

# THE TRANSIENT SKY

ARNE RAU (MPE GARCHING)

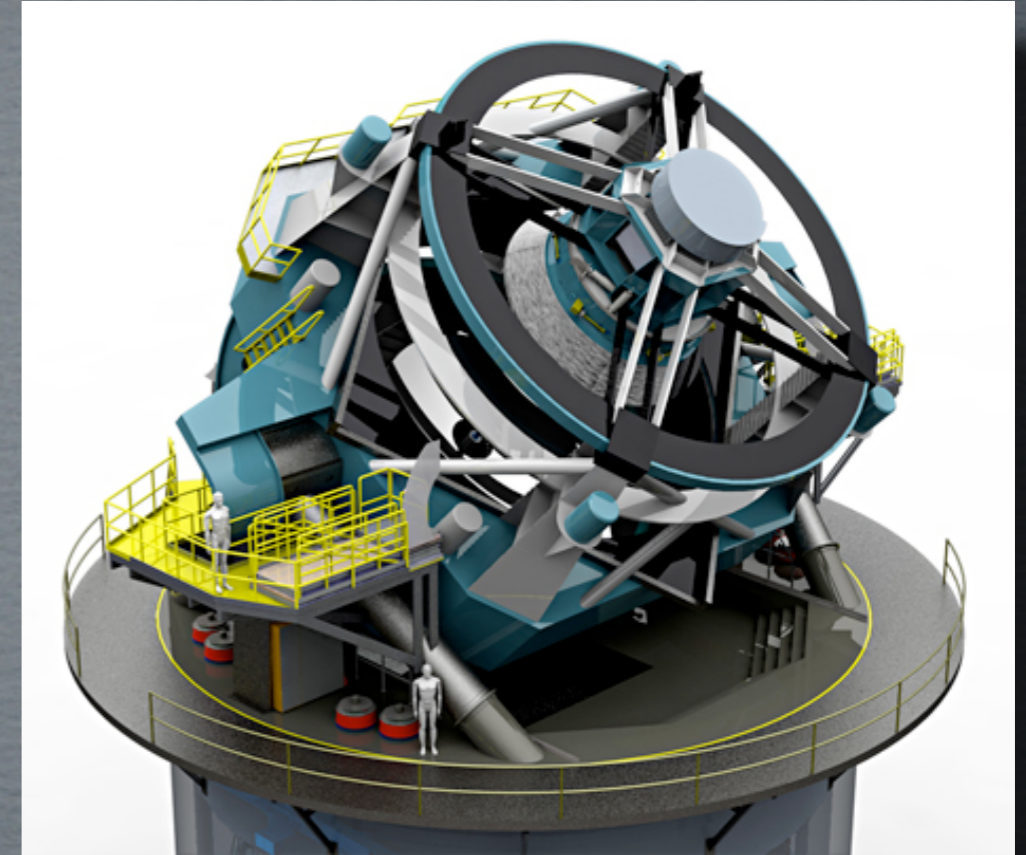




# (SOME) FACILITIES

## CURRENT:

- PALOMAR TRANSIENT FACTORY (OPTICAL, 1.2M, 7.7DEG<sup>2</sup>)
- CATALINA REAL-TIME TRANSIENT SURVEY (OPTICAL, 0.5-1.5M, 1.2-8.1DEG<sup>2</sup>)
- PAN-STARRS-1 (OPTICAL, 1.8M, 3DEG<sup>2</sup>)
- SKYMAPPER (OPTICAL, 1.35M, 5.7DEG<sup>2</sup>)
- ICECUBE (NEUTRINOS)



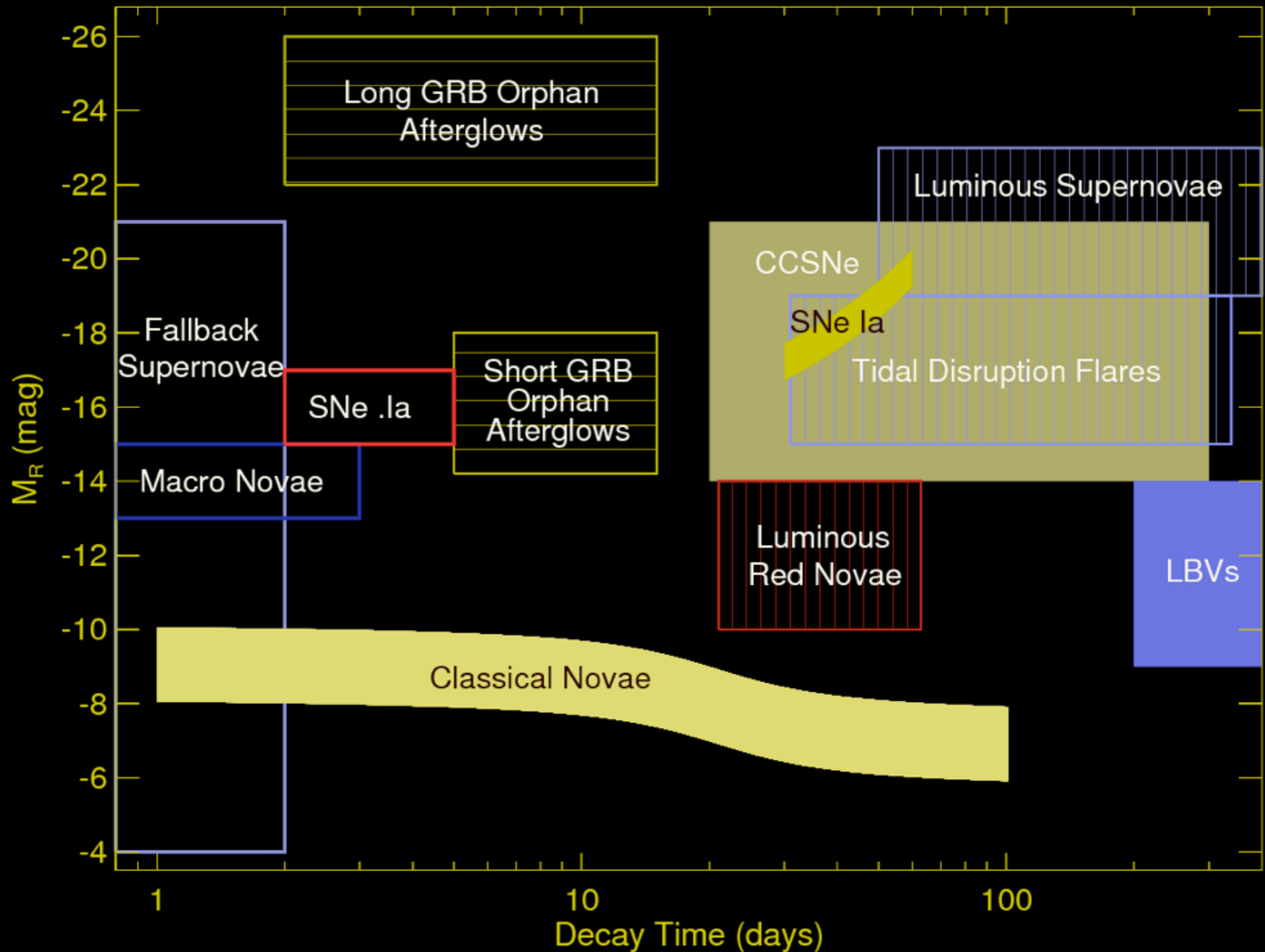
## FUTURE:

- LARGE SYNOPTIC SURVEY TELESCOPE (OPTICAL, 6.7M, 9.6DEG<sup>2</sup>)
- LOW FREQUENCY ARRAY (RADIO)
- ASKAP / MEERKAT -> SQUARE KILOMETER ARRAY (RADIO)
- EROSITA (X-RAY)
- A-LIGO (GRAVITATIONAL WAVES)





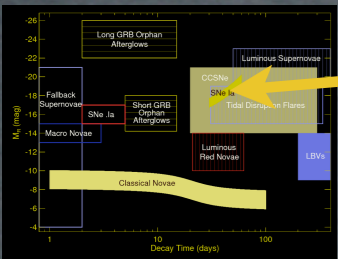
# PHASE SPACE OF OPTICAL TRANSIENTS



(RAU ET AL. 2009)



# TYPE IA & CORE COLLAPSE SNE

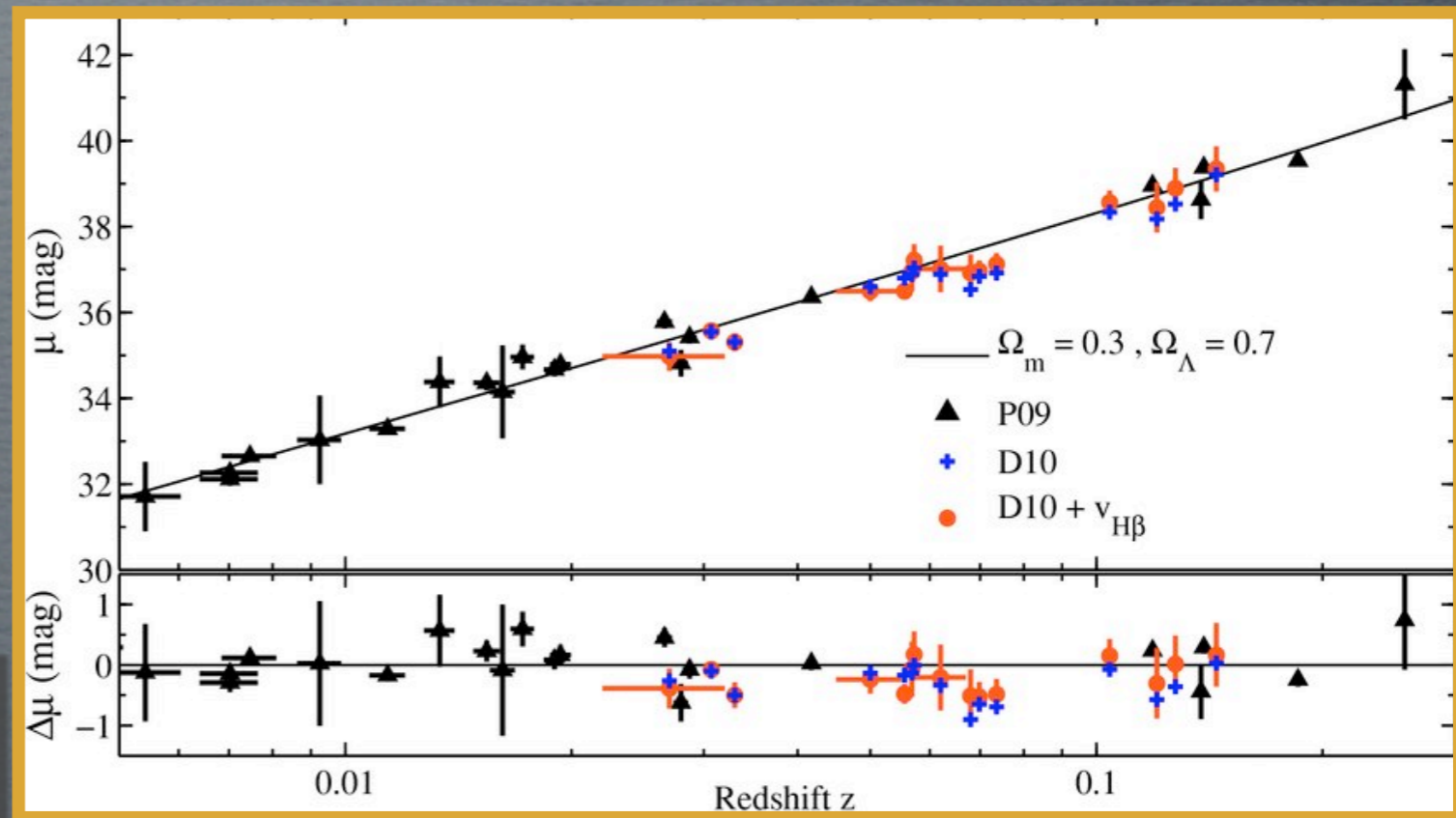
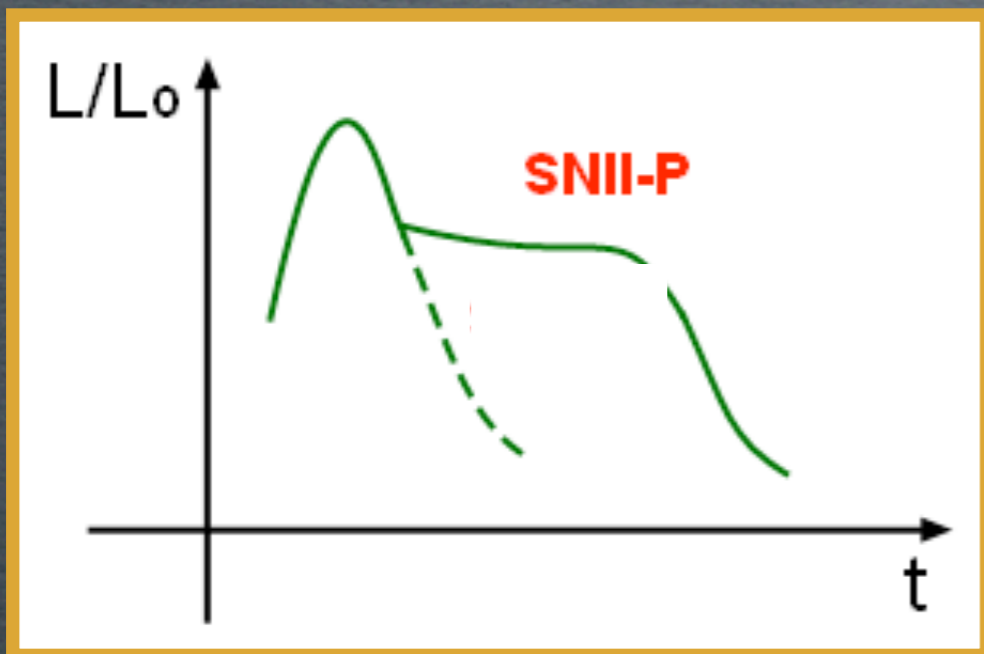


## SNE IA:

- LOW-Z SAMPLES TO UNDERSTAND SYSTEMATICS AND HOST EXTINCTION
- SELECTION EFFECTS FOR NEAR-IR HIGH-Z SEARCHES (E.G., WFIRST)
- PTF:  $>300 \text{ YR}^{-1}$ , LSST:  $\sim 30 \text{ NIGHT}^{-1}$

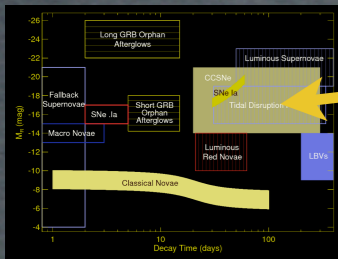
## CORE COLLAPSE SNE:

- GRB CONNECTION WITH BROAD-LINE SNE Ic
- SNE IIP ALTERNATIVE TEST FOR COSMOLOGY
- CORRELATION BETWEEN LUMINOSITY AND Fe II 5169 VELOCITY



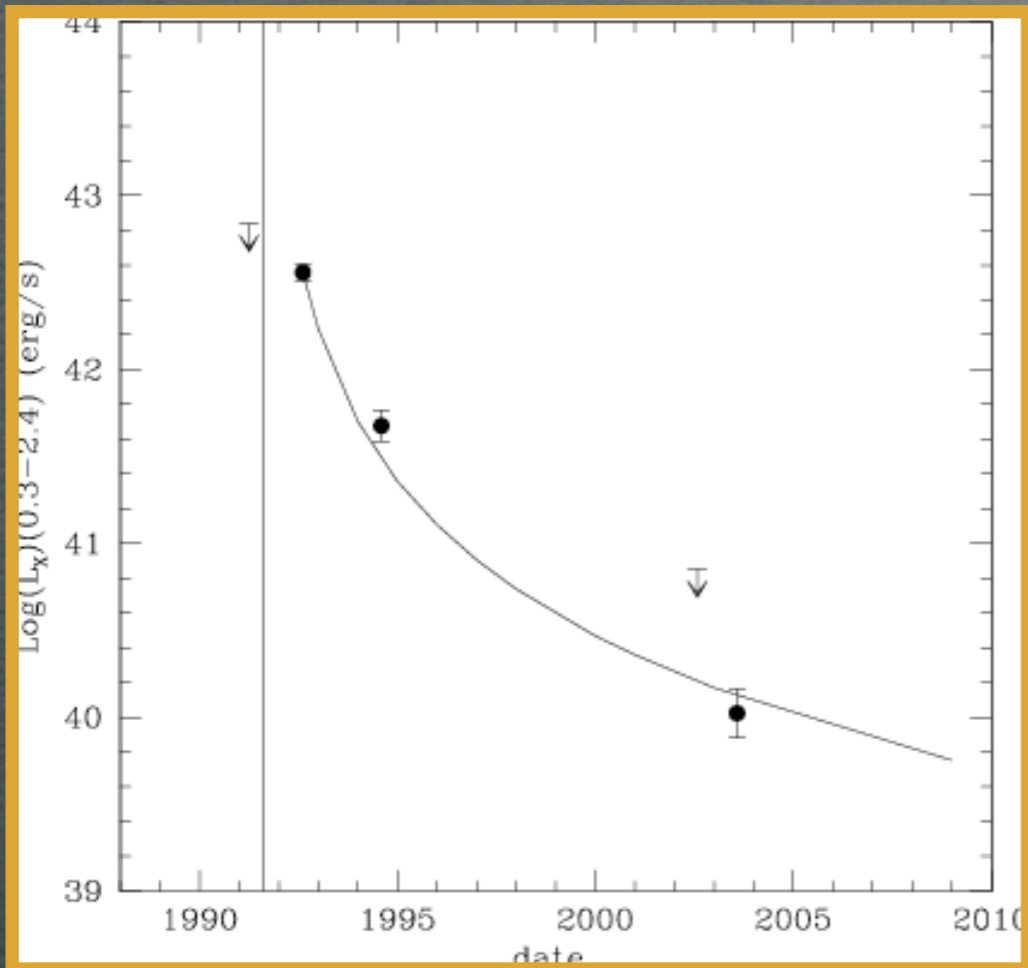
(POZNANSKI ET AL. 2010)



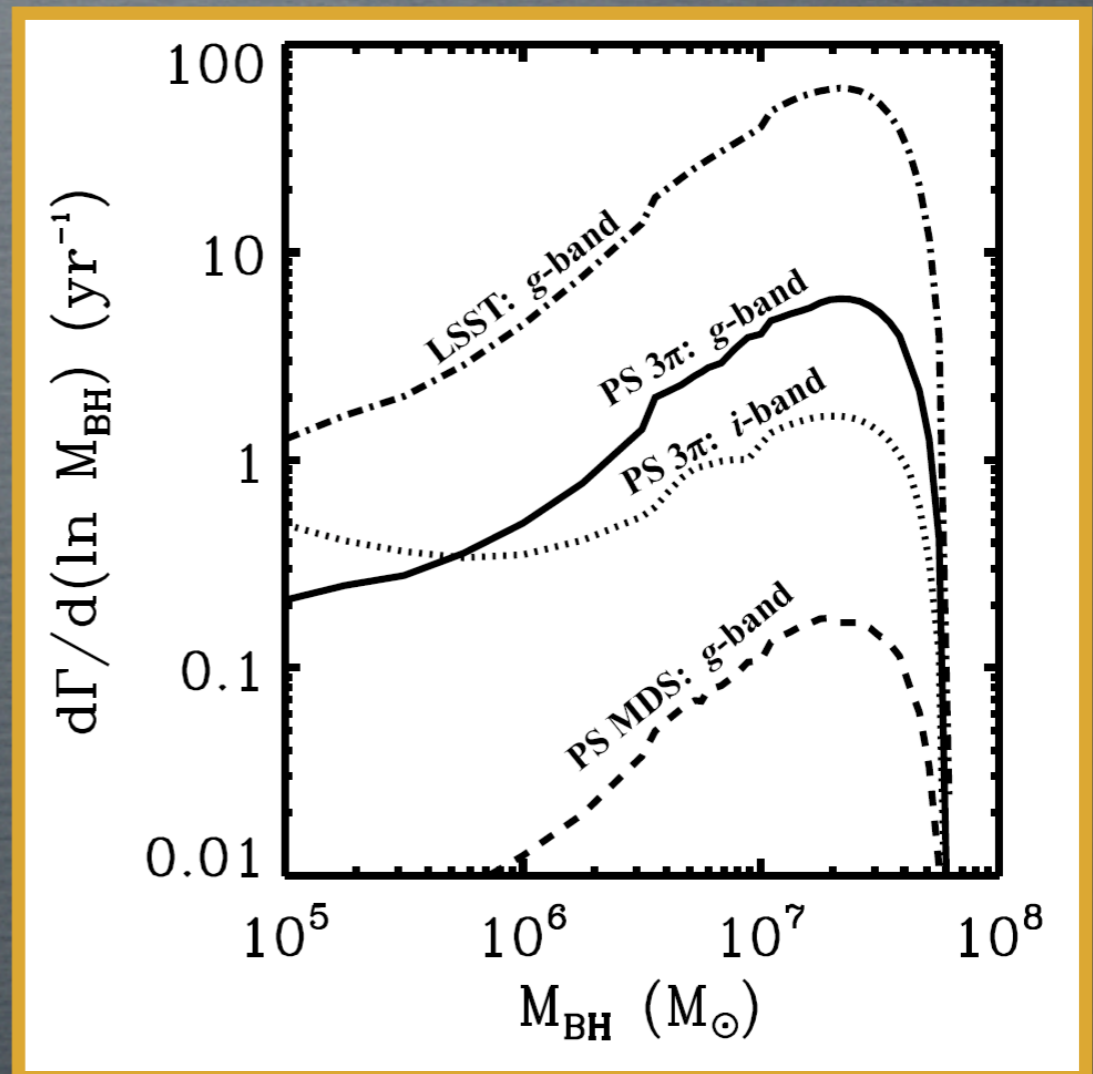


# TIDAL DISRUPTION EVENTS

- STARS DISRUPTED BY TIDAL GRAVITATIONAL FIELD OF SMBH  $< 10^8 M_{\text{SOLAR}}$
- A DOZEN CANDIDATES (ROSAT, GALEX)
- EROSITA, LSST: 100s  $\text{YR}^{-1}$
- BLACK HOLE MASSES, INDEPENDENT TEST OF  $M_{\text{SMBH}}-\sigma$  RELATION



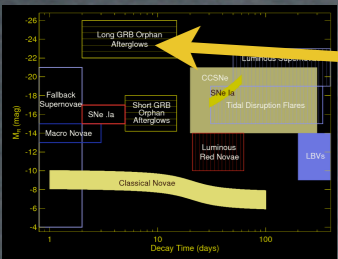
(CAPPELLUTI ET AL. 2009)



(GEZARI ET AL. 2009)

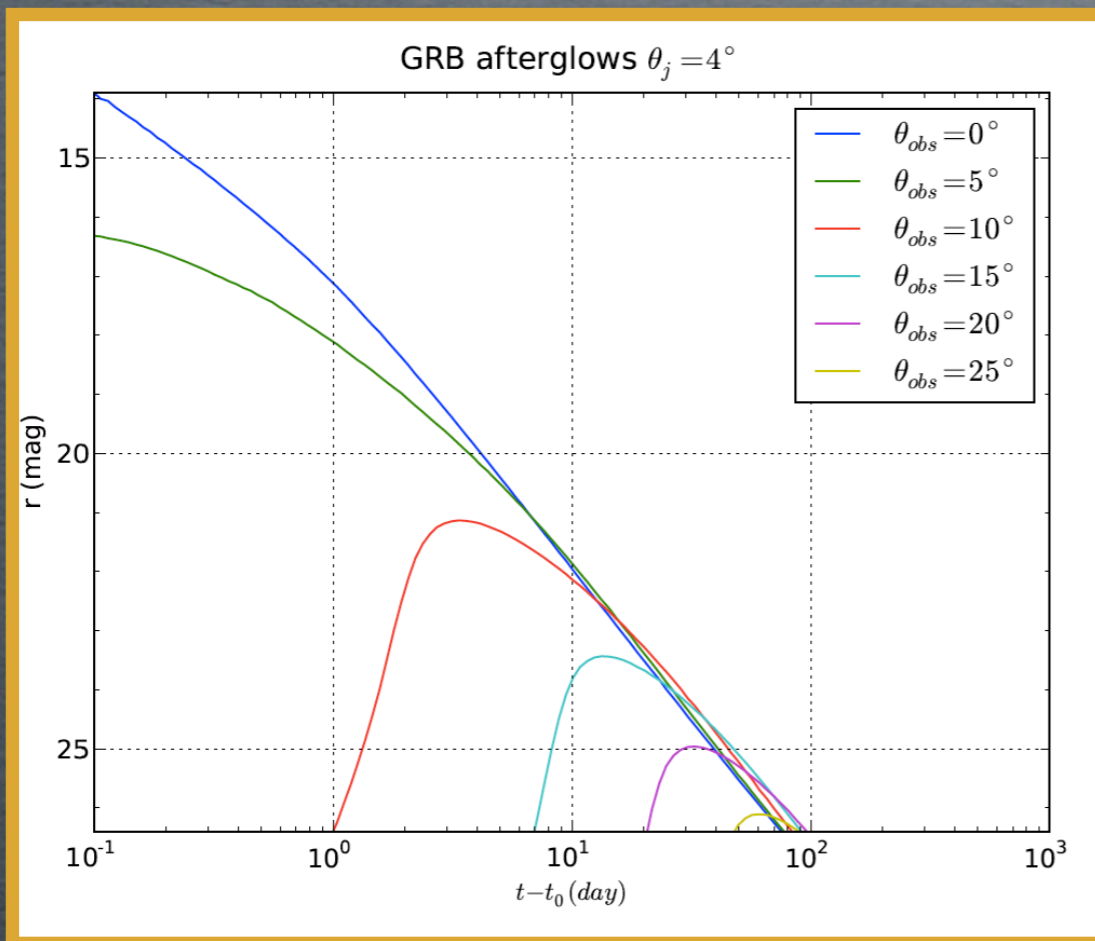
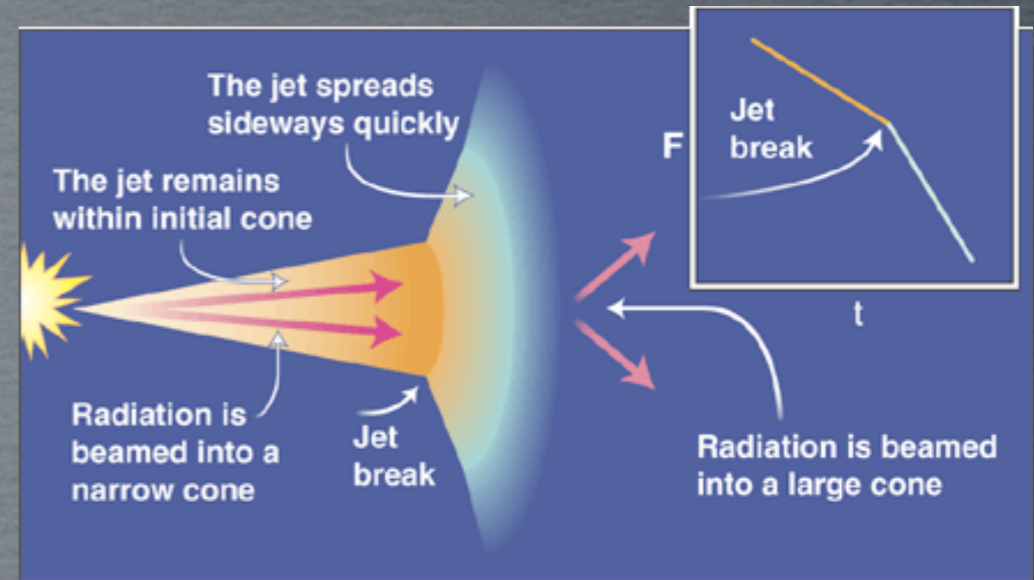


# ORPHAN AFTERGLOWS

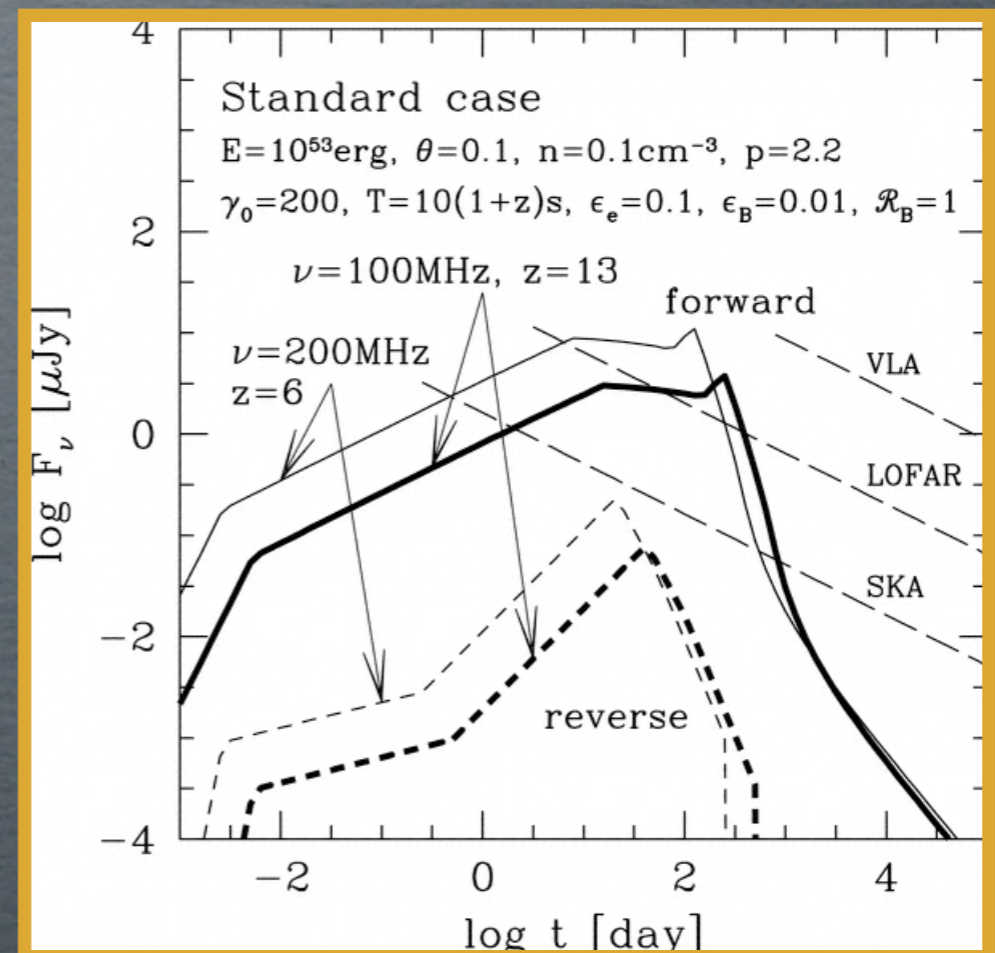


- OFF-AXIS GRB: NO  $\gamma$ -RAYS, ONLY AFTERGLOW
- 1000 AT  $R < 24$  MAG ALL SKY AT ANY TIME
- LSST: 1000  $\text{YR}^{-1}$
- LOFAR, SKA WILL PROBE HIGH REDSHIFT
- EROSITA
- BEAMING FRACTION, TRUE GRB RATE
- 10X MORE GRB-SNE (E.G. SN2009BB; SODERBERG ET

AL. 2009)

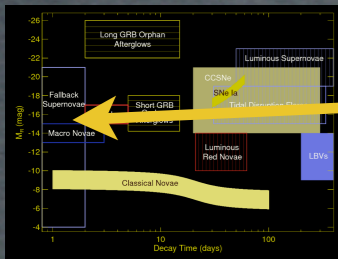


(LSST BOOK)



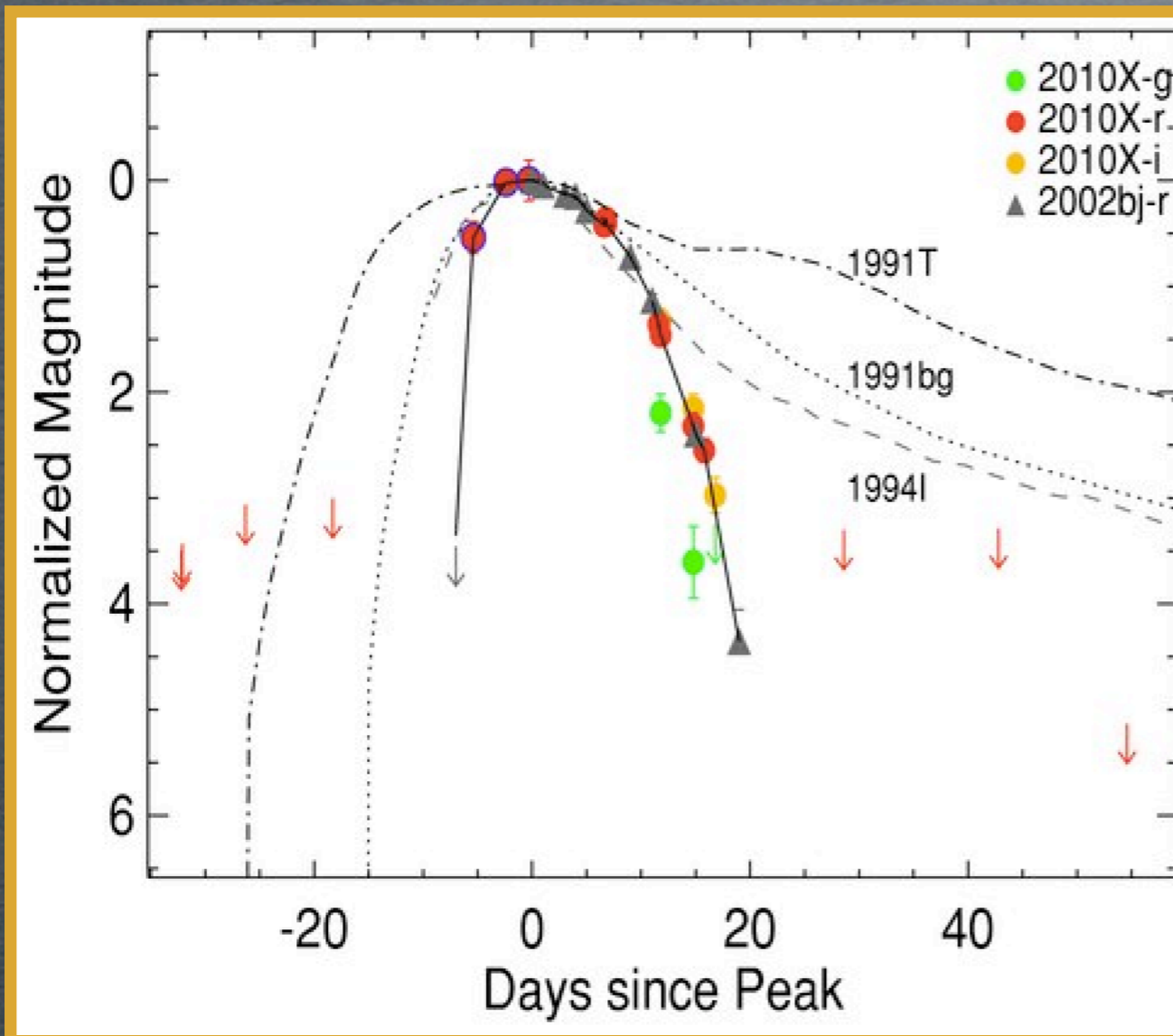
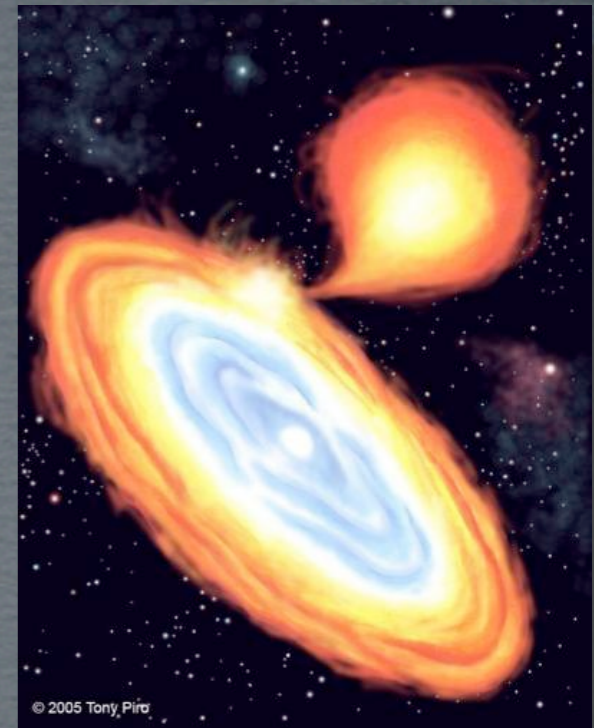
(LOKA & MESZAROS 2005)





## FAINT / FAST TRANSIENTS:

- ACCRETION INDUCED COLLAPSE
- SNE ASSOCIATED WITH MERGING COMPACT OBJECTS
- THERMONUCLEAR EXPLOSIONS FROM AM CVN BINARIES (E.G., BILDSTEN ET AL. 2007)



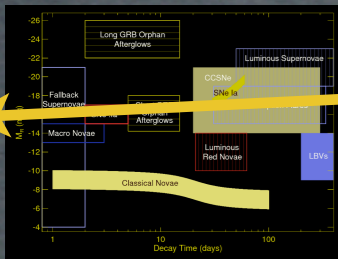
## SN2010X:

- PEAK  $M_R = -17$  MAG ( $10^{42}$  ERG/S)
- EXPONENTIAL DECAY WITH  $\tau \sim 5$  D
- SIMILAR TO SN2002BJ (POZNANSKI ET AL. 2010)
- $v \sim 10000$  KM/S,  $0.16 M_{\text{SOLAR}}$  EJECTA
- IF NI POWERED:  $0.02 M_{\text{SOLAR}}$  NI
- IF AL PRESENT: ACCRETION INDUCED COLLAPSE OF O-NE-MG WD
- IF HE PRESENT: .IA
- NEED DEDICATED EXPERIMENTS (PTF, LSST MINI-SURVEYS)

(KASLIWAL ET AL. 2010c)

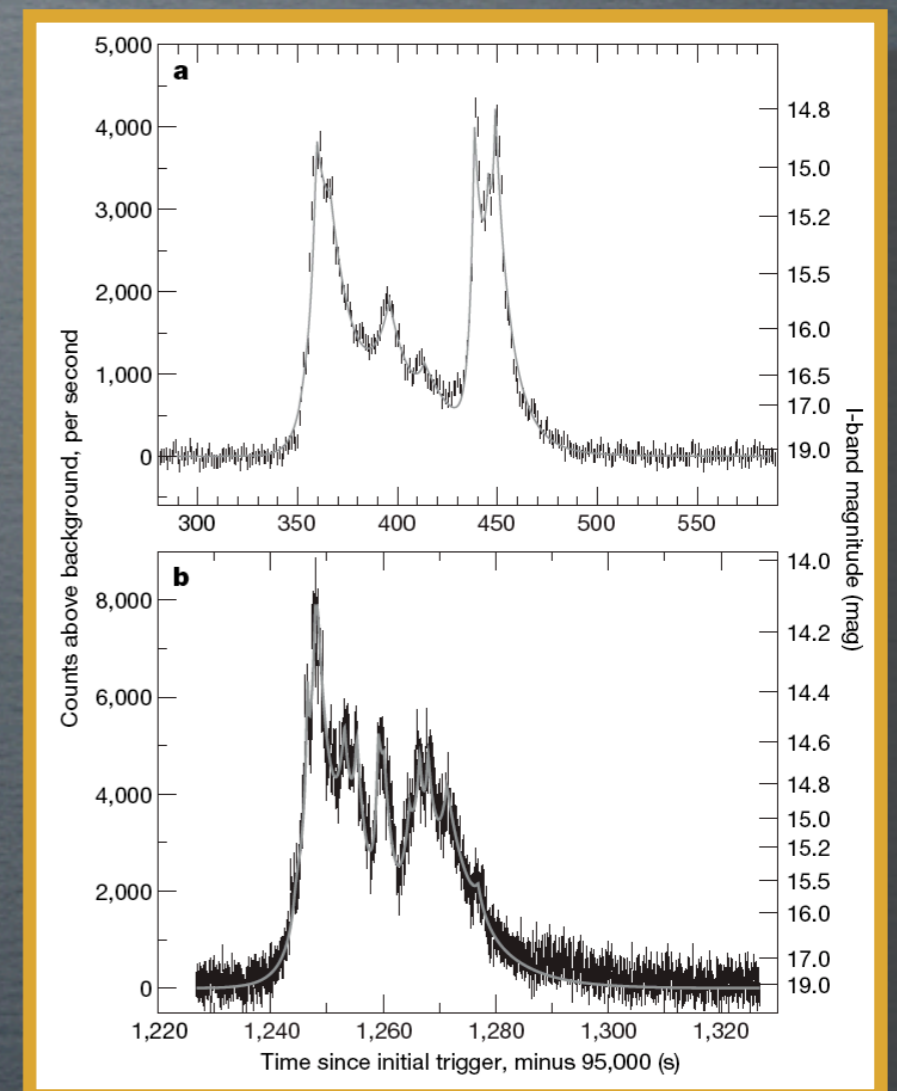
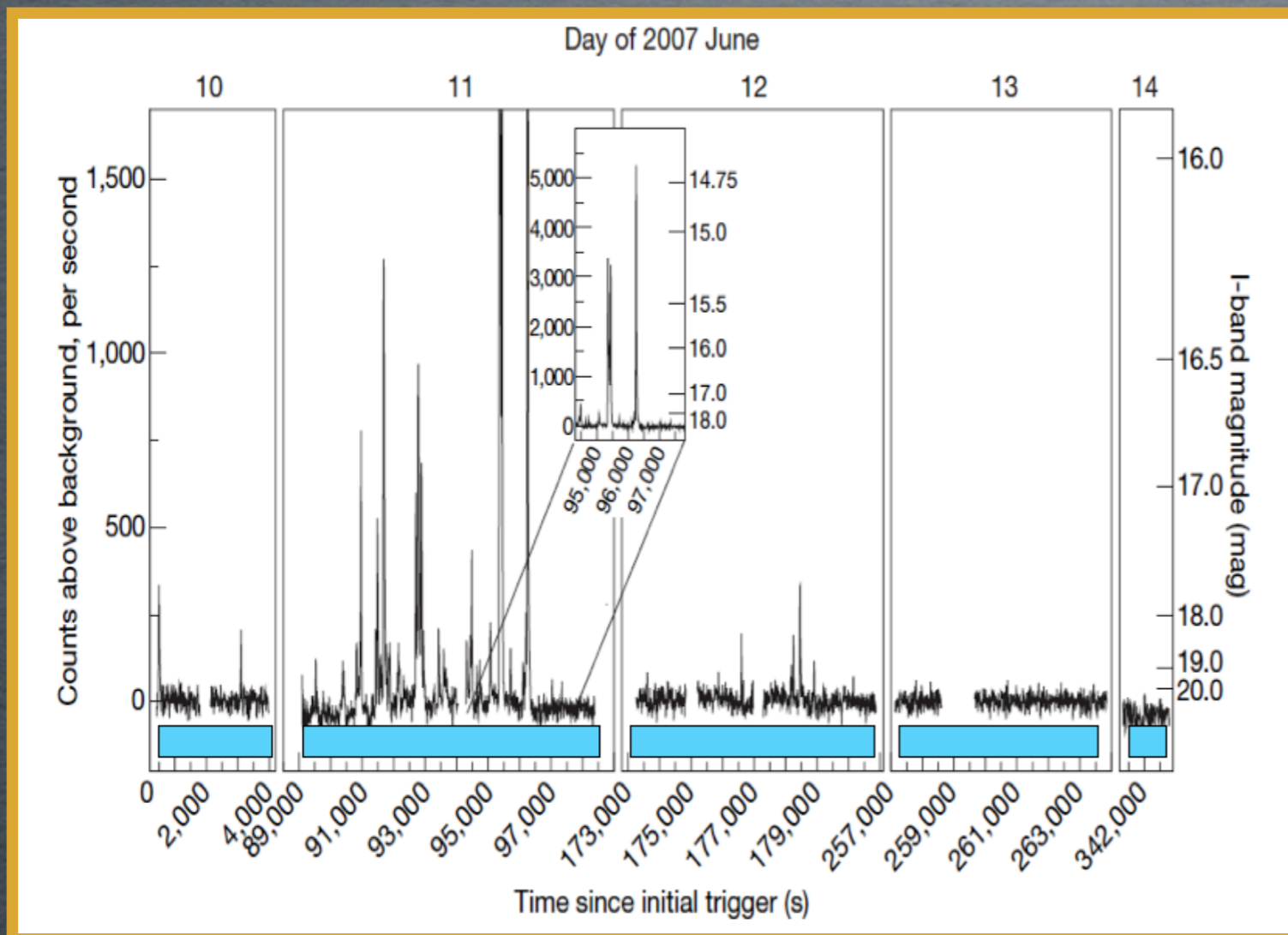


# ULTRA-SHORT EVENTS



## SWIFT 1955 / GRB 070610

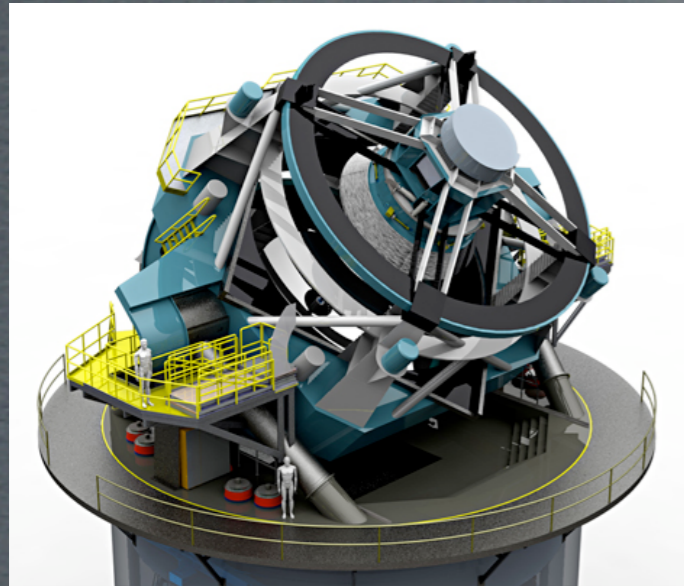
- GRB IN GALACTIC PLANE?
- OPTICAL LIGHT CURVE SIMILAR TO HIGH-E BEHAVIOR OF SGRs (OPTIMA, P60)
- 200-10000X INCREASE IN SECONDS + EXPONENTIAL DECAY
- POSSIBLE X-RAY PERIODICITY SEEN AS OPTICAL QPOs (6-8s)
- NEEDS SPECIAL INSTRUMENTATION (HTRA FOR E-ELT)



(STEFANESCU ET AL. 2008)



# SUMMARY

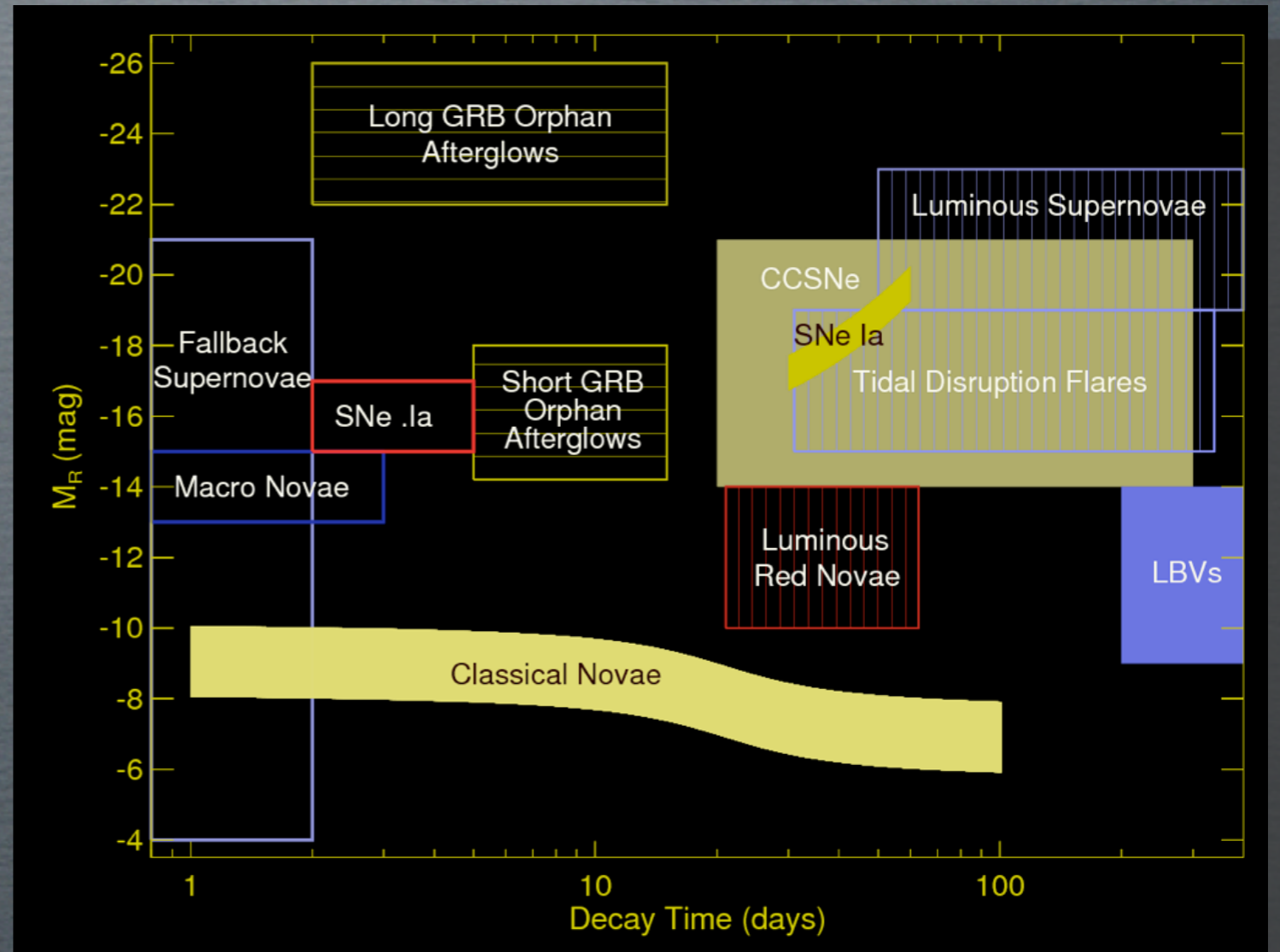


## A NEW ERA OF TIME DOMAIN SCIENCE

- ACROSS THE EM-SPECTRUM AND BEYOND
- CURRENT (PTF, CRTS, PAN-STARRS1,...)
- NEAR FUTURE (LOFAR, EROSITA, LSST,...)

## GOALS:

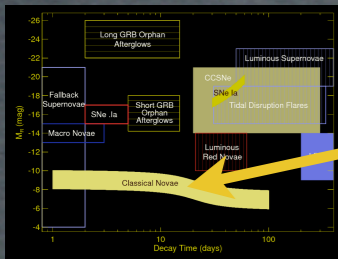
- ACCRETION & EXPLOSION PHYSICS
- STELLAR EVOLUTION
- GALAXY AND ISM EVOLUTION
- COSMOLOGY
- LINK TO NON-EM MESSENGERS



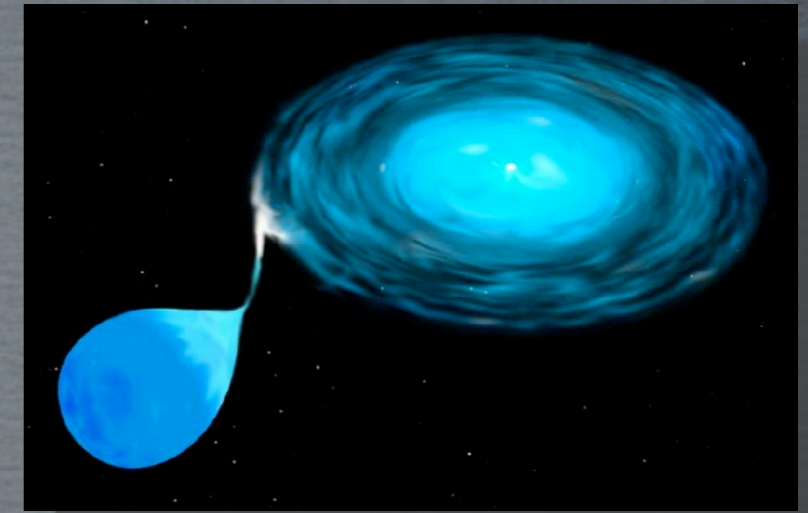






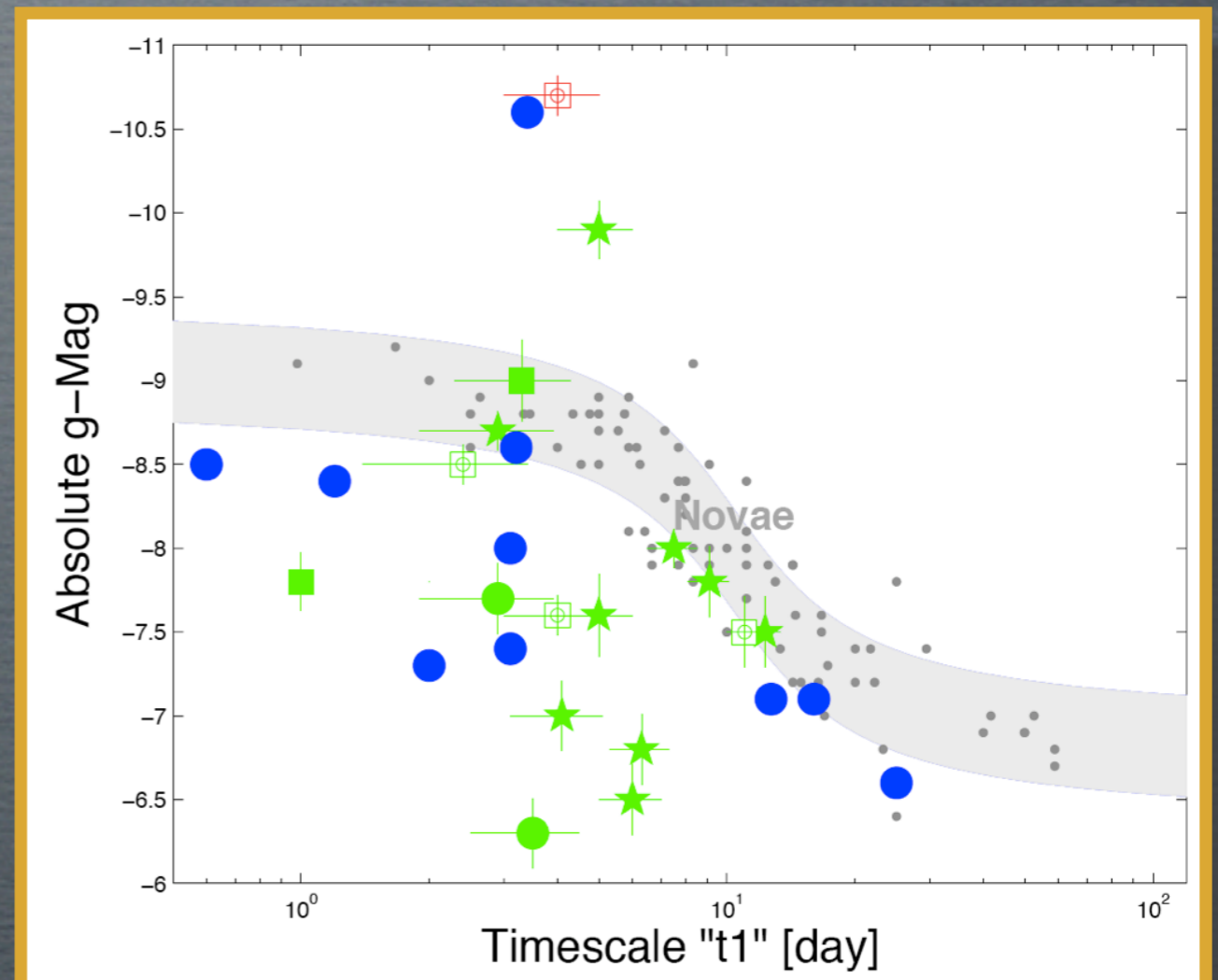
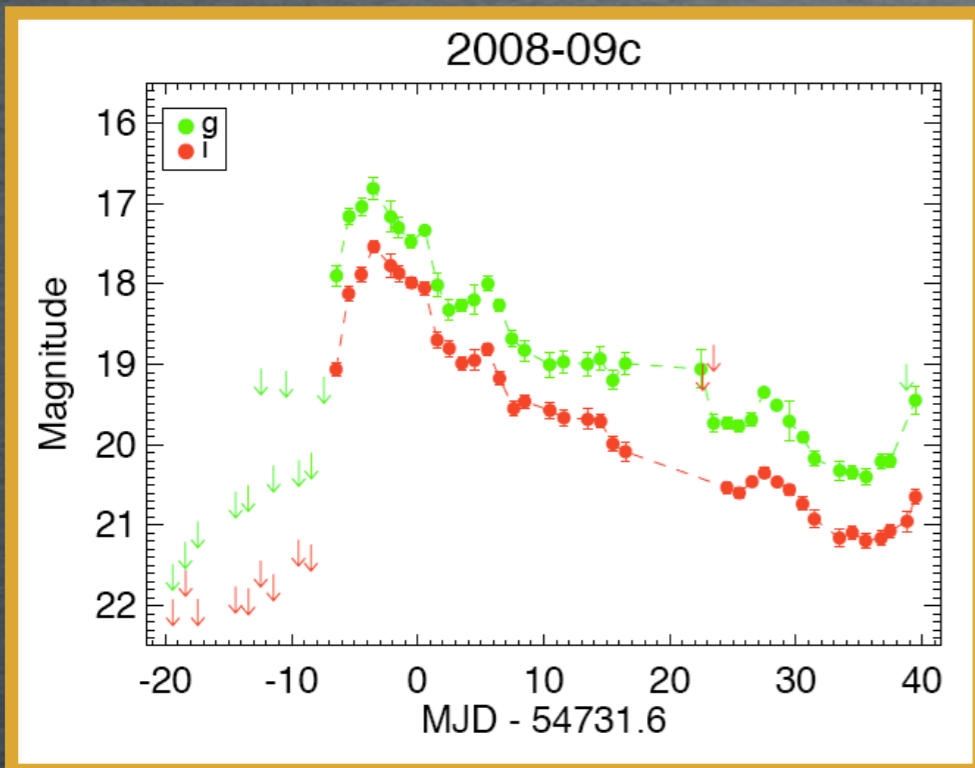


# CLASSICAL NOVAE



## NO LUMINOSITY-DECAY CORRELATION?

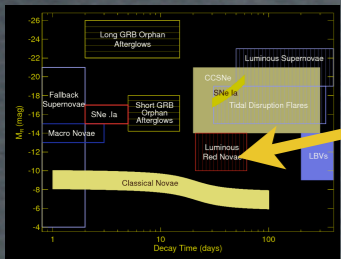
- MAXIMUM-MAG RATE-OF-DECAY (MMRD; LIVIO 1992)
- DUE TO WHITE DWARF MASS
- P60FASTING (1D CADENCE, G<21 MAG)
- INCONSISTENT WITH MMRD (OR RECURRENT NOVAE)
- HOT, MASSIVE WD WITH HIGH ACCRETION RATE (YARON ET AL. 2005)?
- PAN-STARRS-1, LSST



(KASLIWAL ET AL. 2010A)



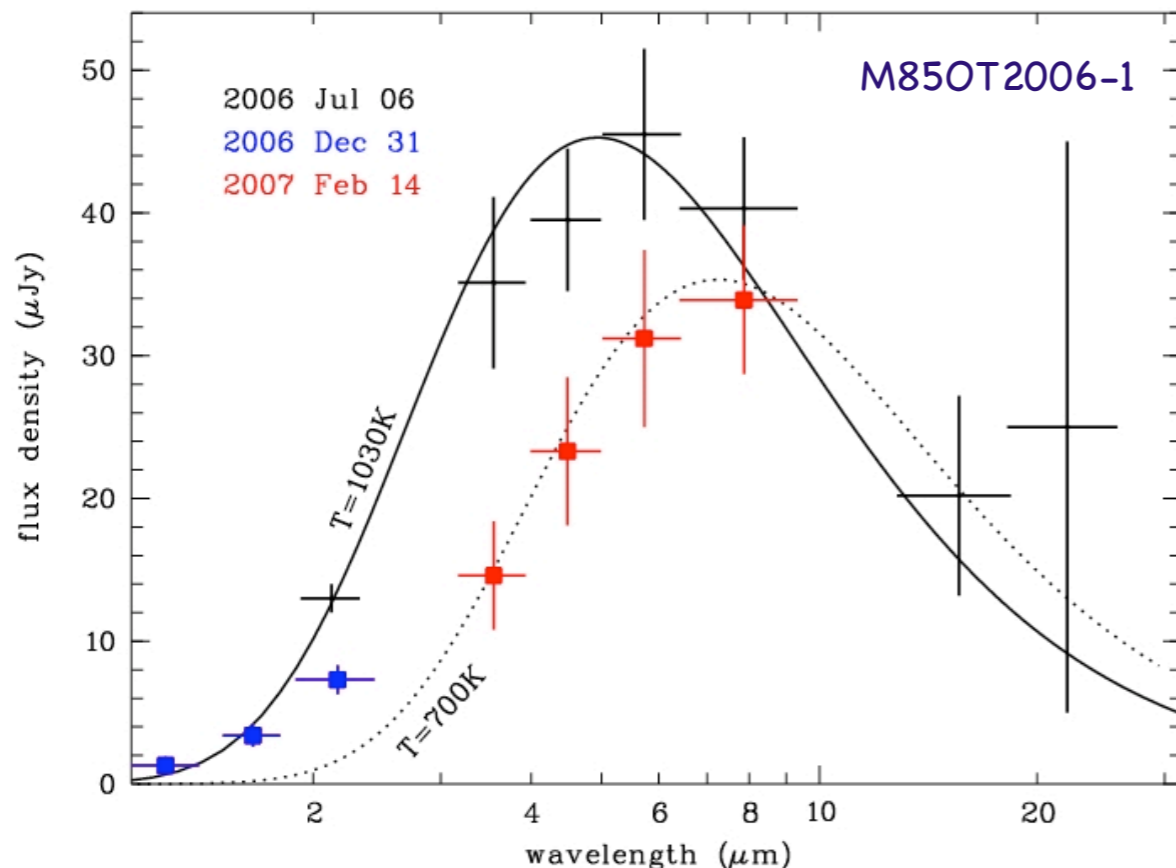
# LUMINOUS RED NOVAE



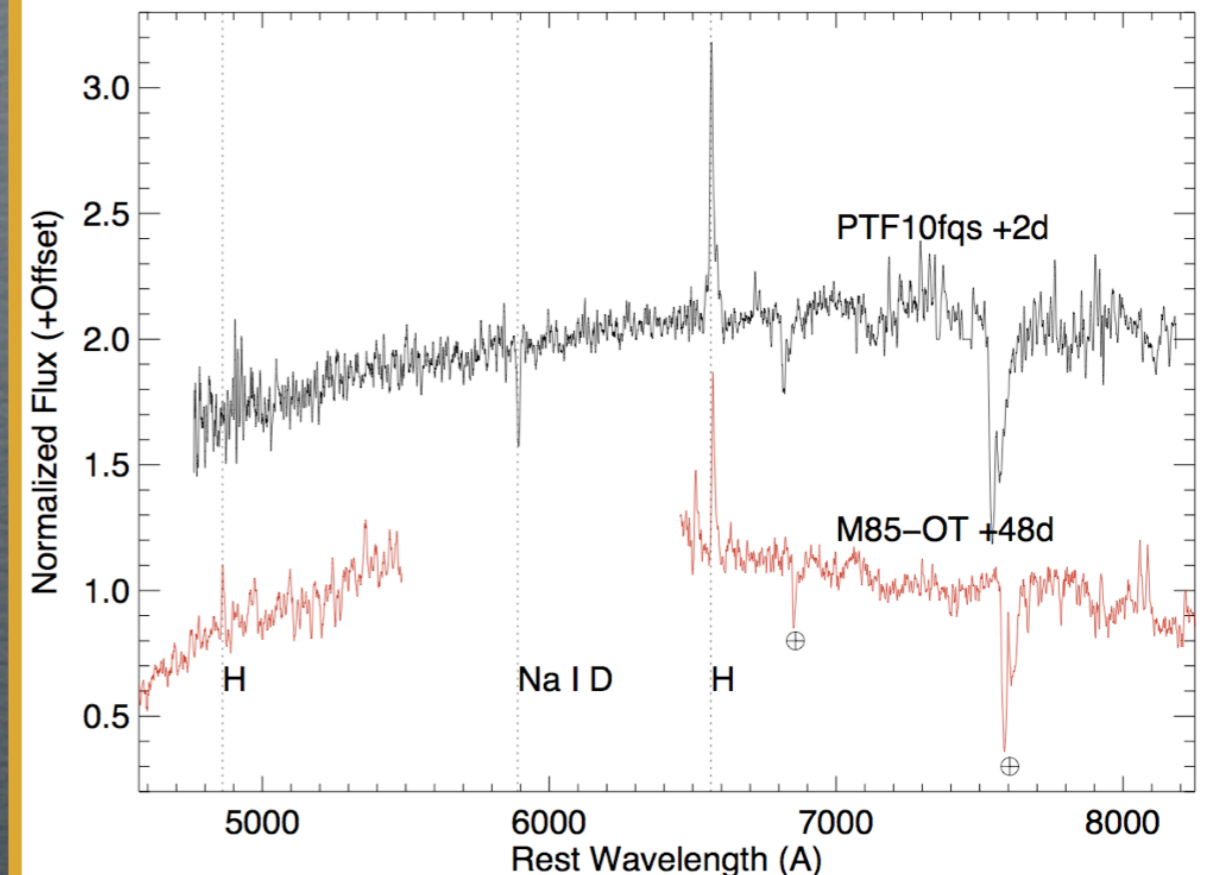
(BOND ET AL 2003)

## A GAP BETWEEN CNE AND SNE:

- SMALL GROUP (~5-8)
- SLOW EVOLVING WITH STRONG RED WAVE EVOLUTION
- BRIGHT SPITZER PROGENITOR (SN2008S, NGC300-OT)
- MODELS: EXTREME AGB STAR, COMMON ENVELOPE, INSPIRAL OF GIANT PLANET, WEIRD CNE, SNE?
- PTF, LSST ~50 NEW SOURCES



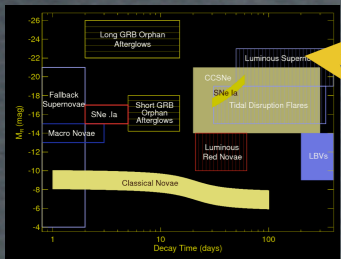
(RAU ET AL. 2007)



(KASLIWAL ET AL. 2010B) 2010 Dec 6th / TEXAS 2010

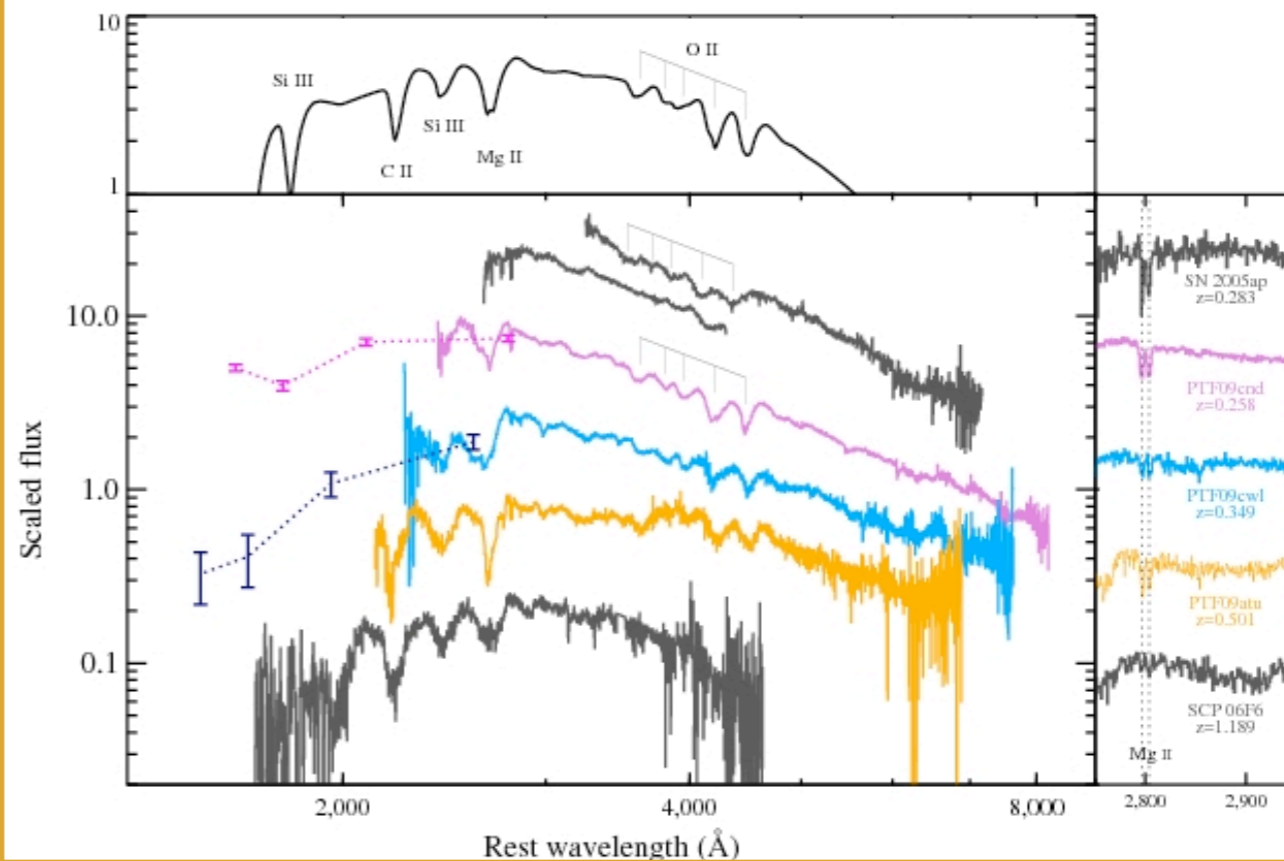
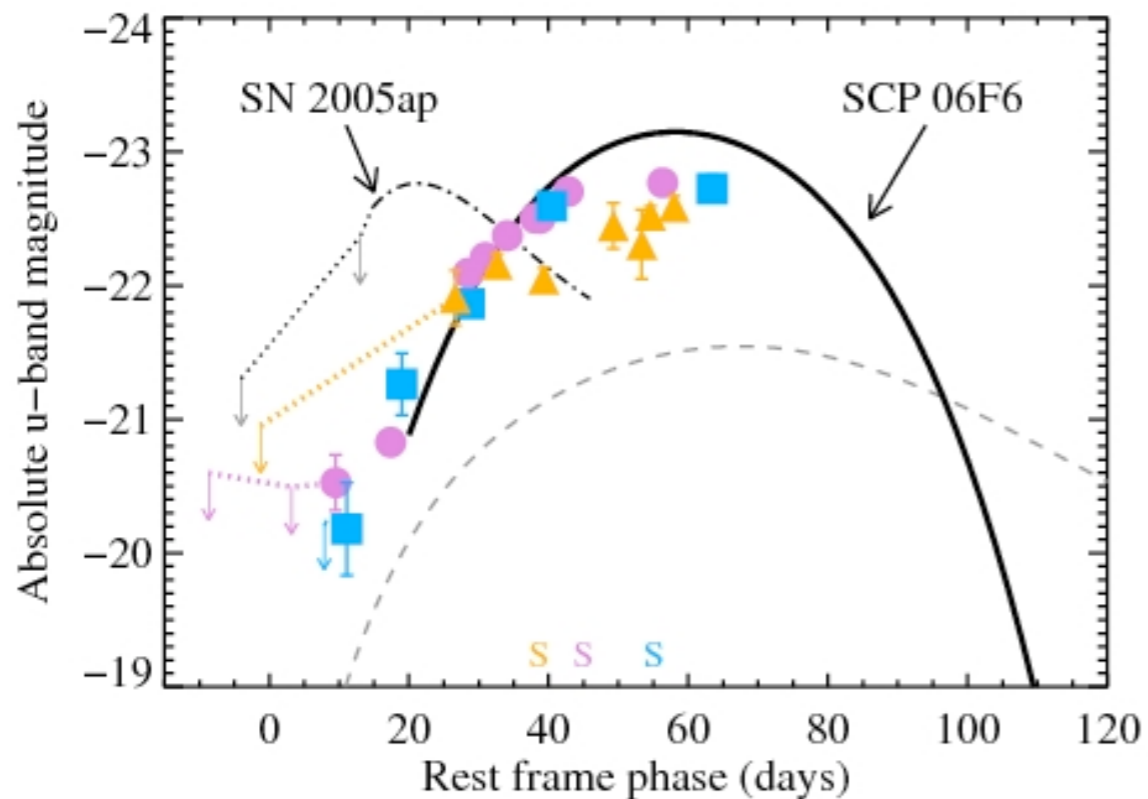
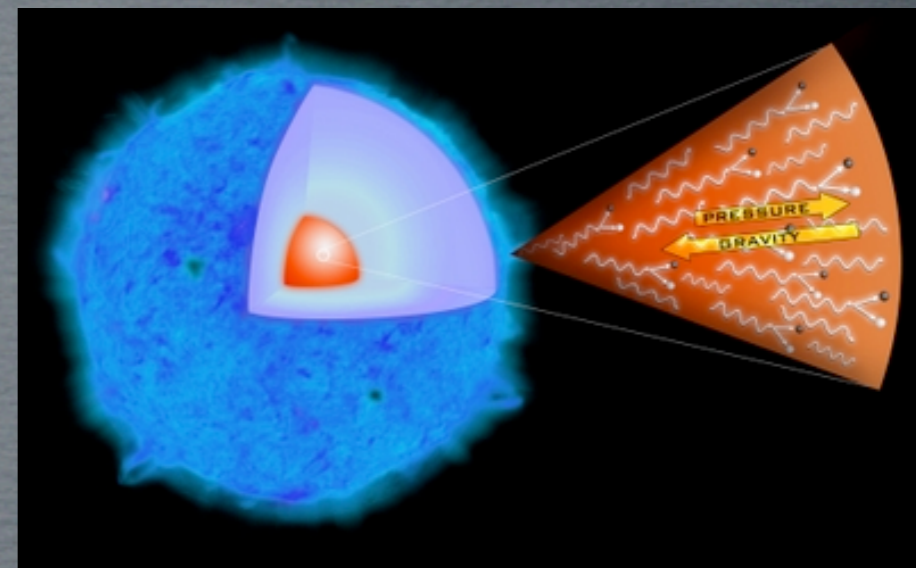


# LUMINOUS SUPERNOVAE



## 5 LUMINOUS SNE:

- ENIGMATIC SCP06F6 ( $z=1.2$ ) (BARBARY ET AL. 2009, GÄNSICKE ET AL. 2009)
- 3 NEW FROM PTF + SN2005AP ( $z=0.26-0.5$ )
- UV-BRIGHT (-23MAG)
- INCONSISTENT WITH  $^{56}\text{Ni}$  POWERED AND CCSNE
- LACK OF H AND HE  $\rightarrow$  PULSATIONAL PISNE ?
- THOUSANDS WITH LSST
- BRIGHT BEACONS FOR HIGH-Z STUDIES



(QUIMBY ET AL 2010)