(LC et al 2015. prelim results)

Three-dimensional simulations of variable GRB jets

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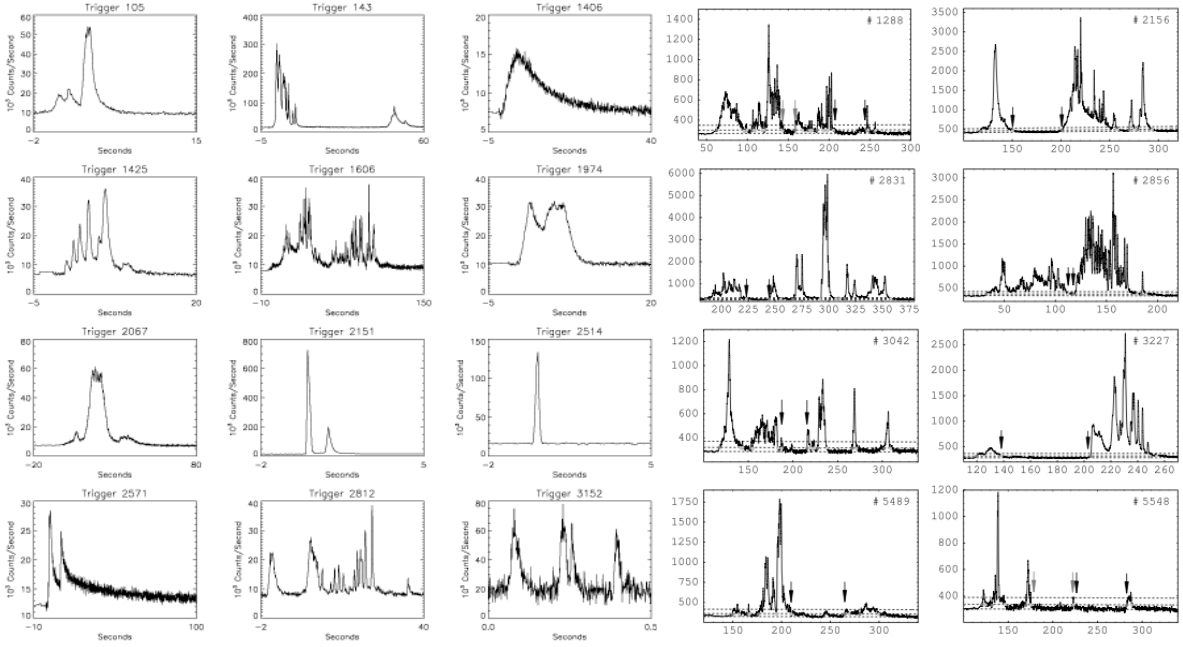
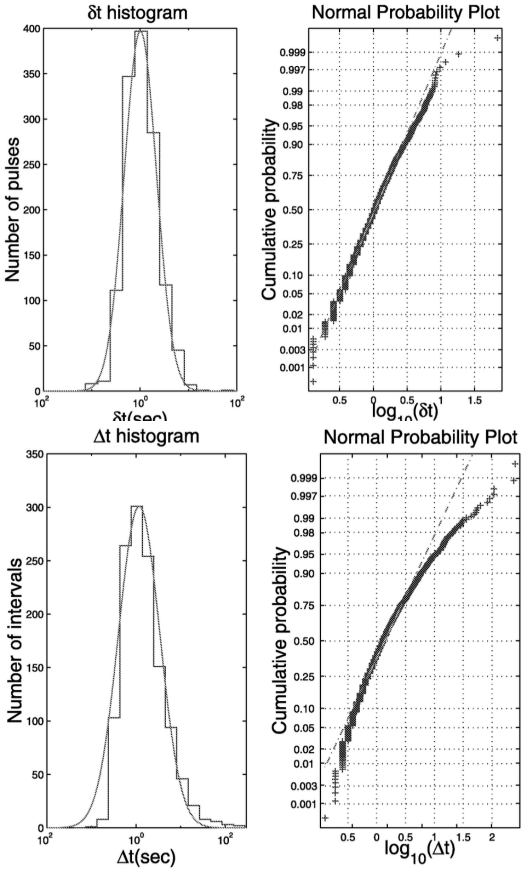
GRBs (no GRB is the same as any other)

> 4000 and all are ≠



(Borgonovo et al. 2007)



(Drago & Pagliara 2007)

(Nakar & Piran 2002)

Variability in a high fraction on GRBs

$\Delta t_{active} \approx \Delta t_{quiescence}$

Δt_{active} process

≠

$\Delta t_{quiescence}$process

Objective

3D simulations of variable GRB jets

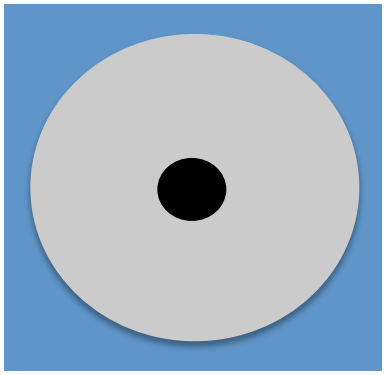
$\Delta t_{active} + \Delta t_{quiescence}$

Comparison vs observations

Model (3D variable jet + progenitor + ISM)

Progenitor

16 M_o (16TI Woosley & Heger 2006)



ISM

$\rho_{ISM} = 10^{-10}$ g cm^{-3}

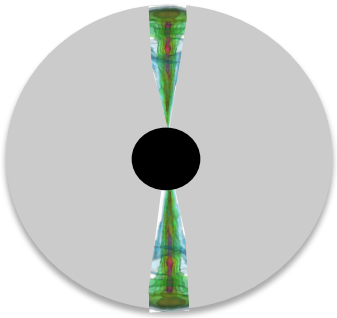
Jet

$L = 5.33 \times 10^{50}$ erg s^{-1}

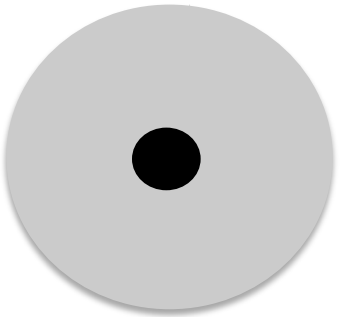
$r_0 = 10^9$ cm ($\Delta M \approx 12\ M_\odot$)

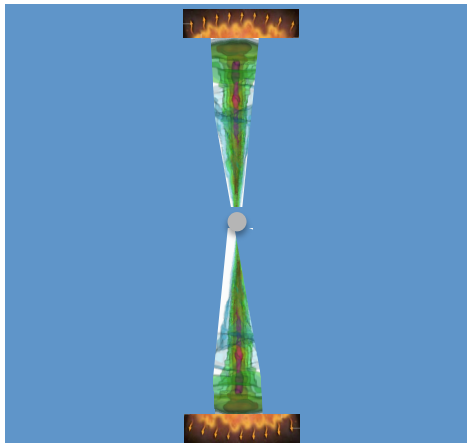
$\Gamma_0 = 5$ (Γ_∞=400)

$\theta = 10^\circ$



or





…Emission

Model (3D variable jet + progenitor + ISM)

Model	3D/2D	$\Delta t(s)$	$t_{max}(s)$	Δ	$t_{bo}(s)$
m3D0.1lr	3D	0.1	17.40	LR	5.60
m3D0.5lr	3D	0.5	15.20	LR	7.80
m3D1.0lr	3D	1.0	17.13	LR	6.73
m3D2.0lr	3D	2.0	13.33	LR	6.80
m3D0.1hr	3D	0.1	13.50	HR	11.00
m3Donlr	3D	always on	7.80	LR	5.27
m2D0.1lr	2D	0.1	50.00	LR	5.02
m2D0.5lr	2D	0.5	50.00	LR	10.07
m2D1.0lr	2D	1.0	50.00	LR	11.93
m2D2.0lr	2D	2.0	50.00	LR	12.34
m2Dranlr*	2D	random	50.00	LR	-

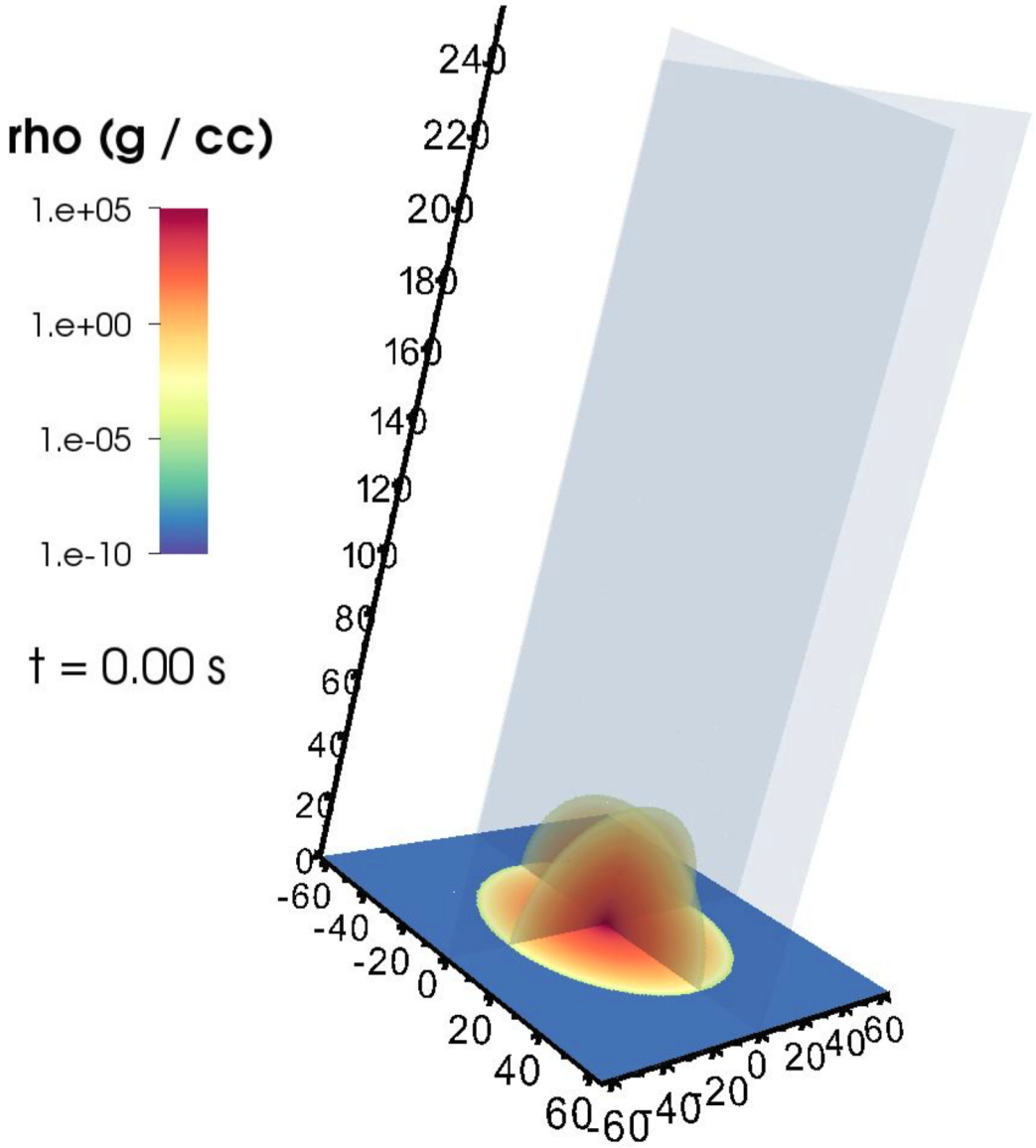
*Note: 20 models

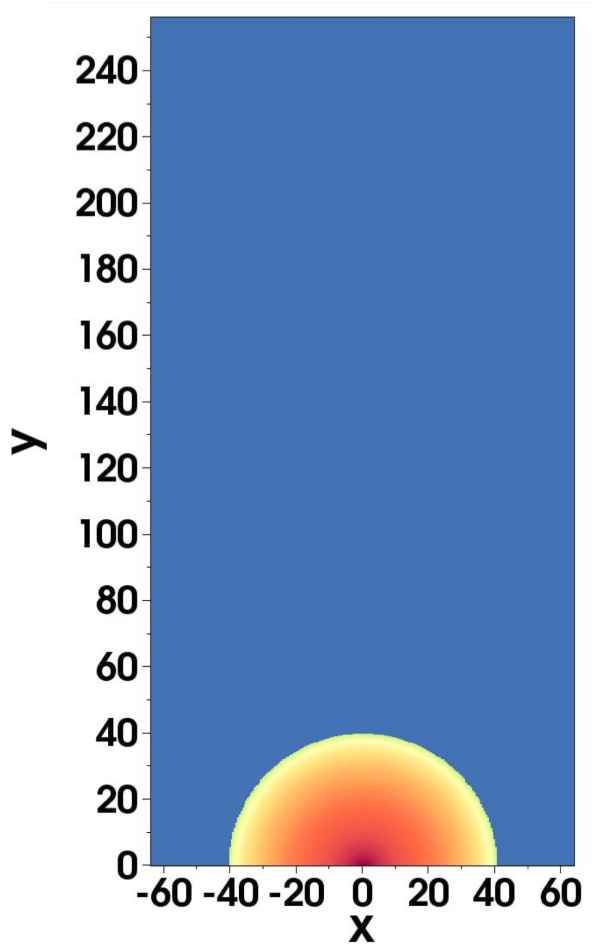
Flash 2.5 (3D+AMR) (Fryxell et al 2000)

Mesh: (5.12, 25.60, 5.12) x 10^{11} cm

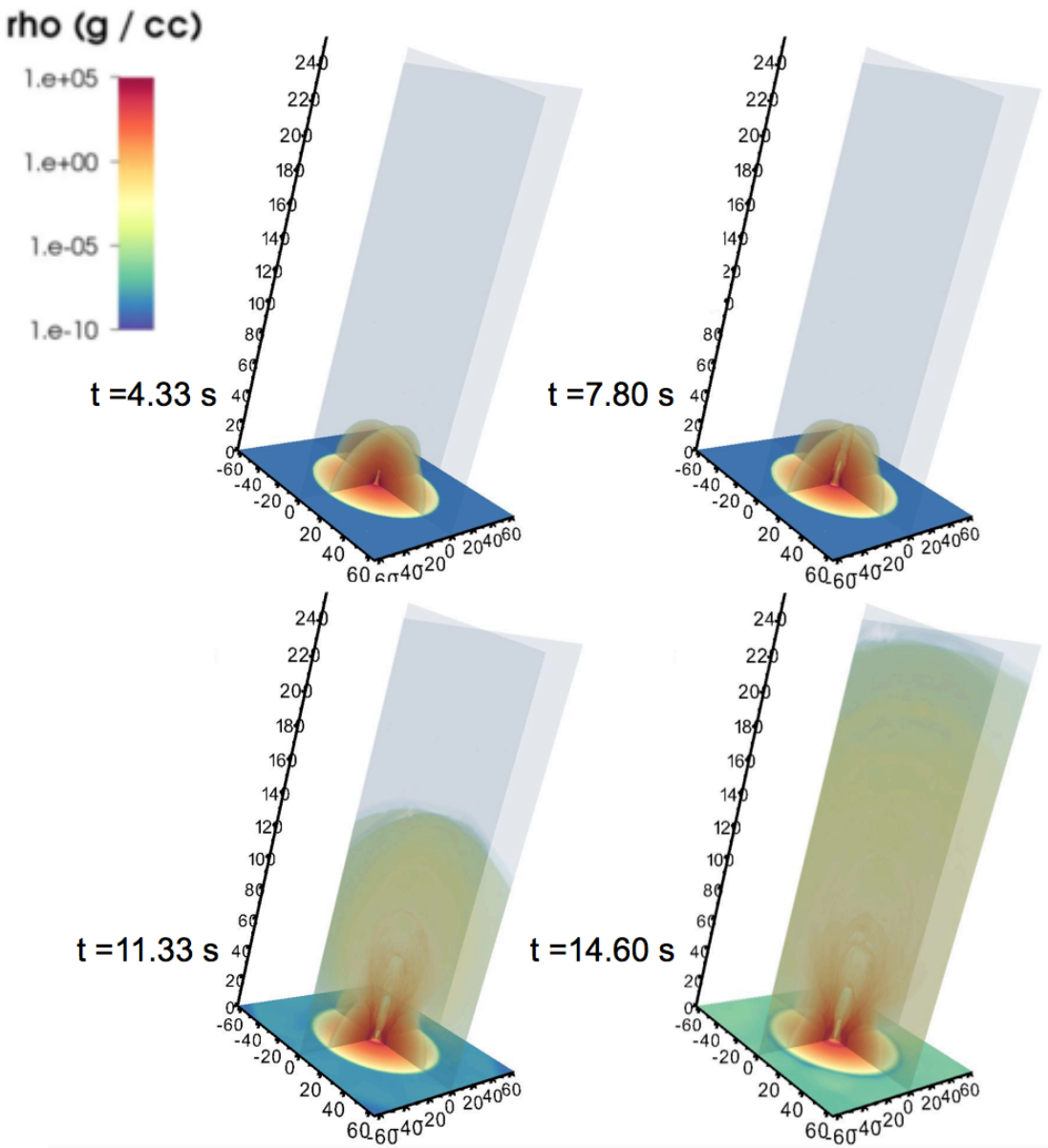
Resolution: $\Delta x = \Delta y = \Delta z = 7.8125 \times 10^{6}$ cm

Results (3D 0.5 s pulsed model)





Results (3D 0.5 s pulsed model)



Pulses ↓ρ – ↑Γ

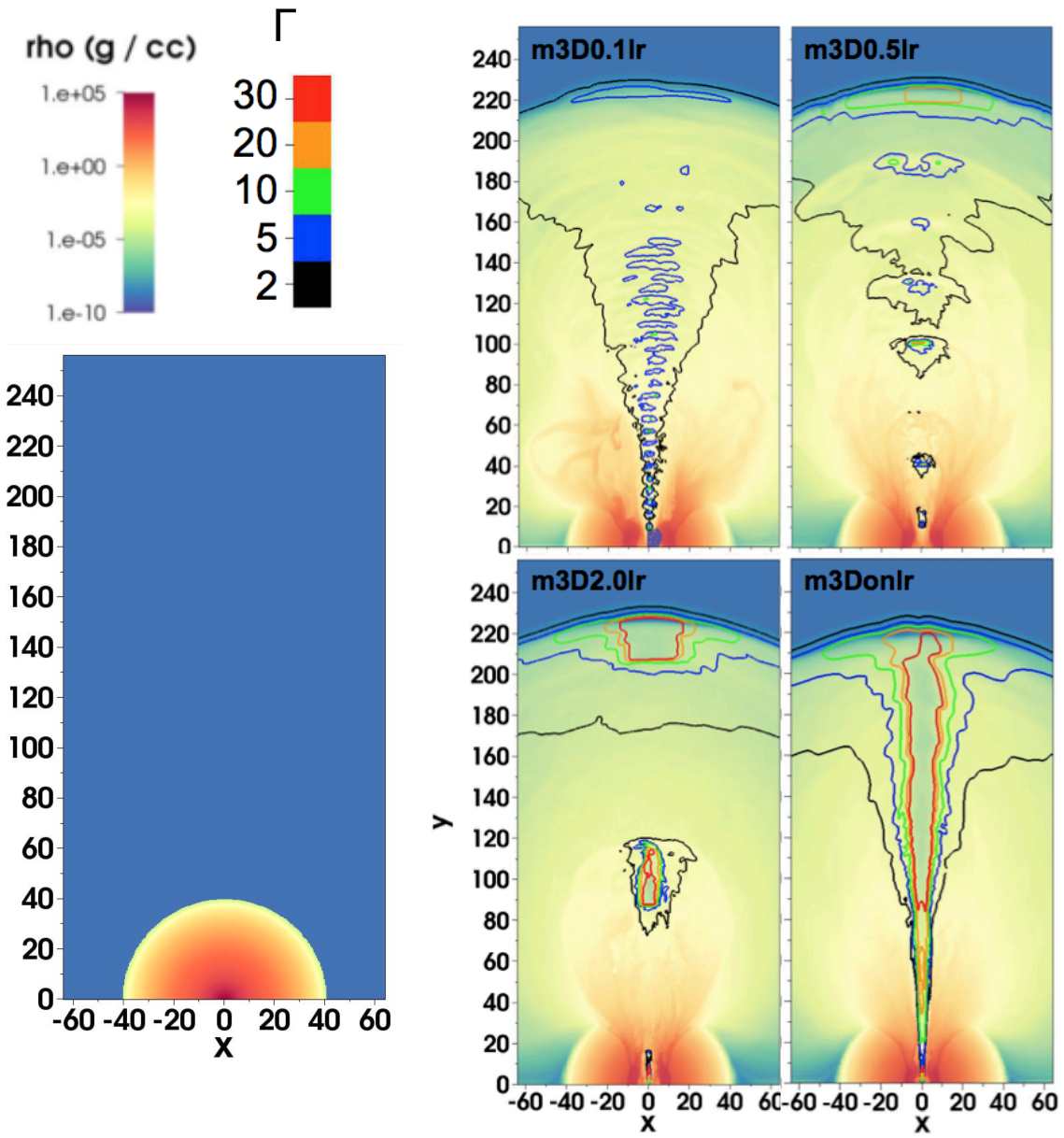
t_{bo} = 7.8 s

2 phases

pre-t_{bo} (↓-relativistic)

post-t_{bo} (ultra-relativistic)

Results (3D pulsed models)



Pulses ↓ρ – ↑Γ

t_{bo} = 7.8 s

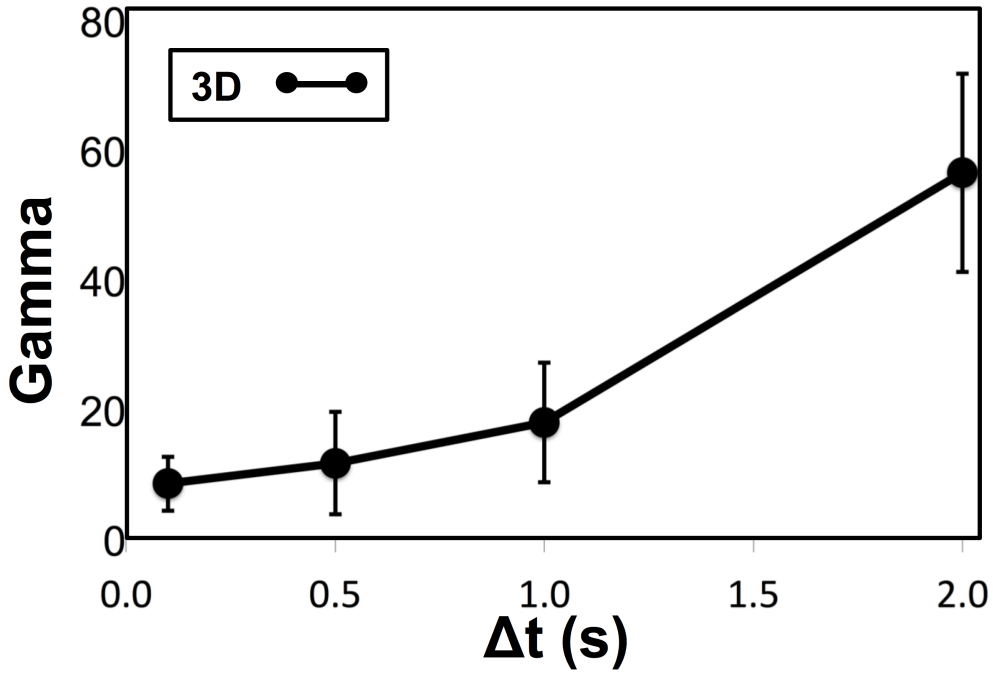
2 phases
pre-t_{bo} (↓-relativistic)
post-t_{bo} (ultra-relativistic)

Γ > 30

Same behaviour in all models (≠ t_{bo} , ≠ Γ)

Γ α Δt ?

Results (3D pulsed models)



Pulses ↓ρ – ↑Γ

t_{bo} = 7.8 s

2 phases
pre-t_{bo} (↓-relativistic)
post-t_{bo} (ultra-relativistic)

$\Gamma > 30$

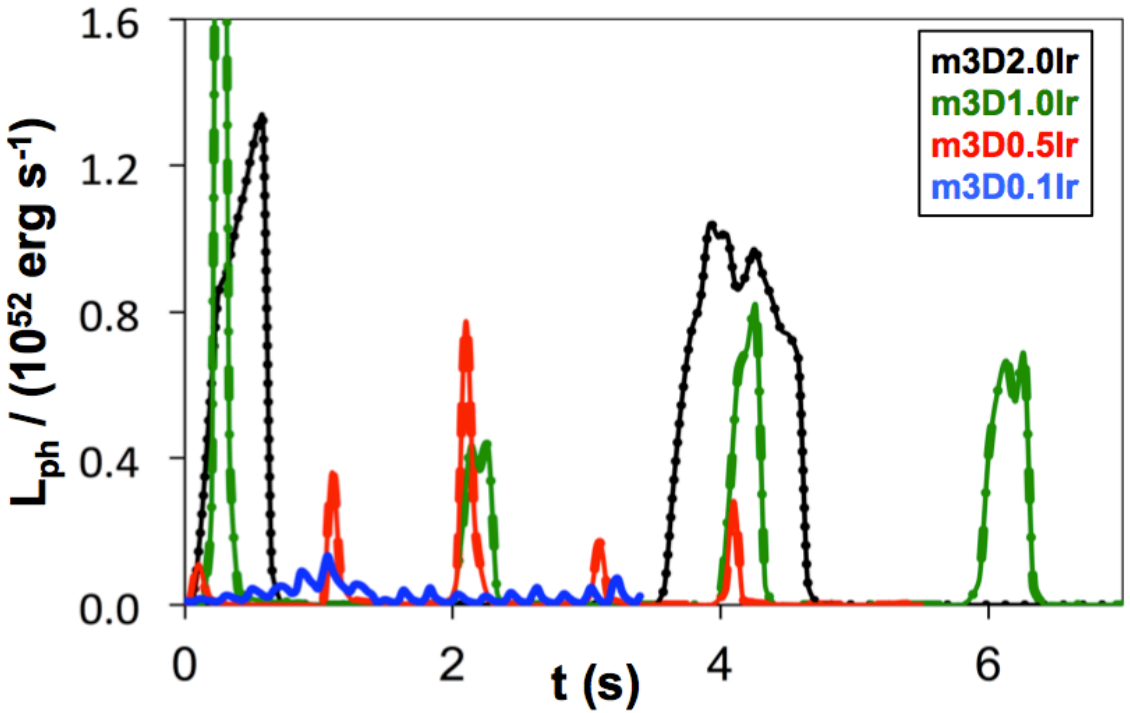
Same behaviour in all models ($\neq t_{bo}$, $\neq \Gamma$)

$\Gamma \propto \Delta t$?

$\Gamma \propto \Delta t$ ✔

Results (photospheric luminosity)

Variability behavior present in the LC

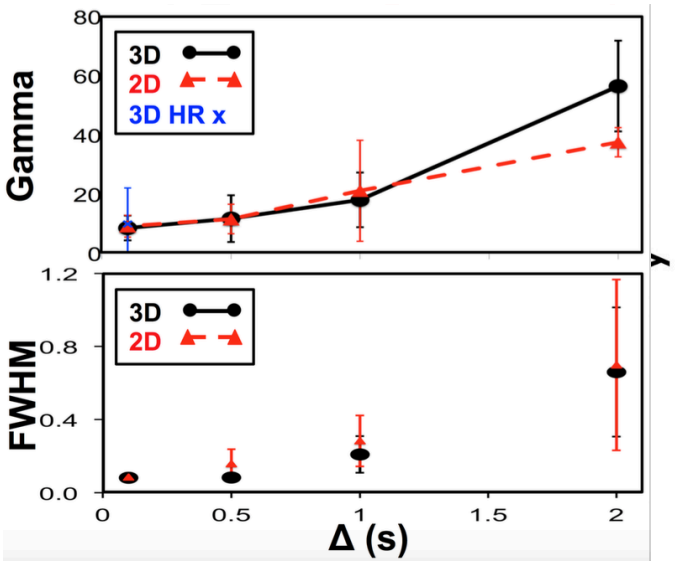


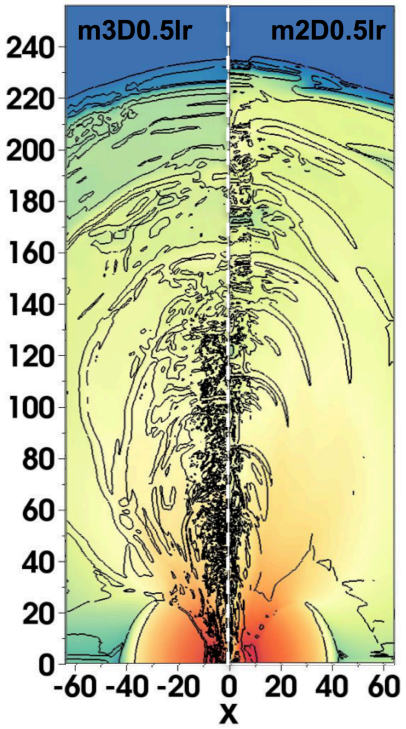
… 3D is expensive …

(in latin america we are somewhat used to this)

We ran a set of 2D models excatly the same input conditions as the 3D

Results (3D vs 2D)





t_{bo} 2D ≈ t_{bo} 3D (↑ 10%−50%)

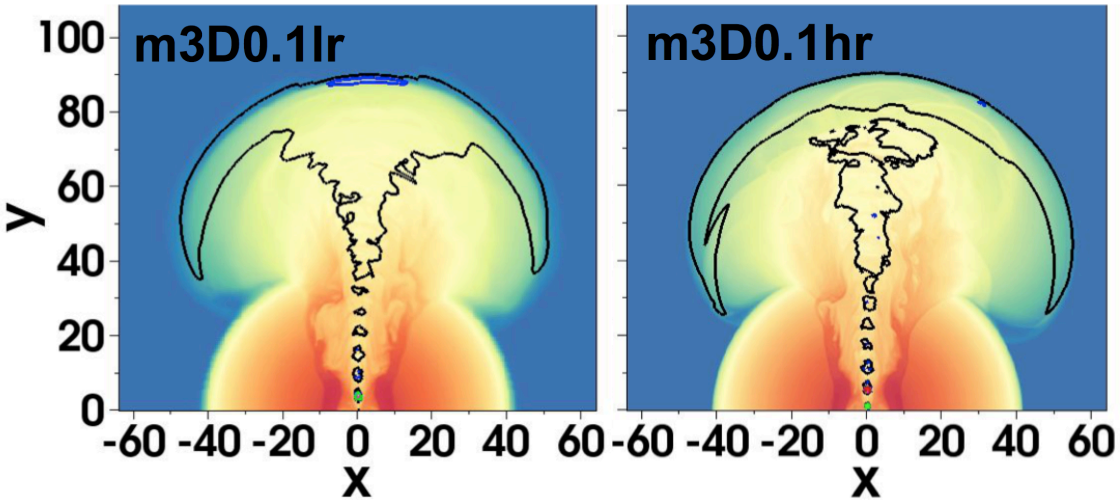
Γ α Δt ✔

FWHM within ≈ (±1σ)

≈ Schlieren maps (turbulence) ✔

Gral characteristics (ρ, Γ) ✔

2D ✔✔



HR has more turbulence

t_{bo} are comparable (≈ 2 times)

Gral characteristics (ρ, Γ) ✔

Resolution ✔✔

Results (photospheric luminosity… round 2)

Photospheric emission & comparison with observations

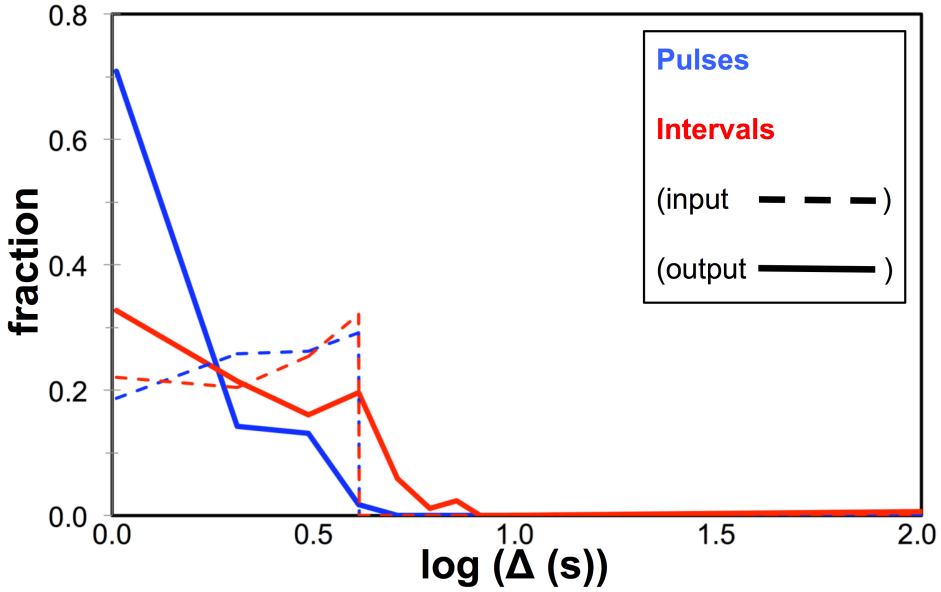
(using 2D models with the resolution we trust)

We ran twenty variable jet models with random Δt_{active} & $\Delta t_{quiescece}$

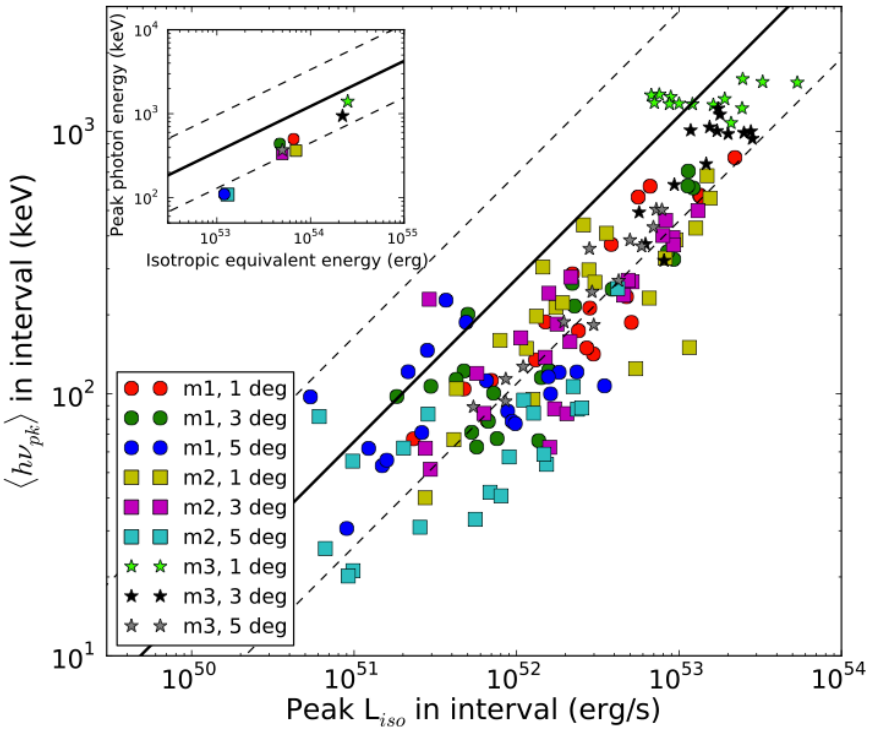
(Δt_{active} & $\Delta t_{quiescece}$ between 0-4 s)

Results (photospheric luminosity)

Distribution of the Δt_{active} & $\Delta t_{quiescence}$



(LC et al 2014)



Models ✓ with Nakar & Piran 2002:

Δt_{active} distribution ≠ $\Delta t_{quiescence}$ distribution

But: Pulses & quiescence from same process

Golenetskii (aka internal Yonetoku) ✓

✓ with Fermi data (Lu 2012)

Conclusions

3D and 2D variable jet models (≈) break out of the progenitor

Pulsos ⬇ρ – ⬆Γ

$\Gamma > 30$, $\Gamma \propto \Delta t$ ✔

Variability behavior present in the LC

Pulses & quiescence ≠ distributions (but from same process)

Reproduces Golenetskii (internal Yonetoku)