Investigation of Single-Event Effects for Micro and Nano Devices Using Pulsed Laser in NSSC SEELab

Han Jianwei

hanjw@nssc.ac.cn

National Space Science Center (NSSC), CAS

Beijing , China

Other Contributors at SEELab: MaYingqi, Chen Rui, Shangguan Shipeng, Zhu Xiang, Li Yue, Tao Mengze, Li Sai, Chen Qian, Wang Xuan, Wang Tian

RADLAS2017-Montpellier, France

October 9, 2017

Outline

- **Brief Introduction of NSSC and SEElab**
- **Typical SEE Tests Using Laser Facility**
  - For RadHard Device Manufacture
  - For Spacecraft Electronic Instrument Development
  - For SEE Mechanism Investigation
- **Conclusions and Prospect**

Brief Introduction of
NSSC and SEELab




Space Science Study Center

Space Science Program Center

Space Science Mission Operation Center

Support &Experimental Validation Center

Administration & Common E

Support for Science Satelli

Department of Space Technology, Spa

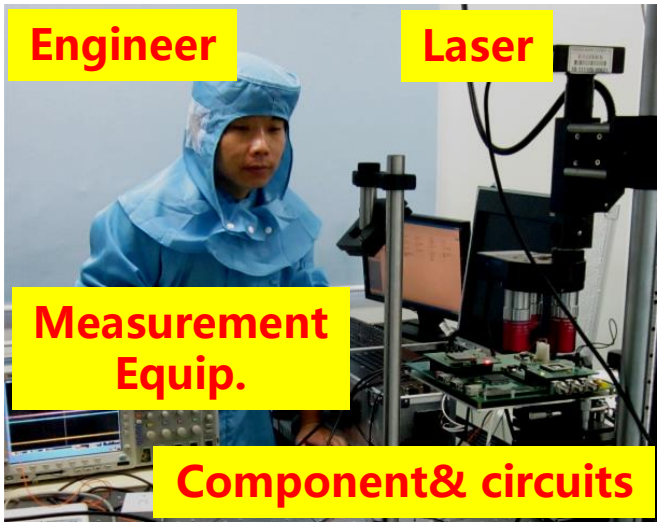
Environment, Microwave Rem

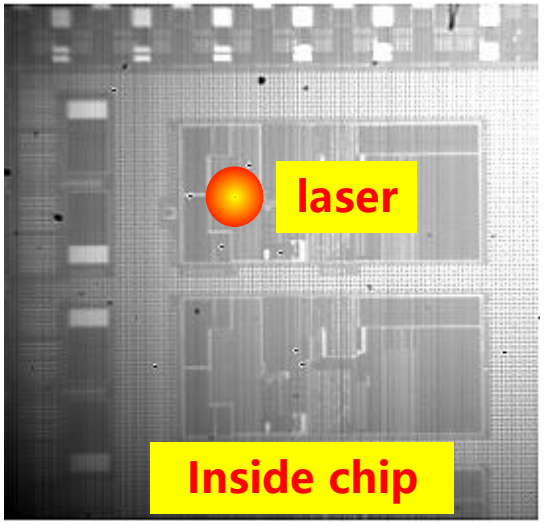
Fundamental Science & Key

Support for Science Satell

- EEE Components Procurement
- Quality & Reliability Assurance for EEE Components
- Environment Simulation for Payloads and Parts
- Space Environmental Suitability & Radiation Hardness Assurance

SEE Test Capability of SEELab



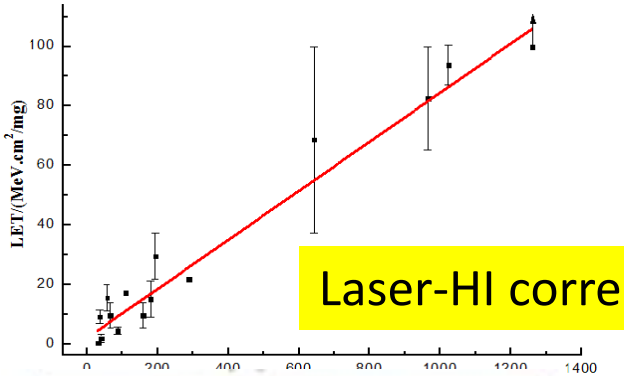


Leading Single-Event Effects Laser Testing in China

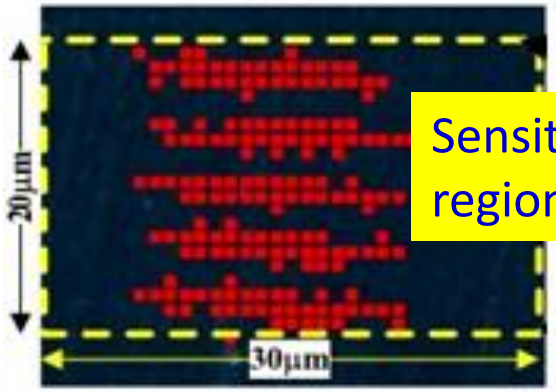
- 7 full-time staffs involved in laser facility development, test methods and techniques study, and test service
- 3 self-setupped laser facilities of nano-, pico-, and femo-seconds duration, with 1064nm and 260-2600nm wavelength
- Provide ~1000 hours test for over 30 organizations, for all of Chinese RadHard device manufacturers

Leading Single-Event Effects Laser Testing in China

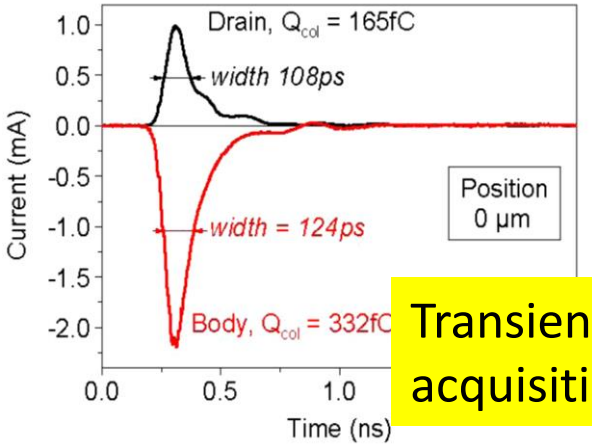
- Quickly pre-evaluation SEE sensitivity, and probing weak point for device manufacture
- Quickly screening candidate components , investigate the SEE influence on circuit, as well as diagnose and validate system mitigation for onboard electronic instrument development
- Dedicatedly acquire spatial, temporal, and physical responses of SEE for fundamental research



Laser-HI correlation



Sensitive region location

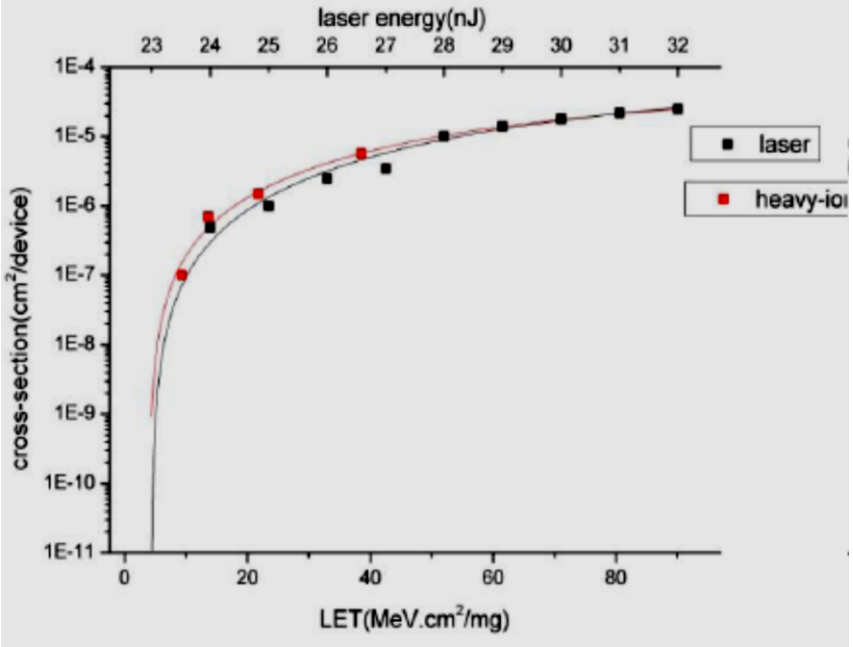


Transient pulse acquisition

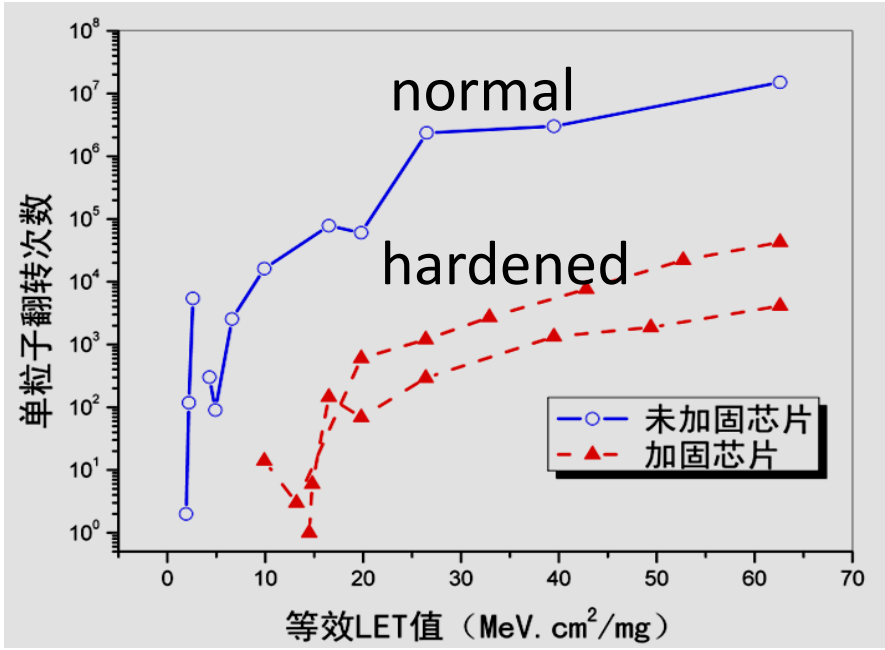
Typical SEE Tests
Using Laser Facility

I. Test for RadHard device manufacture

➢ SEE Sensitivity Pre-evaluation



32Mbit SRAM（0.18μm）



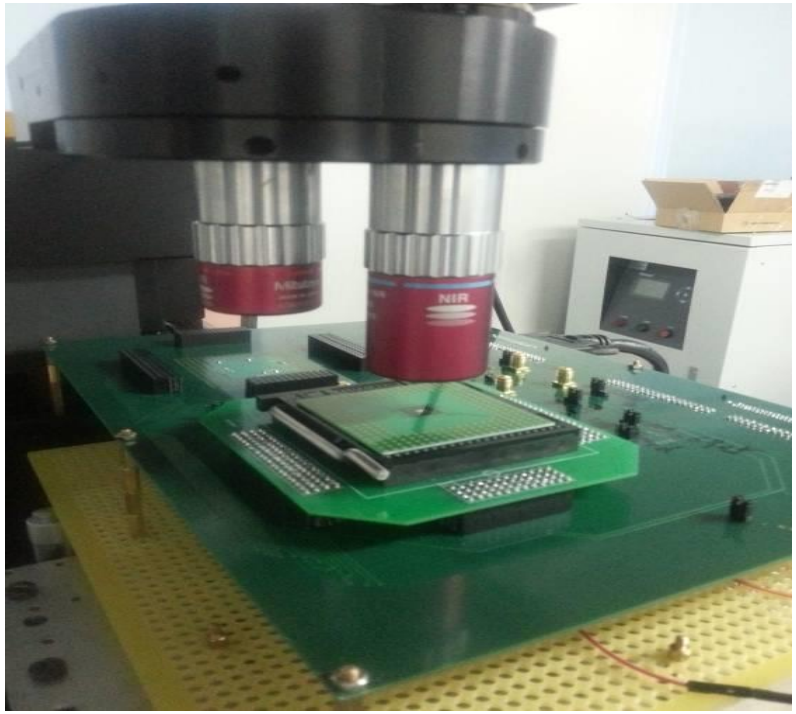
0.18μm CMOS Reading Circuit

SEL threshold

−Normal: 2.6 MeV.cm²/mg

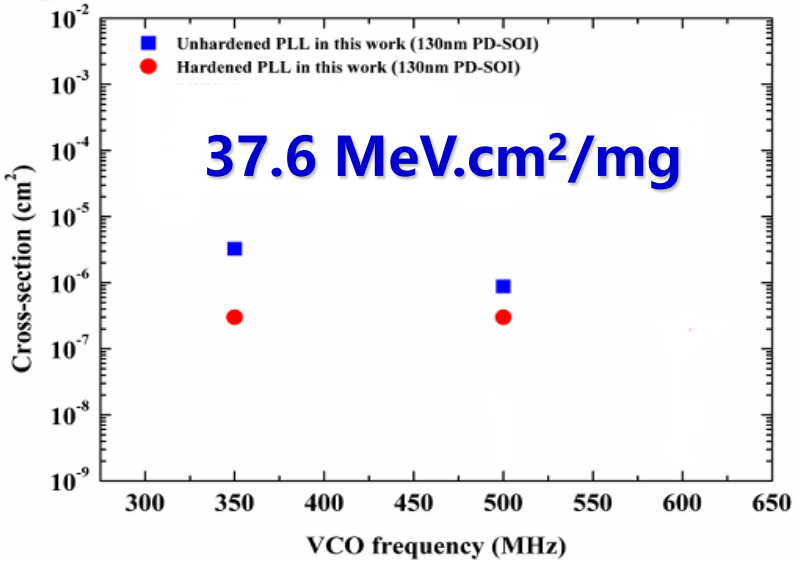
−Hardened:>62.6MeV.cm²/mg

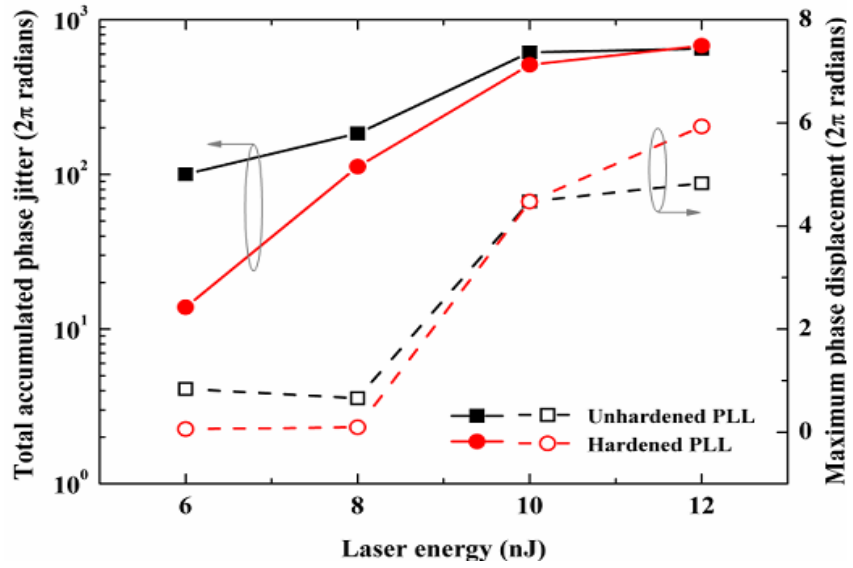
➢ SEE Sensitivity Pre-evaluation



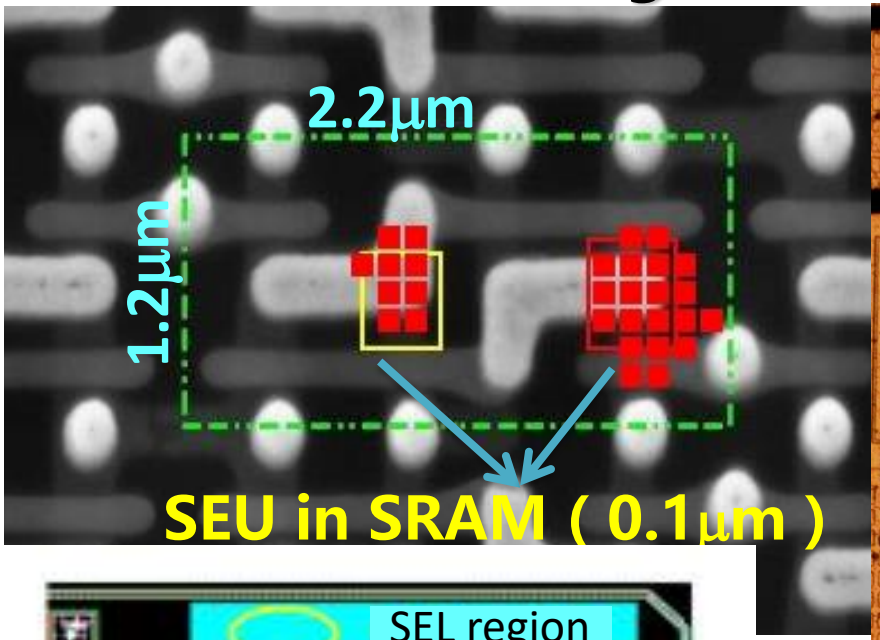
0.13μm SOI PDSOI PLL

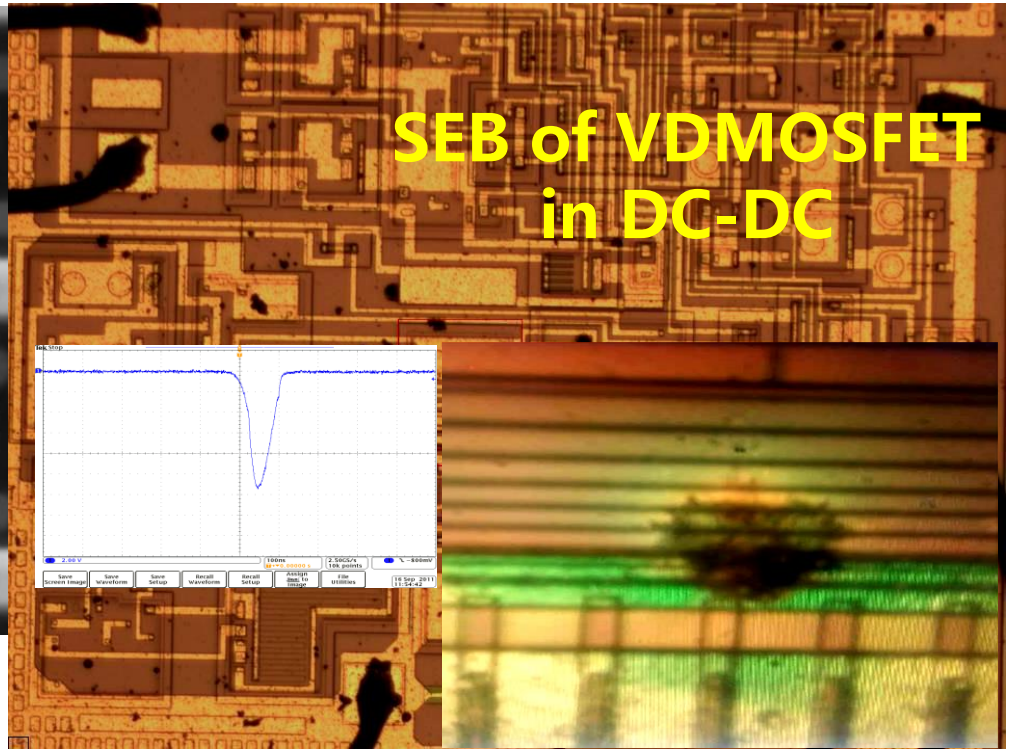
mitigation do not work efficiently at high energy

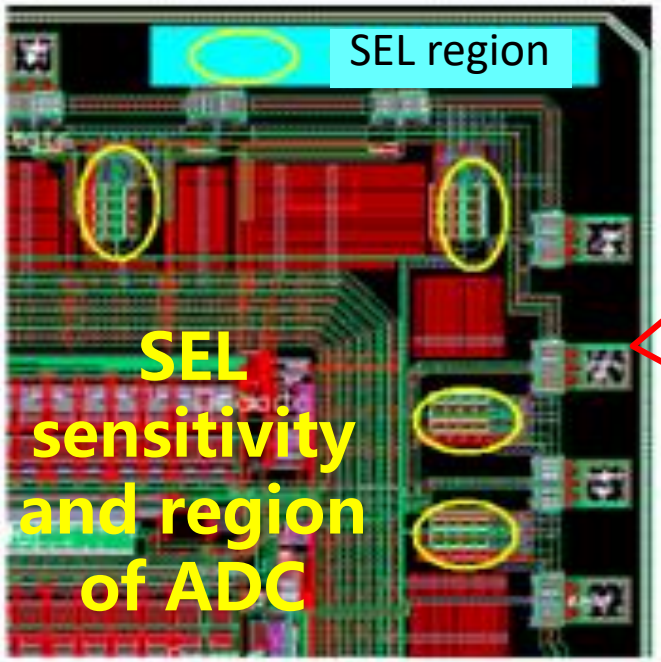




➢ SEE Sensitive Region location





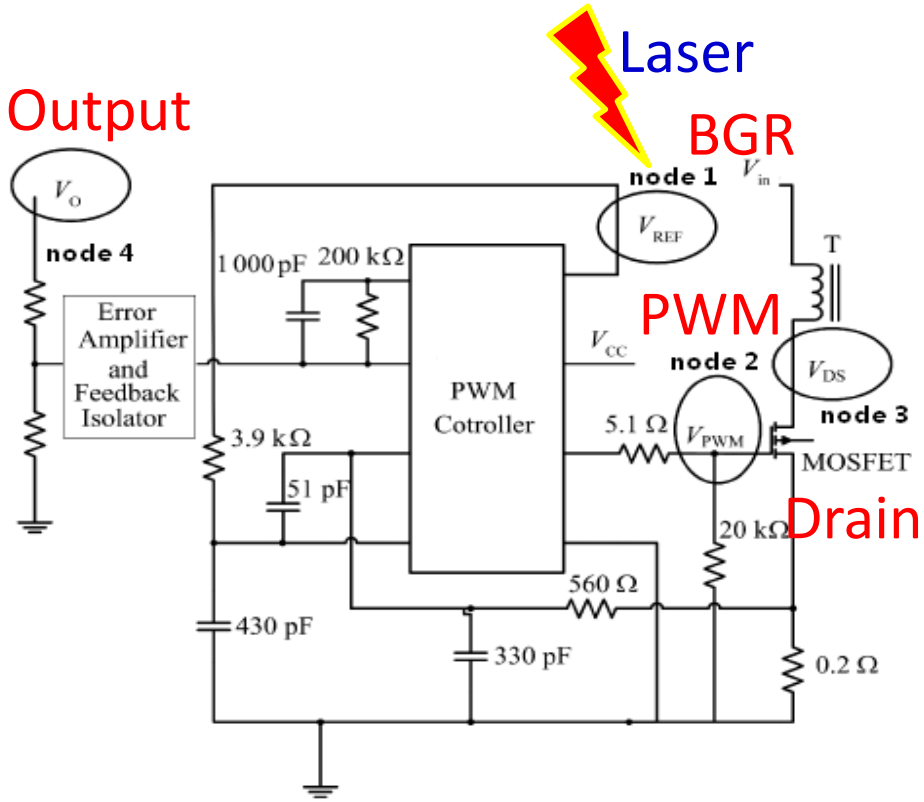


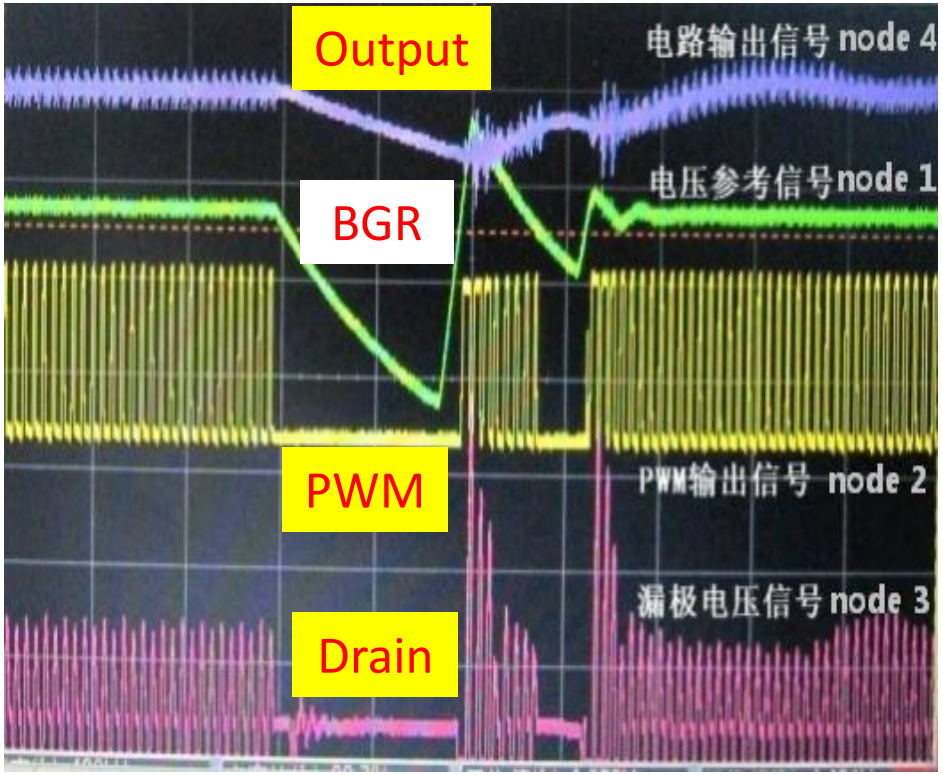
- ✓ SEL 21±5(laser)
- ✓ SEL <37(heavy-ion)
- ✓ Located the active regions

After hardness design

- ✓ SEL > 37(heavy-ion)

➢ SEE Propagation in Complex Components

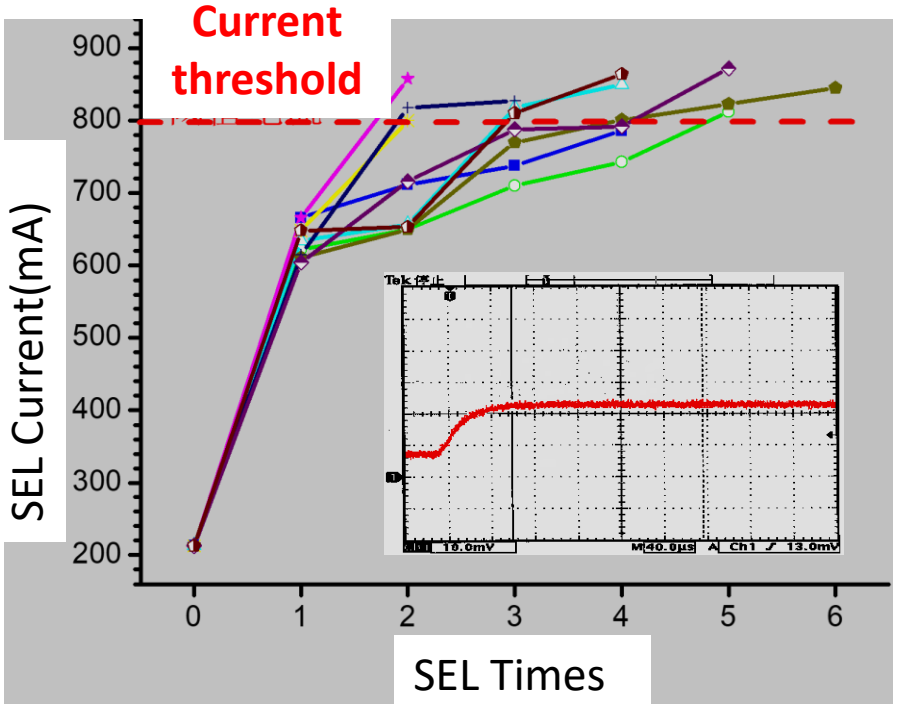




ASET propagation and influence in DC-DC

Ⅱ. Test for electronic instrument development

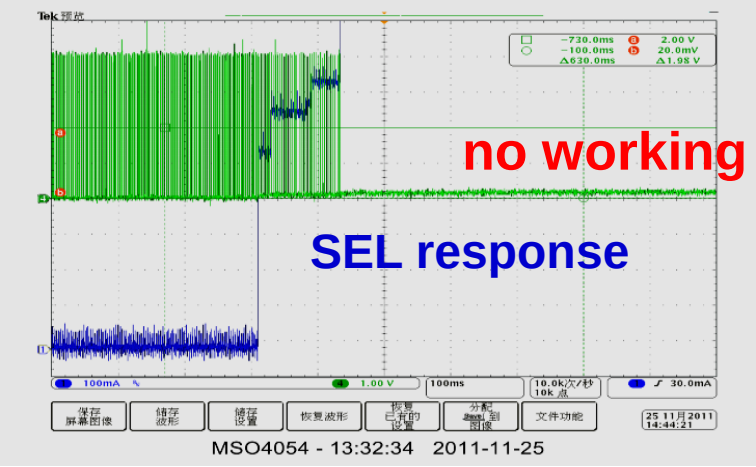
➢ In-orbit instruments failure diagnose and mitigation

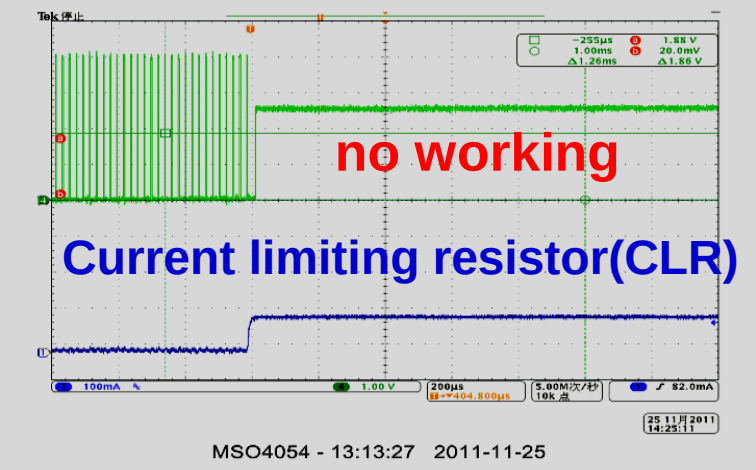


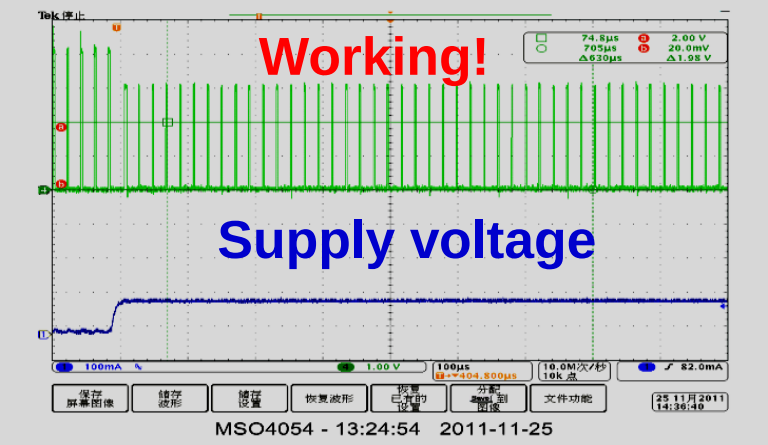
- In 48hours, failure phenomenon observed in ground experiment
- Failure mechanism disclosed for several instruments
- In-orbit countermeasures validated by laser test

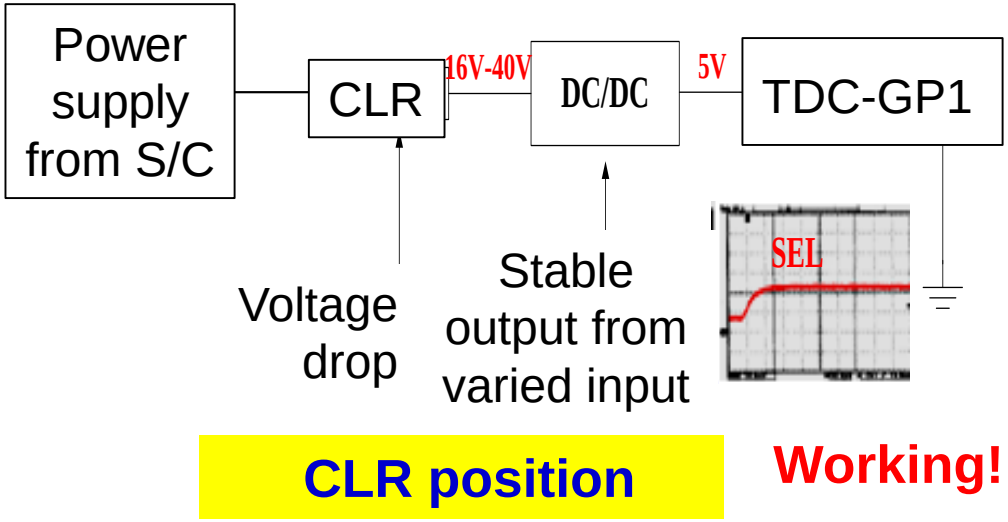
➢ Circuit system design for SEE sensitive devices

SEL tolerant design for TDC-GP1 in CE-3 satellite



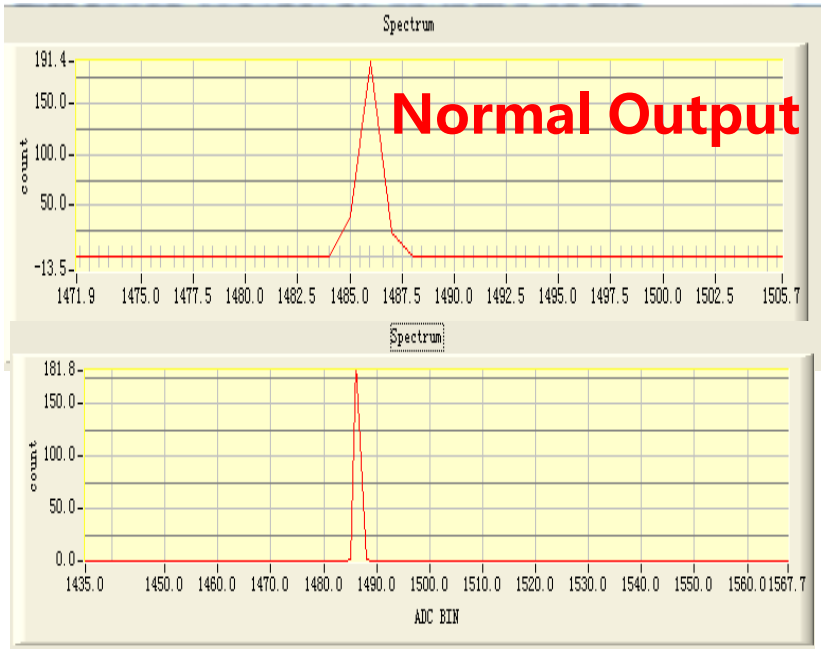


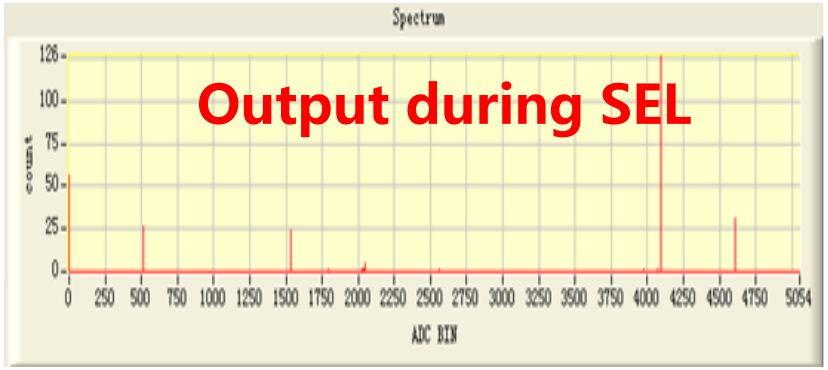




➢ Circuit system design for SEE sensitive devices

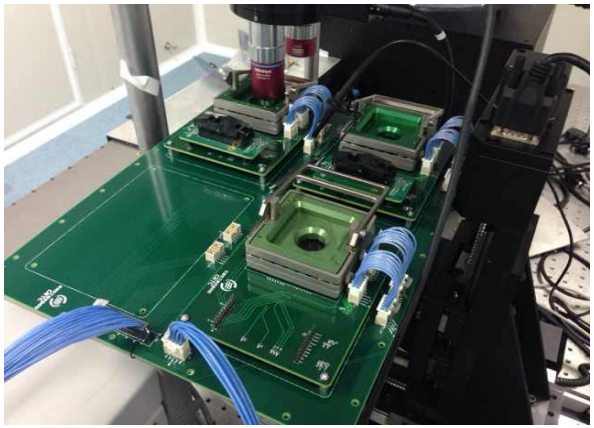
COTS ADC AD7476 onboard DAMPE satellite





Output after 1000 Times SEL mitigations

- Laser energy 160pJ（LET=9），ignite SEU，EDAC valid；
- Laser energy 500pJ（LET=23.5），ignite SEU & MBU ；EDAC valid for SEU，invalid for MBU

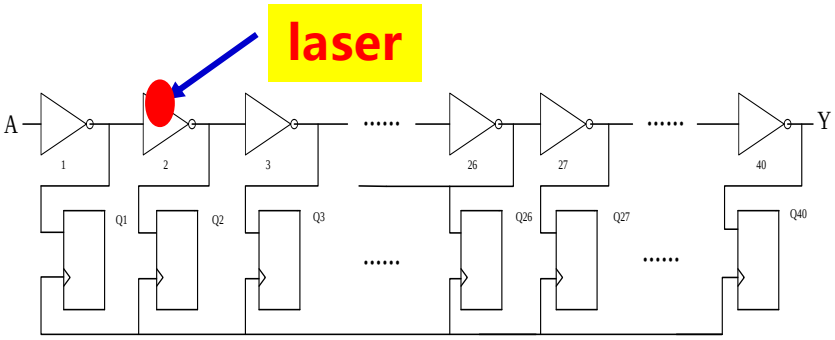


CY7C1061DV33 SRAM onboard COTS satellite

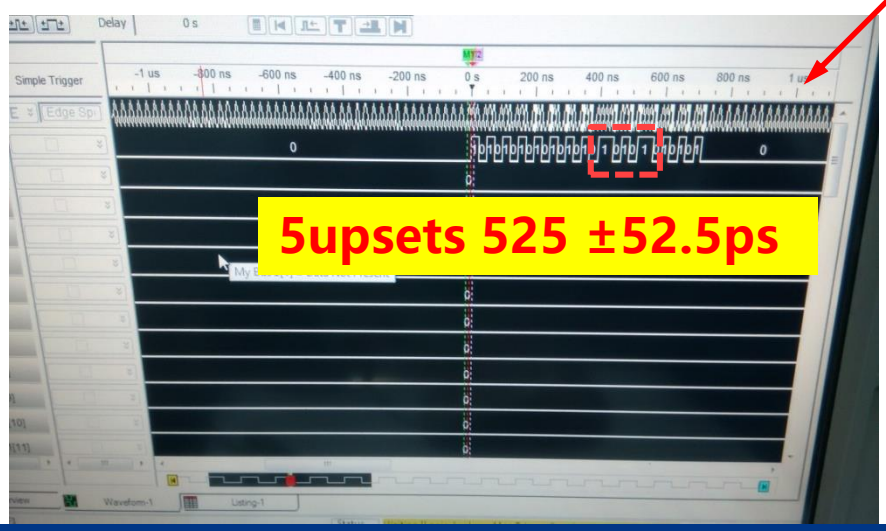
Ⅲ. Test for fundamental research

➢ SET ant its Propagation

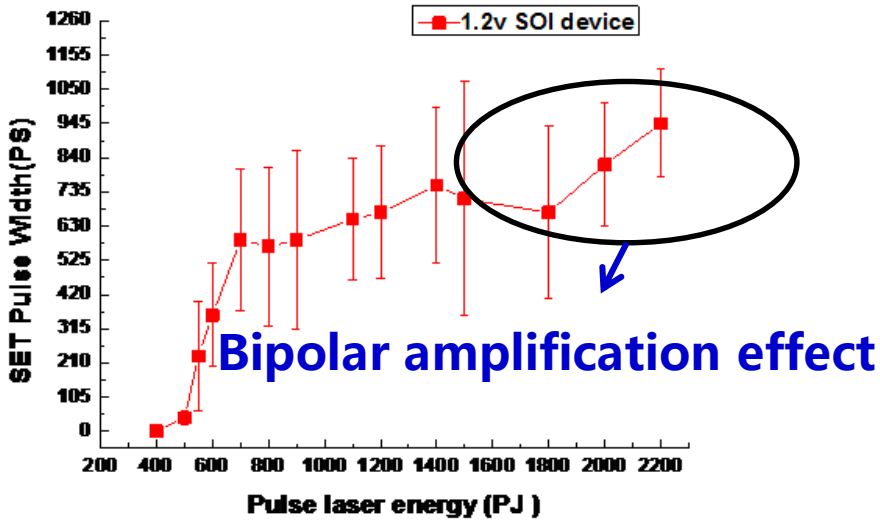
0.13μm SOI inverter chain



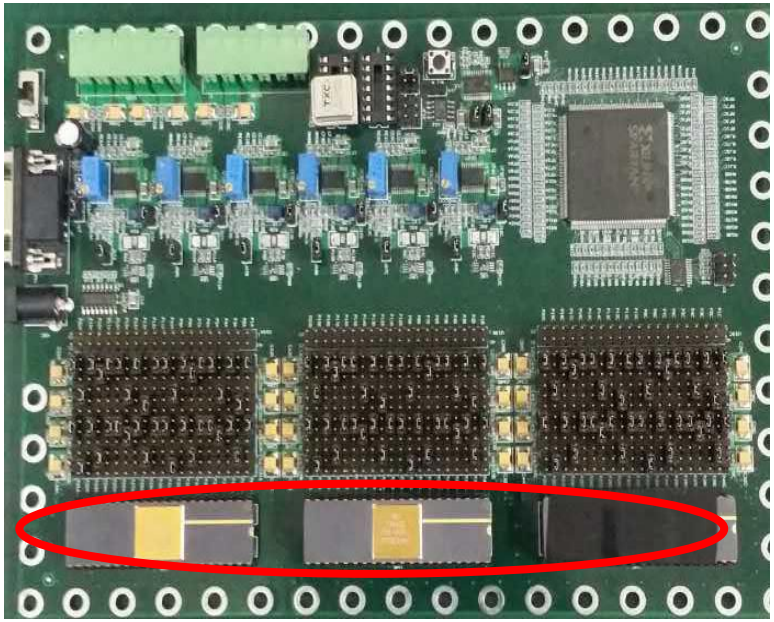
Delay time/level 105ps , SET accuracy ±52.5ps

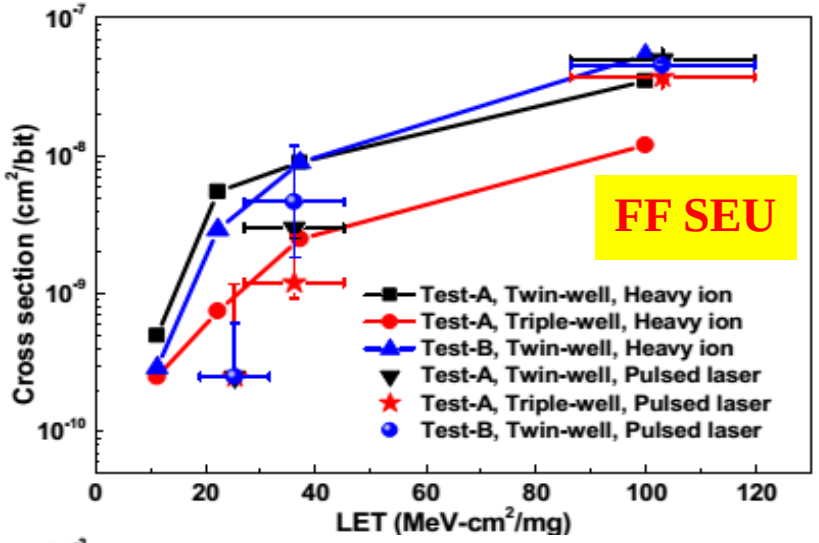


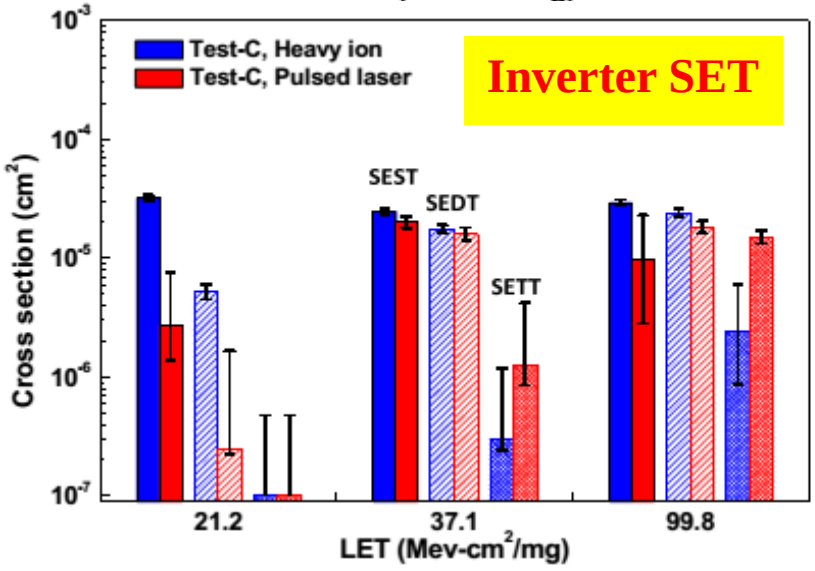
5upsets 525 ±52.5ps



➢ SEU&SET of 65nm Flip Flop and Inverter



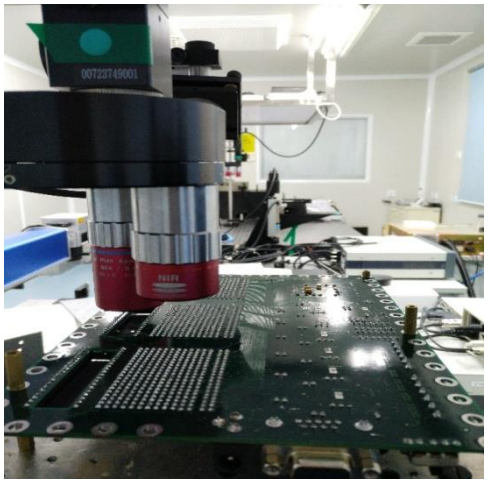


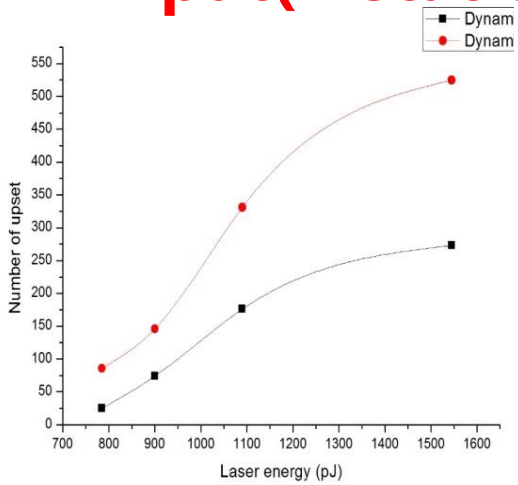


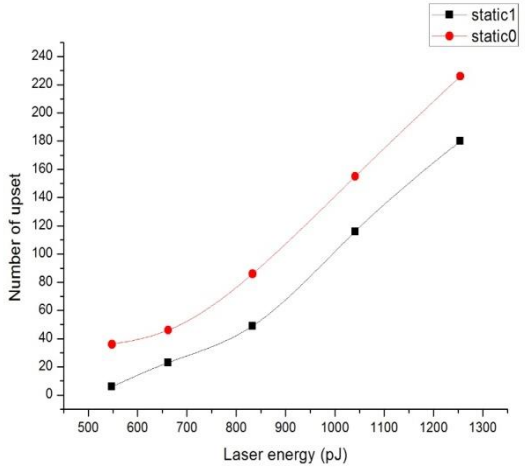
Laser and HI ignite similar SET and SEU

➢ Influence factors for 65nm D-FF SEU

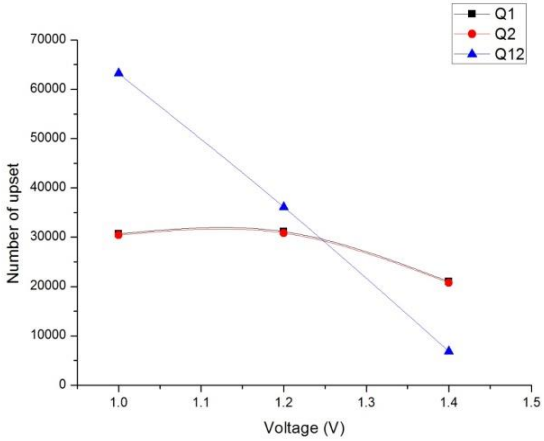
Input(“static 0” is more sensitive)



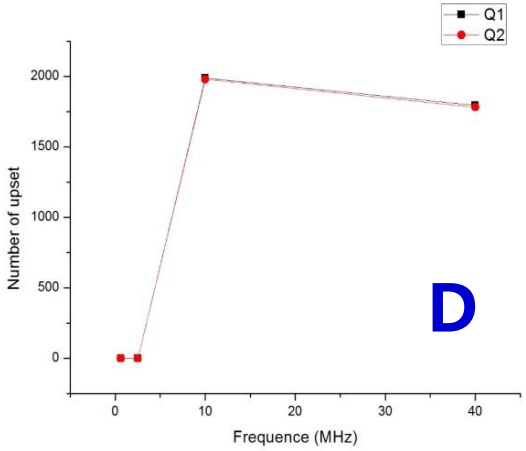


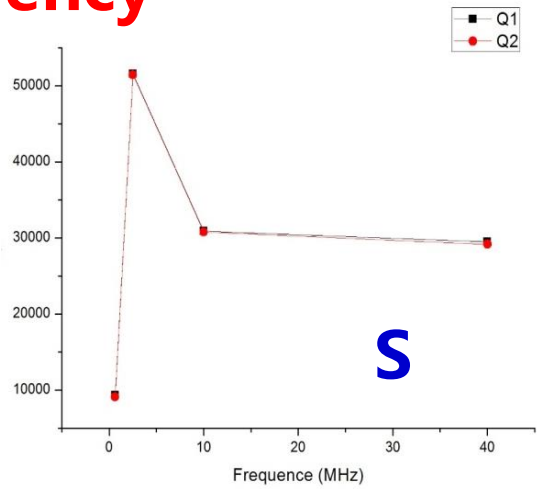


Core voltage

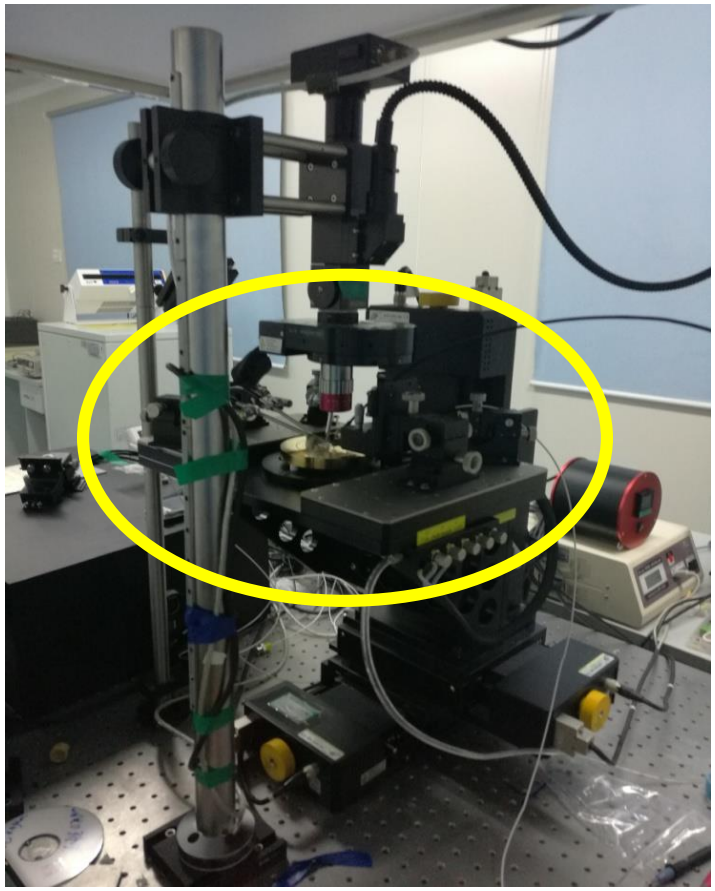


frequency





➢ Original SEE current transient investigation



Laser facility + Probe
+ High Speed Sampler

Dc and RF probe

Conclusions and Prospect

- Pulsed laser is really powerful SEE testing tool for device manufacture, onboard instrument development, fundamental research, and relevant education
- There are still many challenge for the development of laser facility, test technique and method
- There will be more and more demands for the laser facility and test service
- SEELab hope collaborate with different organizations

Nssc

Thanks your attention !