Hopewell Designs, Inc.

Engineering, Design and Manufacturing

New Design Basis Analysis for Self-Contained, Dry-Storage Irradiators

Spencer Mickum, Zach Hope, Robert Rushton, Ryan Howell

Council on Ionizing Radiation Measurements and Standards

March 27, 2017

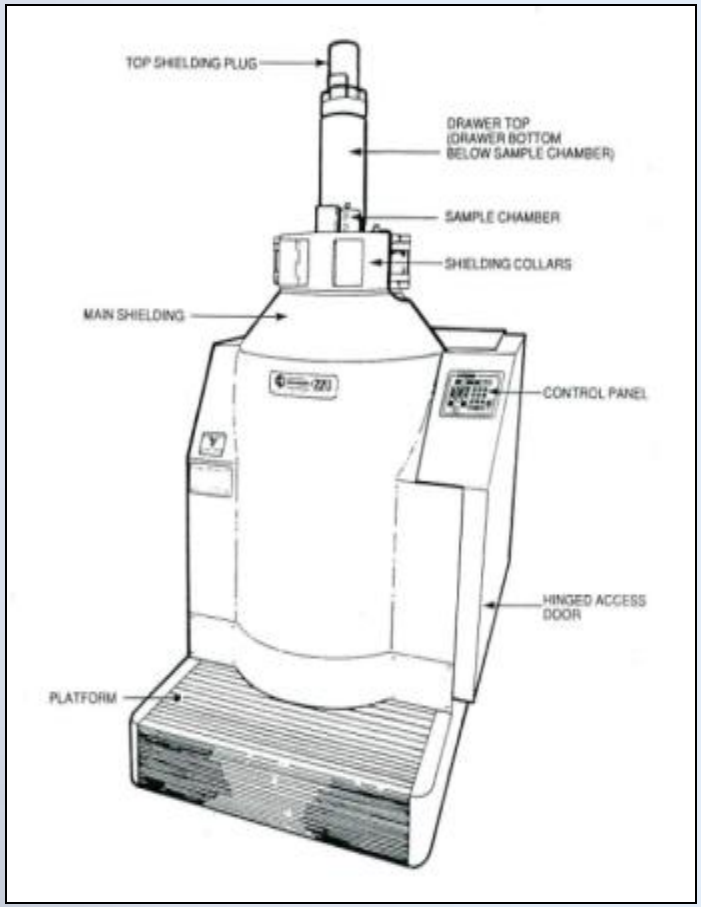
Outline

- **Focus**
- **Monte Carlo simulation used to analyze two self-contained irradiators and develop a new design basis analysis approach.**
- **Analysis of external dose, radiation field, and radiation uniformity of the GR440 Irradiator.**

Outline

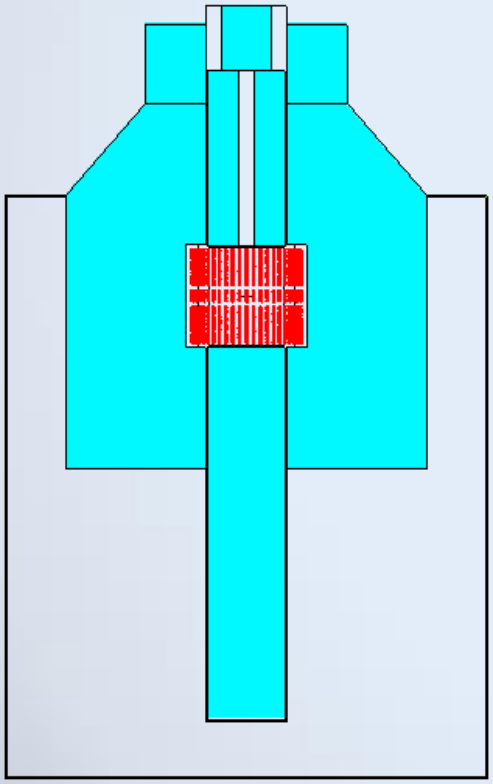
- Focus
- Gammacell 220
- GR 440 Irradiator
  - System Concept
  - Simulation
  - Irradiation Field
  - Characteristics
- Conclusions

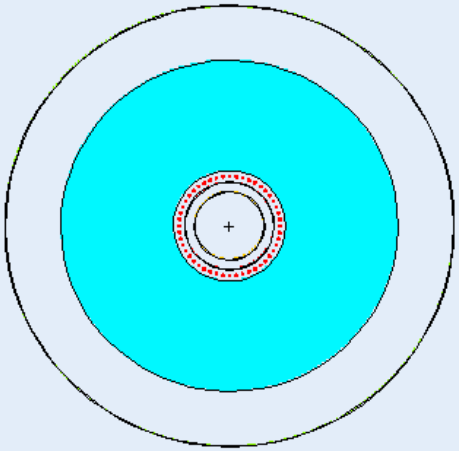
Gammacell 220 – Overview

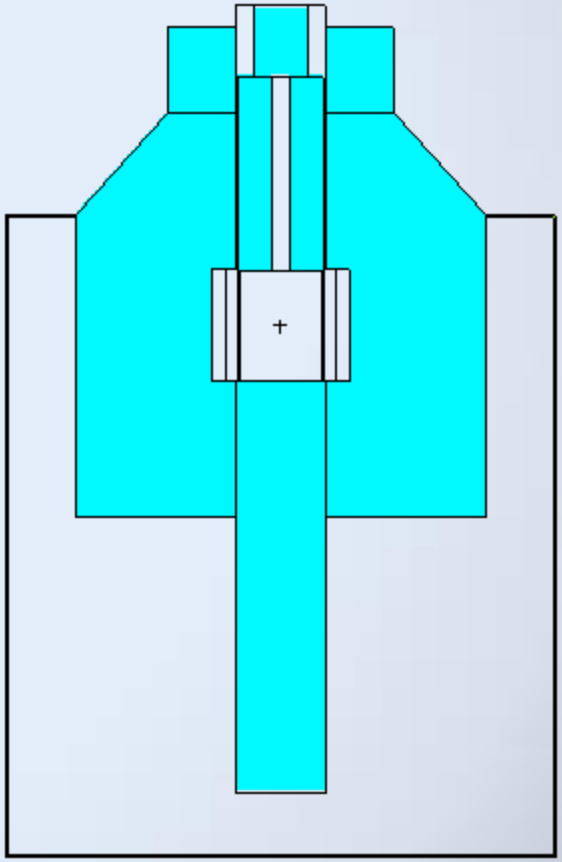


- Premier stand-alone research irradiator
- Simple design, high dose rate, well characterized DUR
- Nordion business decision to discontinue in 2007
- Radiation protection needs improvement

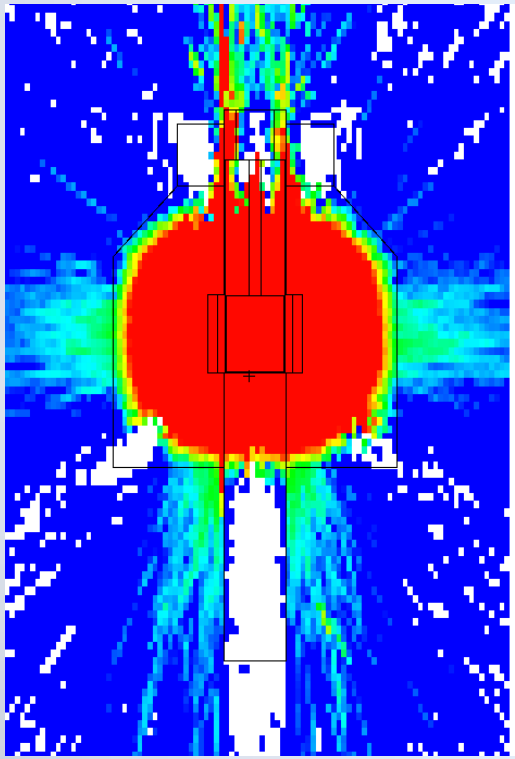
Gammacell 220 – Simulation

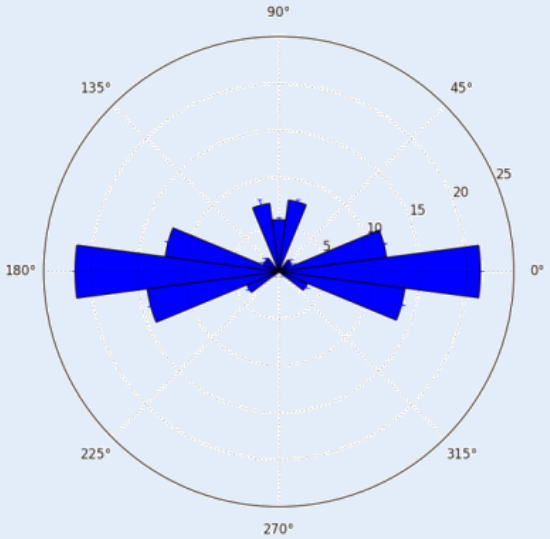


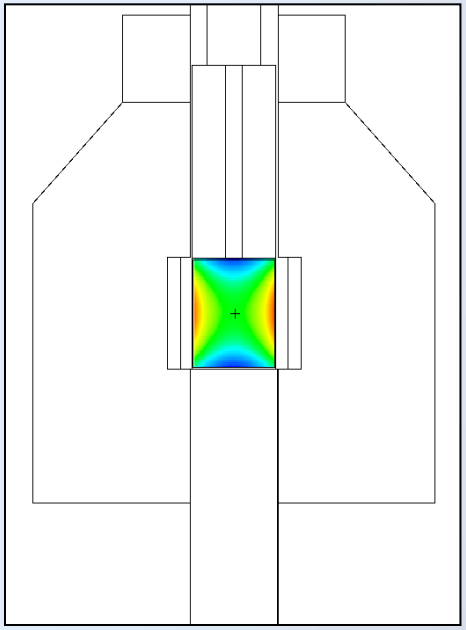




Gammacell 220 – Simulation





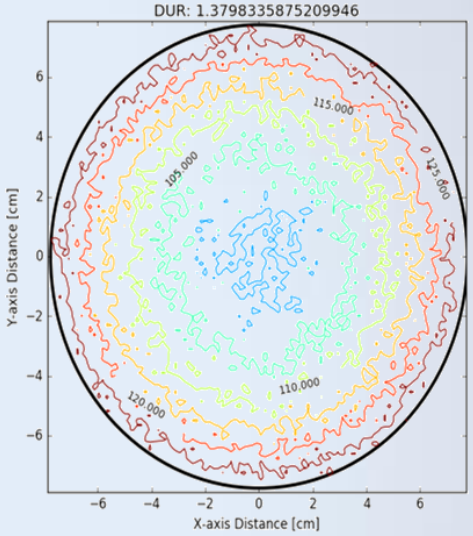


Gammacell 220 – Simulation

- **Dose Uniformity Ratio**

$$DUR = \frac{Highest\ Dose\ in\ Volume}{Lowest\ Dose\ in\ Voume}$$

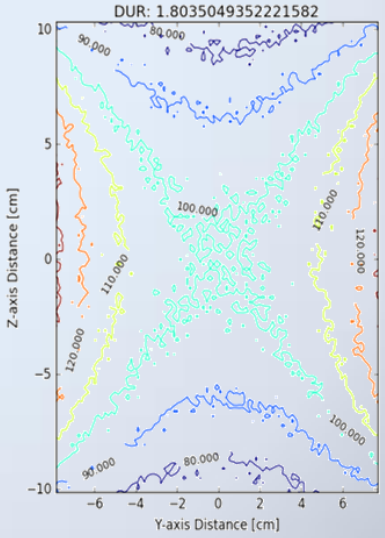
$$DUR = 1.80$$



- **Dose Uniformity Gradient**

$$DUG = \sum_{k=1}^{H} \frac{1}{H} \sum_{j=1}^{R} \frac{1}{R} \sqrt{\frac{1}{n_{j,k} - 1} \sum_{i=1}^{n} (q_{i,j,k} - \overline{q_{j,k}})}$$

$$DUG = 0.95$$



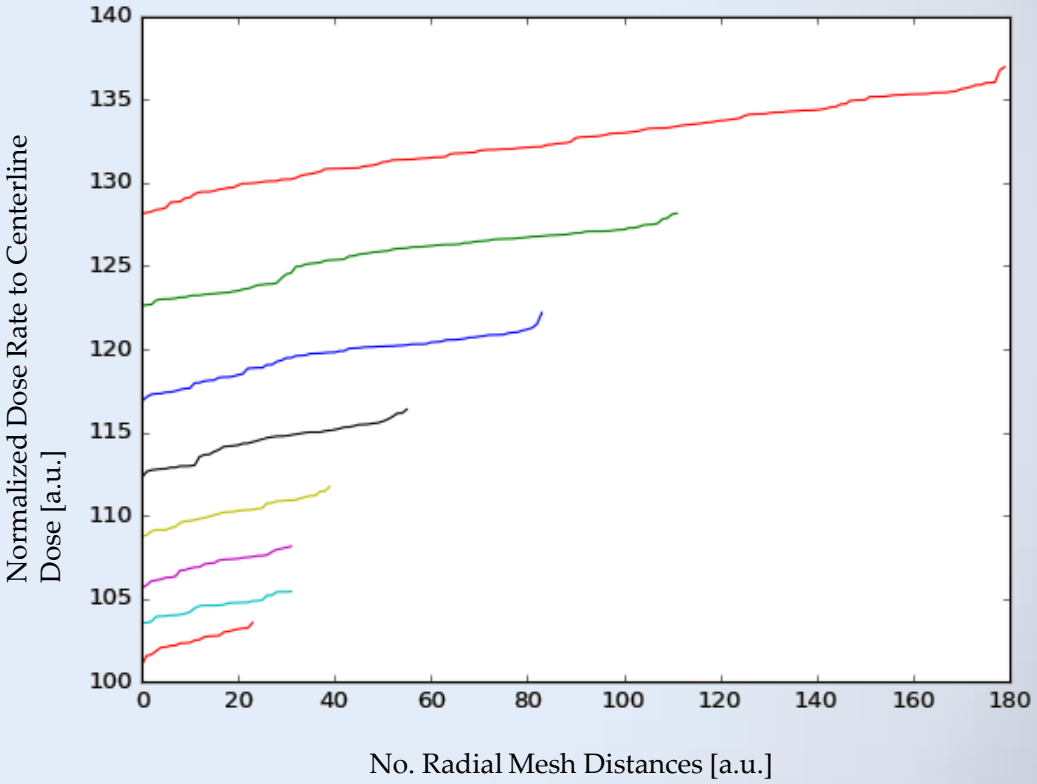
Gammacell 220 – DUG

- **Example:**

  R=10, H=1

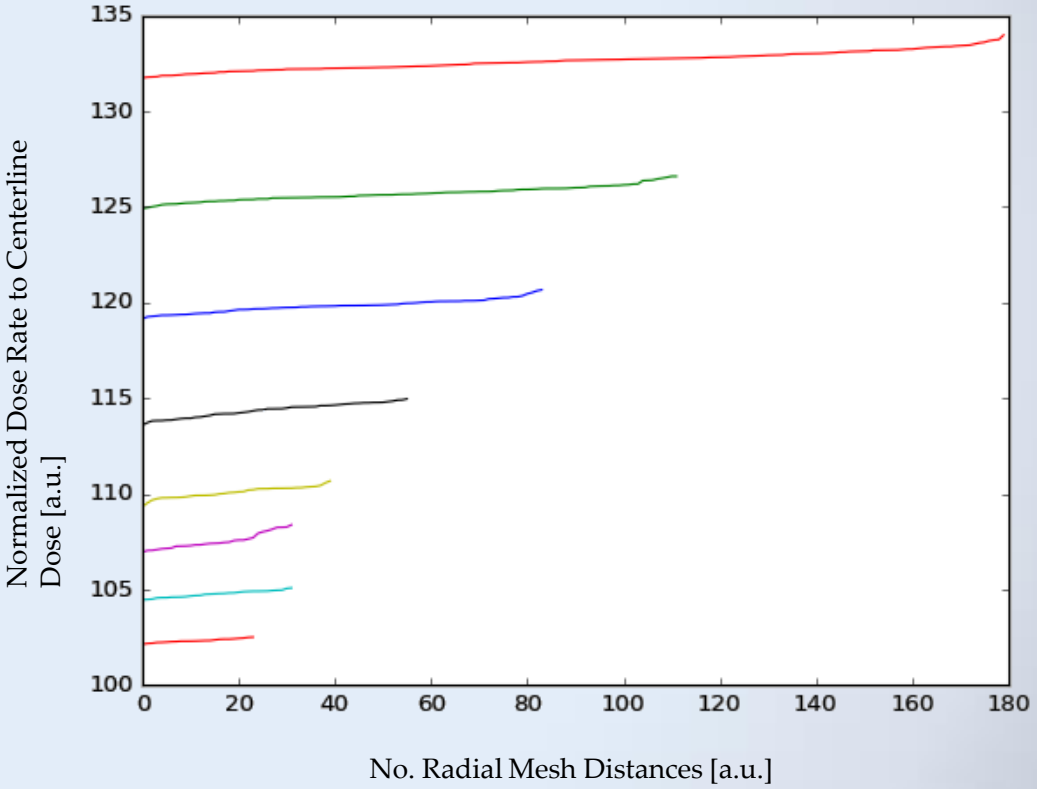
- **DUG:**

  0.95



Gammacell 220 – DUG, Adding Rotation

- Example:
  R=10, H=1
- DUG:
  0.95
- Adding Rotation
- DUG:
  0.30
- Difference: 70%



Outline

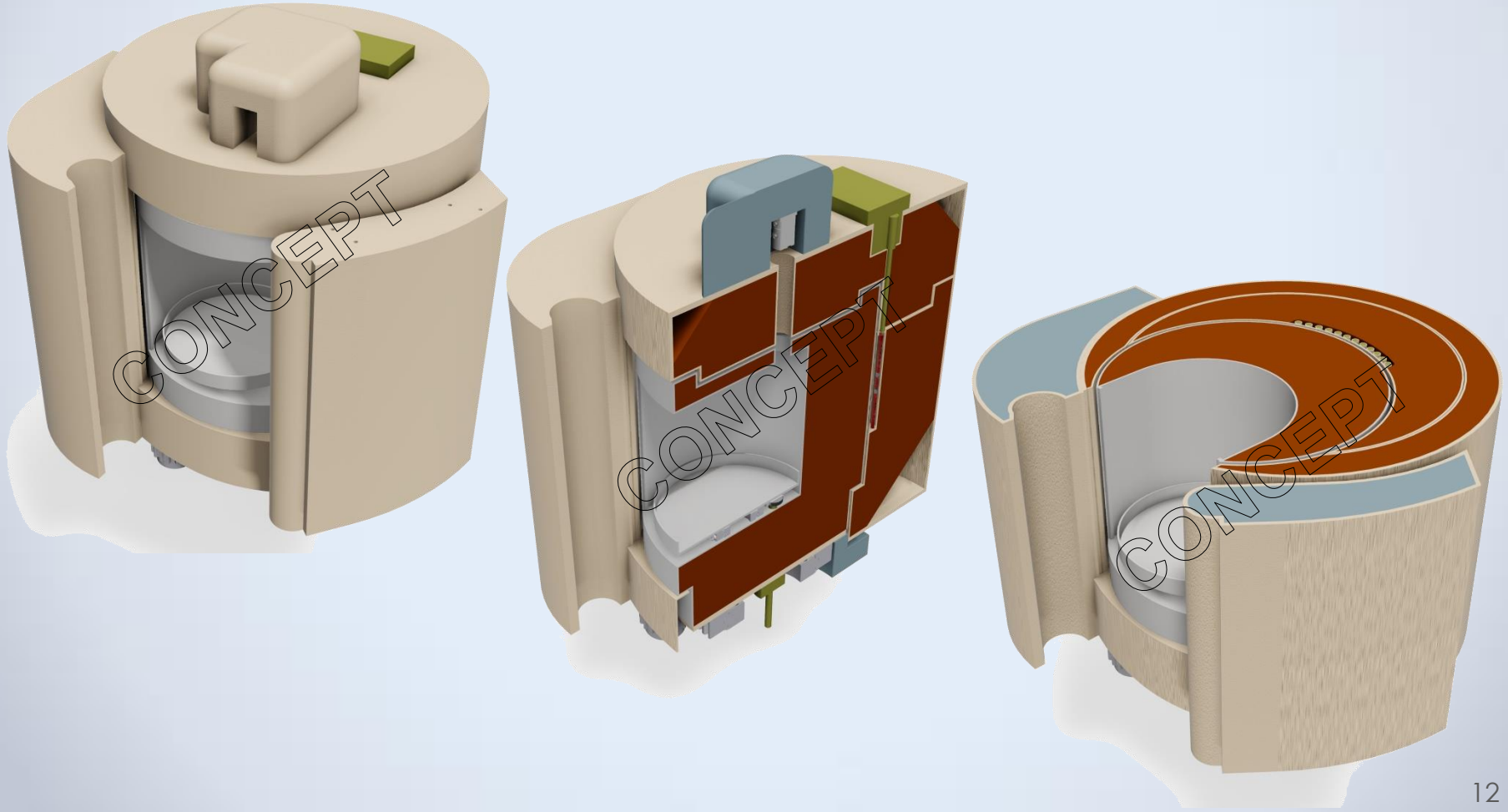
- Focus
- Gammacell 220
- GR 440
  - System Concept
  - Simulation
  - Irradiation Field
  - Characteristics
- Conclusions

New Integrated Shielding Design

- Optimization from Gammacell 220
  - Increase chamber size to 10” dia. X 12” tall
  - Maintain system weight requirements
  - Reduce external dose/transition dose
- Primary Needs
  - Improved flexibility for irradiation field
    - Rotation of chamber
    - Radial location of chamber

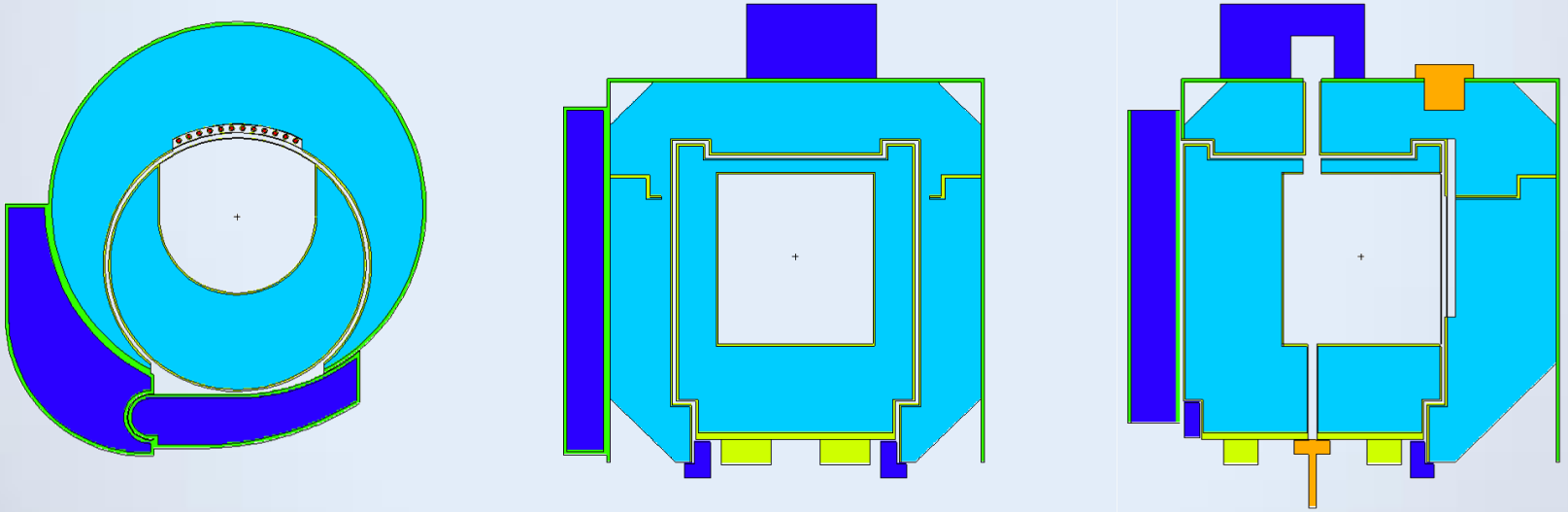
Hopewell Designs, Inc.

GR 440 – System Concept



GR 440 – System Concept

- **Simulation**



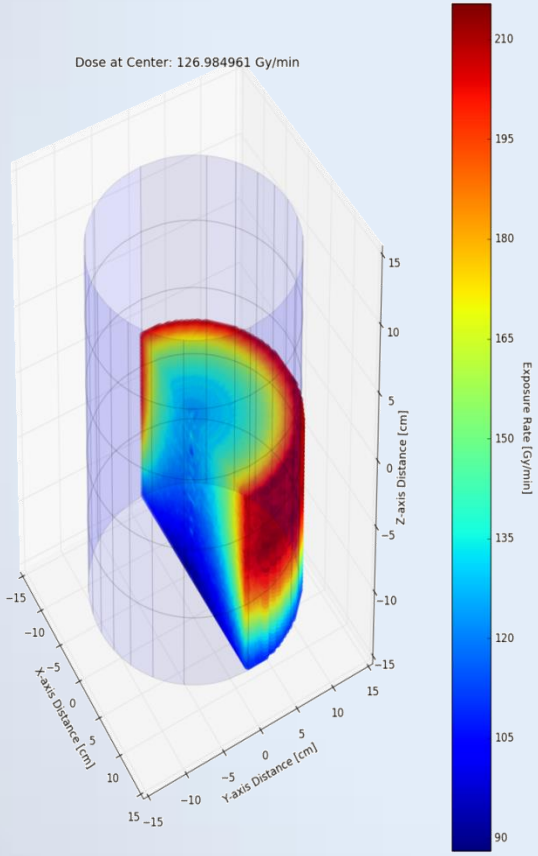
Hopewell Designs, Inc.

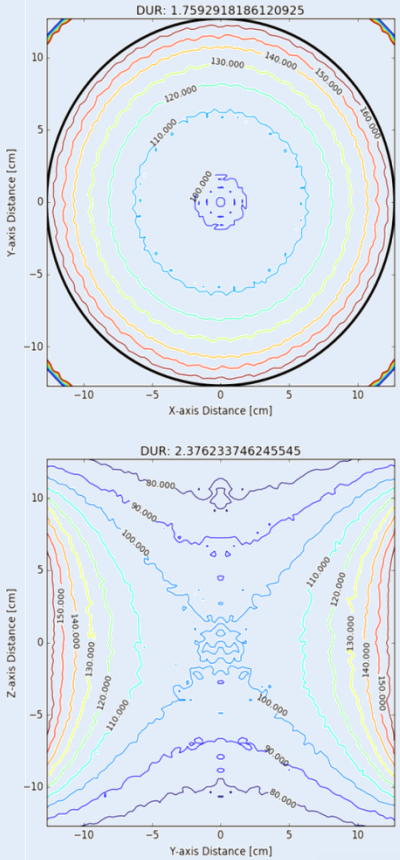
Outline

- Focus
- Gammacell 220
- GR 440
  - System Concept
  - Simulation
  - Irradiation Field
  - Characteristics
- Conclusions

Hopewell Designs, Inc.

GR440 – Irradiation Field



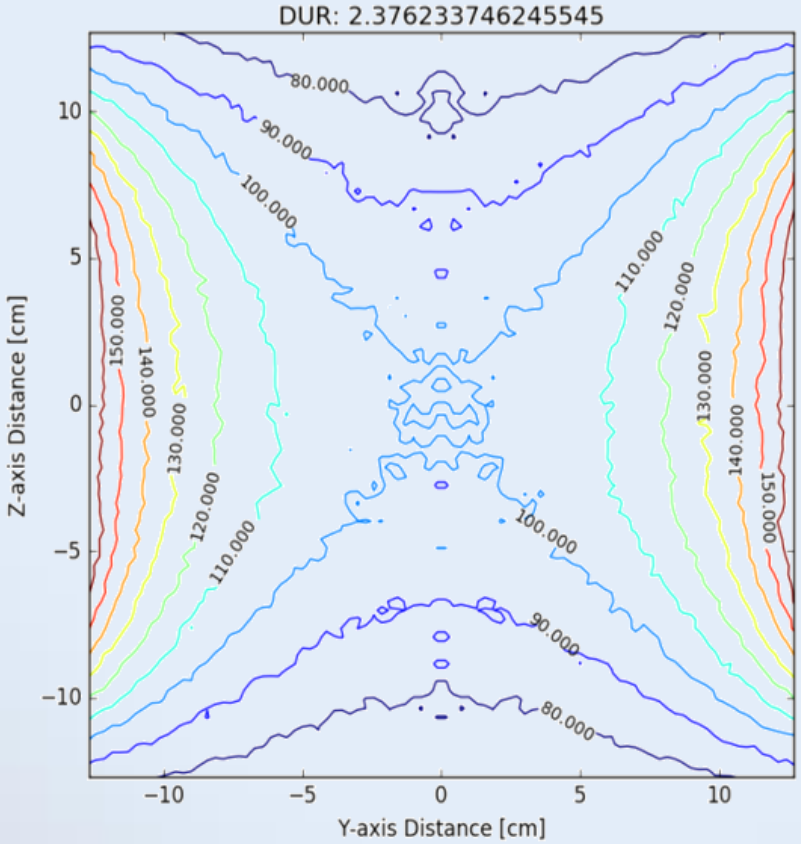


- **CL Dose Rate**
  - **127 Gy/min**
- **DUR**
  - **2.37**
- **DUG**
  - **0.53**

Hopewell Designs, Inc.

GR440 – Irradiation Field

- **Irradiation Field Performance**

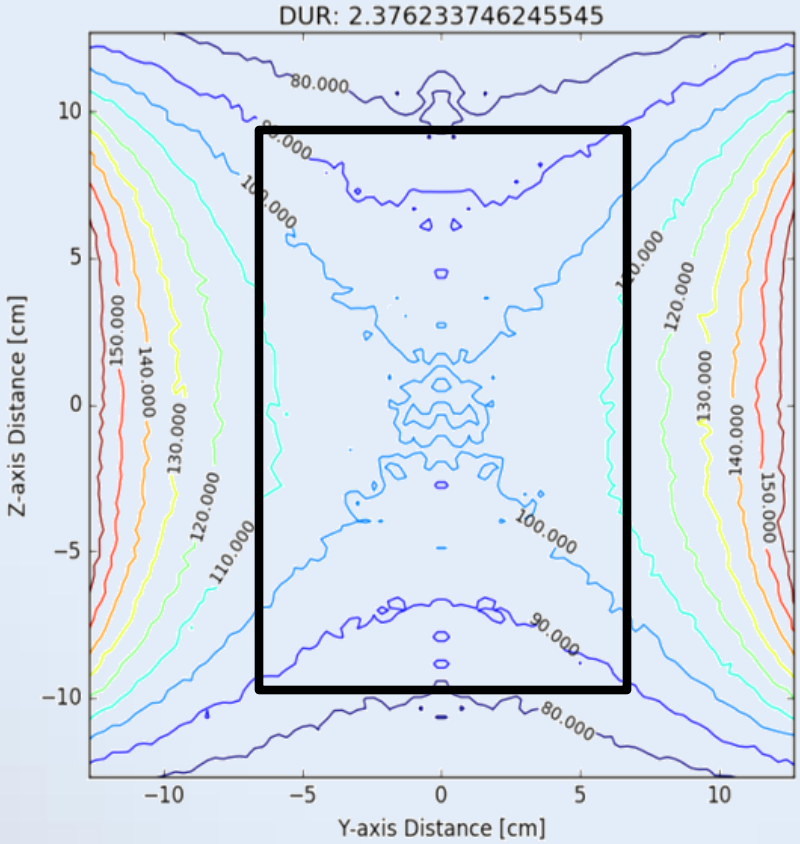


- **CL Dose Rate**
  - **127 Gy/min**
- **DUR**
  - **2.37**
- **DUG**
  - **0.53**

Hopewell Designs, Inc.

GR440 – Irradiation Field

- **Irradiation Field Performance**

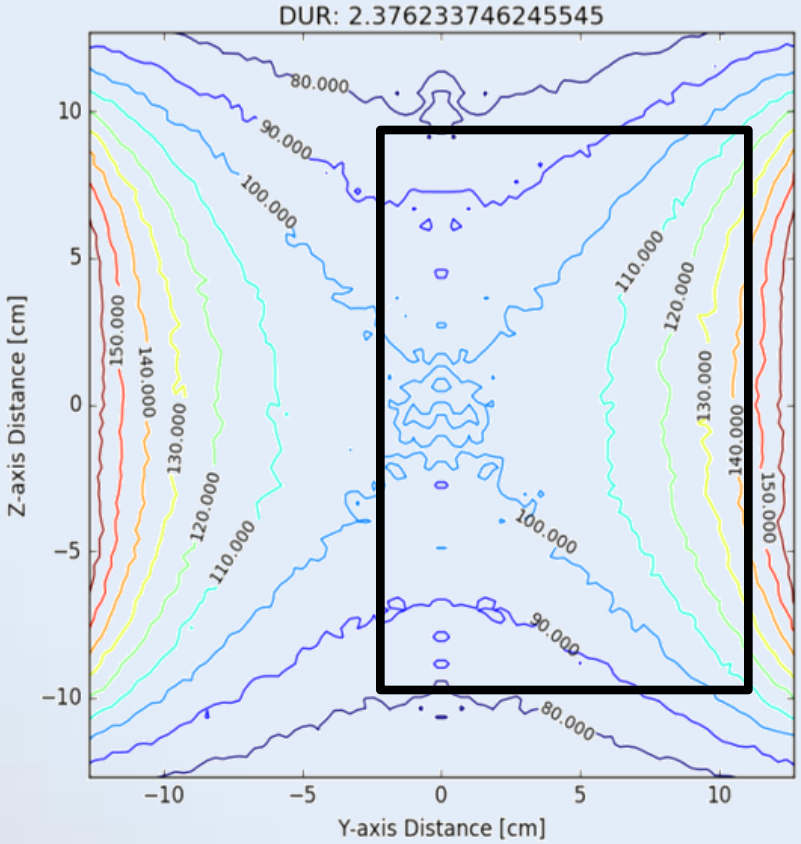


- **CL Dose Rate**
  - **127 Gy/min**
- **DUR**
  - **1.56**
- **DUG**
  - **0.31**

Hopewell Designs, Inc.

GR440 – Irradiation Field

- **Irradiation Field Performance**



- **CL Dose Rate**
  - **219 Gy/min**
- **DUR**
  - **1.76**
- **DUG**
  - **0.37**

Outline

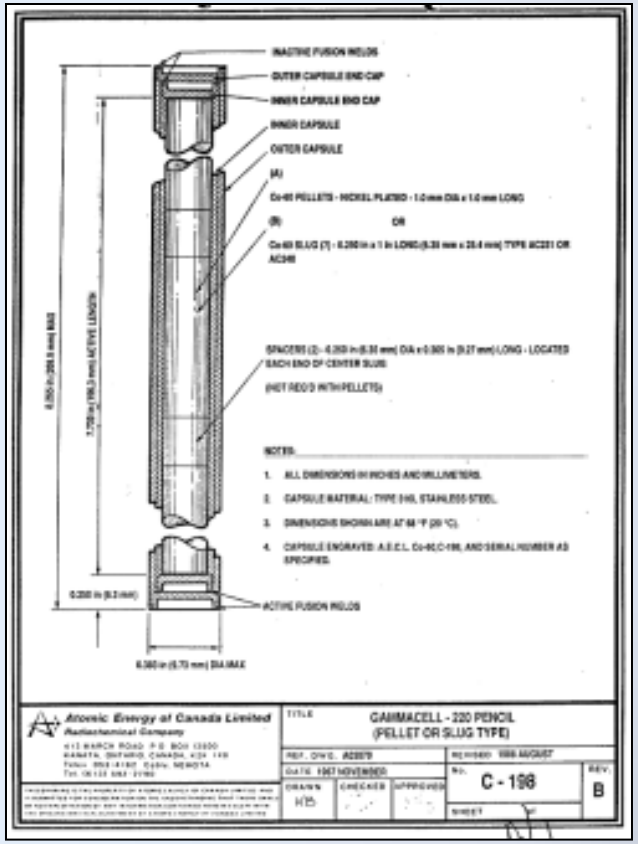
- Focus
- Gammacell 220
- GR 440
  - System Concept
  - Simulation
  - Irradiation Field
  - Characteristics
- Conclusions

New Integrated Shielding Design

- **Source Configuration**
  - **Nominal Idealized Source Loading Configurations with C-198 sources**

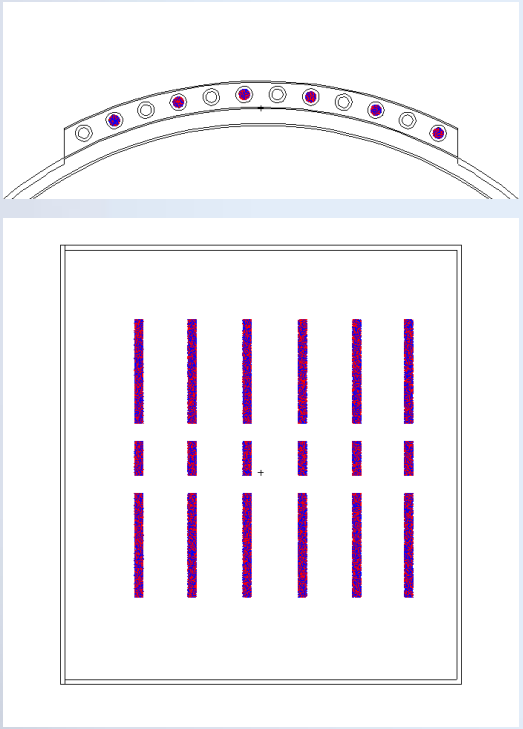
LOADING #1

PENCIL POSITION	NOMINAL ACTIVITY [CI]
1	1881 (7.84%)
5	1924 (8.02%)
9	1924 (8.02%)
13	1881 (7.84%)
17	2078 (8.66%)
21	2078 (8.66%)
25	2088 (8.70%)
29	1881 (7.84%)
33	2054 (8.56%)
37	2131 (8.88%)
41	1912 (7.97%)
45	2155 (8.97%)
TOTAL	***24,000***



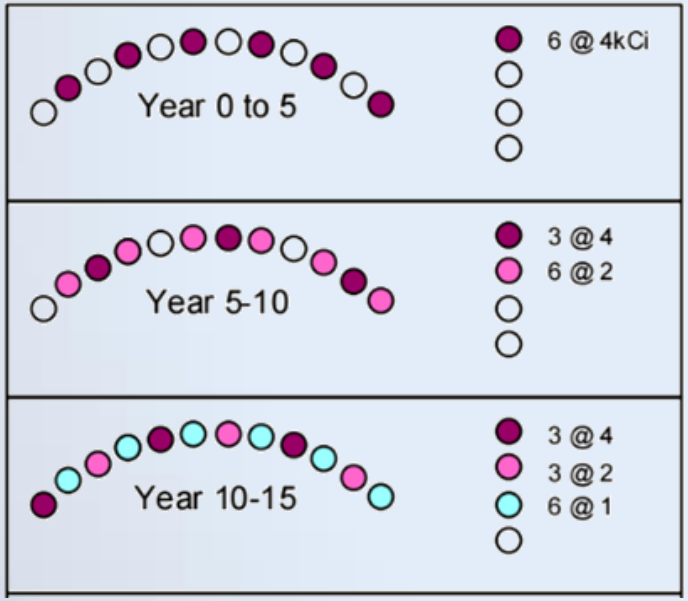
Hopewell Designs, Inc.

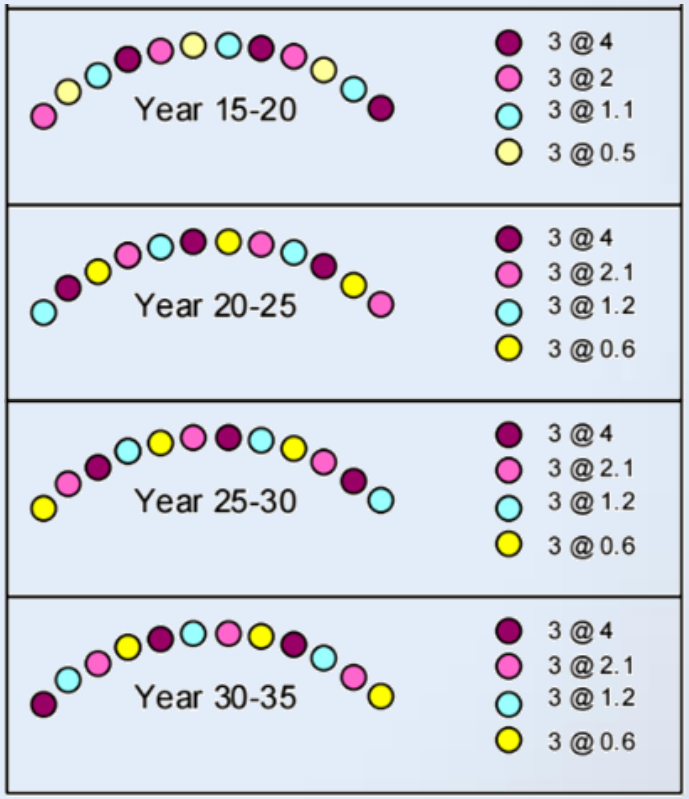
New Integrated Shielding Design



New Integrated Shielding Design

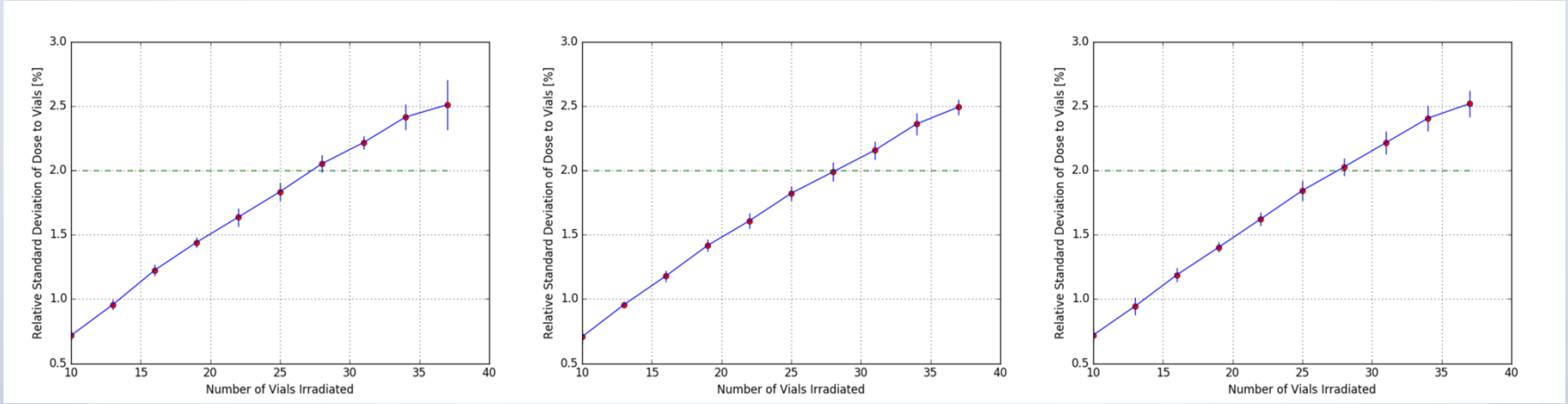
- **Source Configuration**





New Integrated Shielding Design

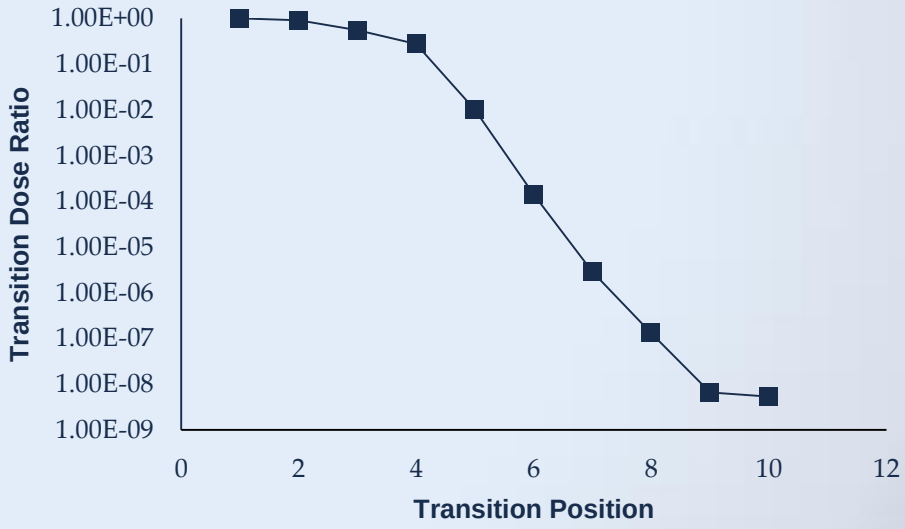
- **Irradiation Field Performance**
  - **Continued uniformity after resourcing**



6 sources **9 sources** **12 sources**

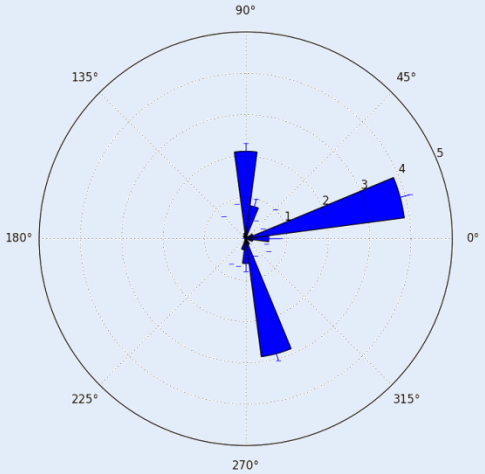
New Integrated Shielding Design

- Irradiation Field Performance
  - Transient Dose
  - Example:
    - 25kGy Dose
    - Transient Dose Ratio 0.04%

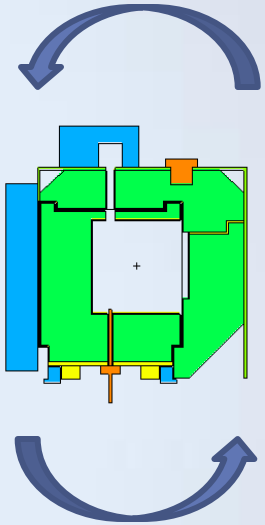


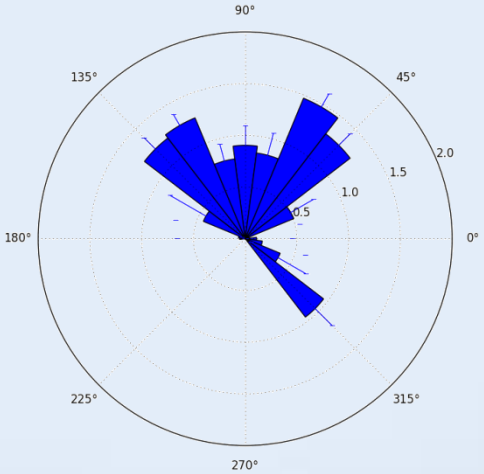
New Integrated Shielding Design

- **Measurement Format:**
- **Individual measurements done around top and bottom (1) and around the circumference (2).**

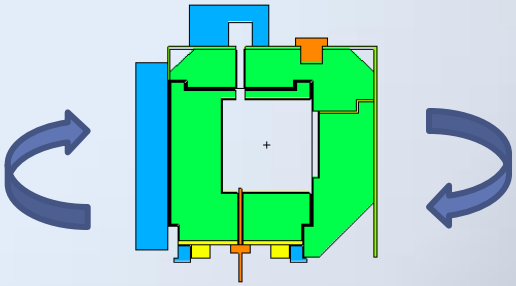


1



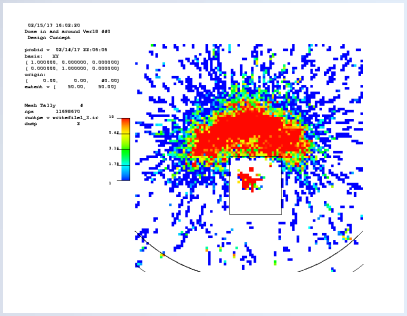
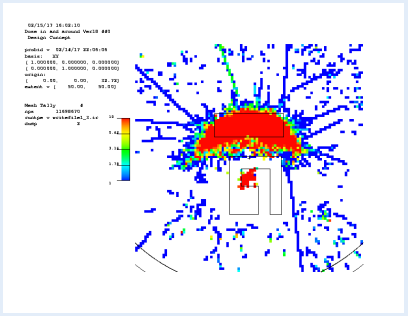
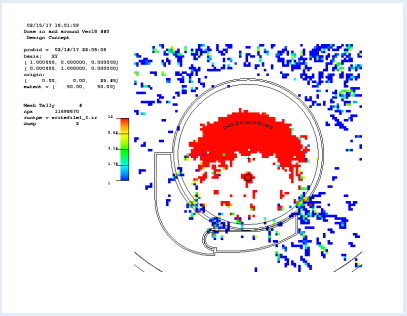
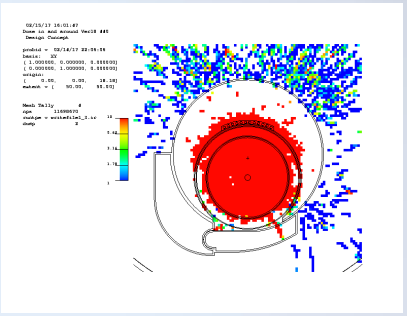
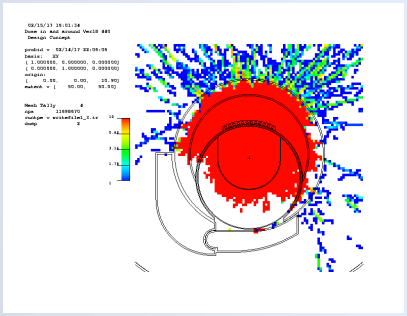
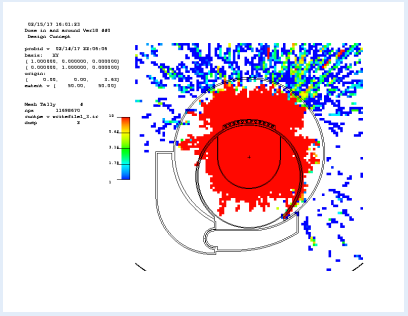
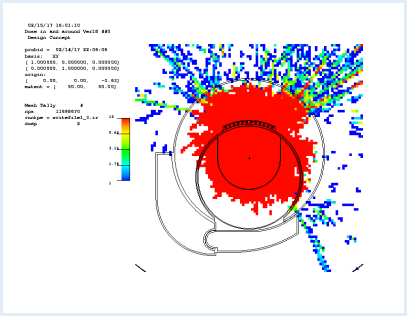
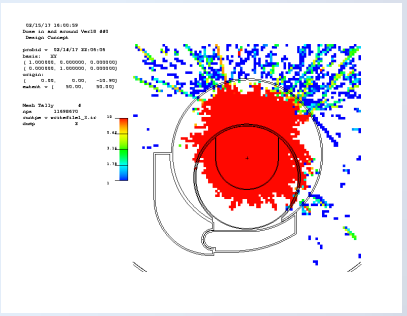
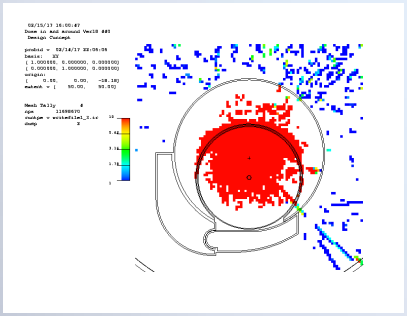
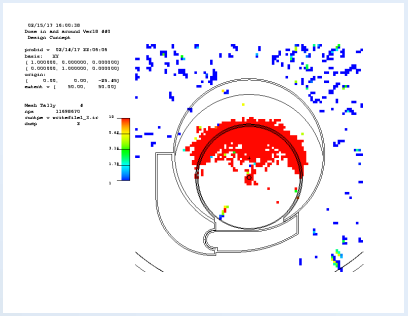
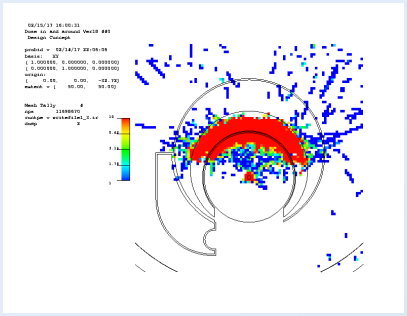
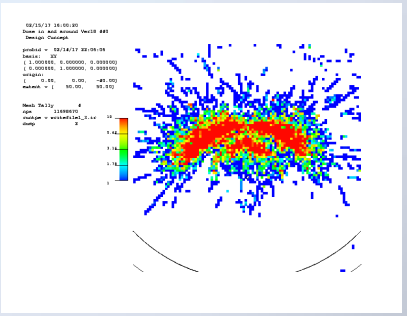


2



Hopewell Designs, Inc.

New Integrated Shielding Design

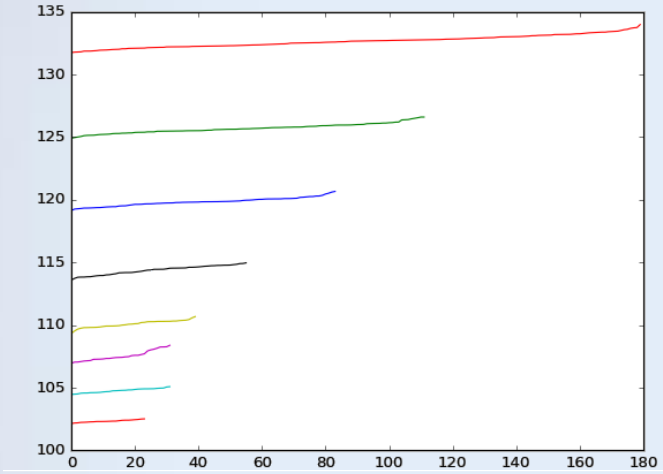













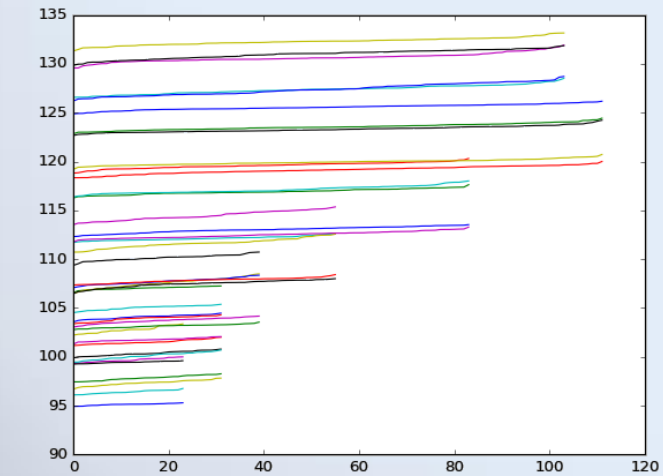
Thank you!

Hopewell Designs, Inc.

Gammacell 220 – Rotation

Rotation





Stationary