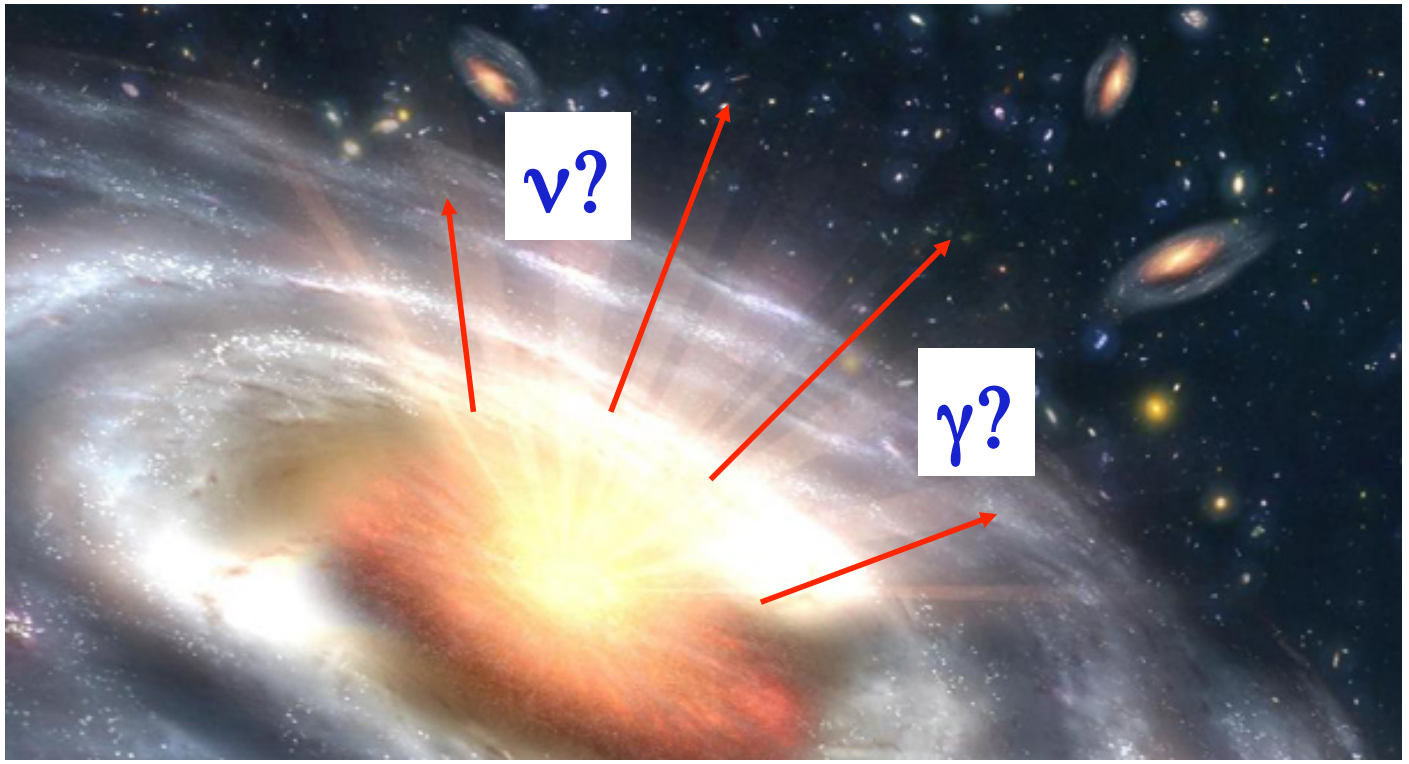
High-energy neutrino & gamma-ray emission from AGN-driven winds (in NGC 1068)

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



Any way the wind blows
does really matter to me…

importance of AGN winds

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

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

2. Plausibly expected from accretion disks via various mechanisms (unlike jets): thermal, radiative, magnetic…

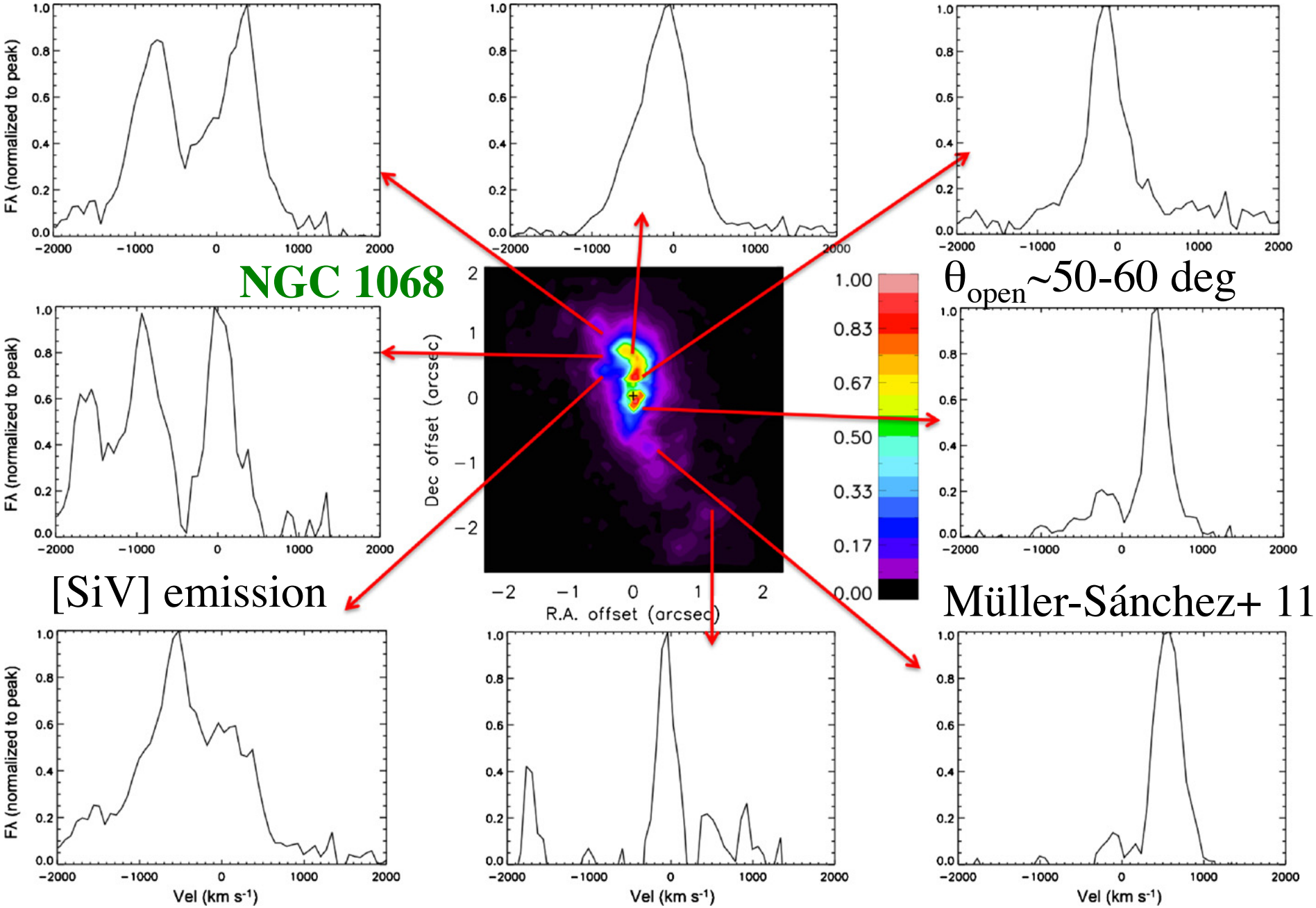
3. May be important for collimating jets in radio-loud objects

4. May provide mechanical/thermal feedback onto host gas
   -> observed BH scaling relations, star formation quenching

5. 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: subkpc - fast, highly ionized winds

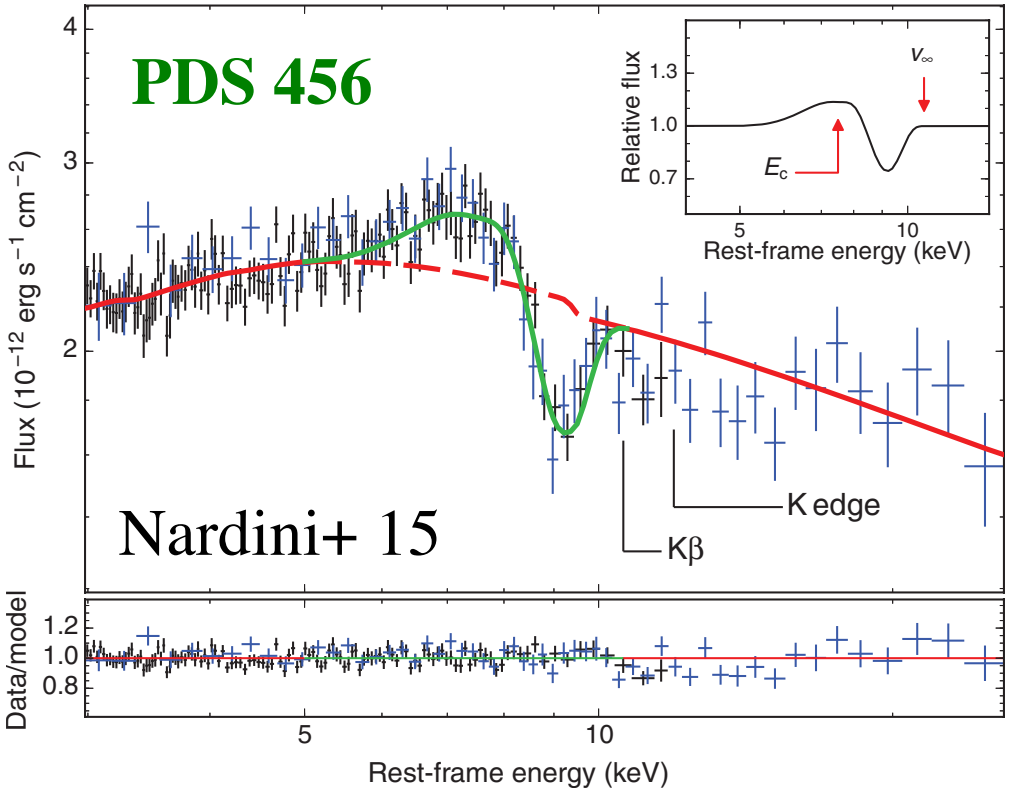
UV/optical/NIR emission/absorption lines -> few 1000 km/s



AGN winds: observations

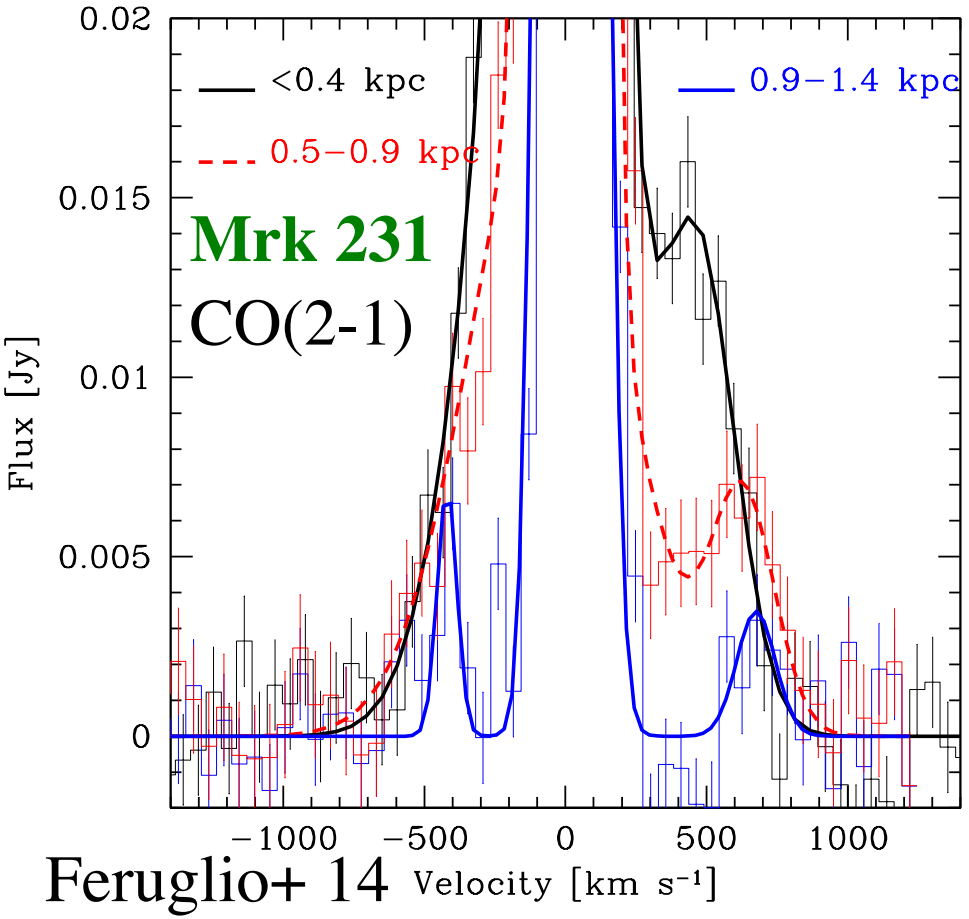
subpc: ultra-fast outflows (UFOs)

- blue-shifted X-ray absorption lines
- v~0.05-0.3c
- L_{kin}~0.01-0.1 L_{edd}
- >~40 % of all AGNs <-> jets



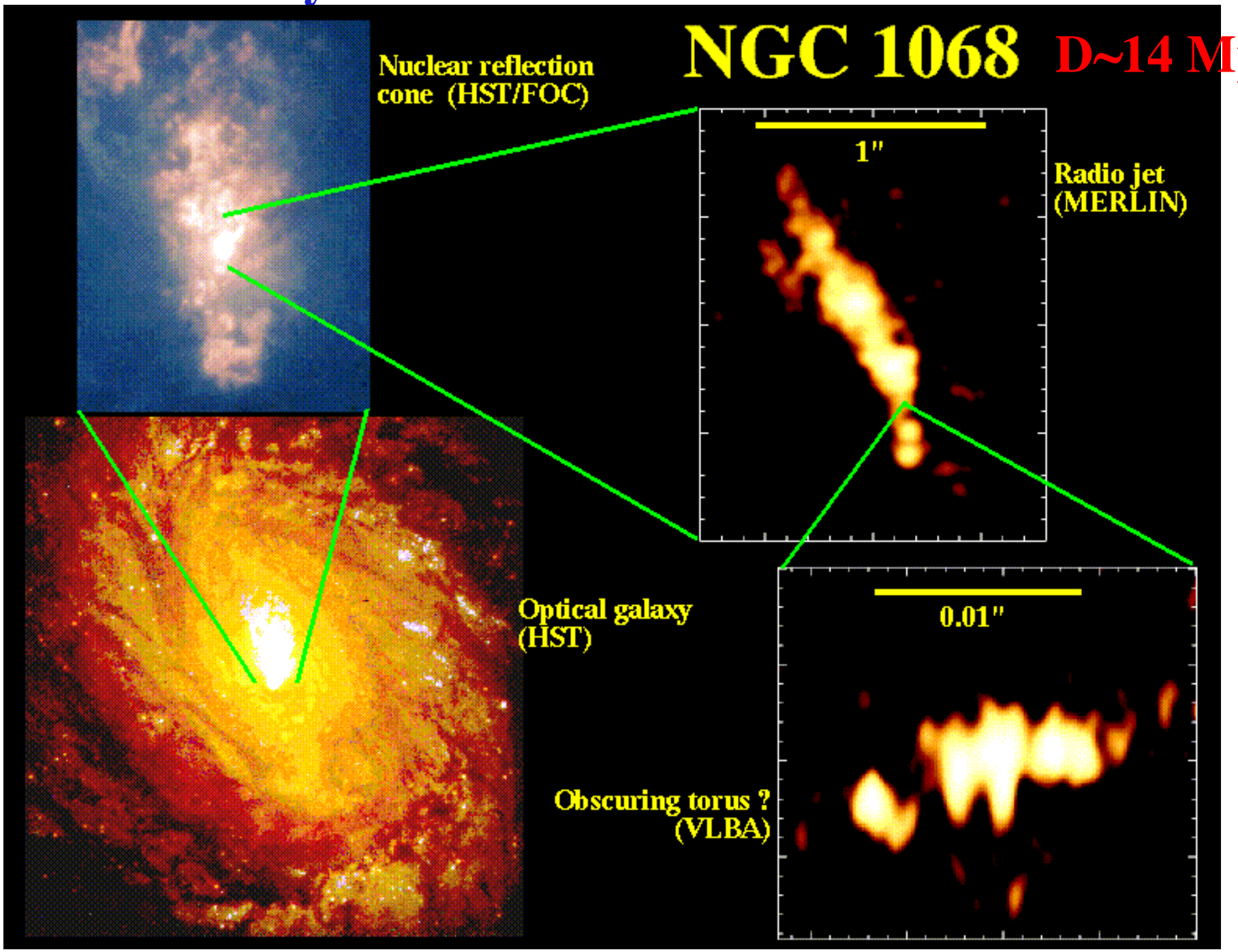
>~kpc: massive molecular outflows

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



Feruglio+ 14

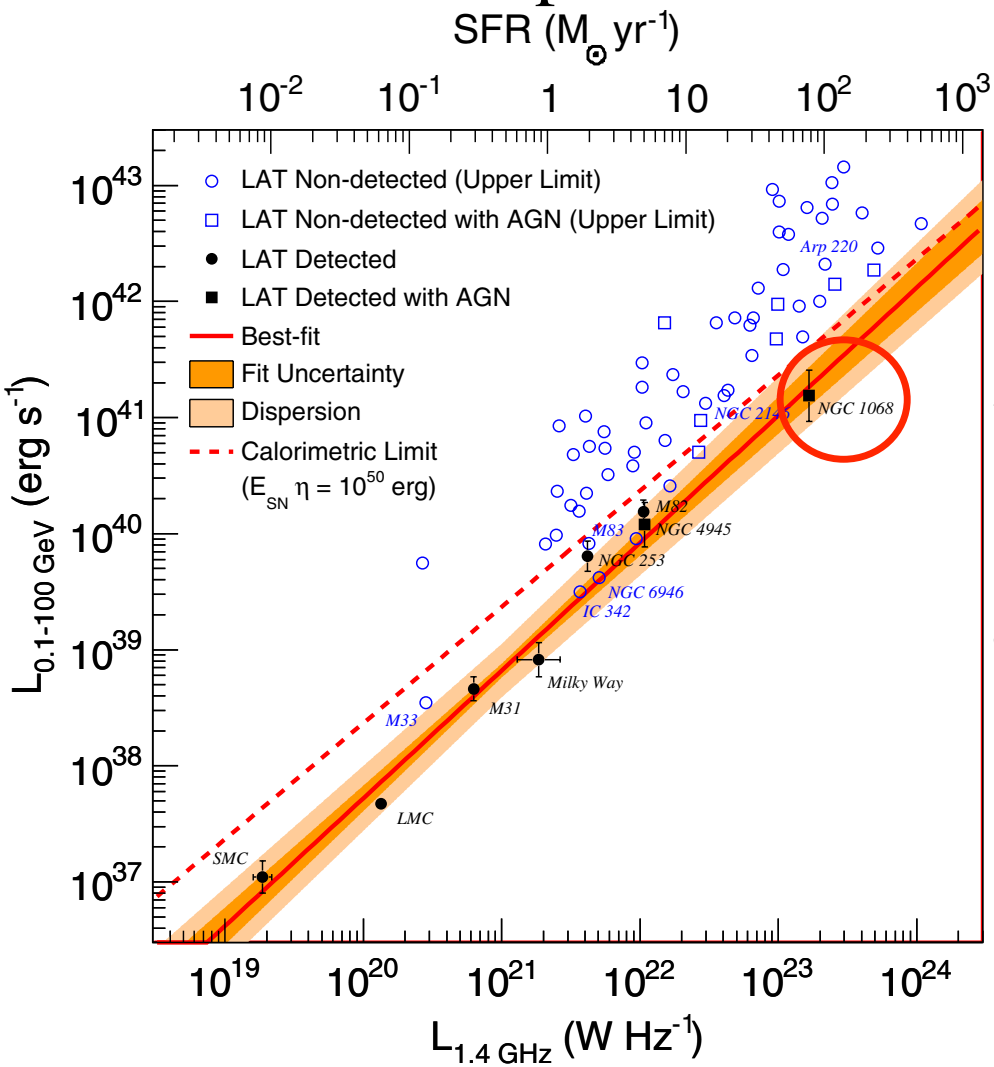
NGC 1068: Seyfert II with fast wind + molecular outflow

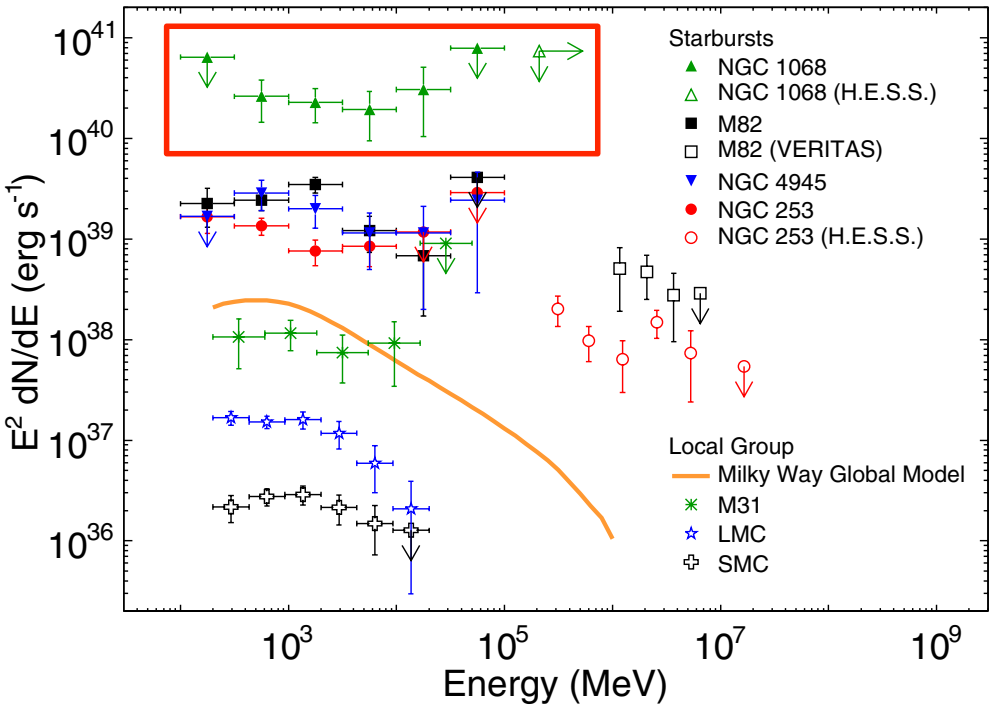


GeV gamma rays from NGC 1068: starburst?

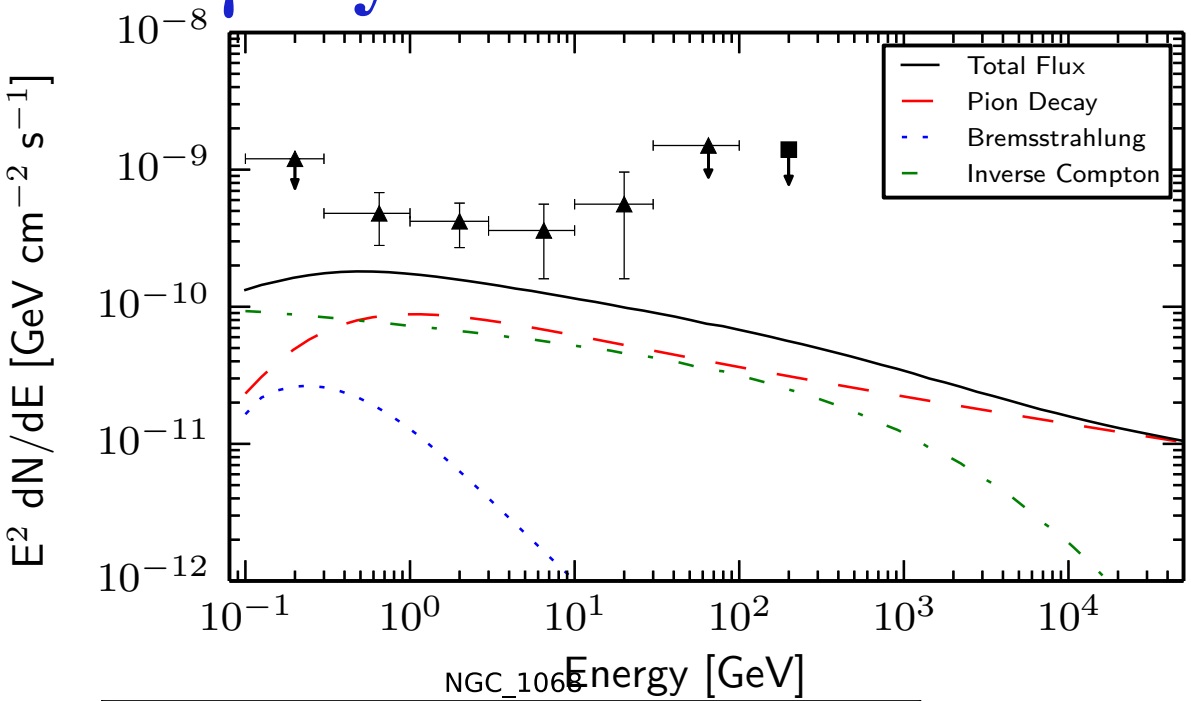
Fermi-LAT sample of "starburst"+normal galaxies

Ackermann+ 12

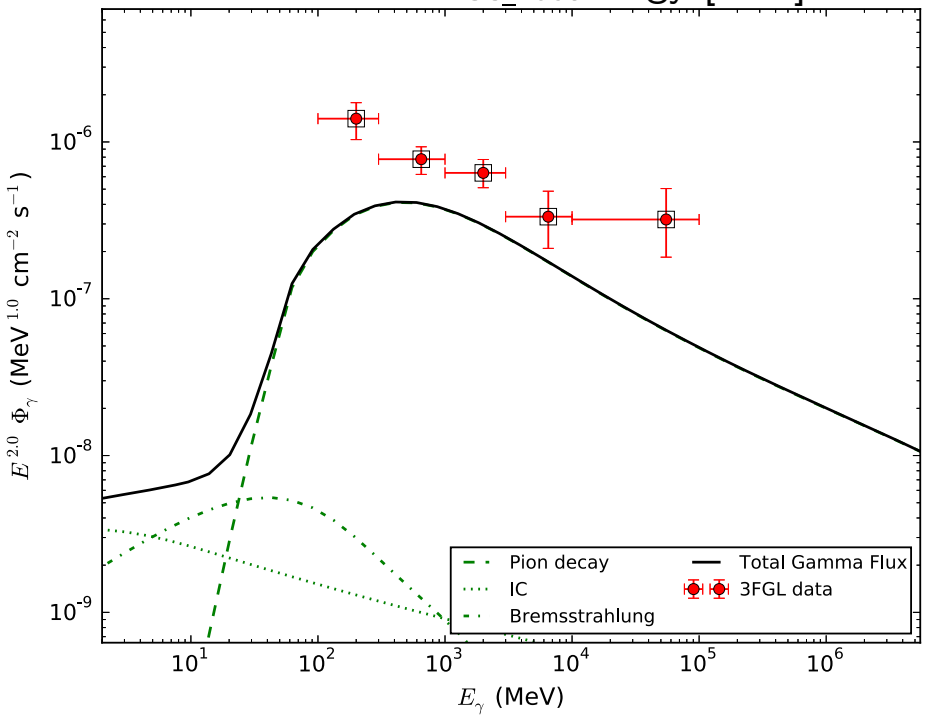




GeV γ rays from NGC 1068: difficulties as starburst



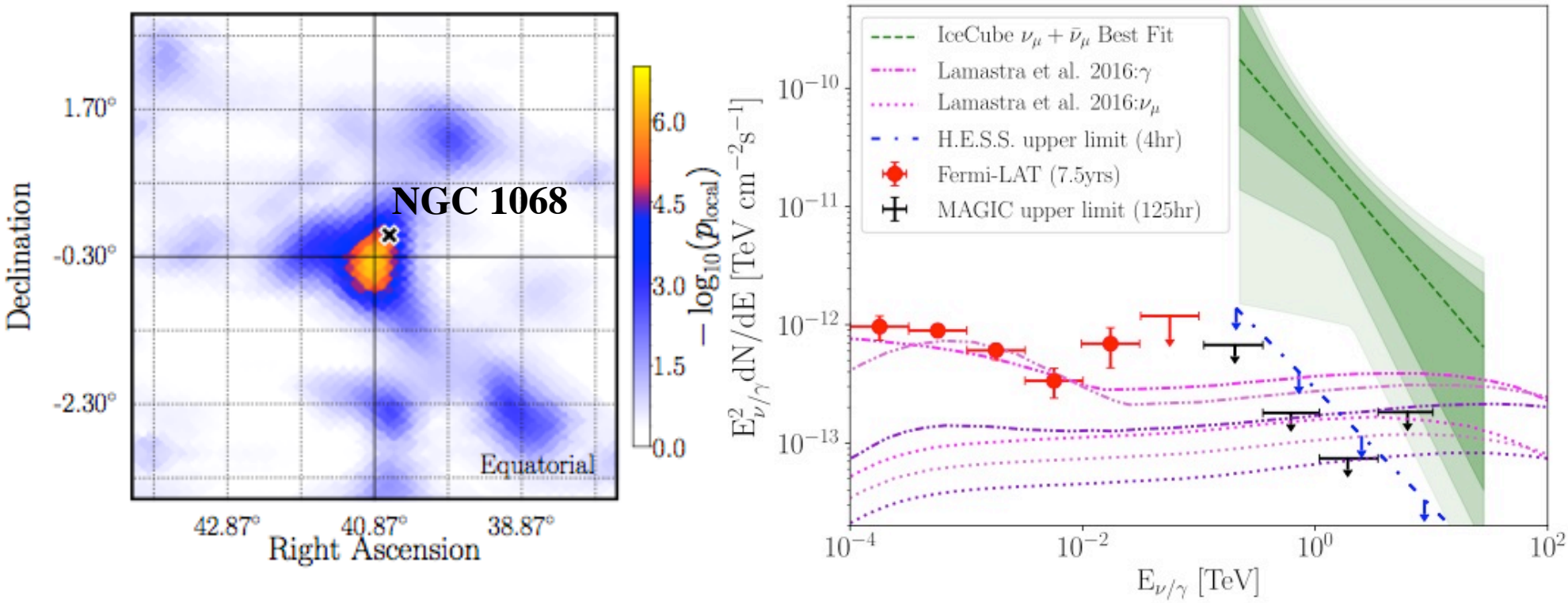
Yoast-Hull+ 14:
…our starburst model consistently underestimates the observed γ -ray flux and overestimates the radio flux for NGC 1068; these issues would be resolved if the AGN is the primary source of γ -rays.



Eichmann & Becker Tjus 16:
…Supernovae are the dominant particle accelerators for NGC 253, M82, NGC 4945 but NOT for NGC 1068…

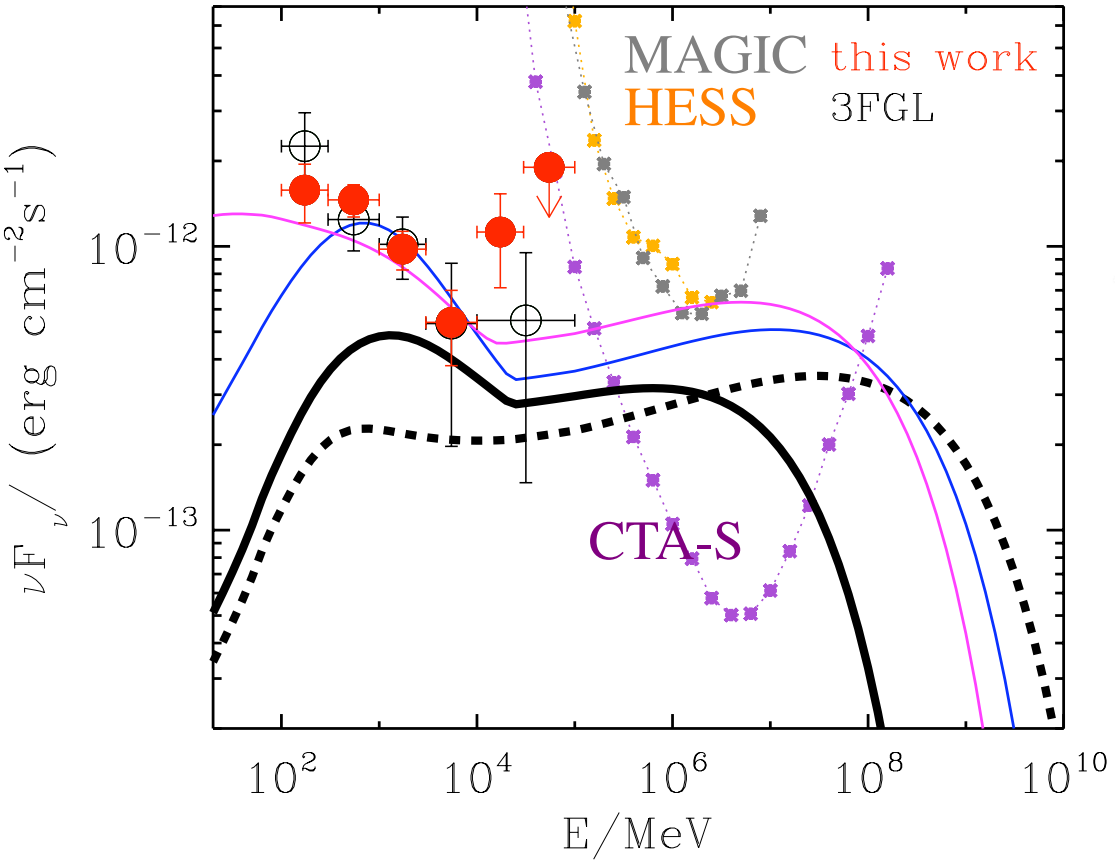
high-energy neutrinos from NGC 1068?

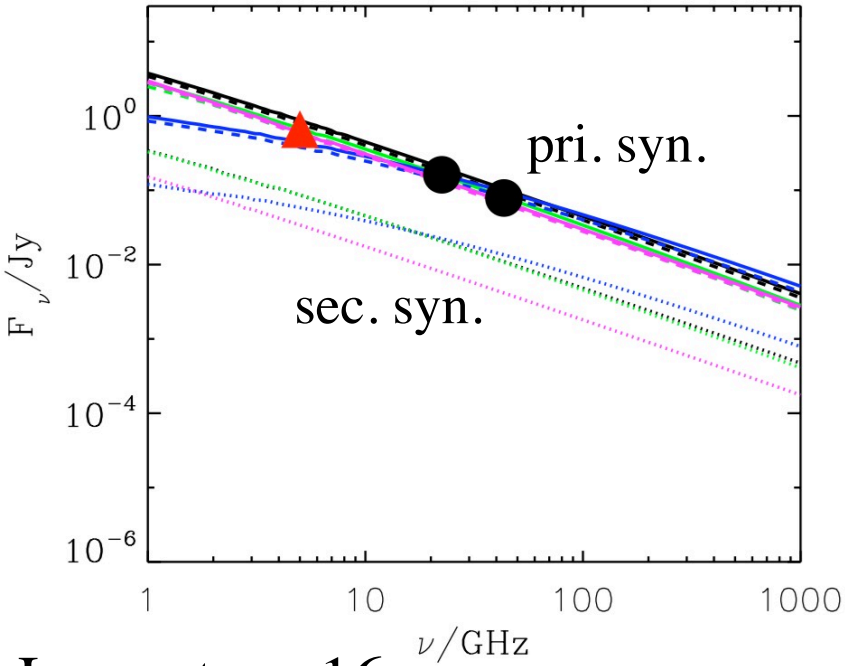
IceCube 10-yr time-integrated source search 1910.08488



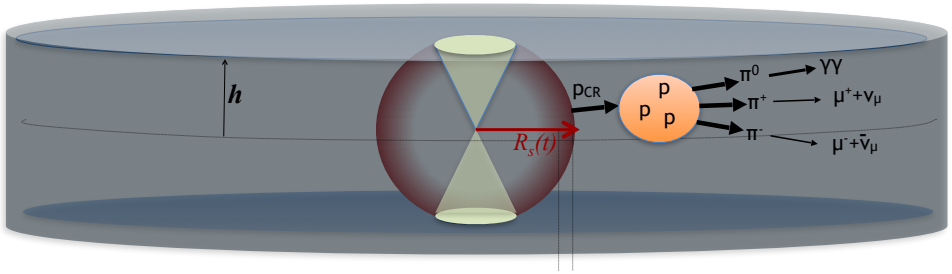
- most significant point in North from full-sky scan coincident with NGC 1068
- 2.9σ excess at position of NGC 1068 in source catalog search

wind external shock model for NGC 1068



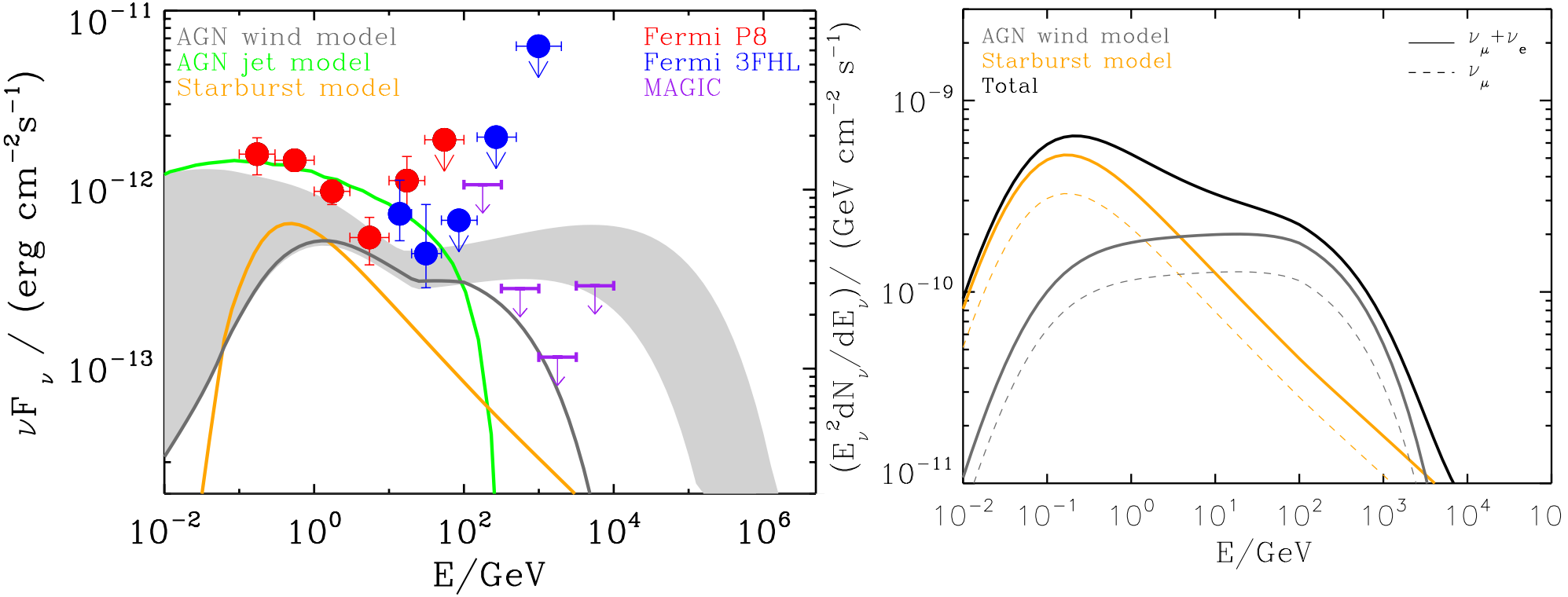


Lamastra+ 16



- hard pp π^0 component expected
- hint from Fermi-LAT?

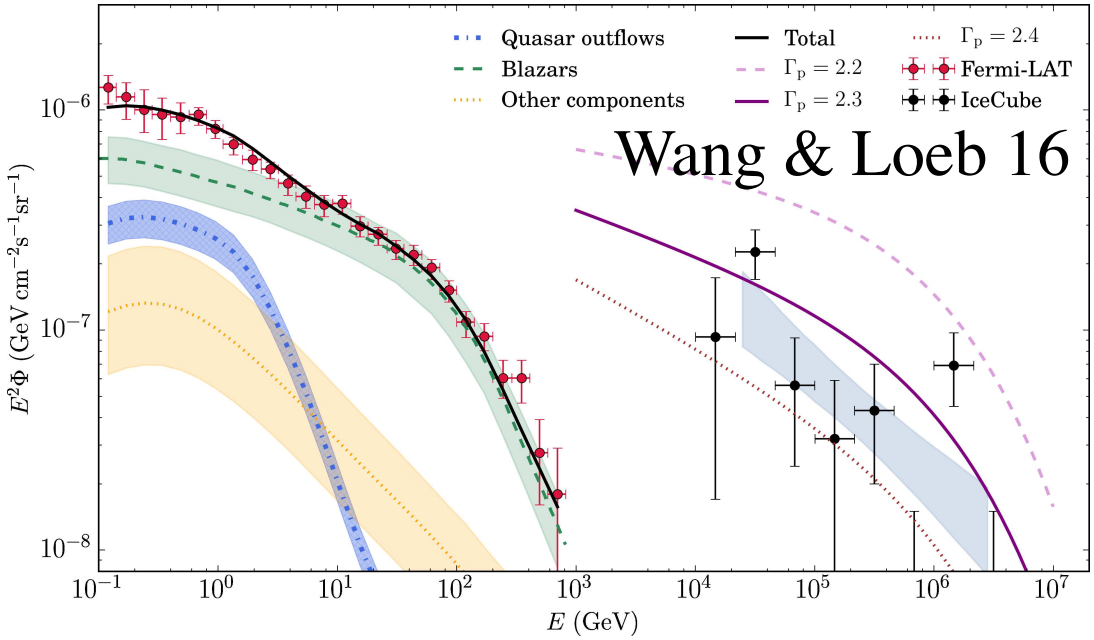
wind external shock model for NGC 1068: TeV ULs



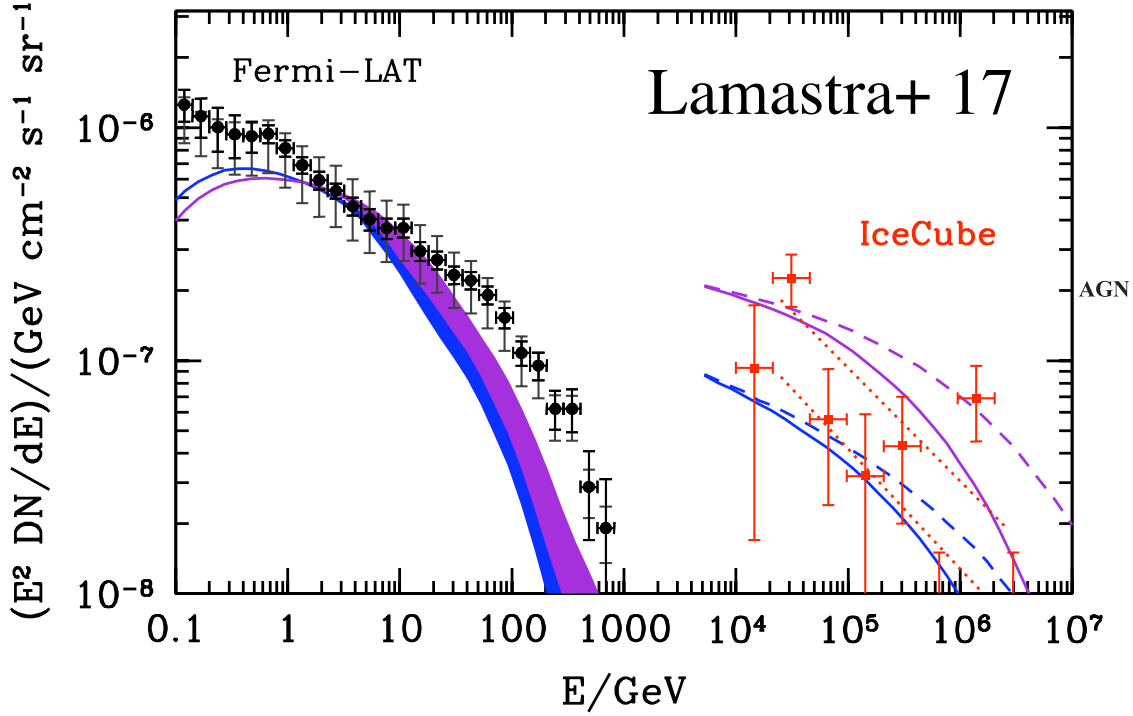
MAGIC Col. 1906.10954

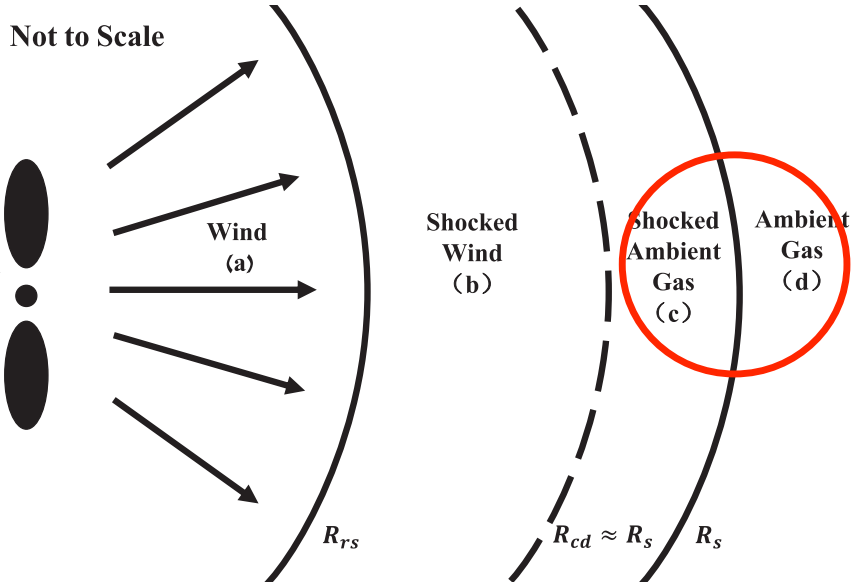
- MAGIC observations strongly constrain pp origin of gamma rays
- corresponding IceCube event rate <0.07 yr^{-1}

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

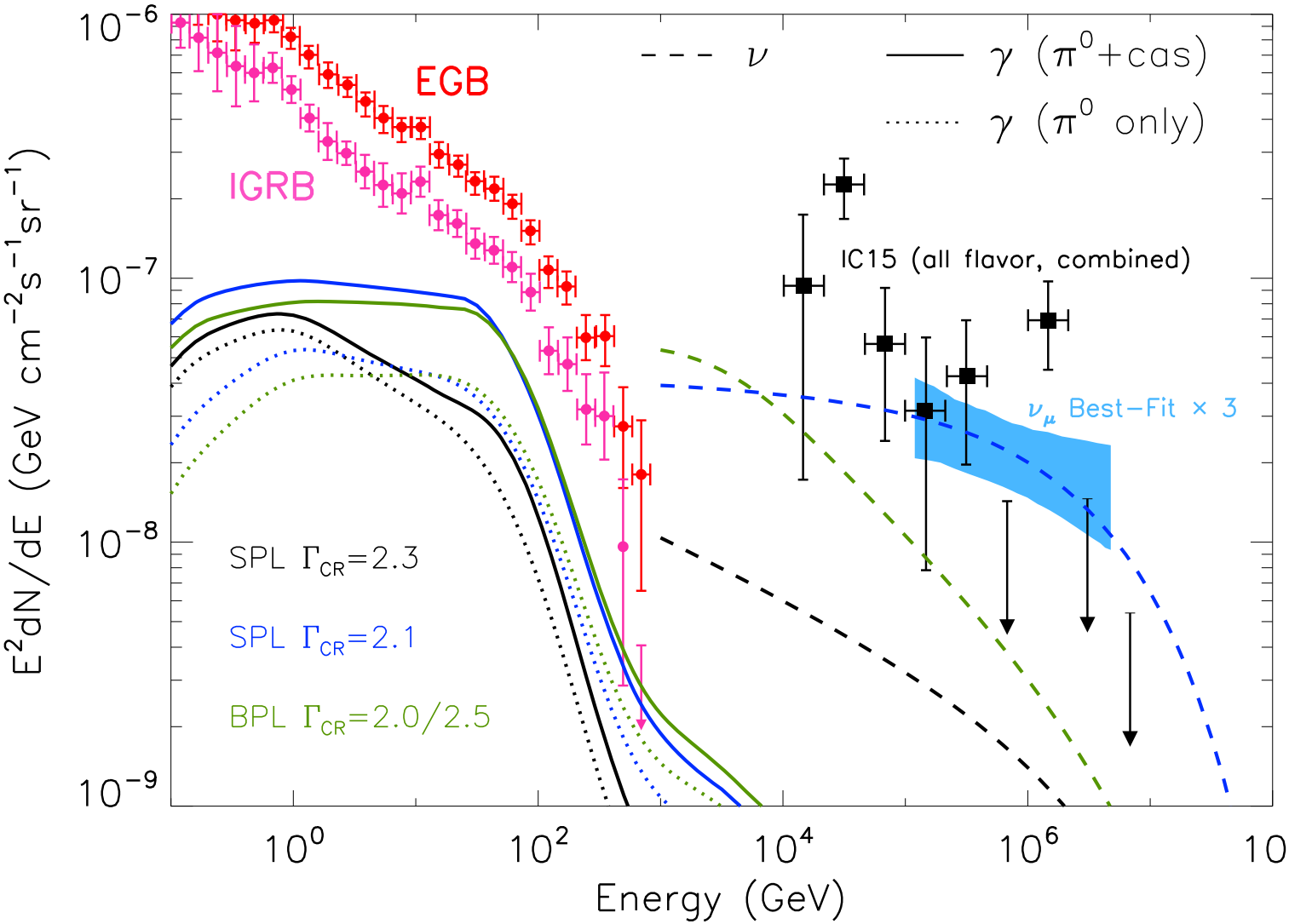


Claim of reproducing both diffuse GeV γ & ν bkgds via pp processes in external shocks





ν + GeV γ backgrounds from AGN wind ext. shocks



Liu, Murase, SI et al. 2018

improved accounts of:
- wind dyn. evolution
- proton accel. and escape
- IGRB
- EBL
- ...

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

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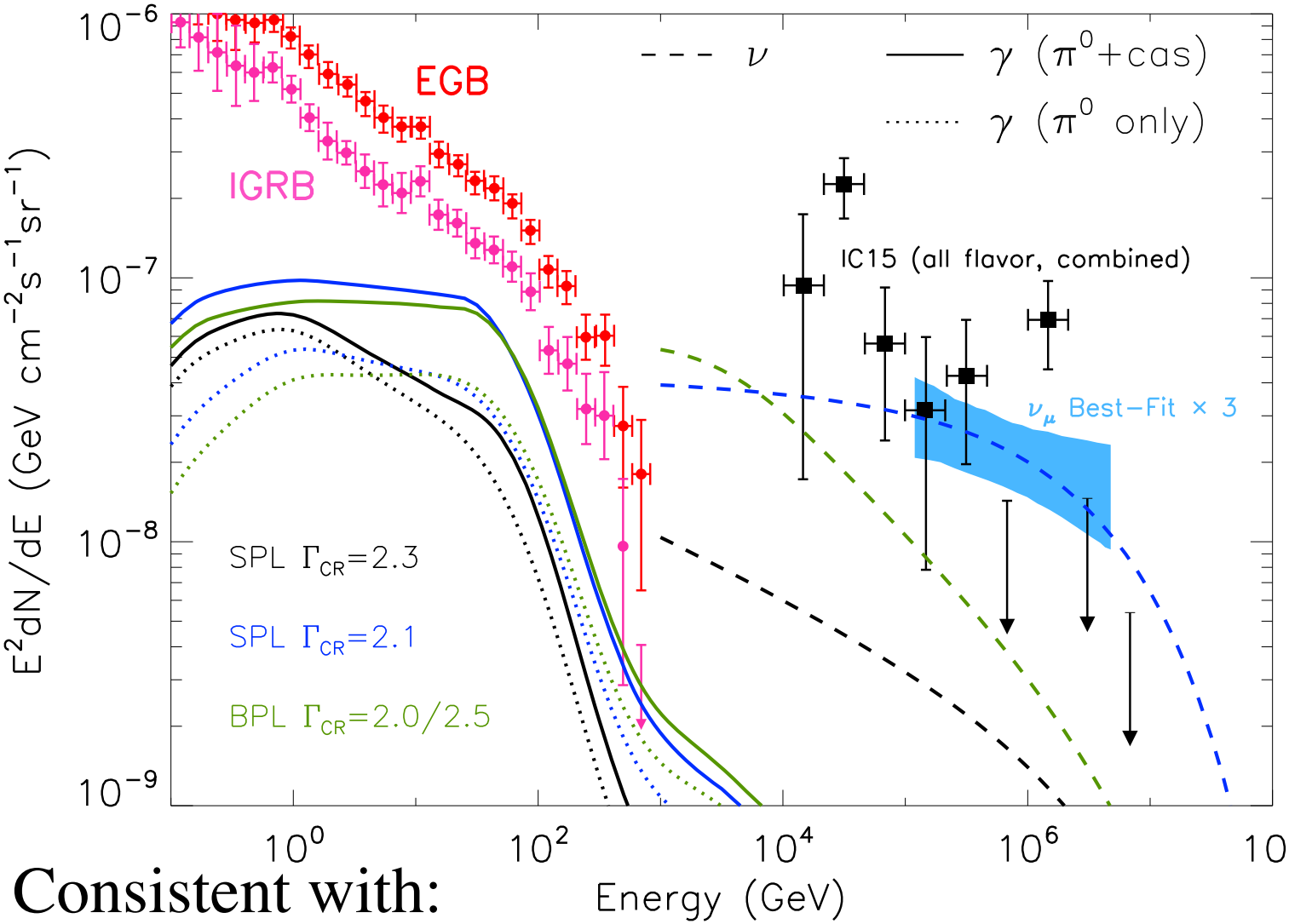

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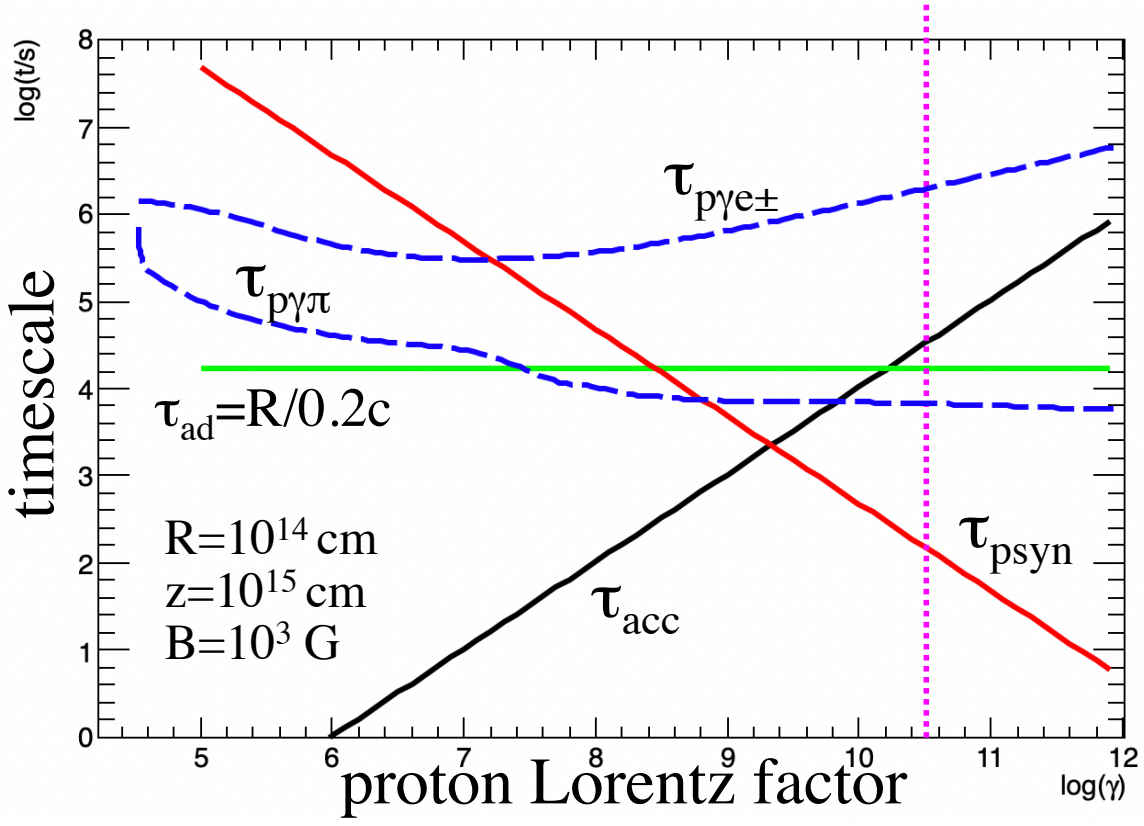
Consistent with:
- detection of few LAT sources, e.g. NGC 1068
- no clear correlation of IC neutrinos with known AGN winds

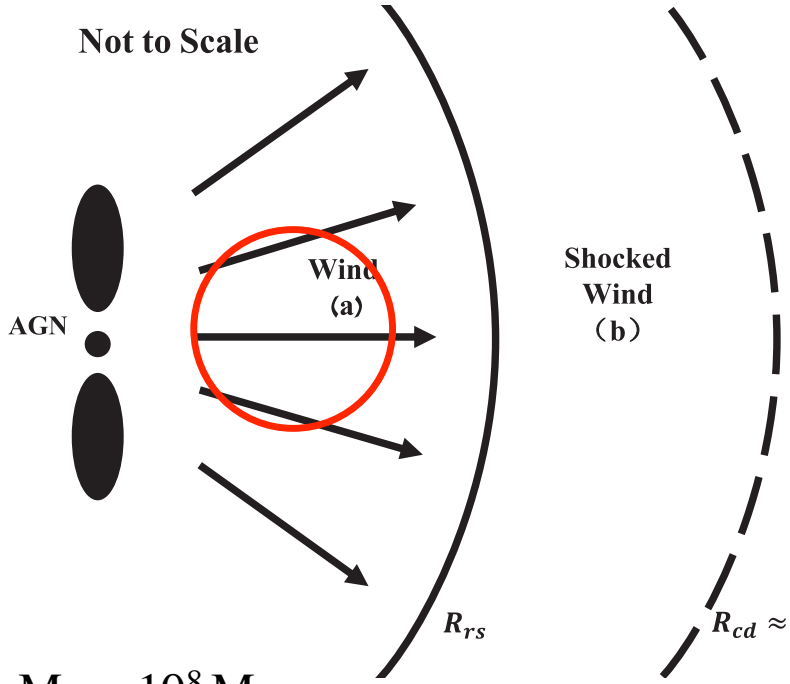
Few nearby sources detectable with IceCube-Gen2

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

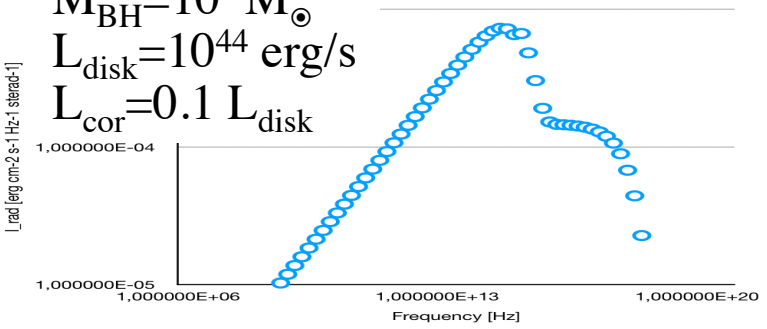
potential particle acceleration via:
- internal shocks caused by highly variable wind ejection (observational evidence + theoretical support)
- interaction shocks with external or internal clouds/stars

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 + γ-rays from AGN-driven winds

fact: widespread existence of powerful, fast or ultrafast baryonic(ionic) outflows in AGN, independent of rel. jets

wind external shocks

- external shocks potential site of particle acceleration and nonthermal emission
- neutrino + γ-rays from NGC 1068 by pp processes?
  -> strongly constrained by TeV upper limits
- neutrino and γ-ray background by pp processes?
  -> dominant contribution unlikely, except >100 TeV neutrinos

wind internal regions

- potentially interesting contribution to IceCube neutrinos consistent with γ-ray constraints - work in progress!
- testable with future neutrino+ γ-ray observations of nearby Seyferts

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The answer, my friend, is blowin' in the wind…