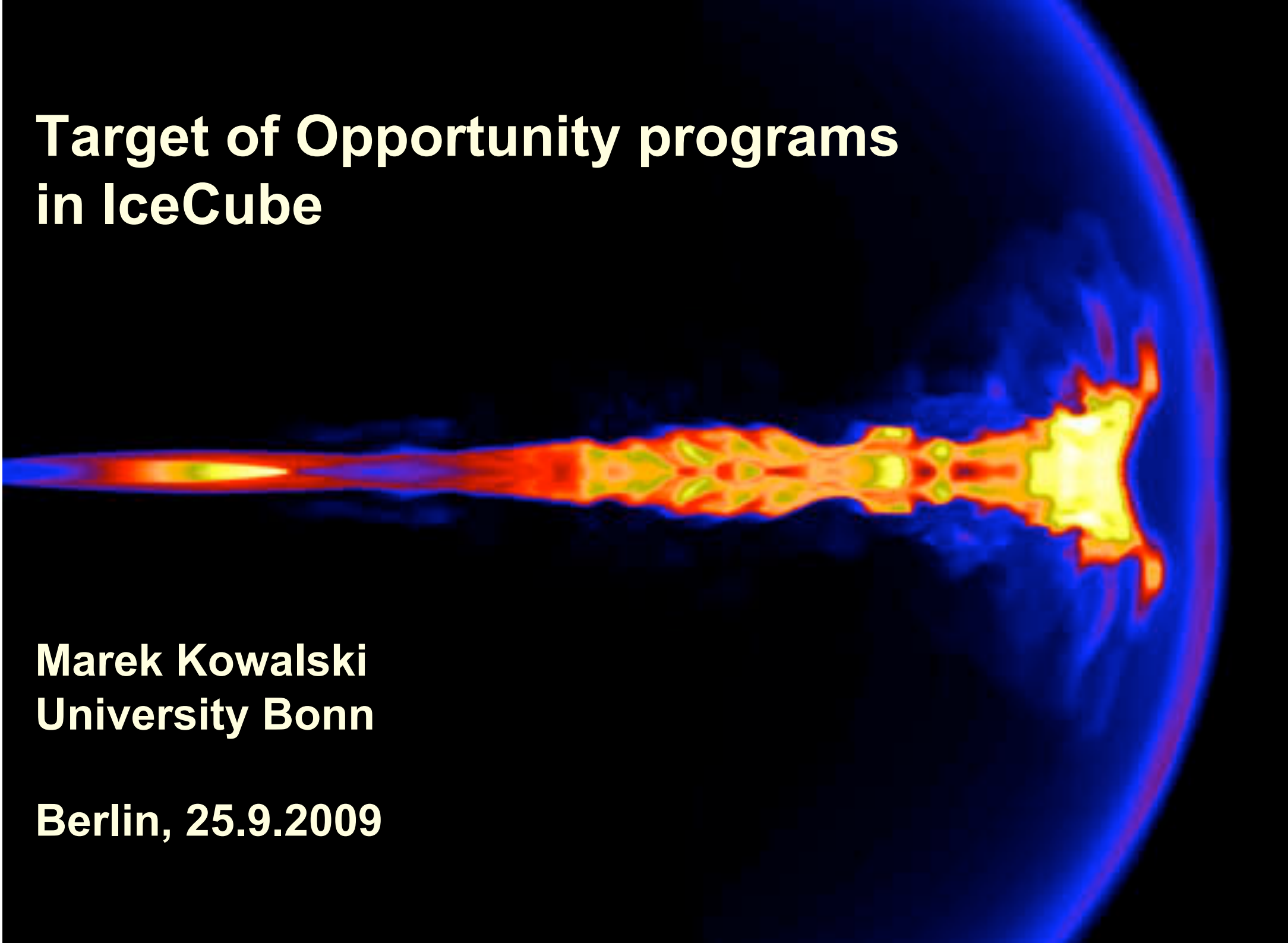
Target of Opportunity programs in IceCube



Marek Kowalski
University Bonn

Berlin, 25.9.2009

Introduction

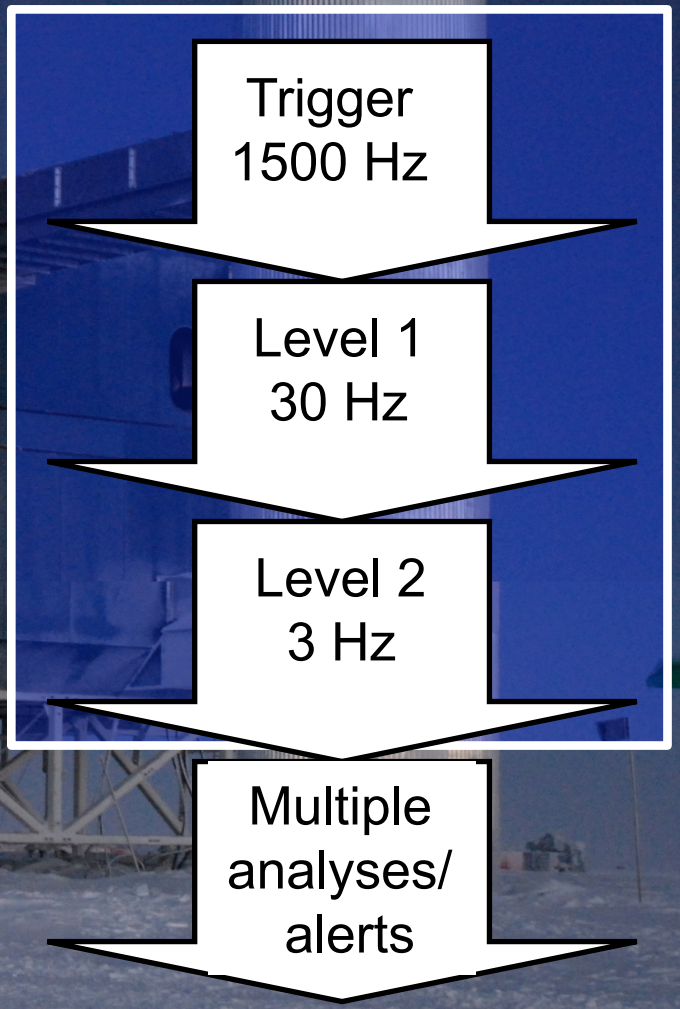
Idea of Target of Opportunity Program:

Obtain data from other observatories that otherwise would not have been taken

Implementation:

- **Gamma-ray** follow-up with MAGIC
- **Optical** follow-up with ROTSE

IceCube online data processing pipeline

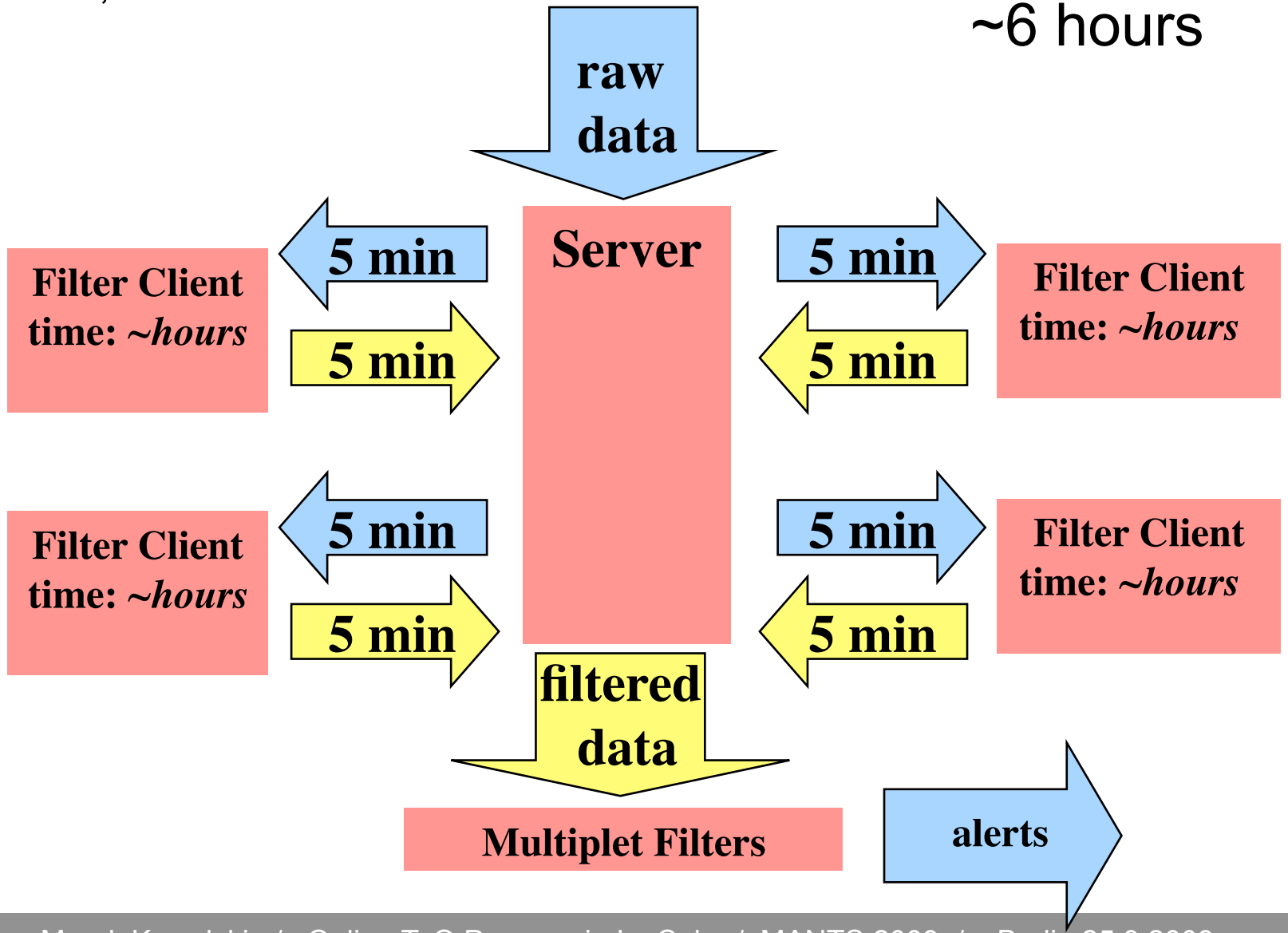


6 hours latency at the moment;
~ seconds latency for the future

Online Reconstruction

Erik Blaufuss, Thorsten Schmidt

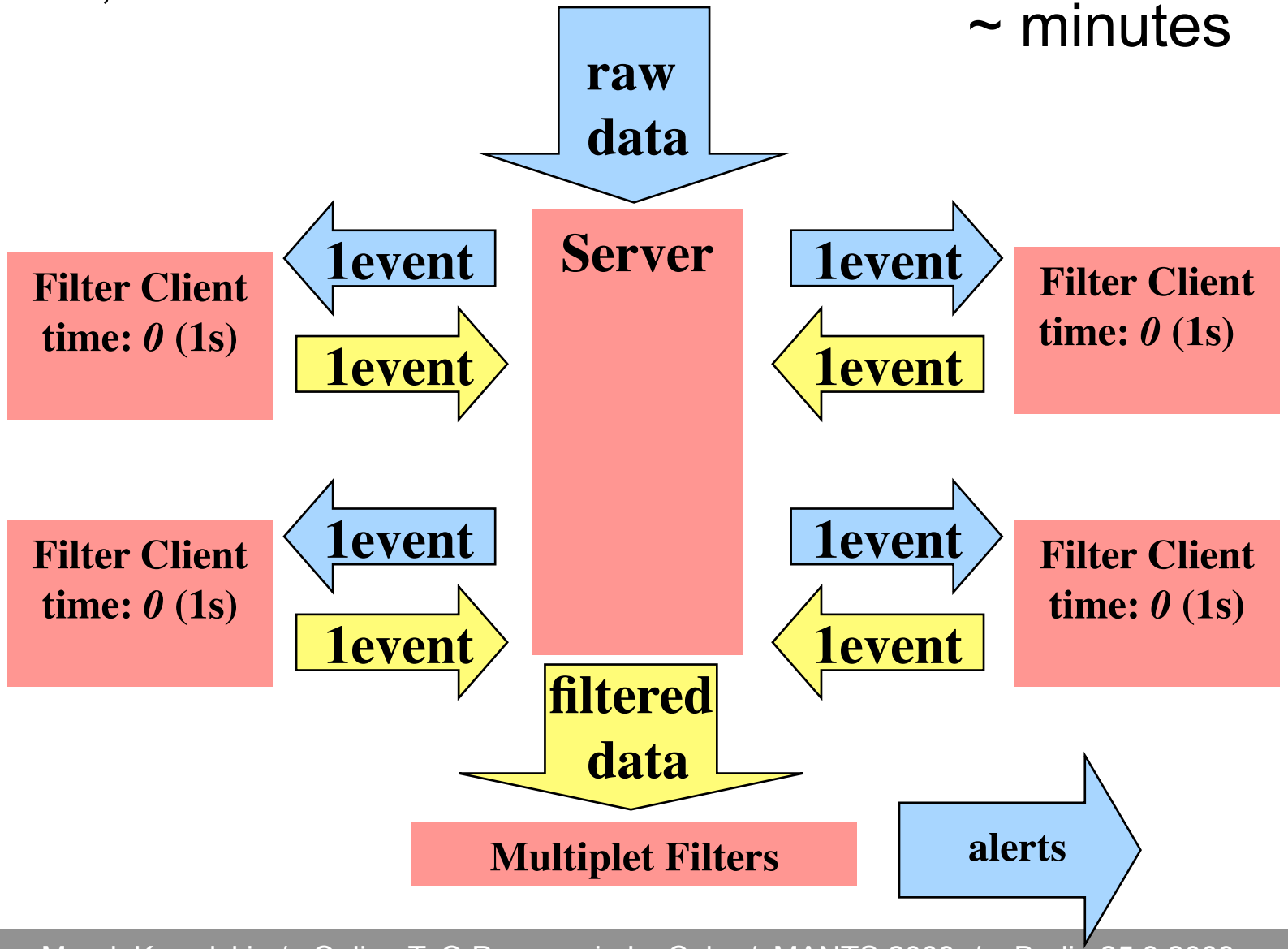
Current Latency
~6 hours



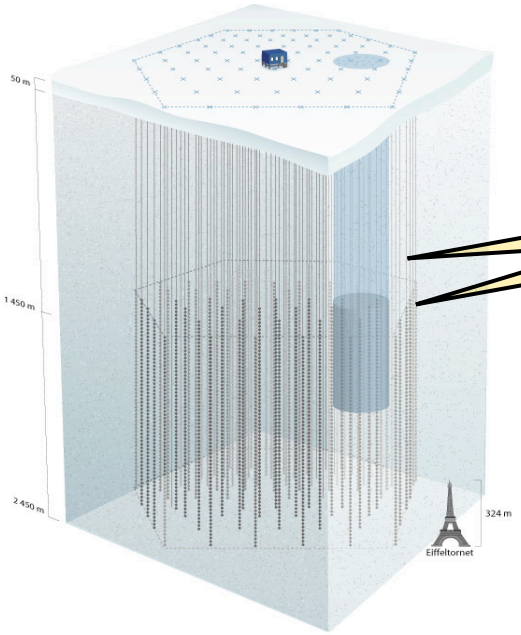
Online Reconstruction

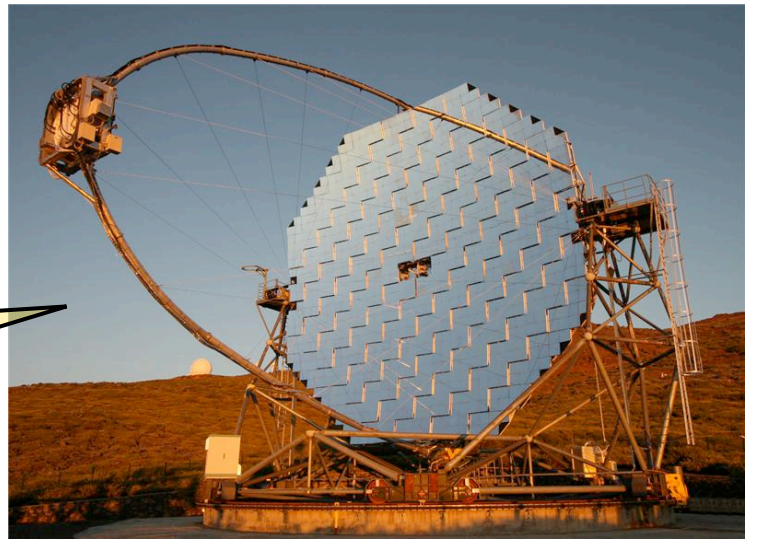
Erik Blaufuss, Thorsten Schmidt

Future Latency:
~ minutes



Gamma-ray Follow-up





MAGIC

Motivation:
Detect gamma flares from AGNs and Microquasars in association with neutrino flares

Elisa Bernardini
Robert Franke
Pratik Majumdar
Konstancja Satalecka

Status:
- Feasibility study with AMANDA & MAGIC (2006)
- Current proposal under internal IceCube review

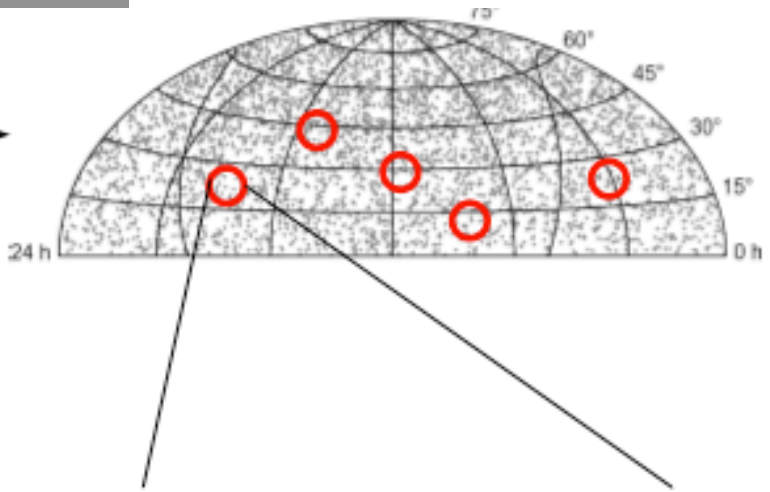
Gamma-ray Follow-up

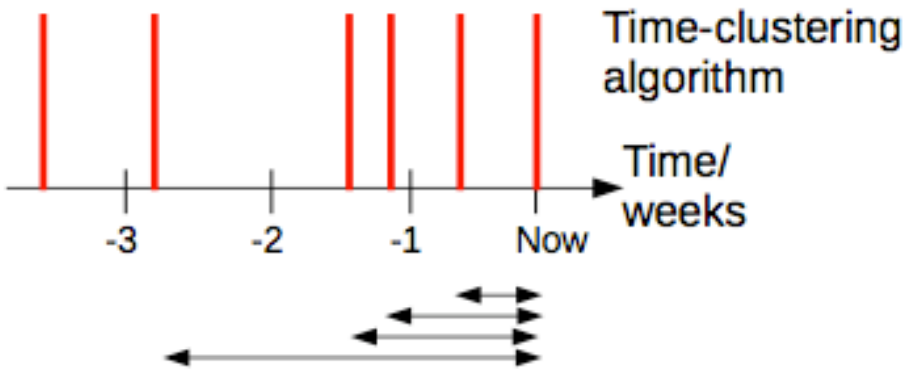
Trigger
1500 Hz

Level 1
30 Hz

Level 2
3 Hz

Final Level
10^{-3} Hz





Alert generated when a cluster reaches a predefined significance (20 hours on MAGIC granted)

Gamma-ray Follow-up

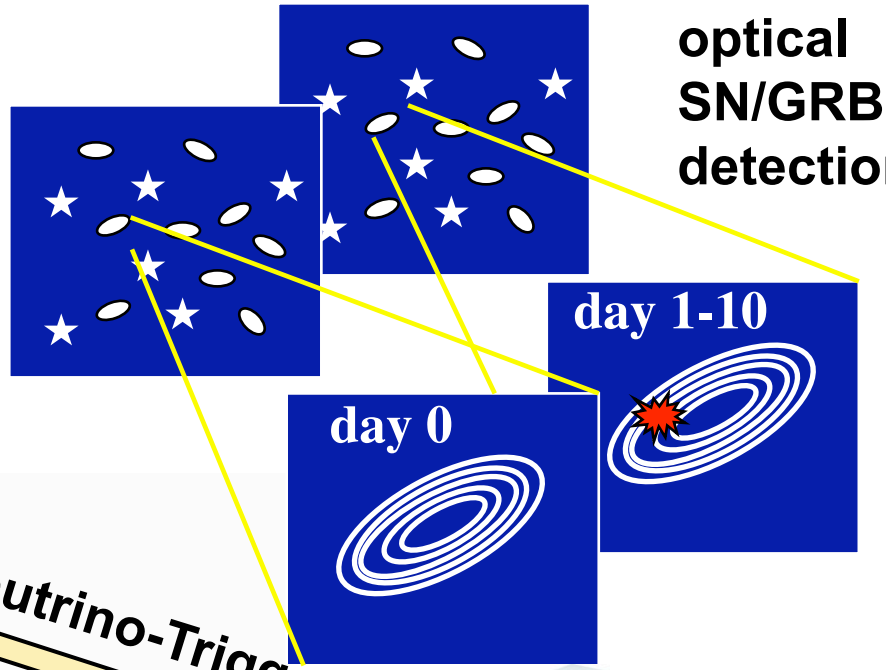
Target Source Catalog

Critieria: variability and brightness in EGRET and FERMI catalog + some known flaring TeV sources

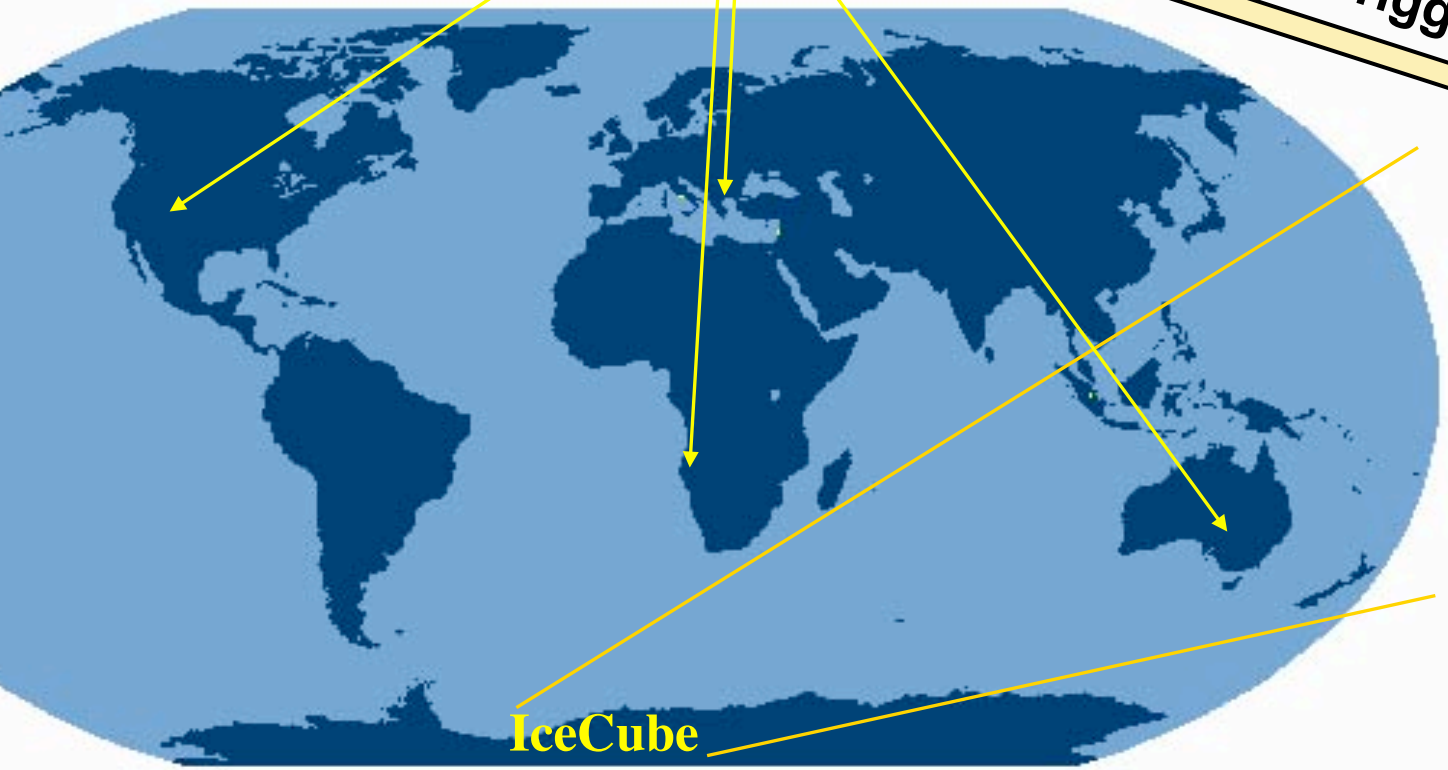
Source name	AGN type	Dec. [°]	RA [°]	z	TeV obs.	Alert thresh.[σ]	Flare thresh. [crab]
3C 273	FSRQ	2.0	187.3	0.158	No	5	0.2
PG 1553+113	MQ	11.190	238.929	0.36	Yes	3	0.5
CTA 102	FSRQ	11.7	338.1	1.037	No	5	0.2
M 87	Misal. BL Lac	12.39	187.71	0.0042	Yes	3	0.1
GEV J0530+1340	FSRQ	13.5	82.7	2.06	No	5	0.2
3C 454.3	FSRQ	16.1	343.5	0.859	No	5	0.2
GEV J0237+1648	LBL	16.6	39.7	0.94	No	5	0.2
W Comae	HBL	28.23	185.38	0.102	Yes	3	0.2
Mrk421	HBL	41.13	166.11	0.031	Yes	3	2.0
3C66A/B	BL Lac/FRI	43.04	35.67	0.444/0.0215	Yes	3	0.2
Mrk501	HBL	50.40	253.47	0.034	Yes	3	0.5
1ES1959+650	HBL	65.15	300.0	0.048	Yes	3	0.5
S5 0716+71	LBL	71.343	110.473	>0.3	Yes	3	0.2

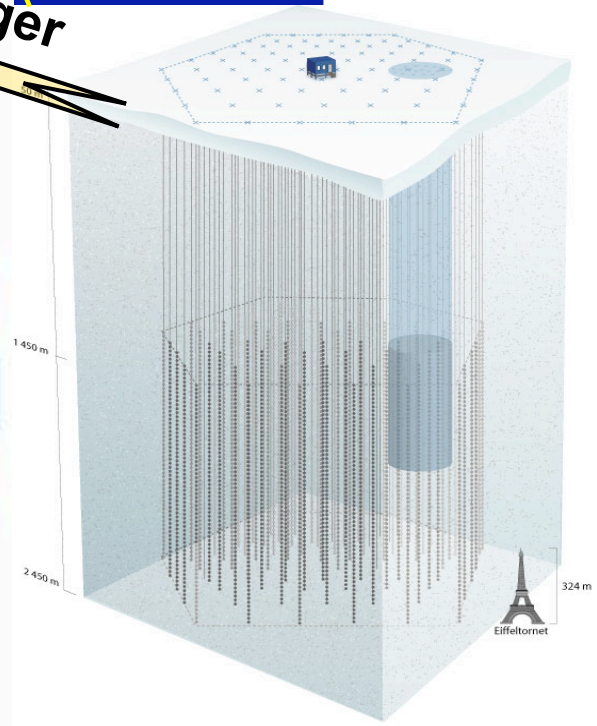
Optical follow-up

Doug Cowen
Anna Franckowiak
Andreas Homeier
Marek Kowalski
Thorsten Schmidt

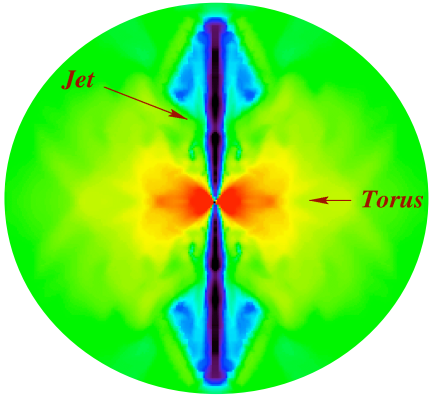


IceCube Neutrino-Trigger





Optical Neutrino Follow-up



Search for transient sources:

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

Alert if two events arrive within:

$\Delta t < 100$ s & $\Psi < 4^o$

(~30 alerts / year)

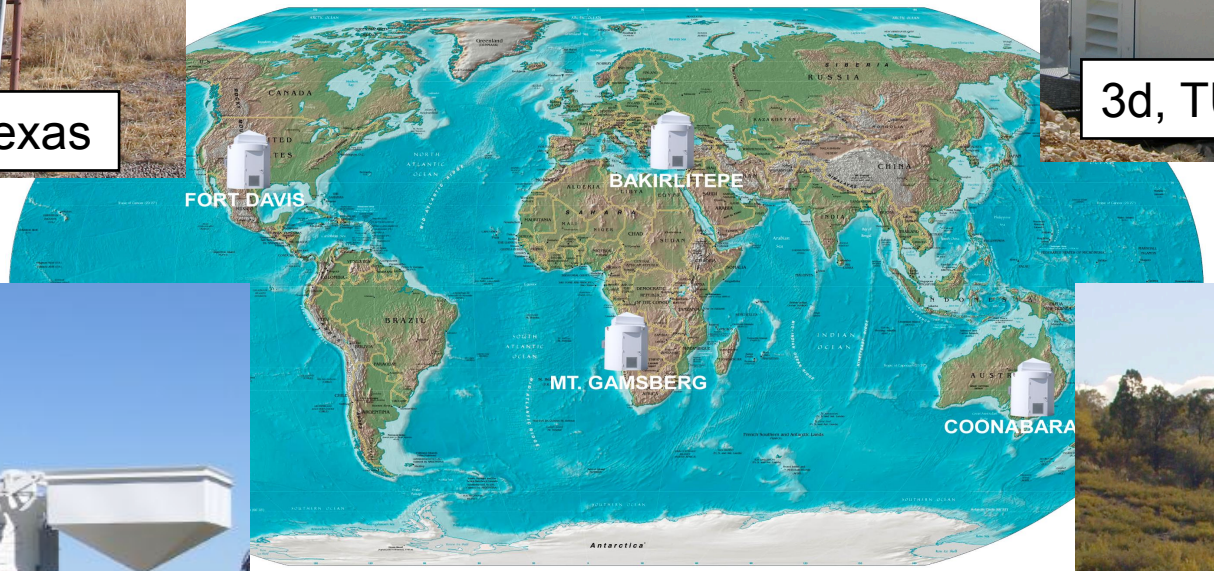
Optical Neutrino Follow-up

The ROTSE Network

3b, McDonald, Texas

“The sun never rises over the ROTSE empire”

3d, TUG, Turkey



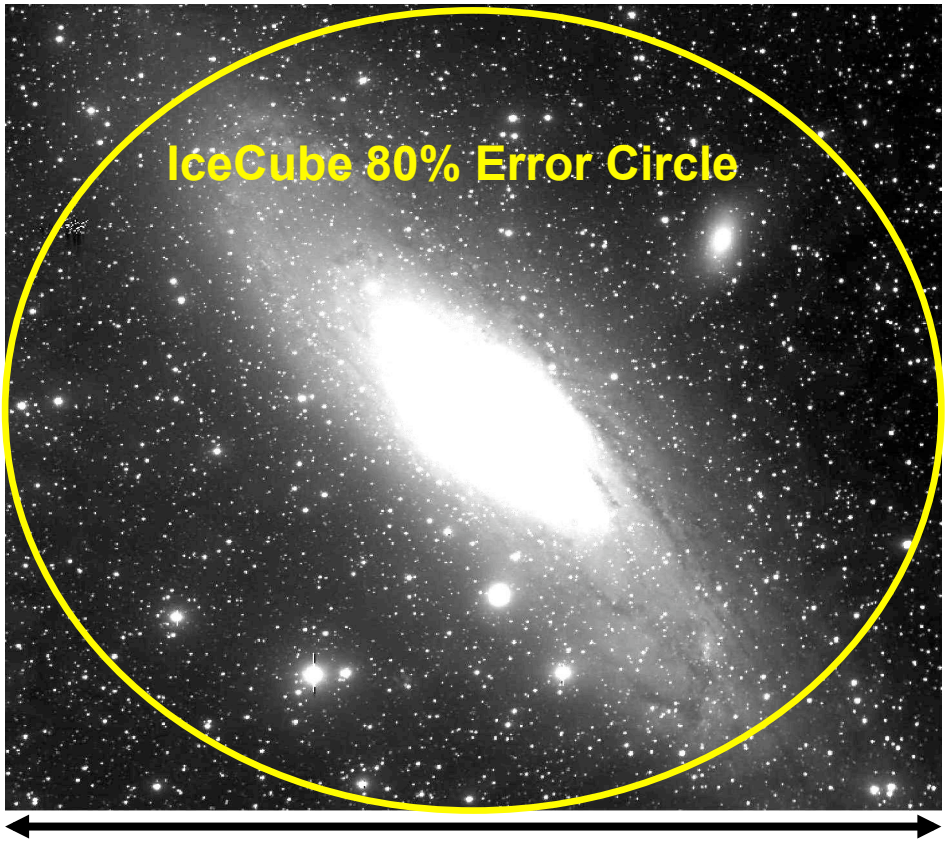

3c, H.E.S.S., Namibia

4 x 0.45 m
FoV: 1.85º x 1.85º
fully automated system

3a, SSO, Australia

Optical Neutrino Follow-up

The ROTSE Telescopes

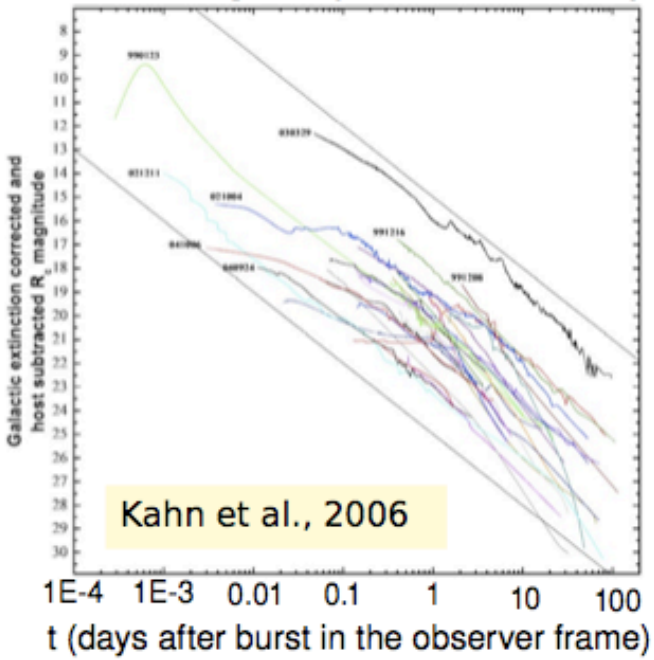


Optical Neutrino Follow-up

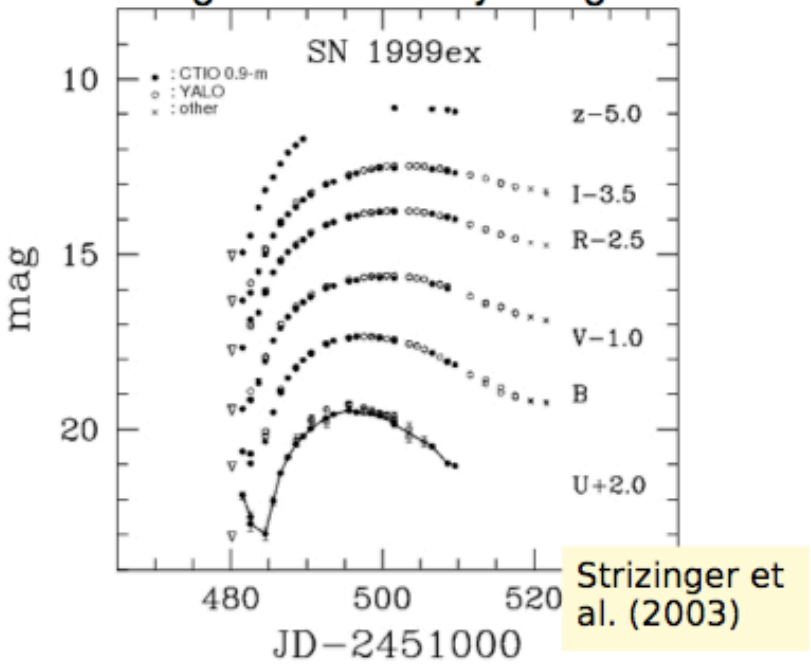
Observing schedule

- First night: ten 5 sec, ten 20 sec, twenty 60 sec exposures
- Following 14 nights: Ten 60s exposures

GRB afterglow: power-law decay



SN lightcurve: slowly rising



Since October 2008:
ROTSE follow-up is active

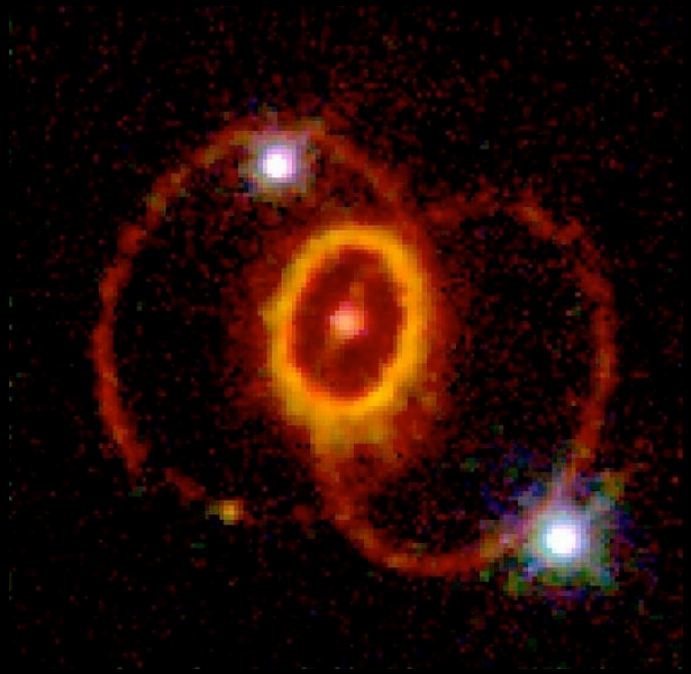
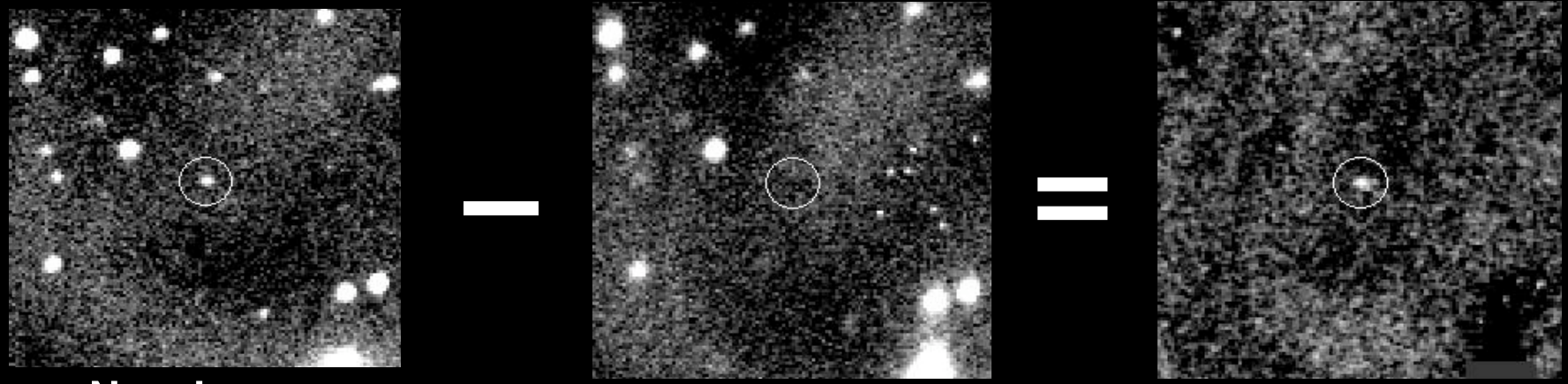


Image Subtraction

New image — reference image — subtraction

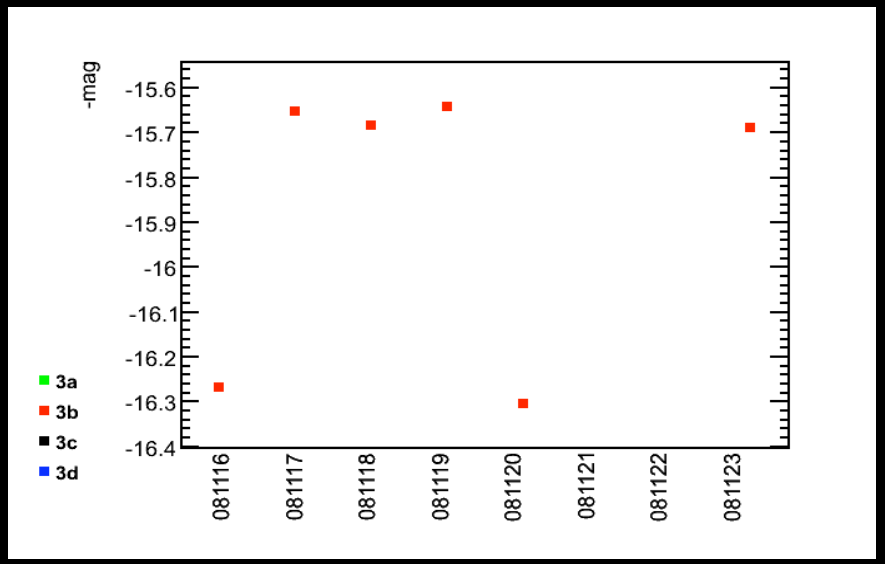
- First night's coadd used as reference image
- Deep reference images are currently being taken
- Cross-convolution to match the Point spread function

Candidate Identification



- Automated candidate selection
- Currently inspecting subtractions and lightcurves

Variable star?



Optical Neutrino Follow-up

A global network of telescopes

- ROTSE
- Telescopes for the future: PTF, SkyMapper,…

Some References

Gamma-Ray Follow-up:

- M. Ackermann, E. Bernardini et al., ICRC 2007
- M. Tluczykont, et al., J. of Phys., Conf. Series (2007).
- R. Franke, E. Bernardini et al., ICRC 2009

Optical Follow-up:

- M. Kowalski, A. Mohr, Astropart. Physics (2007)
- A. Franckowiak et al., ICRC 2009
- D. Cowen et al., Astropart. Phys., submitted