
PROGRESS ON GALACTIC BLACK HOLE
BINARIES OVER THE PAST 7 YEARS:
A SELECTION OF RECENT RESULTS

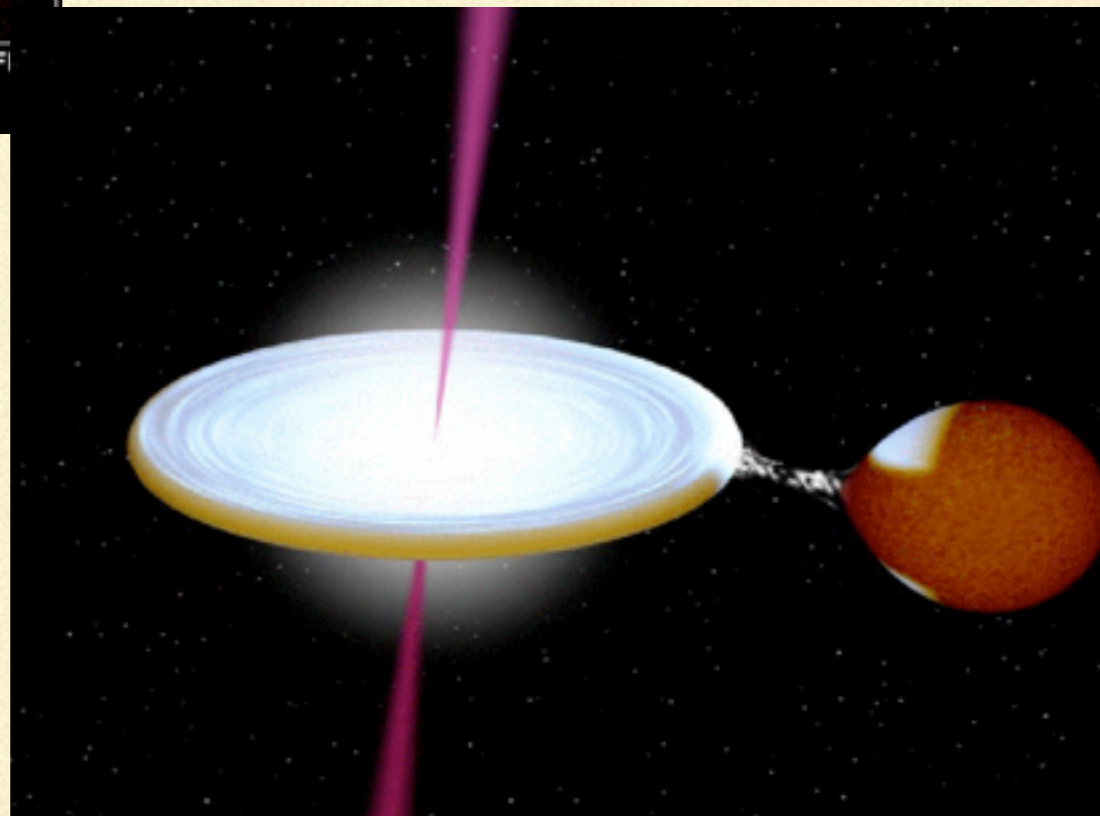
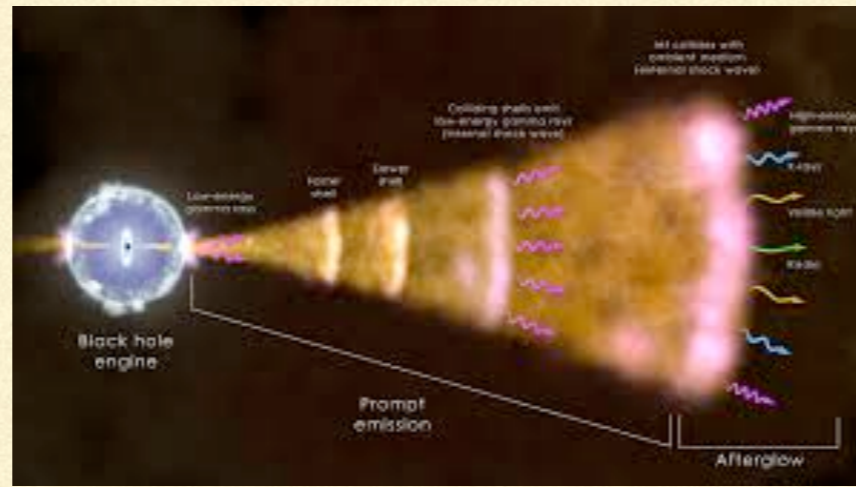
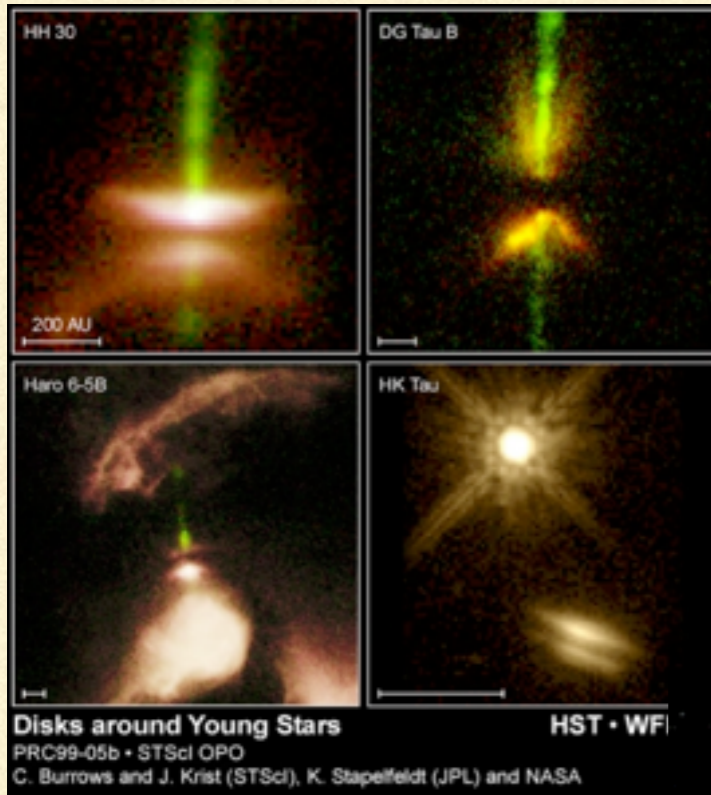
J. Rodriguez, CEA Saclay - Astrophysics division

ACCRETION(-EJECTION) AN UBIQUITOUS PHENOMENON

Star formation.....

fate of most massive stars

Centres of galaxies



...And XRBs

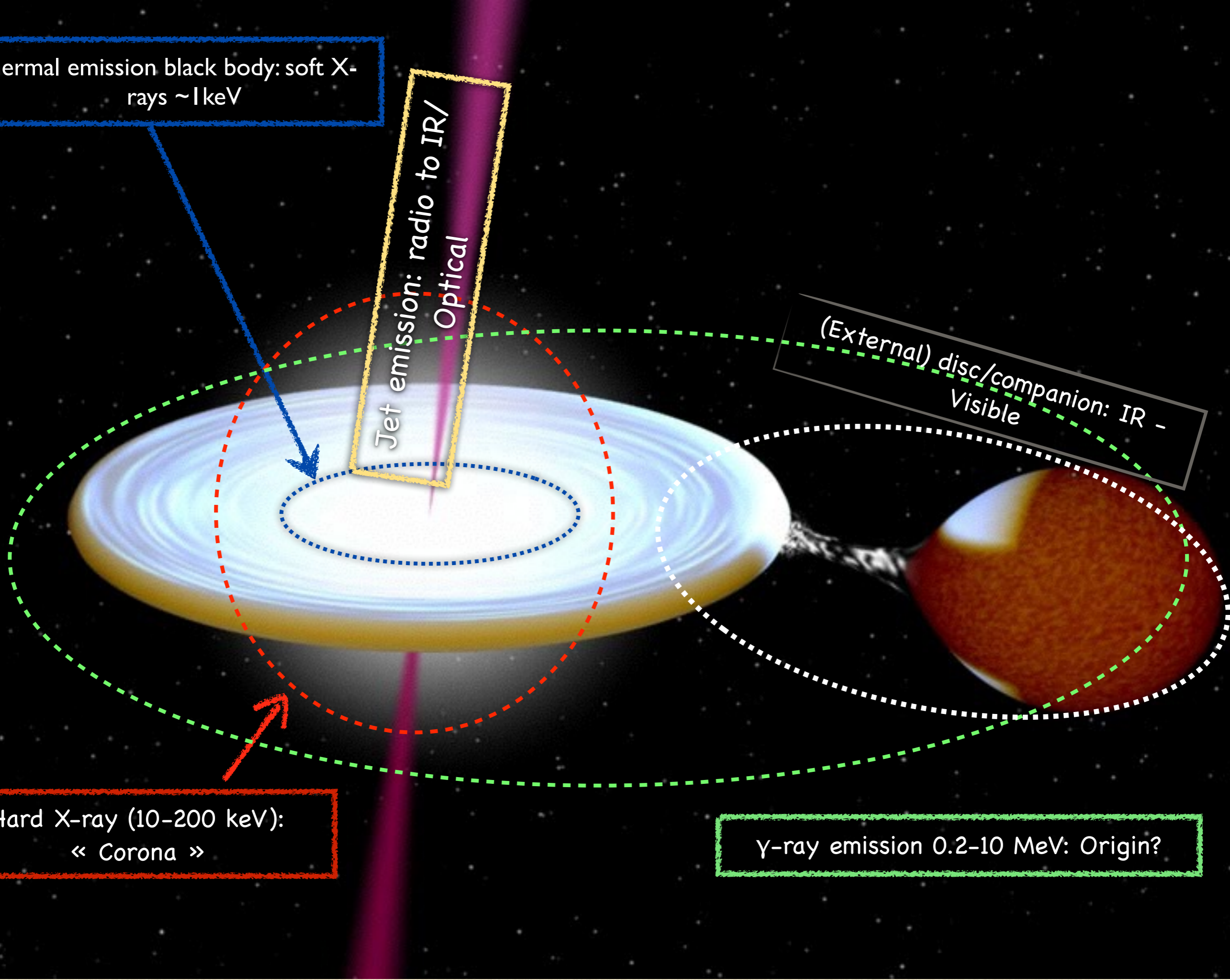
Thermal emission black body: soft X-rays ~ 1 keV

Jet emission: radio to IR/
Optical

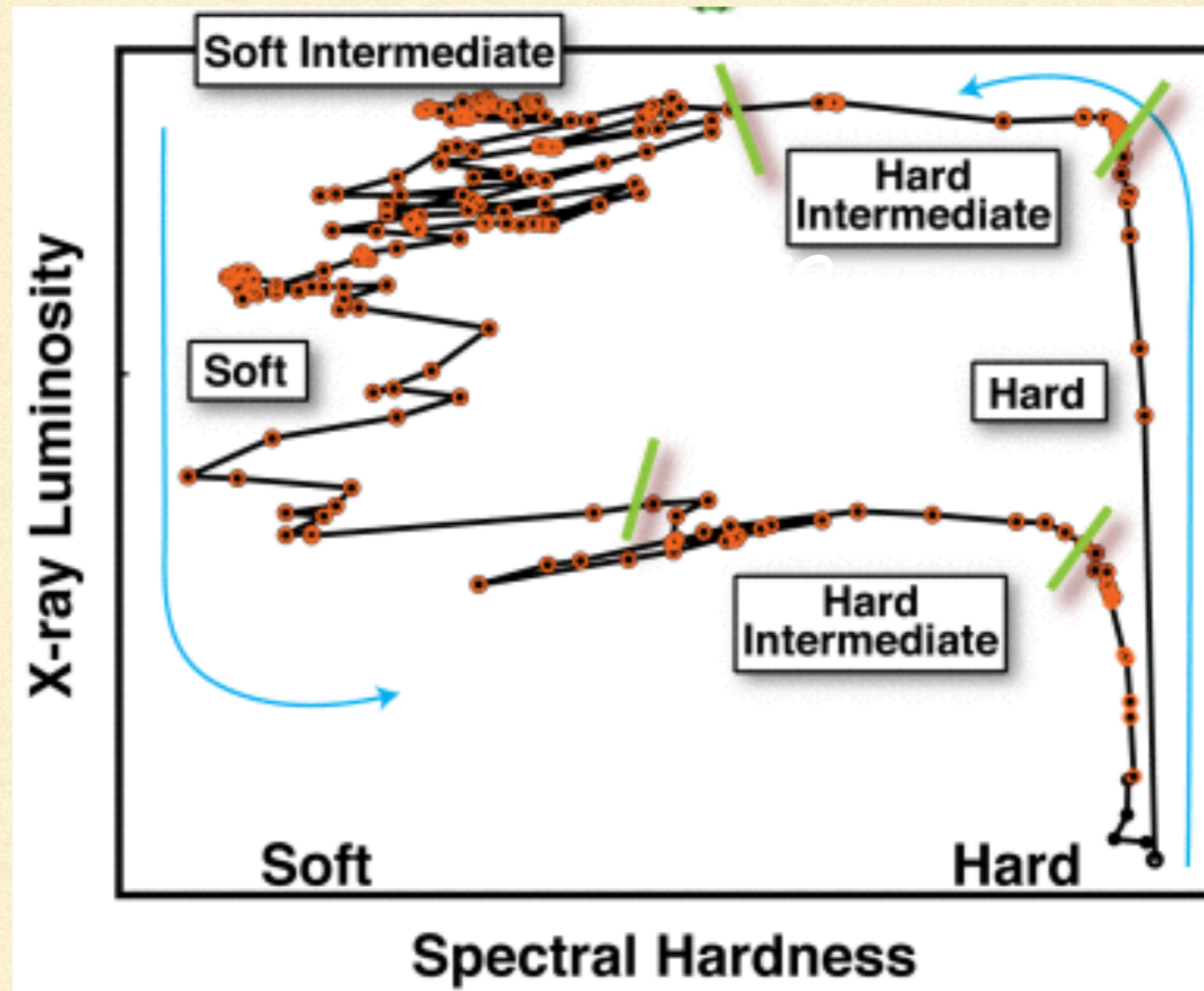
(External) disc/companion: IR -
Visible

Hard X-ray (10-200 keV):
« Corona »

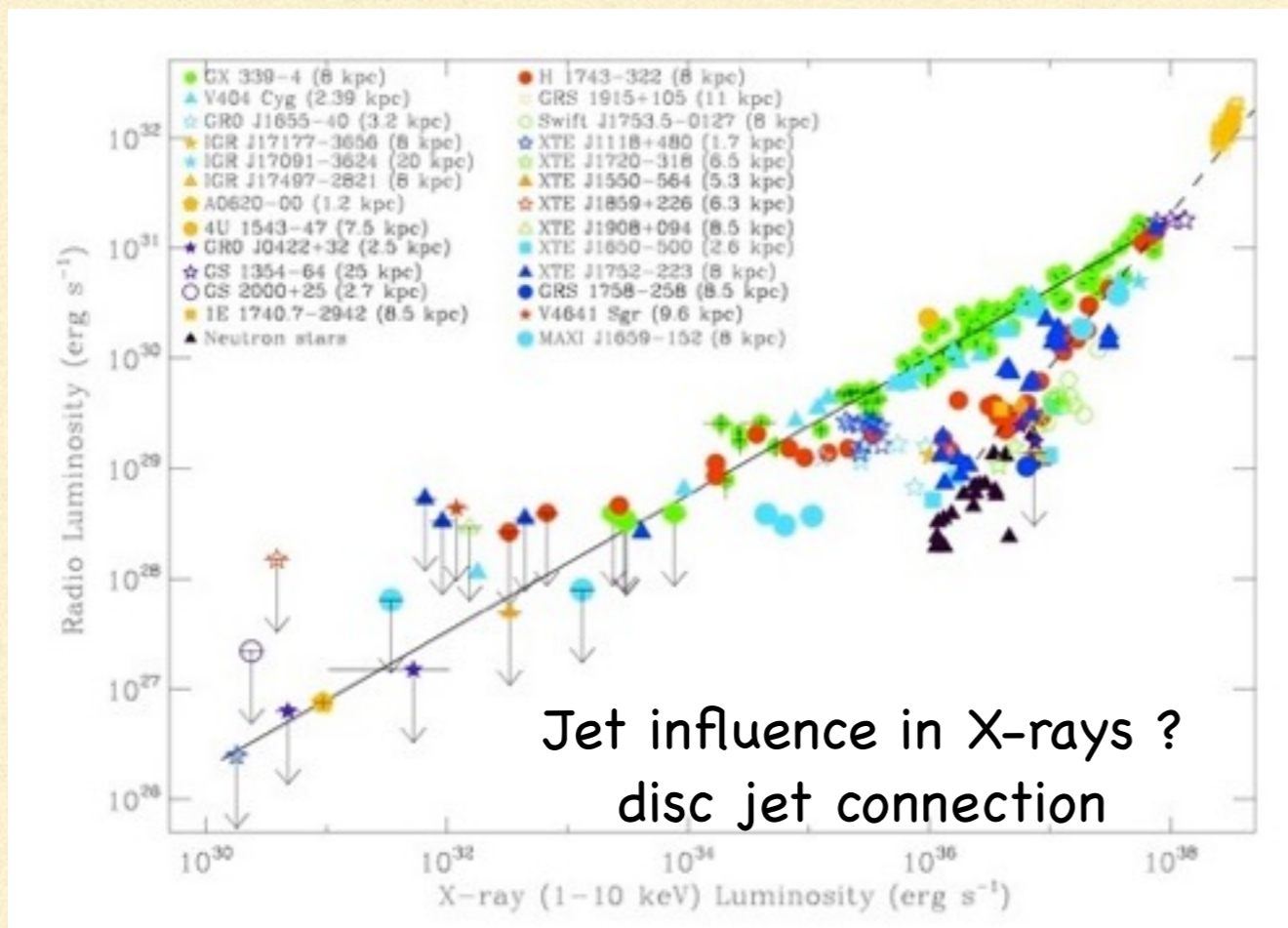
γ -ray emission 0.2-10 MeV: Origin?



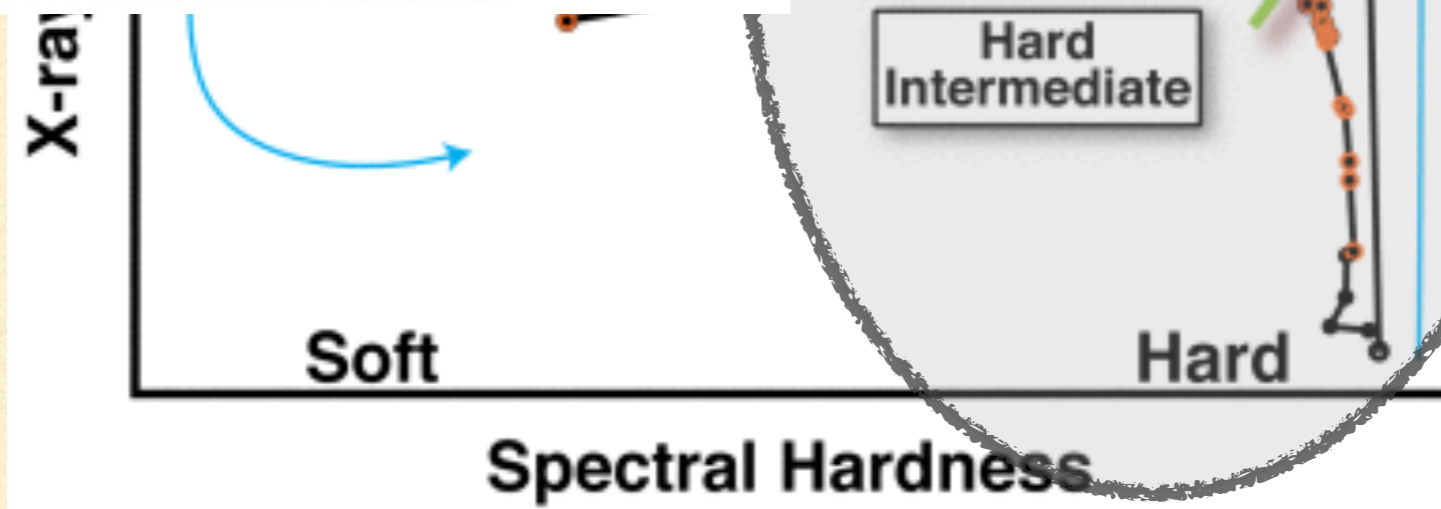
HARDNESS INTENSITY DIAGRAM



HARDNESS INTENSITY DIAGRAM

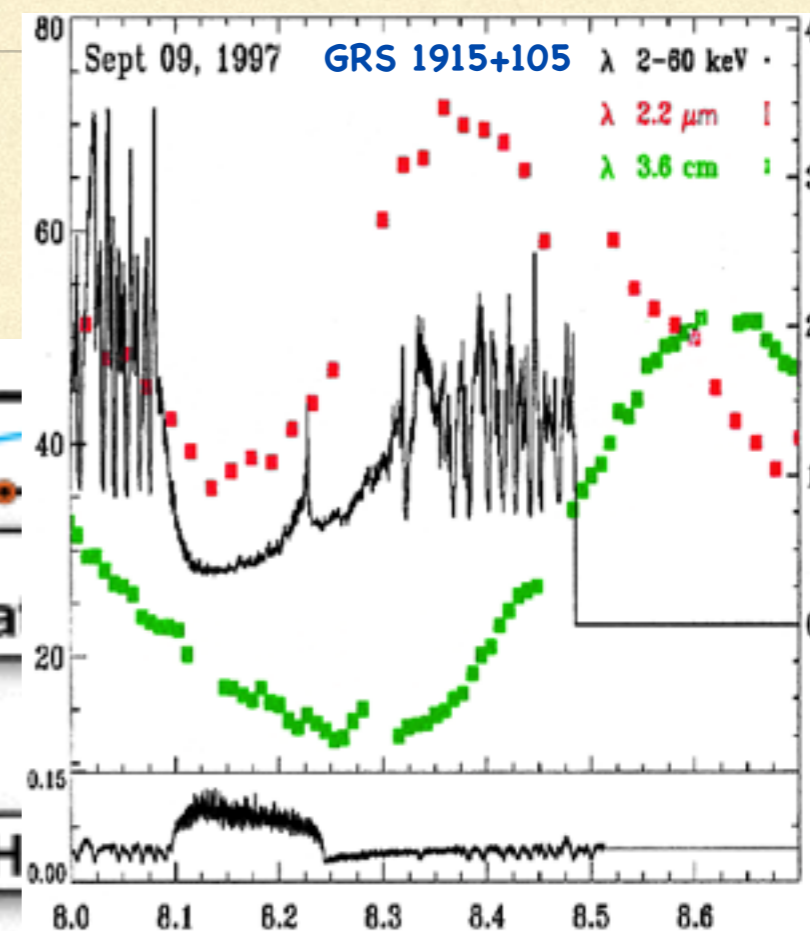


+multi- λ

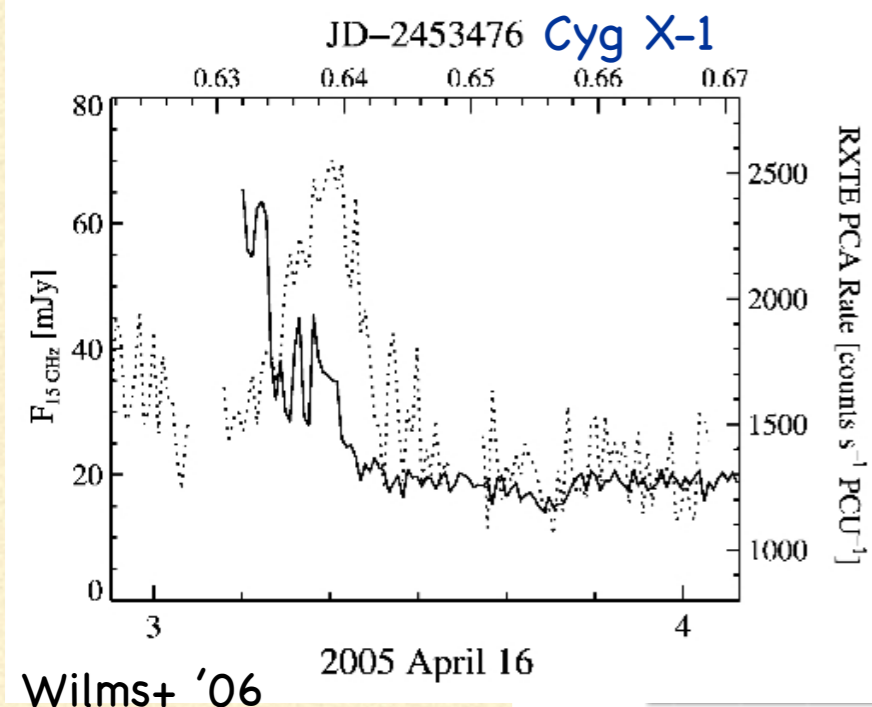
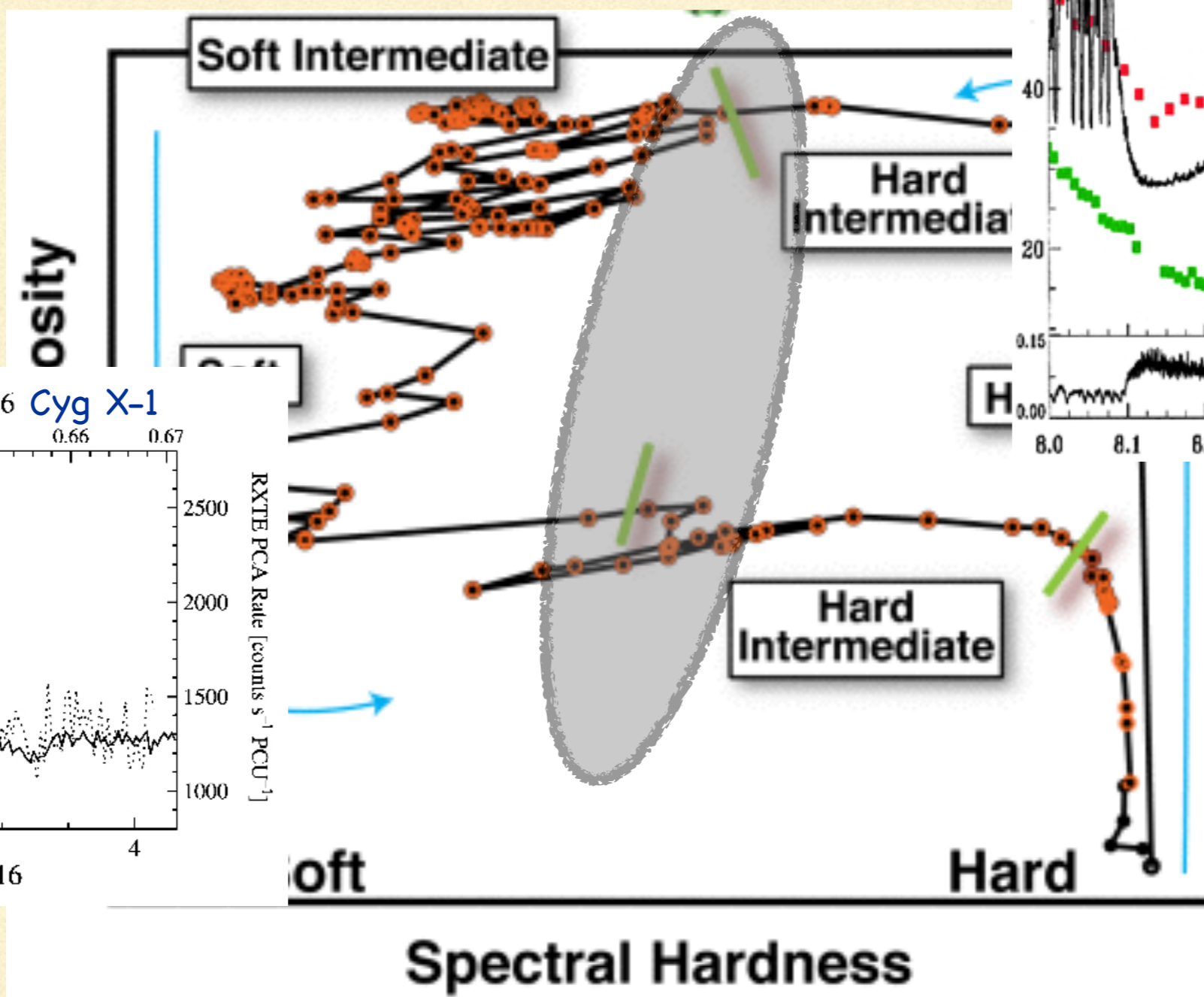


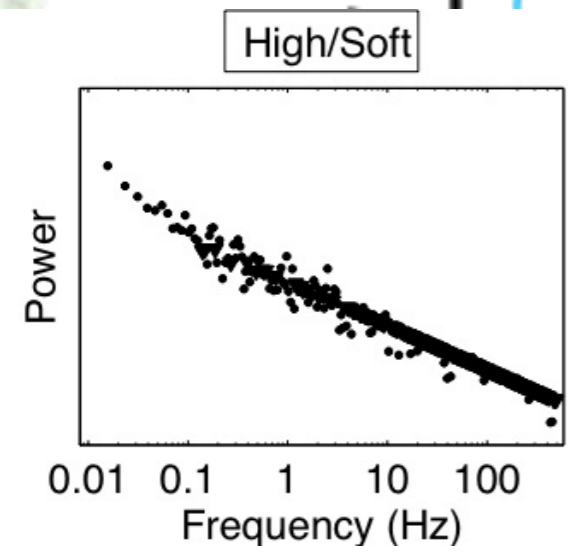
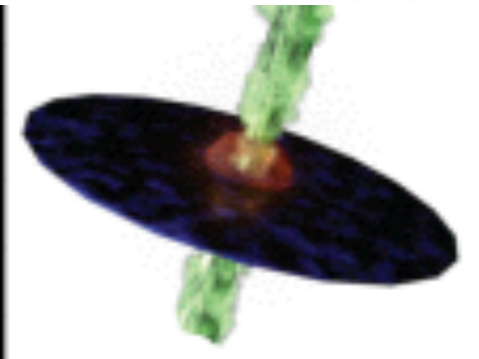
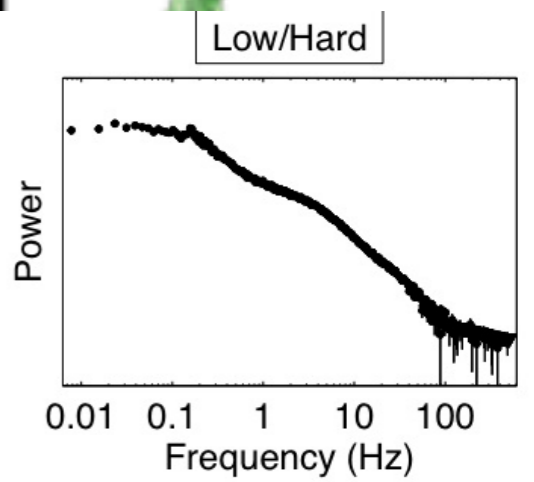
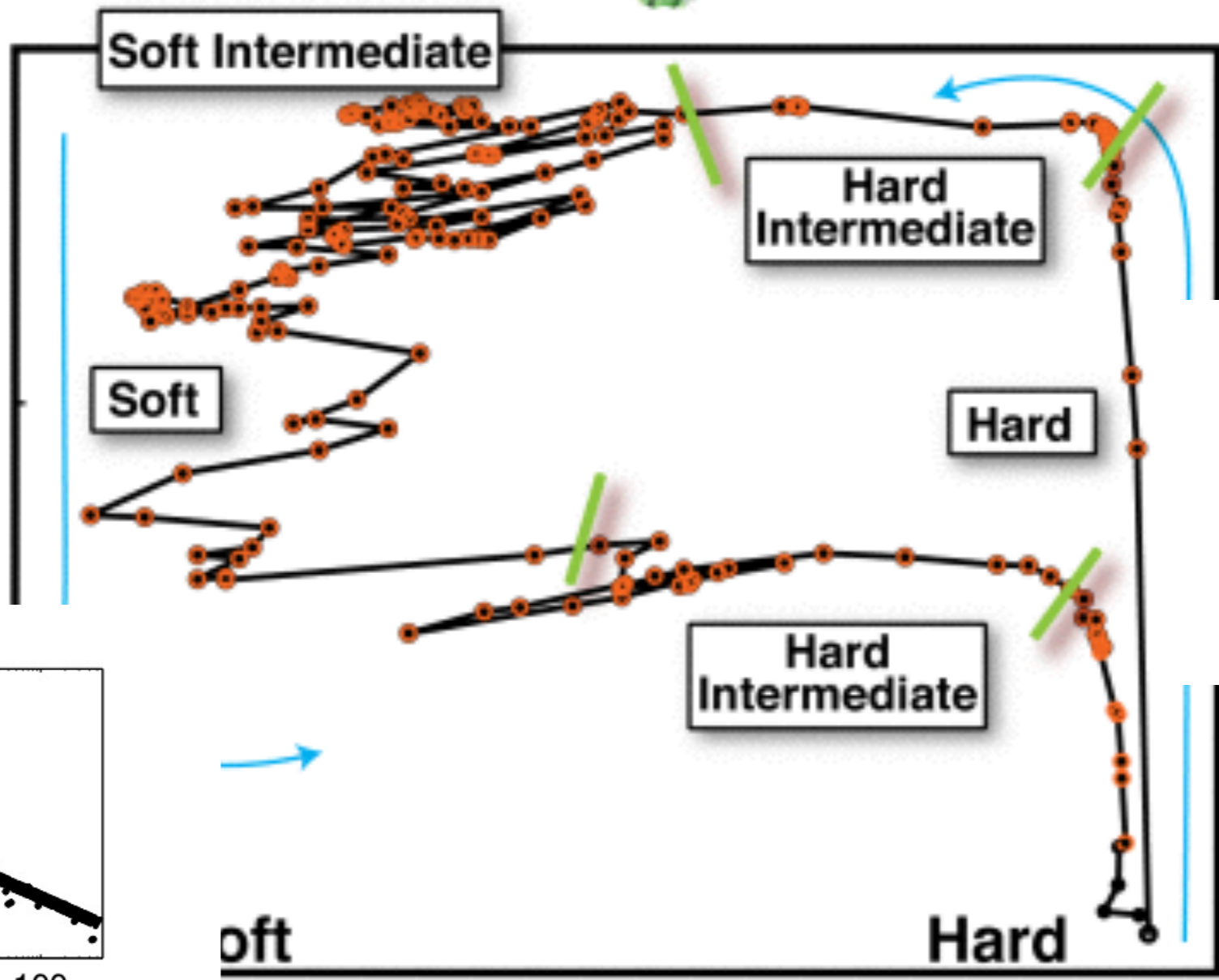
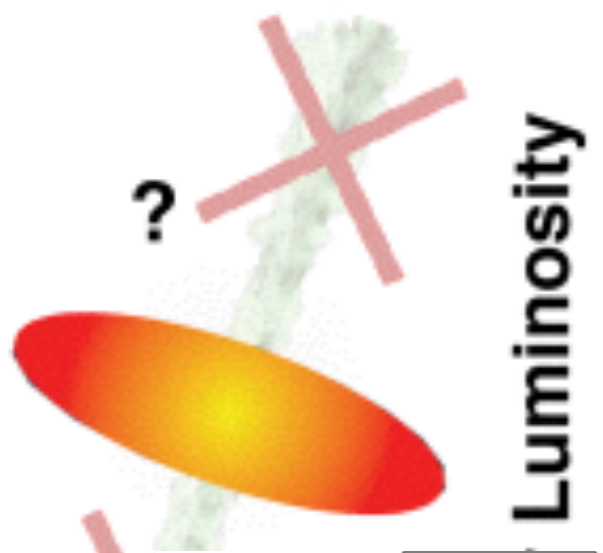
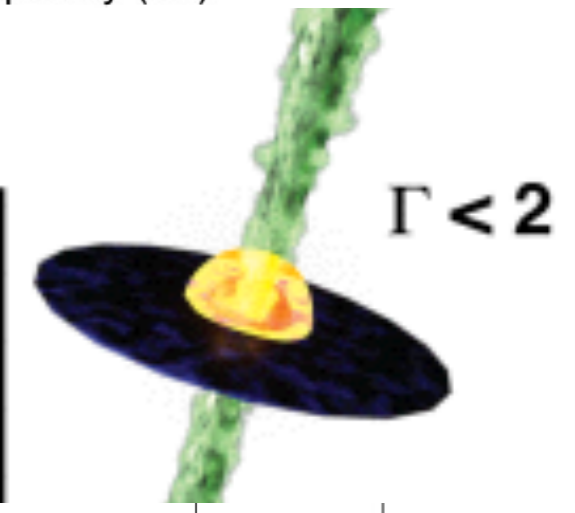
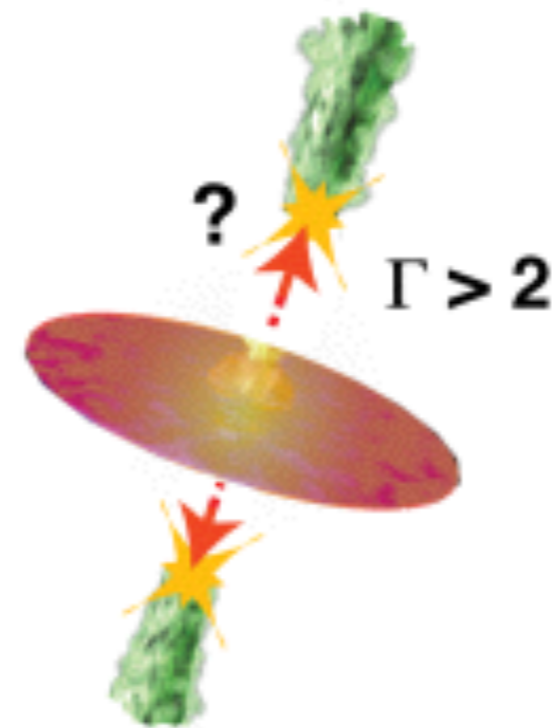
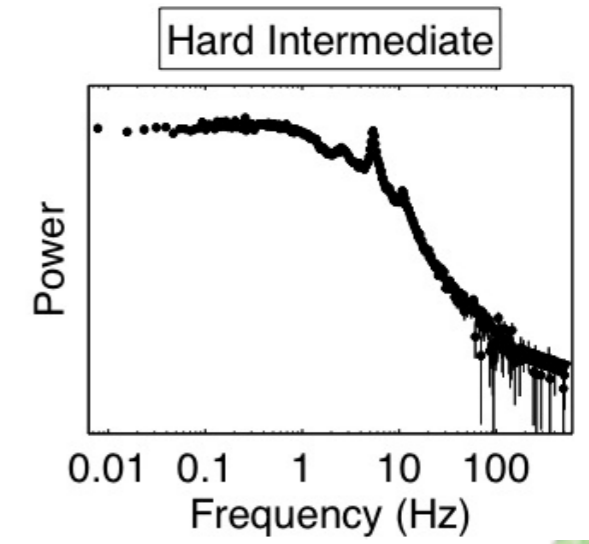
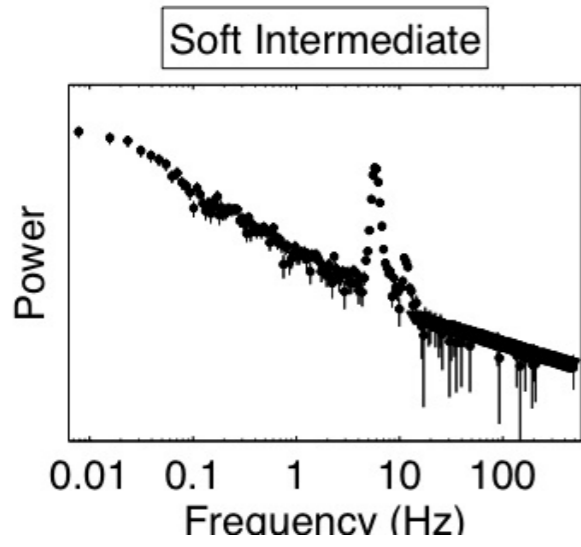
S. Corbel's talk

THE « JET LINE »

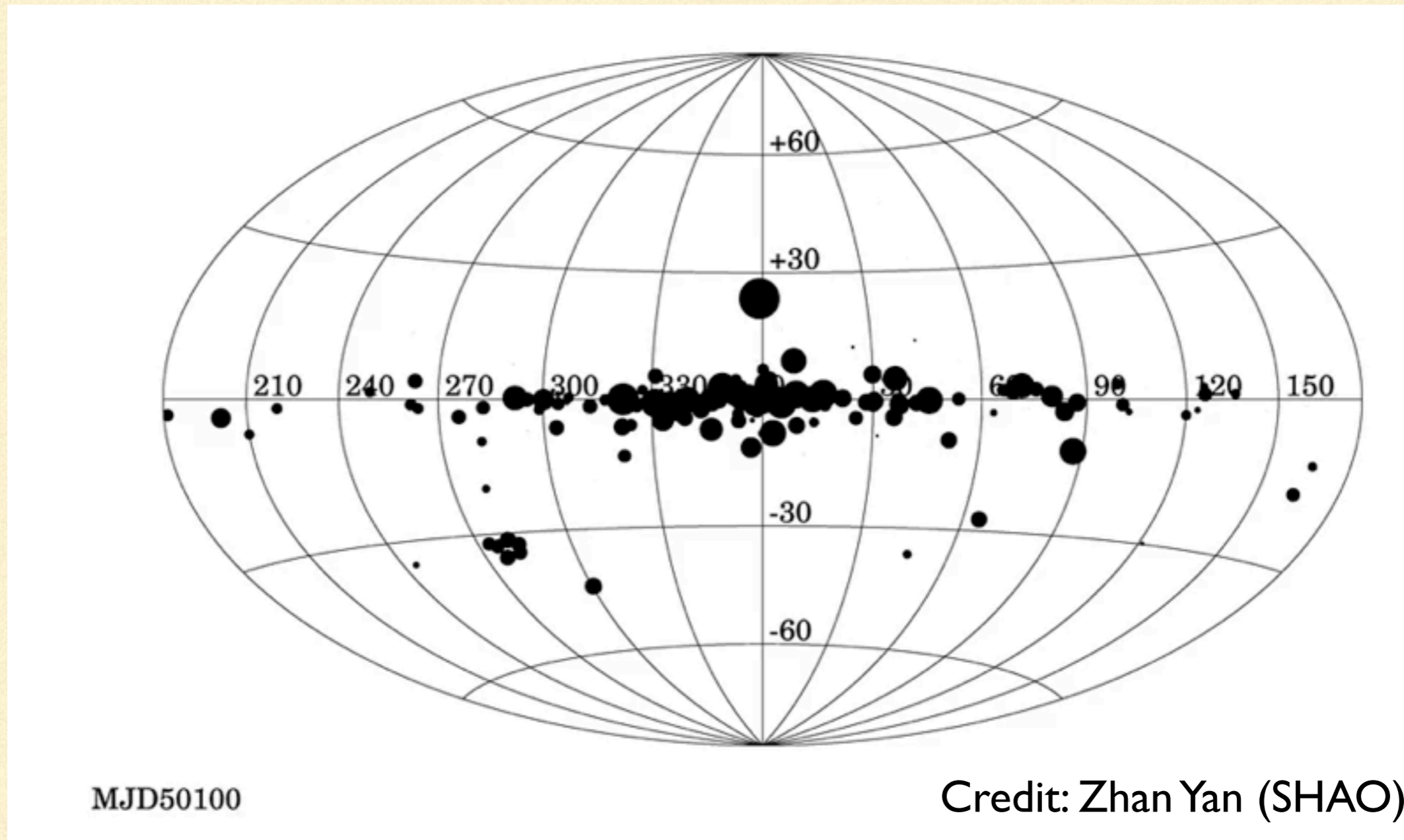


Mirabel+ '98; R.+ '08



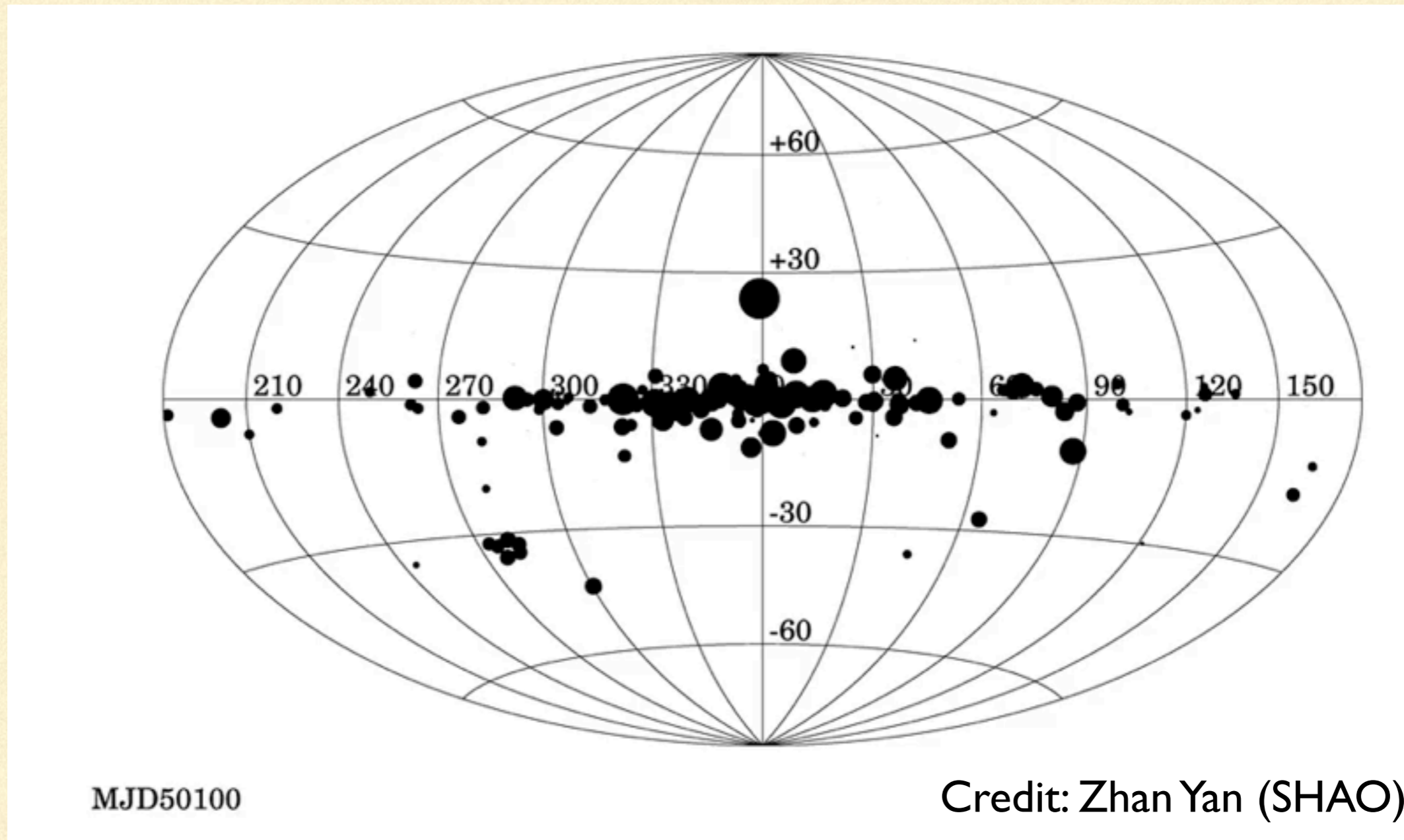


X-RAY BINARIES ARE TRANSIENT



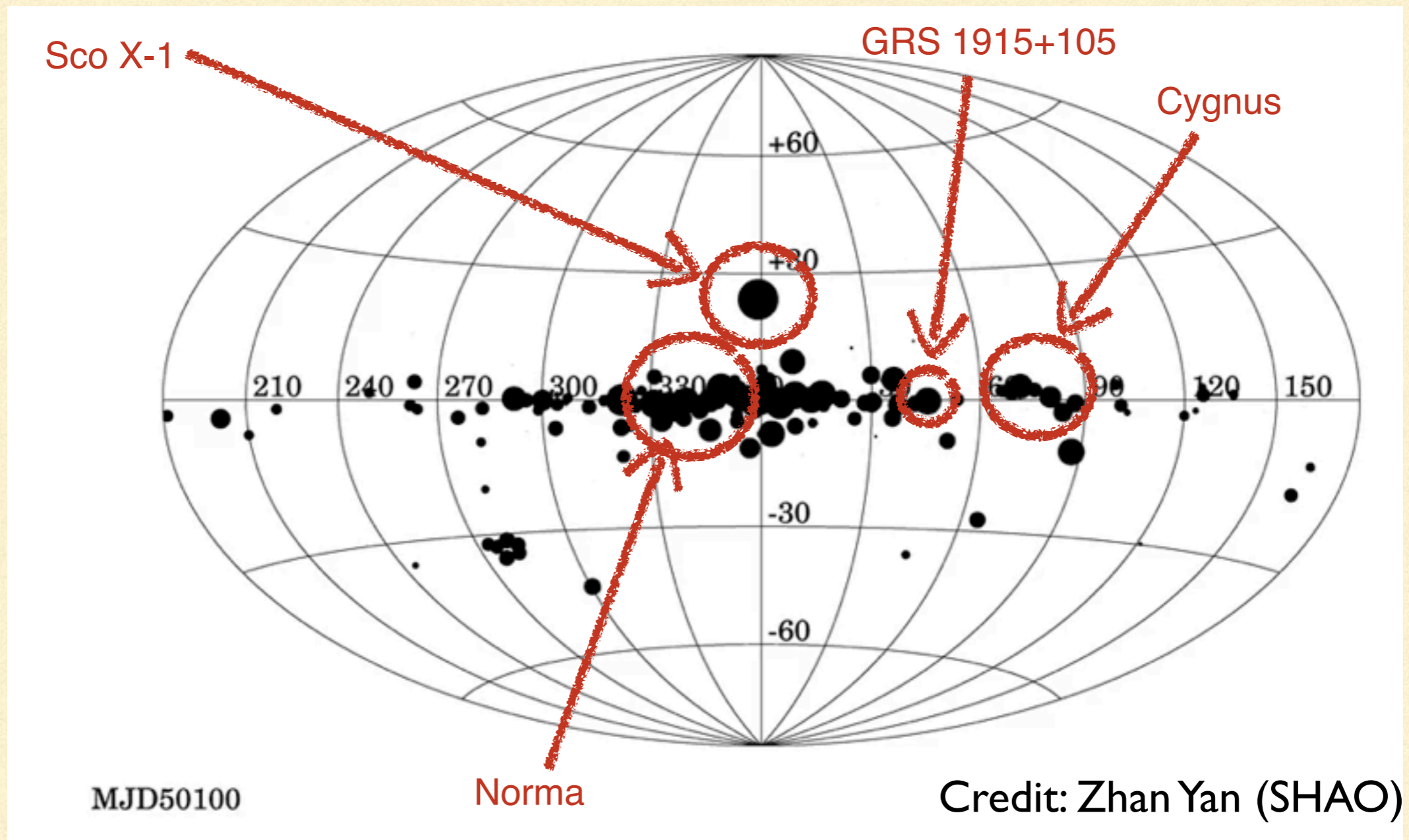
RXTE/ASM: 16 years all sky monitoring of the X-ray sky

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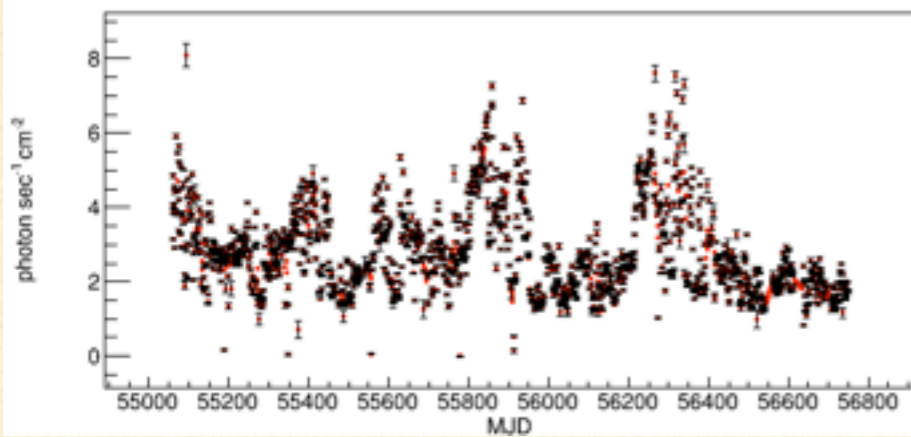


RXTE/ASM: 16 years all sky monitoring of the X-ray sky

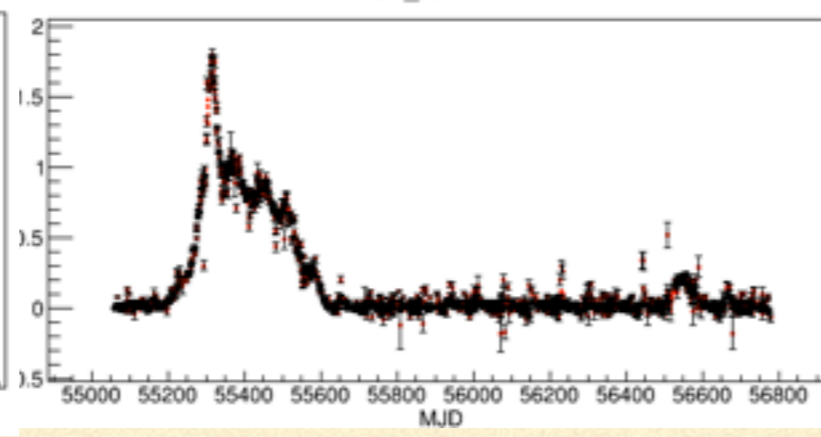
A FEW MAXI LIGHT CURVES

Old

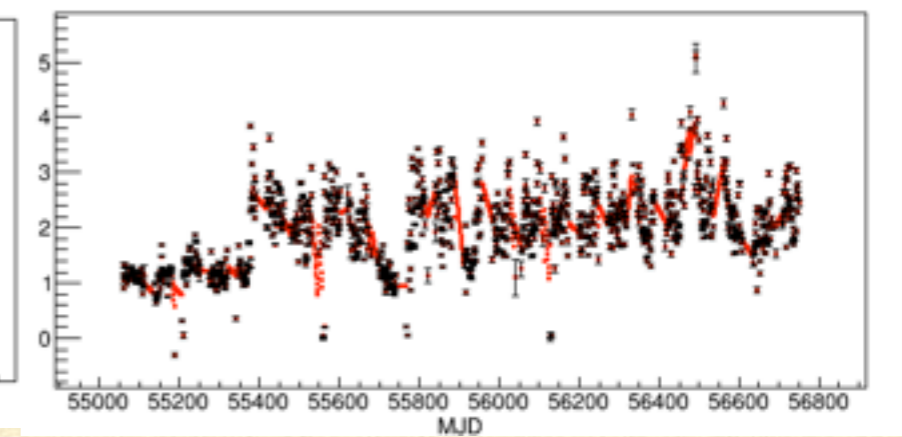
GRS_1915+105 LC



GX_339-4 LC

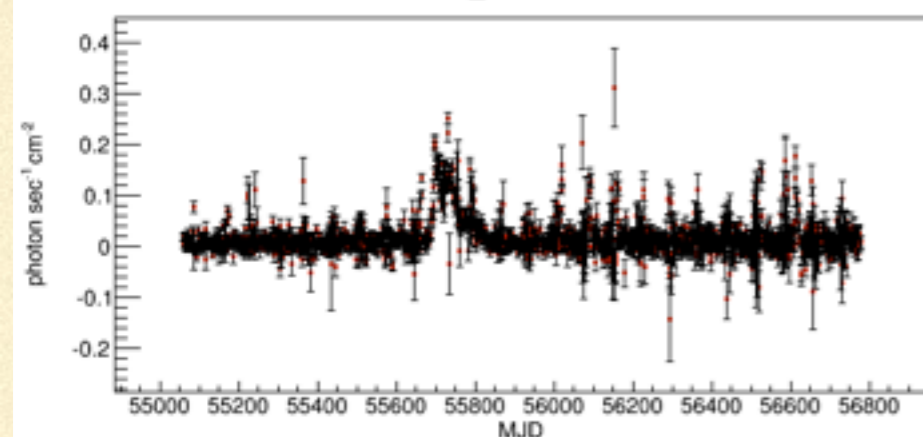


Cyg_X-1 LC

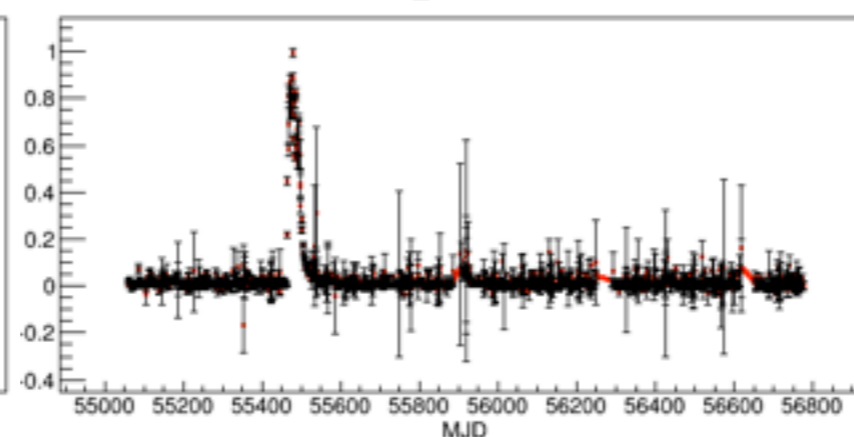


... and new friends

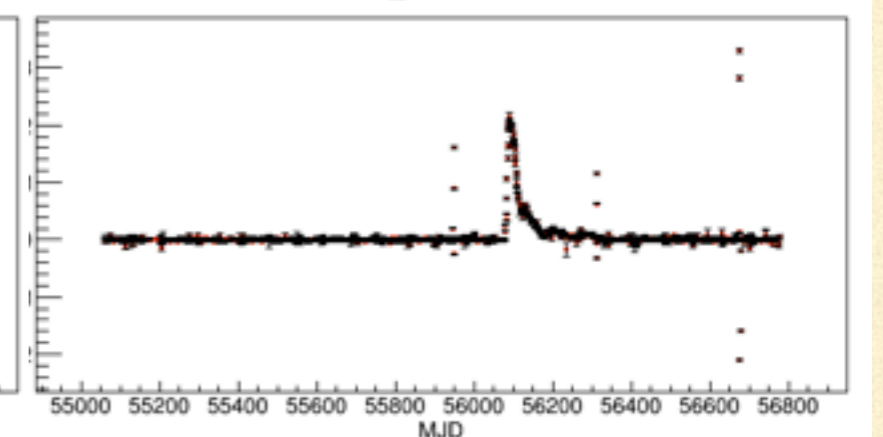
MAXI_J1543-564 LC



MAXI_J1659-152 LC

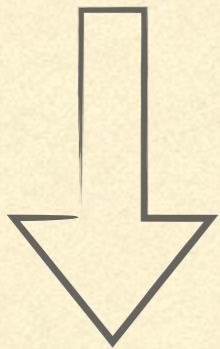


MAXI_J1910-057 LC

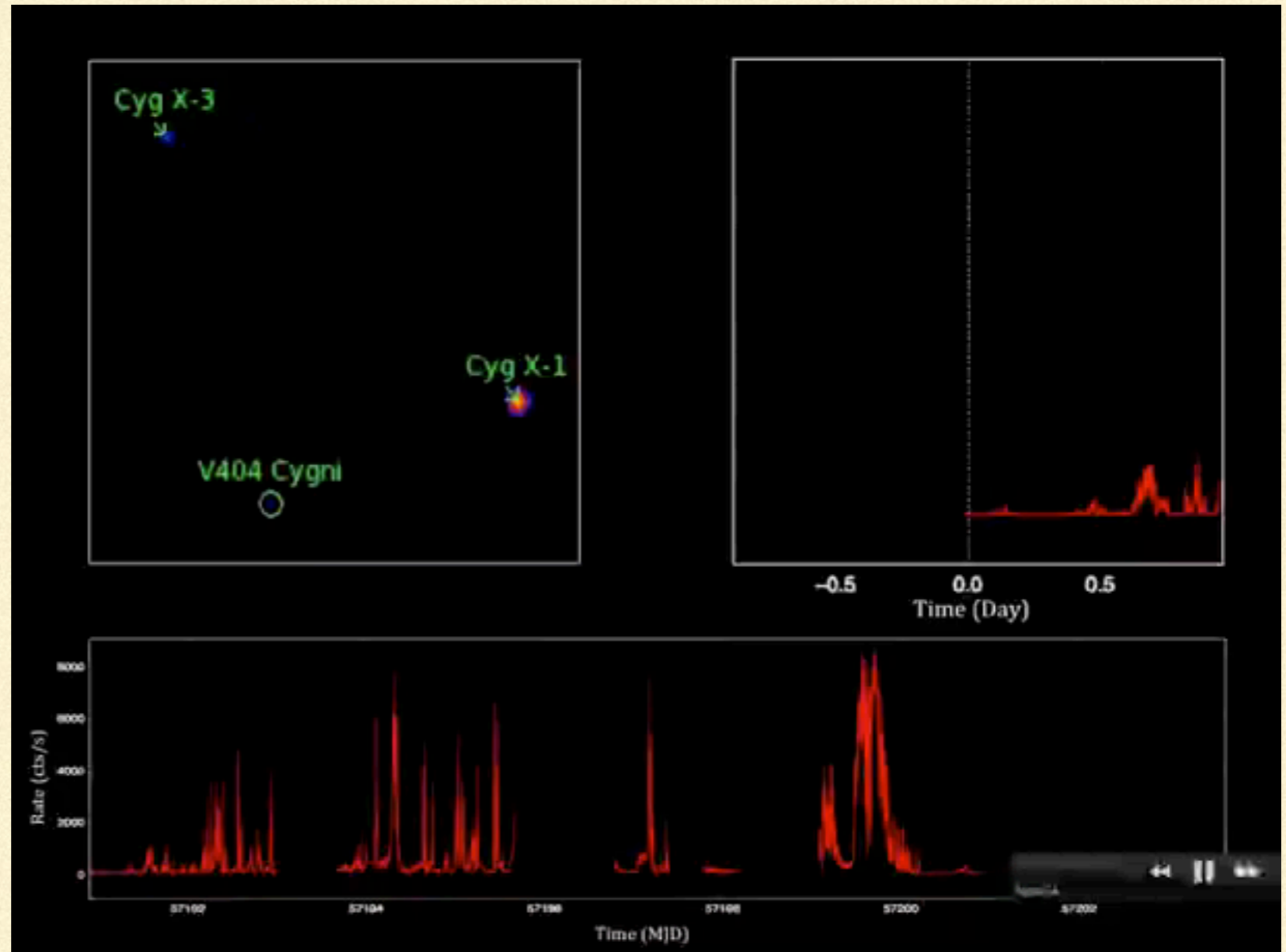


THE V404 CYGNI'S EXTREME OUTBURST

Swift (Barthelmy+ '15)
Maxi (Negoro+ '15)
INTEGRAL (Kuulkers+ '15)

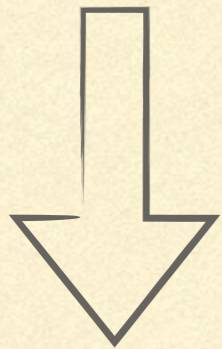


Worldwide largest
multi-wavelength effort
from radio to gamma-
rays

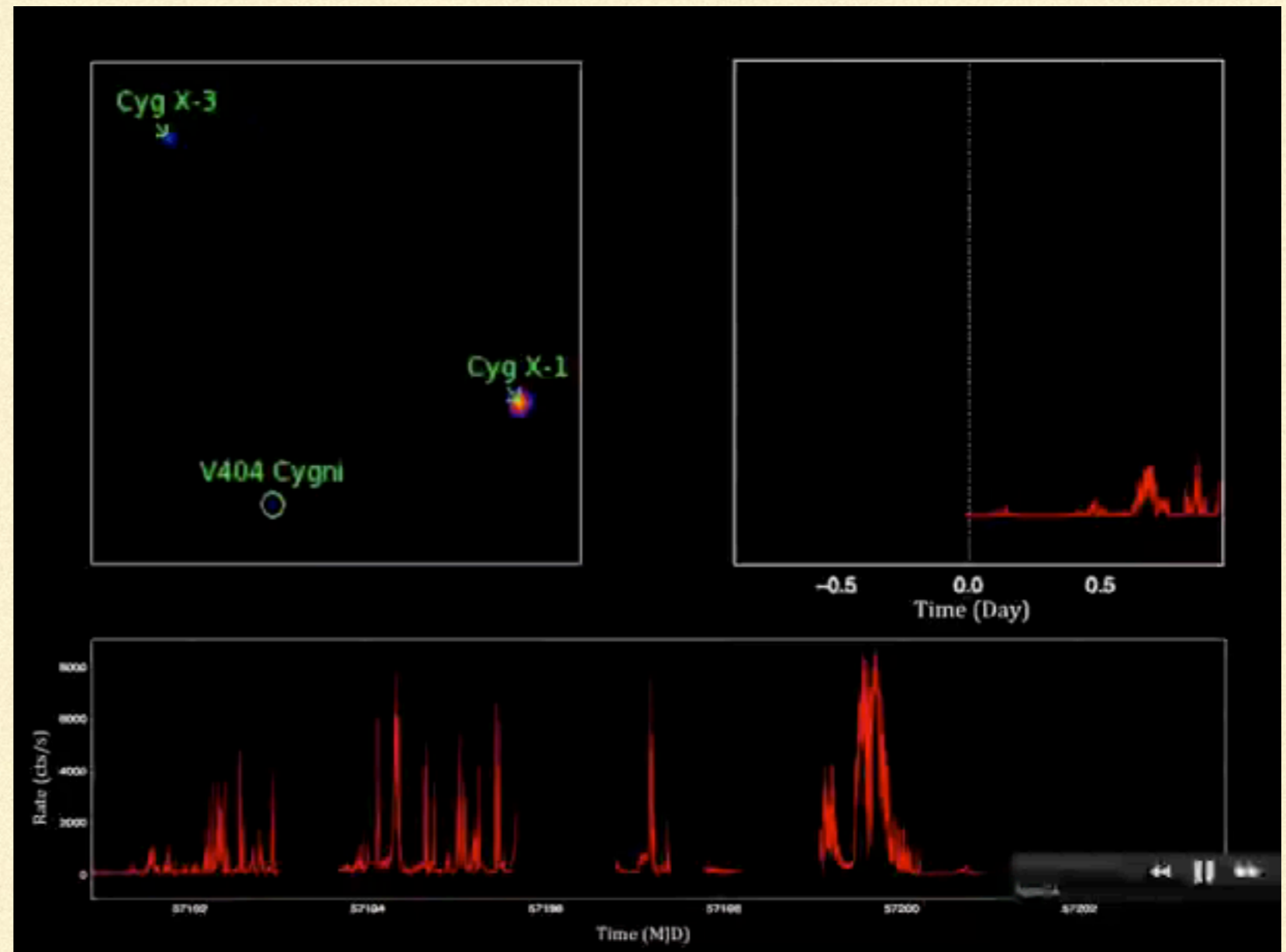


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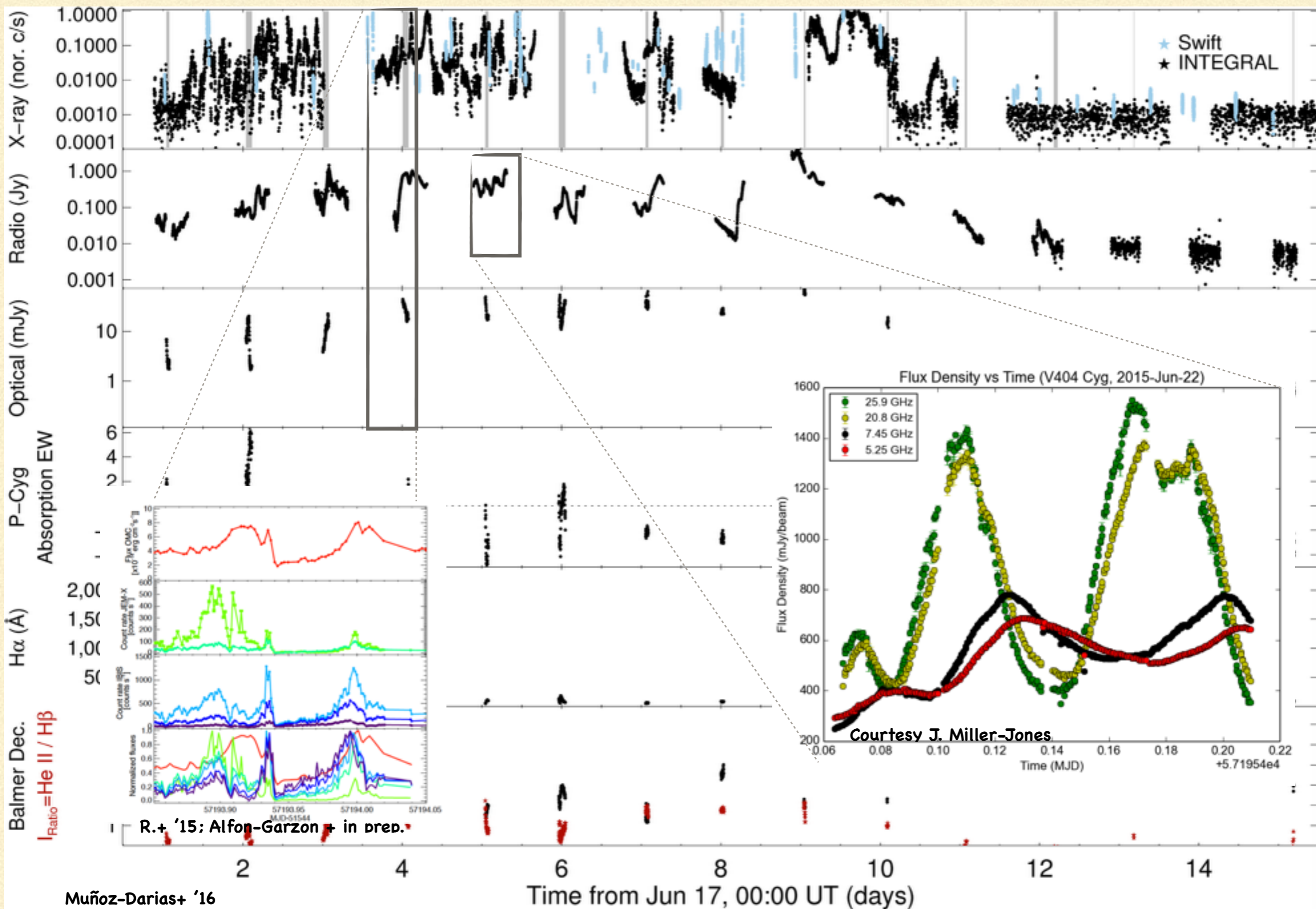
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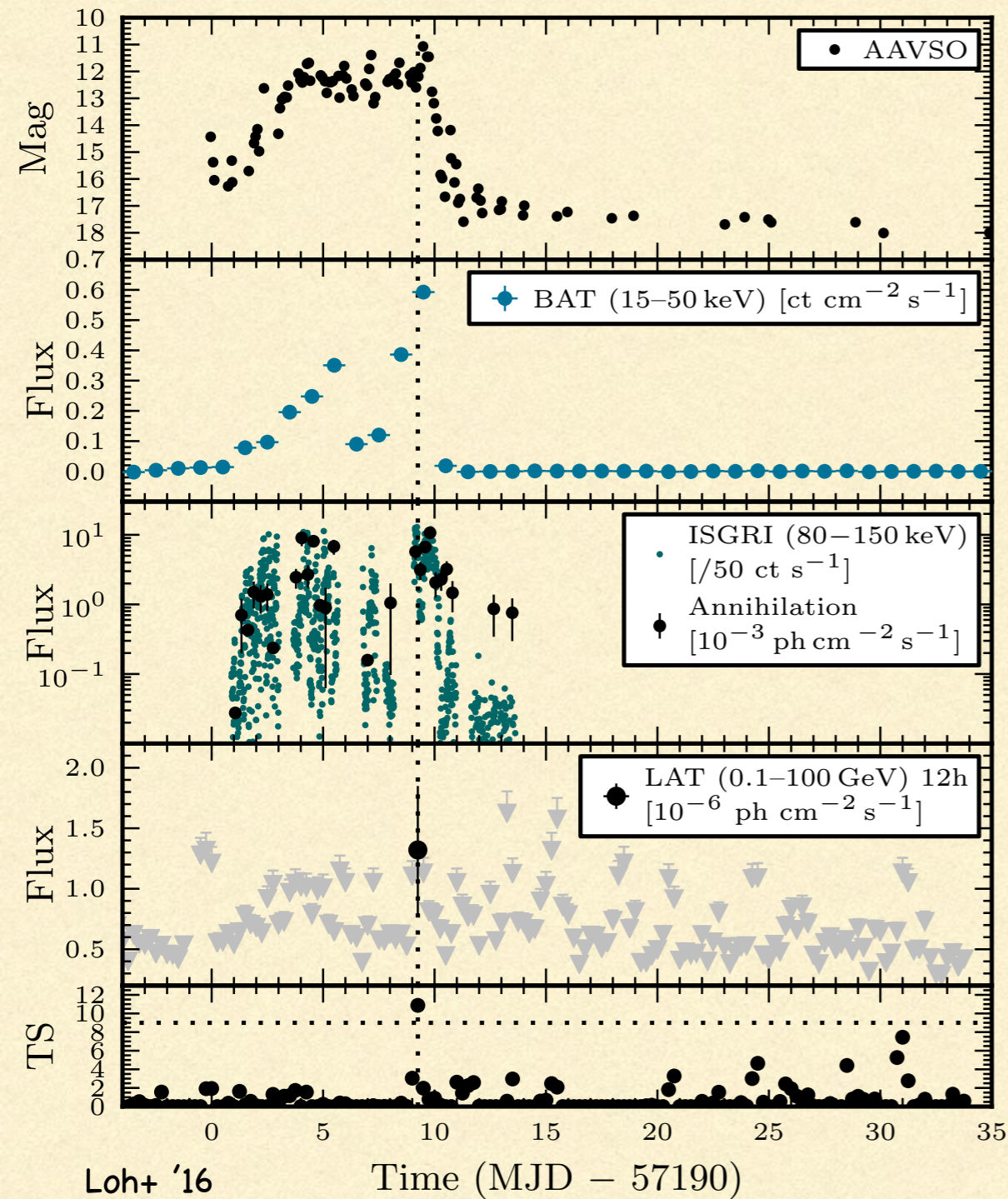
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A SAMPLE OF MULTI WAVELENGTH LIGHT CURVES



SELECTED RESULTS

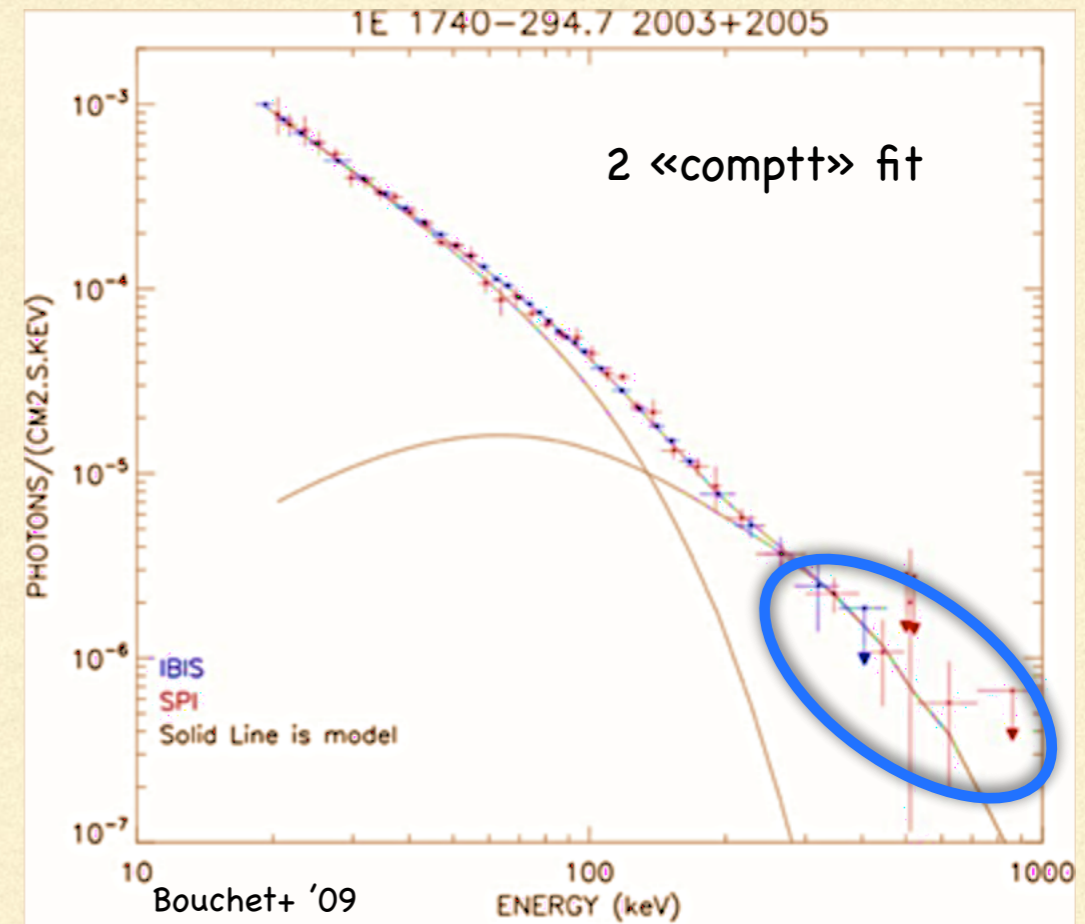
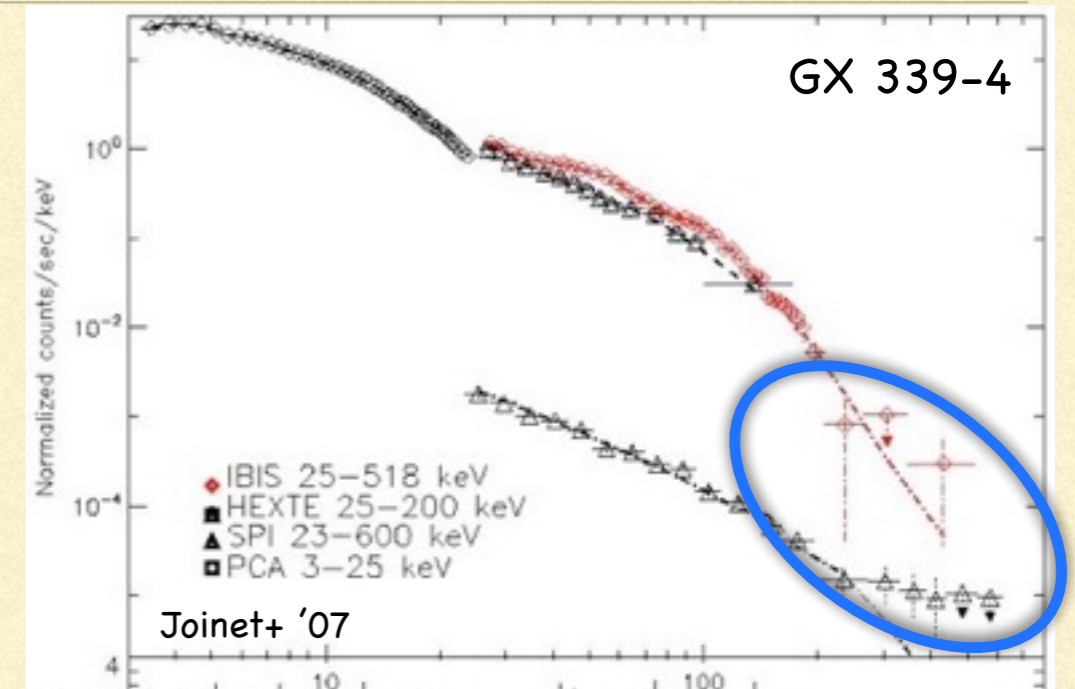
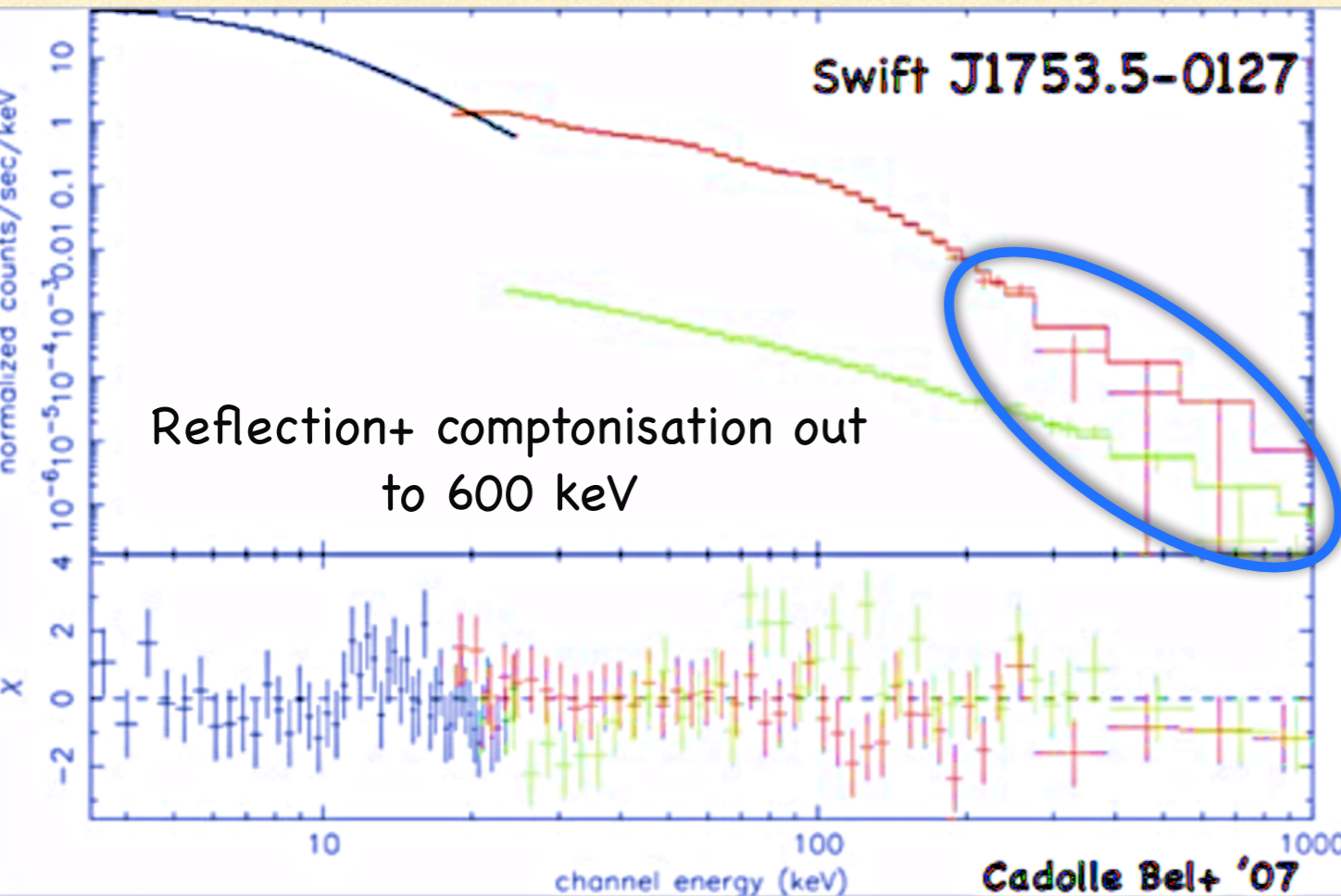


- 50 Crab flares at 20 keV: brightest X-ray source, > 20 keV spectra have similar shape (R.+ '15)
- Detection of a variable 511 keV line (Siegert + '16): e-/e+ jet, pair plasma production
- Detection with Fermi @ GeV + 511 keV line => origin related to jet (Loh+ '16)
- Multi- λ flaring activity => evacuation of inner accretion disc before ejection (Radhika+ '16)
- Optical analysis => a sustained disc wind regulating the outburst (Muñoz-Darias+ '16) but flares due to disk reprocessing (Kimura +'16)

Talks by M. Kimura & Y. Tachibana (Optical)
& S. Corbel (high energies)

Γ -RAY TAILS

Thermal Comptonisation + ?

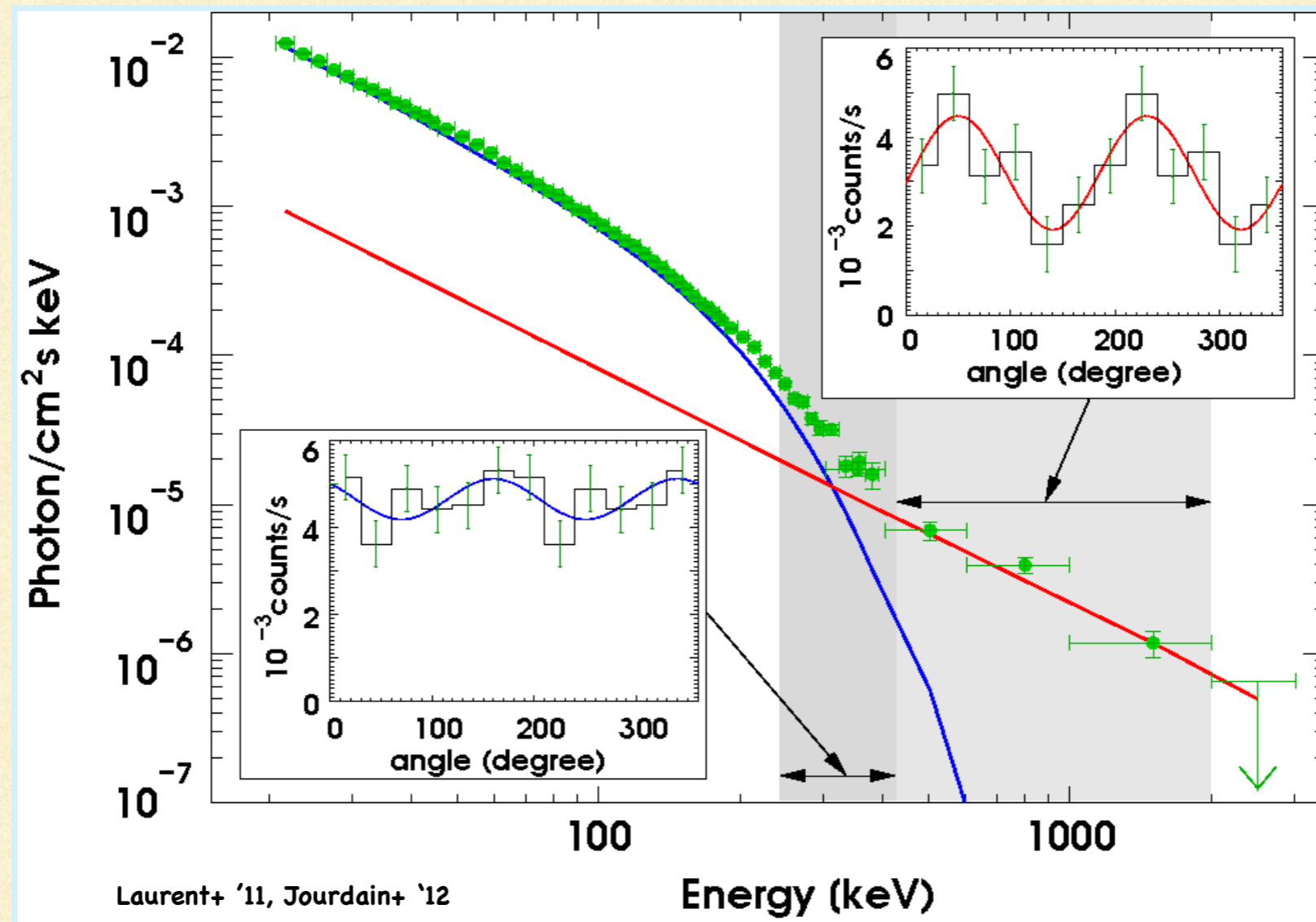


=> An ubiquitous component

=> Origin debated

V404 Cyg => emission from jet?

HIGH ENERGY TAIL AND POLARIZED EMISSION IN CYG X-1

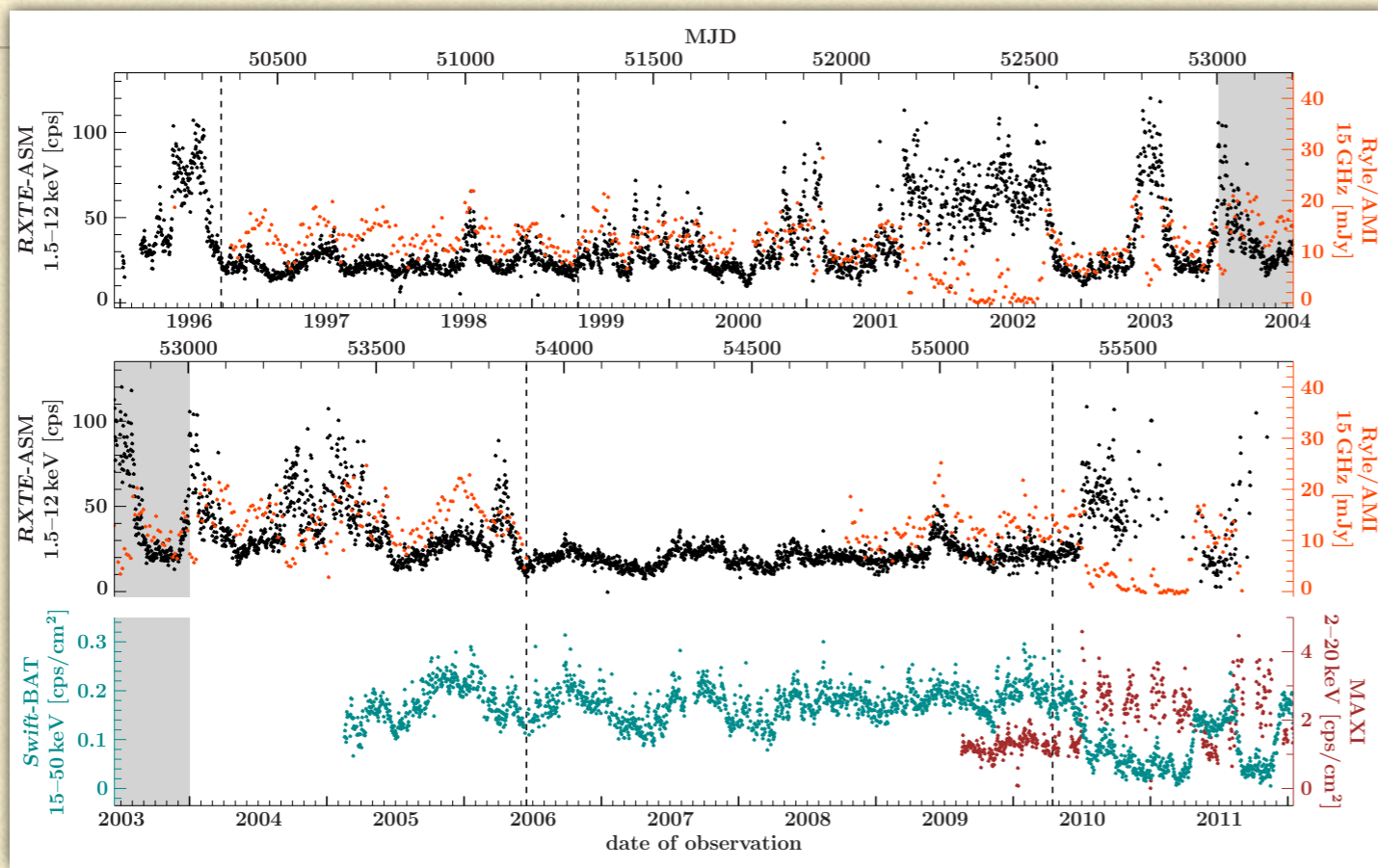


- \Rightarrow Compton + high E power law, crossing @ 350-400 keV
- \Rightarrow Polarised emission above 400 keV \Rightarrow jet?

BUT

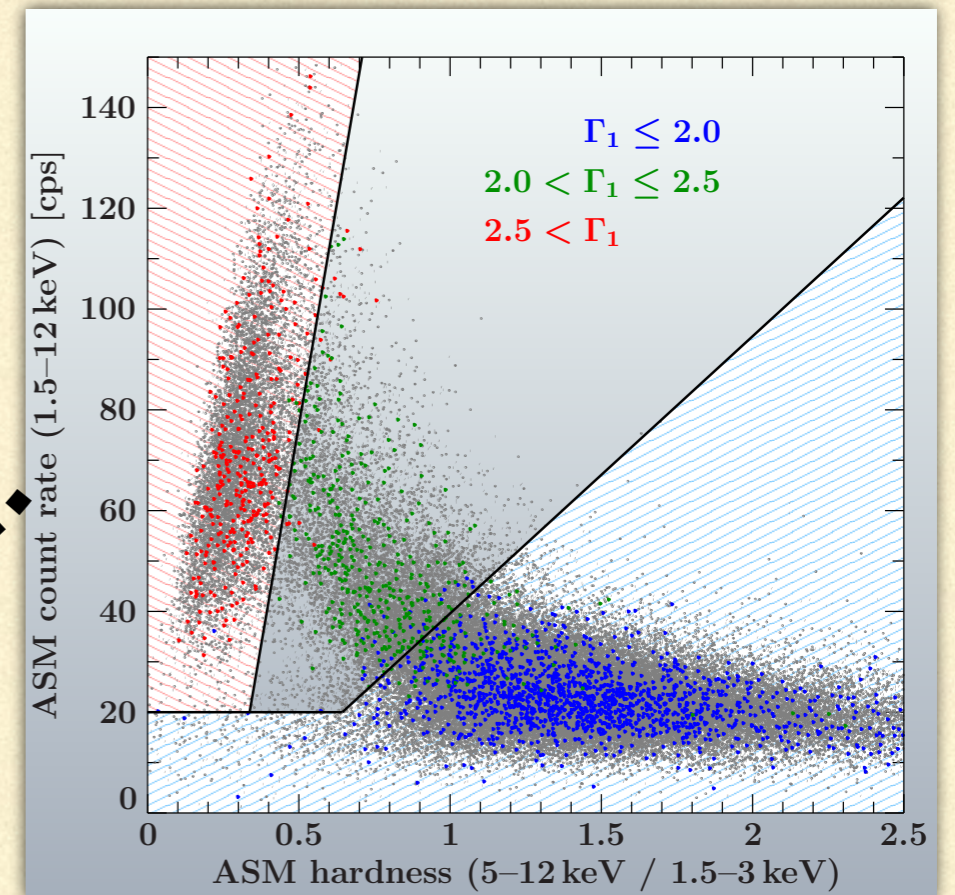
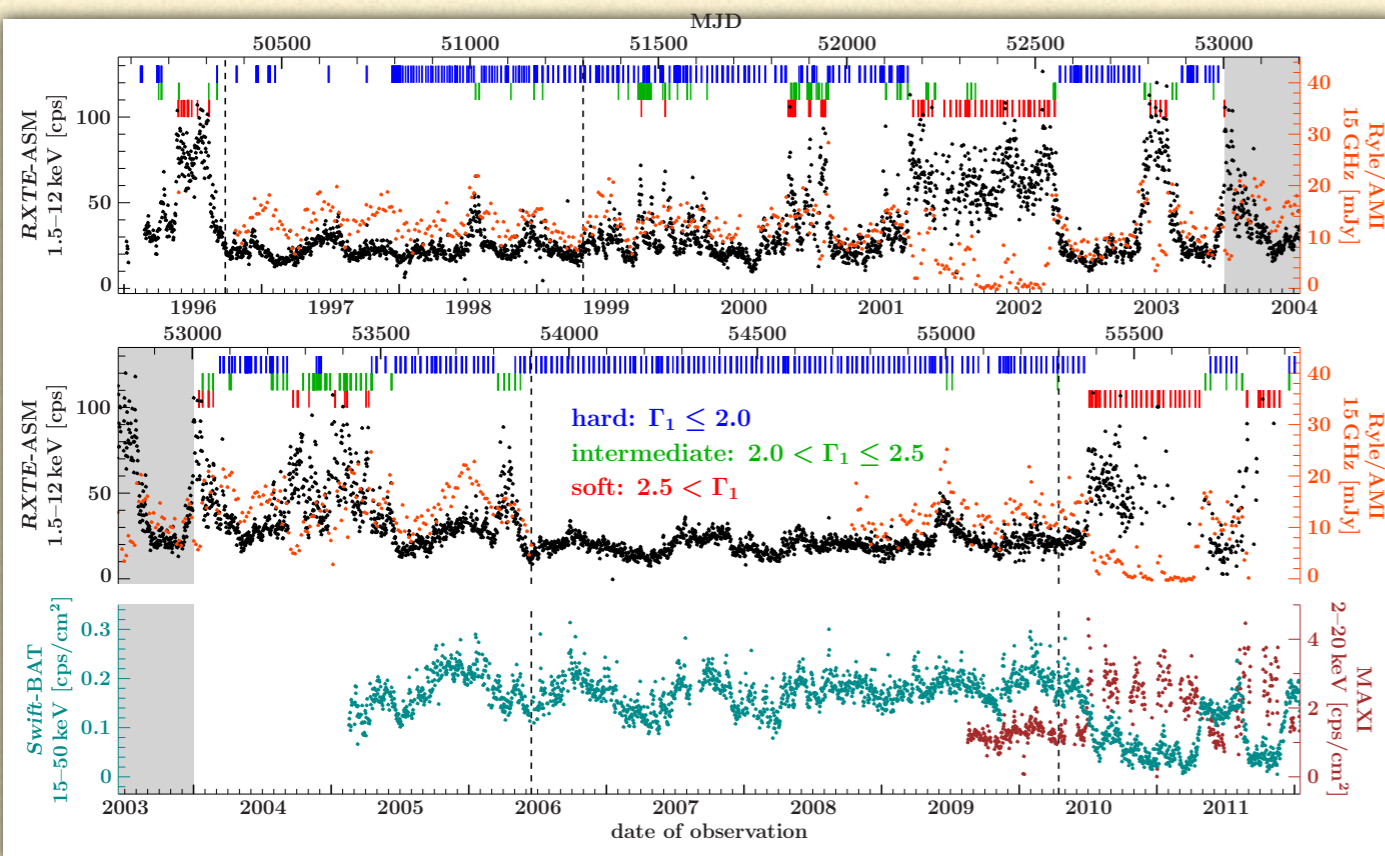
Mixed spectral state and no radio data studied

TO TRY AND GO FURTHER



- Separate into states
- Radio behaviour vs state

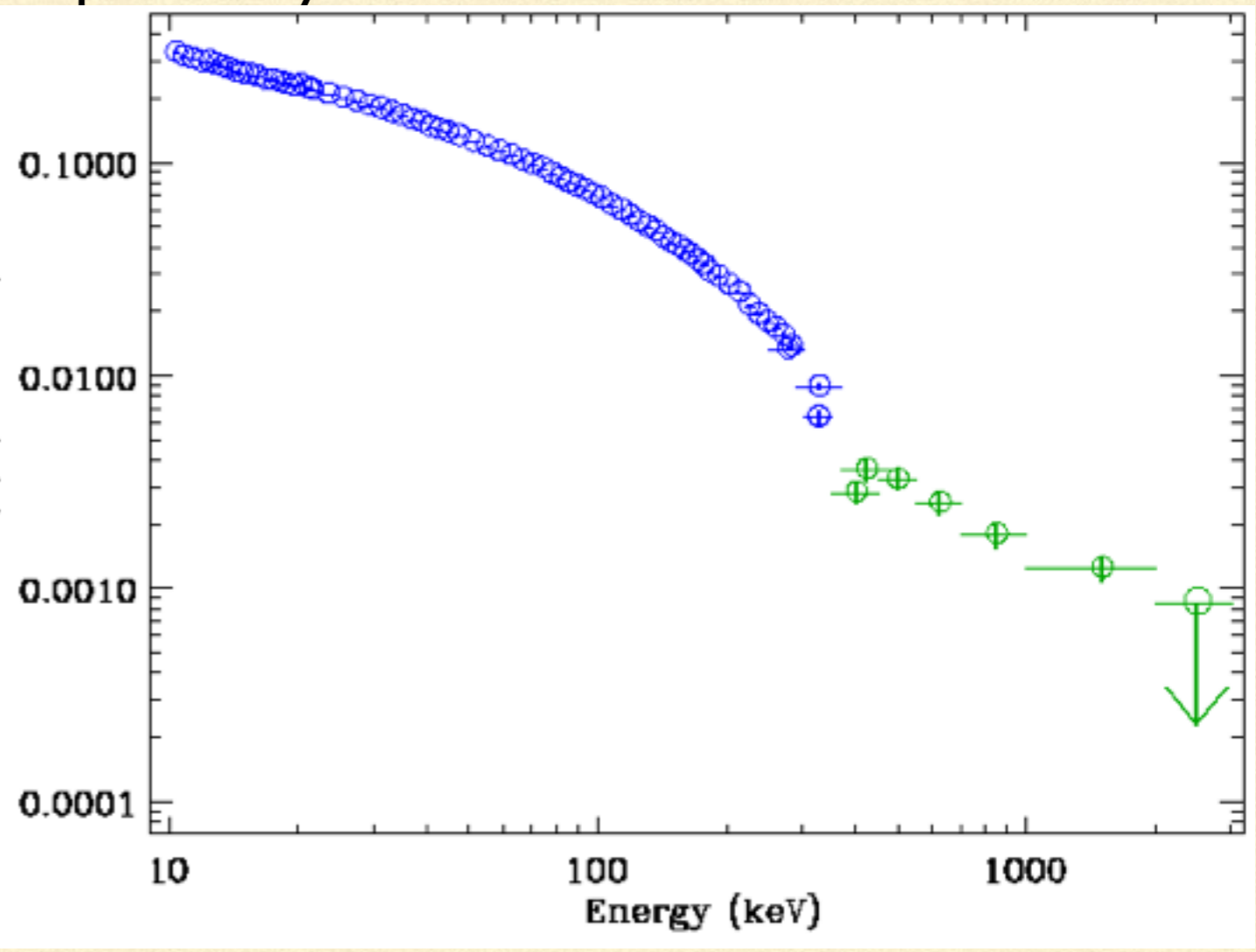
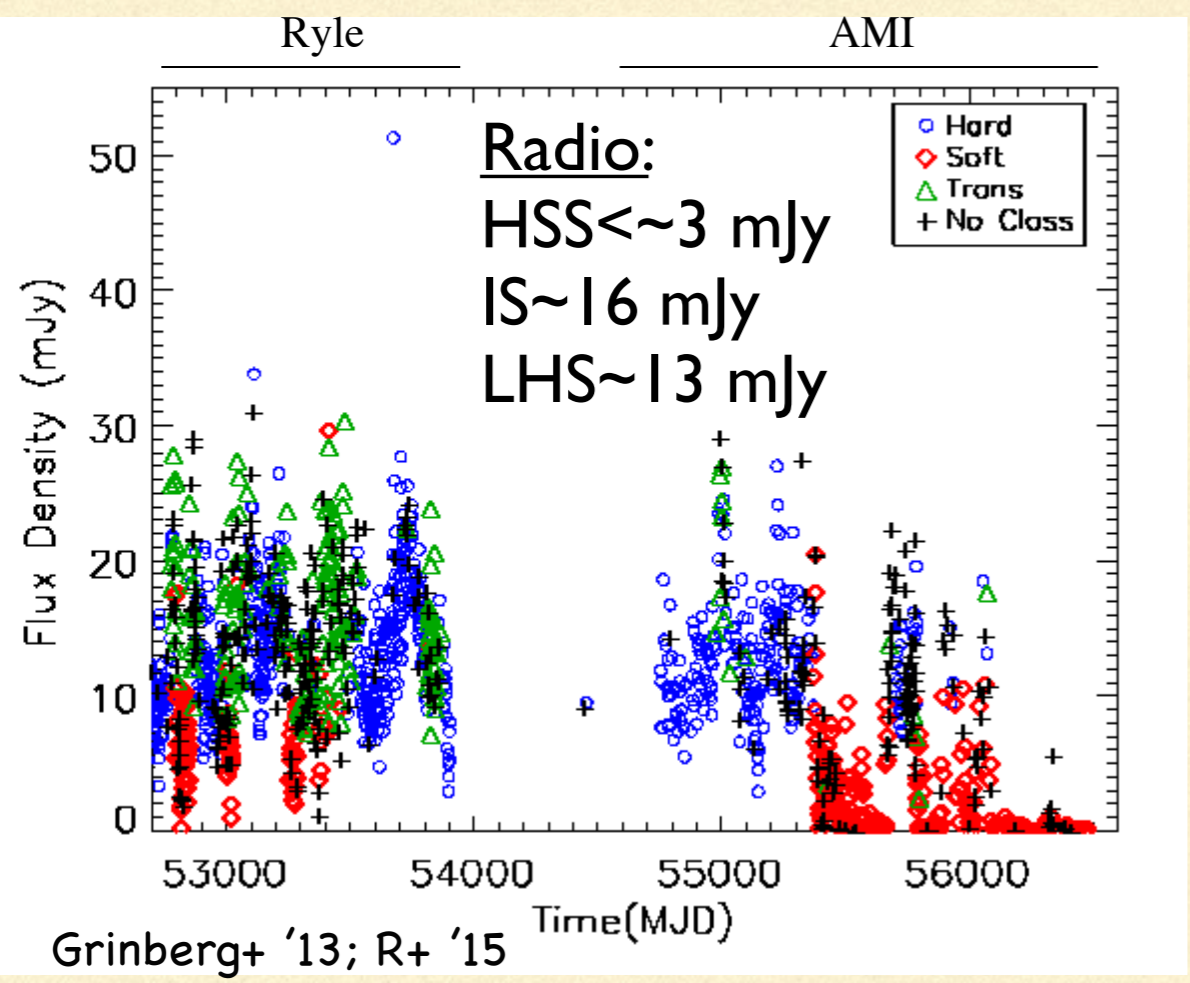
Model-independent ASM based criterion (Grinberg+ '13)



Grinberg+ '13

SOFT VS HARD STATES

Compton + PL in LHS/IS
Compton only in HSS

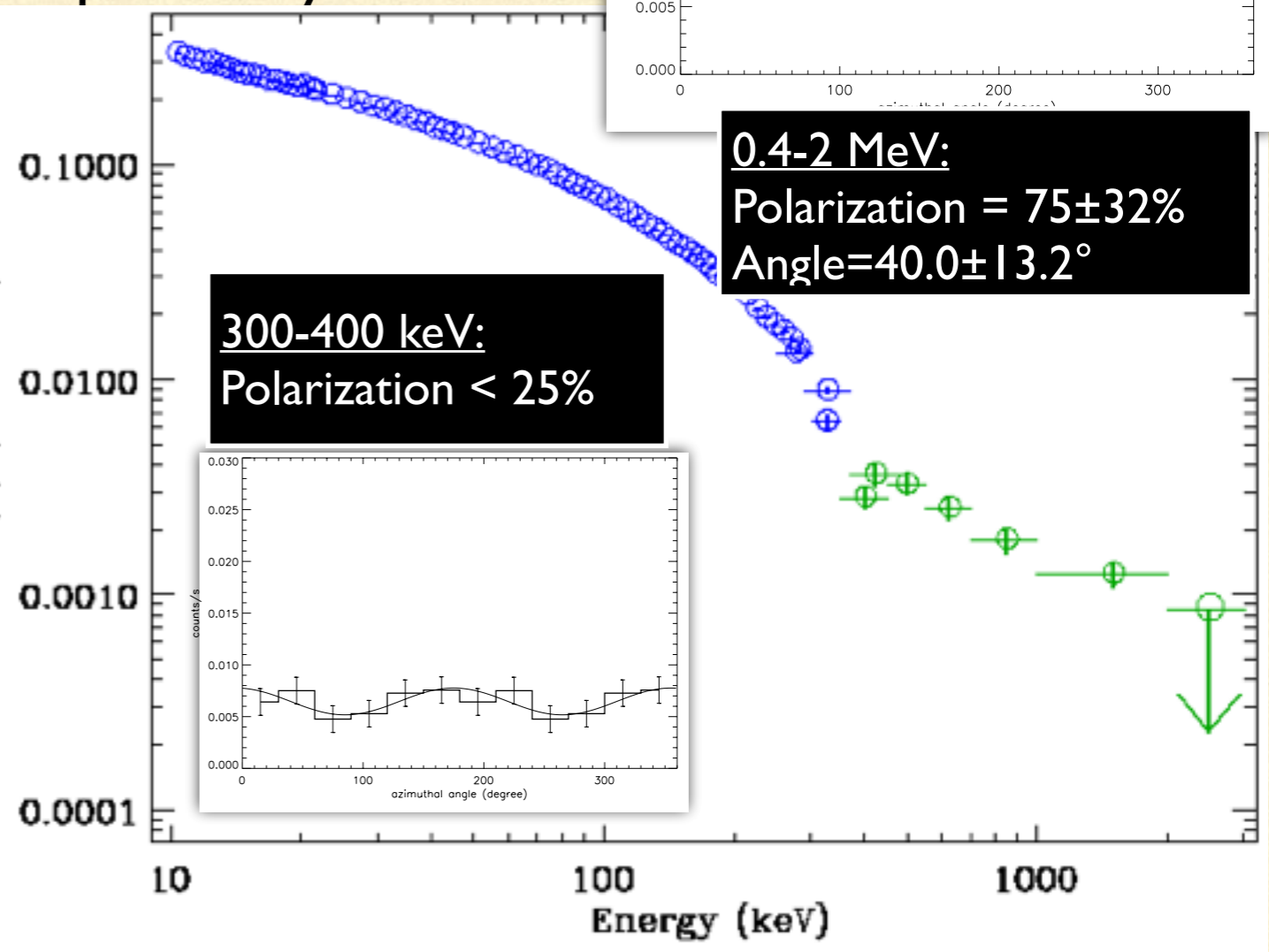
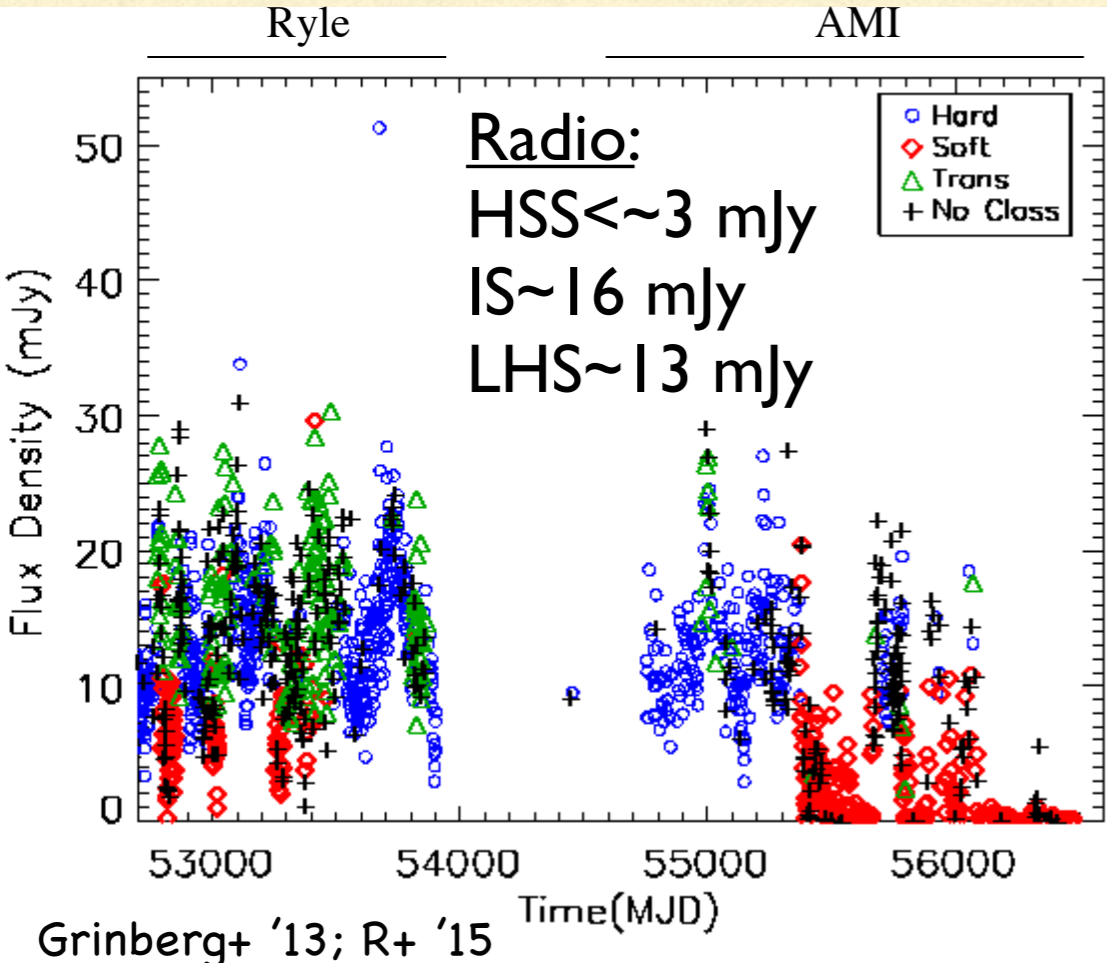


- Hard tail associated with hard state
- Radio (jet) associated with hard state
- Strongly polarized >400 keV tail (LHS)

Detection of compact jet @ high energies (R.+ '15)

SOFT VS HARD STATES

Compton + PL in LHS/IS
Compton only in HSS

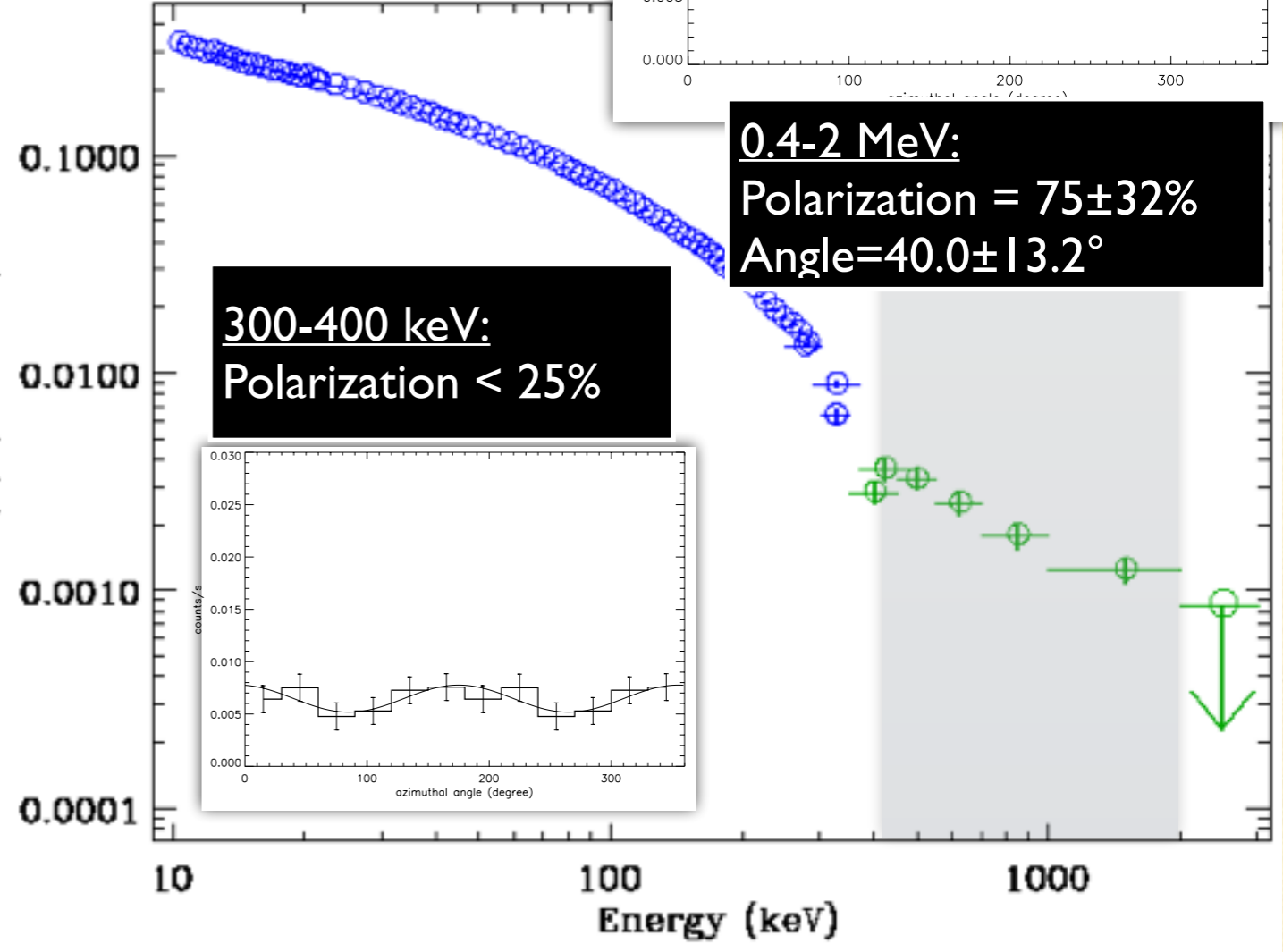
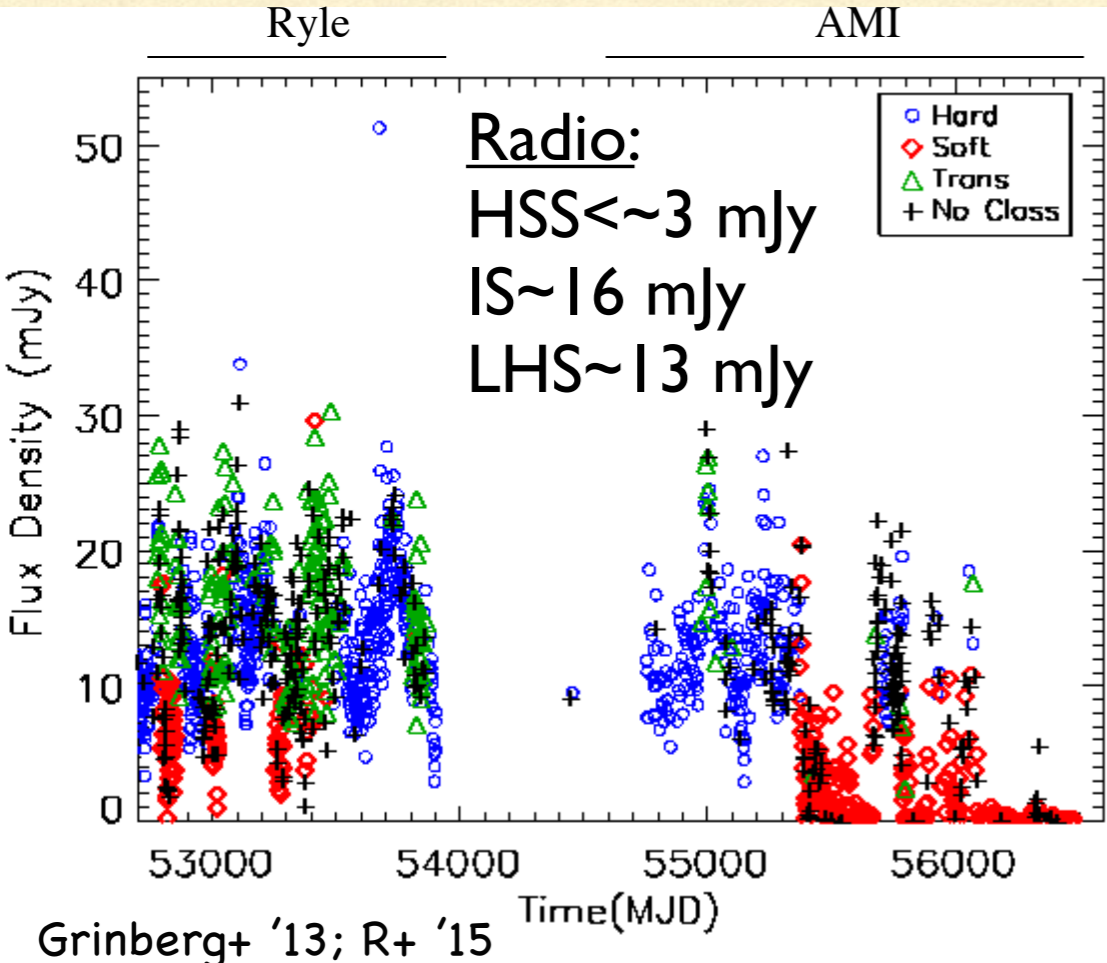


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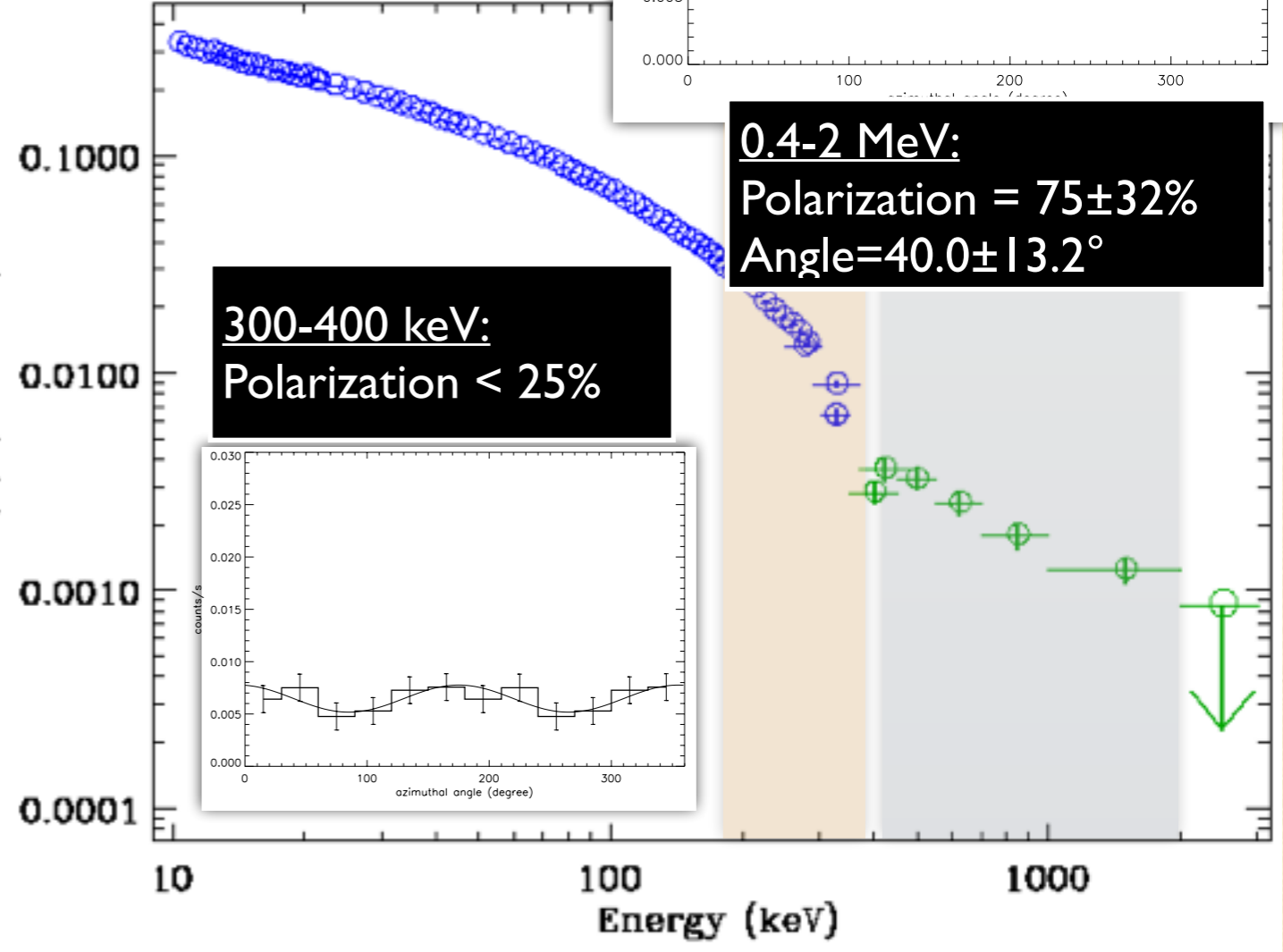
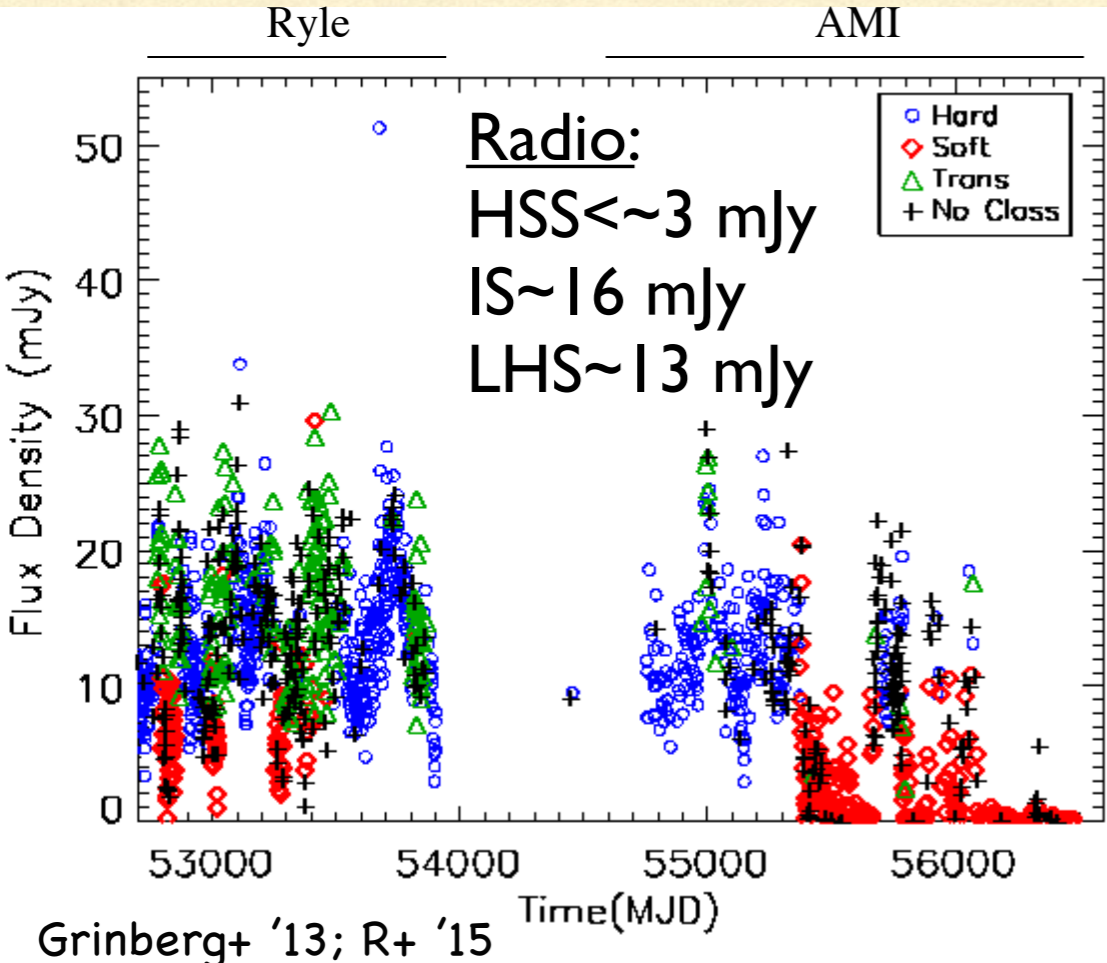


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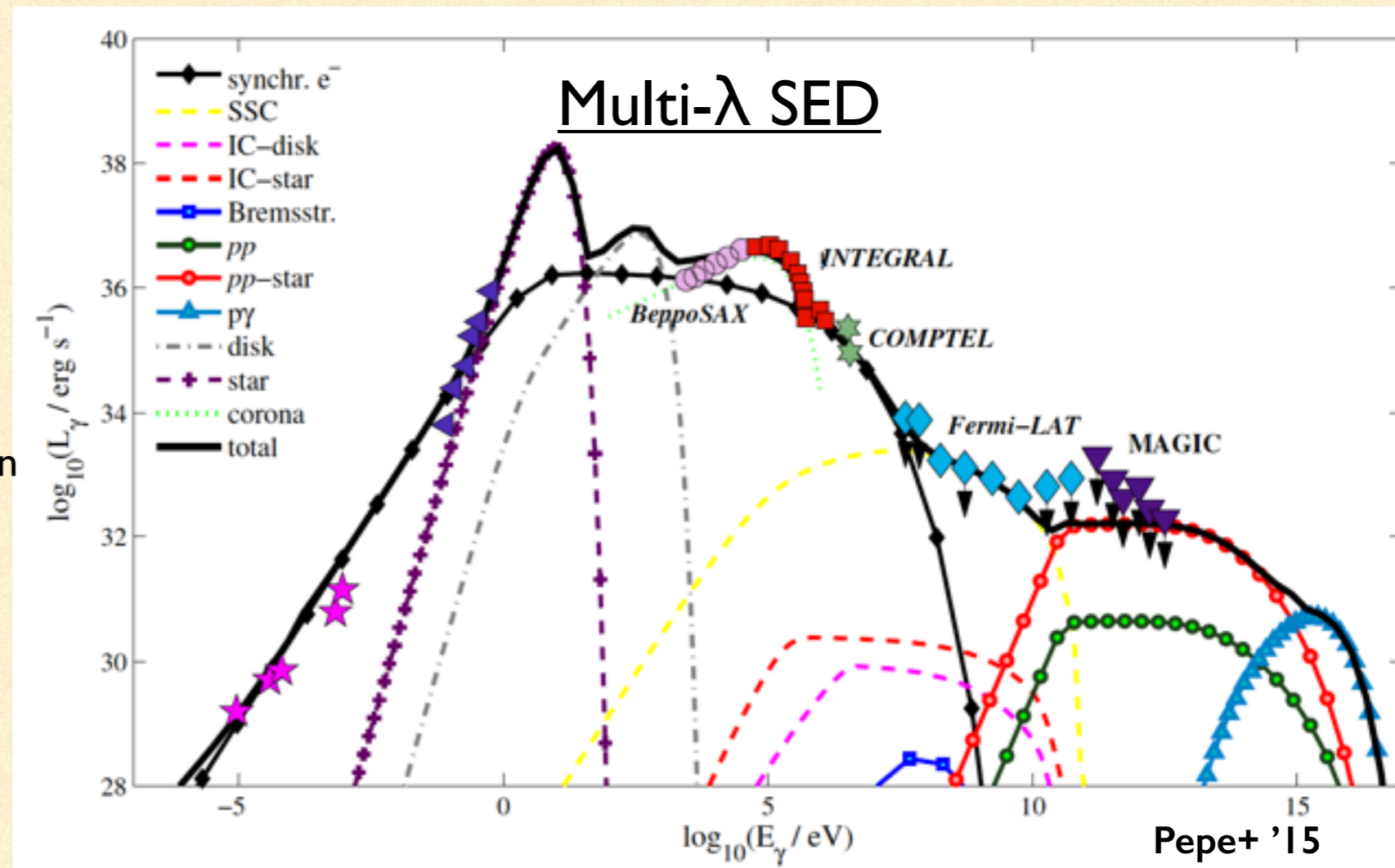


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Detection of compact jet @ high energies (R.+ '15)

JET CONTENT AND MODELS

- Compact jet in LHS
- Discrete ejection / X-ray flares (Wilms+'06)
- Canonical spectral states
- Polarised emission @ MeV
- Detection @ GeV (Bodaghee+'13, Zanin+'16) associated with jet (Zanin+'16)
- Flares @ TeV (Magic)
- Inflated bubbles (Gallo+'05) => jet carry significant E_{kin}



Lepto-Hadronic model for Cyg X-1

1-150 keV : Compton of disk photons

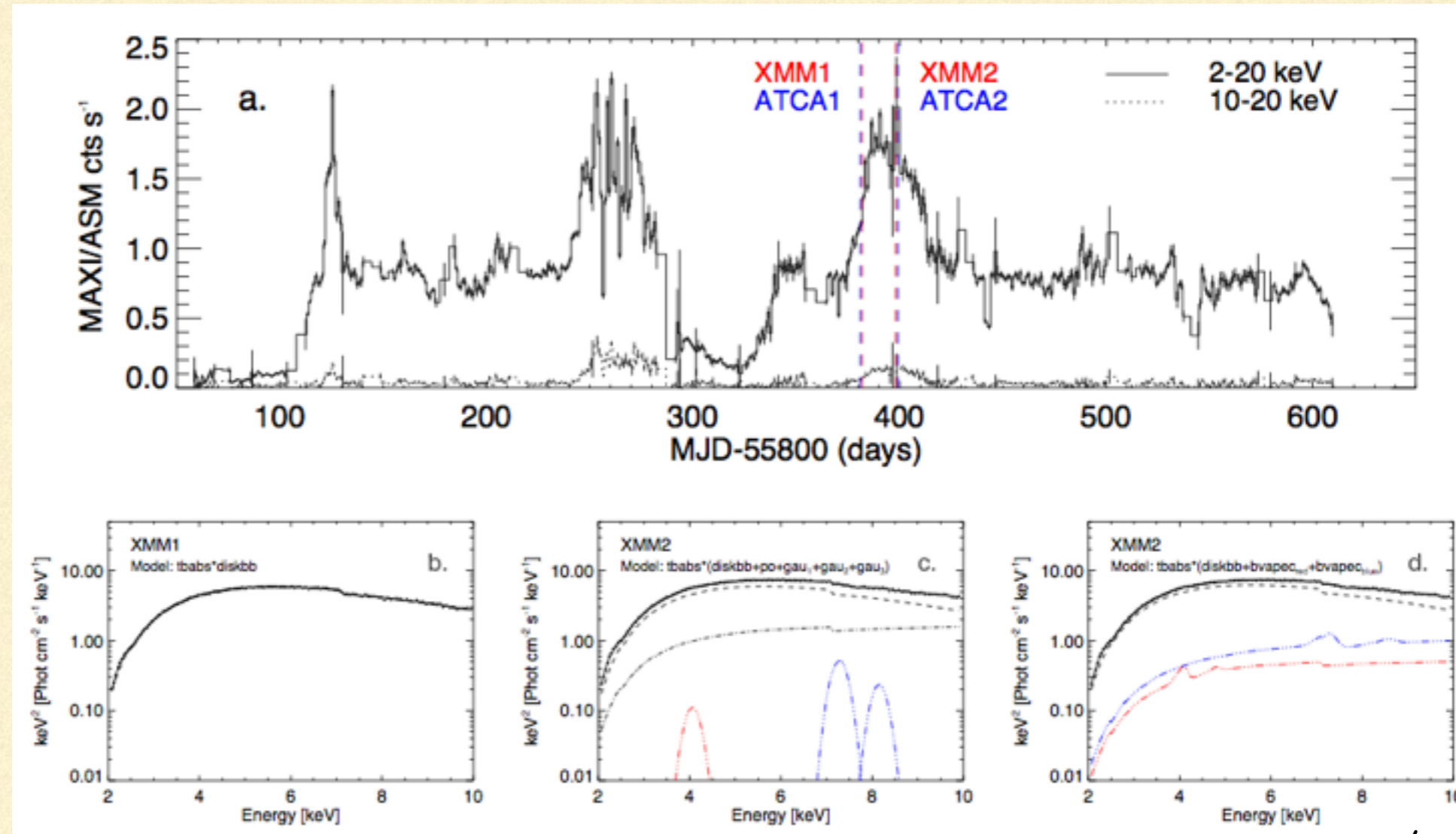
Radio/ γ -rays (10 MeV): Synchrotron from jet

VHE: SSC, pp and $p\gamma$ interactions =>

Hadronic component in jet + TeV flaring expected (Romero+'10)

BARYONS IN JETS ?

- Baryonic jet only in SS 433 (Margon+ '79; Kotani+'94)
- Baryons in jets=> (V)HE emission.



Diaz Trigo+ '13

4U 1630-47: XMM / ATCA observations (Diaz-Trigo+ '13)

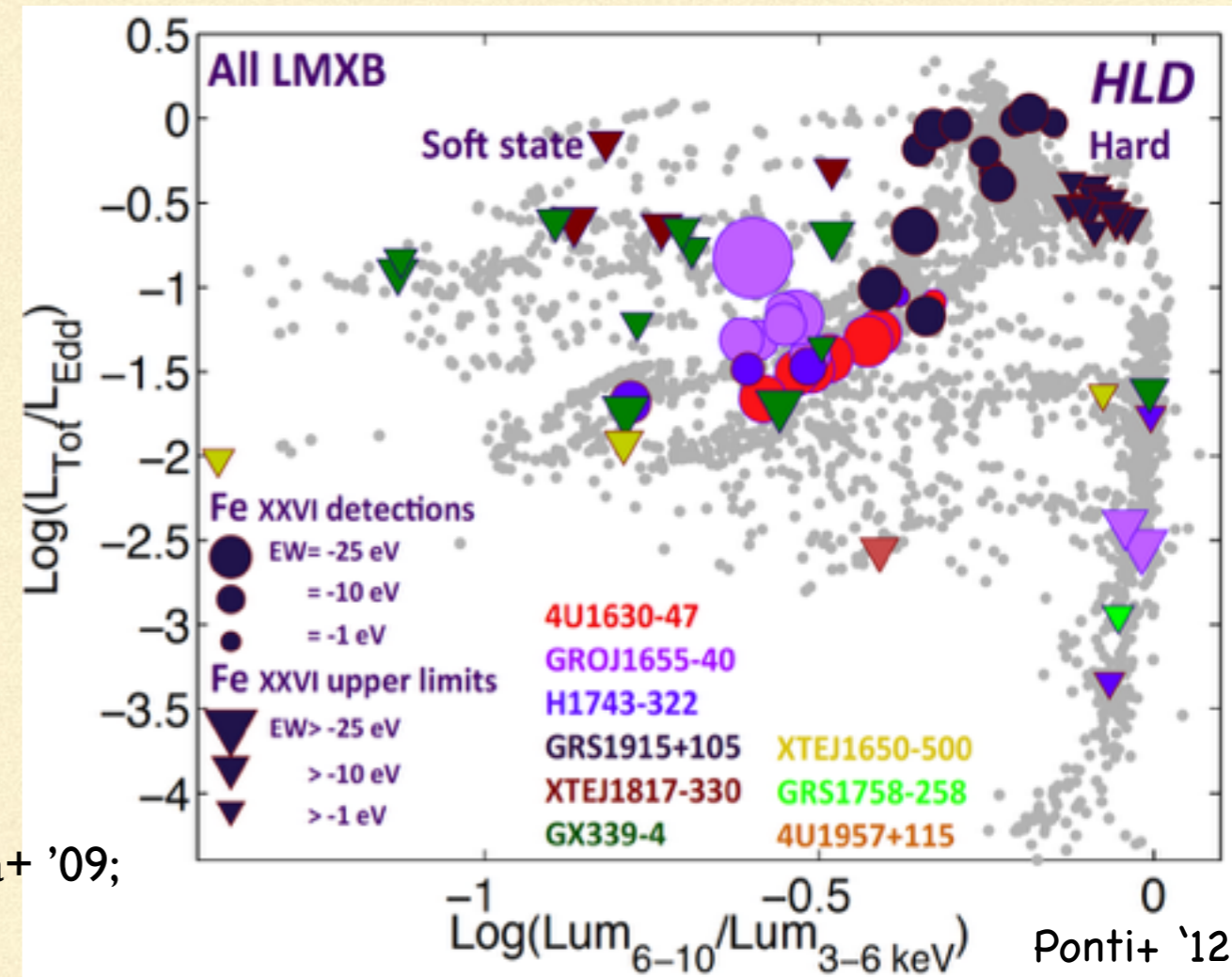
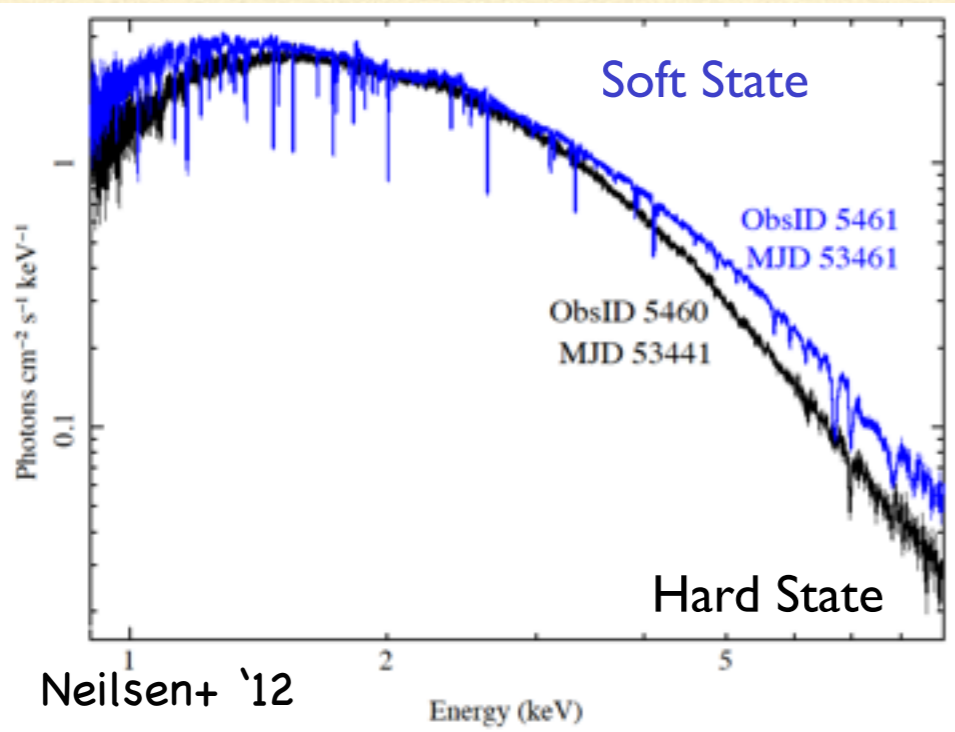
- No radio in XMM 1
- Radio/jet in XMM 2
- Fe Doppler-shifted lines in XMM2
- => Consistent with a $v \sim 0.66c$ jet
- => Flux ratio consistent with Doppler boosting

=>

- Presence of heavy element/nuclei
- Strong impact on E/material feedback (Favour Accretion disk powered jet)
- but
- HE emission expected (not seen yet)
- Line detection controversial

WINDS VS JETS

ASCA => Highly ionised plasma in GRO J1655-40 and GRS 1915+105 (Ueda+'98; Kotani+'00)



=> Confirmed in many systems (e.g. Miller+ '06, '08; Ueda+ '09; Neilsen +'09, '12; King +'12; Diaz-Trigo+'14)

=> Typical outflow velocities $\sim 1000 \text{ km/s}$, as high as $\sim 1e4 \text{ km/s}$ ($0.3c$) in IGR J17091-3624 (King+'12)

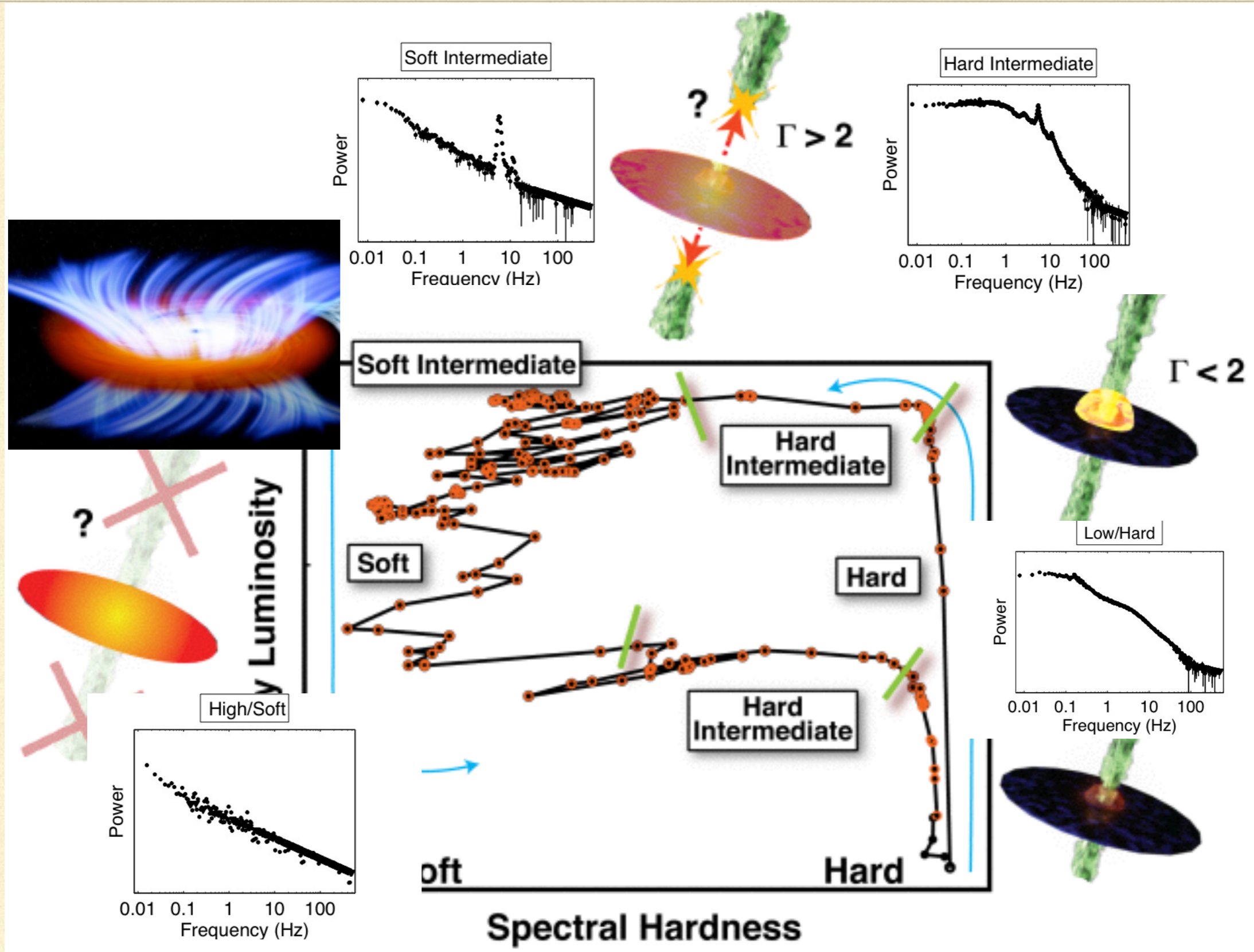
=> Associated with HSS (e.g. Neilsen+ '12; Ponti+'12)

=> Mutually exclusive with compact jet (Neilsen & Lee '09; Ponti+'12)

=> Amount of mass in outflow $> \sim$ mass accreted (Ponti+'12)

Production?
Instabilities, state transitions ?
Regulation of accretion ?

A NEW UNIFIED PICTURE



SUMMARY

- Characterisation of emitting media : composition of jets, energetics, feedback, through HE emission (X to gamma-rays)
- Ionised plasma and disc atmosphere associated with outflows (wind)
- Outflows during HSS in anti-correlation with jets

Ejections/winds might carry away most of the accretion energy/material

+

Other « hot » topics ignored in this talk :

- Spin of BH
- Jet productions: BZ vs BP
- Geometrical approaches through reverb. Mapping
- Fast timing analysis: QPOs and models link to accretion properties

CONCLUSIONS

- High throughput/ narrow field instruments (Chandra, XMM, Nustar, Suzaku...)
=> deeper into the physics of accreting sources
- This would have not been possible without alerts on outburst / state transitions / flares / unpredictable behaviour from wide field/all sky monitors

=> Need for all sky monitor such as Maxi, Swift
- 2020 is the era of large radio array and sky surveys / alerts in radio/optical with a very high expected discovery space

=> Need for the possibility to quickly react to alerts