Radiation Dose is More than A Number

September 15 and 16, 2011

Sponsored by NCI, NIAID, & NIST

Cell Culture Studies

presented by

Woody Armour

Collaborator – Erik Tryggestad

Johns Hopkins University

presented by Woody Armour
Johns Hopkins University

What is being irradiated In Vitro

In Vitro cell culture - fortunately is no longer cells growing ‘on glass’ but ‘on plastic’.

Cells are either attached to a plastic surface (typically about 1 mm thick) or suspended in an aqueous medium.

For the attached method, cells are located as a very thin layer (~5 to 10 um in thickness) on the surface of a polystyrene sheet and are covered by an aqueous medium of thickness 1 to 5 mm.

The cell containers take various forms:

dishes, flasks, multi-well plates, etc

	aqueous thickness above cells			
type of flask,			typical added	thickness (mm)
dish or plate	diameter (mm)	area (cm^2)	volume (ml)	of medium above
T175		175.0	35.0	2.0
T150		150.0	30.0	2.0
T75		75.0	15.0	2.0
T25		25.0	10.0	4.0
T12.5		12.5	5.0	4.0
150mm	150	176.6	25.0	1.4
100 mm	100	78.5	10.0	1.3
60 mm	60	28.3	5.0	1.8
25mm	25	4.9	2.0	4.1
6 well	35	9.6	2.0	2.1
12 well	22	3.8	1.0	2.6
96 well	6.5	0.3	0.2	6.0

presented by Woody Armour
Johns Hopkins University

Goals of In Vitro Irradiation

1) Reproducible Dose
   a) Currently available
   b) Problem when changing radiation instruments

2) Uniform Dose
   a) Currently available- but user must be careful

3) Accurate Dose
   a) Currently available- but user must be very careful

4) Translate Dose conditions to In Vivo situation
   a) Available with careful help from physicst

presented by Woody Armour
Johns Hopkins University

Typical path to In Vitro Irradiation

Vendor Rep Promises

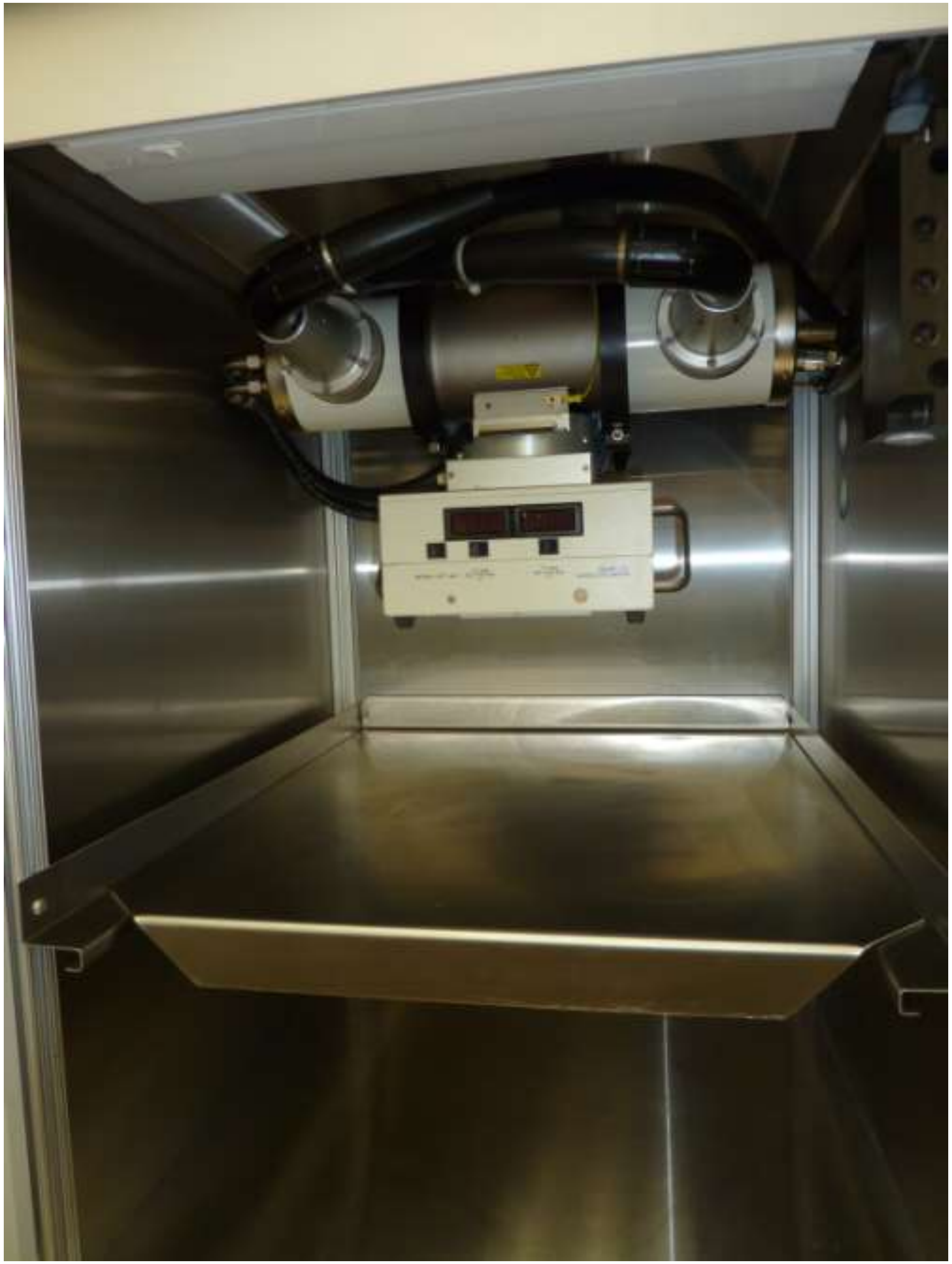
a) ease of use

b) stability

c) accurate dose

GammaCell 40

X-RAD 320



presented by Woody Armour
Johns Hopkins University

Typical path to In Vitro Irradiation

Vendor Provides

a) Radiation Device
b) Dose Rate in Air under very specific condition
c) Usable area for uniform dose
d) Means of verifying stability of dose rate

presented by Woody Armour
Johns Hopkins University

Everything is fine until :
Evil physicist shows up talking about

a) electron equilibrium
b) depth dose
c) Build-up
d) Mass attenuation coefficients
e) heal effect, kerma, ---- etc-----------

presented by Woody Armour
Johns Hopkins University

What is role of Physicist?

a) Confirm that basic parameters provided by manufacturer are true;
    Reference dose to AAPM TG61

b) Define and analyze Standard experimental conditions that meet researchers "goals"

c) Analyze Non-Standard experimental conditions

d) Communicate

presented by Woody Armour
Johns Hopkins University

What are Physicists' Tools

a) Ionization Chamber

(absolute reference)

(low resolution measurement)

b) GAFChromic film

(cut to desired size; 2D dosimetry)

(thickness and material simulates cells)

(complicated to use - measuring dose requires expertise)

c) MonteCarlo dose modeling

(treatment planning systems in development for this application)

Setup for
AAPM TG61
measurement

presented by Woody Armour
Johns Hopkins University

What is Important for In Vitro Dosimetry?

a) Build-up?

b) Attenuation?

c) Depth Dose?

d) Backscatter?

e) Uniformity?

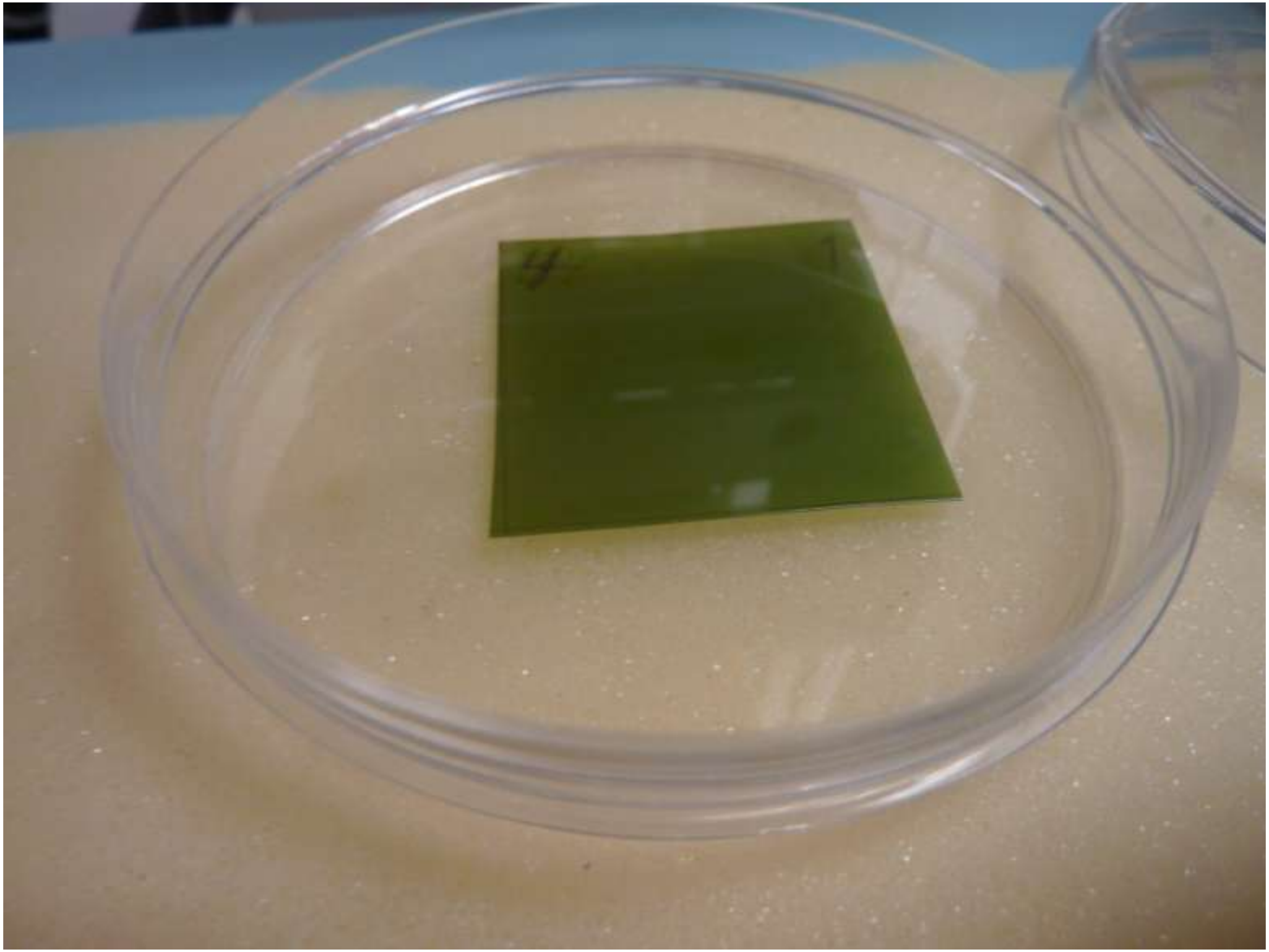
f) Photon energy

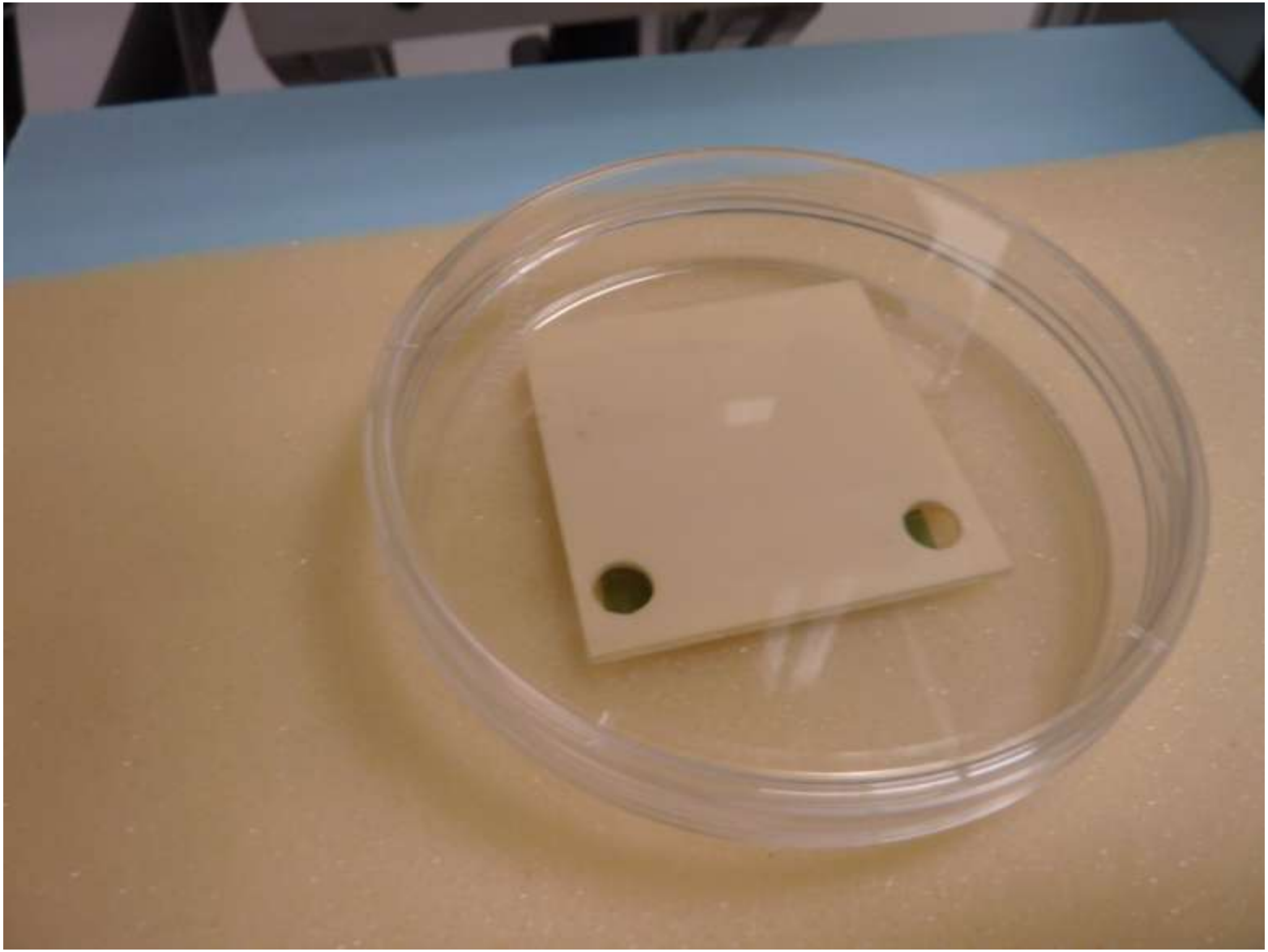
presented by Woody Armour
Johns Hopkins University

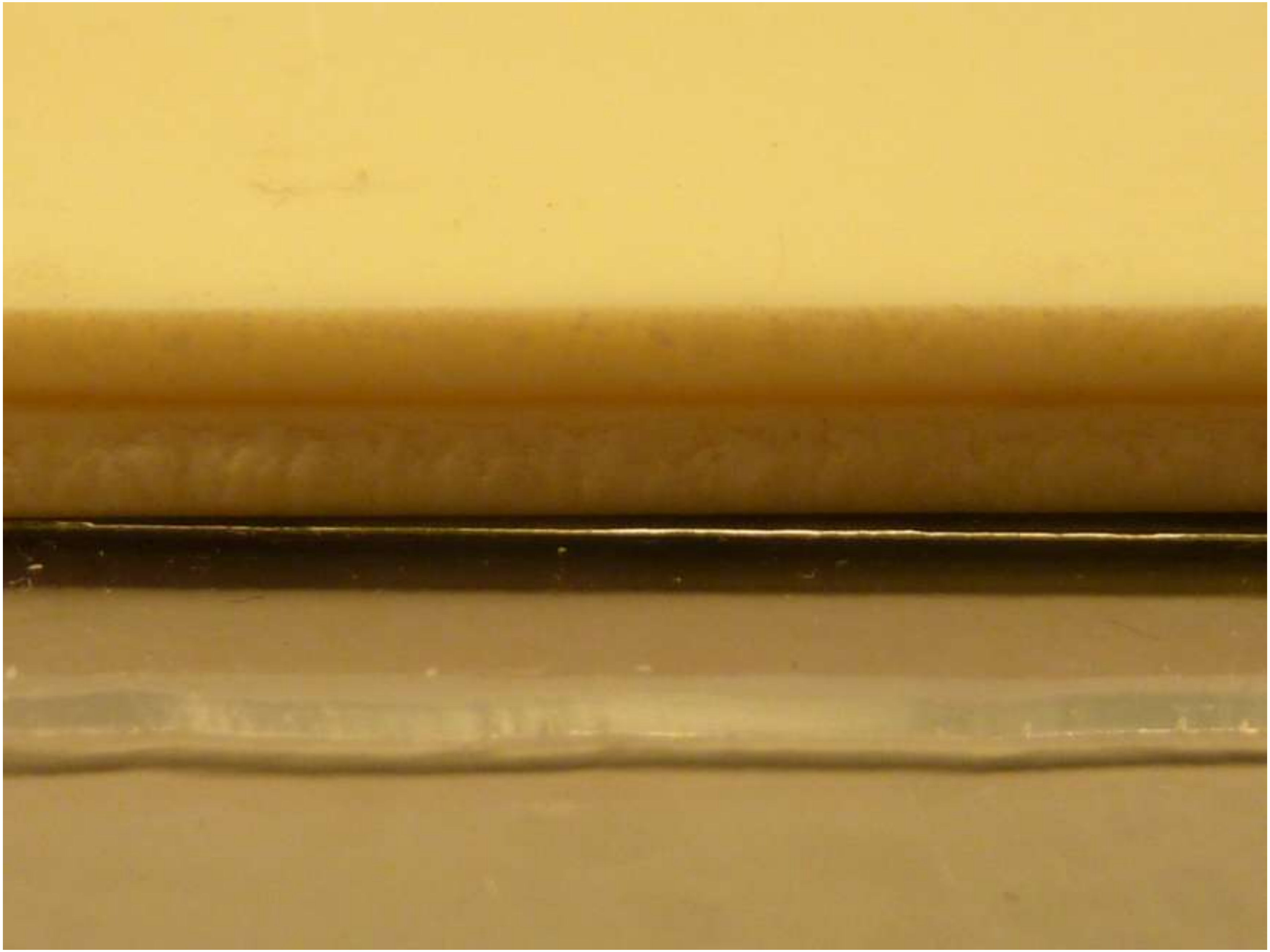
Attenuation and Buildup?
Depth Dose

a) In dishes or flasks:
depth of aqueous medium above cells typically varies from 1 to 5 mm

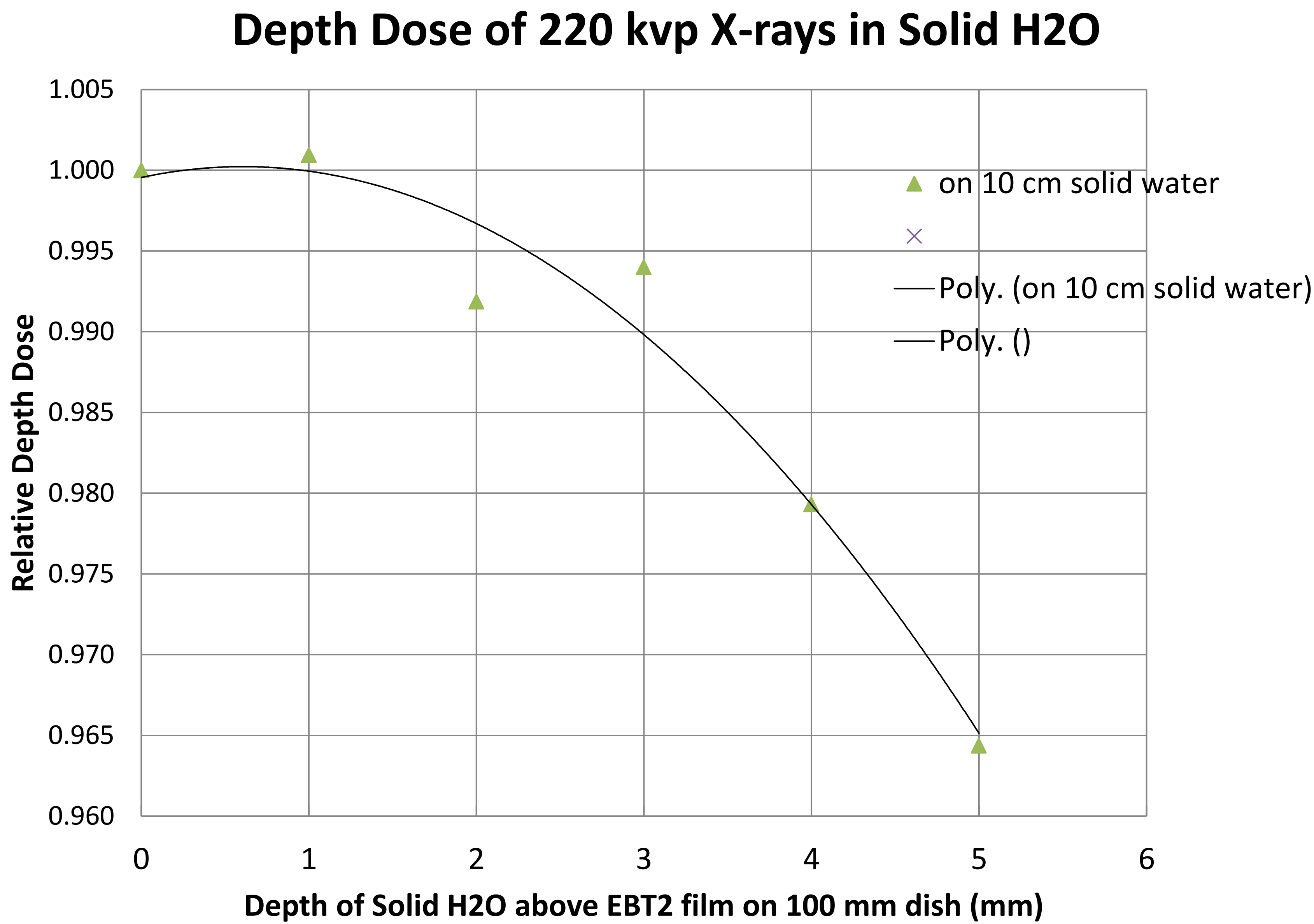

LOT#
A090310-1B
• New Look!
• Better performance
GAFCHROMIC®
EBT2
QD+
Quality dosimetry plus:
• Self developing
• No processing required
• Energy independent
• Water resistant
• Now - More stability in room light
• Built-in uniformity enhancement
Advanced Materials
ISP
INTERNATIONAL SPECIALTY PRODUCTS
25 SHEETS, EACH 8" x 10"



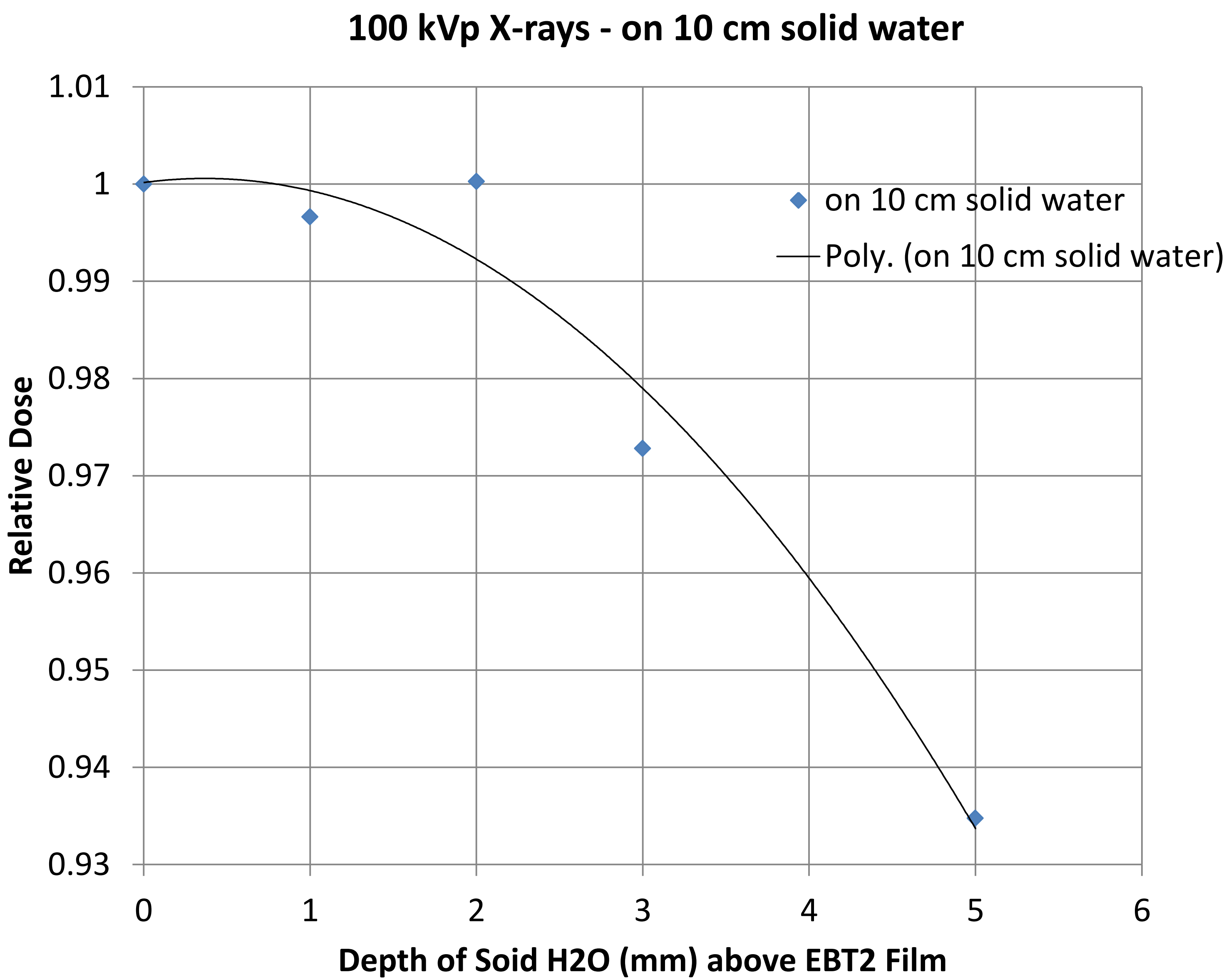




Dish on
Solid water



Depth Dose of 220 kvp X-rays in Solid H2O
1.005
1.000
0.995
0.990
0.985
0.980
0.975
0.970
0.965
0.960
Relative Depth Dose
0
1
2
3
4
5
6
Depth of Solid H2O above EBT2 film on 100 mm dish (mm)
on 10 cm solid water
Poly. (on 10 cm solid water)
Poly. ()


100 kVp X-rays - on 10 cm solid water
Relative Dose
1.01
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0
1
2
3
4
5
6
on 10 cm solid water
Poly. (on 10 cm solid water)
Depth of Soid H2O (mm) above EBT2 Film

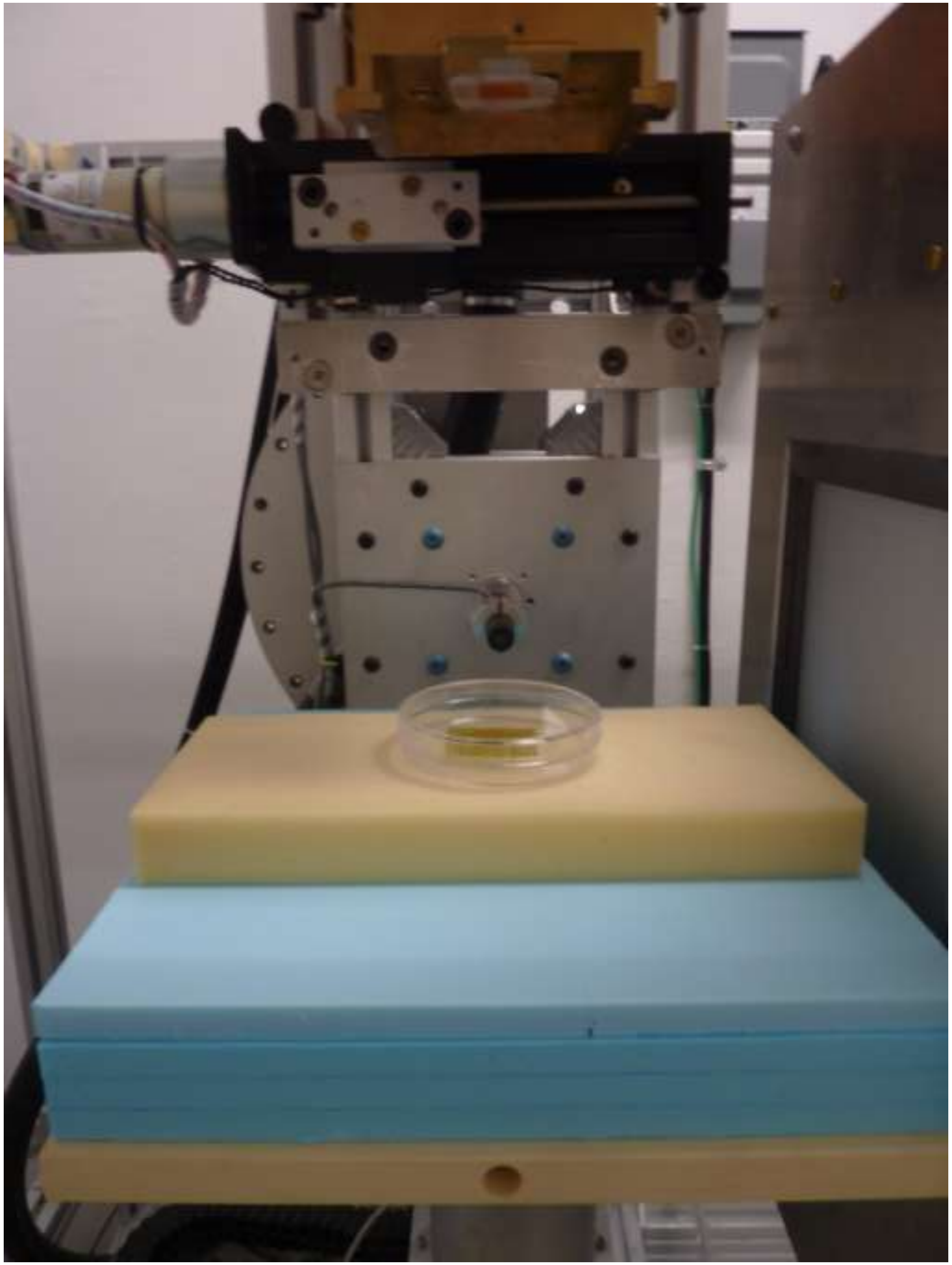
presented by Woody Armour
Johns Hopkins University

Backscatter Material

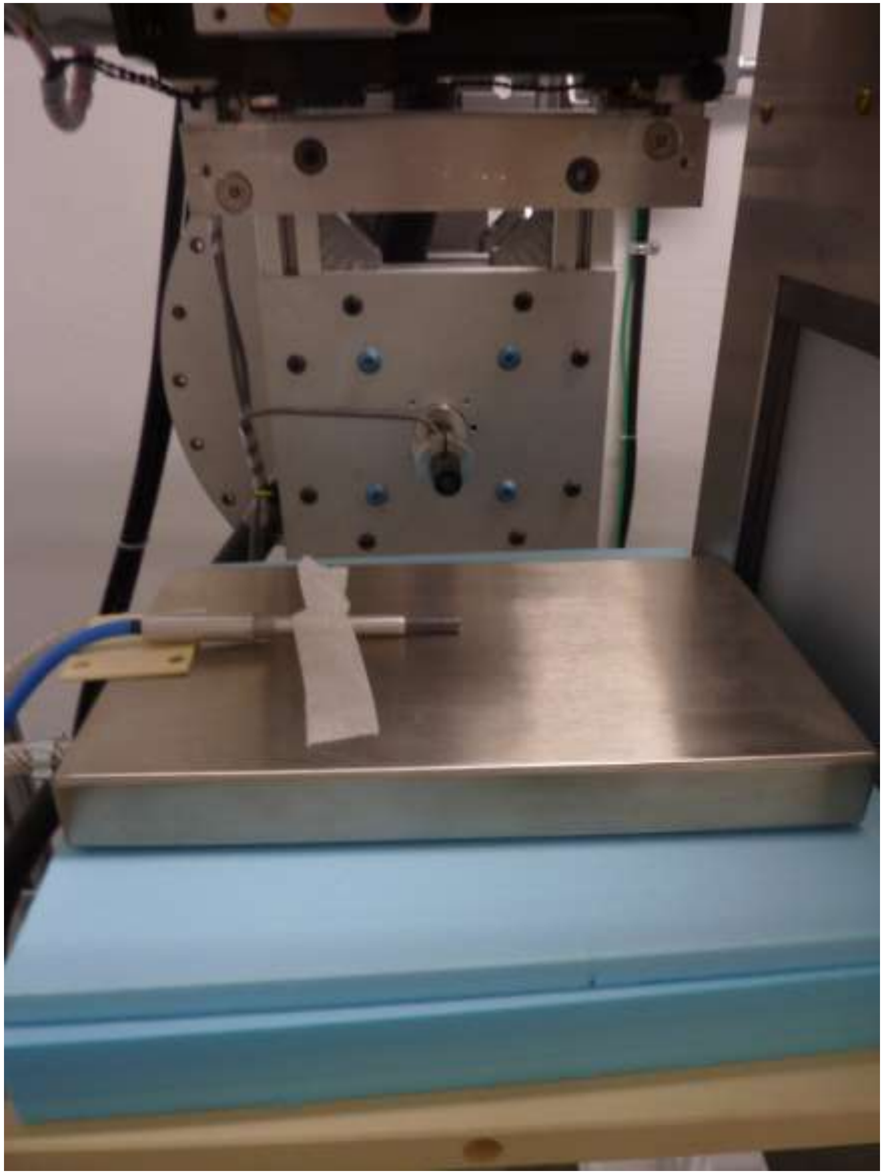
The dose modifying effects of the material on which flasks or dishes are placed during irradiation is not sufficiently appreciated by many researchers.

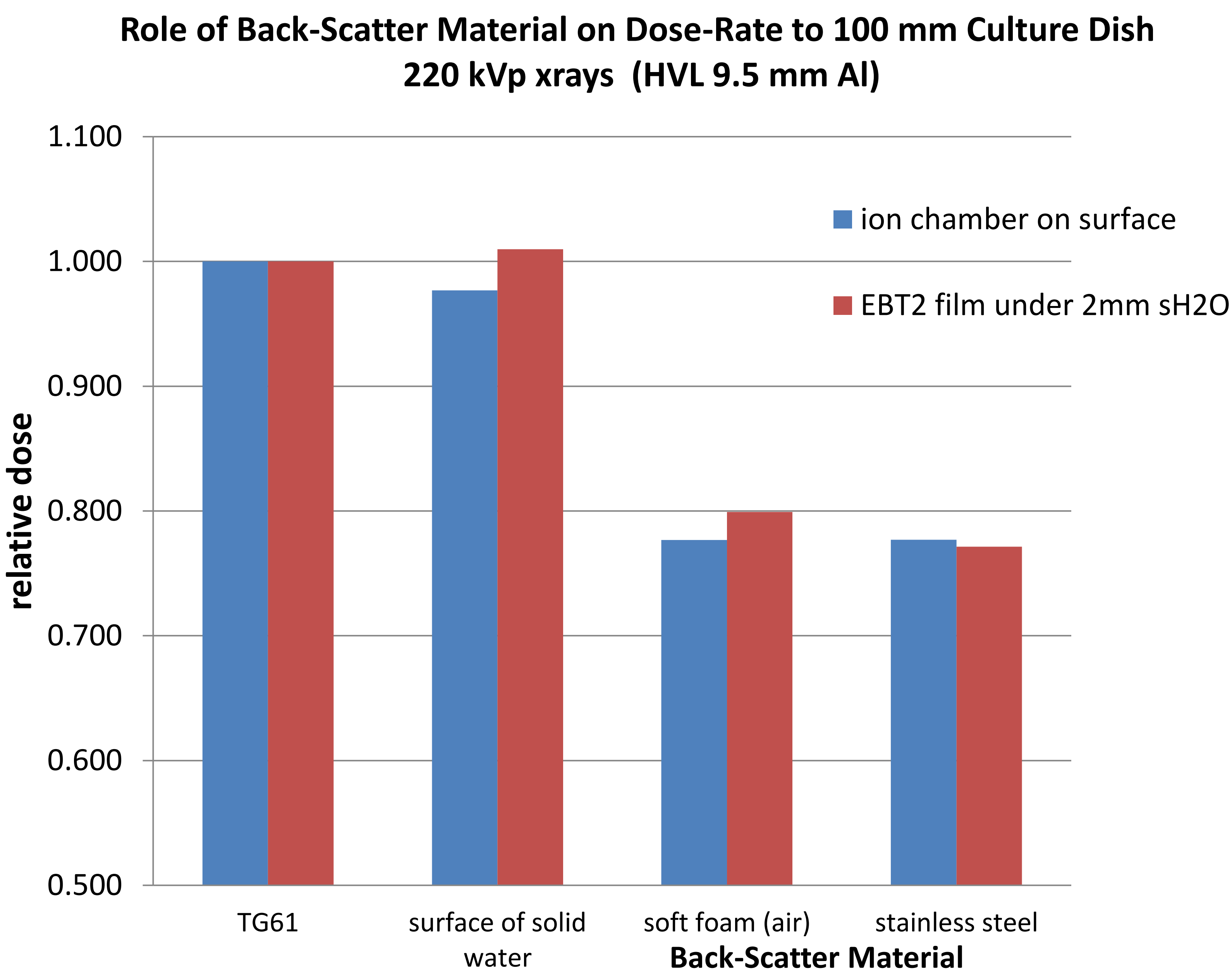
This backscatter material may vary from Stainless steel, to foam, to dense plastics, and who knows what else.

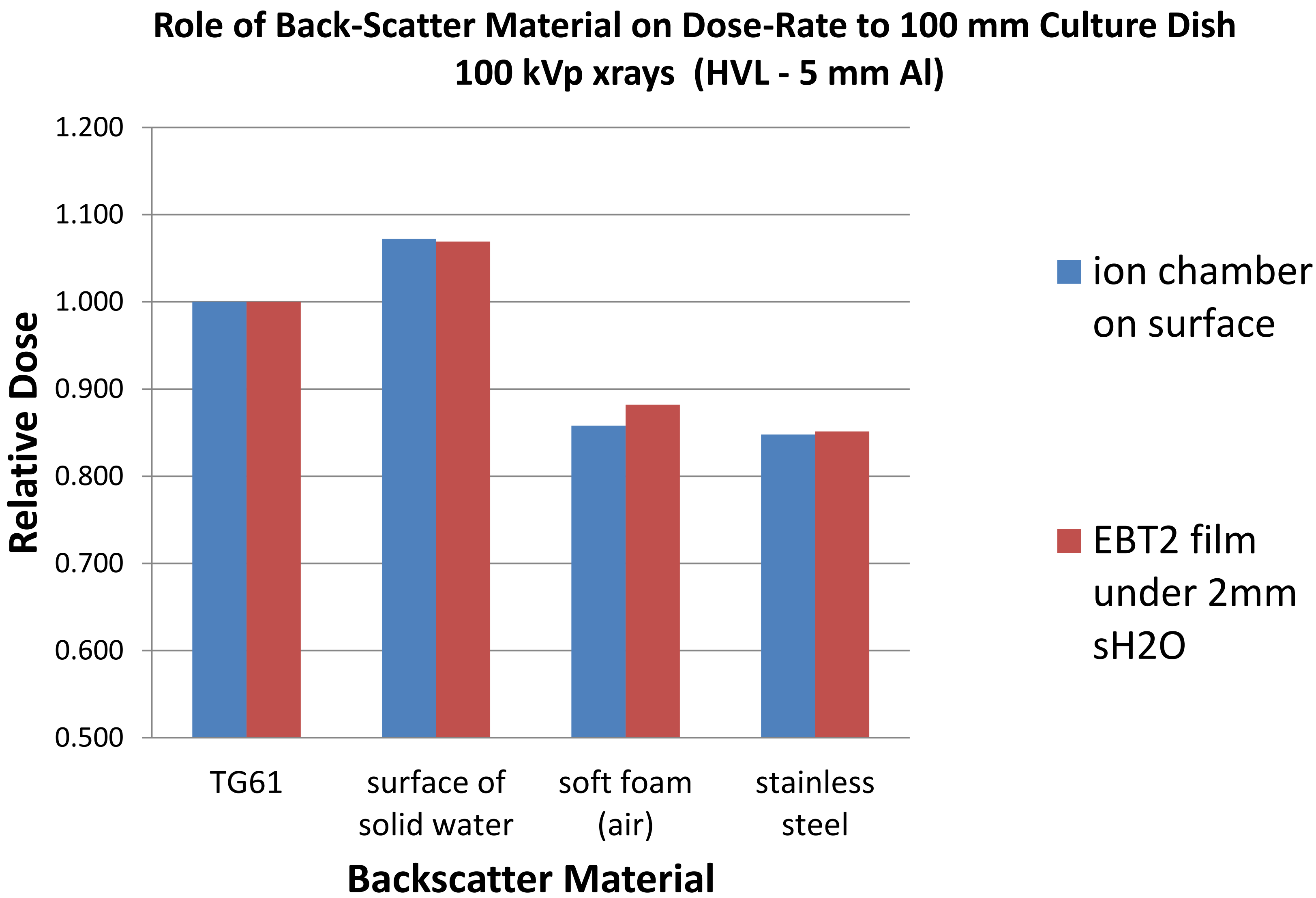
Dish on
Foam (in air)



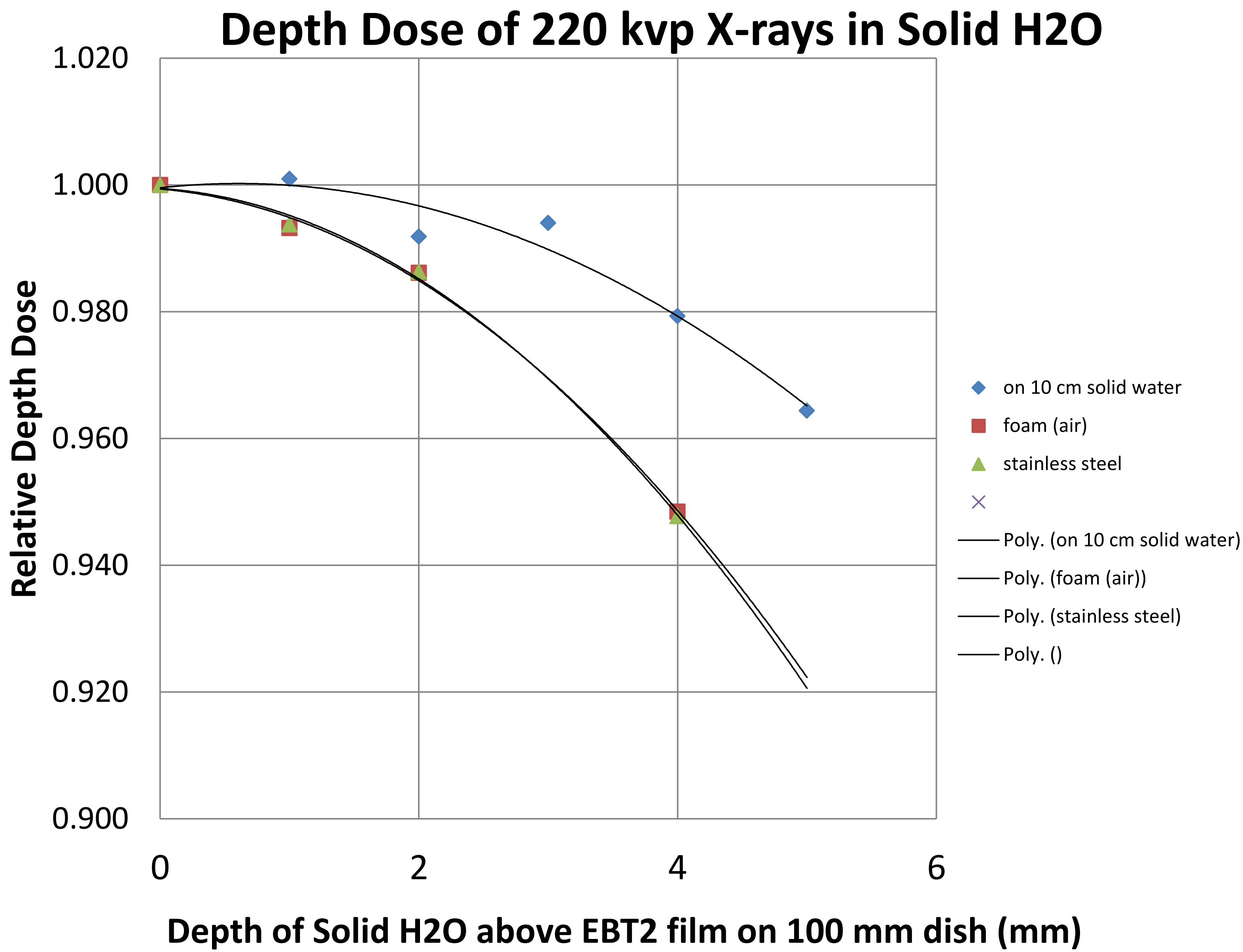
Chamber on
Stainless steel



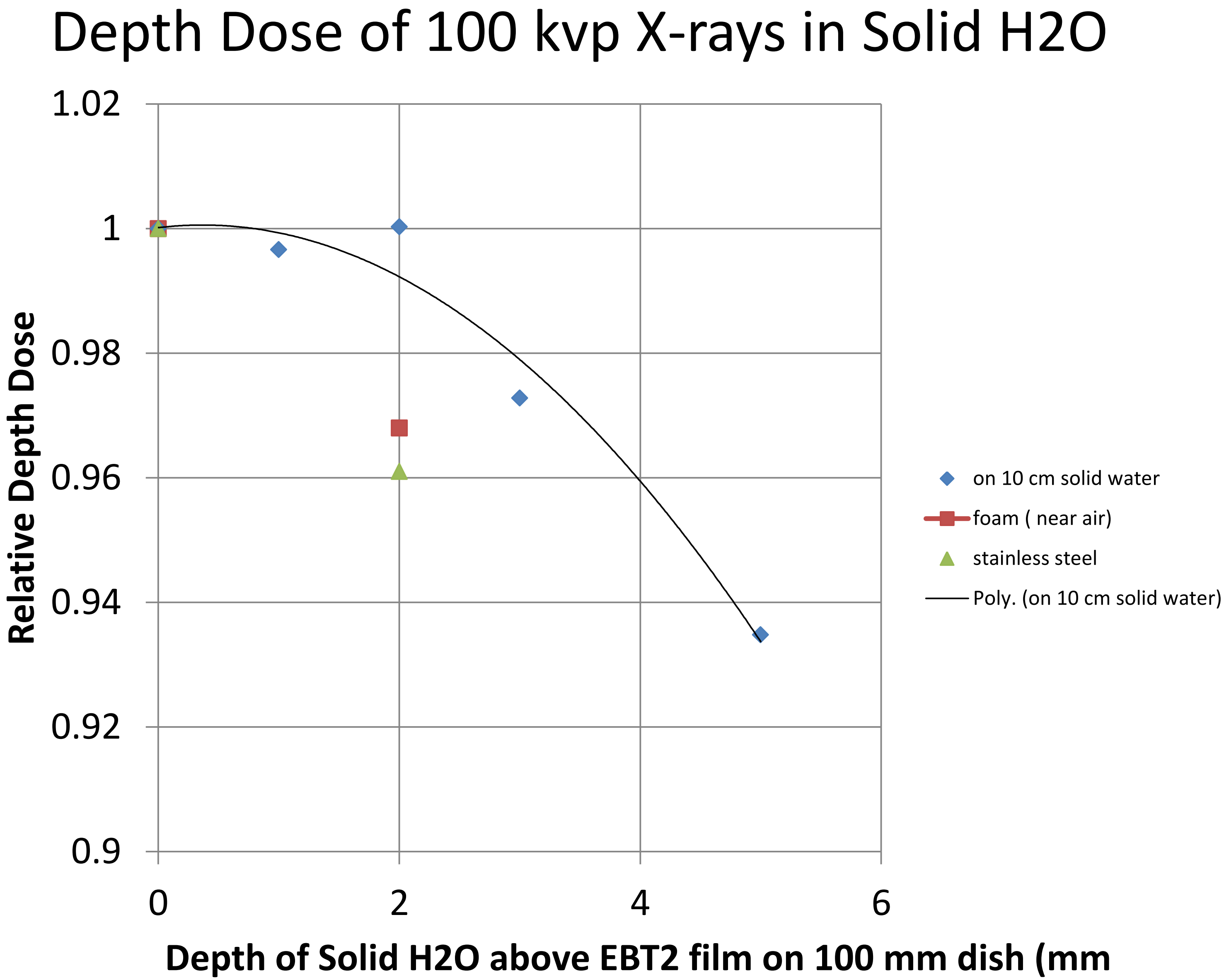

Role of Back-Scatter Material on Dose-Rate to 100 mm Culture Dish
220 kVp xrays (HVL 9.5 mm Al)
relative dose
1.100
1.000
0.900
0.800
0.700
0.600
0.500
ion chamber on surface
EBT2 film under 2mm sH2O
TG61
surface of solid water
soft foam (air)
stainless steel
Back-Scatter Material



Role of Back-Scatter Material on Dose-Rate to 100 mm Culture Dish
100 kVp xrays (HVL - 5 mm Al)
Relative Dose
1.200
1.100
1.000
0.900
0.800
0.700
0.600
0.500
TG61
surface of solid water
soft foam (air)
stainless steel
Backscatter Material
ion chamber on surface
EBT2 film under 2mm sH2O



Depth Dose of 220 kvp X-rays in Solid H2O
Relative Depth Dose
1.020
1.000
0.980
0.960
0.940
0.920
0.900
0
2
4
6
Depth of Solid H2O above EBT2 film on 100 mm dish (mm)
on 10 cm solid water
foam (air)
stainless steel
Poly. (on 10 cm solid water)
Poly. (foam (air))
Poly. (stainless steel)
Poly. ()



Depth Dose of 100 kvp X-rays in Solid H2O
1.02
1
0.98
0.96
0.94
0.92
0.9
0
2
4
6
Relative Depth Dose
Depth of Solid H2O above EBT2 film on 100 mm dish (mm
on 10 cm solid water
foam (near air)
stainless steel
Poly. (on 10 cm solid water)

presented by Woody Armour
Johns Hopkins University

The above was for simplest geometry. What about more complex

a) What is dose at edge of dish ?

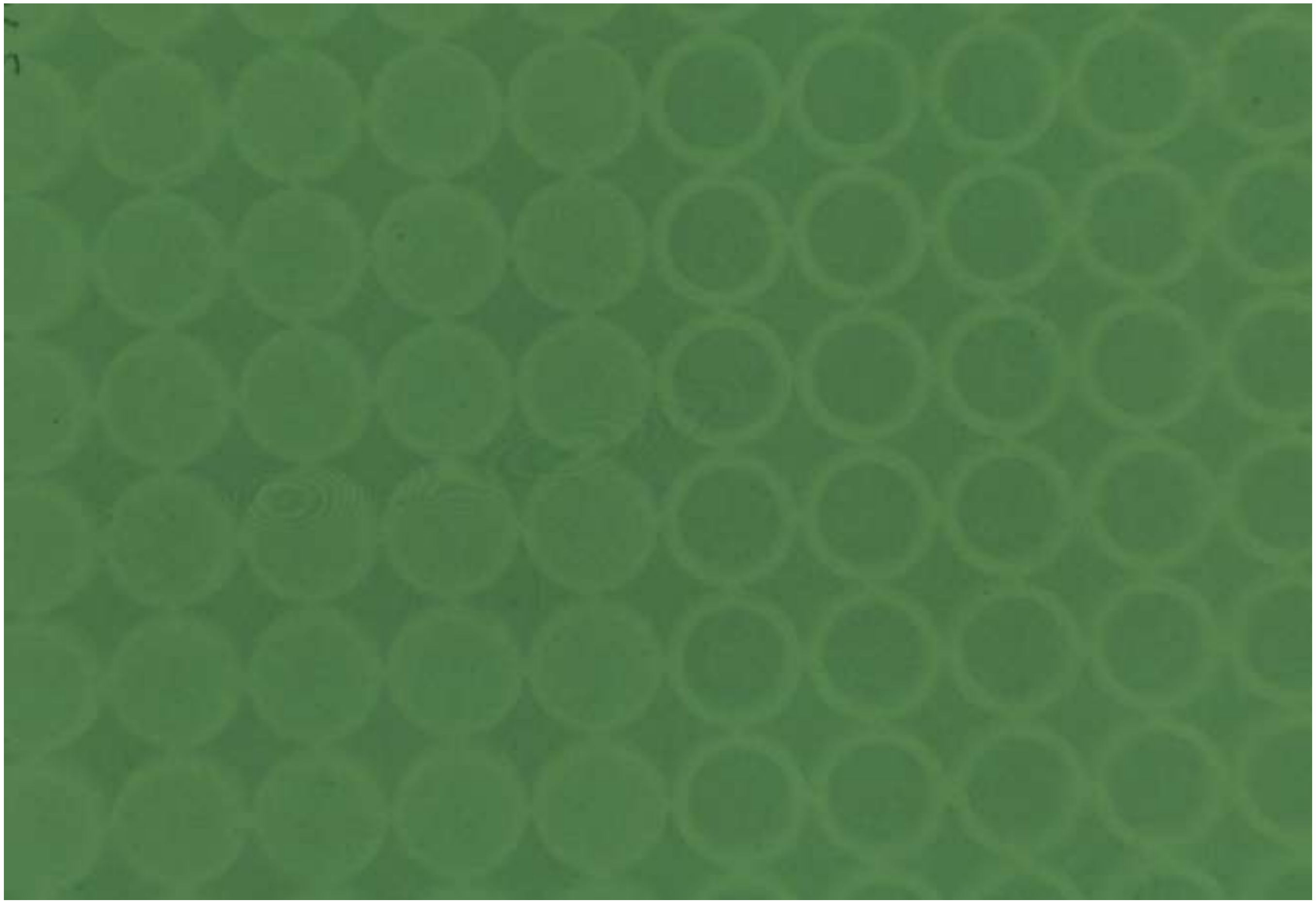
b) How does complexity of multiwell plates affect dose?

c) Should dishes be stacked?


BD Falcon

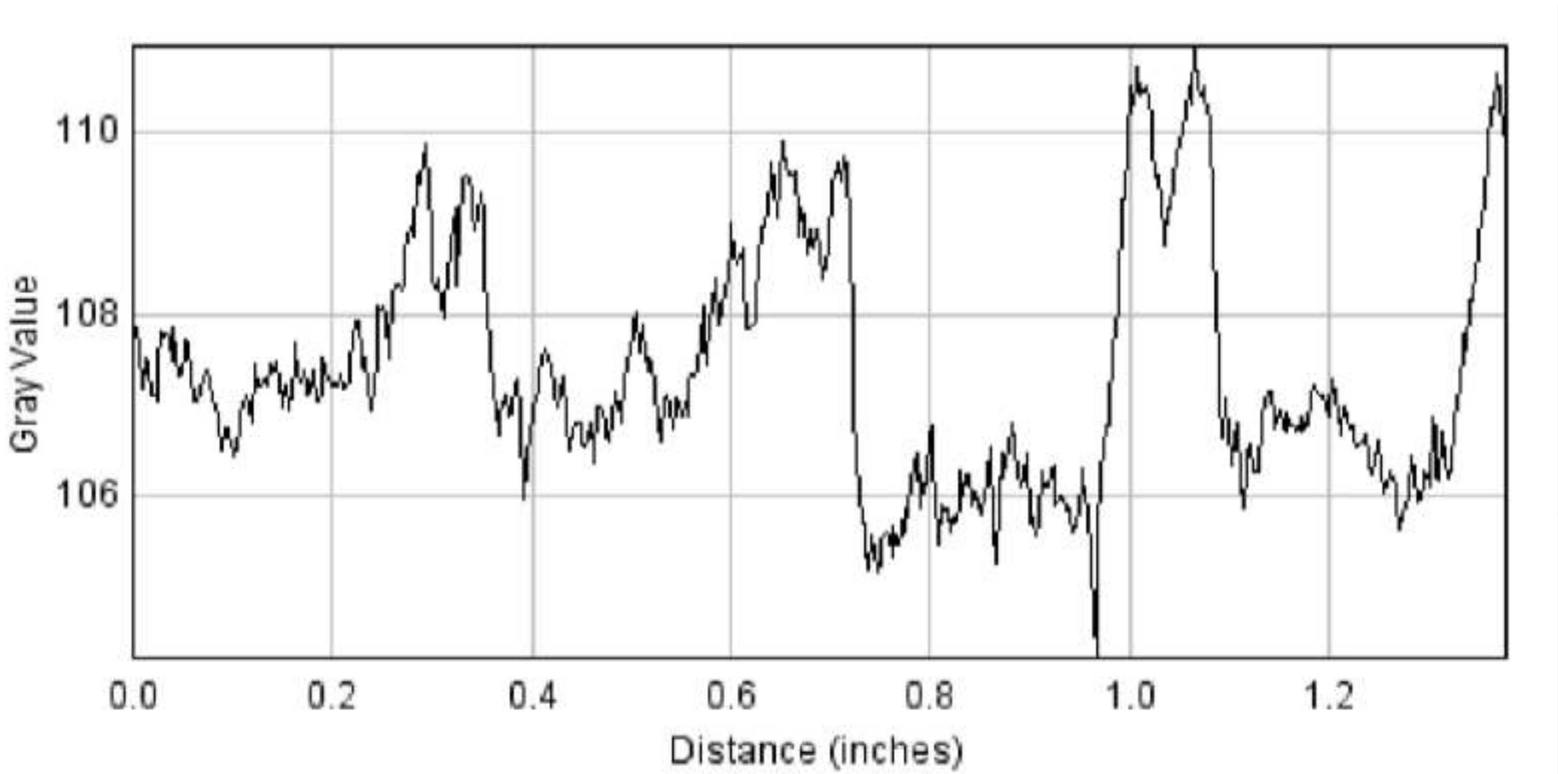
96 well plate 220 kVp

EBT2 film on bottom of dish



0.2 ml of H_2O on left side wells ---- right side empty.

220 kVp X-ray - EBT2 film on bottom of 96 well plate



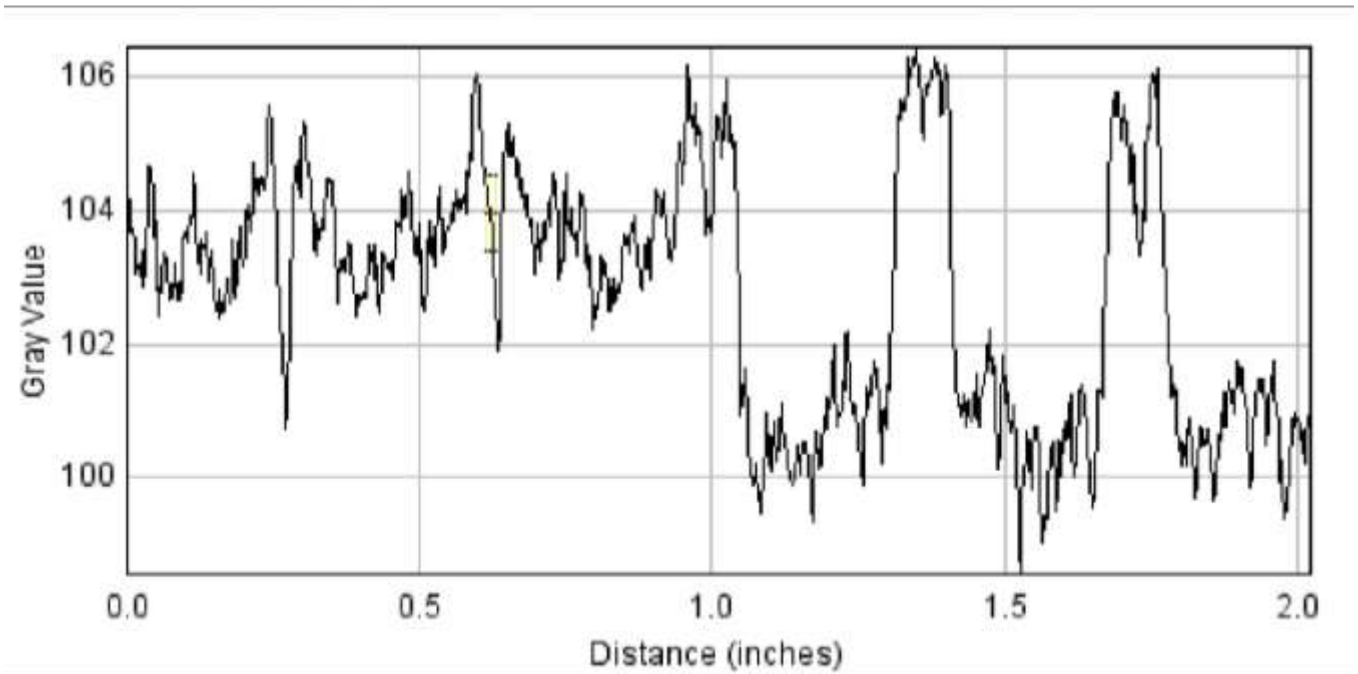
	water well	air well	wall
Dose	351 cGy	362 cGy	320 cGy
Relative Dose	0.97	1.0	0.89

96 well plate 100 kVp

EBT2 film on bottom of dish

0.2 ml of H_2O on left side wells ---- right side empty.

100 kVp X-ray - EBT2 film on bottom of 96 well plate



	water well	Empty well	wall
Dose	389 cGy	423 cGy	367 cGy
Relative Dose	0.92	1.0	0.86

presented by Woody Armour
Johns Hopkins University

What is important

a) Back scatter material > 20%
b) Medium depth < 5%
c) Complex object(96 well plate)
d) Beam quality

presented by Woody Armour
Johns Hopkins University

What is important

Determine needs of researcher

a) How accurate does dose need to be? Some experiments may need 2% whereas others need 20%

b) Will cold spots cause problems?

presented by Woody Armour
Johns Hopkins University

What is the role of Biologists in dosimetry and QA

a) Budget requires that biologists do much of their own routine QA

b) Biologists should not do complex physics tasks such as GAFChromic film dosimetry

c) Biologists should be aware of basics and know what “not” to do

presented by Woody Armour
Johns Hopkins University

What should be done to improve the current situation?

a) Do nothing – no gain

b) Do everything for free – will not happen

c) Physicists aid when asked and available – current situation in large academic centers (limited impact over all)

d) Require training of researchers

e) Provide funds to researchers for physics QA support

presented by Woody Armour
Johns Hopkins University

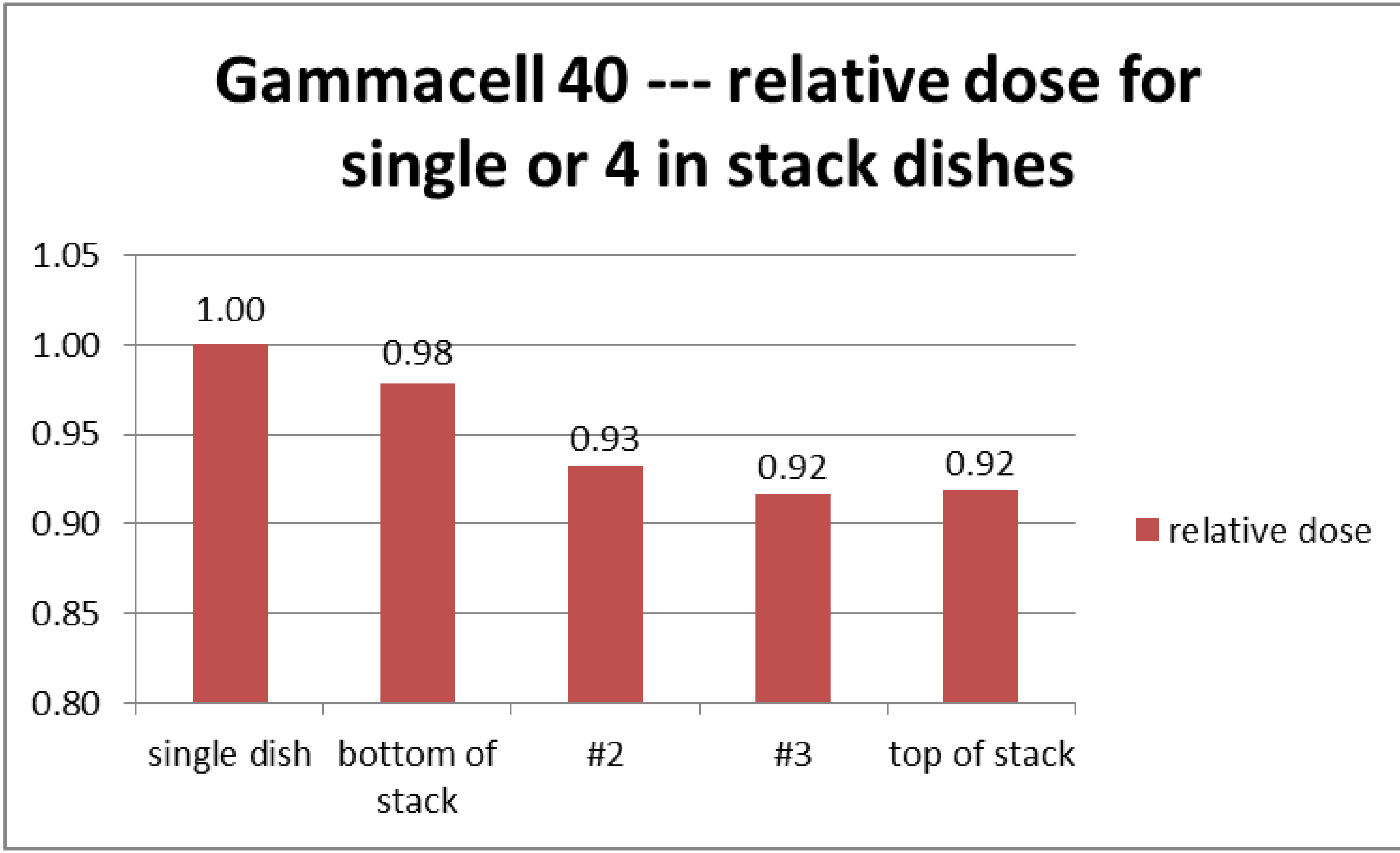
Other things physicists can do?

a) Define class solutions
b) Recommend “do’s” and “do not’s”
c) Offer special physics services for custom problem solving

presented by Woody Armour
Johns Hopkins University

How to replace Cs-137 Irradiators?

a) Single or Duel Tube X-ray?
b) kVp Energy?


Gammacell 40 --- relative dose for single or 4 in stack dishes
1.05
1.00
0.95
0.90
0.85
0.80
1.00
0.98
0.93
0.92
0.92
single dish
bottom of stack
#2
#3
top of stack
relative dose