



Diffuse GRB Neutrino Background

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Outline

📍 Neutrinos from the Gamma-ray Bursts

(UHE neutrinos & **MeV neutrinos**)

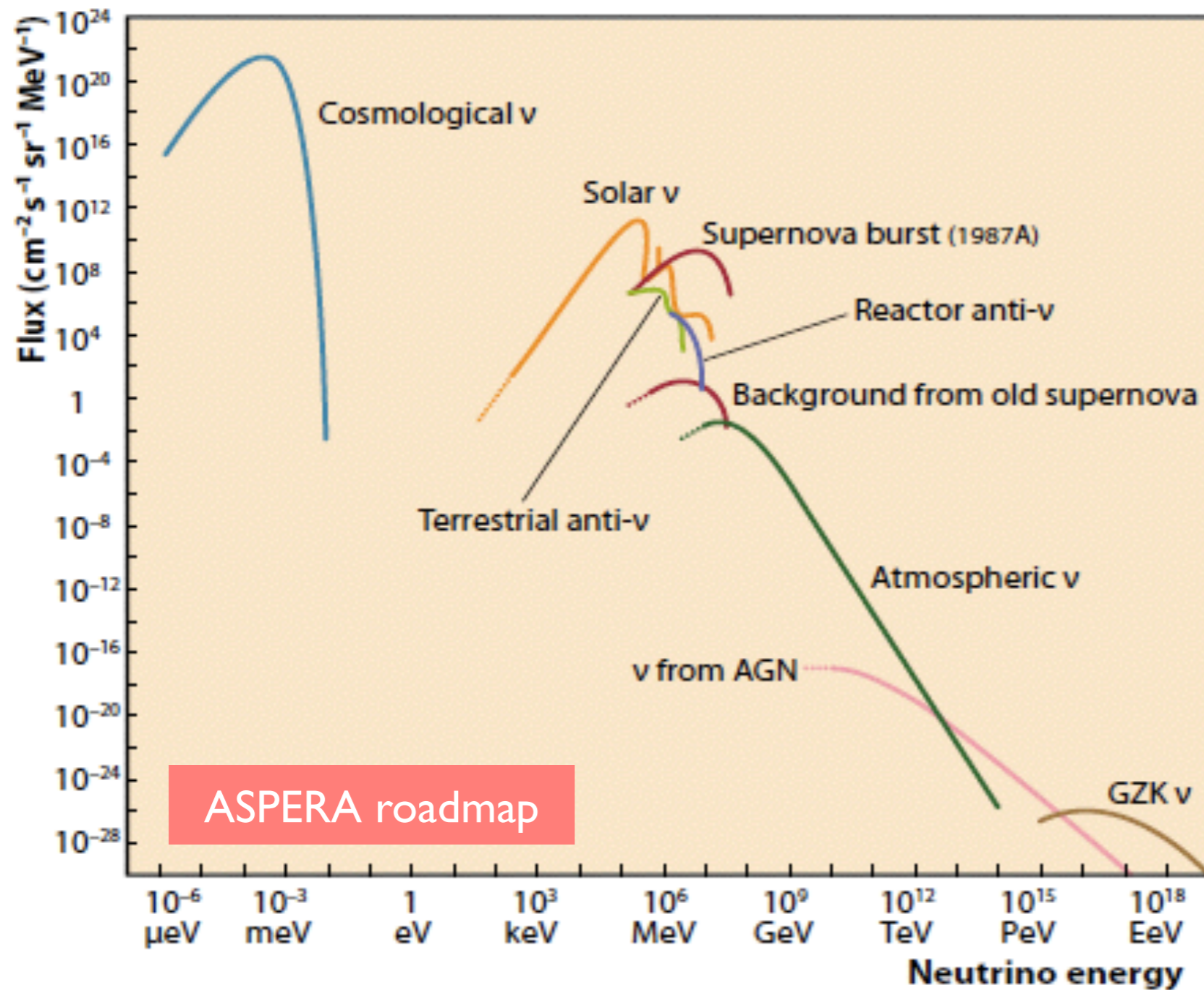
Why? Detectable?

📍 Calculate the diffuse GRB neutrino background spectrum

- **neutrino spectrum from a single GRB**
- **rate of the GRB at a given redshift z**

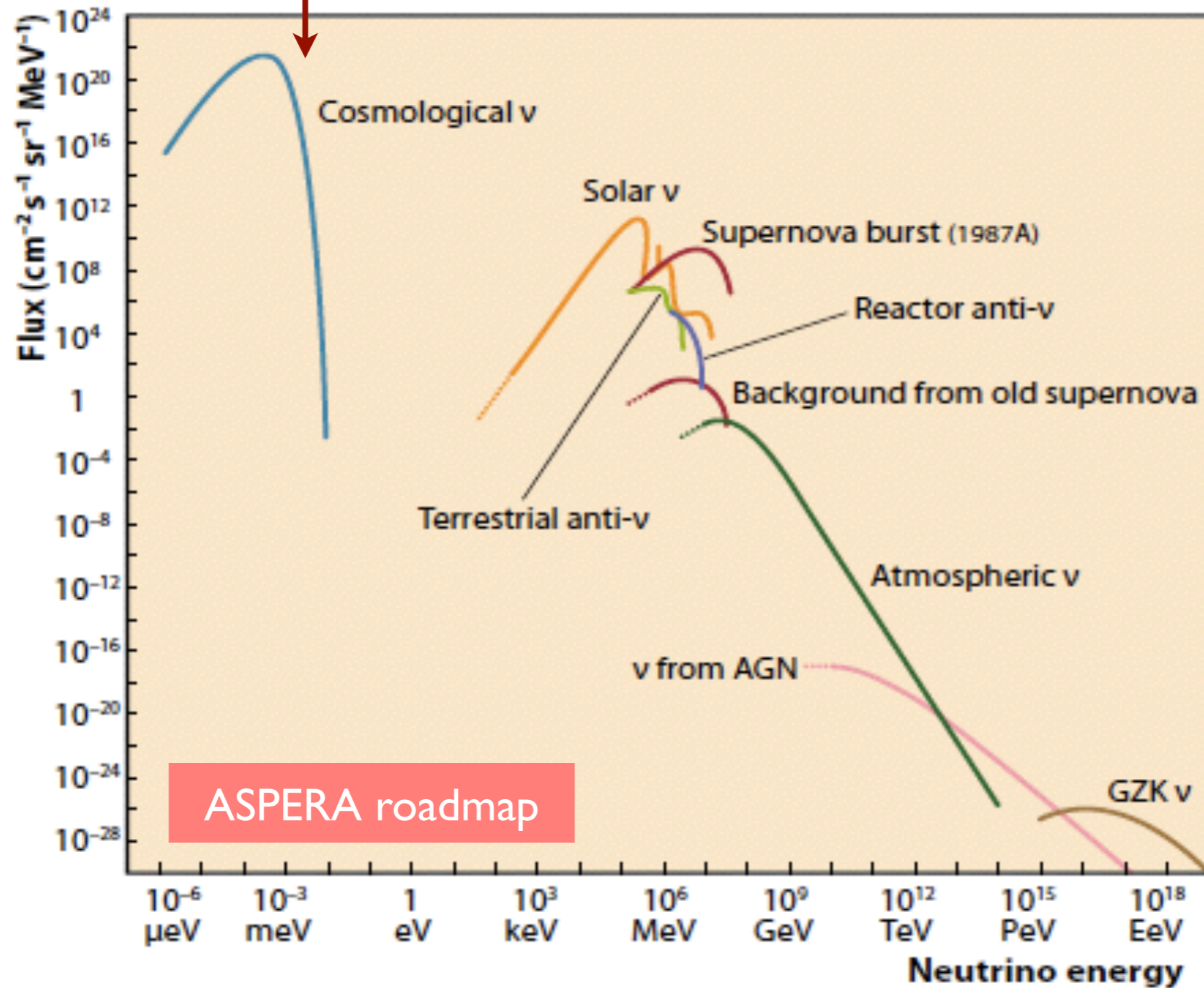
(very preliminary results)

Neutrino Energy Spectrum



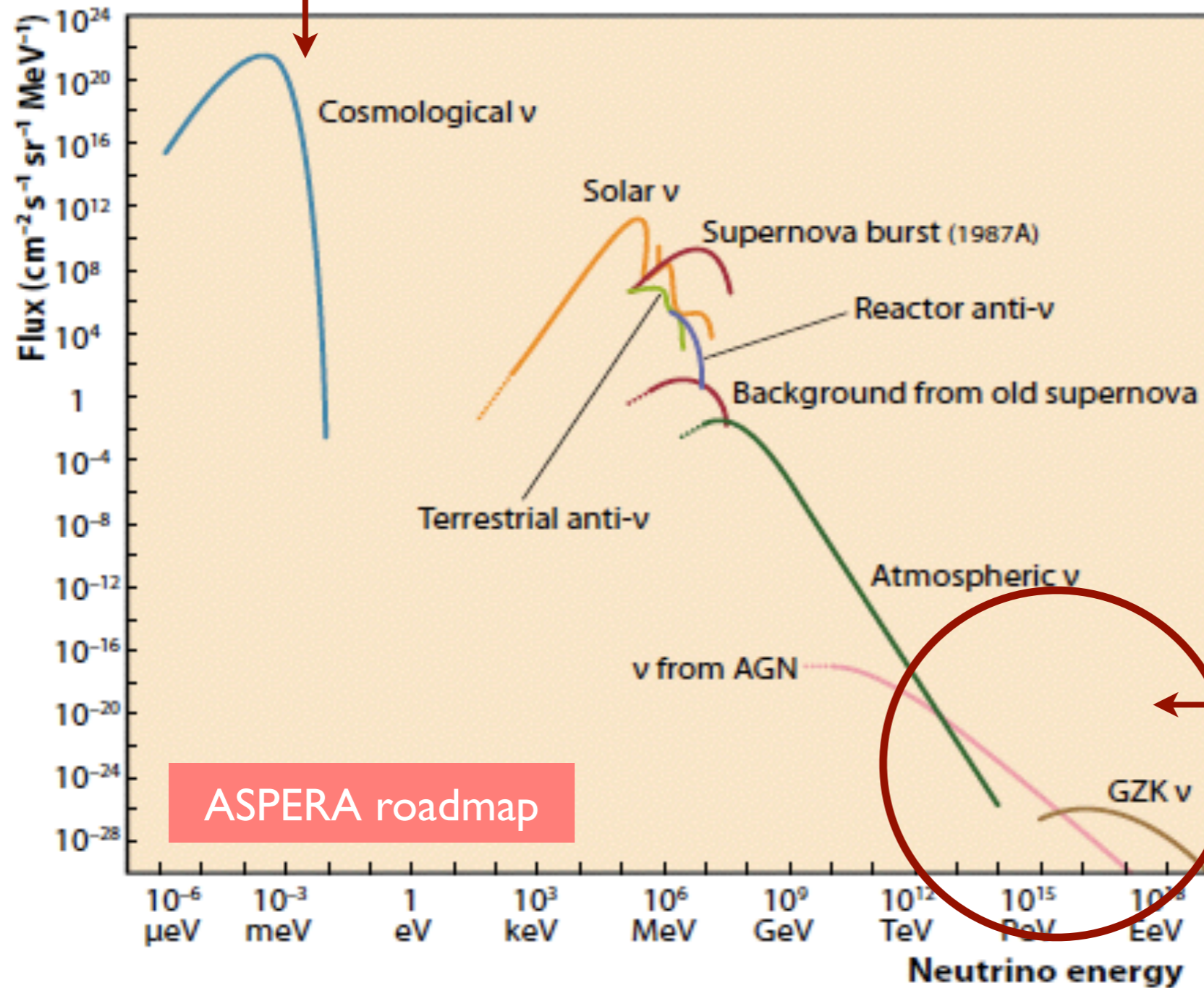
Neutrino Energy Spectrum

Cosmic Neutrino Background



Neutrino Energy Spectrum

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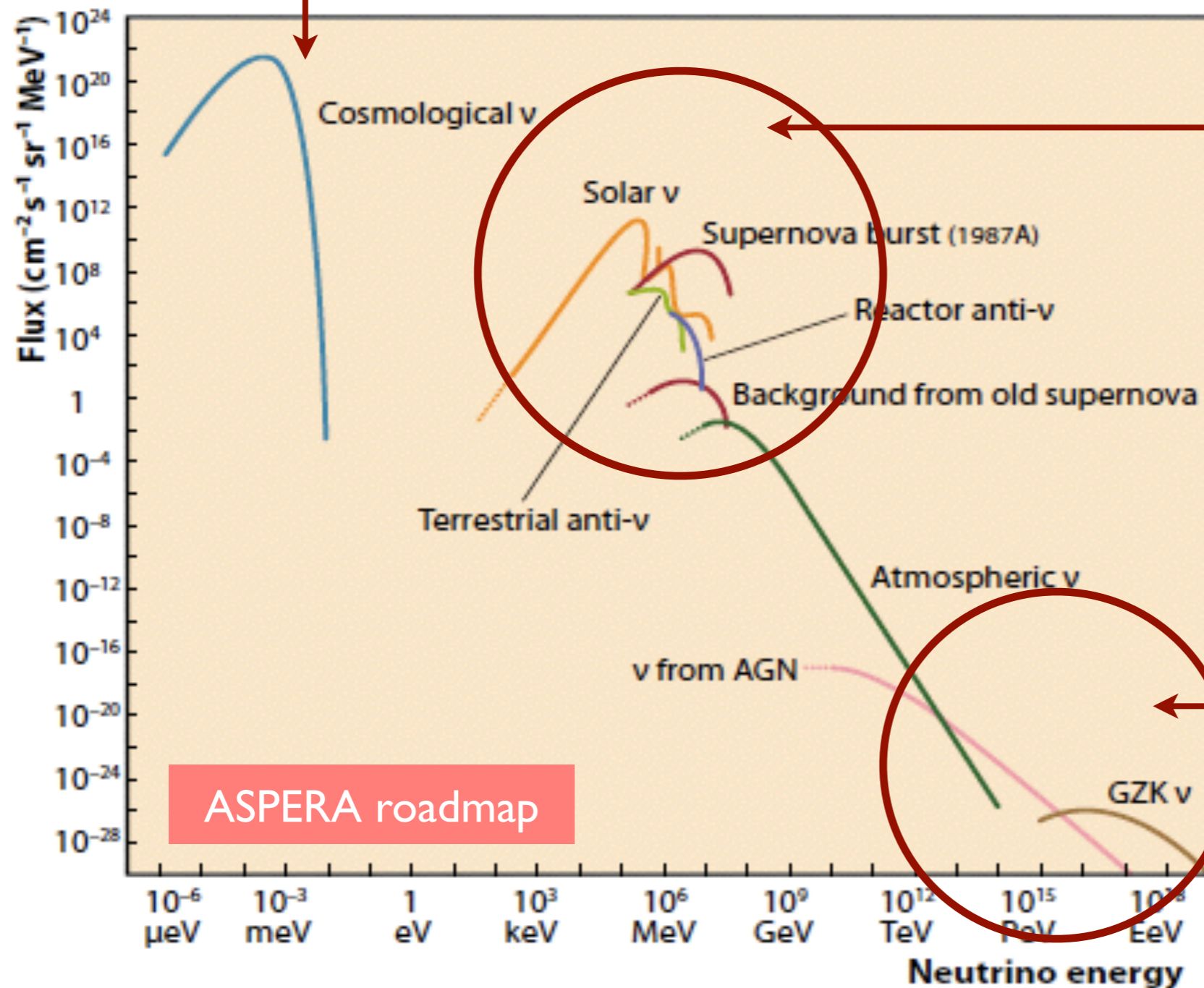


Ultra-high Energy Neutrinos

- GRB / AGN / GZK
- pp / p γ collisions

Neutrino Energy Spectrum

Cosmic Neutrino Background



MeV Neutrinos

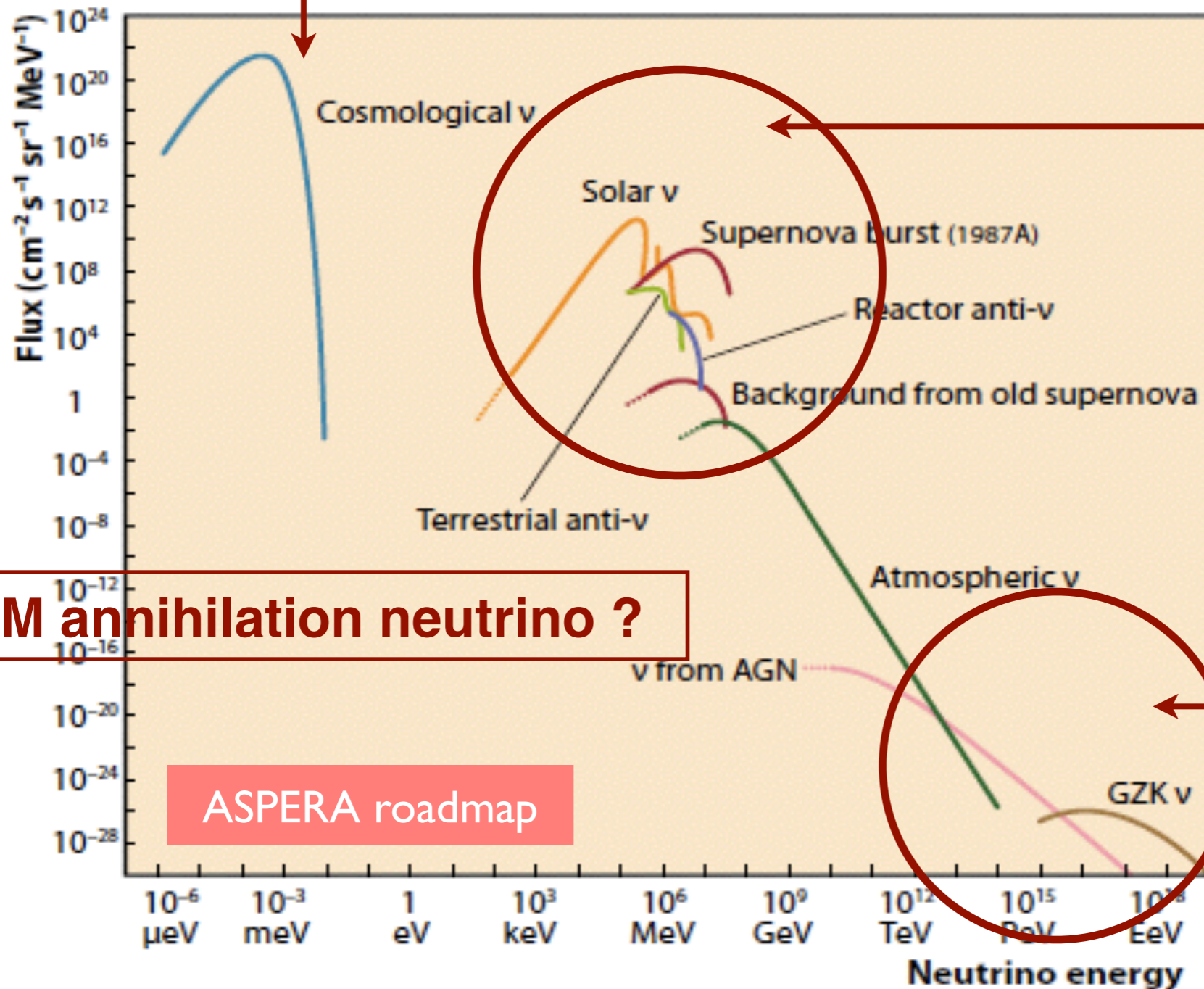
- Solar
- SN burst / BG
- centre of GRB
-
- beta decay

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MeV Neutrinos

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DM annihilation neutrino ?

Ultra-high Energy Neutrinos

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Gamma-ray Bursts (GRBs)

Gamma-ray Bursts

— — Brightest Explosions Since the Big Bang



- are extragalactic (isotropic distribution)
- release $\sim 10^{48} - 10^{55}$ ergs in a few seconds (sun: 10^{33} erg/s; supernova: 10^{53} ergs/days)
- followed by a longer-lived “afterglow”

two populations of GRBs:

- **Short Bursts** (few milliseconds to 2 seconds)
 N^*+N^* or N^*+BH merger
- **Long Bursts** (2 seconds to several minutes)
core collapse of a hypernova

Neutrinos from GRBs



Neutrinos from GRBs

observer



Neutrinos from GRBs

observer



gamma-ray, X-ray, ultraviolet, optical, infrared, microwave and radio, **(UHE) neutrinos** ...



Neutrinos from GRBs

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gamma-ray, X-ray, ultraviolet, optical, infrared, microwave and radio, **(UHE) neutrinos** ...

 **the jet acceleration mechanism**



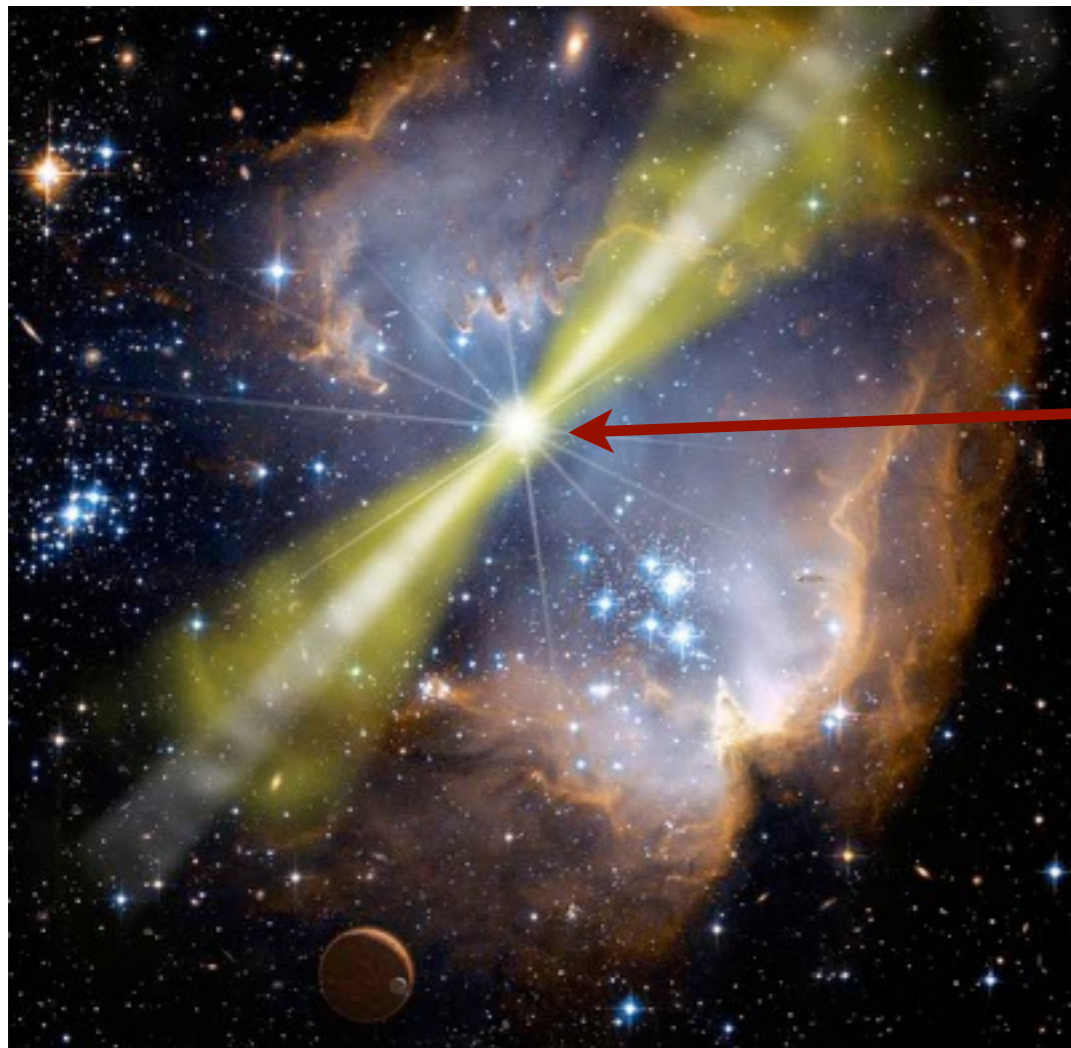
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What's the central engine looks like ?

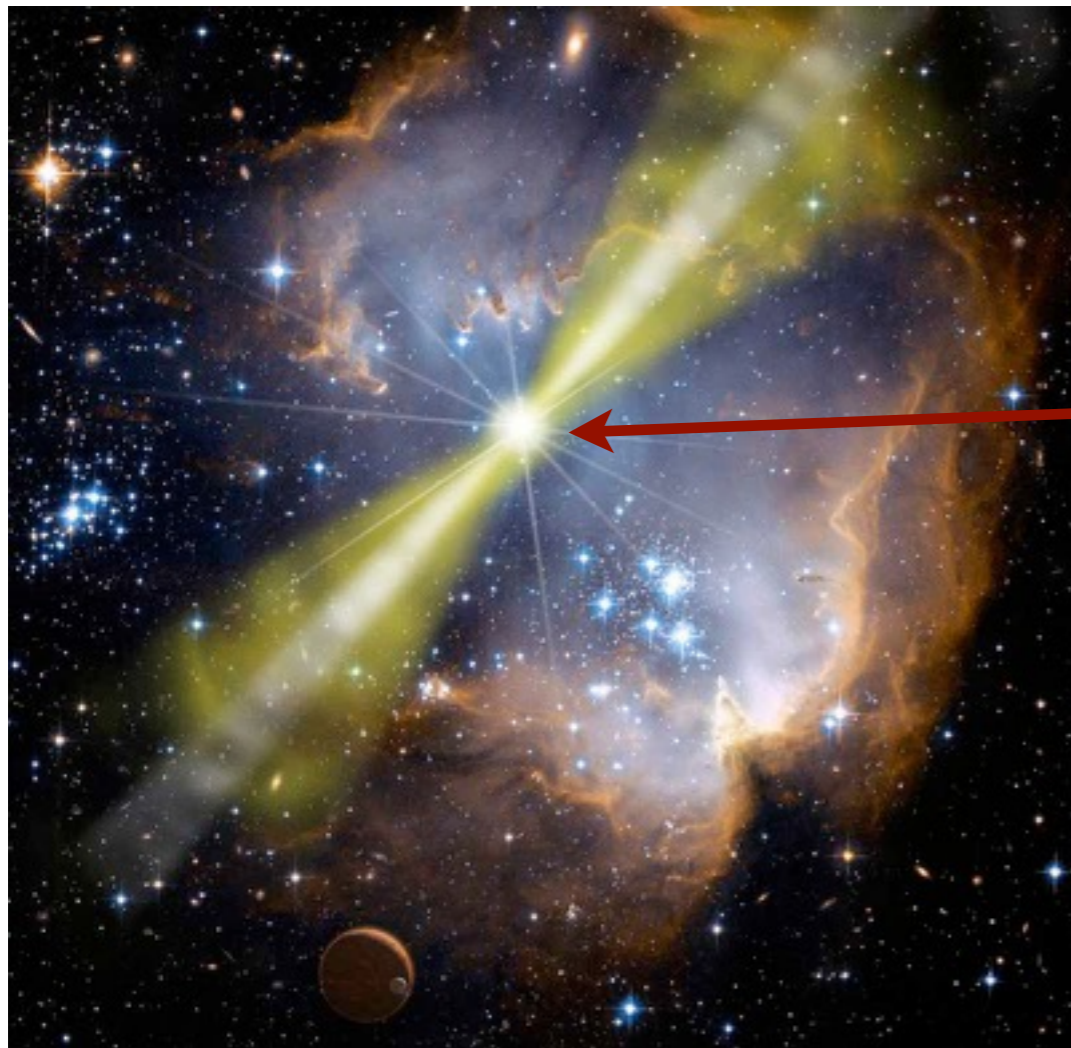
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**blackhole accretion flow ?
(with hyper-accretion rate)**

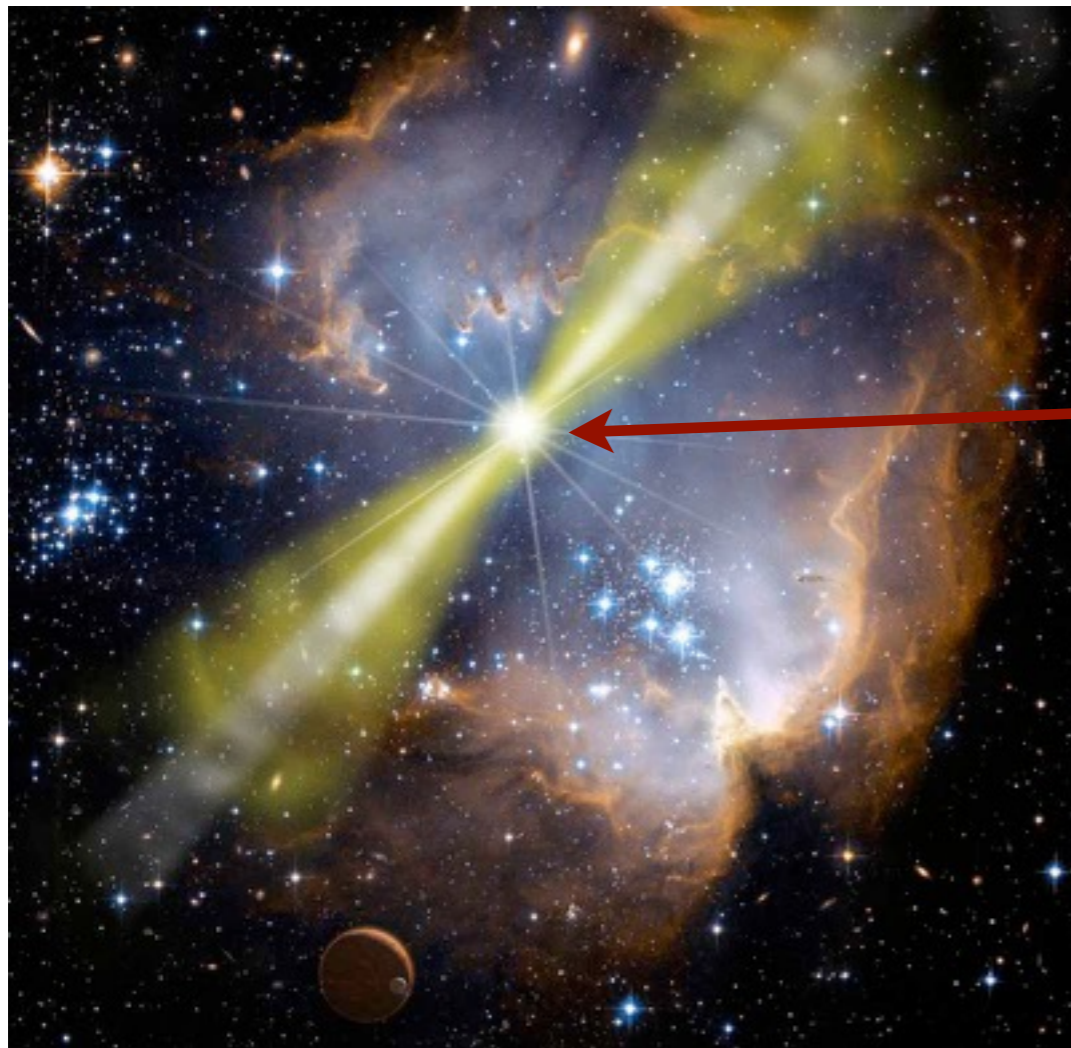
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**blackhole accretion flow ?
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neutrino, gravitational wave

Central Engine

- the central engine should be able to drive an relativistic outflow with extremely high luminosity and energy



the driving mechanism:

Magneto-driven jet
(BZ/BP process, MHD process)

Neutrino-driven jet (neutrino annihilation)

Central Engine

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the driving mechanism:

Magneto-driven jet
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Neutrino-driven jet (neutrino annihilation)

accretion discs around black holes
with rather high accretion rates

Central Engine

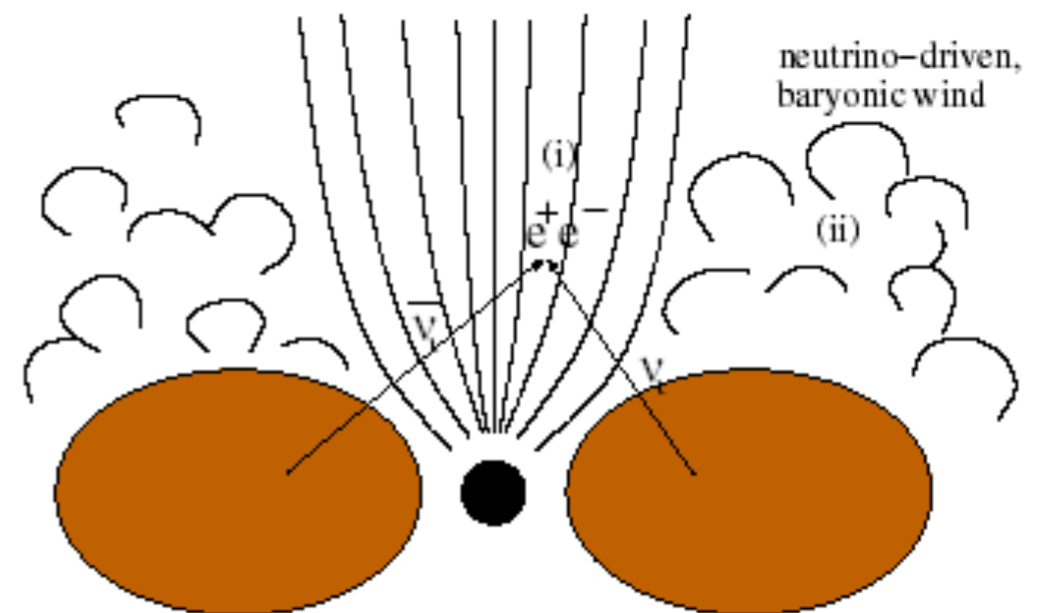
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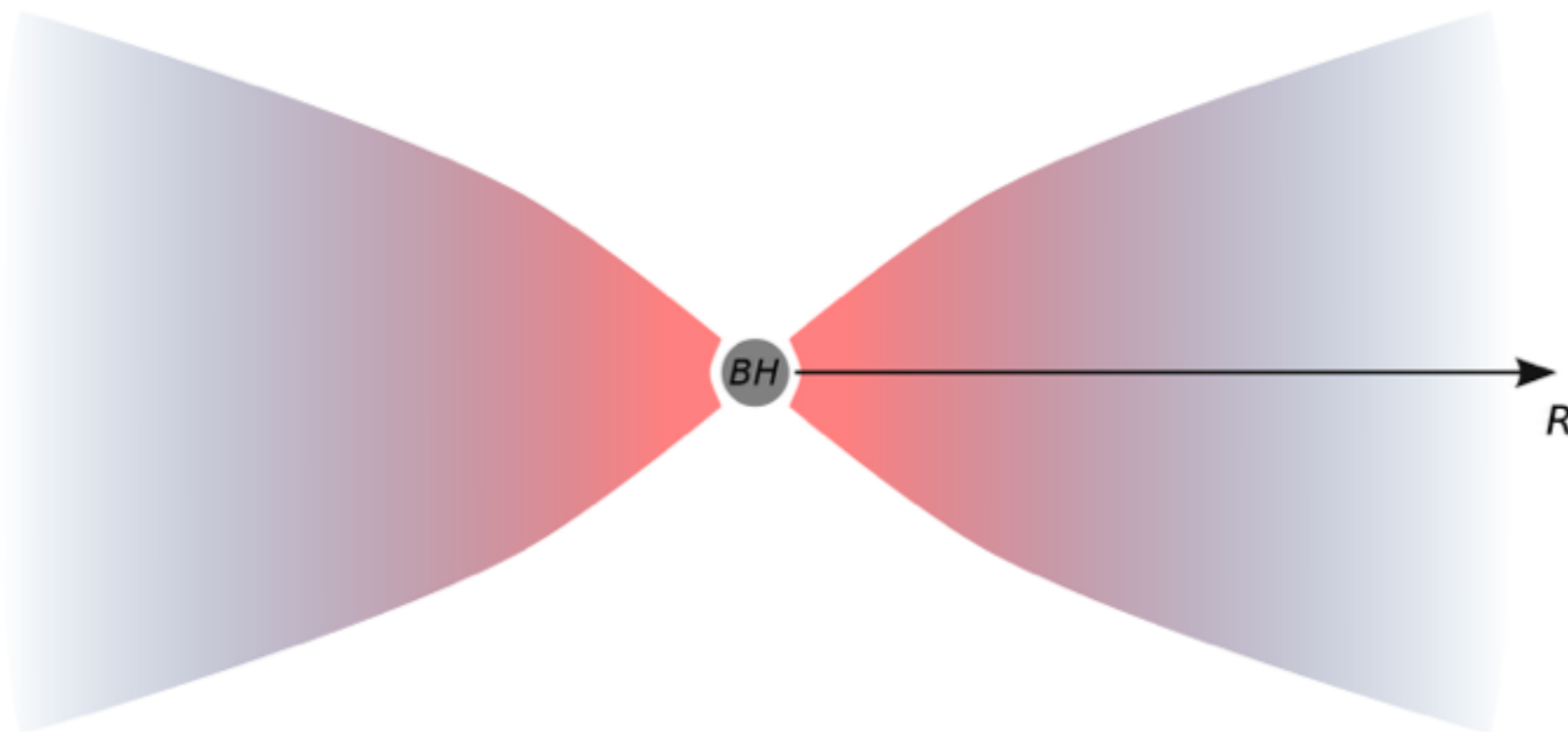
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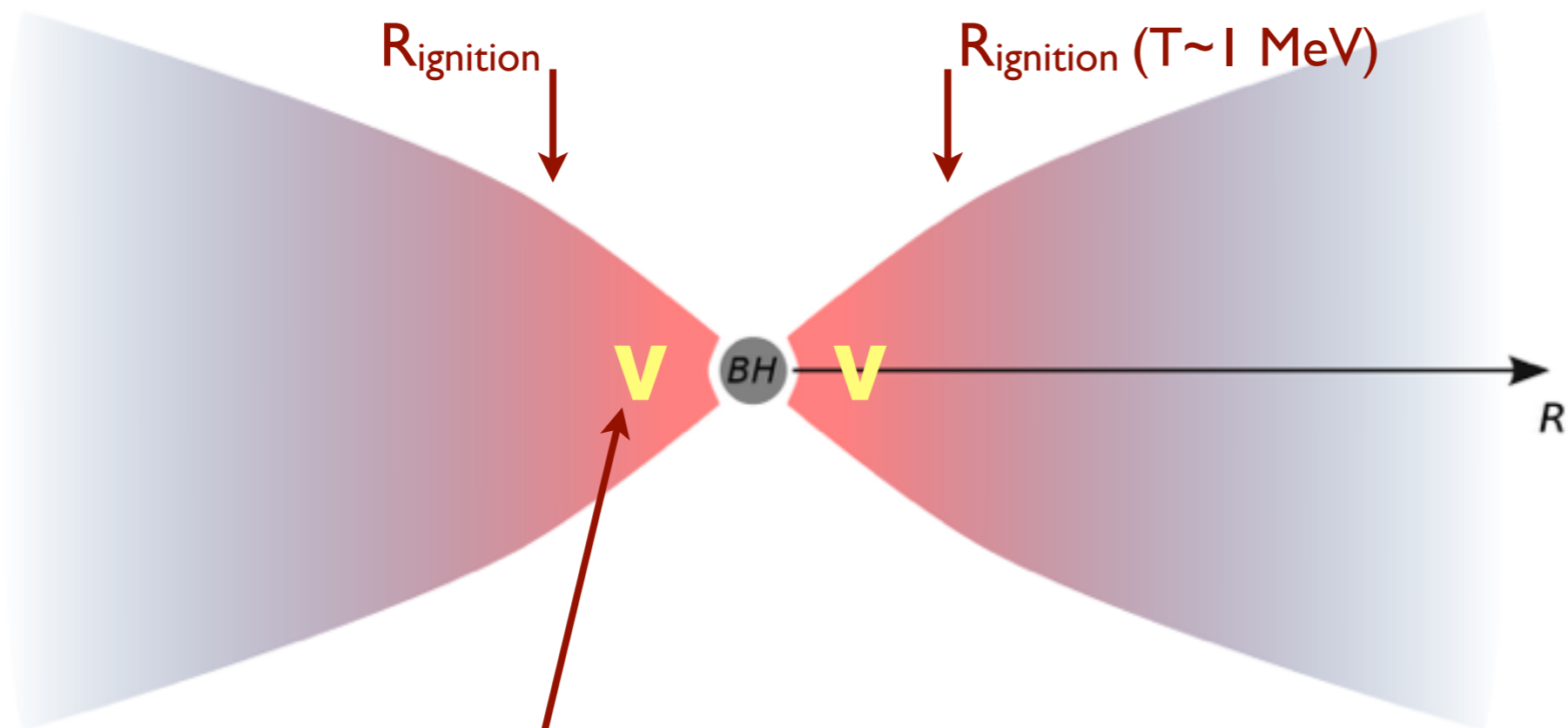
Neutrino-Dominated Accretion Flow

 a rather **hot** and **dense** hyper-accretion flow (optically thick)

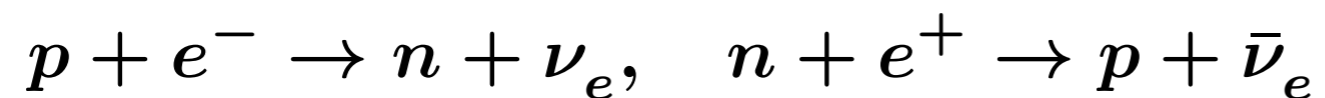


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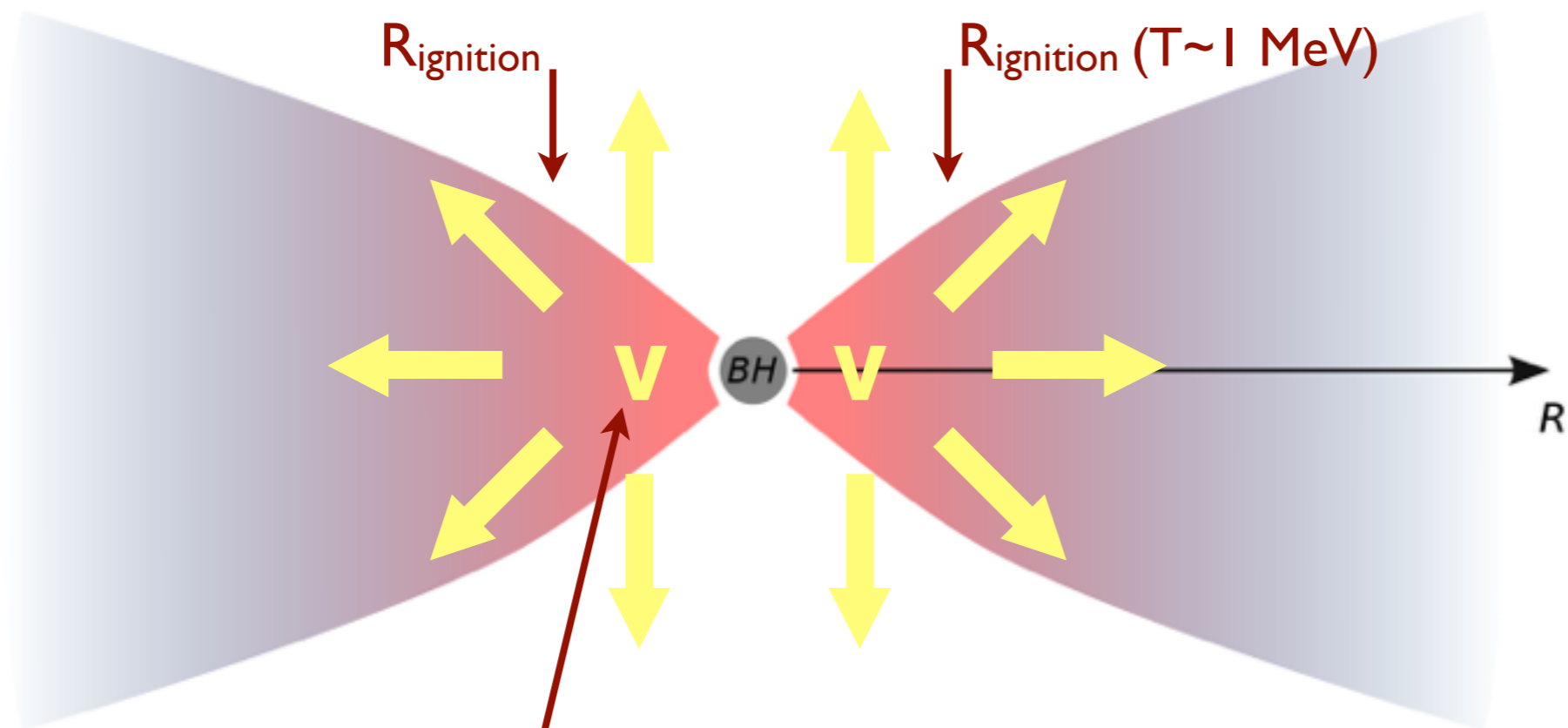


pair capture of electron & positron (**URCA** process)

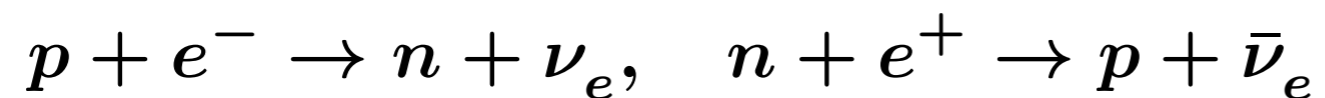


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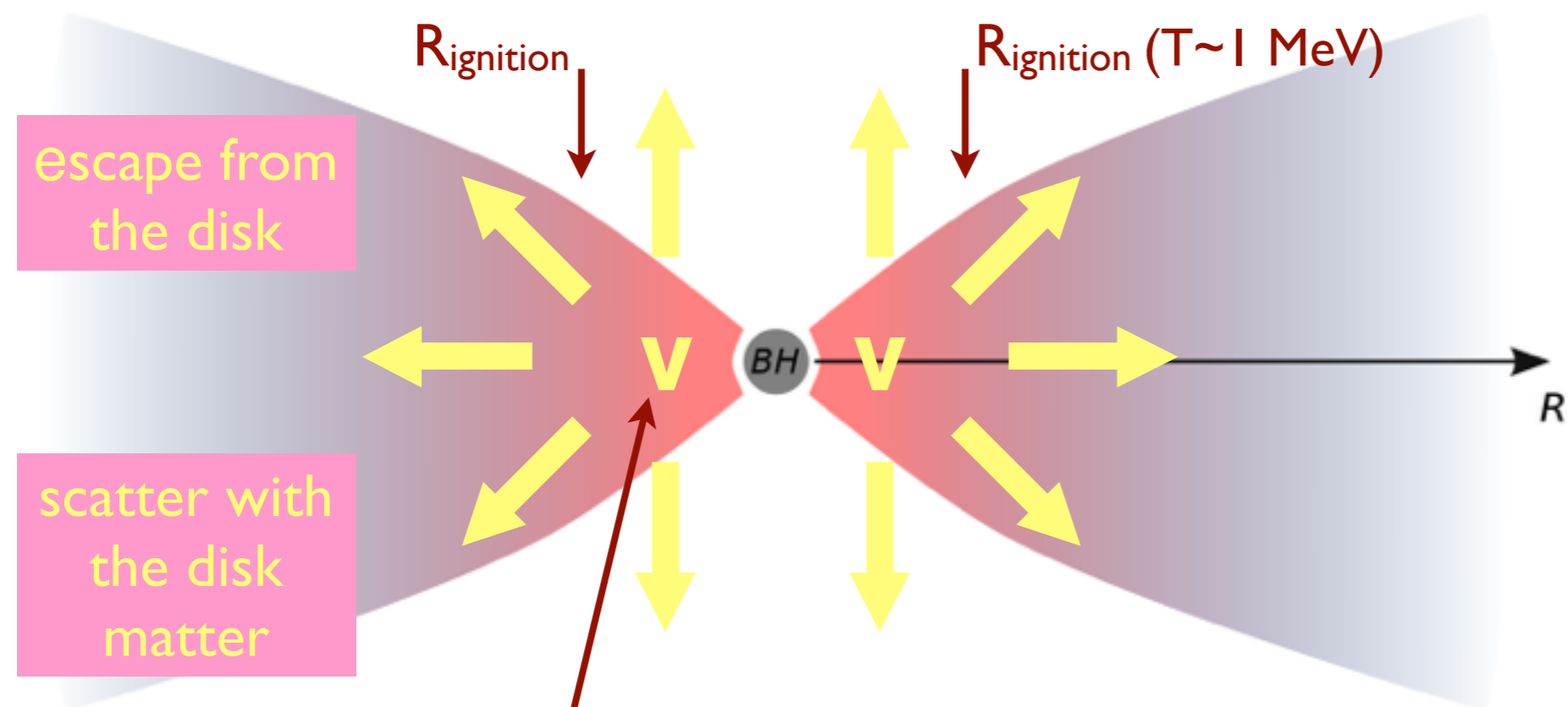


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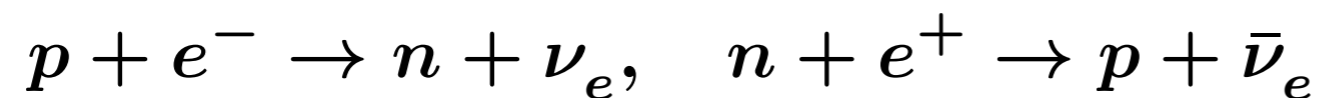


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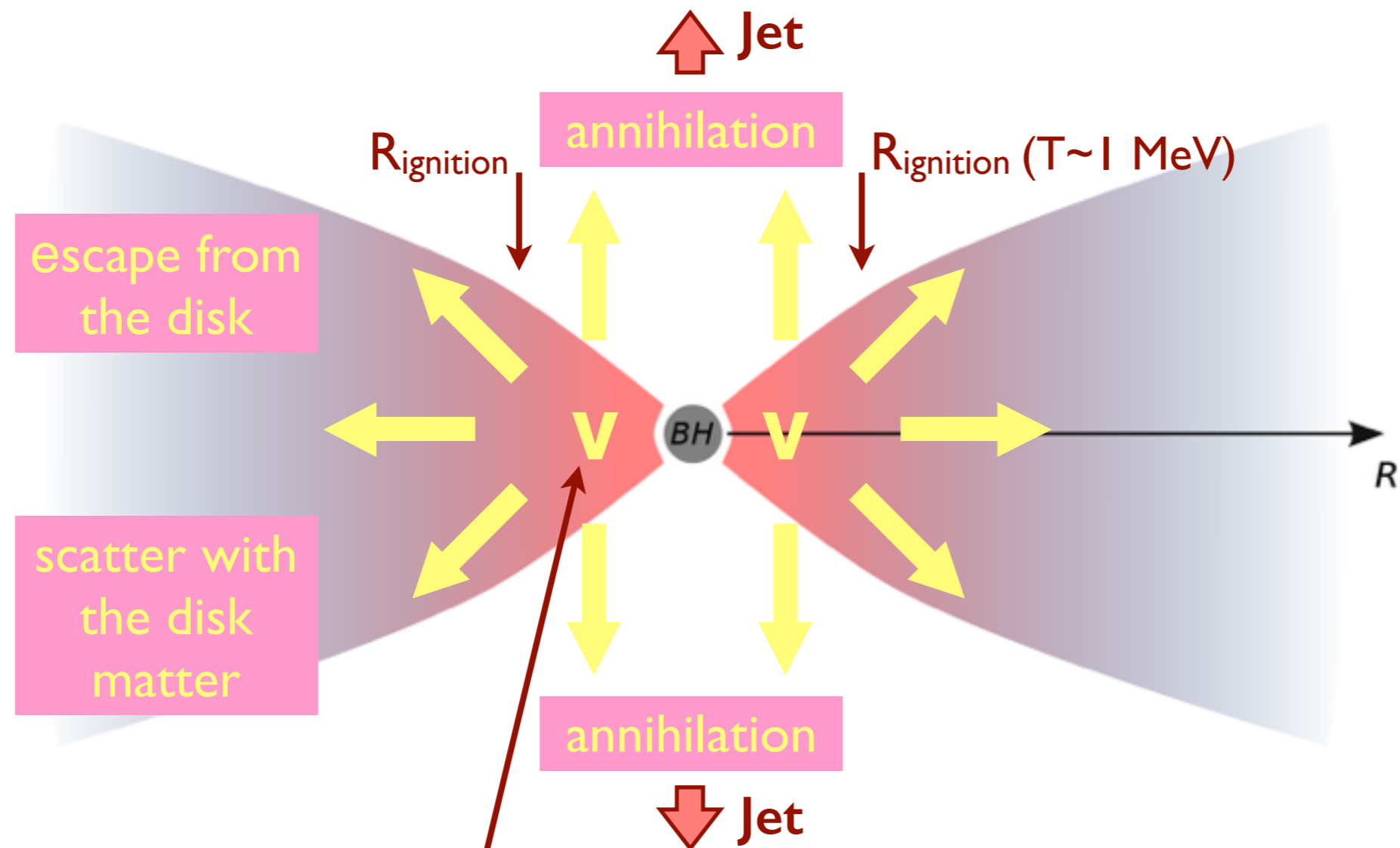


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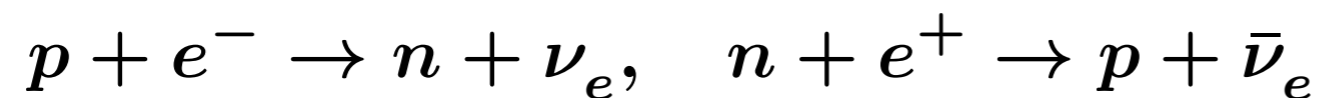


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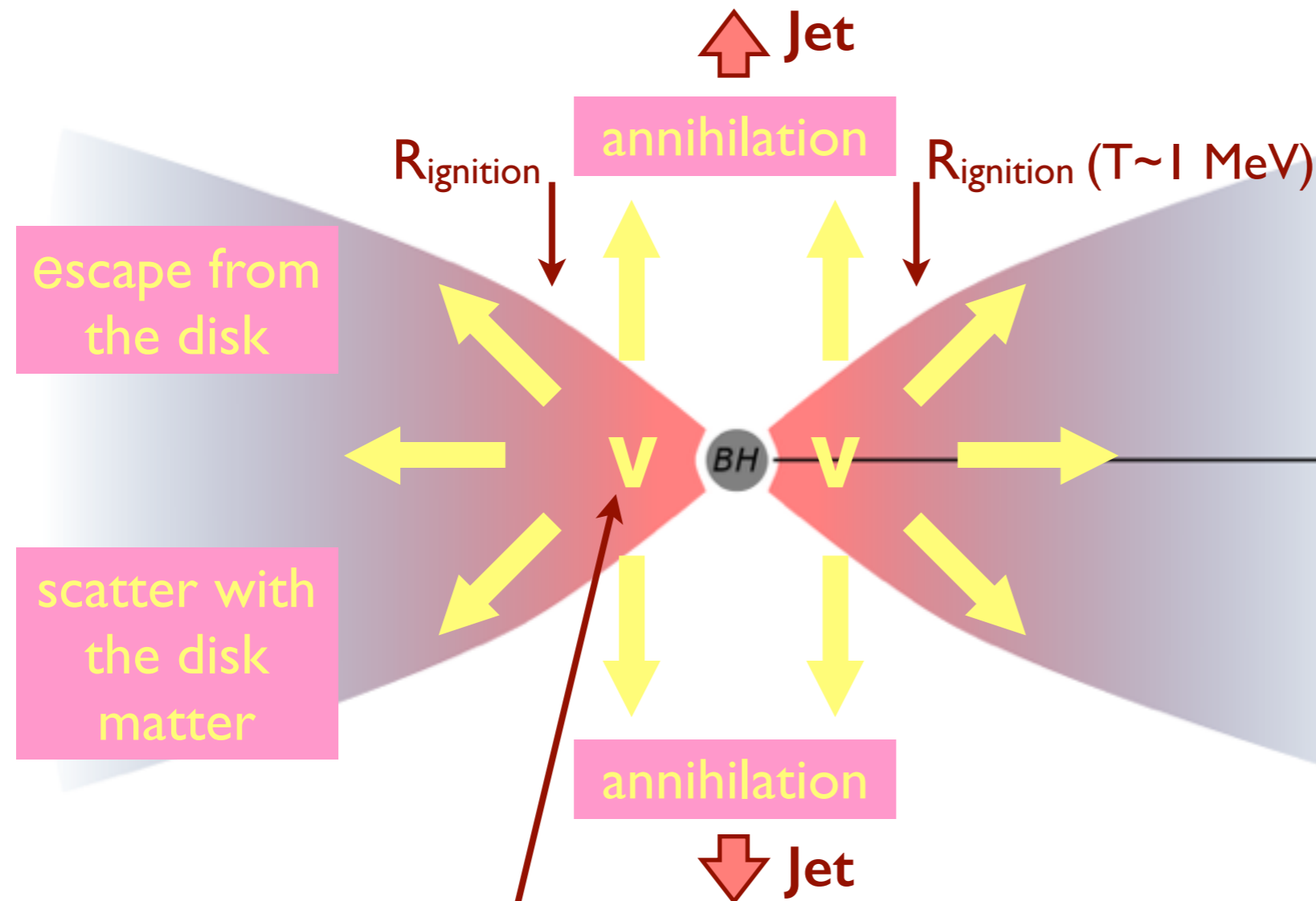


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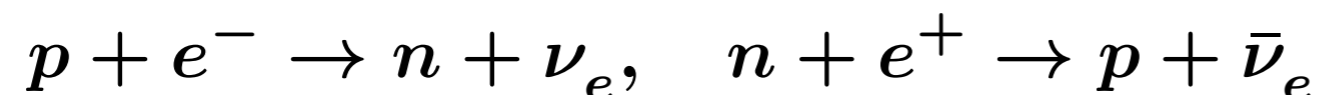
Neutrino-Dominated Accretion Flow

• a rather hot and dense hyper-accretion flow (optically thick)



- consider an NDAF with
 - $M_{BH} = 3 M_{sun}$
 - $\dot{M} = 1 M_{sun} s^{-1}$
- released potential energy $\sim 10^{54}$ erg/s
- total neutrino luminosity $L_\nu \sim 10^{54}$ erg/s (90%)
- energy for neutrino-driven jet $L_{\nu\nu} \sim 10^{52}$ erg/s (1%)

pair capture of electron & positron (URCA process)



GRBs v.s. SNe (core-collapse)

	SNe	GRBs
Total Neutrino Luminosity	10^{53-54} erg / per SN	10^{54-58} erg / per GRB
Rate	a few per second in the visible universe one every few decades in the Galaxy	a few per galaxy per million years

- because the GRBs are extragalactic, the event rate of neutrinos from a single GRB is rather low
- Diffuse GRB Neutrino Background (v.s. DSNB)

GRB neutrino Background

- Diffuse GRB neutrino background spectrum (isotropic)

$$\frac{dF_{\nu_e/\bar{\nu}_e}}{dE_{\nu_e/\bar{\nu}_e}} = \frac{c}{H_0} \int_0^{z_{\max}} dz \frac{R_{\text{NDAF}}(z)}{\sqrt{\Omega_m(1+z)^3 + \Omega_\Lambda}} \frac{dN_{\nu_e/\bar{\nu}_e}(E'_{\nu_e/\bar{\nu}_e})}{dE'_{\nu_e/\bar{\nu}_e}}$$

GRB neutrino Background

Diffuse GRB neutrino background spectrum (isotropic)

single GRB neutrino spectrum

calculated numerically for
a given M_{BH} & \dot{M}

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GRB neutrino Background

Diffuse GRB neutrino background spectrum (isotropic)

line-of-sight integral
over cosmic redshift z

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the rate of NDAFs

- $R_{\text{NDAF}}(z) \propto f R_{\text{SF}}(z)$
- we choose $f = 1$
(failed GRB also counted)

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line-of-sight integral
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- How to determine \dot{M} ?

$$\dot{M} = k m_{\text{initial}}^\alpha$$

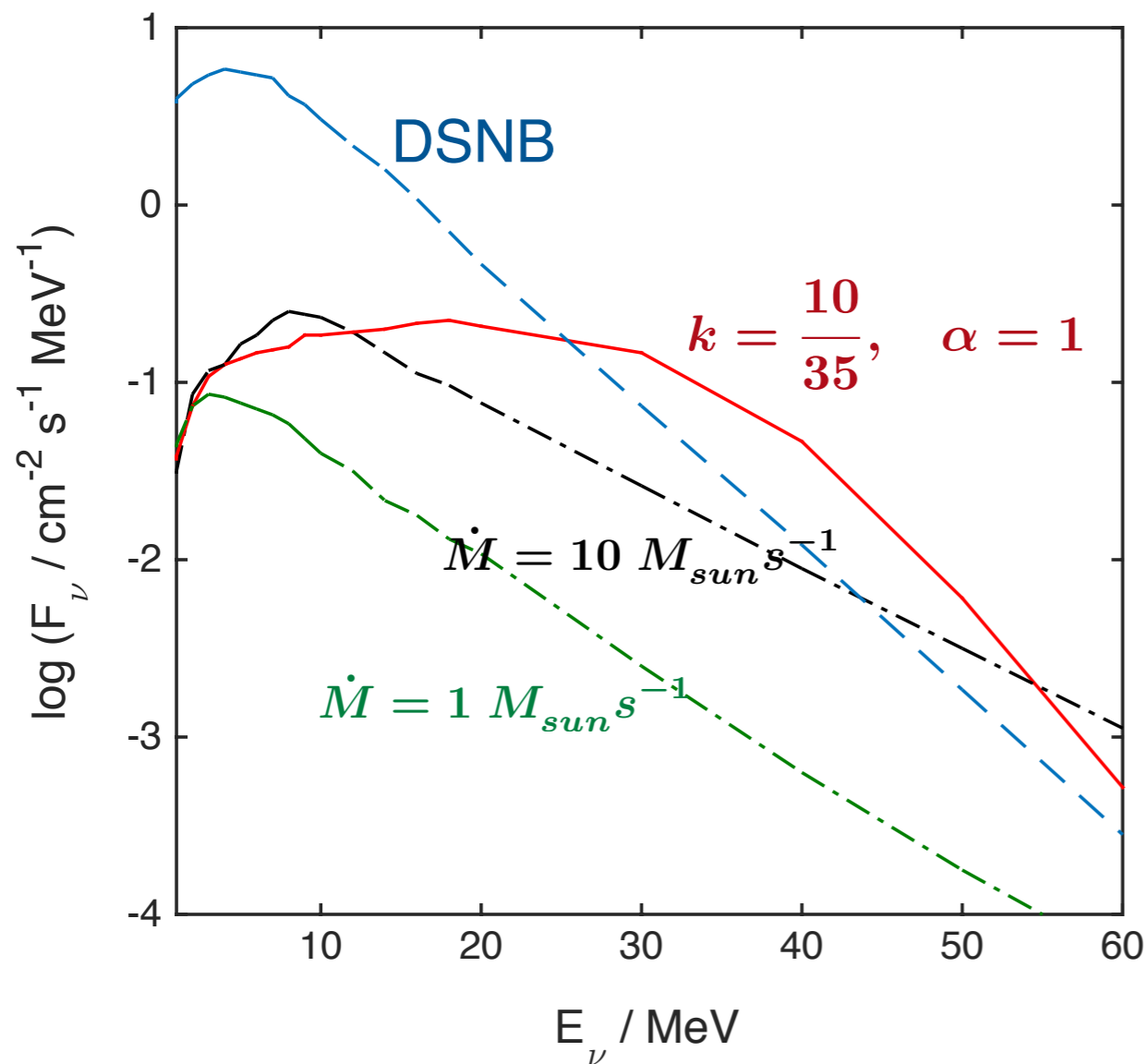
- the accretion time scale $\tau \propto \frac{m_{\text{initial}}}{\dot{M}}$

- $M_{BH} \sim 3 M_{\text{sun}}$

& increase during the accretion

GRB Neutrino Background

Diffuse GRB Neutrino Background Spectrum (preliminary results)

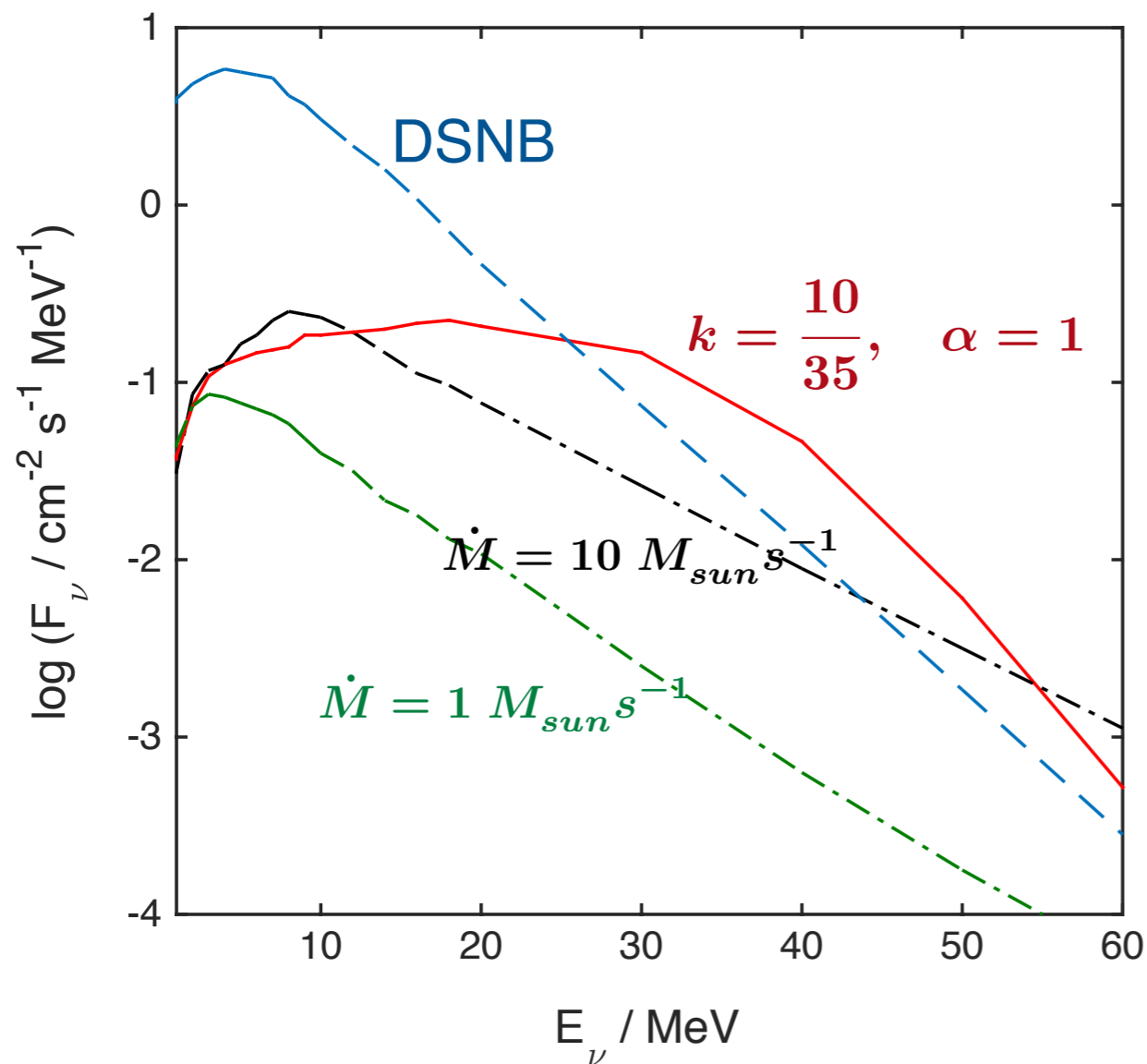


- in the optimistic situation (the average \dot{M} is relatively large), the flux of the diffuse GRB neutrino background are comparable to the F_{DSNB}
- the feature of the spectrum depends largely on how the accretion rate is determined

GRB Neutrino Background

Diffuse GRB Neutrino Background Spectrum

(preliminary results)



- this results need to be further examined
- further discussions on the feature of the spectrum & its hints on the accretion rate and possible theoretical model
- further discussions on the possibilities of detecting the GRB neutrino background



Thanks ~