

Calcul des coefficients de conversion $H_p(3) / K_{air}$ au moyen du code de Monte-Carlo PENELOPE et comparaison avec les résultats de calculs MCNP

J. Daures, J. Gouriou, JM. Bordy
CEA-LIST/LNHB

Codes de calculs en radioprotection, radiophysique et dosimétrie

4^e journées scientifiques francophones

28-29 avril 2010 Sochaux

- **Dosimétrie du cristallin en radiologie/cardiologie interventionnelle**
- **ORAMED project (Optimization of RAdiation protection for MEDical staff)
FP7 Grant Agreement 211361, Bruxelles.**

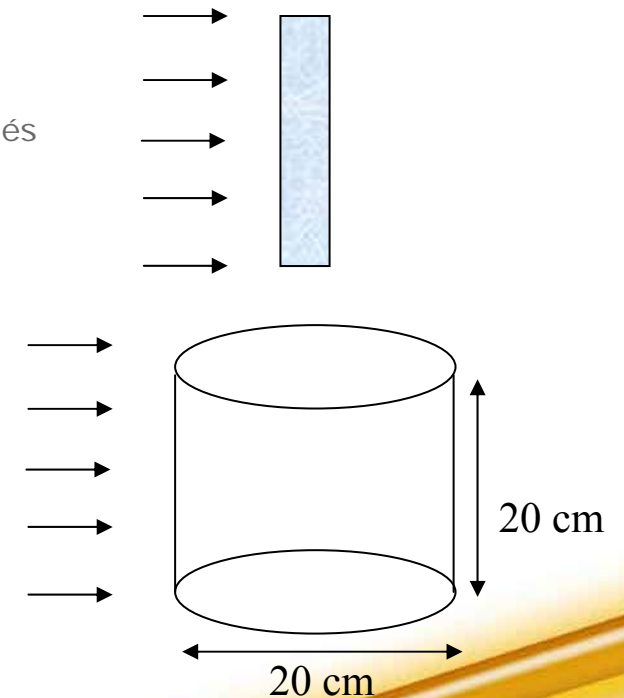
- Détermination des coefficients de conversion
 $H_p(3) / K_{air}$

- Comparaison de deux codes de calculs

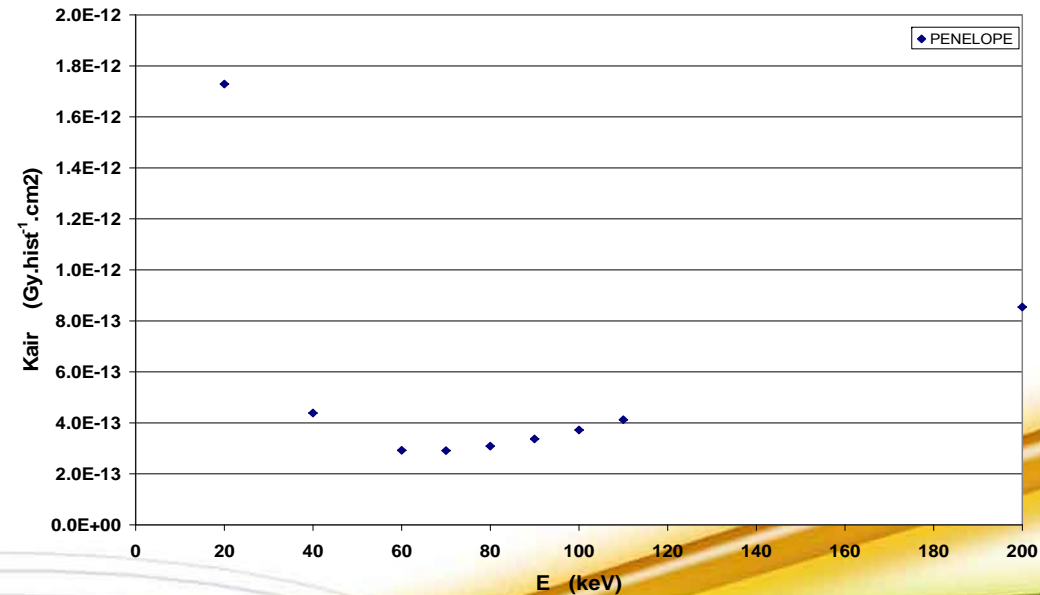
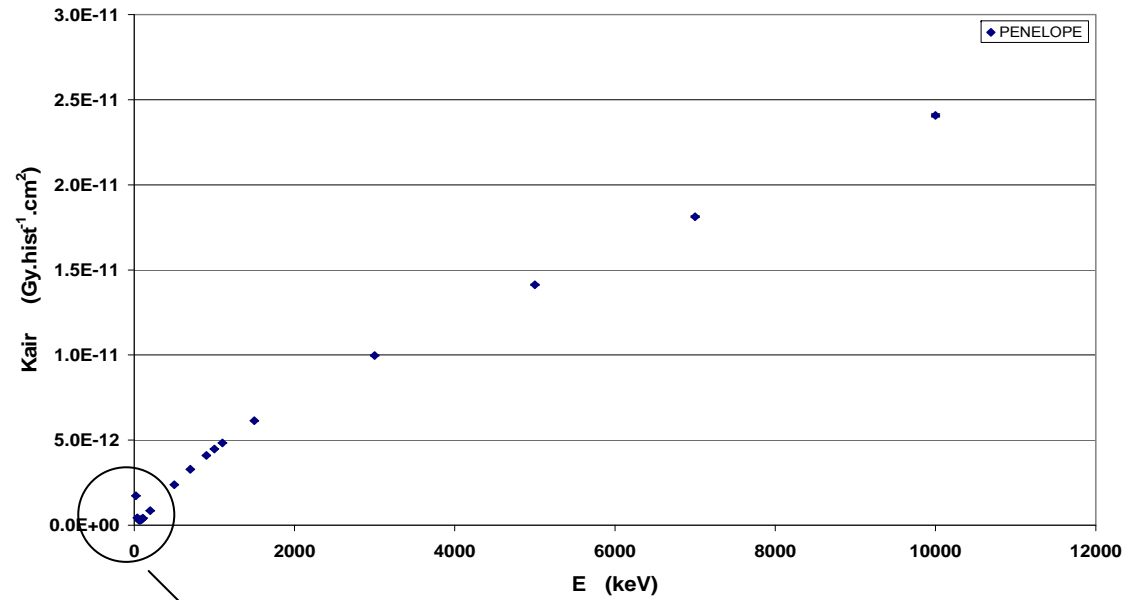
- PENELOPE LNHB
- MCNP4 ENEA
- MCNP5 LNHB

$H_p(3) / K_{air}$

- $H_p(3) / K_{air}$
- K_{air}
 - $K_{air} / \Phi = E \cdot (\mu_{tr} / \rho)_{air}$
 - $(\mu_{tr} / \rho)_{air}$ (ATTIX and HUBBELL 93)
 - ICRU 57
 - PENELOPE / MCNP
 - Les électrons créés par les photons sont immédiatement arrêtés après l'interaction ce qui correspond à la définition du kerma
- $H_p(3)$
 - PENELOPE / MCNP
 - Fantôme en matériau tissu 4 éléments
 - Dose absorbée à 3 mm de profondeur

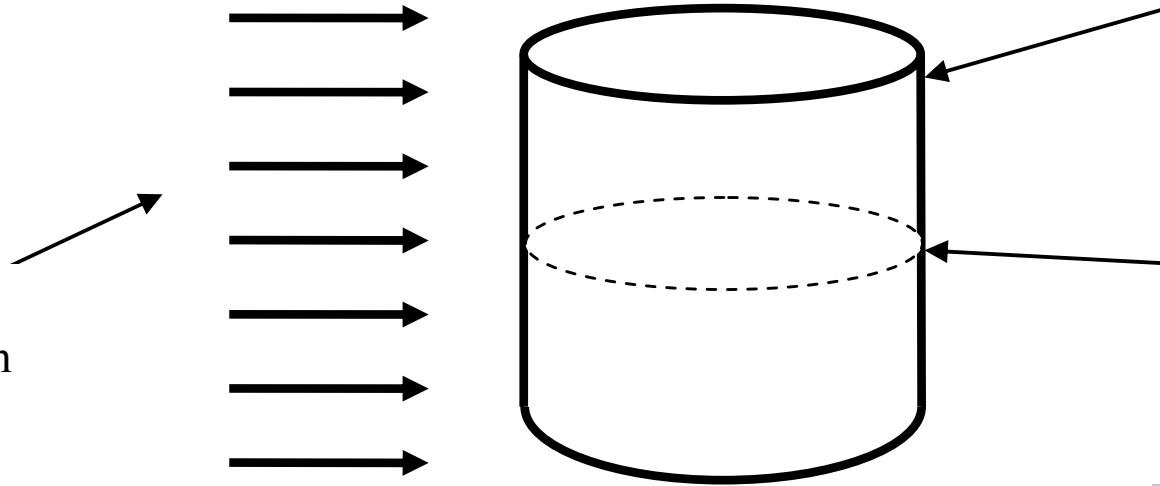


1: PENELOPE			2 : MCNP5		ratio : 1/2
Energy (keV)	Ka Gy.cm ²	1s %	Ka Gy.cm ²	1s %	
10			7.578E-12	0.01	
20	1.729E-12	0.01	1.727E-12	0.01	1.001
30	7.400E-13	0.01	7.382E-13	0.01	1.002
40	4.388E-13	0.03	4.380E-13	0.02	1.002
50	3.288E-13	0.01	3.284E-13	0.01	1.001
60	2.924E-13	0.03	2.924E-13	0.01	1.000
70	2.912E-13	0.03	2.911E-13	0.02	1.000
80	3.088E-13	0.02	3.086E-13	0.02	1.000
90	3.375E-13	0.03	3.370E-13	0.02	1.001
100	3.724E-13	0.02	3.726E-13	0.02	0.999
110	4.120E-13	0.03	4.127E-13	0.02	0.998
150	5.989E-13	0.01	5.993E-13	0.01	0.999
200	8.541E-13	0.02	8.566E-13	0.03	0.997
300	1.380E-12	0.01	1.380E-12	0.02	1.000
400	1.889E-12	0.01	1.890E-12	0.01	0.999
500	2.380E-12	0.03	2.378E-12	0.02	1.001
600	2.842E-12	0.01	2.840E-12	0.02	1.001
700	3.284E-12	0.01	3.280E-12	0.02	1.001
800	3.703E-12	0.01	3.700E-12	0.02	1.001
900	4.098E-12	0.01	4.095E-12	0.02	1.001
1000	4.473E-12	0.01	4.476E-12	0.02	0.999
1100	4.839E-12	0.01	4.834E-12	0.02	1.001
1500	6.137E-12	0.01	6.136E-12	0.02	1.000
2000	7.547E-12	0.02	7.544E-12	0.02	1.000
3000	9.952E-12	0.02	9.953E-12	0.02	1.000
4000	1.211E-11	0.02	1.211E-11	0.02	1.000
5000	1.414E-11	0.02	1.415E-11	0.02	1.000
6000	1.613E-11	0.02	1.613E-11	0.02	1.000
7000	1.810E-11	0.02	1.810E-11	0.02	1.000
8000	2.008E-11	0.02	2.008E-11	0.02	1.000
10000	2.405E-11	0.03	2.407E-11	0.03	0.999



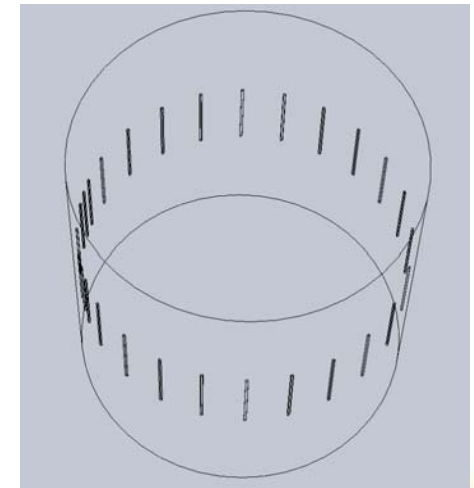
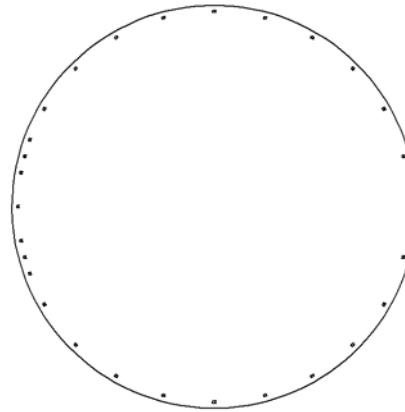
$H_p(3)$

Parallel
photon beam
in vacuum

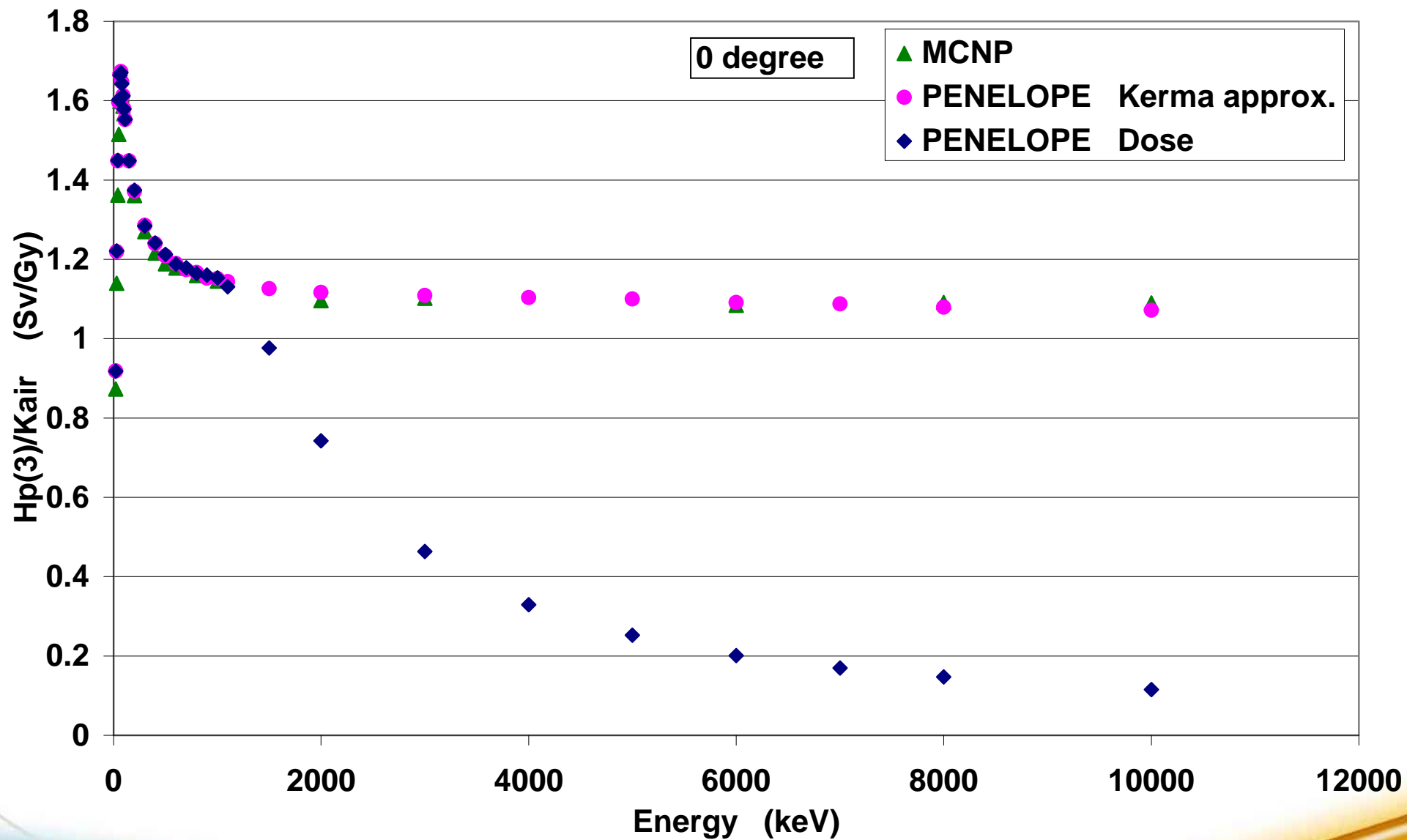


ICRU tissue
phantom
 $\Phi = 20\text{cm}$
 $h = 20\text{cm}$

Phantom
Mid-plane
for scoring
volumes



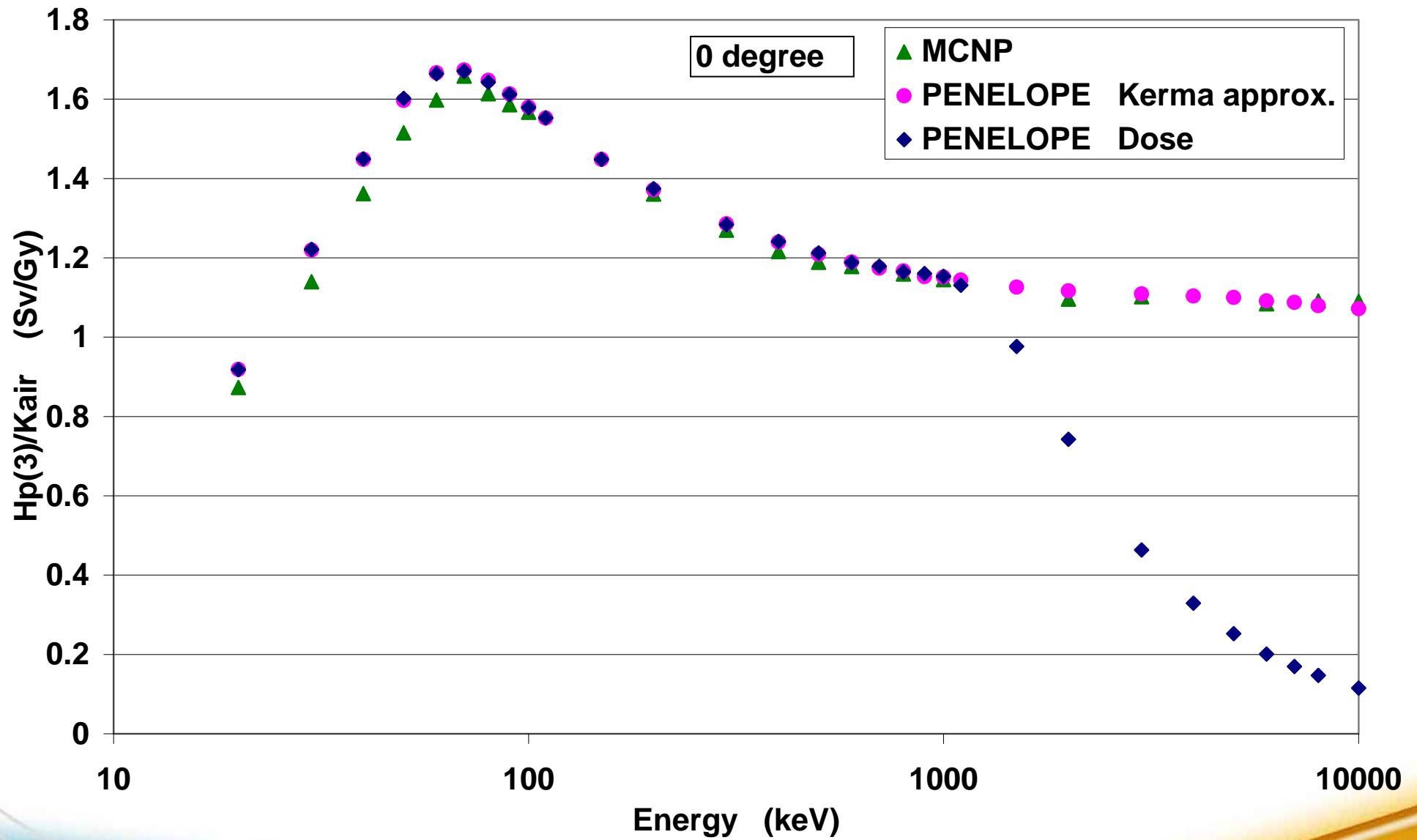
$H_p(3)/K_{air}$ 0 degré



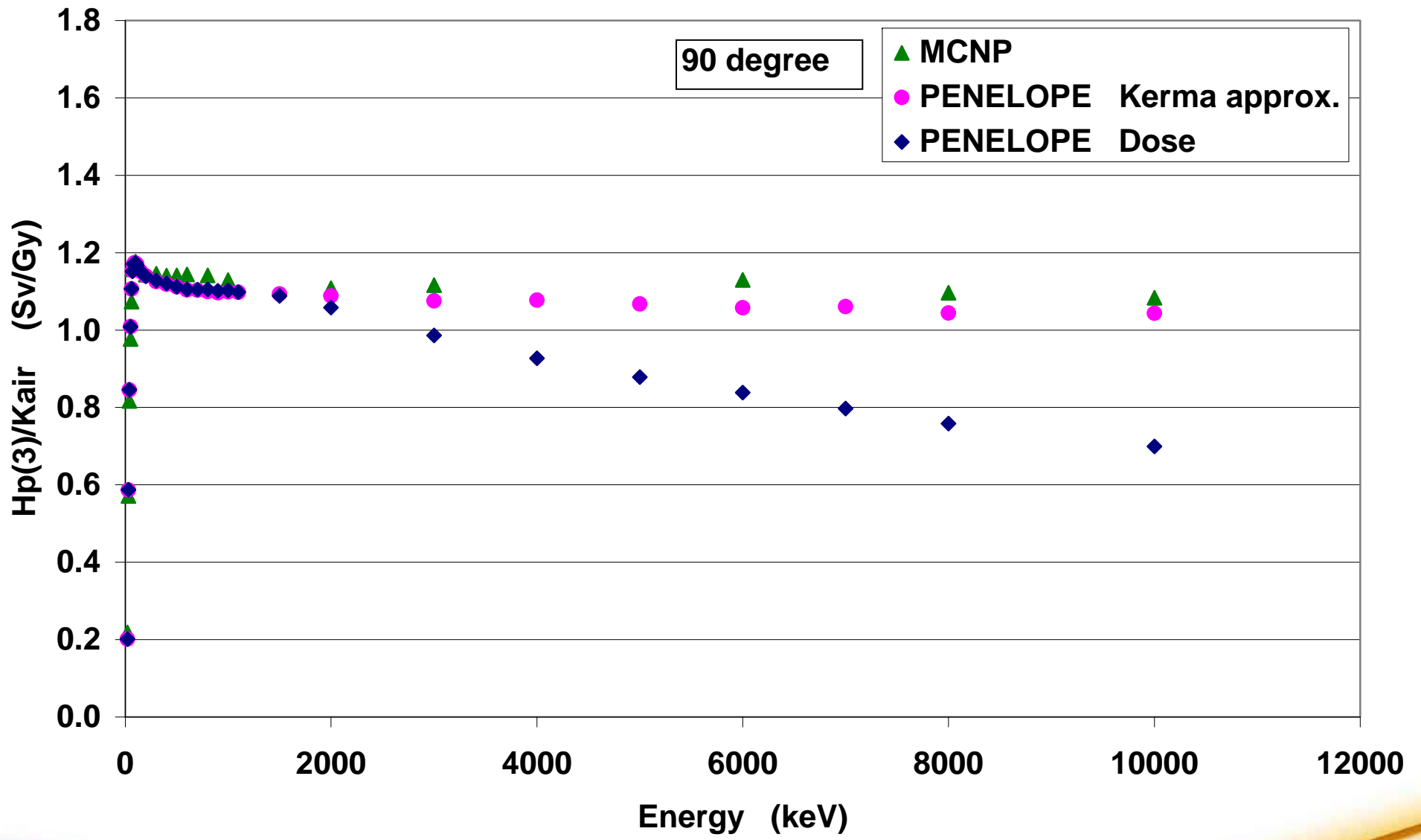
$H_p(3) / K_{air}$

0 degré

semi log



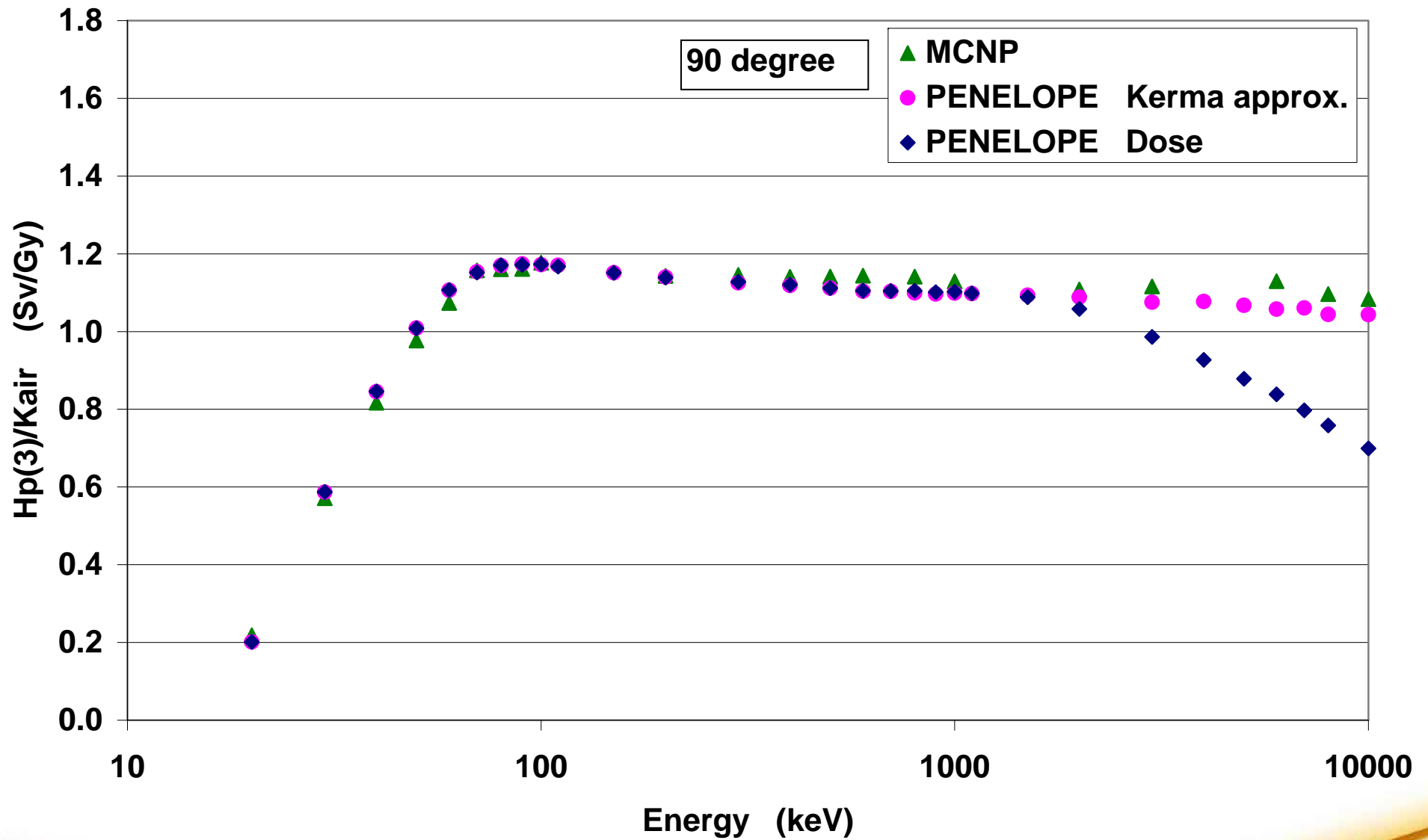
$H_p(3) / K_{air}$ 90 degrés



$H_p(3) / K_{air}$

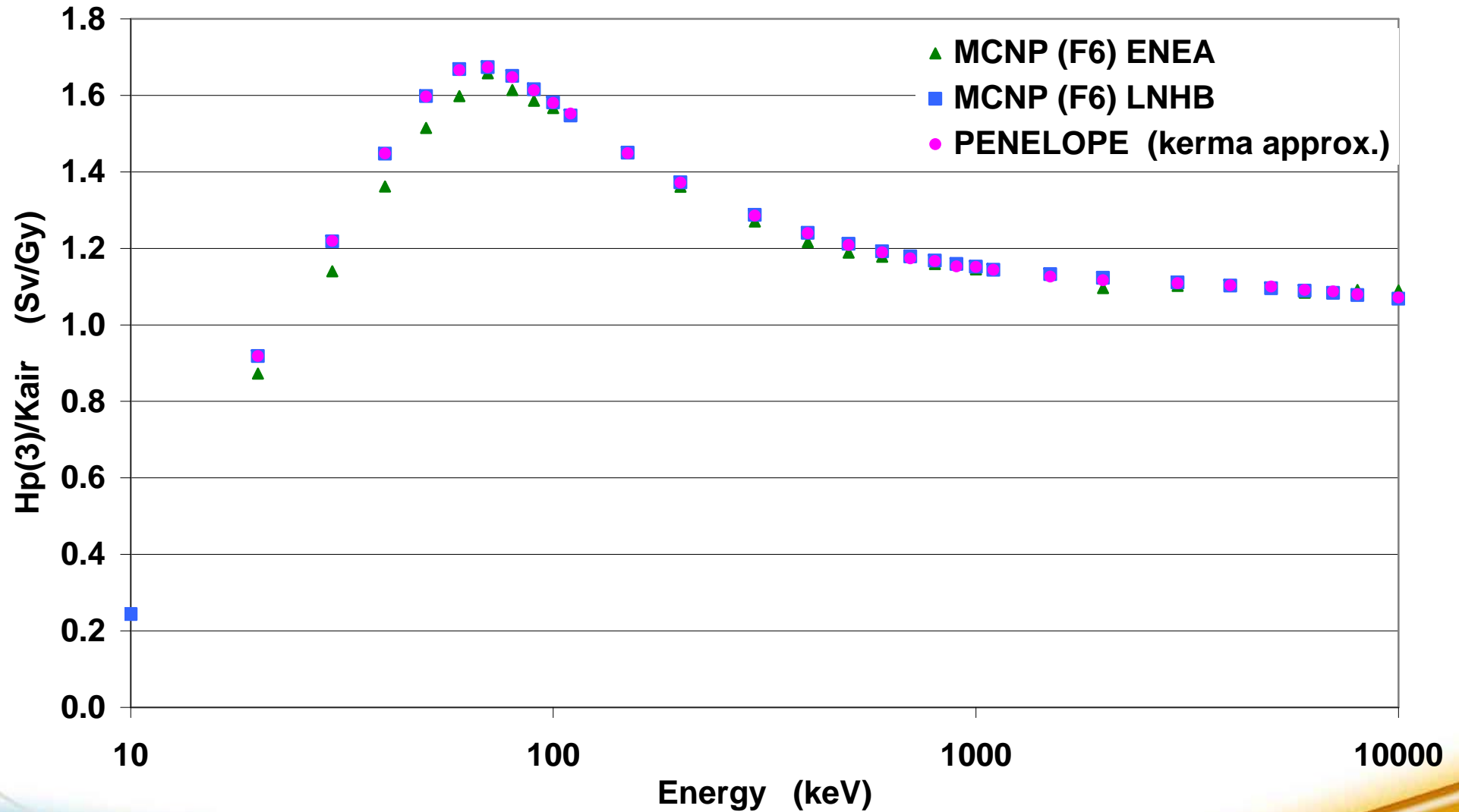
90 degrés

semi log



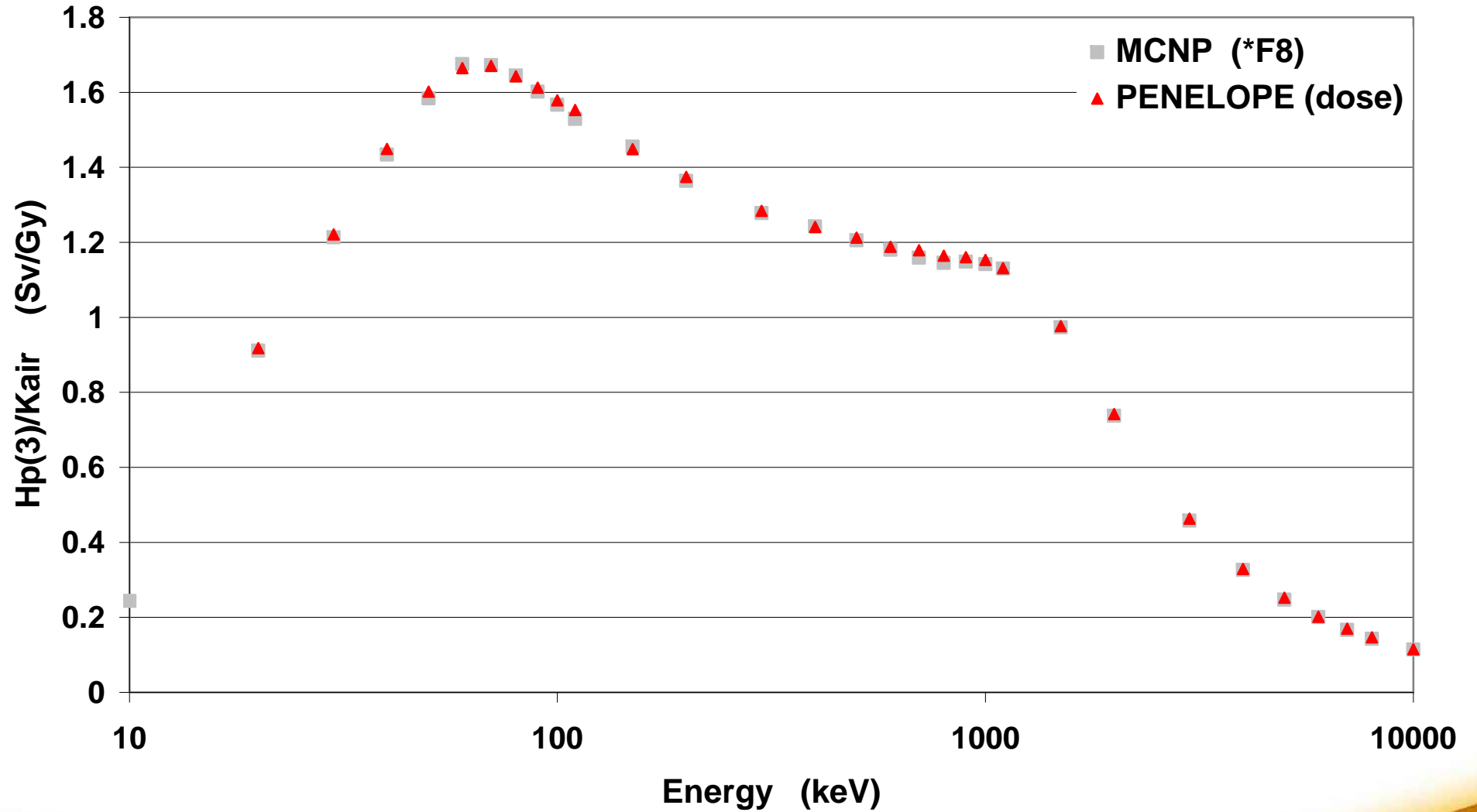
$H_p(3) / K_{air}$ 0 degré

PENELOPE (kerma approx.) and MCNP (F6)



$$H_p(3)/K_{air}$$

PENELOPE (dose) and MCNP (*F8)



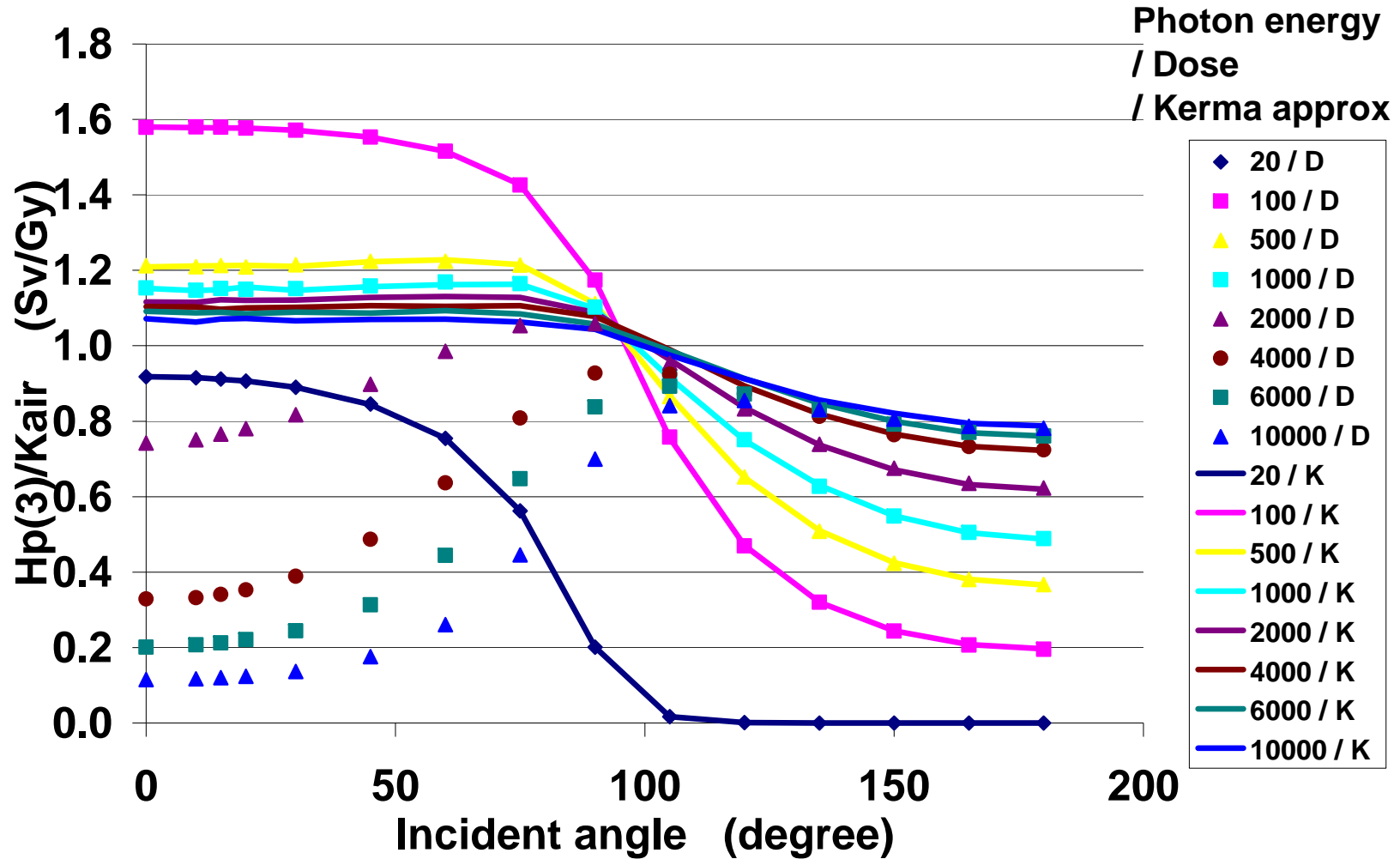
Hp(3)/Ka values calculated with PENELOPE and MCNP5 for 0 degree incident angle (absorbed dose mode).

Energy (keV)	3 : PENELOPE		4 : MCNP5		ratio 3/4
	Hp(3)/Kair (Sv/Gy)	1 s (%)	Hp(3)/Kair (Sv/Gy)	1 s (%)	
10			0.244	0.2	
20	0.918	0.1	0.911	0.2	1.008
30	1.221	0.1	1.213	0.4	1.007
40	1.449	0.2	1.434	0.5	1.010
50	1.602	0.2	1.584	0.6	1.011
60	1.664	0.2	1.675	0.6	0.993
70	1.670	0.2	1.672	0.5	0.999
80	1.643	0.2	1.645	0.5	0.999
90	1.612	0.2	1.602	0.5	1.006
100	1.579	0.2	1.566	0.5	1.008
110	1.553	0.2	1.529	0.5	1.016
150	1.448	0.2	1.455	0.5	0.995
200	1.374	0.2	1.364	0.5	1.008
300	1.284	0.2	1.278	0.5	1.004
400	1.241	0.3	1.242	0.5	0.999
500	1.212	0.3	1.205	0.5	1.006
600	1.188	0.3	1.180	0.6	1.007
700	1.179	0.2	1.159	0.6	1.017
800	1.164	0.3	1.145	0.5	1.016
900	1.160	0.2	1.148	0.6	1.011
1000	1.153	0.3	1.142	0.5	1.010
1100	1.131	0.2	1.130	0.2	1.001
1500	0.977	0.2	0.973	0.5	1.004
2000	0.742	0.4	0.738	0.5	1.006
3000	0.463	0.4	0.458	0.6	1.012
4000	0.329	0.5	0.326	0.6	1.008
5000	0.252	0.5	0.247	0.7	1.021
6000	0.201	0.5	0.201	0.8	1.002
7000	0.170	0.5	0.167	0.9	1.016
8000	0.147	0.6	0.143	0.9	1.030
10000	0.115	0.6	0.114	0.9	1.007

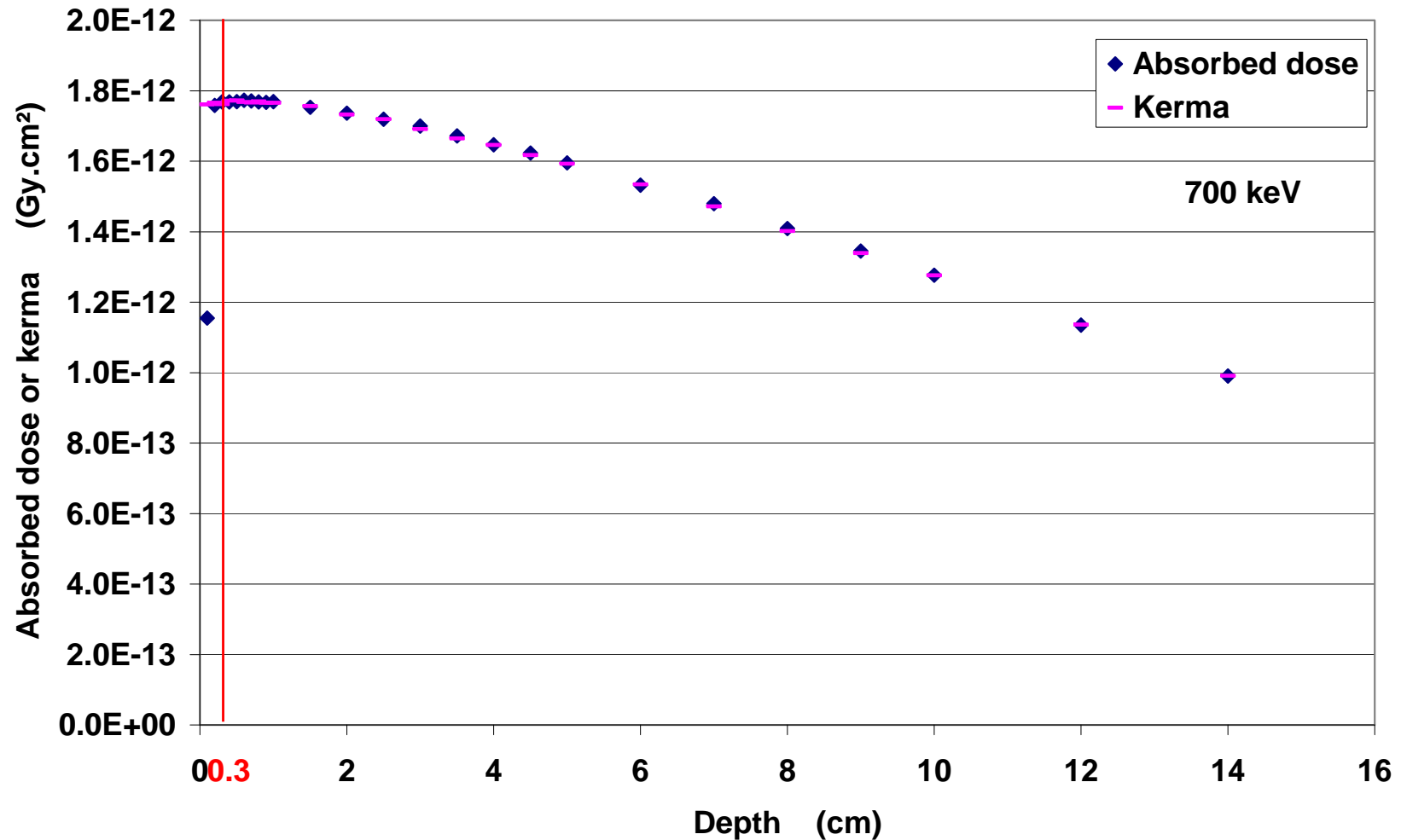
Hp(3)/Ka values calculated with PENELOPE and MCNP5 for 0 degree incident angle (approximation kerma mode).

Energy (keV)	1 : PENELOPE		2 : MCNP5		ratio 1/2
	Hp(3)/Ka (Sv/Gy)	1 s (%)	Hp(3)/Ka (Sv/Gy)	1 s (%)	
10			0.244	0.2	
20	0.918	0.1	0.919	0.1	1.000
30	1.219	0.1	1.218	0.1	1.001
40	1.448	0.1	1.448	0.1	1.000
50	1.597	0.1	1.598	0.1	0.999
60	1.666	0.2	1.668	0.1	0.999
70	1.673	0.1	1.674	0.1	1.000
80	1.648	0.2	1.651	0.1	0.998
90	1.613	0.1	1.616	0.1	0.998
100	1.580	0.1	1.582	0.1	0.999
110	1.552	0.3	1.547	0.1	1.003
150	1.449	0.1	1.450	0.1	0.999
200	1.372	0.2	1.373	0.1	0.999
300	1.286	0.2	1.287	0.1	0.999
400	1.240	0.2	1.241	0.1	0.999
500	1.209	0.2	1.212	0.1	0.998
600	1.189	0.2	1.192	0.1	0.998
700	1.174	0.3	1.179	0.1	0.996
800	1.167	0.3	1.168	0.1	0.999
900	1.153	0.3	1.159	0.1	0.994
1000	1.152	0.3	1.152	0.1	1.000
1100	1.144	0.3	1.144	0.1	1.000
1500	1.126	0.3	1.132	0.1	0.995
2000	1.116	0.2	1.123	0.1	0.994
3000	1.109	0.2	1.111	0.1	0.998
4000	1.103	0.3	1.103	0.1	1.000
5000	1.100	0.3	1.096	0.1	1.004
6000	1.091	0.4	1.089	0.1	1.002
7000	1.088	0.4	1.083	0.1	1.004
8000	1.080	0.4	1.078	0.1	1.002
10000	1.072	0.4	1.069	0.1	1.003

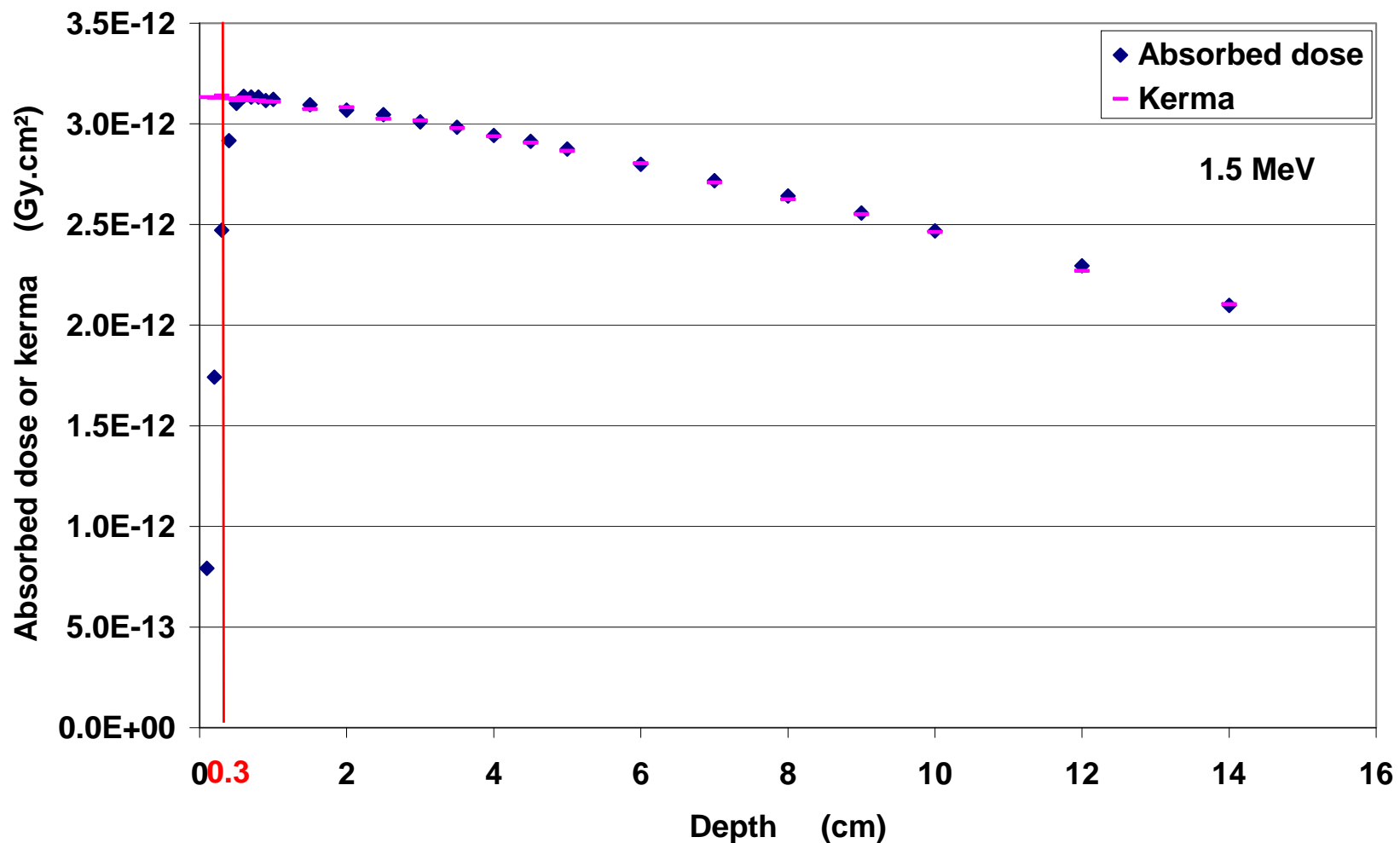
$$H_p(3) / K_{air}$$



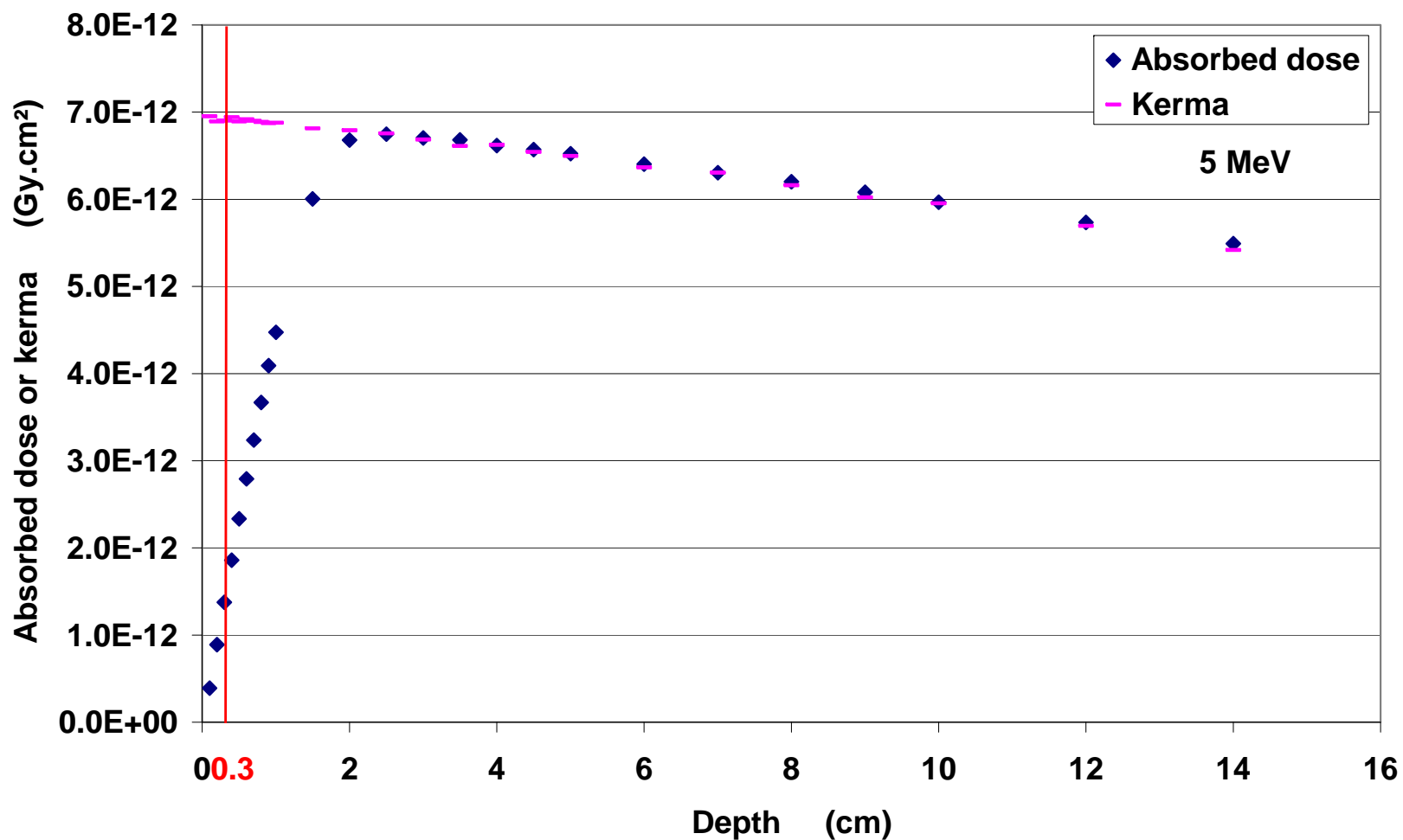
Dose absorbée et kerma en profondeur 700 keV



Dose absorbée et kerma en profondeur 1,5 MeV



Dose absorbée et kerma en profondeur 5 MeV



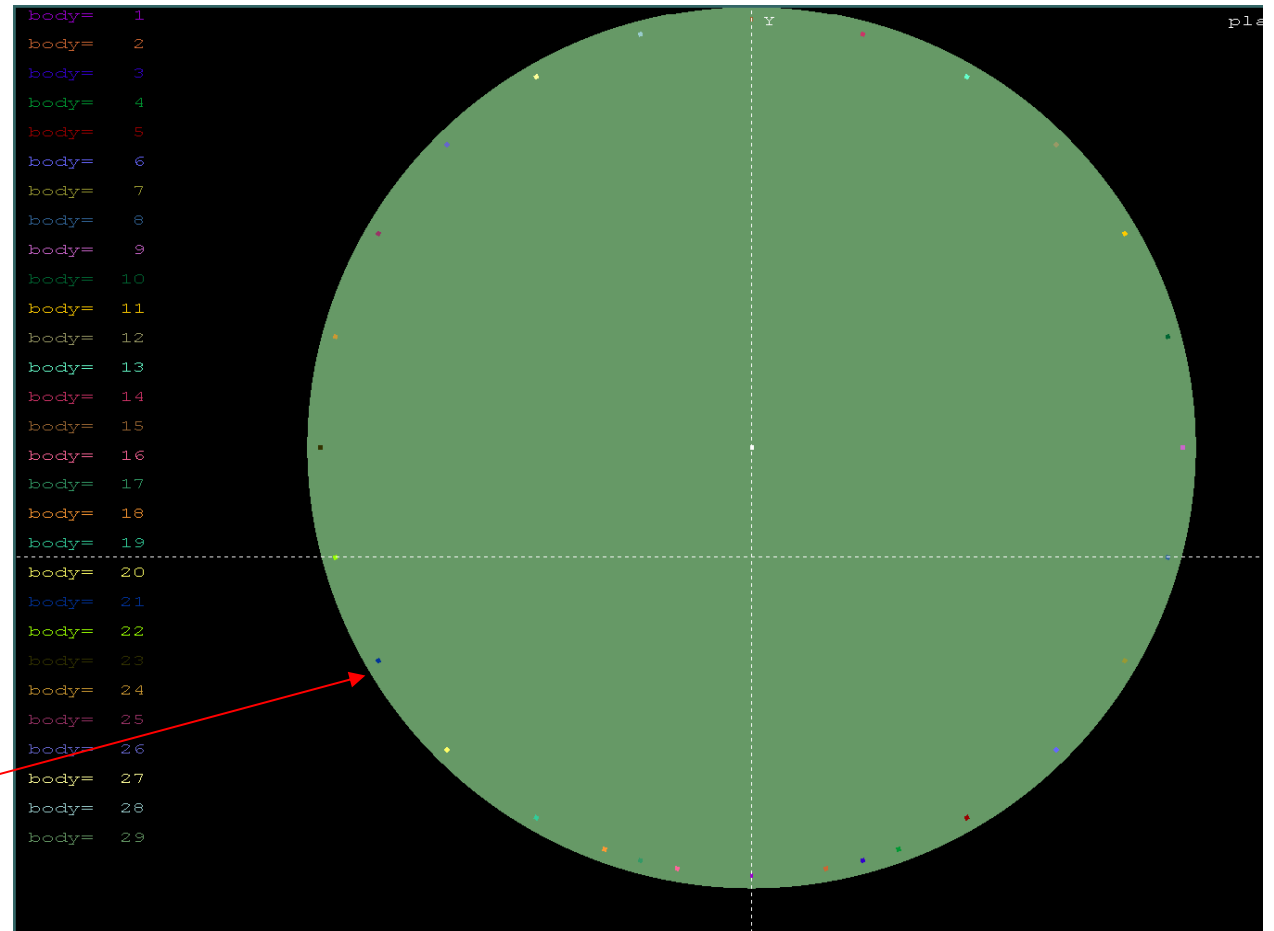
CONCLUSIONS

- *Coefficients de conversion $H_p(3)/K_{air}$ dans le fantôme cylindrique, calculés de 10 keV à 10 MeV de 0 à 180 degrés et publiés dans*
 - *CEA-R-6235,*
 - *Rad. Prot. Dosimetry à paraître.*
- *Importance des paramètres physiques sur le résultat des calculs (approximation kerma ou dose pour le calcul de $H_p(3)$)*
- *Importance d'effectuer des calculs aussi indépendants que possible (codes, paramètres physiques, laboratoires...)*
- *Valider les hypothèses simplificatrices*
- *Analyser de façon critique et physique les résultats des calculs de Monté-Carlo*

Merci de votre attention

$H_p(3)$ PENELOPE

volume element
thickness 0.5 mm
width 1 mm
height 5 cm



parallel extended beam