Transient Source Searches with DeepCore

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Neutrino Transients

GRB, AGNs, SGRs, …
Decoupled neutrons in GRB Jets: 1-100 GeV

Choked GRBs / jets inside core-collapse SNe
Typical energy: 10 GeV – 10 TeV
High event rates for nearby SNe
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Choked Jets in Core Collapse Supernovae

Evidence for choked jets / anisotropy

Correlation between GRBs and Type Ic Sne:

Neutrinos from Choked Jets in CC SNe


\[
E_v^2 \frac{dN_v}{dE_v} = \begin{cases} 
E_v^0 & \text{decay dominated} \\
E_v^{-1} & \text{hadronic cooling dominated} \\
E_v^{-2} & \text{radiative cooling dominated} 
\end{cases}
\]

K  200 GeV  20 TeV
p  30 GeV  100 GeV

IceCube

SN @ 10 Mpc

2nd Low Energy Workshop
Neutrino-Matter interactions

ANIS: neutrino simulation
MMC: particle dE/dx near the detector

All the caveats mention in this workshop apply
Effective Area Calculation

Cascade

$\mathbf{E} > 10 \text{ GeV}
\mathbf{H} = 350 \text{ m}
\mathbf{R} = 125 \text{ m}$

Starting

Through going

$n$

$n_m$

$R$

$H$

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2nd Low Energy Workshop
Effective Areas

Supernova at 10 Mpc with default Ando & Beacom parameter choice:

- $11\ n_m$ with oscillations
- $28\ n_m$ without oscillations

(Oscillations do not lead to 1:1:1)
Event rates in Deep Core

Supernova at 10 Mpc with default Ando & Beacom parameter choice > 10 GeV:
0.6 $n_e$ ; 3.0 $n_m$ ; 0.4 $n_t$

(Oscillations included and it’s not 1:1:1)
What can we see?

Jet pointing prob. 10 – 20 % (???)
CC SN rate within 10 Mpc 1 – 2/yr

Leo I group is just outside this box (~10.8 Mpc)

Ando, Beacom, Yuksel PRL (2005)
Supernova Explosion time

- Given (well sampled) core collapse SN lightcurves, explosion time can be determined to within \(~0.5\) days. Cowen et al. Astropart.Phys. (2010)
- DeepCore Neutrino rate is 300 / day, and 10 GeV neutrinos direction can’t be reconstructed (well enough)
Complement to the Optical Follow Up

IceCube

CPU
Northern Hemisphere

Iridium

SN/GRB

ROTSE III

Fort Davis

Bakınlı Tepe

MT. GAMSBERG

COONABARABRAN

SNe
Optical follow up enhancement

Search for $N \geq 1$ “TeV” event (IceCube) and $M$ “10 GeV” events (DeepCore) in coincidence

$$R_{N,M} = R_a^N R_b^M \frac{\Omega_a^{N-1}}{2\pi} \frac{\Omega_b^M}{2\pi} \frac{\Delta T^{M+N-1}}{(N-1)!M!}$$
Accidental rate examples

Assume $10^5 \, n_m/\text{yr}$ in IceCube; $10^5 \, \text{bckg}/\text{yr}$ in DeepCore; no angular resolution for DeepCore; 100 s search window

1 IceCube $n_m$ & 2 DeepCore evts: 94 / year
1 IceCube $n_m$ & 3 DeepCore evts: 1.4 / year
What’s next?

• Calculate event rates using IceCube software (Jacob Daughhetee)
• Develop a filter, analyze data, etc: farther ahead
• Determine best search strategy. Example 1 > TeV $n_m$ and 1 > 100 GeV $n_m$ ($4^\circ$ resolution – search out to 17 Mpc)
Conclusions, Caveats, Comments

Example SN at 10 Mpc results in 4 DeepCore events.

For CC SNe, DeepCore is sensitive to the pion component of the spectrum and IceCube is sensitive to the kaon component.

Sensitivity to (at least) 10 Mpc – but probably higher due to fluctuations.

I assumed 0.2:0.4:0.4 flavor ratio at Earth, but an energy dependent calculation is needed.

An IceCube software calculation is forthcoming.