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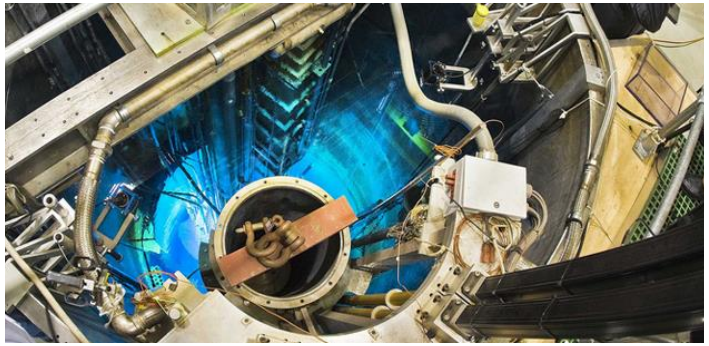

Automated detection of single particle-induced gain degradation in irradiated heterojunction bipolar transistors

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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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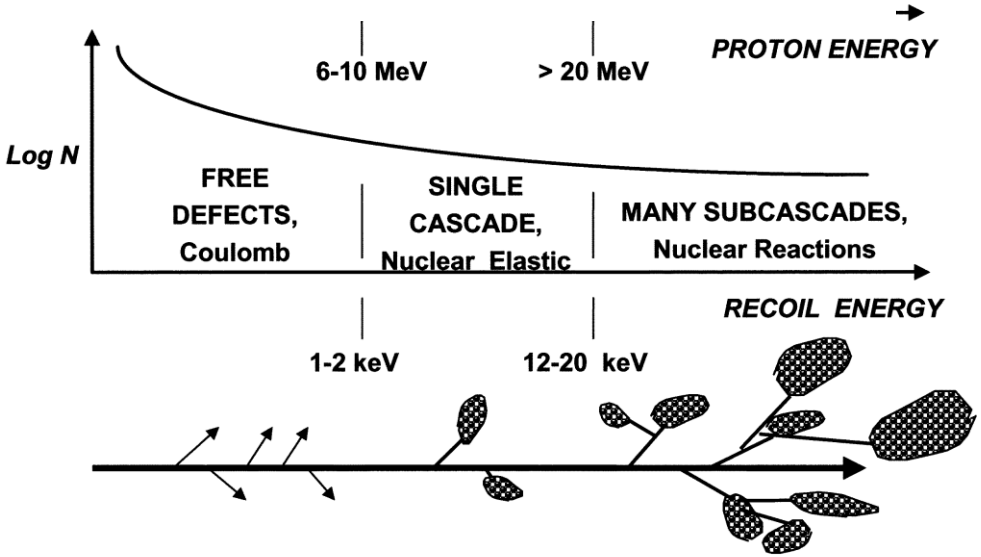
Motivation

Goal: model discrete electrical degradation caused by radiation

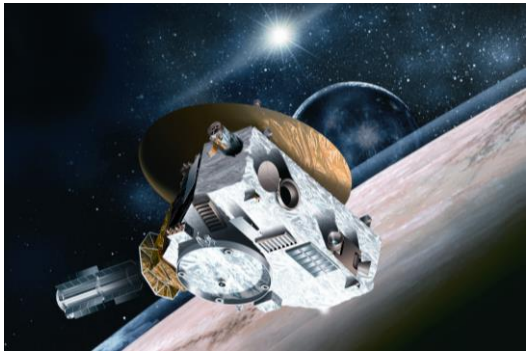
- Energetic particles create damage cascades
- Damage clusters → electrical degradation in semiconductors



Displacement damage processes

Applications

Military

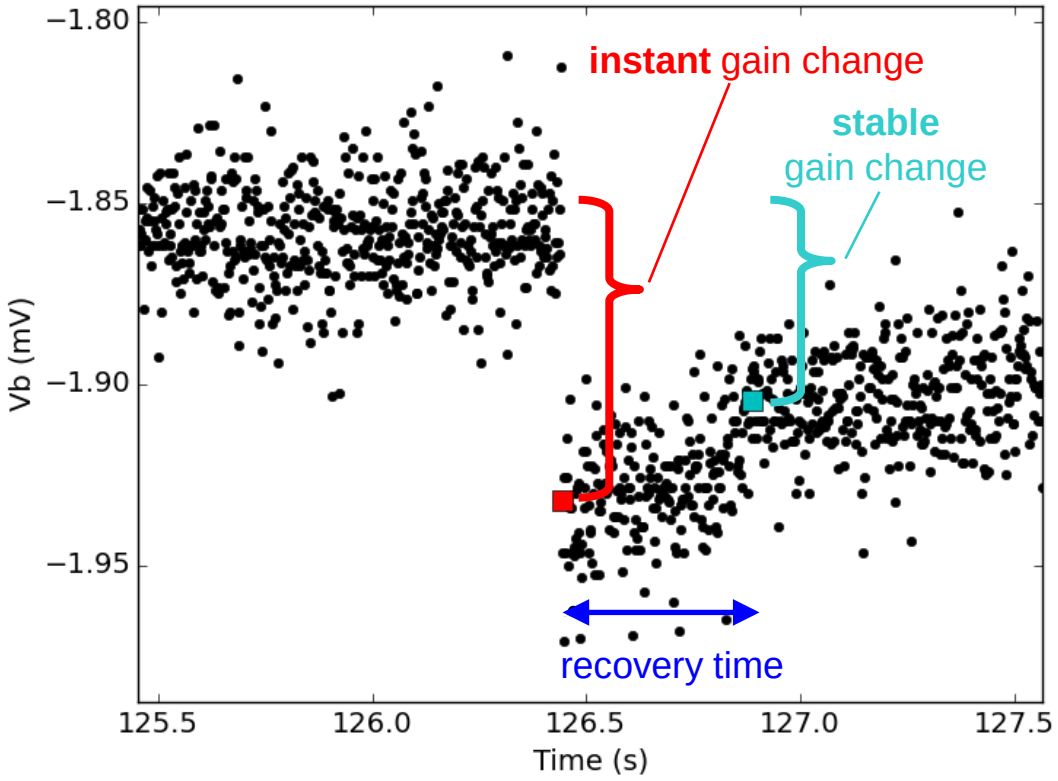


Space

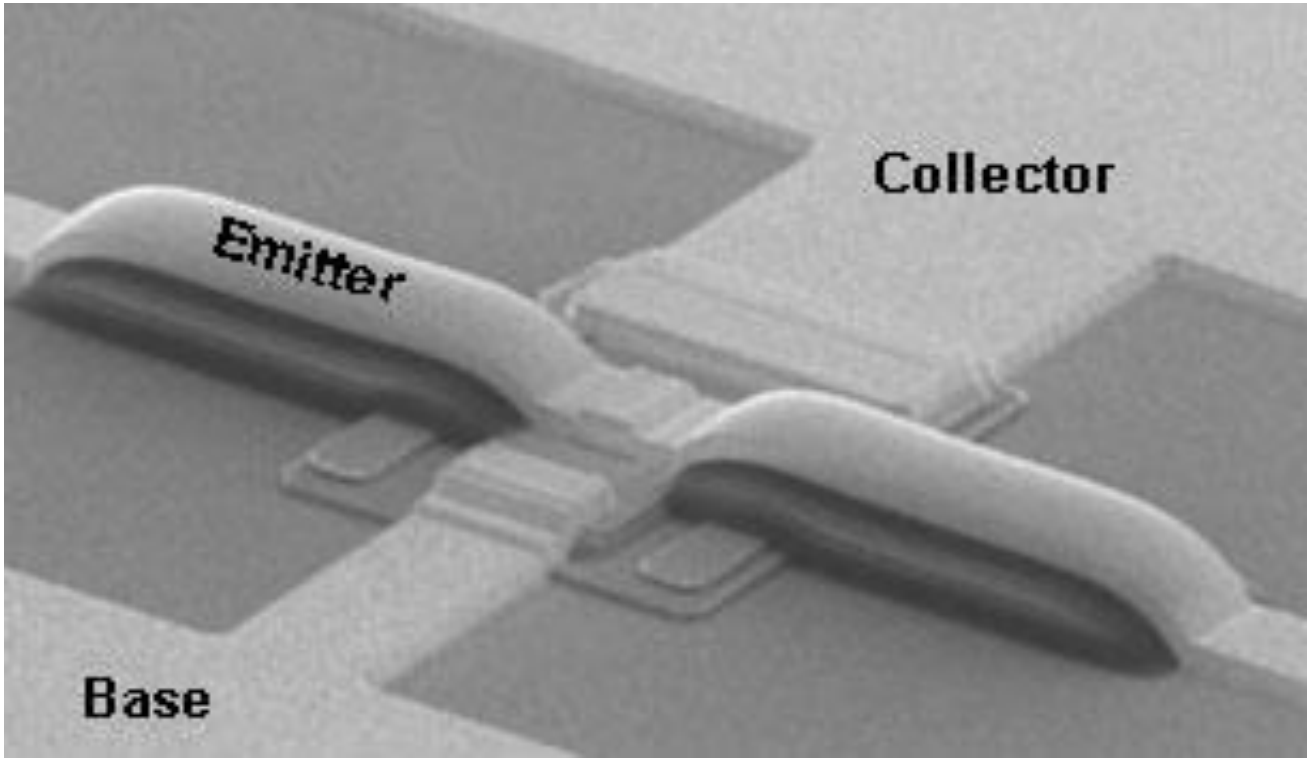
Experiment

Identify discrete gain degradation in heterojunction bipolar transistors

- Radiation: ions and neutrons
- Find tiny, infrequent changes in long time series → **AUTOMATE**



Device



GaAs heterojunction bipolar transistor (HBT)

Irradiation

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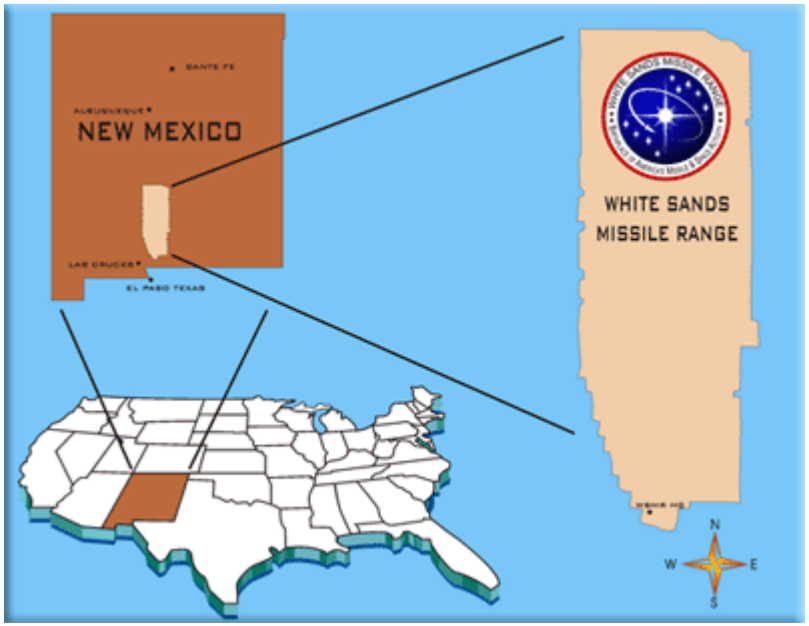
Radiation sources:

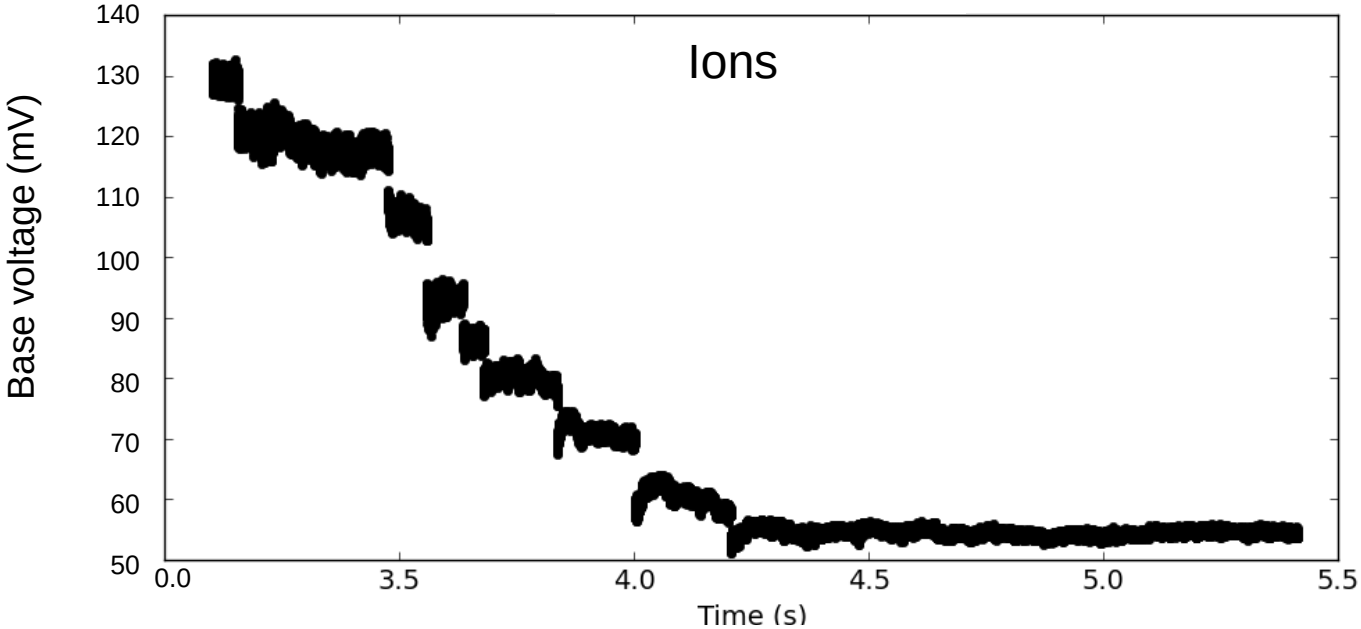
- **Ions:** Sandia National Labs 6 MeV Van de Graaff tandem accelerator
- **Neutrons:** White Sands Missile Range (WSMR) fast burst reactor

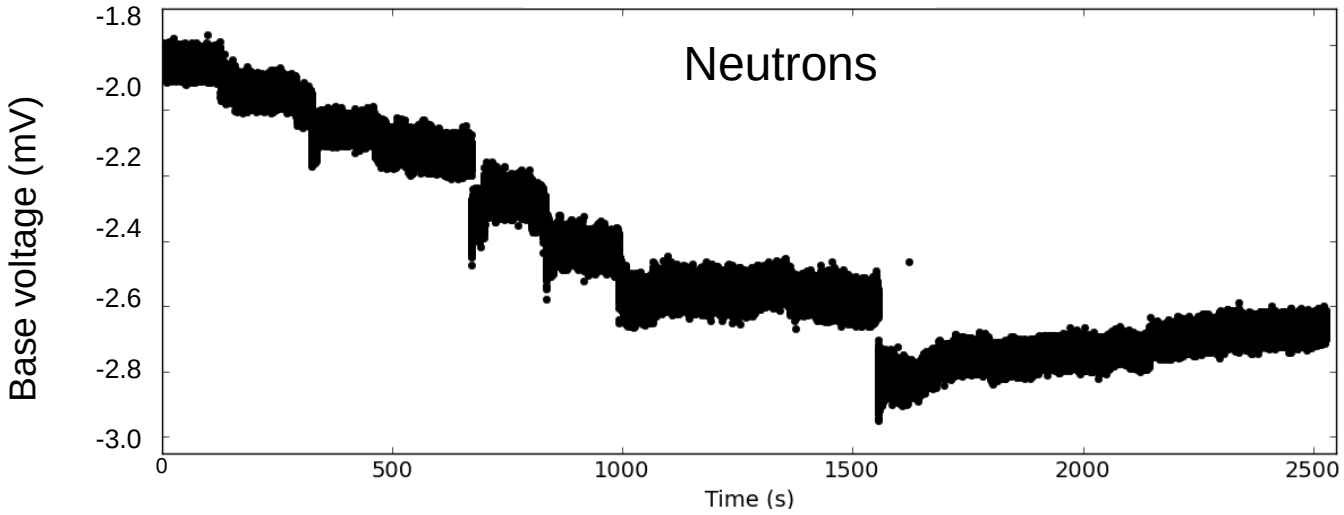
Sandia Ion Beam Laboratory



White Sands Missile Range

Ion and neutron data



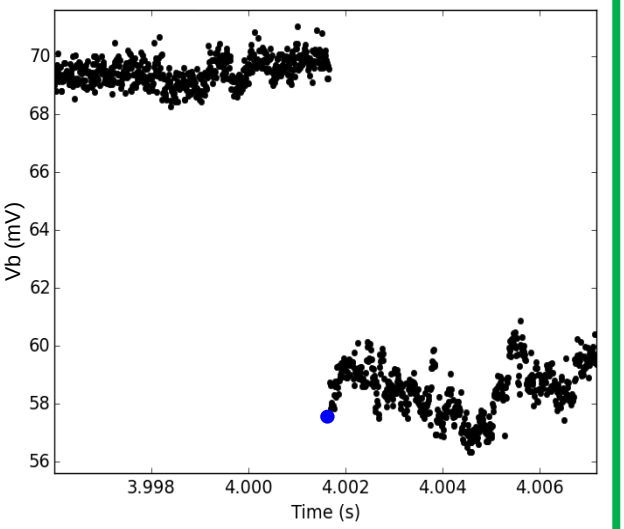


Simple algorithm

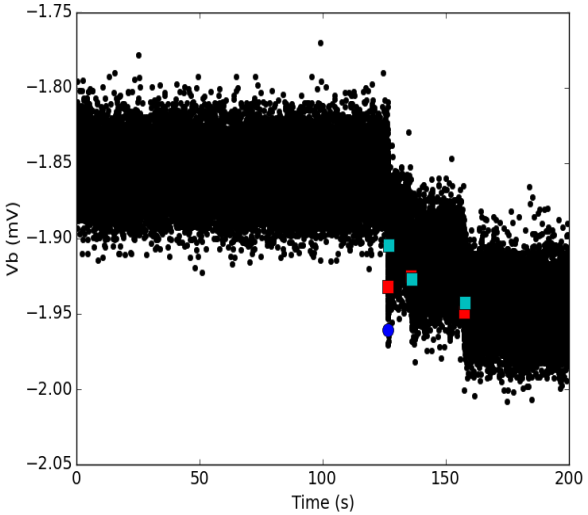
Instant gain decrease: define threshold between two data points

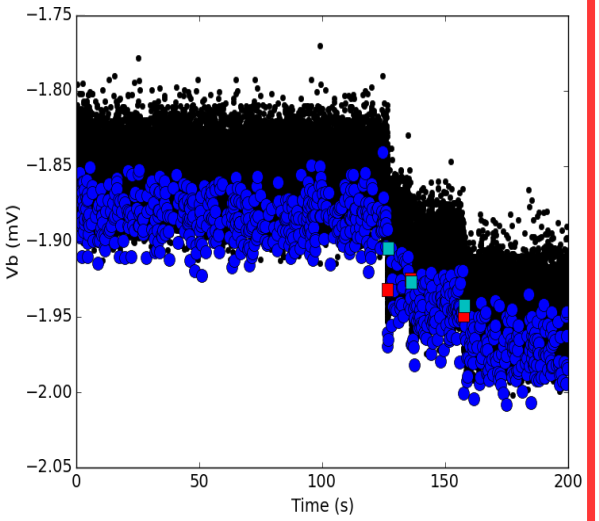
- **Works great for ion data**
- **Over- or underestimates discrete gain changes in neutron data**

Ions

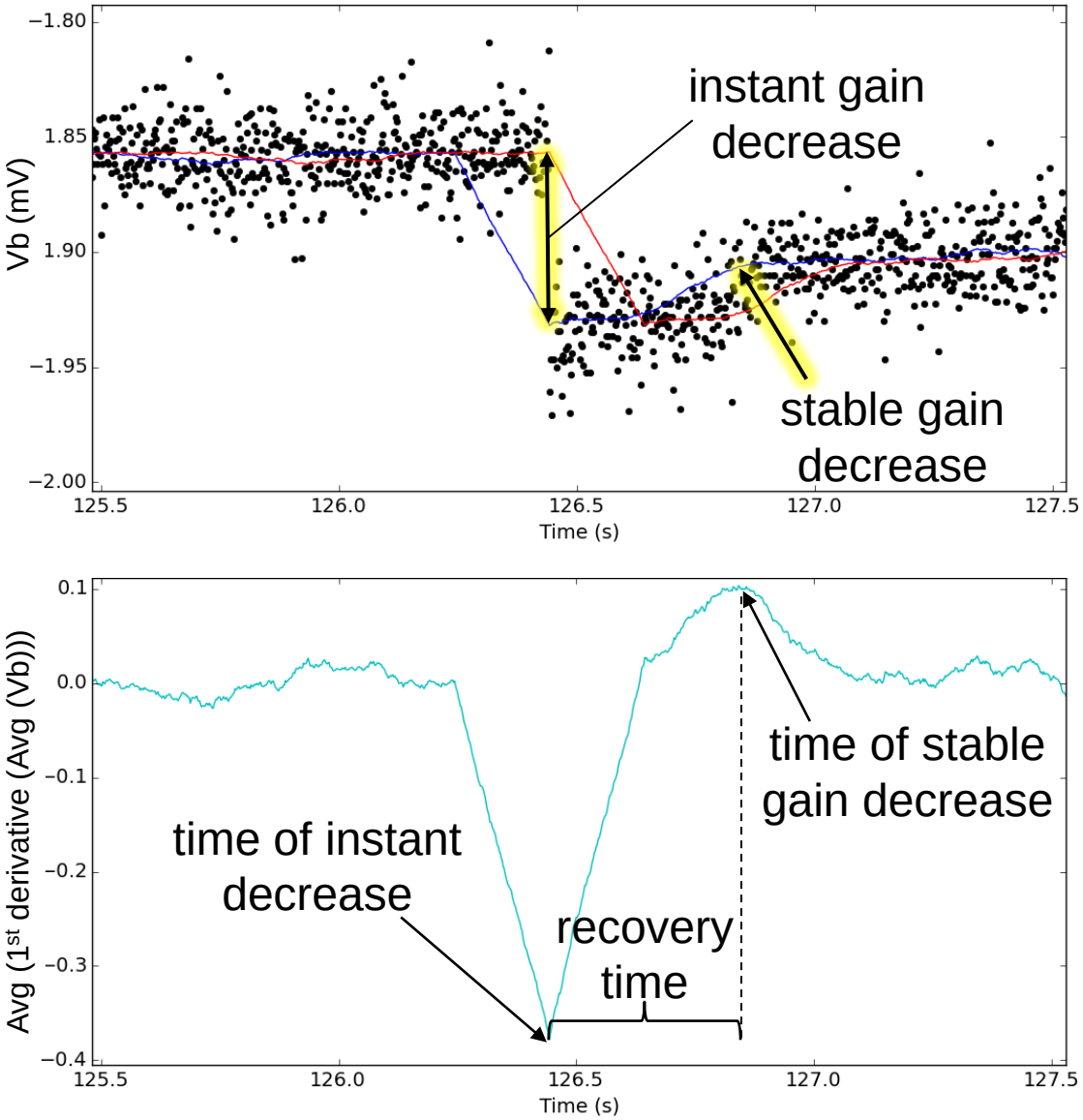


Neutrons

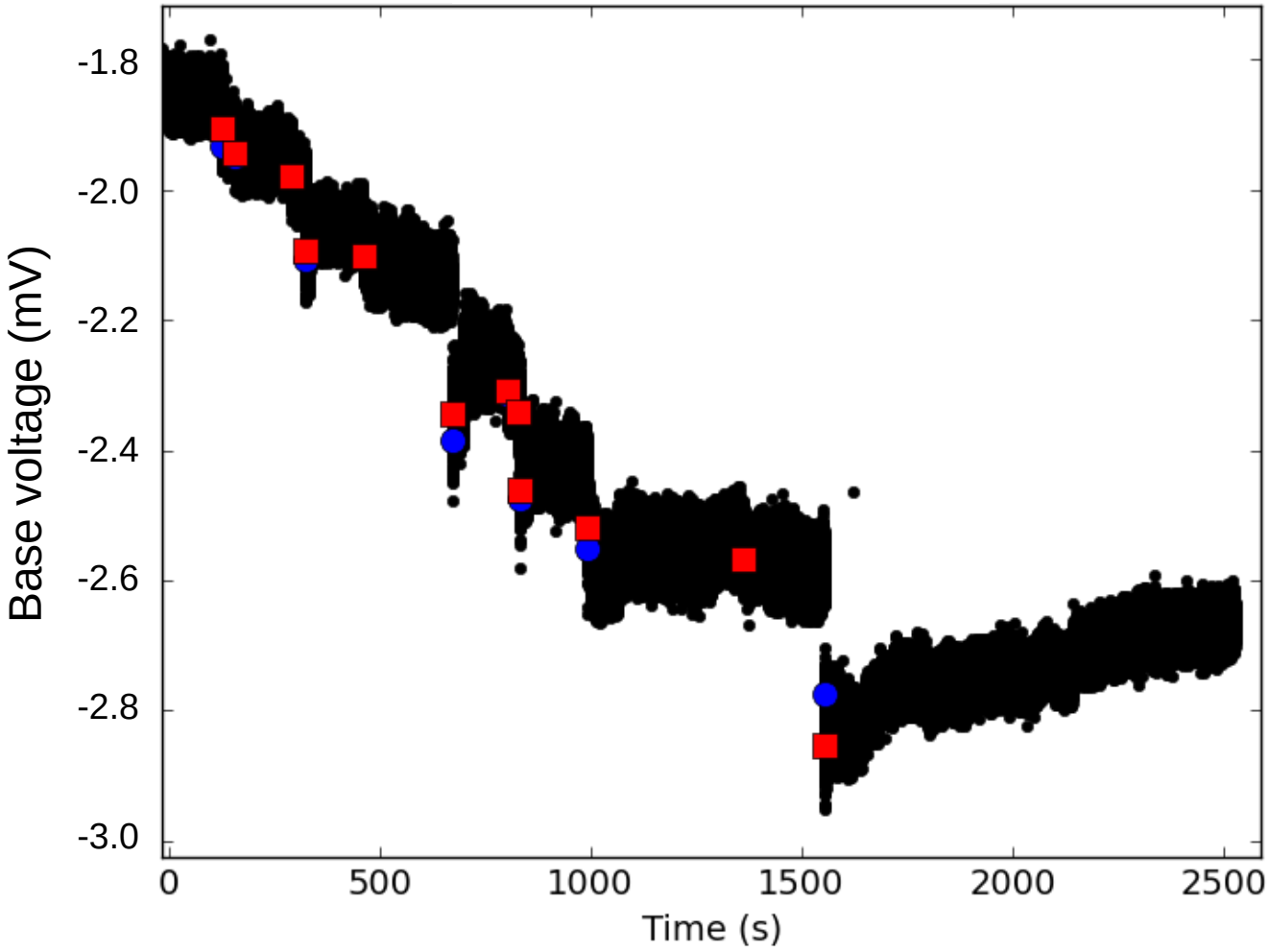




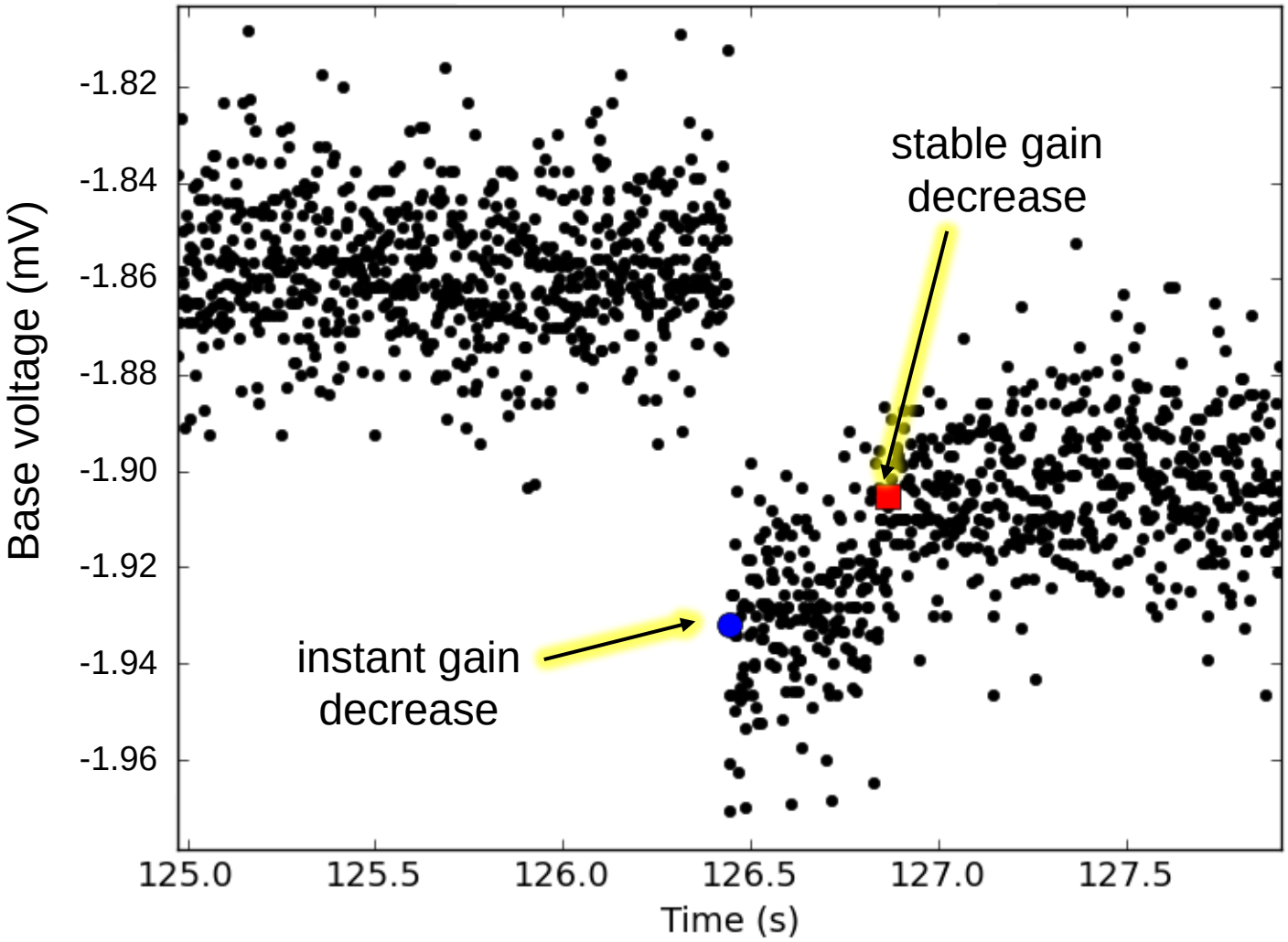
Detailed algorithm



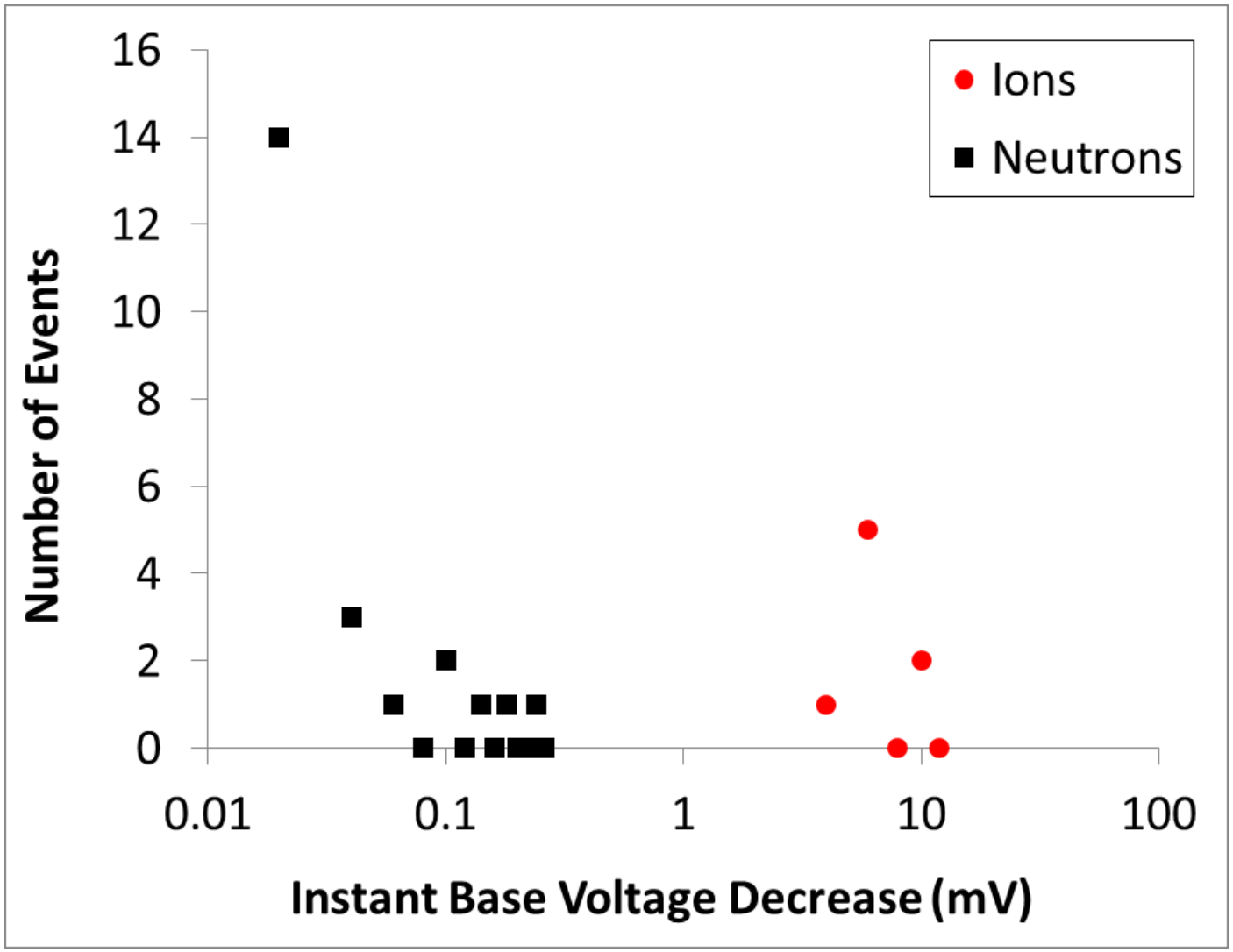
WSMR data


Base voltage (mV)
-1.8
-2.0
-2.2
-2.4
-2.6
-2.8
-3.0
0
500
1000
1500
2000
2500
Time (s)

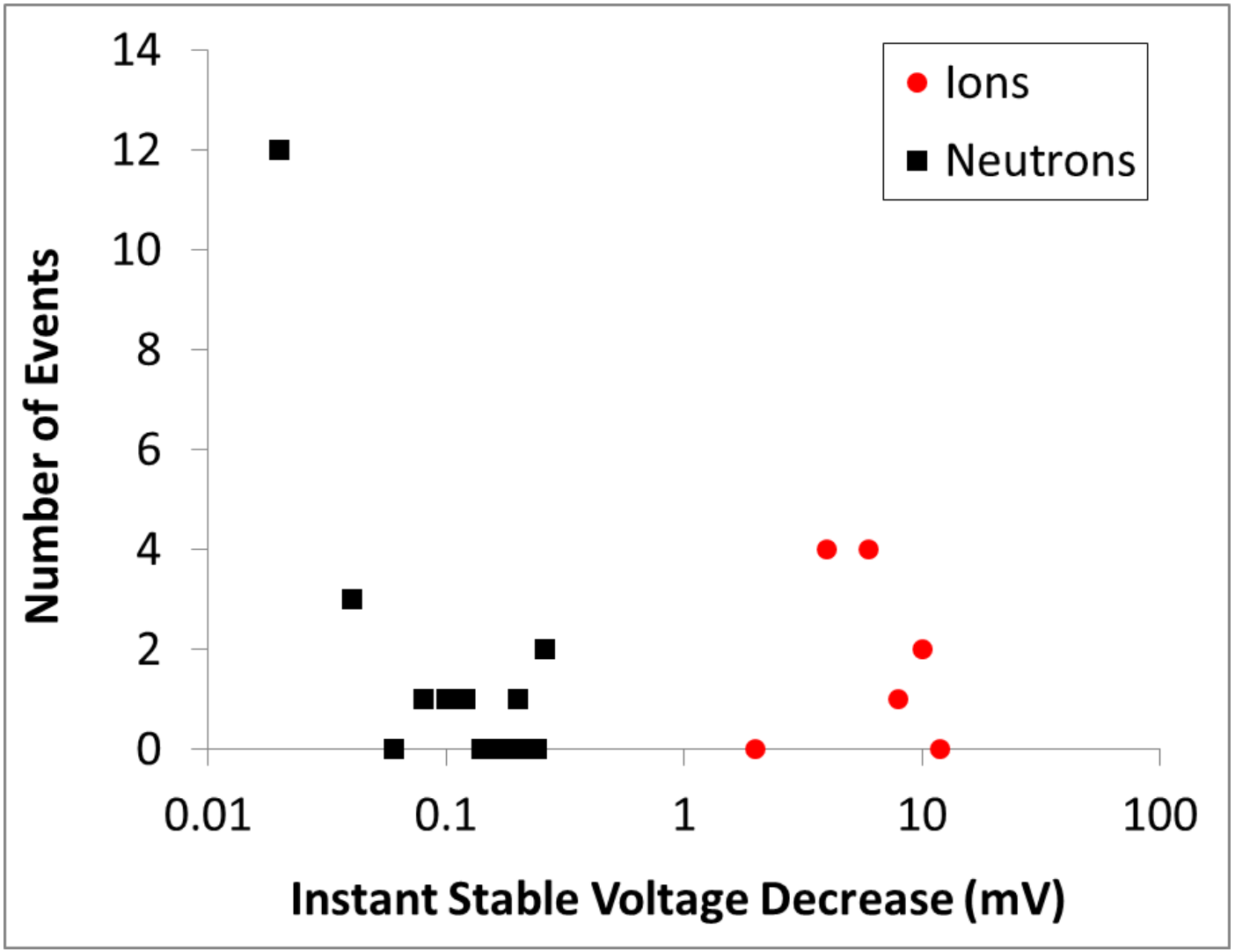
WSMR data: single event



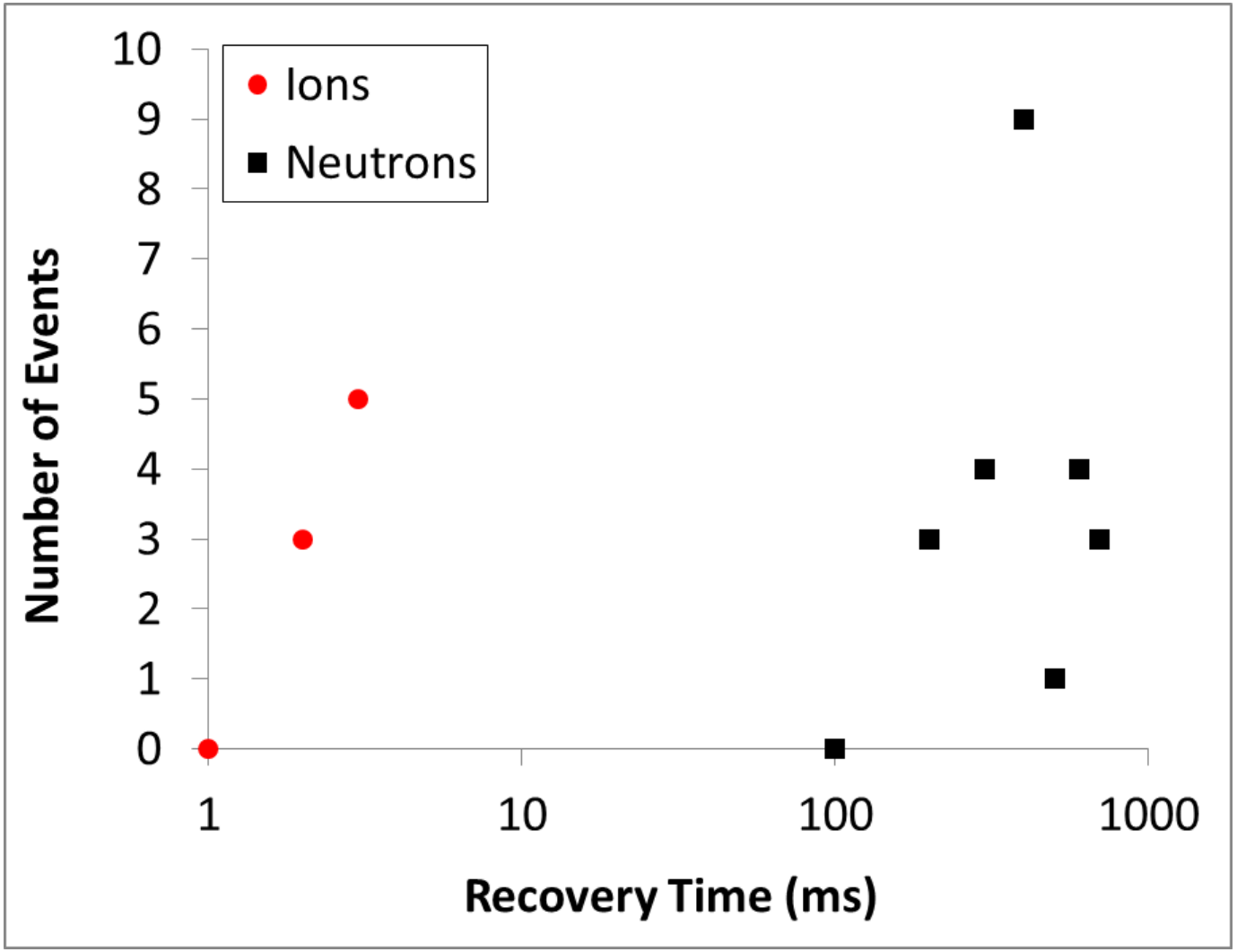
Instantaneous gain changes



Stable gain changes



Recovery time



Conclusions

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1. **Goal achieved:** automated detection of discrete, neutron- and ion-induced gain decreases in HBT's

2. **Algorithm:**
   - Instant decrease
   - Stable decrease
   - Recovery time

3. **Analysis:**
   - Ions cause larger discrete gain decreases than neutrons
   - Base voltage recovers more quickly after single ion damage