Neutron background comparison – LN_2 vs. LAr

Daniel Kollár

Max-Planck-Institut für Physik, München

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Summary previous talk

- Using LCS for neutron transport simulation
- Irradiating with primordial neutron spectrum
- Looking at the neutrons in central sphere with $R = 25$ cm
- Calculating the neutron produced ^{77}Ge activity in crystal area

Now compare the LN_2 vs. LAr for PRIMORDIAL NEUTRONS

Nitrogen vs. Argon

from neutron's point of view

Neutron moderation:

- neutrons loose energy mostly in elastic collisions with nuclei
- lower *A* means more energy lost per collision
- fraction of kinetic energy loss per collision (non-relativistic)

mean: $\langle f \rangle = \frac{2A}{(1+A)^2}$ maximum: $f_{max} = \frac{4A}{(1+A)^2}$

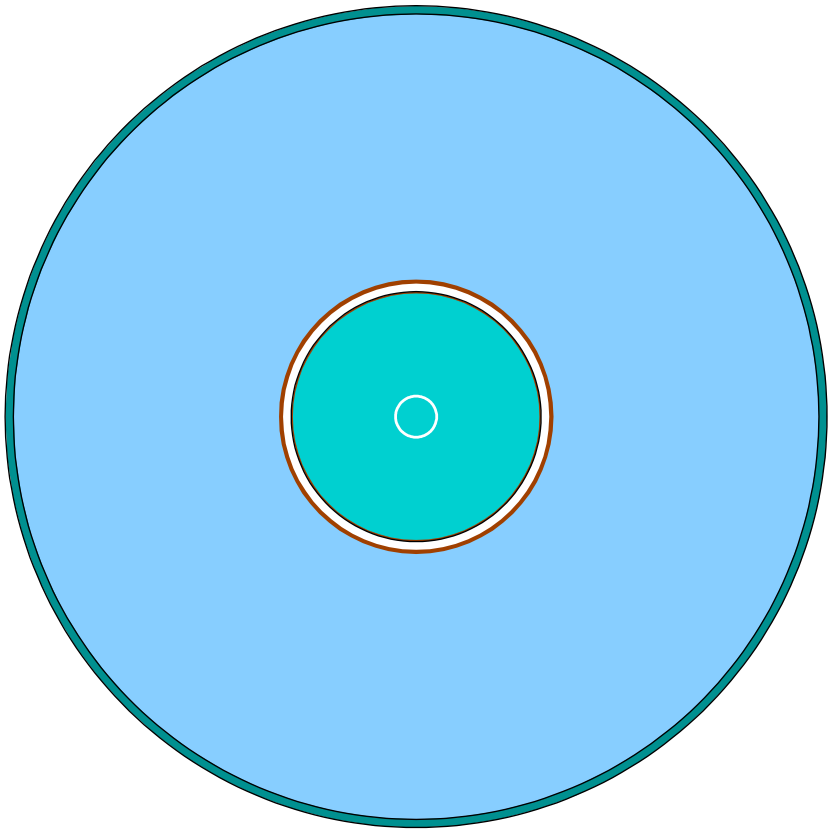
- **N: <*f*> = 12.4 %** **Ar: <*f*> = 4.8 %**

Neutron absorption:

- different cross sections for neutron absorption
- **N: σ_{abs} = 1.9 barn** **Ar: σ_{abs} = 0.66 barn**

Nitrogen thermalizes the neutrons faster and absorbs them better

Simulated geometry



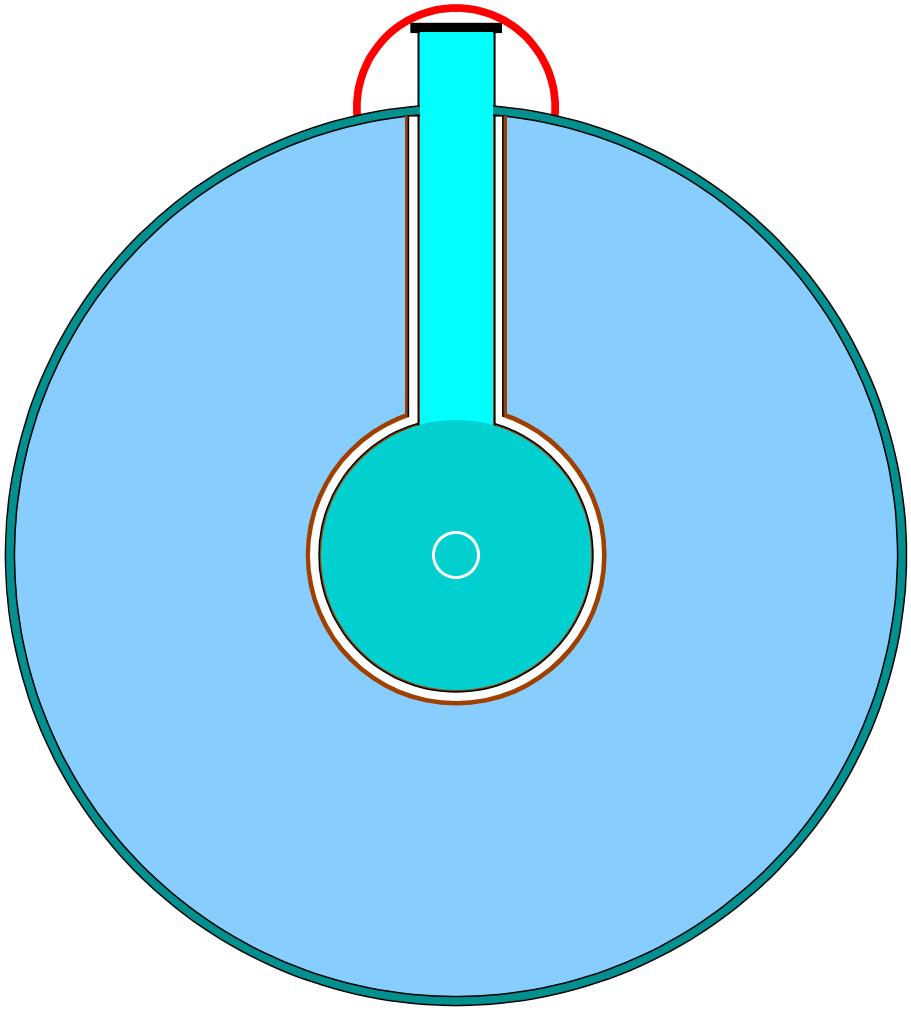
Spherical shells

Radius [cm]	Material
800–500	Air
500–490	Stainless Steel
490–167	Water
167–162	Copper
162–152	Vacuum
152–150	Copper
150–0	$LN_2 \rightarrow$ **LAr**

– Simulated neutron transport inside the setup using LCS

– Calculated neutron spectrum inside the sphere in the center with $R = 25$ cm

Geometry with the neck



– cylindrical neck with: R = 40 cm
  filled with Ar gas
– hight above tank: 80 cm
– Lead cover: 15 cm thick

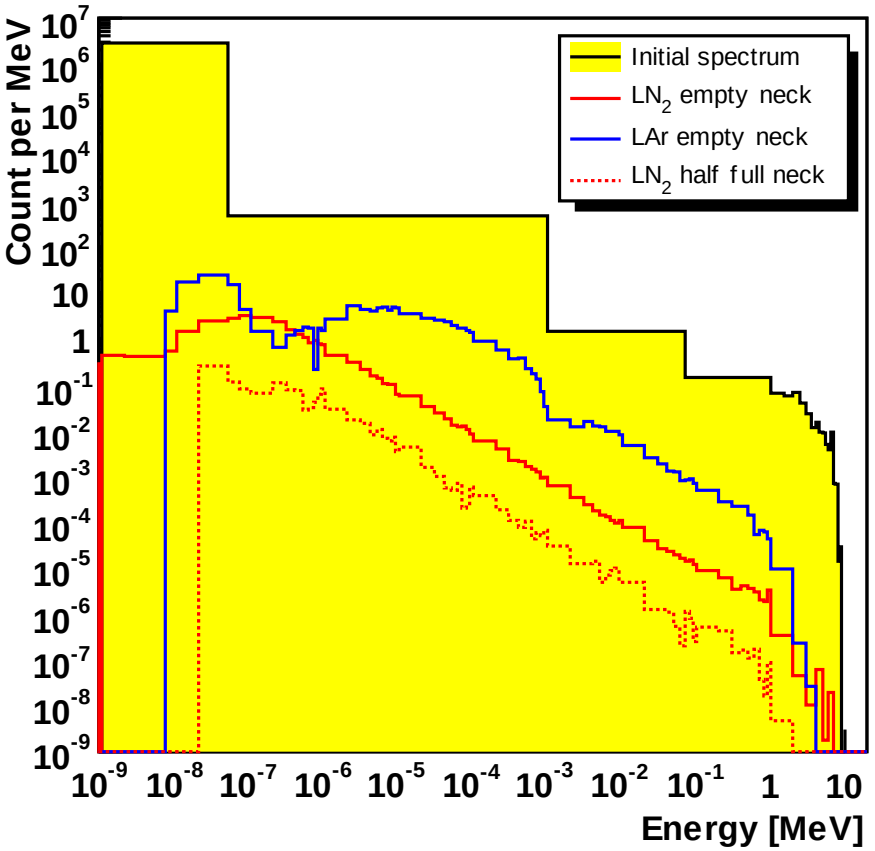
Primordial neutrons generated around neck entrance

+ setup with neck half filled with LAr
+ setup with PE shield around the neck entrance

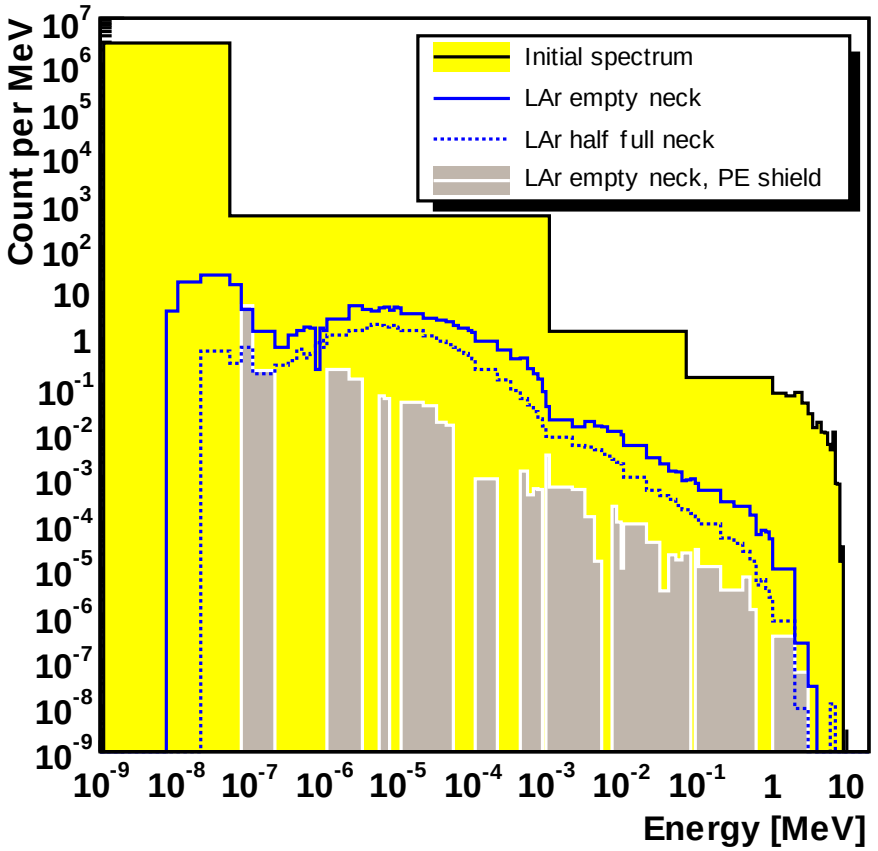
Neutron spectra in the crystal area

No neutrons observed for scenario without the neck as all neutrons are shielded away by the water tank.

Liquid Nitrogen



Liquid Argon



Comparison - neutron flux

	Total neutron flux [$cm^{-2}\ y^{-1}$]		[y^{-1}]	
	LN_2	**LAr**	**LN_2**	**LAr**
no neck	0	0	0	0
empty neck	2.1×10^{-3}	0.13	16	1000
half filled neck	10^{-4}	0.03	0.8	240
empty neck 25 cm PE	0	0.001	0	10

Comparison - ^{77}Ge production rate

	P (^{77}Ge) [kg^{-1} y^{-1}]	
	LN2	**LAr**
no neck	**0**	**0**
empty neck	**9×10^{-5}**	**0.01**
half filled neck	**5.6×10^{-6}**	**0.002**
empty neck 25 cm PE	**0**	**2.5×10^{-5}**

Summary

→ Argon is performing much worse in shielding the neutrons than Nitrogen

→ In LAr setup the ^{77}Ge production still below sensitivity

$0.01\ ^{77}\mathrm{Ge\ kg^{-1}\ y^{-1}} \Rightarrow$ **background rate $\approx 10^{-6}$ kg^{-1} y^{-1} keV^{-1}**

BUT!

→ only one reaction calculated

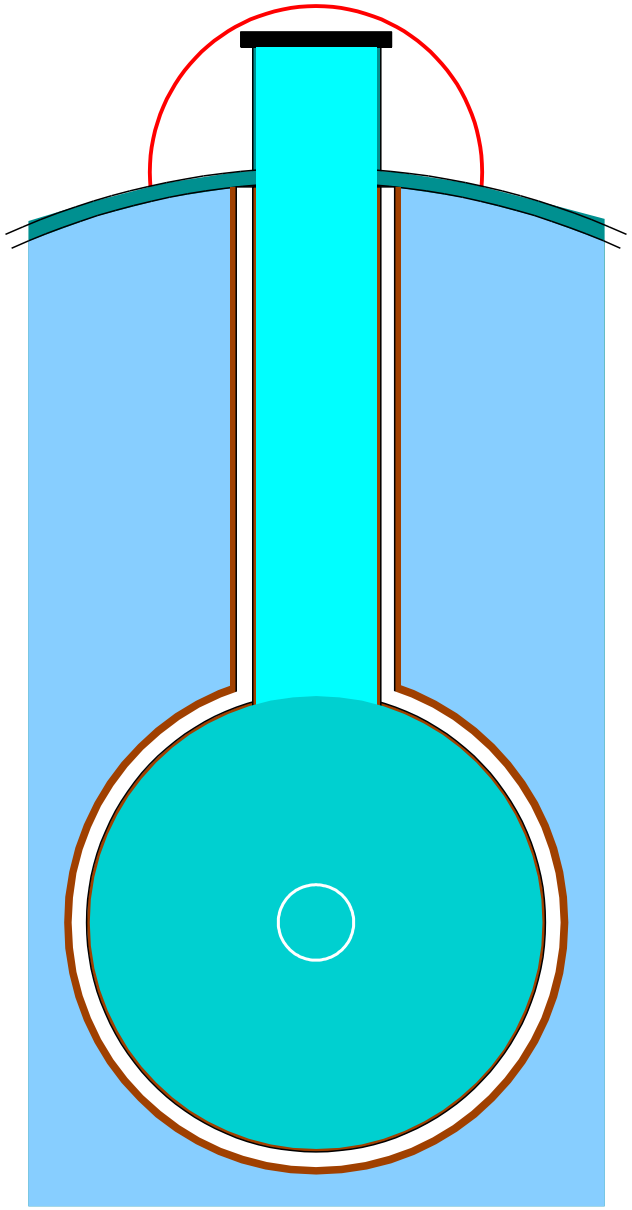
→ no muon induced neutrons taken into account

→ geometry setup too optimistic

Q: How much worse this can get?

A: We have to investigate...

A few "neck" remarks



1) neck is no problem for primordials and LN_2

2) situation worse for LAr
   → still no problem, but much closer to the edge
   → need to investigate

3) most μ induced neutrons going downward
   → high energy neutrons hit the thick Lead shield (or any high-Z-material above) and create huge neutron showers going down the neck towards the crystals
   → these you cannot shield with PE around the neck
   → has not yet been simulated