

Radiation tolerance test for the new muon detector electronics at the HL-LHC ATLAS experiment

High Energy Physics laboratory (N-lab)

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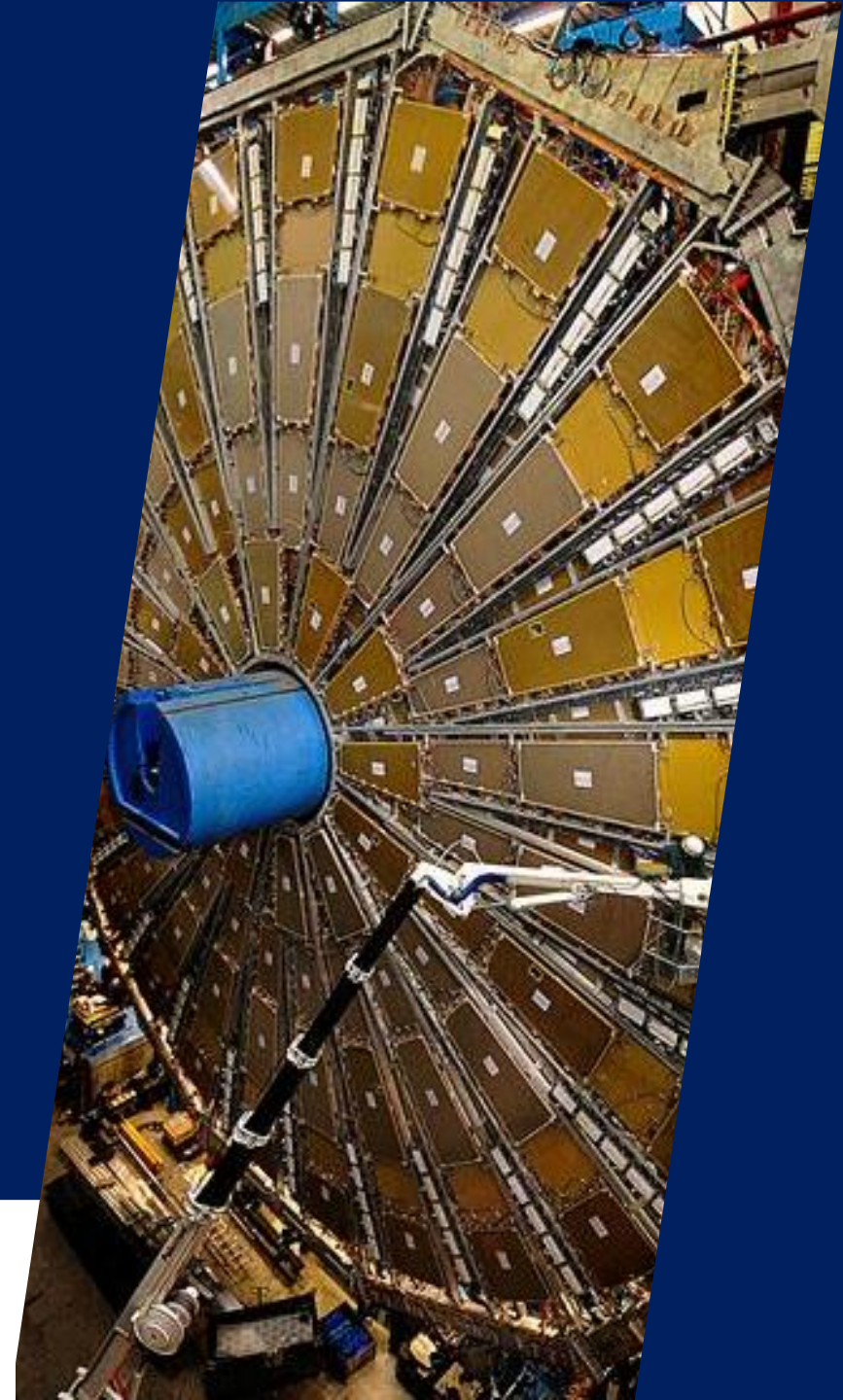
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2023年2月22日



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LHC-ATLAS experiment

➤ Standard Model

- Unresolved issues (Dark matter, SUSY, etc.)

Study objective

Obtain evidence of new physics

→ Energy frontier experiments

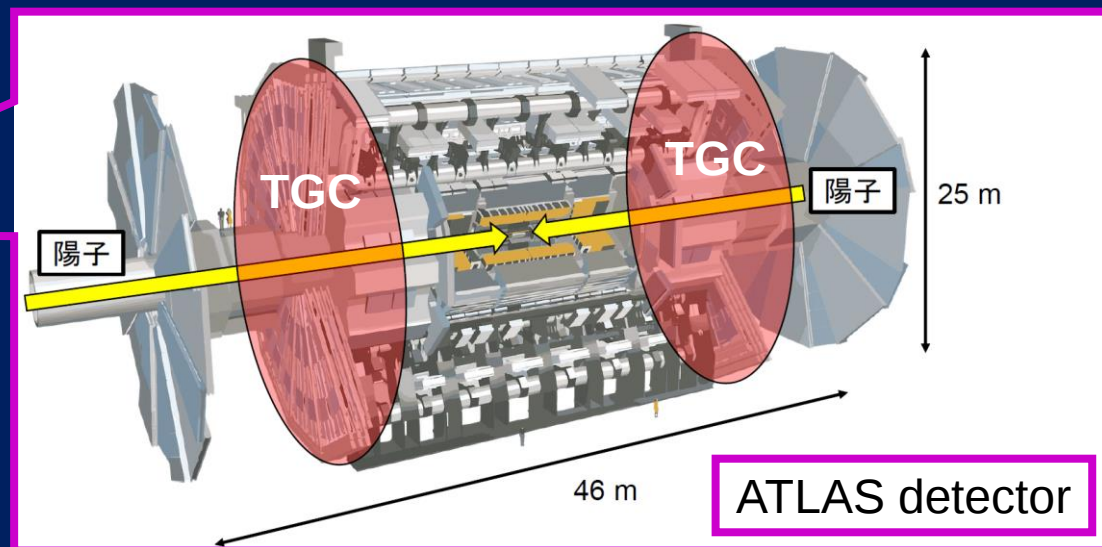
➤ LHC-ATLAS experiment

- Observation of events in pp collisions with the world's highest energy
- 2012: Discovery of the Higgs boson!!

Upgraded LHC from 2029

Data volume increase (~20 times)

→ Detector readout circuits need improvement



New TGC Electronics

➤ TGC (Thin Gap Chamber): Gas detector for muon detection

PS board (**new circuit**)

- Adjust signal timing
- High-speed hit data transfer to next circuits, etc.



Require high Radiation tolerance for elements

→ Guaranteed stable operation for 10 years

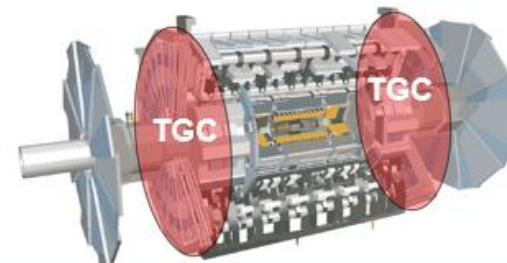


Irradiation tests

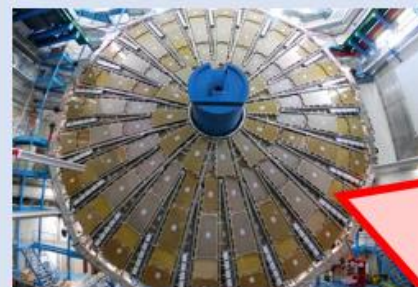
My study goal

Show that the elements have sufficient radiation tolerance

Detector area



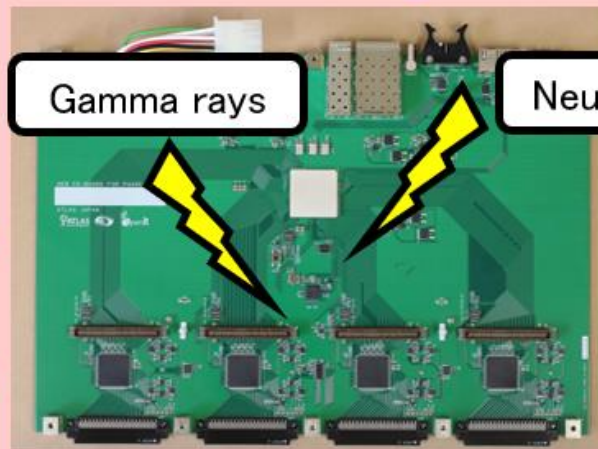
TGC



PS board

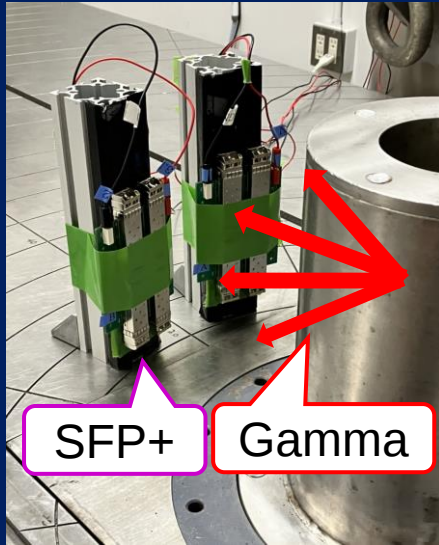
Gamma rays

Neutrons

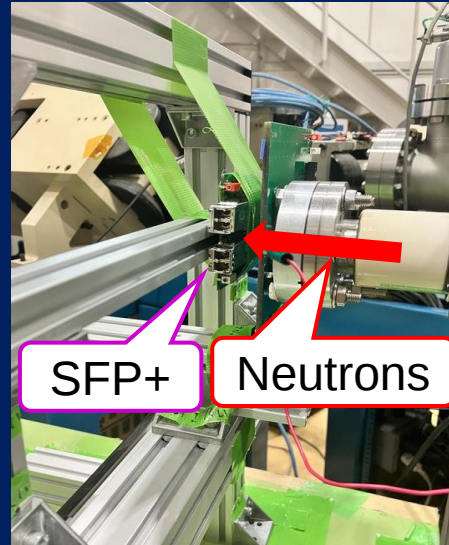


Irradiation Tests for SFP+

➤ Gamma irradiation



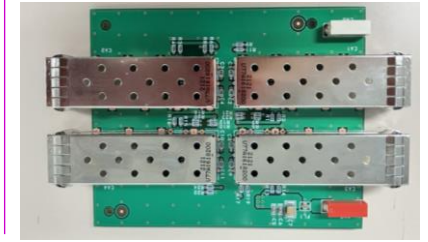
➤ Neutrons irradiation



SFP+



Insertion boards



Overall experiment design

- Setup, Test Manual, etc.
- Creation of SFP+ insertion boards
- Operation management

➤ Verification method

→ Communication test after irradiation

Status	Bits	Errors	BER
8.000 Gbps	7.77E12	0E0	1.287E-13

Working well

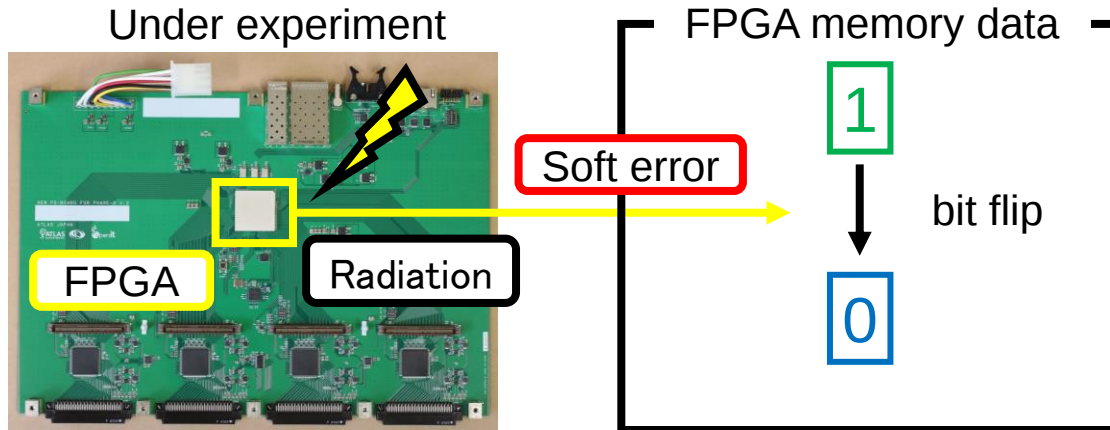
➤ Result

	Gamma test	Neutrons test
Requirements	33 Gy	$1.3 \times 10^{12} \text{ n/cm}^2$
Data	600 – 800 Gy	$> 1.7 \times 10^{12} \text{ n/cm}^2$

→ Showed sufficient radiation tolerance

Single Event Upset(SEU) Test

SEU overview



Solution

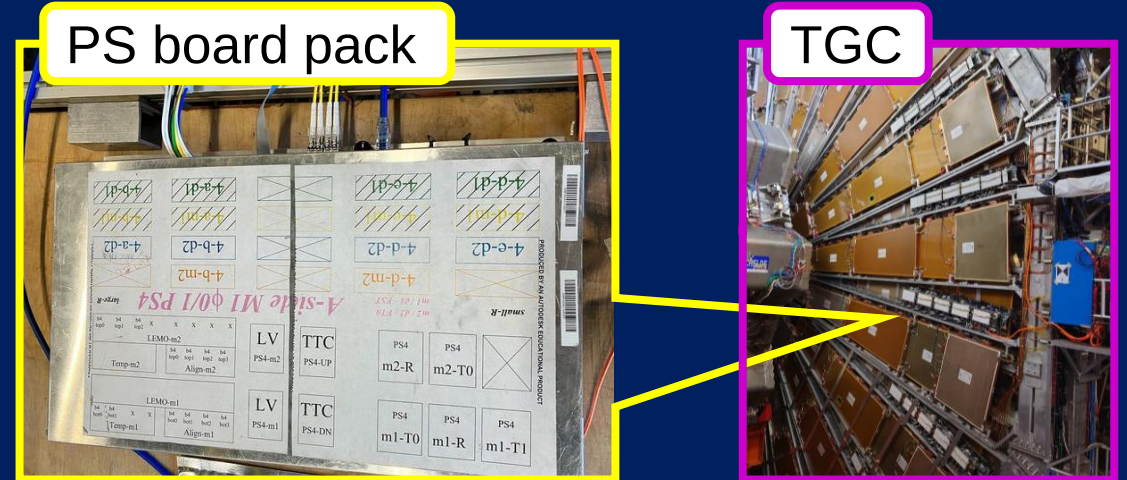
Auto Recovery Function

Observe a bit error → Automatic FPGA recovery

Study objectives

- Test under actual beam operation (April~)
- Check FPGA recovery, measure errors

➤ Preparation for the SEU test @CERN



➤ My plan

- Complete verification of the FPGA auto-recovery function
- Install the PS board by myself

Summary

- LHC-ATLAS experiment focuses on obtaining evidence of new physics
- Elements on the PS board of TGC requires high radiation tolerance
 - Gamma and neutron irradiation tests were all completed (including SFP+ test)
 - Now, I prepare for SEU tests @ CERN
- Next
 - Complete verification of the FPGA auto-recovery function
 - Install the PS board to the TGC of ATLAS detector by myself