Status of the ZEPLIN II Detector

Edward Daw, University of Sheffield

On Behalf of the Zeplin II Collaboration...

Imperial College, London (ICL)

University of Sheffield

CCLRC (Rutherford Appleton Lab.)

University of Edinburgh

ITEP, Moscow

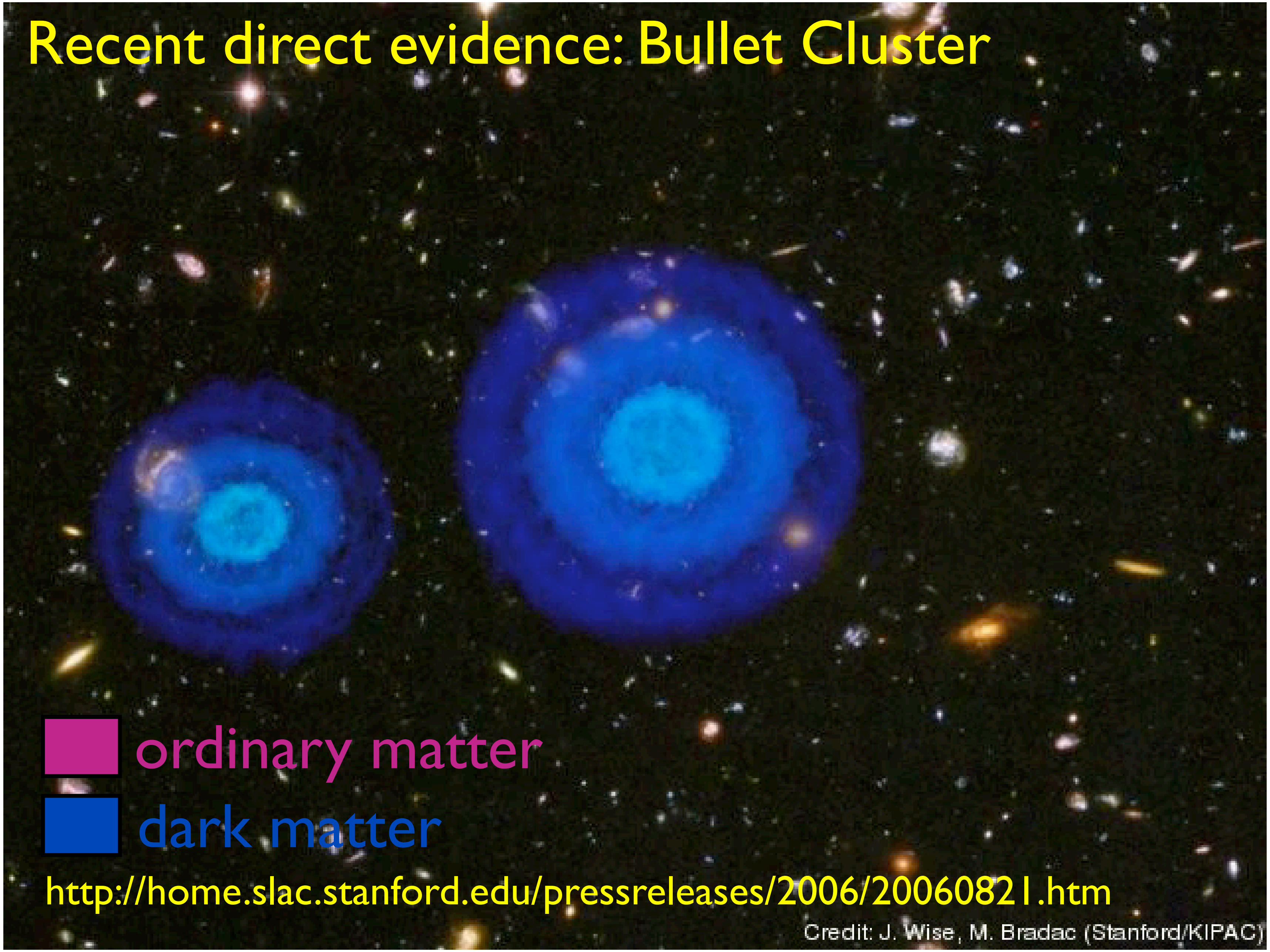
University of California Los Angeles (UCLA)

Texas A&M

University of Rochester

LIP-Coimbra, Portugal

Dark Matter makes up: 95% of galaxies
25% of the observable universe.



Dark Matter Candidates

Lots of different ones, but 2 major classes, WIMP-like particles and axion-like particles

AXIONs

Mass in the range $1\ \mu\mathrm{eV} - 1\ \mathrm{meV}$

Number density at Earth's galactic position ~ 10^{17} per litre

WIMPs

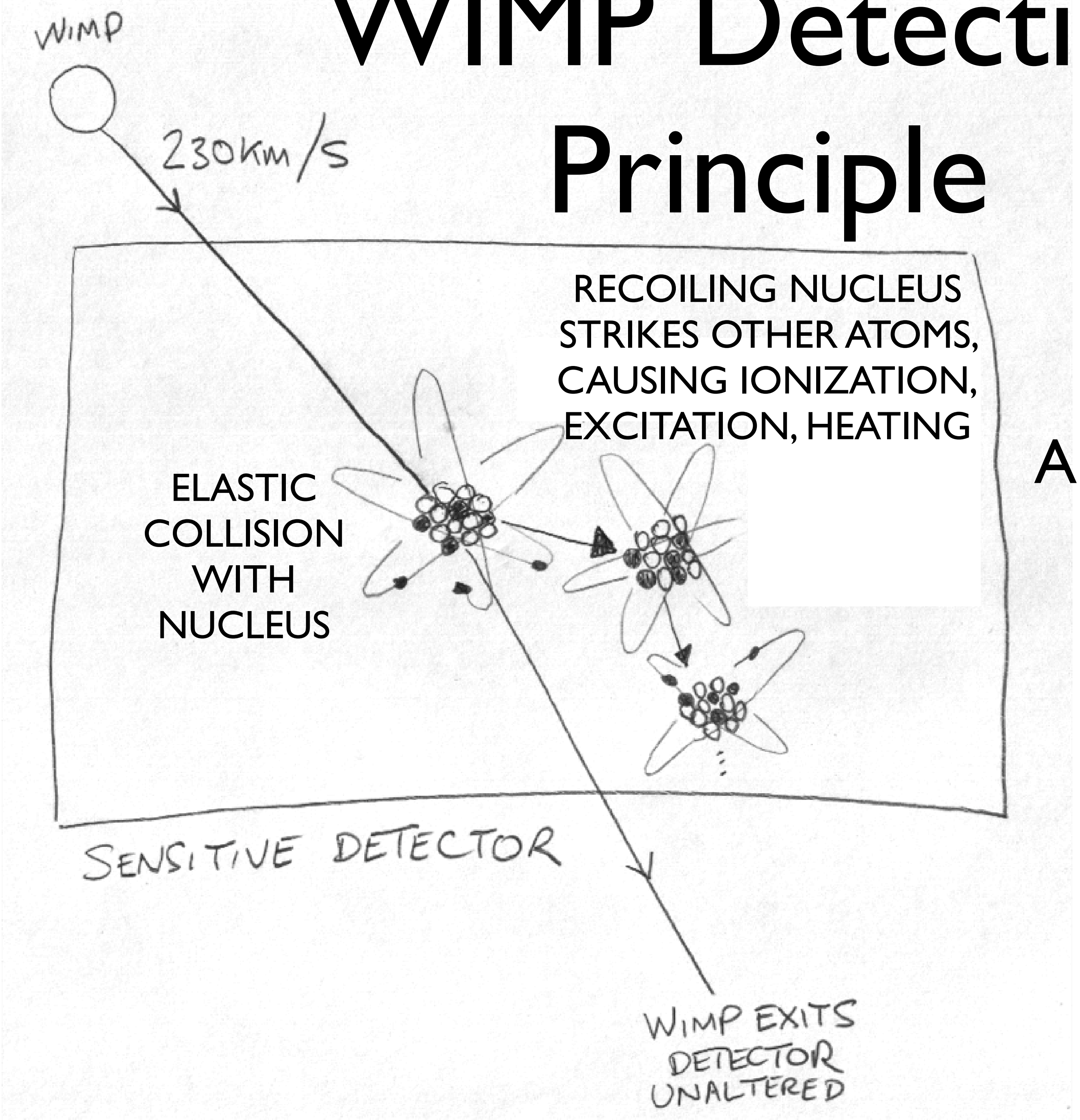
Mass in the range 10-1000 GeV

Number density at Earth's galactic position, ~tens per litre.

Popular candidate, as supersymmetric WIMP discovery would confirm supersymmetric extensions to standard model as well as identifying dark matter.

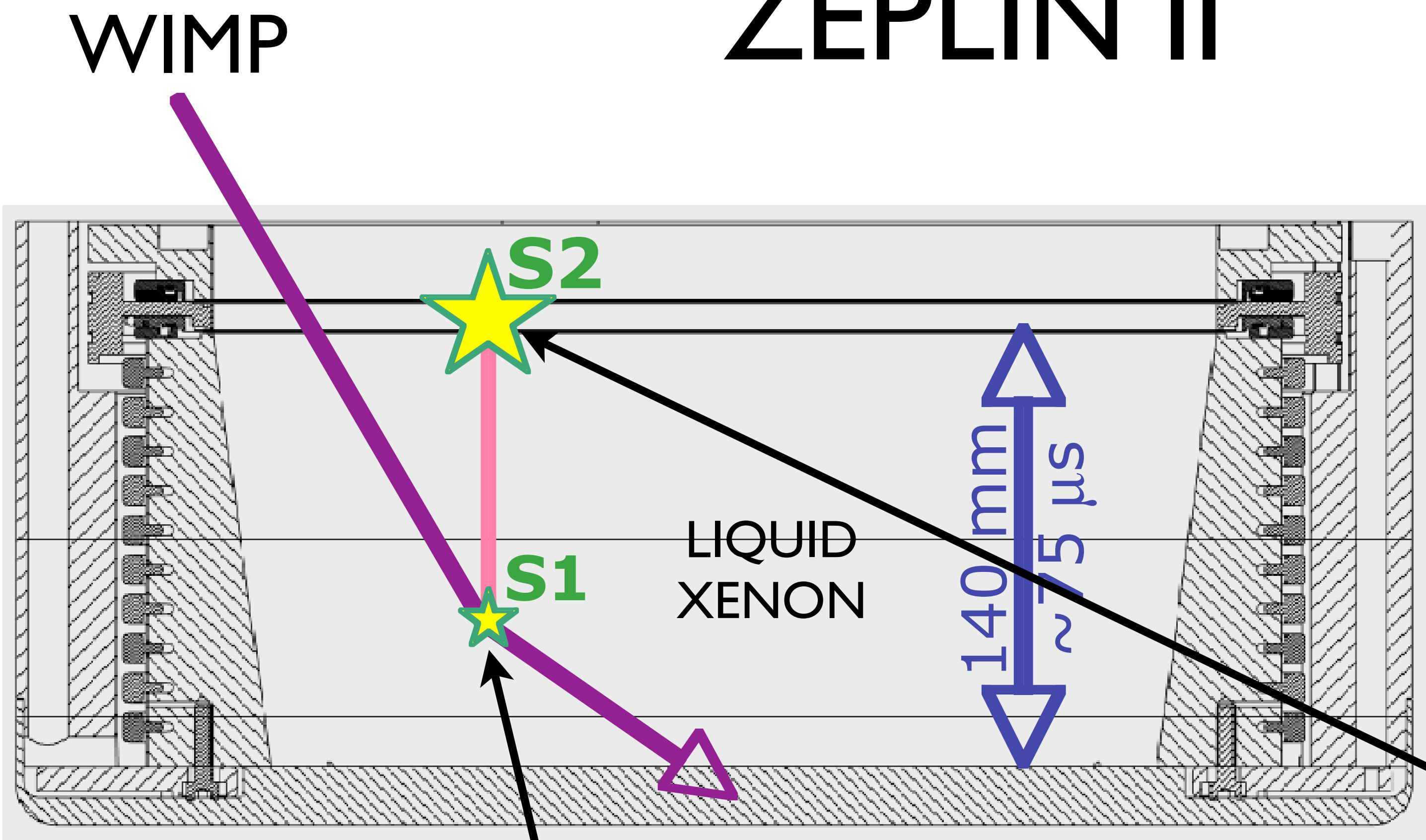
ZEPLIN II LOOKS FOR WIMPS IN OUR GALACTIC HALO

WIMP Detection Principle



Analogy - multi-car pile up!

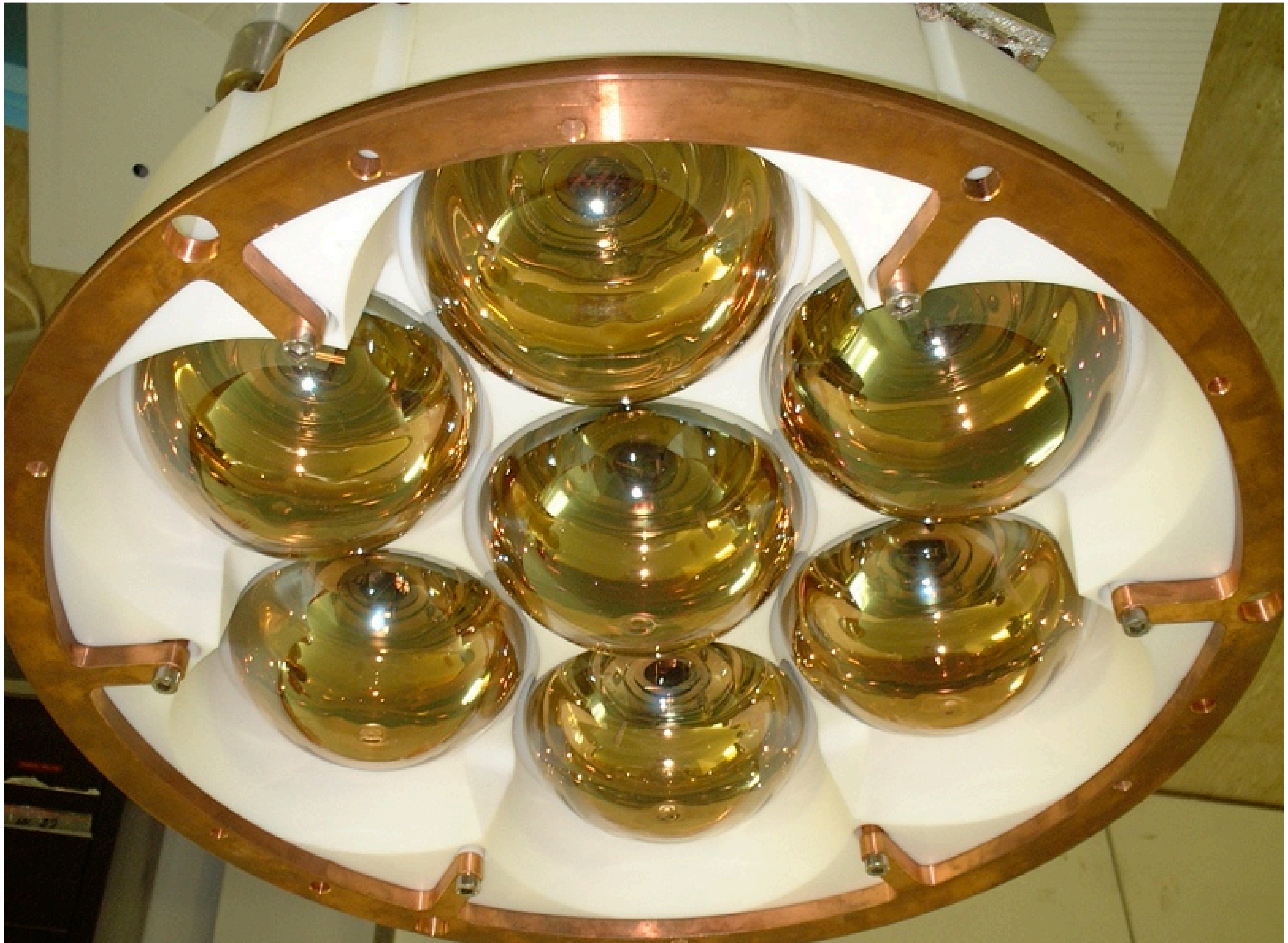
Detecting Nuclear Recoils in ZEPLIN II



WIMP-nucleus elastic collision
Recoil causes excitation of
Xe atoms into Xe_2^* dimers.
Decay back to 2Xe leads to
primary ultraviolet light pulse.

Electrons
leaving the
liquid lead to
electroluminescence,
a second flash
of ultraviolet light.

Photomultiplier Tubes



Electron Tubes D742QKFL, 5 inch.

Potential Backgrounds I

Gamma rays
from detector, surroundings

Interact with electrons in the xenon, so the recoil is of an electron, which has lower ionization density along track than a recoiling nucleus.
Use ratio of scintillation to electro-luminescence yields (S2/S1) to discriminate between electron and nuclear recoils.

Neutrons
from detector, surroundings, cosmic ray muon showers

Cause nuclear recoils, just like WIMPs.
Reject if they scatter in the veto, or if there are multiple target scatters. Minimize with hydrocarbon shielding, underground operation, low activity detector components.

Potential Backgrounds II

Alphas

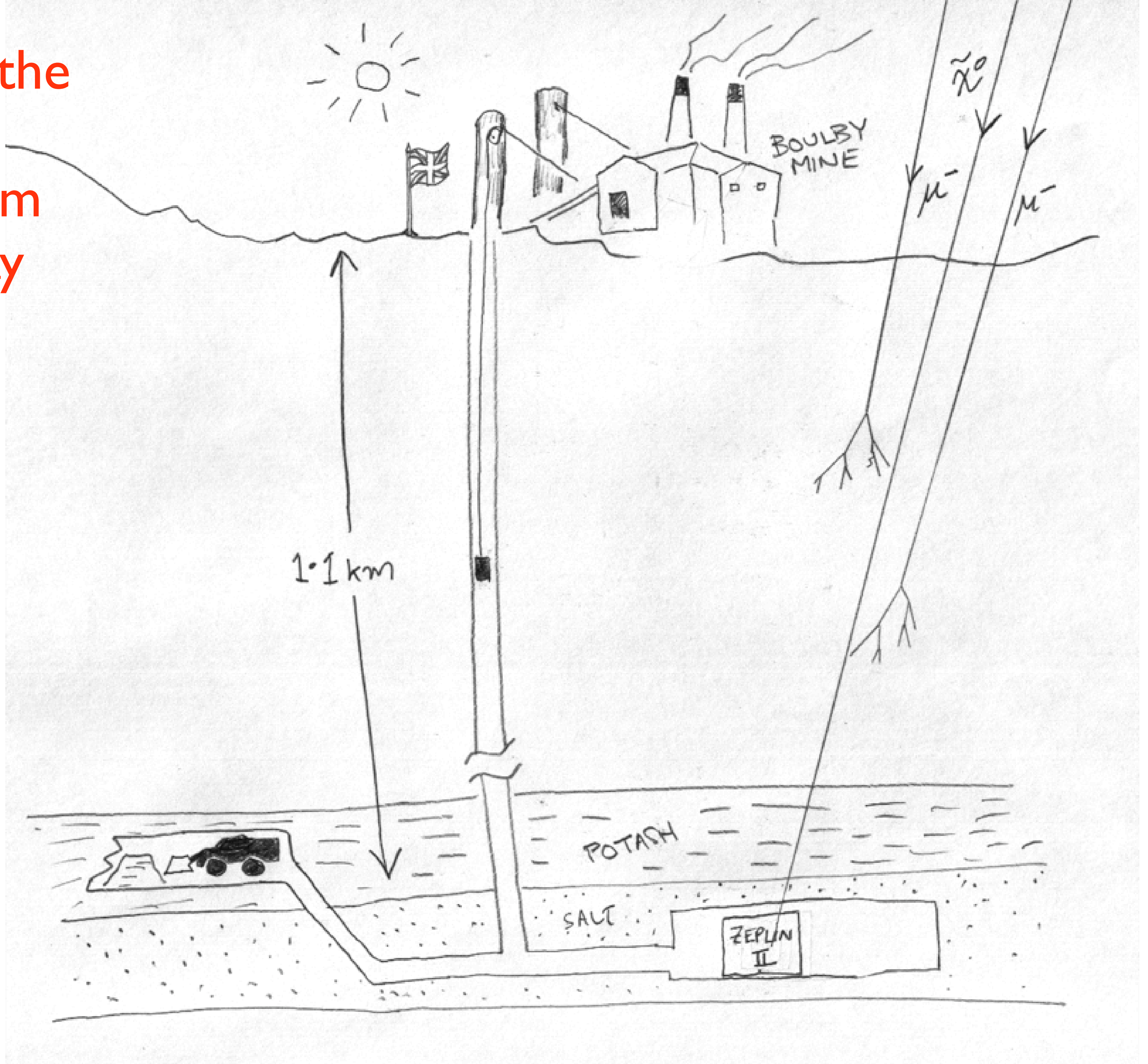
from detector, surroundings, U/Th chain isotopes.

Interact with electrons and nuclei. Typically a few MeV, so discriminate by cutting events whose energy deposition is too high. Ionization density along track high, leading to characteristic pulse lifetime of 22ns.

Nuclear Recoils

Alphas from contaminants that have plated out on detector surfaces may be lost in the wall, and the decaying nucleus may recoil into the xenon. Since this is a nuclear recoil, mimics WIMP signal. Avoid plate-out of impurities, minimize surface areas in contact with target volume.

Shielding the xenon target from cosmic ray muons



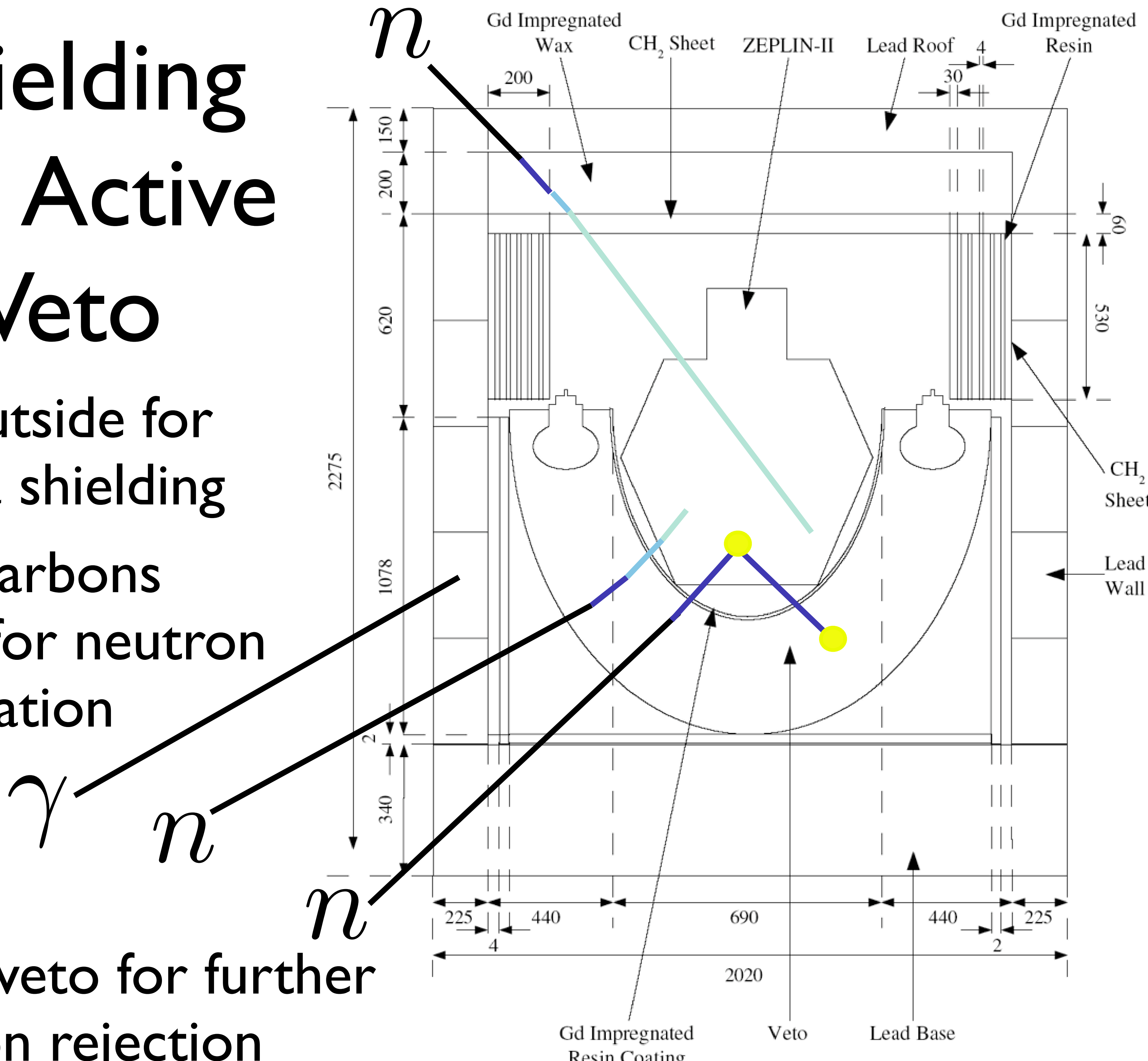
ZEPLIN II in Boulby JIF area

Shielding and Active Veto

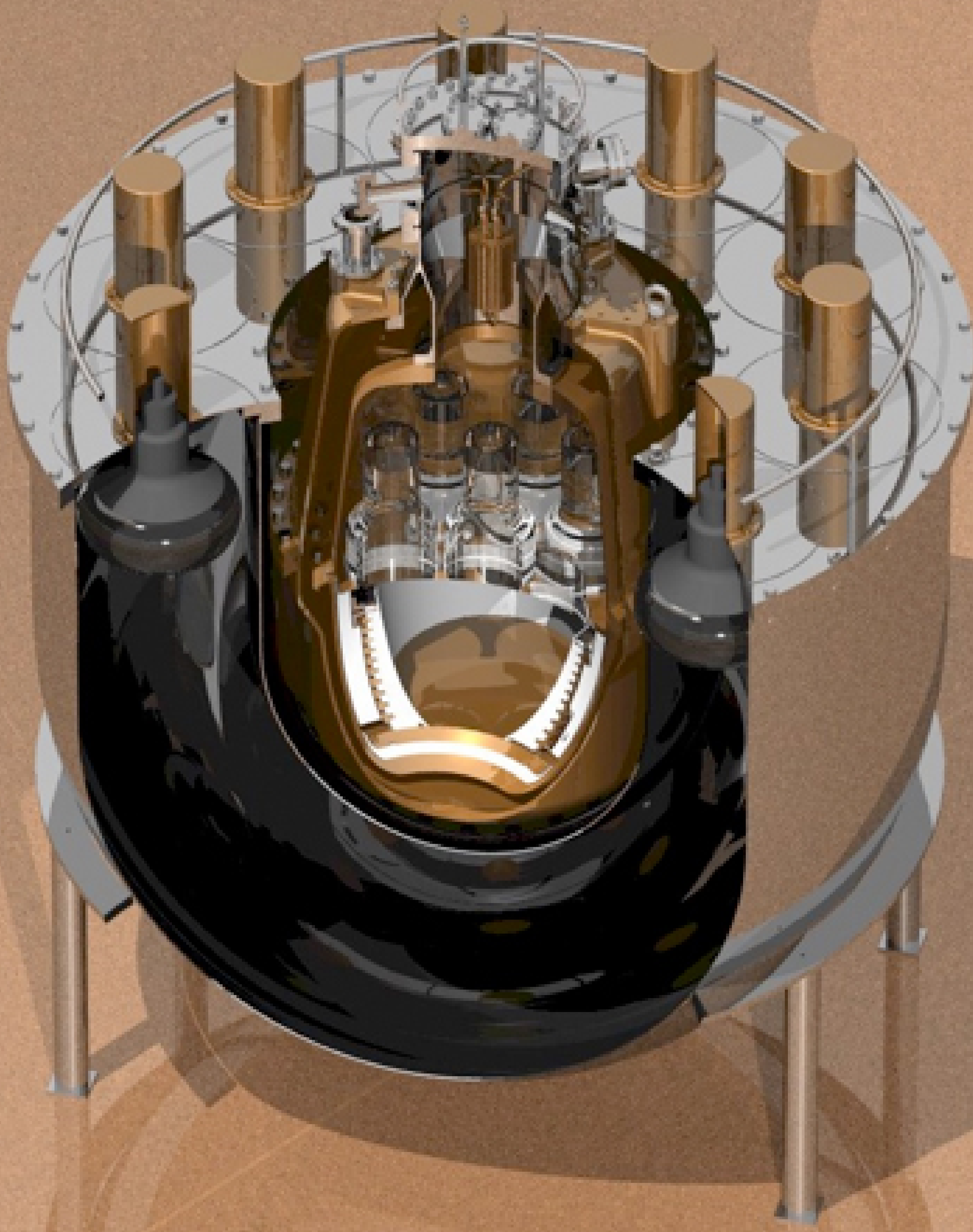
lead outside for gamma shielding

hydrocarbons inside for neutron moderation

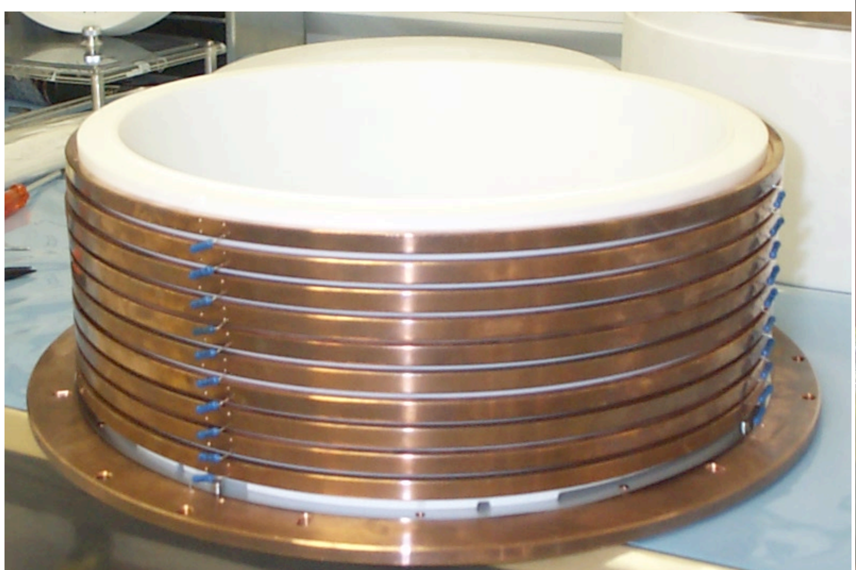
active veto for further neutron rejection



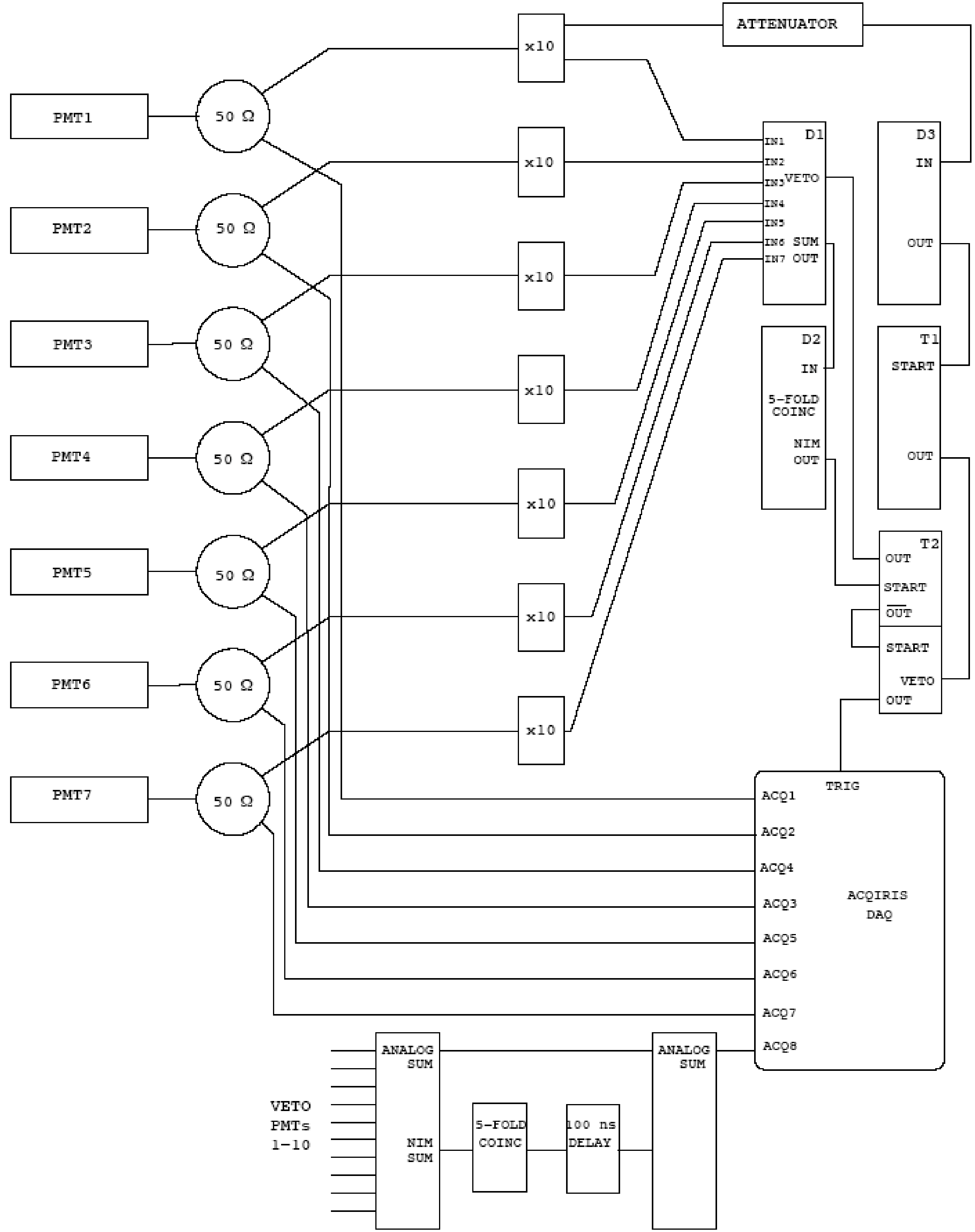
Xenon Target in Veto



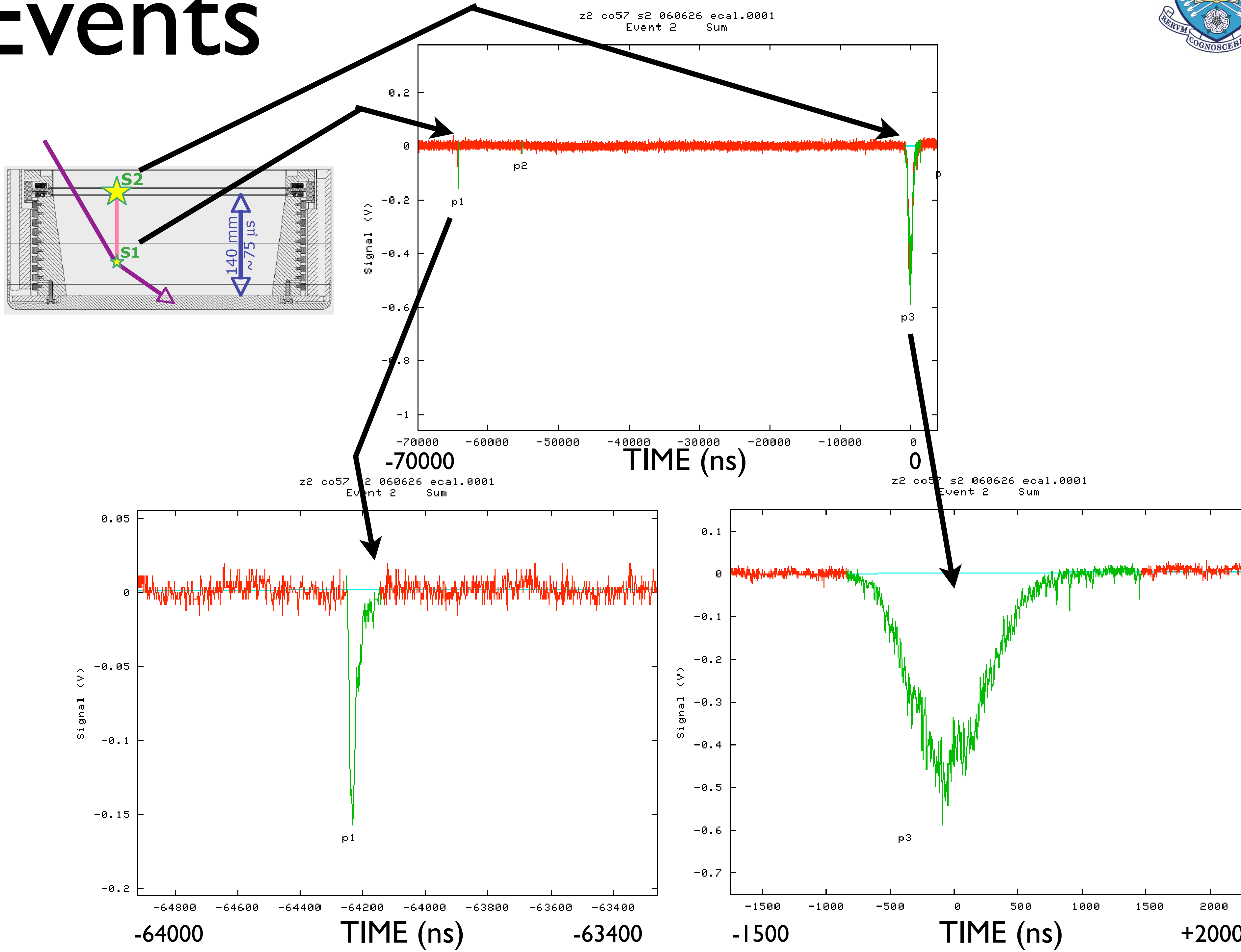
Some Detector Components



Readout Electronics

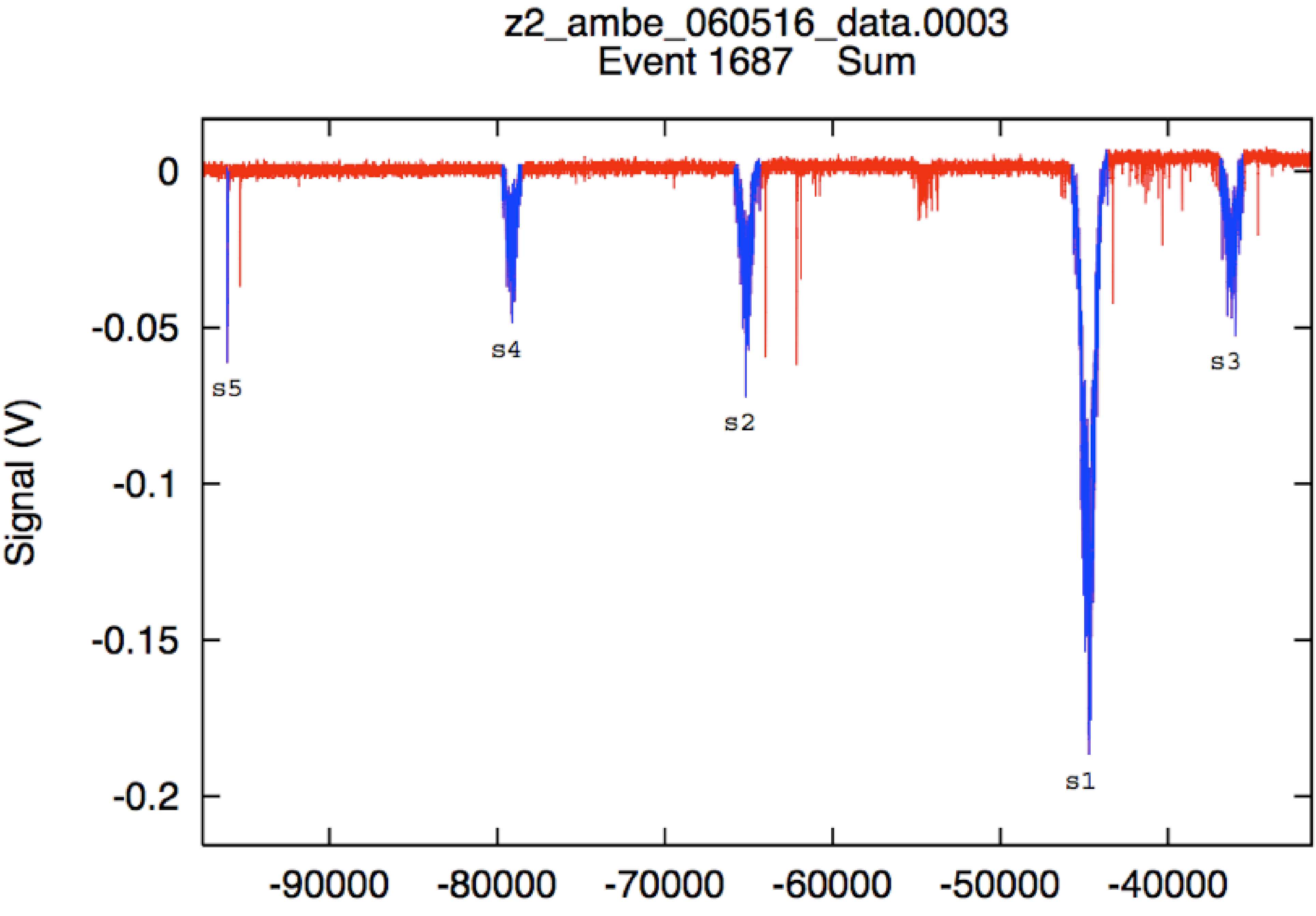


Events



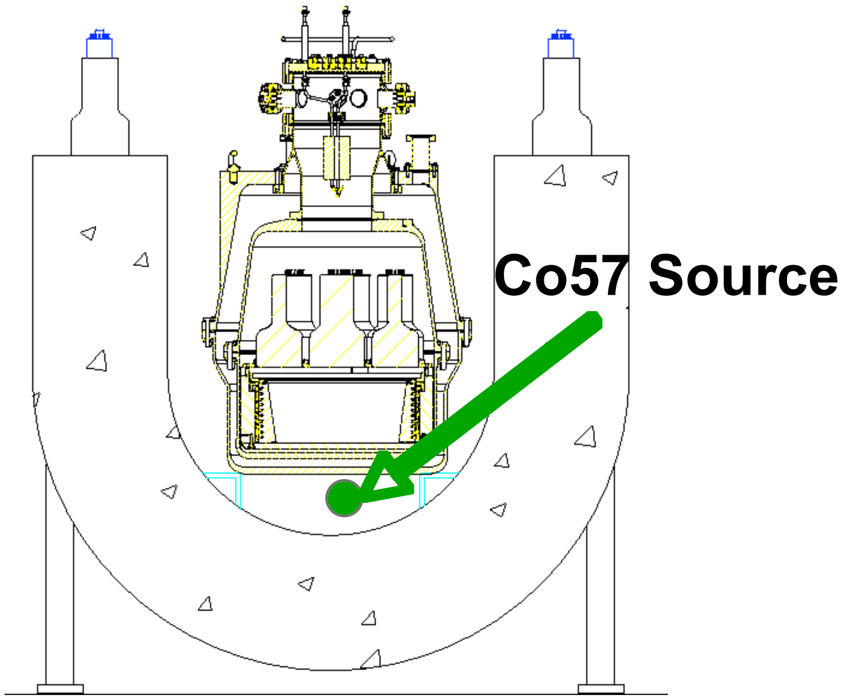
S2
S1
140 mm
~75 µs
z2 co57 s2 060626 ecal.0001
Event 2 Sum
Signal (V)
p1
p2
p3
-70000
0
TIME (ns)
z2 co57 s2 060626 ecal.0001
Event 2 Sum
-64000
TIME (ns)
-63400
z2 co57 s2 060626 ecal.0001
Event 2 Sum
-1500
TIME (ns)
+2000

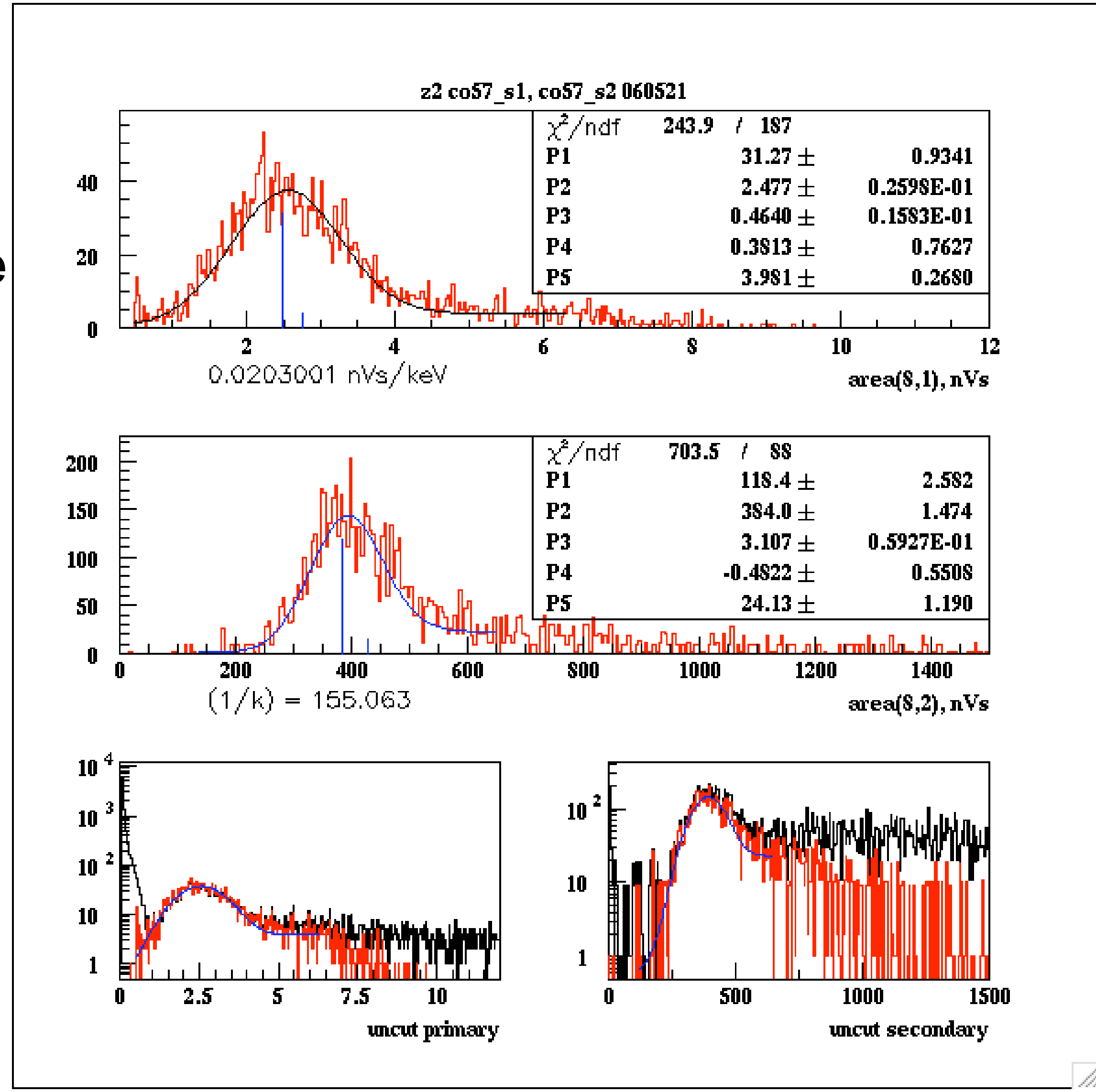
A Multiple Scatter Event



Energy Calibration

Calibrate with a ^{57}Co source, 122keV and 136keV gammas





Event Selection Cuts

All selected events must have a single identifiable secondary preceded by a single identifiable primary.

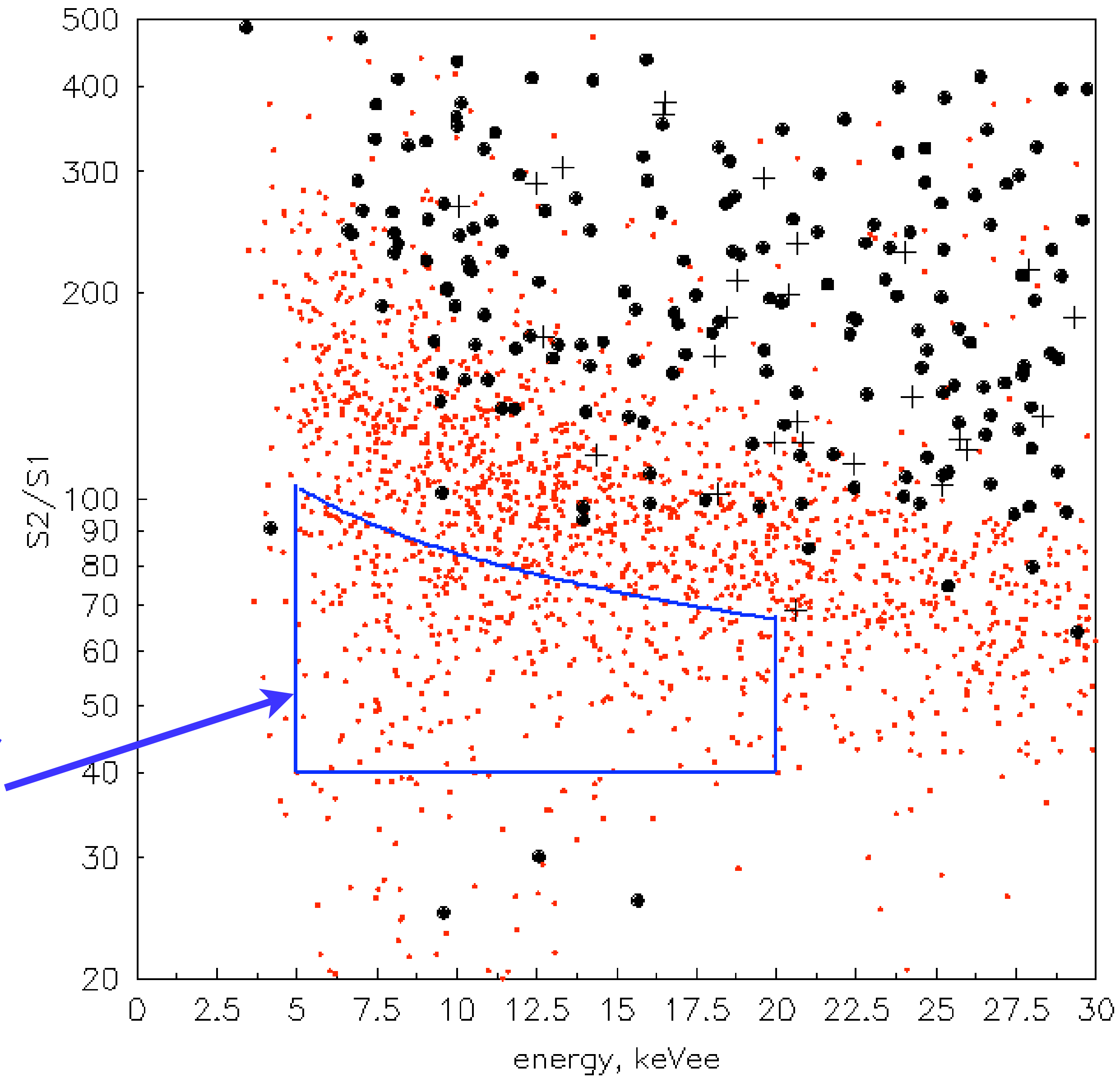
Secondaries : 5-fold PMT coincidence (hardware trigger), time duration cut, minimum area cut

Primaries : 3-fold PMT coincidence (software cut). time duration cut, cut on time window for single PMT signals.

Fiducial cut rejects events from bottom 12mm of the target and outer 3/7 of target radius, restricting active volume to 7kg.

Events that also trigger the veto are rejected. This has a measured efficiency of 49% on neutron events in the target.

Analysis of 10% of Run 1.



Box contains 25% of neutron (nuclear recoil) events from our AmBe (nuclear recoil) run, and no events from the background run.

Current Status

Data from the remaining 90% of run 1 is under examination.

Underground running will next focus on taking ^{60}Co data with higher statistics.

Whether to immediately start run 2, or to perform a hardware access will depend on the results of the analysis currently underway.

Publications based on our recent data run are in preparation.