

IKON19

NEUTRON CHOPPERS UPDATE: COMMON CHOPPER AND T0 PROJECTS REPORT FOR IKON19

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1. COMMON CHOPPER PROJECT

- As part of the quality assurance (QA) phase of the project we have now received all the components required for assembly of the first standard chopper inclusive of coated discs from our ISIS partners. The complete standard chopper assembly has undergone vacuum testing and we have reached an acceptable leak rate which allows the project to move forward to balancing the rotor SKF spindle assembly and achieve first rotation.
- We have been successful in developing a process for achieving fabrication/machining process that results in low tolerance <0.1mm large diameter aluminum discs based on 6082T6 alloy.
- We have now developed and fabricated the first in house B4C coated 700 mm discs. The discs will go through several tests including rad hardness and pull off tests in the same way we assess external manufacturers. If the development is successful all low speed metal-based discs as part of the CCP will be produced in house.
- The ESS - SKF framework agreement is nearly complete. After several rounds of negotiations over 6 months all technical and cost details have been agreed and awaiting final approval from S2M legal team in France (SKF Canada and S2M have joined earlier this year). The scope of supply of the framework are magnetic spindles, controllers, cables and other maintenance related items purchased by ESS.
- MAGIC chopper delivery:
 - The first major milestone of the project, the MAGIC PDR, has taken place on time and has been well received. We thank the team for the great communication and collaboration. We have performed simulations of Eddy currents in the chopper discs in collaboration with our LLB and Julich partners (MAGIC is capable of polarisation analysis and contains polarised guides). The simulations showed that the magnetic braking effect on the disc is very small and has no effect on the phase accuracy but

the heating effect is of the order of 20-25 Watts at the required MAGIC chopper speeds. Although this effect can be mitigated by disc anodisation and coating of the internal chopper surfaces we have selected CFRP for the fast MAGIC chopper discs.

- As of September 2020. We are in the final stages of the MAGIC detailed design stage which is progressing as planned albeit with some small delays from a knock-on effect from the QA phase (delayed disc deliveries leading to delay of verification of design choices). Contract signed for the MAGIC CFRP discs. Kick-off meeting for the sub system took place on the 15th of September and delivery time is 9 months.
- In collaboration with ICS we have finalised an FBS structure for the MAGIC chopper system while at the same time EPLAN drawings are being created and we are starting to populate the FBS.
- The order of discs will be followed immediately by the SKF spindle order resulting in all long lead and risk items to have been ordered ahead of CDR which will reduce schedule and delivery risk of the MAGIC chopper system to a minimum.
- The HEIMDAL instrument has officially joined the common chopper project and the kick-off meeting will take place 1st October 2020. The scope is the complete chopper system delivery. Updated costing proposals has been sent to BIFROST instrument in August.
- The NMX instrument has joined the common chopper project. The scope includes 3x chopper unit delivery and racks while suppliers deliver bottom housings. The NMX chopper kick off has taken place in March 2020.
- On instrument request, updated proposals have been sent to the BIFROST instrument
- A number of kick offs for rack delivery for LOKI, FREIA, ESTIA(spindle and cables) and MIRACLES have taken place.

Project overview

Participating Instrument	Current Status	Scope	Kick-off	PDR	CDR	IRR	Project completion
MAGIC	Detailed Design	Full System	2019-12-10	2020-04-02	2020-11-26	2021-07	2022-01
LOKI	Awaiting standard system completion	Racks	2020-01-20	N/A*	N/A*	2021-01	2021-11
FREIA	Awaiting standard system completion	Racks	2020-01-20	N/A*	N/A*	2021-04	TBD
NMX	Preliminary Design	Racks and Assemblies	2020-03-06	2020-12-10	2021-03	2022-01	2022-10
ESTIA	Awaiting standard system completion	Rack and Spindle	2020-03-26	N/A*	N/A*	2021-06	TBD
HEIMDAL	Updated proposal	Full System	2020-10-01	TBD	TBD	TBD	TBD
DREAM	Kick-off Meeting	Racks	2020-05-20	N/A*	N/A*	2021-09	2022-09
SKADI	Kick-off Meeting	Racks	2020-05-15	N/A*	N/A*	2023-06	TBD
MIRACLES	Kick-off Meeting	Racks	2020-06-10	N/A*	N/A*	TBD	TBD

Common chopper project status: Current instrument participation, assigned scope and current project stage for each of the participating instruments. Highlighted green indicates stage has completed successfully, yellow indicates pending.



Figure 1. Fabrication of the first standard chopper as part of QA Phase. Top left: SKF Shaft with new Julich style disc coupling to be incorporated in the first QA phase chopper. Top middle: Upper chopper housing awaiting assembly. Top right: Uncoated test discs fabricated from 6082 and 7021 aluminum alloys (disc design based on a slow band chopper). Middle left: Upper housing cover plate. Vacuum and sensors ports as well as spindle fixation port visible. Middle middle standard chopper rack middle right Complete assembly QA phase chopper undergoing vacuum tests. Bottom left coated ISIS discs delivered Right: First inhouse coated NSS chopper disc

T0 Chopper

- The manufacturing of the T0 prototype is continuing. Major assembly and a vacuum test of the entire assembly has taken place in April 2020. There was a delay in the procurement of Tungsten from China due to the COVID which resulted in a delay of the FAT of the system by 4 months from June to October 2020.
- The T0 top housing has been assembled and vacuum tested with satisfactory results. The entire T0 rotor has now been assembled (including tungsten and other absorbers) and first manual rotation of rotor appears to be successful
- The T0 CTVs for ODIN and HEIMDAL (larger T0 than ESS prototype) have been completed. A study for potentially using a common design for both instruments was made to ensure better pricing and maintainability in the future.
- We have received updated costing estimates for T0s based on the T0 prototype dimensions. The estimates are within expectation. The cost estimates for the larger modified T0 potentially for ODIN and HEIMDAL is significantly higher and an internal discussion has taken place of how to manage costs.
- We are now ready to start procurement of the larger T0 for ODIN while the HEIMDAL team is considering the use of the prototype.

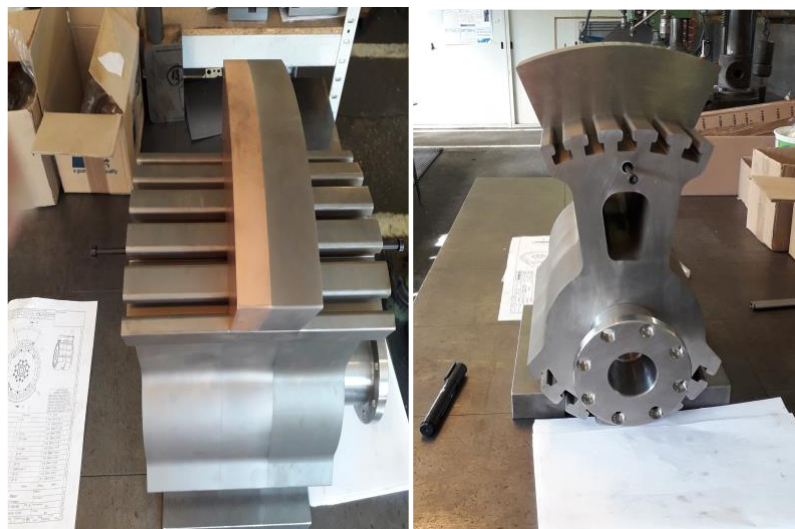


Figure 2. Fabrication of the 1st T0 prototype fulfilling DREAM & T-REX specs. (Left) Top view of the T0 rotor with Ni and Cu alloy based absorbers already attached Front view: Inverted T-slots cut with wire EDM technique and absorber locking bolt visible.

The next major milestone for the T0 project is the FAT of the T0 planned for end of October 2020.



Figure 3. Fabrication of the 1st T0 prototype fulfilling DREAM & T-REX specs. Top Left: Bottom T0 housing with Z-alignment features in each corner. Top Right: Detail of internal flange option for vacuum separation of T0 from guide vacuum. Bottom left: Top housing of T0 after CNC fabrication completion. Bottom Right: Control cabinet in

preparation for installation of T0 control equipment. Bottom: Fully assembled upper housing: successful manual rotation has taken place mid-September 2020.

Chopper Controls – CHIC Julich in kind prototype and new ESS production version

- The CHIC Prototype was built and delivered by Airbus in Q42019. We have performed a full testing campaign which resulted in a number of iterations of the prototype code. The full vertical integration using an SKF spindle with EPICS including realistic timing system from ICS has been successfully proven in late Q12020. Following the success of the first CHIC we have begun the assembly of a production version of the CHIC for utilisation within the framework of the common chopper project.
- We are currently in the final stages of building the first production version of the Chopper Integration Hardware (CHIC). Several hardware modifications to improve function, durability and reduce cost were implemented.
- We have fully optimised the back plate of the CHIC considering all sensors from the Common chopper. Last modifications were the sourcing and incorporation of low smoke halogen free cables as well as their inclusion in the ESS cable database. Furthermore, we are sourcing radiation hard cables for our temperature and flow switch sensors to be installed in every cooled chopper.
- We are keeping close contact with Airbus in order to ensure a standardised system irrespective of CHIC supplier. Updated costing estimates for CHIC and rack have been also created in order to keep long term costing estimates more accurate.

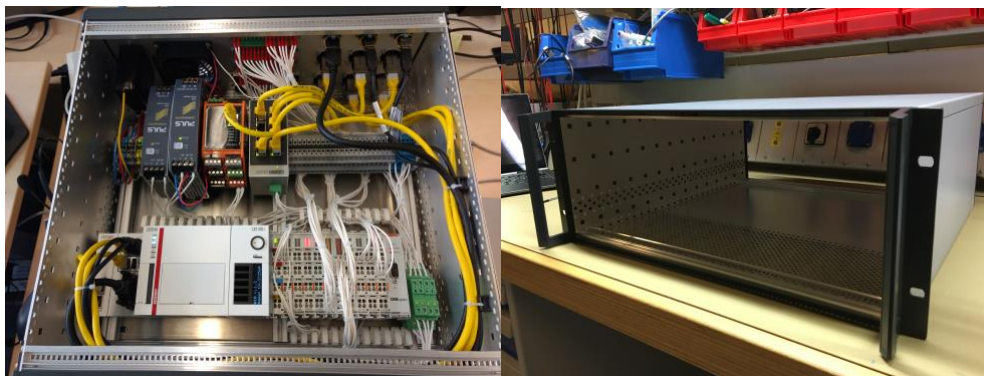


Figure 4. Left: Final layout of chopper integration controller. Right: Beginning assembly of the 1st production model of the CHIC controller.