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SM physics:

- ν oscillations
- strong interactions:
  - $\sigma^{pp}_{\text{inel}}$, K^{pp}_{inel}, $\mathrm{d}N/\mathrm{d}\eta_X$, pO run
  - nothing more to come from LHC?
  - only a one-way street?

Connection to particle physics: strong interactions

Input for MC generators:

- $\sigma^{pp}_{\text{inel}}$, K^{pp}_{inel}, string fragmentation
- Glauber formalism: $pp \to NN$ – deviations?
- what about collective effects (QGP – à la core-corona)?

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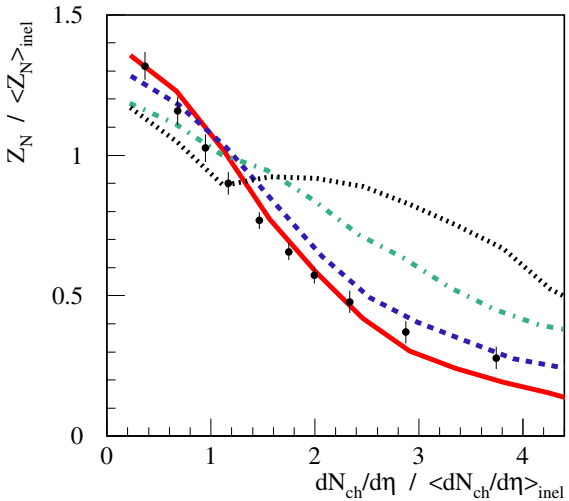

[*Ostapchenko, Pierog, Sigl '26*]

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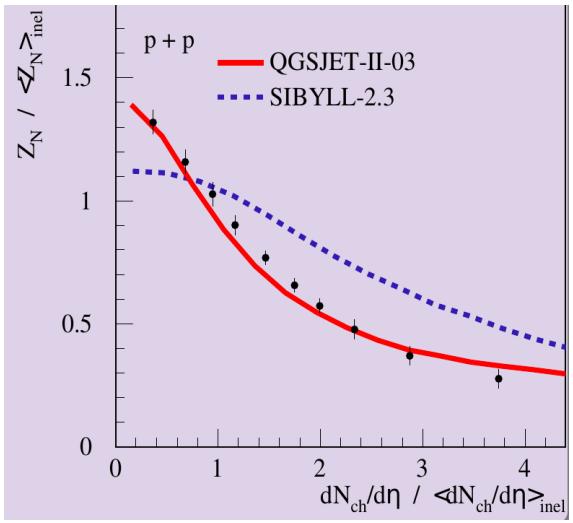

same analysis for pO?

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  - sufficiently luminuous: $R \lesssim Q/(\tau L_{\rm min}) \sim 10^{-8}/{\rm Mpc^3/yr}$ (for $\tau \sim 10^3\,{\rm yr}$)
  - avoid multiplets: $R \sim n_s/\tau \gtrsim 10^{-8}/{\rm Mpc^3/yr}$

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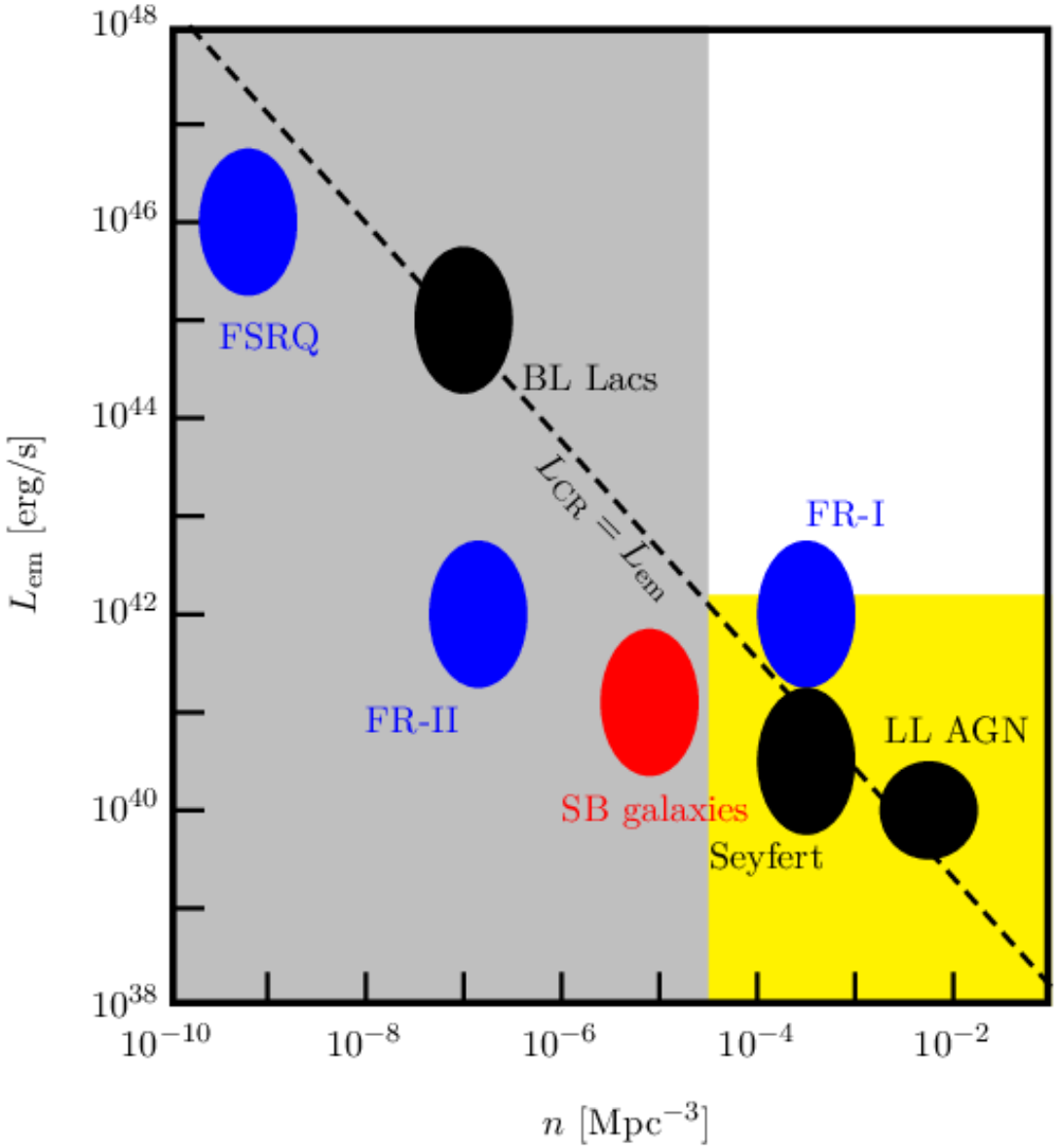
$\Rightarrow$ source density/rate tightly constrained

Density vs. luminosity constraint:



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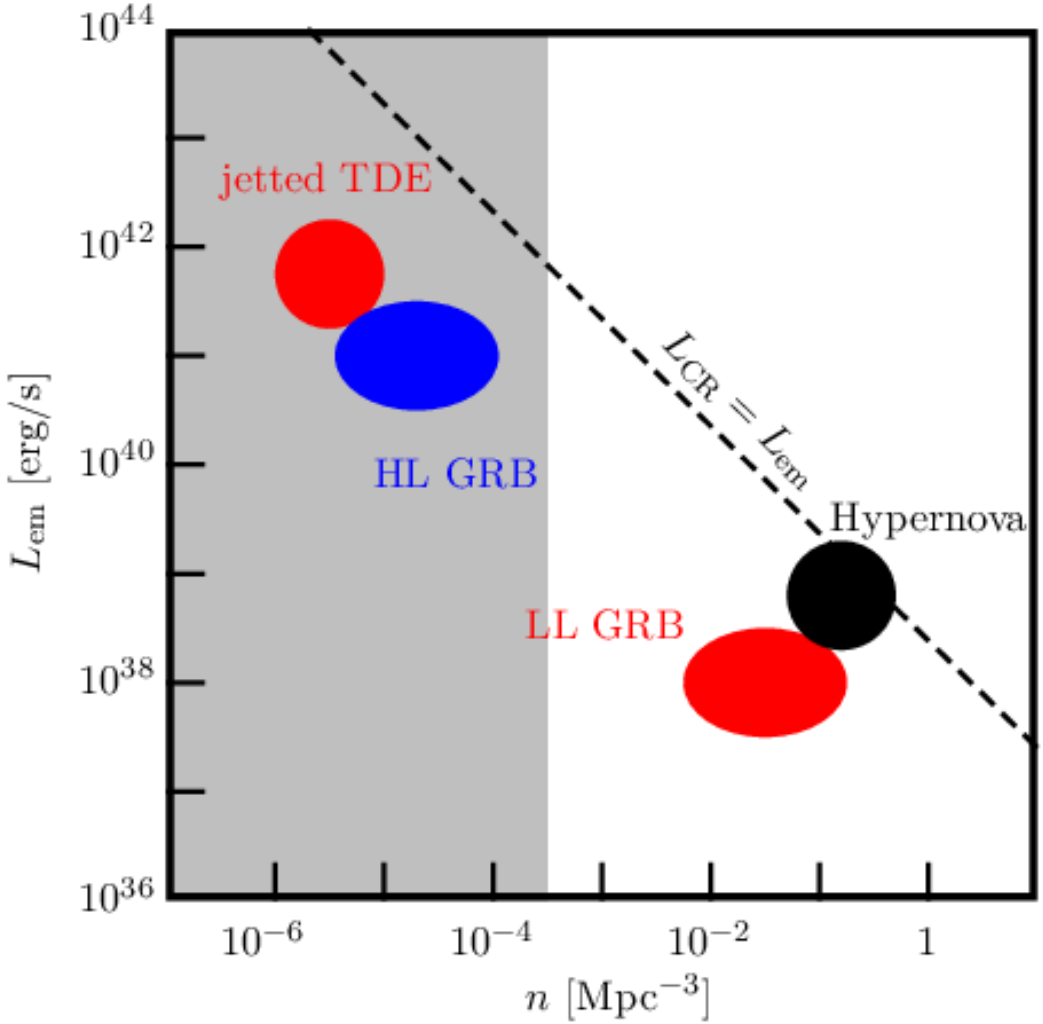

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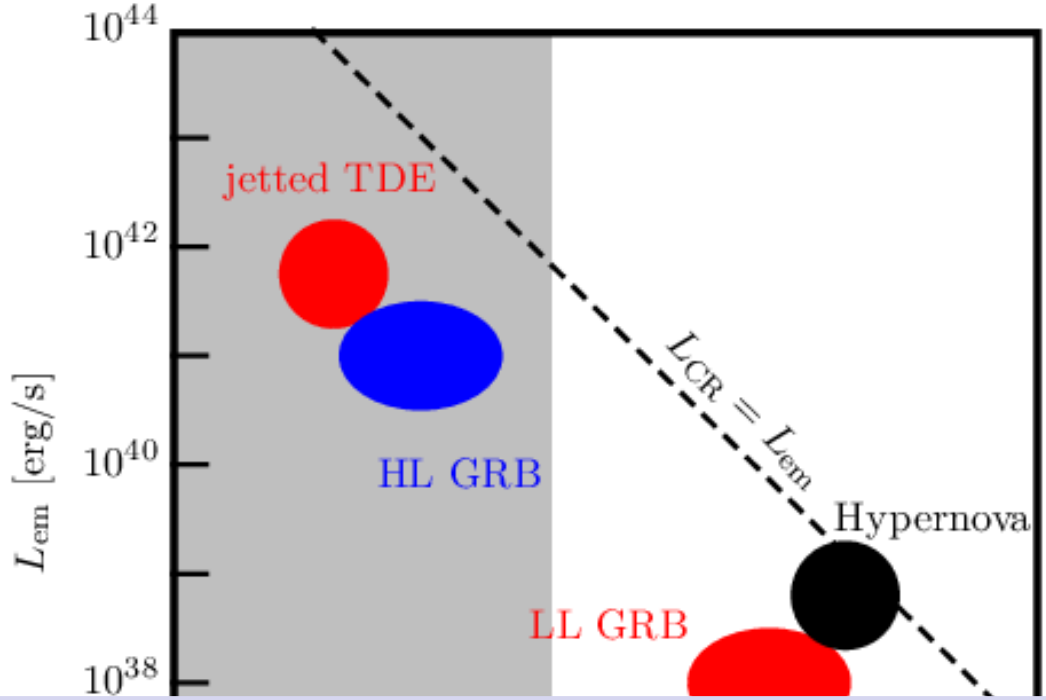
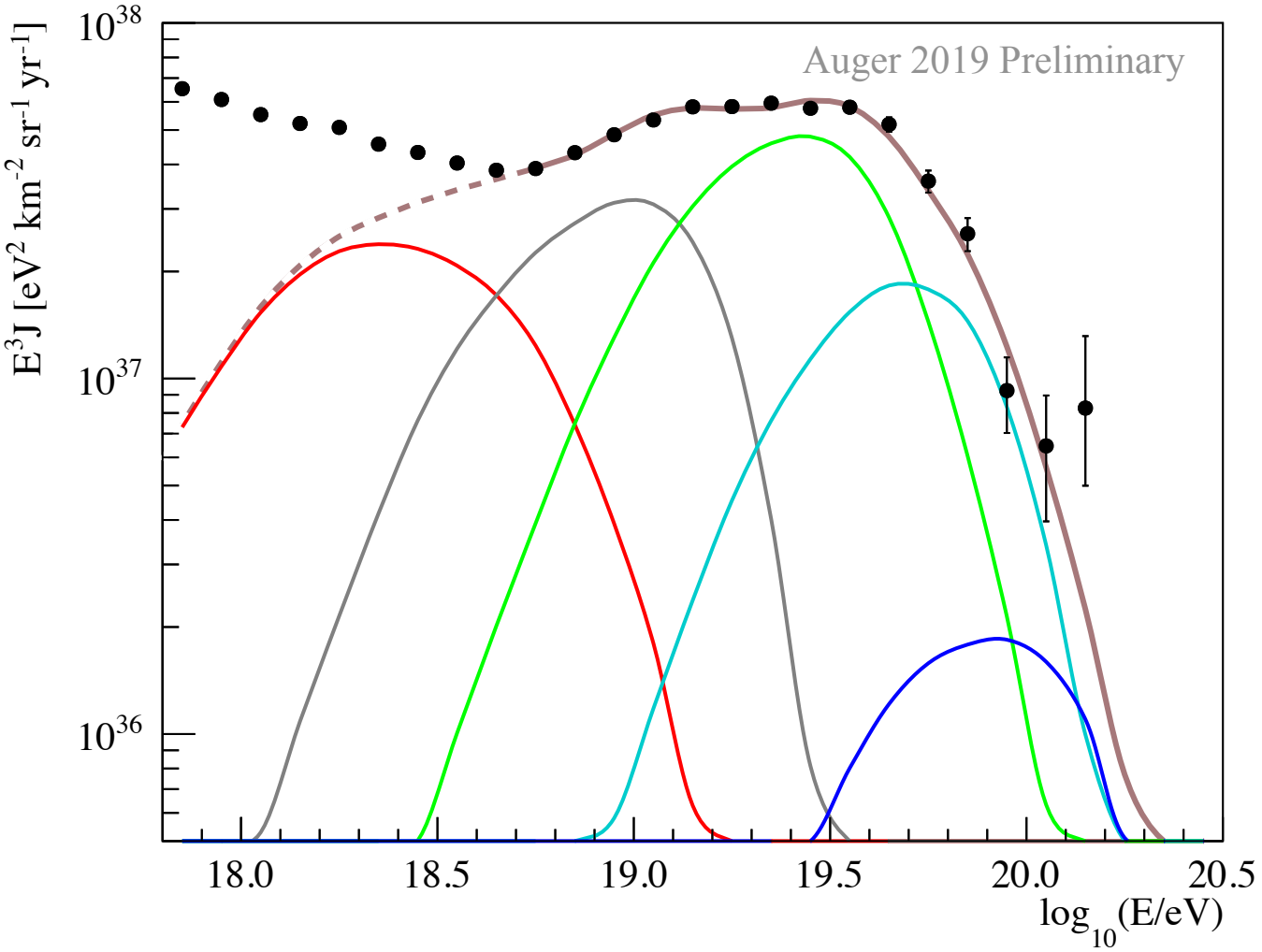


better, but:

- rare: emissivity too small
- τ could be much smaller

Energy spectrum & composition

- sharp transitions between different nuclear groups:



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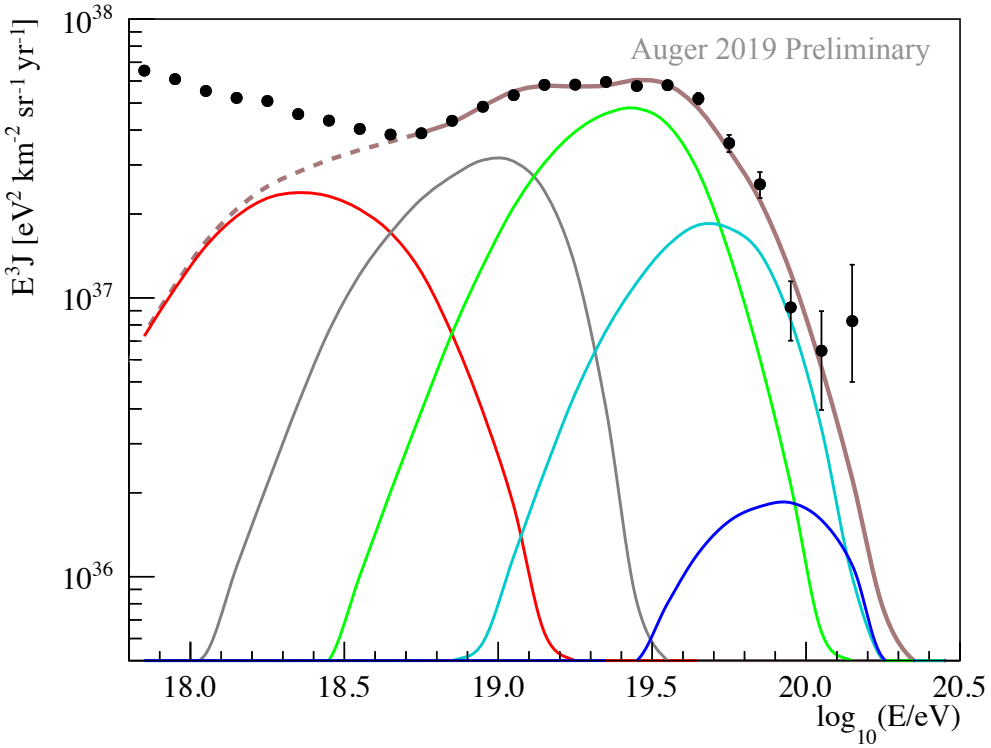
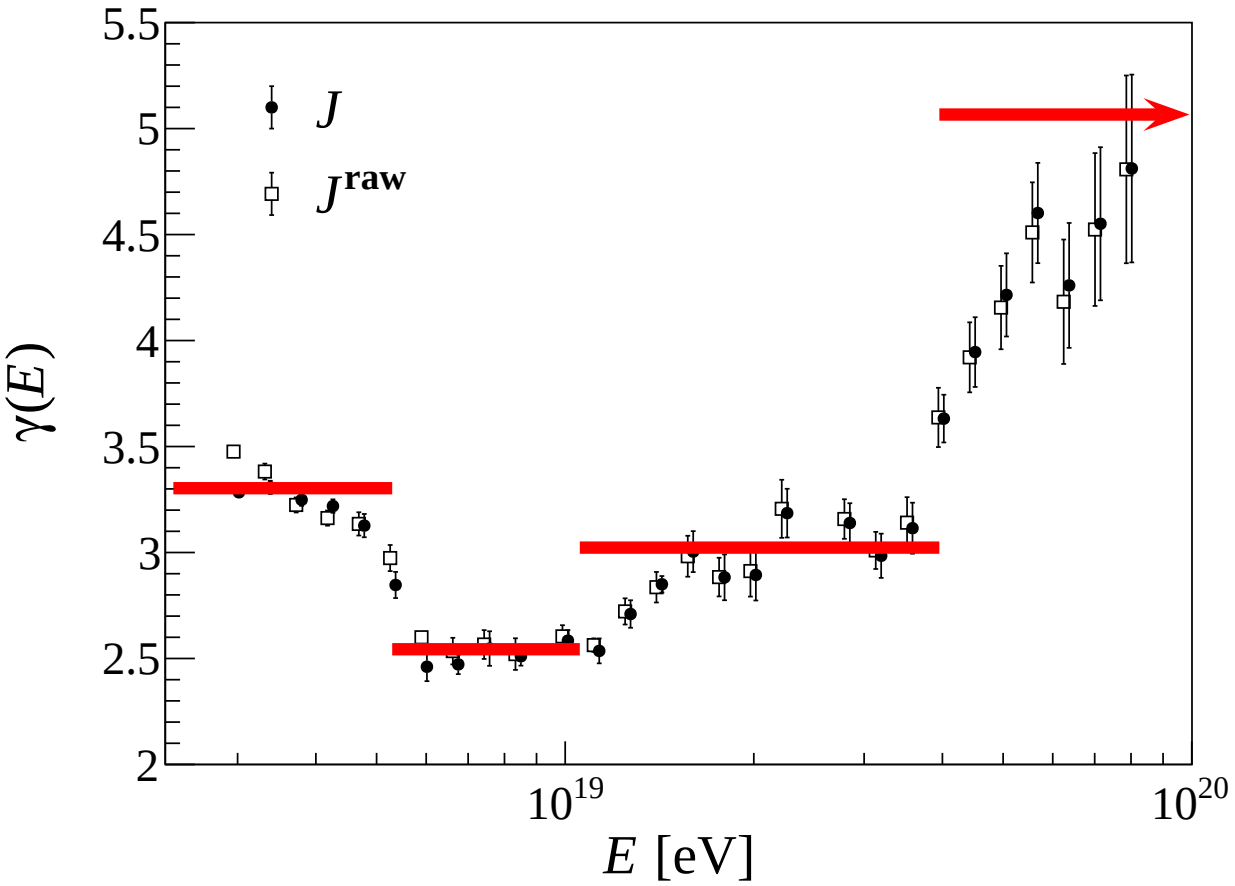


\+ eases acceleration

‣ additional component below ankle needed

\- surprising values for slopes and composition

Energy spectrum: sequence of power-laws?



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- Multi-messenger connection: weak?