Investigation of Potential Fluorescence Influence in Bremsstrahlung X-Ray Techniques

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Goals

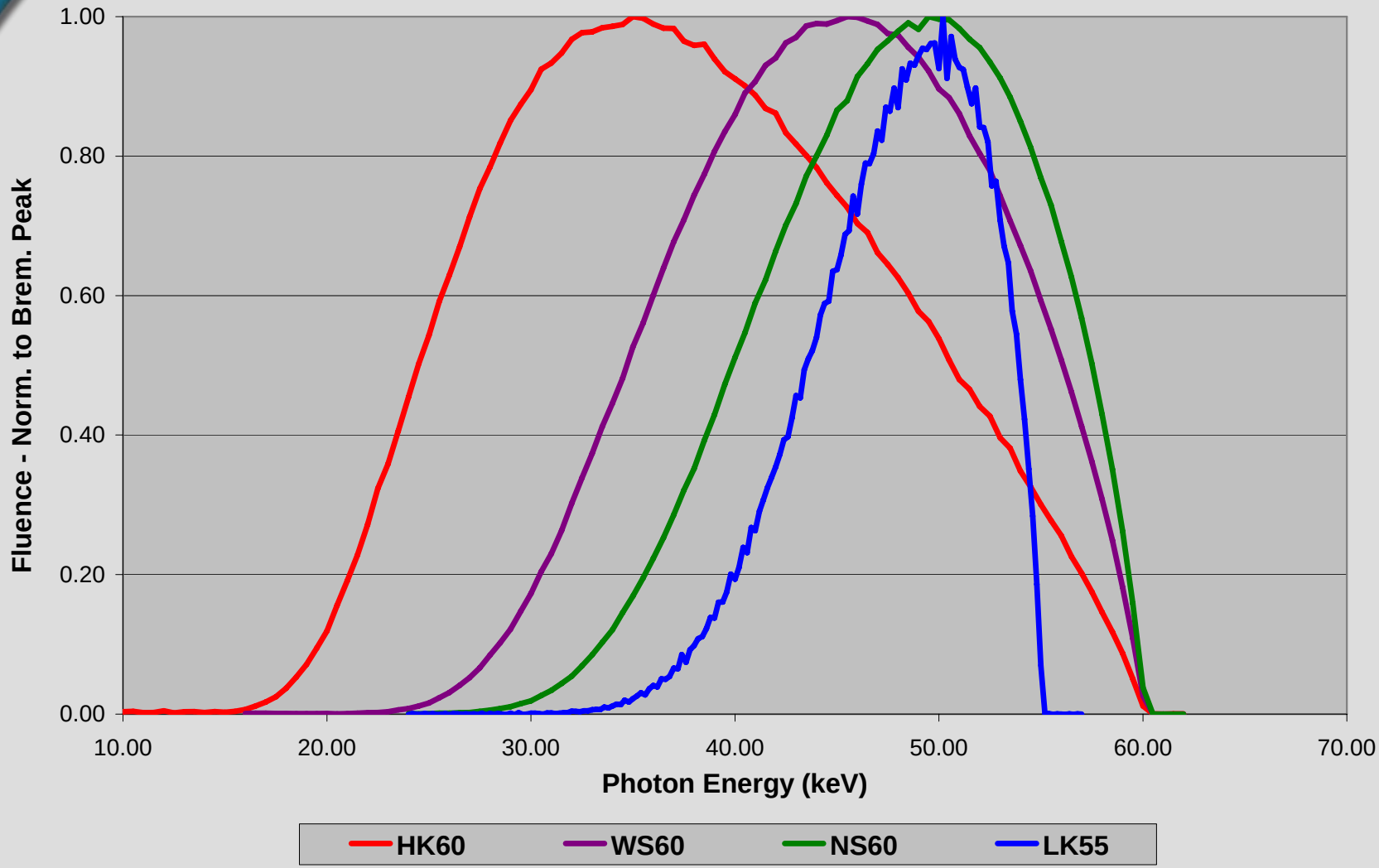
Collect input from others

Suggest alternative to current NIST Performance Test methods

History / Background

- X-ray Capability Expansion
  - ANSI/HPS N13.11-2001
  - Added roughly 41 bremsstrahlung techniques
  - Standard filter recipes (N13.11)
    - NIST (L, M, H, S)
    - ISO (HK, WS, NS, LK)
    - Some NIST-ISO similarities

Comparison of Energy Distribution for ~60 kVp ISO Techniques*

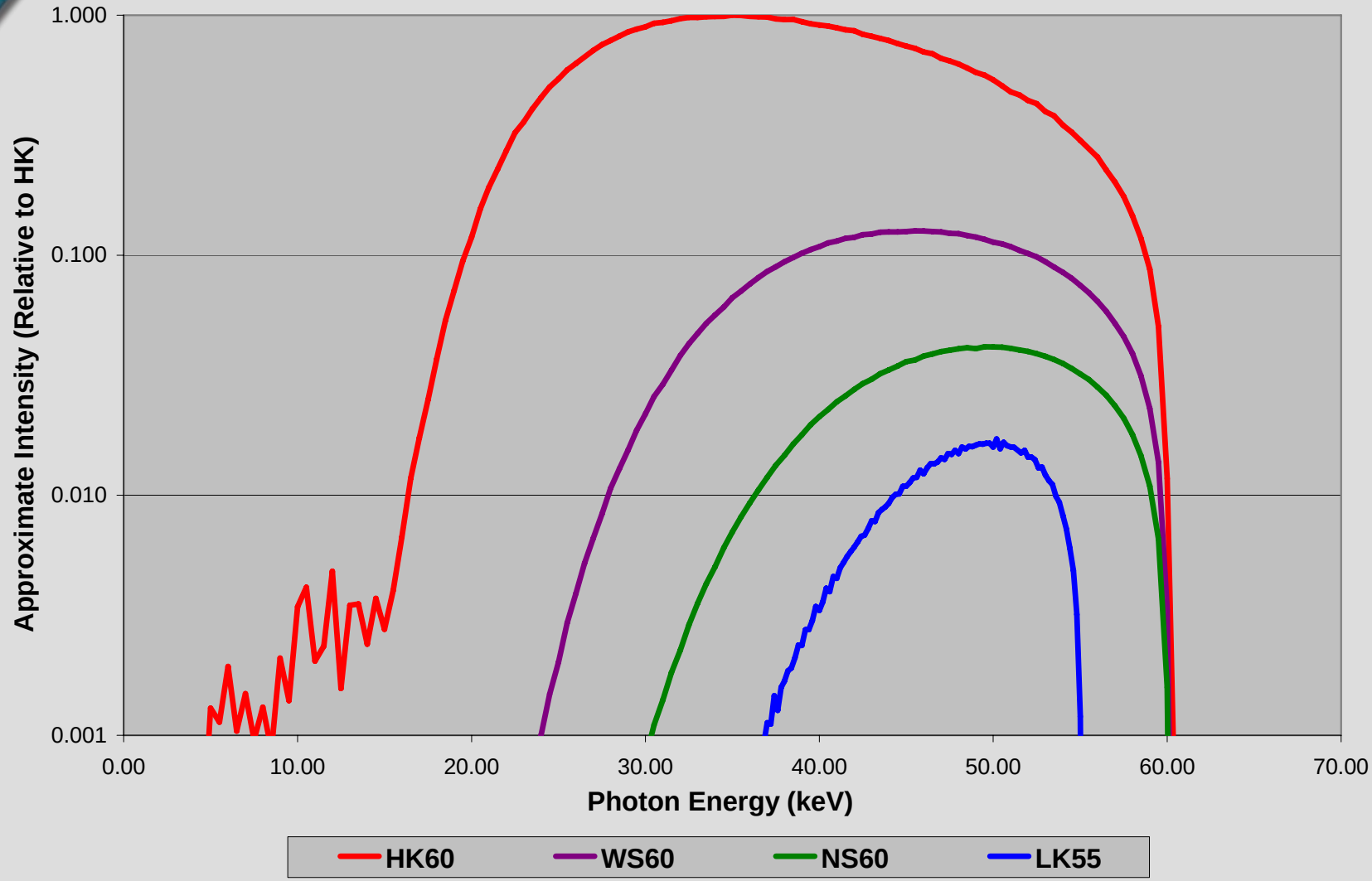


* Spectra obtained from Ankerhold, U. Catalogue of X-ray spectra and their characteristic data - ISO and DIN radiation qualities, diagnostic and therapy radiation qualities, unfiltered X-ray spectra -. PTB Bericht, PTB-Dos-34, April 2000, ISBN 3-89701-513-7.

Low Air-Kerma Rate (LK) Series

- LK series unique to ISO
- 30, 35, 55, 70, 100, 125, 170, 210, 240 keV
- Intensity (relative to beam current) is significantly lower than comparable energy H, NS techniques

Comparison of Beam Intensity for ~60 kVp ISO Techniques*



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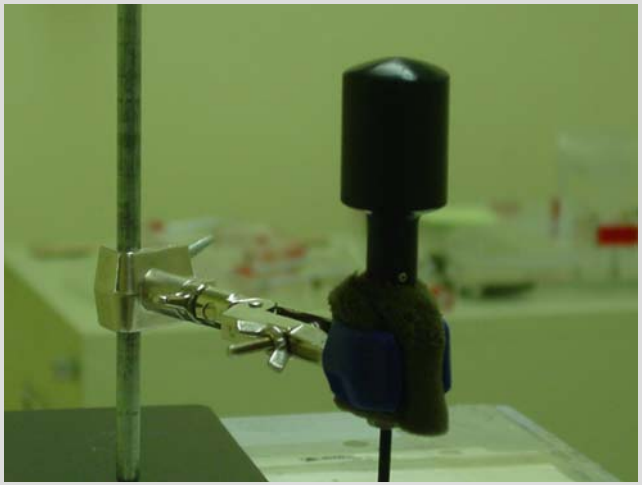
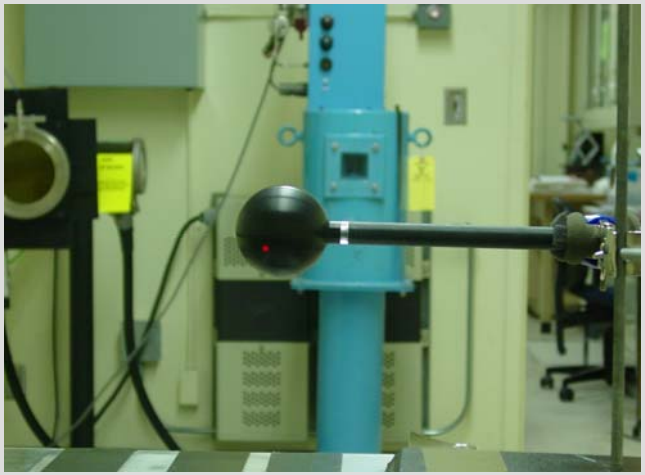
LK Development

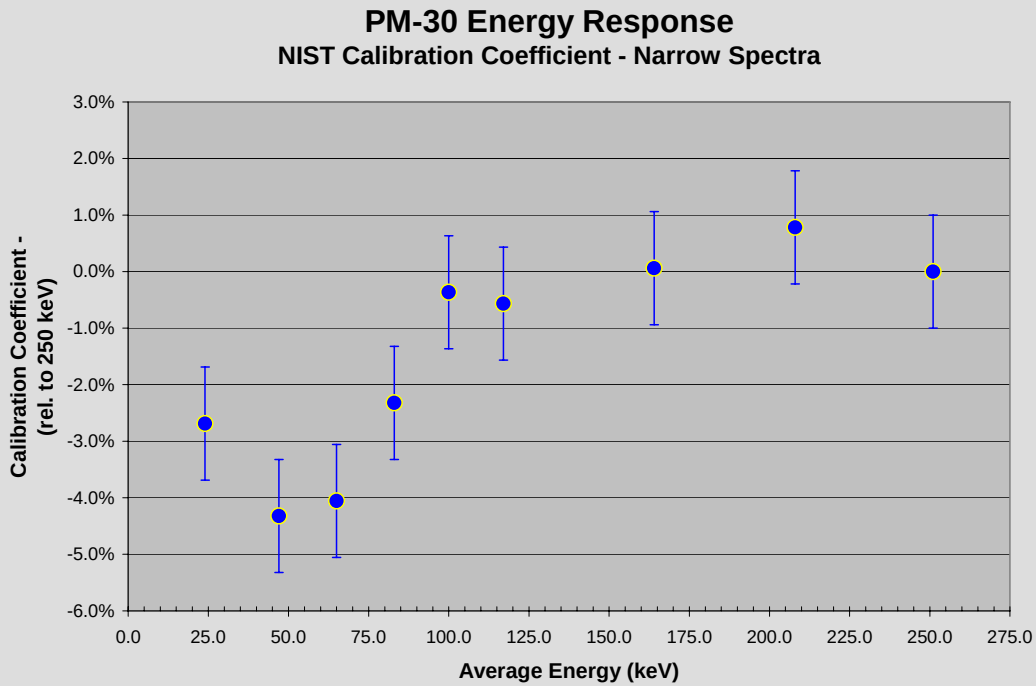
- New Techniques Characterized
  - Half-Value Layer
  - Homogeneity Coefficient
  - Uniformity
  - Spectra (rough qualitative view)
  - Calibrated w/NIST traceable Ion Chamber
- Implemented in 2002

Calibration/Performance Test Tools





- Calibration based on reference-class ion chambers
- Performance testing based on similar chambers

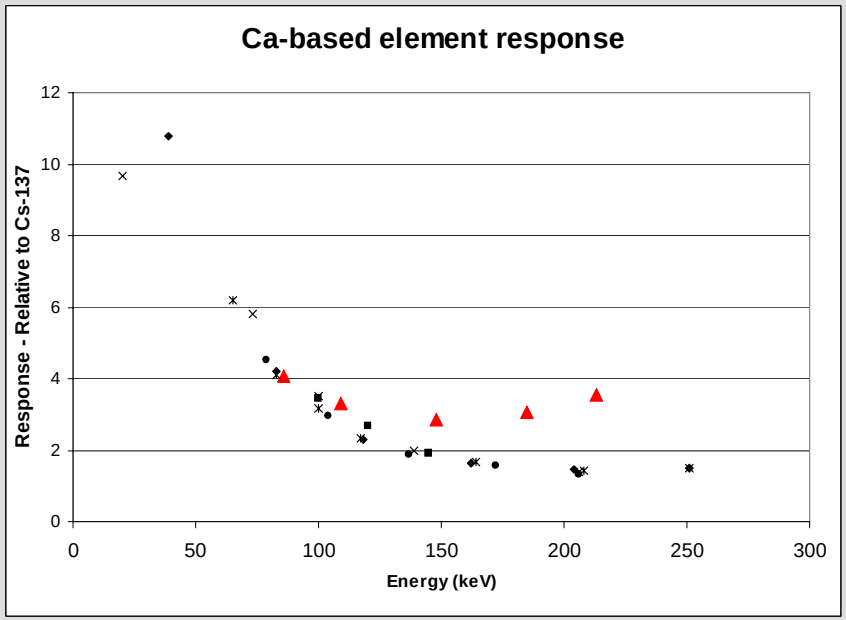


LK Implementation

- Processors - evaluate algorithms
- Discontinuity with LK techniques
  - Response inconsistent with average energy
  - Calcium – based phosphors
  - 2 independent reports w/data

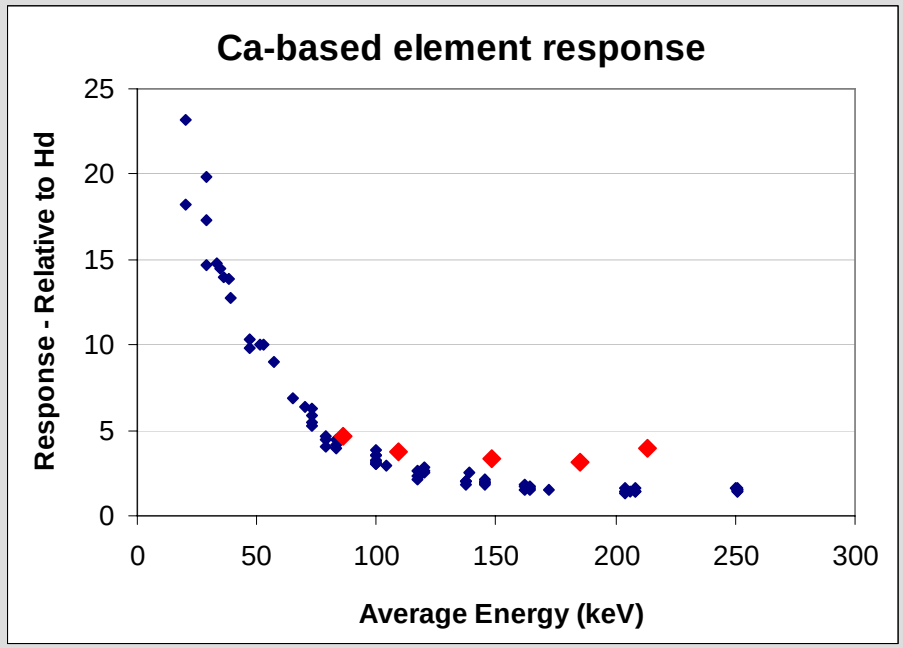
LK Implementation - Issues -

- *Abnormal response indicated on Ca-based phosphor*



- *Courtesy of Stanford Dosimetry, LLC*

- *Courtesy of Mike Lantz, et.al.*



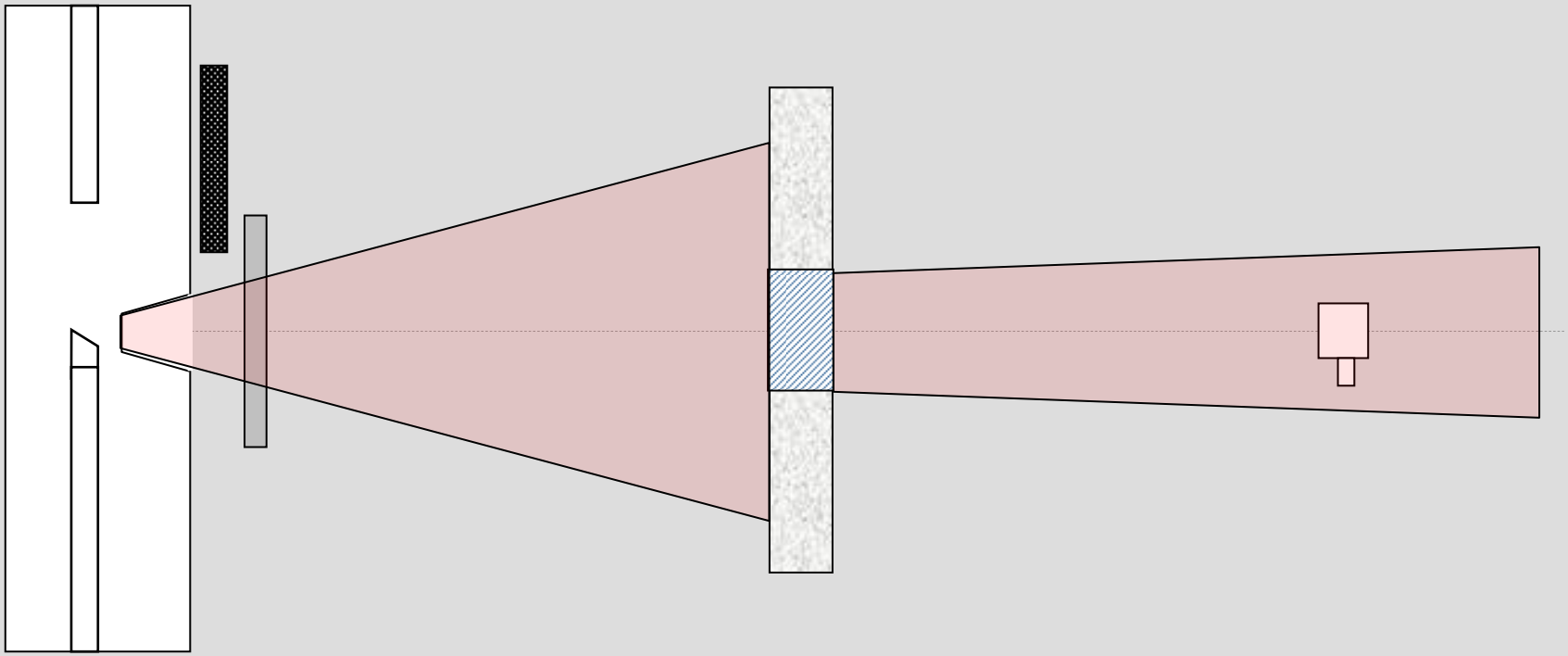
LK Implementation
- Issues -

- Discontinued use
  - 170, 210, 240
- Initiated Investigation
  - Earlier HVL challenges
  - HPGe Spectra
  - TLD Evaluation

HVL Measurement
- LK-240 -

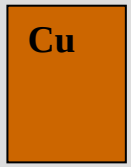
- Reconsidered initial difficulty with HVL assessment
  - Initial HVL measurement ~25% high
  - Suggests higher energy
  - Initial HC measurement ~15% low
  - Suggests spectrum too broad

HVL Measurement (light filtration)

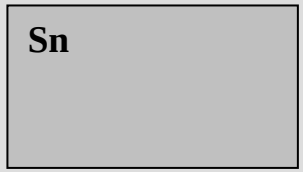


Filters for ~240-250 keV

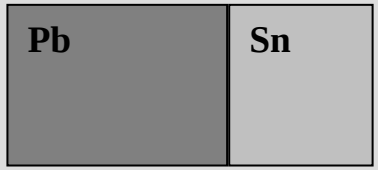
HK-250



WS-250

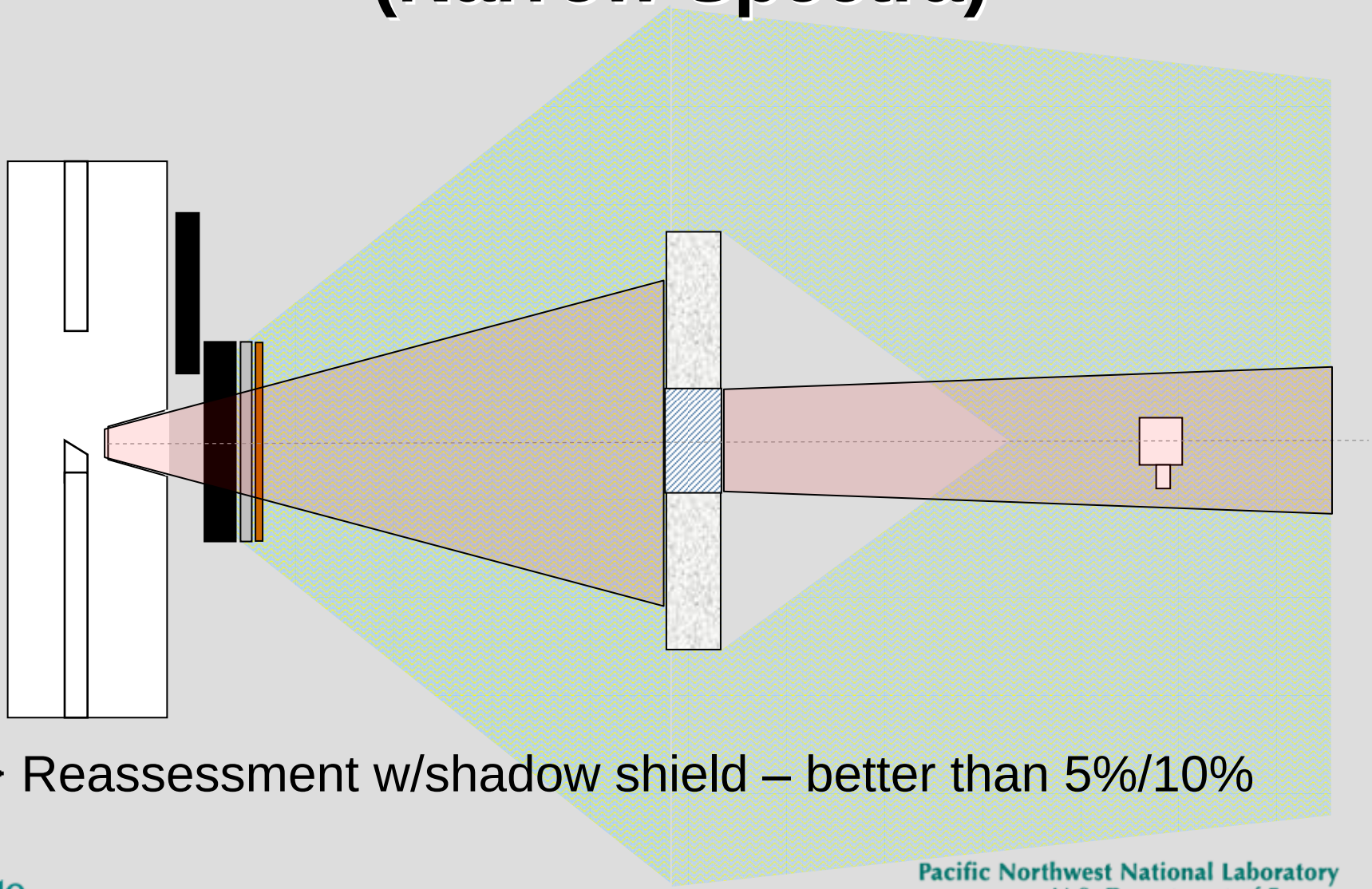


NS-250



LK-240

HVL Measurement (Narrow Spectra)

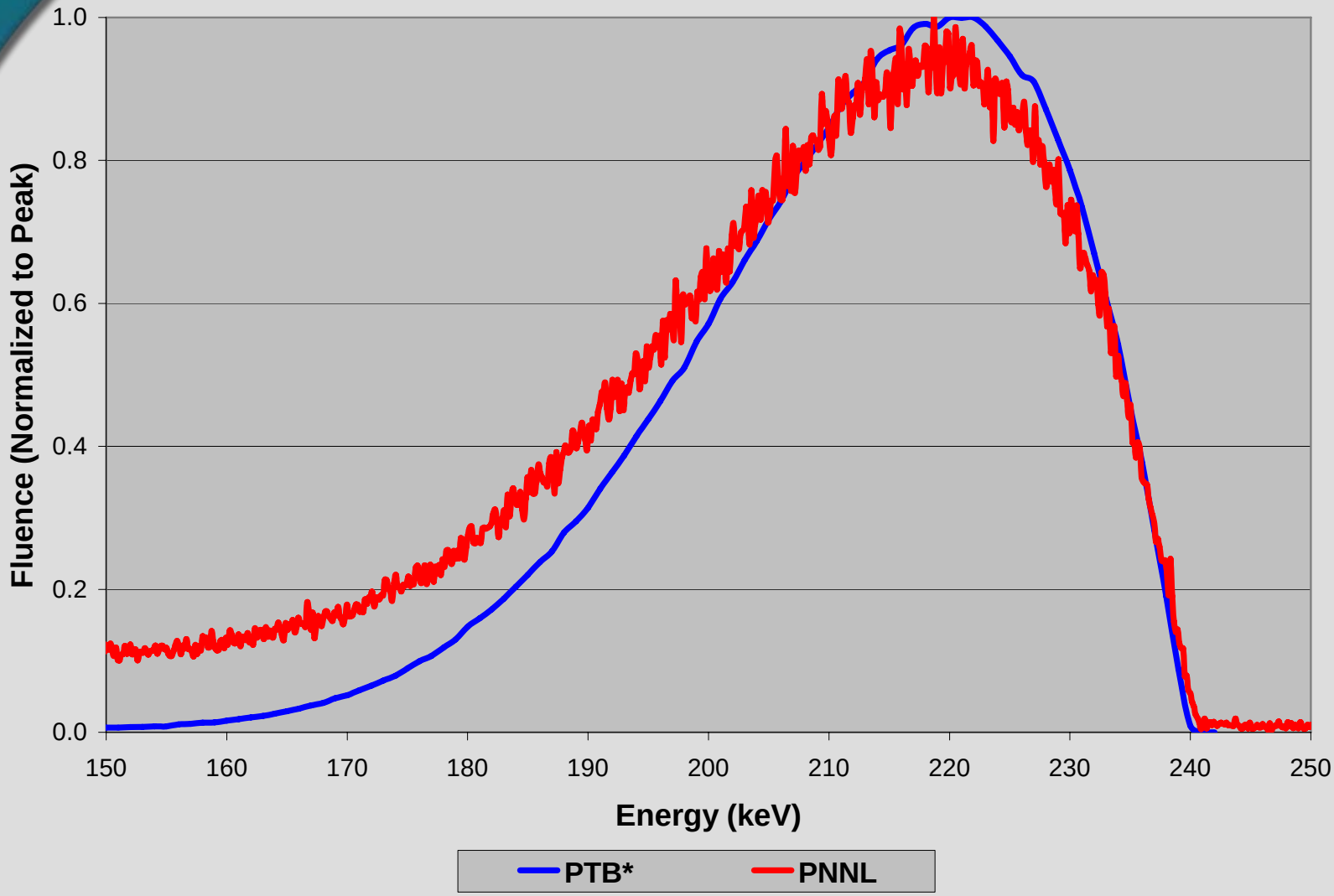


- Reassessment w/shadow shield – better than 5%/10%

Spectrum Evaluation

- Low Efficiency HPGe
- Requires low beam current (~0.1 mA)
- For most – requires “pin-hole” collimator
  - Adds scatter and fluorescence
- Artifacts possibly induced by detector
  - Ge, In and normal scatter influences
- Calibration
  - Energy - Yes
  - Efficiency - No

LK-240 Bremsstrahlung Spectrum



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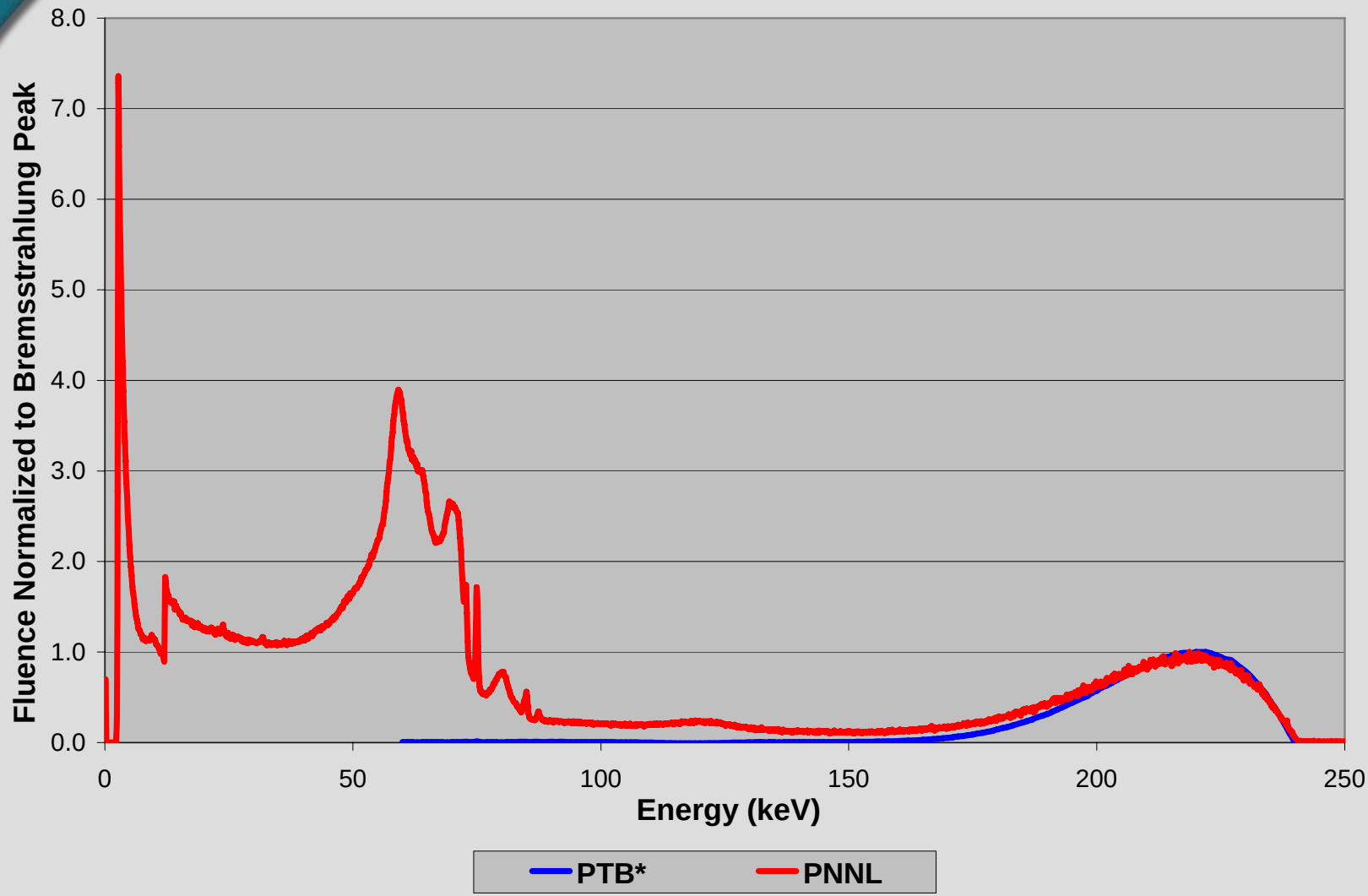
LK-240 Total Spectrum



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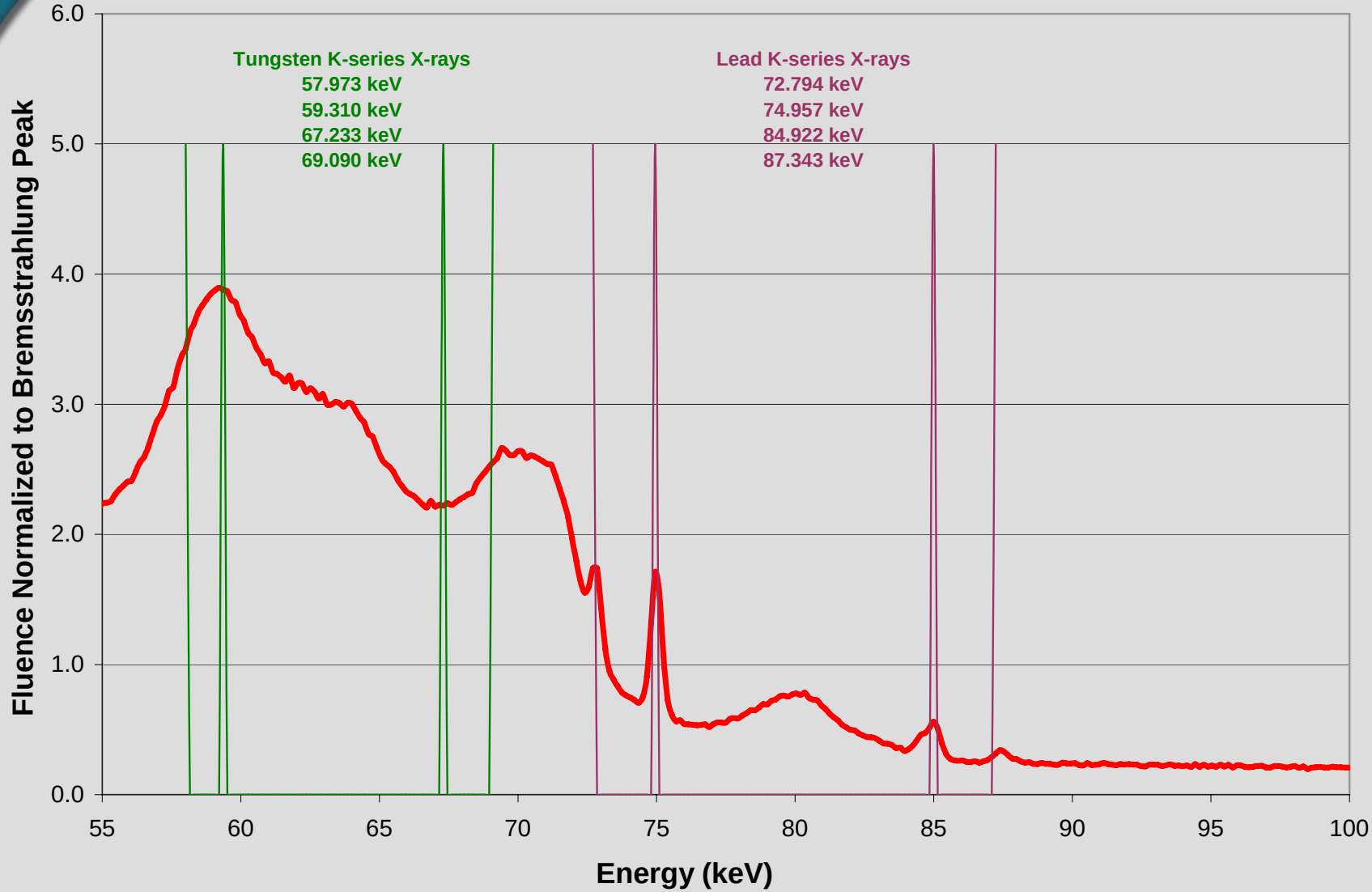
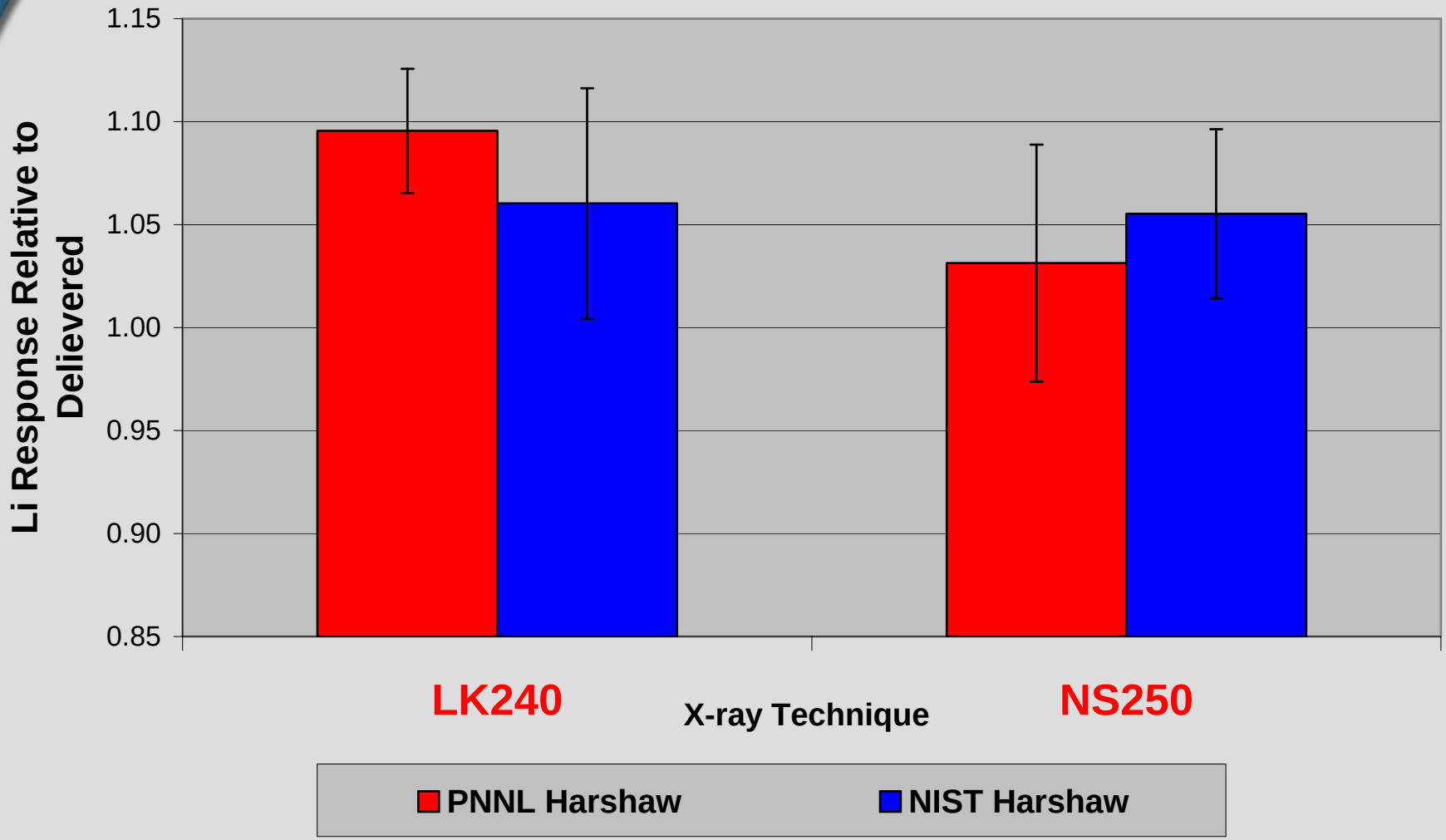
PNNL LK-240 - Low Energy Region



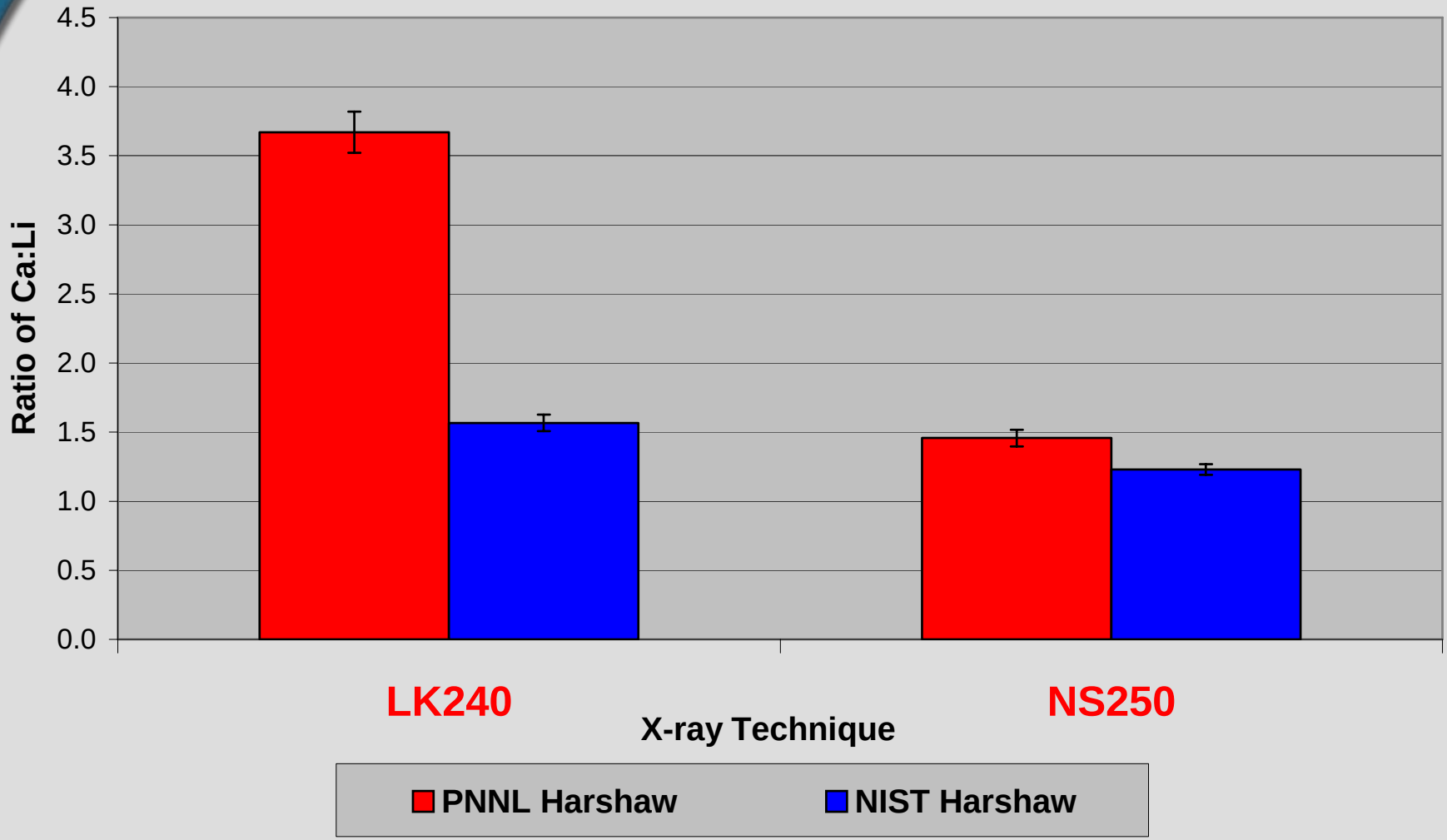
NIST
TLD Intercomparison

- Used modified 8807 dosimeter
  - 2 x CaF_2
  - 2 x LiF
  - All filtered the same (plastic)
- Exposures conducted in air
- Wide beam aperture (NIST)
- Same air-kerma
- Same irradiation date
- Evaluated LK240 and NS250
  - Total signal on LiF
  - CaF_2:LiF ratio

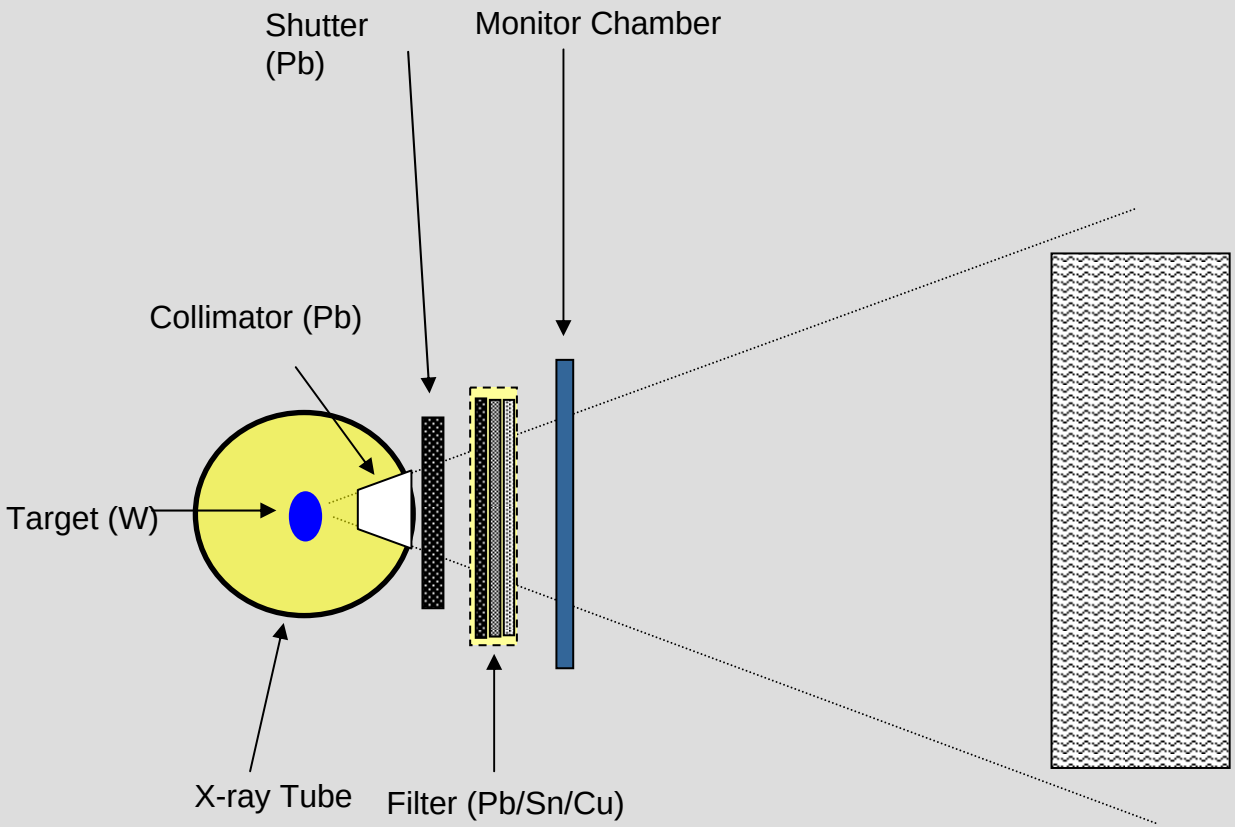
Intercomparison of NIST/PNNL X-rays
Li-based Element Response



Intercomparison of NIST/PNNL X-rays
Ca:Li Phosphor Ratio



X-ray System Components (Top View)



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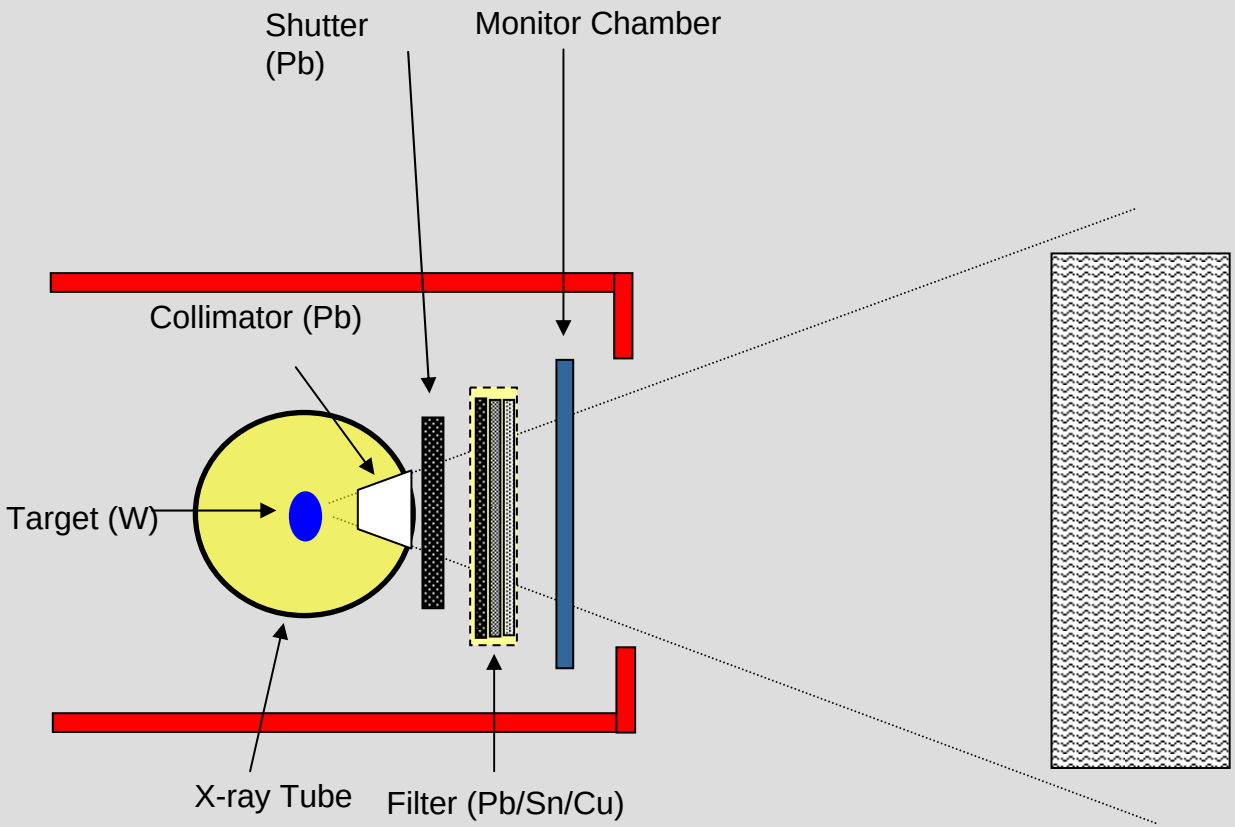
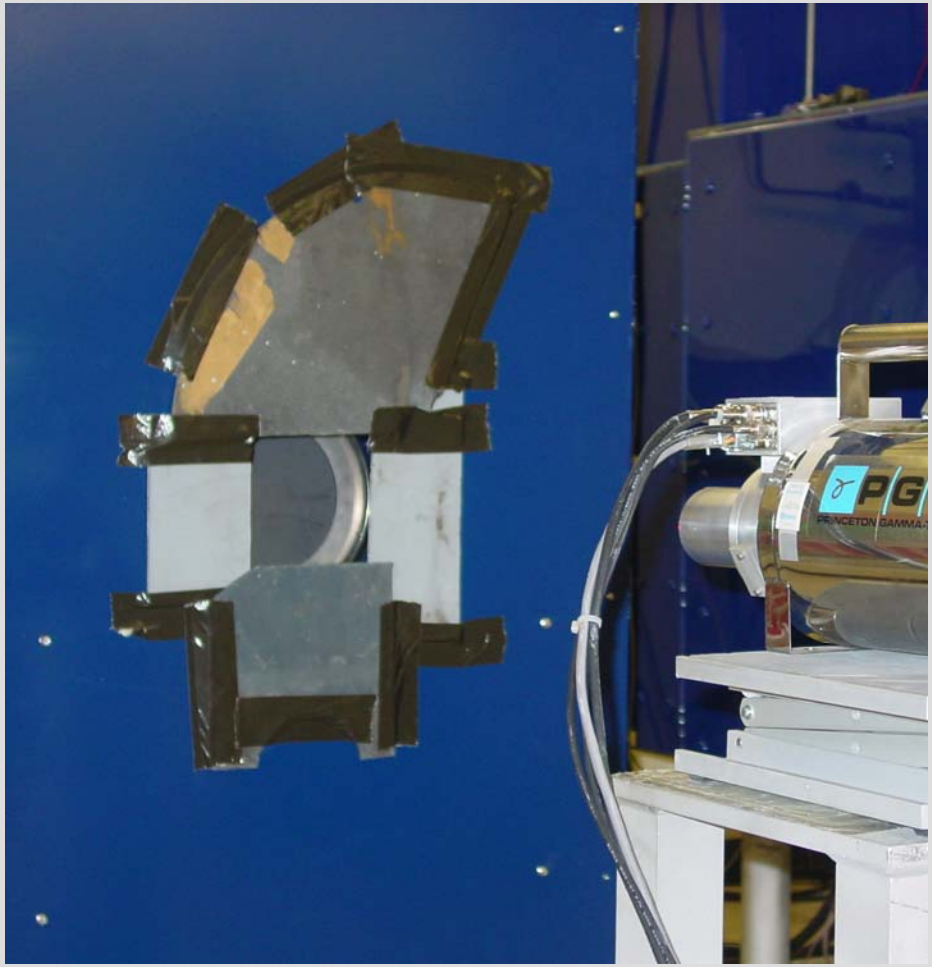


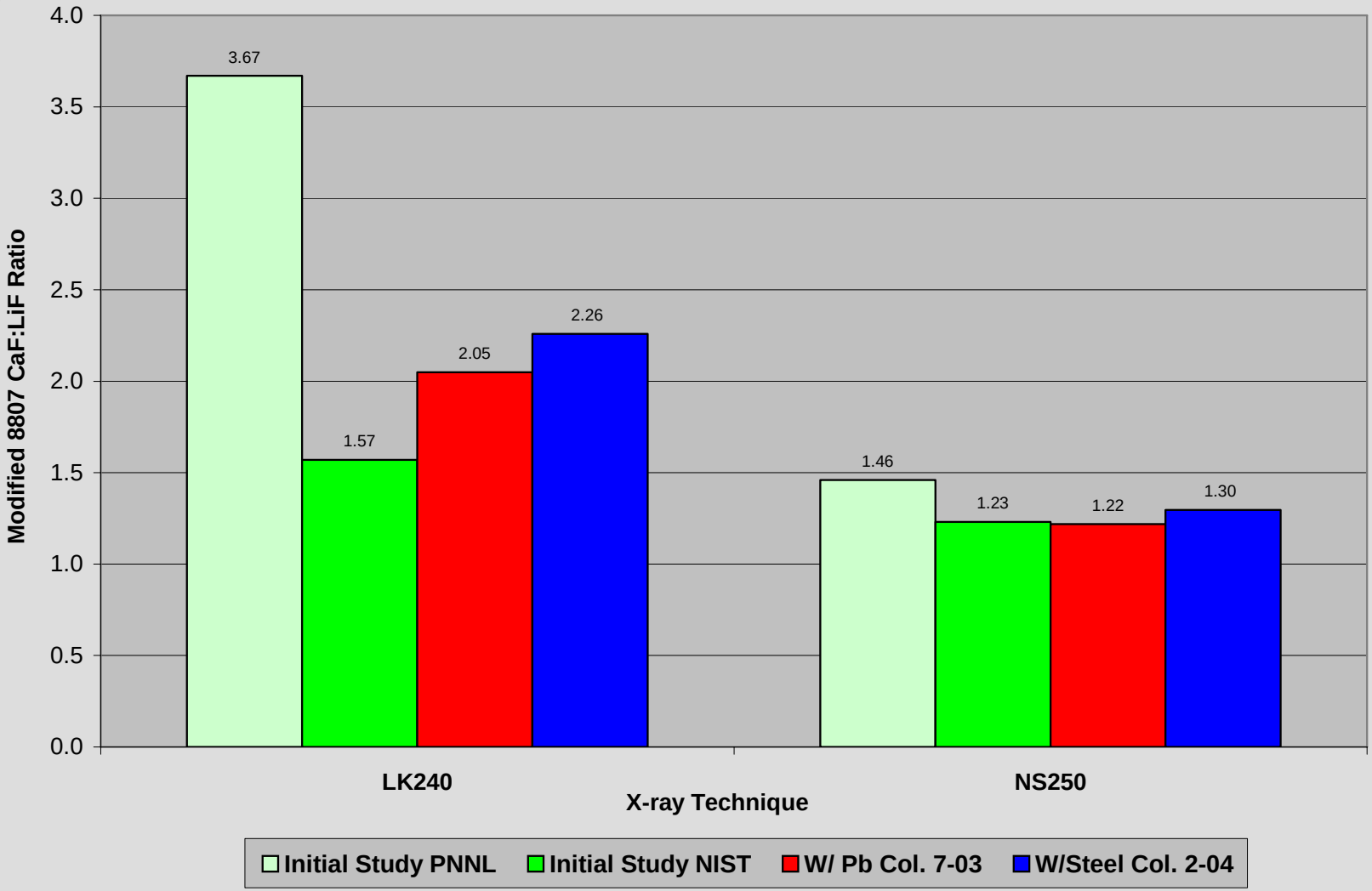
X-ray Shield

- Steel construction
- Large aperture – keep penumbra from reflecting
- Reduce aperture as needed
- Use other materials (W, Pb, SS)



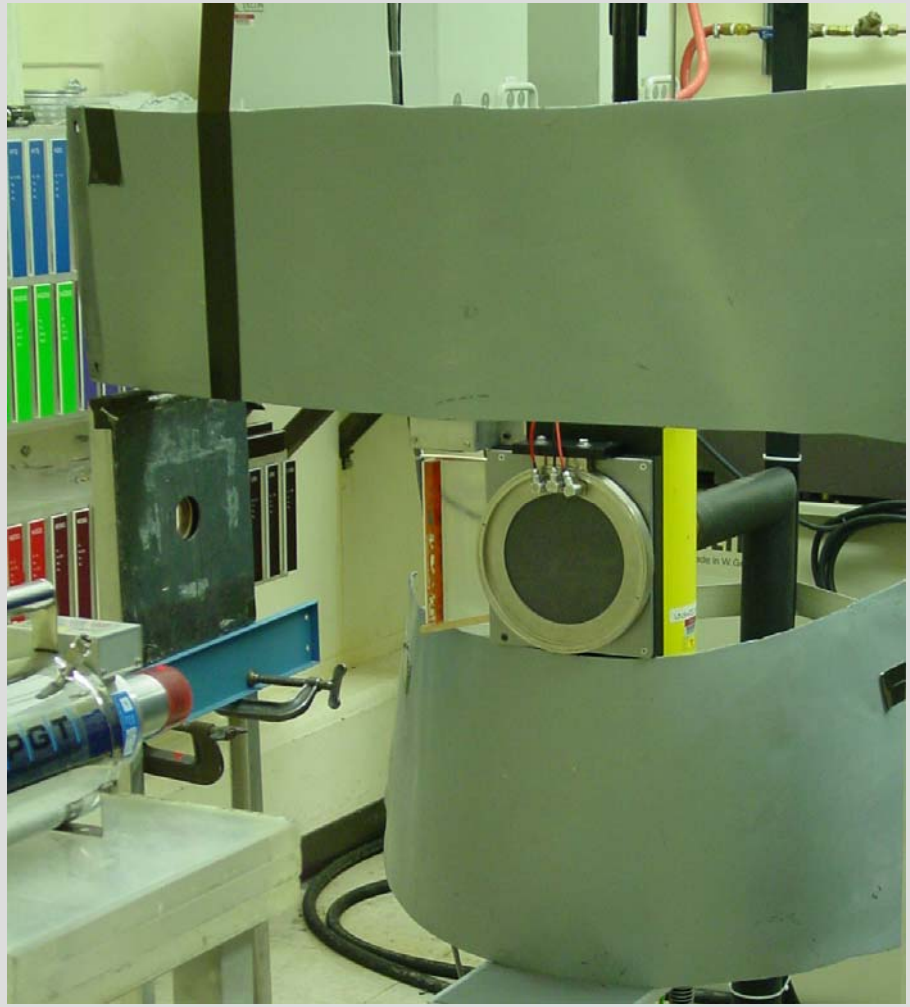
Summary of LK Collimator Studies

NIST, PNNL(7/2003), PNNL(2/2004)



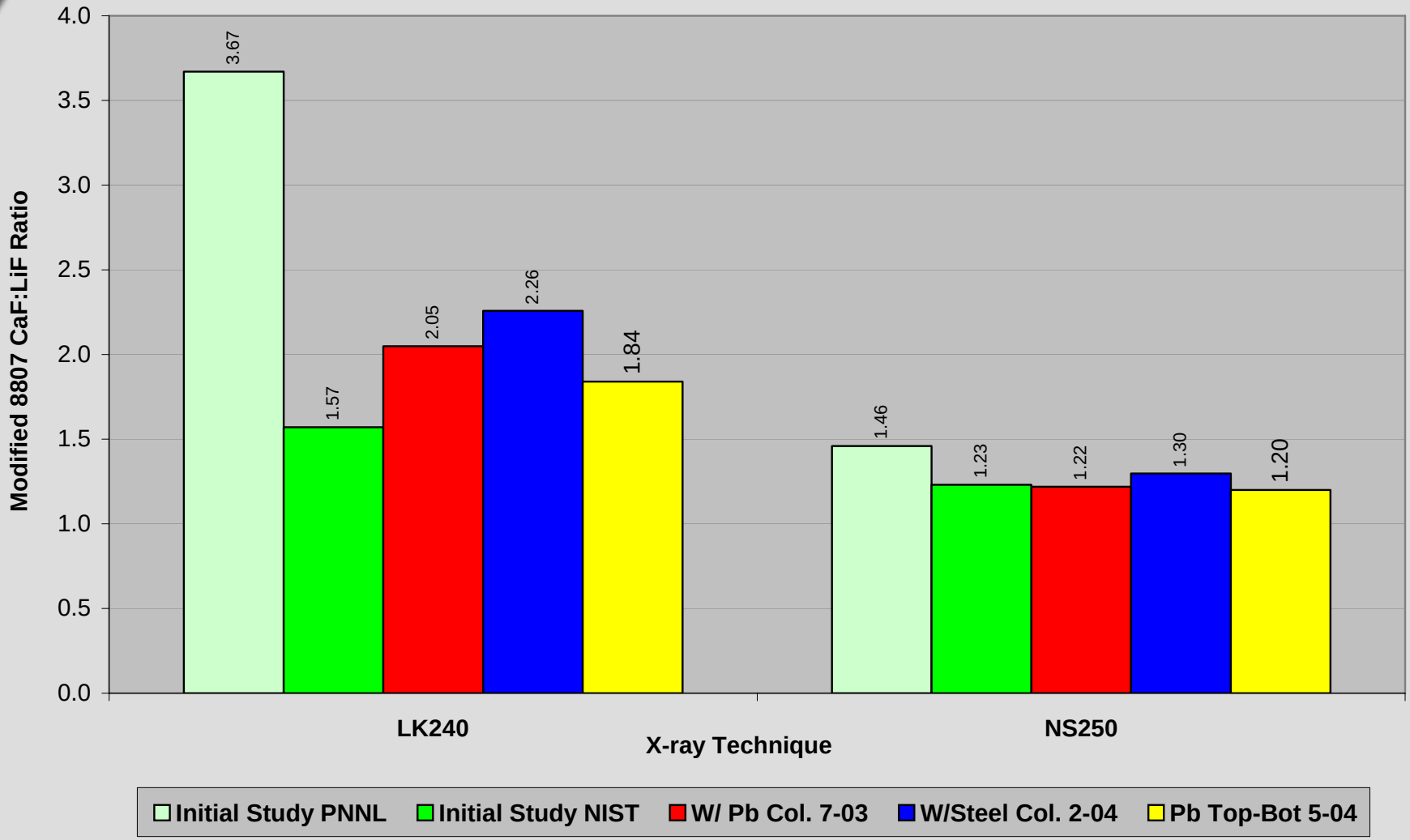
X-ray Shield II
(May 2004)

- Earlier success limited
- Shield creating scatter?
- Limited to Pb sheets



Summary of LK Collimator Studies

NIST, PNNL(7/2003), PNNL(2/2004), PNNL (5/2004)



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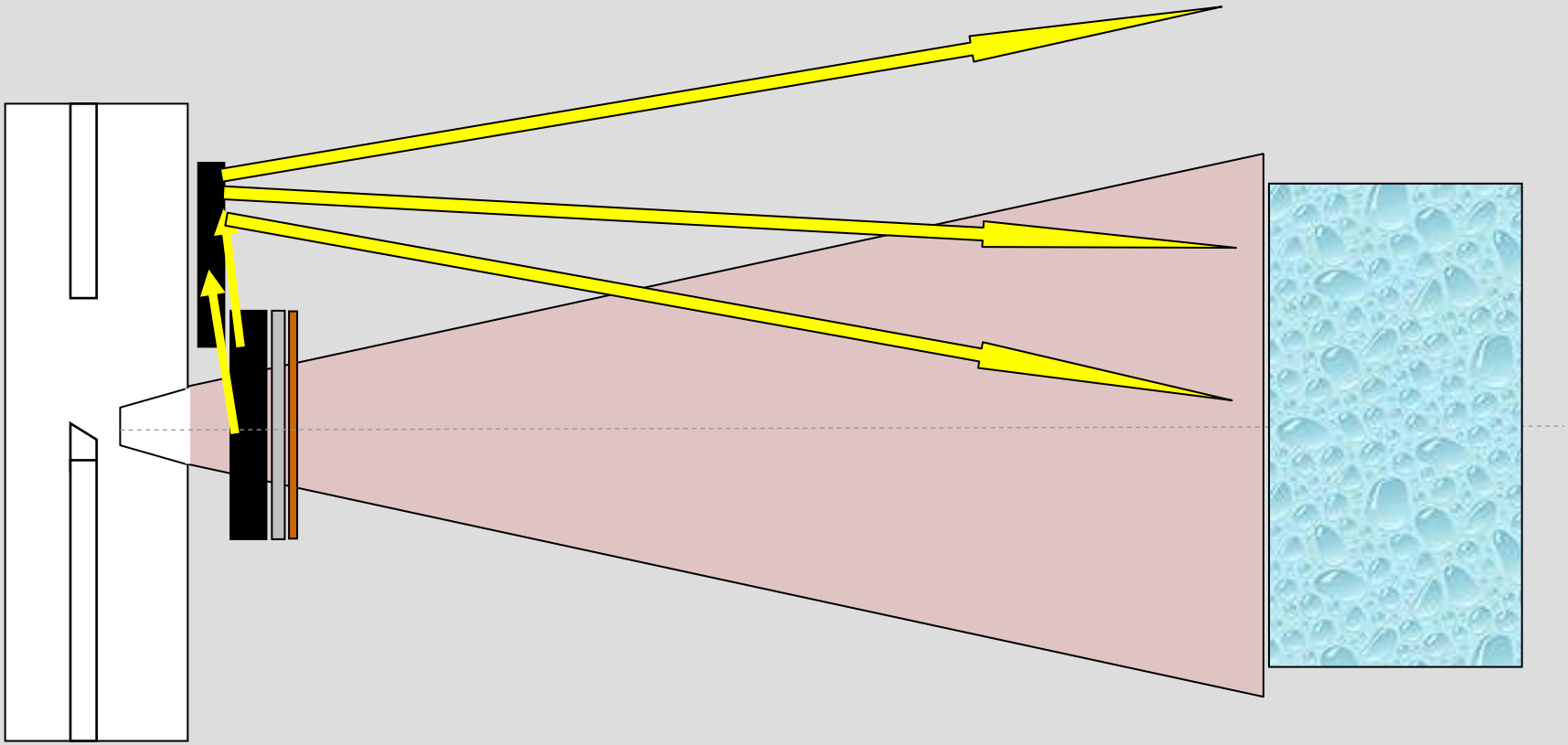

Summary

- Urgency curtailed for LK Techniques
  - Undesirable for passive dosimetry exposures
  - Anticipated removal from N13.11
  - Investigation invasive upon facility
- New applications may benefit
  - Low rate photon detector evaluations

Summary (Cont'd)

- Improve spectrum measurement capability
  - Use better collimators
  - Proficiency in measurement and striping capability
  - Efficiency calibration of spectrometer
- Once origin of "contamination" identified...
  - Isolate (via shielding)
  - If necessary recalibrate and recharacterize affected techniques
  - If system modifications are necessary – recalibrate entire inventory.

Summary (Cont'd)

- Develop intercomparison system
  - Energy sensitive
  - Adequate sensitivity to resolve subtleties
  - Active detector – immediate feedback
  - Interlaboratory evaluations
  - NIST/NVLAP performance testing
  - National Need?

Contacts

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