Beam monitor online system design

BMOS readout design and DAQ plan

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Introduction

This work presents a beam monitor online system design for the 1.6 GeV proton beam at China Spallation Neutron Source (CSNS), based on silicon carbide (SiC) PIN sensors. Key aspects of the design include:

- **Halo detection strategy:** Detectors are placed outside the direct beam path (2×2 cm^2 core) to monitor particles at beam edge, minimizing damage of beam while reconstructing beam parameters.
- **Readout Electronics:** A charge-sensitive amplifier with CR-RC shaping circuit processes signals.

The system enables real-time monitoring of the instensity, position, and uniformity of the updgraded CSNS beam.

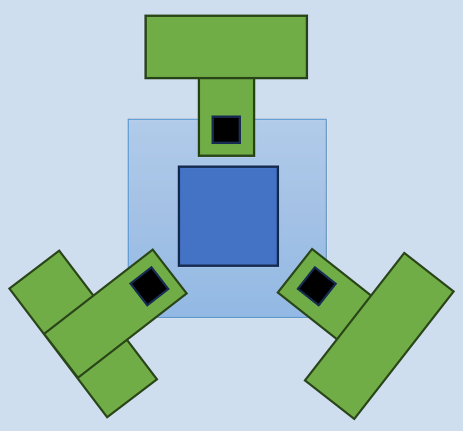
Design Objectives & Strategy

Key Objectives:

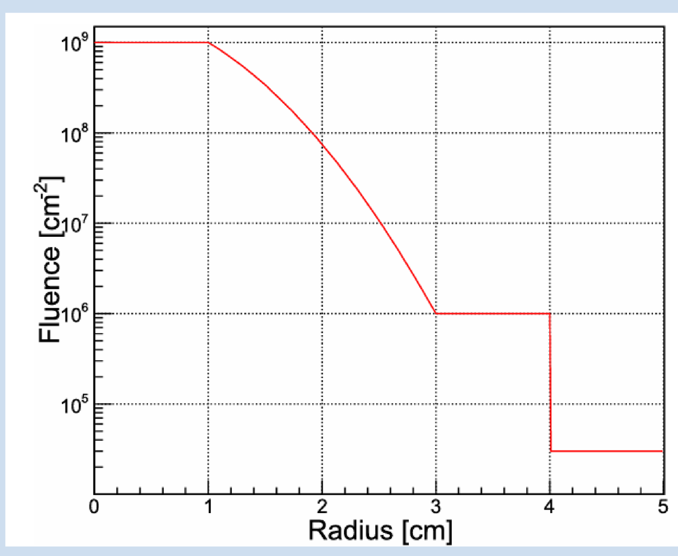
- **Real-time Monitoring:** Measure beam intensity, position, and uniformity with high precision
- **High Reliability:** Designed for 5,000+ hours/year continuous operation

Innovative Halo detection strategy:

- **Beam Center:** 2×2 cm^2 central zone
- **Peripheral Detection:** SiC detectors placed outside direct beam path
- **Key Advantage:** Monitors particles at beam edge to reconstruct beam parameters while avoiding direct damage of beam



The layout of BMOS detector. It consists of 3 movable detector boards around the beam center



The relationship between radius and fluence

Sensor Features:

1. **Radiation Hardness:** 4H-SiC's wide bandgap and high atomic displacement threshold ensure stable operation in high-radiation environments
2. **Thermal Performance:** High thermal conductivity enables reliable room-temperature operation and effective heat dissipation

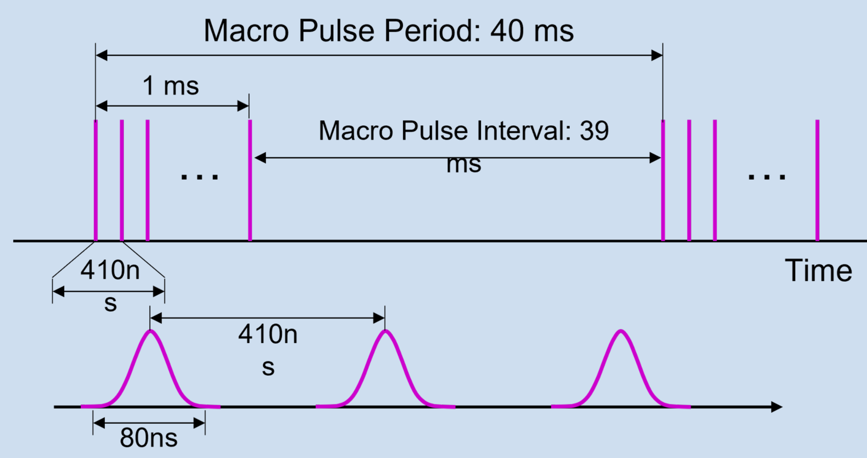
Beam Structure and Sensor Response

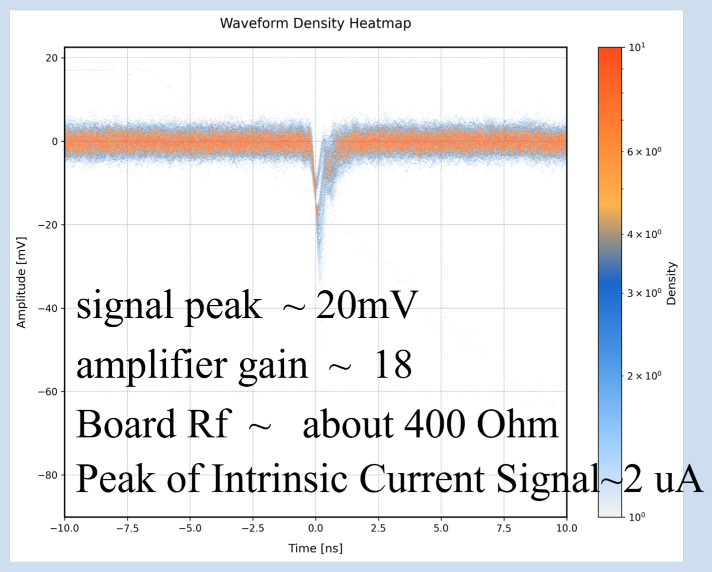
Macro Pulse Frequency: 25 Hz (24 Hz effective)

Macro Pulse Length: 1 ms, Interval: 39 ms

Micro-pulse in macro-pulse

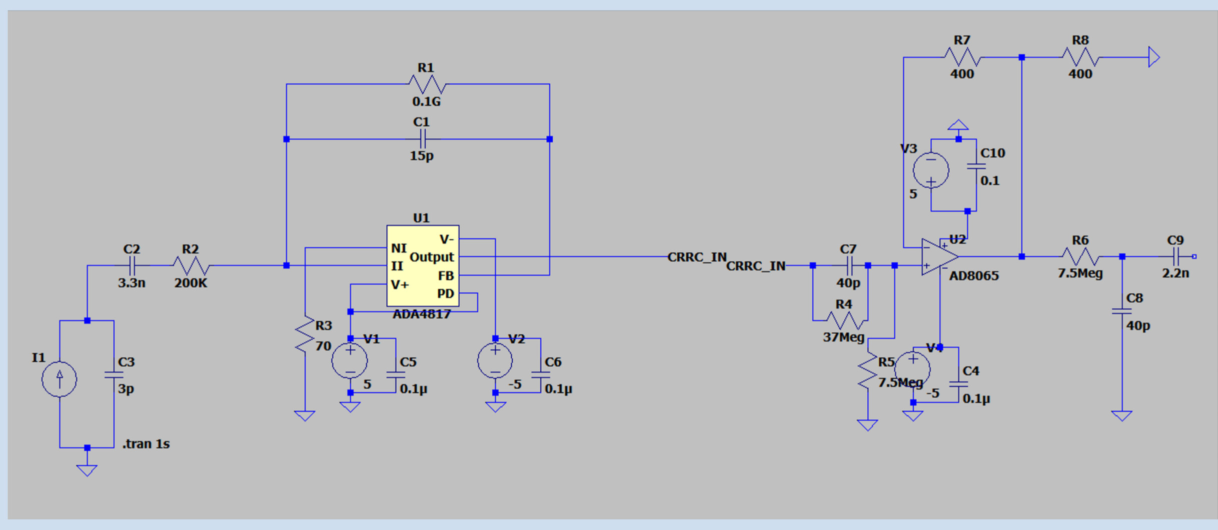
Micro-pulse period: 410 ns,
Micro-pulse Length : 80 ns



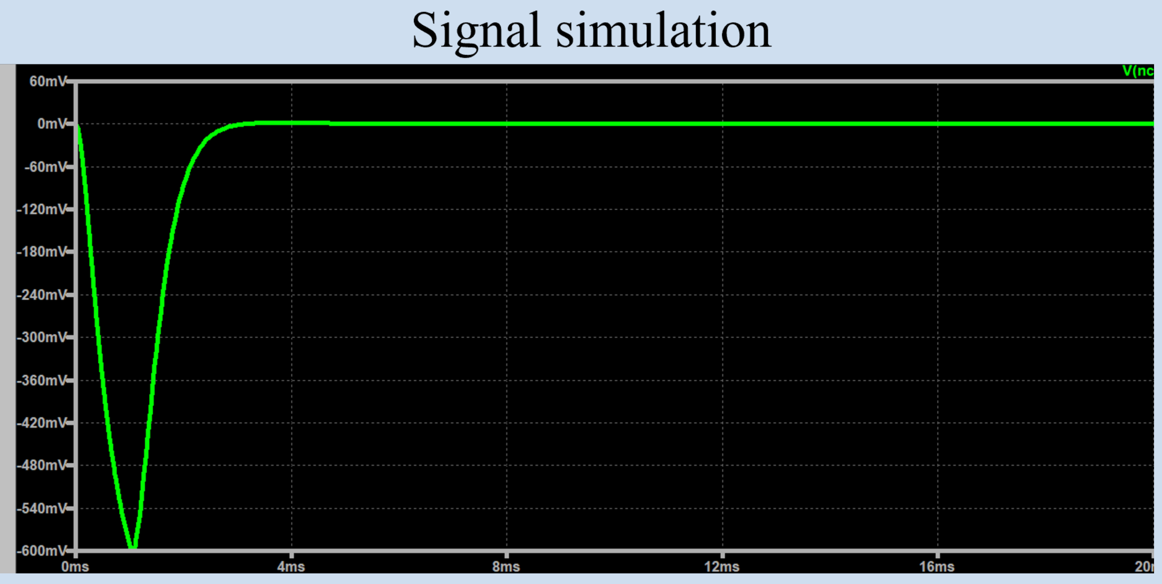


Total Read-out Design and Simulation

Readout design

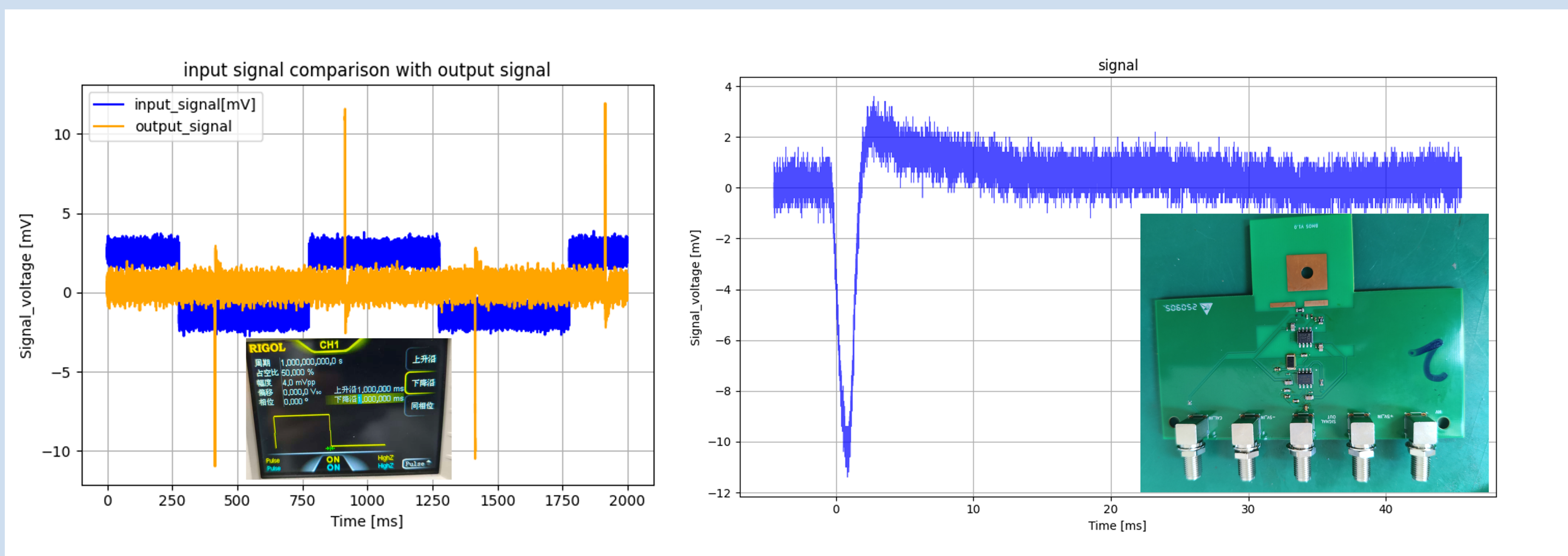


Signal simulation



Charge-sensitive amplifier design with ADA4817 (Input resistance 500 GOhm, Open-Loop Gain 65 dB) (Integration capacitance 15 pF, Discharge time about 15 ms)

Measurement Result



Signals generated by the signal generator are injected into the circuit board through the cal-in port, and the output of the circuit board is observed

Future Work Plan

- **Laser Testing:** Validate circuit board response using laser-simulated detector signals and optimize signal processing algorithms.
- **ADC/FPGA Development:** Implement ADC and FPGA-based real-time beam intensity calculation.
- **Vacuum Compatibility:** Modify board materials and layout for vacuum chamber integration and conduct stability testing.

References

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