An example of Big Science infrastructure in Sweden

Neutron converters for detectors –

How ESS tackled the challenge of He3 shortage by setting up a mass production facility for depositions of thin films of 10B4C

ESS Detector Coatings Workshop, Linköping

PRESENTED BY LINDA ROBINSON
DETECTOR COATINGS SECTION LEADER
2021-05-05

Organisation and People

516
Employees

57
Nationalities

> 100
Collaborating Institutions

Neutronic coatings section

ESS Detector Coatings Workshop, Linköping

Linda Robinson
Neutronic Detector Coatings Section Leader

Chung-Chuan Lai
Coatings Scientist

Per-Olof Svensson
Production Technician

Oliver Rosvall
Coating Junior Engineer

Contact:
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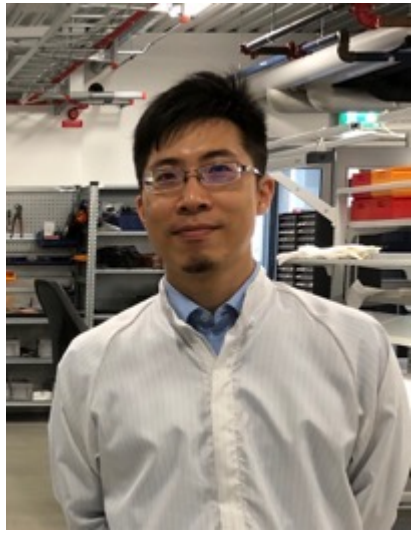
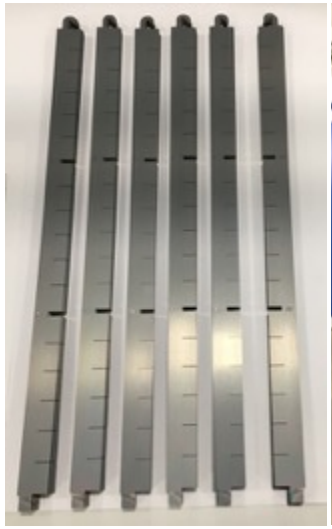
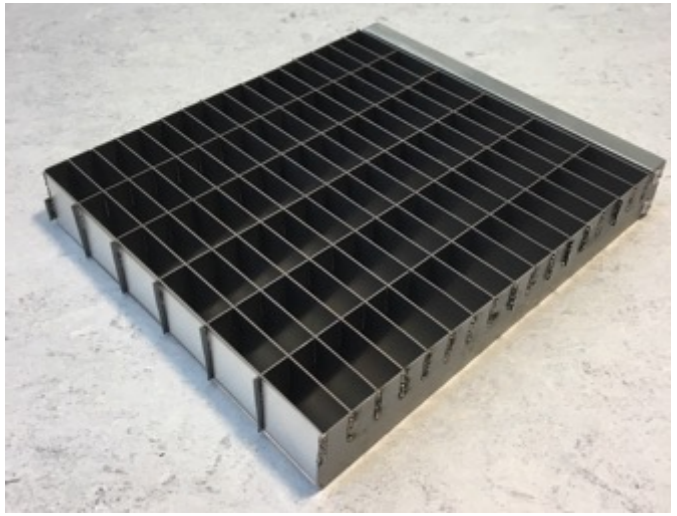
ESS Detector Coatings Workshop, Linköping, established 2014

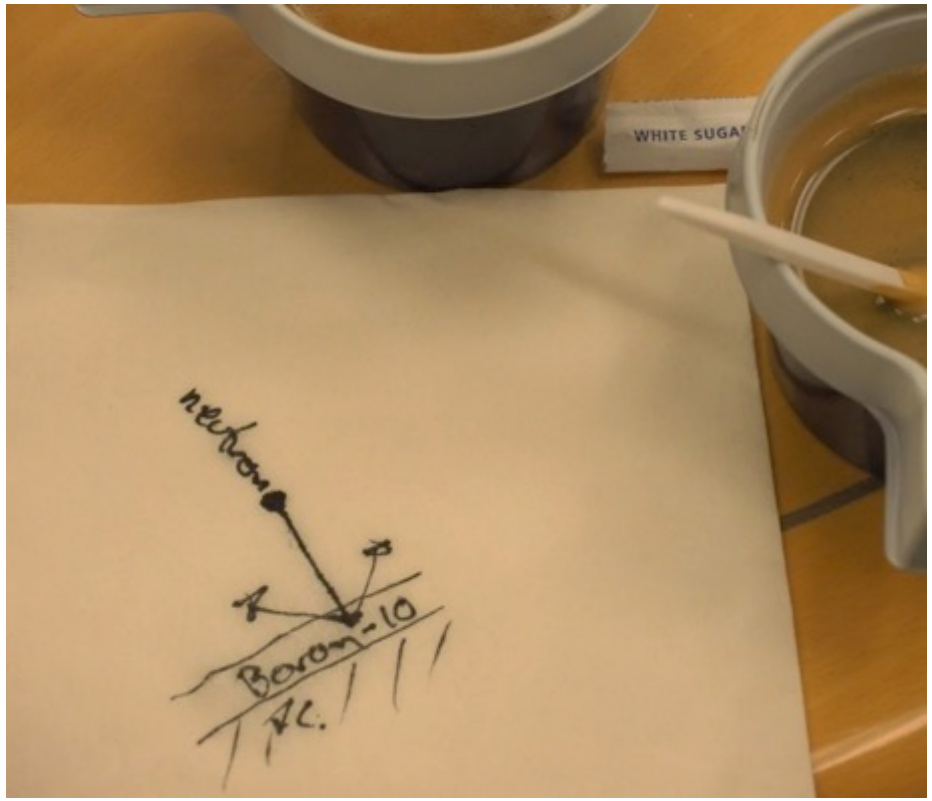




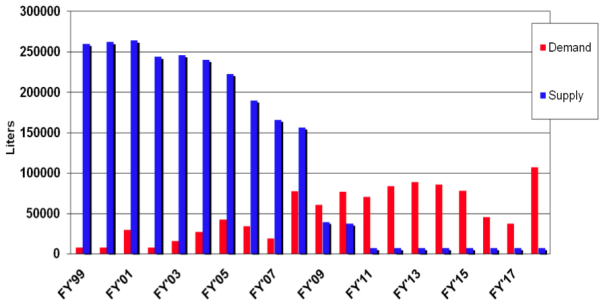


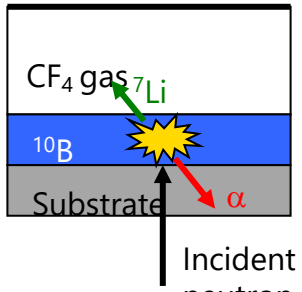
Why do ESS have a Coating facility in Linköping?

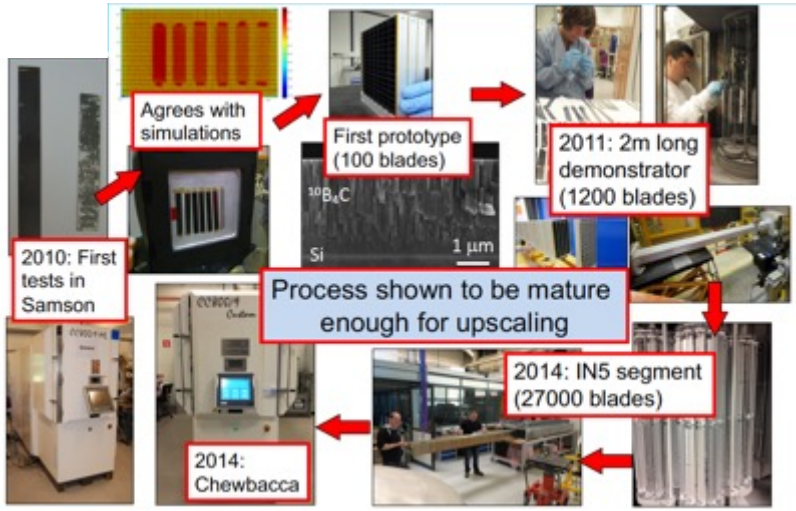
ESS' former Science Director Christian Vettier and Jens Birch shared table at a coffee break…



^{3}He crises =>
Development of new detection method needed







LINKÖPING UNIVERSITY

NEUTRONS FOR SCIENCE

Coating facility milestones

Inauguration of
ESS Detector Coatings Workshop
7 Nov 2014

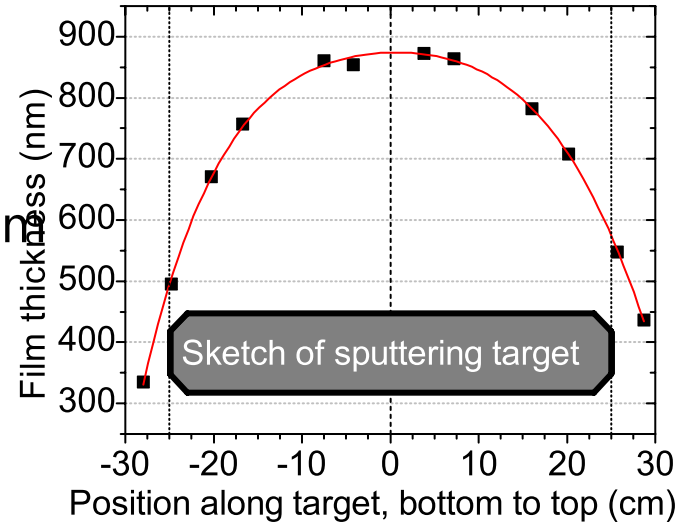
- Sep 2013 - **Sputtering machine ordered**
- Feb 2014 - **Contract signed** for the ESS Detector Coatings Workshop in Linköping
- Summer 2014 - sputtering machine, **installed and tested**
- 7th of Nov 2014 **inauguration event** sputtering machine named -**Chewbacca!**
- April 2017 **moved to a new address**
- The Workshop is **set up for production until at least 2025**

ESS in Linköping,
Wahlbecksgatan 25,
Ebbe Park

Coatings

About Chewbacca

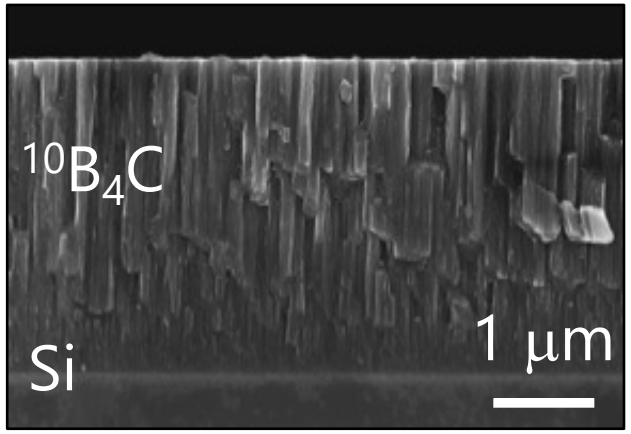
- CemeCon CC800/9 batch loading industrial system
- DC magnetron sputtering
- Up to four $^{10}B_4C$ targets (50 cm height)
- 1-, 2-, 3-fold rotation



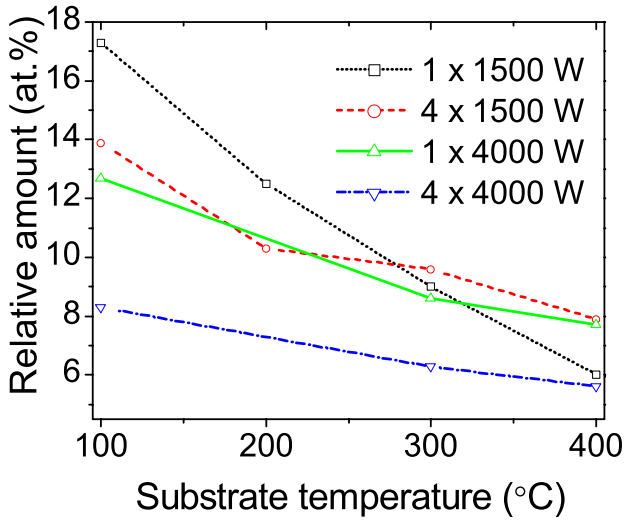
Coatings

High quality 10B4C coatings with DC magnetron sputtering

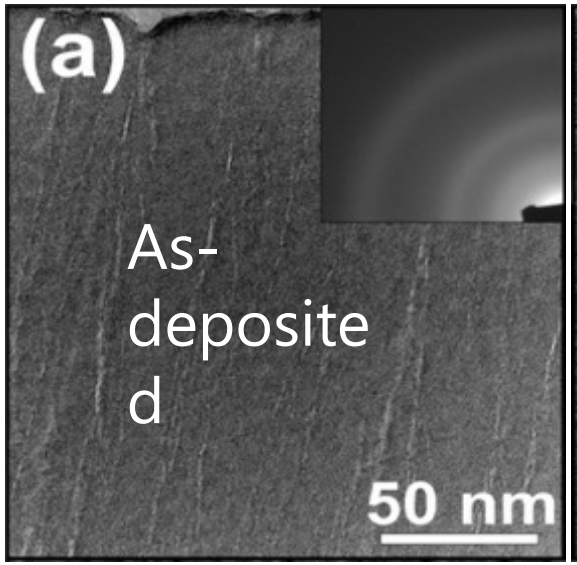
Required property	Result	OK?
Good adhesion	> 1 μm on Al, Si, Al_2O_3, etc	☺
Low residual stress	0.09 GPa at 1 μm $^{10}B_4C$ on Si	☺
High density	2.45 g/cm^3, 97% of bulk	☺
High ^{10}B content	79.3 at.% of ^{10}B	☺

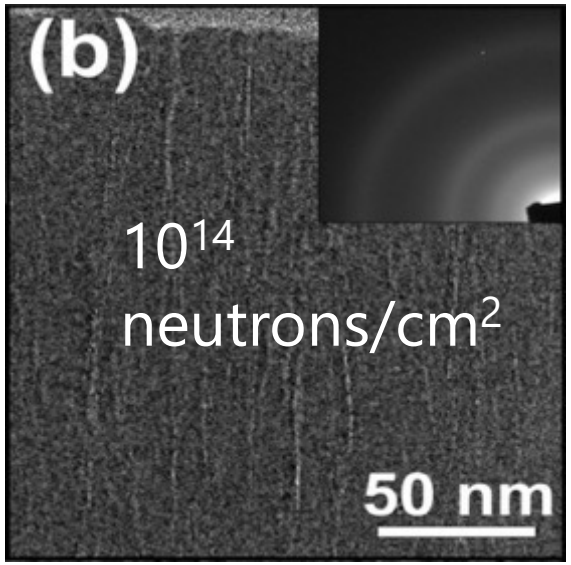


Patent SE 535 805 C2
EU patent applications ongoing



*C. Höglund et al., J. Appl. Phys. **111**, 104908 (2012)*





Neutron radiation hardness, Collaboration LiU-ESS-FRM II

➔ **No influence** on adhesion, composition, morphology, structure, etc

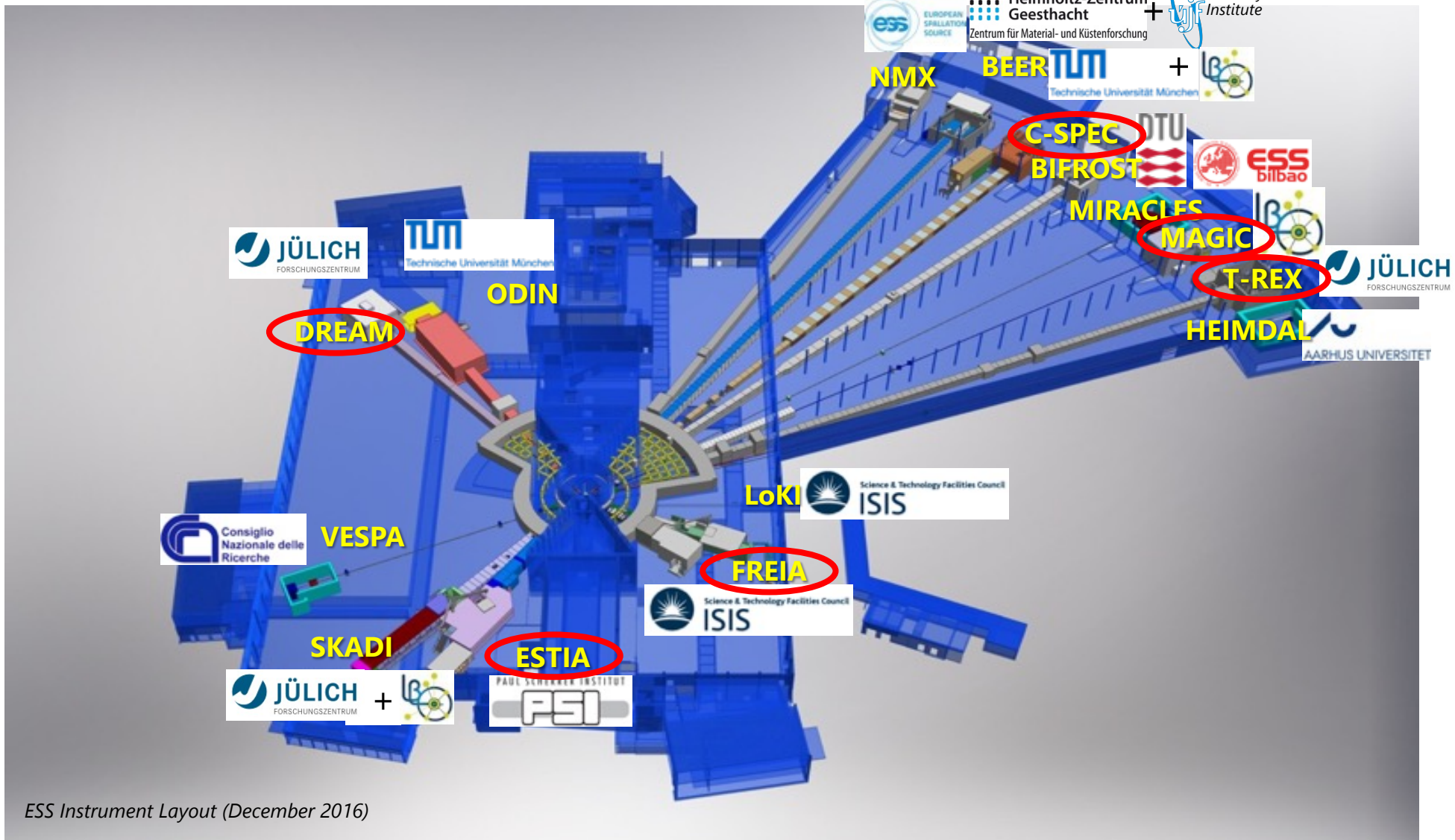
➔ 0.000156 % of the ^{10}B atoms were consumed

Lifetime of ^{10}B atoms with 10^8 n/cm^2/s is >20 000 years ☺

C. Höglund et al., Rad. Phys. Chem. 113, 14 (2015)

NSS Neutron Instrument positions

ESS Lead Partners for instrument construction



ESS Instrument Layout (December 2016)

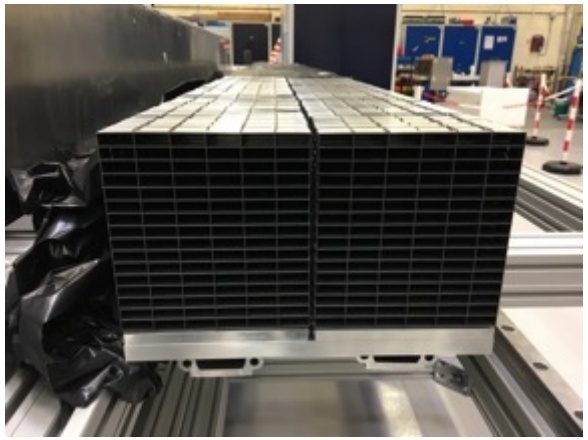
Our main focus coatings in Linköping

Multigrid and Multiblade

Multigrid - MG

CSPEC and T-REX

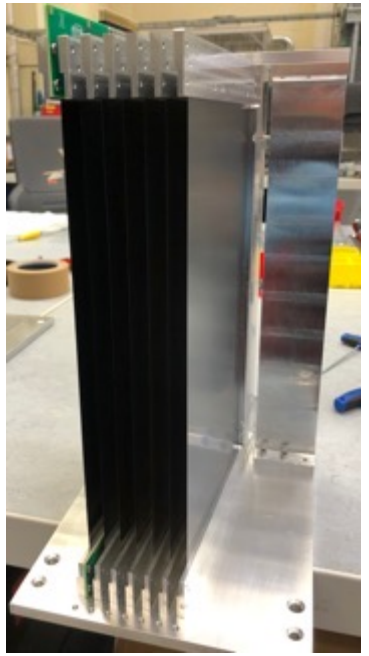
Estimated time to produce coatings for multigrid instruments 1-2 years / instrument



Multiblade - MB

ESTIA and FREIA

Estimated time to produce coatings for multiblade detectors 1-2 months / instrument



Our main focus coatings in Linköping, cont.

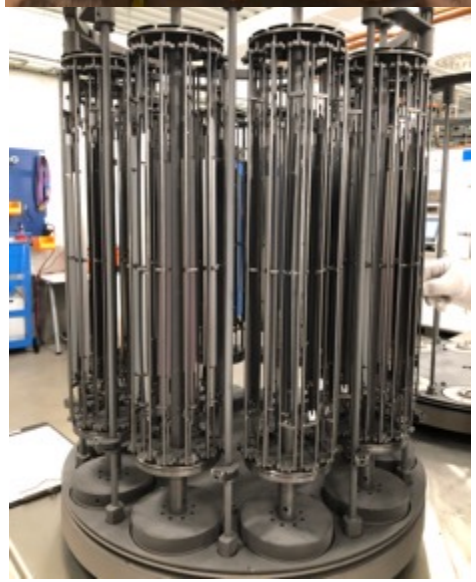
CDT (MAGiC, DREAM)

MAGiC

- 67% of CDT's need of coatings for MAGiC-B - done in Aug 2020
- First sharp coating production for an ESS instrument
- The production process was adopted from MG detectors with excellent outcome. Yield of the coatings was 99,5%
- CDT asked for remaining 33% coatings for MAGiC-B (due to problems with their other coating vendor)
- Estimated time to produce coatings for MAGiC-B - 1 month

DREAM

- Linköping has agreed to do coatings for DREAM
- Estimated time to produce coatings for DREAM - 1 month



"Guys, you are awesome. These are very nice coatings."
"We have made all our adhesion tests and the coatings have passed all of them very successful (tape, ultrasonic, glue, freezing)" CDT

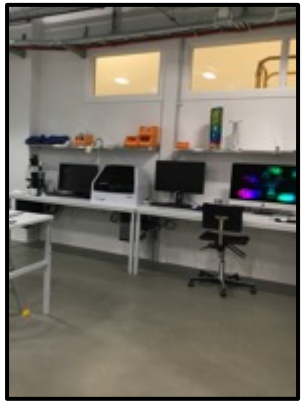
Production flow

In pictures

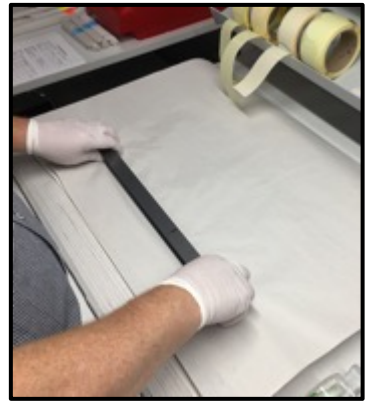
Receive and iteration of deposition requests

Receive samples and holders

Batch production of B_4C coated samples



Sample characterization and documentation



Packing and shipping

Procurement and industry opportunities

Securing radio pure Al substrates for MG

500 kg radio pure Al sheets

- Radio pure Al sheets from Joinworld
- First test batch delivered April 2021
- Procurement process started in Aug 2020, estimated delivery time June 21

Etching Al sheets

- Different techniques to pattern the sheets have been tried out, etching has proven to be the best so far regarding cleanliness of samples to achieve good adhesion of the Boron carbide

Procurement and industry opportunities

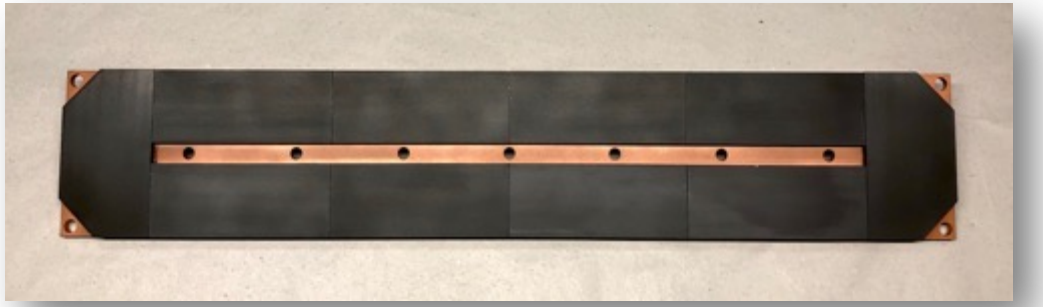
Securing target delivery for all 4 instruments (MG and MB)

50 kg enriched 10B4C powder

- Enough for both MG and MB
- Procurement started Aug 2020
- Last delivery made in April 2021 from 3M
- Quality tested at third party (ongoing)

Manufacturing of targets

- Call of agreement for 10B4C target manufacturing signed in April 2021 with RHP
- Agreement for maximum 80 targets
- Expected first delivery in May 2021

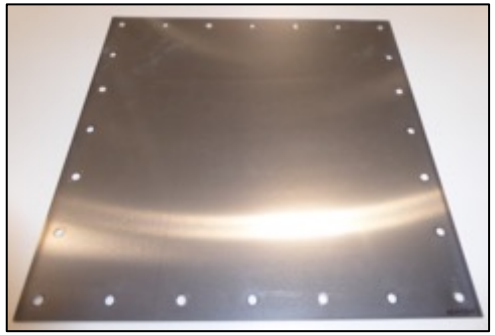


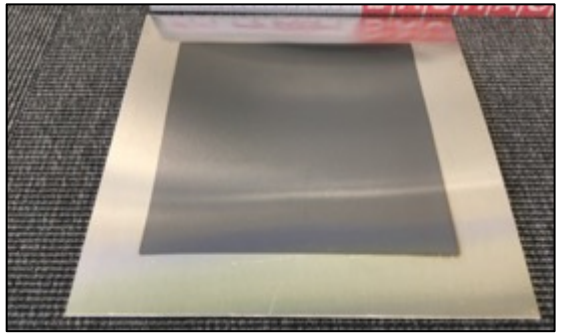
=> Procurement strategy payed of with cheaper price/targets

Continues development for coatings

What we can provide to the community

- Coatings on substrates like Al, Ti, Si, Al2O3, Ni, Cu, glass, etc.
- Low temperature B4C deposition on substrates like FR4, G10, Kapton, Teflon, Si diodes, etc.
- Flat substrates even though 1-side coated
- Coating with shadow mask
- B_4C depositions with different resistivity

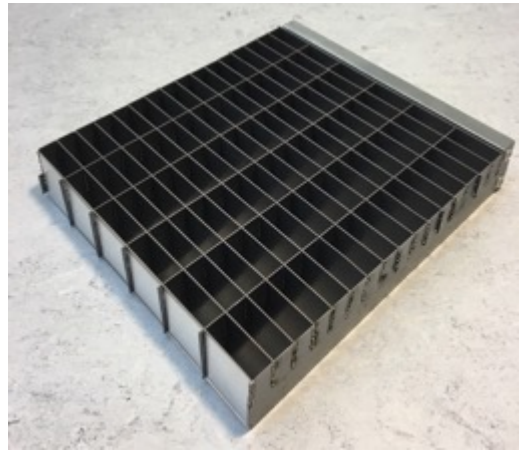




During the years we have learned a lot from the coatings we have provided to our Partners at ESS, In-kind contributors and other research groups

Summary

From napkin to full production facility



MultiGrid Detector Technology Review Panel (2020-09-11):

Ralf Engels (JCNS)

Toby Perring (UKRI STFC)

Graham Smith (BNL)

Jon Taylor (ESS/DMSC)

Karl Zeitelhack (MLZ)

Review:

"As a general comment, it should be said that the panel was extremely impressed by the material presented and the results shown and congratulated the ESS and its detector group on their excellent and enormous work.

The MultiGrid detector technology has been developed and analyzed comprehensively and systematically in the 10 years since its invention.

In particular, the production of high-quality, large-area B4C coatings was perfected during this period and brought to industrial maturity."