TRIUMF	Design Review	DR.P0353.06

Title	Concept Review for the AETE Target Station		
Proponent	P. Bricault, A. Gottberg		
Objectives	To review the concept for the AETE Target Station and decide if it meets the review charges: 1) Is the presented concept a viable solution for a 50 kW operation of RIB production? 2) Does the presented AETE solution allow to be operational at 100 kW in the future? 3) Is the presented AETE RIB development and upgrade strategy appropriate? This review applies to project P353.		
Location, Date, Time	MOB Auditorium	1-April-2016	9:00 a.m. – 7:00 p.m.

Panel members	**Initials**	**Distribution:**
Organizer: J. Dilling		P. Bricault, A. Gottberg, J. Mildenberger, W. Paley, G. Minor, A. Trudel, M. Nozar, A. Messenberg, B. Laxdal, R. Kruecken, R. Dawson, E. Guetre, A. Perera
Reviewers: L. Young (SLAC) R. Bennett (MSU) P. Delahaye (GANIL, chair) Excused: D. Stracener (ORNL) (notes received after the review) Note: It is not practical to get signatures from external reviewers		

Review Panel Findings	**YES**	**NO**
Are the requirements adequate?	x	
Does the concept have the capability of meeting the requirements?	x	
Additional problems identified? More development is needed, per enclosed report	x	

Proponent Action	YES	NO
Continue with concept development?	x	
Signature of Proponents:		

Other Actions		By	Date

Documents

Type	Identification	Description
Requirements	Document-118534	ARIEL Top Level Requirements

Comments

AGENDA

09:00 Welcome and goals of review Jens Dilling
09:10 ARIEL target stations design study overview Pierre Bricault
10:00 Electron target, converter and target station concept Alexander Gottberg
10:55 Coffee break
11:20 Waste disposal strategy Joe Mildenberger
11:40 ARIEL target life cycle William Paley
12:10 Lunch
12:55 Tour
13:40 Remote handling services & hot cell facility Grant Minor
14:10 Shielding requirements Anne Trudel
14:40 ARIEL Target Station Shielding Design Mina Nozar
15:00 Coffee break
15:25 ARIEL Target Hall Layout Allon Messenberg
15:50 Design and commissioning plan Pierre Bricault
16:10 Start-up and development strategy Alexander Gottberg
16:35 Discussion
17:20 Closed meeting for the committee
18:20 Close-out meeting

PRESENTATIONS

http://elinac.triumf.ca/targets/presentations/aete-target-station-external-review

REVIEW PANEL REPORT

Following pages

Review of the ARIEL Electron Target Station East Conceptual Design

Report from the review panel

TRIUMF, Vancouver, 2016 / 4 / 1

Review contributors

P. Bricault, A. Gottberg, J. Mildenberger, W. Paley, G. Minor, A. Trudel, M. Nozar, A. Messenberg

Hosts: J. Dilling and Robert Laxdal (Review organization)

Panel composition

L. Young (SLAC), R. Bennett (MSU), P. Delahaye (GANIL, chair)

Excused (notes received after the review): D. Stracener (ORNL)

Table of contents

The review consisted of talks and discussions around the **A**RIEL **E**lectron **T**arget Station **E**ast (**AETE**) Conceptual Design. The agenda of the review is given in appendix. The material presented and received before the review gave to the panel precise information on the AETE conceptual design and present status. The panel appreciated the high quality of the documents and talks relative to the review and in general the review preparation and organization.

<u>Mandate</u>

The review panel has to answer the following questions in reviewing the concept of AETE (ARIEL Electron Target station East):

1) Is the presented concept a viable solution for a 50 kW operation of Radioactive Ion Beam (RIB) production?

2) Does the presented AETE solution allow to be operational at 100 kW in the future?

3) Is the presented AETE RIB development and upgrade strategy appropriate?

The answers to the questions are briefly summarized below. Recommendations and comments are developed in the following sections.

<u>Is the presented concept a viable solution for a 50 kW operation of RIB production?</u>

The review panel believes the solution of the electron to gamma converter proposed by the proponents will arguably be meeting the requirements of an operation at 50kW for RIB production at ARIEL. The solution was very well justified in the presentations. The converter is an elegant solution to cope with the high power required by the operation of AETE to be competitive with other facilities producing RIBs by the ISOL method. It will permit to overcome the problem related to high power deposition in the fissioning target without compromising the fission fragment yield.

<u>Does the presented AETE solution allow to be operational at 100 kW in the future?</u>

Yes, it arguably does. The solution with one converter is limited to 80kW operation because of the deposited power in the target (11% of the incoming power) which is difficult to actively cool down. An operation at 100kW or more would either necessitate the use of several converter and targets, or extending the size of the converter and target. Reservation of space in the target vessel should be done in this intent. It has to be noted that lighter targets could also possibly cope with higher power than 80kW in the converter.

As discussed during the review, the RIB intensities will scale at very best linearly with the primary beam power. The extension of the target and converter size, or the addition of converters and targets coupled by new transfer lines to the ion source will certainly cause longer effusion times that will reduce the release efficiency for short-lived isotopes. For this reason, it is recommended that other developments aiming at reducing the release times, potentially yielding RIB intensity increase higher than 1 order of magnitude as presented during the review, are given higher priorities than the 100kW power increase.

<u>Is the presented AETE RIB development and upgrade strategy appropriate?</u>

The review panel has found that the upgrade strategy presented in the review was very convincing. The development strategy relies on learned experience from facilities worldwide. The development of the modular system allows for long term perspectives, easing target exchange, maintenance, repair operations and upgrades. The hermetic target vessel allows for conditioning the target - ion source before getting it on-line, and the use of target materials that may be reactive to air. The phased development of the converter, from simple to more difficult, sounds very appropriate. The upcoming test using the electron beam irradiation test stand to qualify the material bond of the high Z converter to the aluminum cooler will certainly give rapid information on the technical feasibility of the converter. Based on present experience with ISAC, the whole process flow including target changes/remote handling, life cycle, target disposal, required shielding, and infrastructure has already been investigated quite in depth for a conceptual review. No showstopper has been found in this investigation.

Recommendations

During the review, some points were raised concerning the critical parts of the target station. These particular points should be addressed for the preparation of the Preliminary Design Review (PDR).

- The methodology developed by the proponents is excellent (e.g. PFMEA and DFMEA before final design, using a Remote Handling System wherever applicable, mockups for testing the RHS, commissioning strategy and eventually operation of the RHS, 7 shifts/week). Applying such methodology will require manpower. It is therefore recommended to proceed to the evaluation of the requirements in manpower for all these phases for the next review.
- Expect pressure to scale back RH testing when time and budget become scarce. Develop resource loaded schedule that identifies adequate time and resources to complete the required testing.
- It is also recommended to develop automated processes ("Push Button/Get Result") for reducing the manpower needed for target exchanges.
- HV breakdown of the ISAC target module: this problem should be fixed using a HV feedthrough. For the development of the solution it is recommended to get advice from a HV expert.
- Continue pursuing avenues that will keep thermal risks at a manageable level, but result in the needed increase in isotope yield or purity. For the PDR, provide a cost-benefit analysis for comparison of the various paths, including increase in power.
    - Analyze and/or experimentally measure the yield increase of UCx nano-structures.
    - Analyze and/or experimentally measure the yield/beam purity increase of various ion sources.
    - Analyze and experimentally measure the thermal improvements achieved by the wedge-style converter. Optimize converter geometry and materials.
    - Calculate/quantify the improvement in desired purity using e-beam vs protons
    - Optimize (a) target shape; (b) converter-target geometry; (c) target shape-ion extractor arrangement, or report on such studies if already done, or quantify the maximum gain that could be obtained with such optimization.
    - Estimate the risk of failure of multi-targets for P_e>50kW compared to single targets for P_e<=50kW.

- Given all the above, determine the maximum practical likely operating P_e (which could be lower than the desired 100kW design target), and define the thermal management strategy to meet this level of operation as well as what paths might be needed to get to 100kW if deemed a necessary future operating realm.

- Demonstrate reliability and robustness of critical connections (HV, water, vacuum) as part of prototype design. Consider setting up cycle-testing for one or more of the planned connection designs; consider a set-up that mimics the likely remote handling parameters. Continue developing module interconnect design with emphasis on remote handling and reliability.
- For vacuum design: Design carefully any proposed activity near inaccessible vacuum sealing surfaces so that such surfaces will not easily be damaged. (For example, the motion of retraction and lift of the target vessel should be done with ample clearance from the beamline seal surfaces).
- For PDR, consider addressing critical spares strategy (Target Module).
- For PDR, address retraction mechanism/methodology – how to achieve high reliability in high rad zone? Does the retraction/insertion mechanism have to be electrically driven? Can it be all mechanical? Perhaps pneumatic? Design of the mechanism for remote maintenance should also be addressed.
- For PDR, estimate the necessary resource for operation and running costs, taking into acount the risk of failure of one of the three operating target station component. Integrate the repair time in the operation / maintenance schedule estimate.
- By PDR, resolve method of supporting the modules within the shielding (i.e. the structural framing).
- For PDR, address sensor (mechanical position, engagement, etc.) strategy – how to ensure high reliability (how much redundancy?) in high rad zone?
- For PDR, address the radiation sensor strategy – placement, etc. to verify shielding calculations and define what needs to be monitored during operation.
- For PDR, address the requirements for safety controls/interlocks to be integrated with the e-beam safety system.

<u>Observations/Comments:</u>

- The AETE team's "systems" philosophy/approach is excellent and shows not only deep understanding of the technologies and implementation, but also the high value of incorporating the many collective lessons learned by experience into the design. Especially impressive is the great attention that has been made (a) to identify and set up plans to address high risks (via PFMEA and DFMEA and experience), (b) to consider all requirements across the full range of design, build, install, commissioning, operation and service, and (c) to consider all use cases, including the "what could go wrong" along with usual operation.
- The modular approach is a very good way to manage risks and "localized" serviceability as well as to develop a system that can be extended or for which not every aspect is perfectly known.
- The approach of a hermetically sealed target vessel enables radiation containment and also manage serviceability/maintenance costs (time/parts).

- The approach of providing utilities services (high voltage, water, compressed gas, vacuum) through main feedlines to the modules should minimize risks of leakage or other service discontinuities while enabling straightforward troubleshooting and service. Deploying the HV, gas, and water feeds through the TM and then distributing to the Target Vessel should work (but see recommendation to test the critical connections!). Keeping the disconnects outside of the target vacuum vessel is an excellent design choice. It appears that operations would be possible even with small amount of leakage.
- The commissioning vision appears to be well thought out, too, taking a stepwise approach, testing each of the portions of the system, and then testing the full system end-to-end first at low power then increasing to higher powers.
- Calculations are showing that increasing electron power beyond 50kW may not result in dramatic increases in isotope yields, but does increase the complexities of thermal management. At some point beyond 50kW, the heat dumped into the target will exceed what is needed to maintain the 2000C for isotope extraction. This introduces the need to cool the target, which is an added complexity.
- The team has identified a number of critical tests that must be performed early on (converter, high voltage connections, remote handling tests, etc.). In some cases, plans are complete and in other cases, the plans are in formulation.
- Waste management and general radiation protection seem well understood. The radiation generation contributions from protons far exceed those of electrons. Basing the waste handling strategy on the current known process is an excellent decision that is expected to result in successful waste handling, free up resources to work on other tasks, and result in lower cost to the project.
- License for the disposal of nano UCx will likely need to be applied for separately from the current solid material license. This is already integrated in the plan for development of nano UCx.
- The remote handling sequences for exchanging target vessels and target modules have been conceptually determined. It appears that a number of use cases have been considered and analyzed to define the general use of each of the three hot cells, and the materials flow between them.

Appendix: Review agenda

TRIUMF | Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

ARIEL Electron Target Station East
Conceptual Design Review

Friday, April 1st, 2016
Auditorium

Agenda

Time	Talk	Presenter	Duration	Questions/ Discussion
09:00	Welcome and goals of review	Jens Dilling	10m	0m
09:10	ARIEL target stations design study overview	Pierre Bricault	40m	10m
10:00	Electron target, converter and target station concept	Alexander Gottberg	45m	10m
10:55	Coffee break		25m	
11:20	Waste disposal strategy	Joe Mildenberger	15m	5m
11:40	ARIEL target life cycle	William Paley	20m	10m
12:10	Lunch		45m	0m
12:55	Tour		45m	0m
13:40	Remote handling services & hot cell facility	Grant Minor	20m	10m
14:10	Shielding requirements	Anne Trudel	20m	10m
14:40	ARIEL Target Station Shielding Design	Mina Nozar	15m	5m
15:00	Coffee break		25m	
15:25	ARIEL Target Hall Layout	Allon Messenberg	20m	5m
15:50	Design and commissioning plan	Pierre Bricault	15m	5m
16:10	Start-up and development strategy	Alexander Gottberg	20m	5m
16:35	Discussion	All	45m	0m
17:20	Closed meeting for the committee		60m	0m
18:20	Close-out meeting		30m	0m
18:50	Dinner			

<u>Review Committee Members:</u>
Pierre Delahaye, GANIL (Chair)
Richard Bennett, FRIB
Dan Stracener, Oak Ridge National Laboratory
Lydia Young, SLAC