CLASSE

CLASSE 924/925

Portable Radiation Survey Meter Training (Classroom/Online)

Why?

- Verify integrity of new or altered shielding
- Verify work/public areas comply w/ALARA levels
  - *Below 0.05 mrem/h outside exclusion areas averaged over 1yr*
  - *Below 2 mrem/h averaged over 1 hour*
- Check activated materials (see CLASSE 121 for policy)
  - *It takes a lot of electron radiation >6 MeV to activate!*
  - *High Z materials more susceptible (e.g. some welds)*
  - *Typically in Linac (e^+ converter & elsewhere), injection lines, collimators*
  - *Below 0.05 mrem/h on contact is "not activated"*
  - *"Weakly activated"*
    - 0.05-50 mrem/h on contact, AND
    - < 0.05 mrem/h at 60 cm
  - *"Highly activated" is*
    - >50 mrem/h on contact, OR
    - >0.05 mrem/h at 60 cm
- Check radioactive sources (rare)

Technology

- Usually looking for gammas (photons, γ's)
  - *Some radioactive sources emit betas (electrons)*
  - *On rare occasions one looks for neutrons*
- Geiger-Mueller tube (beta, gamma)
  - *Anode at high voltage surrounded by gas*
  - *Photon knocks off an atomic orbital electron (photo-electric effect) in the tube wall or gas*
  - *Gas is ionized, avalanche electrons collected at anode*
  - *Current is roughly proportional to **rate** of radiation*
  - *Some probes/meters are "energy compensated" meaning dose rate accounts for energy spectrum*
- Neutron detection requires a different probe

Gamma energy loss

Photo-electric effect dominates!

G-M tube operational range

Log scale

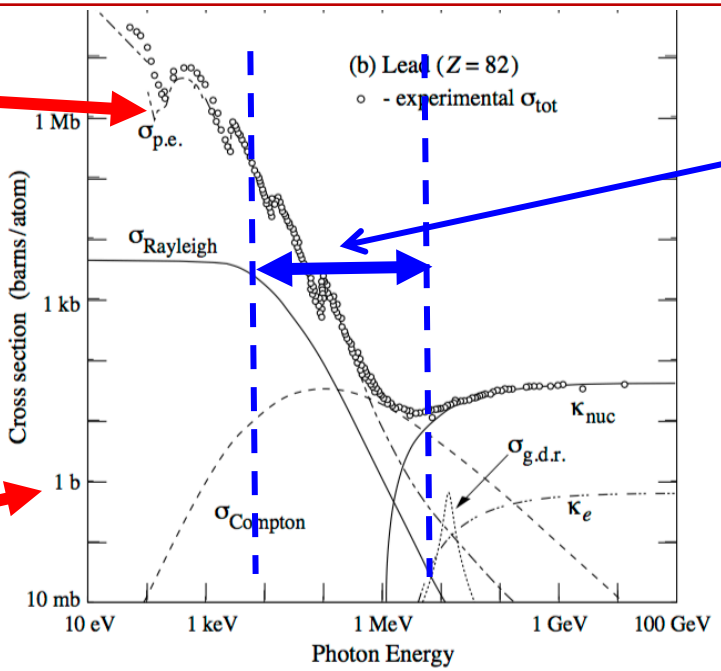
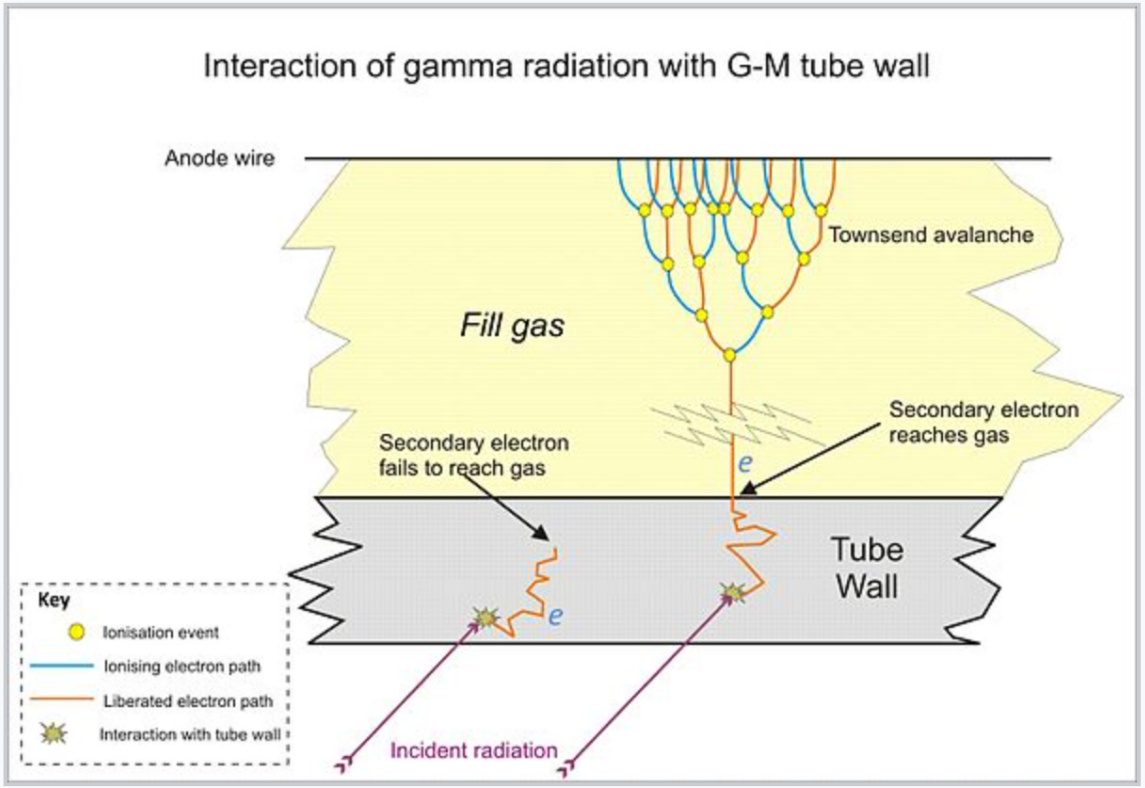


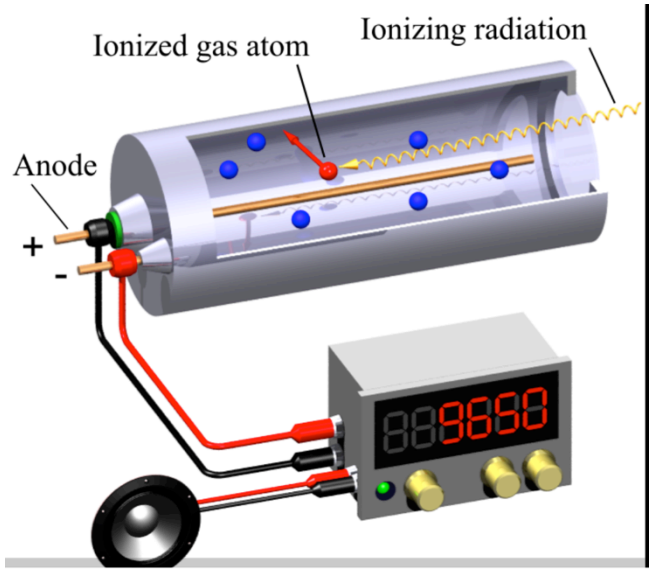
Figure 33.15: Photon total cross sections as a function of energy in carbon and lead, showing the contributions of different processes [51]:

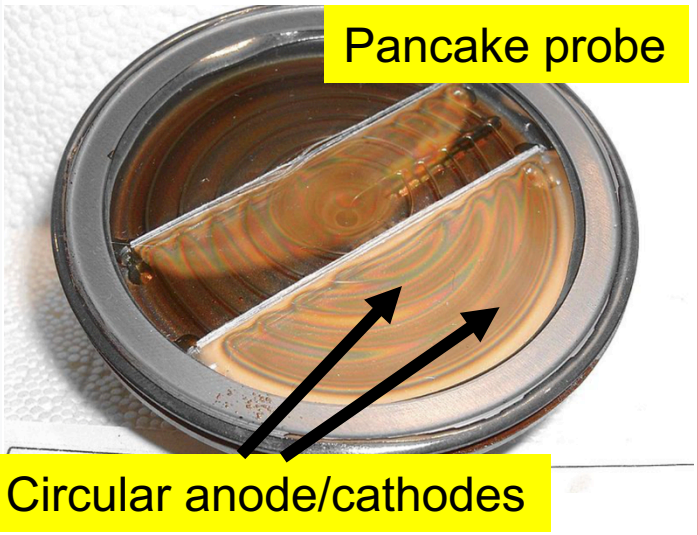
$\sigma_{\text{p.e.}}$ = Atomic photoelectric effect (electron ejection, photon absorption)
σ_{Rayleigh} = Rayleigh (coherent) scattering–atom neither ionized nor excited
σ_{Compton} = Incoherent scattering (Compton scattering off an electron)
κ_{nuc} = Pair production, nuclear field
κ_e = Pair production, electron field
$\sigma_{\text{g.d.r.}}$ = Photonuclear interactions, most notably the Giant Dipole Resonance [52]. In these interactions, the target nucleus is broken up.

Original figures through the courtesy of John H. Hubbell (NIST).

Geiger-Mueller tube







Detection of higher energy gamma in a thick-walled tube. Secondary electrons generated in the wall can reach the fill gas to produce avalanches. Multiple avalanches omitted for clarity

GSM-115


DETECTOR
VOLTS
R/HR
PROBE
X100
X10
X1


PROBE
X100
X10
X1
BATT.
X1
RESET
HIGH
VOLTS
X100
SLOW
FAST
AUDIO
GSM-115

Other meters

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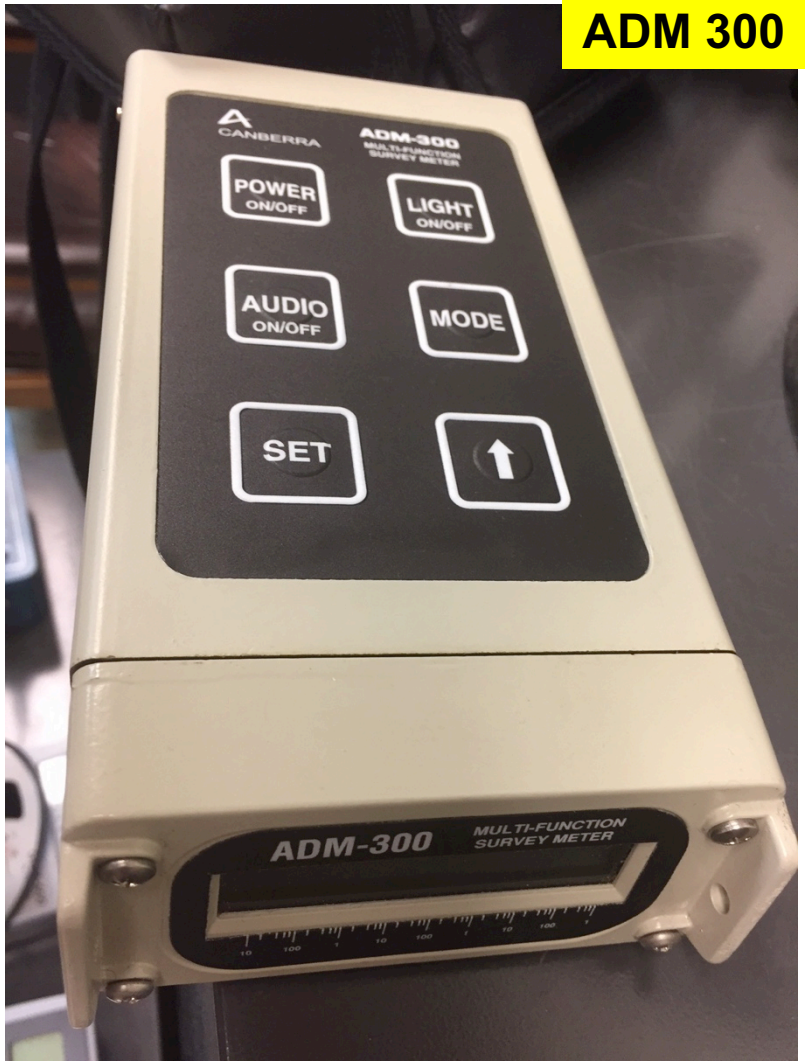
CPM & mR/h reversed!

Microrem

More meters


Ludlum 19
(microrem)
BLACK scales
RED scales
MICRO R/hr
BAT OK


ADM 300
CANBERRA
ADM-300
POWER ON/OFF
LIGHT ON/OFF
AUDIO ON/OFF
MODE
SET
ADM-300
MULTI-FUNCTION SURVEY METER

Probe selection

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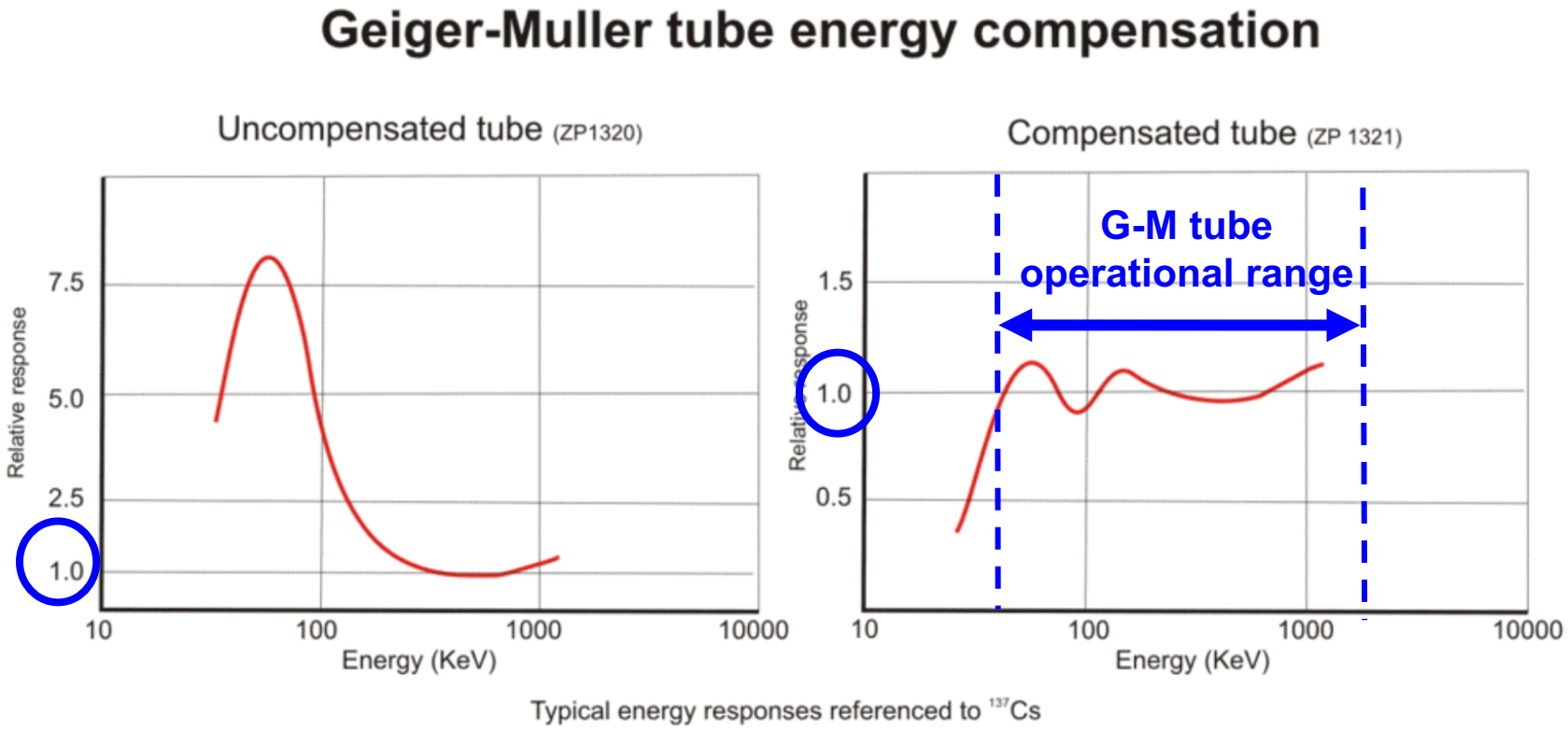
- "Pancake probe" has thin window
  - *Most sensitive probe for low energy betas & gammas*
  - ***Absolute calibration of dose rate is NOT reliable***
  - *Most useful for **locating** low energy radiation sources, NOT measuring absolute ALARA levels*
  - *Beta > 100 keV*
  - *Gamma: 20 keV – 2 MeV*
- Energy Compensated probe
  - *Low energy photons get too much weight relative to their impact on dose in a GM tube*
    - Compensation usually done by filtering out some fraction of them
  - *Best for ALARA measurements*
  - *Gamma 50 keV to 2 MeV*
- Neutron probe
  - *Only for neutrons; response can be slow*

Energy Compensation



Probes for portable meters

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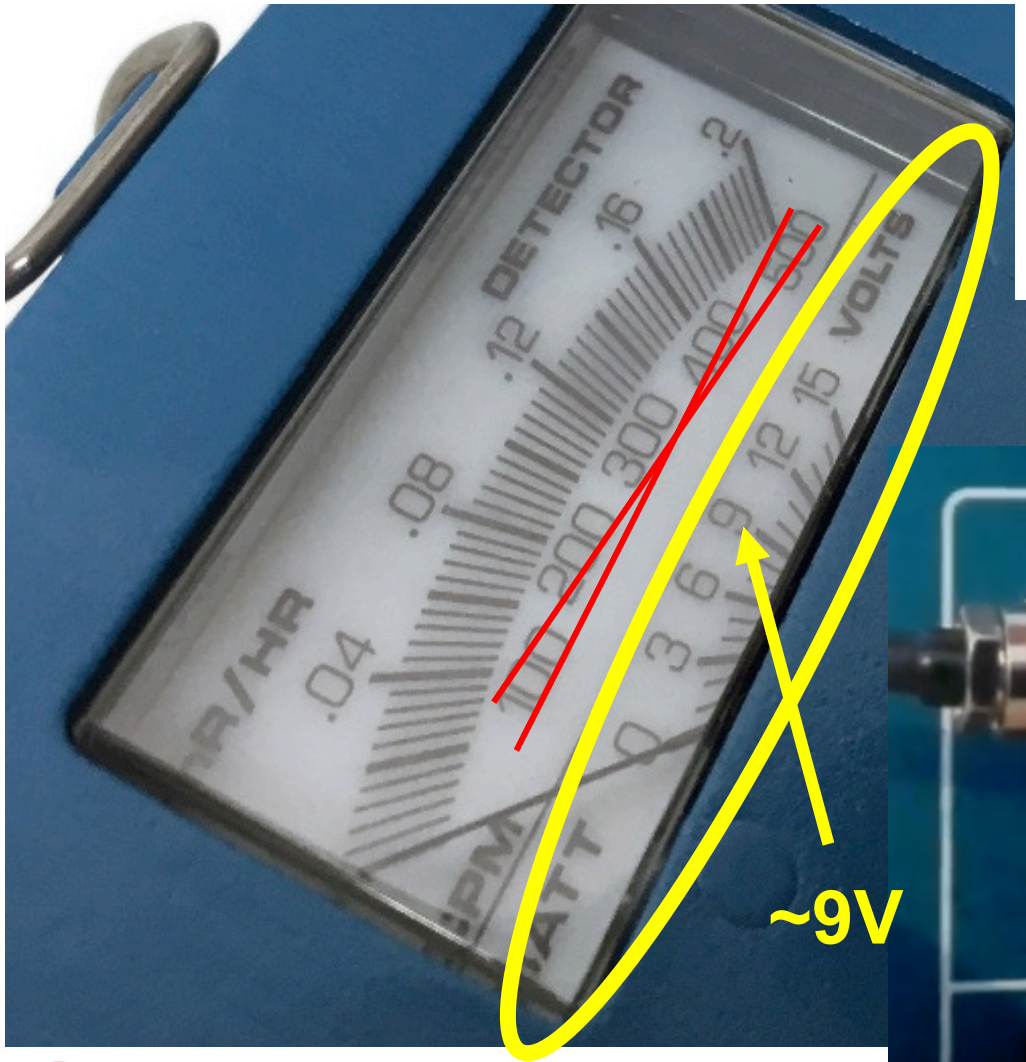
Gamma – energy compensated

Pancake Probe

Neutron Probe for ADM 300

Battery & Range

- Use mR/h (top scale)
- This one is 0.2 mR/h max
- 200 mR/h max on X1000
- ~9V/900V



Response time; sound

- Frequently response time is adjustable
- Fast response can result in jumpy readings
- Slow response can require much patience!

GM tube saturation

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- At high does rates a GM tube can “saturate”
- This means that too many gas atoms have reached excited states, causing a long dead time for the meter as the avalanche clears
- First, the reading may very rapidly go high or off-scale
- Next, during such dead time, the meter may remain pegged at zero, the exact opposite of what it should
- Hence, it is generally recommended to either
  - *Start on the least sensitive (x1000) scale and work down from there, gradually; or*
  - *Bring the probe from a low radiation area to the target location slowly, while watching response and not letting it go off-scale*

Measuring background level

- Background in Wilson Lab typically ranges from 10-40 micro-rem/h (0.01-0.04 mrem/h)
- Depends upon
  - *Overburden (concrete and soil above you that shield cosmic rays)*
  - *Proximity to weakly active materials (like concrete)*
- Generally, we ignore background when surveying activated material and write the full, unsubtracted value on the tag
  - *You may indicate bgd level on the tag, clearly, if you like*
- When surveying for effectiveness of shielding, background is often measured and recorded, because compliance with the 50 micro-rem/h threshold may require it, so record both background level and full, unsubtracted value measured at a given location

Operation

- Look for any DO NOT USE labels or markings
- Inspection/calibration should be no more than 6 months overdue
  - *Could be technically expired. Generally annual, but delays can occur*
- Do a battery check (usually 9V)
  - *Do not use if weak! Get another meter or change batteries.*
- If there is a “check source” mounted on the meter, verify that the probe responds to it
- Check background level away from source
  - *May have to wait for stable operation*
- Start on biggest scale (least sensitive)
  - *Otherwise can saturate and become unresponsive, faking 0 dose rate*
  - *Alternately, bring in probe from a distance very slowly to target, always keeping the reading on-scale*
- Adjust response time; *wait for stable response*
- If a reading seems odd, *double check with a 2nd meter*
- **Power off unit!**

Notes

- If any meter or probe behaves questionably
  - *Tag it with the date, your name, and DO NOT USE*
  - *Bring to Radiation Safety Specialist*
- If you ever have a question, contact
  - *Radiation Safety Specialist*
  - *Safety Director*
  - *Permit Holder*
  - *CHESS Safety Officer*
  - *CESR Technical Director*


GSM-500
CPM
100
200
300
400
500
.04
.08
.12
.16
.2
mR/hr
X
1
10
100
1000
BATT
PROBE


GSM-501
MICRO R/HR
0
1
2
3
4
5
X
1
10
100
1000
BATT
PROBE


10
20
30
40
50
0
5
10
15
20
25
MICRO R/hr
ON
OFF
LAMP
5000
500
250
50
25
HV
BAT
RES


R/HR
.04
.08
.12
.16
.2
PM
100
200
300
400
500
ATT
0
3
6
9
12
15
VOLTS
DETECTOR