

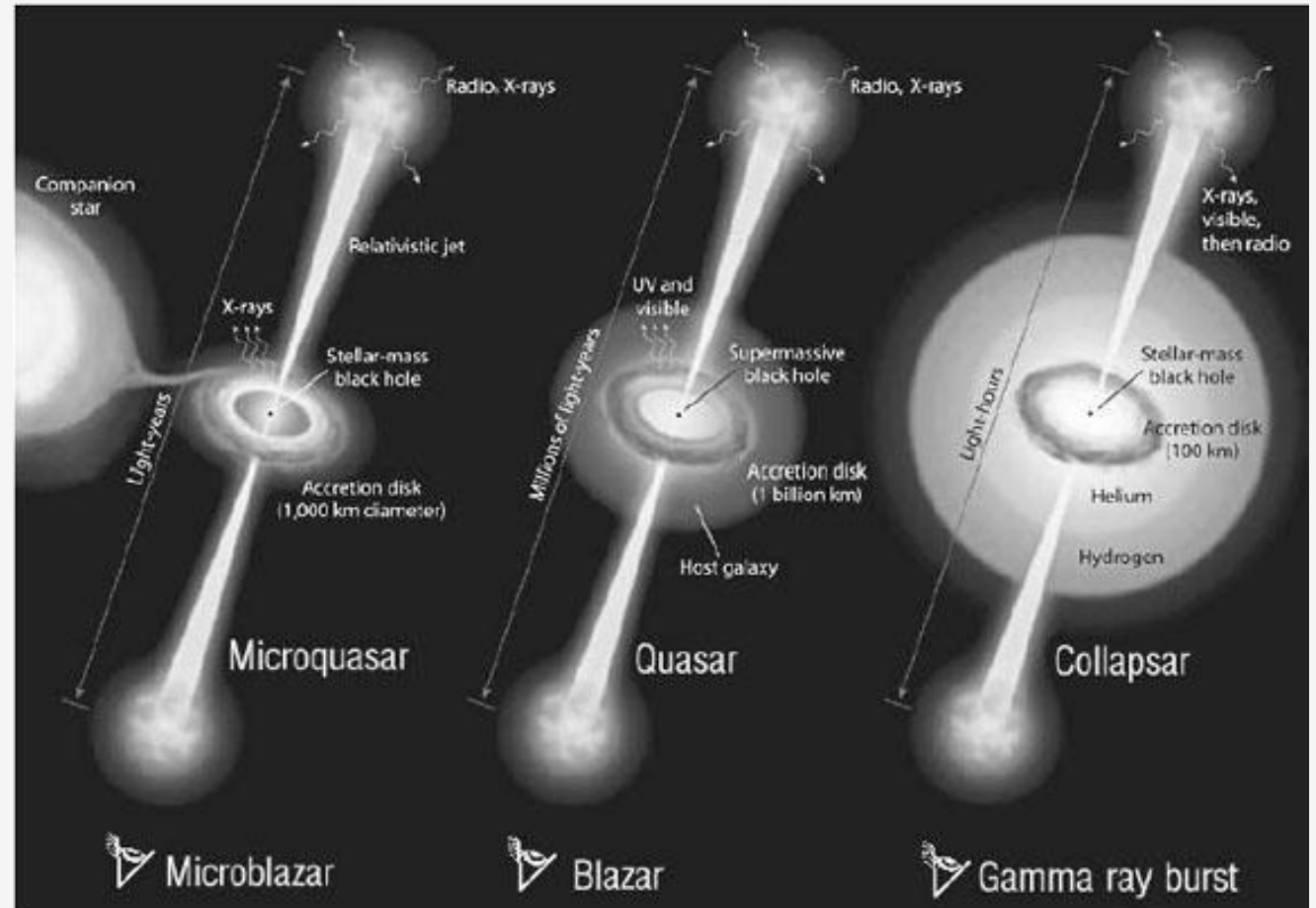
SIMILARITY AND DIVERSITY OF BLACK HOLE SYSTEMS

View from the Very High Energies

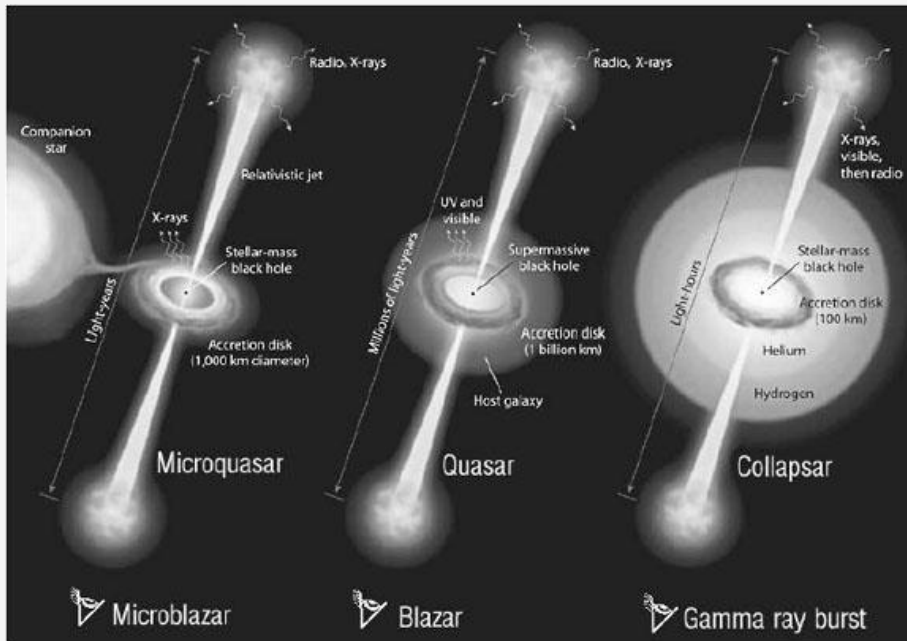
*Elina Lindfors, Tuorla Observatory @ IAU Symp. 324, 12-16
September, 2016*

Classical view

*Spinning black hole
Accretion disk
Collimated jets of particles*



Looking at the big picture



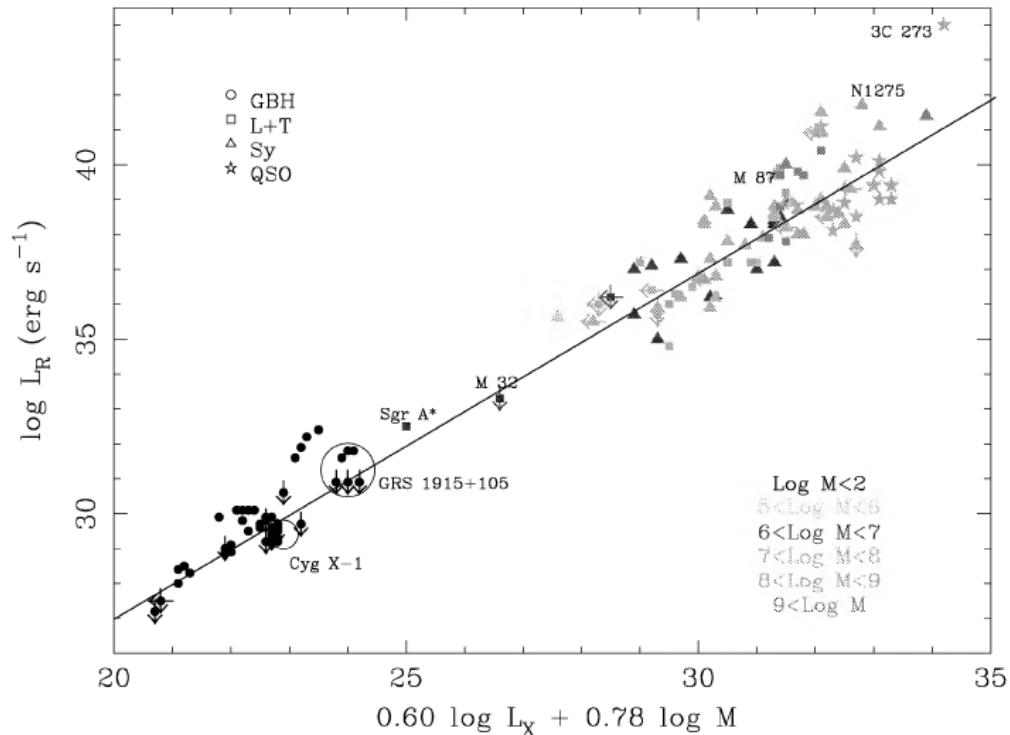
Central engines share the same basic astrophysical ingredients but vastly different mass scales

- What properties simply scale with the black hole mass? Could be sign of something fundamental?
- Does everything just scale?
- Same flaring mechanism?

Scalings

Fundamental plane of black hole activity
(Merloni et al. 2002)

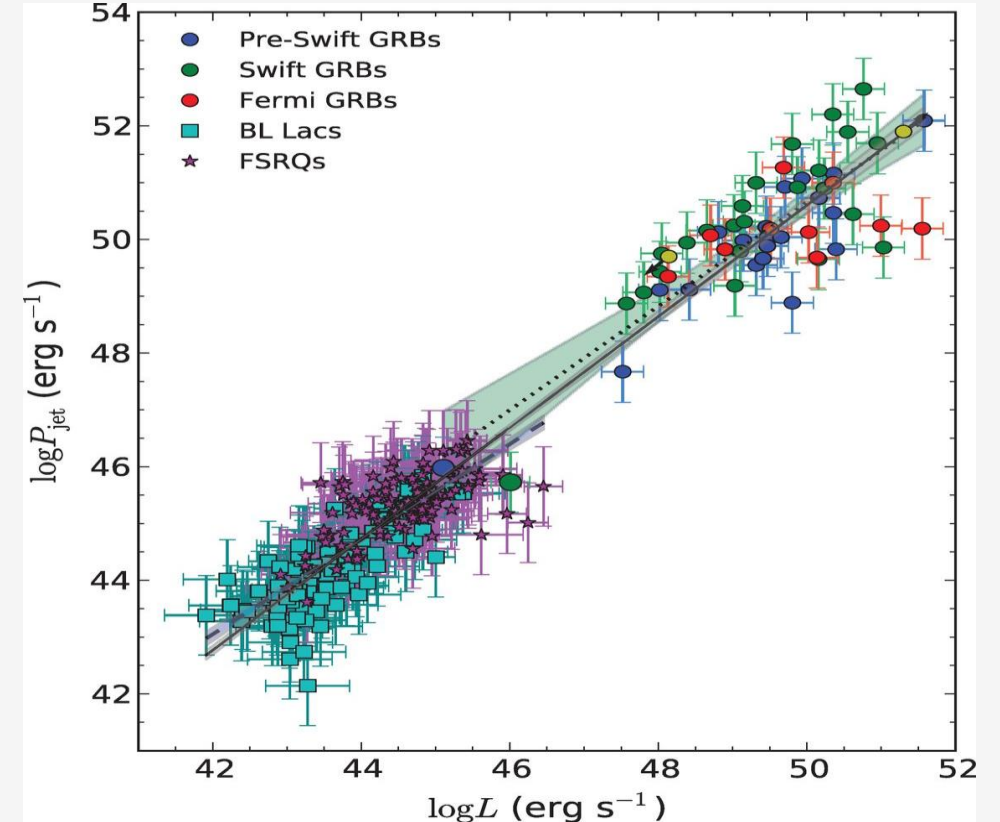
Active galaxies and galactic black holes: points in three dimensional space (L_R , L_X , M) lie on a plane



*Elina Lindfors, Tuorla Observatory @ IAU
Symp. 324, 12-16 September, 2016*

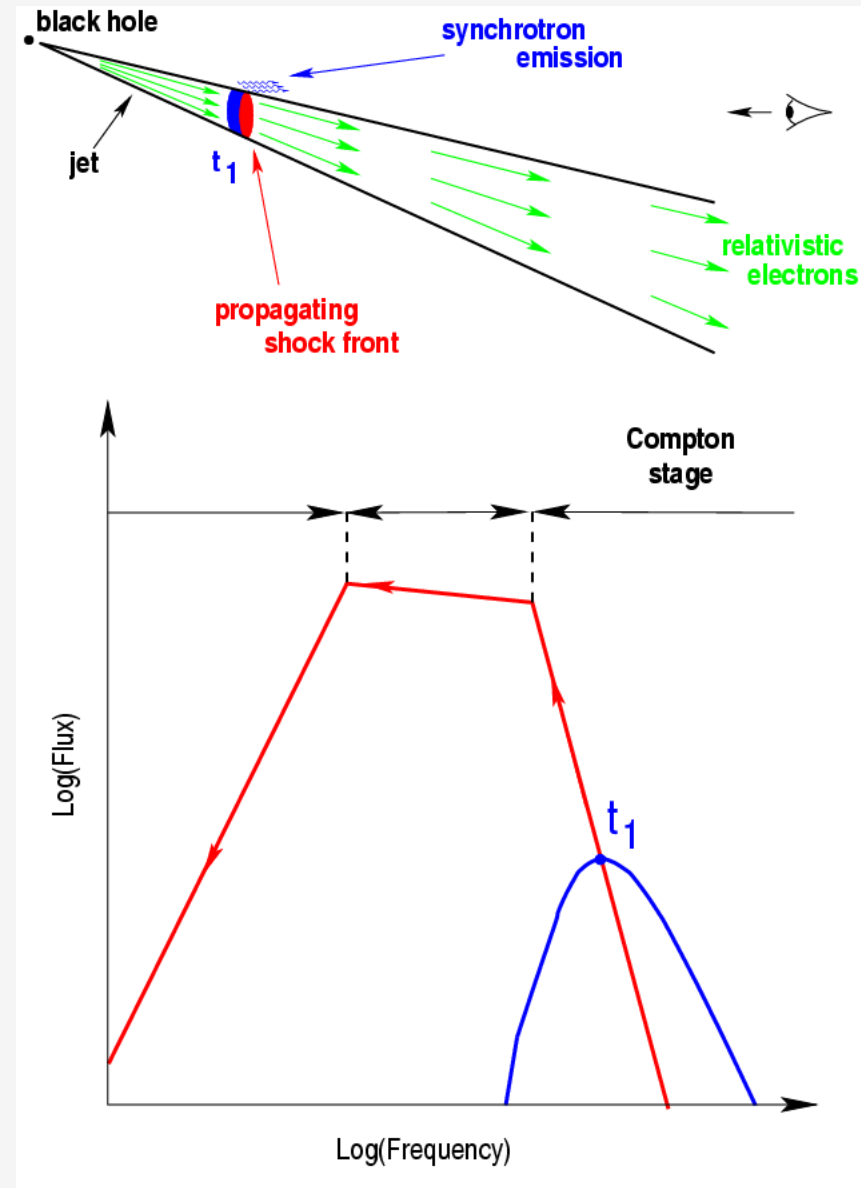
Collimation-corrected gamma-ray
Luminosity vs. kinetic jet power in
AGN and GRBs (Nemmen et al. 2012)

Jets created by black holes maintain
the same coupling between the total
power carried by the jet and power
radiated away.



Flaring behavior

Radio to optical flares are shocks travelling in a jet, going through three stages of evolution



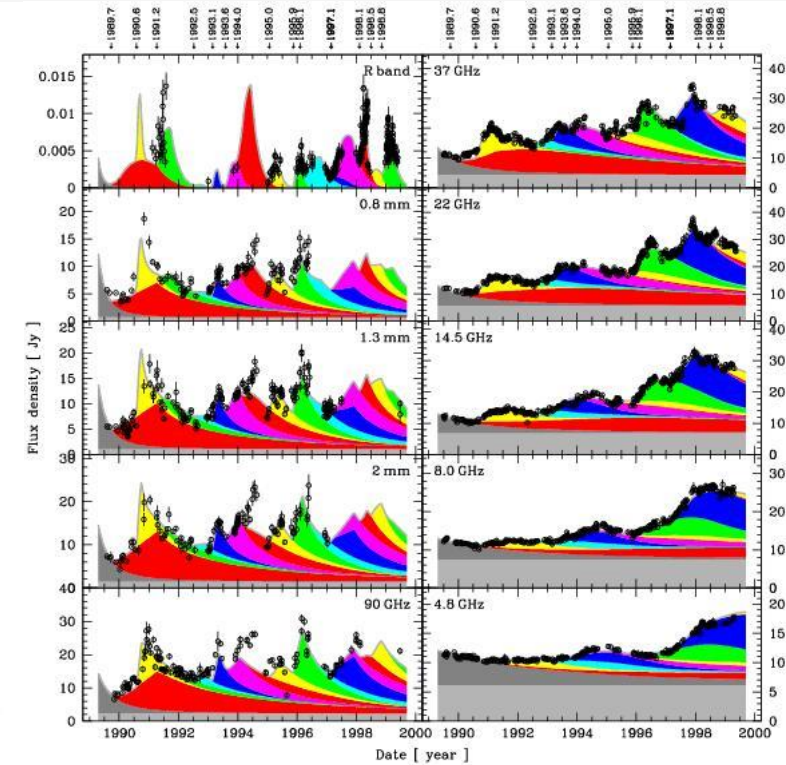
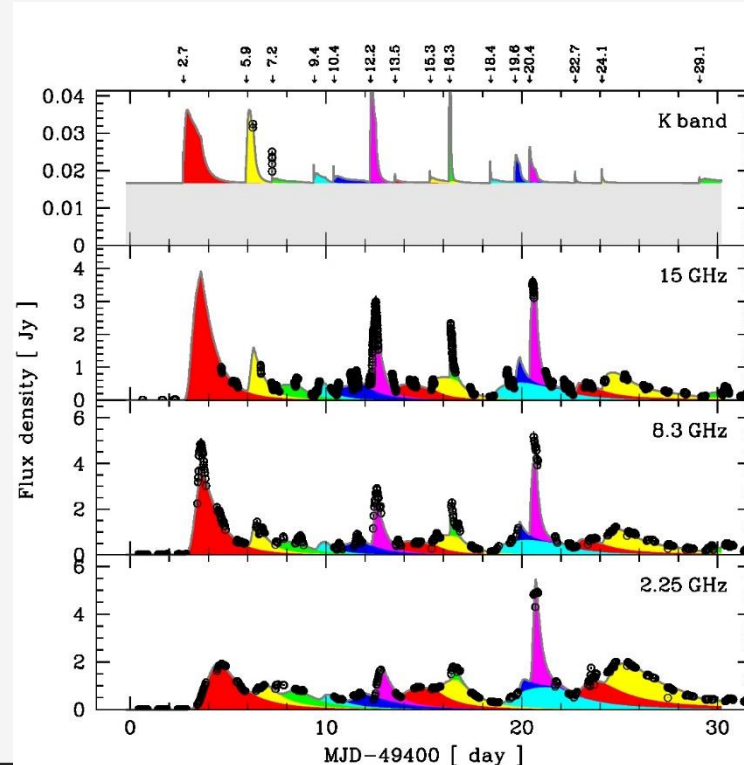
Flaring behavior

Decomposing the lightcurves to derive the evolution of the jet parameters.
Method developed by Türlér et al. 2000

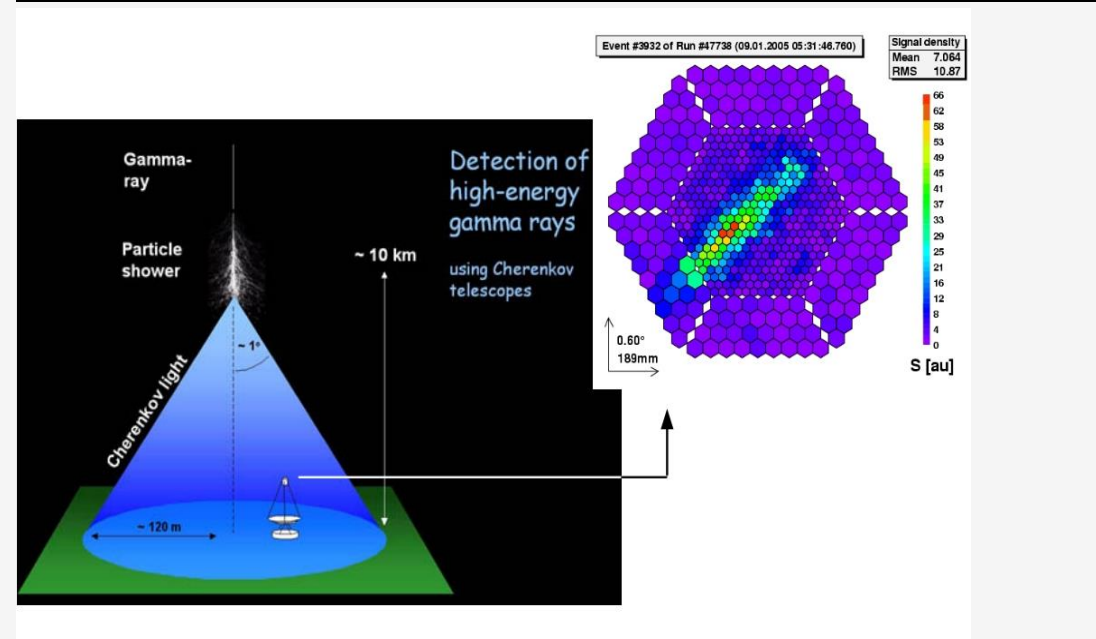
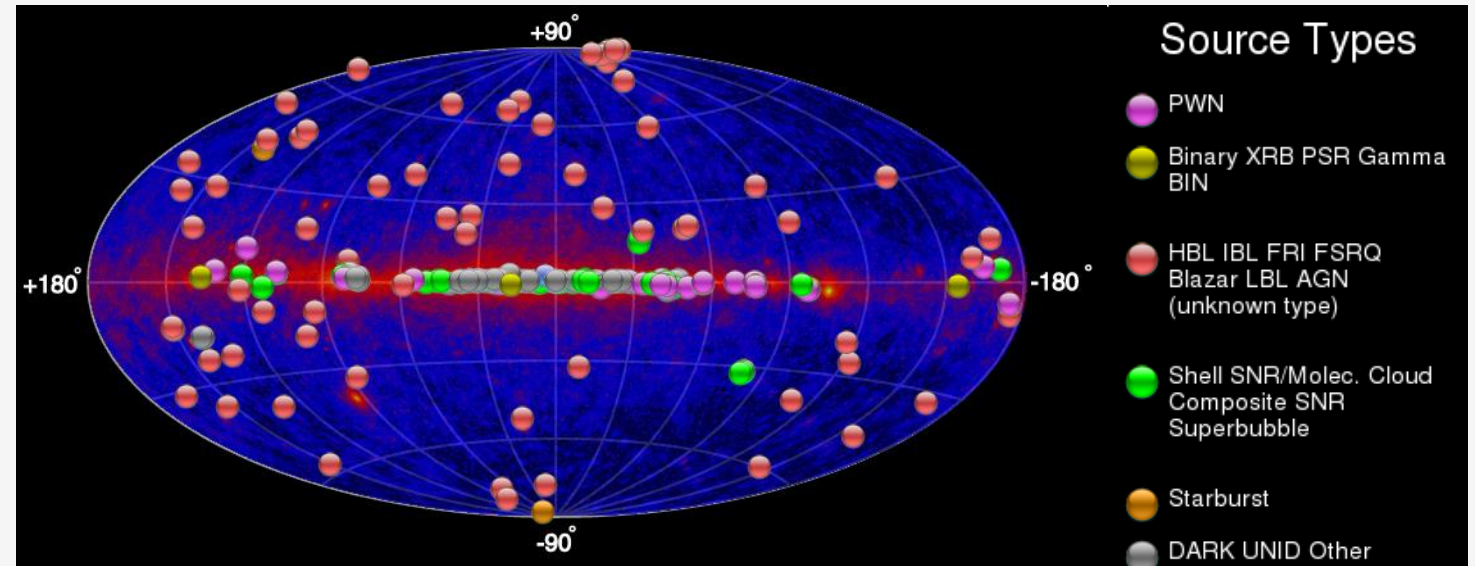
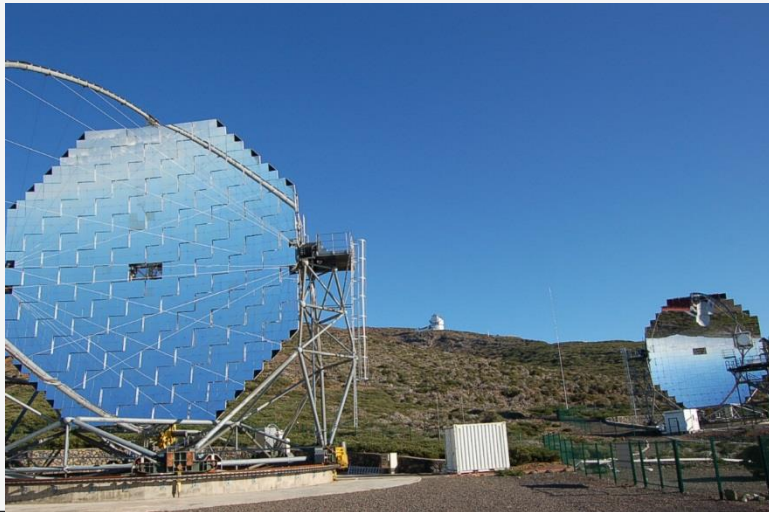
Cyg X-3

3C279

- Outbursts in blazar 3C279 and microquasar Cyg X-3 are well described by shock in jet model.
- Jet parameters derived were similar for both jets

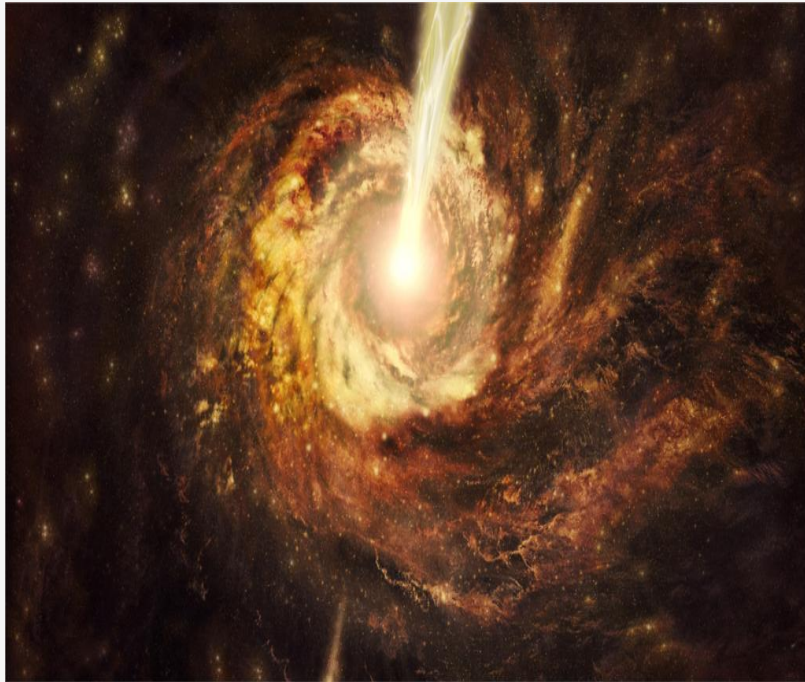


View from the Very High Energies



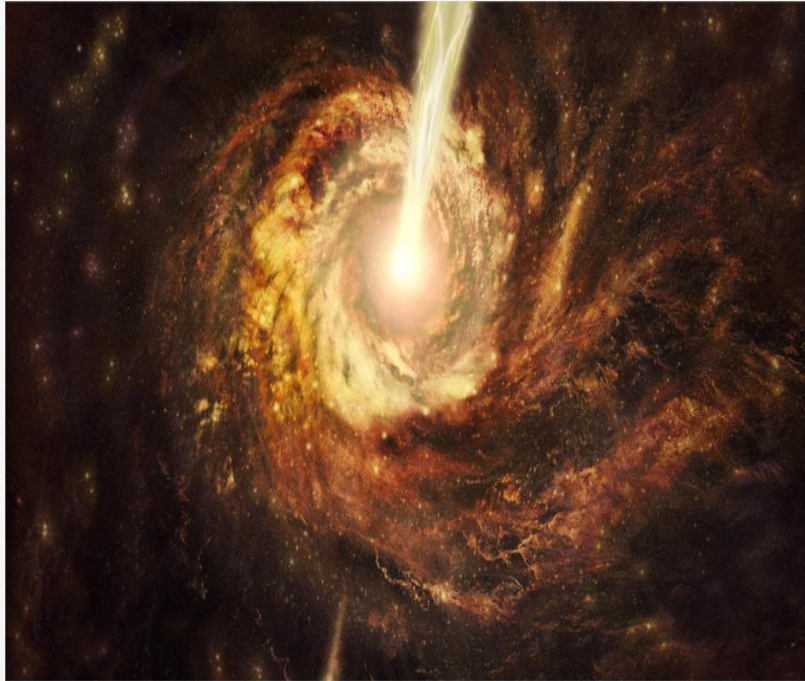
Elina Lindfors, Tuorla Observatory @ IAU
Symp. 324, 12-16 September, 2016

Active Galactic Nuclei



- The most numerous sources in the VHE gamma-ray sky
- Mostly blazars of High Synchrotron Peaking BL Lac type
- But diversity is increasing: radio galaxies, low synchrotron peaking sources
- Moreover starburst galaxies
- ...and the center of our galaxy

Radio galaxies

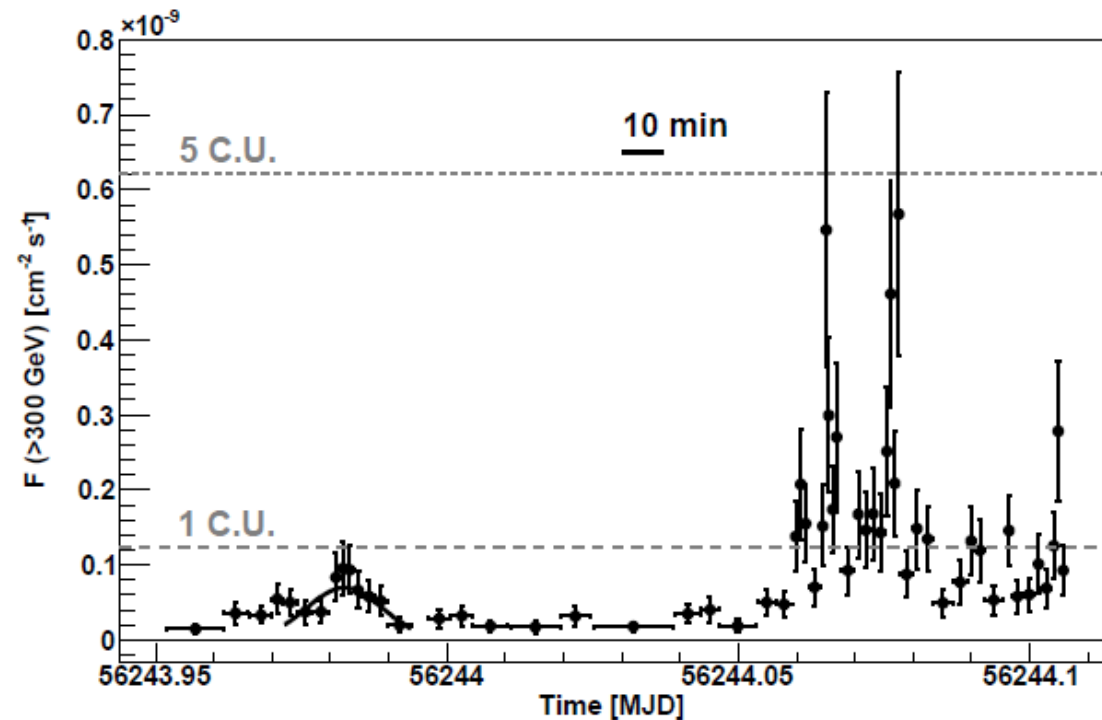
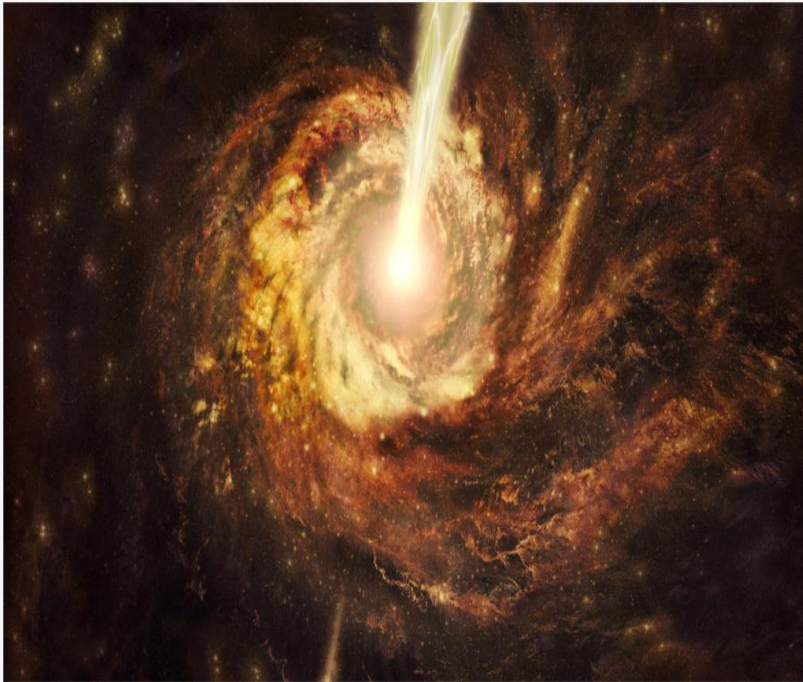


Four known to emit VHE gamma-rays:

- Cen A (presentation on Wednesday by Paula Chadwick)
- M87 (presentation on Tuesday by Cornelia Arcaro)
- NGC1275 (origin of the VHE gamma-rays: spine-sheath structure of the jet? Aleksic et al. 2014)
- IC310

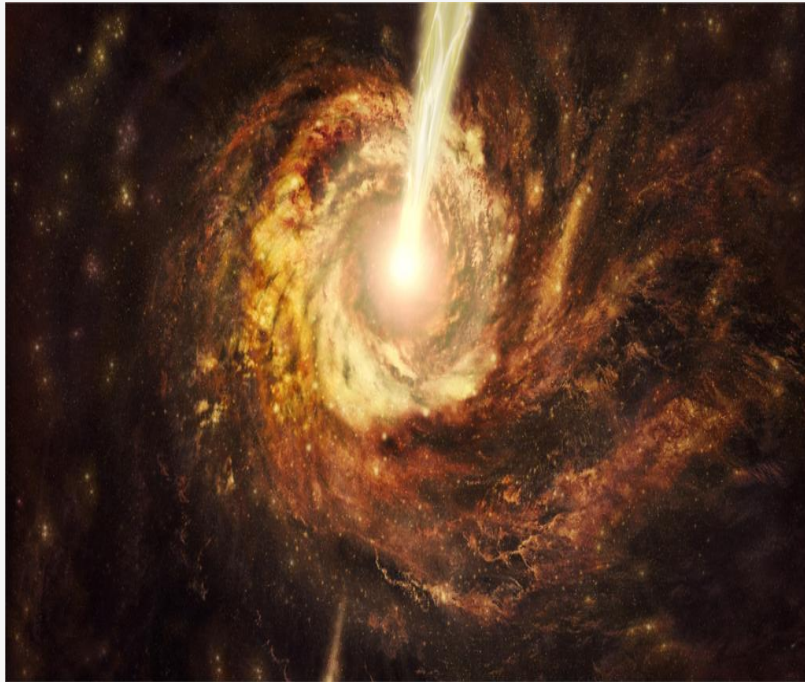
IC310

- In Perseus cluster; VLBA shows blazar like jet with viewing angle 10-20 degrees
- Variable in VHE band (MAGIC Collaboration 2014)
- Huge flare in Nov 2013

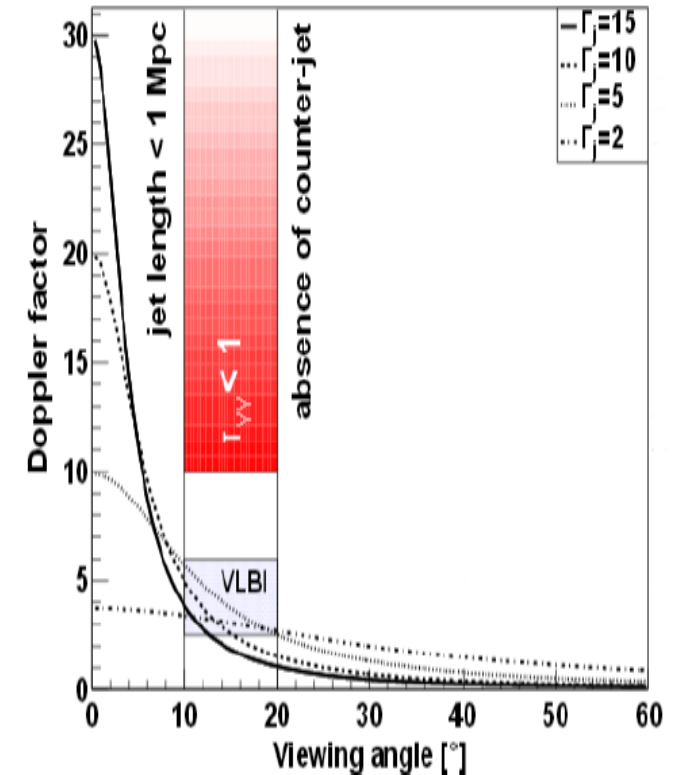


Aleksić et al. 2014, *Science*

IC 310

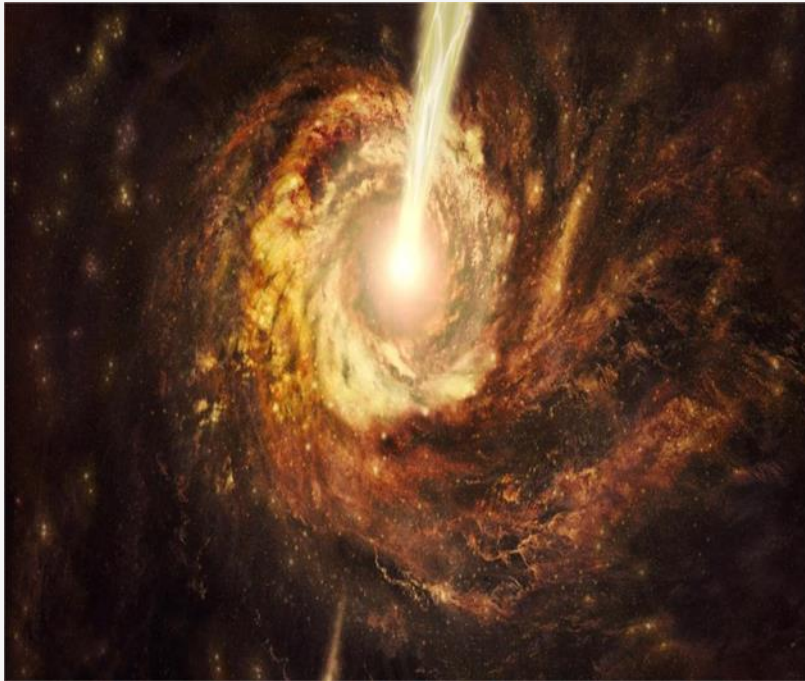


- $R < \delta c \tau_{\text{var}} = \delta \cdot 0.2 \cdot R_G$ (for 4.8 min, $M_{\text{BH}} = 3 \times 10^8 M_{\odot}$ Aleksić et al. 2014, *Science*)
- Opacity problems: typically solved by $\Gamma \sim 50$ (Begelman et al. 2008)
- Here: $\delta \gtrsim 10$ required
- Possible production mechanism:
 - Jets-in-jet models based on magnetic reconnection? Giannios et al. 2010
 - Or star/cloud-jet interaction? Bednarek & Protheroe 1997, Barkov et al. 2010/2012

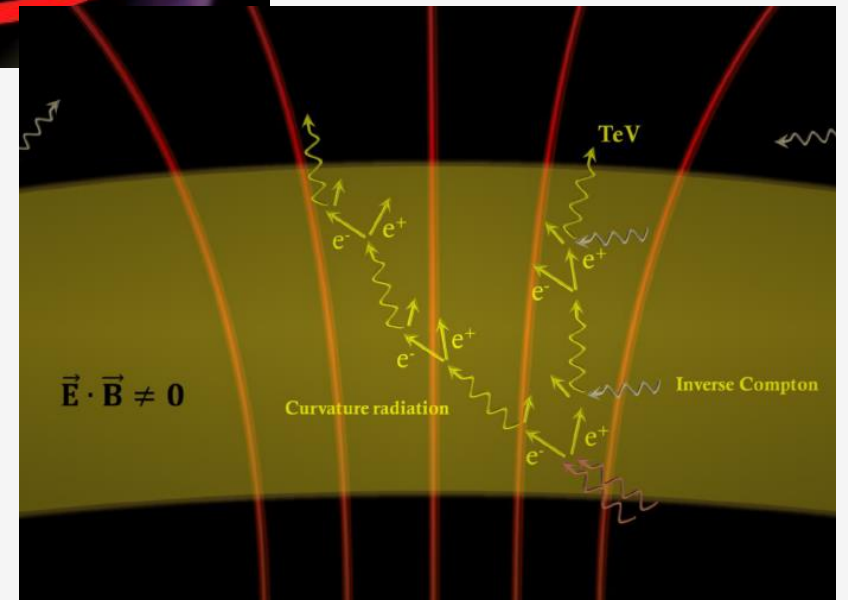
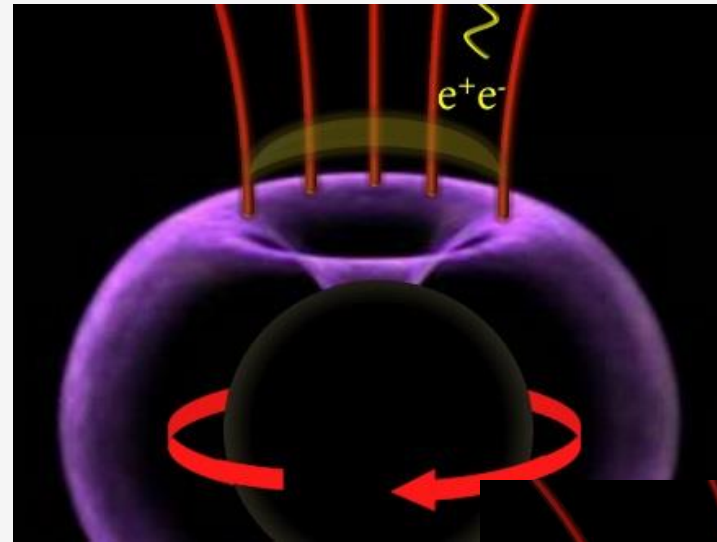


Aleksić et al. 2014, *Science*

IC 310 *Black hole* *lightning*



- Magnetospheric models:
Curvature radiation, Inverse Compton

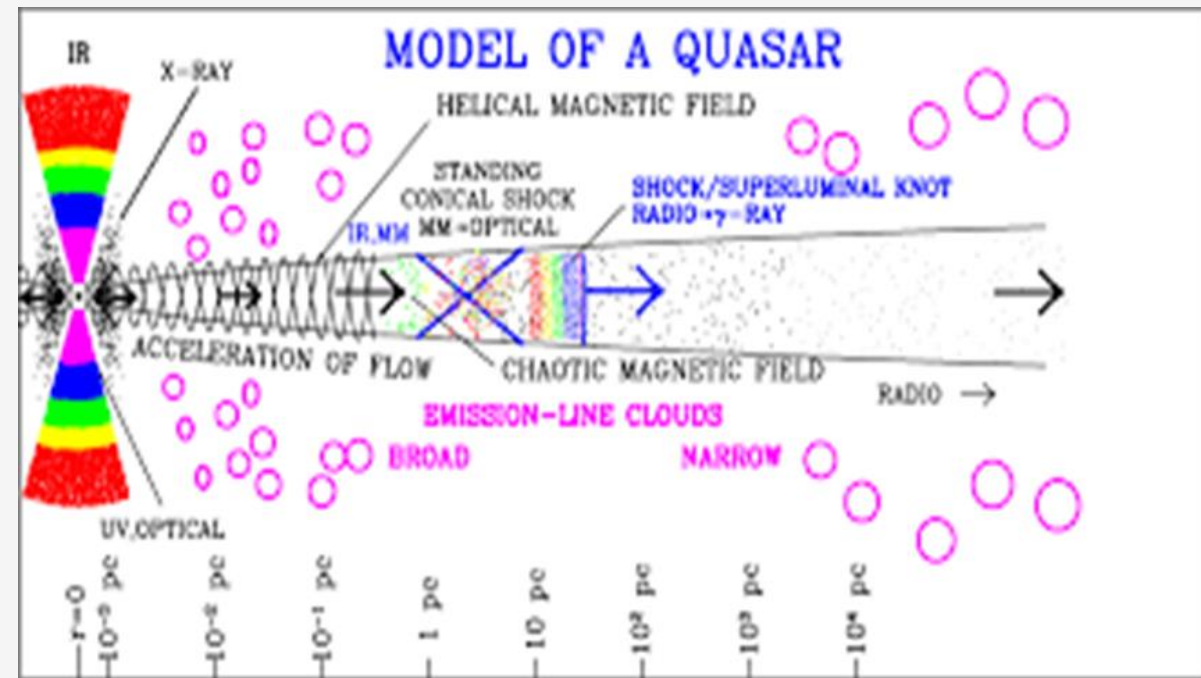
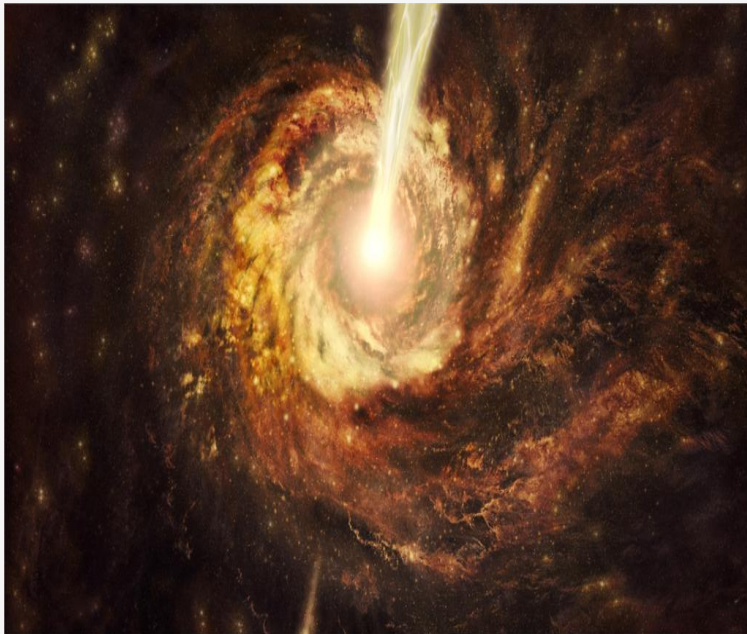


Blazars

Talks on Tuesday and Wednesday

Tuesday afternoon M. Barkov on fast variability

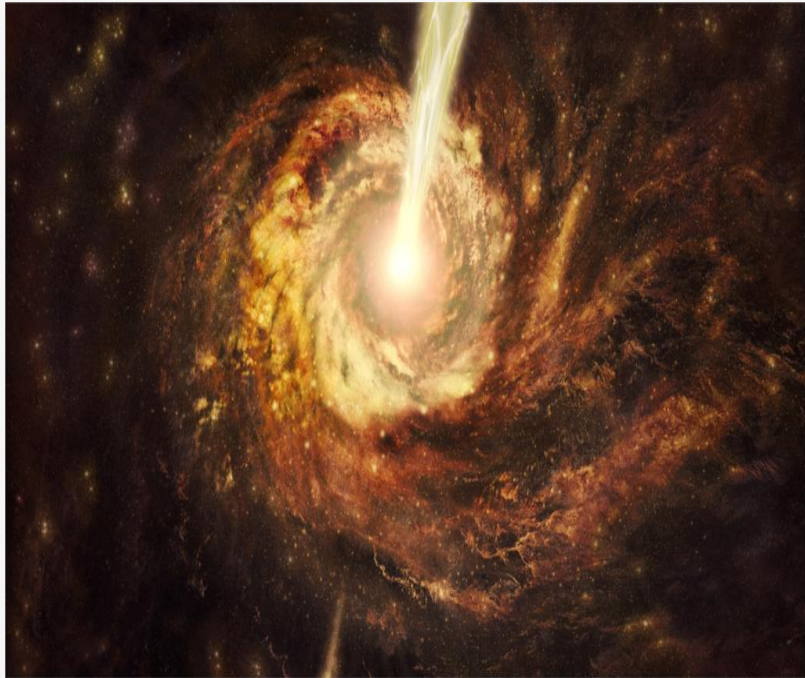
- Fast variability seen in all types of VHE blazars (timescales down to minutes)
- Tempting to place the emission region close to the black hole
- But very difficult for VHE gamma-rays to escape



Blazars

Talks on Tuesday and Wednesday

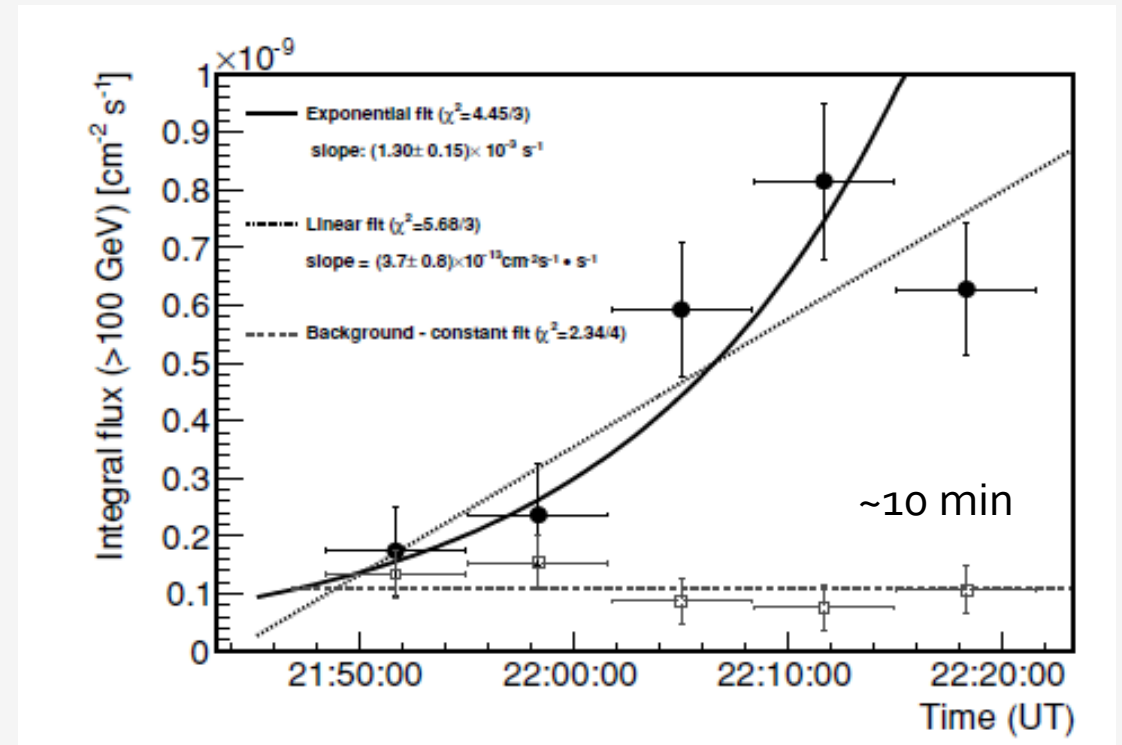
Tuesday afternoon M. Barkov on fast variability



Many possible models:

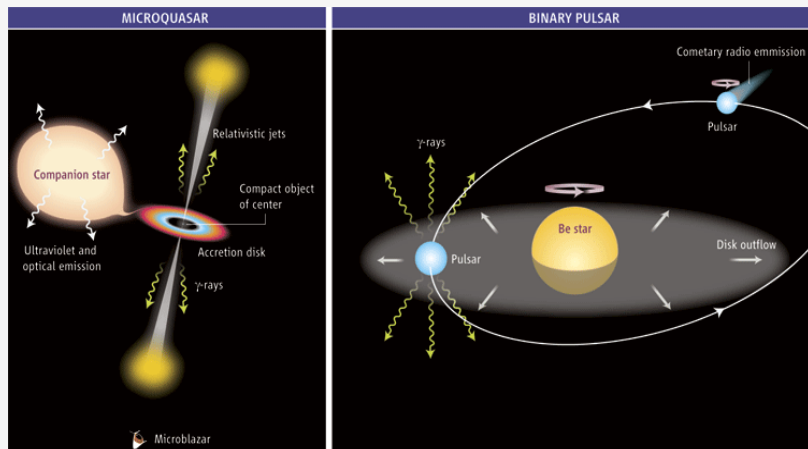
- strong recollimation of the jet
- very compact region embedded within large scale jets (spine-sheath, jets-in-jet, ring-of-fire)

PKS1222+216



Microquasars

- Detections of VHE gamma-rays from LS5039 and LSI +61 303 (Aharonian et al., Science 309, 746 (2005), Albert et al. Science 312, 5781 (2006))
- Periodic emission, later observations favored binary pulsar model
- Observations of Cyg X-1 and Cyg X-3: no detection of VHE gamma-rays
- Observations of GRS 1915+105, Circinus X-1, V4641: no detection of VHE gamma-rays

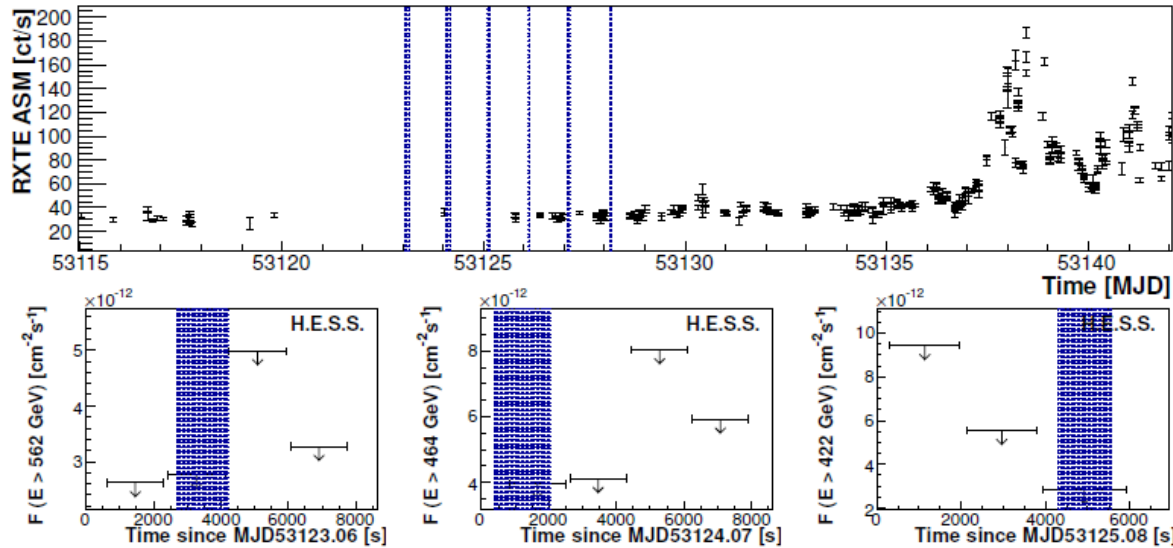


Microquasars

Why dont we see them in the VHE gamma-rays?

They dont emit gamma-rays?

Observational bias?



HESS Collaboration, 2016, 1607.04613

Fermi (>100MeV) sees Cyg X-3 (variable emission) and now Cyg X-1, strong correlation of gamma excess with X-ray state: **the jet**

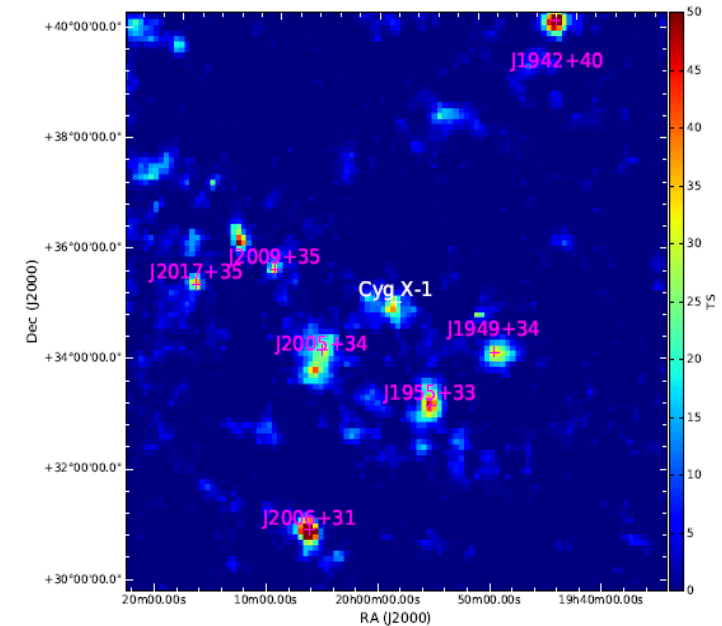


Fig. 2. $5^\circ \times 5^\circ$ TS map centered at the nominal position of Cygnus X-1 above 1 GeV obtained when including only the 3FGL sources in the background model.

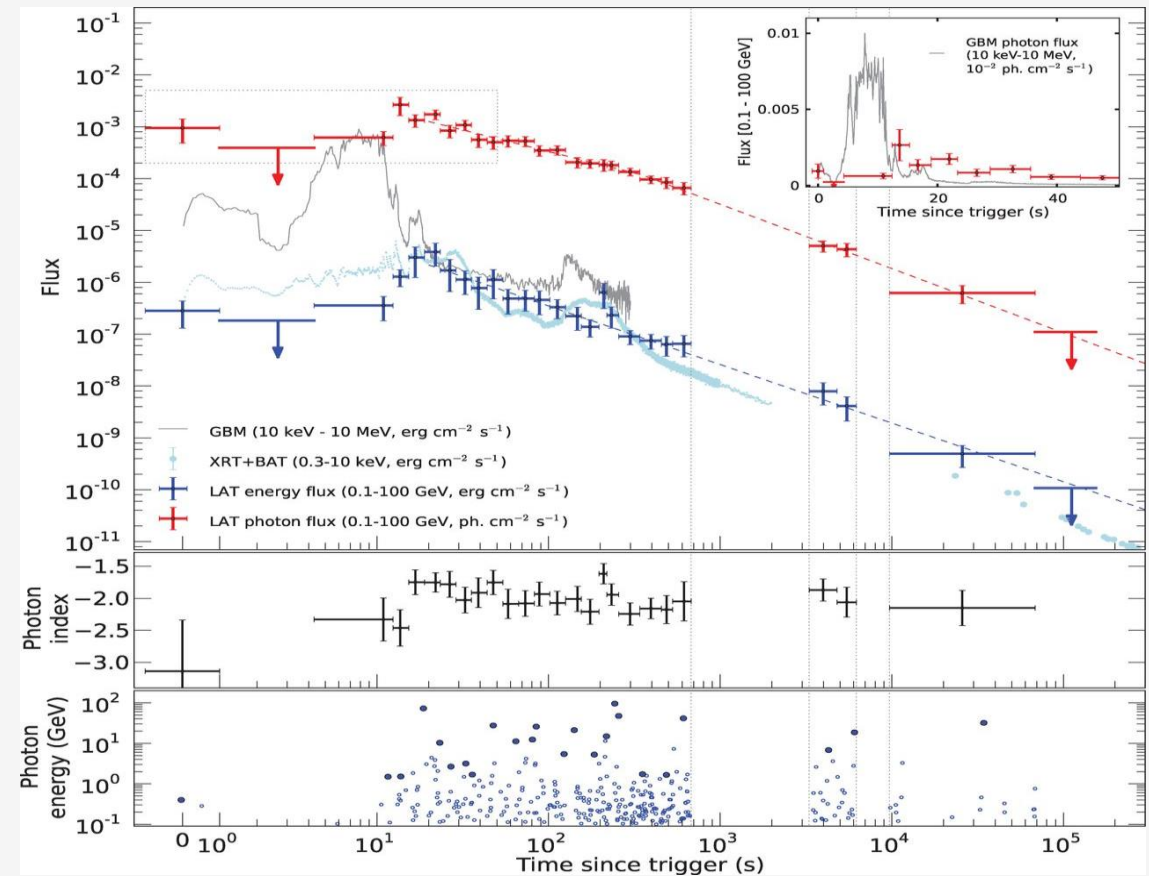
Zanin et al. 2016, 1605.05914

Gamma-ray bursts

This afternoon

On prospects for CTA: S. Inoue on Friday

- Late time VHE emission from GRB's seen by Fermi
- LAT sees ~5/yr GRBs with photons >1GeV

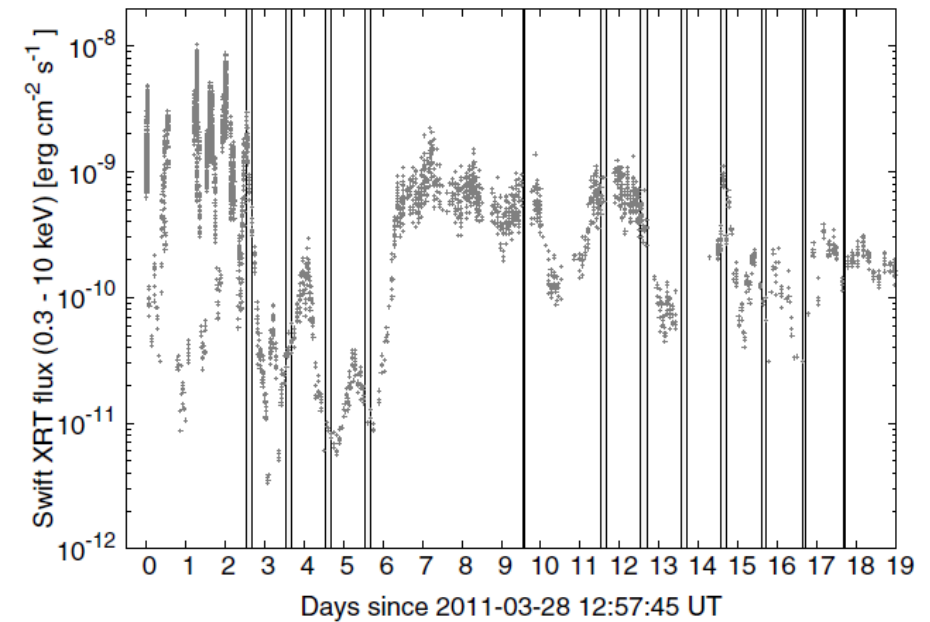
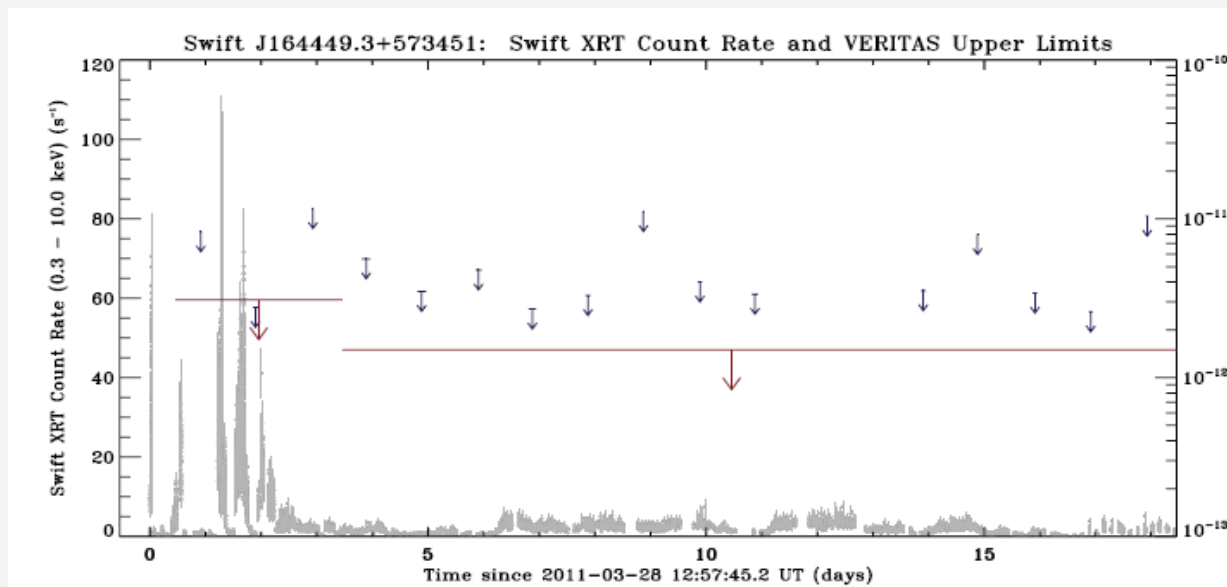


Fermi Collaboration 2014

Tidal Disruption Events

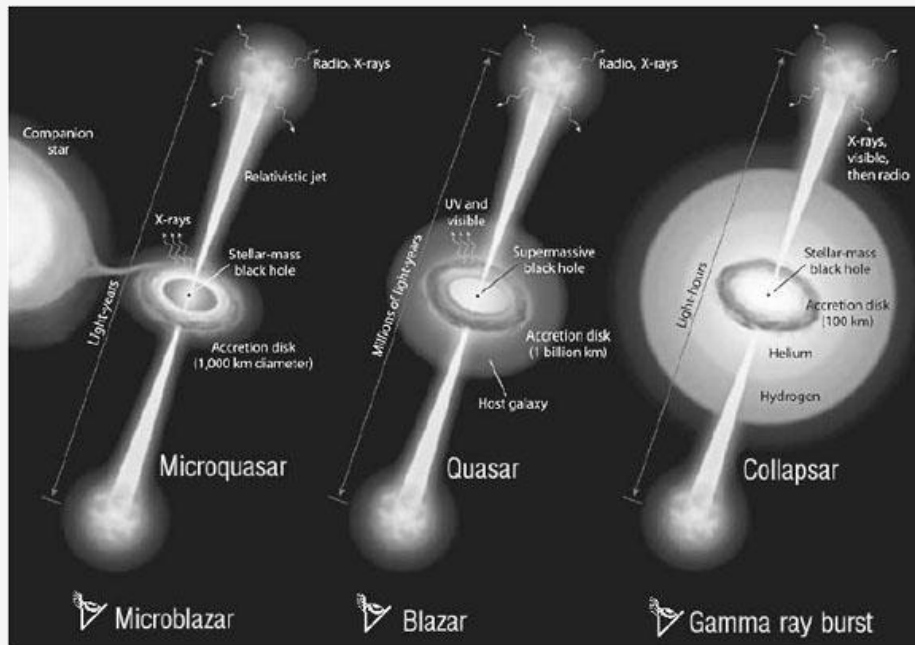
- Swift 1644+57 is the only event that has been observed with IACTs
- Rather unlucky timing of the VHE observations
- The upperlimits not so constraining for the models

Talks on Tuesday



Similarity and Diversity

- Phenomenon related to black holes on Very High Energy gamma-rays are transient and/or extremely variable
- Huge observational challenge, many open questions
- Very High Energy emission mostly from the jets launched by the black holes
- But sometimes we see a lightning from the black hole?



I did not cover

- Galactic center
- Intermediate mass black holes
- Binary black hole systems

... we will be hearing about those during this week