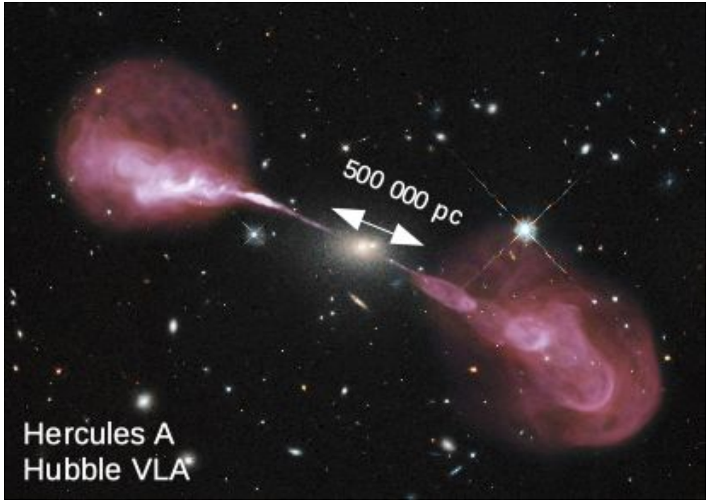
Imaging of XRB disks and outflows

Cosmic Explosion 2019

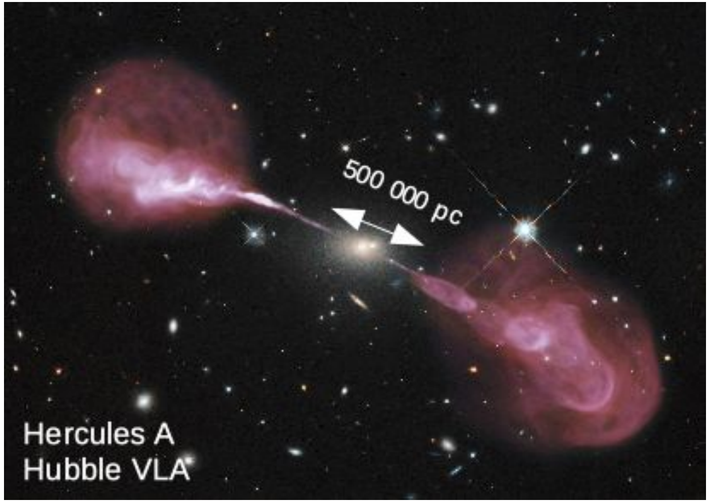
J.-G. Ducoin, S. Lescaudron, N. Dagoneau,
J. Jacquemin, A. Siciak

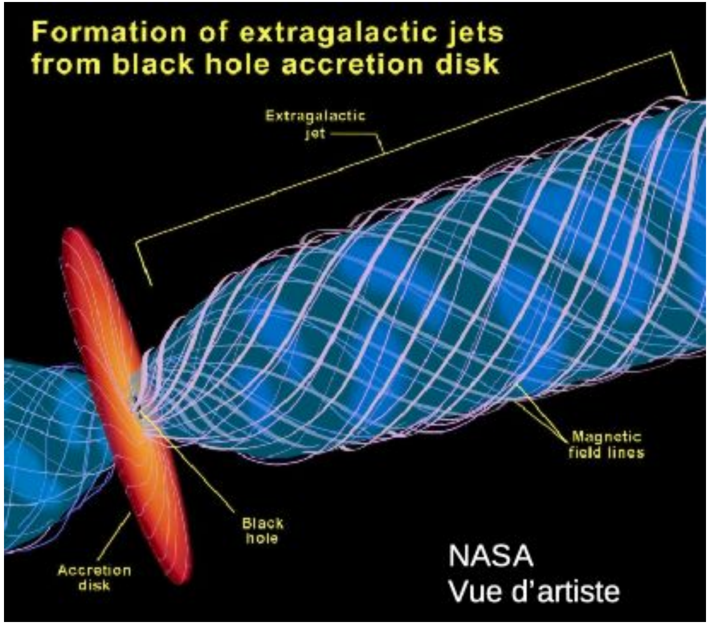
Science Case



Science Case

Relativistic Jets need **magnetic field** to explain their **acceleration**

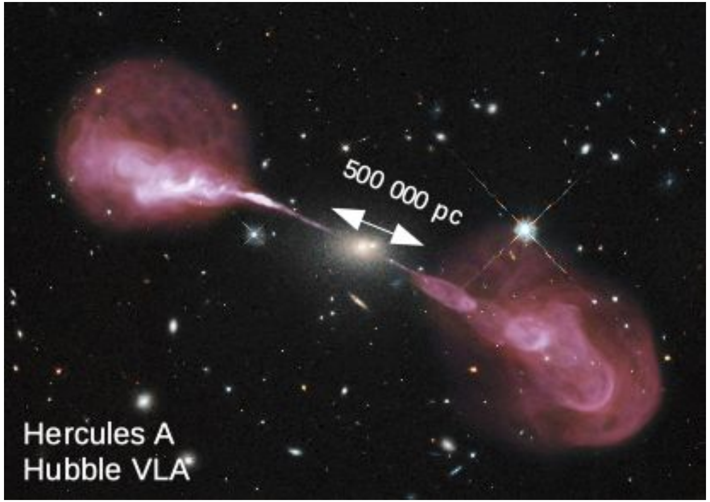


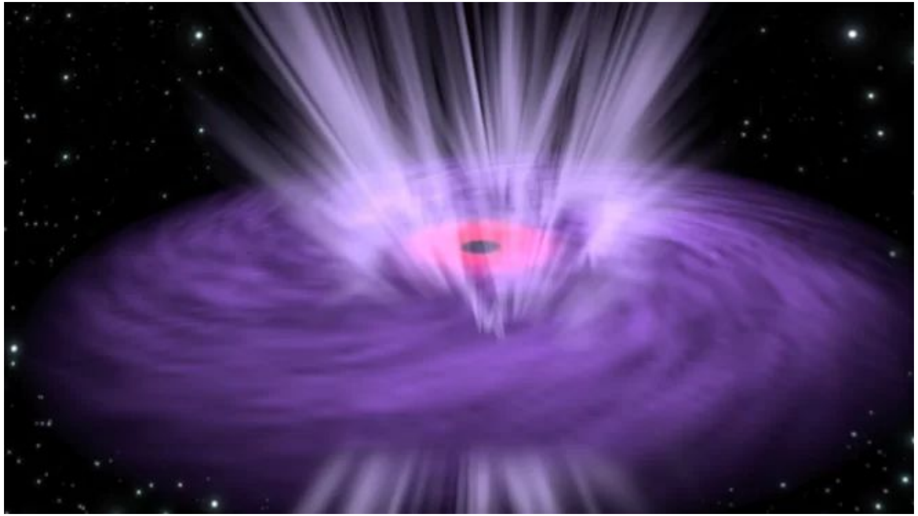


The details are **not understood**

Science Case

But what about the **winds** ?





Winds are even Harder **two** different explanations for the **acceleration**

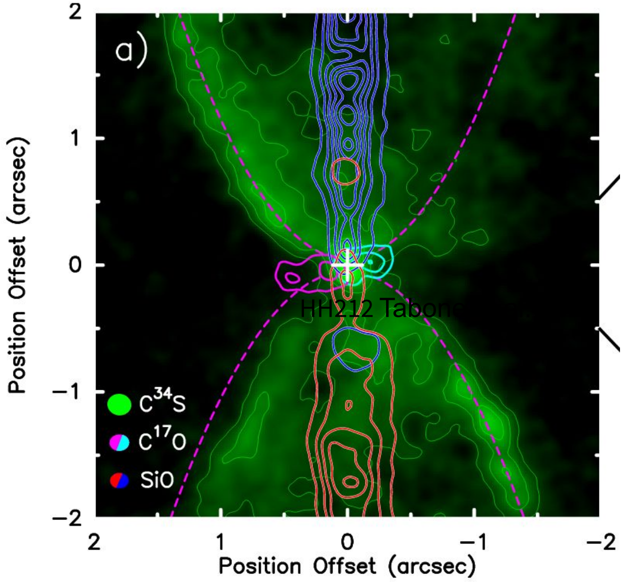
Science Case

The dynamics accretion disk are determined by
angular momentum transport

$$L = \Omega r^2 + F(r, z) \qquad (1)$$

specific angular momentum

Acceleration process



HH212 Tabone et al. 2017

if we calculate Ω we can determine the acceleration process

SEXI

Space **E**uropean **X**-ray **I**nterferometer

The Team

Instrument scientist

N. Dagoneau

Mission scientist

J. Jacquemin

PI

S. Lescaudron

System lead

A. Siciak

Project manager

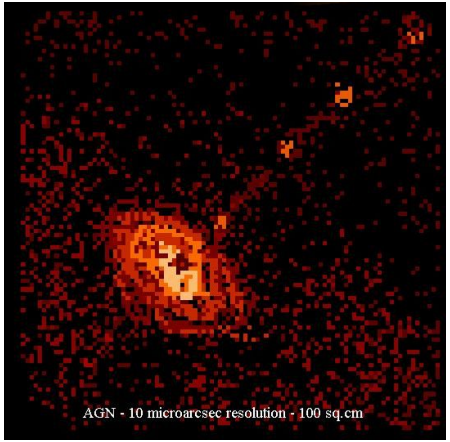
J.-G. Ducoin

Targets

★ Accretion disks, outflows, winds around X-ray binaries (Core program)
  - Crab nebula will be used as a calibration source
  - Cyg X-1 as the first target

★ Stellar surfaces (General program)

★ Each kind of small structures emitting in X-rays



Webster Cash, University of Colorado

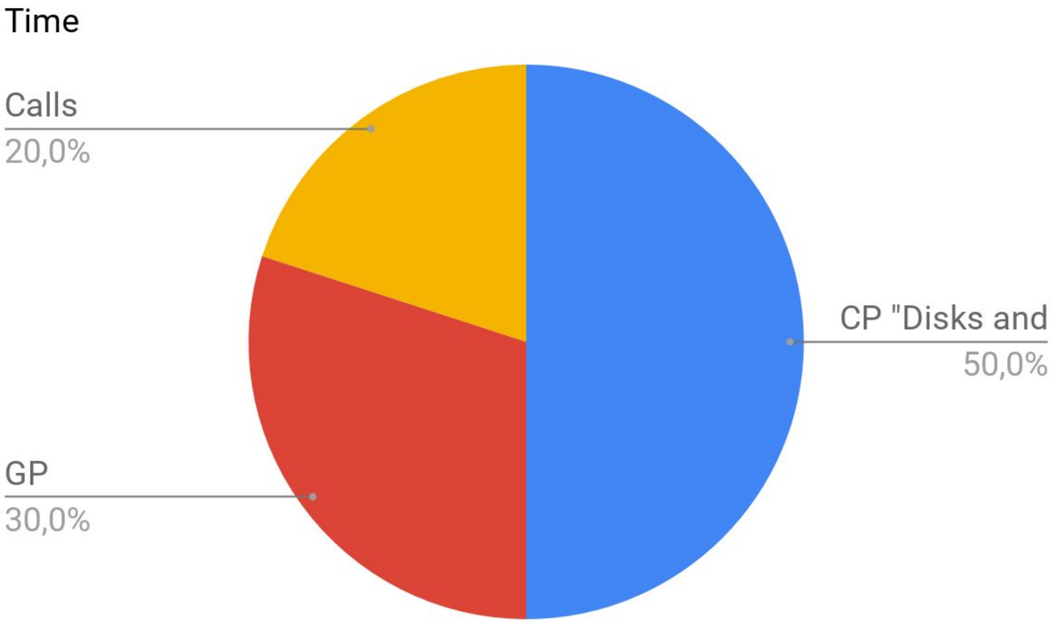
Requirements

Chandra resolution: 0.5 arcsec

Angular resolution	< 10^{-5} as
Field of view	few mas
Energy range	3 - 20 keV
Collecting area	> 300 cm^2
Orbit	Heliocentric (1 AU), sun avoidance
Incident angle	~ 89°
Sensitivity	1 Crab in 1 s

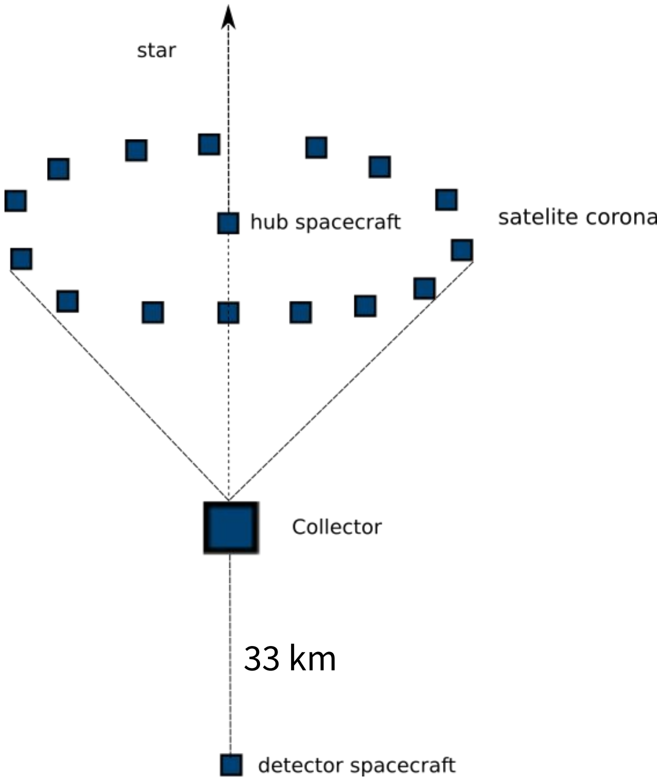
Mission profile

First 5 years



Technical Challenges

- ➔ Reach a good angular resolution → X-ray interferometry
- ➔ Formation flying (will be addressed by LISA)
- ➔ Miniaturization of the positioning system onboard the microsats
- ➔ Pointing accuracy



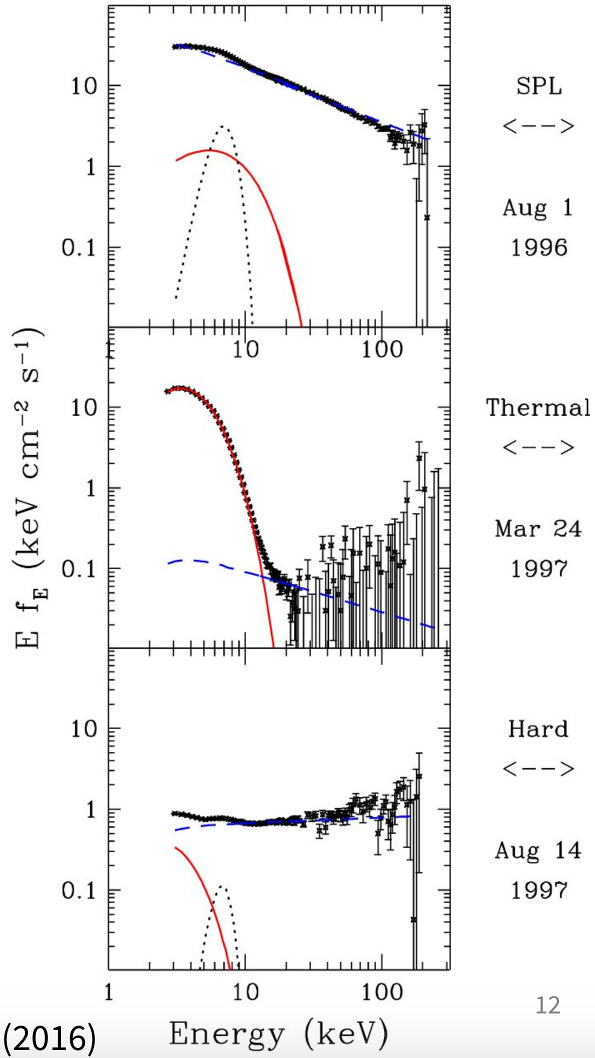
Signal reception

Total effective surface = 300 cm² (3m large mirror)

$$\Rightarrow E_{tot} = 300\ keV\, s^{-1}$$

$$\Rightarrow \frac{\#X}{s} = 30$$

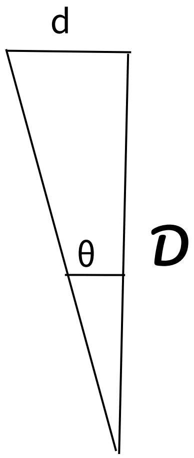
Sensible to variations slower than ~ 10 s



Remillard et al (2016)

Angular resolution

What is needed?



$\theta \sim d/\mathcal{D}$

$\theta \sim$ 0,01 AU / 2000 pc

$\theta \sim 3 \times 10^{-6}$ arcsec

d size of the disk
$\mathcal{D}$ distance to Cygnus X-1

What we will have?

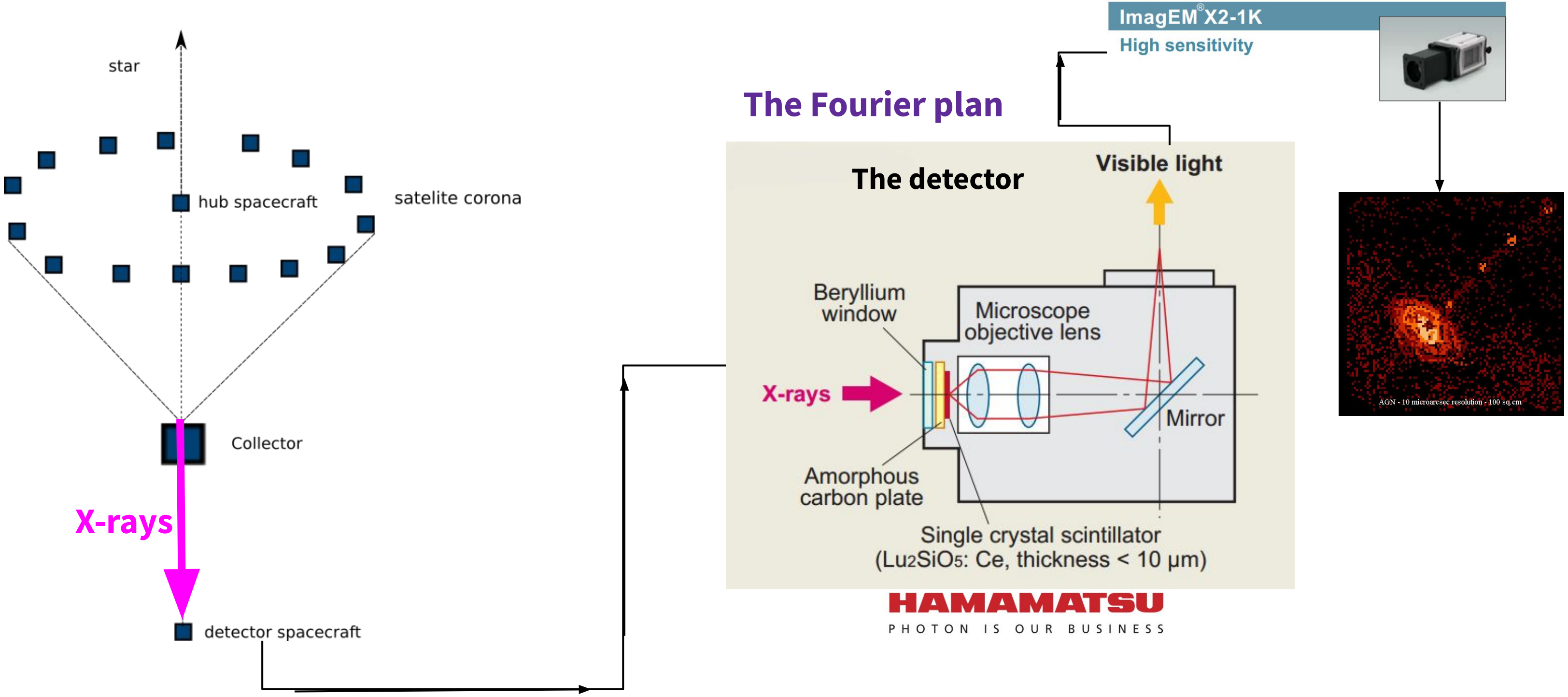
Interferometer angular resolution :

$\theta \sim \boldsymbol{\lambda / D}$

$\theta \sim 10^{-10}$ **/ 1000**

$\theta \sim 10^{-13}$ rad $\sim 2 \times 10^{-8}$ arcsec

X-rays interferometry for imaging



Spectroscopy by intensity correlation

In each pixel Intensity, I(t), is recorded.

We record its time-fluctuations (res. of 40ns).

We use Siegert relation to recover the spectrum of the field V(t):

$$\frac{\langle I(t)I(t+\tau)\rangle}{\langle I(t)\rangle^2} = 1 + \beta \left| \frac{\langle V(t)V(t+\tau)\rangle}{\langle V(t)\rangle^2} \right|^2 \quad (2)$$

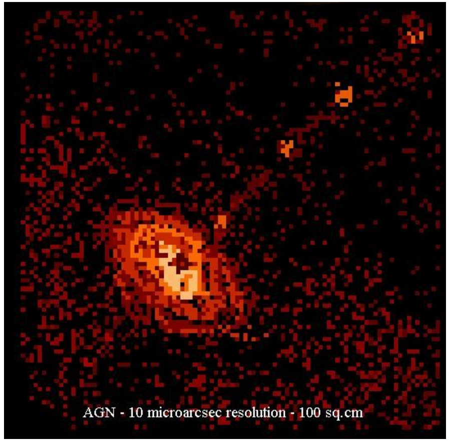


Image after Fourier inversion

Founding

Device:

30 micro-satellites ⇒ 30 x 200 000€ ⇒ 5 000 000€

Hub craft ⇒ 1 000 000€

Collector + detector ⇒ 10 000 000€

Launch:

~10 000€/kg

30 micro-satellites ⇒ 30 x 10kg ⇒ 3 000 000€

Hub craft ⇒ 20kg ⇒ 200 000€

Collector + detector ⇒ 1050kg ⇒ 10 500 000€

TOTAL:

29 700 000€

+ research budget

~ 500 000 000.60€

Thank you!

Detailed informations at contact@sexi.eu