neutron stars. Would help to place constraints on the mass of neutron stars.

Observations of the higher kHz QPOs will allow the study of reverberation lags for neutron star binaries. More Information: http://www.colibrirxte.com

Taking the pulse of Neutron Stars and Black Holes

- Spectral line observations would measure the atmosphere composition and the ratio of $M/R$. Measurement of the width of the spectral line of the edge of the accretion disk and the innermost radius relationship of $R_{\text{in}}$.

- Correlation of primary and secondary emission would establish the existence of thermal processes in the accretion disk.

- Other X-ray emission from isolated neutron stars could be associated with narrow line profiles, which would help to place constraints on the mass of neutron stars.

Spectral line observations would measure the atmosphere composition and the ratio of $M/R$. Measurement of the width of the spectral line of the edge of the accretion disk and the innermost radius relationship of $R_{\text{in}}$.

The transition to hard X-rays.

- Timing resolution: better than 1 ms.
- Energy Resolution: finer than 1 eV at 2 keV (3 eV at 6 keV).
- Energy Range: 0.1 - 10 keV.

What is the structure of spacetime surrounding black holes?

How are relativistic jets launched?

How do accretion disks transport matter?
Colibrì: Take Home Message

High- Time Resolution
High-Spectral Resolution
High-Throughput

Transition Edge Sensor (TES) Detectors in Space
The Colibrì Team

Gregory Sivakoff, Alberta

Kostis Michelakis, SBQMI, UBC

Coordinated Observations Lead

Detectors

Neil Rowlands, Honeywell

Piotr Jasiobedzki, MDA

Payload

Satellite

http://www.colibri-telescope.ca
# The Colibrì Team

**Principal Investigator:**
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**Project Scientist:**
Ilaria Caiazzo, University of British Columbia

**Project Manager:**
Kelsey Hoffman, Bishop’s University

**Working Group Leads:**
- **Black Holes** - Sarah Gallagher, Western University
- **Neutron Stars** - Samar Safi-Harb, University of Manitoba

**Mission Planning Lead:**
Daryl Haggard, McGill University

**Coordinated Observations Lead:**
Gregory Sivakoff, University of Alberta

**Detector Technical Lead:**
Kostis Michelakis, SBQMI, University of British Columbia

**Detector Technical Team members:**
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- Josh Folk, SBQMI, University of British Columbia
- Jeff Young, SBQMI, University of British Columbia
- Pinder Dosanjh, SBQMI, University of British Columbia
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**Science Payload Mechanical/Thermal Engineering Lead:**
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**Satellite Technical Lead:**
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**Satellite Technical Team members:**
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- Jagannath Kshetriya, MacDonald Dettwiler

**Science Working Group Members:**
- Luigi Gallo, St. Mary's University
- Sharon Morsink, University of Alberta
- Demet Kirmizibayrak, University of British Columbia
- Paul Riposte, University of British Columbia
- Andrew Cumming, McGill University
- Craig Heinke, University of Alberta
- Ingrid Stairs, University of British Columbia
- Bob Rutledge, McGill University
- Benson Guest, University of Manitoba

http://www.colibri-telescope.ca
Colibrì Mission Overview

- High-time resolution, high-spectral resolution and high throughput
- Science questions:
  1. Does general relativity apply in the strong gravity regime? Is spacetime around black holes well described by the Kerr metric?
  2. Can we better understand the physics of accretion? How do accretion disks lose angular momentum? What is the mechanism behind winds? How are jets launched?
  3. How does matter behave in extreme environments in terms of density, gravity and magnetic fields? What is the physics of ultra-dense matter? What are the masses, radii and atmospheric composition of neutron stars?
- Current Status: 18-month concept study (September 2018 - February 2020)
Colibrì Mission Specs

- Energy Range: 0.5 - 20 keV
- Energy Resolution: 2 - 5 eV
- Timing Resolution: 250 ns
- Effective Area: 3000 cm²
- Count Rate: >100 kHz
- Orbit: Sun Synchronous, 500-800km
- Mission Lifetime: 5 years
- Ground Ops: X-band, CSA Sat-Ops / NRCan

- Focal Length: 4.9 m
- Number of Arrays: 7
- Foils per Array: 30
- Coating: Iridium
- Detectors: TES Bolometers
- Bath Temp: 70 mK
- Tc = 100 mK
Colibrì: TES Detectors

- Transition Edge Sensors: high energy resolution and sensitivity
- Canadian TES detector development to be at Stewart Blusson Quantum Matter Institute at UBC
- On-board pulse processing - Sample every 5 microseconds
- Use of Linear filters (Paul Ripoche, Graduate student at UBC)

![TES array for X-ray detection from Lee et al. 2015](http://www.colibri-telescope.ca)
Colibrì Science Goals

Black Holes
- Reverberation mapping: Test GR, measure BH Mass
- Quasi Periodic Oscillations
- Warm/Hot Intergalactic Medium
- High Velocity Hot Outflows

Neutron Stars
- Lines/Spectroscopy: Isolated and Accreting
- Magnetar Spectral Lines
- Accretion Disk Winds
- Quasi Periodic Oscillations
- Thermonuclear bursts
- Mass & Radius of Neutron Stars

See WP 036 for more details, Talk by Ilaria Caiazzo at UBC Town Hall (Nov 26)
Spectral Features: PSR J1833-1034

Blue line: Hitomi detection of line at 9.296 keV of PSR J1833-1034

Key mission specs:
- High-Spectral Resolution
- High Throughput
- High-Time Resolution

Colibrì Single f/10
Colibrì Double f/10

Simulations by Benson Guest, PhD Student at U Manitoba

http://www.colibri-telescope.ca
Magnetar Outbursts: SGR 1900+14

Key mission specs:
High-Spectral Resolution
High-Throughput
No pile up issue for bright bursts

Simulations by Demet Kirmizibayrak, PhD Student at UBC
SGR 0418+5729 Phase Resolved Spectroscopy

Key mission specs:
High-Time Resolution
High-Spectral Resolution

Simulations by Demet Kirmizibayrak, PhD Student at UBC

http://www.colibri-telescope.ca
Colibrì: Training and Retention

❖ HQP Training:
  ❖ Student involvement has already been instrumental for the progress of the study
  ❖ Preparation of the next generation of leaders

❖ HQP Retention:
  ❖ Science office staff positions (R6 of WP: 64)
  ❖ Continued mission development also supports the Space Sector
Colibrì and the Canadian Landscape

- BRITE
- NEOSSat
- JWST
- XRISM
- Euclid
- POEP
- LiteBIRD
- CASTOR
- ÉPPÉ
- Colibrì
- SPICA

Main Mission

Extended Mission

2020  2025  2030  2035
Colibrì: Next Steps

- FAST — Recently submitted, will increase SRL
- SMS — Validate Science requirements, increase SRL
- Develop secondary science goals
- STDP — Increase TRL of Canadian made TES detectors
The Colibrì Mission

- Canada’s First Flagship X-ray telescope
- Builds on CSA’s investment in Hitomi and XRISM
- Study the laws of the Physics of the Extreme
- Combination of high-time resolution, high-spectral resolution and high throughput
- Development of TES detectors in Canada
- Opportunities for HQP training throughout development and mission operations
- Job Creation: Through HQP retention via science office, grow the detector industry in Canada, support Canadian space sector — Build a robust and experienced workforce in the Space Sciences
- In order to continue the development through 2020-2030, build capacity through a space program and support in the LRP report is required

http://www.colibri-telescope.ca
Back up slides
Colibrì Effective Collecting Area

Baseline Mission
Comparison to other X-ray Missions

- **Effective Area [m²]**
  - RXTE
  - NICER
  - XMM RGS
  - Chandra Gratings
  - Colibri
  - ATHENA
  - Hitomi SXS

- **Maximum Count Rate [Hz]**
  - RXTE
  - XMM EPIC pn Burst
  - Chandra HRC
  - Chandra ACIS
  - ATHENA Blur

- **Spectral Resolution [E/ΔE]**
- **Time Resolution [ns]**

http://www.colibri-telescope.ca
Spectral Features: PSR J1833-1034

Blue line: Hitomi detection of line at 4.2345keV of PSR J1833-1034

Colibrì Single f/10
Colibrì Double f/10

Calculations by Benson Guest, Phd Student at U Manitoba