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College of Pharmacy and Pharmaceutical Sciences

Mapping ^{226}Ra Micro-distribution in Radium Dial Painter Skeleton

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iQID: *Mapping Radionuclide Distribution*

ionizing radiation quantum imaging detector (iQID)

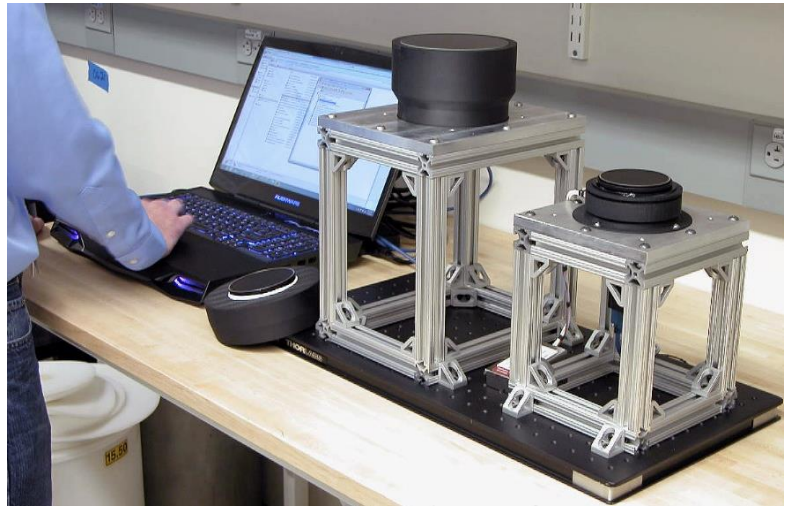
Ionizing-radiation imaging: gamma/X-rays, alpha particles, beta particles, neutrons, fission fragments

Grasshopper® 3 USB 3.0 CMOS detectors

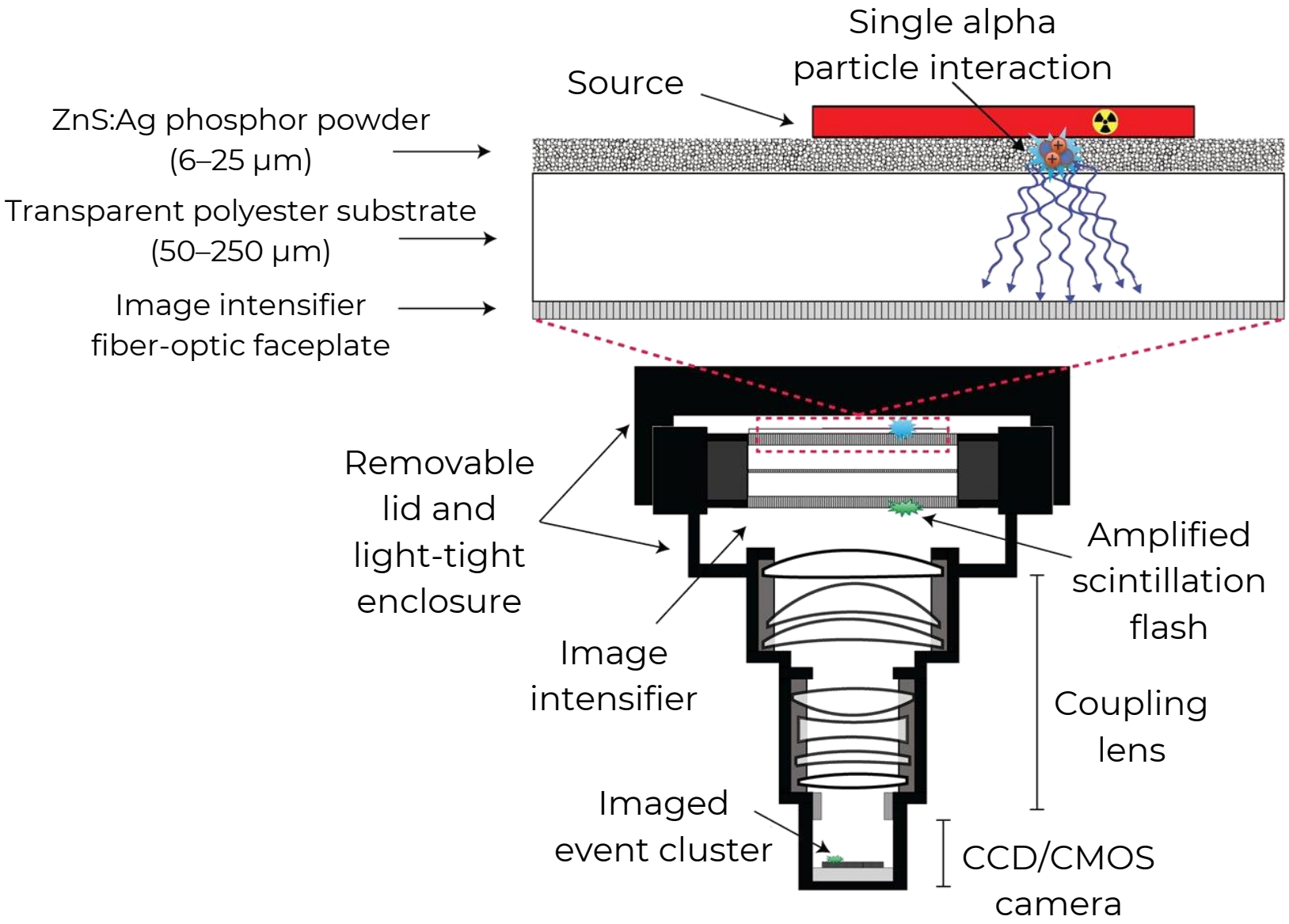
- 4.1 MP, 2048×2048 @ 90 fps
- 1” CMOS sensor

Optical pixel size

- 19.5×19.5 μm^2 pixels with 40 mm diameter intensifier



iQID: *Cross-sectional View*



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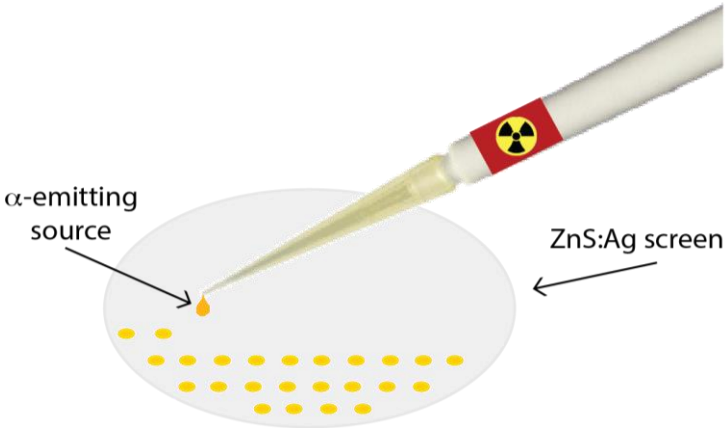
Testing iQID Capabilities

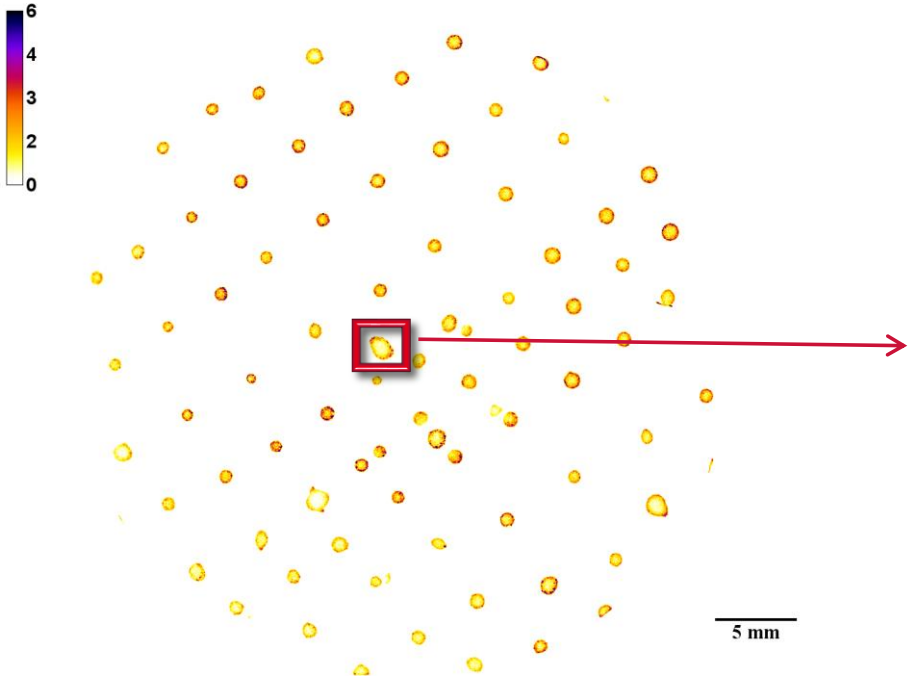
– Feasibility Studies –

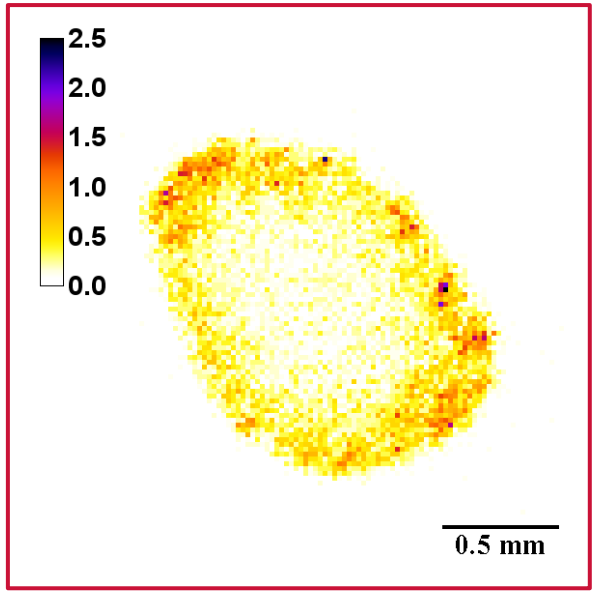
^{252}Cf Alpha Particles and Fission Fragments (I)

Cf-252, mBq scale

- ~100 Bq total, 5 hours acquisition, 40 fps
- ZnS:Ag screen: Eljen EJ-444 (3.25 ± 0.25 mg/cm2 ZnS:Ag)



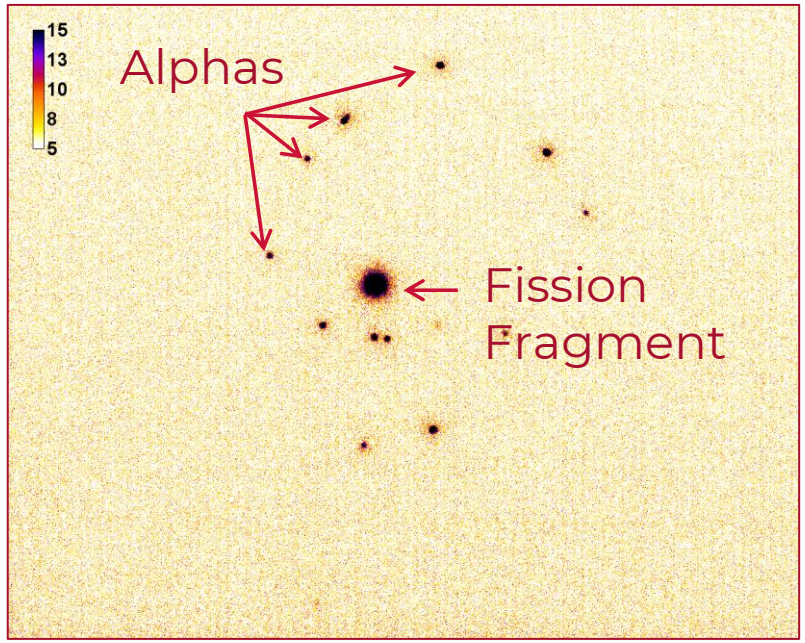


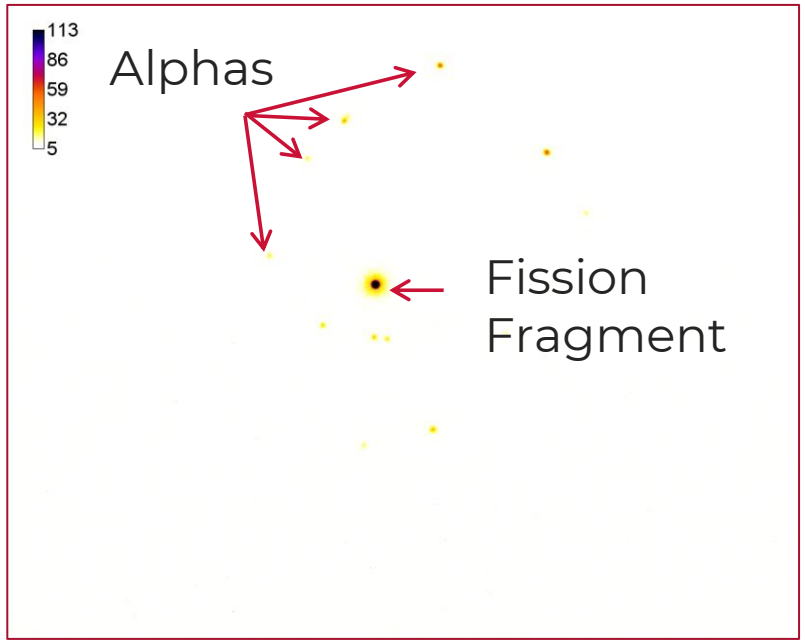


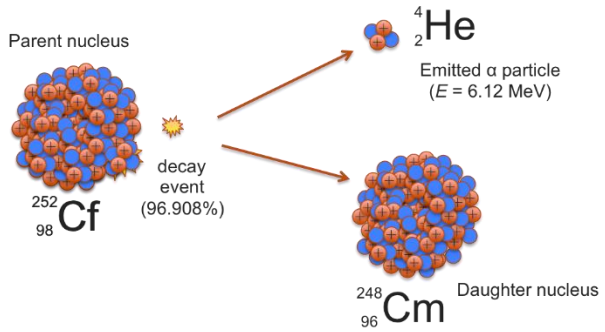
Sub-region: ~21.6k counts over 5 hours → ~1.2 Bq (32.4 pCi)
Centroid coordinate estimate to nearest sub-pixel quadrant (20.7 µm/pixel)

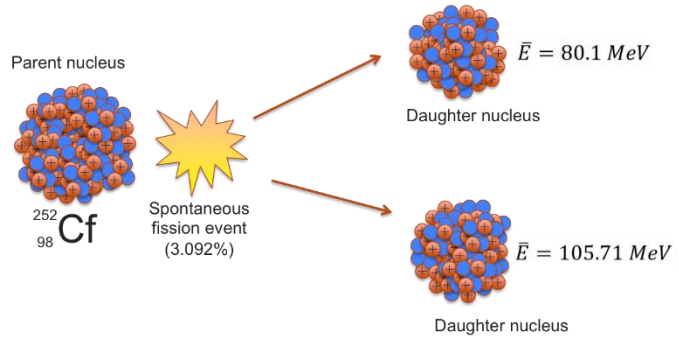
^{252}Cf Alpha Particles and Fission Fragments (II)

- Single Event Detection









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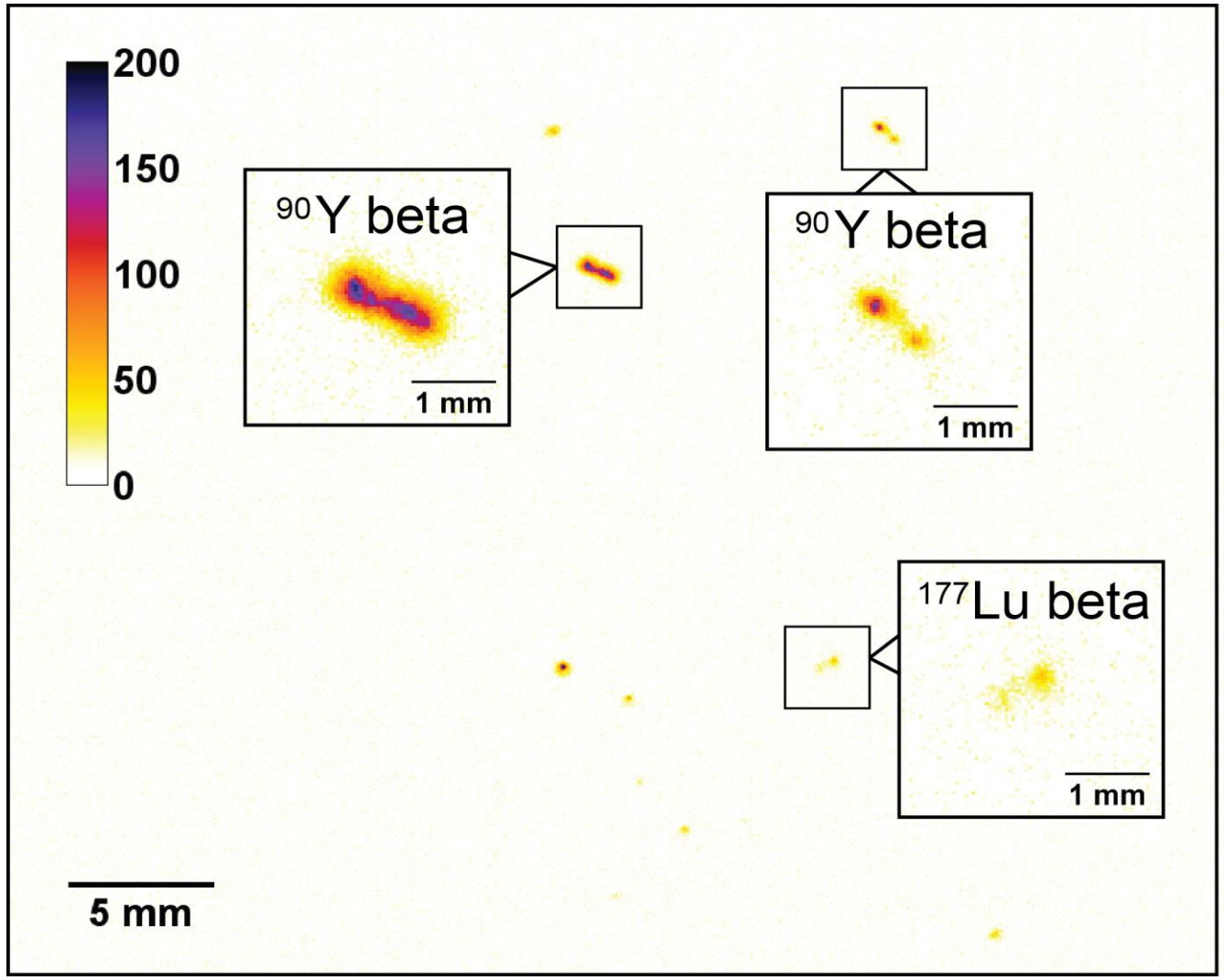
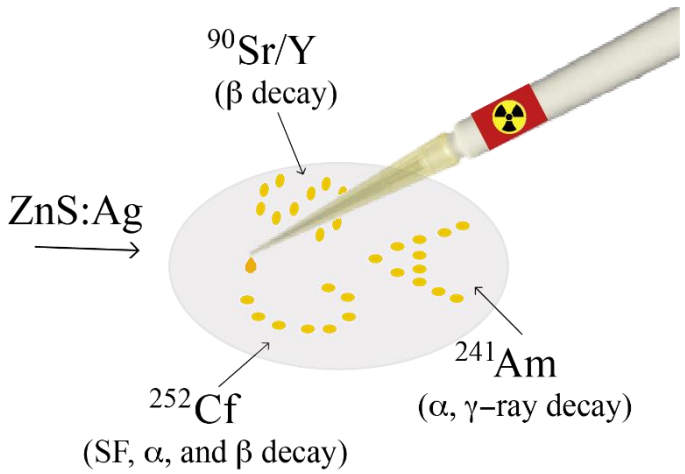
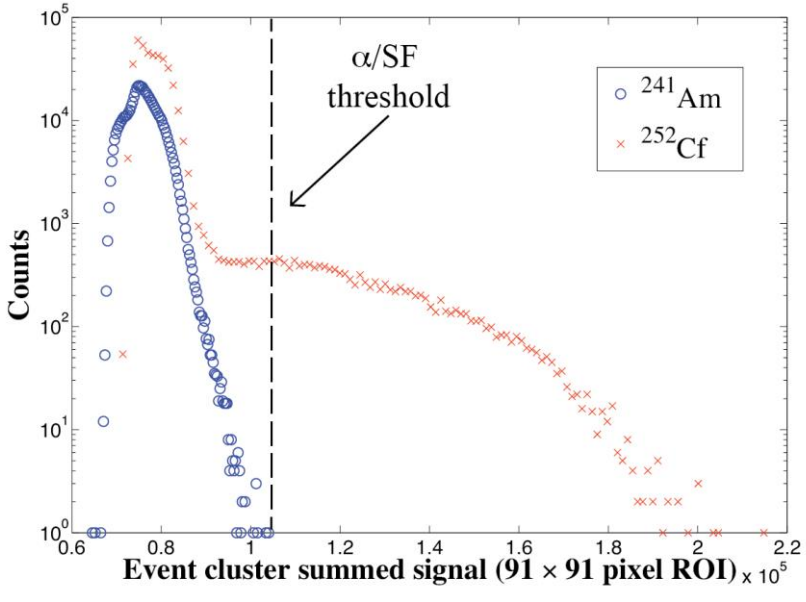
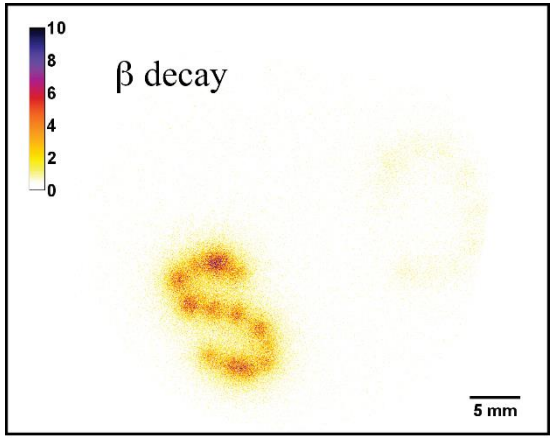
^{77}Lu and ^{90}Y Beta Particles

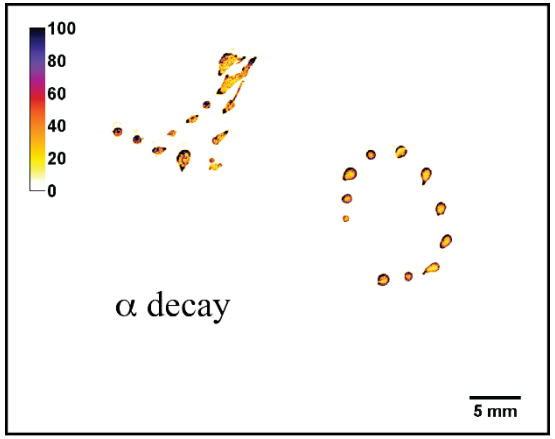


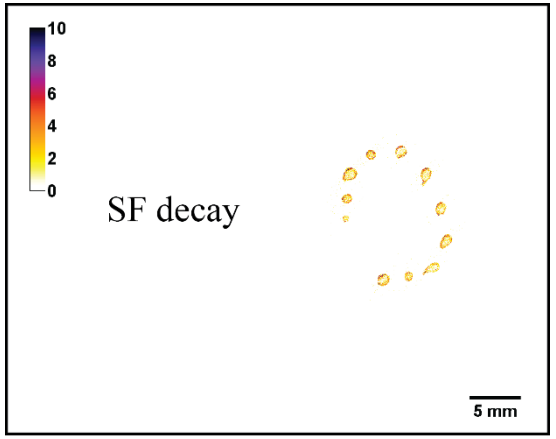
Particle Discrimination











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iQID Calibration

Detector size: Ø40 mm

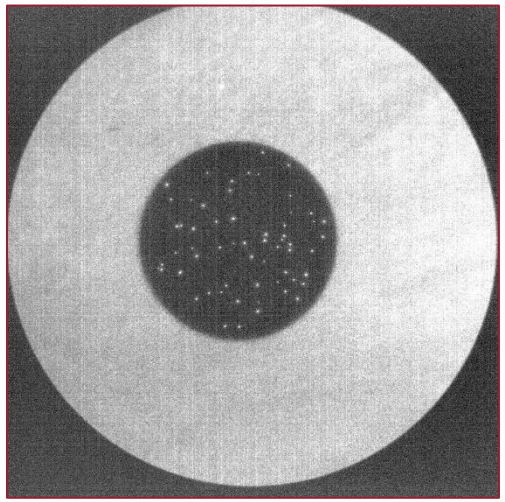
Source: ^{242}Pu, ^{239}Pu, ^{241}Am

Activity: 260 dpm

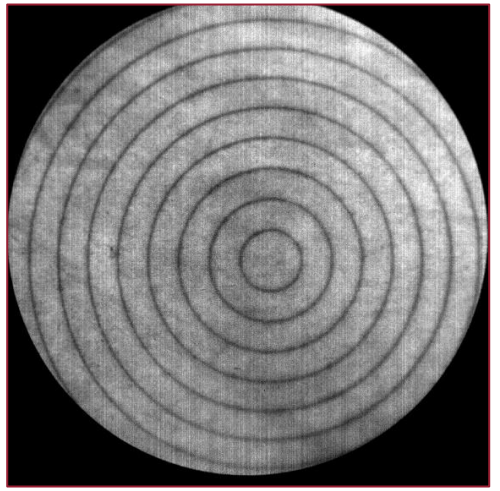
Detection Efficiency: 92%

Resolution: 19.5×19.5 μm

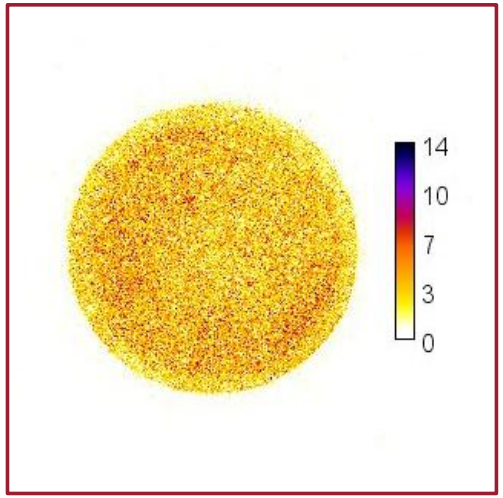
Source Placement



Shadow Image



Scale Calibration



iQID Image

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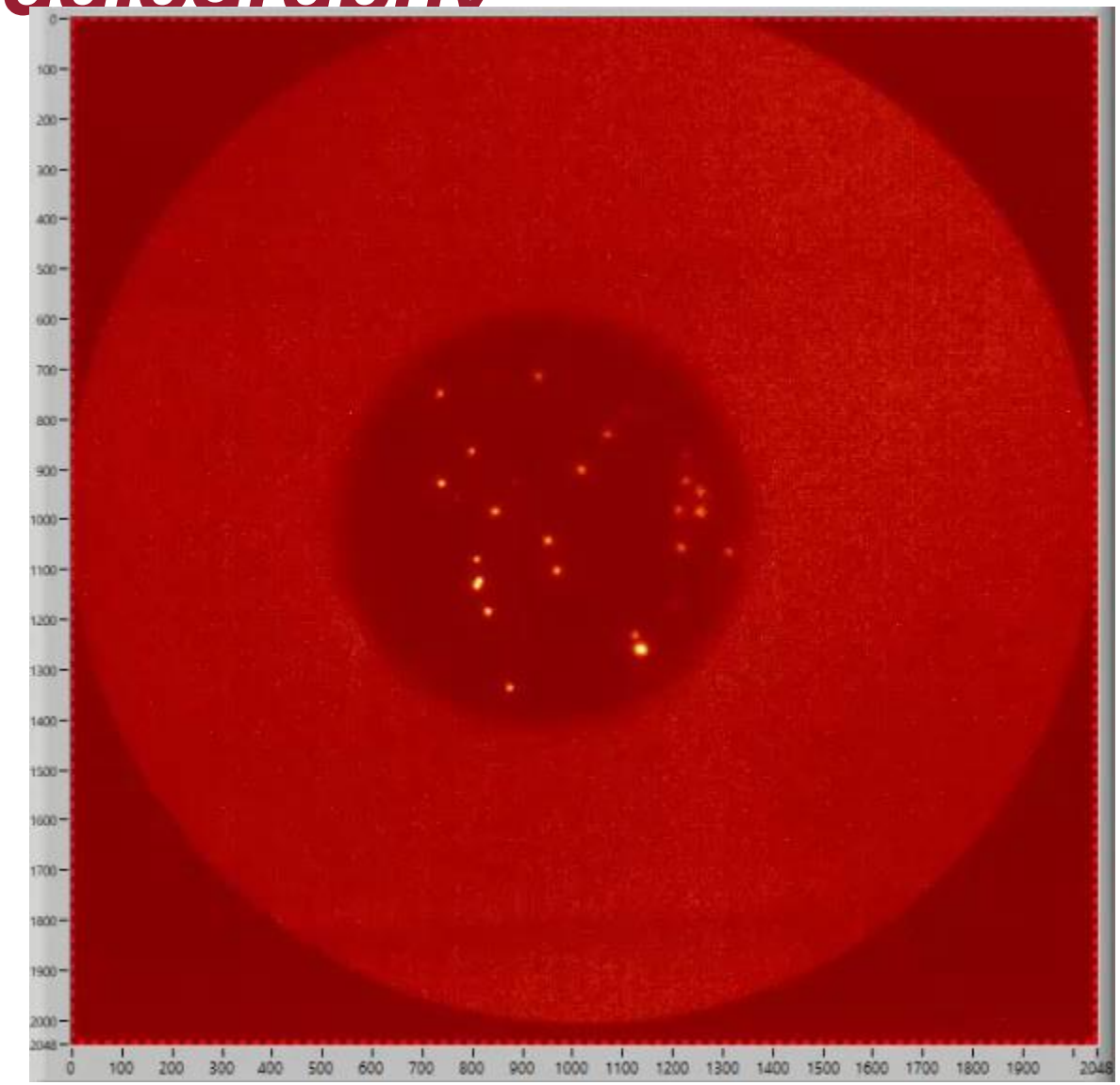
iQID: *Real-Time Quantitative Autoradiography*



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Radium Samples at USTUR/NHRTR

Frozen Tissue Samples

Cases: 159

Rawland/Sharpe: 76

Samples: 433

Plastic Embedded and Microslides

Cases: 210

Rawland: 210

Samples*: GOK

0 → **Intake** → 77.7 MBq (2099.5 µCi)

** NHRTR radium sample inventory is an ongoing project; numbers on this slide are a rough estimate!*

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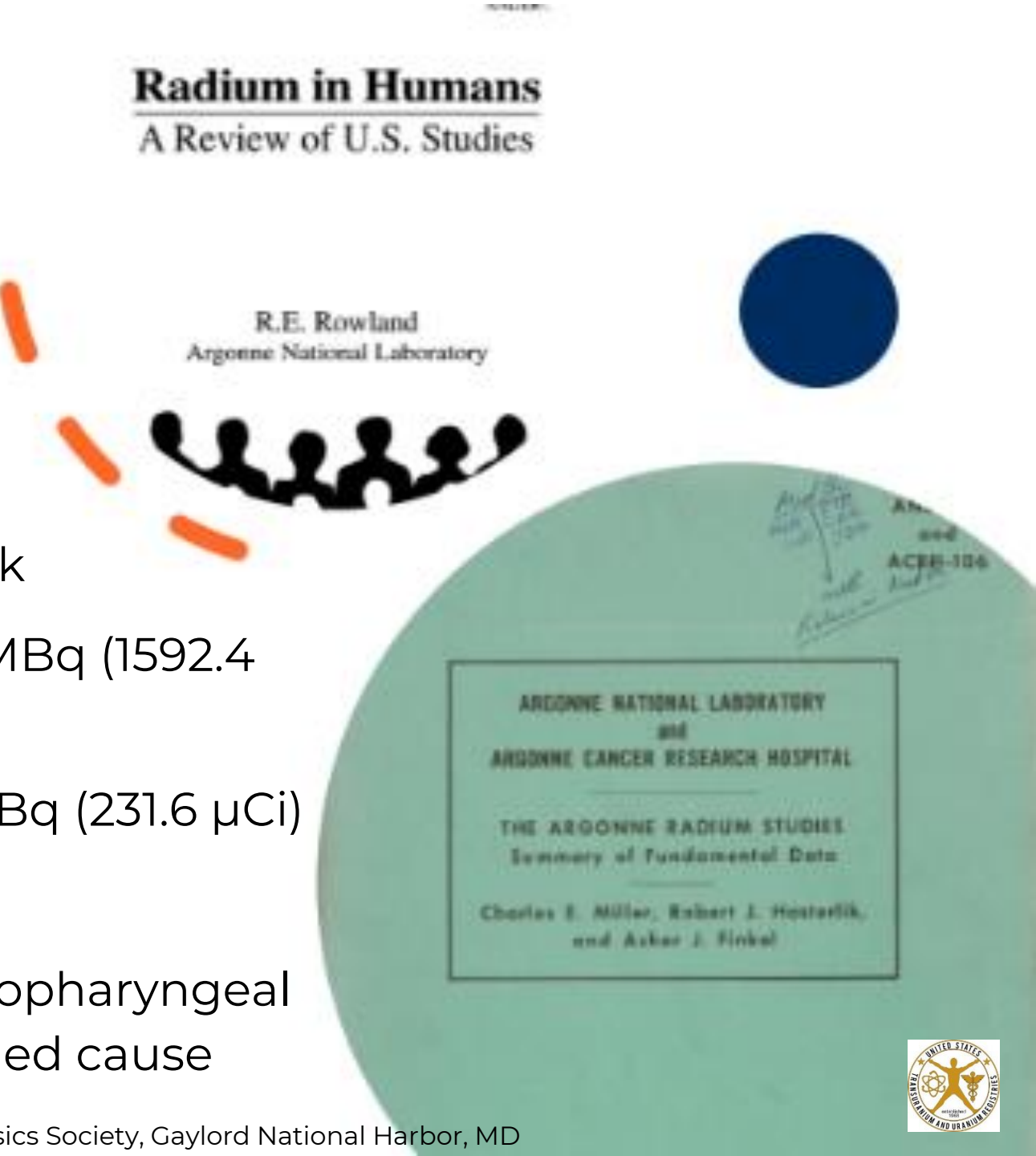
Radium Samples at USTUR/NHRTR

Dry Tissue Samples

NOTE: NHRTR radium sample inventory is an ongoing project; numbers on this slide are a rough estimate!

Case Description



Case number: 03-666

Occupation: dial painter

Gender: female

Duration of employment: 347 wk

Estimated intake of ^{226}Ra: 58.9 MBq (1592.4 µCi)

Estimated intake of ^{228}Ra: 8.6 MBq (231.6 µCi)

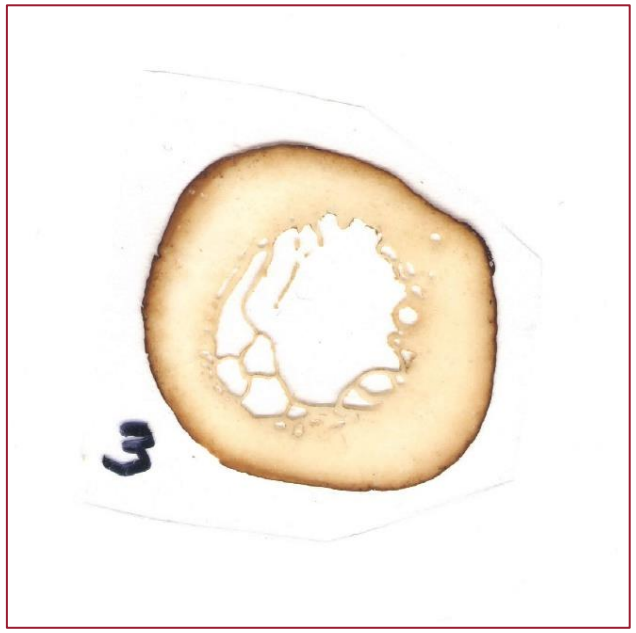
Age at the time of death: 24 y

Causes of death: diphtheria, nasopharyngeal bronchopneumonia, undetermined cause

Case 03-666: *Sample selection*

K5C1: femur (L) middle shaft (MS)

Q8B1: 7th thoracic (T7) vertebra – left half

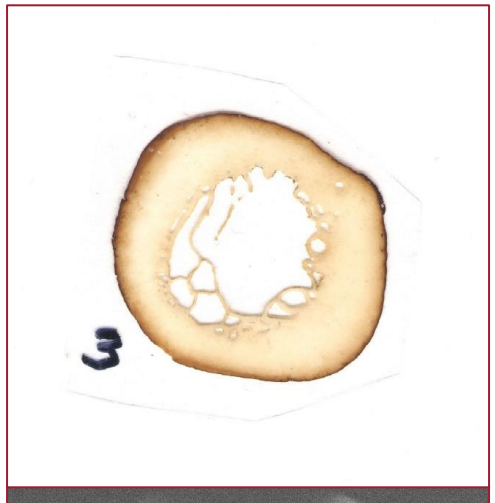


K5C1

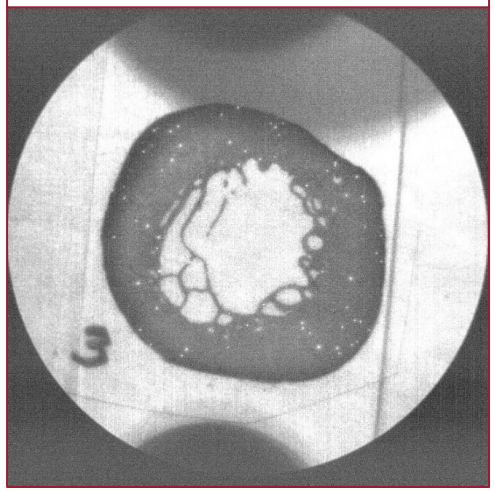
Q8B1

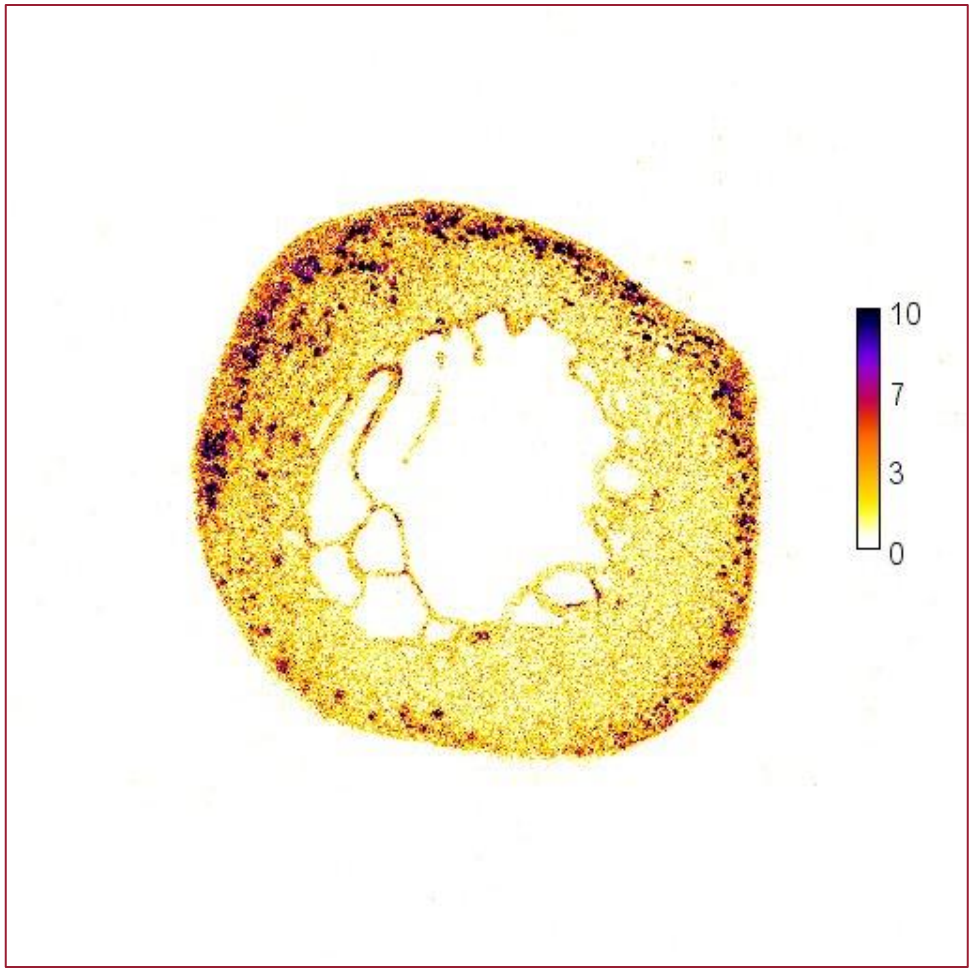
Case 03-666: *K5C1, Femur (L) Middle Shaft*

Digital Scan



Shadow Image



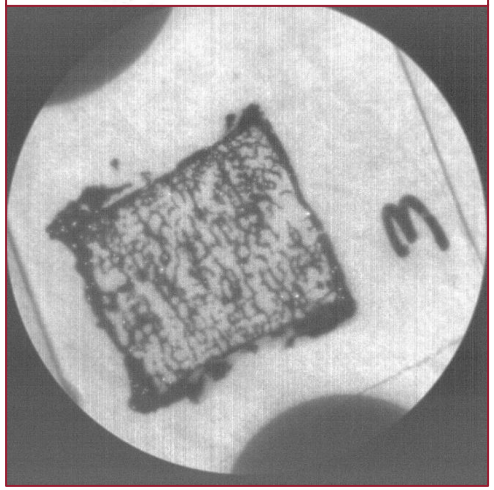


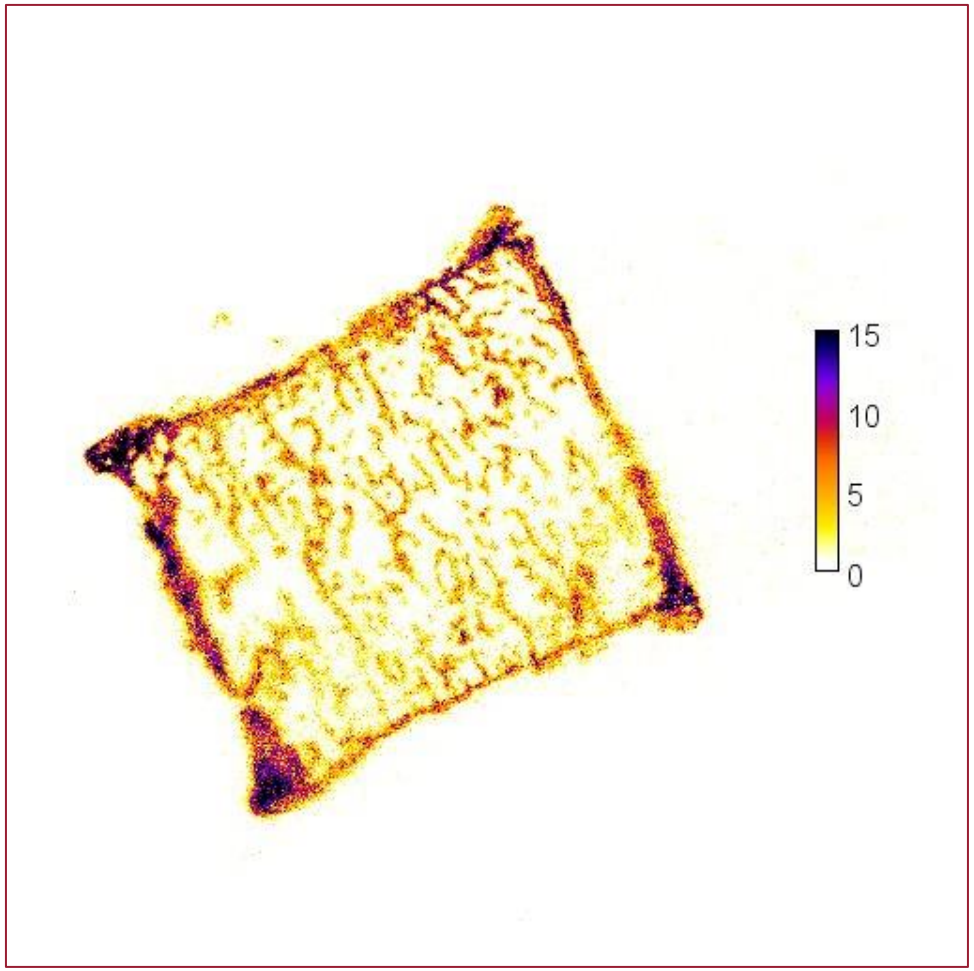
iQID Image

Case 03-666: Q8B1, 7th Thoracic Vertebra – Left Half

Digital Scan

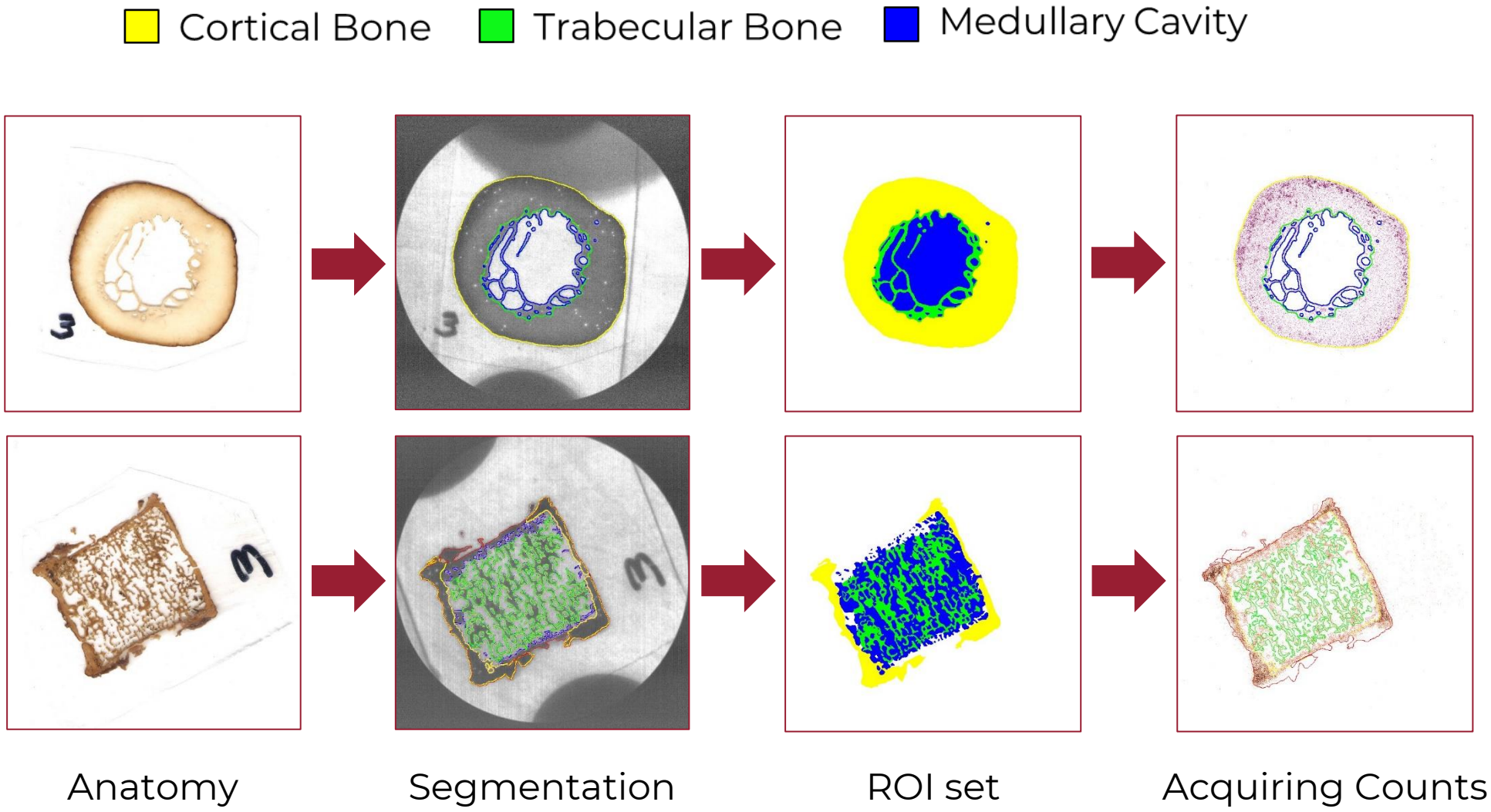
Shadow Image





iQID Image

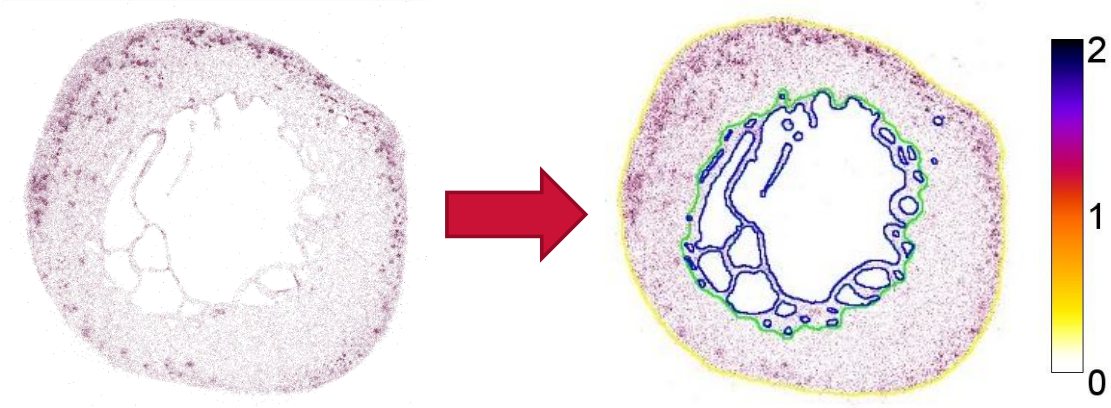
Bone Segmentation: *ROIs*



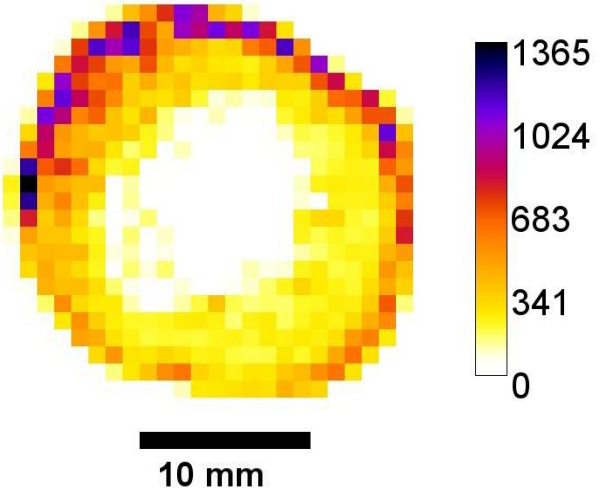
Surface Activity

- Average surface activity ($\overline{A}_s$): average over ROI or entire surface
- Surface activity range: min. and max. activity (μm → mm image binning)

Average surface activity ($\overline{A}_s$)



$A_{s,min}$ and $A_{s,max}$ (1mm/px)



Bone	Surface activity ($\overline{A}_s$), mBq mm^{-2}	
	Average	Range
Femur (L)		
MS (K5C1)	17.2	1.3 – 56.9
Vertebra		
T7 (Q8B1)	14.5	0.6 – 27.5

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Summary

- Thousands of tissue samples from radium dial worker studies are available for future research at USTUR/NHRTR.
- iQID allows for real-time quantitative autoradiography at 20-μm resolution for ^{226}Ra
- Microdistribution of ^{226}Ra in bone was visualized and quantified
  - ✓ Identified ROIs
  - ✓ Measured average surface activity
- iQID is an effective technique for studying the heterogeneous distribution of alpha-emitters on a micro scale

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Thank you!

Questions?

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