Overview

I have run and collected data from simulations in liquid argon with shifted triplet and singlet lifetimes, with the contamination profile below. The next slide has the shifted lifetimes as a function of any N or O contamination.

The profile is given in ppm.

No email updates from MiniCLEAN, but they are setting up and preparing for the new wave of argon flow.

NProfile = {0, 0.01, 0.05, 0.1, 1, 5, 10, 20, 50};

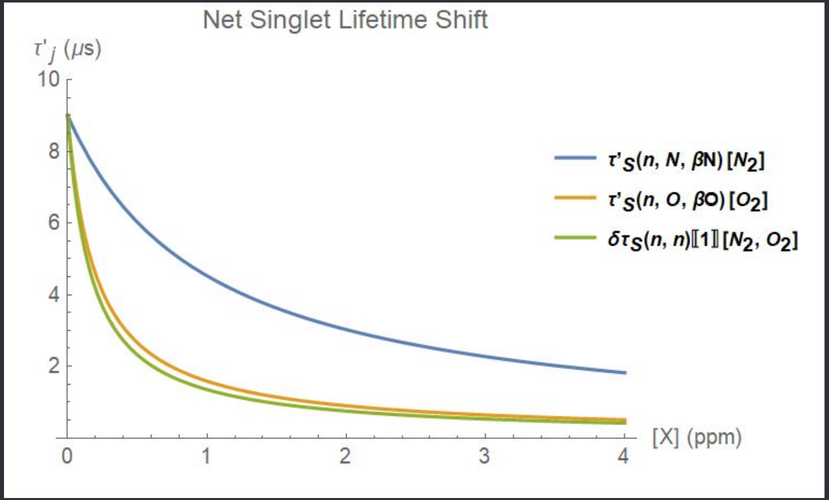
OProfile = {0, 0.01, 0.05, 0.1, 1, 5, 10, 20, 50};

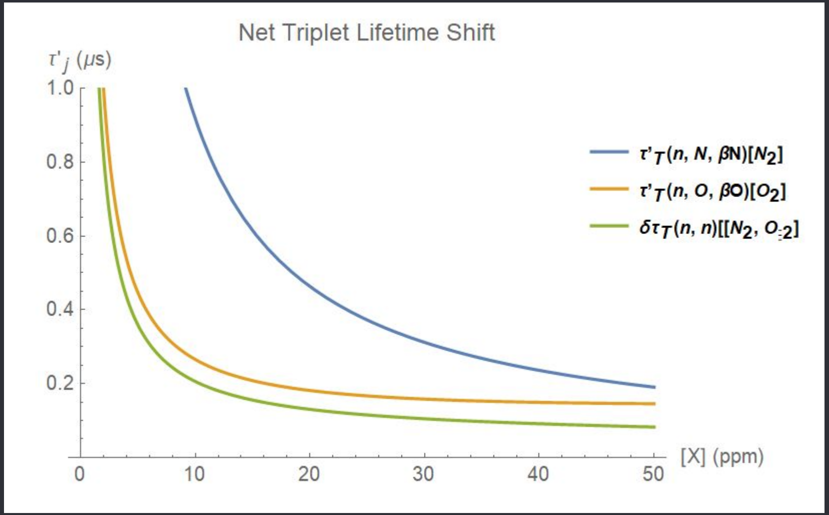
Lifetime Shifts

Net Singlet Shift

The lifetime shift is given as a fractional value of the standard lifetime

Net Triplet Shift





KE Histogram Analysis

-General idea for analysis

The many histograms correspond to a given [O] and [N] profile value, or *j* and *k* indexes. For the collection h_{jk} dof *j* histograms at a given *k* (the hists for different [O] values at a constant [N]) I wish to iterate over each bin in each histogram, and compare each bin with the corresponding bin for the rest of the *k*-profile histograms. This comparison could possibly be a fit, and at the same time also store the corresponding uncertainties. Doing this, I can obtain a histogram change as a function of [O] and [N]

The plotting is tricky, I'm unsure how exactly to go about plotting this gradient the best way possible. The plot could be a 3D contour.

The good news: I have code that analyzes data from all the different root files for each contamination profile, so I can use any histogram, not just kinetic energy, for further analysis.

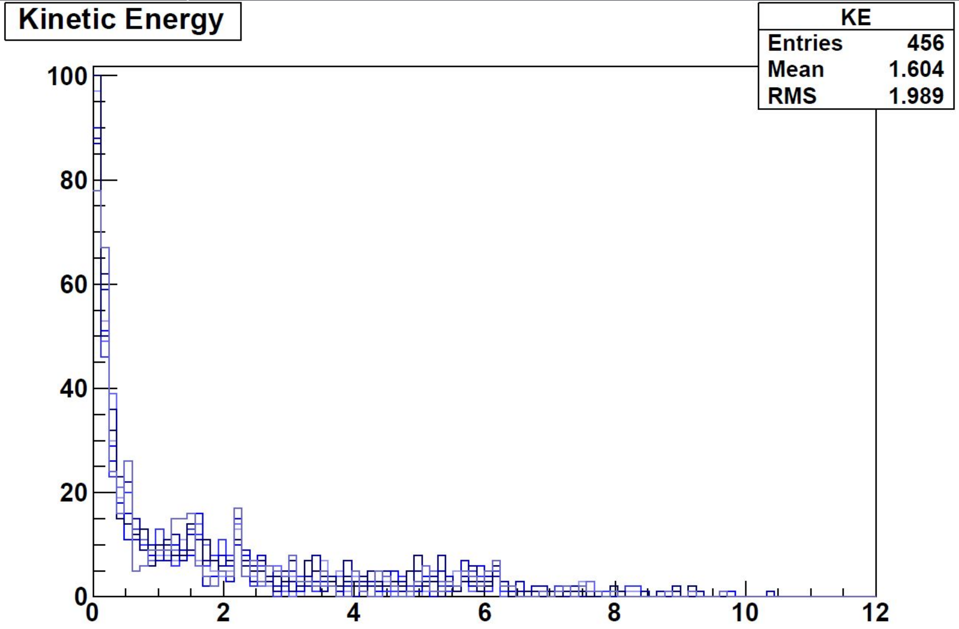
Preliminary Analysis

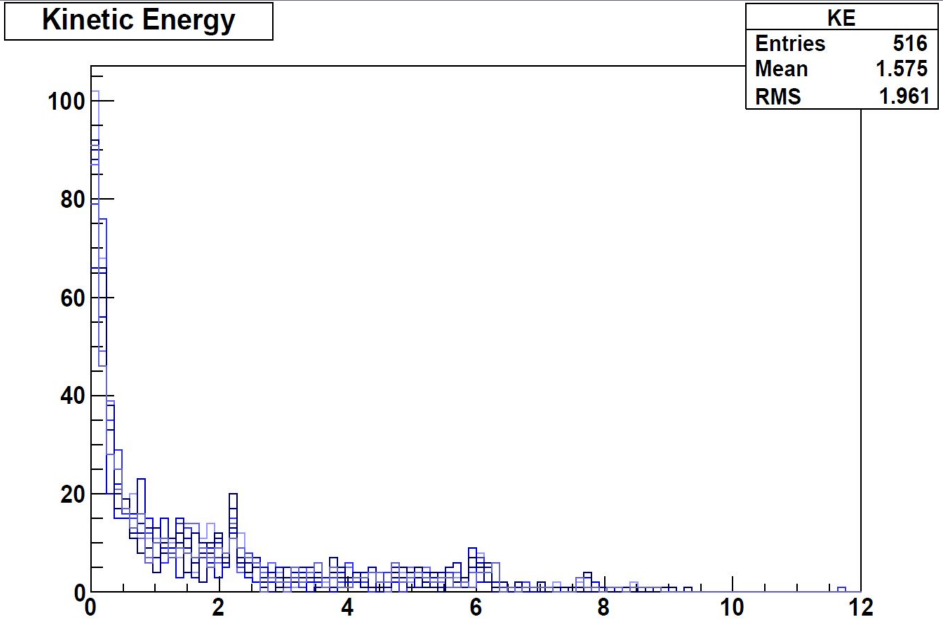
Left: Histograms for N[1],O[i]

Right: Histograms for N[i],O[i]

Light blue = Lower contamination

At least from this data, no significant correlation is apparent in the KE. I may need to run another round of jobs with more events to get cleaner histograms.





Argon Contamination Modelling

This paper[1], cited in Tom's theses, has useful analysis relevant to the contaminated argon analysis for future runs of MiniCLEAN

- Nitrogen absorbs Ar scintillation with $1.51 * 10^{-4}$ cm^{-1} ppm^{-1} (arXiv:1306.4605)
  - This is valid for 0 - 50 ppm contamination
- Oxygen has a large effect on the triplet lifetime, but current literature has valid analysis for low N_2 concentration (< 1 ppm)
  - The quenching rate process of oxygen is then

$$k(O_2) = 0.54 +/- 0.03\ us^{-1}\ ppm^{-1}$$

Compared with

$$k(N_2) = 0.11\ us^{-1}\ ppm^{-1}$$

The quenching rate from oxygen is much higher, so what purification can be done ought to be oxygen filtration

[1] *A Measurement of the Absorption of Liquid Argon Scintillation Light by Dissolved Nitrogen at the Part-Per-Million Level*, B.J.P. Jones et. al. (arXiv:1306.4605)

Nitrogen contamination

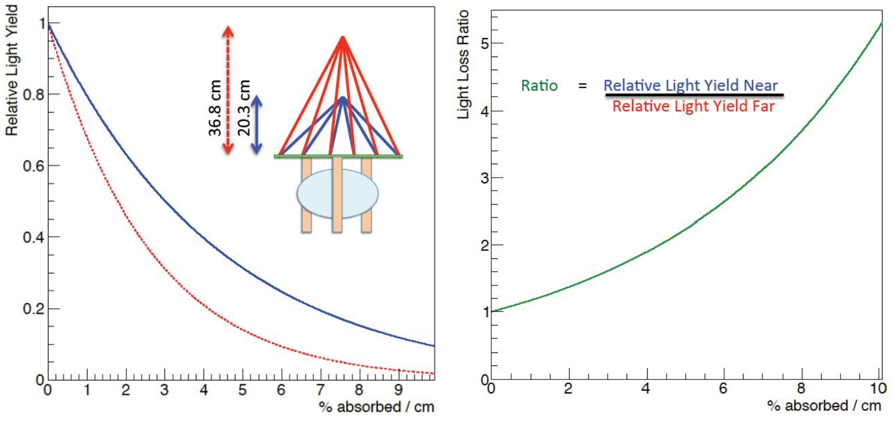
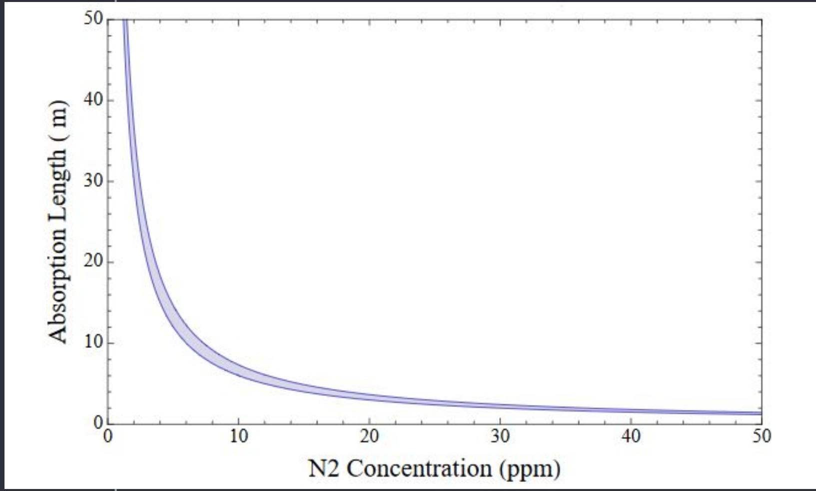


Figure 3. Left : Fractional light yield expected as a function of absorption strength for each source position. Right: Ratio of the two fractional light yields, in which any quenching effect cancels.



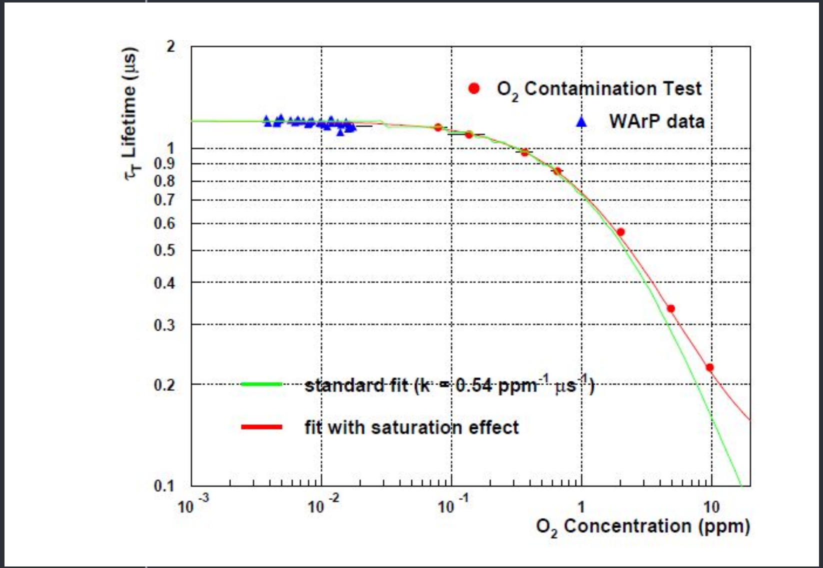
The authors find the conversion factor between %absorption and N_2 concentration by comparing fractional light yield ratio as a function of N_2 concentration to the curve of figure 3, right. For low % absorbed/cm, this is a valid linear approximation. This ‘low’ threshold is around 0-50 ppm.

Therefore, we can extract the absorption strength the N_2 by measuring the *gradient* of the linear relationship between fractional light yield ratio and N_2 concentration.

This absorption strength can therefore be implemented in RAT via a corresponding fractional decrease in **SCINTILLATION_YIELD** of the material in the macro.

Both figures from (arXiv:1306.4605)

Oxygen Contamination



The oxygen behavior has a definite effect on the triplet lifetime component, which can be modified via **`SLOWTIMECONSTANT`** in RAT. This paper by the WArP Collaboration analyzes the change in lifetime as a function of oxygen concentration.

Not excluding N_2 contamination, in fact maximizing it, the variability range due to oxygen and nitrogen 1.21us < t < 1.28 us

This maximum N contamination limit is the highest based on the well known quenching rate of 0.11 us^{-1}ppm^{-1} while the O_2 quenching model remains valid.

[2] *Oxygen contamination in liquid Argon: combined effects on ionization electron charge and scintillation light*, WArP Collaboration, (arXiv:0804.1222)

Logistics

- Hopefully I will be in contact soon to set up a PNNL account. I'm looking for who else to contact, Chris Jackson has unfortunately been flakey
- Condor jobs are now working perfectly, and I have output data from my new jobs.
- I'll be inquiring about the characteristics of the less pure argon

Fall 2018 Work

10/04/2018

This week:

- Renewed certificate
- Started 2 fresh sets of gas and liquid data
- Talked with Chris Jackson about work going forward.
  - I'm going to be doing preparation simulation for the detector with less pure argon.

Coming Week:

- Discuss with Chris the specifics about analysis work, including triplet lifetime/contamination dependence.
- Make a PNNL account to view/use existing run data

Notes for contamination model:

Decrease overall light yield by some fraction ~15%, check old LY (5.5-6.5). Cut the triplet lifetime by a lot, maybe 30%.

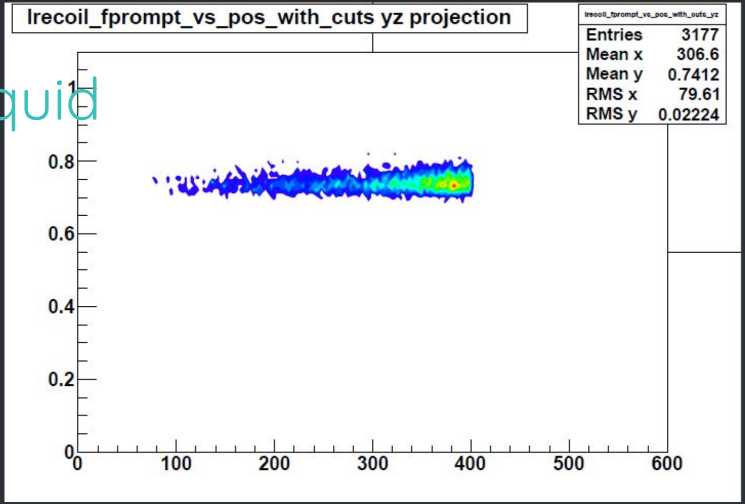
Gas Simulations Overview

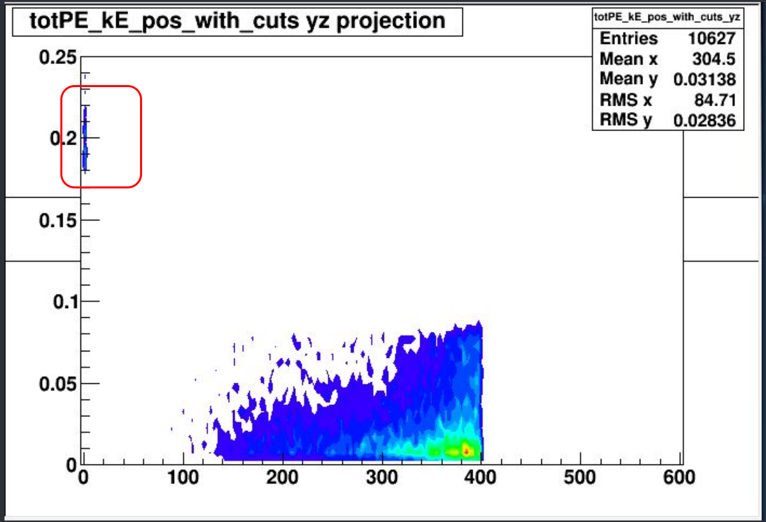
Macro Code that sets the cryoliquid to gas

```
/rat/db/set MC scintillation "deapmc_argon_gas"
/rat/db/set OPTICS[gaseous_Ar_ratdeap] SCINTILLATIONYIELD 13333.0
/rat/db/set MATERIAL[gaseous_Ar_ratdeap] density 6.0e-3
/rat/db/set OPTICS[gaseous_Ar_ratdeap] SLOWTIMECONSTANT 3670.0
/rat/db/set GEO[cryoliquid] material "gaseous_Ar_ratdeap"
.
.
.
/rat/proc singlepe
/rat/procset material "gaseous_Ar"
```

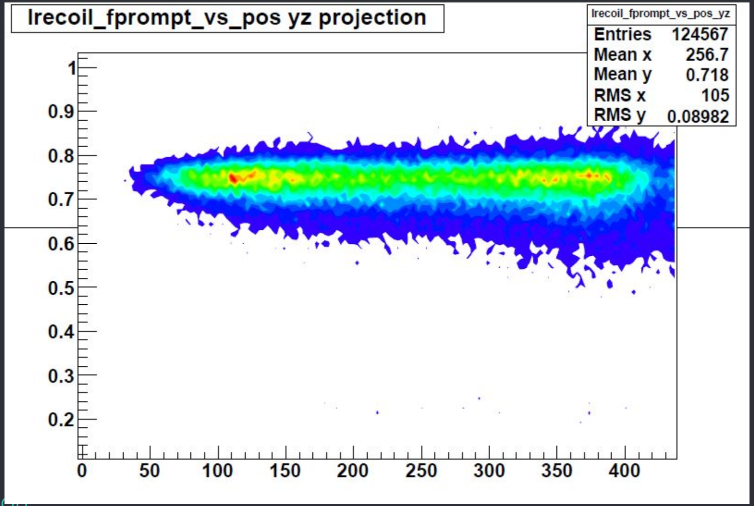
For new cuts, run analysis for tracks of neutrons in liquid to see where in the detector the gamma events tend to occur.

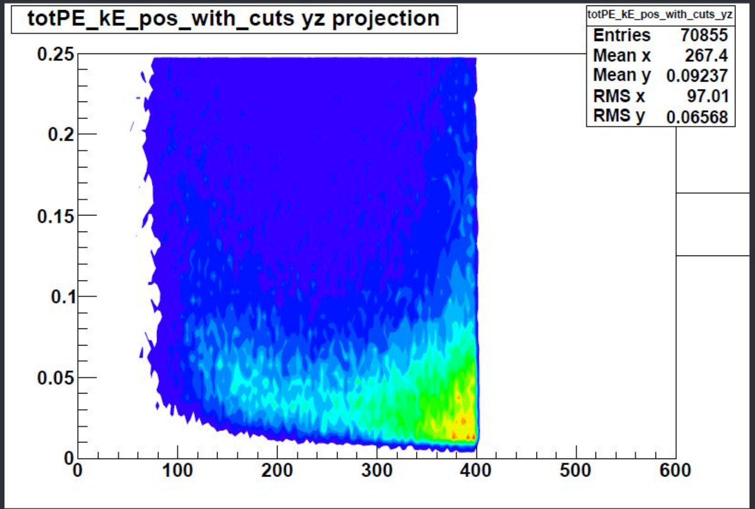
Liquid


lrecoil_fprompt_vs_pos_with_cuts yz projection
lrecoil_fprompt_vs_pos_with_cuts_yz
Entries 3177
Mean x 306.6
Mean y 0.7412
RMS x 79.61
RMS y 0.02224

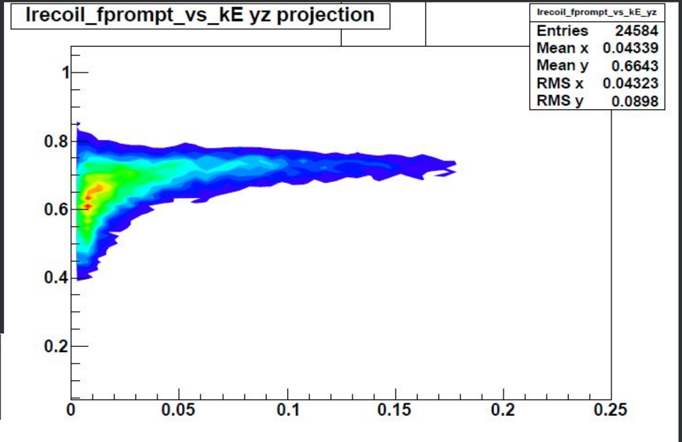

totPE_kE_pos_with_cuts yz projection
totPE_kE_pos_with_cuts_yz
Entries 10627
Mean x 304.5
Mean y 0.03138
RMS x 84.71
RMS y 0.02836

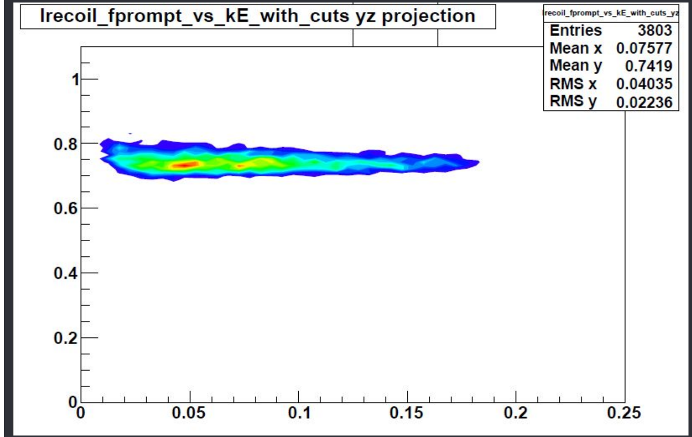
Gas

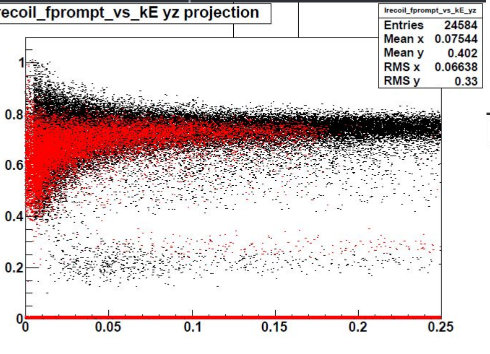

lrecoil_fprompt_vs_pos yz projection
lrecoil_fprompt_vs_pos_yz
Entries 124567
Mean x 256.7
Mean y 0.718
RMS x 105
RMS y 0.08982

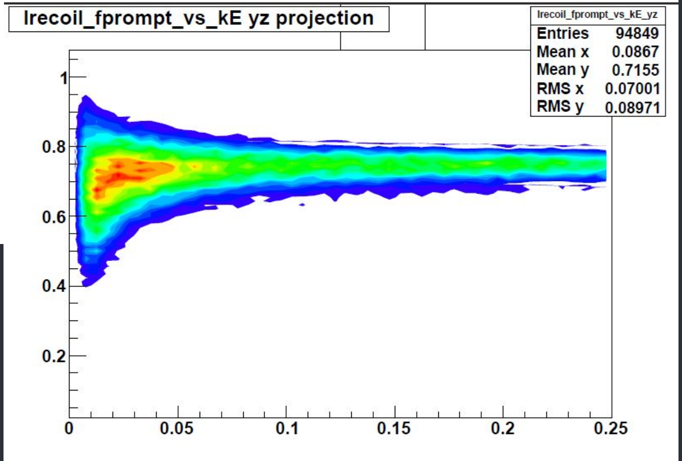

totPE_kE_pos_with_cuts yz projection
totPE_kE_pos_with_cuts_yz
Entries 70855
Mean x 267.4
Mean y 0.09237
RMS x 97.01
RMS y 0.06568

Liquid


lrecoil_fprompt_vs_kE yz projection
lrecoil_fprompt_vs_kE_yz
Entries 24584
Mean x 0.04339
Mean y 0.6643
RMS x 0.04323
RMS y 0.0898


lrecoil_fprompt_vs_kE_with_cuts yz projection
Entries 3803
Mean x 0.07577
Mean y 0.7419
RMS x 0.04035
RMS y 0.02236


ecoil_fprompt_vs_kE yz projection
lrecoil_fprompt_vs_kE_yz
Entries 24584
Mean x 0.07544
Mean y 0.402
RMS x 0.06638
RMS y 0.33


lrecoil_fprompt_vs_kE yz projection
lrecoil_fprompt_vs_kE_yz
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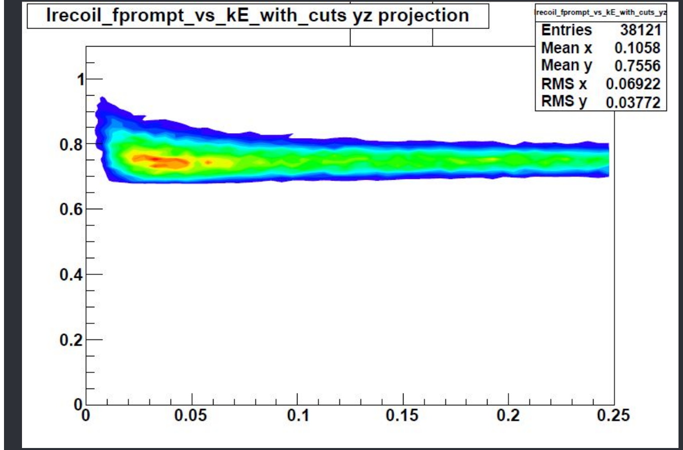
Mean y 0.7155
RMS x 0.07001
RMS y 0.08971

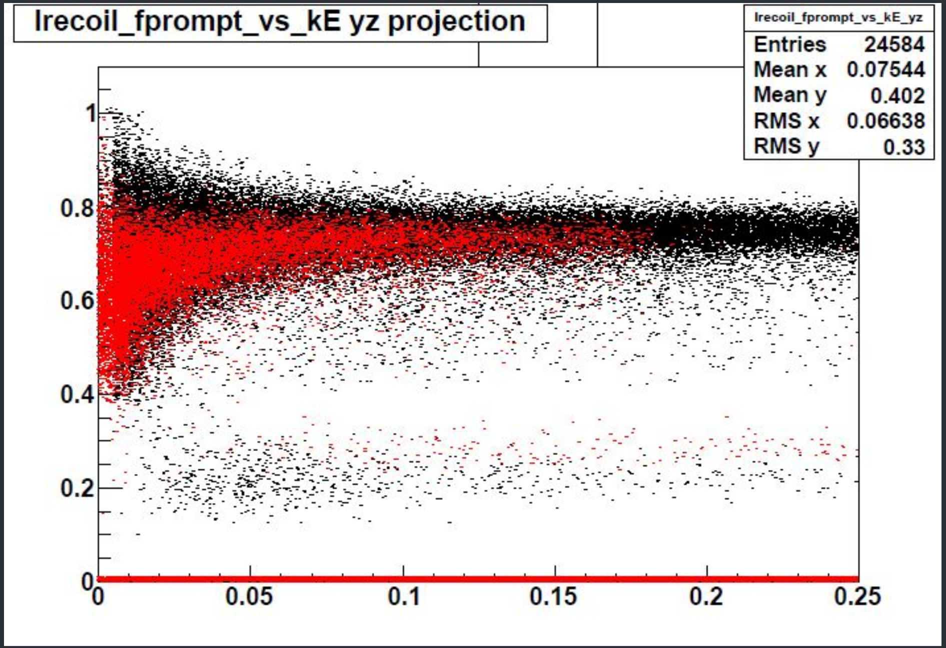

lrecoil_fprompt_vs_kE_with_cuts yz projection
Entries 38121
Mean x 0.1058
Mean y 0.7556
RMS x 0.06922
RMS y 0.03772

Gas

Gas v Liquid Analysis

Cuts

- [copy here from script]
- Refactored analysis code to use variable cuts for different values.
- More plots to come (tomorrow)
- Need to run more liquid simulations to obtain better trends
- Fprompt: >0.681
- totalPE: >20, <500
- KE: <0.25
- Pos: < 400

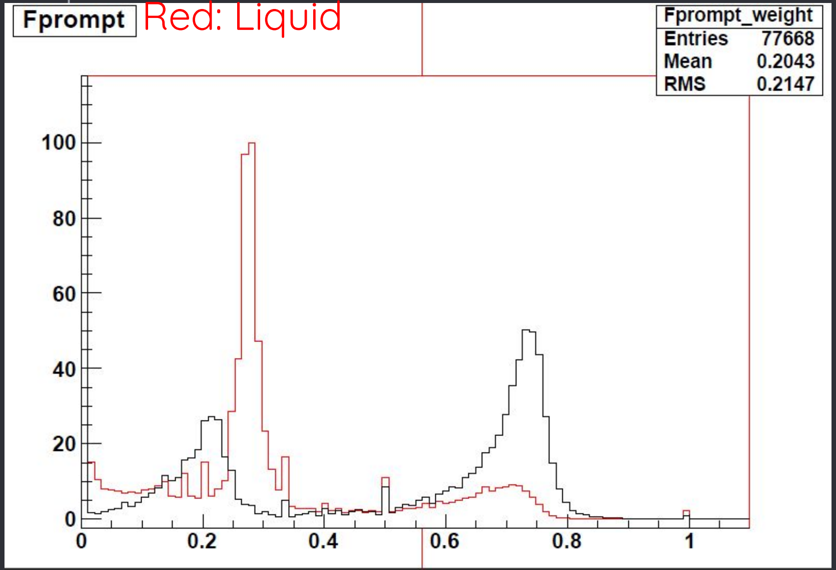


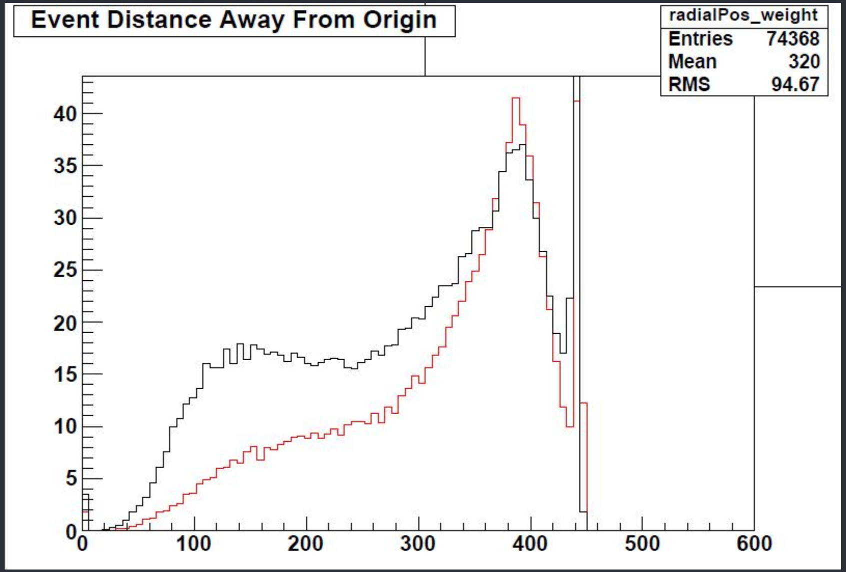
Gas v Liquid Analysis 4/24/2018

These plots are shown **without** cuts to show full behavior

Black: Gas

Red: Liquid





MiniCLEAN Progress

Nick Decheine

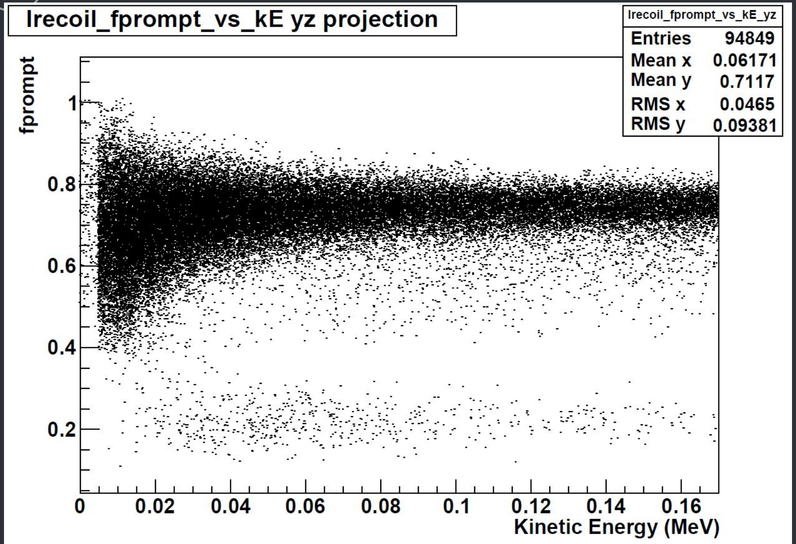
- Poster creation went well, we showed our poster at the symposium.
- Working with Chris, Kolahol, Ryan et al. on pulse discrimination in gas referencing work from Ryan's thesis.

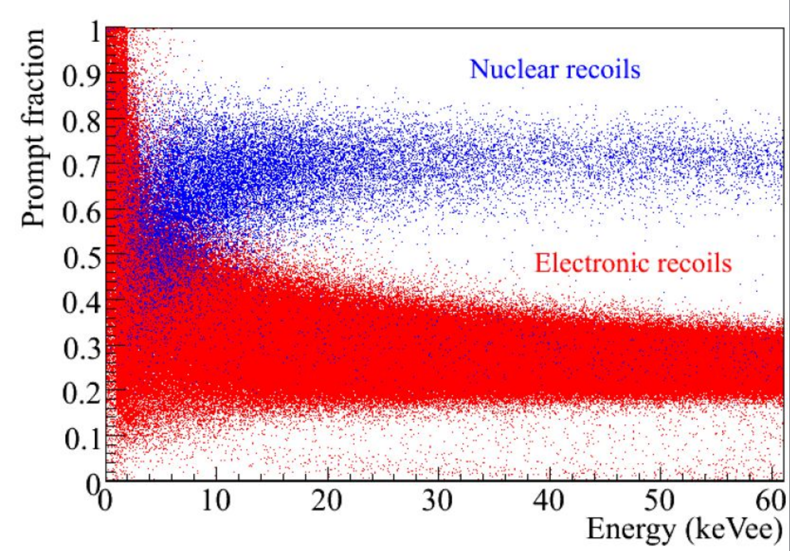
Plans + Problems

- Working on further understanding geometry in RAT to make a geometry configuration with both gas *and* liquid. We will use data from the detector to define the distribution of gas.
- New pulse discrimination, if valid, could prove a remarkable method to discriminate α, β, and γ completely.
- Working towards a comprehensive description of

4/10/2018

Nick Decheine



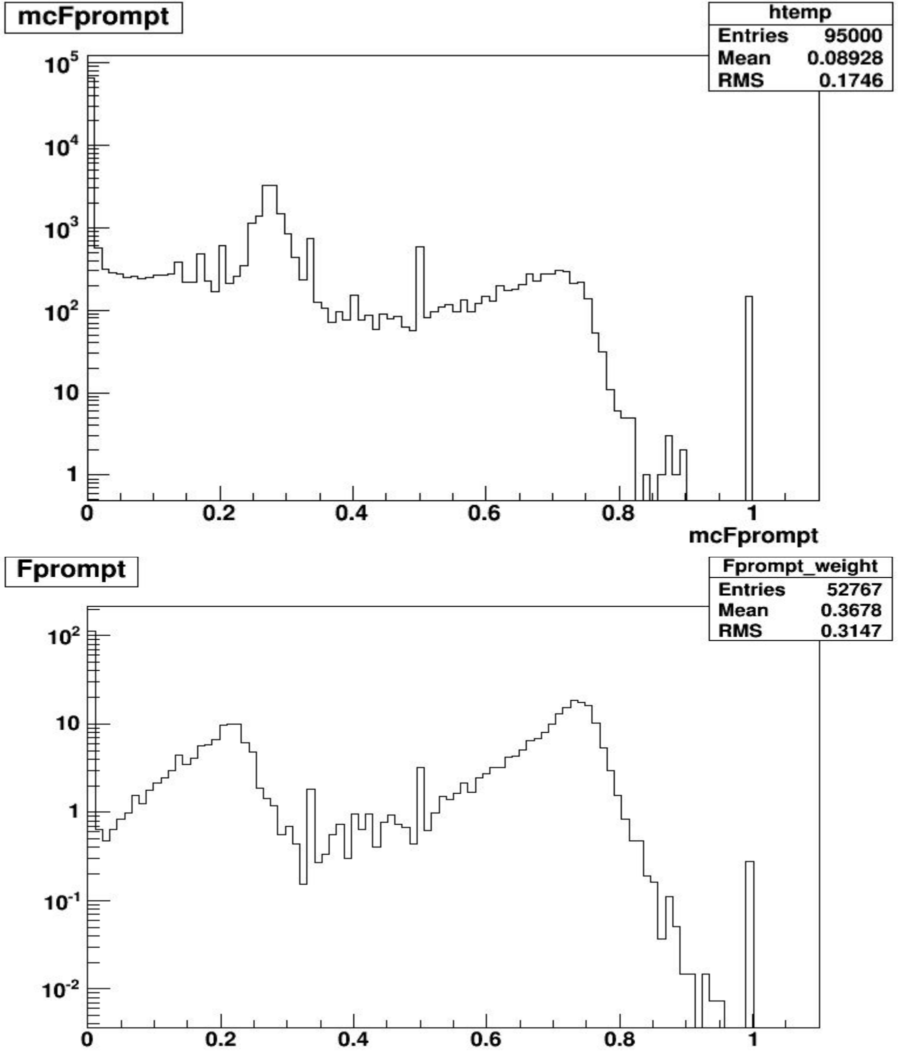


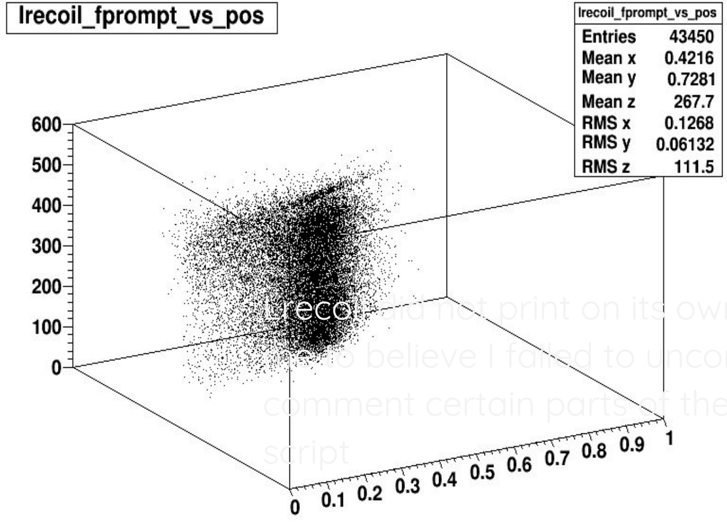
Neutron Simulation in Gaseous Argon

Summary of simulation

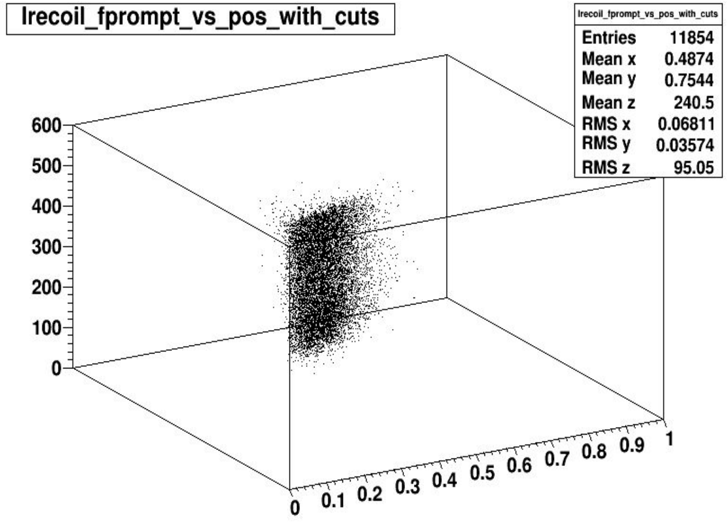
[fill]

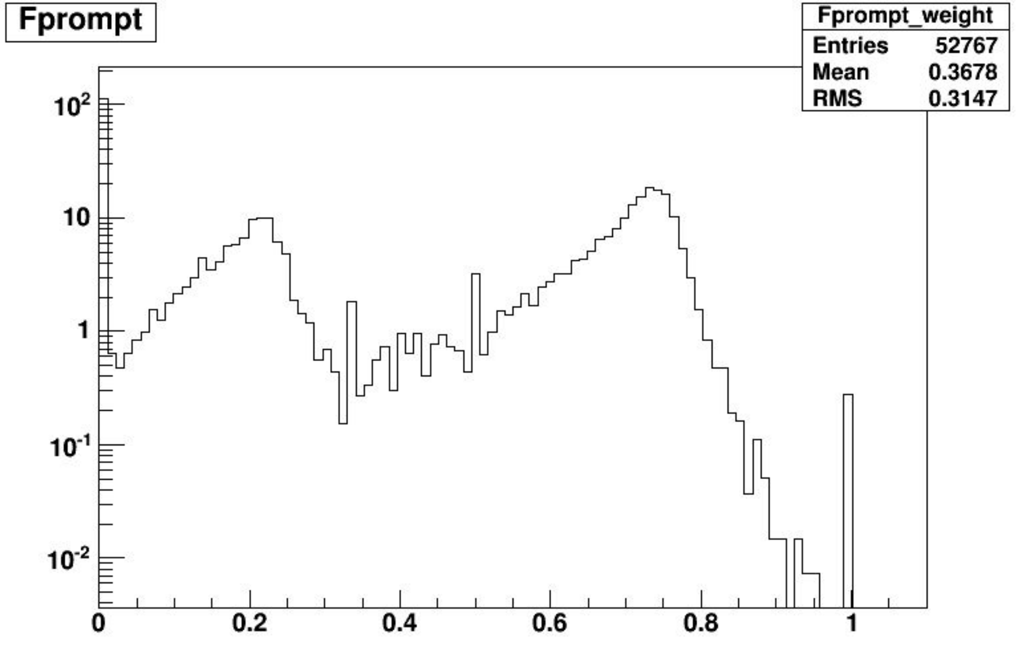
liquid fprompt





Lrecoil did not print on its own, leading me to believe I failed to uncomment or comment certain parts of the analysis script





MiniCLEAN

Progress

Nick Decheine

- Successfully ran neutron simulations in gas, plots on next slide.
- MiniCLEAN has made some progress, and is currently in the processing of filling. More monitoring shifts will be done.
- See next slide for plots
- Regarding my runtime problem,

Plans + Problems

- Solve my runtime Problem
- Once this runtime problem is addressed, I can finally make production analysis using either more neutron data, or neutron data and simulated wimps to make a final discrimination plot.
- Work with Hans on the symposium presentation.

MiniCLEAN

Progress

Nick Decheine

- Updated RAT to r2178
- Resolved my (ignominious) condor simulation problem, so now running jobs on condor works.
- Utilized gen_shellfit to build the shellfit tables for MiniCLEAN so they can be loaded directly prior to initialization, so startup time for macros will be much faster.
- Gaseous processors for my neutron simulations work.

Plans + Problems

- Find the source of *another* problem, which is RAT's outroot processor not being able to write to the disk when I run tests straight through command line and not through condor. Always get the message:

```
SysError in <TFile::TFile>:
file output.root can not be
opened (Disk quota exceeded)
```

- This makes doing offline testing much more difficult. This also causes the gen_shellfit python script to fail before it can output the .root file containing the table.
- I plan to have cut plots and

Progress

MiniCLEAN

Nick Decheine

- Successfully running Nathan's analysis script on liquidAr neutron events.
- Reaching out to Kolahal about his document regarding background plots and neutron events.
- Obtained a more solid understanding of the ROOT data structure, so I have resolved all my previous problems with data manipulation and acquisition from .root files.
- The analysis script is running as I speak, but has not terminated in time for this meeting, so no plots unfortunately

Plans + Problems

- Odd issue with the server, as my jobs are taking *much* longer to compute than they have in the past. Although able to run successfully, even less than worthwhile simulations (test jobs) take hours, meaning worthwhile jobs could take days or weeks. This may be a problem on my end, however I do not know yet.
- Run a clean macro job to condor for purposes of diagnostics for the above issue.
- Learn more about more sophisticated ROOT analysis techniques, like the 3D histogram cut technique and ROOT

Progress

MiniCLEAN

Nick Decheine

- On the next slide are the mcFprompt plots for liquid argon alongside the preliminary gaseous estimate.
- For the gas value, oddly, RAT would crash if the IV was filled with anything but liquid_Ar, even if the other material had the same properties.
- Instead, I set the liquid_Ar density to that of gaseous argon at standard conditions, as the density of liquid_Ar already set was of standard liquid argon density. The gaseous density was ~1.784 x 10^-3 g/cm³.
- Interestingly, the gaseous

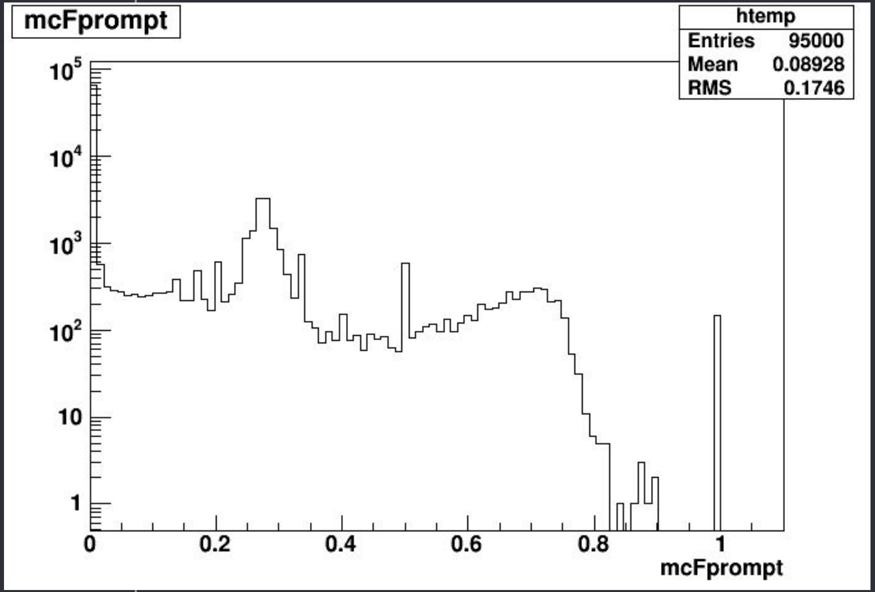
Plans

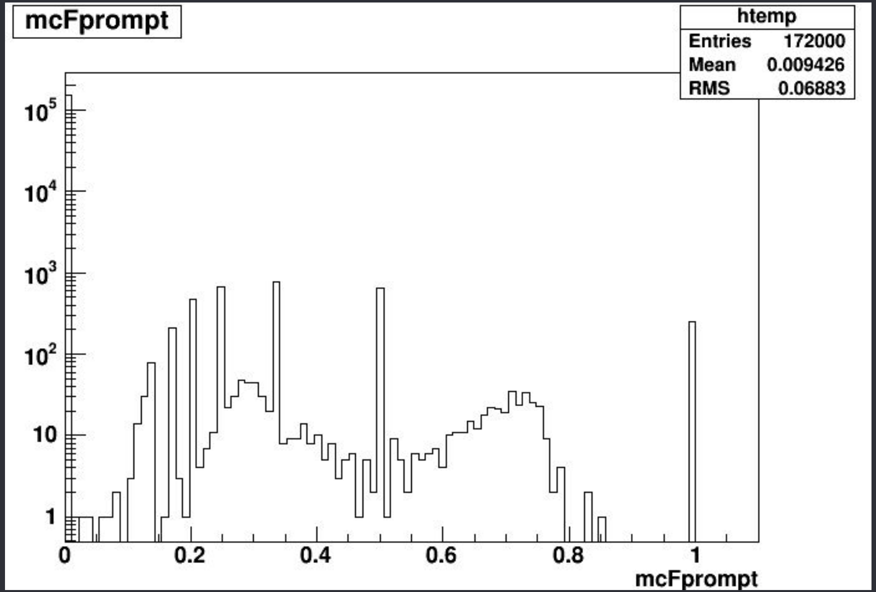
- System training today
- Find the material bug/interaction in the detector simulation, because I'm guessing there is an additional calling of liquid_Ar that I'm not accounting for
- Run wimp simulations with better understanding of GEANT4 and RAT simulation framework

Liquid Ar
mcFprompt

Nick Decheine

Gaseous (?) Ar





Progress

MiniCLEAN

Nick Decheine

- Wrote a ROOT File renaming script - streamline data processing
- Wrote a TChain analyzer script that also Draws a chained fPrompt, or whatever leaf I choose
- Learned about RAT reactor geometry files.
  - Imported (and found) MATERIAL file for gaseous Argon, labeled “gaseous_Ar_ratdeap”
  - Attach modified MiniCLEAN.geo (.ratdb) and MiniCLEAN_IV.geo files, replacing the cryoliquid in *_IV with gaseous argon, referencing the altered IV

MiniCLEAN

Plans

Nick Decheine

- Odd bug found with RAT submissions - about ⅖ of submissions cannot find and source RAT environment variables, therefore only ~40% of submission actually simulate
- More severe bug, which has already ruled out material altering as an origin, the .root files are either not being created or not being successfully copied/found by condor, so I cannot get any more outputs.
- These bugs will (hopefully) soon be fixed so I can continue work
- Hopefully learning about system monitoring

MiniCLEAN

Nick Decheine

Progress

- Created a new submission shell script
- Successfully ran jobs on the cluster and copied the output back to me
- Installed Ubuntu, overcame my previous problem

Plans

- Become more proficient with UNIX, ROOT, and Rat
- Further the neutron and wimp simulations for data analysis
- Start training on system monitoring for MiniCLEAN

Progress

MiniCLEAN

Nick Decheine

❖ With finals looming over me, I've had little time to put towards the project over the past week, however I have still made some progress. Nathan ran his simulation from the berkeley cluster

❖ I also have the submission for a job using runWiscJobs correct, except for a working proxy/certificate, although I have a certificate, it doesn't read it. I'll figure it out.

Overall

- Over the course of this project, I have learned so much. I have gained a greater understanding and handle of UNIX, become integrating in the university research process, learned more about ROOT as well as C and Python.
- Learning about this experiment, as well as all of the processes that go into these simulations, has been a truly enlightening experience, and I can't wait to come back to it in the fall.

MiniCLEAN

Progress

Nick Decheine

- Successfully ran a RAT simulation off of the university cluster, outputting a valid ROOT file
- Obtained a Grid Certificate for the new runWiscJobs script (thank you Carl!)
- Obtained an analysis script for compiling results from Nathan

Forward

- Successfully run a macro using runWiscJobs
  - Configure so that the output files have different names depending on run
- Finish the analysis script
- After all this, hopefully finally run my wimp macro