First simulations for a 4th (REAR) and 5th (DEAR) neutron beam lines at n_TOF

V. Bécares, D. Cano Ott, M. Bacak, E. Mendoza

Avda. Complutense 40, 28040 Madrid – España

daniel.cano@ciemat.es

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN
Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Motivation

n_TOF has excellent overall conditions for performing neutron induced reaction cross sections. The prompt spallation cascade and the fast neutrons deposit large amounts of energy in our detectors in a very short time. Many systems are limited due to that.

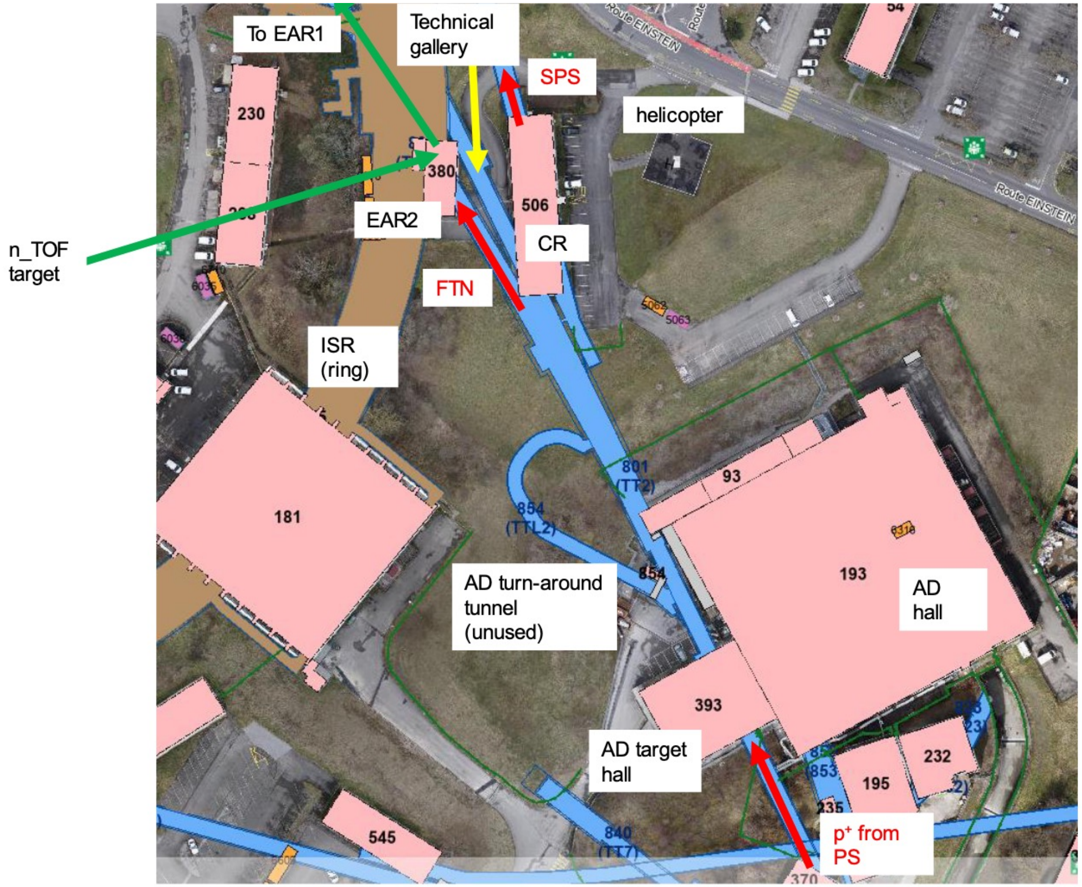
- (n,γ) – from thermal to ~1 MeV. C_6D_6 detectors work Ok but the TAC is limited up to ~10 keV due to the background and the flash.
- (n,f) – from thermal up to hundreds of MeVs – GeVs. Some detectors are limited up to 10 MeV due to the flash / baseline oscillations.
- (n,xn) – work in progress and significant improvements, but still difficult due to the saturation of detectors.
- (n,ch.p) – thermal up to 100 MeV (typically in the fast range). Some experimental limitations due to the flash.

Could we get rid of the high energy neutrons somehow?

- Looking from the rear side.
- Looking at a neutron moderator/scatterer and not at the target.

Is there space for REAR?

The spallation cascade is highly directional and focussed forward, in the direction of the proton beam. Would an experimental area “behind” our spallation target (actual or future) offer better conditions.



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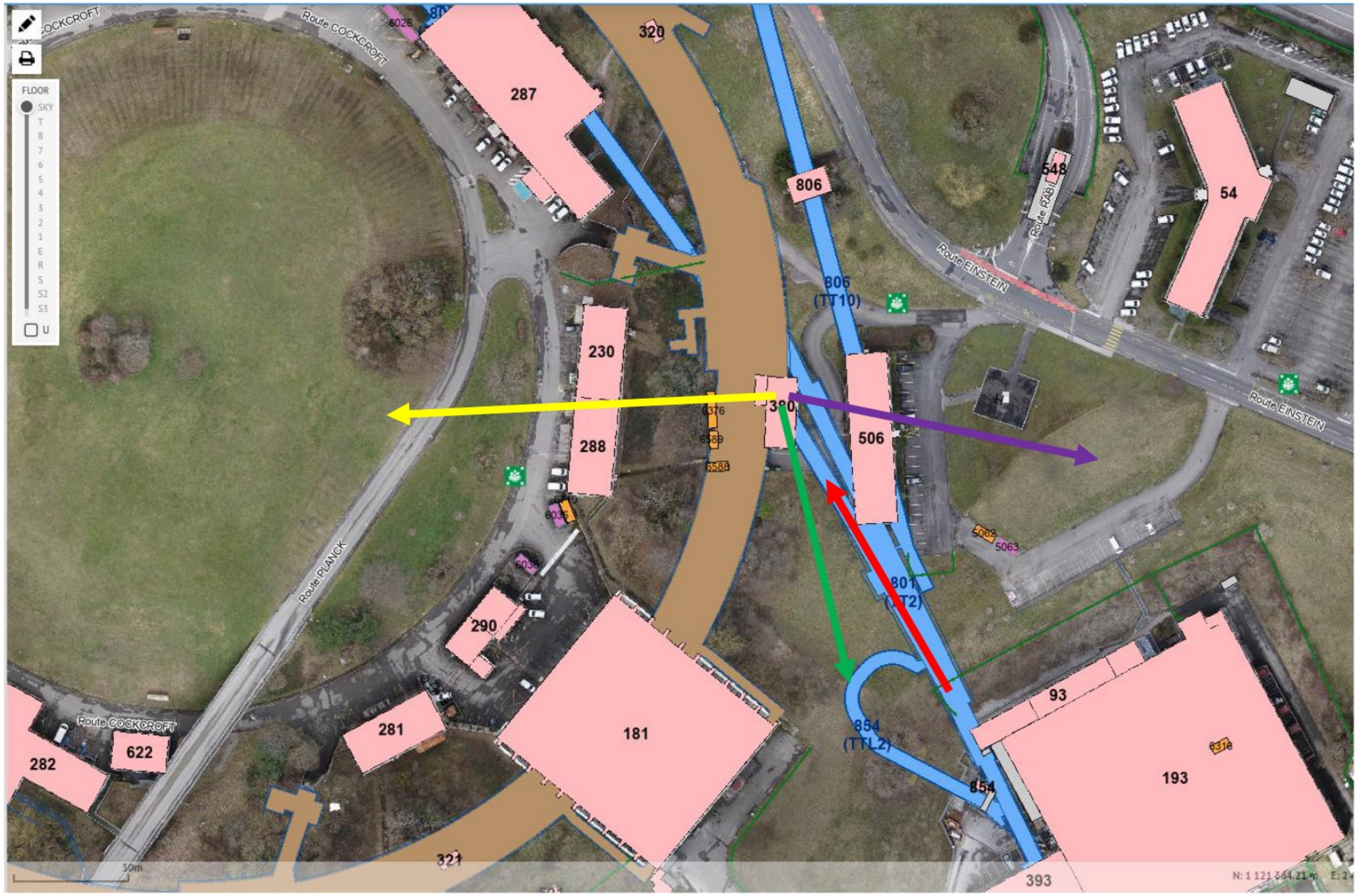
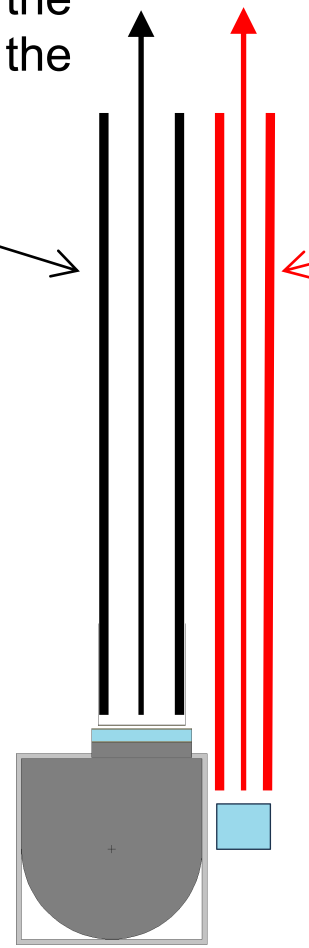


A deflected neutron experimental area (DEAR)

Our actual **neutron beam** from the water moderator on top of the target.

neutron beam from a side water moderator (no direct neutrons from the target)



New beam line going to EAR-2, parallel to the existing one and not looking at the target.

Check the idea of having a second vertical beam line looking at a new moderator, thus avoiding direct neutrons and gammas from our spallation target.

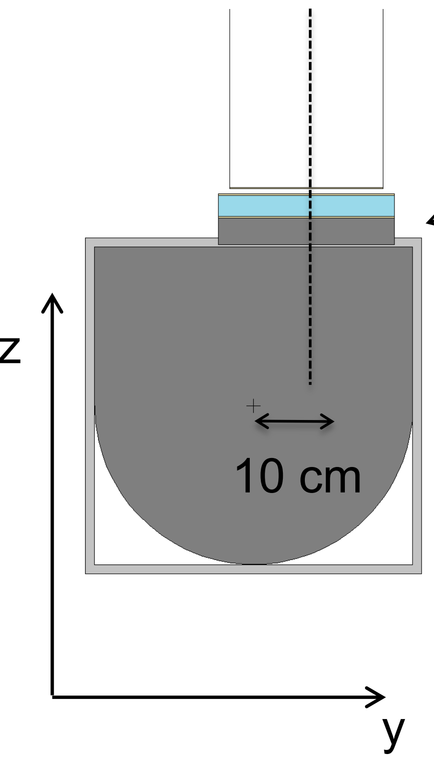
Small water moderator

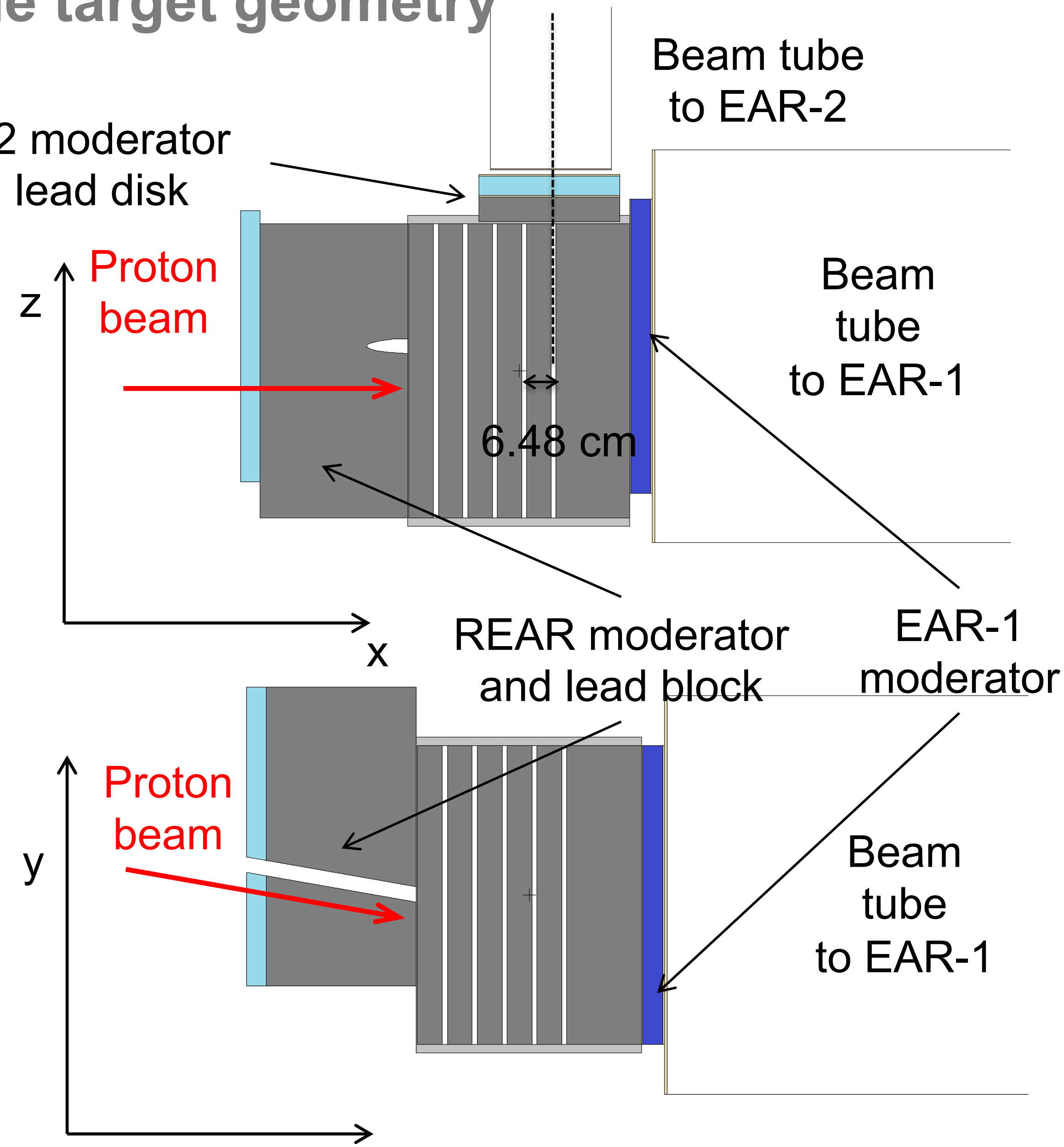
Simulations done for REAR and DEAR

The MCNP simulations carried out so far provide more qualitative than quantitative results:

- Simplified version of our actual target.
- Low statistics yet due to the target huge computing power required.
- Only approximate results due to the scoring of neutrons at large emission angles (5º).
- Use of an extra lead block backwards.
- Simplified version of the effect of having narrow collimators for neutron capture (~2 cm in diameter)

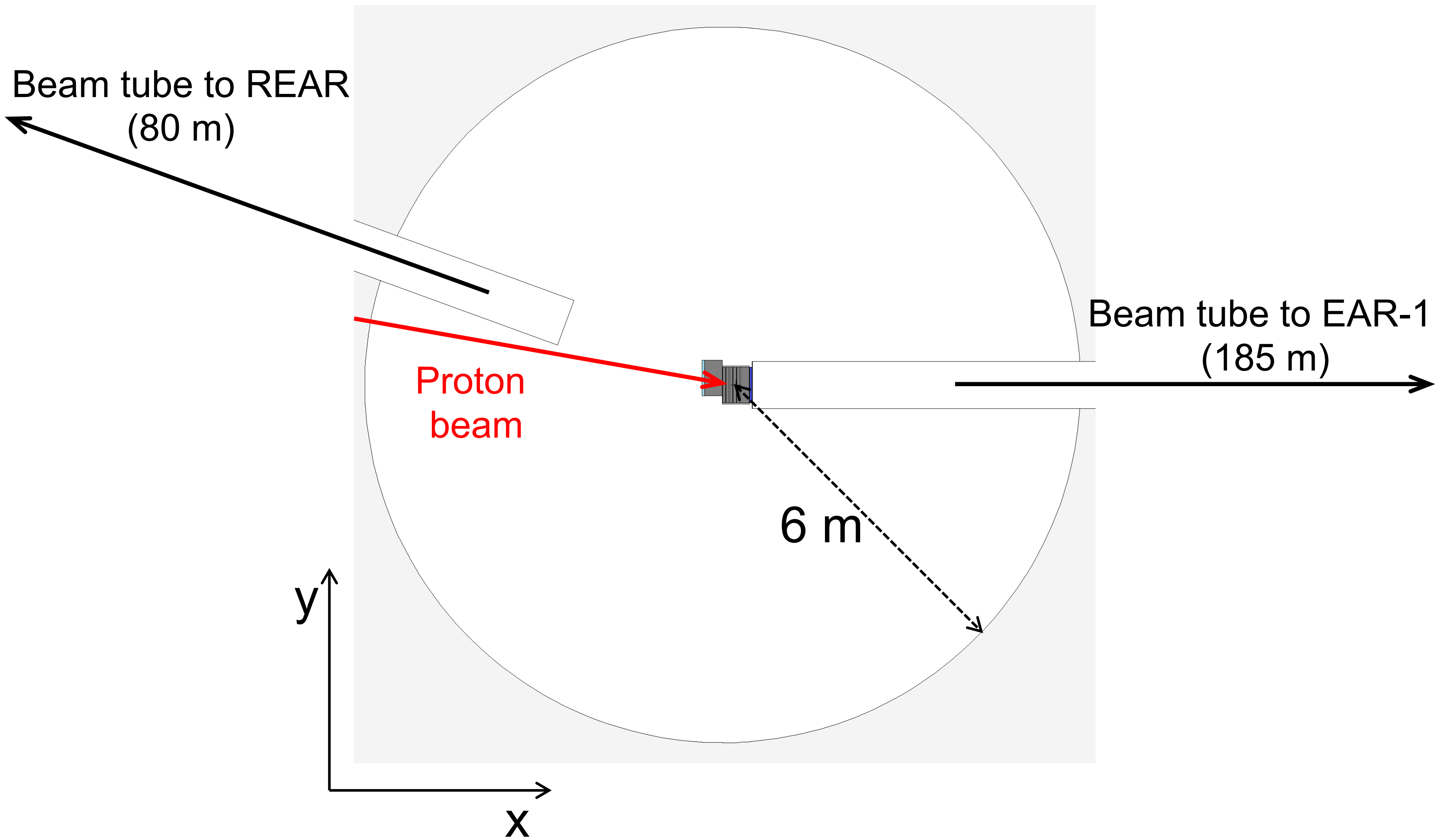
The target geometry



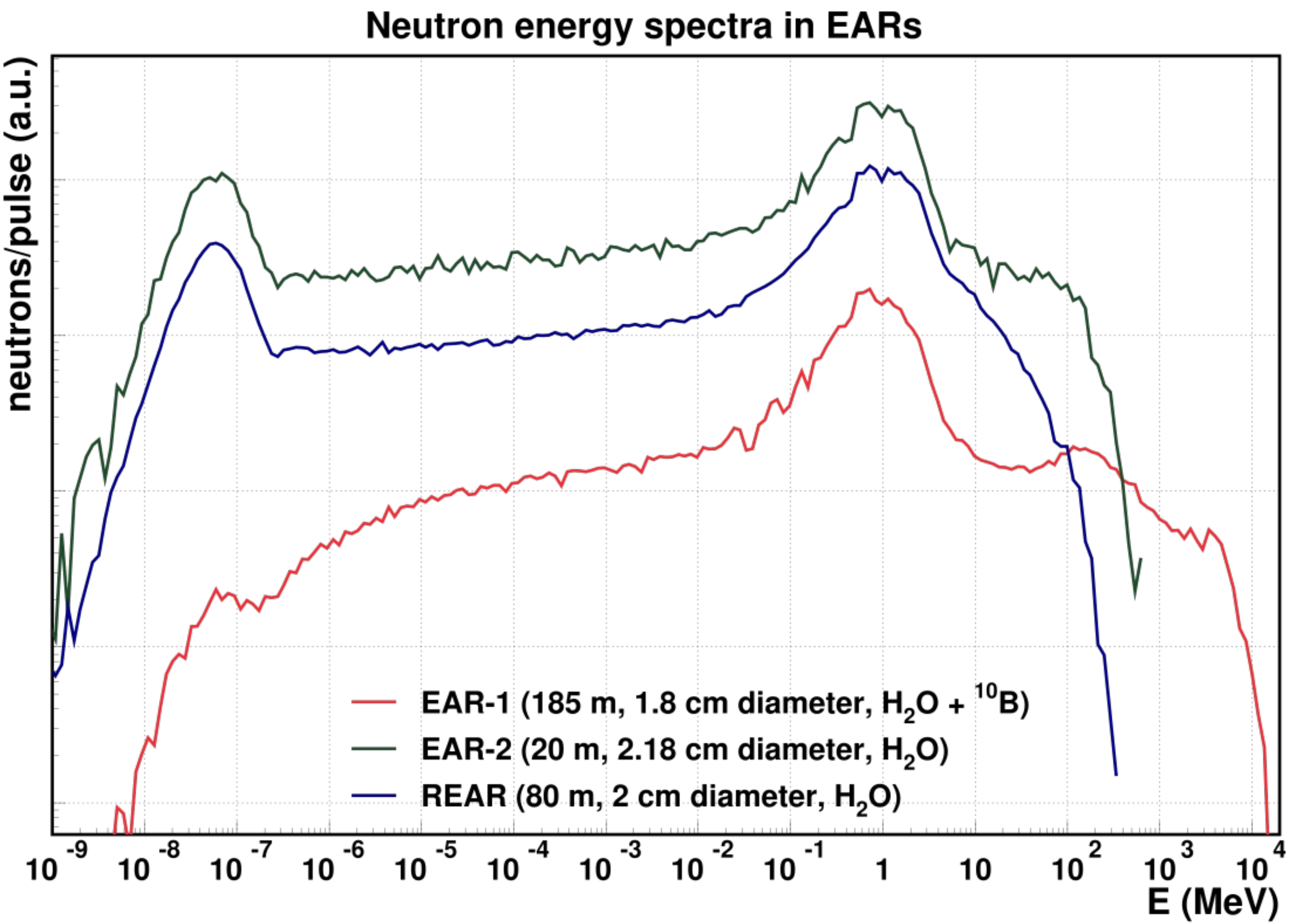


Lead
Aluminium
Steel (316L)
Water
Borated water (1.28% weight of boron, 99% ^{10}B)

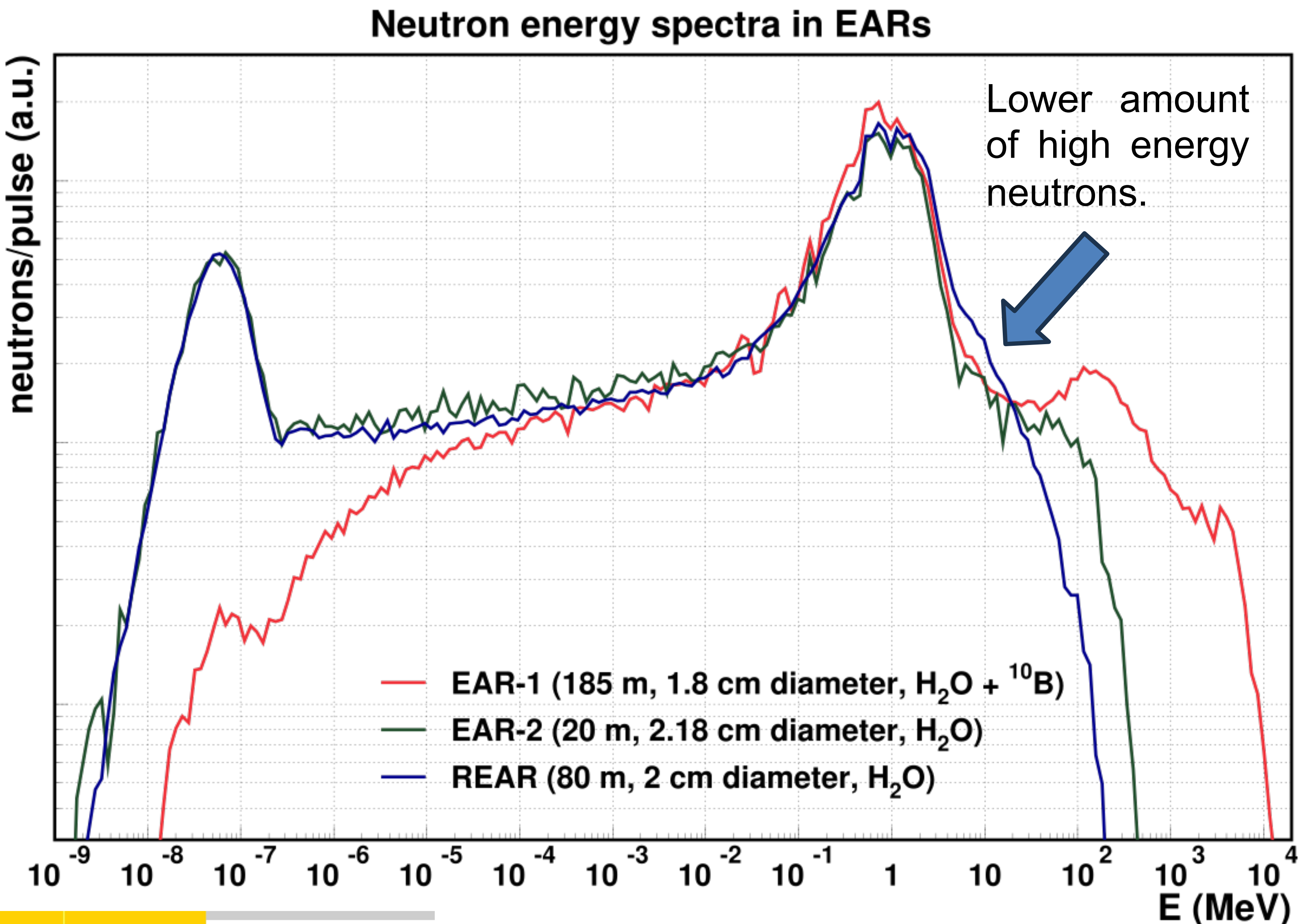
The target geometry



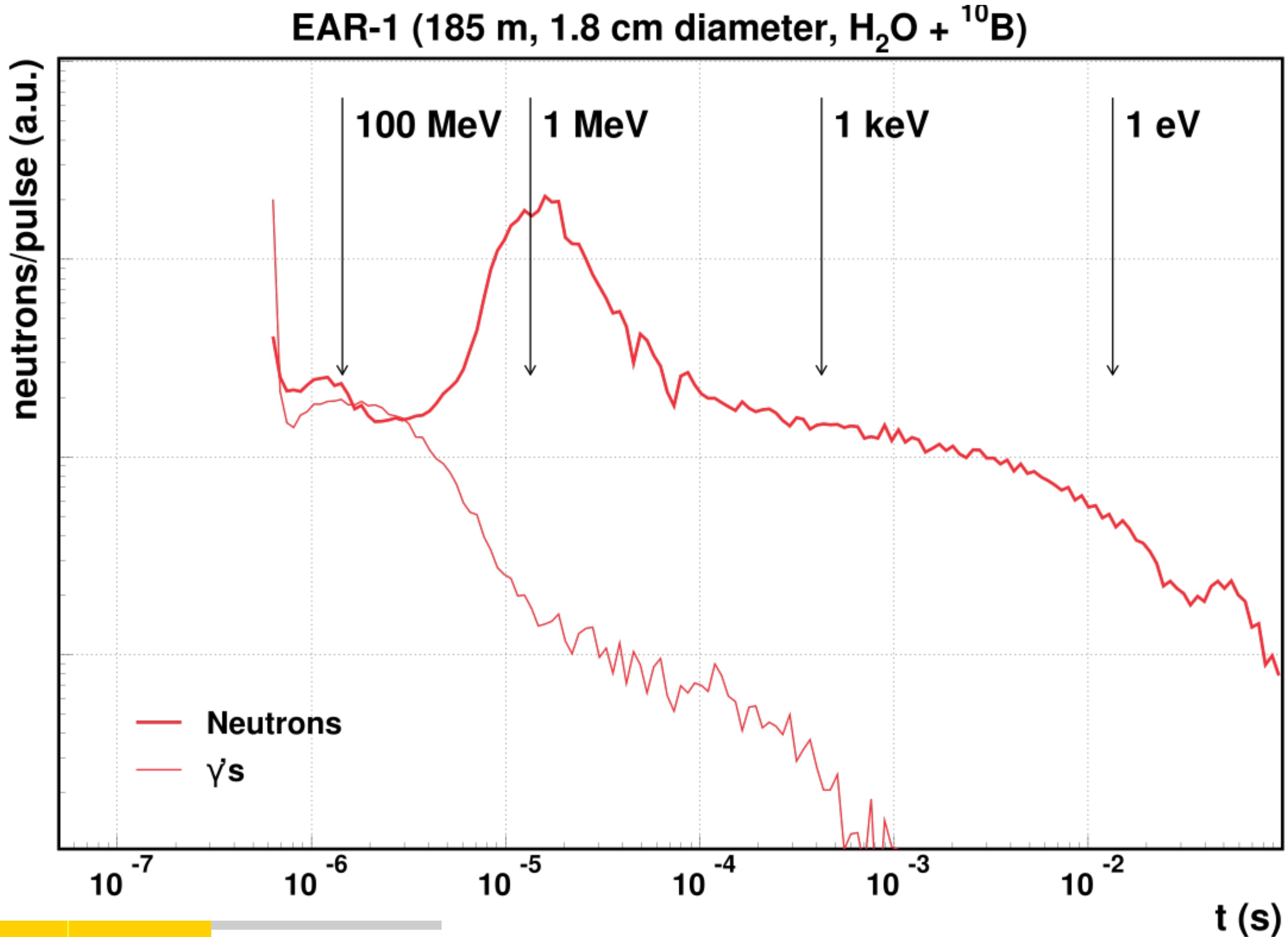
Comparison of the EAR-1, EAR-2 and REAR fluences



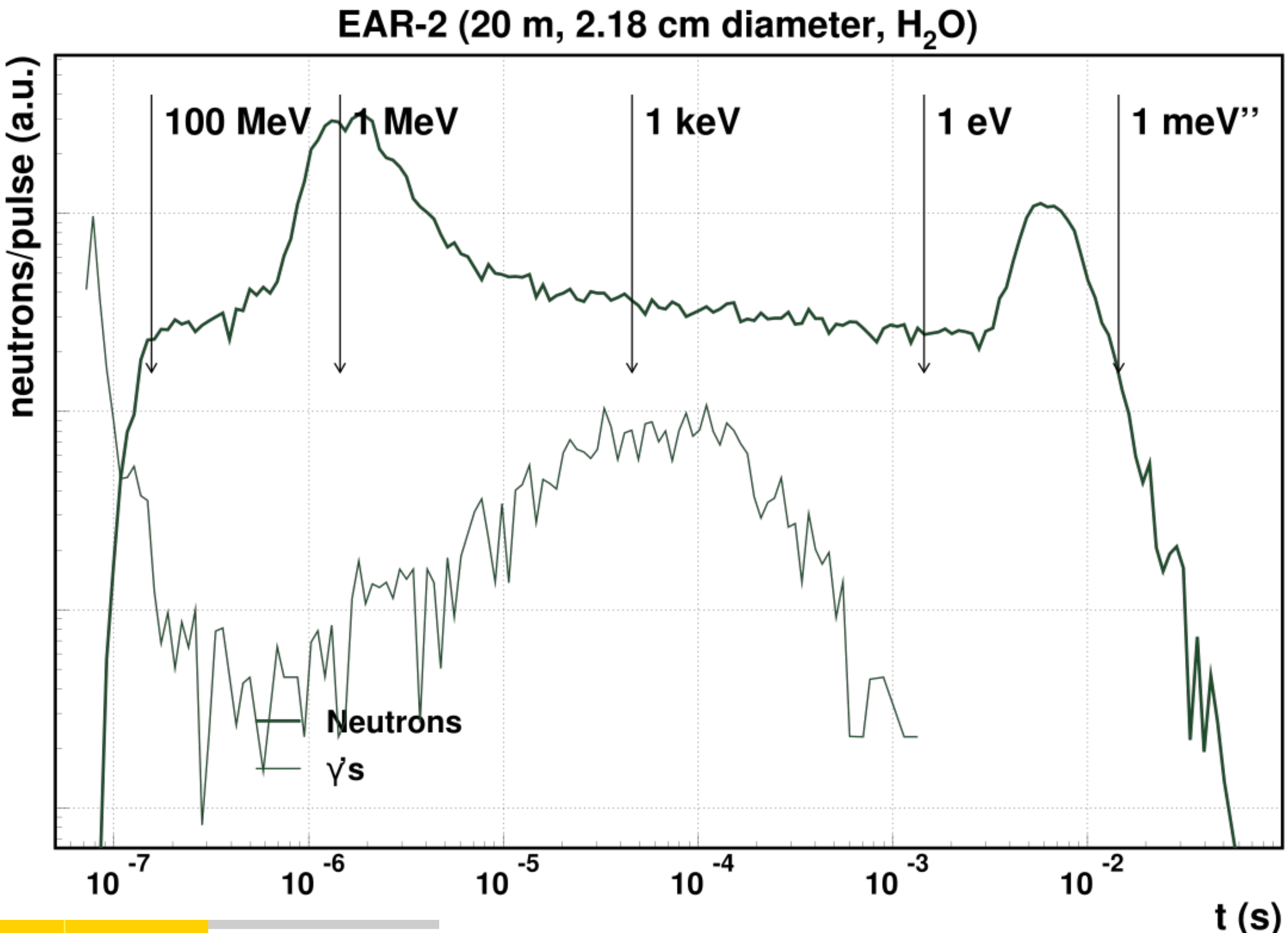
Comparison of the neutron fluence shapes



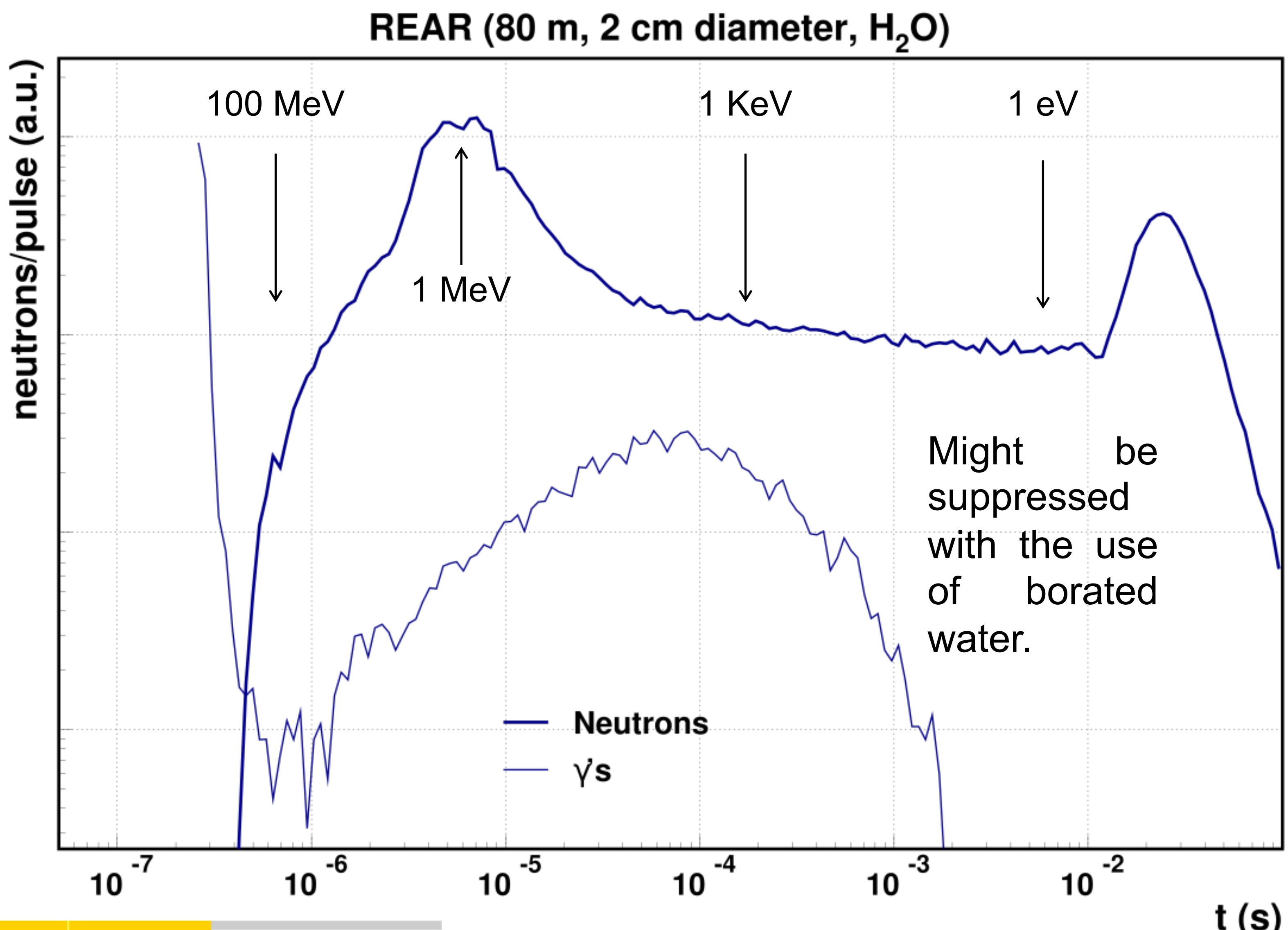
EAR-1 neutron and γ-ray TOF distributions



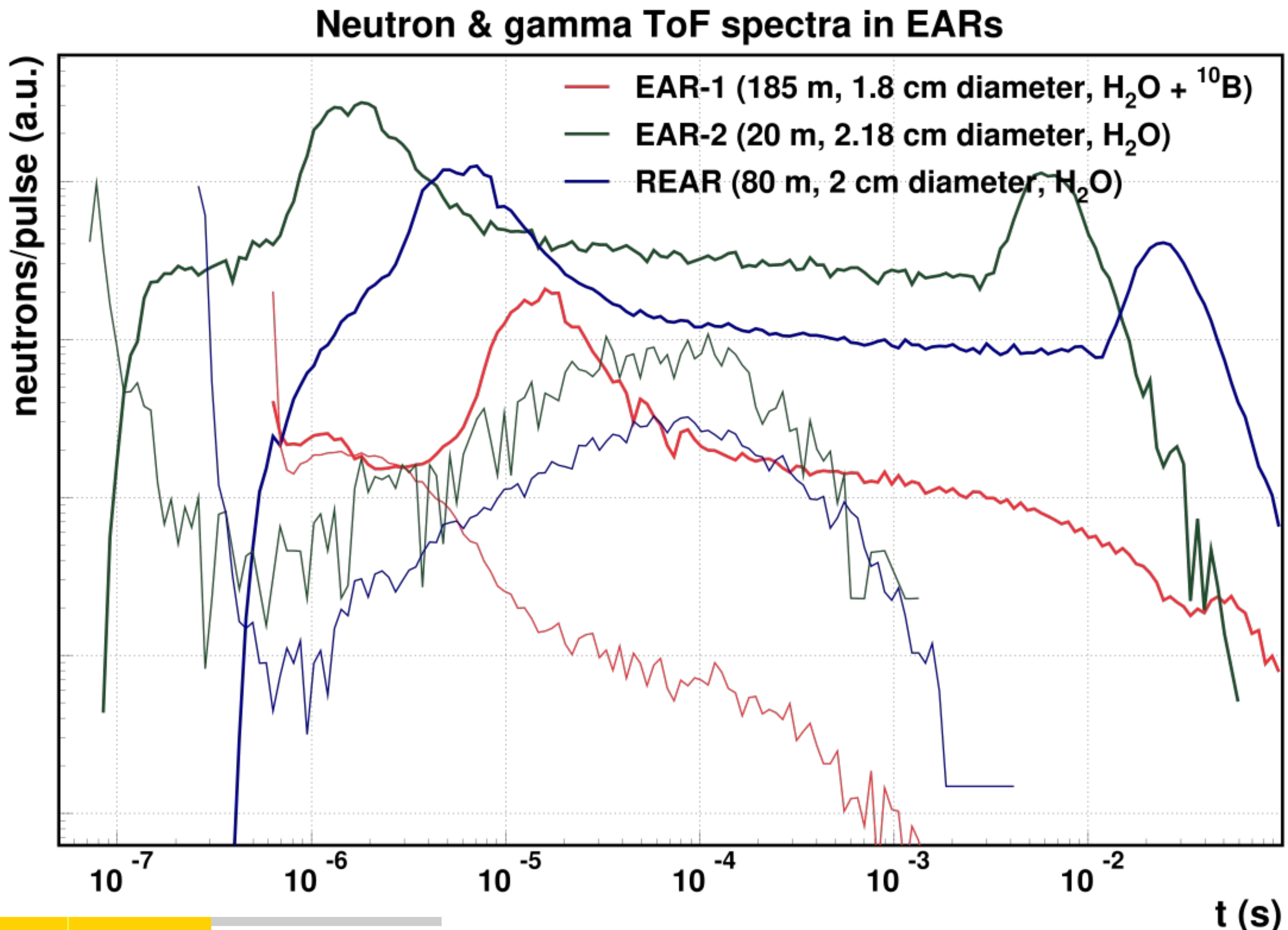
EAR-2 neutron and γ-ray TOF distributions



REAR neutron and γ-ray TOF distributions

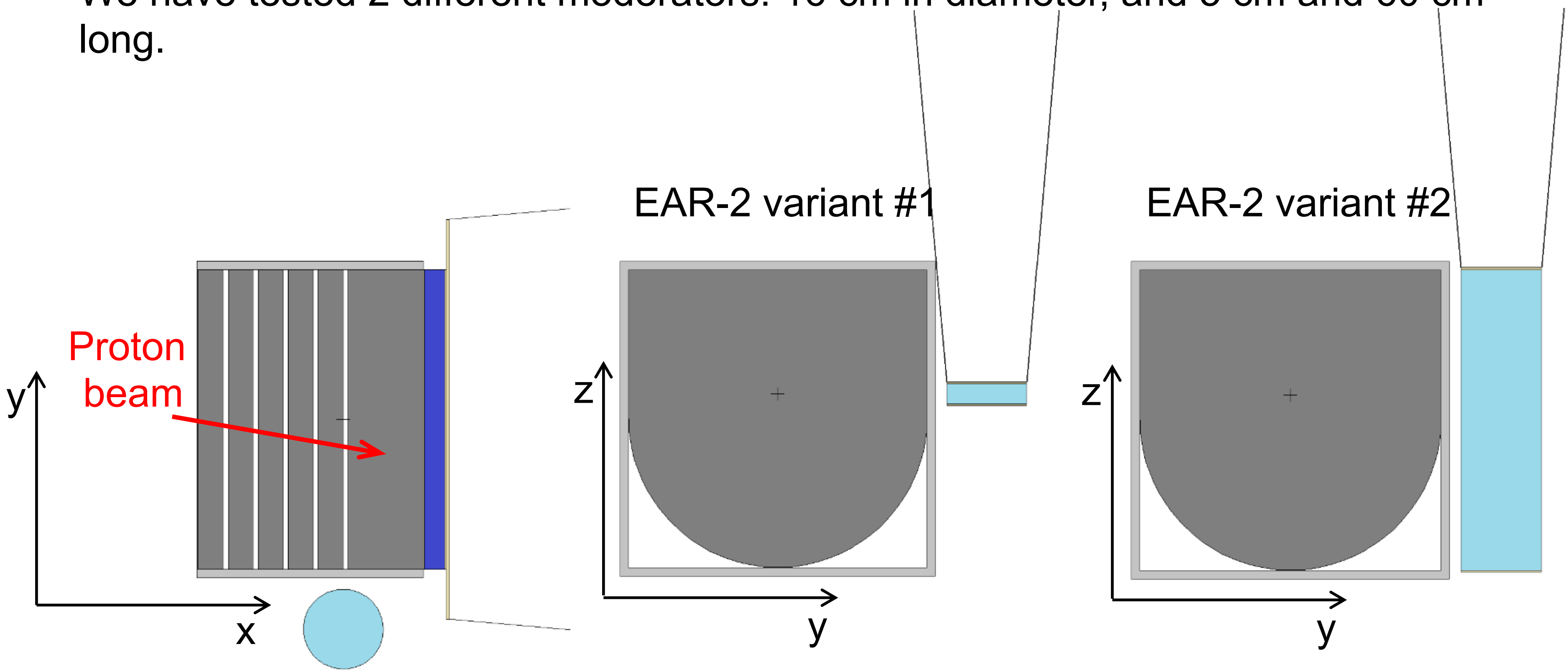


neutron and γ-ray TOF distributions



The DEAR beam line facing only a moderator

We have tested 2 different moderators: 16 cm in diameter, and 5 cm and 60 cm long.



Lead

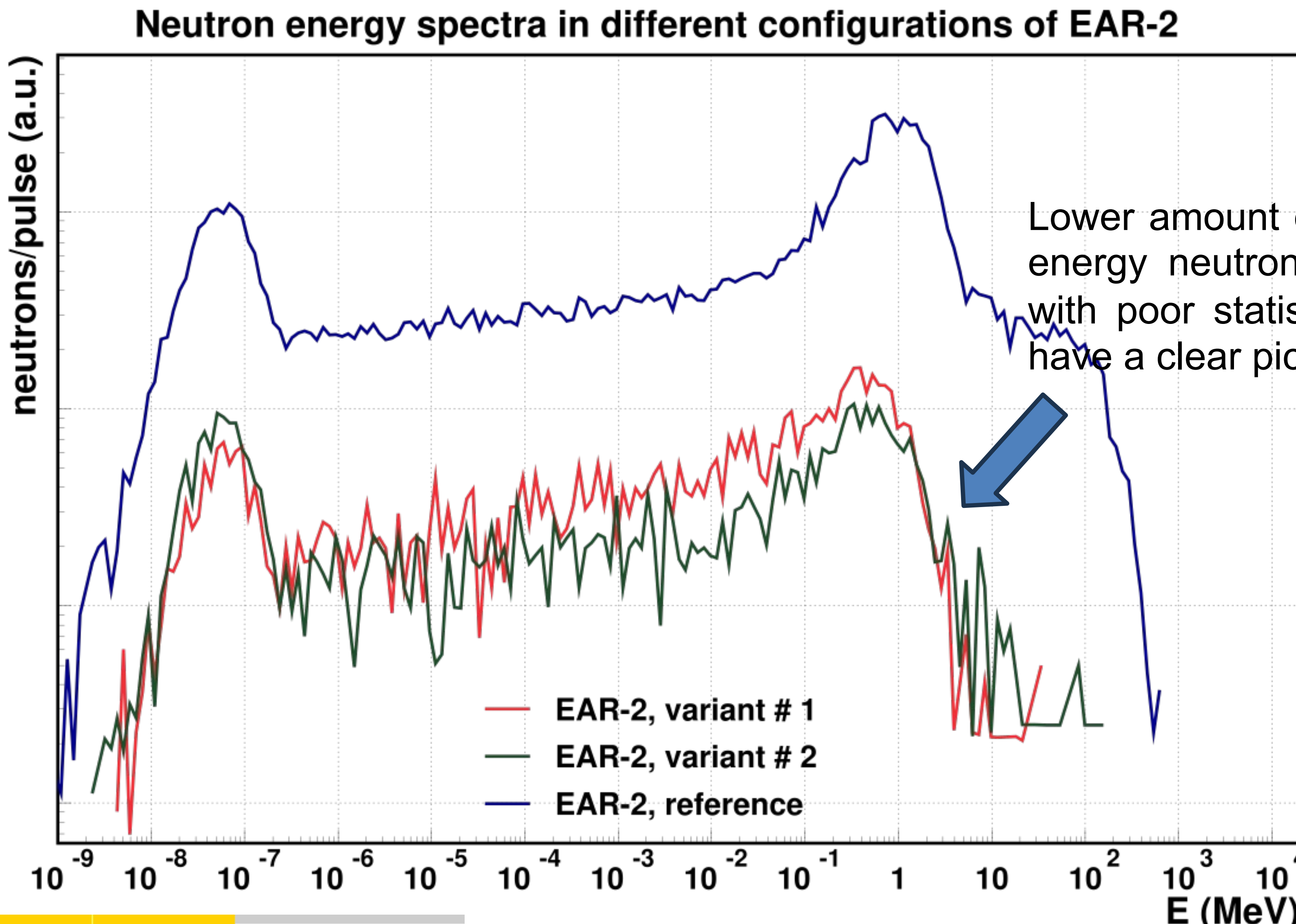
Aluminium

Steel (316L)

Water

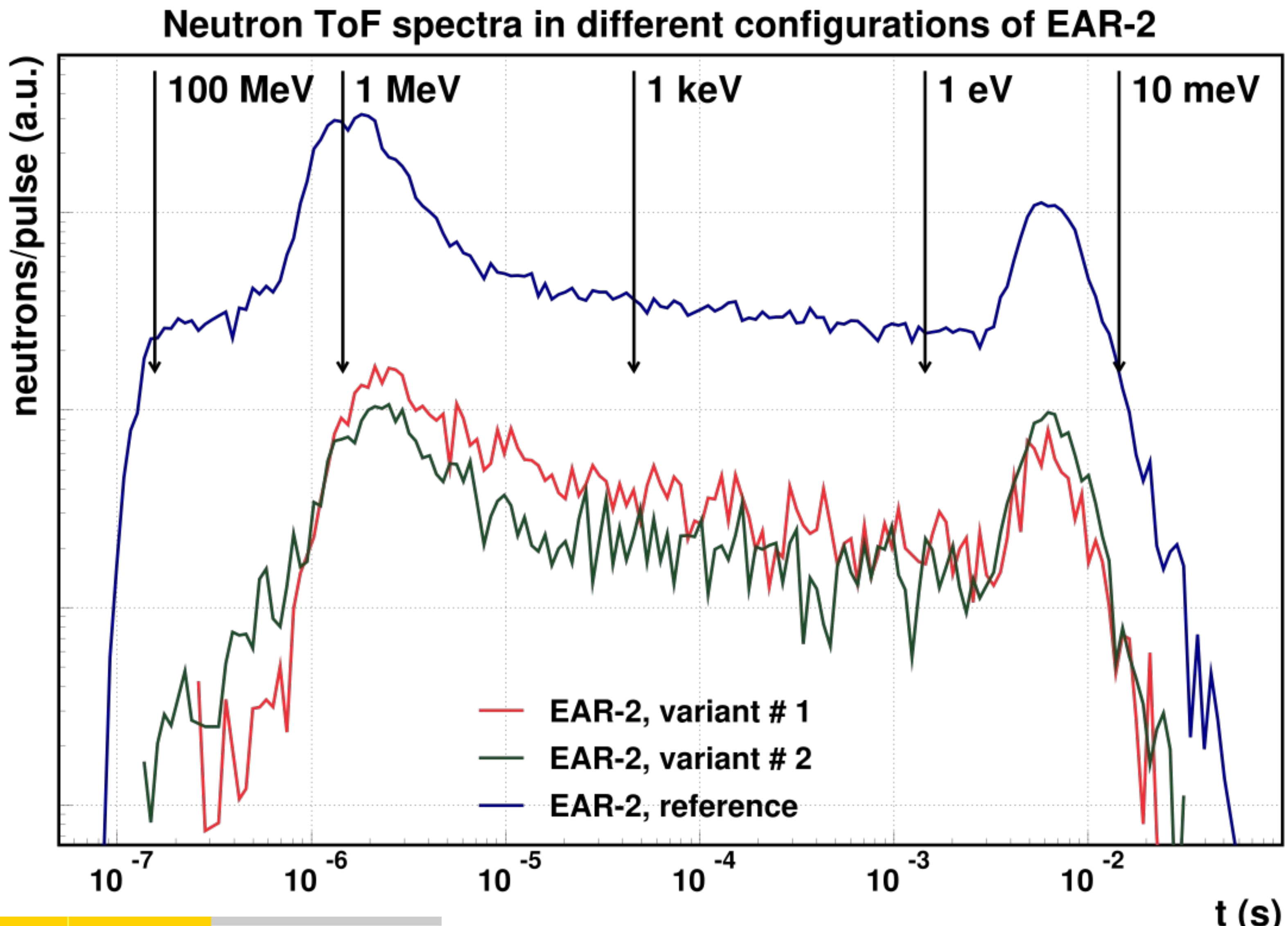
Borated water
(1.28% weight of boron, 99% ^{10}B)

Comparison of EAR-2 and DEAR

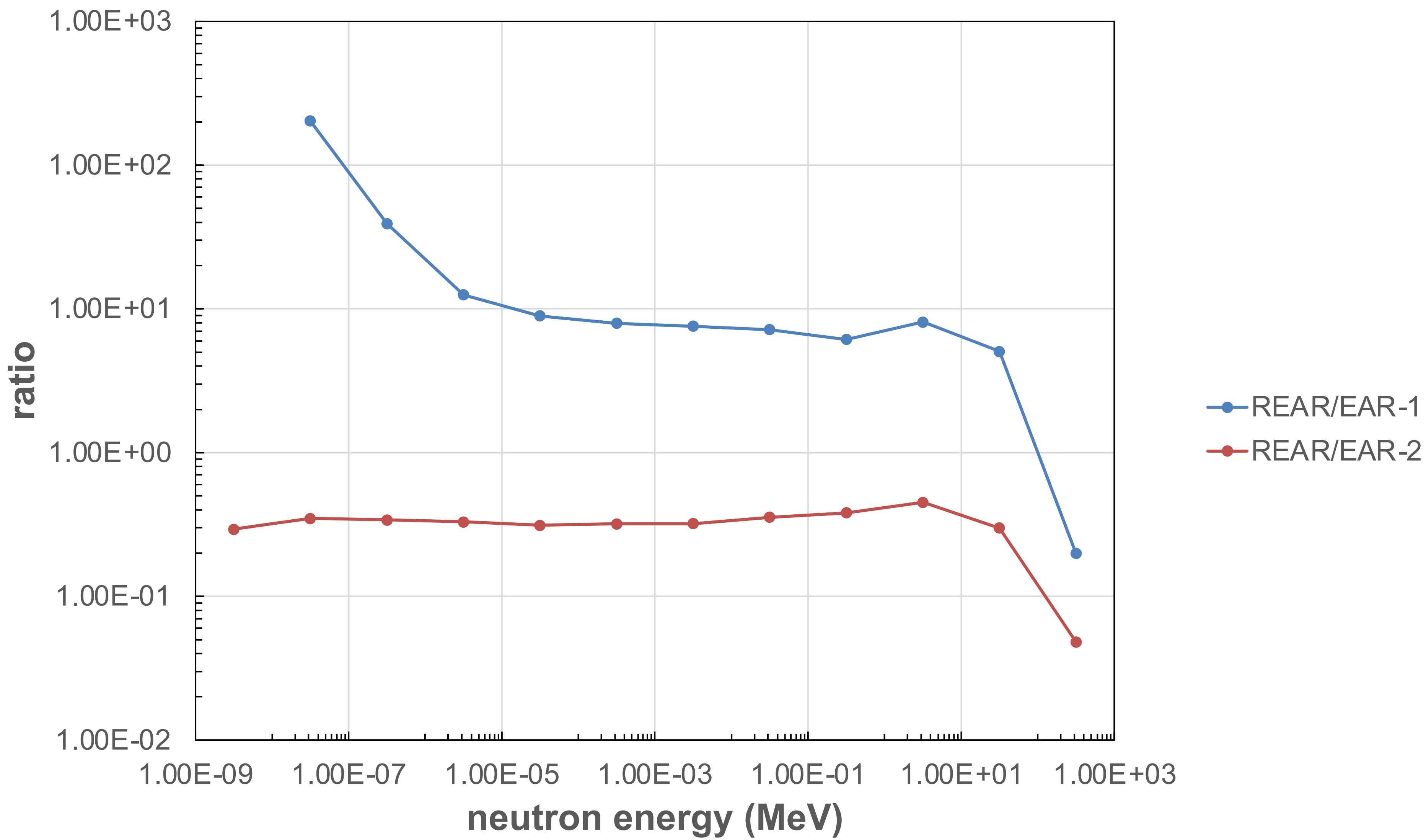


Lower amount of high energy neutrons. Still with poor statistics to have a clear picture.

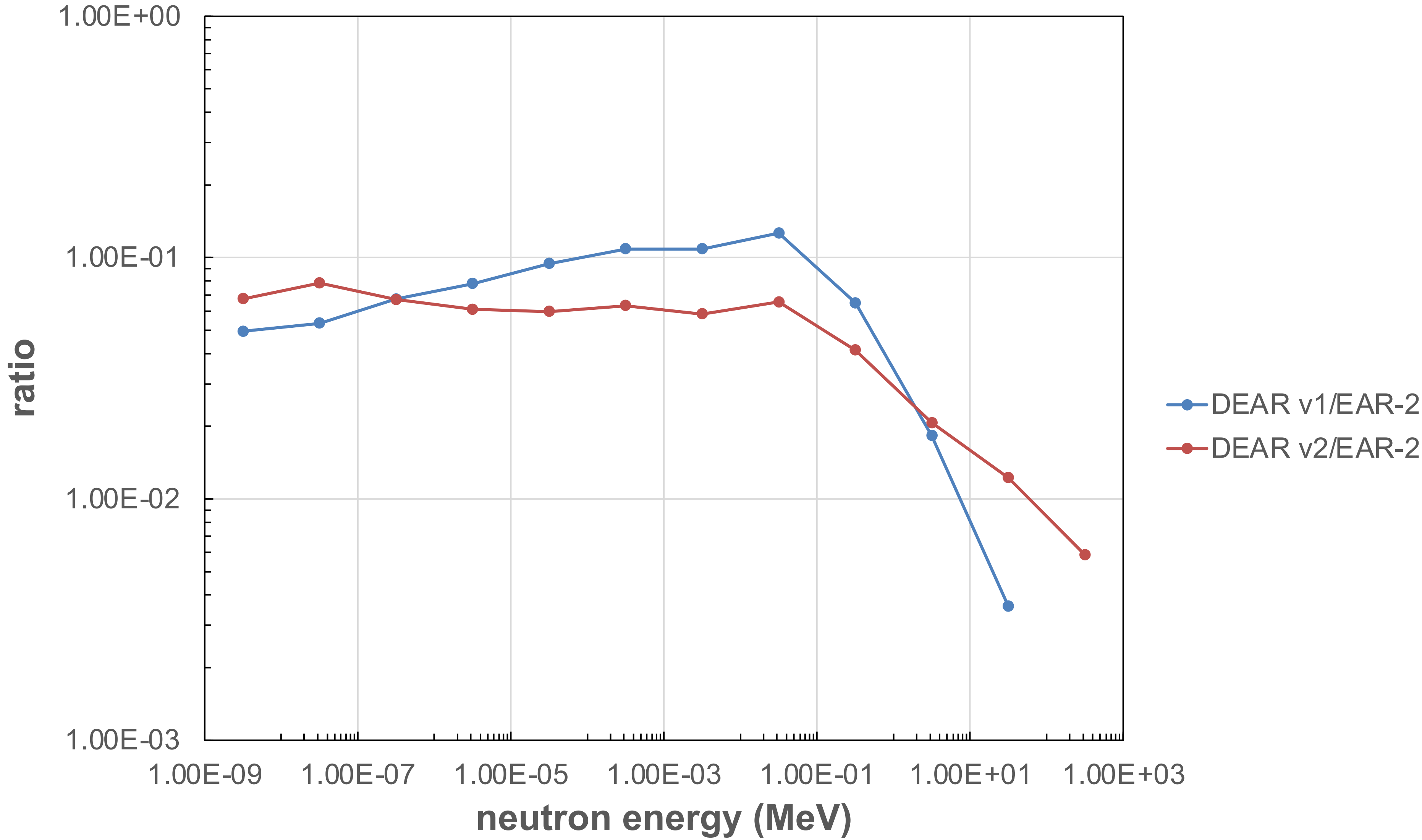
Comparison of the EAR-2 fluences



REAR vs EAR-1 and EAR-2



DEAR beam lines v1 and v2 vs EAR-2



Summary and conclusions

First simulations have been done for investigating:

- The performance of a REAR station at 80 m from the spallation target.
- The idea of having a second beam line in EAR-2 looking at a moderator and not at the spallation target.

Preliminary conclusions about REAR:

- There is a reduction in the high energy neutron component, but it is not evident that it will be enough for having better background conditions.
- There is also not a big change in the in-beam gamma-ray background with respect to EAR-2.

Maybe some good idea / further shaping of the beam in the backward direction may help. More simulations are required.

Summary and conclusions

Preliminary conclusions about the DEAR neutron beam line (in EAR-2) looking at a moderator.

- A reduction of the flux in a factor of 10 is expected. This may be acceptable for some experiments if a better signal to background ratio is achieved.
- The reduction of neutron fluence could be compensated if the flight path is shorter. ¿Useful for a 10 m flight path?
- More statistics are necessary for having a more accurate picture on the energy distribution of the neutrons and gamma-rays (not yet calculated) and for having some clue about the time-energy relation.

We will keep exploring some ideas for a while and additional help/proposals are of course welcome!

Comparison of the fluences

Energy (min-max) (MeV)		EAR-1 n/pulse	EAR-2 n/pulse	REAR n/pulse	EAR-2 v1 n/pulse	EAR-2 v2 n/pulse
1.00E-09	1.00E-08	0.00E+00	4.42E+04	1.30E+04	2.19E+03	2.99E+03
1.00E-08	1.00E-07	1.75E+03	1.02E+06	3.55E+05	5.43E+04	7.97E+04
1.00E-07	1.00E-06	4.20E+03	4.83E+05	1.64E+05	3.25E+04	3.23E+04
1.00E-06	1.00E-05	9.82E+03	3.73E+05	1.23E+05	2.91E+04	2.28E+04
1.00E-05	1.00E-04	1.48E+04	4.23E+05	1.32E+05	4.00E+04	2.53E+04
1.00E-04	1.00E-03	1.91E+04	4.76E+05	1.52E+05	5.16E+04	3.01E+04
1.00E-03	1.00E-02	2.34E+04	5.51E+05	1.77E+05	5.98E+04	3.22E+04
1.00E-02	1.00E-01	3.77E+04	7.60E+05	2.71E+05	9.61E+04	4.98E+04
1.00E-01	1.00E+00	1.70E+05	2.74E+06	1.04E+06	1.78E+05	1.13E+05
1.00E+00	1.00E+01	1.13E+05	2.03E+06	9.16E+05	3.71E+04	4.20E+04
1.00E+01	1.00E+02	2.23E+04	3.78E+05	1.13E+05	1.36E+03	4.62E+03
1.00E+02	1.00E+03	2.06E+04	8.48E+04	4.09E+03	0.00E+00	4.97E+02