

MultiGrid detectors for T-REX at ESS

Ken Livingston, University of Glasgow Sept 2027

What is MultiGrid

The concept of MultiGrid

T-REX at ESS

T-REX spectrometer instrument
European Spallation Source

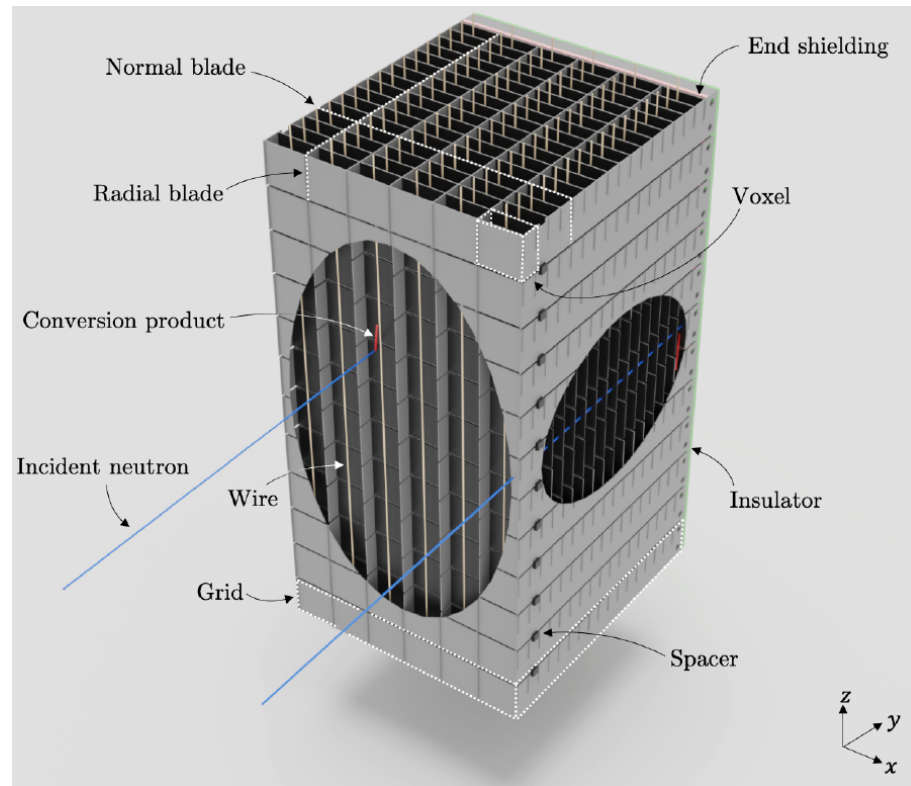
Design of MultiGrid for T-REX

From prototype to full scale detector

Construction of MultiGrid for T-REX

In progress: current status

Summary and Outlook

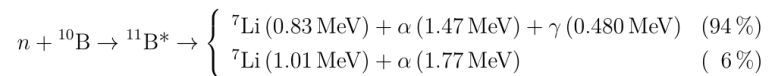


MultiGrid detectors for T-REX at ESS

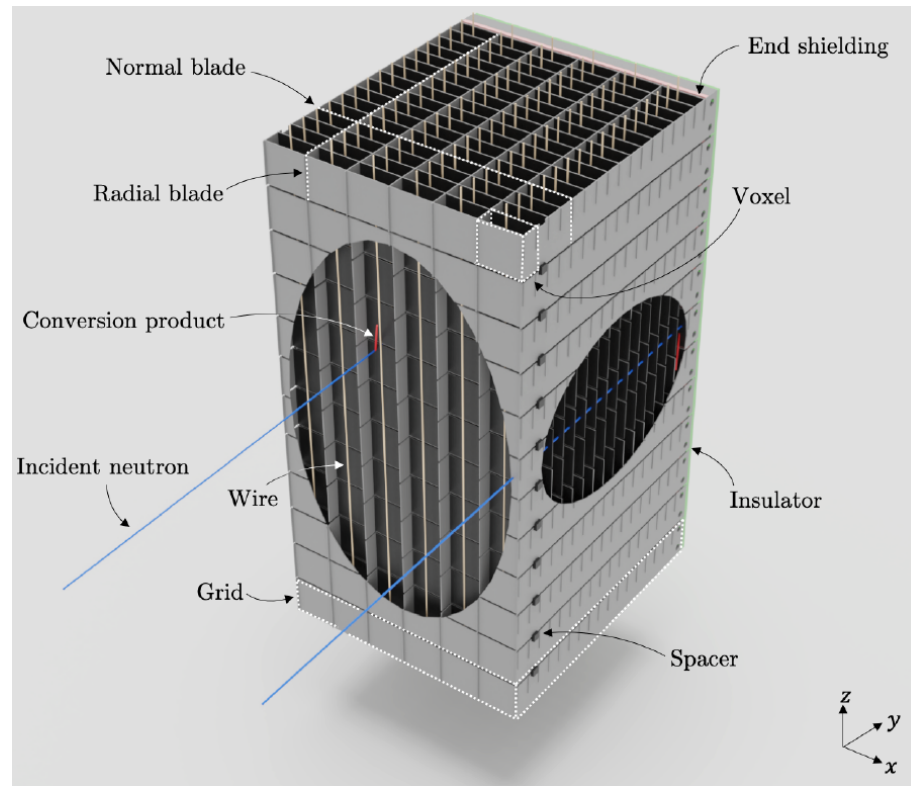
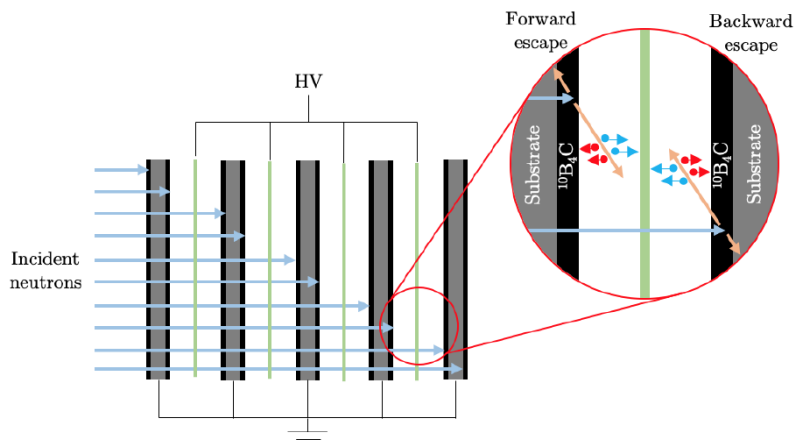
What is MultiGrid

The concept of MultiGrid

Neutron capture on ^{10}B decay to ^7Li and ^4He



Detect charge particles in a segmented detector to get time (ToF) and position information.

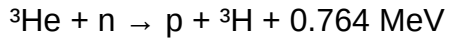


MultiGrid detectors for T-REX at ESS

Why MultiGrid ?

As an alternative to ^3He tubes (the standard)

Neutron capture on ^3He decay to proton + tritium:

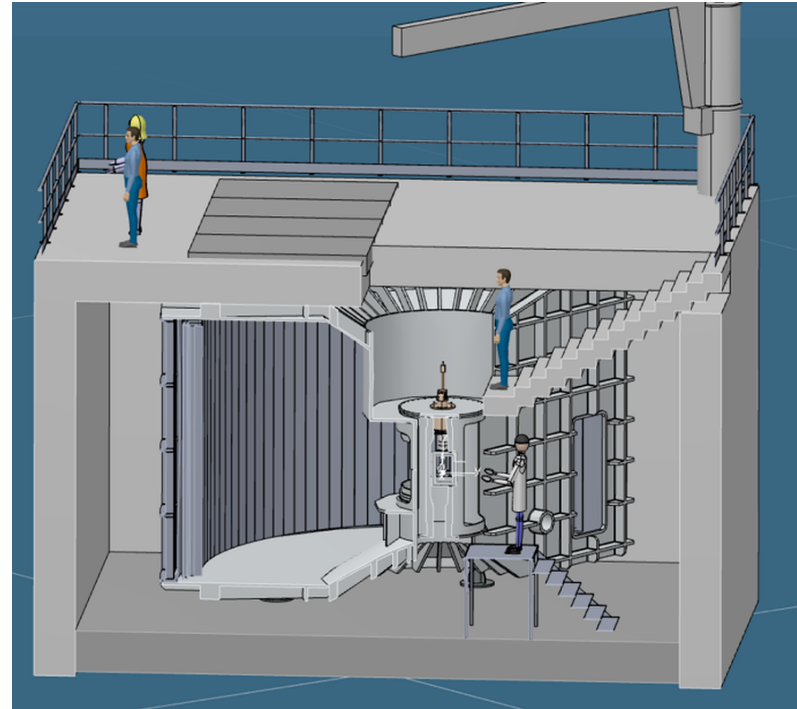


^3He	prohibitively expensive
^3He Tubes	rate limited

MultiGrid designs proposed and prototyped over 10 years ago
(eg M. Anastasopoulos et al 2017 JINST 12 P04030)

MultiGrid at T-REX, ESS

will be the first full scale detector.



CSPEC at ESS with ~4m array of ^3He Tubes

T-REX at ESS

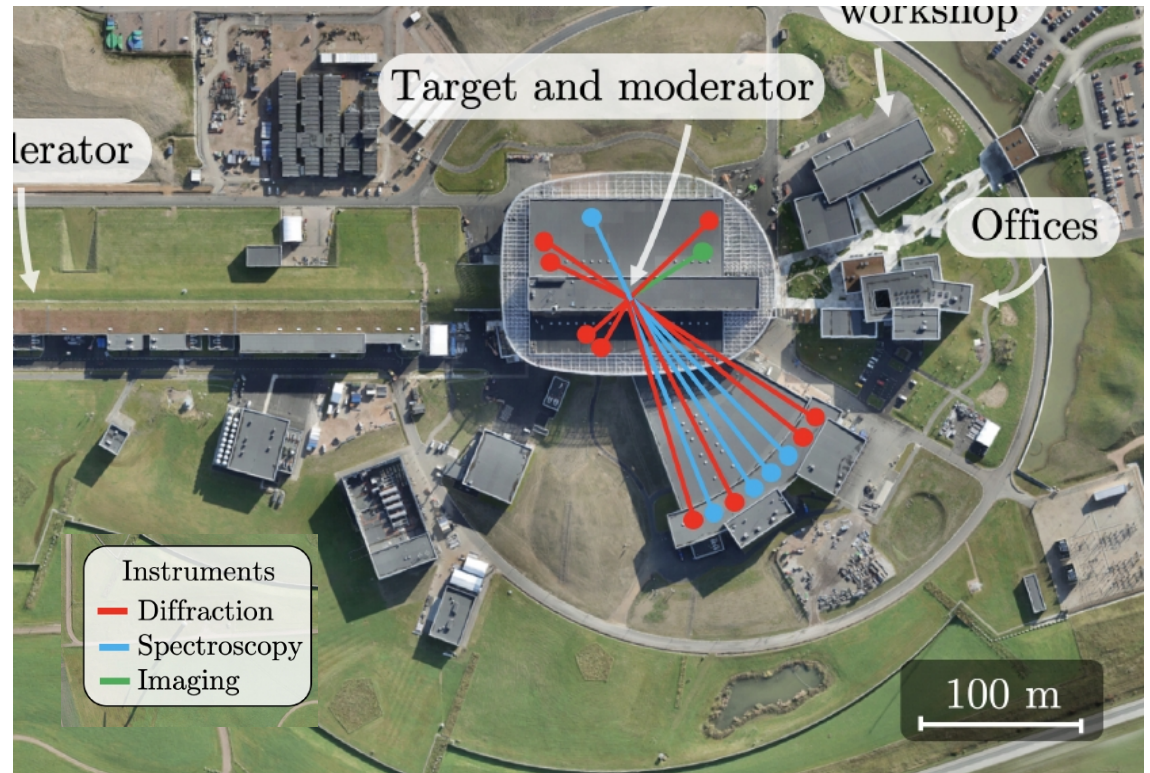
European Spallation Source (ESS) Lund, Sweden

To be world's most intense neutron beam
 $\sim 10^{14}$ neutron/cm²/s/sr/Å at 5 Å

2 GeV proton LINAC → Tungsten target

Multiple instruments:

Diffraction
Spectroscopy
Imaging



T-REX at ESS

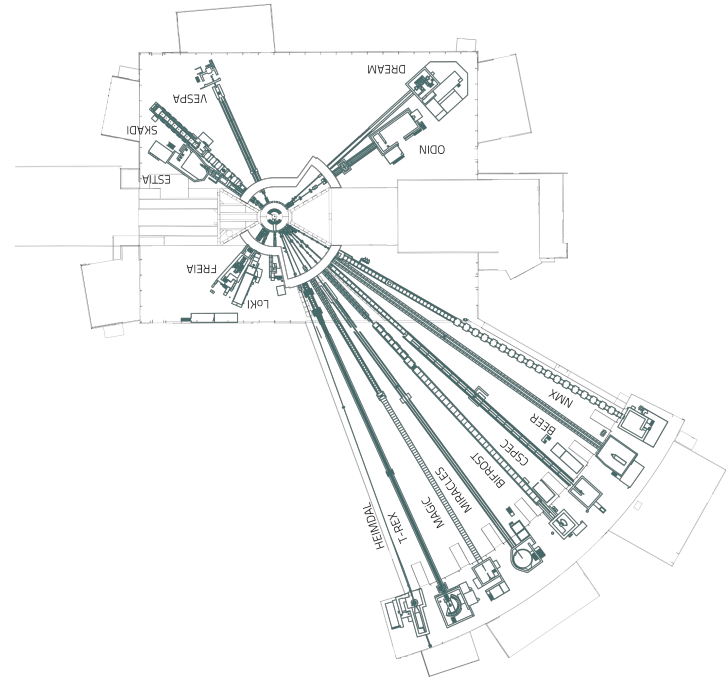
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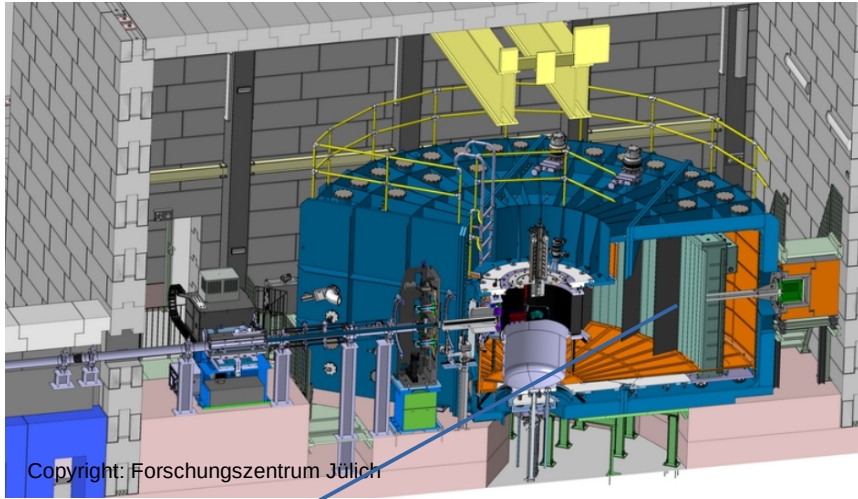
Diffraction
Spectroscopy
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T-REX at ESS

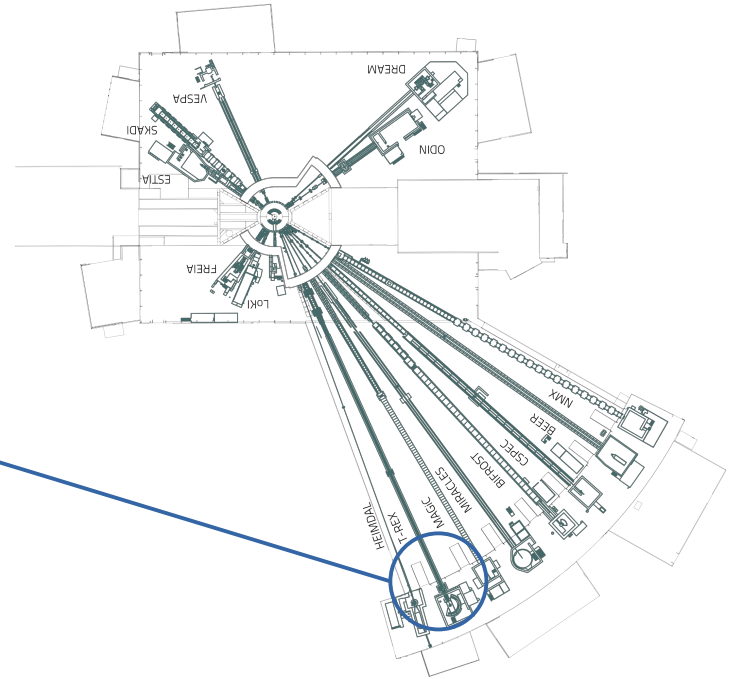
Time-of-flight Reciprocal space Explorer (T-REX)

<https://www.fz-juelich.de/en/jcms/divisions/departments/instruments-for-ess/instruments/t-rex>



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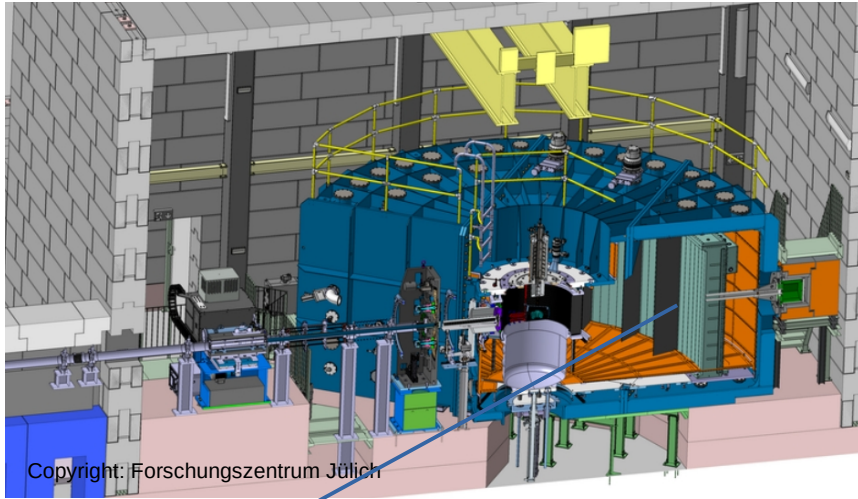
Wall of MultiGrids 2.2m high, at distance of 3m from target
Covering 2sr.



T-REX at ESS

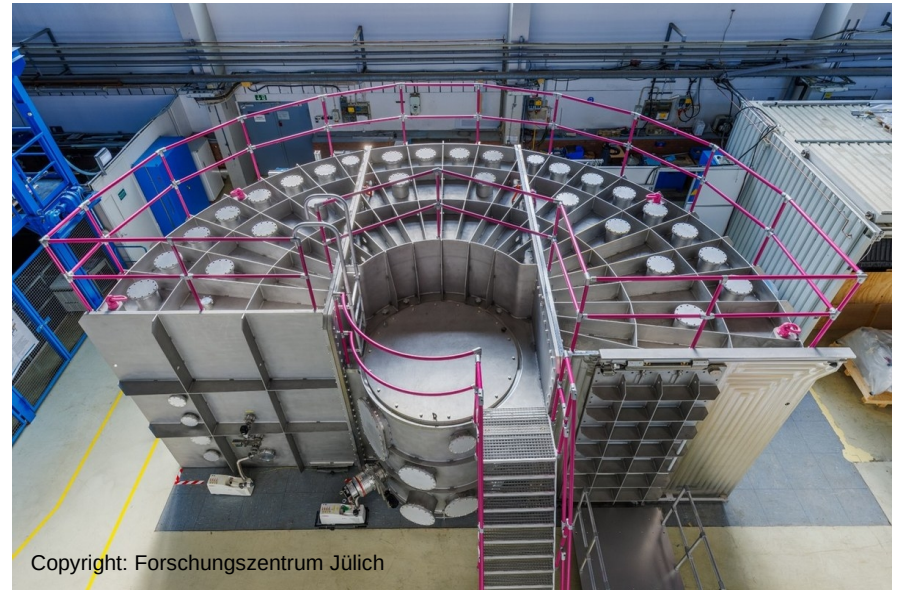
Time-of-flight Reciprocal space Explorer (T-REX)

<https://www.fz-juelich.de/en/jcns/divisions/departments/instruments-for-ess/instruments/t-rex>



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Wall of MultiGrids 2.2m high at distance of 3m from target
Covering 2sr.



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T-REX detector vessel arrived in June 2024 at Forschungszentrum Jülich

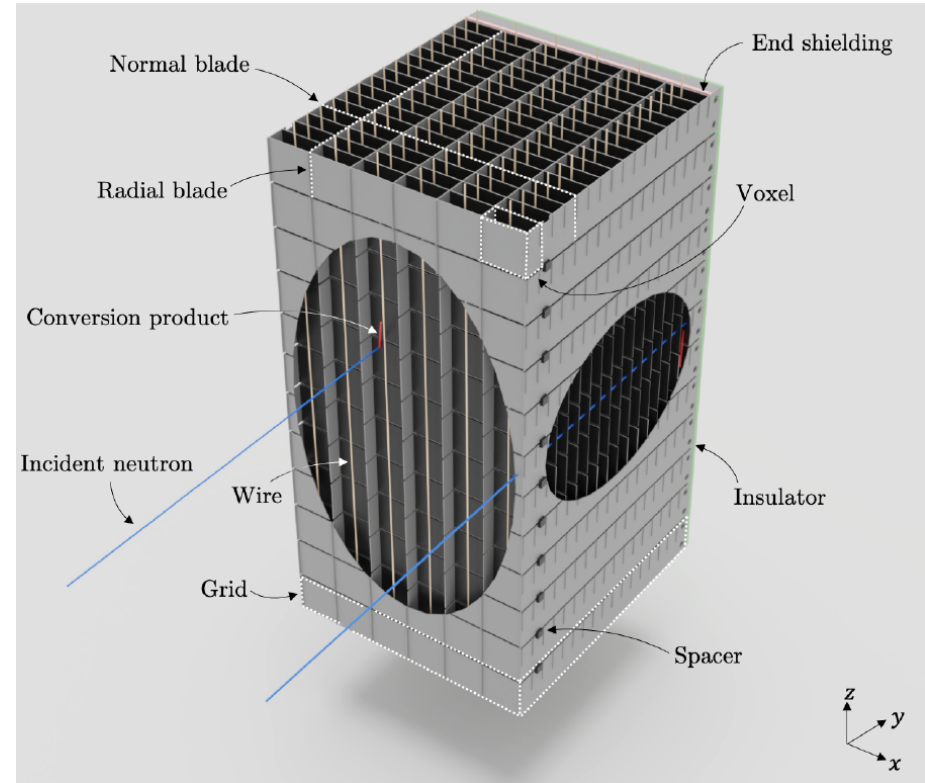
Design of MultiGrid for T-REX

Specifications

Solid Angle	$-36^\circ \leq \Phi \leq 144^\circ$
Position resolution	x: 20 mm, y: 20 mm, z: 10 mm
Time resolution	$< 5\mu\text{s}$ @ 1.8 Å
Efficiency	$\geq 70\%$ at 1.8 Å
....	

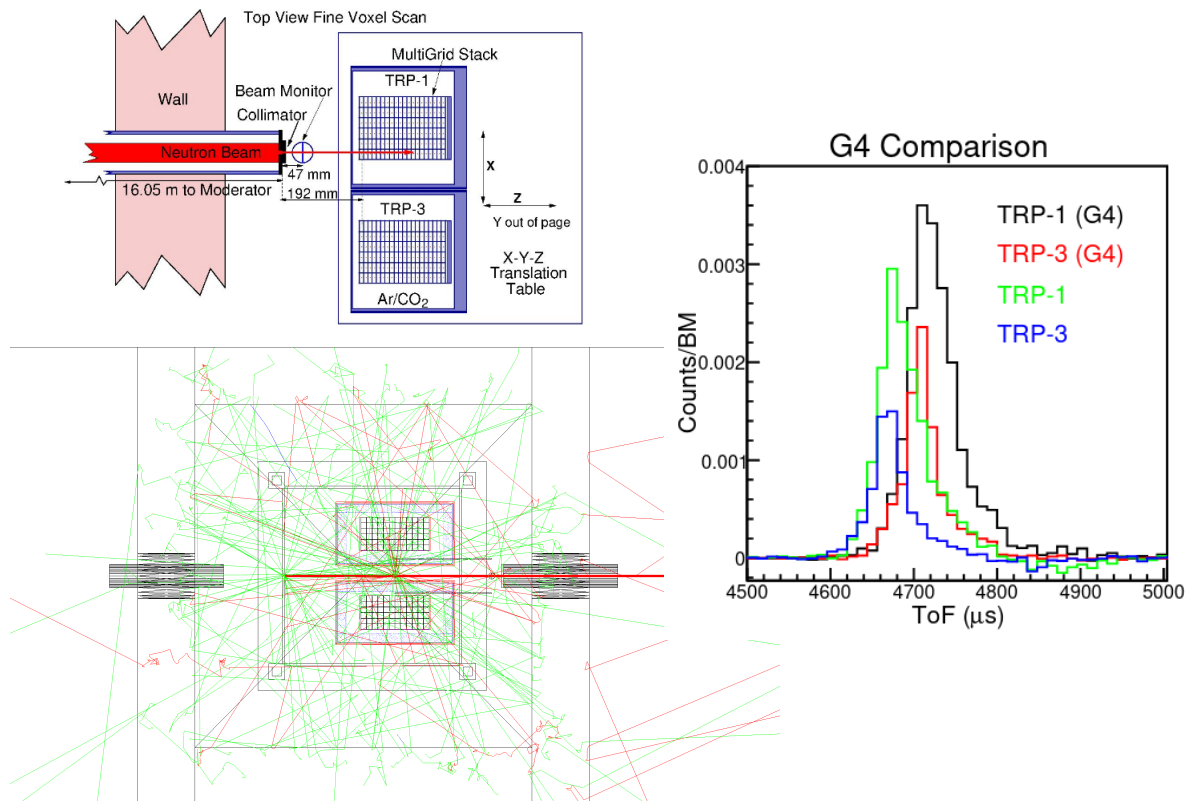
How to achieve them

What will hold the ^{10}B and maximise efficiency ?
How many cells in a grid, and what dimensions ?
How to minimise rescattering / backscatter ?
How many to make a 2sr array ?
How to fabricate the grids and make columns ?
Vessels to hold the columns.



Simulations, prototypes and beam tests

Simulation v results for ToF resolution from 2 prototypes tested on EMMA at ISIS



Simulation (J. Annand, Glasgow)

Geant 4 (CERN standard)

[Nucl. Instrum. Meth. A 835 \(2016\) 186-225](#)

Ncrystal (Thermal Neutron add on)

[Xiao-Xiao Cai, Thomas Kittelmann, "Ncrystal"](#)

[Computer Physics Communications 246 \(2020\) 106851. \[1\]](#)

Garfield (Ionisation)

<https://garfieldpp.web.cern.ch/>

Toolkit for development of general
MultiGrid detectors.

Simulations, prototypes and beam tests

Blades

Normal blades

0.5 mm Al with 2um B₄C

Radial blades

1 mm Al-B₄C (31 wt% B₄C) + 25 μm Ni-plating

Grids

Voxel size: x: 22.5 mm, y: 24 mm, z: 0.95 mm

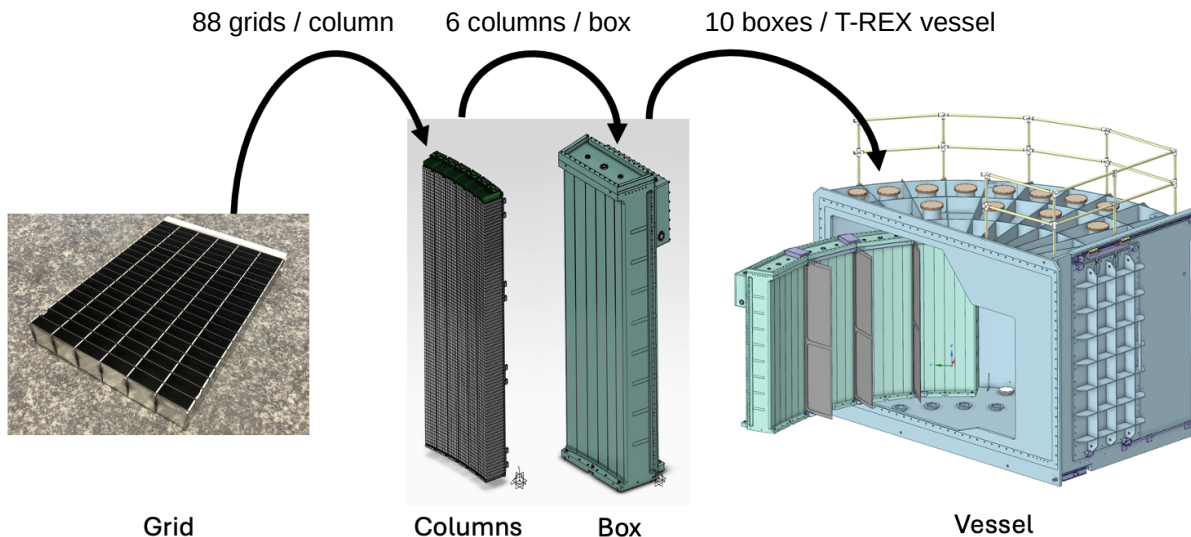
21 Normal blades, 7 Radial blades

Wires

120 wires per column, soldered under tension (6N)

Totals

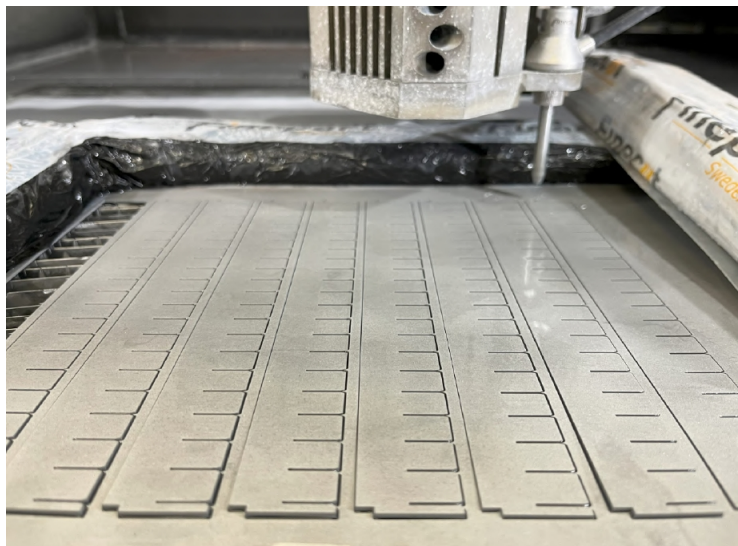
10 boxes, 60 columns, 5280 Grids, 700 Wires, 110,880 Normal blades, 36,960 Radial blades (+10% spares)



Construction of MultiGrid at T-REX

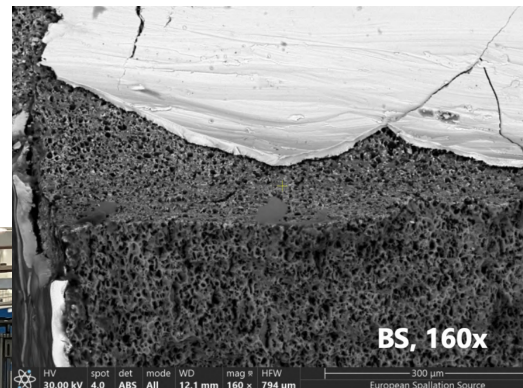
Step 1

Blades are cut
water jet (contractor)



Step 2

Blades are coated
 B_4C on all (ESS)
Nickel on radials(contractor)



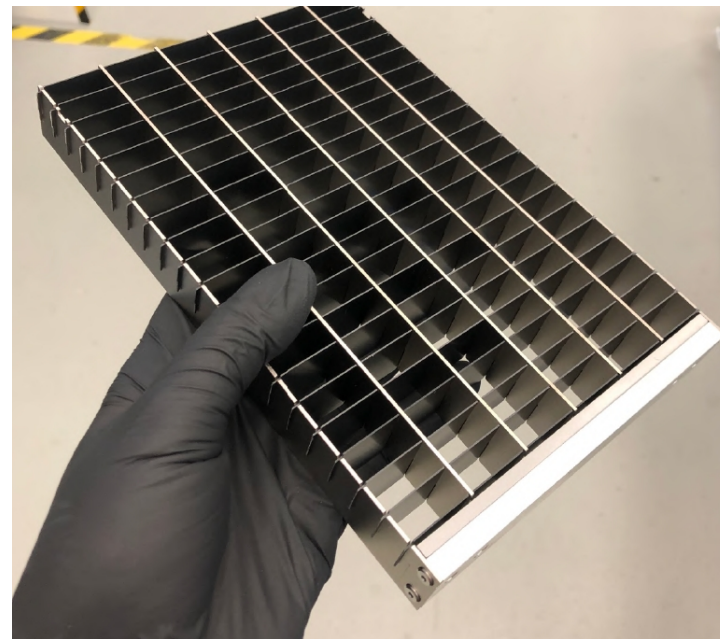
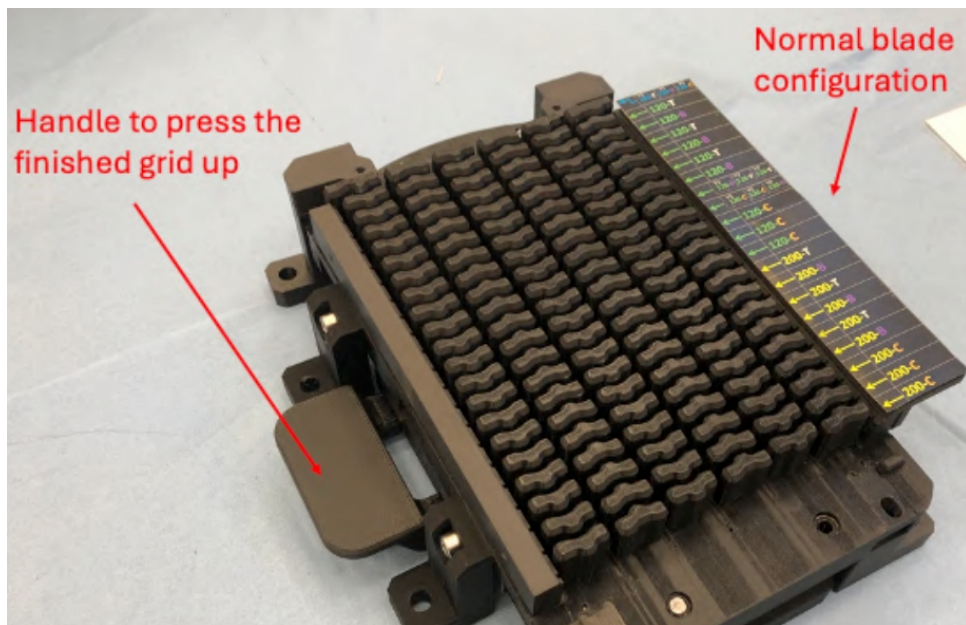
Construction of MultiGrid at T-REX

Step 3

Grids are made.

Jig from ESS

Production from contractor.



Construction of MultiGrid at T-REX

Step 4

Columns are made.

Grids mounted on backbone (Glasgow team)

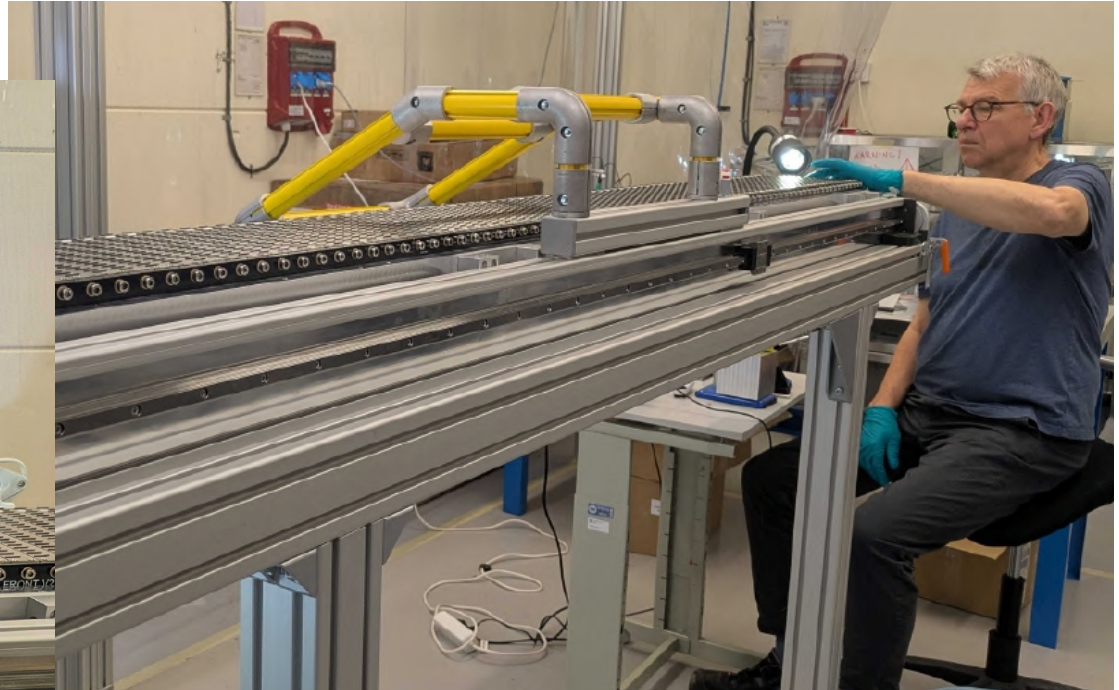


Construction of MultiGrid at T-REX

Step 4

PCBs added and Grids are wired.

Blown with compressed air and soldered to PBCs

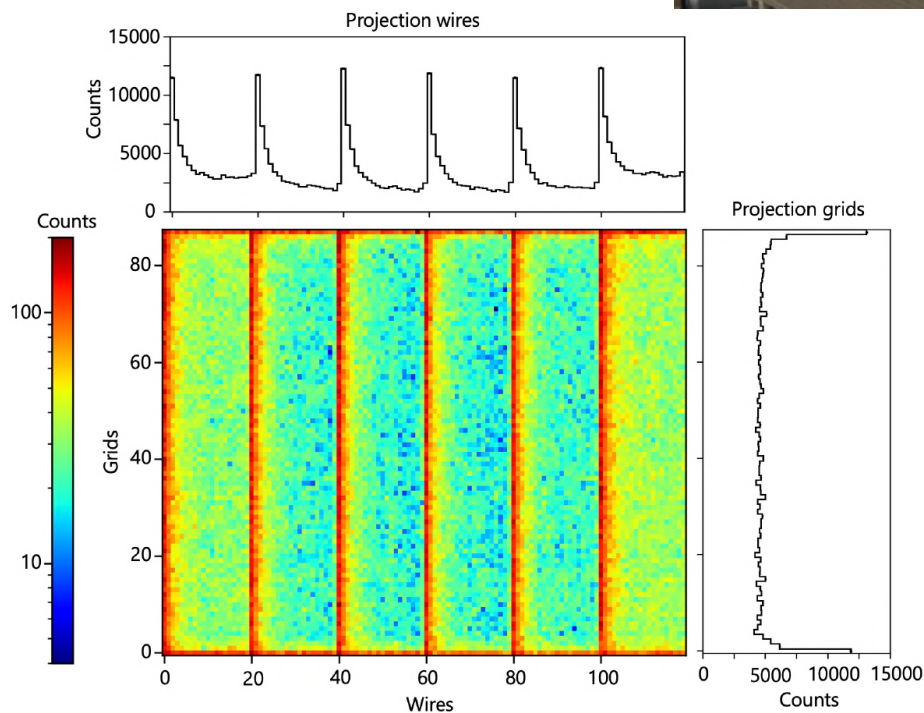
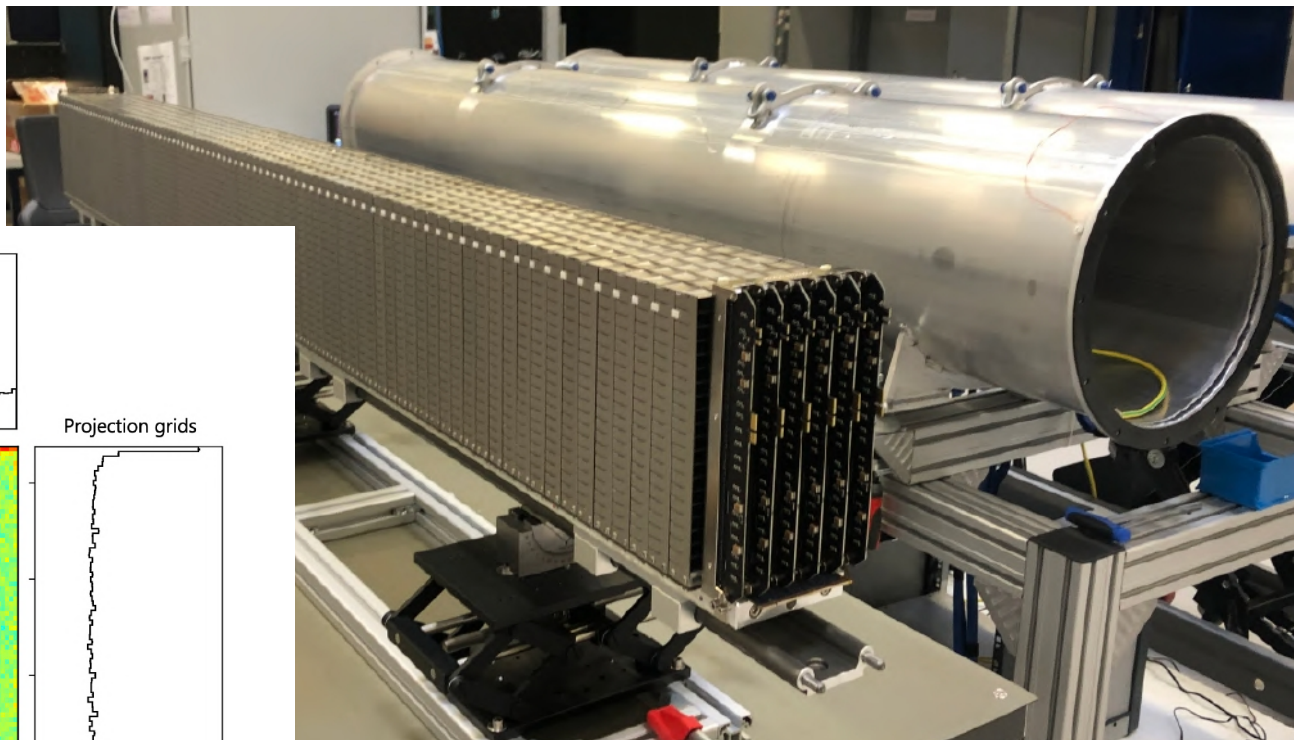


Construction of MultiGrid at T-REX

Step 5

Column in test chamber

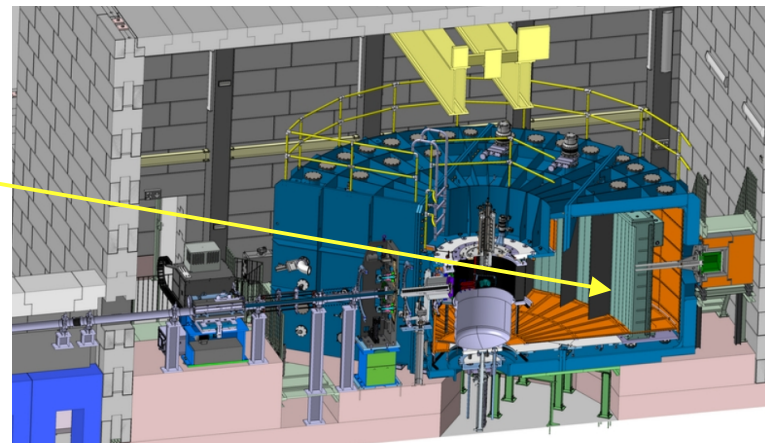
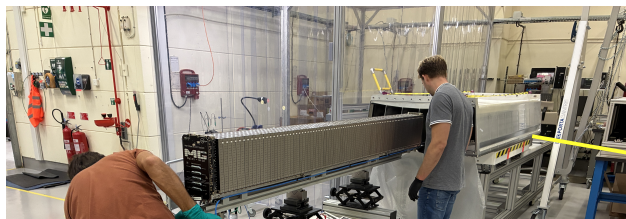
Wires and GRIDS signals tested with cosmic neutrons over 2 days.



Construction of MultiGrid at T-REX

Step 6

When 6 columns are ready, populate a (fancy, expensive, milled aluminium) box.
First one populated last week. **A milestone**



Full tank arriving at ESS site next week.
Another milestone

Steps 7-29

Coming soon.
Beam test in 2027.

Summary and outlook

What is MultiGrid

New alternative to ^3He based neutron detectors
Cheaper and higher rate capability.
Developed over a period of many years.

MG for T-REX at ESS

First full scale MG on a instrument.

Design of MultiGrid for T-REX

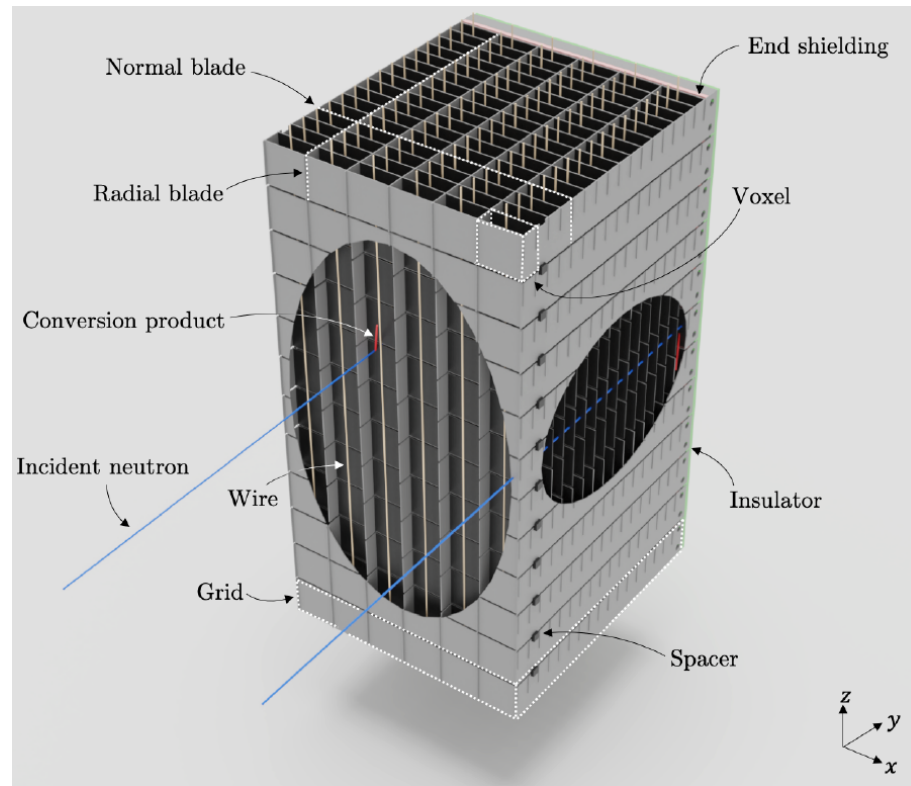
Geant4 based simulations and tests at ISIS.

Construction of MultiGrid for T-REX

In progress. First beam test in 2027.

Future

MG can be an option for future instruments at neutron Scattering facilities.



Thanks

MultiGrid team

A Backis*	MG Development Leader	ESS
C Lai	Coatings specialist	ESS
K Fissum	Detector Group leader	ESS
F Piscatelli	MG and Multi Blade devel	ESS
D Hansson	Detector Engineer	ESS
E Shahu	Detector Technician	ESS
K Livingston	UK - MG project leader	Glasgow
J Annand	Simulation and Analysis	Glasgow
S Gardner	Construction and analysis	Glasgow
A Clarkson	Construction	Glasgow
K Kelly	Construction	Glasgow
M Ewins	Construction	Glasgow
G Woodward	PhD student	Glasgow

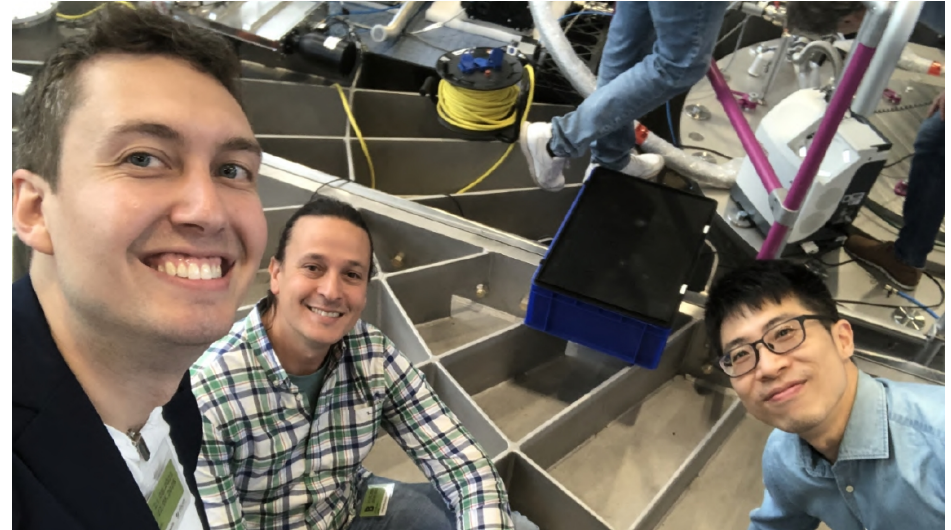
T-REX team

C Franz	T-REX instrument, physics	Juelich
M Aouane	T-REX instrument, physics	ESS
A Laloni	T-REX design and const.	CNR, Italy

Selected references

Khaplanov, A., et al.: Multi-Grid detector for neutron spectroscopy: results obtained on time-of-flight spectrometer CNCS. Journal of Instrumentation 12(04), 04030–04030 (2017)

Backis, A., et al: The application of VMM3A readout for Multi-Grid neutron detectors. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 1084, (2026)



Alex, Alessio and Lai in the big tank at Juelich

* All images from Alex, unless otherwise indicated.

Backis, A., et al.: Time- and energy-resolved effects in the boron-10 based multi-grid and helium-3 based thermal neutron detectors. Measurement Science and Technology 32(3), 035903 (2020)

Backis, A. et. al.: Neutron interaction properties of structural materials for multi-grid neutron detectors, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 1086 (2026)