cience Questions

How do accretion disks transport matter?

How are relativistic jets launched?

- What is the structure of spacetime surrounding black holes?
- What are the masses and radii of neutron stars?

lission Parameters

Energy Range: 0.1 - 10 keV

Energy Resolution: finer than 1 eV at 2 keV (3 eV at 6 keV) High throughput: count rates up to 100 kHz

- Timing resolution: better than 1 μ s, matching the innermost rbit period for a 10 solar-mass black hole
- Total effective area: 2000cm² at 6.4 keV

eutron Star Science

e neutron star science objectives are the study of accreting and lated neutron stars to understand the physics of accretion onto the rface and measure properties such as mass, radius and atmospheric mposition. The high sensitivity and high-timing resolution of Colibri Il allow for detection of reverberation lags in neutron star binaries. ectral line observations would measure the atmosphere composition d the ratio of M/R. Measurement of the width of the spectral line of oulsar with known spin period, as in the case of the 61.9 ms PSR 833-1034, could provide extra constraints on the neutron star's radius e Test Case Box).

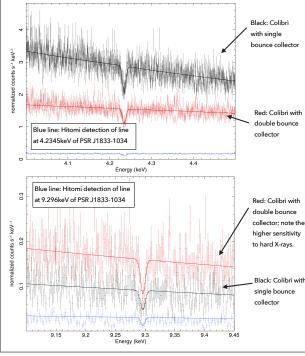
uasi-Periodic Oscillations

oservations of BHBs with RXTE have driven extraordinary progress the study of their variability properties. In many of these systems, asi periodic oscillations (QPOs) were discovered and thought to iginate in the inner regions of the accretion disk. The mechanism ponsible for QPOs is still debated, but a careful study of their aracteristics can lead to a better understanding of the physics of ack-hole accretion and of general relativistic effects in the strong field

oservations of the higher-frequency peak of neutron star kHz QPOs ould help to place constraints on the mass-radius relationship of utron stars

Test Case: Neutron Star Spectral Lines

Recently the Hitomi satellite found evidence for weak and narrow absorption lines from the rotational-powered pulsar PSR J1833-1034 in the supernova remnant G21.5-0.9 at 4.2345 keV and 9.296 keV. The upper figure shows the line detected with Hitomi at 4.2345keV from PSR J1833-1034 (blue) compared to simulations for Colibri for the same observing time with two mirror configurations: single-bounce collector (black) with three times the geometric area of NICER and double-bounce collector (red) with the same geometric area as NICER. The lower figure is the comparison of the Hitomi detection of the line at 9.296keV to the same simulations using the two different mirror configurations of Colibri. Colibri will allow for the search of narrow spectral lines from a diversity of isolated and accretion powered pulsars, including nursing magnetars and XRBs.



Black Hole Science

The science objectives of Colibri include the study of accretion disk physics and the effects of strong field gravity around black holes, as well as probing the spacetime around black holes and putting constraints on different theories of gravity.

One of the most subtle consequences of GR is the^{\u00e4}no hair" theorem, for which black holes can be fully characterized by their mass, angular momentum and charge. The only way to test this theorem is to probe the spacetime very close to the hole. Fortunately, the X-ray emission of accreting black holes carries information about the inner region of the accretion disk, within a few gravitational radii from the hole, encoded in the fast variability of its spectrum. In particular, the emission from the accretion flow very close to accreting compact objects presents highprecision diagnostics of their spacetime, including reverberation mapping and quasi-periodic oscillations Furthermore, variability in the X-ray emission from accreting compact objects also carries information on the accretion processes themselves.

Reverberation Mapping

In both neutron stars and black holes, X-ray emission from outside the disk (coming from the neutron star's surface or from a glowing corona above the black hole) can be reflected by the disk into our line of sight. By correlating the primary emission with the reflected one we can map the accretion disk: as more distant regions of the accretion disk will be illuminated in subsequent times, photons of different energy will present different time delays.

The combination of high sensitivity and high timing resolution of Colibri will enable the detection of reverberation lags for neutron star binaries.

of eutre nustars and black holes MANITOBA AcGilMission Coverview Queens Western Stewart Blusson proposed Wantym Matter dissistive ations of isolated and telescope concept designed to accreting neutron stars. he neutrounveil the mysteries of offeting and The Colibri concept is based plated neutron stars to understand the physics of accretion onto the

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UNIVERSITY 0,0 <u>of</u> Manitoba Western Stewart Blusson

Quantum Matter Institute

n multiple aperture nonimaging X-ray collectors

similar to NICER but with

cryogen'ically cooled

transition edge detectors for

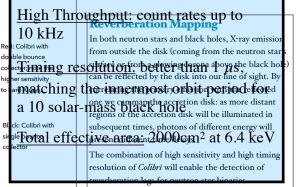
high energy resolution and

sensitivity. This concept study

- is being funded by the
- Canadian Space Agency.

ALBERTA







McGill

TRIUMF Honeywell MDA



Colibri: Key Science Questions

1 - Accretion Physics

This key science theme will explore the accretion physics in the inner regions of compact objects:

- What happens within the innermost region of the accretion disc around black holes?
- What is the structure of the X-ray emitting region of the accretion disc?
- What powers the corona? What drives X-ray weak and strong sources?

2 - Feedback Mechanisms on all Scales

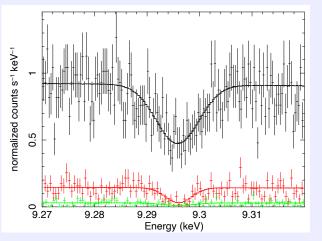
This key science theme will explore questions such as:

- What drives outflows in AGN?
- What are the properties (density, velocity, geometry, kinetic luminosity) of outflows?
- Where are the missing baryons?

3 - Physics of Extreme Matter

This key science theme will explore questions related to understanding dense matter and extreme magnetic fields:

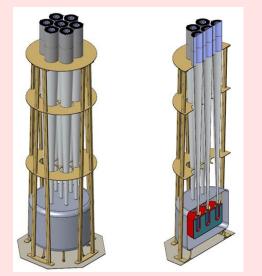
- What is the equation of state for neutron star material and how can we probe the interiors of neutron stars?
- What are the properties of material and light in strong magnetic fields?
- What is the magnetic field structure in pulsar wind nebulae and SNRs that accelerate cosmic rays?



Comparing the detection of a 9.296keV spectral feature between Colibri (black line), ATHENA (red line) and Hitomi (green)

Colibri: Driving Canadian Innovation

In order to achieve the science goals, Colibrì will require high-energy resolution, high-time resolution and high sensitivity. This will lead the X-ray collectors to have cryogenically cooled **Transition Edge Detectors (TES)**. The major components of the X-ray collectors are be developed and fabricated in Canada, pushing Canadian innovation forward and increasing the capacity within Canada for X-ray space missions. The key technologies in the collectors are: the **Cryrocooler**, The TES detectors and **read-out electronics**, and the **mirrors**. The Stewart Blussom Quantum Matter Institute in Vancouver has already been identified for TES detector development.



A schematic of the 7 detector Colibri telescope.