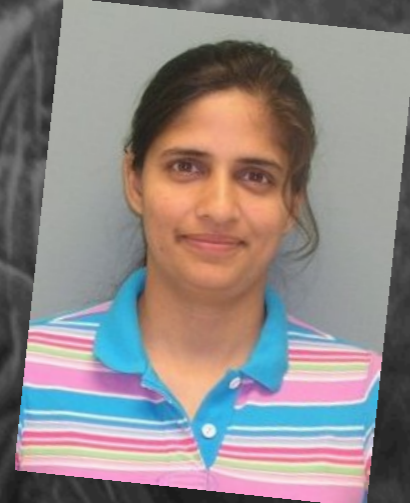




Observational Searches of Type Ia Supernovae Progenitors

Nando Patat - ESO



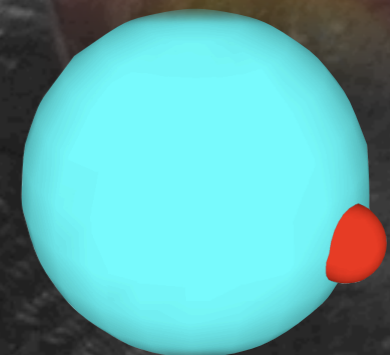
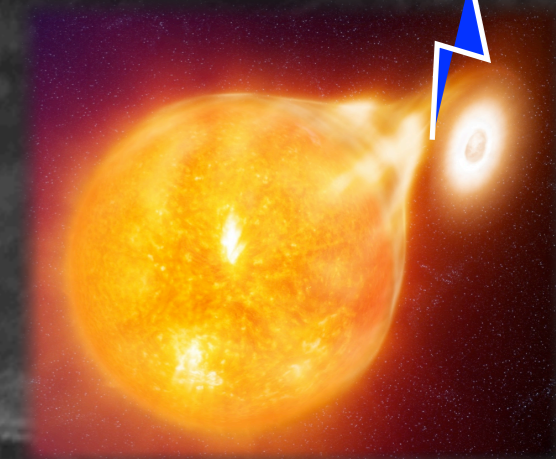
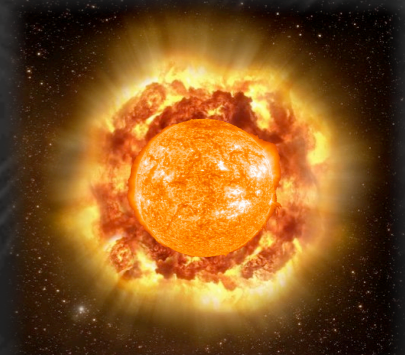
“The fact that we do not know yet what are the progenitor systems of some of the most dramatic explosions in the universe has become a major embarrassment and one of the key unresolved problems in stellar evolution”.



M. Livio (2000)

Observational Attempts

- Direct observation of companion (La Puente +2004. But see Kerzendorf+ 2009 & n.t.)
- Detection of pre-SN X-Ray emission (Voss & Nelemans 2008. But see Roelofs+ 2008)
- Observations of SNRs (Badenes+ 2007; Reynolds+ 2007)
- Entrained material (Wheeler+ 1975, ...). No detection (Leonard 2007)
- The CSM-interaction family (no radio, X-Ray, narrow emission detection of Ia. $3 \times 10^{-8} M_{\text{sun}} \text{ yr}^{-1}$ ($v_{\text{wind}} = 10 \text{ km s}^{-1}$). Cavities? +++



Not through hydrogen: yet another method?

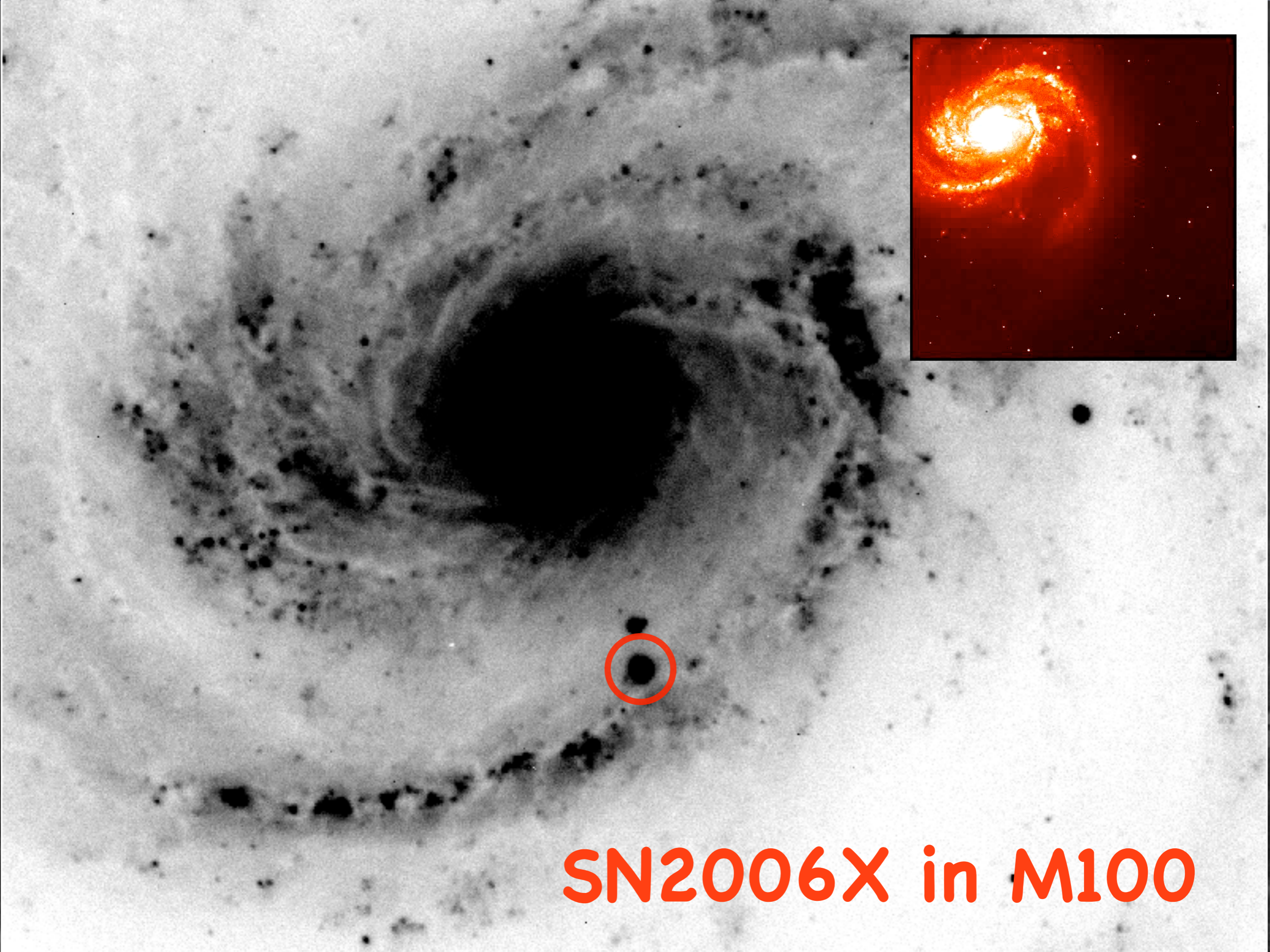
- UV line-blocking by Fe/Co/Ti/Cr UV in Type Ia (Pauldrach et al. 1996; Mazzali 2000). Luckily so...
- If there is gas, we might see it in absorption in some strong optical transition (CaIHK, NaID, KI. **Sensitive!**)
- If this gas is close to the SN, it might feel the radiation field (ionization/recombination. $r_{\text{Na}} < 10^{18}$ cm, $n_e > 10^6$ cm $^{-3}$).
- If it is too close, at some point it might be swept away by the ejecta ($r \sim 100$ AU @ max)
- Probe CSM between 10^{16} and 5×10^{17} cm (different from the nova case; cf. Bob William's talk). L.O.S only..

The NAVAR project

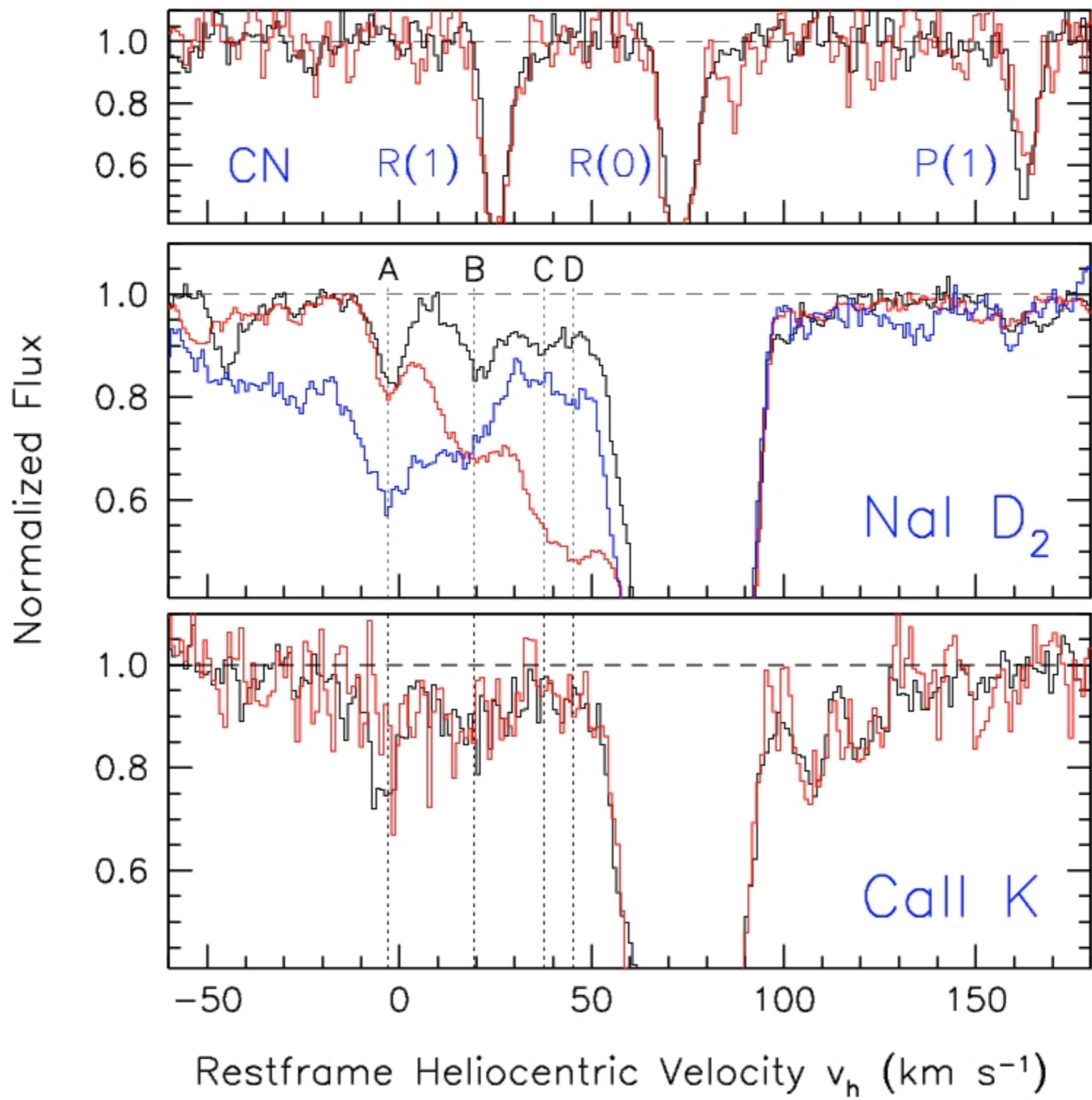
UVES @ ESO-VLT

Multi-epoch, high-resolution (50,000) spectroscopy of any bright ($V < 14$) Type Ia.
~1/semester

Similar programme running at Keck (J. Simon) ⁶



SN2006X in M100



Pataf et al., Science, 2007a

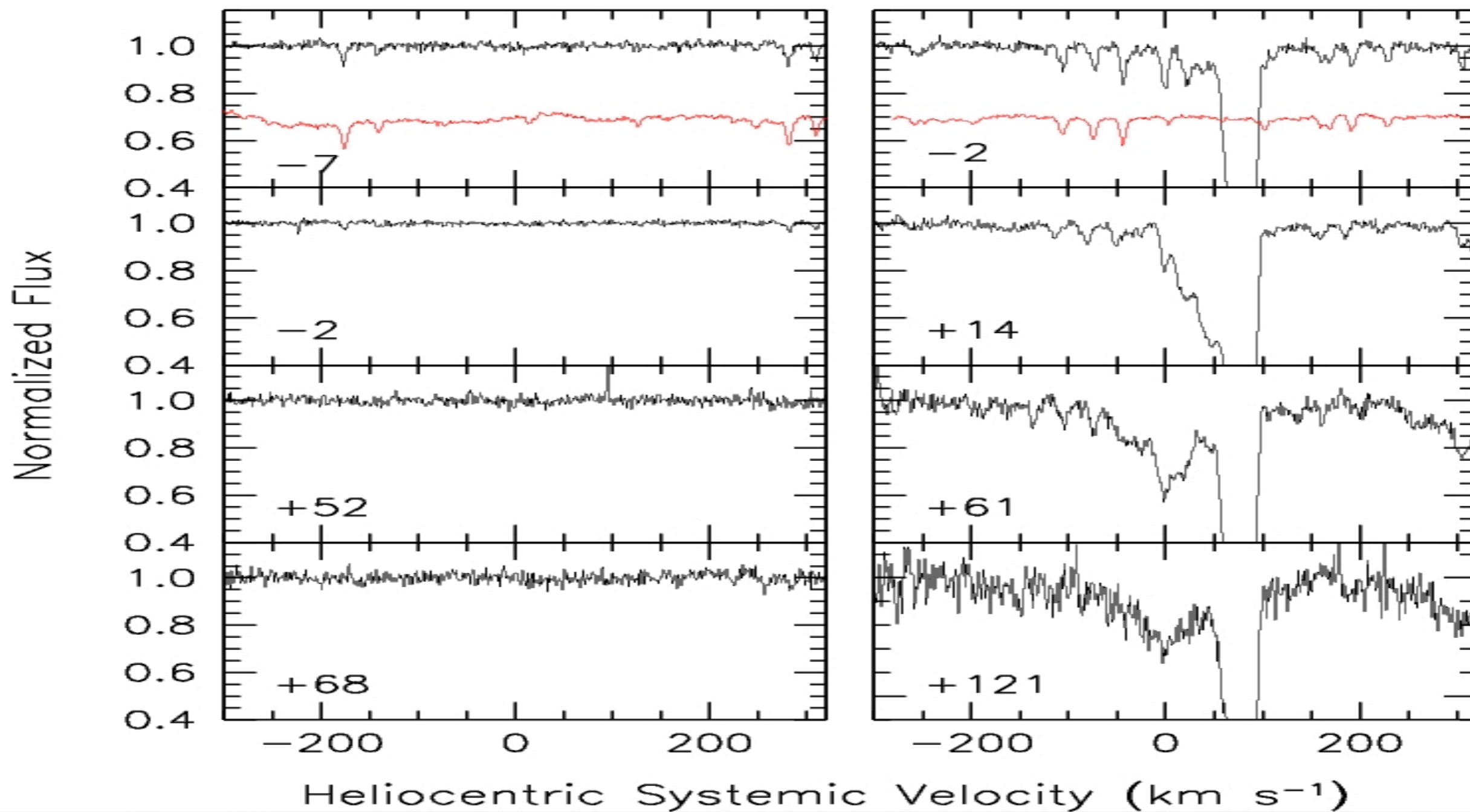
CSM is expanding at velocities spanning a range of about 100 km s^{-1} ($N_{\text{NaI}} \sim 10^{12} \text{ cm}^{-2}$)

For $r=10^{17} \text{ cm}$ and $v_w=50 \text{ km s}^{-1}$

the material would have been ejected some 500 yrs before the explosion.

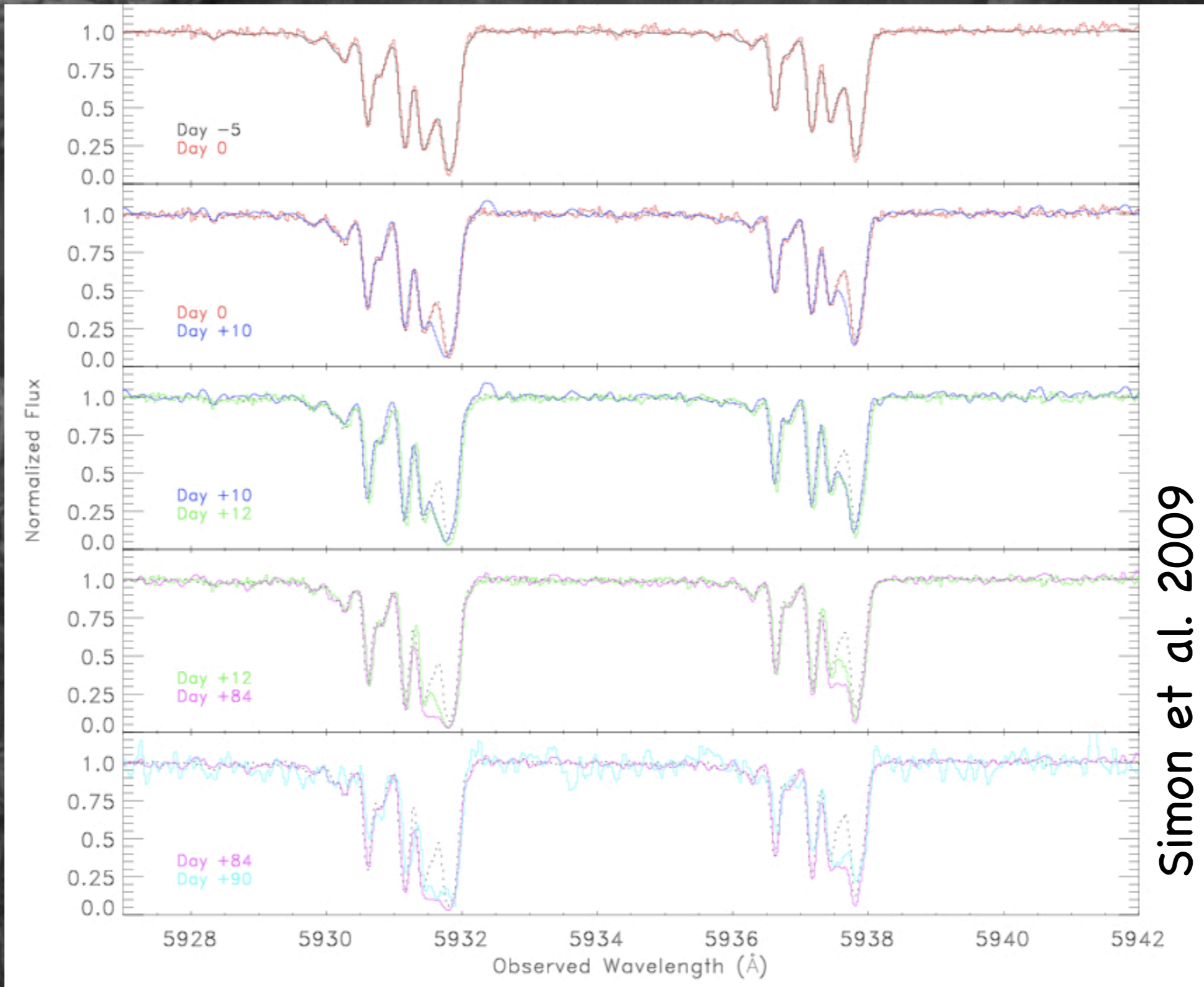
The observed velocities are more consistent with the shorter-period end of the symbiotic formation channel (WD+RG) (Munari & Renzini 1992)

SN2000cx



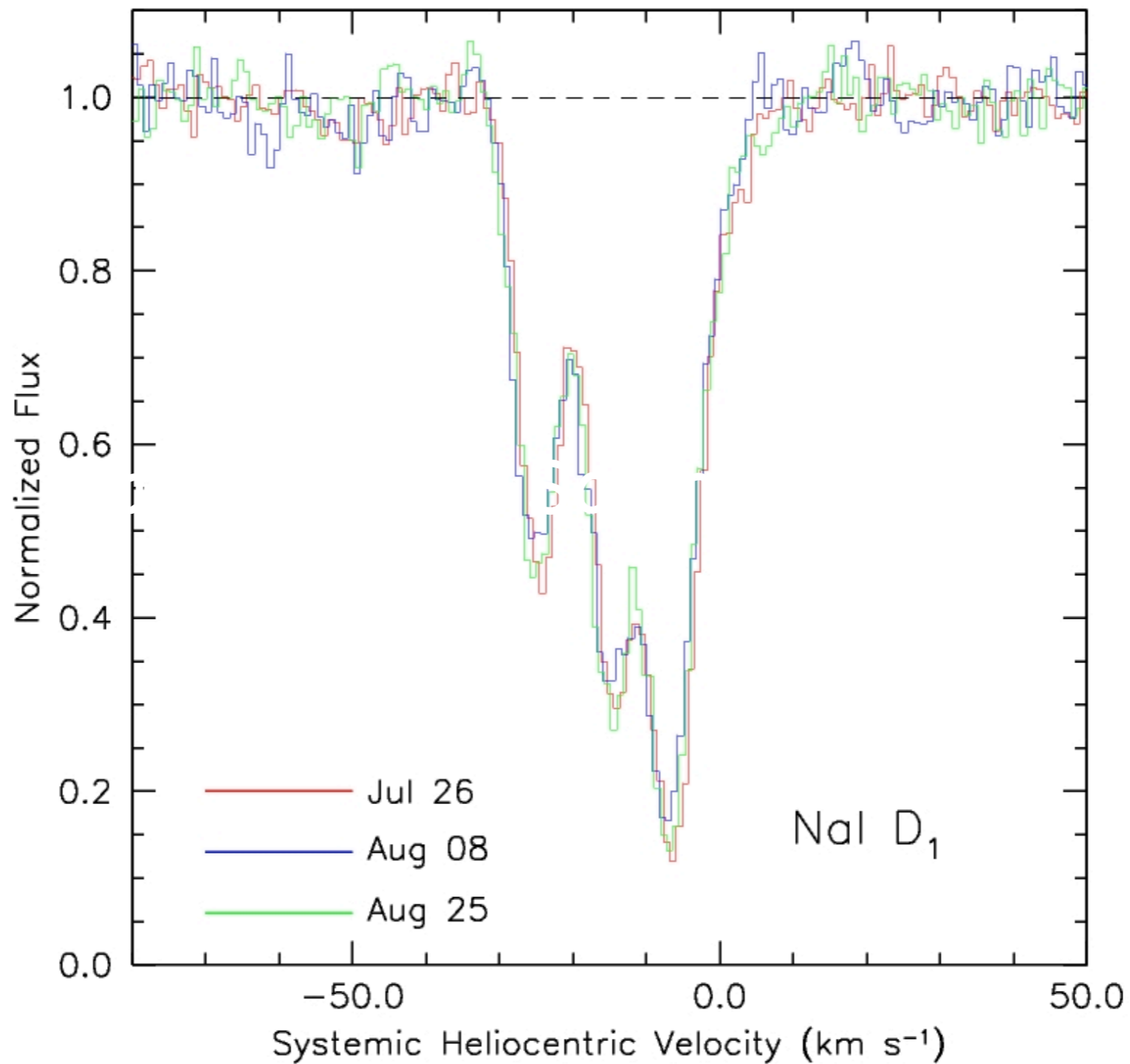
Patat et al. 2007b

SN2007le

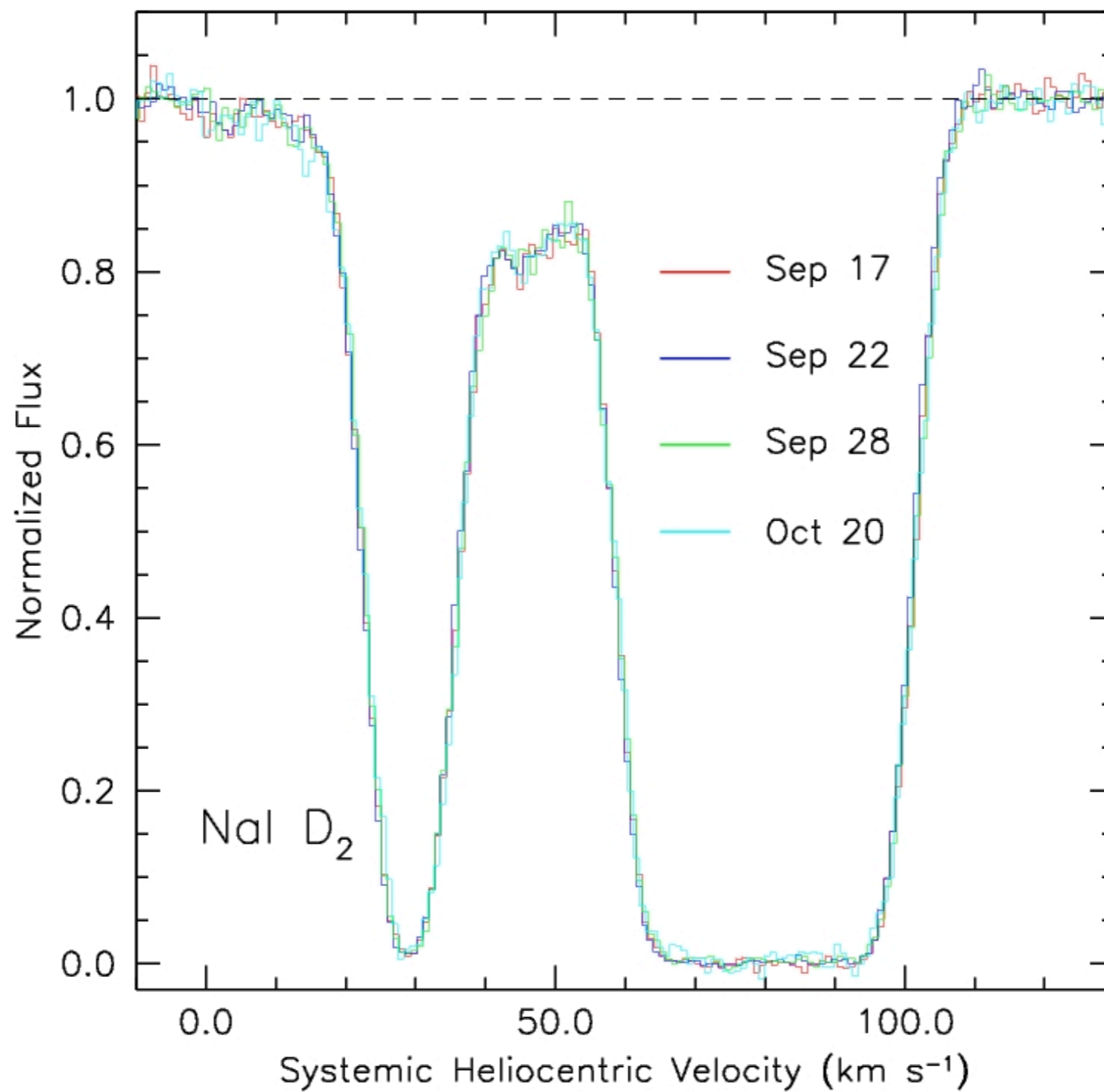


Simon et al. 2009

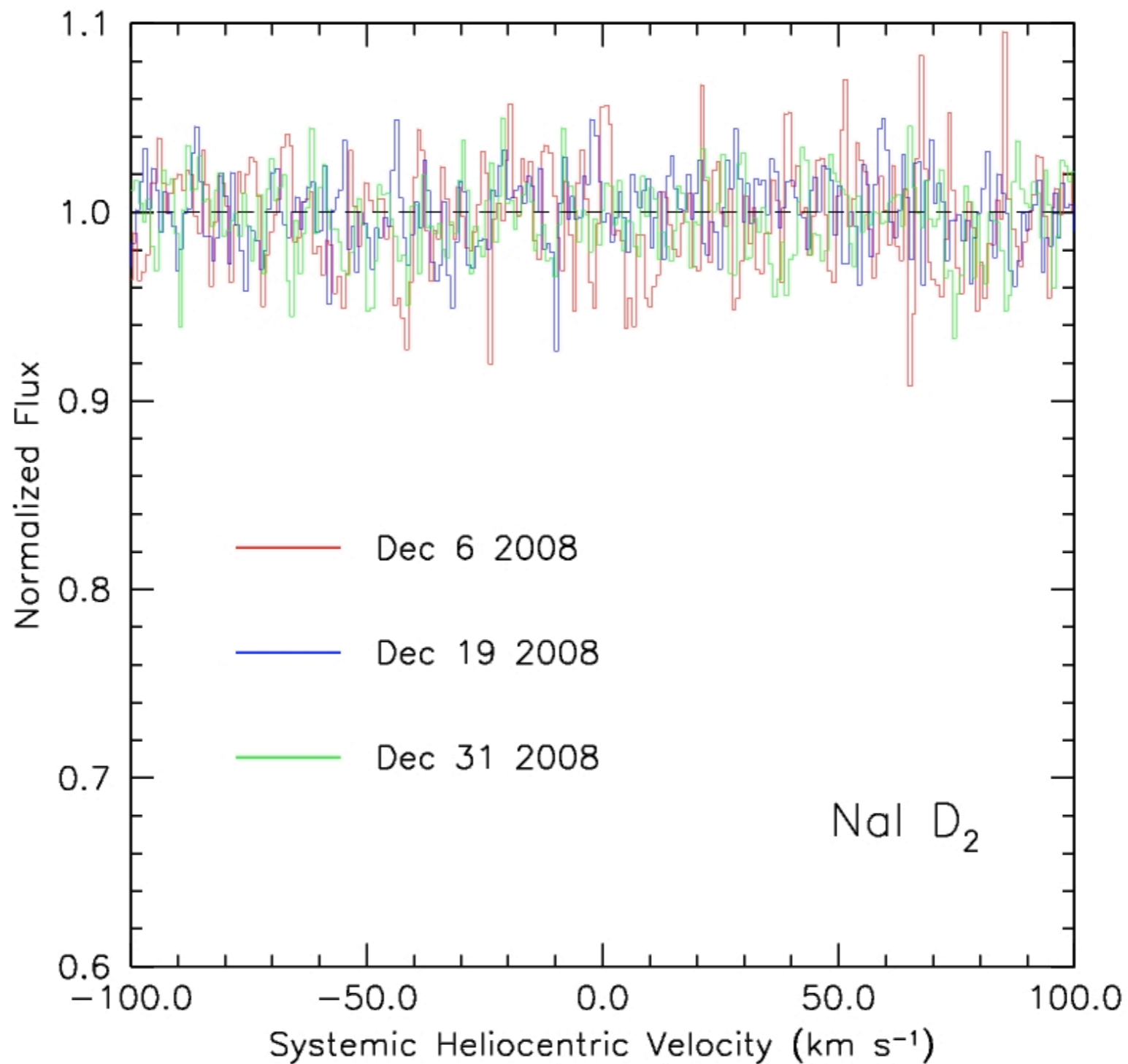
SN2008ec



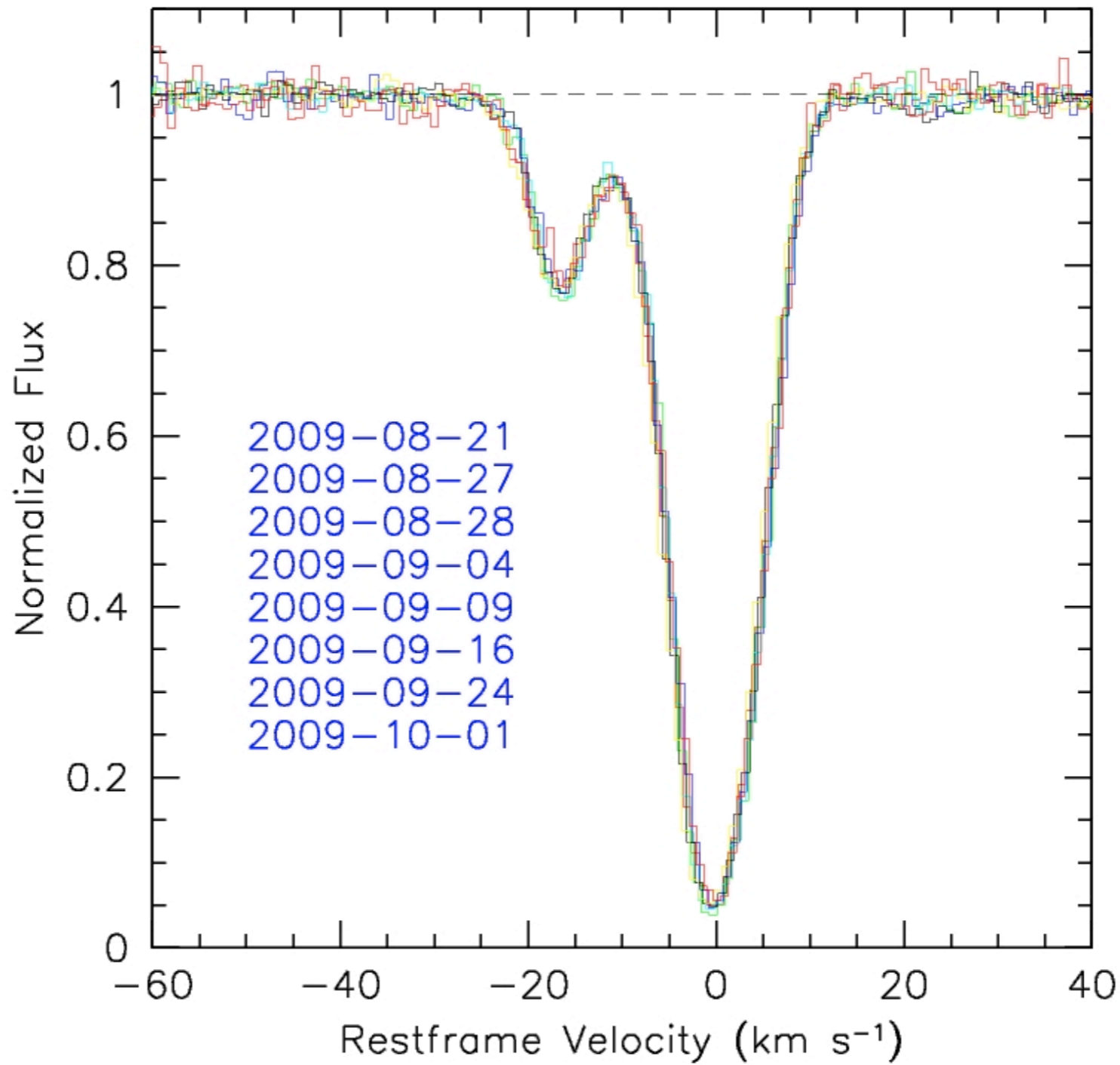
SN2008fp



SN2008hv



SN2009ig



Patat et al. 2010, in prep

The sample as of today

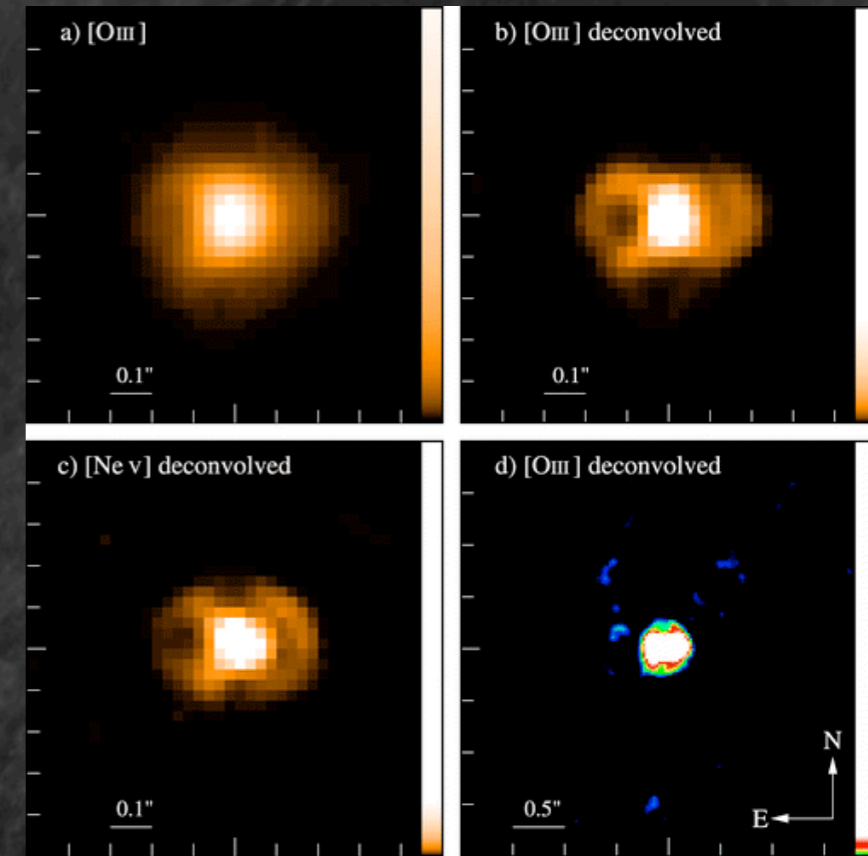
2000cx	VLT		2008ec	VLT
2006X	VLT	✓	2008df	Keck
2007af	Keck		2008fp	VLT
2007le	Keck	✓	2008hv	VLT
2007on	Keck		2009ds	Keck
2007sr	Keck		2009ig	VLT

(*) 1999cl, Blondin et al. 2009, but low-res

1/6 → viewing angle effects? DD??

Is the structure of the CSM more complex than we think?

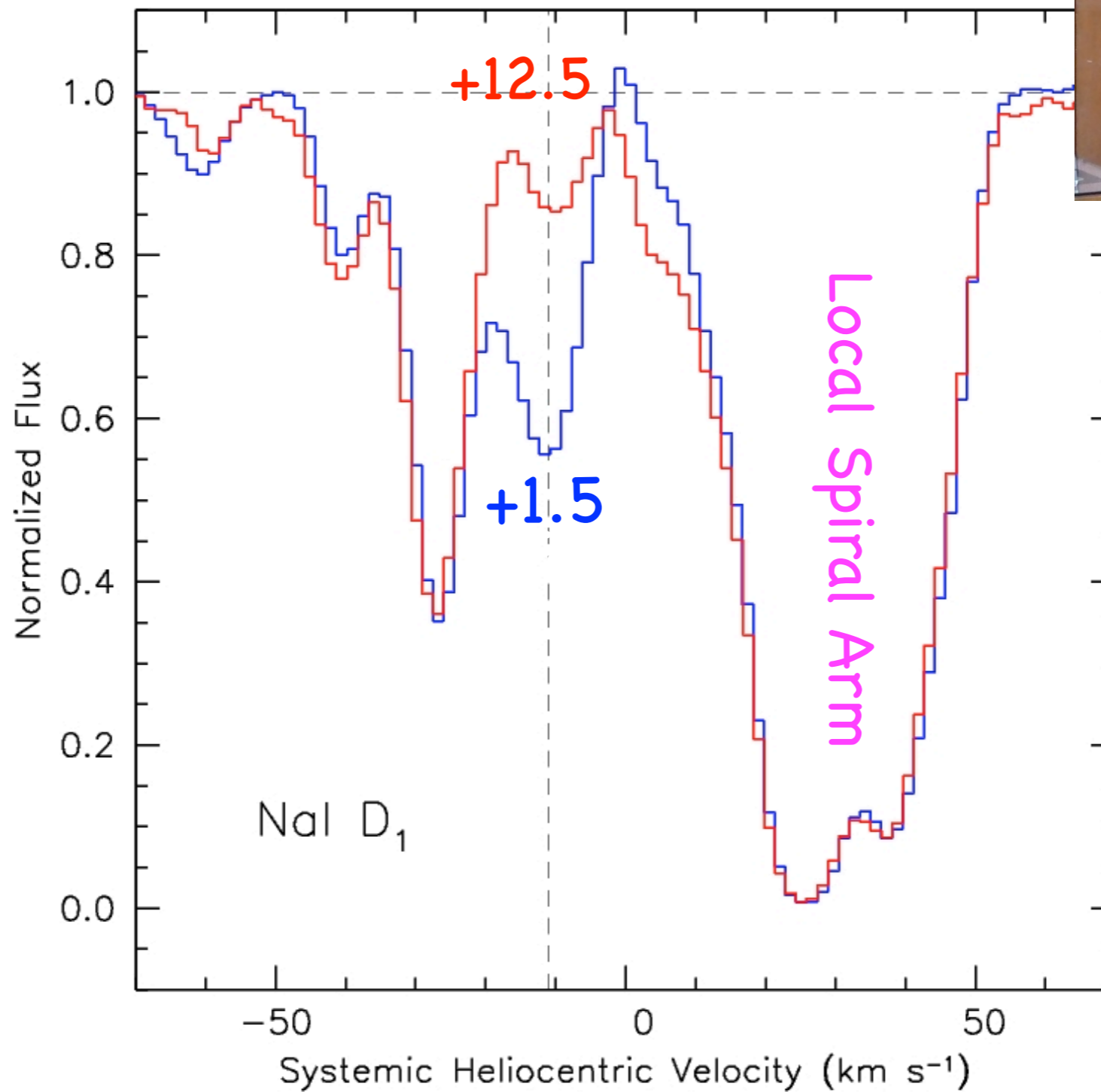
- variability in the RG wind? (Willson 2000)
- remnant shells of successive novae? (Judge & Stencel 1991; Hachisu & Kato 2001; Wood-Vasey & Sokoloski 2006)
- complex CSM environment? (cf. Bob's talk yesterday). RS Oph docet...



(Bode et al. 2007)



RS OPh



Patat et al., in preparation

Is this telling us something? Let's talk (tomorrow)₁₈

