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Title: Personal Dose Equivalent Conversion Coefficients for Photons, Electrons, and Positrons

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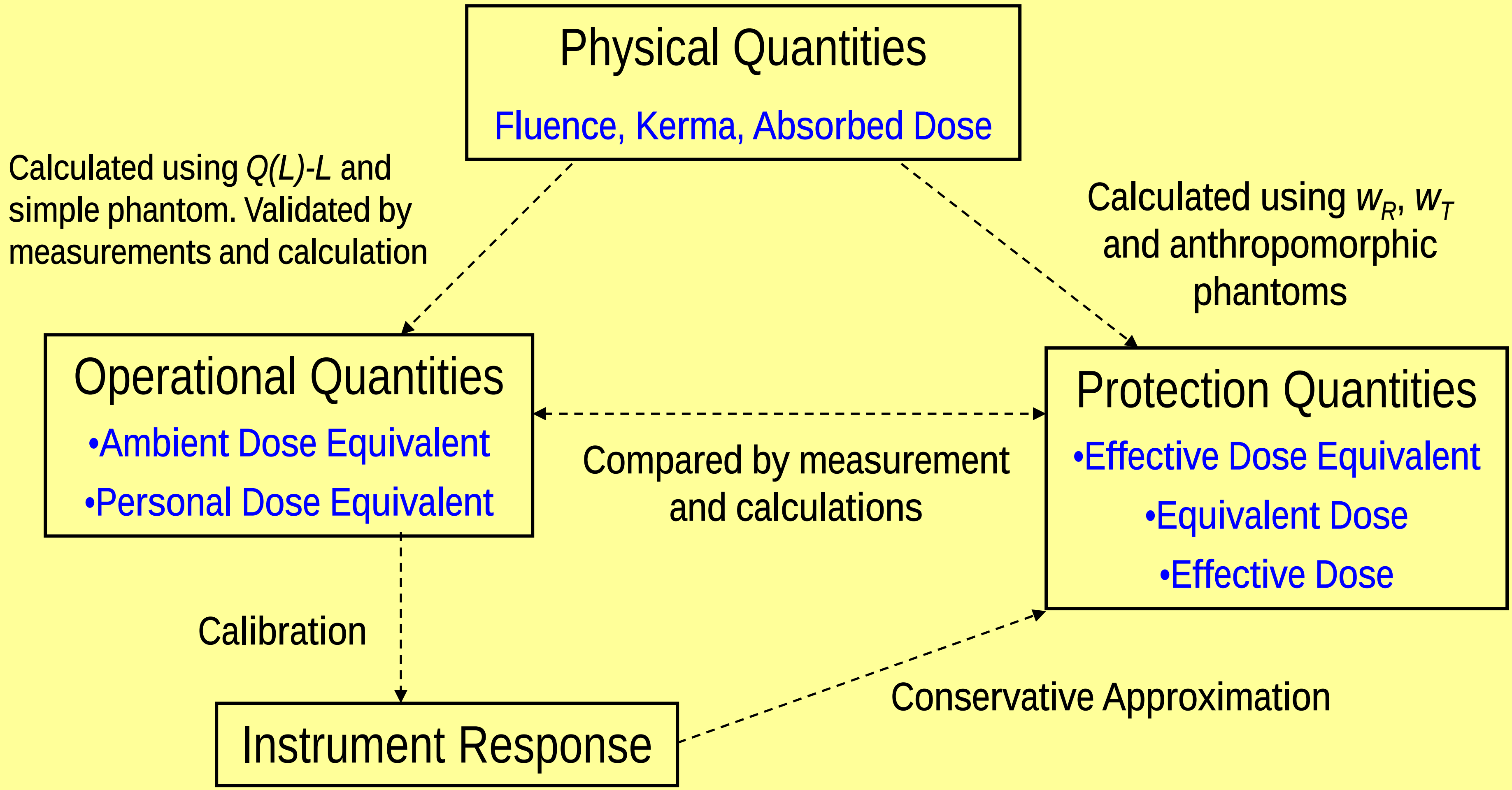
Personal Dose Equivalent Conversion Coefficients for Photons, Electrons, and Positrons

K.G. Veinot

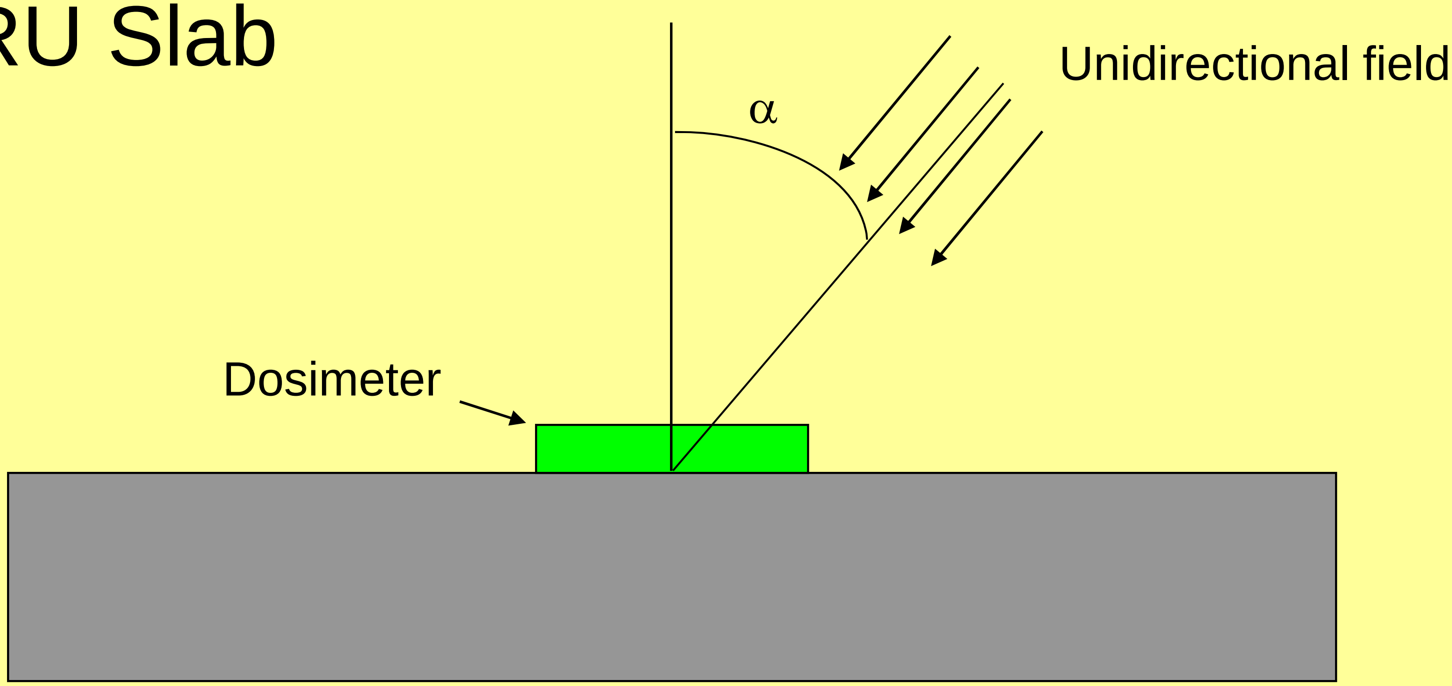
Y-12 National Security Complex

System of Radiation Protection



Personal Dose Equivalent

- Monitoring for individuals
- Defined in the body – multi-valued quantity
- Usually the trunk = 30 cm X 30 cm X 15 ICRU Slab



Use of $H_p(d)$

- Dosimeter calibrations
- Compliance with protection quantities (e.g. skin dose, lens of eye dose, effective ("whole body" dose)
- $H_p(0.07)$ used for skin
- $H_p(3)$ used for lens of eye
- $H_p(10)$ used for effective dose

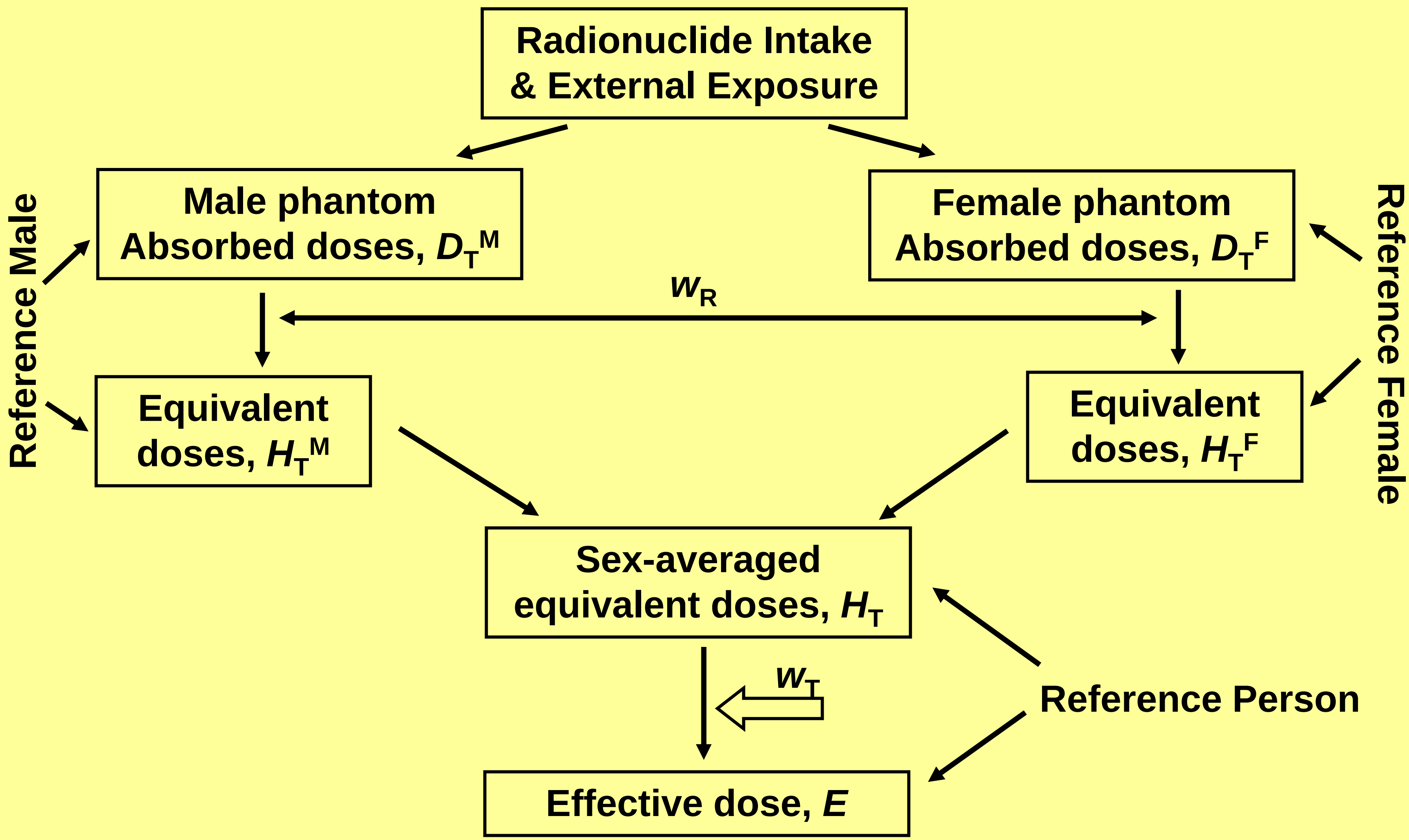
Calculations

- MCNPX 2.6.0
- ICRU slab phantom (30 cm X 30 cm X 15 cm)
- Parallel broad beam
- Air and vacuum for photons
- Kerma and absorbed dose for photons
- Air kerma for photons
- Vacuum for electrons, positrons
- Fits for photons and electrons
- Tally errors <3%

Protection Quantities

- ICRP-103
- Male and female phantoms
- AP geometry
- ICRP developing advanced LOE model
- Skin voxels large
- DOCAL working group

ICRP-103 Protection Quantity Calculations



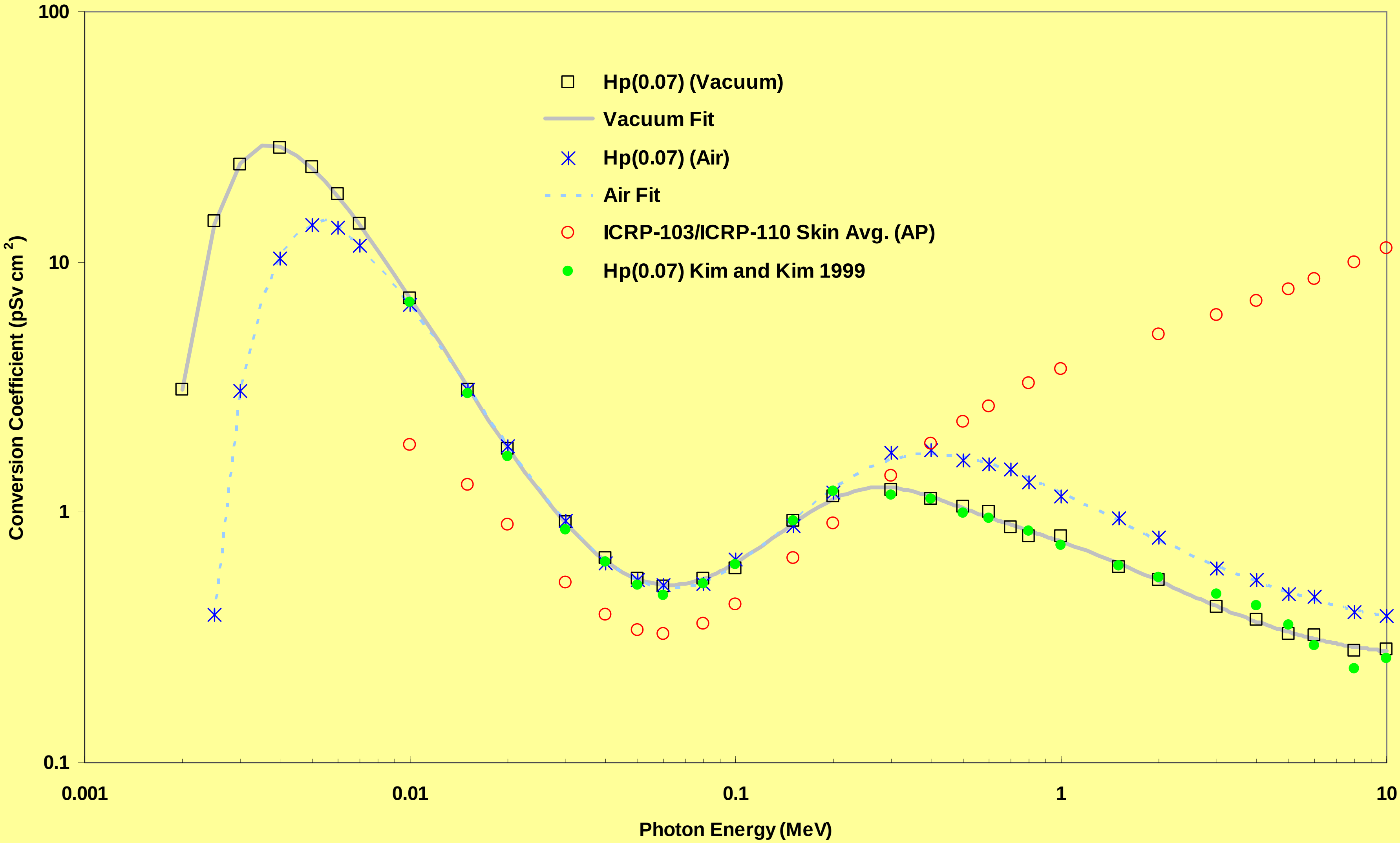
Fits to DCFs

- Marquardt-Levenberg algorithm

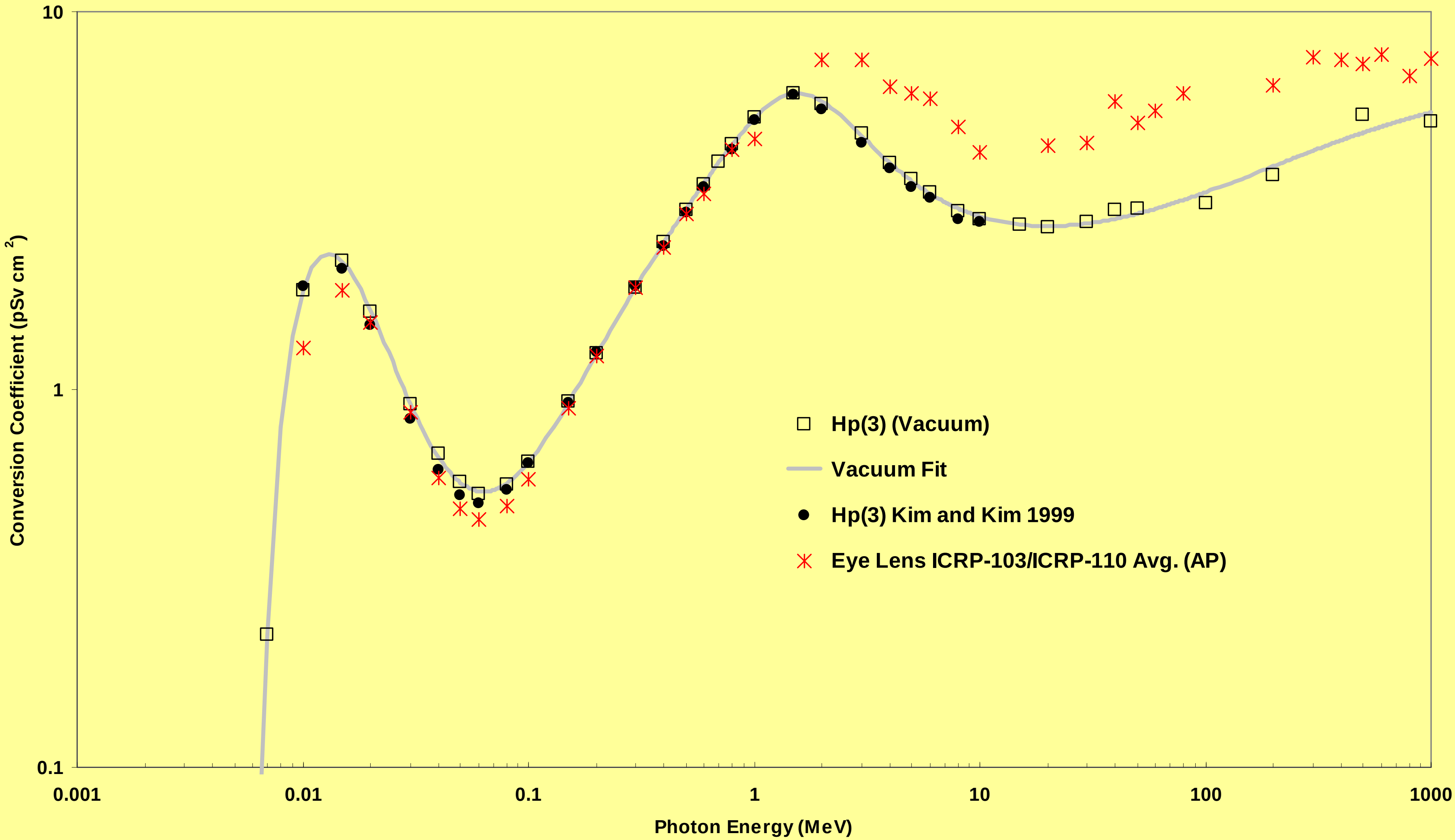
$$f(x) = \frac{a}{1+(b+cx)^2} + \frac{d}{1+(f+gx)^2} + \frac{h}{1+(j+kx)^2} + \frac{l}{1+\exp(m+nx)} + \frac{o}{1+\exp(p+qx)}$$

- f(x) = logarithmic (base 10) value of the conversion coefficient and *x* equals $\log_{10}(E)$ with *E* having energy units of MeV

Photon $H_p(0.07)$

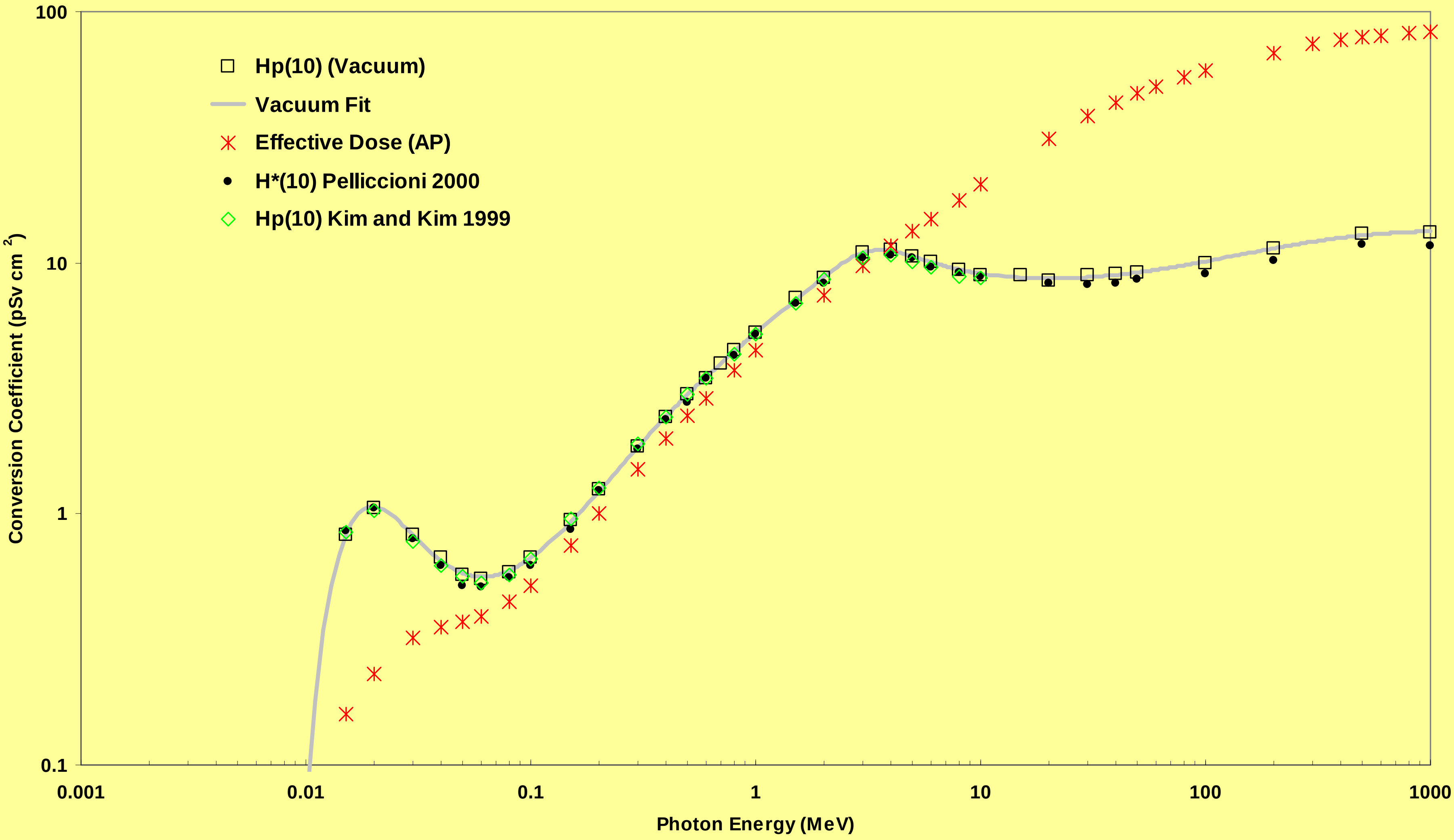


Photon $H_p(3)$



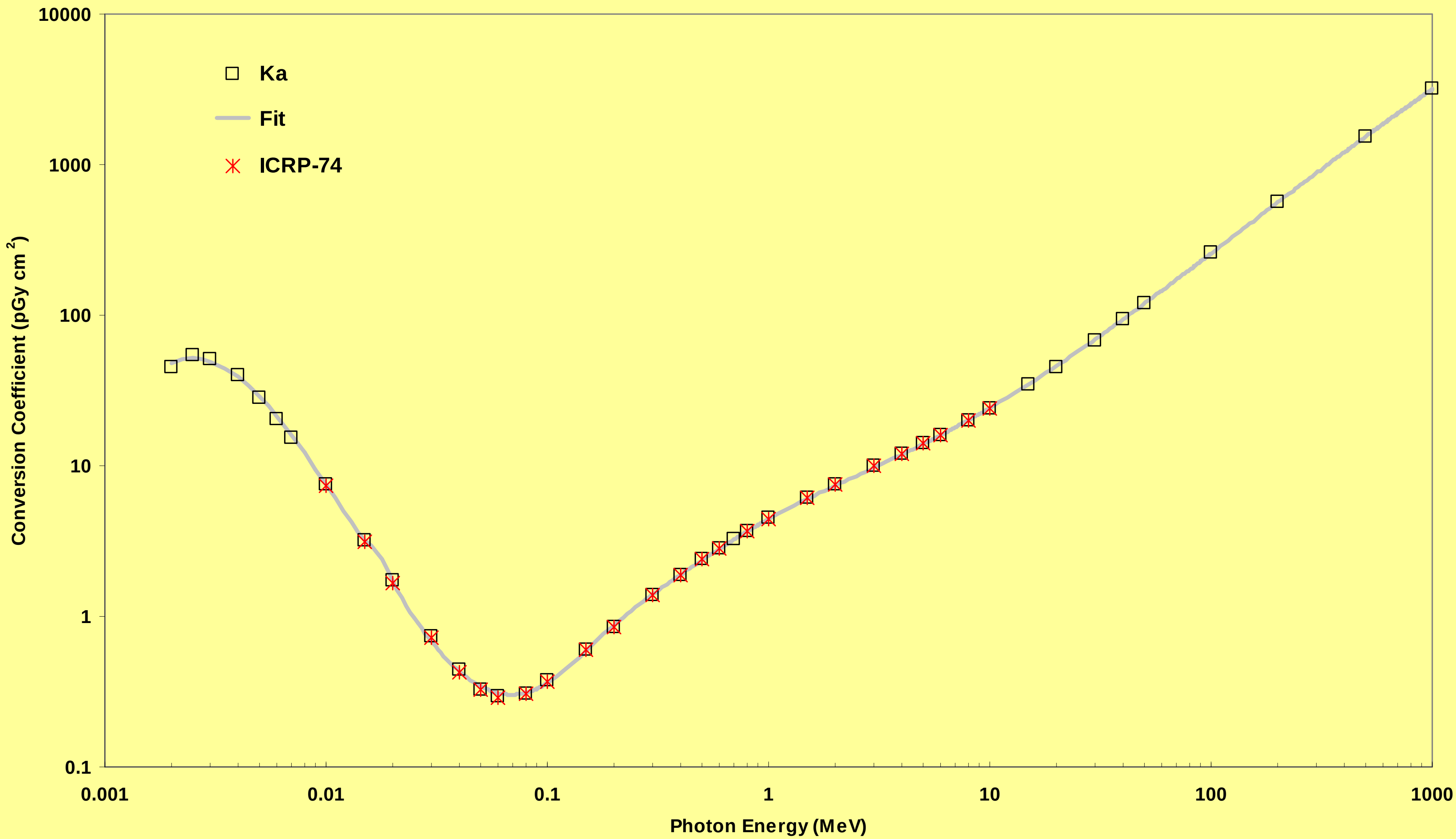
10
1
0.1
0.001
0.01
0.1
1
10
100
1000
Conversion Coefficient (pSv cm 2)
Photon Energy (MeV)
Hp(3) (Vacuum)
Vacuum Fit
Hp(3) Kim and Kim 1999
Eye Lens ICRP-103/ICRP-110 Avg. (AP)

Photon $H_p(10)$

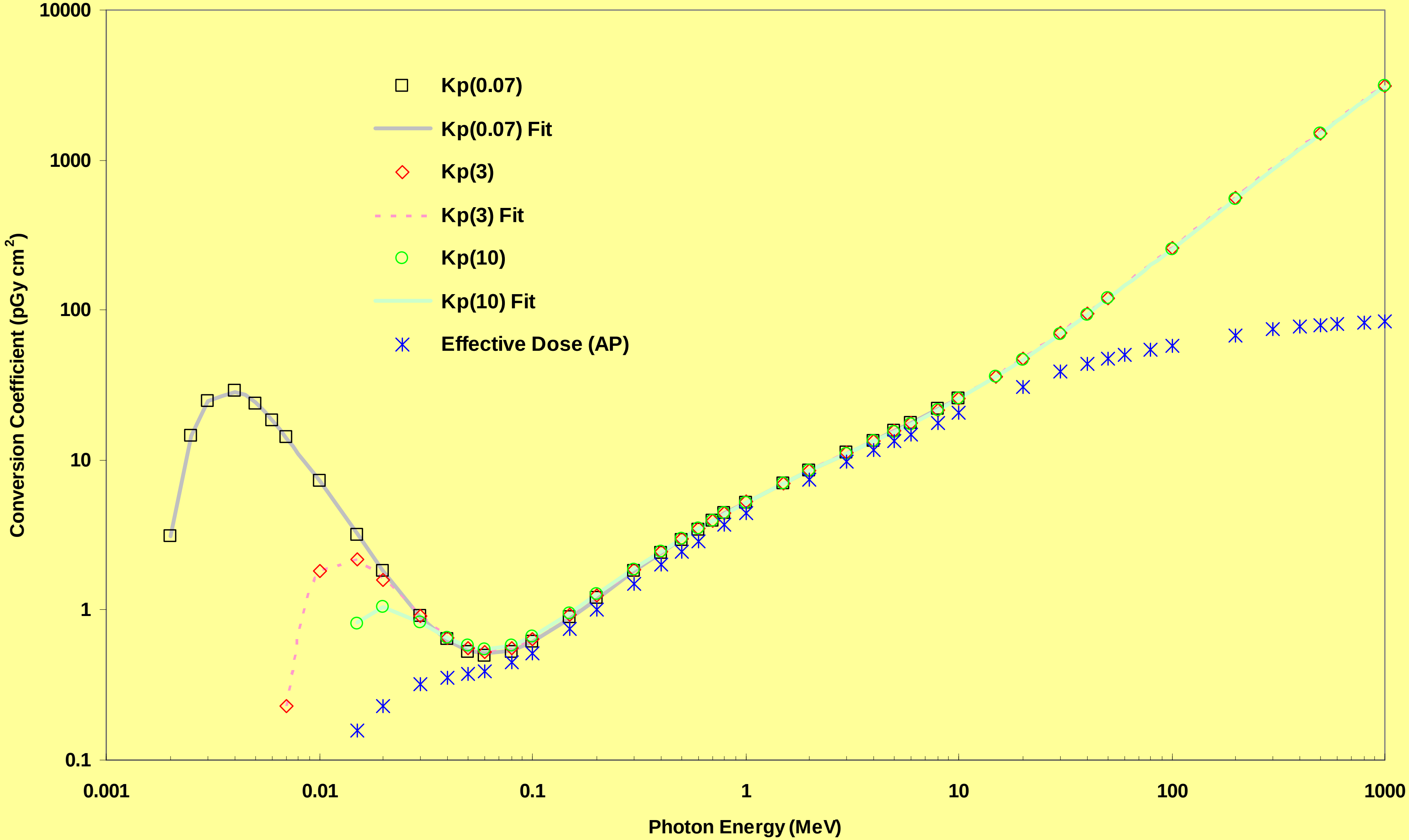


Hp(10) (Vacuum)
Vacuum Fit
Effective Dose (AP)
H*(10) Pellicccioni 2000
Hp(10) Kim and Kim 1999
100
10
1
0.1
Conversion Coefficient (pSv cm 2)
0.001
0.01
0.1
1
10
100
1000
Photon Energy (MeV)

Photon Air Kerma, K_a



Photon Kerma

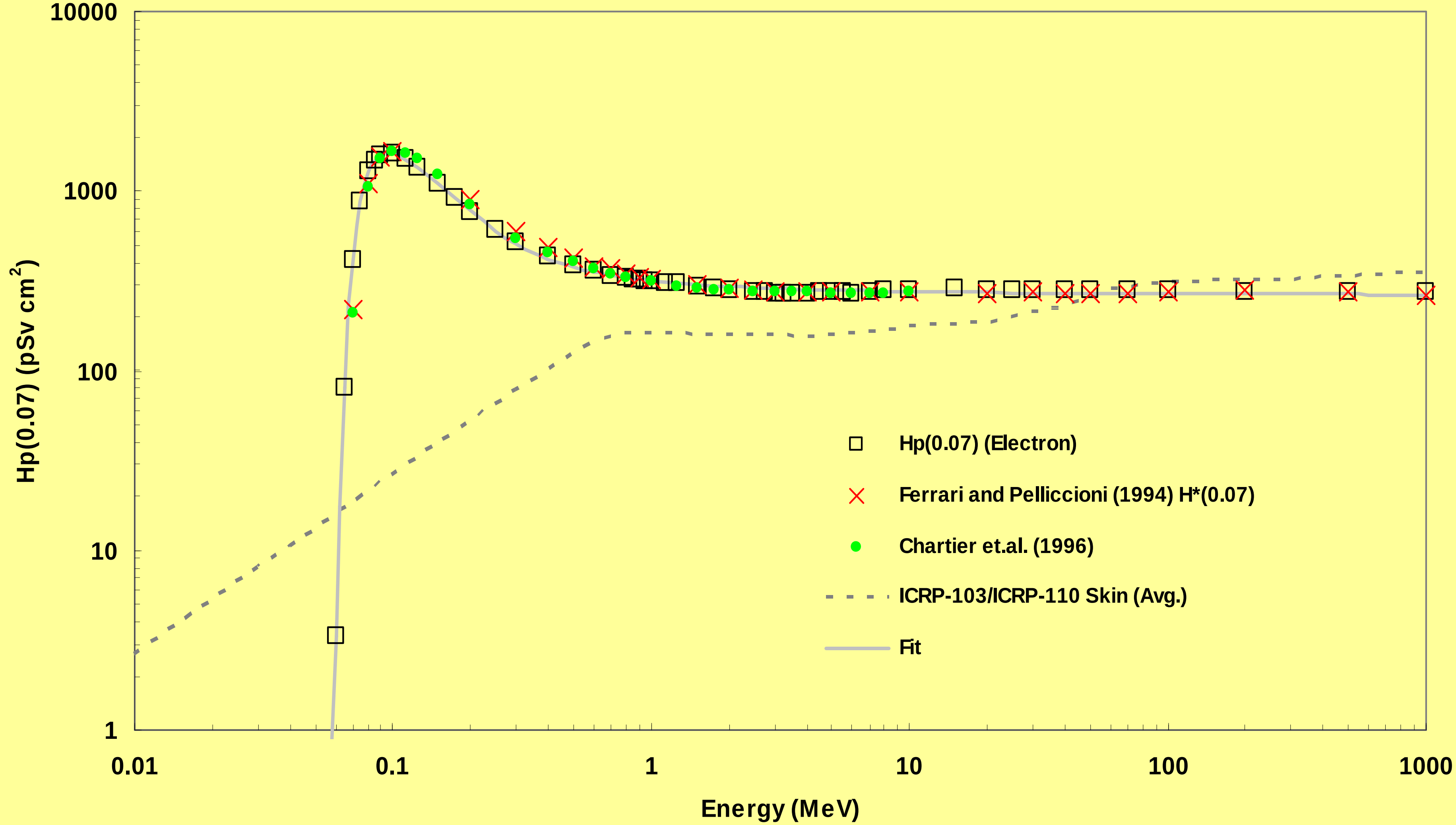


Photon DCF Fit Values

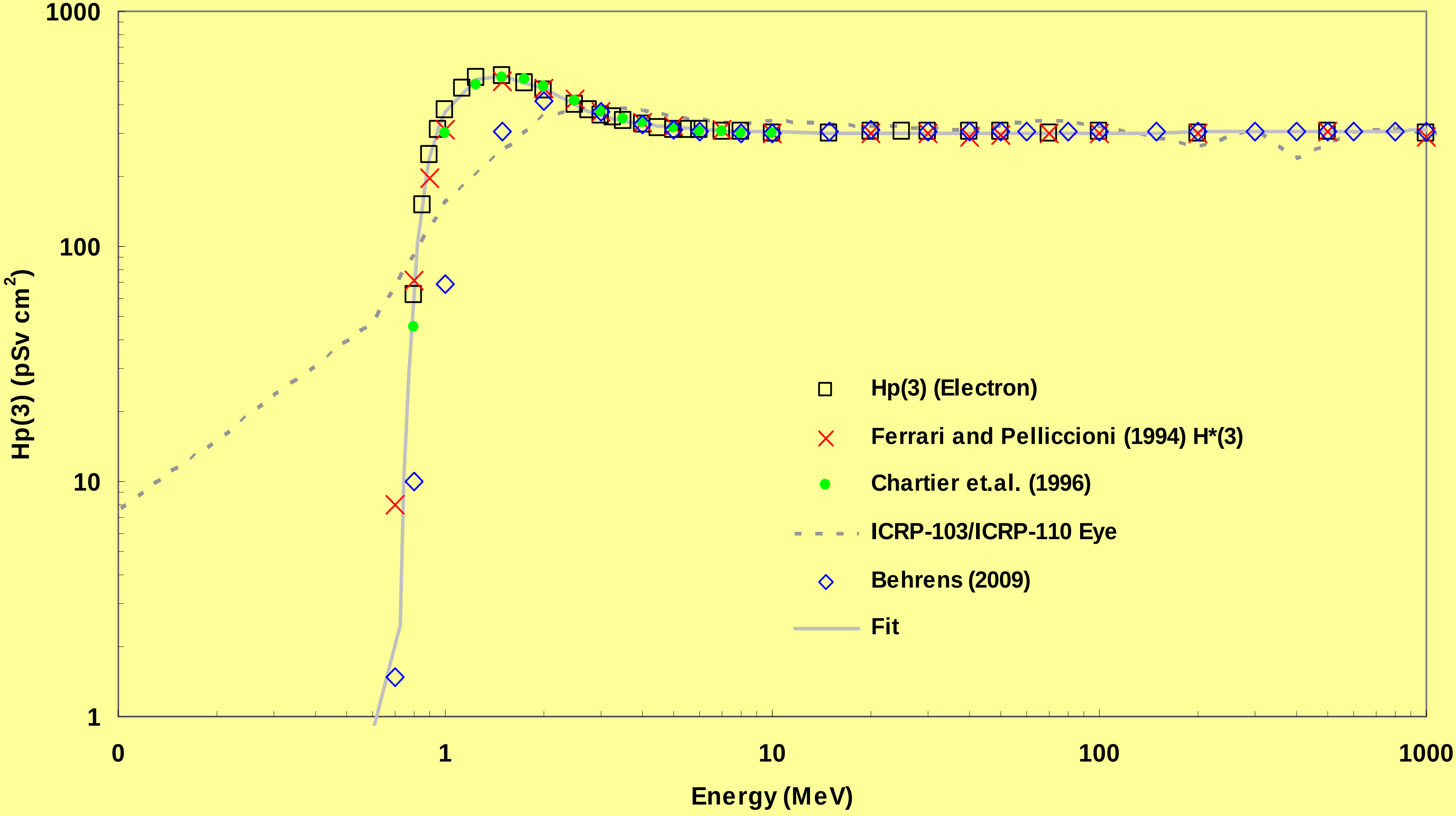
- Reported in RPD

	Vacuum						Air	
	$H_p(0.07)$	$H_p(3)$	$H_p(10)$	$K_p(0.07)$	$K_p(3)$	$K_p(10)$	$H_p(0.07)$	K_a
a	7.57E+00	3.50E+00	1.85E+01	1.47E+01	7.43E-01	1.08E+00	1.65E+01	3.40E+01
b	-5.02E+00	2.48E+00	2.45E+00	3.70E+00	-1.77E-01	-9.43E-02	9.35E-01	1.15E+00
c	-1.75E+00	1.25E+00	1.13E+00	1.36E+00	8.40E-01	7.67E-01	-1.93E-02	3.64E-01
d	-3.80E+00	4.53E-01	2.24E-01	1.07E+01	2.35E+01	2.05E+01	-1.43E+01	5.08E-01
f	1.08E+00	-3.66E-01	-1.38E+00	1.92E+00	1.53E+00	1.62E+00	-2.19E+01	1.47E+00
g	8.82E-01	1.97E+00	2.76E+00	9.70E-01	6.56E-01	7.63E-01	-7.66E+00	2.02E+00
h	-1.93E+01	-1.69E+00	-4.75E-01	-1.09E-01	-7.13E-01	-2.92E+00	4.93E-02	1.04E-01
j	6.25E+00	2.87E+01	3.13E+01	2.90E+01	3.07E+01	3.01E+01	3.91E+01	2.58E+01
k	1.92E+00	1.29E+01	1.53E+01	1.18E+01	1.42E+01	1.43E+01	1.74E+01	1.48E+01
l	9.26E-01	-3.28E+00	-4.45E+01	-5.19E+01	-5.69E+01	-5.74E+01	-3.82E+00	-4.63E+01
m	2.76E+00	2.77E+00	3.05E+00	5.93E-01	1.23E+00	1.33E+00	3.22E+00	4.43E-01
n	6.07E+00	2.77E+00	1.36E+00	1.28E-01	4.10E-01	4.02E-01	3.57E+00	4.42E-01
o	3.10E+00	7.82E-01	7.31E-01	1.68E+01	6.08E+00	6.28E+00	-9.77E+00	4.61E+00
p	-2.94E-01	3.42E+00	4.18E+00	-2.84E+00	-3.08E+00	-3.33E+00	-1.97E+00	-1.82E+00
q	2.34E+00	-1.62E+00	-2.00E+00	-1.96E+00	-2.80E+00	-2.93E+00	-1.25E+00	-2.76E+00
SSR	0.0038	0.0058	0.001	0.0011	0.0001	0.0001	0.004	0.0088

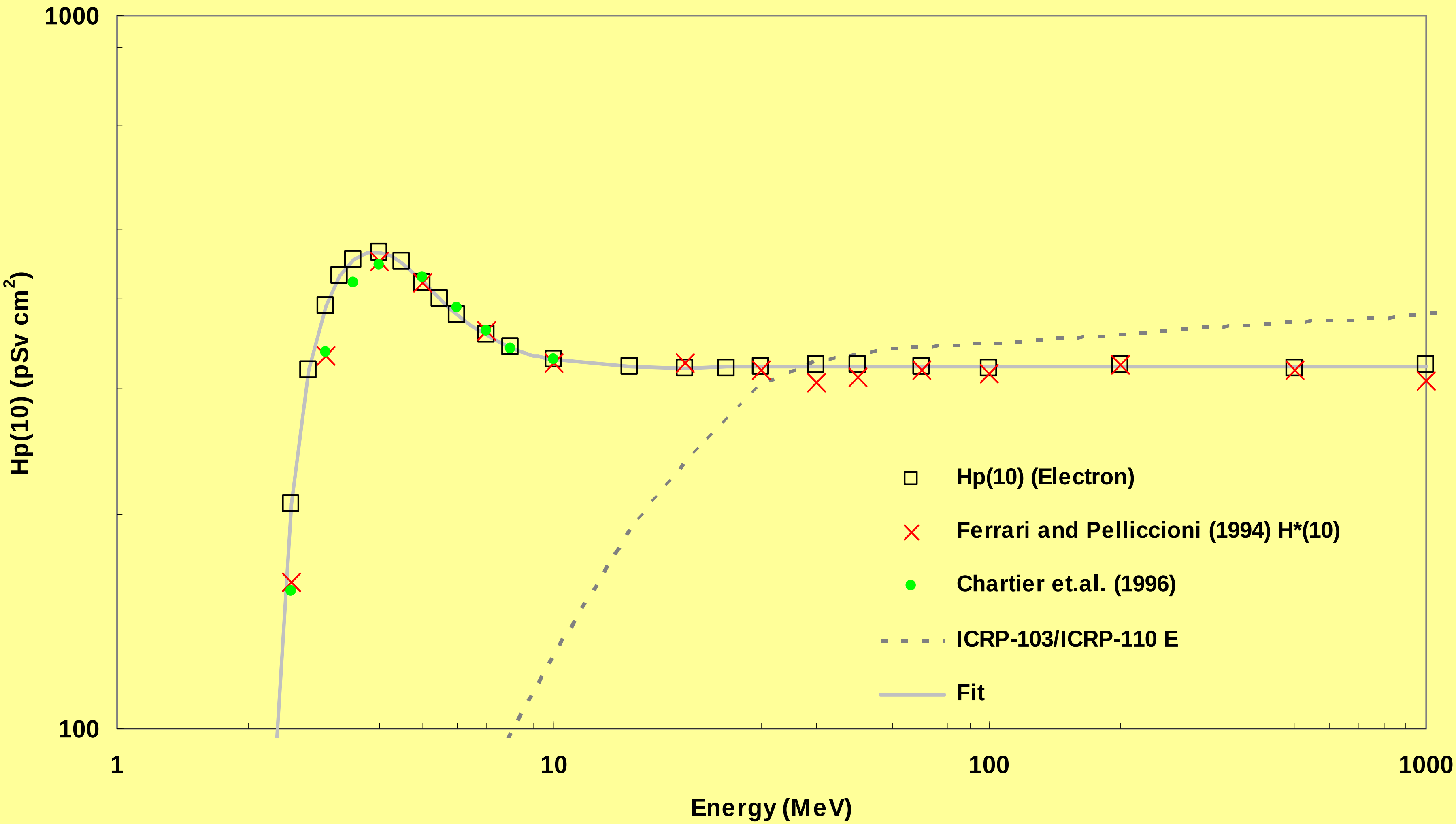
Electron $H_p(0.07)$



Electron $H_p(3)$



Electron $H_p(10)$



Electron DCF Fit Values

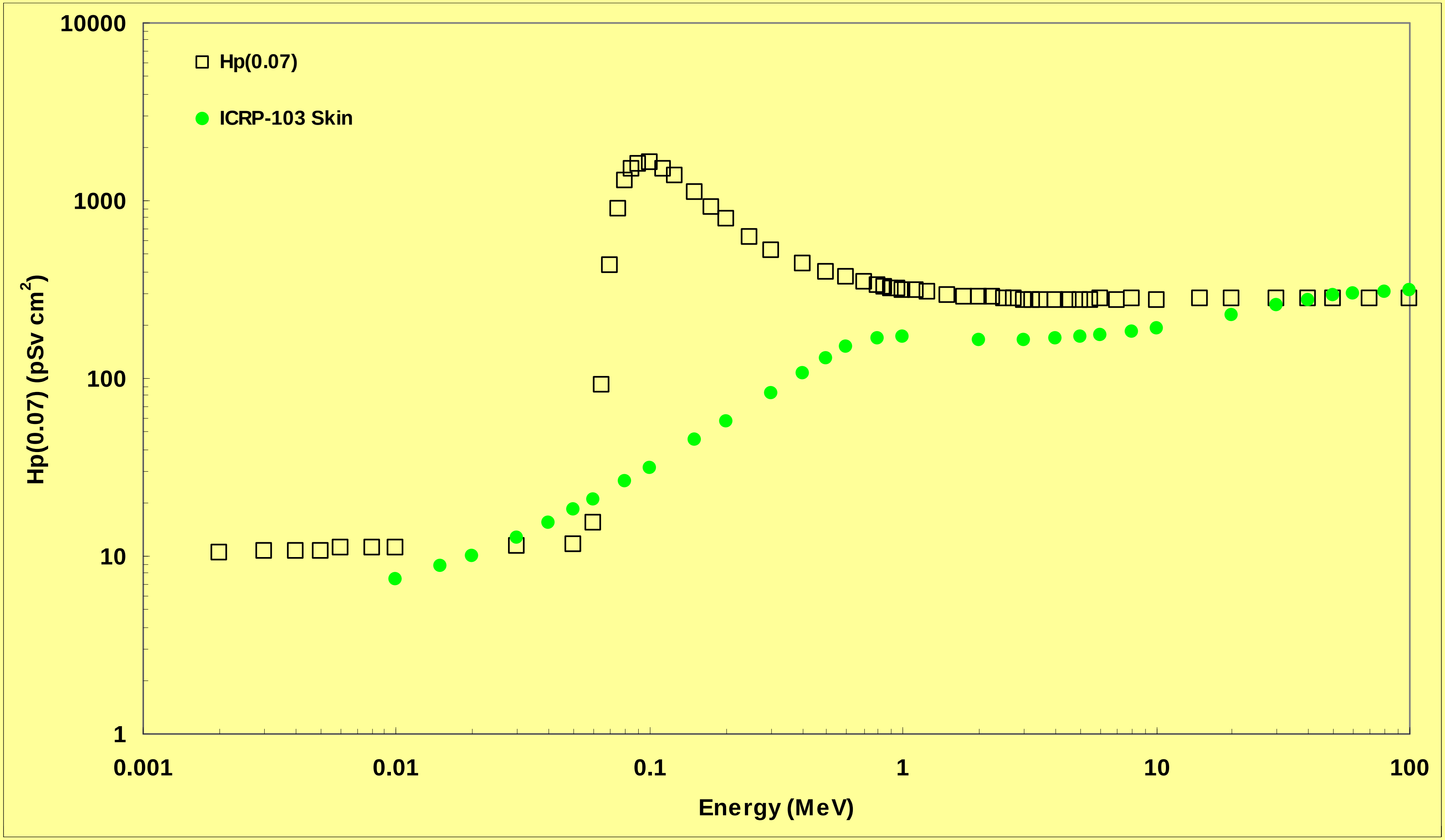
- Submitting to RPD

	$H_p(0.07)$	$H_p(3)$	$H_p(10)$
a	**0.00000**	**-9.17202**	**1.06130**
b	**0.00000**	**1.07748**	**4.26778**
c	**0.00000**	**0.00298**	**-12.60500**
d	**2.28538**	**0.35681**	**-1.44847**
f	**5.47047**	**0.87056**	**1.38694**
g	**5.26064**	**-5.66019**	**-2.72475**
h	**2.99892**	**1.21225**	**5.40744**
j	**17.70670**	**-1.74448**	**1.92784**
k	**15.06170**	**-14.00330**	**-4.97399**
l	**2.41815**	**0.15603**	**-4.79346**
m	**-54.56750**	**7.05332**	**3.62313**
n	**-47.82990**	**-27.97430**	**-25.28860**
o	**-2.85755**	**6.54168**	**7.29895**
p	**11.37260**	**-3.33105**	**5.57345**
q	**11.84780**	**-23.36220**	**-12.14040**
SSR	**0.00968**	**0.00076**	**0.00006**
Min E (MeV)	**0.06**	**0.7**	**2**
Max E (MeV)	**1000**	**1000**	**1000**

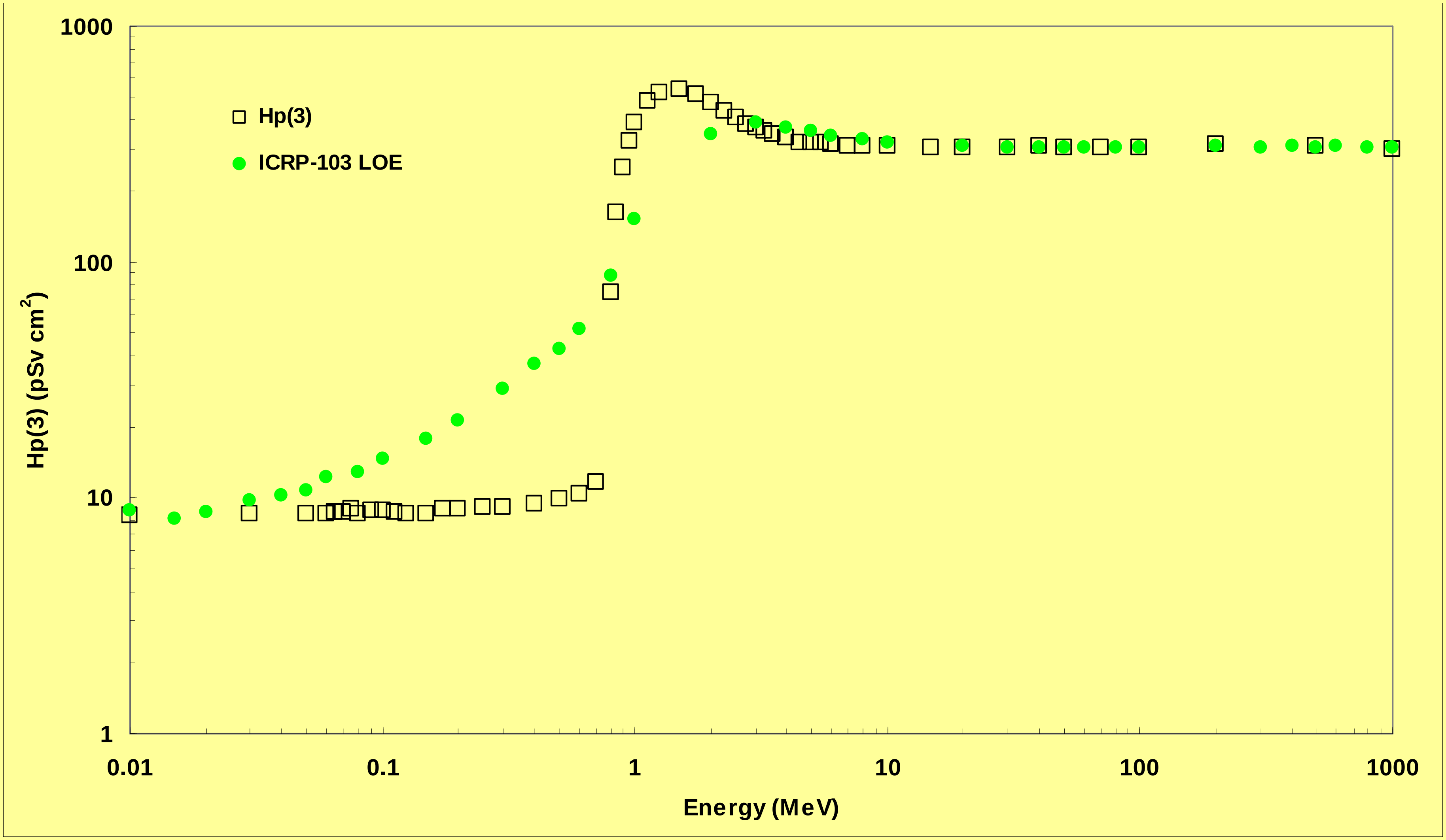
Positron DCFs

- Some differences in stopping powers of electrons and positrons
- MCNPX does not currently account for these
- Positron DCFs are approximations only

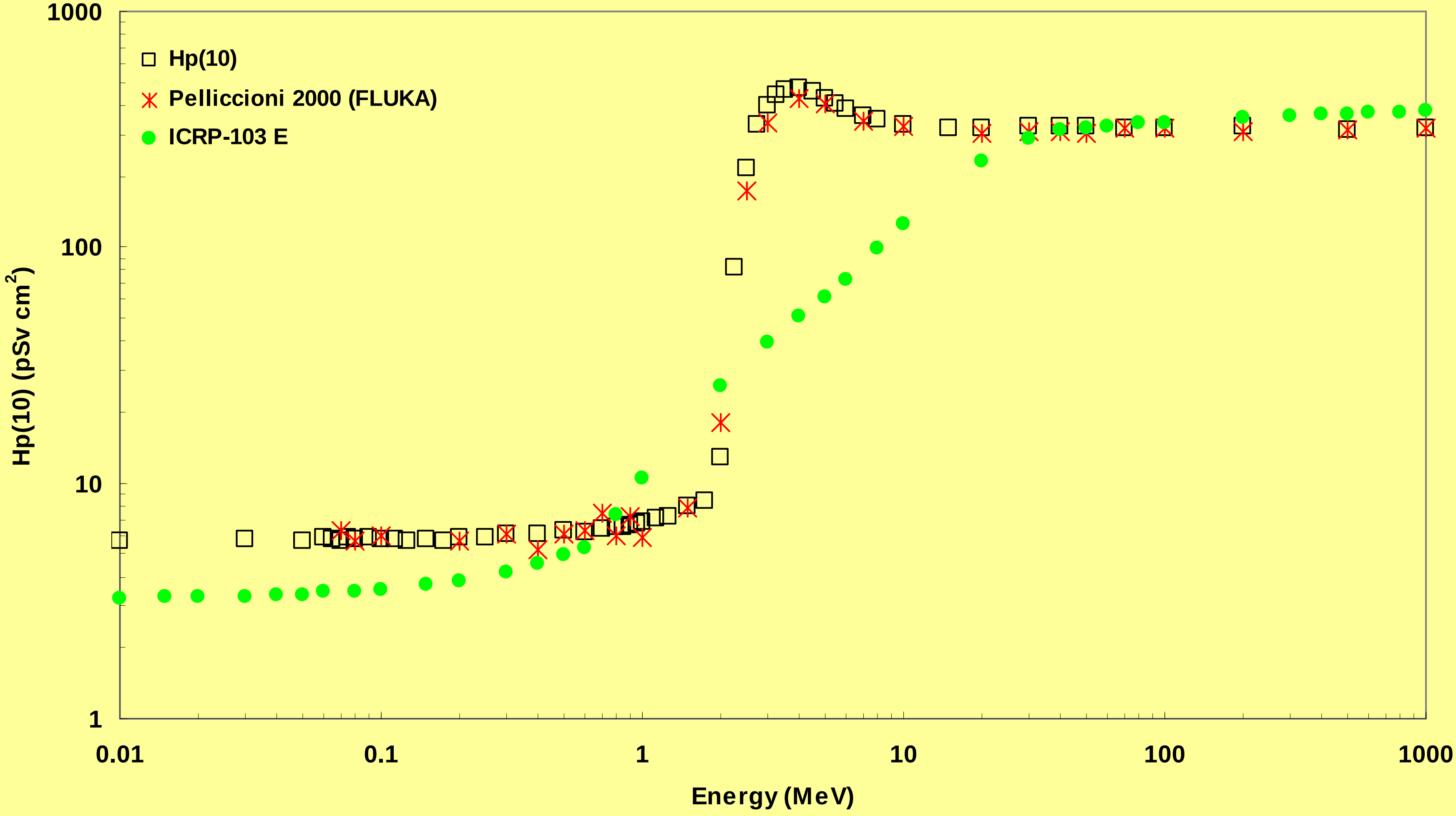
Positron $H_p(0.07)$



Positron $H_p(3)$



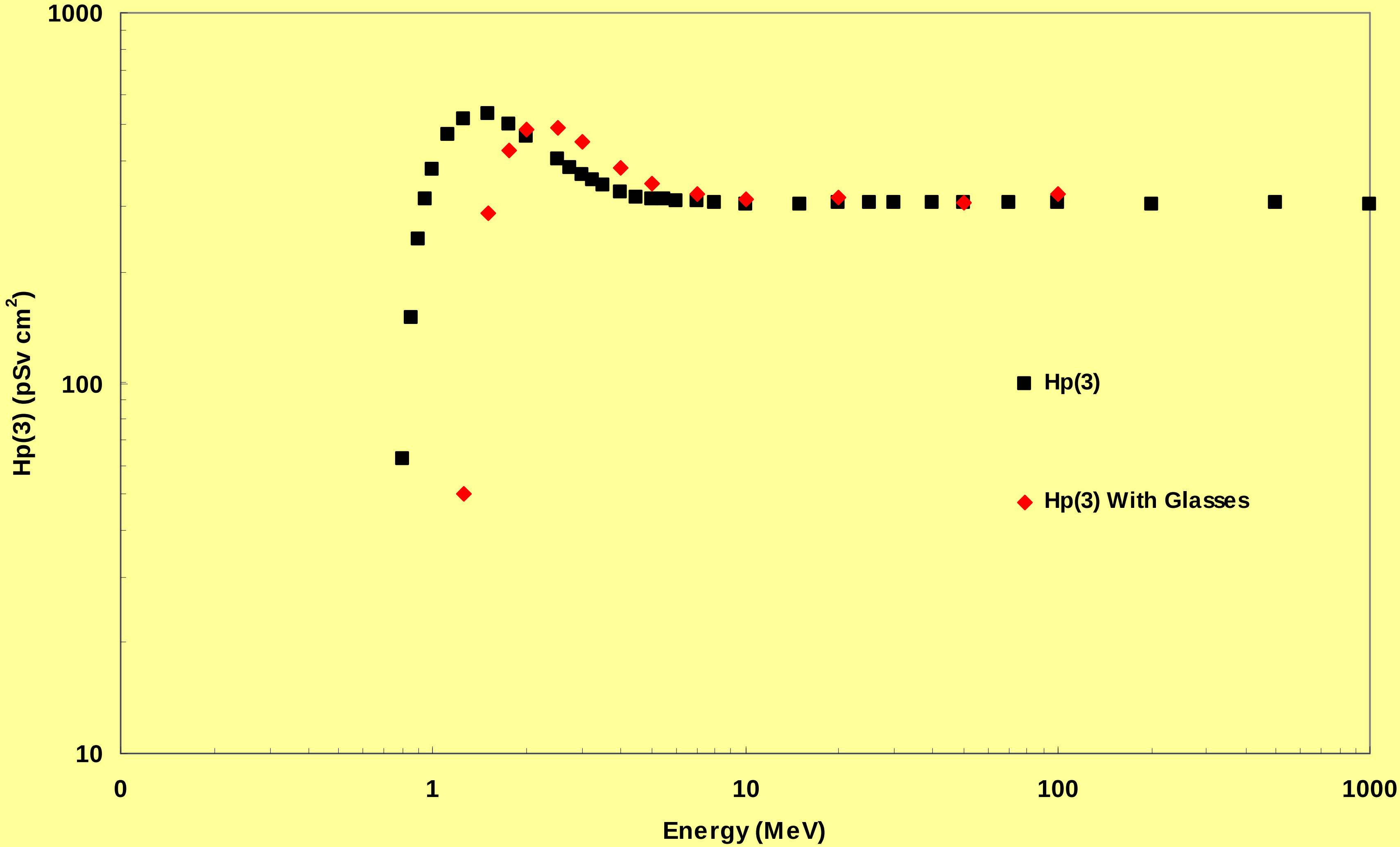
Positron $H_p(10)$



Special Considerations for $H_p(3)$

- Improved eye model
- New cataract risk factors
- In operational settings – eyewear (glasses, safety glasses, contact lenses)
- 0.2 cm polycarbonate lenses

Effect of Glasses on $H_p(3)$



Conclusions

- DCFs calculated
- $H_p(d) = H^*(d)$ Phantom unimportant?
- Photons – track secondary electrons
- Photons – $H_p(d)$ conservative until CPE lost
- Electrons - $H_p(d)$ conservative for most energies
- Positrons – Generally conservative
- Fits to DCFs allow easy conversion for spectra or other energies