STAR Forward sTGC Tracker Review Recommendation Responses

Chi Yang (Shandong University)

fSTAR Face to Face Meeting, Jan.19-20 2021

STAR

Review Charge Questions

1. Has the team demonstrated through prototyping and measurements that the performance of the component meets the physics requirements?
2. Is the QC program in place to ensure the testing and assembly of the component will yield a device that meets the requirements? Are the procedures for mechanical production, and assembly well documented and understood?
3. Does the schedule and workforce allow for installation in 21-22 shutdown period (summer 21)?
4. Are the installation process and the component interfaces sufficiently understood to ensure that the components can be installed safely and without damage? Are the installation procedures adequate?
5. Are safety and ES&H addressed in design for installation and procedures.

- **Review Webpage**
  - https://indico.bnl.gov/event/9882/
- Review webpage password available form the STAR collaboration.

Executive Summary

- The sTGC group is completing an extensive prototyping effort for the STAR sTGC. Data collected on earlier prototypes indicate the sTGC design will exceed the required performance. However the data on the final pentagon module design is not yet available. A couple points in the pentagon module are concerning. The capacitors used in this module are not qualified so there is some risk of failure. There is also concern related to the traces on the PCB board which could lead to increased crosstalk. The collaboration may choose to proceed with construction, but they should be cognizant of the outstanding risk. Hopefully the test data will be available soon.
- The production schedule is tight but feasible.
- STAR intends to perform full system tests to the detector using the prototype detectors. The FEB are very flexible and can be used to test the DAQ early. The 2021 run will be used to test the full system under operating conditions. This plan is likely to yield a successful 2022 run.
- The safety of the gas system has been thoroughly investigated and the group is in good contact with BNL safety. A full system review should be performed when appropriate.
- The design of the installation infrastructure is proceeding rapidly, but is in good shape. Additional engineering support should be considered to maintain schedule.
- Additional QC steps are included in the recommendations.

1. Has the team demonstrated through prototyping and measurements that the performance of the component meets the physics requirements?

Not yet but soon. The prototype data exceeds requirements, but the data from the final design modules is not yet available.

1.1 Findings

- The Shandong University group has extensive experience in constructing sTGC modules having built ~20 prototypes. The performance of the prototype modules exceeds the performance requirements with a detection efficiency >95%, the number of bad channels of <1% and a resolution <200 um. Cosmic-ray measurements on the 60cm by 60cm module has an efficiency of 98%@2800V and resolutions /sigma σ_x (σ_y) = 144μm(135μm). However, the results on the pentagon modules are not yet available.
- The Shandong group has benefitted from the extensive ATLAS sTGC group efforts.
- The readout electronics has been successfully tested in the magnetic field present in the STAR magnet endcap where the detector will be positioned.

1. Has the team demonstrated through prototyping and measurements that the performance of the component meets the physics requirements?

1.2 Comments

- In the new pentagon module design the bias capacitors were changed from the traditional units to a different chip capacitor. The capacitors used have not undergone the extensive QC tests and years of use in the field that the traditional capacitors have. If possible the group should go back to using the proven capacitors. Otherwise the group will need to accept the risk of failure and they should perform QA testing to evaluate the probable impact.

Switched the capacitors to the traditional Murata units which were proven for long term use.

- The crosstalk should be evaluated with the newly designed pentagon modules. Some of the internal traces in the new pentagon modules look close which may lead to higher crosstalk than in previous prototypes.

Tested based on the pentagon prototype showed the signal distributions on the readout pads with both longest and shortest traces are comparable which indicated small impact of crosstalk.

- The consortia should evaluate the use of a low pressure regulator instead of the bubbler in the vent line as this makes the system operation independent of the vent line location information is on the last slide.

Low pressure regulator has been added.

- A lengthy discussion on the merits of moving to a 25ns shaping time instead of the presently used 50 ns took place. The collaboration should evaluate the existing data and the merits to taking data at 25 ns.

With VMM DAQ available, this check will be done.

1. Has the team demonstrated through prototyping and measurements that the performance of the component meets the physics requirements?

1.3 Recommendations

1. The collaboration management must decide if they accept the risk associated with starting the module procurement prior to having the results of the pentagon prototype module. In any event Shandong should present to the collaboration the results of the pentagon tests as soon as they are available.

Now we got preliminary results for pentagon prototype performance with position resolution which met the requirement.

2. The readout boards are being modified to add attenuation to the input. The boards should be reviewed after the change is implemented and tested.

The mapping of readout boards have now been reviewed by both USTC and SDU.

2. Is the QC program in place to ensure the testing and assembly of the component will yield a device that meets the requirements? Are the procedures for mechanical production, and assembly well documented and understood?

Yes - The QC procedures presented seem adequate for the production.

2.1 Findings

- Travelers which document the production testing are available. The travelers include the ranges and criteria for when to accept the production step and when to reject the unit.
- The QC specifications for the readout boards will follow the ATLAS requirements.
- The procedures for shipping equipment from Shandong to BNL are well developed.
- The chamber wire tension is set by the winding machine. A qualitative check on the post soldered wire tension is achieved by looking at the uniformity of the wire deflections after the frame is released from the winding table.

2. Is the QC program in place to ensure the testing and assembly of the component will yield a device that meets the requirements? Are the procedures for mechanical production, and assembly well documented and understood?

2.1 Findings – Continued

- The front end electronics will dissipate more than a KW of power in a rather confined space. A forced air cooling system is foreseen. The design operating temperature is ~50 degrees with an air flow of 300 cfm.

2.2 Comments

- The collaboration has developed a chip testing board and protocol for testing the VMM chip. It is unclear if the full functionality of the VMM chip is planned to be tested.

Yes. It is planned to be tested at USTC.

- The cleanliness requirements for all gas components should be checked.
- Native speakers should review the procedures and travelers used for the module construction and provide feedback to the upgrade coordinators.

Done.

- A prototype test of the gas cooling might provide answers to both the thermal adequacy of the design and also address the concern of possible vibrations due to the high air flow rate.

See responses from Prashanth.

- The flatness in the region where the signal feedthroughs are on the chamber cathode board should be checked as part of the QC process. In general the smoothness of the cathode surface should also be checked.

Have been added in the QC procedure.

-

2.3 Recommendations

3. The full functionality of the VMM chip should be tested following the ATLAS protocols.

It is planned to be done at USTC.

4. The travelers should include the name of the person filling them out and the date.

Corrected.

3. Does the schedule and workforce allow for installation in 21-22 shutdown period (summer 21)?

Yes – The module production schedule has roughly 1 month of float. Other systems are less critical. The schedule is tight but possible. The collaboration appears to have the required workforce. Additional engineering support for integration installation would be advisable.

3.1 Findings

- The Shandong University team consists of 3 faculty, 1 PhD student, 1 engineer, and 3 technicians. The group has extensive experience in both ATLAS and STAR. The team is well qualified to manufacture the sTGC modules.
- The group has manufactured numerous prototypes which has allowed the production process to be optimized. The groups has a realistic schedule for manufacture based on fabrication experience.
- If fabrication begins in November the module production will be complete in April including the week break for Chinese new year. If shipping requires 1 month (allowing possible customs delays), then the delivery would be in may of 2021. This gives 1 month of float. This is tight but possible. The collaboration should continue to monitor the progress and develop contingency plans if there is slippage.

3. Does the schedule and workforce allow for installation in 21-22 shutdown period (summer 21)?

3.1 Findings – continued

- The FEB and ROD production can be competed concurrent with the module production.
- The sTGC will be installed in STAR in July of 2021. The schedule is included below”

Small Strip Thin Gas Chamber (sTGC)	61 days	Wed 7/7/21	Thu 9/30/21
Remove West Scaffolding	1 day	Wed 8/25/21	Wed 8/25/21
Install West Poletip	1 day	Thu 8/26/21	Thu 8/26/21
New Platform Installation	3 days	Fri 8/27/21	Tue 8/31/21
Rail and Support Structure installla	5 days	Wed 9/1/21	Wed 9/8/21
sTGCs Assembly onto the Frame	10 days	Wed 7/7/21	Tue 7/20/21
sTGC Installation in Poletip	5 days	Thu 9/9/21	Wed 9/15/21
Testing STSG	5 days	Thu 9/16/21	Wed 9/22/21
Comissioning STSG	5 days	Thu 9/23/21	Wed 9/29/21
Remove STSG Platform	1 day	Thu 9/30/21	Thu 9/30/21

3. Does the schedule and workforce allow for installation in 21-22 shutdown period (summer 21)?

3.2 Comments

- If the travel restrictions to BNL persist into next spring then the installation and commissioning of the detector will become much more difficult. The groups should consider how best to proceed in these circumstances. Steps could include training additional experts, setting up additional test stands to train US collaborators, and other measures.

Regular online discussion on electronics and DAQ was planned. All essential experts are on their positions.

3.3 Recommendations

BNL should provide any assistance possible to enable critical travel.

4. Are the installation process and the component interfaces sufficiently understood to ensure that the components can be installed safely and without damage? Are the installation procedures adequate?

The interfaces have been adequately defined to enable chamber production as long as no fiducial monuments are needed. The installation infrastructure is still being designed, but we see no serious show-stoppers. A review of the full system should be performed after the design is complete.

4.1 Findings

- Design of the support structure and installation tooling is proceeding rapidly, converging on a final design and review, with an anticipated completion by Jan ‘21.

4.2 Comments

- The chambers have no external fiducial points. The collaboration should verify that none are needed. Adding targets to the hanging brackets would not be difficult. A survey plan is needed.
- For the in-depth engineering analysis consider all out-of-plane forces that may be introduced into the support structure. Forces/moments such as electronics, cooling connections, cables if applicable should all be considered.

See responses from Rahul and the integration group.

4. Are the installation process and the component interfaces sufficiently understood to ensure that the components can be installed safely and without damage? Are the installation procedures adequate?

- A 300 CFM design air flow for cooling could cause unanticipated vibrations in the tracking system. Consider examining design velocities and ensure a positive means to reduce vibrational effects to the system if needed.
- From a very brief examination of the present design of the pentagon connections, it appears that the system could be statically indeterminate. This potential over-constraint should be examined in order to reduce any possible internal stresses generated from these supports.
- The lead engineer is planning to hold a final design review of the support structure, installation tooling, lift plan and installation procedure. The committee fully endorses this. It is a valuable step in ensuring that there are no unanticipated problems in the design, fabrication, installation, and operation of the tracker. This should be done prior to the start of fabrication of the installation infrastructure.
- Please ensure that the structure is adequately grounded.
- If dry gas is used then the piping needs to be designed to prevent static charge buildup.
- The lead engineer has done a fine job in reaching out to the BNL shops (F&O Fabrication Services) early so that they are aware of the scope and timeframe for the support system fabrication. In this way he can work with shops management to ensure the appropriate level of priority that this fabrication work requires in order to be completed by spring of ’21 and stay on schedule.

See responses from Rahul and the integration group.

4. Are the installation process and the component interfaces sufficiently understood to ensure that the components can be installed safely and without damage? Are the installation procedures adequate?

- The lead engineer for the sTGC support structure and associated installation tooling has many concurrent jobs that he is presently working on. It is important to have a realistic plan for his workload in order to ensure that his obligations to the sTGC program remain a top priority. Additional engineering support may help alleviate any potential delays in getting this work completed. Consider bringing in temporary help to assist him in some of the analysis that needs to be done or help in developing the written lift plans and installation details that will be needed for the design review.
- The lead engineer has done a great job of anticipating the safety requirements for installation. His efforts in reaching out to C-AD and other lab level safety subject matter experts is commendable. He is addressing the need for a safe and efficient method of transporting the assembled tracking system from the Assembly Building into the IR area. He is also addressing the need to adequately protect the IR vacuum pipe, and along with his plan to develop an Engineered Lift Plan should provide a seamless and safe installation plan for the detector. They should continue these efforts.

See responses from Rahul and the integration group.

4. Are the installation process and the component interfaces sufficiently understood to ensure that the components can be installed safely and without damage? Are the installation procedures adequate?

- The route of the gas vent line should be determined as its height will impact the system back pressure. The pressure head will impact the gas system if a low pressure regulator is not adopted. This gas line needs to be heated at the exhaust.

Vent line from sTGC chambers is mostly flat. A low pressure regulator is adopted now. Both supply and vent lines are heated.

4.3 Recommendations

6. A final design review must be performed prior to the start of fabrication of the installation infrastructure. This should include the support structure, lifting plan, installation tooling, and the installation plan.
7. A design of the cabling system, including cable strain relief, is needed. Here strain relief is critical as the load is transferred to the connectors on the detectors which are surface mount. Cabling weights need to be included in the structural analysis.

5. Are safety and ES&H addressed in design for installation and procedures.

The group is addressing ES&H considerations appropriately.

5.1 Findings

- Safety officials at the sTGC module fabrication facility perform monthly random inspections.
- The gas system group has been in good contact with the Brookhaven safety committee and the prototype gas system has passed the safety reviews.
- The gas system exhaust line will be heated to prevent condensation.
- The sTGC system as a whole will be reviewed by the accelerator division as part of the readiness review process.

5.2 Comments

- The air cooling system has yet to be shown to the gas safety system. With the continuous air purge from the cooling system it seem unlikely that the gas sniffers will ever trigger if the cooling is on. The safety review committee should look at the interaction of the cooling system and the gas detection system.
- Redundant gas sniffers should be considered to decrease false alarms.

5.3 Recommendations

8. The gas system should proceed to a full system review as soon as possible.

Not done yet, but we invite/talk to safety experts time to time.