AGN Science Analysis Group:

Science Goals – current standing

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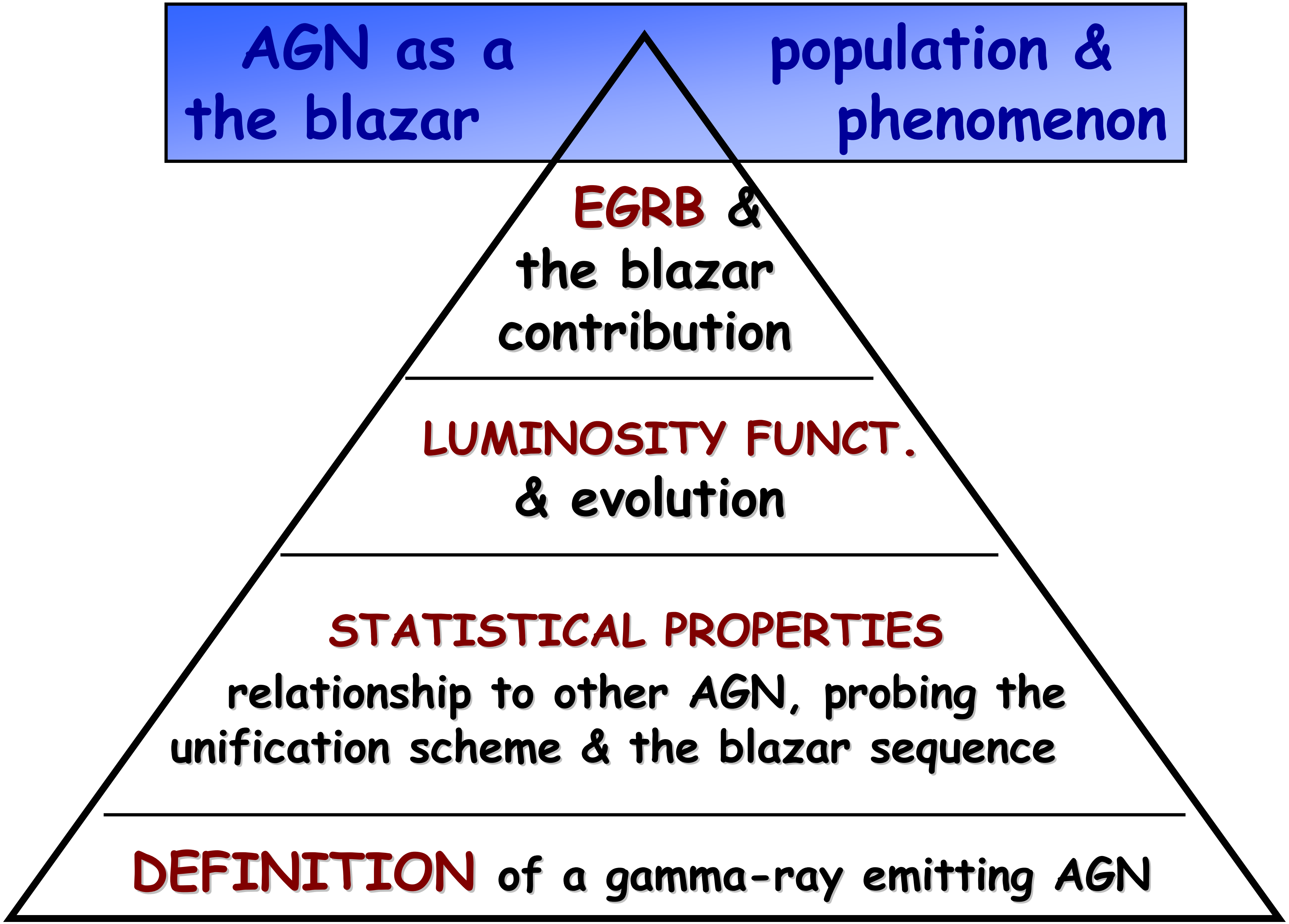
Three “top-level” science goals:

A. AGN AS A POPULATION AND THE BLAZAR PHENOMENON

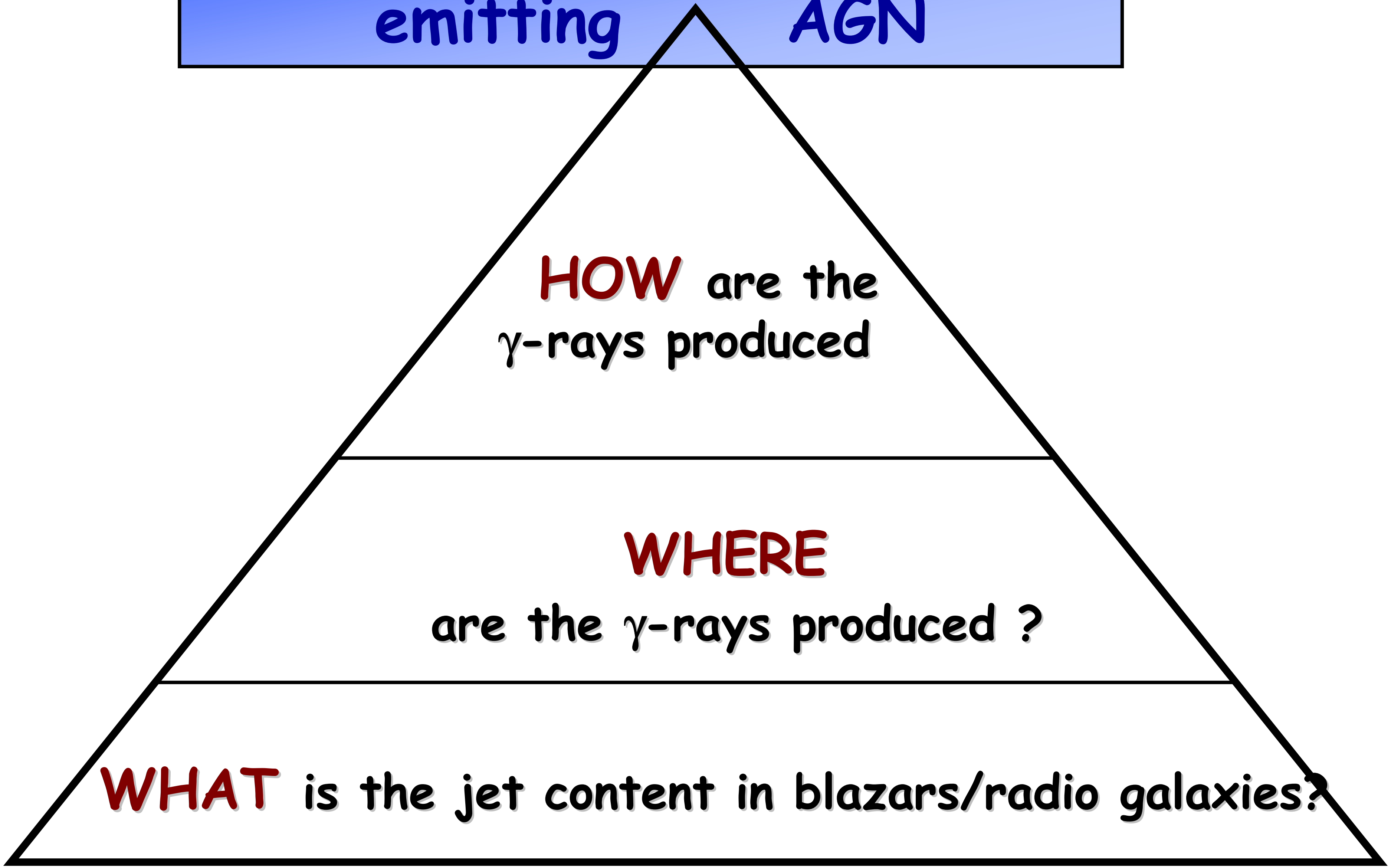
B. THE PHYSICS OF GAMMA-RAY EMITTING AGN

C. AGN AS A TOOL

What does each goal encompass?
What are the needed approaches and data in other bands?


AGN as a population &
the blazar phenomenon
EGRB &
the blazar
contribution
LUMINOSITY FUNCT.
& evolution
STATISTICAL PROPERTIES
relationship to other AGN, probing the
unification scheme & the blazar sequence
DEFINITION of a gamma-ray emitting AGN

The Physics of γ-ray emitting AGN



The Physics of γ-ray emitting AGN

Approach:
search for 'bulk-Compton' X-ray precursors to γ-ray flares

MWL-data:
soft X-rays during pre-flare & flare state; time lag info

……

composition of the γ-ray emitting part of jet

content of the innermost part of jet

WHAT is the jet content in blazars/radio galaxies?

On the composition in the γ-ray emission region

Approach 1: Identify dominant emission process of γ-rays

Detailed broadband modeling using state-of-the-art leptonic & hadronic models; for unambiguous model fits simultaneous broadband SEDs plus variability info (light curves, hysteresis, etc.) are required.

Approach 2: Field strength ?

Many (not all) hadronic models require "large" (~order 10G) B-field strengths, leptonic SSC need significantly lower field values in the γ-ray producing region: use auto-correlation functions, multi-λ lags on the basis of long data trains with sufficiently short sampling times

Approach 3: Neutron-decay/cascade features in γ-spectra

Search for γ-ray spectra consistent with n-decay *[a la Aotyan & Dermer 03]* and/or hadronic cascades/features ("orphan flares" in HBLs linked to hadronic jet components?)

…ETC.

The Physics of γ-ray emitting AGN

Approach:
γ-γ attenuation arguments
MWL-data:
correlated X-ray observations

energization site

Approach:
quasi sim. flares at IR-UV and
γ-rays for one-zone SSC
MWL-data:
sim. monitoring in IR-UV at cadence
to temporally resolve flare

photon production site of
low/HE-comp. co-spatial ?

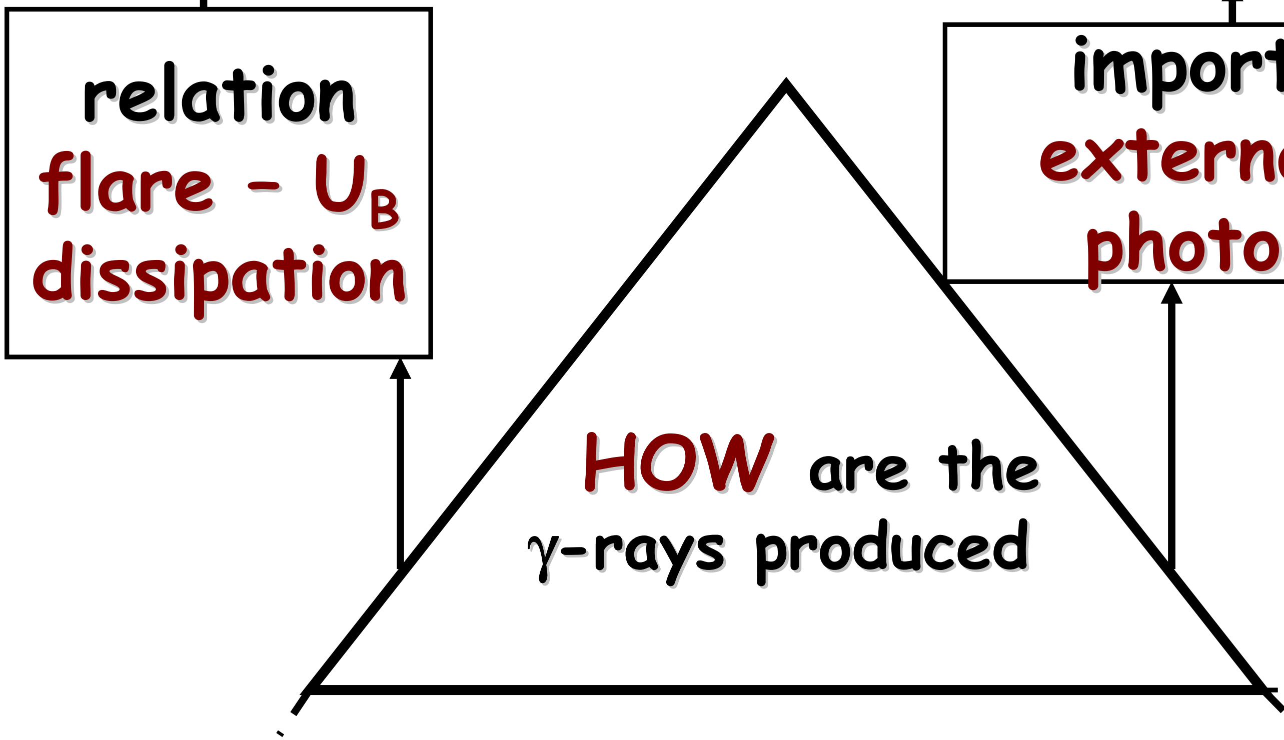
WHERE
are the γ-rays produced ?

The Physics of γ-ray emitting AGN

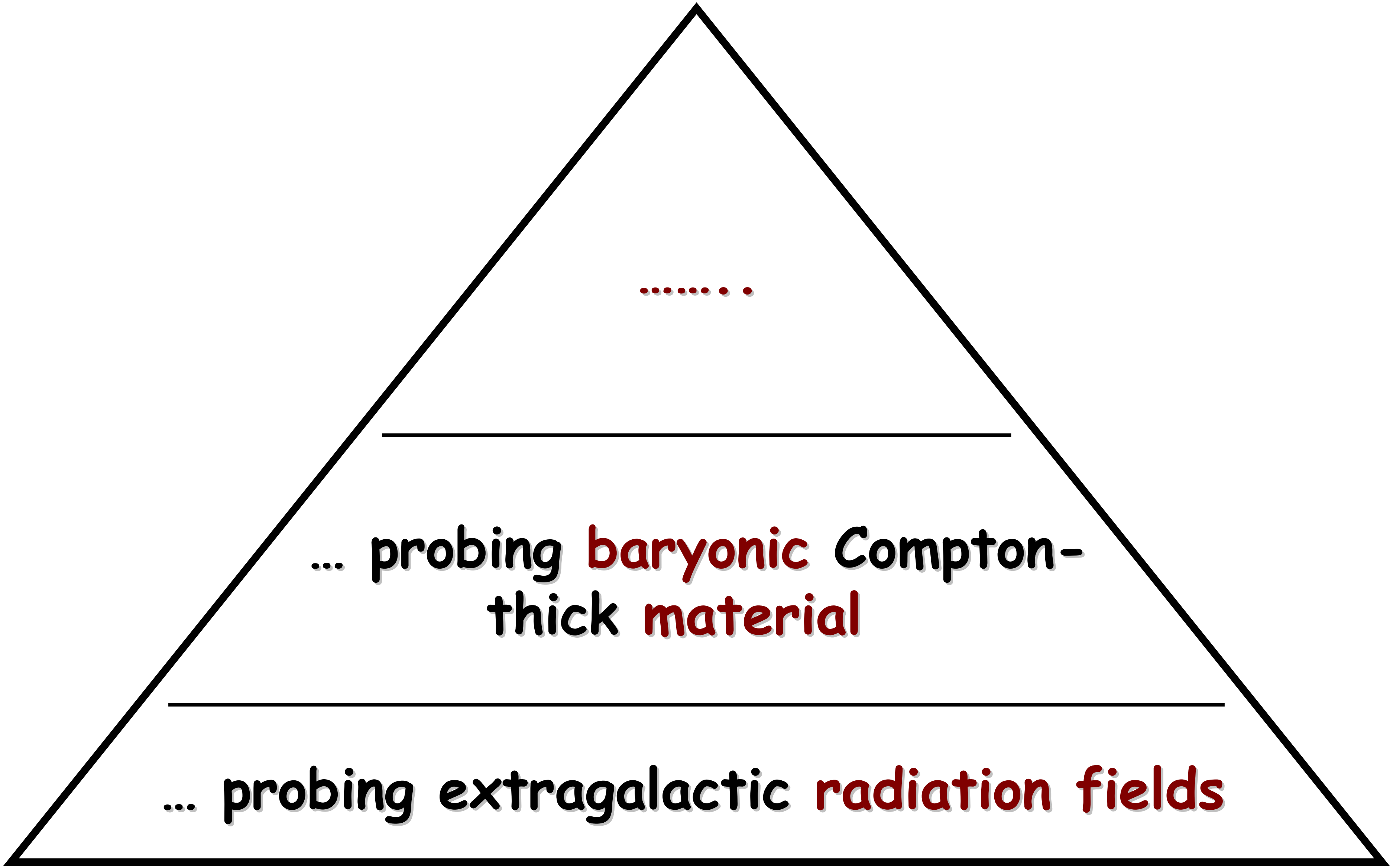
Approach: monitor IR/opt. polarization near syn.peak component

MWL-data: opt. polarization @ good temporal resolution

Approach:
- measure strength of putative target photon fields, e.g. BLR emission lines
- test Compton-scattered CMBR interpretation of extended X-jets through measurement of min. non-variable flux



AGN as a TOOL



……. .
… probing baryonic Compton-thick material
… probing extragalactic radiation fields

B. PHYSICS OF GAMMA-RAY EMITTING AGN

(includes blazars and radio galaxies)

This is about how gamma-ray emitting AGN work, including the jet structure, content, and radiative processes

* *B.1 WHAT is the structure (ingredients/content) of jets in blazars and radio galaxies?*

* *B.1.(a) the content of innermost part of the jet (e+e-, baryon load, Poynting flux)*

* **Approach:** Is there a substantial e+/e- component to those? Are they most likely Poynting flux dominated? --> search for X-ray "precursors" to gamma-ray flares; presumably if jets are particle dominated to begin with, one should see "bulk-Compton" radiation prior to dissipation events - the intensity of the "precursors" should reveal the total e+ /e- content of the jet; however be aware of some hadronic models (e.g. blast-wave model) who predict in general the X-ray flare to precede the gamma-ray flare

Targets: Bright blazars in flaring states: 3C279, 1622+398, PKS 0528+134
Other data needed: Good coverage in soft X-rays during pre-flare and
flare state; time lag information

** B.1.(b) composition of <u>gamma ray emitting part</u> of jet (e+/e-, p/e or UHECRs, B field)*

* **Approach 1:** Test leptonic models: Any non-expected behavior calls for alternative model solutions which may be linked with the need for hadronic jet components (see ``orphan flares``, low-E component lagging high-E component, etc

Examples here are: are SSC models in trouble for the HBL-type blazars? SSC model precludes flares that are seen only in one, but not in the other component: "orphan" flares pose substantial problem to SSC models; a few were reported in previous data, but no clear consensus

Targets: HBL blazars Mkn 421, Mkn 501, 1ES1959+65
Other data needed: good coverage in soft X-rays and in the TeV band

* **Approach 2:** Identify dominant emission process (IC versus synchrotron.) at gamma-ray energies; apart from (non-available) polarization data at these energies, this goal can be approached through detailed broad-band modeling (including simultaneous broadband data and variability information) using competing blazar emission models

Targets: nearby strong emission line FSRQs (3C273, 3C279, 3C454.3, PKS 0528+134)
Other data needed: For unambiguous model fits both simultaneous broad-band SEDs plus variability information (light curves, hysteresis...) are required in energetically equally distributed energy bands.

** B.1.(b) continued: composition of gamma ray emitting part of jet*

* **Approach 3:** Derive a measurement or UPPER limit on B field strength in the gamma-ray emitting region; useful may be: equipartition arguments using low-E peak flux, width of ACF, multi-lambda leads/lags (apart from (non-available) polarization data at GeVs)

Targets: nearby blazars
Other data needed: broadband long continuous data trains, very short sampling time scales

* **Approach 4:** Derive an unbiased estimate for the total jet luminosity / total charged particle content / kinetic energy of the blazar jet.

Targets: should yield inferences about the particle content from modeling of the Compton component - presumably the "low end" of the distribution is due to less energetic but much more numerous particles (thus sources with hard X-ray spectra are best), such as BL Lacertae, PKS 1510-089

* **Approach 5:** Search for gamma-ray emission from radio galaxies that display spectra consistent with neutron-decay and hadronic cascade origins for synchrotron and Compton components (cf. Atoyan & Dermer 2003 etc..).

Targets: 3C 279, PKS 0528+135, Mrk 421, Cygnus A, Pictor A, others
Other data needed: Multiwavelength coverage of blazars at energies of most highly variable synchrotron flares.

** B.2 WHERE are the X-rays/gamma-rays produced ?*

** B.2.(a) photon production sites of low & high energy (HE) component*

* **Approach:** if those are indeed produced by the same electron population, the light curves for the synchrotron and Compton component flares should be strictly simultaneous, meaning no measurable leads or lags of the IR/opt/UV and gamma-ray flares

Targets: HBL blazars Mkn 421, Mkn 501, 1ES1959+65
Other data needed: Simultaneous monitoring in the IR/opt/UV bands, at a cadence allowing to temporally resolve the flares (implied by the GLAST data)

** B.2.(b) energization sites*

* **Approach:** Use gamma-gamma attenuation arguments to place a minimum limit on the bulk relativistic Lorentz factor of blazar jets, and to set minimum distances of the location of the emitting jets from the central supermassive black holes. Correlate Lorentz factors with blazar types.

Targets: 3C 279, CTA 102, others
Other data needed: Correlated X-ray observations

** B.3 HOW are the X-/gamma-ray flares produced in blazars and radio galaxies?*

** B.3.(a) Importance of external photon fields (BLR, accretion disk, CMB, ...) for X- & gamma-ray production*

<u>* Blazars:</u>

* **Approach 1:** Is Self-Compton or External Compton more applicable for objects with strong emission lines? Gamma-ray flares (presumably Compton) should obey the simple quadratic (for SSC) or linear (for ERC) relationship against the amplitudes of the IR/Opt/UV flares (presumably synchrotron component) IF the low and HE component are co-spatially produced (which is doubted considering the most recent MWL results). In this case correlated variability between optical and 100 MeV - GeV emission, and X-ray and >>GeV – TeV emission should be examined as evidence for SSC and EC processes by comparing with model expectations.

* **Approach 2:** via direct verification of the strength of the putative external target photon fields (e.g. BLR, accretion disk through emission line measurements, etc.)

Target(s): Bright blazars in flaring states: 3C279, 1622+398, PKS 0528+134

Other data needed: Simultaneous monitoring in the IR/opt/UV/X-ray bands, at a cadence allowing to temporally resolve the flares (implied by the GLAST data); BLR emission line strengths around times of gamma-ray activity

* *B.3.(a) continued: Importance of external photon fields (BLR, accretion disk, CMB, ...) for X- & gamma-ray production*

<u>* Radiogalaxies</u>:

* **Approach:** Tests of the Compton-scattered CMBR interpretation of extended X-ray (Chandra) jets; Highly relativistic motions on hundred kpc scale is required to explain X-ray knot emission in Chandra jets through Compton-scattering of the CMBR, with definite predictions for GLAST

Targets: PKS 0637-752
Other data needed: Measurements of the minimum non-variable flux of PKS 0627-752 will test this model.

* *B.3.(b) Relation between flares an dissipation of magnetic energy*

* **Approach:** Are gamma-ray flares related to dissipation of magnetic energy? This can be accomplished via monitoring of the IR/optical polarization near the peak of the synchrotron component, and correlation of polarization direction changes with gamma-ray flares

Targets: AO 0235+164, 3C454.3, others
Other data needed: good optical polarization coverage, at good (< hour) temporal resolution