

EVALUATION OF THE MURR THERMAL BNCT FACILITY IN TREATMENT OF CANINE NASAL/SINUS TUMORS USING A PHANTOM.

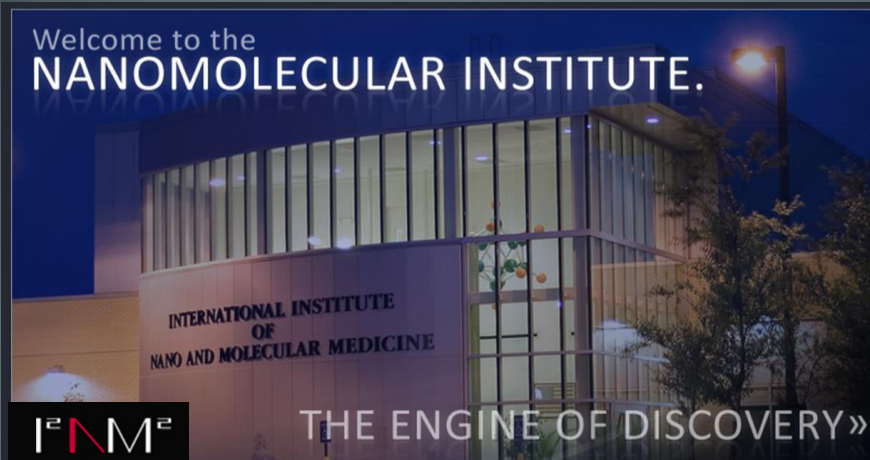
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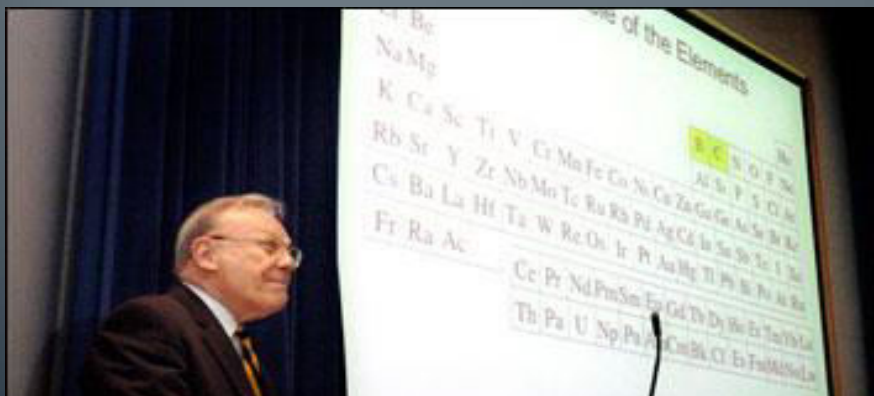
1. University of Missouri Research Reactor, UMC
2. International Institute of Nano and Molecular Medicine, UMC



BNCT at the University of Missouri IINMM and the MURR



Mr. Ralph Butler and the 10 MW University of Missouri Research Reactor (MURR)



Dr. Fred Hawthorne and the International Institute of Nano and Molecular Medicine (IINMM)

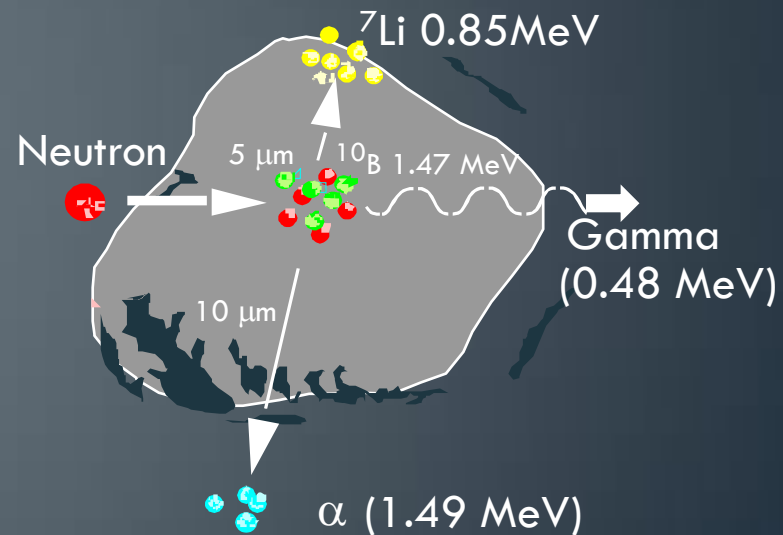


MURR
Matters...

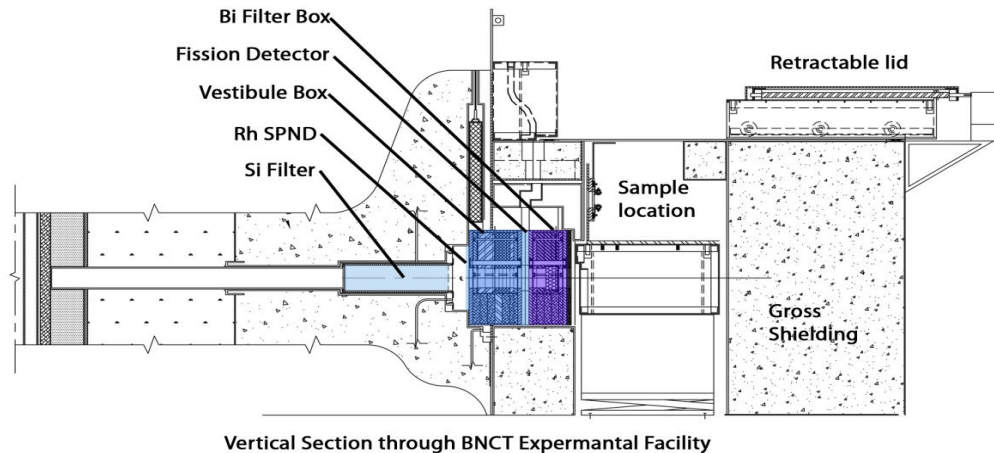
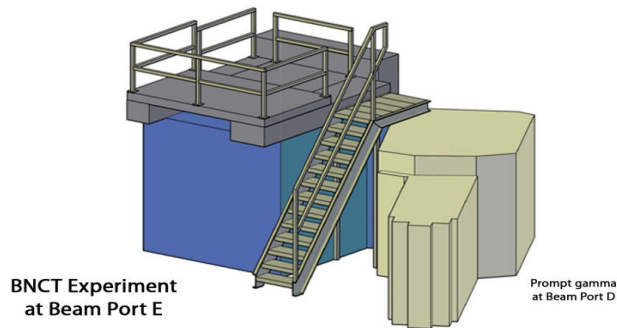
Boron Neutron Capture Therapy

Targets of traditional
and **current interest:**

- High-grade Glioma
- Primary and Metastatic Melanoma
- Metastatic Liver Tumors
- **Head and Neck Tumors**



Thermal Neutron BNCT at MURR

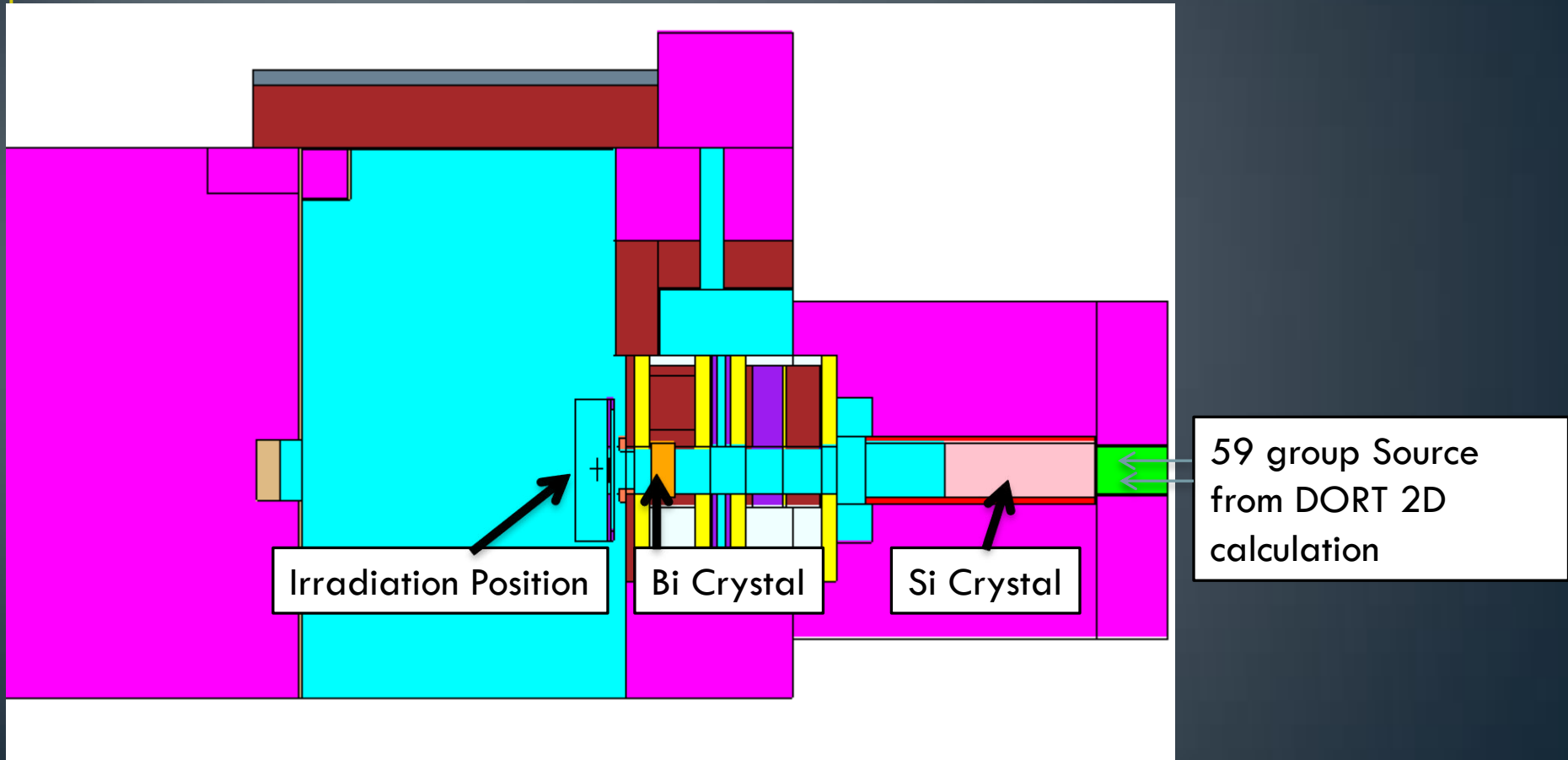


- Thermal neutron beam
 - Cd Ratio 130
 - Th flux 8.8×10^8 n/cm²/s
 - Low gamma dose
- Accessible during reactor operation
- Irradiate mice up to large dogs

Key Design Feature: Single Crystal Silicon and Single Crystal Bismuth Neutron Filters



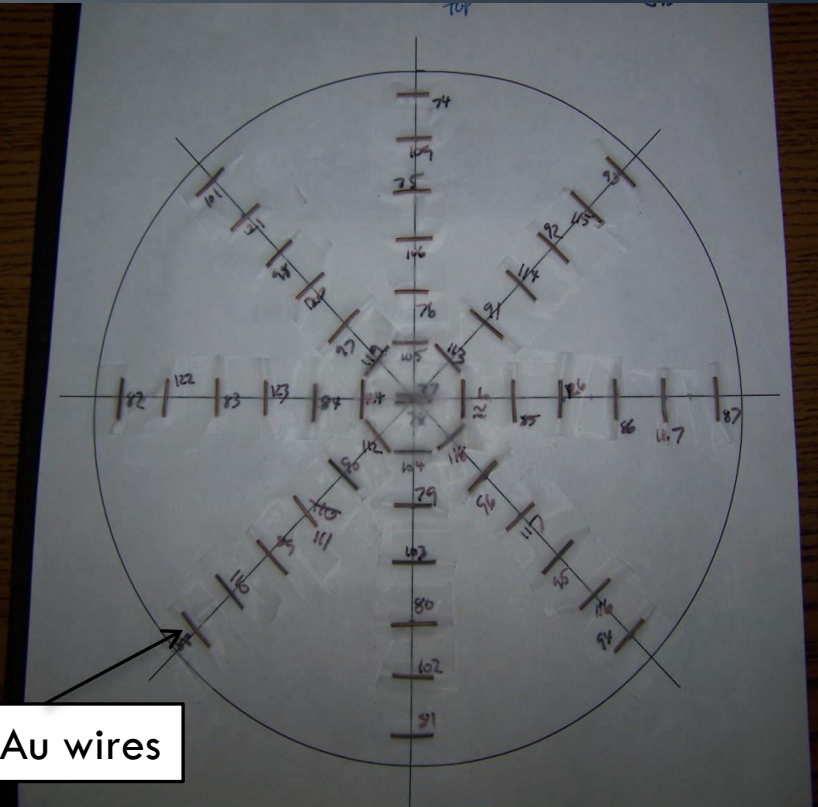
Coupled DORT and MCNP5 Model



Neutron Spectrum Measurements



Radial Flux Distribution

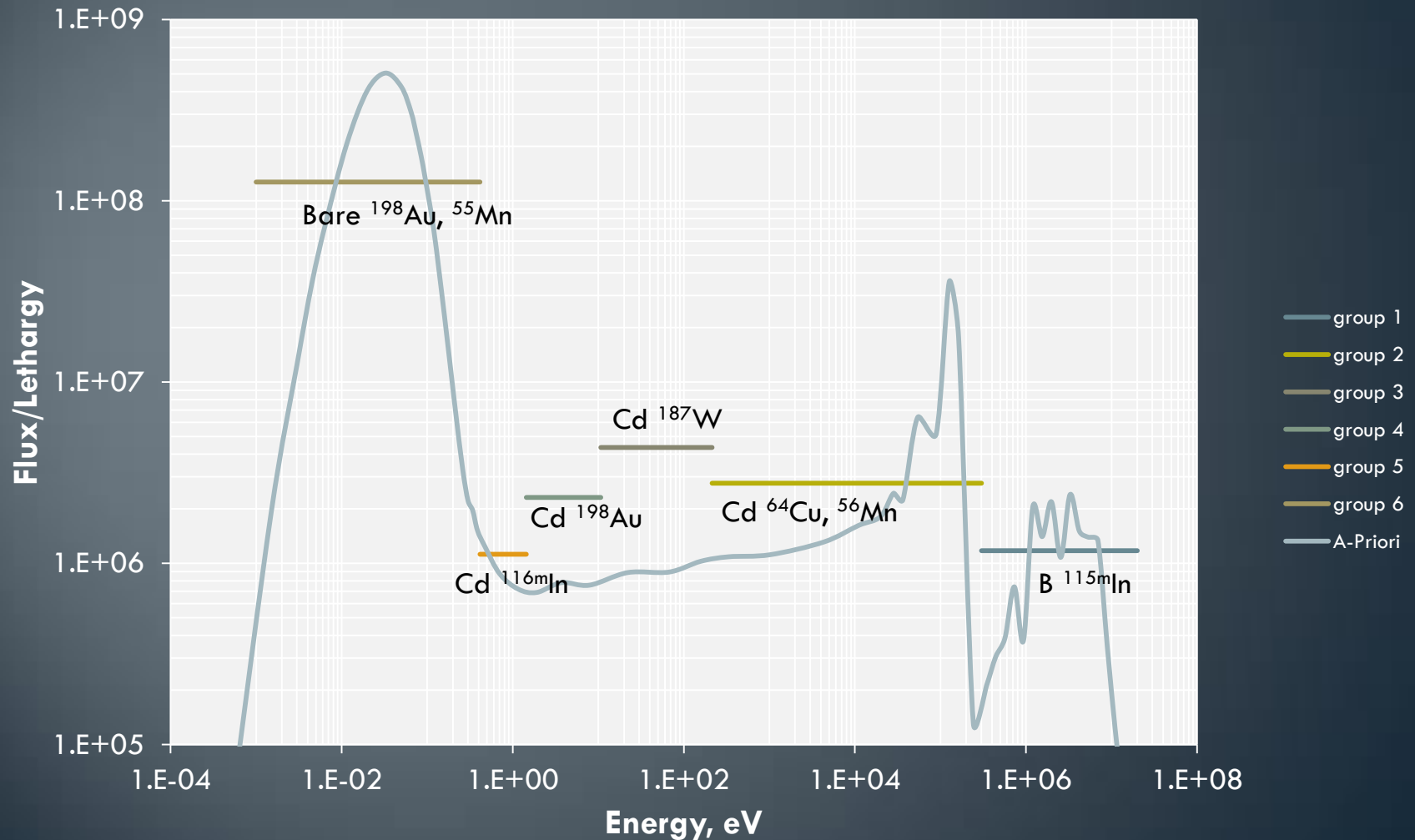


Cu/Au wires

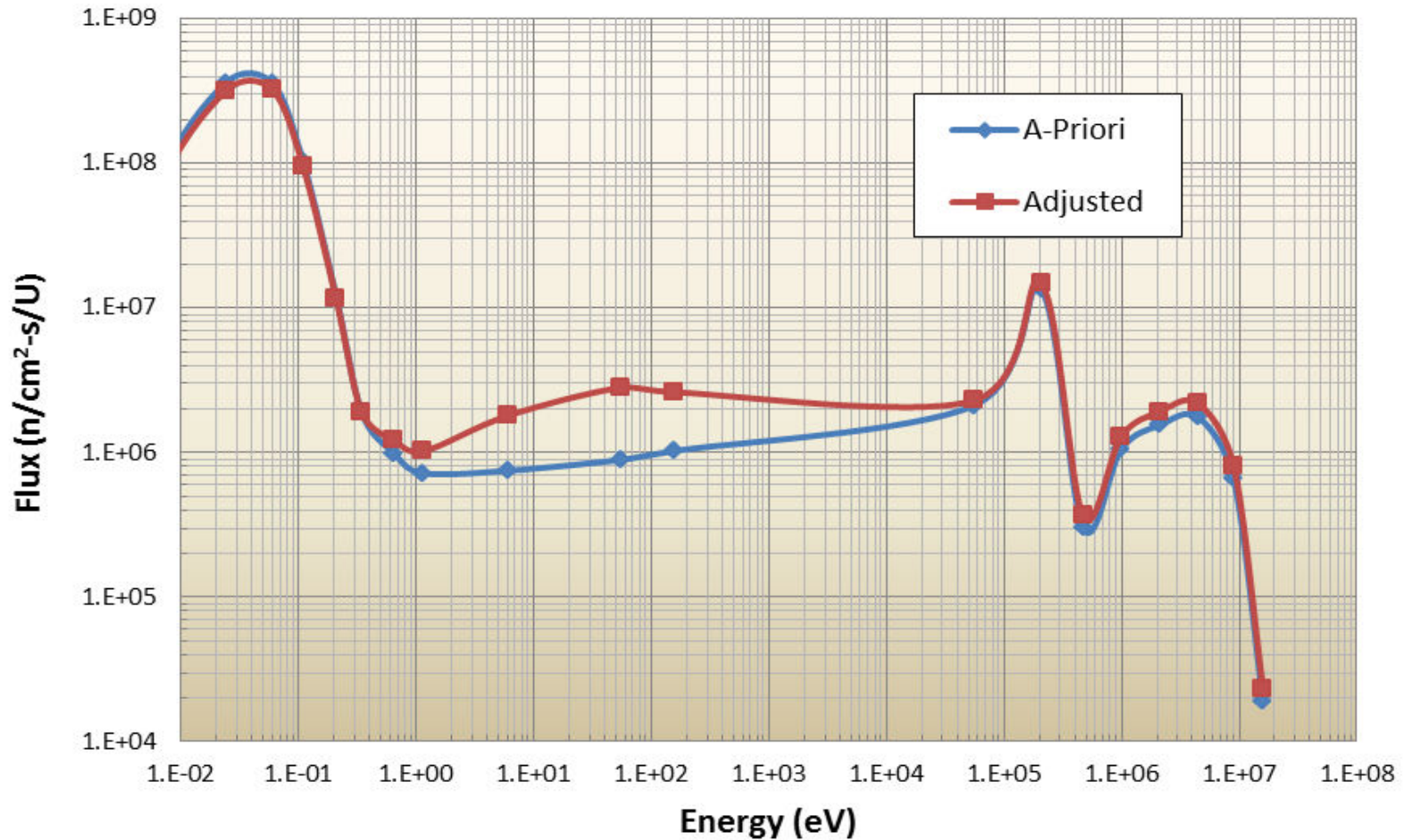
Mean Au activity: 9.73×10^{14} dps/n \pm 4%

Mean Au/Cu ratio: $22.1 \pm 1.7\%$

Over determined 6 Group Neutron Spectrum



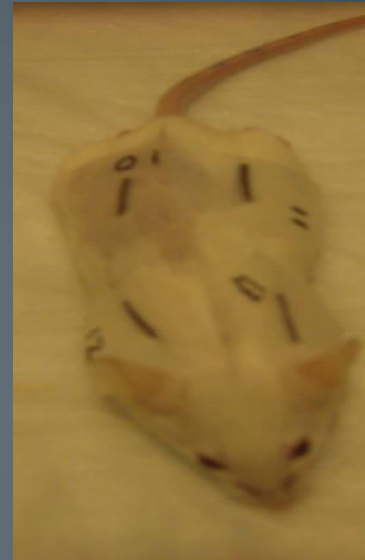
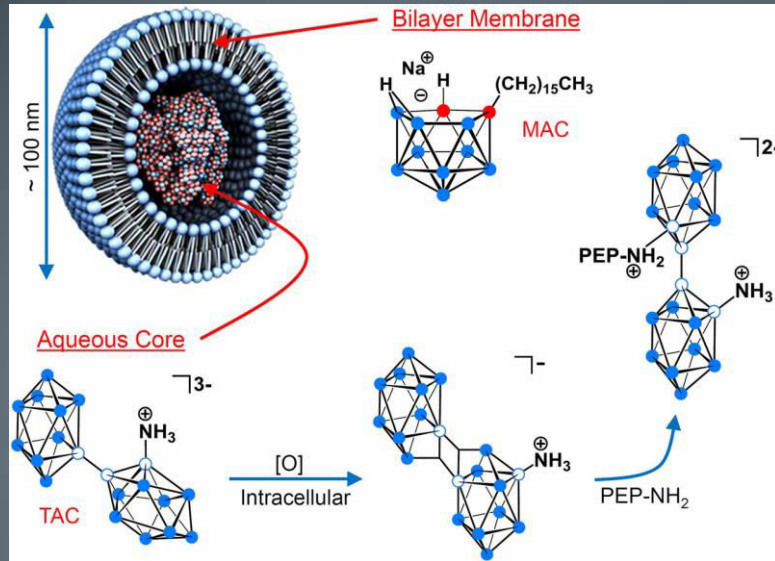
Under determined 20 Group Neutron Spectrum



Thermal Neutron Beam Characteristics

- Thermal neutron Flux
 - 8.8×10^8 n/cm²/s. Cd Ratio = 130:1
- Photon Dose (Ion Chamber)
 - 64 cGy/hr
- $^{14}\text{N}(n,p)^{14}\text{C}$
 - 62 cGy/hr
- Hydrogen Recoil (Knock On)
 - 82 cGy/hr
- Boron Capture Dose with 60 $\mu\text{g/g}$ B in tissue
 - 15.5 Gy/hr

Treatment of Mice bearing EMT6 tumors with liposomes containing MAC and TAC



Tail vein injection

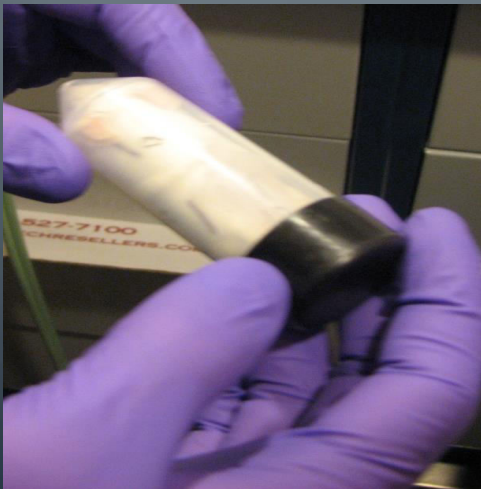
Liposome delivery of
MAC and TAC

injection protocol

54 h post injection

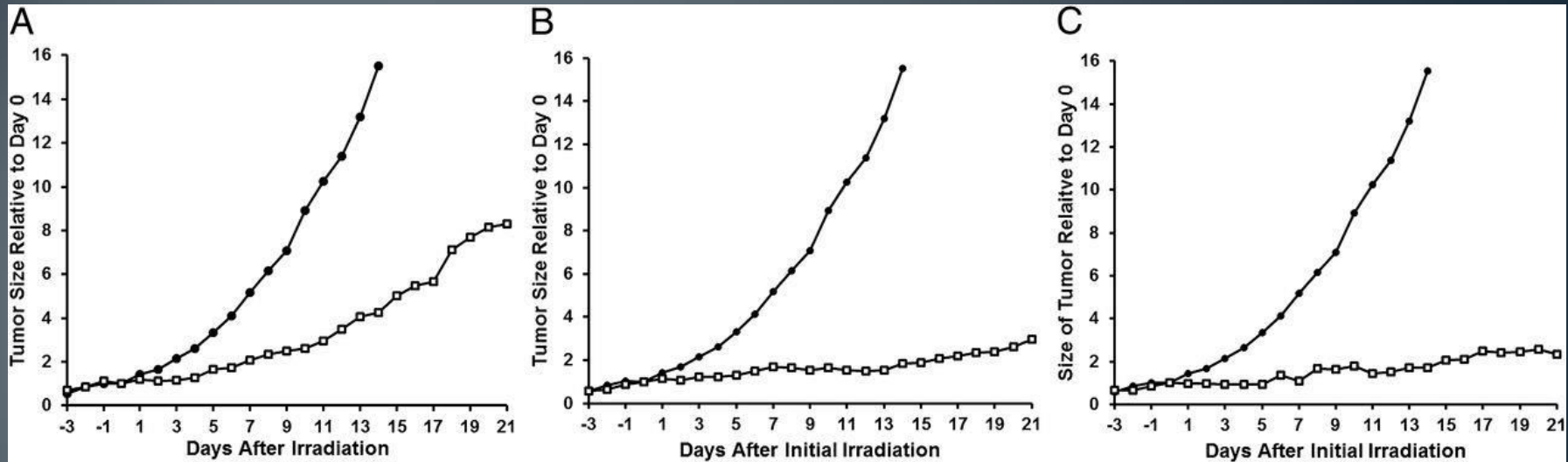
68 $\mu\text{g/g}$ B in tumor

Tumor/blood 1.88:1



Kueffer P J et al. PNAS
2013;110:6512-6517

Tumor growth curves for EMT6 Mice



Black: control
Open: 30 min irradiation

Black: control
Open: two 30 min
irradiations 1 week
apart

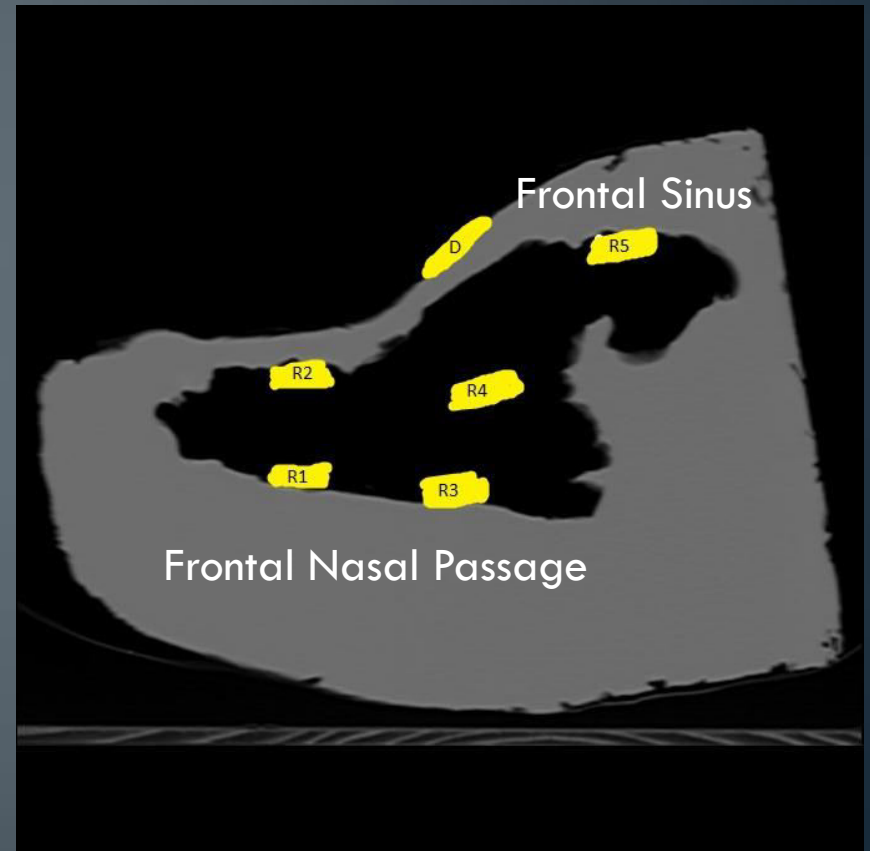
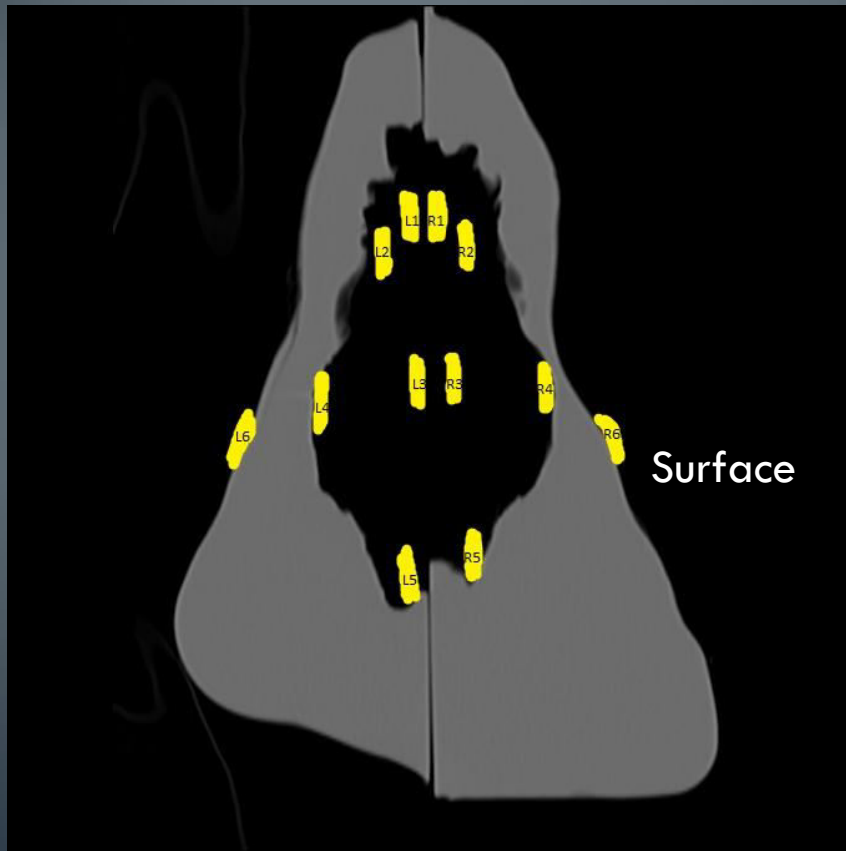
Black: control
Open: 60 minute
irradiation

Y Axis: Tumor Growth Volume normalized to average volume at day zero
X Axis: Days Following Irradiation

Potential Treatment of Canine Nasal Tumors

- Canine nasal carcinoma and sarcoma are rare.
- Radiation therapy is gold standard for treatment.
- Median Survival Time with radiation treatment 12-18 months.
- Most dogs die of local disease
 - akin to human nasal sino tumors.

Nasal-Sino Dog PMMA Phantom



CT SCAN

Dog Phantom Irradiation



Dog Phantom Irradiation



Flux Wire Position	Lt Lateral % Flux	Rt Lateral % Flux	Dorsal % Flux
R1 Nasal Passage	44	43	49
R2 Nasal Passage	40	42	59
R3 Nasal Passage	39	33	50
R4 Nasal Passage	34	46	49
R5 Frontal Sinus	14	12	55
L1 Nasal Passage	53	26	49
L2 Nasal Passage	52	28	54
L3 Nasal Passage	42	26	47
L4 Nasal Passage	48	23	46
L5 Frontal Sinus	23	12	44
R6 Surface	9	100	78
L6 Surface	100	9	48
Dorsal	56	19	100

Results

- Conformational Irradiation of Dog Phantom for treatment of Nasal tumors
 - 28% left lateral
 - 20% right lateral
 - 52% dorsal
- All regions receives $1.0E+12$ n/cm² in 58 minutes
- Nasal passage receives $1.0E+12$ n/cm² in 33 minutes

Conclusion

- A therapeutic neutron dose for treatment of sino-nasal cavity cancer in dogs is feasible.
- **Future Work**
 - Experimentally measure treatment depth in canine sino-nasal cavity.
 - Develop treatment model using MCNP or other treatment protocol software such as SeraMC from INL to fully calculate neutron dosimetry based on patient specific geometry.

Acknowledgements

Dr. Frederick Hawthorne IINMM

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MURR Staff

Operations

Health Physics

Machine Shop

Electrical Shop