A neutrino emission model to calculate neutrino fluxes from pp and pγ interactions for different Gamma Ray Bursts populations

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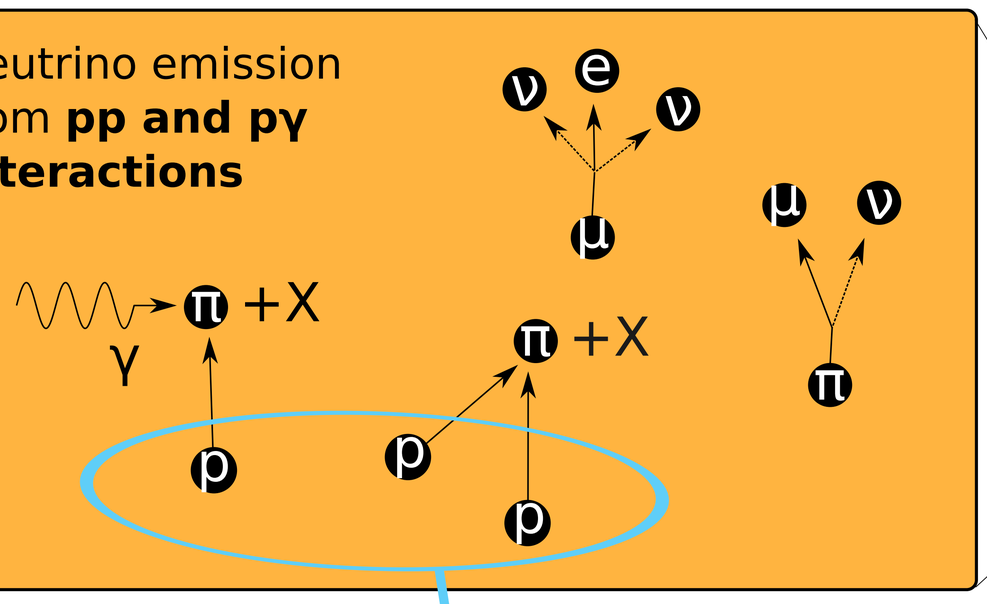
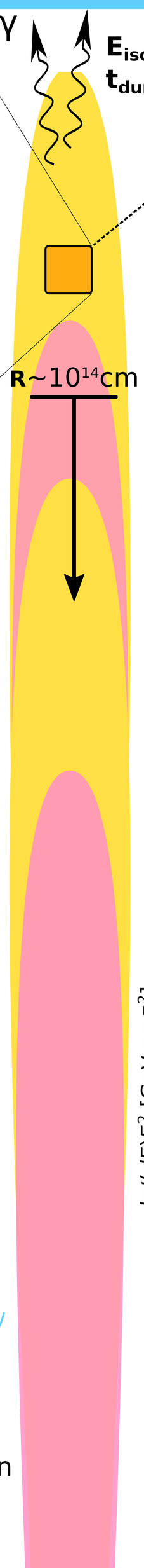
Neutrino emission from **pp and pγ interactions**

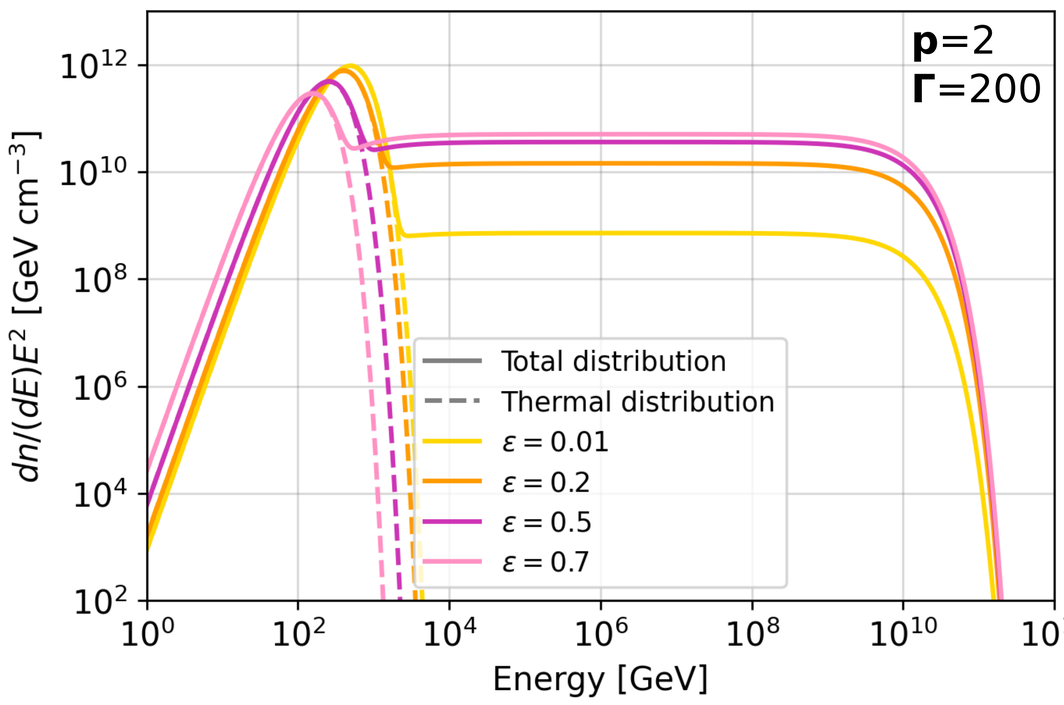




Protons have non-thermal powerlaw + thermal distribution[1,2]

Fraction non-thermal **ε**:
$E_{p,non\text{-}th} = \varepsilon \bullet E_{p,tot}$

Proton distributions

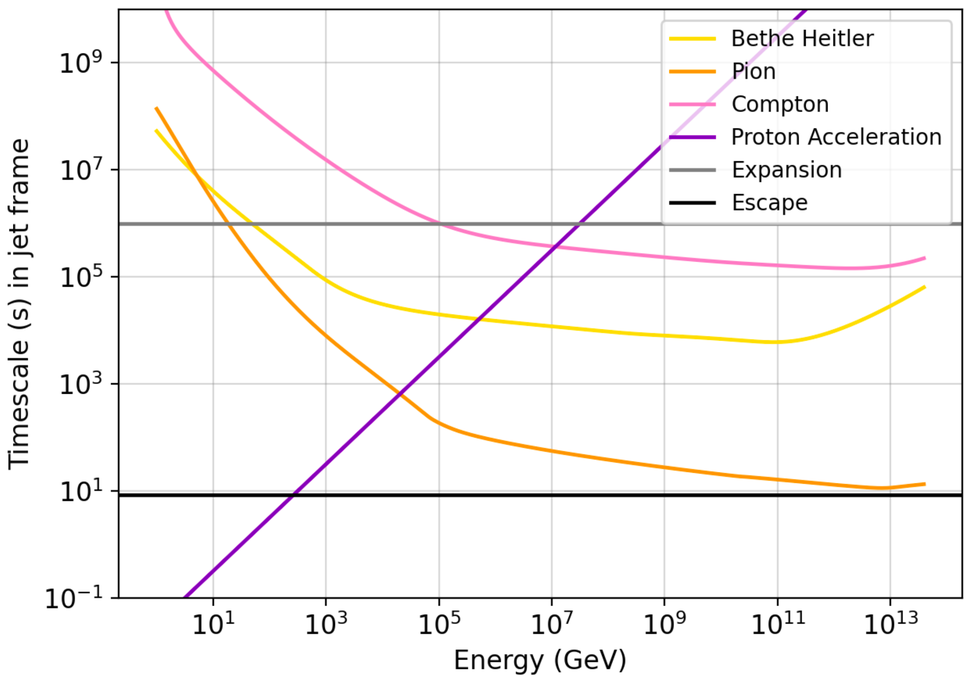


pp interactions
- pp → π calculated analytically
  - ✧ Proton self-interaction
- π decay modeled with AM3[3]

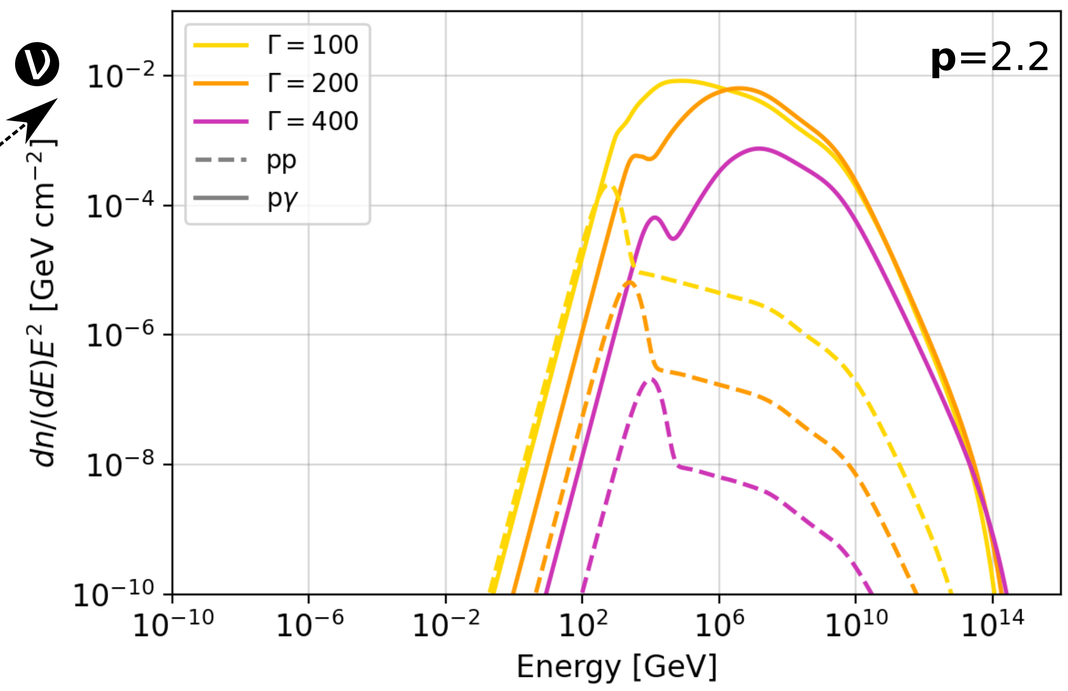
pγ interactions
- pγ → π and π decay modeled with AM3[3]
- γ modelled with band function

- Magnetic field in GRB defined as fraction of internal energy: ε_B
- Included: Escape, Synchrotron, Bethe Heitler, Proton Acceleration, Expansion, and Compton processes

Proton interaction timescales



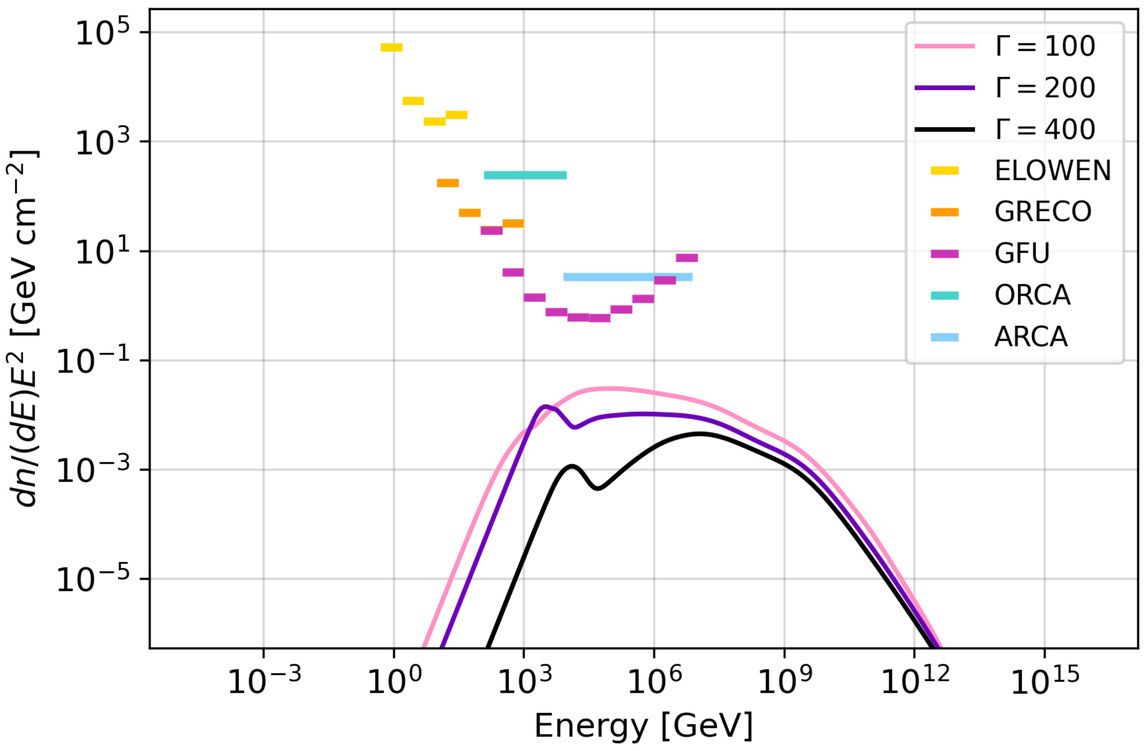
Neutrino flux at earth



At low energies (>1 TeV) and low Γ, the neutrino spectrum is augmented by including pp as well as pγ interactions.

This neutrino emission model can cover a large parameter space to **probe different GRB environments** for neutrino fluxes, combining non-thermal and thermal distributions of protons.

GRB 221009A and upper limits



The results of this model can be compared to upper limits in neutrino flux found by IceCube (ELOWEN, GRECO, and GFU)[4] and KM3NeT (ORCA and ARCA)[5] for specific GRBs, and can be used to guide neutrino searches towards GRBs that are likely to emit larger fluxes of neutrinos than GRB 221009A.

This new neutrino model will allow us to constrain the physical quantities of GRB environments.

References:
1. K. Murase, K. Kashiyama, and P. Mészáros, Phys.Rev.Lett. 111 (2013) 131102
2. D. C. Warren et al, Astrophys.J. 835 (2017) 2, 248
3. M. Klinger et al, arXiv 2312.13371 (2023)
4. IceCube Collaboration PoS ICRC2023 (2023) 1511
5. KM3NeT Collaboration arXiv 2404.05354 (2024)