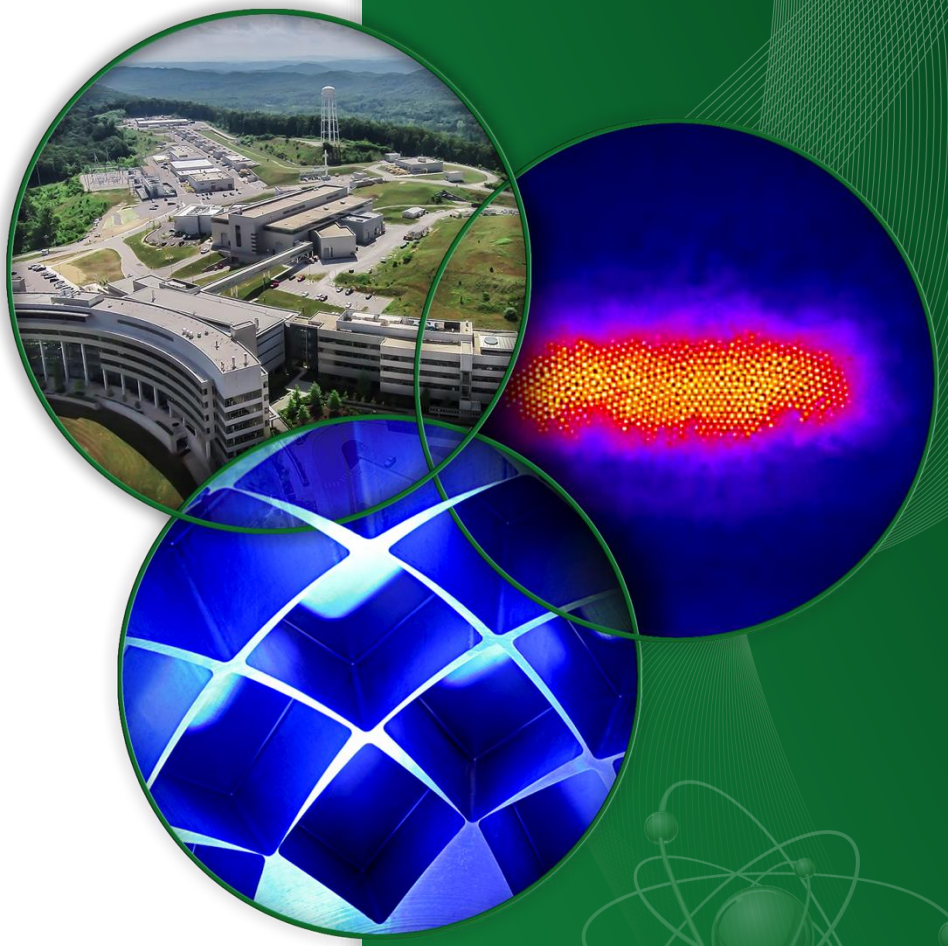
# Detector Update-SNS

R. Riedel

Oak Ridge National Lab



ICND Collaboration Meeting-2019

# Events since last meeting

- November 2018 HFIR operation was suspended.
  - Core/fuel element review
  - Restart Oct 29
- March 2019  SNS operation went into a long shut down (3 months) due to mercury cooling loop issues. Restarted in July.
- December 2018: Triennial Review conclusions received.
- Second Target Station directorate formed.
- Ken Anderson to head technologies division.
- Budget is stable with additional money expected for second target station.

# Detector R&D efforts

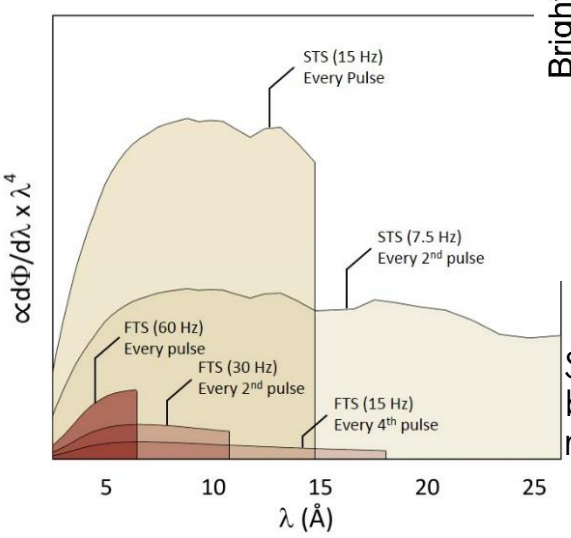
- High rate detectors for reflectometers
- Anger Cameras…better resolution..better gamma rejection.
- Timepix3 T.O.F imaging detector (25um resolution).
- WLSF

# Second Target Station Update

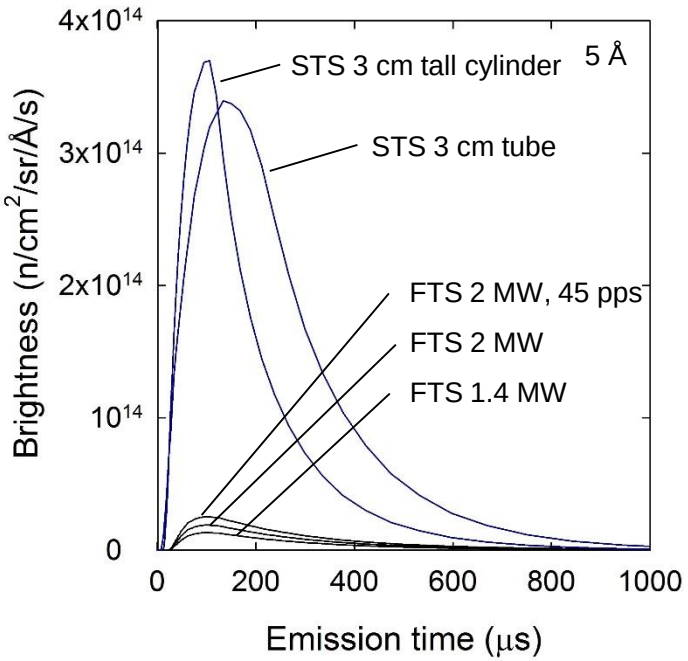
- Cold pulsed source to complement FTS and HFIR.
- Multiple reviews and workshops over the last two years.
- 15Hz repetition rate using pulse stealing.
- Small moderators
- Rotating target.
- Eight instruments are planned for the initial instrument suite.
- John Haines will head the directorate.

# STS complements the strengths of FTS and HFIR

- FTS – optimized for the sharpest neutron pulses (decoupled, poisoned moderators)
  - Highest wavelength resolution ($\Delta\lambda/\lambda$: 0.05 to 0.15%)
  - Emphasizes short wavelength neutrons
- HFIR – optimized for highest time-average neutron brightness
  - Low-wavelength resolution ($\lambda/\lambda$: 0.1 to $\varepsilon$ 10%)
  - Pinpoint focus into reciprocal space
- STS – optimized for high peak brightness cold neutrons
  - Modest wavelength resolution ($\Delta\lambda/\lambda$: 0.1 to 0.6%)
  - Time-resolved phenomena across a large range of length scales




Evolution of coupled moderators at SNS

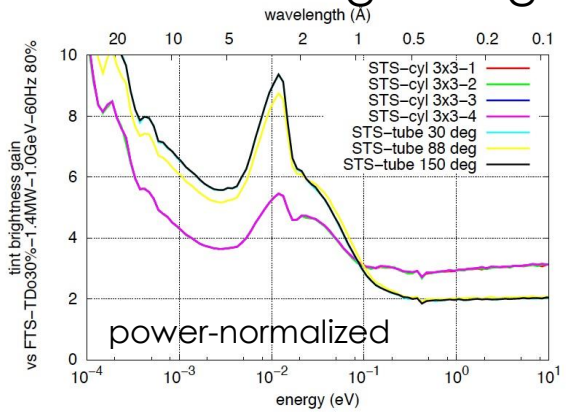


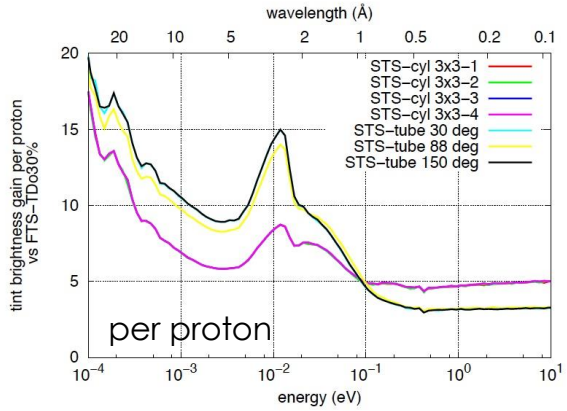

STS delivers the high flux and wide bandwidth required for time-resolved phenomena

# STS Cylinder and Tube Moderator: Gains over FTS

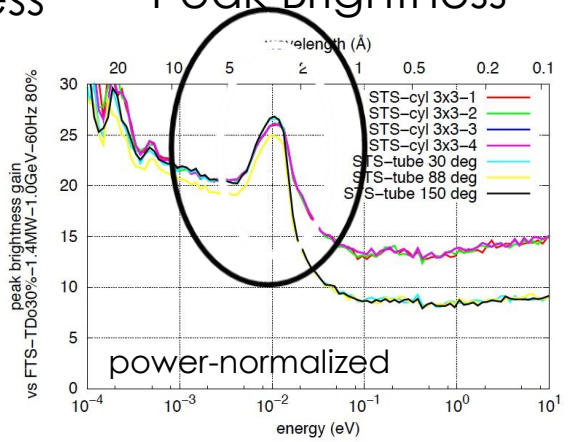
- Time-integrated and peak brightness gains compared to FTS coupled moderator

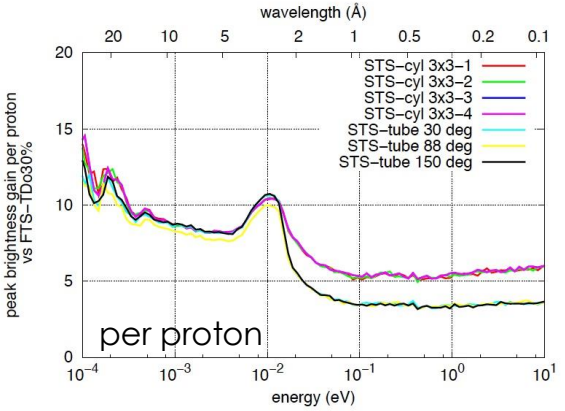
Time-averaged Brightness



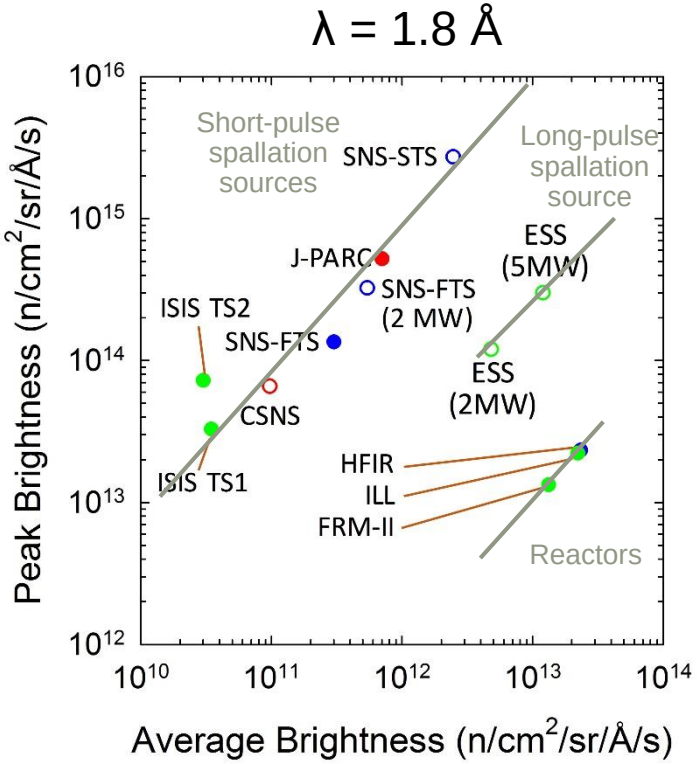



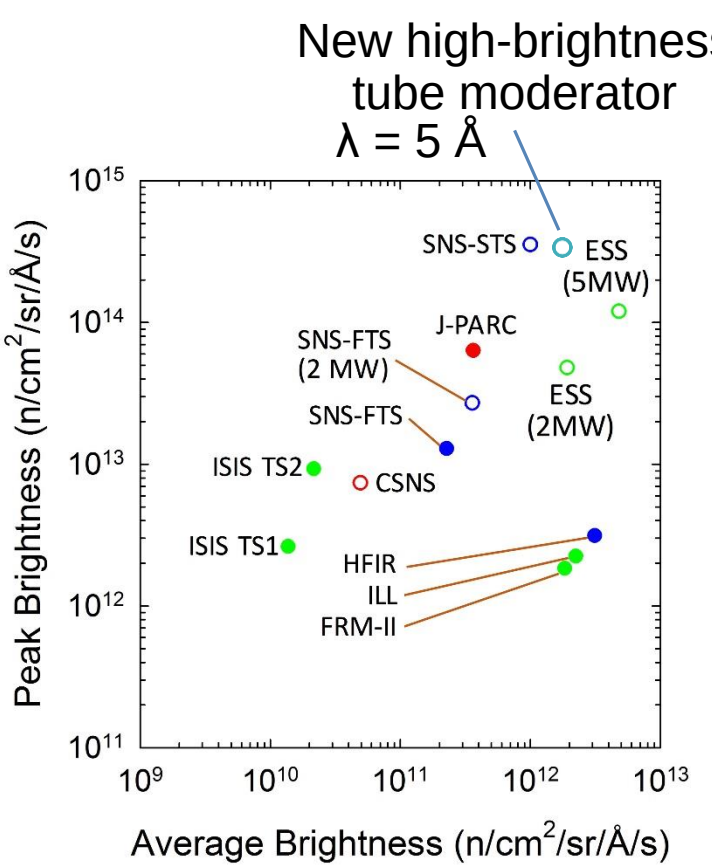

Peak Brightness

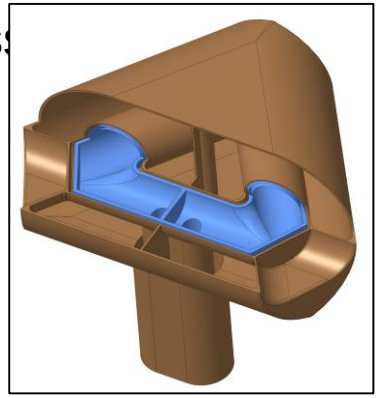


# STS will deliver world leading cold neutron peak brightness

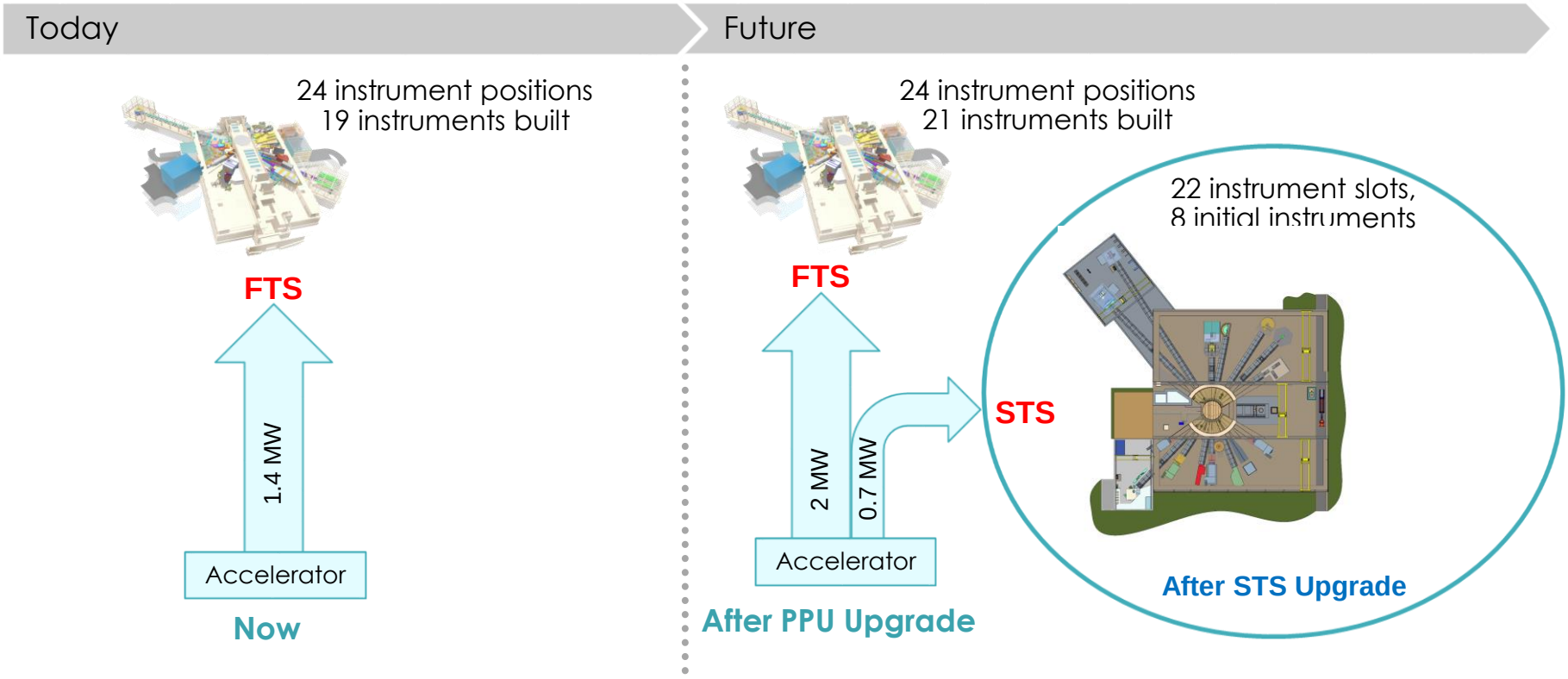


# Second Target Station

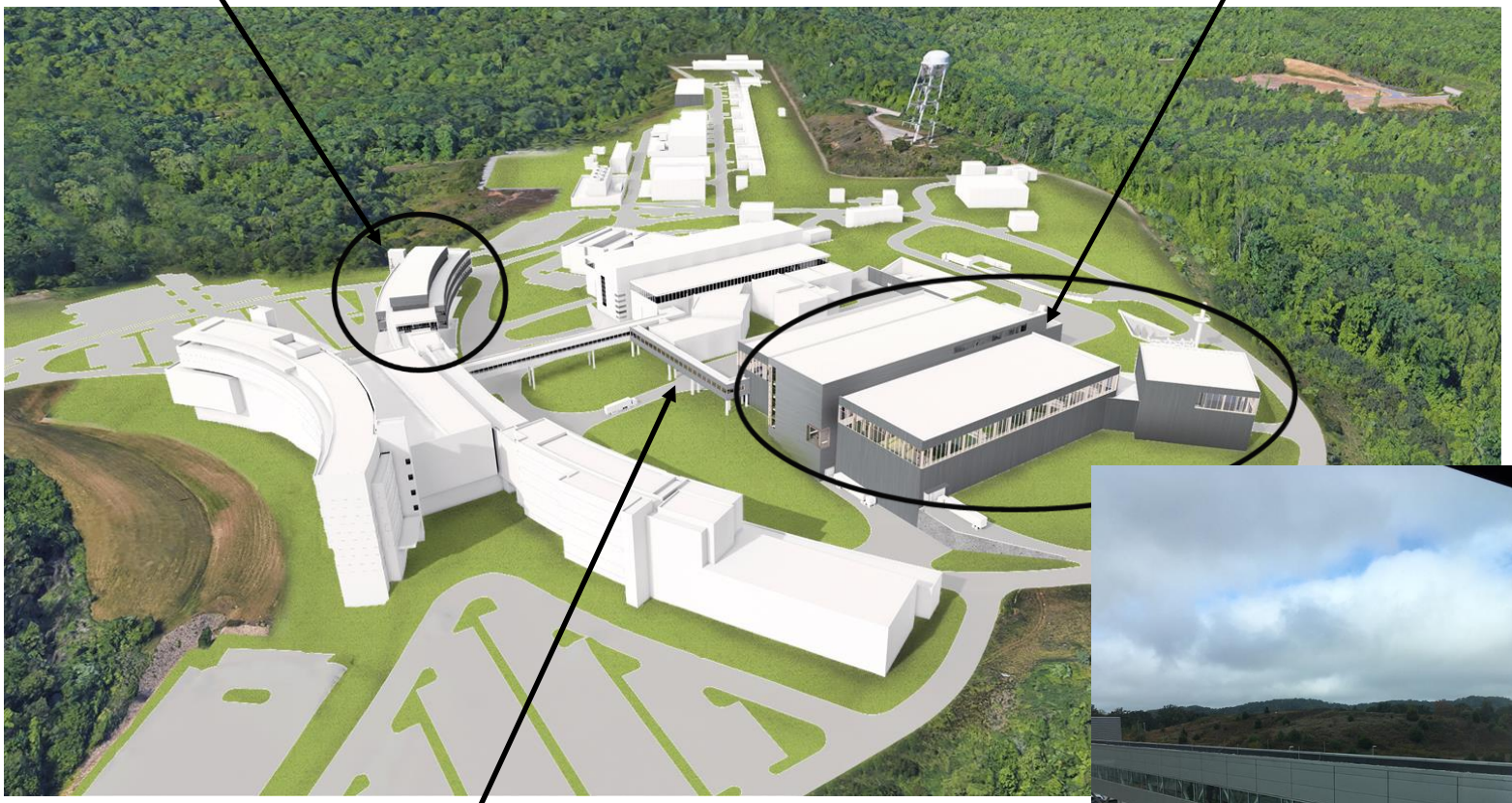
- Second Target Station will provide a new instrument hall with world class cold neutron brightness
  - Approximate Cost ~$1.5B



# A neutron instrument view of STS

CLO Extension

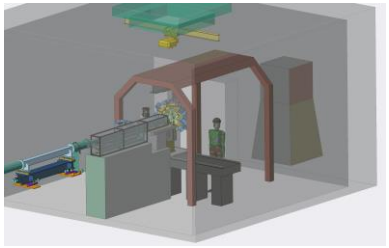
Target Buildings





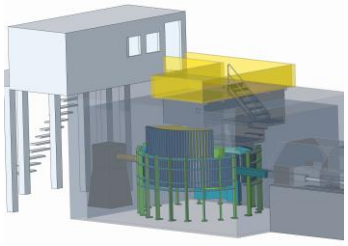
Cool new bridge!

# Proposed Eight Initial Instruments

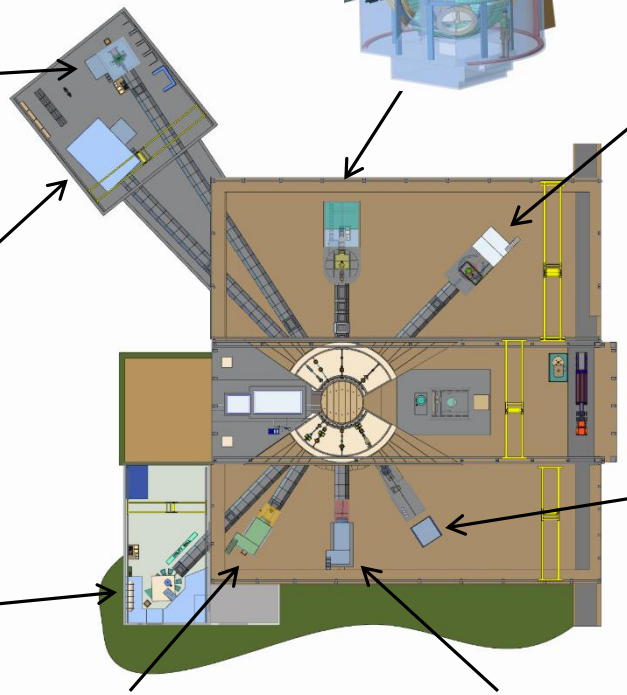


EWALD – Enhanced Wide-Angle Laue Diffractometer

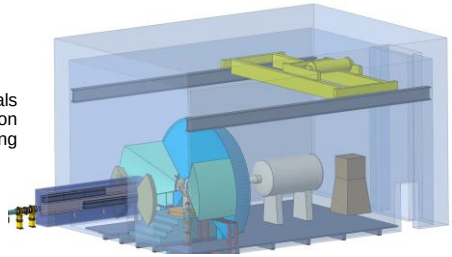
CHESS – Chopper Spectrometer for Small Samples

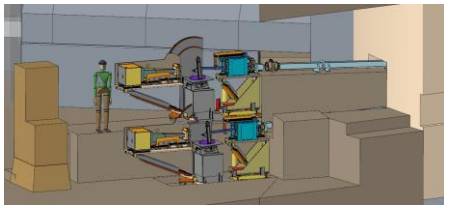


VERDI – Versatile Diffractometer

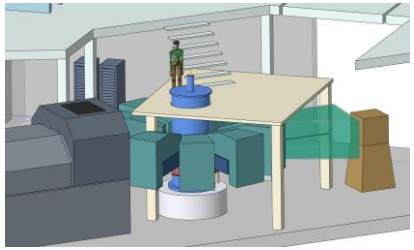


MENUS – Materials Engineering by Neutron Scattering

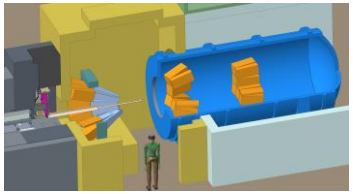




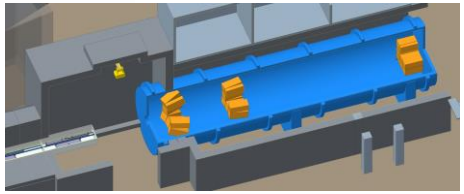
QIKR – Quite Intense Kinetics Reflectometer



ZEEMANS – High Magnetic Field Instrument



CYGNUS - SWANS



SANS1

# Instrument Upgrade progress

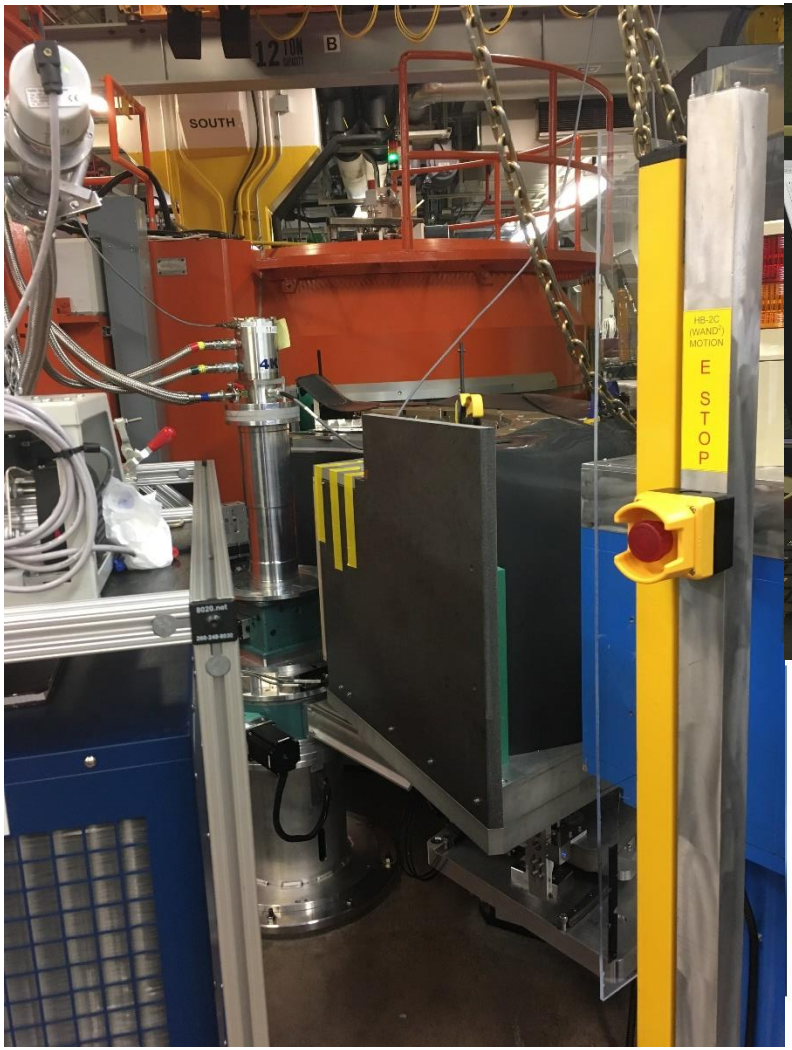
- HFIR
  - WAND
  - Residual Stress
  - HB-3a
  - CG-4b
  - SANS
- SNS
  - New electronics—including preamps, power supplies and communication links at ARCS
  - Four additional eightpaks at SEQUIOA

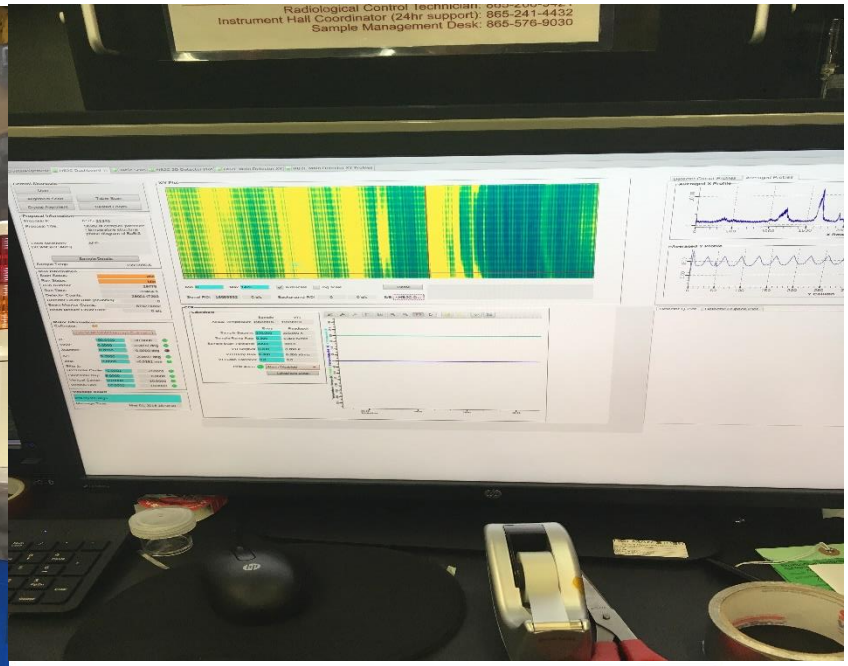
# WAND Installation

Radial Collimator

Detector
Formerly at LANSE PCS

# WAND PCS Detector ready for operation



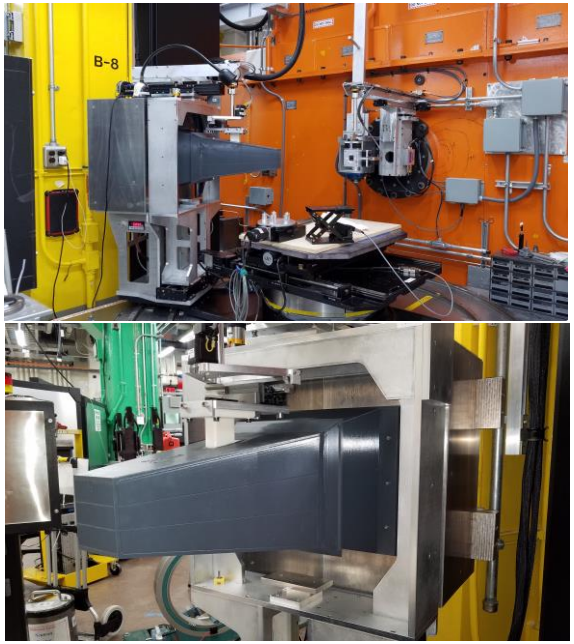

BNL 120° (PCS)

# New detector (DENEX) installed at HFIR HB-2B Beam Line

- initial commissioning underway (motion control, testing with Cf-252)
- awaiting HFIR restart to commission with beam neutrons

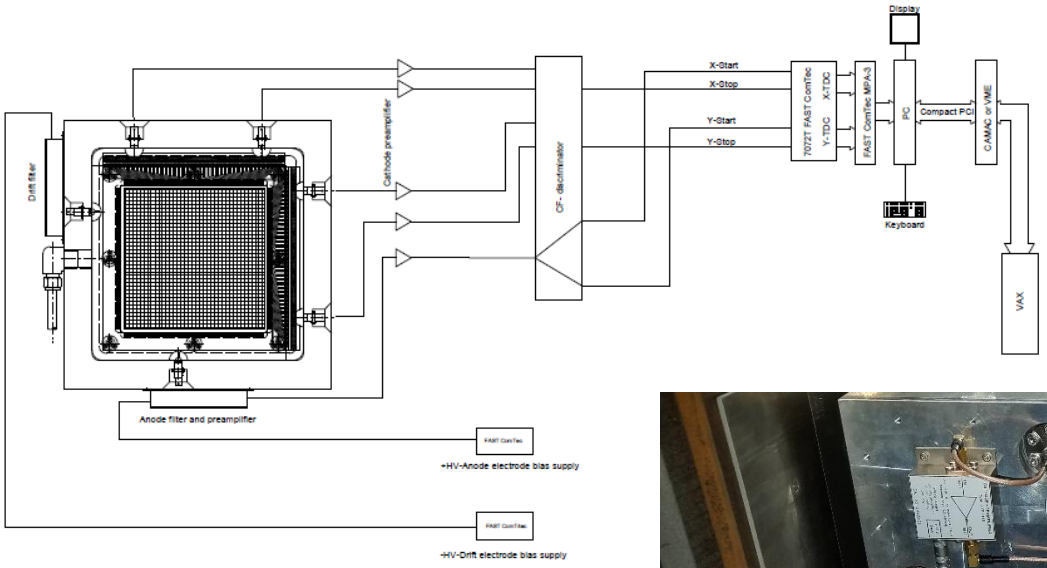
Front View
showing detector entrance window

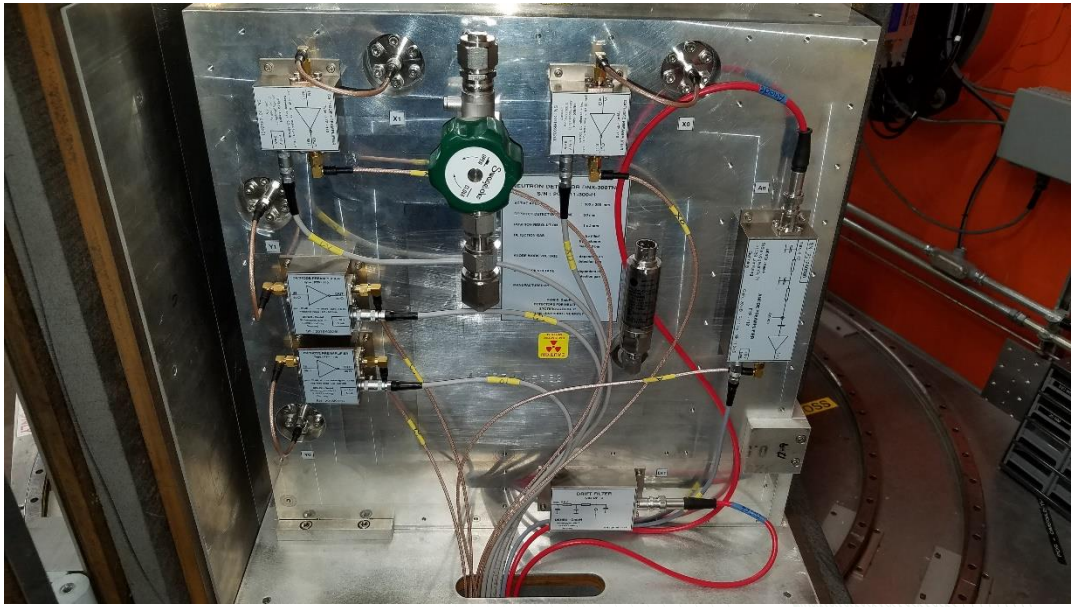
Rear View
showing neutron/gamma shielding enclosure



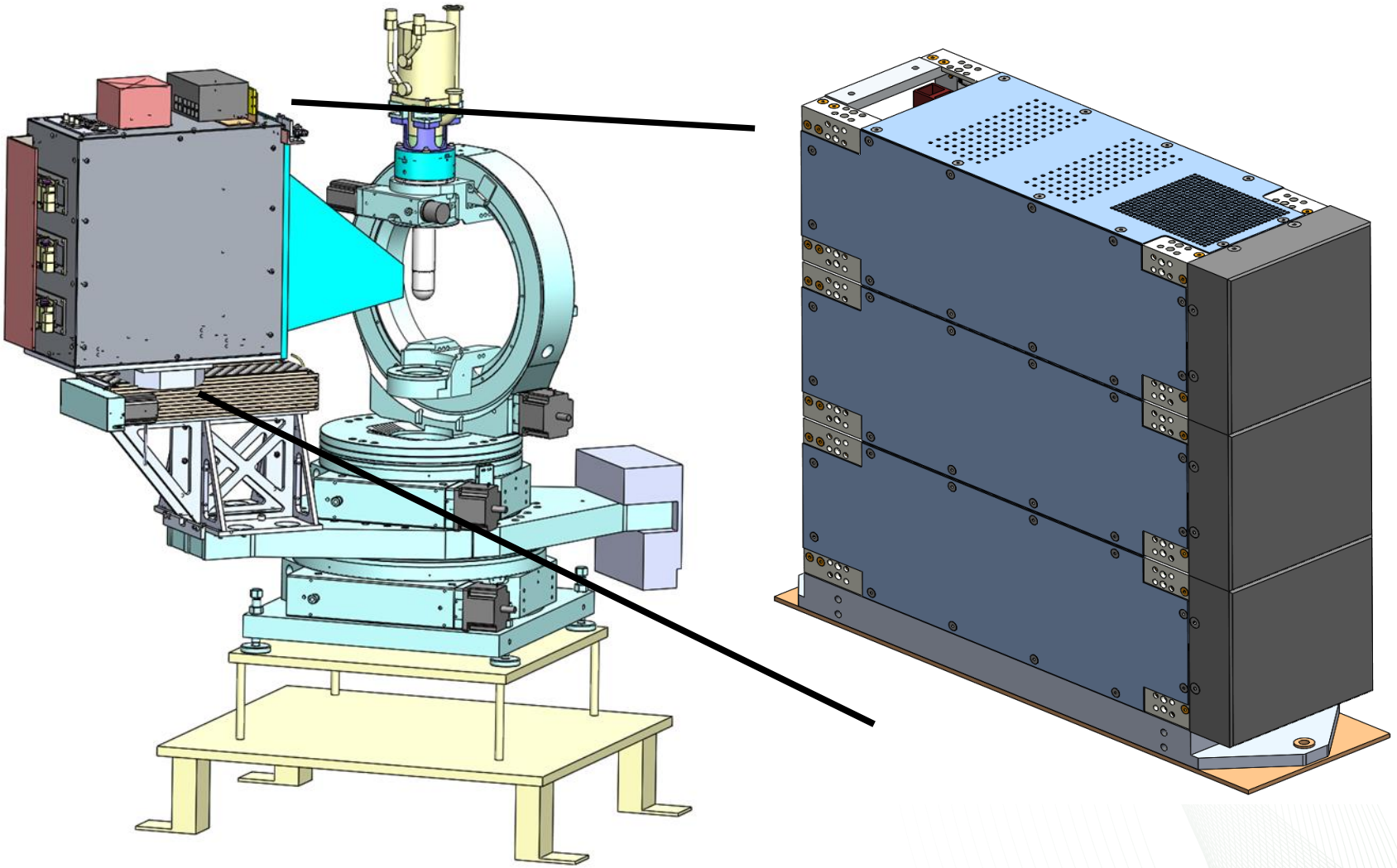

New 3D printed collimator installed

# DENEX Detector is Delay Line Type

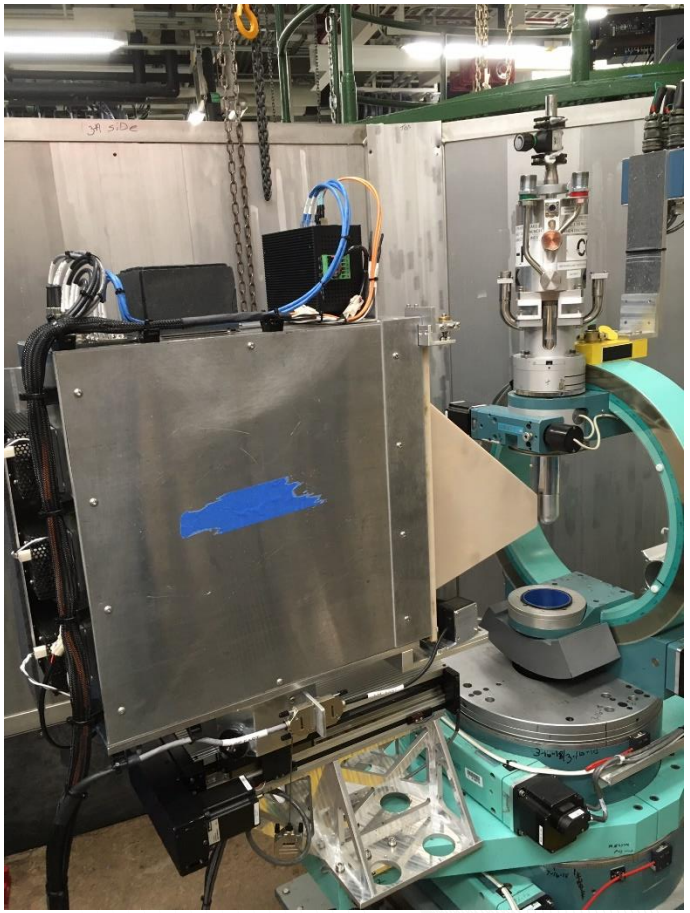


# HB-3a Engineering Drawing



# Three Detectors Installed. Awaiting beam.



Additional Six to be installed

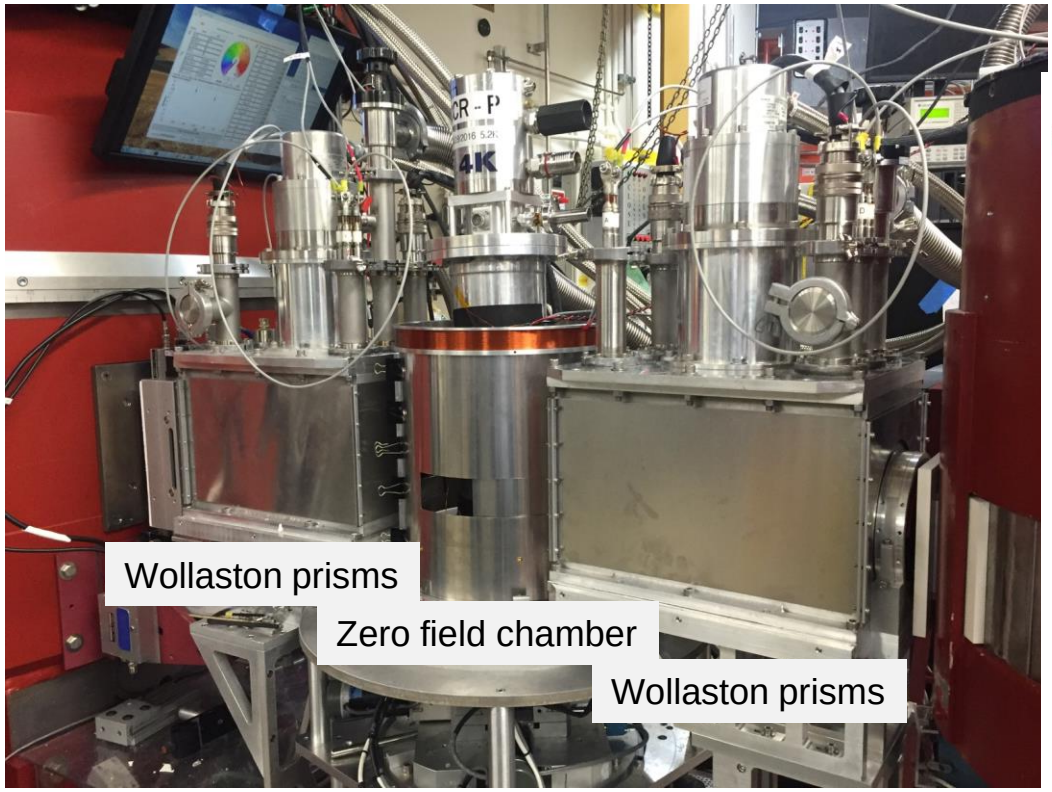
# New Additions to HFIR Beam Lines

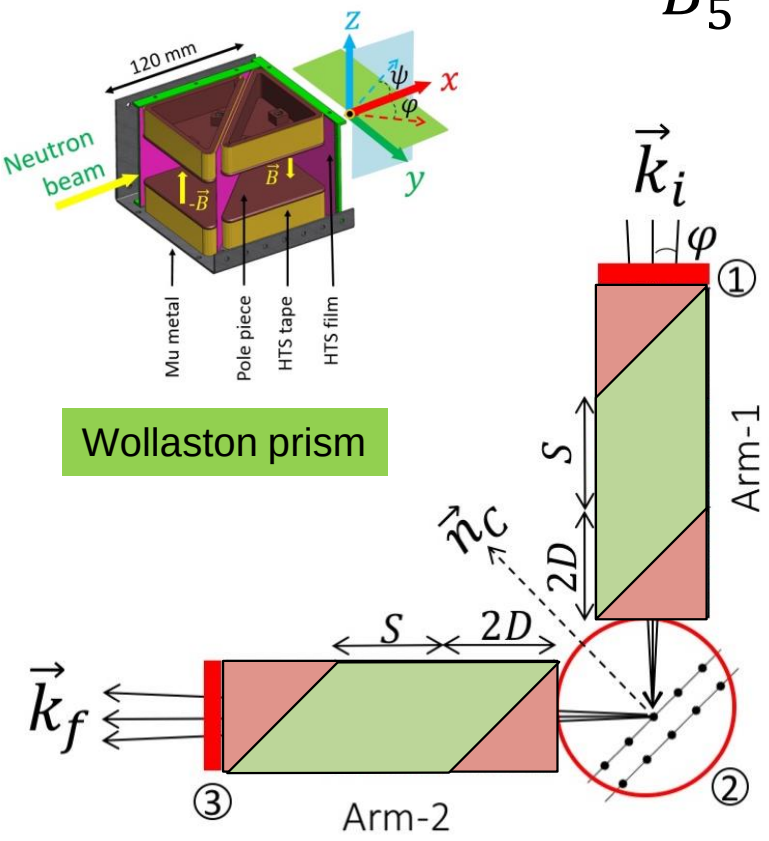
New guides for SANS Instruments

CG-4B for Polarization R&D

# Instrument setup on HB1 to be relocated

$$\theta_B = f(\frac{B_4}{B_5})$$



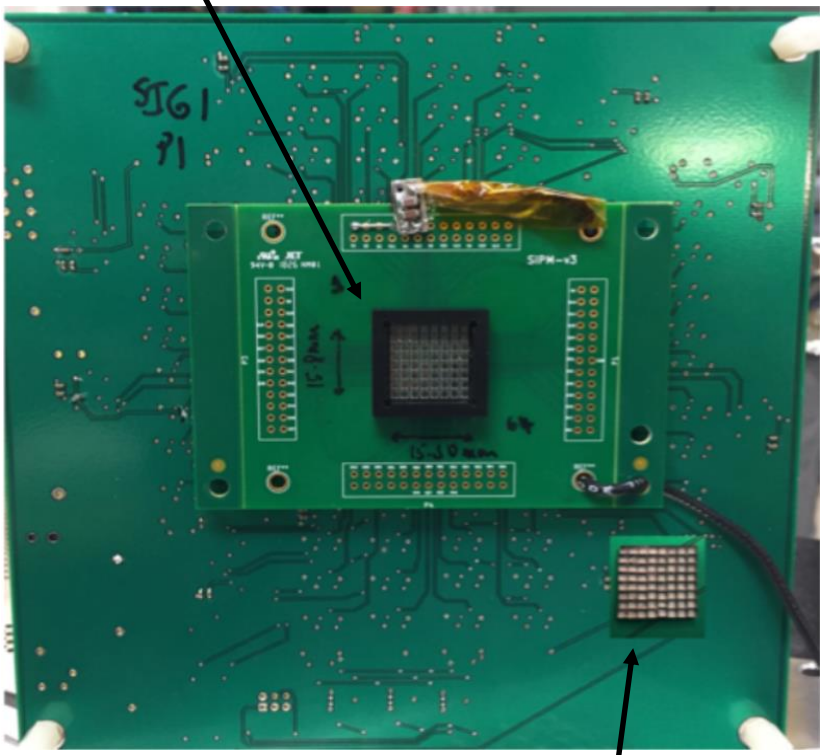

F. Li, J. Appl. Cryst. (2014). 47, 1849–1854

# Detector R&D

- Pixelated detector
- Anger Camera.
- Timepix3/MCP Imaging Detector
- High Speed Image Analysis
- WLSF

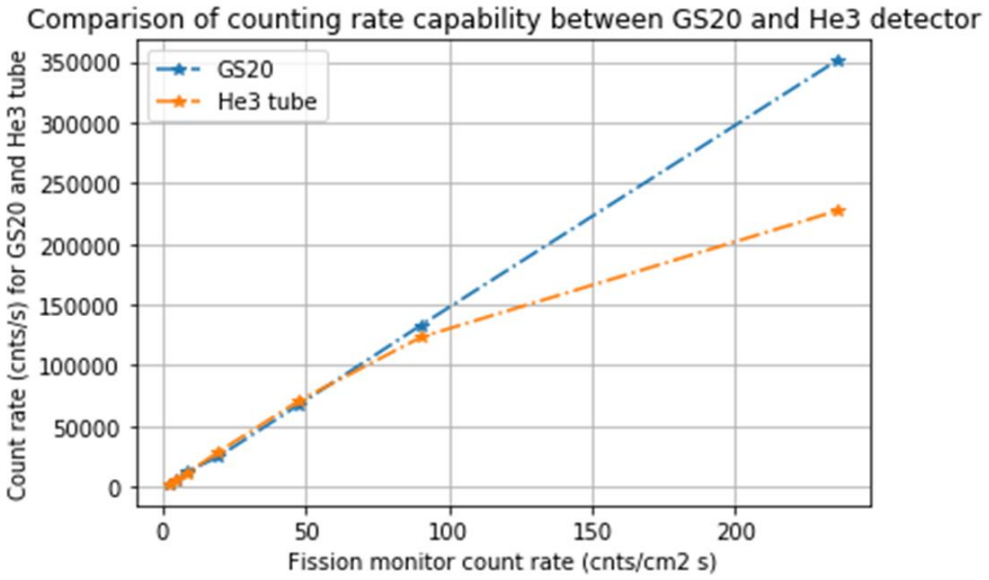
# Pixelated Detector

2mm C.C. SiPM Sensor Array

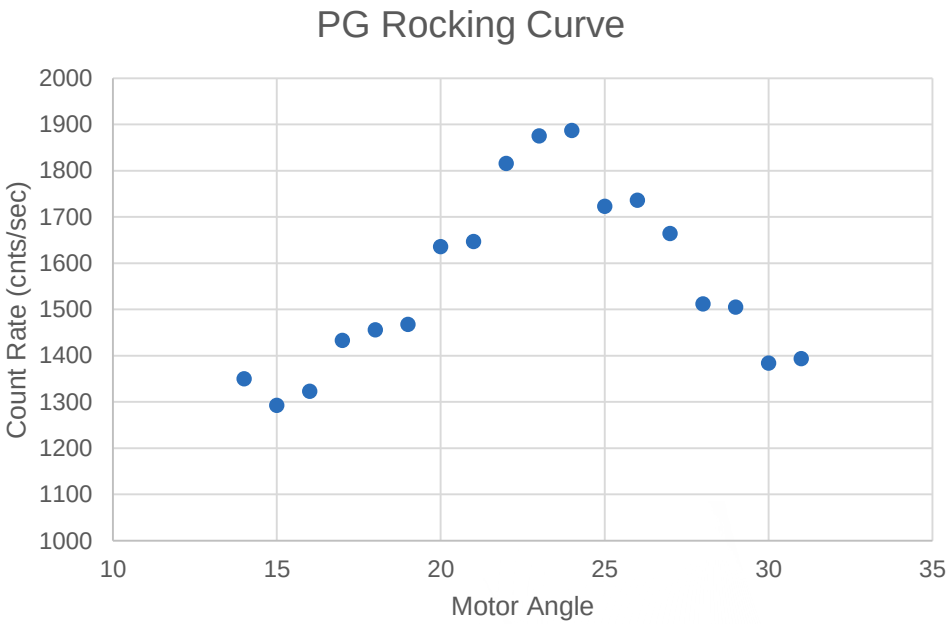


Pixelated GS20 scintillator

Linear to limit of MURR beam flux

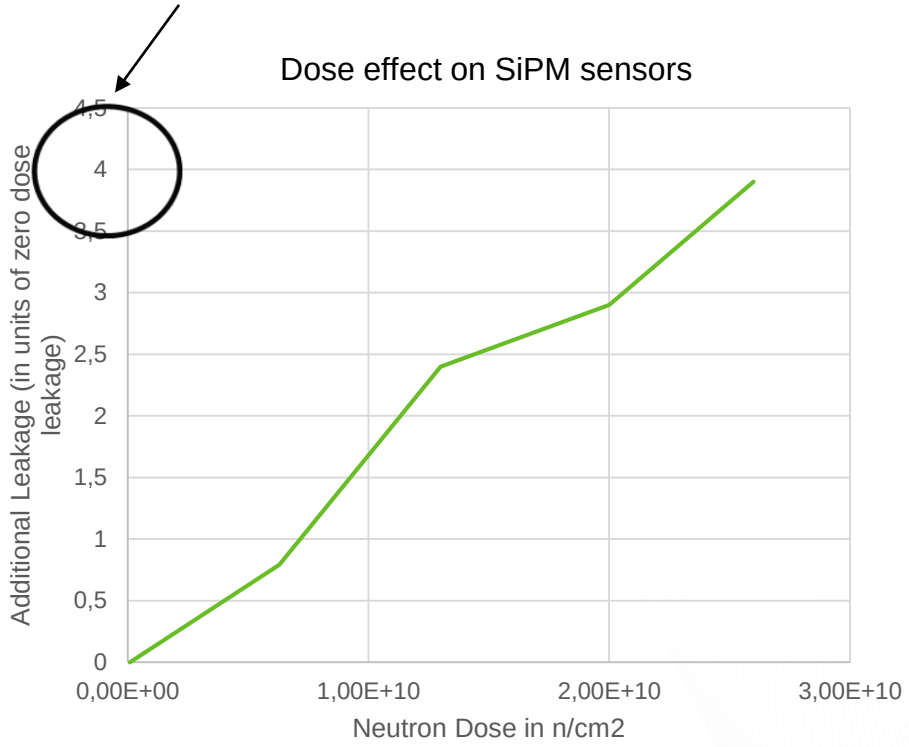


# Anger Camera at Phoenix DD gun facility



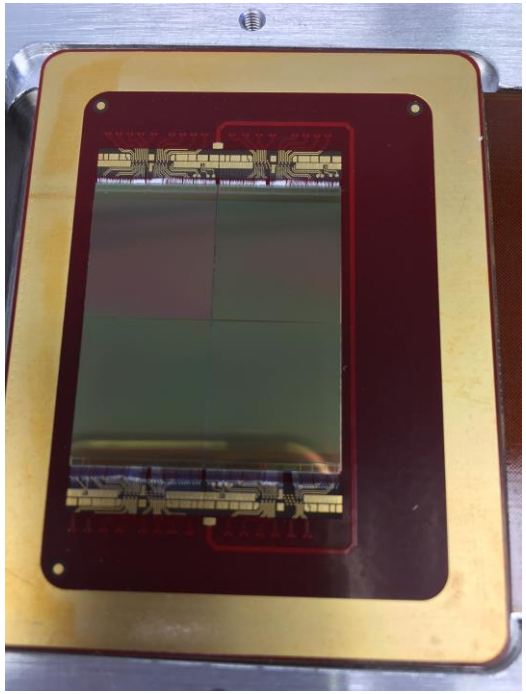
# Exposed to direct beam.

Estimated operating point at Phoenix after exposure



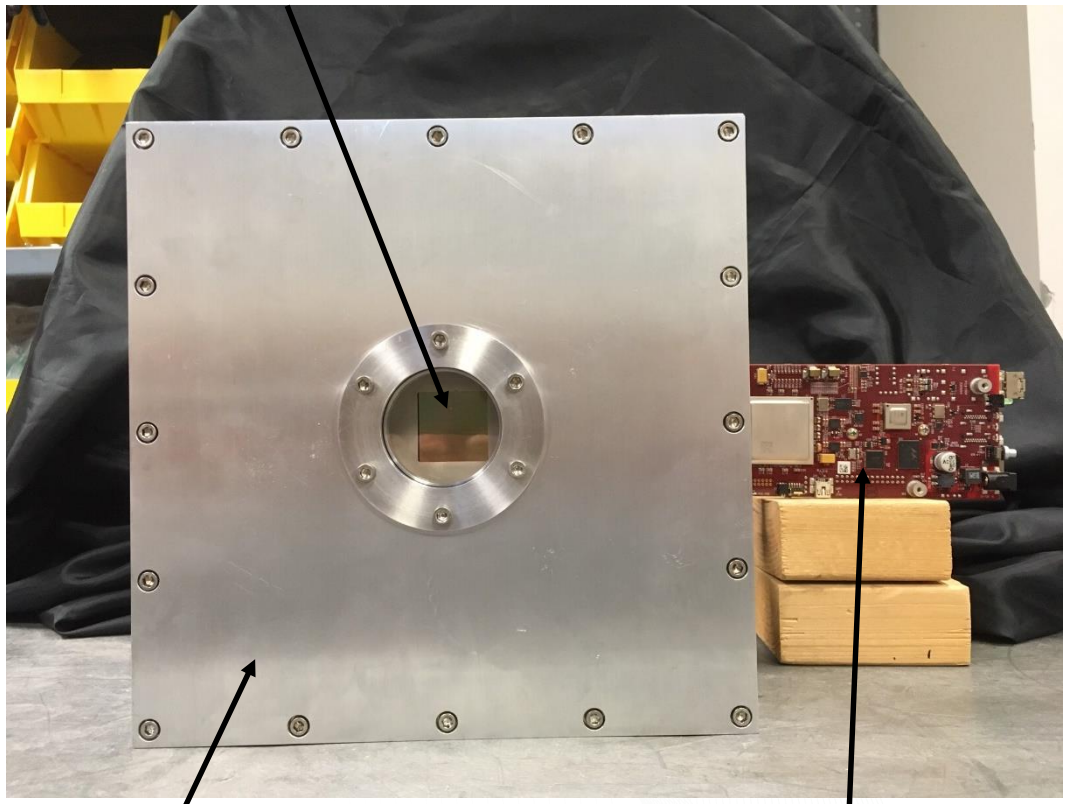

Estimated Phoenix dose
$10^{11}$ to $10^{12}$ n/cm$^2$

# Timepix3-MCP Imaging Detector



2x2 Timepix3 array
(28mm x 28mm)

Control Board and
Timepix3 array purchased
from ASI



# Image Processing: Scintillation Pinpointing

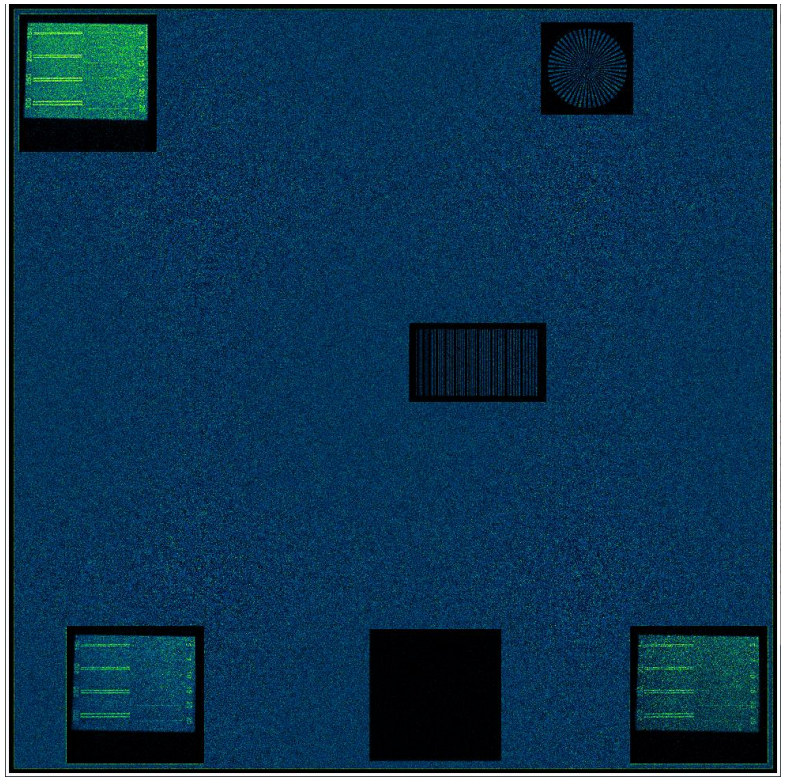
- Goal is Real Time Processing

- Process 1 image on a CPU core:
  - Least-Squares 2D-Gaussian fits = ~ hour
  - Full image filter based on DoG = 12 seconds

- Process 1000 images on 100 CPU cores:
  - Least-Squares 2D-Gaussian fits = ~ 10 hours
  - Full image filter based on DoG = 2 minutes

- Process 1 image on a GPU:
  - Full image filter based on DoG = 0.15 ms

- Process and transfer 1000 images with GPU:
  - Full image filter based on DoG = 3 minutes
  - Much of the transfer time probably can be eliminated



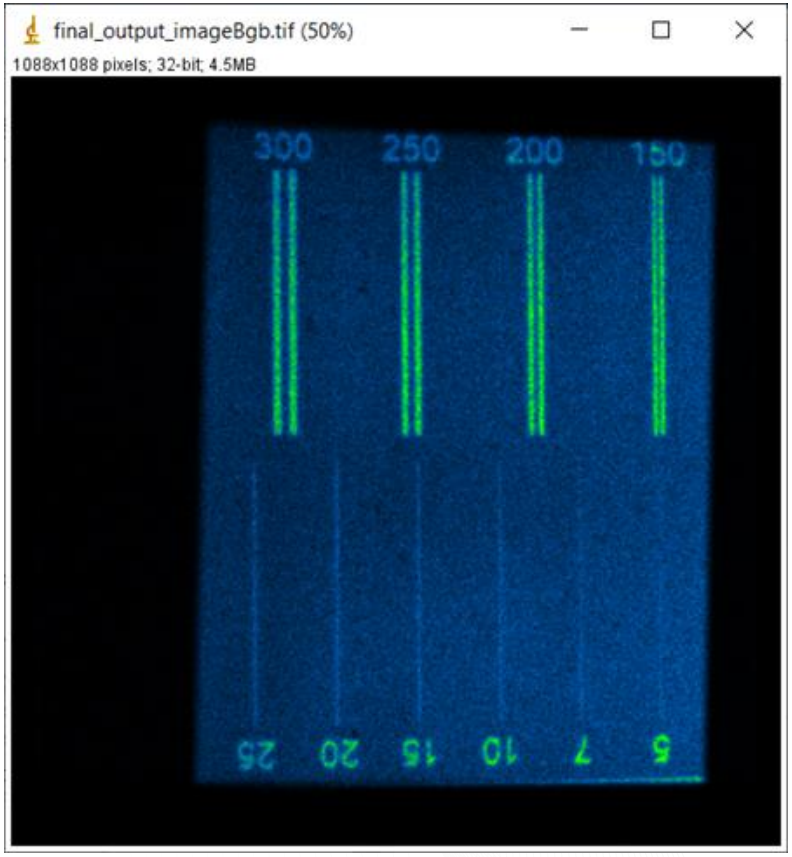
6,000 processed:
33 MPixel output image

# Overall Results:

Events > 20


50% MTF resolution is ~350 microns

Events > 70




50% MTF resolution is ~150 microns

Better Case; higher threshold used.

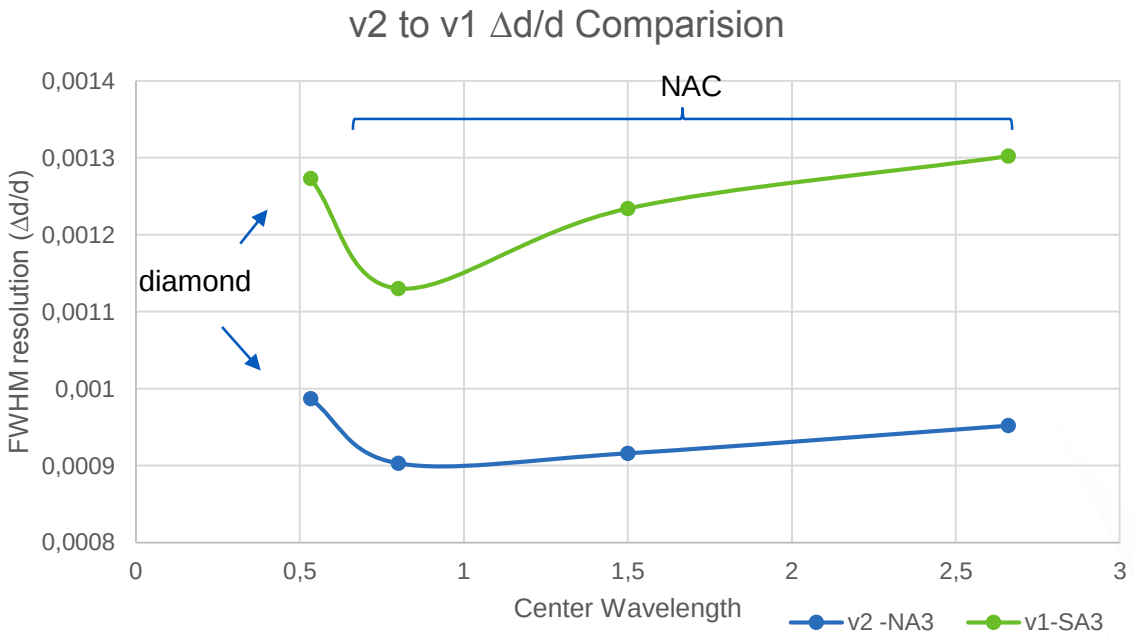
# GEN2 WLSF

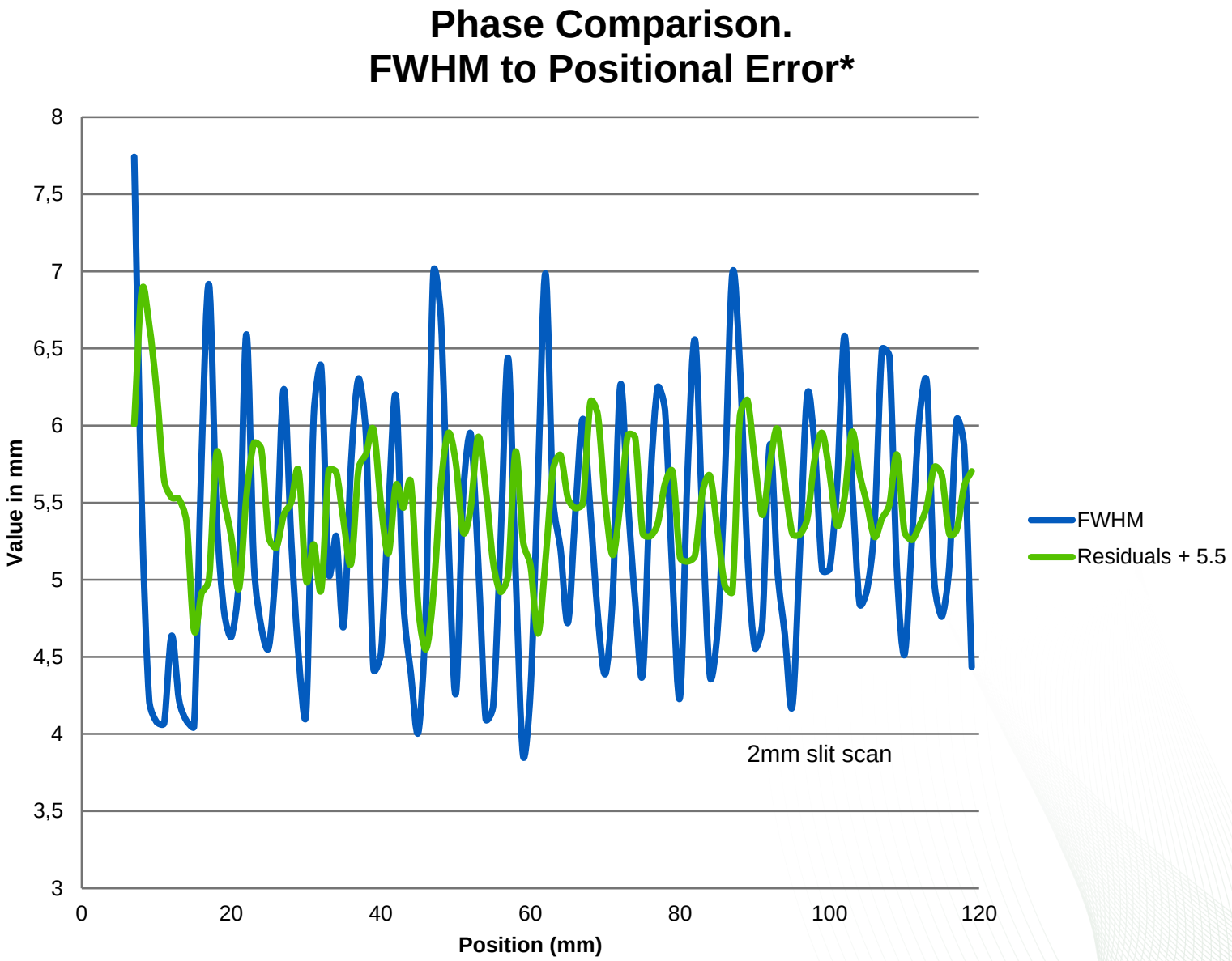
- Improved y-axis resolution. (1cm)
- No encoding
- Double scintillator.
- X-axis interpolation

Scintillator replaces diffuse Alzak

# GEN2 WLSF at Instrument Testing

30% improvement in resolution at backscattering position.






*Single scintillator (Front only)