DEVELOPMENT AND CHARACTERZATION OF A NEW DYNODE MULTIPLIER FOR MISSIONS TO HARSH RADIATION ENVIRONMENTS.

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Introduction: Focused mesh electron multipliers with discrete dynodes, such as the Johnston MM1, gained popularity through their use in mass spectrum devices, including the highly successful mass spectrum dust instrument, the Cosmic Dust Analyzer (CDA) on Cassini [1]. Due to their desirability in this area, the next generation of these detectors is being developed for future cosmic dust instruments such as the SUrface Dust Analyzer (SUDA) instrument proposed for NASA's planed mission to Europa [2]. The detectors are being fabricated by Microworks in Karlsruhe, Germany and tested at the Laboratory for Atmospheric and Space Physics (LASP) and the Institute for Modeling Plasmas, Atmospheres, and Cosmic dusT (IMPACT) in Boulder, Colorado. This paper presents the findings of these tests and describes tests underway to characterize the detector.

Scientific Motivation and Background: The SUDA instrument is a time of flight (TOF) mass spectrum instrument optimized to measure the compositional structure of micron sized particles *in-situ* around the moon Europa [2]. The particles detected in fly-by around Europa originate from the surface due to micrometeor bombardment [3] or from the recently discovered plumes [4]. Since these grains are direct samples from the moons' icy surfaces, unique composition data will be obtained that will help to define and constrain the geological activities on and below the moons' surface [5, 6].

The SUDA instrument design follows that of standard laboratory mass spectrometers with a folded ion path using reflectron (ion mirror) optics [7]. The advantage of this design is the high mass resolution. The disadvantage is the that the ion sensor faces open space and is, therefore, exposed to dust impacts and radiation. Thus, inherent ruggedness of the ion sensor in harsh environmental conditions is essential for the performance of reflectron-type impact mass spectrometers.

Detector Design and Fabrication: SUDA employs an electron multiplier ion detector that consists of twenty discrete dynodes. The top dynode acts as the ion-to-electron converter. The detector is similar to the MM1 multiplier from Johnston Technologies that has heritage and proven excellent performance from previous dust analyzer instruments, including the CDA on *Cassini* [1]. Because the MM1 device is no longer available, a detector of a similar design is being built by the company Microworks in Karlsruhe, Germany.

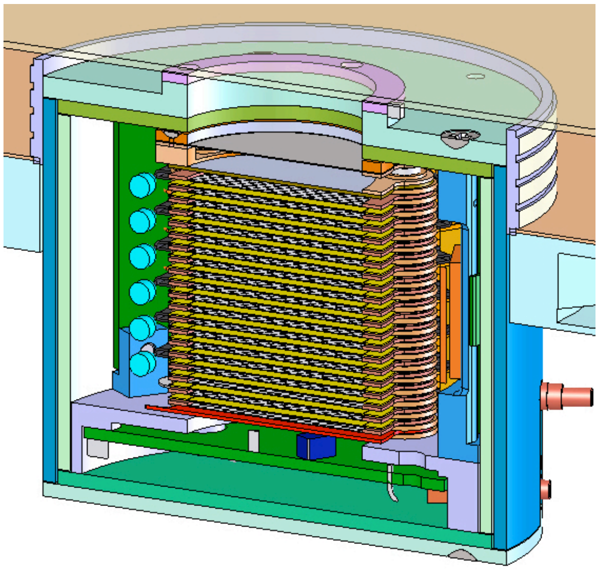

Fig. 1 SUDA ion sensor unit composed of the stacked dynode multiplier, electronic boards, and the Al/Ta radiation shielding containment, integrated into the SUDA mass spectrometer.

The ion detector consists of 20 dynodes that have a functional microstructure that focuses the electrons from one stage to the next, while providing amplification. The multiplier operates over a wide range of bias voltages with equal potential at each the stage. The typical gain is of these multipliers is 10^6-10^8. The dynodes are etched out of solid BeCu plates and will not be damaged by dust impacts. The detector is powered from a single power supply with a chain of resistors distributing the voltage evenly among the dynodes. Capacitors are added to the resistors for fast recovery allowing high detection rates. To shield the ion detector, it is housed together with three electronic boards in an Aluminum Tantalum container (Fig. 1).

Radiation Environment: Due to the harsh radiation environment expected for a mission to Europa and its instruments [8], SUDA has dedicated resources and time to testing and modeling the specific environment for the instrument.

The radiation shielding design was a collaborative effort between the modeling experts at Tech-X Corporation and LASP to mitigate against radiation effects.

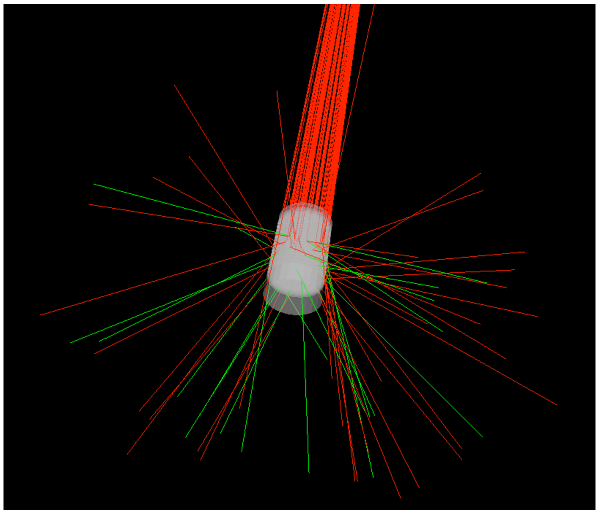

Fig. 2 Visualization of the simulation for radiation testing (electrons in red and gammas in green).

Simulations using GRAS [9] were used to determine the doses for various components. An iterative process between the model and design was used to optimize the detector housing for maximum protection using high Z (tantalum) and low Z (aluminum) layering (Fig. 2). We performed multiple simulations to calculate the total ionizing doze (TID) from environmental spectra of electrons and protons and their fluxes. We found the effect from electrons is dominant and that the effect of higher energies (above 30 MeV for electrons and 40 MeV for protons) is negligible for global effects (although could be important for single event effects, which should be investigated in future studies). For shielding of 2mm Al (outside), 2mm Ta (inside), and an opening of r=14mm, the maximum TID for the detector plates was about 2MRad and for the Si electronics parts - 400kRad. The detector housing assembly has been fabricated and is scheduled for radiation testing by the end of October.

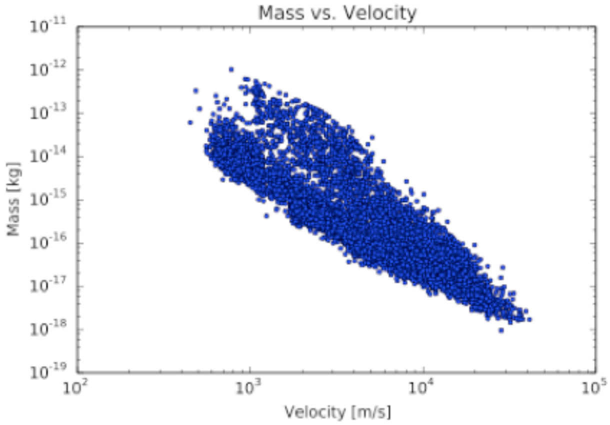

Fig. 3 Velocity versus mass of the approximately 10,000 particles that hit the multiplier in the impact experiments.

Micrometeoroid Environment: The instrument resistance to micrometeoroids was verified at the dust accelerator at IMPACT [10]. High velocity dust was used to determine the effects of direct impacts to the detector surface. The detector was subjected to 10000+ impacts of mass 10^{-18} < mass < 10^{-12} kg and velocities of 0.5 < velocity < 45 km/s (Fig 3.). The gain was recorded at various steps along this process to determine stability. The results, showing no change in gain within the uncertainty of the measurement, are shown in Fig. 4. Plans to image the impact area with a 3D optical are also underway.

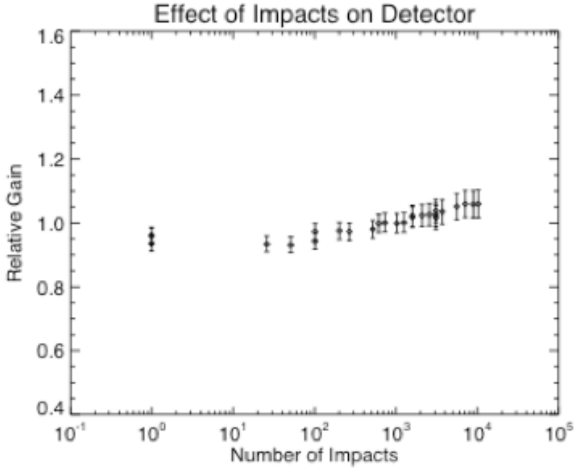

Fig. 4 Relative change of the multiplier gain as function of the number of hypervelocity impacts onto the detector. The gain is not affected by the direct dust impacts.

Summary: Hypervelocity impact experiments show that the detector survives direct micrometeor bombardment without degradation of the multiplier. This verifies that multipliers can be used on instruments with configurations exposing them to direct space. Based on simulations, we have designed a housing allowing the detector to survive the harsh radiation environment in the inner Jovian system. We will verify the validity of the radiation design with 4-40MeV electrons at the Idaho Acceleration Center and 5-65MeV protons at the UC Davis Cyclotron.

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