Multi-wavelength and multi-disciplinary approach to the study of the emission from accretion/ejection processes in young stars with disks: combining observations, numerical models, and laboratory experiments

Rosaria (Sara) Bonito

INAF – Osservatorio Astronomico di Palermo (Italy)

Rosaria (Sara) Bonito

INAF – Osservatorio Astronomico di Palermo (Italy)

Costanza Argiroffi[2,1], Salvatore Orlando[1],
Marco Miceli[2,1],
Loredana Prisinzano[1], Francesco Damiani[1],
Teresa Giannini[3], Simone Antoniucci[3]
GES collaboration

[1]INAF – Osservatorio Astronomico di Palermo
[2]Universita' degli Studi di Palermo
[3]INAF – Osservatorio Astronomico di Roma

Young star+disk+accretion+ejection

https://www.facebook.com/boknito/

Very complex systems:

- multi-band (optical, UV, X-rays)
- multi-disciplinary (observations, models, laboratory experiments)
- multi-technique (statistical samples, single object)

Large Synoptic Survey Telescope

- Expecting 10 million alerts, 15-30 Terabytes of data every night

- 10 year survey of the sky (37 billion objects)
- FoV: 9.6 deg^2
- 6 filters (ugrizy; r = 27.5)
- 8.4-m mirror

WIDE:

- Widest Digital Camera

FAST:

- Rapidly scan the sky

DEEP:

- To faint magnitudes

- Transients and Variable Stars Science Collaboration:
- ✓ Primary contact of the Non-degenerate Eruptive Variables subgroup (FUor/EXor)
- ✓ Spokesperson of the Deep Drilling Fields and mini-surveys proposals planning Task Force
- Stars, Milky Way & Local Volume Science Collaboration

LSST Team: Francesco Damiani (OAPa, PI 2018), Teresa Giannini (co-PI), Rosaria Bonito (OAPa), Simone Antoniucci (OAR), Loredana Prisinzano (OAPa)
External collaborators: Dario Lorenzetti (OAR), Katia Biazzo (OACt), Laura Venuti (OAPa), BUT: Alerts (brokers) public, possible spectroscopic follow-up

LSST
Main Survey/Special programs

- Impressive new instrument (Wide Fast Deep main survey)
- Some transients and variable objects will need different cadence, set of filters, exposure, field (e.g. GP)
- Therefore:

Special programs: MS & DDF (multiple pointings/single pointing)

LSST DDF & MS

(Stelzer, Giannini, Bonito: e-Rosita project on EXors)

- Call on June 30
- Deadline: late November
- "Young stars with variability" (Bonito, Damiani, Prisinzano, Giannini, Sacco, Antoniucci @INAF):

  - Investigate stellar variability of single objects or in statistical samples in stellar clusters
  - Analyze variability due to stellar activity , accretion process, also in eruptive burst (FUors and EXors), etc.
  - Take advantage of data collected in existing surveys and previous programs (Gaia-ESO Survey, Chandra) for a multi-band characterization

Very complex systems:

- multi-band (optical, UV, X-rays)
- multi-disciplinary (observations, models, laboratory experiments)
- multi-technique (statistical samples, single object)

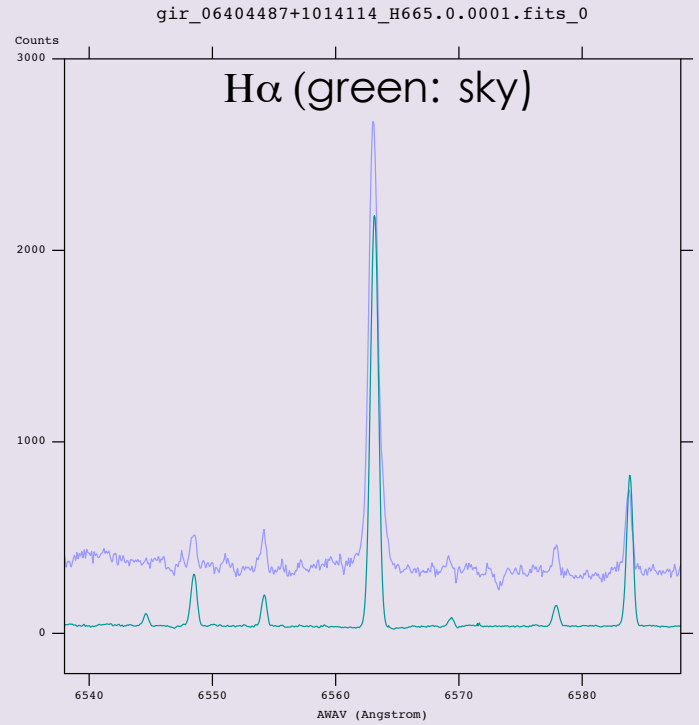
Very complex systems:

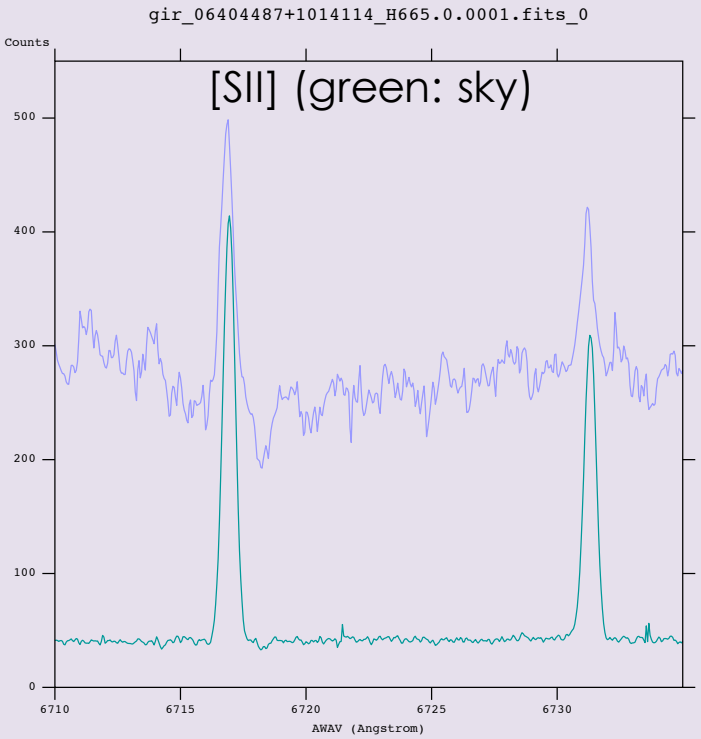
- optical
- observations
- statistical sample

NGC 2264: FLAMES (GES)

ACCRETION/OUTFLOW IN NGC 2264

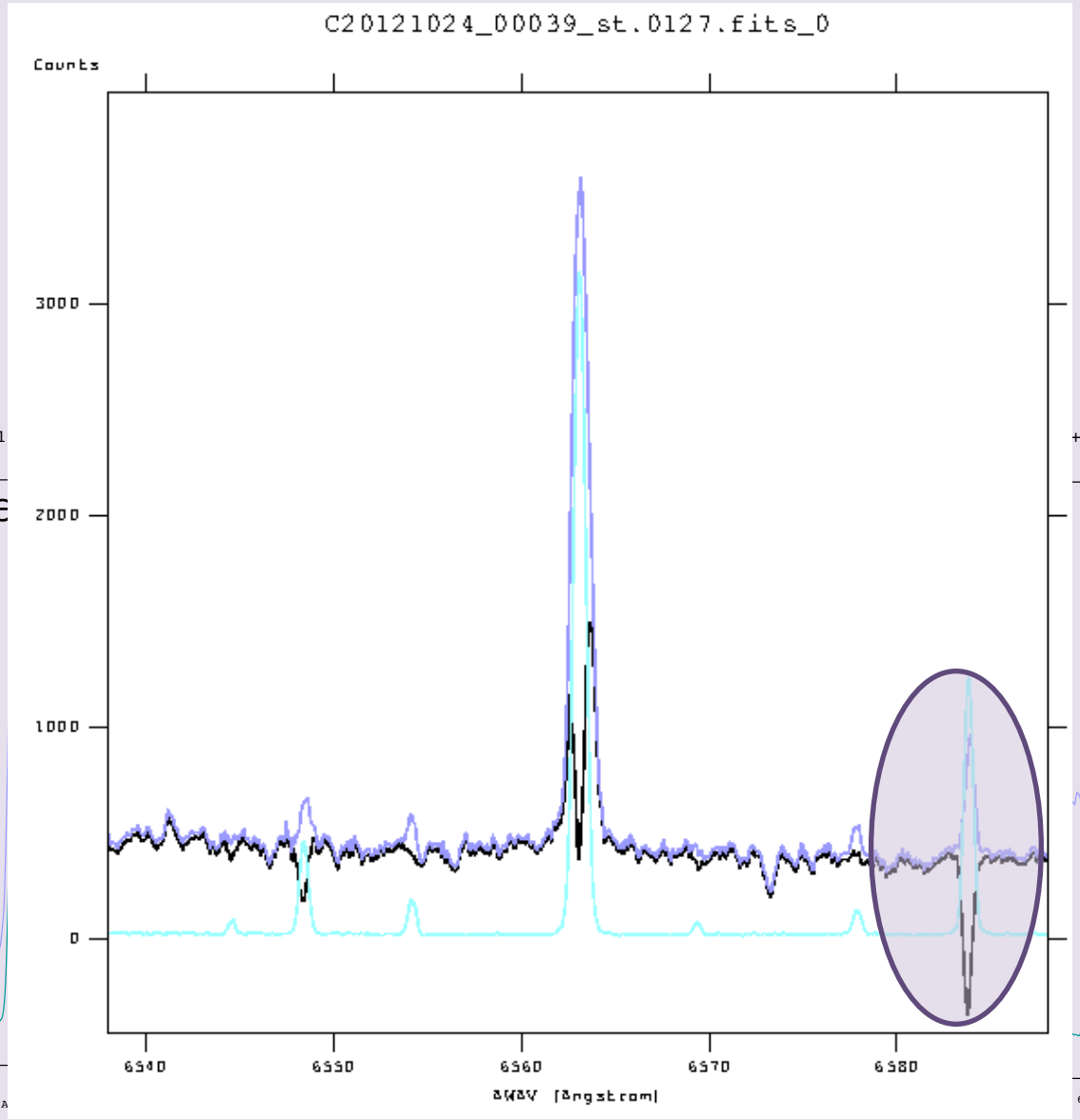
- Nebular contribution to both Hα and FELs
- Narrower than stellar (Hα)

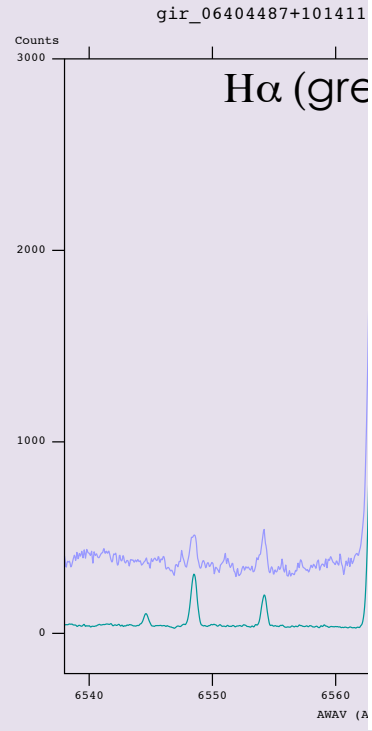




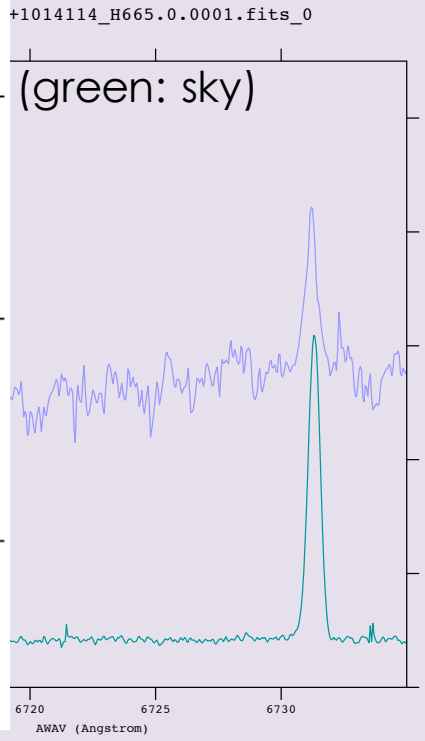
ACCRETION/OUTFLOW IN NGC 2264

FWZI method: EW and H$\alpha_{10\%}$ are not reliable





Hα (gre



(green: sky)

FELs AS A PROXY FOR SKY SUBTRACTION

- Tool to flag spurious absorption FELs
- Warning for a bad sky subtraction
- Use the original spectra
- FWZI measurement is reliable (EW and $H\alpha_{10\%}$ are not)

Flagged spectra:
over-subtracted sky contribution
avoid misinterpretation of the physical properties

- 20% flagged spectra: [SII] doublet in absorption
- 50% [SII] spurious absorption single line

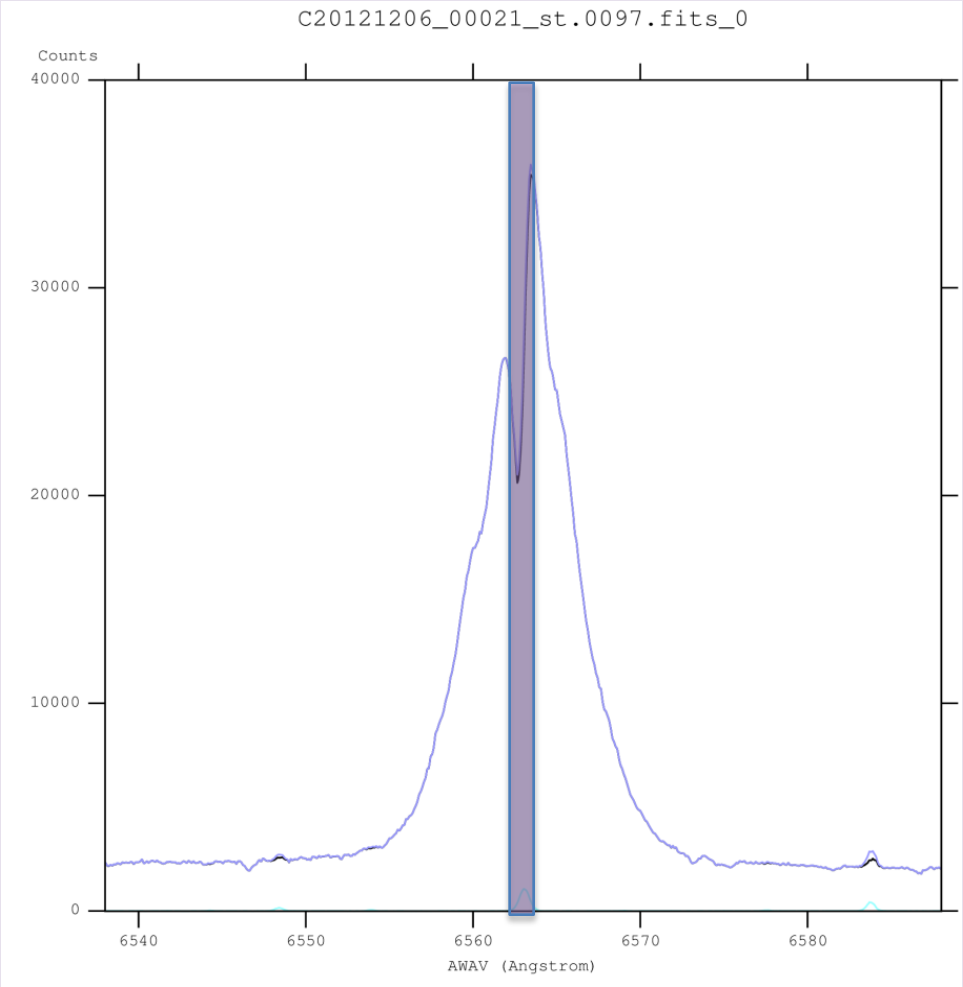
35 accretors (> 22%) in Venuti et al., 2017

Compare original spectra with sky subtracted spectra

NO FLAG + GOOD SPECTRA

- FWZI(Hα) star >> FWZI(Hα) sky
- Parameters released: reliable

(See also the case of NGC 6611, Bonito et al. 2013)

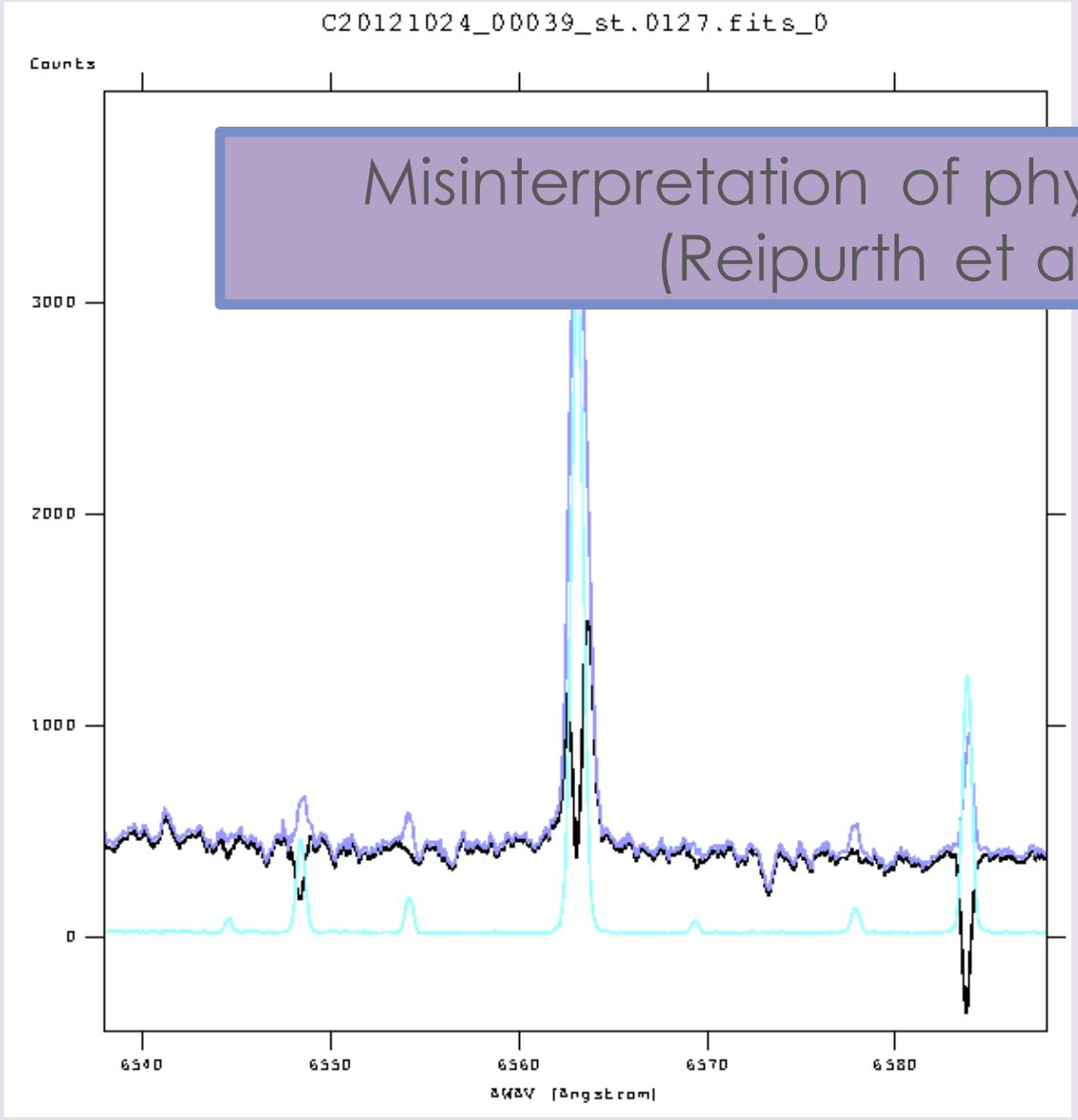


(Bonito et al. in prep.)

NGC 2264: X-ray source

(06411678+0927301: CSI877, class II accreting Venuti et al., 2017)

FLAG: "BAD" SKY SUBTRACTION



Misinterpretation of physical properties (Reipurth et al. 1996)

- GES spectrum
- Original spectrum
- SKY spectrum

Very complex systems:

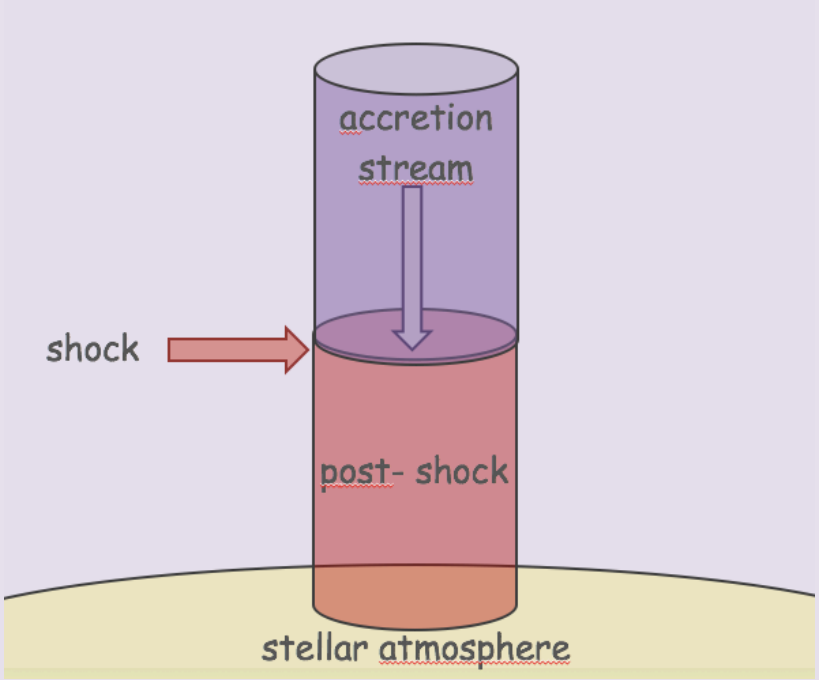
- multi-band (optical, UV, X-rays)
- multi-disciplinary (observations, models, laboratory experiments)
- multi-technique (statistical samples, single object)

Very complex systems:

- UV/X-rays
- observations + model + laboratory experiments
- single object

TW Hya: Chandra

ACCRETION AND X-RAYS



Accretion on classical T Tauri stars generate shocks at the stellar surface:

v_{ff} = 400 km/s

v_{ps} = 100 km/s: T = 1-3 MK

soft X-rays

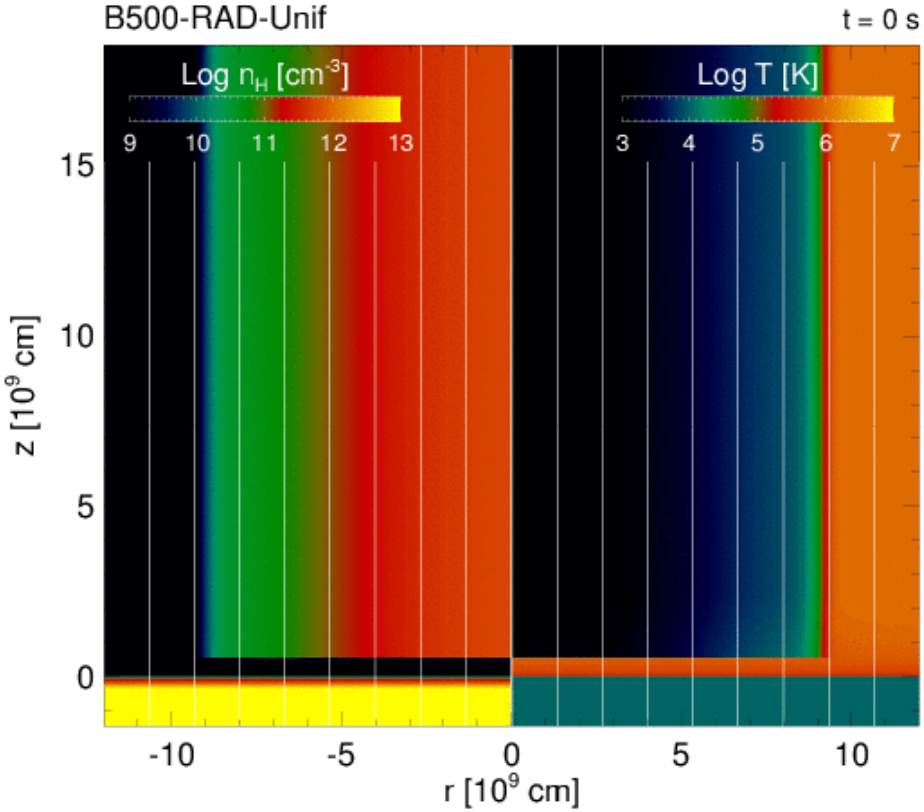
(high resolution spectra of CTTSs with XMM and Chandra)

X-rays from YSOs:

- influence on the physics, chemistry, and lifetime of circumstellar disks (heating, ionization)
- inhibit exo-planets formation
- investigate the properties of the accreting material and of the shock

NUMERICAL SIMULATIONS:

(Orlando et al. 2013;
Bonito et al. 2014)



Radiative losses
Thermal conduction
Gravity
Stellar atmosphere

MHD
(PLUTO code, Mignone et al. 2007)

Radial profile:
$n = 5 \times 10^{10}\ cm^{-3} - 5 \times 10^{11}\ cm^{-3}$
(as suggested by
Romanova et al. 2004)

(Bonito et al. in prep.)
Spectral synthesis of the
UV and X-ray emission

Exploring the effects of:

- local absorption
- geometry
- Doppler shift

ACCRETION SHOCKS: UV/X

Figure 1

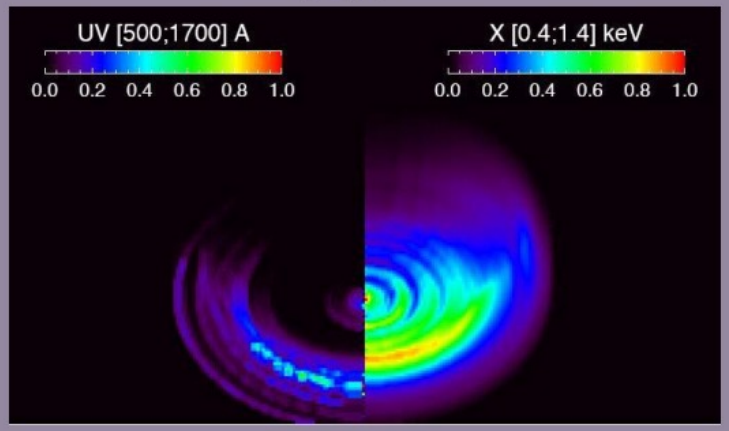


Figure 2

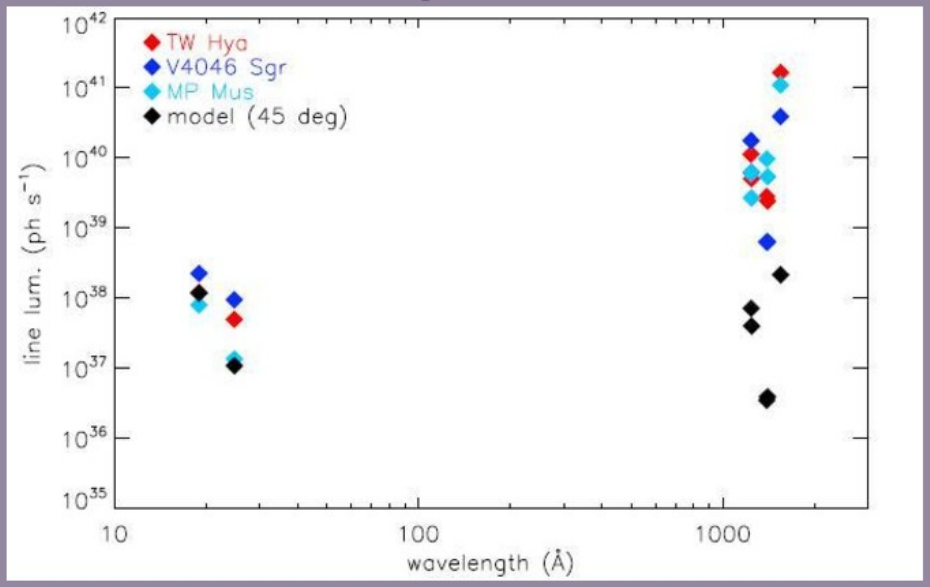
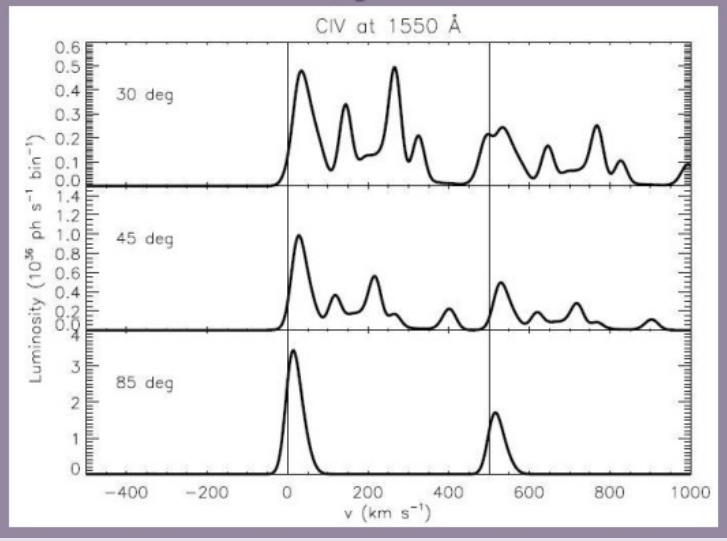
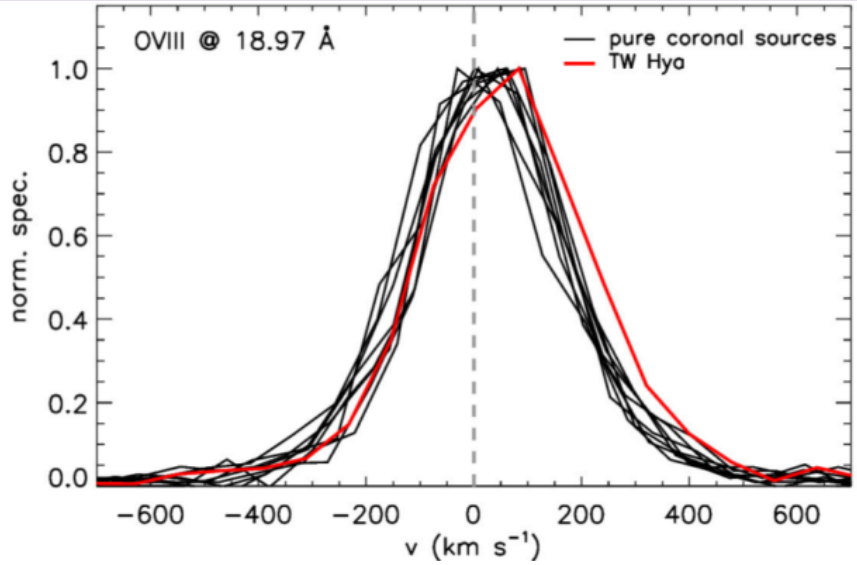


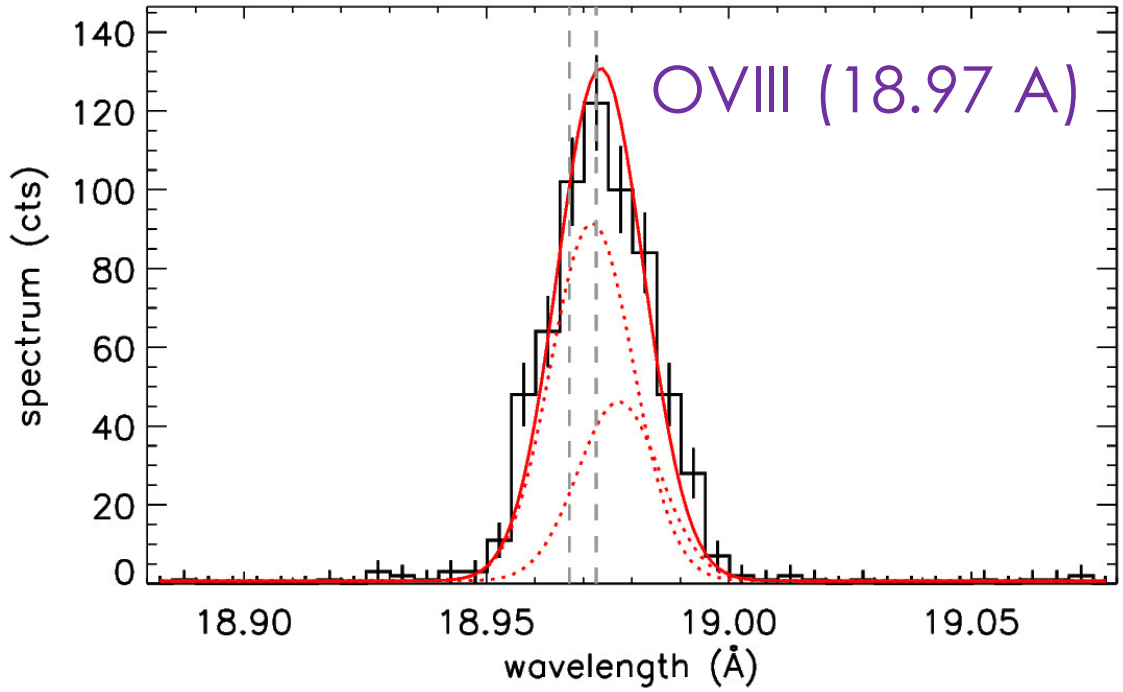
Figure 3



(Bonito et al. in prep.)
(Argiroffi, Drake, Bonito et al. 2017)
(Consistent with Ardila et al. 2013)

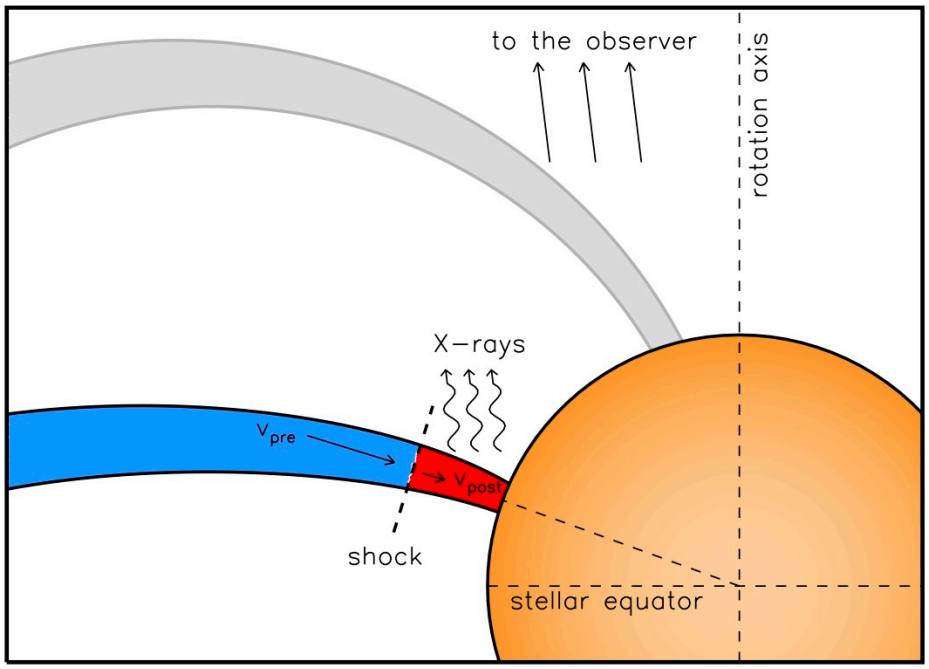
Red-shift



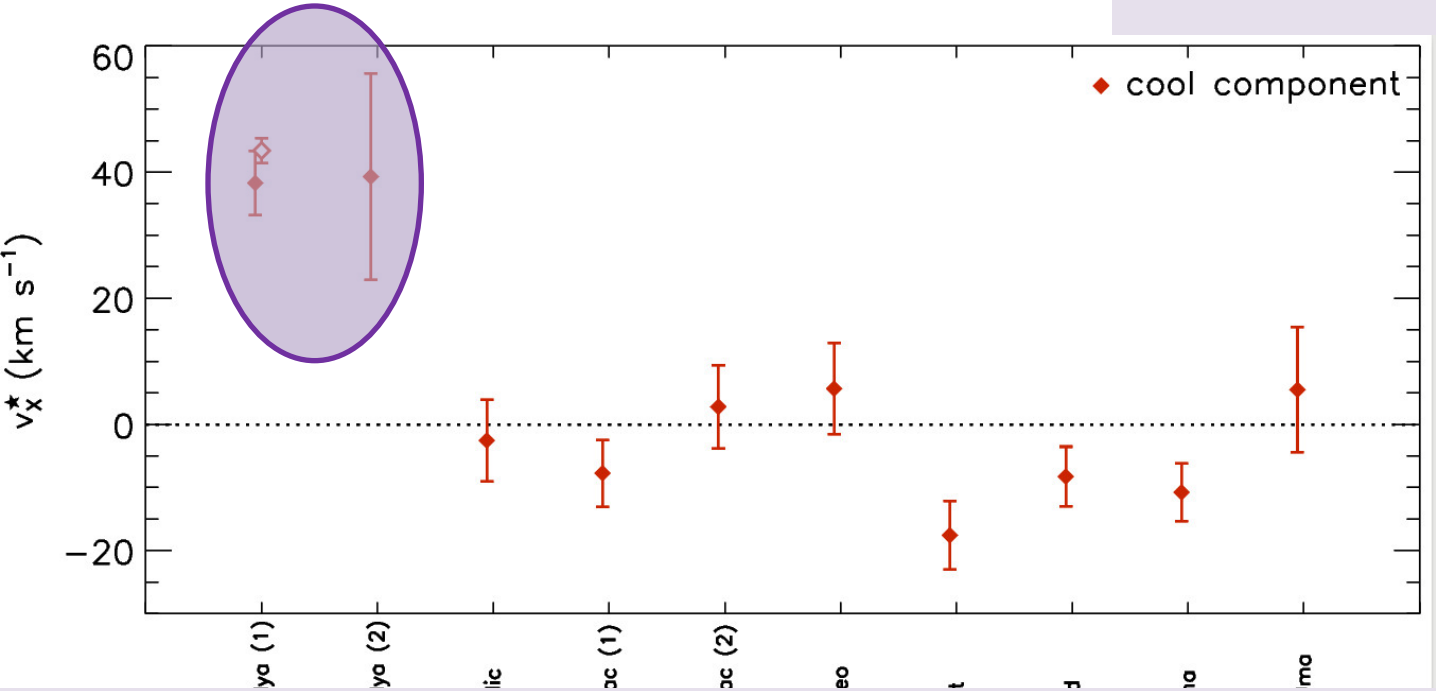


Observations
(Argiroffi, Drake, Bonito et al. 2017)

Model prediction
(Bonito et al. in prep.)

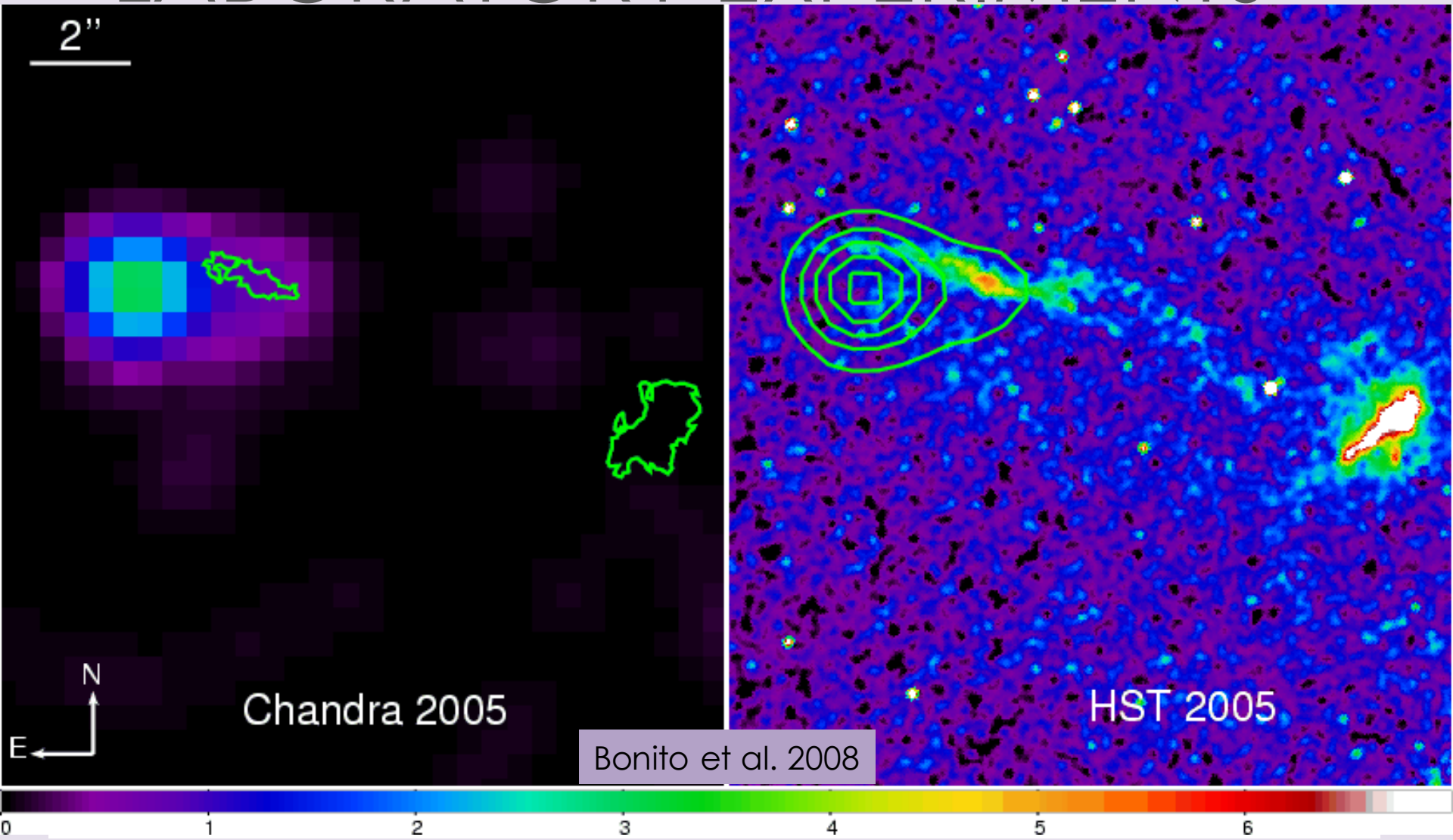


(Argiroffi, Drake, Bonito et al. 2017)



Redshift: 35 km/s
First detection
Infalling material
Geometry

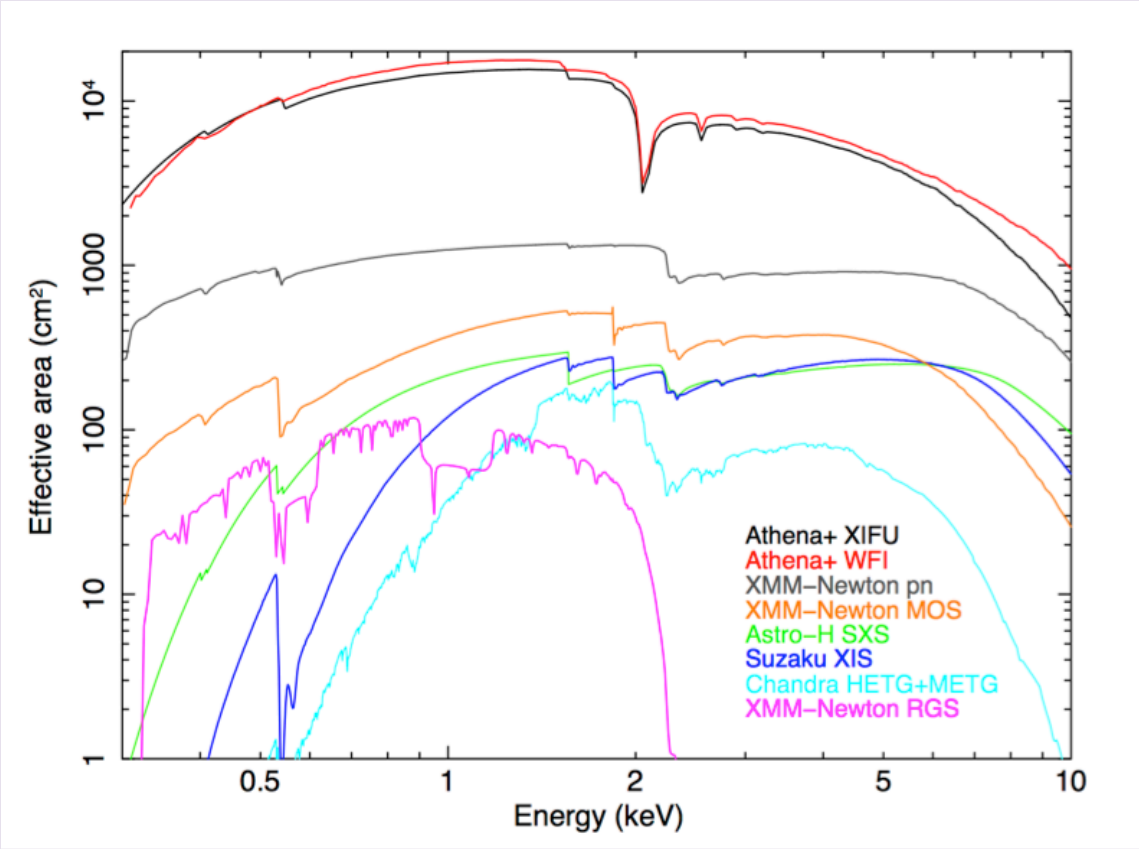
LABORATORY EXPERIMENTS



Revet, Chen, Bonito et al. 2017, Science Advances HH 154 jet

Albertazzi, Ciardi, Nakatsutsumi, Vinci, Beard, Bonito et al. 2014, Science

ATHENA



- Improve the statistics
- Different properties (age, mass, geometry, …)

ATHENA

Exploring the Hot and Energetic Universe:
The second scientific conference dedicated to the Athena X-ray observatory

24-27 September 2018, Palermo, Italy

http://www.astropa.inaf.it/athena18/

LSST

Large Synoptic Survey Telescope (LSST)
Special Programs workshop at INAF

October 8-10 2018, Palermo, Italy

(Contact: sbonito@astropa.unipa.it)