SINTRA Proposers' Day
RFI Number: IARPA-RFI-22-04
Dr. Lindy Espina Dejarme
Due Date: 5 August 2022

Orbital Debris Detection and Tracking

Fourier Transform Mass Spectrometry

Objective

- **Demo feasibility of simulating, detecting, and tracking hypervelocity small space debris**
  - Actual/Physical Simulation
    - Charged debris
  - Characterization
    - 1] Fourier Transform Mass Spectrometry
    - 2] Time-of-Flight Mass Spectrometry
  - Detection
    - Direct Detection - photoacoustic transducer
    - Indirect Detection - Constructive/Destructive Interference, resultant wave deconvolution for soliton detection

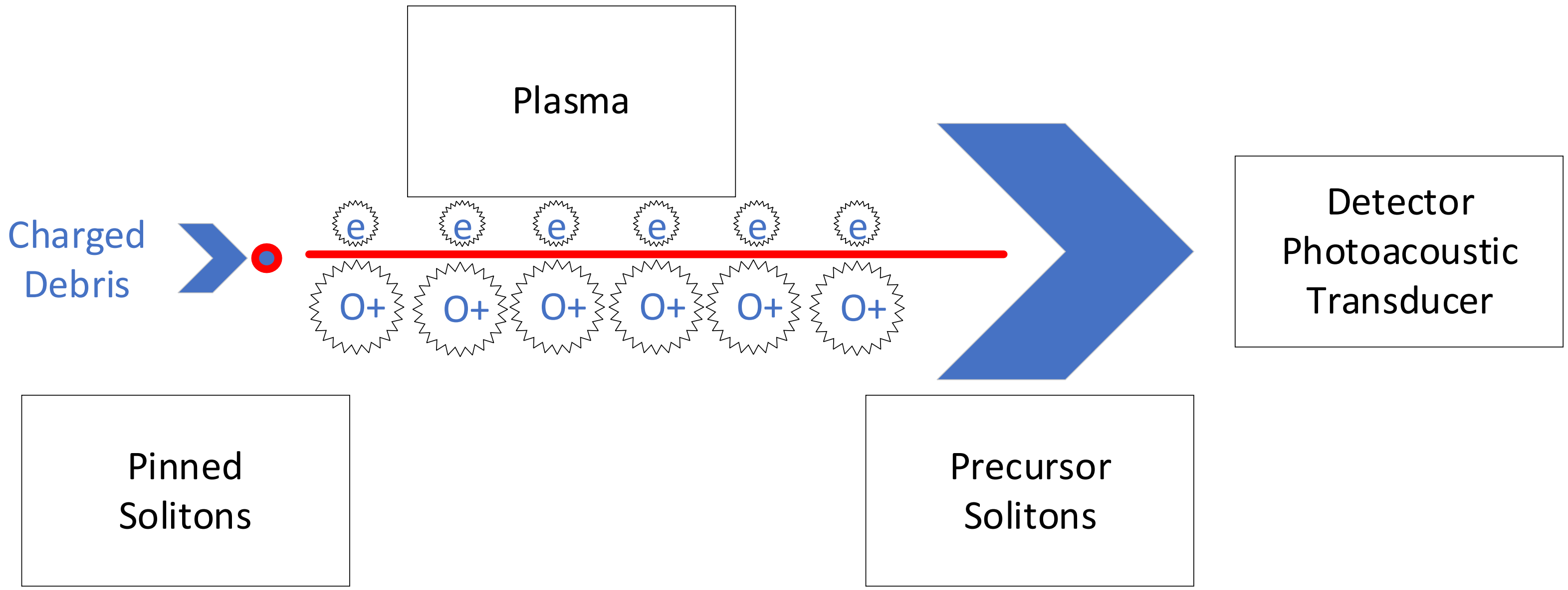
BATTELLE

Simulation of Charged Debris:
- Charged Particles

- Use large “particles” to simulate debris
  - known proteins, synthetic polymers,
  - Pecan pollen
- Charge particles by
  - Glow discharge
  - Electrospray
  - Apply direct current (+, -) for positive vs negative charge
- Inject particles into mass spectrometer
  - Perpendicular to the flow of the spray
  - Use attracting voltage to impart velocity to charged particles
    - Negative DC potential for positively charged debris
    - Positive DC potential for negatively charged debris
- Plasma addition to the flight path of the charged debris

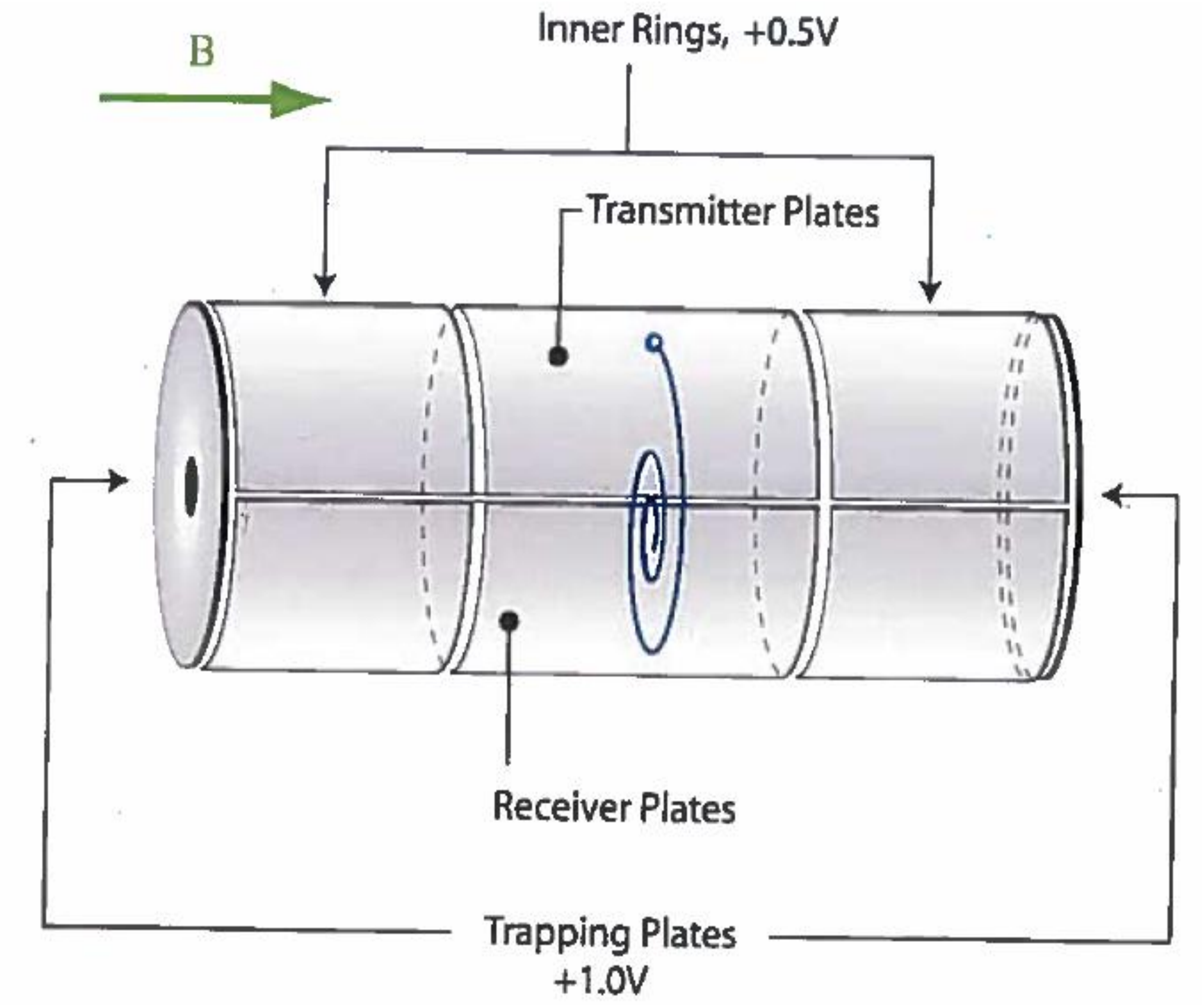
Detection Scheme for Solitons

- Solitons production due to interaction of charged debris and plasma



BATTELLE

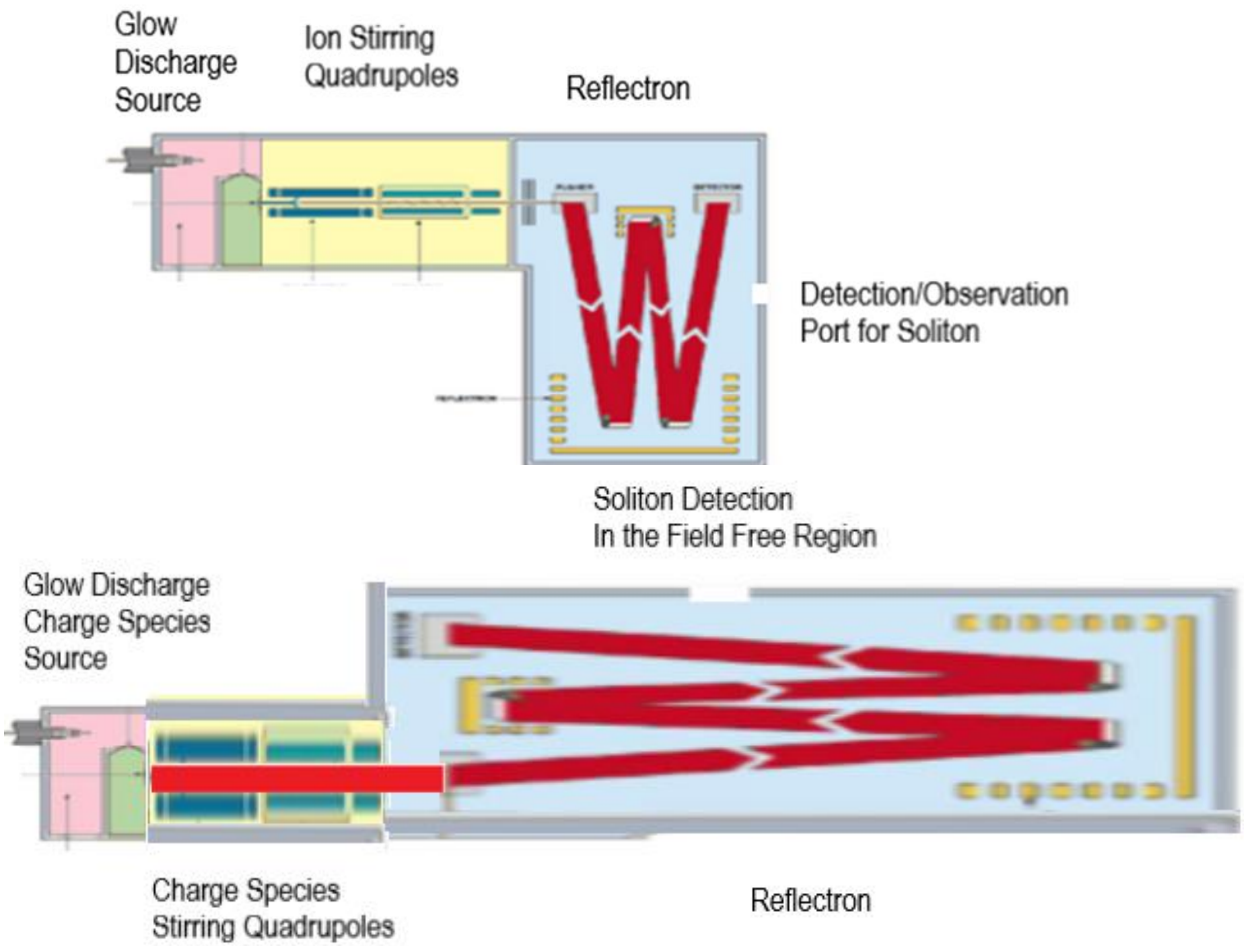
Characterization of Charged Debris: Fourier Transform Mass Spectrometry



- Cyclotron Motion of charged species is $f = qB/(2\pi m)$
- Trapping motion, trapping in radial direction
- Magnetron motion
- Introduce plasma in the cell while charged debris are trapped
- Use photoacoustic transducer to collect solitons signal in time
- Performed Fourier transform to determine frequencies of solitons
- For indirect detection use interrogation beam
  - Fourier transform of resultant beam

BATTELLE

Characterization of Charged Debris: Time-of-Flight Mass Spectrometry



- Introduce plasma in the field free region in the path of the charged debris (red ribbon)
- Use photoacoustic transducer to collect solitons signal in time
- Performed Fourier transform to determine frequencies of solitons
- For indirect detection use interrogation beam
  - Fourier transform of resultant beam

Summary of Soliton Detection Scheme

- Direct Detection of Solitons
  - Perform Fourier Transform to extract frequencies of solitons
- Indirect Detection
  - Use interrogating beam
    - Known frequency not at frequencies associated with solitons
  - Collection of Resultant Waves
  - Constructive, Destructive, Fractional Interference
  - Perform Fourier Transform of resultant waves to extract frequencies of solitons

Proposed Next Step:

- *Preliminary design for satellite sensor prototype…*
  - *Incorporate attenuator that compensates for distance to simulate long distance soliton signal sources and adjust sensor to pick up those signals. . .*