TeV observations of Blazar Jets

What did we learn so far?

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TeV observations of Blazar Jets

A quiescent floor of VHE emission appears to be present

Emitting volumes can be *extremely* compact

Peak energies can be *very* high

SEDs can be very diverse

We may have to reconsider ideas about
particle acceleration and radiation mechanisms

TeV Blazars

M87	0.004
Mrk 421	0.031
Mrk 501	0.033
Mrk 180	0.034
2344+514	0.044
1959+650	0.047
0548-322	0.069
BL Lac	0.069
2005-489	0.071
2155-304	0.116
1426+428	0.129
0229+200	0.139
2356-309	0.165
1218+304	0.182
1101-232	0.186
0347-121	0.188
1553+113	???

current VHE Blazars (Whipple, HEGRA, HESS, MAGIC)
a few additional sources not yet confirmed
Many more to come

For a collection of family properties
see poster # 34 (Robert Wagner)

The quiescent emission

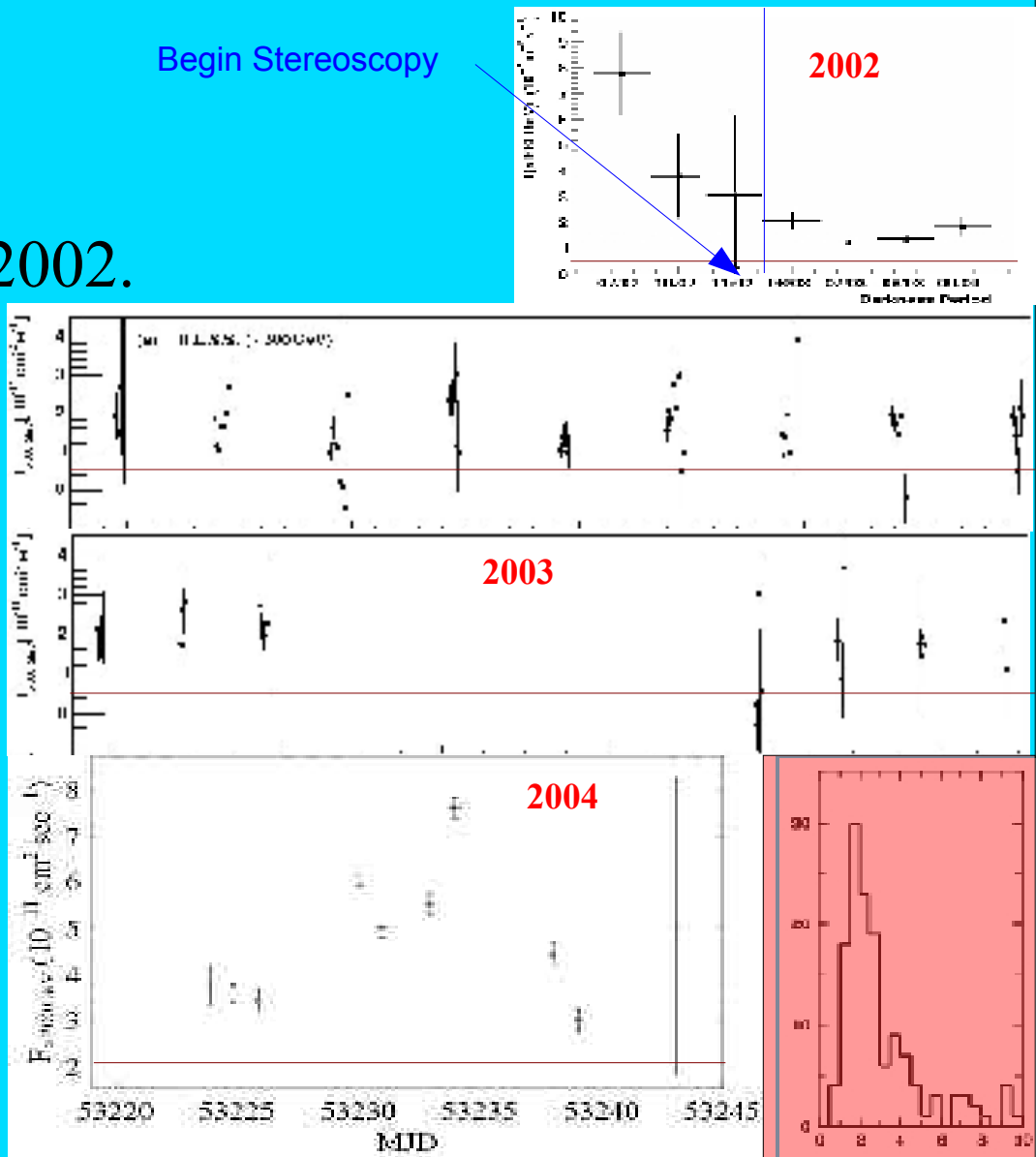
PKS 2155-304 has already been observed during the installation phase with a single telescope in 2002.

Observations were taken in 2002-2007

Source was always detected at or above same level

Quiescent level plus flares

1st detection above the synchrotron branch



The quiescent emission

Detection of a quiescent level of VHE emission:
How do we know it will not go fainter?
Covering 1500 days, sampling >100 days, flares last ~1 day

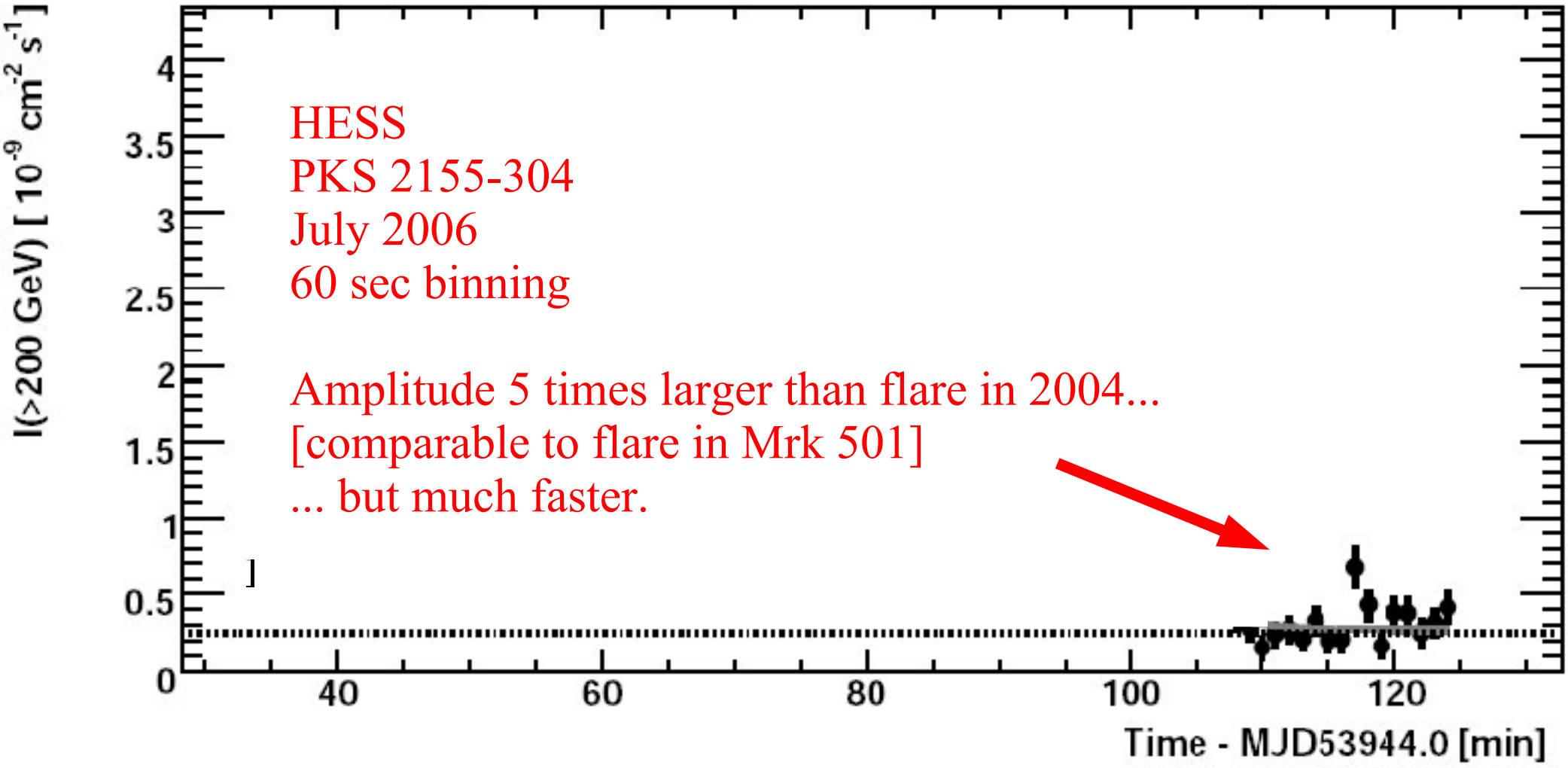
Cannot rule out that quiescent level has very long-term trends with
$(I/dI)_{QL} > 1000\ (I/dI)_{Flare}$

What does it mean?

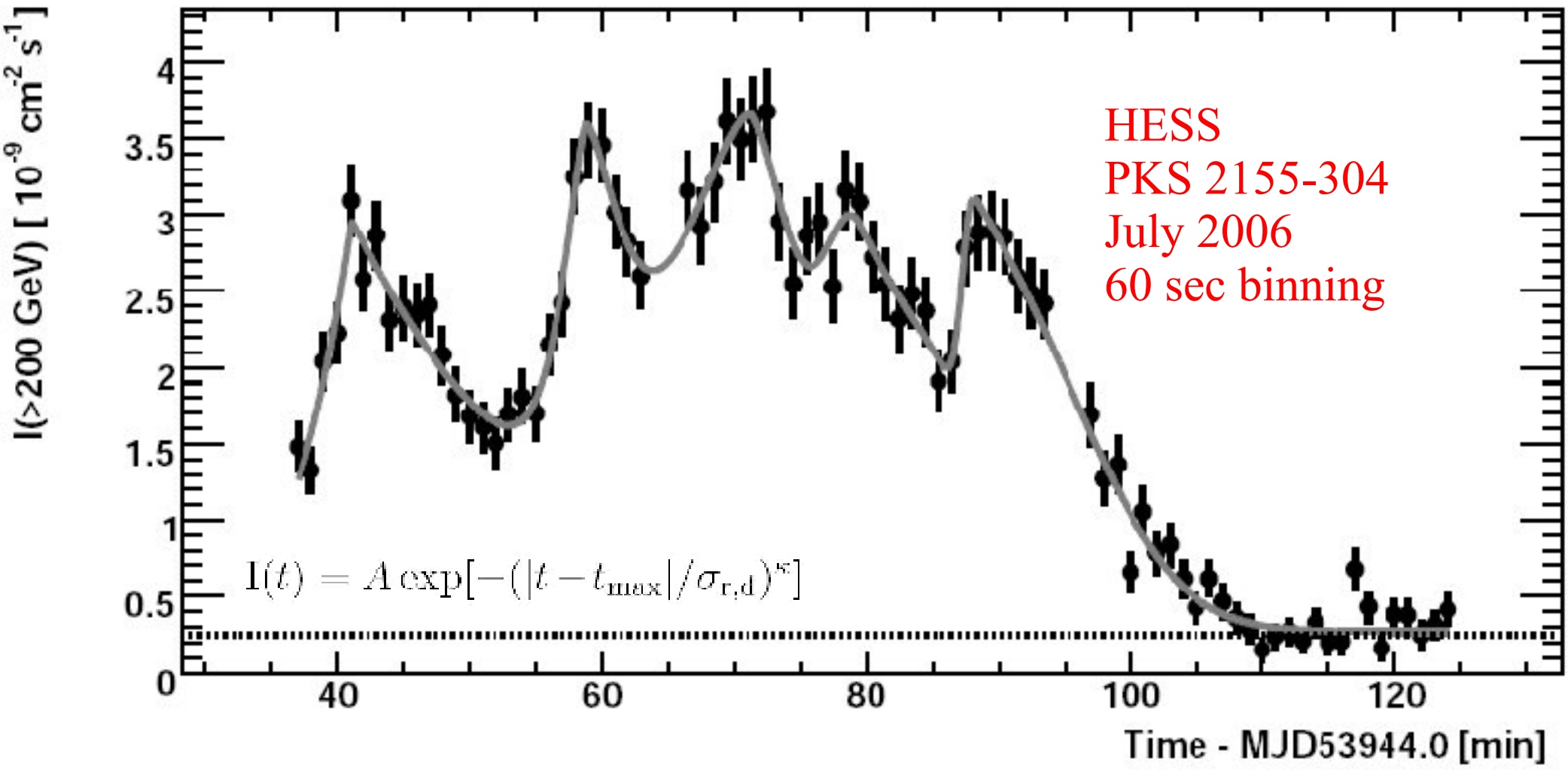
1) continuous emission of VHE radiation
would imply distributed acceleration

2) superposition of very many flares
would require a very significant break in distribution function.
of flare amplitudes (what are physical implications?)

Flaring events



Rapid variability



Rapid variability

Variability time scales:

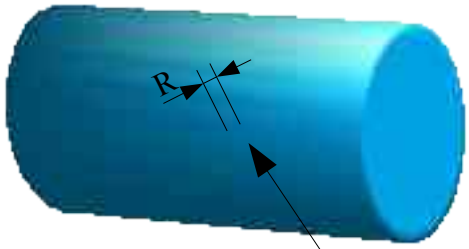
Doubling time-scales > 90 sec (>5 sigma)
67s < < 404s among the five bursts fitted
variability time-scale: 300 sec (PDS)

at z=0.116 this corresponds to ($\mathcal{D}$ 600) pas (pico-arcsec)

Source	Reference	correction dt	M(BH)
Markarian 421	Gaidos (WHIPPLE), 1996	1.031	1E8.22
Markarian 501	MAGIC, 2007	1.033	1E8.72
PKS 2155-304	HESS, 2006, 2007	1.116	1E9.33

What does this imply?

TeV radiation is emitted at large distances from the nucleus



cylindrical jets

Diameter: 1 pc (?) $M_{BH} \sim 1E9$

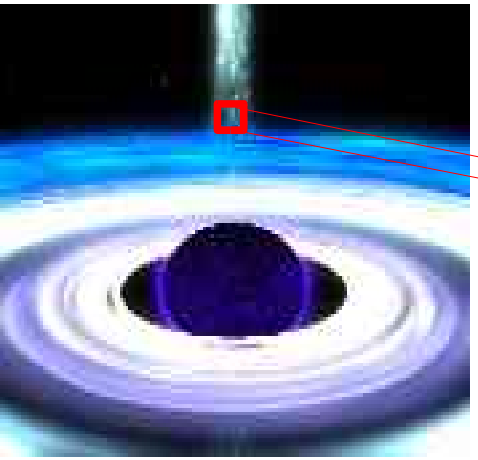
Emitting volume: $R\mathcal{D} < 4.6E12$ cm

Cross-section of emitting volume: $\mathcal{D}^2$ E-11 A (A= cross-section of jet)

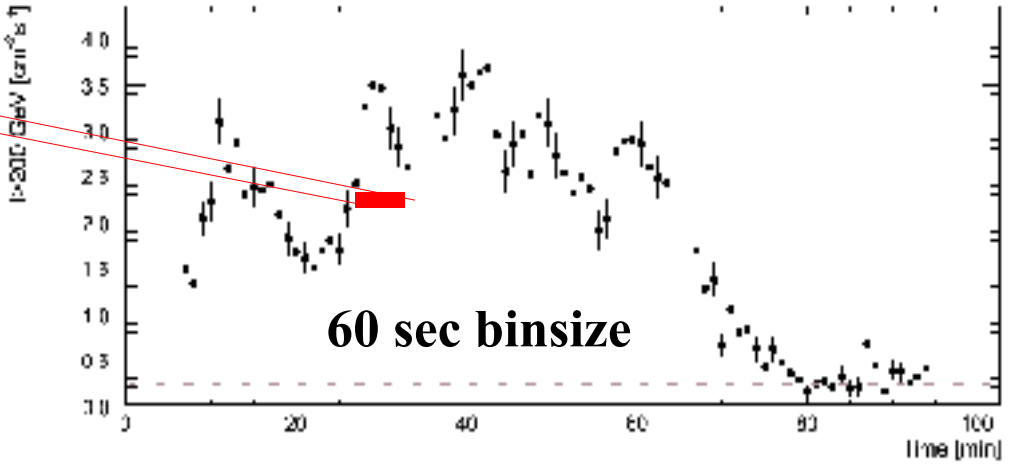
Can we channel enough energy into such sub-volumes to produce flares of amplitudes ~100 ?

Why don't we see this at other wavelengths?

Are we close to the base of the jet?



Fast variability – small distances from nucleus?



$R_S = 2GM/c^2$, constaints from host luminosity

$$M \leq (c^3 t_{\rm var} \delta / 2G(1+z)) R_S/R \sim 1.6 \times 10^7 M_\odot \delta R_S/R$$

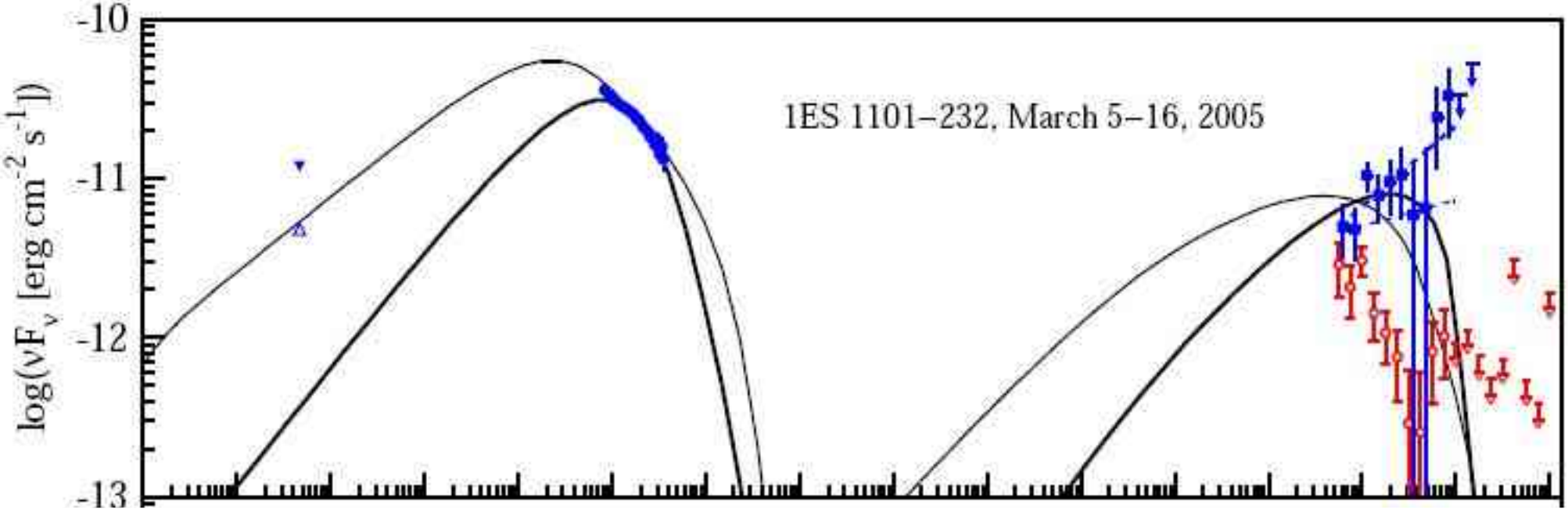
$M_R = -24.4$
$\sim 90\ R/R_S$

Are we probing strong gravity?
(Not consistent signature on flare asymmetries)
How do we get the emission out?
(Where) are the jets decelerated? (Piner & Edwards: v/c = 4.4 +-2.9)

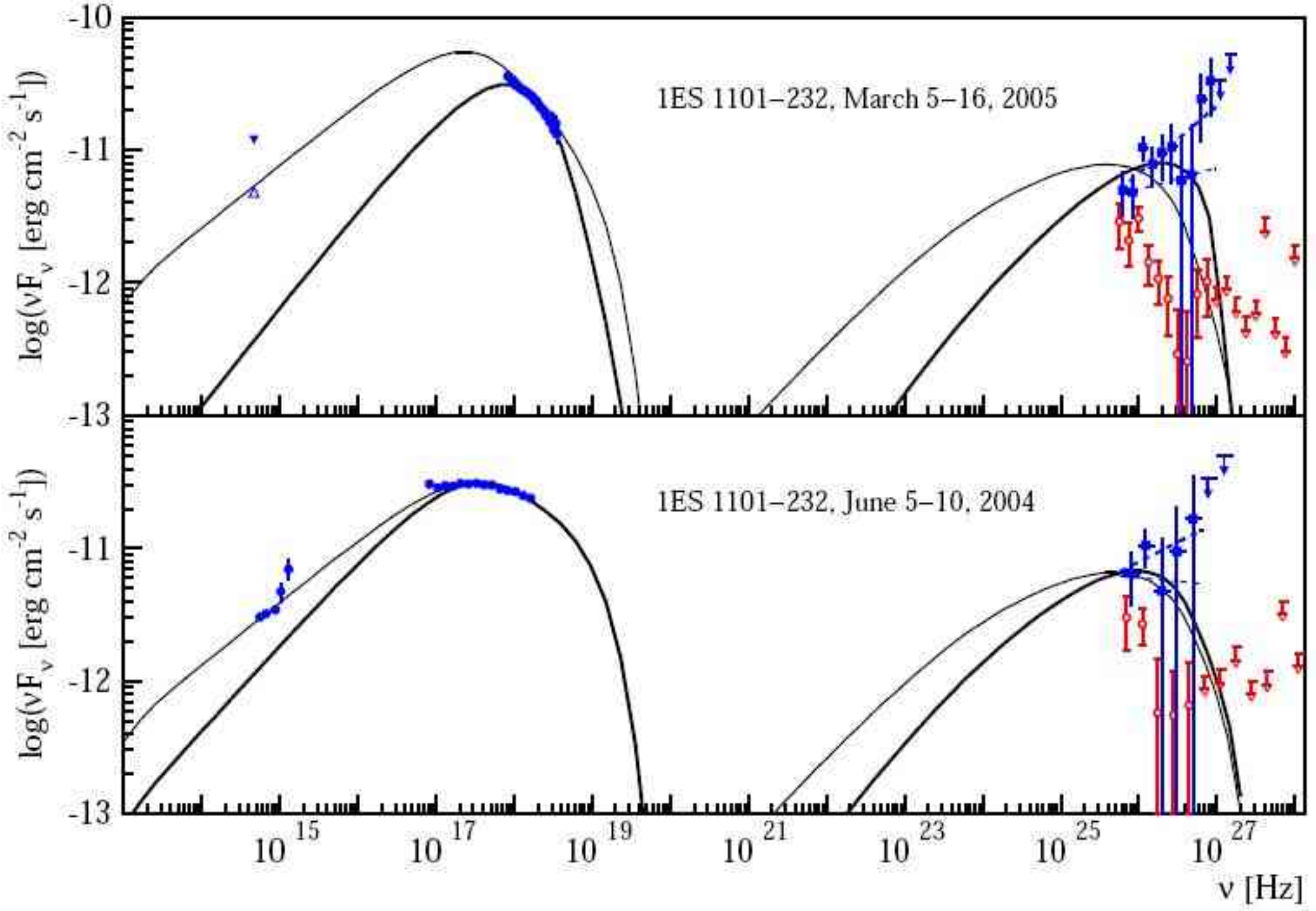
Extreme spectra

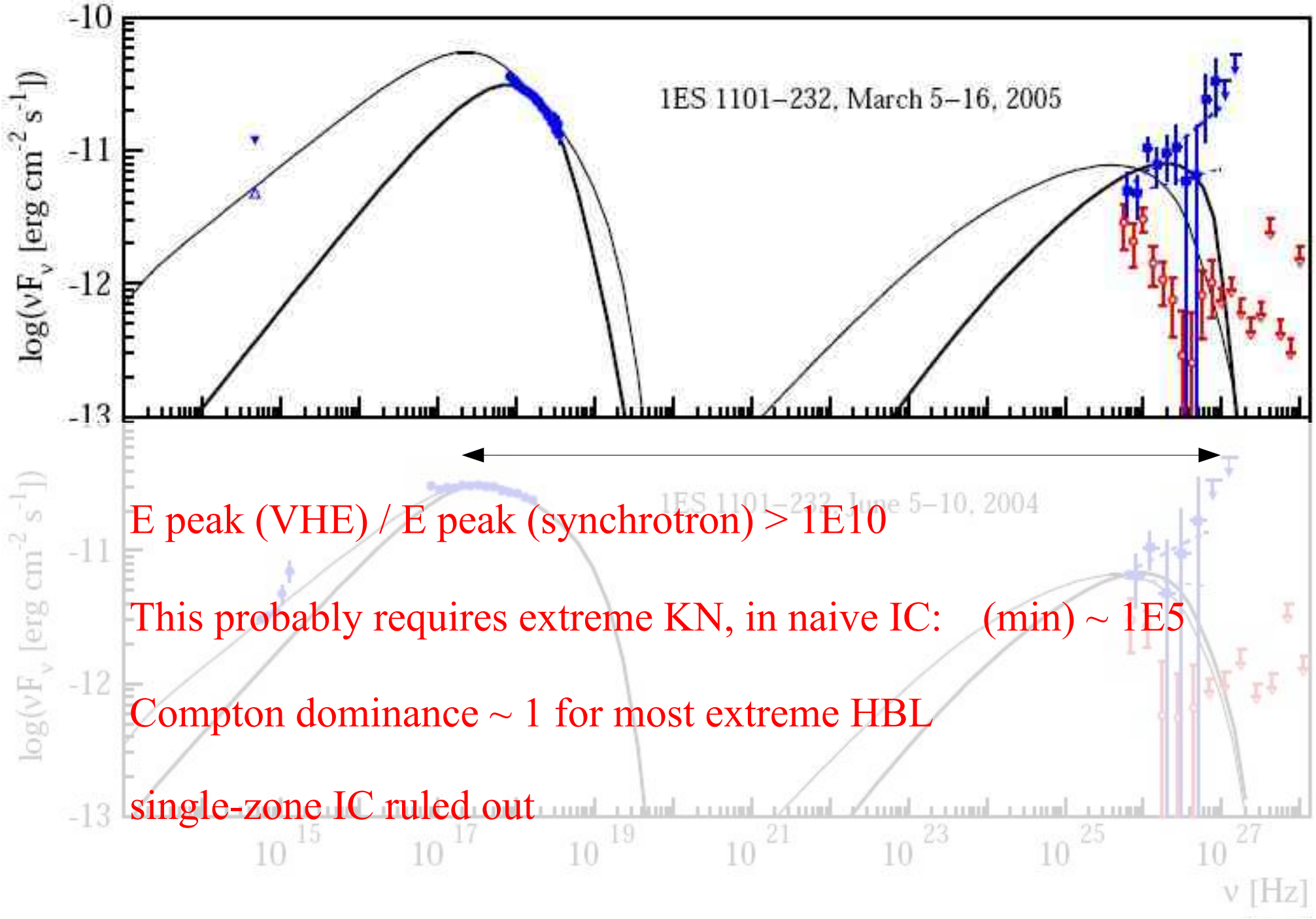
Most VHE spectra were indicating peak energies below VHE range

1ES 1101-232 is different:



"High" Redshift – beware of extinction on EBL
Here: correct with minimum EBL (resolved background)


1ES 1101−232, March 5−16, 2005
1ES 1101−232, June 5−10, 2004
log(νF_ν [erg cm^-2 s^-1])
-10
-11
-12
-13
10^15
10^17
10^19
10^21
10^23
10^25
10^27
ν [Hz]



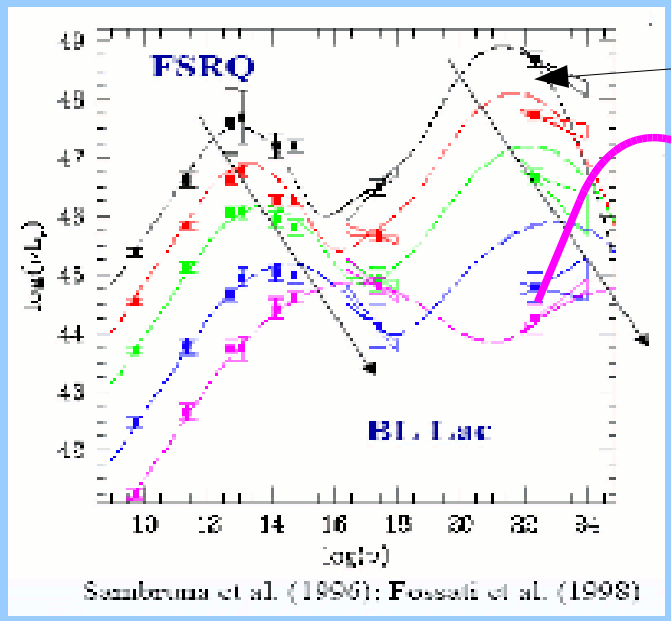
E peak (VHE) / E peak (synchrotron) > 1E10

This probably requires extreme KN, in naive IC: (min) ~ 1E5

Compton dominance ~ 1 for most extreme HBL

single-zone IC ruled out

Variability Bias and Blazar sequence



Few flares in many years

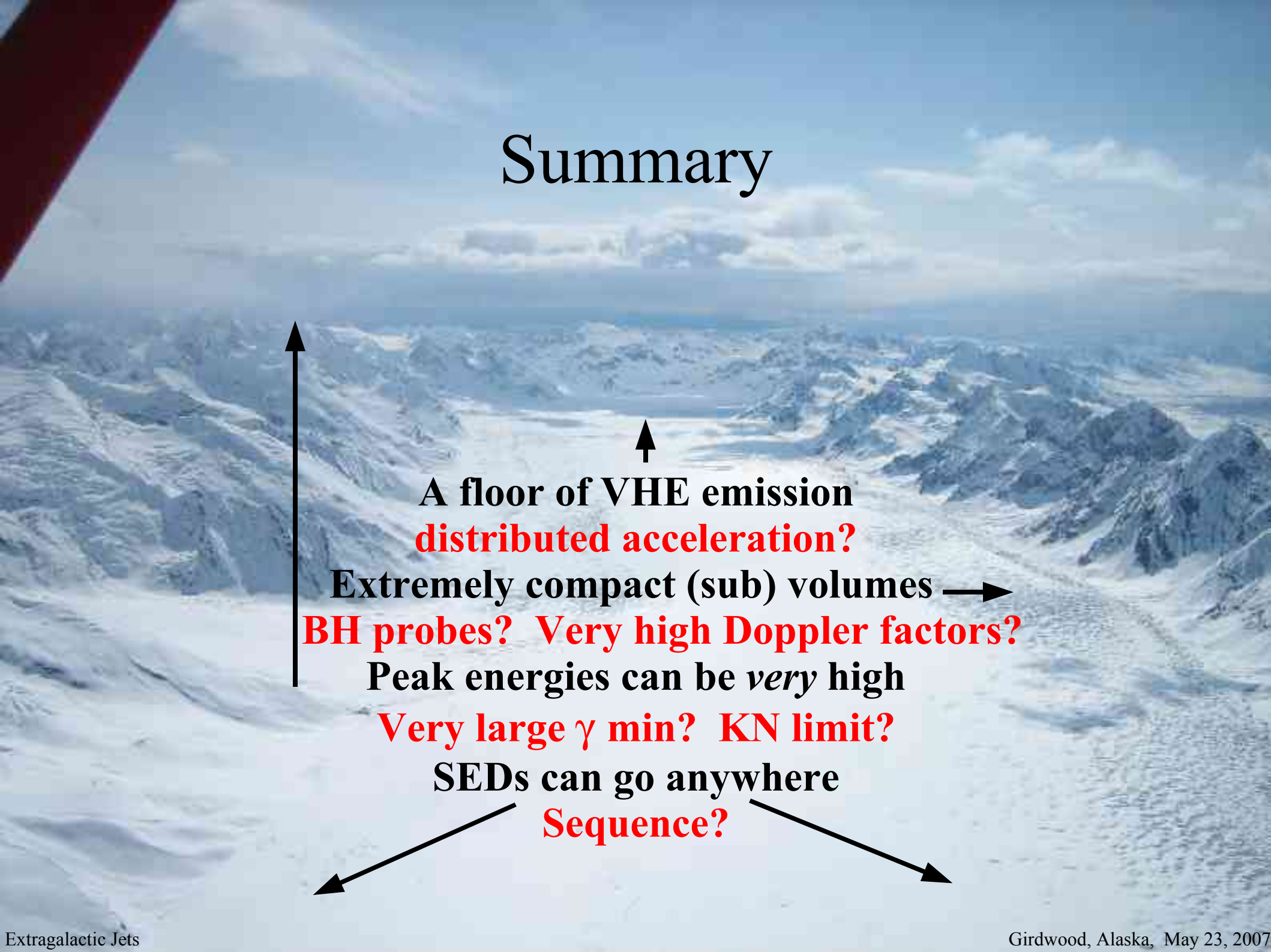
Two bright flares in several years

Compton-dominance independent of $_{max}$ if variability is taken into account?
(these are very few events/sources !)

Luminosity – $_{max}$ relation subject to variability.
Note also that VHE Blazars are from volume-limited sample,
and hence biased against bright sources.

The identification of biases does not falsify the explanation!

Summary



A floor of VHE emission

distributed acceleration?

Extremely compact (sub) volumes

BH probes? Very high Doppler factors?

Peak energies can be *very* high

Very large γ min? KN limit?

SEDs can go anywhere

Sequence?