



*Neutron and Gamma Dose  
Equivalents from Two  
ISFSIs*

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# ISFSIs

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- Independent Spent Fuel Storage Installation(s)
  - Dry Cask Fuel Storage
  - Fuel Elements Contained in Steel Canister
  - Steel Canister Contained in Concrete “Vertical Concrete Container”, or VCC
  - Gamma and Neutron Emissions from VCCs

# Two ISFSIs

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Connecticut  
Yankee

Maine  
Yankee



# Goal

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- Establish the Unrestricted Area Boundary
  - 40CFR190 Dose Limit
  - 25 mrem/year
  - 100% Occupancy
  - 2.85 urem/hr

# Gamma Exposure Measurements

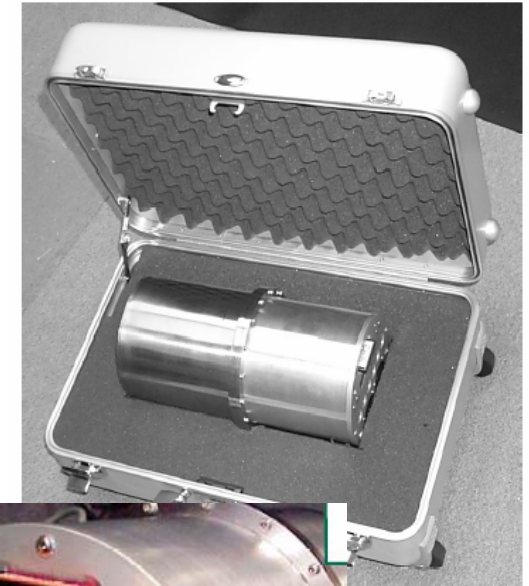
- High Pressure Ionization Chamber
  - Reuter Stokes RS-111
  - 8 Liter Chamber
  - 25 ATM Argon
- Omni-Directional
- Flat Energy Response
- Excellent Sensitivity
- Ten 30 sec Integrations at Each Location
- 21 Pre-Op Locations for BKG (10.89 uR/hr +/- 9%)



# Neutron Measurements

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- Tissue Equivalent Proportional Counter, TEPC
  - Far West Technologies (FWT) “Hawk” TEPC
  - Initially Conceived for Air-flight Dosimetry
  - Measures Gamma and Neutron Dose and Dose Equivalent
  - Based on Micro-dosimetry Principles



# Hawk (TEPC) Operation

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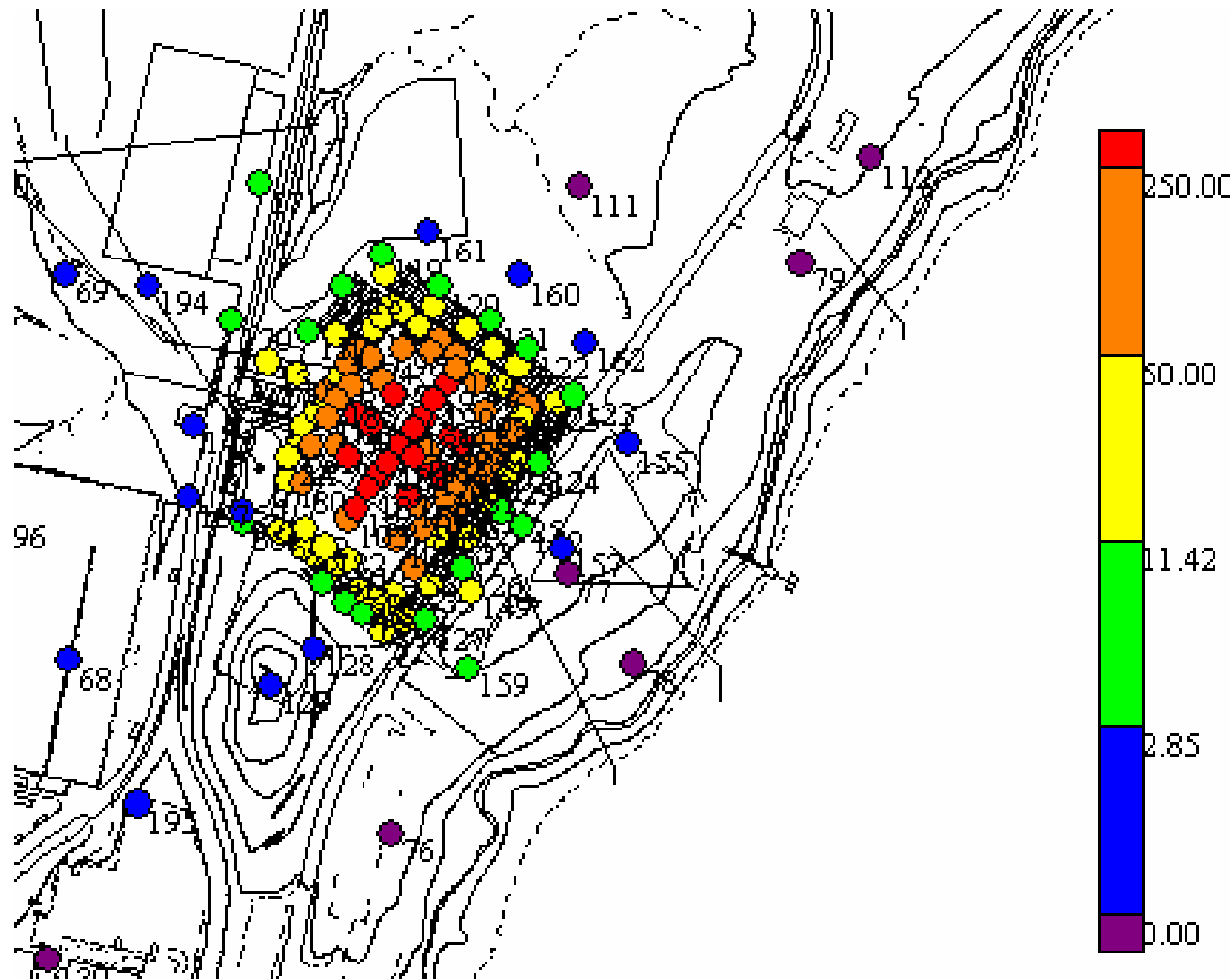
- 5 inch Hollow Sphere of A150 Plastic in SS Cylindrical Housing
  - 7 Torr (0.0135 psig) TE Proportional Gas
  - Simulates 2 um Tissue Sphere
  - Bragg-Gray Principle
  - Measures LET Distribution
  - High and Low Gain MCAs
- 15 Minute to 3 Hour Integrations (1 minute Measurements)
- NIST Traceable Calibration (Cf-252 & Cs-137)
- QFs from ICRP-21 vs ICRP-60



# Maine Yankee Results

## Gamma Rate (uR/hr)

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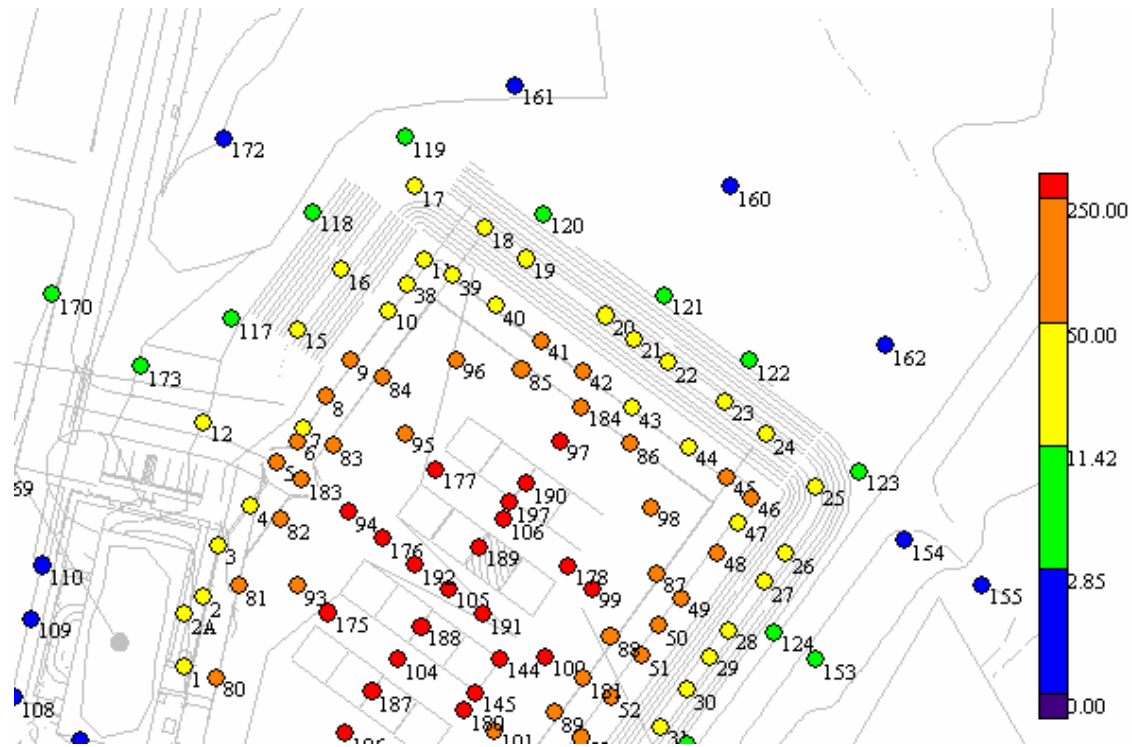




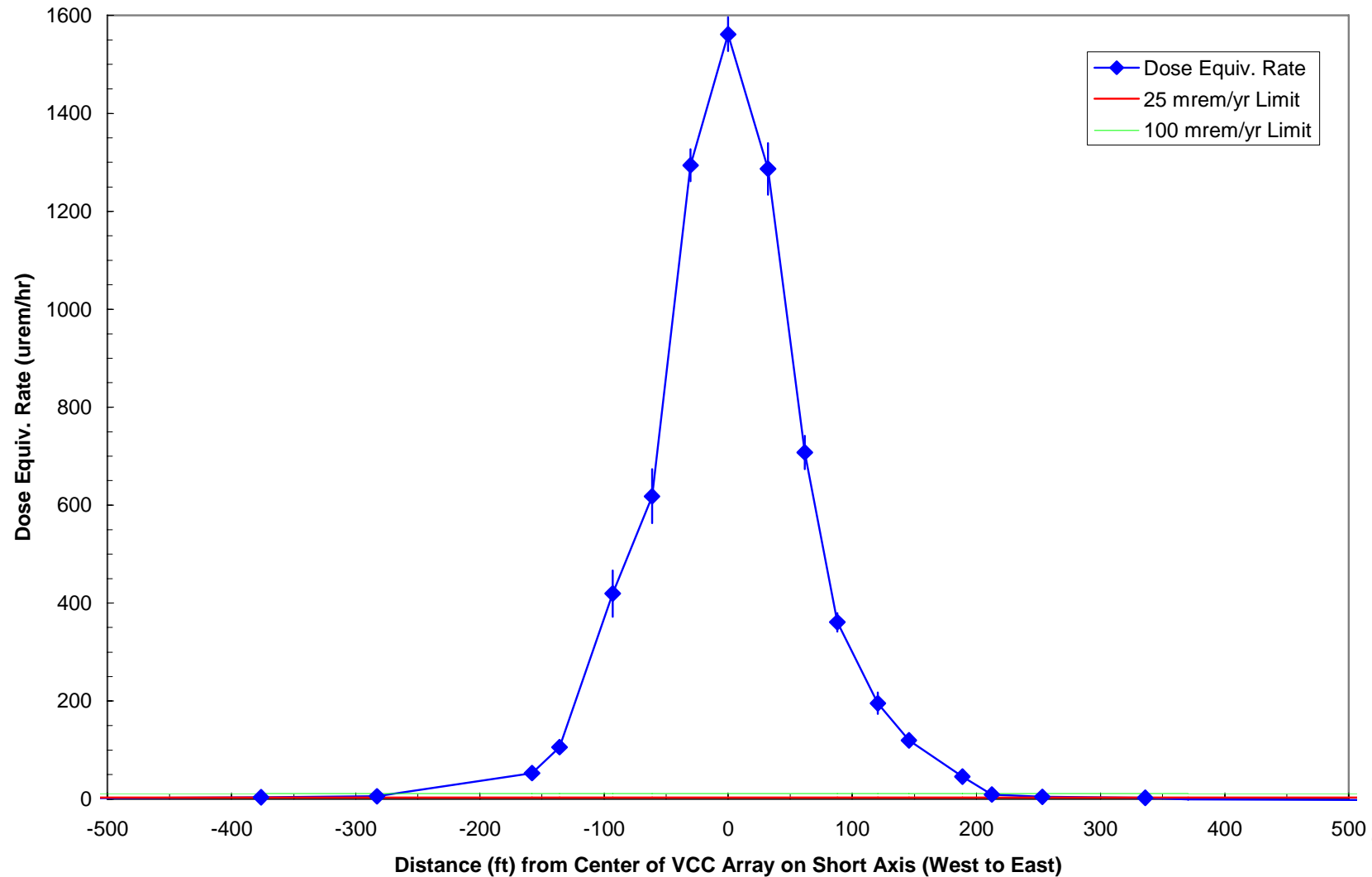
# Maine Yankee Results

## Gamma Rate Detail, $\mu\text{R/hr}$

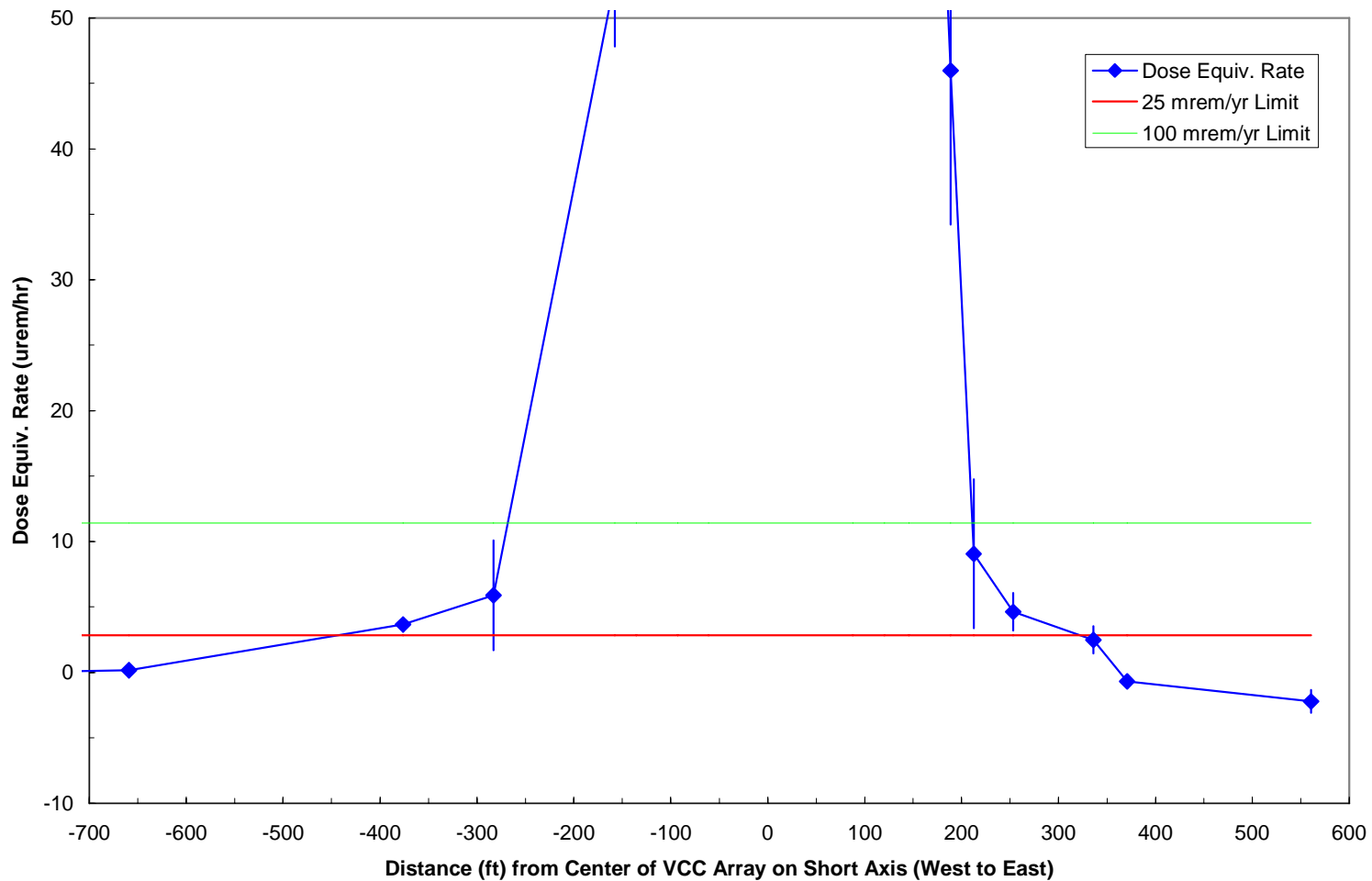
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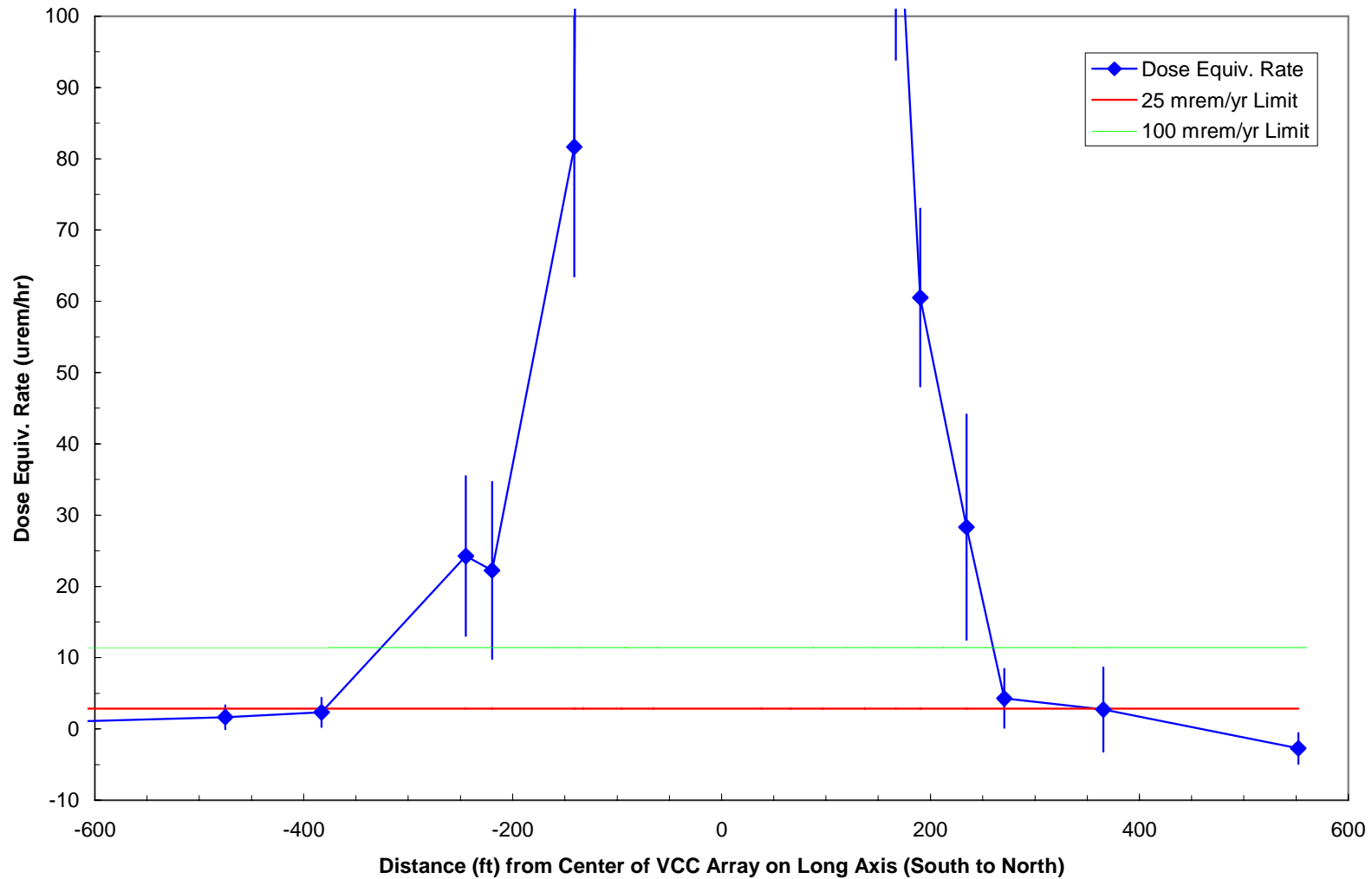
# Maine Yankee Results ("Short Axis")



# Maine Yankee Results ("Short Axis")



# Maine Yankee Results ("Long Axis")



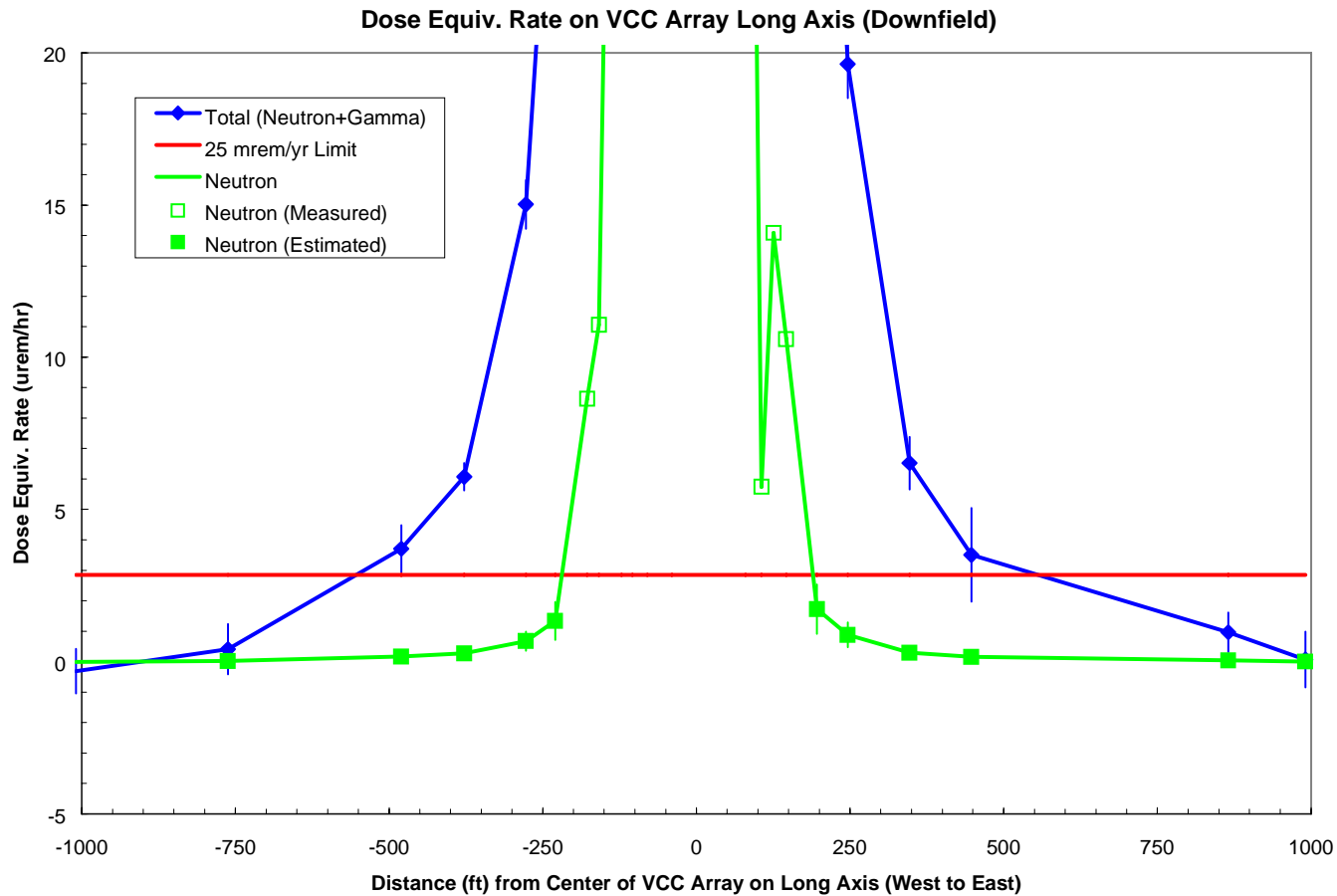
# Maine Yankee Summary

- 169 Gamma Locations
- 55 Neutron Locations

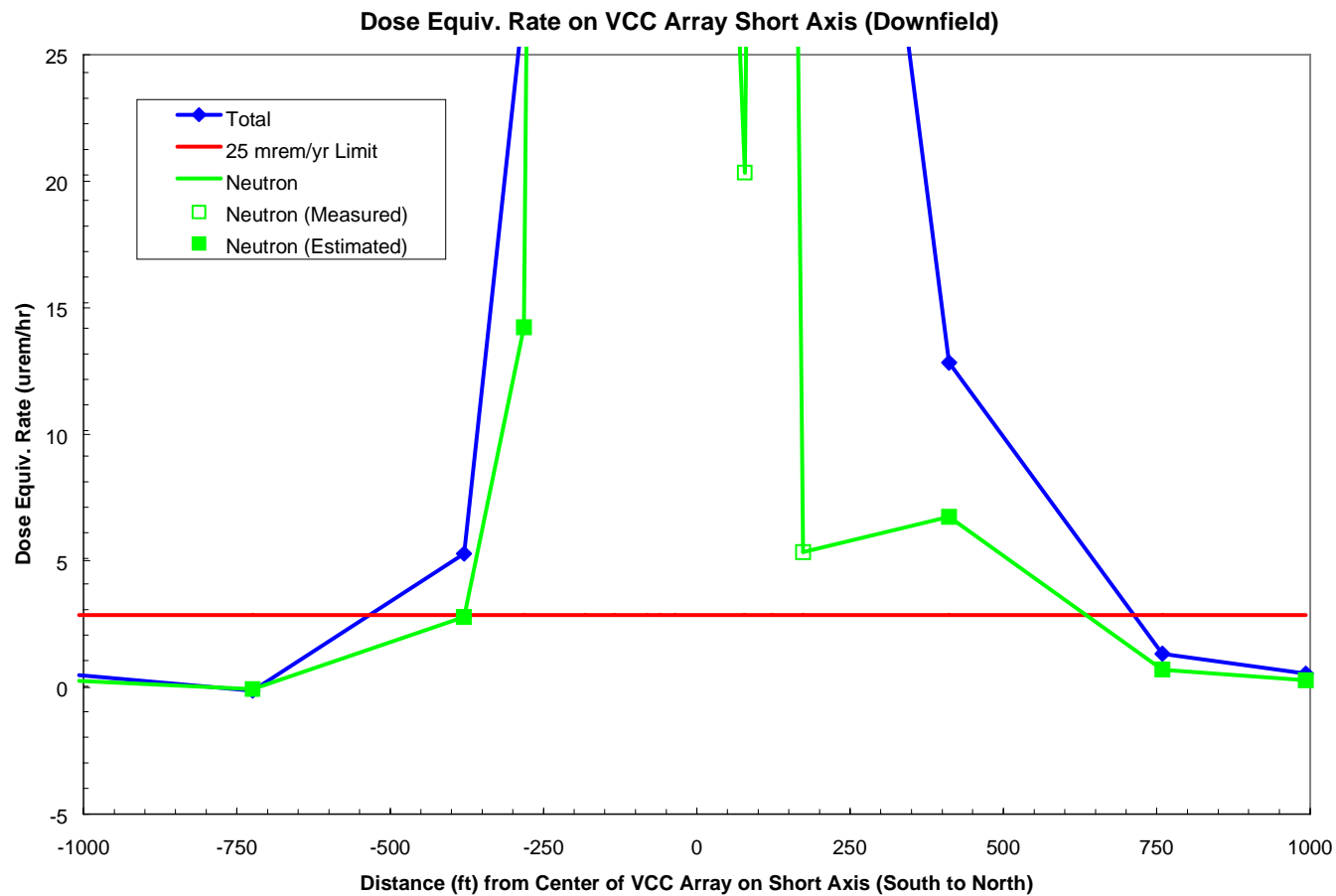


<b>Boundary</b>	<b>Axis</b>	<b>Distance to 25-mrem/yr from Center-of-ISFSI Array</b>
<b>South</b>	<b>Long</b>	<b>-379.8</b>
<b>North</b>	<b>Long</b>	<b>357.6</b>
<b>West</b>	<b>Short</b>	<b>-441.4</b>
<b>East</b>	<b>Short</b>	<b>321.5</b>

# Connecticut Yankee Results ("Long Axis")



# Connecticut Yankee Results ("Short Axis")



# Connecticut Yankee Summary

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- 142 Gamma Locations
- 40 Neutron Locations

<b>Boundary</b>	<b>Axis</b>	<b>Distance to 25-mrem/yr from Center-of-ISFSI Array</b>
<b>South</b>	<b>Short</b>	<b>-534.5</b>
<b>North</b>	<b>Short</b>	<b>713.3</b>
<b>West</b>	<b>Long</b>	<b>-553.3</b>
<b>East</b>	<b>Long</b>	<b>555.1</b>



# TEPC Quality Factor Summary

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- Wt. Average
- Dose Event Spectra

Measurement	Quality Factor	Quality Factor Uncert.
Maine Yankee ISFSI	7.20	6.3%
CT Yankee ISFSI	7.61	1.3%
Bare Cf-252 (PNNL)	7.58	0.3%