P3. SIGMA SIMULATED WORKPLACE NEUTRON FIELD

CIEMAT solution with MCNPX and GEANT4

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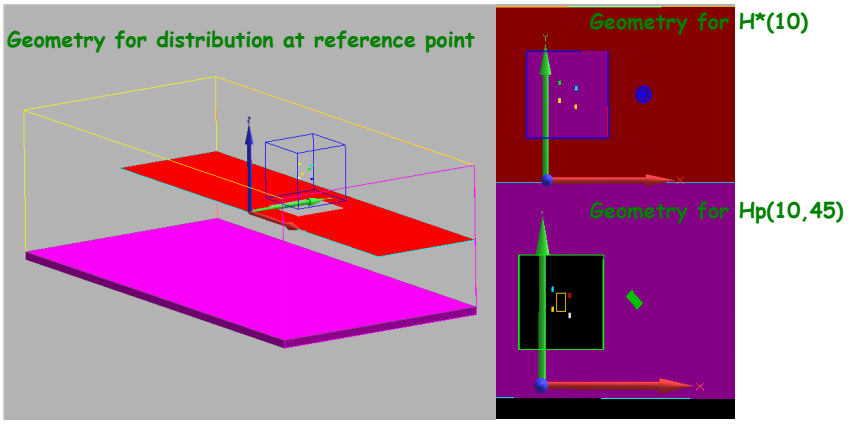
MC codes

- We have made the simulations with MCNPX 2.6b and GEANT4 8.1.p01
  - MCNPX 2.6. b uses the ENDF/B-VI.r8 libraries
  - GEANT4 uses the G4QGSP_BERT_HP physics list, based on ENDF/B-VI.r2 data
    - We used the **GAMOS** framework, a GEANT4-based framework to ease the use of GEANT4

- The calculations are based on the F5 tally (point detector) of MCNP
- As this tally is not included in the official GEANT4 release we have simulated it as in MCNP
  - We added a Russian roulette with weight 1/10 if probability is less than 1.E-15

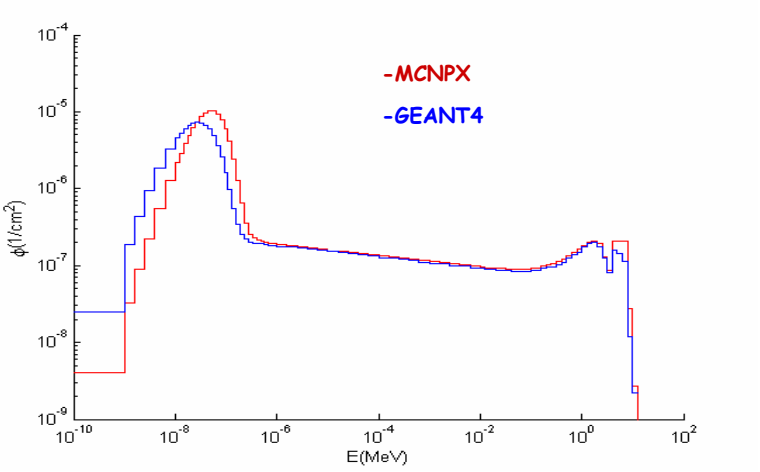
Setup



- We used the geometry and primary source distributions as described in the problem description document

Fluence rate at reference point

- We used a 1mm exclusion sphere
- No S(α,β) model of thermal neutron scattering in GEANT4



Fluence rate at reference point

- **Integrated fluence:**

Data type	Radius of exclusion sphere (mm)	MCNPX		GEANT4	
		Value	Relative Error (%)	Value	Relative Error (%)
Φ at reference point (10^{-6}/(cm^{2}s^{-1}))	**1**	**1791**	**0.07**	**1543**	**0.08**
Φ from wall, concrete and platform (10^{-6}/(cm^{2}s^{-1}))	**1**	**59**	**3**	**40.5**	**0.14**
Density graphite (ΔΦ/Δρ) (10^{-9}cm/(s g))	**1**	**540**	**4.4**	**650**	**4.4**
Dewnsity source (ΔΦ/Δρ) (10^{-9}cm/(s g))	**1**	**22.9**	**130**	**22.7**	**240**

Fluence from Wall, concrete and platform:

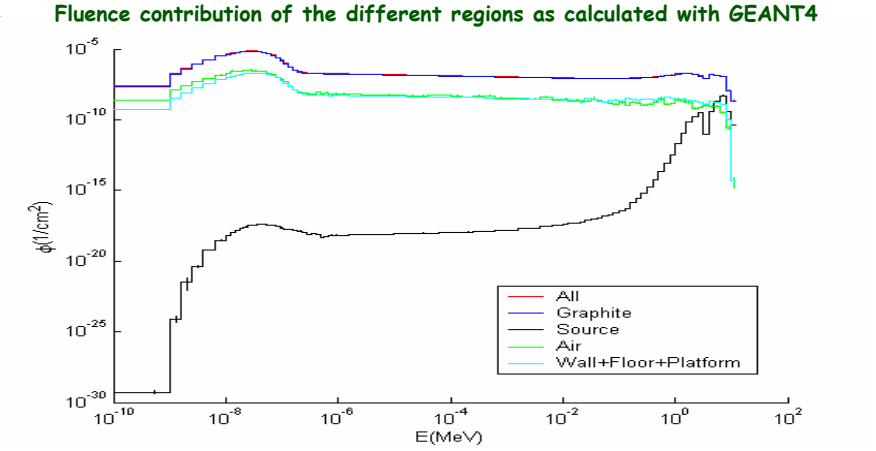
- **GEANT4**: compute calculation of fluence rate depending on the volume of the scattering
- **MCNP**: Fluence rate with full geometry – Fluence rate without those volumes

Fluence rate at reference point

➢ Good agreement at intermediate energies but discrepancies at thermal energies and at the high energy end

▪ Let´s try to understand which geometry region makes the difference

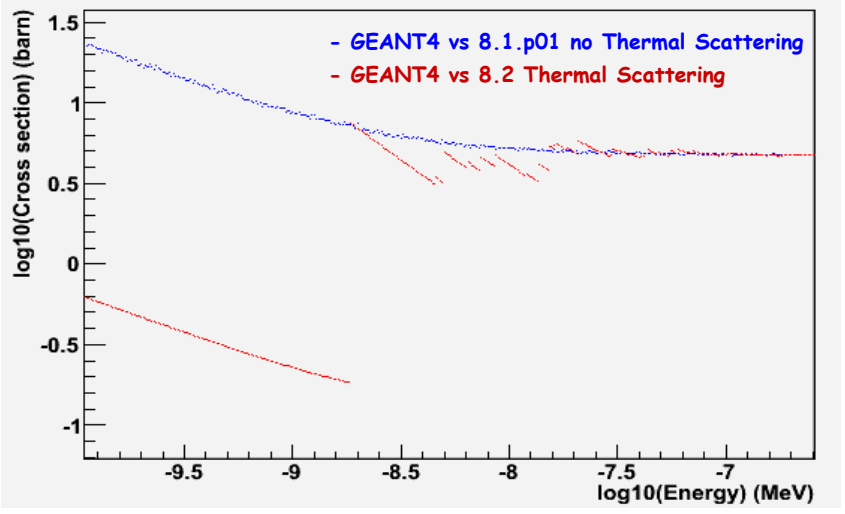
Fluence contribution of the different regions as calculated with GEANT4



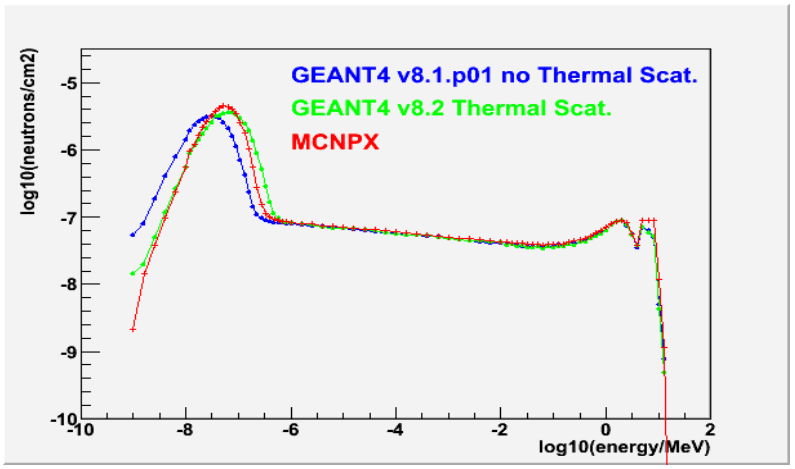
Thermal scattering in GEANT4

• S(α,β) model was introduced in GEANT4 only after the release used for this calculations

• We have repeated the calculations with it



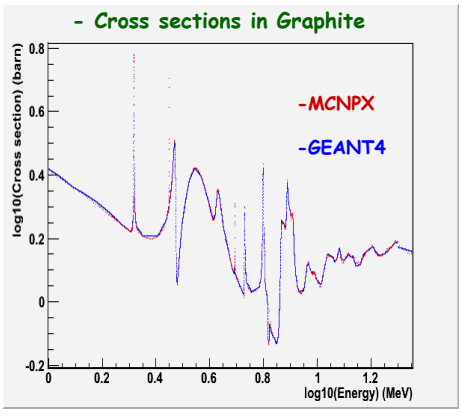
Thermal scattering in GEANT4

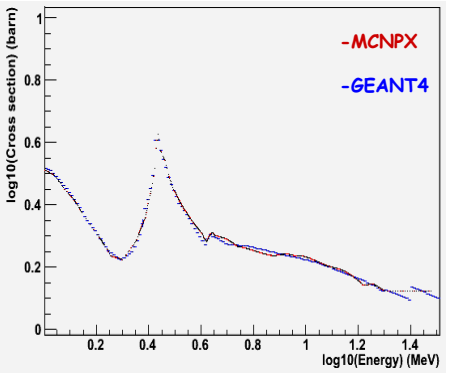


Data type	Radius of Excl. (mm)	MCNPX		GEANT4	
		value	Rel.Error (%)	Value	Rel.Error (%)
Φ at reference point (10^{-6}/(cm^2s^{-1}))	1	1799	0.39	1707	0.8

Fluence rate at reference point

Discrepancy at high energy end:





- Small difference in cross sections of AmO2Be at these energies…

H*(10), Hp(10,0), Hp(10,45)

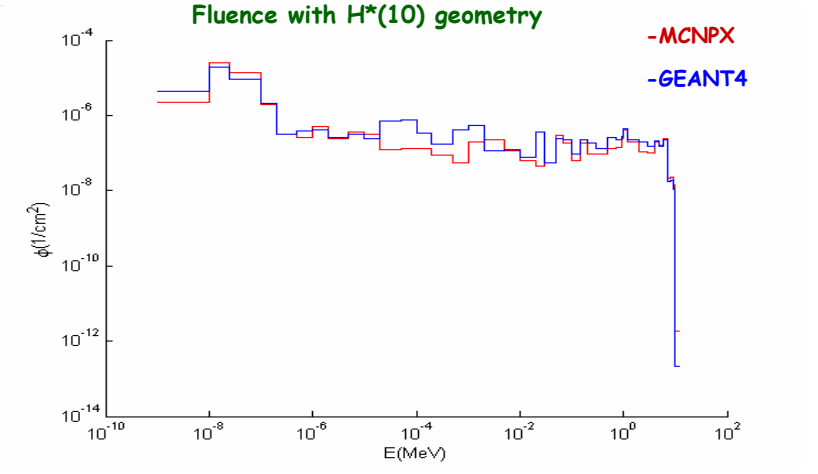
- No S(α,β) model of thermal neutron scattering
  - ➢ Errors are big, even with 100 million histories (3days in 24 CPU's)
  - ⇒We made several runs with different random number and exclusion sphere radii

Data type	Radius of Excl. (mm)	MCNPX		GEANT4		
		value	Rel.Err(%)	value	Rel.Err(%)	N hist(10^6)
H*(10) (mSv/h)	1	0.245	6	0.158	9	6
	5	0.241	3	0.245	4	56
	5	0.245	4			
	9	0.248	2	0.227	8	50
Hp(10,0) (mSv/h)	1	0.328	12	0.223	6	17
	5	0.277	3	0.245	8	8
	5	0.266	4			
	9	0.263	2.3	0.202	6	25
Hp(10,45) (mSv/h)	1	0.133	7	0.148	13	10
	5	0.140	6	0.104	9	10
	5	0.140	5			
	9	0.137	3	0.108	6	26

- ➢ It seems 1 mm is not a good choice for exclusion sphere radius

H*(10) vs energy

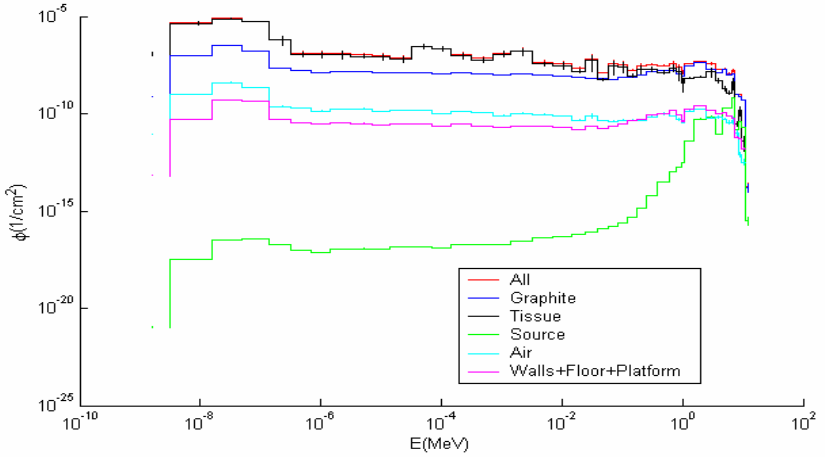
- ❑ Some discrepancies at thermal energies and at intermediate energies (statistical fluctuations?)



H*(10) vs volume

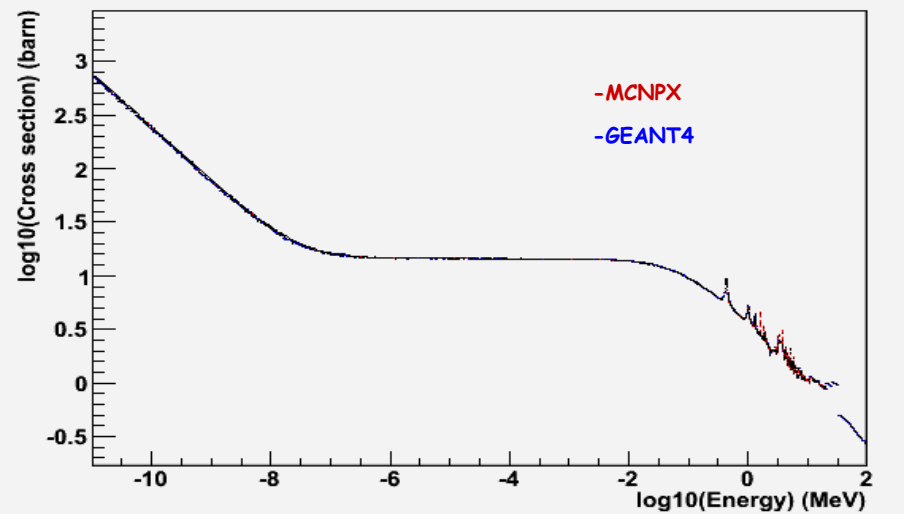
- Most of the contribution comes from tissue sphere:

H*(10) fluence contribution of the different regions as calculated with GEANT4



H*(10) vs volume

- But cross section in tissue is the same:



Summary

- We have calculated the SIGMA workplace neutron field with MCNP and GEANT4
  - Computations based on MCNP F5 tally

- Fluence distribution as a function of energies shows some discrepancies between MCNP and GEANT4
  - Use of S(α,β) model of thermal neutron scattering (not available in GEANT4 at the time of the simulation) improves agreement

- H*(10), Hp(10,0), Hp(10,45) shows some differences between both codes
  - We made several runs of 100 million events to check statistical behaviour (sensible discrepancies for 1 mm exclusion radius)