Gravitational Waves: Astronomy for the 21st Century

Bernard Schutz
Albert Einstein Institute
Potsdam, Germany

The long road

1960's

10^{-16}

2000's

10^{-21}

Astronomy/Cosmology

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- Precision ΛCDM cosmology: inflation, detailed study of CMB, hierarchical galaxy formation

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- Census of NSs, tie to γ bursts
- Discover/study (SM)BH binaries
- Detailed test of strong-field GR
- Search for GW pulsars
- Find a GW stochastic background
- Measure cosmic distances, H_0, w
- Watch SMBH growth at high z
- Illuminate stellar evolution
- Find cosmic strings, exotica
- Deep view of SNe Type II

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- Coincident GW-EM observing is important: multimessenger astronomy. LV currently working with many projects, exchanging triggers.

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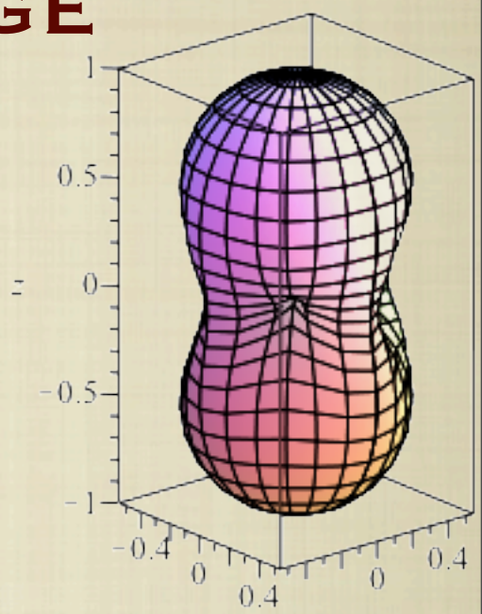

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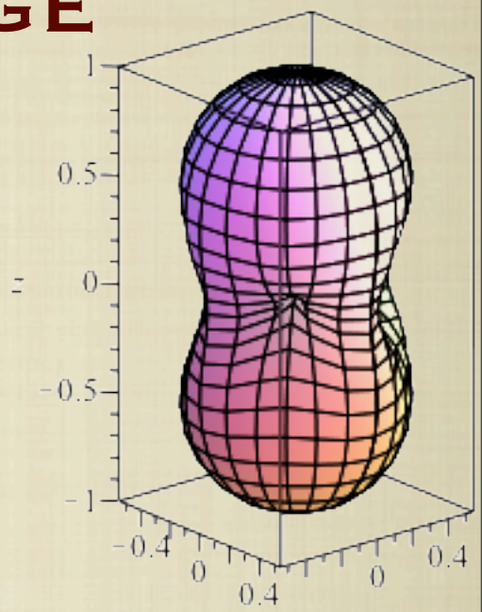

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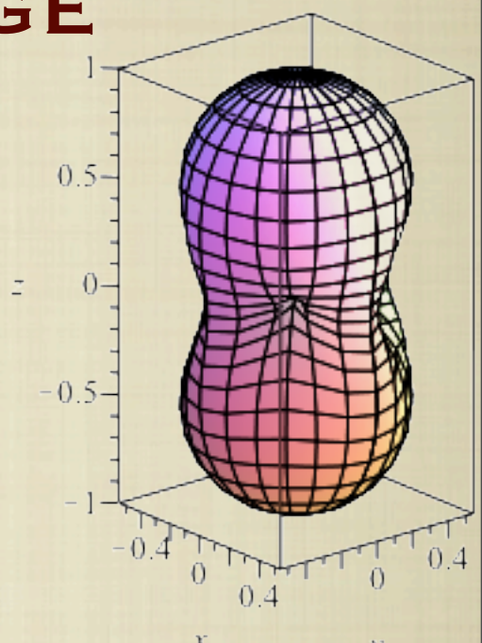

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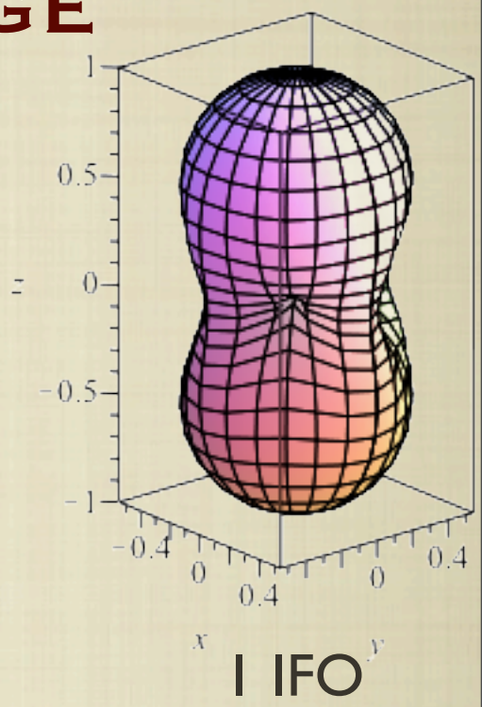

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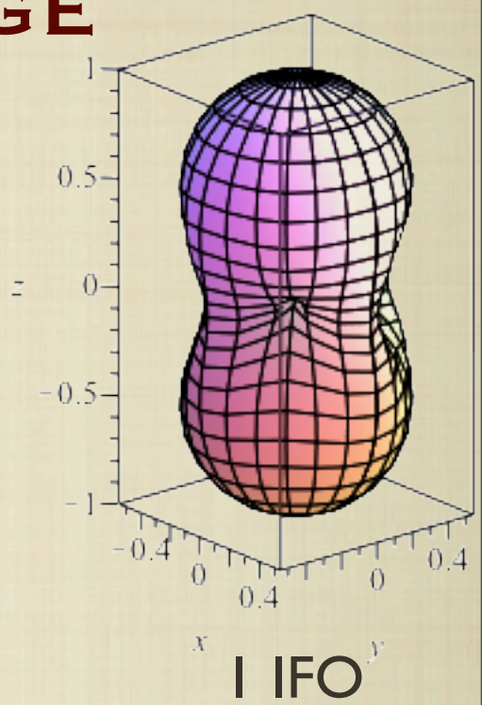

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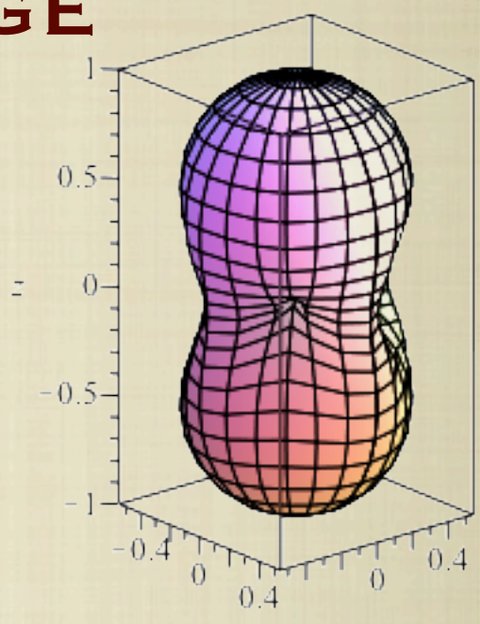

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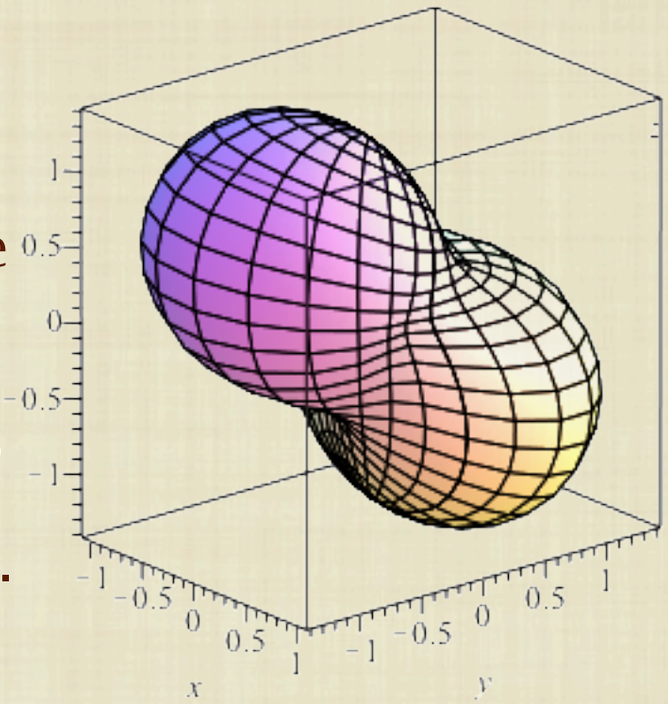
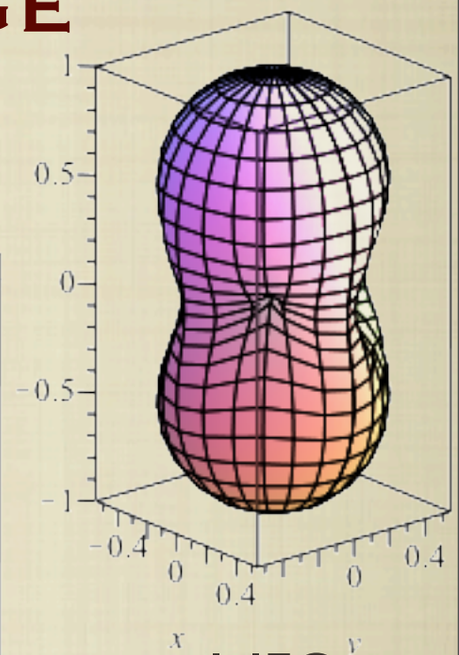


HL



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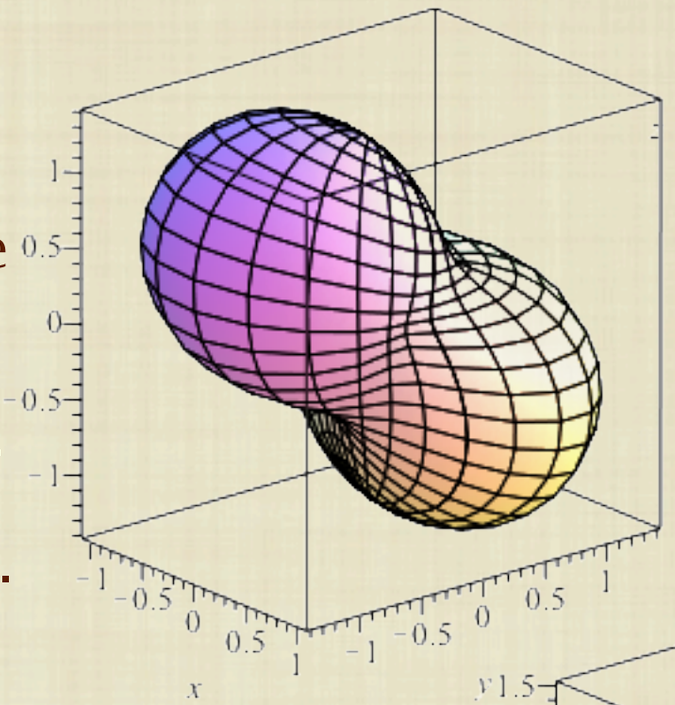

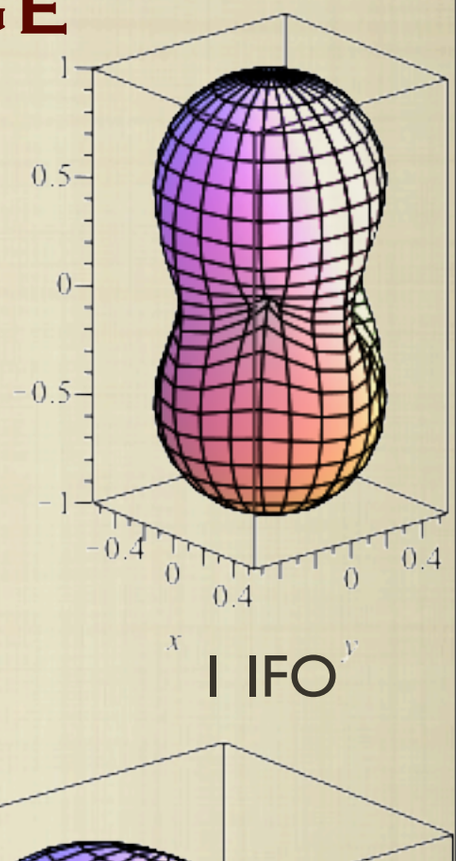

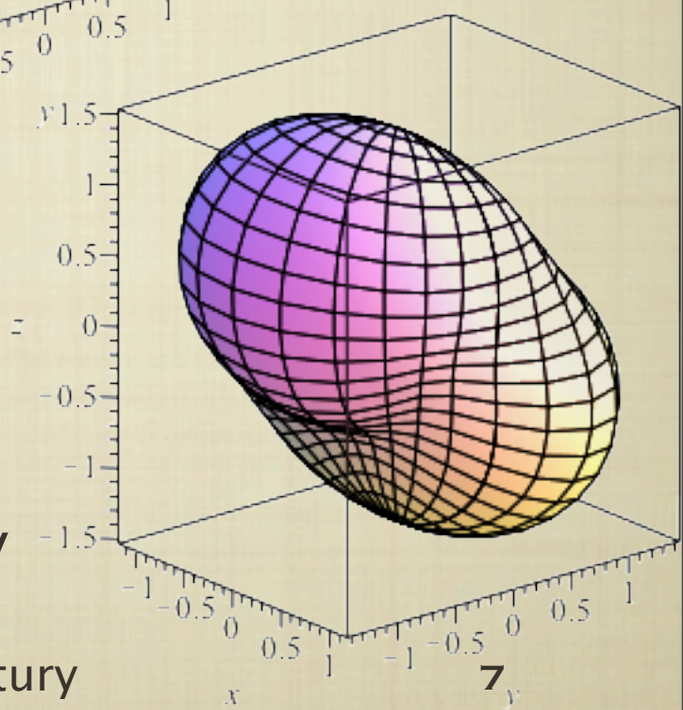

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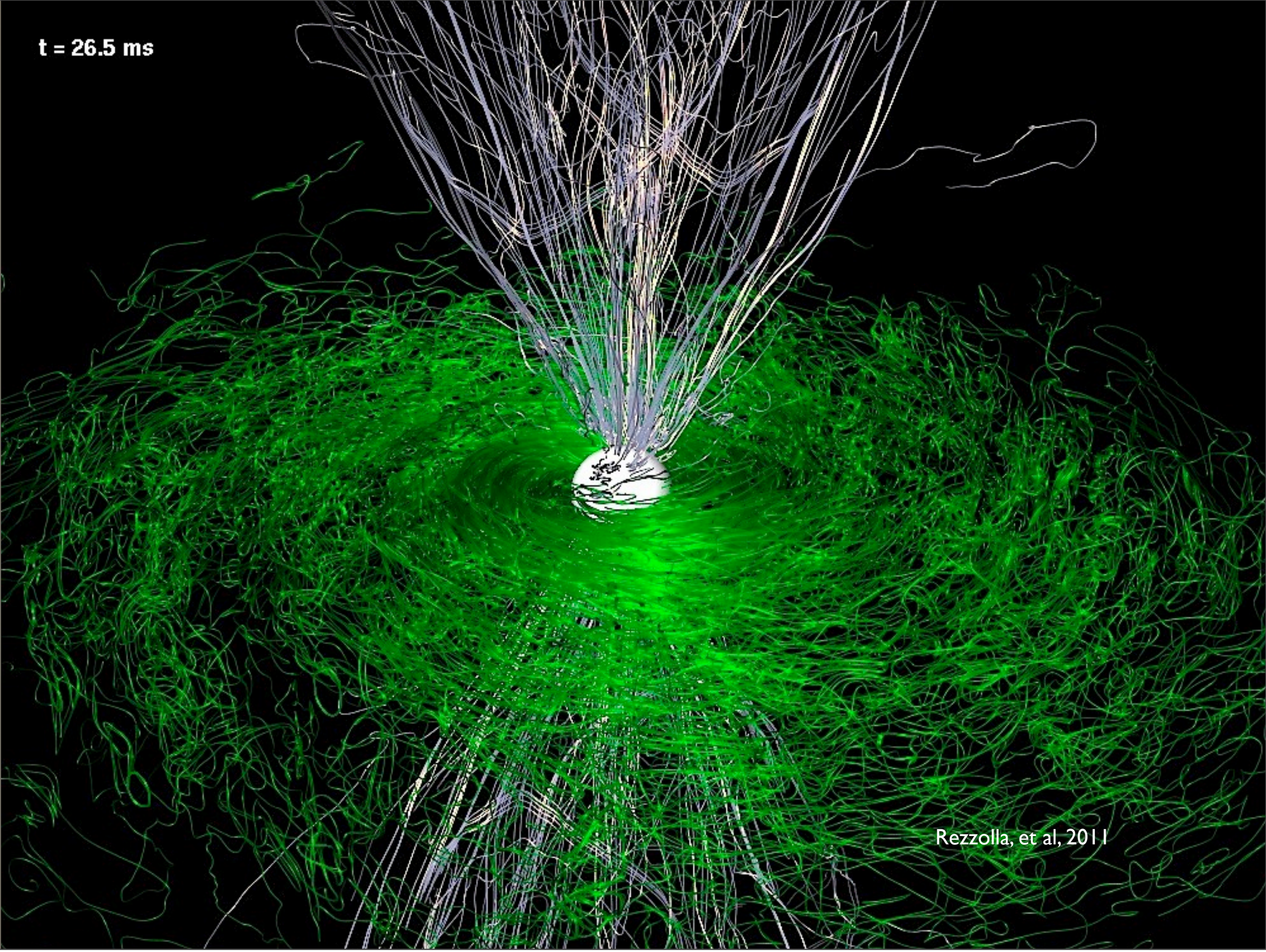
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Rezzolla, et al, 2011

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- Identifications will lead to understanding of off-beam "afterglow" , and this will allow transient EM monitors to find more.

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  - Measure H_0 on distances up to 1 Gpc. See poster by del Pozzo. Do *not* need a-priori identifications of galaxies. Expect accuracy of a few percent after ~50 events, similar to current accuracy.

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  - Exotica like cosmic strings may turn up, although sensitivity may not be good enough to find something we don't have a filtering template for.
- The data analysis is itself an interesting science and can be applied in other fields. *Einstein@Home* is being used now to find radio pulsars in radio data and gamma-ray pulsars in gamma data. (Talk by B. Allen.)

Science with India & Japan (1)

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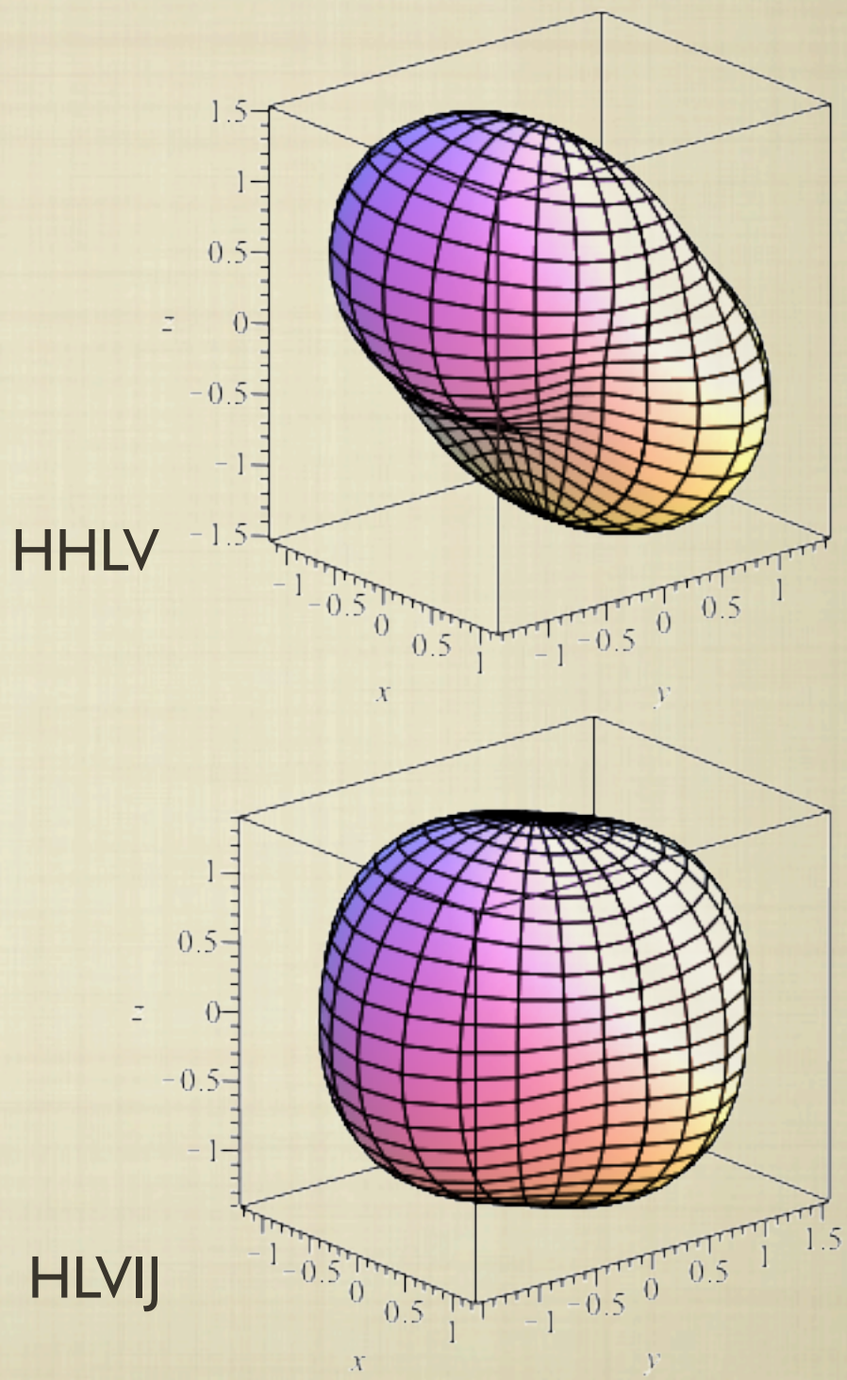

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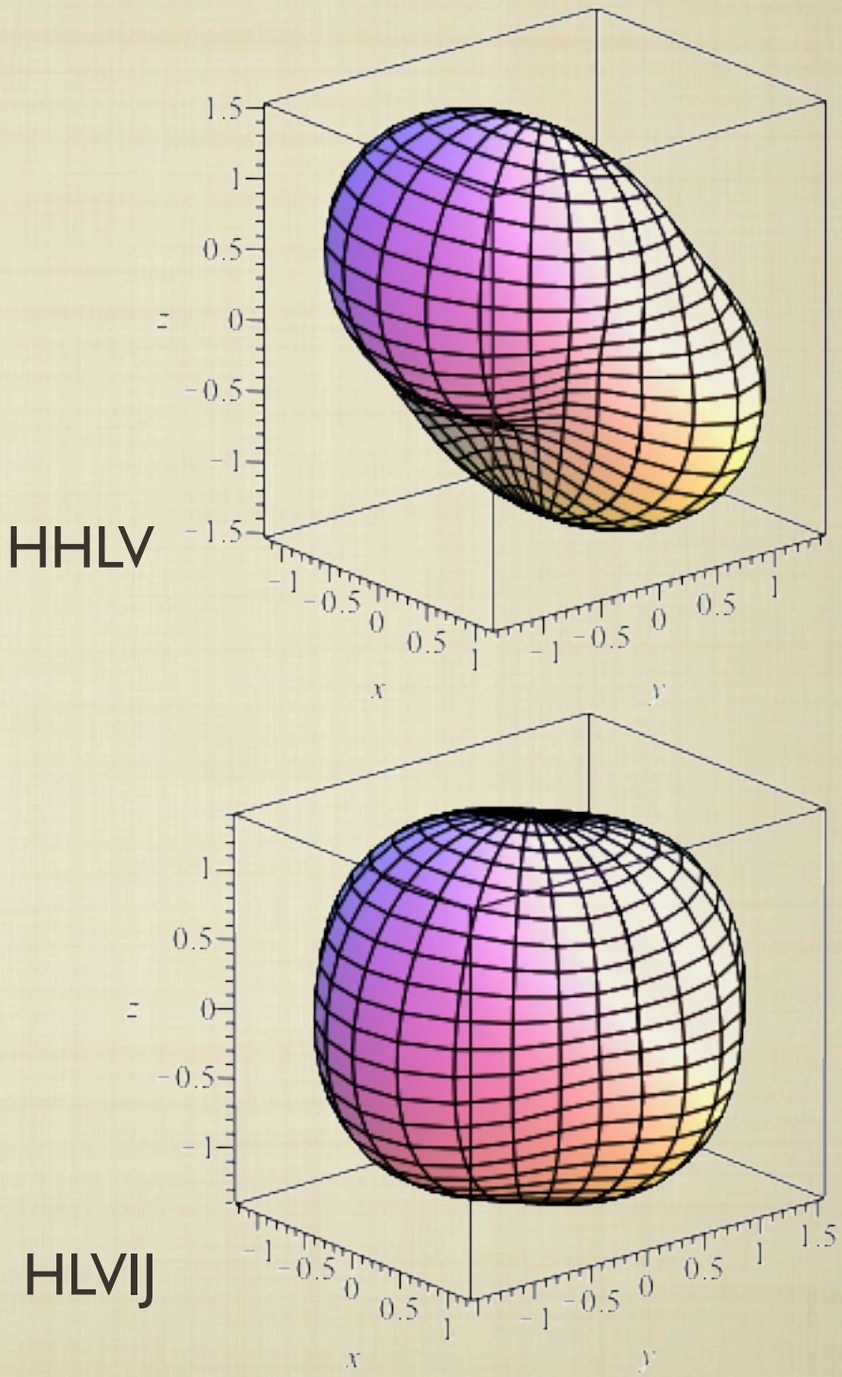

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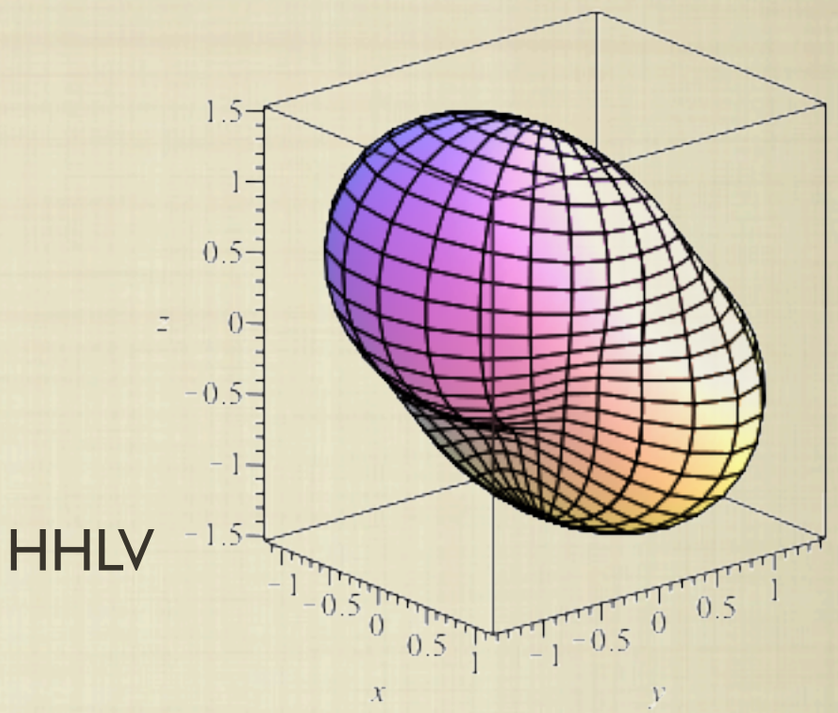

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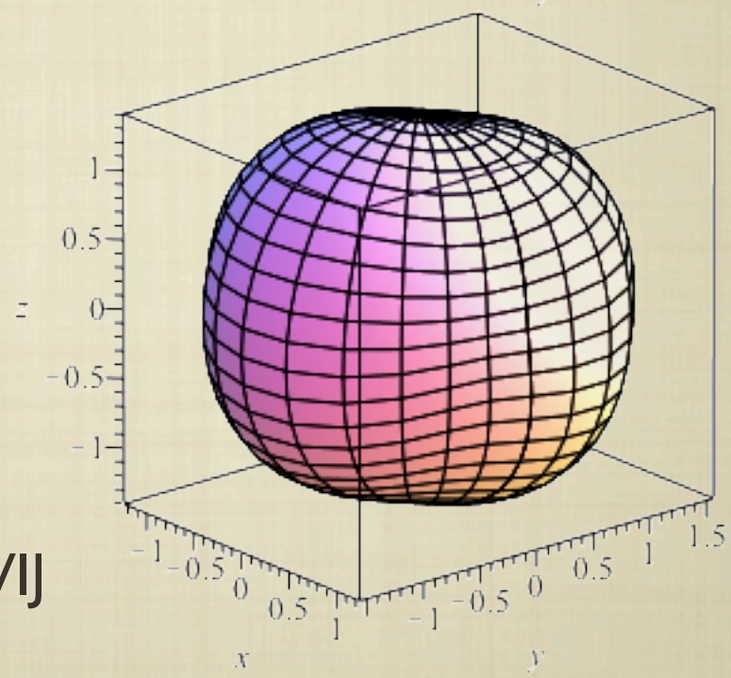

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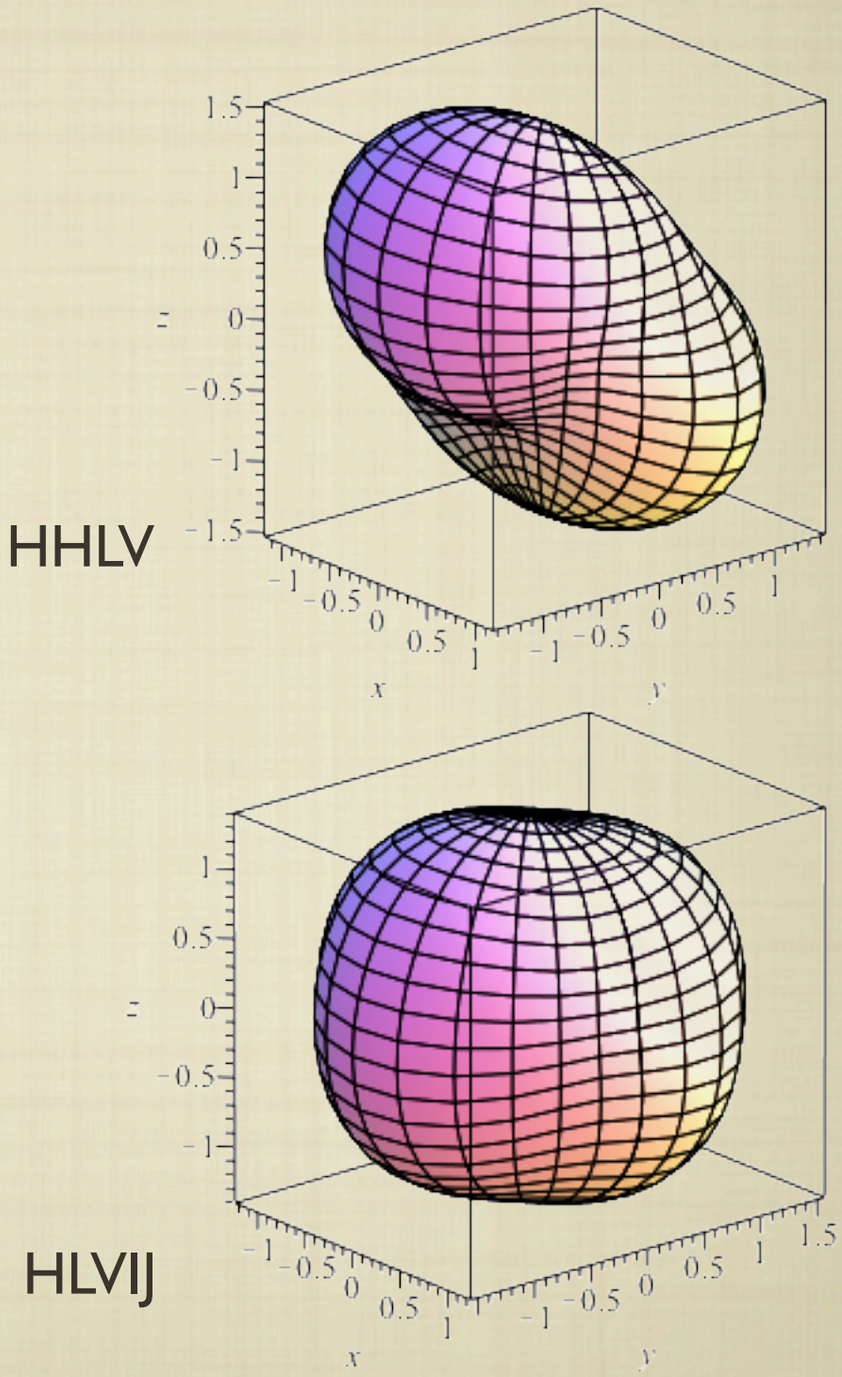

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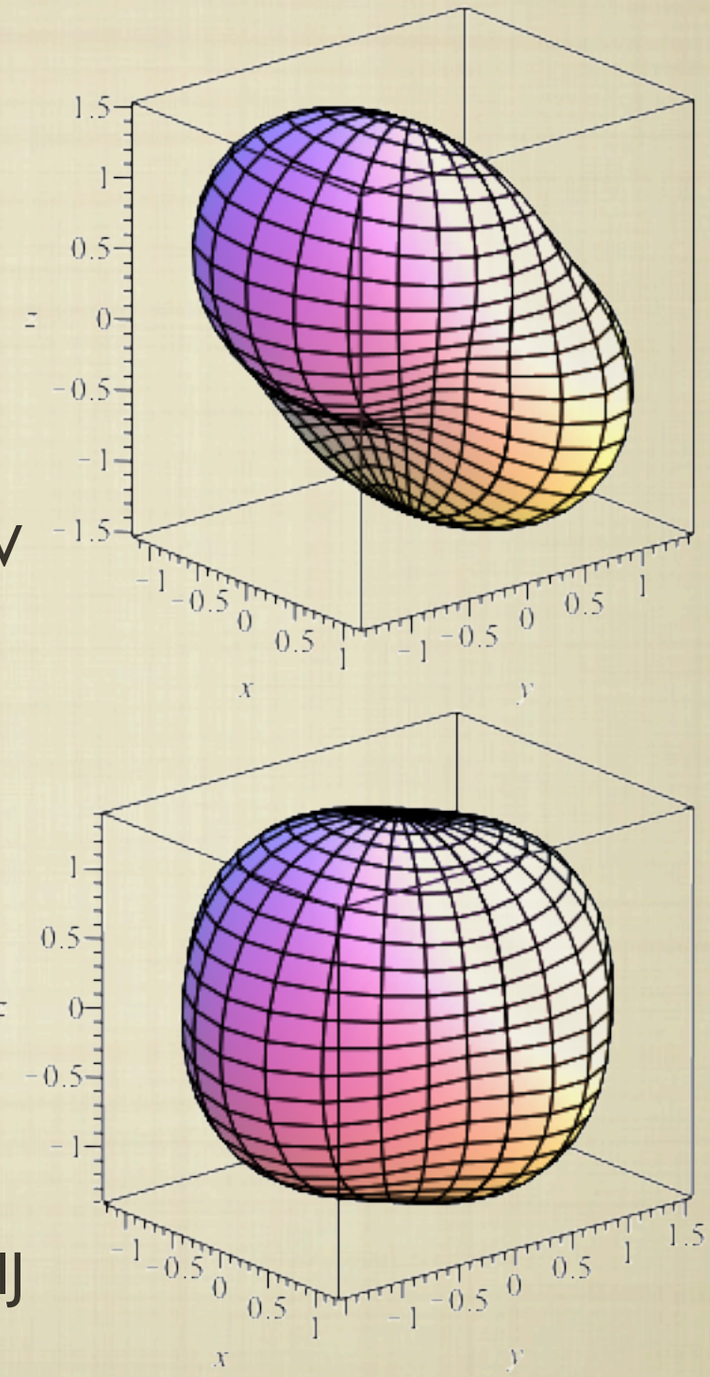

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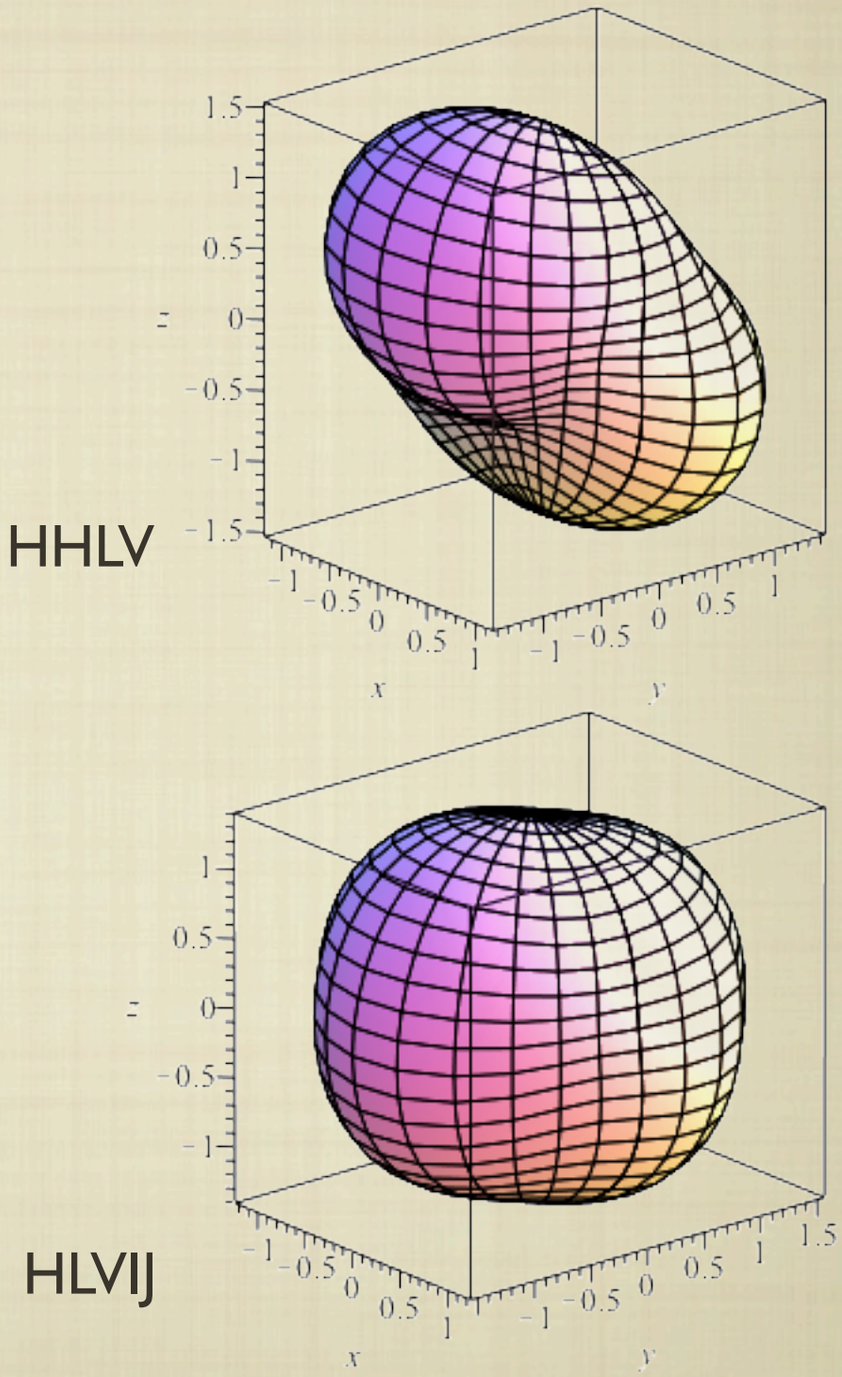

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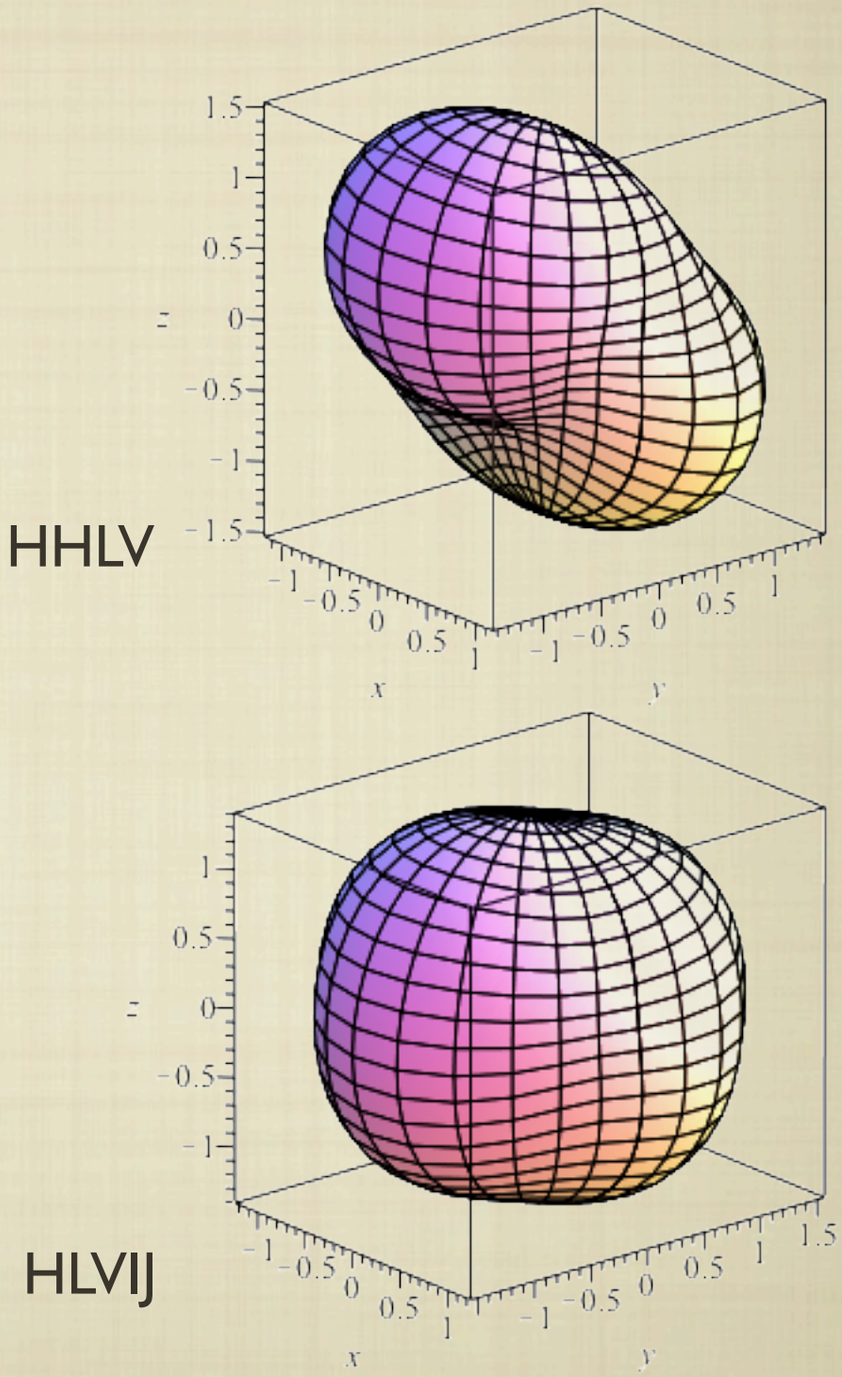
- Full network could detect 200+ NS-NS events per year.



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- Suppression of "glitch" background will make searches for unexpected exotic signals much deeper.

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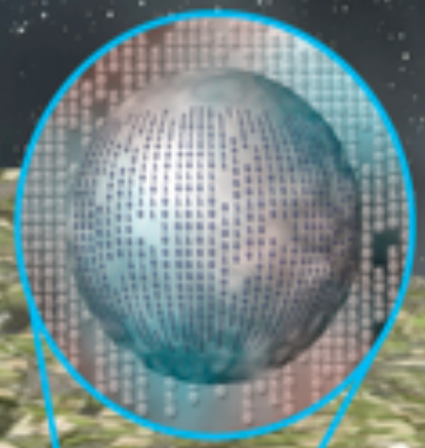
  - Included in EU priority list (“Magnificent 7”) for astroparticle physics (2008), but unlikely to get funding until after first GW detections.

EINSTEIN TELESCOPE

gravitational wave observatory

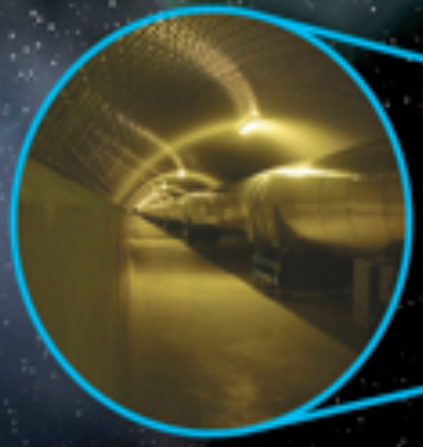
CENTRAL FACILITY

COMPUTING CENTRE



DETECTOR STATION

END STATION

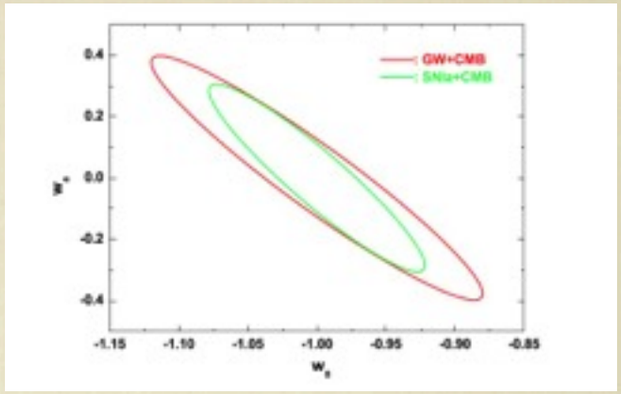


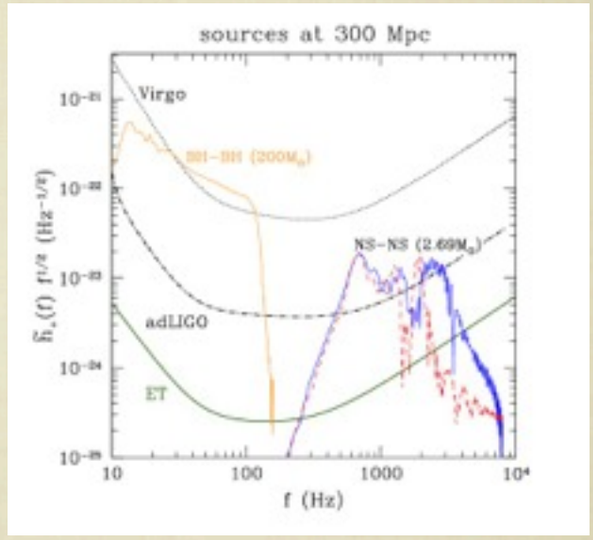
Length ~10 km

TUNNEL ∅ ~5 m

SEVENTH FRAMEWORK PROGRAMME

Third Generation Science





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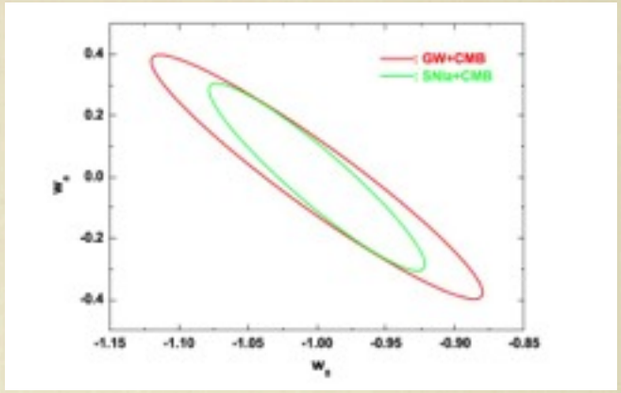

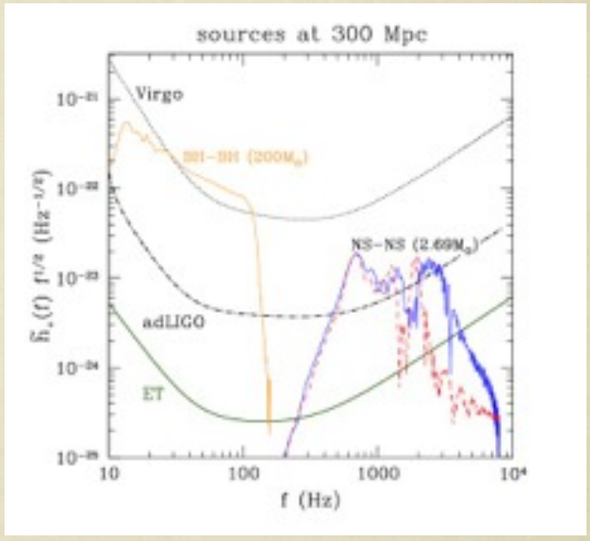

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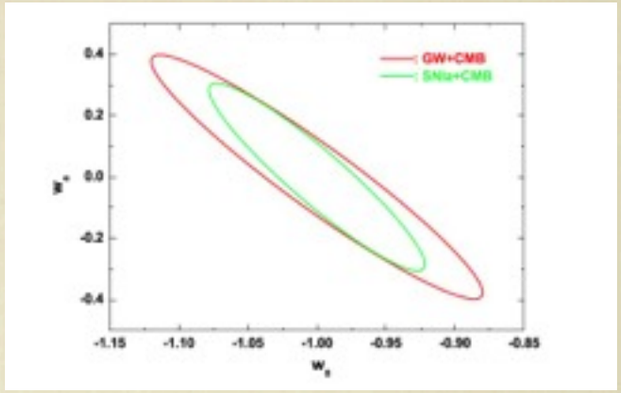

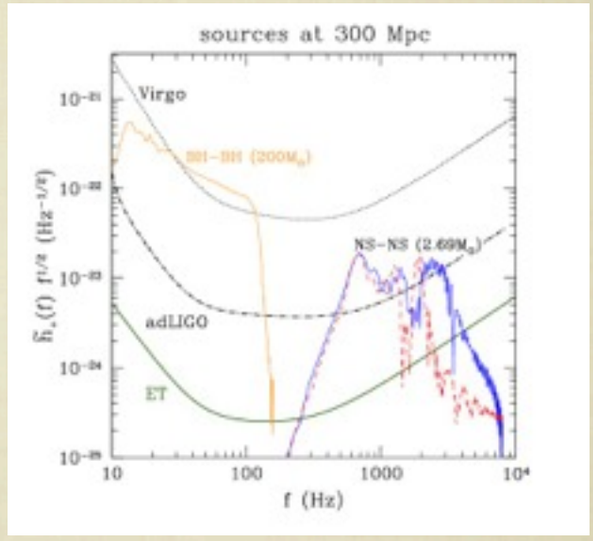

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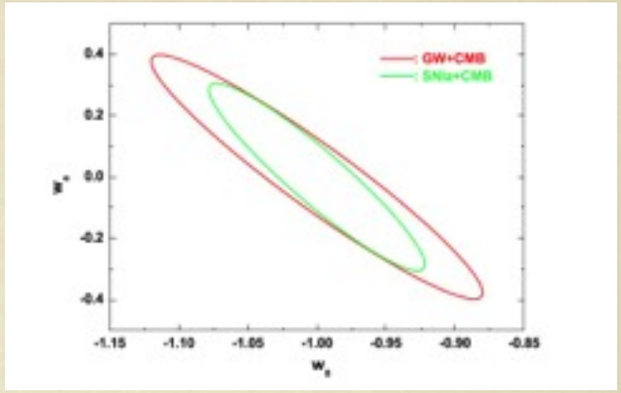

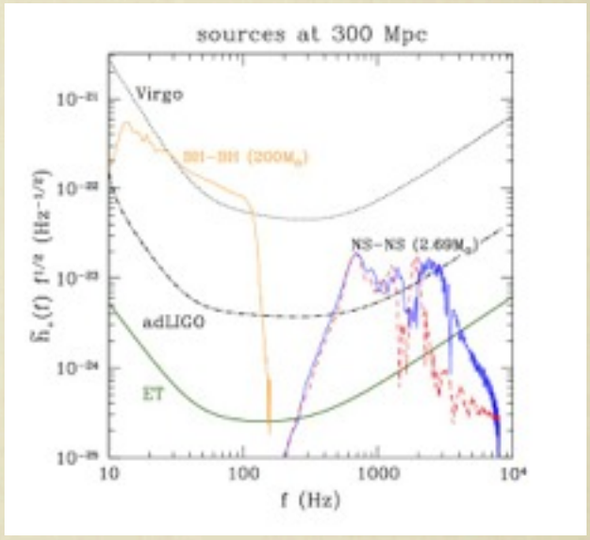

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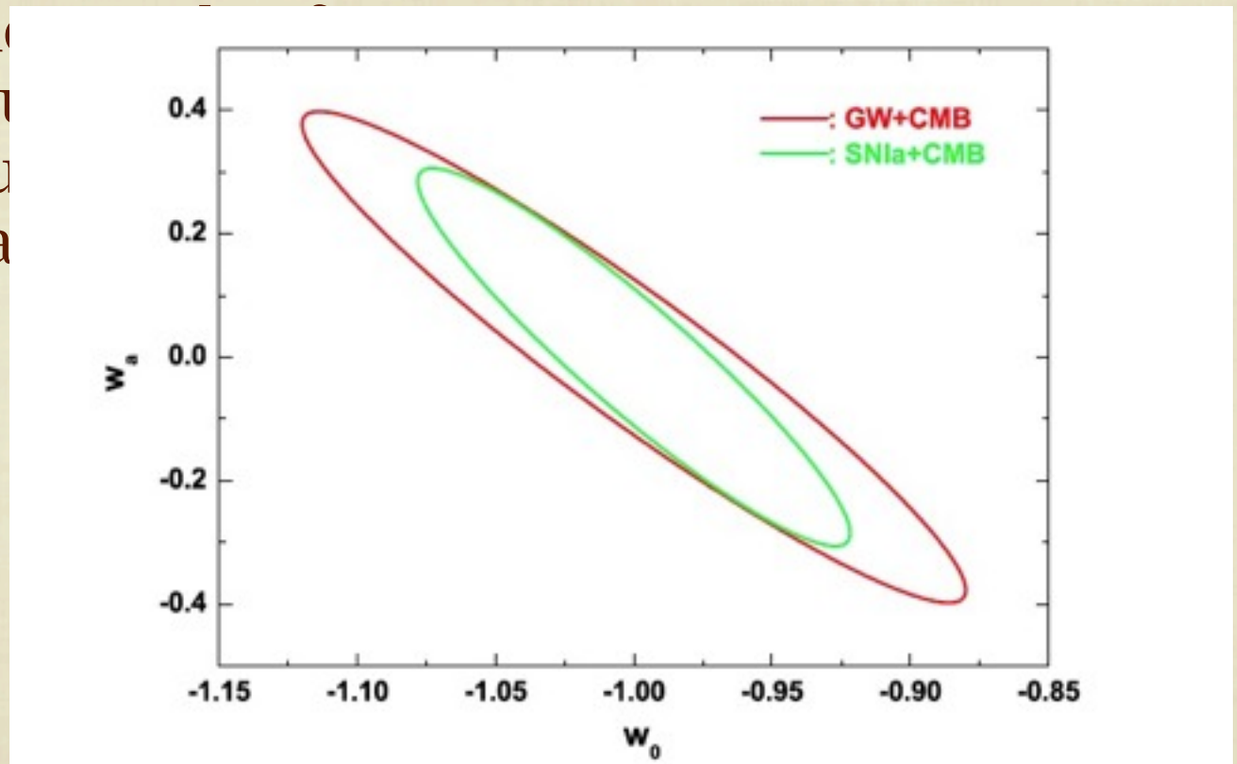

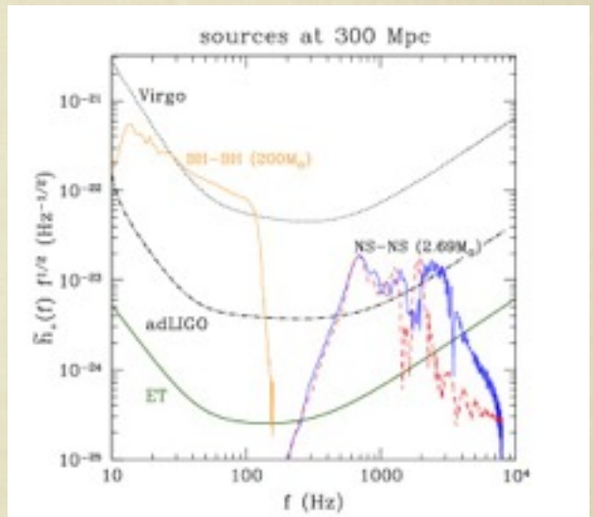

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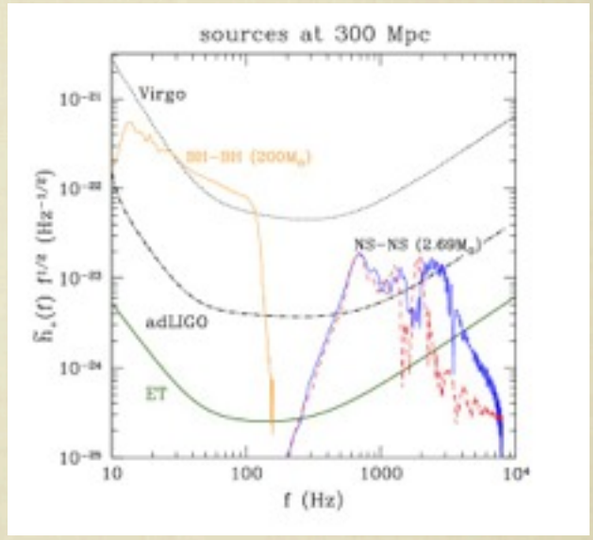

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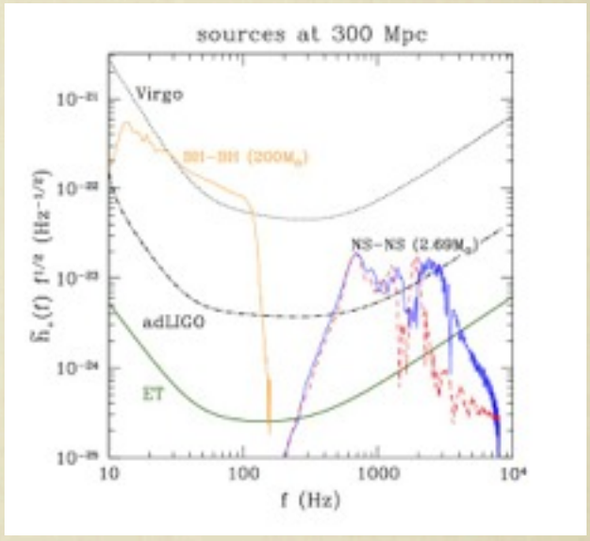

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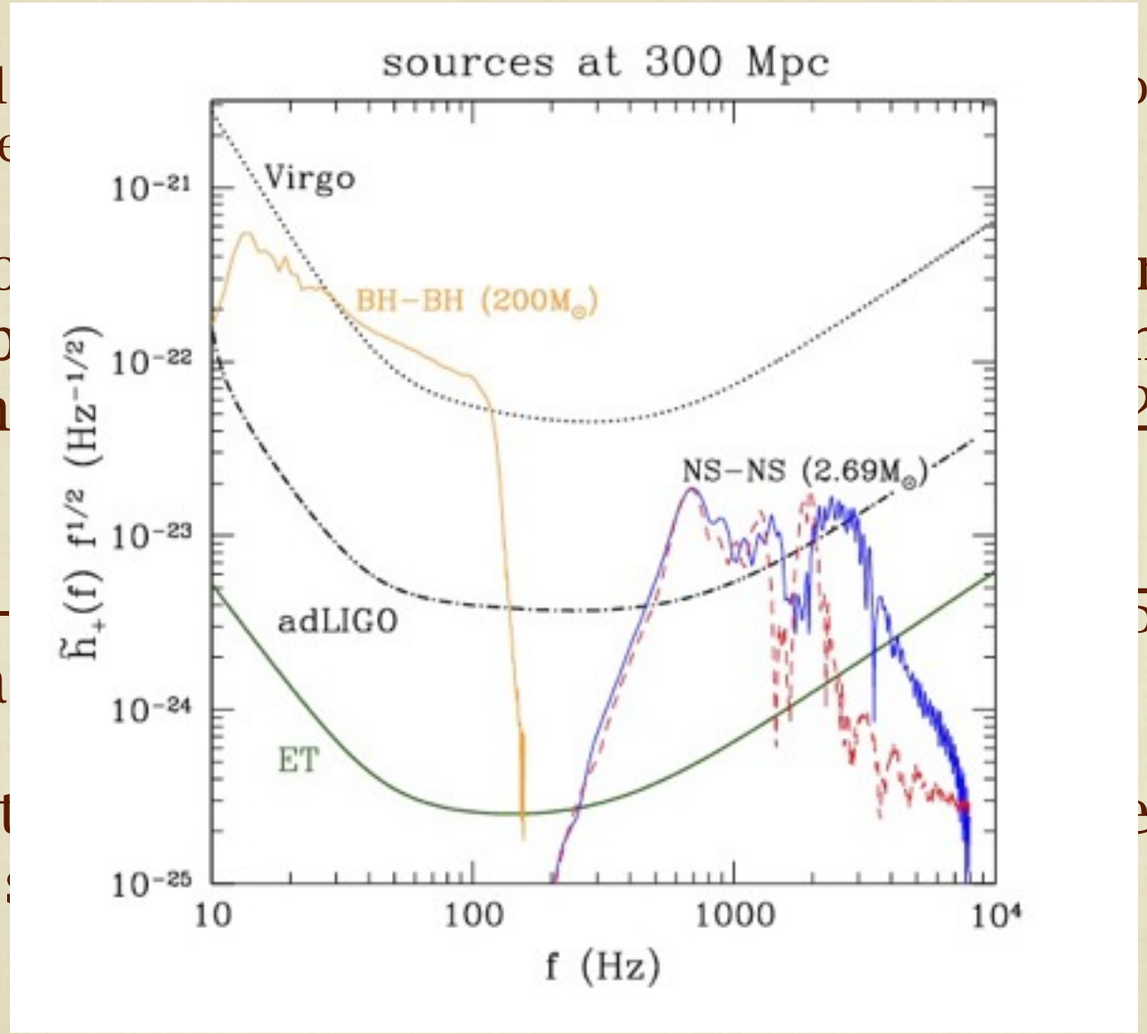

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- Discovery potential: ultra-high sensitivity, perfect for serendipity.

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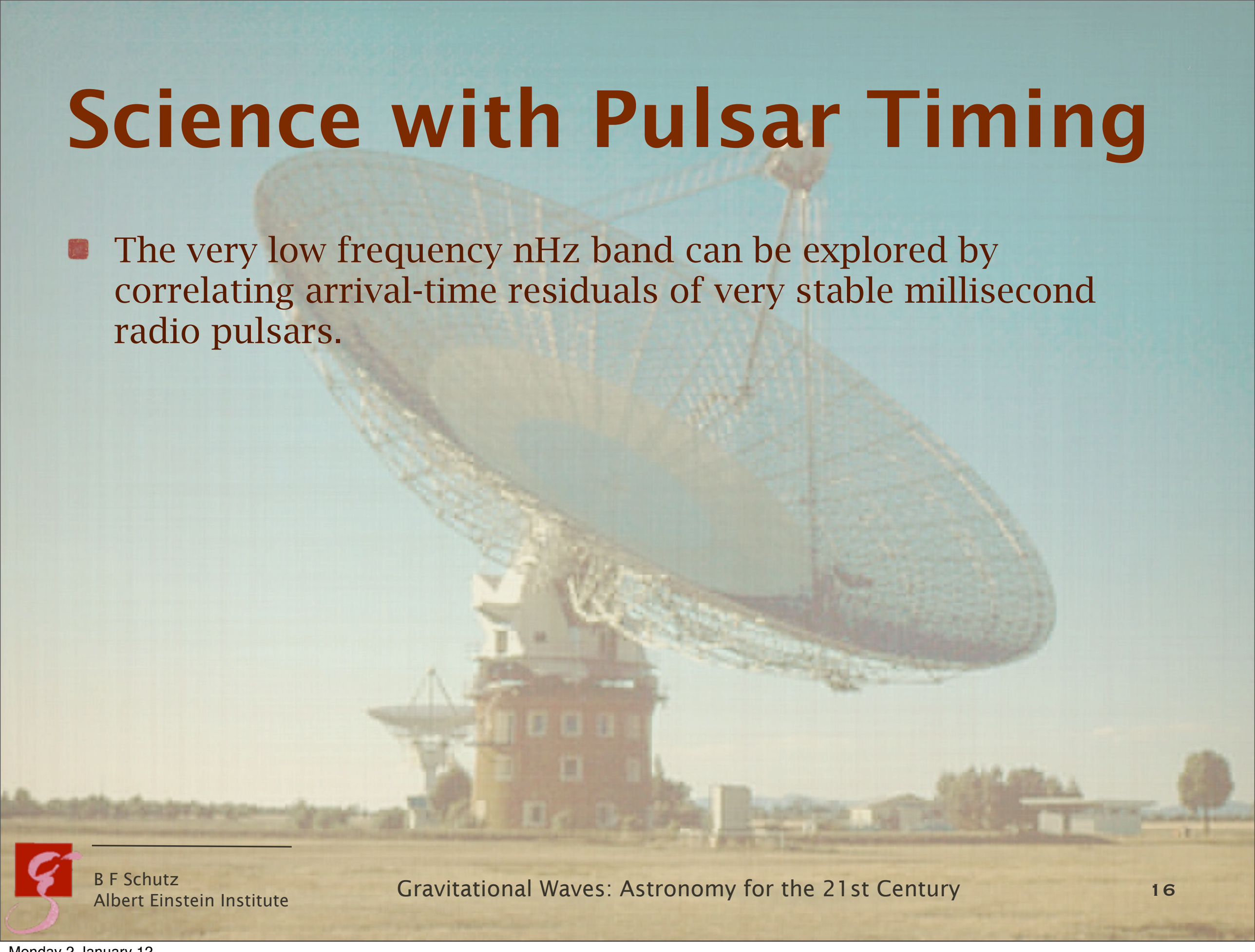

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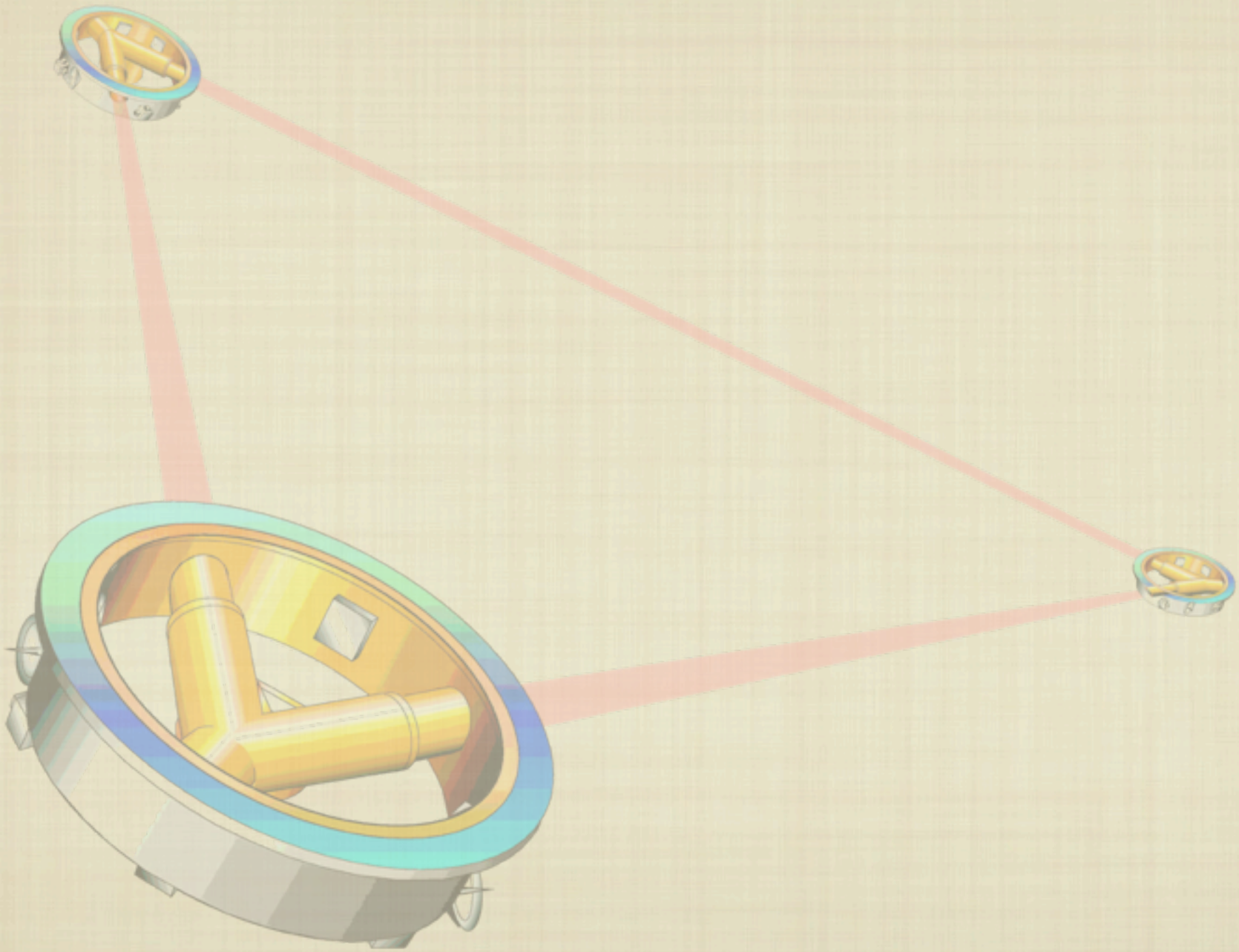
Going into Space



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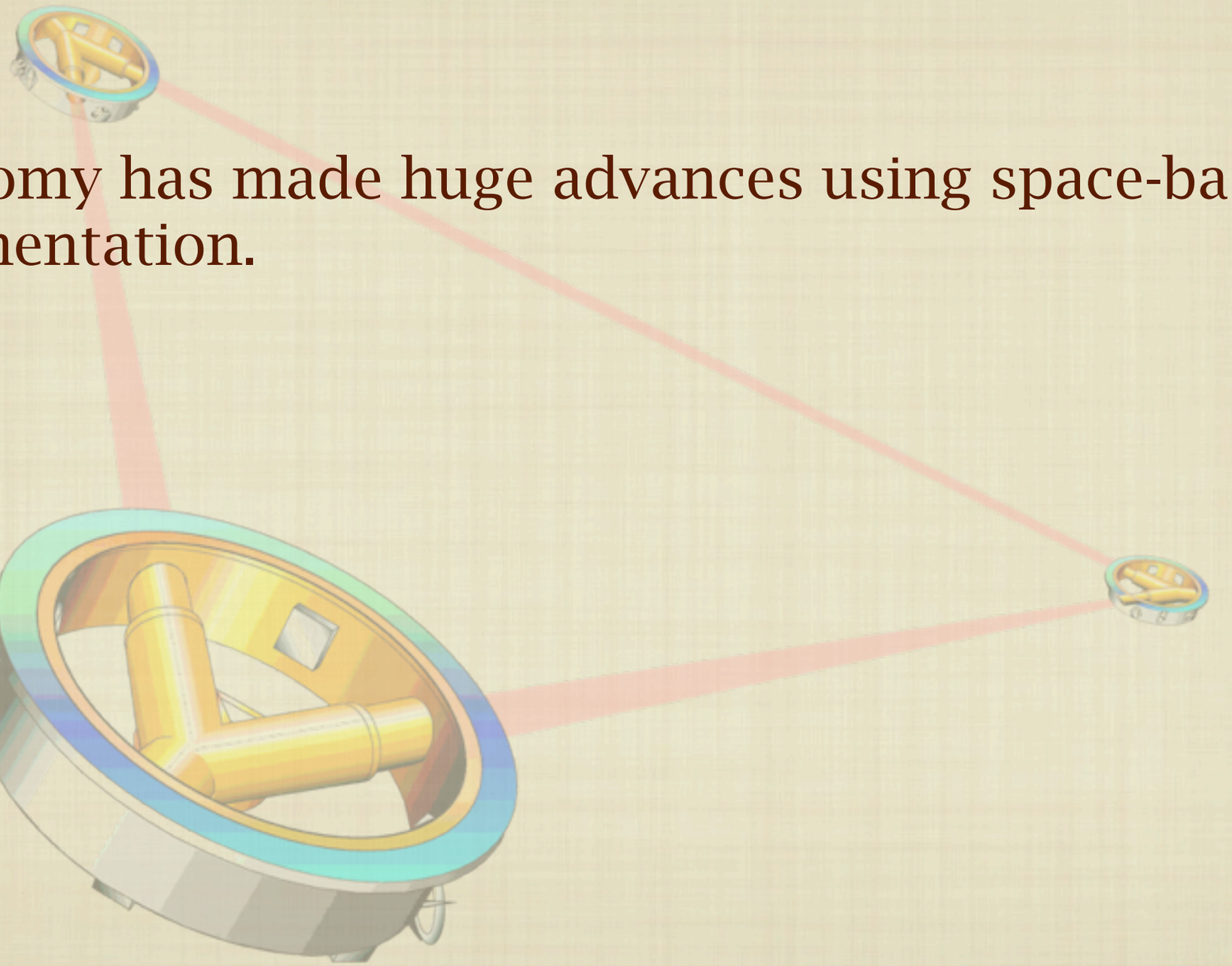

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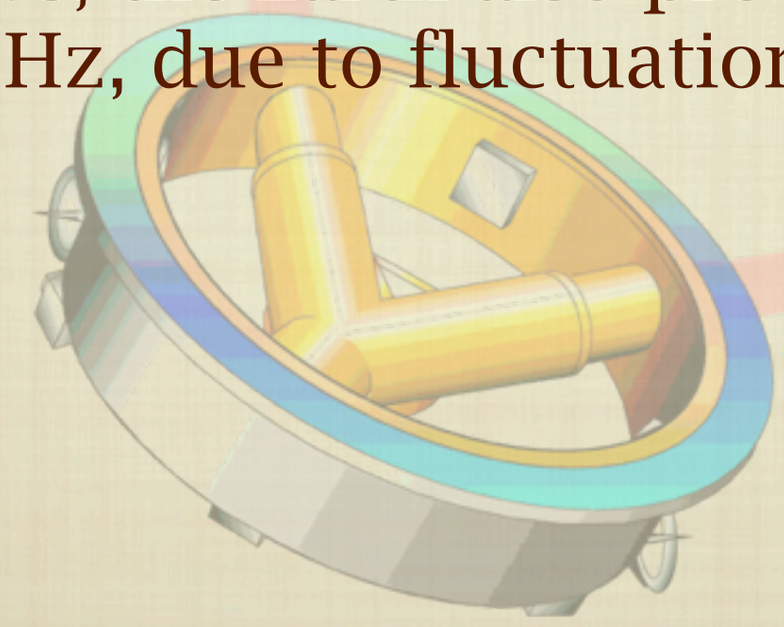

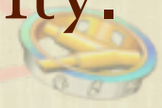

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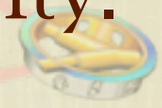

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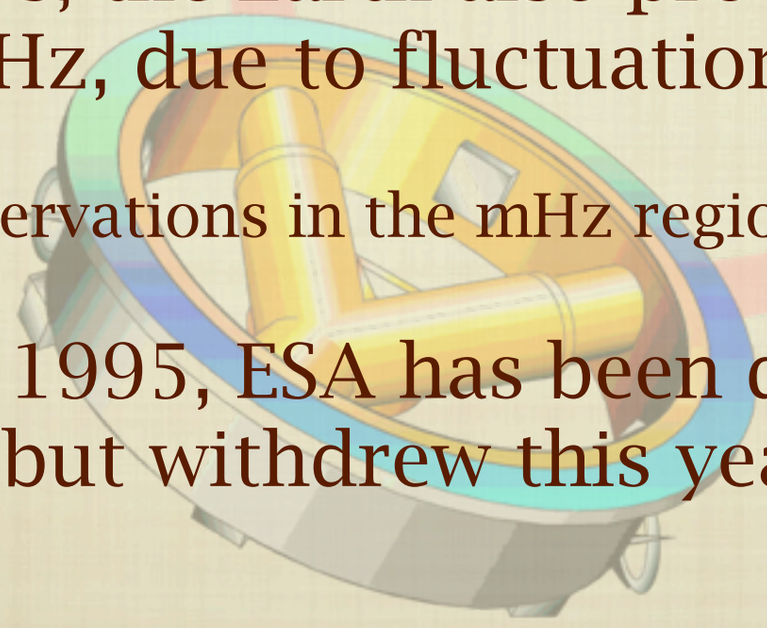
- Since 1995, ESA has been developing LISA. NASA joined in 1998 but withdrew this year.



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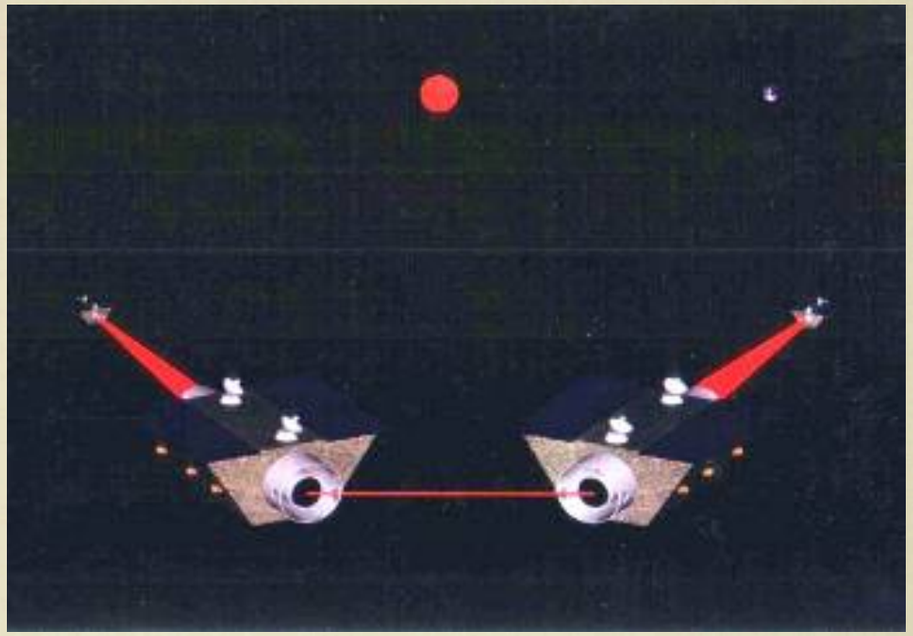

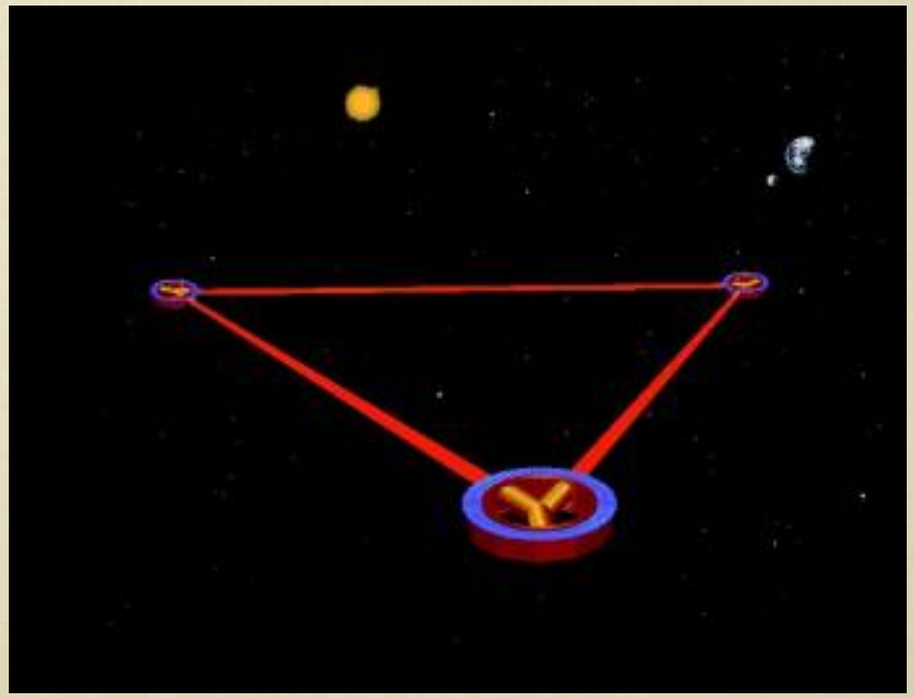

LISA Mission Formulation Study

Design Consolidation Review Agenda

28./29. January 2010

All the space you need

esa

EADS astrium

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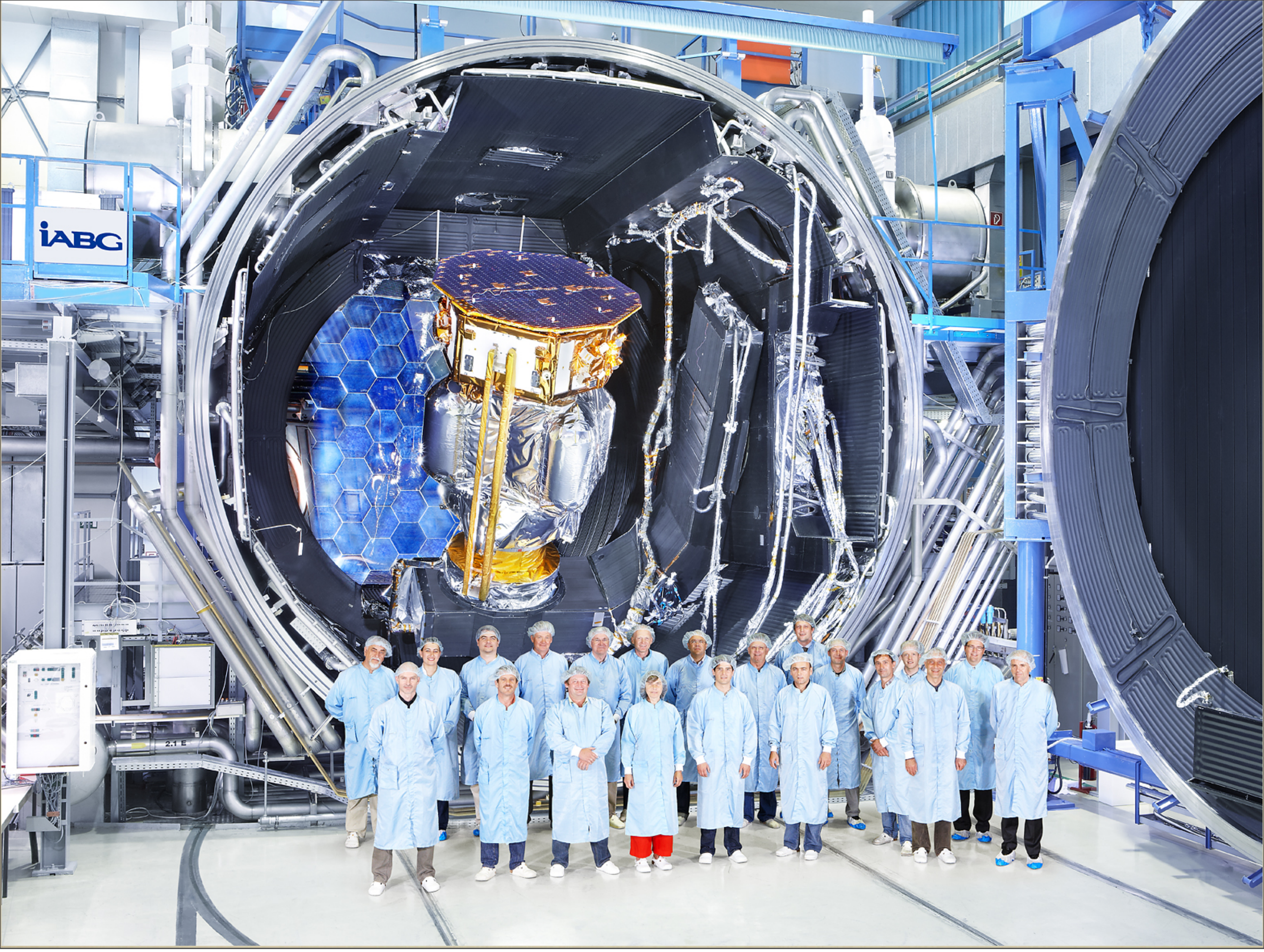
iABG

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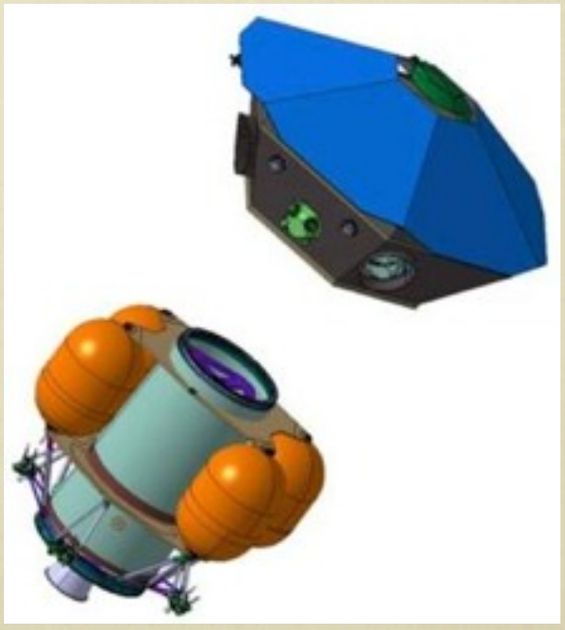

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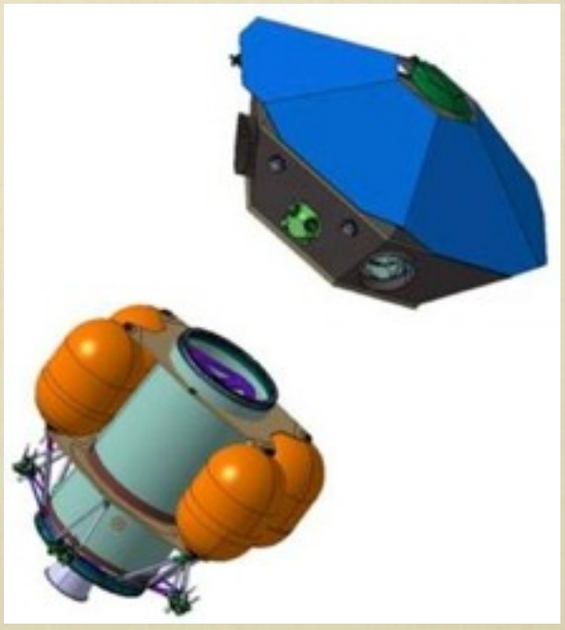

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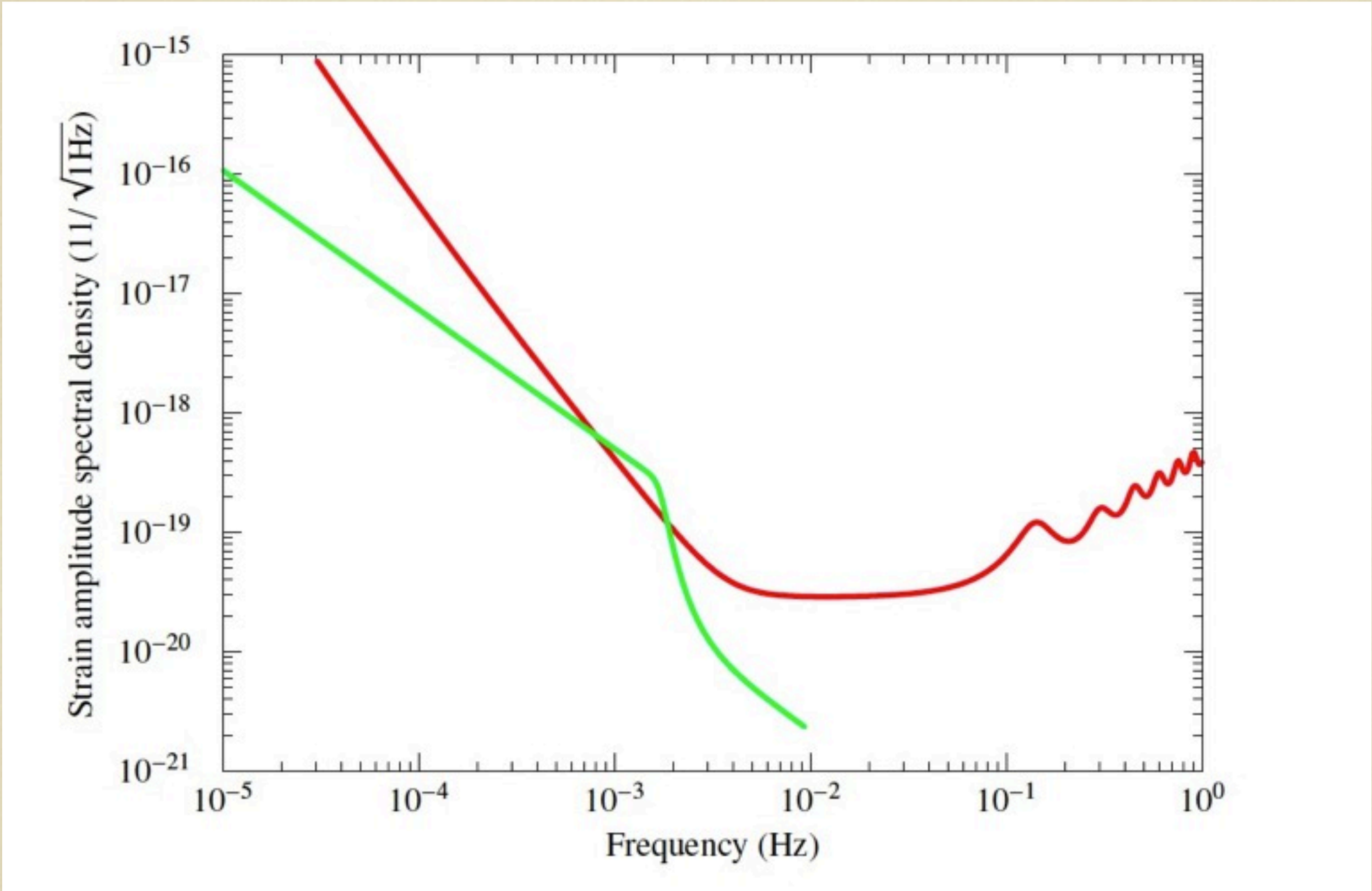

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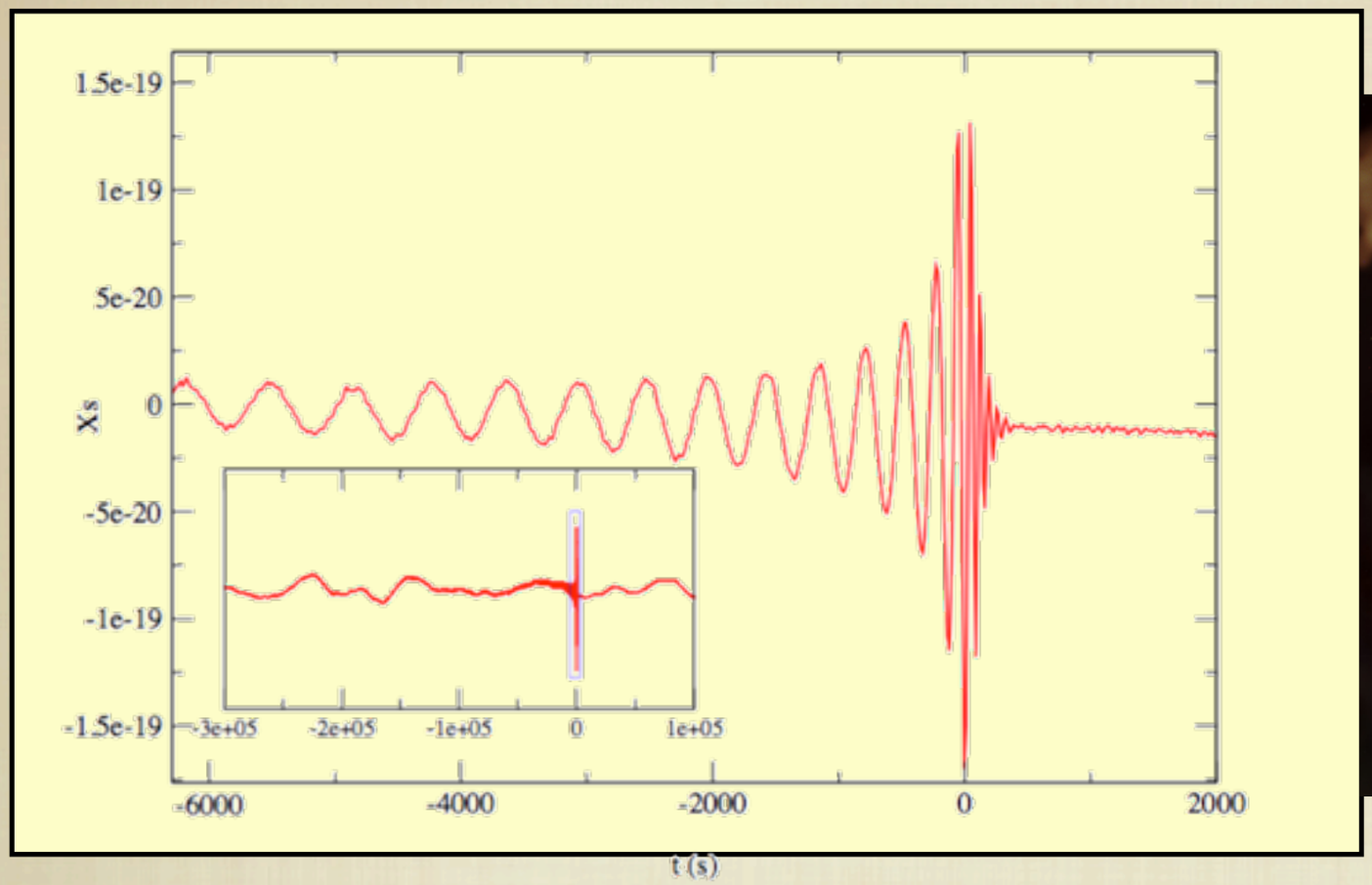

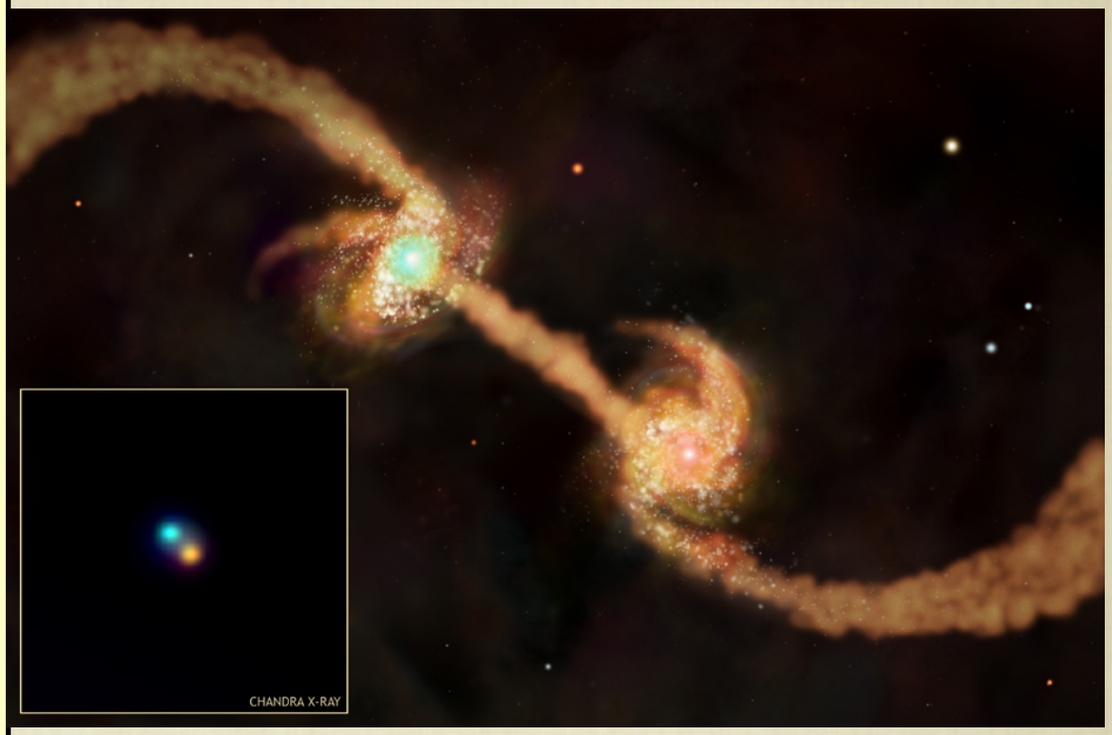

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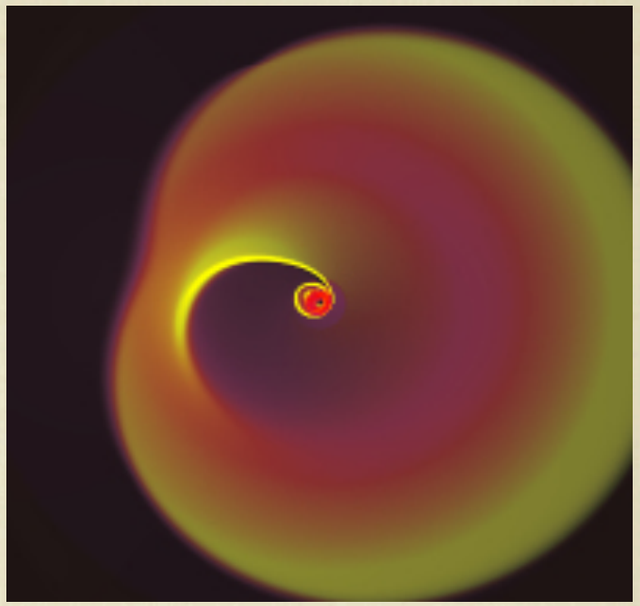

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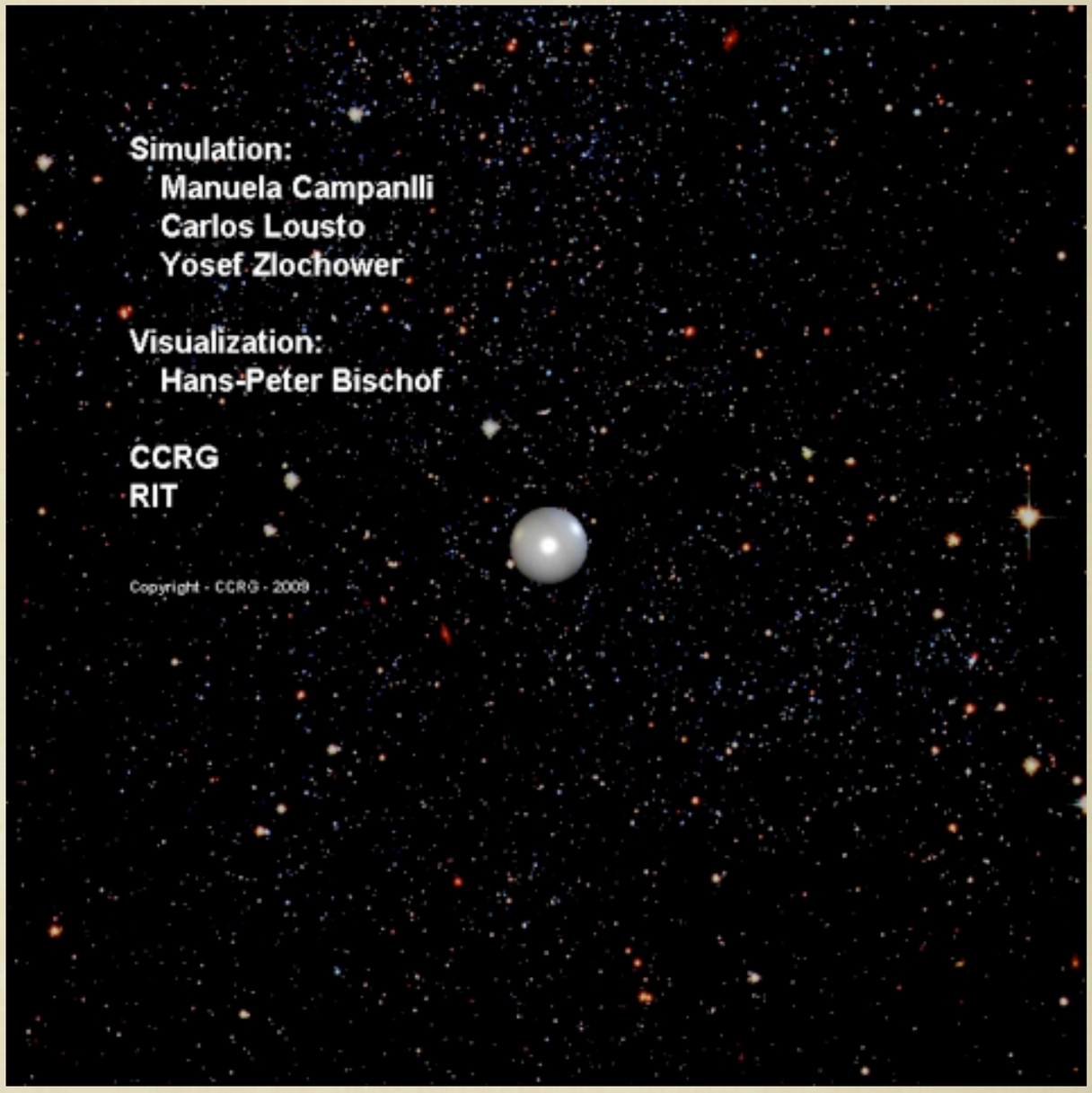

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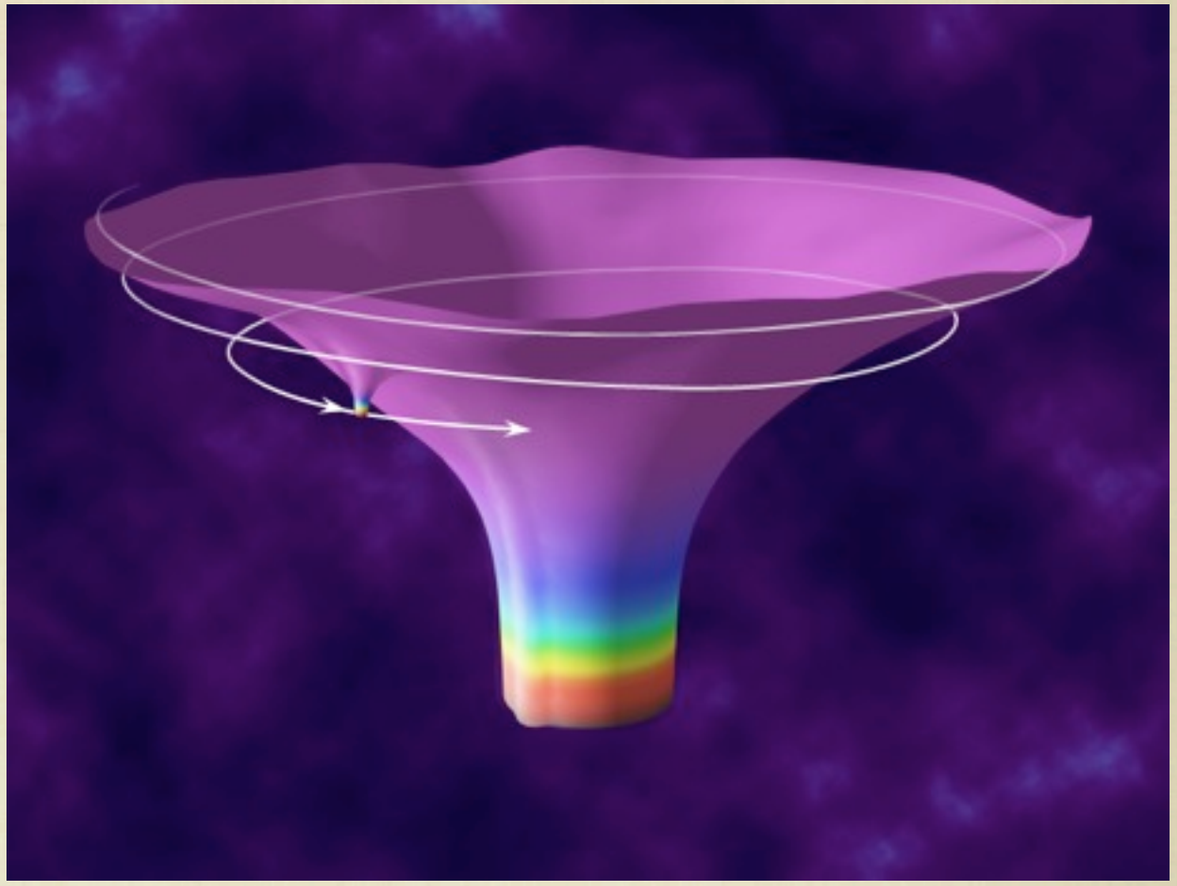

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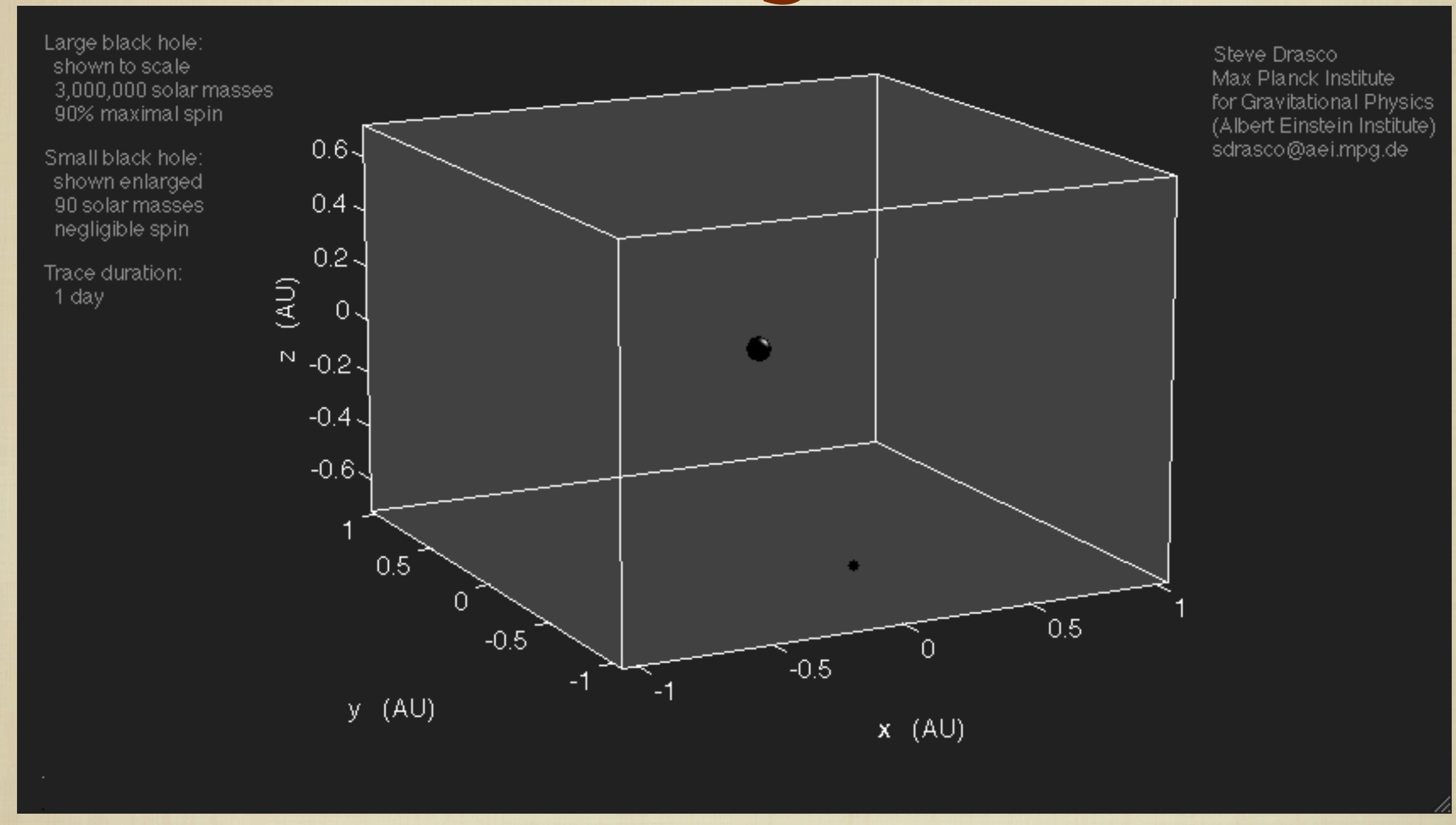
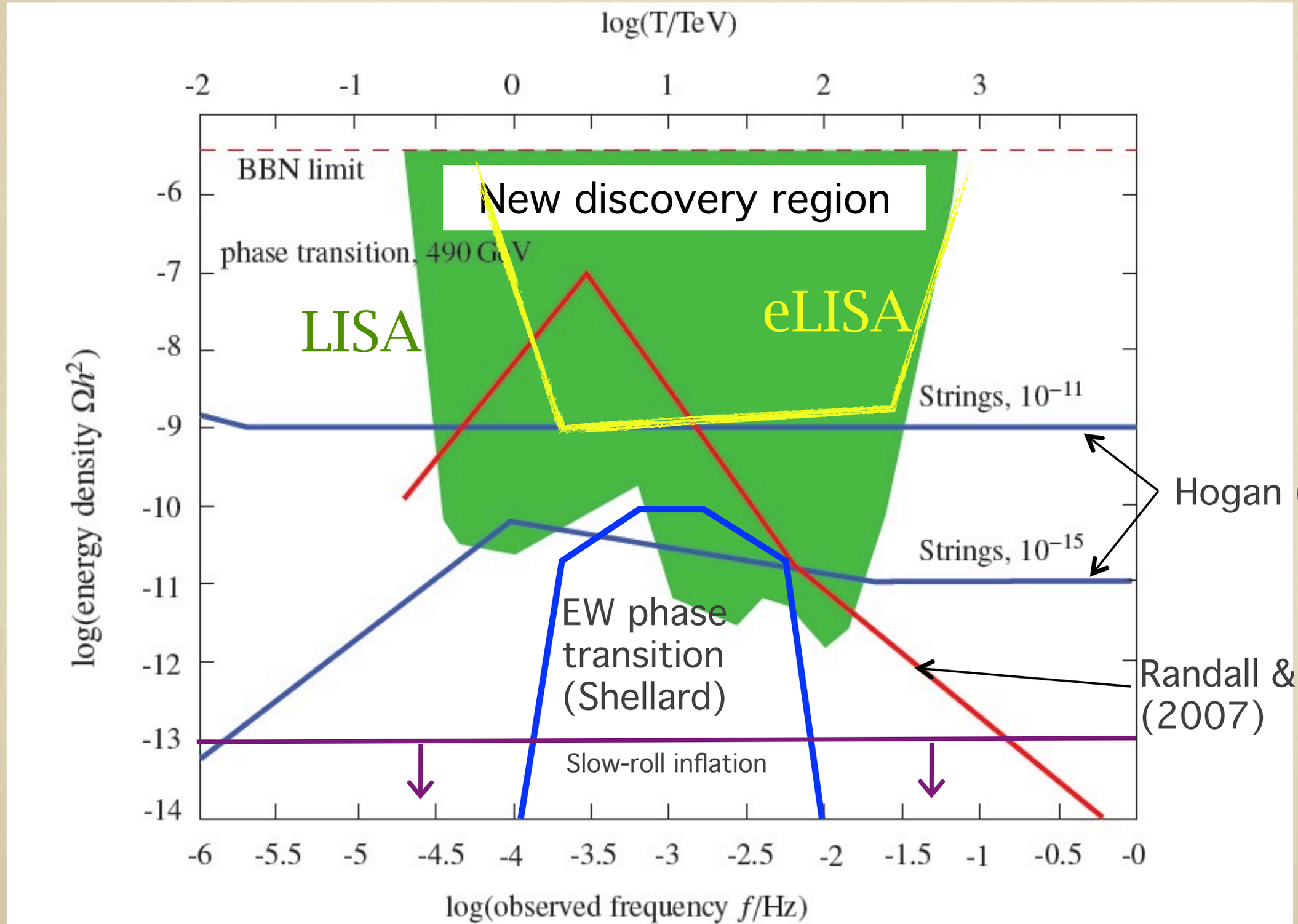


Space-based GW band



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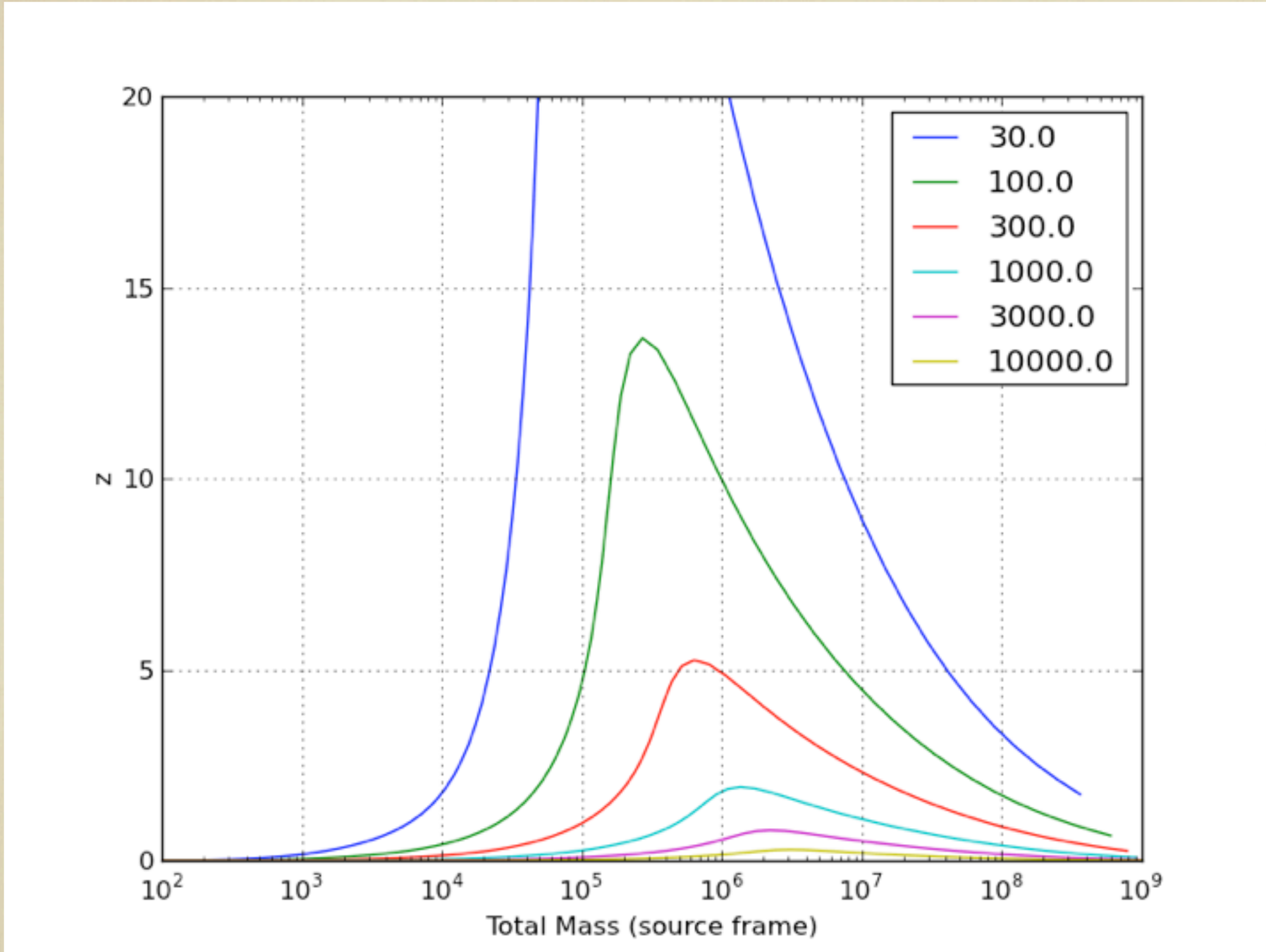

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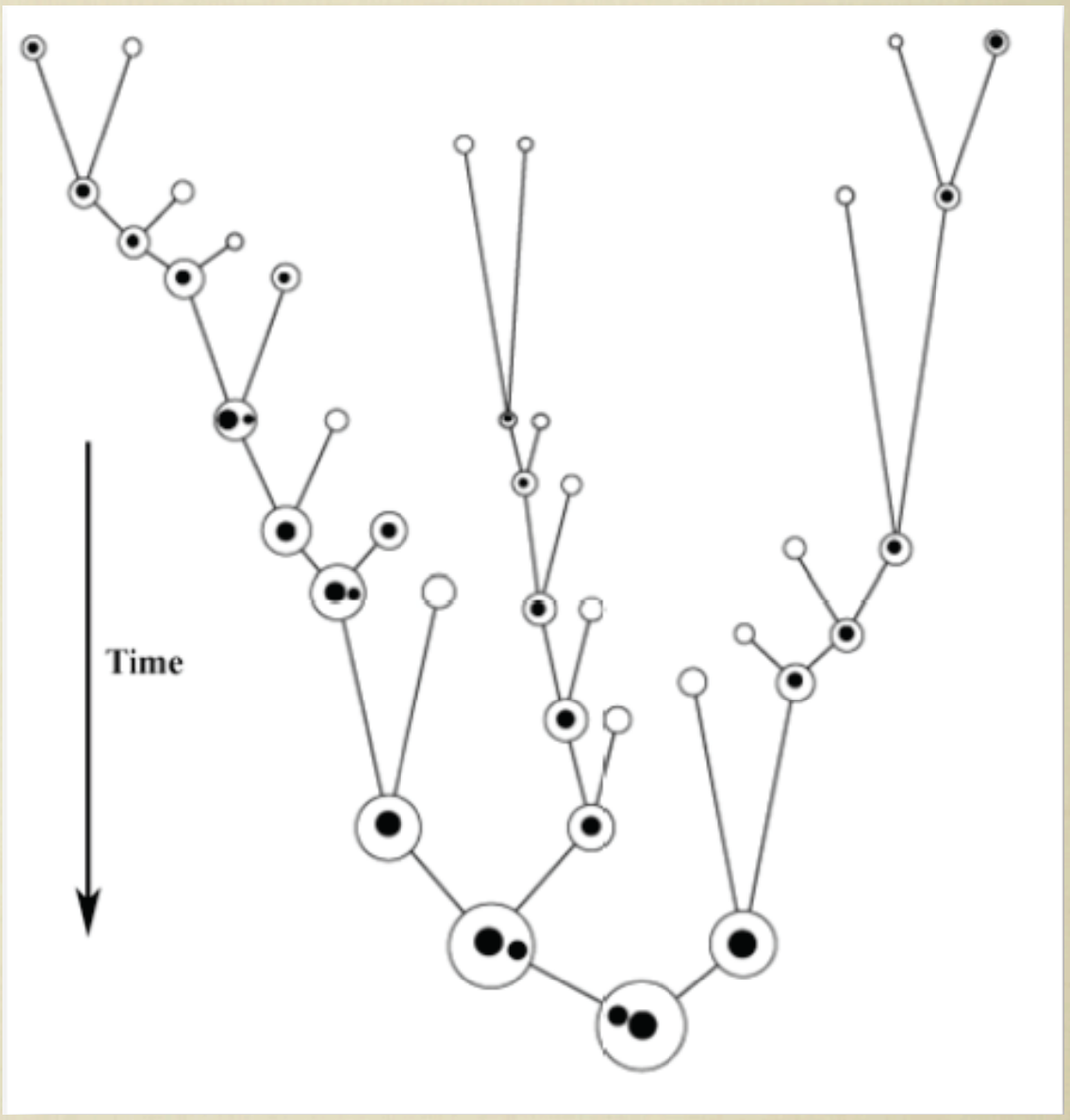
- Simulations (eg Volonteri) produce a variety of merger populations, depending on (a) assumed seeds and (b) gas accretion efficiency.



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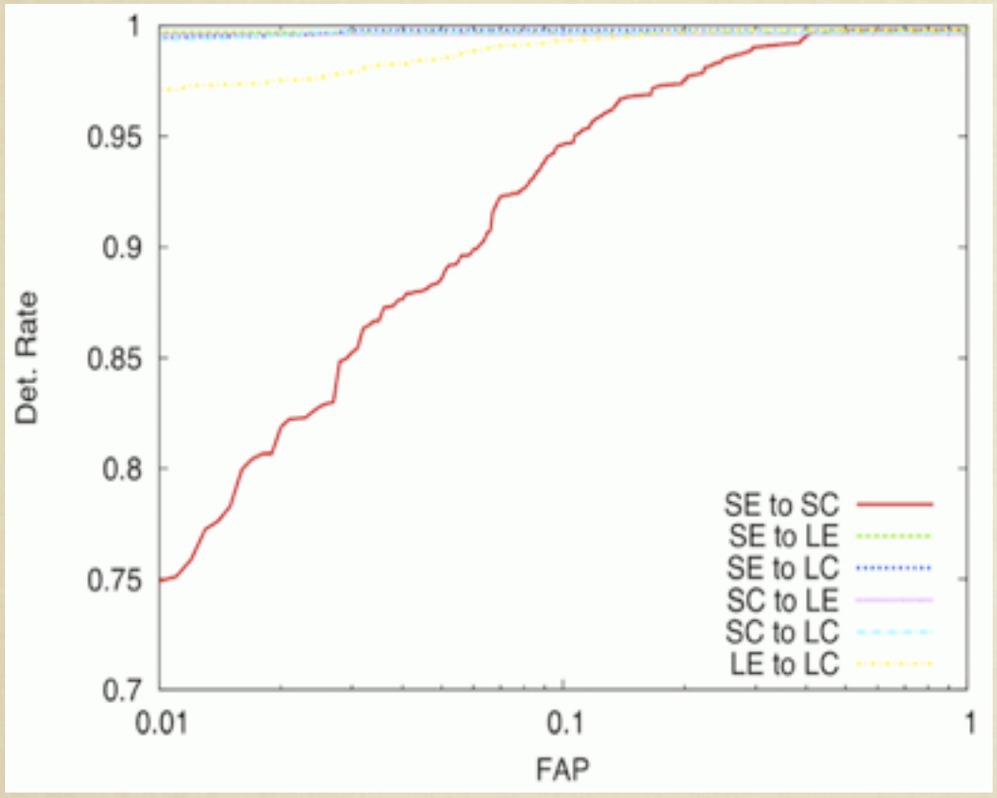

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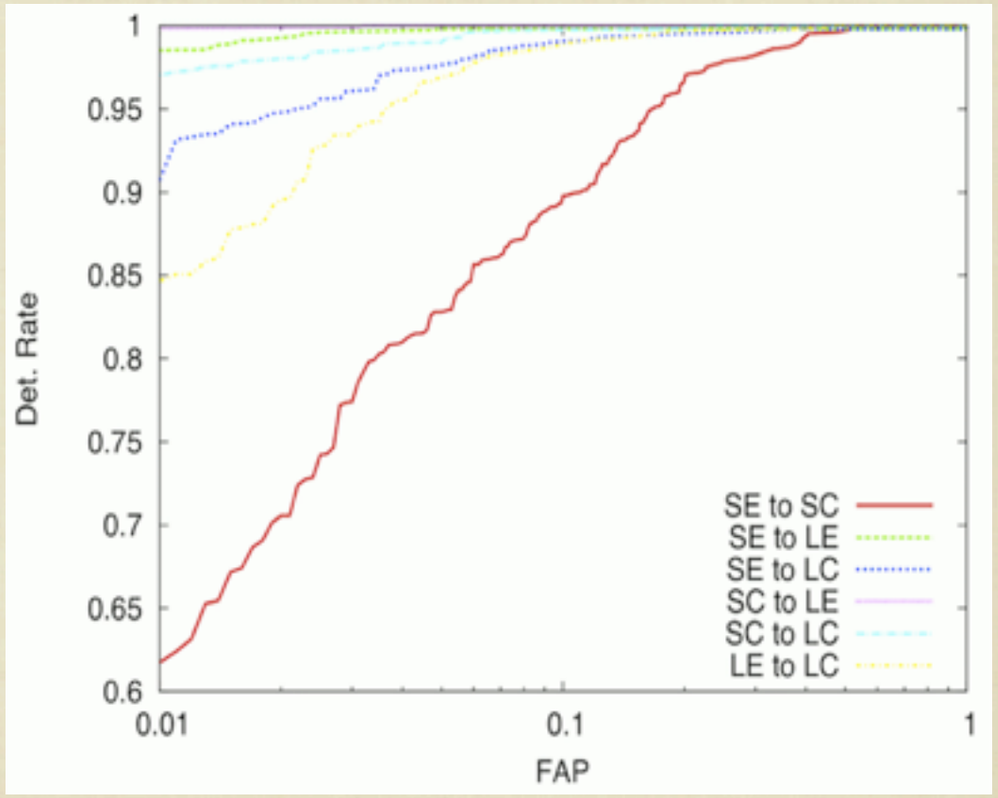

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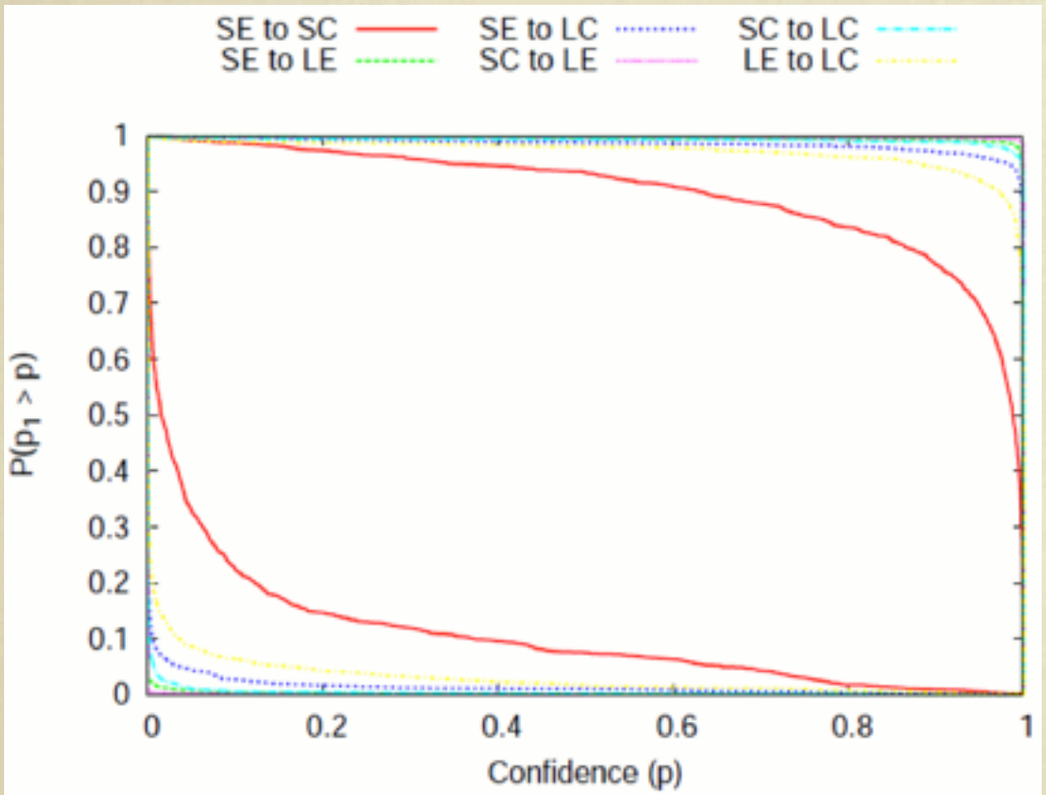

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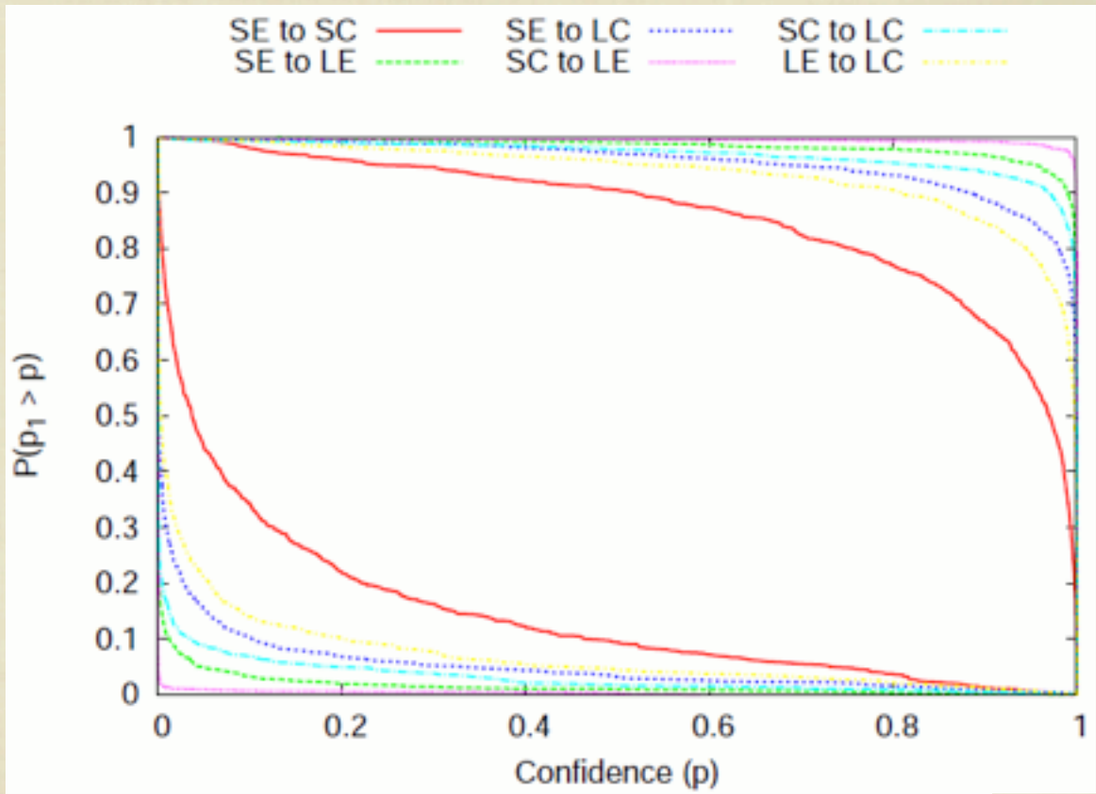

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- Every newly opened astronomical window has found unexpected results, but not always with the first instruments.

Window	Opened	1st Surprise	Year
Optical	1609 (Galileo)	Jupiter's moons	1610
Cosmic Rays	1912	Muon	1930s
Radio	1930s	Giant Radio Galaxies CMB Pulsars	1950s 1964 1967
X-ray	1948	Sco X-1 X-ray binaries	1962 Uhuru (1969)
v-ray	1961 (Explorer 11)	GRBs	Late 1960s++ (Vela)


31

Science with eLISA

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The Dark Side (KST)

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- talk about neutrinos