Detector rate estimate for the BIFROST instrument

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Detectors and Data Acquisition for Instruments Meeting,
Paris, 12 February 2018

Outline

- BIFROST Instrument
- Simulation Tools
- Simulation Model
- Results
- Outlook

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- **BIFROST Instrument**
- Simulation Tools
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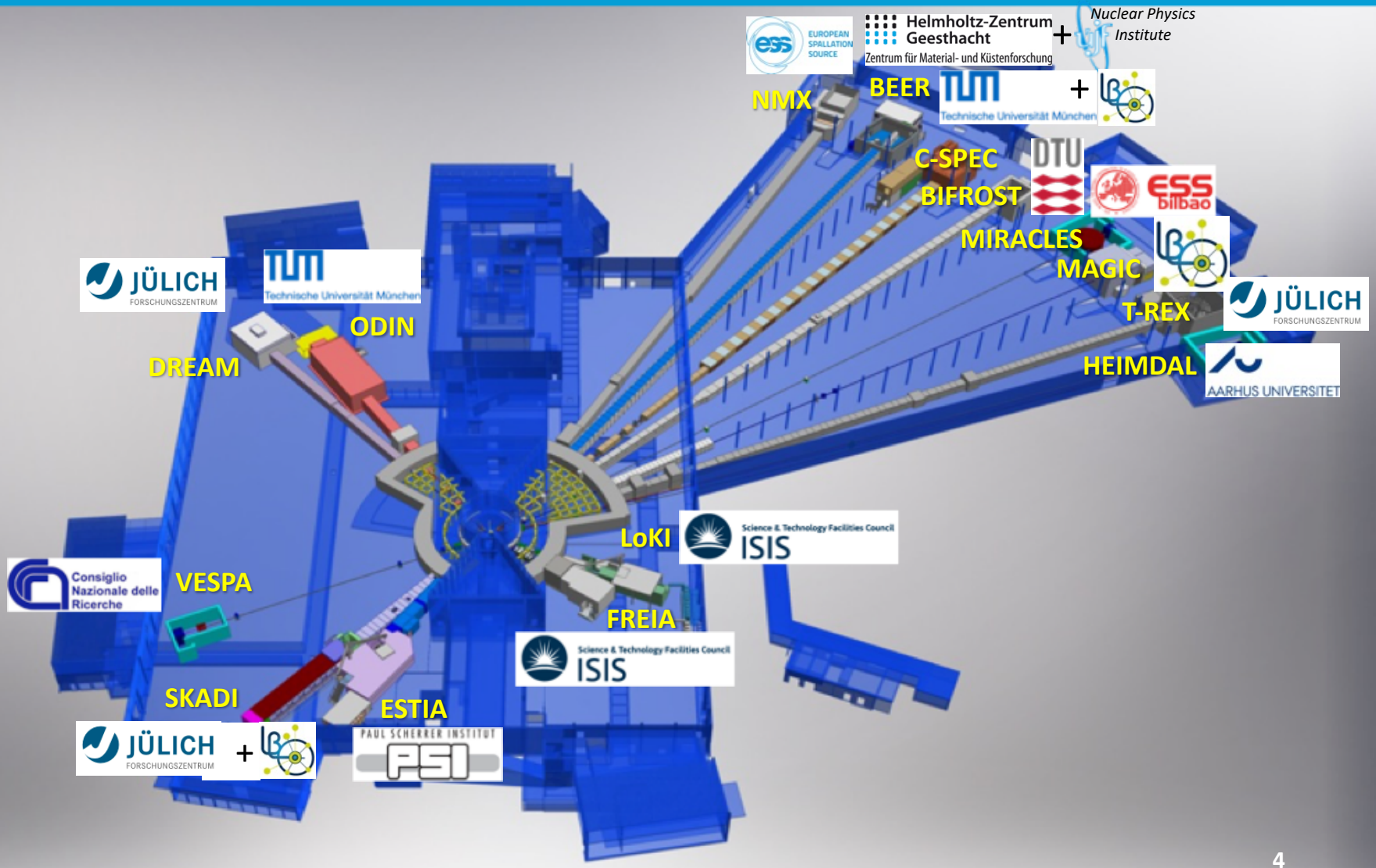
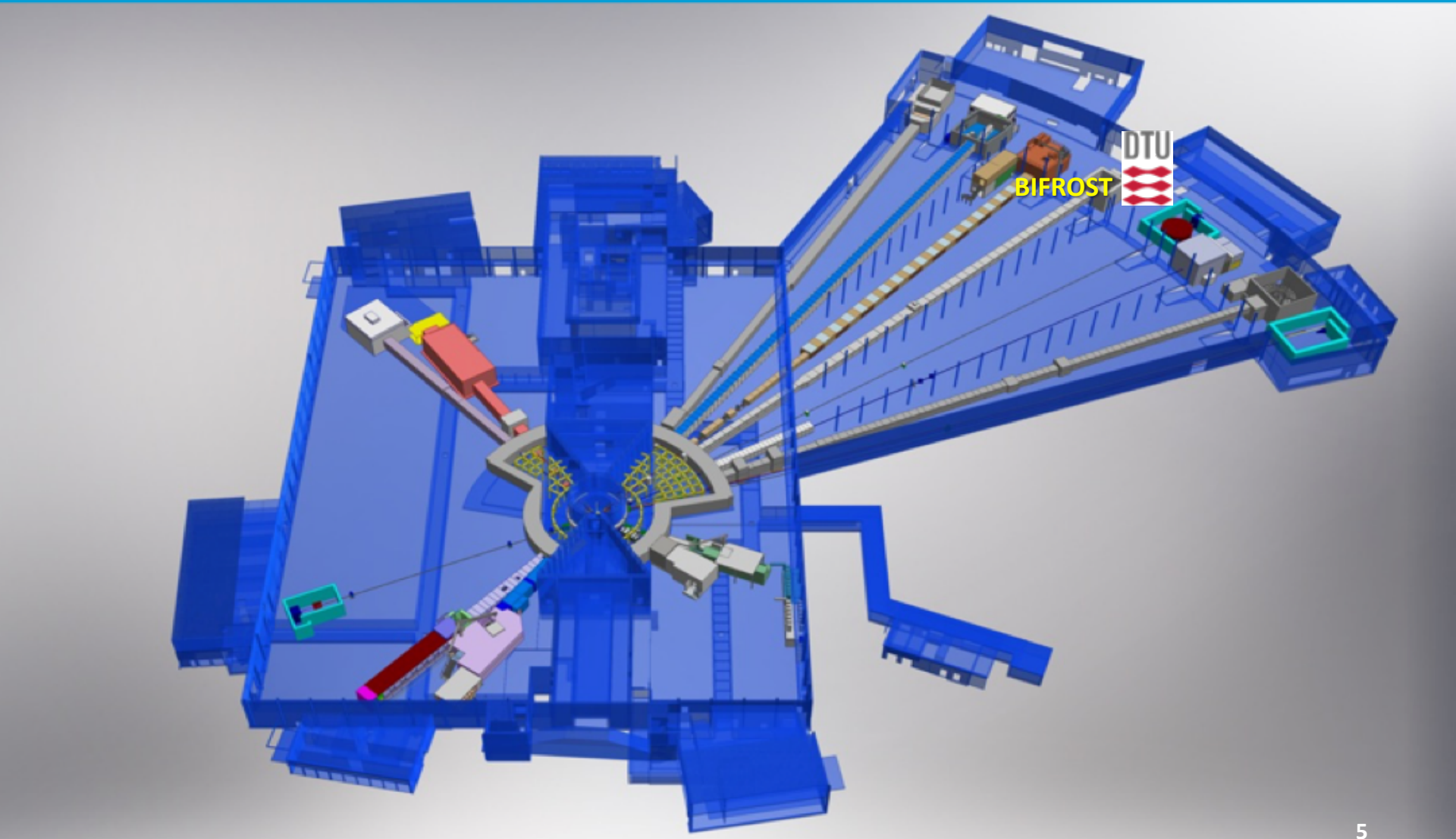
ESS - Instruments

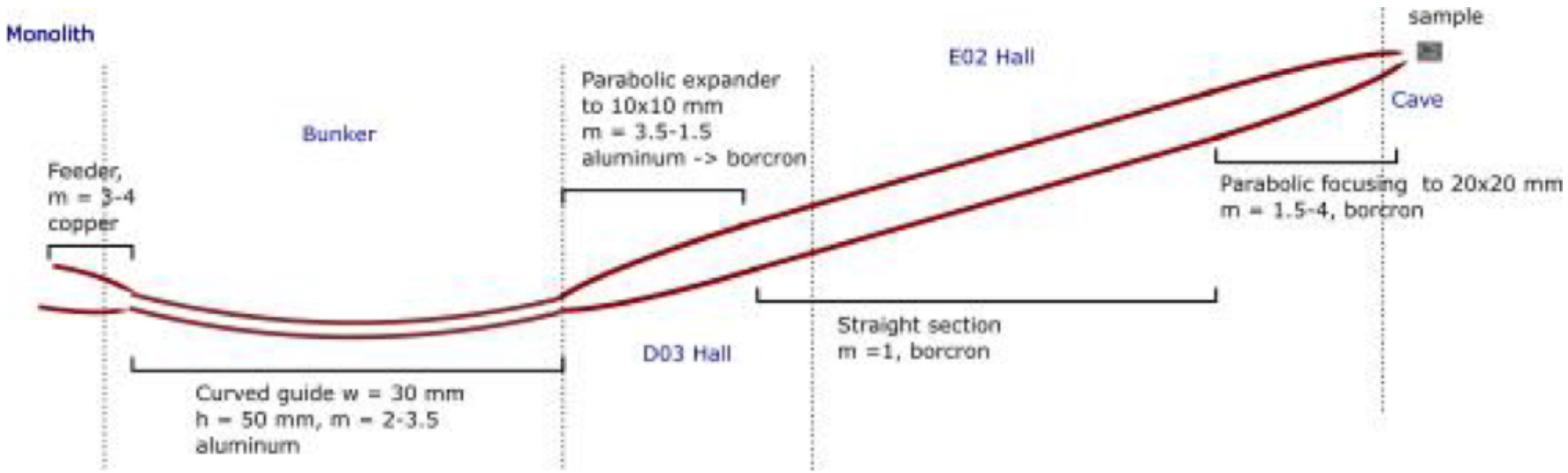


Location of BIFROST



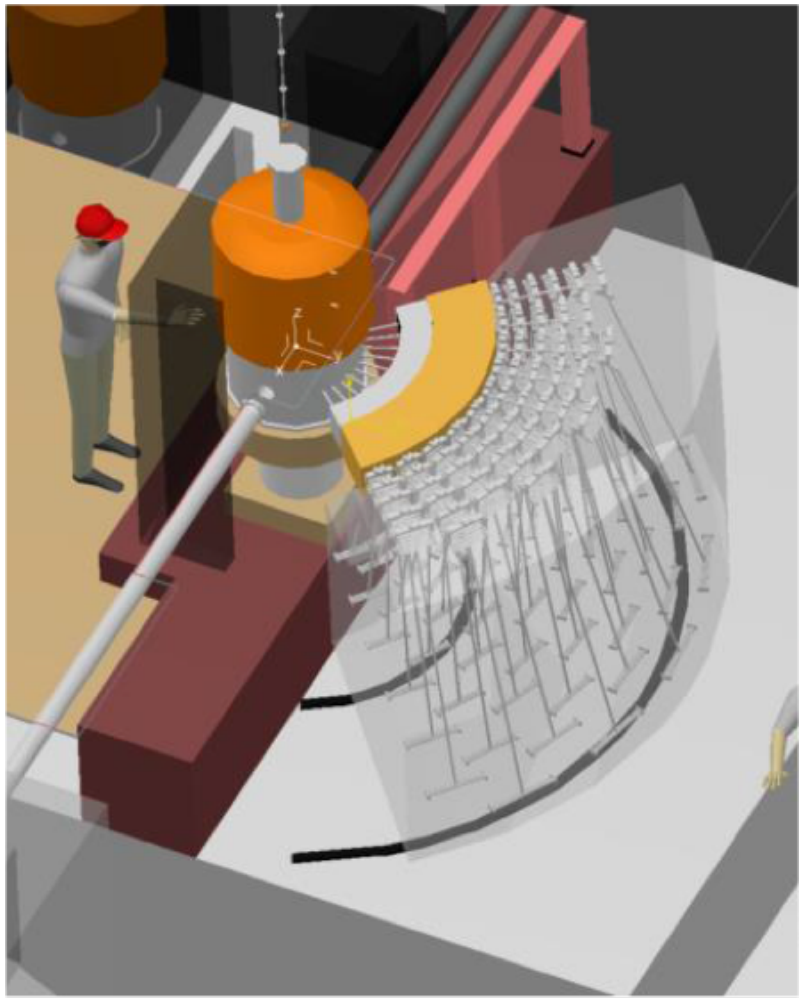
Beam transport and conditioning system

- Curved guide section
- Copper blocks
- 4 choppers (PSC, FOC, FOC, BC)
- **Option to use full ESS pulse**



Scattering Characterization System

- Filtering system
  - Beryllium filter
  - Radial collimator
- Secondary spectrometer tank
  - Vacuum vessel
  - Analyzers
  - Detectors and electronics
  - Crosstalk shielding
  - Tank positioning system



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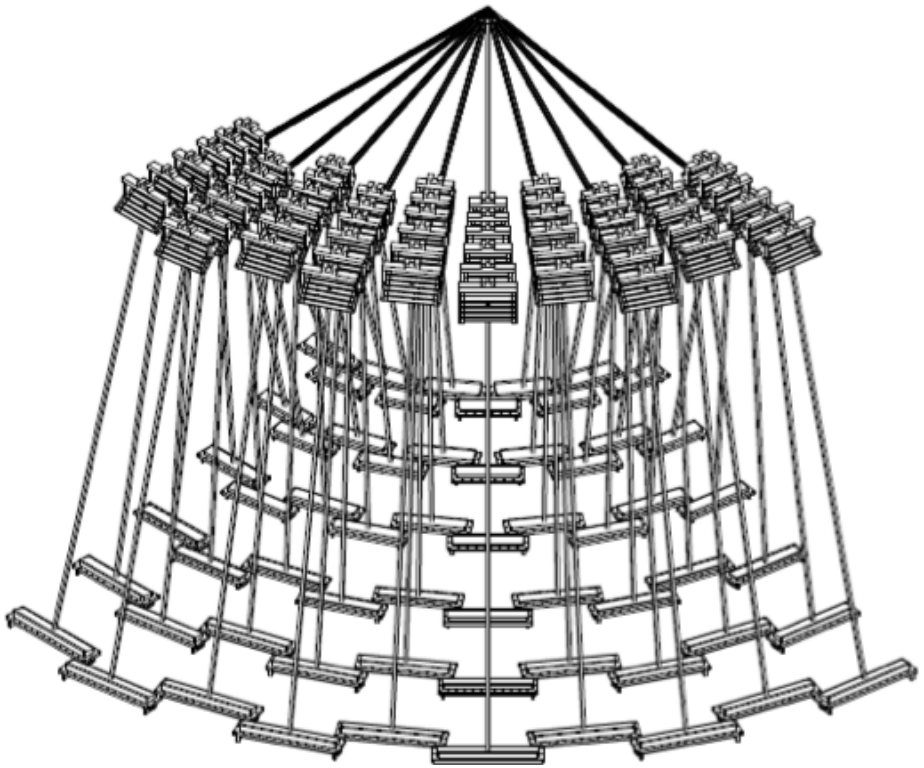

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Simulation Tools - Options

Guide

Sample + analyzers

Detectors

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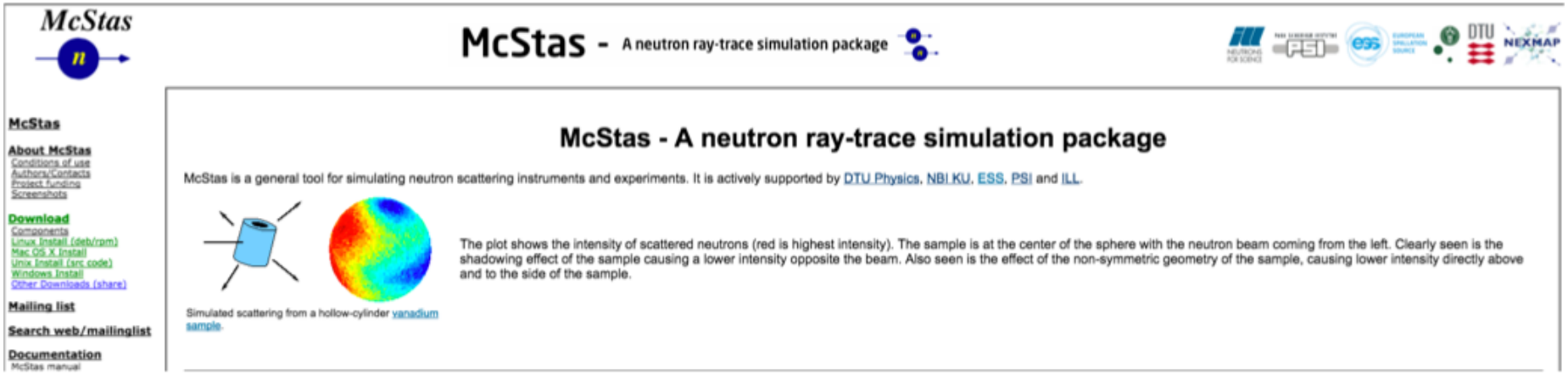
Simulation Tools: McStas

- Simulation of neutron scattering instruments and experiments
- Monte Carlo ray-trace algorithm
- Cross-platform, open source
- Version 2.4.1 (Jun. 26, 2017)

- Collaboration:
  - DTU Physics
  - University of Copenhagen
  - Paul Scherrer Institute
  - Institut Laue-Langevin



Source: http://mcstas.org/

Simulation Tools - Options

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McStas

Geant 4

Simulation Tools: Geant4 + DG Framework

EUROPEAN SPALLATION SOURCE

- General purpose
- Developed in CERN
- Application in various fields

- Detector Group Framework
  - Code repository + build system
  - Tools, issue tracker, wiki
  - Geant4, C++, Python, Mercurial

Source: http://geant4.cern.ch/

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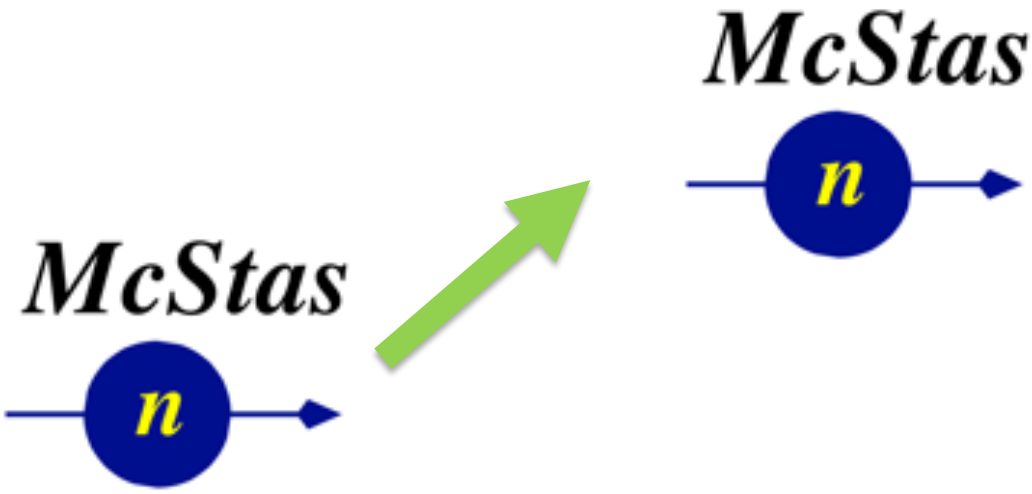

Geant 4

Geant 4

Source: https://mctools.github.io/ncrystal/

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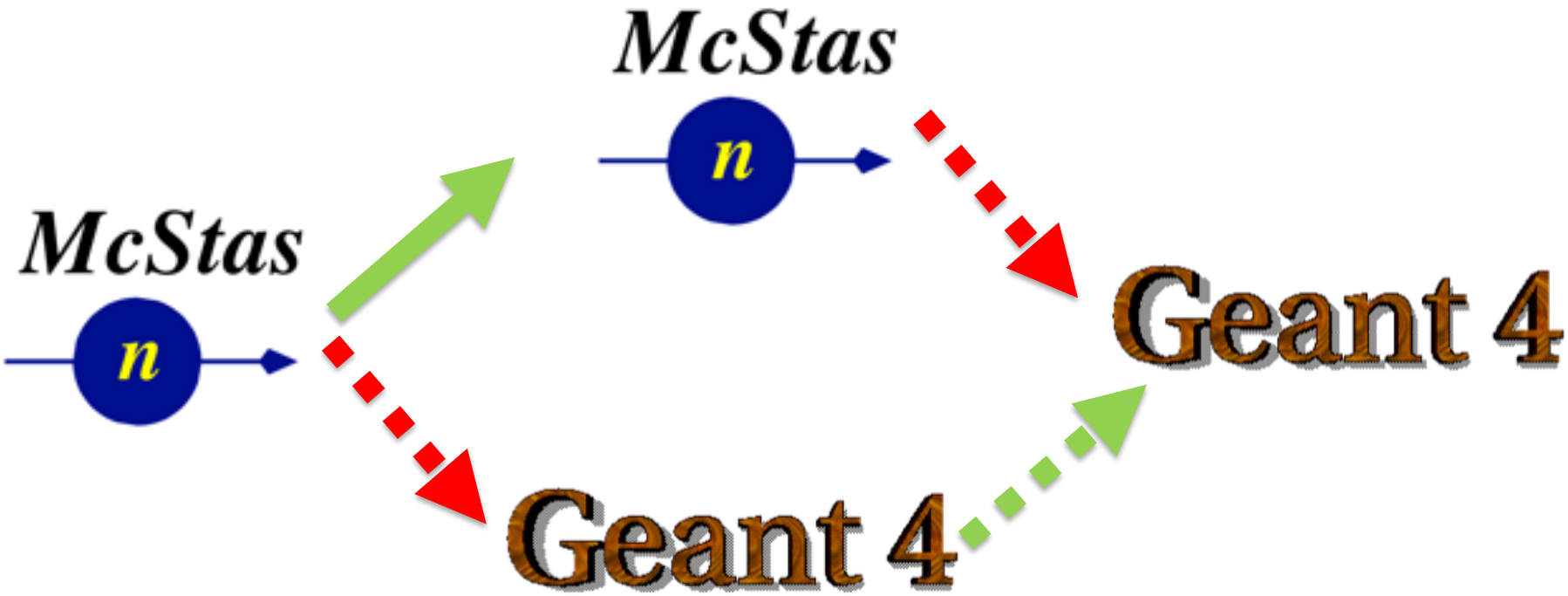

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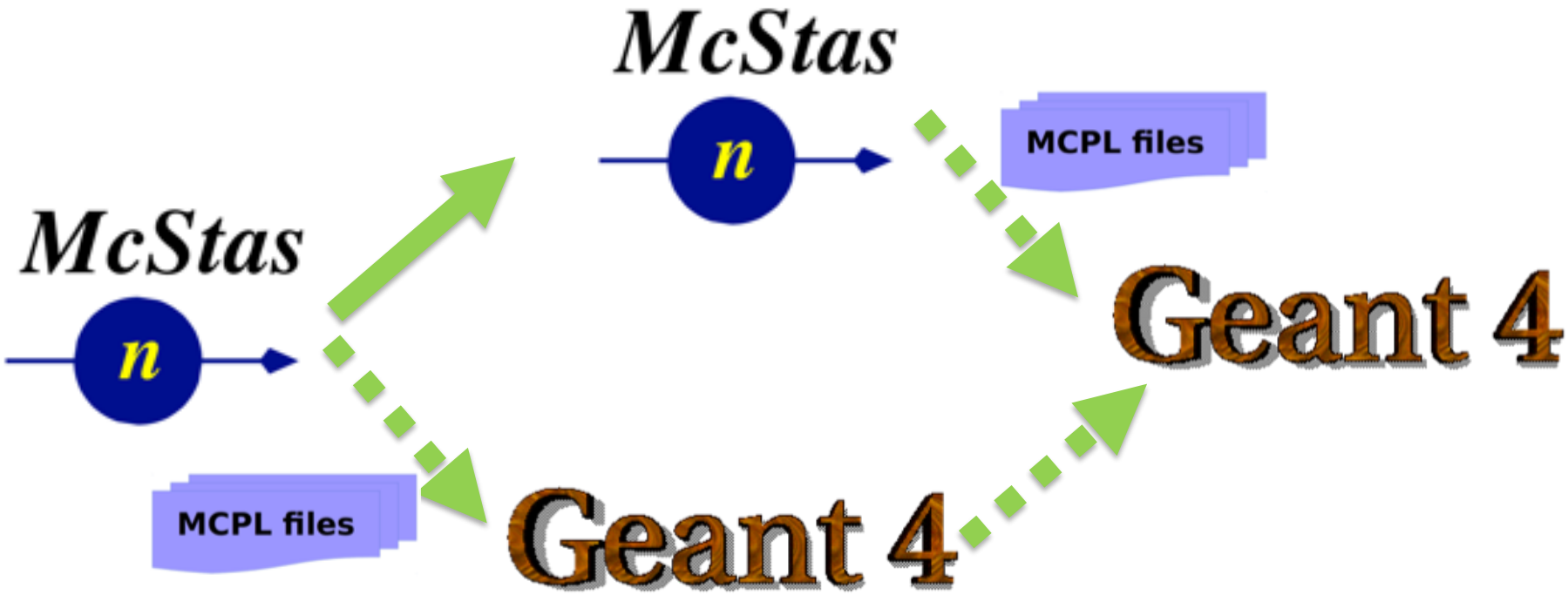
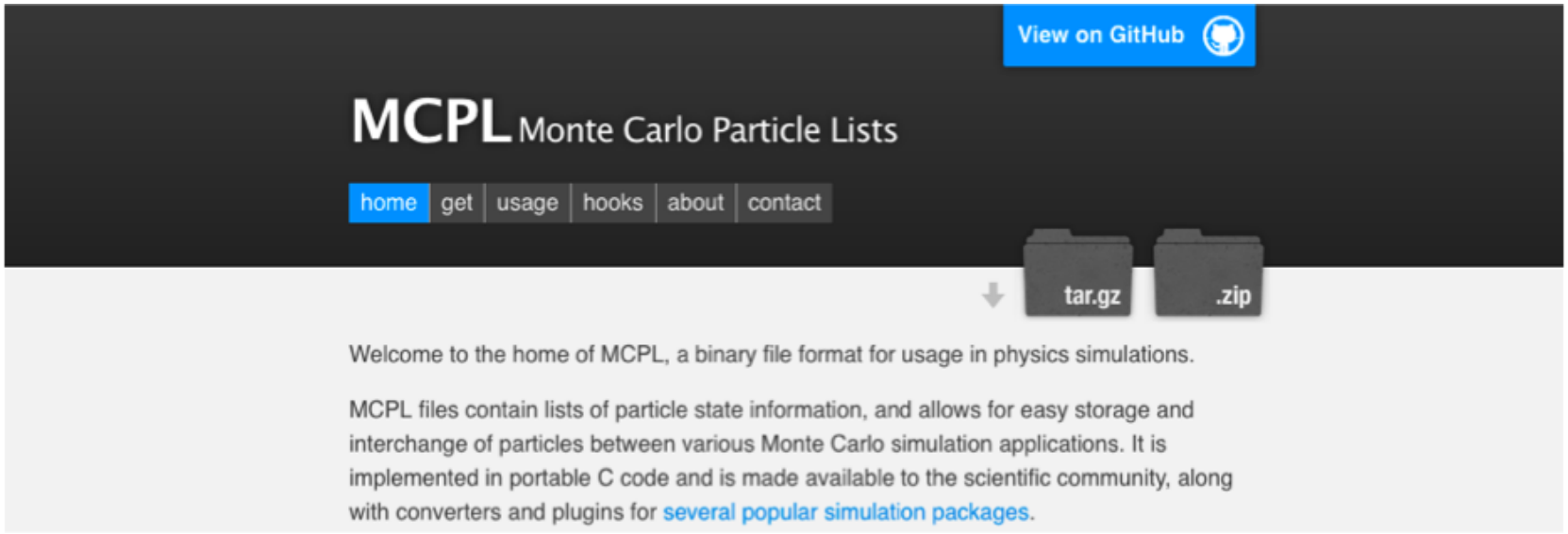


Monte Carlo Simulation: MCPL

- **M**onte **C**arlo **P**article **L**ist
- Binary format
- Open source

- Compatible MC tools
  - McStas
  - McXtrace
  - Geant4
  - MCNP6, MCNPX



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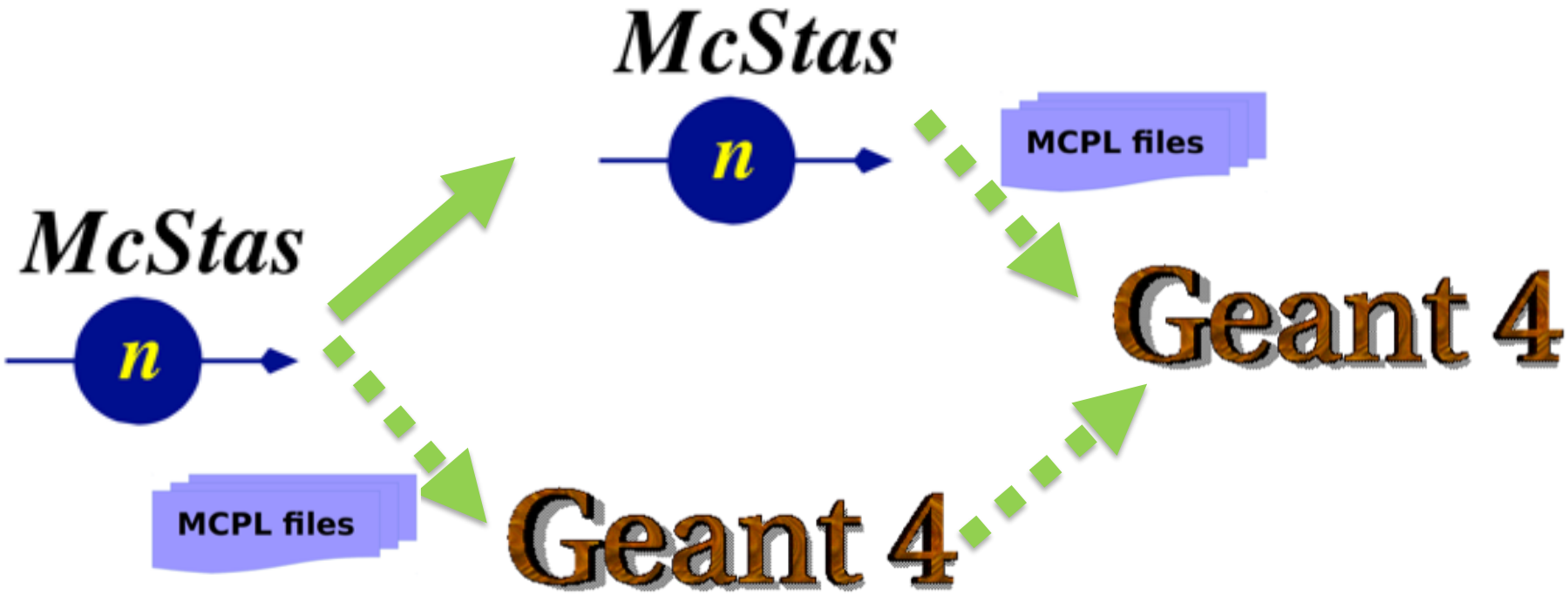

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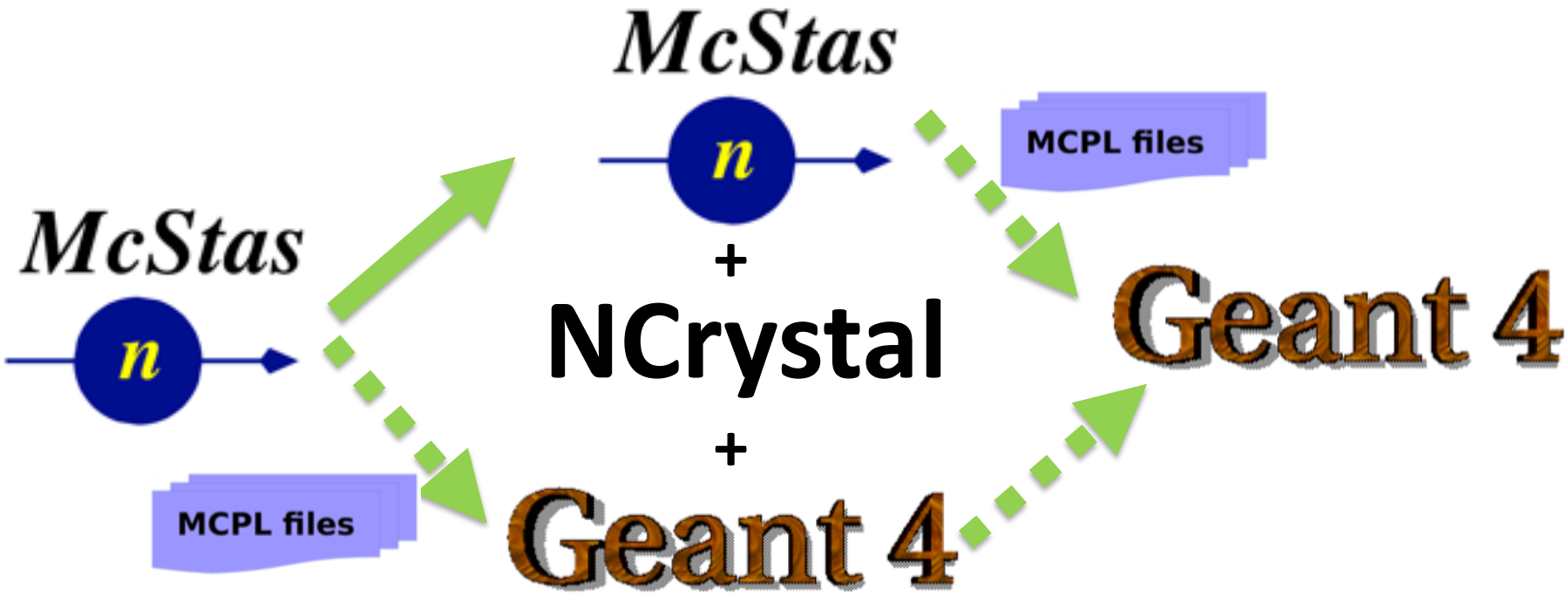
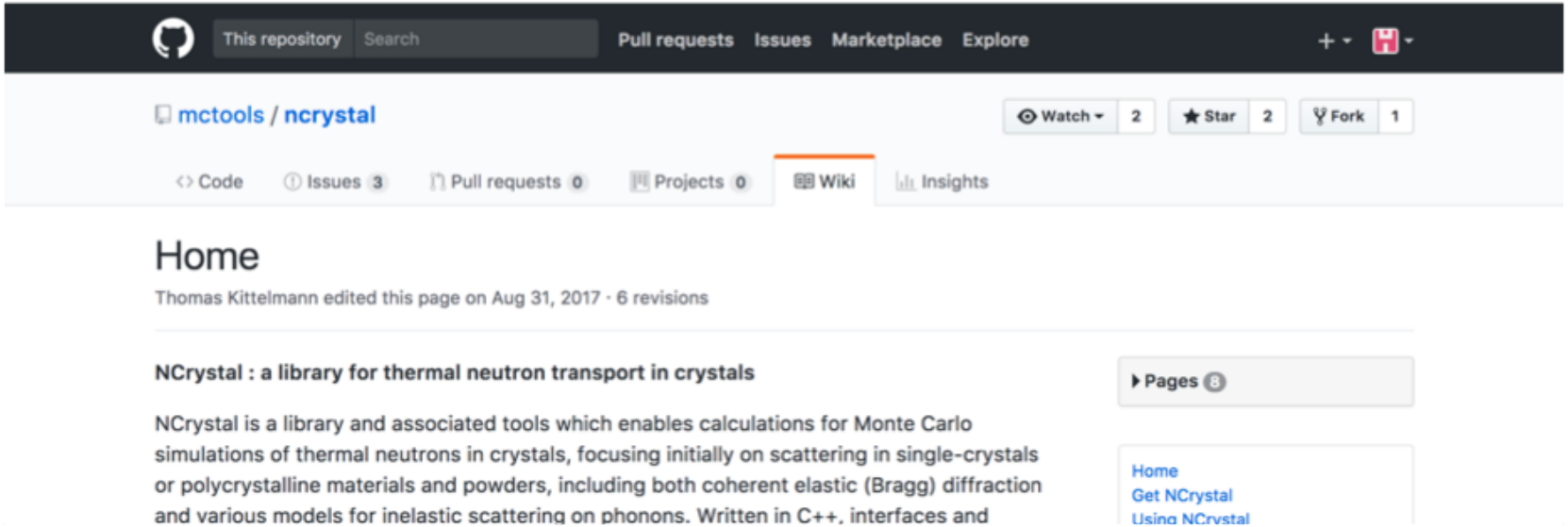


Simulation Tools: NCrystal

- Library + tools for thermal neutron transport in crystals
- Cross-platform, open source, v0.9.4
- Multiple interfaces (Geant4, McStas, …), validated results
- Collaboration:
  - Xiao Xiao Cai (DTU, ESS)
  - Thomas Kittelmann (ESS)
- Supported by:
  - BrightnESS (No 676548)



Source: https://mctools.github.io/ncrystal/

Simulation Tools: NCrystal

- Enables Monte Carlo simulation of neutrons in crystals
- Single-crystals
- Polycrystalline/powder materials
- Coherent elastic (Bragg) diffraction
- Includes ”background” (inelastic/incoherent)
  - harmonic approximation
  - incoherent approximation
  - Debye approximation

Source: https://mctools.github.io/ncrystal/

Simulation Tools: NCrystal

- Written in C++
- Direct usage from C, C++, or Python code
- Command-line tools
- **Components available for McStas and Geant4**

Source: https://mctools.github.io/ncrystal/

Simulation Tools - Options

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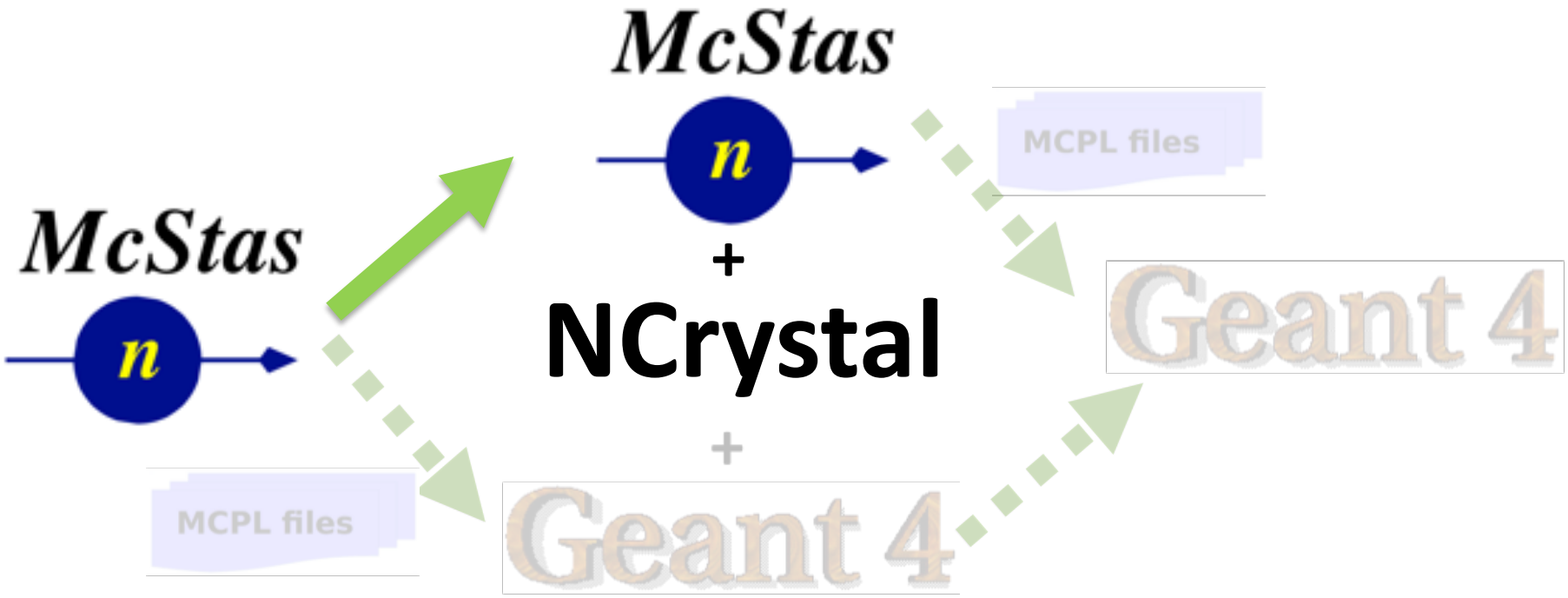

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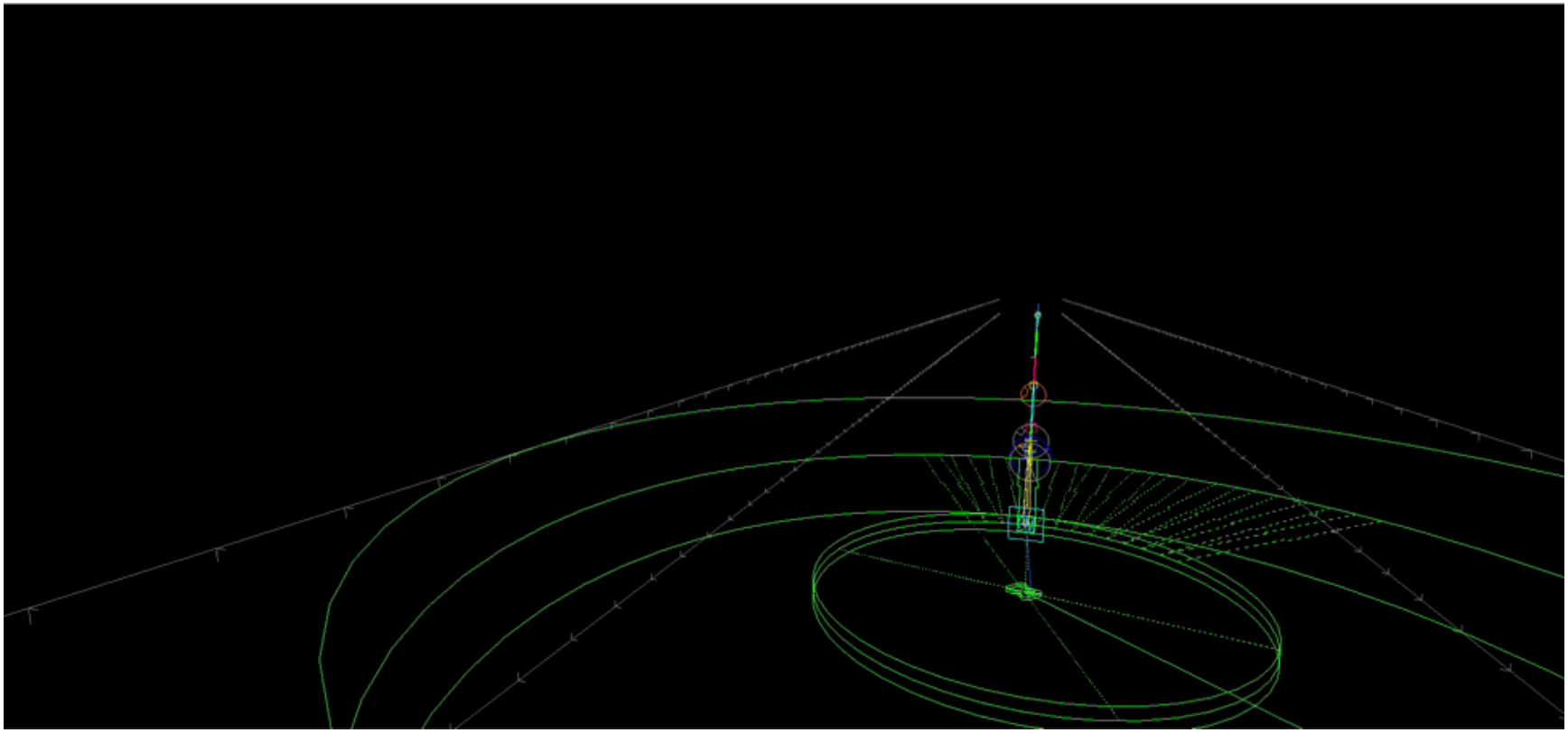
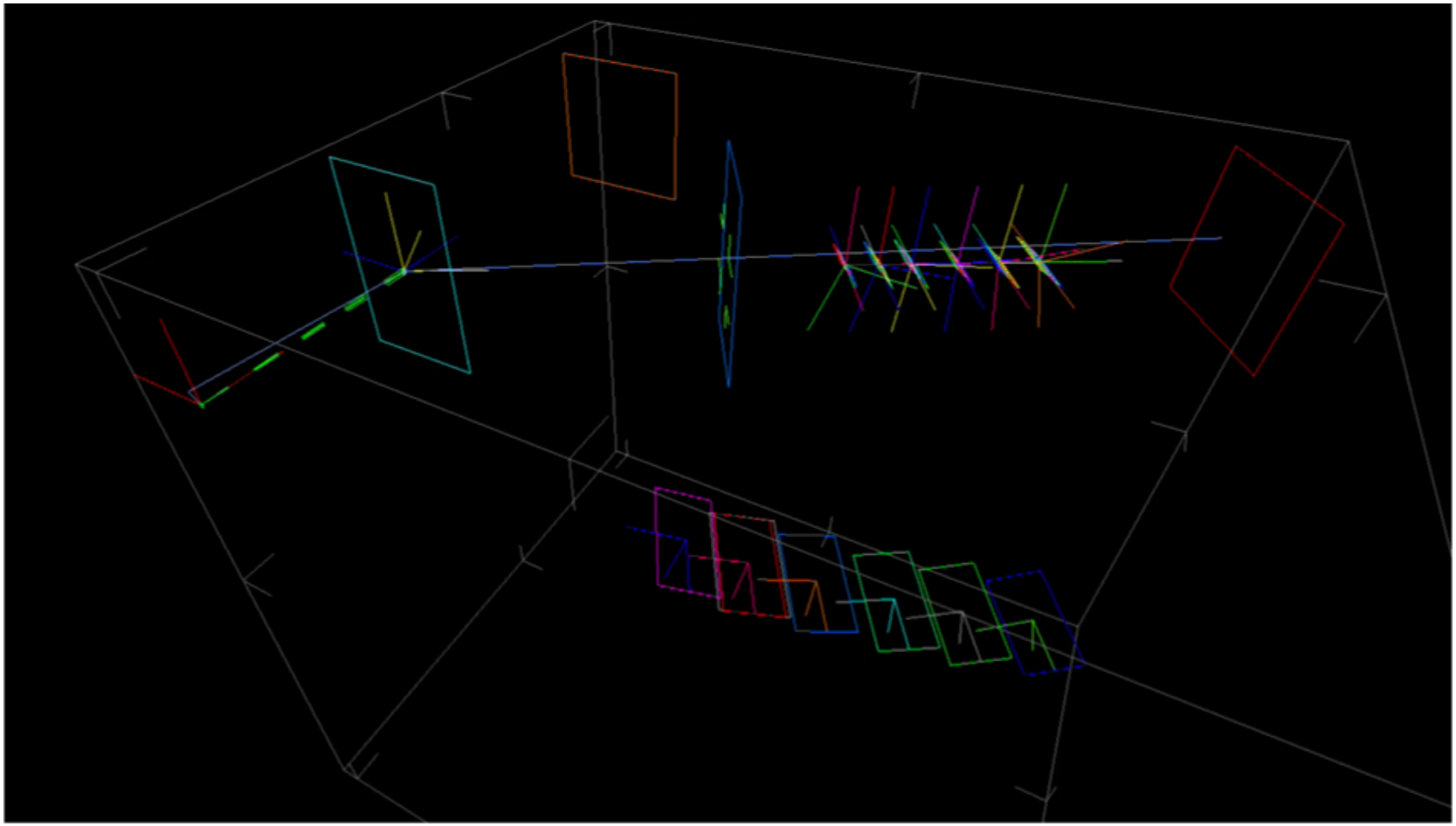
McStas Model – Full Instrument



McStas Model – Analyzer-Detector system



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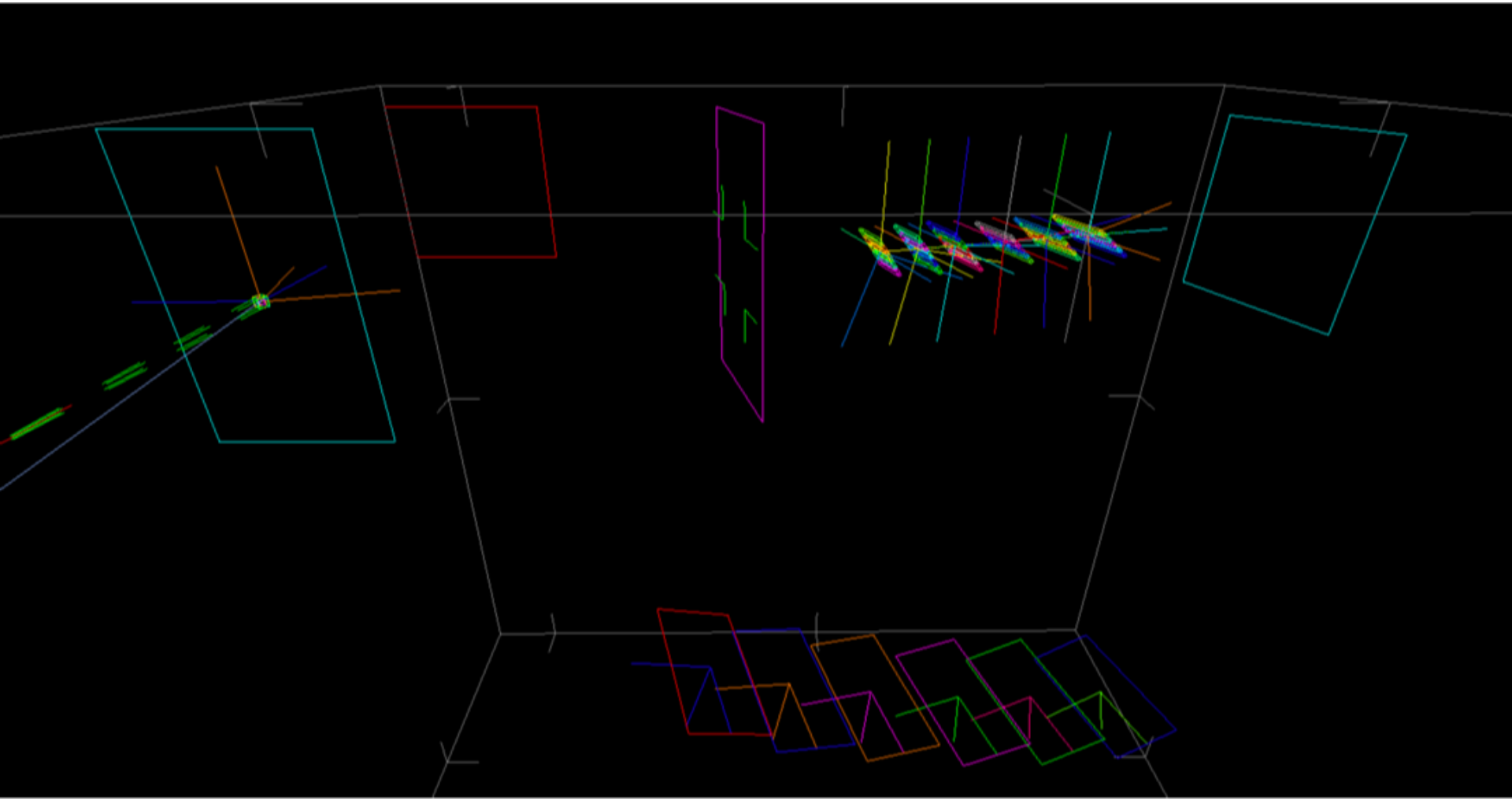
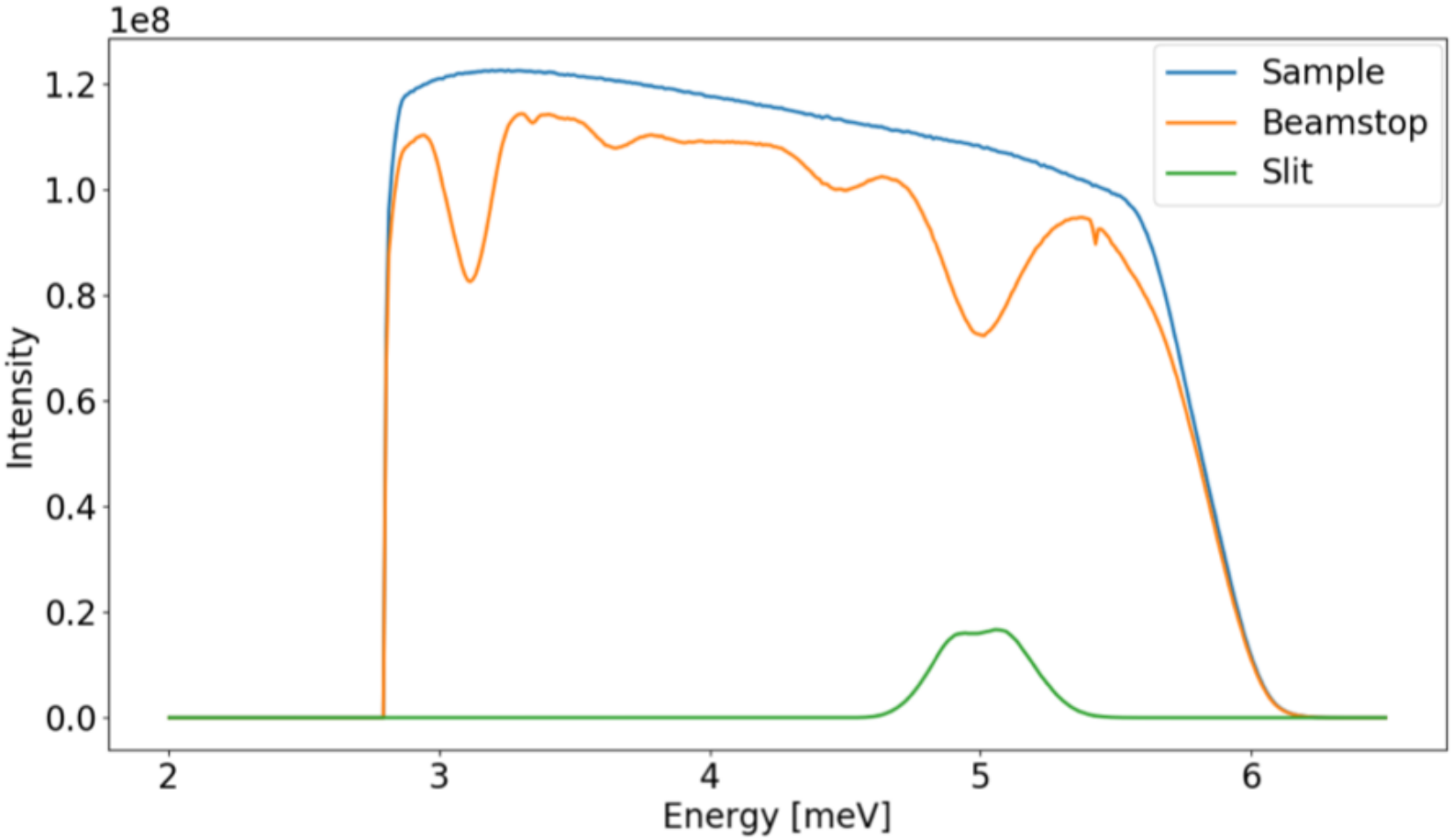
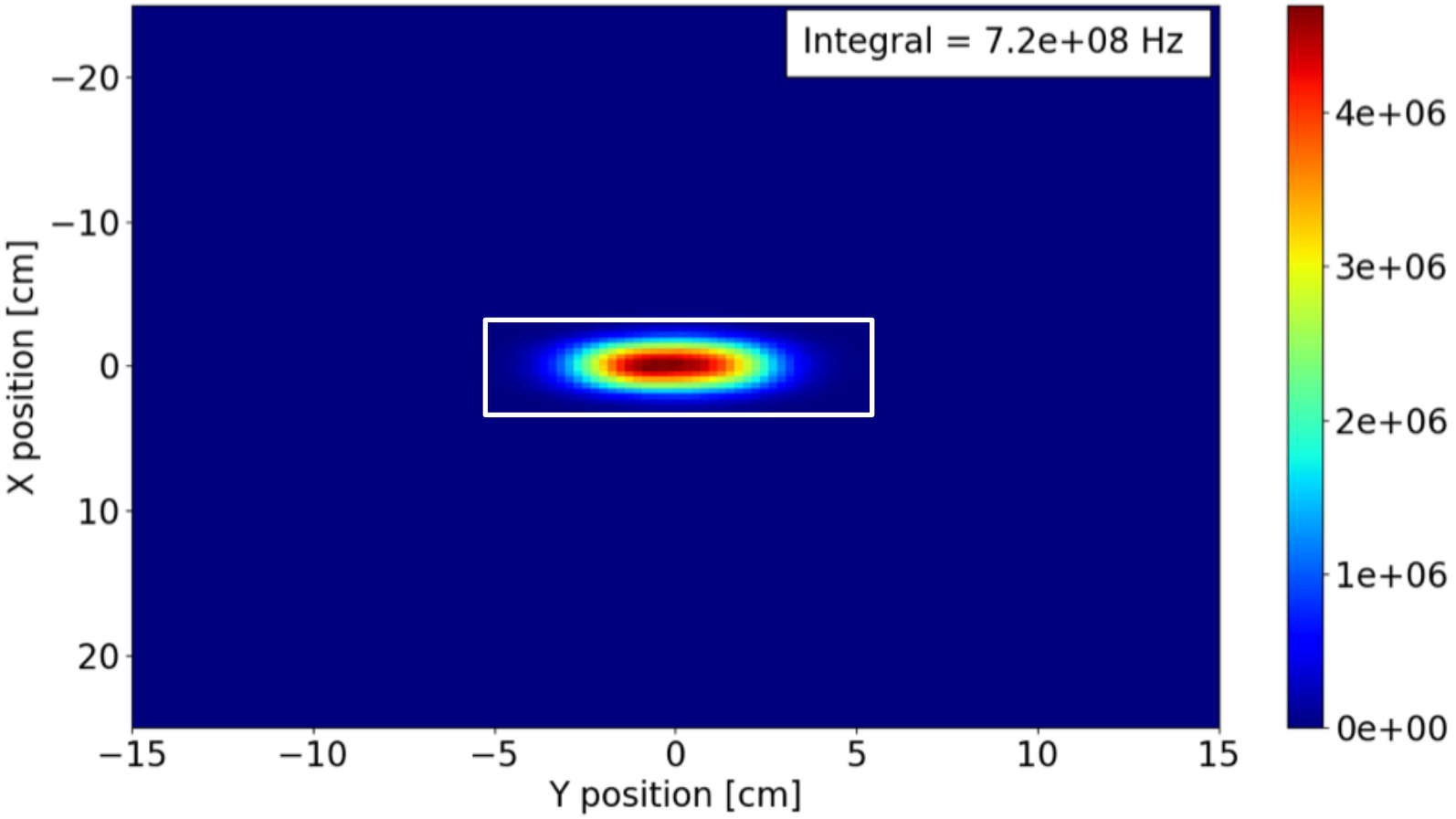
TODO



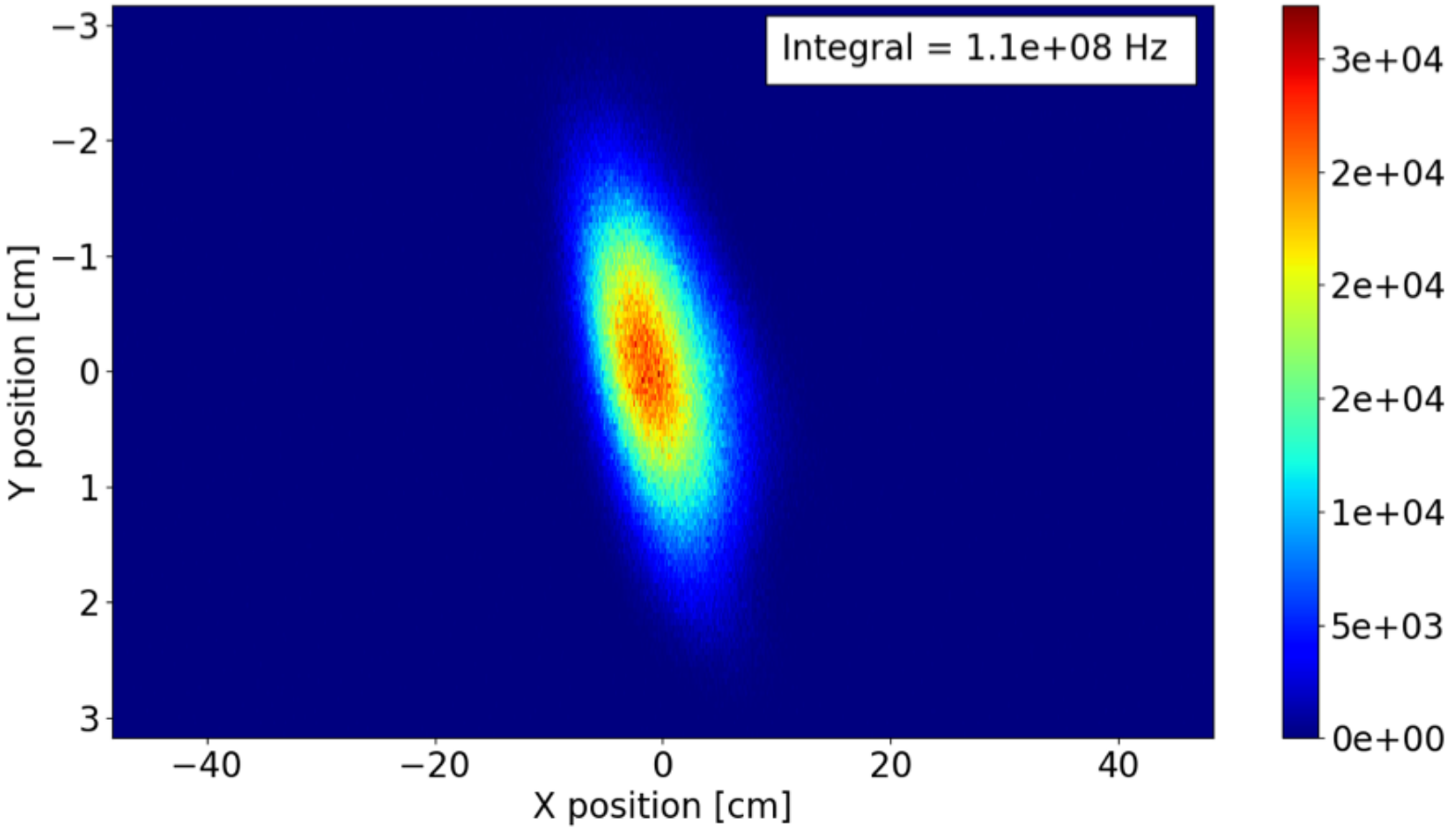
Change of energy spectrum on sample



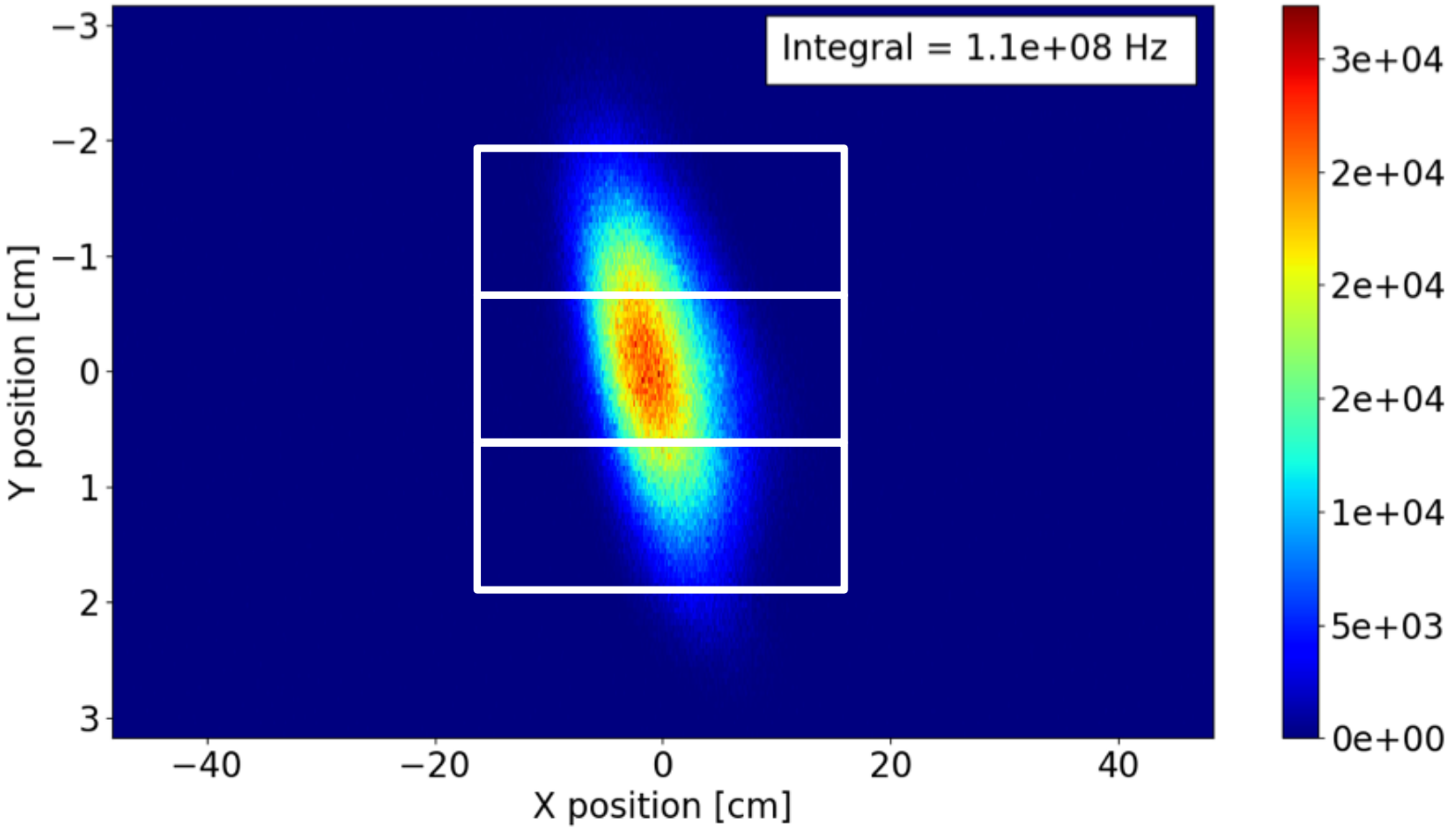
Position on slit



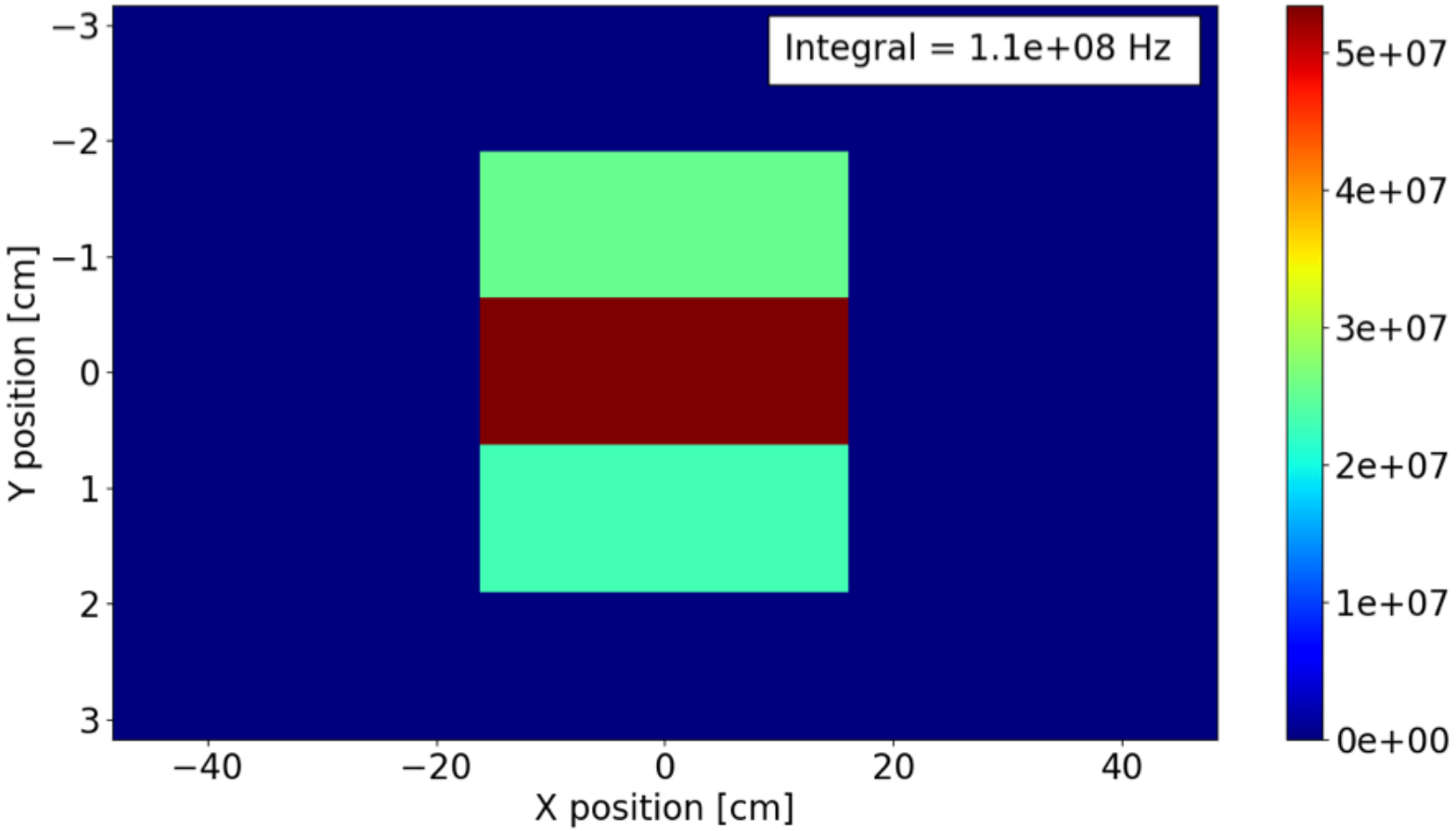
Position on detector



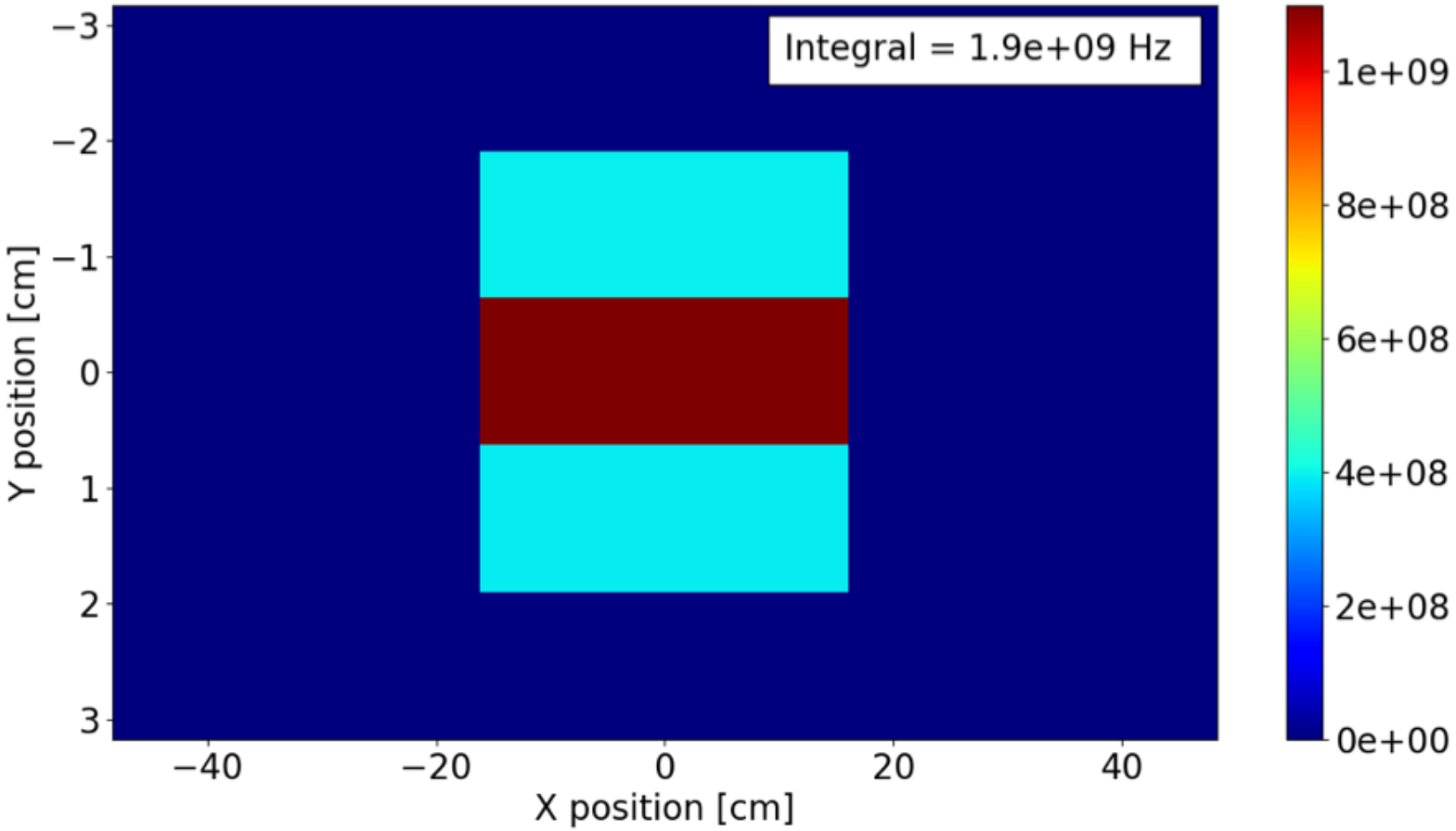
Position on detector



Time averaged incident rate



Peak instantaneous incident rate



Preliminary results

- Parameters:
  - Sample: Y_2O_3 single-crystal, hkl=2,-2,-2 (d_{hkl} = 3.0724 Å)
    size = $(1.5\ cm)^3$, mosaicity = 60 acrmin
  - Analyzer: thickness = 2 mm, mosaicity = 10 arcmin
  - Source power = 5 MW
  - PSC opening time = 5 ms (full ESS pulse)

- Time averaged incident rate on one He tube: **5e7 Hz**
- Peak instantaneous incident rate on one Tube: **1e9 Hz**

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Cross-check and Detector simulation

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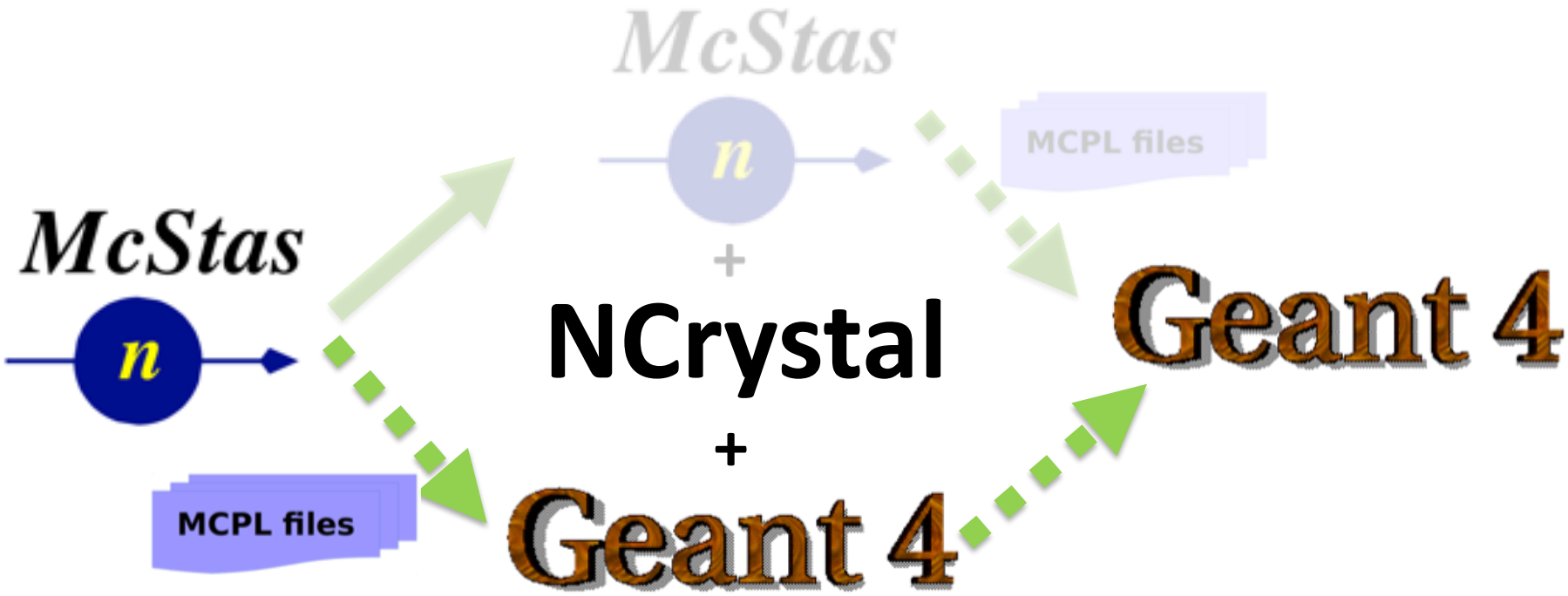
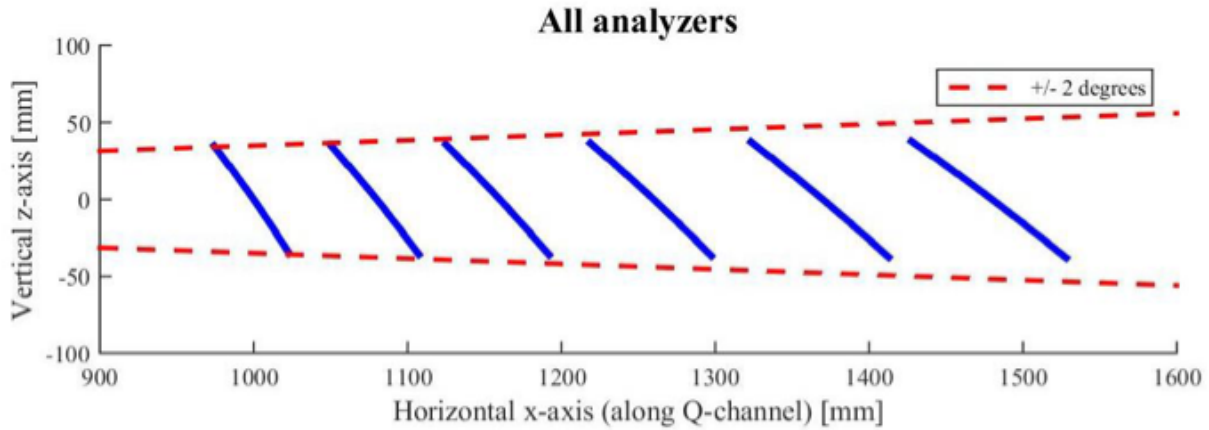


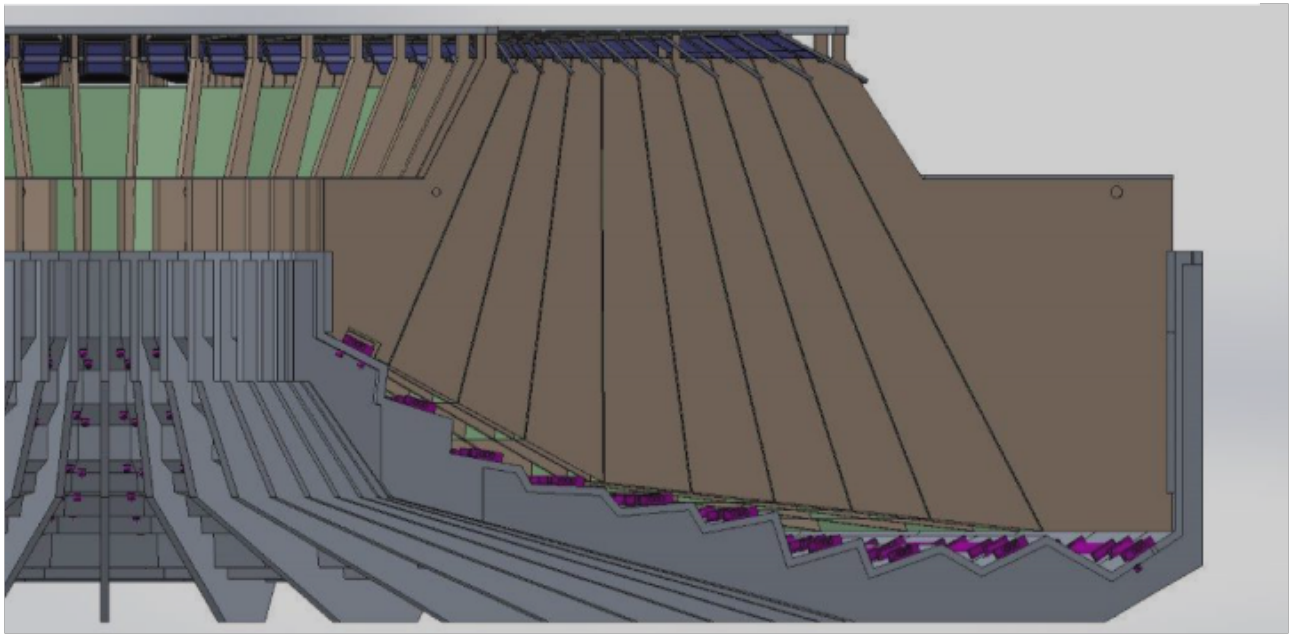
Acknowledgments

- Rasmus Toft-Petersen, Fatima Issa
- Thomas Kittelmann, Xiao Xiao Cai, Peter Willendrup
- Kalliopi Kanaki, Richard Hall-Wilton
- Data Management&Software Centre (DMSC)

Thank you for your attention!

Secondary spectrometer tank - Analyzers





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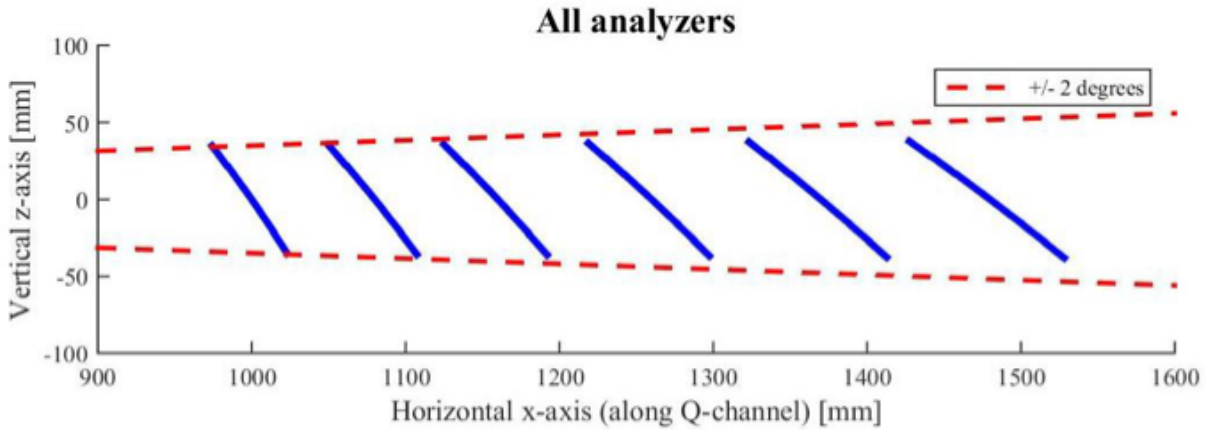
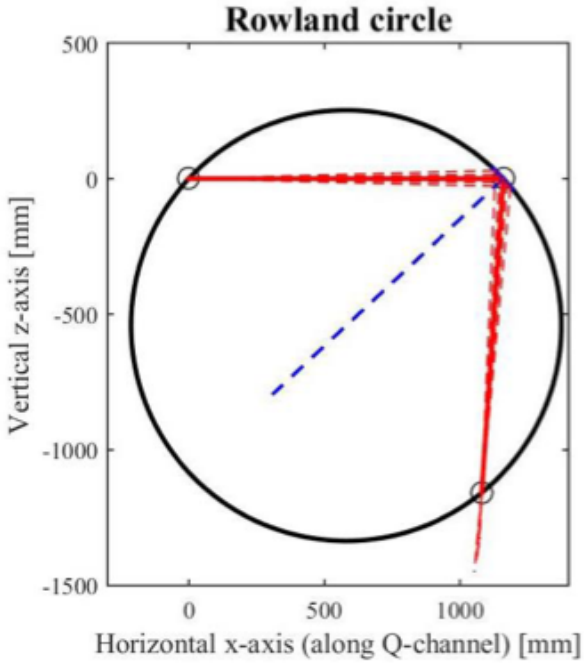
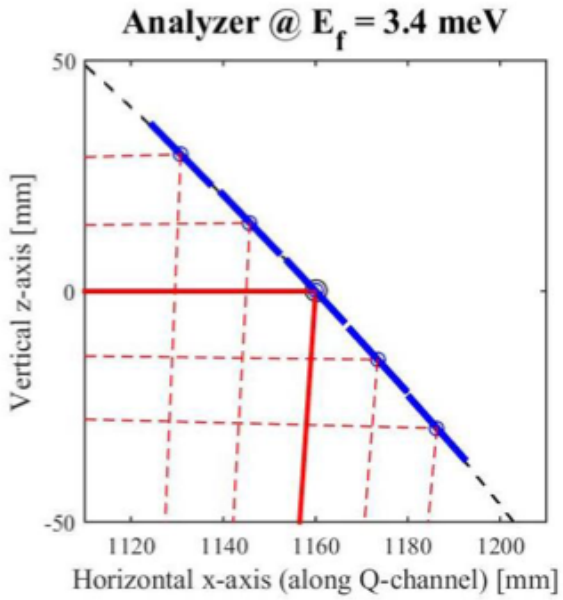
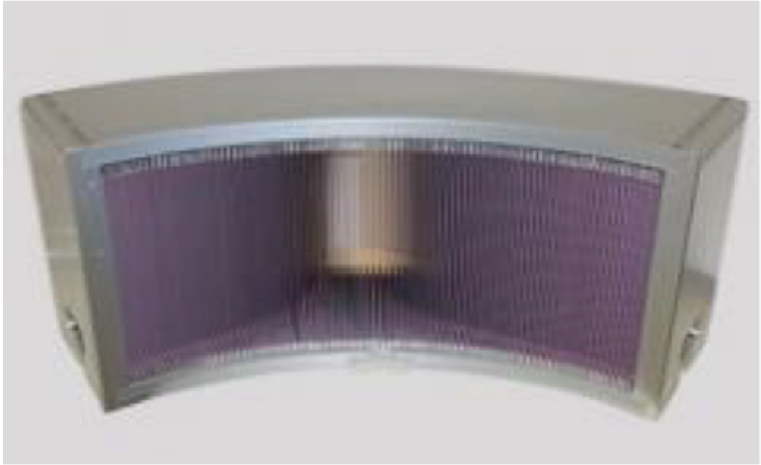


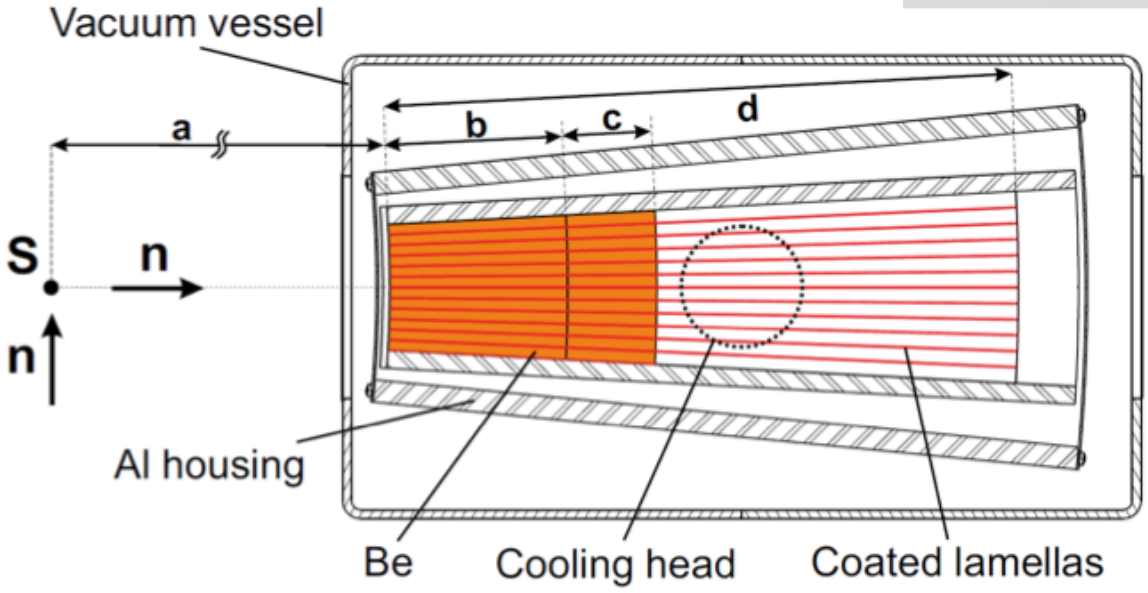




Scattering Characterization System

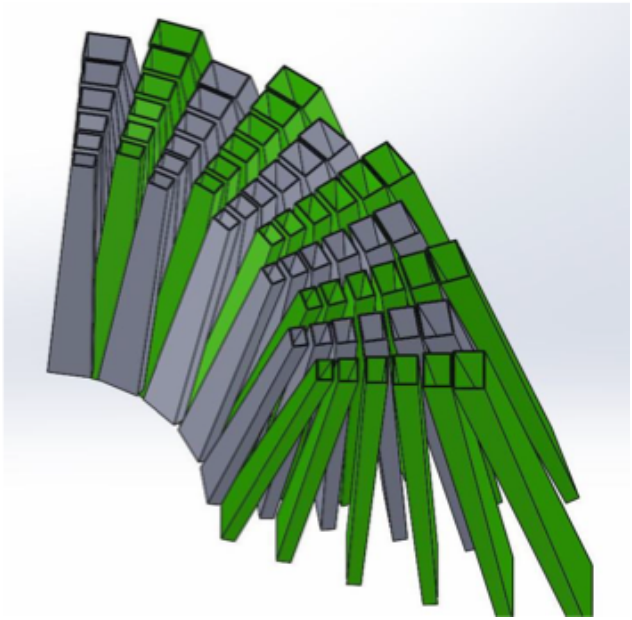
- Filtering system
  - Beryllium filter
  - Radial collimator

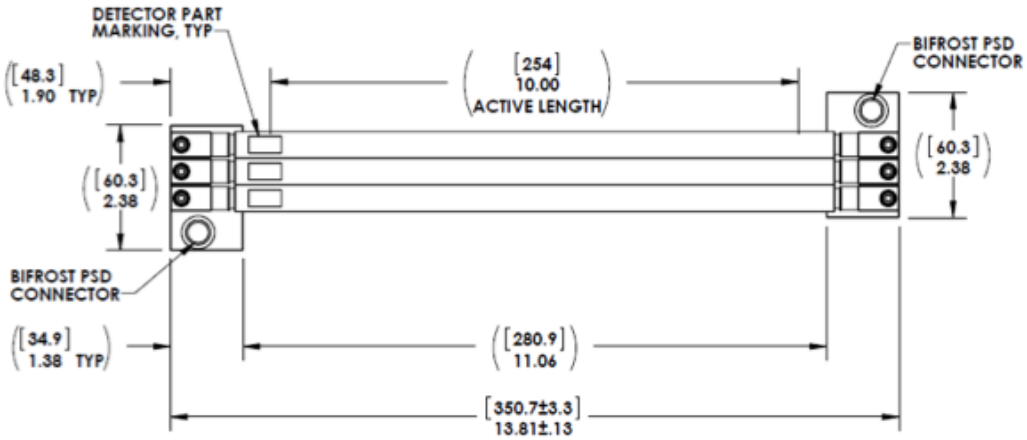




Secondary spectrometer tank - Detectors

- Crosstalk shielding
  - Prevent crosstalk between channels
- Detectors and electronics
  - He-3 tubes
  - Approx. 2x analyzer length





Ncrystal - Data library and validation

```
NCMAT v1
#converted from the cif file of the entry 0014675 in the AMCSD
#reference: Trucano P, Chen R, Nature, vol. 258, p. 136-137, 1975.
#Validated against EXFOR subentries 11359002,21149003 and 13761003
#(see https://github.com/mctools/ncrystal/wiki/Data-library)
#It is suitable to model large mosaicity graphite monochromators or analysers.
@CELL
    lengths 2.464 2.464 6.711
    angles 90. 90. 120.
@SPACEGROUP
    194
@ATOMPOSITIONS
    C 0. 0. 0.25
    C 0. 0. 0.75
    C 0.333333333333 0.666666666667 0.25
    C 0.666666666667 0.333333333333 0.75
@DEBYETEMPERATURE
    C 730.950029766
```

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