Noble Gas Energy Distribution and Implications to RMS Response

Ken Sejkora

Entergy Nuclear Northeast – Pilgrim Station

Presented at the 13th Annual RETS-REMP Workshop

Pittsburgh, PA / 23-25 June 2003

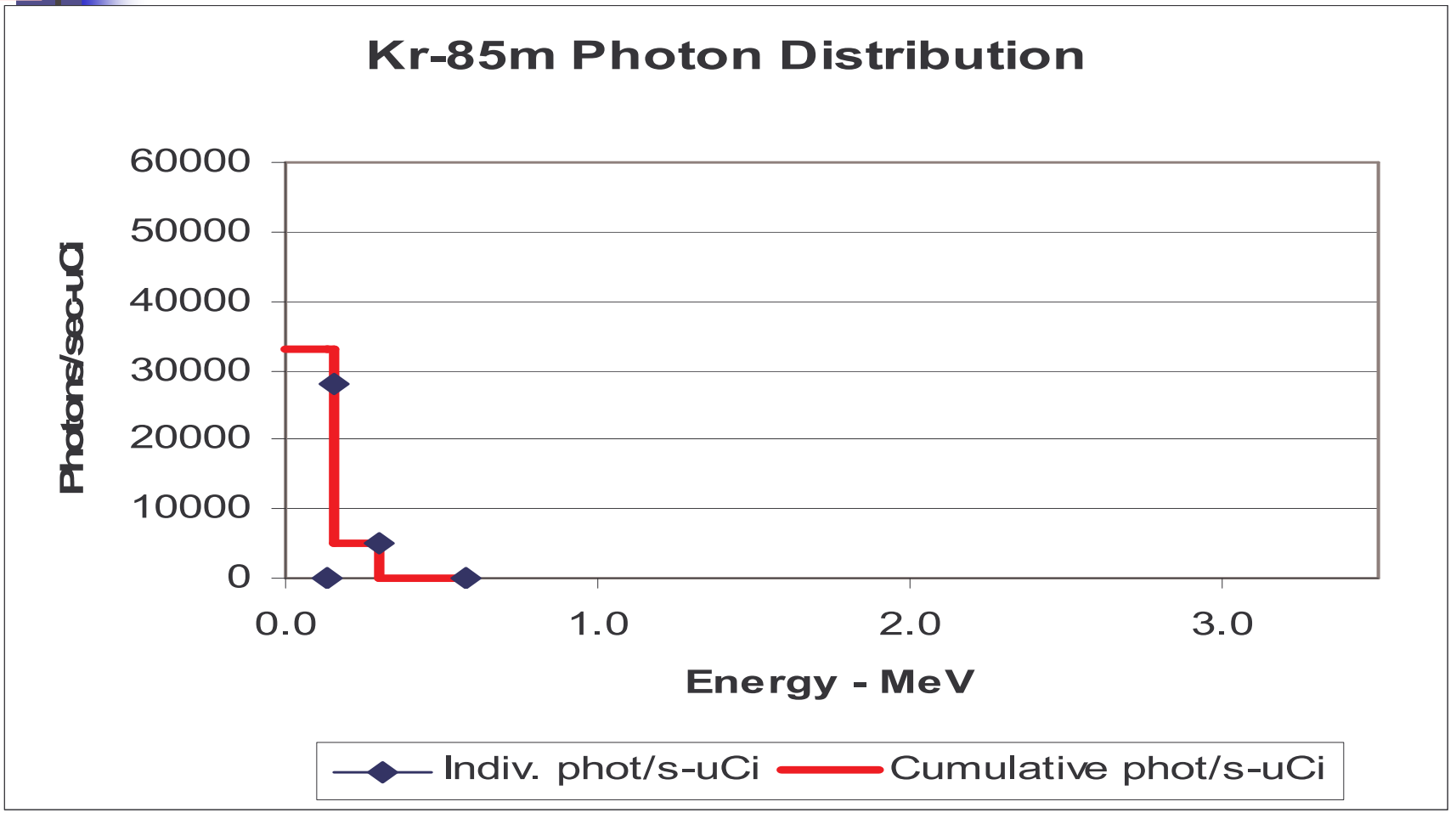
Typical RMS Configuration

- Usually done in a 'gross' detection mode
- Offgas RMS – high concentrations
  - mR/hr levels… ion chamber, GM tube
  - Small chamber volume; <250 mL
- Effluent RMS – low concentrations
  - ODCM LLD requirement of 1E-6 uCi/mL
  - cps levels… scintillation detector
  - Larger chamber volume; 600 mL

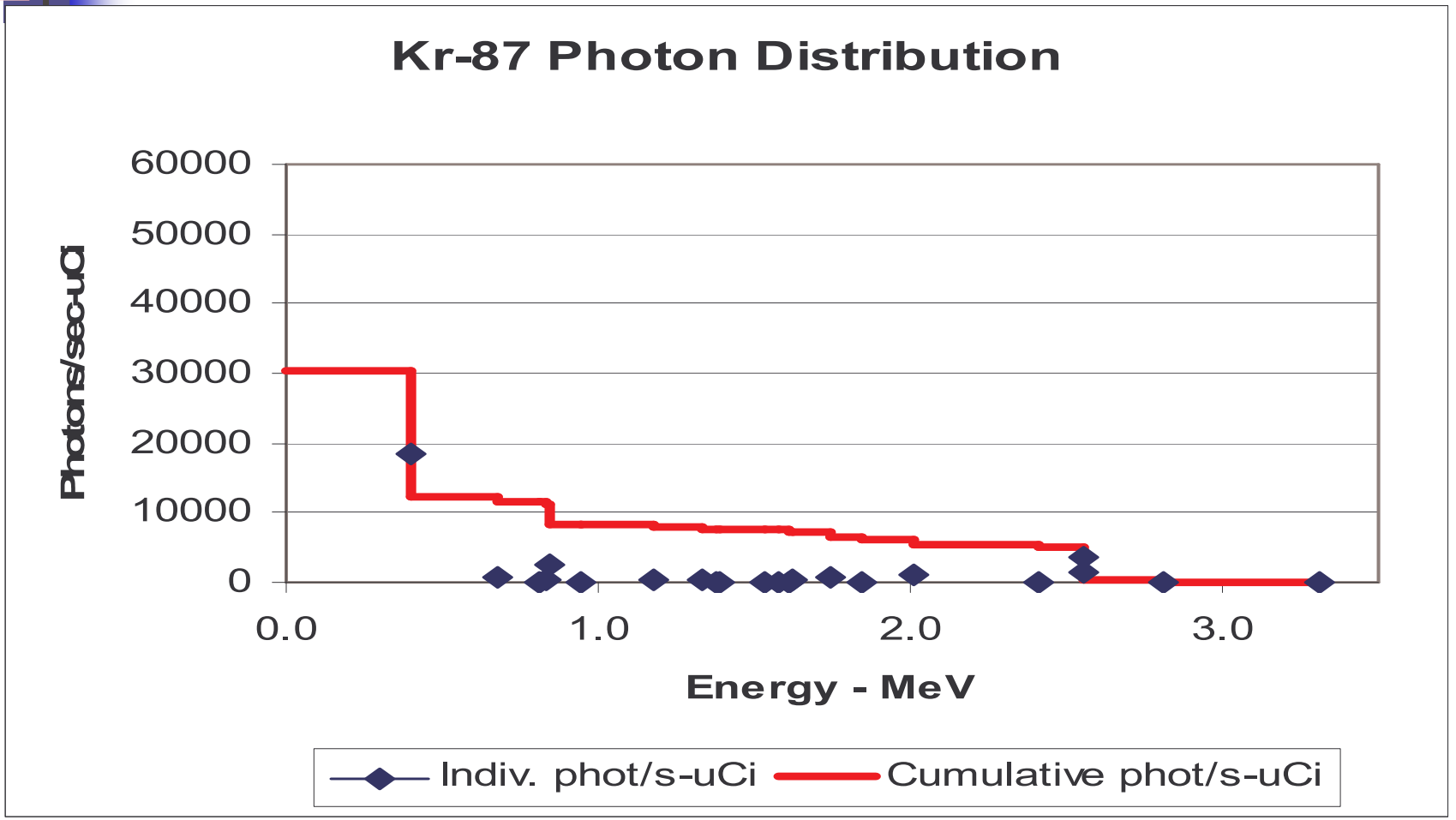
‘Standard’ Noble Gas Mix

- NUREG-0133 for main condenser offgas system
- Assumes 4.7E6 uCi/sec total NG production rate
- Sum-of-six (Kr-85m, Kr-87, Kr-88, Xe-133, Xe-135, Xe-138) comprise 5.7E5 uCi/sec… 12%
- Dominated by short-lived noble gases
- Does not include activation gases:N-13, N-16

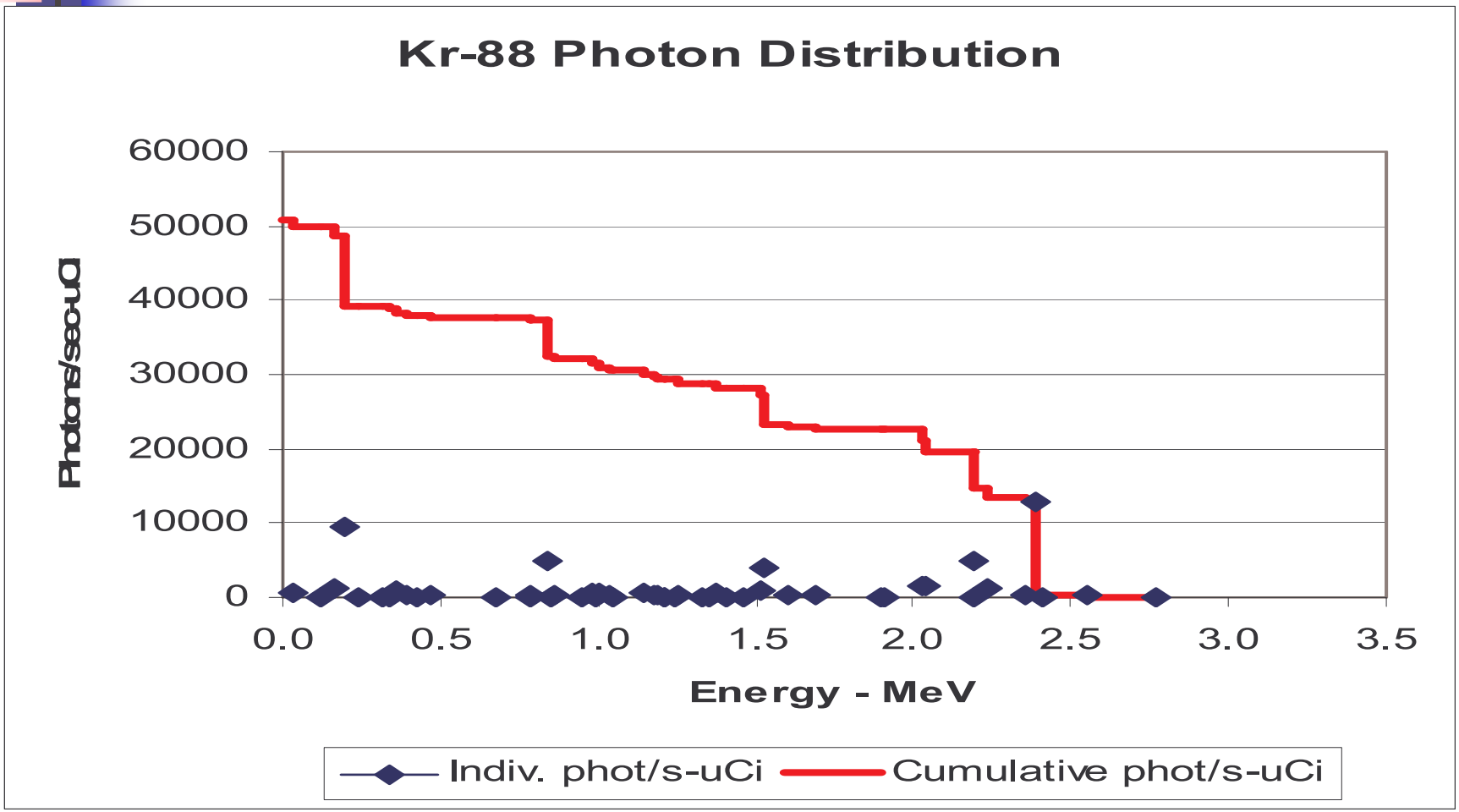
Kr-85m: 1.61E4 s, 0.2% NUREG-0133



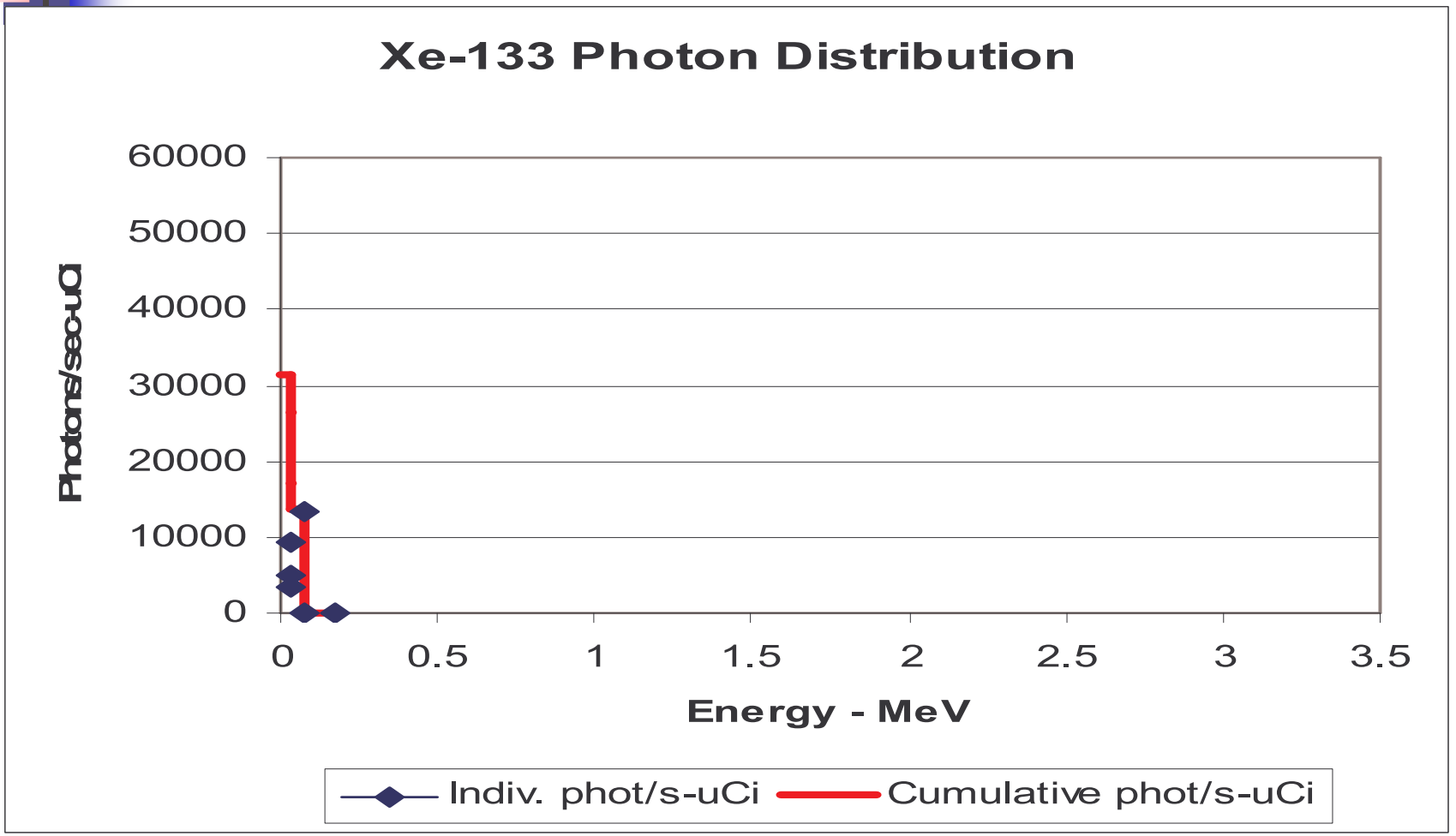
Kr-87: 4.58E3 s, 1.5% NUREG-0133



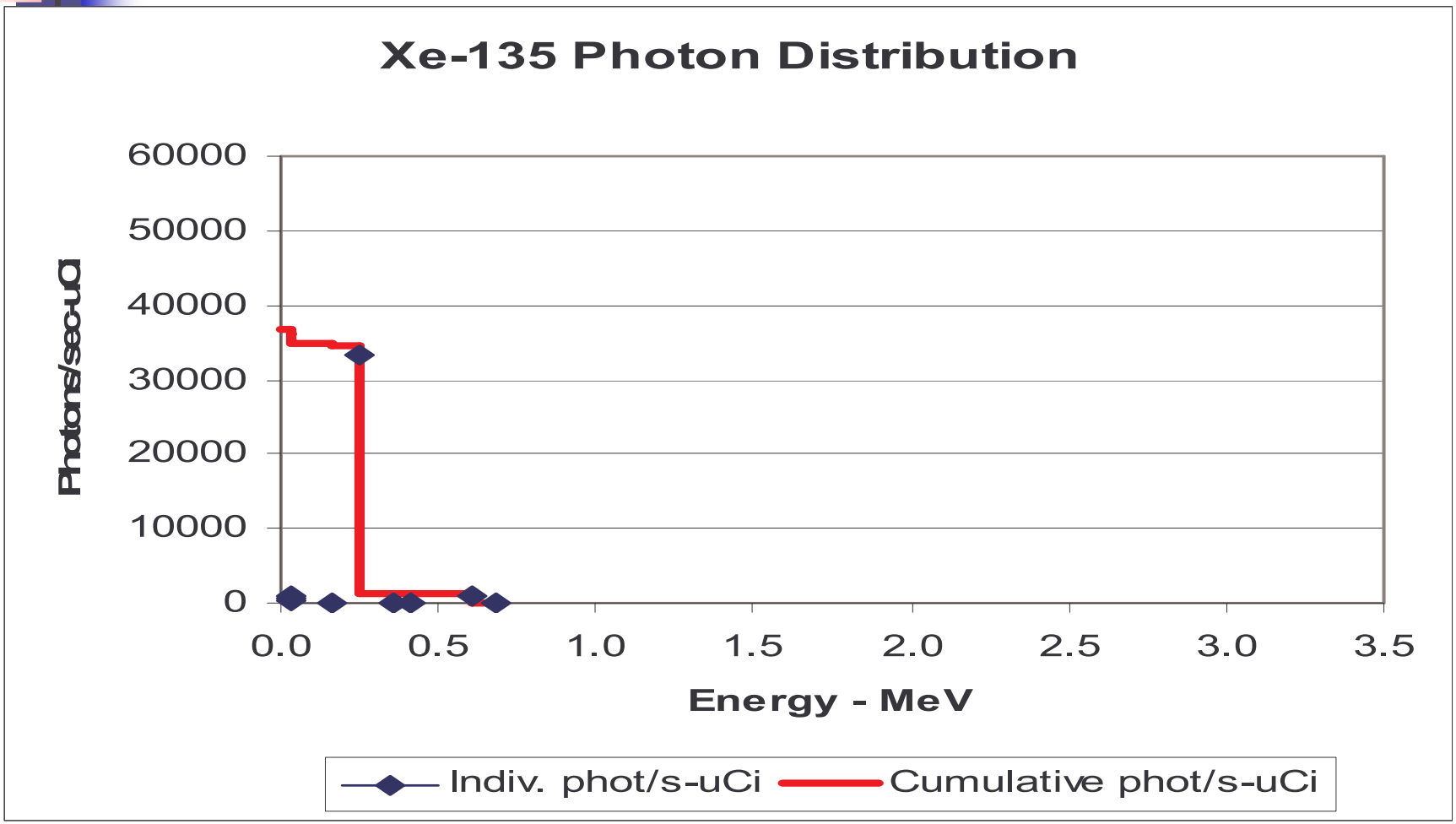
Kr-88: 1.02E4 s, 1.5% NUREG-0133



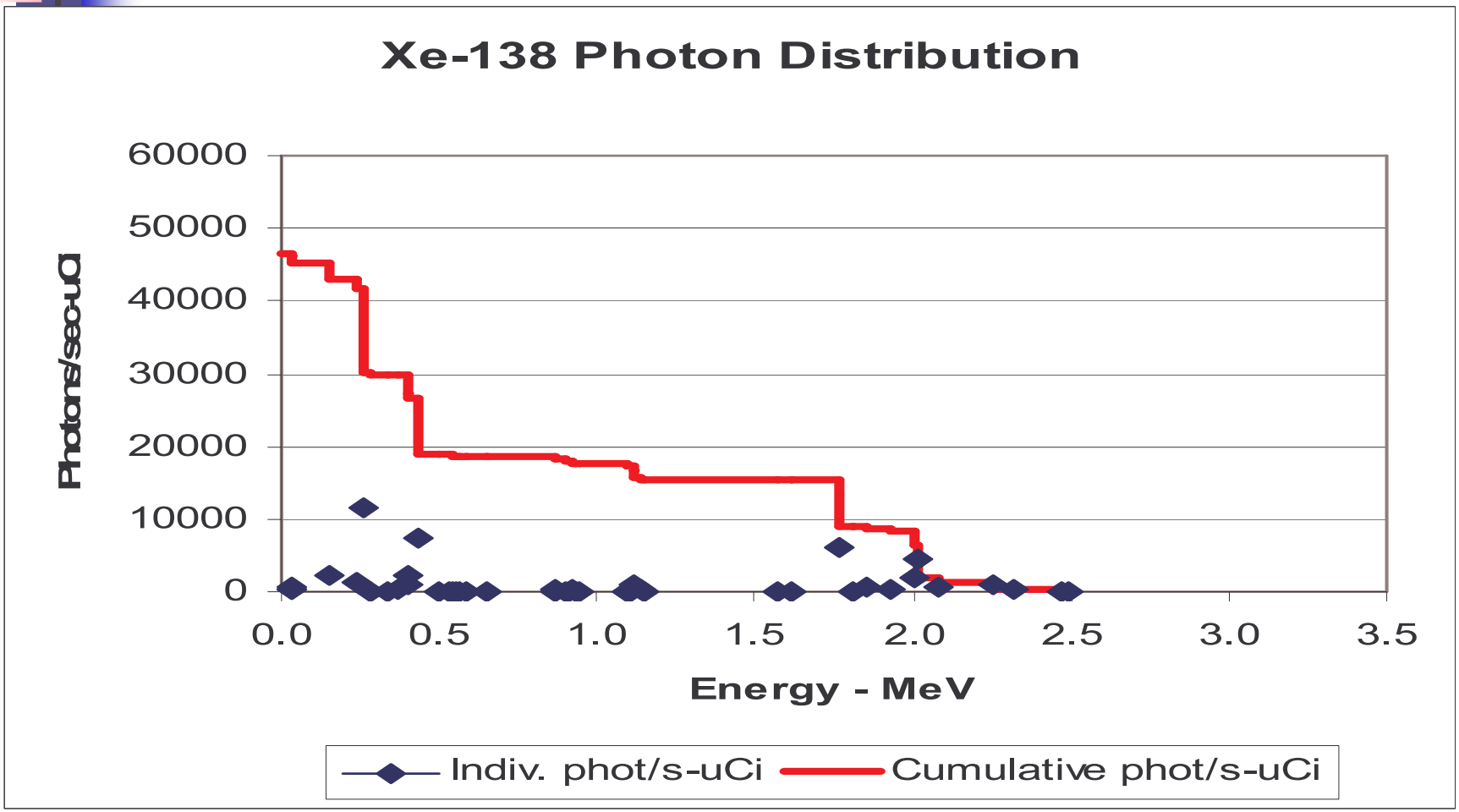
Xe-133: 4.53E5 s, 0.6% NUREG-0133



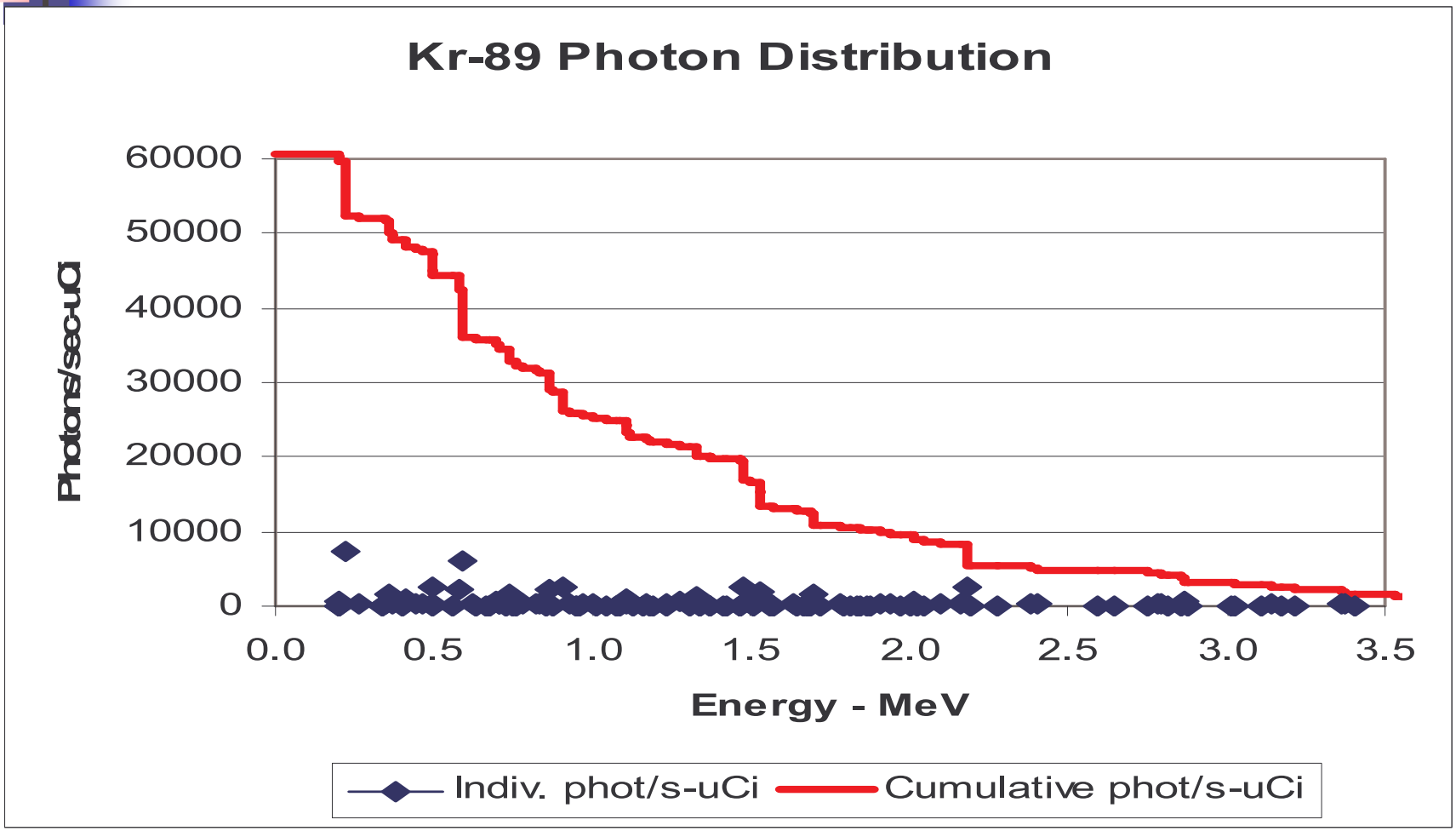
Xe-135: 3.28E4 s, 1.6% NUREG-0133



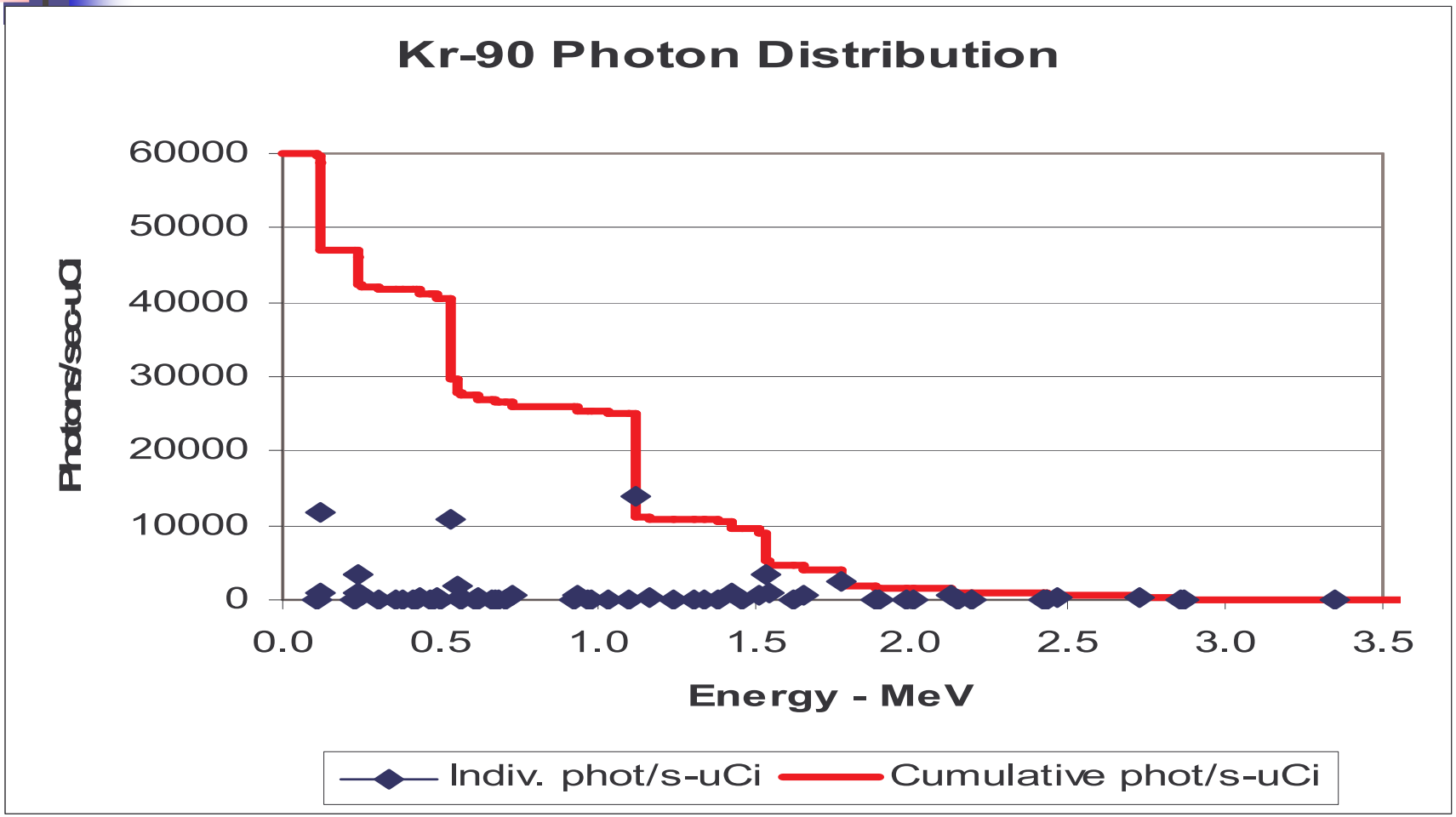
Xe-138: 8.46E2 s, 6.6% NUREG-0133



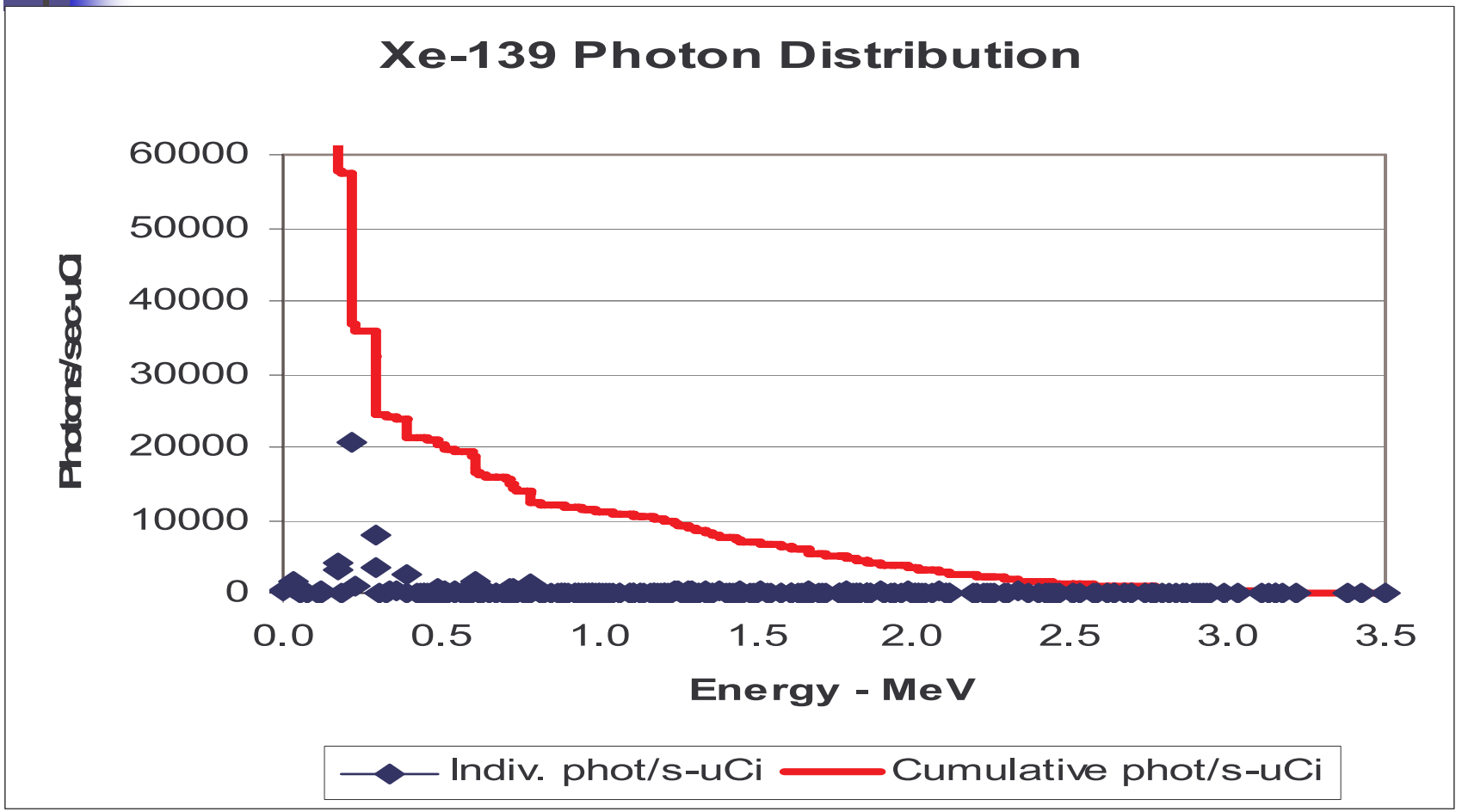
Kr-89: 1.89E2 s, 9.7% NUREG-0133



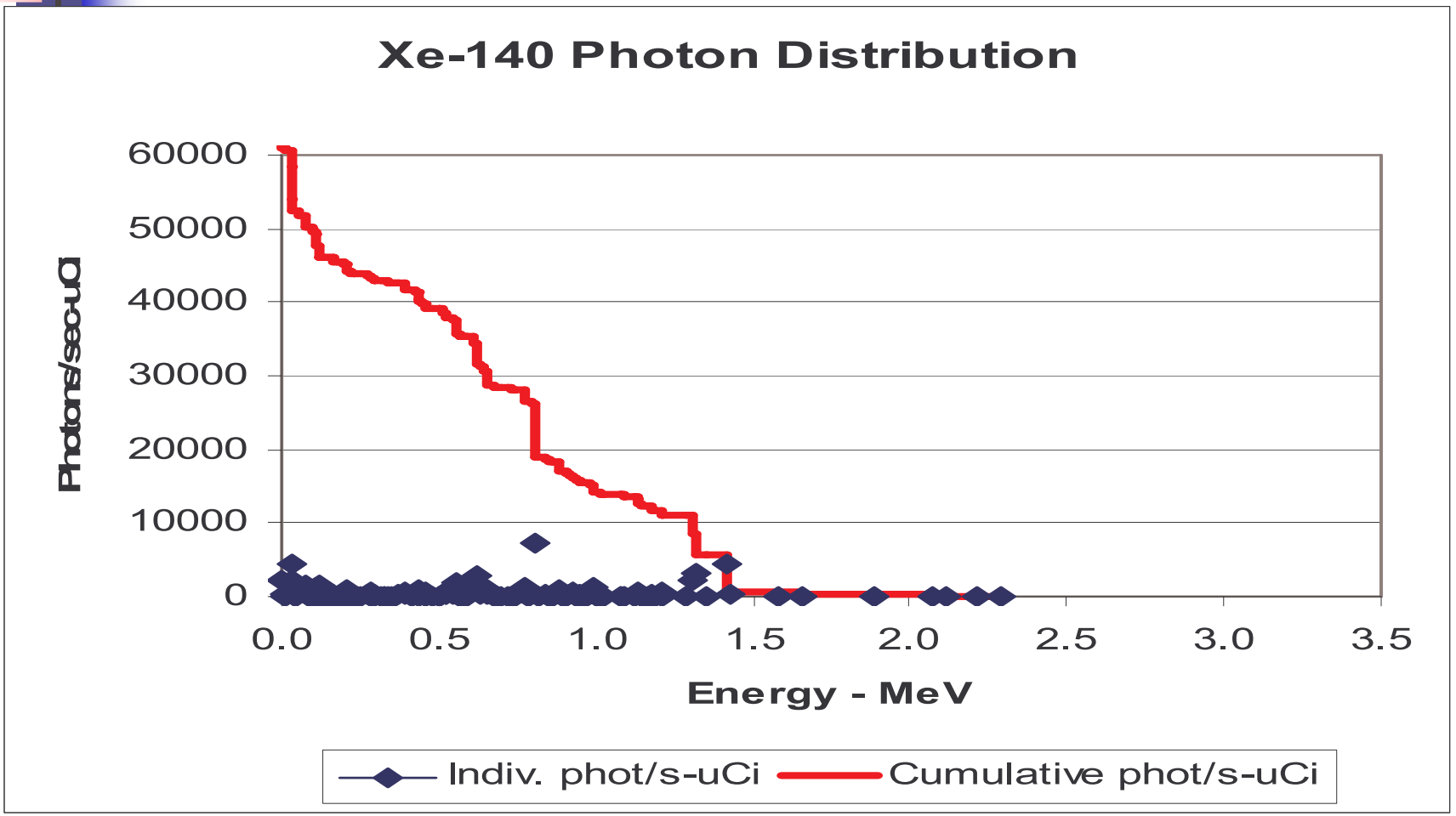
Kr-90: 3.21E1 s, 20.8% NUREG-0133



Xe-139: 3.97E1 s, 20.8% NUREG-0133



Xe-140: 1.36E1 s, 23.3% NUREG-0133



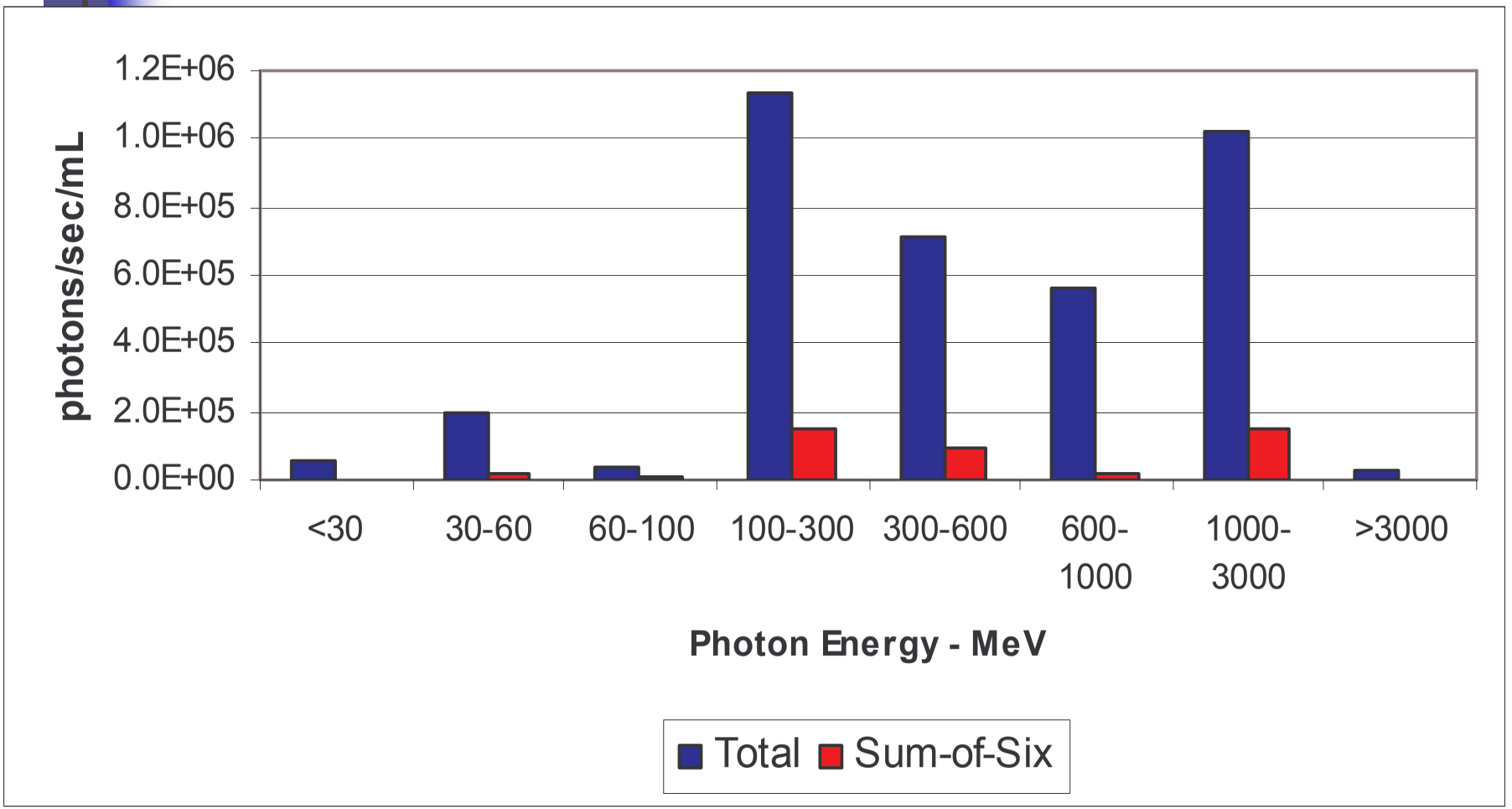
NUREG-0133 Bounding Case

- Total = 4.7E6 uCi/sec
- SOS = 5.7E5 uCi/sec… 12% of total
- Distributed in 150 scfm offgas flow
- Activity at T=0: 67 uCi/mL, 3.7E6 γ/s/mL
- Does not include activation gases or NG daughter products

NUREG-0133 Mix: Zero Decay

67 uCi/mL, 3.7E6 photon/sec/mL

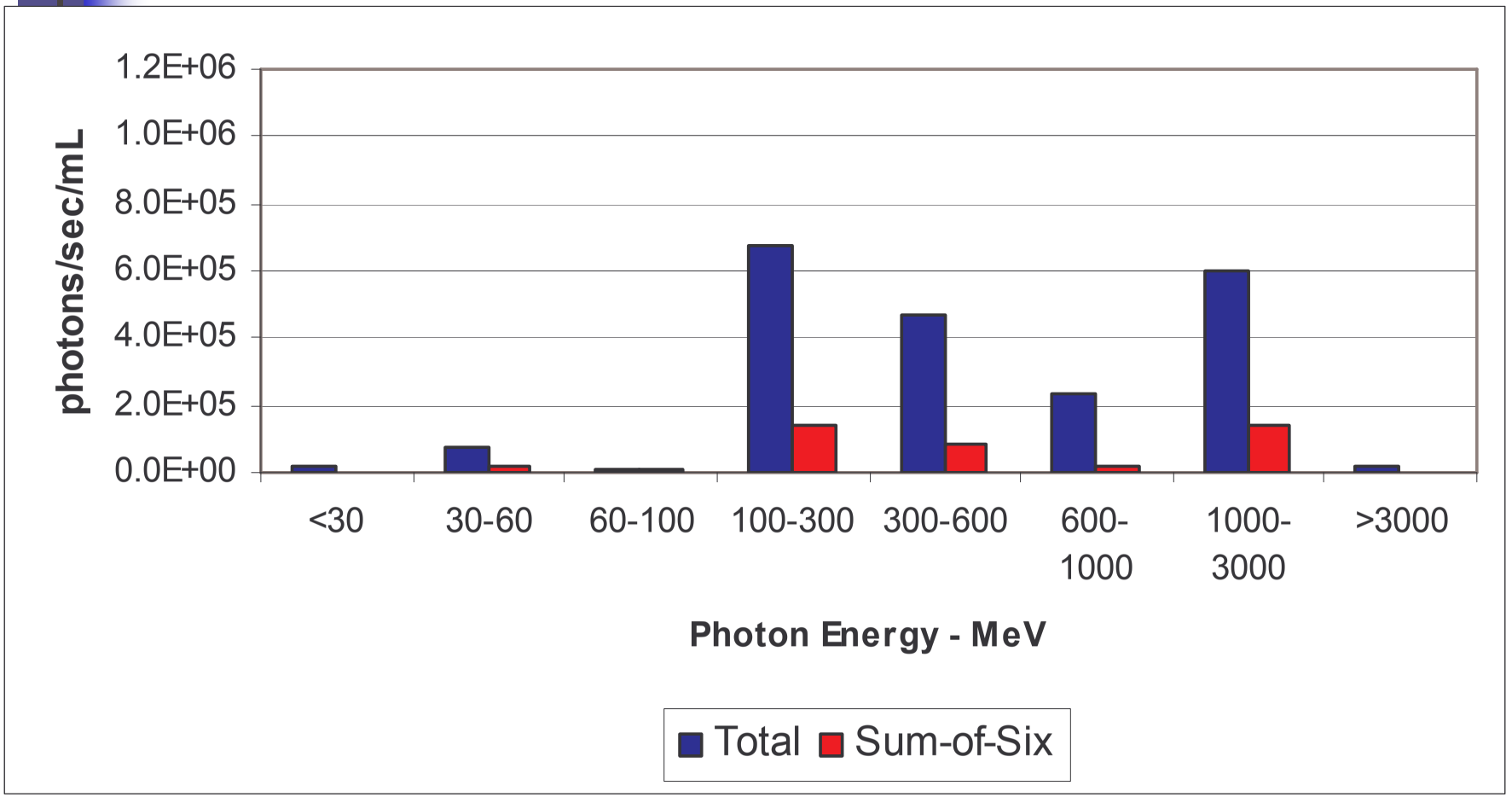
SOS = 12% activity, 12% photons



NUREG-0133 Mix: 30s Decay

41 uCi/mL, 2.1E6 photon/sec/mL

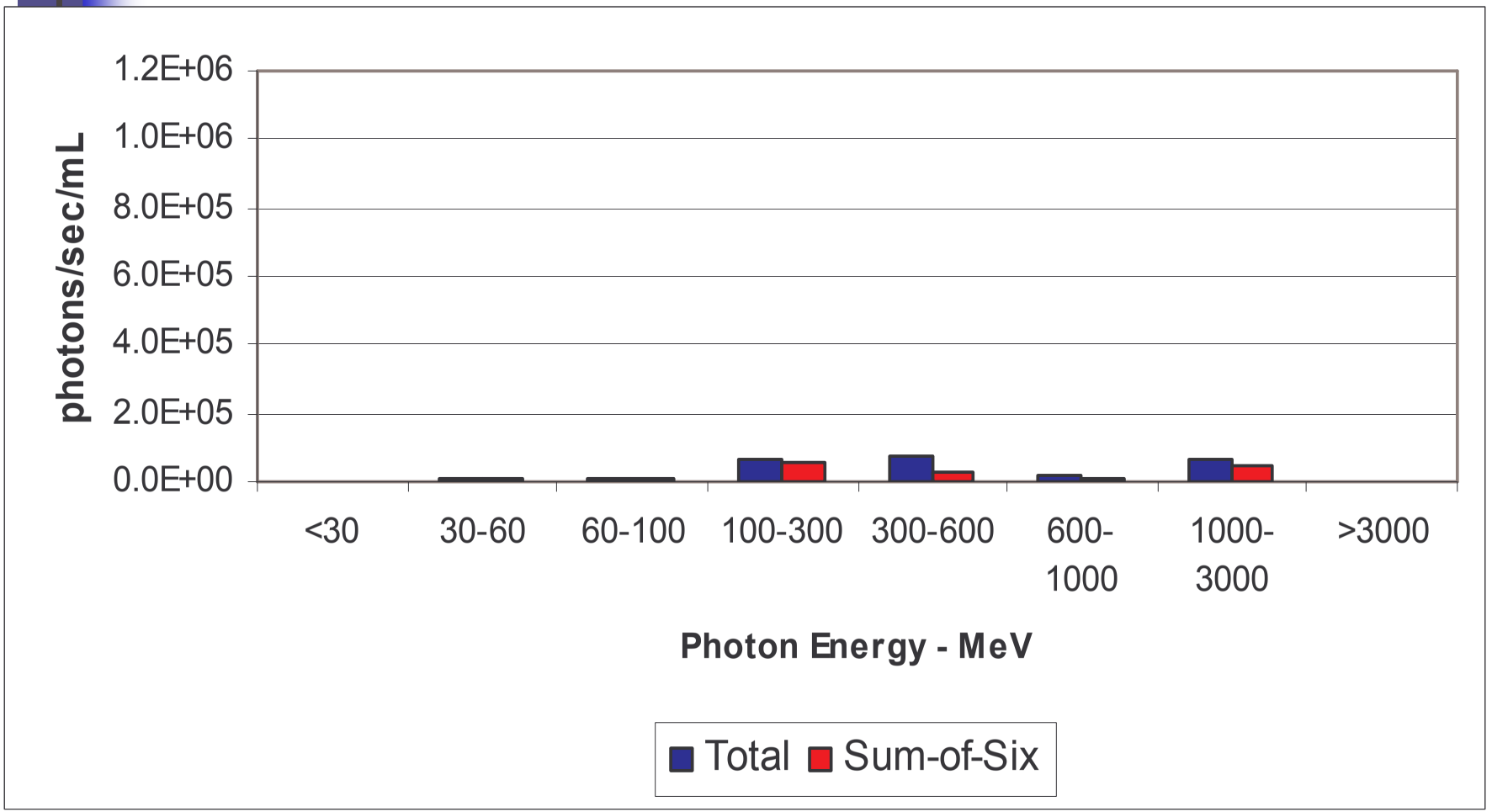
SOS = 19% activity, 19% photons



NUREG-0133 Mix: 10m Decay

9 uCi/mL, 2.5E5 photon/sec/mL

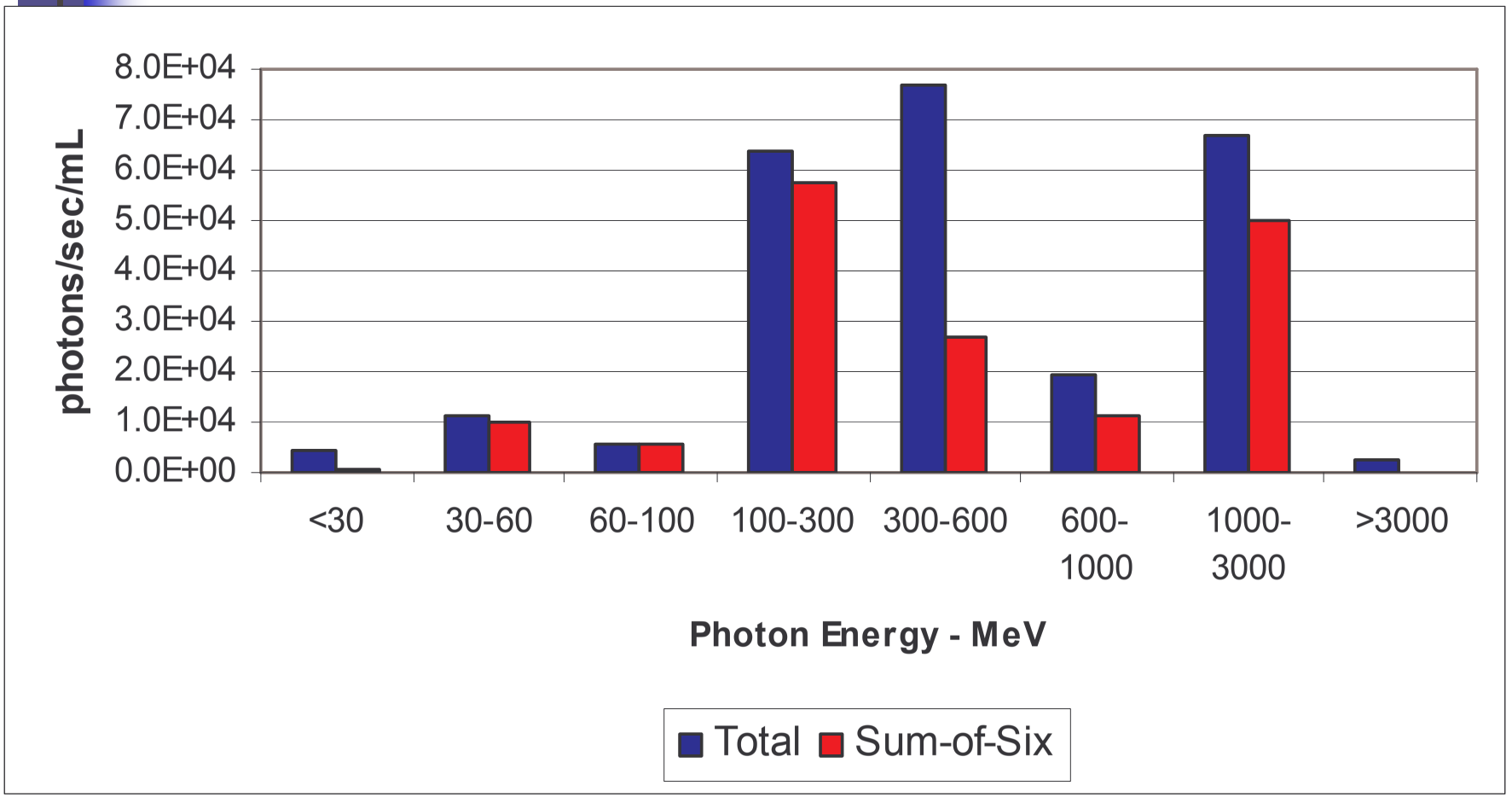
SOS = 67% activity, 65% photons



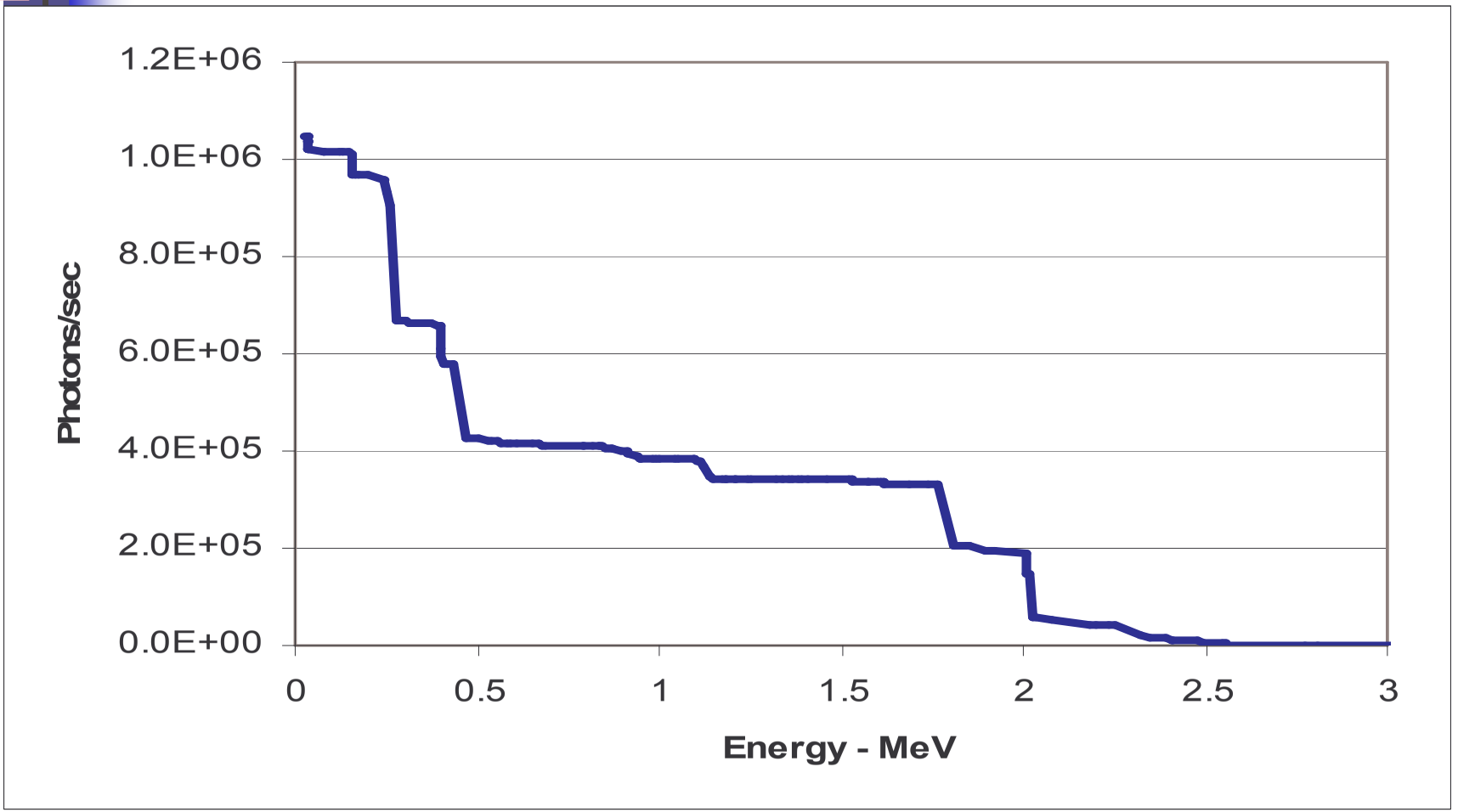
NUREG-0133 Mix: 10m Decay

9 uCi/mL, 2.5E5 photon/sec/mL

SOS = 67% activity, 65% photons



‘Typical’ SOS Offgas Mix
1000 uCi/sec, 275 mL Detector Chamber



Xe-133 Calibration

- Long halflife: 5.25 days… long enough to work with
- Limited photon production
  - Max Energy = 81 keV @ 36% yield
  - Remainder @ ~30-35 keV
  - Conversion: cps/uCi/mL vs. cps/photon/s/mL
- *Question*: Does Xe-133 provide a representative calibration for the energies in your plant's NG mix?

Sensitivity/LLD Response

- ODCM requirement for effluent monitors is 1E-6 uCi/mL
- Typical chamber volume = 500 mL
  - 5E-4 uCi total activity in chamber
  - 18.5 dps in entire chamber
  - Assuming 1 photon/decay = 18 photon/sec
  - Assuming 20% efficiency = 3.7 cps, ***IF*** all photons produced in chamber enter detector
- *Question*: Can your RMS discern 3 cps?

Observed RMS Response

- Derive conversion factor by comparing RMS observed response (cps) to concentration in gamma spec analysis of 4 Liter Marinelli… lab LLD << RMS field sensitivity!
  - 2E-8 uCi/mL lab sensitivity x 500 mL chamber = 0.37 dps in chamber = 0.07 cps @ 20% eff.
  - If you see RMS response > 0.07 cps, you're not looking at noble gas!
- *Question*: Does your observed RMS conversion factor make sense?

Summary

- Typical sum-of-six nuclides may make up small fraction of actual offgas mix
- Short-lived NG make up >80% of 'fresh' offgas activity
- Offgas RMS is 'seeing' an entirely different mix than what you analyze in lab
  - How does your SOS activity relate to your total activity?

Summary (continued)

- Implications of sample line transit times to observed offgas mix
  - Transit time of 1 minute to sample station can reduce activity 2-fold
- Xe-133 calibration
  - Low energy, low yield
  - Conversion: cps/uCi/mL vs. cps/photon/s/mL
  - Suitable calibration standard for mix of NG?

Summary (continued)

- Conversion factor methodology: Offgas
  - Offgas RMS 'sees' a mix of fresh NG… responds to *all* gases, not just the SOS
  - Lab sample may only analyze for SOS
  - Conversion factor matches RMS response against SOS activity… total vs. SOS
  - Don't overlook activation gases… N-13, N-16

Summary (continued)

- Conversion factor methodology: Effluent
  - Effluent RMS may not have sensitivity to see 1E-6 uCi/mL above plant background
  - 'Typical' effluent concentrations would not be expected to yield any counts… if you're seeing a response, what are you looking at?
  - Mismatch between lab sensitivity and RMS field sensitivity
  - Do your conversion factors pass the 'common sense' test?