Monitoring campaign of bright sources

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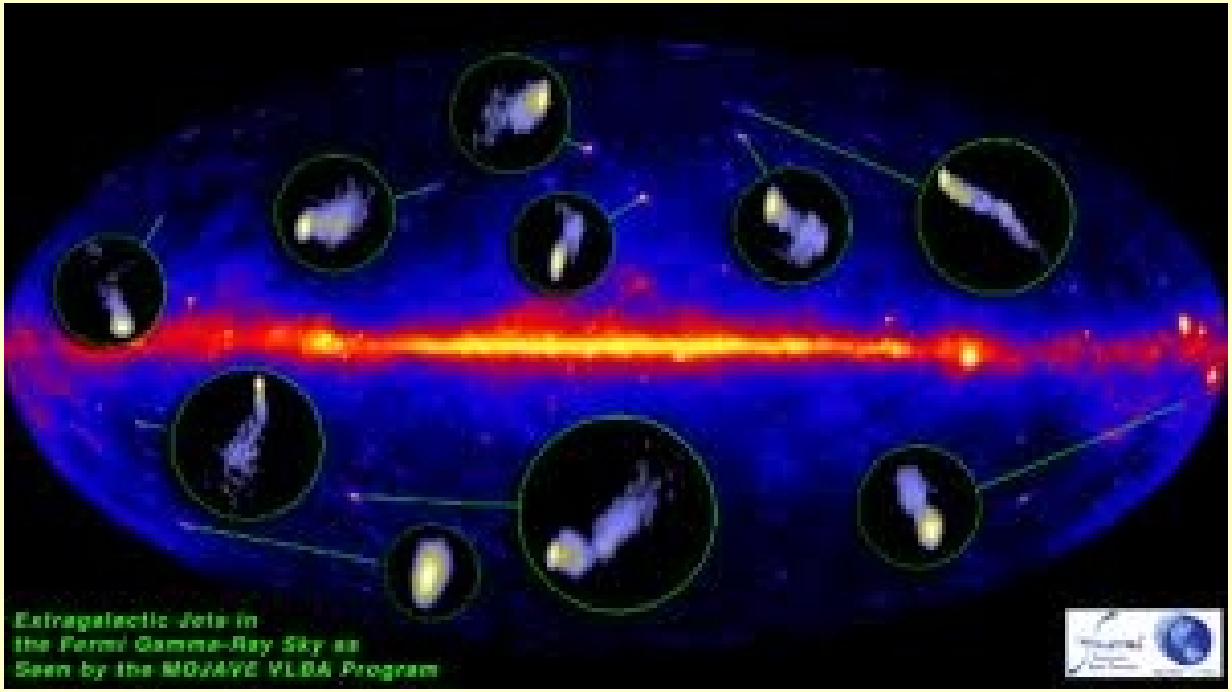
The extragalactic γ-ray sky

EGRET: 100% RL-AGN

In the 2LAC (Ackermann+11):

- 97% blazars
- 3% other objects
  - MAGN
    - CenA lobes (Abdo+10)
  - RL-NLsy1
  - RQ AGN+SFG (CR)
    - NGC1068 (CR+AGN)

Hayashida+13



Strong γ-ray emitters:

- High radio luminosity
- Fast apparent jet speed
- High variability Doppler

Savolainen+ 2010, Lister+ 09, Kovalev+ 2009

Extragalactic γ-ray sky dominated by radio-loud AGN

Relativistic jets

Non-thermal emission

- Low energy: **synchrotron**

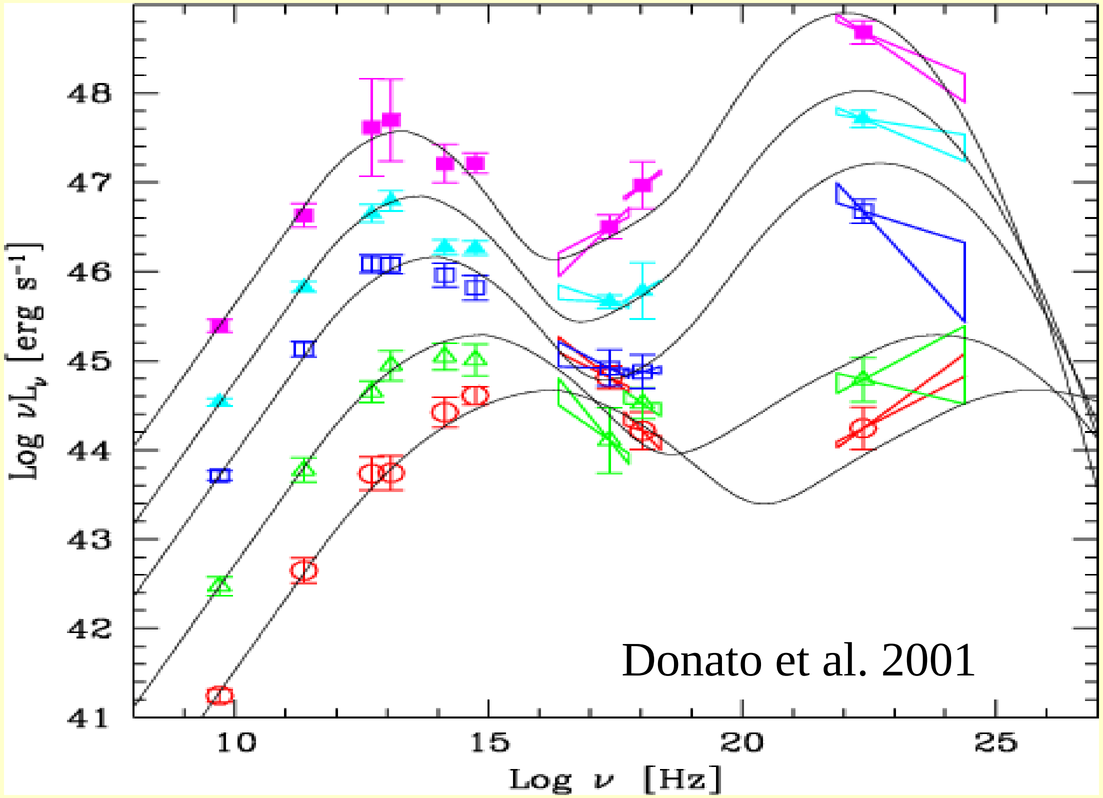
Relativistic electrons can scatter low energy photons

- High energy: **inverse Compton**

Seed photons:

- external photons from torus, disk, BLR... (External Compton)

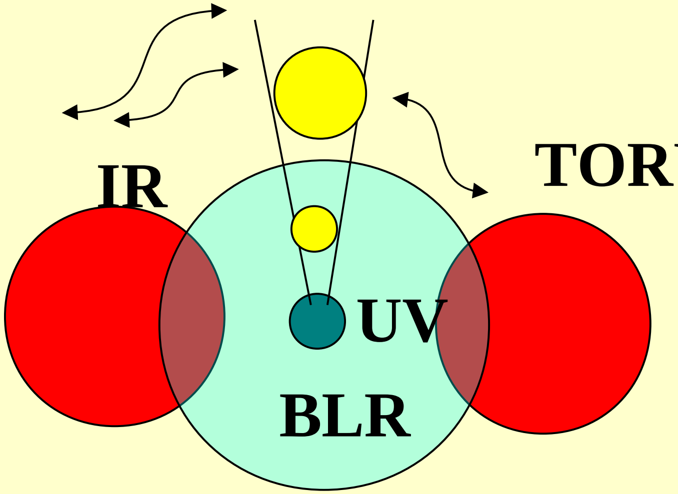
- their own synchrotron photons (Synchrotron-self Compton)



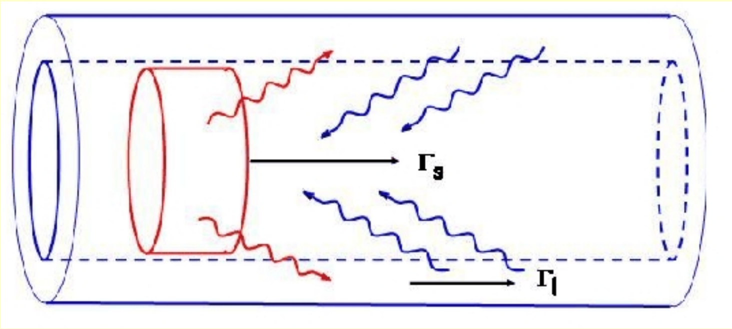
Luminosity ~ 10^{49} – 10^{50} erg/s
Linear size ~ (sub-)pc to Mpc

Open questions

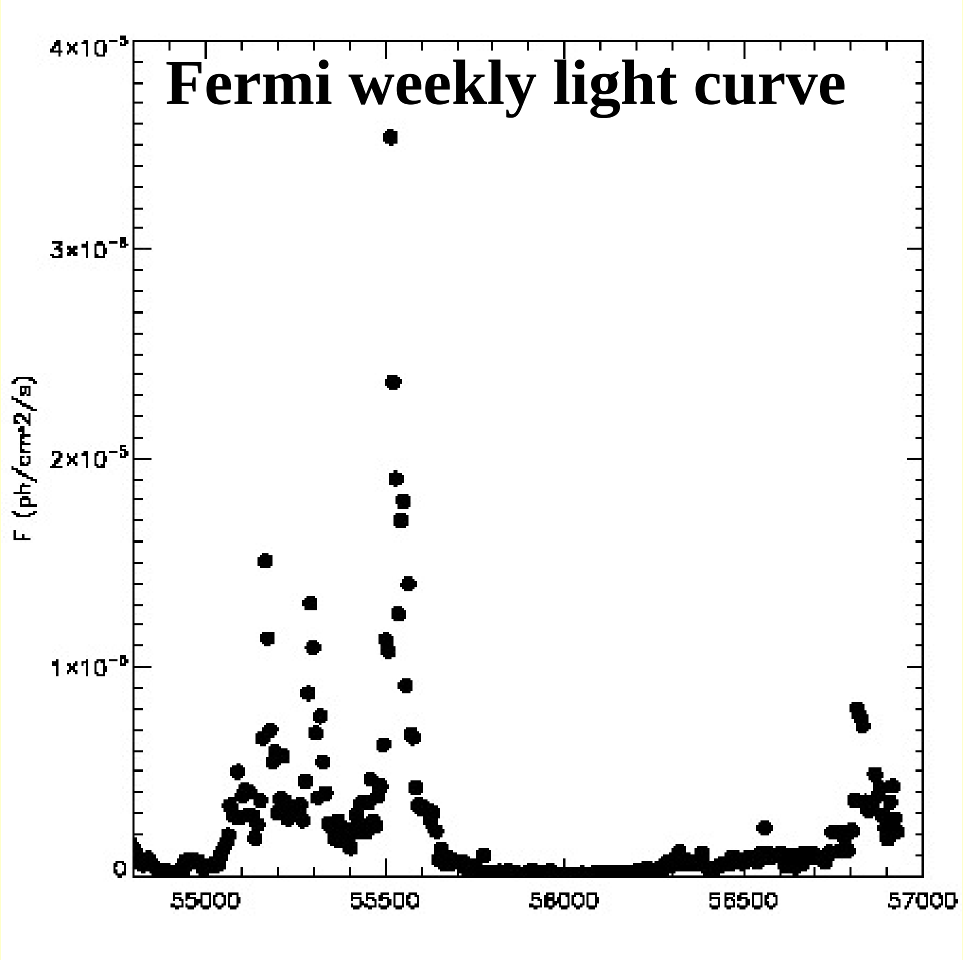
WHERE?	WHO?	HOW?
• Sub-pc scale	Magnetic field reconnection	UV, optical from BLR
	Internal shock	
• pc scale		IR from torus
	Reconfinement shock	
• > 10 parsec	Standing conical shock	Synchro from different e^- population
• Two-zone model	Velocity gradient	Synchro from different e^- population

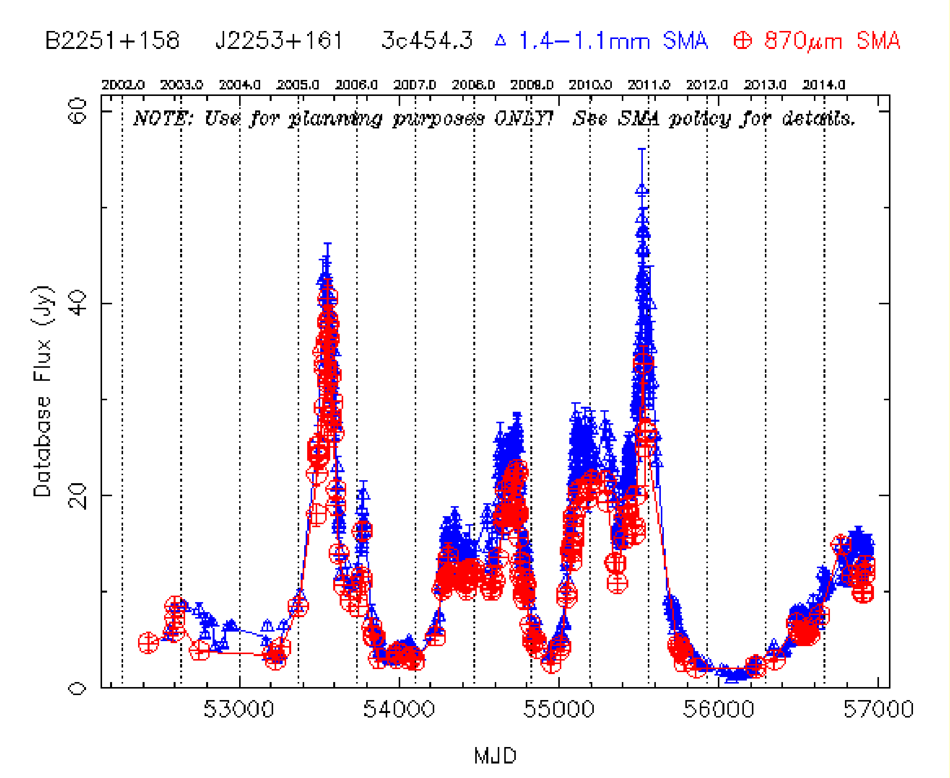


Ghisellini+08



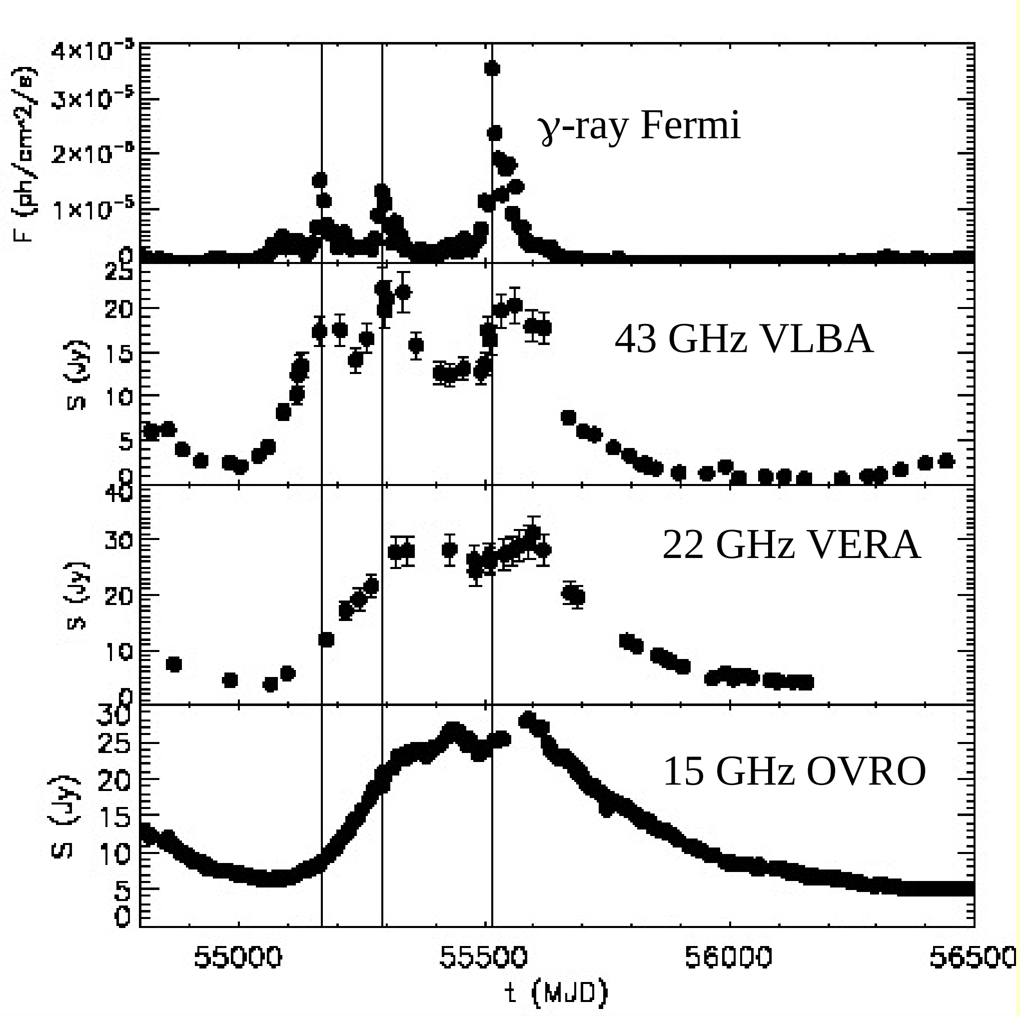
3C 454.3: γ-ray light curve





3C 454.3 was the most active blazar in gamma rays during the first 3 years of Fermi operation. Then it entered in a sleeping state. Now it is waking up...

The γ-ray region



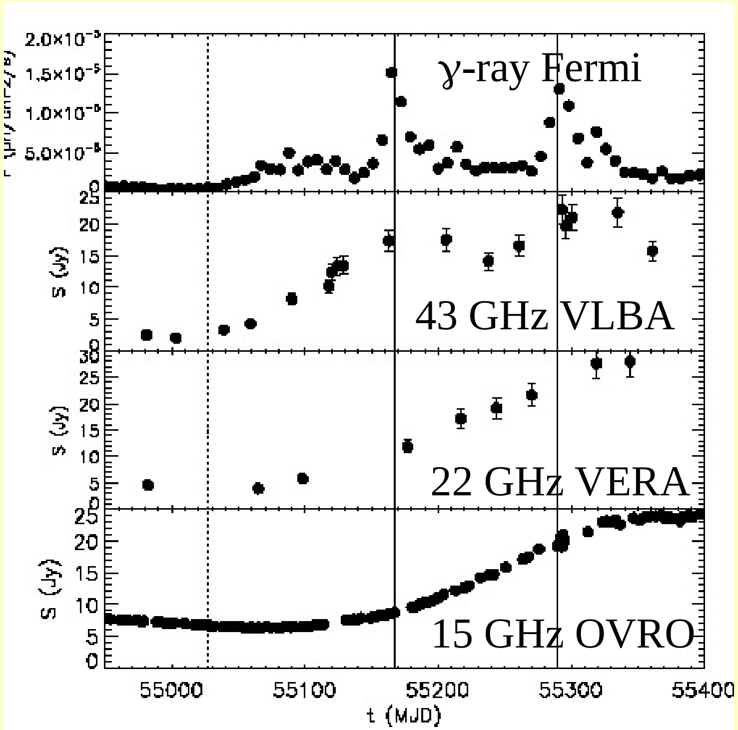
The rise of the mm flux density precedes the γ-ray flare

γ-ray produced pc away from the core

γ-ray region opaque to cm emission

The γ-ray region

3C 454.3



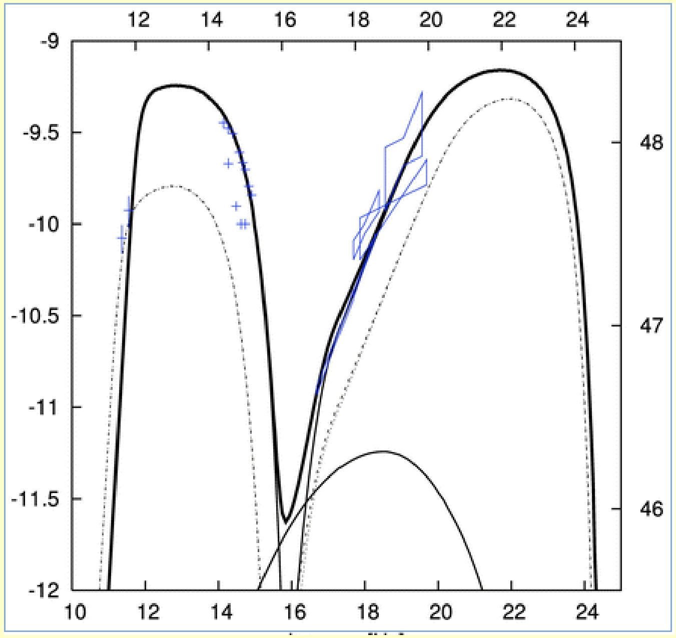
The increase of **γ-ray and mm emission** seems **simultaneous**.
At 15 GHz it is delayed by about 2 months.

↓

Co-spatiality of γ-ray and mm emission produced on pc scale

↓

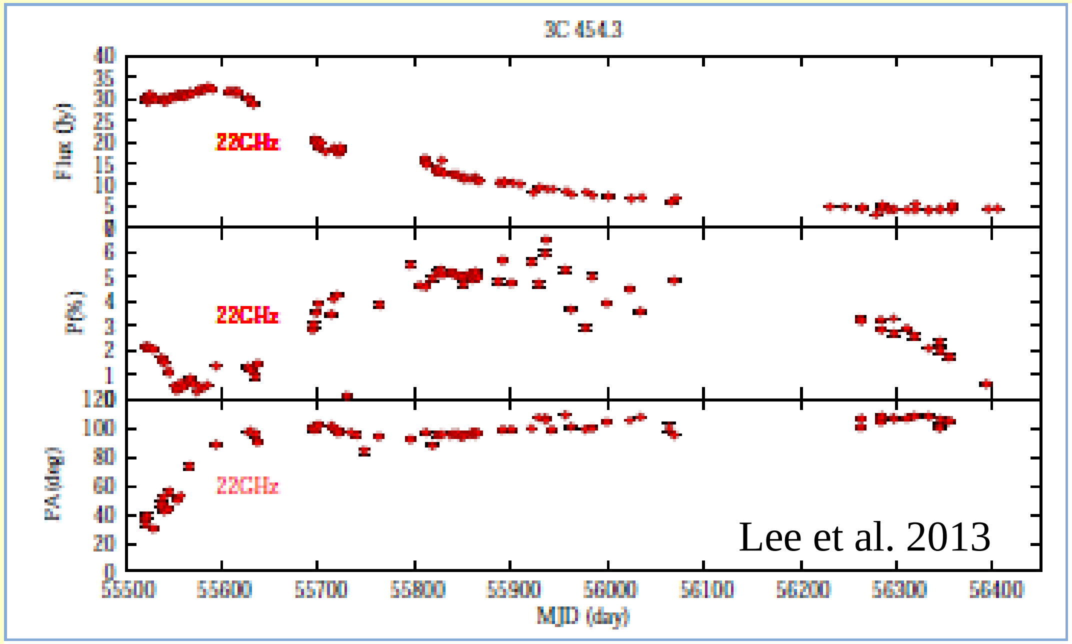
- IR photons from the dusty torus
- Synchro photons from different e^- population



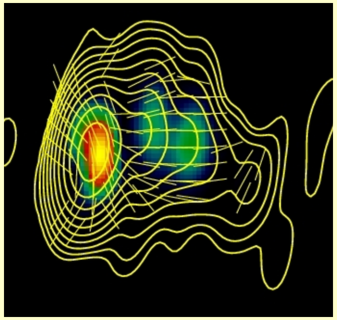
Sikora+08

Reconfinement shock in toroidal magnetic field + IR photons

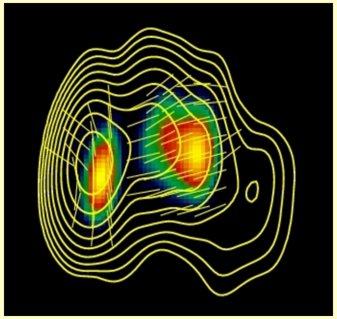
Magnetic field



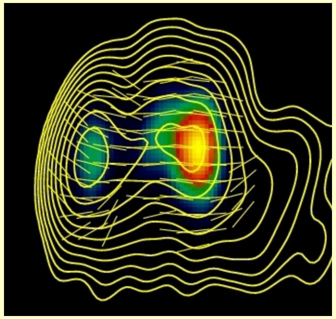
Jorstad et al. 2013



Mar 11



Apr 11



Jul 11

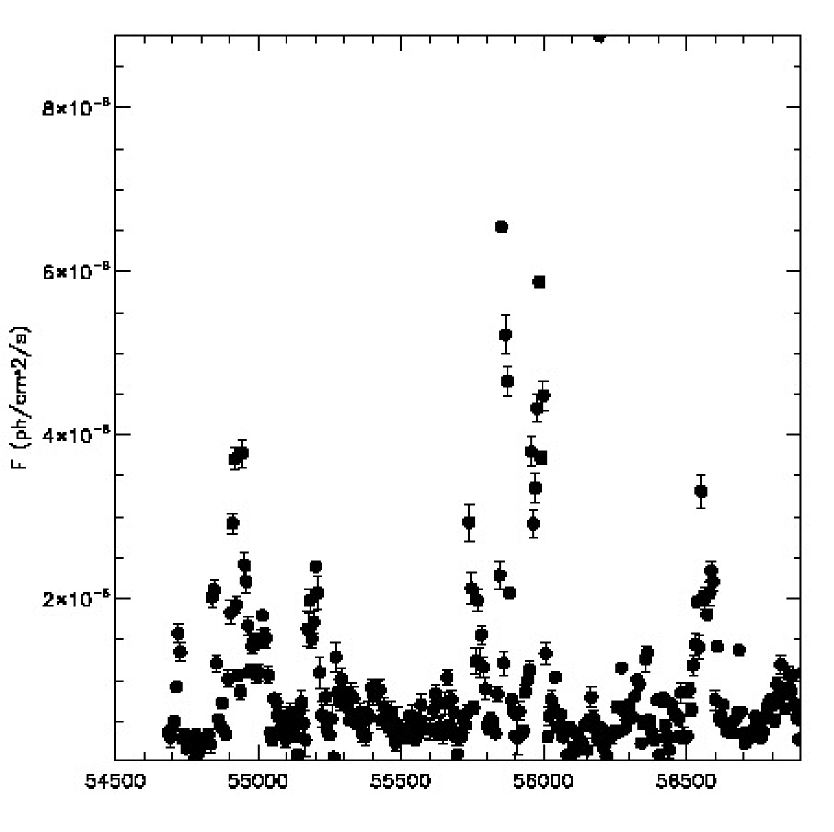
- Single dish: EVPA rotates of about 90°

- VLBI: Flux and polarization dominated by the knot ejected in Dec 2009.

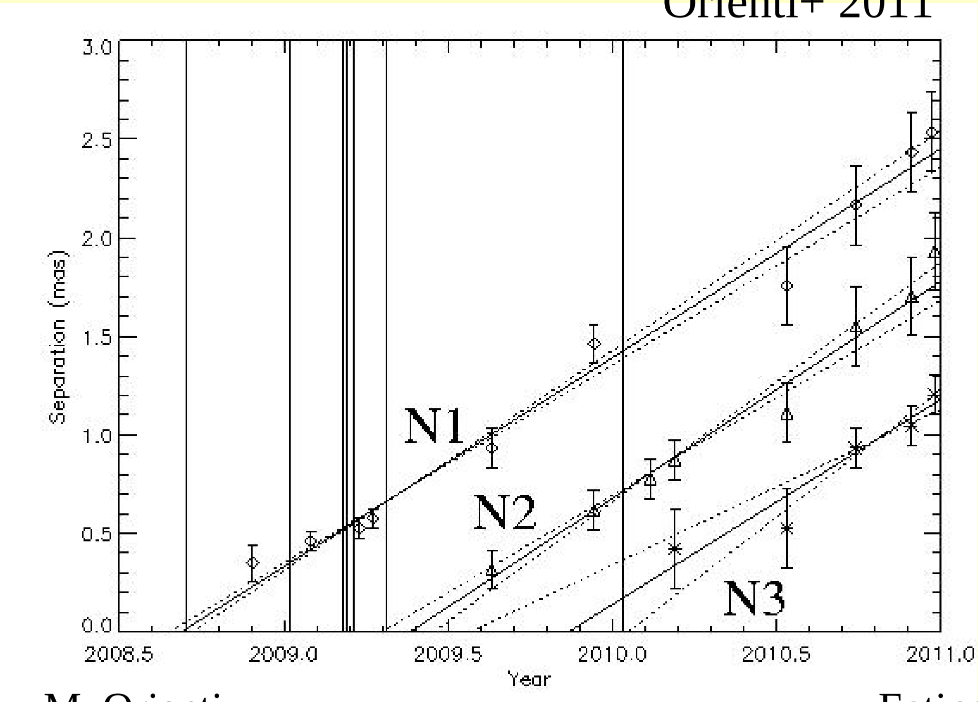
Knot EVPA parallel to the jet axis, as expected for internal shock or reconfinement shock in a **toroidal magnetic field** (e.g. Sikora+08)

Why study PKS 1510-089?

- FSRQ at z=0.361
- **Strong variability across the entire e-m spectrum**
- Highly superluminal jet components ejected close in time with a γ-ray flare
- **Detected at VHE (E>100 GeV)**



Orienti+ 2011



- High level of polarized emission in radio and optical bands
- **Large rotation of the EVPA** close in time with γ-ray flares

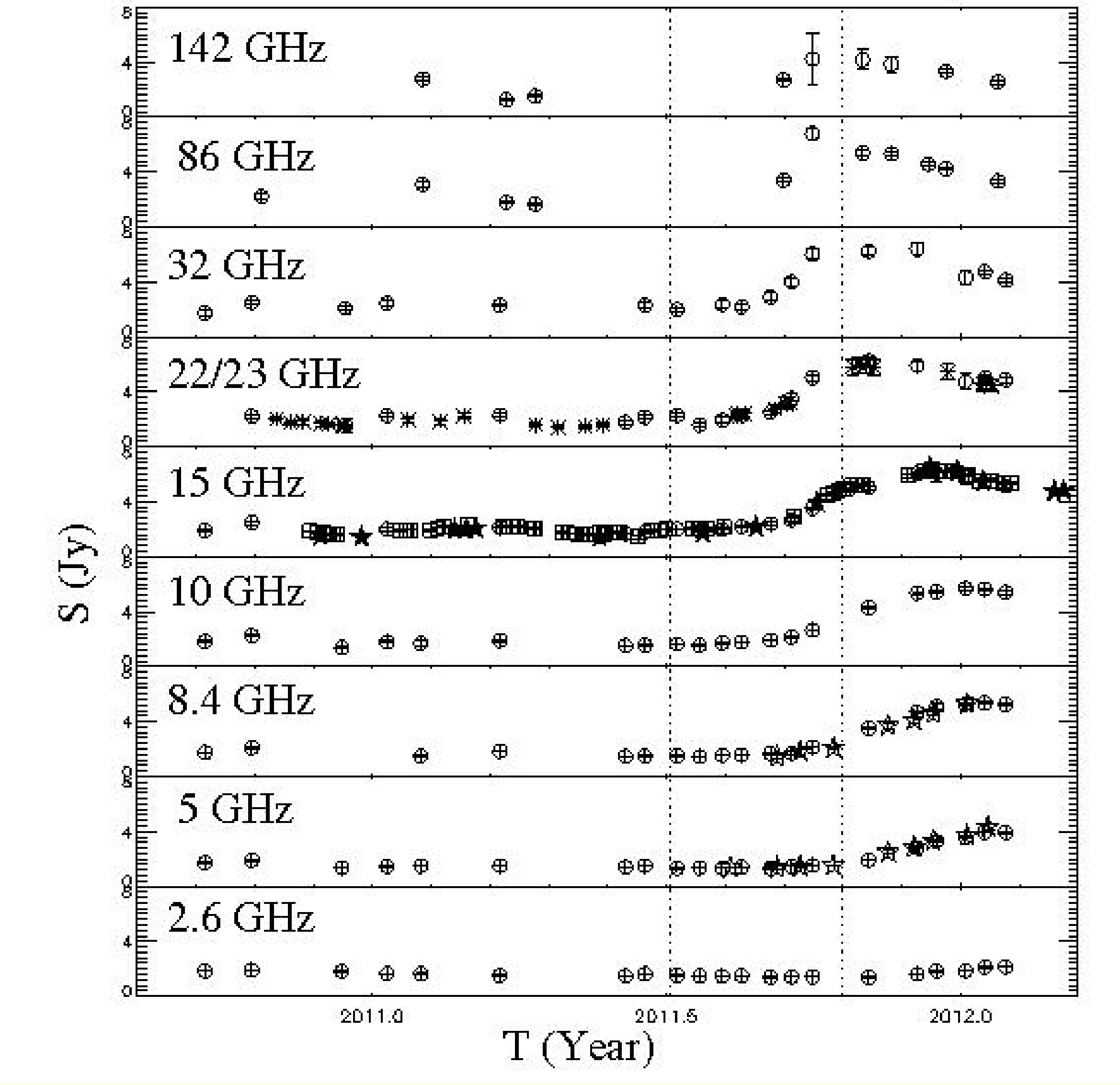
Multi-wavelength analysis

The peak flux density is not simultaneous at the various frequencies due to opacity effects.

In the millimeter regime the maximum occurs at the end of September, although the sparse time coverage does not allow an accurate estimate.

At decimeter wavelength (2.6 GHz), the flux density was still increasing on 2012 January.

Orienti+ 2013



The origin of the γ-ray emission

The huge radio flare reached its maximum in the millimeter close in time with the γ-ray flare of 2011 October, suggesting a common emitting region. If the onset of the mm flare is a consequence of a shock propagating along the jet, it turns out that the γ-ray flare occurs off-nuclear:

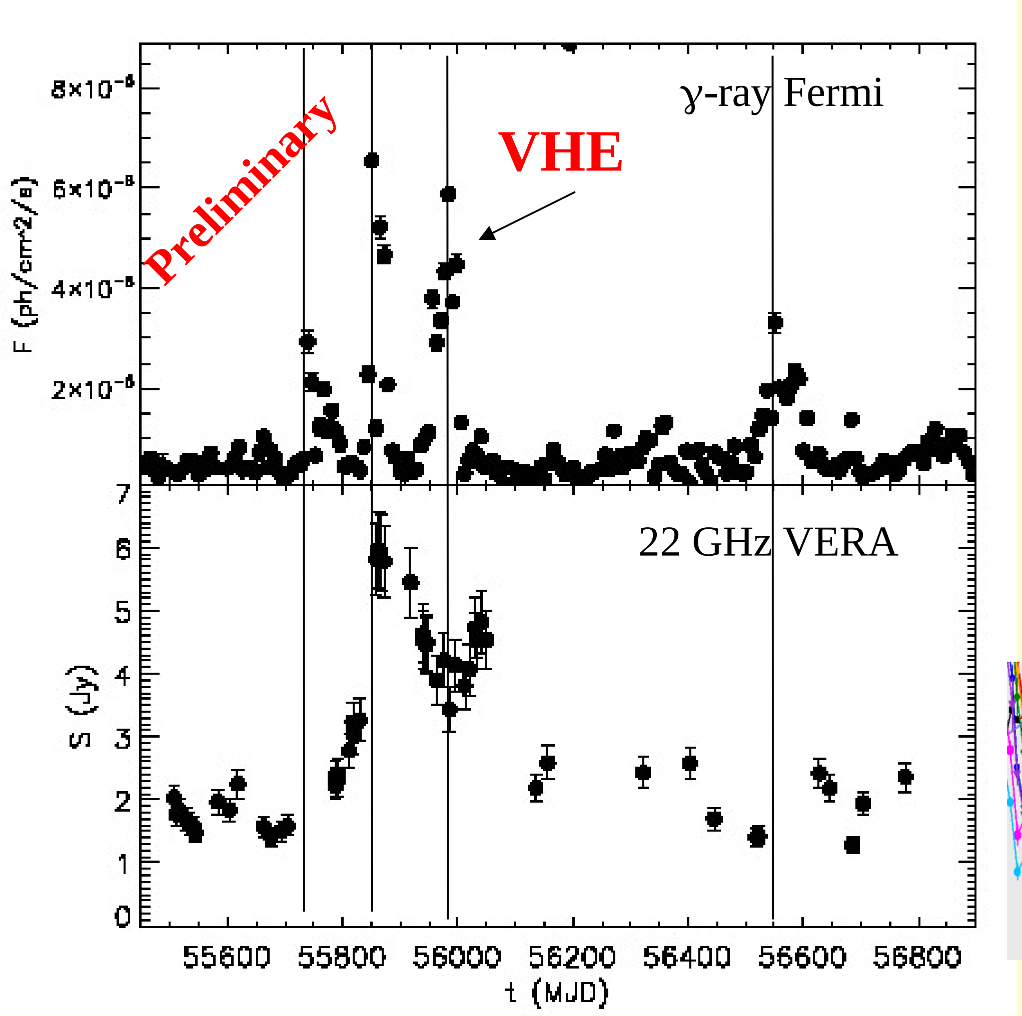
$$\Delta r = \frac{\beta_{\mathrm{app}} c}{\sin\theta} \frac{\Delta t_{\mathrm{obs}}}{1+z}$$

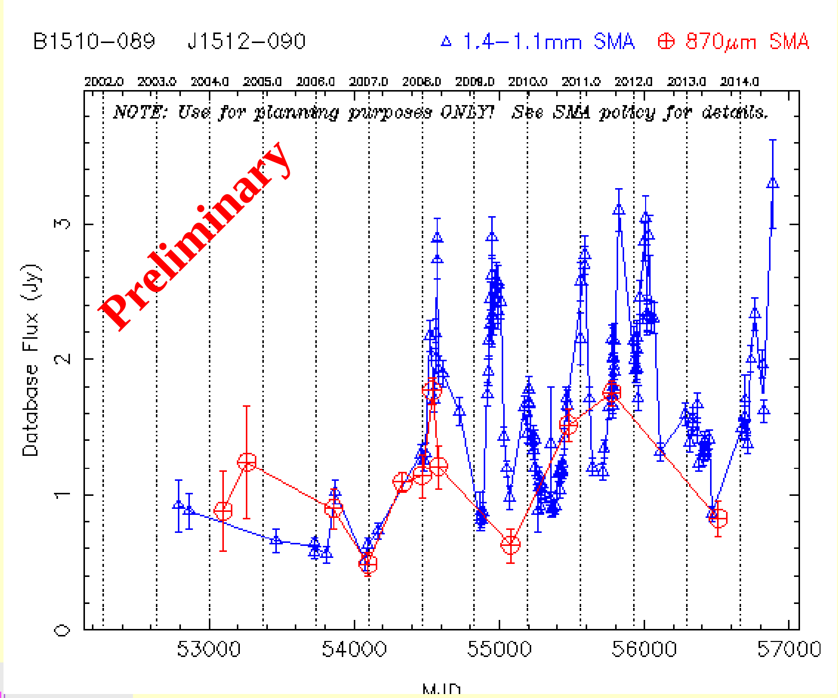
ΔT_{obs} = 40 days
β_{app} = 20.5c
θ = 3°

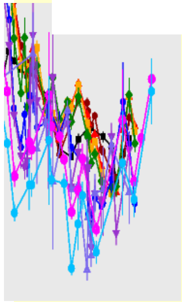
Δr_{proj} ~ 0.5 pc
$\Delta\theta$ ~ 0.1 mas
Δr ~ 10 pc

The July γ-ray flare may be due to a **first perturbation occurring in the central region opaque to the radio emission.** As it propagates it becomes visible at longer wavelengths. **As it passes through a standing shock a second γ-ray flare is produced**, while the shock becomes visible as a superluminal knot.

Light curves







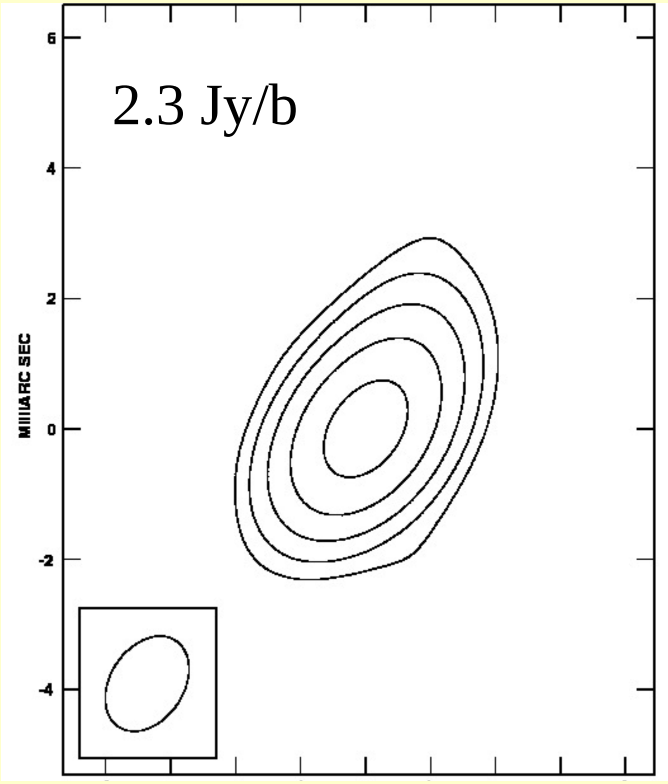
The source entered in a new high activity period

VERA lc poorly sampled, but in agreement with F-GAMMA

Towards the future

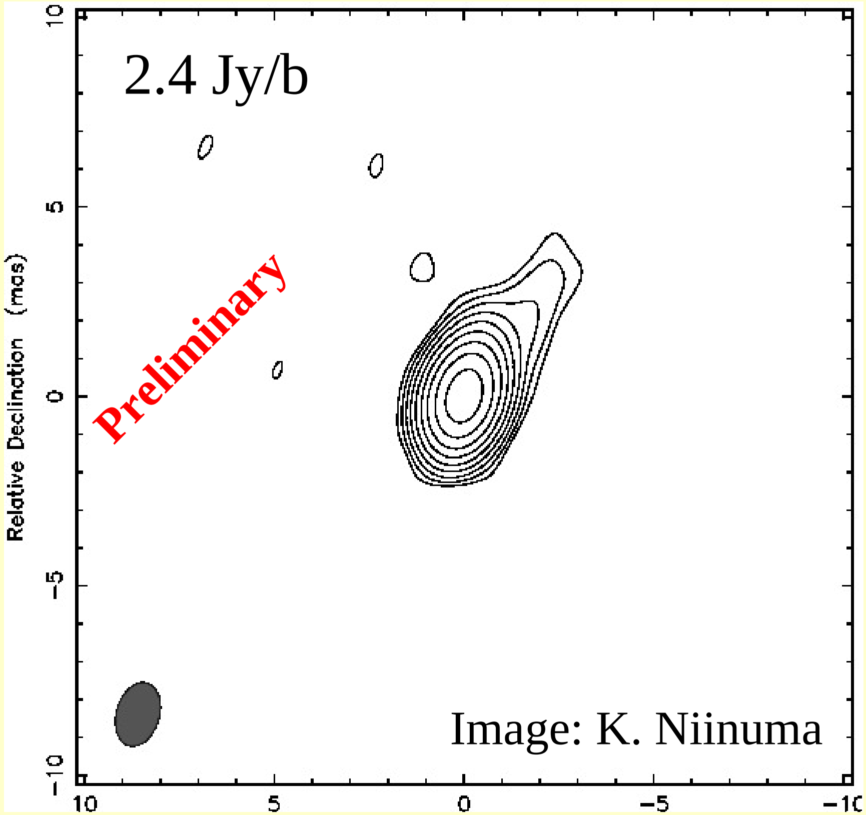
VERA

2013/12/2



KAVA

2013/12/5



KAVA can image the jet base

MOJAVE is changing strategy

B1950 Name	J2000 Name	Common Name	Right Asc. (J2000)	Declination (J2000)	z	Opt. ID	SED Class	Radio Spectrum	Fermi 2FGL Name
0011+189	J0013+1910	RGB J0013+191	00 13 56.376	+ 19 10 41.915	0.477	B			J0013.8+1907
0019+058	J0022+0608	PKS 0019+058	00 22 32.441	+ 06 08 04.269		B	LSP		J0022.5+0607
0044+566	J0047+5657	GB6 J0047+5657	00 47 00.429	+ 56 57 42.395		B			J0047.2+5657
0138-097	J0141-0928	PKS 0139-09	01 41 25.832	- 09 28 43.674	0.735	B	LSP	Flat	J0141.5-0928
0151+081	J0154+0823	GB6 J0154+0823	01 54 02.770	+ 08 23 51.068	0.681	B	ISP		J0153.9+0823
0159+723	J0203+7232	S5 0159+723	02 03 33.385	+ 72 32 53.667		B	LSP		J0203.6+7235
1215+303	J1217+3007	ON 325	12 17 52.082	+ 30 07 00.636	0.13	B	HSP	Flat	J1217.8+3006
1222+216	J1224+2122	4C +21.35	12 24 54.458	+ 21 22 46.389	0.434	Q	LSP	Flat	J1224.9+2122
1224-132	J1226-1328	PMN J1226-1328	12 26 54.419	- 13 28 38.[illegible]86		B	ISP		J1226.7-1331
1226+023	J1229+0203	3C 273	12 29 06.700	+ 02 03 08.598	0.1583	Q	LSP	Flat	J1229.1+0202
1236+077	J1239+0730	PKS 1236+077	12 39 24.588	+ 07 30 17.189	0.4	U	LSP		J1239.5+0728
1246+586	J1248+5820	PG 1246+586	12 48 18.785	+ 58 20 28.717		B	ISP		J1248.2+5820
1441+252	J1443+2501	PKS 1441+25	14 43 56.892	+ 25 01 44.491	0.939	Q	LSP		J1444.1+2500
1537+279	J1539+2744	MG2 J153938+2744	15 39 [illegible].1[illegible]7	+ 27 44 38.211	2.191	Q	LSP		J1539.5+2747
1542+616	J1542+6129	GB6 J1542+6129	15 42 5[illegible].944	+ 61 29 55.346		B	ISP		J1542.9+6129
1546+027	J1549+0237	PKS 1546+027	15 49 29.437	+ 02 37 01.163	0.414	Q	LSP	Flat	J1549.5+0237
1549+089	J1552+0850	TXS 1549+089	15 52 03.262	+ 08 50 47.336		B			J1551.9+0855
1551+130	J1553+1256	OR 186	15 53 32.698	+ 12 56 51.716	1.308	Q		Flat	J1553.5+1255
1553+113	J1555+1111	PG 1553+113	15 55 43.044	+ 11 11 24.365		B	HSP		J1555.7+1111
1557+565	J1558+5625	VIPS 0926	15 58 48.289	+ 56 25 14.120		B	LSP		J1559.0+5627
1633+382	J1635+3808	4C +38.41	16 35 15.493	+ 38 08 04.500	1.813	Q	LSP	Flat	J1635.2+3810
1637+574	J1638+5720	OS 562	16 38 13.456	+ 57 20 23.979	0.751	Q	LSP	Flat	
1638+118	J1640+1144	CRATES J1640+1144	16 40 58.893	+ 11 44 04.212	0.078	G			J1641.0+1141

MISSING!!

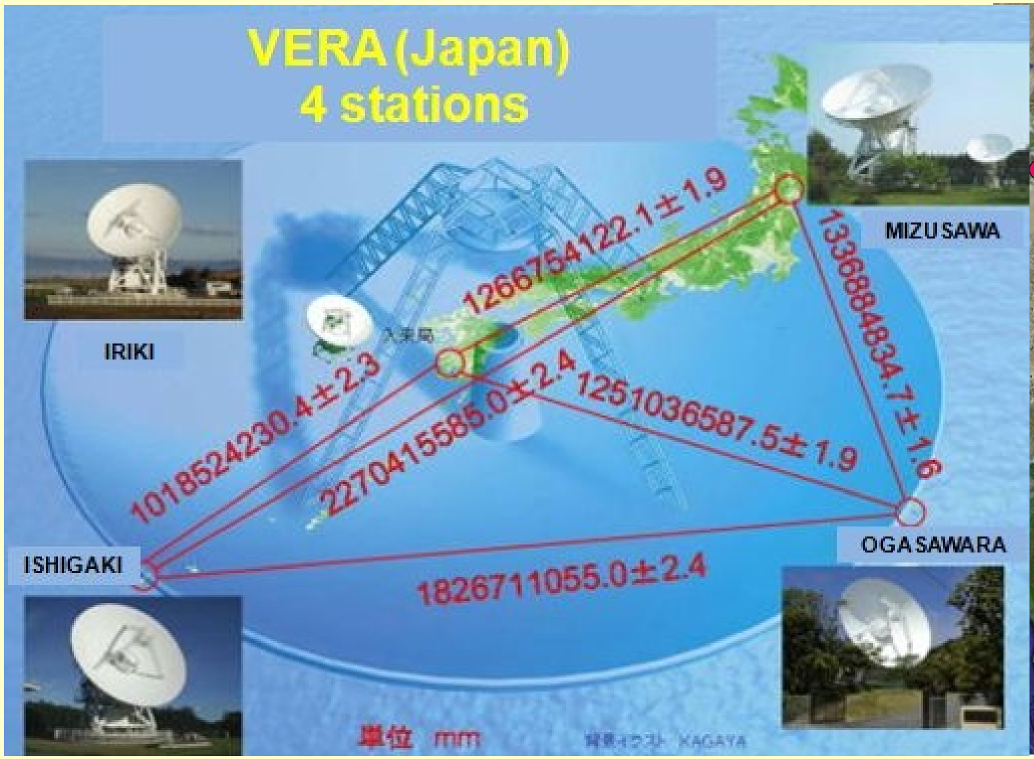
DA 55

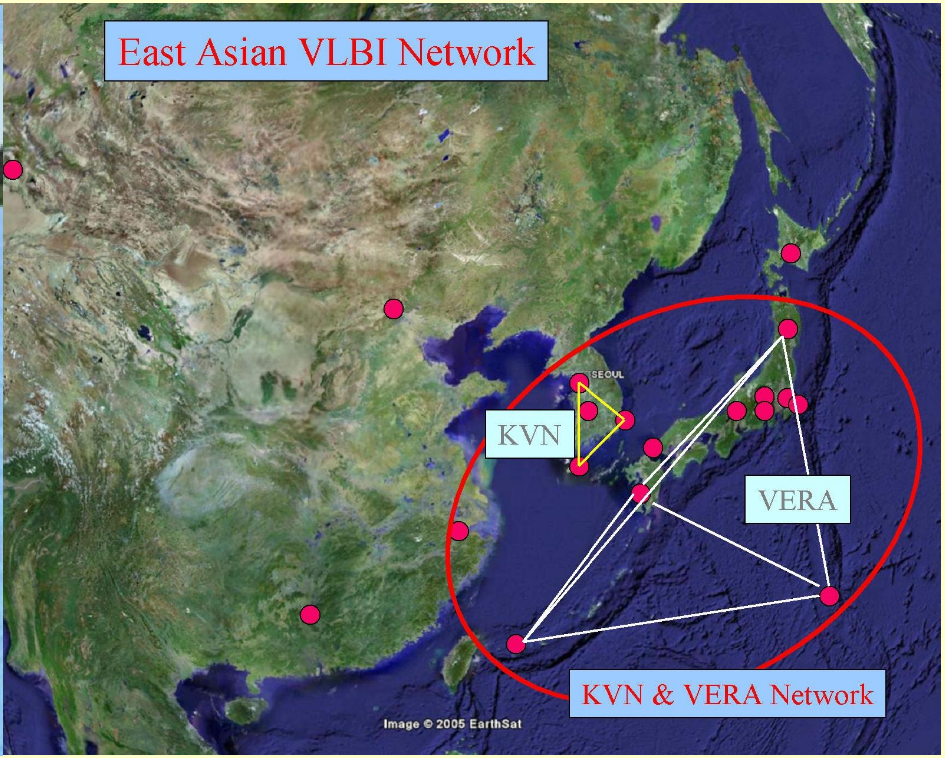
M 87

1510-089

DA 406

Summary

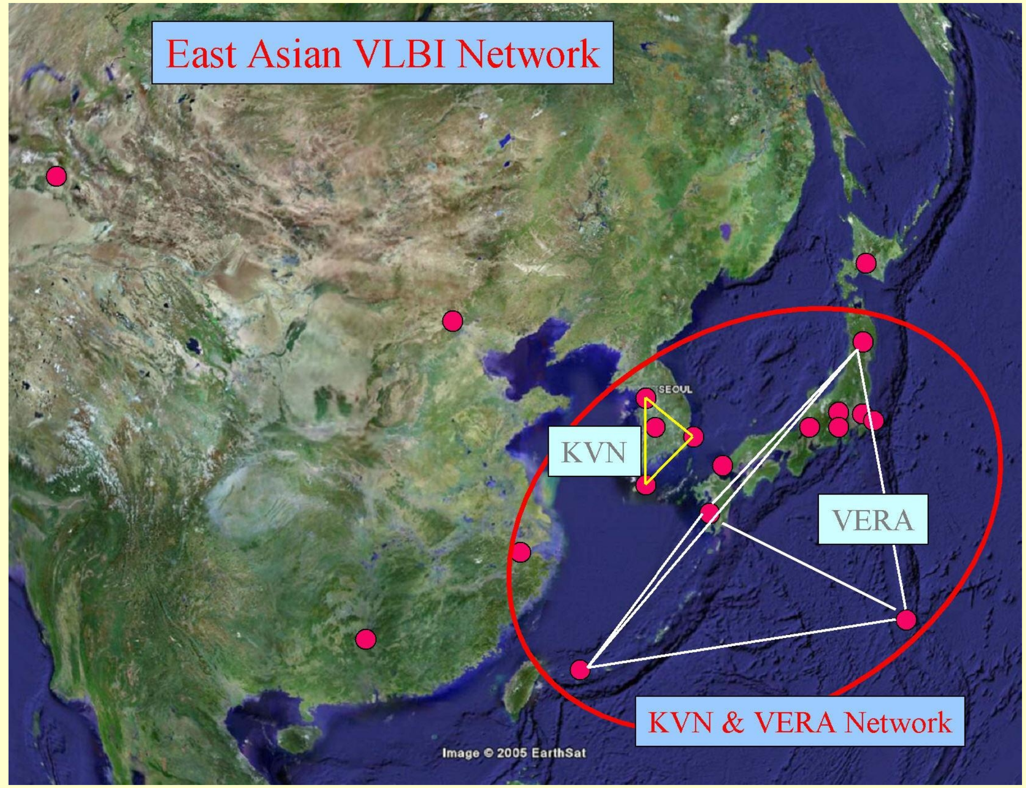




VERA monitoring of the bright sources is crucial for investigating the variability of the core region

KAVA can pick up the jet structure and reveal changes in the jet

Towards the future

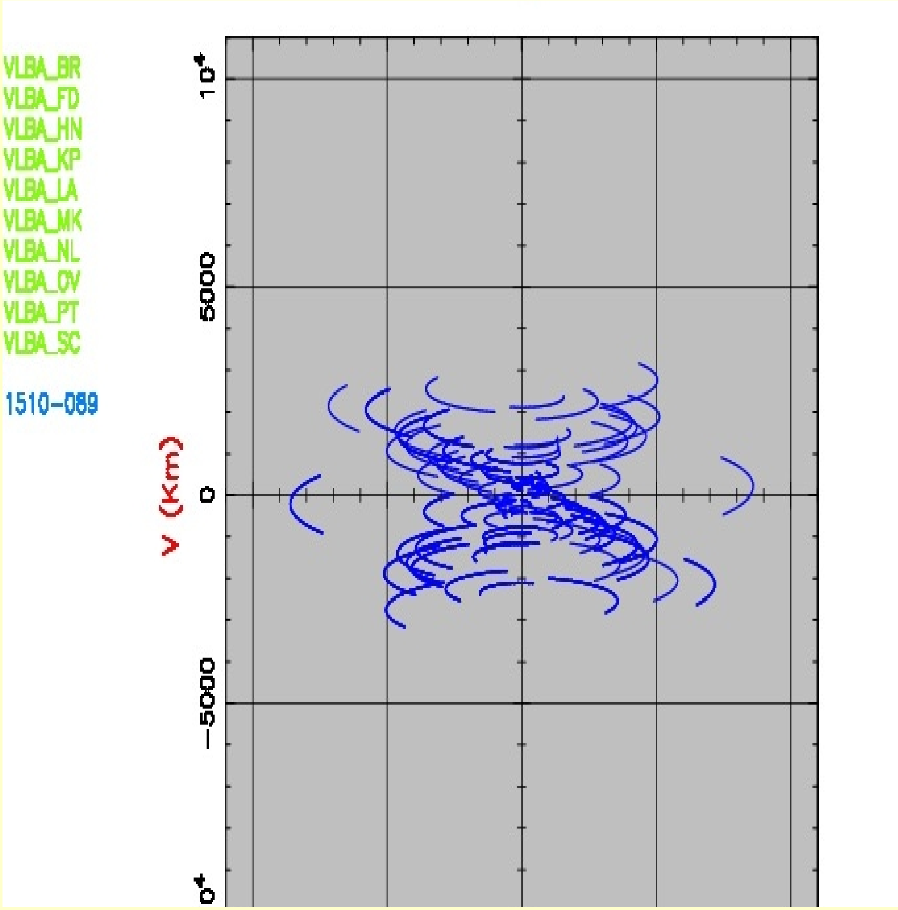


Italy+Japan will provide very long baselines →

The angular resolution will improve of ~ an order of magnitude

Towards the future

VLBA



KAVA+Italy