The committee has met on a weekly basis to discuss issues and solutions. The experts have presented their summary and finding in one of the weeks and the material has been uploaded to an indico: https://indico.bnl.gov/event/10740/

We also have constant email exchanges and small group meetings to discuss progress and action items. I would like to take this opportunity to thank all the committee members and TPC experts for their dedication and determination to identify issues and propose solutions.

In summary, we believe that the main issue is resolved. The root cause is from an inconsistent use of database of a critical calibration table which transfers drift timing between Gating Grid and anode wire to effective geometry (see details below). The proposed and agreed strategy is to use same geometry and T0 calibration method for all BESII data and calibrate them (all run19,20,21) all together. There are still difference in dynamic distortion more severe at 19.6GeV and progress better toward lower energy. Another issue is the event-by-event T0 variation due to the long bunch up to one full bunch crossing (100ns). This results in a track displacement variation of up to 5mm. The TPC calibration team has carried out R&D before the review and is finalizing the project to deploy into final production.

The committee has focused on the most basic calibration from the beginning, the timing calibration. It is possible that there may be other issues related to the geometry and distortion. Those are believed to be relatively minor for BESII but may be major for high luminosity datasets. On the other hand, I believe that it is outside of the scope of this review.

1. What is the status of the tracking and production calibration?

   the initial calibration was done with express stream and others, which yields reasonable data quality; However, there is a sDCA (negative at about 2mm at low luminosity) issue. The second round of calibration done with Irakli by changing the alignment to reduce the sDCA creates splitting in TOF. There seems to be no remedy to these two issues in 2019 and 2020 before the review started in February 2021.

   The issue has been identified:

   a) The EffectiveGeometry database entries are parameters used to correct for the drift between GG and anode, due to the wire location difference between inner and outer (0.8 and 1cm). the result difference in the drift by Garfield is about 1.2 and 1.7cm.
      Those are in the runs before run19. It is not really a geometry but a drift timing converted to distance.
   b) In run19,20,21, different approach is used to determine the tpcSectorT0offset, currently use prompt hits, however, the prompt hit correction time is different between inner and outer (0.32 vs 0.53cm).
      This results in the new database entries in the EffectiveGeometry of 0.93 and 1.1cm
   c) Because of this change, the triggerT0TimeOffset has to be changed as well because part of the time offset has been absorbed by the tpcSectorT0Offset from the prompt hit timing.
   d) TrgT0TimeOffset+tpcSectorT0Offset+EffectiveGeometry have to be updated correctly and coherently
   e) These crucial database tables were updated by Yuri in his calibration but the EffectiveGeomtry database table was not updated in the version used by Irakli or subsequent production
   f) With the fix, everything seems to fall into places.

We went through details of the timeOffset (T0). there are quite a few of them:

t1: timeOffset in padrow from pulser;
There is still a missing step of equalization of timing offset between rows.
t2: tpcSectorT0OffsetC from prompt hits;
t3: tpcRDOT0offsetC; (RDO deviation from prompt hits)
t4: triggerTimeOffsetC set at 2.372249us in April 2019 but was a different value before that. This is likely due to the change in iTPC electronics;
t5: tpcElectronicsC->tZero() set at -0.119 us;
t6: effectiveGeometry (another sets of timing) due to the drift between GG and anode, and also different drift timing between outer and inner sectors and prompt hits and regular hits.
t7: t0zoffset = -3*tau*Diftvelocity (tau=55ns for signal shaping time)
These 7 numbers have to add up together to get the final Z position.

2. Where is the bottleneck of the TPC calibration procedure?

the bottlenecks are:
a. there are not enough monitoring tools and plots which are consistent and agreed upon among the experts at different calibration steps.
b. there is not checklist (similar to travellers during the detector construction phase) to confirm and clearly document changes, updates and database entries from one step to the other.
c. major concern is the breakdown in some of the communication channels and coordination.

3. Are there enough collaboration manpower and resources for the tasks?

From Gene's presentation as the calibration team coordinator, it is clear that there are only two permanent experts on TPC calibration (Yuri and Gene). Yuri mainly focuses on T0, geometry, drift velocity, dE/dx, tracking and reconstruction; Gene on coordination of all detector calibration, space-charge distortion and alignment. Potential helpers in the collaboration usually do not stay long enough and usually lose the expertise when they leave.

4. How are the online/operation/fast-offline/PWGs efforts coordinated to accomplish the goals?

This is related to the lessons learned. In every step, the knowledge from the limited expert manpower is relatively self-contained and does not propagate well to the next step. This includes the information about trigger/T0/pulser from operation at first step, timing, dE/dx calibration at second step, distortion and geometry at third step and physics quantity QA at last step. Both experts and committee feel the need to improve communication and coordination. If the communication and work format stay as it is, we have to establish documentation, checklists and QA tools consistently throughout the steps from operation to PWG analyses.

5. Is there a clear document of procedures in calibration and what are the unexpected and expected issues in BES-II datasets? What are the steps in calibration, and how are the current responsibilities assigned?

Documentations in blogs are available to the experts and collaboration. A centerized documentation was available before 2014. Every year, there is something new and unexpected

which consumes all the experts' effort. See slide#10 in Gene's presentation: https://indico.bnl.gov/event/10740/contributions/45615/attachments/32765/52338/TPC_CalibrationOrganization.pdf
Specifically to BESII, iTPC is effectively a new detector in run19. This new detector with new electronics requires new calibration in T0. That is what the committee focuses on to figure out potential issues. Refers to item#1 for the details of issues and solutions.

Documentation of such T0 values and database entries are necessary. The priority is to use the documentation as an administrative/engineer control tool to have checks/confirmations and reduce mistakes.

6. What is the timeline and path toward completion of whole BES-II calibration for production?

We believe that we have established a path forward.
a. Test production of 19.6GeV is done,
will also process 14.6GeV, and 11.5GeV and 9.2GeV for comparison and consistent checks of issues and calibration of T0 (separate time bucket vs cable delay)
b. Known issues need to be worked on and updated from the test production
TOF calibration; dE/dx calibration; dynamic distortion; event-by-event T0
c. Known issues without a good understanding or solutions:
I. known issues with inner sector time offset (distance) measured by charge step increase from 0 to 600um from inner most padrow to outer radius, but such feature now seen in outer sector.
II. variation of charge step (measured in distance from prompt hits) shows sin-wave variation and similar in east and west (cannot due to central membrane because both east and west show same pattern), TPC drift velocity from laser are measured to be quite consistent within different sectors. Gene brought up an issue with inner sector cluster deconvolution having discrete charge distribution. This certainty is more severe in the inner vs outer radius. Does this distort the charge step distribution?
c. We discussed about monitoring.QA. ALICE has a suit of automatic QA plots with different distortion/displacement monitoring.
https://lists.bnl.gov/mailman/private/star-tpccalrev-l/2021-March/000137.html
STAR has slightly different approach, Fast offline monitoring the large scale data quality. Offline calibrations are divided into several steps.
each step, experts monitor specific observables. Last monitoring QA step is from PWGs, which is quite productive in the fast offline phase. For the test production, similar QA is in the work.

7. Any lesson learned toward future runs?

	Drift v	Time offset	dE/dx	T0	dR_{Inner}	dR_{outer}	dR_{sector}	ExB static	GG	Distortion sDCA	QA
Pulser		x	X								
Laser	X										
Cosmic					X						
Data		prompt hits	X	X? 2018		X2014	x	Model		x	V0
Survey									Garfield		
GMT											
TOF											x

Lessons from the TPC calibration issues in run 19 (listed in order of priority and urgency):

1. there should establish a checklist of changes and QA plots which are same at each step. Some of them may not be filled at early steps, but should be available with same quantities to be able to compare at each step the improvement or deterioration. Although there are significant QA at each step, it is often impossible to judge what changes because the quantities used are quite different.

2. in every step, the knowledge from the limited expert manpower is relatively self-contained and does not propagate well to the next step. This includes the information about trigger/T0 from operation (first step), timing, dE/dx calibration at second step, distortion and geometry at third step and physics quantity QA at last step. Both experts and committee feel the need to improve communication and coordination.

3. documentation and categorization of different parts of the calibrations could make it easier for non-experts to understand and participate in a meaningful way of helping.

4. There are different sets of calibration tools and data. It should be made clear what information is used for which specific calibration, and what data is used for QA. The precision and requirements should be clearly identified. The committee understands why the calibration is heavily relied on the actual production data in RFF magnetic setting only, which creates degeneracy between timing and geometry. The other datasets (pulser, cosmic ray, laser, GMT and FF) are under-utilized (see table above). This is where more collaboration manpower and resources may be used for.

Charge letter and committee 1/26/2021

We just formed the STAR TPC calibration review committee. It is timely and critical to look at the offline calibration tasks and issues. The committee is charged to evaluate the readiness of the TPC calibration for the BES-II data production and provide answers to the following questions by the end of March 2021:

1. What is the status of the tracking and production calibration?
2. Where is the bottleneck of the TPC calibration procedure?
3. Are there enough collaboration manpower and resources for the tasks?
4. How are the online/operation/fast-offline/PWGs efforts coordinated to accomplish the goals?
5. Is there a clear document of procedures in calibration and what are the unexpected and expected issues in BES-II datasets? What are the steps in calibration, and how are the current responsibilities assigned?
6. What is the timeline and path toward completion of whole BES-II calibration for production?
7. Any lesson learned toward future runs?

The members are:
Zhangbu Xu (Chair)
Bill Christie
Carl Gagliardi
Frank Geurts
Marian Ivanov
Ivan Kisel
Tonko Ljubicic
Maria Stefaniak
Jim Thomas
Qinghua Xu
Xin Dong (ex officio)
Rongrong Ma (ex officio)