Multi-Grid Prototype Tests @ ISIS

John Annand
University of Glasgow
Alex Backis, Mo Aouane, Doro Pfeiffer, Roy Andersson, Kevin Fissum
European Spallation Source
Giacomo Mauri, Davide Raspino
ISIS Neutron and Muon Source

Experimental Programme

T-REX Multi-Grid prototypes tested at EMMA beamline of ISIS, May/June 2025

Detectors:

TRP-1 original prototype with 0.5mm Al radial blades, no internal shielding (EMMA-I)

TRP-3 prototype with 1mm Al/B_4C radial blades & 4mm Al/B_4C rear shield (EMMA-III)

6 grids "Alumeco" and 6 grids "In-House" (nominal 25 μm Ni plating on Al/B_4C)

ISIS 10-tube ^{3}He array

TRP = T-REX Prototype

Direct-beam comparisons of TRP-1 and TRP-3.

Fine-beam horizontal scans, perpendicular incidence, white neutron beam, 2 mm Ø

Thereafter quasi-monochromatic beam: $\lambda_n \approx 1.06$ Å, $E_n \approx 72$ meV

10x10 mm beam, perpendicular incidence, @ centre and edge of voxel

10x10 mm beam 5-deg off perpendicular, horizontal scan 2 mm steps

Neutron Scattering comparison TRP-1 and TRP-3

Solid rod of Vanadium 8 mm diameter, 10x20 mm beam, $\lambda_n \approx 1.06$ Å

No shielding, sample IN and OUT (OUT run short of statistics)

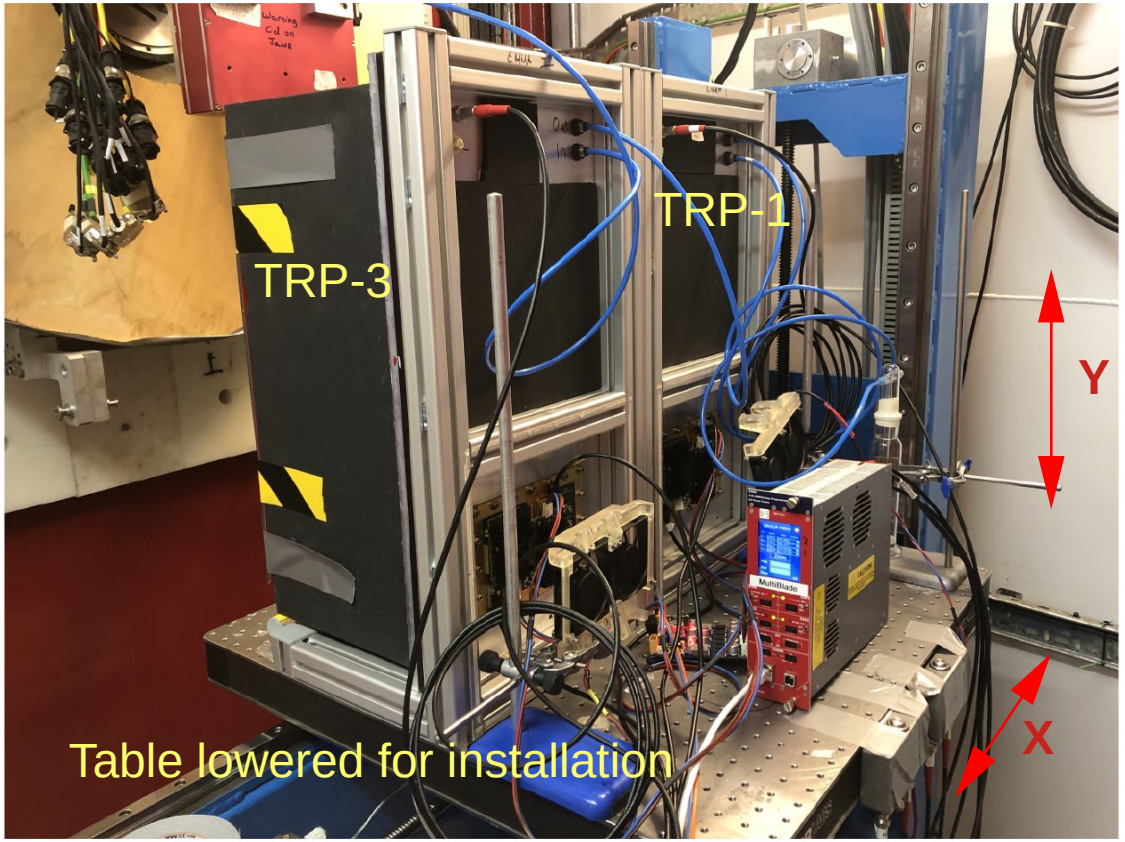
B_4C shielding enclosure, sample IN/OUT/Beam-blocked

Neutron Scattering comparison TRP-3 and ^{3}He Array

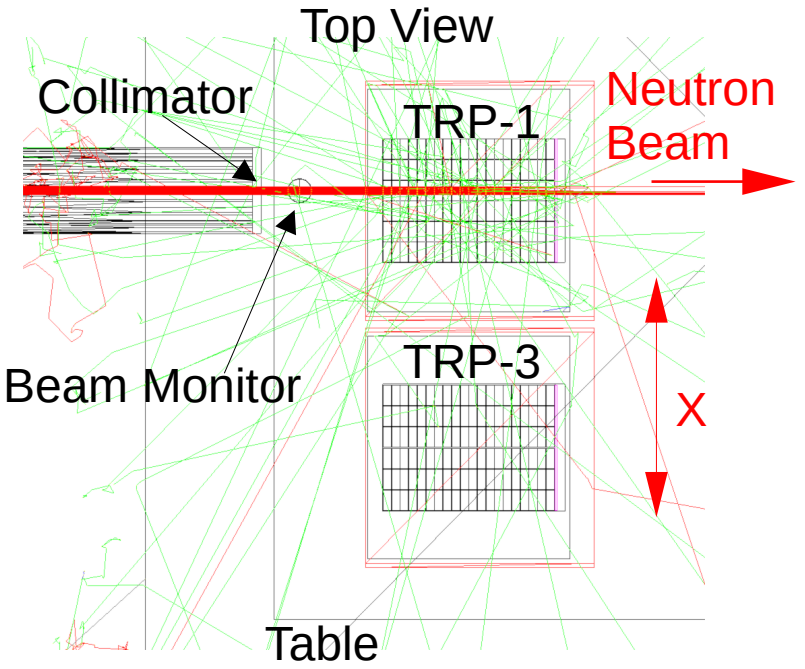
2 mm V sheet, 1.5 mm PMMA, 10 mm B_4C beam stop, 30x30 mm beam, $\lambda_n \approx 1.06$ Å,

Additional Cd shielding tube around neutron beam.

Direct Beam Setup



TRP-1 and TRP-3 installed on X-Y translation table



Horizontal beam scans: 2 mm Ø pinhole collimator placed after moveable slits

Otherwise B_4C slits set for 10x10 mm beam

Normal (w.r.t. front window) neutron incidence and 5 deg. off normal incidence

Geant4 Model

EMMA "cave" and shielding

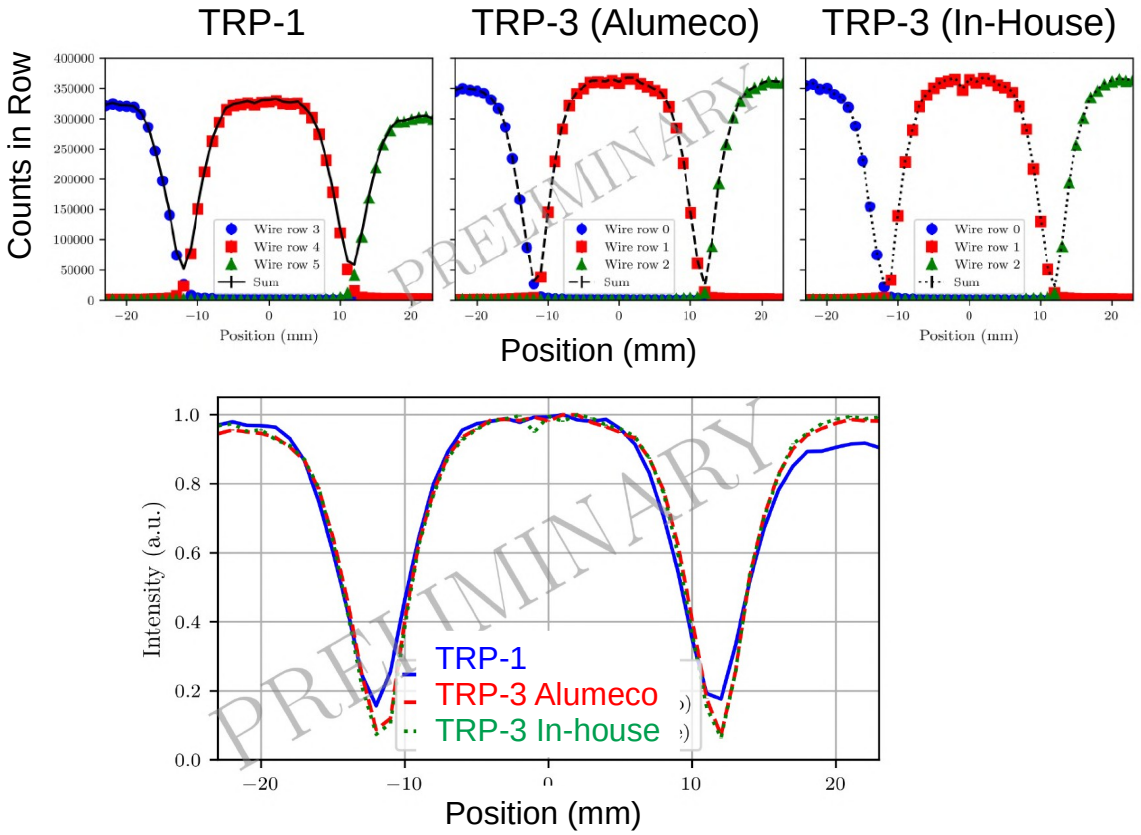
More materials described by NCrystal (e.g. B_4C)

EMMA beam halo and resultant background not modelled

Alpha background not included

Horizontal Position Scans (Preliminary)

June 2025 Scan of TRP-1 and TRP-3



Perpendicular neutron incidence, white beam

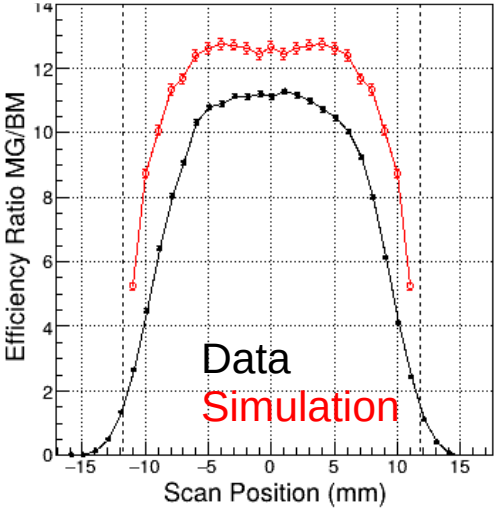
B_4C pinhole collimator 2 mm diameter

Small difference TRP-1, TRP-3 at radial blade due to blade thickness and ^{10}B absorption

No significant difference Alumeco and In-House grids

Results very similar to 2024 TRP-1 scan

November 2024 Scan TRP-1 in prep. for publication Signal readout by VMM3A

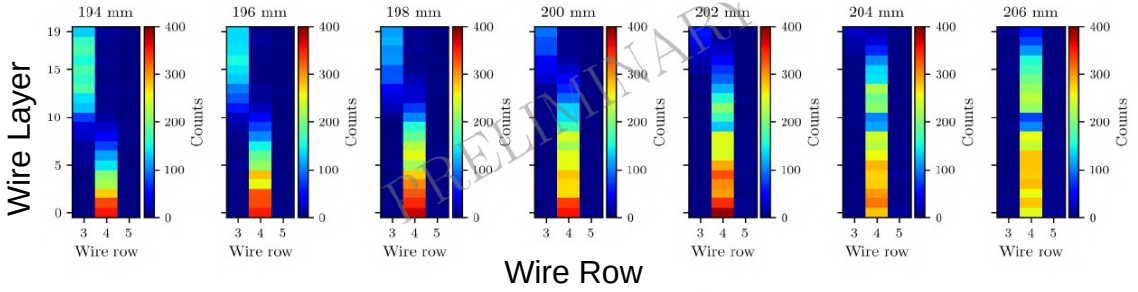


Efficiency ratio: integrated counts in front 6 voxels of the illuminated wire row divided by beam monitor counts.

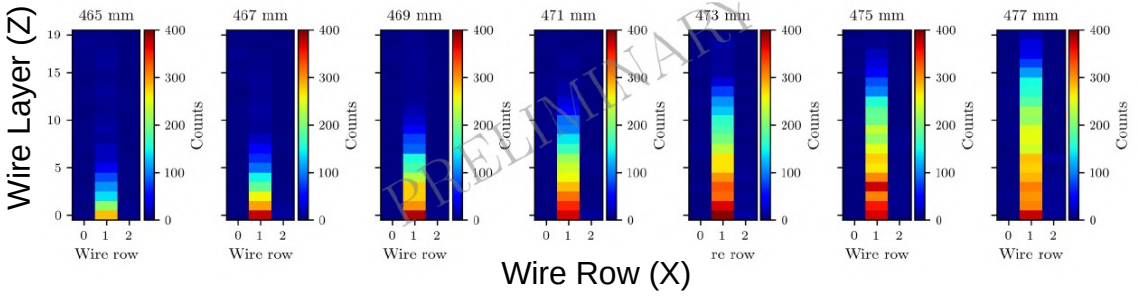
Simulation: Geant4 + Garfield++. Systematic uncertainty in calculation ~11%

Direct Beam, 5-degree Incidence (Preliminary)

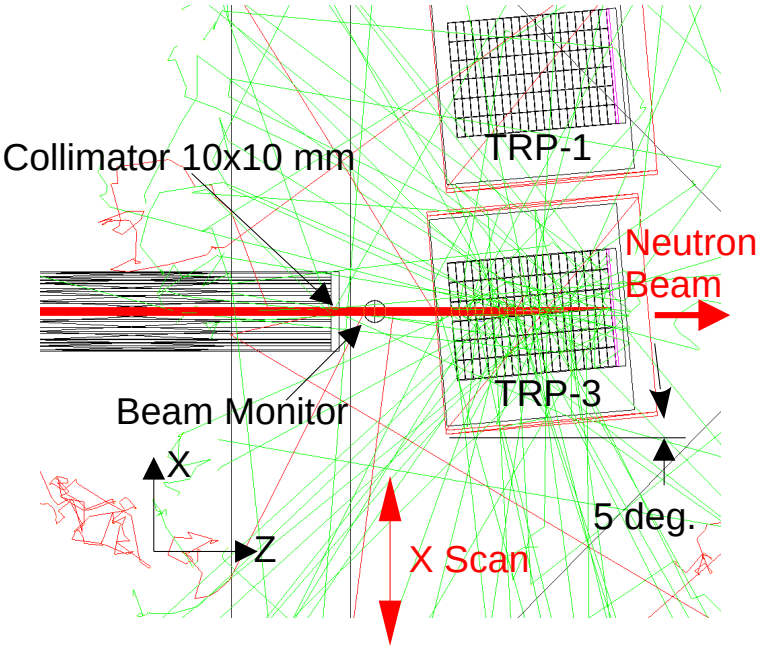
TRP-1 Scan across voxel



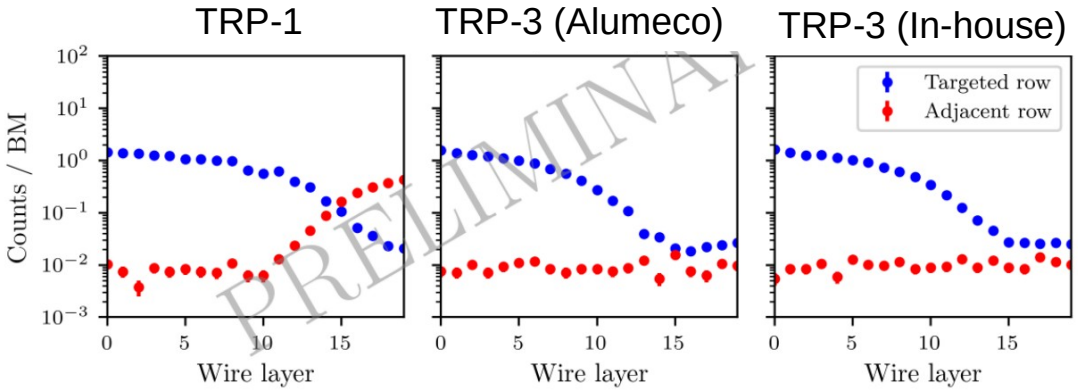
TRP-3 scan across voxel



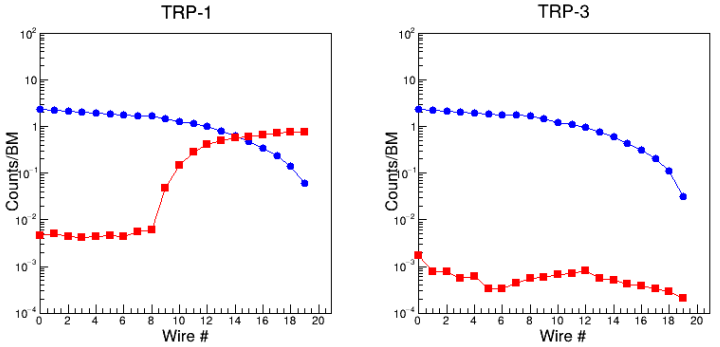
Top View: G4 Model of Setup



Measurement

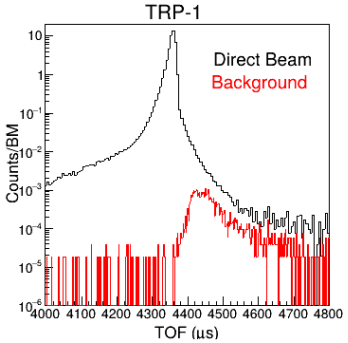


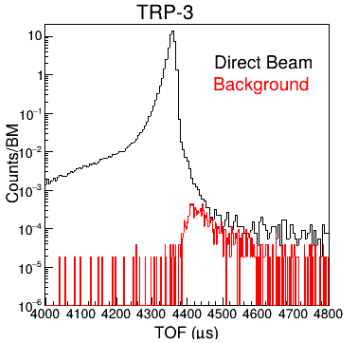
Simulation

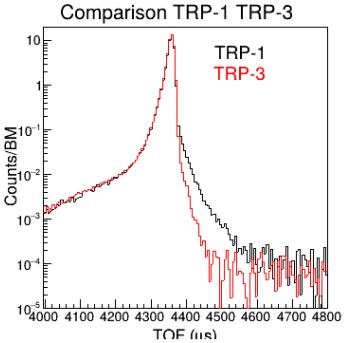


No Garfield++ correction
No background in simulation

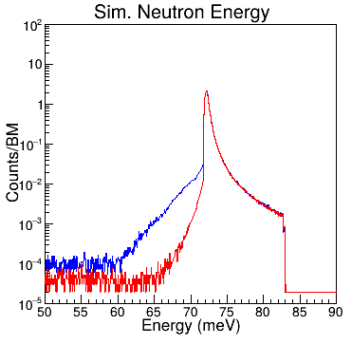
Direct Beam Neutron TOF & Energy (Preliminary)

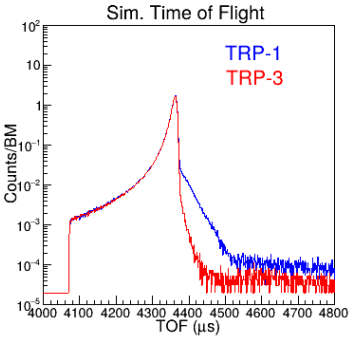






Background measured with beam blocked





Data taken at centre of voxel (voxel edge data very similar)

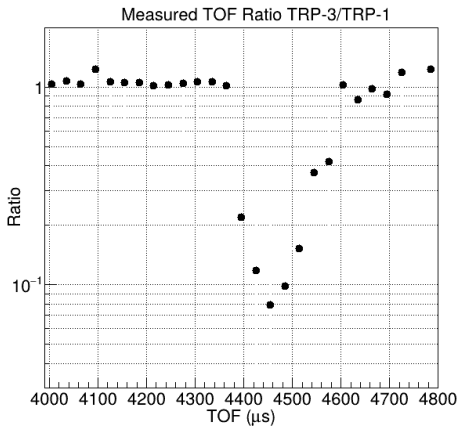
TOF distributions corrected for voxel-dependent flight path

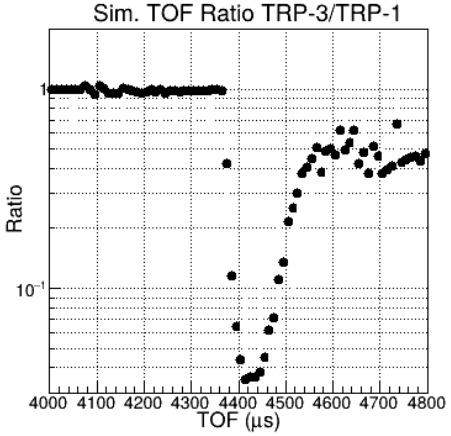
Ratio TRP-3/TRP-1 (effect of Al/B_4C radial blades) shows shoulder reduction factor vs TOF and energy

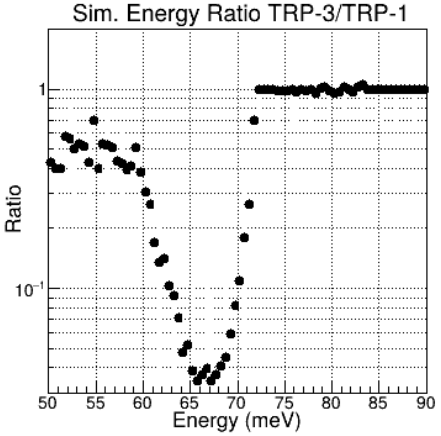
G4 model slightly overpredicts reduction factor

Model does not include beam-halo background.

Ratio TRP-3/TRP-1

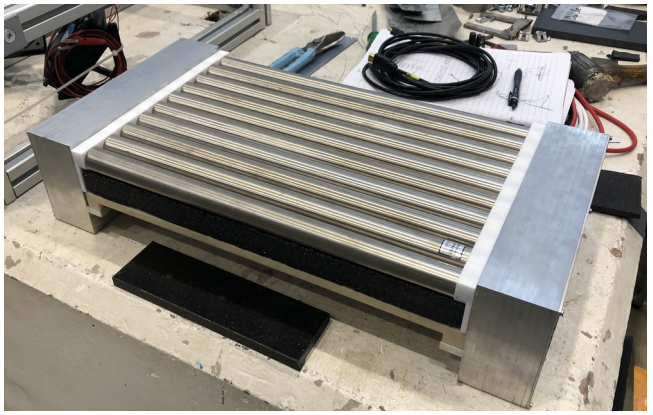




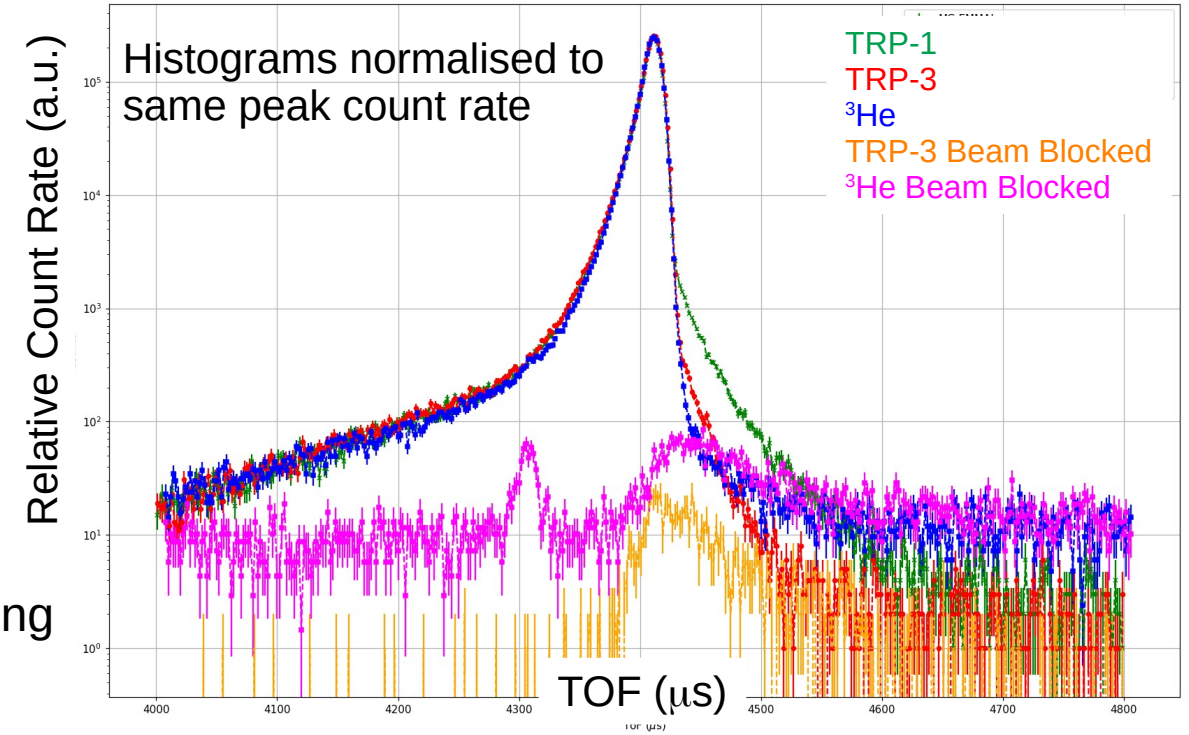


Direct-Beam Comparison TRP and ^{3}He (Preliminary)

ISIS ^{3}He Array



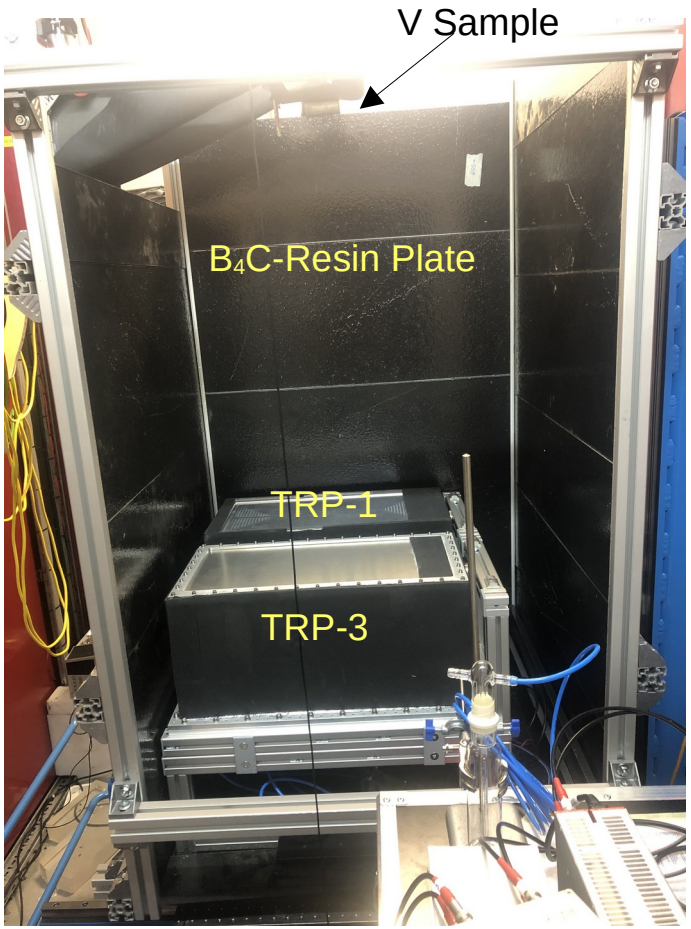
TOF Profile Comparison

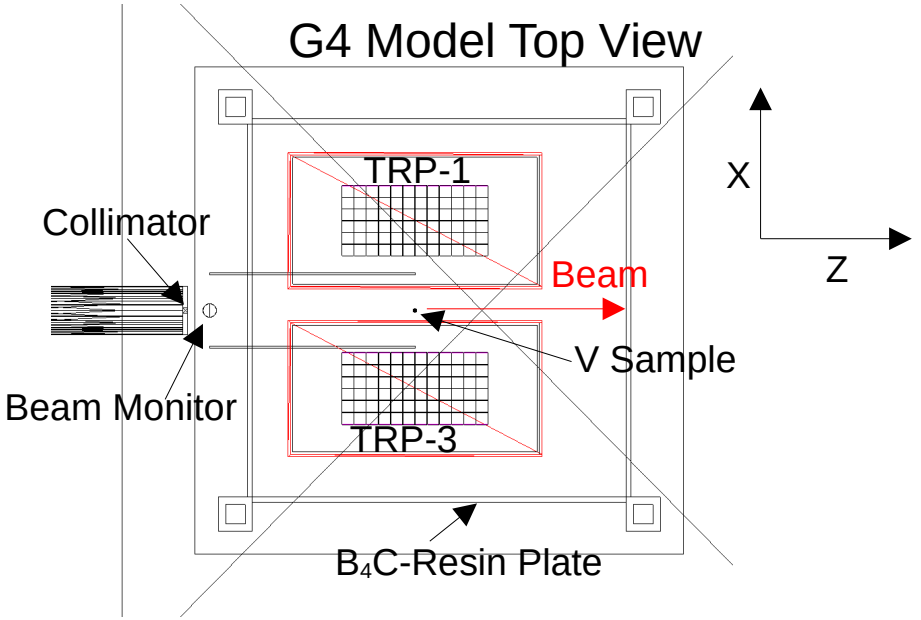


10 ^{3}He Tubes 25.4 mm Ø, 380 mm long
Filled with 10 bar ^{3}He, 3 bar Ar

2 mm Ø beam incident on ^{3}He tube
10 x 10 mm beam incident on TRP-3,TRP-1
(factor ≈ 32 higher neutron intensity)
^{3}He detectors masked by B_4C sheet apart from central 20 mm slit

Vanadium Scattering Shielding-1 Setup



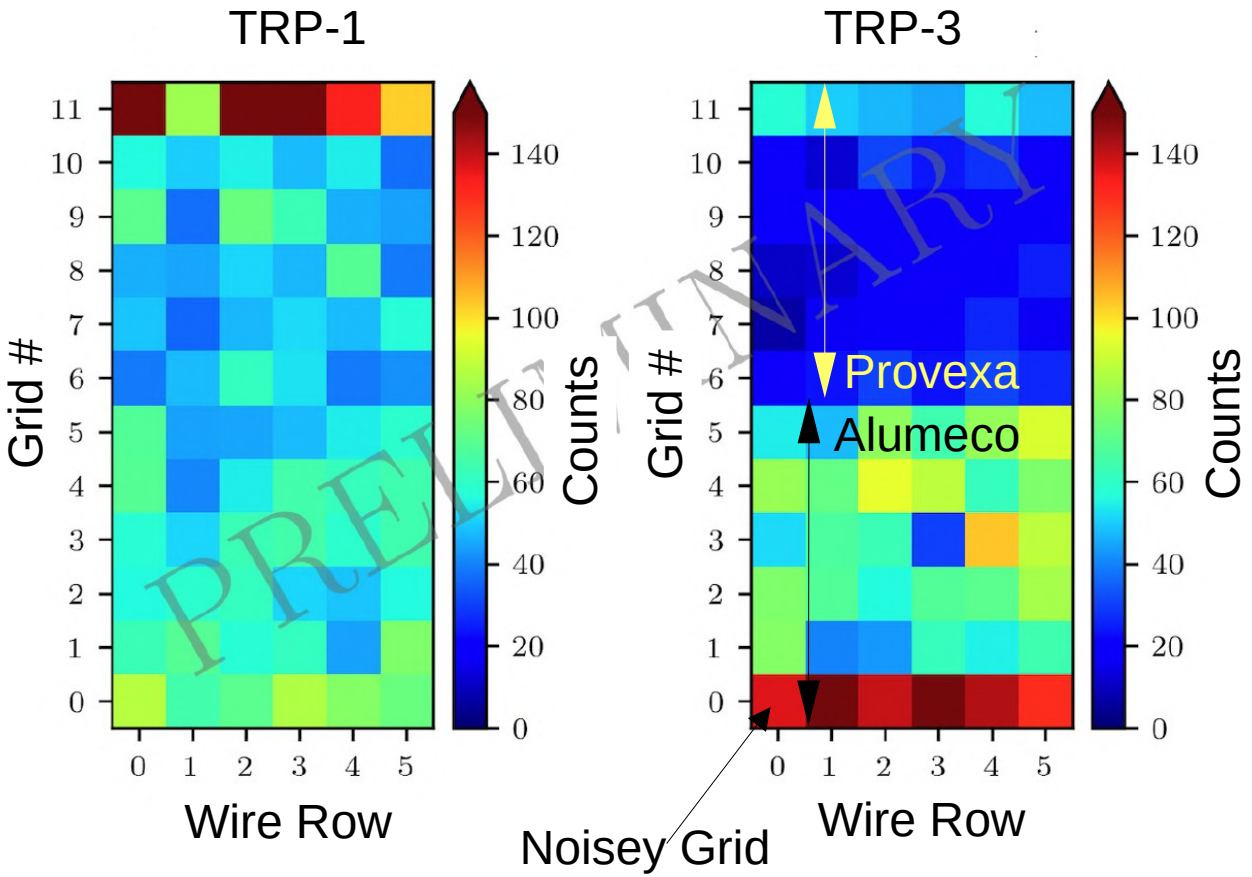


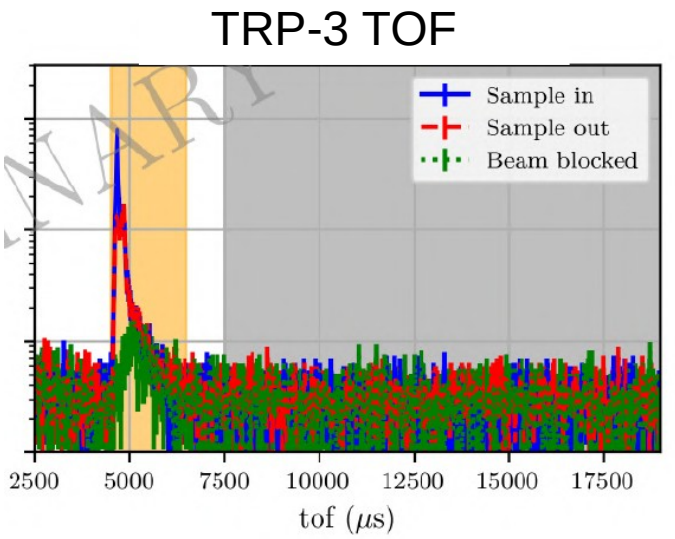
Significant halo around EMMA beam
EMMA beam after moderator sees 16 m of air.
Region around beam line has weak shielding

Sample: V cylinder, 8 mm Ø
Slits: 10x20 mm beam size
B4C-Resin shielding enclosure around MG detectors.
Both detectors have Mirrobor sheet glued to outer vessel...probably partially obscures effect of internal TRP-3 shielding

V Scattering Uncorrelated Background (Preliminary)

Actinide impurities in Al produce α background. Al in Al/B_4C is not radio pure





Alumeco Al/B_4C grids have similar background to radio-pure Al TRP-1

Provexa-plated grids have lower background

Provexa Ni plating possibly thicker & more uniform than Alumeco (both specified as ~25 μm)

Select long flight times ……. 7500 < TOF < 19000 μs, no visible structure. Compare TRP-1, TRP-3

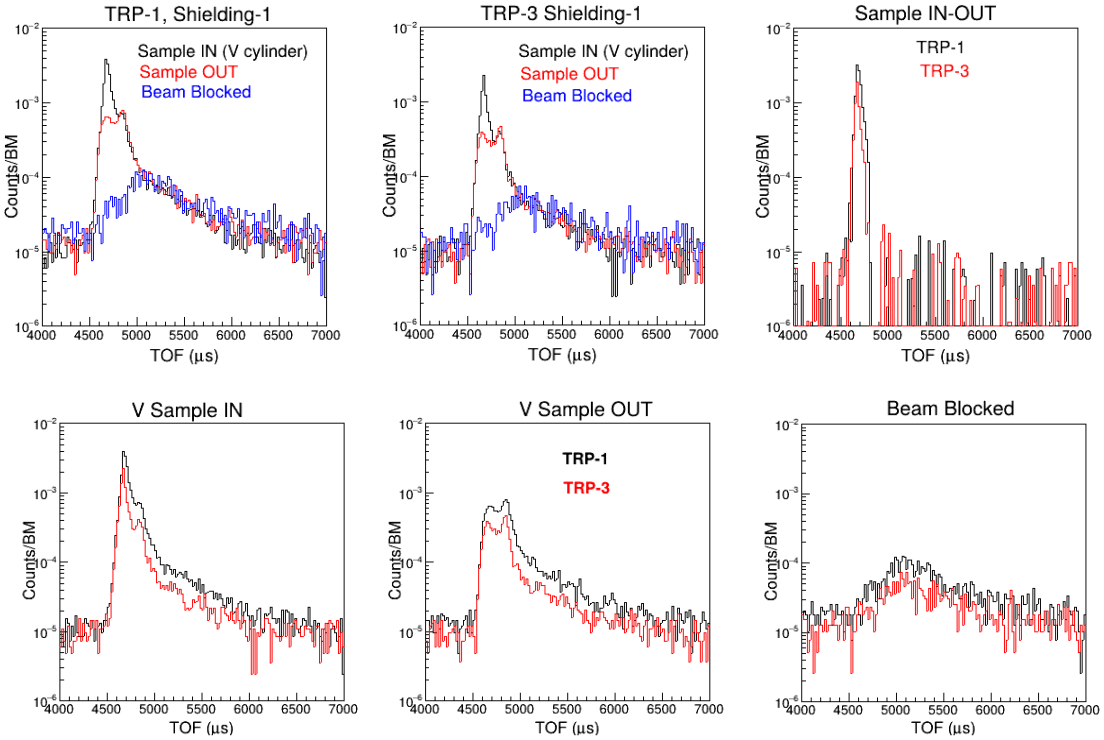
TRP-3 grids 0-5 Ni plated and assembled by Alumeco

TRP-3 grids 6-11 Ni plated by Provexa and assembled at ESS

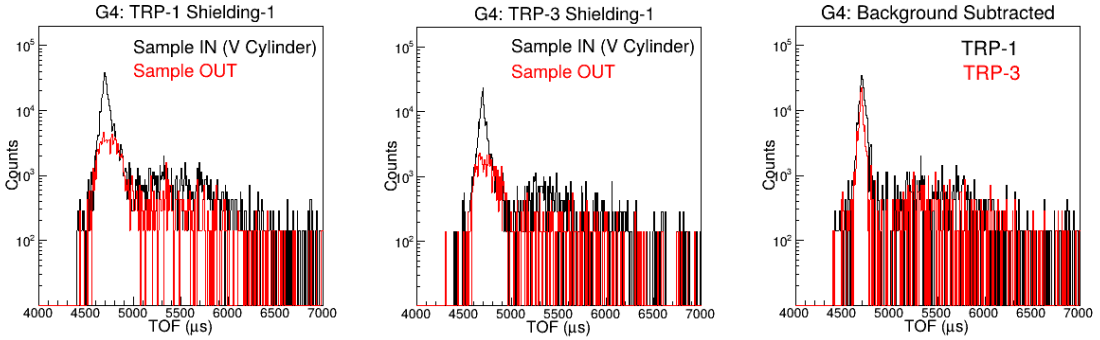
TRP-1 grids all radio-pure Al 0.5 mm thick

MG TOF Comparison, Shielding-1 (Preliminary)

Measurement

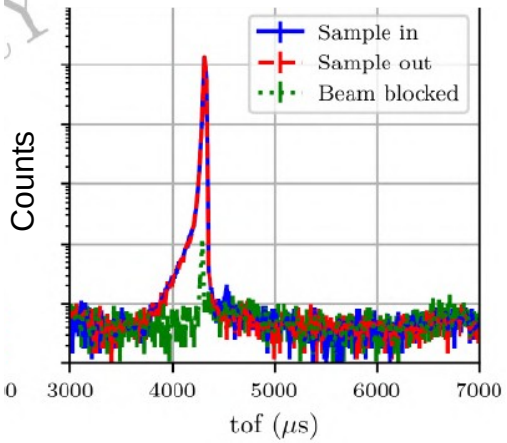


Simulation

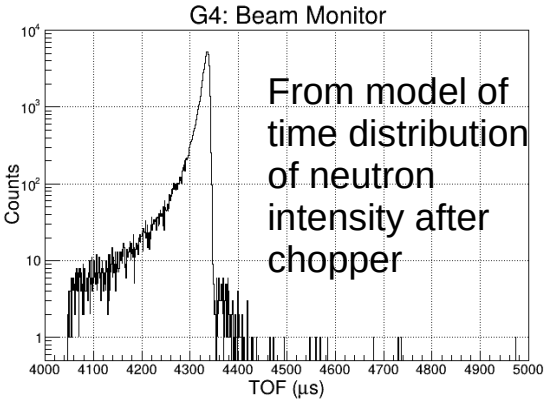


No beam-blocked simulation: beam halo calculation would need spec. of EMMA beam line

Measured Beam Monitor 0.25mm GS1 Li-Glass



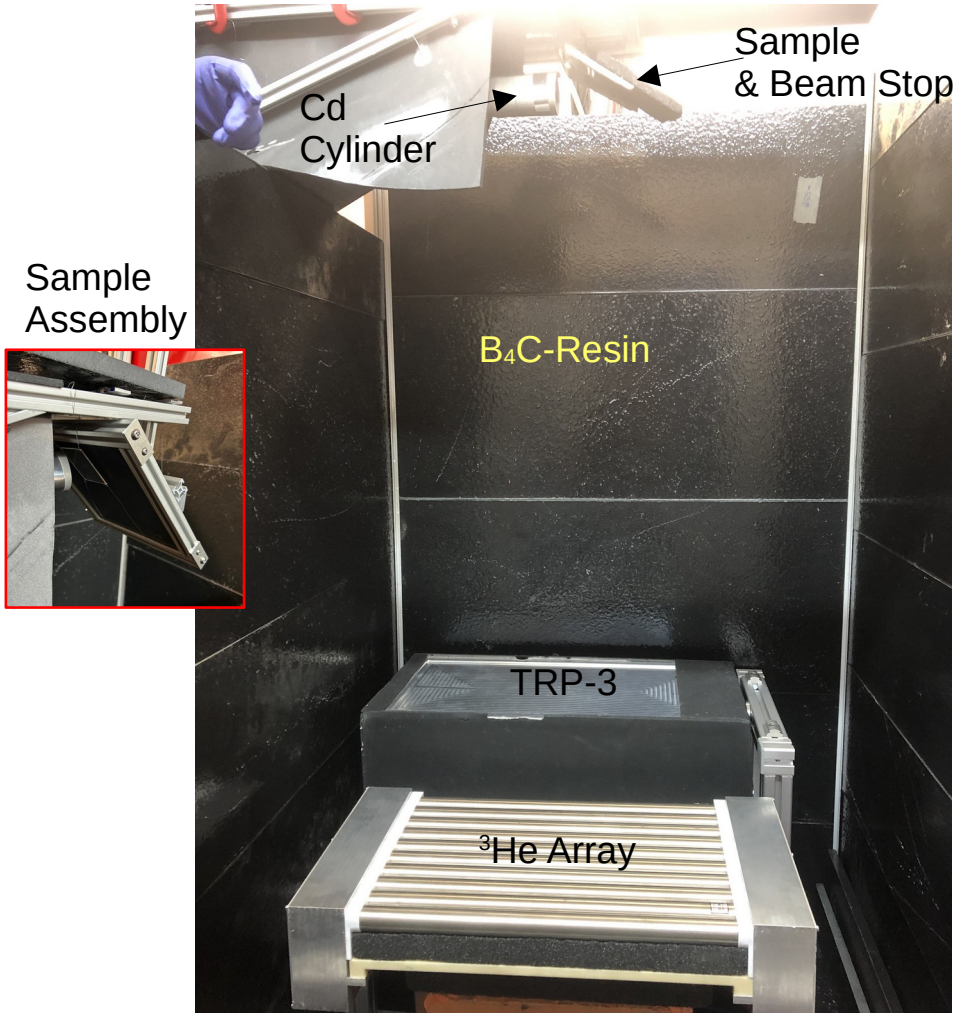
Simulated Beam Monitor

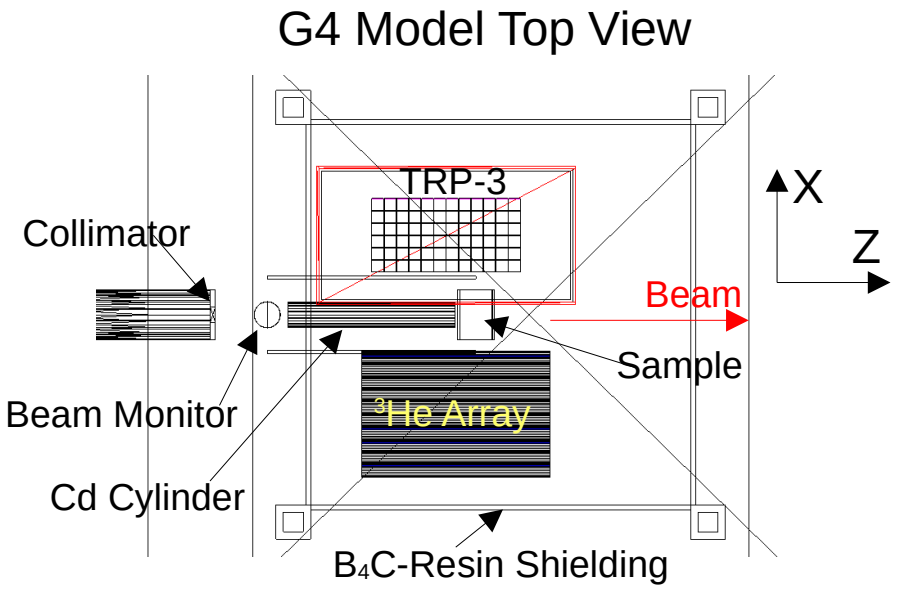


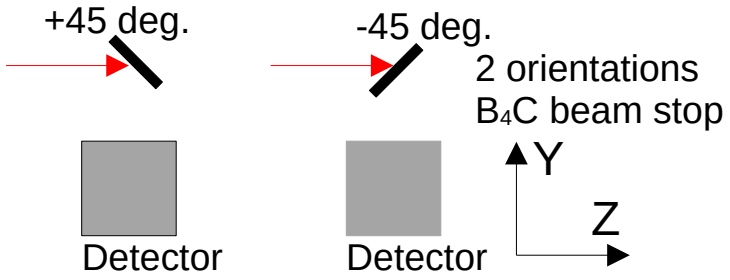
From model of time distribution of neutron intensity after chopper

V sample IN 24 hr
Sample OUT 24 hr
Beam blocked 19 hr
(B_4C tile over collimator)

Comparison TRP-3 and ^{3}He Array







Cylinder of Cd installed around neutron beam

Sample sheets: 2.0 mm V + 1.5mm PMMA + 10.0mm B_4C +45 deg. (beam stop)

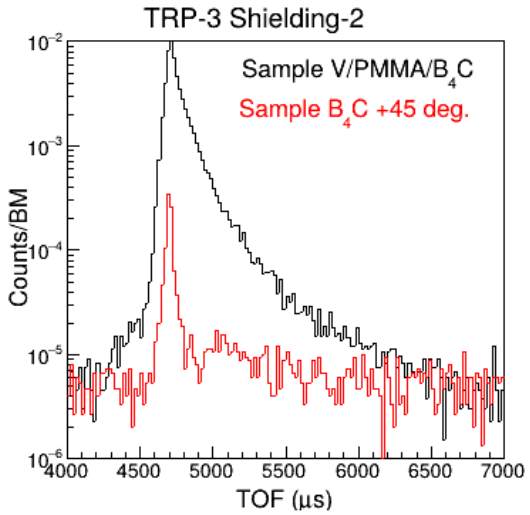
1.5 mm PMMA + 10.0 mm B_4C +45 deg.

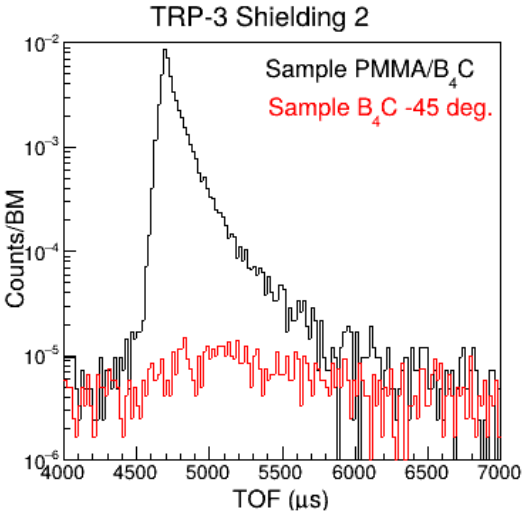
10.0 mm B_4C +45 deg

10.0 mm B_4C -45 deg.

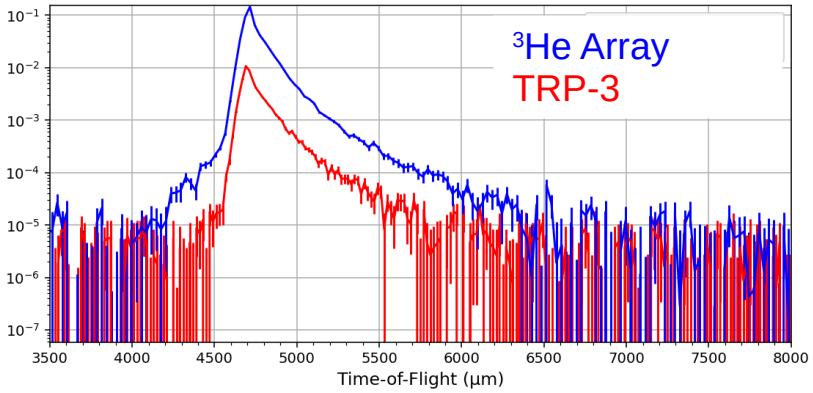
MG TRP-3 and ^{3}He TOF Comparison (Preliminary)

Measurement

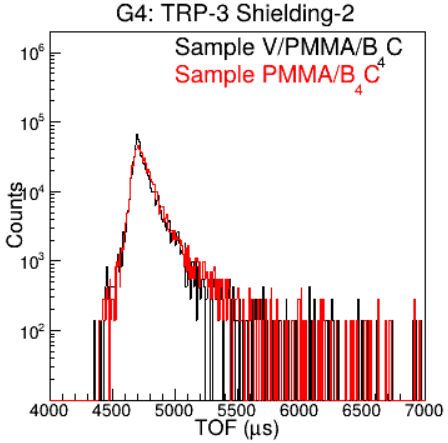


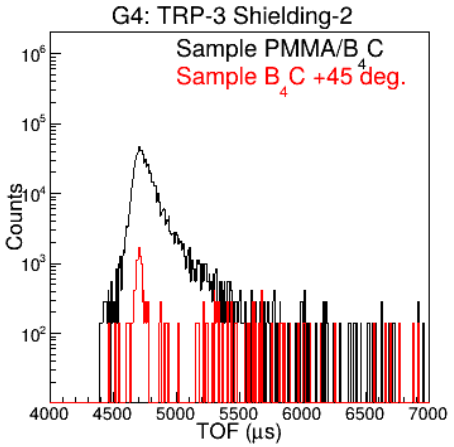


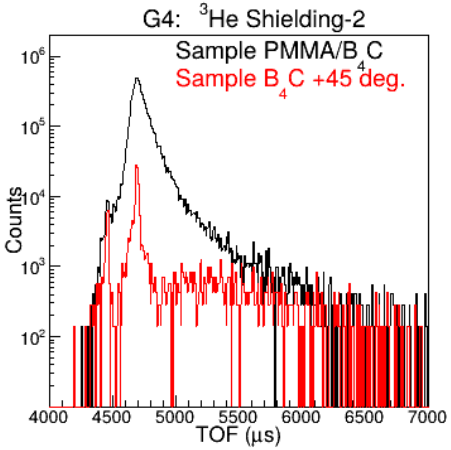
Measurement

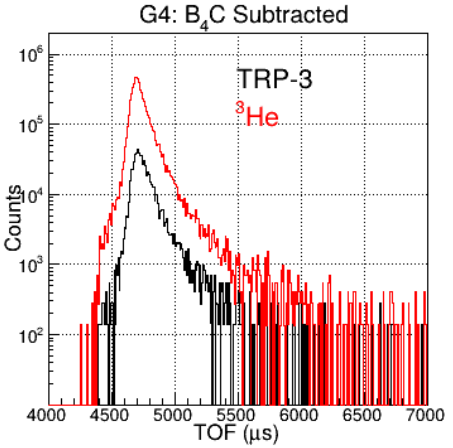


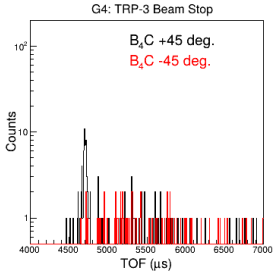
Simulation

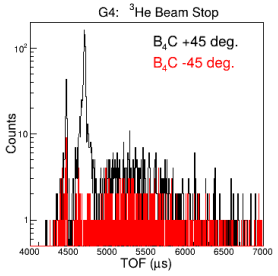












PMMA scattering dominates TOF spectra

V elastic shoulder obscured... comparison not possible

^{3}He count rate factor ~10 higher than TRP-3

Elastic peak from B_4C visible

Summary

T-REX prototypes TRP-1 and TRP-3 tested at EMMA test beam line of ISIS

Fine-beam position scan: no significant difference between TRP-1 and TRP-3

Direct-beam illumination at ~1Å: factor ~10 reduced “shoulder” in TOF distribution for TRP-3 compared to TRP-1

Direct-beam at 5 deg. Incidence: Al/B_4C radial blades effective at stopping neutrons traversing laterally across TRP-3. Al radial blades of TRP-1 transparent to lateral neutrons.

TRP-1, TRP-3 compared in scattering from V sample. Considerable structured background in TOF spectra. EMMA beam has significant halo extending beyond collimated area. Elastic-peak shoulder differences obscured. TRP-3 counts less sample-out and beam-blocked background than TRP-1

TRP-3 and ISIS ^{3}He array compared in scattering from 2mm sheet V sample, with 1.5 mm PMMA sheet and 5 mm B_4C beam stop added to sample stack. PMMA TOF distribution obscures V signal. ^{3}He factor ~10 higher counting rate. ^{3}He has twice the solid angle and no perpendicular-focusing as in TRP-3.

Small elastic-scattering signal from B_4C beam stop observed

Geant4 model of test reproduces differences of TRP-1 and TRP-3 and differences of TRP-3 and ^{3}He. Simulated scattered-neutron TOF distributions show main features of measurements, but EMMA beam halo effects not modelled.

Test will be written up for publication **after further analysis**

Thanks for your attention

Backups