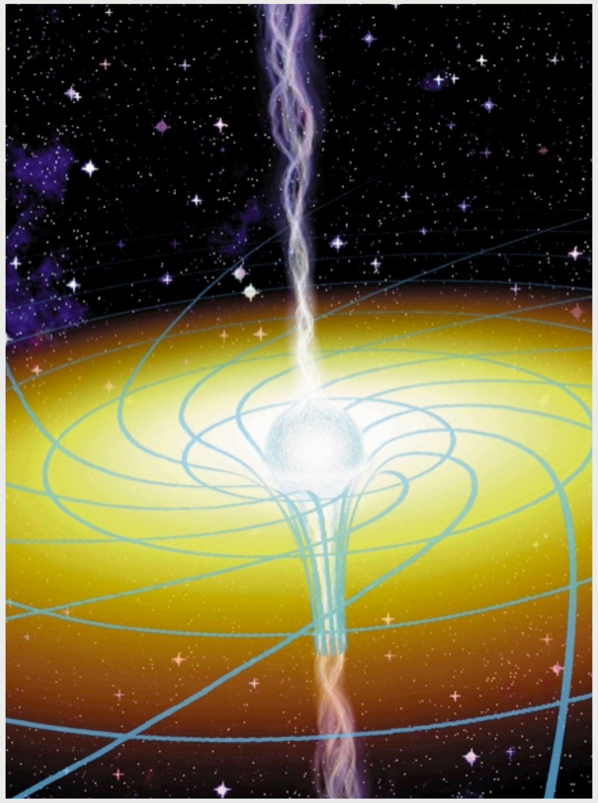
A HIGH TIME RESOLUTION SPECTROMETER (HTRS) FOR IXO & ITS SCIENCE

Didier Barret
CESR, Toulouse, France
on behalf of the HTRS working group: M. Mendez (University of Groningen), J. Wilms (University of Erlangen-Nuremberg) & T. Belloni (Brera), S. Bhattacharyya (TIFR), C. Done (Durham), K. Ebisawa (ISAS), P. Jonker (SRON), E Kendziorra (Tubingen), M. Gilfanov (MPA & IKI), E. Gogus (ASTRONS), J. Homan (MIT), M. van Kerkwijk (Univ. Toronto), D. Lai (Cornell), S. Mereghetti (IASF), M. C. Miller (Maryland), J. Miller (Michigan), S. Paltani (Geneva), J.M. Paredes (Univ. Barcelona), I. Papadakis (Univ. of Crete), J. Poutanen (OULU), M. G. Revnivtsev (MPA), J. Rodriguez (CEA), A; Schwope (AIP), L. Stella (INAF, Roma), P. Uttley (Southsampton), A. Zdziarski (CAMK)

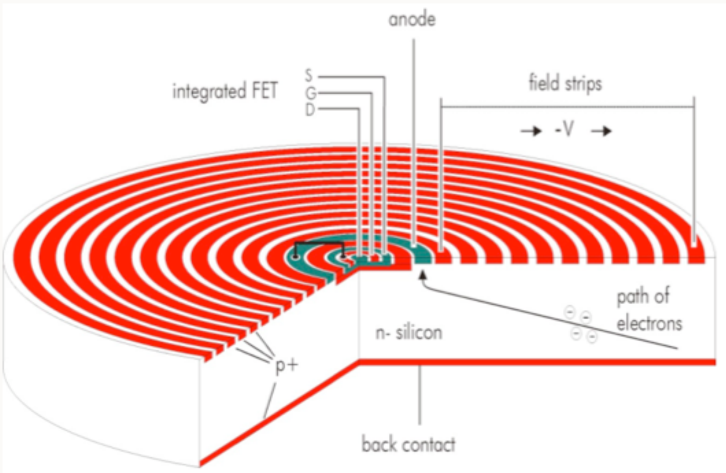
THE HTRS

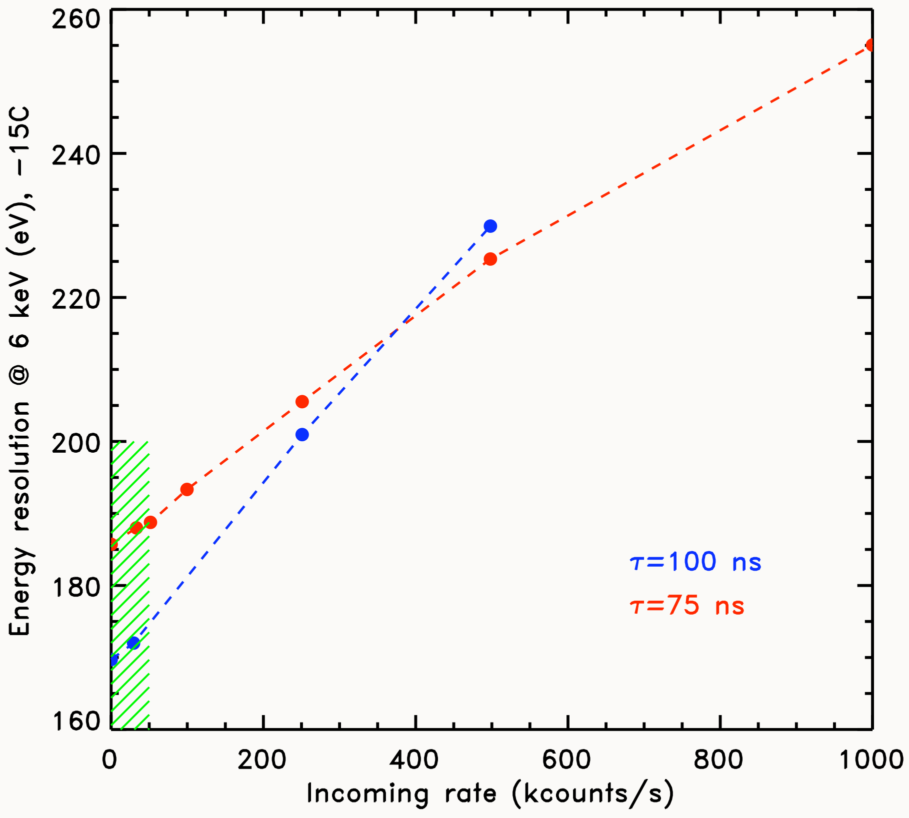
- The HTRS science is focussed on the "Matter under extreme conditions" theme of ESA Cosmic Vision
  - ✓ Strong gravity & dense matter - See *talks by M. Mendez, Ph. Uttley, C. Done, ...*
- Capability for IXO to observe **bright** X-ray sources:
  - ✓ sub-millisecond time resolution
  - ✓ CCD like energy resolution (120-150 eV @ 6 keV)
  - ✓ broad band pass: 0.5-40 keV
  - ✓ low deadtime (< 2%), low pile-up (< 2%)
- The main requirement: coping with **2 10^6 counts/s**
- Collaboration between CESR (Toulouse), MPE/MPI (Munich), Pn-Sensor (Munich), University of Tübingen



THE HTRS

- The HTRS is an array of 37 Silicon Drift Detectors (SDDs)
  - ✓ operated out of focus ($1 cm^2$, 20 cm)
  - ✓ *CdTe pixelated detector underneath*
- Standard analog chain with fast shaping time 75 ns - **less than 200 eV at 100 kcts/s**
  - ✓ DSP as an alternative
- No critical issues
  - ✓ Detectors exist and are space proven
- Modest instrument: 31 kg, 100 W
- Could be integrated to the WFI (if MPE provided)

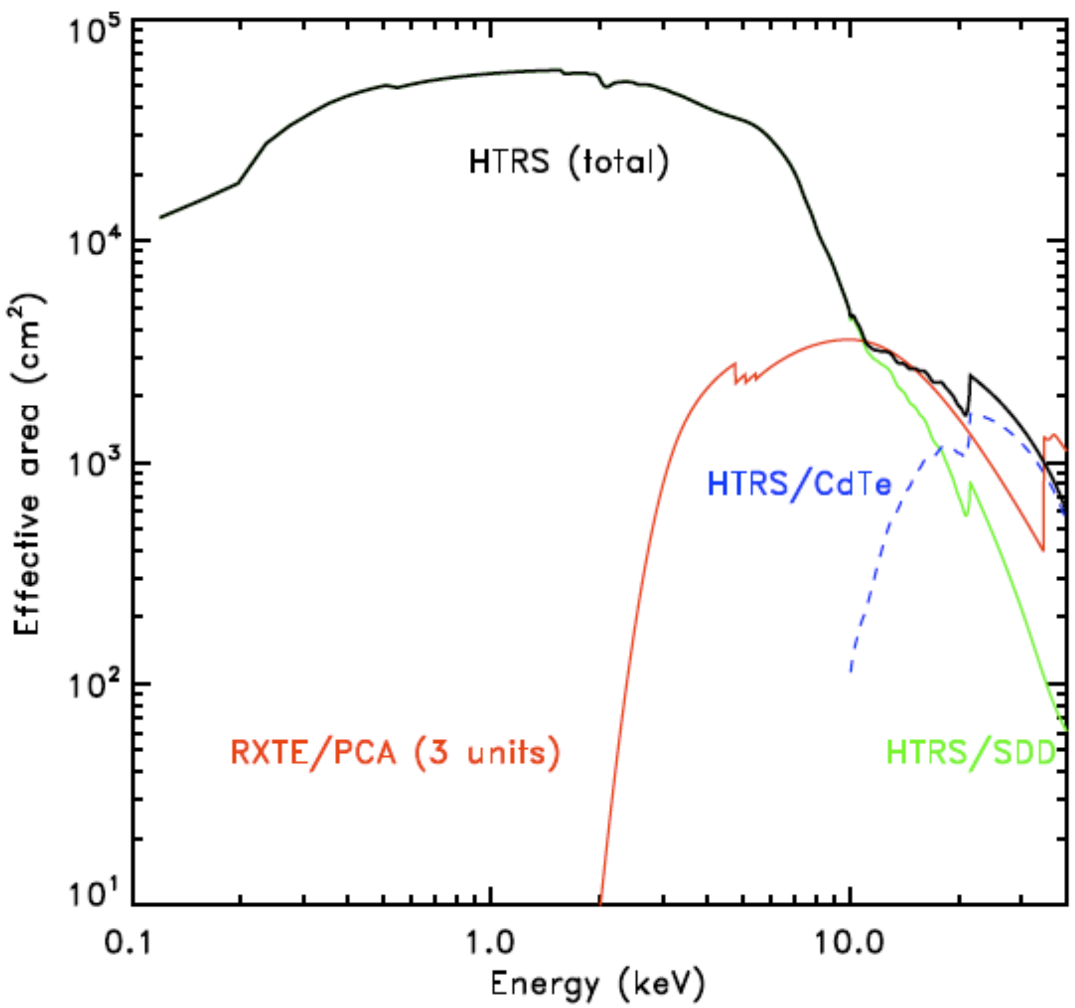




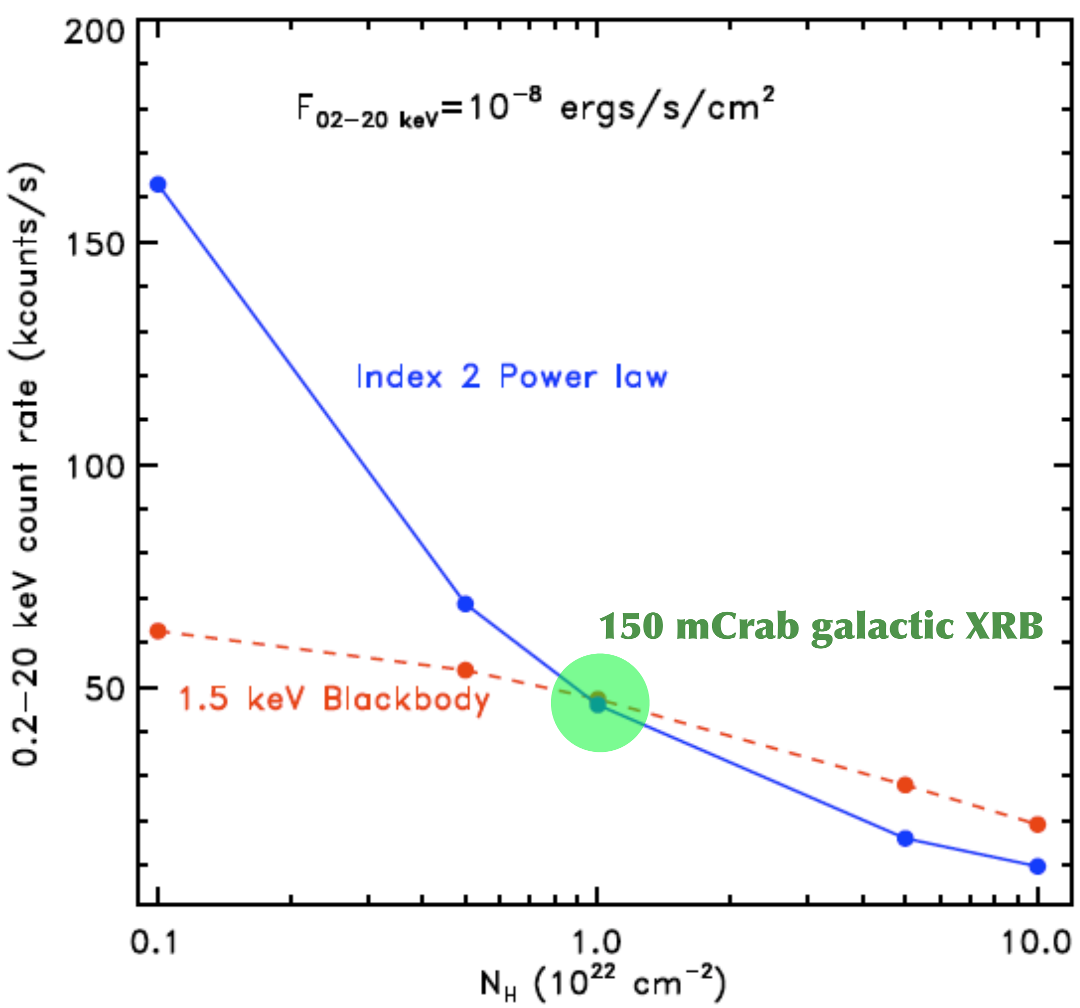
HTRS EFFECTIVE AREA & COUNT RATES

- XEUS (maximum configuration)

Effective area

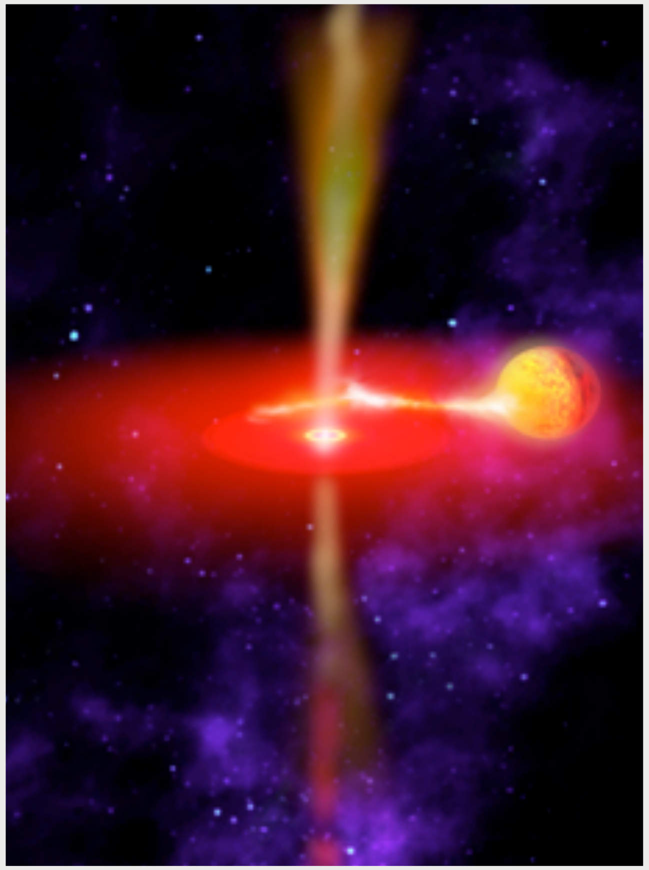


Count rate versus Nh (kcts)



HTRS TARGETS

- HTRS will observe galactic compact objects:
  - ✓ powered by accretion
    - ➡ Over a wide range of accretion rates, e.g. x-ray novae, microquasars
  - ✓ powered by magnetic energy
    - ➡ Over a wide range of magnetic fields, e.g. from millisecond pulsars to magnetars
  - ✓ powered by internal energy
    - ➡ Over a wide range of ages, e.g. cooling neutron stars

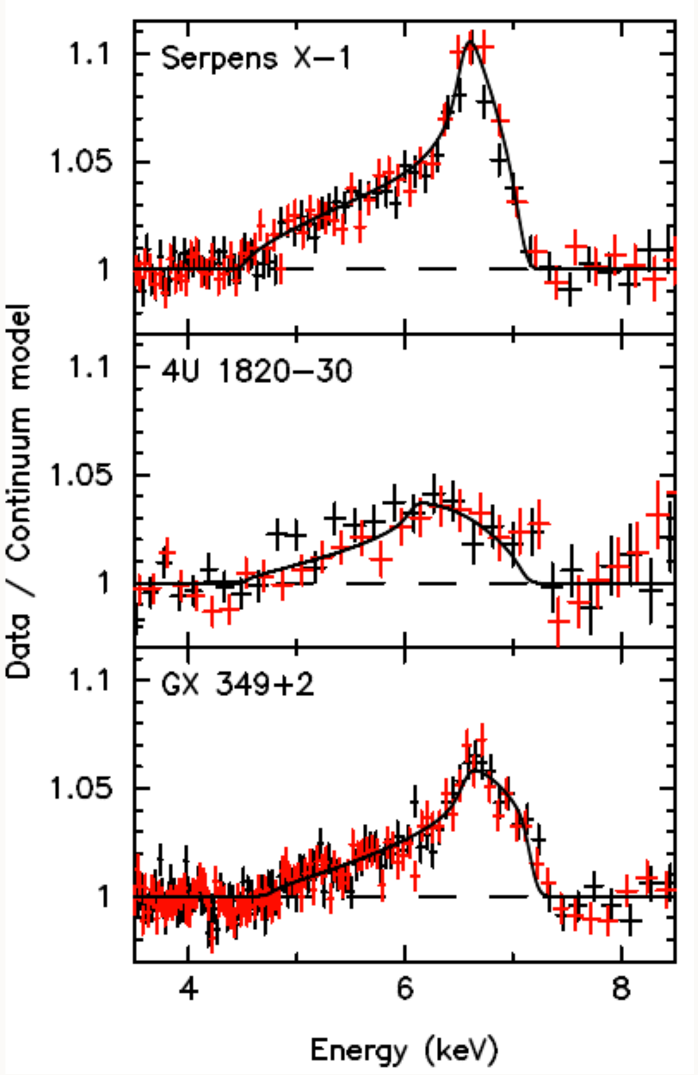


STRONG GRAVITY SIGNATURES IN X-RAYS

- Secured (but yet to be fully exploited):
  - ✓ Relativistically smeared iron line tracing matter moving close to the compact objects: seen in black hole systems and in **neutron stars**
- To be confirmed:
  - ✓ Redshifted absorption lines from radiation emitted at the surface of a neutron star
  - ✓ The innermost stable circular orbit (from timing and spectroscopy)
  - ✓ Lense-Thirring precession (from timing)
  - ✓ The black hole event horizon
- The HTRS has the potential to confirm the above findings and to use them to probe strong field GR

Broad iron lines in NSs

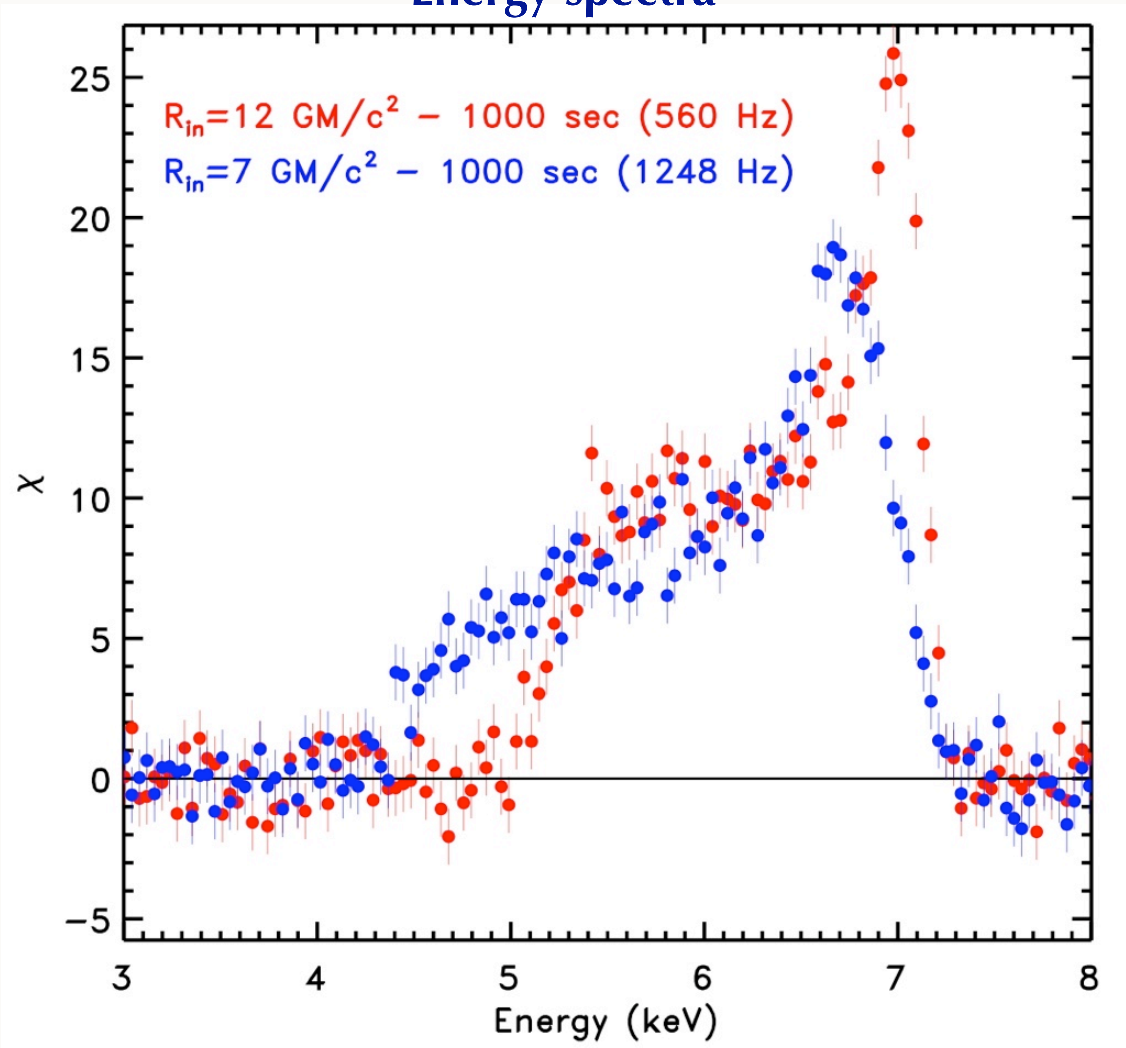
Cackett et al. (2008)



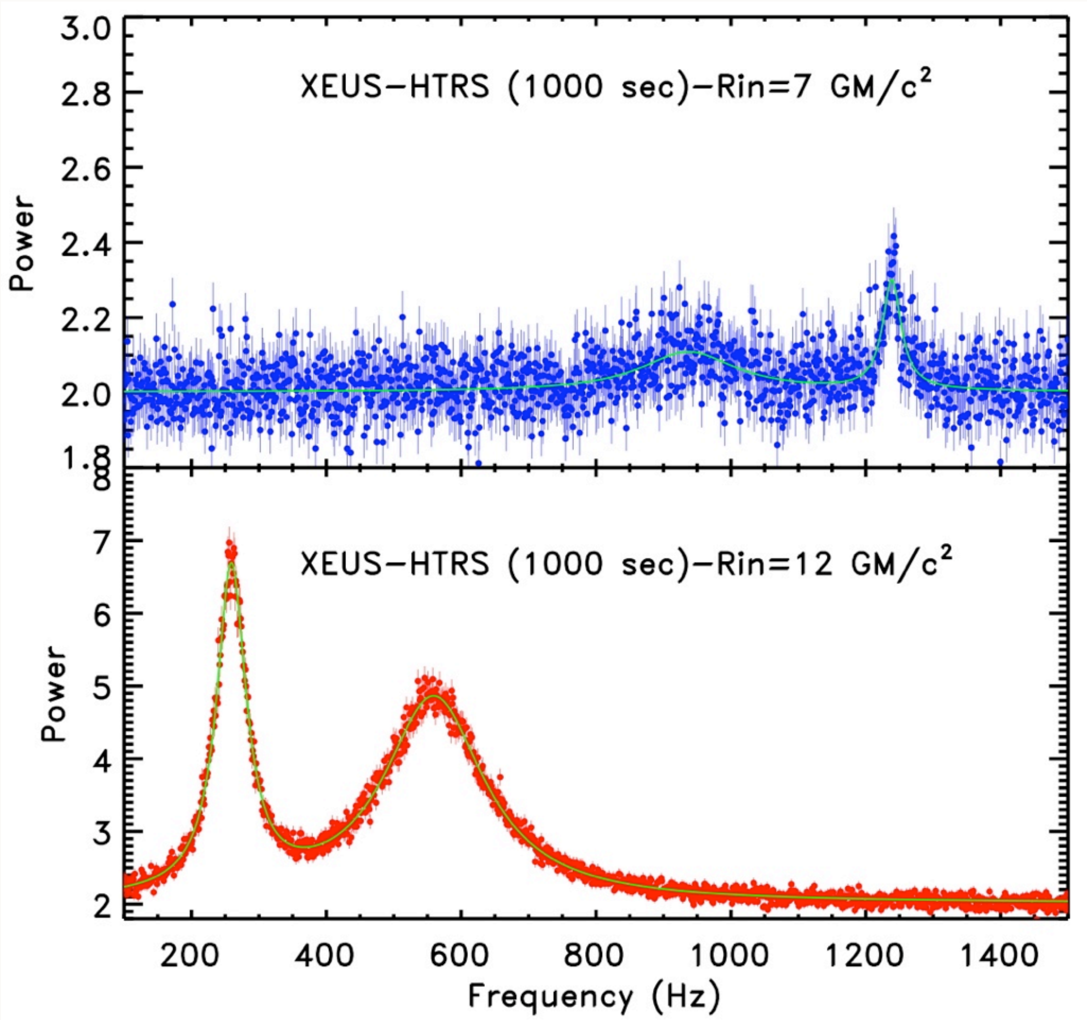
ORBITAL VARIABILITY

- Combining fast timing and spectroscopy - tracking the inner disk radius with the iron line and the kHz QPOs - Test the orbital nature of kHz QPOs

Energy spectra



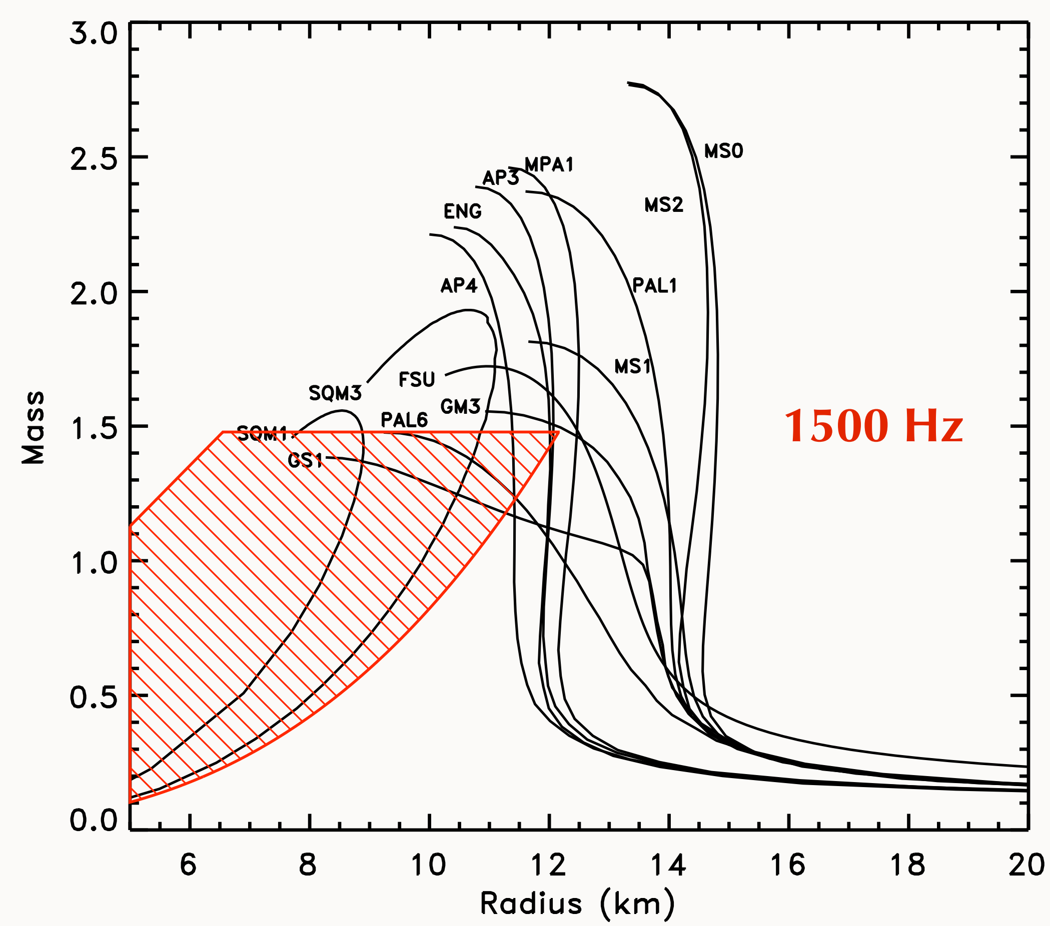
Fourier PDS



RADIOGRAPHY OF NS

- The composition of NS depends on the nature of strong interactions - Physics allows NS to be made of exotic matter: strange matter, pion condensates,...
- X-rays: a privilege tool to study NS
  - ➡ Fastest orbital variability sets limits on the ISCO and hence NS radii
  - ➡ Absorption edges from burst ashes yields M/R
  - ➡ Waveform modelling of oscillations (either during bursts or in the persistent emission) constrains the NS compactness
  - ➡ *Additional diagnostics: atmosphere emission, cooling curves*

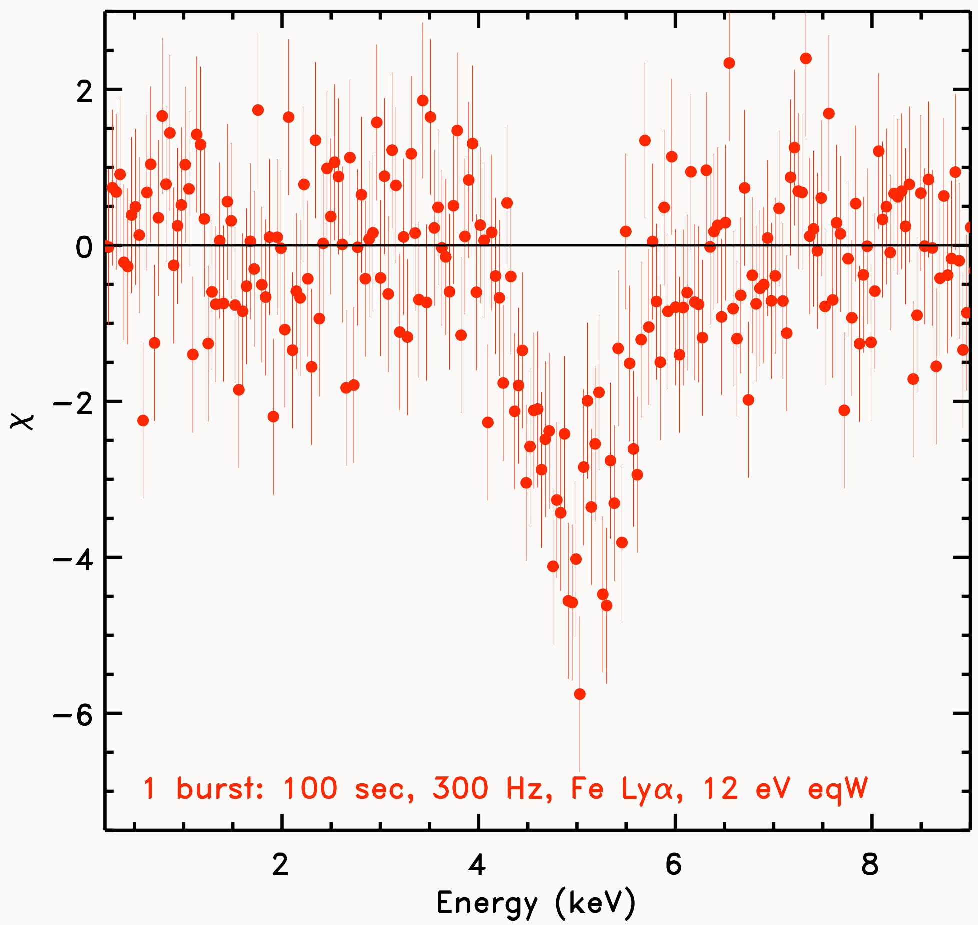
Mass-radius relations - Constraints for a Keplerian QPO at 1500 Hz



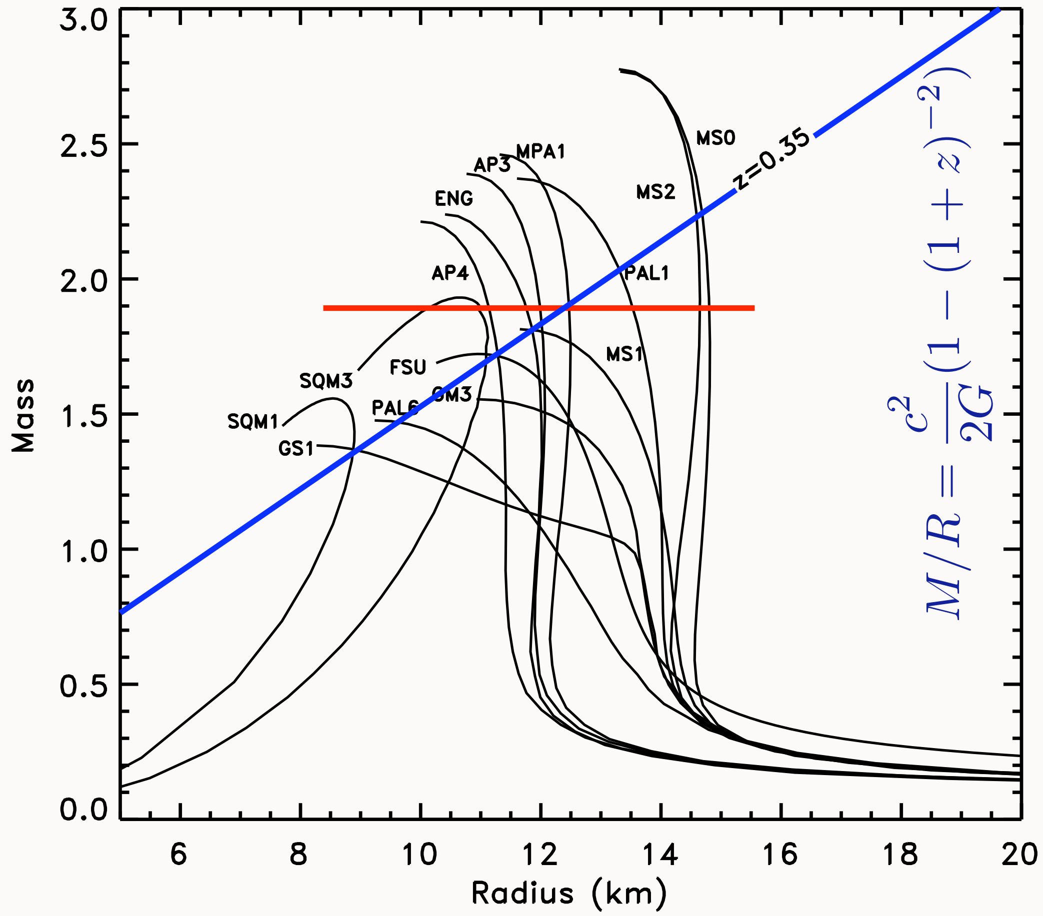
COMBINING DIAGNOSTICS

- Requirement: a capability to look at **bright** X-ray sources with good timing resolution and moderate spectral resolution

Absorption edge



M-R relations for various EoS and constraints



CONCLUSIONS

- Bright galactic X-ray sources should not be excluded from the IXO target list
  - ✓ Offer a complementary tool for probing strong gravity (and more generally accretion) in the vicinity of accreting black holes (and neutron stars), through simultaneous fast X-ray timing and spectroscopy
  - ✓ Offer a unique tool to probe matter at supra-nuclear densities
    - ➡ This requires a dedicated **high count rate** instrument in the focal plane, capable of dealing with Crab like count rates (several 100 000 cps)
- A dedicated follow-up (non-imaging) mission to RXTE, in the 3-5 m^2 class, is unlikely to happen, due to complexity and cost issues
- The HTRS, previously studied in the context of XEUS, is an already mature instrument, not technically challenging, and not demanding in terms of resources