PPAC counting rate characterization

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Parallel Plate Avalanche Counters (PPAC) are widely used in nuclear physics to measure the presence of an ionizing particle and provide an accurate timing signal. It is widely rumored that these detectors are capable of handling a rate of up to one million particles per second. However, achieving this high counting rate is not trivial. In this report, we investigate the performance of a PPAC using a beam of ^{57}Fe @ 7.5 MeV/u.

The PPAC was fabricated at Michigan State University's National Superconducting Cyclotron Laboratory and subsequently refurbished there by John Yurkon. The detector has a 10cm x 10cm square active area. Aluminized mylar foils contain the detection gas (isobutane). A central anode foil (gold coated mylar) is positively biased to collect electrons. Adjacent foils with strip segmentation of the gold coating collect cations; these are 3mm from the anode foil. The gas-containing foils are 6mm from the strip foils when there is no bowing of the windows. Typical gas pressure of isobutane is 6 Torr, and bias voltages are typically between +500V and +600V.

Direct beam of ^{57}Fe from the TAMU K150 cyclotron was focused onto phosphor target approximately 30 cm downstream of the standard MARS detector focal point. The PPAC was positioned approximately 90 cm farther downstream. During the experiment, the phosphor used for focusing was replaced with a 709 ug/cm^2 CD_2 foil. The rate measured by the PPAC was studied as a function of the PPAC gas pressure, the PPAC bias voltage and the beam intensity.

The beam intensity was measured on FC02, a Faraday cup immediately at the exit of the cyclotron; this is not electron suppressed. It should be noted that due to drifts in the beamline optics magnets, this beam current can drift relative to the beam current at the PPAC position. For measurements taken sufficiently close in time, direct rate comparisons can be made.

The gas pressure is controlled with a gas-handling system (GHS) which utilizes an MKS520 controller. A pressure gauge just after the controller matches the set pressure on the MKS setting dial. A precision analog relative pressure gauge measures the pressure on the output line of the PPAC just before re-entering the GHS en route to the output line vacuum pump. The pressures reported in all figures correspond to the set pressure from the MKS controller. The reading on precision analog gauge is typically 0.6 Torr lower. The gas flow rate was varied from 15 to 50 cc/min and did not have a discernible impact on the measured event rates reported below.

The anode output of the detector was amplified with a fast timing pickoff (Spielier-type), which was then amplified with a fast amplifier (Ortec FTA 820) and then discriminated with a Tennelec constant fraction discriminator (TC-454) with an external cable delay of ~0.5ns. The bypass output of the fast timing pickoff went to a standard preamplifier ("hex-amp"), followed by a shaping amplifier (Caen N568B) which was sent to an oscilloscope for monitoring sparking in the PPAC.

Fig. 1 shows the measured PPAC rate as a function of beam current on FC02 with 8 Torr of isobutane in the detector with 580 V, 590 V, and 610 V applied to the anode. As beam current was raised, the measured counting rate rose, and then saturated. At rates below saturation, the counting rates agree within experimental uncertainty. The counting rate at saturation is higher for higher voltages. The lower two curves were stopped when saturation became evident. The higher curve was terminated when a single spark event was observed on the oscilloscope.

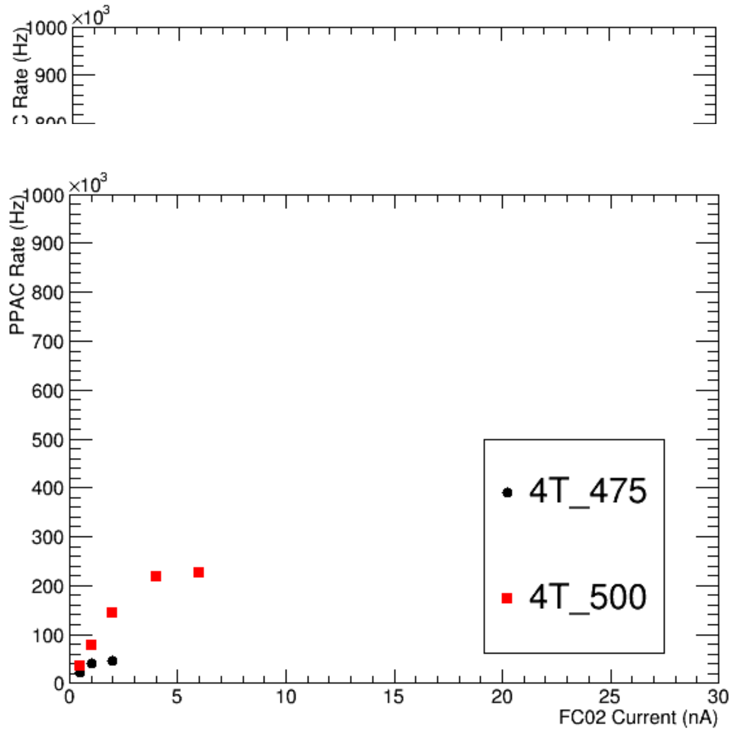

Fig. 2. Measured rate vs beam current, 4 Torr.

Fig. 2 shows the measured PPAC rate as a function of the beam current on FC02 with 4 Torr of isobutane at voltages of 475V and 500V on the cathode. These curves clearly saturate at a lower rate than at 8 Torr. A curve at 515V was attempted but stopped early on at the occurrence of a single spark event. It is not surprising that at lower pressure, a lower voltage is needed to induce sparking.

Higher voltages were explored at 8 Torr, allowing for some occasional sparking. Fig. 3 shows the measured rate as a function of beam current using 8 Torr with voltages of 620V, 630V, and 640V. The

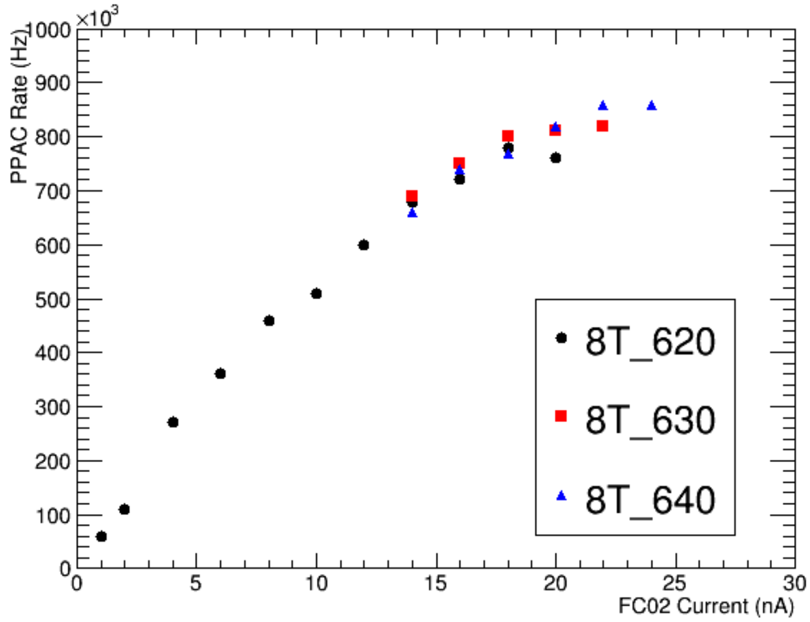

Fig. 3. Measured rate vs beam current, 8 Torr, high voltage.

horizontal axis cannot be compared directly to Fig. 1 due to slight changes in the beam optics which affect the transmission efficiency from the cyclotron to the detector. Still, it is clear that as the voltage is increased, the saturation rate rises. For this detector 860,000 counts per second was the highest measured rate. However, the actual rate on the detector must have been higher because some saturation is already present. Worse, the sparking at this pressure, voltage and beam rate, is steadily damaging the detector. These highest voltages are not sustainable on the time scale of even an hour, at least not with a beam of ^{57}Fe @ 7.5 MeV/u with an intensity of 100,000 particles per second spread out within a 1cm radius on the PPAC.

Sparking appears to come in bursts. At a particular voltage, a spark occurs on average once a minute for ten or fifteen minutes, and then for several tens of minutes only occurs closer to once every ten minutes.

After significant sparking, the detector reaches a lower saturation rate. Fig. 4 shows the measured rate as a function of the FC02 current for 8 Torr and 610V. After only minimal sparking damage (circles), the rate continues to climb, only beginning to saturate above 600kHz. After moderate sparking damage (squares), the performance is poorer, strongly saturating around 550kHz. After significant sparking damage, the voltage and/or beam intensity must be reduced to avoid constant sparking.

In Fig. 5, the saturation rate is shown as a function of the applied bias voltage. Data is shown for four different pressures from 4 Torr to 8 Torr. In general, higher voltage achieves a higher saturation rate. Higher pressure is needed to allow higher voltage to be applied. It is possible that at pressures beyond 8 Torr, higher voltage could be applied and allow the detector to measure more than 1,000,000 counts per

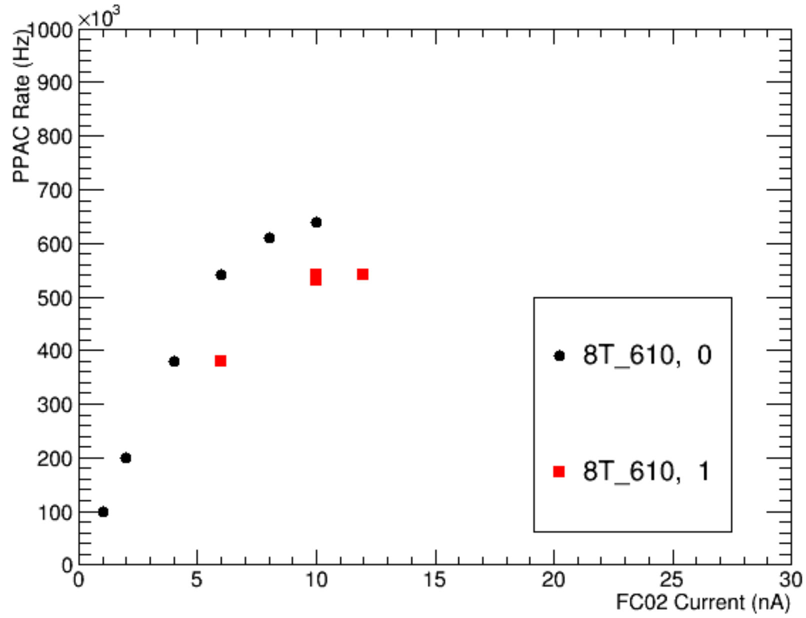

Fig. 4. Measured rate vs beam current, 8 Torr, moderate voltage. Damage evident. The 0 label refers to the earlier run, and the 1 to the later run.

second. Again, we note that such performance is not sustainable even on the timescale of an hour, as a few sparks cause damage, allowing (on average) more frequent sparking, and causing ever more rapid damage. It is certainly possible that having the ionizing radiation spread out evenly over the detector rather than concentrated within a 1cm radius would allow longer term survival of the detector; this is beyond the scope of this study.

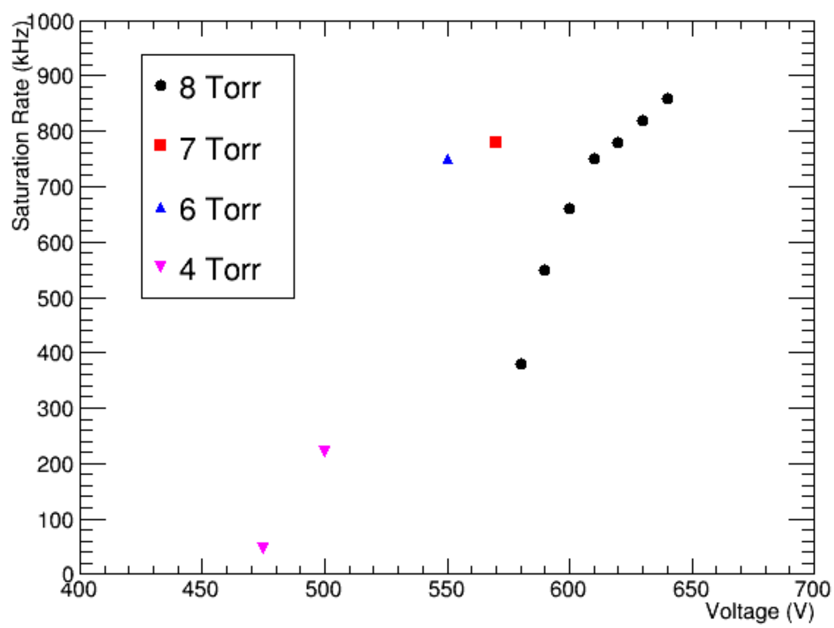

Fig. 5. Measured rate at saturation vs detector voltage.