

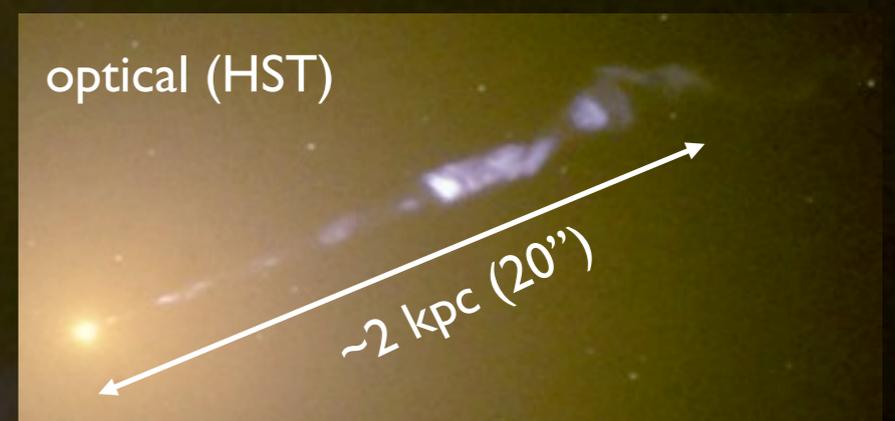
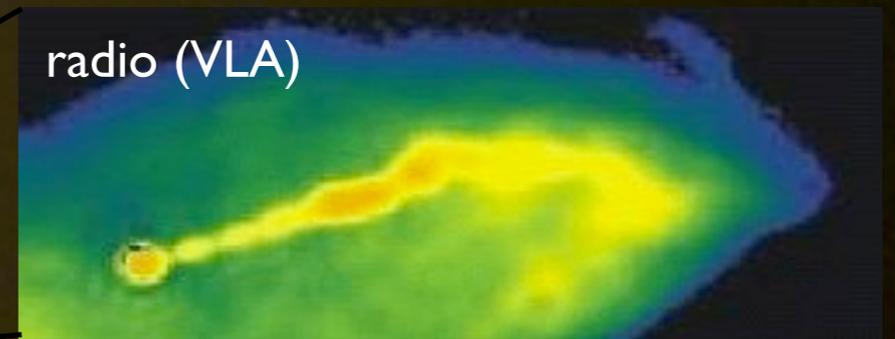
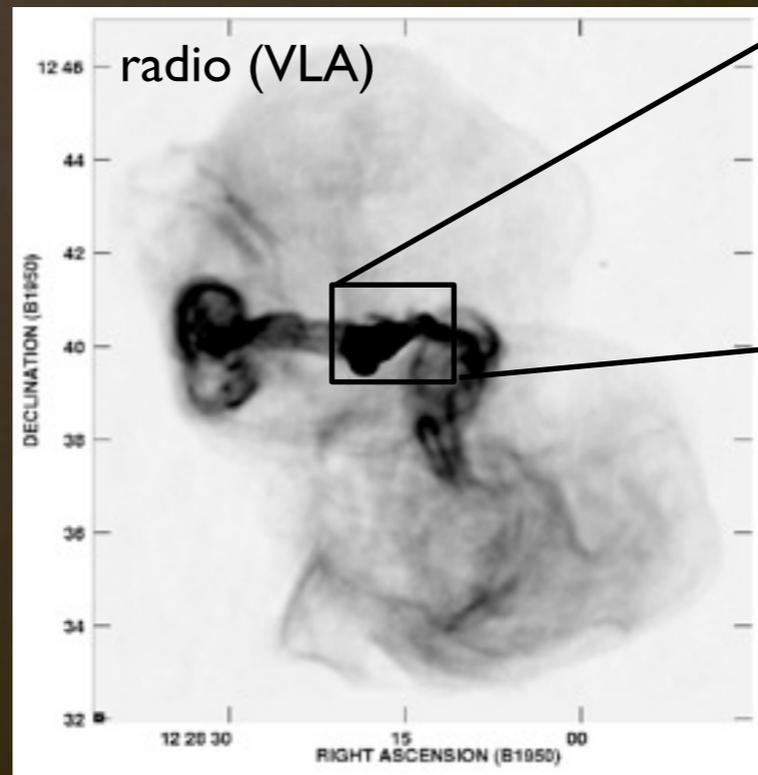
# Probing the origin of VHE emission from M 87 with H.E.S.S., MAGIC, VERITAS, VLBA, & Chandra

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Monitoring Team, Chandra M 87 Monitoring Team

*Cospar 2010 - July 18-24, 2010 - Bremen, Germany*

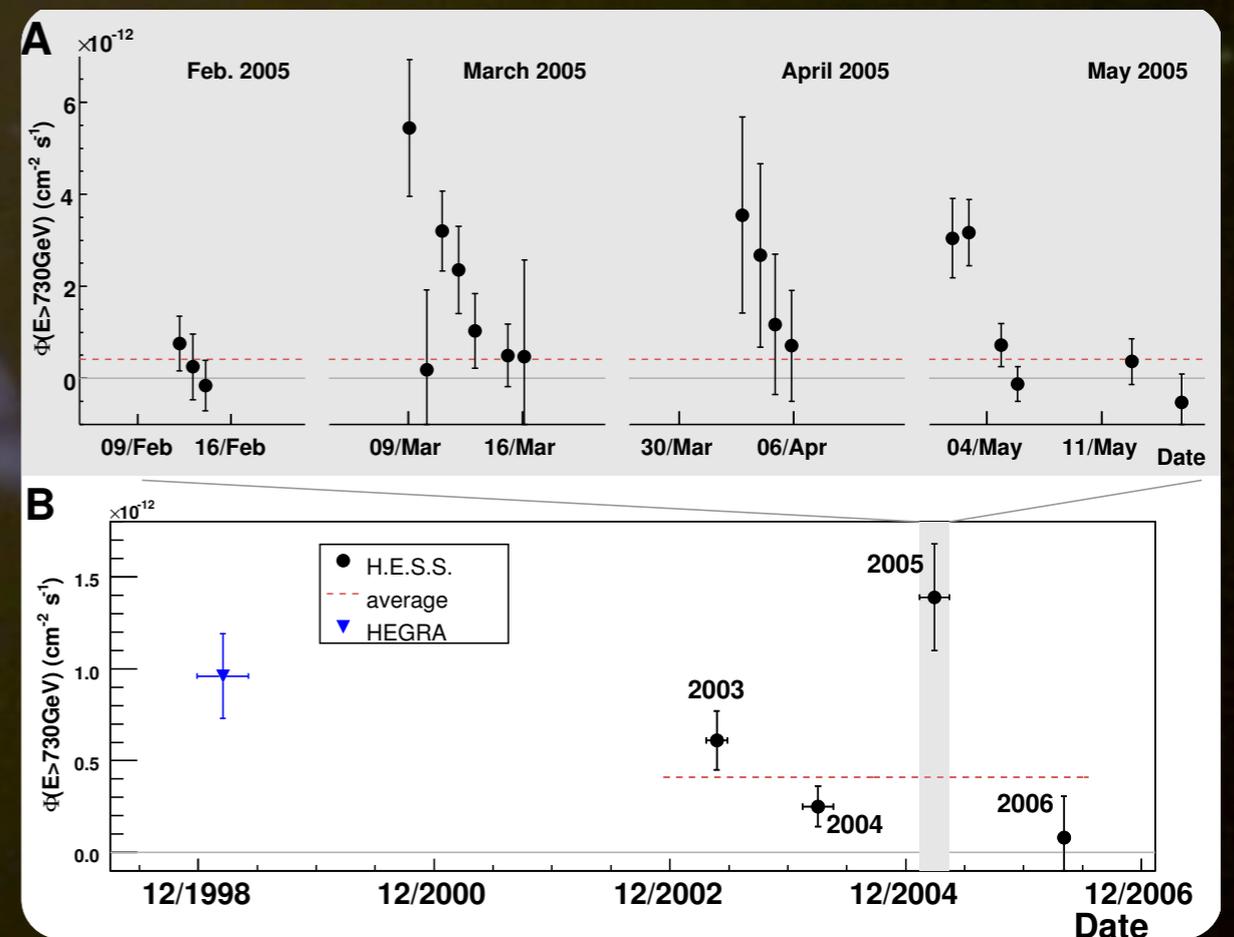
# Radio Galaxy M 87

- Distance:  
~16 Mpc
- Central BH:  
 $M_{\text{BH}} \sim 6 \times 10^9 M_{\odot}$
- Jet angle:  $\sim 30^\circ$
- Giant outer radio lobes  
0.2 x 0.2 deg
- Highly structured inner jet (knots) resolved  
in radio, optical, X-ray
- Apparent superluminal motion in jet  
⇒ relativistic particle population



# M 87 at very high energies

- First evidence for VHE emission 1998/99 (HEGRA)
- Detection by H.E.S.S. (2003-2006)  
Signal confirmed by MAGIC & VERITAS
- VHE flare and fast variability (2005)
  - ▶ Discovery of vast variability on time-scales of days **strongly constrains** emission region  $R < 5 \times 10^{15}$  cm  $\sim 5 \times \delta \times R_S$
- Detected at HE by Fermi (2008/9)



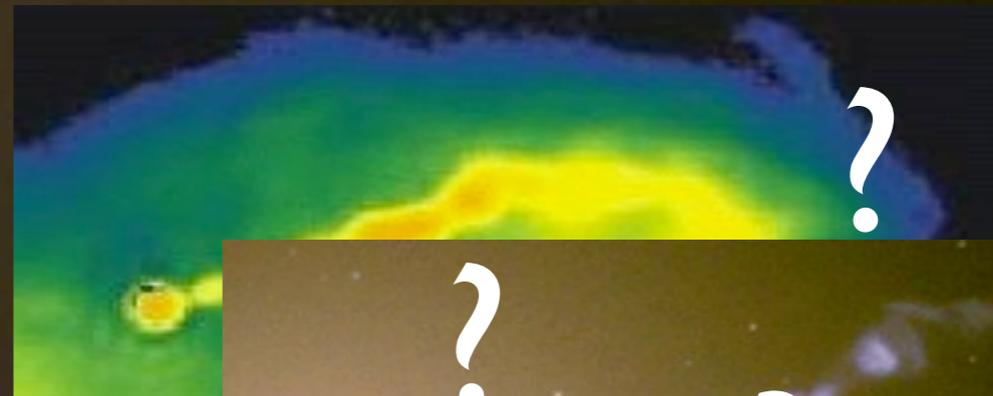
# Origin of the VHE emission?

- **Possible mechanism/sites for VHE emission**

- ▶ Dark matter annihilation ✘
- ▶ CR in M 87 ✘
- ▶ Intra-cluster gas ✘
- ▶ Large scale jets ✘
- ▶ Inner/Outer-jet (Hadronic/Leptonic) ✓
- ▶ Knots? HST I? ✓
- ▶ Vicinity of black hole ✓
- ▶ ...

➔ **Further observations to ..**

- ▶ .. confirm short-term VHE variability
- ▶ .. pin down location of VHE emission



# 2008 Campaign - Instruments



H.E.S.S., MAGIC, & VERITAS collected  $>120$  h of data from Jan to Jul 2008

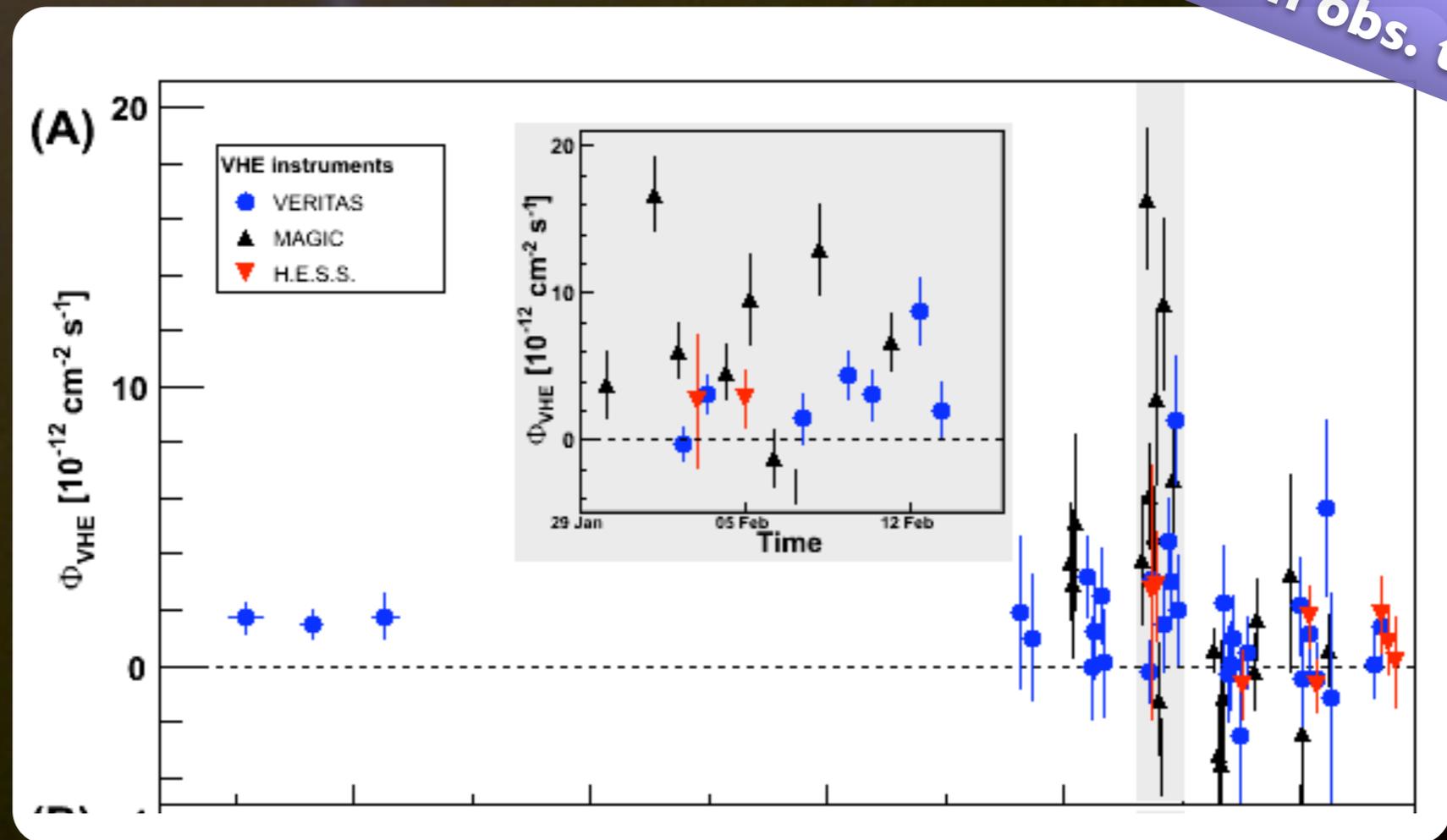
*Acciari et al. 2009, Science Express, Jul 2*

# 2008 Campaign - VHE Results



> 120 h obs. time

- 50 nights
- Feb 08: increased VHE activity
- MAGIC and VERITAS detected rapid flares with  $t_{\text{var}} \approx 1$  day



Albert et al. (MAGIC Collaboration) 2008,  
Beilicke et al. (HESS/MAGIC/VERITAS) 2008

# 2008 Campaign - Instruments

- **VLBA** observations at 43 GHz

*C. Walker et al. 2009*

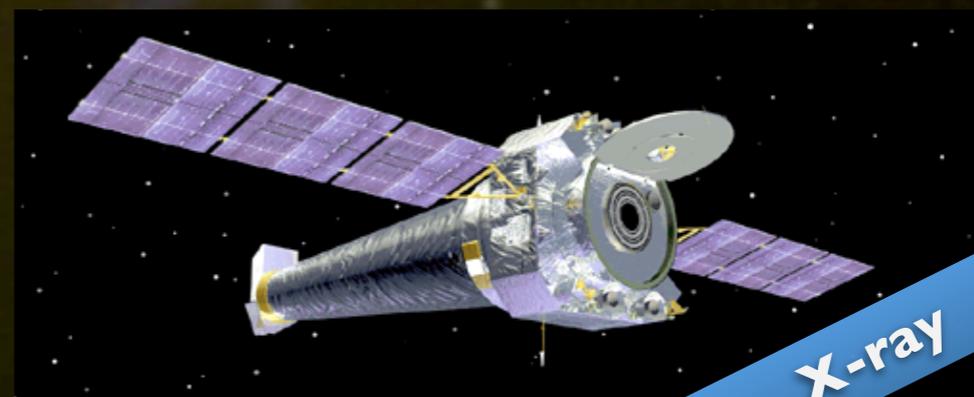
- ▶ Resolution:  $0.21 \times 0.43$  mas ( $30 \times 60 R_s$ )
- ▶ **Scale:**  $< \text{pc}$   $\Rightarrow$  direct vicinity of the BH
- ▶ Movie project: 13 obs. in 2007, every three weeks; 14 obs. in 2008, every 5 days



- **Chandra** observations in X-rays since 2002

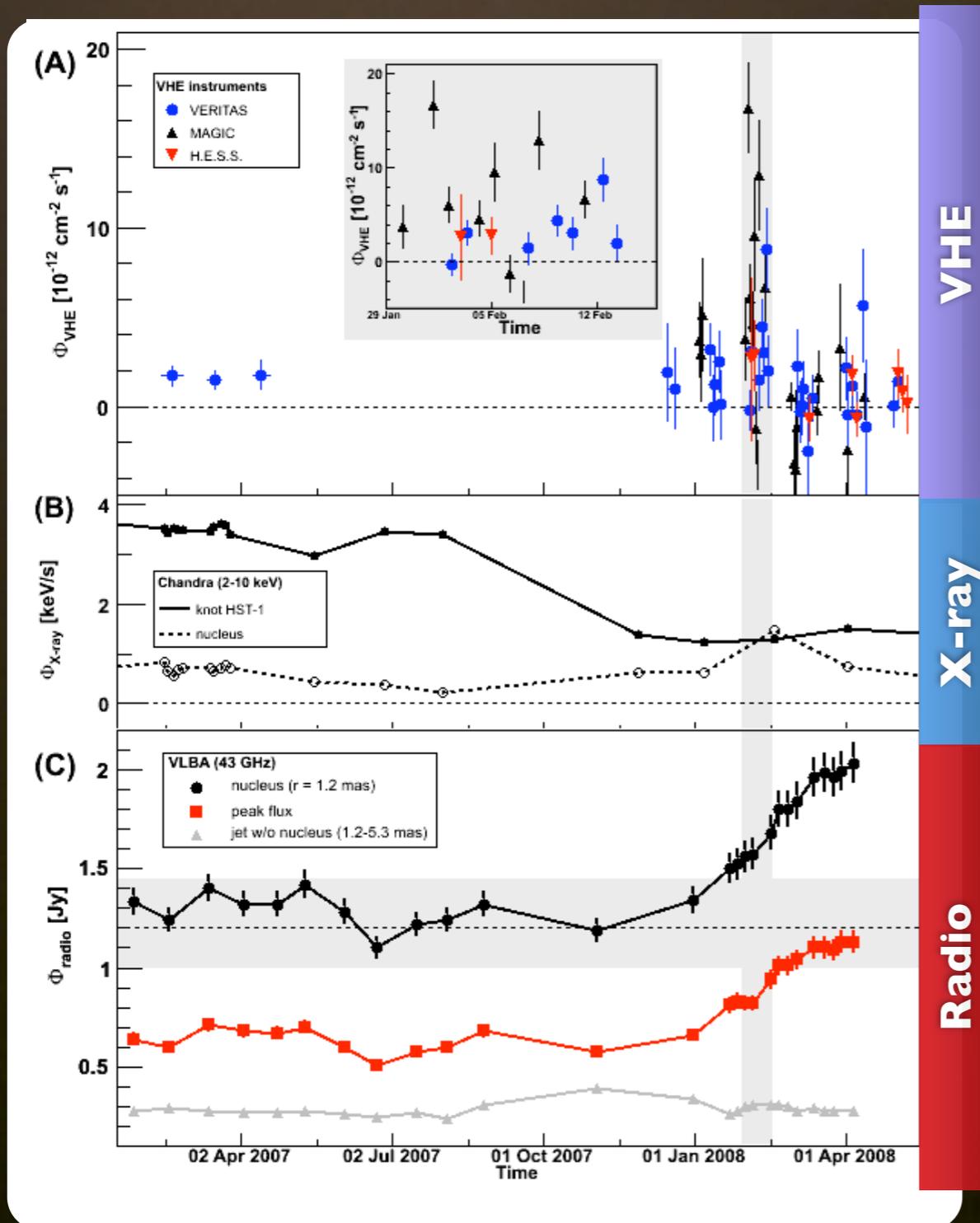
*D. Harris et al. 2007/8/9*

- ▶ **Scale:** kpc  $\Rightarrow$  inner jet
- ▶ Every 6 weeks



*Acciari et al. 2009, Science Express, Jul 2*

# 2008 Campaign - MWL Results



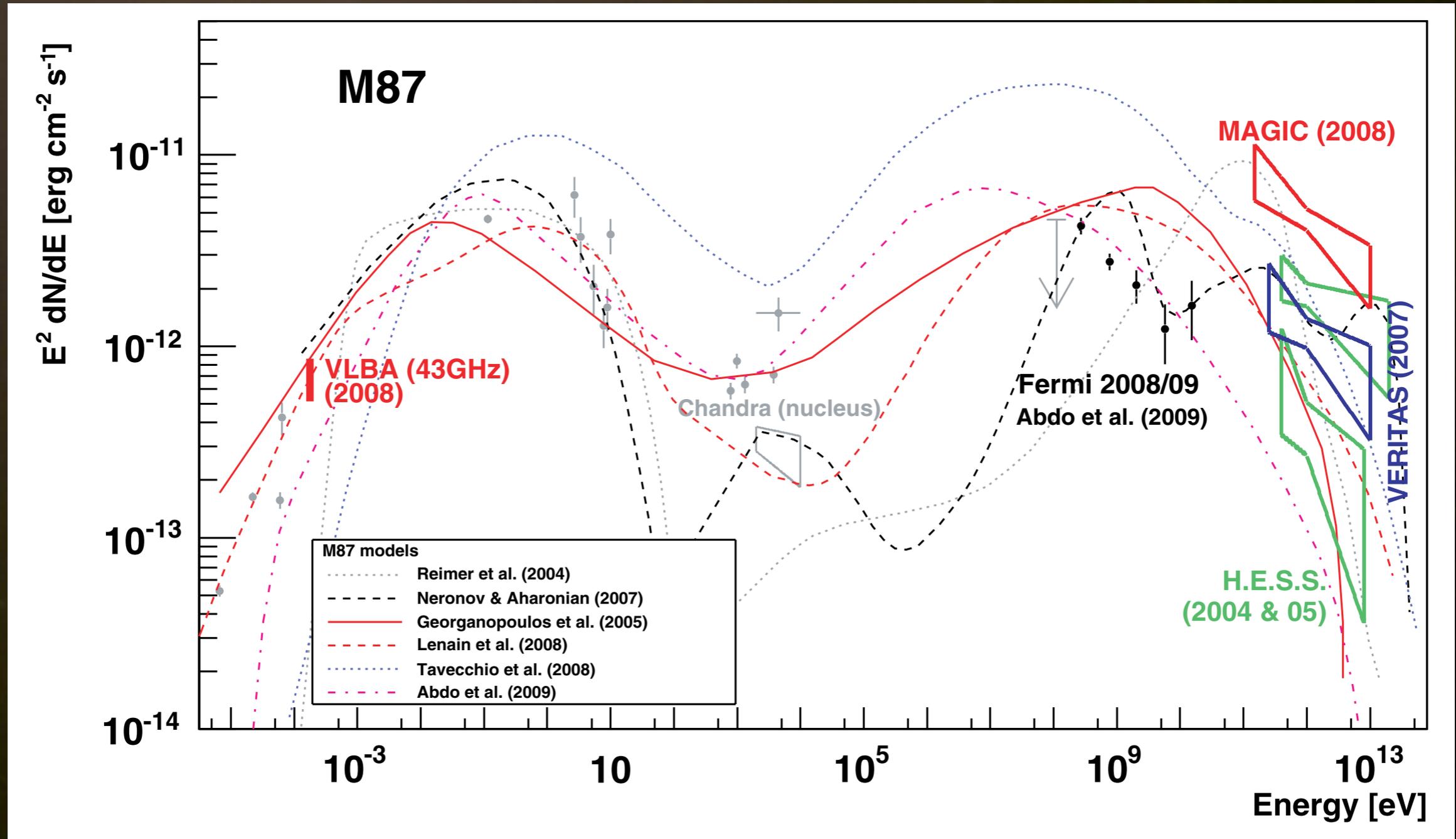
VHE

X-ray

Radio

- **VHE** activity in Feb '08
  - **X-ray**: core flux increases
  - **Radio**: inner core flux increases coinciding with the VHE flare
- ➔ **Strong indication for VHE emission from the direct vicinity of the SMBH**

# M 87 - SED



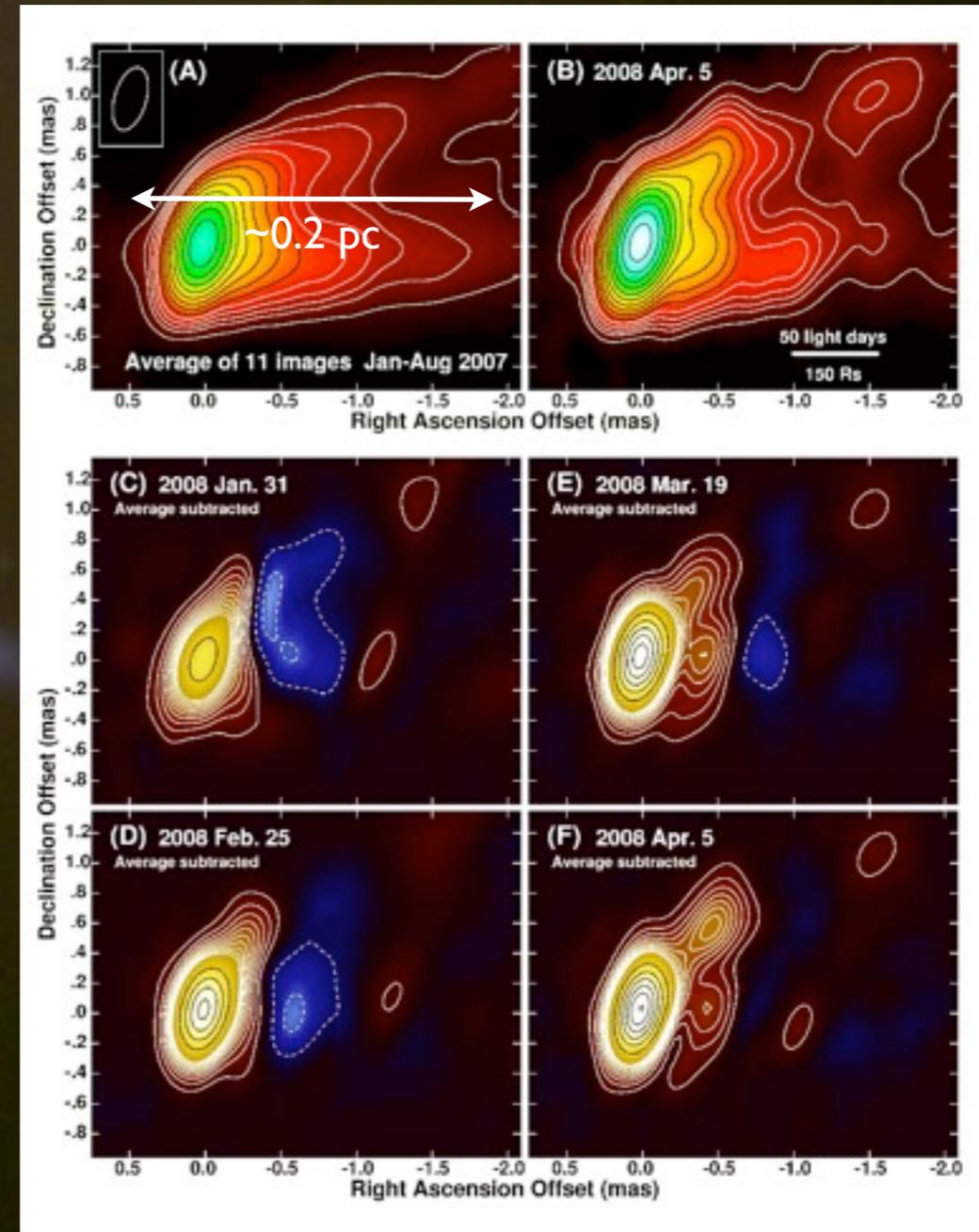


# Summary & Conclusion

- Radio galaxy M 87
  - ▶ Laboratory to probe the origin of VHE emission from SMBH and relativistic jets
- 2008: H.E.S.S., MAGIC, VERITAS + VLBA, Chandra
  - ▶ VHE flare detected, coinciding with rise in radio core and enhanced X-ray core flux
  - ▶ Indication for origin of VHE emission very close to the SMBH ( $< 100R_s$ )
- 2010: MAGIC, VERITAS, + ToO (H.E.S.S., VLBA, Chandra, ...)
  - ▶ VHE high state (Feb) and flare (April) detected (ATel #2431, #2542)
  - ▶ MWL campaign triggered (Radio, X-ray, optical polarimetry, ...)
  - ▶ Analysis ongoing

Backup

# VLBA radio observations



- **VLBA** observations at 43 GHz
  - ▶ Movie project: 13 shots in 2007, every three weeks; 14 shots in 2008, every 5 days
- Resolution:  $0.21 \times 0.43$  mas  
**~30x60 R<sub>s</sub> !!!**

Acciari et al. 2009, Science Express, Jul 2