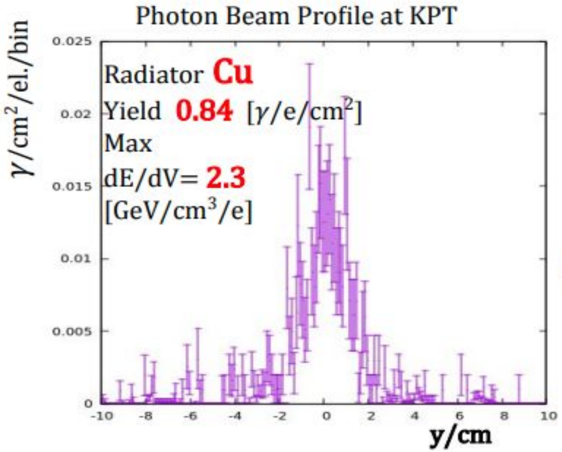
Effect of radiator material. Slide from CPS meeting 20-May-2022.

Option 2: **Energy** Deposition **vs Radiator Material**.

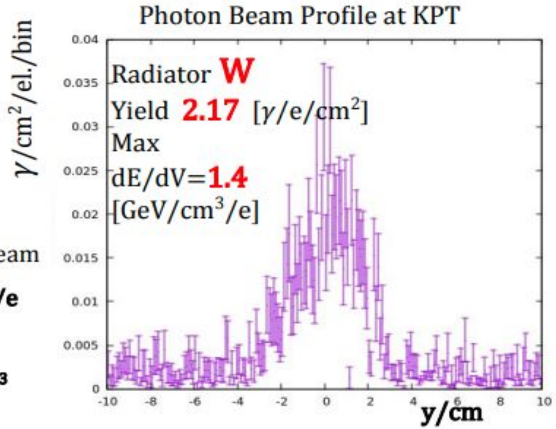


At 5μA current of e-beam

dE/dV=1. GeV/cm³/e

translates to

dP/dV = 5. kW/cm³

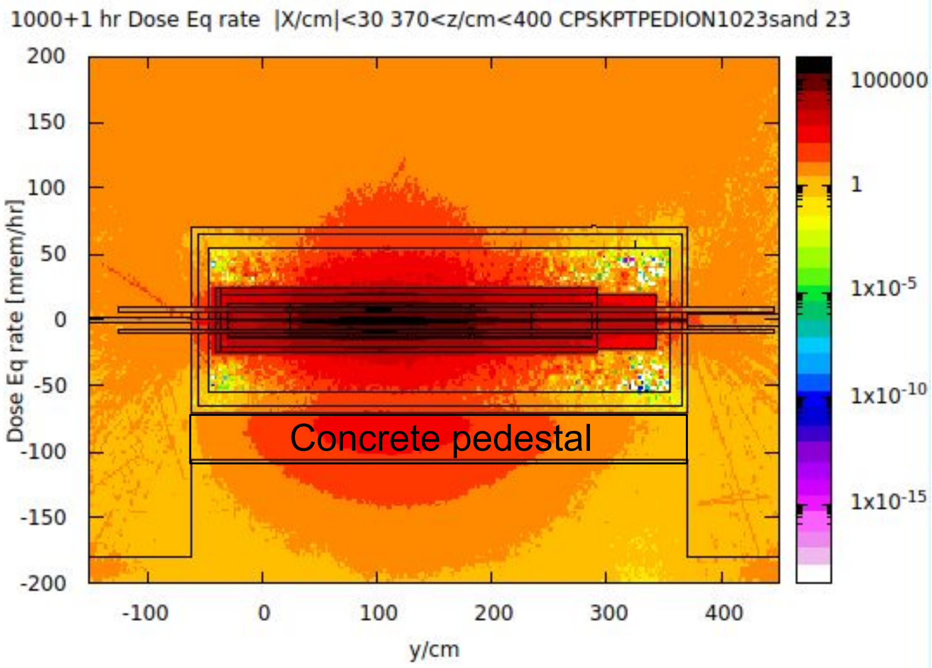


- **W**-converter provides **× 1.6 lower** dE/dV in the hot spot and **× 2.6 higher yield** of photons.
- We may have **factor 2.6 × 1.6 = ~4** to **scale down** dE/dV in the "**hot spot**".
- However photon beam is **wider**. What is photon **energy spectrum**?

15

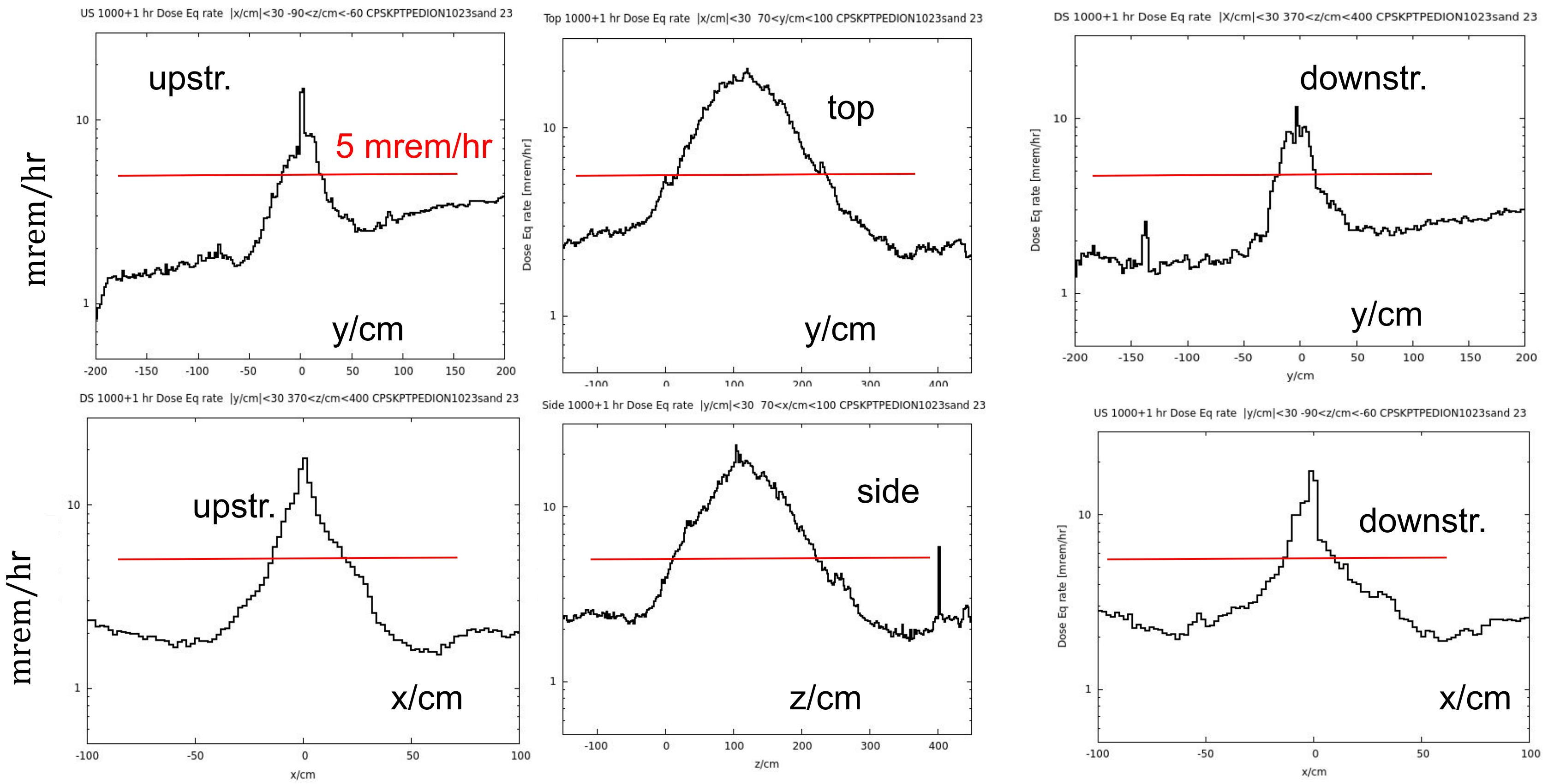
- **Wider photon beam – beam quality is worse –photon conversion in very long beam pipe.**
- **Wider z-profile of energy deposition – higher radiation in coils (insulation lifetime).**

Effect of Tagger Hall ceiling. Dose Equivalent after 1000+1 hrs.



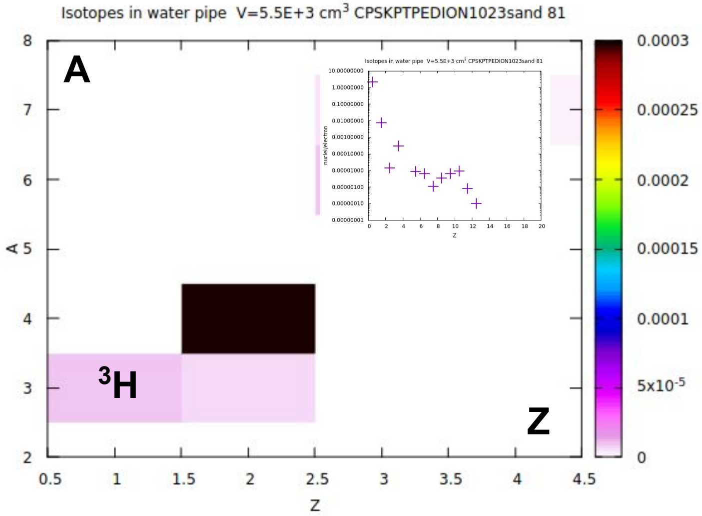
- Higher dose rate at positive y. Corresponding dose equivalent profiles at the next slide.

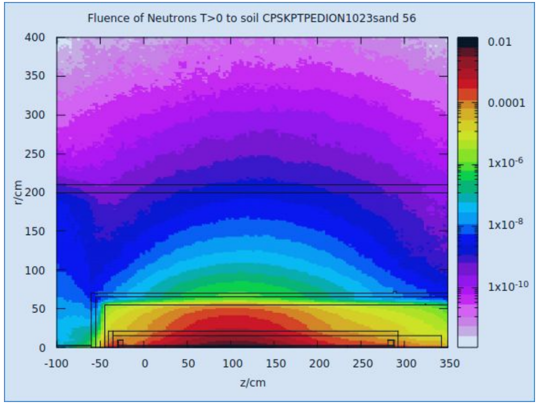
Effect of Tagger Hall ceiling. Dose Eq. profiles after 1000+1 hrs.

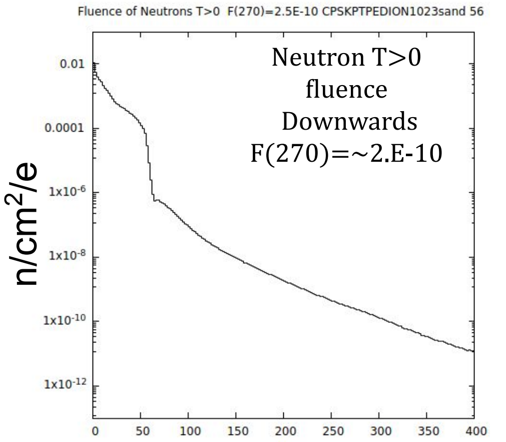


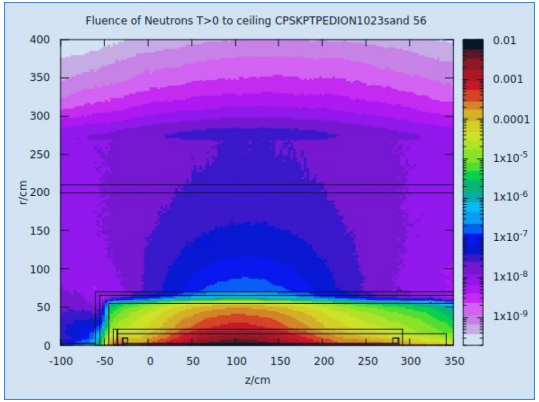
- Some of these profiles are included into Overleaf document.

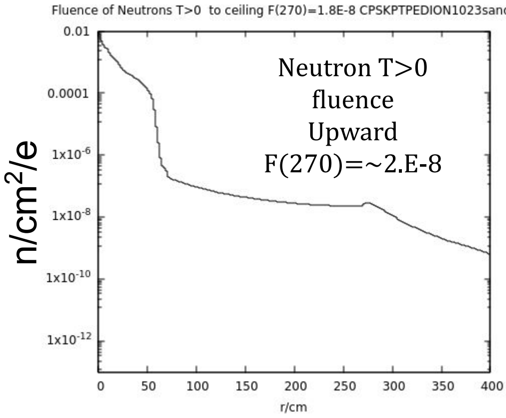
Tritium in cooling waters and neutron fluence.











Yield of ^{3}H in the cooling water ~1.E-5 [T/e]

Number of T nuclei produced in one year: =

N_T=1.E-5 [T/e] 3.E+13 [e/s] 3.14E+7[s] =~1.E+16 [T]

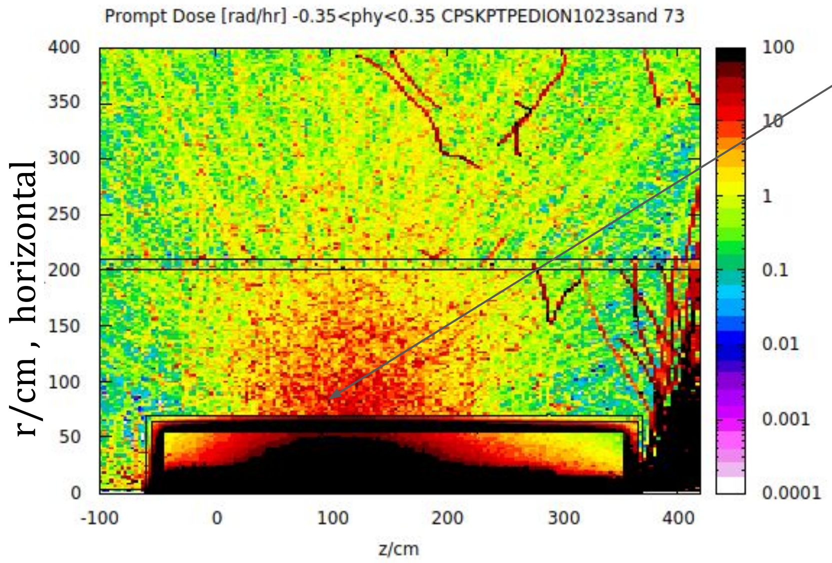
Actility to be absorbed after one year

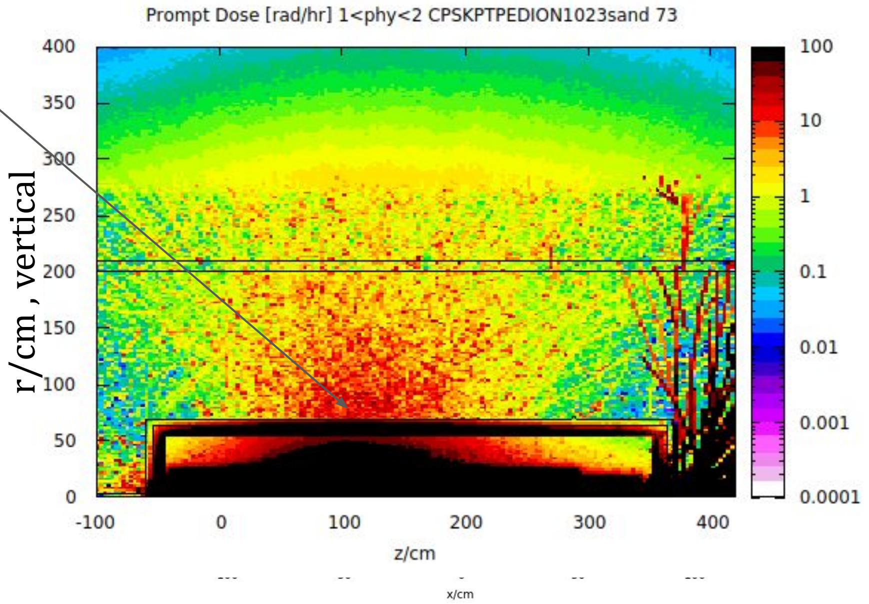
$-dN_T/dt$=1.E+16 / (12*3.14E+7 s) = ~2.6 E+7 Bq

May be diluted to 7,000 Bq/L in 3.7 m^3 of clear water.

Prompt Dose Rate.

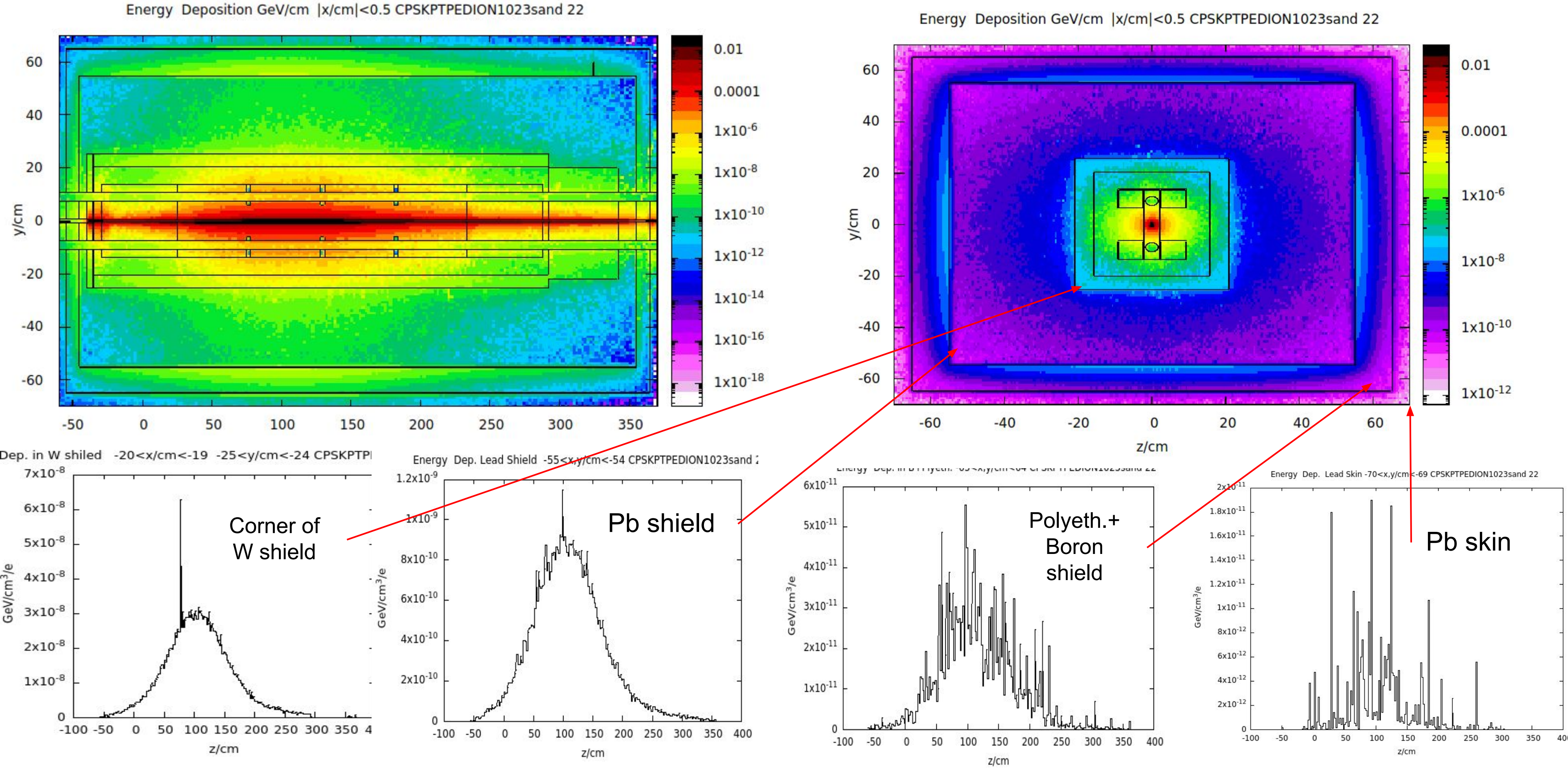
Prompt Dose
10 rad/hr





- Maximum prompt dose rate at the CPS surface is of 10 rad/hr.
- May be reduced via shield shape optimisation.

Energy Deposition Map 0.5×1×2× cm^3 for temperature calculations.



Energy deposition map is ready for the conceptual design.

What do we need.

1. (ASAP) Temperature map for the conceptual design **with tungsten** shield.

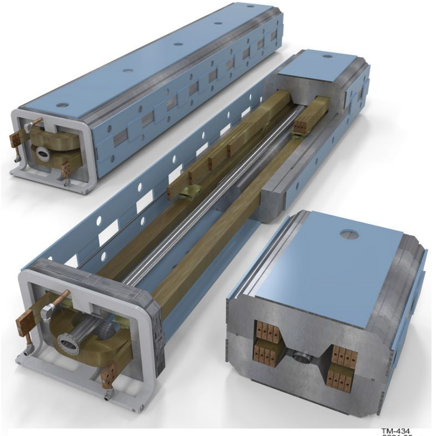
   To decide whether we need additional cooling of magnet poles and/or lead shield.

2. Map for the design **with lead** on place of the tungsten shield.

   With a hope to have a cheaper CPS.

3. Map for the design **with iron** on place of the tungsten shield.

Export from FLUKA does not work properly.
Very simple model for Temperature Calculations in CPS shield layers.



1. Include Magnet design (FNAL DIPOLE)

2.Box is formally described below in a following way (dimensions given in cm):

box(“X_{min}”:”X_{max}”, “Y_{min}”:”Y_{max}”, “Z_{min}”:”Z_{max}”) = box(-15.88:15.88,-20.4:20.4,-35:292)

Include shield layers as a difference of two boxes :

2.1   Cu Absorb. = box(-2.2:2.2,-13.5:13.5,-29:281) - none

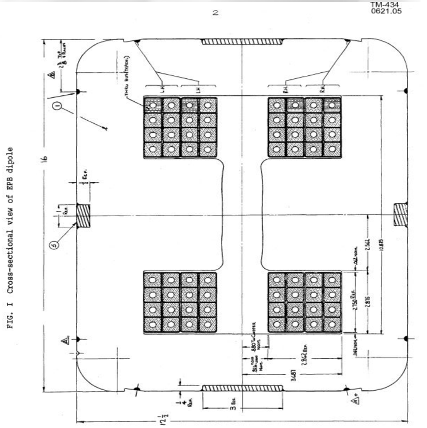
2.2   Fe   Yoke   = box(-15.88:15.88,-20.32:20.32,-35:292)-box(-2.2:2.2,-13.5:13.5,-29:281)

2.3   W   Shield = box(-20.88:20.88,-25.32:25.32,-40:355)-box(-15.88:15.88,-20.32:20.32,-35:292)

2.4   Pb Shield = box(-50:50,-50:50,-44:356)-box(-20.88:20.88,-25:25,-40:355)

2.5   B-Polyeth = box(-65:65,-65:65,-55:365)-box(-50:50,-50:50,-44:356)

2.6   Pb   Skin = box(-70:70,-70:70,-60:370)-box(-65:65,-65:65,-55:365)



Copper coil1 =box(2.5: 9,-13.5:13.5,-28.5:287)-(-9.4:9.4,-6.5:6.5,-23.5:281)-box(-2.2:2.2,-13.5:13.5,-29:281)

Copper coil2 =box(-2.5:-9,-13.5:13.5,-28.5:287)-(-9.4:9.4,-6.5:6.5,-23.5:281)box(-2.2:2.2,-13.5:13.5,-29:281)

The End

Next Step for Temperature Calculations in CPS shield layers to be sure that Lead does not melt.

Hello , Tim. As FLUKA export to “OPEN SCAD” does not work correctly, let’s make your t-model manually.

I think it will not take much time since it is very simple. In particular You may

1.Include Magnet design (FNAL DIPOLE) from the drawing in the right corner together with the Absorber; here, the Iron Yoke is a box which wraps the coil and the absorber.

For example the Yoke box is formally described in a following way (dimensions given in cm):

box(“X_{min}”:”X_{max}”, “Y_{min}”:”Y_{max}”, “Z_{min}”:”Z_{max}”) = box(-15.88:15.88,-20.4:20.4,-35:292)

Here we neglect the copper coils

2. Include shiel layers as a difference of two “box(x:X,y:Y,z:Z)” as:

2.1 CuAbsorber = box(-2.2:2.2,-13.5:13.5,-29:281) - none

2.2 Iron Yoke = box(-15.88:15.88,-20.32:20.32,-35:292)-box(-2.2:2.2,-13.5:13.5,-29:281)

2.3 W Shield = box(-20.88:20.88,-25.32:25.32,-40:355)-box(-15.88:15.88,-20.32:20.32,-35:292)

2.4 Lead Shield = box(-50:50,-50:50,-44:356)-box(-20.88:20.88,-25:25,-40:355)

2.5 Bor-Polyeth = box(-65:65,-65:65,-55:365)-box(-50:50,-50:50,-44:356)

2.6 Lead Skin = box(-70:70,-70:70,-60:370)-box(-65:65,-65:65,-55:365)

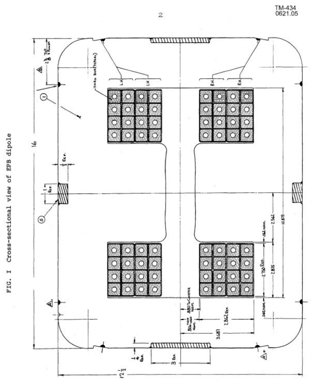
For the moment we neglect the material of

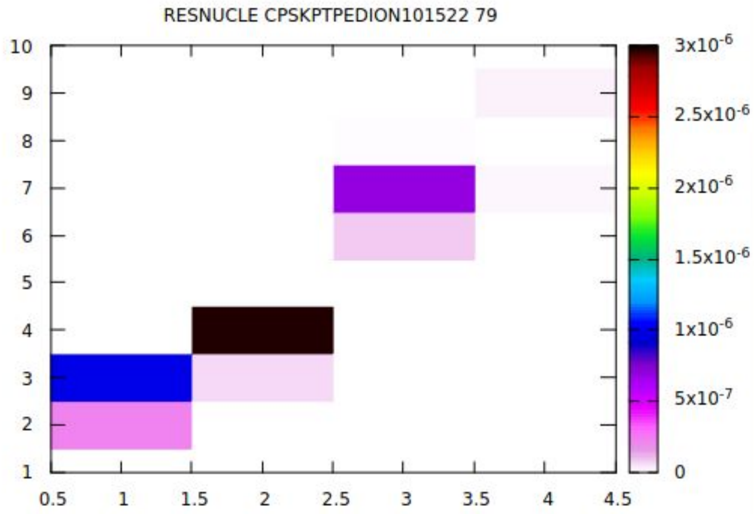
Copper coil1 =box(2.5: 9,-13.5:13.5,-28.5:287)-(-9.4:9.4,-6.5:6.5,-23.5:281)-box(-2.2:2.2,-13.5:13.5,-29:281)

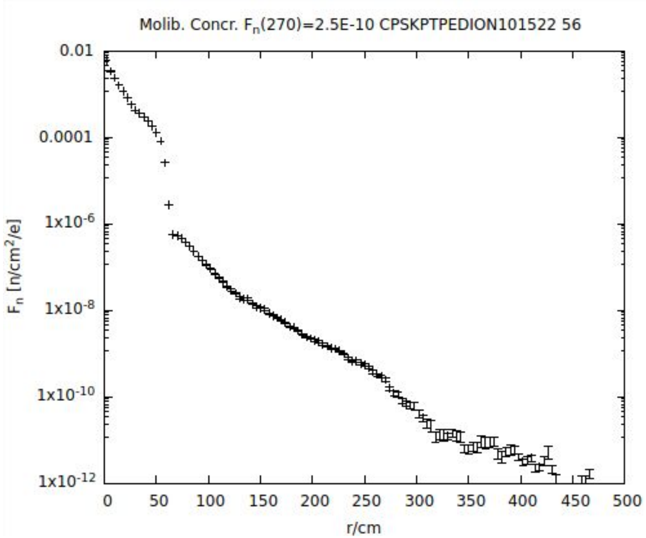
Copper coil2 =box(-2.5:-9,-13.5:13.5,-28.5:287)-(-9.4:9.4,-6.5:6.5,-23.5:281)box(-2.2:2.2,-13.5:13.5,-29:281)

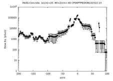
Call me if you have questions: 757 633 5669

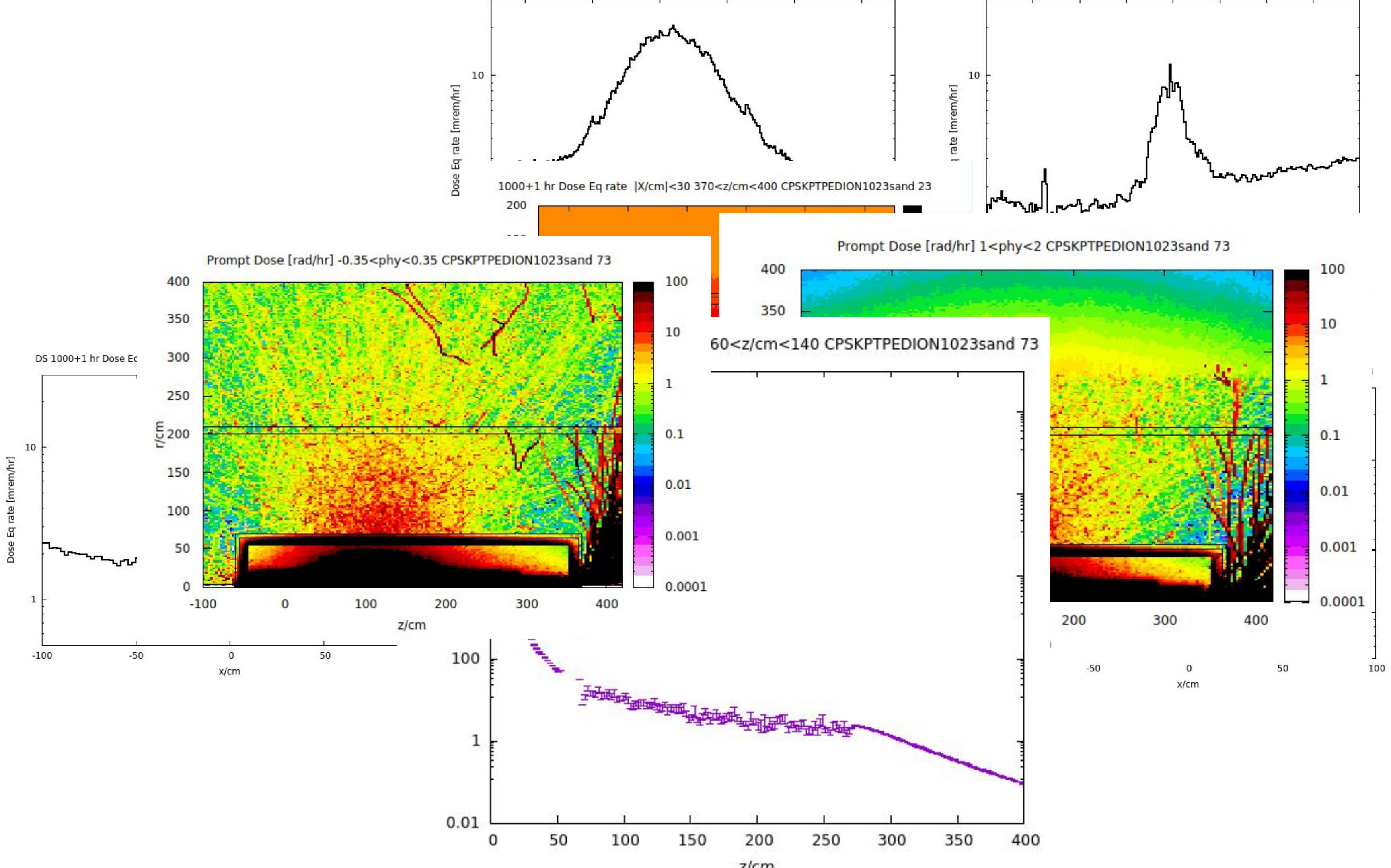
Meanwhile I am doing the energy deposition calculations




RESNUCLE CPSKPTPEDION101522 79
10
9
8
7
6
5
4
3
2
1
0.5
1
1.5
2
2.5
3
3.5
4
4.5
3x10-6
2.5x10-6
2x10-6
1.5x10-6
1x10-6
5x10-7
0


Molib. Concr. Fn(270)=2.5E-10 CPSKPTPEDION101522 56
0.01
0.0001
1x10-6
1x10-8
1x10-10
1x10-12
Fn [n/cm2/e]
0
50
100
150
200
250
300
350
400
450
500
r/cm

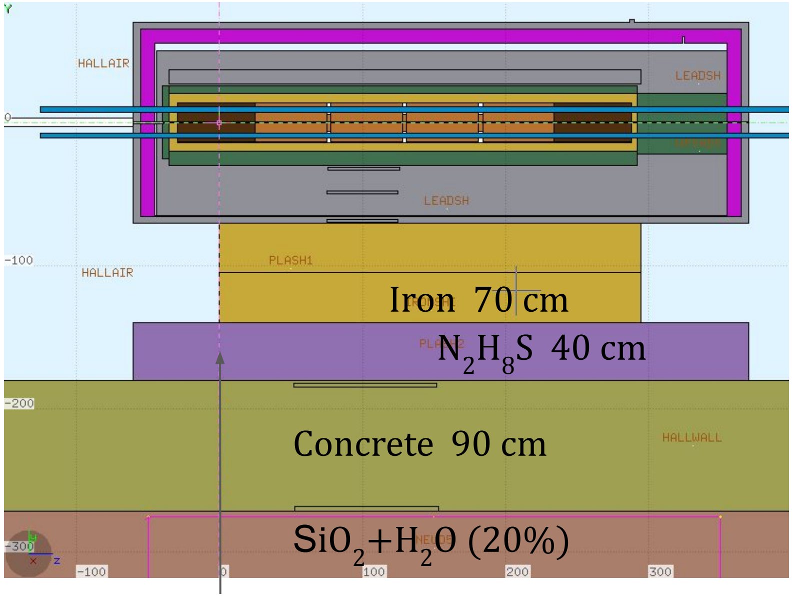


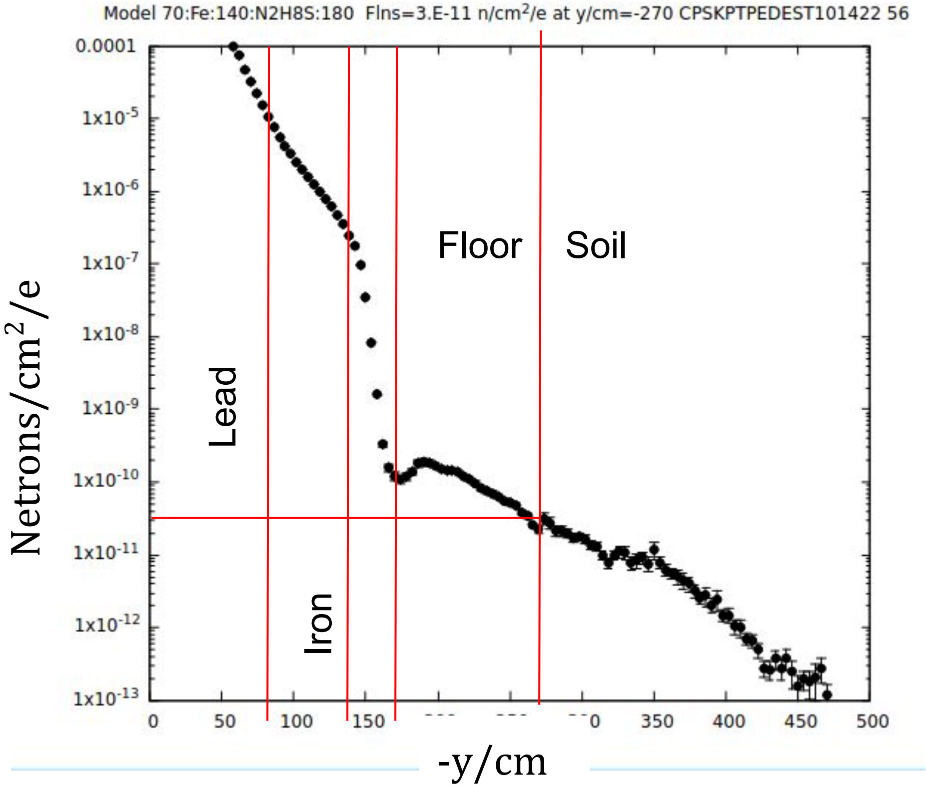


1000+1 hr Dose Eq rate |X/cm|<30 370<z/cm<400 CPSKPTPEDION1023sand 23
Prompt Dose [rad/hr] -0.35<phy<0.35 CPSKPTPEDION1023sand 73
Prompt Dose [rad/hr] 1<phy<2 CPSKPTPEDION1023sand 73
60<z/cm<140 CPSKPTPEDION1023sand 73
DS 1000+1 hr Dose Ec
Dose Eq rate [mrem/hr]
r/cm
z/cm
x/cm

Previous presentation

Neutrons T > 0 MeV in soil at 1 m depths after Iron/N_2H_8S pedestal

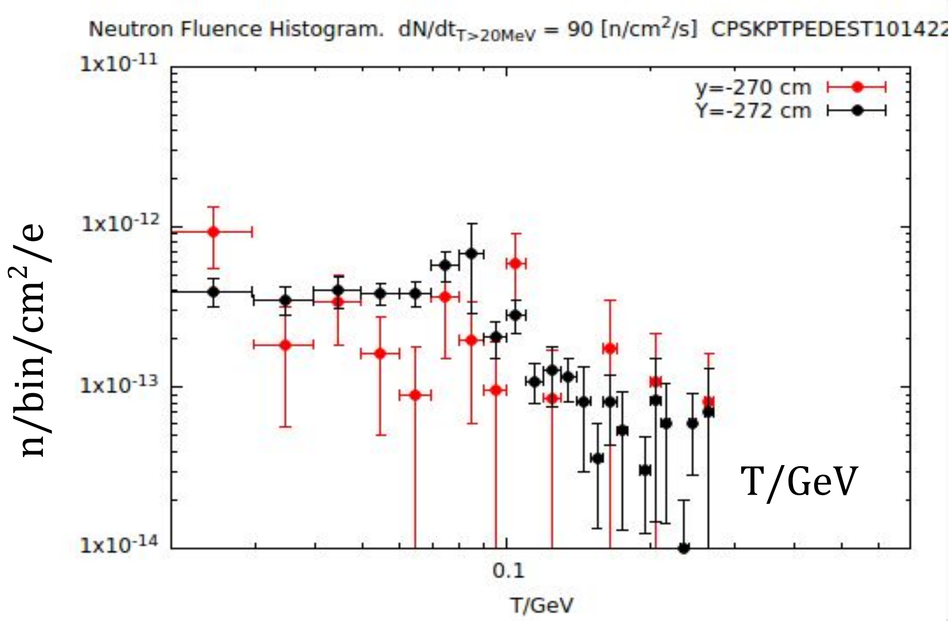




https:Ammonium sulfide

- Neutron Flux T>0 = 3.E-11 [$n/e/cm^2$]*3.E+13 [e/s] = ~ 900 [$n/cm^2/s$].
- What fraction of T>20 MeV that is responsible for Tritium production in soil?

Neutron Flux T>20 MeV in soil at 1 m depths after Iron/N_2H_8S pedestal.



- Neutron Flux (red) = 33.E-13 [n/e/cm^2]*3.1E+13 [e/s] = ~ 100 [n/cm^2/s].
- Black -150 [n/cm^2/s]. Reference 30 [n/cm^2/s] 3-5 times lower.
- How many tritium under the floor after 1 year and what is its decay rate?

Tritium concentration and activity in 1 m deep soil after 1 year.

What is $T(^3H)$ production in $2m*4m*1m=8\ m^3$?

From the plot we read:

$\sim$1.E-8 [$^3H/e$]

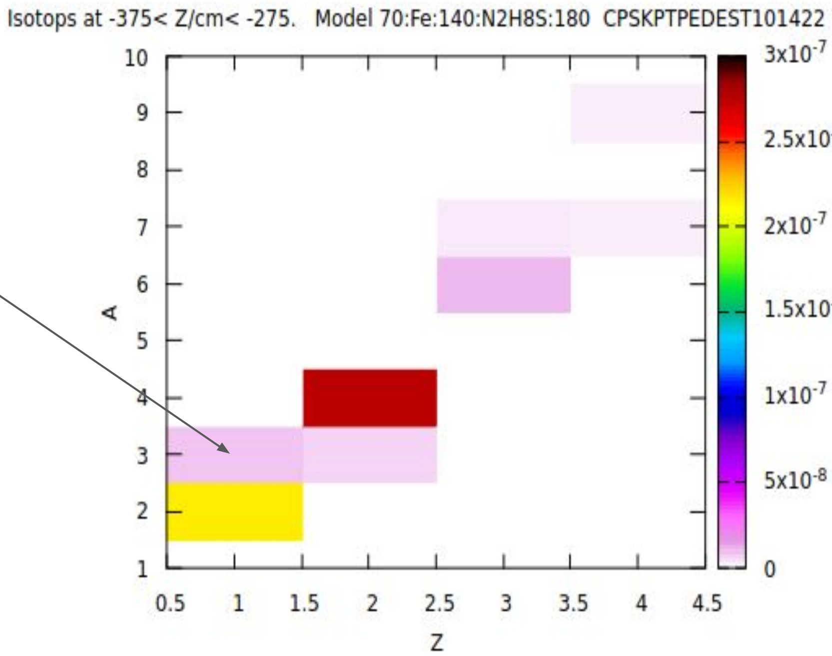
We calculate the production rate:

$dn_T/dt = \sim 1.E\text{-}8[^3H/e]*3.E\text{+}13[e/s]\ 0.125E\text{-}6\ [cm^{-3}]=$

$= \sim 0.04\ [T/s/cm^3]$

In one year (3.E+7 s) soil accumulates (neglect decay):

$n_T = \sim 1.2E\text{+}6\ [T/cm^3]$



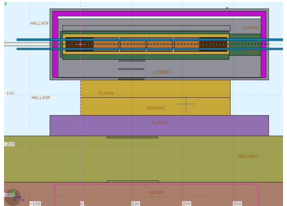
Desintegrations (~12 years):

$dn_T/dt= -1.2E\text{+}6\ [T/cm^3]\ /\ (36.E\text{+}7\ s)=$

$=-3.E\text{-}3\ [\ T\ /s/cm^3]$

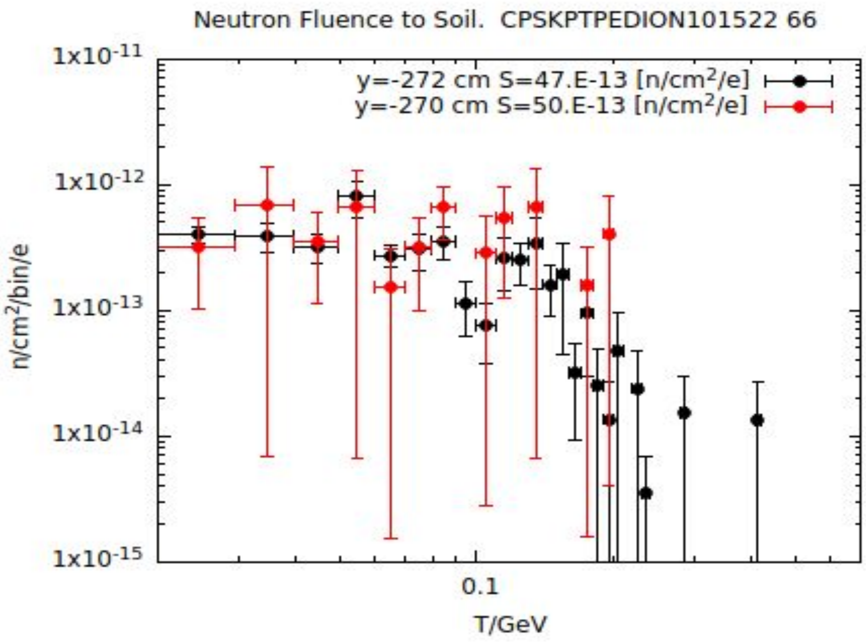
Reference for drink water:

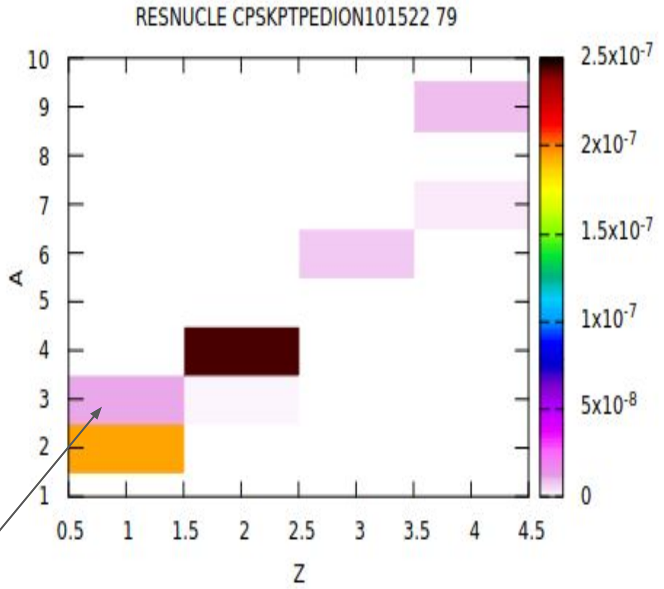
$7000\ [T/s/L]=7\ [T/s/cm^3]$ https



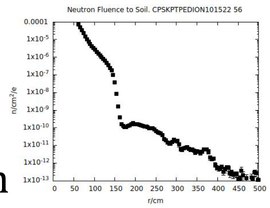
- In tagger hall soil the decay rate of T is $\sim 0.5*10^{-3}$ of reference.

Flux of neutrons T>20 MeV in soil at 1 m depths and ^3H concentration. Effect of ion EM-dissociation and Isomers.

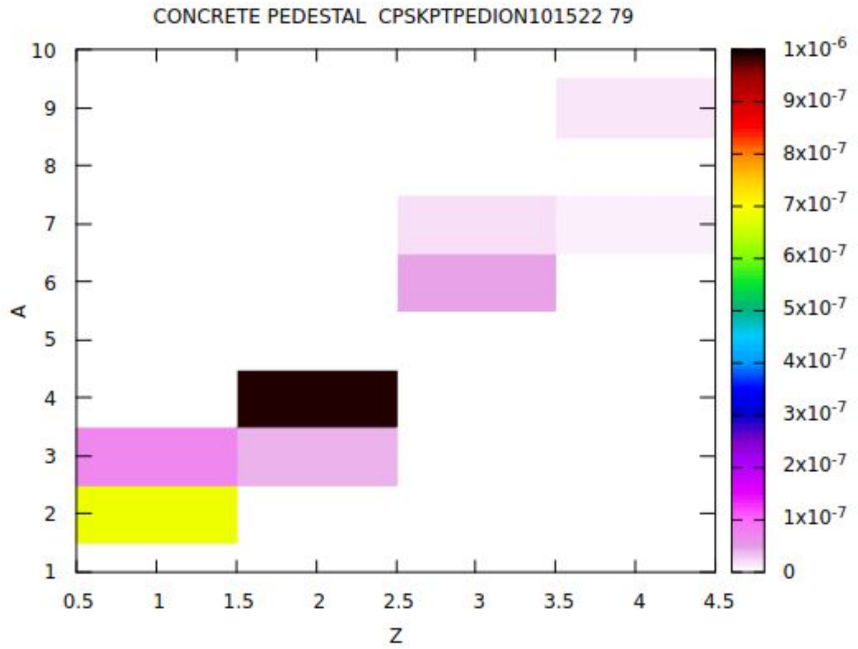


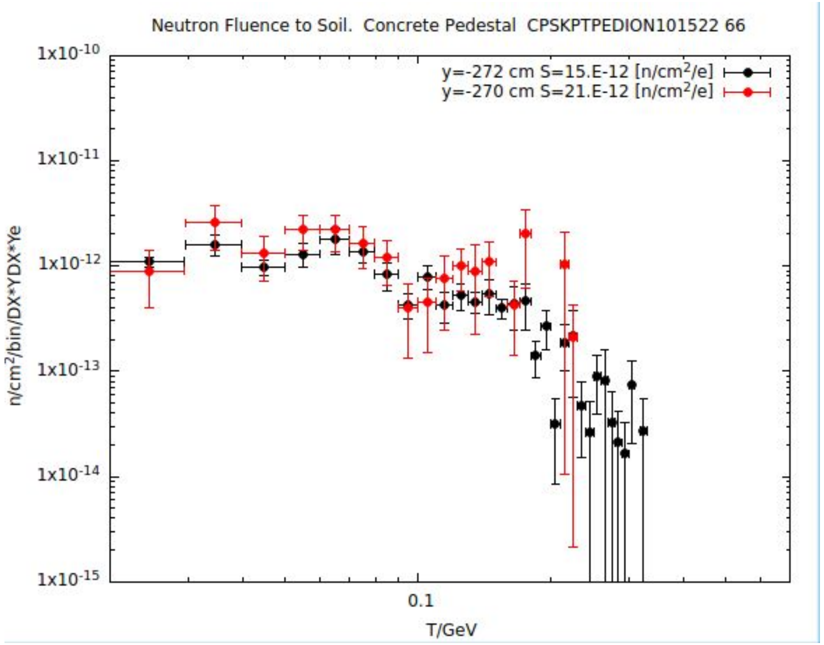


- Neutron Flux (red) = 50.E-13 [n/e/cm^2]*3.1E+13 [e/s] = ~ 150 [n/cm^2/s].
- Black - 145 [n/cm^2/s]. About 50% higher.
- Tritium fluence is about the same =1.2E-8 [T/e/V] V=2*4*8* m^3 at y=-272 cm

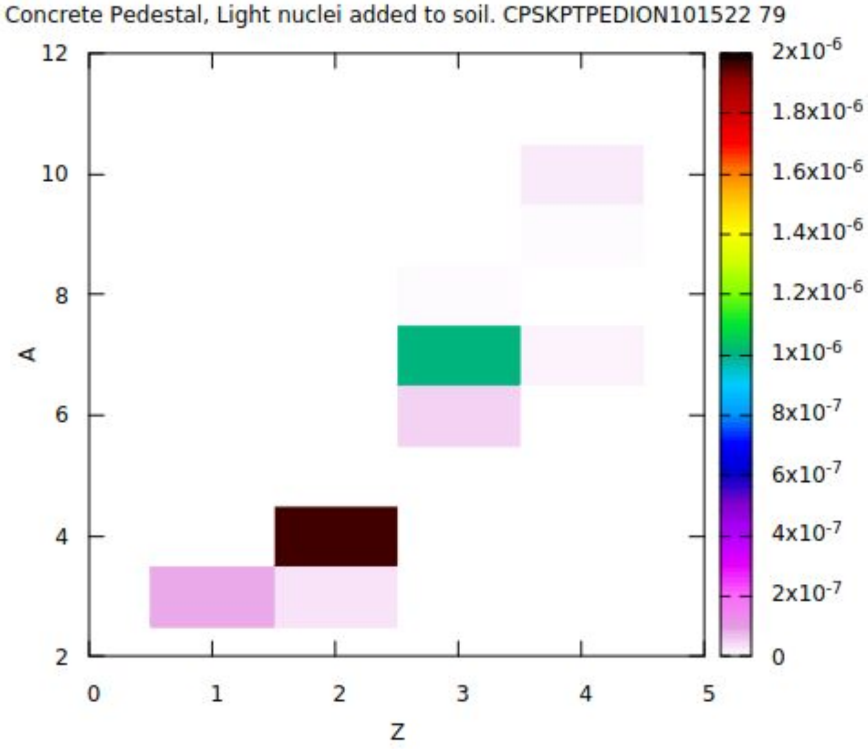


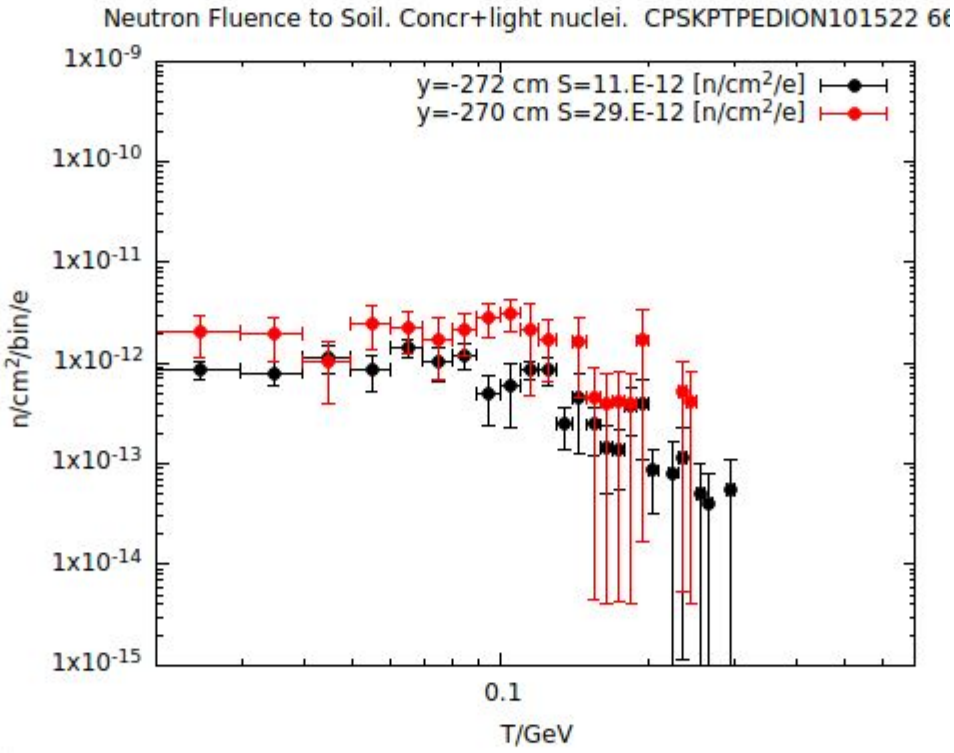
Flux of neutrons T>20 MeV in soil at 1 m depths and ^3H concentration. Effect of ion EM-dissociation and Isomers and concrete pedestal.





- Netrun fux is of ~ 5 times higher.
- Tritium yield is 1.e-7 T/e that is ~5-10 times higher then for Iron/Plastic pedestal.
- Tritium decay rate is of 0.02 [T/s/cm^3] ; reference for a drink water ~10[T/s/cm^3].


Concrete Pedestal, Light nuclei added to soil. CPSKPTPEDION101522 79
A
Z
2x10-6
1.8x10-6
1.6x10-6
1.4x10-6
1.2x10-6
1x10-6
8x10-7
6x10-7
4x10-7
2x10-7
0


Neutron Fluence to Soil. Concr+light nuclei. CPSKPTPEDION101522 66
y=-272 cm S=11.E-12 [n/cm2/e]
y=-270 cm S=29.E-12 [n/cm2/e]
n/cm2/bin/e
T/GeV
0.1

Conclusion and Outlook

1. All safety parameters are met by CPS design including tritium concentration in soil.
2. Tritium concentration in 30 cm layer of soil under floor.
3. Include into the "CPS conceptual design report" (https).
4. Optimization of pedestal material based on T-activity.
5. Model test by Radcon group (Pavel).