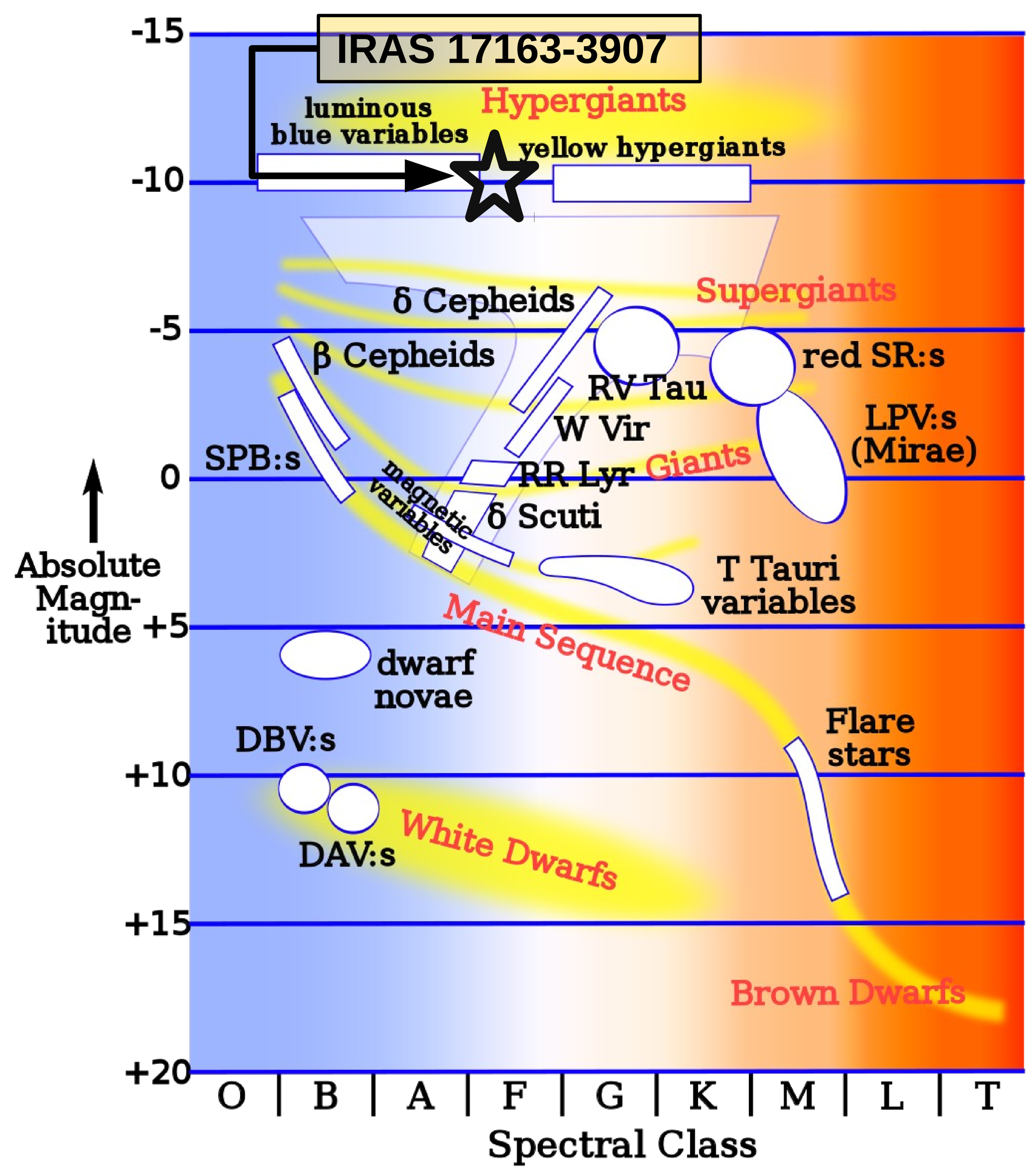
MULTIPLE SHELL EJECTIONS TOWARDS THE FRIED EGG NEBULA

Evgenia KOUMPIA[1], R. D. Oudmaijer, V. Graham, G. Banyard, J. H. Black, C. Wichittanakom, K. M. Ababakr, W.-J. de Wit, F. Millour, E. Lagadec, S. Muller, N. L. J. Cox, A. Zijlstra, H. van Winckel, M. Hillen, R. Szczerba, J. S. Vink, S. H. J. Wallström

1. BACKGROUND

The fate of a massive star during the latest stages of its evolution is highly dependent on its **mass-loss** rate and **geometry**.



HR diagram showing different classes of evolved objects including the transitional post-Red Supergiant (RSG) phase, the yellow hypergiants (YHGs).

- **What** is the mechanism that shapes the nebulae around evolved stars?
- **What** are the properties of the mass-loss episodes?

OUR STUDY

- We aim to provide insight into the nature (i.e. geometry, rates) of mass-loss episodes, by an in depth study of one of the very few known **post-RSG** yellow hypergiants, IRAS 17163-3907 and its associated Fried Egg Nebula (FEN).

Note: IRAS 17163-3907 was only recently classified as a **massive yellow hypergiant** by Lagadec et al. (2011). Mid-IR images (VISIR/VLT) revealed **at least** two ejections of massive amounts of gas and dust.

2. IMAGE RECONSTRUCTION

INTERFEROMETRIC OBSERVATIONS: GRAVITY/VLTI on ATs: **K-band** (2-2.4 μm)
We present the first image reconstruction of the continuum, Brγ, and NaI emission towards IRAS 17163 in NIR and at milli-arcsecond scales.

The Four Auxiliary Telescopes at Paranal

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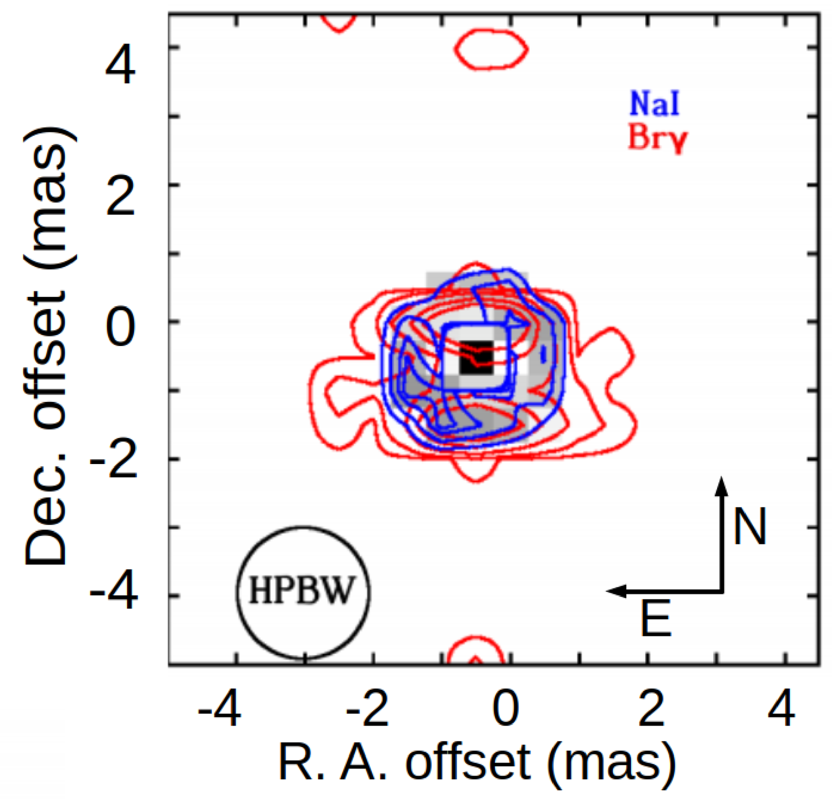
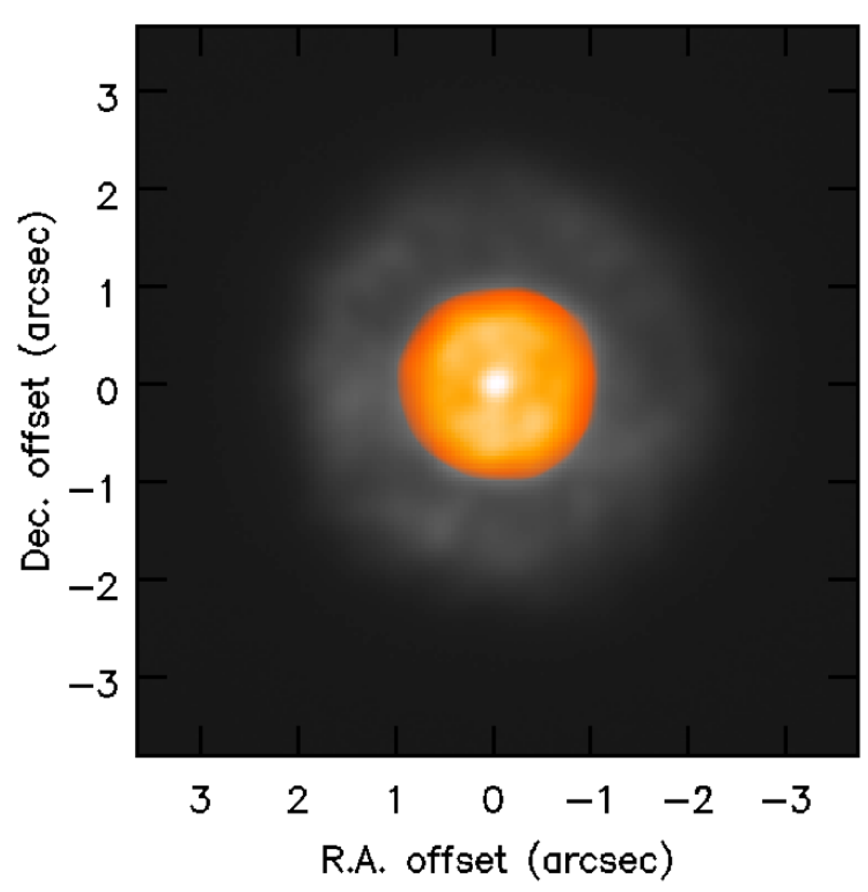


- The **Brγ** emission (ionised gas) appears to be more **extended** and **asymmetric** compared to the **continuum** and **NaI** emission.

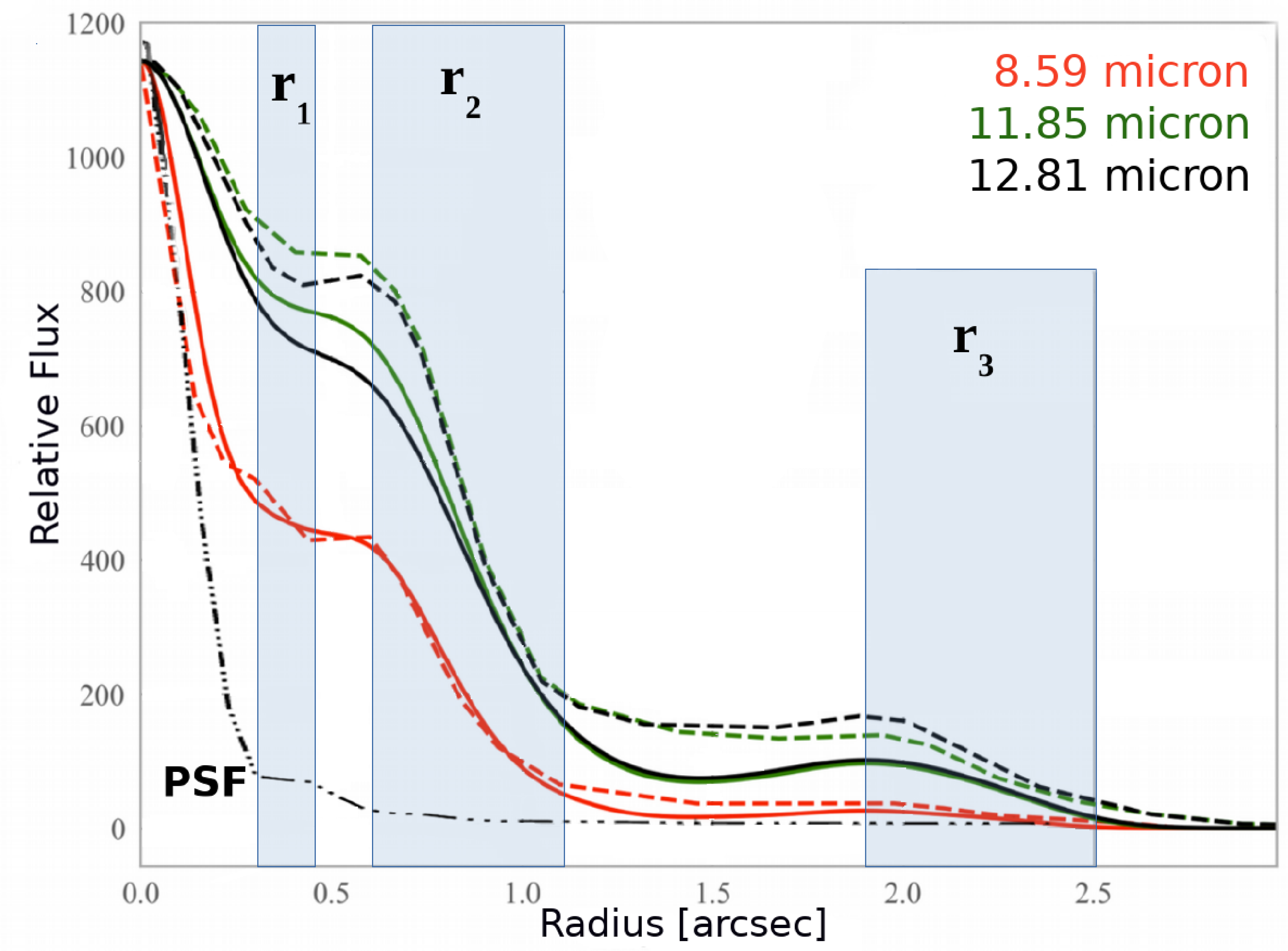
3. REVEALING A THIRD HOT INNER SHELL

We perform radiative transfer modeling (2-Dust; Ueta & Meixner 2003) to simultaneously fit the **flux maps** (radial profiles) at 8.59 μm, 11.85 μm, and 12.81 μm (upper plots) and the **SED** (bottom). Our models reveal a **third hot inner shell** for the first time.

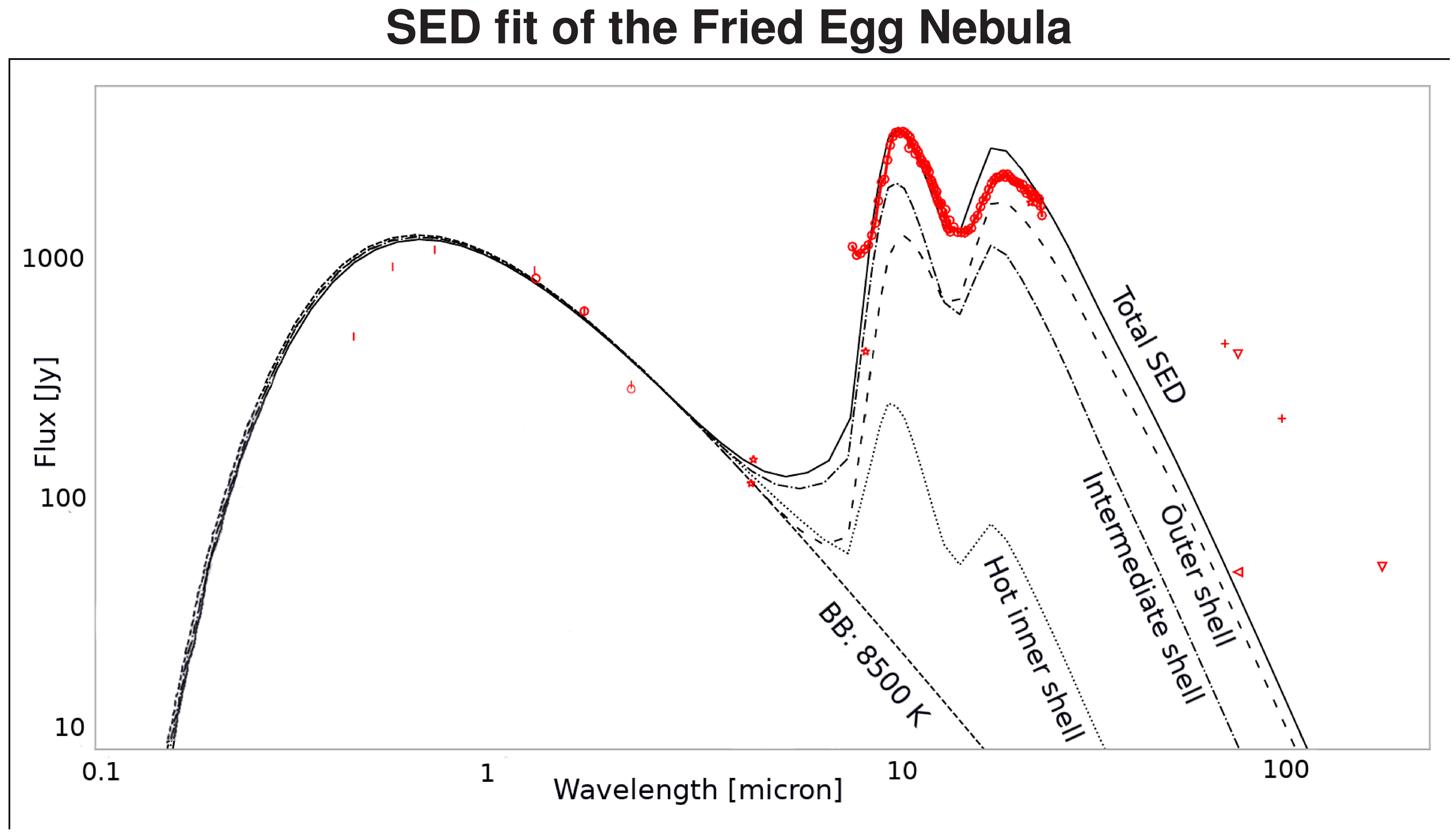
VISIR/VLT image at 8.59 μm



Observed (dashed) vs modeled (solid) radial profiles



SED fit of the Fried Egg Nebula



4. MASS-LOSS: PROPERTIES

Physical parameters of the central star and the three shells of FEN.

IRAS 17163	$\log(L_\star/L_\odot)$	$T_\star$ (K)	d (kpc)		
	5.7	8500	1.2		
Fried Egg Nebula	M_{gas} (10^{-3} $M_\odot$)	T_d (K)	r_d ('')	t_{kin} (yr)	$\dot{M}$ ($M_\odot$/yr)
Hot inner shell	0.021	620-480	0.3-0.45	30.8	6×10^{-7}
Intermediate shell	0.90	460-320	0.6-1.1	102.7	9×10^{-4}
Outer shell	5.6	240-200	1.9-2.5	123.2	5×10^{-5}

5. CONCLUSIONS

- We find a third inner, hot shell, which has a kinematic age of only 30 yr.
- The mass loss from this post-RSG is not steady; the 3 distinct mass-loss episodes indicate the object underwent **3 outbursts** in the past 130 years.
- The 2μm imaging reveals a more extended and asymmetric Brγ emission compared to NaI and continuum, which is consistent to our LTE line model.
- In the paper we discuss **pulsational**-driven and **line**-driven mass-loss. We are the first to introduce the **bi-stability** jump to explain mass-loss episodes towards a YHG.

6. PUBLICATION

Koumpia et al. 2020, A&A, 635, 183

contact: ekoumpia@eso.org
1st author affiliation: [1]ESO, Chile