Insights on particle acceleration at the core of Centaurus A

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- Main contributors:
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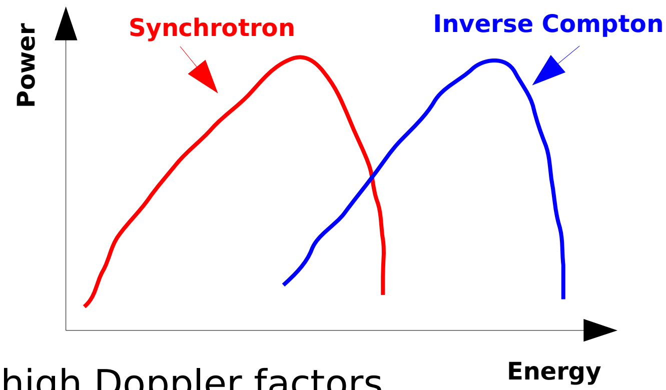
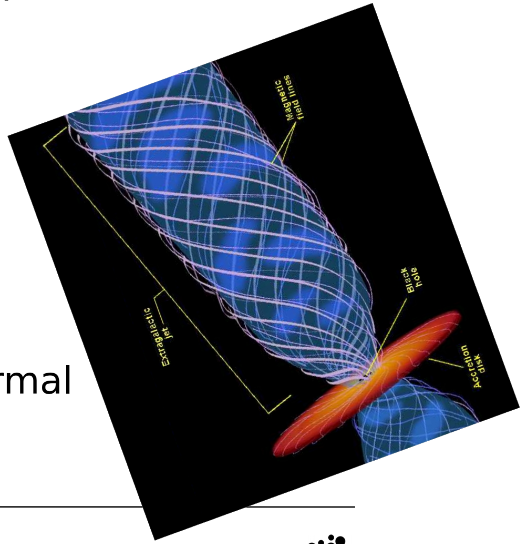
Particle acceleration in Active Galactic Nuclei
Radio galaxies as gamma-ray sources

H.E.S.S.

- Spectacular particle accelerators provided by Nature

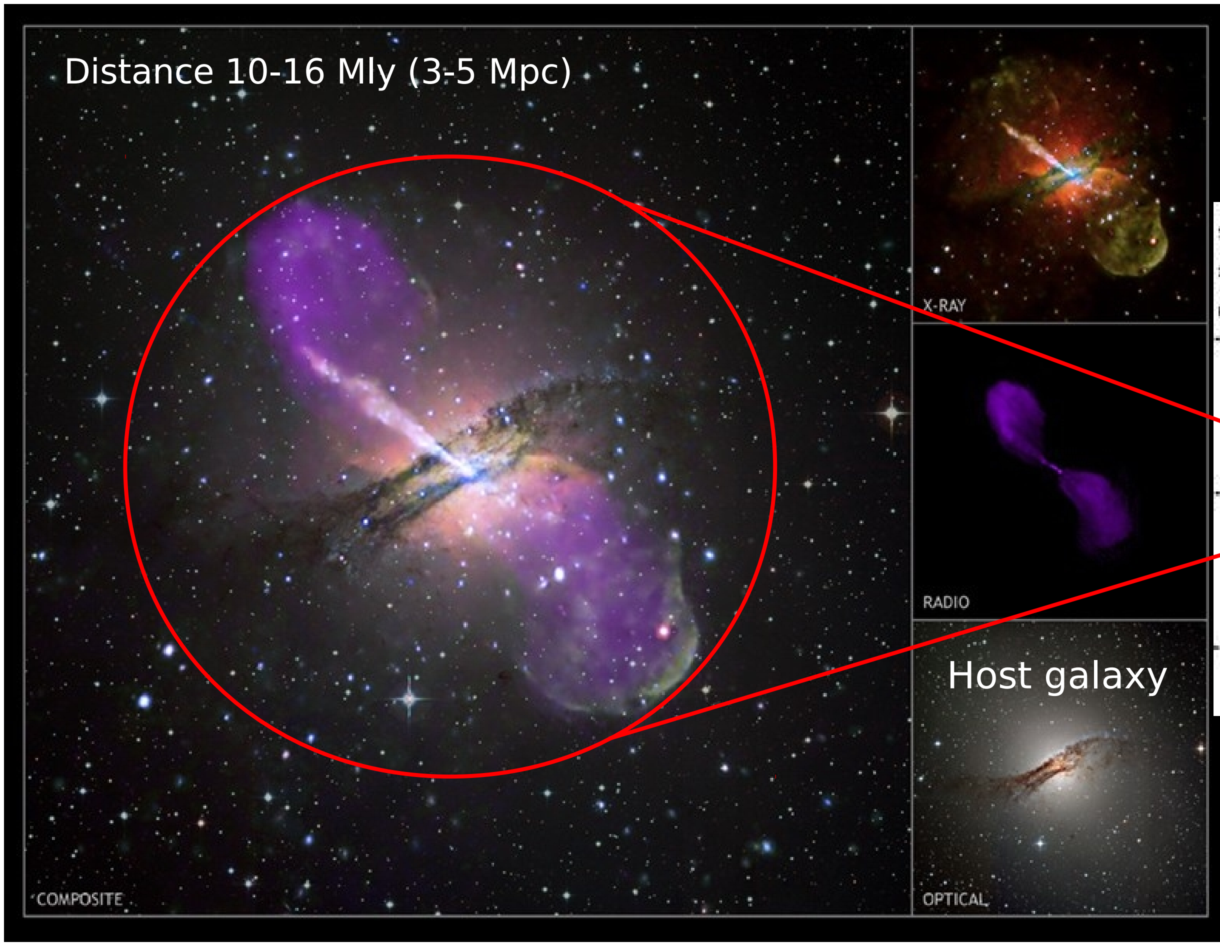


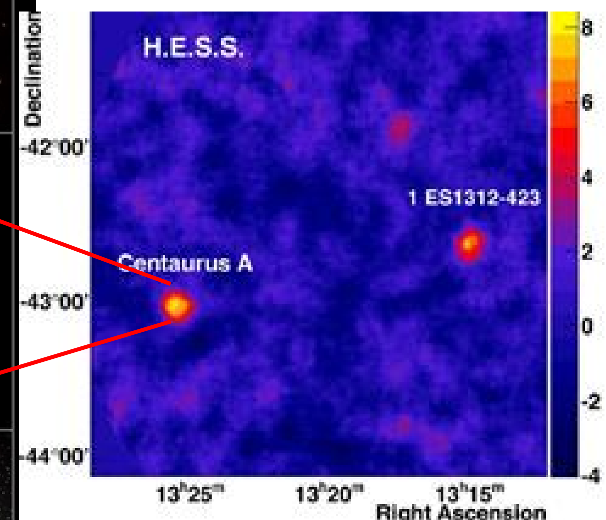
- Active Galactic Nuclei have characteristic double-humped Spectral Energy Distributions (SED)
- SEDs have been satisfactorily fitted by single-zone leptonic Synchrotron-Self Compton (SSC) models with high Doppler factors
- Radio galaxies are
  - Active Galactic Nuclei where the jet direction is inclined by a large angle with respect to the line of sight (if the jet points at us, it is a “blazar”)
  - Relatively small in number, but interesting laboratories offering unique insights some of the fundamental non-thermal processes in gamma-ray emitting AGN



Centaurus A, the closest radio-galaxy

H.E.S.S.

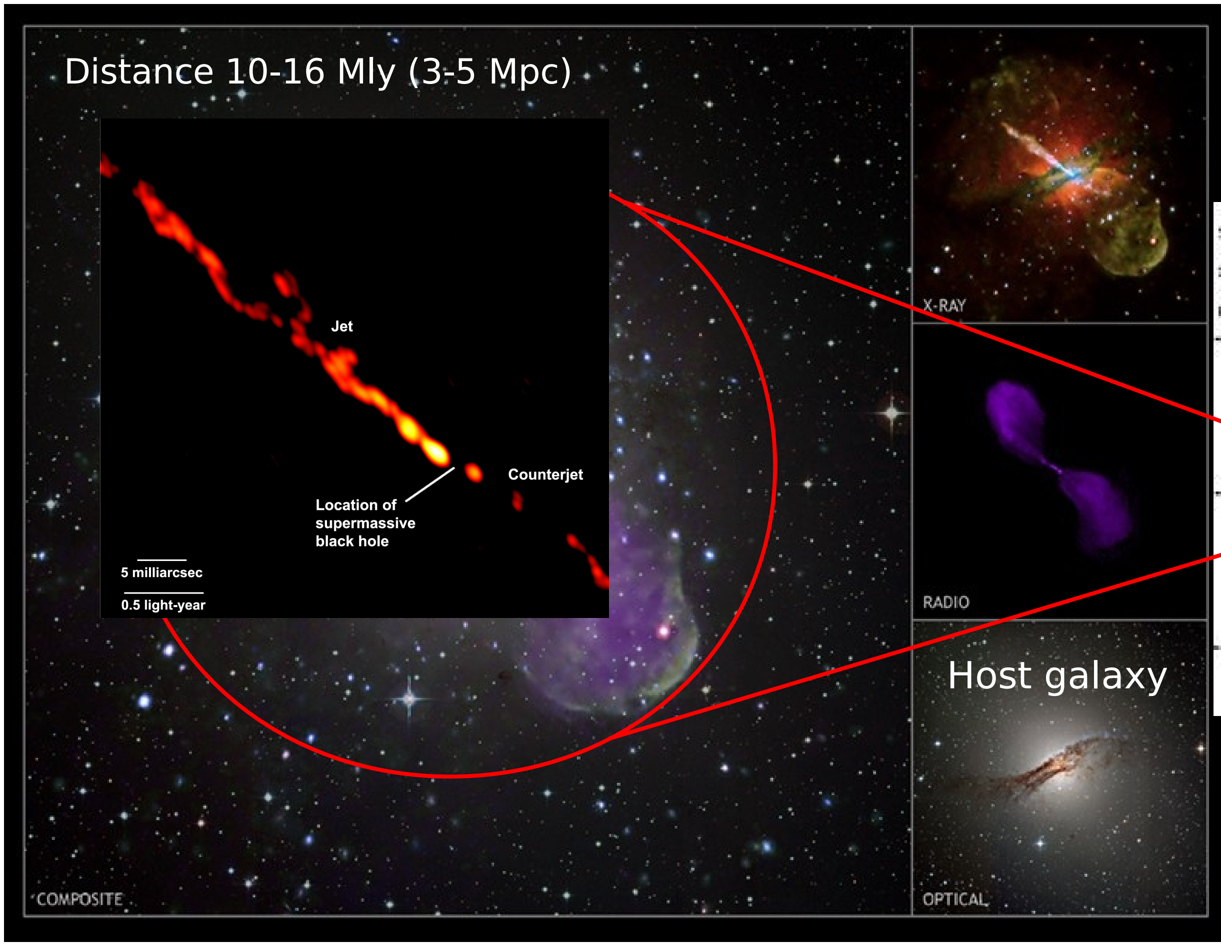


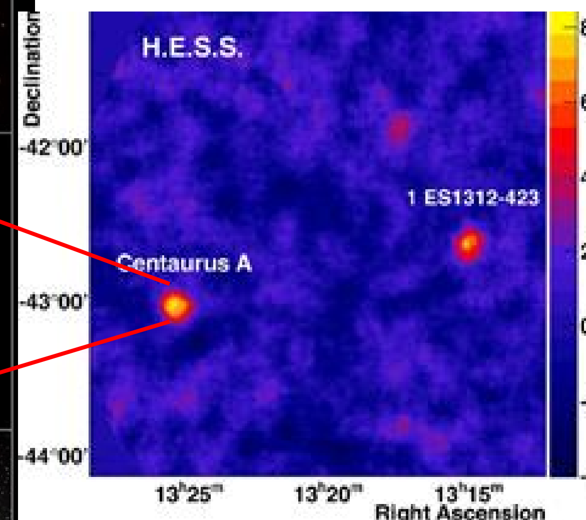


MNRAS, 434, 3, 2013, 1889–1901

From http://chandra.harvard.edu/

Centaurus A, the closest radio-galaxy

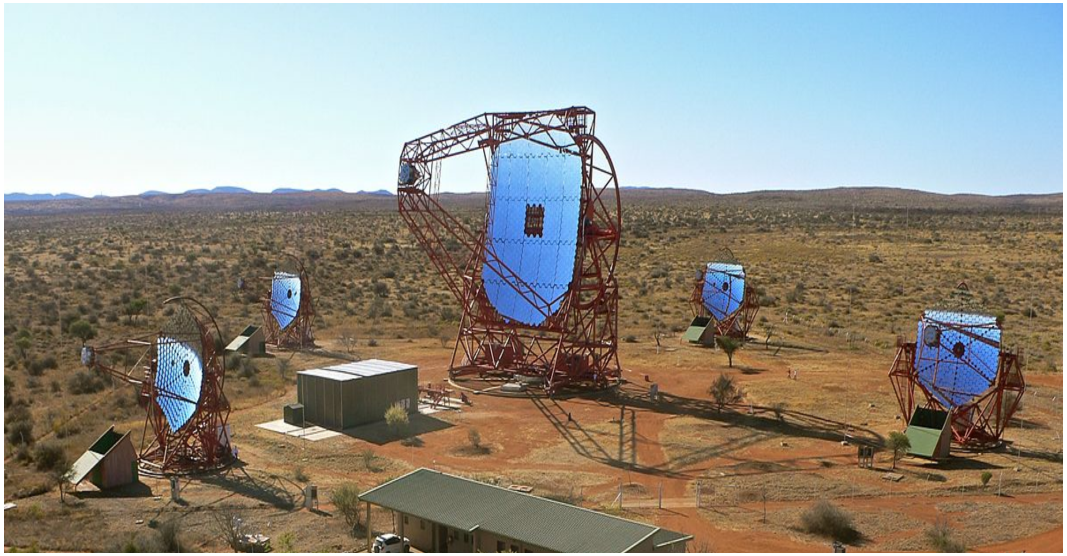




MNRAS, 434, 3, 2013, 1889–1901

From http://chandra.harvard.edu/
and Tanami Collaboration

The High Energy Stereoscopic System (H.E.S.S.)



2003-2009. 4-telescopes and “standard Hillas” analyses

2009-2012. Enhanced analyses strategies gave a factor of two in sensitivity gain
Y. Becherini et al. Astroparticle Physics, 34, 12, 2011, 858-870, among other methods

2012 – Addition of a large-area telescope at the centre of the 4-tel array
2016 – Major upgrade of electronics of the 4 Davies-Cotton telescopes

Centaurus A, HE and VHE datasets

H.E.S.S.

– new observations with H.E.S.S.
(213 hours total exposure)

– new high sensitivity methods
(Becherini et al. 2011;
Parsons and Hinton 2014)

– energy range: 250 GeV – 10 TeV

– Cen A core detected at ~ 12σ

– compatible with
a power-law at VHE

– no evidence for
significant variability

Fermi-LAT

– 8 years with new Pass 8 analysis

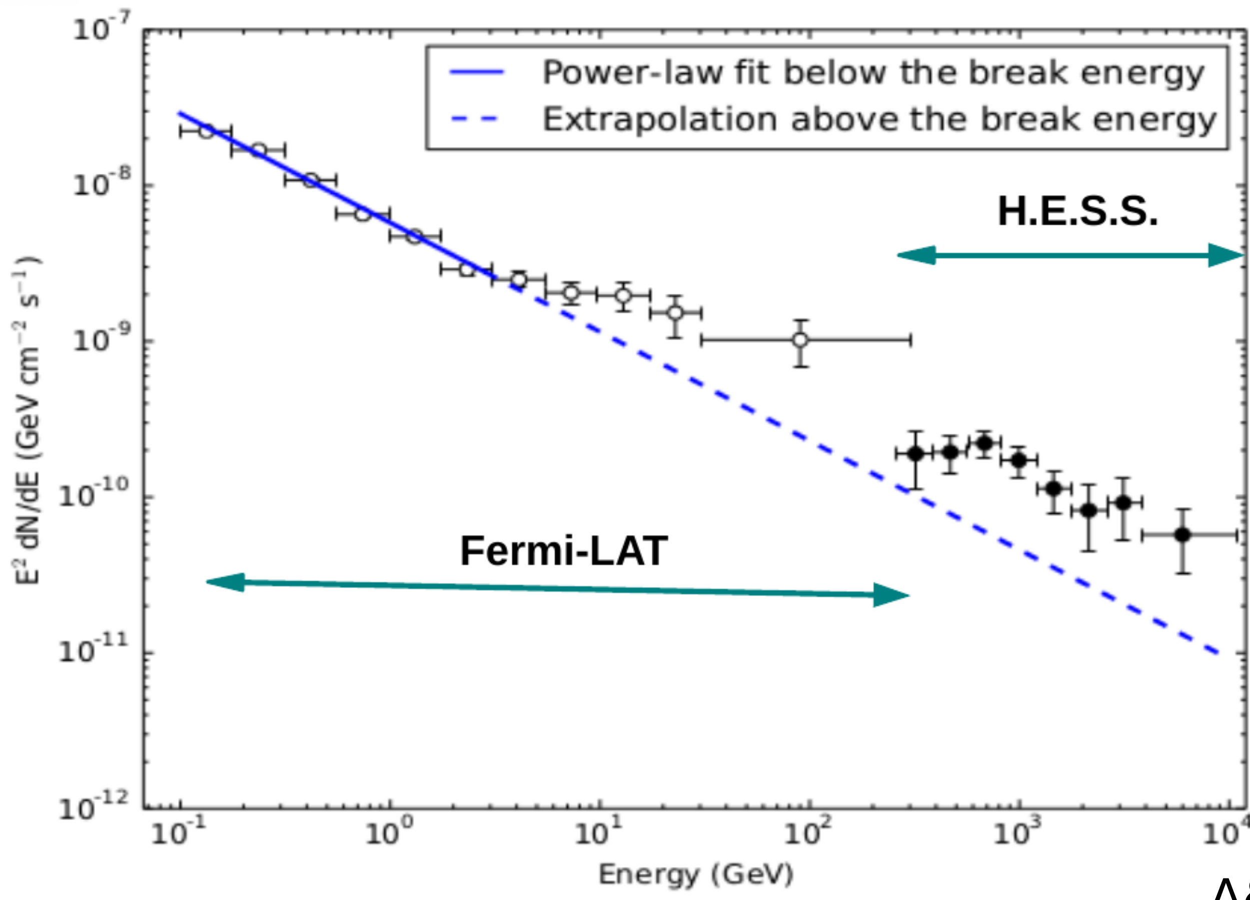
– energy range: 100 MeV – 300 GeV

– detected at 76σ

– spectral break significance at 4σ

– no evidence for
significant variability

The most up-to-date view of the core emission of Centaurus A



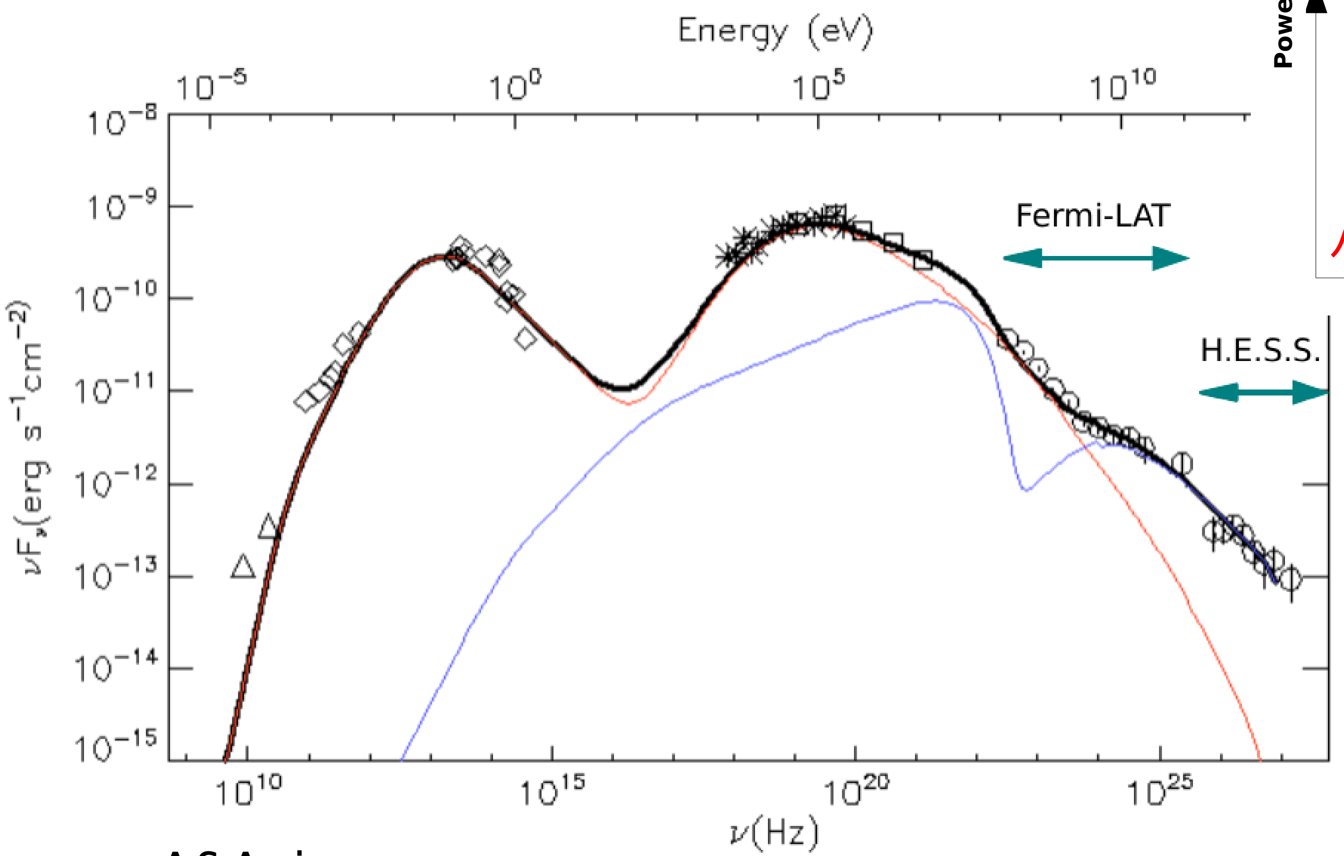
A&A, in press

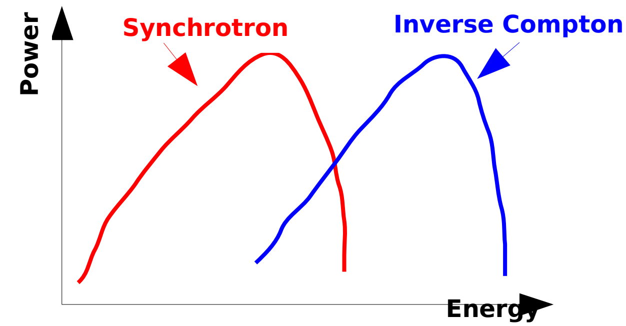
Interpretations for the additional component

H.E.S.S.

Inner Jet	multiple SSC-emitting components (i.e., differential beaming) (e.g. Lenain' 08)
	pɣ-interactions in the inner jet (e.g., Kachelrieß+ 10; Reynoso+11; Sahu+ 12; Petropolou+14)
	ɣ-ray-induced pair-cascades in a torus-like region (Roustazadeh & Boettcher+ 11)
BH vicinity	rotational acceleration & IC (e.g. Rieger & Aharonian 09)
Extended	HE from pp-interaction of relativistic p ("Fermi Bubble-like") (Sahakyan+ 13)
	EC starlight photons (e.g. Stawarz+06)
	Millisecond Pulsar Population (GeV + IC broadening) (Brown+ 16)
	inverse-Compton processes in the kpc-scale jet (e.g., Hardcastle & Croston+ 11)
New Physics	Dark Matter (mass ~3 TeV, central spike) Self-Annihilation (Brown+ 16)

The broadband view of the core of Cen A





A&A, in press

Conclusions

- Using all the available H.E.S.S. and Fermi-LAT exposure on the core of Cen A we found that:
  - Cen A is a VHE source with a 12σ significance
  - The VHE flux exceeds a high-energy power-law extrapolation of the γ-ray spectrum measured below the break energy and therefore the VHE flux exceeds expectations from a single-zone SSC scenario
- HE and VHE spectra are indicative of a new broad spectral component

- Future observations of Cen A at VHE
  - With the Southern array of CTA - will provide a unprecedented view of the source and will help constraining the emission models
  - With a wide-field of view high-altitude array (see next talk) in a continuous way could reveal flaring episodes
  - Possible scenario: different acceleration sites resolved

Backups

SSC modelling

- In the paper we present the modelling of the SED using the numerical code SED Builder

- We introduce a second SSC-emitting zone where we set the following constraints:
  - *Confinement constraint* - the energy density in the particles is comparable to (or less than) the energy density in the magnetic field $B^2/(8\pi)$
  - *Efficiency constraint* - the dynamical timescale ≈ R/c is larger than the synchrotron cooling timescale at high energies
  - *Acceleration constraint* - the synchrotron loss timescale is longer than the gyro-timescale at the max Lorentz factor
  - *Opacity constraint* - the optical depth to internal γγ absorption is less than one