

PROGRESS ON BEAM MONITORS

REPORT FOR SPECTROSCOPY STAP 21 OCTOBER 2020

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1. REPORT ON PROGRESS OF BEAM MONITOR COMMON PROJECT

In the confluence page of the beam monitor common project you can find all up-to-date information about the technology options considered, the beam monitor (BM) positions and respective CAD reservations, and the indicative response from the instrument contact. This information is summarised in the table on the next page. The Confluence page is:

<https://confluence.ess.lu.se/display/DG/Beam+monitors+common+project>

The indicative response means that the instrument has been or will be provided with an offer document detailing the requirements that have to be met with the design, as well as the cost and schedule for the provision, installation and cold commissioning of the beam monitors. So far, 47 (+4) monitor locations have been reserved for the entire instrument suite.

#	Instrument / BM partner	Spatial envelope status	Status of McStas/Vitess model	Indicative participation status
1	ESTIA / PSI	Reservations in CAD	Up-to-date	Interested in utilities and services (V-monitor)
2	ODIN / PSI	Reservations in CAD	Up-to-date	YES
3	DREAM / FZJ	Reservations in CAD	Up-to-date	NO (CDT monitors)
4	BEER / HZG	Reservations in CAD	Up-to-date	YES (in-bunker BMs), MWPC by HZG (pre-sample)
5	CSPEC / TUM	Reservations in CAD	Up-to-date	YES
6	BIFROST / LLB	Reservations in CAD	Up-to-date	YES
7	MAGIC / FZJ	Reservations in CAD	Waiting for update	NO (CDT monitors)
8	LoKI / ISIS	Reservations in CAD	Up-to-date	NO (NitroGEM monitors from ISIS)
9	SKADI / JCNS	Reservations in CAD	Up-to-date	YES
10	VESPA / CNR, ISIS	Reservations in CAD	Up-to-date	NO (B-GEM monitors from University of Milano-Bicocca)
11	NMX / ESS	Reservations in CAD	Up-to-date	YES
12	MIRACLES / ESS Bilbao	Reservations in CAD	Up-to-date	YES
13	T-REX / CNR	No information	2018-09-17	Discussion ongoing – sporadic interactions
14	HEIMDAL / AU	Reservations in CAD	Up-to-date	No information available
15	FREIA / ISIS	Reservations in CAD	Up-to-date	YES

Table 1. Up-to-date information about the BM technology options considered, the BM positions and respective CAD reservations, and the indicative response from the instrument contact.

1.1. Status per instrument

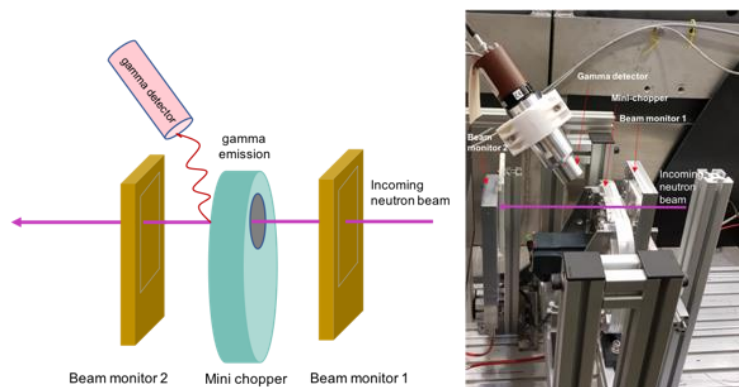
- The BIFROST offer was discussed and prepared months in early summer, comments have been received and a new offer will be sent including the design details of the monitors. It was agreed that the final design review would take place in September-October. Due to summer events causing delays, it was not possible to conclude the offer earlier.
- CSPEC received a draft offer in order to clarify a few points before assigning a monitor technology in each location.
- MIRACLES offer sent to F. Villacorta for a first round of input. We agreed he would send back comments and questions in the coming 2 weeks.
- T-REX had the last interaction with us at the end of May. They were working on a document analysing requirements and would get back to us to discuss suitable choices per location. No decision on participation in the common project yet.
- VESPA is not taking part in the common project. Their solution is a GEM monitor designed and supplied by the University of Milano-Bicocca. We have planned a meeting with the detector people involved at the end of October.

1.2. V-based Monitor

The V-based monitor results were published in the Physical Review Accelerators and Beams ([PRAB 23 \(2020\) 072901](#), [arXiv:2002.10108](#)). The focus is on limits of operation with respect to background and the extraction of absolute neutron flux. The results indicate that the V-monitor will work as intended, as it can reliably reconstruct the absolute neutron beam flux. The systematics are well understood and can be now controlled. This gives confidence the performance and operation can be assured with a solid engineering design. The results were presented in detail at IKON18.

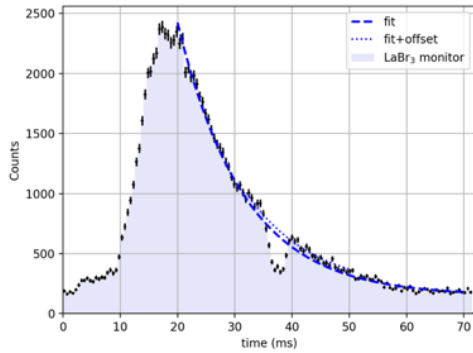
1.3. Fully Parasitic Beam Monitor – Proof-of-concept

The proof-of-concept for a fully parasitic monitor based on γ detection from the boron coating of a chopper disk has been accepted by Europhysics Letters and is pending publication ([arXiv:2004.07336](#)). The results imply that this approach has good potential for diagnostics of chopper operation. The sketch and photo below show the setup at V20. Two classical beam monitors are placed before and after the mini-chopper and a LaBr_3 scintillator is facing the chopper at a favourable angle. All monitors collect time-stamped data.

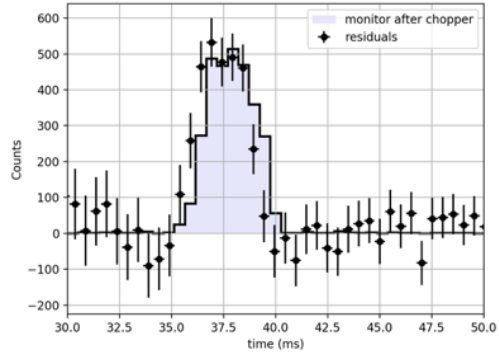


Sketch and photo of the parasitic monitor at V20.

The figures below show the raw neutron pulse as seen from the scintillator with a gap during the time that the chopper disk was open (left) and the residuals from a fit on the left plot compared to the raw measurement of the downstream monitor (right).



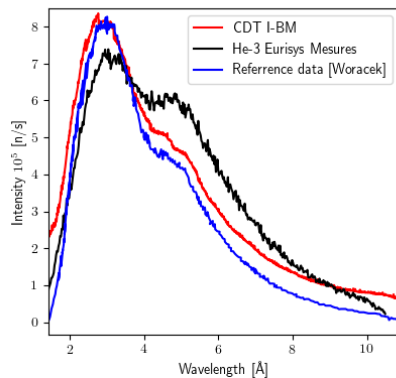
Time-resolved measurement with the LaBr₃ scintillator. The gap between 35-40 ms represents the time window when the chopper window is open.



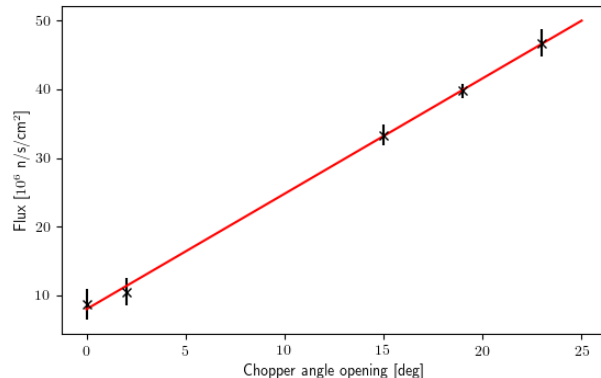
The residuals from the left plot compared to the measurement of the downstream monitor.

1.4. Beam Monitor Based on Ionisation Chamber Principle

The analysis of the ionisation chamber (I-BM) data has concluded. A draft article is being finalised, in collaboration with the supplier of the monitor (CDT). It presents the evaluation of such a device for a neutron beam monitoring application, based on data collected in summer 2019 at V20. The CDT I-BM demonstrated good linearity, timing capability for various flux ranges, sensitivity to neutrons within the V20 range of 0.6-10 Å and pulse-by-pulse monitoring capability. Adjustability of the design was discussed and stability and attenuation are subject to future measurements.



Wavelength distribution with I-BM compared to other reference measurements.



Absolute flux of I-BM as a function of chopper settings at V20.

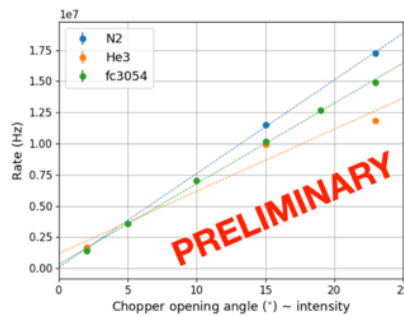


Photo of the ionisation beam monitor from CDT.

1.5. Data Analysis of TOF Characteristics

The last available data set taken at V20 in 2019 is being analysed. Five monitor technologies were exposed to the beam and time-stamped data were collected. A first glimpse of the data was shown at IKON17. The effort is focusing on producing absolute fluxes for white neutron spectra,

understanding TOF characteristics and chopper function, as well time-dependent response with respect to the environmental conditions and the reactor power. With this data analysis complete, the performance of all selected monitors is understood.



Absolute beam intensities as a function of chopper settings for 3 beam monitors, a ³He-based, a N₂-based and a fission chamber.

1.6. MultiTube Beam Monitor from ILL

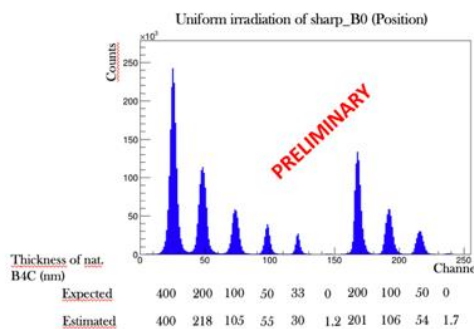
Two additional beam monitors have been assembled, bringing a total to 4 devices being tested during the current reactor cycle at ILL. The first two are destined for local instruments. The other two provide 1D information. One of them is equipped with Boron layers of different thicknesses, created as thin Al foils coated at the ESS Linköping coating facility. This leads to cells with distinct detection efficiencies. Preliminary rate tests indicate that data can be acquired at 330 kHz with a 2% event loss. A detailed operational parameter scan is performed and further analysis is expected to conclude in the coming months about the optimal conditions for achieving the highest counting rates.



Thin Al foils coated with various B₄C thicknesses. They are folded and fixed inside the MultiTube monitor cells.



MultiTube beam monitor with the coated foils in place.



Events for the various cells of the MultiTube, equipped with varying B₄C thicknesses.

1.7. News from Suppliers

Over the summer a good amount of interactions took place with CASCADE Detector Technologies GmbH (CDT), the supplier of the ionisation beam monitor for the common project, as well for DREAM and MAGiC. A new engineering design has incorporated our requirements for space, connectivity

and interfaces. An agreement has been reached that the design will be common for all ESS instruments who adopt the technology. The only free parameter is the B4C coating thickness of the cathode, which determines the detection efficiency and for the sake of simplicity it should be reduced to 2-3 values in total to allow for coating time optimisation. The design allows for an easy replacement of the coated cathode, enabling the adjustment of the efficiency at higher power values of the ESS source.

1.8. Resources of the Project

After Anders Lindh Olsson's departure at the end of 2019, two more people are going to or have already left the project. Vendula Maulerová has already left ESS and is temporarily employed as a consultant until 31 October 2020. Ioannis Apostolidis has already started at another position within NSS since August 2020. Steven Alcock remains available for electronics support per demand. Kalliopi Kanaki is dedicating up to 40% of her time. 20% of a mechanical engineer from EIS/MET within ESS has been secured and will become immediately available. The progress of the project is subject to recruitment approvals. The issue has been raised to NSS management.

1.9. Miscellaneous

- A TG3 review document is released (CHESS ID: ESS-2505100) for non-participating instruments in the common project.
- A regular biweekly meeting with Andrew Jackson has been set up to provide updates on the progress of the BM common project and address questions that arise from instruments.
- Regular update on status of BM common project are given in the NSS monthly newsletter.