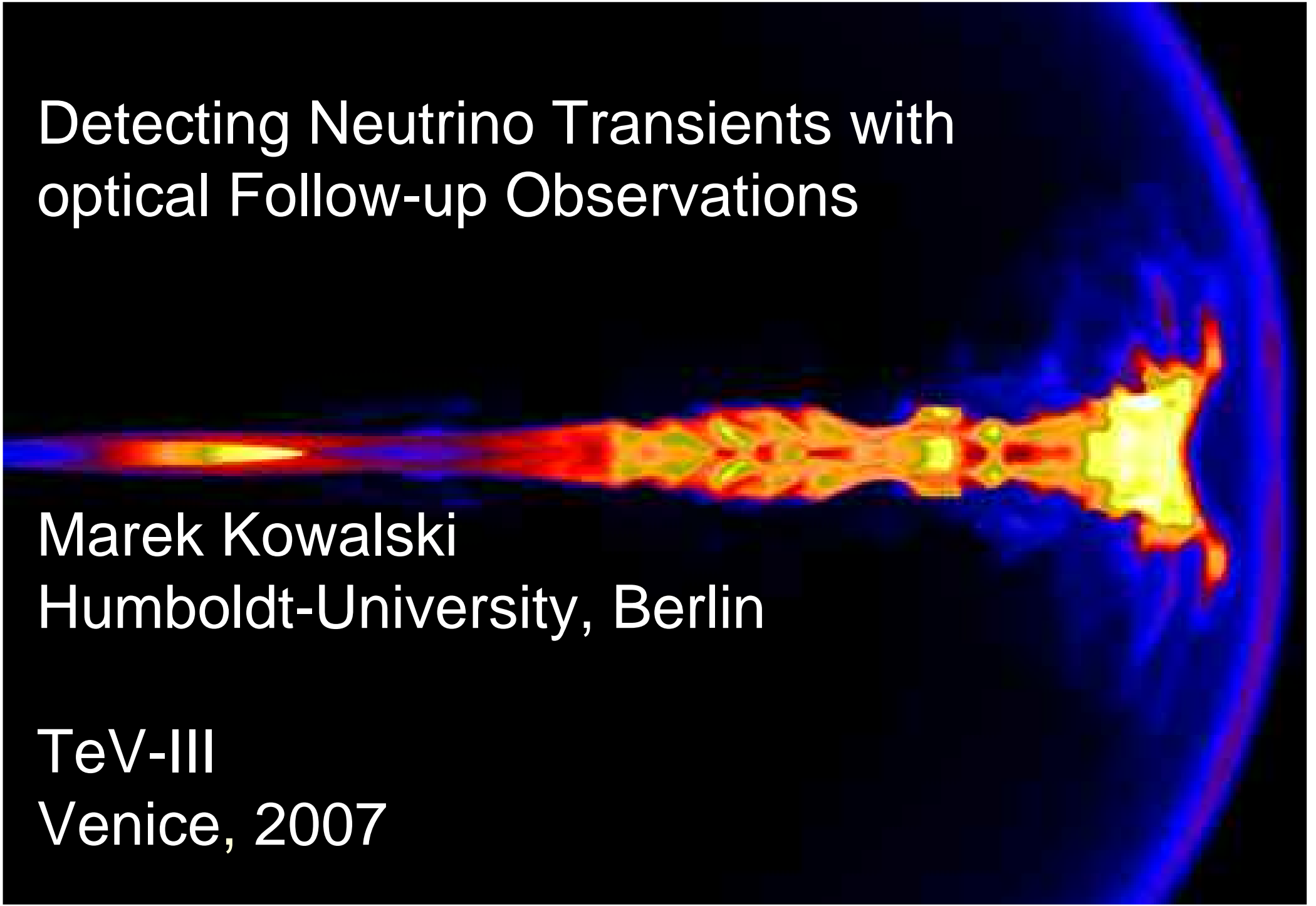


# Detecting Neutrino Transients with optical Follow-up Observations

Marek Kowalski  
Humboldt-University, Berlin

TeV-III  
Venice, 2007



# Testing the Supernovae-GRB connection

Gravitational collapse of  
a very massive, rotating  
star ( $>25 M_{\odot}$ ):

## Observation:

Rate of GRBs is just  $\sim 1\%$  of SNe Ib/c.

## Question:

Could there be mildly relativistic jets  
( $\Gamma$  of a few) inside many SNe?

## Neutrinos could provide the answer:

SN @ 10 Mpc: 30 neutrino events in a  
cube-kilometer detector!

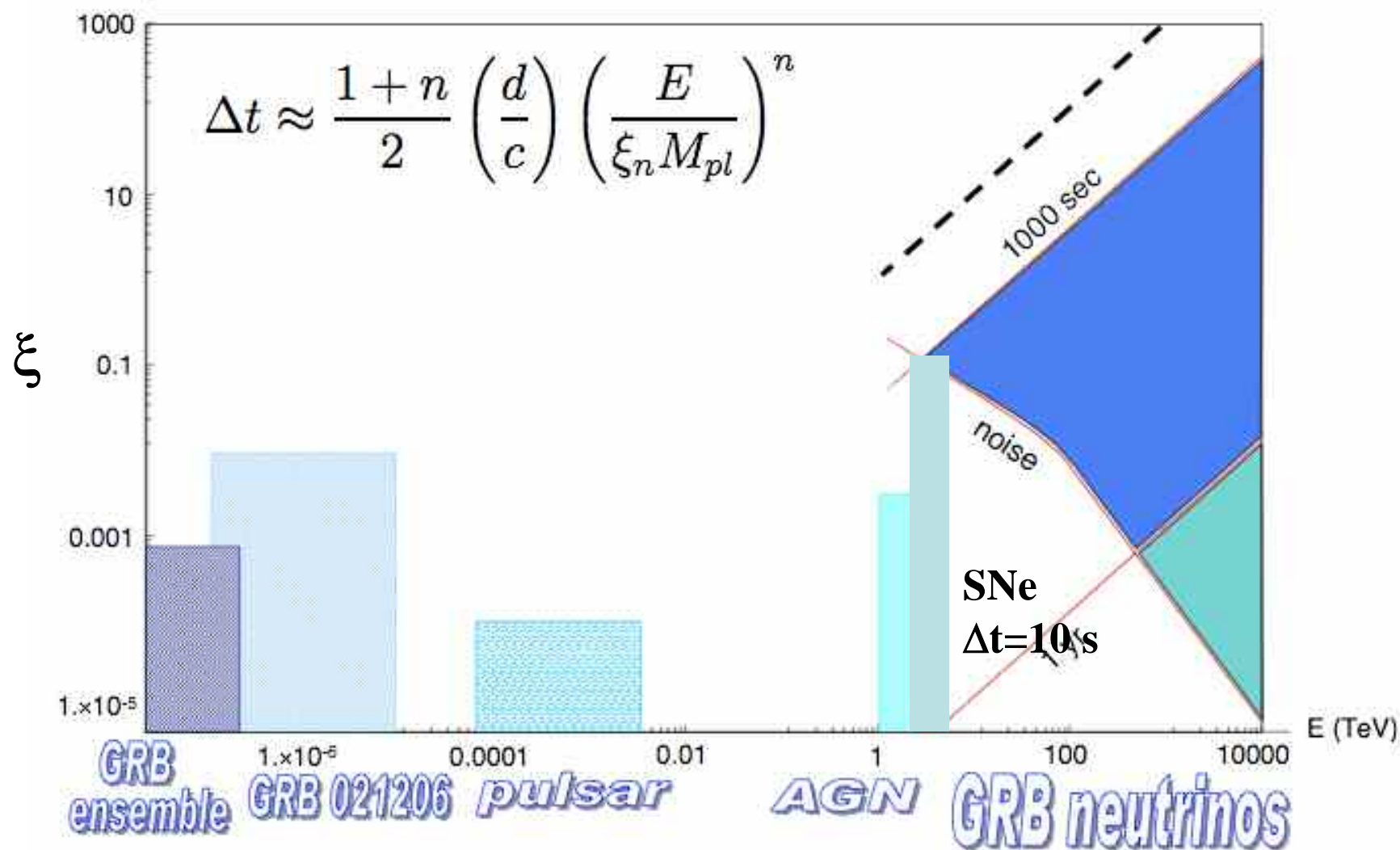
Ando & Beacom, PRL (2005);

Razzaque, Meszaros & Waxman, PRL (2005).

Simulation: MacFadyen (2000)

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

# Constraints on Quantum Gravity



Energy (TeV)

Jacob, Piran 2006

# Optical Neutrino Follow-up



**IceCube**

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

# Optical Neutrino Follow-up

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

network of optical  
telescopes

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

IceCube Neutrino-Trigger



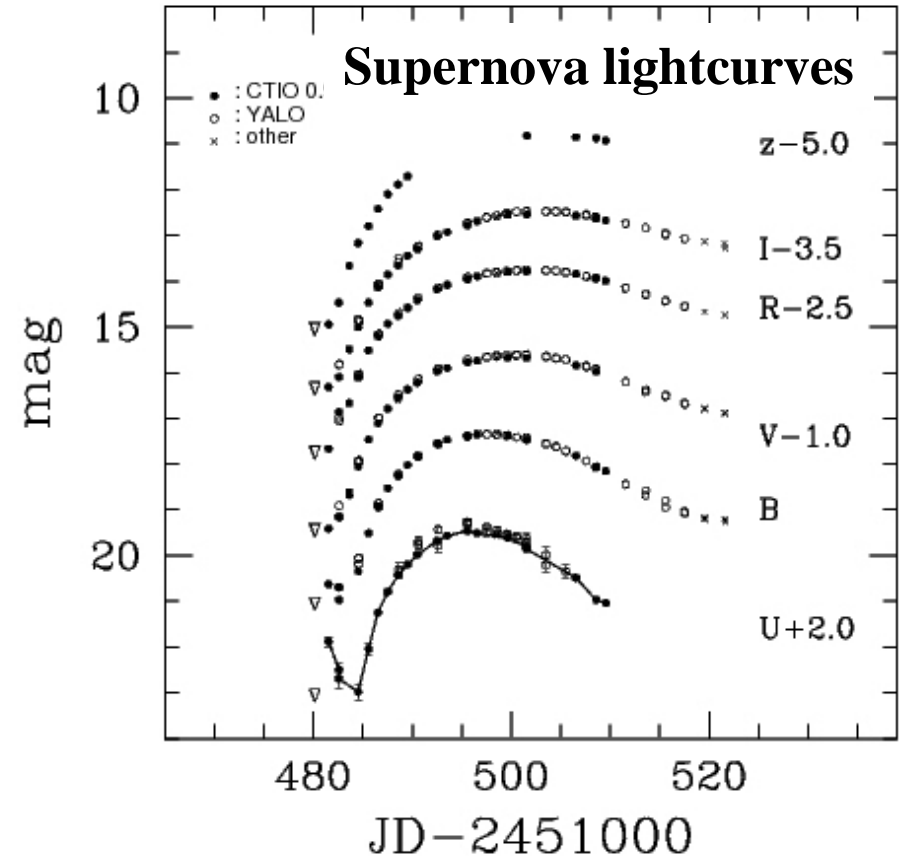
optical  
detection

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

# GRB / Supernova identification

## Search for transient sources:

- ✓ **Supernova** (rising lightcurve)

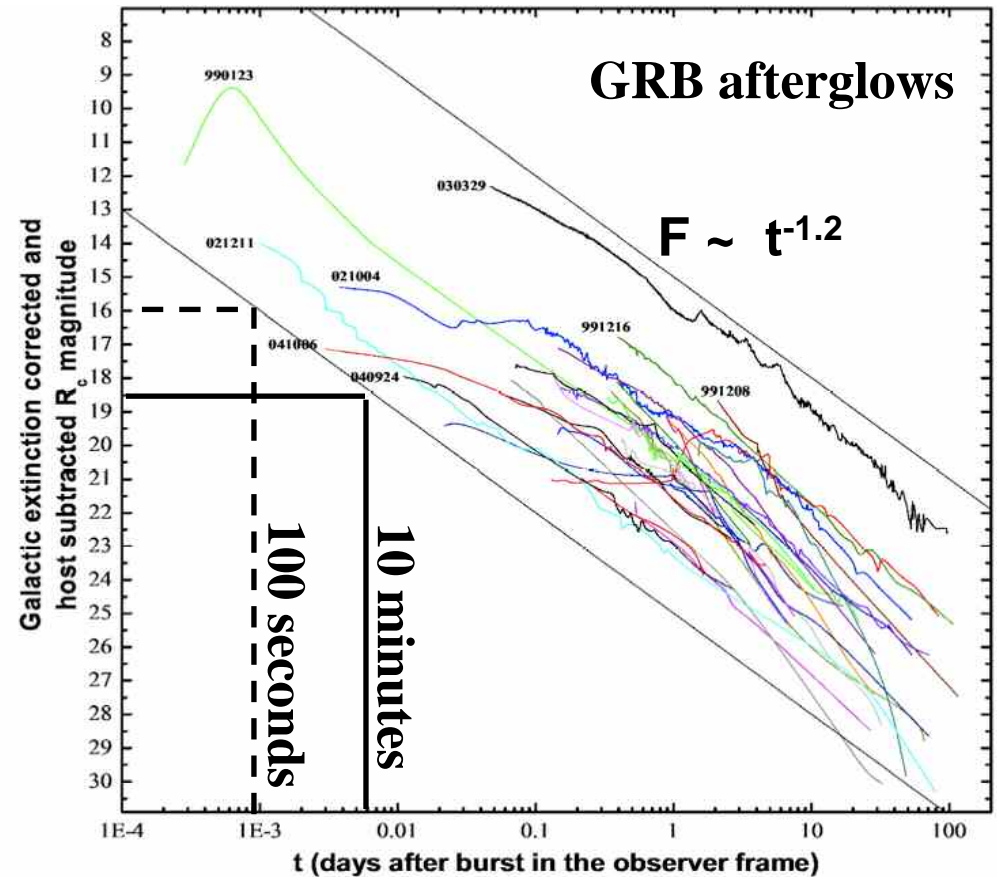


Strizinger et al. (2003)

# GRB / Supernova identification

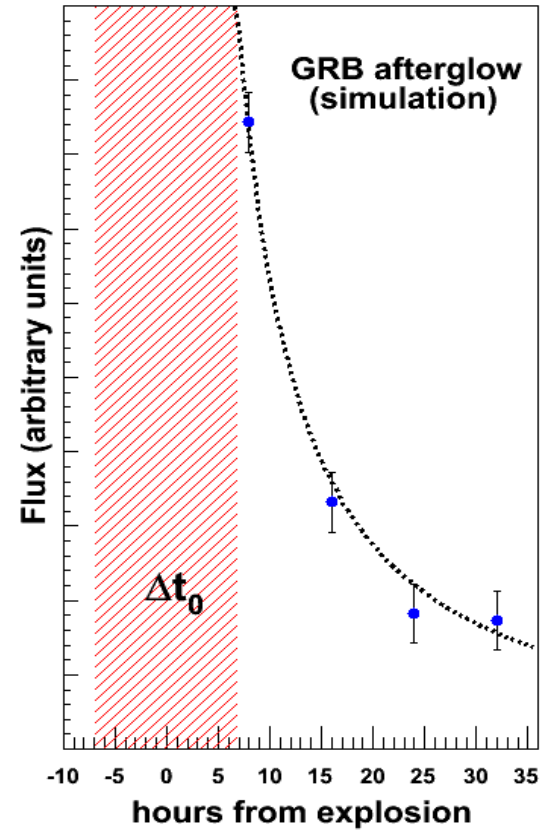
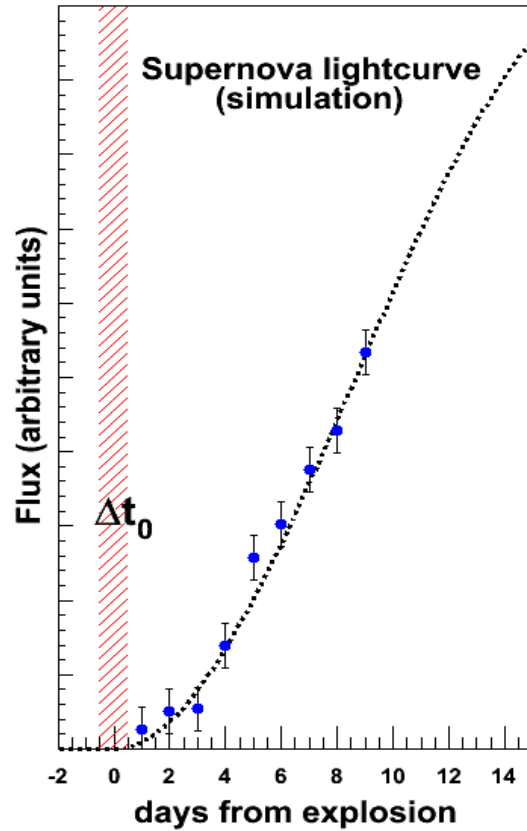
## Search for transient sources:

- ✓ **Supernova** (rising lightcurve)
- ✓ **Gamma-Ray Burst** (afterglow)
- ✓ **Gamma-Dark Bursts** (orphan afterglows)



Kahn et al., 2006

# GRB / Supernova identification



Time of explosion:

$$\sigma(F) = 5\% \Rightarrow \sigma(t_0) \approx 0.5 \text{ days}$$

# Neutrino burst trigger

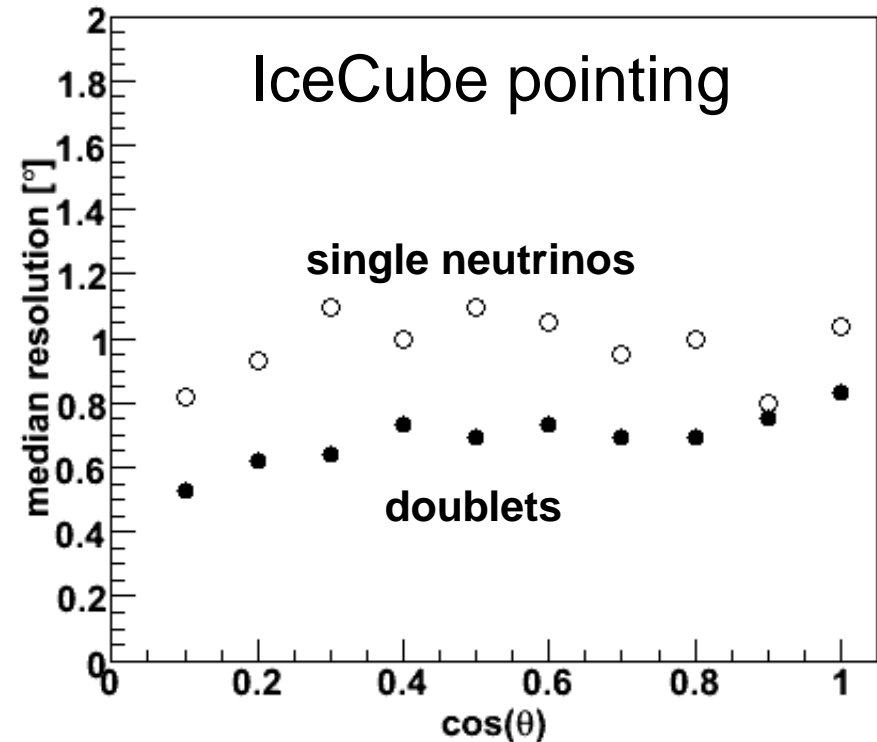
Doublet background rate:

$$R_{doublet} \approx R^2 \frac{\Delta\Omega}{2\pi} \Delta t \approx 5 \text{ yr}^{-1}$$

250  $\nu_\mu$  a day  
For IceCube

$2^\circ \times 2^\circ$

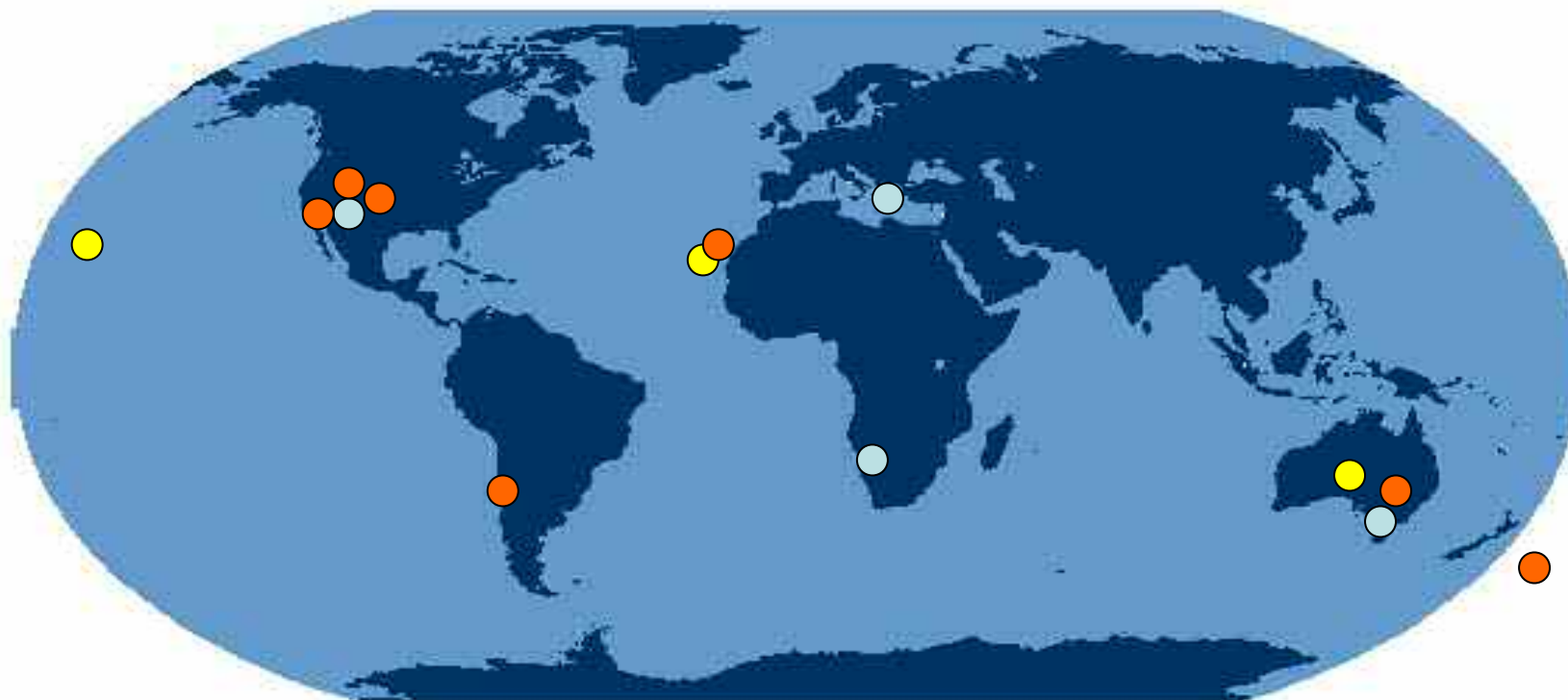
100 seconds



Kappes et al., 2007

**Background rate of 5 per year,  
but Field-of-View of  $2^\circ \times 2^\circ$  needed.**

# Global network of robotic telescopes



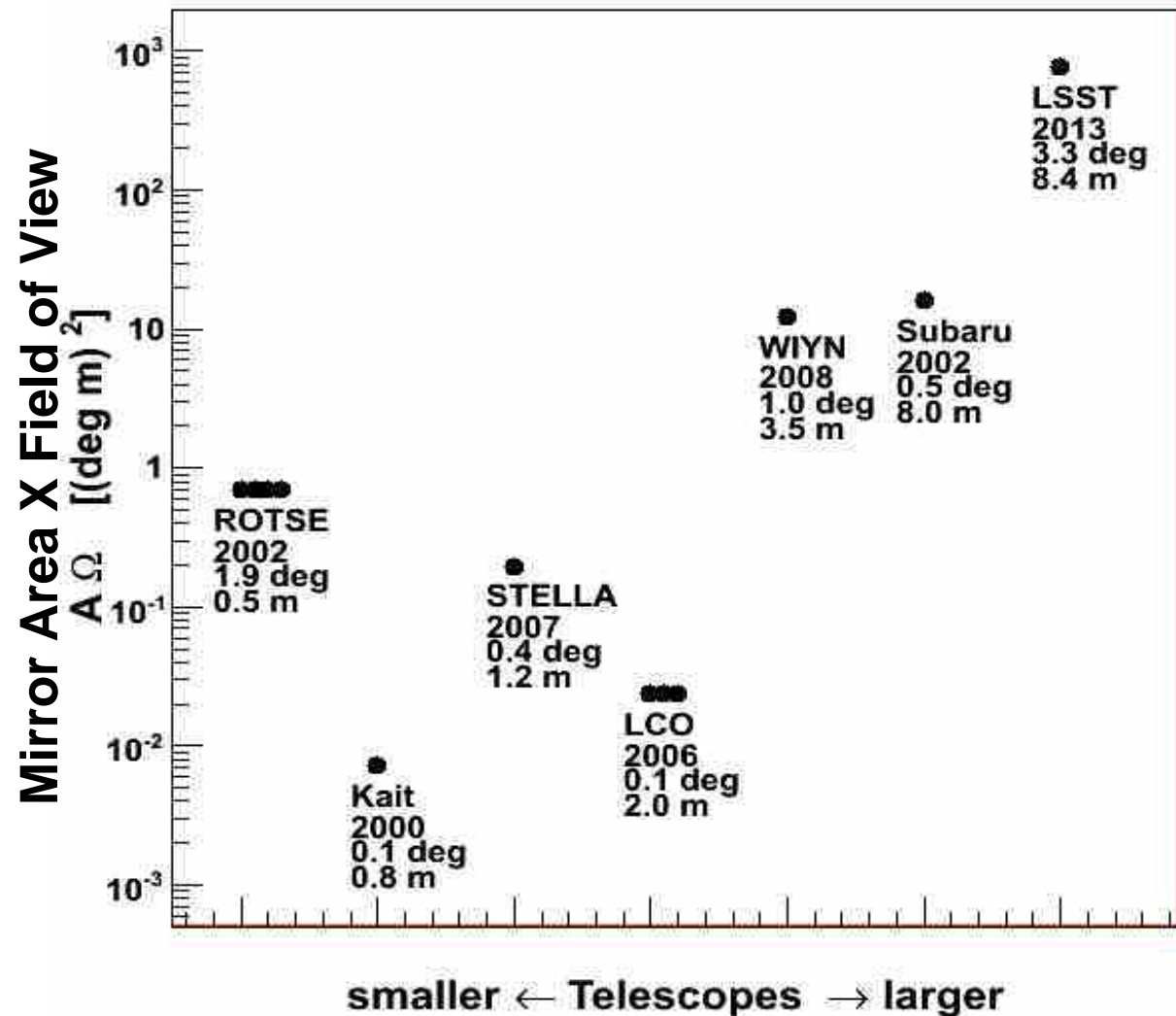
- ROTSE III  
4 x 0.45 m  
FoV:  $1.9^\circ \times 1.9^\circ$   
rapid follow-up

- Robonet-1.0  
3 x 2.0 m  
FoV:  $0.1^\circ \times 0.1^\circ$   
follow-up of ROTSE

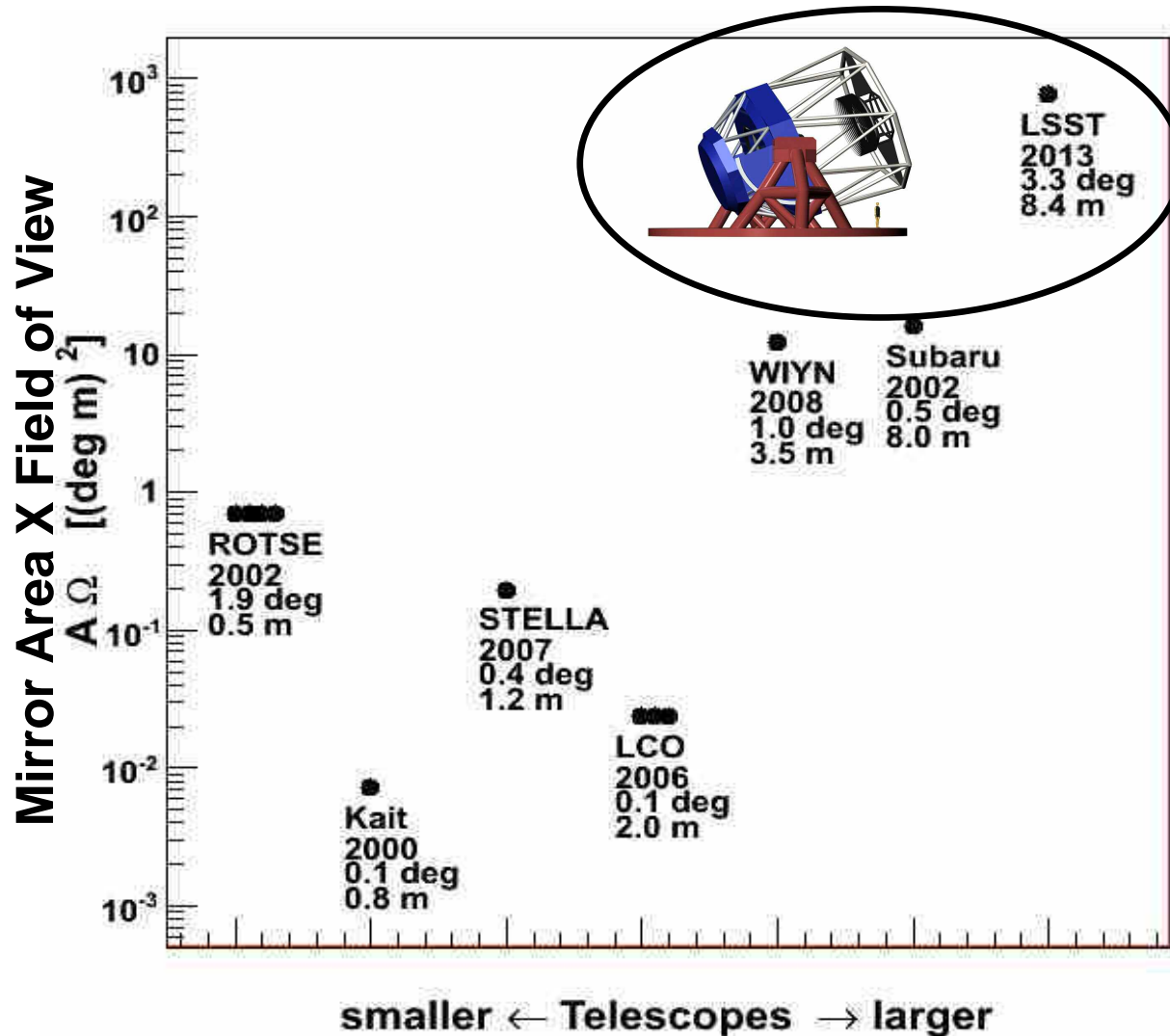
QuickTime™ and a  
TIFF (Uncompressed) decompressor  
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# Correlating every neutrino ( $\sim 10^5/a$ )?



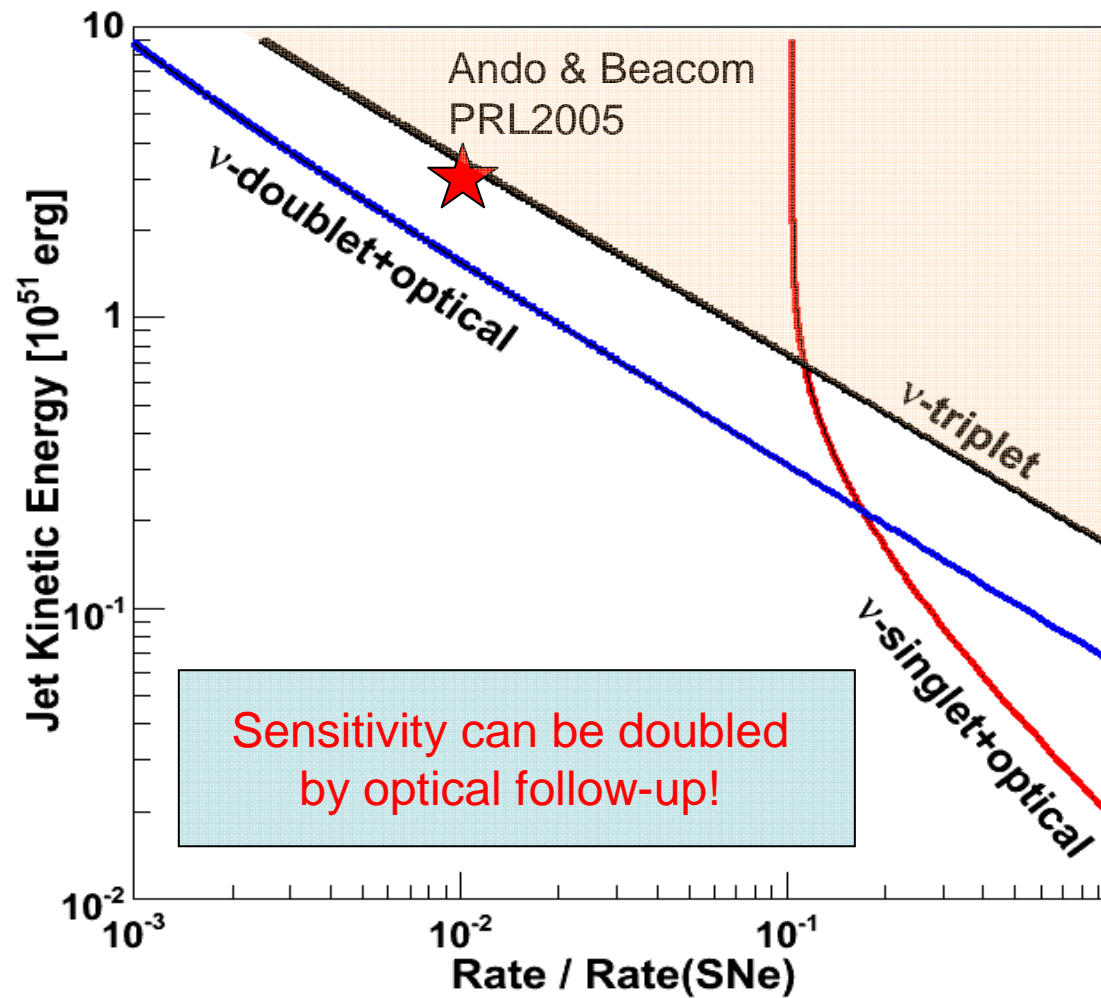
# Correlating every neutrino ( $\sim 10^5/a$ )?



**Next generation of Wide-Field-Imagers: full sky coverage of the optical sky with 3-7 day cadence.**

**Offline correlation of every neutrino will be possible!**

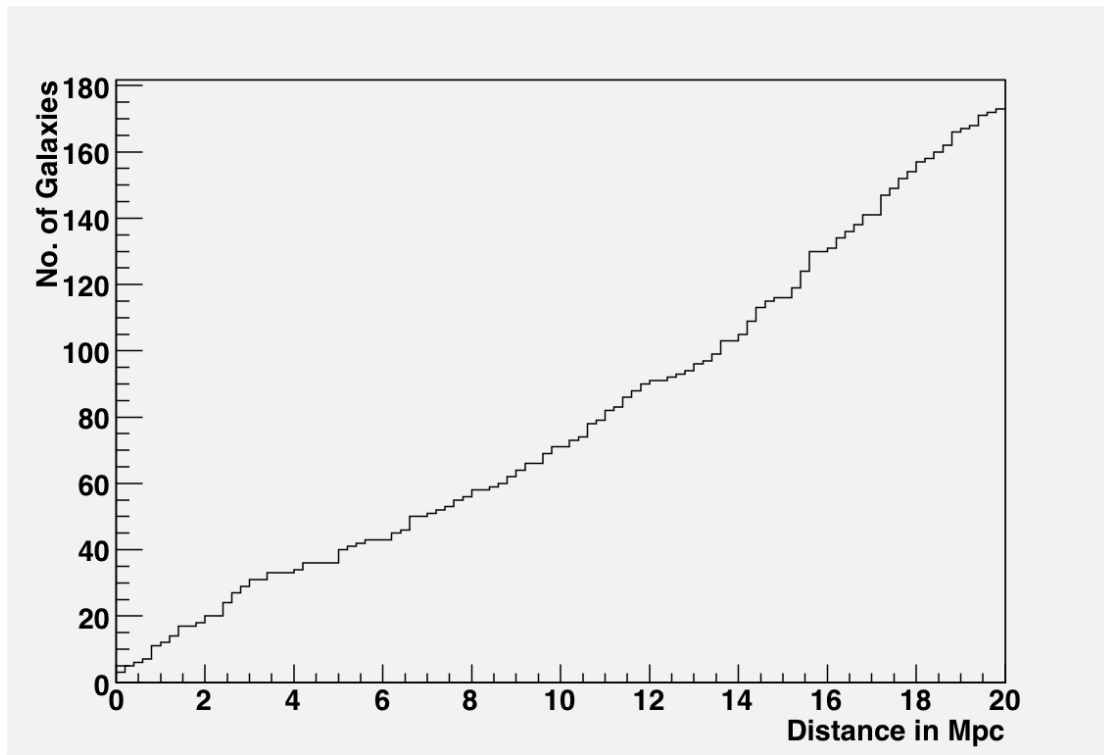
# Supernova sensitivity



# Conclusion

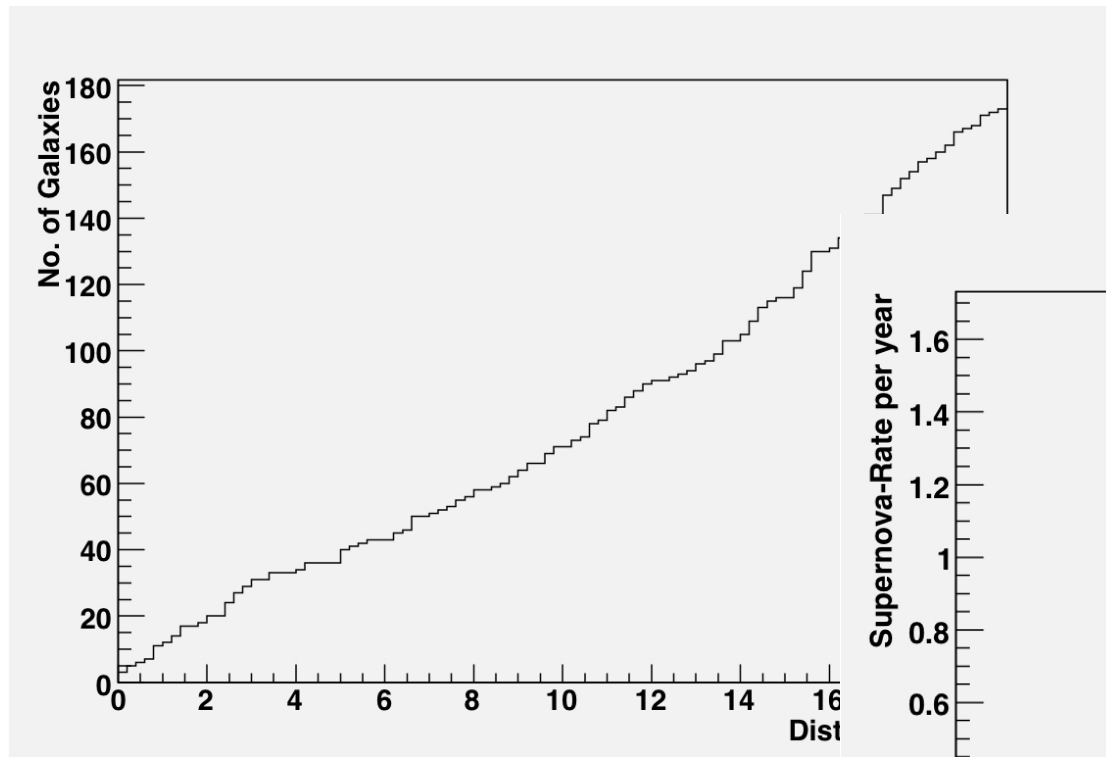
- An observation proposed using neutrinos to trigger follow-up observations (see also talk by M. Tluzykont)
- Significant sensitivity improvement for SNe, and perhaps GRBs
- For some cases it is the only way to identify the source
- Robotic telescopes for follow-up observations exist and are ready

# Can we observe all SNe within a certain distance and do the correlation with neutrinos offline?



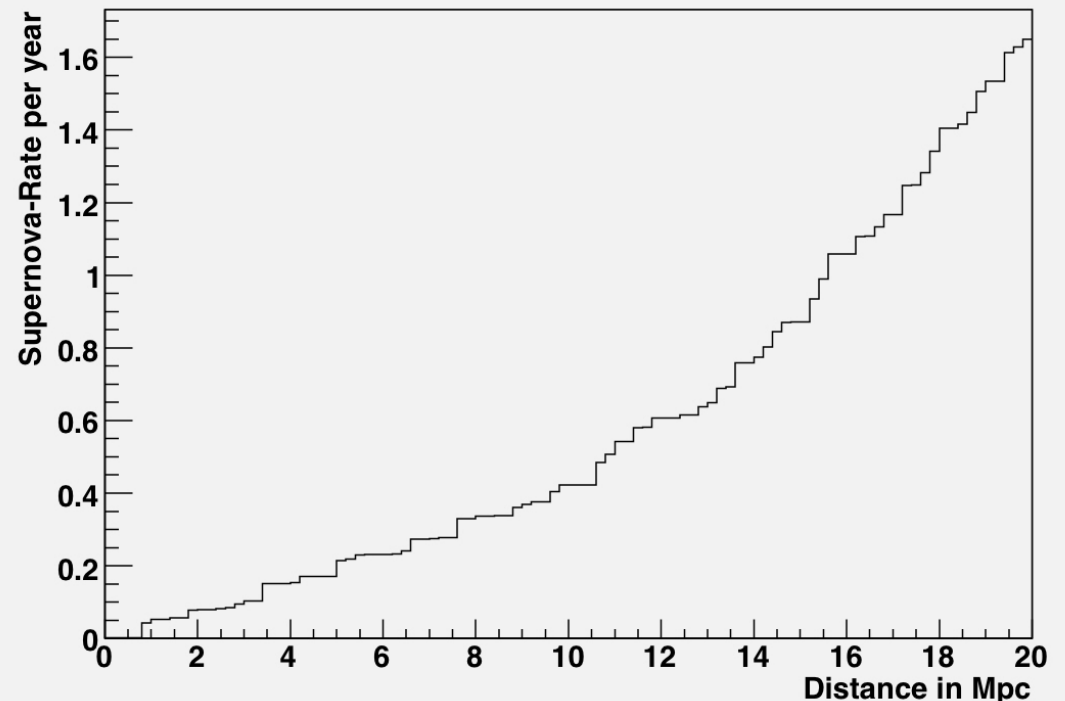
Galaxy data from HyperLeda,  
[Paturel et al. 2003 A&A,412, 45]

# Can we observe all SNe within a certain distance and do the correlation with neutrinos offline?

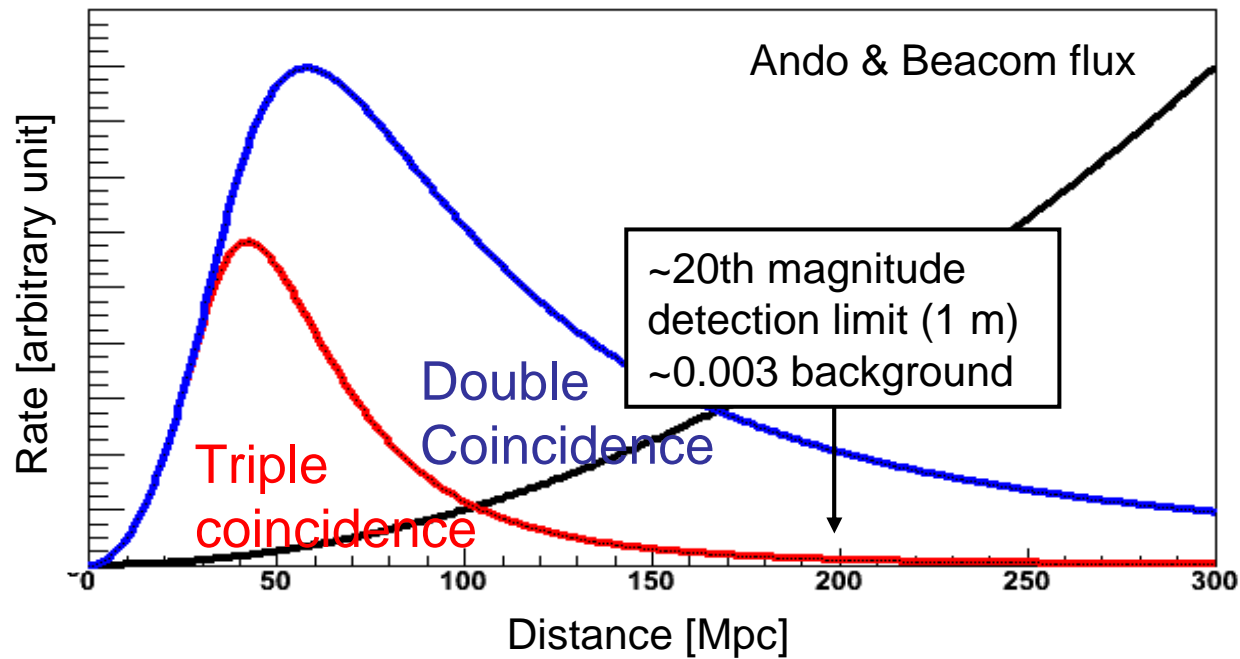


Galaxy data from HyperLeda,  
[Paturel et al. 2003 A&A,412, 45]

Galaxy B-band magnitude converted to SNe rate using type dependent conversion [Cappellaro 99]



# Distribution of Supernovae (simulation)



# Optical Neutrino Follow-up

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.