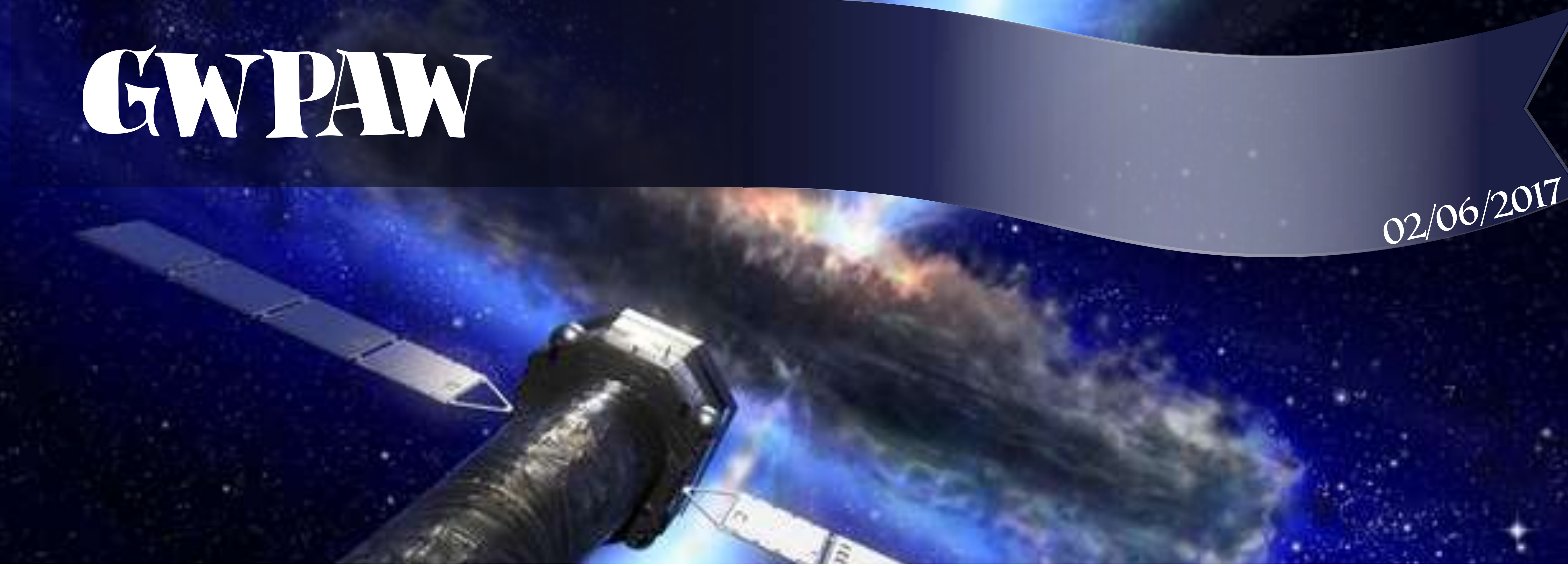
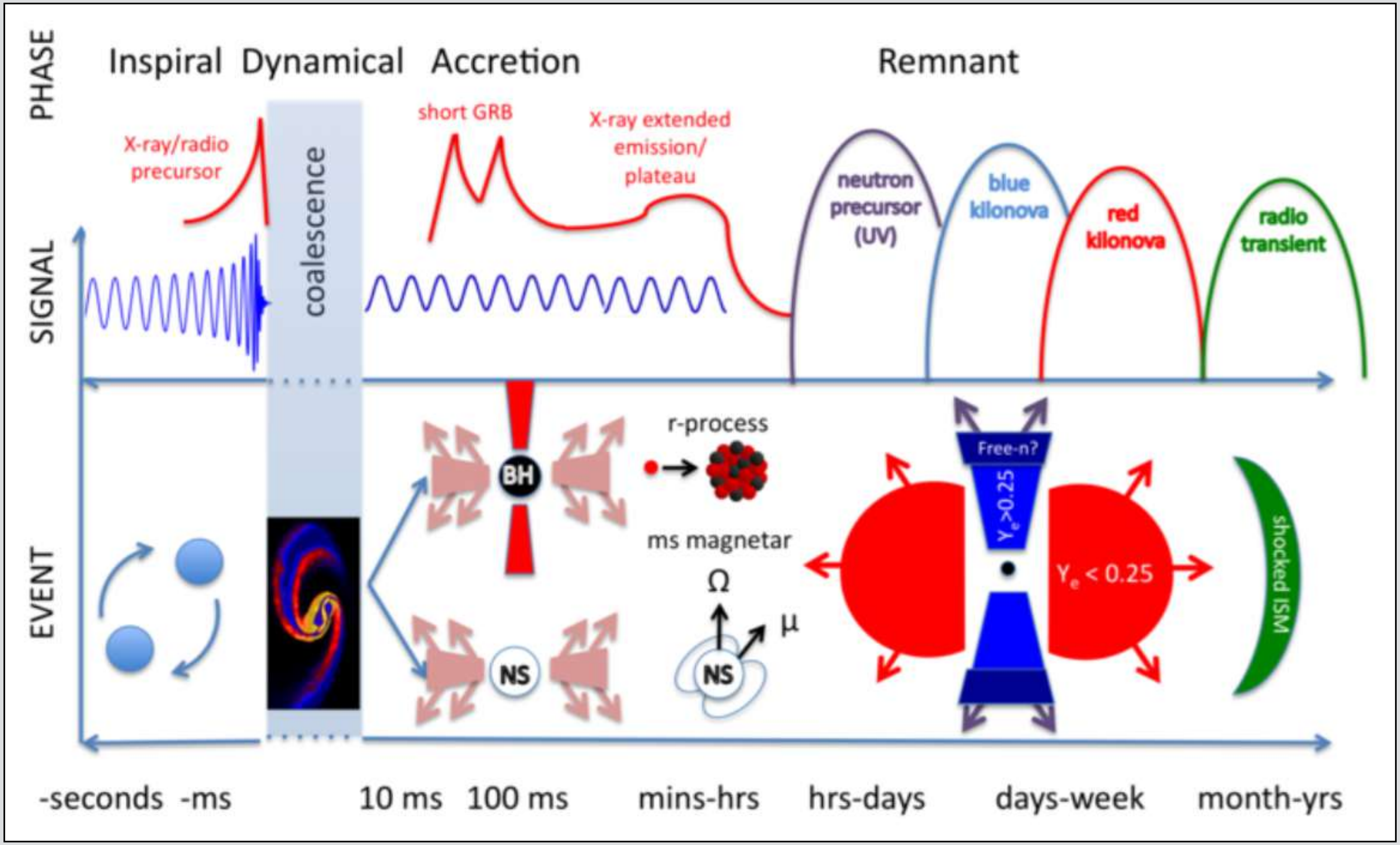


Constraining BNS merger rates and X-ray counterpart models with existing data

S.Vinciguerra, M.Branchesi, I.Mandel, R.Ciolfi, A.Tiengo, R.Salvaterra, A.Belfiore, A.De Luca, D.Salvietti, M.Marelli and G.Stratta.

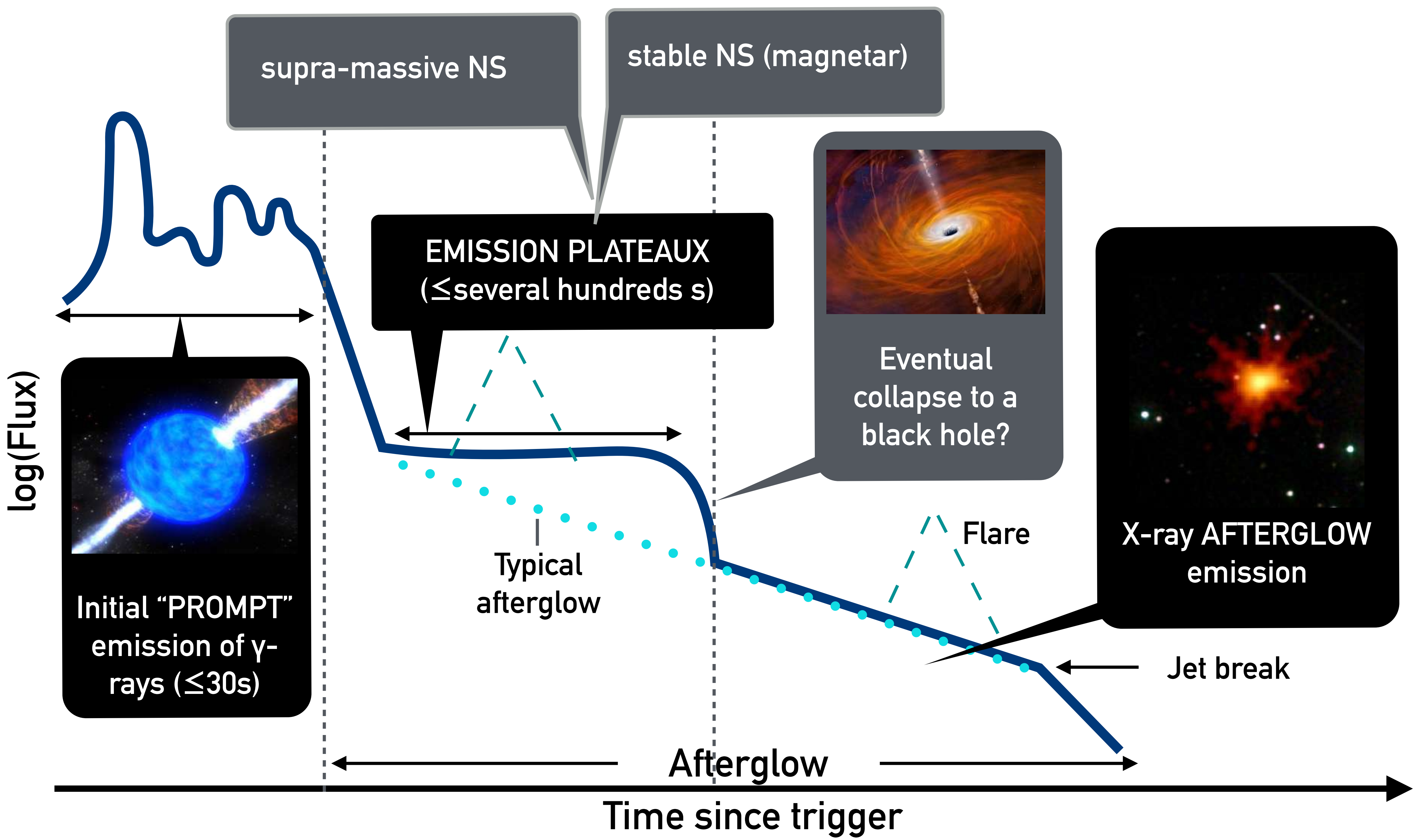
GraWIToN
GW Initial Training Network
MARIE CURIE ACTIONS
UNIVERSITY OF BIRMINGHAM
1506 UNIVERSITÀ DEGLI STUDI DI URBINO CARLO BO
UNIURB OPEN JOURNALS

most popular emissions in BNS mergers



Rodrigo Fernández and Brian D. Metzger Ann. Rev. Nuc. Part. Sci. 2016. 66:1–24

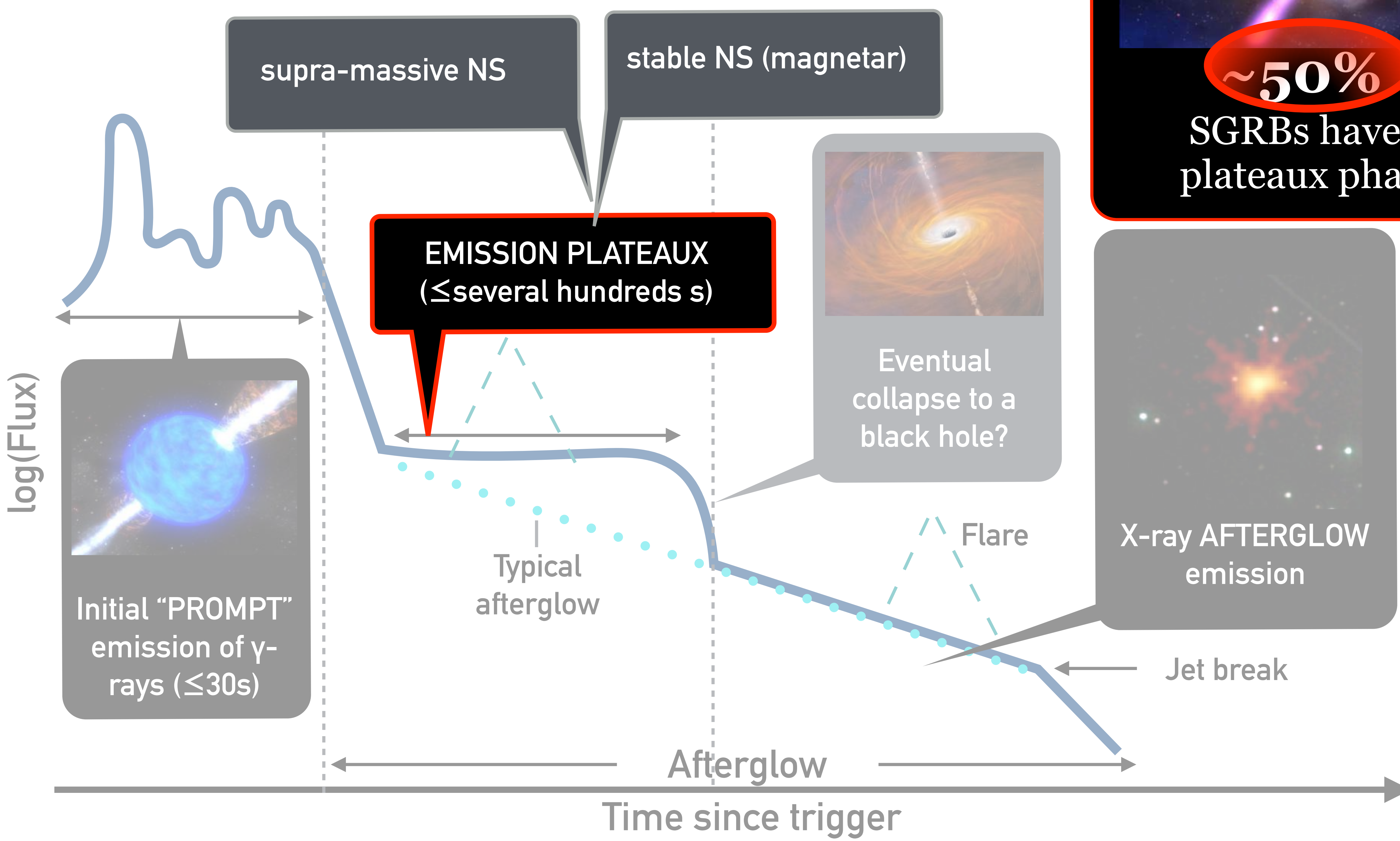
Short gamma-ray bursts

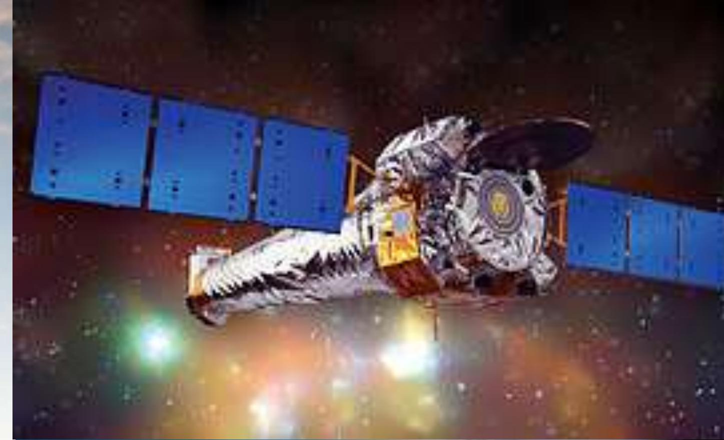


Short gamma-ray bursts

Rowlinson et al.
MNRAS Vol. 430, 2,
1061-1087

~50%
SGRBs have a
plateaux phase

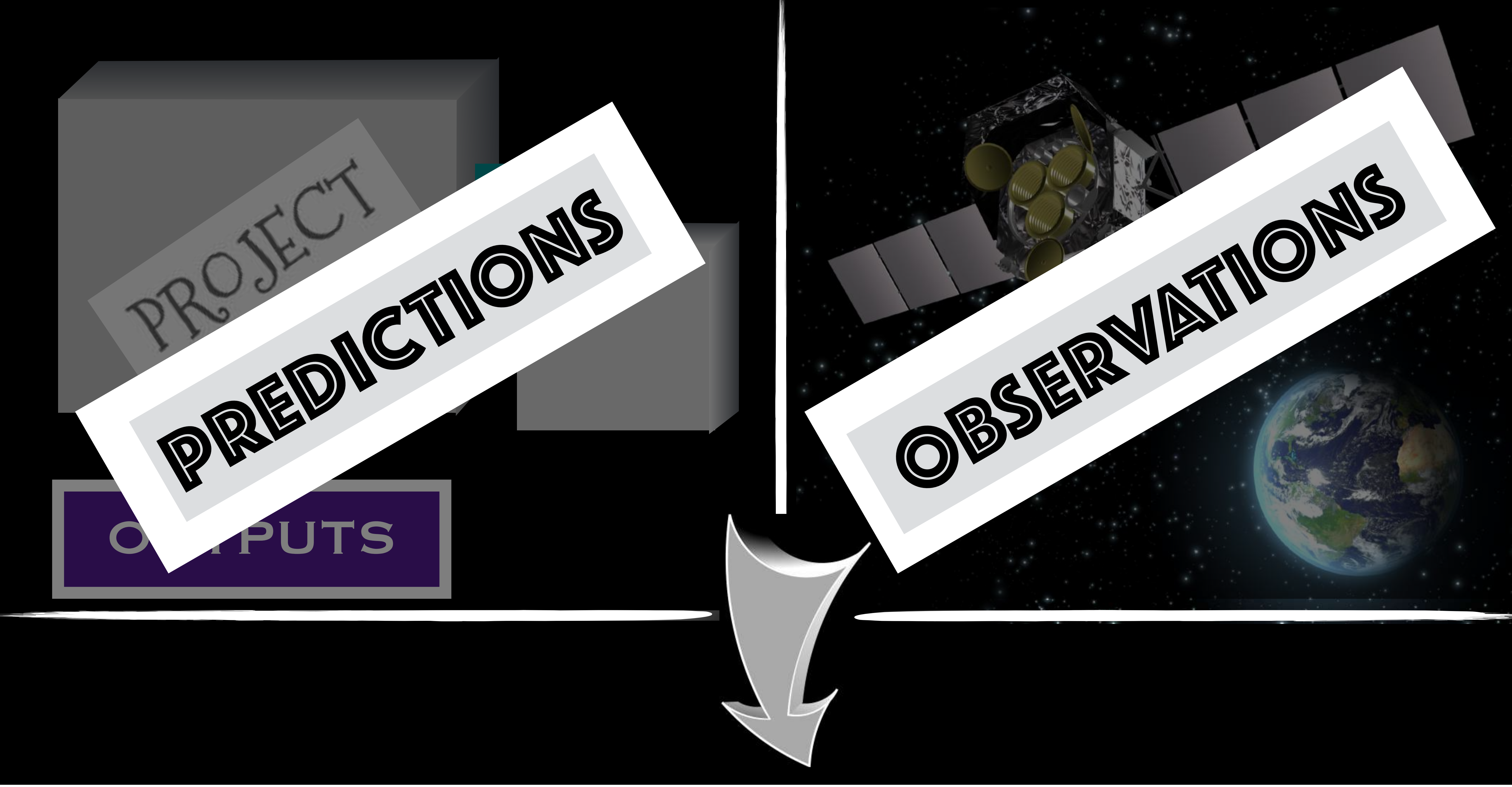



Can archived data already tell us something about **BNS emission***?*







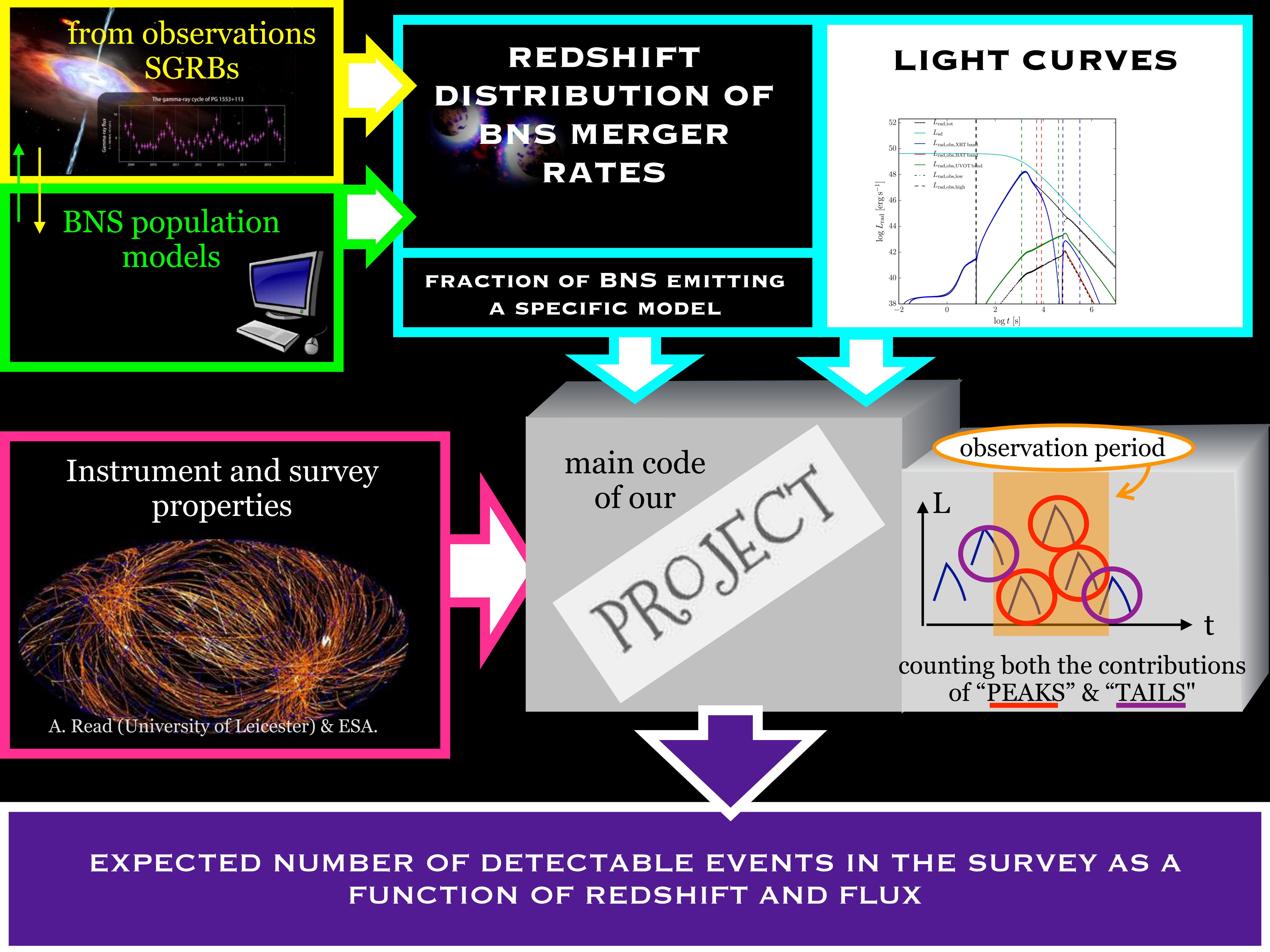
CONSTRAINS ON THE EMISSION MODELS OR BNS MERGER RATES

PREDICTIONS

saprEMo

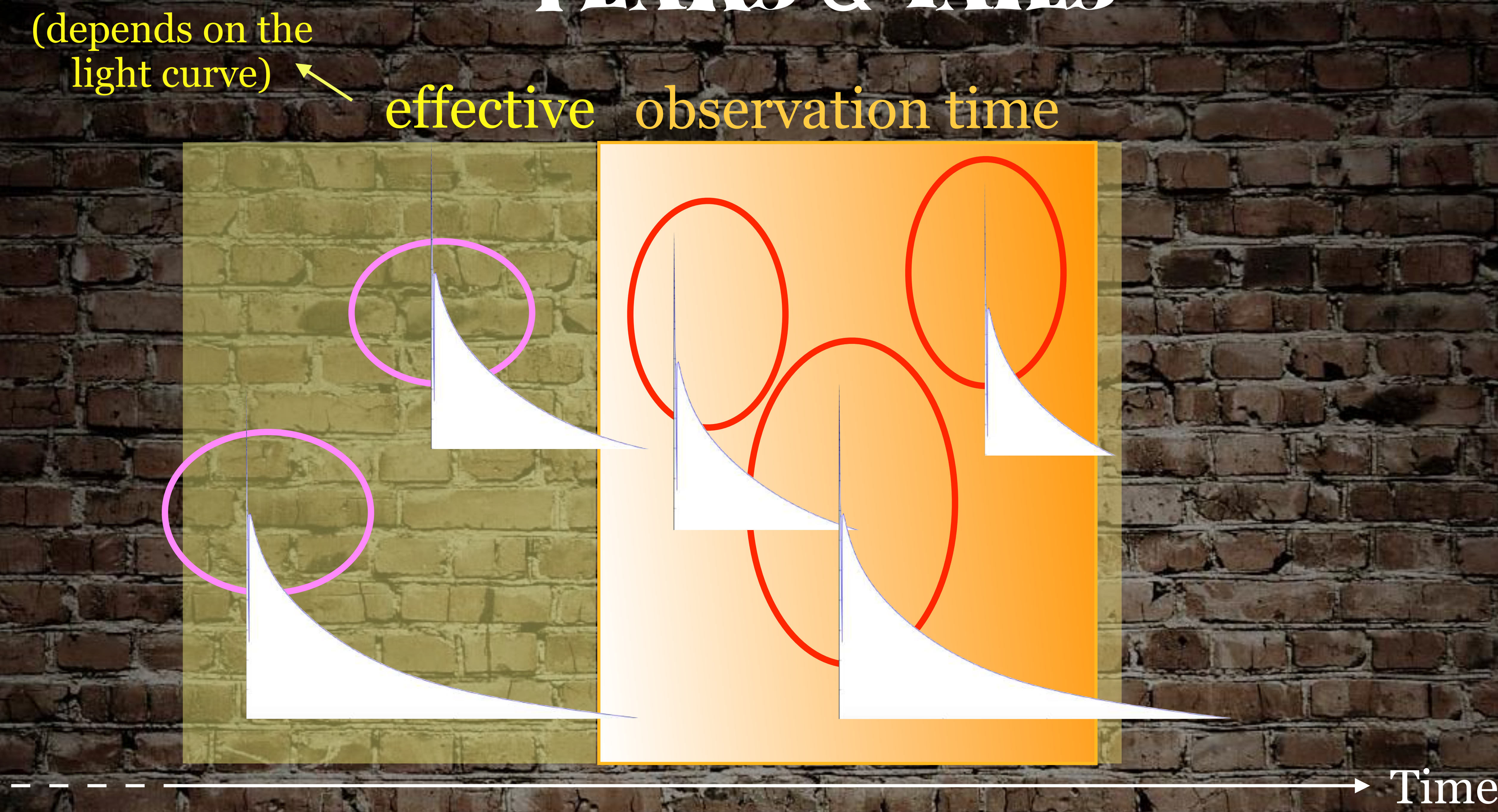
Simplified Algorithm for pREdicting EM Observation

S.Vinciguerra, M.Branchesi, I.Mandel, R.Ciolfi, & G.Stratta.



from observations
SGRBs
The gamma-ray cycle of PG 1553+113
BNS population
models
REDSHIFT DISTRIBUTION OF BNS MERGER RATES
FRACTION OF BNS EMITTING A SPECIFIC MODEL
LIGHT CURVES
log t [s]
Instrument and survey properties
A. Read (University of Leicester) & ESA.
main code of our
PROJECT
observation period
L
t
counting both the contributions of "PEAKS" & "TAILS"
EXPECTED NUMBER OF DETECTABLE EVENTS IN THE SURVEY AS A FUNCTION OF REDSHIFT AND FLUX

PEAKS & TAILS

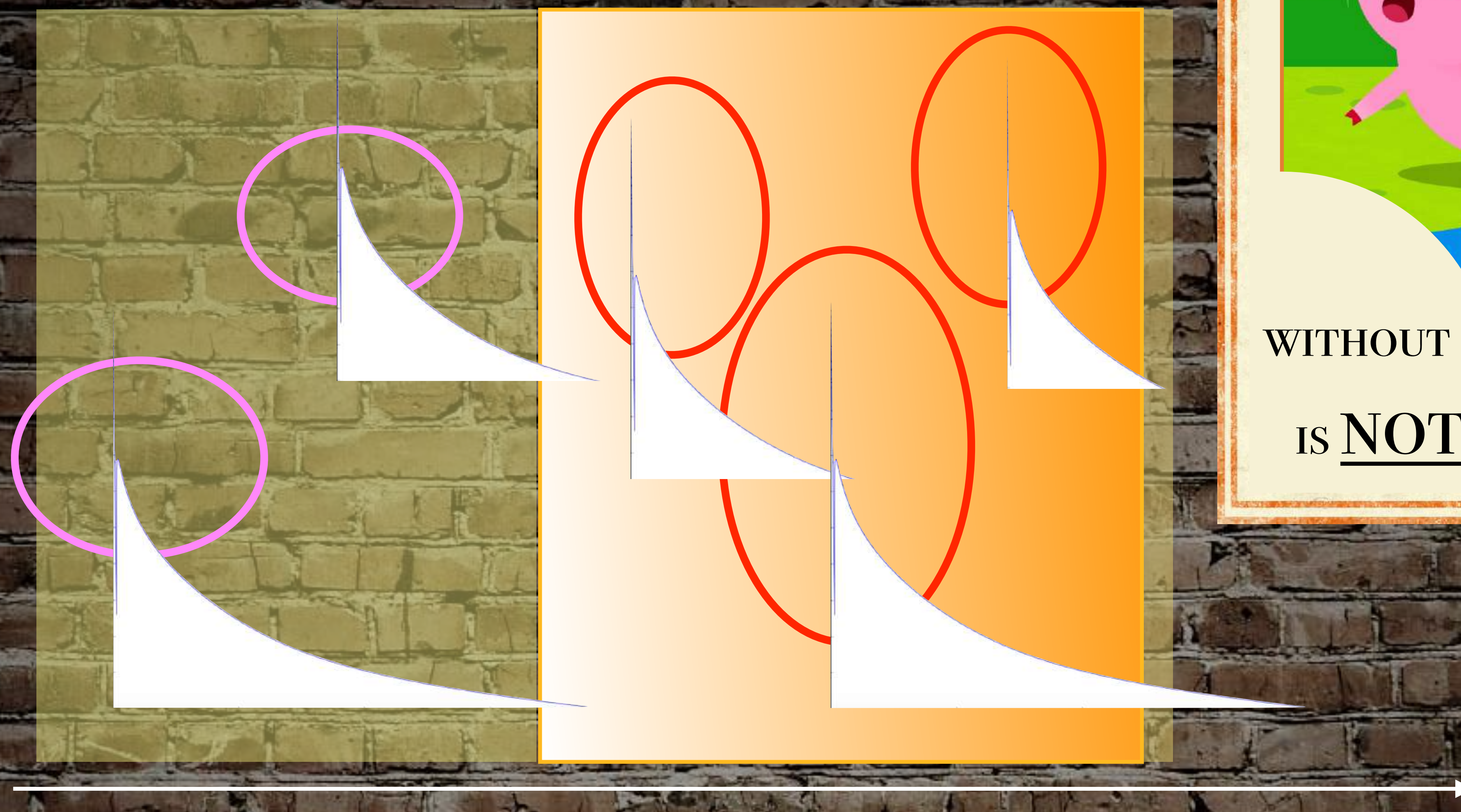


PEAKS

TAILS

$$N^{a}_{tot} \approx f_{NS} \cdot n_{obs} \frac{FOV}{Area_{sky}} \left[T^{eq}_{obs} \int_{0}^{z_{max}} \frac{R_V(z)}{1+z} \frac{dV c}{dz} dz + \int_{-\infty}^{+\infty} \int_{0}^{z_t(L(t))} \frac{R_V(z)}{(1+z)^2} \frac{dV c}{dz} dz\, dt \right]$$

PEAKS & TAILS



WITHOUT THE TAILS IS **NOT** THE SAME

PEAKS

TAILS

$$N^a_{tot} \approx f_{NS}\cdot n_{obs}\frac{FOV}{Area_{sky}}\left[T^{eq}_{obs}\int_0^{z_{max}}\frac{R_V(z)}{1+z}\frac{dVc}{dz}\,dz+\int_{-\infty}^{+\infty}\int_0^{z_t(L(t))}\frac{R_V(z)}{(1+z)^2}\frac{dVc}{dz}\,dz\,dt\right]$$

CODE STRENGHTS

Fixing the BNS merger rate model,
we can constrain the emission model;

Fixing the emission model,
we can constrain the BNS merger rate model;

Versatile in EM windows:
can be applied in different EM bands;

Versatile in topic:
BNS mergers motivated the development of the code,
nevertheless other EM source can be used as well;

can be applied also for future instrument:

- to predict observations as well as
- for defining an observational strategy

OUR FIRST CASE STUDY: X-ray

ADVANTAGES

- **Many** X-ray emission **models** have been recently proposed;
- most of them are **very bright** and substantially **isotropic**;
- very **few contaminants** for the soft band (0.2-10 keV) (in comparison with the other EM bands);
- characterised by lower absorption than the optical band.

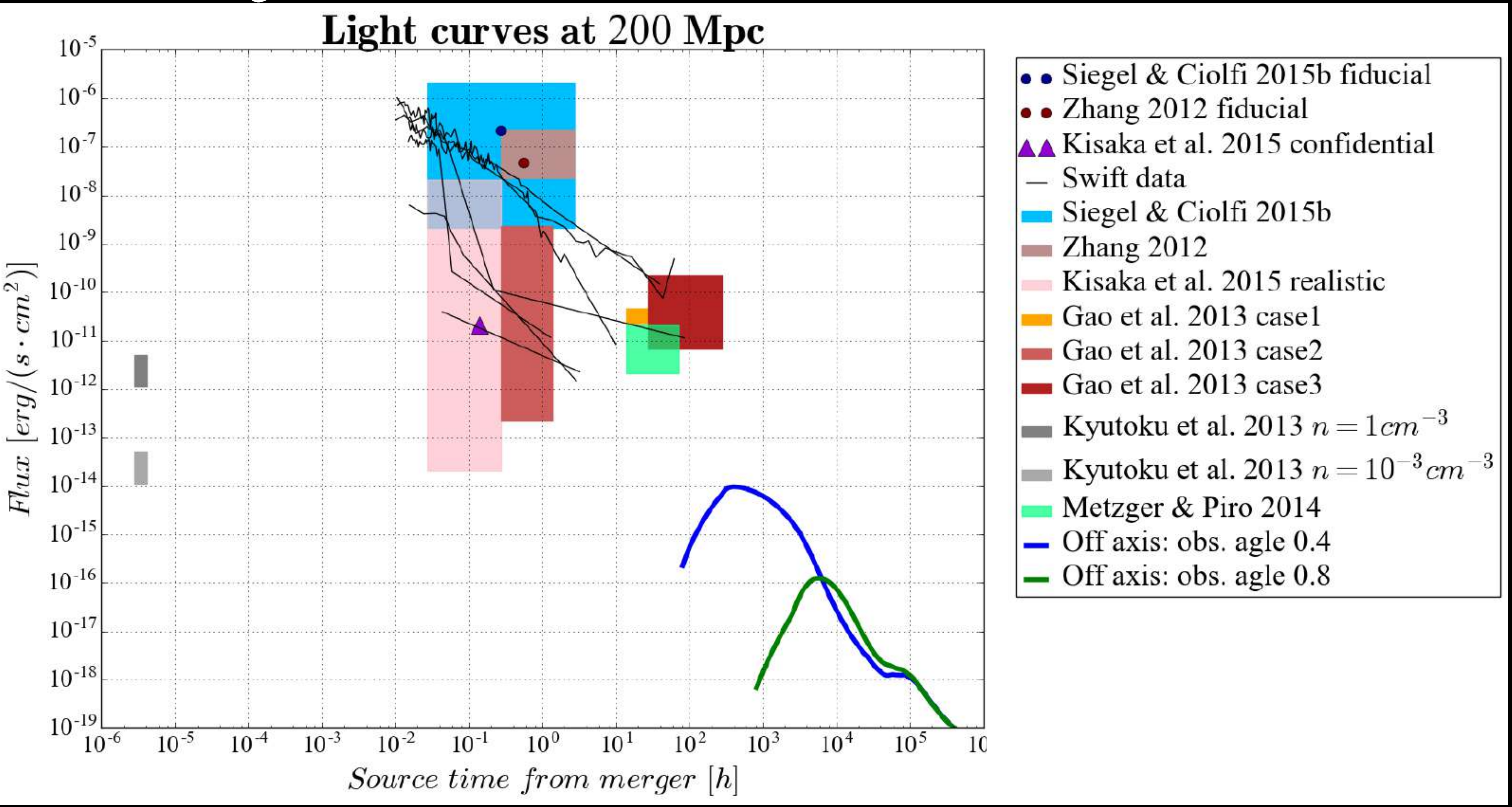
DISVANTAGES

- Satellites with **small (arcmin) FoV.**

XMM Newton (0.2–12) keV

FoV ~ 1/4 deg^2	SLEW DATA	POINTED OBSERVATIONS
SENSITIVITY	~10^{-12} erg s^{-1} cm^{-2}	~10^{-15} erg s^{-1} cm^{-2}
COVERED AREA	~80%	~3.3%
AVERAGE TIME OF OBSERVATION	~10s	~21 ks

X-ray model luminosities & SGRBs



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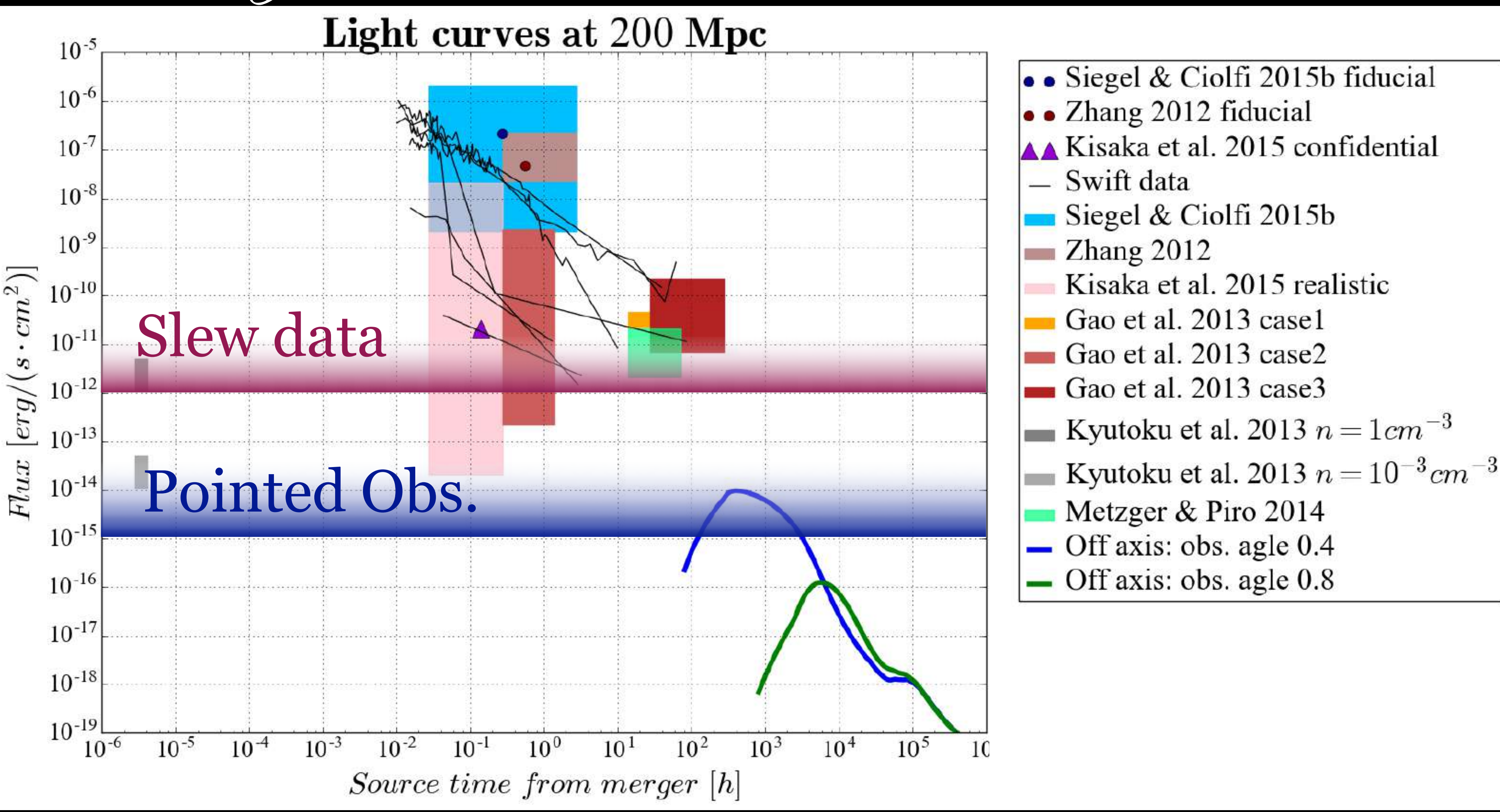
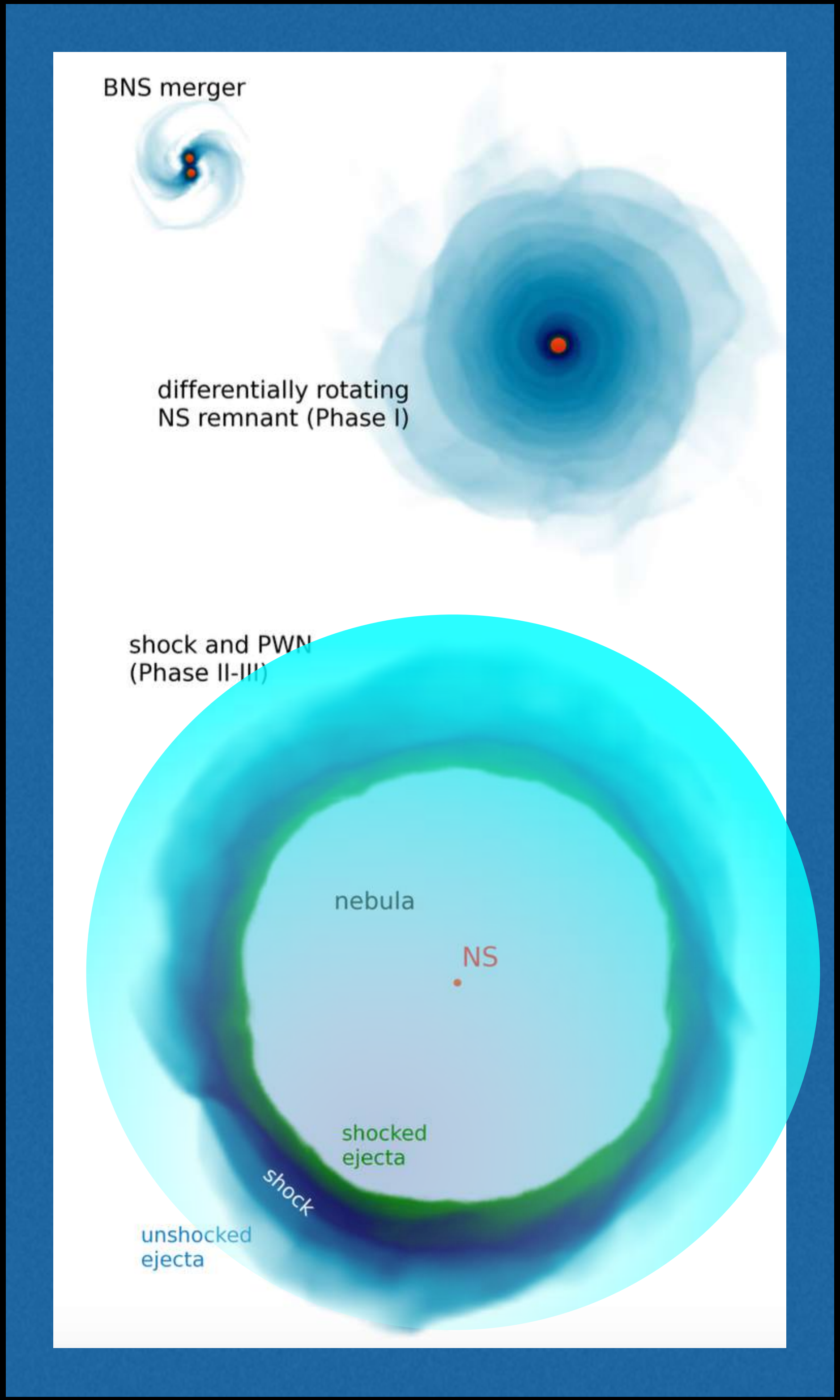
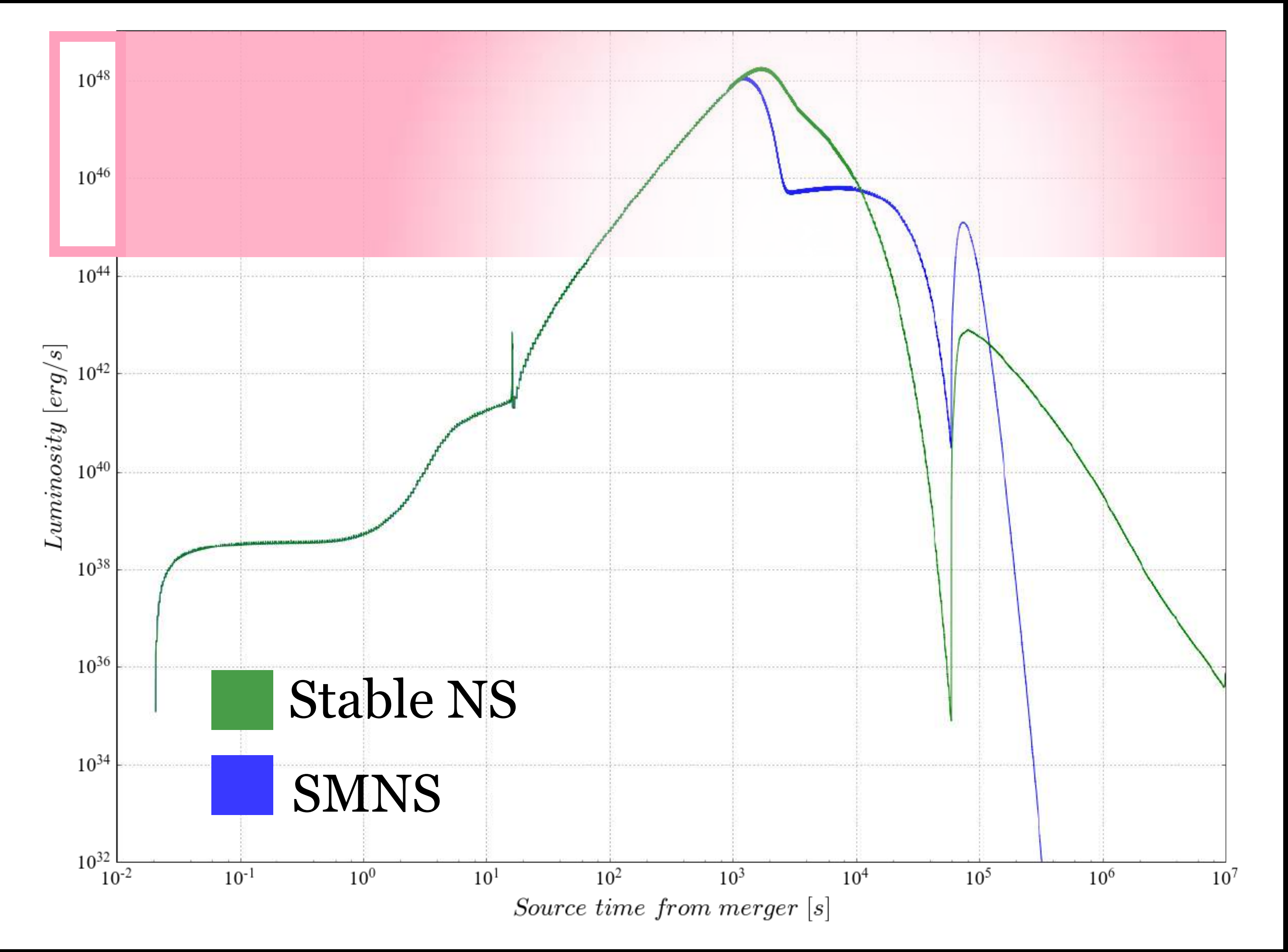


X-ray model - Siegel & Ciolfi (2016)



- ISOTROPIC
- VERY BRIGHT
- SPECIFIC SPECTRUM MODEL



First preliminary results

RATES FOR BNS MERGERS

from

synthetic universe

Dominick et al.(2013)

-high-

http://www.syntheticuniverse.c

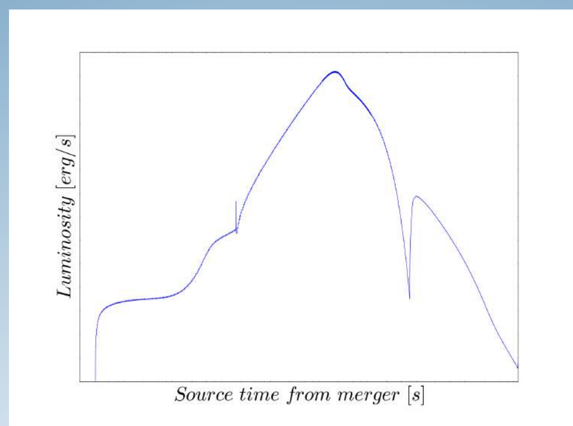
EMITTED LIGHT CURVE

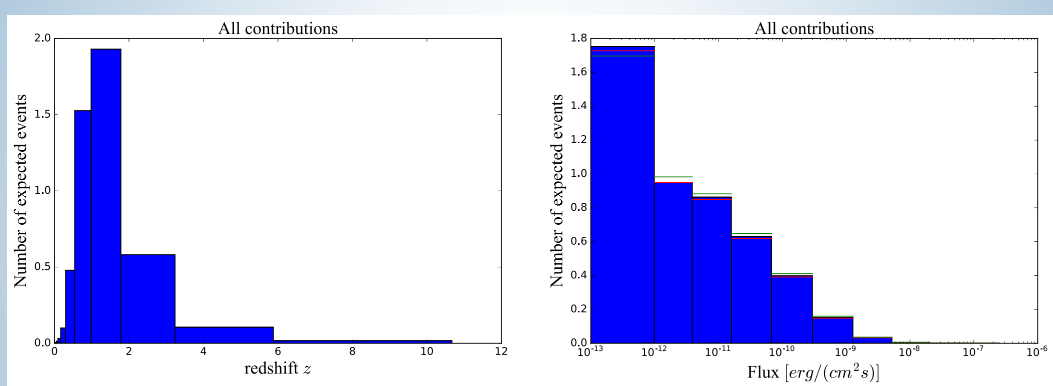
from

Siegel & Ciolfi 2015

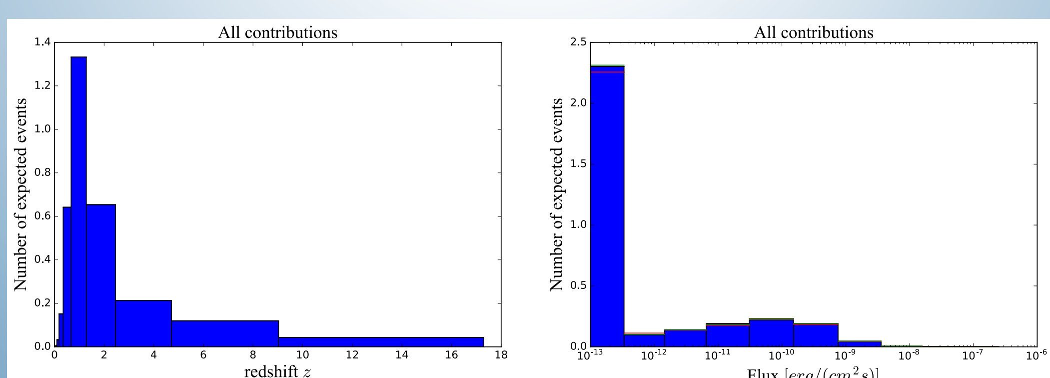
First preliminary results

Stable NS



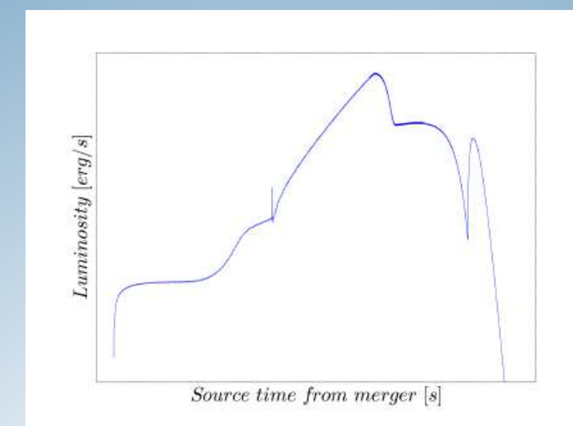


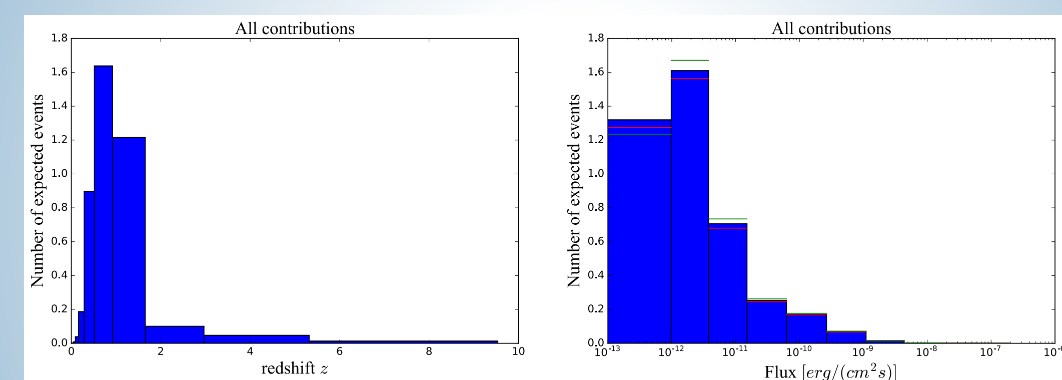
Slew data: N~ 5



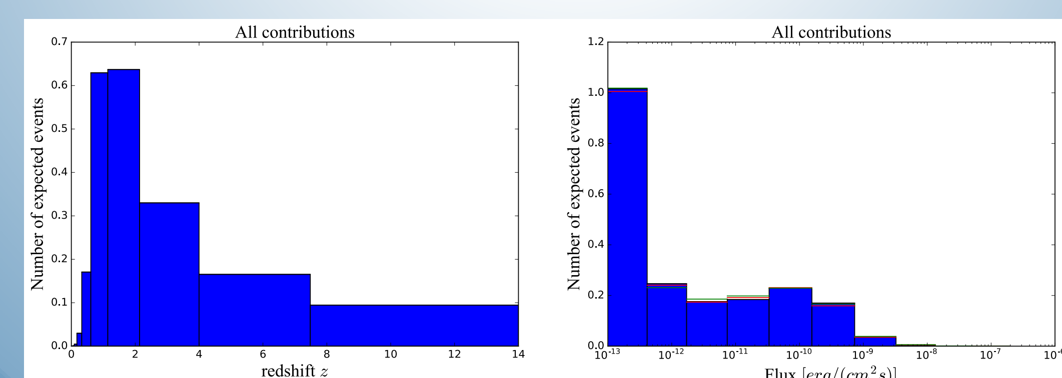
Pointed Obs.: N~3

SMNS



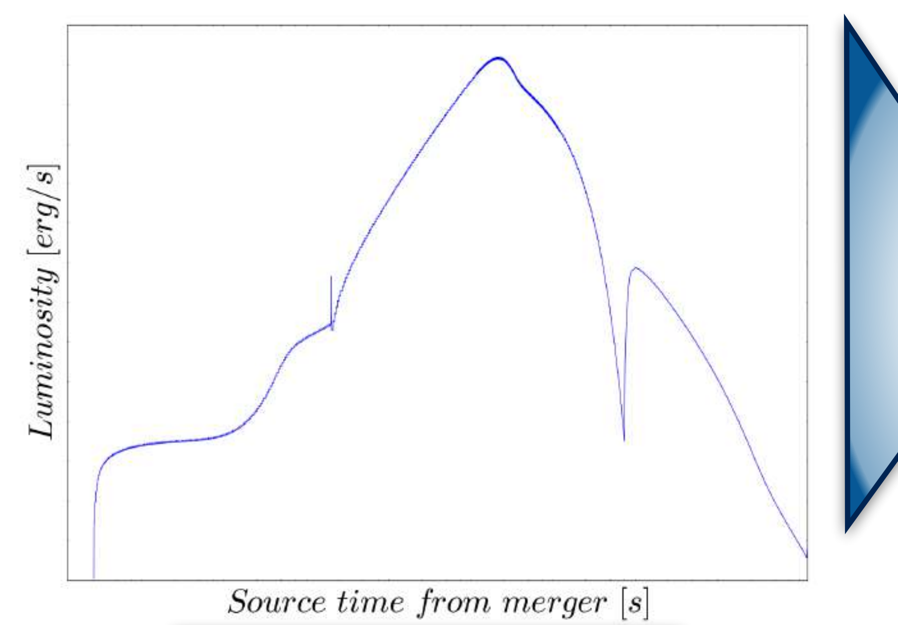


Slew data: N~4



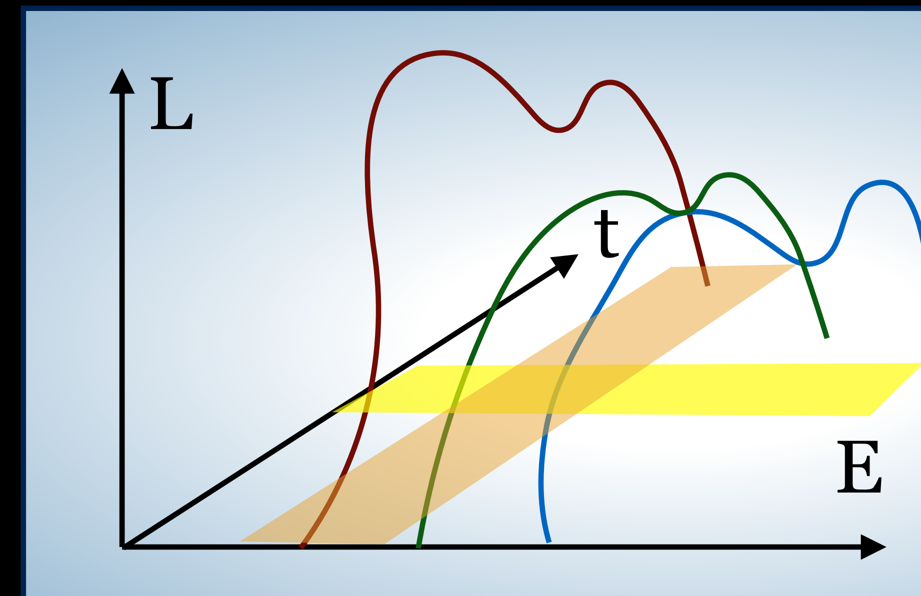
Pointed Obs.: N~2

First results - code optimisation



Light curve at different energies

more precise account for light curve shifts in redshift and sensitivity



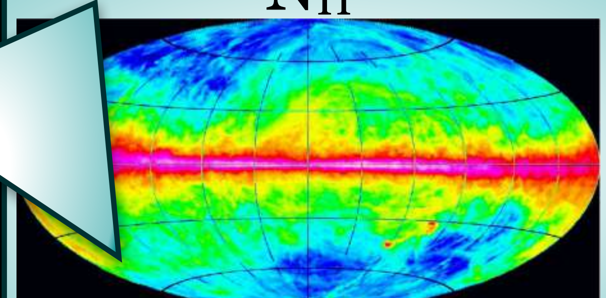
Galactic absorption model

$$f(E) = f_0(E) e^{-\sigma(E) n_H}$$

for specific observations

position of observations
compared to the galactic plane

N_H



$0 < N_H < 2\ 10^{22}\ cm^{-2}$, logarithmic scale

P. M. W. Kalberla et al 2005

CROSS SECTION

$$\sigma(E) = (c_0 + c_1 E + c_2 E^2) E^{-3} \times (10^{-24} cm^2)$$

Wisconsin (Morrison and McCammon; ApJ 270, 119)

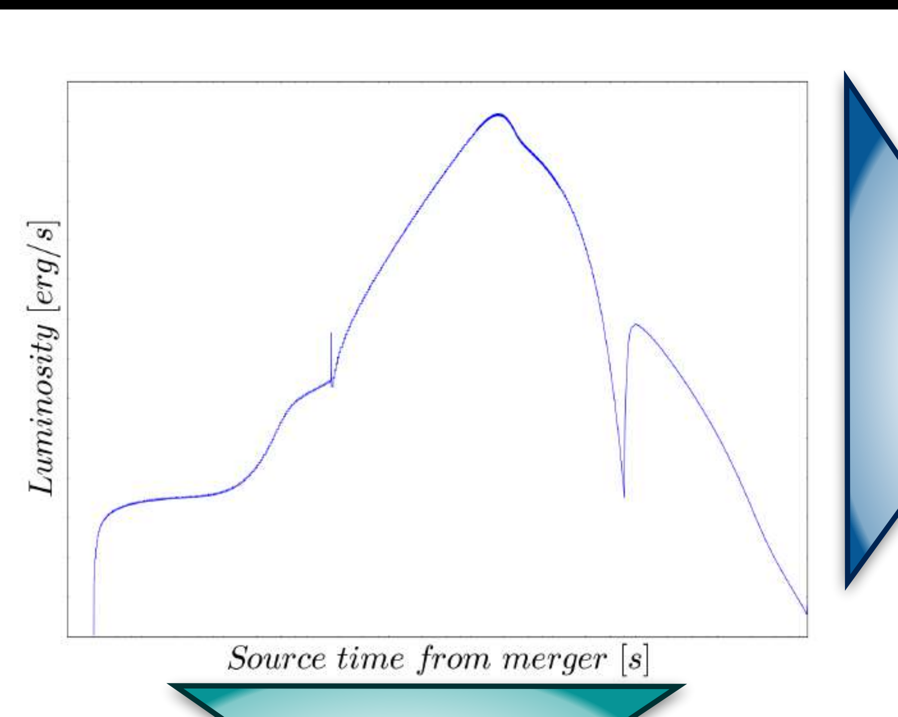
molecular

$$N_{H,g} = N_{HI} + 2N_{H_2}$$

$$N_{H_2} = N_{H_2 max} \left[1 - \exp\left(\frac{-N_{HI}}{N_c}\right)\right]^{\alpha}$$

R. Willingale et al. 2010 eq(5-6)

First results - code optimisation



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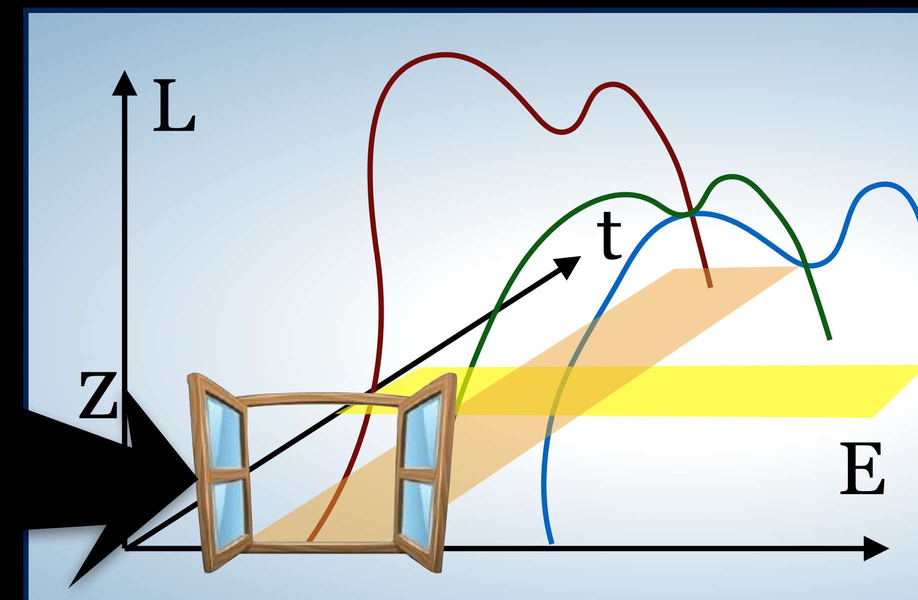

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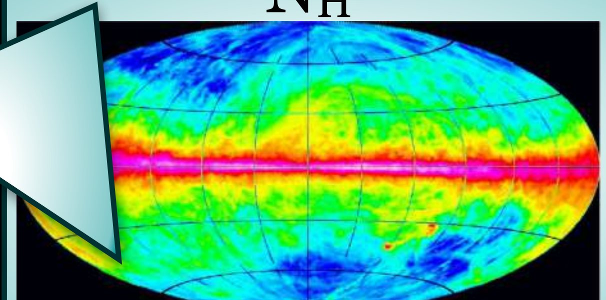

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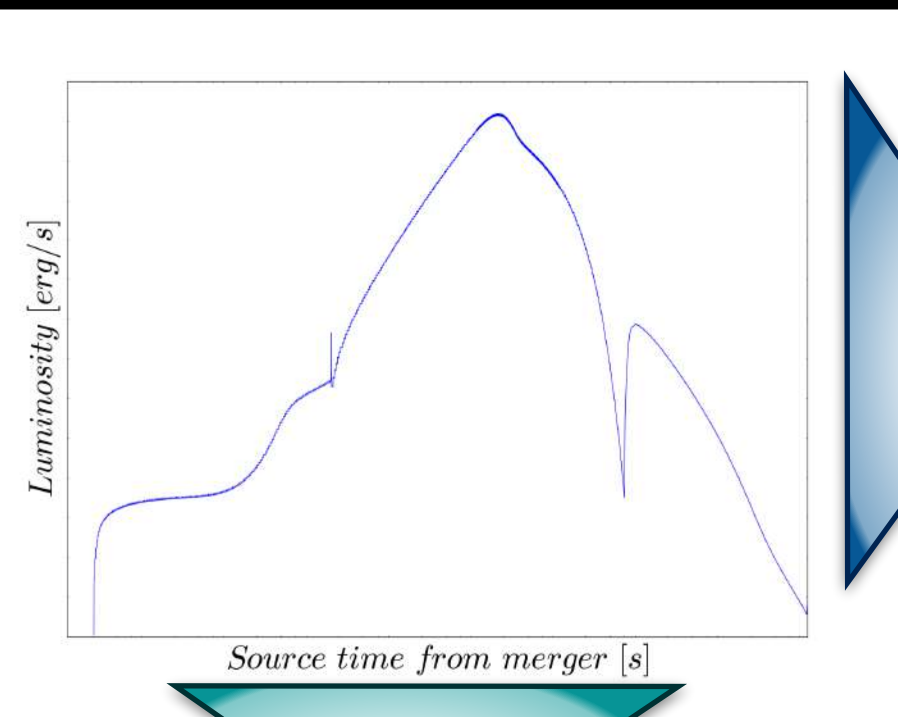

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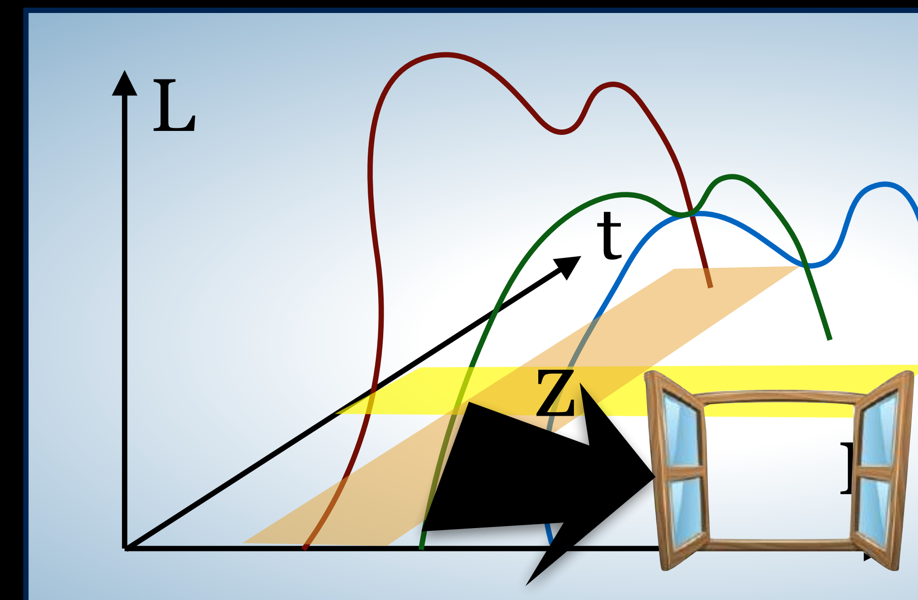

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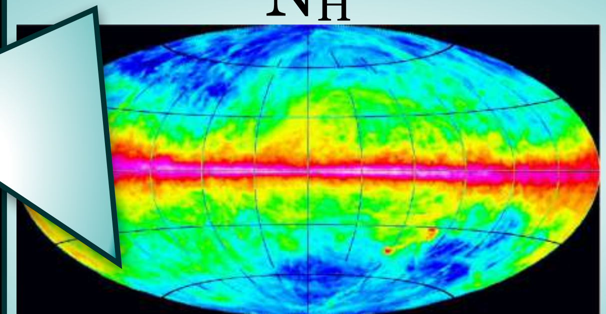

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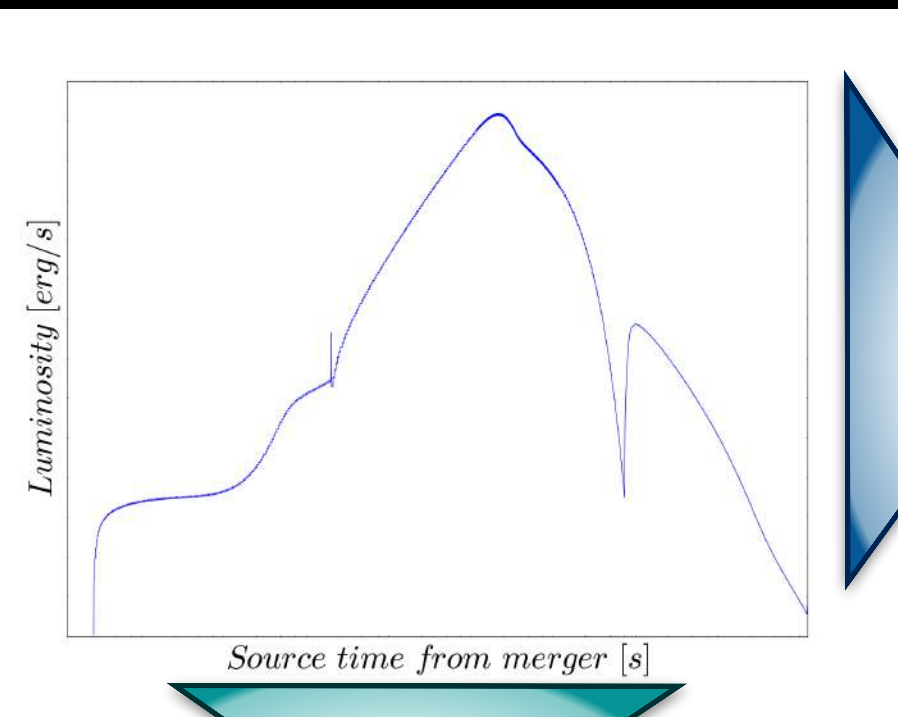

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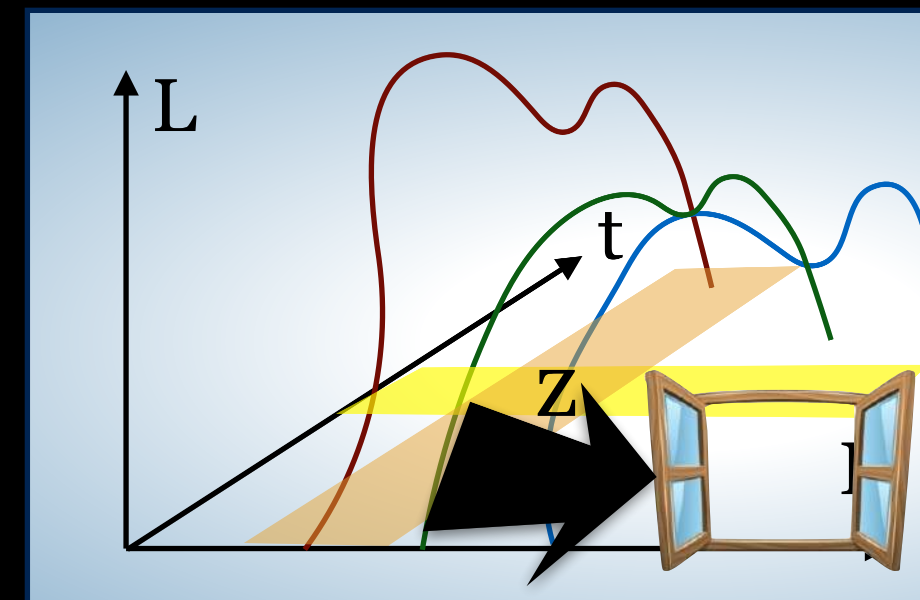

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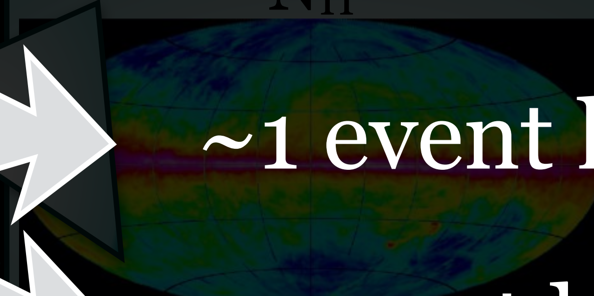

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R. Willingale et al. 2010 eq(5-6)

ABSORPTION → ~1 event less in slew

ABSORPTION → ~1 event less in pointed observations

OBSERVATIONS

exTraS

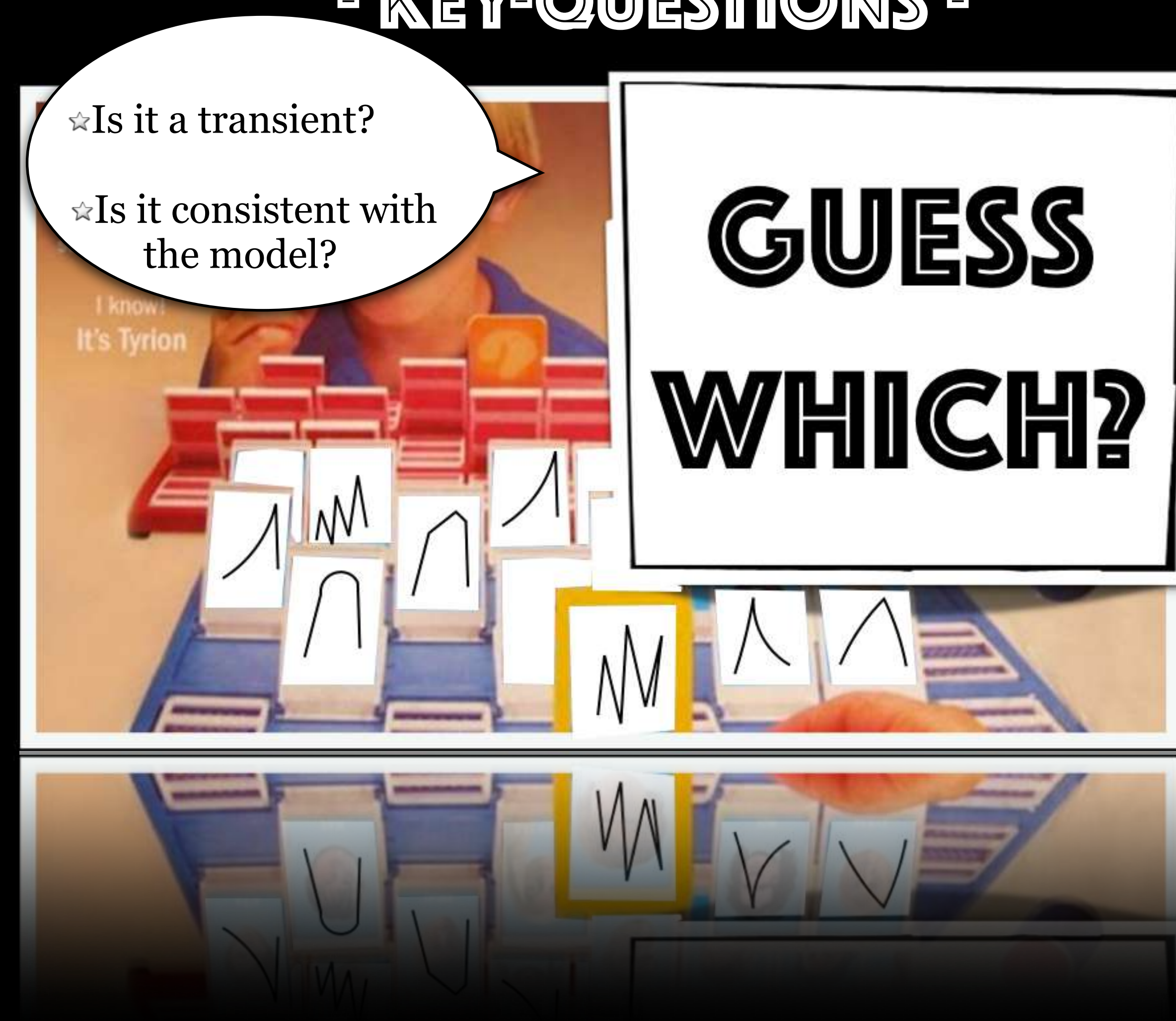
S.Vinciguerra, M.Branchesi, I.Mandel, R.Ciolfi, A.Tiengo, R.Salvaterra, A.Belfiore, A.De Luca, D.Salvietti, M.Marelli and G.Stratta.

DATA ANALYSIS – status & plan

1. sanity checks on data ✓
2. discarding extended sources ✓
3. discarding observations inconsistent with the proposed emissions ✓
4. selecting unknown objects by cross-matches with catalogues: ✗
   - setting correct match-radio ✗
5. selecting characteristic consistent with the emissions ✗

Within all the data we need to find the "right" ones!

- KEY-QUESTIONS -



We need to apply filters consistently to the algorithm dedicated in predicting the number of events in the data

On going/future investigations

BNS MERGER
RATE MODELS

LIGHT CURVES
models
distributions

DIFFERENT
INSTRUMENTS

ENVIRONMENT

DATA
ANALYSYS

CODE DEVELOPING
(detection criteria)
more informative outputs

Summary

many years of observations are already available in archive data

many new emission models have been proposed to be associated to BNS mergers

Thank you

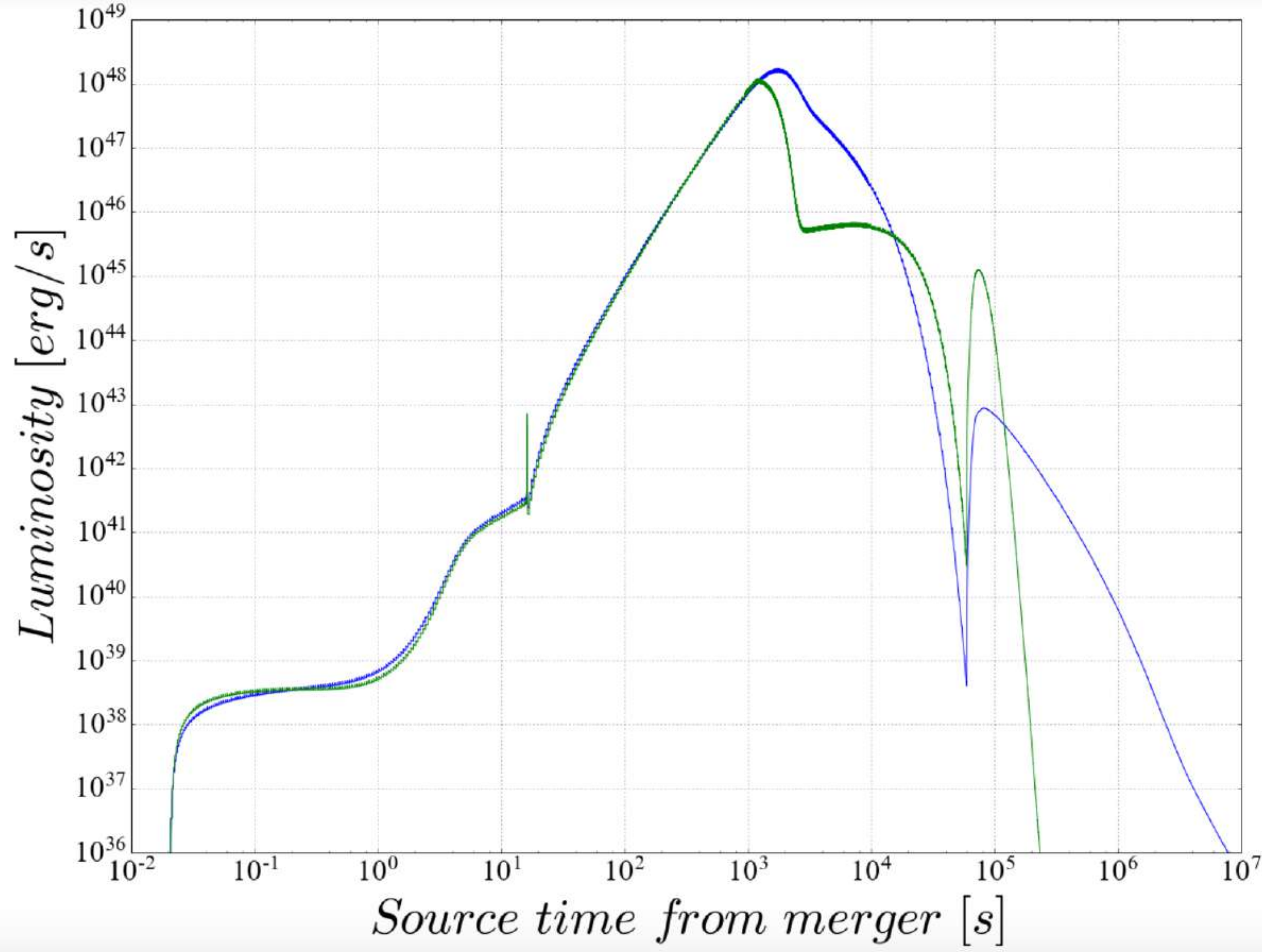
saprEMo + DATA ANALYSIS

- constrains on models
- predictions for new instruments

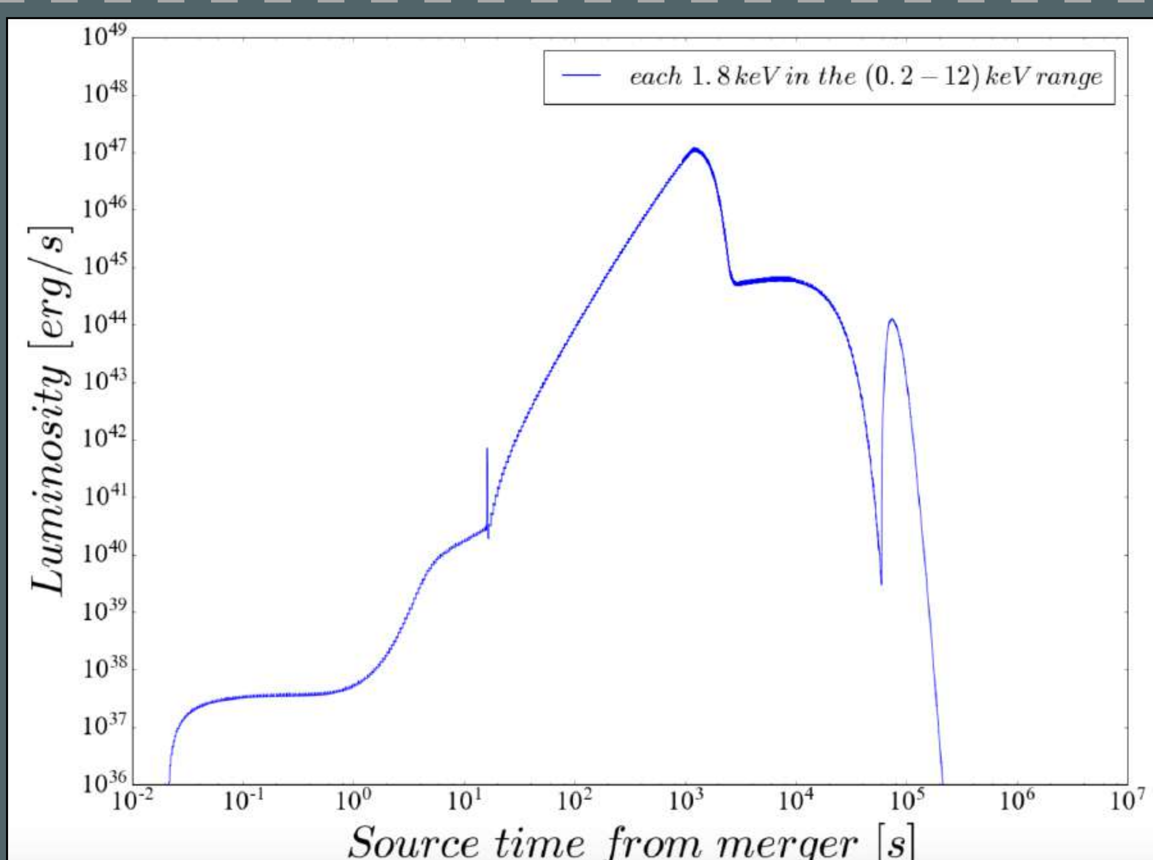
helping organising new observing strategies

-Extra Slides-

STABLE NS vs SMNS



SMNS spectra
z =0



Stable NS spectra
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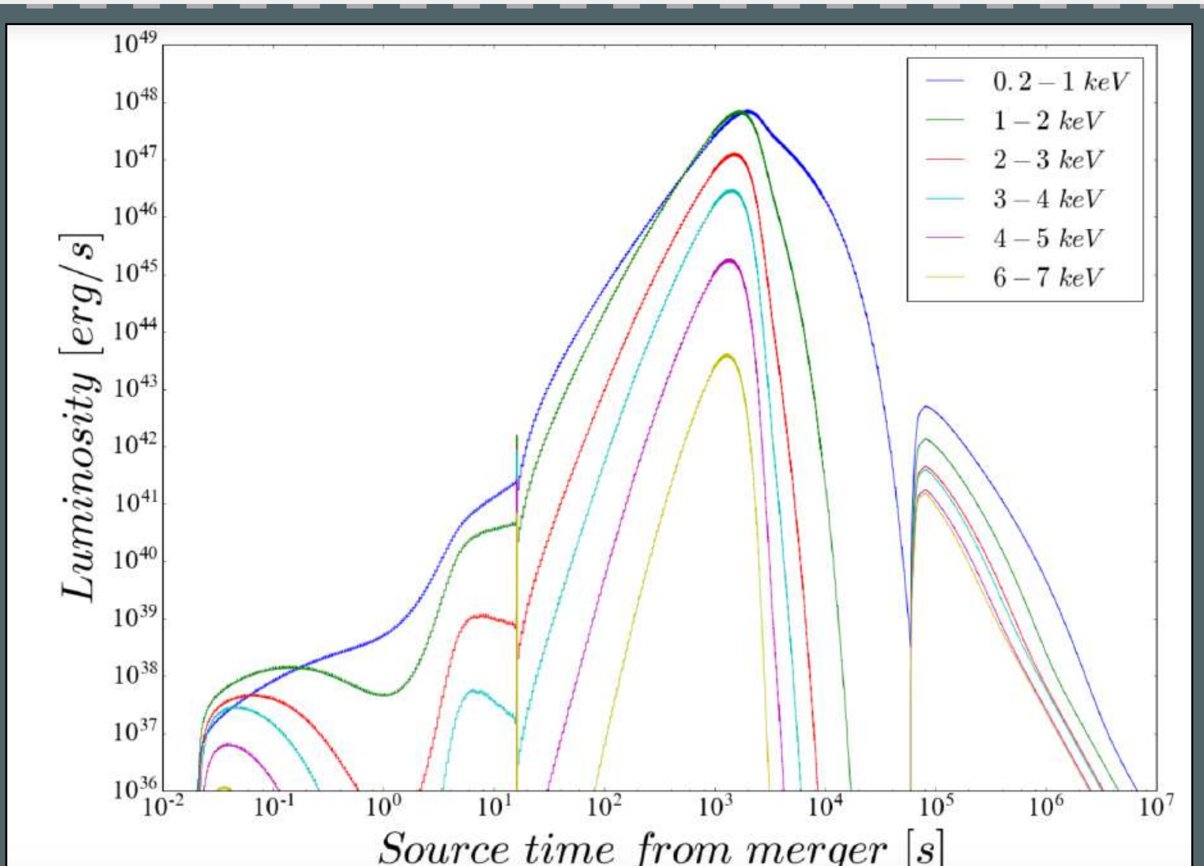
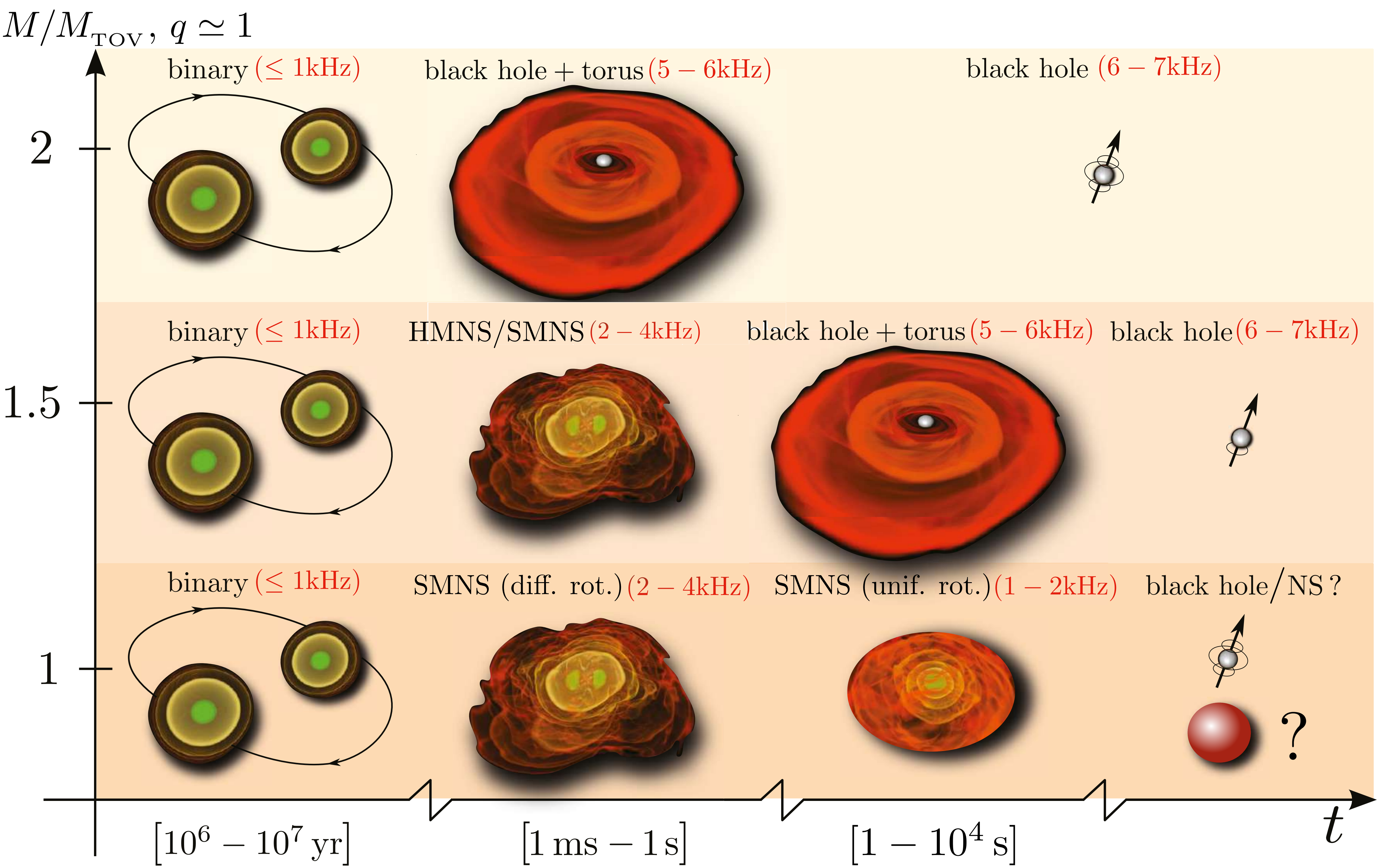


Binary neutron star mergers



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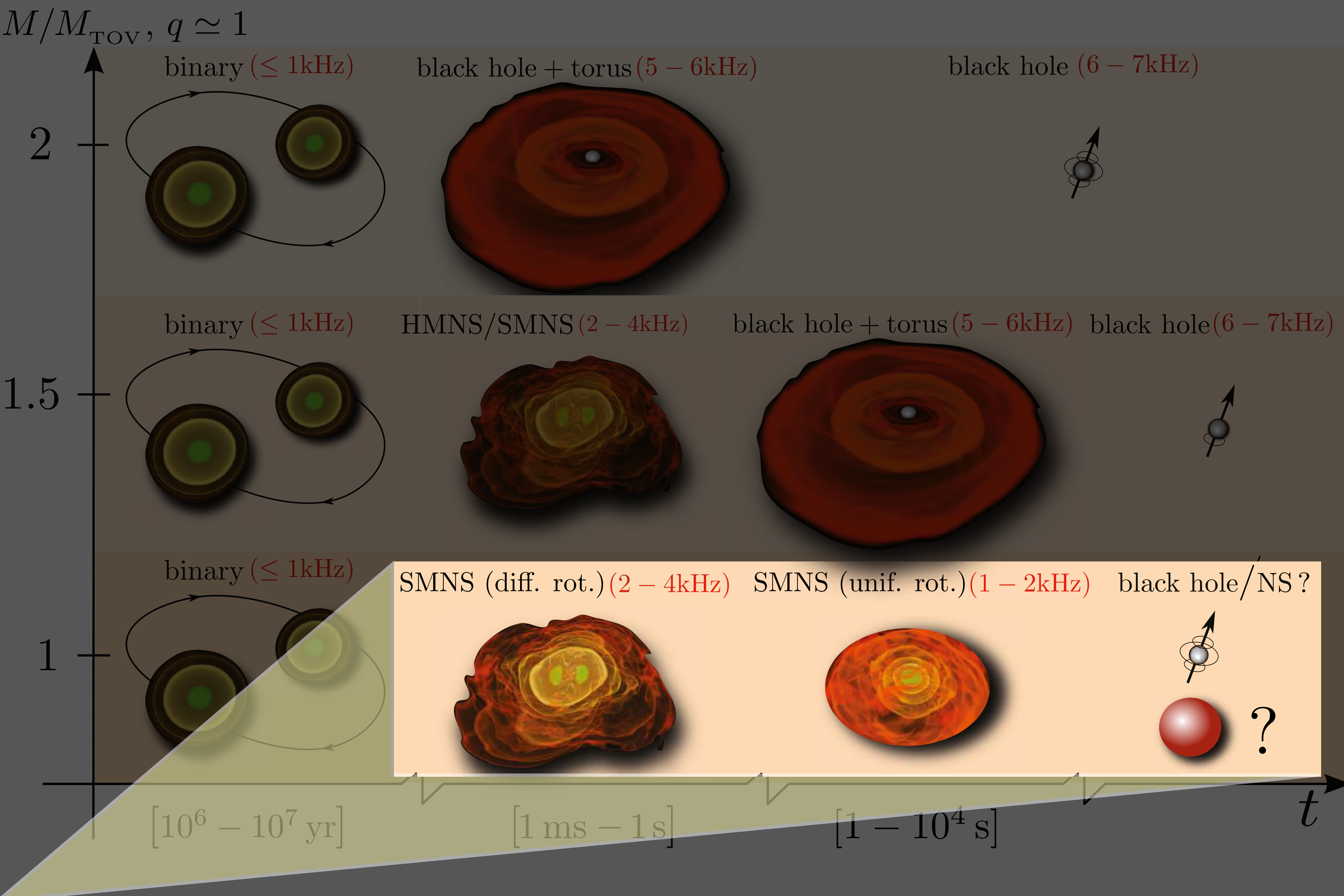
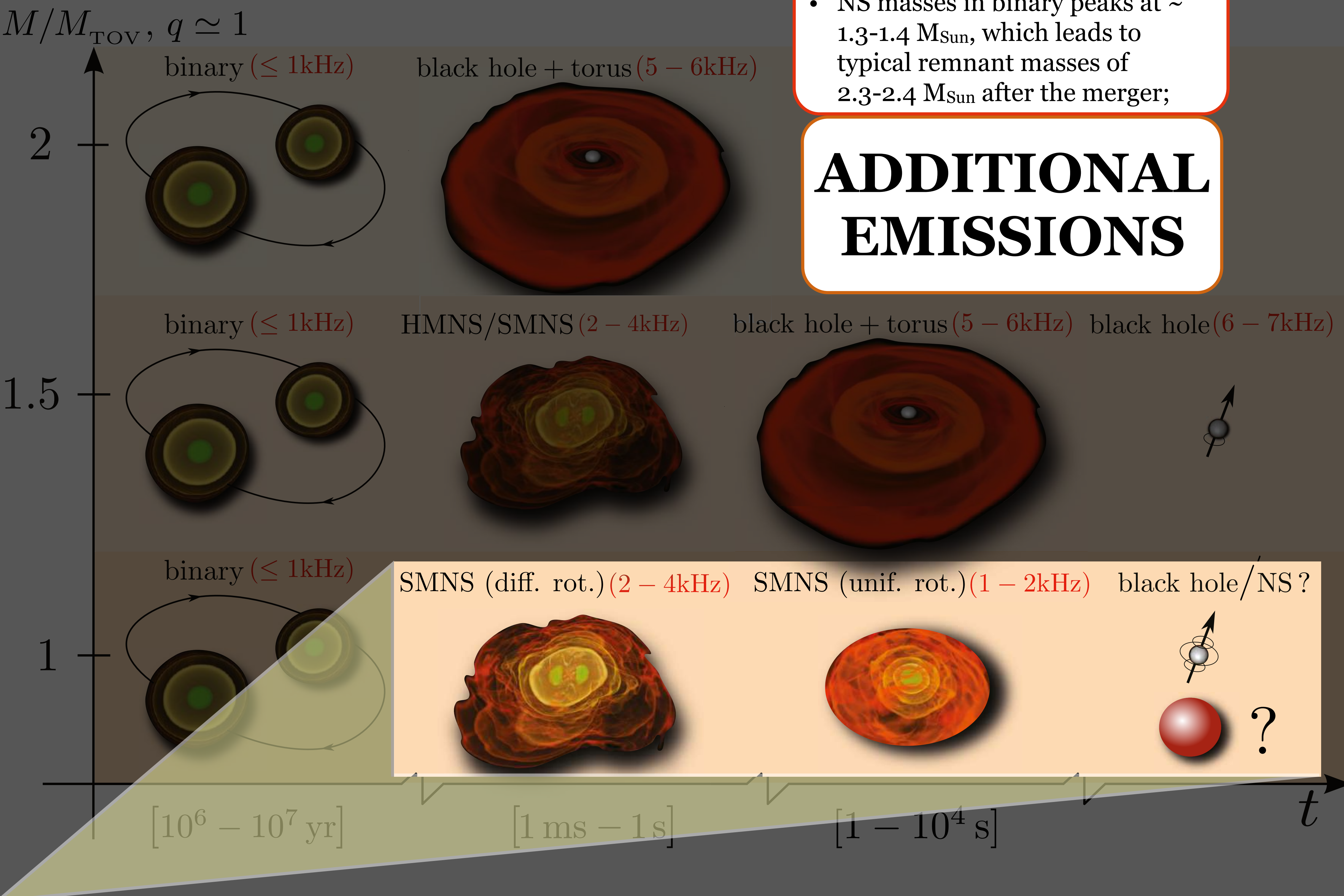


Binary neutron star mergers

long-lived NS likely

- From observations maximum NS mass is about 2 M_{Sun};
  - higher mass up to 2.4 M_{Sun} for uniform rotation support
- NS masses in binary peaks at ~ 1.3-1.4 M_{Sun}, which leads to typical remnant masses of 2.3-2.4 M_{Sun} after the merger;

ADDITIONAL EMISSIONS



Binary neutron star mergers