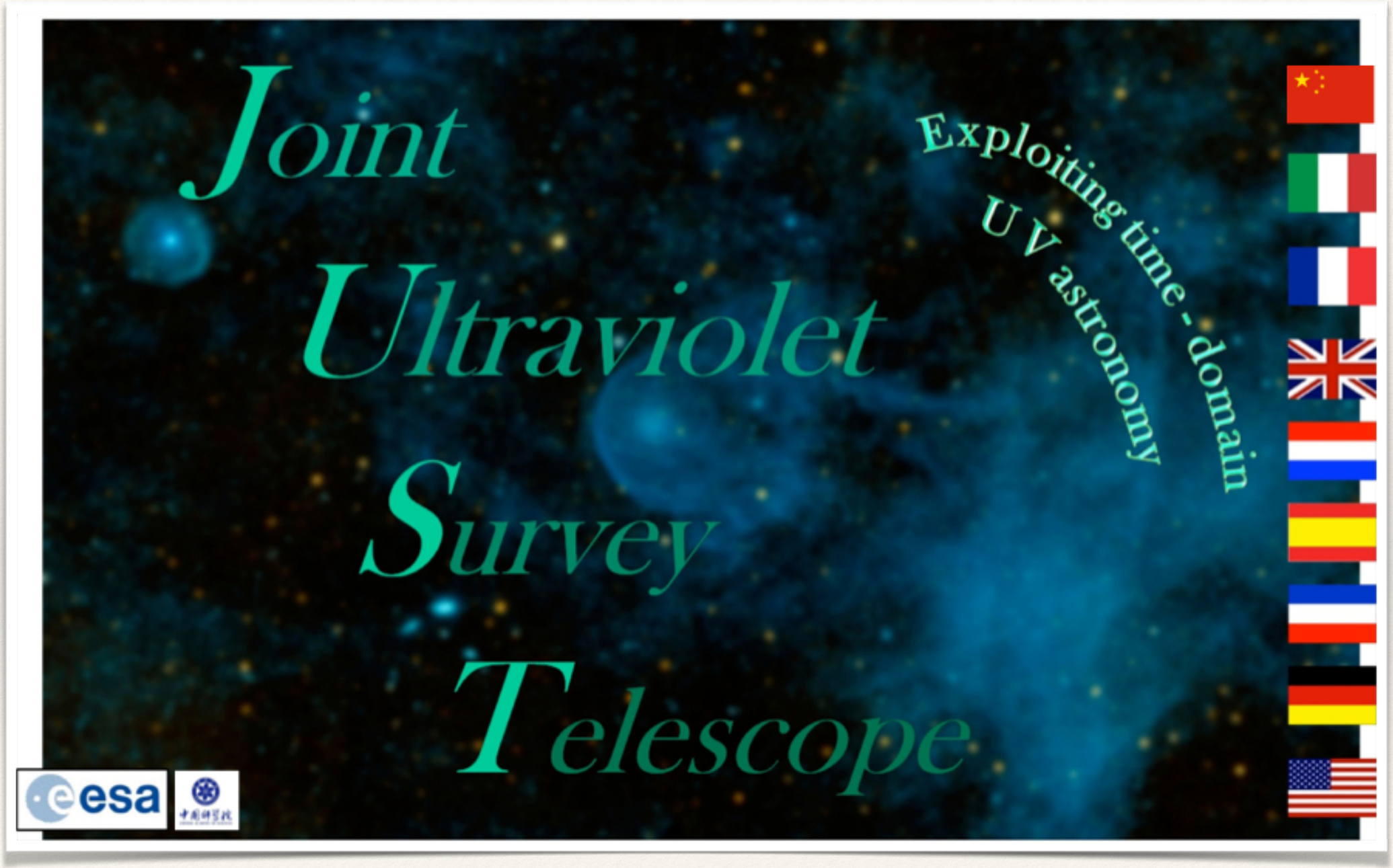


S. Basa, Laboratoire d'Astrophysique de Marseille, France

The transient sky

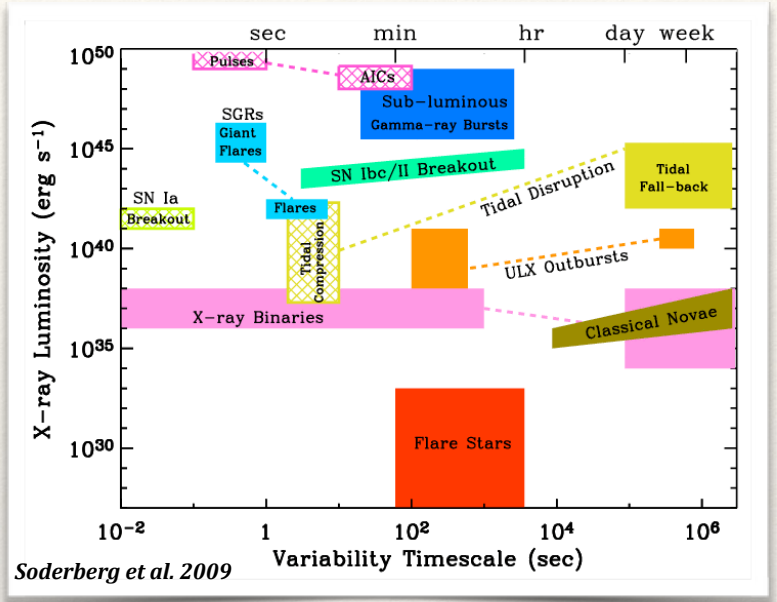
Sky is intrinsically variable!

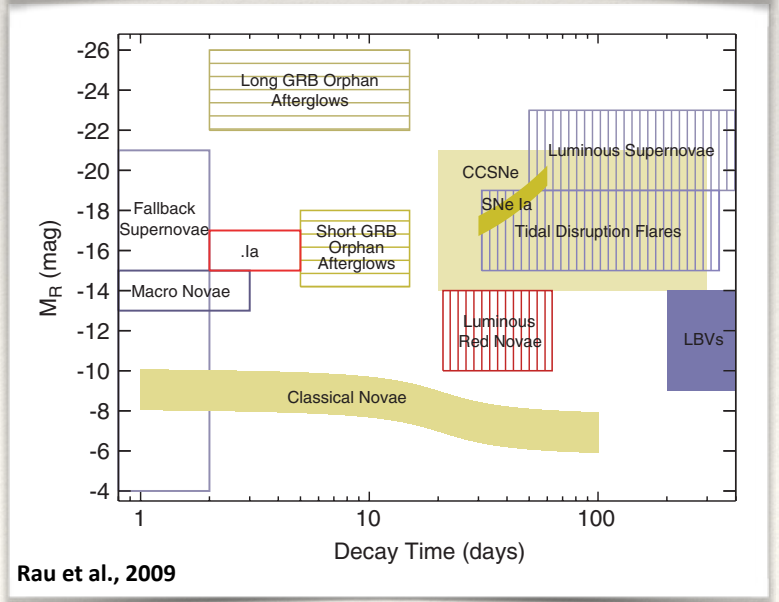
- Hard X-ray monitoring instruments show a restless X-ray sky (Swift-BAT, INTEGRAL, MAXI).

Time domain astronomy still in its infancy, but should quickly evolve especially at optical (PTF, PanStarr, SkyMapper, LSST) and radio (LOFAR, SKA) wavelengths.

However:

- **Short time still to be explored.**
- **UV domain very favorable!**



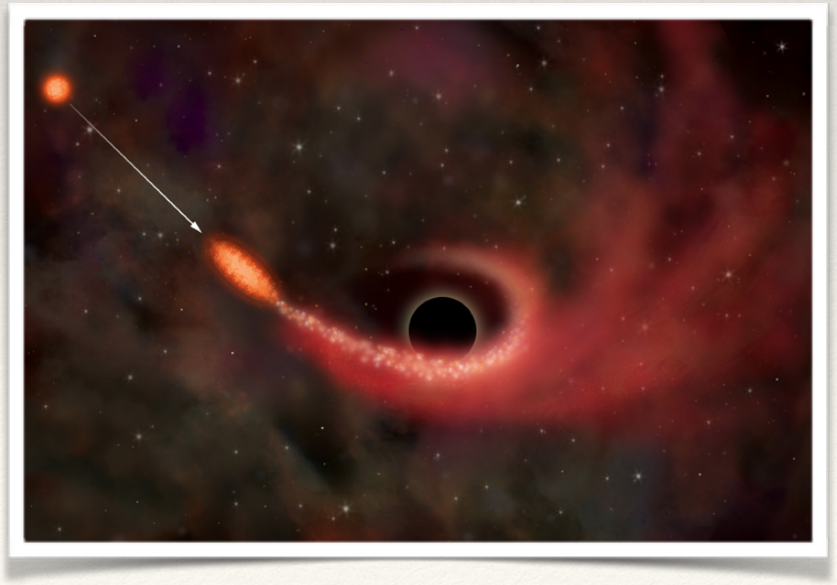


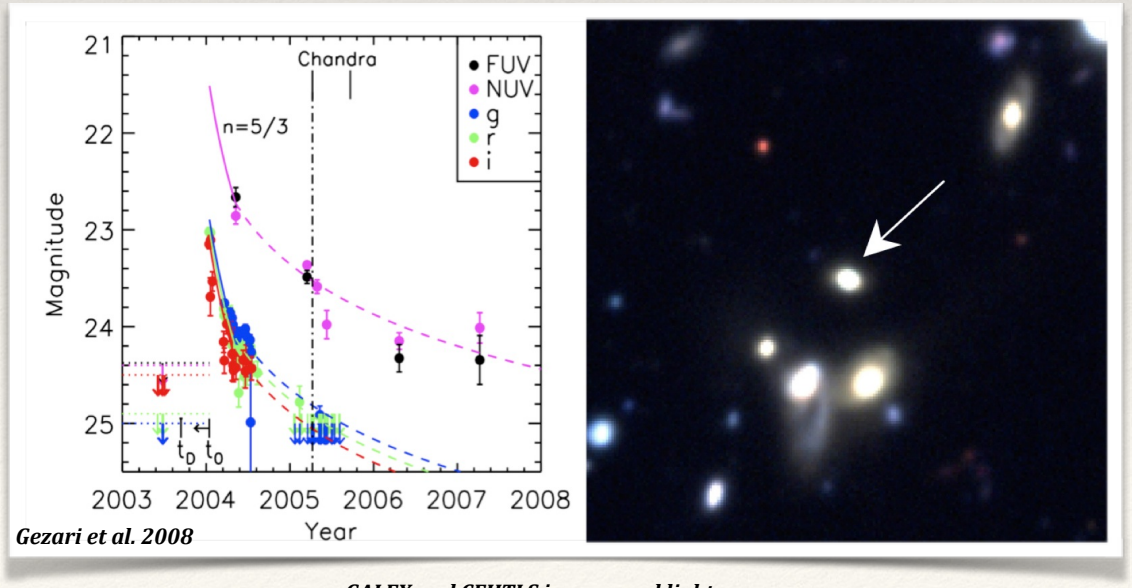
Tidal Disruption Events

Signature of a catastrophic event: a star on the orbit around a massive black hole makes a close approach and is pulled apart by black hole's tidal forces.

TDE provide an independent and unique means of measuring the masses and spins of dormant BHs in distant galaxies:

- Understand the population of BHs in galactic centres as a function of cosmic time is crucial for understanding the growth of structure in the Universe.





Gezari et al. 2008

GALEX and CFHTLS images and light curves.

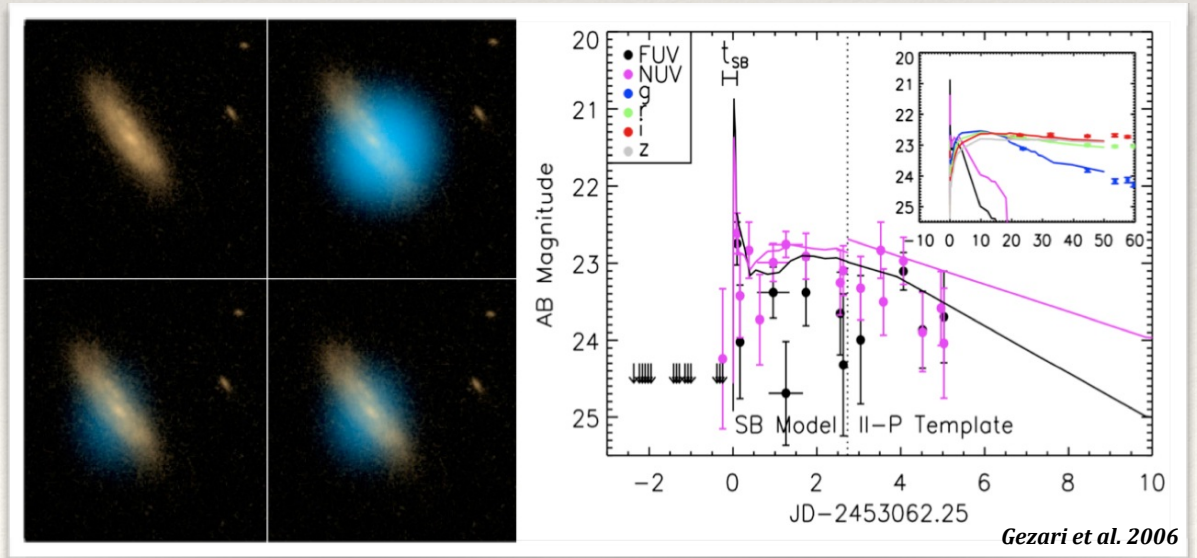
Supernova Shock Break Out

Mark the first escape of radiation from the blast wave that breaks through the surface of the star:

- Signal should accompany every core-collapse SN and provide unique information on the progenitor

SN breakout provide a precise and unique time-stamp for the gravitational collapse of the star:

- Searches for coincident gravitational waves and neutrinos that encode the explosion physics.



GALEX and CFHTLS images and light curves of SNLS-04D2dc

JUST, basic idea

Explore the transient sky and the deep universe.

- An original idea proposed by Sergio Campana (INAF, Brera).

Main scientific constrains:

- Explore the UV domain.
- Sensitive to short time phenomena (>1 min).
- Be in time with the current or forthcoming facilities: LSST (visible), Euclid (visible and IR), LOFAR (radio), SKA (radio), IceCube (neutrinos), etc.

A simple technical concept:

- Based on the successful NASA SMEX mission GALEX concept (280 kg).

Mission Concept

Concept:

- Scan large regions of the sky in the UV domain with a 60-70 cm telescope.

Observing mode:

- Drift mode: à la GAIA.
- *Discovery with a high-cadence mode:*
  - Scan at a rate of ~1° min^{-1}, providing three 30 s images twice per day over an area of ~400 deg^2.
  - About 50% of the observing time.
- *Follow-up with a medium-cadence mode:*
  - The same field followed for the next 5 months with a time step increasing in a logarithmic fashion.

- Total area after three years: ~14,000 deg^2 to 26.3 magnitude (AB, S/N=5).

Expected event rates

Transient events	*Rate*
SN Shock Breakouts	>3-10
Tidal Disruption Events	~500
Asteroids & NEOs	~1,000
Stellar superflares	~40
Microlensing events	~200-300
Cataclysmic Variables	~200
Type Ia Supernovae	~300
Core-collapse Supernovae	~300
GRBs and orphans GRBs	>10
Neutrino sources	?
Gravitation wave sources	?

In each case, conservative predictions used .

A simple Factor of Merit

Factor of Merit for a Discovery Rate of transient Events (*DRE*): $C \times D = DRE$

with

- $C = R \times N_p \times f_{eff}$ (characterize the Survey Coverage)
- $D = [A \times t_{exp} \times \varepsilon]^{1/2} / FWHM$ (~S/N) (characterize the Survey Depth)

Survey	*R (deg*	*N*	*f*	*Area (m*	*t (s)*	*ε*	*FWHM (arcsec)*	*C*	*D*	*DRE*
CRST	2200	4	0.70	2.33	30	0.7	3.0	6160	0.89	5470
PTF	1000	2	0.70	1.31	60	0.7	2.0	1400	3.45	4820
Skymapper	800	2	0.70	0.79	60	0.8	2.0	1120	3.07	3440
PanSTARR	1000	4	0.70	2.54	30	0.8	1.0	2800	7.81	21860
LSST	5000	2	0.75	34.9	15	0.8	0.8	7500	25.6	192000
JUST	768	6	1.80	1.54	180	0.8	0.8	8295	18.6	154400

The Deep Universe

An absolutely unique UV legacy survey (at least) a factor of ~100 deeper than the large scale GALEX survey and at a better angular resolution:

- **Total area after three years: ~14,000 deg^2 to 26.3 magnitude (AB, S/N=5).**

Possible science themes (besides transient sky):

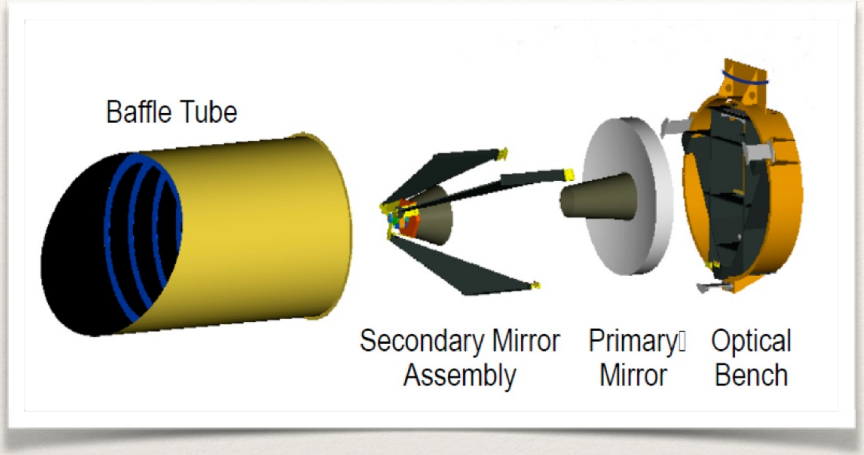
- **Provide valuable information on low redshift Universe**: galaxy luminosity function UV, Star Formation Rate (SFR), Specific Star Formation Rate (SSFR).
- **Combining Euclid and JUST will improve very significantly Euclid photometric redshifts:**
  - Photometric redshifts suffer from a fundamental degeneracy between low- and high-redshift galaxies.
  - Well-known Euclid problem.

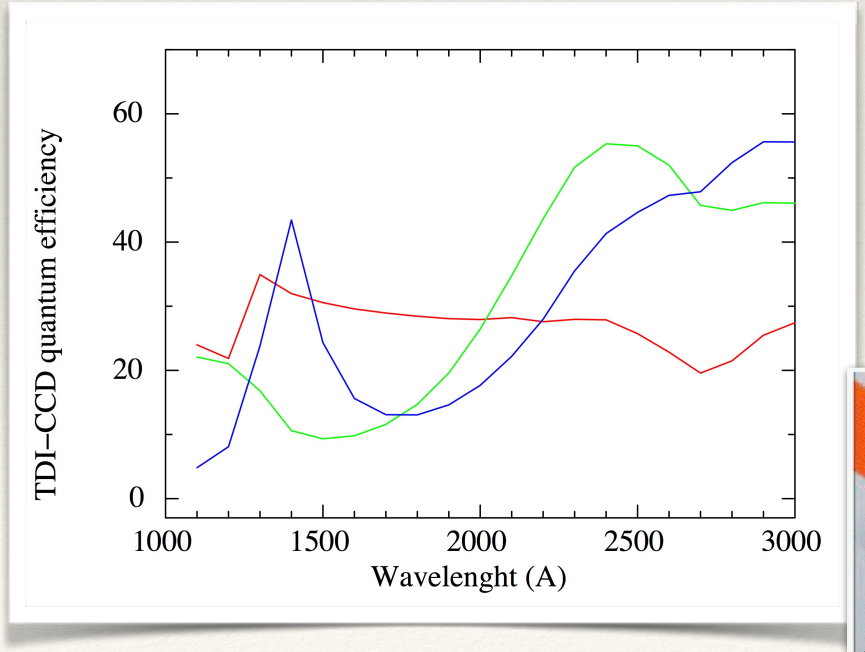
Possible payload

- Platform: small platform with 3-axis stabilized.
- Orbit: no particular requirements identified (low Earth orbit slightly preferred).
- Pseudo real-time capability (but with no strong requirement: within a day).

Parameter	Value
Orbit	LEO, ~600 km
Pointing strategy	Scanning
Pointing stability	<30 arcsec (3 σ)
UV telescope	60-70 cm diameter primary mirror
Field of view	2° perpendicular to the scanning direction and 2° parallel (thanks to scanning)
Energy range	FUV: 1350 – 1750 Å
Angular resolution	0.8 arcsec
Degree	1,500
Single pass sensitivity	~20.2 (AB, S/N=5) in 180 s
Survey sensitivity	~26.3 (AB, S/N=5)

Possible technical solutions





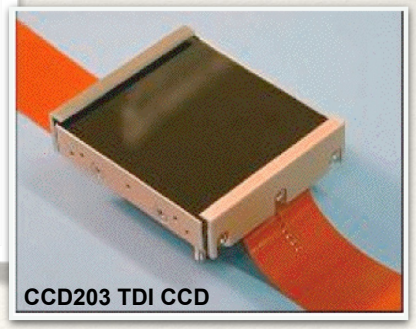
Telescope:

- A modified Ritchey-Chrétien
- 60-70 cm diameter with a 2° FoV

Focal plan:

- CCD: E2v CCD203
- An array of 3 rows of 4 CCDs each.

No ITAR components identified.



Heritage from previous missions

Payload based on existing and well-studied technology:

- Lightweight optical telescopes built in increasing number: GALEX (50 cm), COROT (35 cm), WISE (40 cm), Euclid (120 cm).
- TDI-CCDs on the market since many years: our baseline is a Gaia-like TDI mode.
- TDI-CCDs data commonly processed and download of the produced data rate accomplished with more than a factor of two margins.

No special development required: Technology Readiness Level (TRL) high.

Technology Readiness	Level
Telescope	≥6
Focal plane TDI	≥8
Thermal control	5
Electronics	5

Collaboration Europe/China

Scientific questions addressed by JUST endorsed by several communities:

- **Cosmology.**
- **Stellar physics.**
- **Compact objects physics.**
- **Astro-particle** (unique mission capable of providing independent and accurate triggers!).

➡ **All these communities are widely represented in China and in Europe.**

Already supported by scientists (reduced list):

- **Europe** (France, Germany, Italy, UK, etc.): S. Campana, S. Basa, S. Gezari, A. Holland, S. Savaglio, etc.
- **China** (NAOC Beijing): X. Zhou, T. Zhang, J. Wei, Y. Qui, J. Deng, etc.

➡ **Of course, list to be extended.**

Summary

JUST addresses questions highlighted by the international scientific community:

- **ESA's Cosmic Vision Themes:** "What are the fundamental physical laws of the Universe?" (Theme 3) and "How did the Universe originate and what is it made of?" (Theme 4).
- **US Decadal Survey:** "How do matter, energy, space, and time behave under the extraordinarily diverse conditions of the cosmos?" and "How did the Universe originate and evolve to produce the galaxies, stars, and planets we see today".

JUST is (and must stay) a simple mission to explore the transient sky and the deep Universe!