Measuring and Understanding Coherent Neutrino Scattering

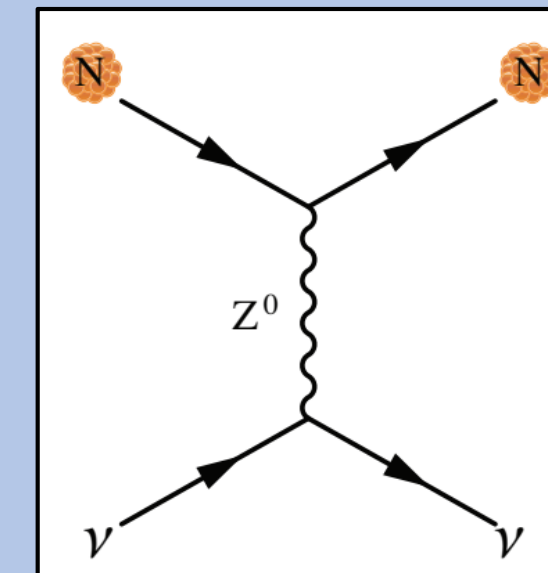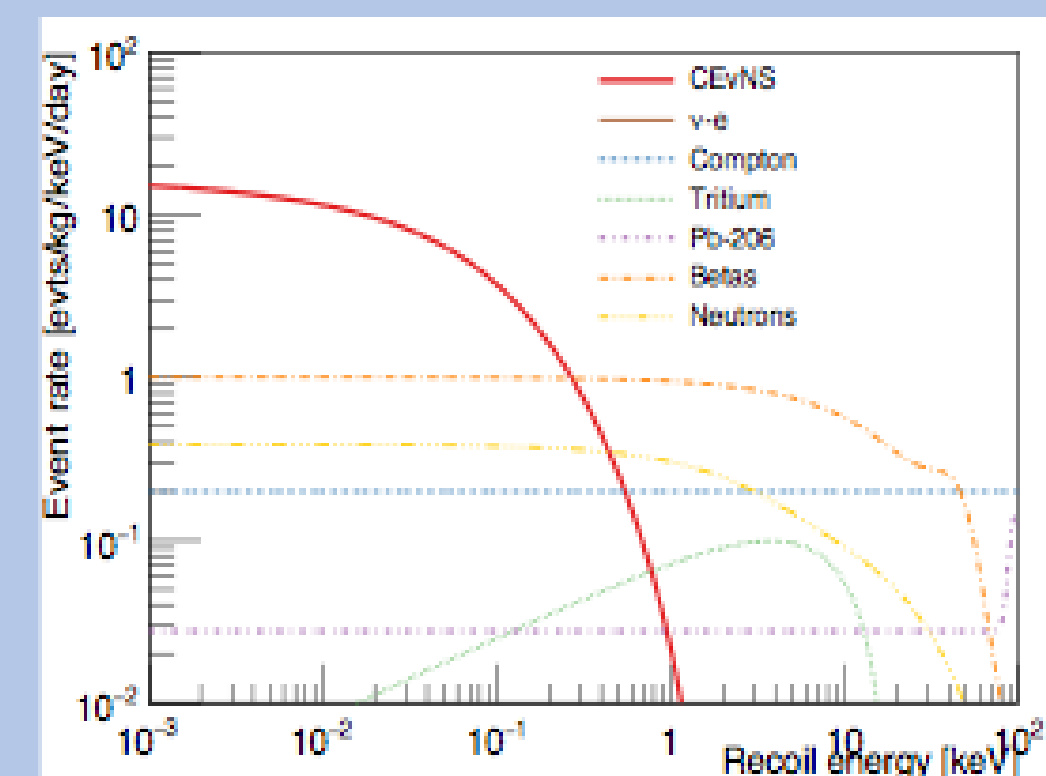S. Branson, K. Palladino, C. Hasselkus

Background
What is coherent neutrino scattering?

- Neutrino enters and collides with a neutron
- Elastic collision, energy is conserved with no loss
- Both neutrino and neutron are scattered
- Detector senses the recoil, gives a readout
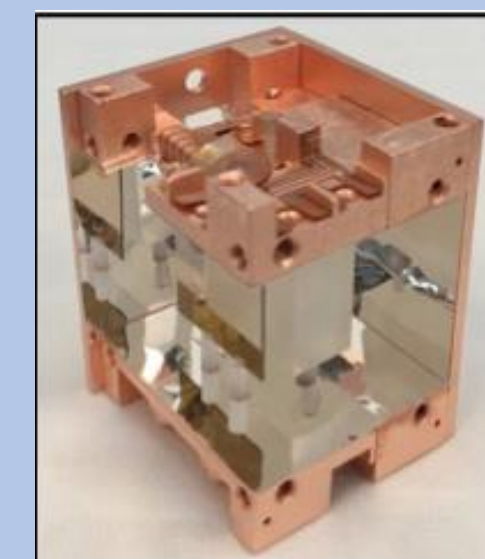- Happens for all flavors of neutrinos

What does the detector look like?

- Next to a nuclear reactor (M.I.T. then CHOOZ)
- Proximity allows a high flux of neutrinos to come through
- Creates early universe like conditions
- Could cause a high neutron background
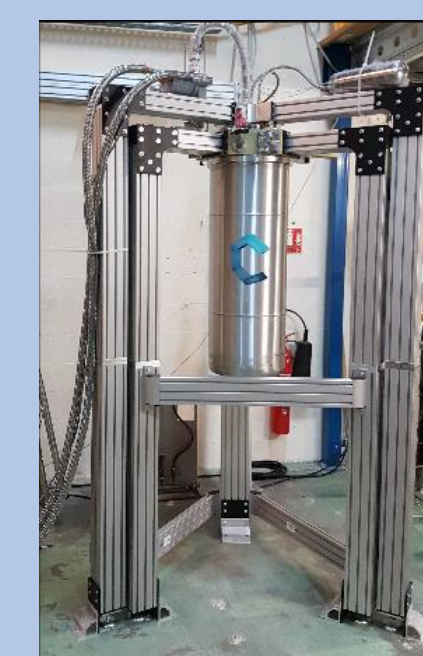
Germanium NDT readout (EDELWEISS)
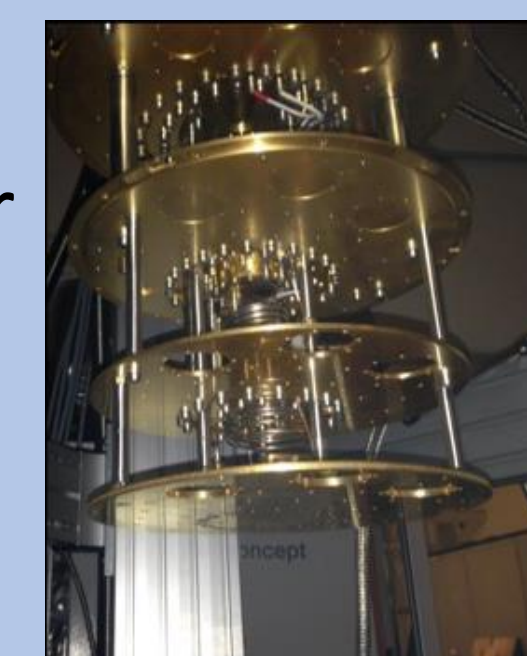
CaWO4 (CRESST) TES-SQUID readout

Zn TES-SQUID readout

Zn crystals grown by RMD in Massachusetts

Diultion Refrigerator called Desperaux, commissioned at M.I.T.

- 8.54 GW combined power
- both reactors on 60% of the time
- 8 x 1010 ν /cm2/s
- CHOOZ near detector site 355 m and 469 m from the reactors
- overburden 140 m.w.e.
- No reactor neutron backgrounds
- Infrastructure in place for experiments
- Schedule aims for 2019

Importance of Simulations

- Have an understanding of what kind of problems we will run into
- Can work to understand signal before everything is implemented
- Understand background that comes from the decector
- Try to solve problems before they arise

Abstract
Ricochet is a detector searching for coherent neutrino scattering. It will be placed next to a nuclear reactor at M.I.T. The purpose is to detect coherent neutrino scattering, as well as better understand it, as coherent neutrino scattering has many practical applications for research in many fields, such as finding a better understanding of supernova physics, searching for sterile neutrinos, understanding nuclear form factors at low Q^2 and understanding nuclear proliferation monitoring. Coherent neutrino scattering has only just been measured for the first time, and continued measurement can bring along a greater understanding of the physics of neutrinos.

Ricochet's Strengths

- Colliaboration on the intereanional level gives experience from a wide range of experiments and specialities
- Reduction of backgrounds (Goal: 1.5 events/kg/day)
- Multiple targets/technologies
- CHOOZ site has overburden and water tank shielding, and no reactor operation correlated neutrons
- Pushing detector technology to low thresholds (<100 eV) nuclear recoil, such low thresholds can help with dark matter detection efforts

Backgrounds

External
- Primary concern is cosmogenic neutrons
- Normalized to the Double CHOOZ measure of ~3.4 per day
- Upper limit of 1 per day, but with additional borated poly shielding, we expect this to come < .1 per day

Internal
- EDELWEISS-III backgrounds are applied to Ricochet
- This will require radon-free air and copper etching
- Red: gammas with cosmogenic activation lines, tritium beta decay
- Blue: 210Pb betas (with uncertainty in extrapolation to low energies)
- Green: 206Pb nuclear recoils
- Not considered: cosmic activation of 65Zn
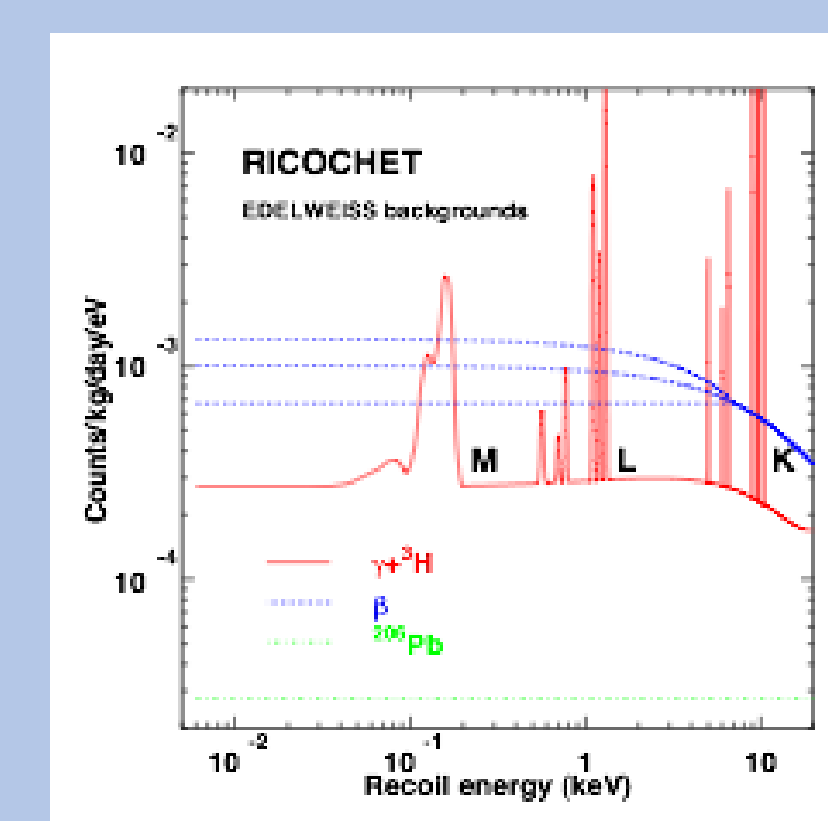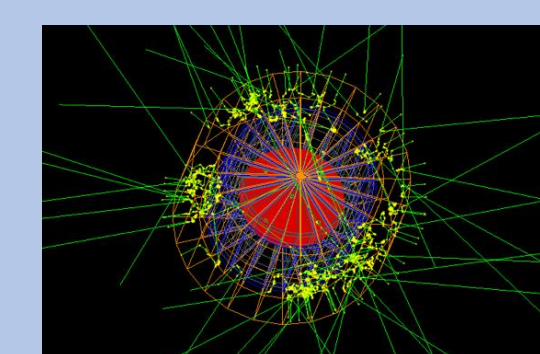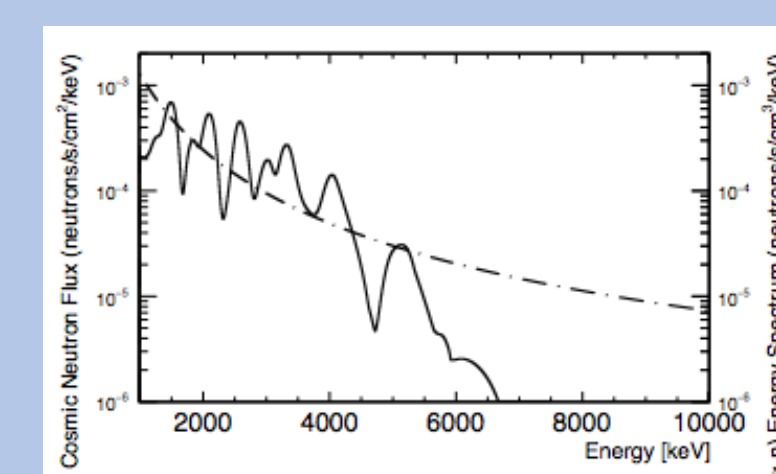
What I do
ChoozSimulation

- Detector has yet to be built in its final state
- ChoozSimulation is a program written by Alex Leder (M.I.T.)
- Simulated the detector
- I installed and built it and the various components requited to run ChoozSimulation

Refrigerator Geometry

- Changing ADR (Adiabatic Demagnetization Refrigerator) to Dilution Refrigerator "Despereaux"
- Rewriting the geometry, including a visualization tool that we hope to get working on our servers
- Despereaux is currently at M.I.T., undergoing hardware updates and fixes
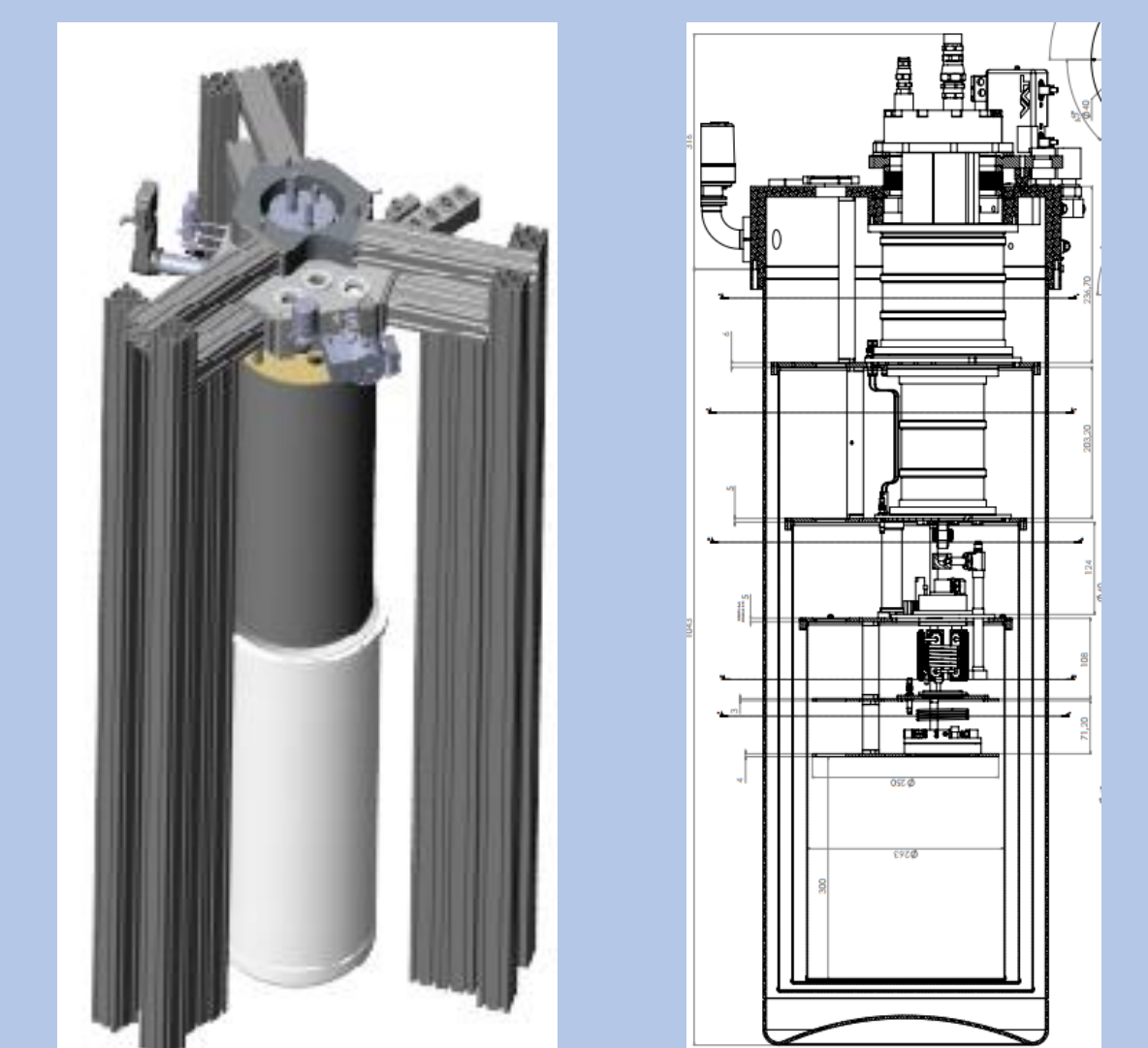
What is Next?

- Hardware updates
  - Northwestern designing and fabricating TES chips
  - Zn crystals grown at M.I.T.
  - Zn crystals being grown in France
  - Bringing Despereaux into commission
- Testing at M.I.T.
- Moving detector to France and be in operation in 2019

Citations

Akimov, D., et al. "Observation of Coherent Elastic Neutrino-Nucleus Scattering." *Science*, 3 Aug. 2017, doi:10.1126/science.aao0990.
Double ChoozDtection paper
Ricochet paper 1
Ricochet Paper 2
Ricochet Paper 3