COLINA: Conical liquid noble gas apparatus for CEvNS detection

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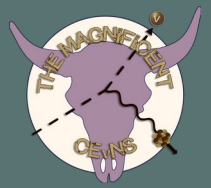

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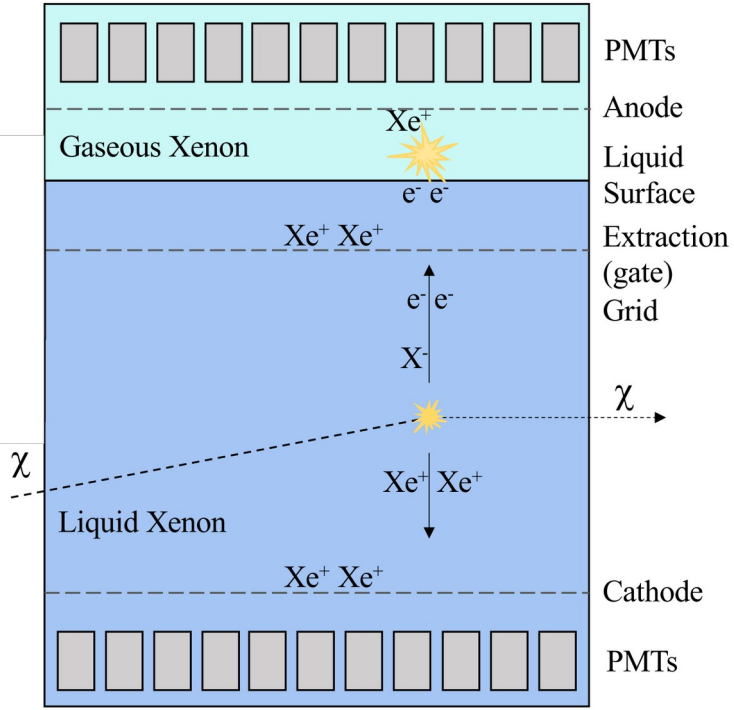
Dual-phase liquid noble gas TPCs



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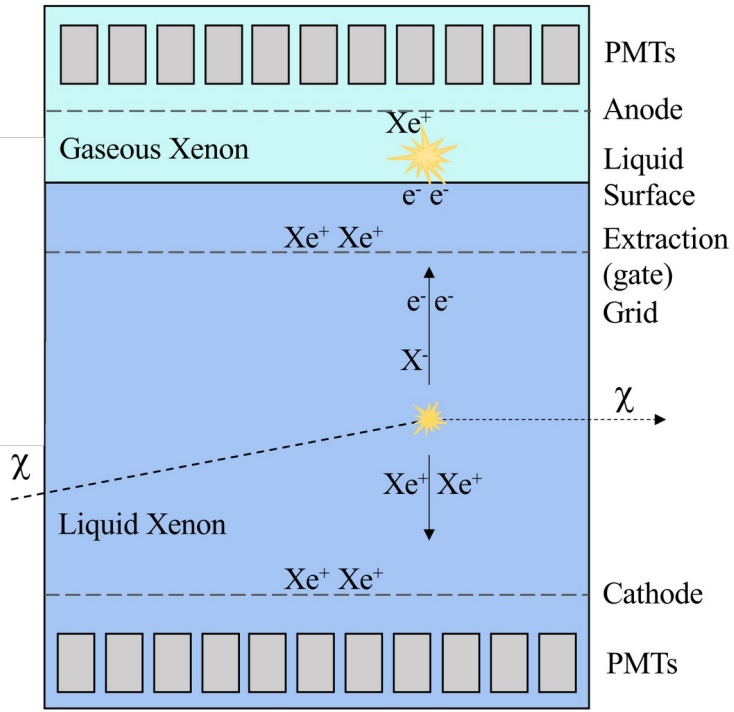
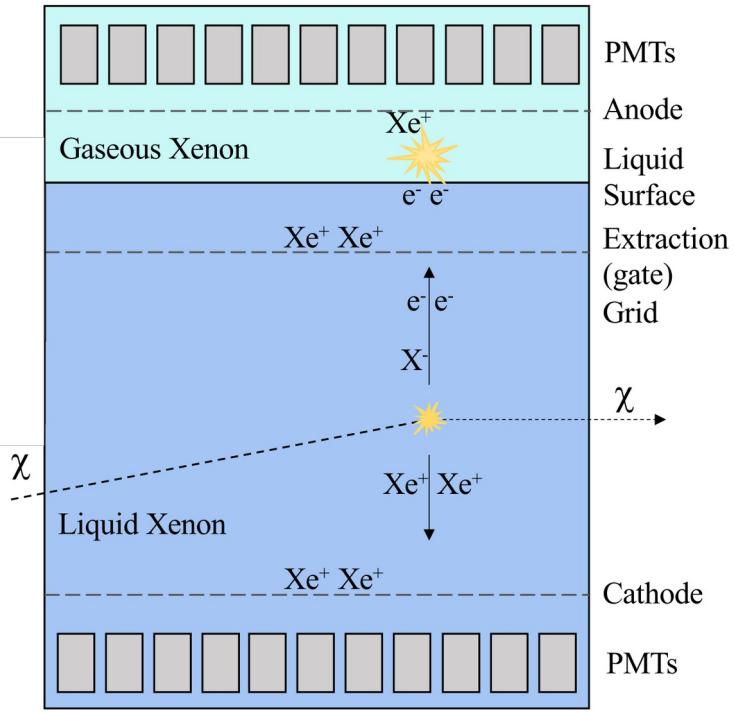


Noble gas detector → **Different mediums**

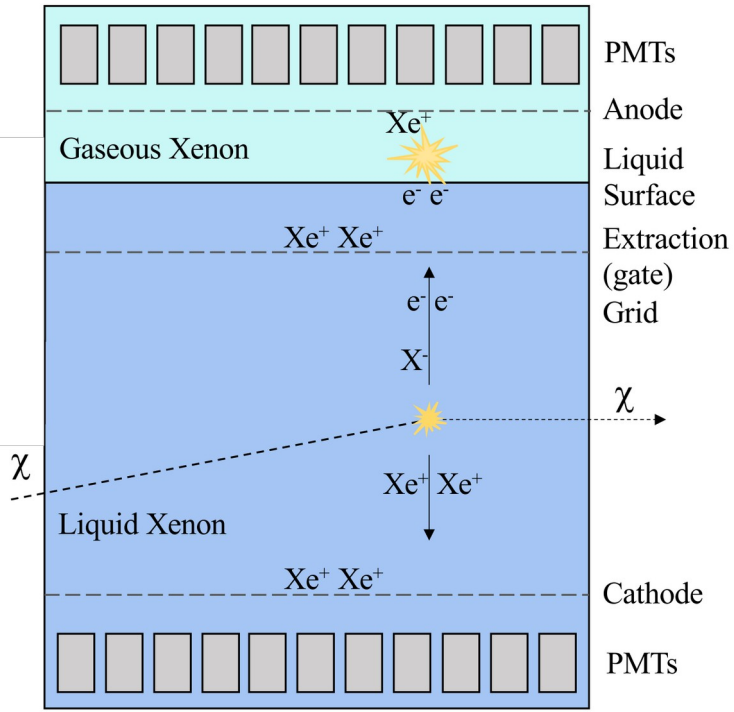
Dual-phase liquid noble gas TPCs



Noble gas detector → **Different mediums**

Liquid phase → **High density**

Dual-phase liquid noble gas TPCs

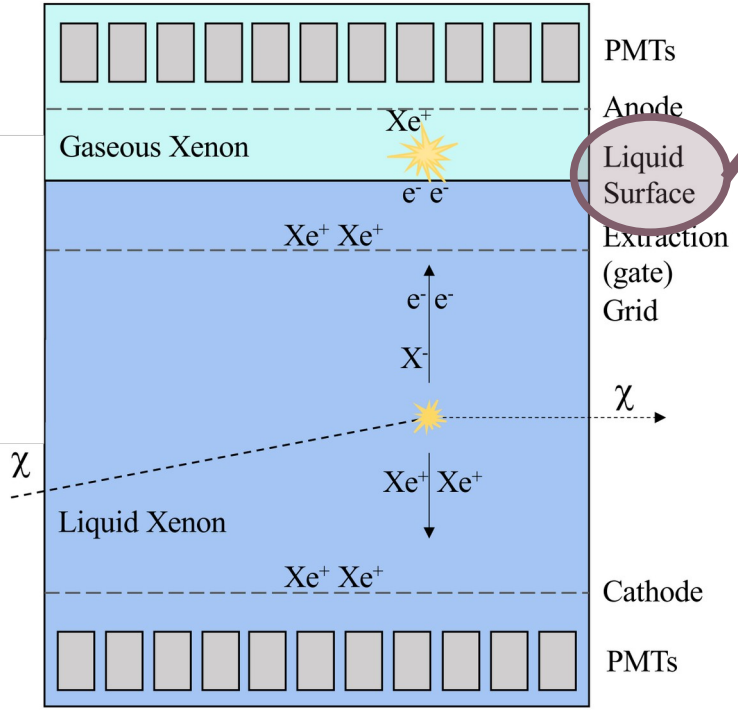


Noble gas detector → **Different mediums**

Liquid phase → **High density**

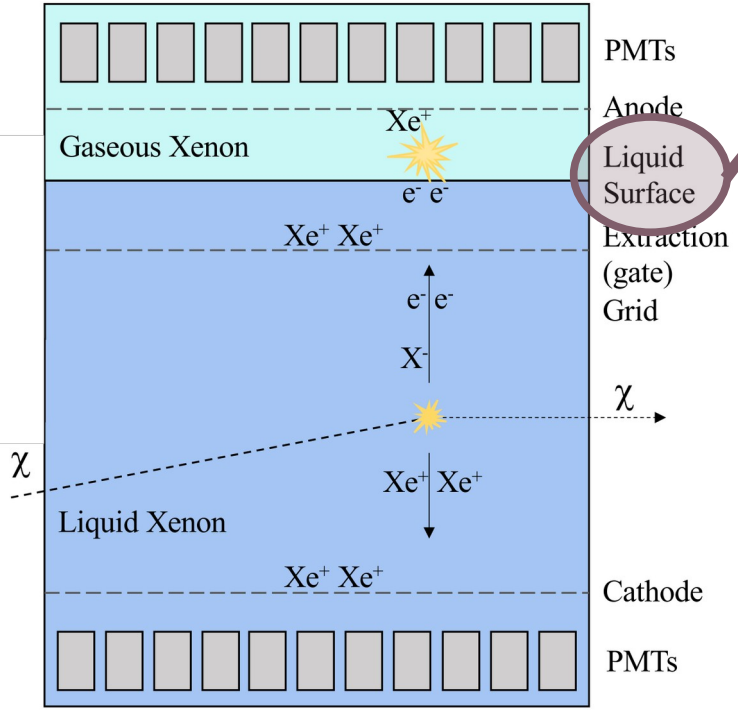
Electroluminiscence amplification → **Low energy threshold**

Dual-phase liquid noble gas TPCs



Charge trapping

Dual-phase liquid noble gas TPCs



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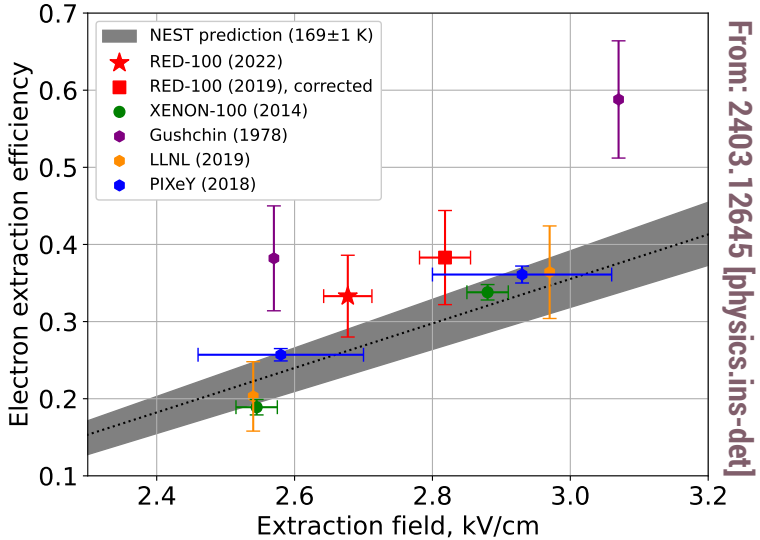
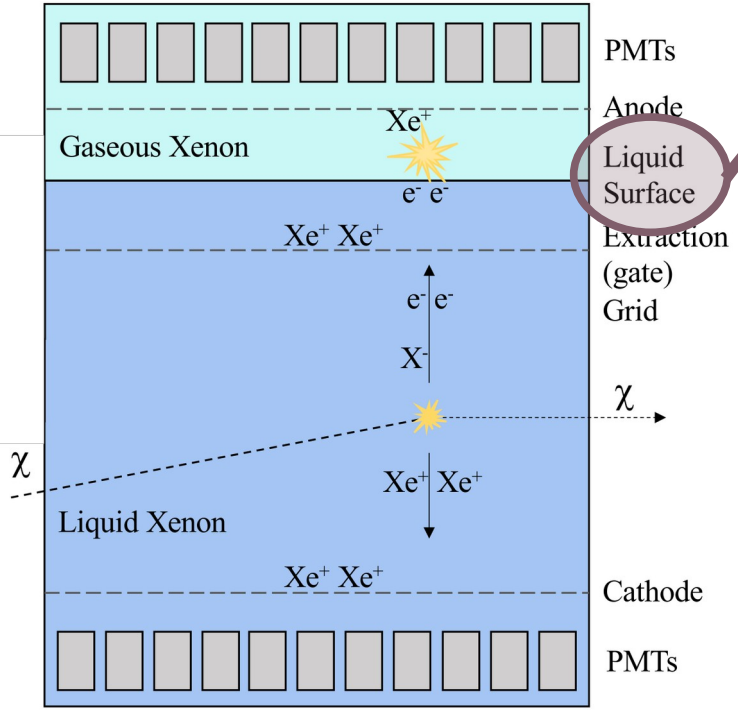


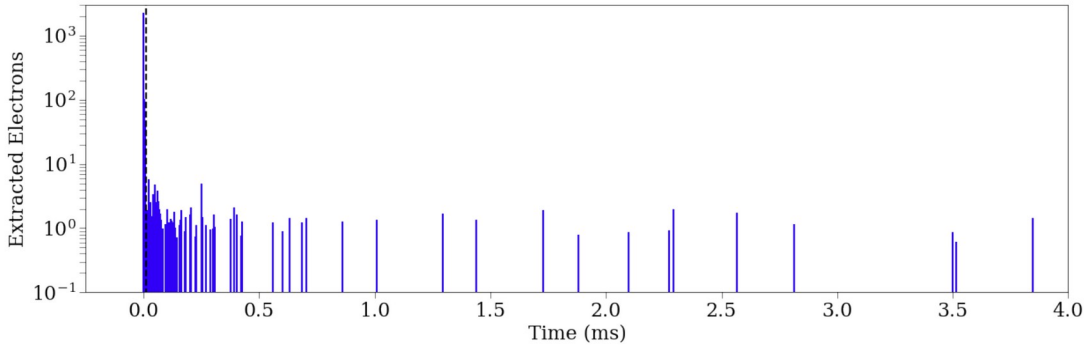
Signal loss

Dual-phase liquid noble gas TPCs



Charge trapping

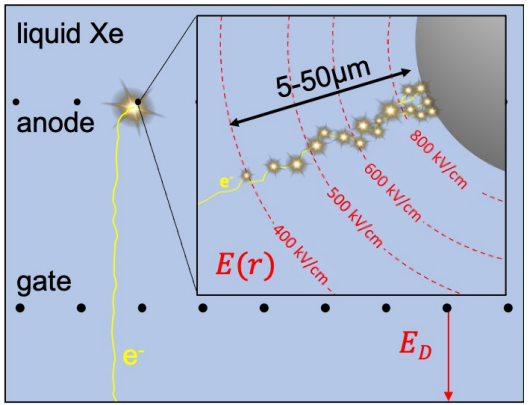
From: JINST 16 (2021) 07, P07014



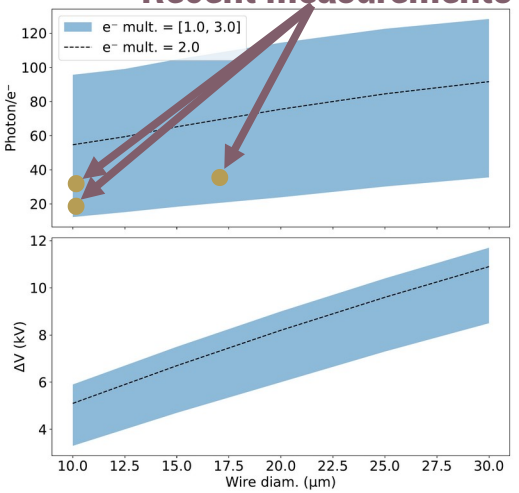
Delayed signal-like backgrounds

Liquid phase electroluminescence

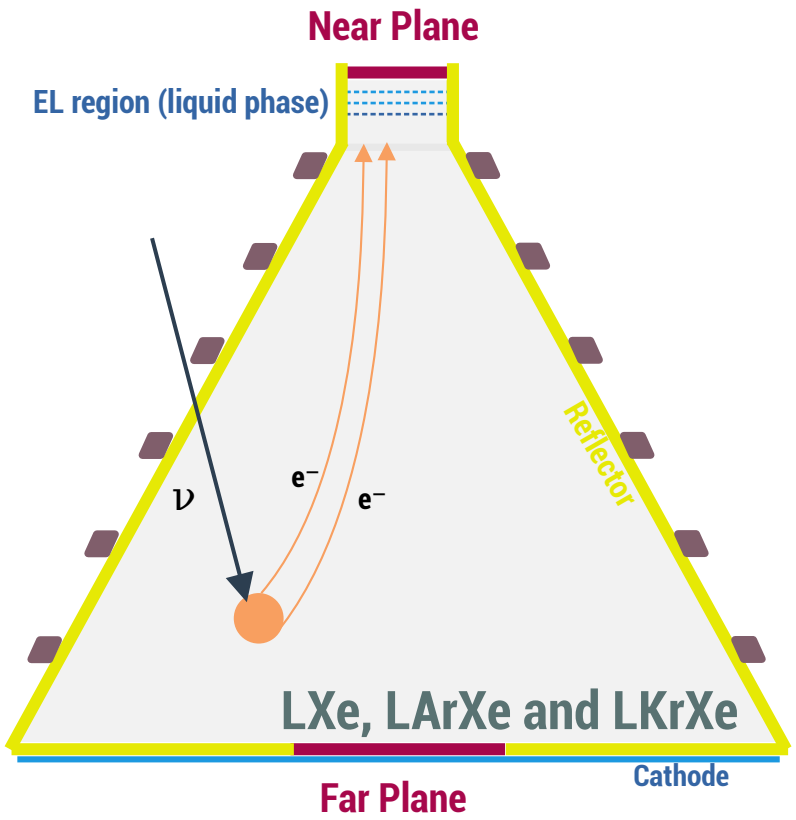
- Only possible with very intense electric fields (>400 kV/cm in Xe)
  - Achievable with thin wires (~10 μm diameter)
- Electroluminiscence only in the close vicinity of wires
  - Low yield.
  - Short scintillation → Improved time resolution
- Charge amplification may occur if field gets too high.
- Wire tensioning is a challenge → EL size limited → Target volume limited.
  - **New ideas are needed to fully exploit this!**



Recent measurements



COLINA: Detector concept



Conical shape TPC

↓

Focus charges into small EL region (liquid phase)

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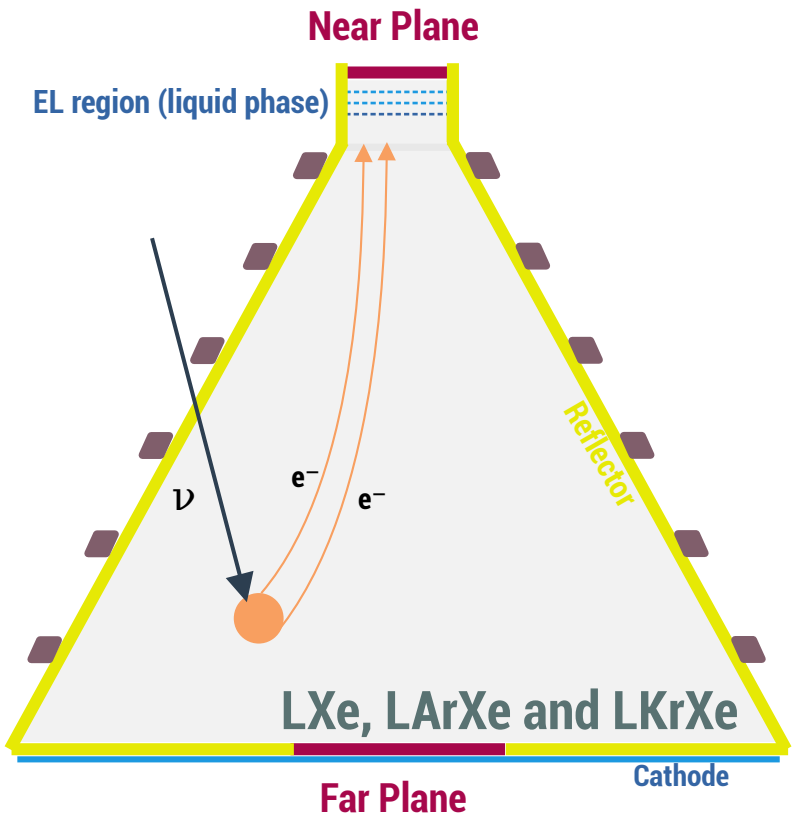

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Allows for 'large' target volumes

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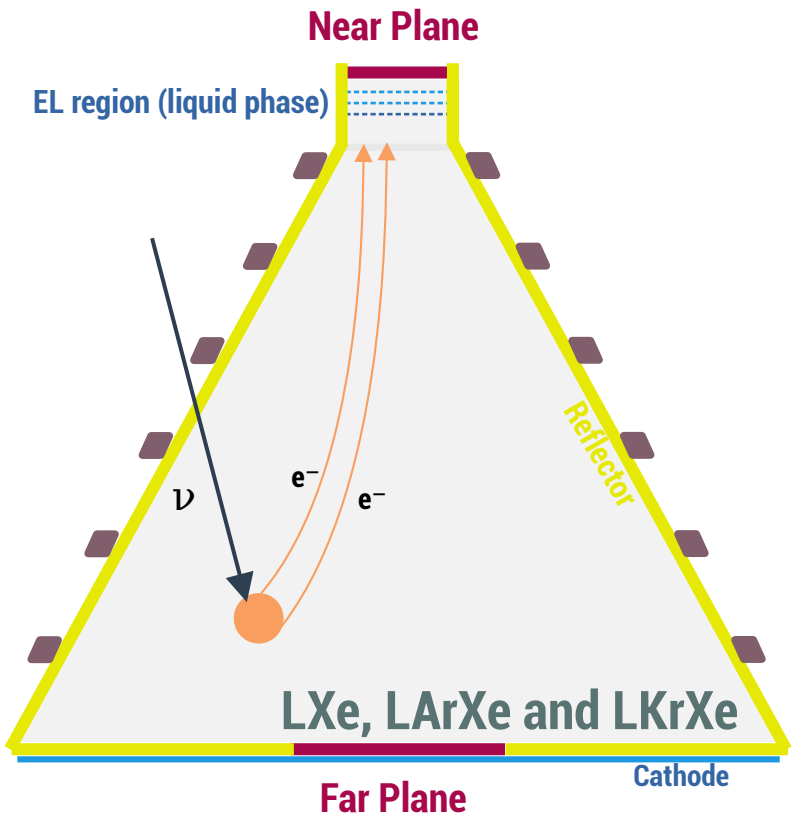

Conical shape TPC

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Focus charges into small EL region (liquid phase)

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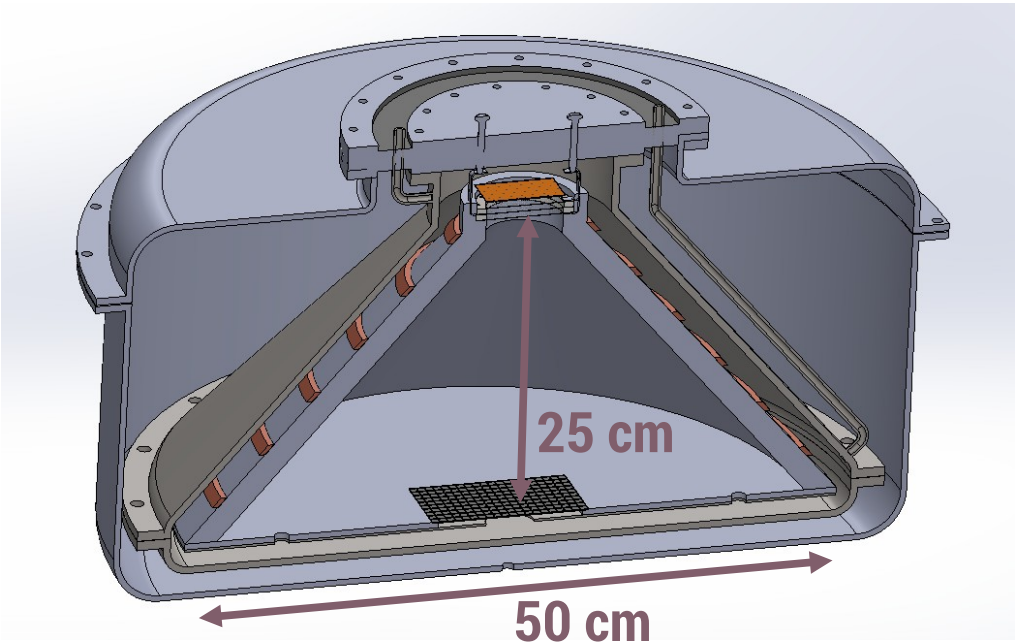
Allows for 'large' target volumes

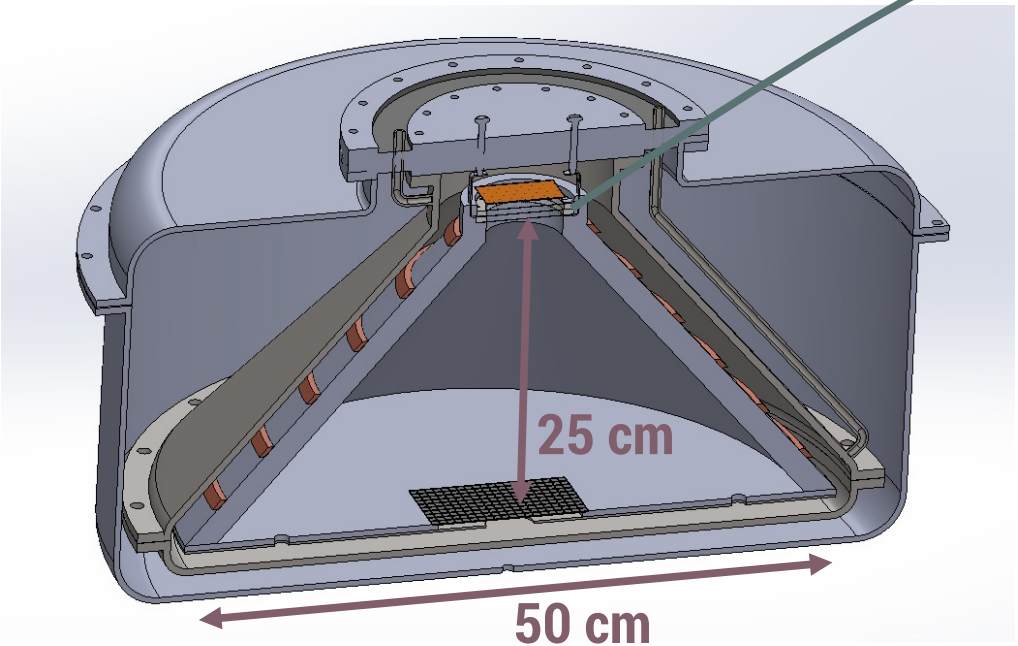
Good coverage with few sensors

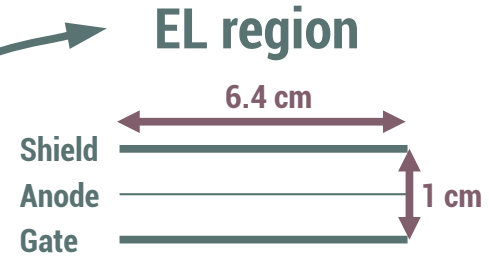
The COLINA detector



Volume ~17 dm³
(50 kg Xe, 42 kg Kr, 24.5 kg Ar)

The COLINA detector





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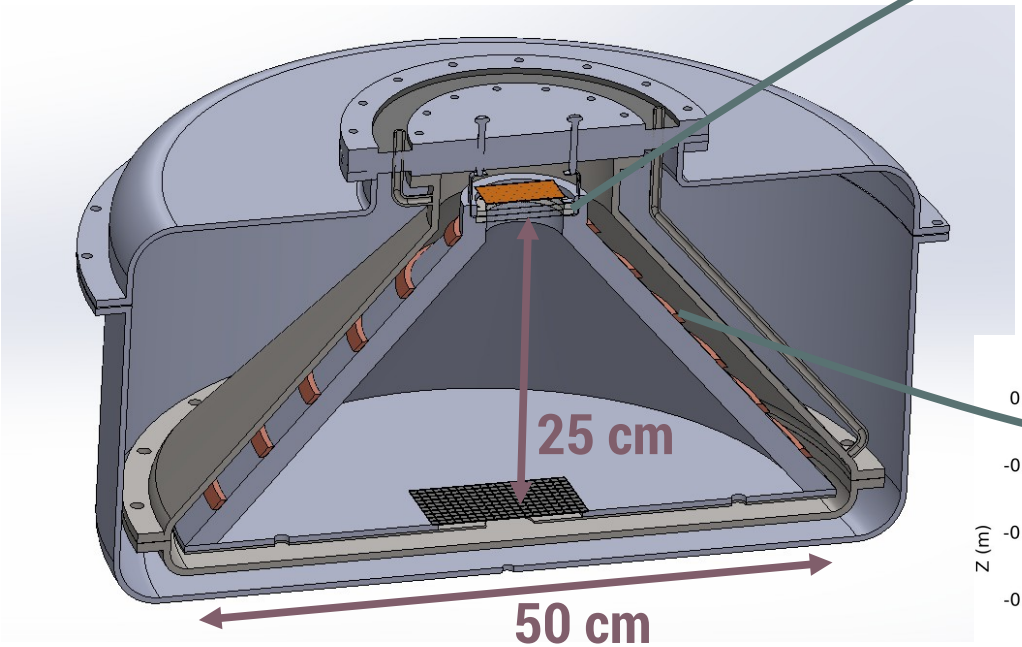
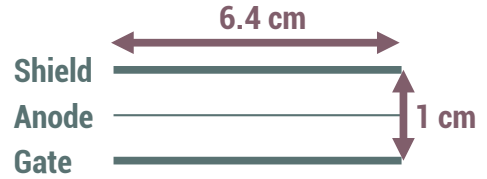
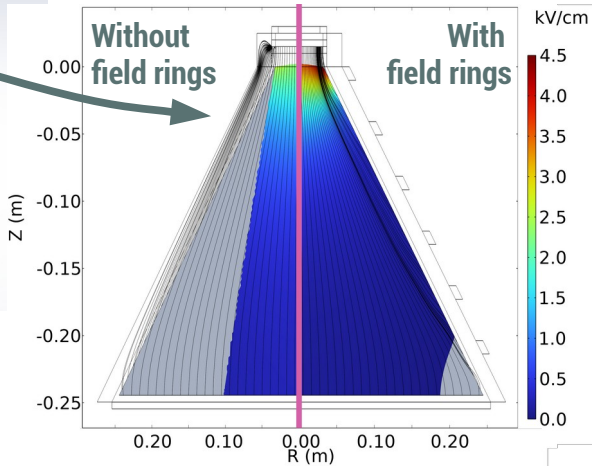


EL region



Drift field



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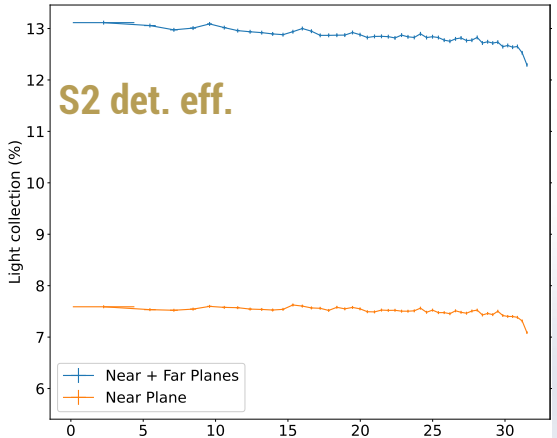
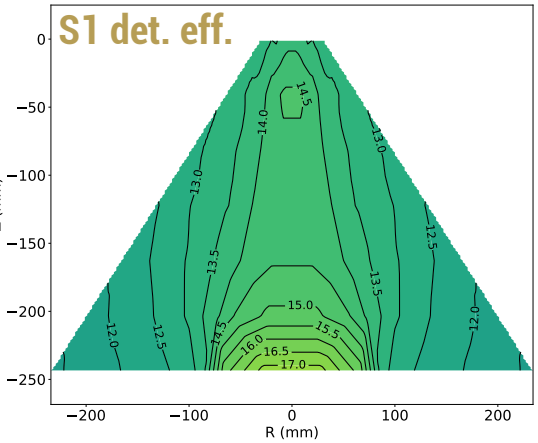
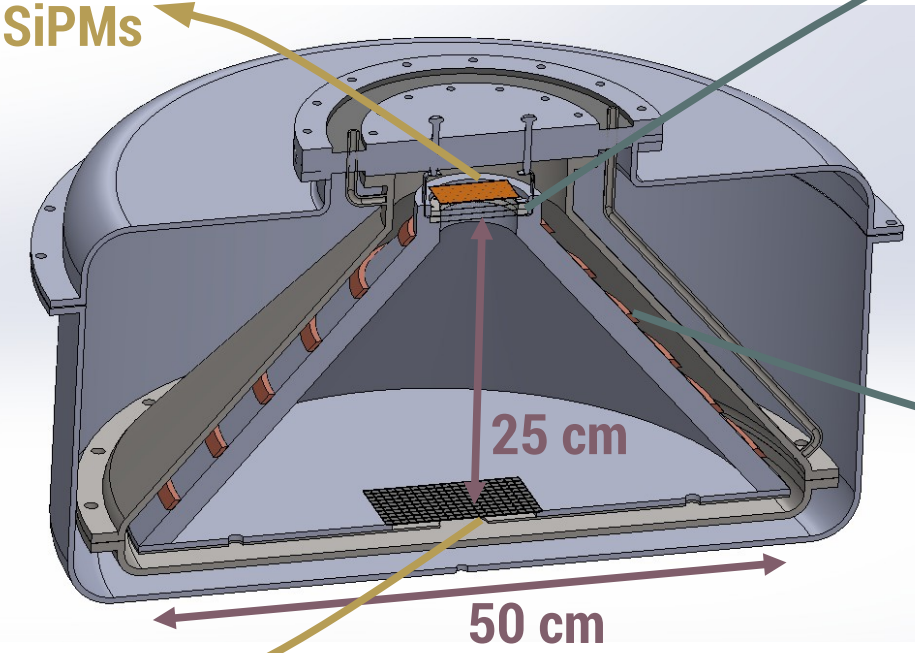




100 VUV SiPMs

400 VUV SiPMs



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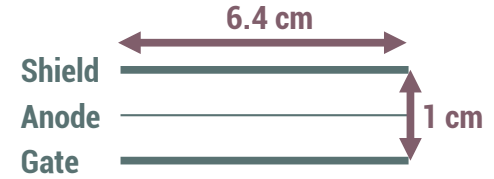

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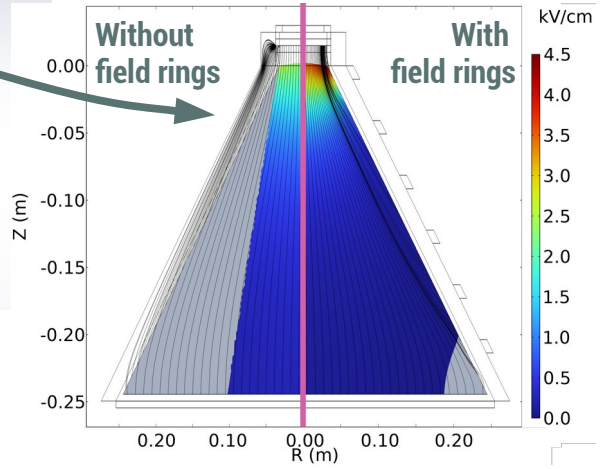

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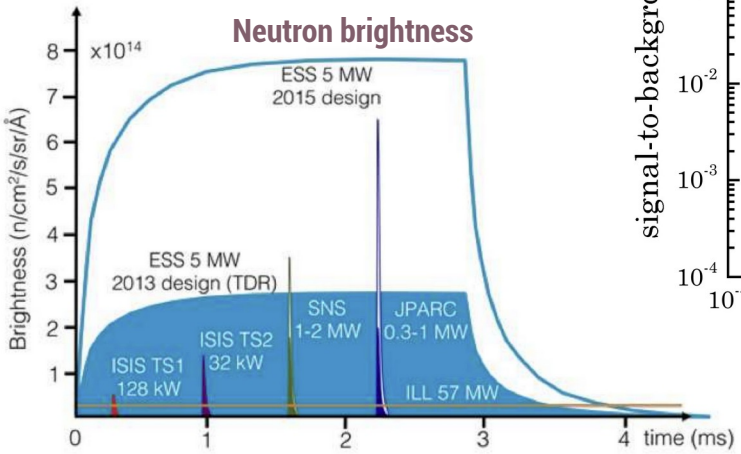
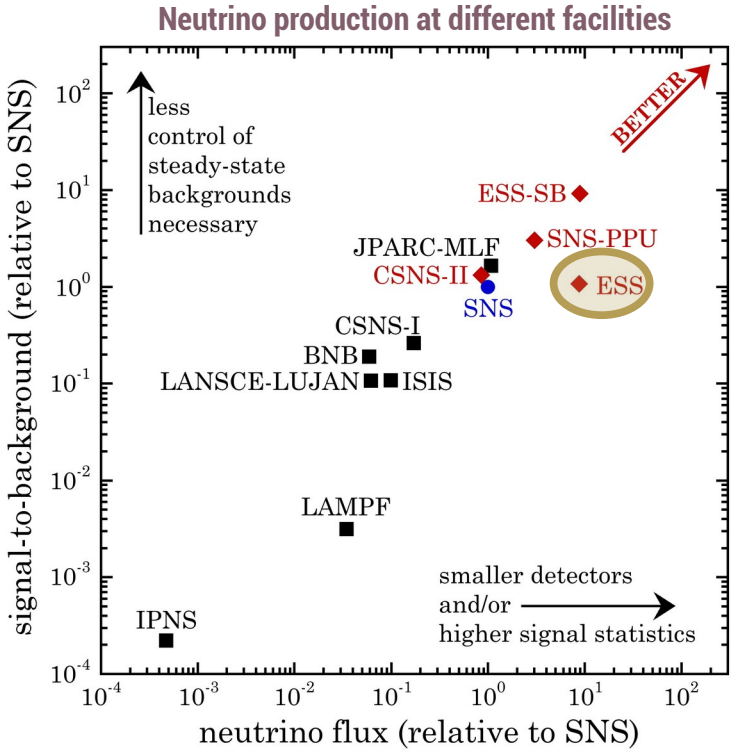
European Spallation Source (ESS)

- The ESS will generate the most intense neutron beams for multi-disciplinary science.
- But also, the largest low-energy neutrino flux!
- ν production @ ESS is x9.2 @ SNS
- Similar s/b to SNS but much higher statistics.

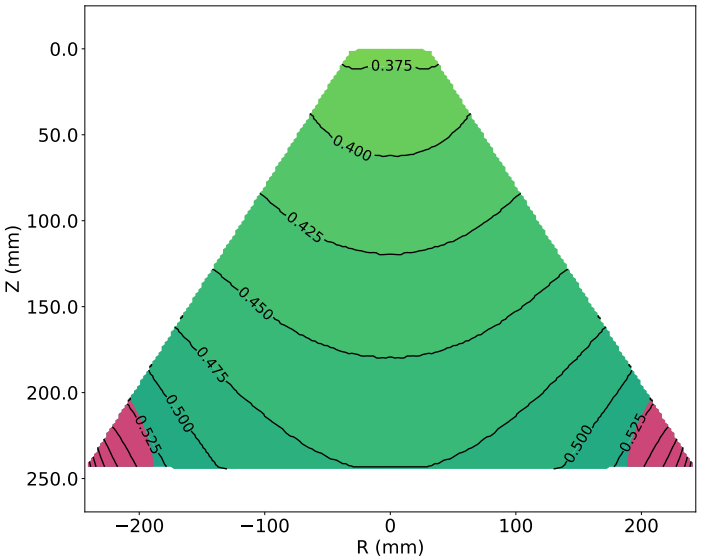




Experimental potential

Detection threshold

(in keVnr)



< 0.525 keVnr

[4 photons detected → 2 e^- at 17 phot./e^-]

(conservative, recently reported ~30 photons/e^- yield)

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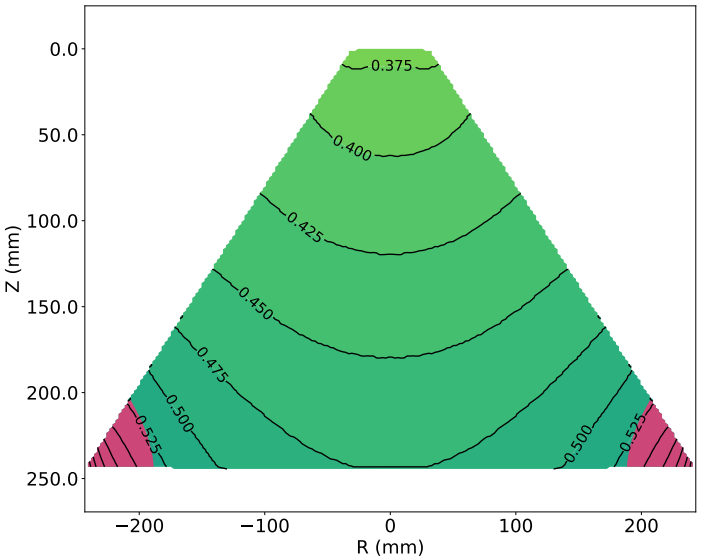

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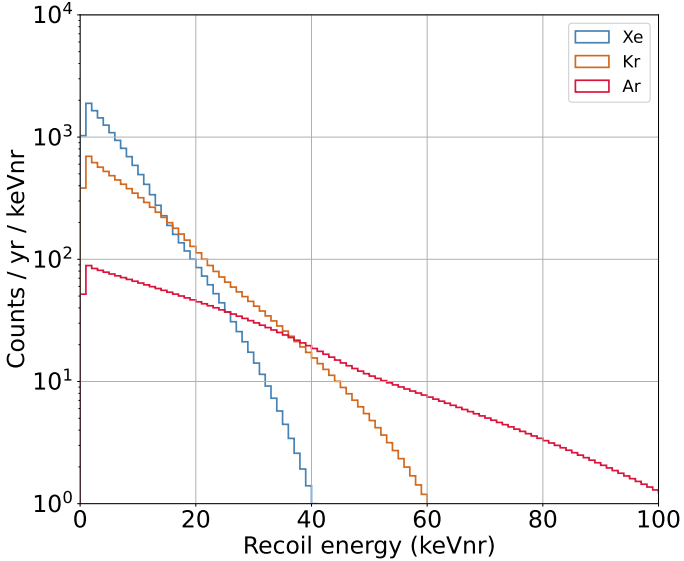
Event rate @ ESS



11,400 evts/year in Xe

6,500 evts/year in Kr

1,800 evts/year in Ar

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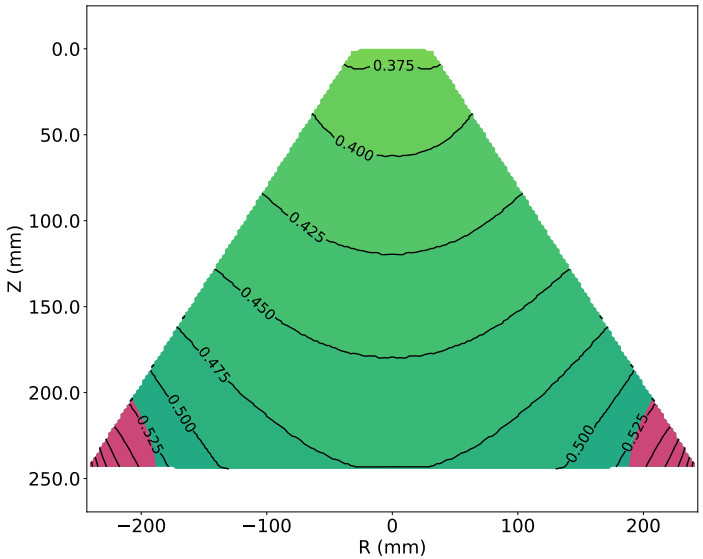

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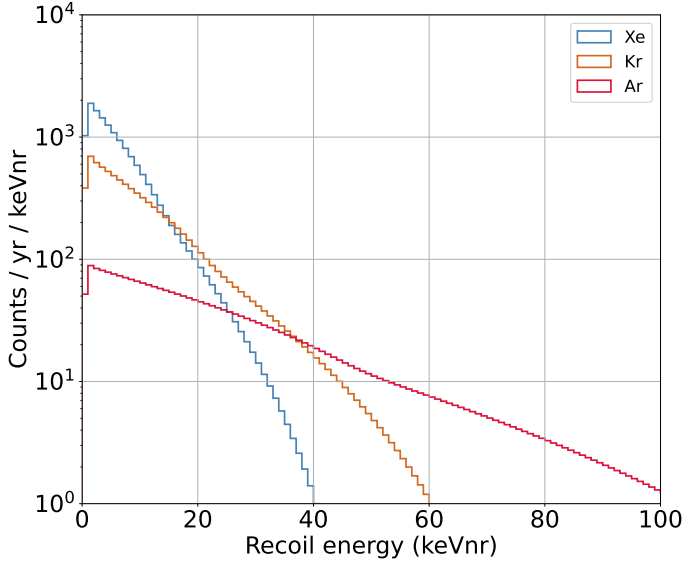

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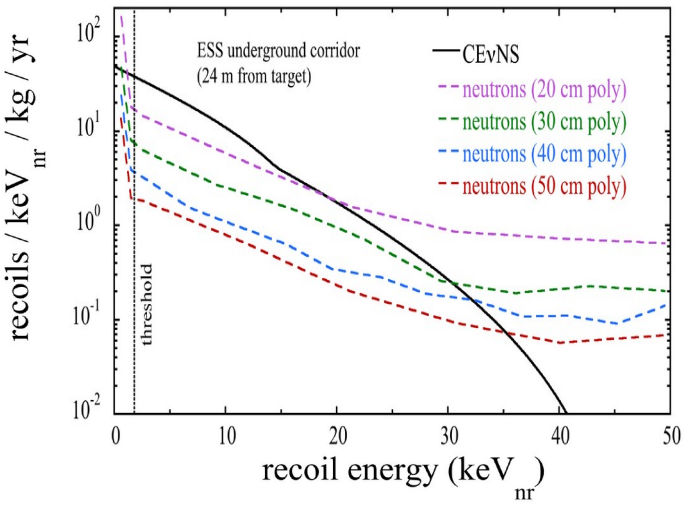
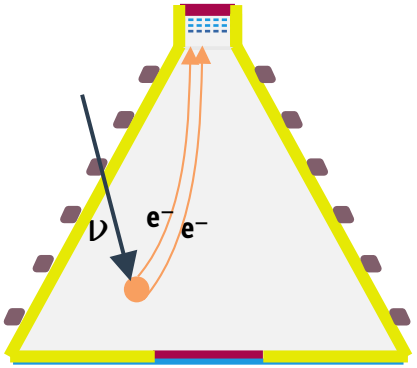
Beam-related bckg

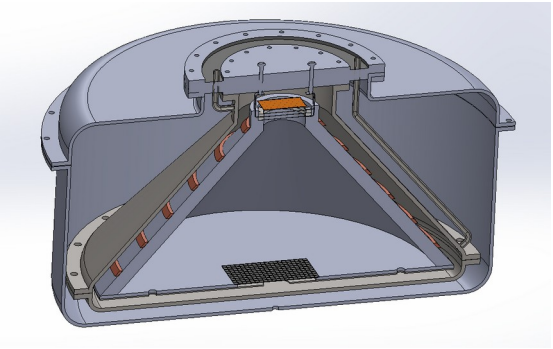


40 cm of HDPE is enough

Summary

- CEvNS detection opens a new avenues in the search of physics beyond the Standard Model.
- ESS will become the largest low-energy neutrino source. Perfect facility to study this process.
- The COLINA project will develop the **first conical time projection chamber to maximally exploit CEvNS** at the ESS with extraordinary potential:
  - Liquid noble gases → Large statistics
  - Electroluminiscence → Low detection threshold (~0.5 keV_{nr})
  - High light collection eff. with few photosensors.
  - Operation with different targets with minimal intervention.





Thank you