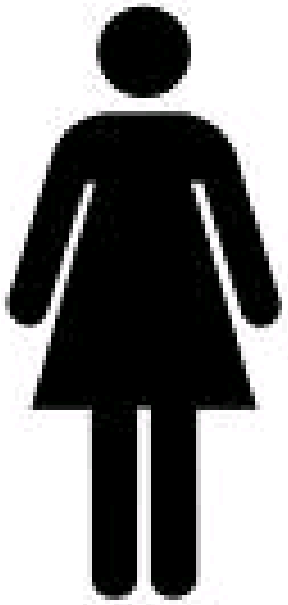
DEFINITION BY RADIATION PROPERTIES: A PROPOSAL FOR NEXT-GENERATION ANTHROPOMORPHIC PHANTOMS

MARY CHIN & NICHOLAS SPYROU

UNIVERSITY OF SURREY

HOW DO WE DESCRIBE A HUMAN BODY TO A MONTE CARLO SIMULATION?



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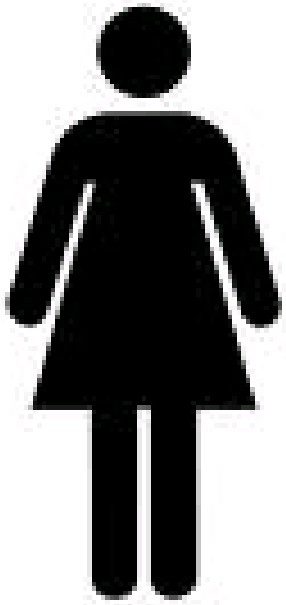

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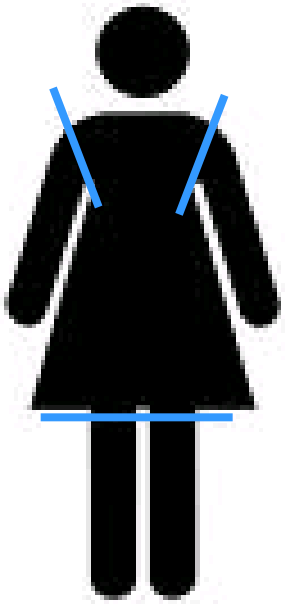

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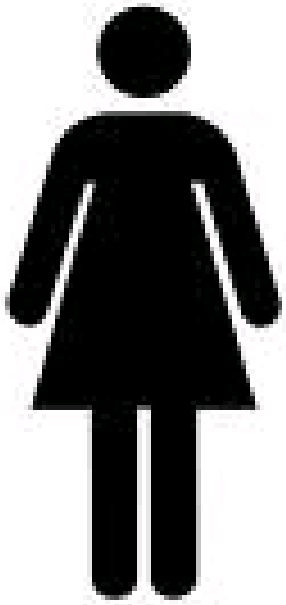

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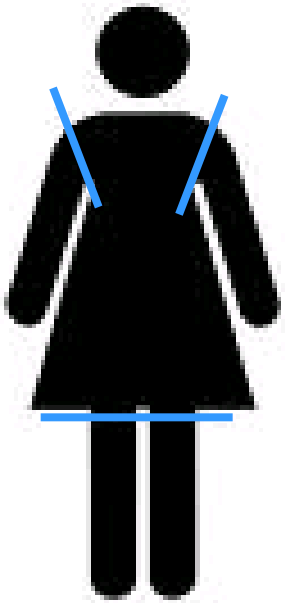

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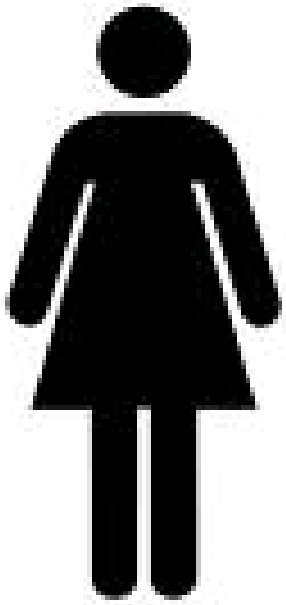

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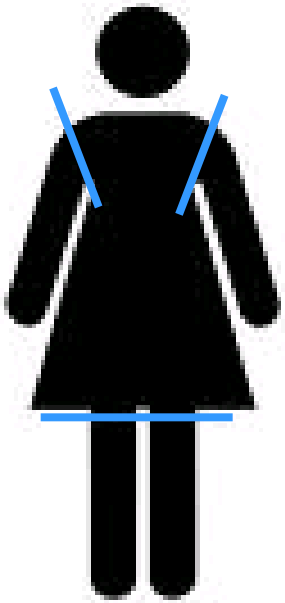

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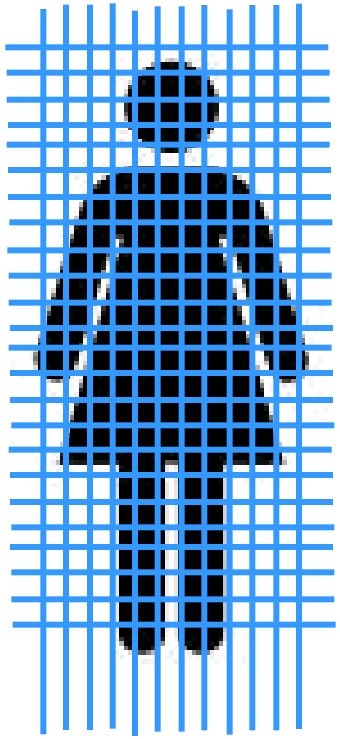

BLIND DIVISION INTO PIXEL/VOXELS?

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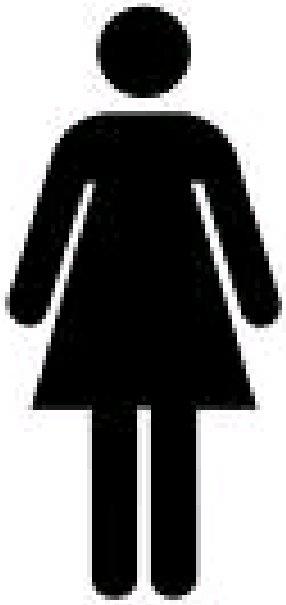

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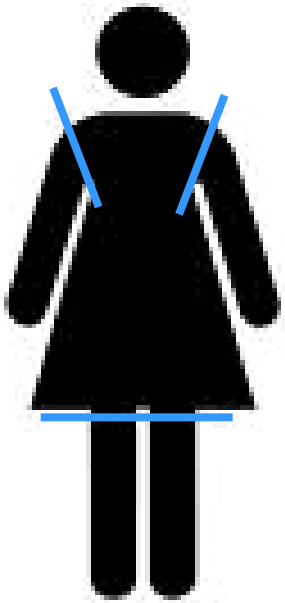

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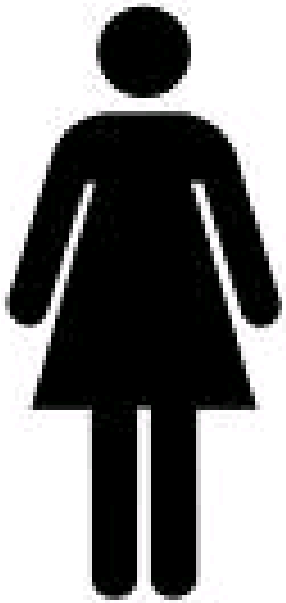

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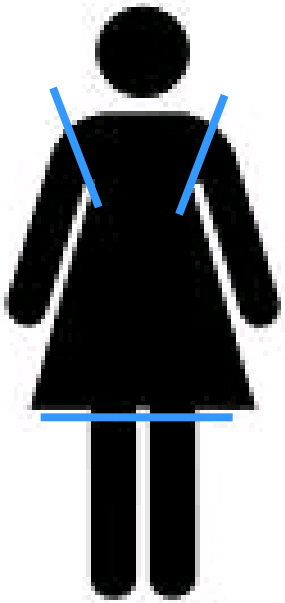

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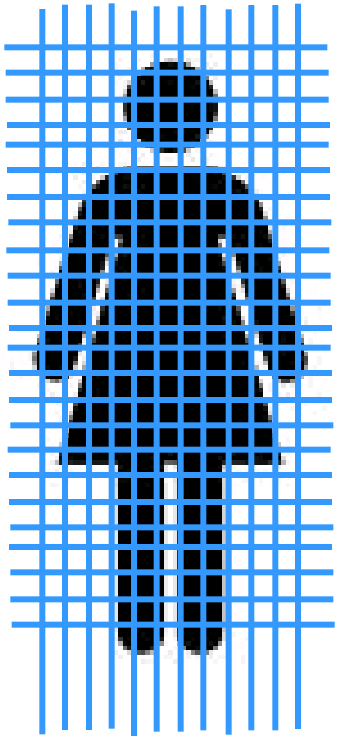

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YES, MANY HAVE DONE IT.

WITHIN AN ORGAN THERE WILL BE INTRA-ORGAN HETEROGENEITY (COMPOSITION AND DENSITY)

ORGAN-BASED DIVISION

Lee, C; Lodwick, D; Hasenauer, D; et al.
Hybrid computational phantoms of the male and female newborn patient: NURBS-based whole-body models
PHYSICS IN MEDICINE AND BIOLOGY, 52 (12): 3309-3333 JUN 21 2007

Segars, WP; Lalush, DS; Tsui, BMW
A realistic spline-based dynamic heart phantom
IEEE TRANSACTIONS ON NUCLEAR SCIENCE, 46 (3): 503-506 Part 2 JUN 1999

ORGAN-BASED

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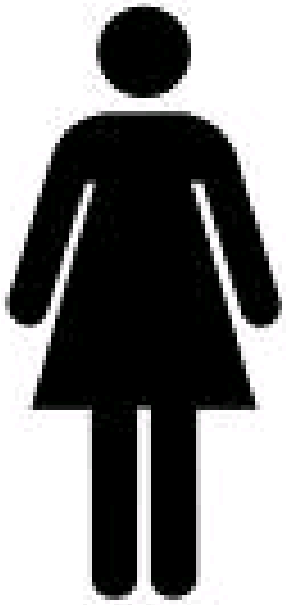

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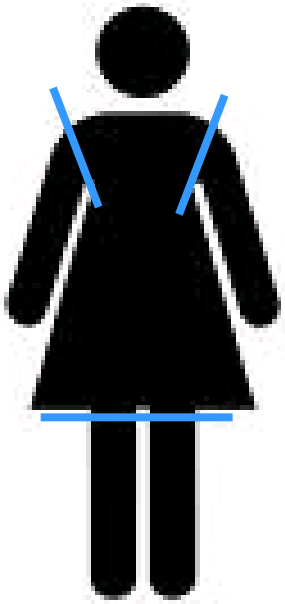

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STEP ARTEFACTS, ...

THE DILEMMA ON RESOLUTION

- THE HIGHER THE BETTER
- BUT DO WE REALLY NEED IT

REDUNDANCY illustrated

in the coming slides:

1. EGSnrc (electrons, photons)
2. MCNPX (neutrons)

AN EXAMPLE: THE VIP-MAN

as downloaded from ANS CMPWG database

REDUNDANT SPATIAL DIVISIONS

COLOUR-CODED
ACCORDING TO
TISSUE TYPE

IMPRESSIVE
HETEROGENEITY

COLOUR-CODED
ACCORDING TO
COMPOSITION

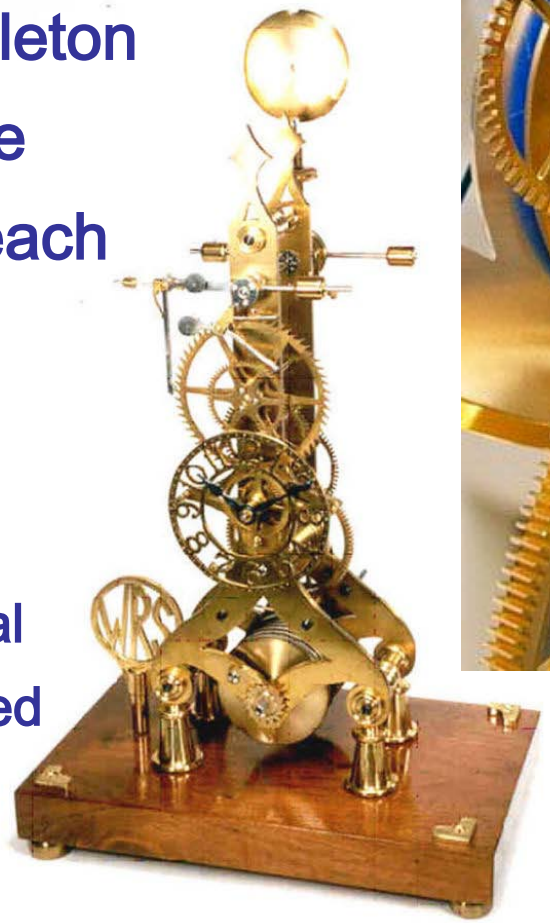
NOT SO
HETEROGENEOUS
ANYMORE

PROFILING FOUR EGSnrc SIMULATIONS

A tool (*usu.* used in software engineering) to gauuge how routines call each other

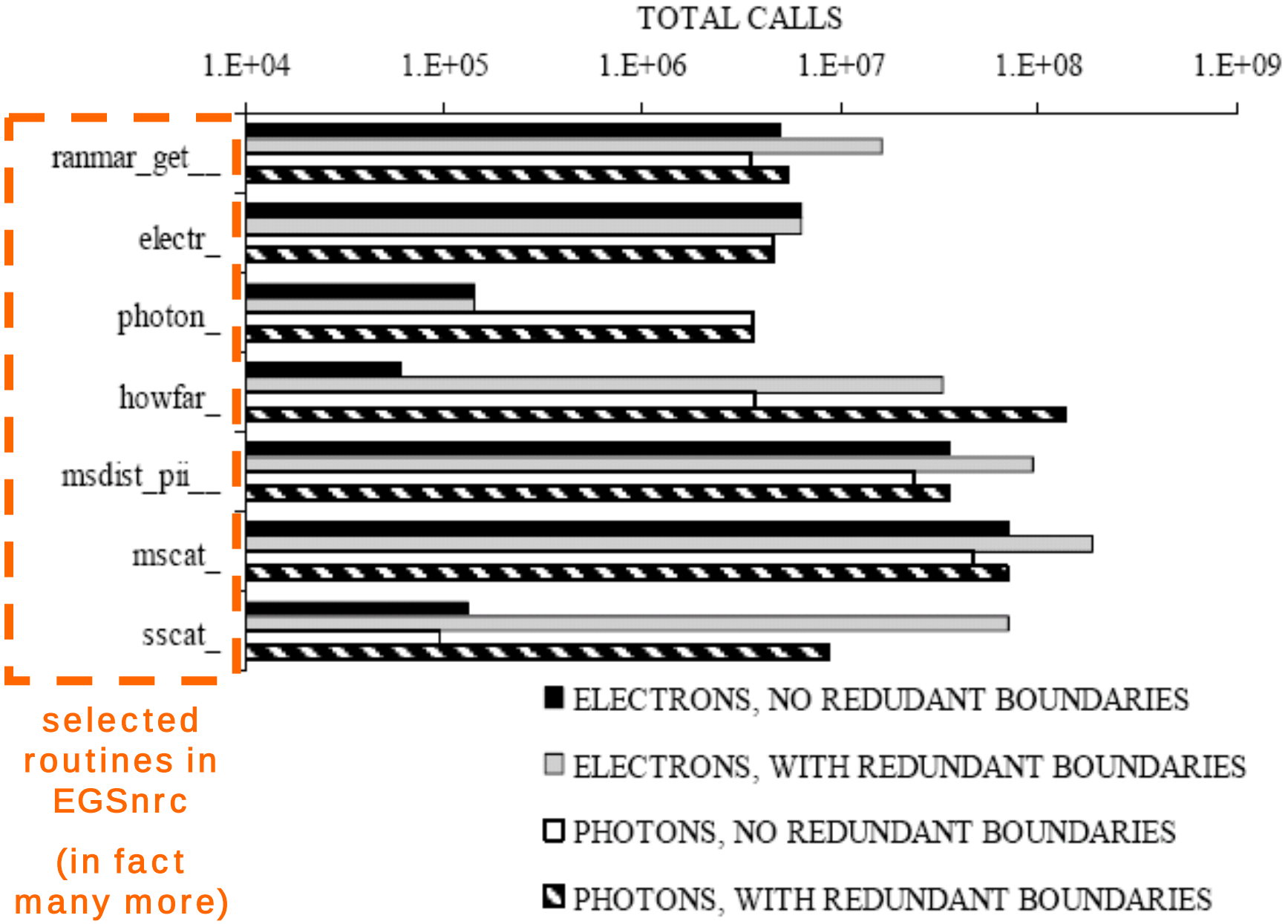
What is 'profiling'?

Like observing a skeleton clock, we can see the mechanism behind each and every tick.



Technically this requires recompilation with special options, and a utility called *gprof.*

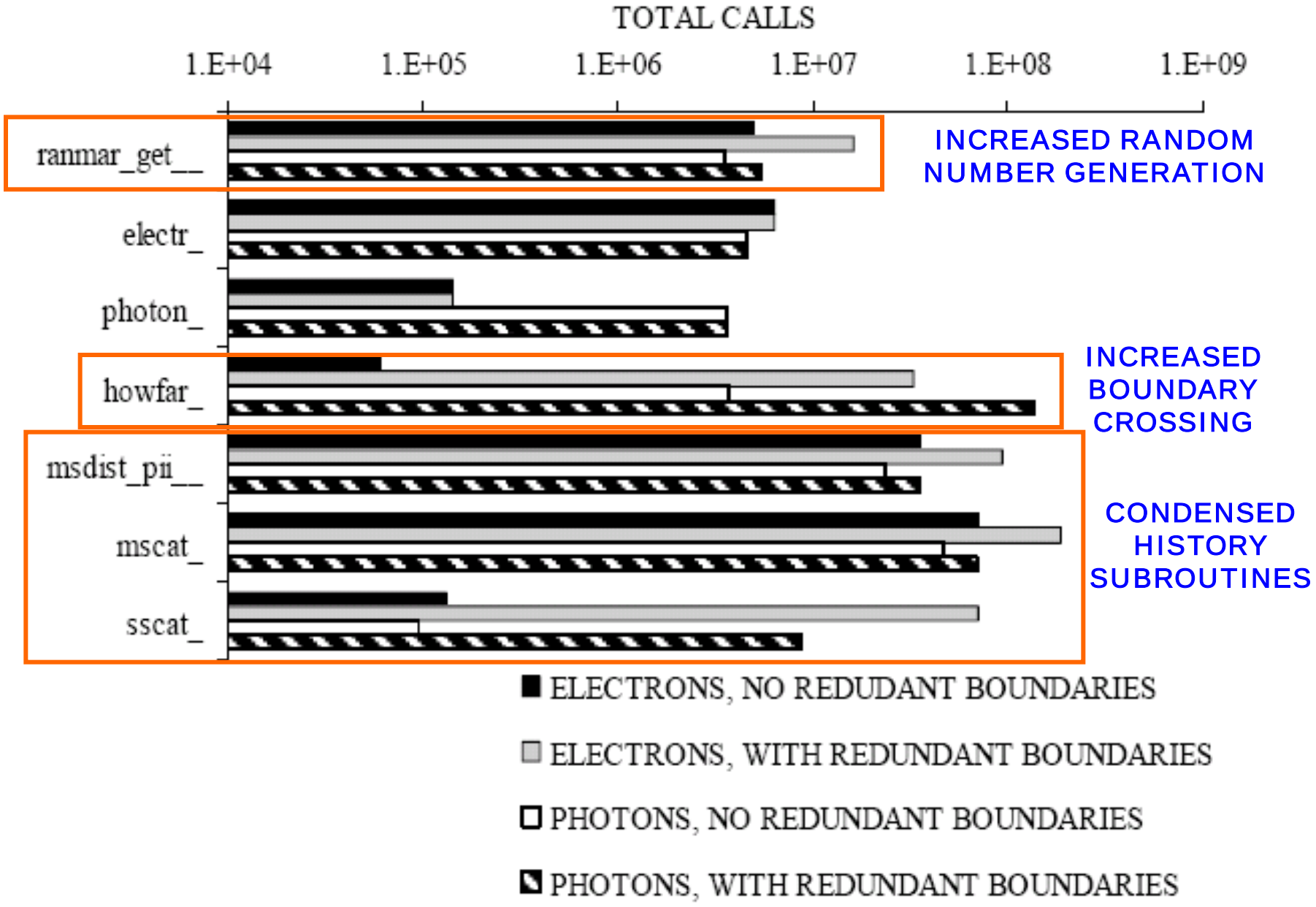
PROFILING FOUR EGSnrc SIMULATIONS



selected routines in EGSnrc

(in fact many more)

PROFILING FOUR EGSnrc SIMULATIONS



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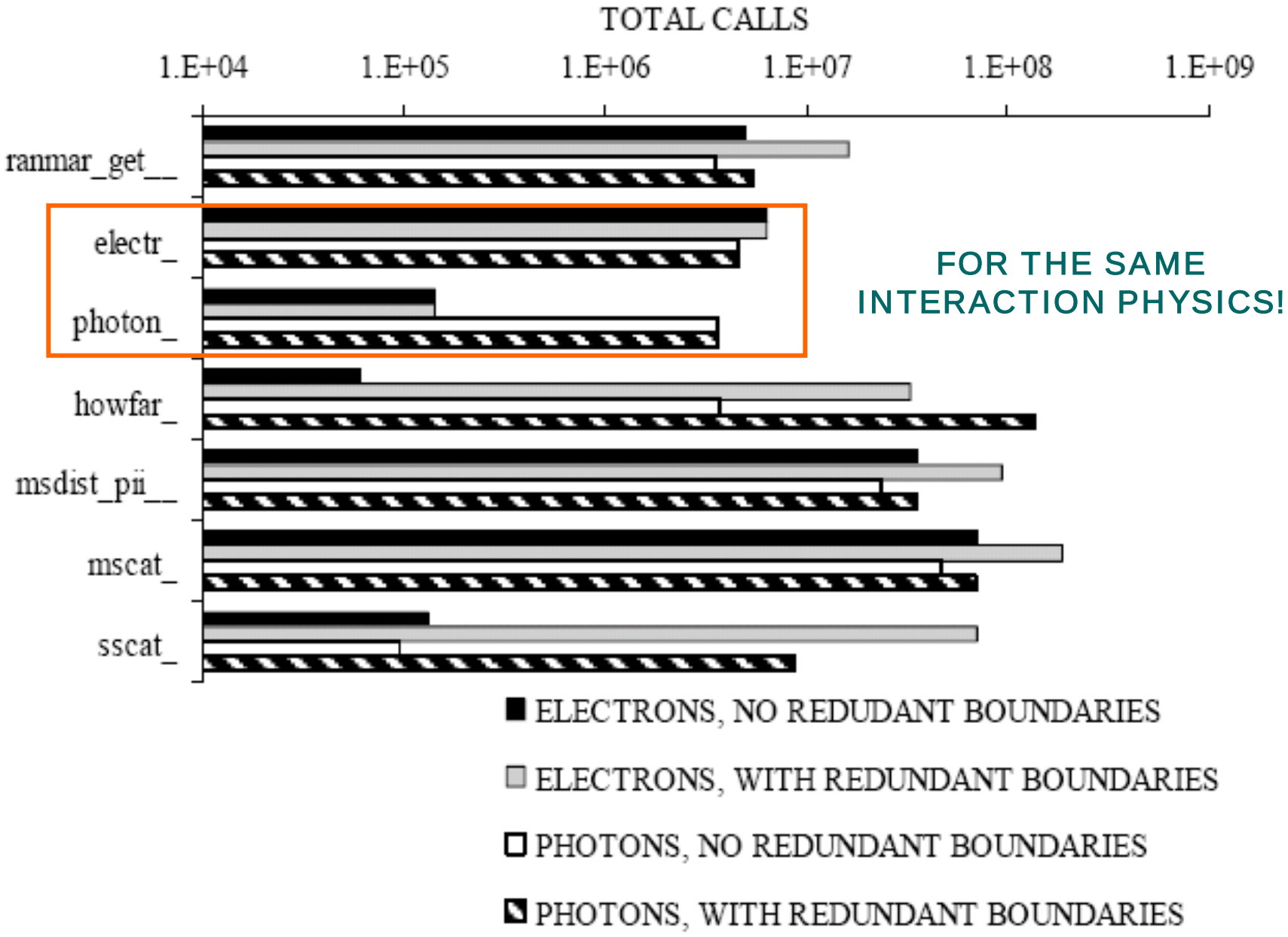

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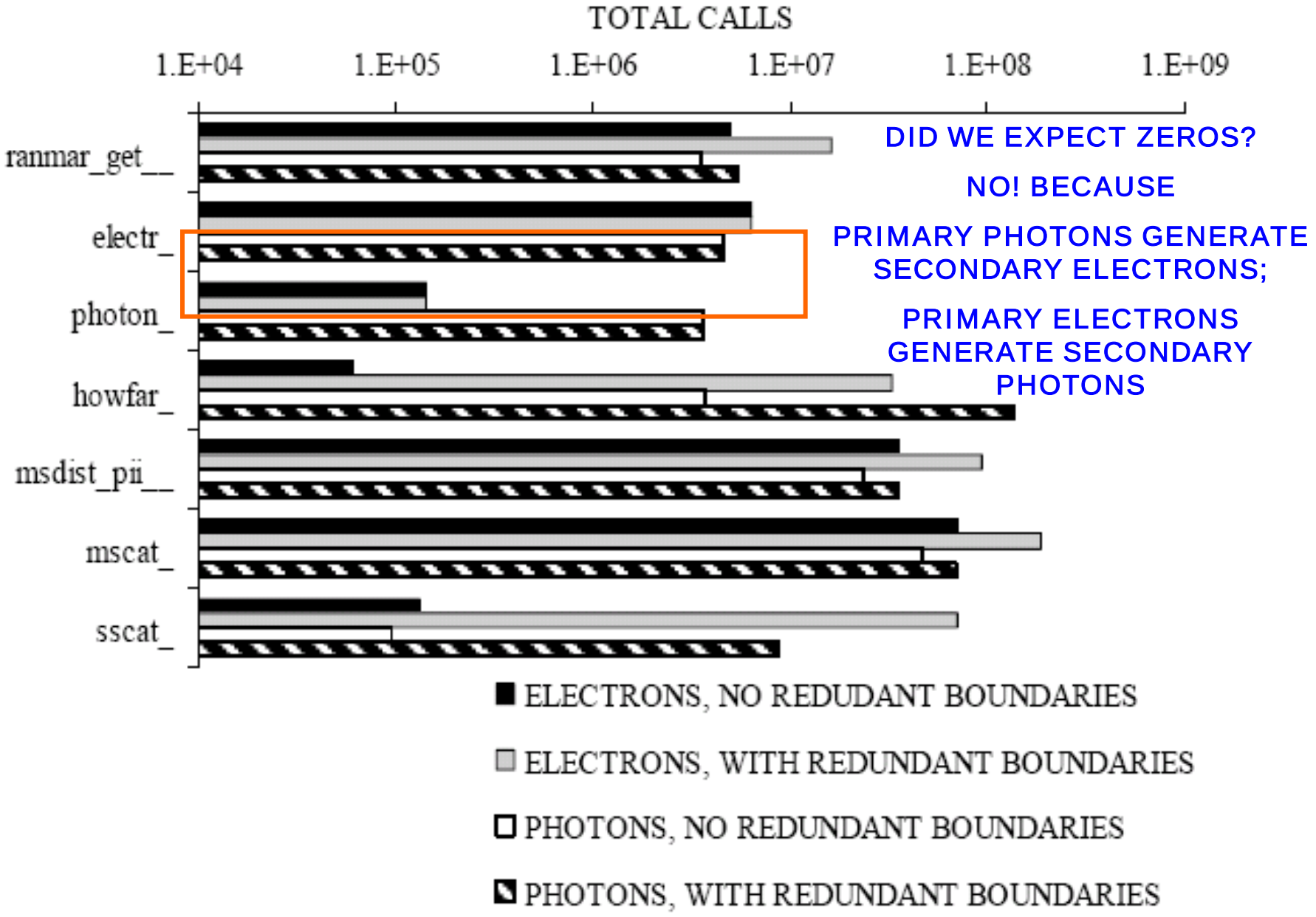


DID WE EXPECT ZEROS?

NO! BECAUSE

PRIMARY PHOTONS GENERATE SECONDARY ELECTRONS;

PRIMARY ELECTRONS GENERATE SECONDARY PHOTONS

BOUNDARY, BOUNDARY, BOUNDARIES!

```
   3000      1     40      1    199     64      0
-0.11700E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.00000E+00
   3000      2     11      0      1    199     64      0
-0.11400E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.16498E+00
   3000      3     11      0      1    199     64      0
-0.11000E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.38495E+00
   3000      4     11      0      1    199     64      0
-0.10600E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.60493E+00
   3000      5     11      0      1    199     64      0
-0.10200E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.82490E+00
   3000      6     11      0      1    199     64      0
-0.98000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.10449E+01
   3000      7     11      0      1    199     64      0
-0.94000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.12648E+01
   3000      8
-0.90000E+01 -0.                                                                                          14848E+01
   3000      9
-0.86000E+01 -0.                                                                                          17048E+01
   3000     10
-0.82000E+01 -0.                                                                                          19248E+01
   3000     11
-0.78000E+01 -0.                                                                                          21447E+01
   3000     12
-0.74000E+01 -0.                                                                                          23647E+01
   3000     13     11      0      1    199     64      0
-0.70000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.25847E+01
   3000     14     11      0      1    199     64      0
-0.66000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.28047E+01
   3000     15     11      0      1    199     64      0
-0.62000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.30246E+01
   3000     16     11      0      1    199     64      0
-0.58000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.32446E+01
   3000     17     11      0      1    199     64      0
-0.54000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.34646E+01
   3000     18     11      0      1    199     64      0
-0.50000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.36846E+01
   3000     19     11      0      1    199     64      0
-0.46000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.39045E+01
```

A SAMPLE *PTRAC* OUTPUT FROM MCNPX SIMULATION OF THE VIP-MAN UNDERGOING BORON NEUTRON CAPTURE THERAPY (BNCT)

BOUNDARY, BOUNDARY, BOUNDARIES!

NO CHANGE IN ENERGY

```
   3000      1     40      1    199     64      0
-0.11700E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.000                +01  0.00000E+00
   3000      2     11      0      1    199     64      0
-0.11400E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.16498E+00
   3000      3     11      0      1    199     64      0
-0.11000E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.38495E+00
   3000      4     11      0      1    199     64      0
-0.10600E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.60493E+00
   3000      5     11      0      1    199     64      0
-0.10200E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.82490E+00
   3000      6     11      0      1    199     64      0
-0.98000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.10449E+01
   3000      7     11      0      1    199     64      0
-0.94000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.12648E+01
   3000      8     11      0      1    199     64      0
-0.90000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.14848E+01
   3000      9     11      0      1    199     64      0
-0.86000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.17048E+01
   3000     10     11      0      1    199     64      0
-0.82000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.19248E+01
   3000     11     11      0      1    199     64      0
-0.78000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.21447E+01
   3000     12     11      0      1    199     64      0
-0.74000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.23647E+01
   3000     13     11      0      1    199     64      0
-0.70000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.25847E+01
   3000     14     11      0      1    199     64      0
-0.66000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.28047E+01
   3000     15     11      0      1    199     64      0
-0.62000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.30246E+01
   3000     16     11      0      1    199     64      0
-0.58000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.32446E+01
   3000     17     11      0      1    199     64      0
-0.54000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.34646E+01
   3000     18     11      0      1    199     64      0
-0.50000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.36846E+01
   3000     19     11      0      1    199     64      0
-0.46000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.39045E+01
```

BOUNDARY, BOUNDARY, BOUNDARIES!

(u, v, w) NO CHANGE IN DIRECTION

```
   3000      1     40      1    199
-0.11700E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.00000E+00
   3000      2     11      0      1    199     64      0
-0.11400E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.16498E+00
   3000      3     11      0      1    199     64      0
-0.11000E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.38495E+00
   3000      4     11      0      1    199     64      0
-0.10600E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.60493E+00
   3000      5     11      0      1    199     64      0
-0.10200E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.82490E+00
   3000      6     11      0      1    199     64      0
-0.98000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.10449E+01
   3000      7     11      0      1    199     64      0
-0.94000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.12648E+01
   3000      8     11      0      1    199     64      0
-0.90000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.14848E+01
   3000      9     11      0      1    199     64      0
-0.86000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.17048E+01
   3000     10     11      0      1    199     64      0
-0.82000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.19248E+01
   3000     11     11      0      1    199     64      0
-0.78000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.21447E+01
   3000     12     11      0      1    199     64      0
-0.74000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.23647E+01
   3000     13     11      0      1    199     64      0
-0.70000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.25847E+01
   3000     14     11      0      1    199     64      0
-0.66000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.28047E+01
   3000     15     11      0      1    199     64      0
-0.62000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.30246E+01
   3000     16     11      0      1    199     64      0
-0.58000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.32446E+01
   3000     17     11      0      1    199     64      0
-0.54000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.34646E+01
   3000     18     11      0      1    199     64      0
-0.50000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.36846E+01
   3000     19     11      0      1    199     64      0
-0.46000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.39045E+01
```

BOUNDARY, BOUNDARY, BOUNDARIES!

(x, y, z) ONLY x CHANGED

```
                                                        4          0
 0.11700E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.00000E+00
      3000          2         11          0          1        199         64          0
 0.11400E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.16498E+00
      3000          3         11          0          1        199         64          0
 0.11000E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.38495E+00
      3000          4         11          0          1        199         64          0
 0.10600E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.60493E+00
      3000          5         11          0          1        199         64          0
 0.10200E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.82490E+00
      3000          6         11          0          1        199         64          0
 0.98000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.10449E+01
      3000          7         11          0          1        199         64          0
 0.94000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.12648E+01
      3000          8         11          0          1        199         64          0
 0.90000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.14848E+01
      3000          9         11          0          1        199         64          0
 0.86000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.17048E+01
      3000         10         11          0          1        199         64          0
 0.82000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.19248E+01
      3000         11         11          0          1        199         64          0
 0.78000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.21447E+01
      3000         12         11          0          1        199         64          0
 0.74000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.23647E+01
      3000         13         11          0          1        199         64          0
 0.70000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.25847E+01
      3000         14         11          0          1        199         64          0
 0.66000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.28047E+01
      3000         15         11          0          1        199         64          0
 0.62000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.30246E+01
      3000         16         11          0          1        199         64          0
 0.58000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.32446E+01
      3000         17         11          0          1        199         64          0
 0.54000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.34646E+01
      3000         18         11          0          1        199         64          0
 0.50000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.36846E+01
      3000         19         11          0          1        199         64          0
 0.46000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.39045E+01
```

BOUNDARY, BOUNDARY, BOUNDARIES!

JUST WASTING TIME

ALL ARE SURFACE-CROSSING EVENTS

```
 3000     1    40     1   199    64     0
-0.11700E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.00000E+00
 3000     2    11     0     1   199    64     0
-0.11400E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.16498E+00
 3000
-0.11000E+                                0000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.38495E+00
 3000
-0.10600E+                                0000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.60493E+00
 3000
-0.10200E+02 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.82490E+00
 3000     6    11     0     1   199    64     0
-0.98000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.10449E+01
 3000     7    11     0     1   199    64     0
-0.94000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.12648E+01
 3000     8    11     0     1   199    64     0
-0.90000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.14848E+01
 3000     9    11     0     1   199    64     0
-0.86000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.17048E+01
 3000    10    11     0     1   199    64     0
-0.82000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.19248E+01
 3000    11    11     0     1   199    64     0
-0.78000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.21447E+01
 3000    12    11     0     1   199    64     0
-0.74000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.23647E+01
 3000    13    11     0     1   199    64     0
-0.70000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.25847E+01
 3000    14    11     0     1   199    64     0
-0.66000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.28047E+01
 3000    15    11     0     1   199    64     0
-0.62000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.30246E+01
 3000    16    11     0     1   199    64     0
-0.58000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.32446E+01
 3000    17    11     0     1   199    64     0
-0.54000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.34646E+01
 3000    18    11     0     1   199    64     0
-0.50000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.36846E+01
 3000    19    11     0     1   199    64     0
-0.46000E+01 -0.87718E+01  0.12289E+02  0.10000E+01  0.00000E+00  0.00000E+00  0.17284E-01  0.10000E+01  0.39045E+01
```

BOUNDARY CROSSING:

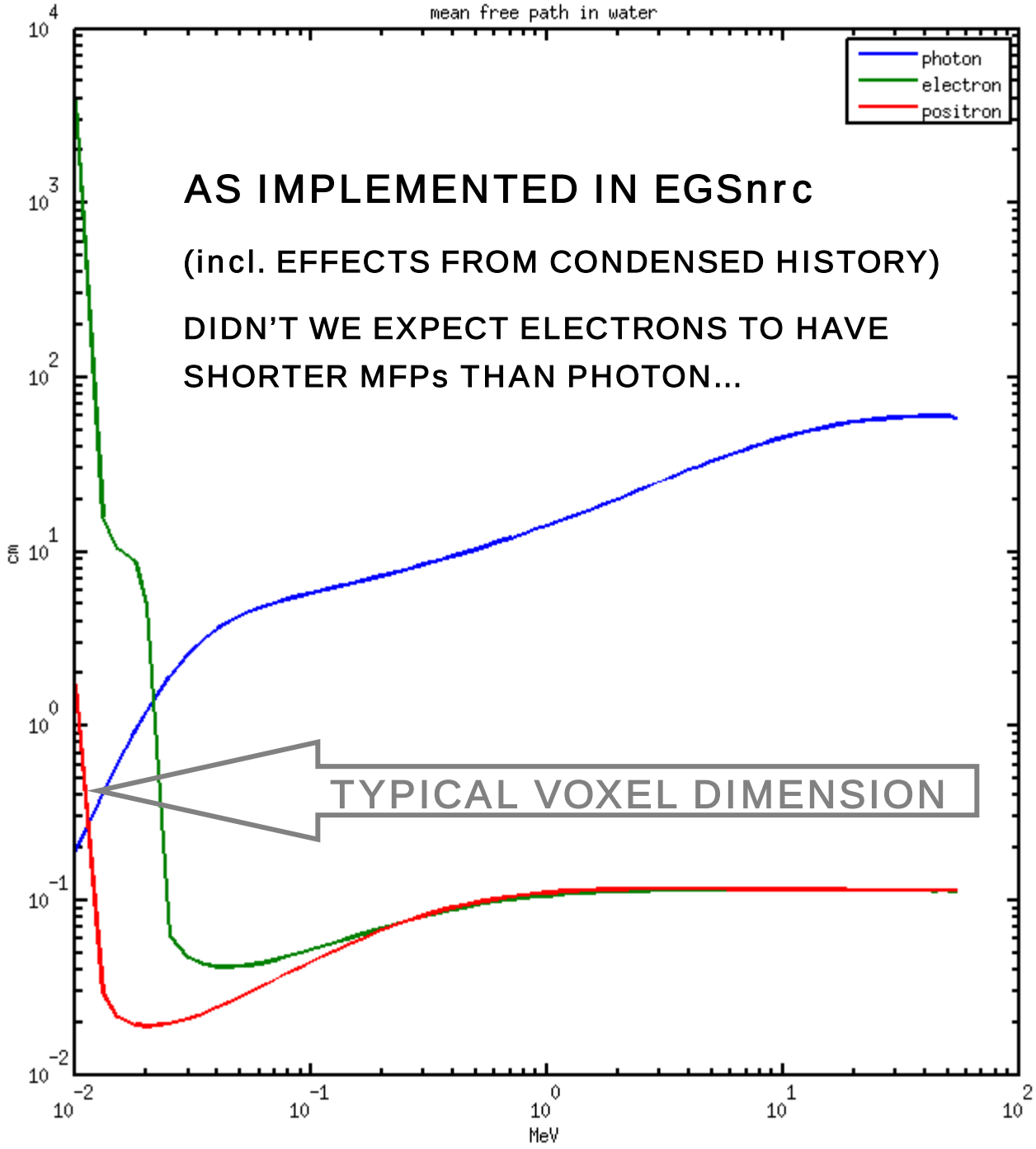
JUST HOW REDUNDANT IS REDUNDANT?

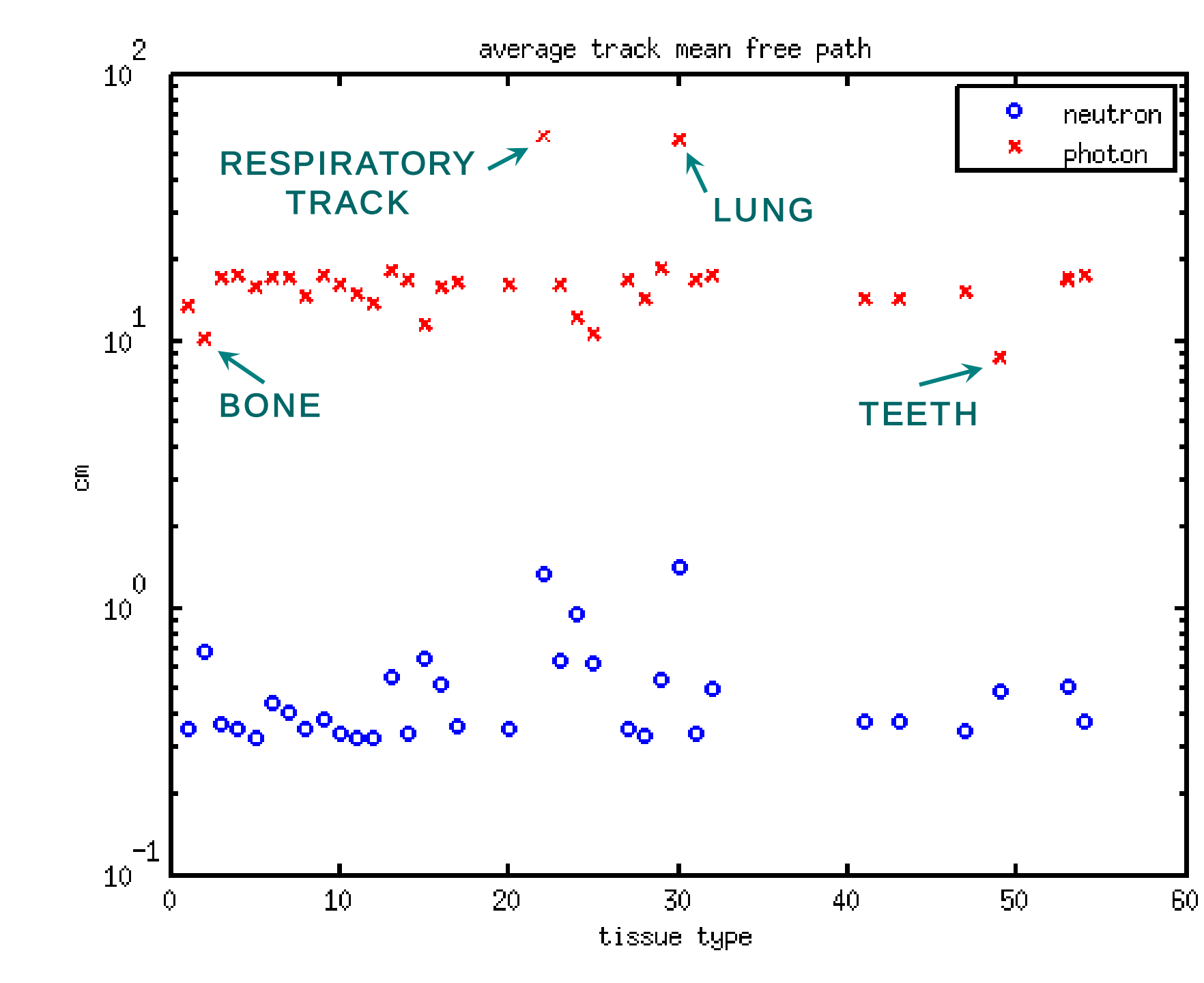
DEPENDS ON HOW THE MEAN FREE PATH METERS?

compares with

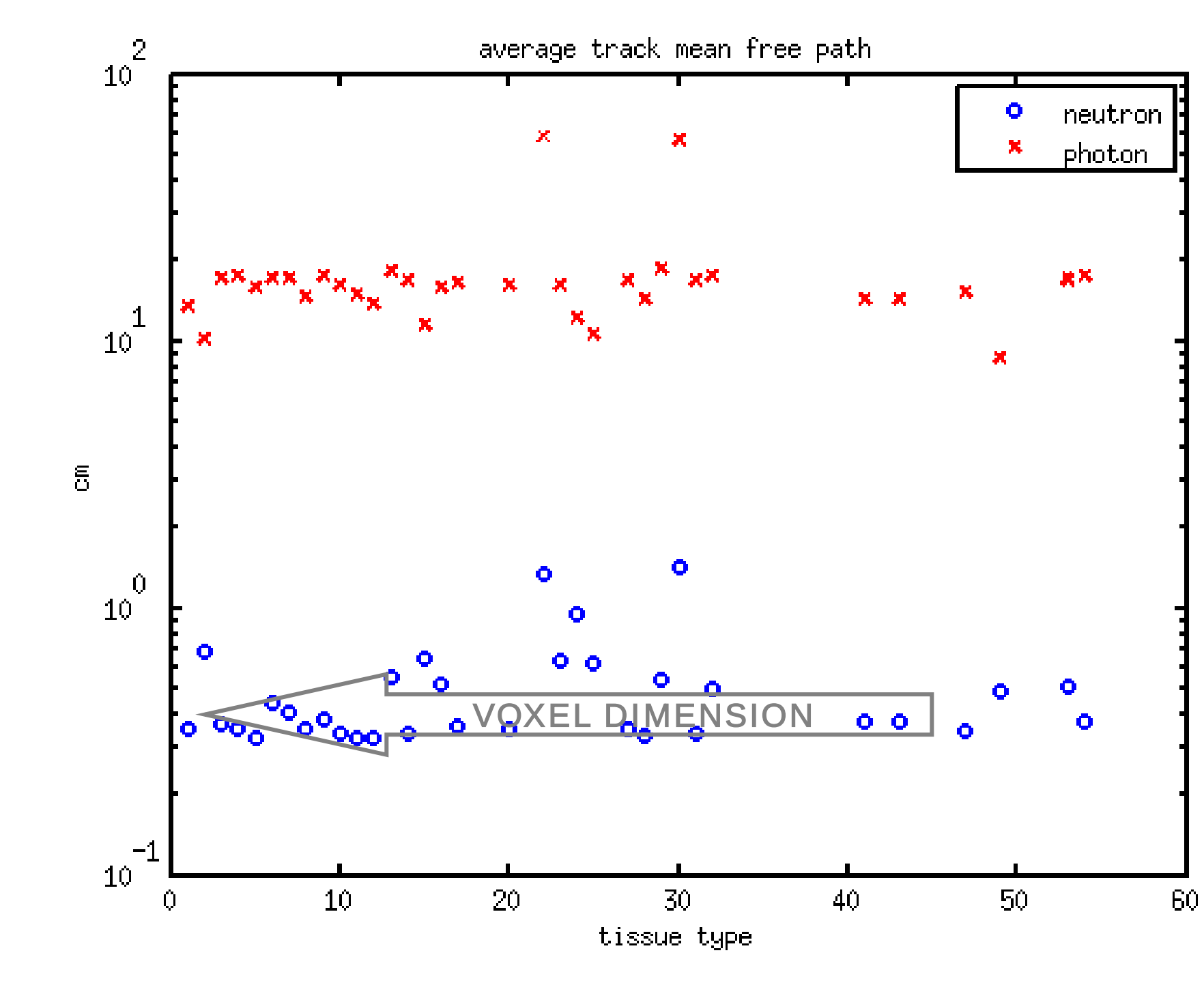
THE VOXEL DIMENSIONS MILLIMETERS?

REDUNDANCY SCALES TO THE POWER OF THREE


mean free path in water
photon
electron
positron
AS IMPLEMENTED IN EGSnrc
(incl. EFFECTS FROM CONDENSED HISTORY)
DIDN'T WE EXPECT ELECTRONS TO HAVE SHORTER MFPs THAN PHOTON...
TYPICAL VOXEL DIMENSION
cm
MeV

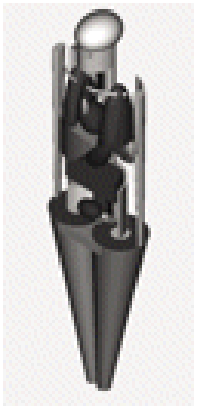


AN MCNPX SIMULATION OF VIP-MAN UNDERGOING BNCT



AN MCNPX SIMULATION OF VIP-MAN UNDERGOING BNCT

MIRD-LIKE PHANTOMS



quadratics;

not powerful enough to describe organ shapes in details

UNDER-DIVIDE

VOXEL PHANTOMS

convenient;

minimal maths;

blind/indiscriminate mass segmentation into a uniform lattice

mathematically & computationally not elegant at all

OVER-DIVIDE

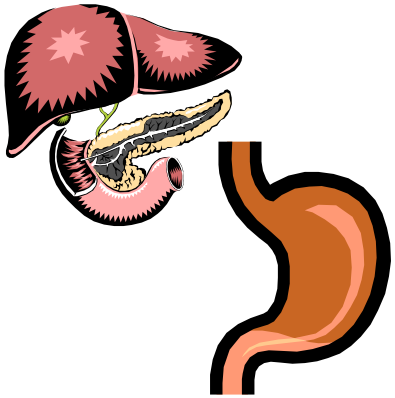
OUR PROPOSAL

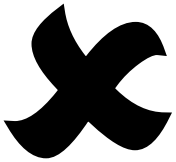
A COLLECTION OF SHAPES WE LEAST EXPECT

spatial division according to radiation properties (composition & density) instead

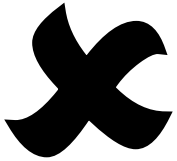
no redundant boundary crossing

ORGAN-BASED





VOXELS



OUR PROPOSAL

ODD SHAPES WE CAN'T RECOGNISE AS BODY PARTS

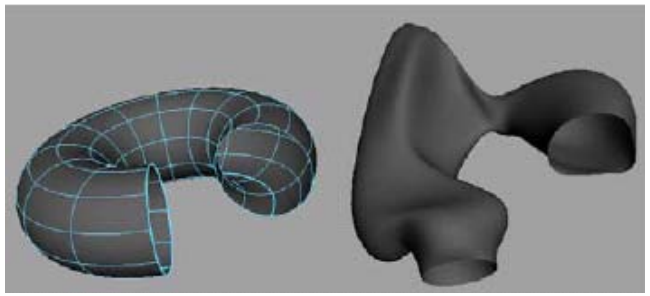
SHAPES DELINEATING REGIONS WHICH HAPPEN TO HAVE THE SAME COMPOSITION AND DENSITY

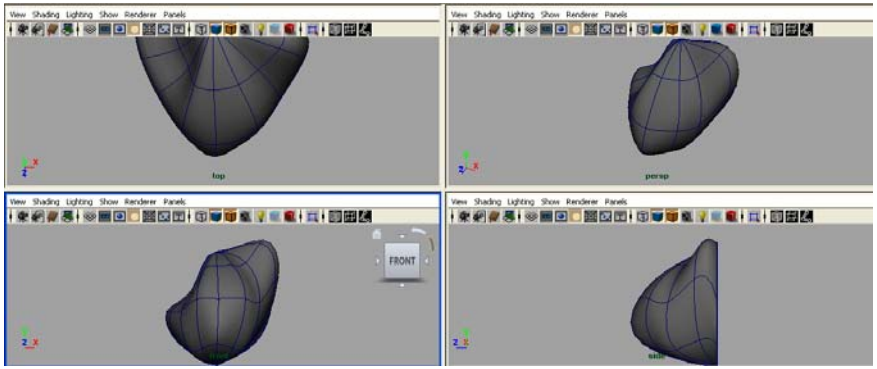
MATHEMATICS AT OUR DISPOSAL

POSSIBLE CANDIDATES:

- NURBS (Non-uniform Rational B-Splines)
- SUPERQUADRICS
- ...

Eugene Zhang *et al* 2005 *Feature-based surface parameterization and texture maping* ACM Trans Graphics





OUR PROPOSAL

A COLLECTION OF SHAPES WE LEAST EXPECT

spatial division according to radiation properties (composition & density) instead

no redundant boundary crossing

MATHEMATICS AT OUR DISPOSAL

POSSIBLE CANDIDATES:

special notes

- NURBS (Non-uniform Rational B-Splines)
- SUPERQUADRICS
- ...

WE AREN'T THE FIRST TO ASSOCIATE NURBS WITH ANTHROPOMORPHIC PHANTOMS, BUT ...

MATHEMATICS AT OUR DISPOSAL

POSSIBLE CANDIDATES:

special notes

- NURBS (Non-uniform Rational B-Splines)

the limited mathematical surface equations of stylized phantoms. A previously developed whole-body voxel phantom of the newborn female was utilized as a realistic anatomical framework for hybrid phantom construction. The construction of a hybrid phantom is performed in three steps: polygonization of the voxel phantom, organ modeling via NURBS surfaces and phantom voxelization. Two 3D graphic tools, *3D-DOCTOR*™ and *Rhinoceros*™, were utilized to polygonize the newborn voxel phantom and generate NURBS surfaces, while an in-house *MATLAB*™ code was used to voxelize the resulting NURBS model into a final computational phantom ready for use in Monte Carlo radiation transport calculations. A total of 126 anatomical organ and tissue models, including 38 skeletal sites and 31 cartilage sites, were described within the hybrid phantom using either NURBS or polygon surfaces. A male hybrid newborn phantom was constructed following the development of the female phantom through the replacement of female-specific organs with male-specific organs. The outer body contour and internal anatomy of the NURBS-based phantoms were adjusted to match anthropometric and reference newborn data reported by the International Commission on Radiological Protection in their Publication 89. The voxelization process was designed to accurately convert NURBS models to a voxel phantom with minimum volumetric change. A sensitivity study was additionally performed to better understand how the meshing tolerance and voxel resolution would affect volumetric changes

MATHEMATICS AT OUR DISPOSAL

POSSIBLE CANDIDATES:

special notes

- NURBS (Non-uniform Rational B-Splines)

THAT IS NOT OUR POINT

1. WE DO NOT WANT ORGAN-BASED GEOMETRY; WE WANT DEFINITION BY RADIATION PROPERTIES

2. WE DO NOT WANT VOXELS IN MONTE CARLO SIMULATIONS

based phantoms were adjusted to match anthropometric and reference newborn data reported by the International Commission on Radiological Protection in their Publication 89. The voxelization process was designed to accurately convert NURBS models to a voxel phantom with minimum volumetric change. A sensitivity study was additionally performed to better understand how the meshing tolerance and voxel resolution would affect volumetric changes

MATHEMATICS AT OUR DISPOSAL

POSSIBLE CANDIDATES:

special notes

- NURBS (Non-uniform Rational B-Splines)
- SUPERQUADRICS
- ...

AND BY THE WAY...

NURBS ISN'T THE SOLUTION

... IT CAN'T DO SHARP BENDS

THE POWER OF MATHEMATICS & COMPUTER GRAPHICS

IF THE MONSTERS HAVE DONE IT

WE CAN DO IT

ORGAN MOTION

RECALL THAT MOTION OF THE MONSTERS' FURS

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