Neutrino observatories in high-pressure salt caverns

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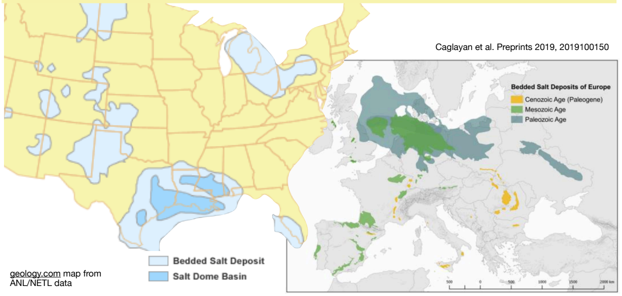
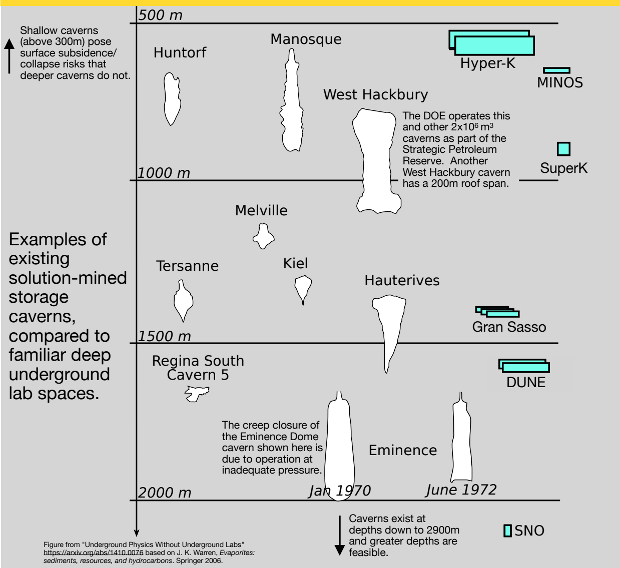
Deep geological bodies of solid salt are common in North America and Europe.

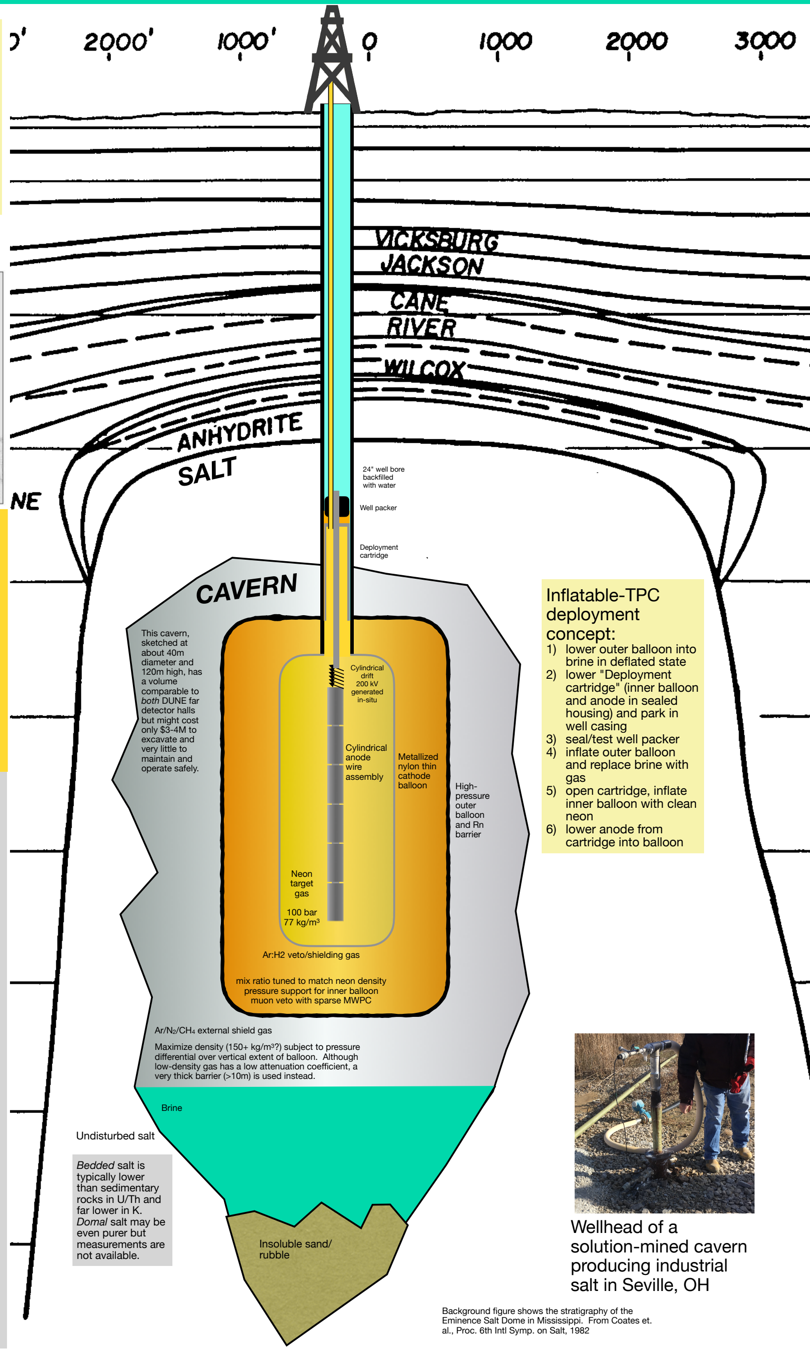
WIPP, Boulby, and the IMB site are in abundant "bedded" salt deposits. Tall, pure "domal" salt sites are common on the US Gulf Coast, northern Germany, and the Persian Gulf. Note that the edge of the "Pine Salt" formation is 1.5° off-axis from the DUNE neutrino beam, and salt beds underlay many nuclear reactor sites.



The natural-gas industry routinely creates large, stable high-pressure caverns in salt via *solution mining.*

Solution-mined caverns are made from the surface by pumping in fresh water and extracting brine; the cavern shape is managed by manipulating a cover gas. The process is far cheaper ($20/m³) than conventional lab excavation ($1000/m³) and volumes to 2x10⁶ m³ are possible. Our hope is to piggyback on this cheap, existing technology by designing detectors that can deploy remotely via the otherwise-conventional 12"-24" well pipe.





Wellhead of a solution-mined cavern producing industrial salt in Seville, OH

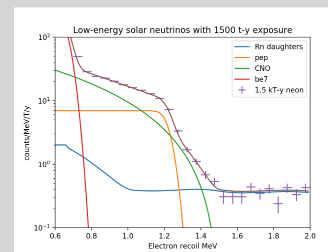
Salt caverns' vast sizes and high pressures give us a unique path to ton- or kiloton- scale gas TPCs.

High-pressure TPCs are a well-known detector medium, with longer tracks and better calorimetry than liquids. However, detectors like NEXT, NEWS-G, and HPgTPC are constrained to small target masses because they need heavy, expensive pressure vessels.

Salt caverns have nearly-unlimited pressurized space. We can make use of it under a challenging constraint: can the detector be engineered to squeeze down a 24" well?

One possibility: kiloton-scale neon gas TPC to study CNO and pp neutrinos

Strawman design (zoom in on center figure for details):
- 10 m diameter x 80 m tall *inflated cathode balloon cylinder*
- Cylindrical drift under 100-200 kV voltage
- 50 cm segmented anode cylinder. Conventional multiwire gain grid.
- Target: 500 t neon at 100 bar (77 kg/m³)
- Shielding/veto: >15 m of Ar-based gas mixtures



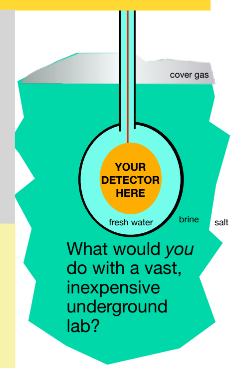
This 500 t (Borexino-like) scale allows very sensitive solar neutrino spectroscopy; here we have nearly 7000 CNO events above the ⁷Be edge (and 300 above the *pep* edge) suggesting 1-2% precision on a rate measurement. Background issues require further study.

Background-reducing considerations

- Electron tracks are 10-20 cm long; cut on sun direction
- TPC resolves gamma ray interactions as multisite Compton scattering
- Dissolved (?) beta emitters (²¹⁴Bi, etc.) often have a displaced gamma
- Cosmogenic ¹¹C production is low on ²⁰Ne target
- The major pp-neutrino background ¹⁴C is absent

Case Underground Salt Observatory

600m below Case Western Reserve University is a 20m-thick salt unit of the Salina Formation. We are in the early stages of designing/ proposing a small on-campus well and cavern, sized for ton-scale H_2/He dark matter searches.



Seeking collaborators

Are you interested in detector brainstorming, design, simulation for dark matter, neutrinos, 0νββ? Grad student or undergrad in need of a side project or thesis topic? Talk to the author!