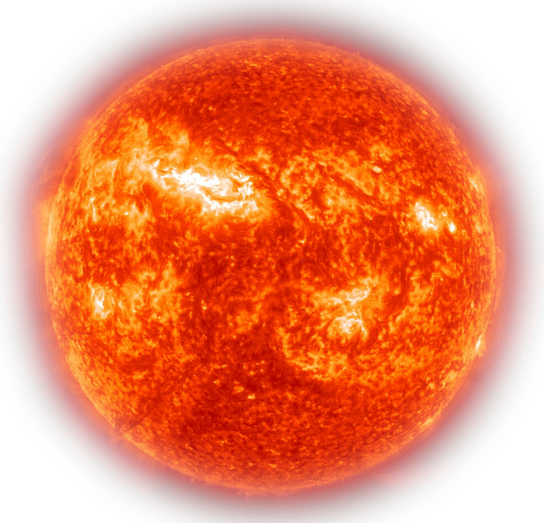
Neutrino Physics Research at McGill

McGill Neutrino Research Group

What are neutrinos?

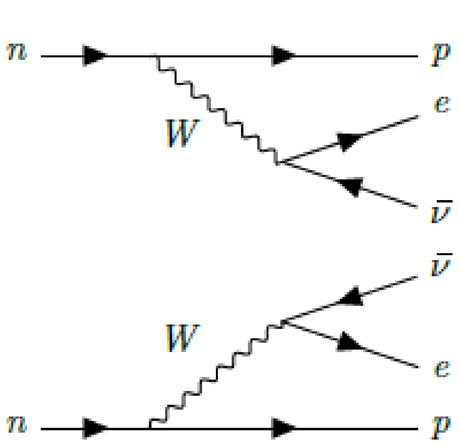
- Neutrinos are extremely light neutral particles.
- They are some of the most abundant particles in the universe and are produced in copious amounts in stars, like our own Sun for instance.



- Around 7 billion solar neutrinos pass through your thumbnail per second[2]!
- They interact very little and are hard to detect.

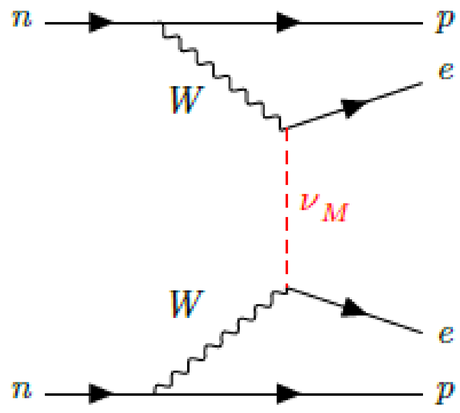
Why study neutrinos?

- Neutrinos could be a Majorana-like particle, a type completely different from other elementary particles.
- Majorana particles are their own antiparticles.
- This discovery will represent new physics beyond the Standard Model of Particle Physics.
- It could provide an explanation for why we live in a matter dominated universe (leptogenesis).
- McGill is part of the EXO-200 and nEXO collaborations, which study neutrinos.



Double Beta Decay

M. Goeppert-Mayer second woman to win a Physics Nobel Prize.



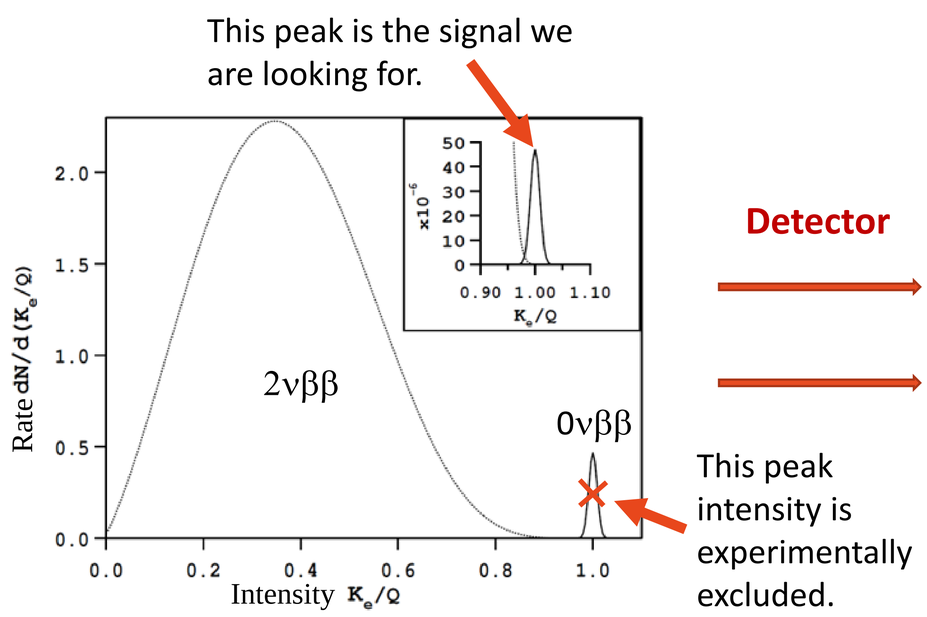
Neutrinoless Double Beta Decay

Ettore Majorana

New Physics!

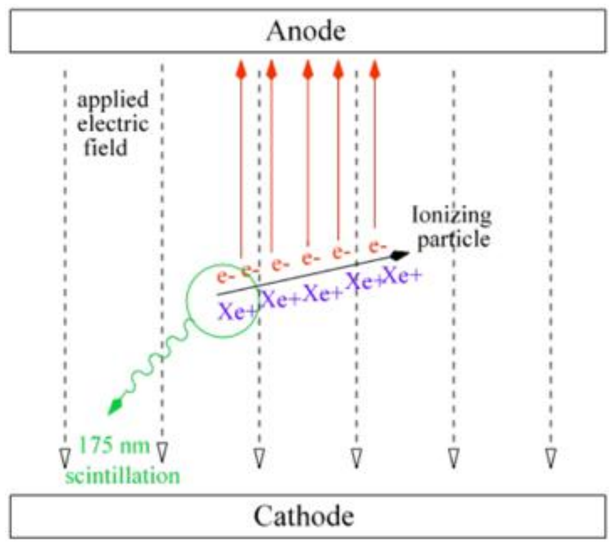
Probing the Quantum nature of neutrinos with EXO-200 and nEXO

- Searching for the Majorana nature of neutrinos by looking for double beta decays in which no neutrinos are emitted, the neutrinoless double beta decay ($0\nu\beta\beta$).
- Ultra-low background detectors are necessary to search for these decays.
- In order to suppress the influence of cosmic backgrounds on measurements, hundreds of meters of shielding are necessary → deep underground facilities required.
- Neutrinoless double beta decay may occur in only very few isotopes, ^{136}Xe is one of them.



Expected Signal in a "calorimeter" detector[4].

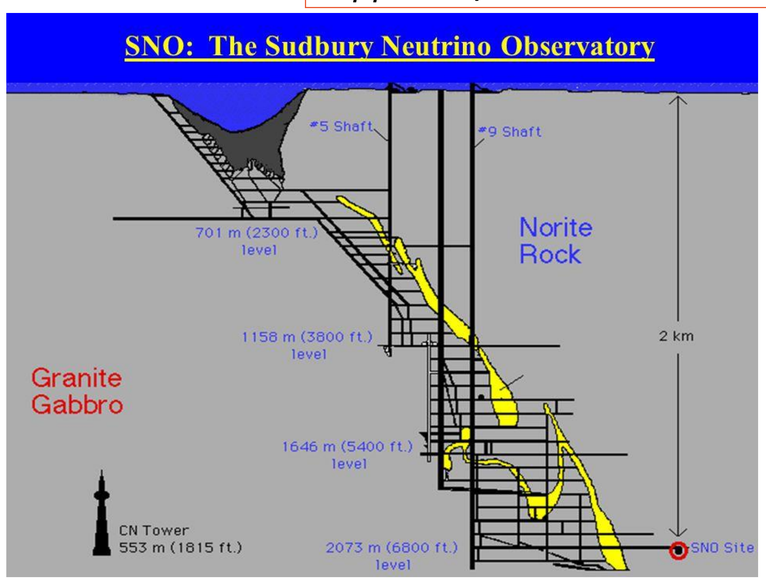
Detector

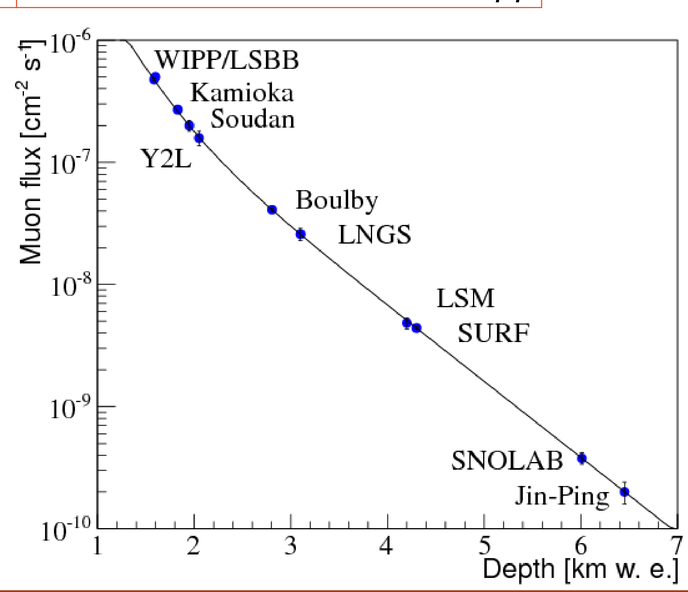


Detector Concept: Monolithic liquid Xe (~165K), enriched in ^{136}Xe.

Natural Radiation Decay Rates

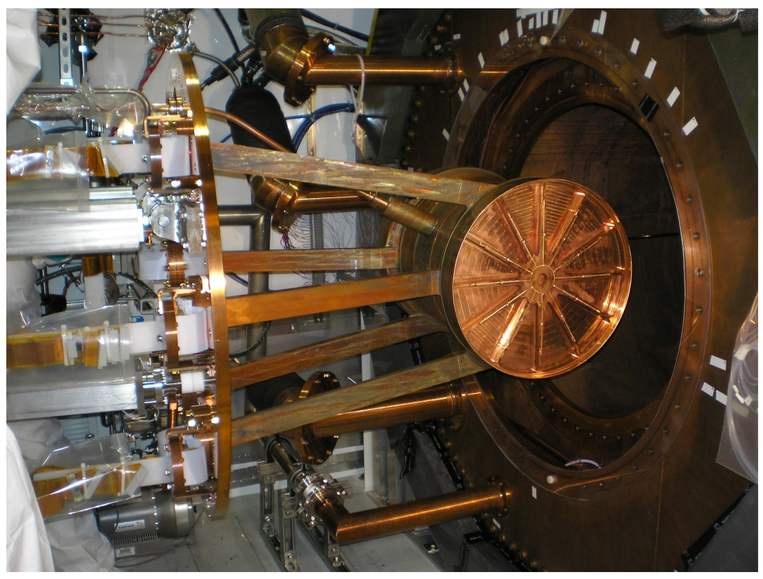
A banana	10 decays/s
A bicycle tire	0.3 decays/s
1L of air	1 decay/min
100 kg of ^{136}Xe ($2\nu\beta\beta$)	1 decay/10 min
$0\nu\beta\beta$ decay	> 10000 times rarer than $2\nu\beta\beta$





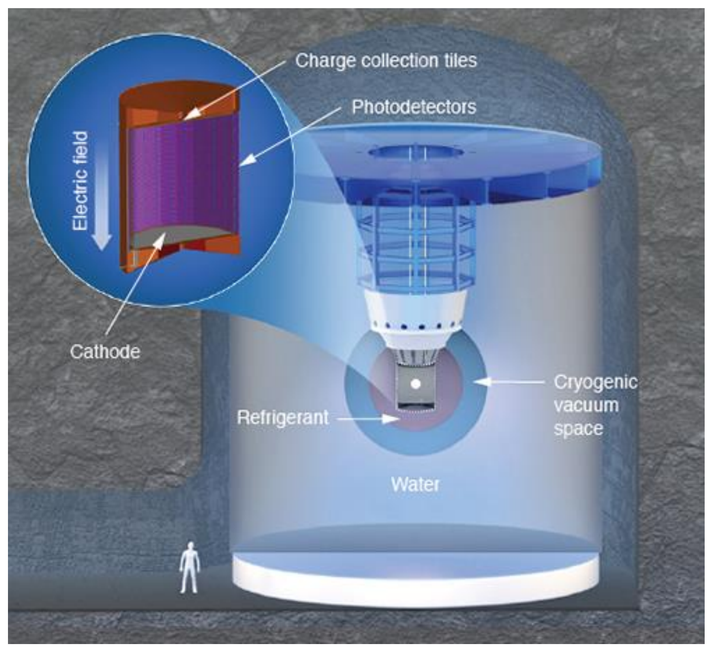
EXO-200

- Time-projection chamber (TPC) filled with ~175kg of pure liquid xenon with ~80% ^{136}Xe.
- Located at the WIPP mine in New Mexico, USA.
- First experiment to observe $2\nu\beta\beta$ decay in ^{136}Xe and measured its half-life to be 2.2×10^{21} years[7].
- Set lower limit on the $0\nu\beta\beta$ decay half life to 1.8×10^{25} years at the 90% C.L[8]. The universe is 1.4×10^{10} years old for comparison[9].



nEXO

- TPC with 5 tonnes of liquid xenon enriched at 90% in ^{136}Xe.
- Anticipated to be in SNOLAB; Ontario, Canada, 2 km under ground[10].
- Liquid Xe TPC surrounded by an outer water shield that doubles as a muon veto detector.
- nEXO seeks to meet a target sensitivity of 10^{28} years for the half-life of the $0\nu\beta\beta$[11].



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References

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