Multi-wavelength emissions associated with X-ray flares of GRBs

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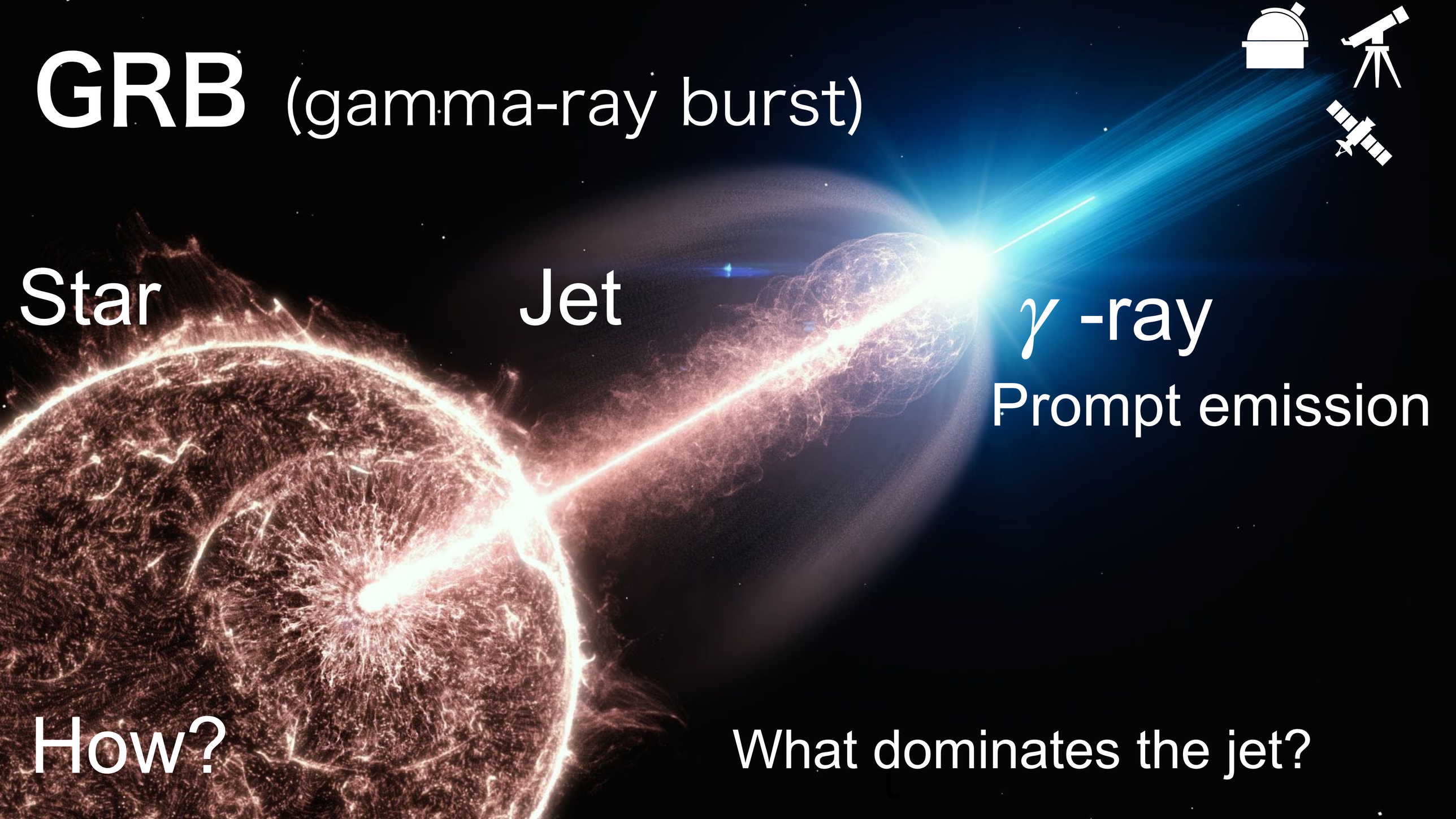
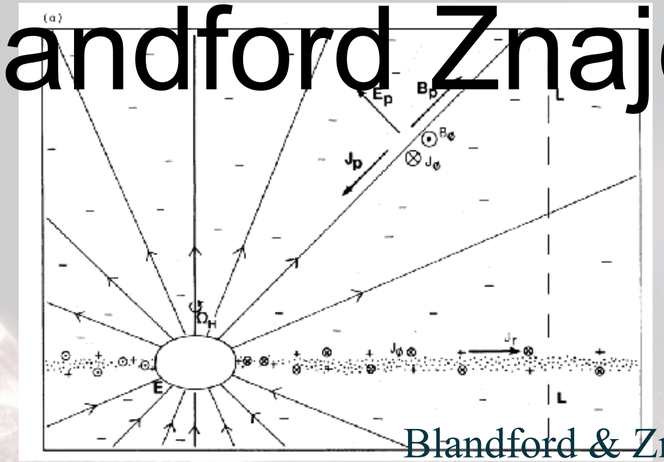
Multimessenger Astronomy 3rd Conference


GRB (gamma-ray burst)
Star
Jet
γ -ray
Prompt emission
How?
What dominates the jet?

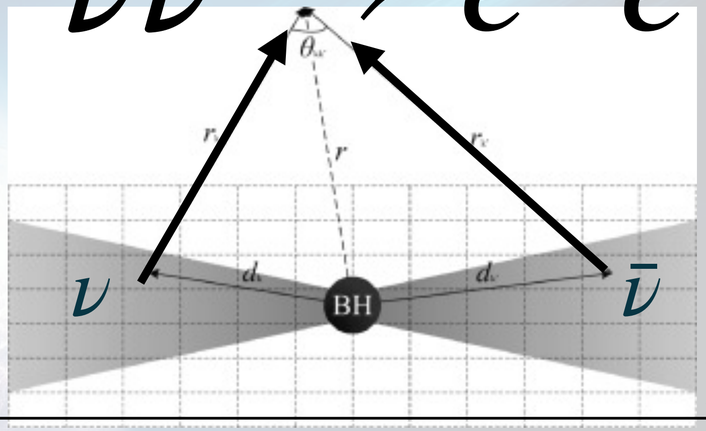
B field v.s. Thermal

Blandford Znajec



Blandford & Znajek +1976

$\nu\bar{\nu} \rightarrow e^- e^+$



Liu +17

Energy injection

Acceleration

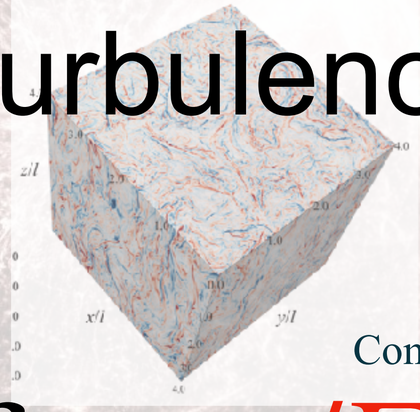
$\Gamma \propto r^{1/3}$

Granot +11

$\Gamma \propto r \rightarrow \Gamma = \text{const.}$

Dissipation

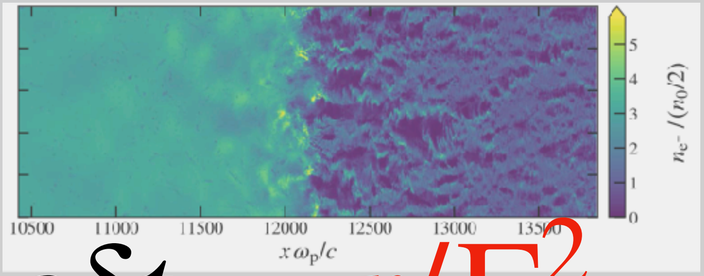
Turbulence



Comisso & Sironi 2019

$c\delta t < r/\Gamma^2$

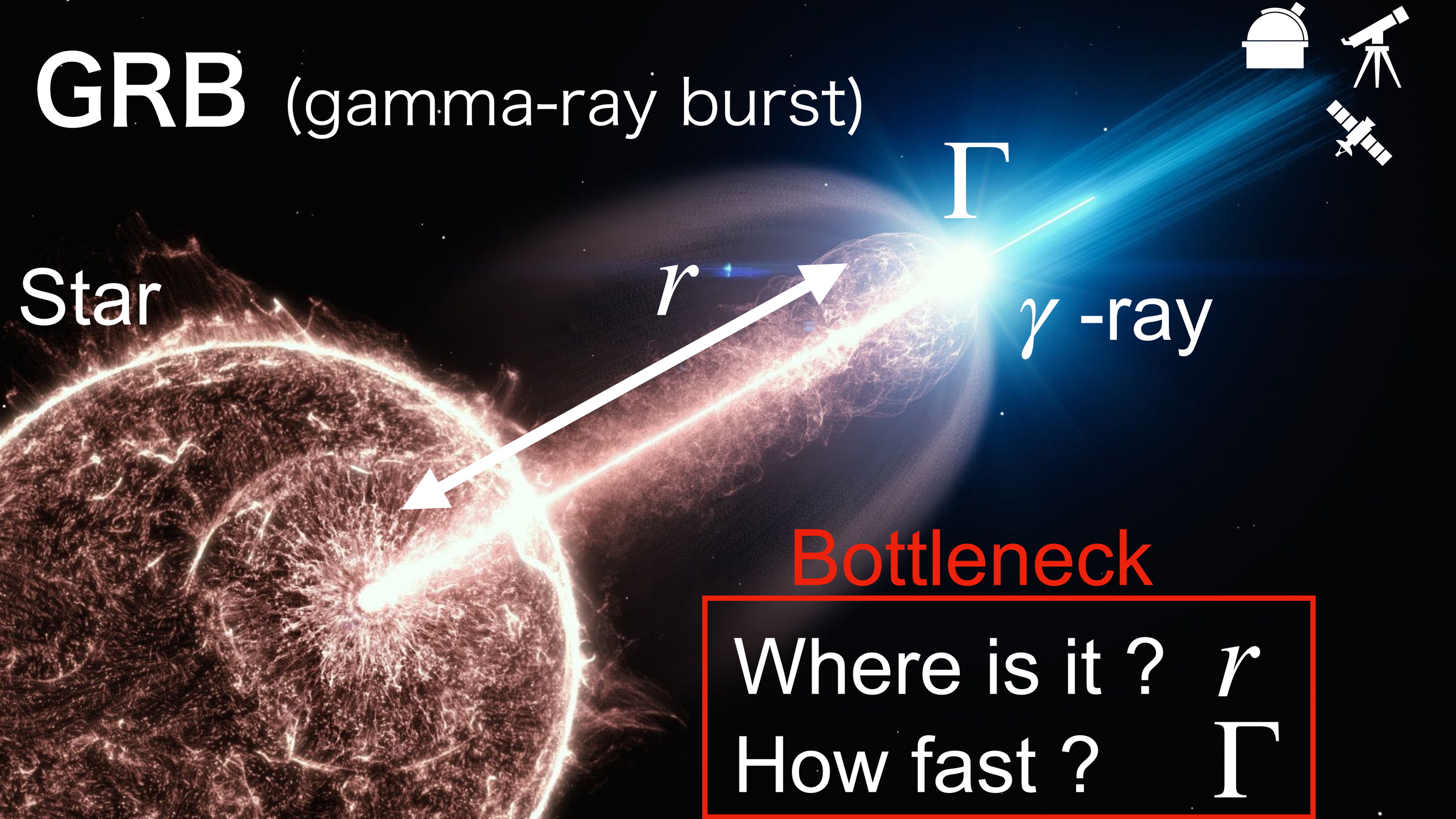
Shock



Groseji+24

$c\delta t \sim r/\Gamma^2$

GRB (gamma-ray burst)



Bottleneck

Where is it ? r

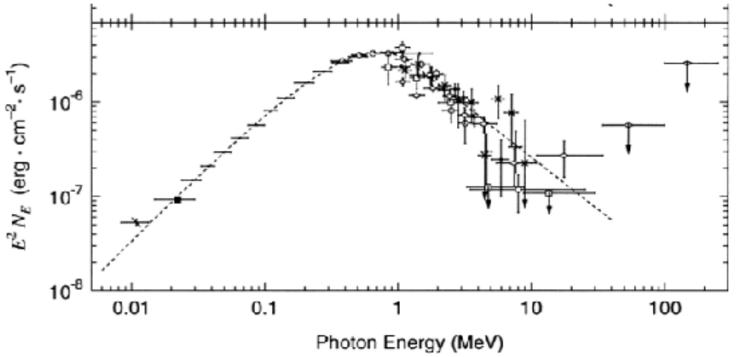
How fast ? Γ

Challenge

GRBs last only ~10 s.

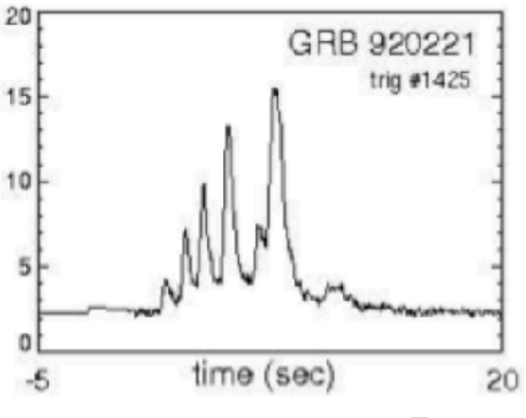
→ Need both of ・ huge field of view

・ high sensitivity



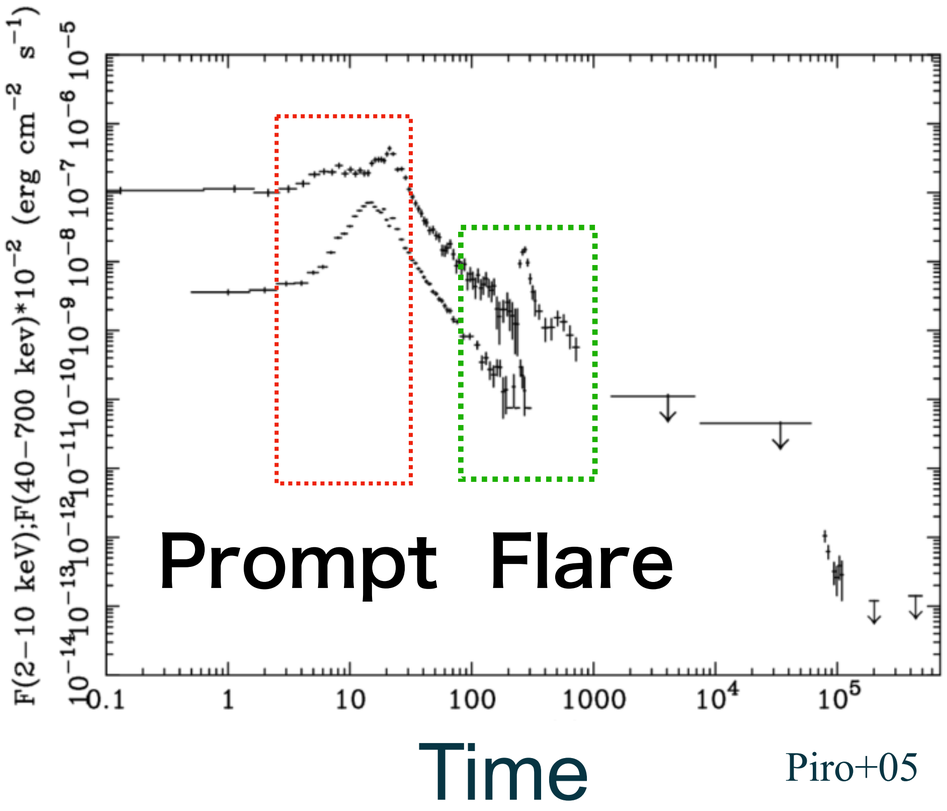
→ We only know ・ Nonthermal process

・ $\Gamma > 100$

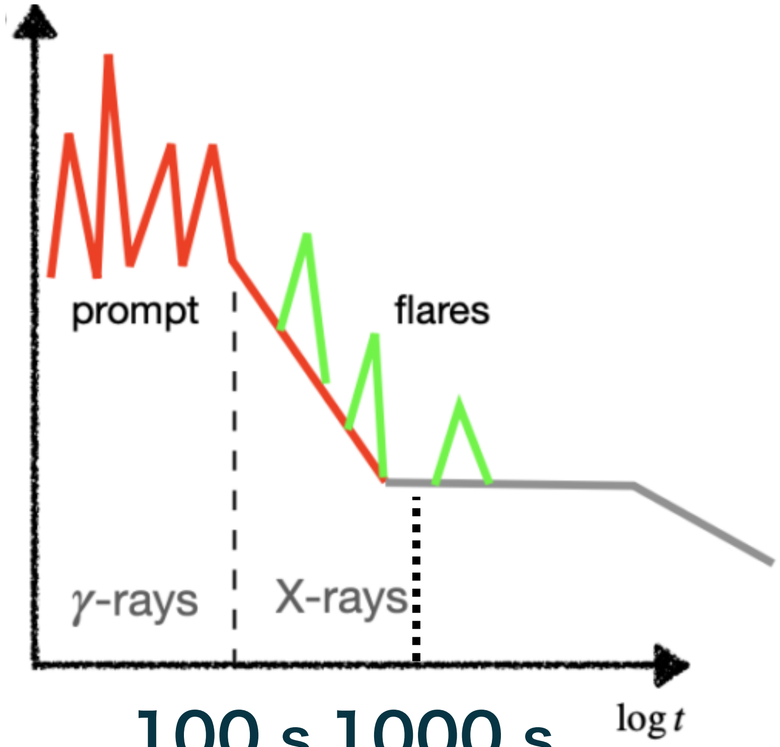


Solution : Let's see in 100 - 1000 s

X-ray Flare : X-ray emission after 100-1000 s after main GRB



Piro+05

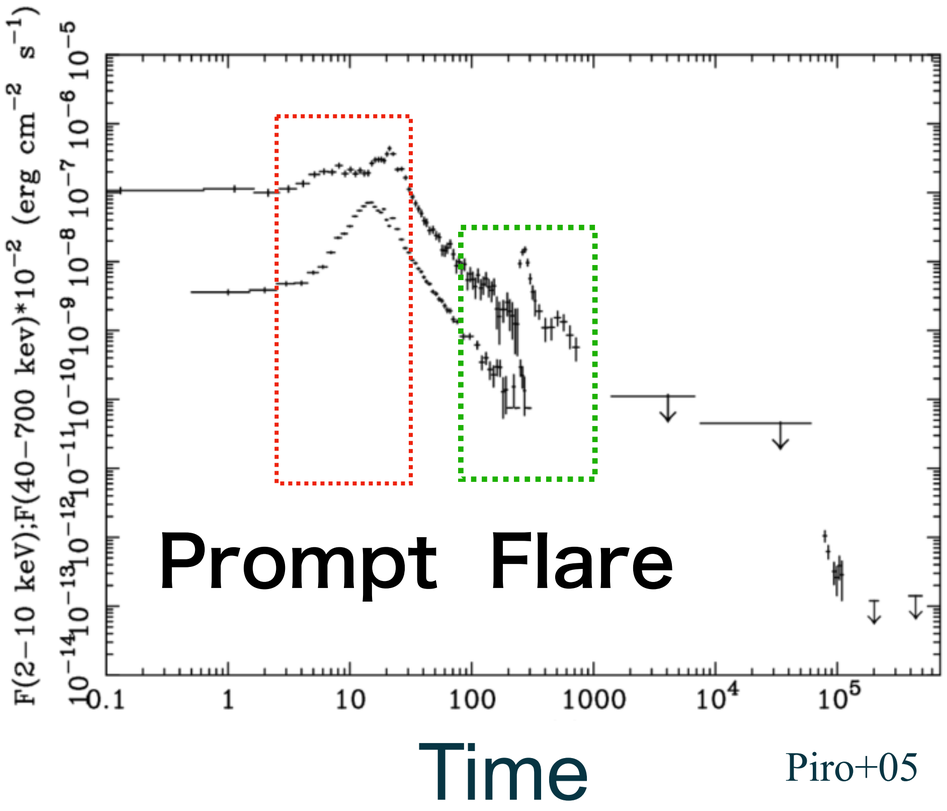


Duque+22

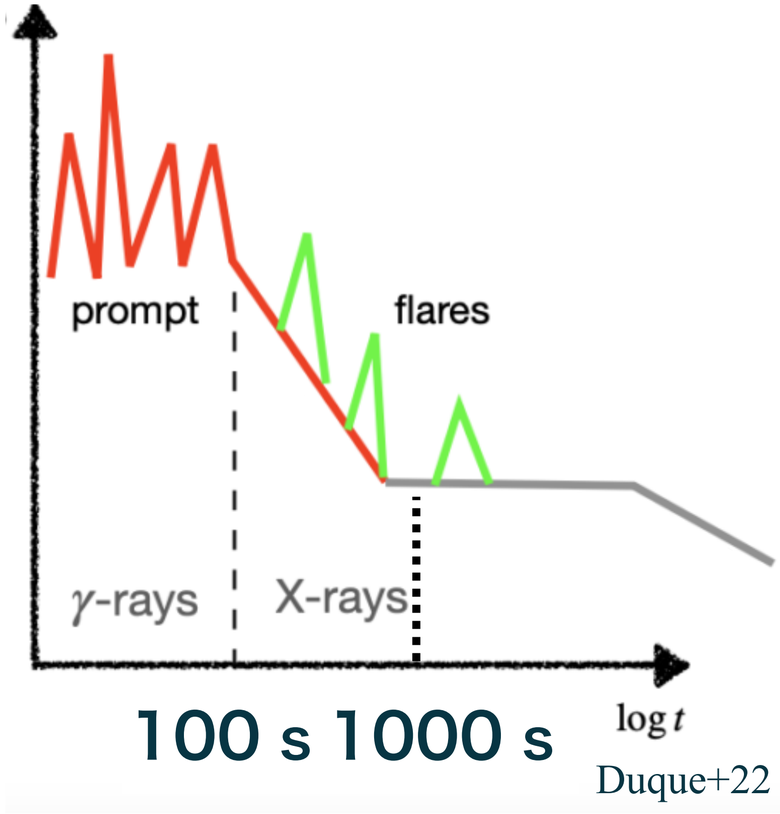
The jet production lasts for 100 -1000 s.

Solution : Let's see in 100 - 1000 s

X-ray Flare : X-ray emission after 100-1000 s after main GRB



Piro+05



Duque+22

Less luminous,

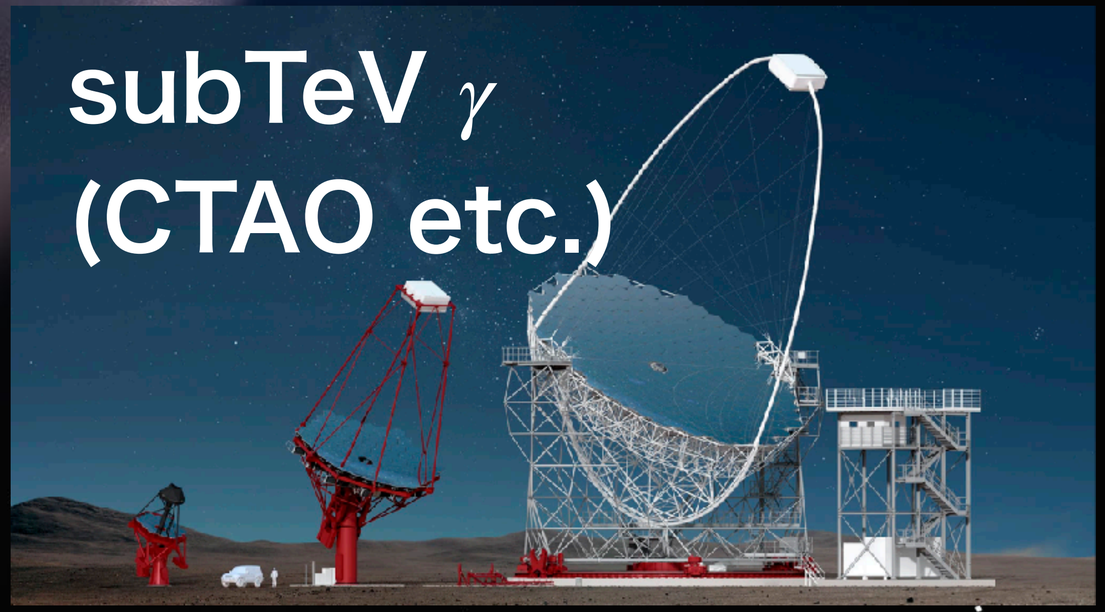
but good chance to observe with recent facilities

We need a combination

X, γ-ray
(EP, SVOM, HiZ. etc.)

UV-optical
(SVOM, HiZ. etc.)

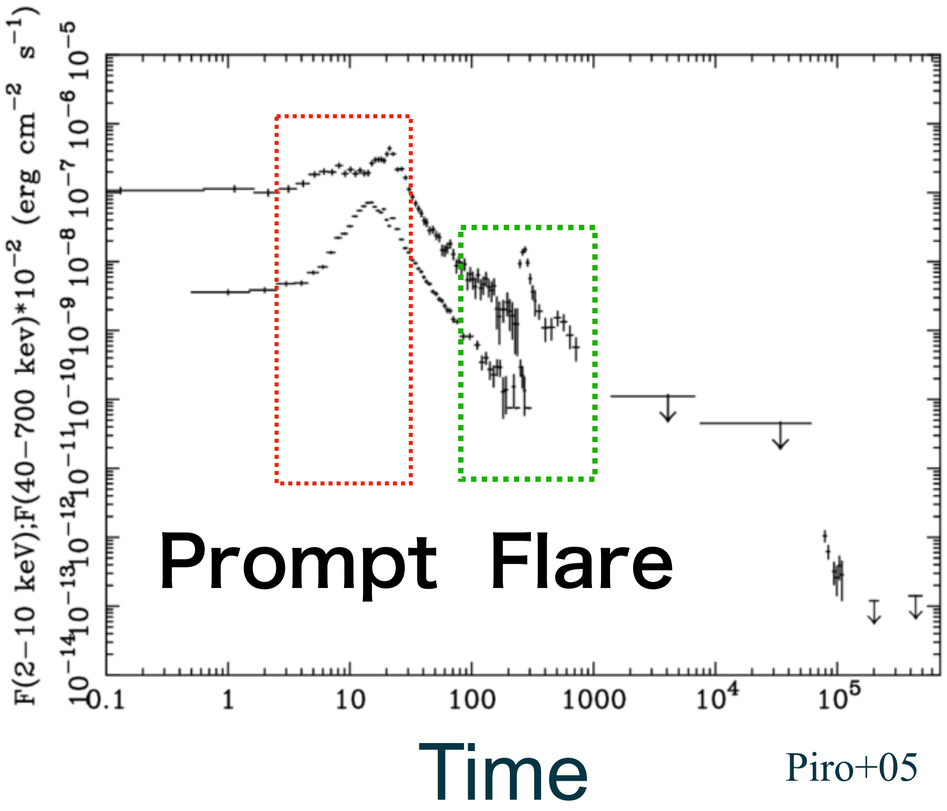
Neutrinos
(IceCube etc.)



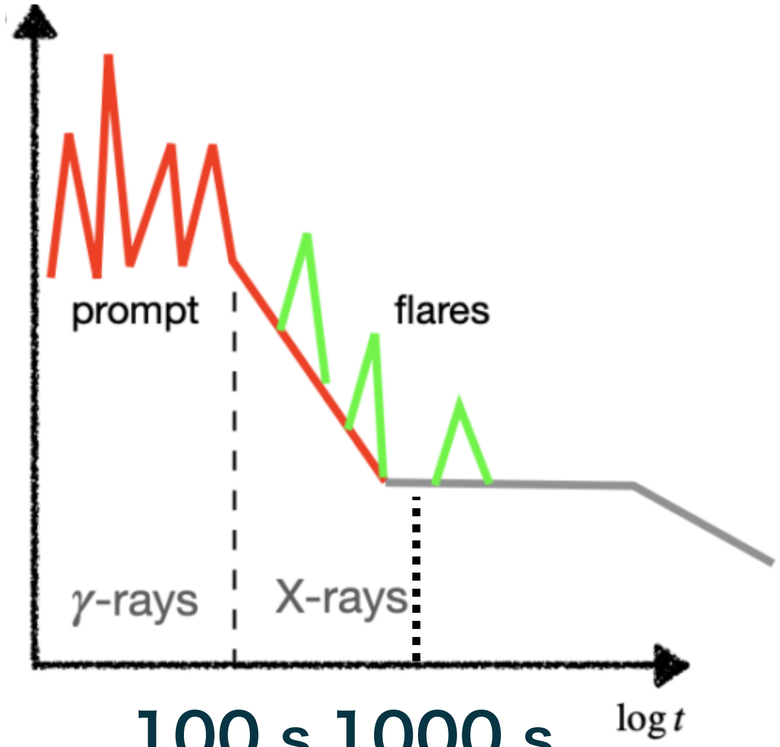
subTeV γ
(CTAO etc.)

Solution : Let's see in 100 - 1000 s

X-ray Flare : X-ray emission after 100-1000 s after main GRB



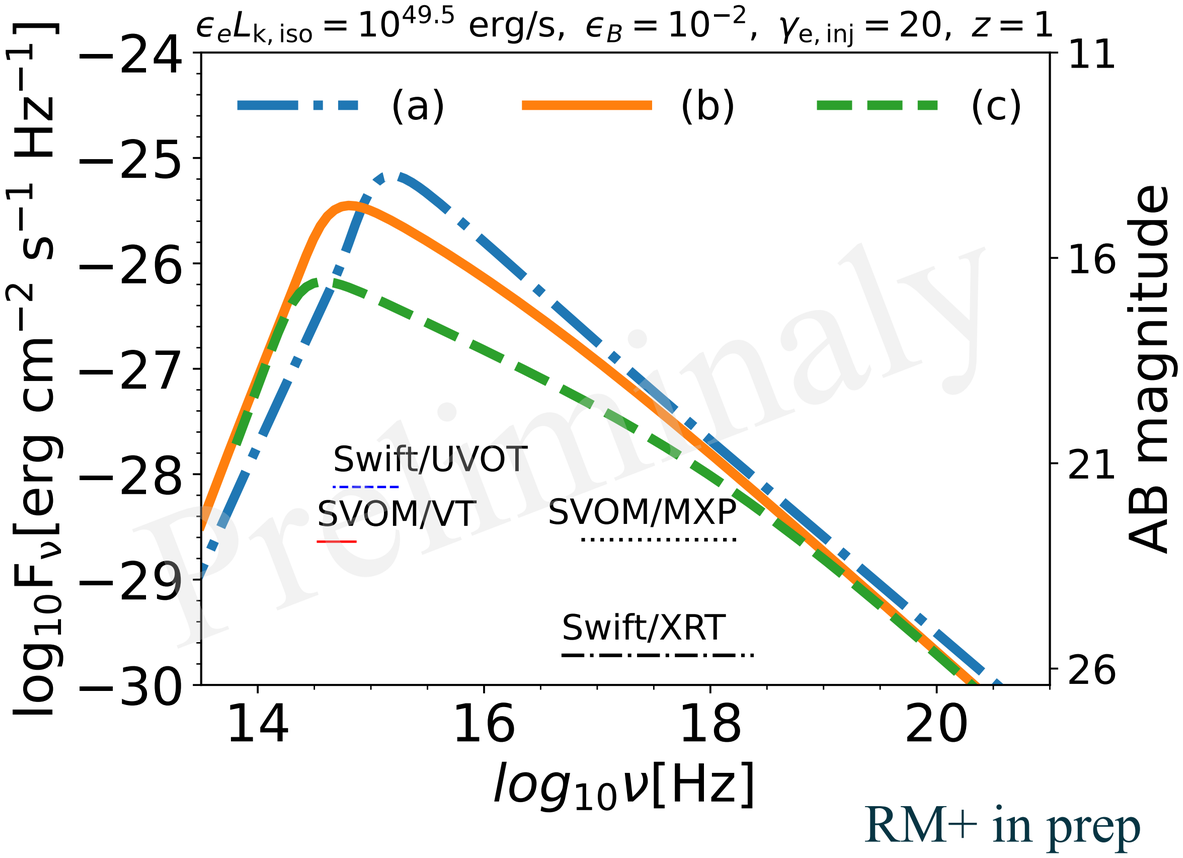
Piro+05

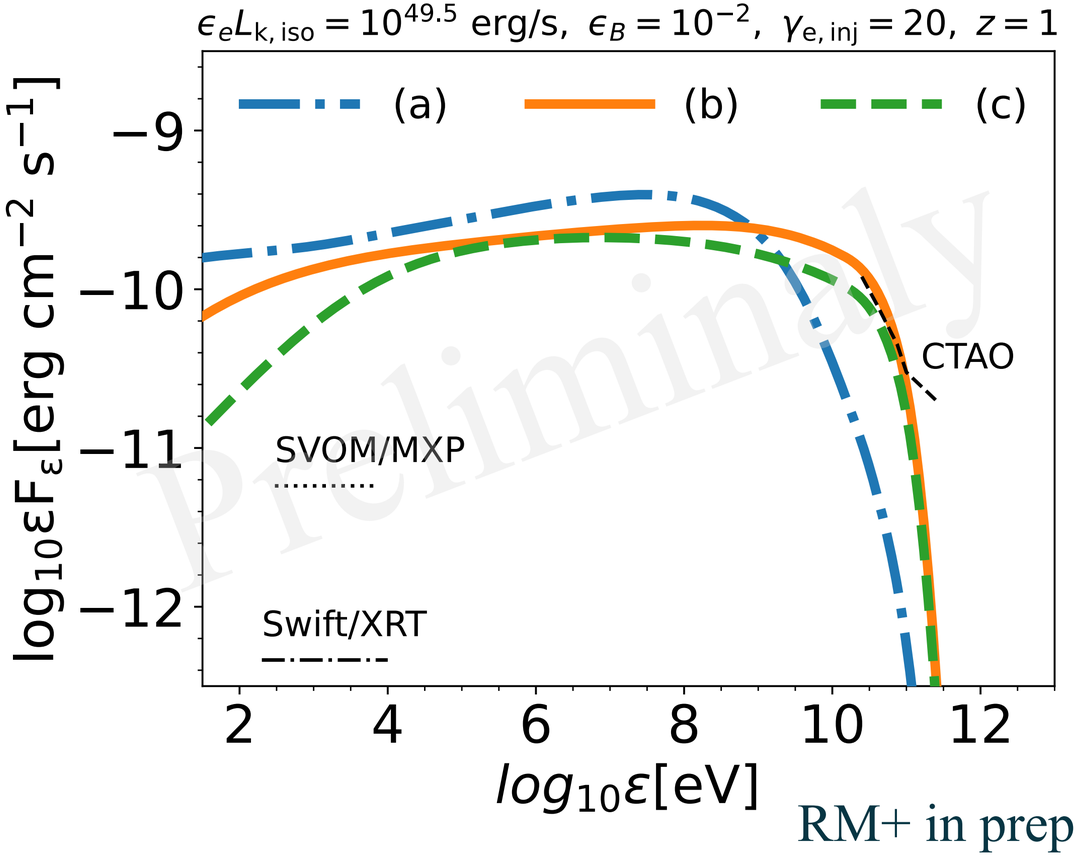


Duque+22

My work: Multi-wavelength expectation

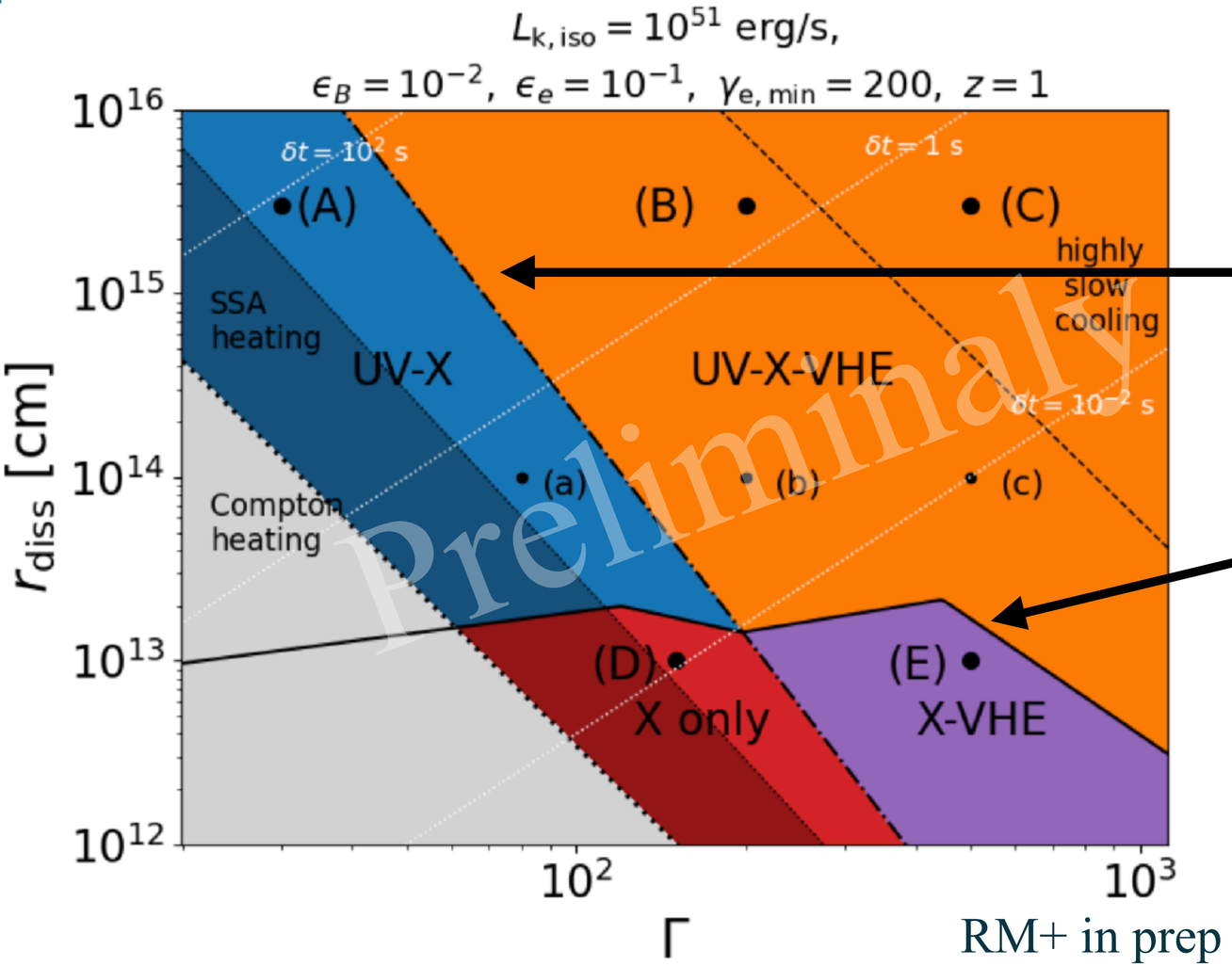
Multi-wavelength Detectability





Possible detection in UV, X-ray, and subTeV γ.

Multi-wavelength Detectability



RM+ in prep

$\gamma\gamma$ at 10 GeV

SSA at 30 eV

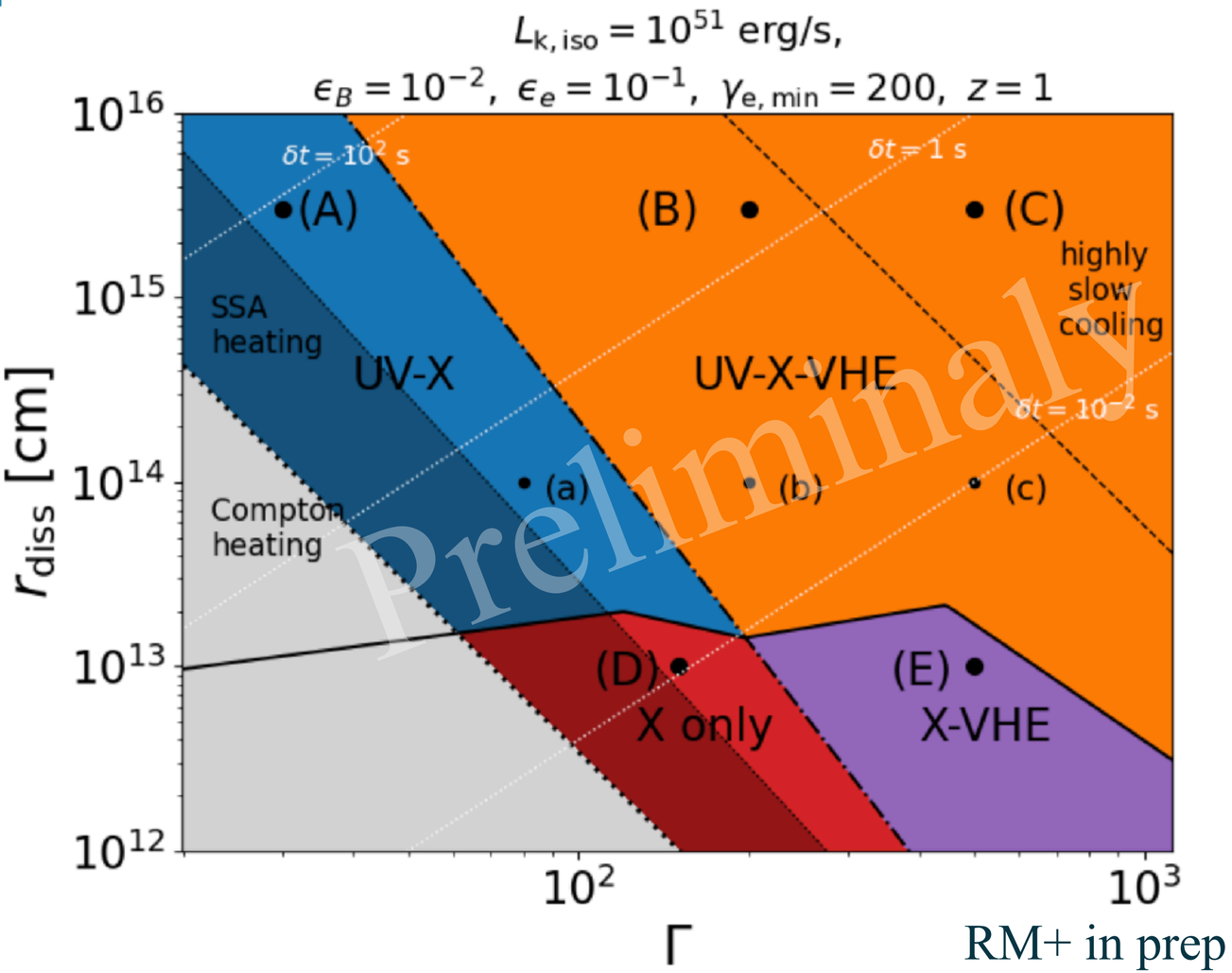
$X \rightarrow L_{jet}$

$UV \rightarrow r$

$VHE \rightarrow \Gamma$

(Non)detection provides R and Γ.

Multi-wavelength Detectability



RM+ in prep

Swift/UVOT

Observations are conducted.
30% of GRBs have flares.
Association?

CTAO

→ ~ 1 deg localization

→ Swift/BAT detection

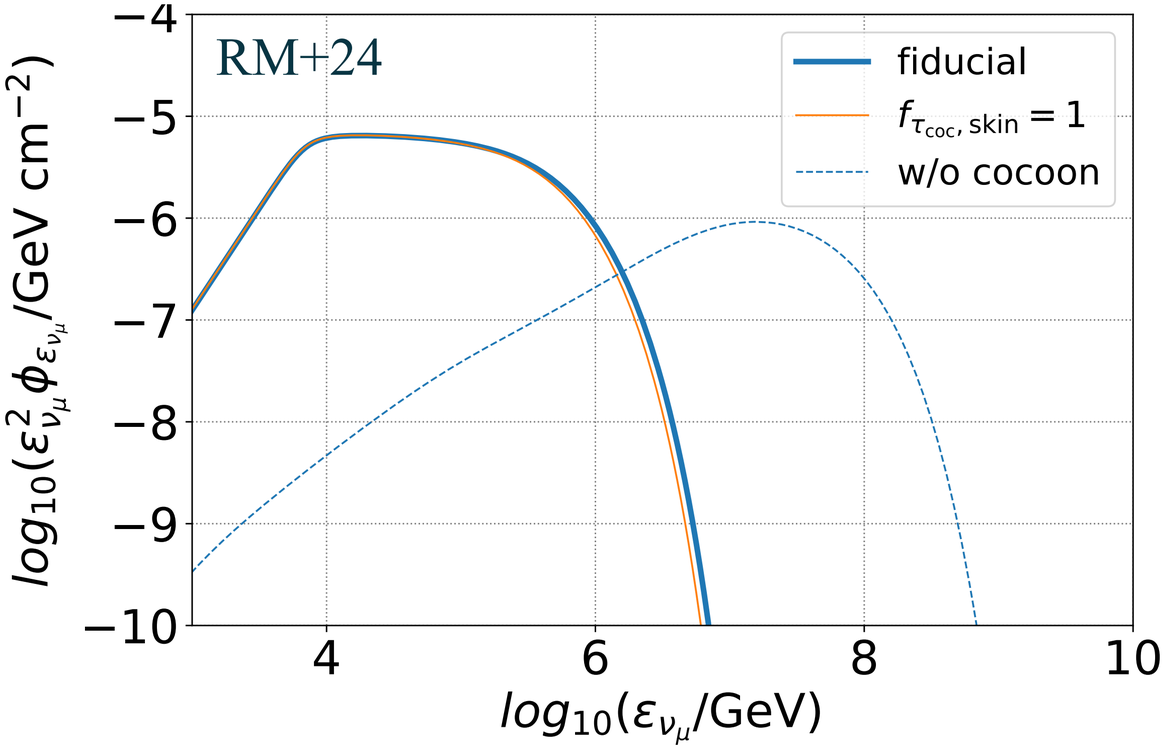
→ 80 GRB/yr

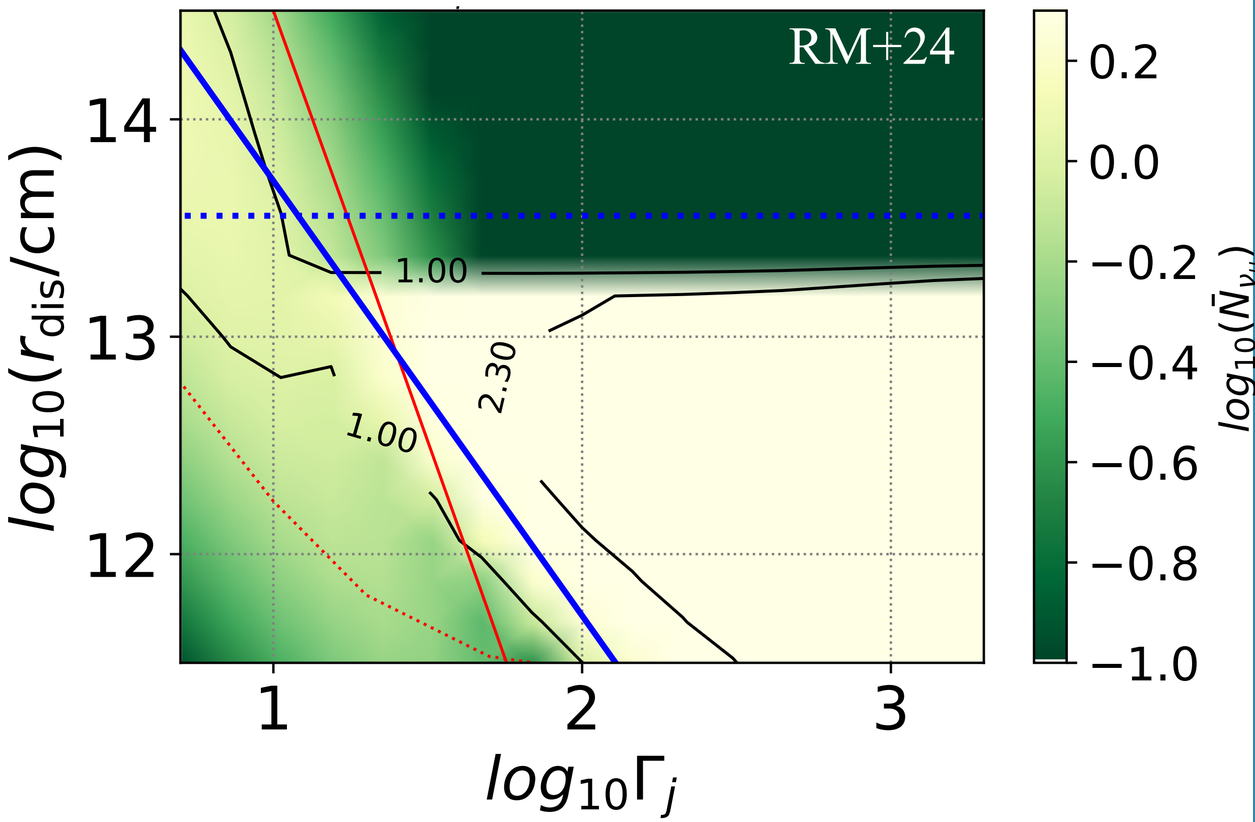
→ 20 GRB($z \lesssim 1$)/yr

→ 7 flare($z \lesssim 1$)/yr

→ 0.7 CTAO flare/yr

Neutrino Detectability





Possible detection by IceCube-Gen2 (10yr stack)

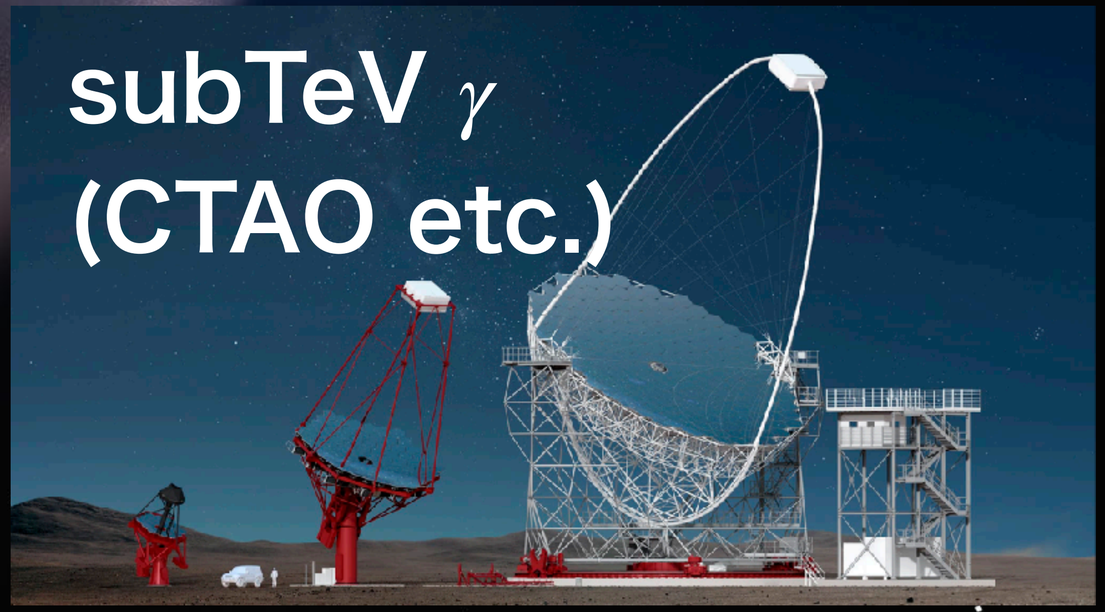
(Non)detection provides (r, Γ) and the proton fraction.

We need a combination

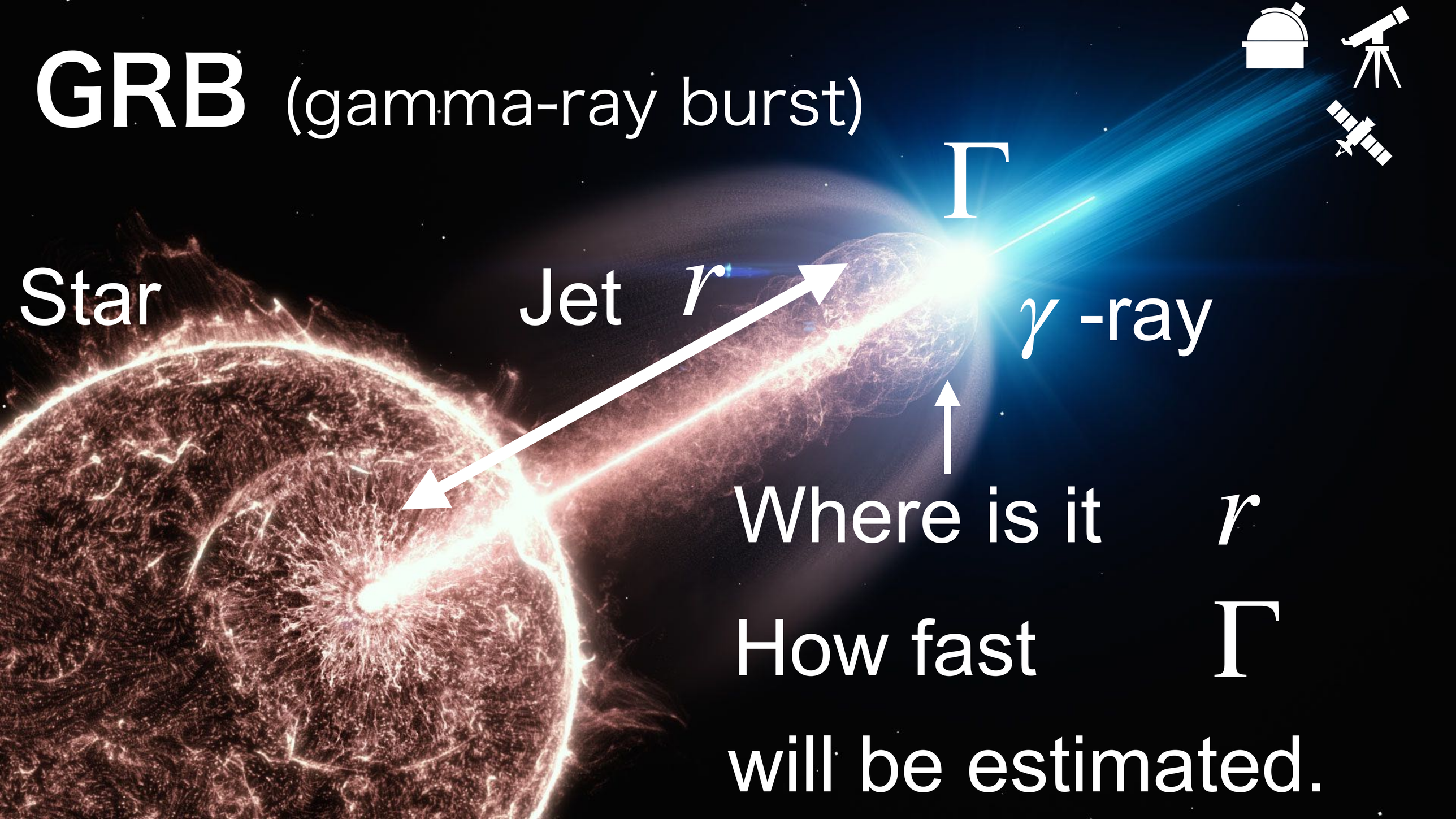
X, γ-ray
(EP, SVOM, HiZ. etc.)

UV-optical
(SVOM, HiZ. etc.)

Neutrinos
(IceCube etc.)



subTeV γ
(CTAO etc.)


GRB (gamma-ray burst)
Star
Jet
r
Γ
γ -ray
Where is it r
How fast Γ
will be estimated.

Summary

- It is difficult to detect multi-wavelength emission from (main burst of) GRBs

  due to the short duration $\sim$ 10 s.

- X-ray flare at 100-1000 s after the GRB is good to observe in multi-wavelength.

- **I found that** Future UV, subTeV, and Neutrino observations will reveal the jet physics.