  - High speed counter-rotative pulse shaping (150/300 Hz)

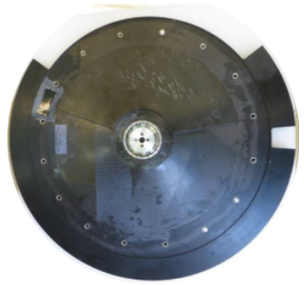




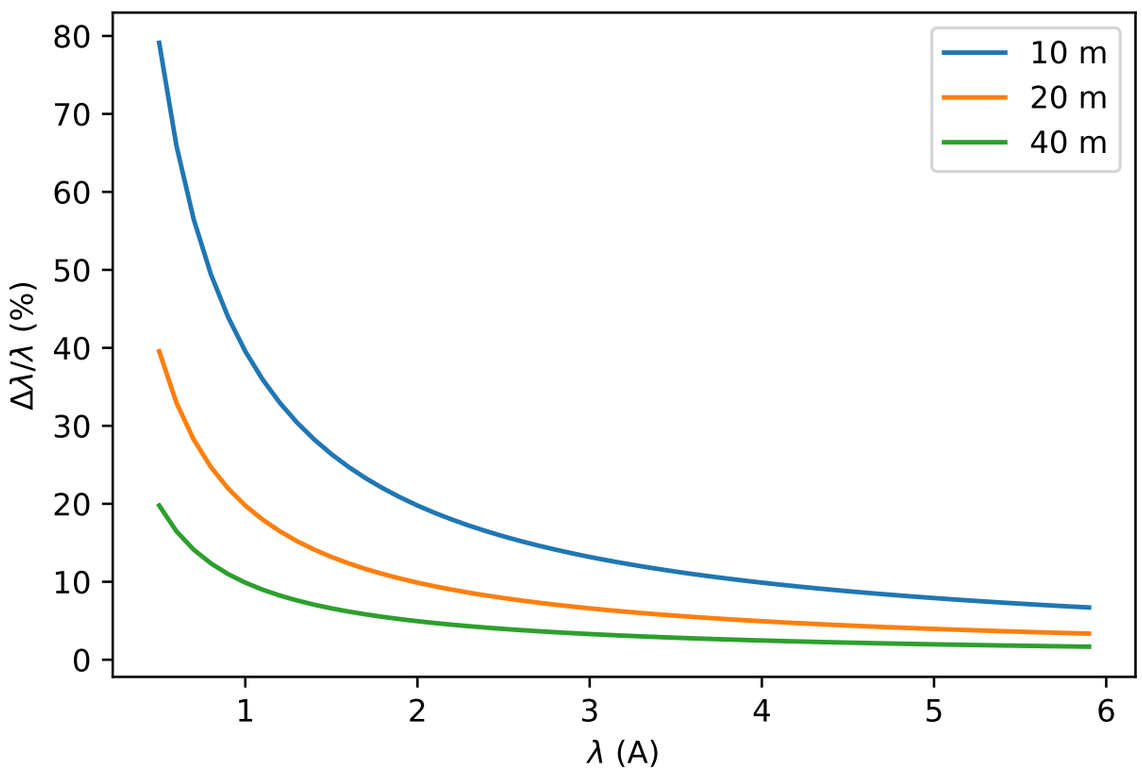
wavelength dependent pulse length
short hot pulse + full cold pulse

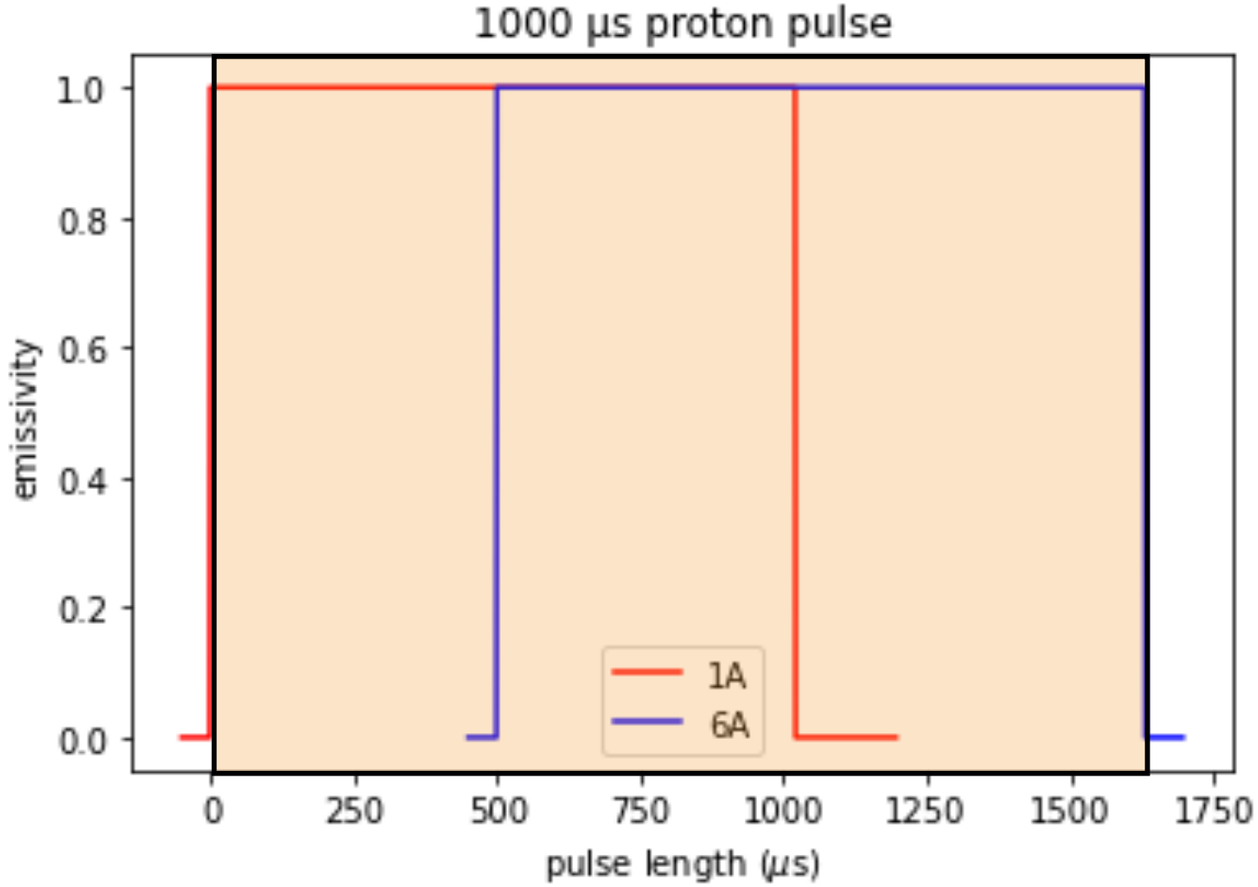
wavelength resolution

- 50 Hz frequency => 20 ms measurement intervals



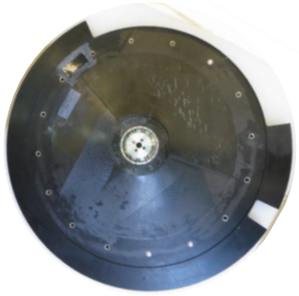
1 ms pulse length
full pulse (PSC off)

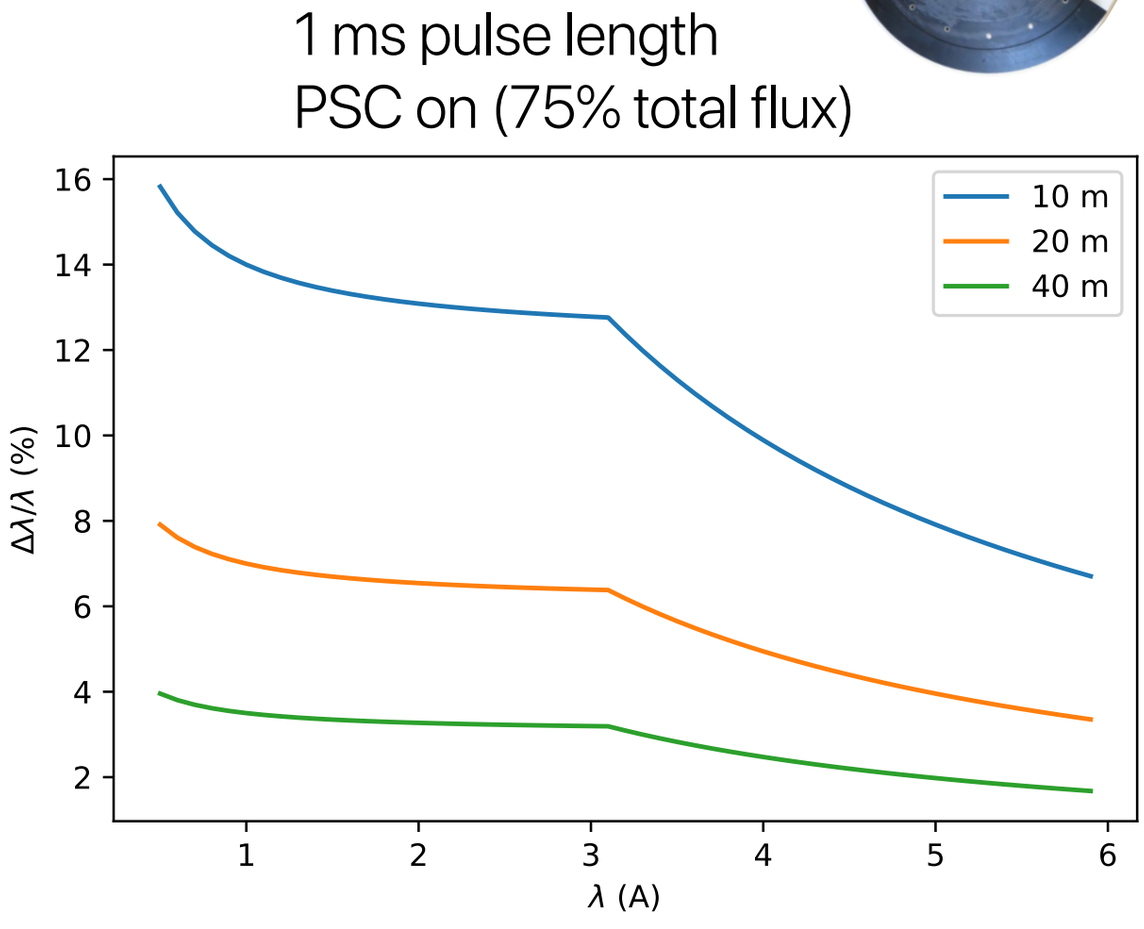


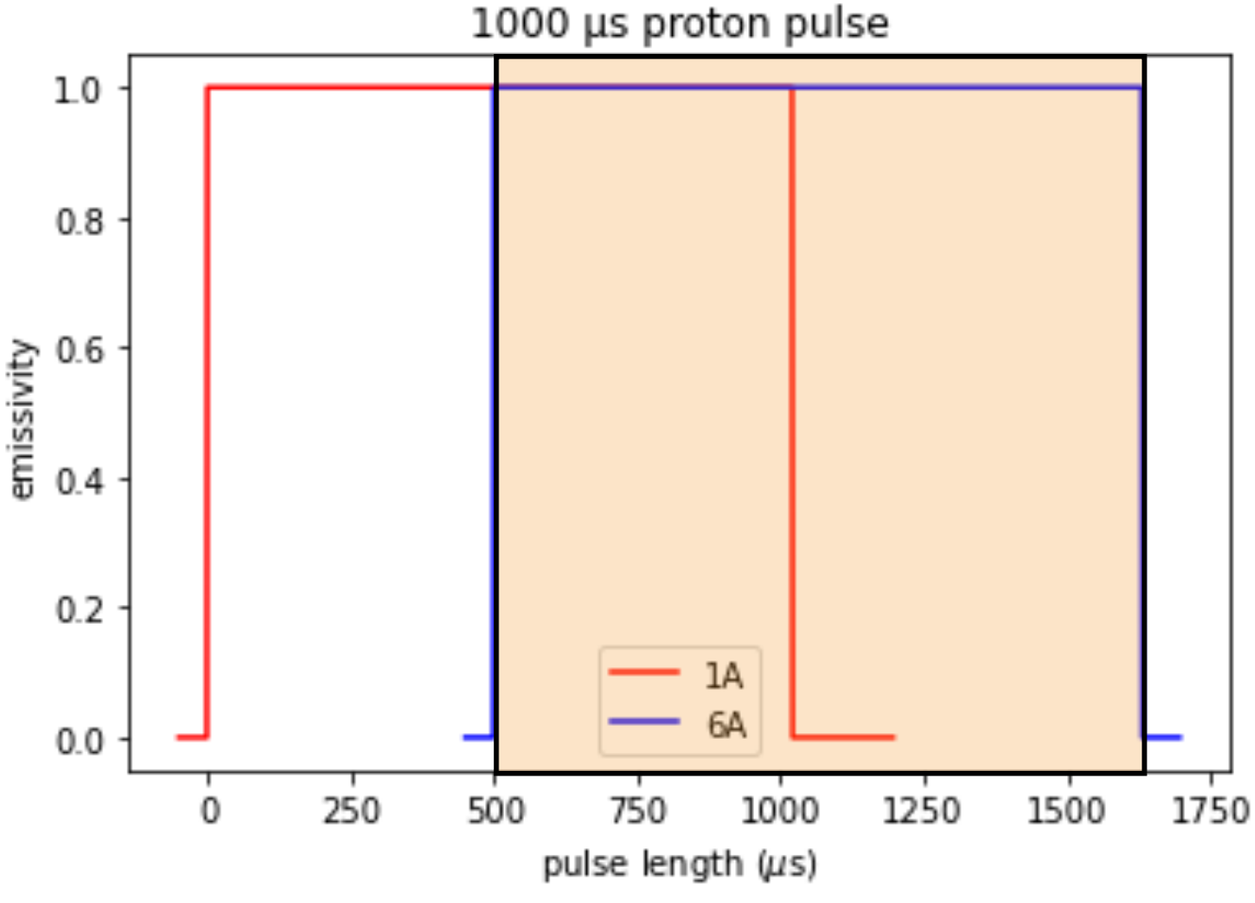


wavelength resolution

- 50 Hz frequency => 20 ms measurement intervals
- “Flat” resolution







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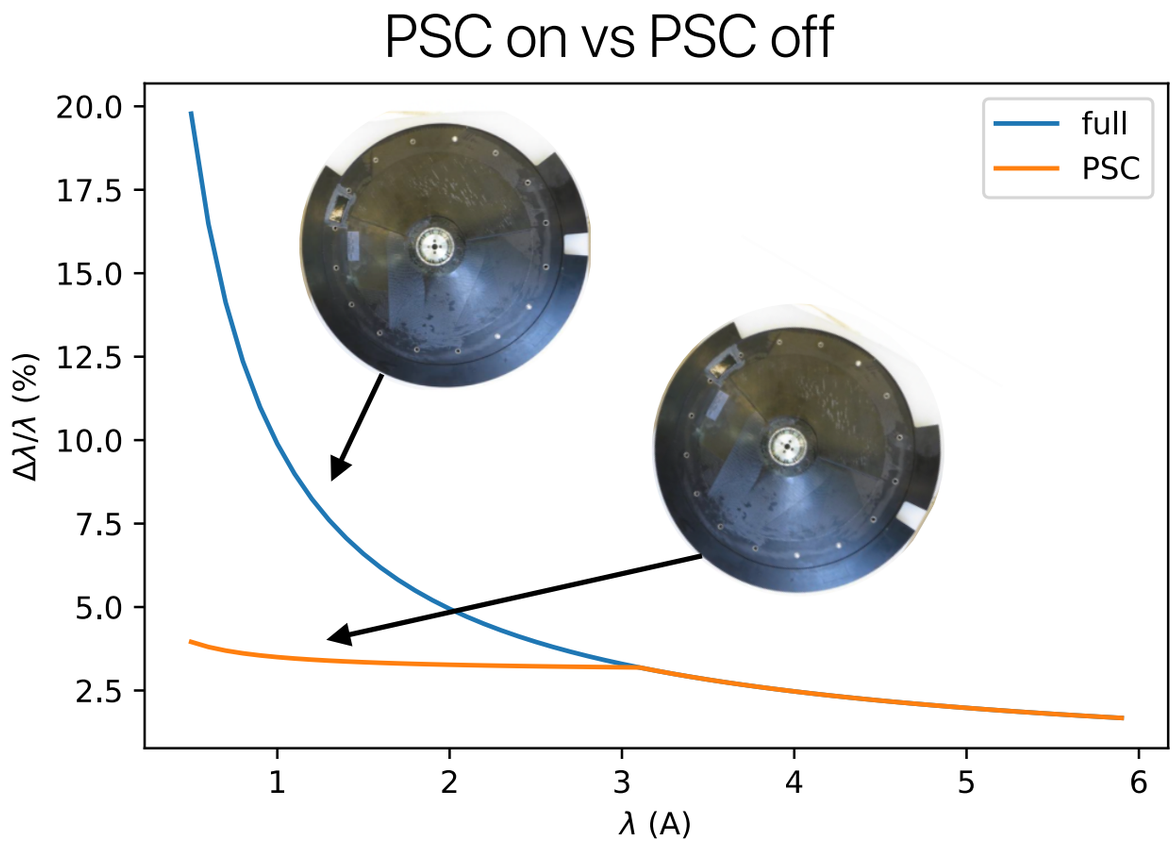
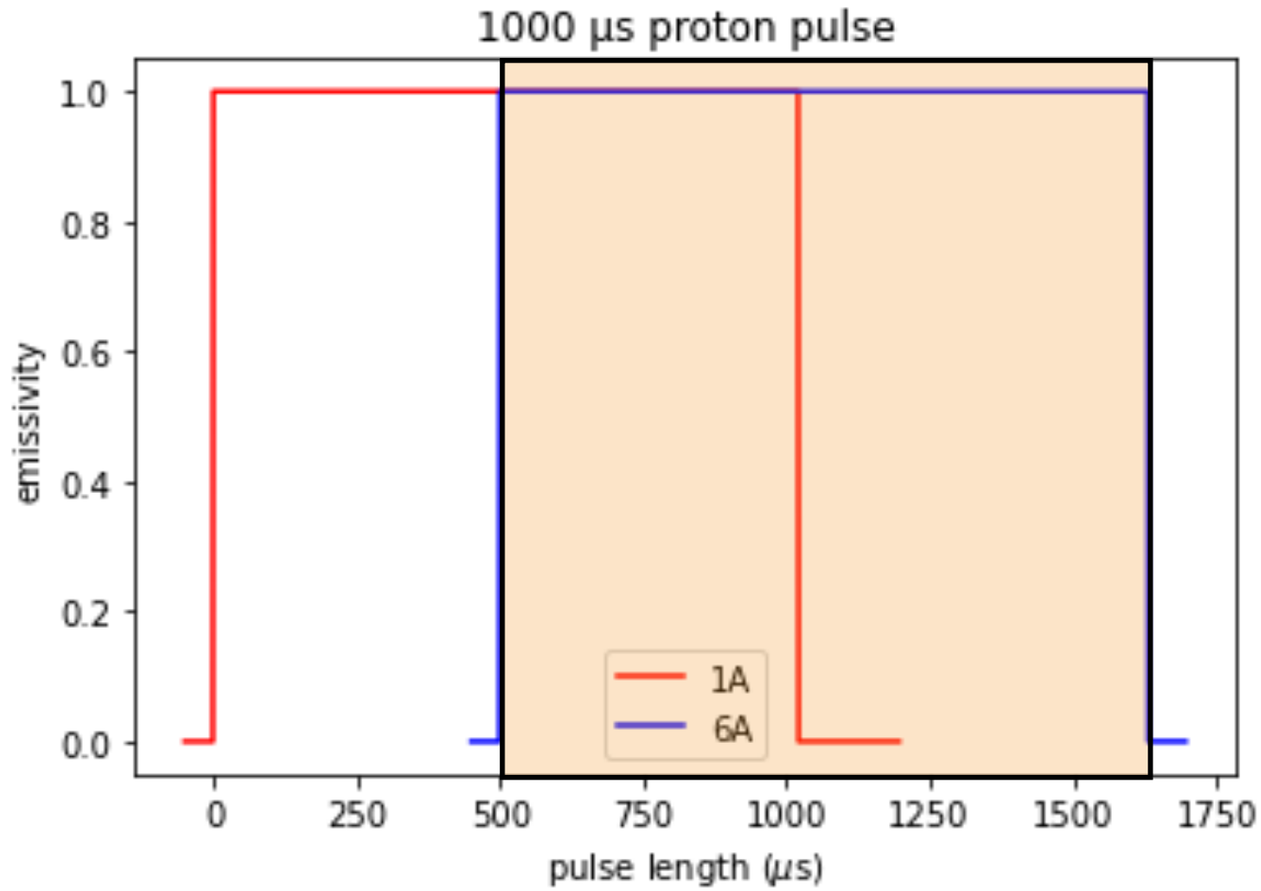
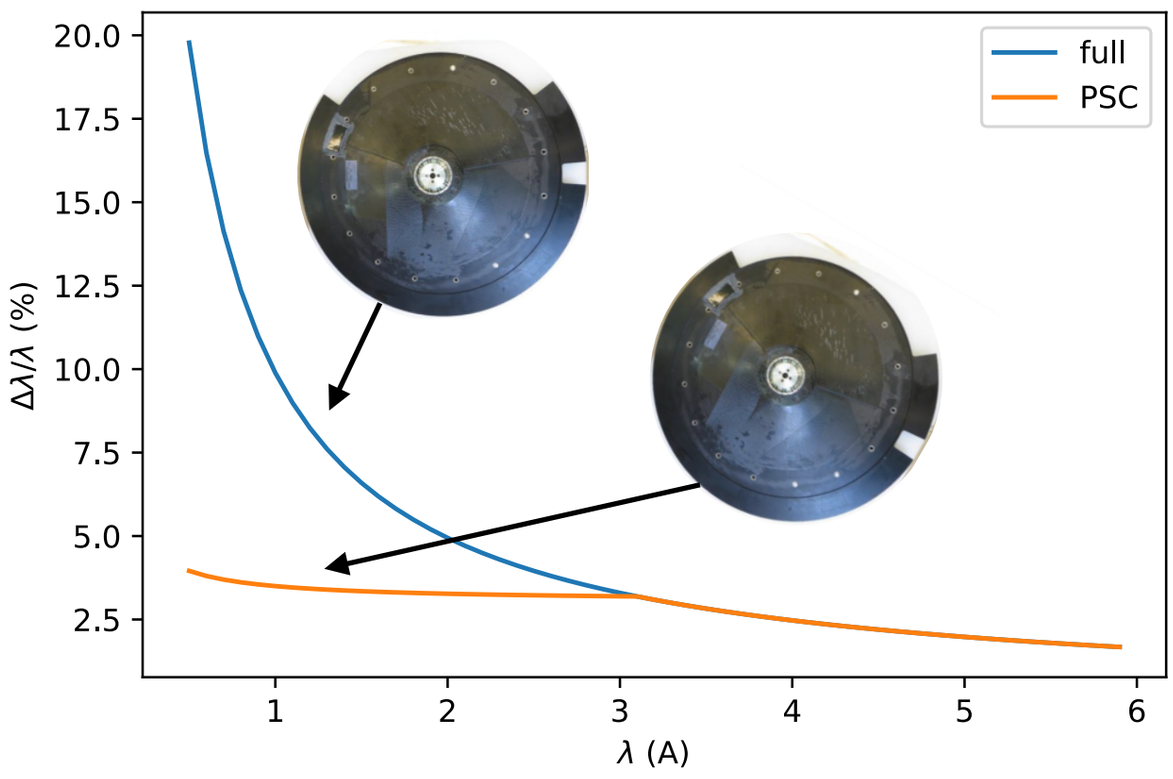


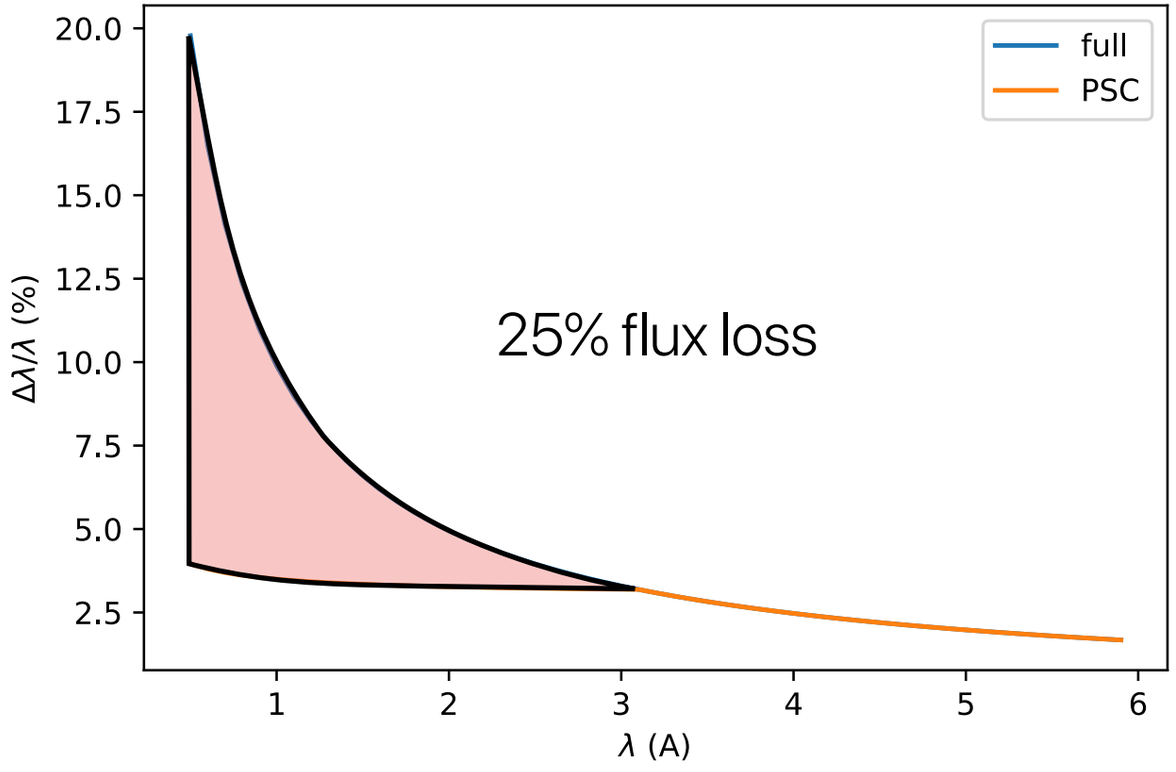


wavelength resolution

- 50 Hz frequency => 20 ms measurement intervals
- “Flat” resolution

PSC on vs PSC off





Design constraints

- Pulse length: source + choppers
- Repetition rate: source
- Instrument length: science case + 2 above

- Q resolution from pulse length and distance
- Wavelength range from frequency and distance
- Q-space covered

- No MC = uniform resolution in and out of plane (big 2D detectors can be used !)

Codename PRESTO

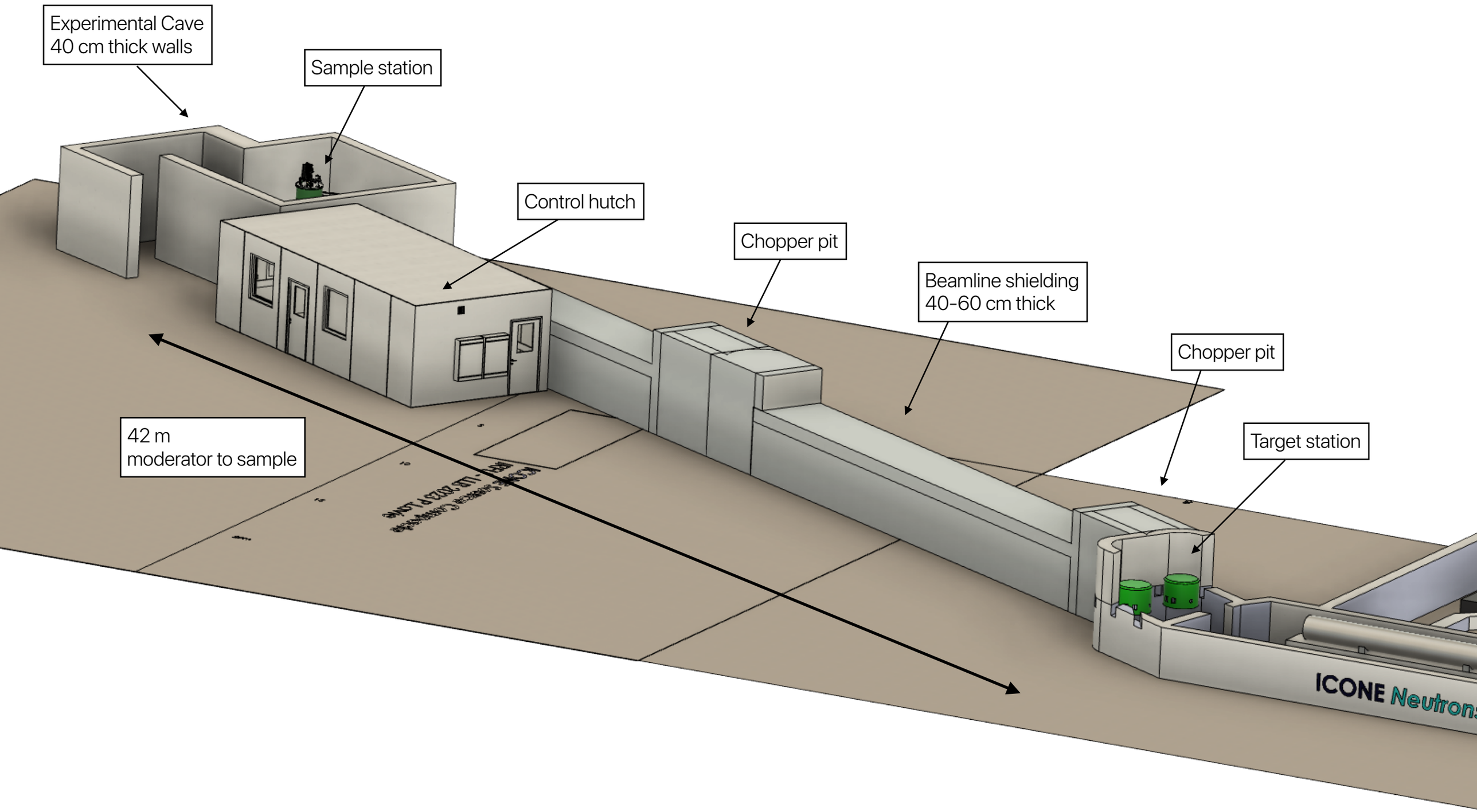
ICONE
Neutrons for Materials Sciences

- Source parameters (from HBS source term / 4)
  - Duty cycle limited to 4%
  - 800 µs @ 50 Hz
  - Cold spectrum: 60 K centered
  - Thermal spectrum: 300 K centered

- Main instrument characteristics
  - 43.5 m long instrument
  - ~1.8A wavelength band @ sample position
  - Counter rotative pulse shaping choppers
  - 10x20 mm^2 beam size with +-0.3° divergence

PRESTO: overview

ICONE
Neutrons for Materials Sciences



PRESTO: overview

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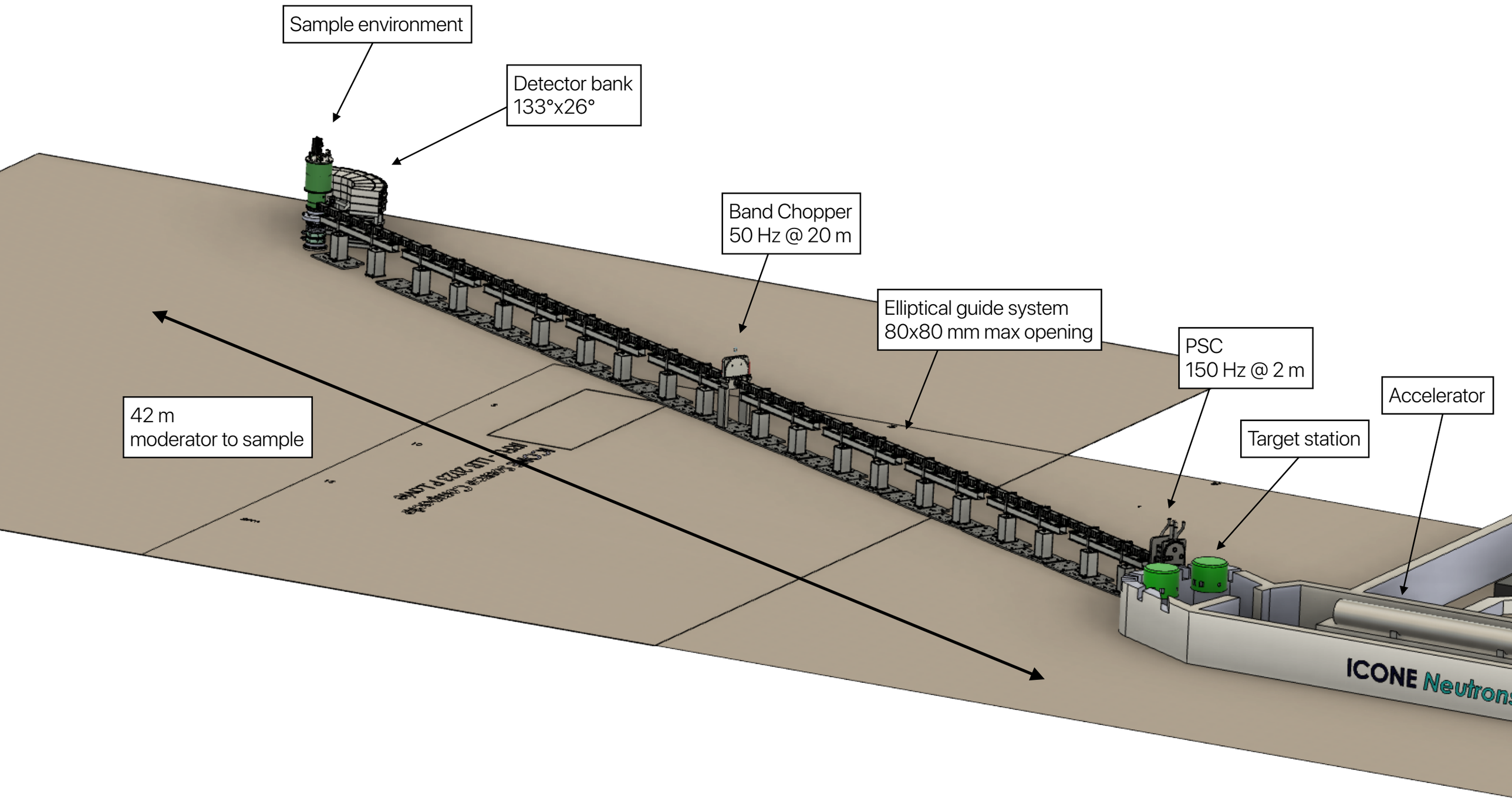


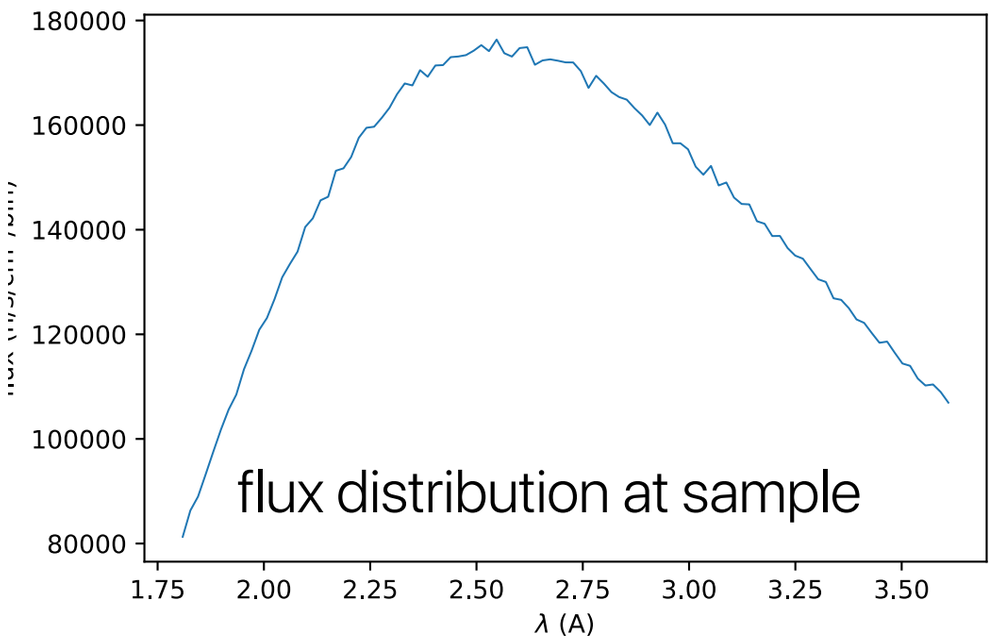
PRESTO: virtual experiments

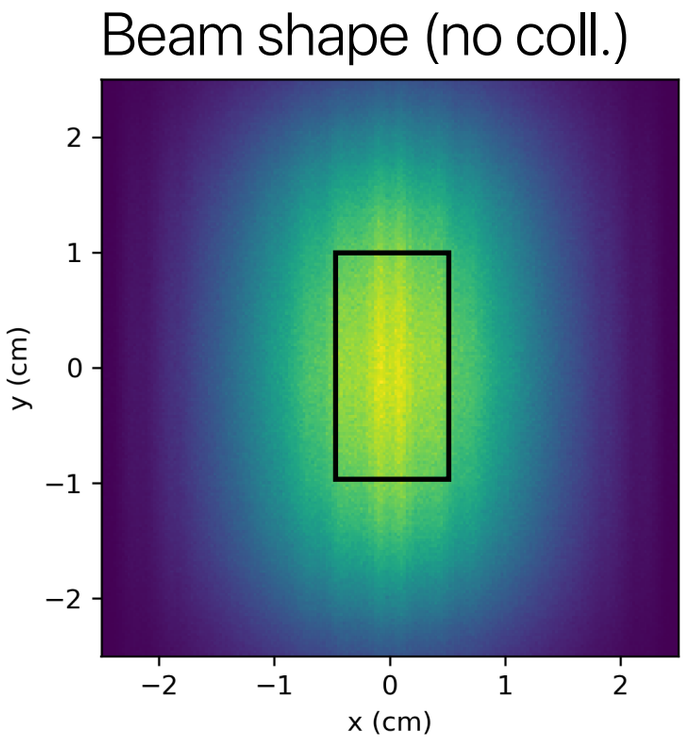
- Dedicated moderator: 20x50 mm (WxH)
- Cold spectrum centered at 60K (~2.6 A)
- 1-4 % duty cycle
    - 200 µs @ 50 Hz (HR)
    - 800 µs @ 50 Hz (HF)

- +- 0.3° collimation at sample position (set of slits)
- $Na_2C_3Al_2F_{14}$ reference sample from mcstas library

- Cubic sample of 1 cm^3
- Diogène/7C2 detector:
    - 133°x26° angular aperture
    - 256 tubes with 128 channels

- 2 modes:
    - HR: 1.4x10^7 n/s/cm^2
    - HF: 5.2x10^7 n/s/cm^2





PRESTO: virtual experiments

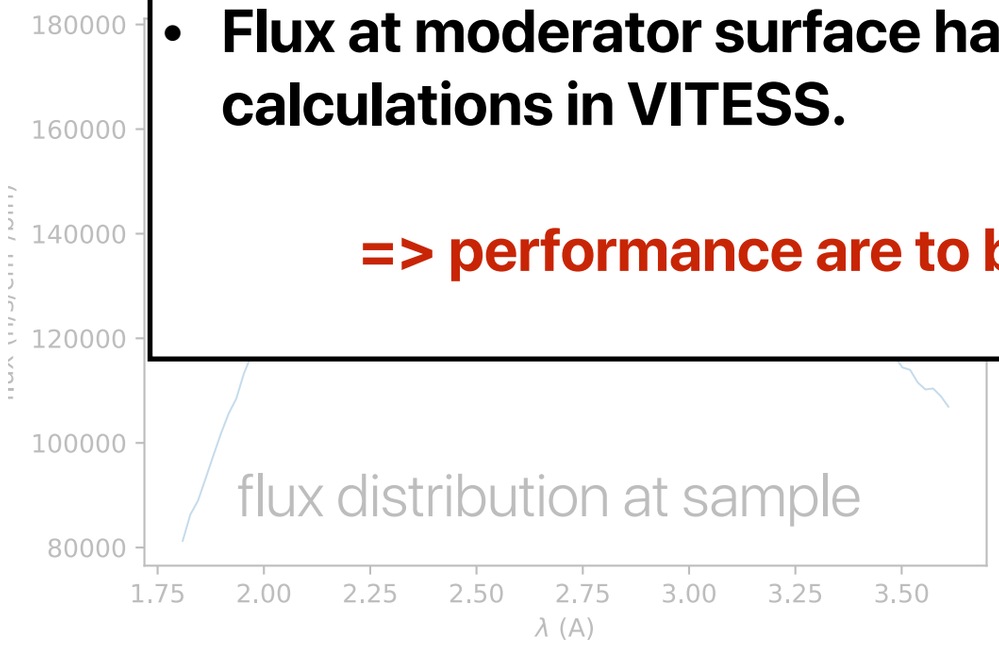
- Dedicated moderator: 20x50 mm (WxH)
- Cold spectrum centered at 60K (~2.6 A)
- 1-4 % duty cycle
  - 20
  - 80
- +- 0.3°
- Na_2C_3A

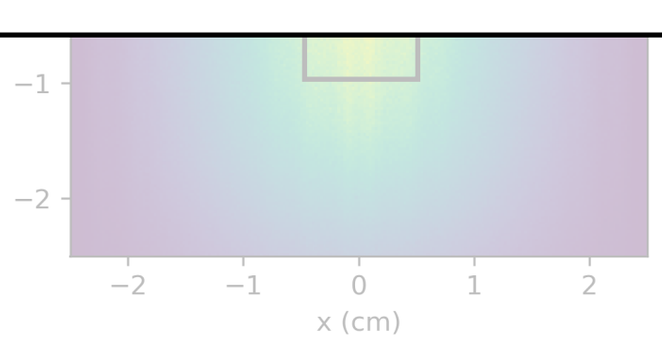
- Cylindrical sample of 1 cm^3
- Diogène/7C2 detector:
  - 133°x26° angular aperture

DISCLAIMER:

- **mcstas results are not experimental results !**
- **All calculations are made using a scaling of the HBS source term to account for different proton energy and current.**
- **Flux at moderator surface have been scaled with K. Lieutenant calculations in VITESS.**

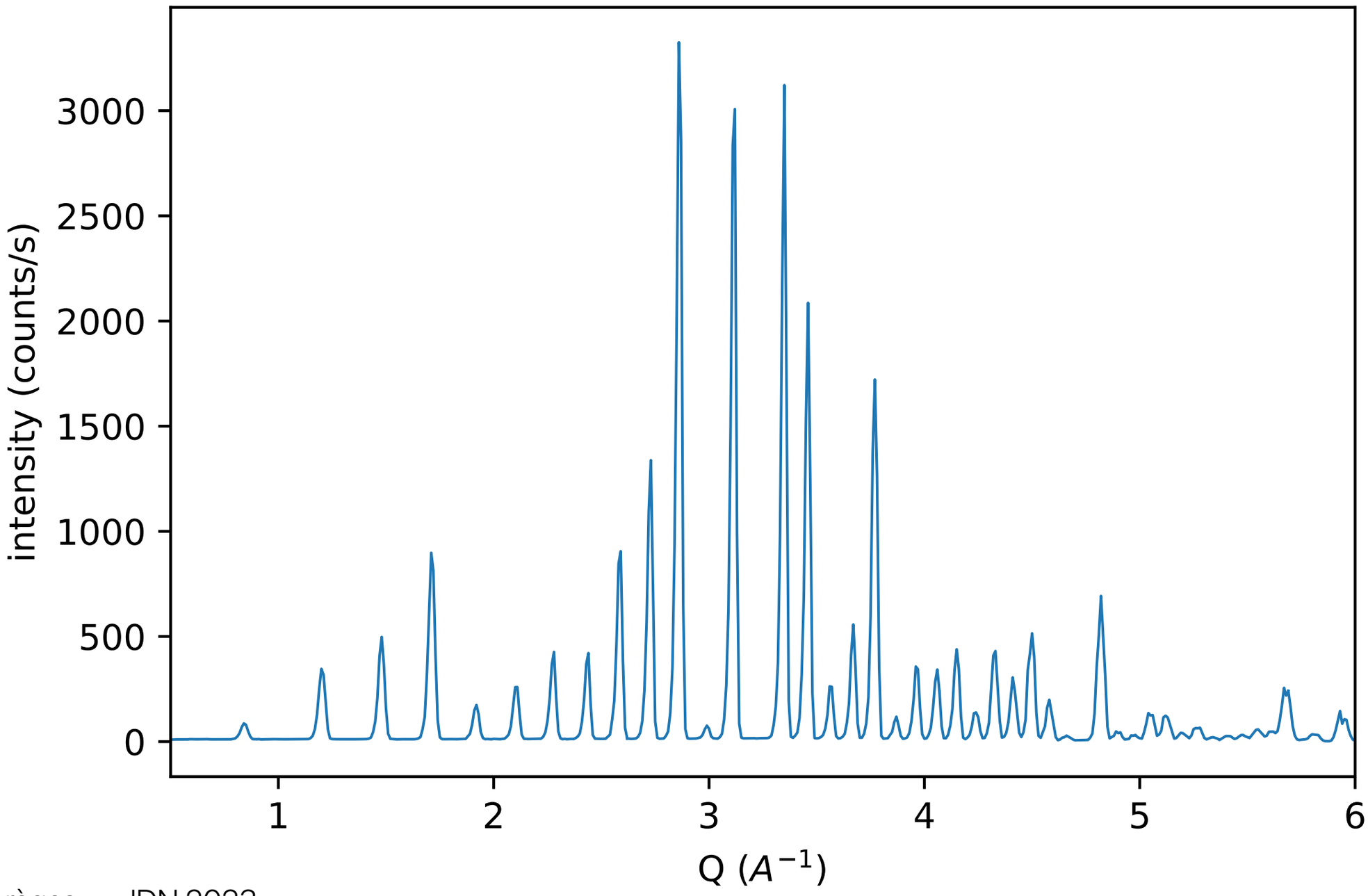
=> performance are to be taken with a grain (rock) of salt





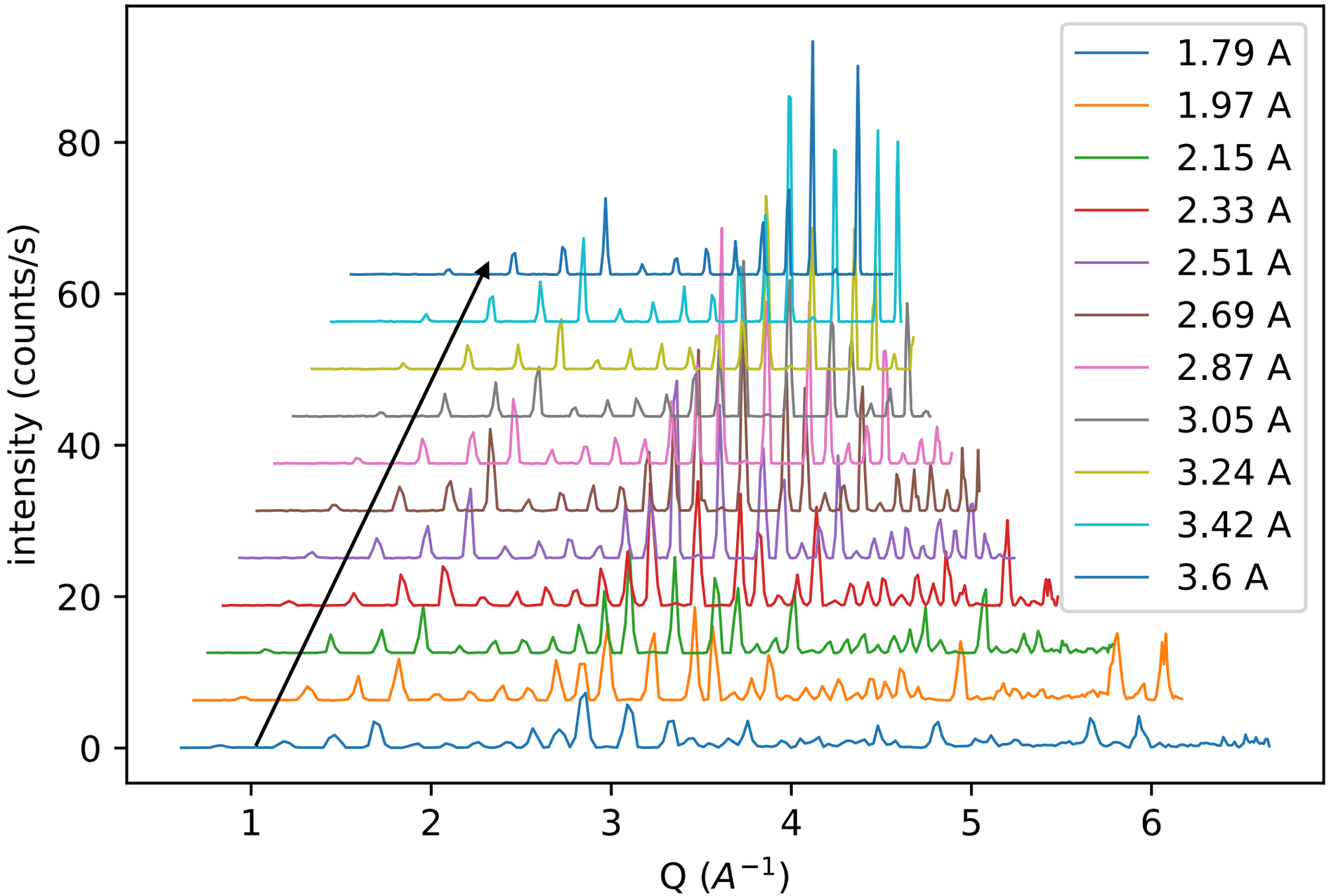
PRESTO: virtual experiments

- HR mode: reduced to 1D pattern (raw data)



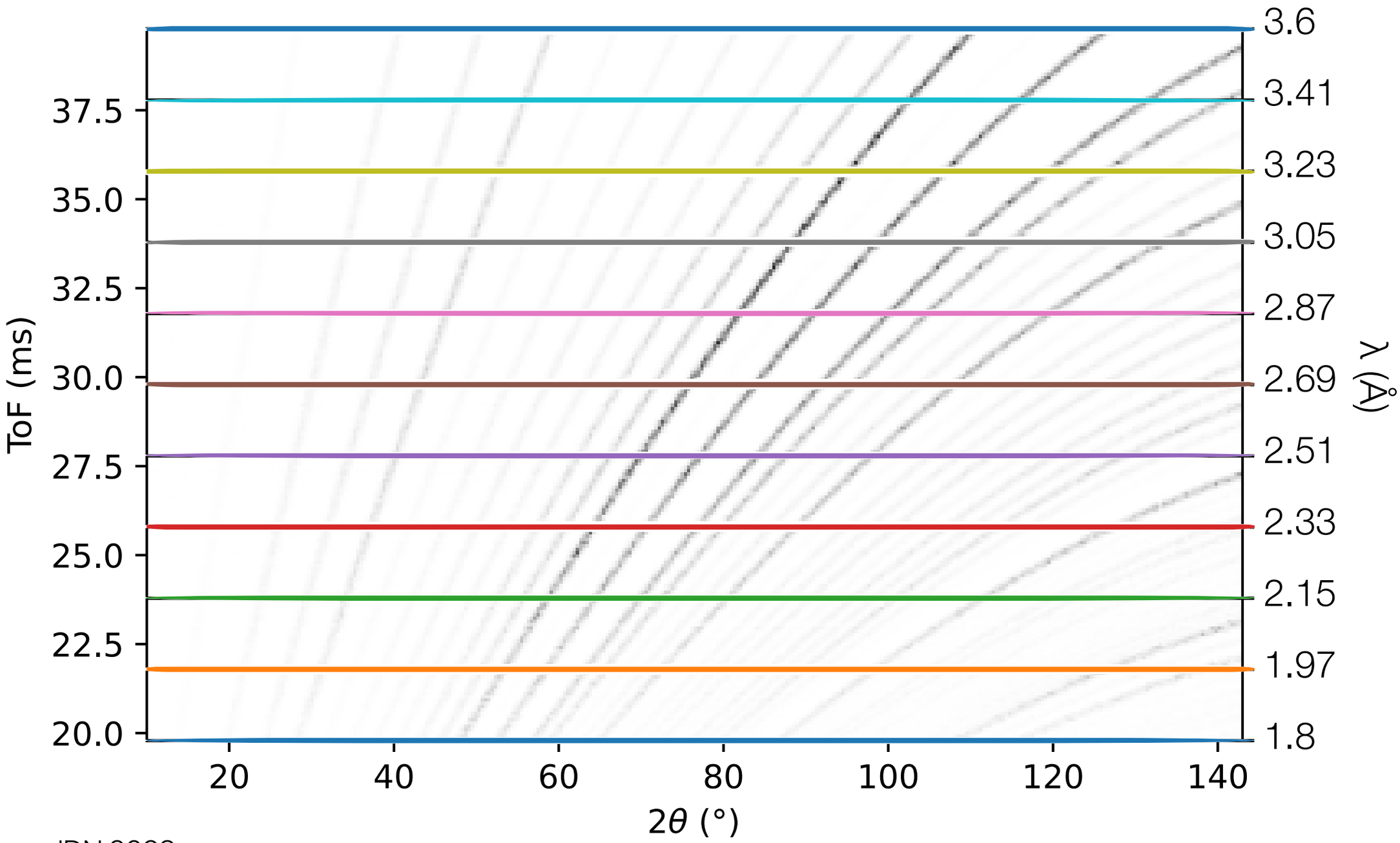
Reality: multiple sub-patterns

- HR mode: cat of multiple 1D pattern (raw data)



Less reduction / more details

- 200 µs pulse length — +- 0.3° divergence



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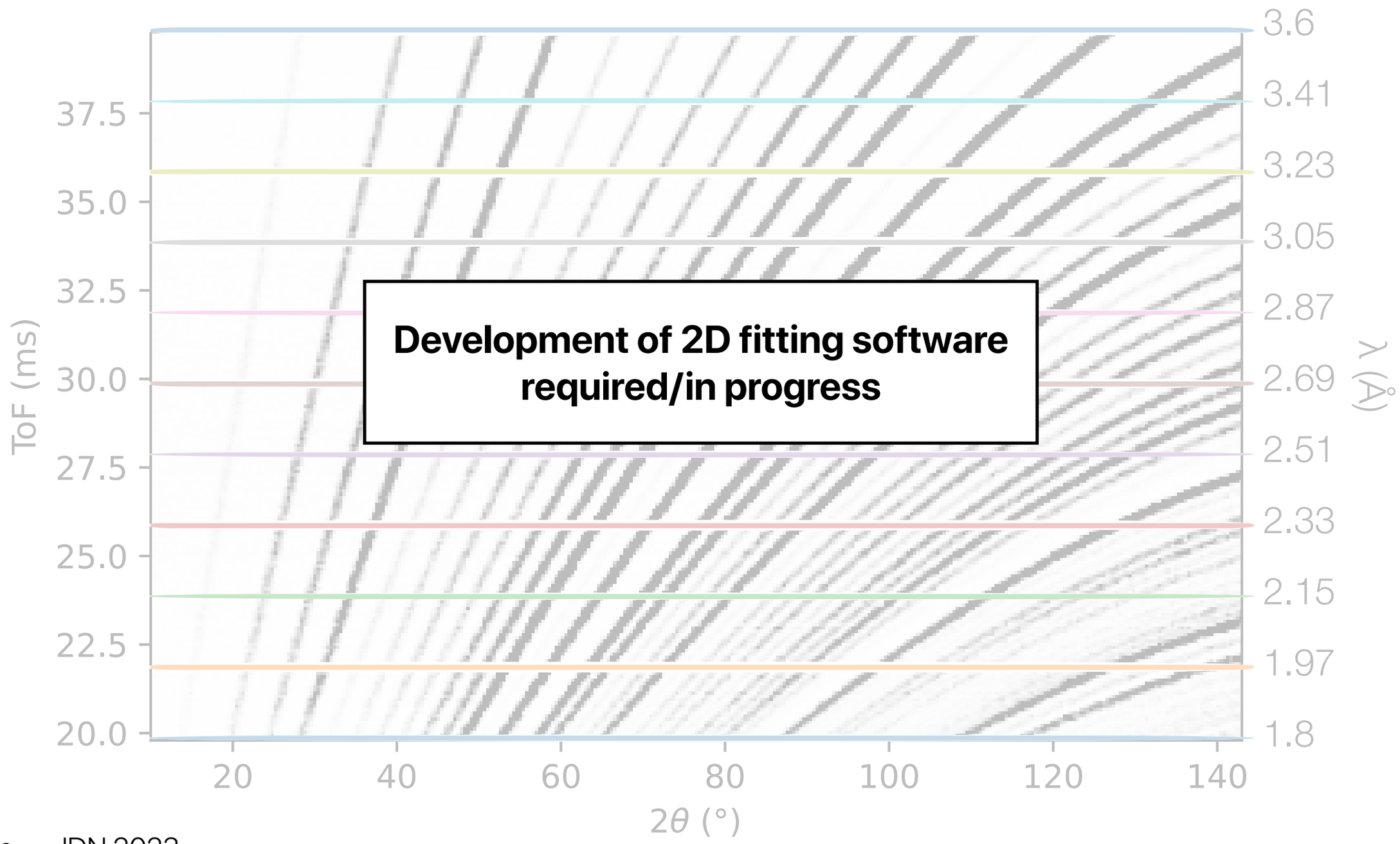

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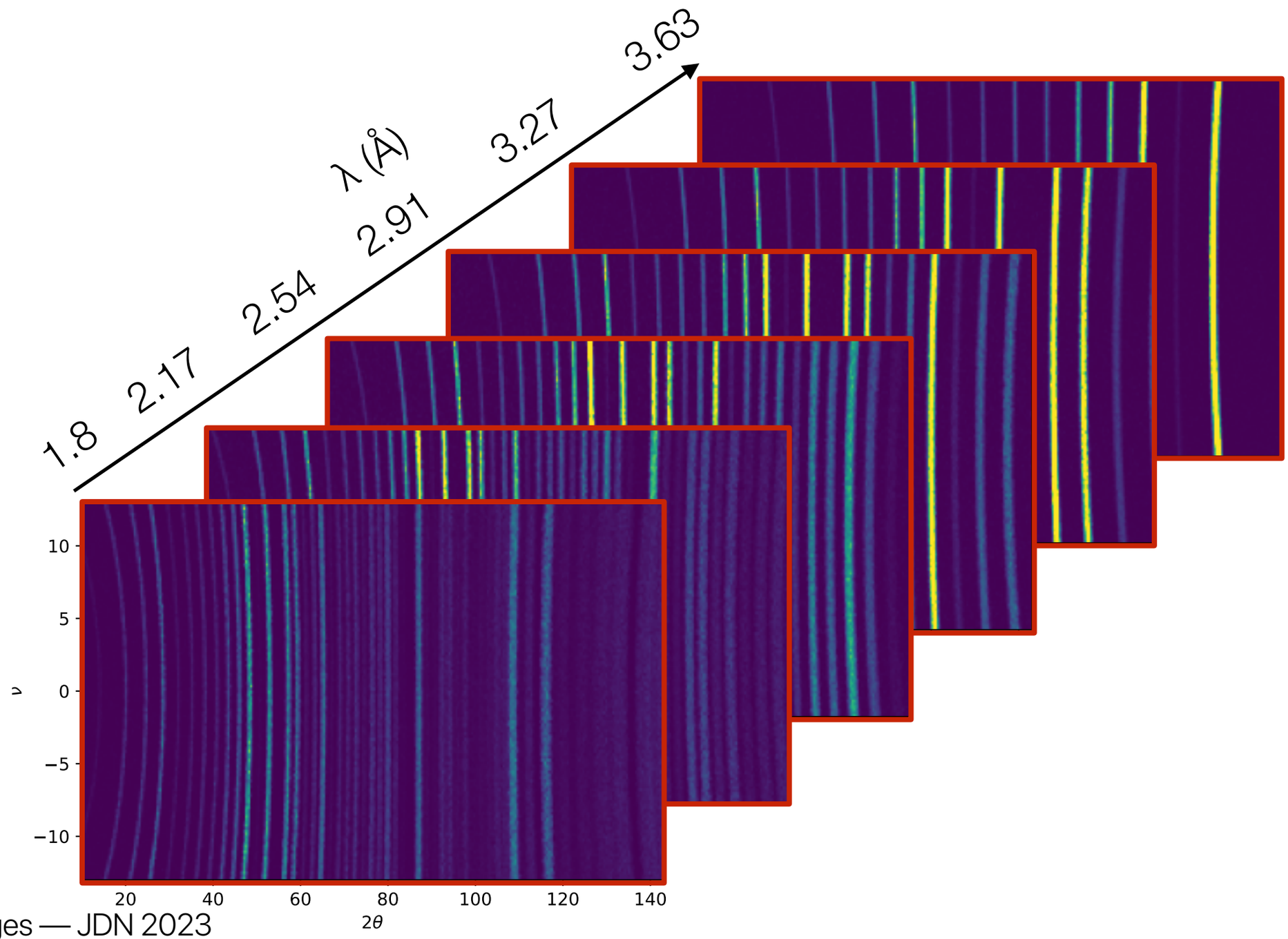

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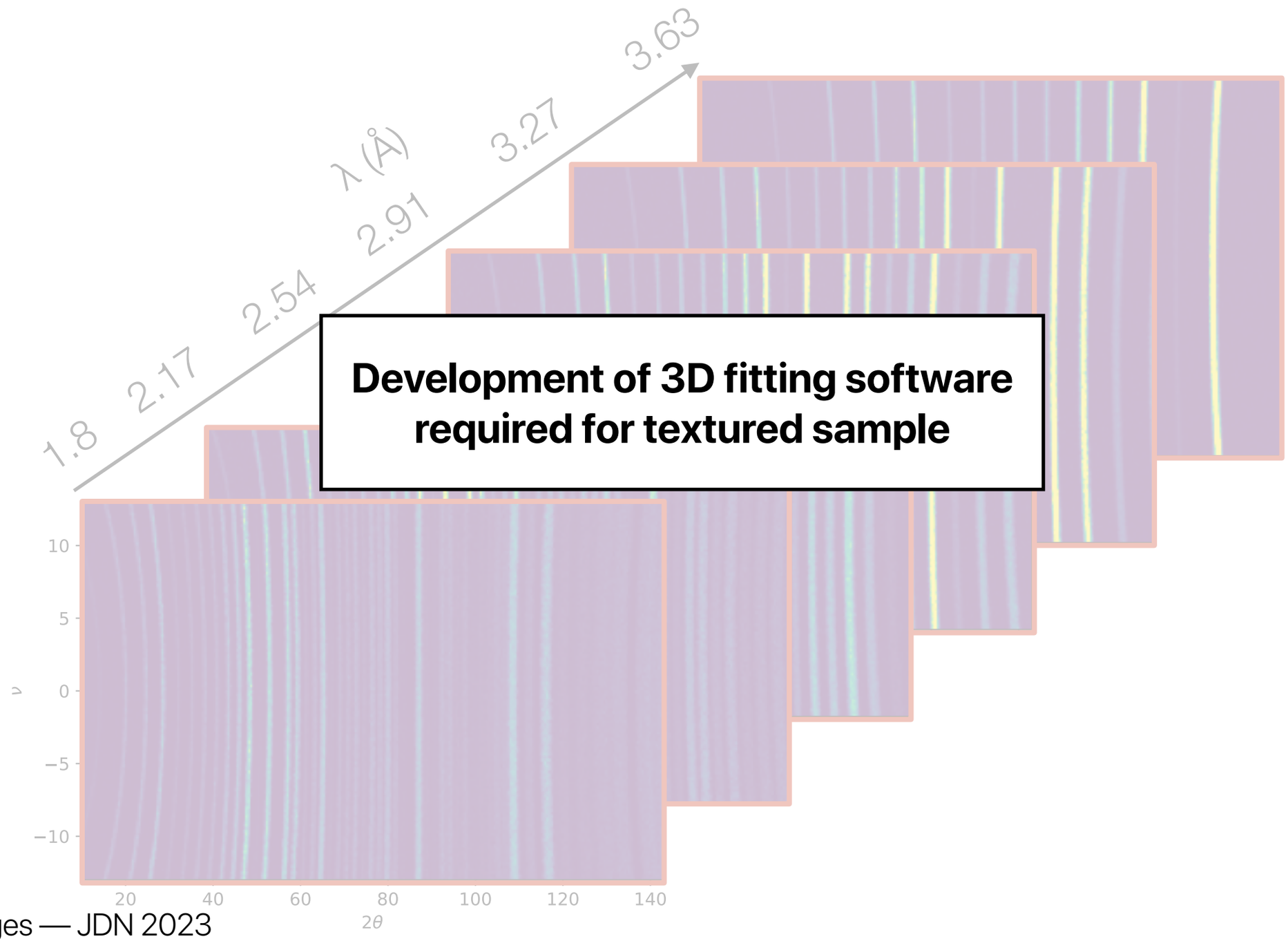
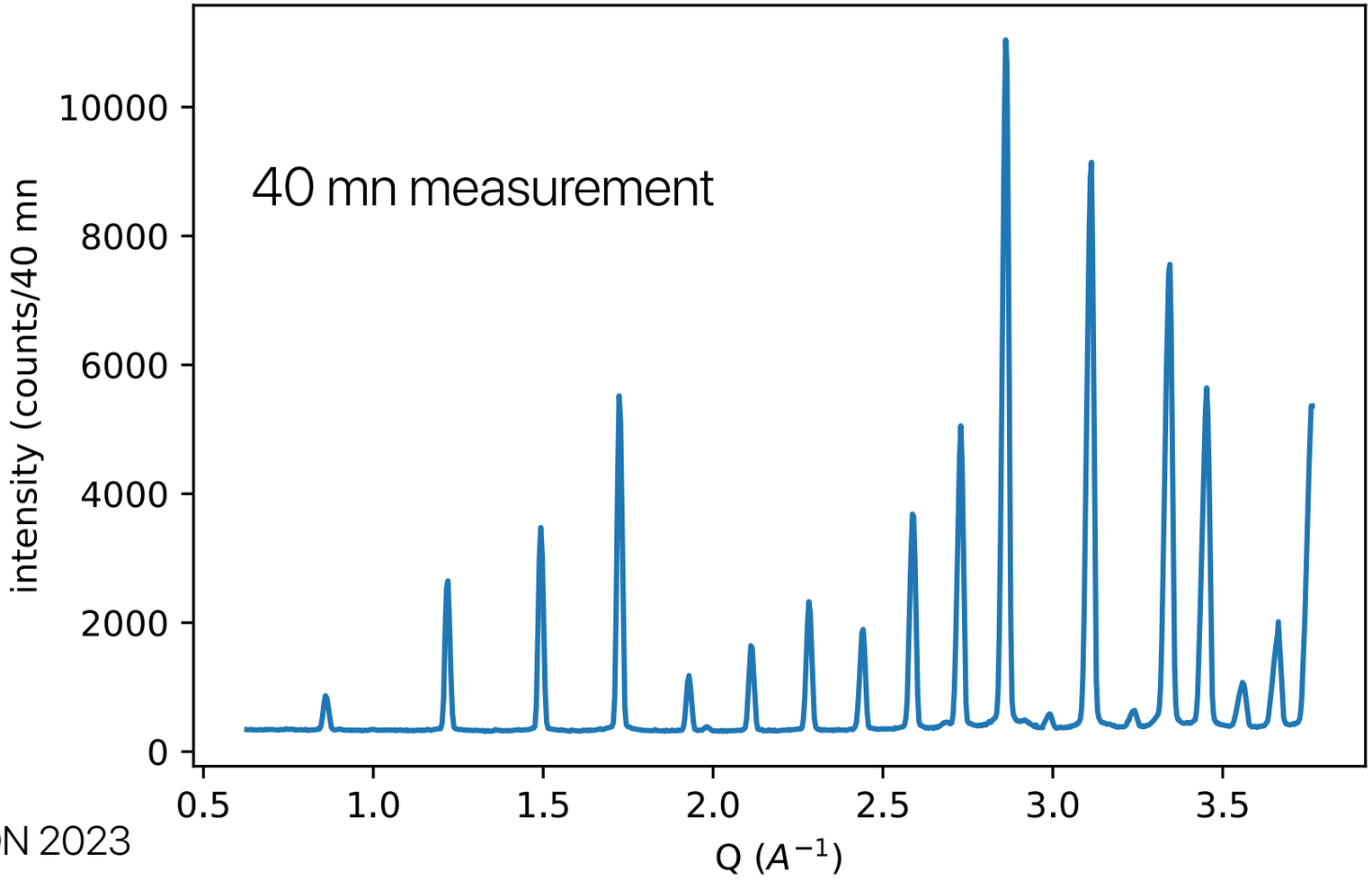


G4.1: measured sample

- Reference/calibration sample: $Na_2C_3Al_2F_{14}$
- Comparison with measured pattern on G4.1 (Orphée) in 2015
  - 1 cm3 sample, BF_3 detector
  - gold foil flux measurement at MC position
  - 0.1° tube width



PRESTO: virtual experiments

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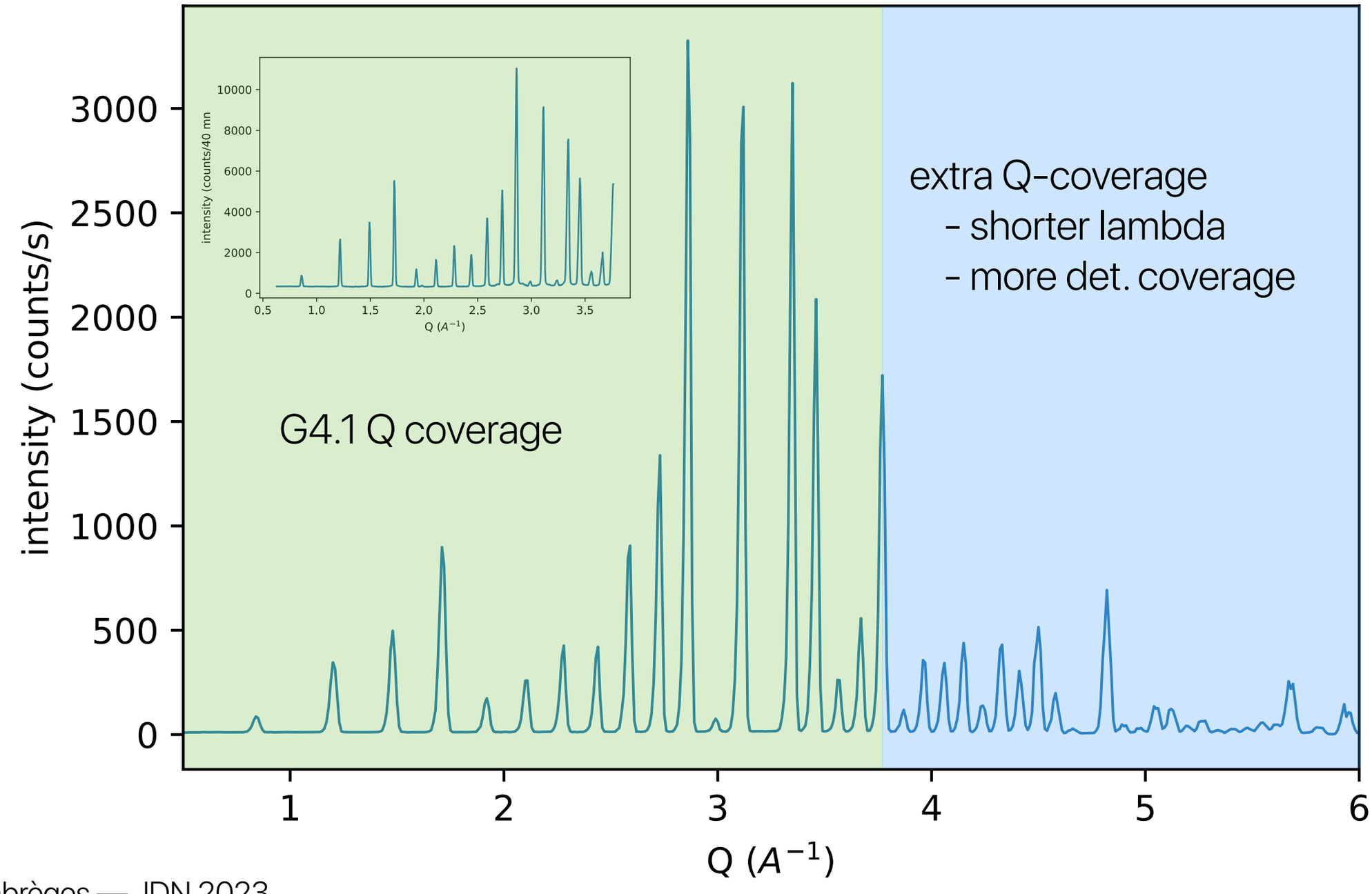

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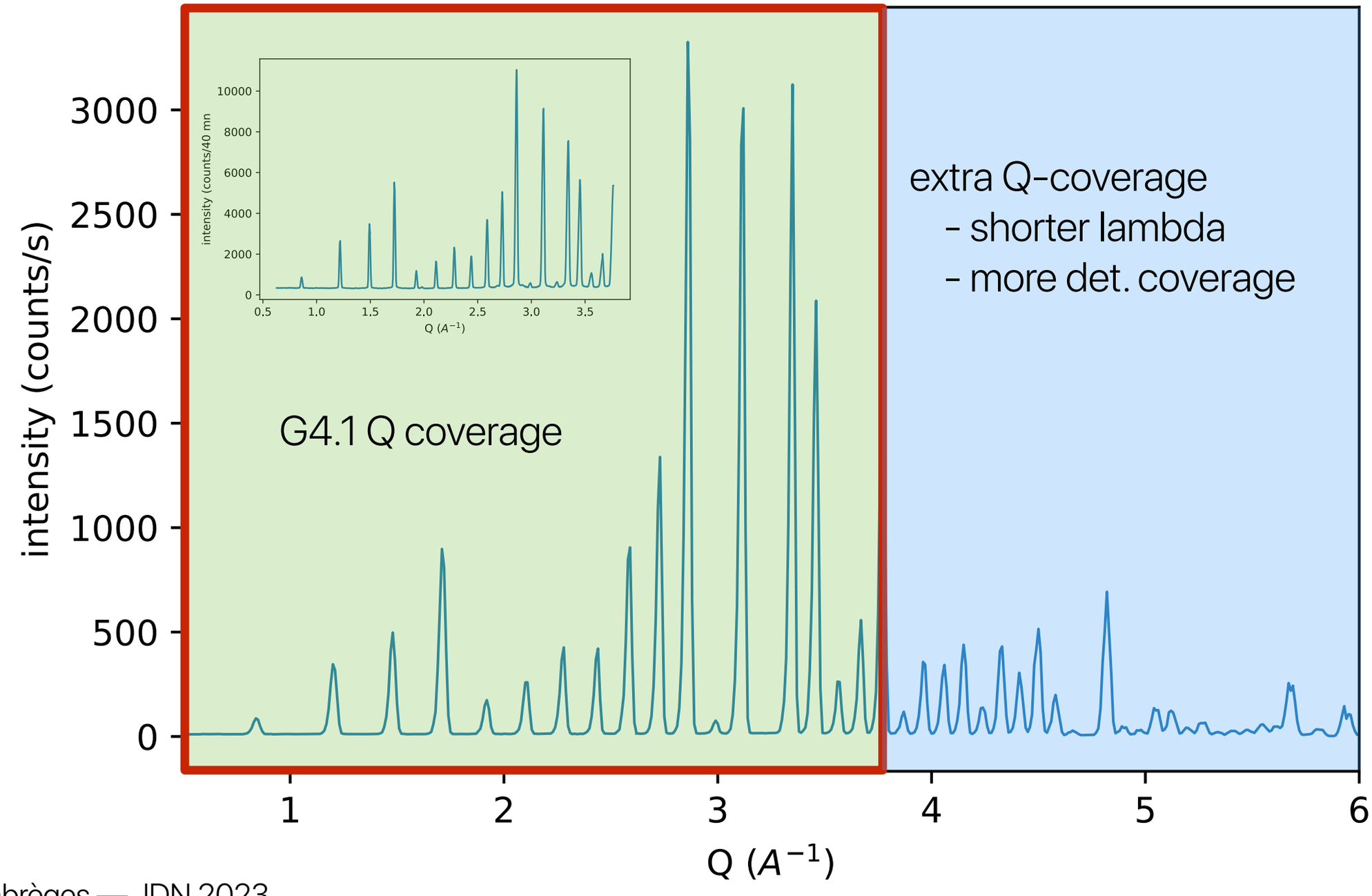

PRESTO: HR configuration

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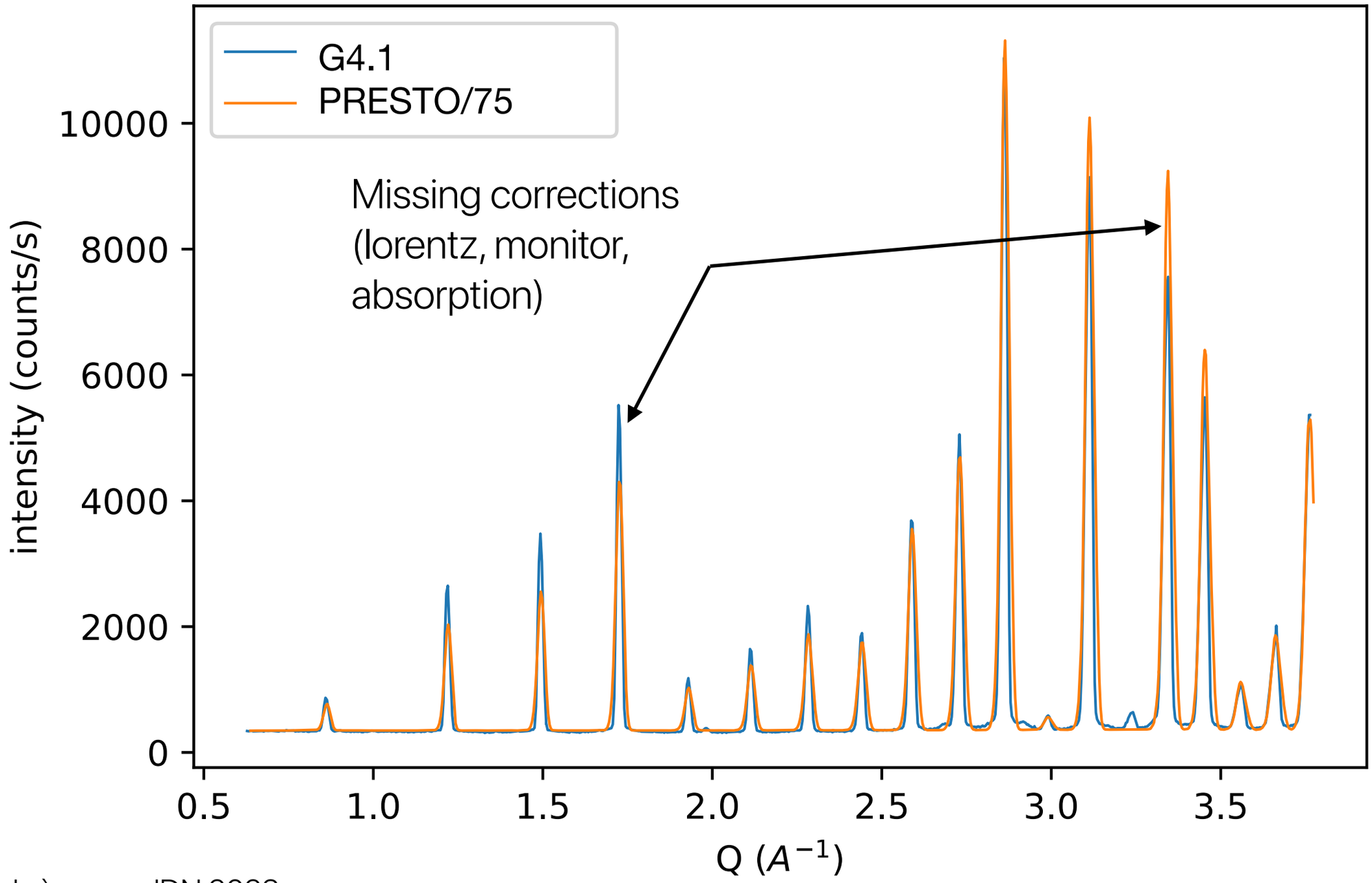

PRESTO: HR configuration

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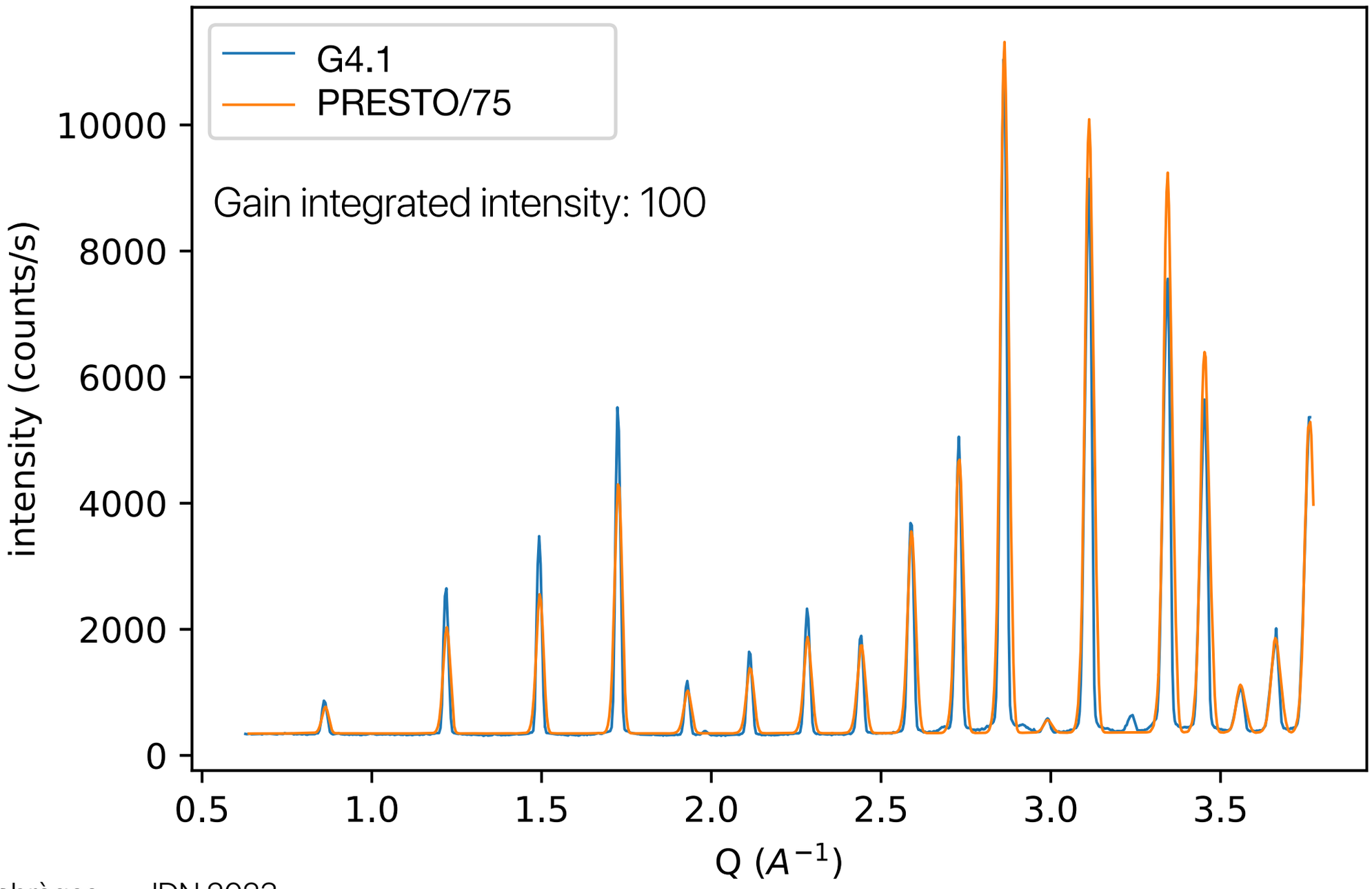
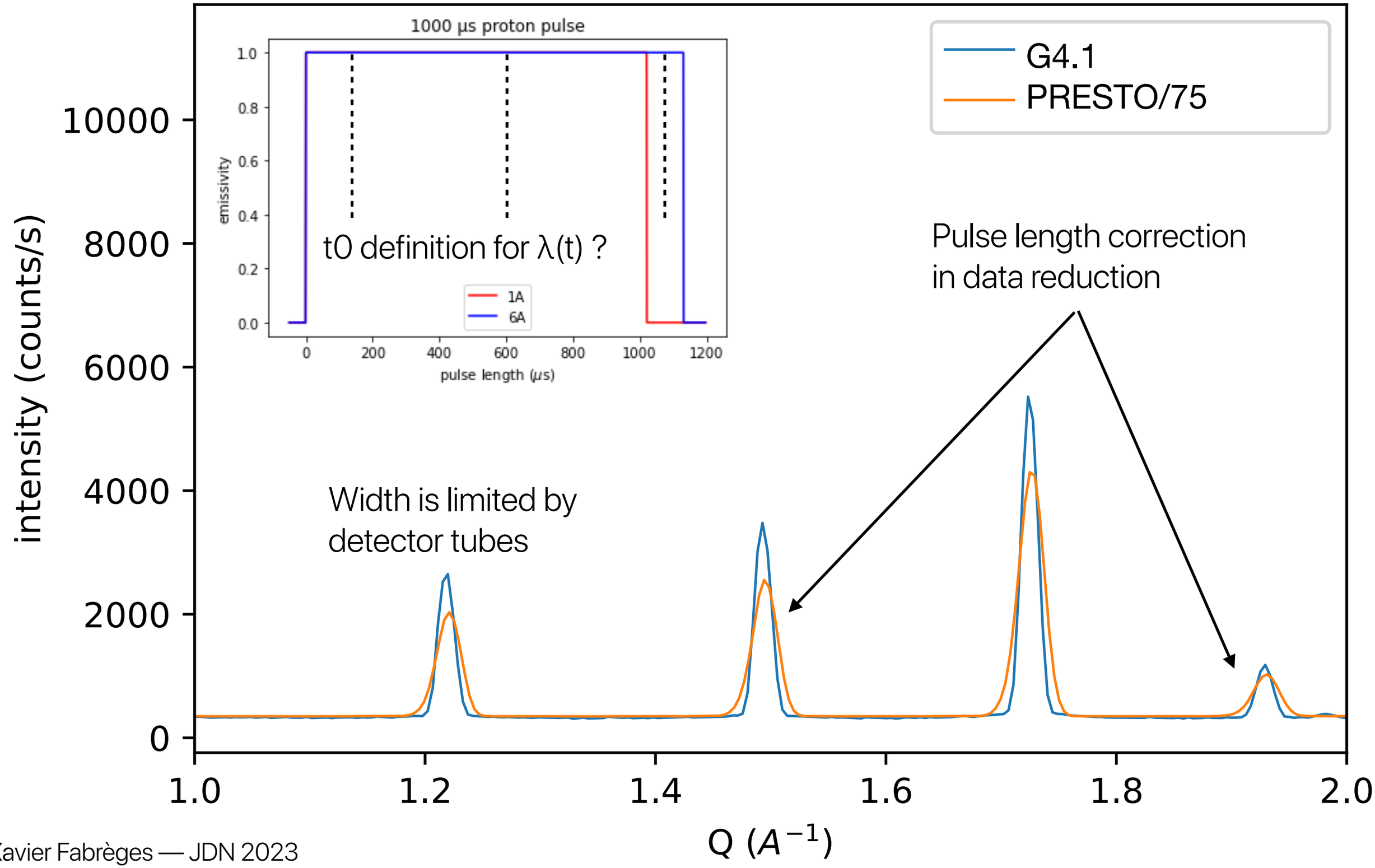
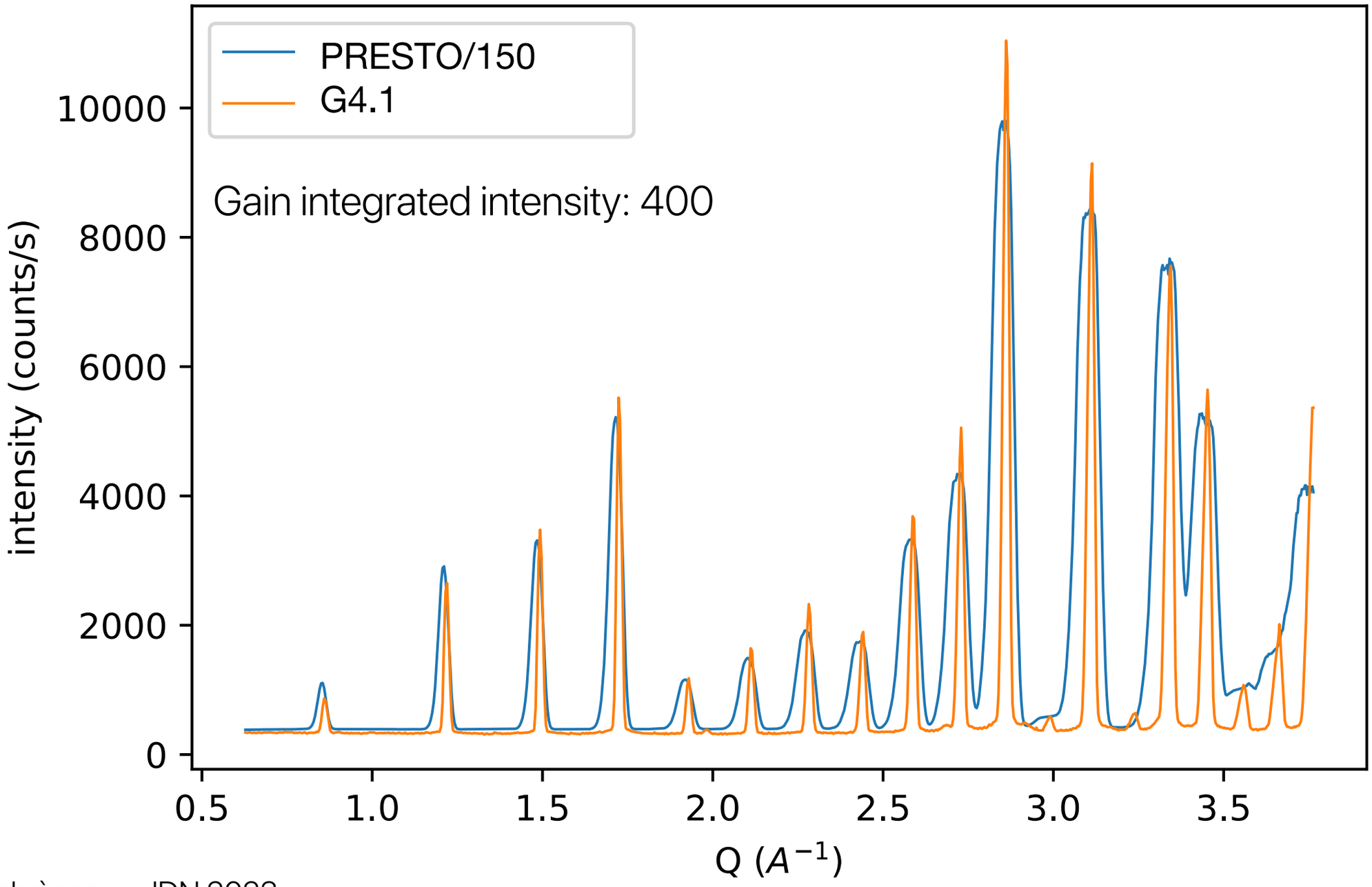


PRESTO: HR configuration



PRESTO: HF configuration

- 800 µs pulse length — +- 0.3° divergence



PRESTO vs G4.1: gains ?

Gains	G4.1	PRESTO (HR)	PRESTO (HF)
Flux @ sample (n/s/cm²)	10^6	$1x10^7$	$3.6x10^7$
Detector	80°x4°	133°x26°	
Total			

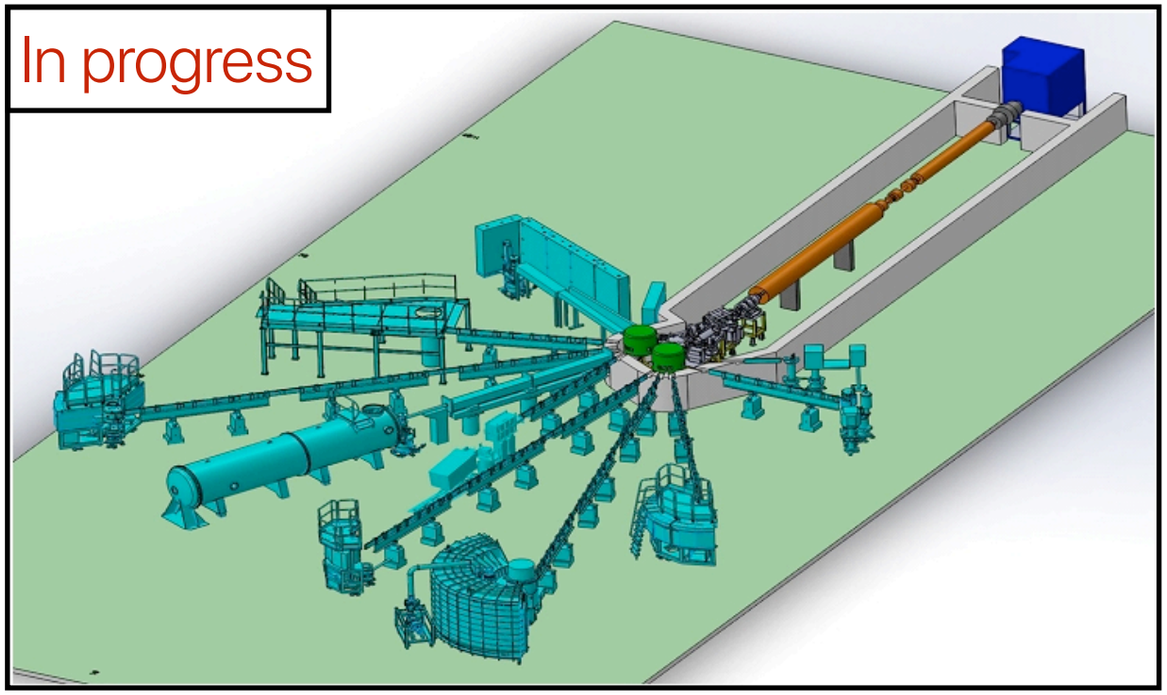
PRESTO vs G4.1: gains ?

Gains	G4.1	PRESTO (HR)	PRESTO (HF)
Flux @ sample (n/s/cm²)	10^6	$1x10^7$	$3.6x10^7$
Detector	80°x4°	133°x26°	
Total	1	**190**	**684**

Take home message

- Diffraction on ICONE will offer excellent performance !

- The same design and simulation efforts are to be made:
  - Reflectometry
  - Imaging
  - SANS
  - Inelastic (see Q. Faure)
  - Spin-echo



- All concatenated in the ICONE "*Avant-Projet Détaillé*"