Searching for Dark Matter using the NOvA upward-going muon trigger

L. Aliaga, P. Ding, C. Group, S. Kurbanov, R. Mina, A. Norman, Y. Oksuzian, C. Principato, A. Tsaris

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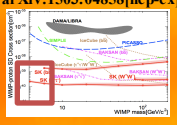


Wimp search

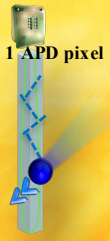
The nature of Dark Matter is still unknown,
One of the leading theories is that it is formed of Weakly Interacting Massive Particles (WIMP).
WIMPs can be collected by the gravitational well of the Sun, interact in its core and produce highly energetic neutrinos we can detect.

NOvA Far Detector

On surface

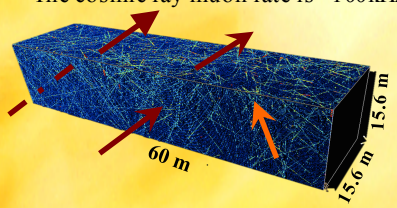
+ Highly segmented low Z tracking calorimeter.
+ 14kTons of liquid scintillator with wave shifting readout

+ 896 readout planes
+ 344,064 pixels



Data and Upward-going muon trigger

The cosmic ray muon rate is ~100kHz

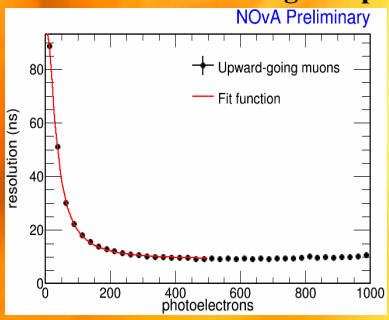


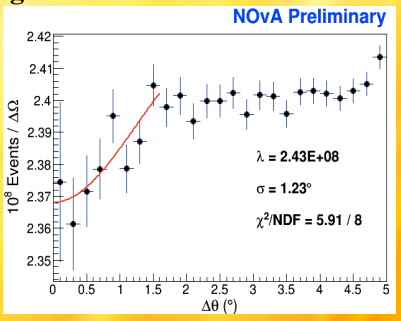
Trigger selection:
The detector's timing resolution allows directionality determination using a timing-based classifier
Triggers run in a stable configuration since December 2014
(275 days of live time)

Trigger rate is ~1 Hz , able to reduce cosmic background by a factor of 10^5

Timing and pointing resolution

Muons travel at the speed of light cross the detector in ~50 ns.
The detector's single hit timing resolution is ~15 ns for a MIP
The red fit is the uncertainty as a function of photoelectrons applied to single hit times used in the LLR fit.

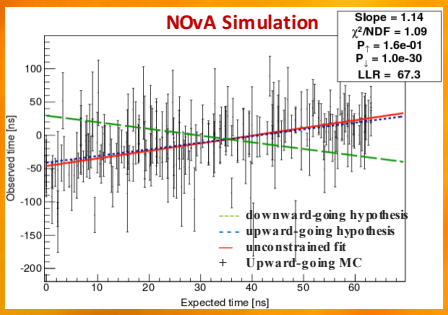




Able to observe the shadow of the Moon in the downward-going cosmic ray muon sample.
Unfolding the angular size of the Moon to extract an upper limit on the angular resolution for pointing at celestial objects.

LLR as discriminant

Three linear fits are then done to the measured time vs the expected time for all hits in the track

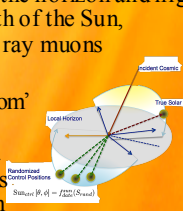


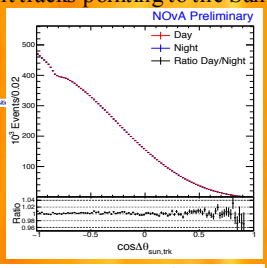
The probability is estimated from upward-going and downward-going hypothesis

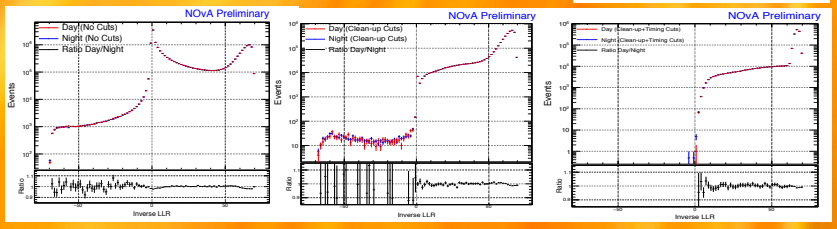
$$LLR = Log_{10}\left(\frac{Prob_{UP}}{Prob_{DOWN}}\right)$$

Control Region and Data Driven Background studies

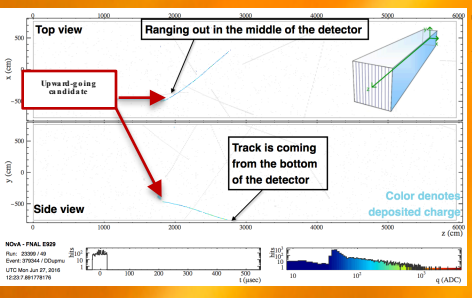
Day tracks pointing at the Sun above the horizon and night tracks pointing to the Sun below the horizon give a different path of the Sun,
so control region check using cosmic ray muons will have a different Δθ distribution
To solve this, we implement a 'phantom' position
for the Sun in the data control region.
For the day sample the Sun position is drawn randomly from the distribution that it follows at night.







Preliminary results

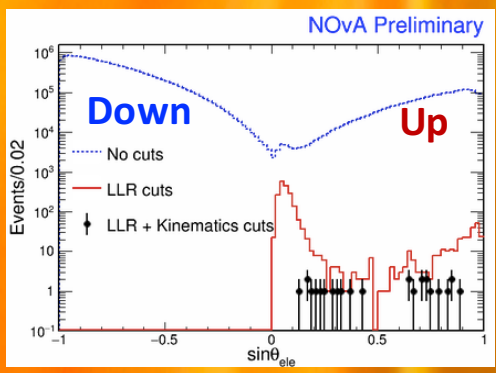


The signal efficiency has been calcutated from cosmic studies and is **~30%**

We Found:

- 33 events in the background sample
- 24 in the twilight region (23 expected)

→ **When unblinding the signal region we expect 63 background events**



Out of ~10^{10} events/day, looking for < 1 event/day!