

Environmental Testing of NI Products for Big Physics Applications

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Agenda

- Introduction
- Gamma Test
- Neutron Test
 - Fast neutrons
 - Thermal neutrons
- Magnetic Field Test

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- **Introduction**
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Radiation and Magnetic Field Testing

- Test NI PXI and cRIO products under neutron and gamma radiation, as well as magnetic field
 - Parameter specification and module selection prioritized for ITER project
 - Information now available in ITER catalogue for Fast Controllers
- Perform functional testing in facilities designed for radiation testing and relevant expertise
- Share experimental results with other NI customers

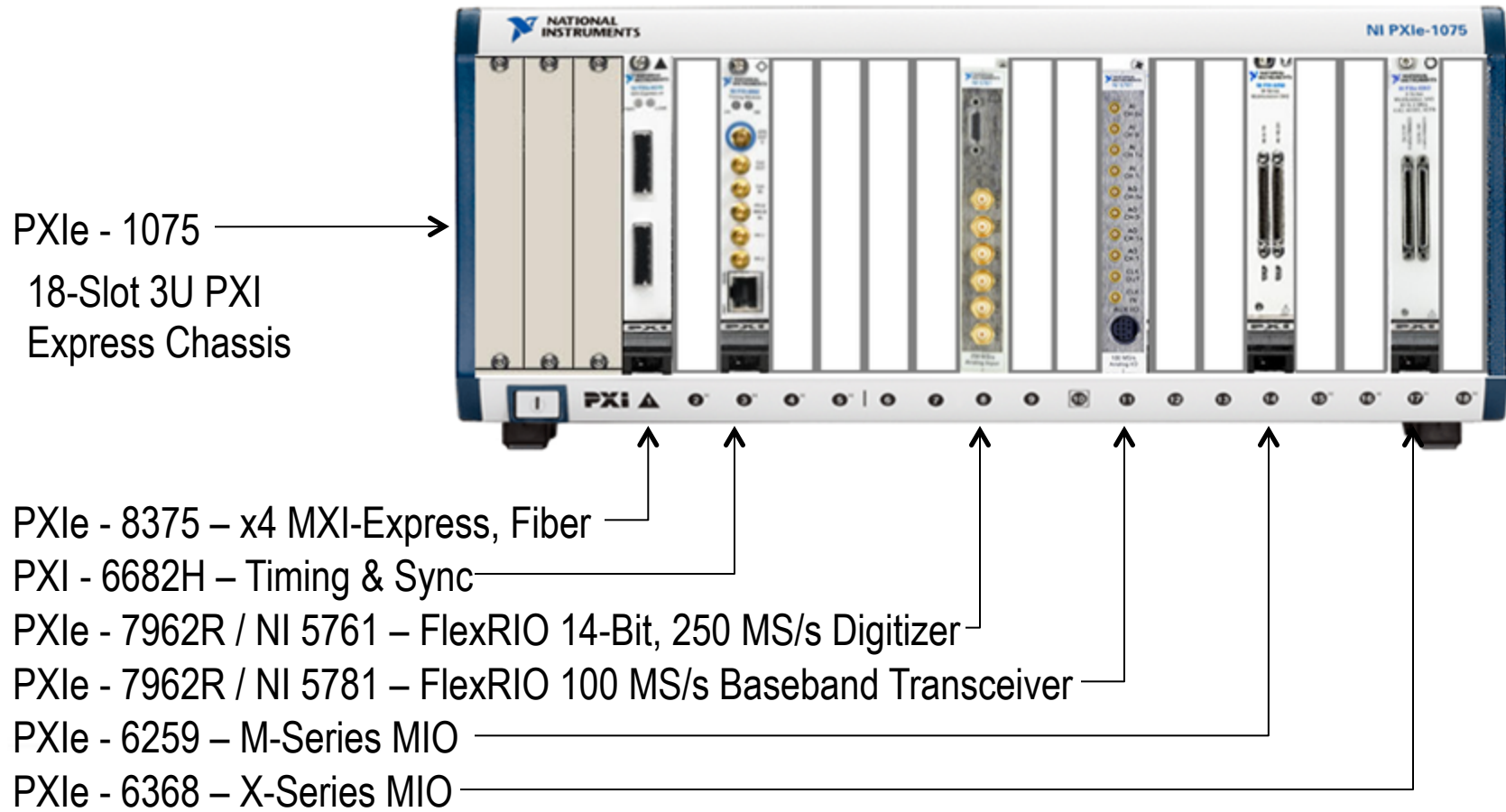
MAGFLD	Explanation
PCDH	Analysis of the module's resistance in variable magnetic fields is available and explained in detailed datasheets
PLAN	The experiment or purchase of the magnetic field resistance information is under planning by the IO
N/A	The magnetic field information might have some importance but currently the IO has no plans to make the tests with this item
N/R	There is no need for the magnetic field information

Table 5 - MAGFLD – Magnetic Field Analysis Availability Categories

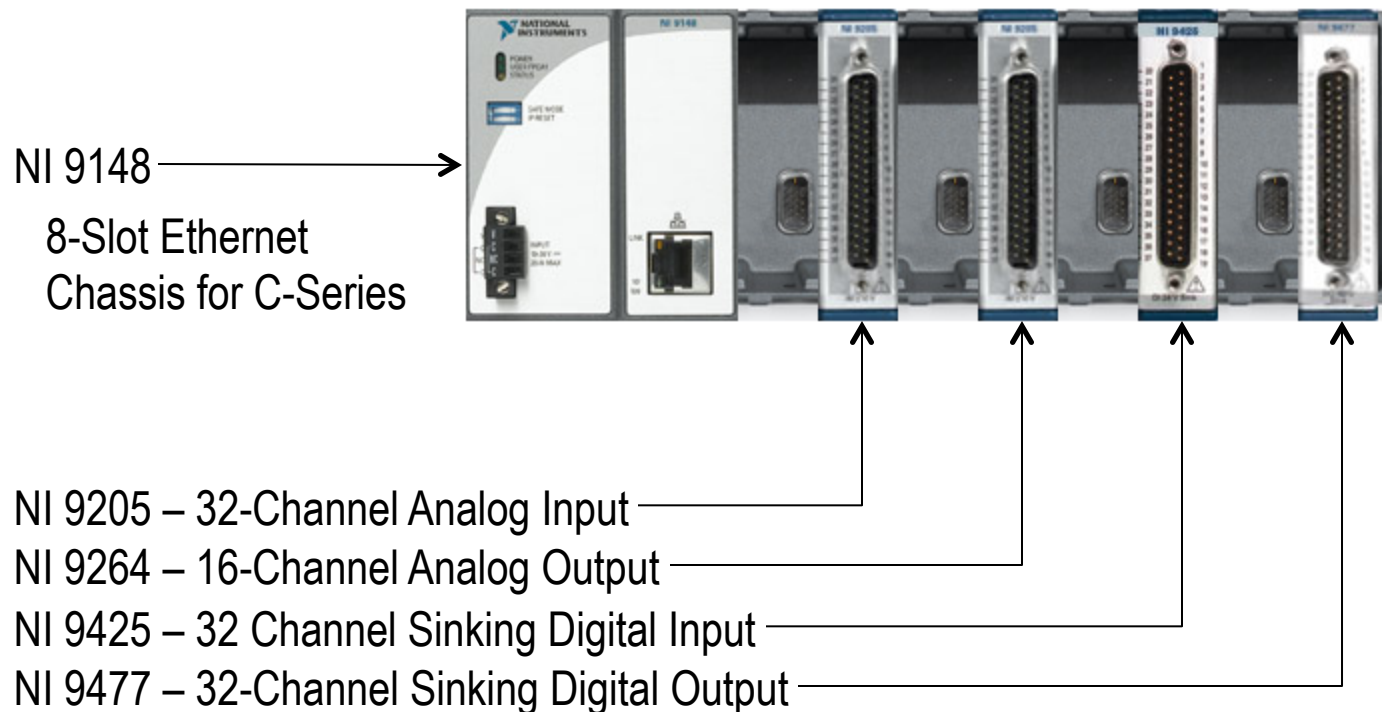
RADFLD	Explanation
PCDH	Analysis of the module's resistance under predicted radiation levels is available and explained in detailed datasheets
PLAN	The experiment or purchase of the predicted radiation level resistance analysis is under planning by the IO
N/A	The radiation level resistance information could be considered useful but the IO has no plans for the time being to obtain it
N/R	There is no need for the radiation level resistance information

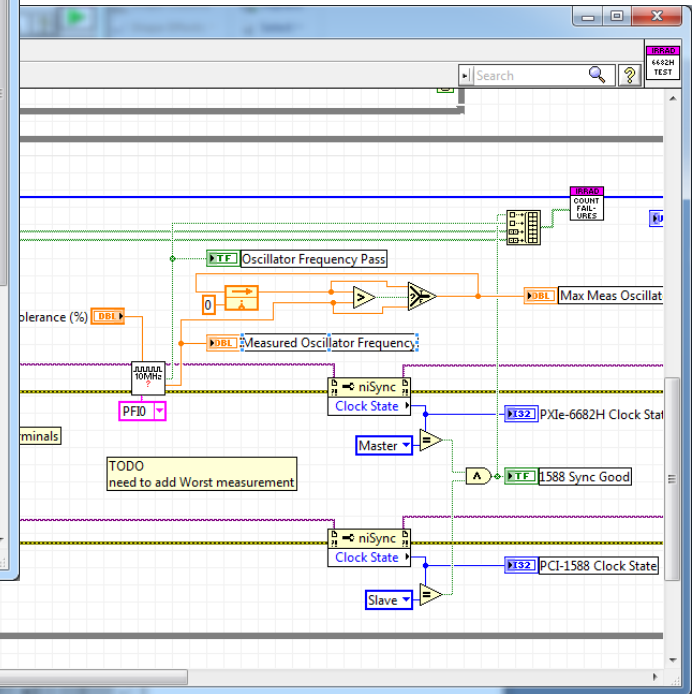
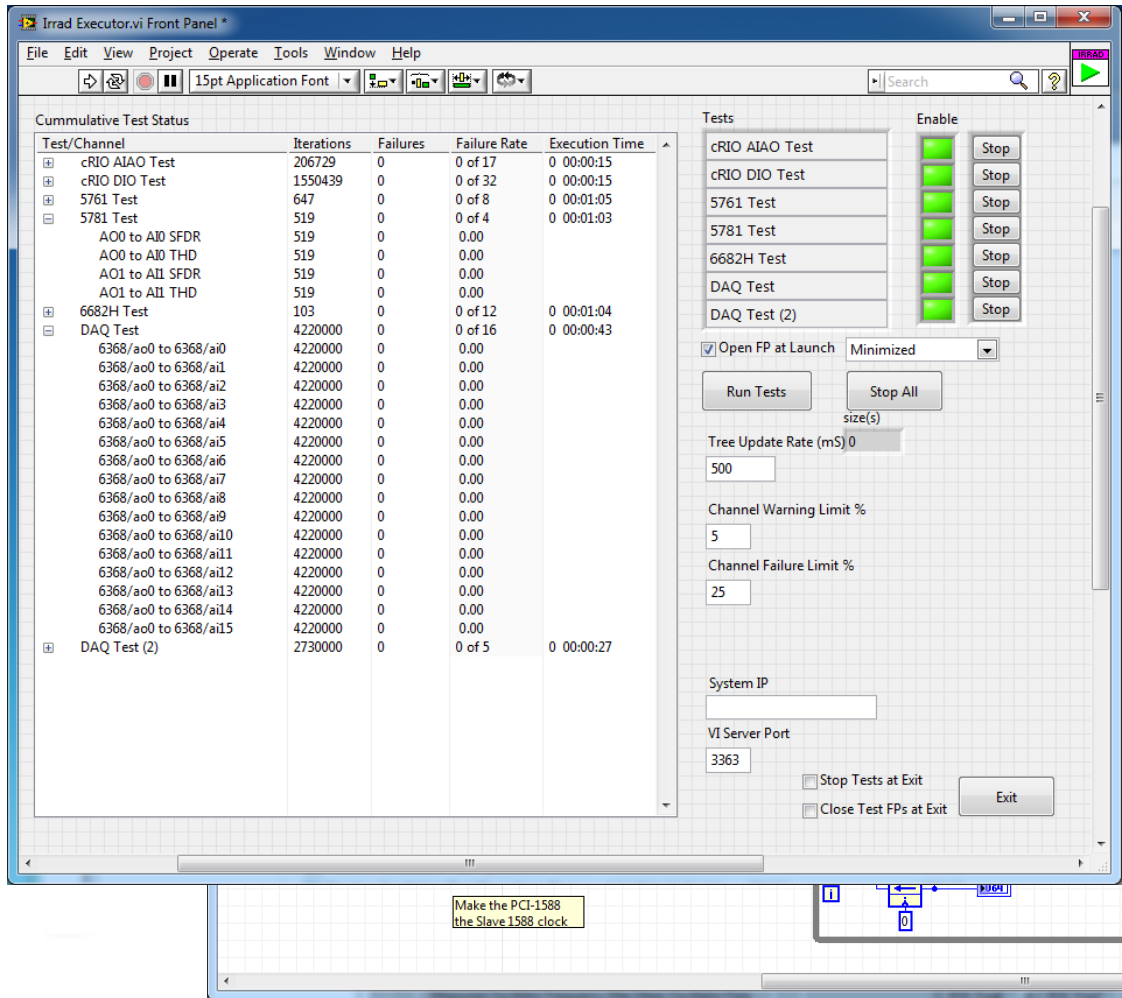
Table 6 - RADFLD – Radiation Resistance Analysis Availability Categories

PXIe System Hardware Layout



cRIO System Hardware Layout





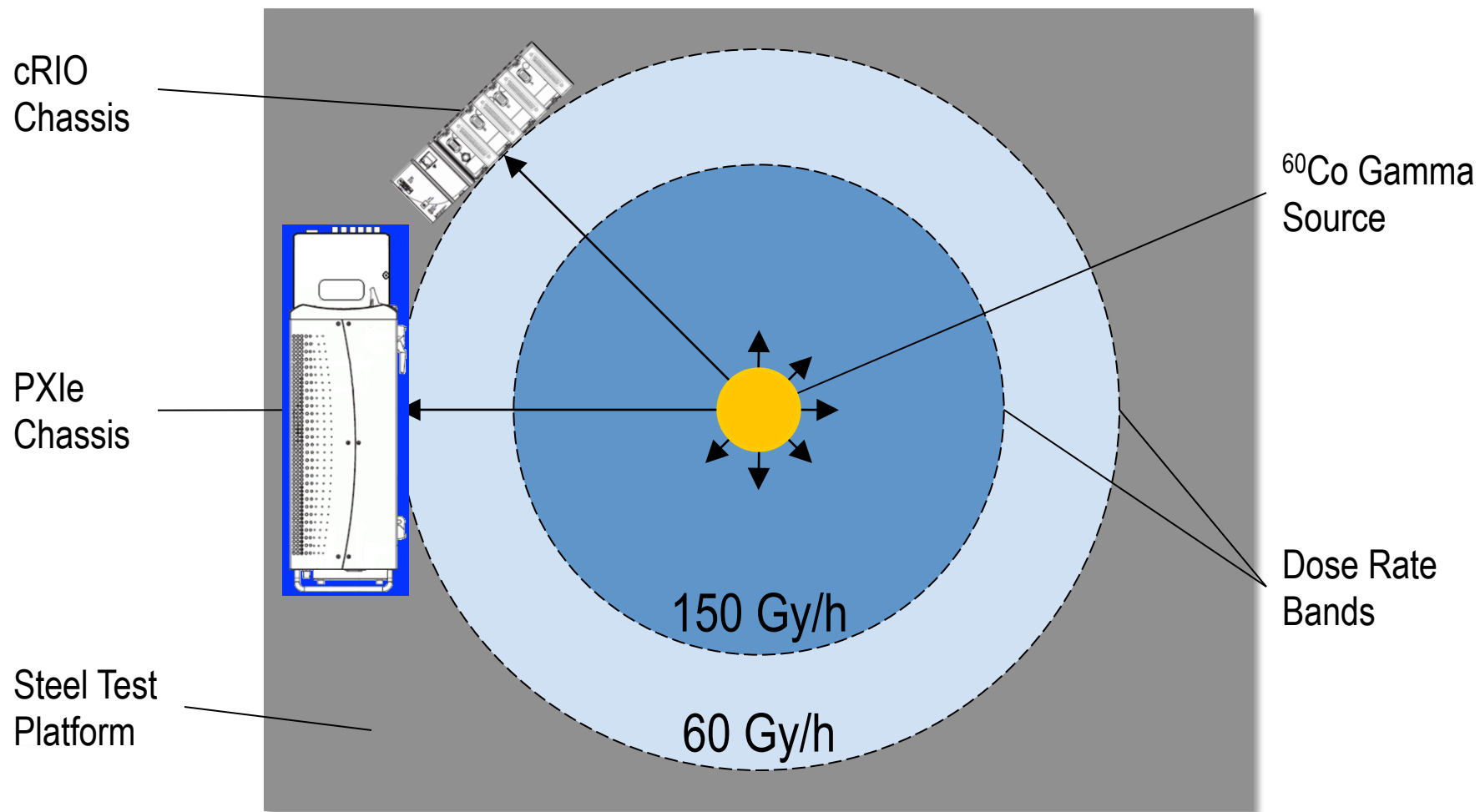
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ITER Guidelines on Expected Gamma Radiation Effects

- For the system and individual components, at what dose level is there
 - degradation in analog signal performance
 - partial and/or temporary functional failures
 - permanent failure
- Permanent failure is expected around 50 Gy (25-100 Gy with high confidence in failure)

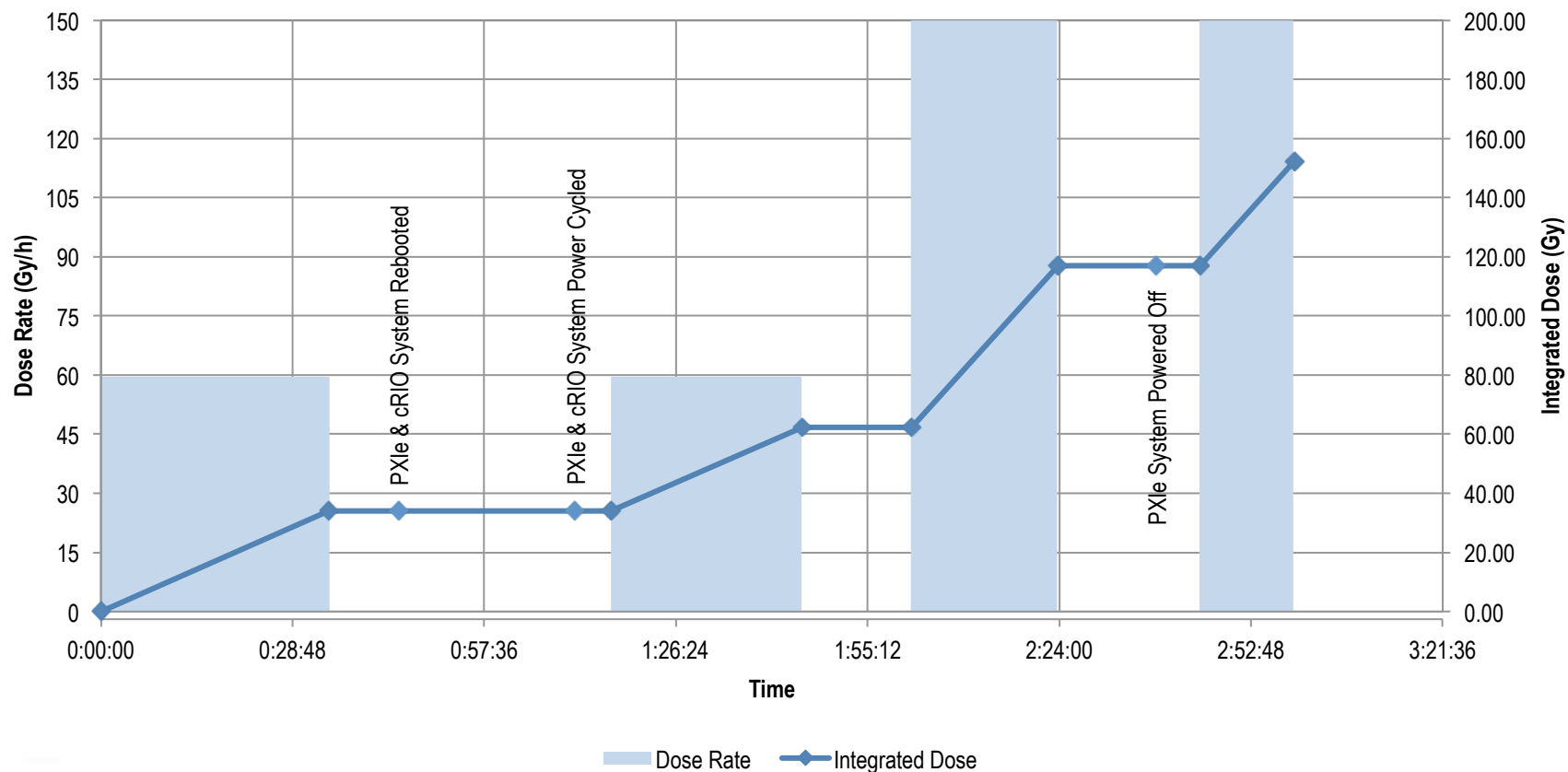
Gamma Testing System Orientation



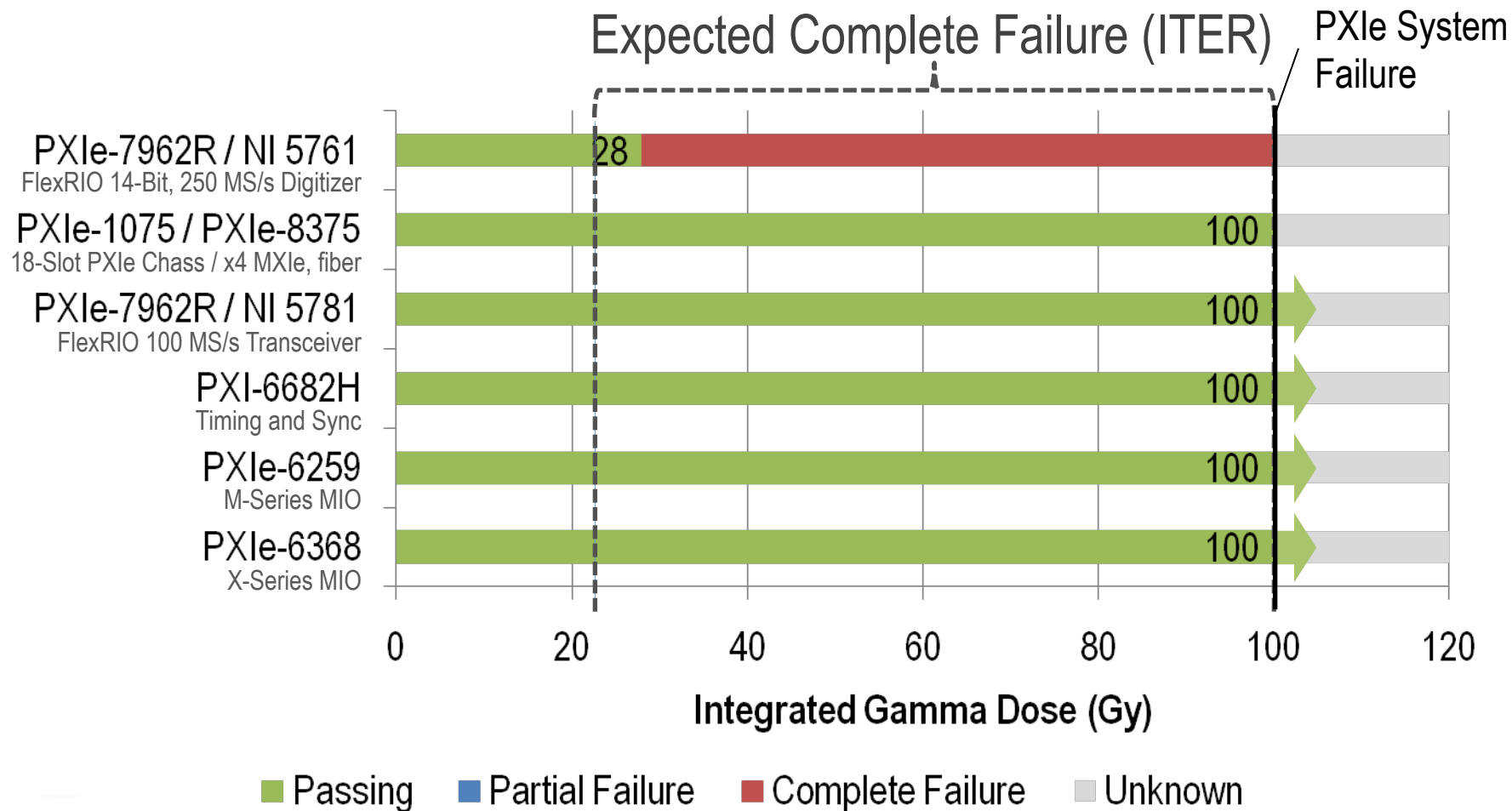
Gamma Test Setup



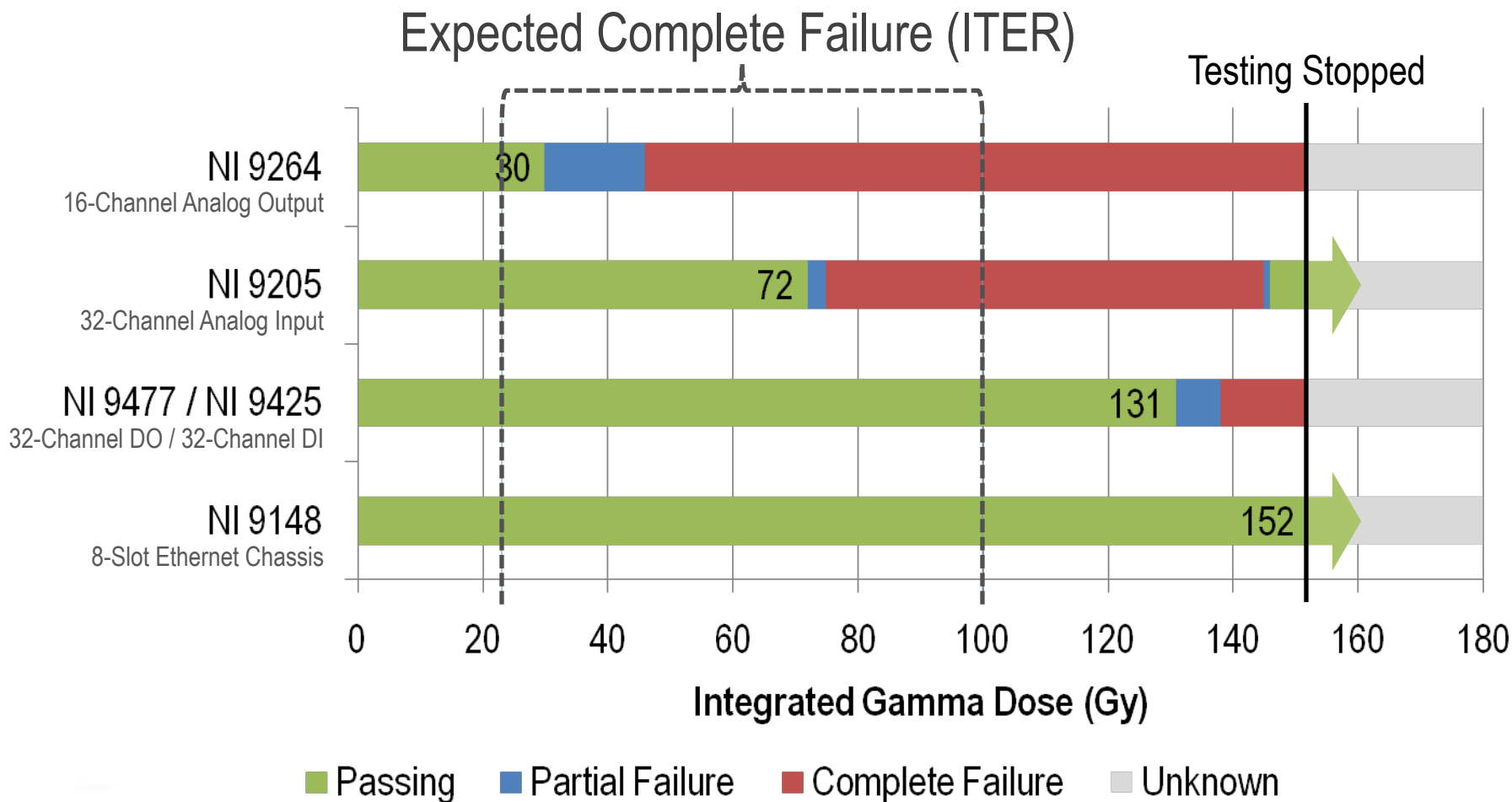
Gamma Radiation Dose



PXle System Irradiation Test Summary



cRIO System Irradiation Test Summary



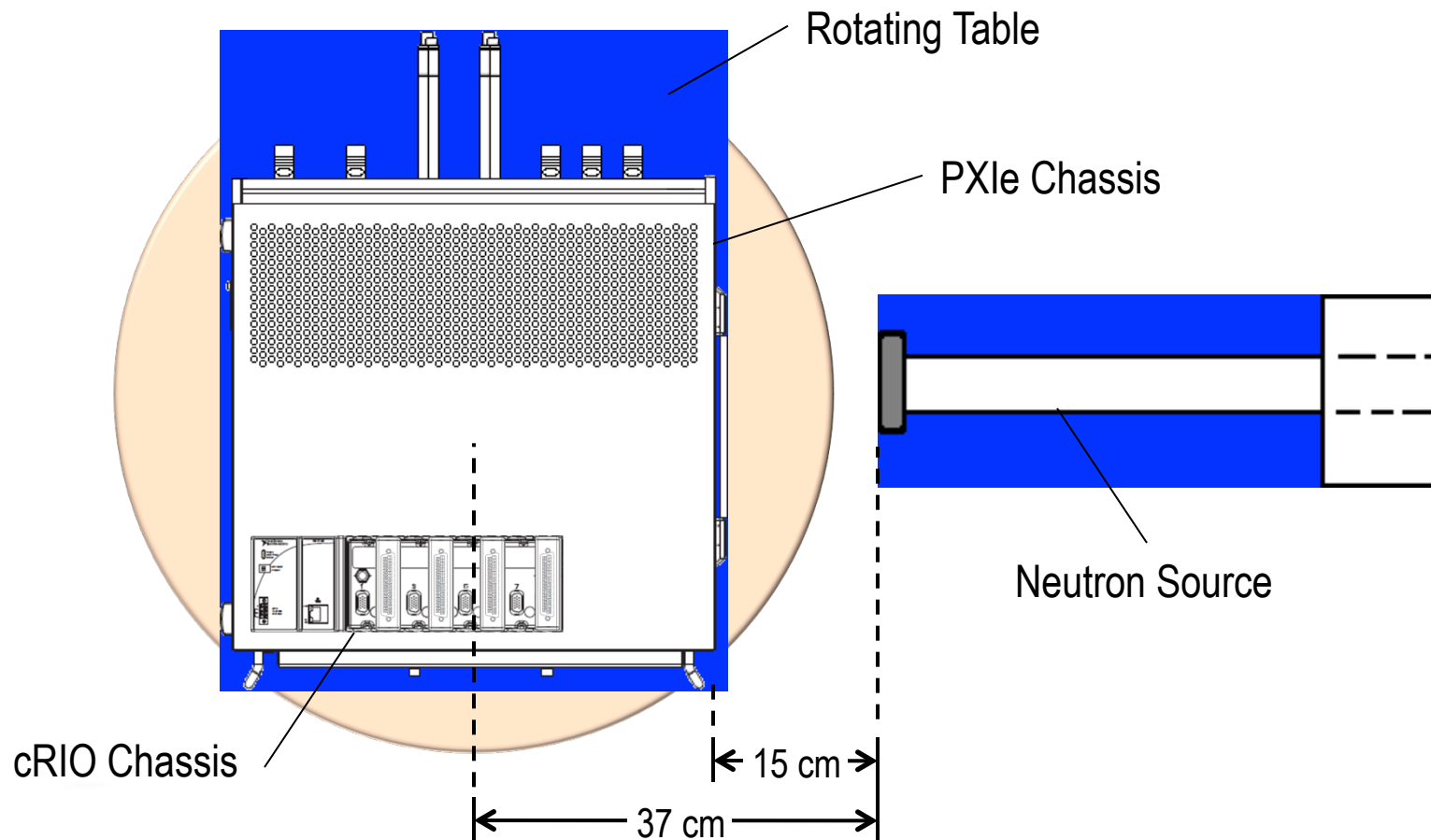
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 - Thermal neutrons
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ITER Guidelines on Expected Neutron Radiation Effects

- Neutron irradiation effects on systems
 - Corrupt data in the SRAM or other memory of a CPU or ADC board
 - Hang-up of the CPU or ADC board requiring a re-boot
 - Corrupt configurations in FPGA or other programmable devices requiring re-configuration to continue operation
- Expect an SEU event every minute in a computer sized electronics (for $1\text{E}+5 \text{ n/cm}^2/\text{s}$)

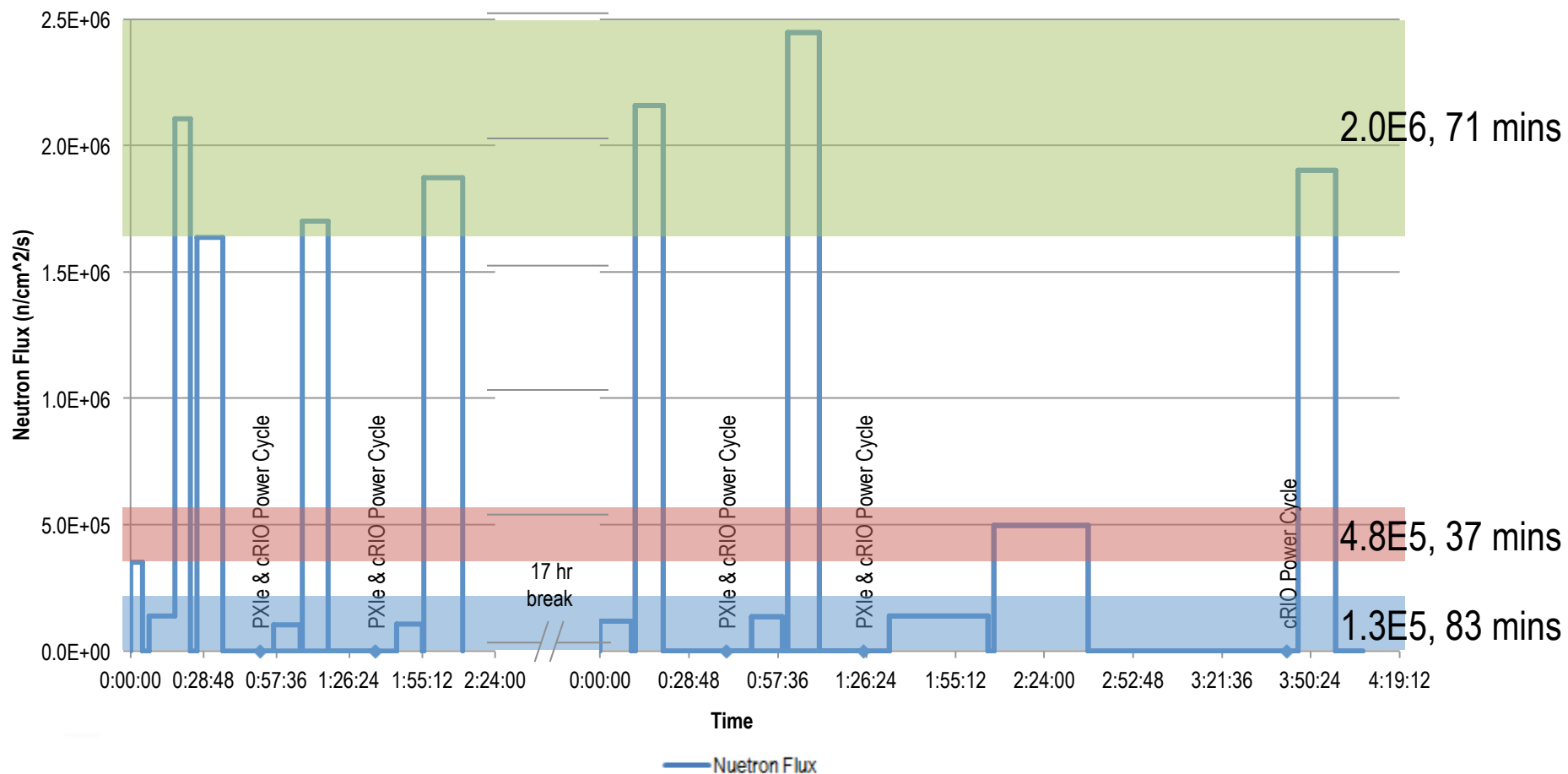
Neutron Testing System Orientation



Frascati Neutron Generator



Neutron Flux over Time

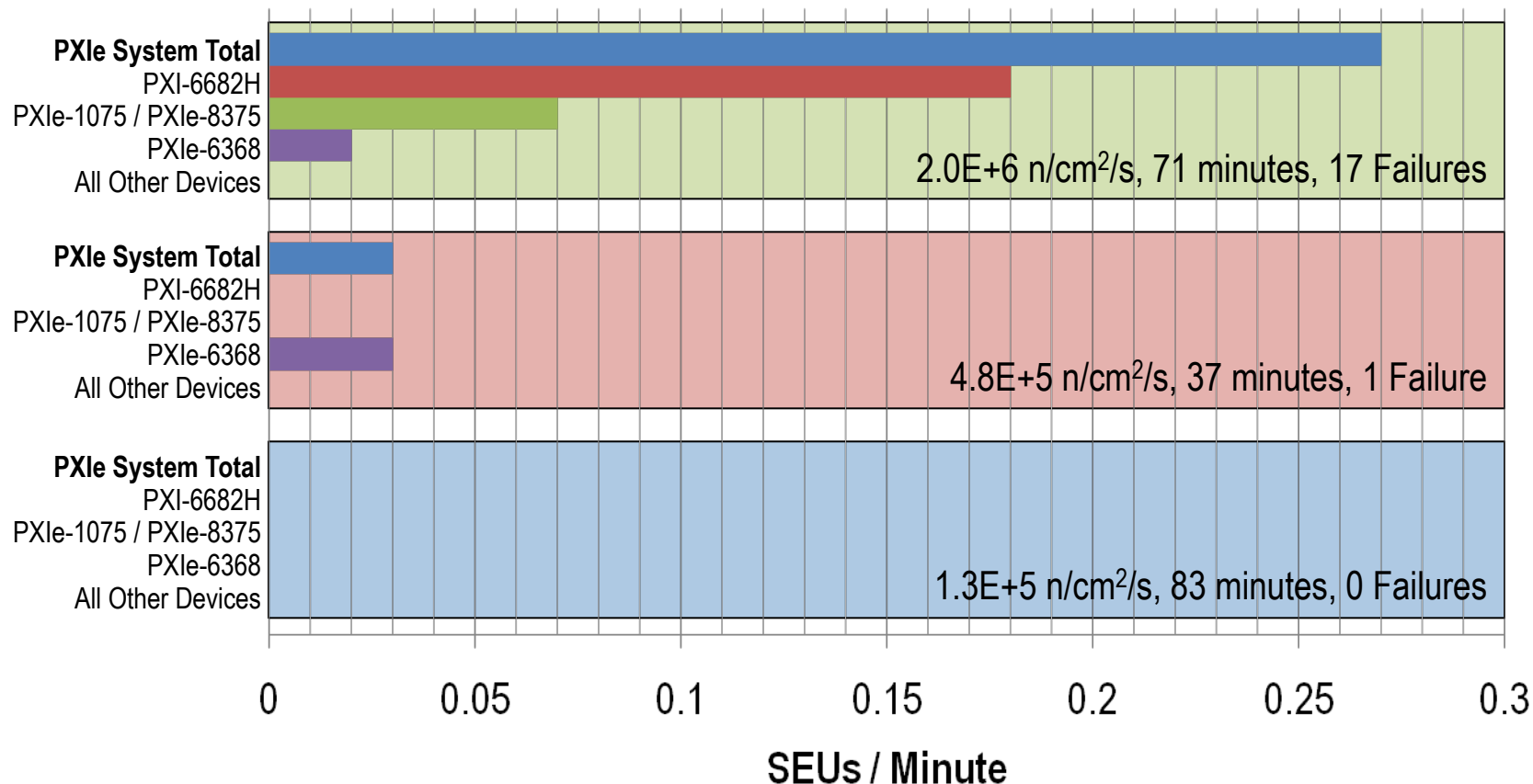


Neutron Test Results Analysis

- 1 SEU is defined as any of the following
 - Single test failure
 - Test failure that fails and continues to fail until reboot
 - System hang

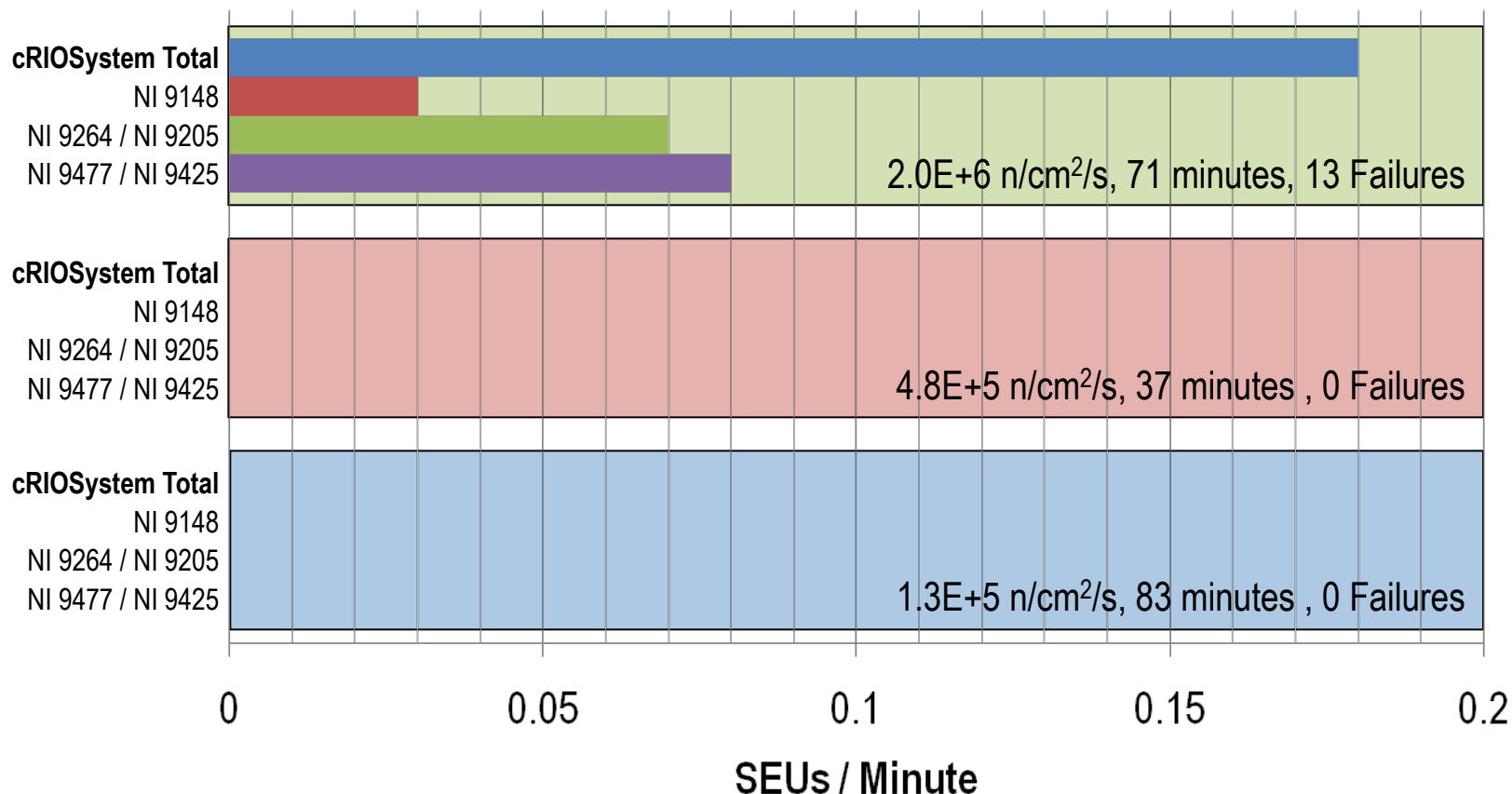
PXle SEUs per Minute

ITER Expected Failure Rate = 1 SEU / min @ $1\text{E}+5$ n/cm²/s



cRIO SEUs per Minute

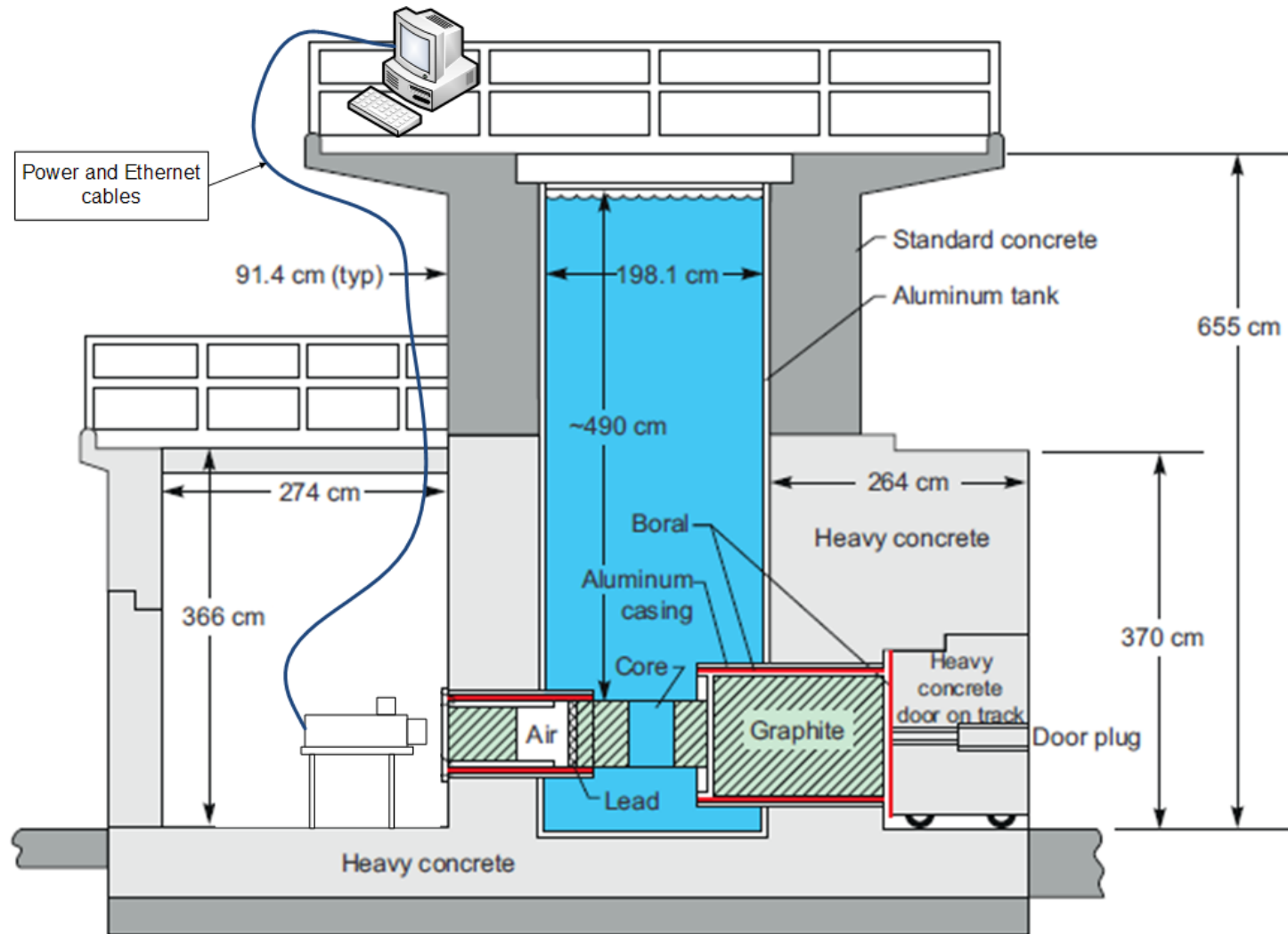
ITER Expected Failure Rate = 1 SEU / min @ $1\text{E}+5$ n/cm²/s



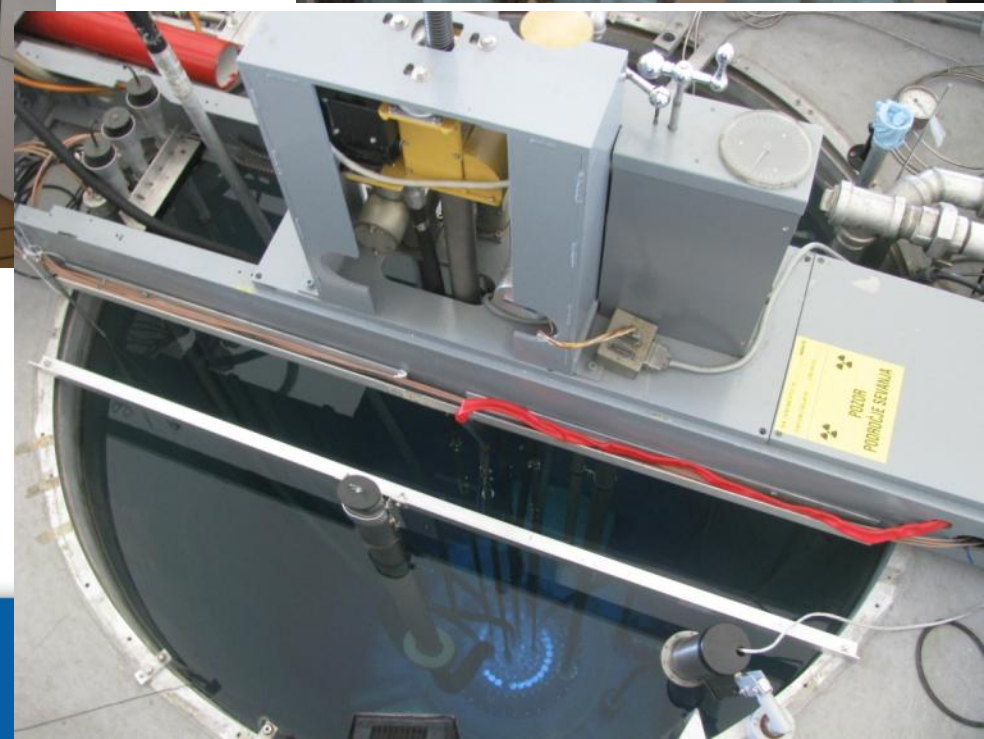
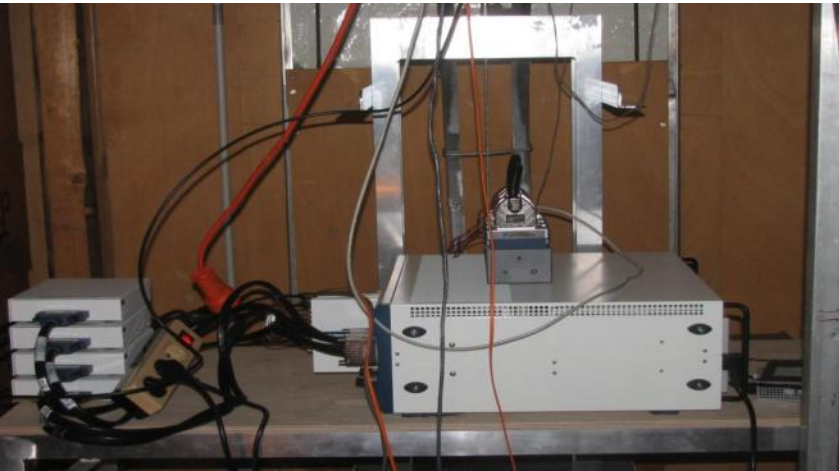
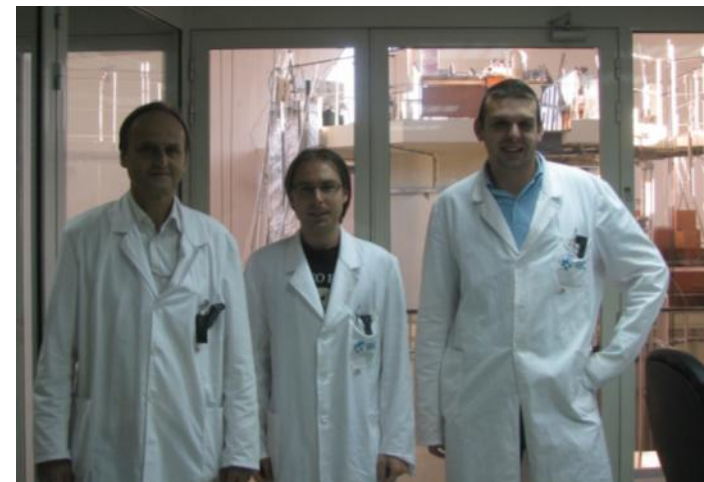
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 - Thermal neutrons (0.625eV) + Epithermal (0.625eV – 0.1MeV)
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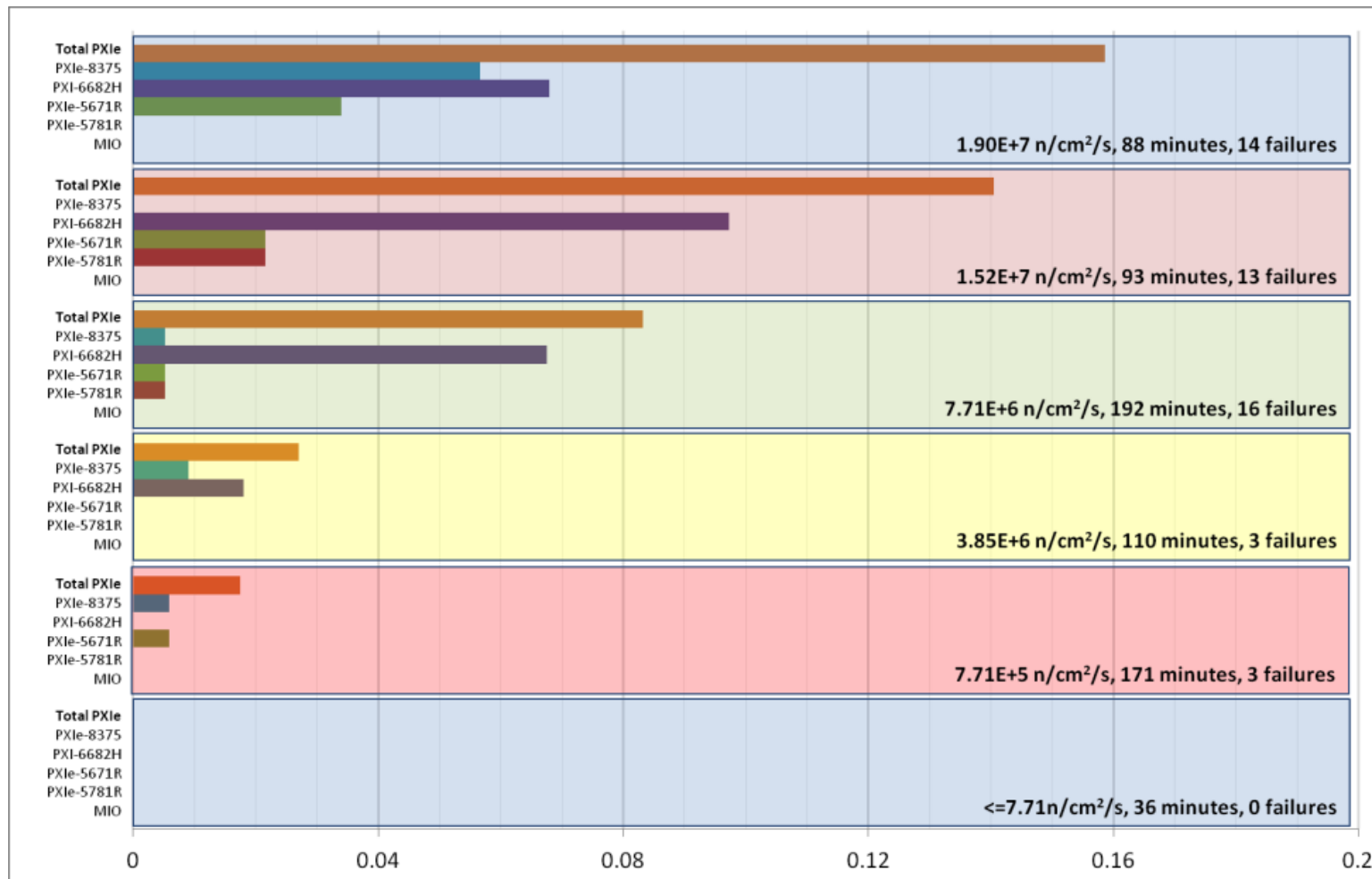
TRIGA Reactor at JSI



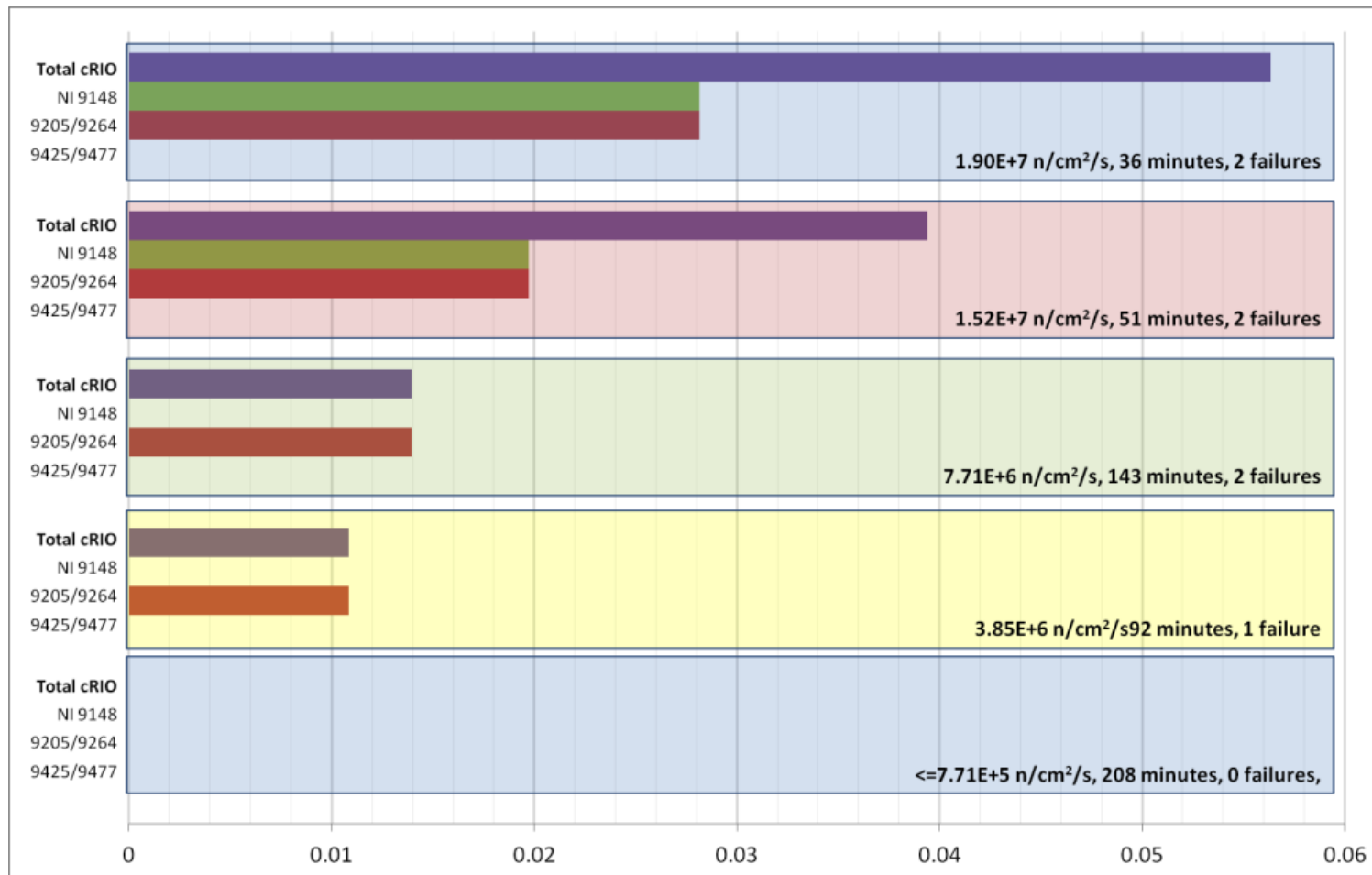
TRIGA Reactor



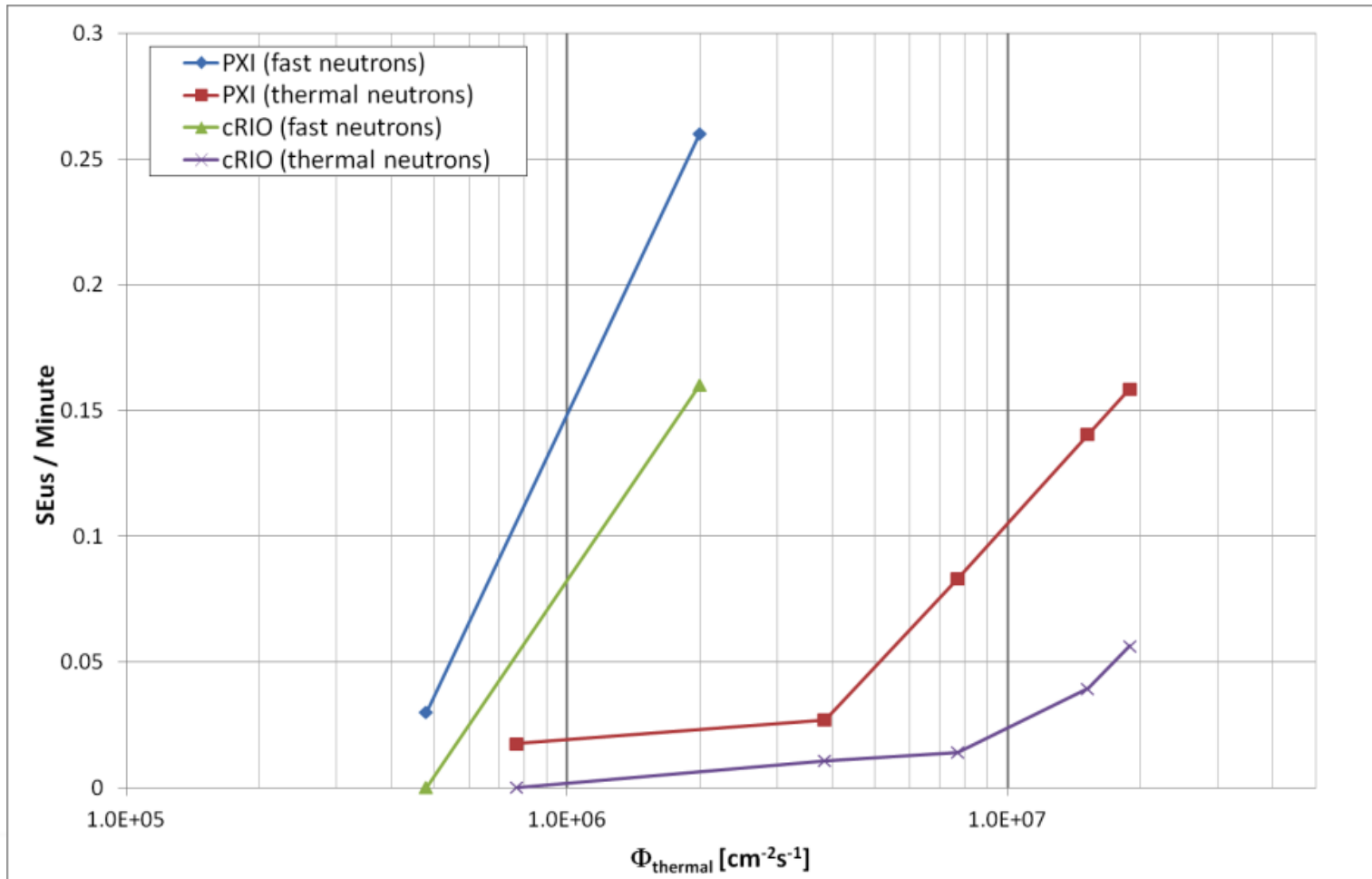
PXle SEUs per Minute



cRIO SEUs per Minute



Failure Rate vs Neutron Flux



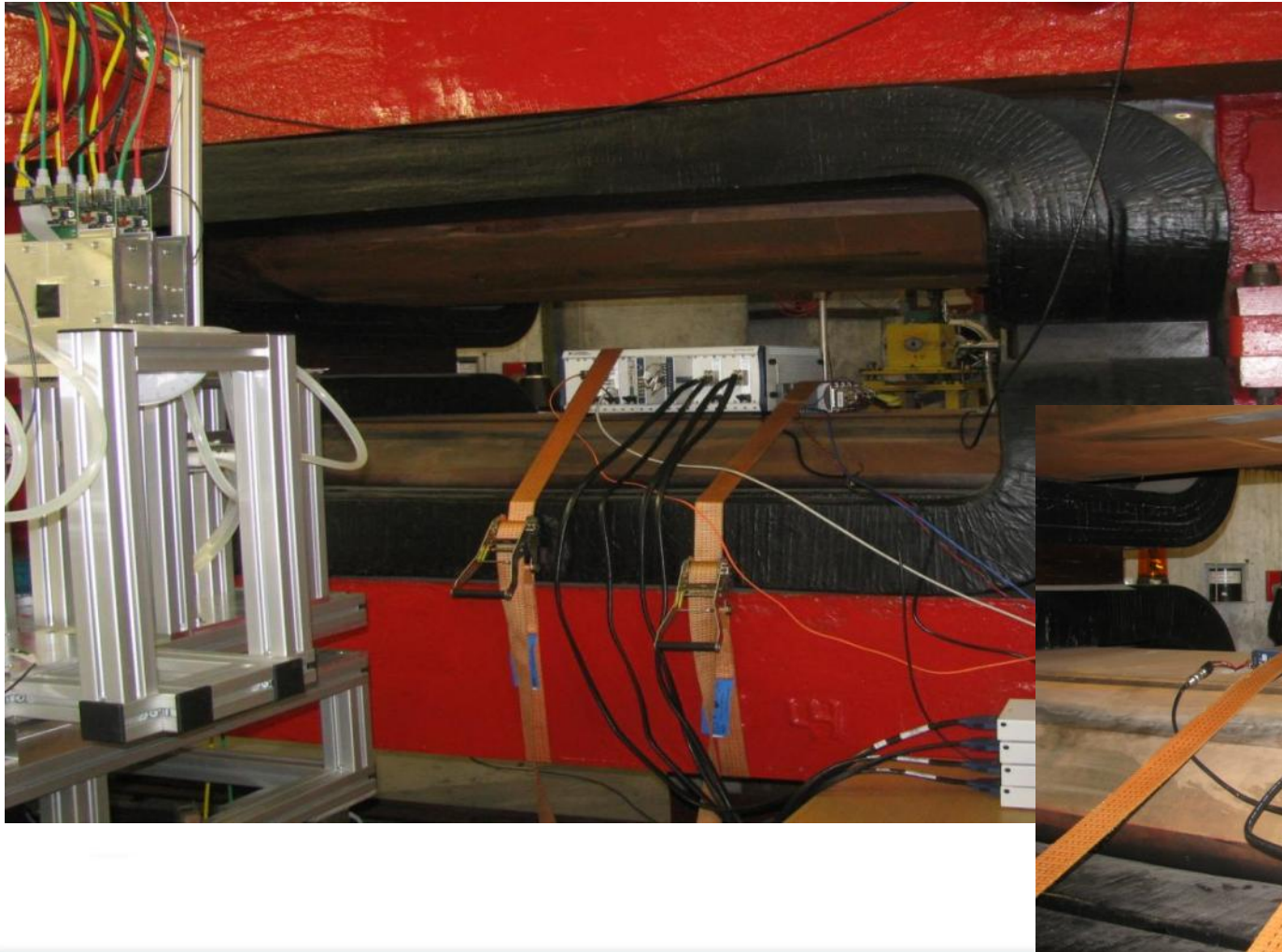
Radiation Testing Conclusions

- Gamma Testing
 - Most devices exceeded expected failure dose of 50 Gy
 - Cumulative effects are evident in the gamma testing
- Fast Neutron Testing
 - Single Event Upsets dominated the neutron results generally meeting ITER requirements
 - Did not see permanent damage
- Thermal Neutron Testing
 - Testing at almost 1 order of magnitude more flux compared to fast neutron
 - Failure rates were less than or equal to what was seen with fast neutron testing
 - MIO hardware handled thermal much better than fast neutron (0 failures)

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Magnetic System Test Setup at DESY



Magnetic Test Results (INITIAL)

- PXI
 - Fans failed at 12 – 13 mT – sooner than expected
 - Fans failed permanently – had not seen before
 - 2 dead fans halted testing of PXIe-1075
- cRIO
 - Worked with 0 errors up to 45 mT
 - AI (9205) failed permanently at 45 mT
 - Communication fails at 55 mT
 - FPGA, AO, DIO work up to at least 100 mT

QUESTIONS ?