How can multi-messenger astronomy benefit to ET ?

Eric Chassande-Mottin
CNRS, AstroParticule et Cosmologie (Paris)

Outline of this talk

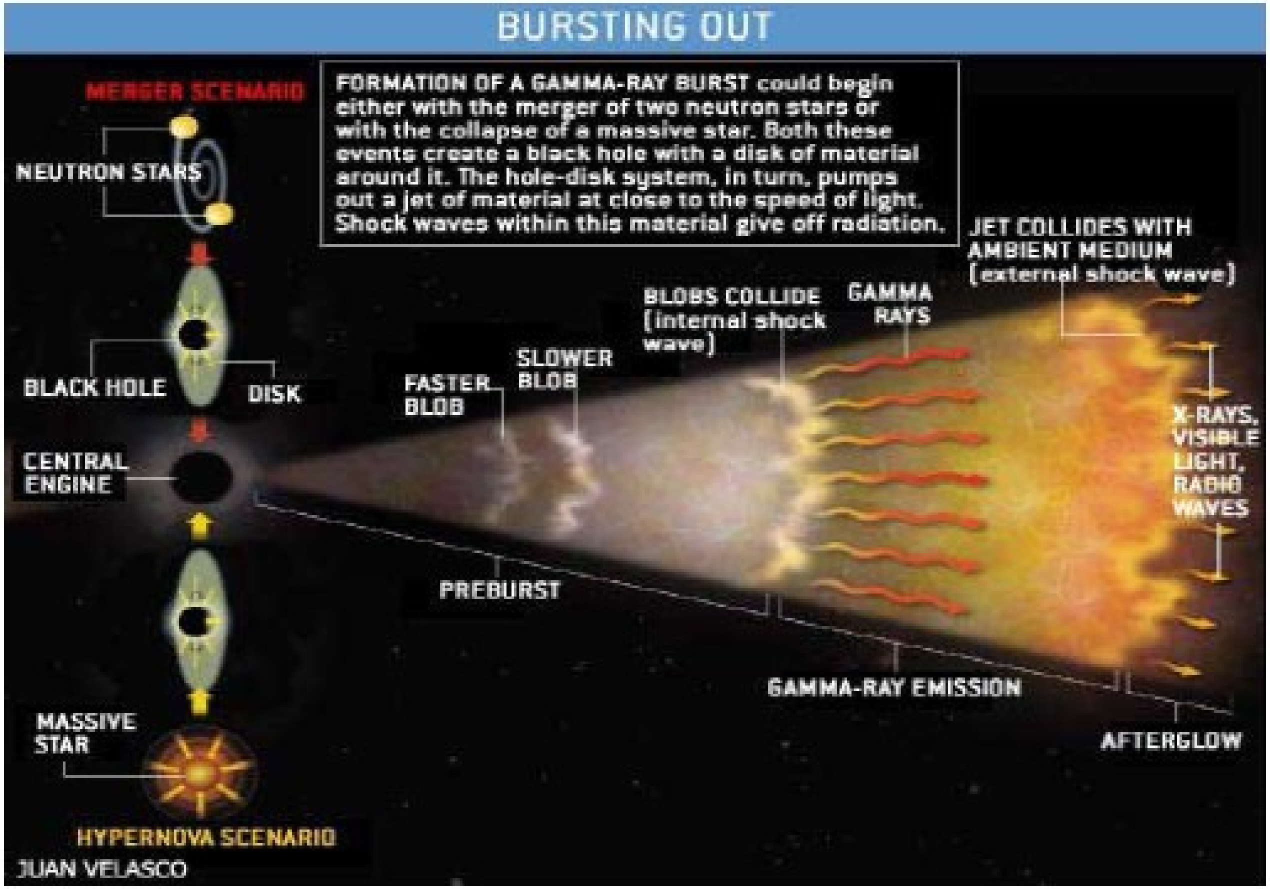
Initiate a catalog of possible multimessenger sources for ET
Complement specific presentation on GRB/SNs done by Gareth
Survey of future detectors planned for 2020
Attempt to prioritize scientific questions related to multimessengers

Multimessenger sources for ET: Fireball model

"standard model" for GRBs

extends to other jet sources

predict the generation of lots of "messengers" (high-energy particles)



accel electrons produce **gamma rays** by synchrotron

accel protons interact and produce pions, which decay in **high-energy neutrinos HEN**

“Failed GRBs”

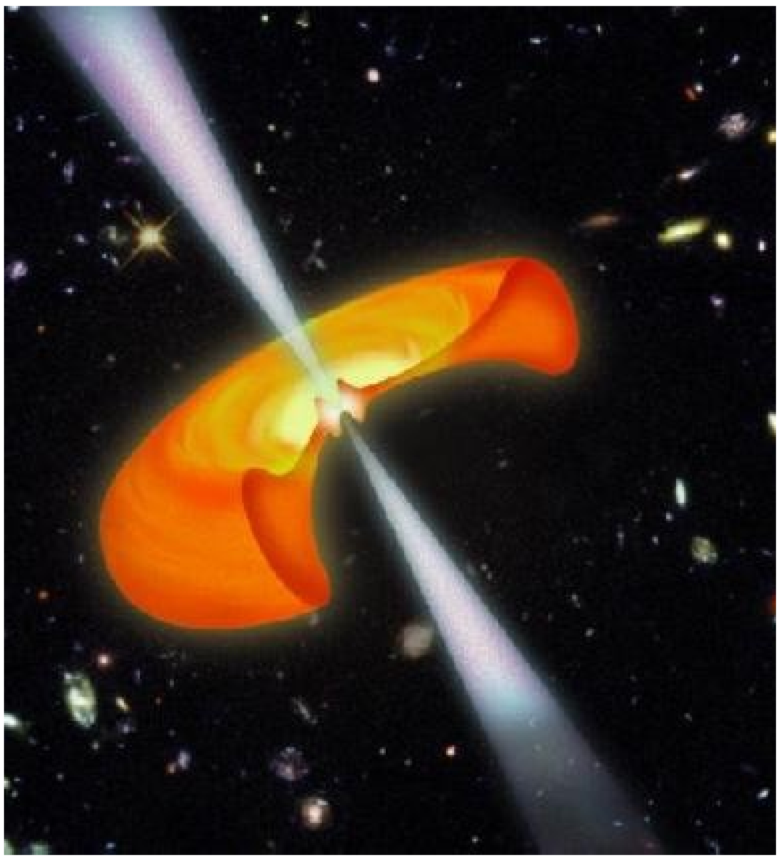
- GRBs are emitted from an ultra-relativistic (Lorentz factor from 100 to 1000) ejecta launched from the central source.
- to boost the ejecta at ultra-relativistic speed, *jets have to be extremely baryon-poor*
- very difficult requirement: this issue is not well understood.

- *Baryon-rich jets are slower* (midly relativistic: Lorentz factor < 10). Jet becomes optically thick: No gamma-ray can escape.
- Possible scenario:
  - Gamma-ray observatories only observe the (possibly small?) fraction of the sources producing baryon-poor jets
  - Remaining population hidden from any conventional telescopes?
- More baryons imply an *enhanced production of neutrinos*

Failed GRBs have same GW emission than conventional GRBs. Coincidence with neutrino telescopes

Ref: Ando and Beacom, astro-ph/0502521

Off-axis GRBs: orphan afterglows



- In many GRBs, a jet break is observed in their light curve (slow to rapid fading)
- The emission is collimated (few degrees ?). Off-axis GRBs are missed.
- More events occur than those actually seen (in the gamma spectrum). “Orphan afterglows”: optical/radio/X transients
- Off-axis GRB have same GW emission than conventional GRBs (attenuation due to inclination).

Crosscorrelation with large optical surveys, follow-up with telescopes

Ultra Luminous X-ray binaries (ULX)

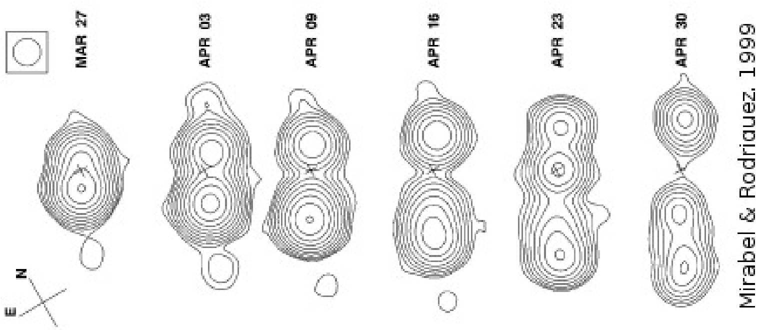
- Stellar-mass BH (< 20 solar mass) have Eddington lum. of 10^{39} erg/s.

Fixes the UL luminosity for “normal” X-ray binaries.

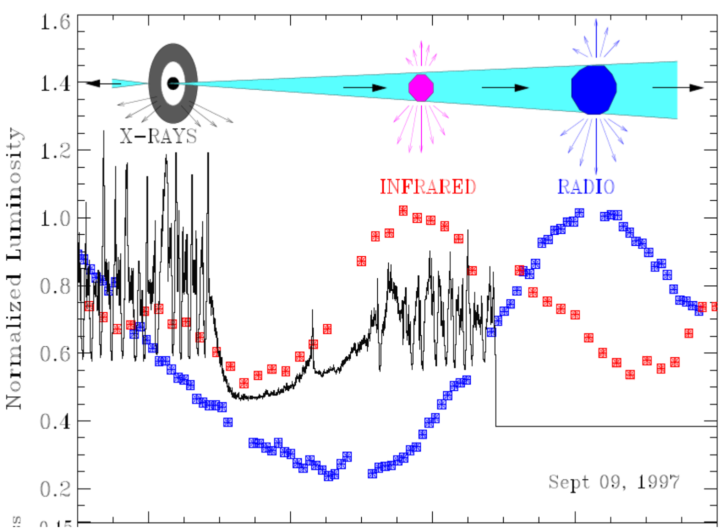
- Several objects (nearest in M33) observed in range 10^{39} to 10^{41} erg/s.
- Three scenarios
  - A: stellar-mass BH but emission is beamed
  - B: stellar-mass BH with isotropic emission, but super Eddington lum.
  - C: intermediate-mass black holes (M > 100 solar masses)
- Discrimates using GW emission? Case C visible by ET: measure BH mass from inspiral,

Ref: Miller Colbert astro-ph/0308402

Micro-quasar flares



- X-ray and radio/IR flares from stellar-mass BH accreting from companion.
- Coupled accretion/ejection explain observations
  - X-ray = inner accretion disk
  - radio/IR = ultra-relativistic (Lorentz fact = 5.0) ejection of blobs of plasma (ballistic motion).



- GW emission from microquasar?

"cannonball model" $h \sim 4.0 \times 10^{-23} \frac{\gamma}{5.0} \frac{m}{10^{-8} M_0} \frac{10\,kpc}{d}$

same order of ET noise level

typ. freq. of burst : acceleration time of blob

rough estimate: grav. time scale = 10^5 Hz M/10 M_o

size accretion disk: 10^2 Hz r/10^3 km

Refs: Mirabel & Rodriguez, 1999, Pradier, arXiv:0807.2562v1 Segalis & Ori, 2001

Multimessenger sources for ET summary

			"Precision" observation of "weak" galactic sources	*ET sees to cosmological distances (cf. Gareth's presentation)*
			galactic	**extra-galactic**
photons	**radio**		*jets (e.g., μquasar)*	
			pulsar glitch	
	IR/visible/UV		supernova *(SN)*	*SN, (off-axis) GRB afterglows*
	X-ray	**~ keV**	*X-ray bin.(incl. ULX)*	
	gamma-ray	**~ MeV**	*SGR magnetar*	*GRBs*
		~ GeV		
neutrinos	**low-e**	**< 100 GeV**	*SN*	
	high-e	**> 100 GeV**	jets (*μquasar)*	*GRBs ("failed")*
GW	**low freq**			BH-WD insp/rd, cosmic strings

2020 : future detectors for astroparticle physics

photons	**radio**		SKA (LOFAR)
	IR/visible/UV		LSST, GAIA, survey subproduct of JDEM/Euclid
	X-ray	**~ keV**	symbol-X, XEUS (narrow-field)
	gamma-ray	**~ MeV**	ASTROSAT, MAXI
		~ GeV	Fermi (2008+10?, wide-field mon.) CTA (HESS, narrow-field)
neutrinos	**low-e**		mega-ton detector
	high-e	**> 100 GeV**	Km3Net
GW			LISA

In Europe, two roadmaps define the future landscape: ASPERA (7 projects for large-scale astro-particle physics) and ASTRONET (space missions)
In the US, upcoming 2010 decadal survey

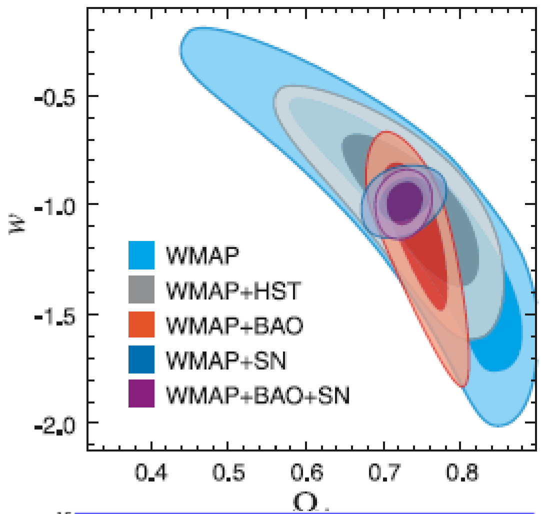
X and Gamma-ray observatories in 2020

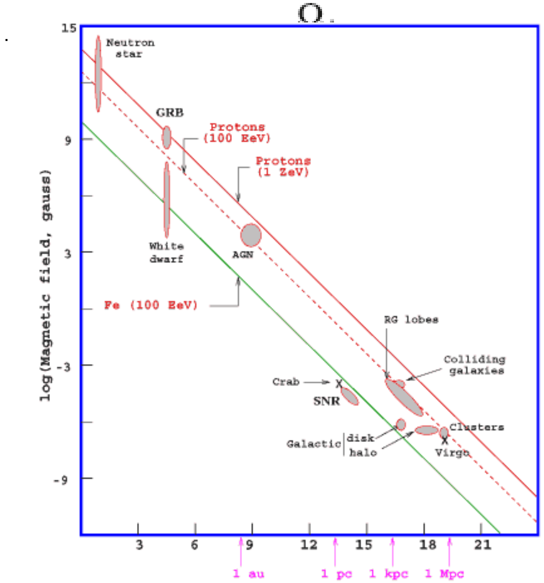
- **In operation now**
  - Integral 2002+2, ext 2010
  - Swift 2004+7
  - GLAST/Fermi 2008+5 (incl. burst monitor)
- **Close to lauch pad**
  - ASTROSAT(IRS India) 2009+5
  - MAXI (JAXA Japan) 2009+5 (all-sky X-ray survey)
  - SVOM (China/France) 2012+2.51
- **Projects**
  - eROSITA 2010 Phase A

no Gamma-ray burst monitor currently foreseen in Europe for the 2020 era

critical questions/key sources/study

What critical scientific question(s) can multi-messenger astronomy answer?
Relevance to fundamental physics, cosmology and/or astrophysics.





GRBs is a key source for ET (see Gareth's talk for more details)

- *cosmology:* GRB as “standard sirens”, constraints on cosmological params. nature of dark energy?
- *origin of GRBs*: what are the populations ? “hidden” population (failed, off-axis)?
- *origin of cosmic rays? GRB as cosmic accelerators?* use of coincidence with neutrino telescopes?

how stringent the model constraints are depending on ET design?
What is the influence of sensivity curve?
Is there a requirement on source localization reconstruction?

critical questions/key sources/study

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Physics of (less energetic) "galactic" sources
Bridge to astrophysics

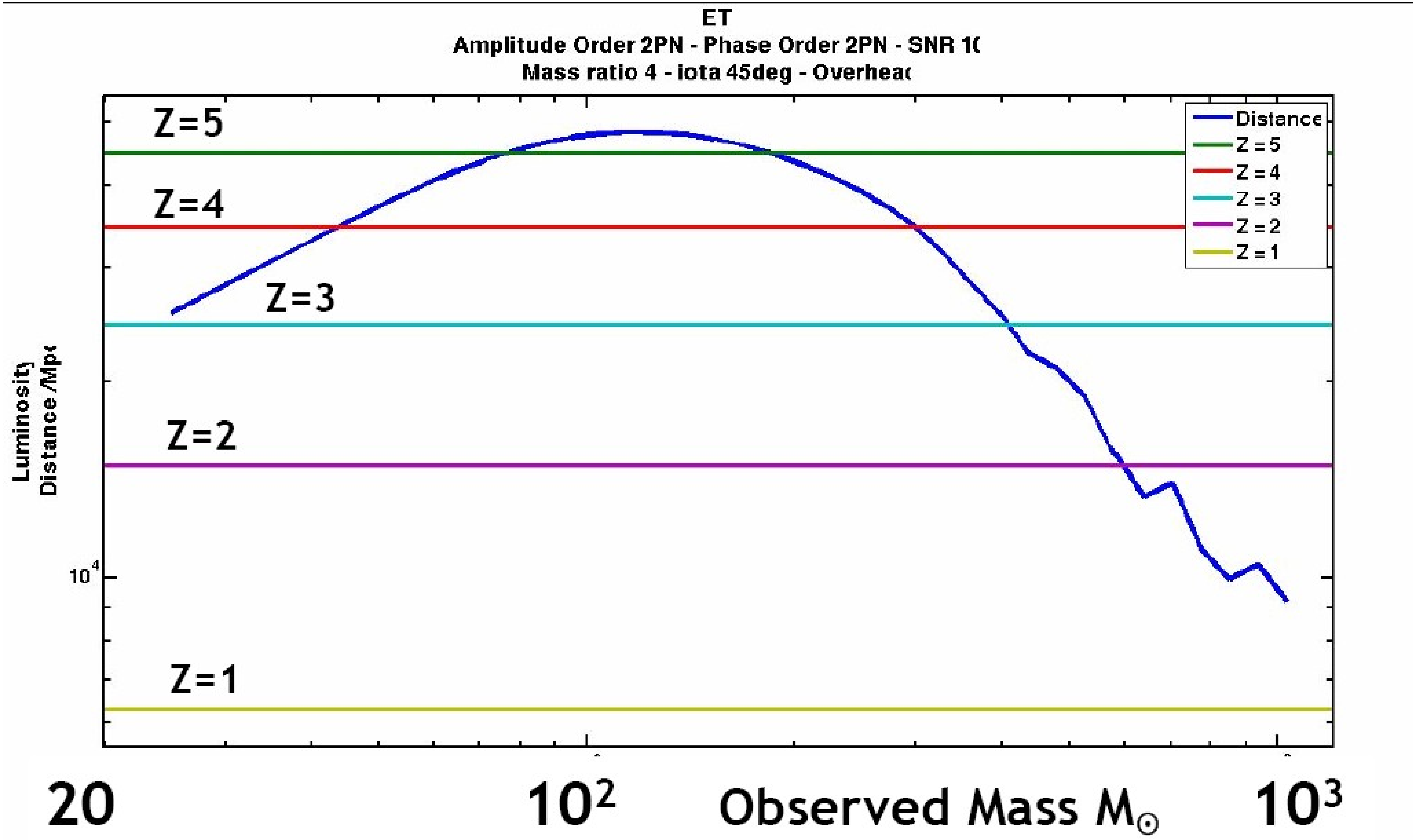
Few examples cited here, others?

- *X-ray binaries, microquasars:* constraints on accretion/ejection

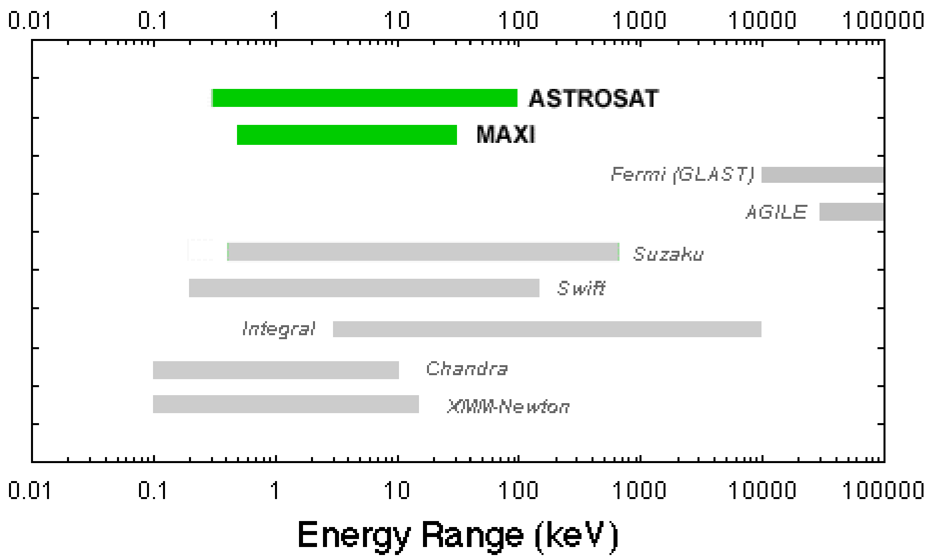
- *are ULX sources IMBH?*

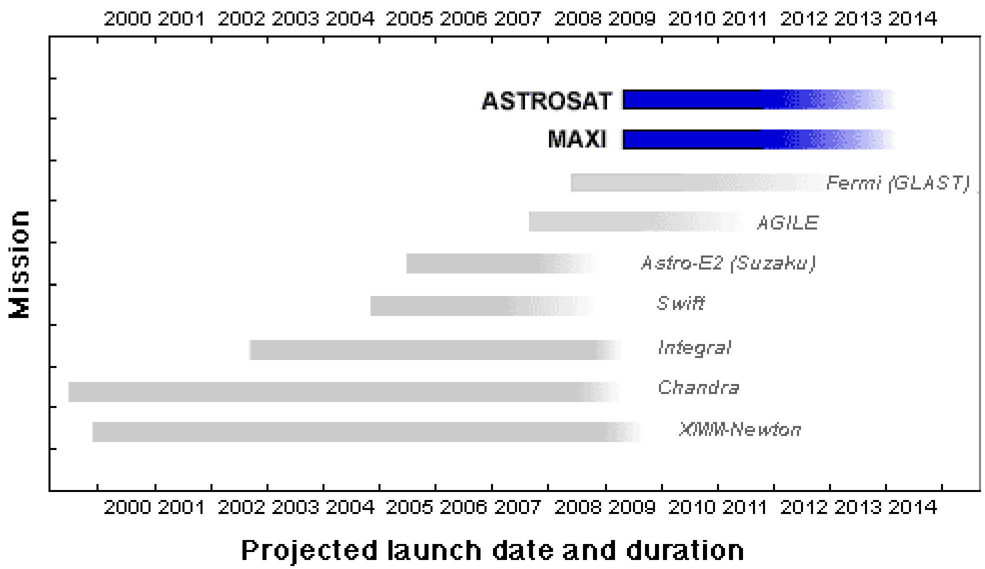
- *Galactic SN, SGR magnetar flares will be observed by ET with high "resolution" (SNR >> 10). which physics can be extracted?*

END



ET
Amplitude Order 2PN - Phase Order 2PN - SNR 1(
Mass ratio 4 - iota 45deg - Overheac
Distance
Z = 5
Z = 4
Z = 3
Z = 2
Z = 1
Z=5
Z=4
Z=3
Z=2
Z=1
Luminosity Distance /Mpc
10^4
20
10^2
Observed Mass M⊙
10^3


0.01 0.1 1 10 100 1000 10000 100000
ASTROSAT
MAXI
Fermi (GLAST)
AGILE
Suzaku
Swift
Integral
Chandra
XMM-Newton
Energy Range (keV)


2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014
ASTROSAT
MAXI
Fermi (GLAST)
AGILE
Astro-E2 (Suzaku)
Swift
Integral
Chandra
XMM-Newton
Mission
Projected launch date and duration