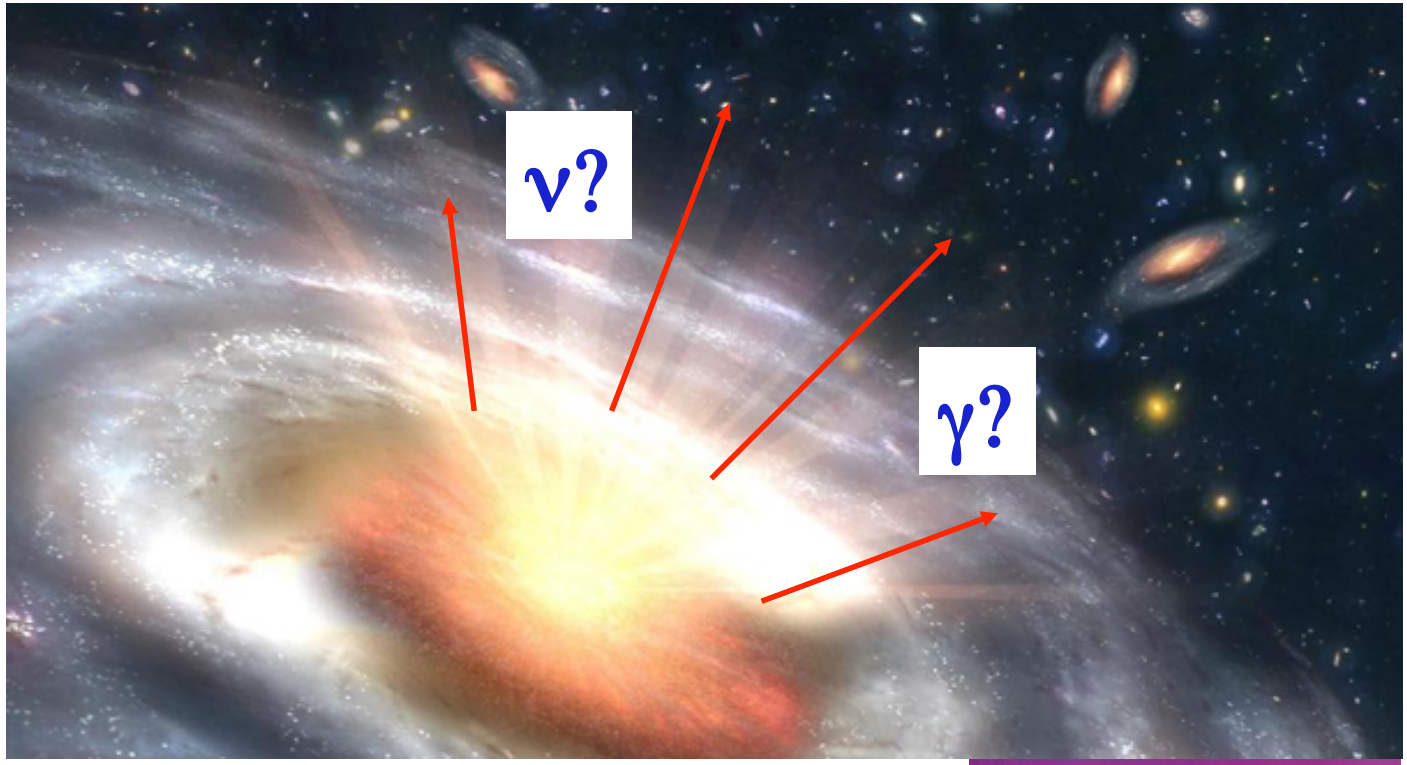
High-energy neutrino & gamma-ray emission from AGN-driven winds

Susumu Inoue (RIKEN)
Ruo-Yu Liu (DESY), Kohta Murase (PSU)
Matteo Cerruti (ICCUB) and collaborators



Any way the wind blows
does really matter to me…

outline

1. brief introduction to AGN-driven winds

2. neutrinos & gamma rays from wind external shocks

   R.-Y. Liu, K. Murase, SI, C. Ge, X.-Y. Wang
   2018, ApJ 858, 9 (arXiv:1712.10168)

+ neutrinos & gamma rays from inner wind regions?

   with Matteo Cerruti and co.
   work in progress

1. importance of AGN winds

thermal, baryonic plasma; weakly collimated <-> rel. jets

1. Observed to exist, widespread (radio-quiet + radio-loud)

<pc - ultrafast (UFOs): X-ray, v>~0.1c, L_{kin}~<L_{Edd}, $\dot{M}$~<M_{Edd}

<kpc - NLR or BAL: UV/opt./IR, v>~1000km/s

>kpc - molecular: CO, OH, etc.

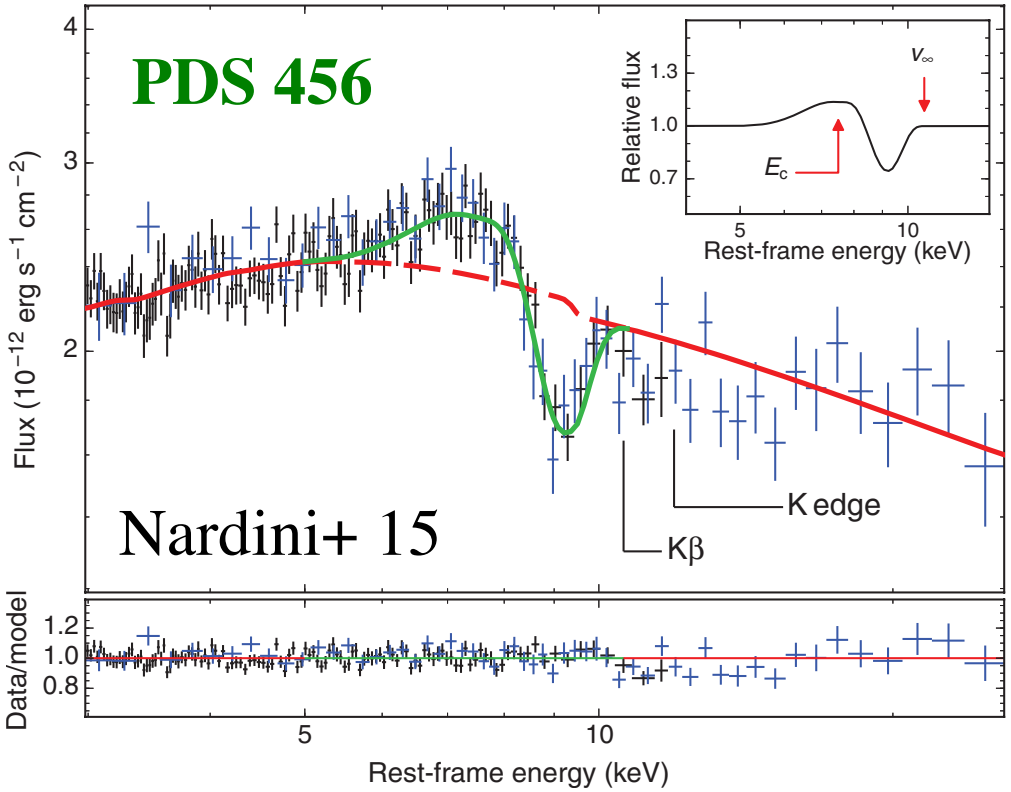
v~<1000 km/s, $\dot{M}$~<100 $M_{\odot}$/yr, L_{kin}~<L_{bol}

2. Can be explained plausibly by various mechanisms (not as difficult as jets): thermal, radiative, magnetic…
3. May provide mechanical/thermal feedback onto host gas -> observed BH scaling relations, star formation quenching
4. May be particle accelerators + nonthermal emitters weakly beamed, quasi-isotropic <-> rel. jets
   - kpc-scale external shocks (wind + host galaxy gas)
   - subpc-scale internal shocks?

AGN winds: observations

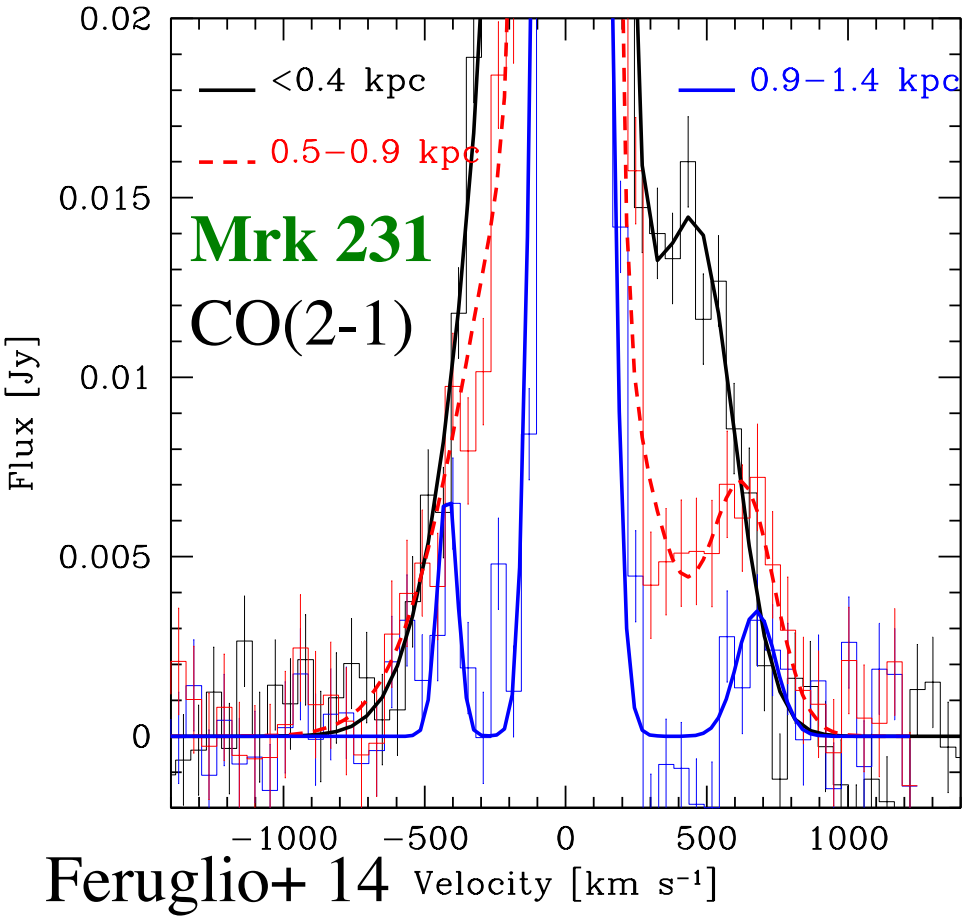
subpc: ultra-fast outflows (UFOs)

- blue-shifted X-ray absorption lines
- v~0.05-0.3c
- L_{kin}~0.01-0.1 L_{Edd}



>~kpc: massive molecular outflows

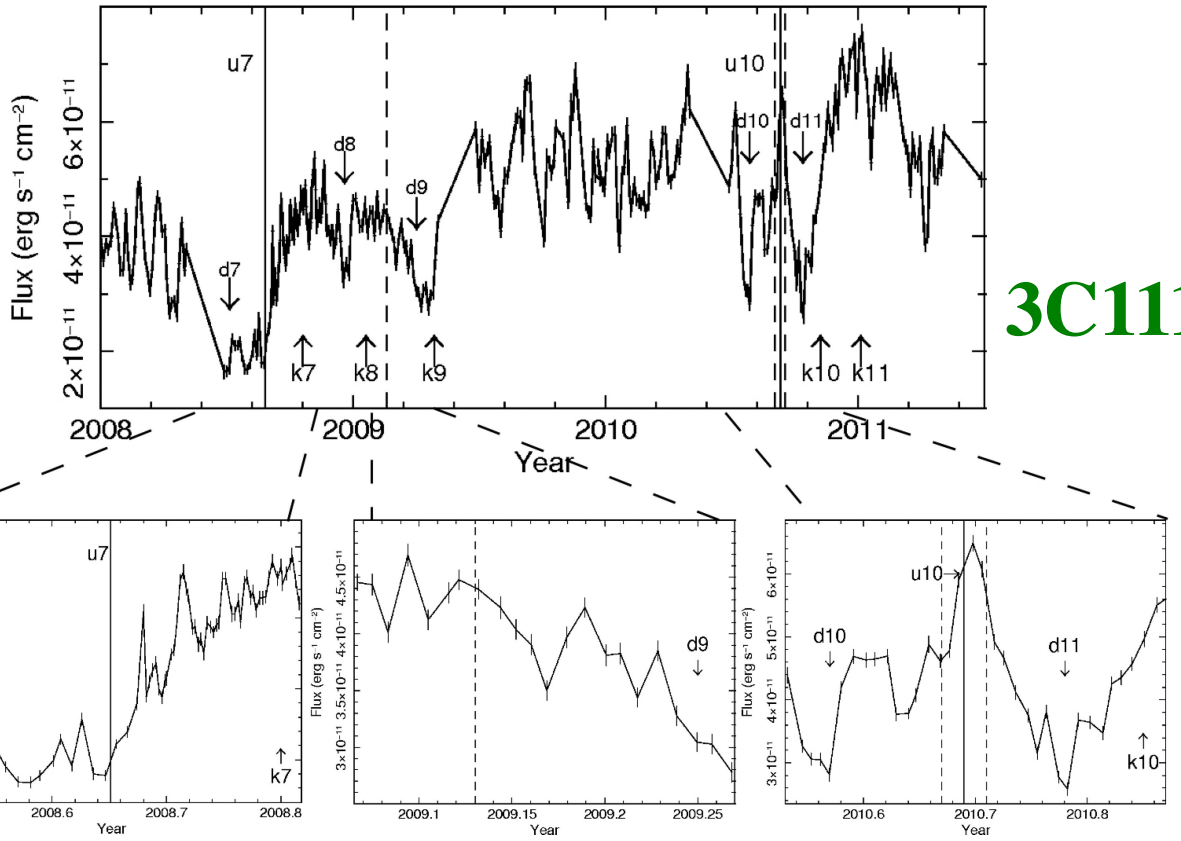
CO, OH etc. emission
-> v~100-1000 km/s,
$\dot{M}$~few 10-100 M_Θ/yr, L_{kin}~<L_{bol}



Feruglio+ 14

radio-loud AGN with UFOs: collimation by winds?

- 7 UFOs/27 radio-loud AGN Tombesi+ 10,14
  -> 50+-20% accounting for selection effects
- jet vs UFO comparison in individual objects
  evidence for coexistence Tombesi+ 12,13
  rough pressure equilibrium $P_{UFO,th} \sim P_{jet,ram}$



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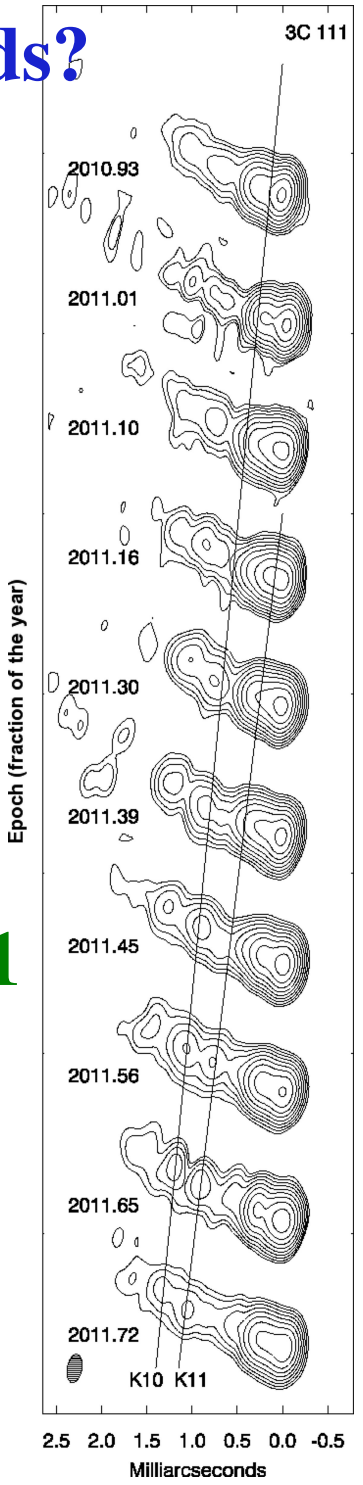
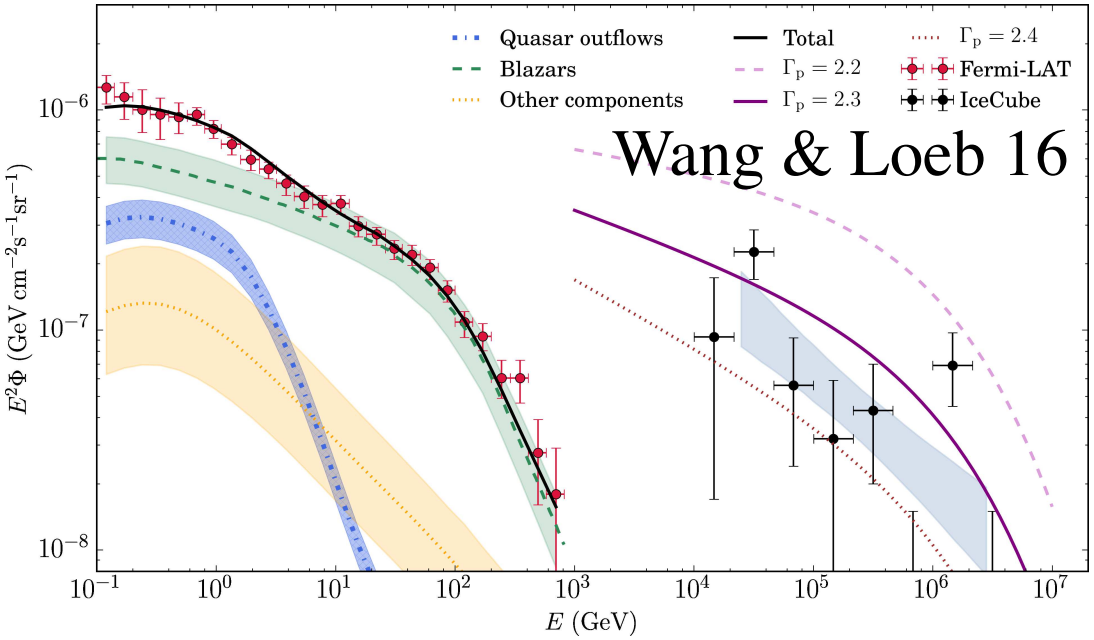
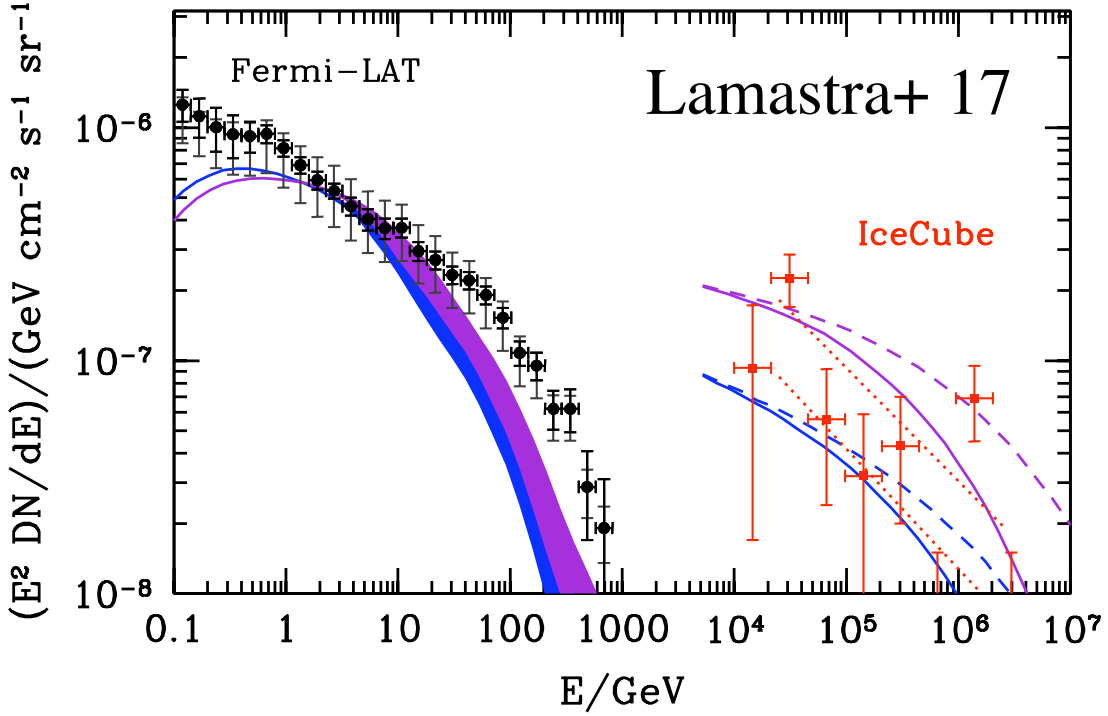


ν + GeV γ backgrounds from AGN wind ext. shocks?





Claim of reproducing both diffuse GeV γ & ν bkgds via pp processes in external shocks

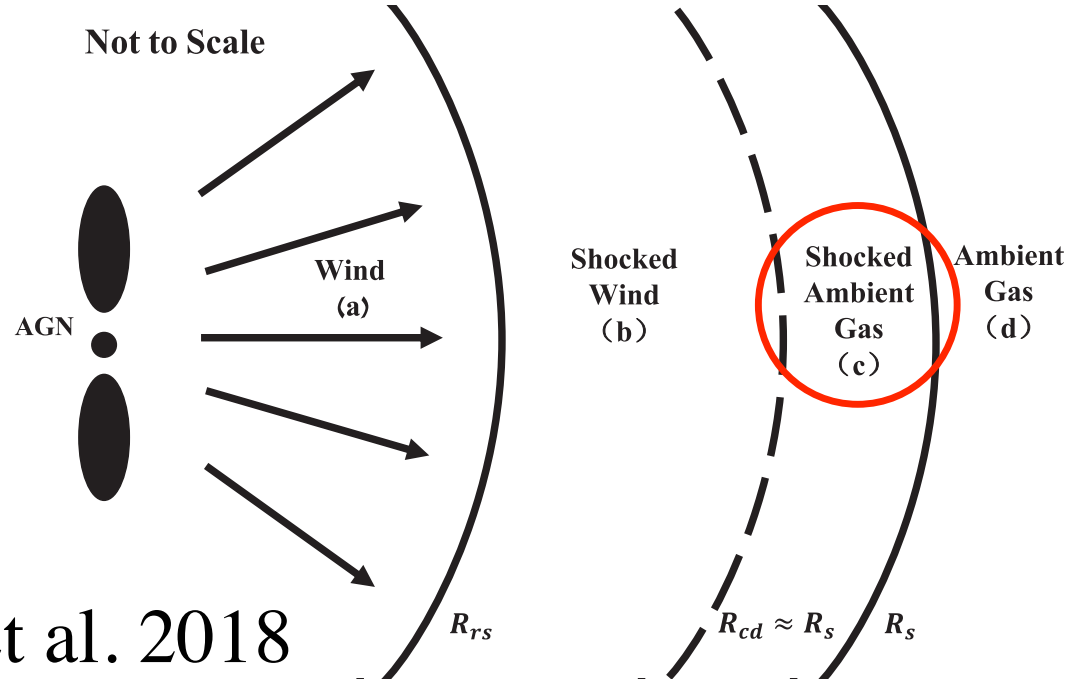
BUT various questions:

- dynamical evolution of wind
- site and mechanism of proton acceleration
- escape of protons out to interaction site
- comparison with EGRB rather than IGRB
- dubious EBL model

...

pp ν + γ from AGN wind ext. shocks: reevaluation

- dynamical evolution of wind: detailed physical treatment including potential 2-temperature structure, following Faucher-Giguère & Quataert 2012
- pp interactions in the post-forward shock region, account of adiabatic losses for protons
- AGN LF of Hopkins+ 2007, consideration of finite AGN activity time
- comparison with IGRB, plausible EBL model



Liu, Murase, SI et al. 2018

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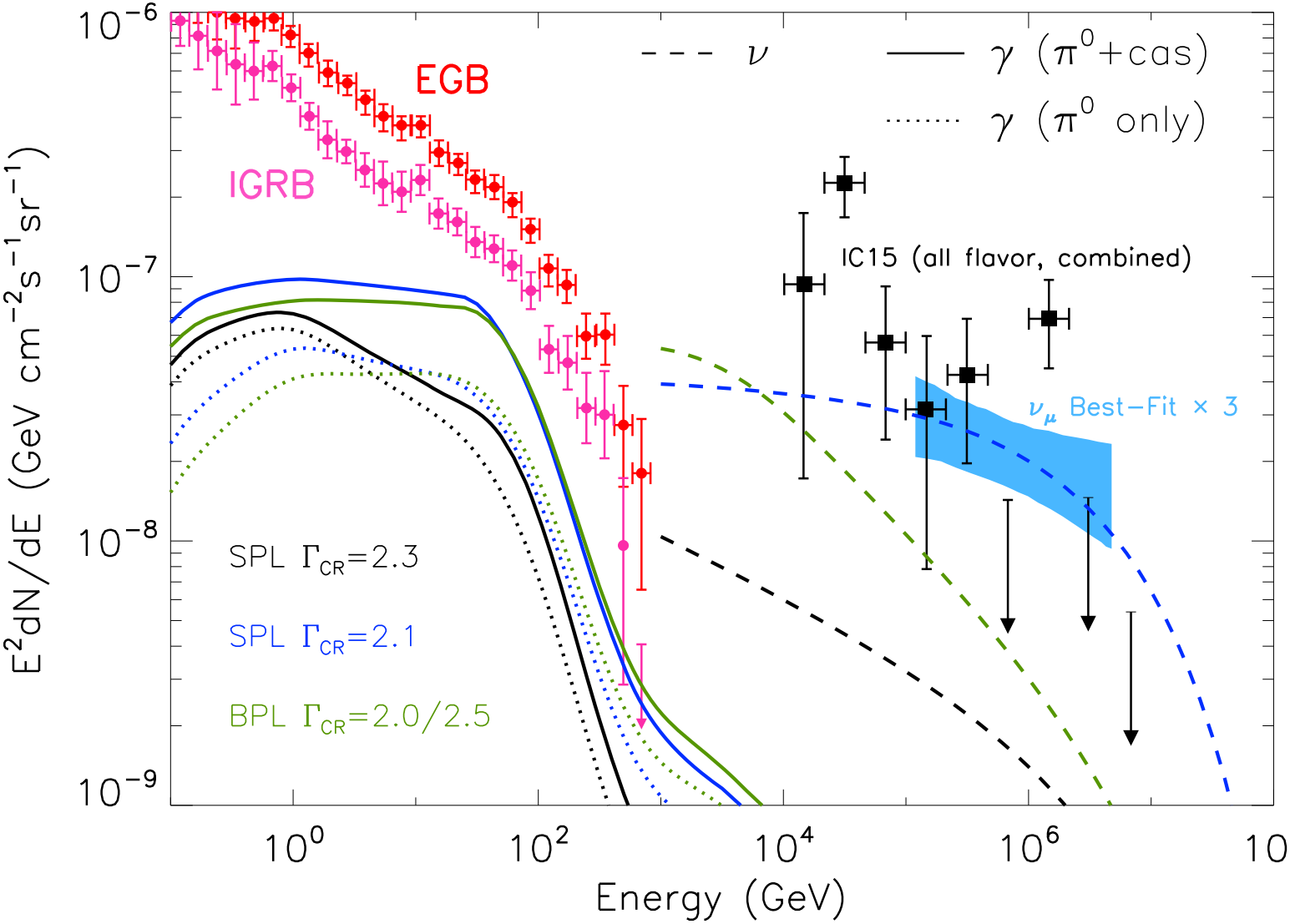

Liu, Murase, SI et al. 2018

- Max <30% of EGRB
- Γ_{CR}~<2.2 required if >20% contribution to DνB
- Large contritbution to DνB >100 TeV possible if Γ_{CR}~2.0-2.1

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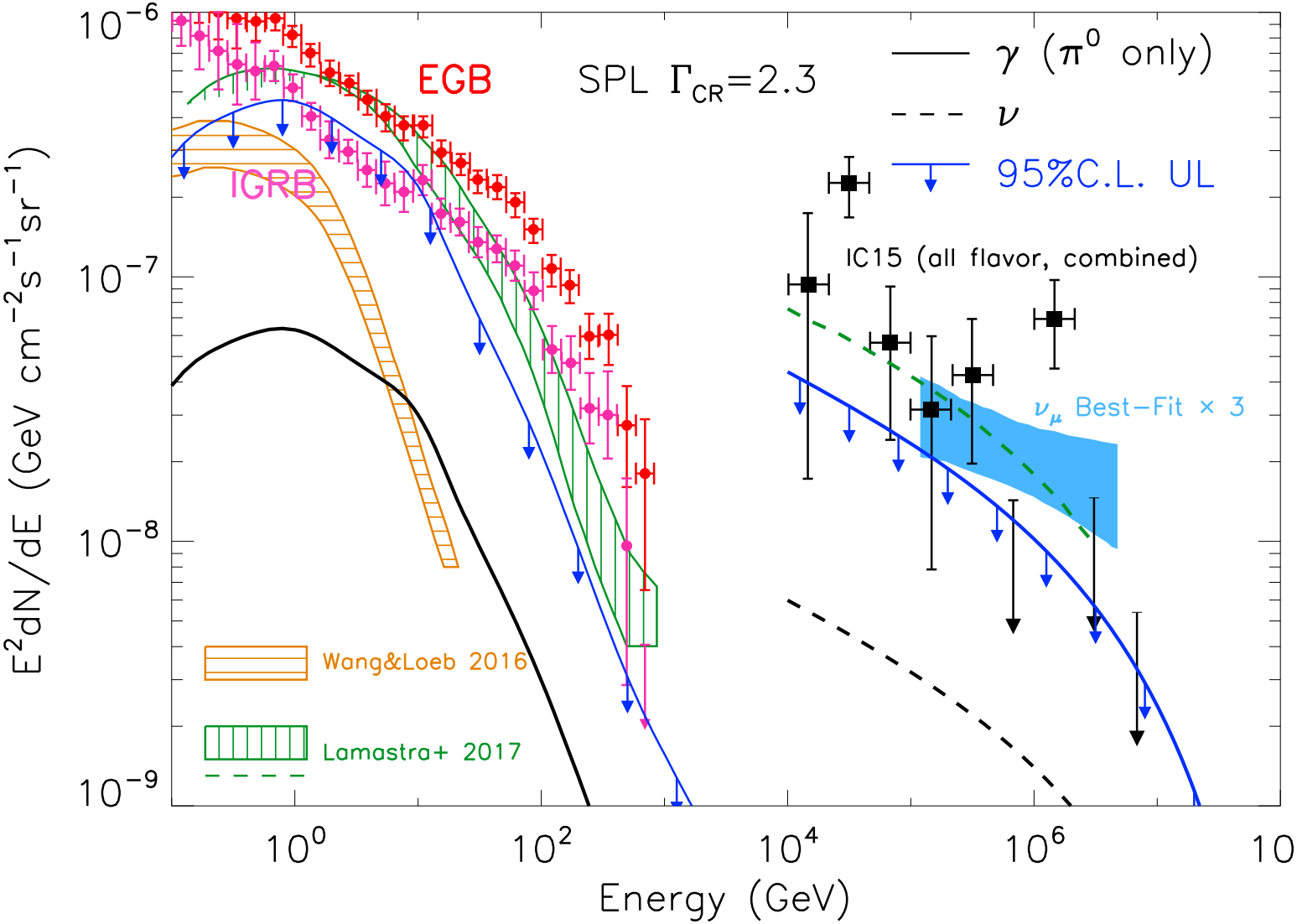

Liu, Murase, SI et al. 2018

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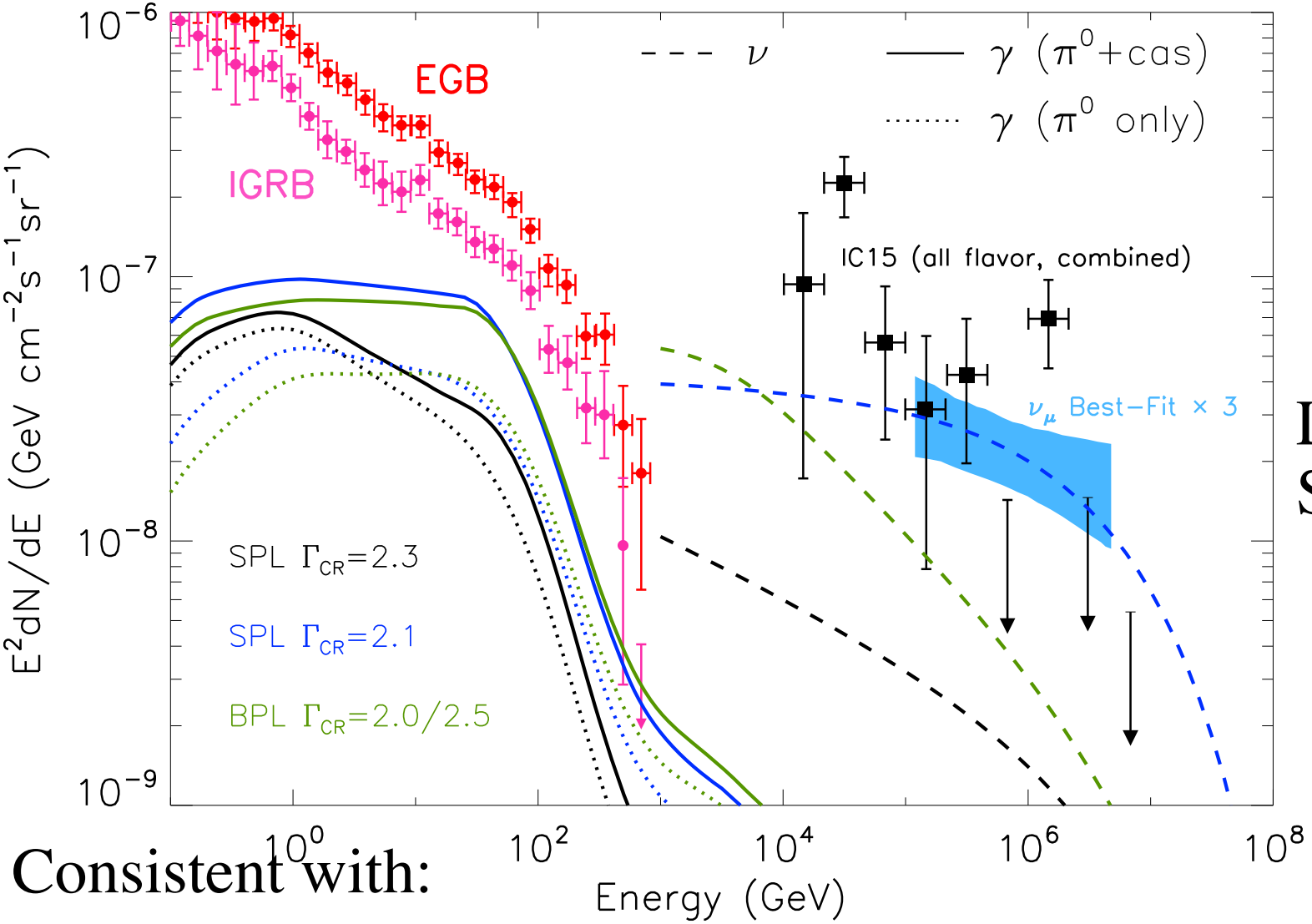


Liu, Murase, SI et al. 2018

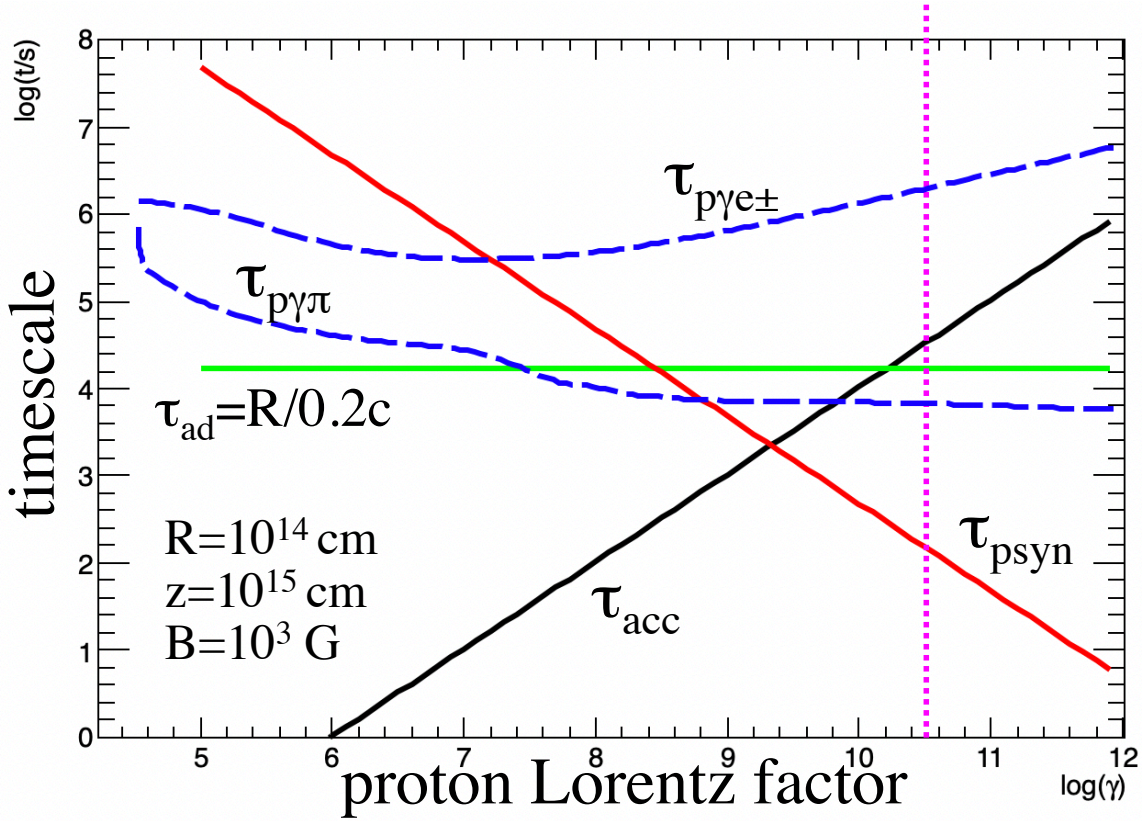
Consistent with:

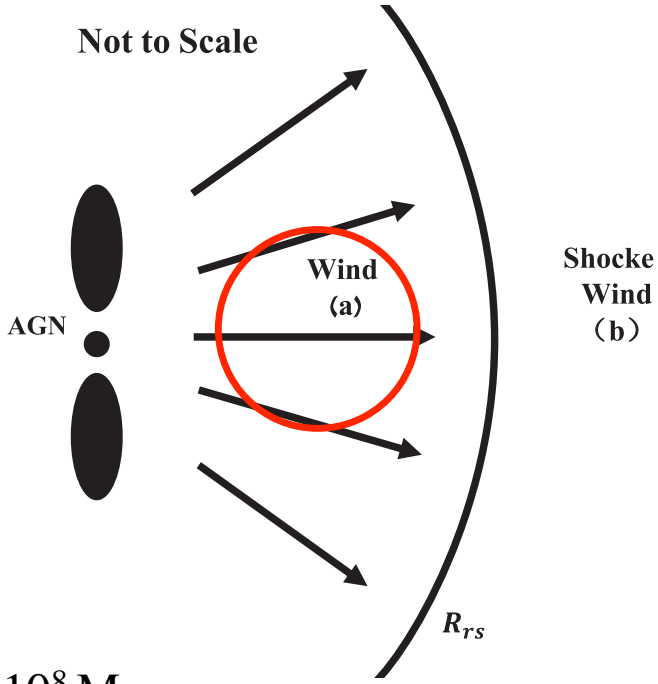
- detection of few LAT sources, e.g. NGC 1068
- no correlation of IC neutrinos with known AGN winds
- Few nearby sources detectable with IceCube-Gen2

pγ ν (+ γ) from near-nucleus regions in AGN winds?

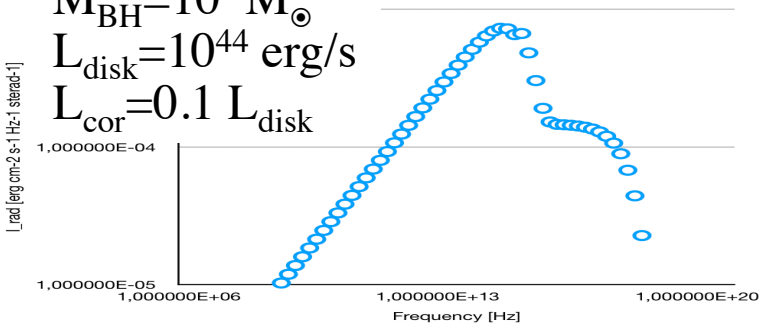
potential particle acceleration via:
- internal shocks caused by highly variable wind ejection (observational evidence + theoretical support)
- interaction shocks with external or internal clouds/stars

pγ interactions with nuclear radiation
- neutrinos ~<10 PeV
- cascade ~<MeV-GeV





$M_{BH}=10^8\ M_\odot$
$L_{disk}=10^{44}$ erg/s
$L_{cor}=0.1\ L_{disk}$



summary neutrinos and gamma rays from AGN-driven winds

wind external shocks

- fact: widespread existence of powerful, fast or ultrafast baryonic(ionic) outflows in AGN, independent of rel. jets
- external shocks potential site of particle acceleration and nonthermal emission (in additional to feedback effects)
- neutrino and GeV γ-ray background from pp processes?
  -> contrary to some earlier studies, dominant contribution to both unlikely, but possible for >100 TeV neutrinos
- testable with future ν and γ obs. of nearby Seyferts

wind inner regions?

- potentially interesting contribution to IceCube neutrinos, work in progress

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