Response to PAC 51 Reader Questions

TDIS Collaboration

1. How has the TDIS collaboration evolved since this experiment was first proposed to today? Have there been any significant changes to the number of institutions, staff, or prospective students?

   With the addition of two run group proposals endorsed by the PAC, the number of spokespersons has grown to 12. The collaboration now includes 20 institutions and the experiment has been endorsed as a Hall A and a Super Big Bite (SBS) collaboration experiment, i.e. TDIS is backed by these two larger collaborations. Recently, a group from U. of Tennessee (N. Fomin, PI) has joined the collaboration and has taken responsibility for building the hadron blind Cherenkov detector. A group from Sao Paolo (M. Bregant, PI) has also joined to help with SAMPA based DAQ for the recoil detector. Several JLab staff (those who are not spokespersons themselves) have taken on responsibility for various sub systems, such as E. Christy (mTPC), E. Jastrzembski (DAQ), S. Malace (electron trigger), and S. Wood (tracking). Graduate students from MSU, Ohio U., U. of Glasgow, U. of Tennessee and U. of Virginia are prospective students on this experiment.

2. Could you please say more about the needs and plans for the additional 33 days of operations? Specifically:
   a) For the 13 day engineering run, it is understood that the beam luminosity will be increased in stages. How many days of running are needed at each stage? How will the optimal luminosity be determined?

   The TDIS experiment will have 3 new and complex detectors. The recent experience with commissioning new and complex equipment, such as the commissioning after the JLab 12 GeV upgrade and commissioning of SBS and BoNUS12 experiments, indicate that an engineering run is essential before beginning production running. Our request for additional time for an engineering run is informed by these experiences and the breakdown of activities listed below are based on the experience of the BoNUS12 experiment (there are significant overlaps of collaborators and spokespersons between the two experiments). The times assigned to these tasks are our best guesses.
   1. Establishing beam through 1 cm diameter 40 cm long straw target with and without solenoid field ON.
   2. Establishing optimal solenoid field with beam. (Tasks 1 and 2 : 0.5 day)
   3. Commissioning new Cherenkov and refurbished LAC as an electron detector with beam. (1 day)
   4. Establish and program electron roads for FPGA to get high-efficiency electron trigger with the SBS. (0.5 day)
   5. Establishing high rate mTPC DAQ and dead-times as a function of luminosity. (1 day, in parallel with task 3.)
   6. Calibration map of HV and gas flow settings for optimal operation of mTPC at different luminosity and target gas pressure. (0.5 day, in parallel with task 4.)
   7. Establishing coincidence between electron DAQ and mTPC DAQ. (0.5 days).
   8. Establishing and calibrating large angle single proton tracking in mTPC as a function of luminosity while monitoring rates and occupancy (with empty and H2 gas). (3 days)
   9. Establishing and calibrating two proton tracking in mTPC as a function of luminosity while monitoring rates and occupancy (with empty and D2 gas). (3.5 days)
   10. Establishing and calibrating proton and pion tracking in mTPC as a function of luminosity while monitoring rates and occupancy for kaon-TDIS (with empty and D2 gas). (3.5 days, in parallel with task 9.)
   11. Establishing background rates of two proton tracks in mTPC as a function of luminosity while monitoring rates and occupancy (with empty and 4He gas). (3 days)

12. Establishing background two hadron (proton/pion) tracks in mTPC as a function of luminosity while monitoring rates and occupancy (with empty, D2 and 4He gas). (3 days)
Total: 15 days- an increase of 13 days from original proposal.

b) For the additional 20 days of running to support pion and kaon SF measurements, how was the duration of 20 days arrived at? What improvement in physics measurement capability is expected with 20 additional days of data-taking? Is it possible to couple this additional 20 days to a quantitative measure of added physics performance?

Establishing high efficiency tracking with GEM based detectors in high rate and high background environments has proven to be very challenging in recent experiments, such as the SBS and BoNUS12 experiments. This experience motivates us to request additional time to run at lower beam currents in order to bank a set of relatively clean data set before running at the higher beam currents in the original proposal. The original proposal was approved with 10 days of running on hydrogen and 10 days on deuterium with a 50 μA beam. We are requesting additional 10 days on hydrogen and 10 days on deuterium at lower beam currents (20-30 μA). This results in the 20 days increase in the requested beam time.

3. The detector redesign and associated prototyping effort that has taken place since the experiment was first proposed is both impressive and important. What is the approximate expected timeline for obtaining results from the two detector prototypes? The first detector prototype will take data in Hall A at JLAB and at Fermilab this fall: what about the second prototype? When is it expected to be operated and where? Could you please comment on roughly when you expect to have results from this full complement of detector prototypes?

   We are done with the square prototype fabrication and plan to test it over the next couple of months, we can start working on the cylindrical prototype as soon as results from the current prototype are available; i.e. in about 2-3 months. Then it would take about 7 to 9 months to build the cylindrical prototype and complete all tests.

4. We note that the previous PAC commented that the choice of a 4.7 T solenoid magnetic field may not be optimal for the lowest momenta recoil protons. How has this been addressed? Has the performance for low momenta protons in this B field been studied in simulation?

   Yes, the proton detection efficiency was simulated using a TOSCA model of the 4.7T solenoidal magnetic field, for a 20 μm target wall thickness and 12 μm inner wall thickness of the mTPC. The target gas density was taken to be 6.4 $\times 10^{-4}$ gcm^{-3} and the region between the mTPC and target was assumed to be a mixture of 90% ^{4}He and 10% CH_4 at 0.1 atm pressure. The plot of the efficiency obtained from this simulation exercise is shown in Fig. 1 below. The experiment will use recoil protons in the 100 - 400 MeV/c range.

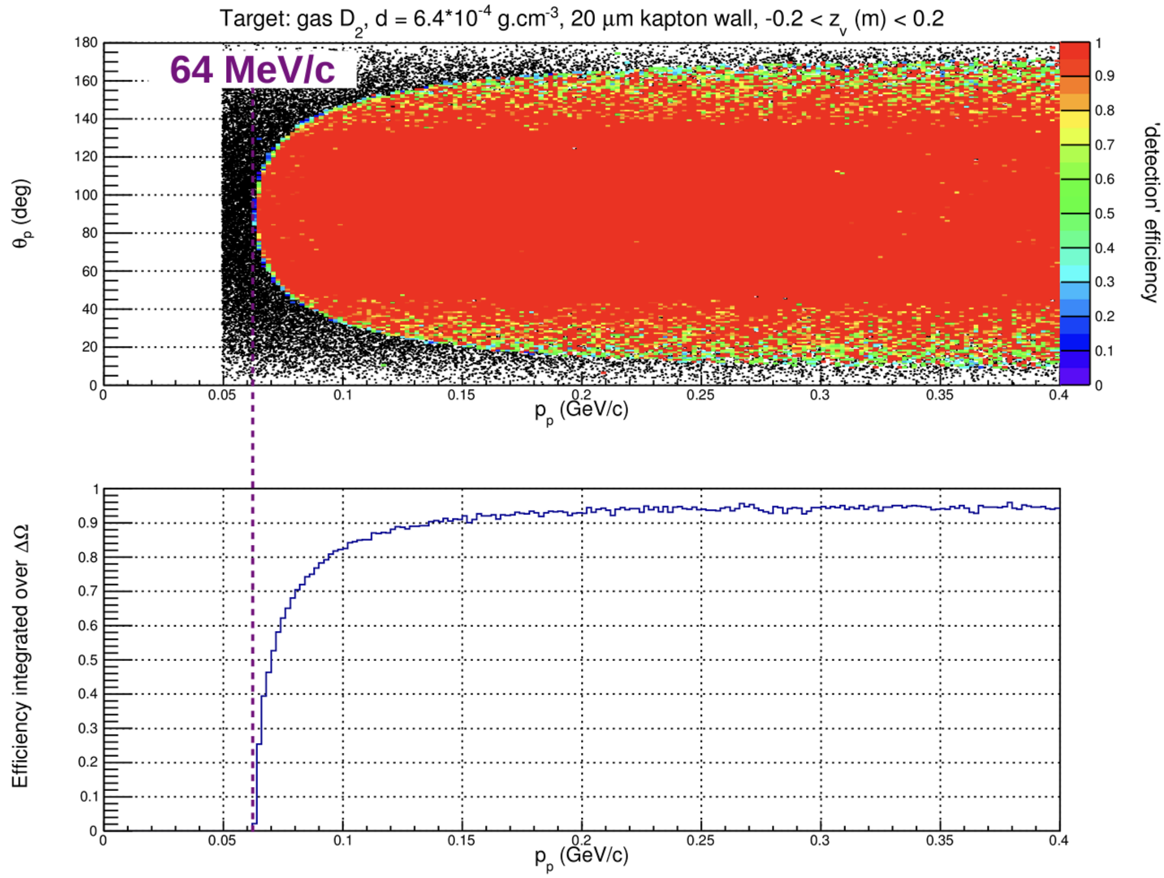

Figure 1: The detection efficiency of recoil protons as function of the azimuthal angle (top) and the proton momentum (bottom).

5. It is mentioned in the update that new developments in TDIS theory since 2015 have resulted in an expected increase in the TDIS signal yield. Could you please give a rough sense of how much larger a signal rate is expected based on these new developments?

   A global analysis including the HERA data on the pion structure function along with the Drell-Yan data has shown some interesting shifts on the peak of the pion valence quark distribution to lower x, these imply that the pion are a larger fraction of the nucleon quark distribution and less sensitive to the pion flux factor. These increases could be as much as $\sim$30% on average. This implies if the predictions are correct we will be able to run the experiment at lower currents than proposed; helping improve the background and hence mitigating some of the high rate and high occupancy tracking challenges. In Fig 2 below we show the ratio of the new to old tagged structure function for the 250 - 400 MeV/c recoil protons.

6. Thank you for providing links to the white and yellow papers, but is it possible to please elaborate on the 50 new publications that have bolstered interest in the TDIS run group of experiments: is it possible to provide a list of these publications?

   Please find attached a list of publications and a citation summary from the Inspire database.

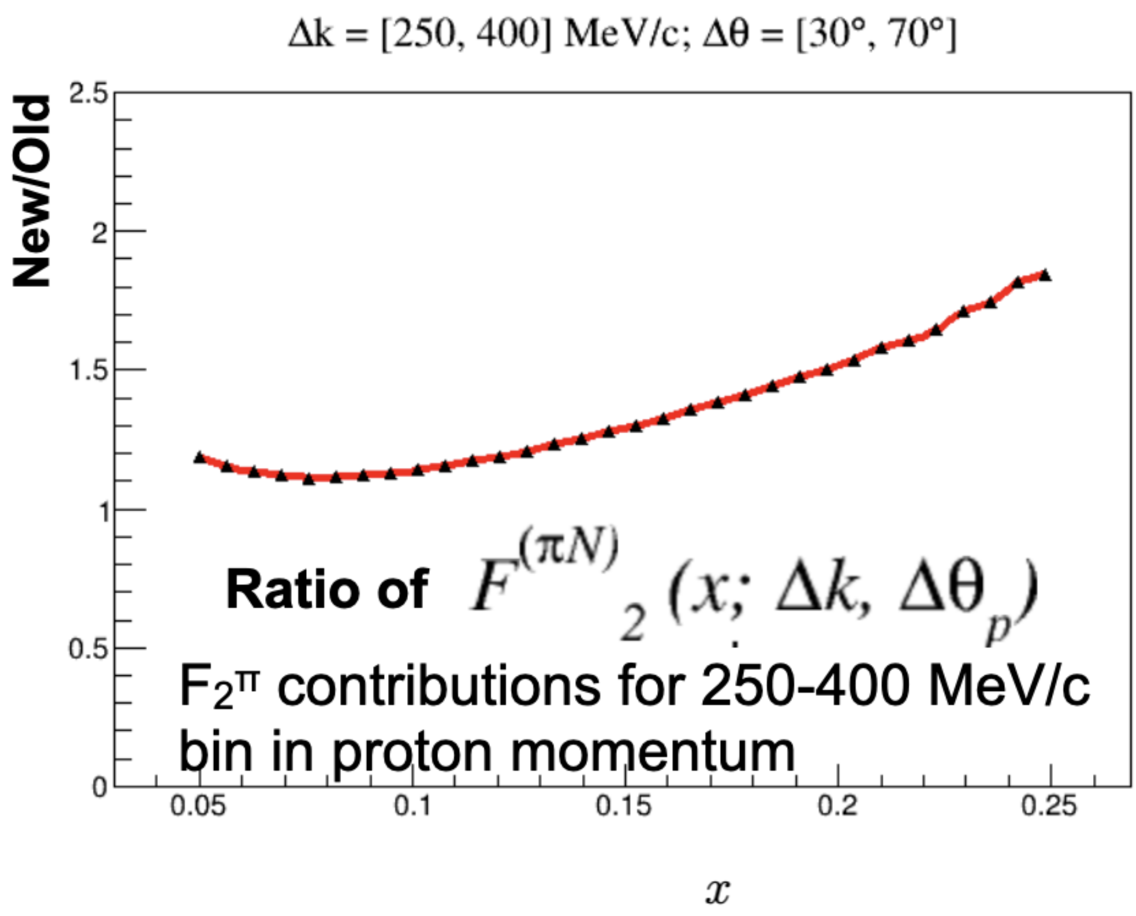

Figure 2: Ratio of the new $F_2^{\pi N}$ tagged structure function for 250-400 MeV/c recoil protons to the old values. The average signal is ∼30% larger.