



Detector rate estimate for the BIFROST instrument

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European Spallation Source ESS ERIC
BUTE Institute of Nuclear Techniques

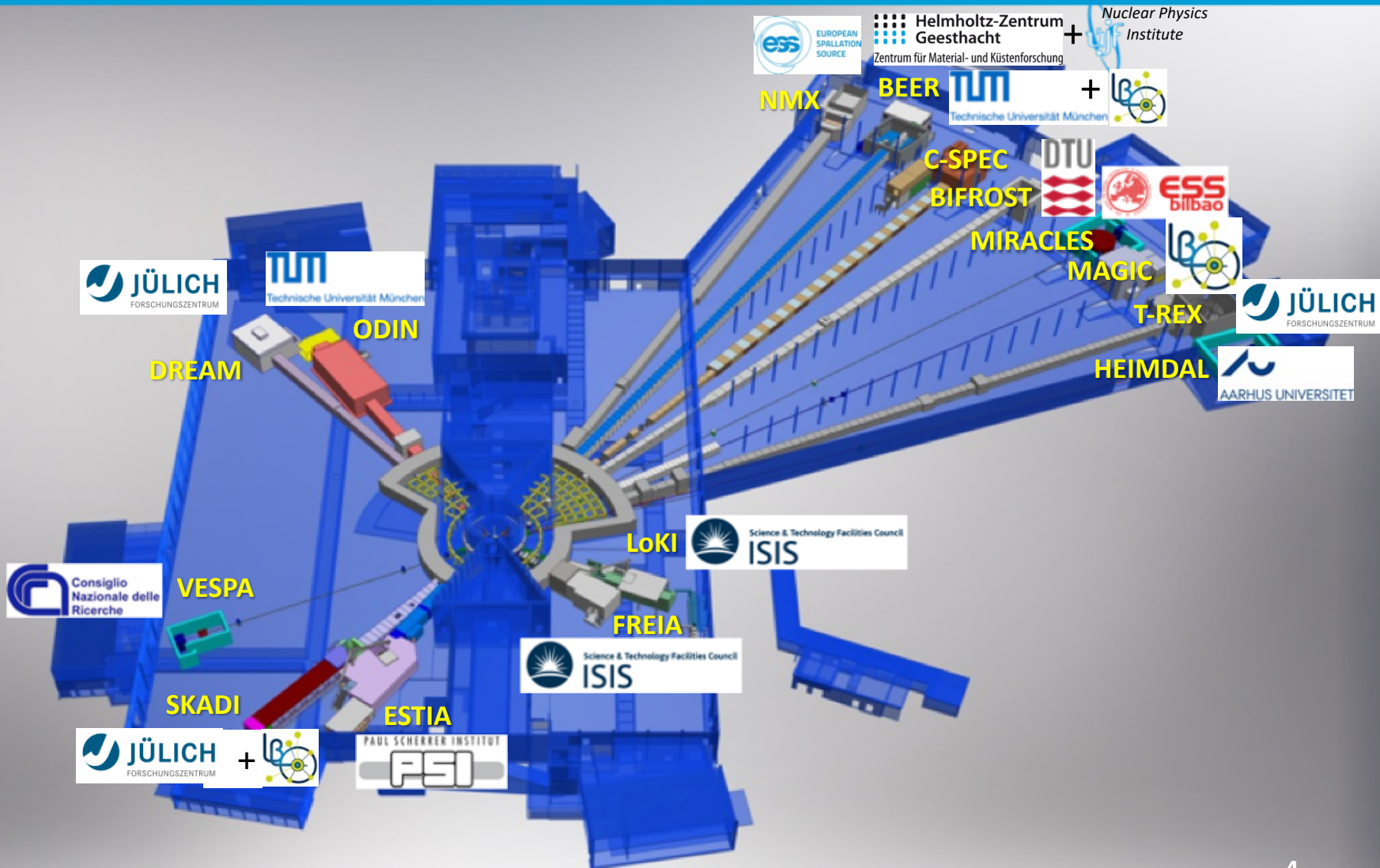
Detectors and Data Acquisition for Instruments Meeting,
Paris, 12 February 2018

Outline

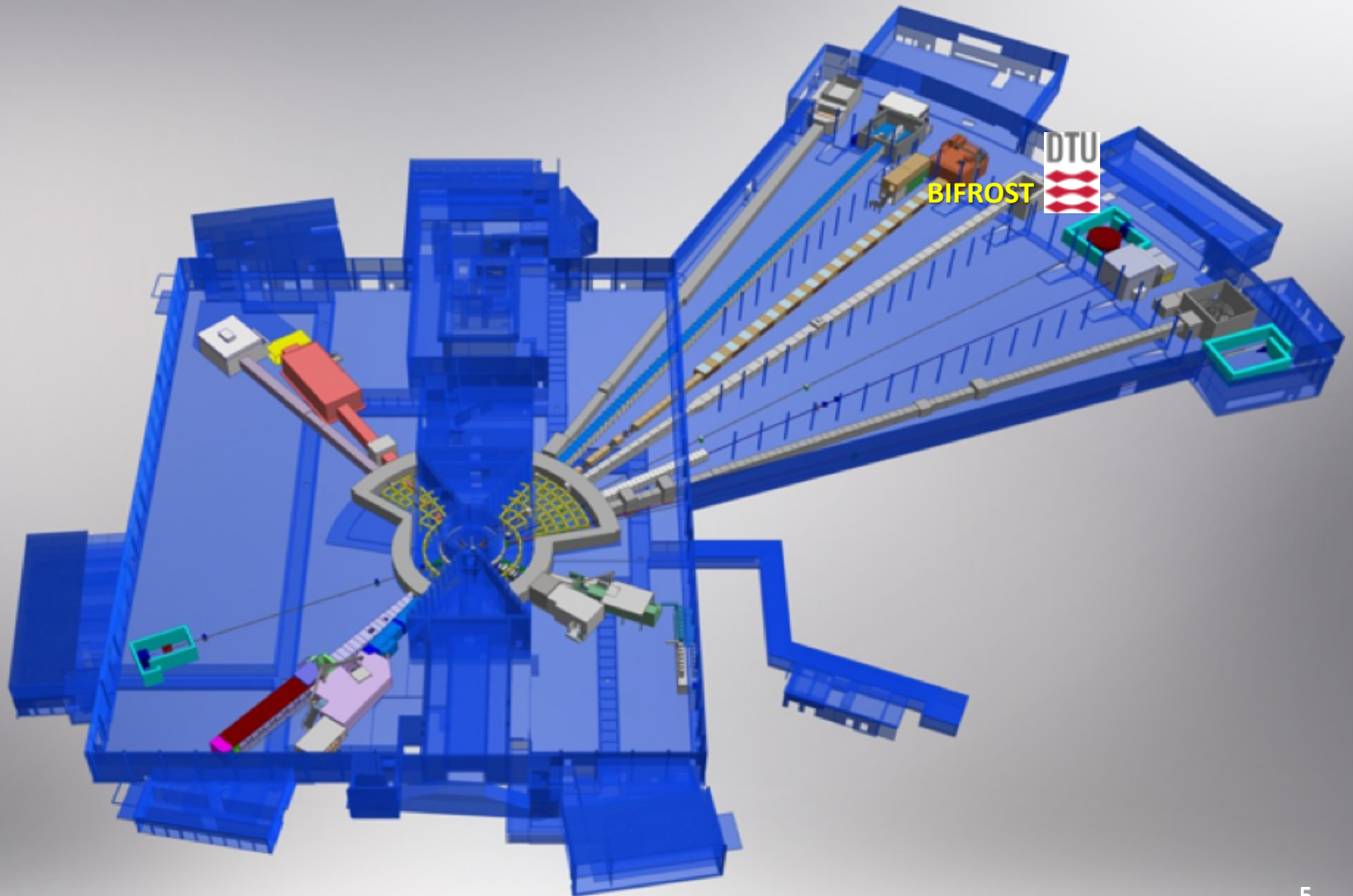
- BIFROST Instrument
- Simulation Tools
- Simulation Model
- Results
- Outlook

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

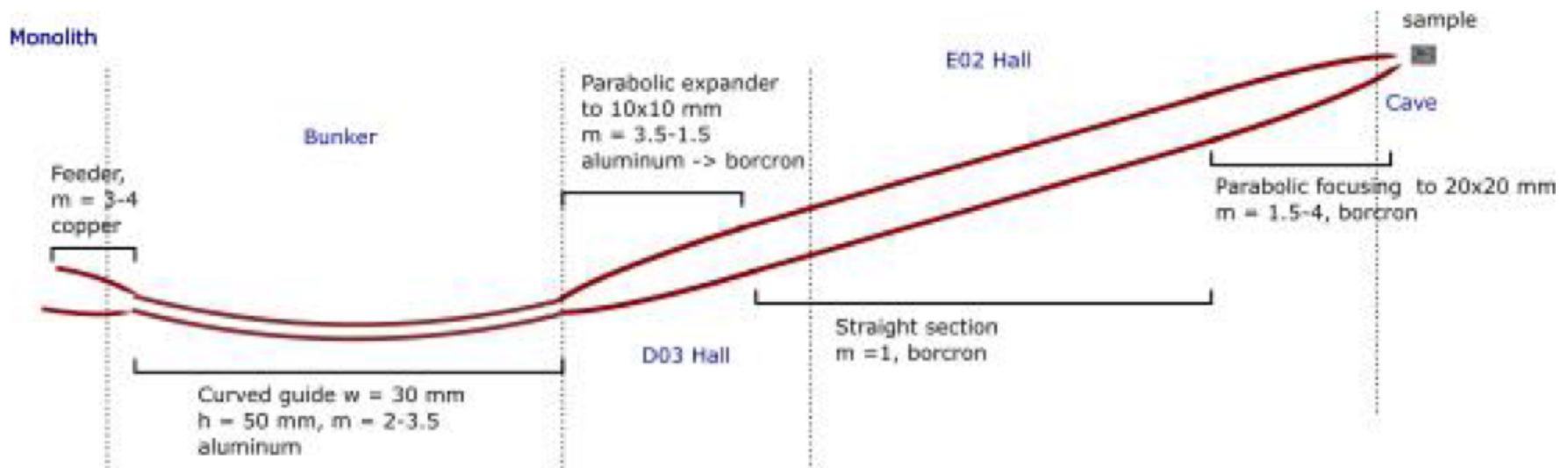


Location of BIFROST



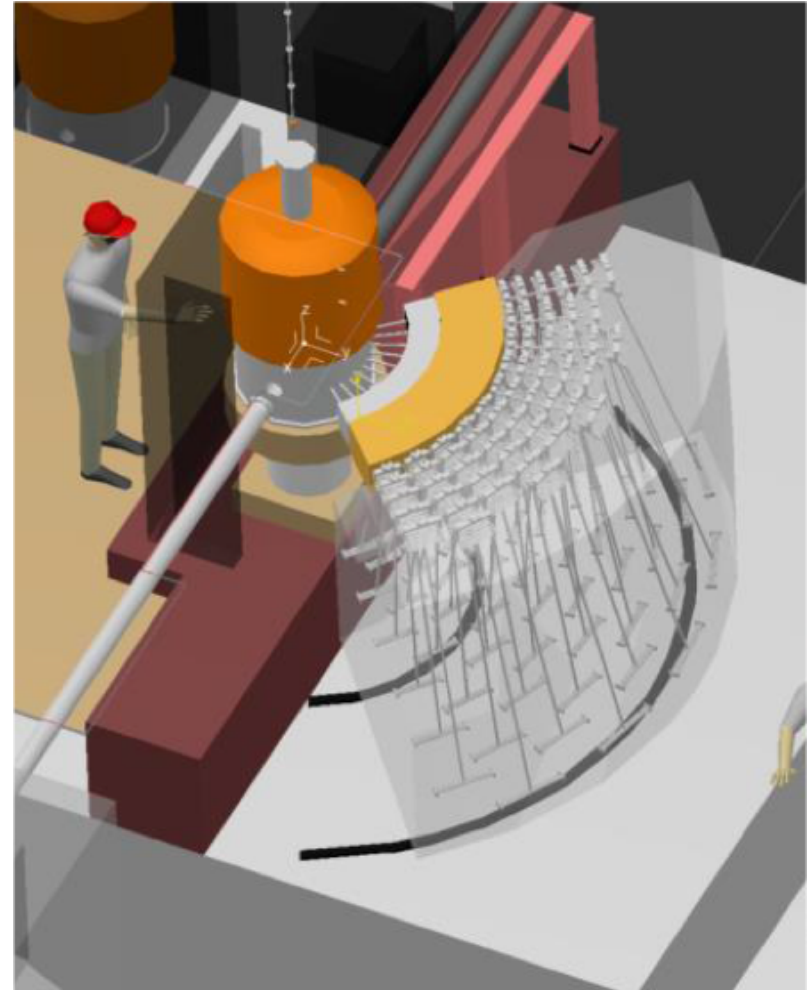
Beam transport and conditioning system

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



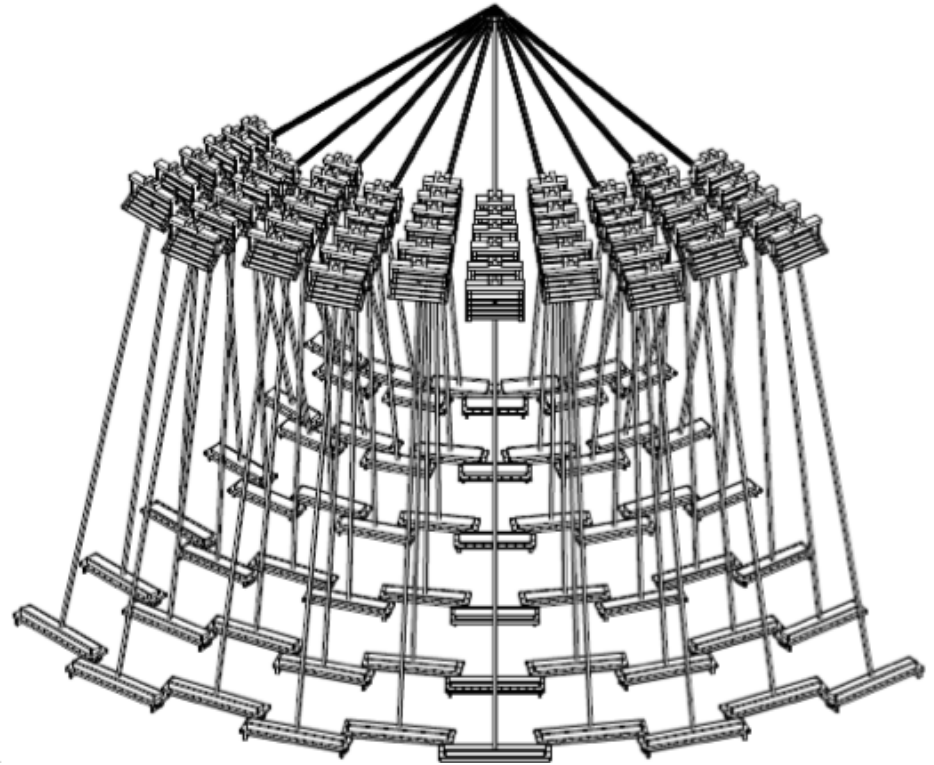
Scattering Characterization System

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



Scattering Characterization System

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- **Simulation Tools**
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- Results
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Simulation Tools - Options



Guide

Sample +
analyzers

Detectors

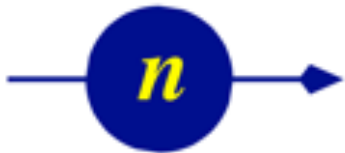
Simulation Tools - Options

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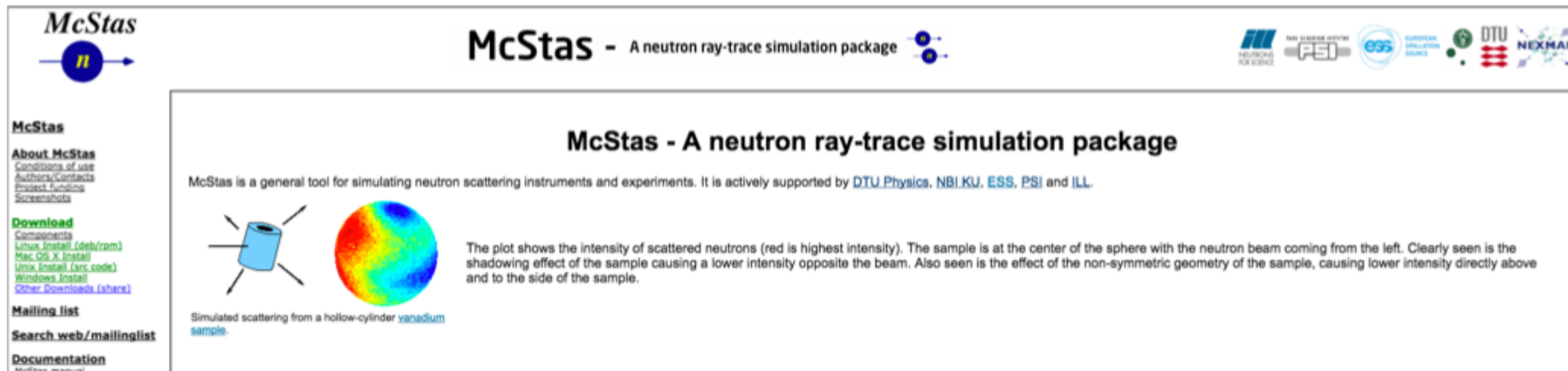
Detectors

McStas



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



The screenshot shows the McStas website. At the top left is the McStas logo, a blue circle with a white 'n' and a blue arrow pointing right. To the right of the logo is the text 'McStas - A neutron ray-trace simulation package' with a small icon of three blue circles. Further right are logos for 'EUROPEAN SPALLATION SOURCE', 'PSI', 'ESS', 'DTU', and 'NEXMAP'. Below the header is a navigation menu with links: 'McStas', 'About McStas' (with sub-links for 'Conditions of use', 'Authors/Contacts', 'Project Timeline', 'Screenshots'), 'Download' (with sub-links for 'Components', 'Linux Install (deb/rpm)', 'Mac OS X Install', 'Unix Install (src code)', 'Windows Install', 'Other Downloads (share)'), 'Mailing list', 'Search web/maillinglist', and 'Documentation' (with sub-link 'McStas manual'). The main content area has the title 'McStas - A neutron ray-trace simulation package' and a paragraph: 'McStas is a general tool for simulating neutron scattering instruments and experiments. It is actively supported by [DTU Physics](#), [NBI/KU](#), [ESS](#), [PSI](#) and [ILL](#).' Below this is a diagram of a hollow-cylinder vanadium sample and a corresponding intensity plot. The plot shows a color gradient from blue (low intensity) to red (high intensity), with a shadowing effect on the right side of the cylinder. A caption below the plot reads: 'Simulated scattering from a hollow-cylinder vanadium sample.'

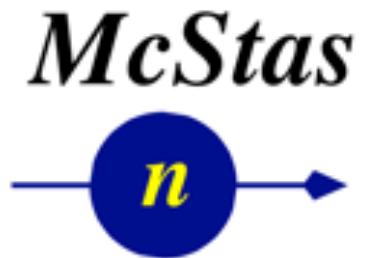
Source: <http://mcstas.org/>

Simulation Tools - Options

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Geant 4

Simulation Tools: Geant4 + DG Framework

- General purpose
 - Developed in CERN
 - Application in various fields
- Detector Group Framework
 - Code repository + build system
 - Tools, issue tracker, wiki
 - Geant4, C++, Python, Mercurial

Geant 4

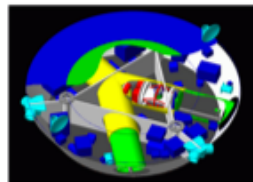
Geant4 is a toolkit for the simulation of the passage of particles through matter. Its areas of application include high energy, nuclear and accelerator physics, as well as studies in medical and space science. The two main reference papers for Geant4 are published in *Nuclear Instruments and Methods in Physics Research A* **506** (2003) 250-303, and *IEEE Transactions on Nuclear Science* **53** No. 1 (2006) 270-278.

Applications



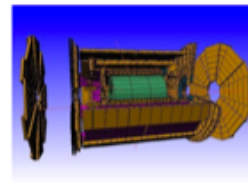
A sampling of applications, technology transfer and other uses of Geant4

User Support



Getting started, guides and information for users and developers

Publications



Validation of Geant4, results from experiments and publications

Collaboration



Who we are: collaborating institutions, members, organization and legal information

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McStas



McStas



Geant 4

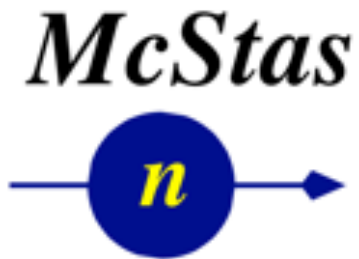
Geant 4

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Geant 4

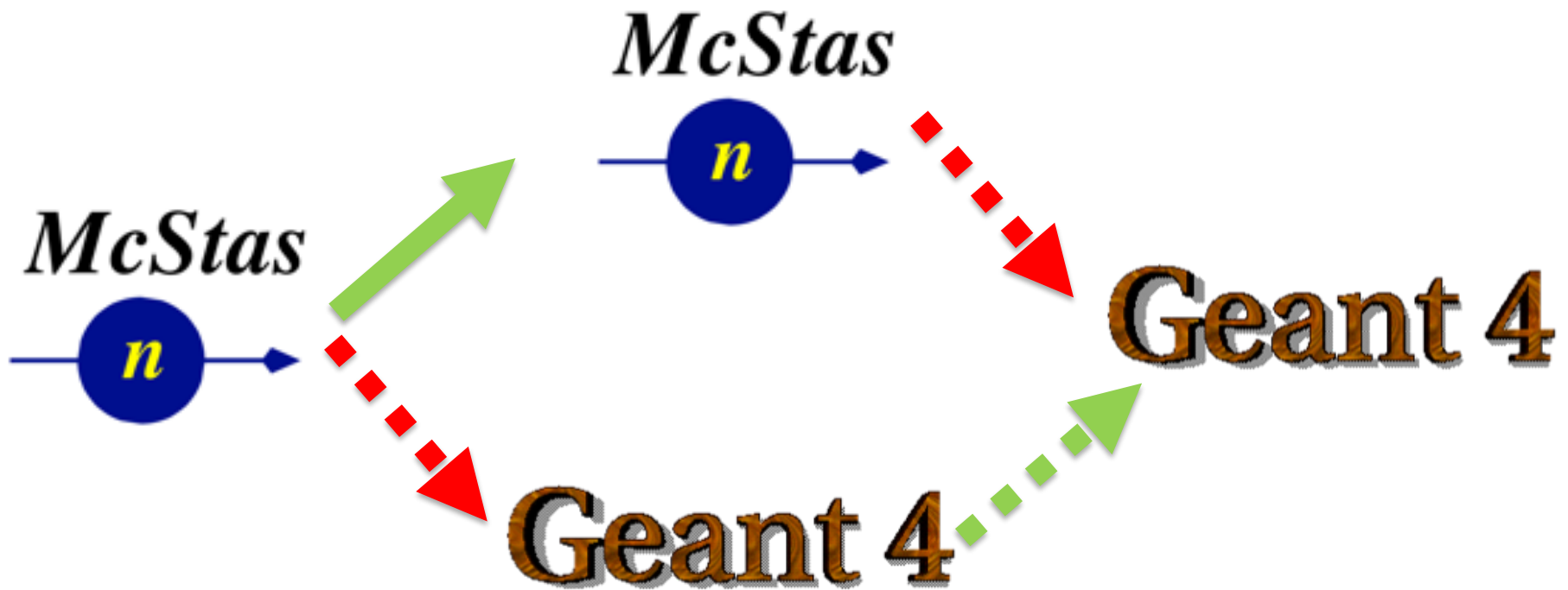
Geant 4

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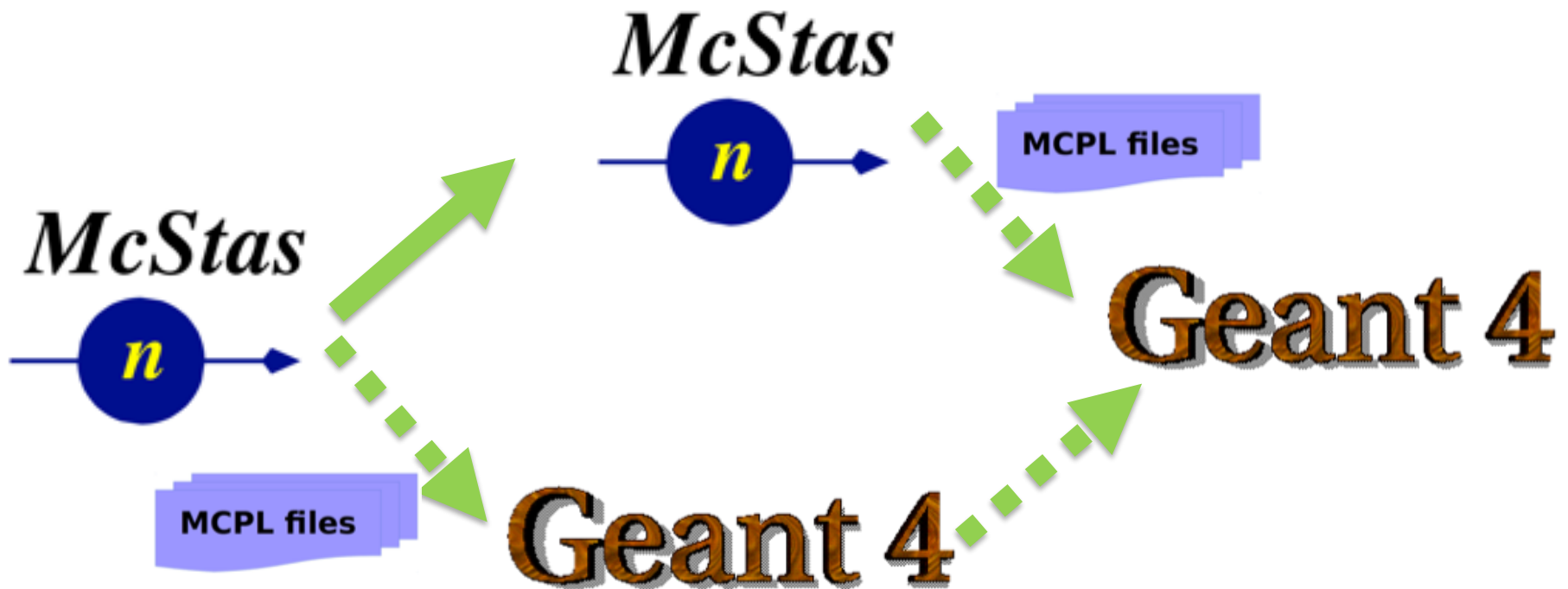


Simulation Tools - Options

Guide

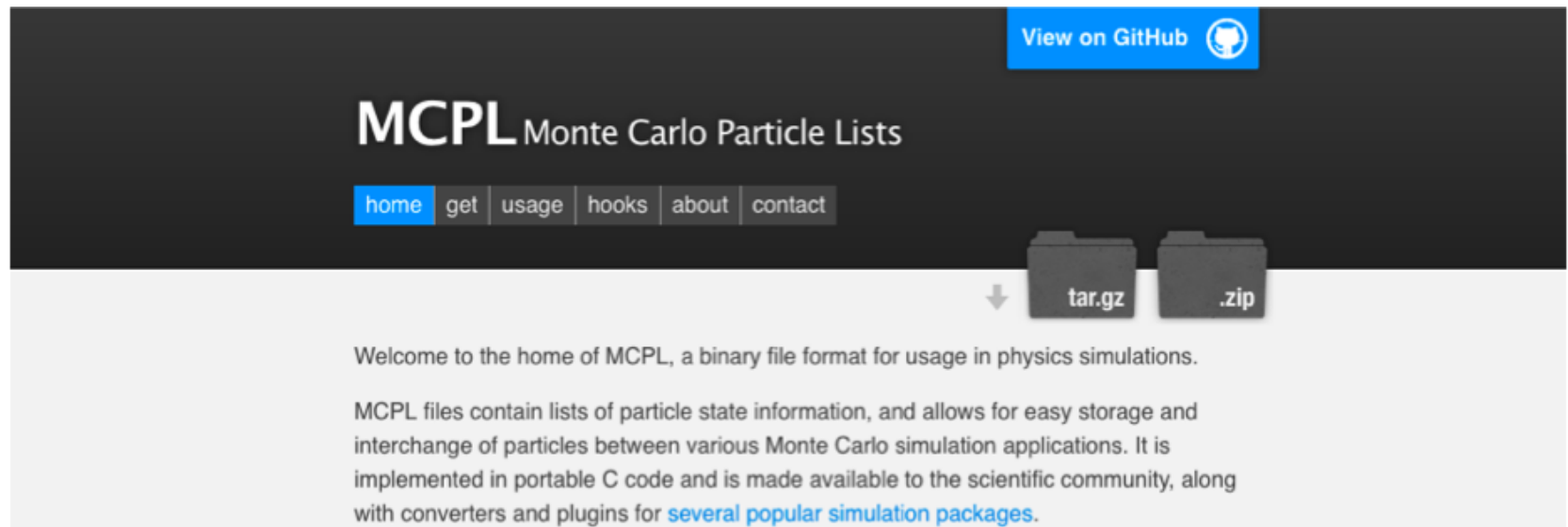
Sample +
analyzers

Detectors




Monte Carlo Simulation: MCPL

- **Monte Carlo Particle List**
 - Binary format
 - Open source
- Compatible MC tools
 - McStas
 - McXtrace
 - Geant4
 - MCNP6, MCNPX



The screenshot shows the homepage of the MCPL project. At the top right, there is a blue button labeled "View on GitHub" with the GitHub logo. The main heading is "MCPL Monte Carlo Particle Lists". Below the heading is a navigation menu with links for "home", "get", "usage", "hooks", "about", and "contact". The "home" link is highlighted in blue. Below the navigation menu, there are two folder icons labeled "tar.gz" and ".zip" with a downward arrow pointing to them. The main content area contains a welcome message and a description of the MCPL format.

View on GitHub 

MCPL Monte Carlo Particle Lists

[home](#) [get](#) [usage](#) [hooks](#) [about](#) [contact](#)

↓ [tar.gz](#) [.zip](#)

Welcome to the home of MCPL, a binary file format for usage in physics simulations.

MCPL files contain lists of particle state information, and allows for easy storage and interchange of particles between various Monte Carlo simulation applications. It is implemented in portable C code and is made available to the scientific community, along with converters and plugins for [several popular simulation packages](#).

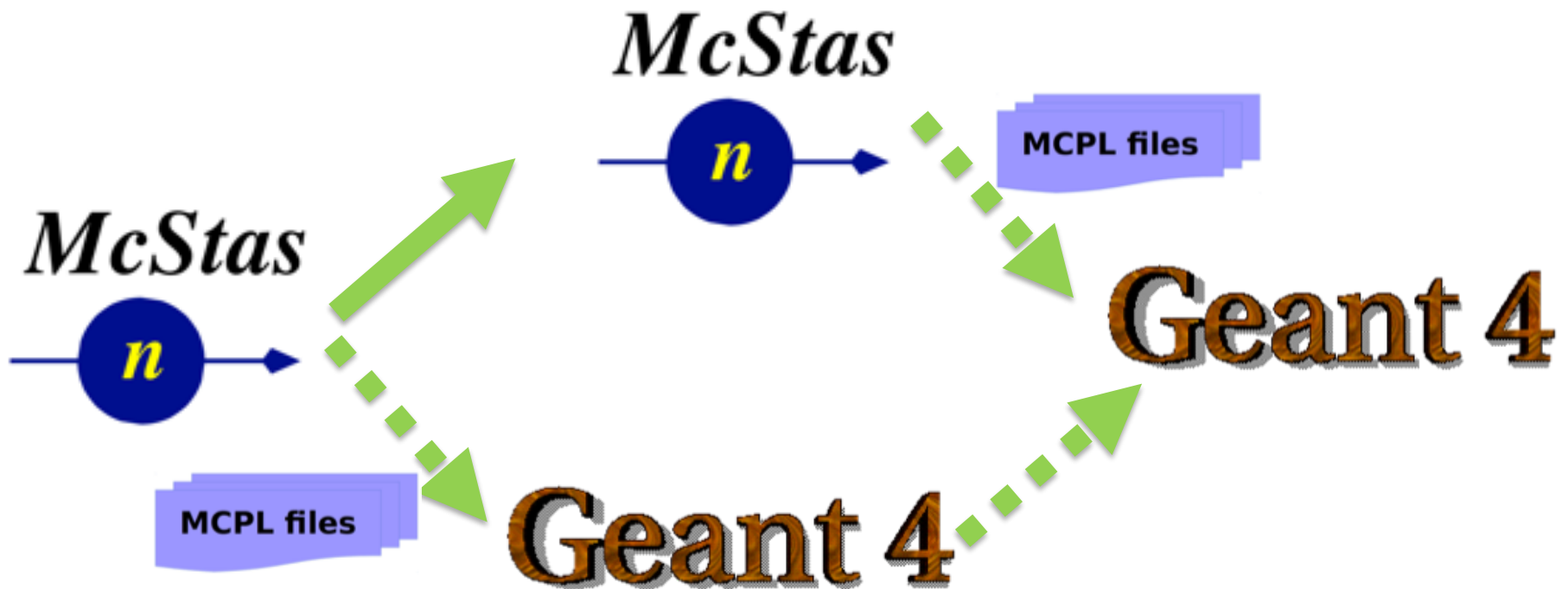
Source: <https://mctools.github.io/mcpl/>

Simulation Tools - Options

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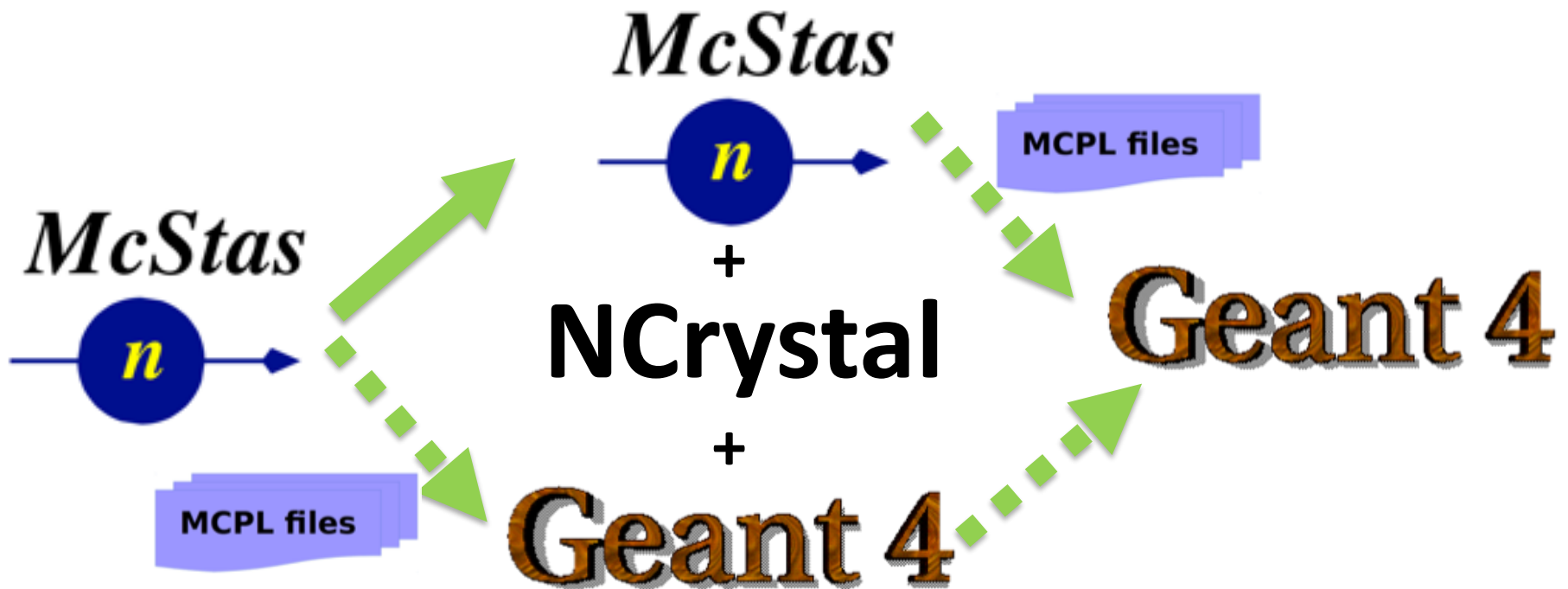


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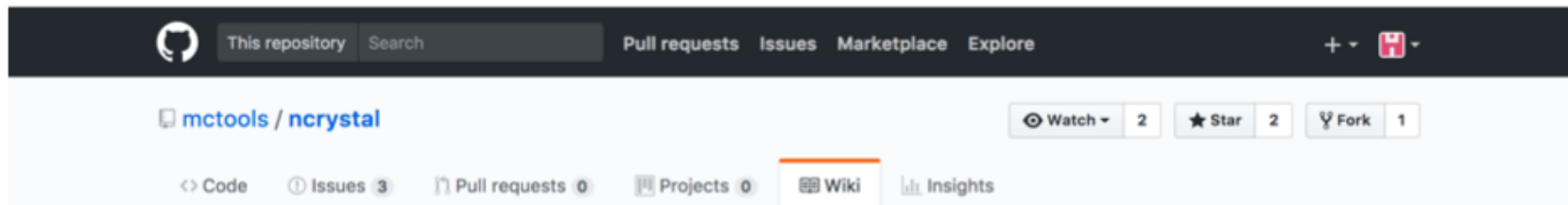
Sample +
analyzers

Detectors



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)



Home

Thomas Kittelmann edited this page on Aug 31, 2017 · 6 revisions

NCrystal : a library for thermal neutron transport in crystals

NCrystal is a library and associated tools which enables calculations for Monte Carlo simulations of thermal neutrons in crystals, focusing initially on scattering in single-crystals or polycrystalline materials and powders, including both coherent elastic (Bragg) diffraction and various models for inelastic scattering on phonons. Written in C++. interfaces and

Pages 8

[Home](#)
[Get NCrystal](#)
[Using 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

Simulation Tools: NCrystal



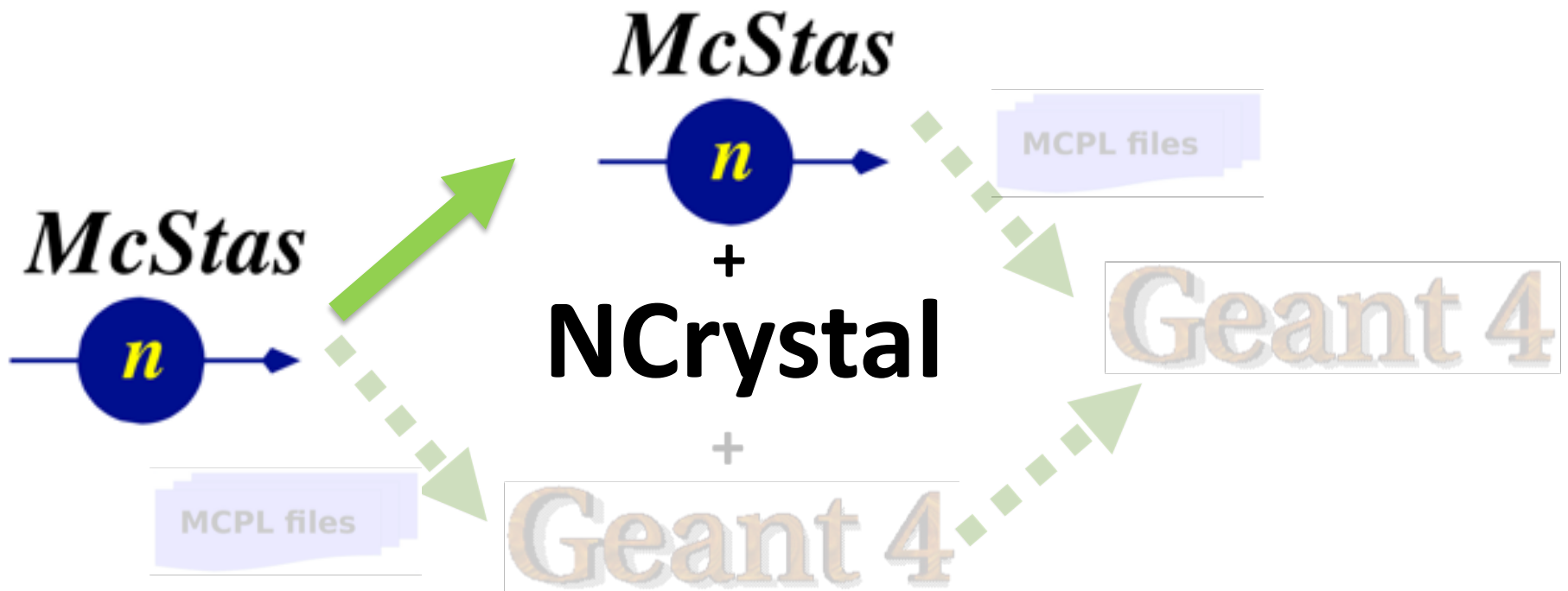
- Written in C++
- Direct usage from C, C++, or Python code
- Command-line tools
- **Components available for McStas and Geant4**

Simulation Tools - Options

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analyzers

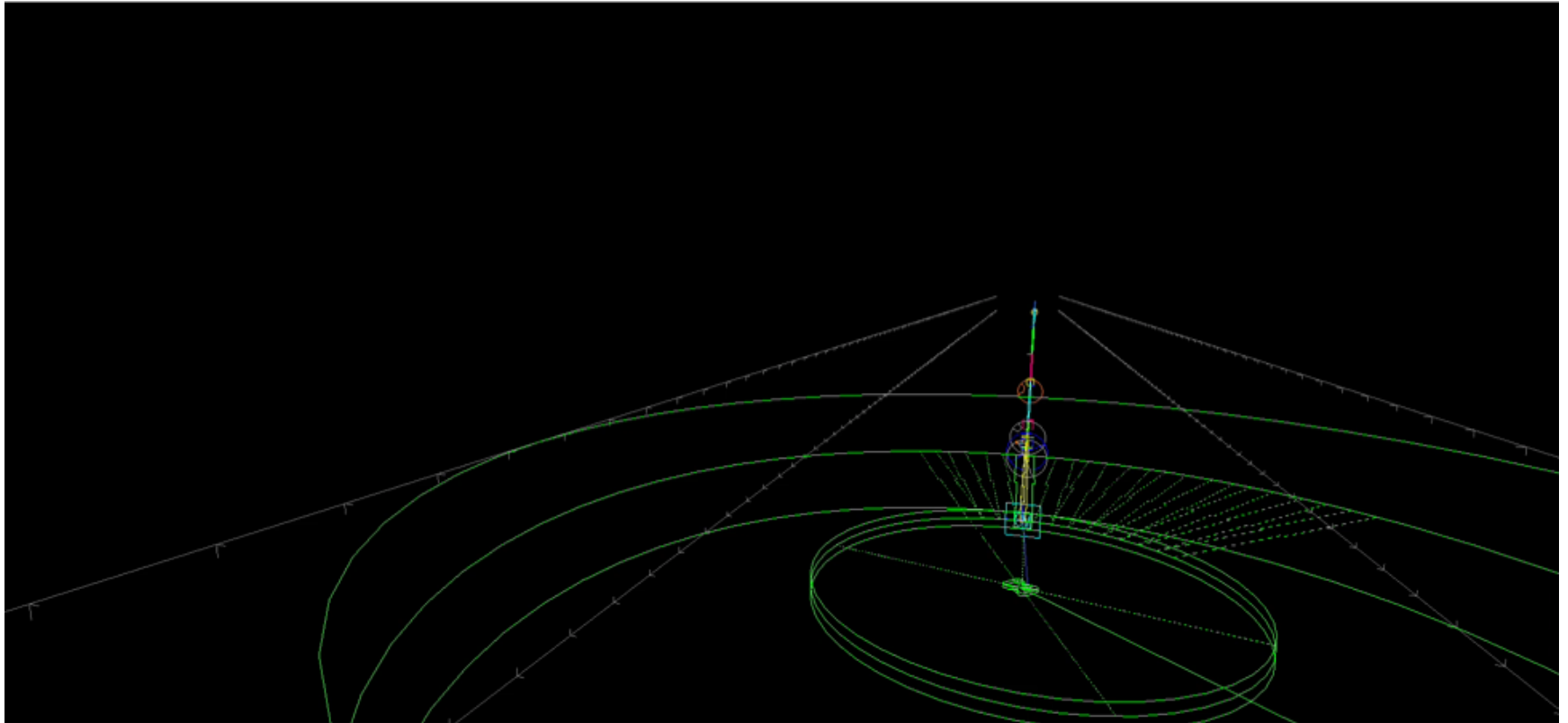
Detectors



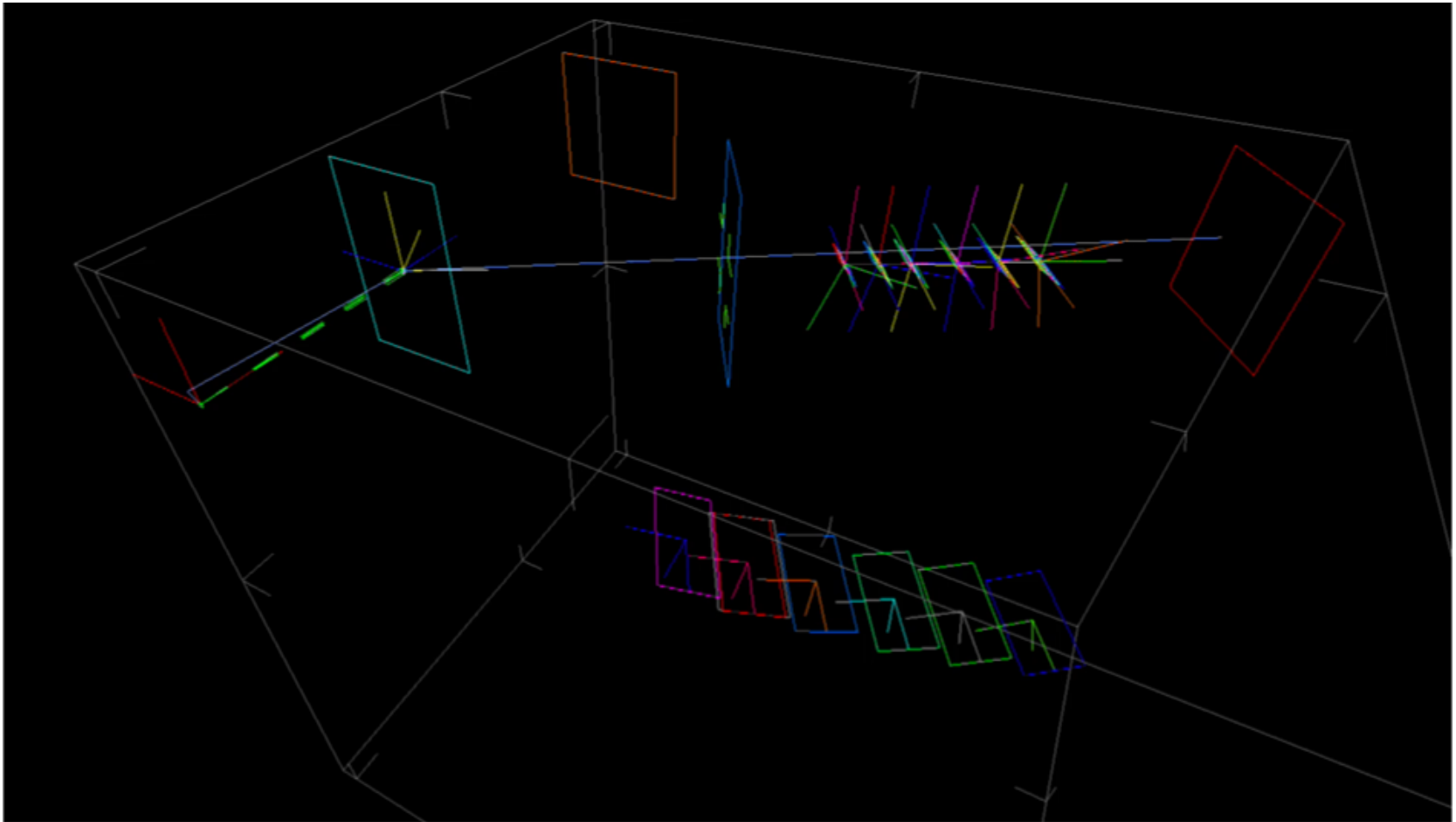
Outline

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McStas Model – Full Instrument



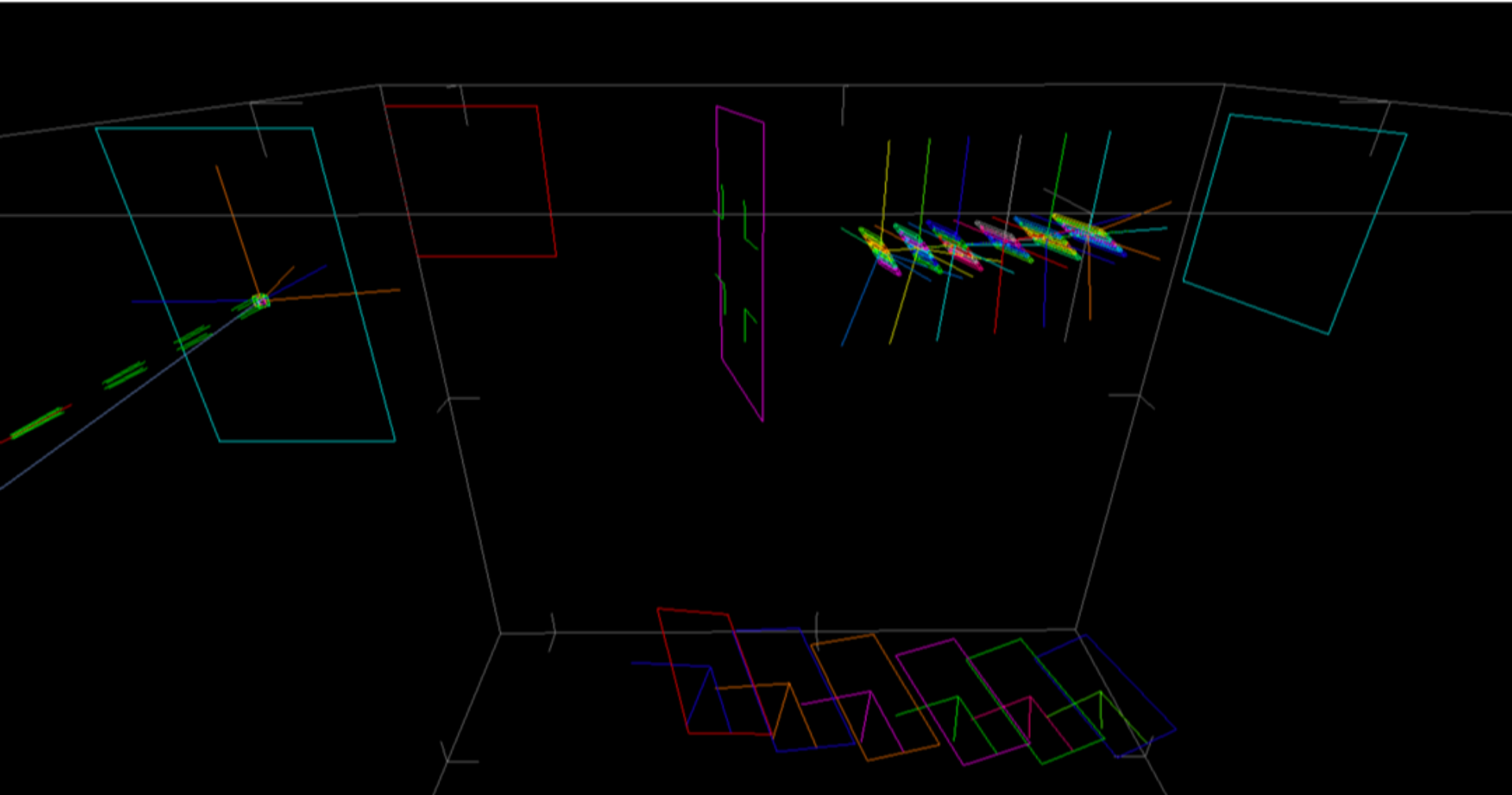
McStas Model – Analyzer-Detector system



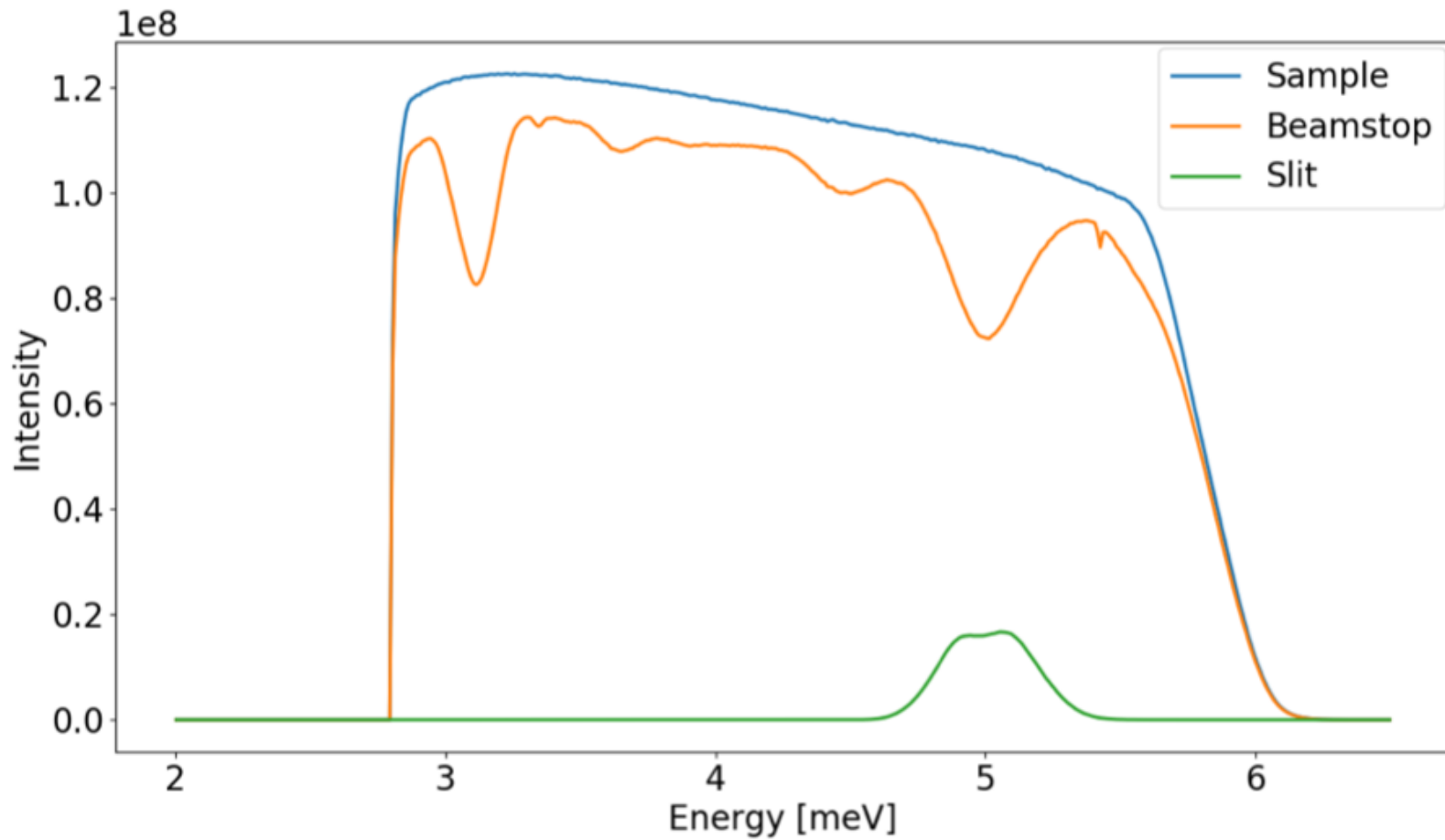
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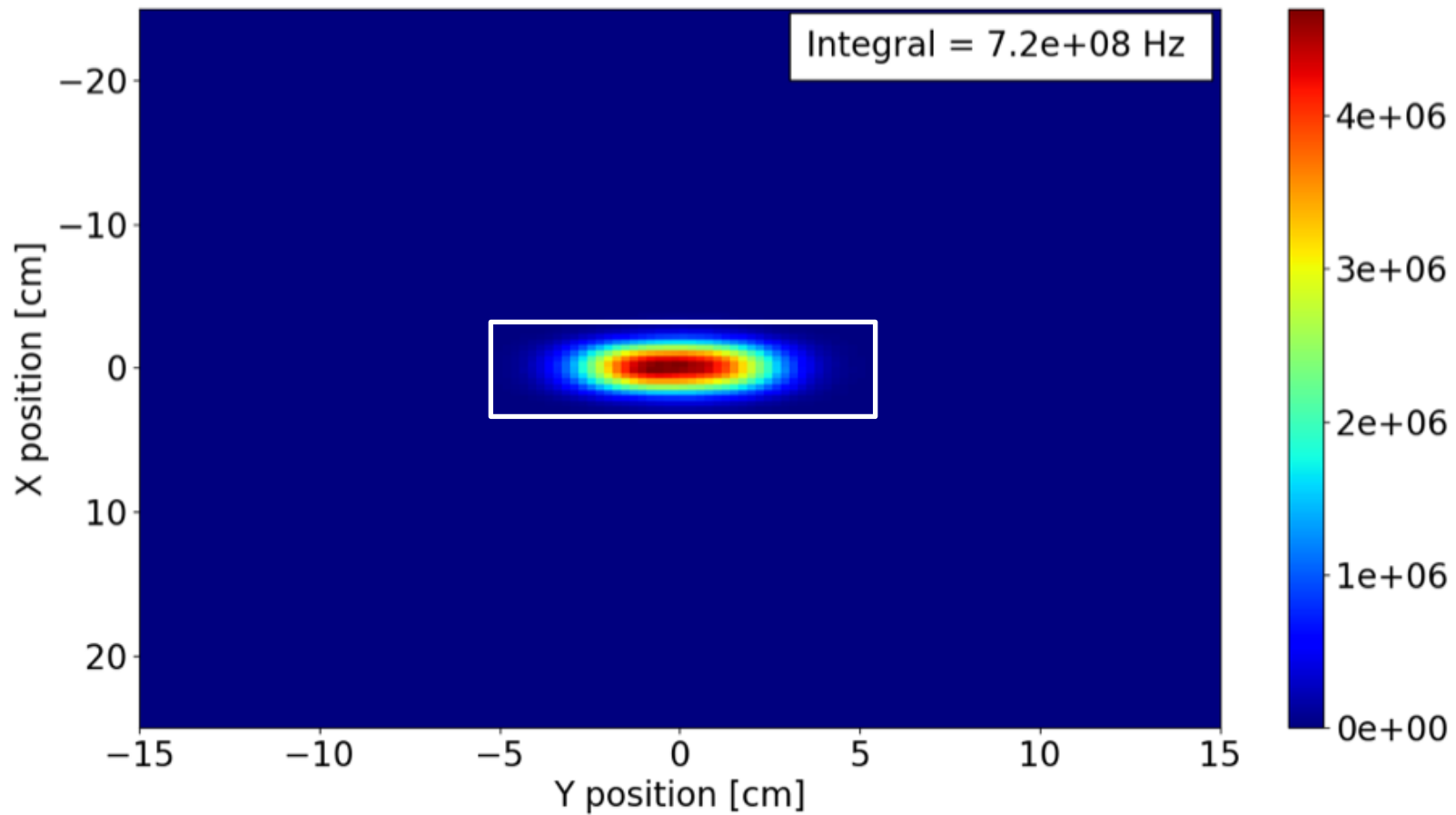
TODO



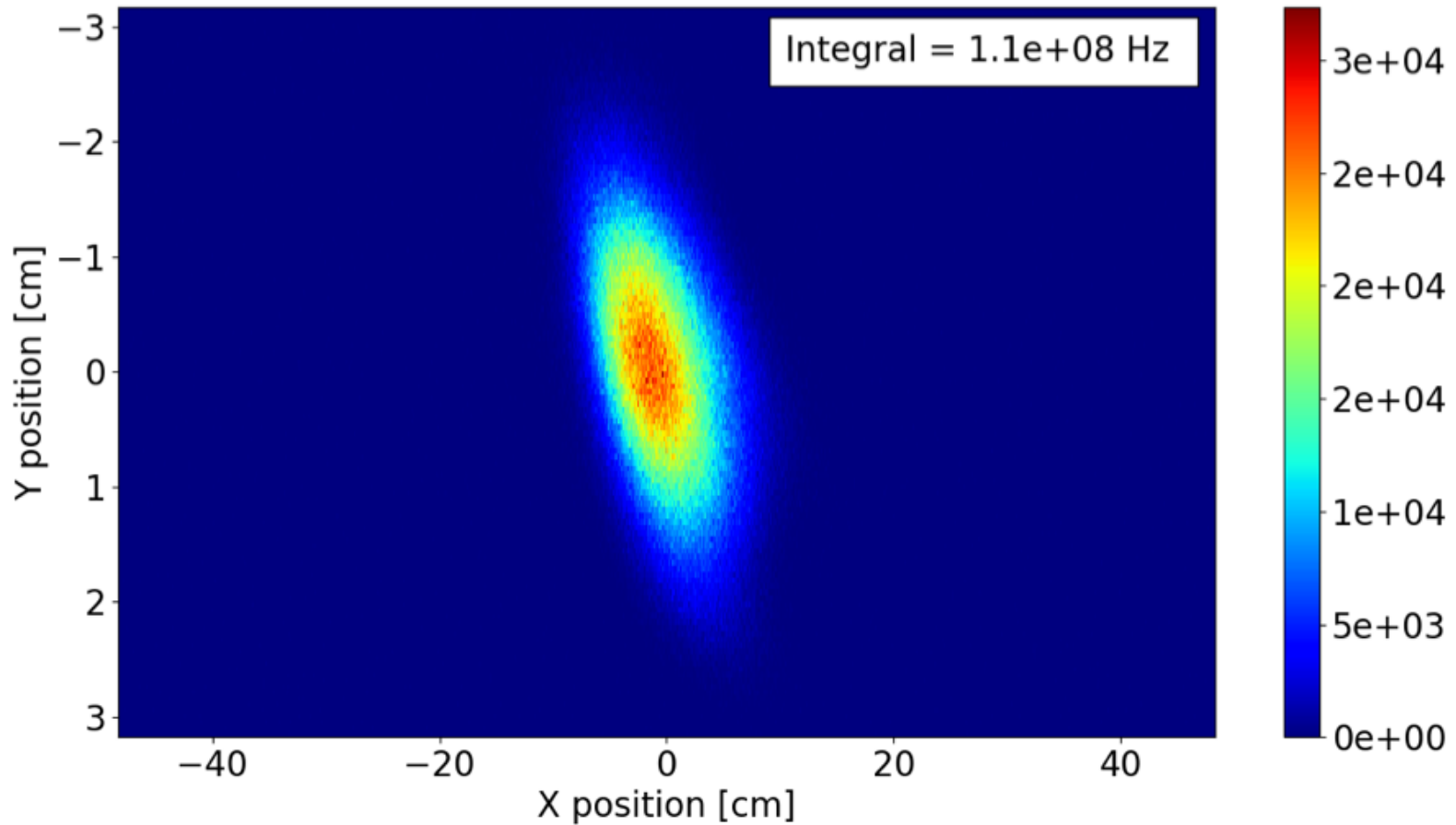
Change of energy spectrum on sample



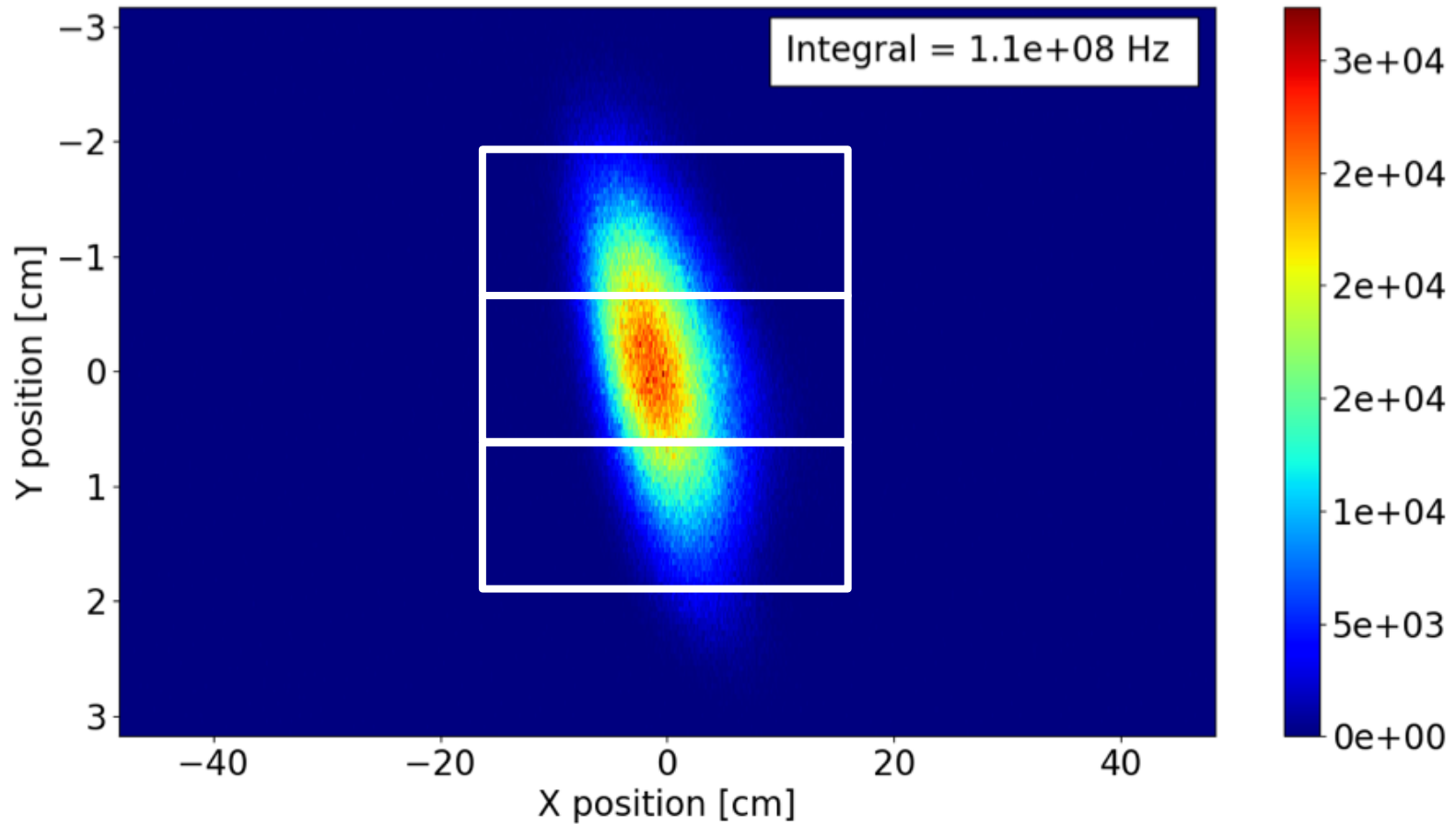
Position on slit



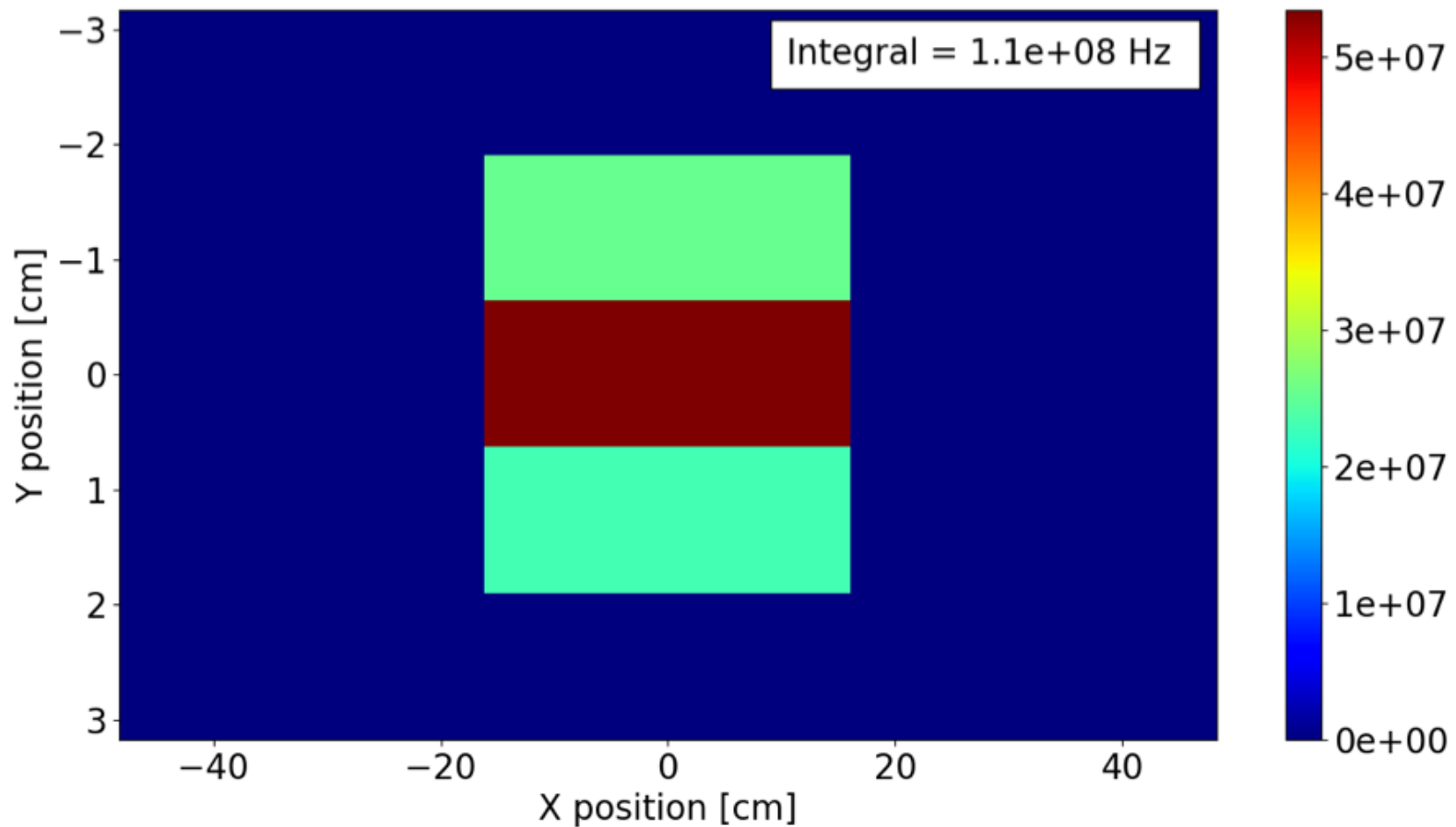
Position on detector



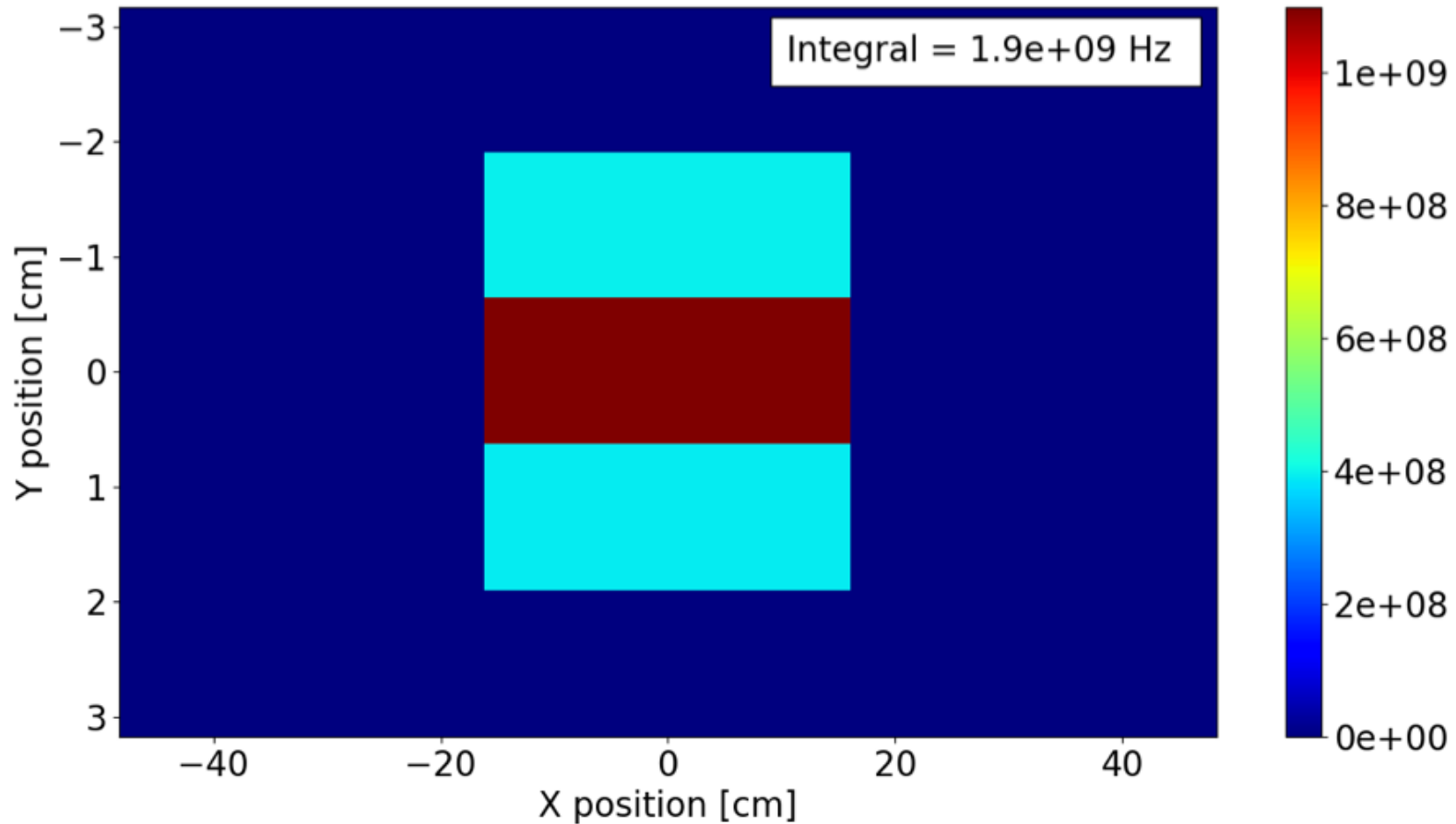
Position on detector



Time averaged incident rate



Peak instantaneous incident rate



Preliminary results

- Parameters:
 - Sample: Y_2O_3 single-crystal, $hkl=2,-2,-2$ ($d_{hkl} = 3.0724 \text{ \AA}$)
size = $(1.5 \text{ cm})^3$, mosaicity = 60 arcmin
 - 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**

Outline

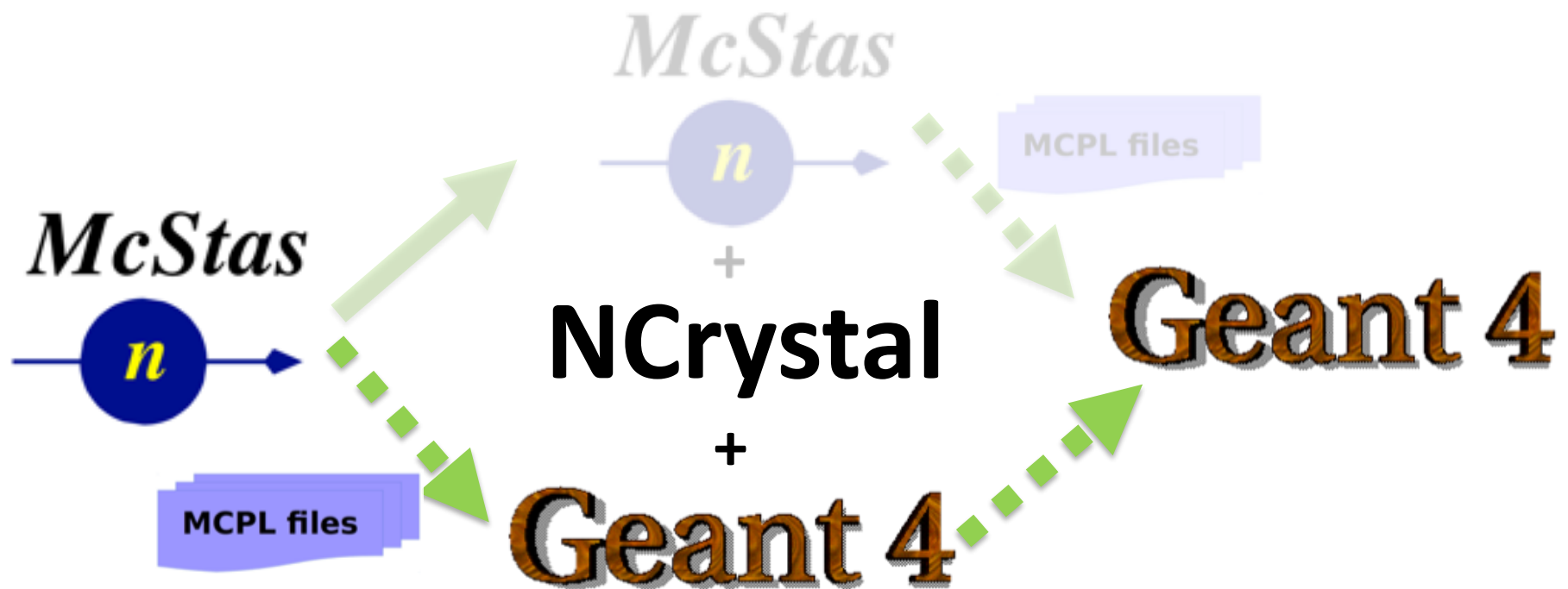
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Cross-check and Detector simulation

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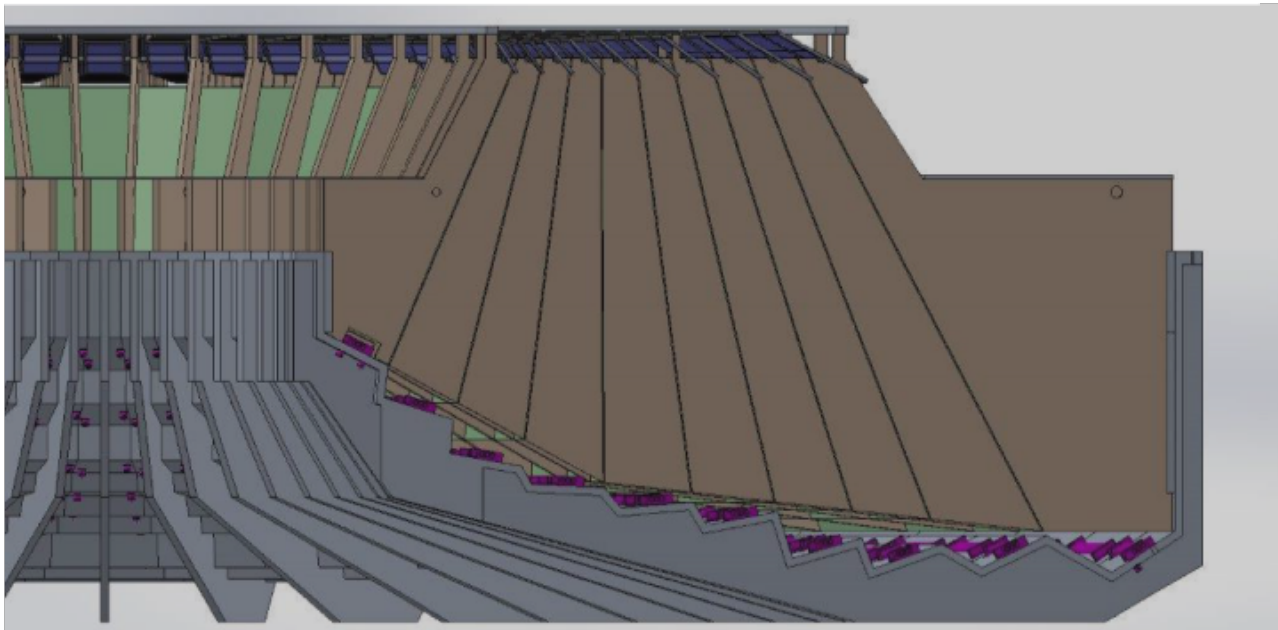
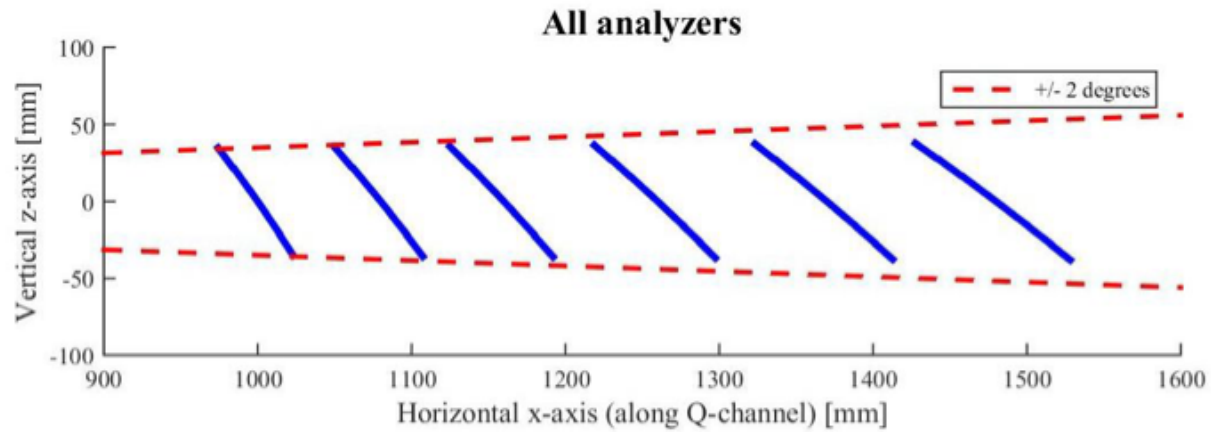


Acknowledgments

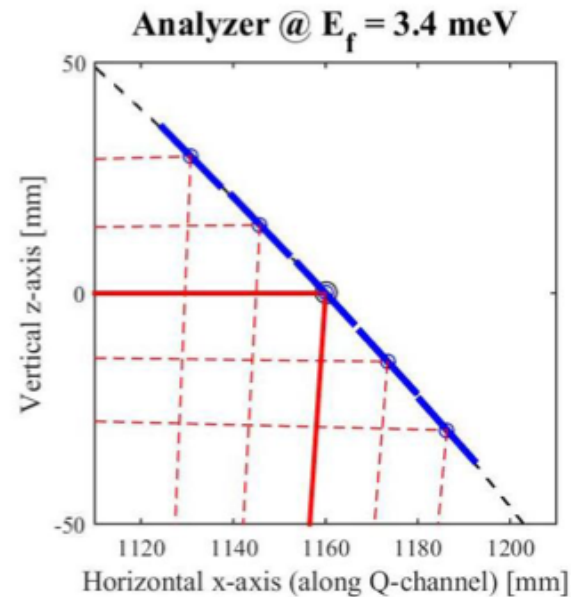
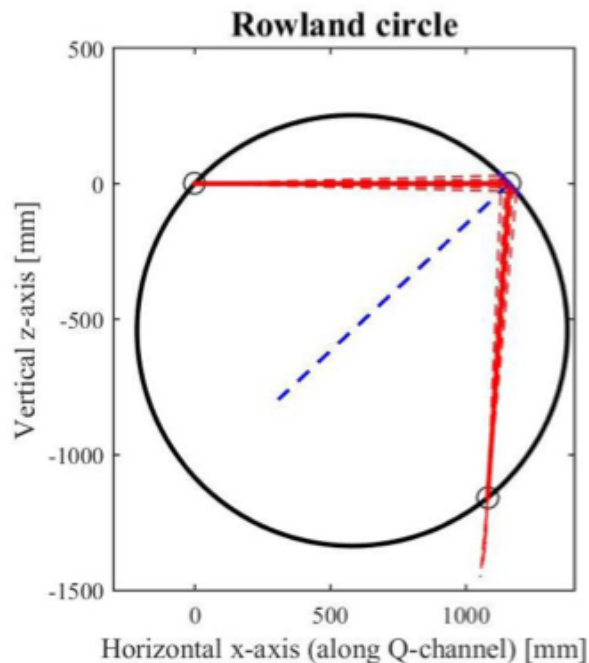
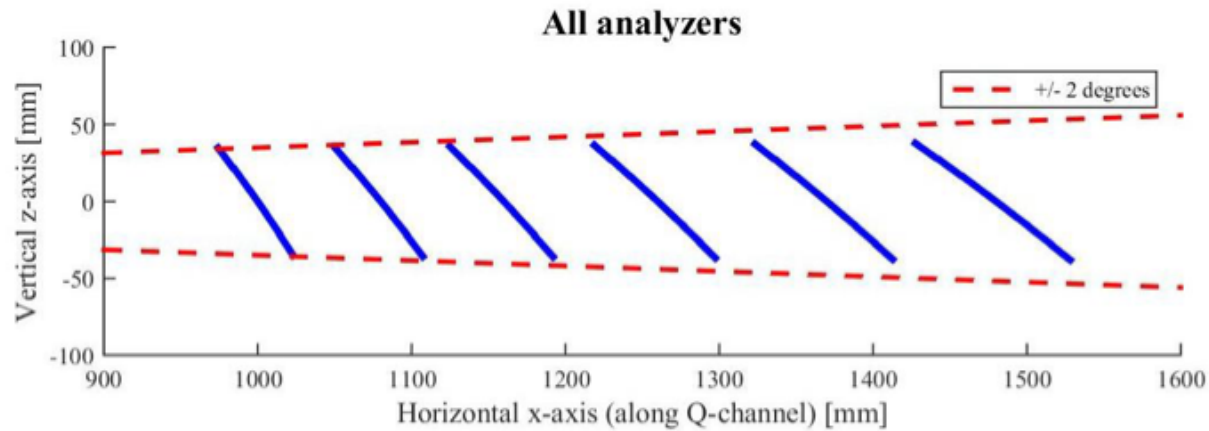
- Rasmus Toft-Petersen, Fatima Issa
- Thomas Kittelmann, Xiao Xiao Cai, Peter Willendrup
- Kalliopi Kanaki, Richard Hall-Wilton
- Data Management&Software Centre (DMSC)

Thank you for your
attention!

Secondary spectrometer tank - Analyzers

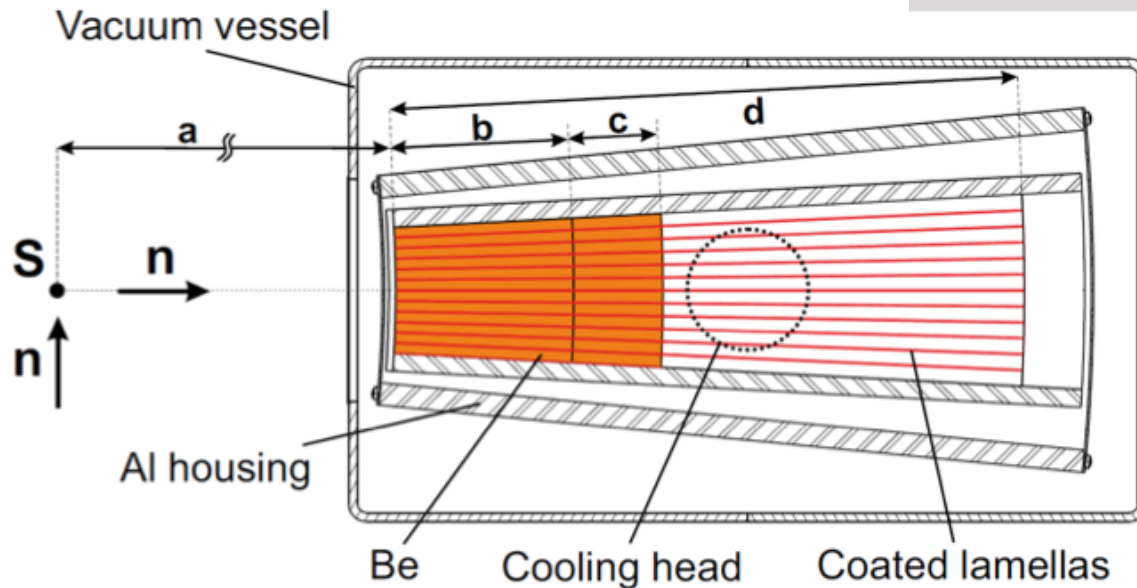
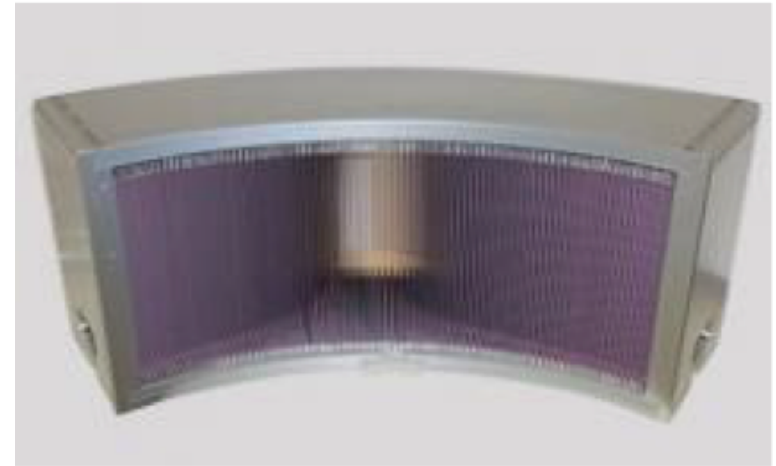


Secondary spectrometer tank - Analyzers



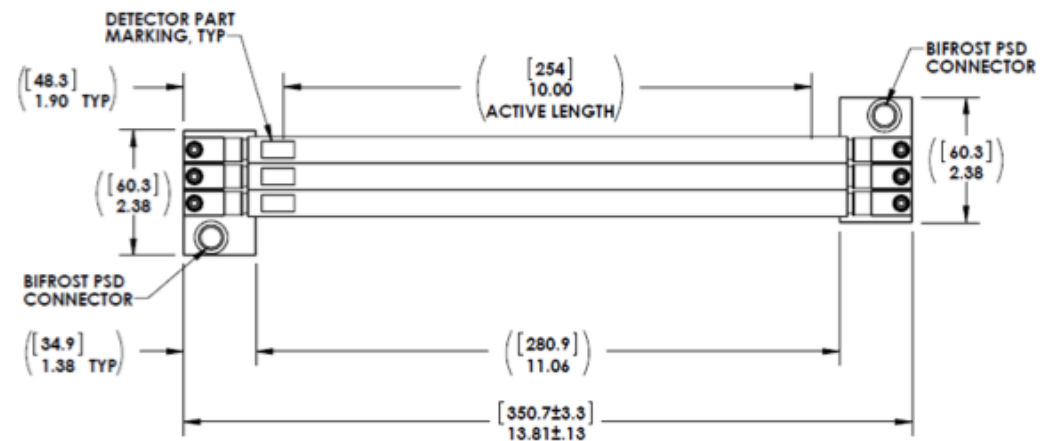
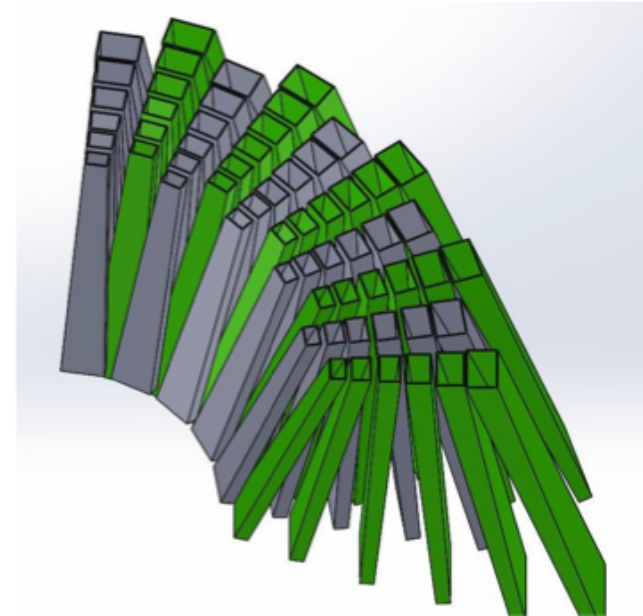
Scattering Characterization System

- 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 AMCSDB
#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
```

Ncrystal - Data library and validation

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  angles 90. 90. 120.
@SPACEGROUP
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@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
@DEBYE TEMPERATURE
  C 730.950029766
```

