

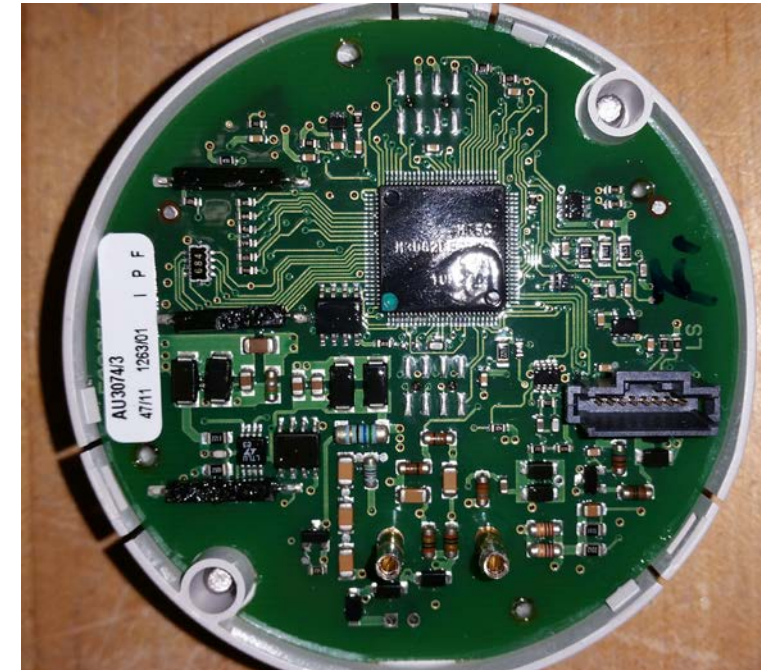
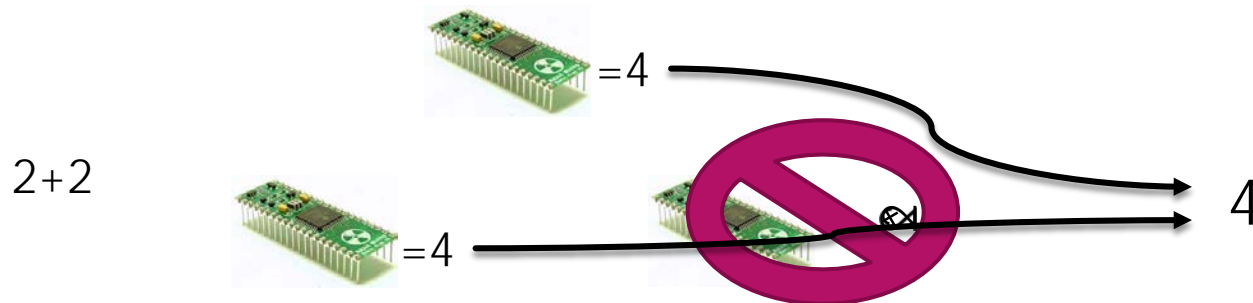
# Characterizing Radiation-Induced Faults in Microprocessors

KURT LYNN

# History

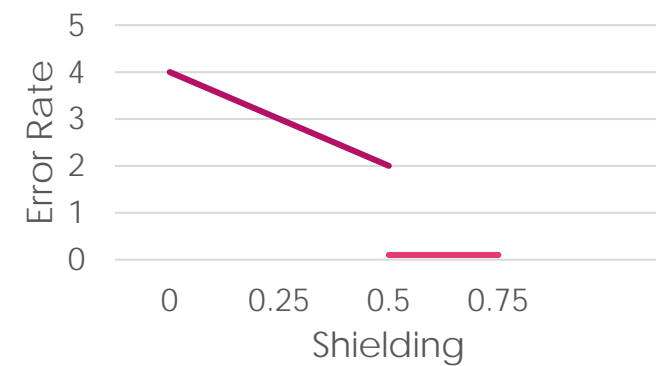
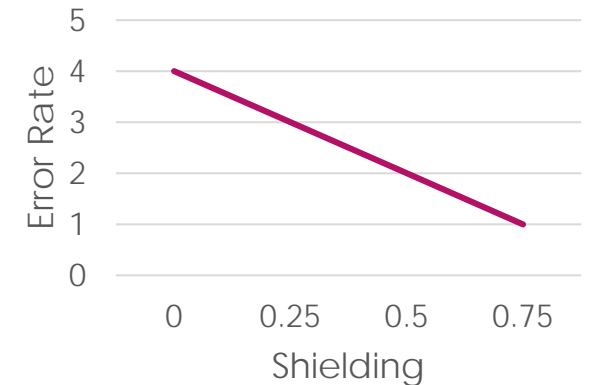
Microprocessors have been affected by radiation for years. The problem is most research has been directed towards space, and the cosmic radiation bombarding satellites.

- ▶ Why haven't we just invented a radiation-proof microchip?
  - ▶ Radiation Hardened
- ▶ Is there a way to keep the microprocessors from having glitches?
  - ▶ Redundant chips for backup that all vote on a result for each calculation.



# What does that mean to us?

- ▶ There are three ways to limit exposure:
  - ▶ Distance
  - ▶ Time
  - ▶ Shielding
- ▶ At what point does shielding have an effect?
  - ▶ Is there a proportional effect with the amount of errors rising with exposure?
  - ▶ Or is there a range of radiation where the microprocessor can still function?
  - ▶ When do the processors have such a low error percentage that they can be called "functional"?





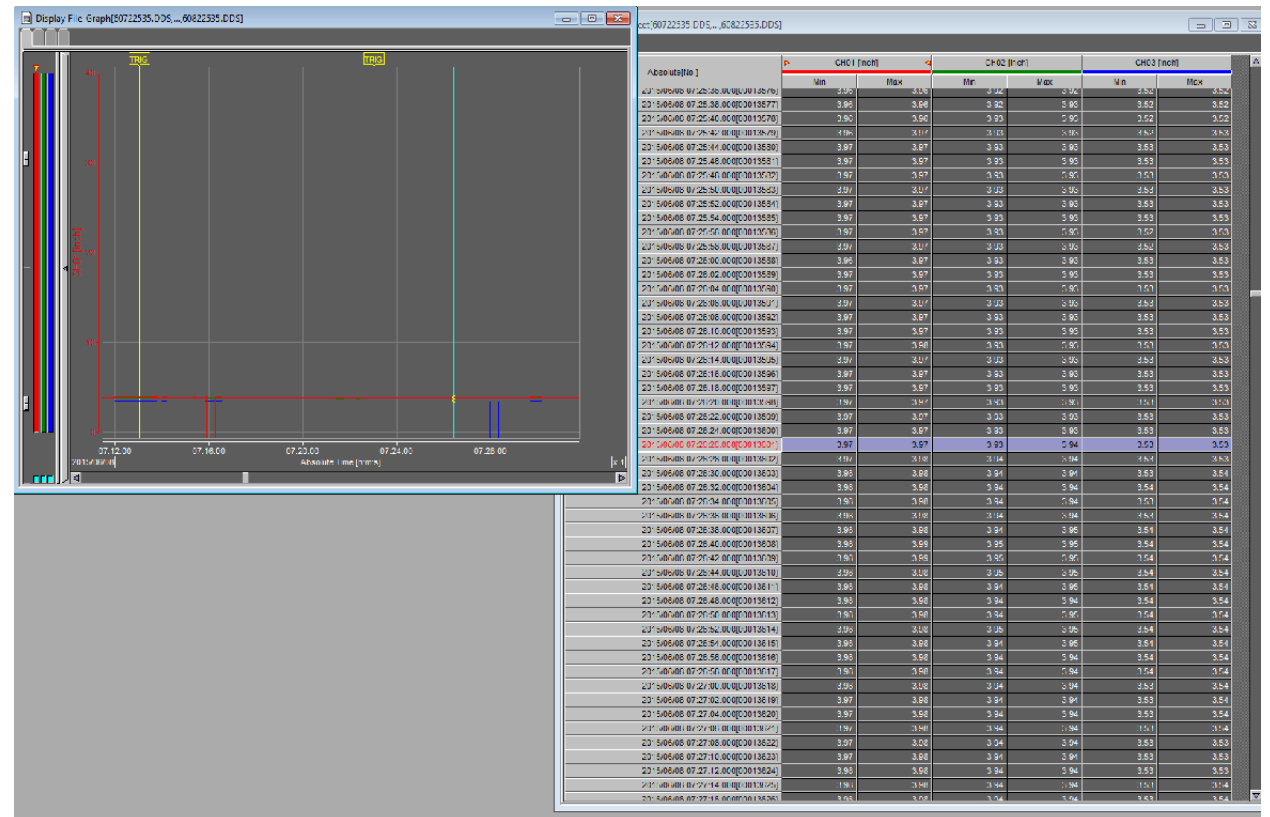
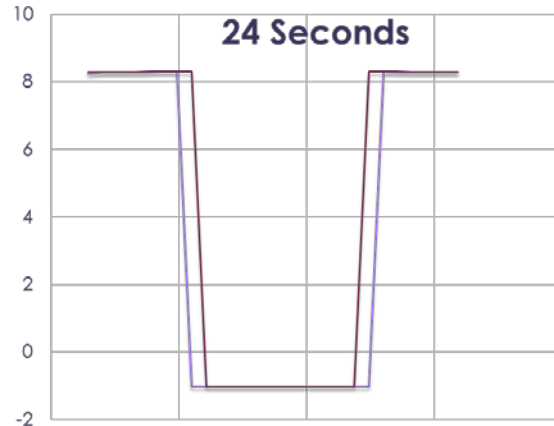
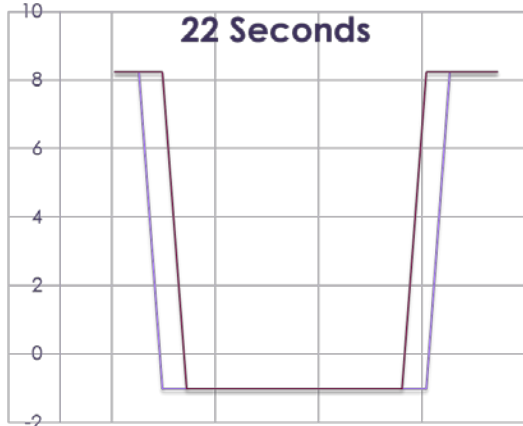
# Setting up the Experiment

- ▶ 3 Flow Transmitters hooked up to a static water source.
  - ▶ Water Max and Min flow values shouldn't change
  - ▶ Readings should remain constant without dips or spikes.
  - ▶ The only reading changes are from the transmitters microprocessor itself.

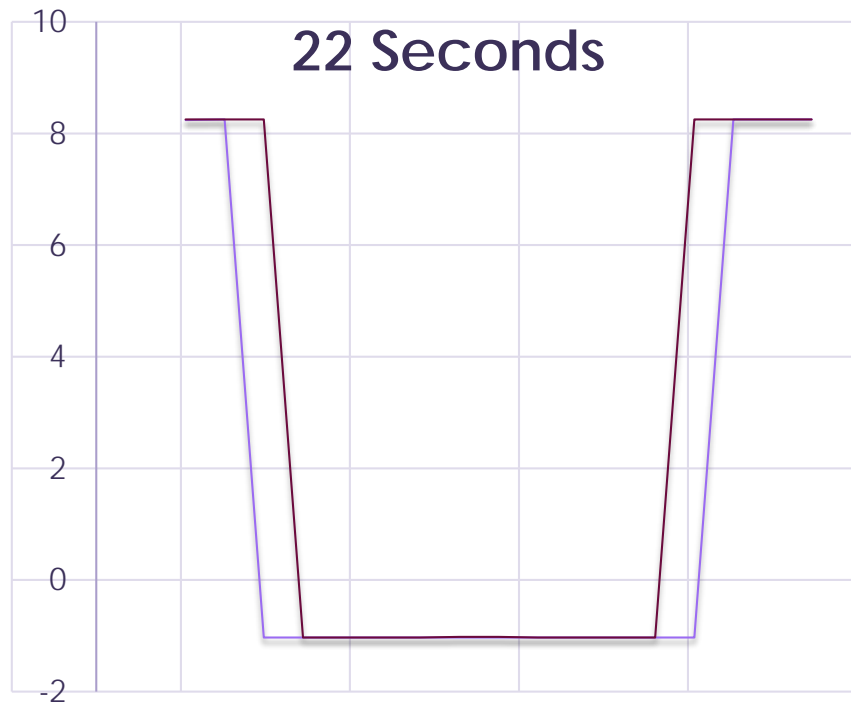


# Types of Failures Encountered

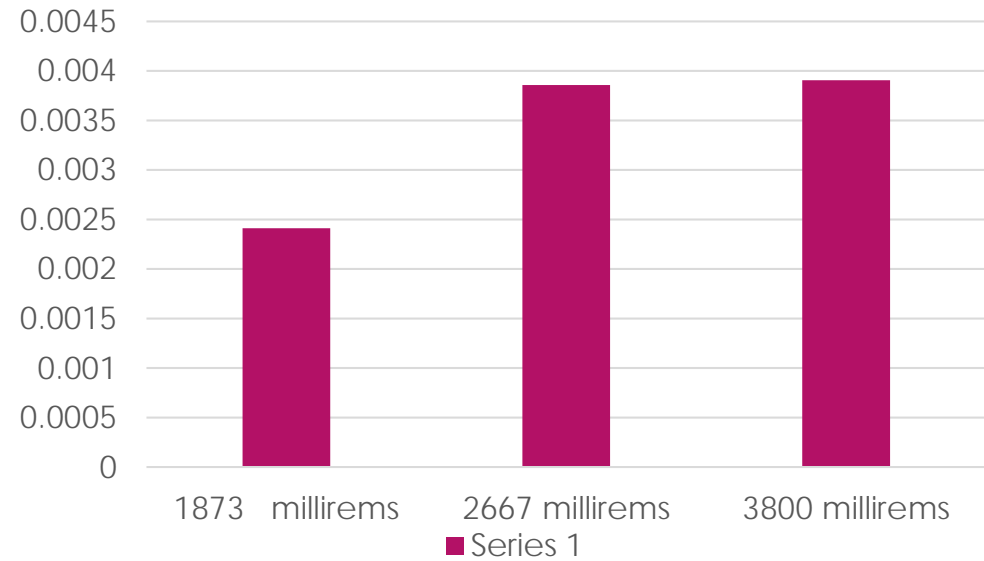
## ► Soft Shutdowns



# Type 1 Failure

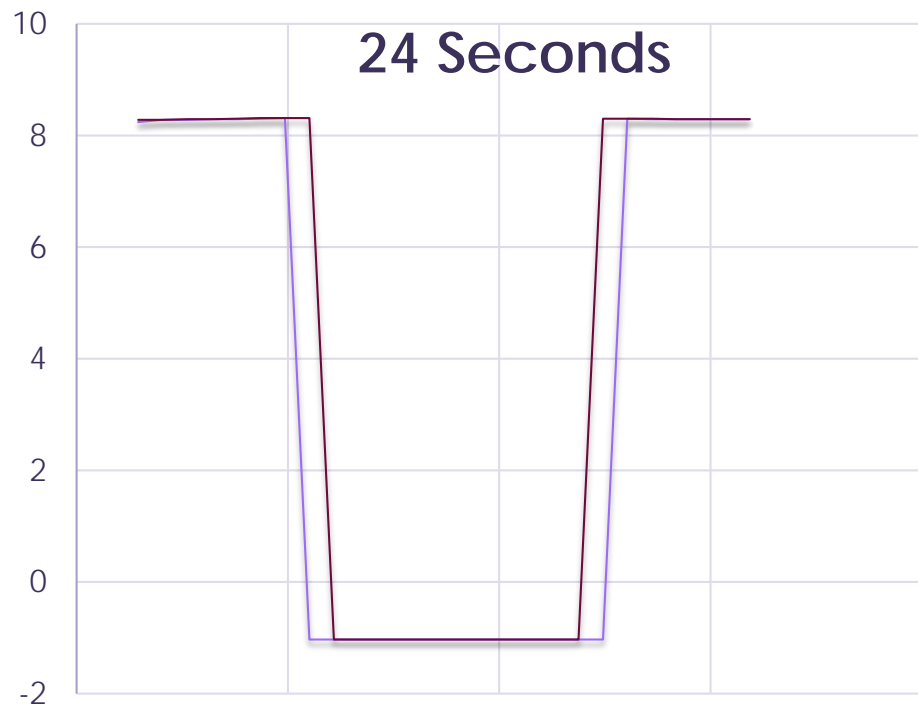


Avg. % of Day Failure Rate

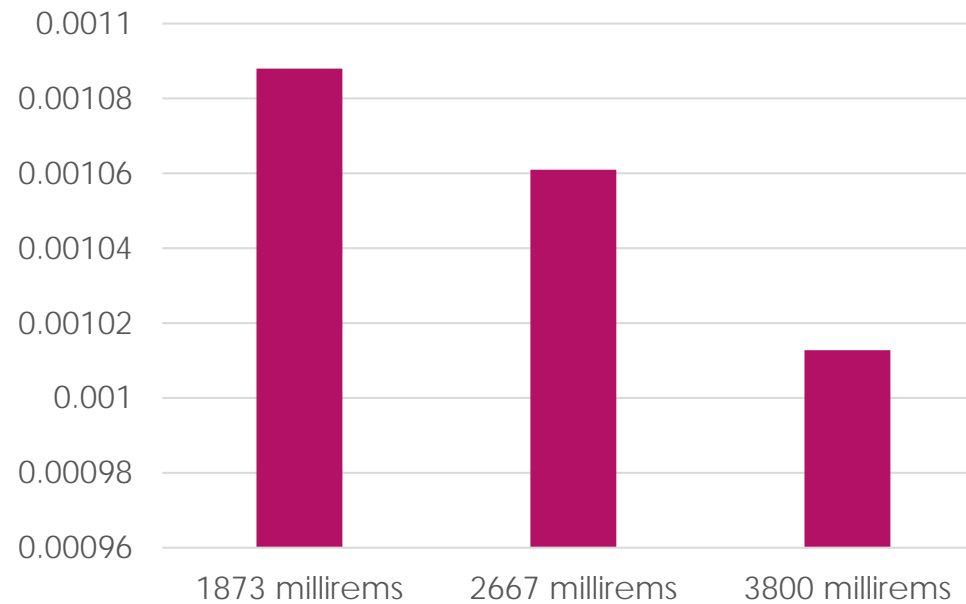


Total Failures:	50	80	81
-----------------	----	----	----

# Type 2 Failure



Avg. % of Day Failure Rate



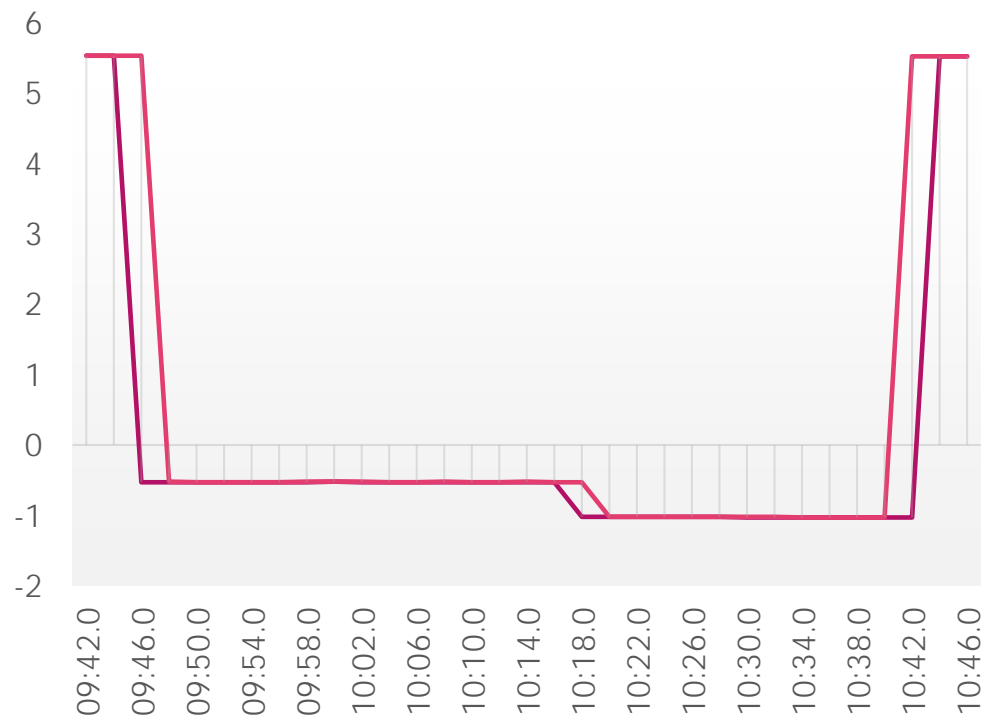
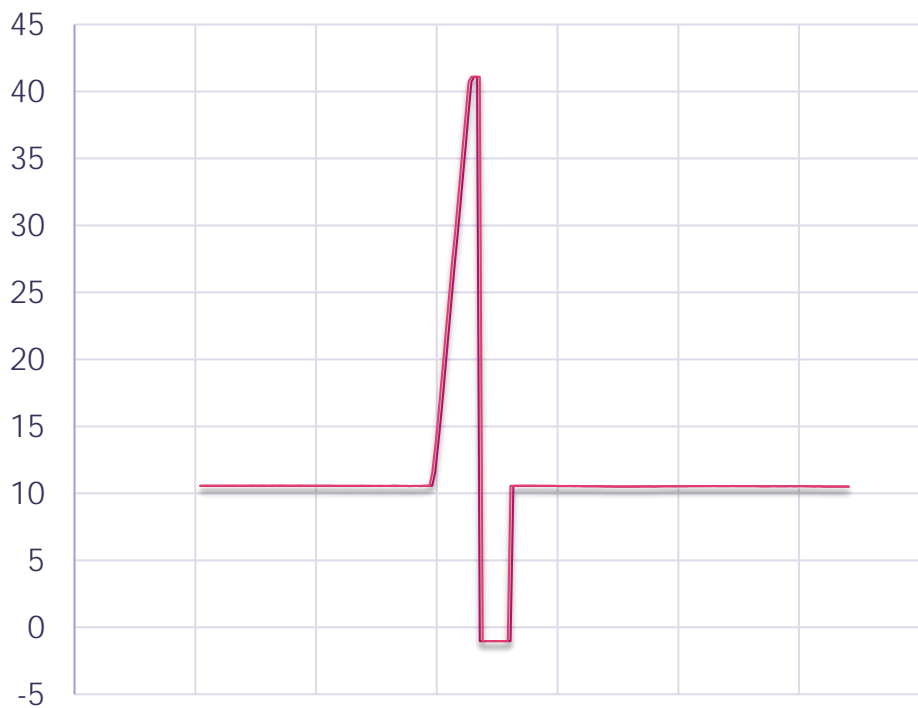
Total Failures:

22

22

21

# Outlier Failures





# Design of Experiment

## ▶ Equipment

- ▶ Power
  - ▶ Fluctuation
  - ▶ Loss of power
- ▶ Built differently
  - ▶ Able to withstand higher amounts of radiation
  - ▶ Different margins of error with each transmitter
- ▶ Damage from previous experiments

## ▶ Radiation

- ▶ Types of possible exposure
  - ▶ Gamma
  - ▶ Neutron
- ▶ Radiation levels
  - ▶ Multiple radiation Sources
  - ▶ Direction of radiation
  - ▶ Fluctuation
    - ▶ Direction
    - ▶ Intensity

# Design of Experiment

## ▶ Equipment

- ▶ Power
  - ▶ Fluctuation
  - ▶ Loss of power
- ▶ Built differently
  - ▶ Able to withstand higher amounts of radiation
  - ▶ Different margins of error with each transmitter
- ▶ Damage from previous experiments

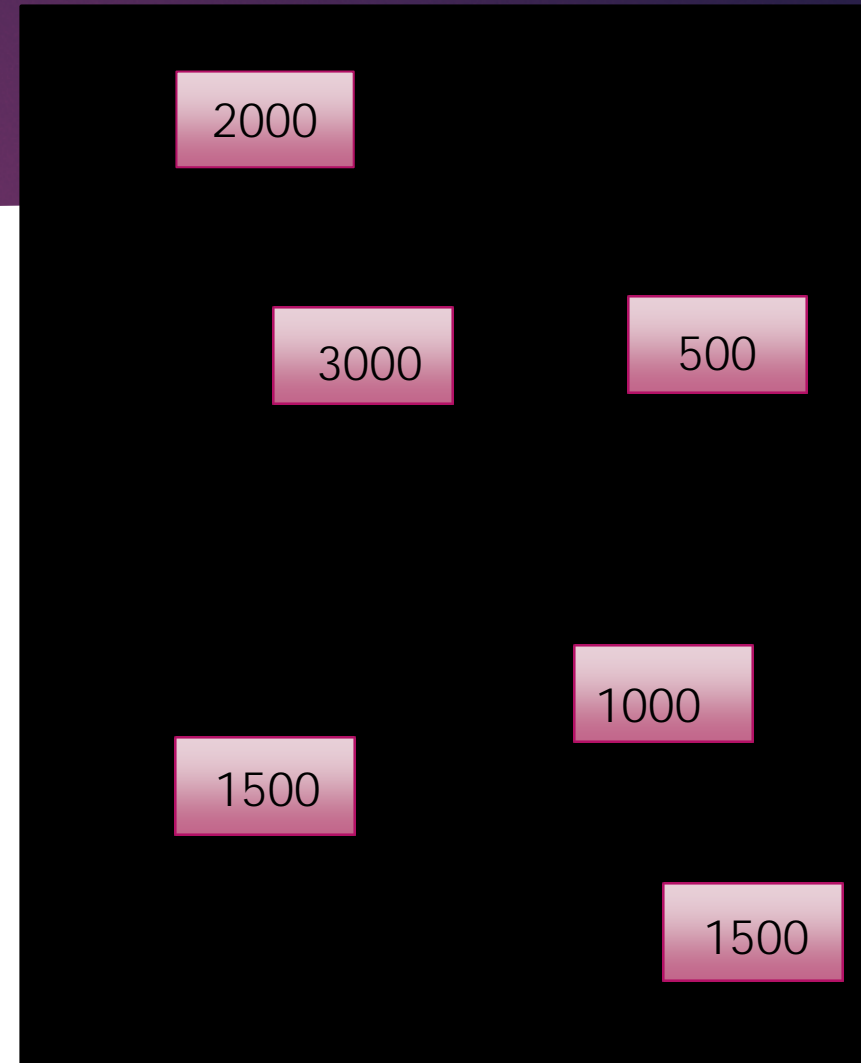
## ▶ Radiation

- ▶ Types of possible exposure
  - ▶ Gamma
  - ▶ Neutron
- ▶ Radiation levels
  - ▶ Multiple radiation Sources
  - ▶ Direction of radiation
  - ▶ Fluctuation
    - ▶ Direction
    - ▶ Intensity



# Where to now?

- ▶ Radiation levels
  - ▶ Multiple radiation Sources
  - ▶ Direction of radiation
  - ▶ Fluctuation
    - ▶ Direction
    - ▶ Intensity





## NIST Center for Neutron Research

A special thanks to:

CHRNS

NSF

Julie Borchers,

Mike Middleton,

Susan Deeb,

Dan Keyser,

NCNR and SURF staff.



# Questions?

If you try to fail and succeed, which have you done?  
-George Carlin

