Looking at issues in the ES Analysis

Janet Conrad, May 14

1. Regrouping in light of the NuSAG Meeting...
2. I'd still like to have a review, here's why...
3. Progress -- Overview and Recent Memos

It looks like we need to decide What We Might Say to NuSAG on the ES Measurement today

- I think we should say something, because...
  - Having extra physics is an asset.
  - The idea appears in the proposal.
  - We are talking about the idea at conferences
  - Braidwood is the only θ_{13} experiment that can do this.

- It should be very short, unless NuSAG is interested in learning more. since the NuSAG charge is about θ_{13}

- I don't think it is absolutely necessary to say anything, but if we don't, we should at least have some backup slides ready should they ask..

If we do decide to present, then...

Points to present might be:

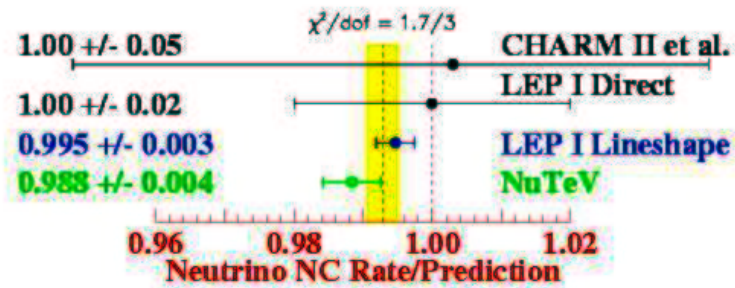
- There is interesting physics to be done
- We have a plan of attack and have set goals
- We are are in the process of seeing if we can achieve these goals
- It is clear we cannot achieve these goals at any other θ_{13} expt.

If we had 3 slides on $\sin^2\theta w$ in the initial presentation, then I would propose they might be...

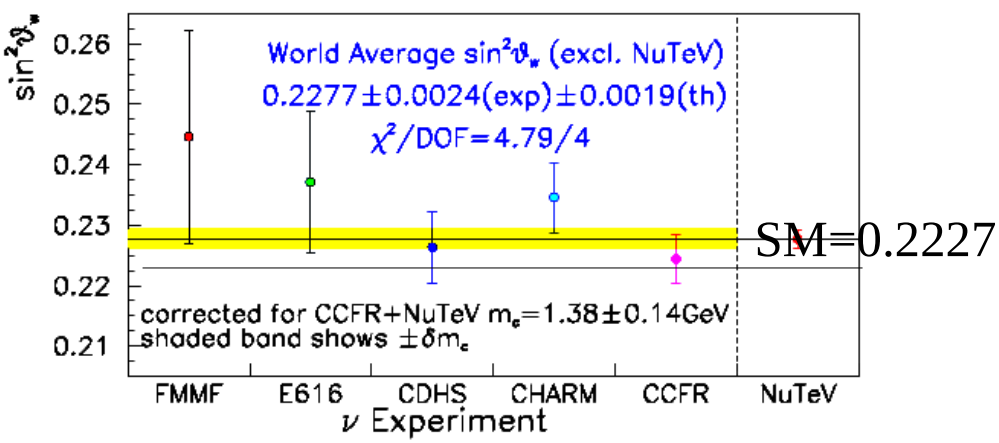
Other Physics at Braidwood:
The Weak Mixing Angle in the Neutrino Sector

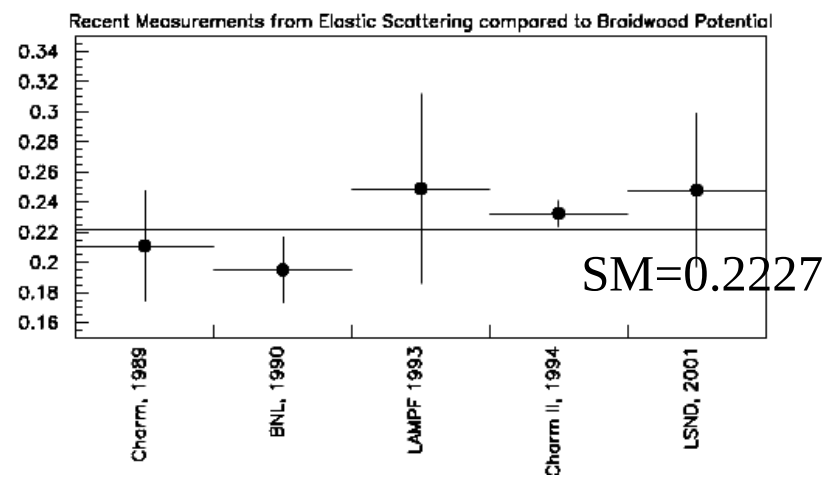
Physics Motivation:

Is there reduced coupling to the Z boson in the neutrino sector?



LEP Line with shows a
2σ effect in agreement w/ NuTeV



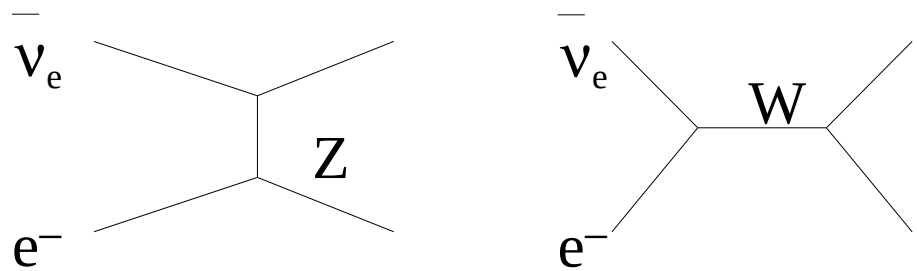


NuTeV: 3σ from the SM;
A systematic shift is seen in all νq expts.

νe scattering may show same effect but with only 1.2σ significance since errors are large.

Plan:
Study ES events in the Braidwood near detector.

Our goal: To measure $\sin^2\theta_W$ from elastic scattering
with an error ×4 better than past νe experiments
e.g., an error comparable to NuTeV



$$\frac{d\sigma}{dT} = \frac{G^2 m}{2\pi}\left\{(C_V+C_A)^2 + (C_V-C_A)^2\left(1-\frac{T}{E}\right)^2 + (C_A^2-C_V^2)\, m\frac{T}{E^2}\right\}$$

$$C_V = \tfrac{1}{2} + 2\,\sin^2\theta_W$$

Tricks to make a precision measurement possible:

- Measure relative to inverse beta decay (not an absolute measurement!)
- Pick a smart visible energy window (3-5 MeV) away from background

Can we reach our goal? We are investigating...

So far appears to be an ambitous but achievable!

Issues under study:	Approach to reduce/constrain error:
Relative fiducial region	Two different analysis techniques allow in-situ constraint on relative error
Relative energy scale, offset	Measure directly using IBD threshold, muon decays and β– decays
Contamination	Purification techniques achieve suffiently low level
Muon-induced isotopes	450 mwe provides sufficient shielding.

Paper accepted to PRD: hep-ex/0403048

Braidwood is unique among θ_{13} experiments in addressing this physics

because of simultaneously having <u>high shielding</u> and high rates due to <u>proximity to the reactor,</u>

What do you think?

A Review of the ES Analysis
Do we still want one? Maybe June 6?

A morning of going over the ES analysis in detail.
I'll arrange for video conferencing.
Everyone welcome!

The original committee was..
Peter Fisher, Steve Biller, Tim Bolton, Ray Stefanski

The original charge was...

As part of preparing for a presentation to the NuSAG panel, please evaluate how an ES measurement should be put forward to NuSAG.

A summary of the remaining questions that should be addressed for the presentation would also be helpful.

My personal goals for the review

beyond thinking about how to present to NuSAG...

Bring together all of the info on the ES analysis as it stands today to get the "Big Picture"

Get together the necessary back-up slides in case we do present this

Since I (and others) will be presenting this at conferences, get some feedback on whether the ideas are clear

Reconsider the long-term priorities (well beyond NuSAG) on the order of addressing questions.

I still think it might be valuable...

The plan:

a series of talks from which we could pick and choose...

- The physics motivation *
- Overview of the Method
- Analysis strategy
- The errors which are most defensible *
- The moderately difficult issues and errors *
- The tough issues and errors
- Getting the sensitivity
- Krasnoyarsk as a protoype-run

* = I already wrote these.

Idea was to make slides on all aspects

Make the slides available ahead of time

Then at the review we could pick and choose, based on what questions are out there...

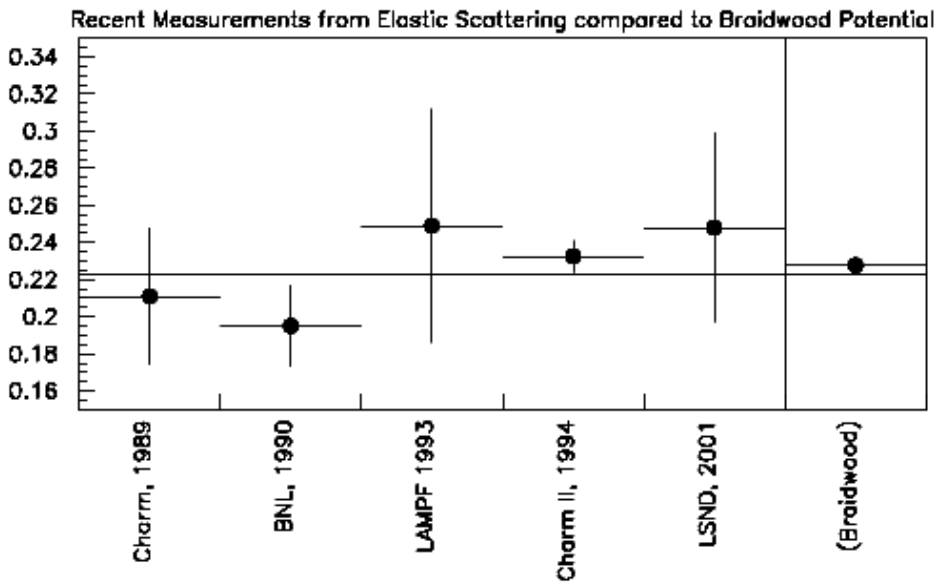
And now for a discussion on the latest progress...

Motivation & Method
Pointing out 3 new memos very briefly
Krasnoyarsk as an opportunity

NEW Motivation plot

We can beat the best elastic-scattering based measurement by a factor of 4.

(I added stat and sys errors in quadrature)



aligned with NuTeV value

These experiments are much less precise than νq!

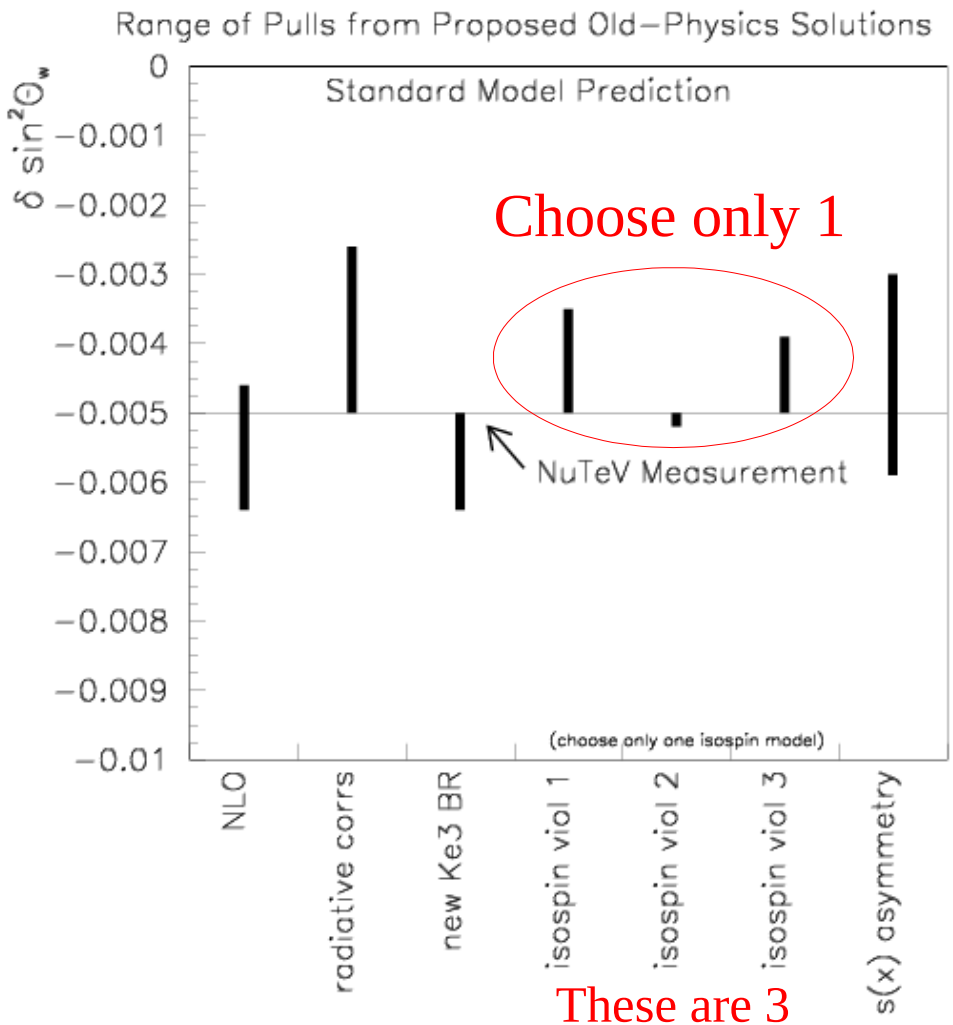
Charm II sets the standard and is 1.2σ above SM (in same direction as NuTeV).

NEW

More Motivation...
How are SM Explanations doing in explaining NuTeV?

No single solution
based on variations within
the SM solve the problem.

Theorists are now writing
papers pointing out
that if you use certain ones
and ignore others, then
you can solve the problem.



These are 3
alternative
models

Update on questions we must address...

Topic:	Simple Calculation	Detailed Simulation	Bench Measure-ment/Test	In-situ Plan
Fiducial Volume	See new memo	Coming this summer	β-source?	β-source? 2-analysis comparison
Contam -ination	Memo on web	Coming this summer	See M-F.Y.'s talk on measure so far	Using Timing
Energy Calibration	See new memo	Not Yet	β-source?	IBD+michel+ betas (see memo)
Spallation	See 1st EW memo	On the way!	VSPLAT?	near-far comparison, tagging.

Red=New info/ideas, Black=shown/discussed previously

Status

At this point we have a at least one idea,
run through the "simple calculation" for...

Contamination,
Spallation, } Pretty well develped

Fiducial Volume
Energy Scale } Still under study -- definitely need work!

on which we can base our sensitivity estimates

What next?

Continue developing more ideas using quick studies

Begin developing the "quick study ideas" more using detailed MC... examples:

- Joe will talk about his work on simulating ES events next.
- Peter is interested in 208Tl reconstruction (this will need hit timing in the MC)
- Jasmine will look at IBD misidentification this summer (related to fiducial volume error studies)

This is Jasmine

We are planning to start up weekly meetings. We'll send email on the time soon!

A new memo on constraining the fiducial volume error
(and a related memo on contamination)

The problem: The MC says the relative error between ES-and-IBD vertexing is about 3mm. But how do we check?

(Yesterday someone mentioned the vertex algorithm from reactor FSIm is giving 10 cm resolution. That doesn't really matter, since this analysis only cares about relative reconstruction, but CTF did 5 cm with a real detector, so we should understand this.)

The idea: pursue an alternative analysis which trades the fiducial volume error for another systematic (IBD mis-id). Make sure the results of the 2 analyses are consistent.

This works as an in-situ test

But it is only a good test if the errors on the two analyses are comparable.

A second analysis method which does not have a fid. vol. cut.

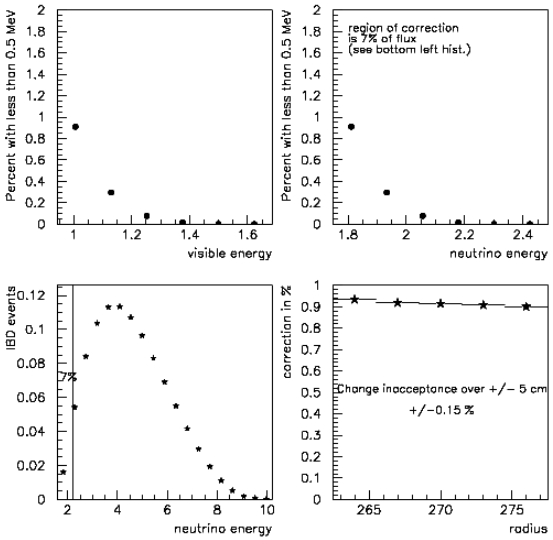
Get the shape of the IBD events vs energy by cutting far from the edge.

Get the total by counting IBD events above 0.5 MeV up to the acrylic edge (same method as θ13 analysis)

for events generated throughout tank, % with < 0.5 MeV --
all are at low nu energy

fraction of events in energy range affected is only 7%.

result: even if you do not know acrylic edge well, sys error is small



Use the IBD cross section to extract flux × targets

Measure the ES event rate using events up to the acrylic

Extract the ES cross section using flux × targets

This has no relative fiducial volume error between ES and IBD

This trades the fid. vol error for contamination & mis-id error.

Will too much contamnation background enter the ES sample if you go all the way to the acrylic edge?

I've posted a memo looking at this -- doesn't look bad. May mean this cross-check analysis uses a higher minimum energy.

What about Mis-id's?

This is the biggest issue.

Reason # 1:
The study used a 6 cm capture length for n's
which is correct, but you also have to *SEE* the n.
20 cm is realistic (from CHOOZ) to incorporate 1st compton step.

total error from study (6cm): 0.0023
total error if you use 20 cm: 0.0028

Compare to
standard analysis:
0.0020

Reason #2:
This didn't include a systematic error.
If events were occuring isotropically I think this is small.
My concern is how well we simulate the "neutrino wind"

I have some ideas which could address the mis-id's
and reduce these errors which I hope to present at the review.
This is work in progress!

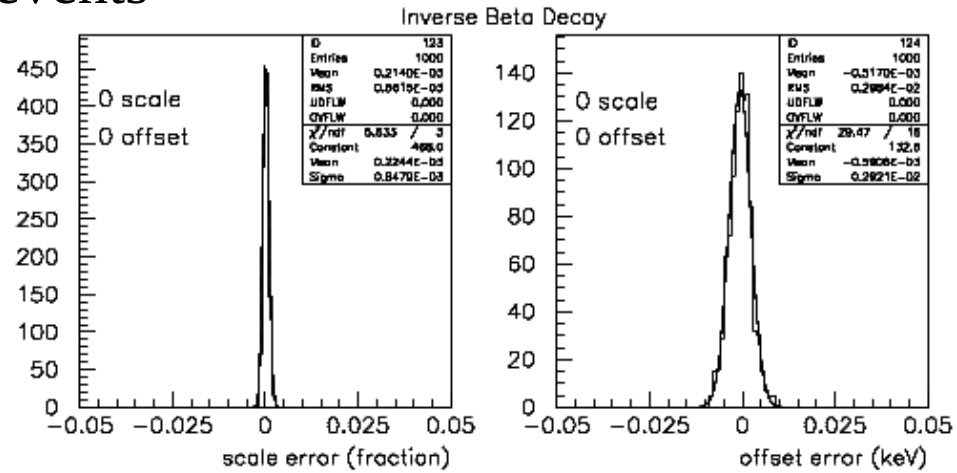
A new memo on the energy scale and offset errors

This describes a 3 step idea to nail down the relative ES-to-IBD scale and offset errors:

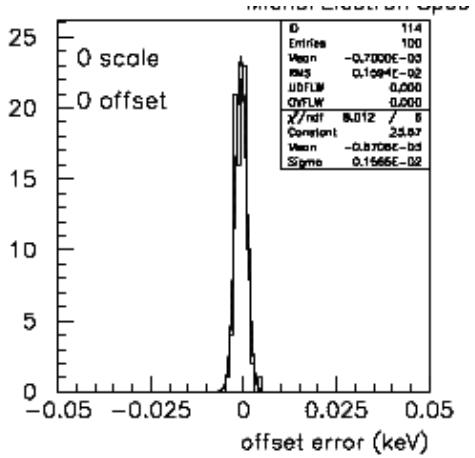
Nail down the IBD scale and offset using near detector IBD events
(same method as Mike S propose for the θ13 analysis)
Nail down the ES offset relative to the IBD using the
michel electron and positron spectrum
Nail down the ES scale by using the β– decays.

Some example plots showing resolution from...

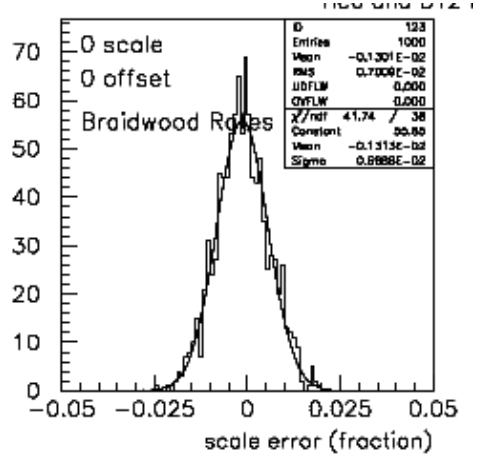
5M IBD events



5 M muon decays



6He and 12B at Braidwood



The main issues at the moment:

We are a factor of 4 short in beta decay rate to achieve the goal we had set. But we were not using all possible sources...

Next question on my list: it works in principle but we need to look more closely at implementing this in practice.

Again, this is a work in progress.

Krasnoyarsk as an opportunity

The Krasnoyarsk reactor is now scheduled to run through 2010 (+).
There are rooms at 20m and 35m

A small version of Braidwood (2m outer radius) would allow us...

- To test our ideas on measuring $\sin^2\theta_W$
- To test algorithms and ideas for θ_{13}
- To build infrastructure for testing and have a working prototype.
- To gain reactor-based experience.

The idea is to run starting in 2008.

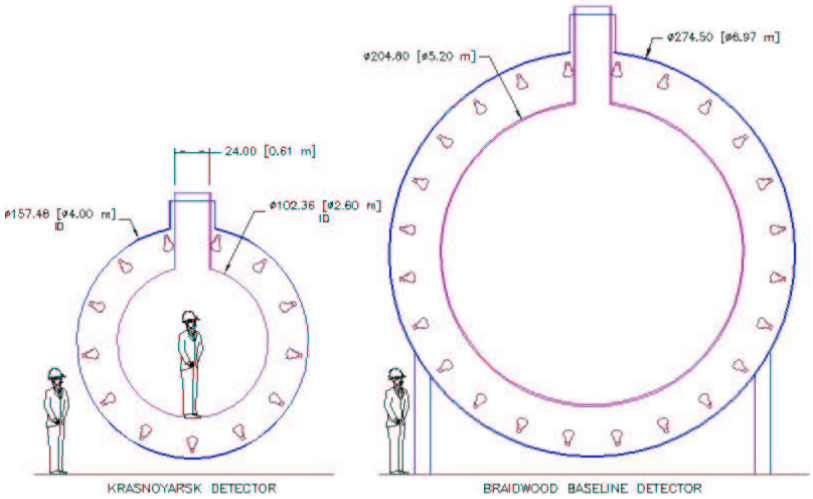
Russians at Kurchatov Institute are interested
Director of Krasnoyarsk is encouraging.

A working prototype for Braidwood that also produces physics...

The present plan (which may change)

A 150 cm inner region, with GDLS *
nylon balloon containment
400 phototubes*
VLAND electronics
calibration system to be developed *

* = can be
same as for Braidwood



TIMESCALES

- Proposal to NSF in the autumn
- Serious engineering work autumn 2005-summer 2006
- Equipment funding by June 2006
- Forward funding through Columbia allows work to start
- Tubes, Gd-LS, electronics, calibration shipped to Russia 2007
- Assembly and running in 2008

Comparison for WMA

WMA at Krasnoyarsk vs. Braidwood:

Signal is nearly the same size (depends on how long we can run)

Backgrounds from muon-induced isotopes and containment
are much smaller since detector is smaller
and flux is much higher.

But this means you cannot use these isotopes to calibrate!

Edge effects are more important since the detector is smaller.

But overall it can provide valuable experience for Braidwood.
This measurement is complementary to Braidwood.