Young and Massive Star Clusters as Galactic PeVatron Accelerators

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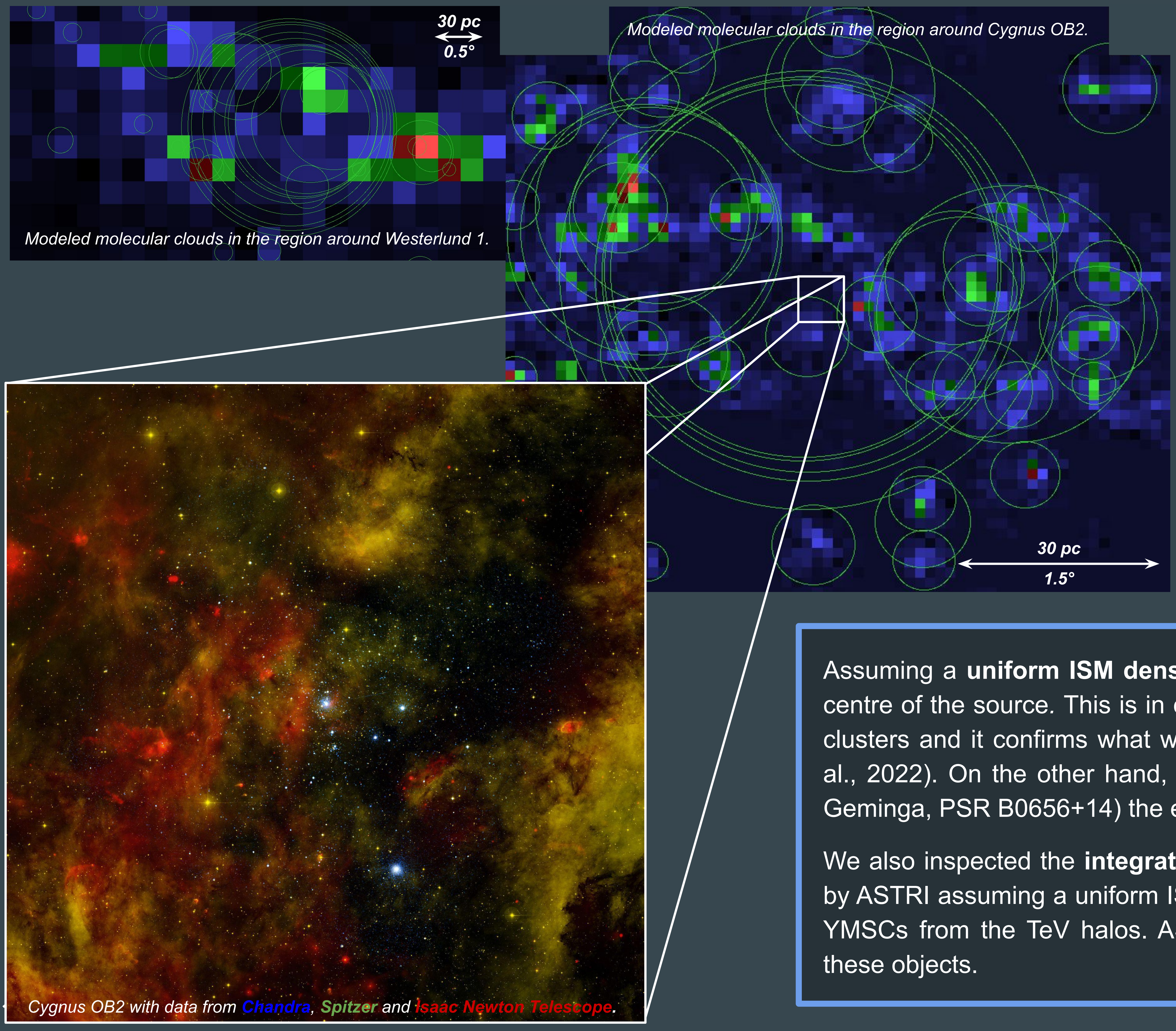
PeVatrons are some of the most energetic particle acceleration sites in the Universe, capable of accelerating particles up to PeV energies (*1 PeV = 10^{15} eV*). These particles interact with the surrounding interstellar medium (ISM) and background radiation fields to produce secondary very-high-energy gamma rays (>100 TeV). In this work, we study two interesting Galactic PeVatron candidates: the **Cygnus OB2** and **Westerlund 1** young and massive star clusters (YMSCs).

Once completed, the ground-based **ASTRI Mini-Array** will have an angular resolution of a few arcmin and an 8° field of view. Therefore it will be suited for **morphological studies** of sources with an angular dimension of a few degrees at TeV energies, such as YMSCs. Inspecting the intensity variations of gamma radiation from YMSCs, we will be able to map the energy and the number of particles accelerated by these sources.

In preparation of the observations with the ASTRI Mini-Array, we produce **observation simulations** using a physical model of YMSCs from Morlino et al. (2021) and the telescope instrument response function to study how it will be able to observe their morphology.

Right: ASTRI-Horn, the ASTRI-Mini Array prototype.

End-to-end Morphological Study of Young and Massive Star Clusters



Modeled molecular clouds in the region around Westerlund 1.

Modeled molecular clouds in the region around Cygnus OB2.

Cygnus OB2 with data from Chandra, Spitzer and Isaac Newton Telescope.

We performed simulations of the regions around the YMSCs, assuming

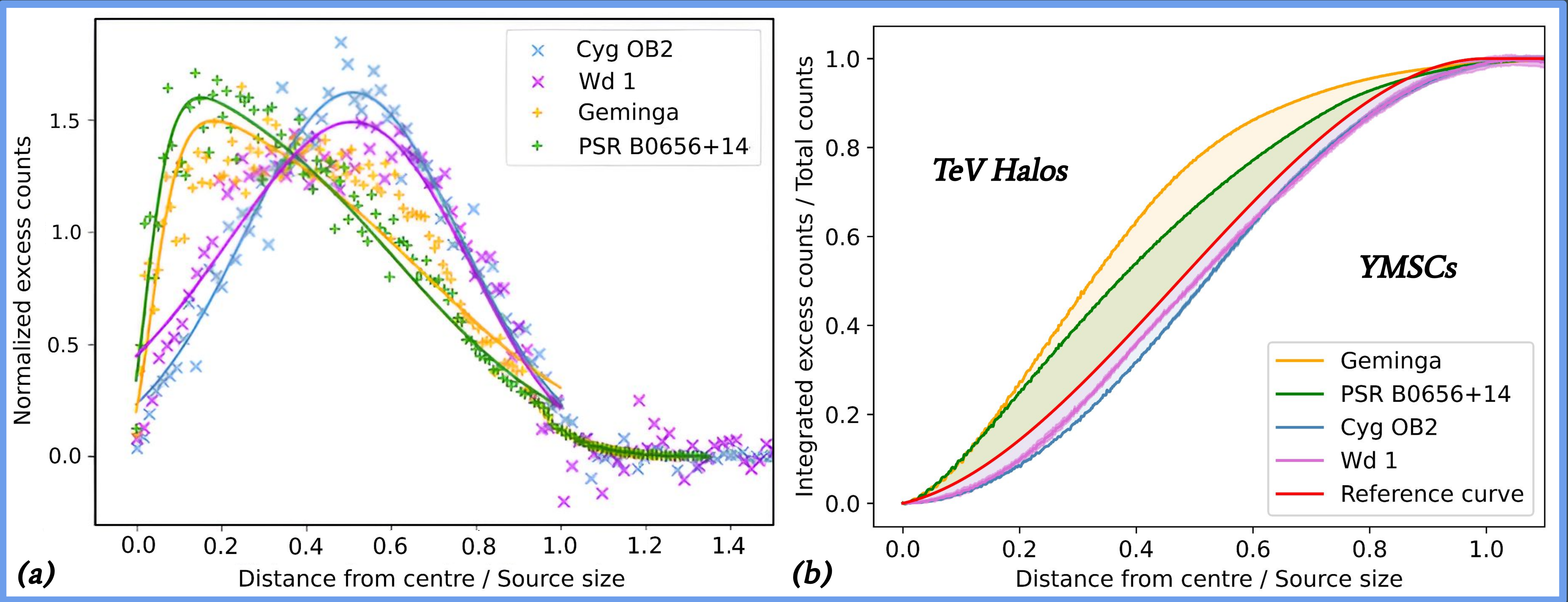
- a **uniform** ISM density.
- an ISM based on **molecular hydrogen clouds.**

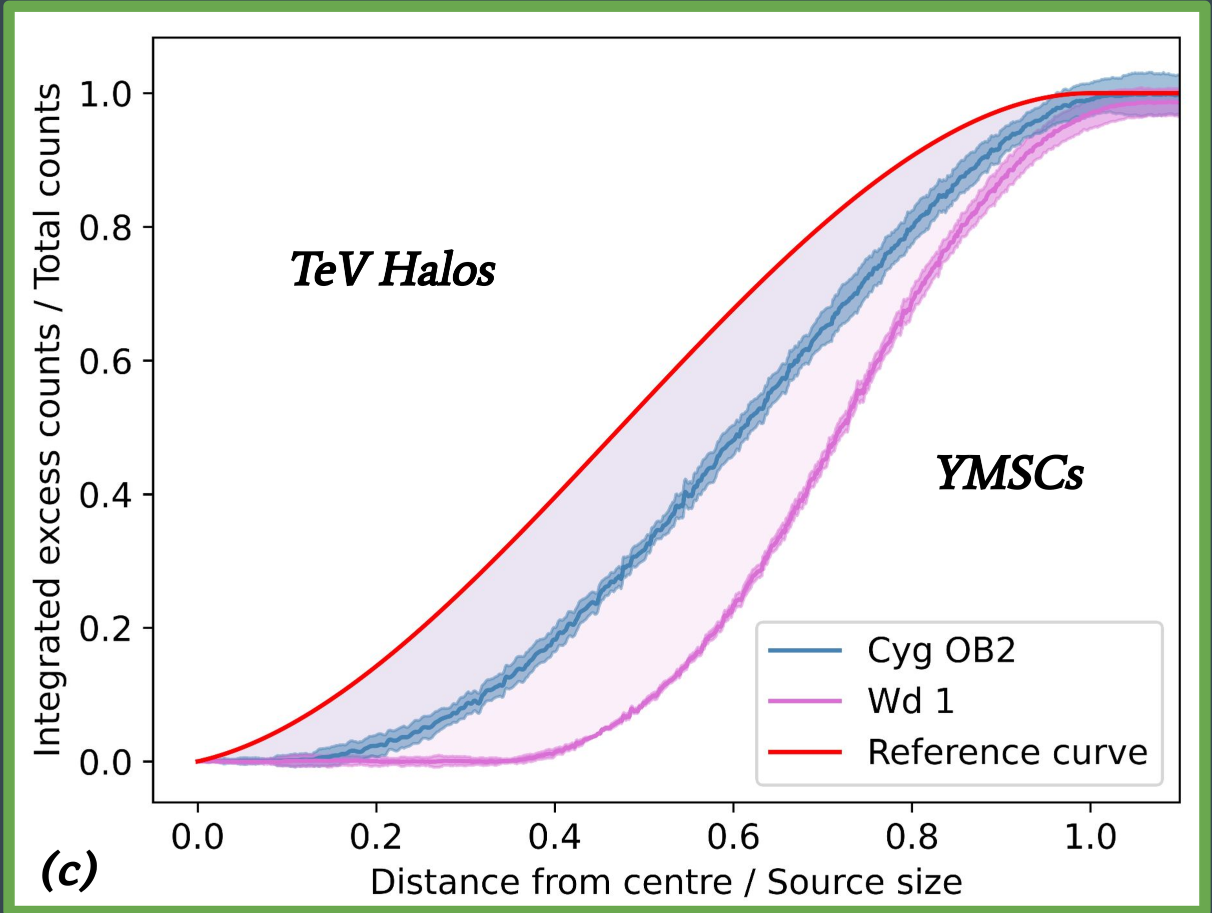
We modeled the clouds around the YMSCs from the temperature maps of Dame et al., 2001. We computed the fluxes and positions of the clouds, then modeled them as more realistic spheres in our simulations.

Assuming a **uniform ISM density**, the emission of YMSCs peaks at a few tens of pc from the centre of the source. This is in correspondence of the **termination shock** that forms around the clusters and it confirms what was hinted by HESS observations of Westerlund 1 (Aharonian et al., 2022). On the other hand, for other classes of TeV extended sources like TeV halos (e.g. Geminga, PSR B0656+14) the emission peaks at the centre (***a***).

We also inspected the **integrated counts profiles** from the centre of each source as observed by ASTRI assuming a uniform ISM density (***b***) and found a reference function that separates the YMSCs from the TeV halos. ASTRI will therefore be able to **classify new sources** between these objects.

We plotted the integrated counts profile for the YMSCs obtained assuming the gas distribution derived from the molecular clouds modeled (***c***). The curves still lie in the same region of the plane (below the reference curve) as before, confirming that ASTRI will be able to resolve and classify these two classes of extended sources.





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