

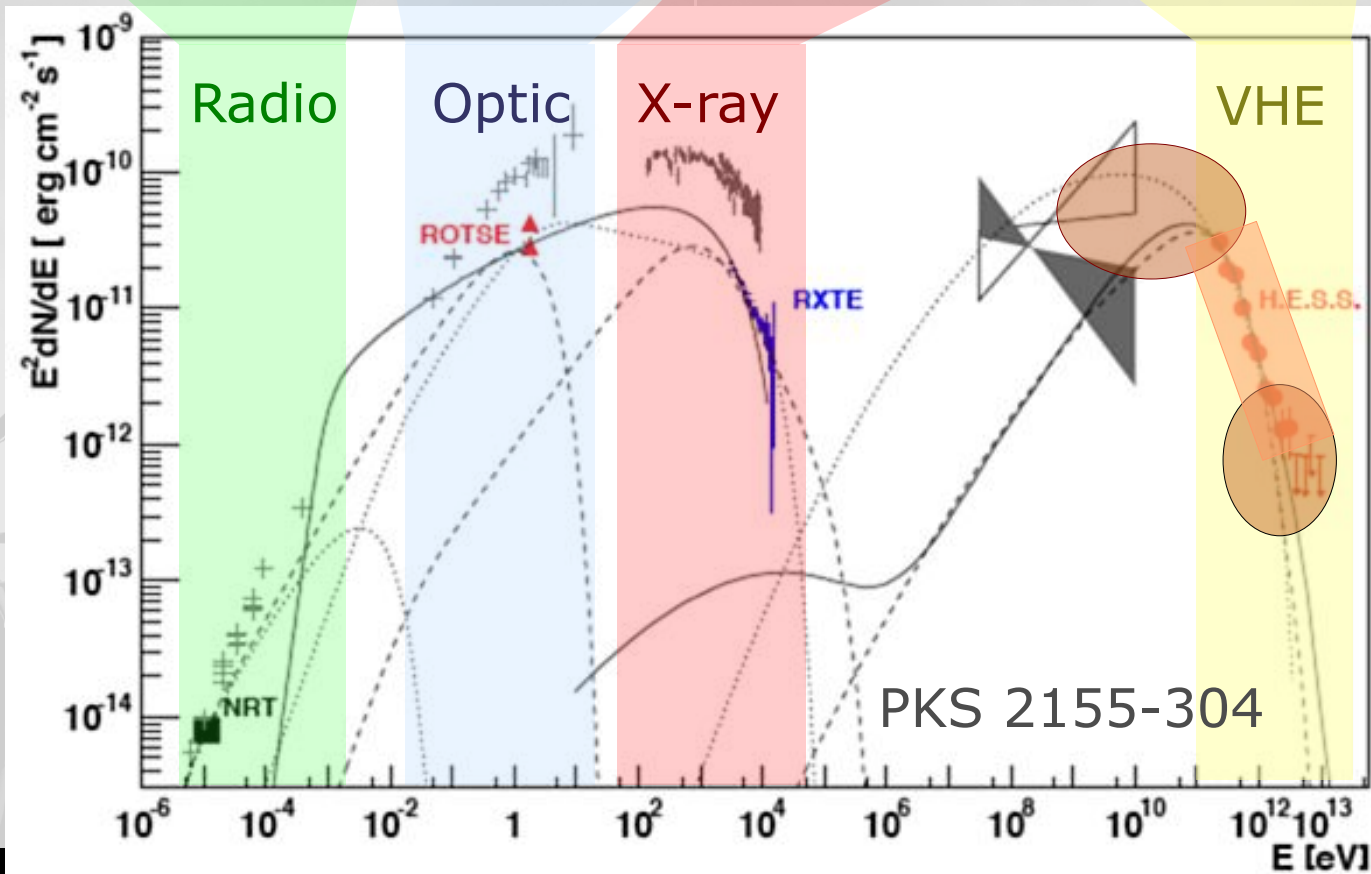
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# Summary on AGN observations at very high energy





# Overview

- Panoramic view on TeV AGN
- Zoom on:
  - M87
  - Mkn 421
  - Mkn 501
  - PKS 2155-304
- Summary

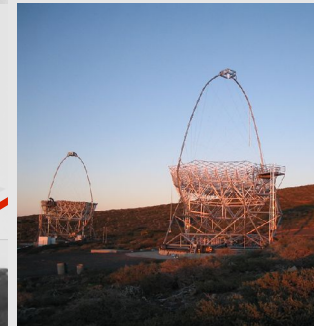
# From 7 to 24 TeV AGN

| AGN           | z      | Discovery   | Year |
|---------------|--------|-------------|------|
| M87           | 0,004  | HEGRA       | 2003 |
| Mkn 421       | 0,030  | Whipple     | 1992 |
| Mkn 501       | 0,034  | Whipple     | 1996 |
| 1ES 2344+514  | 0,044  | Whipple     | 1998 |
| Mkn 180       | 0,046  | MAGIC       | 2006 |
| 1ES 1959+650  | 0,047  | 7-Tel Array | 1999 |
| BL Lac        | 0,069  | MAGIC       | 2008 |
| PKS 0548-322  | 0,069  | H.E.S.S.    | 2007 |
| PKS 2005-489  | 0,071  | H.E.S.S.    | 2005 |
| RGB J0152+017 | 0,080  | H.E.S.S.    | 2007 |
| W Comae       | 0,102  | VERITAS     | 2008 |
| PKS 2155-304  | 0,116  | Mark VI     | 1999 |
| H 1426+428    | 0,129  | Whipple     | 2002 |
| 1ES 0806+524  | 0,138  | VERITAS     | 2008 |
| 1ES 0229+200  | 0,139  | H.E.S.S.    | 2006 |
| H 2356-309    | 0,165  | H.E.S.S.    | 2006 |
| 1ES 1218+304  | 0,182  | MAGIC       | 2006 |
| 1ES 1101-232  | 0,186  | H.E.S.S.    | 2006 |
| 1ES 0347-121  | 0,188  | H.E.S.S.    | 2007 |
| 1ES 1011+496  | 0,212  | MAGIC       | 2007 |
| PG 1553+113   | >0.250 | H.E.S.S.    | 2006 |
| S5 0716+714   | ~0.300 | MAGIC       | 2008 |
| 3C 66A        | ~0.400 | VERITAS     | 2008 |
| 3C 279        | 0,536  | MAGIC       | 2008 |

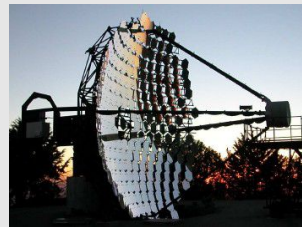
VERITAS



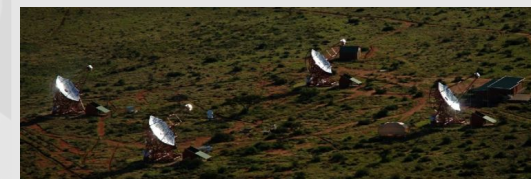
MAGIC



CANGAROO



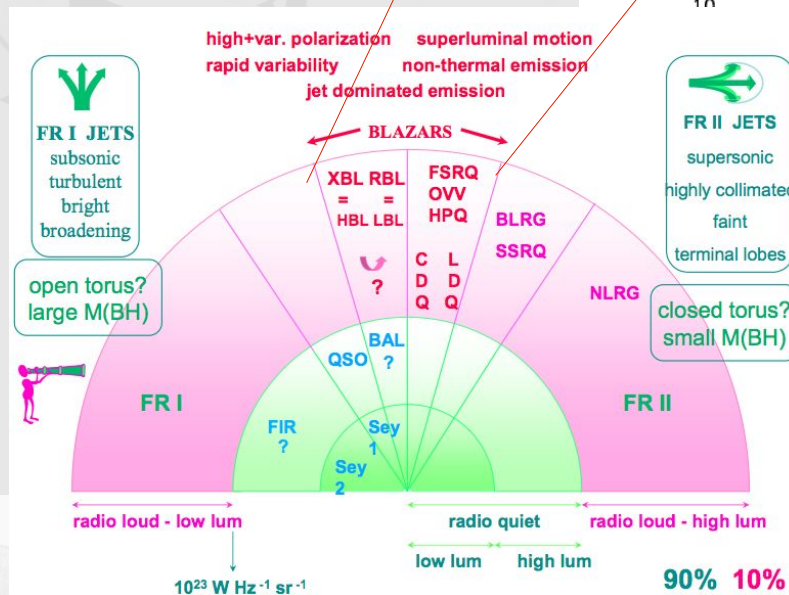
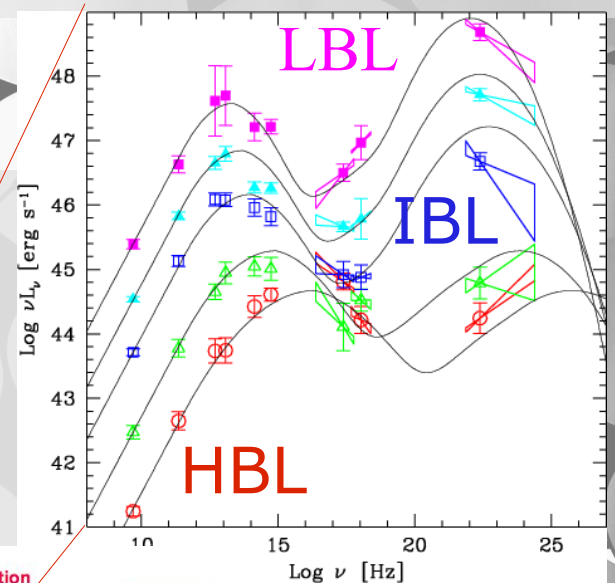
Whipple



H.E.S.S.

# TeV AGN Type

| AGN           | z      | Type |
|---------------|--------|------|
| M87           | 0,004  | FRI  |
| Mkn 421       | 0,030  | HBL  |
| Mkn 501       | 0,034  | HBL  |
| 1ES 2344+514  | 0,044  | HBL  |
| Mkn 180       | 0,046  | HBL  |
| 1ES 1959+650  | 0,047  | HBL  |
| BL Lac        | 0,069  | LBL  |
| PKS 0548-322  | 0,069  | HBL  |
| PKS 2005-489  | 0,071  | HBL  |
| RGB J0152+017 | 0,080  | HBL  |
| W Comae       | 0,102  | IBL  |
| PKS 2155-304  | 0,116  | HBL  |
| H 1426+428    | 0,129  | HBL  |
| 1ES 0806+524  | 0,138  | HBL  |
| 1ES 0229+200  | 0,139  | HBL  |
| H 2356-309    | 0,165  | HBL  |
| 1ES 1218+304  | 0,182  | HBL  |
| 1ES 1101-232  | 0,186  | HBL  |
| 1ES 0347-121  | 0,188  | HBL  |
| 1ES 1011+496  | 0,212  | HBL  |
| PG 1553+113   | >0.250 | HBL  |
| S5 0716+714   | ~0.300 | HBL  |
| 3C 66A        | ~0.400 | IBL  |
| 3C 279        | 0,536  | FSRQ |



# No Variability Observed

| AGN                  | z             | Flux Var.           |
|----------------------|---------------|---------------------|
| M87                  | 0,004         | day scale           |
| Mkn 421              | 0,030         | intra-night         |
| Mkn 501              | 0,034         | minutes             |
| 1ES 2344+514         | 0,044         | day scale           |
| <b>Mkn 180</b>       | <b>0,046</b>  | <b>NO</b>           |
| 1ES 1959+650         | 0,047         | month               |
| BL Lac               | 0,069         | year                |
| <b>PKS 0548-322</b>  | <b>0,069</b>  | <b>NO</b>           |
| PKS 2005-489         | 0,071         | year                |
| <b>RGB J0152+017</b> | <b>0,080</b>  | <b>NO</b>           |
| W Comae              | 0,102         | days                |
| PKS 2155-304         | 0,116         | minutes             |
| H 1426+428           | 0,129         | year                |
| <b>1ES 0806+524</b>  | <b>0,138</b>  | <b>NO</b>           |
| <b>1ES 0229+200</b>  | <b>0,139</b>  | <b>NO</b>           |
| H 2356-309           | 0,165         | month               |
| 1ES 1218+304         | 0,182         | year                |
| 1ES 1101-232         | 0,186         | year                |
| <b>1ES 0347-121</b>  | <b>0,188</b>  | <b>NO</b>           |
| 1ES 1011+496         | 0,212         | year                |
| PG 1553+113          | >0.250        | year                |
| <b>S5 0716+714</b>   | <b>~0.300</b> | <b>NO</b>           |
| 3C 66A               | ~0.400        | -                   |
| <b>3C 279</b>        | <b>0,536</b>  | <b>NO (night ?)</b> |

## 1/3 VHE AGN

**Mkn 180** (11% Crab, MAGIC)

- $5.5\sigma$  in **11 h, 7 days** - Albert et al., ApJ, 648, L105, 2006

**PKS 0548-322** (1.4% Crab, HESS)

- $5.8\sigma$  in **24 h, 3 years** - Superina, Benbow et al., Proc 30<sup>th</sup> ICRC, 2007

**RGB J0152+017** (2% Crab, HESS)

- $6.6\sigma$  in **15 h, 2 months** - Aharonian et al., A&A, 481, L103A, 2008

**1ES 0806+524** (1% Crab, VERITAS)

- $5.8\sigma$  in **46 h, 2 years** - Vacchiari et al., arXiv:0812.0978 , 2008

**1ES 0229+200** (1.8% Crab, HESS)

- $6.6\sigma$  in **42 h, 2 year** - Aharonian et al., A&A, 475, L9, 2007

**1ES 0347-121** (2% Crab, HESS)

- $10.1\sigma$  in **25 h, 5 months** - Aharonian et al., A&A, 473, L25, 2007

**S5 0716+741** (10%Crab, MAGIC)

- $6.8\sigma$  in **2.6h** - Robert, Proc G-2008

**3C 279** (57% Crab, MAGIC)

- $>6\sigma$  in **1night** - Albert et al, Science, 320, 1752, 2008

# Long Term Variability

## ~1/2 VHE AGN

| AGN                 | z                | Flux Var.    |
|---------------------|------------------|--------------|
| M87                 | 0,004            | day scale    |
| Mkn 421             | 0,030            | intra-night  |
| Mkn 501             | 0,034            | minutes      |
| 1ES 2344+514        | 0,044            | day scale    |
| Mkn 180             | 0,046            | NO           |
| <b>1ES 1959+650</b> | <b>0,047</b>     | <b>month</b> |
| <b>BL Lac</b>       | <b>0,069</b>     | <b>year</b>  |
| PKS 0548-322        | 0,069            | NO           |
| <b>PKS 2005-489</b> | <b>0,071</b>     | <b>year</b>  |
| RGB J0152+017       | 0,080            | NO           |
| W Comae             | 0,102            | days         |
| PKS 2155-304        | 0,116            | minutes      |
| <b>H 1426+428</b>   | <b>0,129</b>     | <b>year</b>  |
| 1ES 0806+524        | 0,138            | NO           |
| 1ES 0229+200        | 0,139            | NO           |
| <b>H 2356-309</b>   | <b>0,165</b>     | <b>month</b> |
| <b>1ES 1218+304</b> | <b>0,182</b>     | <b>year</b>  |
| <b>1ES 1101-232</b> | <b>0,186</b>     | <b>year</b>  |
| 1ES 0347-121        | 0,188            | NO           |
| <b>1ES 1011+496</b> | <b>0,212</b>     | <b>year</b>  |
| <b>PG 1553+113</b>  | <b>&gt;0.250</b> | <b>year</b>  |
| S5 0716+714         | ~0.300           | NO           |
| 3C 66A              | ~0.400           | -            |
| 3C 279              | 0,536            | NO           |

### **1ES 1959+650** (obs: 1998-2002)

- Major Outburst: 2002 (Whipple, HEGRA, CAT)

### **BL Lac** (obs: 2005-2006)

- Detected: 2005, Not seen: 2006 (Albert et al., ApJ, 666, L17, 2007)

### **PKS 2005-489** (obs: 2005-2007)

- Monthly variability 2006: Costamante, et al., Proc 30<sup>th</sup> ICRC, 2007

### **H 1426+428** (obs: 1995-2007)

- Bright period : 2000-2001, no with 3<sup>rd</sup> generation

### **H 2356-309** (obs: 2006-2007)

- Month variability 2006: Costamante, et al., Proc 30<sup>th</sup> ICRC, 2007

### **1ES 1218+304** (obs: 2005-2007)

- 13%Crab 2005 – 8%Crab 2006-2007 (MAGIC and VERITAS)

### **1ES 1101-232** (obs: 2004-2007)

- 2%Crab 2004-2006 – Upper Limit 2007 (H.E.S.S.)

### **1ES 1011+496** (2006-2007)

- 2006: Upper Limit, 2007 6.5%Crab (MAGIC)

### **PG 1553+113**

- Flux 2006 = 3xFlux 2005 (MAGIC and H.E.S.S.)

# Short Term Variability

| AGN                 | z            | Flux Var.          |
|---------------------|--------------|--------------------|
| <b>M87</b>          | <b>0,004</b> | <b>day scale</b>   |
| <b>Mkn 421</b>      | <b>0,030</b> | <b>intra-night</b> |
| <b>Mkn 501</b>      | <b>0,034</b> | <b>minutes</b>     |
| <b>1ES 2344+514</b> | <b>0,044</b> | <b>day scale</b>   |
| Mkn 180             | 0,046        | NO                 |
| 1ES 1959+650        | 0,047        | month              |
| BL Lac              | 0,069        | year               |
| PKS 0548-322        | 0,069        | NO                 |
| PKS 2005-489        | 0,071        | year               |
| RGB J0152+017       | 0,080        | NO                 |
| <b>W Comae</b>      | <b>0,102</b> | <b>day scale</b>   |
| <b>PKS 2155-304</b> | <b>0,116</b> | <b>minutes</b>     |
| H 1426+428          | 0,129        | year               |
| 1ES 0806+524        | 0,138        | NO                 |
| 1ES 0229+200        | 0,139        | NO                 |
| H 2356-309          | 0,165        | month              |
| 1ES 1218+304        | 0,182        | year               |
| 1ES 1101-232        | 0,186        | year               |
| 1ES 0347-121        | 0,188        | NO                 |
| 1ES 1011+496        | 0,212        | year               |
| PG 1553+113         | >0.250       | year               |
| S5 0716+714         | ~0.300       | NO                 |
| 3C 66A              | ~0.400       | -                  |
| 3C 279              | 0,536        | NO                 |

## 1/4 VHE AGN

**M 87:** night scale

- HESS, MAGIC, VERITAS

**Mkn421:** 15 minutes

- >100 $\sigma$  in 15h, Flare 2004 (H.E.S.S.)

**Mkn 501:** 2minutes doubling time

- Flare 2005 (MAGIC)

**1ES 2344+514:** night scale

- Flare 2007 (VERITAS)

**W Comae:** night scale

- 2008, ApJ, 684L, 73A, 2008

**PKS2155:**  $\Delta t=3$  min

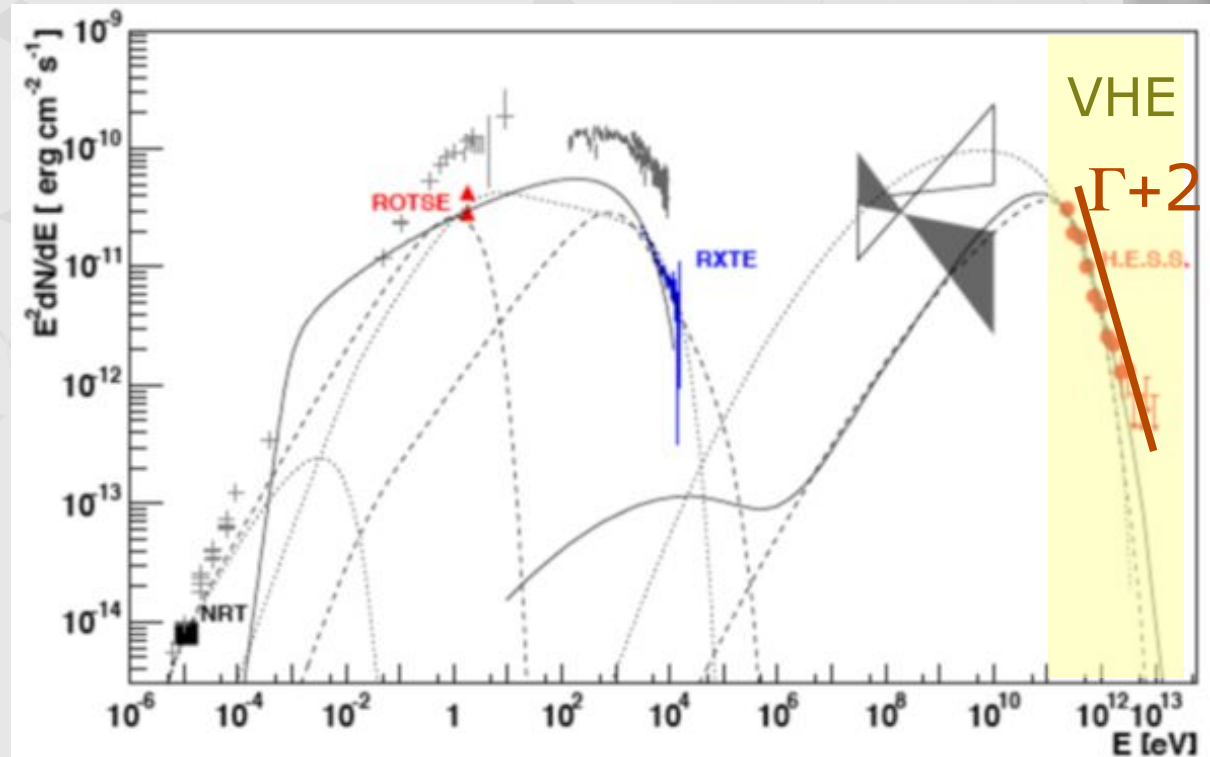
- Flares 2006 (H.E.S.S.)



# Spectral shape : Power Law

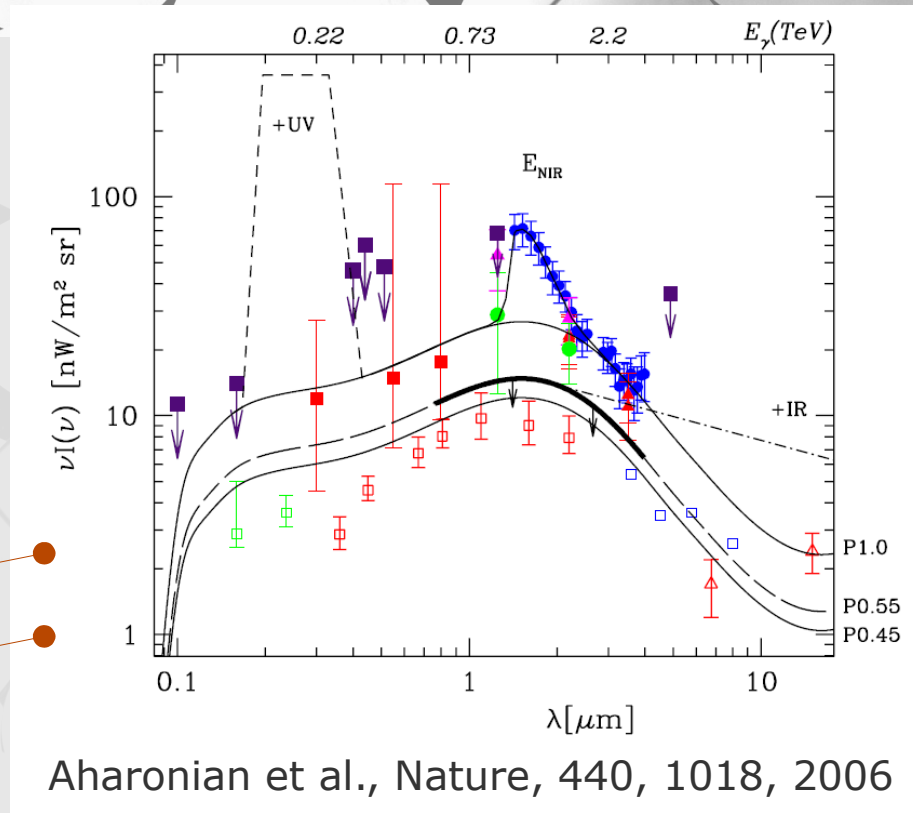
| AGN           | z            | $\Gamma$      |
|---------------|--------------|---------------|
| M87           | 0,004        | 2.3           |
| Mkn 421       | 0,030        | -             |
| Mkn 501       | 0,034        | 2.4           |
| 1ES 2344+514  | 0,044        | 2.9           |
| Mkn 180       | 0,046        | 3.3           |
| 1ES 1959+650  | 0,047        | 2.7           |
| BL Lac        | 0,069        | 3.6           |
| PKS 0548-322  | 0,069        | 2.8           |
| PKS 2005-489  | 0,071        | 4.0           |
| RGB J0152+017 | 0,080        | 2.9           |
| W Comae       | 0,102        | 3.8           |
| PKS 2155-304  | 0,116        | 3.4           |
| H 1426+428    | 0,129        | 3.5           |
| 1ES 0806+524  | 0,138        | $3.6 \pm 1.0$ |
| 1ES 0229+200  | 0,139        | 2.5           |
| H 2356-309    | 0,165        | 3.1           |
| 1ES 1218+304  | 0,182        | 3.0           |
| 1ES 1101-232  | 0,186        | 2.9           |
| 1ES 0347-121  | 0,188        | 3.1           |
| 1ES 1011+496  | 0,212        | 4.0           |
| PG 1553+113   | >0.250       | 4.6           |
| S5 0716+714   | $\sim 0.300$ | ?             |
| 3C 66A        | $\sim 0.400$ | soft          |
| 3C 279        | 0,536        | 4.1           |

$$dN/dE = I_0 (E/1 \text{ TeV})^{-\Gamma}$$



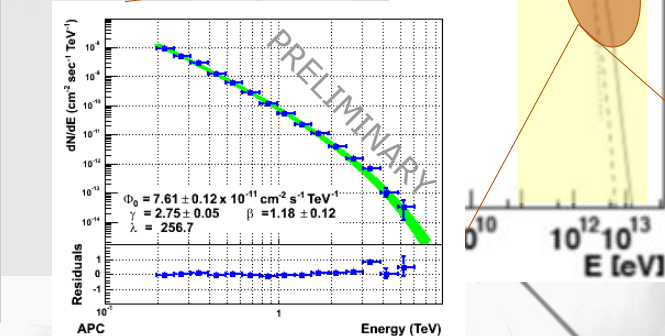
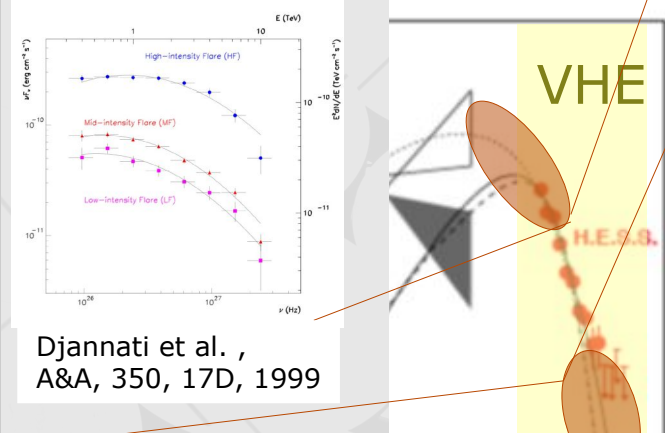
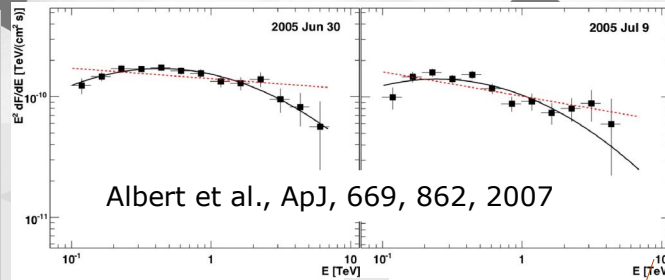
# Constraining the EBL

| AGN                 | z            | Mean $\Gamma$ |
|---------------------|--------------|---------------|
| M87                 | 0,004        | -2.3          |
| Mkn 421             | 0,030        |               |
| Mkn 501             | 0,034        | -2.4          |
| 1ES 2344+514        | 0,044        | -2.9          |
| Mkn 180             | 0,046        | -3.3          |
| 1ES 1959+650        | 0,047        | -2.7          |
| BL Lac              | 0,069        | -3.6          |
| PKS 0548-322        | 0,069        | -2.8          |
| PKS 2005-489        | 0,071        | -4.0          |
| RGB J0152+017       | 0,080        | -2.9          |
| W Comae             | 0,102        | -3.8          |
| PKS 2155-304        | 0,116        | -3.4          |
| H 1426+428          | 0,129        | -3.5          |
| 1ES 0806+524        | 0,138        | ?             |
| <b>1ES 0229+200</b> | <b>0,139</b> | <b>-2.5</b>   |
| <b>H 2356-309</b>   | <b>0,165</b> | <b>-3.1</b>   |
| 1ES 1218+304        | 0,182        | -3.0          |
| <b>1ES 1101-232</b> | <b>0,186</b> | <b>-2.9</b>   |
| <b>1ES 0347-121</b> | <b>0,188</b> | <b>-3.1</b>   |
| 1ES 1011+496        | 0,212        | -4.0          |
| PG 1553+113         | >0.250       | -4.6          |
| S5 0716+714         | ~0.300       | ?             |
| 3C 66A              | ~0.400       | soft          |
| <b>3C 279</b>       | <b>0,536</b> | <b>-4.1</b>   |



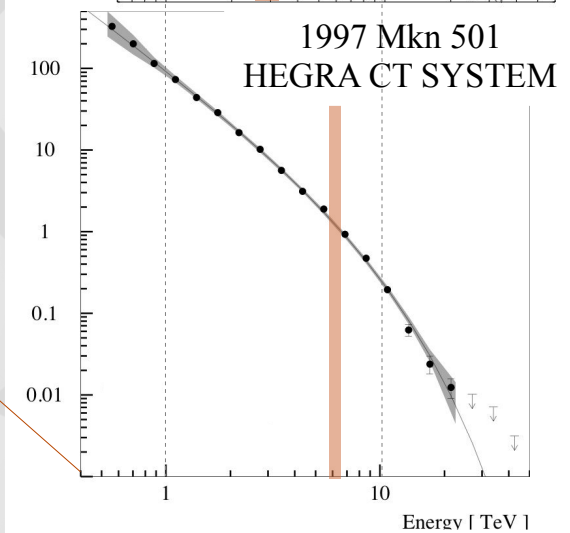
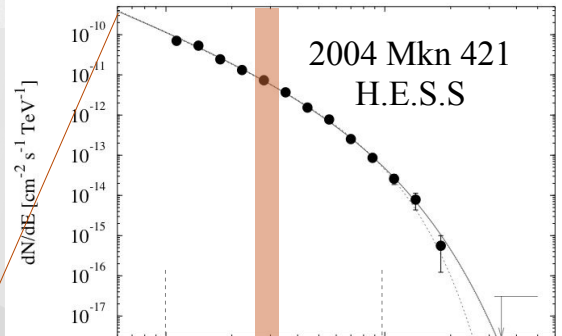
# Curved spectral shape

| AGN                 | z            | Mean Flux       |
|---------------------|--------------|-----------------|
| M87                 | 0,004        | 0.7-3%          |
| <b>Mkn 421</b>      | <b>0,030</b> | <b>50%-300%</b> |
| <b>Mkn 501</b>      | <b>0,034</b> | <b>37%-310%</b> |
| 1ES 2344+514        | 0,044        | 12%-41%         |
| Mkn 180             | 0,046        | 11,00%          |
| 1ES 1959+650        | 0,047        | 10%-20%         |
| BL Lac              | 0,069        | 3,00%           |
| PKS 0548-322        | 0,069        | 1,40%           |
| PKS 2005-489        | 0,071        | 2,50%           |
| RGB J0152+017       | 0,080        | 2,00%           |
| W Comae             | 0,102        | 9,00%           |
| <b>PKS 2155-304</b> | <b>0,116</b> | <b>10%-700%</b> |
| H 1426+428          | 0,129        | 7.5%-50%        |
| 1ES 0806+524        | 0,138        | 1,80%           |
| 1ES 0229+200        | 0,139        | 1,80%           |
| H 2356-309          | 0,165        | 1,40%           |
| 1ES 1218+304        | 0,182        | 10,00%          |
| 1ES 1101-232        | 0,186        | 2,00%           |
| 1ES 0347-121        | 0,188        | 2,00%           |
| 1ES 1011+496        | 0,212        | 5.4%            |
| PG 1553+113         | >0.250       | 3.4%            |
| S5 0716+714         | ~0.300       | 10,00%          |
| 3C 66A              | ~0.400       | 10,00%          |
| 3C 279              | 0,536        | 57,00%          |



Aharonian et al. , A&A, 437, 95, 2005

$$E_{\text{cut}} = 3.1(+0.5 -0.4)_{\text{stat}} \pm 0.9_{\text{sys}} \text{ TeV}$$



$$E_{\text{cut}} = 6.2 \pm 0.4_{\text{stat}} (+2.9 -1.5)_{\text{sys}} \text{ TeV}$$

Aharonian et al. , A&A, 349, 11, 1999

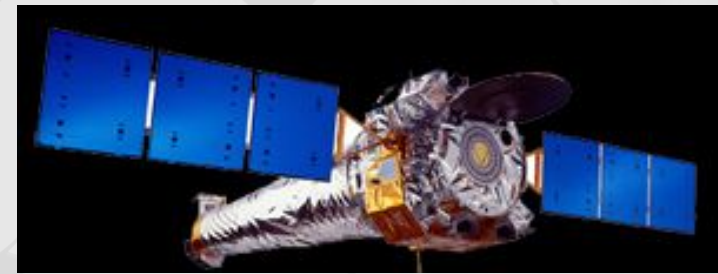
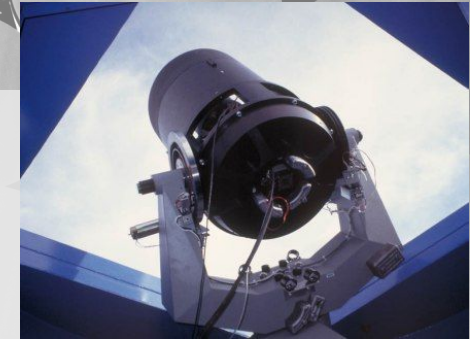
# Spectral evolution

## Spectrum harden when flux increases

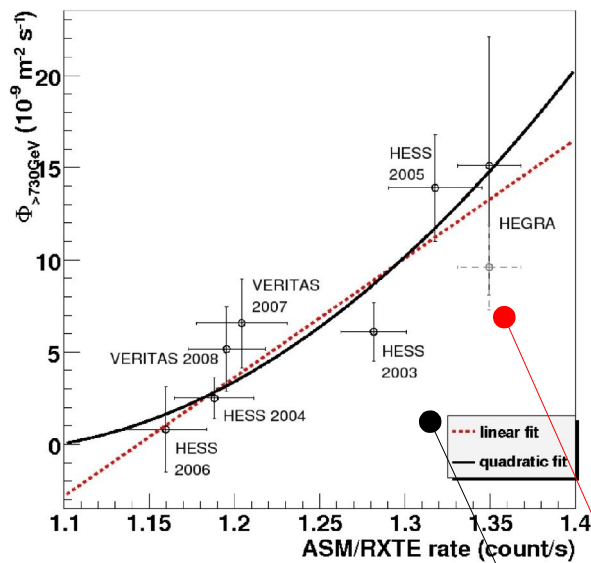
- Mkn 421
  - Long term
    - Grube, PhD Thesis, 2007
    - Albert et al., ApJ, 663, 125, 2007
  - Short term
    - Aharonian et al., A&A, 437, 95, 2005
- Mkn 501
  - Short term
    - Djannati et al., A&A, 350, 17D, 1999
    - Albert et al., ApJ, 669, 862, 2007
- PKS 2155-304
  - Lenain et al., Proc  $\gamma$ -2008

# Simultaneous MWL Data

| AGN                 | z                | MWL data         | Flux Var.  |
|---------------------|------------------|------------------|------------|
| <b>M87</b>          | <b>0,004</b>     | <b>2007</b>      | <b>YES</b> |
| <b>Mkn 421</b>      | <b>0,030</b>     | <b>2005</b>      | <b>YES</b> |
| <b>Mkn 501</b>      | <b>0,034</b>     | <b>1997</b>      | <b>YES</b> |
| <b>1ES 2344+514</b> | <b>0,044</b>     | <b>2008</b>      | <b>YES</b> |
| Mkn 180             | 0,046            | 2006             | NO         |
| <b>1ES 1959+650</b> | <b>0,047</b>     | <b>2004-2006</b> | <b>YES</b> |
| BL Lac              | 0,069            | ?                | Y          |
| PKS 0548-322        | 0,069            | NO               | NO         |
| PKS 2005-489        | 0,071            | NO               | Y          |
| RGB J0152+017       | 0,080            | NO               | NO         |
| W Comae             | 0,102            | NO               | Y          |
| <b>PKS 2155-304</b> | <b>0,116</b>     | <b>2003-2006</b> | <b>YES</b> |
| H 1426+428          | 0,129            | NO               | Y          |
| 1ES 0806+524        | 0,138            | NO               | NO         |
| 1ES 0229+200        | 0,139            | NO               | NO         |
| H 2356-309          | 0,165            | 2004             | NO         |
| 1ES 1218+304        | 0,182            | NO               | NO         |
| 1ES 1101-232        | 0,186            | 2004-2005        | NO         |
| 1ES 0347-121        | 0,188            | 2006             | NO         |
| 1ES 1011+496        | 0,212            | NO               | NO         |
| <b>PG 1553+113</b>  | <b>&gt;0.250</b> | <b>2006</b>      | <b>YES</b> |
| S5 0716+714         | ~0.300           | NO               | NO         |
| 3C 66A              | ~0.400           | -                | -          |
| 3C 279              | 0,536            | NO               | NO         |

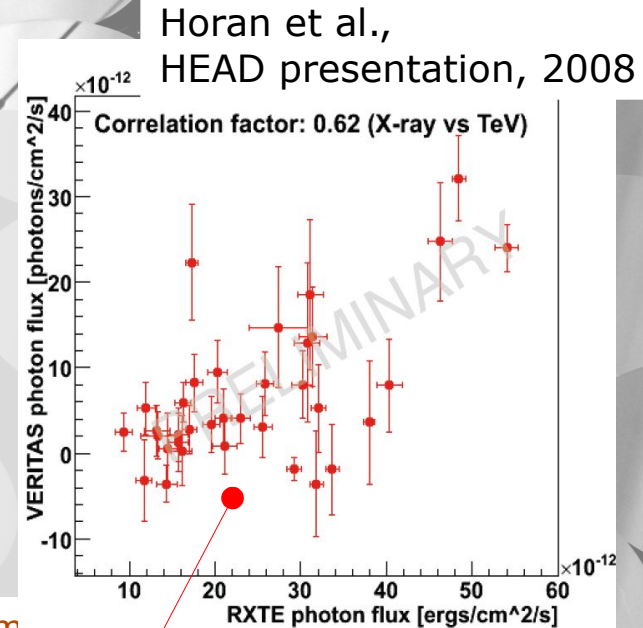


# X/VHE Correlation



Hui et al. 2008

5 AGN



Horan et al.,  
HEAD presentation, 2008

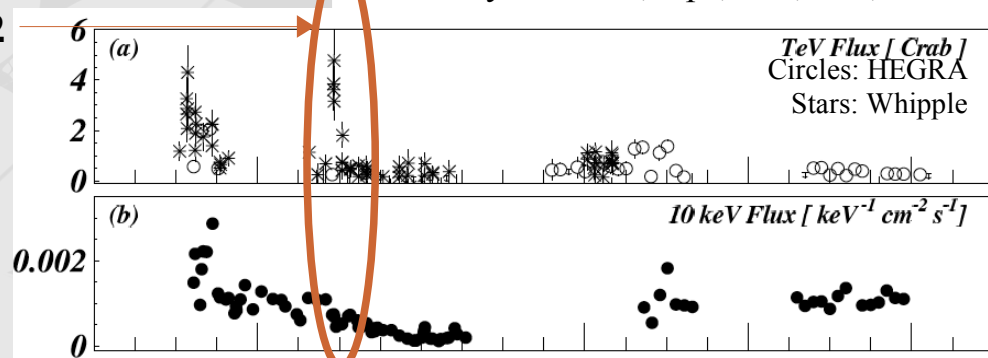
|           | Long-term     | Short-term  |
|-----------|---------------|---|
| Linear    | M87<br>Mkn421 | Mkn421<br>Mkn501 (1997 CAT, 3 nights)<br>1ES 2344+514<br>PKS 2155-304 |
| Quadratic | M87           | Mkn421<br>PKS 2155-304  |
| Cubic     |               | PKS 2155-304  |

# NO X/VHE Correlation

## 1ES 1959+650

Krawczynski et al, ApJ, 601, 151, 2004

- **“Orphan” TeV flare,  $\sim 4\text{Crab}$ , 2002**
  - **X-rays : NO high state**
  - not expected from SSC.
- **Quite, since 2002**
  - **20%Crab, 2004**
    - (6 hours:  $8.2 \sigma$ )
    - Albert et al., ApJ, 639, 761, 2006
    - **X-ray: quiescent state**
  - **10%Crab, 2006**
    - (14.3h:  $10.4 \sigma$ )
    - **X-ray: high state**
    - Tagliaferri et al., ApJ, 2008ApJ, 679, 1029T, 2008



June 4, 2004

# Optical/VHE Correlation ?

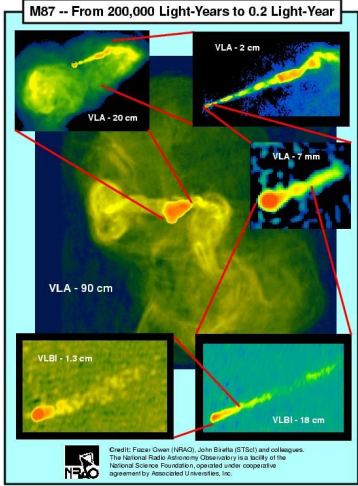
## Hints

- VHE AGN discovered with **Optical Trigger** :
  - **Mkn180** (11%Crab)
    - $5.5\sigma$  in 12.4h
    - Albert et al., ApJ, 648L, 105A, 2006
  - **1ES 1011+496** (5.4%Crab)
    - $6.2\sigma$  in 18.7h
    - Albert et al., ApJ, 667L, 21A, 2007
  - **S5 0716+71** (10%Crab)
    - $6.8\sigma$  in 2.6h
    - Wagner (for the MAGIC Collaboration), Proc.  $\gamma$  2008

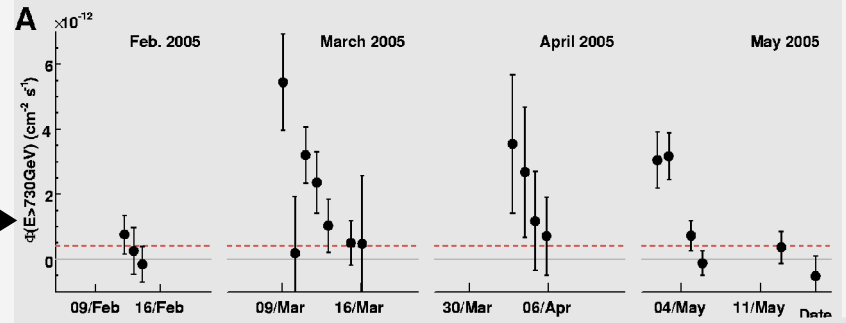


# M 87

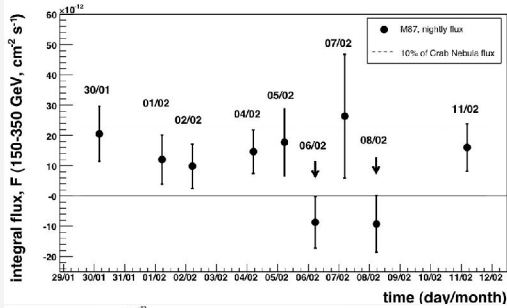
## Day scale variability



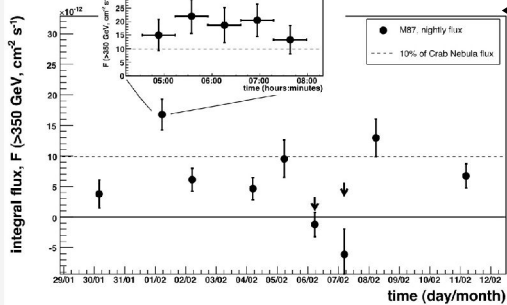
H.E.S.S. 2005



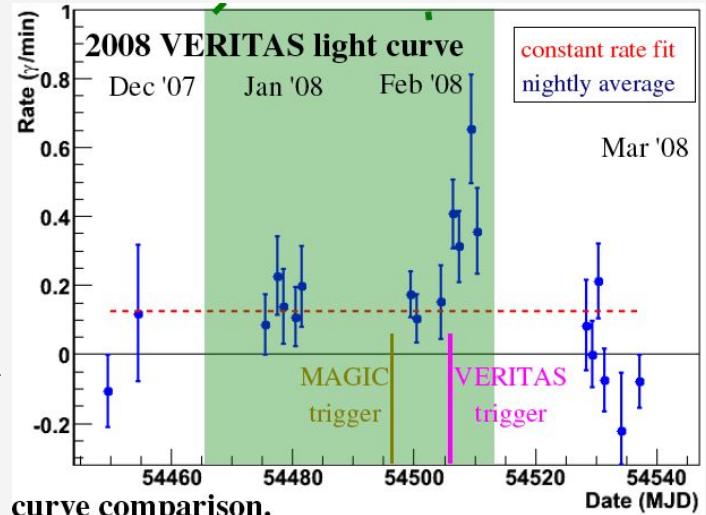
Aharonian et al., Science, 314, 1424A, 2006



MAGIC 2008



VERITAS 2008



curve comparison.

Hui et al. 2008

Albert et al., ApJ, 685L, 23A, 2008

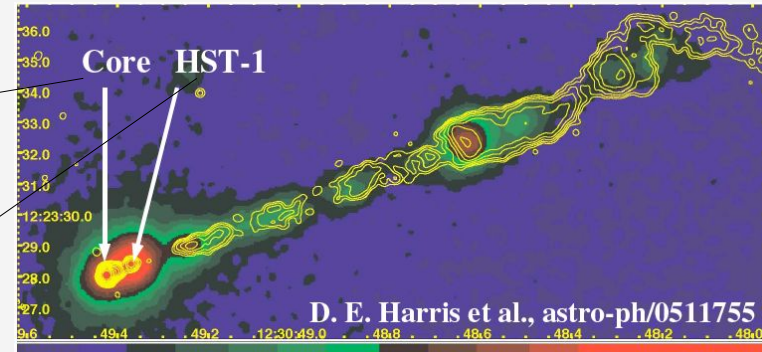
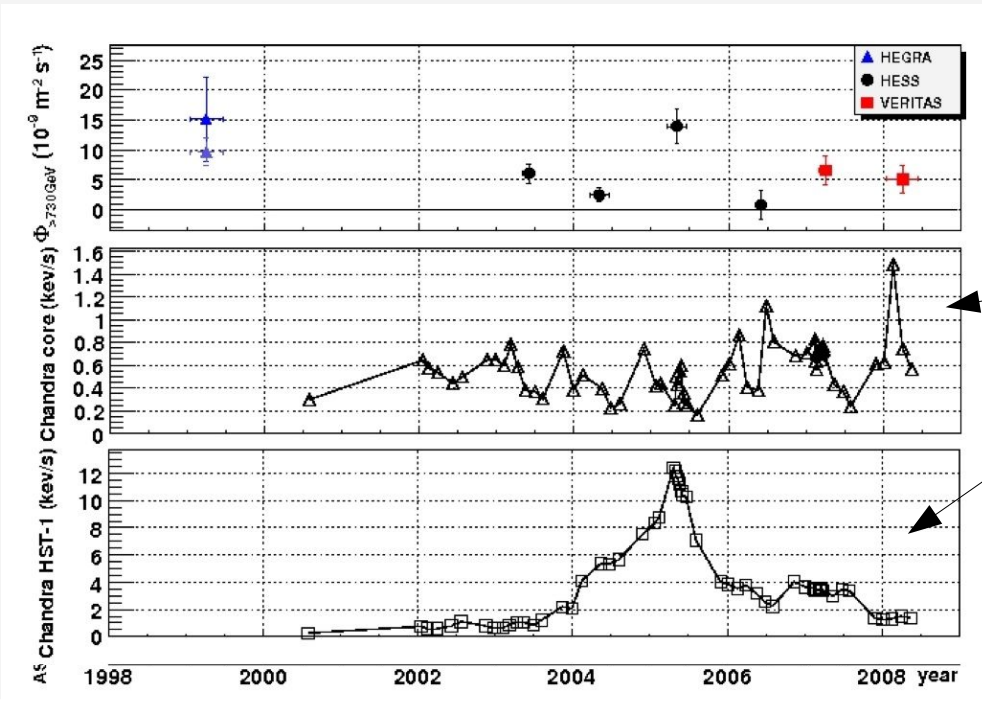
# M87

Day scale variability



Strong constraint on emission region size (causality)

$$R \leq c \Delta t \delta \sim 5 R_{\text{Schwarzschild}}$$

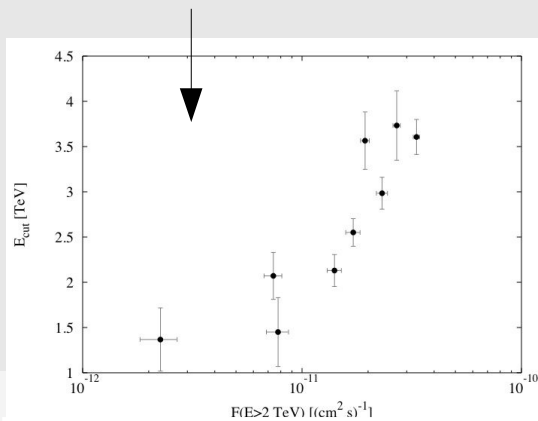


Hui et al. 2008

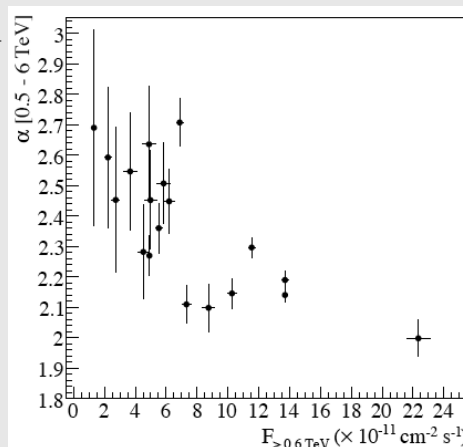
# Mkn 421

## Spectral variability

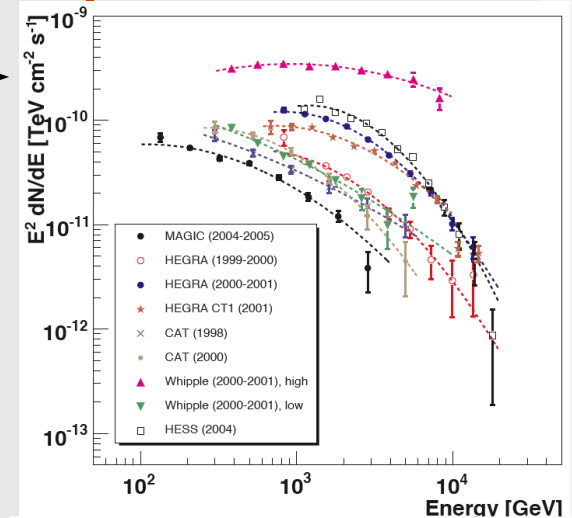
- Shift SED peak
- Hardening when flux increase
  - Long term
  - Short term



Aharonian et al., A&A, 437, 95, 2005



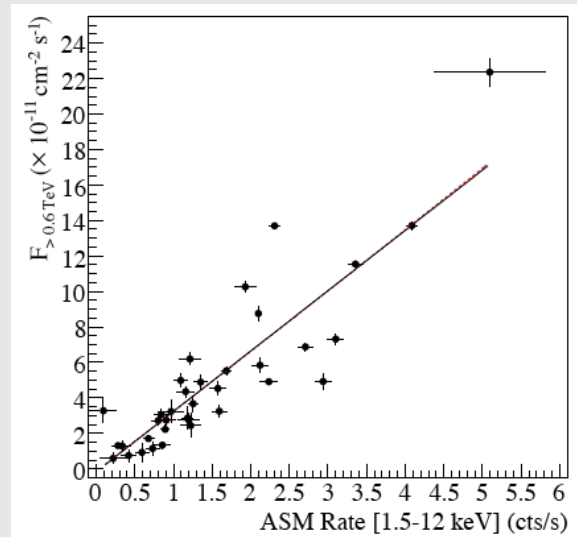
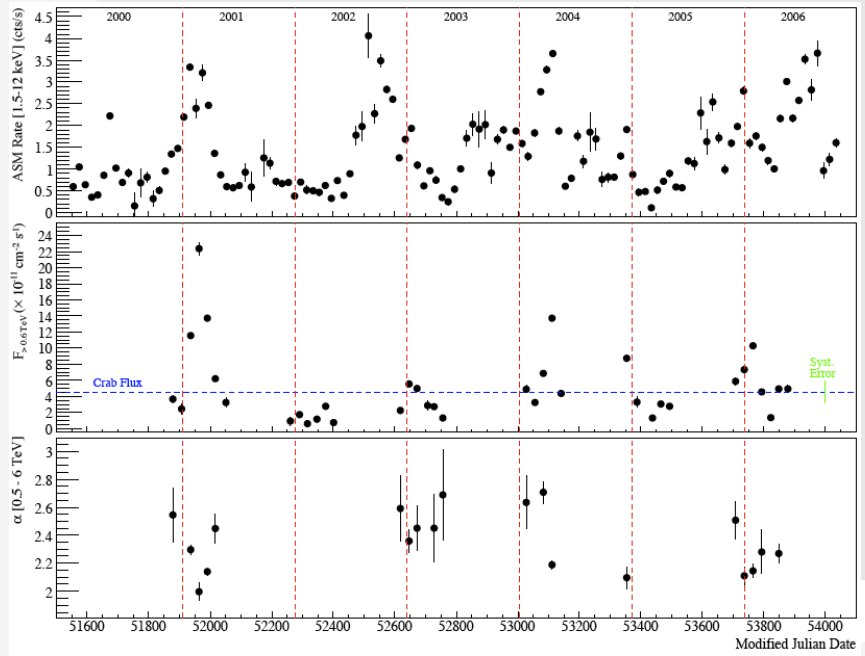
J. Grube, PhD Thesis, 2007



Albert et al., ApJ, 663, 125, 2007

# Mkn 421

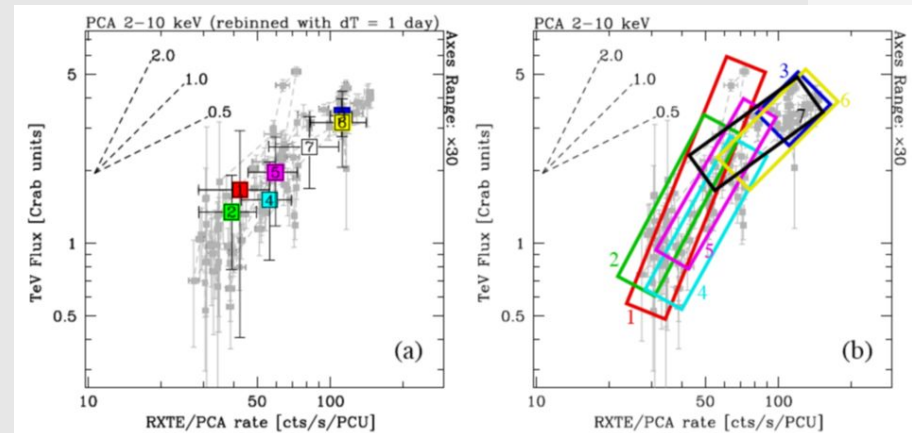
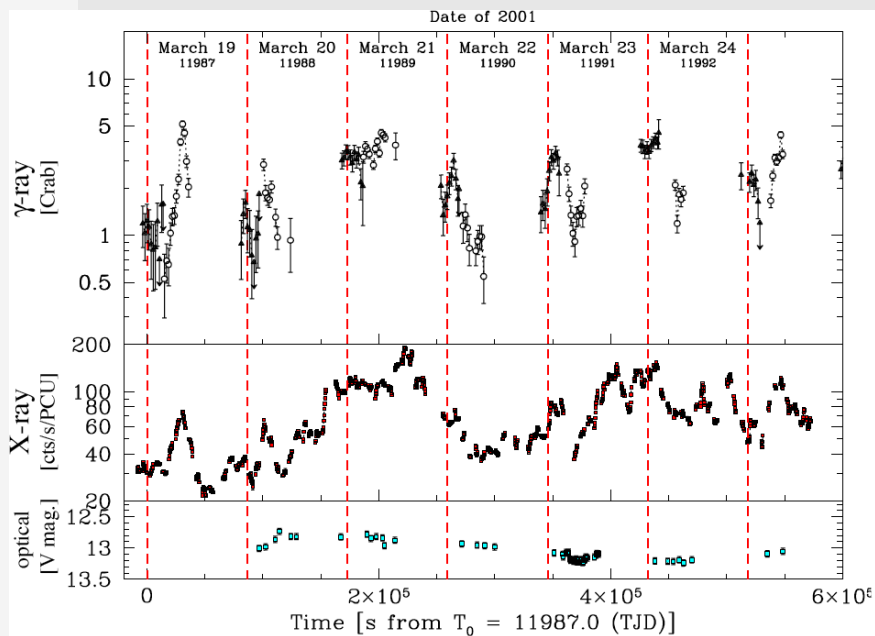
- X/VHE Correlation
  - Long term



J. Grube, PhD Thesis, 2007

# Mkn 421

- X/VHE Correlation
  - Short term



Fossati et al., ApJ, 677, 906F, 2008

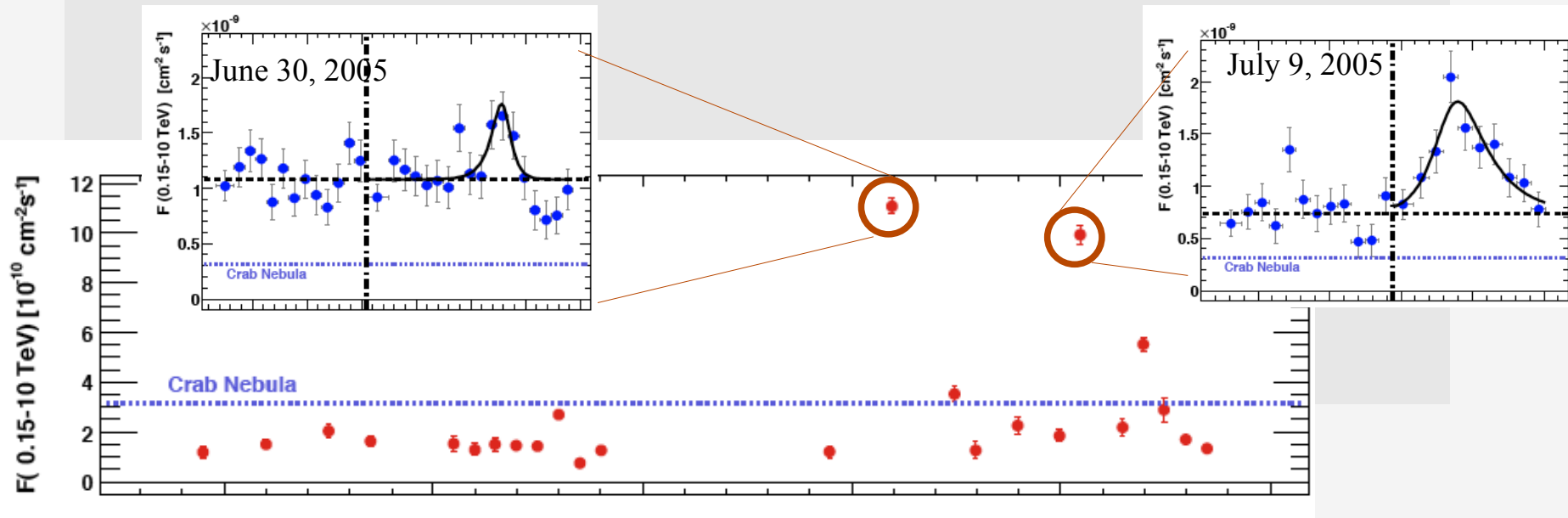
# Mkn 501:2005

Flux variability

Two flare  $\sim 3$  Crab

Doubling time scales  $\sim 2$  minutes

Variation largest at higher energies



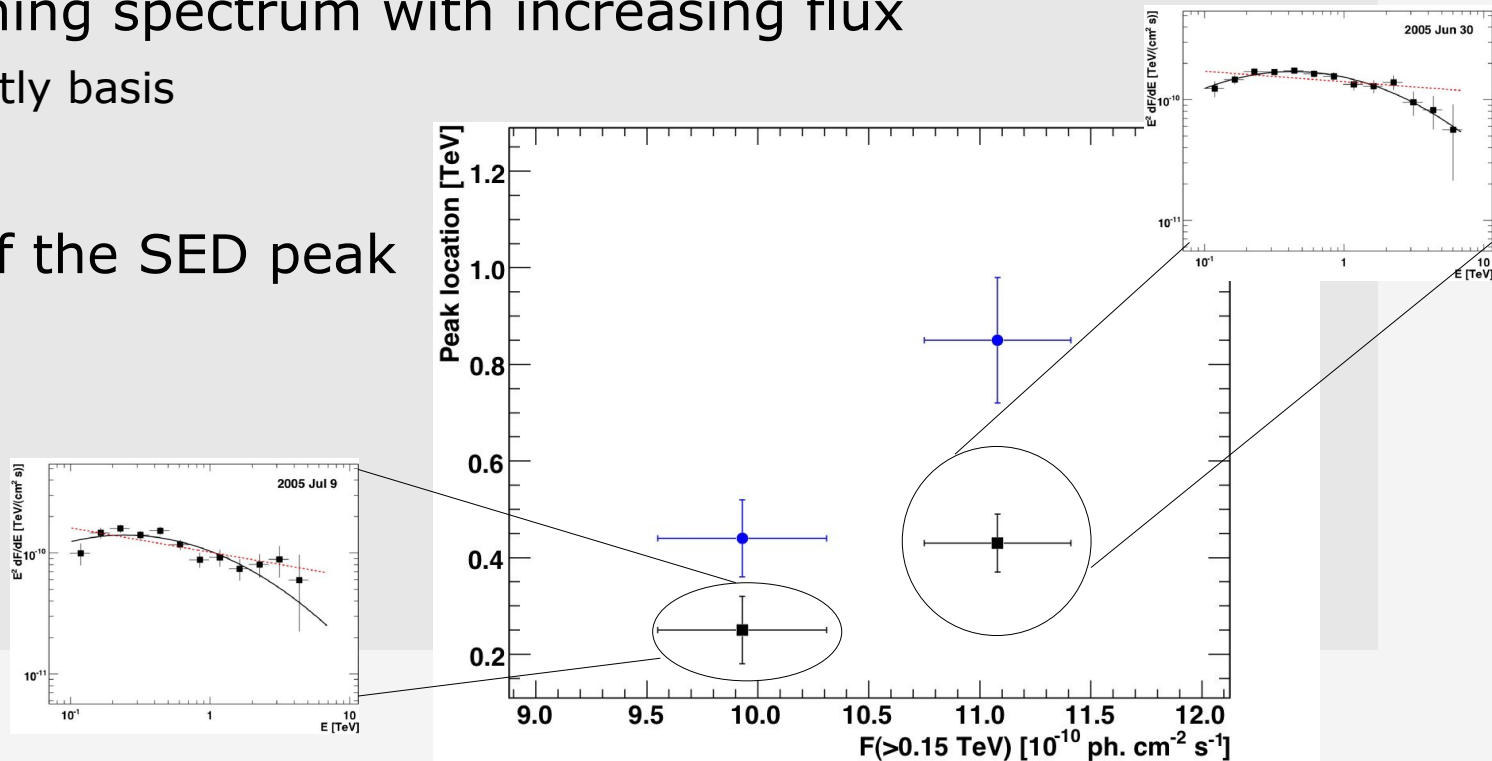
# Mkn 501

- Two Flares: Spectral variability

- Hardening spectrum with increasing flux

- Nightly basis

- Shift of the SED peak



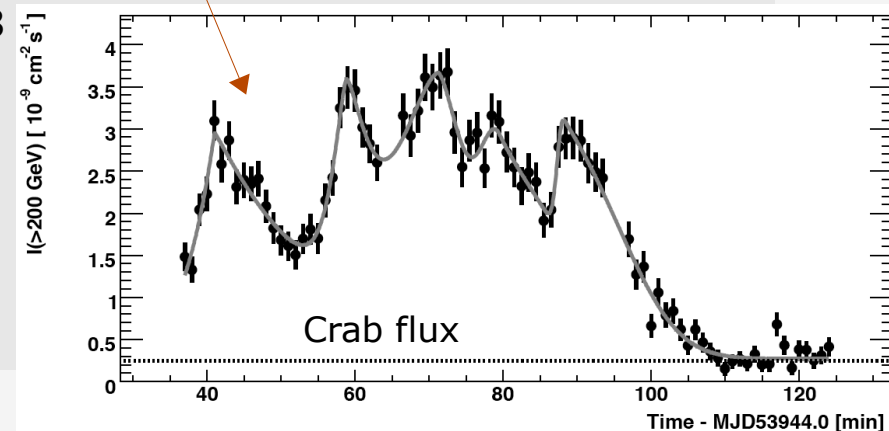
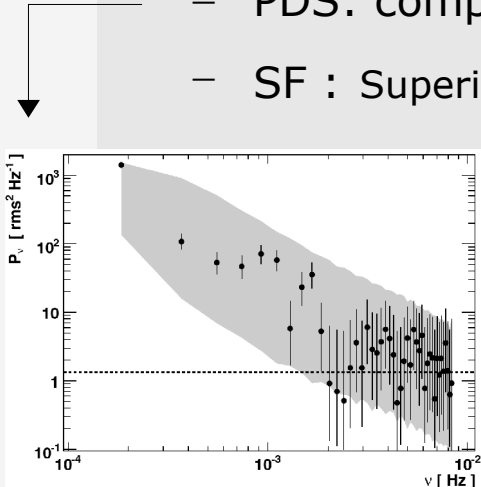
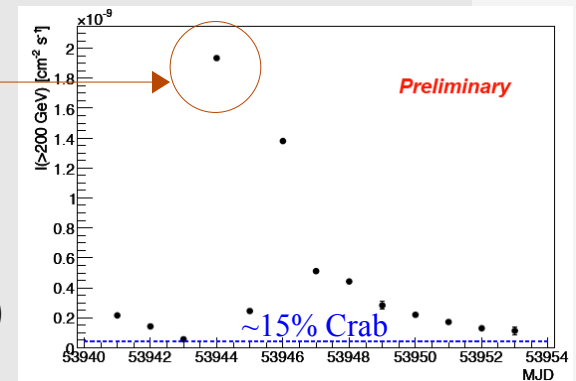
# PKS 2155-304

## Flux Variability

Big Flare: July 28  $\sim 7$  Crab

Aharonian et al, ApJ, 664L, 71A, 2007

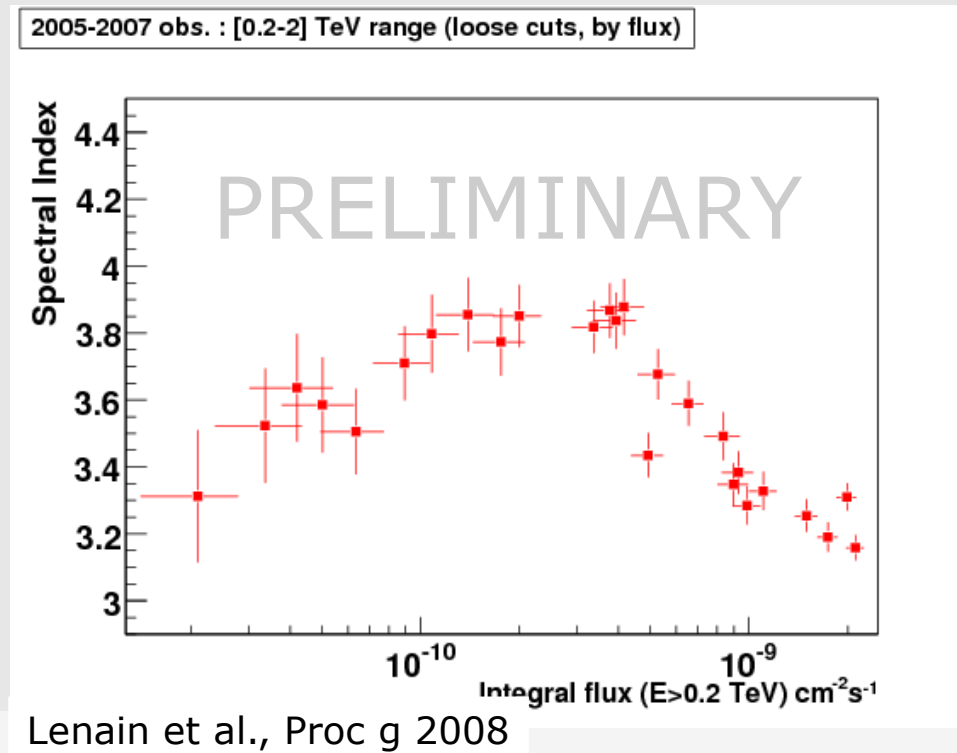
- $\Delta t \sim 3\text{min}$ 
  - constraint on emission region size (if causality)
  - PDS: compatible with red noise
  - SF : Superina et al., Proc SF2A 2008





# PKS 2155-304

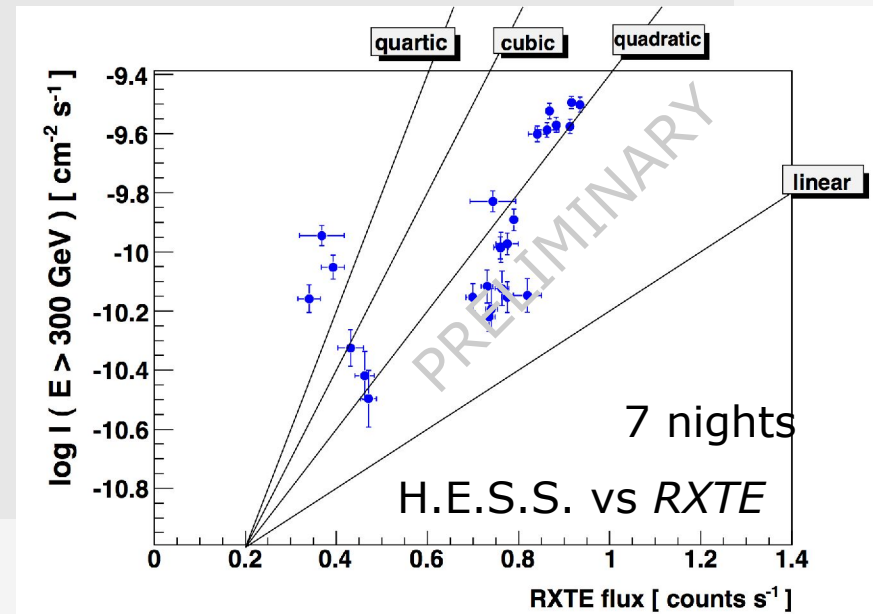
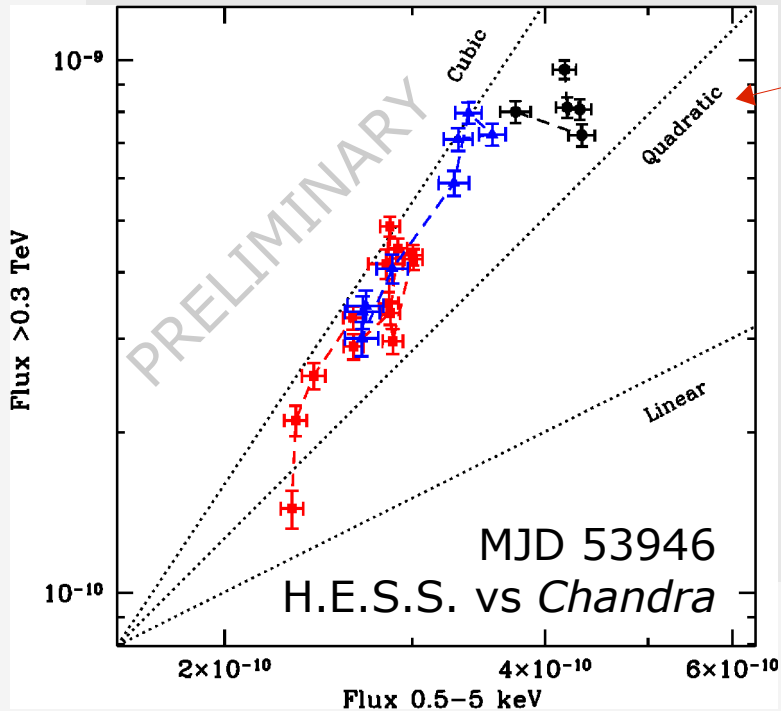
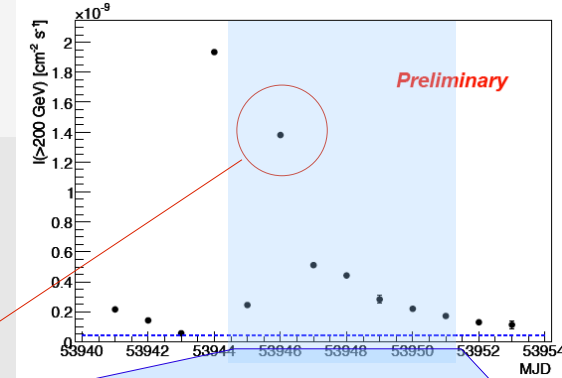
## Spectral variability



# PKS 2155-304

## Correlation VHE/X-ray

- Quadratic
- Cubic : rule out 1 zone SSC model



# Summary

- **24 TeV AGN**,  $z$ : 0.004  $\rightarrow$   $>0.25$
- **Variability**
  - Flux  $\rightarrow$  3 minutes
  - Spectra:
    - Hardening with increasing flux: Mkn 421 and Mkn 501
    - $\downarrow$
    - Complex behaviour: PKS 2155-304
- **Correlation**
  - X-ray/VHE: 5 AGN ok, but not for 1ES 1959+650
  - Optical/VHE: Hints (optical triggers)
- **Interesting results to be published soon**  
(PKS 2155-304 H.E.S.S.-Fermi-X-Opt MWL campaign August 2008)

Thanks

