September 30, 2015

Letter of Interest

Introduction

The CBM collaboration institutions: Heidelberg, Darmstadt, Tsinghua, CCNU, and USTC and the STAR collaboration are interested in installing, commissioning, and operating a "wheel" of CBM TOF detectors mounted on the inside face of the STAR east pole tip, for the RHIC run periods in 2019-2020. This endcap TOF (time-of flight) detector would extend STAR's particle identification (PID) in the intermediate momentum range to at least eta of -1.5. The installation would benefit CBM by providing a large-scale integration test of the CBM TOF system, including PID and calibration of the detectors, prior to the installation in CBM and the start of CBM operations. The installation would benefit STAR by providing critical TOF coverage for BES II (Beam Energy Scan, Phase II). Both the interested CBM institutions and STAR will participate in the analysis of the physics data provided by the CBM TOF detectors and benefit from the study of this data, including authorship of any publications from this data. PID over the extended rapidity range will greatly enhance the search for critical behavior. The energy range accessible to the fixed-target program is also significantly extended. We anticipate that several important questions of interest to the greater physics community may be answered by the data provided by this cooperative venture. These potentially important results would be otherwise unavailable without this endeavor.

This Letter of Interest will introduce the physics topics that can be addressed by this effort, outline the proposed contributions from STAR and from the CBM institutions for the endcap TOF installation, present a preliminary timeline, and address authorship and manpower contributions. We anticipate that the physics topics will be expanded into a physics proposal and presented to BNL for approval and to GSI for endorsement by December 2015. The equipment provided by CBM will be decommissioned and prepared for return to CBM following the 2020 RHIC run.

Physics Topics

The STAR iTPC upgrade is expected to be completed in time for the 2019 run and will increase the pseudorapidity coverage for reconstructed tracks with well-measured momentum from $|\eta|<1$ to $|\eta|<1.5$. However, in the range $|\eta|<1$ to $|\eta|<1.5$, the PID would be based on the iTPC alone unless TOF coverage is extended. That means that pions and kaons could be identified up to 0.75 GeV/c and protons can be identified up to 1.1 GeV/c. However, for $|\eta|>1$, the addition of an endcap TOF detector would extend pion and kaon identification up to 1.6 GeV/c and proton identification up to 3 GeV/c. In addition, electron identification is obtained for the range $0.2<pT<2$ GeV/c. The list of physics topics which will benefit from the endcap

TOF detector in BES II follow. In several cases, the topic is not available at all without the endcap TOF.

1. Dielectron measurements: even with the iTPC upgrade, the electron identification pseudorapidity range would still be limited to eta = +-1. With the endcap TOF, we can extend the electron identification to the range $|\eta|<1.5$. The expanded range will enable rapidity dependent measurement of excess dielectron production.

2. Net-proton, net-kaon, phi meson v1 measurements: extended PID over the larger acceptance in rapidity.

3. Net-proton, net-kaon kurtosis measurements: extended PID over the extended rapidity range. This is very important to the search for critical behavior since we have observed that fluctuation signals strongly depend on the pT and rapidity cuts of the protons.

4. Rapidity-dependent PID pT spectrum measurements: PID over an extended range in rapidity.

5. Rapidity dependent elliptic flow measurements for identified particles: PID over the extend range in rapidity. The phi meson flow measurement in particular will be improved with kaon identification up to 1.6 GeV/c in the extended rapidity range.

6. Proton correlation measurements expanded to the higher rapidity region: this is very important to understand the baryon stopping effect at each beam energy.

7. The fixed target program at STAR runs in parallel with beam-beam collisions. With the iTPC upgrade, the fixed target program would cover the center-of-mass energy range from 3 to 4.5 GeV. With the addition of the endcap TOF, the fixed-target program can cover the energy region 3-7.5 GeV, a region in which the baryon chemical potential range is significantly broader. This will allow the physics topics proposed for the normal beam-beam collision mode to be performed in fixed-target mode with extended baryon chemical potential.

It is anticipated that the physics topics outlined above will be developed into a full proposal and submitted to BNL and GSI by December 2015.

Prototype installation

It is considered essential for a successful installation for 2019-2010 that a prototype CBM TOF detector be installed for the 2017 RHIC run. There is no planned RHIC running in 2018 so this is the only opportunity to commission a limited system prior to 2019. The prototype will consist of at least one CBM TOF module and related read-out electronics. The primary goal of the 2017 installation will be to

commission the clock interface between CBM TOF and STAR TOF and to interface CBM TOF to STAR trigger and DAQ.

Endcap TOF installation for 2019-2020

CBM would provide:

Detectors and electronic readout. Electronic monitoring and configuration controls. Clock source. LV power supplies and controls. HV power supplies and controls. Gas mixing system and controls.

The proposed installation would include 36 CBM TOF modules with a total of 108 MRPCs and 6912 readout channels. The readout chain will terminate at a single PC. The CBM groups will provide software to interface the PC to STAR trigger and DAQ.

STAR would provide:

Gas connections from the mixing room to the detectors and the gas for operating the detectors. Rack space, power, and cooling for the power supplies. The interface to STAR trigger and DAQ. A reference clock signal to tie CBM TOF data to STAR TOF data. The mechanical interface to mount the detectors and the manpower for the mechanical installation. LV and HV cables. CBM could provide some of the cables if they can be reused at CBM.

It is noted that the endcap TOF detector provided by this installation is not intended to be a trigger detector.

Major project milestones

- December 2015: submit the physics proposal to BNL and GSI.
- June 2016: submit the plan and schedule for the prototype installation to STAR operations.
- June 2017: submit the plan and schedule for the endcap TOF installation to STAR operations.
- October 2018: Complete the installation of the endcap TOF system; begin commissioning.
- July 2020: Decommission the endcap TOF system and prepare the CBM TOF equipment for return to CBM.

Authorship, manpower

The participating CBM institutions would have full access to STAR data from run periods that include readout of detectors provided by CBM. There would also be common authorship on all papers making use of data from the CBM TOF detectors.

Heidelberg would provide a project manager to coordinate the installation and commissioning with STAR operations management. Tsinghua would provide a subsystem manager to oversee the operation of the detectors in STAR.
The CBM institutions will also assign PhD students to participate in the project. The total onsite support at BNL provided by the CBM groups for the period 2017-2020 is expected to be at least 24 man-months per year. STAR will provide the necessary technical support to integrate the CBM TOF detectors with the STAR TOF detector and with STAR trigger and DAQ.

STAR Collaboration

CBM Groups:

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