Neutrinos from GRBs & other high energy transients with IceCube

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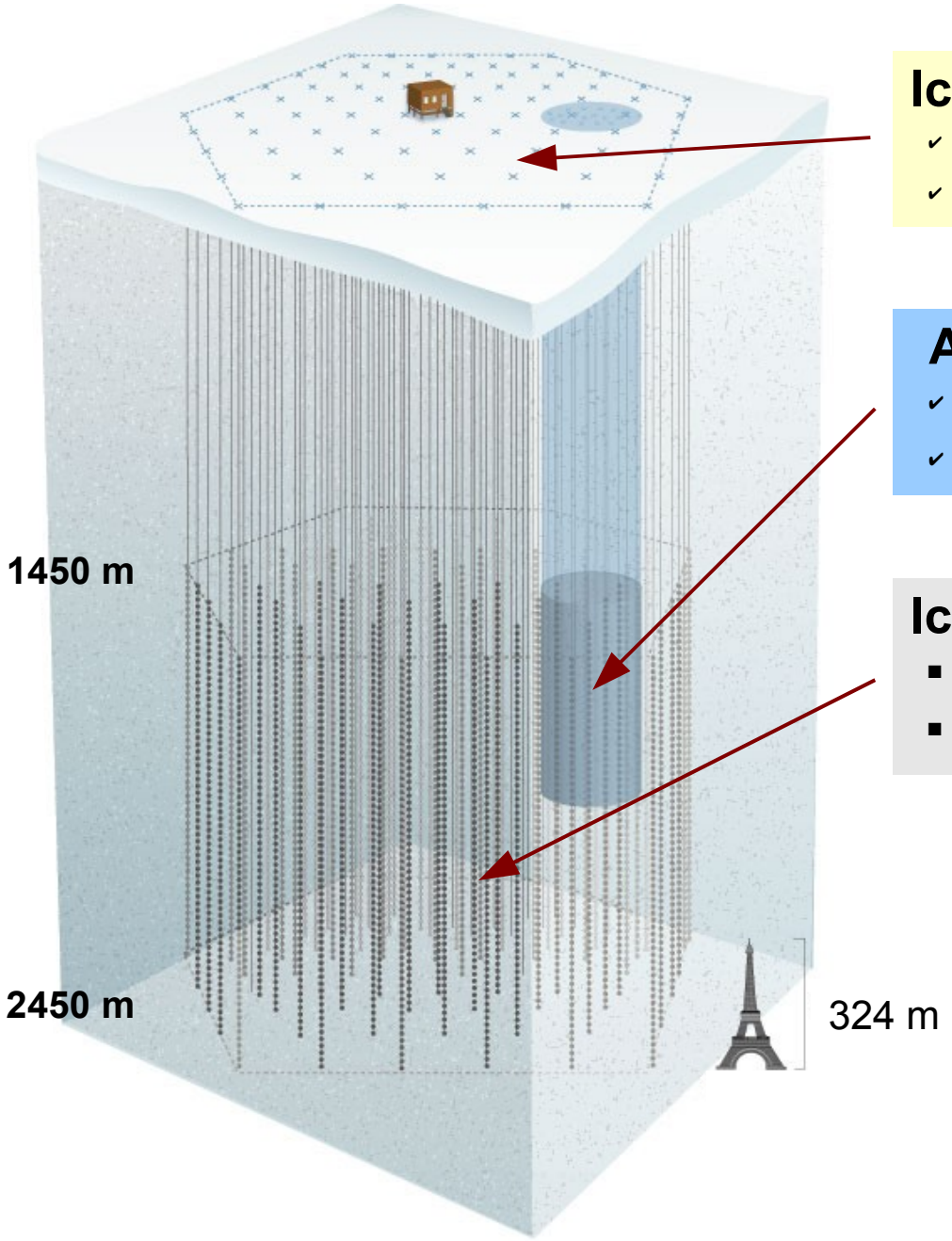
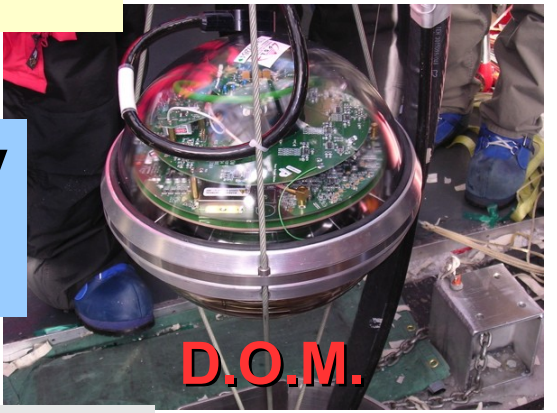
- IceCube
- Short transient search strategies
- Review of AMANDA results
- IceCube Capabilities

IceCube



IceTop: air shower array
- 80 pairs of Tanks
- 2 DOMs per tank



AMANDA: low energy
- 19 strings
- 677 Optical Modules

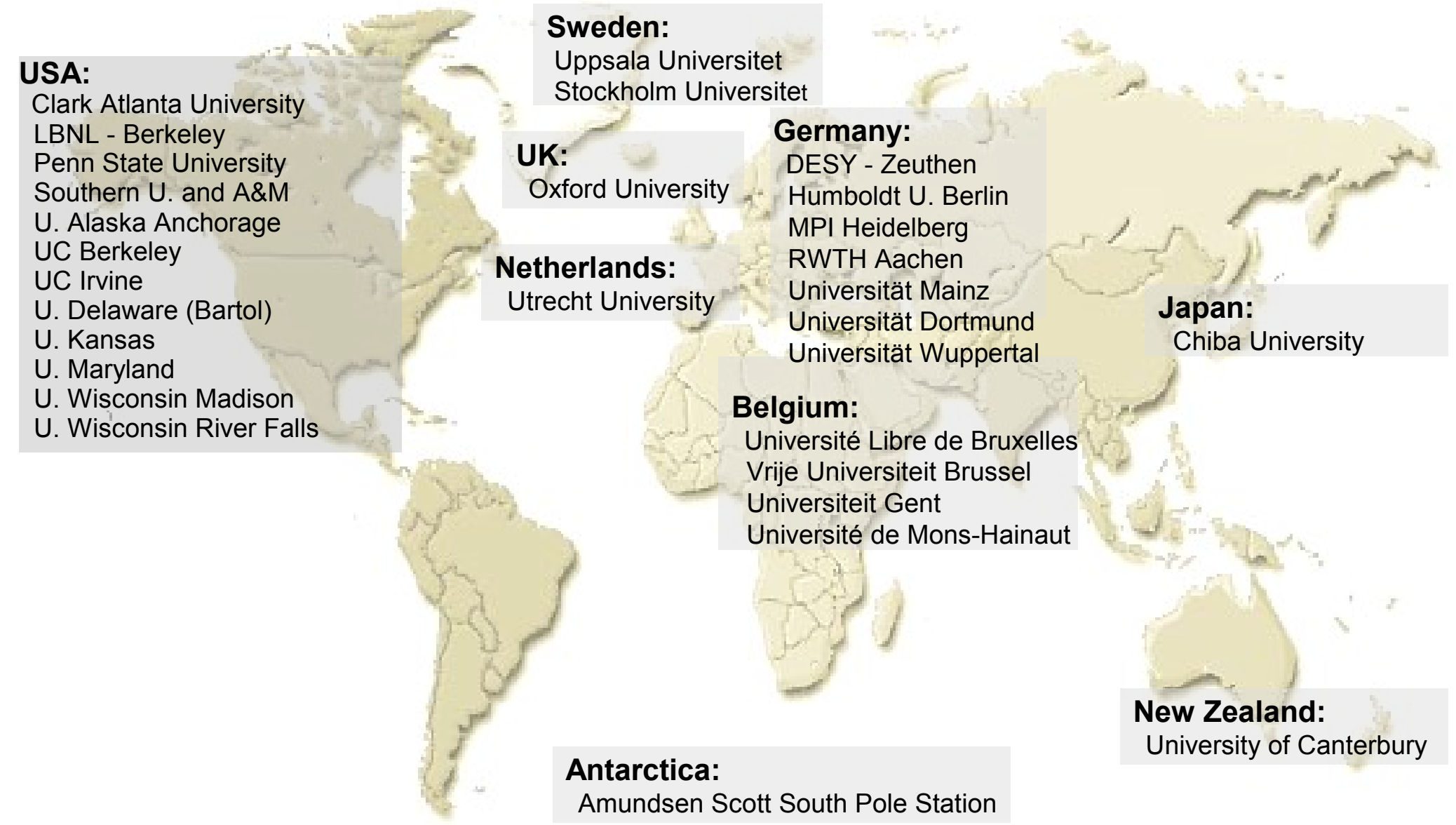
IceCube: deep ice array
- 80 Strings / 60 DOMs each
- 1 km^3 instrumented

Schedule:

2004-2005: 1 String
2005-2006: 9 Strings
2006-2007: 22 Strings
2007-2008: 36-40 Strings

Completion: 2011

The IceCube Collaboration



USA:
Clark Atlanta University
LBNL - Berkeley
Penn State University
Southern U. and A&M
U. Alaska Anchorage
UC Berkeley
UC Irvine
U. Delaware (Bartol)
U. Kansas
U. Maryland
U. Wisconsin Madison
U. Wisconsin River Falls

Sweden:
Uppsala Universitet
Stockholm Universitet

UK:
Oxford University

Netherlands:
Utrecht University

Germany:
DESY - Zeuthen
Humboldt U. Berlin
MPI Heidelberg
RWTH Aachen
Universität Mainz
Universität Dortmund
Universität Wuppertal

Belgium:
Université Libre de Bruxelles
Vrije Universiteit Brussel
Universiteit Gent
Université de Mons-Hainaut

Japan:
Chiba University

New Zealand:
University of Canterbury

Antarctica:
Amundsen Scott South Pole Station

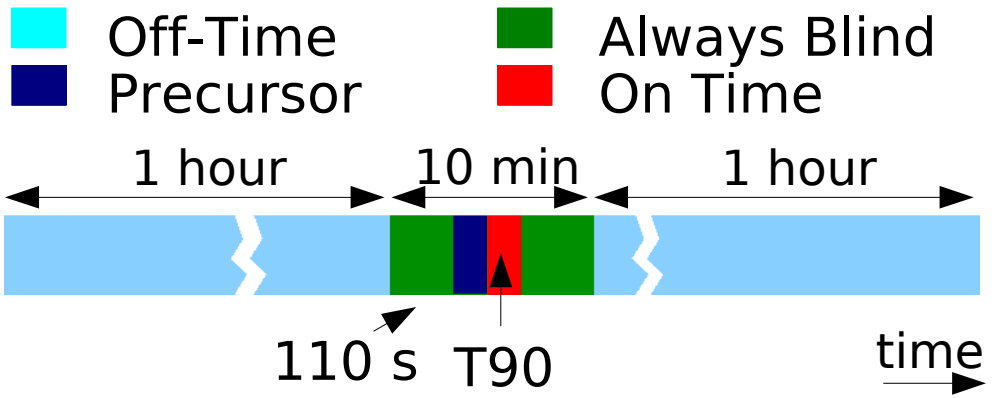
In March 2005, AMANDA merged into the IceCube collaboration

High Energy Short Transient Sources

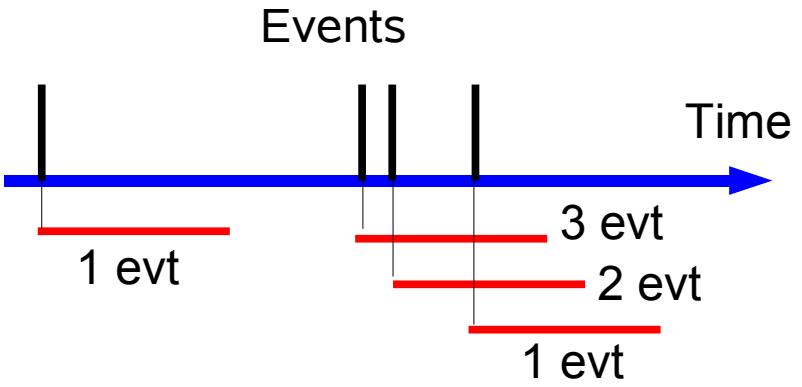
Short Transient: < 1000 s neutrino emission
High Energy: > 1 TeV
(See talk by M. Tluczykont for other high energy transients)

- **Gamma Ray Bursts**
  - Burst
  - Precursor
  - Afterglow and X-ray flares
- Choked GRBs
- TeV neutrinos from Core Collapse Supernovae
- Soft Gamma-ray Repeaters
- Other ...

Short Transient Search Strategies



Satellite Triggered Search



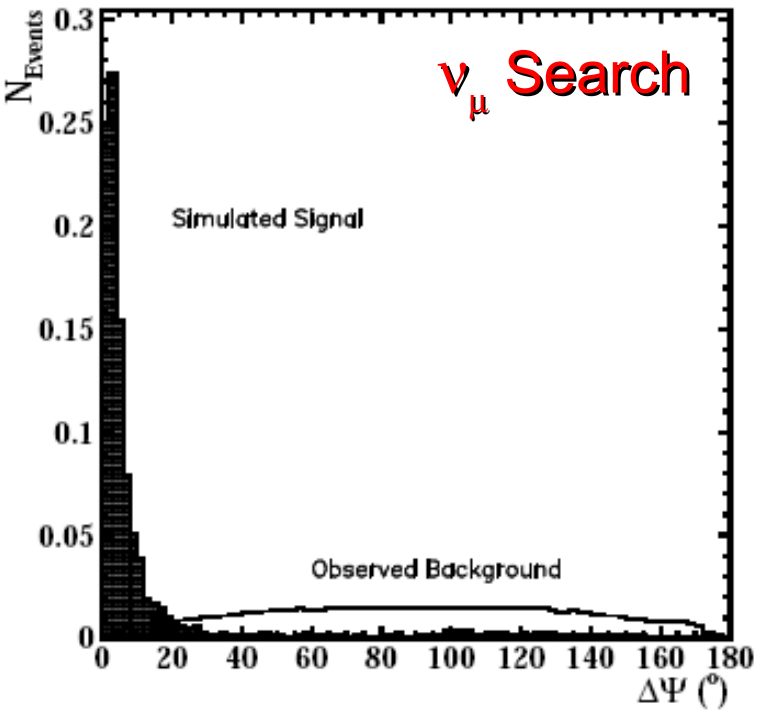
Rolling Search

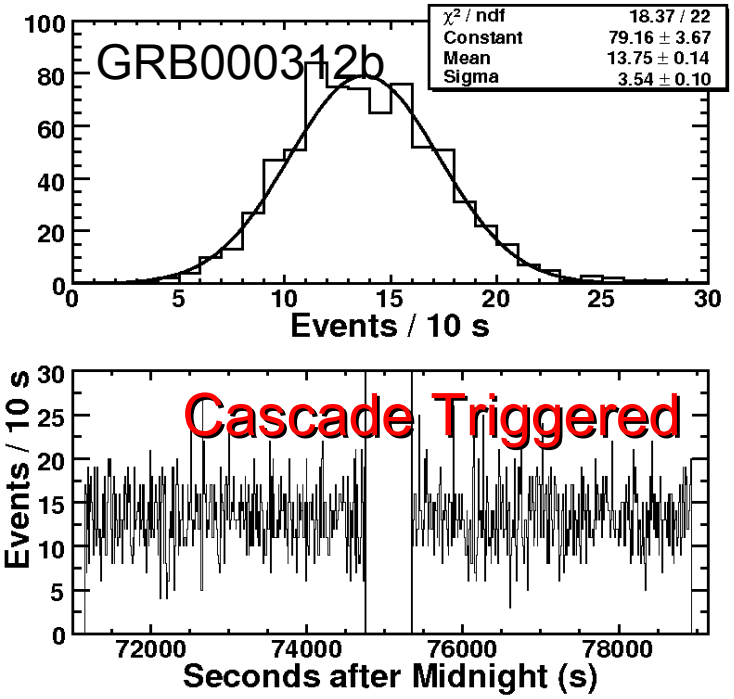
For all techniques:

Time and directional correlation is used to greatly reduce background

Optical Follow-up
(See talk by M. Kowalski)

GRB neutrino searches with AMANDA





Channel	Model	Bursts	Satellite(s)
ν_μ Search	Burst	419	BATSE+IPN
ν_μ Search	Precursor	60	IPN
Cascades (Triggered)	Burst	73	BATSE
Cascades (Rolling)	Burst	(1300)	N/A

Achterberg A. et al. ApJ 664:397 (2007) || Achterberg A. et al. ApJ. In press

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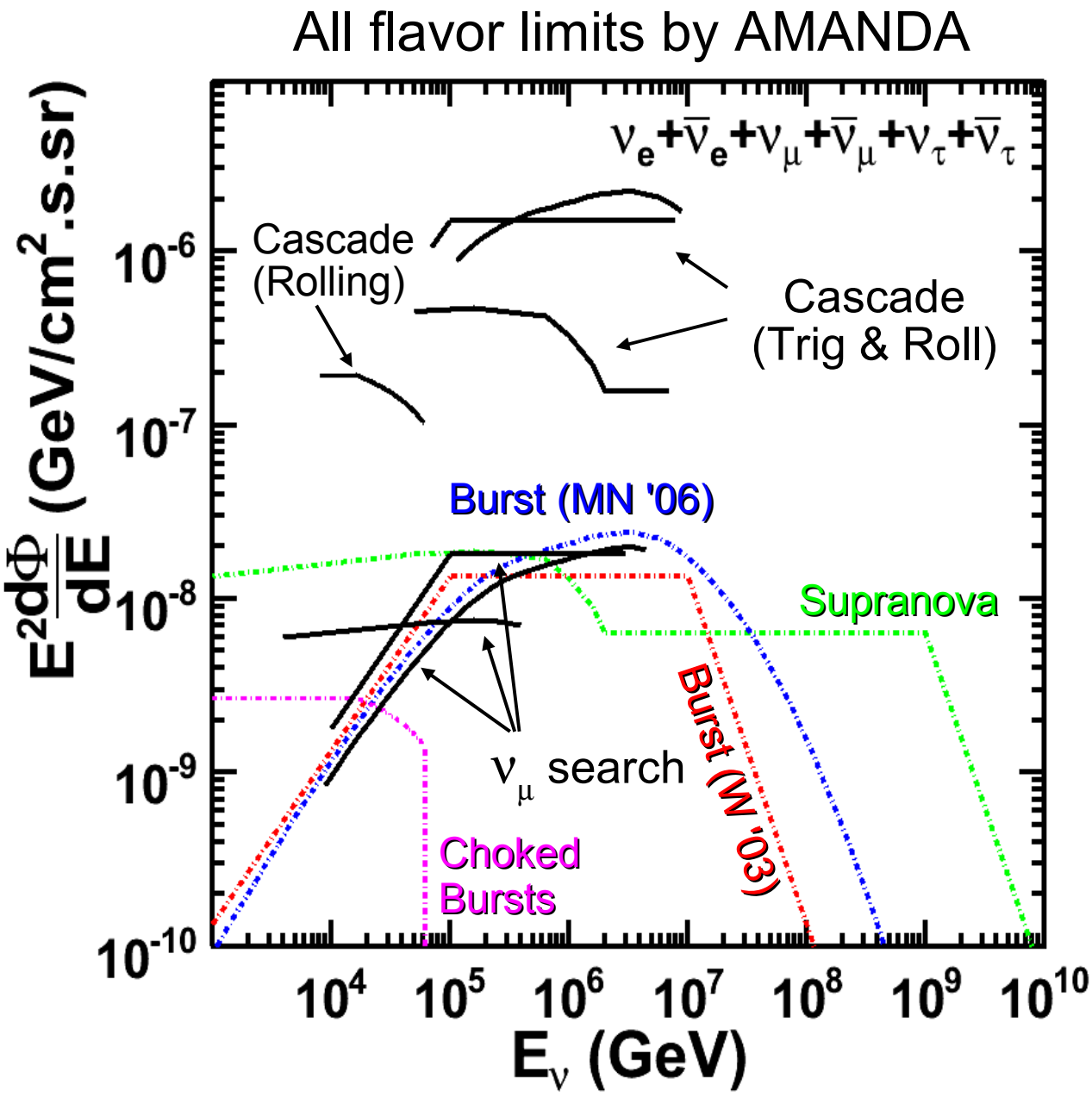
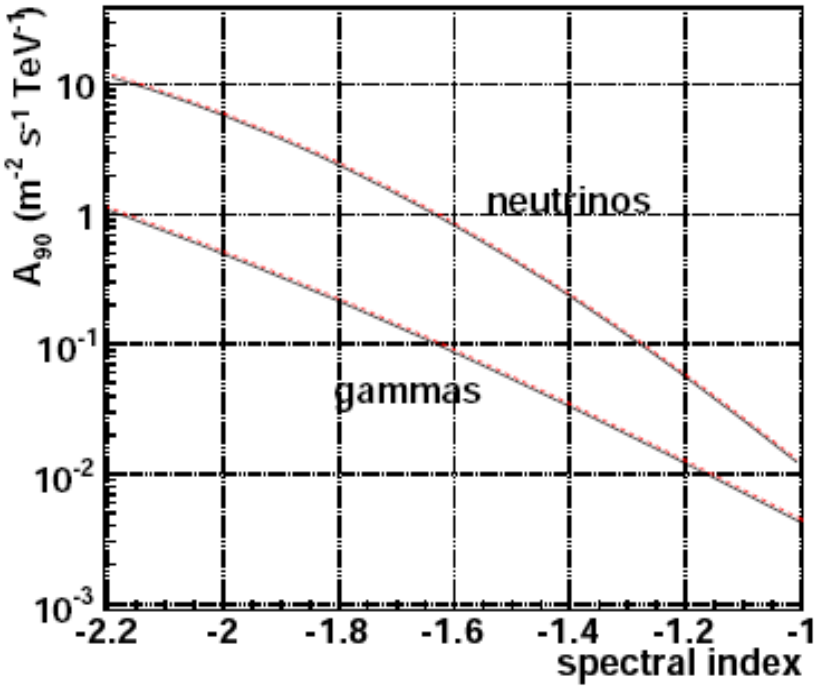
Neutrino Limits from GRBs

- Only rolling search is sensitive to choked bursts (γ-ray dark)
- Searches have focused on burst and precursor emission



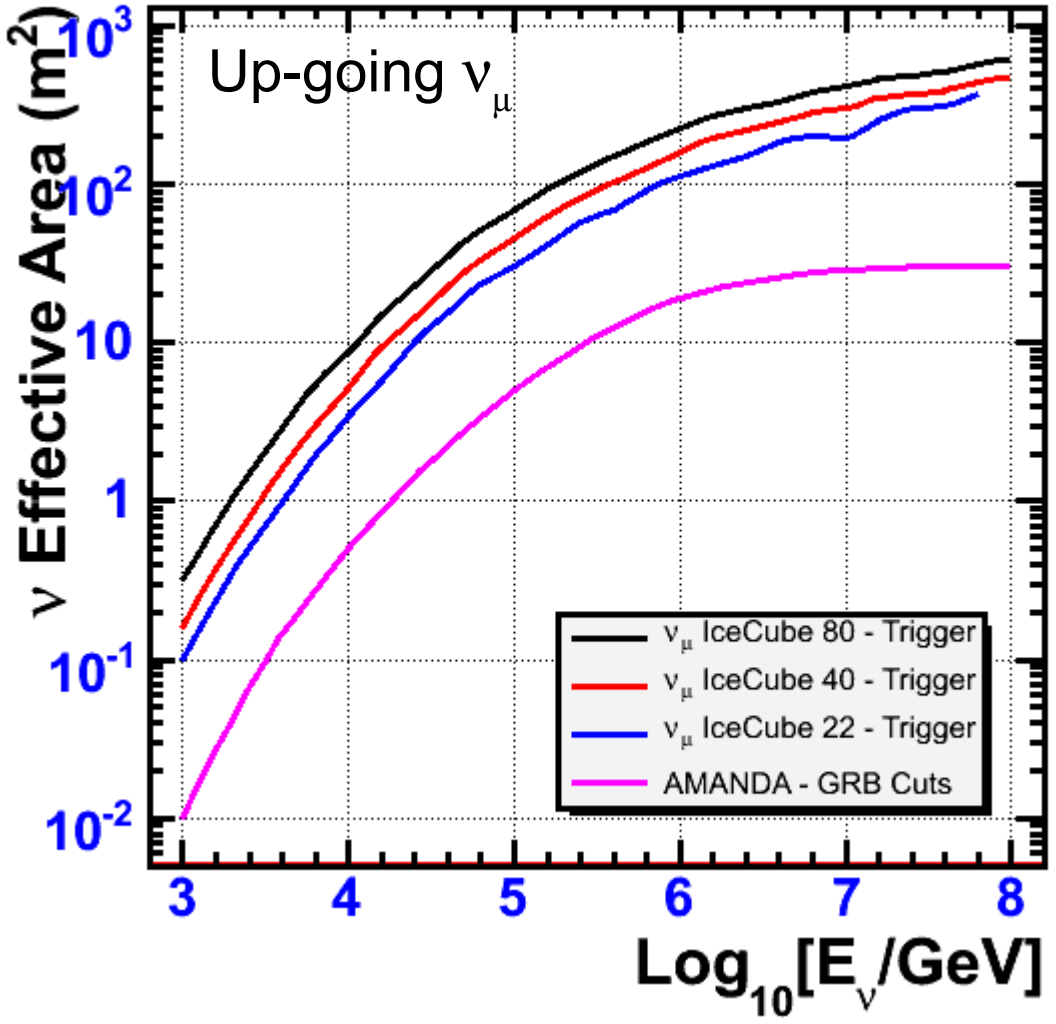
Neutrino/γ-ray limits from SGR 1860-20

- Dec 27, 2004:
  Brightest gamma-ray source ever observed
- Potential source of high energy photons and/or neutrinos.
- Similar search technique as "triggered searches" for GRBs
- It is possible to search above the horizon.



Achterberg A. et al. Phys.Rev.Lett. 97:221101 (2006)

IceCube Capabilities



- IceCube will be more than one order of magnitude more sensitive than AMANDA
- IceCube-22 (2007) and IceCube-40 (2008) are very competitive with full IceCube for short transient sources
- GRB analysis signal efficiency for AMANDA searches: ~75% (with respect to trigger).
- Improved angular resolution: search above the horizon

GRBs, Satellites and IceCube

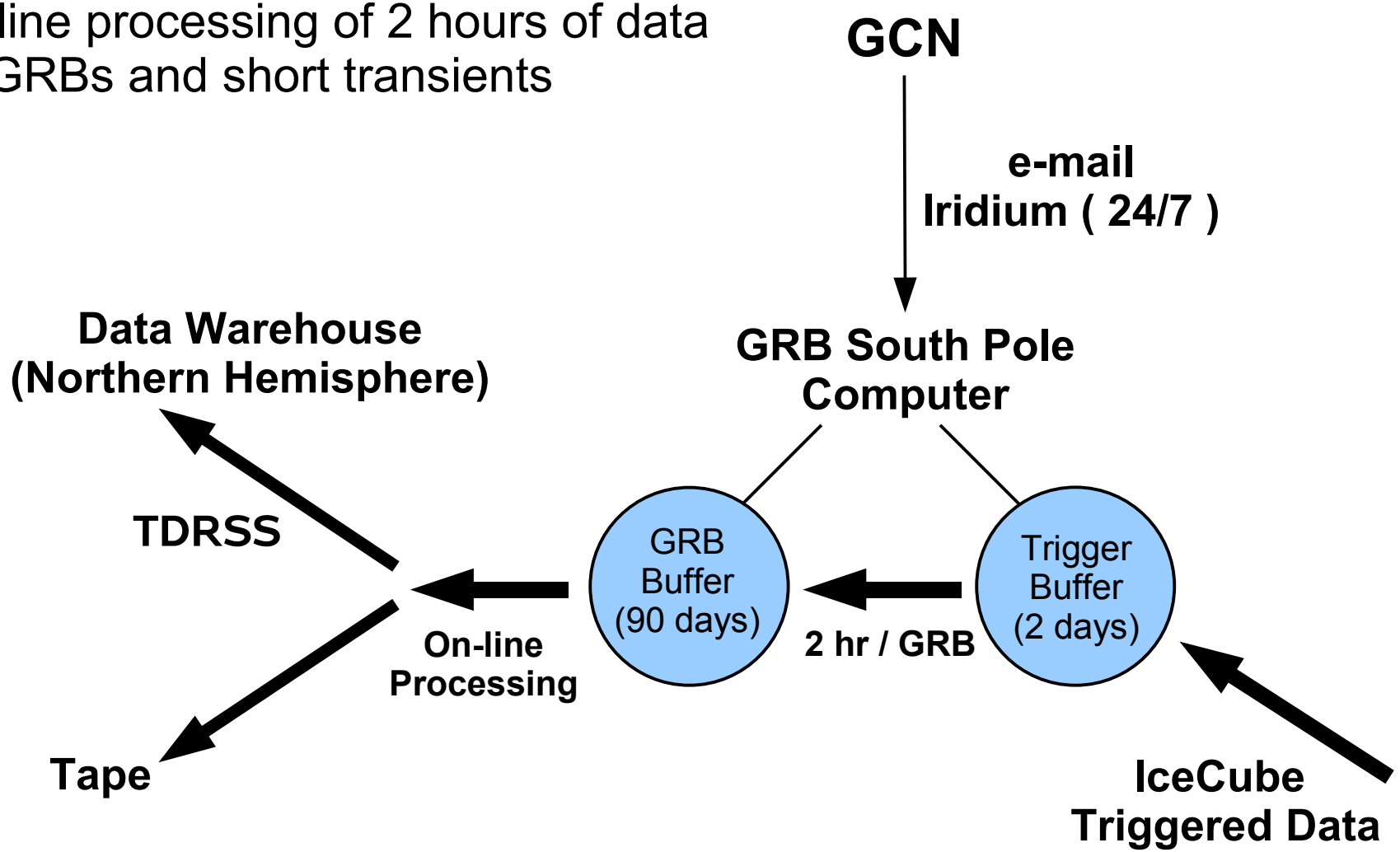
"Ideal Satellite" for IceCube:

- Wide Field of View (shallow and wide search)
- Better pointing than IceCube
- Can measure E_{peak} directly (typically 30 keV – 1 MeV)

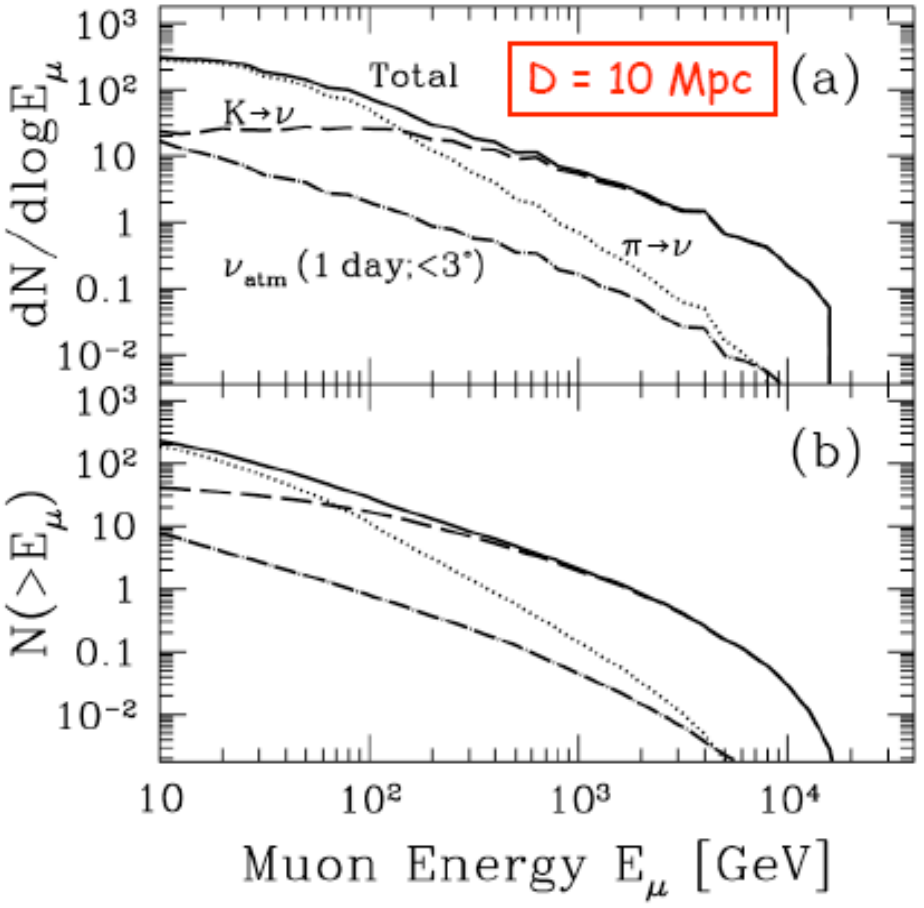
		FoV (sr)	PSF	Band	Operation
IceCube ν_μ		2π (δ>0)	0.5°		
IceCube Cascades		4π	N/A		
Integral	IBIS	0.02	12'	15 keV – 10 MeV	Oct '02 -
Swift	BAT	1.4	15'	15 – 150 keV	Nov '04 -
Agile	SuperAgile	1	6'	15 – 60 keV	Jun '07 -
	mCal	N/A	N/A	300 keV – 100 MeV	
GLAST	GBM	9.5	1.5°	8 keV – 30 MeV	Apr '08 -
	LAT	2.4	15'	20 MeV – 300 GeV	

GRB IceCube Filter

- Fast analysis of GRB / Transients data
- Working since June 2007
- On-line processing of 2 hours of data for GRBs and short transients



TeV ν from core collapse SNe



- For a SN at 30 Mpc, IceCube is predicted to observe ~3 events in 10 s.
- SN explosion time uncertainty ~1 day (rolling analysis)

Ando S & Beacom J, Phys.Rev.Lett 95:061103 (2005)

Analysis in planning stage

Conclusions

- AMANDA has conducted several searches for short transient sources. AMANDA ν_μ limit is very close to Waxman-Bahcall GRB diffuse flux.
- IceCube will be more than one order of magnitude more sensitive than AMANDA.
- IC-22 (2007) and IC-40 (2008) will be very competitive with IC-80 for short transient sources.
- Automatic GCN notice handling system already working
- IceCube will study many interesting objects: GRBs, SNe, SGR, the unforeseen, etc.

OVERFLOW

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GRB neutrino searches - IceCube

- Triggered searches
  - We are striving for fast analysis/publication cycle
  - We will use both up-going muon and cascade channels
  - We will use un-binned methods to enhance up-going muon sensitivity
  - We will have model dependent searches (precursor, burst, afterglow) and model independent searches (2 hour search window, generic power law spectrum)
  - IceCube 3σ sensitivity will reach the WB flux after studying 70 (280) Batse-like GRBs with up-going muons (cascades)
- Rolling analysis in planning stage