Control system for TAMUTRAP

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TAMUTRAP is upgrading from the 90-mm prototype to the full 180-mm diameter cylindrical Penning trap [1, 2] and which has been installed in the 7-T superconducting solenoid by June 2019. In preparation for it, there have been a number of hardware and software upgrades. These upgrades are for a mixture of improved capabilities and further ease of use for the user.

The first is the furthering of our scan automation for mass resonance measurements using the standard time-of-flight ion cyclotron resonance (TOF-ICR) technique. The original approach of patching LabVIEW and Python together [3] has been altered to a Python-oriented implementation, with LabVIEW being secondary. The upgrades to our scan automation are coded entirely in a Python program referred to as the Scan Automation System (SAS). The SAS allows us to get a wide range of measurements and configurations, and outputs the data in an easy-to-parse format for offline analysis.

We analyze the data collected using the SAS using the Time-of-Flight Fitter and Integrator (TOFFI) program. In a majority of publications, the TOF for an ion in a fit to the resonance curve is calculated as either being proportional to the radial energy, or is an integration based on an approximation to the electromagnetic fields. TOFFI however does its fitting through either numerical integration (such as Gaussian quadrature and trapezoidal summing), or through anti-derivatives and approximations like in the literature. The last phase of TOFFI's development is the inclusion of damping due to the cooling gas in the trap. This has been mostly achieved and can be seen in Fig. 1.

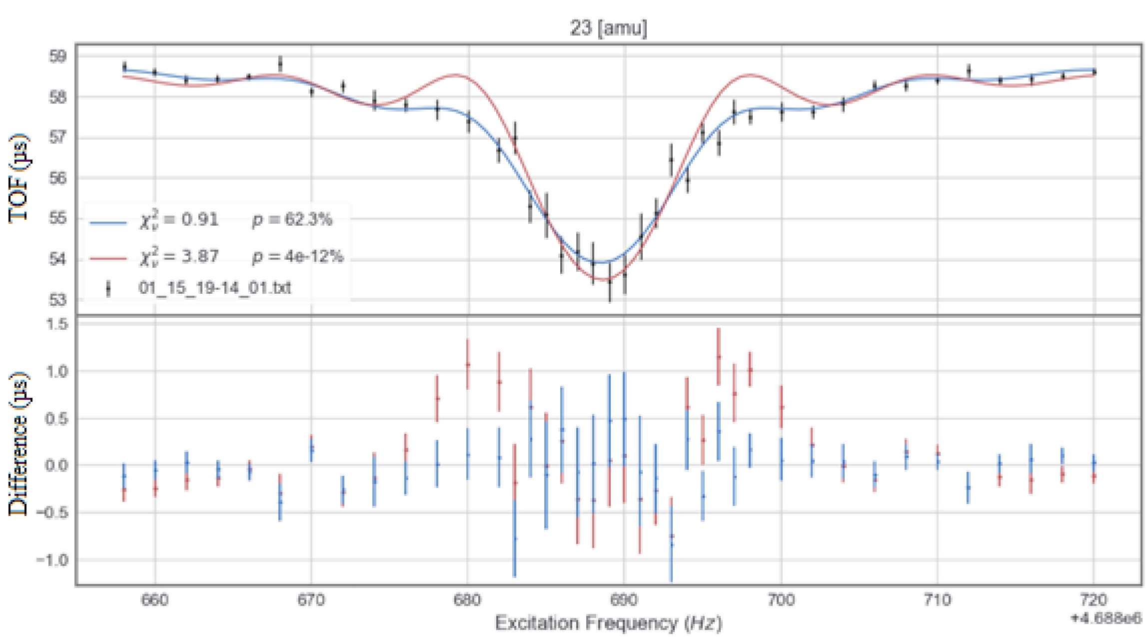

FIG. 1. Resonance spectrum for mass measurement of ^{23}Na. The red curves are fits without dampened structure due to gas pressure, whereas blue are with such structure. The blue is a recent upgrade of May '19, which as the χ^2 indicates represents a significant improvement to the model.

The last large control system project is our PulseBlaster Signal Controller (PBSC). Previously, an FPGA was used to handle pulse timings for controlling electrodes and such. A standing issue though was that its logic TTL was around 2.5V and noisy. For some equipment we required at least 3.3V to operate in certain manners, in particular we were not able to run our function generator in gated mode, complicating our scans as a function of rf frequency. In purchasing a PB24-100-4k-USB timing card, we now have a 5V TTL with the additional benefit of ns resolution on pulse initiation/termination. An enclosure (see Fig. 2.) was constructed for it and software was homebuilt (excluding some pre-made libraries) for use.

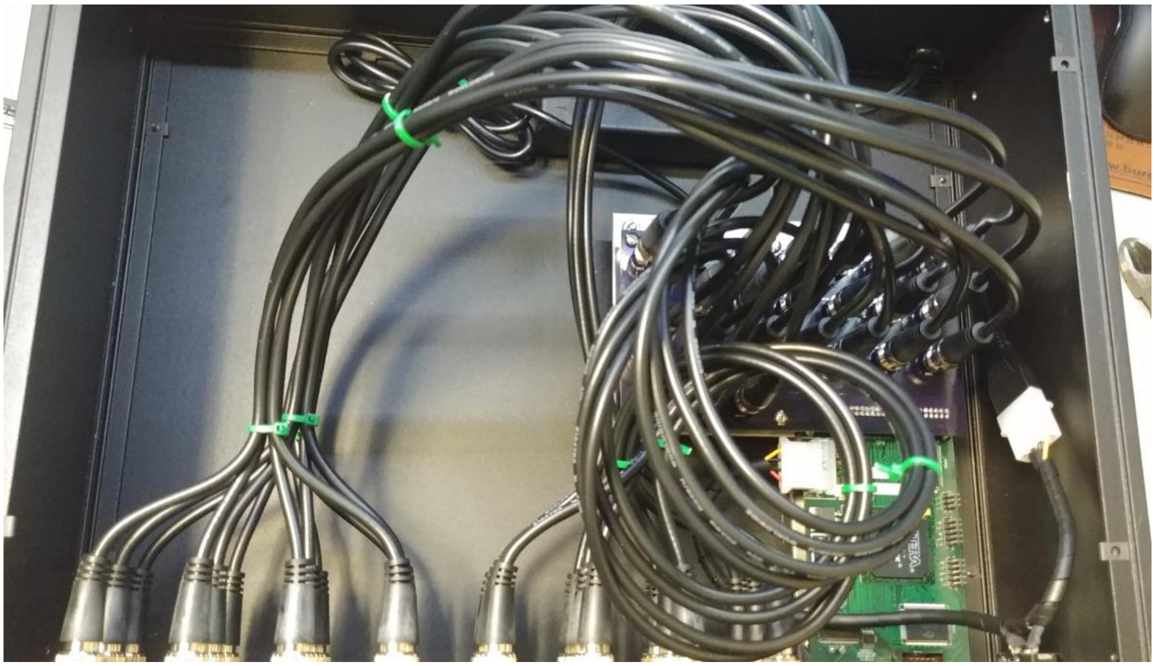

FIG. 2. Inside of the PBSC enclosure during construction. It has 24 channels for signal control run through a USB connection.

[1] V.S. Kolhinen *et al*., *Progress in Research*, Cyclotron Institute, Texas A&M University (2017-2018), p. IV-42.

[2] V.S. Kolhinen *et al*., *Progress in Research*, Cyclotron Institute, Texas A&M University (2018-2019), p. IV-45.

[3] R. Burch *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2017-2018), p. IV-46.