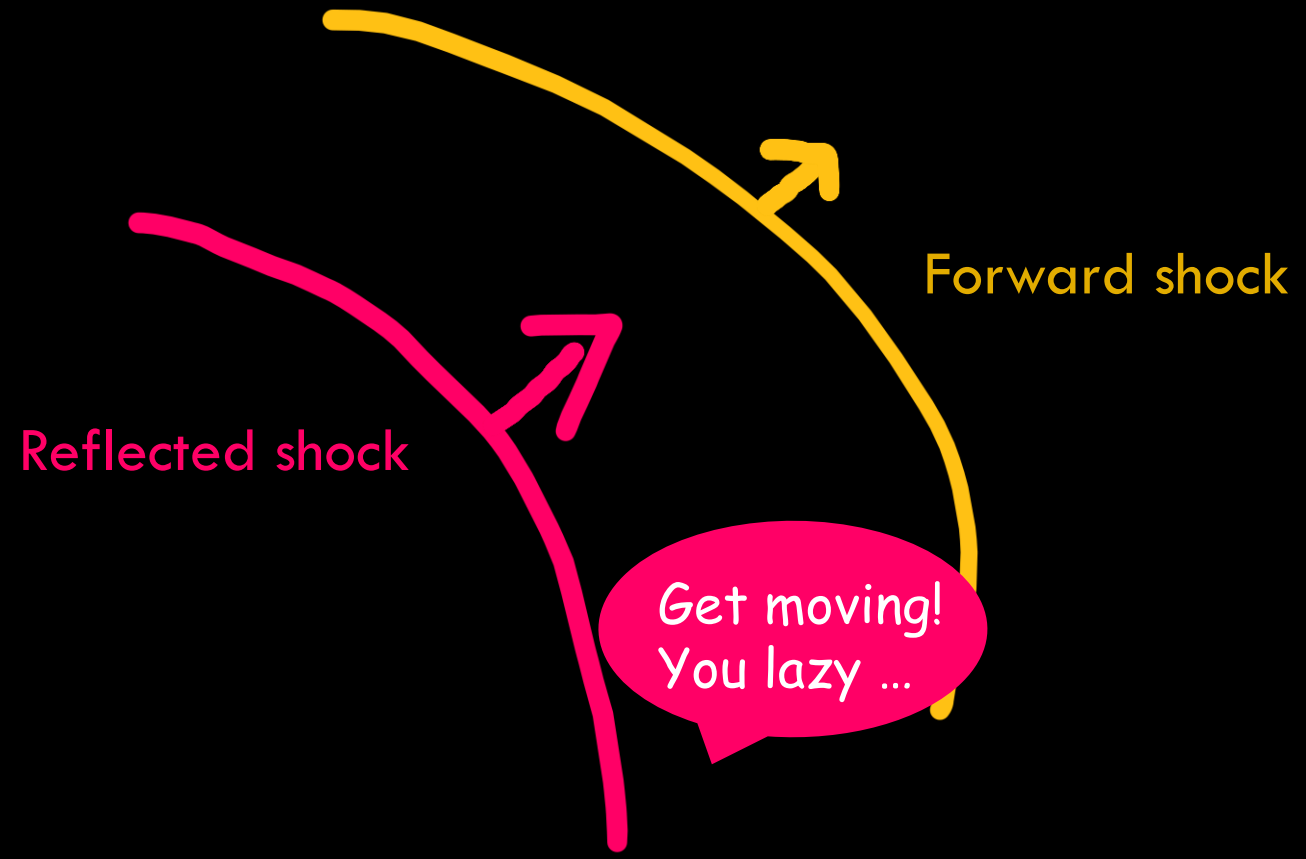


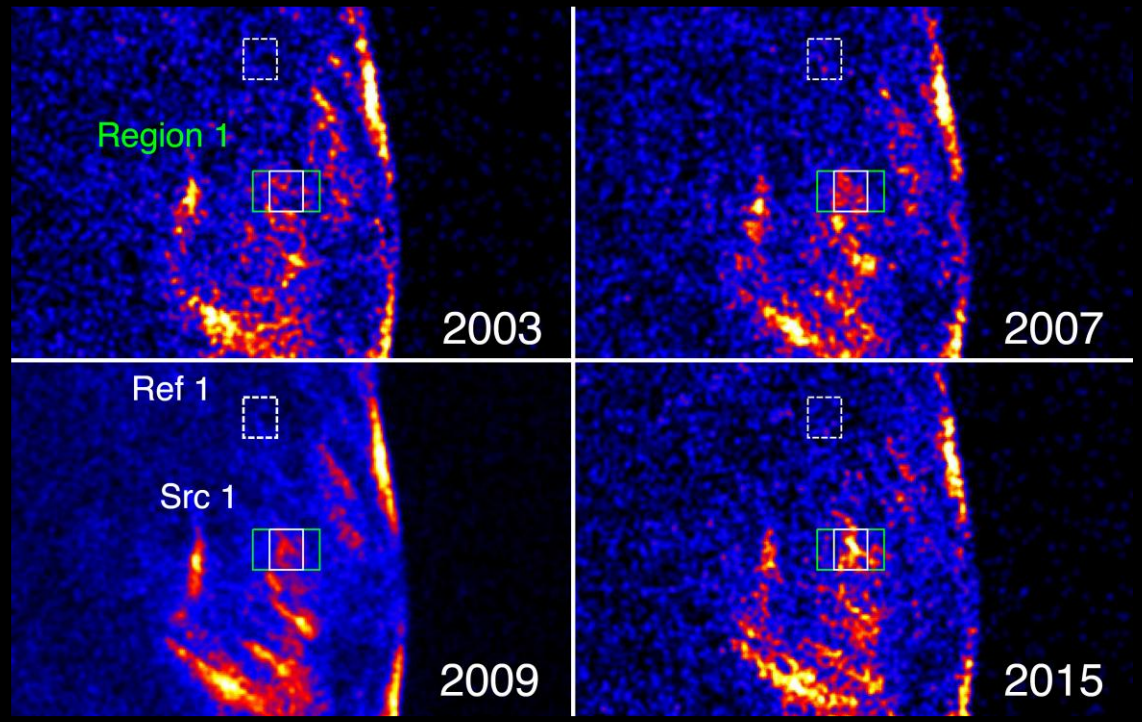
Variability of non-thermal emission from SNRs induced by reflected shocks

Iurii Sushch

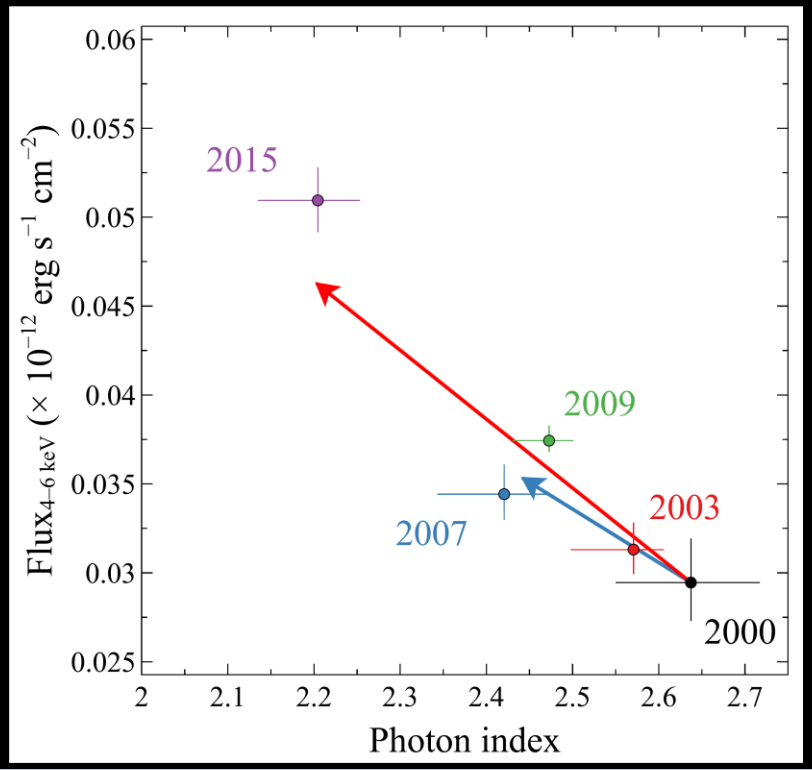
Robert Brose

Variability in SNRs

Localized X-ray variability in the Tycho SNR



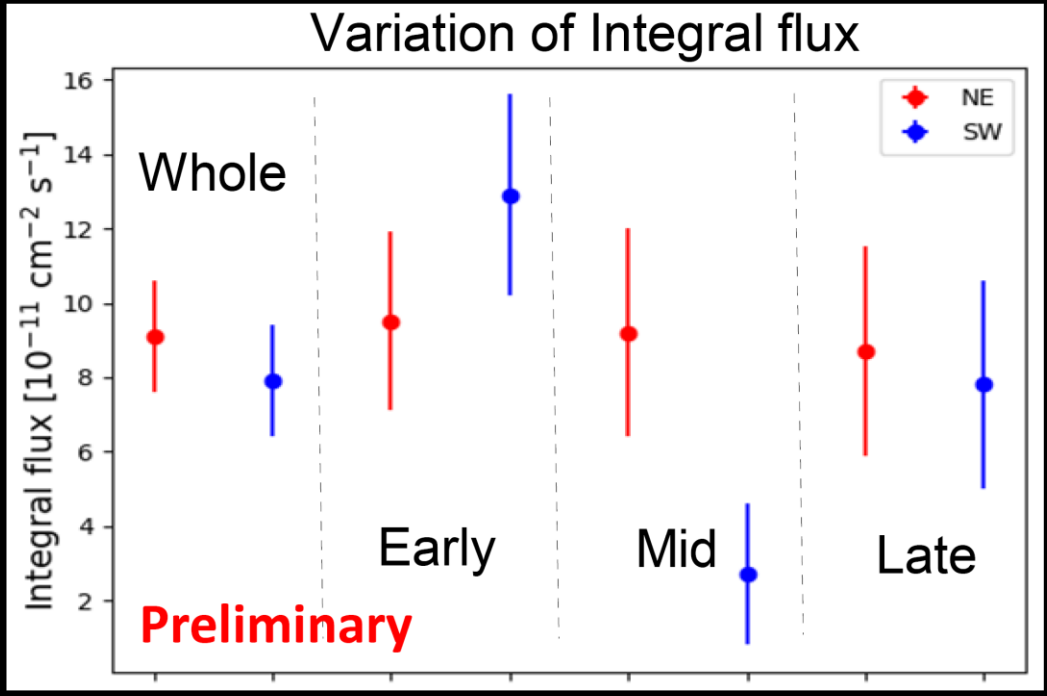
70% brightening over 12 years accompanied by the significant hardening of the spectrum. *(Okuno et al. 2020)*

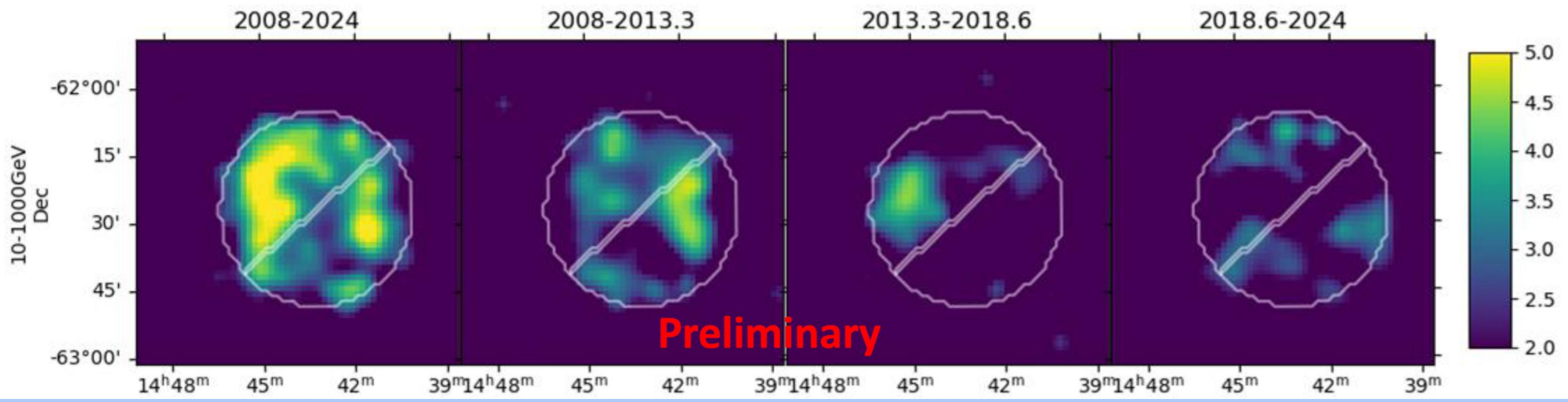


See the poster by Robert Brose

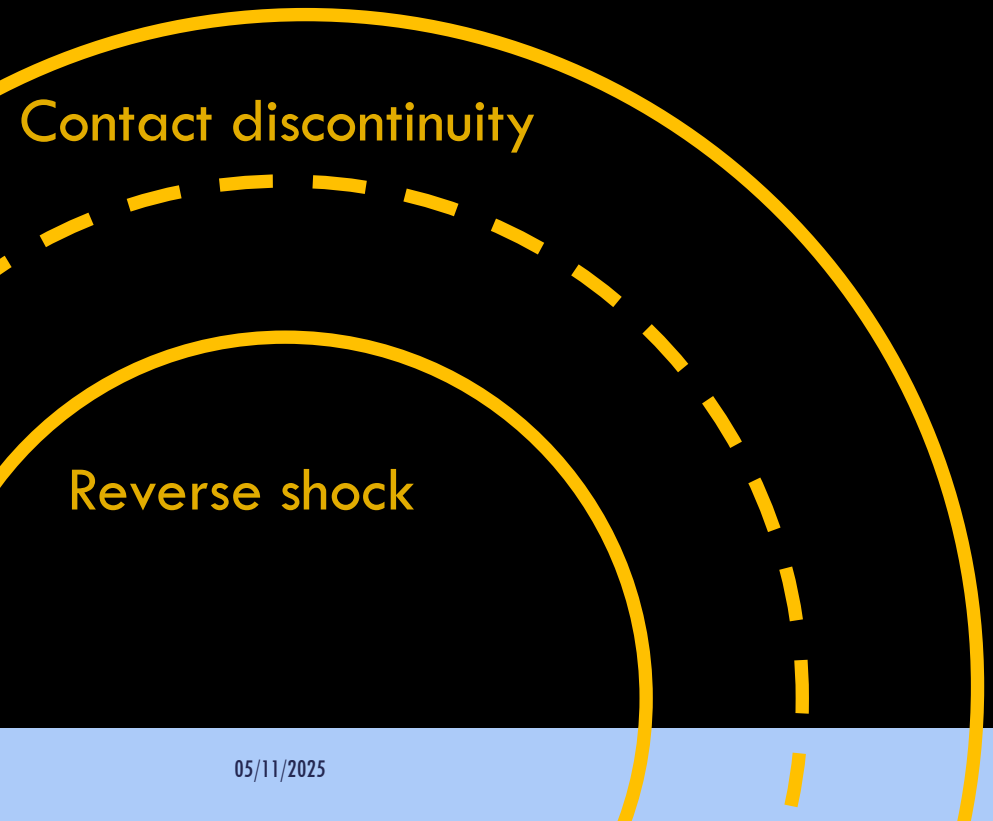
Variability in SNRs

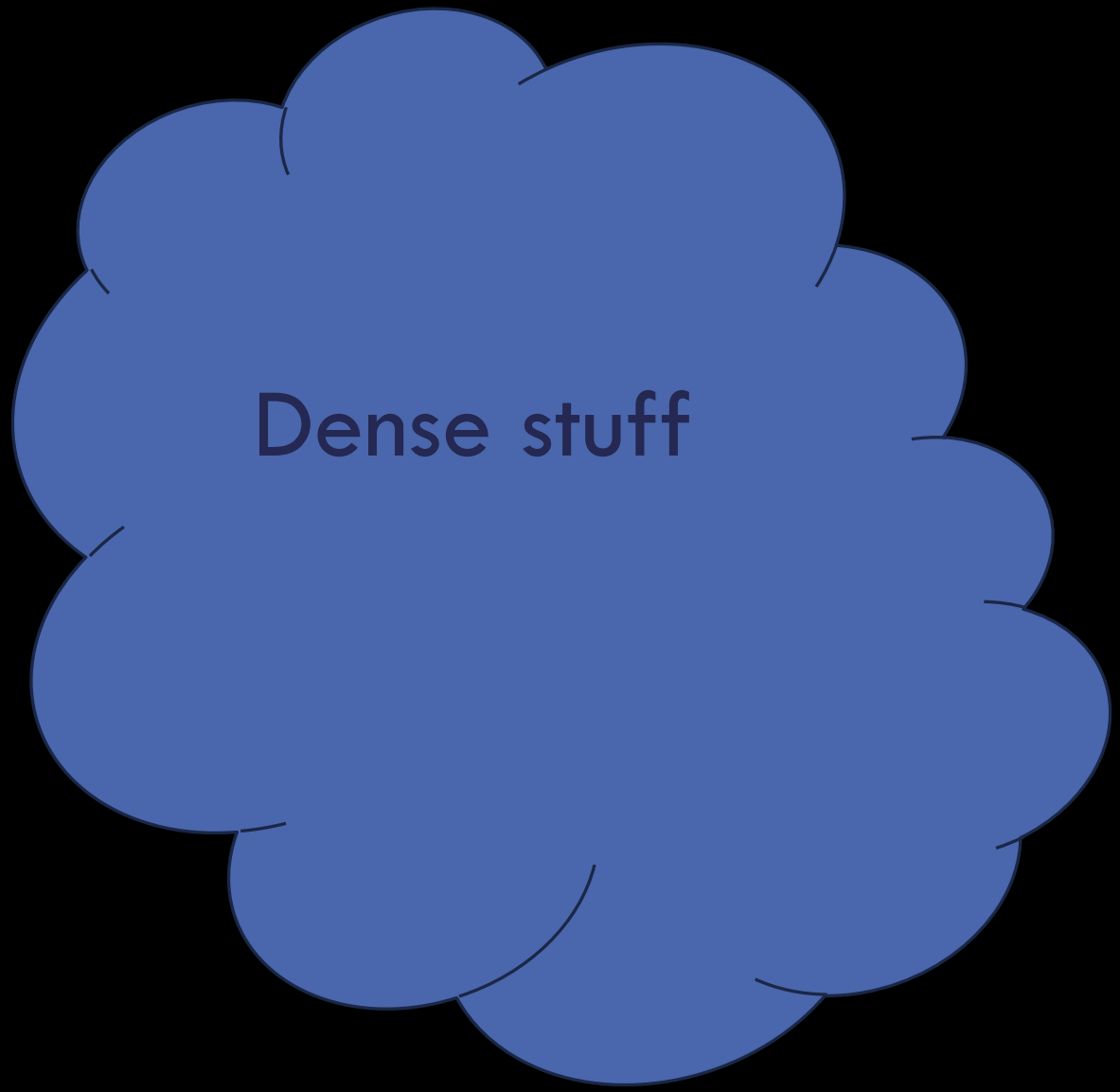
Hints of gamma-ray variability of RCW 86 as observed by Fermi-LAT



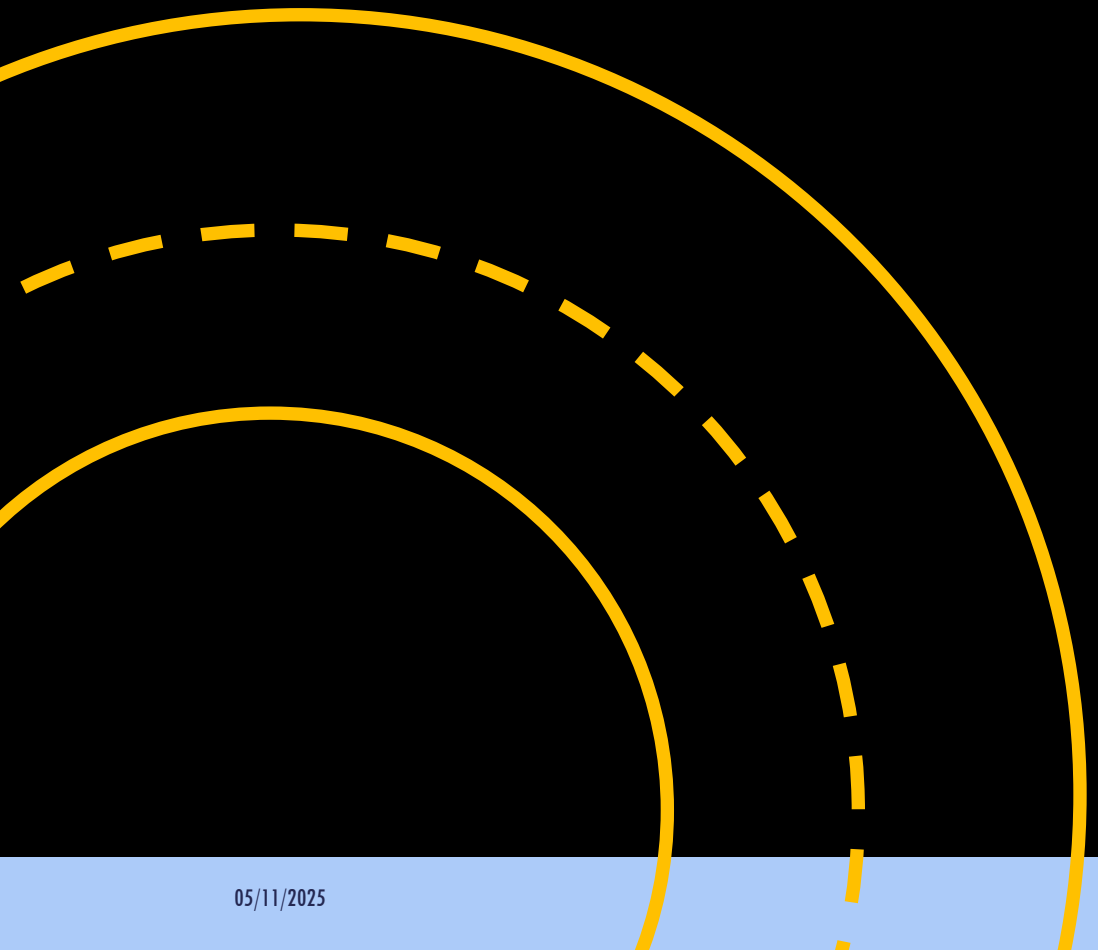


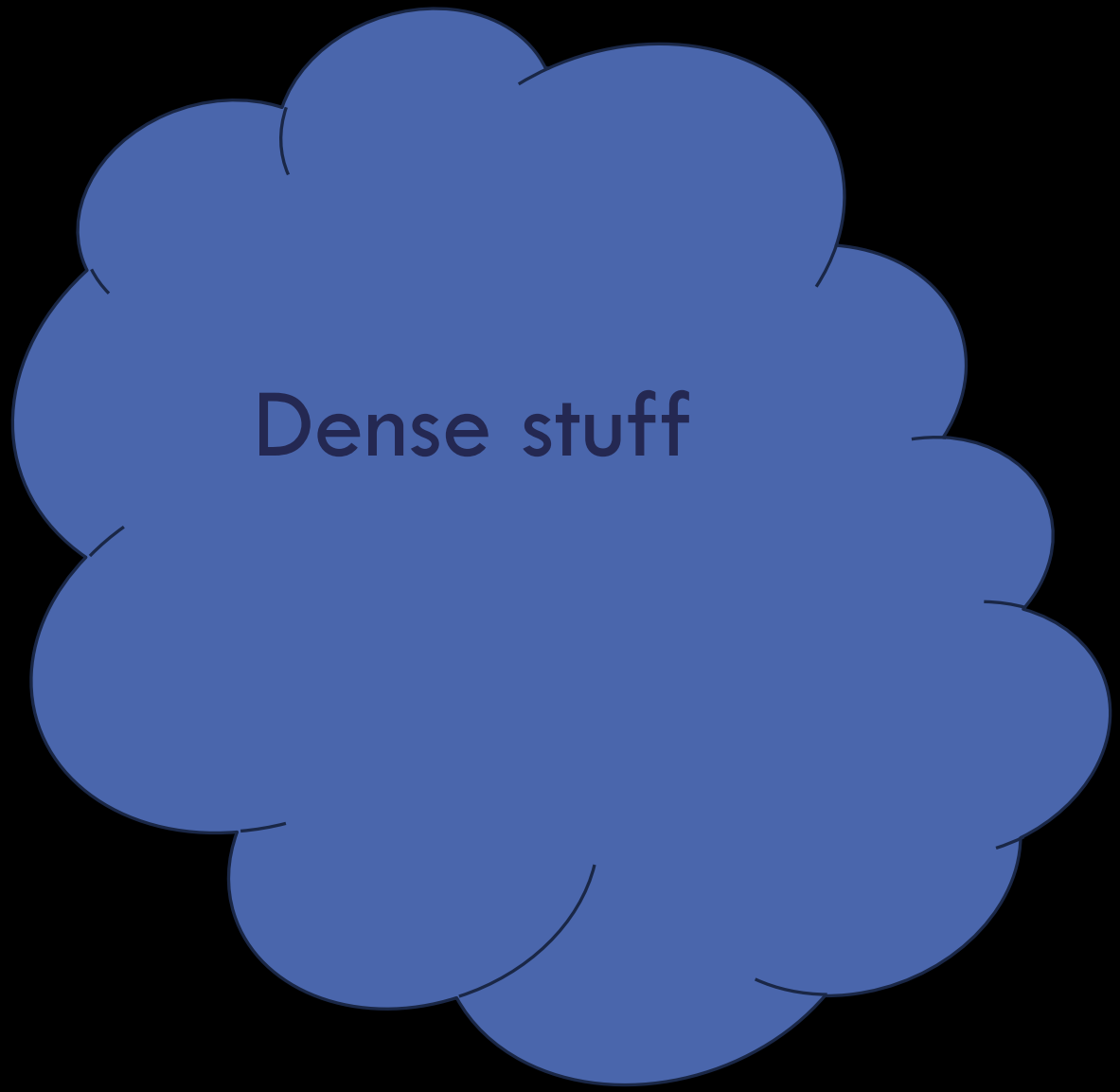
Reflected shock



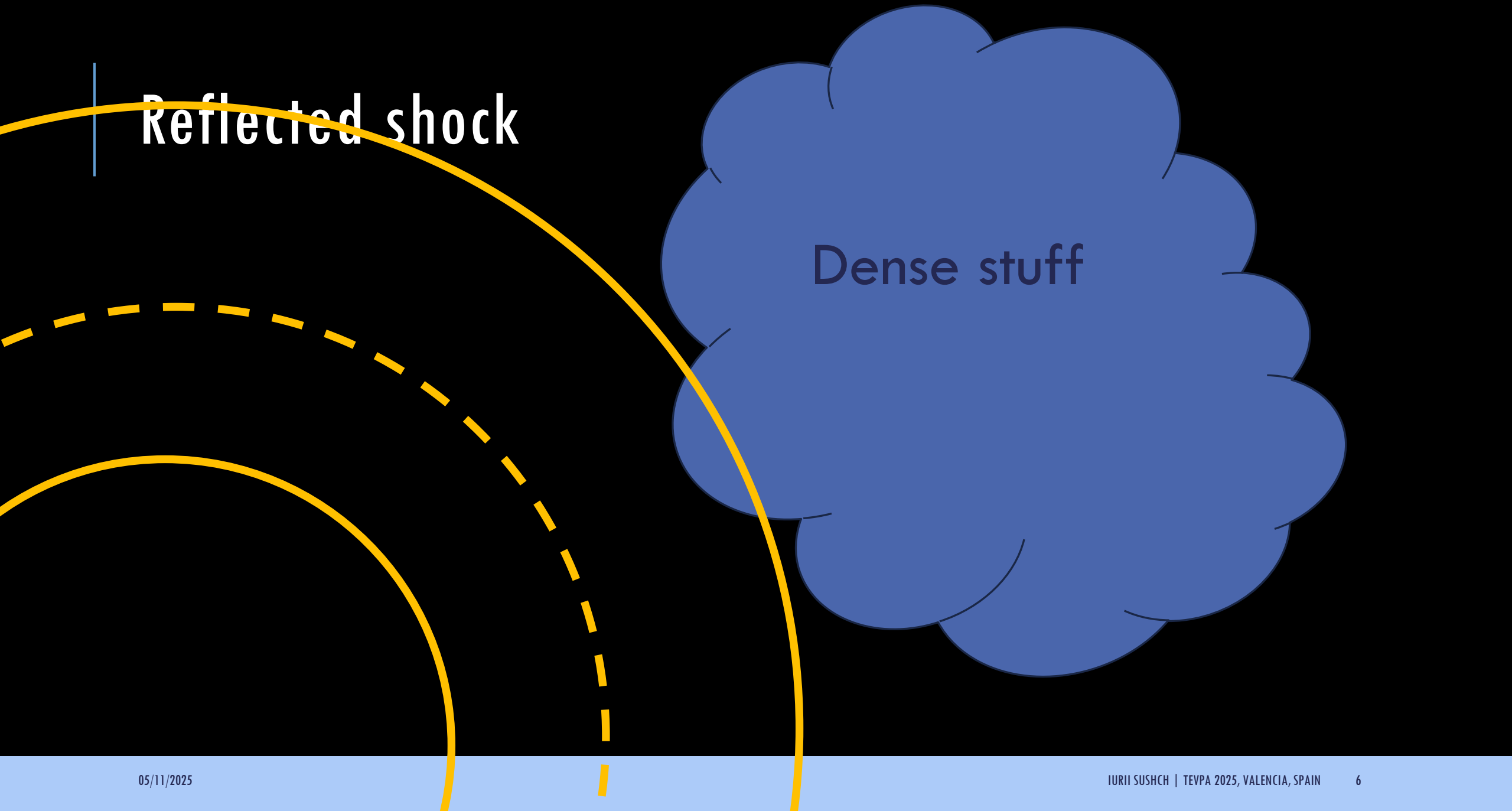


Reflected shock

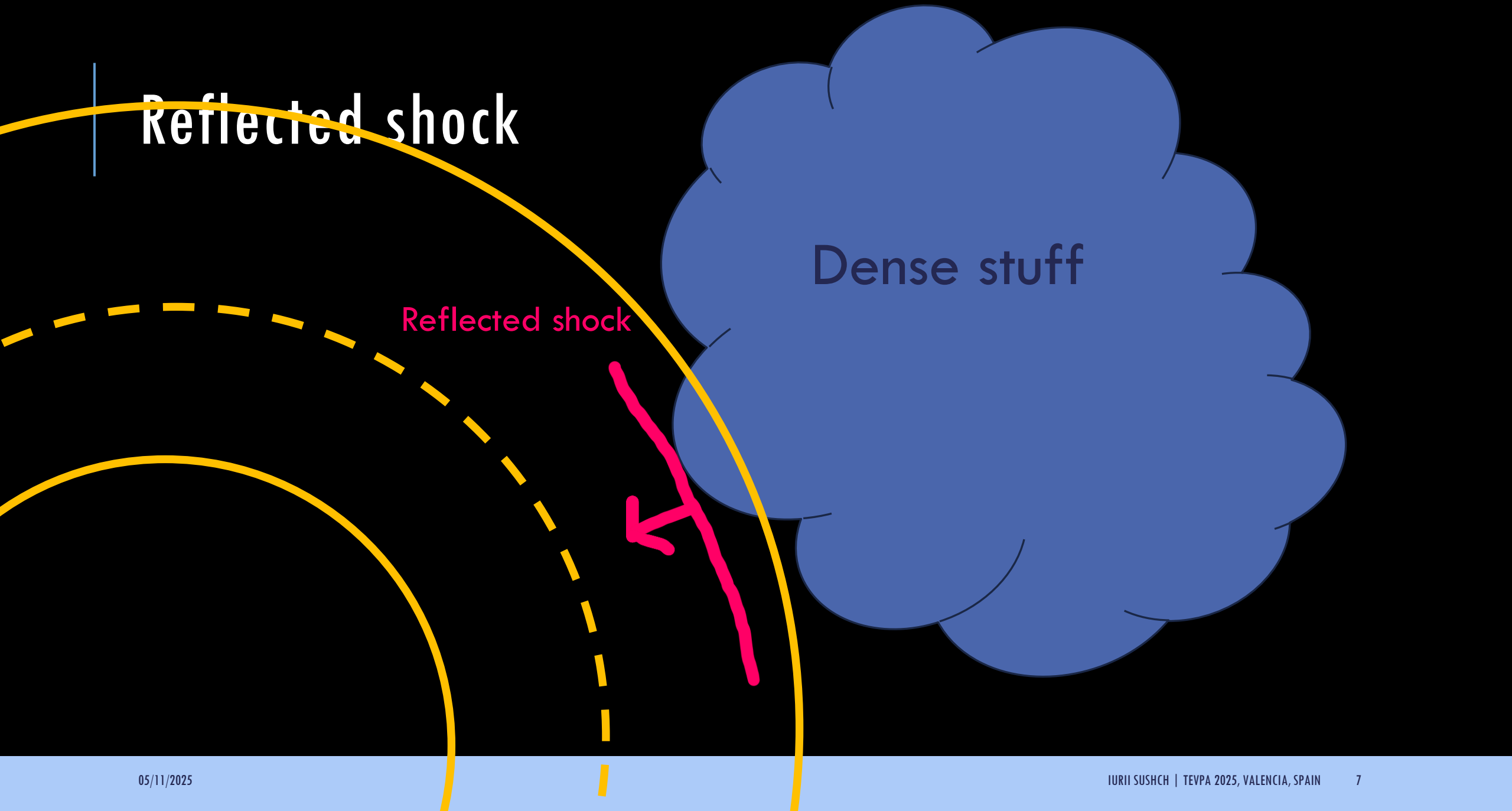




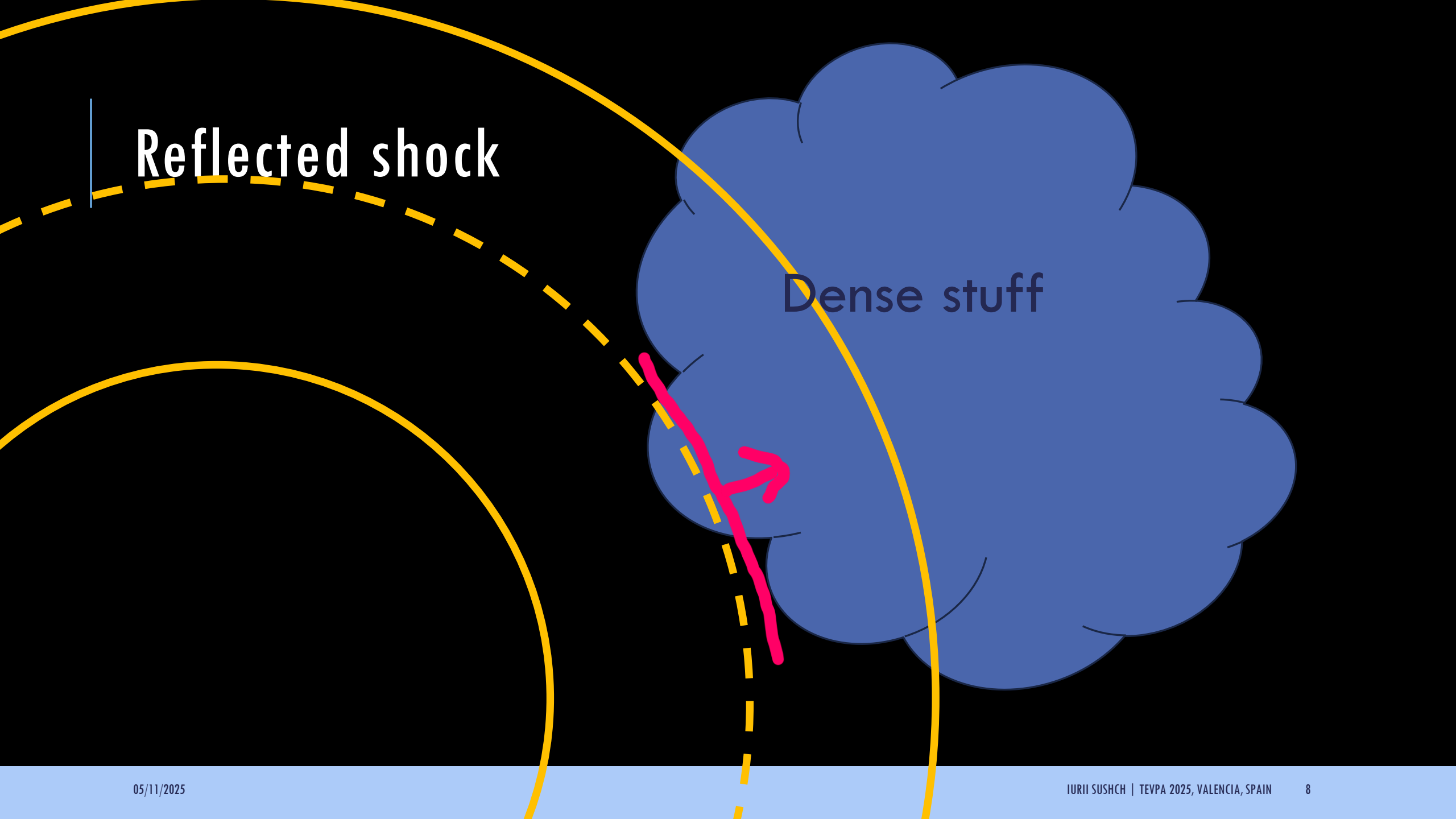
Reflected shock



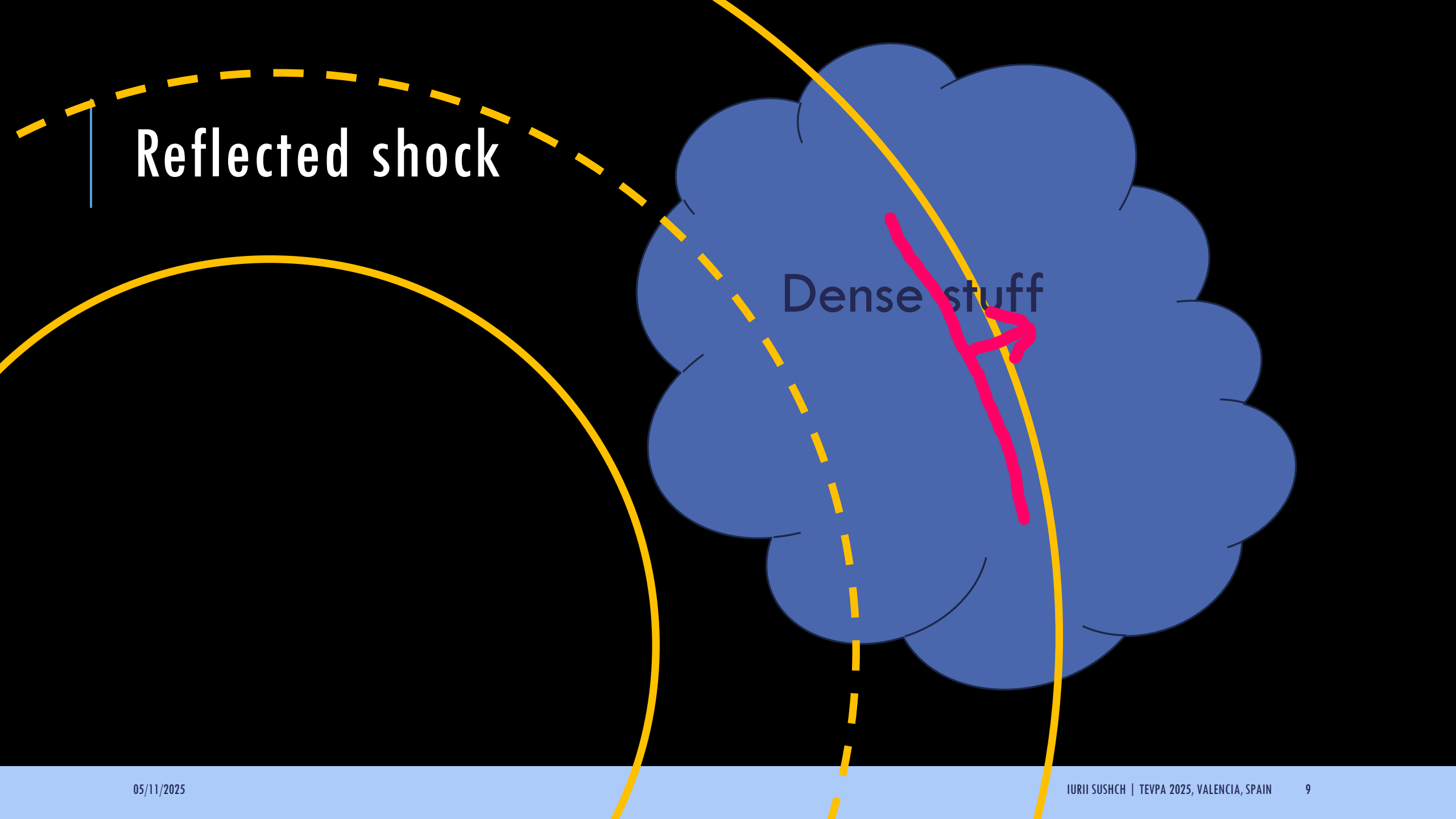
Reflected shock



Reflected shock



Reflected shock



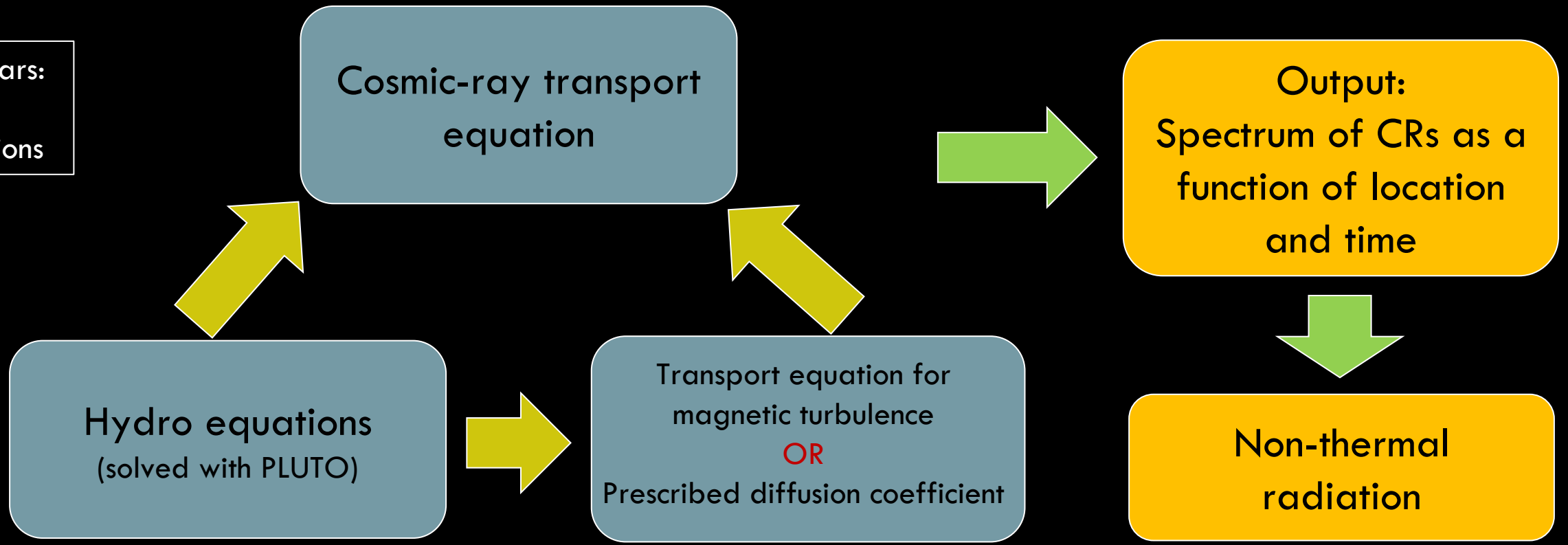
RATPaC

Radiation Acceleration Transport Parallel Code

See also talks:
Robert Brose on 03.11
Qiqi Jiang on 04.11

Powered by RATPaC

In last 5 years:
13 papers
>170 citations



Wind bubble

Setup motivated by previous work: Sushch et al. 2022

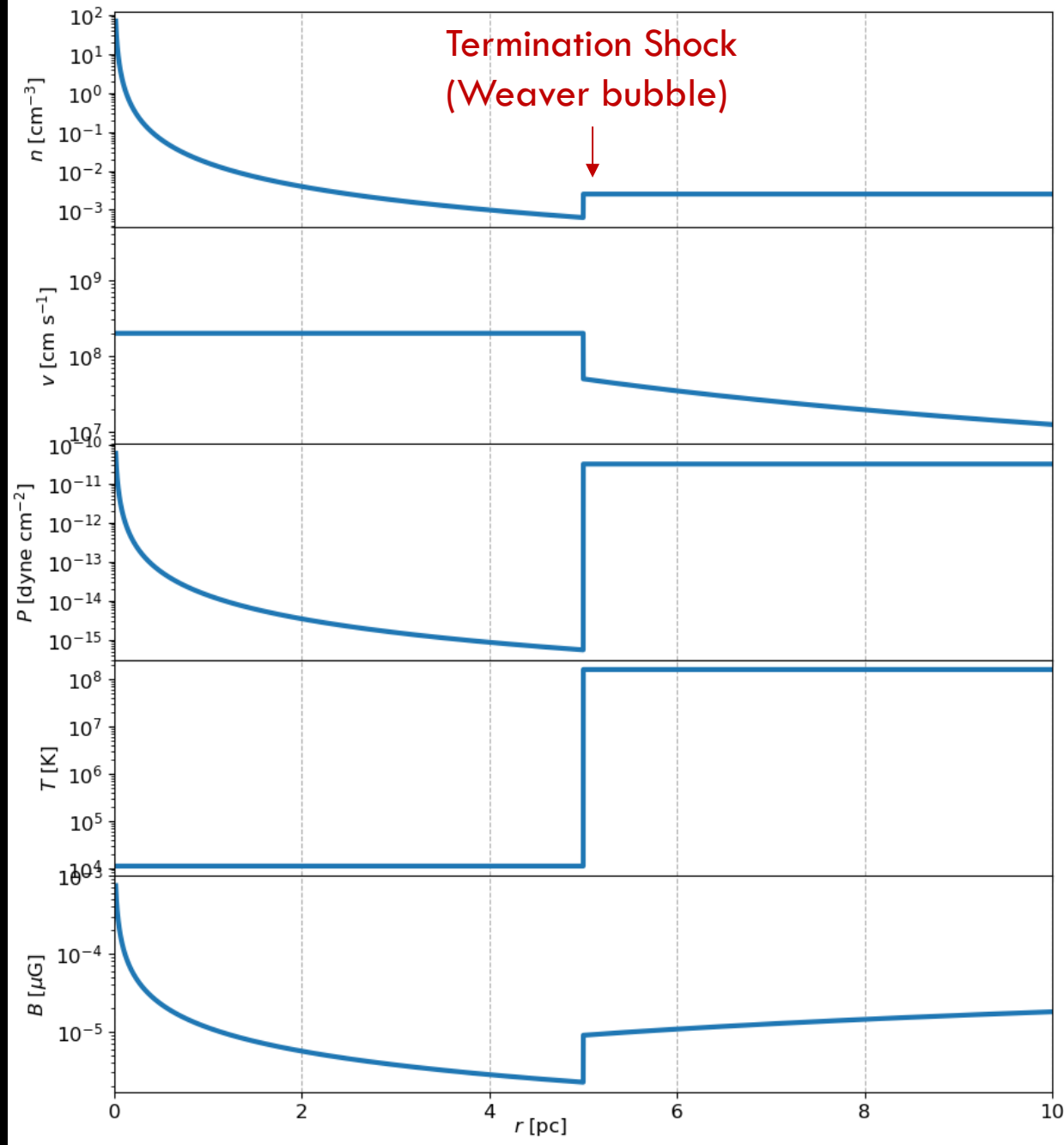
Wolf-Rayet wind:

- $\dot{M} = 10^{-5}\, M_\odot/year$
- $v_w = 2 \times 10^8$ cm/s

Magnetic field:

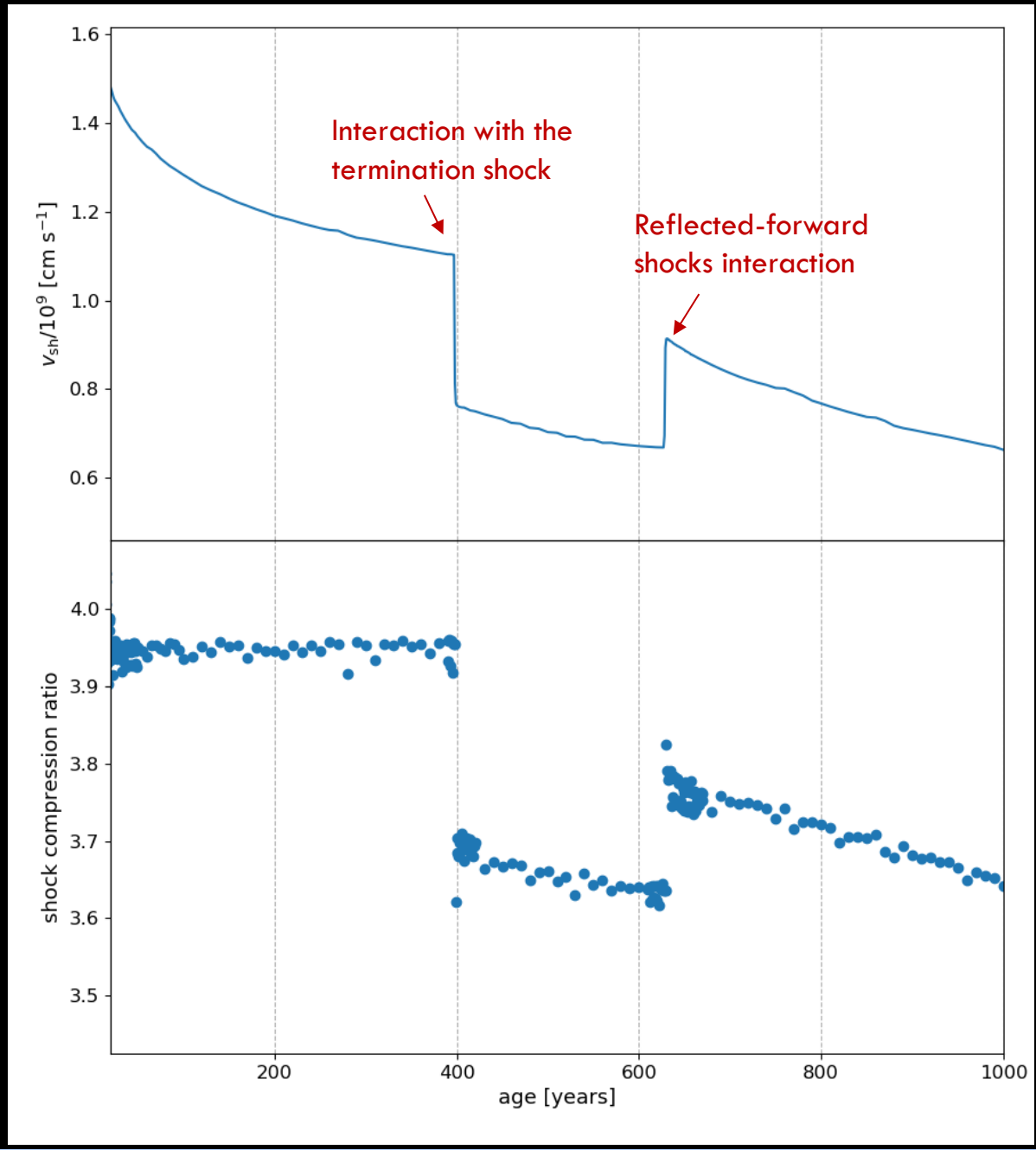
$$\begin{cases} B_0 \dfrac{R_*}{r}, r \le R_{TS} \\ 4B_0 \dfrac{R_*}{R_{TS}} \dfrac{r}{R_{TS}}, R_{TS} < r < R_b \end{cases}$$

$B_0 = 50\ G;\ B_{TS} = 9\ \mu G$



Shock evolution

- Significant weakening of the shock in the hot medium downstream of the termination shock
- Interaction of the reflected shock with forward shock accelerates the latter



Shock evolution

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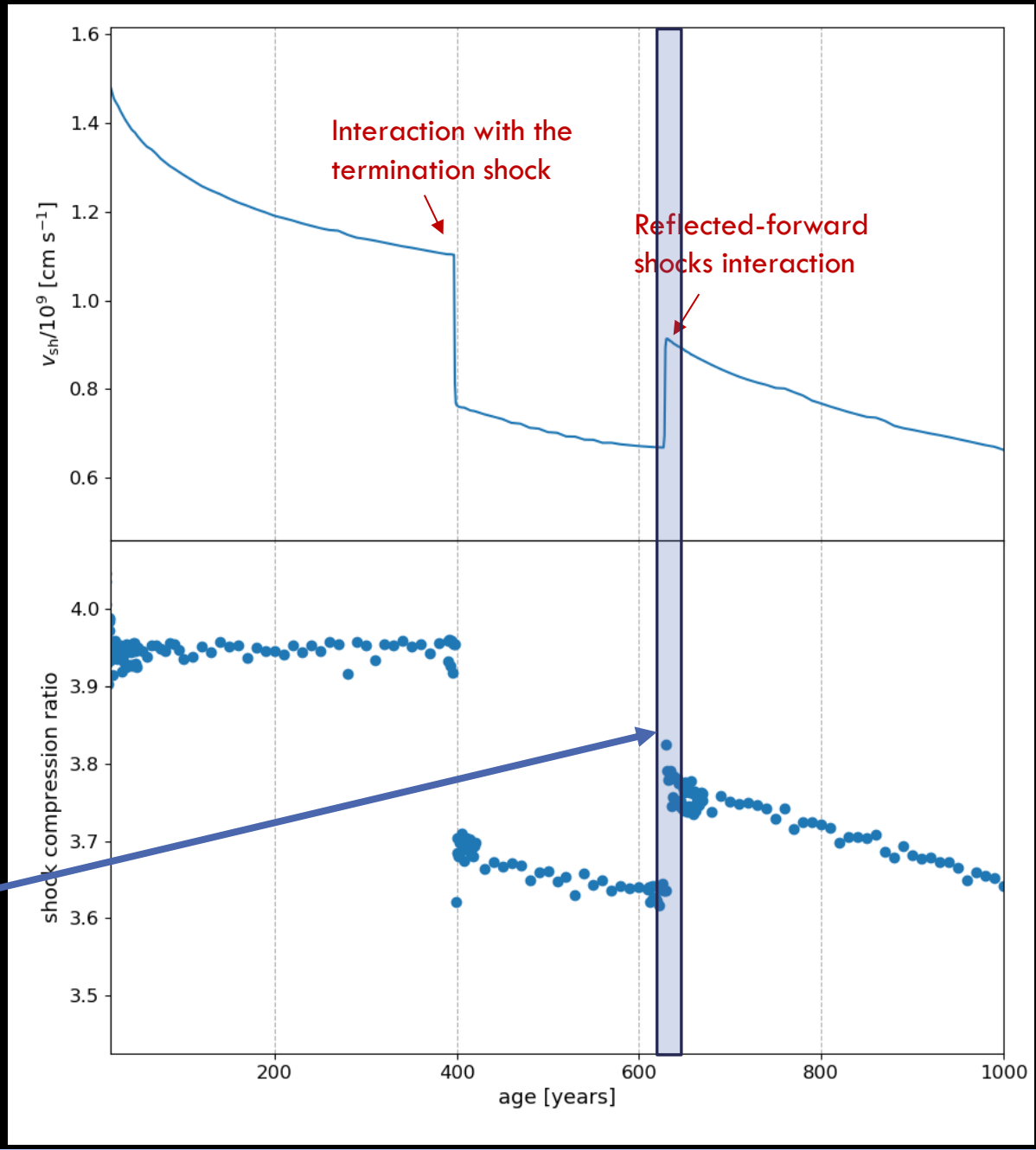
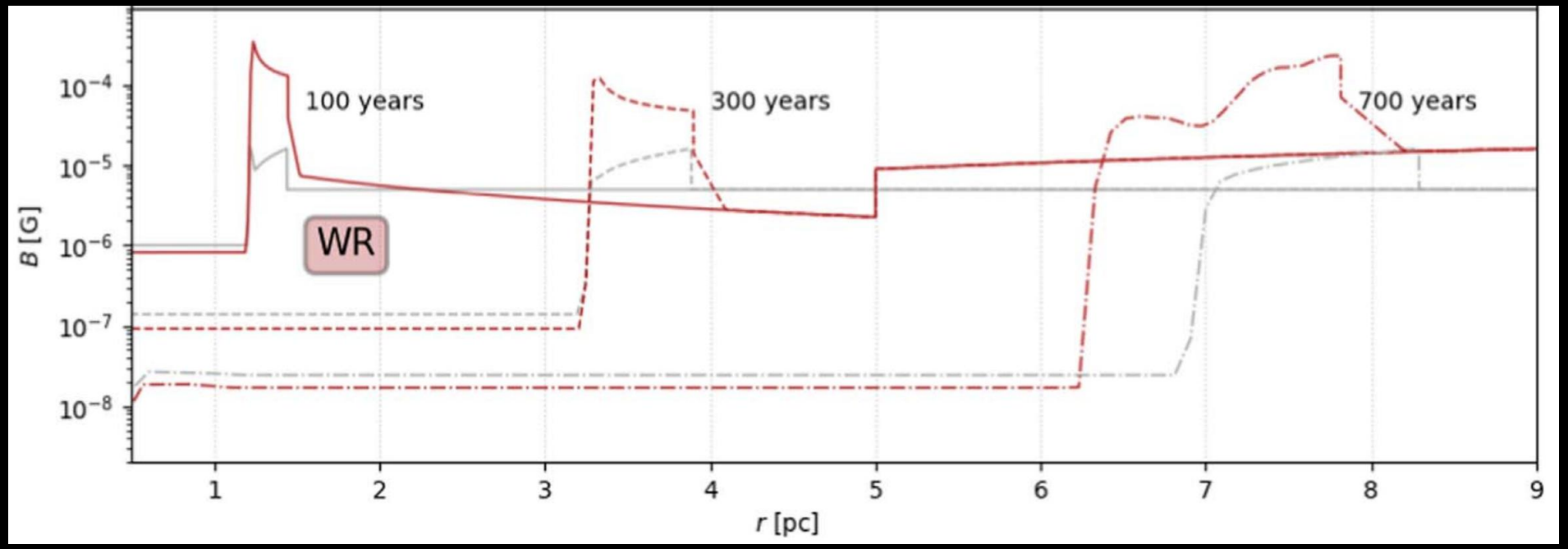
We focus on a short time window around shock-shock interaction event



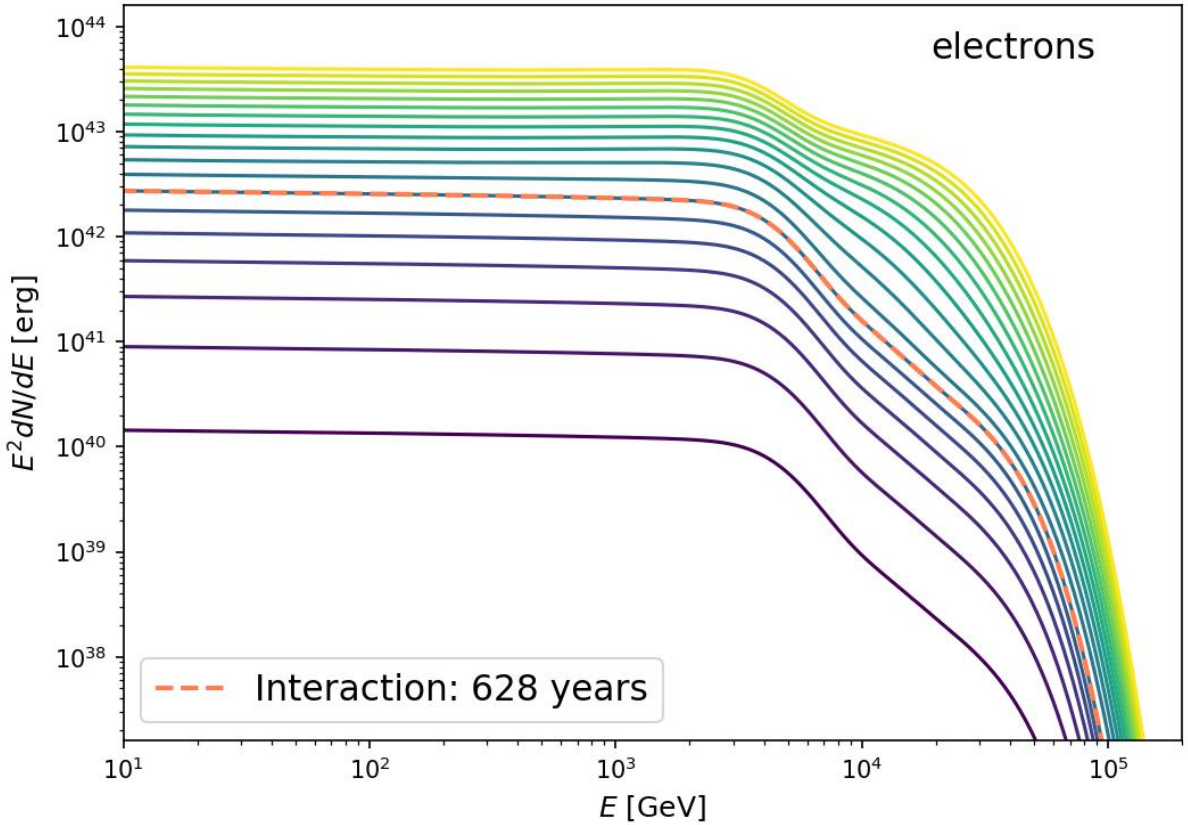
Magnetic field amplification and diffusion

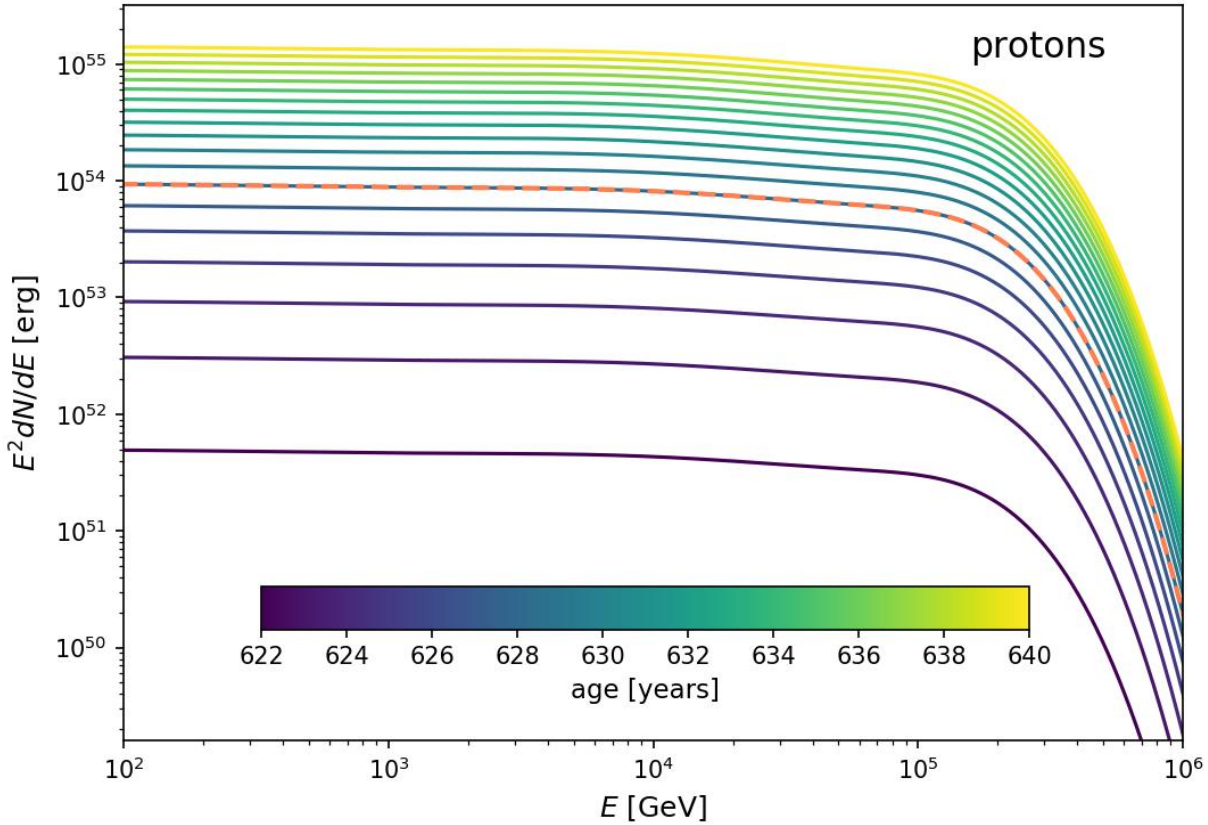
- Magnetic field amplified by a factor of 5 at the shock
- Bohm diffusion $D = \eta_B \frac{pc^2}{3eB}$



Sushch et al. 2022

Electron and proton spectra





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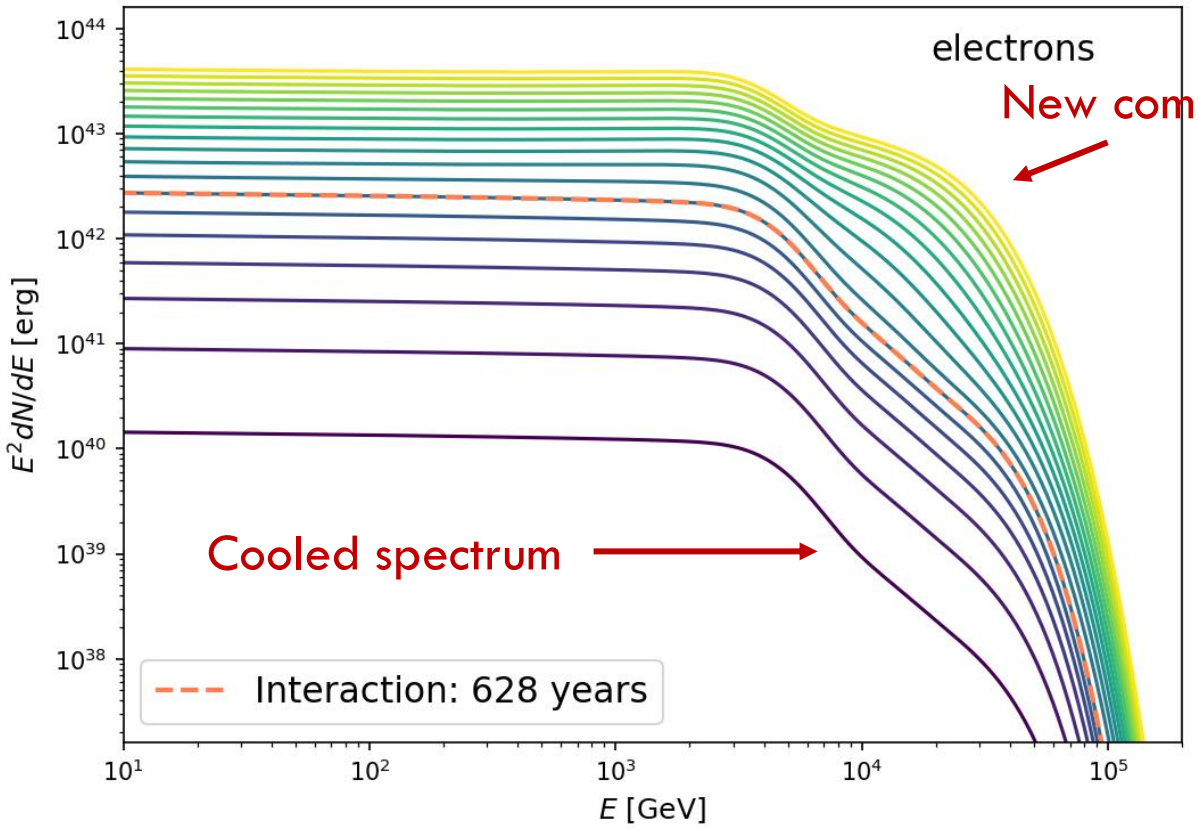
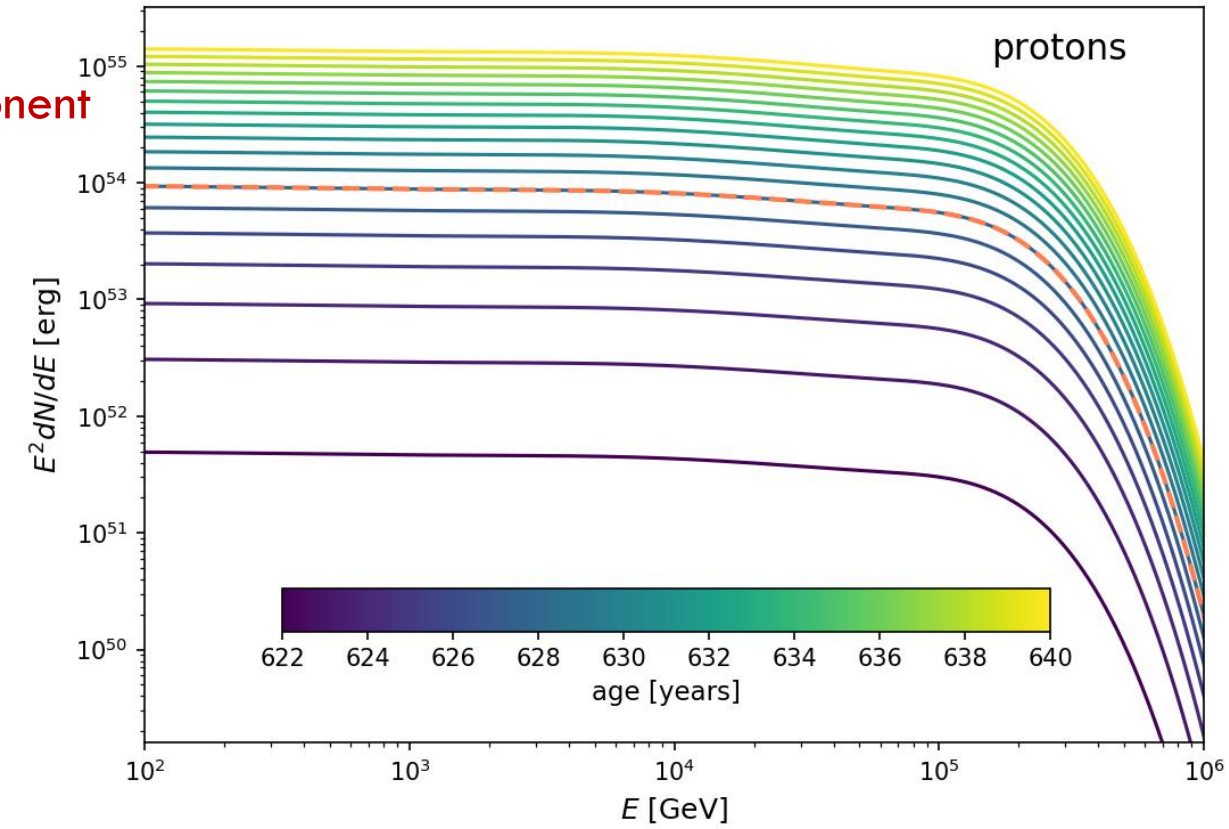
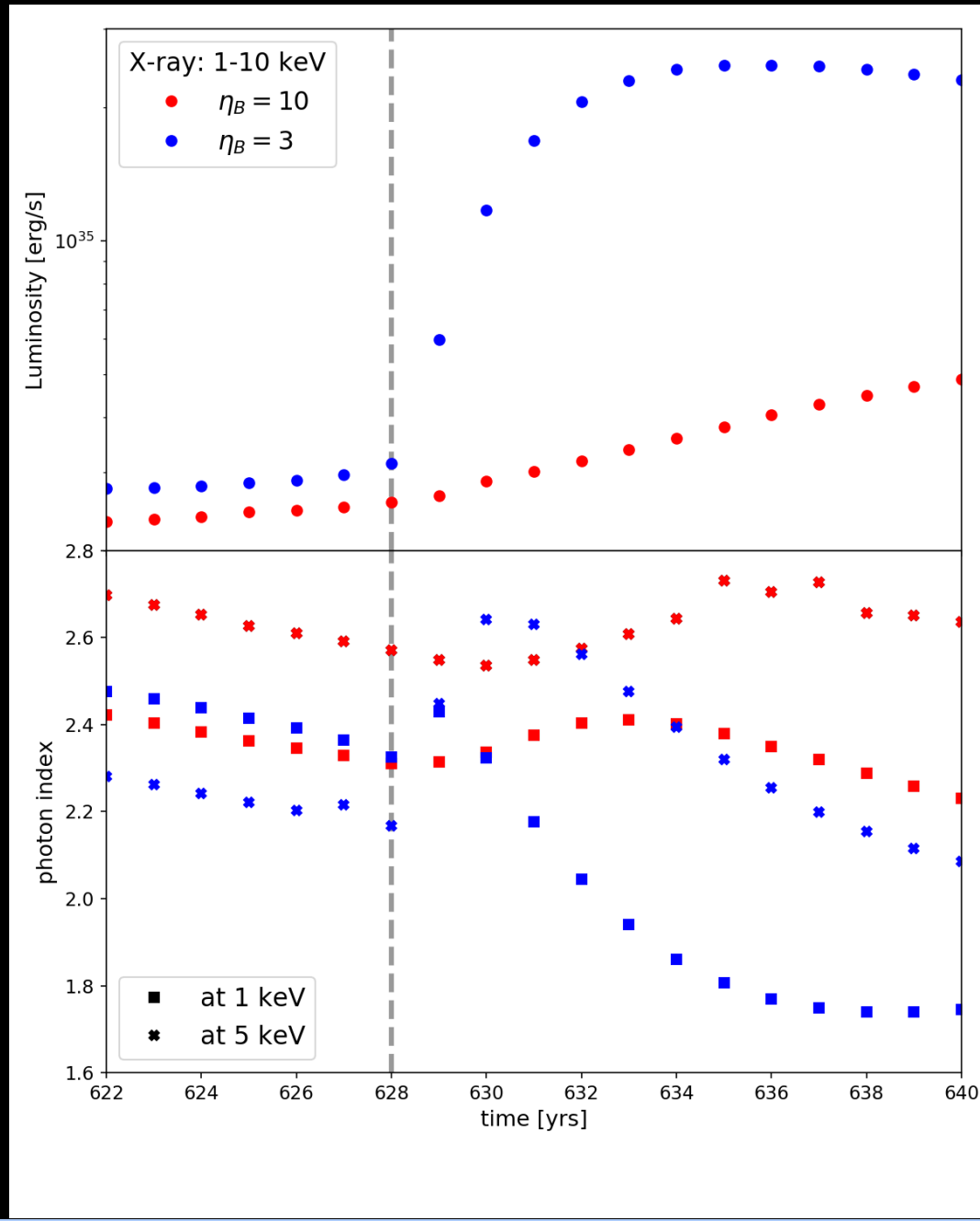




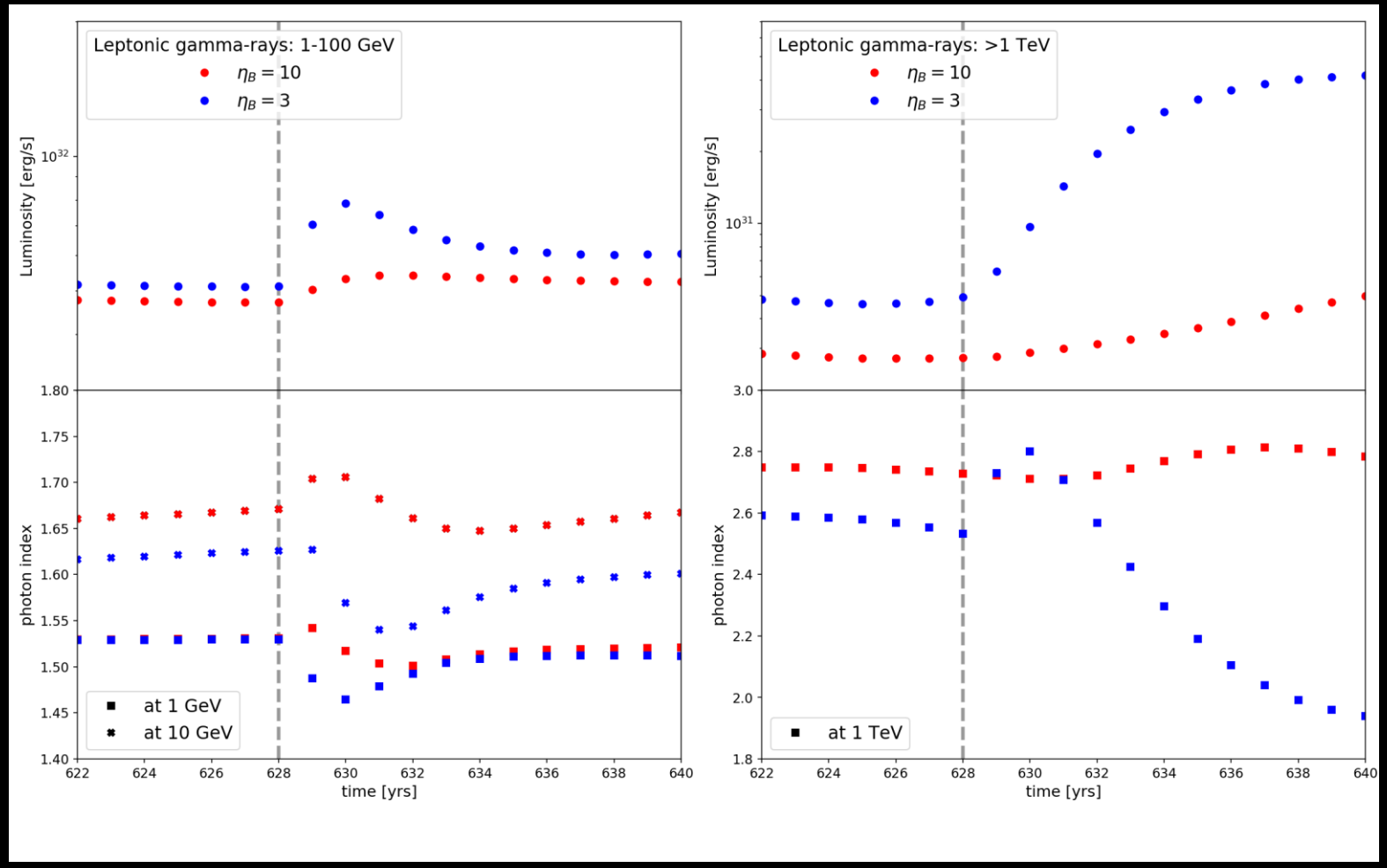
X-ray radiation

- very significant increase of the X-ray emission if the acceleration is efficient
- after interaction spectrum first softens and then starts hardening. This time delay is essentially a measure of acceleration time to the right energies



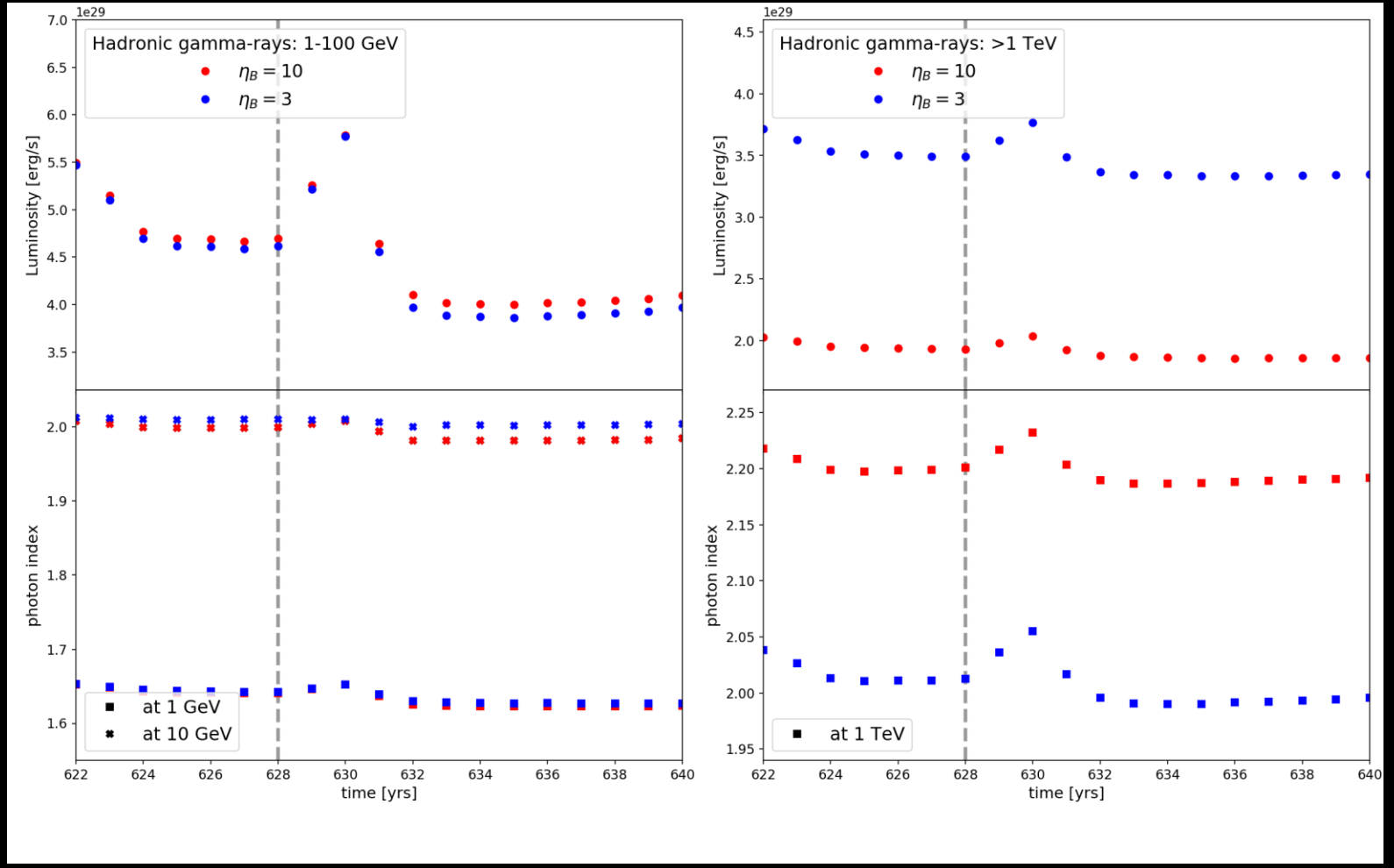
Gamma-ray radiation (leptonic)

- Similar behavior to X-rays
- Changes are naturally less pronounced at lower energies



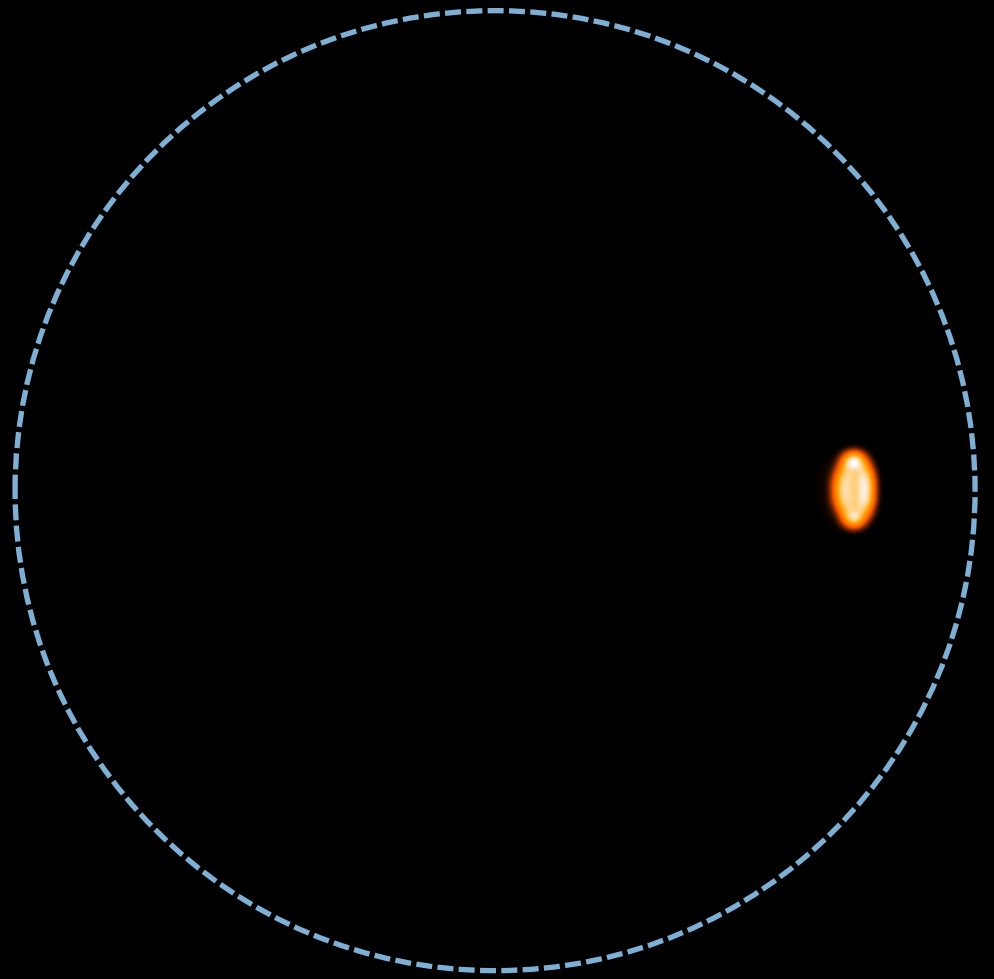
Gamma-ray radiation (hadronic)

- No significant variability
  (note the scale is linear here)



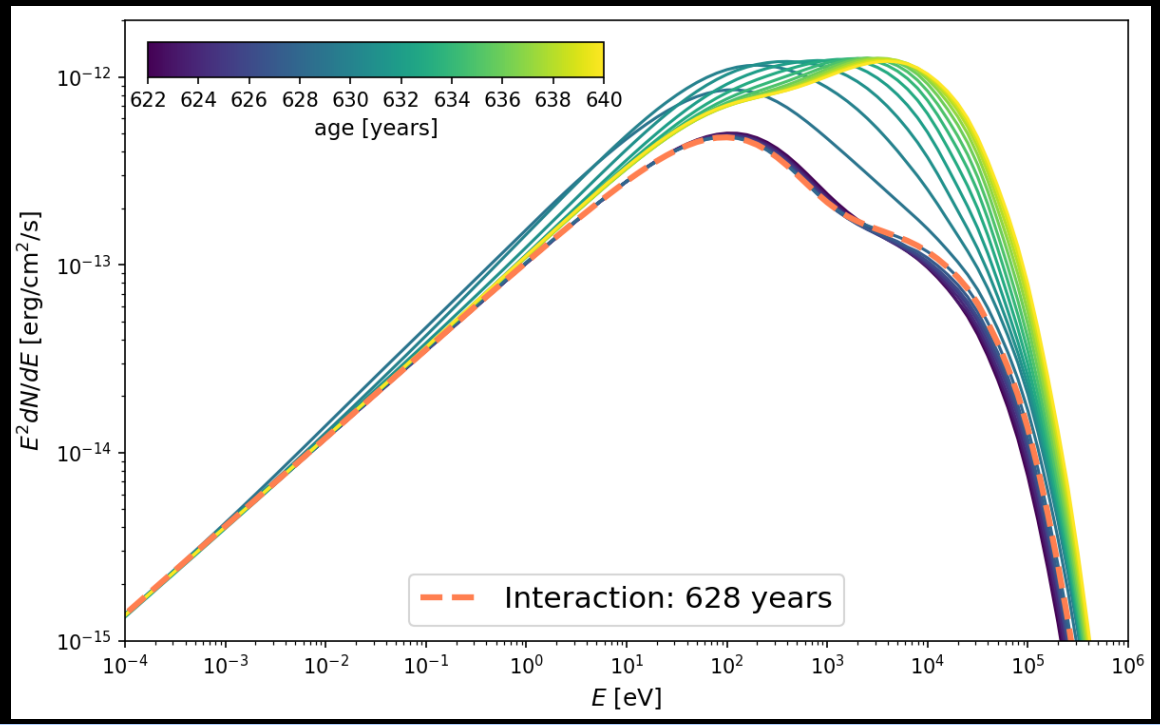
Filament

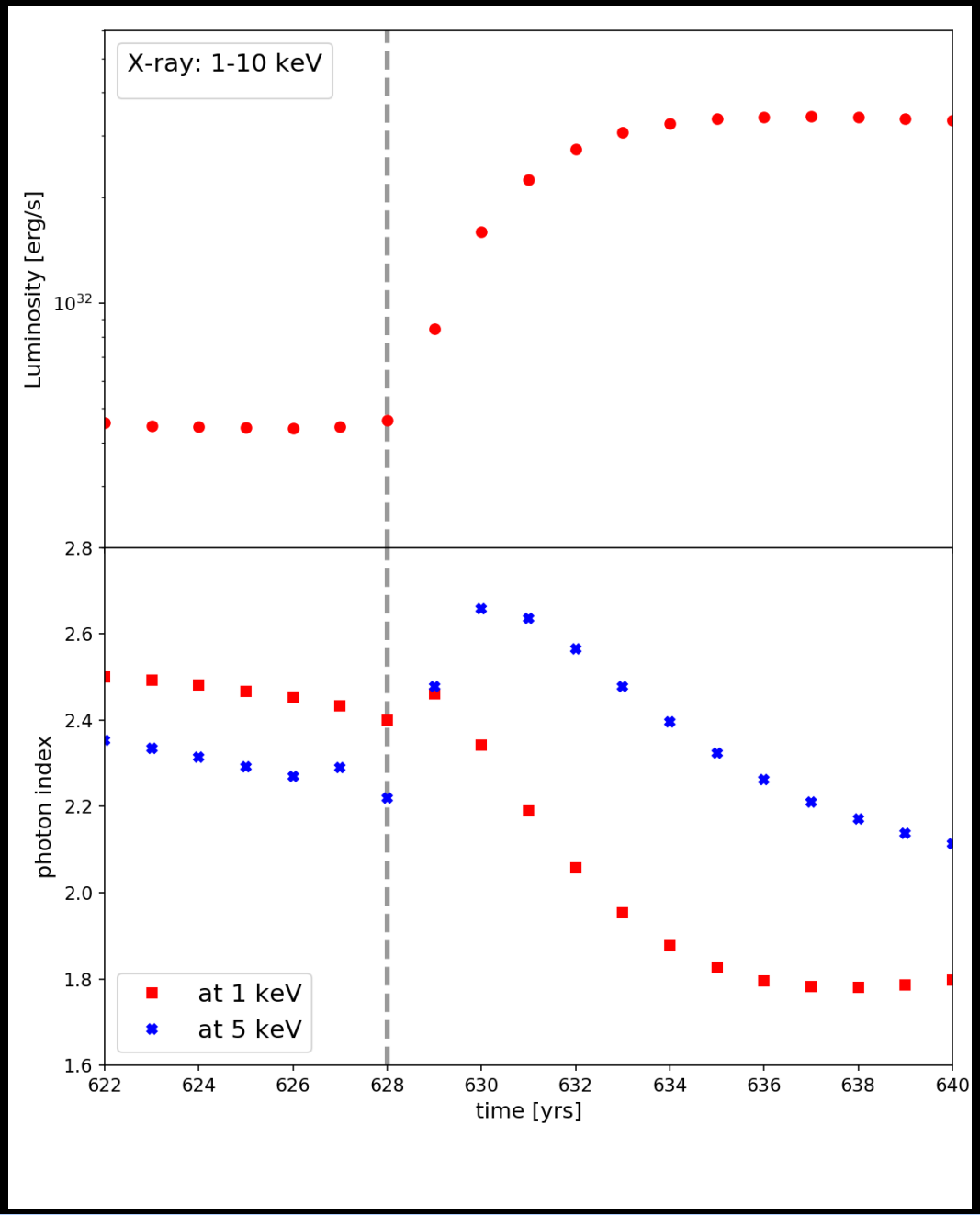
- Emission is considered only within a cone with an opening angle of 5 degrees (instead of the whole sphere)
- The cone is rotated by 30 degrees and the calculated X-ray emission projected on the 2d plane



Filament

- X-ray fluxes and spectra are extracted from the stripe-like emitting region for the times around the reflected shock-forward shock interaction
- $\eta_B = 3$ and the distance to the source of 1 kpc are assumed





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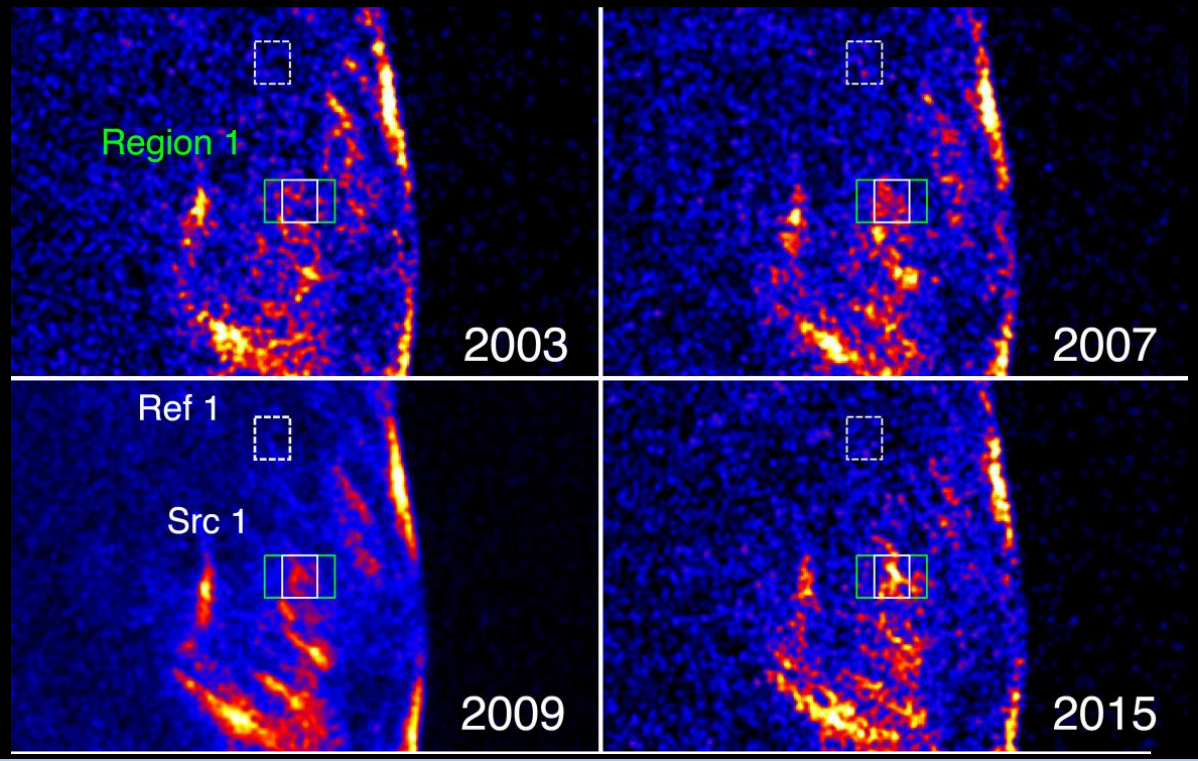

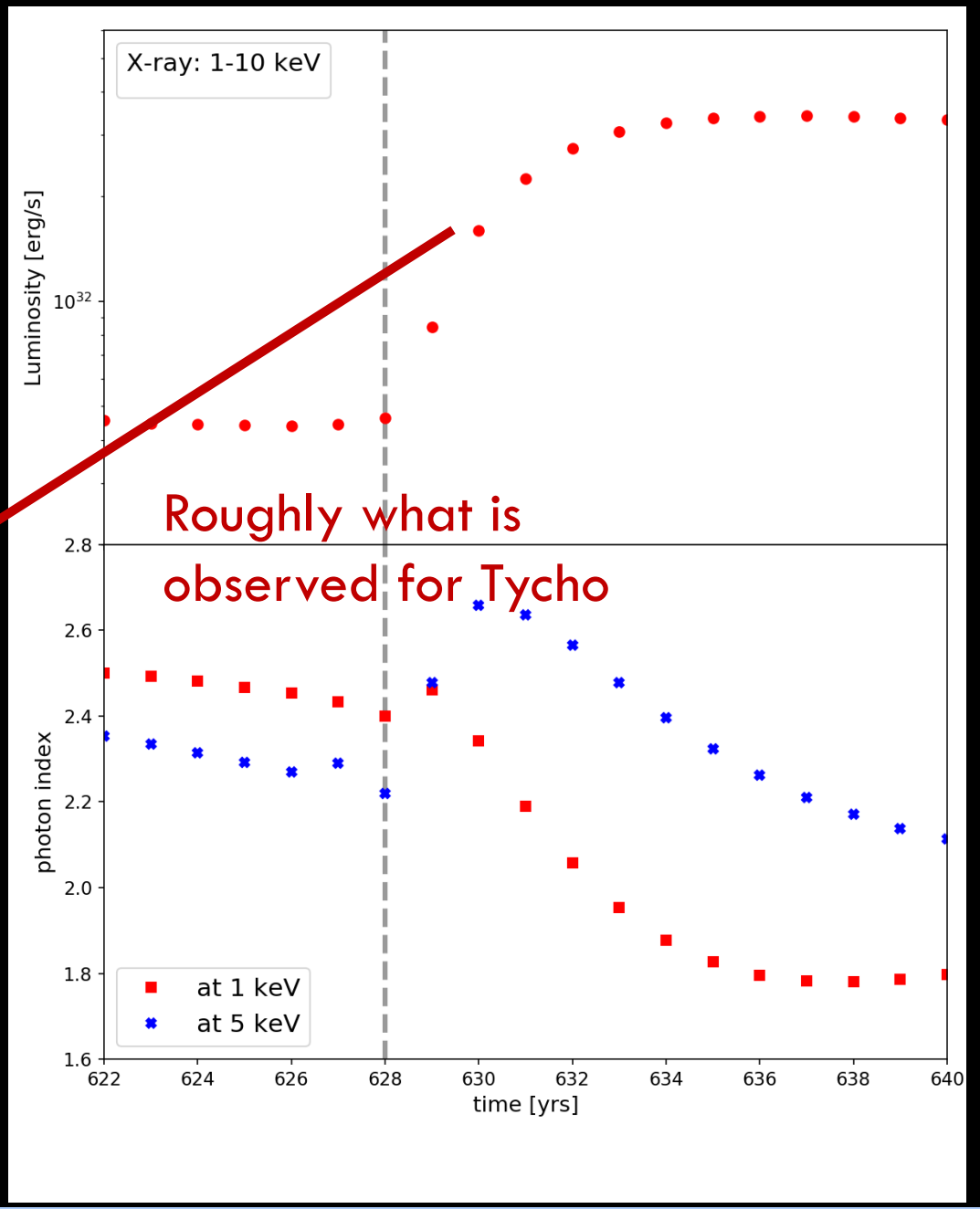

Take-home message

Reflected shocks that are formed when an SNR shock encounters abrupt density changes may cause X-ray and gamma-ray variability through the interaction with the forward shock.