

Efficacy of VARSKIN for Eye Dosimetry

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Introduction

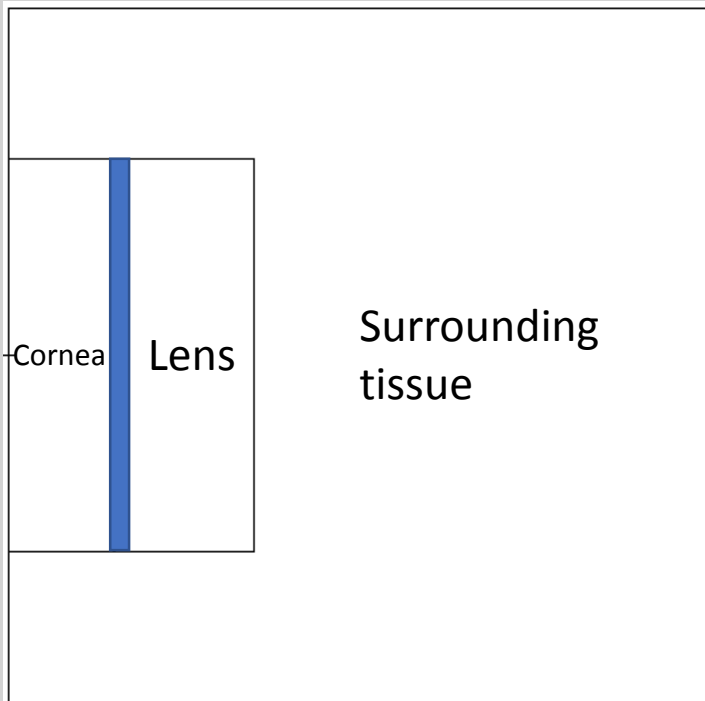
- VARSKIN originally intended for estimating shallow dose from skin contamination
 - to show compliance with 10 CFR 20.1201
- April 2011, new dose limit guidance from ICRP
 - 20 mSv/yr, averaged over 5 yrs, < 50 mSv in any one year
- Users ask about VARSKIN for eye dosimetry
- Therefore, in its current state, how well does VARSKIN estimate eye dose?

Eye Diagram

300 mg/cm²



1 cm²



VARSKIN 5.3 (setup with 1 cm air gap)

Varskin 5.3

File Help

Source Geometry

☐ Point

☐ Sphere

☐ Disk

☐ Slab

☐ Cylinder

Special Options

☐ Include Photon Dose

☐ Perform Volume Averaging

☐ Offset Particle Model

Skin Averaging Area

1.00E+00

cm²

Exposure Time

1.00E+00

sec

Radionuclide Library [Zeff]

Ac-228 [7.42]

Ba-137m [7.42]

Be-7 [7.42]

Bi-210 [7.42]

Bi-212 [7.42]

Bi-214 [7.42]

C-11 [7.42]

C-14 [7.42]

Ca-45 [7.42]

Cl-36 [7.42]

Co-60 [26]

Co-60 [7.42]

Activity Units

Bq

Select

Add

Remove

Selected Radionuclides

Be-7 [7.42]: 1.00E+00 Bq

Edit

Remove

Clear

Point Source Irradiation Geometry

Skin Thickness or Skin Density Thickness:

3.00E+02

mg/cm²

Air Gap Thickness

1.00E+00

cm

Cover Thickness

0.00E+00

cm

Cover Density

0.00E+00

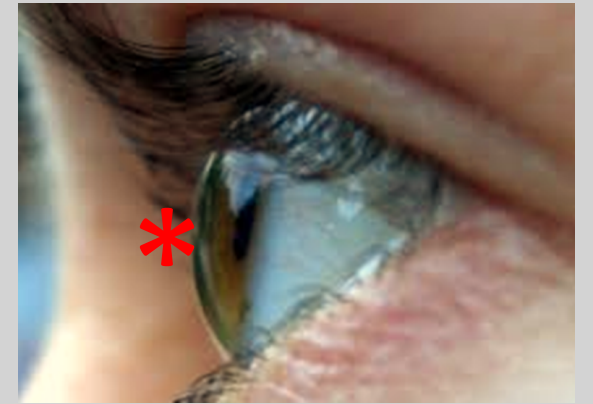
g/cm³

Multiple Cover Calculator

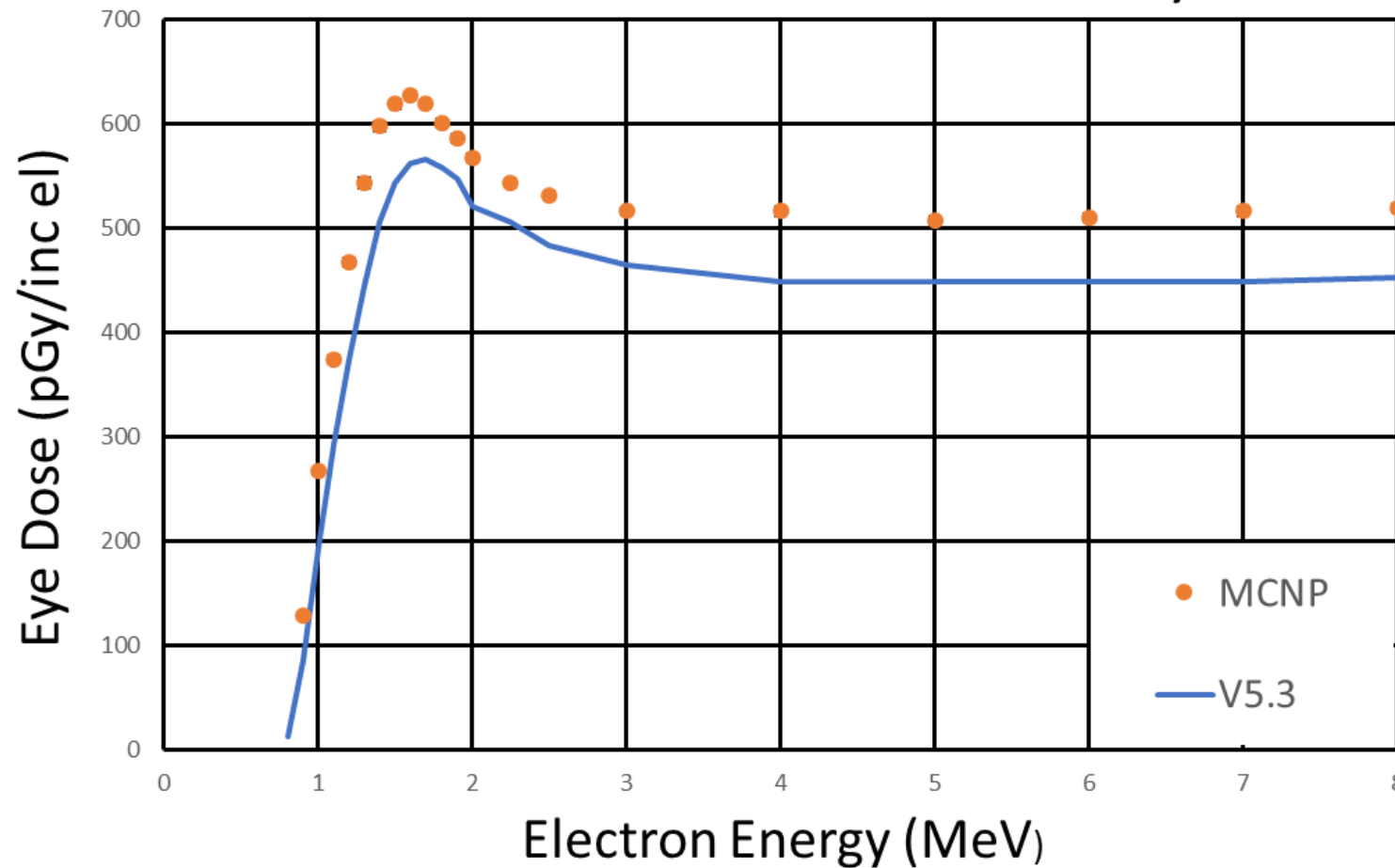
varskin V5

Calculate Doses

No Air Gap



Dose to the Lens - Source on the Eyeball

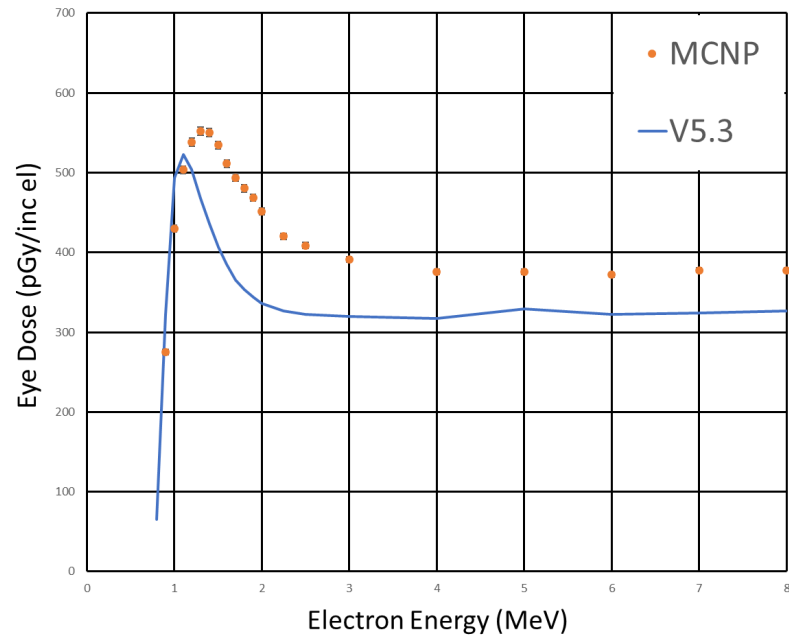


VARSKIN
underestimates
by roughly 10%

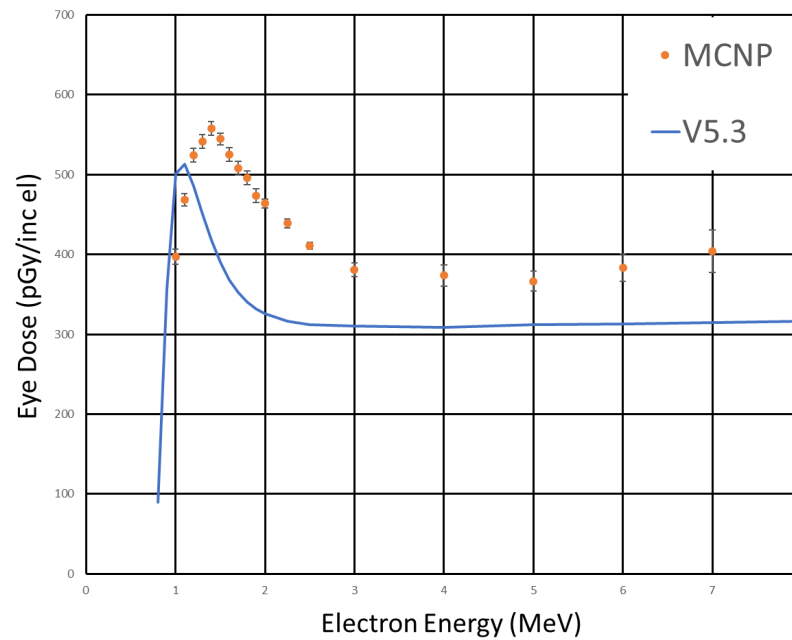
- Equal Scales
- Normalized for incident energy by solid angle
- MCNP standard error expected to increase with distance



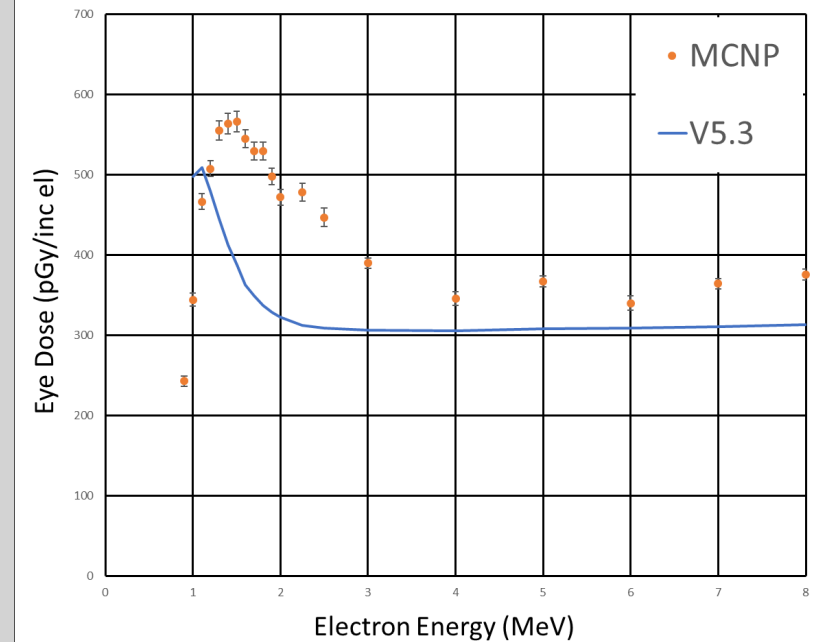
Dose to the Lens - Source 1 cm from Eyeball



Dose to the Lens - Source 2 cm from Eyeball



Dose to the Lens - Source 5 cm from Eyeball



20
*

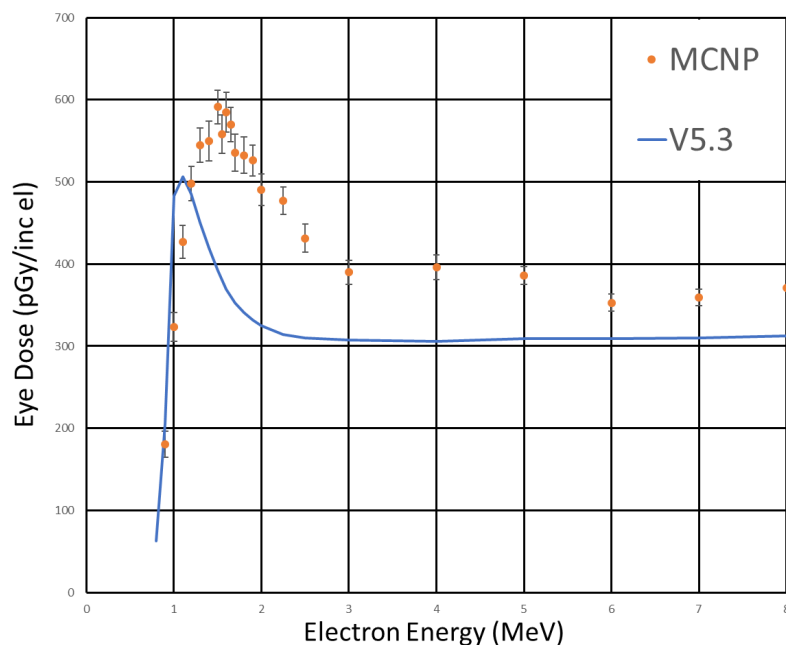
15
*

10
*

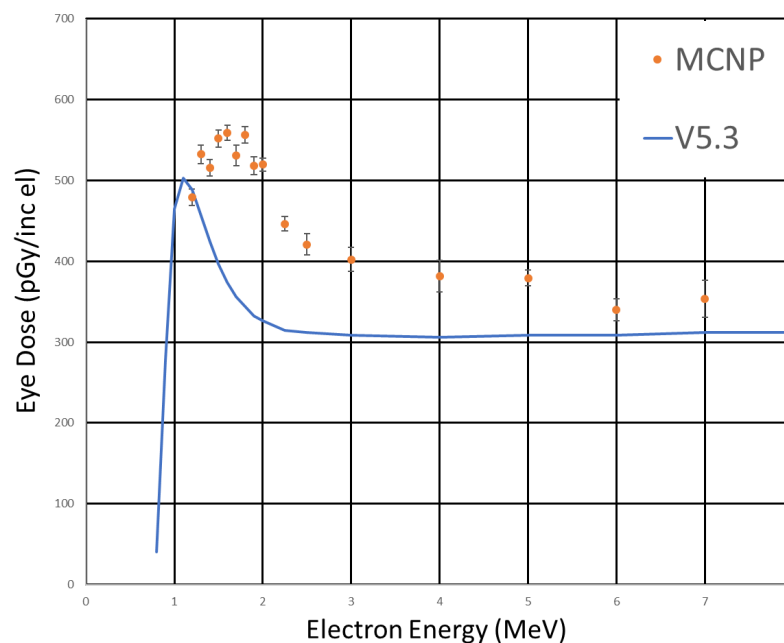
- MCNP accounts for scattered path, VARSKIN does not



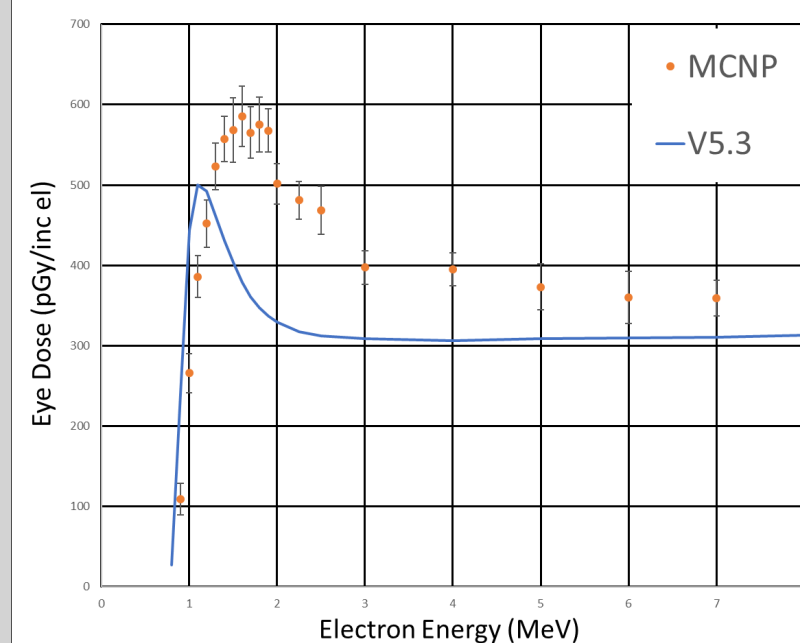
Dose to the Lens - Source 10 cm from Eyeball



Dose to the Lens - Source 15 cm from Eyeball



Dose to the Lens - Source 20 cm from Eyeball



Eye Shields



- Now consider exposure geometry with plastic between source and eye
- Contamination of the face shield leading to eye exposure
- Potentially the worker also wears glasses
- Protection is cumulative (i.e. total thickness)

VARSKIN 5.3 (setup with air gap and acrylic - 20 cm)

Varskin 5.3

File Help

Source Geometry

☐ Point

☐ Sphere

☐ Disk

☐ Slab

☐ Cylinder

Special Options

☐ Include Photon Dose

☐ Perform Volume Averaging

☐ Offset Particle Model

Skin Averaging Area

1.00E+00

cm²

Exposure Time

1.00E+00

sec

Radionuclide Library [Zeff]

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Cl-36 [7.42]

Co-60 [26]

Co-60 [7.42]

Activity Units

Bq

Select

Add

Remove

Selected Radionuclides

Be-7 [7.42]: 1.00E+00 Bq

EditRemoveClear

Point Source Irradiation Geometry

Skin Thickness or Skin Density Thickness:

3.00E+02

mg/cm²

Air Gap Thickness

1.97E+01

cm

Cover Thickness

3.00E-01

cm

Cover Density

1.18

g/cm³

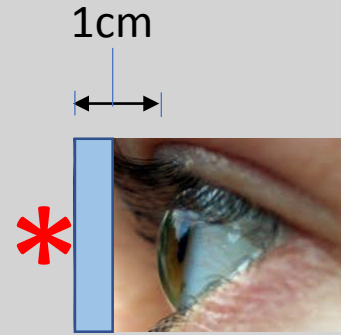
Multiple Cover Calculator

varskin V5

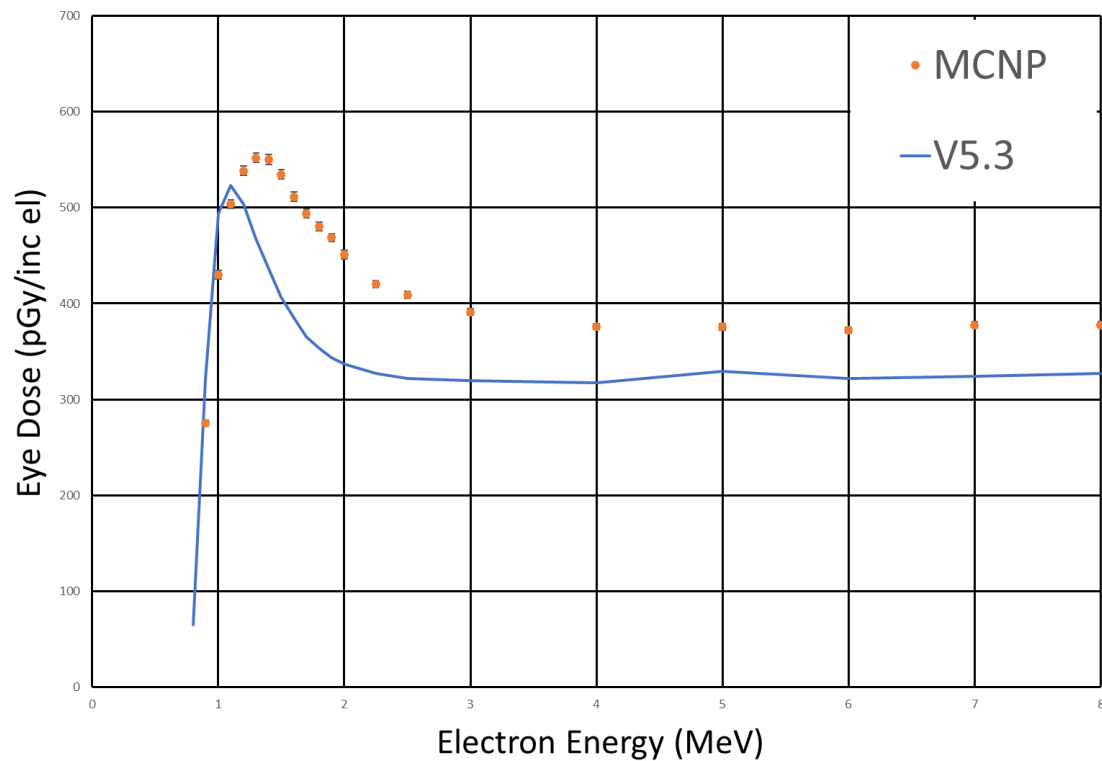
Calculate Doses

1 cm Gap with Plastic

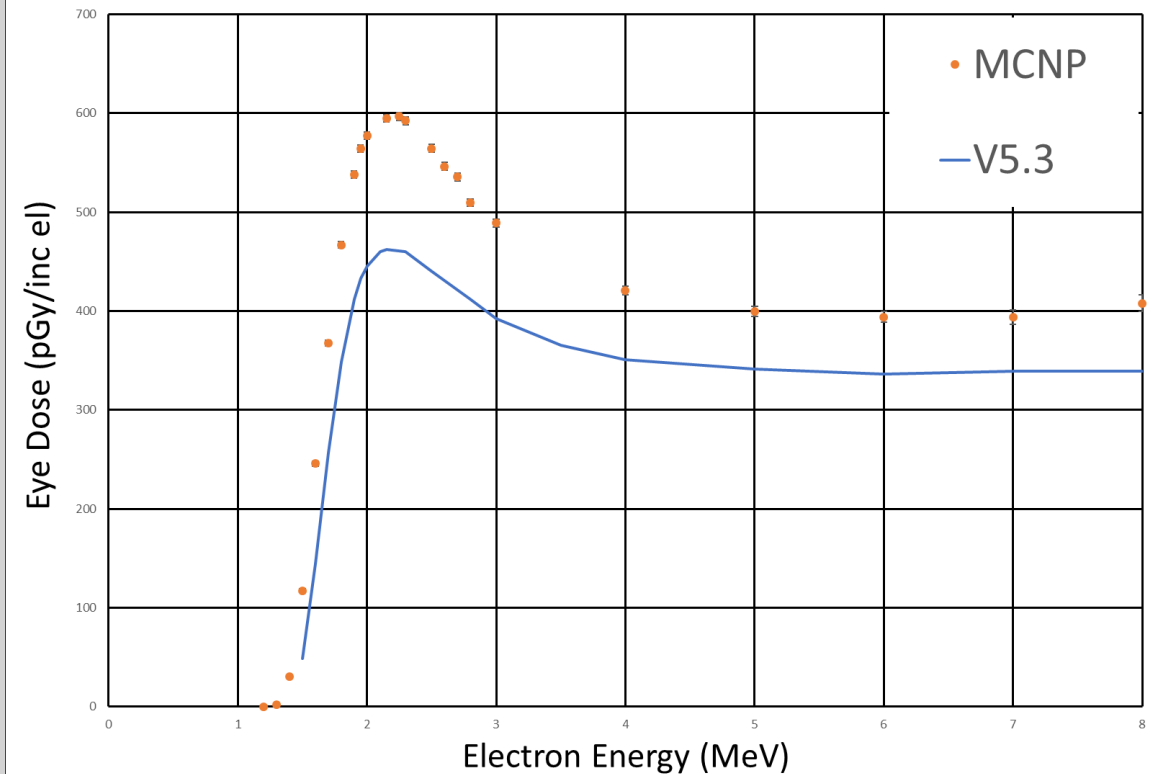
- Broader VARSKIN peak
- Delayed peak formation



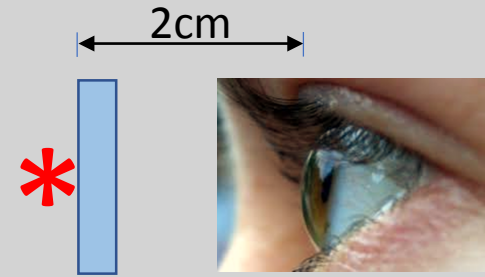
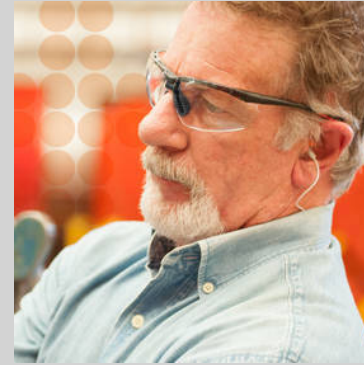
Dose to the Lens - Source 1 cm from Eyeball



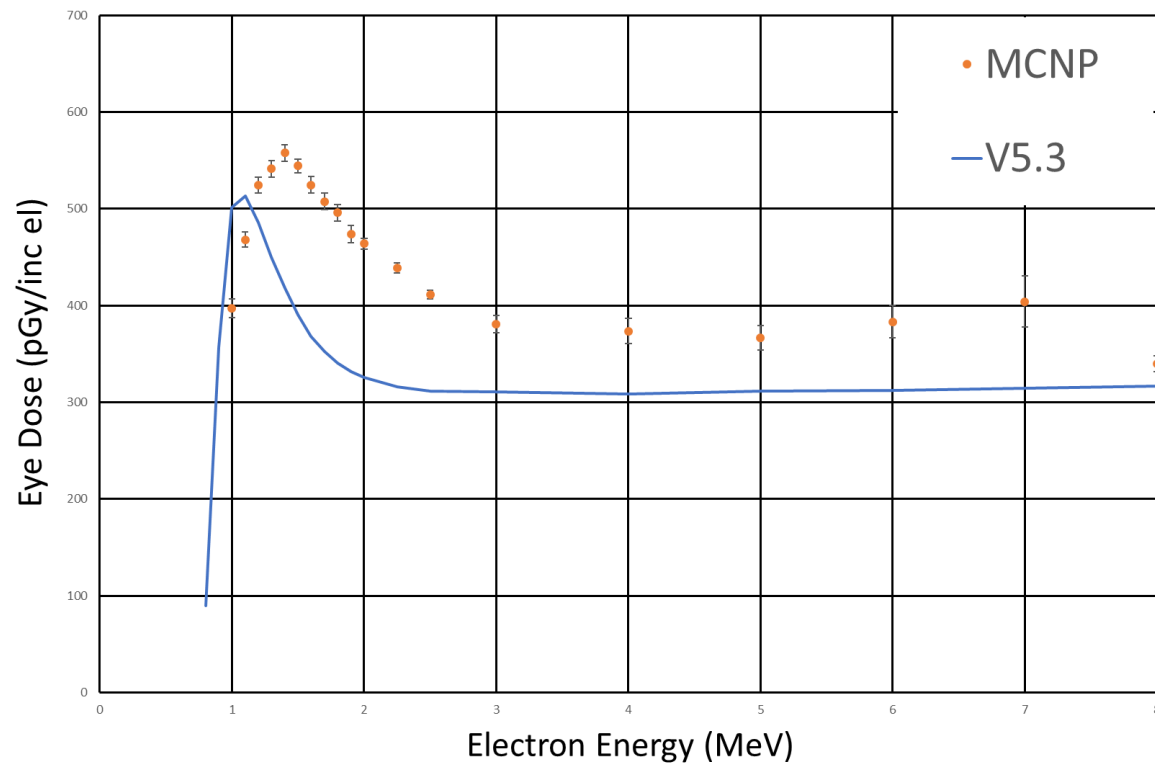
Eye Dose vs. Electron Energy (1 cm w/ Plastic)



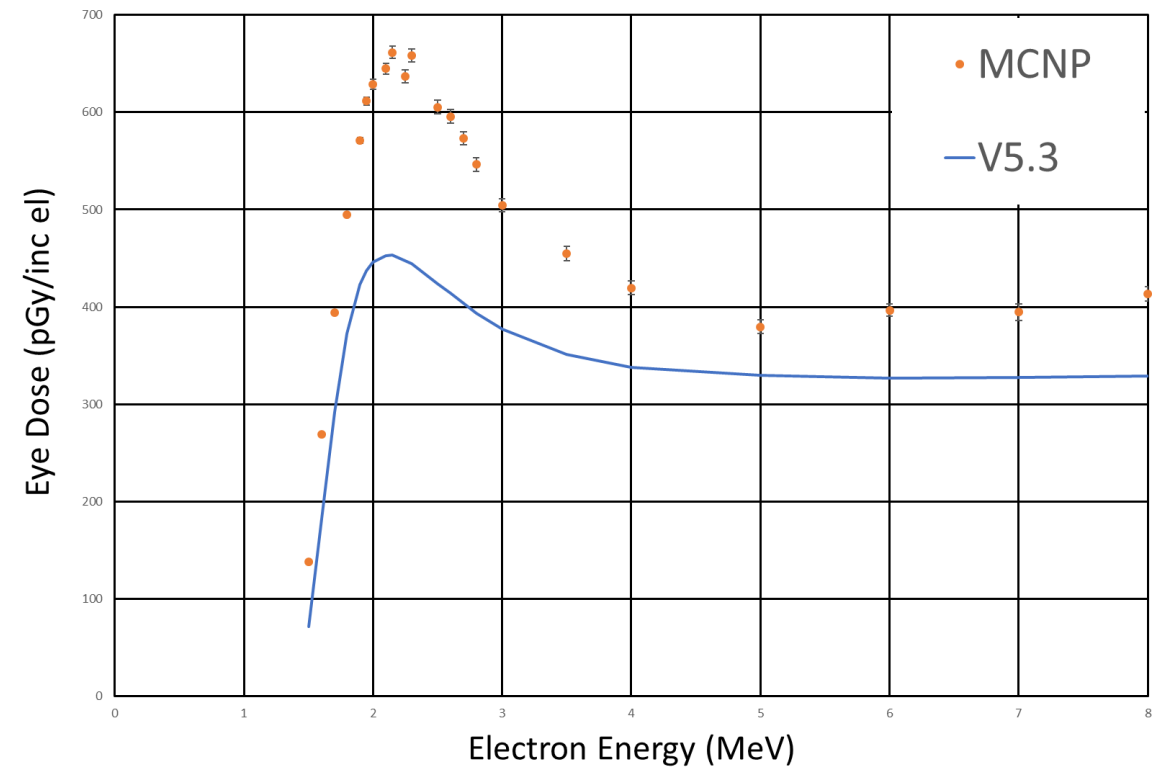
2 cm Gap with Plastic



Dose to the Lens - Source 2 cm from Eyeball

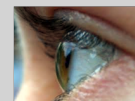


Eye Dose vs. Electron Energy (2 cm w/ Plastic)



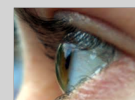
Scenario 1

*

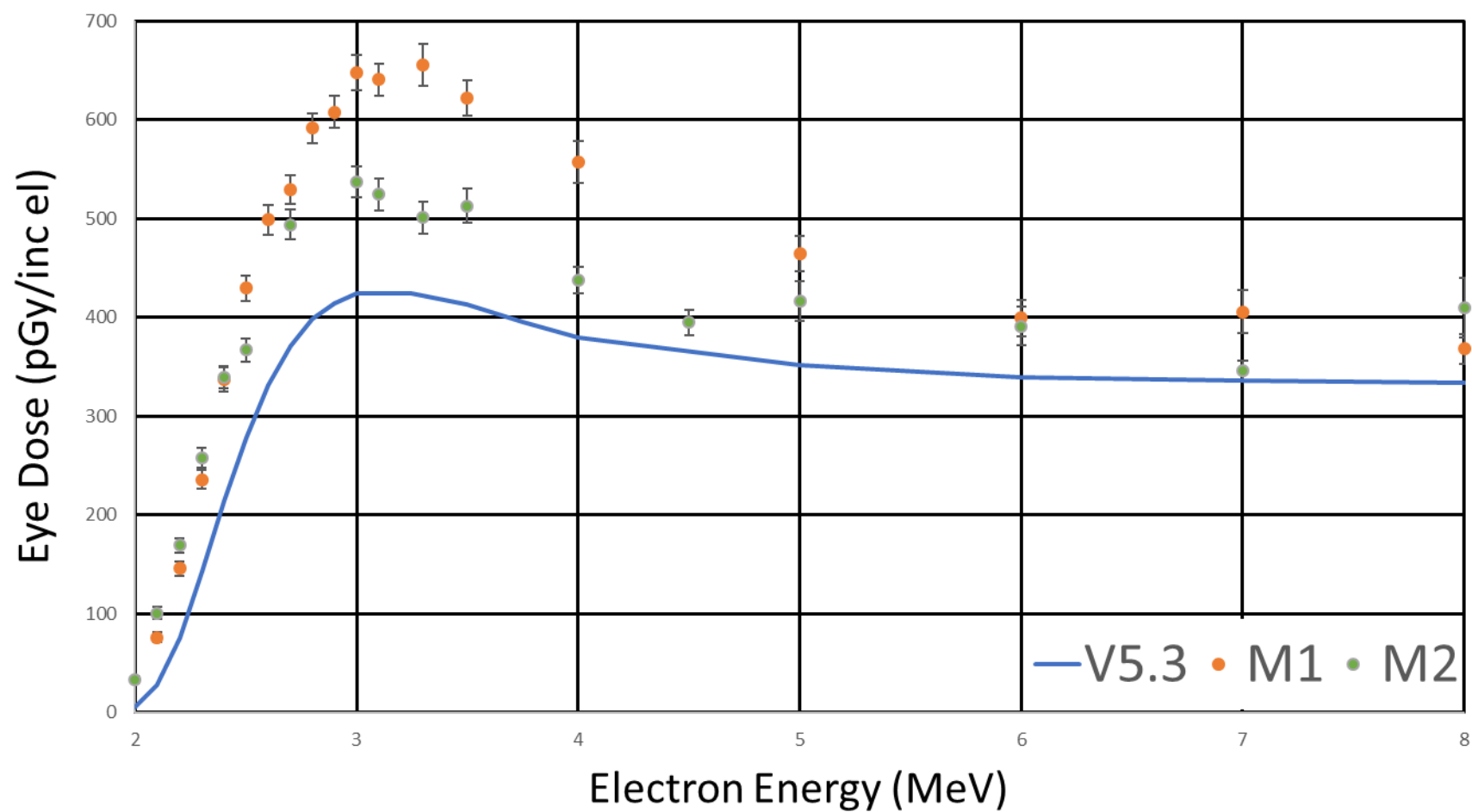


Scenario 2

*



Eye Dose vs. Electron Energy (Double Plastic, 10 cm)



Influence of Eyelid

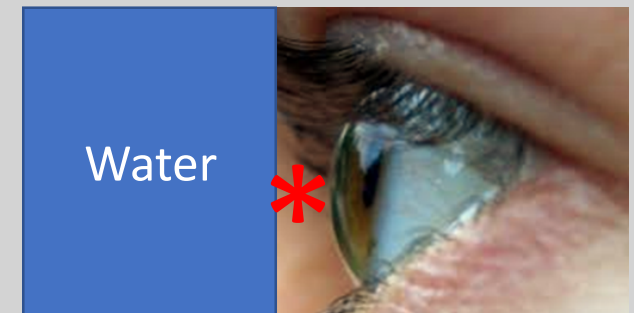
On top of eyelid



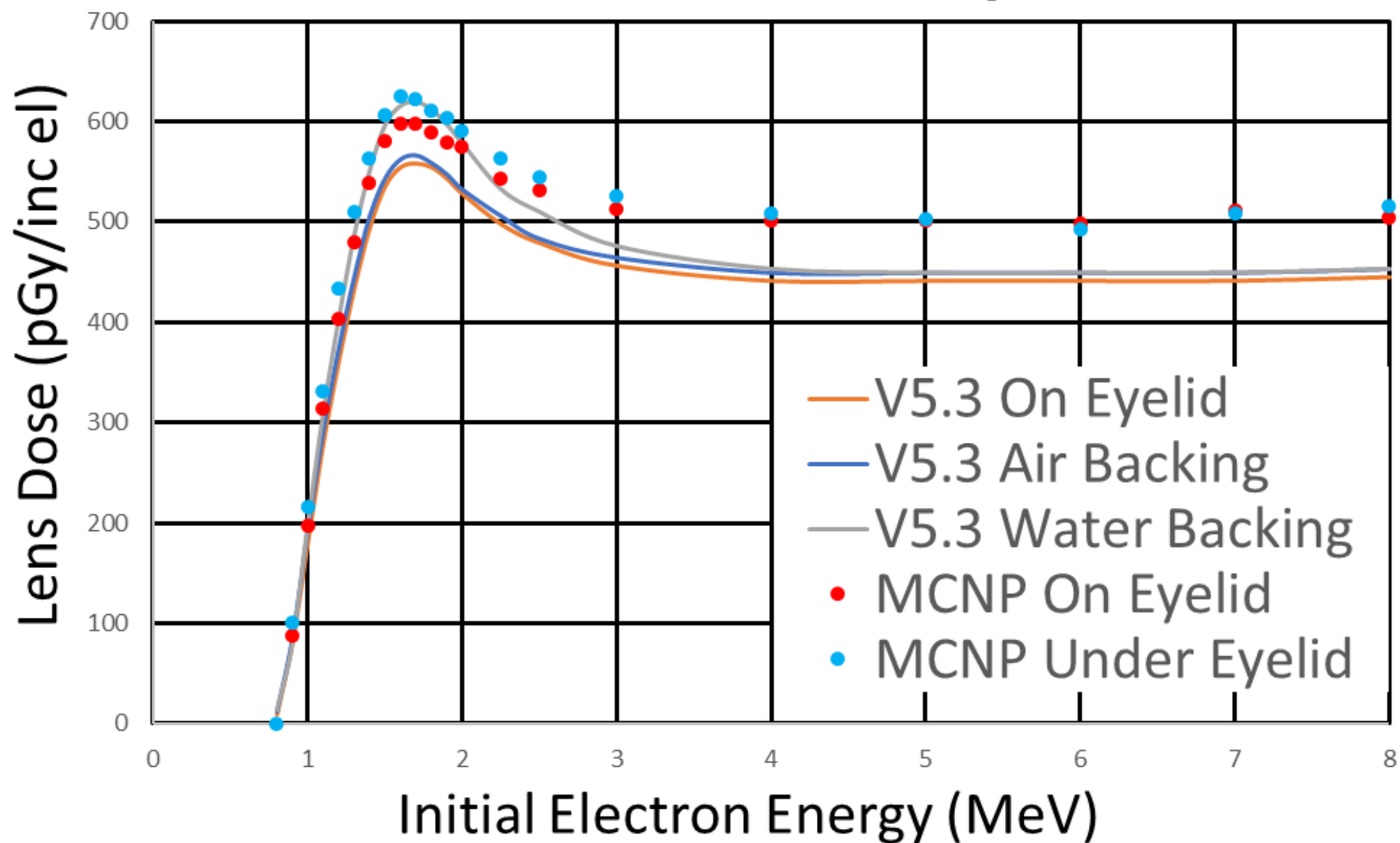
Under eyelid with
air backing



Under eyelid with
water backing



Particle On or Under Eyelid



Qualitative Assessment of VARSKIN for Eye Dosimetry

Particle Position	VARSKIN
Eyeball	✓
High electron energy	✓
Inside of Eyelid	~
Outside of Eyelid	~
Separation (with air/acrylic)	✗

Conclusion/Recommendations

- While accurate for shallow depth, VARSKIN in its current iteration is inadequate for most scenarios of eye dosimetry
- Corrections needed, but VARSKIN structure provides a good foundation for eye dosimetry implementation
- If given no other choice, VARSKIN is “okay”
 - Underestimates by 10-20%
 - Otherwise use Monte Carlo



