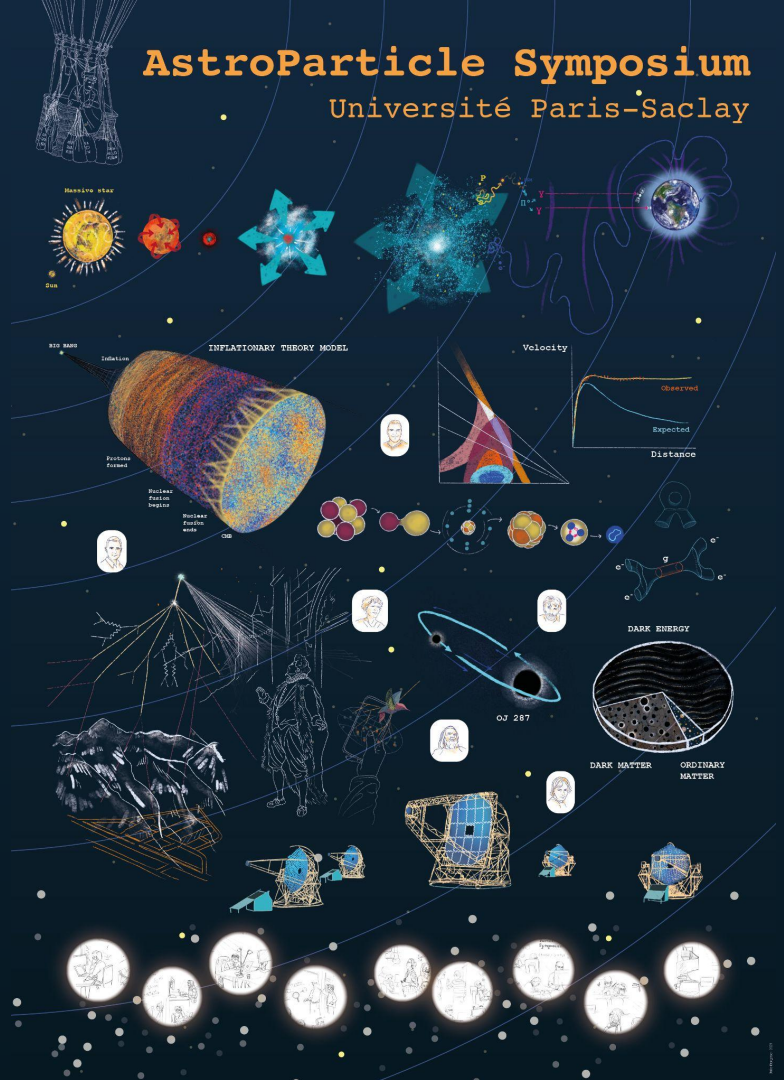
2024 edition - Week 1



Extragalactic backgrounds

Cosmic optical and infrared backgrounds: galaxy counts and direct measurements

Gamma-ray and ultra-high-energy cosmic-ray propagation on cosmological scales

Probe of synthetic extragalactic population models, intra-halo emission, the Hubble constant

Two and a half facts

When I began research in radio astronomy as a research student in 1963, my supervisor Dr Peter Scheuer gave me a copy of Sir Hermann Bondi's classic text *Cosmology* to absorb and warned me that

There are only $2\frac{1}{2}$ facts in cosmology.

Modern Cosmology - a Critical Assessment,
M. S. Longair 1993

Fact 1. The sky is dark at night

This is the well-known observation which leads to what is known as *Olbers' paradox* although the paradox was well known to earlier cosmologists. Sir Hermann in his text *Cosmology* gives a thought-provoking discussion of the meaning of the paradox (Bondi 1952). The fact that the sky is not as bright as the surface of the Sun provides us with some very general information about the Universe. Probably the most general way of expressing the significance of this observation is that the Universe must, in some sense, be far from equilibrium although in what way it is in disequilibrium cannot be deduced from this very simple observation.

Fact 2. The galaxies are receding from each other as expected in a uniform expansion

This was Hubble's great discovery of 1929 and I will say much more about it in a moment. The $2\frac{1}{2}$th fact was as follows:

Fact $2\frac{1}{2}$. The contents of the Universe have probably changed as the Universe grows older

The reason for the ambiguous status of this fact was that the evidence for the evolution of extragalactic radio sources as the Universe grows older was then a matter of considerable controversy, particularly with the proponents of Steady-State cosmology. I was plunged straight into this debate as soon as I began my research programme with Martin Ryle and Peter Scheuer. As we will see, this is no longer a controversial issue – there is no question at all

Current contributions of our field to cosmology:
see talk by Alberto Dominguez

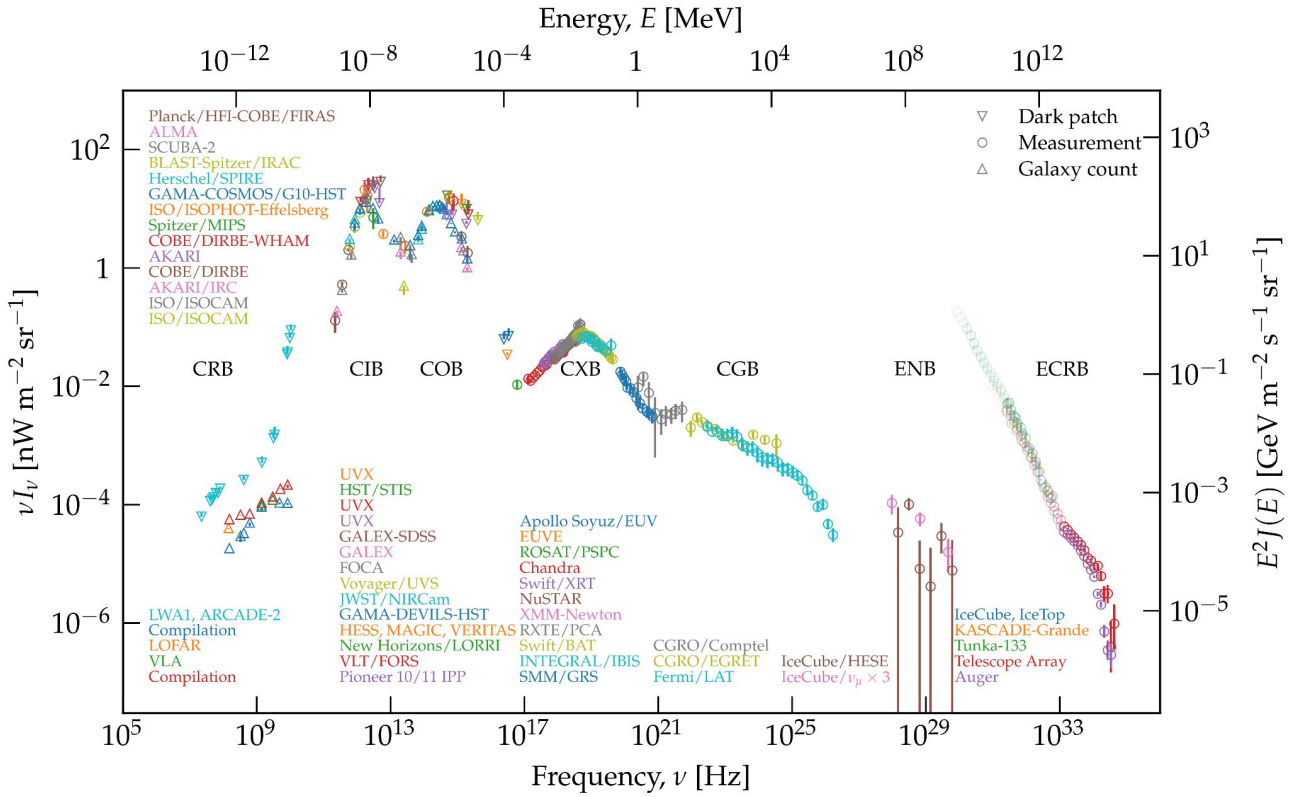
Everything, everywhere, all at once

See talks by Asantha Cooray and Simon Driver
Cooray ‘16, Driver ‘21

Dataset: partly from Hill+ ‘18

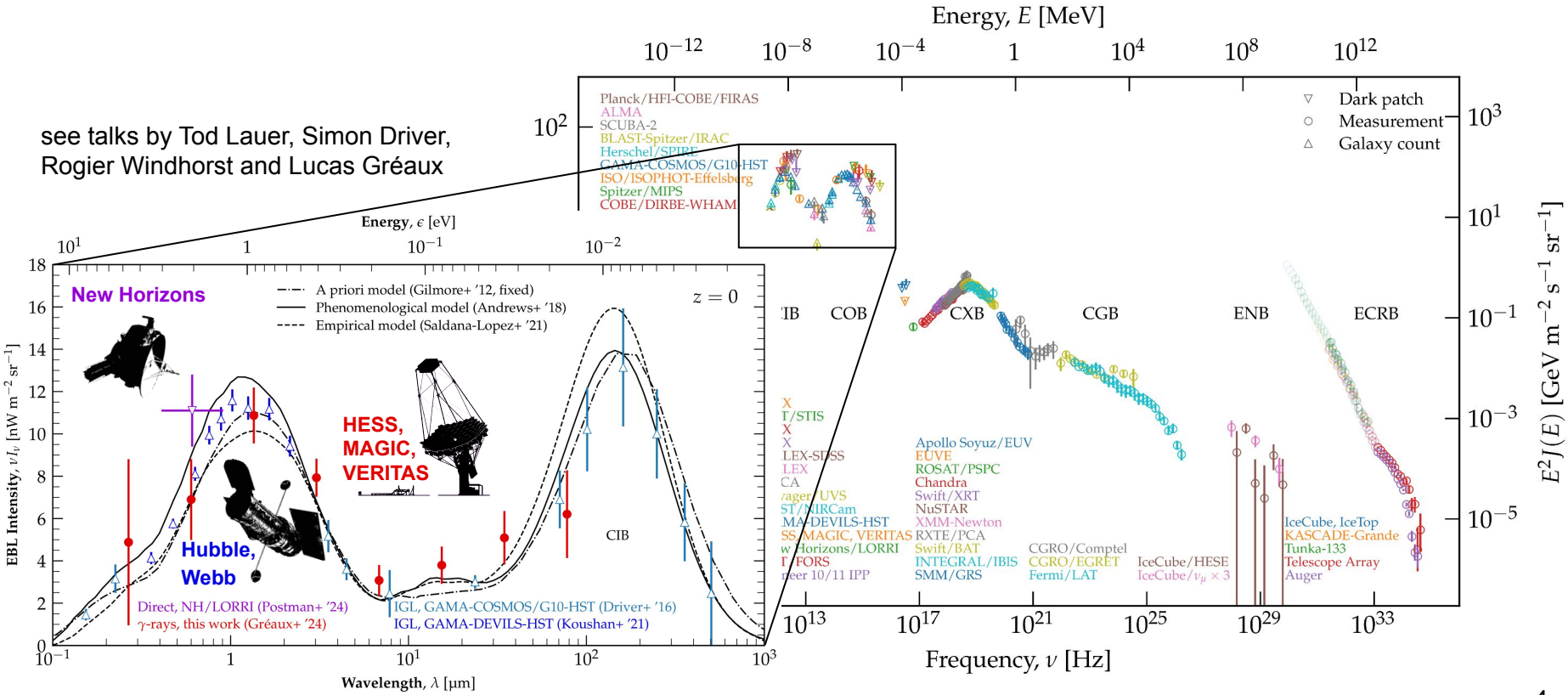
Code: adapted from
Evoli ‘21

Database available on git here
Available on
GitLab

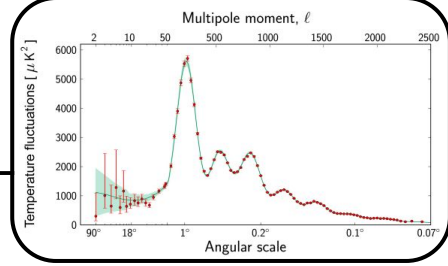


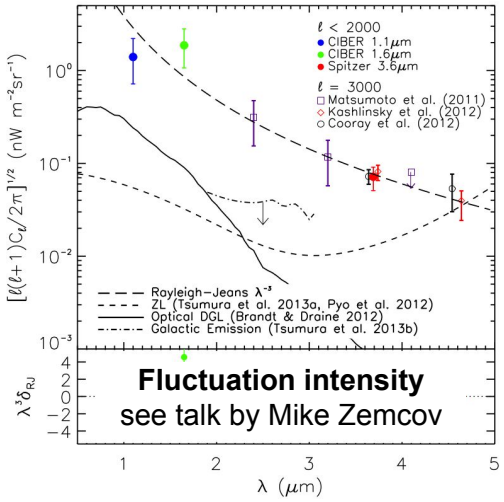
Everything, everywhere, all at once… in a consistent manner

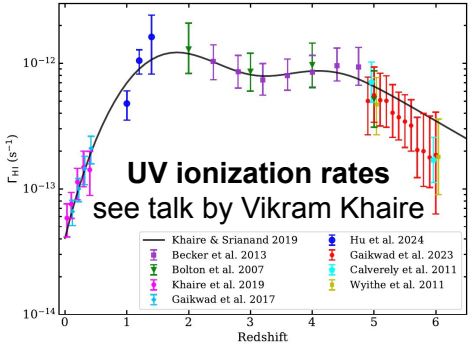
see talks by Tod Lauer, Simon Driver, Rogier Windhorst and Lucas Gréaux

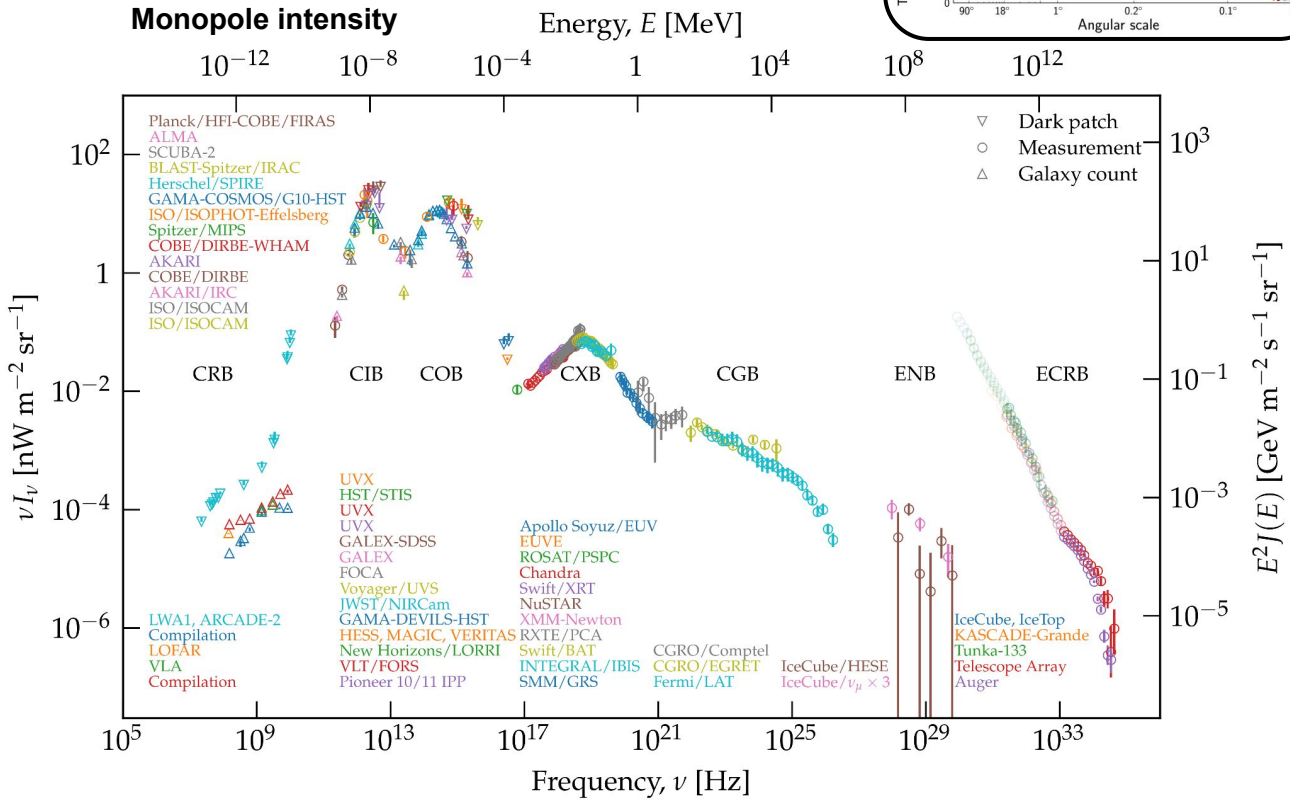


Everything, everywhere, all at once

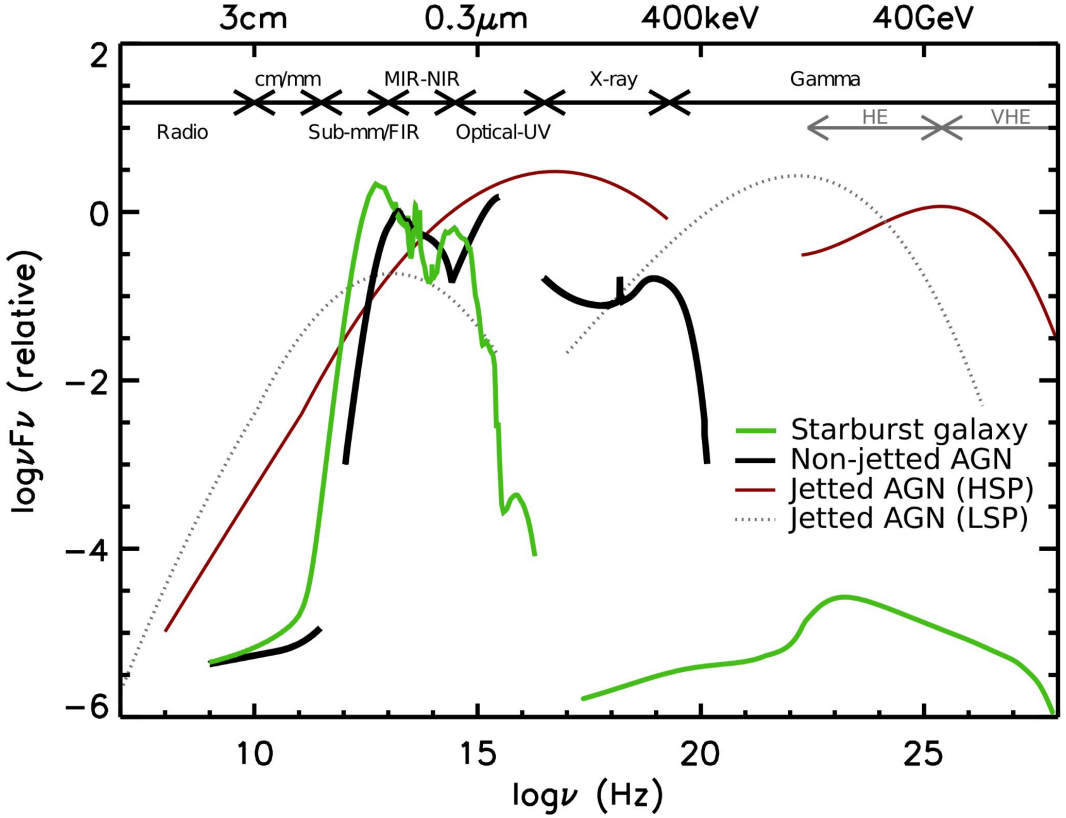








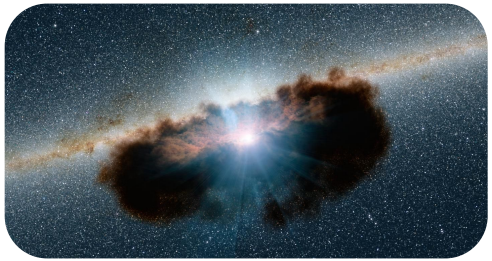
Everything, everywhere, all at once



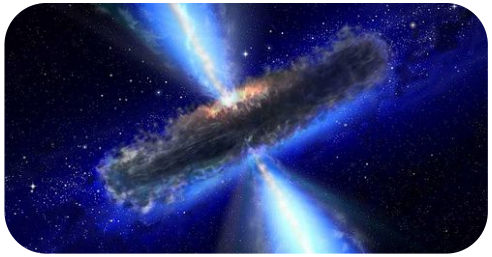
Adapted from C. Harrison's thesis (2014)

Star formation: galaxies

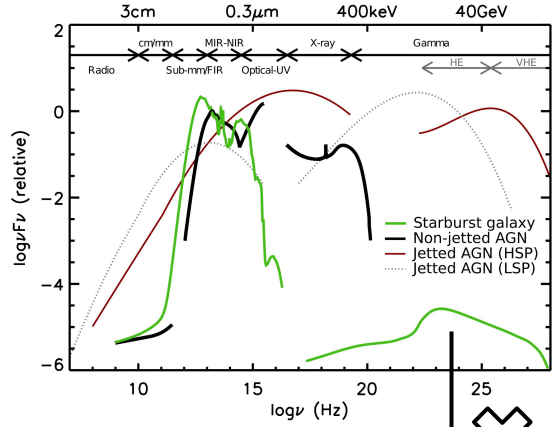
Accretion: Non-jetted AGN

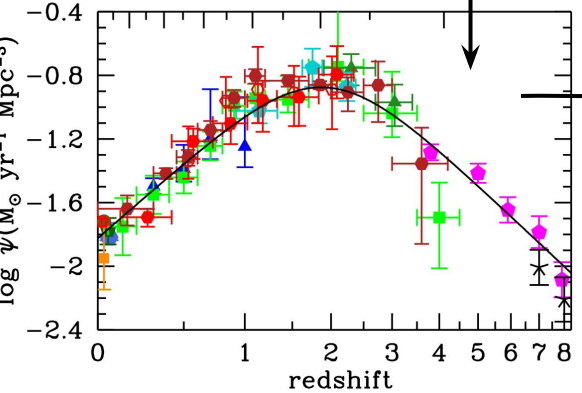


Ejection: Jetted AGN

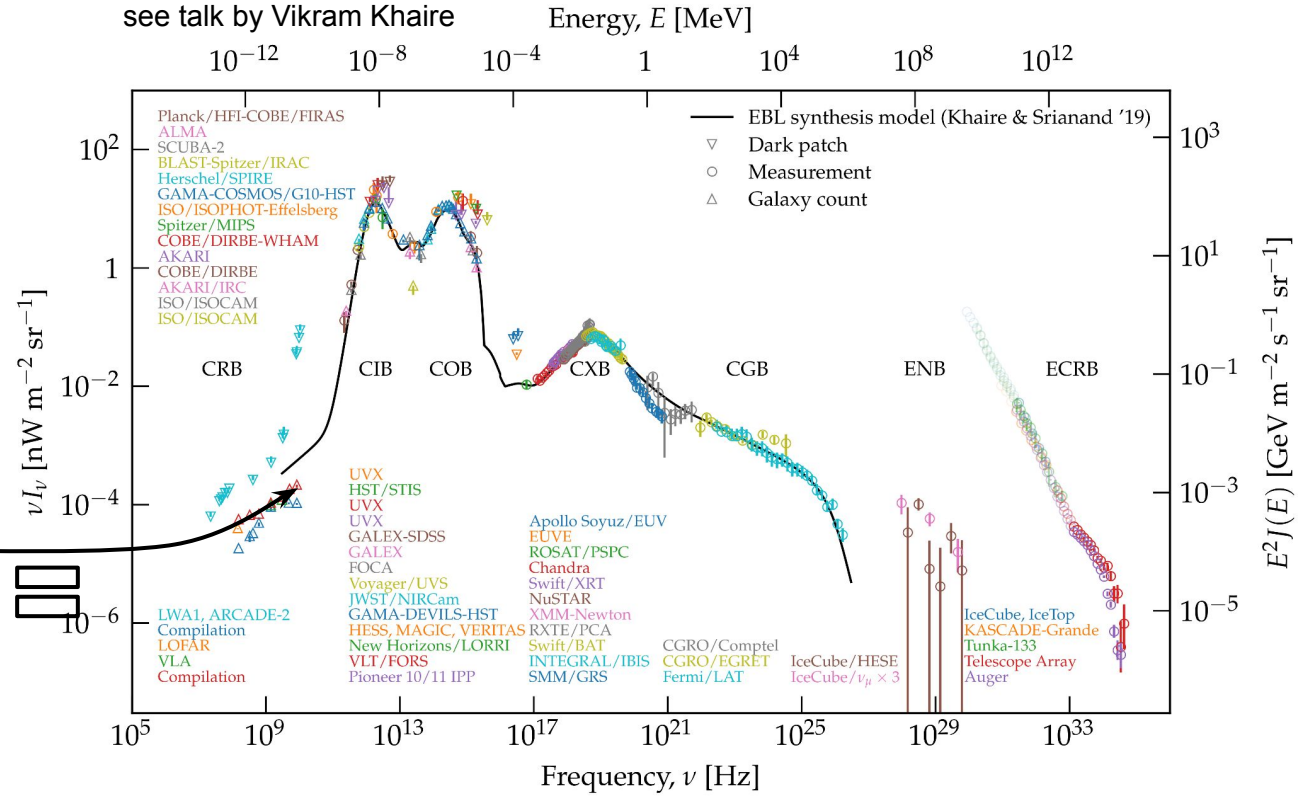


Synthesis models of all galaxies





see talk by Vikram Khaire



What can we learn

Back-of-envelope estimates

Light from nucleosynthesis

$u_{\rm nucl} \approx \epsilon_\odot c^2 \int \psi_\star(t) {\rm d}t \approx 13,000\,{\rm eV\,m^{-3}}$

where $\epsilon_\odot = L_\odot T_\odot / (M_\odot c^2) \approx 0.068\%$

Light from accretion

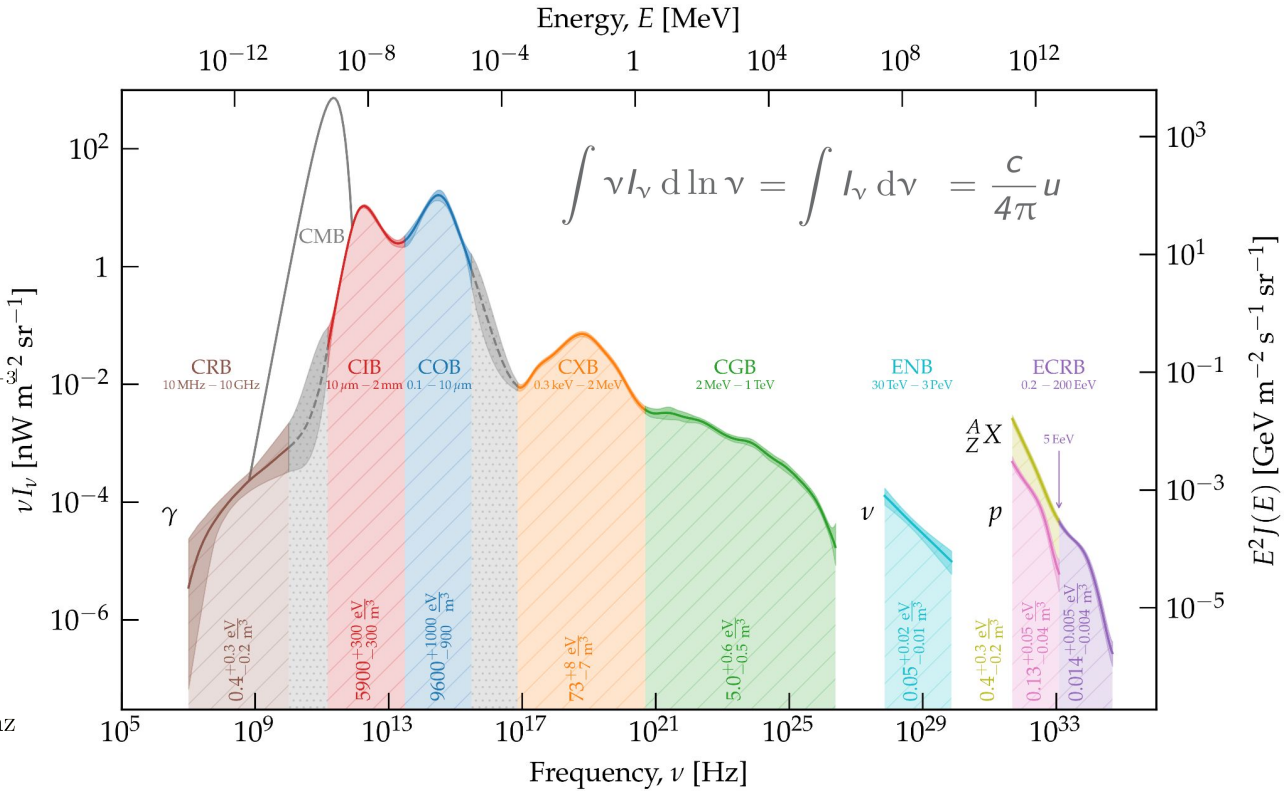
$u_{\rm accr} = \frac{\epsilon_{\rm accr}}{1-\epsilon_{\rm accr}} c^2 \int \psi_{\rm accr}(t) {\rm d}t \approx 1500\,{\rm eV\,m^{-3}}$

where $\epsilon_{accr} = 5.7 - 30.8\,\%$ and
$\psi_{\rm accr}/\psi_\star \approx 1/2000$ for a Chabrier IMF

Light from ejection

$u_{\rm jet} = \eta_{\rm jet} c^2 \int \psi_{\rm accr}(t) {\rm d}t \approx 4\,{\rm eV\,m^{-3}}$

where $\eta_{\rm jet} = \eta_{\rm kin/accr} \times \epsilon_{{\rm kin}\to\gamma} \approx 0.04\%$
with $\epsilon_{{\rm kin}\to\gamma} \approx 10\,\%$ for AGNs and GRBs
and $\eta_{\rm kin/accr} \approx 0.4\,\%$ from Merloni & Heinz



Upcoming facilities

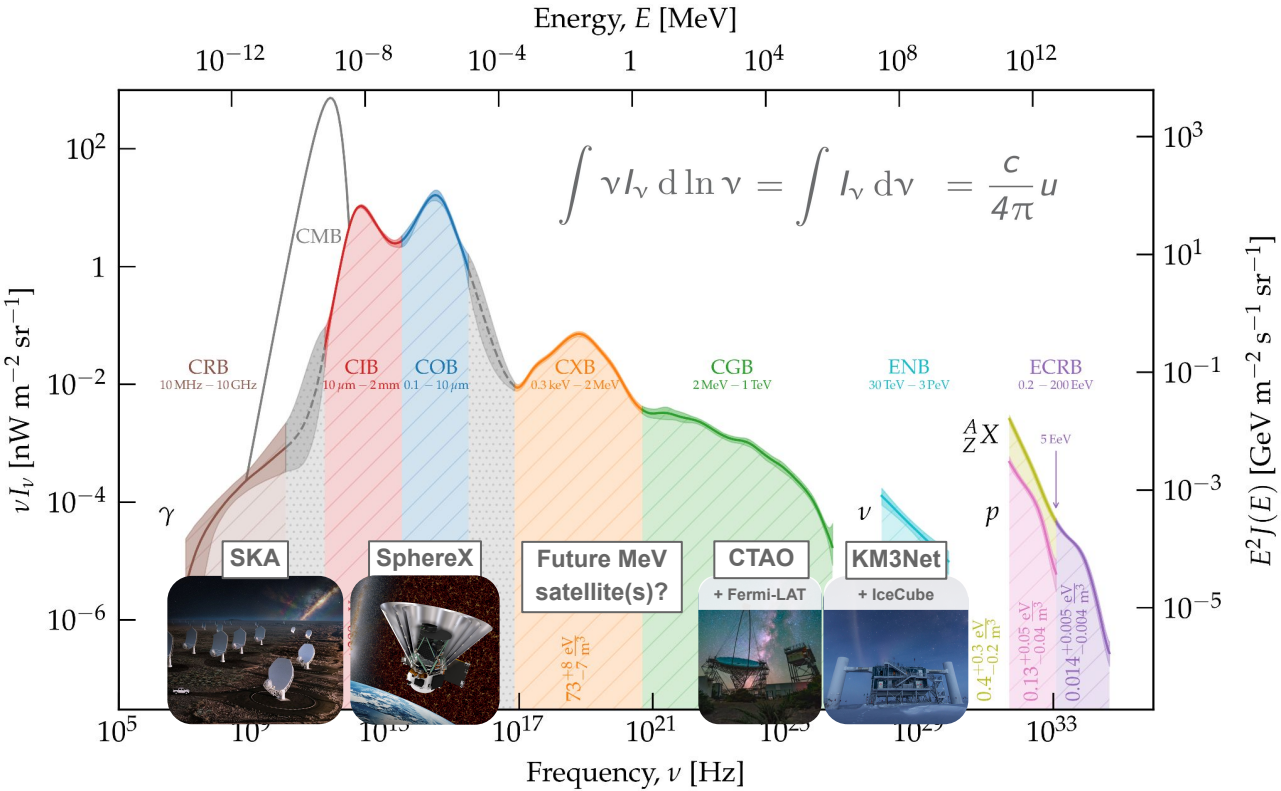
By 2027

SKAO Science verification begins

Scientific results from SphereX

CTAO supersedes HESS, MAGIC and VERITAS

Near completion of KM3Net (2028)



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Extragalactic backgrounds