Yelyzaveta Pulnova (ELI Beamlines; Institute of Theoretical Physics MFF UK)
Supervisor: **Anabella Araudo** (ELI Beamlines; AI of the CAS)

Model

UHECR

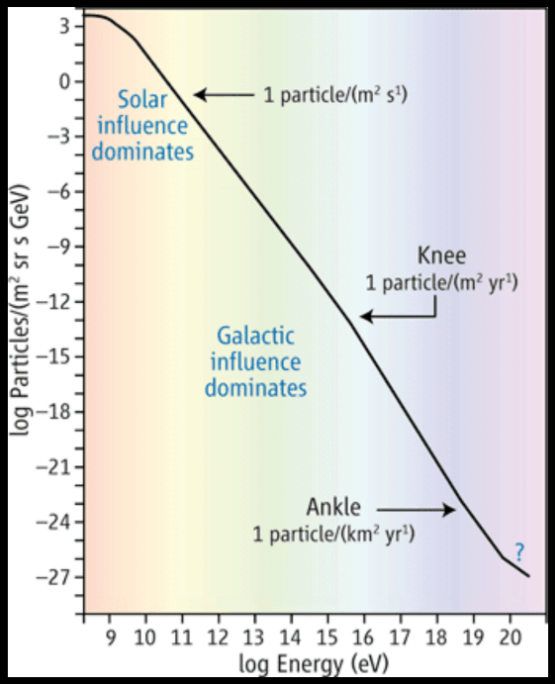
Calculations

Conclusion

Particle acceleration in the hotspot of radiogalaxy 3C 105

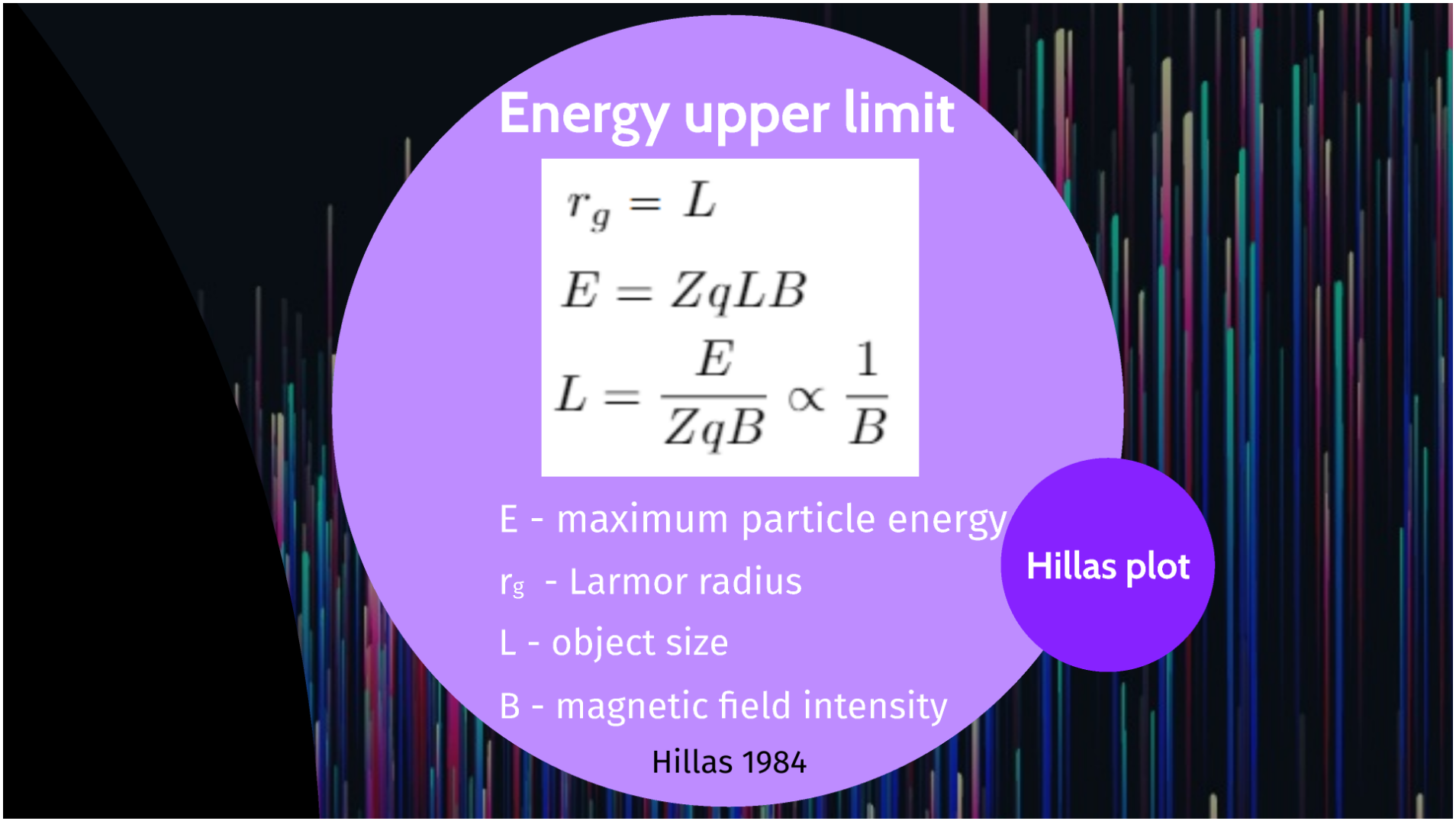
RAGtime 22, Opava 19/10/2020

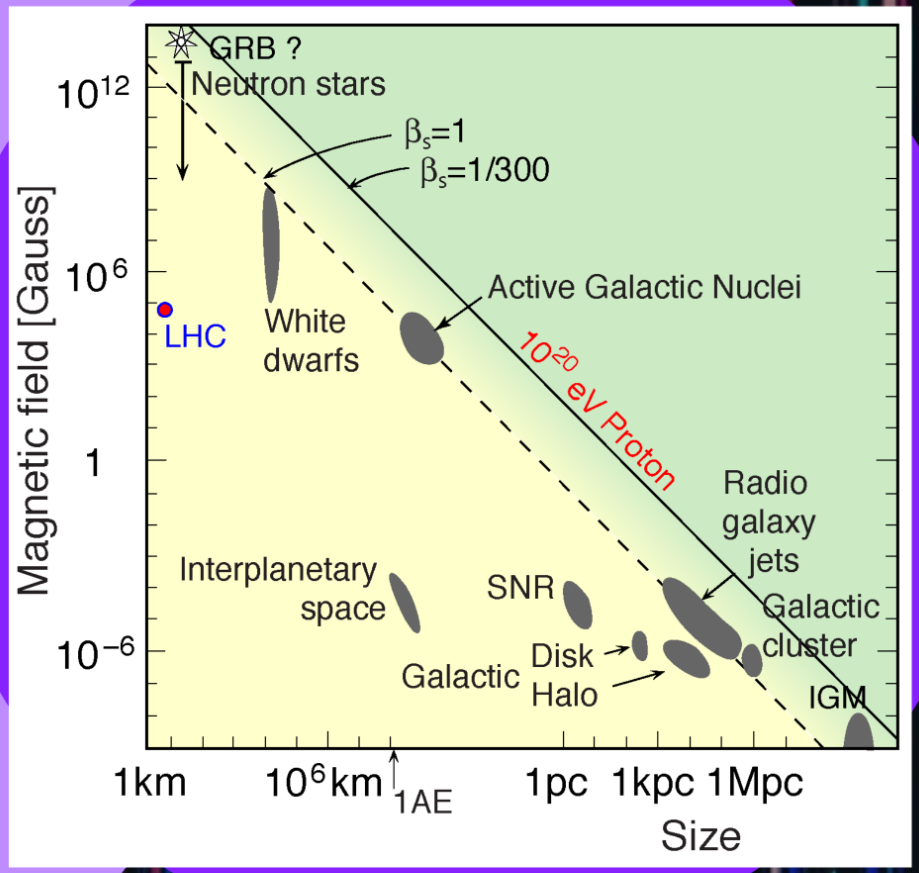
Ultra-high-energy cosmic rays $E \sim 10^{18}$ eV

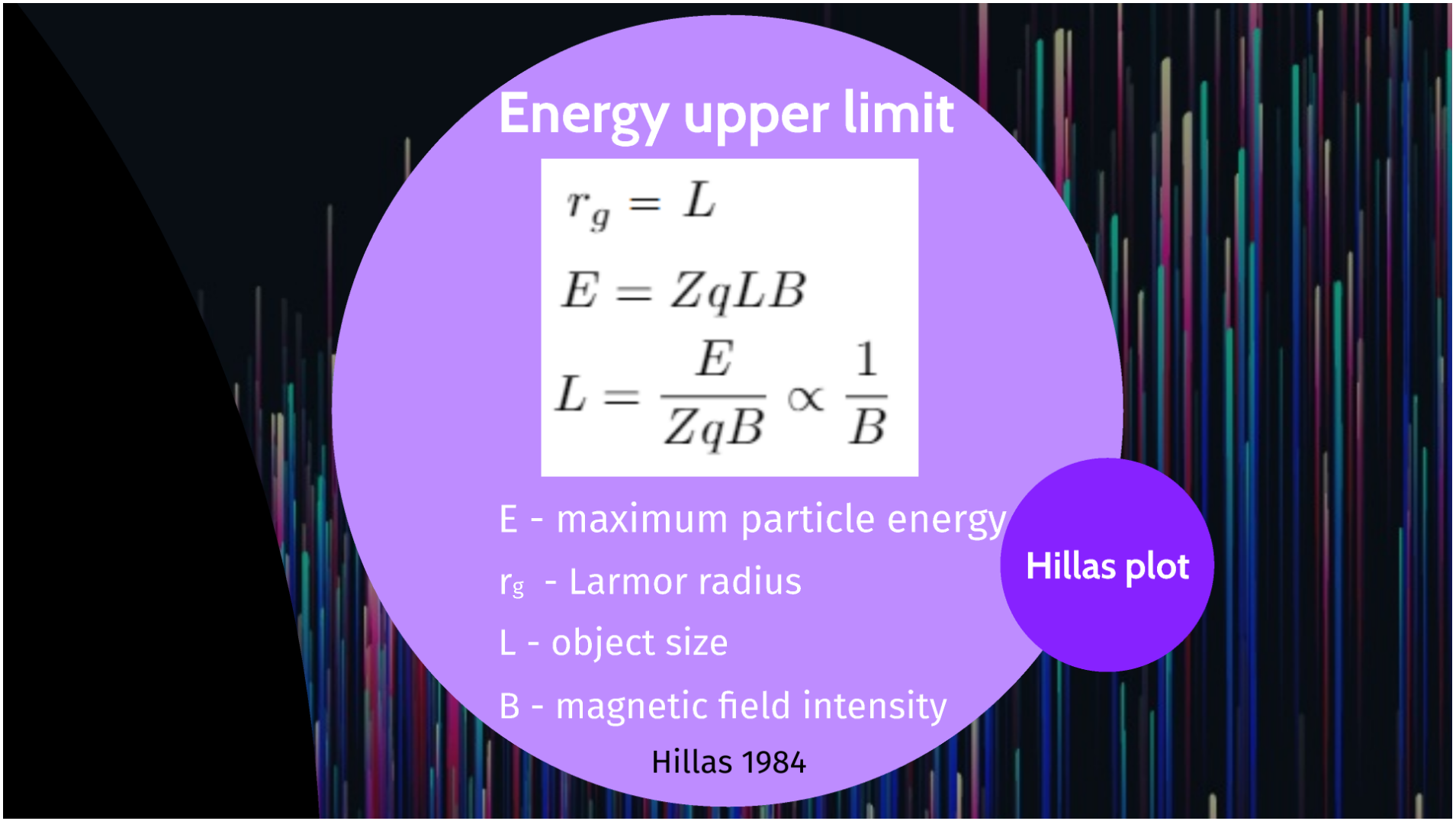


Possible Origin

Radiogalaxies hotspots


Energy upper limit
$r_g = L$
$E = ZqLB$
$L = \frac{E}{ZqB} \propto \frac{1}{B}$
E - maximum particle energy
r_g - Larmor radius
L - object size
B - magnetic field intensity
Hillas 1984
Hillas plot


GRB ?
Neutron stars
β_s=1
β_s=1/300
Active Galactic Nuclei
LHC
White
dwarfs
10^{20} eV Proton
Radio
galaxy
jets
Interplanetary
space
SNR
Galactic
cluster
Disk
Halo
Galactic
IGM
10^{12}
10^{6}
1
10^{-6}
Magnetic field [Gauss]
1km
10^6km
1AE
1pc
1kpc
1Mpc
Size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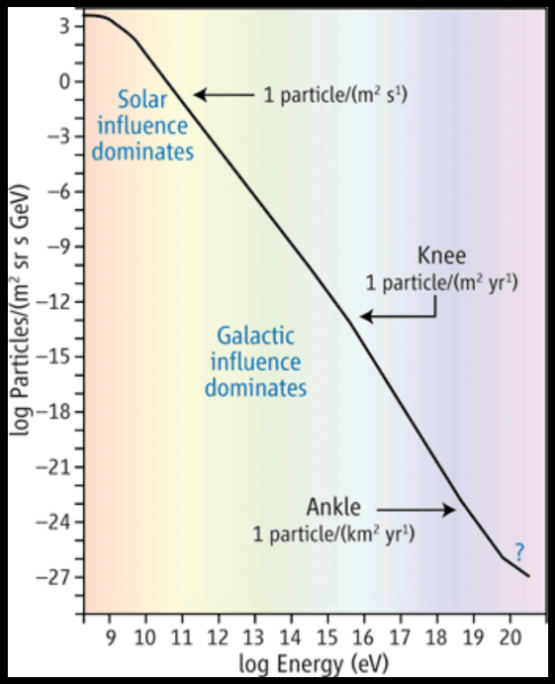

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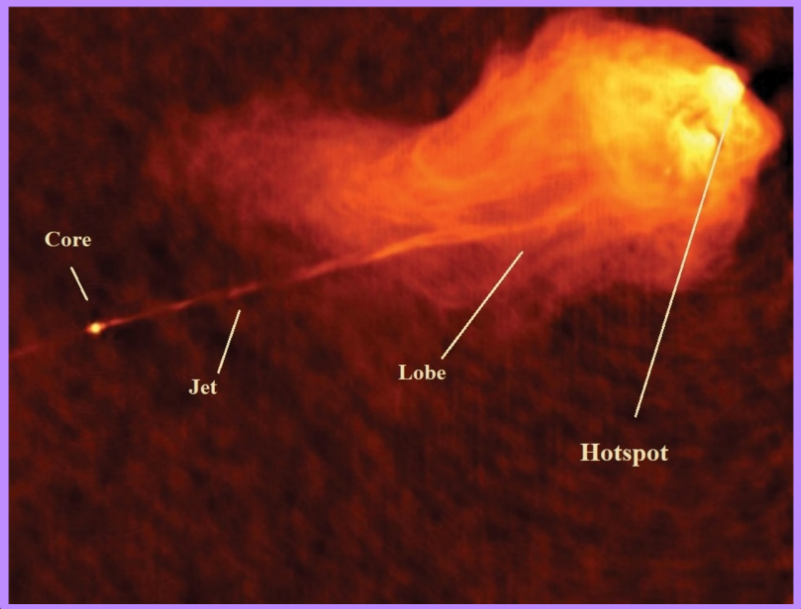
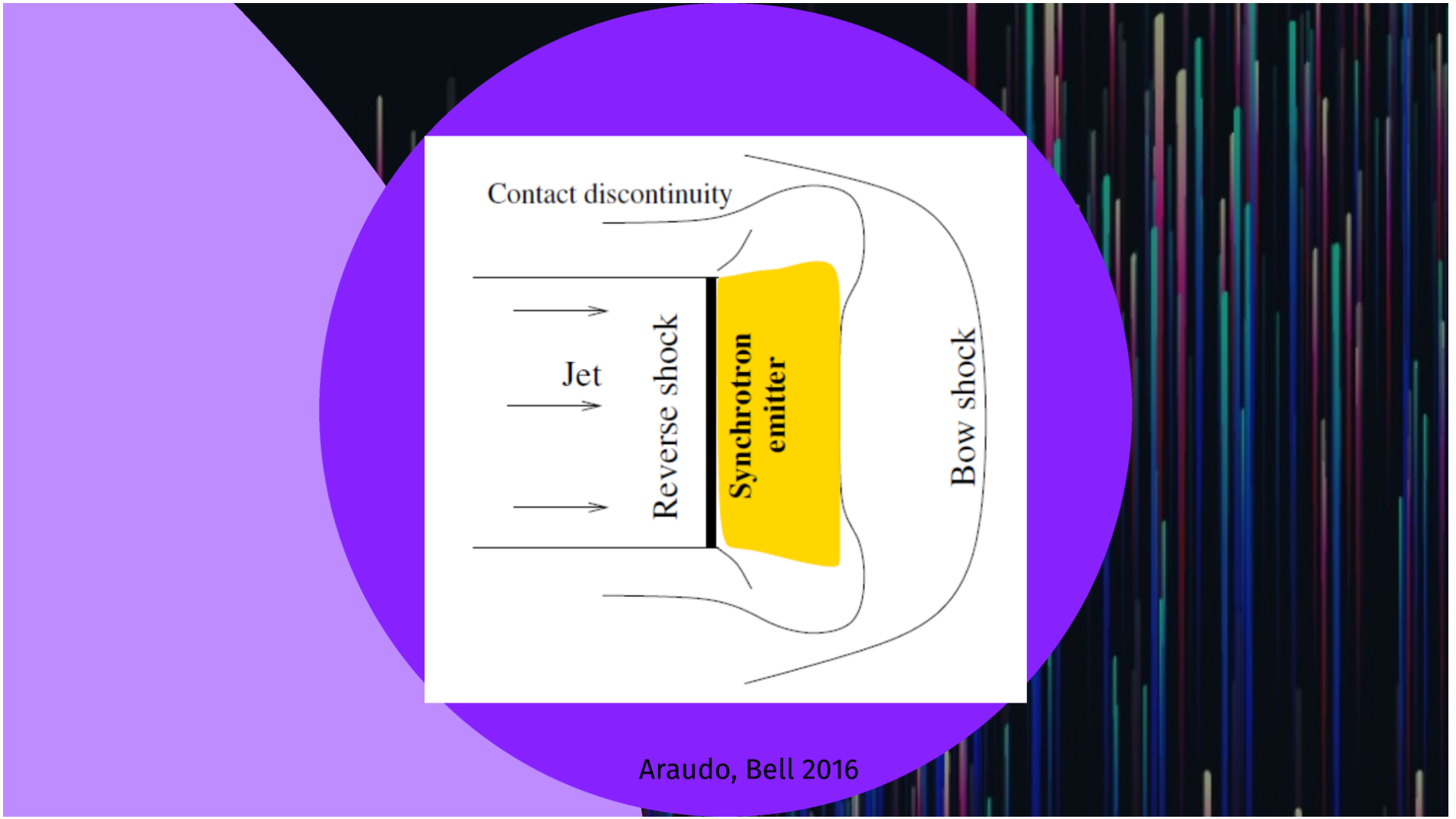


Cyg A

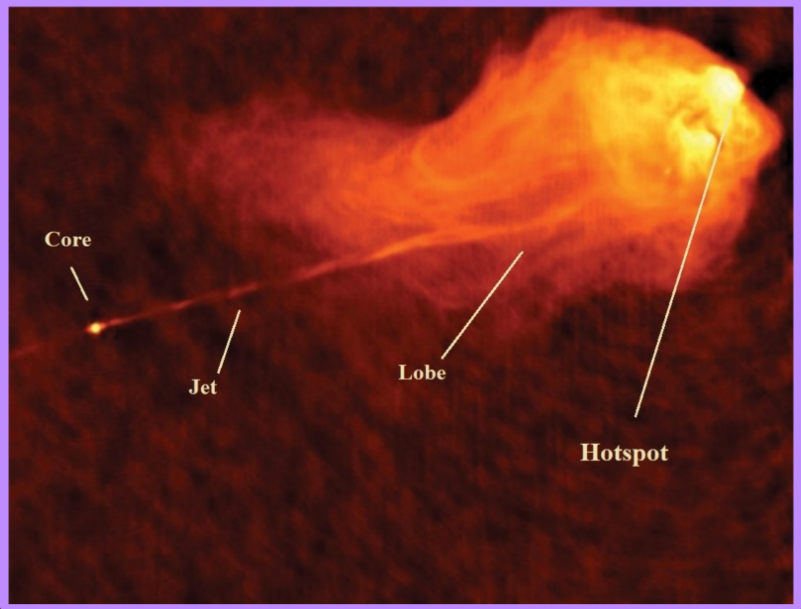
Hotspot

Our source



Araudo, Bell 2016

Radiogalaxies

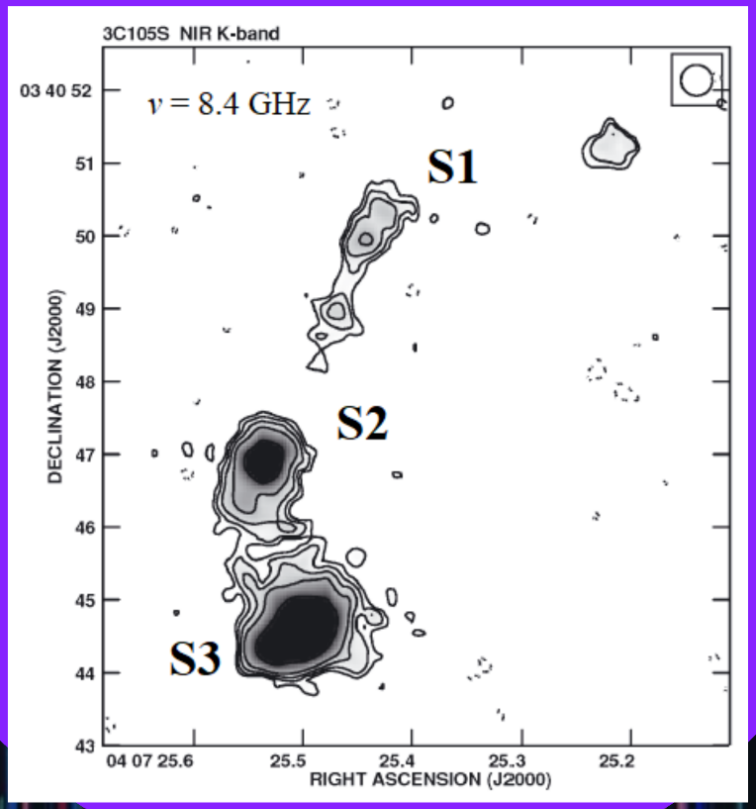


Cyg A

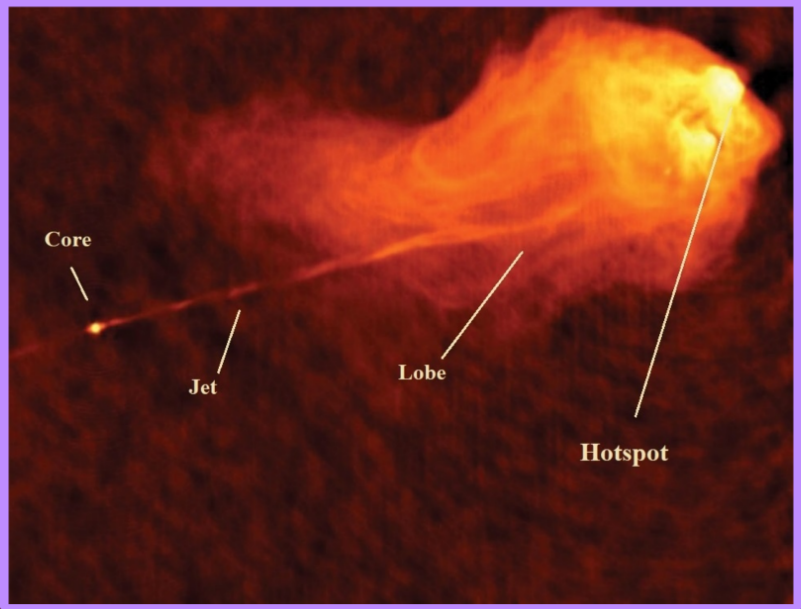
Hotspot

Our source

Radiogalaxy 3C 105 S



Radiogalaxies



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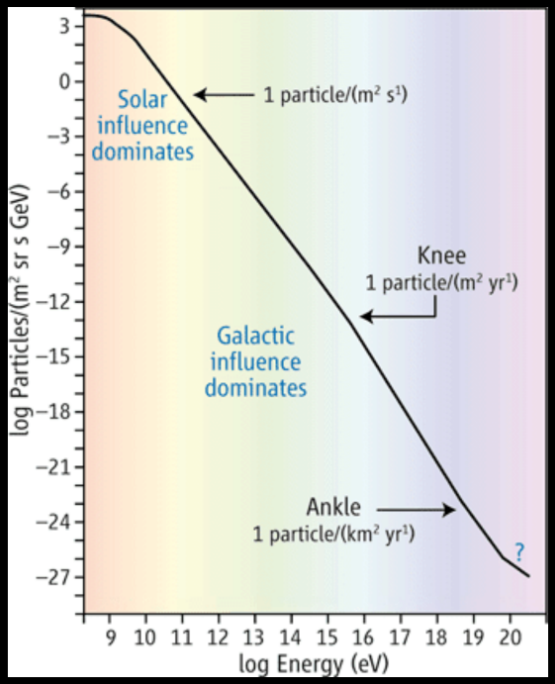

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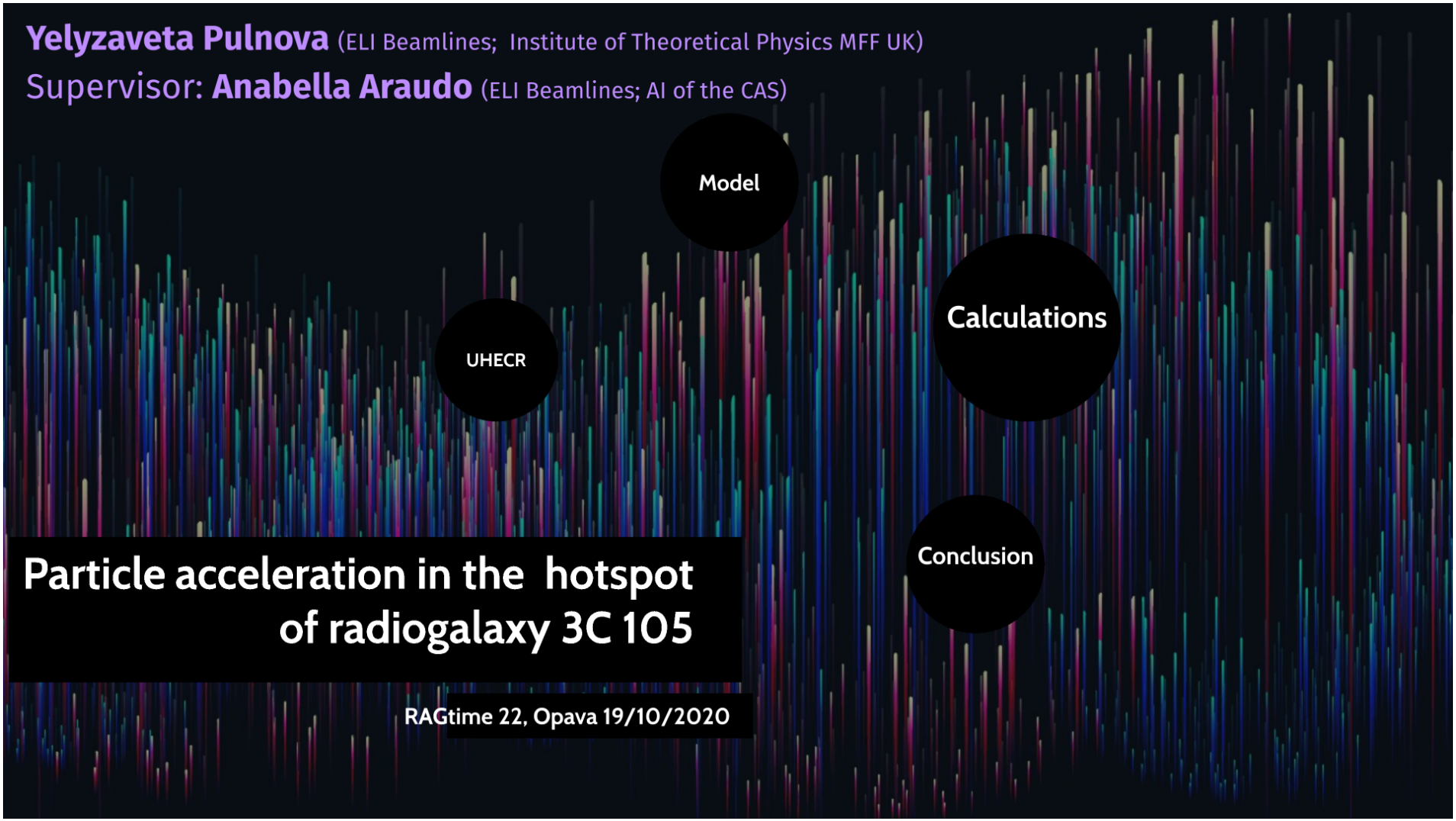
Radiogalaxies hotspots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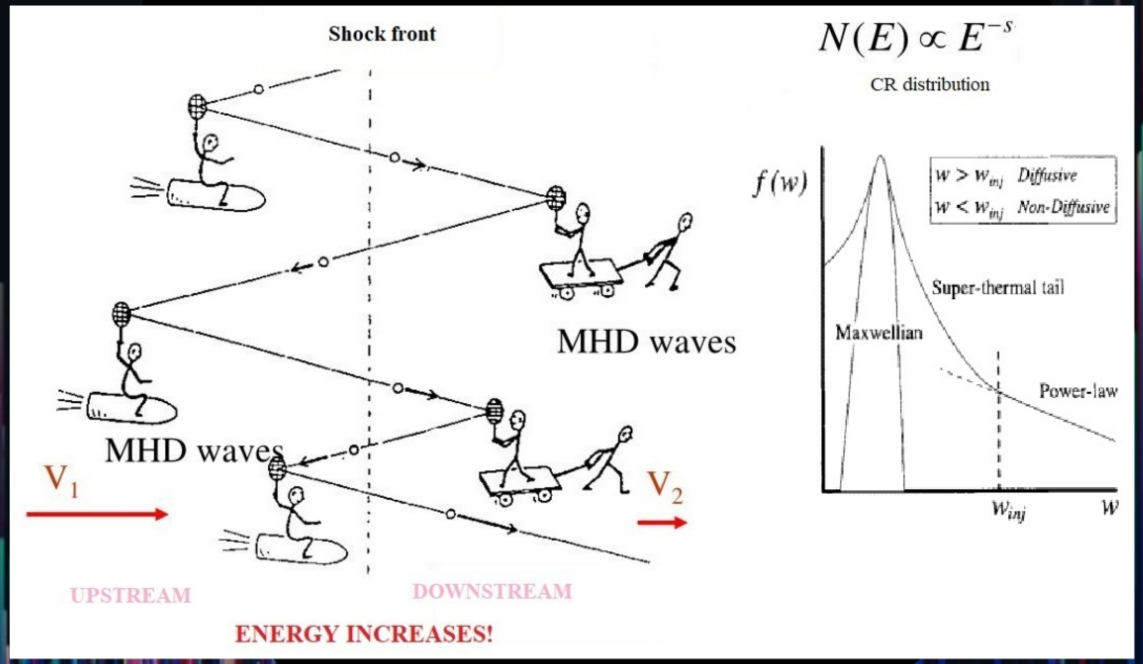
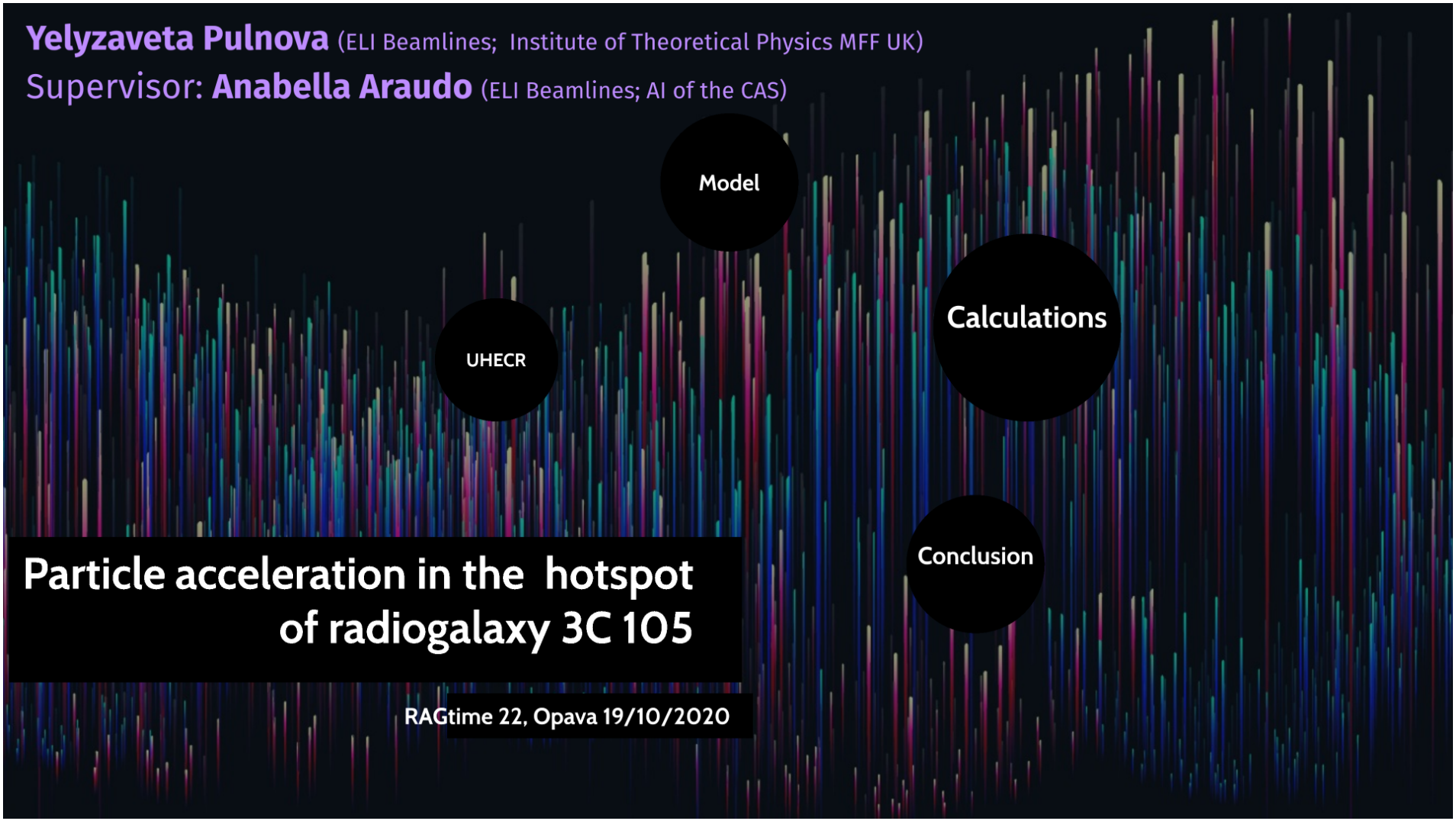
Diffusive shock acceleration (DSA)



Bell 1978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Maximum energy of CR? electrons first!

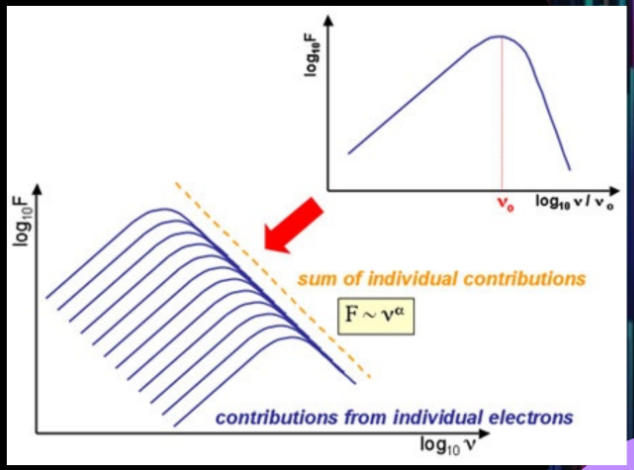
Magnetic field

Energy density

Discussion

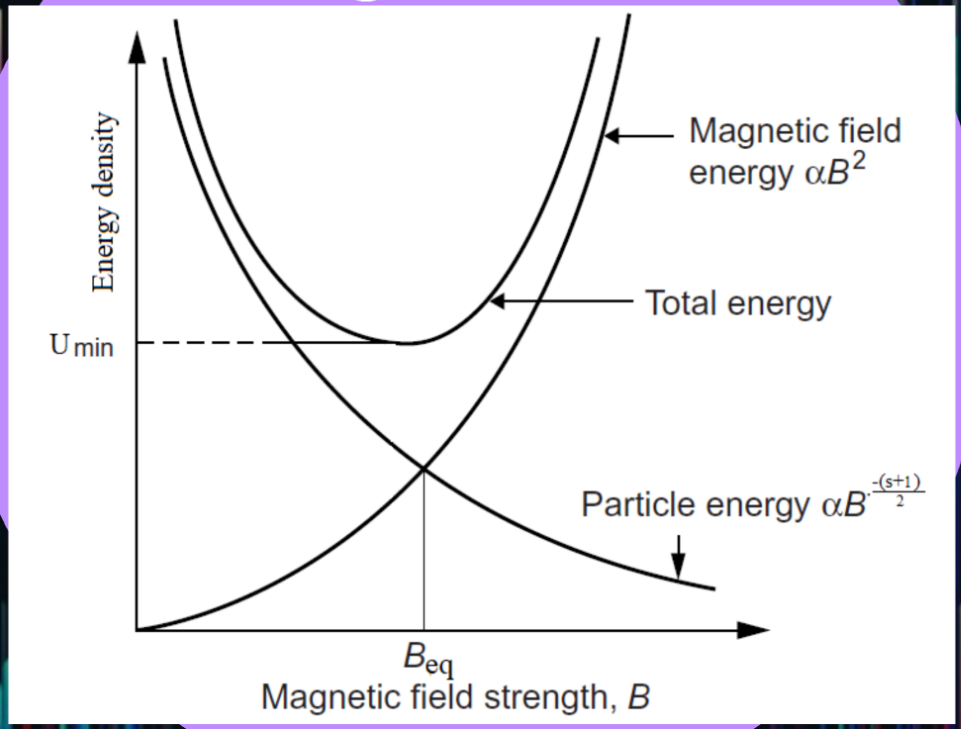
$$E_{e,max} \propto \sqrt{\frac{\nu_c}{B}}$$

ν_c - cutoff frequency



Source	Comp.	$E_{\mathrm{e,max}}$ [TeV]
3C 105	S1	0.97
	S2	0.32
	S3	0.38

Equipartition magnetic field



Longair 1964

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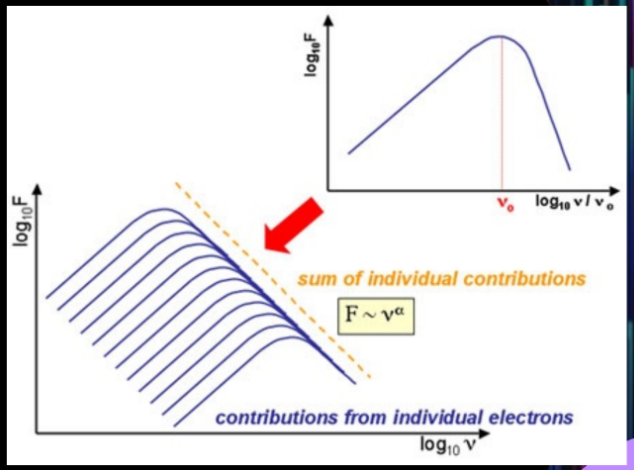

Source	Comp.	$E_{\mathrm{e,max}}$ [TeV]
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	S3	0.38

For energy density calculation:

$$U_{mag} = U_{NT} = U_{NT,e} + U_{NT,p}$$

For equipartition magnetic field calculation:

$$U_{NT,e} = \int_{E_{e,min}}^{E_{e,max}} EN(E)dE \propto B^{-\frac{s+1}{2}} \quad = \quad U_{mag} = \frac{B^2}{8\pi}$$

$$U_p = a(s) \cdot U_e \Rightarrow B_{eq} = \sqrt{1 + a(s)} B_{eq,e}$$

Source	Comp.	$U_{\mathrm{e,tot}}$ [erg cm^{-3}]	$B_{\mathrm{e,eq}}$ [μG]	B_{eq} [μG]
3C 105	S1	$6.06 \cdot 10^{-11}$	84.2	198
	S2	$1.11 \cdot 10^{-10}$	114	267
	S3	$6.11 \cdot 10^{-11}$	84.4	198

We used this values
to calculate $E_{e,max}$