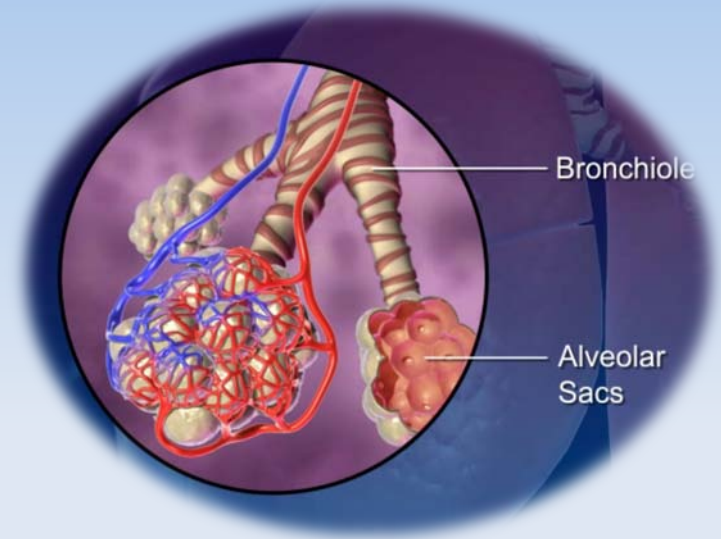
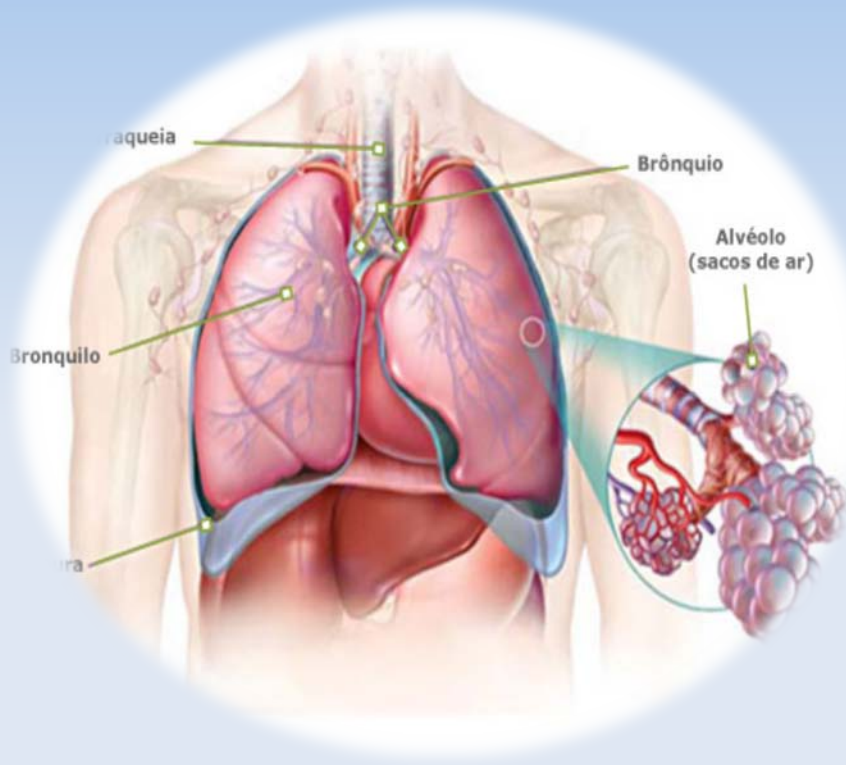


Laboratório de Instrumentação e Física Experimental de Partículas - Lisboa

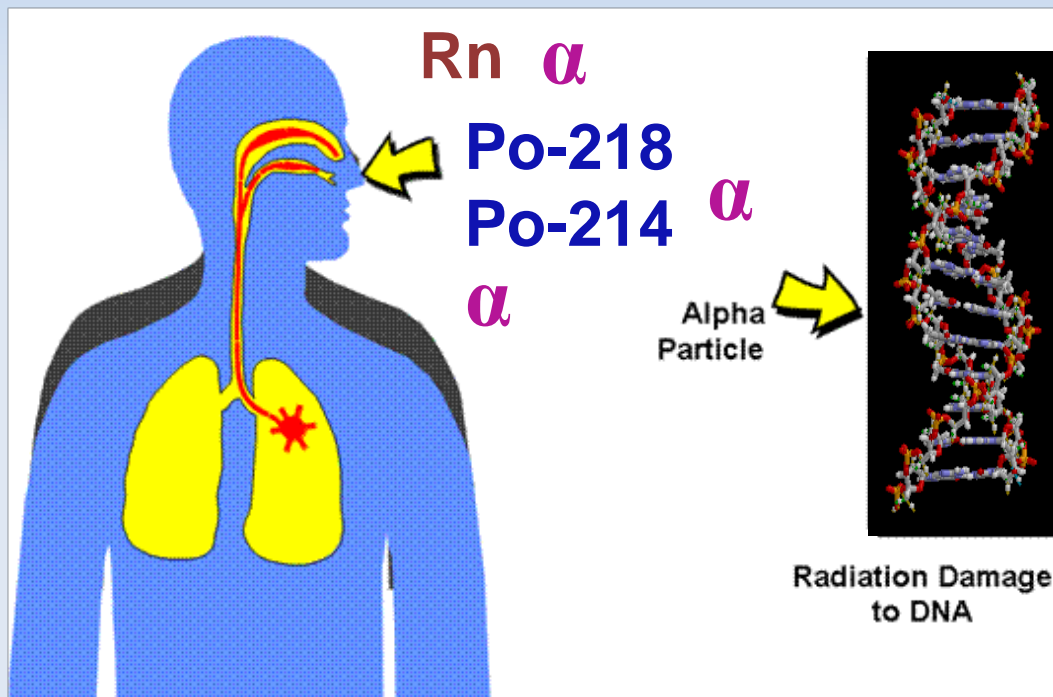


Modelo microdosimétrico das vias respiratórias

Alina Louro, Luís Peralta e Sandra Soares

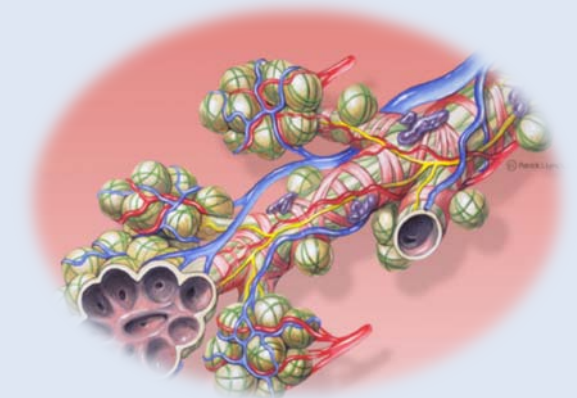
Exposição e risco radiológico

O risco radiológico associado ao radão, deve-se aos produtos descendentes de curto período de semi-vida, que são inalados.

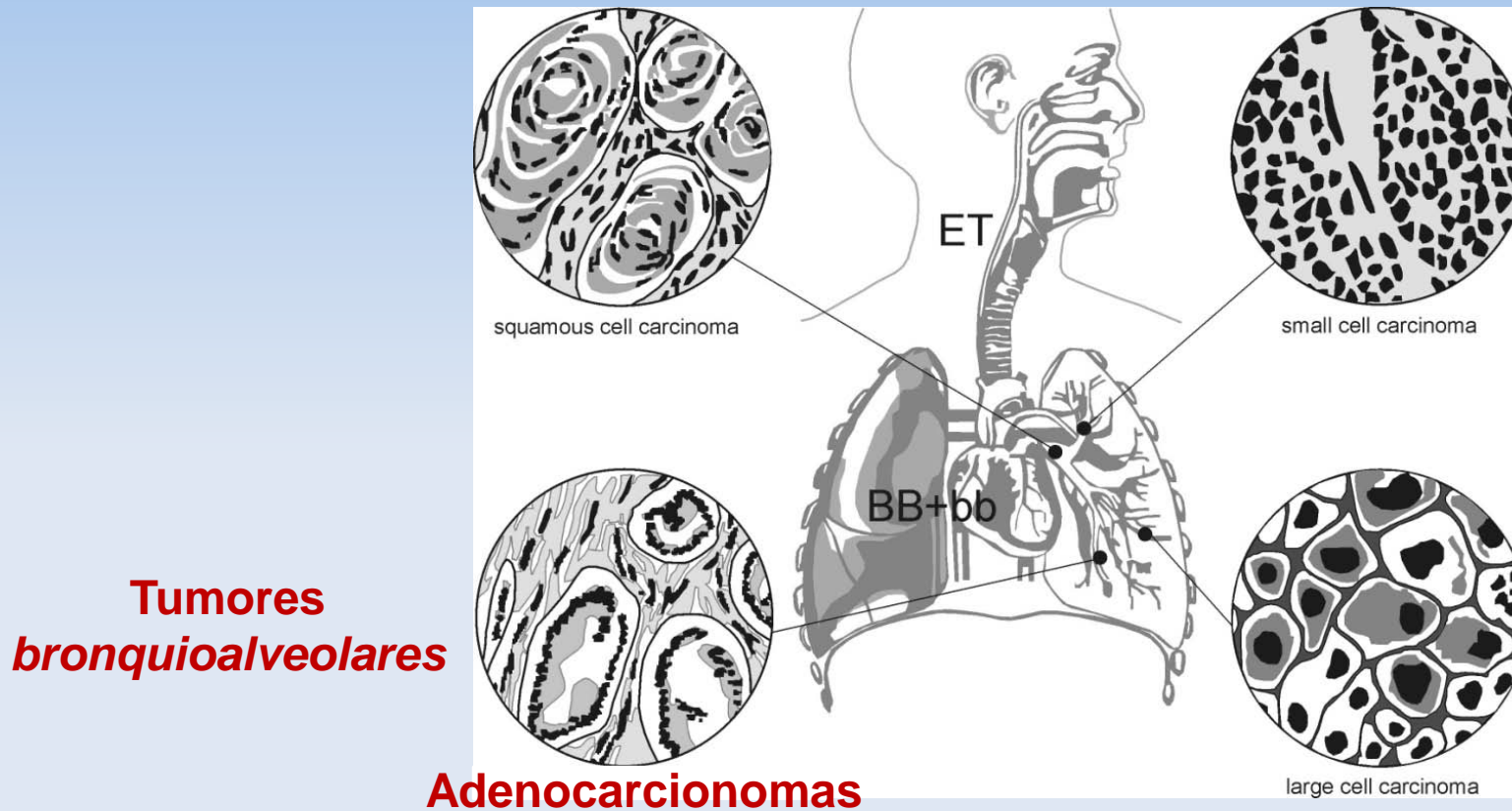


Radão – facilmente eliminado via expiração;

Descendentes directos – podem ficar retidos nas paredes da árvore respiratória contribuindo para a dose interna.



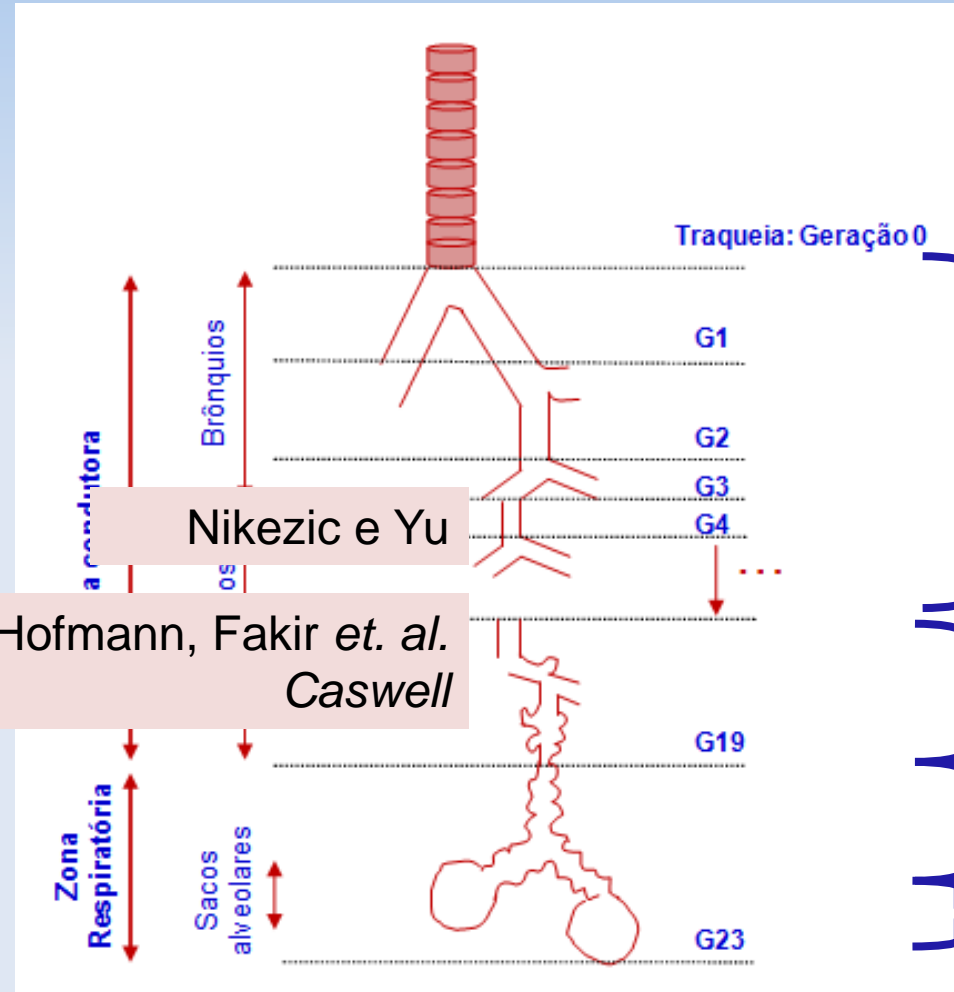
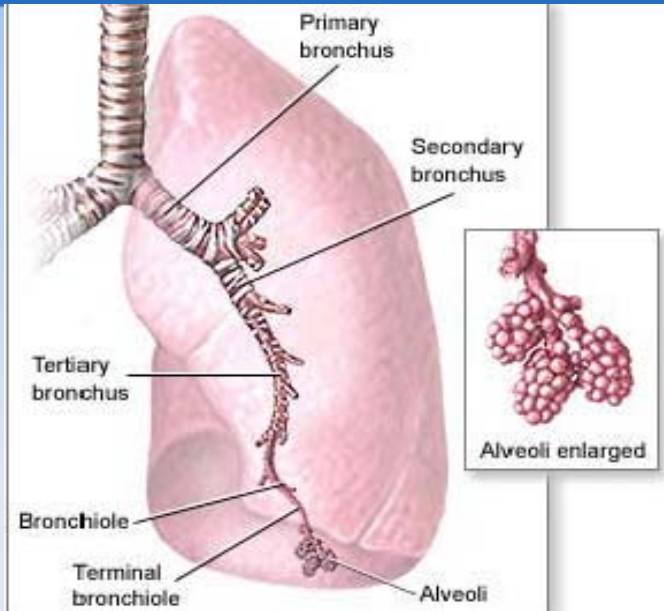
Tumores radioinduzidos



- **25%** dos tumores pulmonares;
- **45%** dos tumores pulmonares em *não fumadores*.

- Abundantes em mineiros e ex-mineiros;
- Abundantes em sobreviventes da bomba atômica e outros acidentes nucleares.

Regiões estudadas na árvore respiratória humana



HRTM (ICRP 65, 1994) – *Human Respiratory Tract*

- *BB* : bronchial region
- *bb*: bronchiolar region
- *AL*: Alveolar interstitial region

Aplicação de códigos MC

AlfaMC

MCNPX

```
air_lung.mat (~/Desktop/Novembro/example_alveolo) - gedit
File Edit View Search Tools Documents Help
air_lung.mat x
MATERIAL: ar alveolar
1.12999999E-03 7.1742387 14.346707 42.453430
1.00000005E-03 90.568855 141.78387 232.35271
1.50000001E-03 112.33910 132.39116 244.73305
2.00000009E-03 130.87144 123.87988 254.75056
2.49999994E-03 147.43425 116.46526 263.90091
3.00000003E-03 162.41882 109.98409 272.47031
4.00000019E-03 189.37483 99.326309 288.67871
4.99999989E-03 213.34505 90.855644 304.17361
6.00000005E-03 235.12292 83.948555 319.87632
7.00000022E-03 255.31627 78.183632 333.44913
8.00000038E-03 274.15961 73.272278 347.46979
8.99999961E-03 291.95648 69.843068 361.00073
9.99999978E-03 308.88446 65.339973 374.24603
1.25000002E-02 348.02393 57.839596 405.83066
1.49999997E-02 383.69312 52.877232 435.69760
1.75000001E-02 416.60645 47.490089 464.11496
1.00000005E-03 147.43425 116.46526 263.90091
```

```
ulgeo.f (~/Desktop/Novembro/example_G19) - gedit
File Edit View Search Tools Documents Help
ulgeo.f x
C Geometry routine: G19

subroutine ulgeo
IMPLICIT DOUBLE PRECISION (A-H,O-Z), INTEGER*4 (I-N)
include 'ulincl.inc'
parameter(hz=9.90D-2)
dimension neigh(nmax), par(nparadim), xcenter(3)

call ulinitarrays ! initialize all arrays ! Mandatory

do i=1,nparadim ! reset parameters
par(i)=0.00
enddo

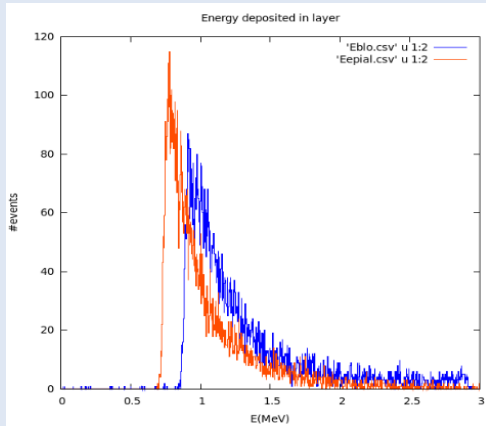
r2=2.5350D-2 ! membrana do bronquiolo respiratorio G19
r3=2.5300D-2 ! epitelio insensivel 1
r4=2.5000D-2 ! epitelio sensivel
r5=2.4200D-2 ! epitelio insensivel 2
r6=2.3800D-2 ! camada de cilios
r7=2.3600D-2 ! camada de muco
r8=2.3500D-2 ! ar bronquiolar

mat2=1
mat3=2
mat4=3
mat5=2
mat6=4
mat7=5
mat8=6
```

```
Ficheiro Editar Formatar Ver Ajuda
Bronquiolo respiratorio G19
C CELLS CARDS
1 1 -9.066E-03 -1 2 imp:A=1 $Rn source
2 2 -1.000E-03 -2 1 imp:A=1 $ar alveolar
3 3 -1.450E+00 -3 1 2 imp:A=1 $muco
4 4 -9.200E-01 -4 1 2 3 imp:A=1 $cilios
5 5 -1.000E+00 -5 1 2 3 4 imp:A=1 $epitelio insensivel1
6 6 -1.045E+00 -6 1 2 3 4 5 imp:A=1 $epitelio sensivel
7 7 -1.000E+00 -7 1 2 3 4 5 6 imp:A=1 $epitelio insensivel2
8 7 -2.330E+00 -8 1 2 3 4 5 6 7 imp:A=1 $membrana basal
9 0 0 -9 1 2 3 4 5 6 7 8 imp:A=0 $universo de vacuo

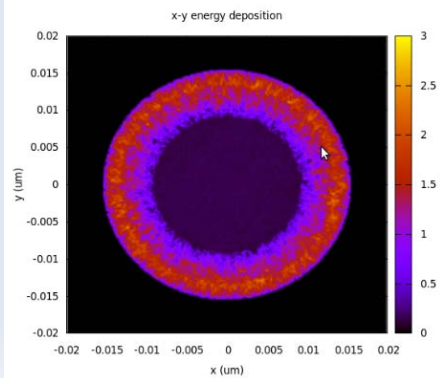
C SURFACES CARDS
1 $o 1.0E-06
2 rcc 0 0 0 0 9.9E-02 2.350E-02
3 rcc 0 0 0 0 9.9E-02 2.360E-02
4 rcc 0 0 0 0 9.9E-02 2.380E-02
5 rcc 0 0 0 0 9.9E-02 2.420E-02
6 rcc 0 0 0 0 9.9E-02 2.500E-02
7 rcc 0 0 0 0 9.9E-02 2.530E-02
8 rcc 0 0 0 0 9.9E-02 2.535E-02
9 rcc 0 0 0 0 1.1E-01 2.778E-02

C DATA CARDS
mode A
PHYS:A 300 33 0
CUT:A 1E34 1E-03 -0.5 -0.25 1
m1 86222 1 $fonte de Rn
m2 7014 -0.7552 8016 -0.2317 6012 -0.00013 18040 -0.0128 $ar
m3 1001 -0.06547 6012 -0.53695 7014 -0.02150 8016 -0.03209
8019 -0.16741 2040 -0.17659
m4 1001 -0.11948 6012 -0.63723 7014 -0.00797 8016 -0.23233
1123 -0.00050 1224 -0.00002 1531 -0.00016 1632 -0.00073
1735 -0.00119 1939 -0.00032 2040 -0.00002 2656 -0.00002
3065 -0.00002
m5 8016 1 1001 2 $epitelio insensivel agua
m6 1001 -0.103 6012 -0.105 7014 -0.031 8016 -0.749
1123 -0.002 1736 -0.003 1531 -0.002 1632 -0.003
1939 -0.002 $epitelio sensivel
m7 1428 1 $511cone
sdef par=34 pos=0 0 0 ergs=.489 $def. fonte
f6:A 2 $energia dep por uni. de massa
f16:A 6
f8:A 6 $energia distribuida por pulso
E8 0 8001 2 0
c tmesh3
c rmesh3 total
c cora3 -SE-04 351 SE-04
c corb3 -SE-04 351 SE-04
c corc3 0 351 6.667E-04
c endmd
print 10 30 41 30 85 126
nps 10000
```

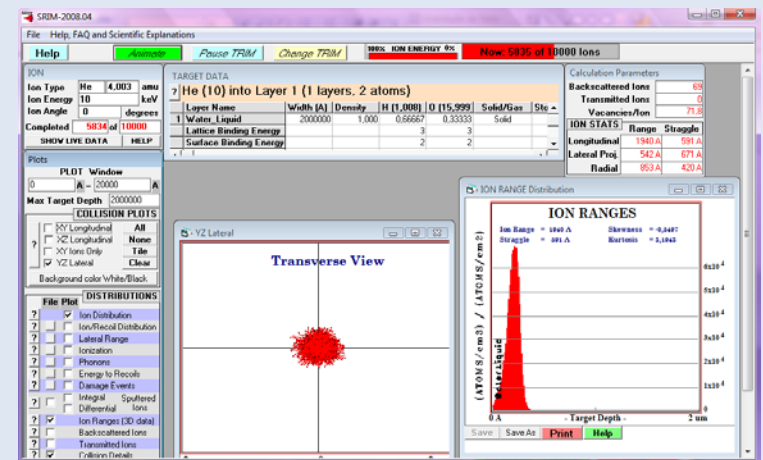


```
alina@pc:~/Desktop/Novembro/example_G19
File Edit View Search Terminal Help
Event: 8600
Event: 8700
Event: 8800
Event: 8900
Event: 9000
Event: 9100
Event: 9200
Event: 9300
Event: 9400
Event: 9500
Event: 9600
Event: 9700
Event: 9800
Event: 9900
Event: 10000
Emed in epite 0.82329+- 0.00019
Emed in ar 0.85249+- 0.00002
Emed in 4 : 0.82329
Emed in 8 : 0.85249

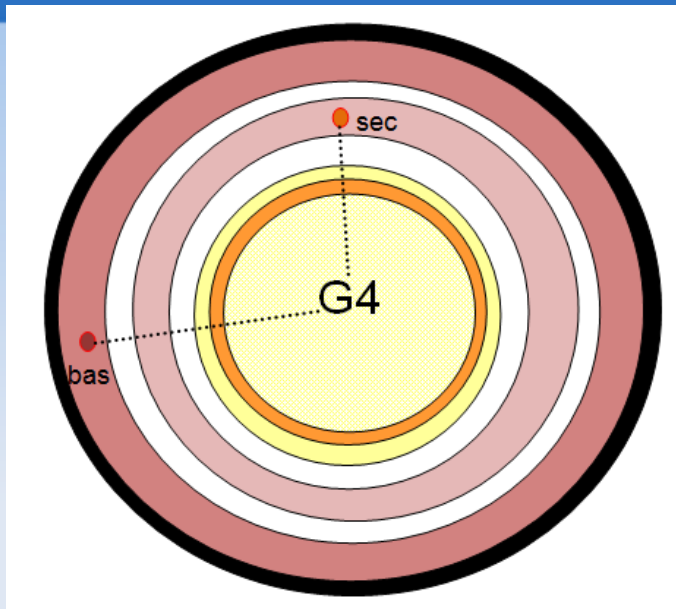
real 0m10.997s
user 0m10.857s
sys 0m0.048s
alina@pc:~/Desktop/Novembro/example_G19
```



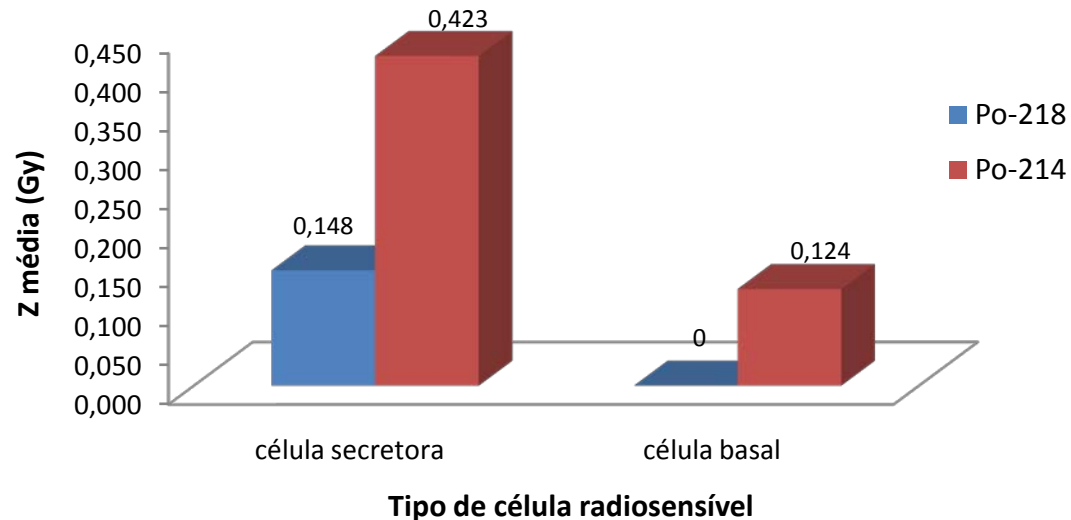
SRIM



Brônquio G4



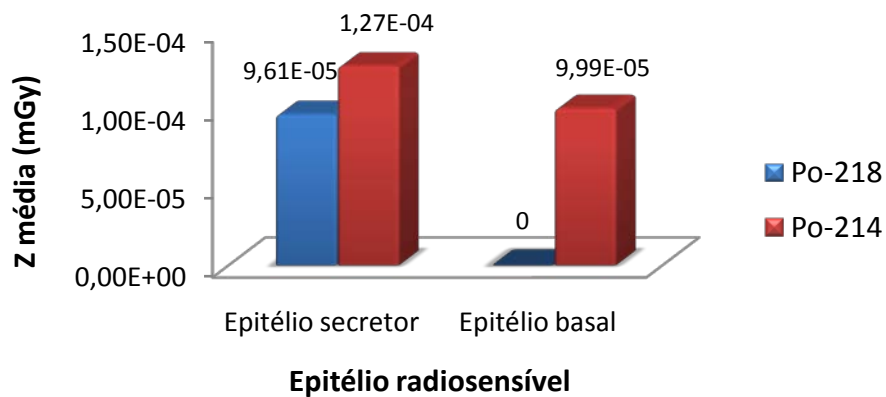
Energia específica média em núcleos de células radiosensíveis do G4 (resultados para um núcleo)



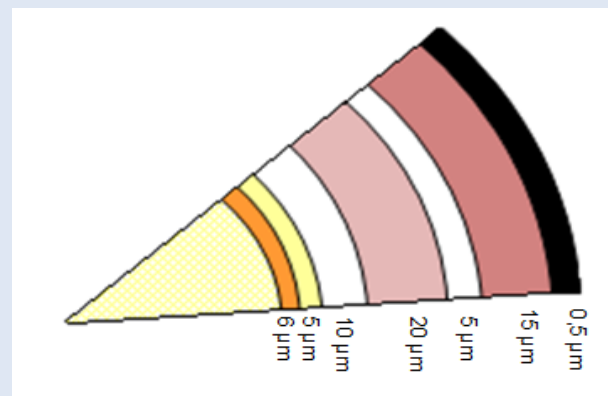
Nikezic e Yu, 1996 até 2011



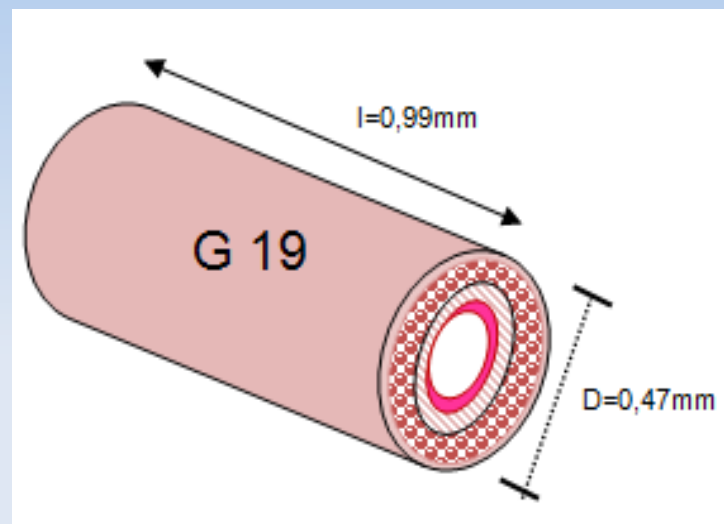
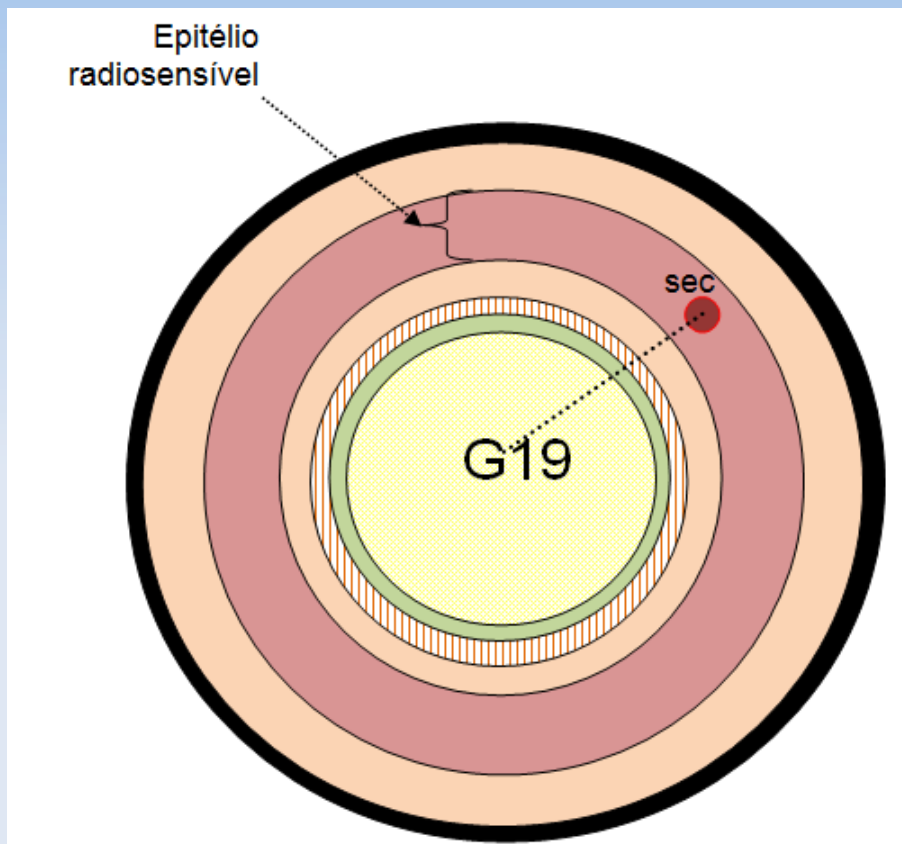
Energia específica média nos epitélios radiosensíveis do G4



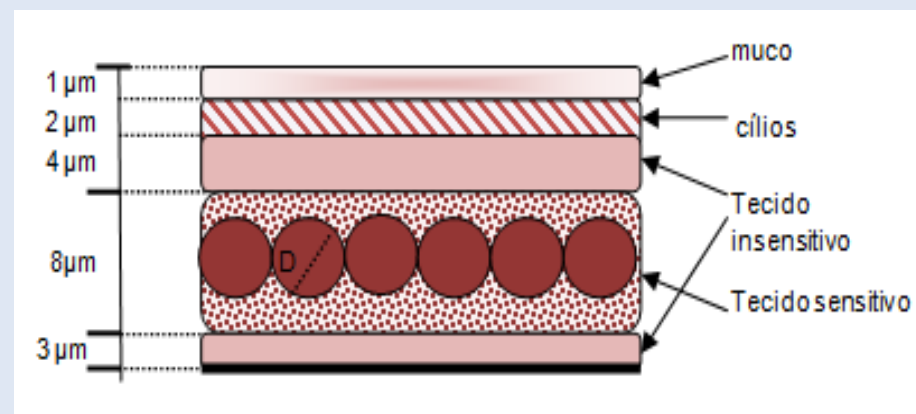
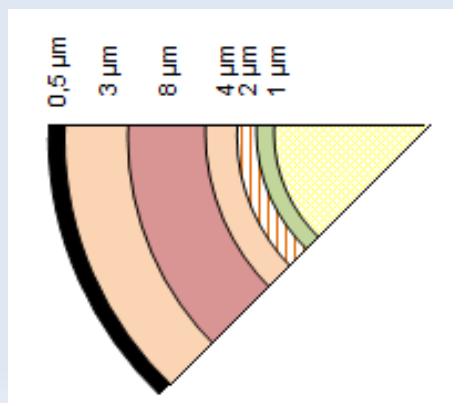
Ar bronquial
Muco
Cílios
Epitélio insensível
Epitélio sensível 1
Epitélio sensível 2
Membrana basal



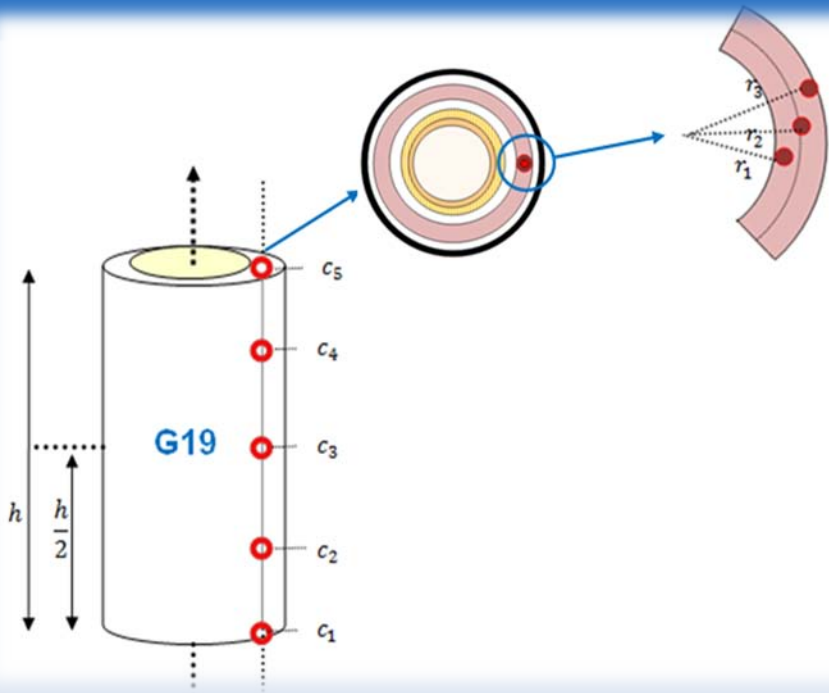
Bronquíolo respiratório G19: modelo da parte inicial do Acino



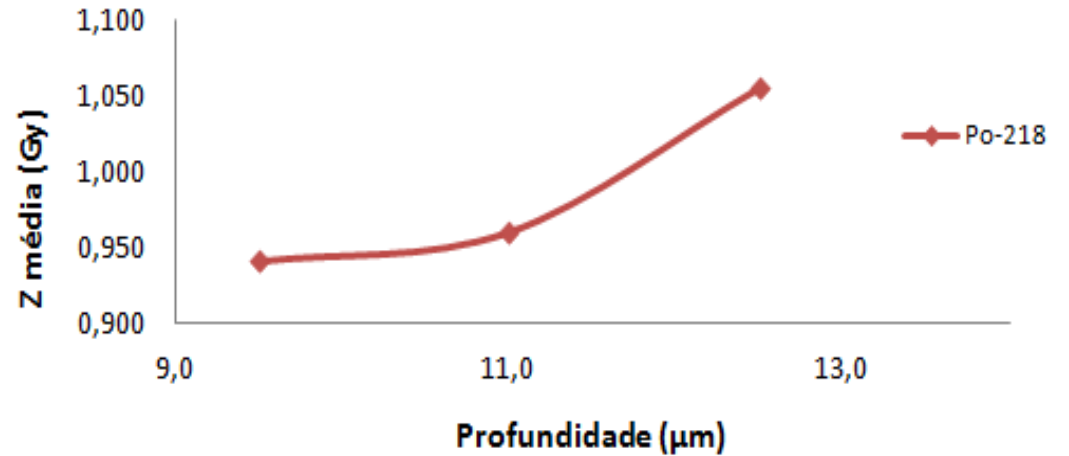
	Ar bronquiolar
	Muco
	Cílios
	Epitélio insensível
	Epitélio sensível 2
	Membrana basal



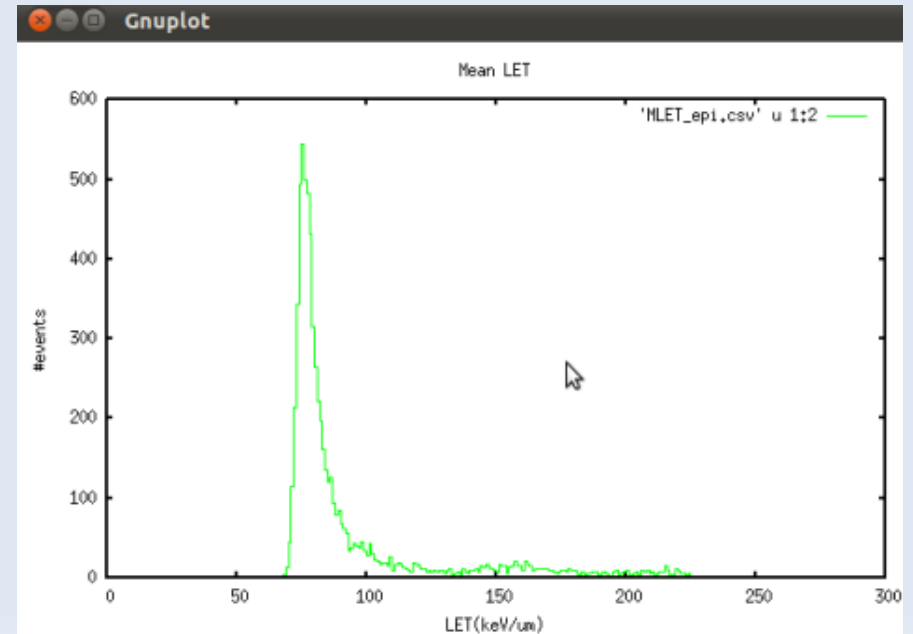
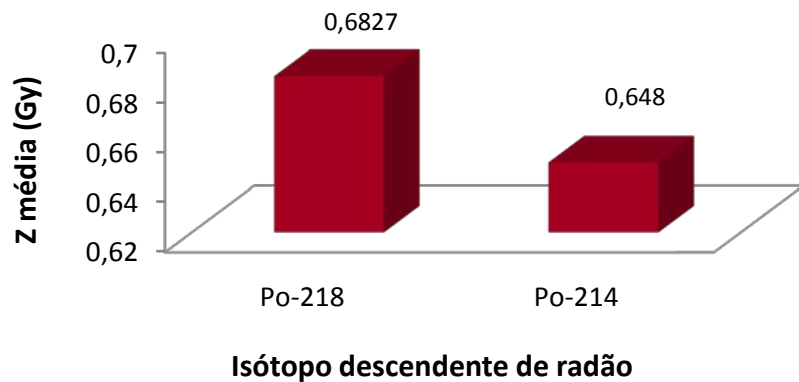
Bronquíolo respiratório G19



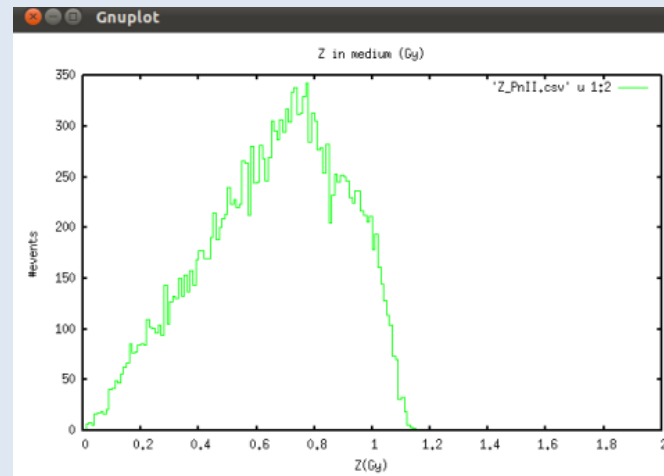
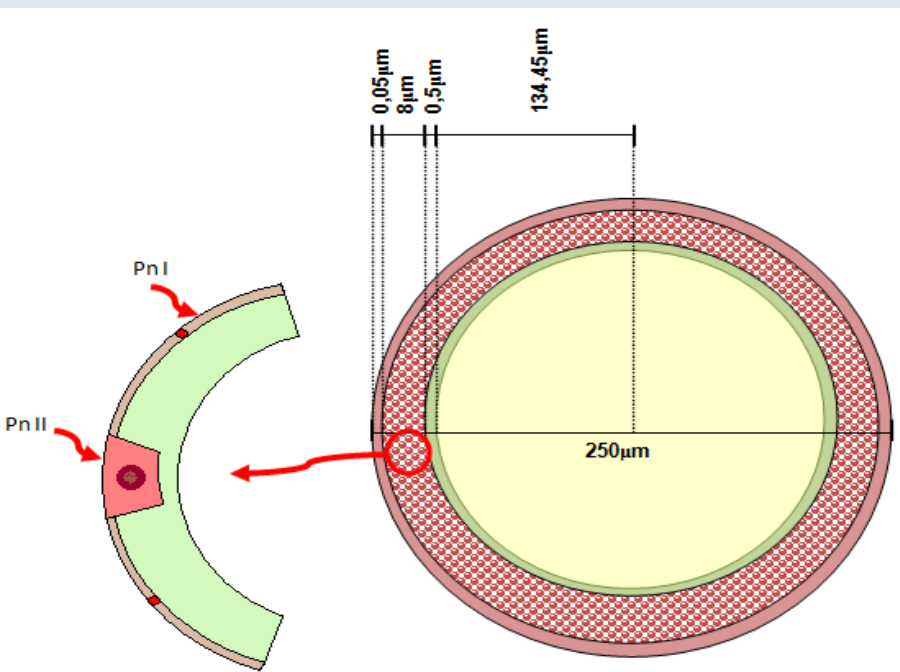
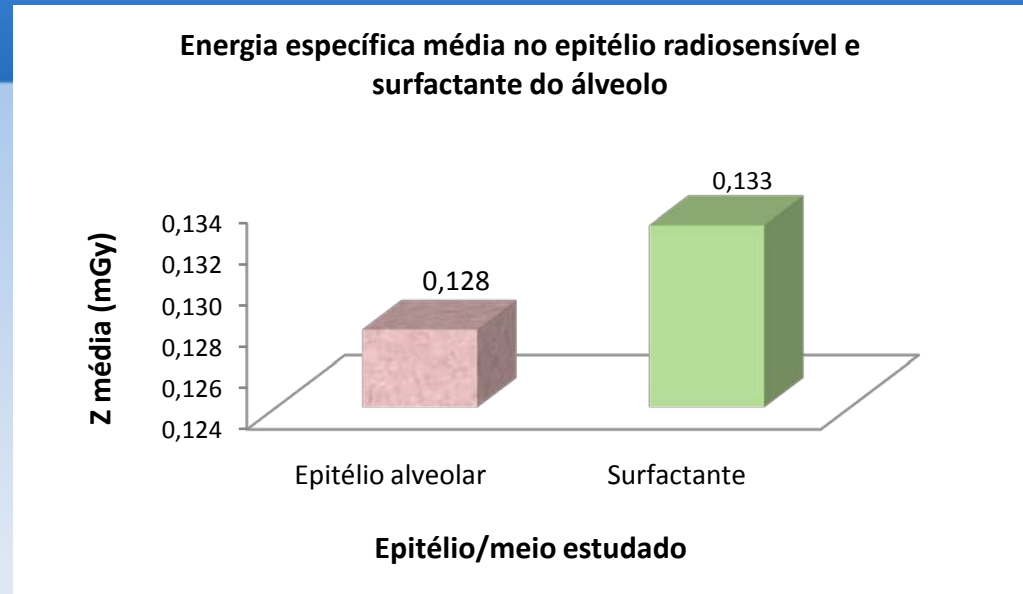
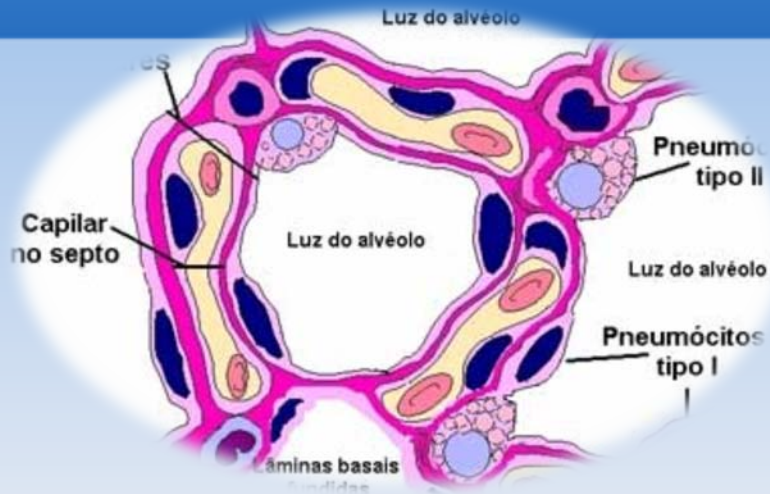
Varição da energia específica média no núcleo de uma célula secretora do G19 com a profundidade no epitélio sensível



Energia específica média no núcleo de uma célula secretora do G19



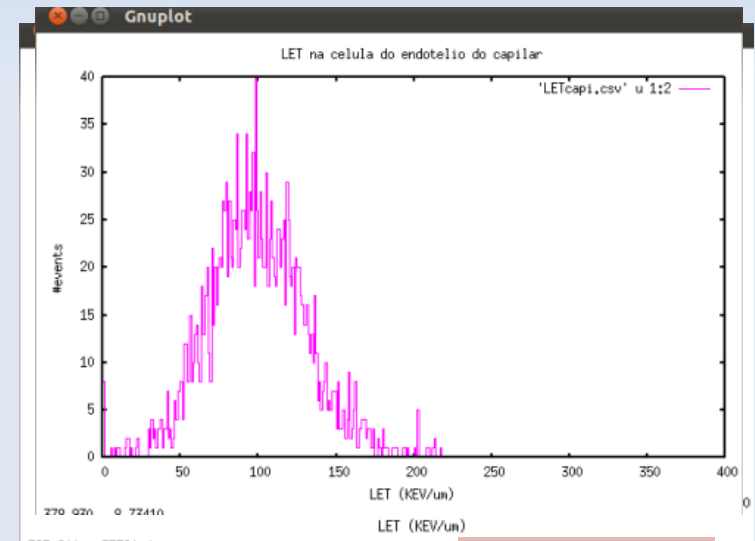
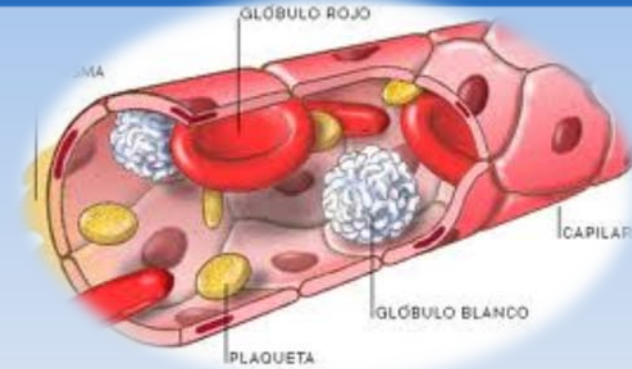
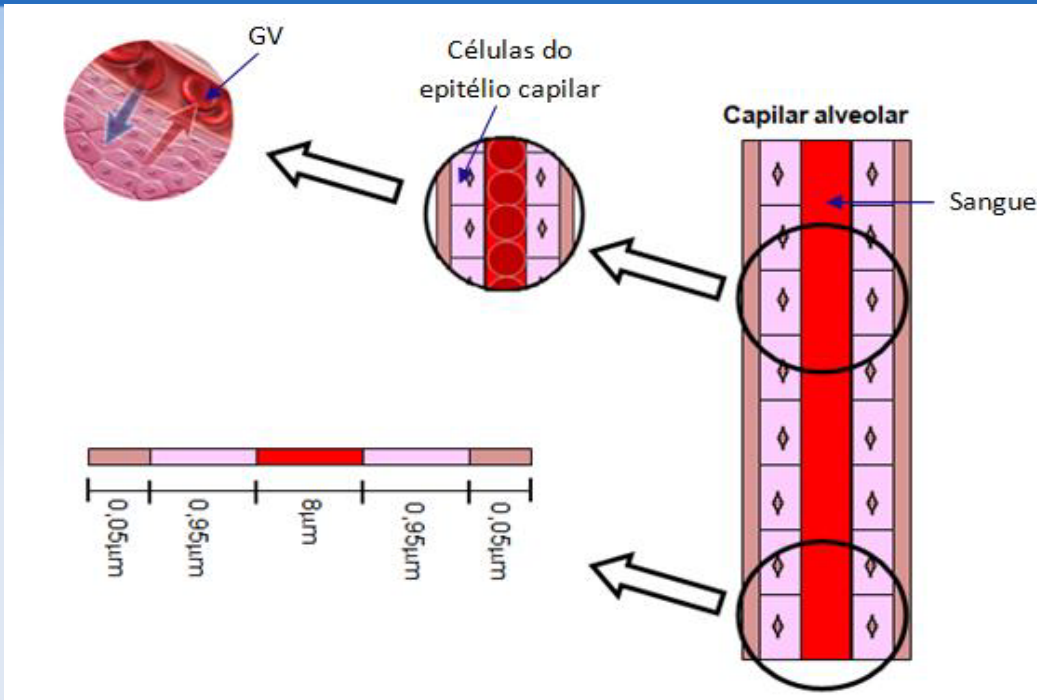
Região alveolar: modelo de um alvéolo respiratório



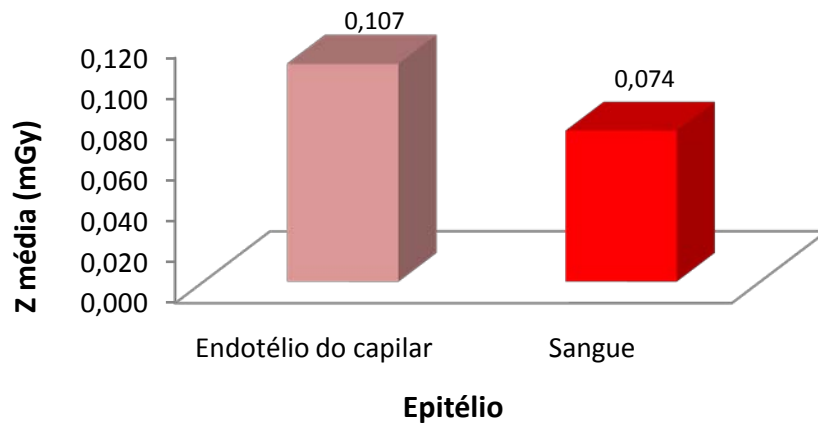
Epitélio alveolar
PnI
PnII

- E dep.
- D/Z
- LET
- N° entradas
- φ_E

Região linfática: modelo de um capilar alveolar



Energia específica média em epitélios da região linfática



Epitélio do capilar
Sangue
Glóbulo vermelho

- E dep.
- D/Z
- LET
- N° entradas
- Φ_E

