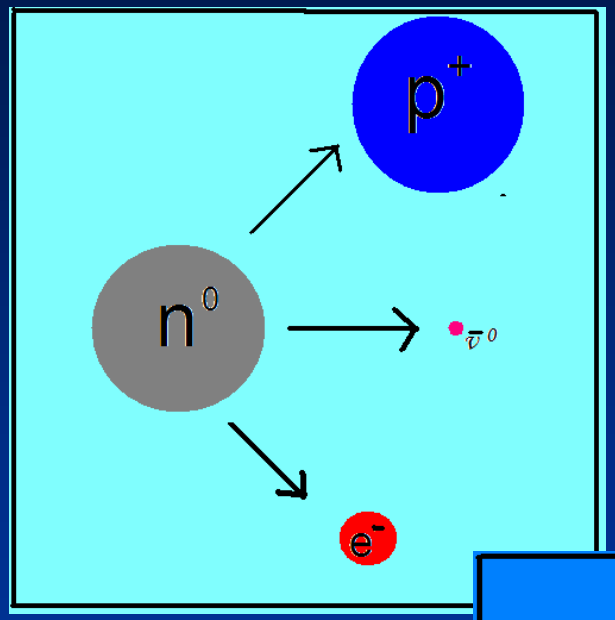
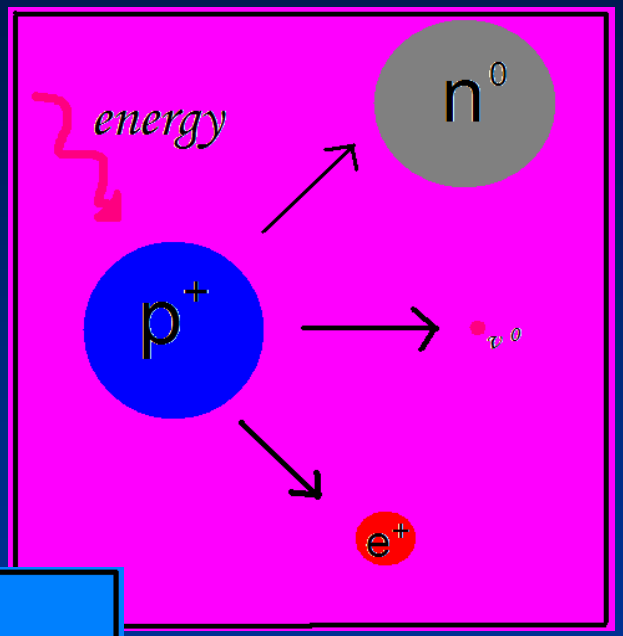
Neutrinos and Neutral Current Detectors

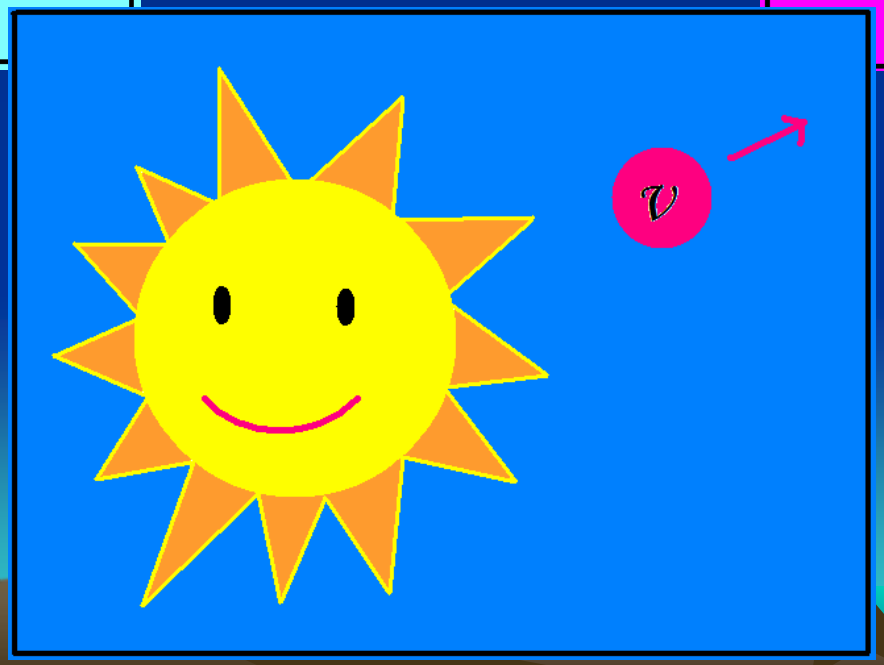
Jennie Ryu

Pre-REU



1. Beta plus decay
2. Beta minus decay
3. Produced in sun





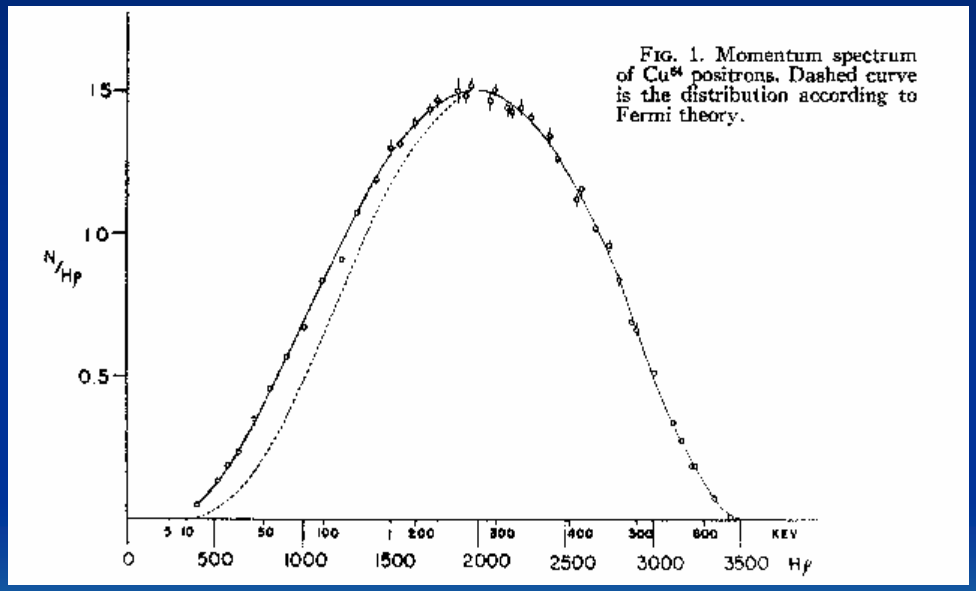
- Neutrinos
- SNO and its 3 phases
- NCDs and Results

Neutrinos

- What indicated the presence of neutrinos?
- What are neutrinos?
- What makes them so interesting to study?
- Why are they important?

What indicated the presence of neutrinos?

- conservation laws!



* graph taken from C. Sharp Cook and Lawrence M. Langer, Phys. Rev. 73, 601 - 607 (1948)

What are neutrinos?

- very light, neutral elementary particles that travel close to the speed of light
- weakly interacting particles that are byproducts of beta-decay

What makes them so interesting to study?

- weak interactions make them difficult to detect
- maximally violate parity
- only known particle that could be a candidate for dark matter

What makes them so important?

- 2nd most numerous particle in the universe
- travel virtually unhindered through space
- disagree with standard model design

Sudbury Neutrino Observatory

Objectives:

- To measure flux, energy, and direction of solar neutrinos
- To show that the discrepancies between solar model and experimental results were due to neutrino oscillations in a more reliable manner

SNO Setup

- Extremely pure heavy water (D_2O) contained in acrylic sphere all enclosed in sphere of extremely pure light water (H_2O)

*Photo courtesy of SNO

http://www.sno.phy.queensu.ca/sno/images/publicity_photos/index.html

PMTs

- 9457 photomultiplier tubes
- PMTs are sensitive light detectors that can detect single photons and convert them into pulses

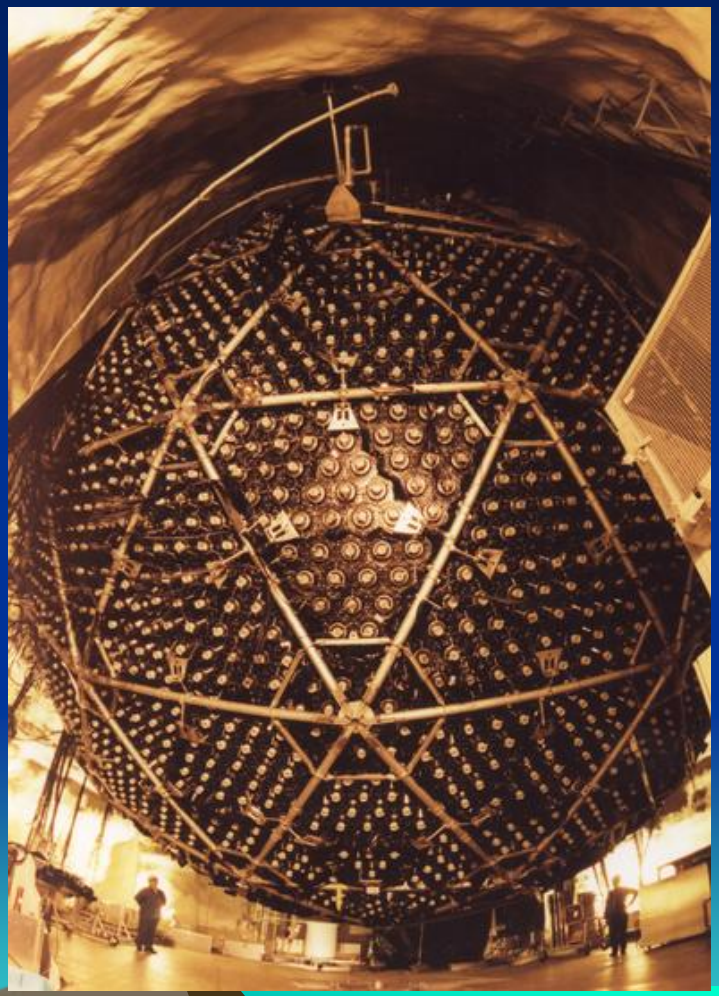


*Photo courtesy of Ernest Orlando Lawrence Berkeley National Laboratory

Neutrino Reactions

1. Elastic Scattering

sensitive to all neutrinos but dominated by electron flavor

2. Charged Current Reaction

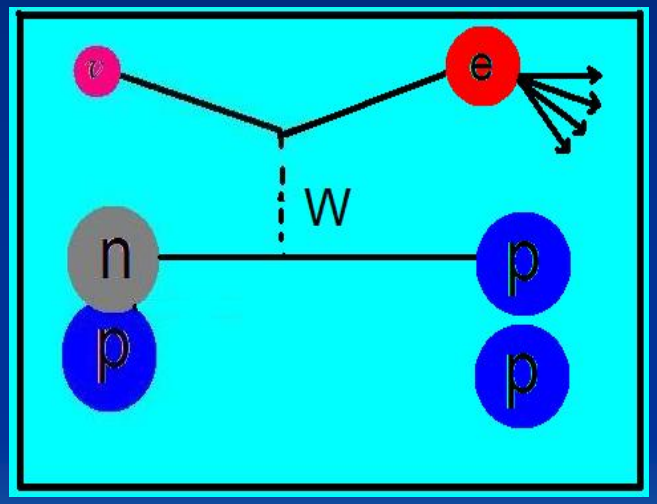
specific to electron neutrinos

3. Neutral Current Reaction

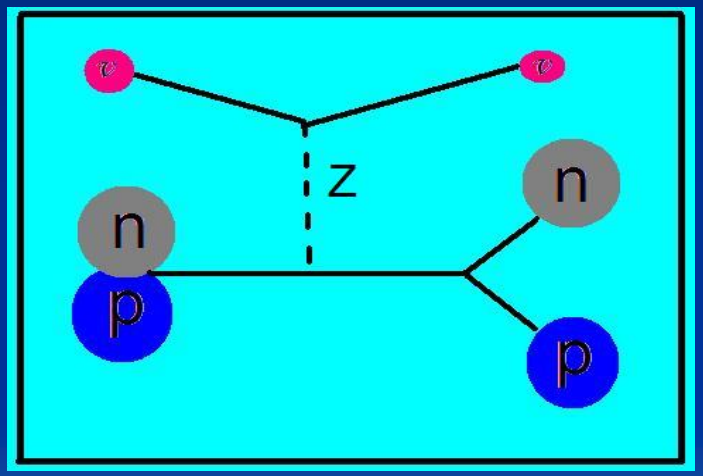
equally sensitive to all neutrino flavors

D_2O

Charged Current
(electron neutrinos)



Neutral Current
(all neutrino types)



Three Phases of SNO

1. Pure D_2O

used photomultiplier tubes to detect all three reactions

2. NaCl added

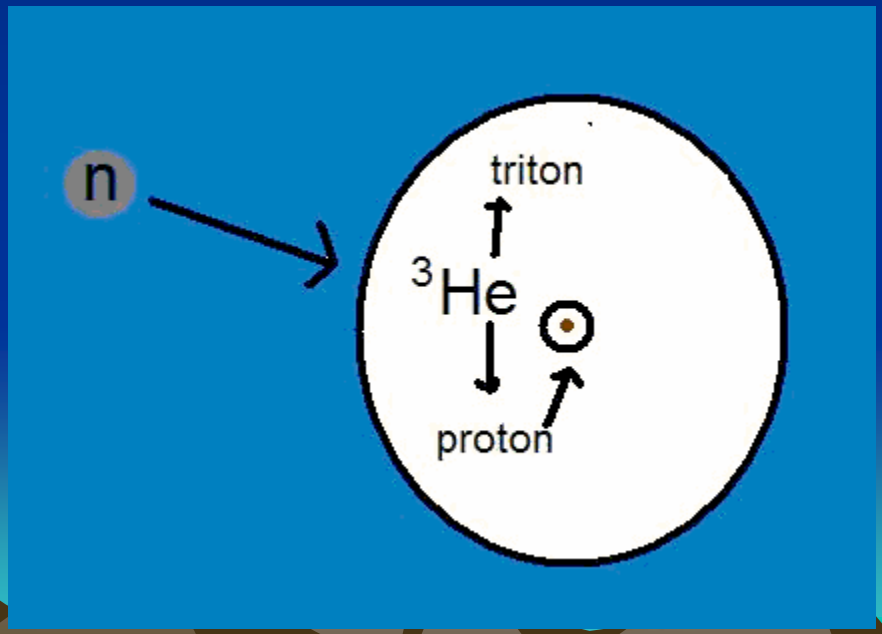
used higher cross section of chlorine to absorb neutrons

3. Neutral Current Detectors

separated detection of neutrons and electrons

Neutral Current Detectors

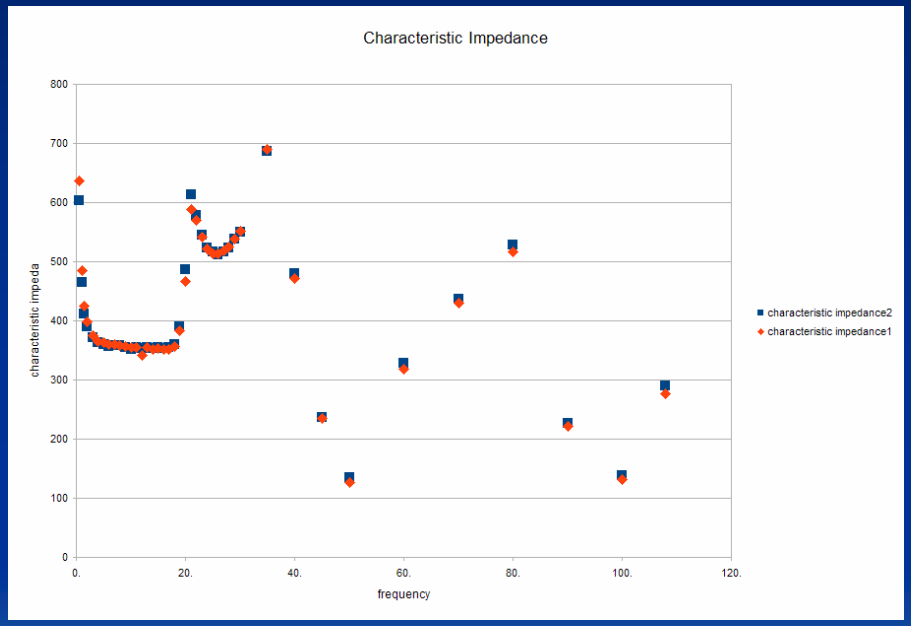
- Helium-3 proportional counters
- high neutron capture cross section

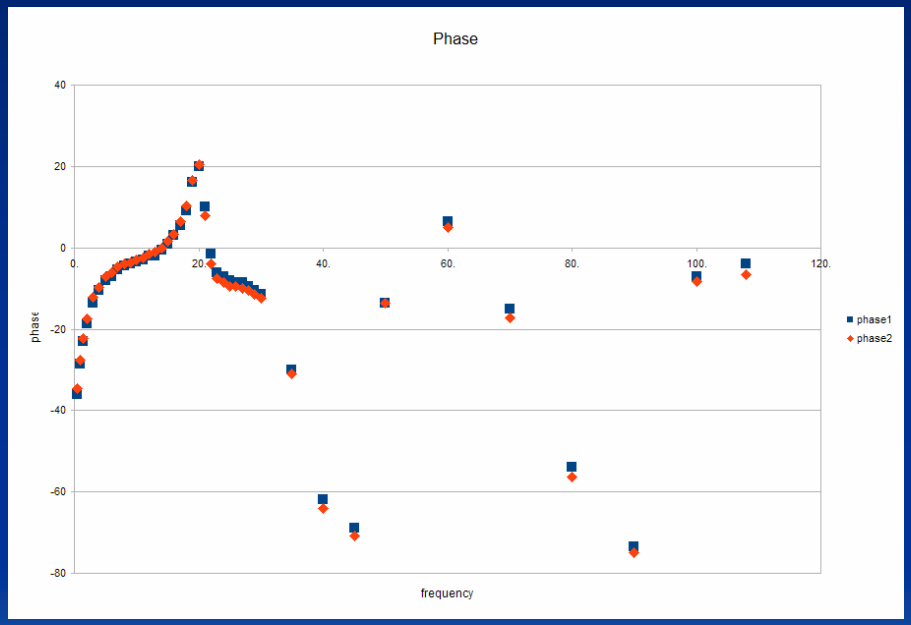


Problems with NCDs

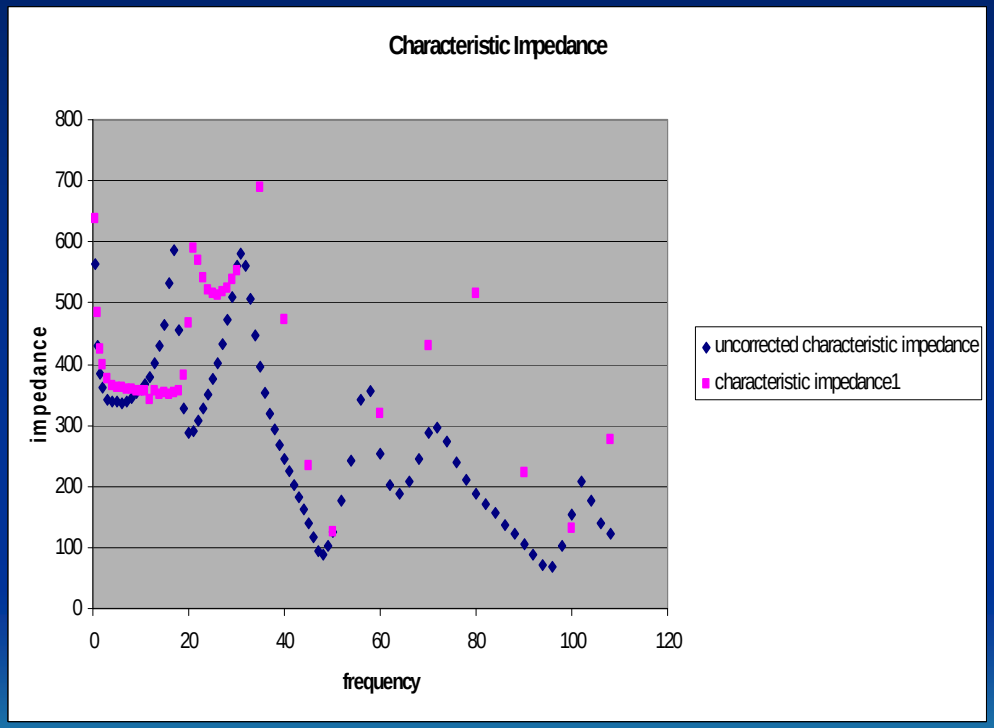
- alpha particles
- ferromagnetic material
- frequency dependent transmission line properties(?)

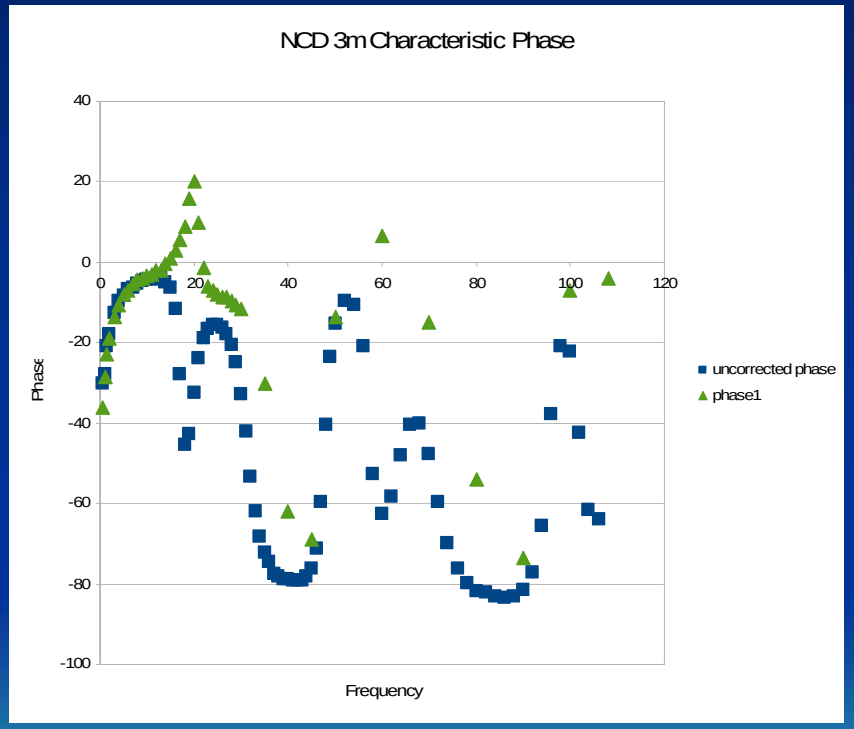
Raw Data Graphs



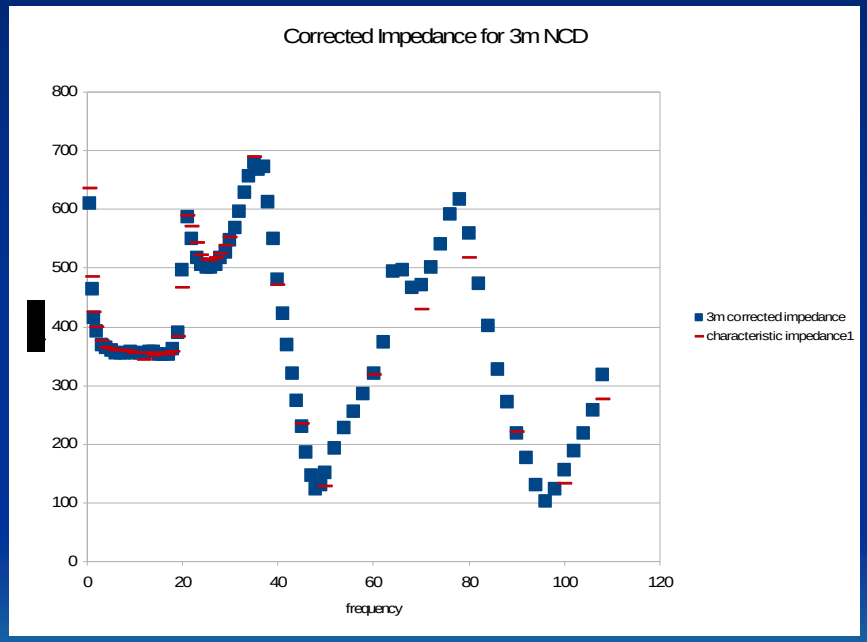


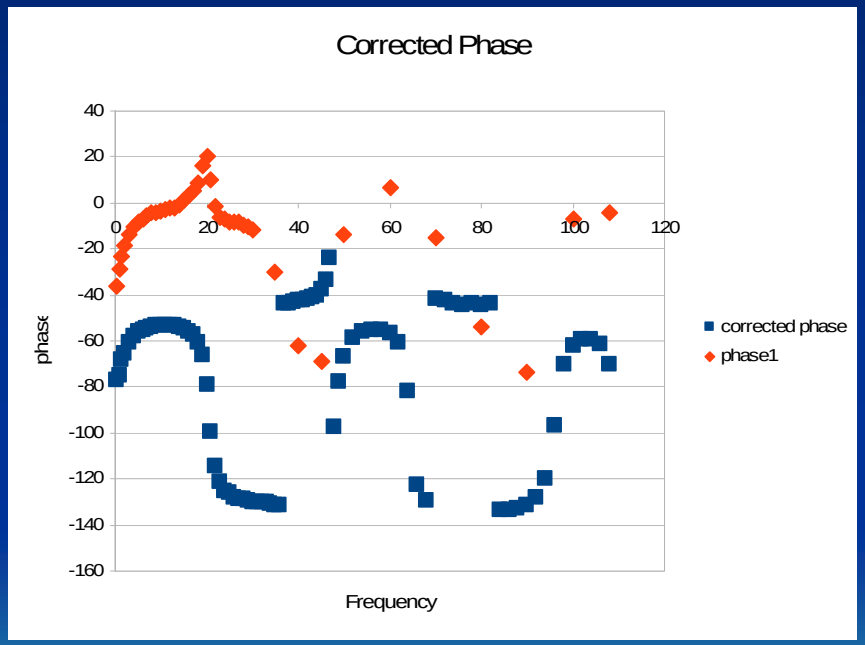
New Setup


Characteristic Impedance
impedance
frequency
uncorrected characteristic impedance
characteristic impedance1

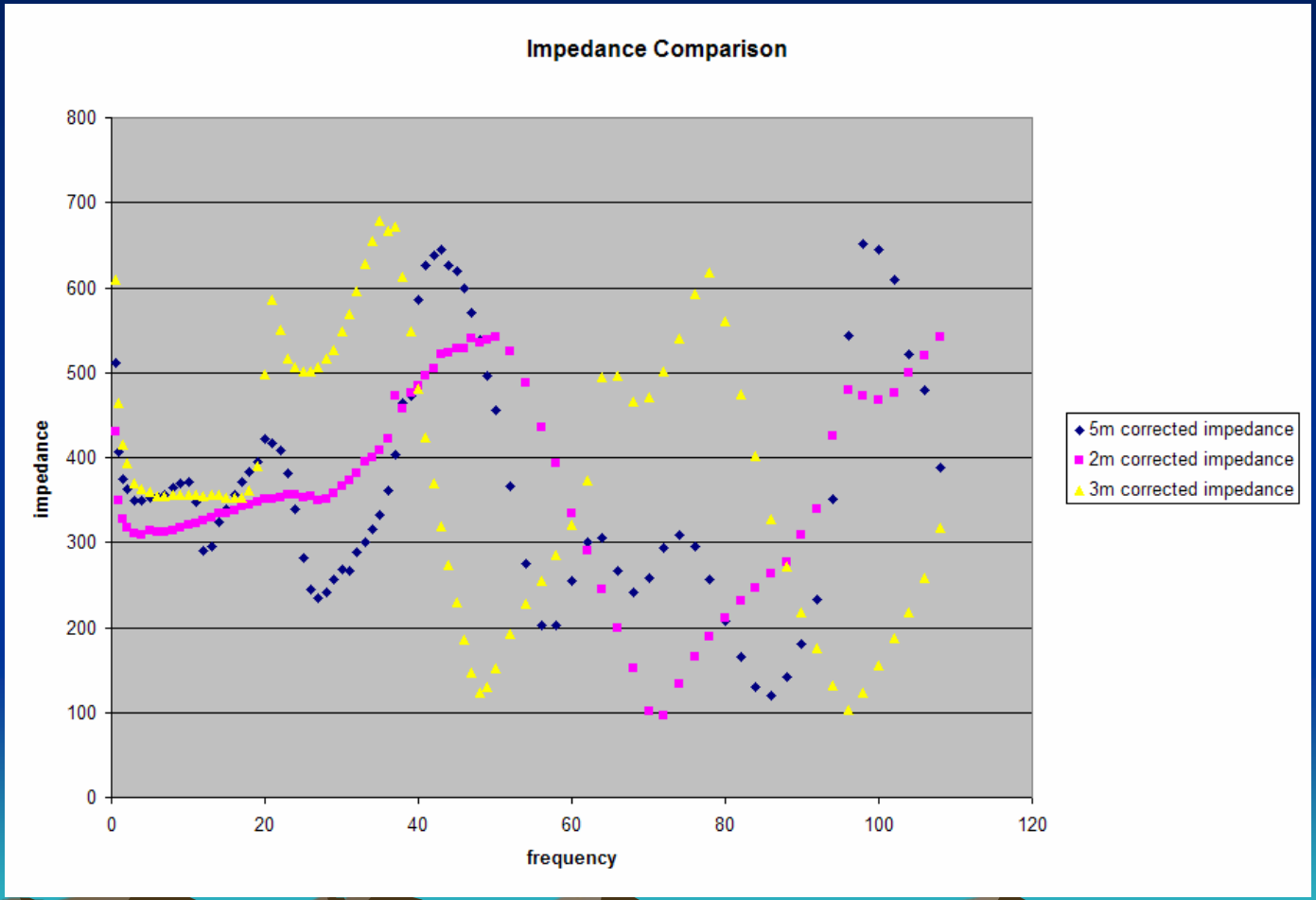

NCD 3m Characteristic Phase
Frequency
uncorrected phase
phase1

open/short correction for 3m NCD

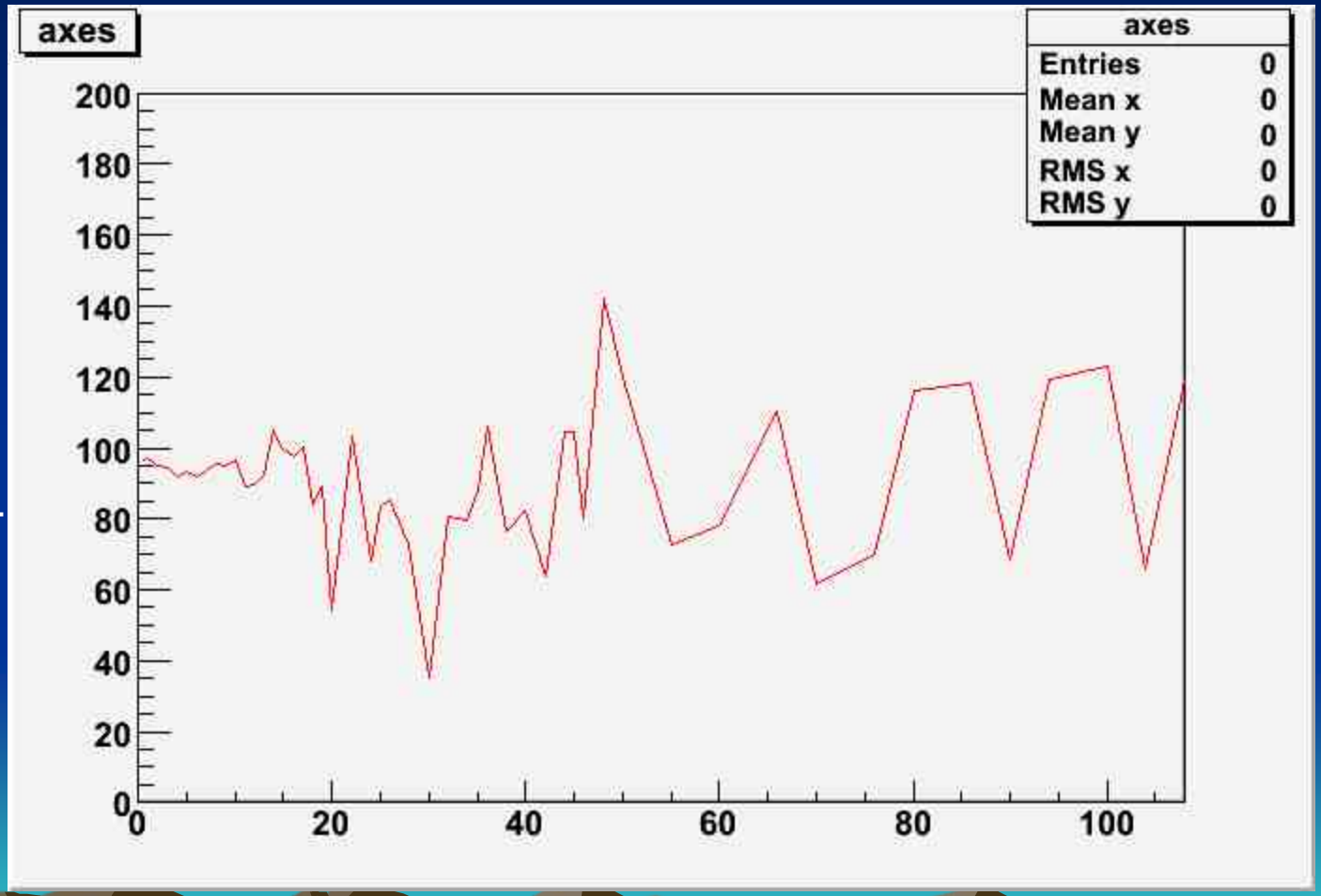




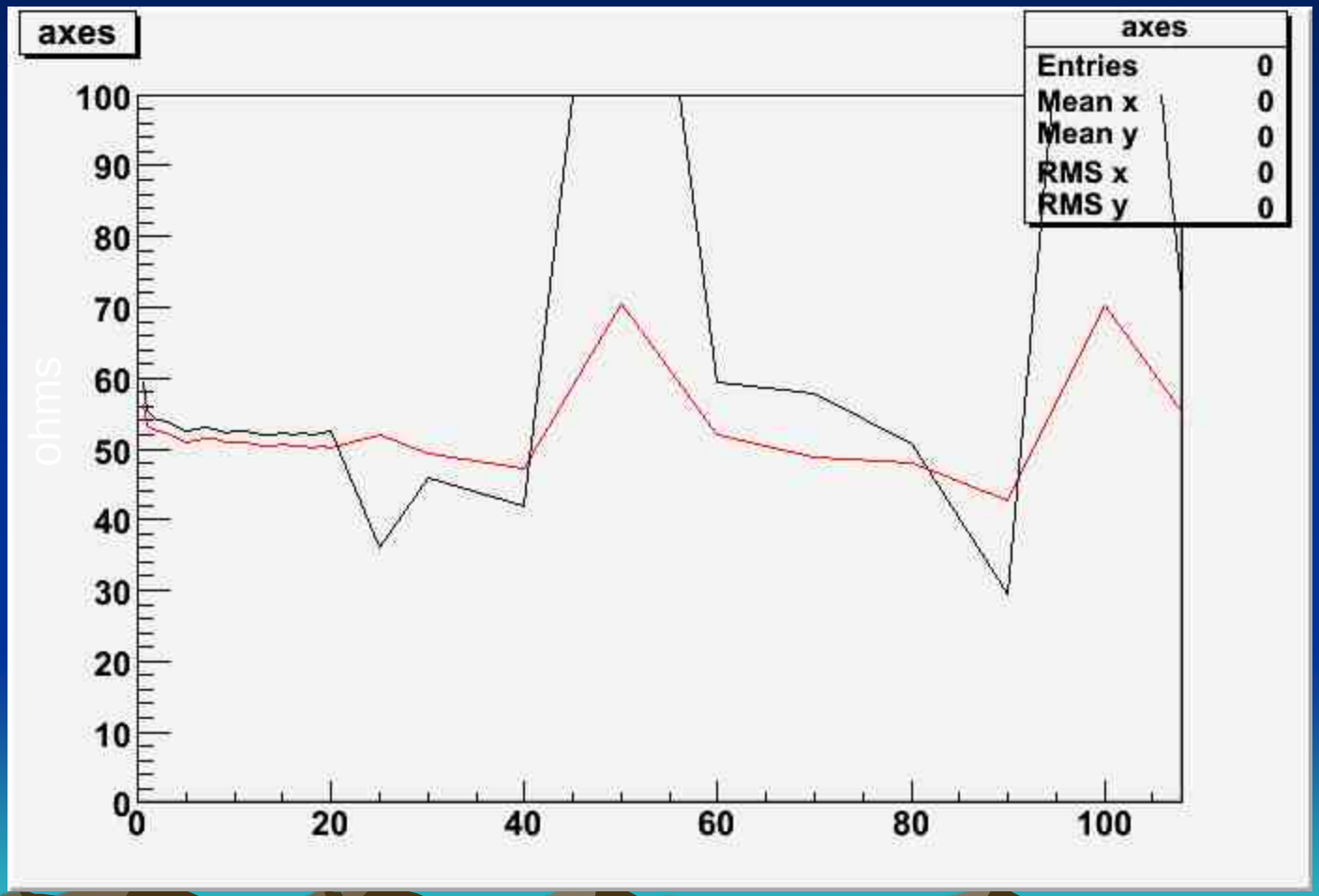
Comparing Impedance Values



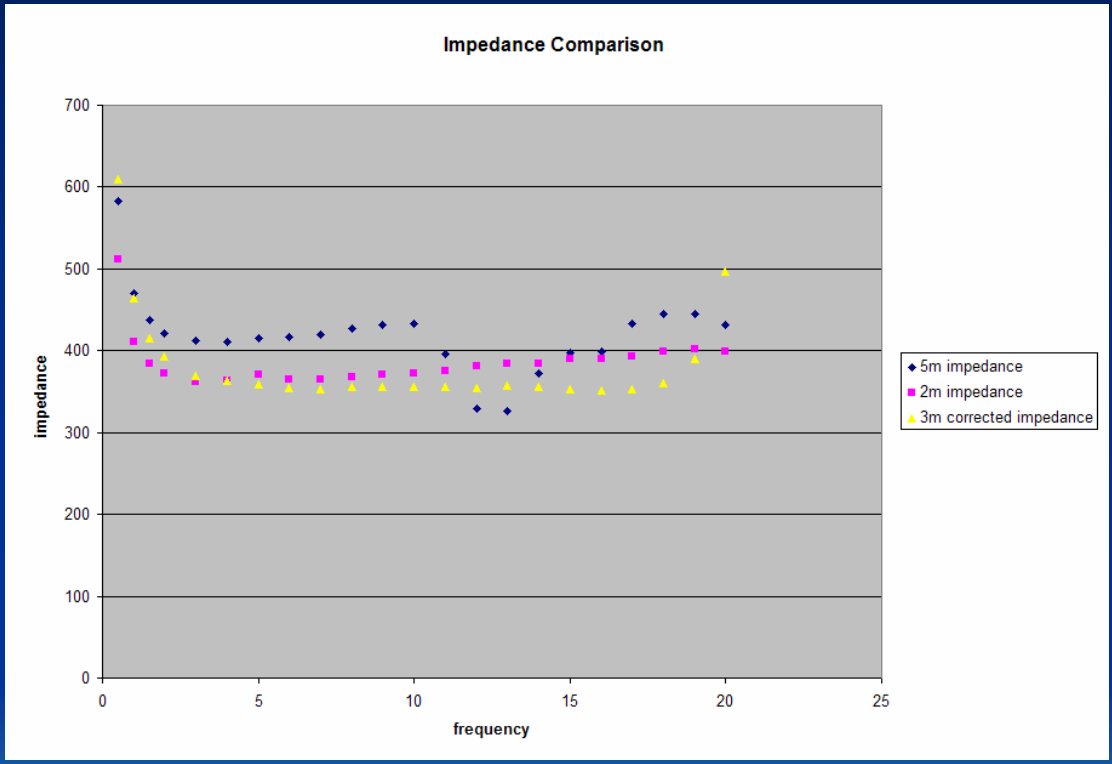
Impedance of Connecting Cable



Testing the Correction



Final Comparison



Conclusions

- Data indicate the impedance of the NCDs are not constant with frequency.
- We think the irregularity in the graphs suggest the corrections are only helpful for a specific range of frequencies.
- Overall, I found the data to be inconclusive about the actual impedance of the NCDs.


the end of sno.