

# CONSTRAINTS ON ULTRA-HIGH ENERGY NEUTRINOS FROM OPTICALLY THICK ASTROPHYSICAL ACCELERATORS

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ORIGIN OF  
COSMIC RAYS  
WITH ENERGIES

$$E \geq 10^{19} \text{ eV}$$



ACCELERATION  
IN  
ASTROPHYSICAL  
SOURCES

DECAYS  
OF  
SUPERHEAVY  
PARTICLES

↑ ↑  
SEEMS TO BE  
RULED OUT

- CLUSTERING OF ARRIVAL DIRECTIONS
- NO GALACTIC ASYMMETRY

● ACCELERATION SITES ARE UNKNOWN

(THOUGH CORRELATIONS OF ARRIVAL DIRECTIONS WITH BLAZARS WERE FOUND)

● THE RELEVANT MECHANISM:

ACCELERATION OF PROTONS  
IN RELATIVISTIC SHOCKS

● LOW PROTON FLUXES → DIRECT PROTONS  
→ PHOTONS

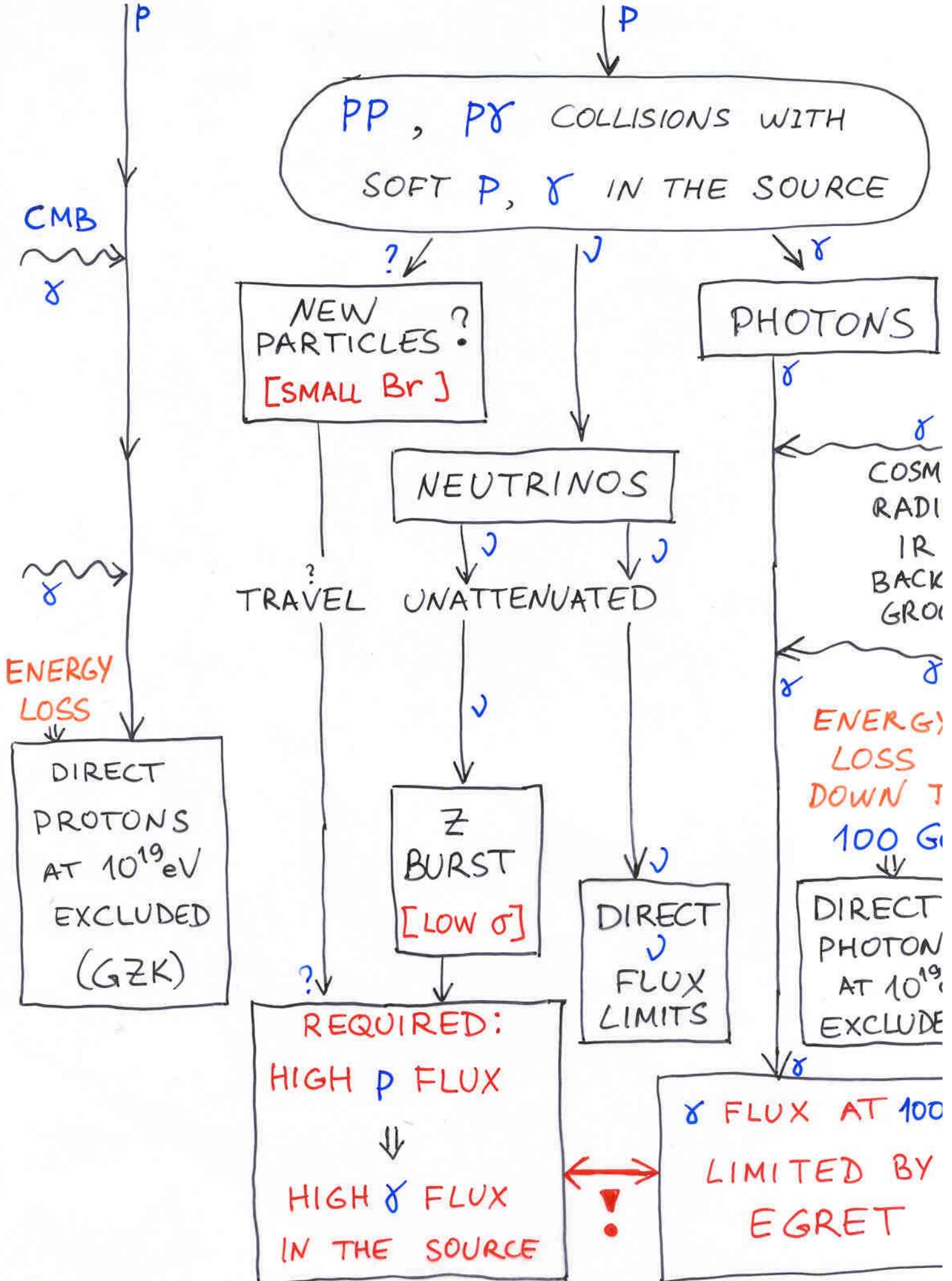
PROBLEMS WITH GZK BOUND

● HIGH PROTON FLUXES → Z-BURST  
→ NEW PARTICLES  
WITH LOW PRODUCTION R<sub>+</sub>

PROBLEMS WITH EGRET BOUND

PROTONS ACCELERATED IN THE SOURCE

PP, P $\gamma$  COLLISIONS WITH SOFT P,  $\gamma$  IN THE SOURCE



# WAYS TO OVERCOME EGRET BOUND

- NEARBY SOURCES

↓

LESS ENERGY LOSS

↓

LOOK IN TeV

- SOURCES OF COSMIC RAYS

||

SOURCES OF  $\gamma$  RAYS

(NOT BACKGROUND!)

- OPTICALLY THICK  
SOURCES

# OPTICALLY THICK SOURCES

ABSORPTION  
SITE

SIZE  $\rightarrow$

$$l > \frac{1}{\sigma n}$$

TOTAL CROSS SECTION  $\sigma_{\gamma p}, \sigma_{\gamma\gamma}$

DENSITY  $n_p, n_\gamma$

- MASS (IF FULL OF PROTONS)

$$M \gtrsim m_p \frac{l^2}{\sigma_{\gamma p}}$$

BLAZAR JETS / HOT SPOTS:  $l \sim$  A FEW KILOPARSEC

$$M \gtrsim 10^{14} M_\odot \quad \text{EXCLUDED}$$

( $10^{13} M_\odot$  : THE HEAVIEST KNOWN GALAXIES)

- IF FULL OF PHOTONS:

$$n_\gamma > \frac{1}{\sigma_{\gamma\gamma} l}$$

CONSTRAINT ON LUMINOSITY

BLAZAR JETS / HOT SPOTS :

ROUGHLY EXCLUDED

(MORE CAREFUL ANALYSIS REQUIRED)

## CONCLUSIONS

Z-BURST + OPTICALLY THICK SOURCES

● EXCLUDED FOR

AGN JETS / HOT SPOTS

FROM MASS AND FLUX ESTIMATE

↑

$P (!)$

↑

$\delta (?)$

● MAY BE EXCLUDED FOR

ANY SOURCES

BY AMANDA-2, AUGER

FROM THE SECONDARY

NEUTRINO FLUX