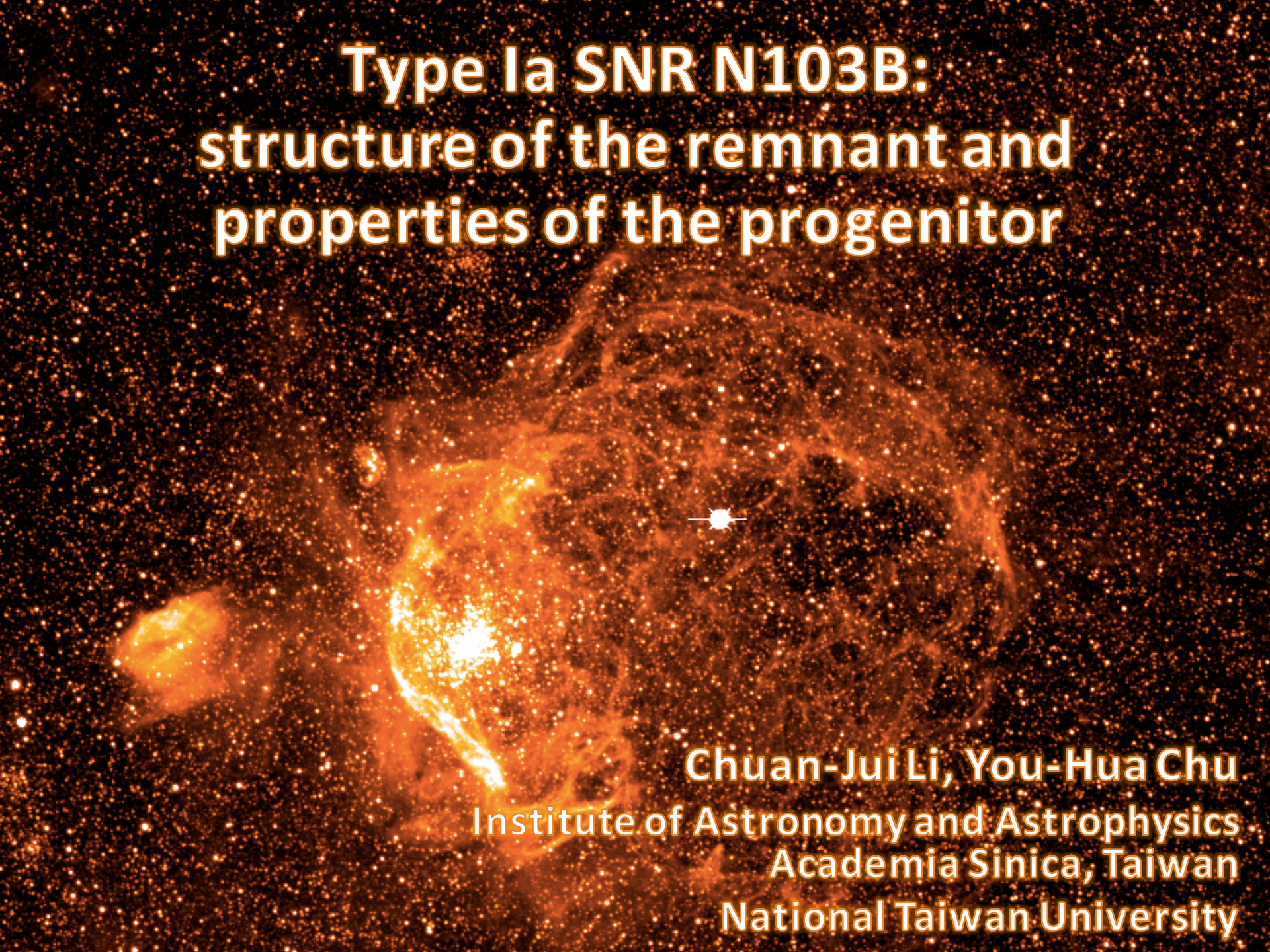
Type Ia SNR N103B: structure of the remnant and properties of the progenitor

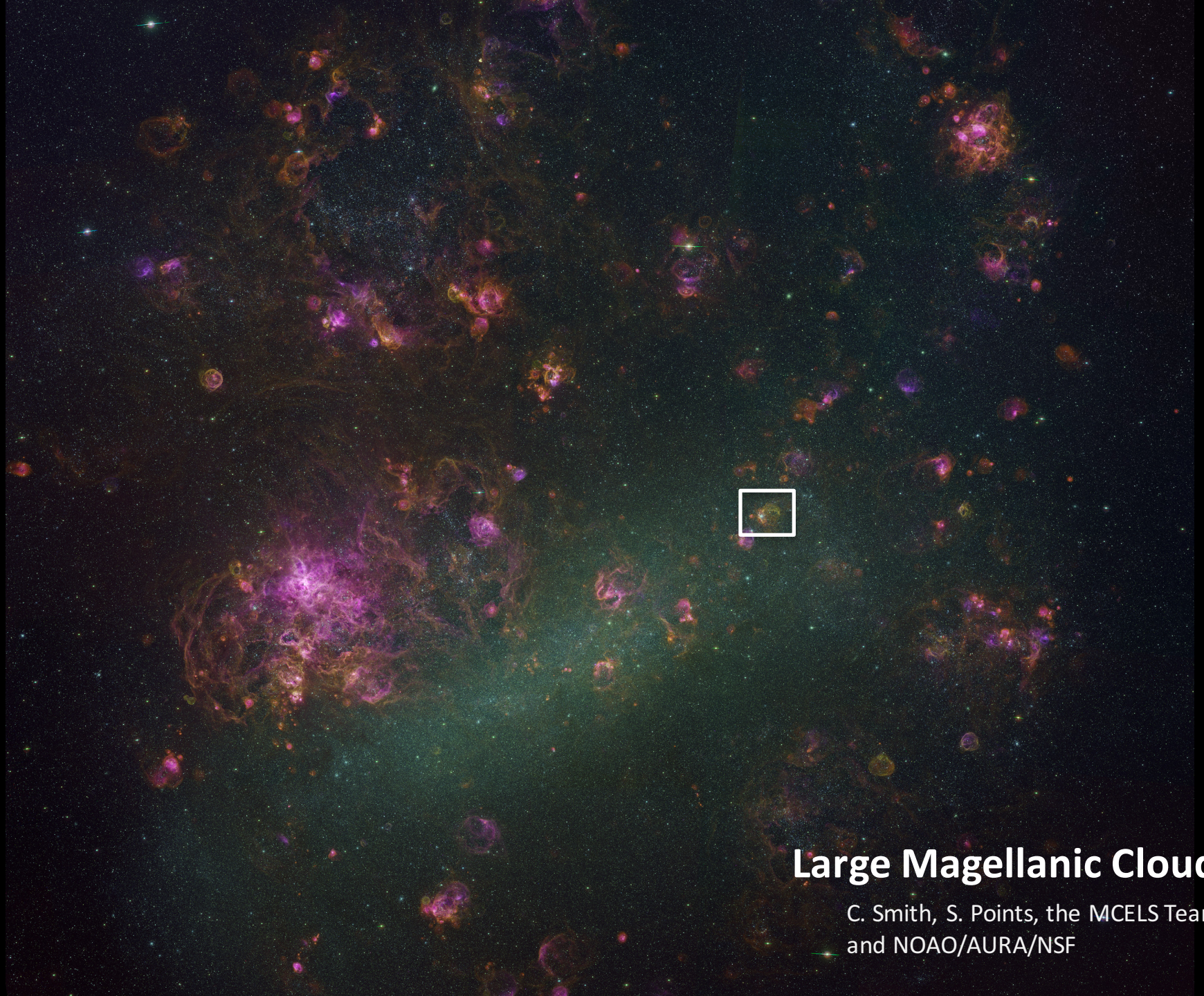


Chuan-Jui Li, You-Hua Chu
Institute of Astronomy and Astrophysics
Academia Sinica, Taiwan
National Taiwan University

Outline

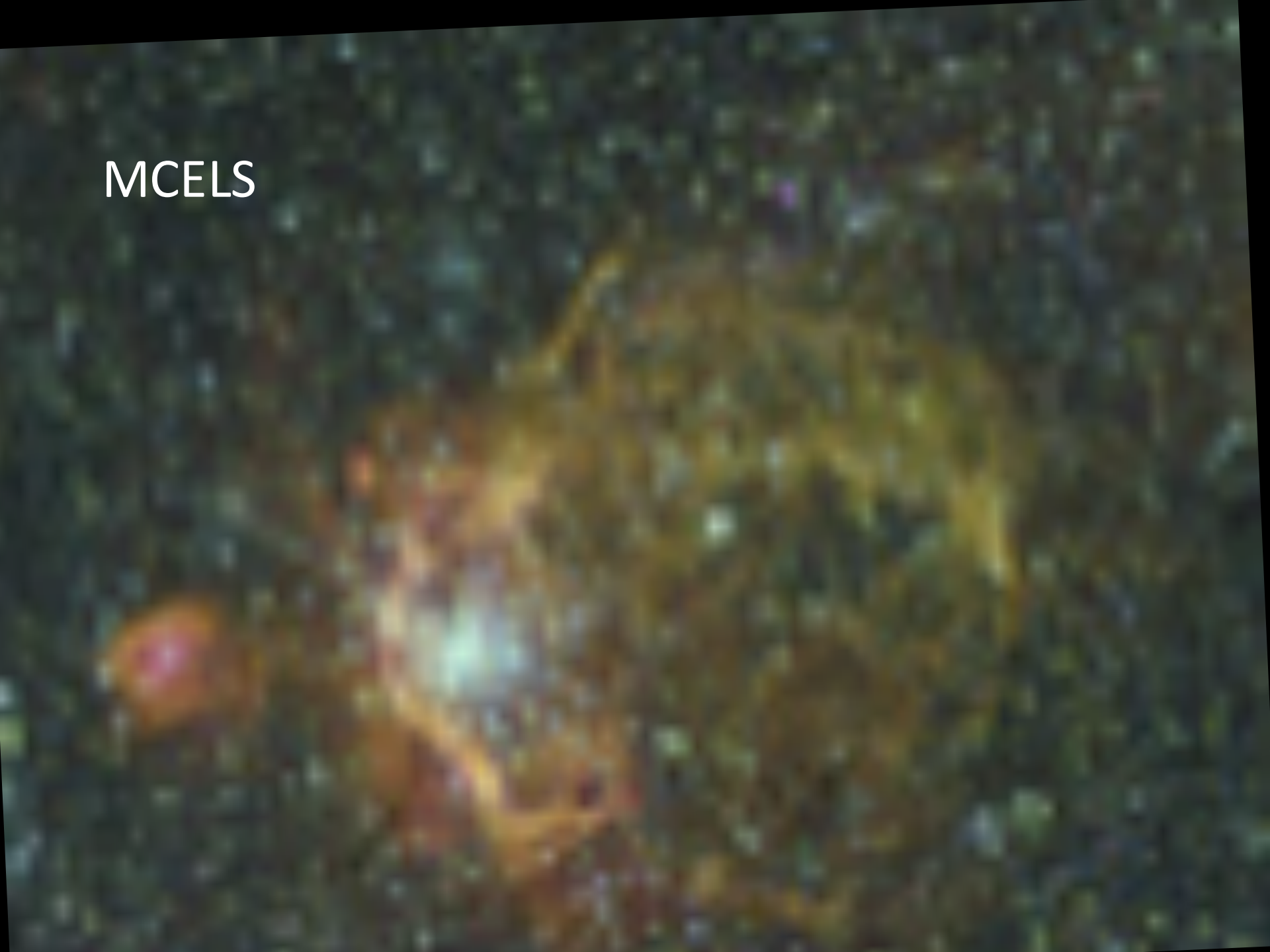
- Environment and physical structure
- Spatiokinematically differentiate SNR and background components
- Proposed model and surviving companion candidates

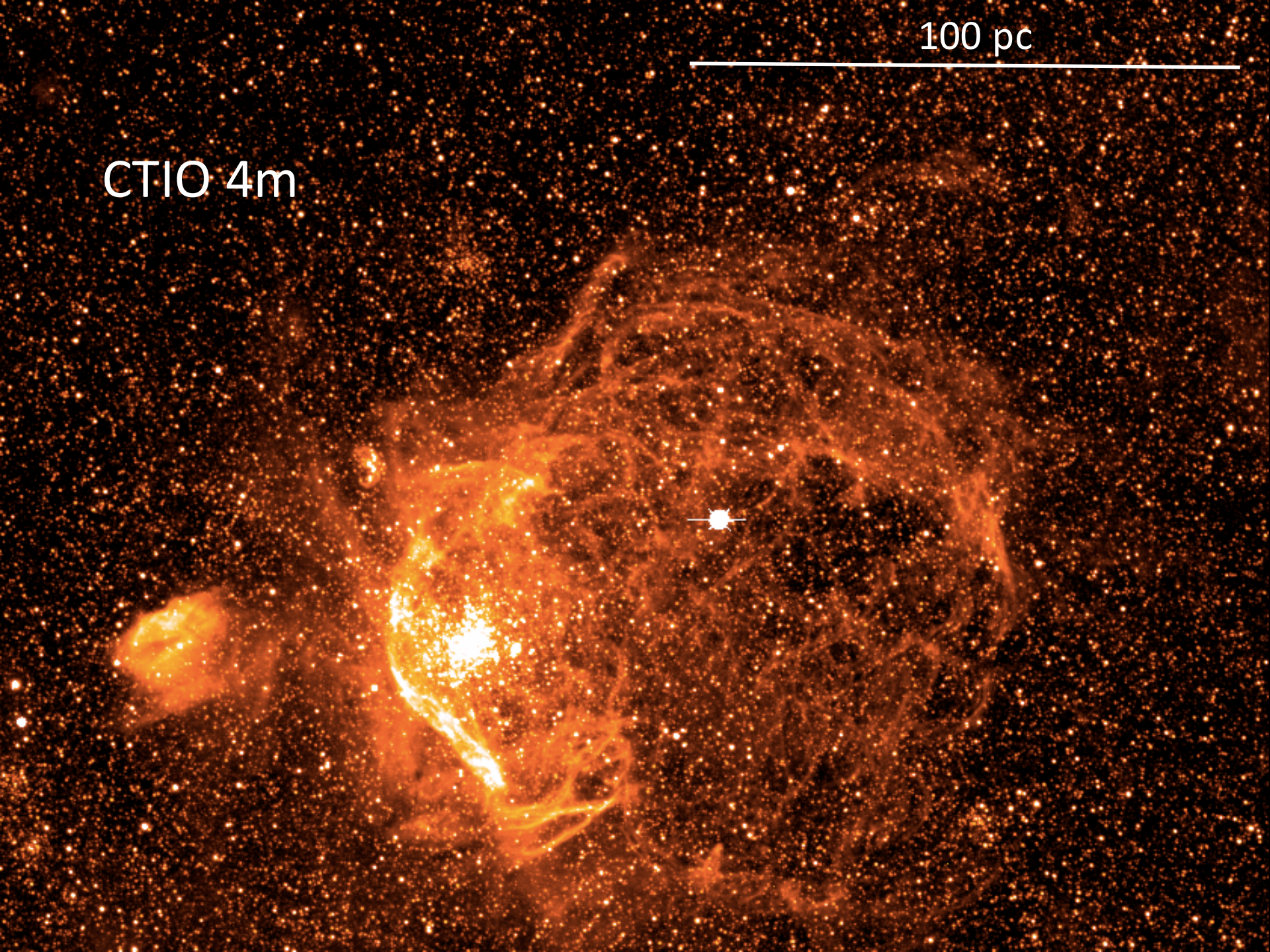

Large Magellanic Cloud
C. Smith, S. Points, the MCELS Team
and NOAO/AURA/NSF

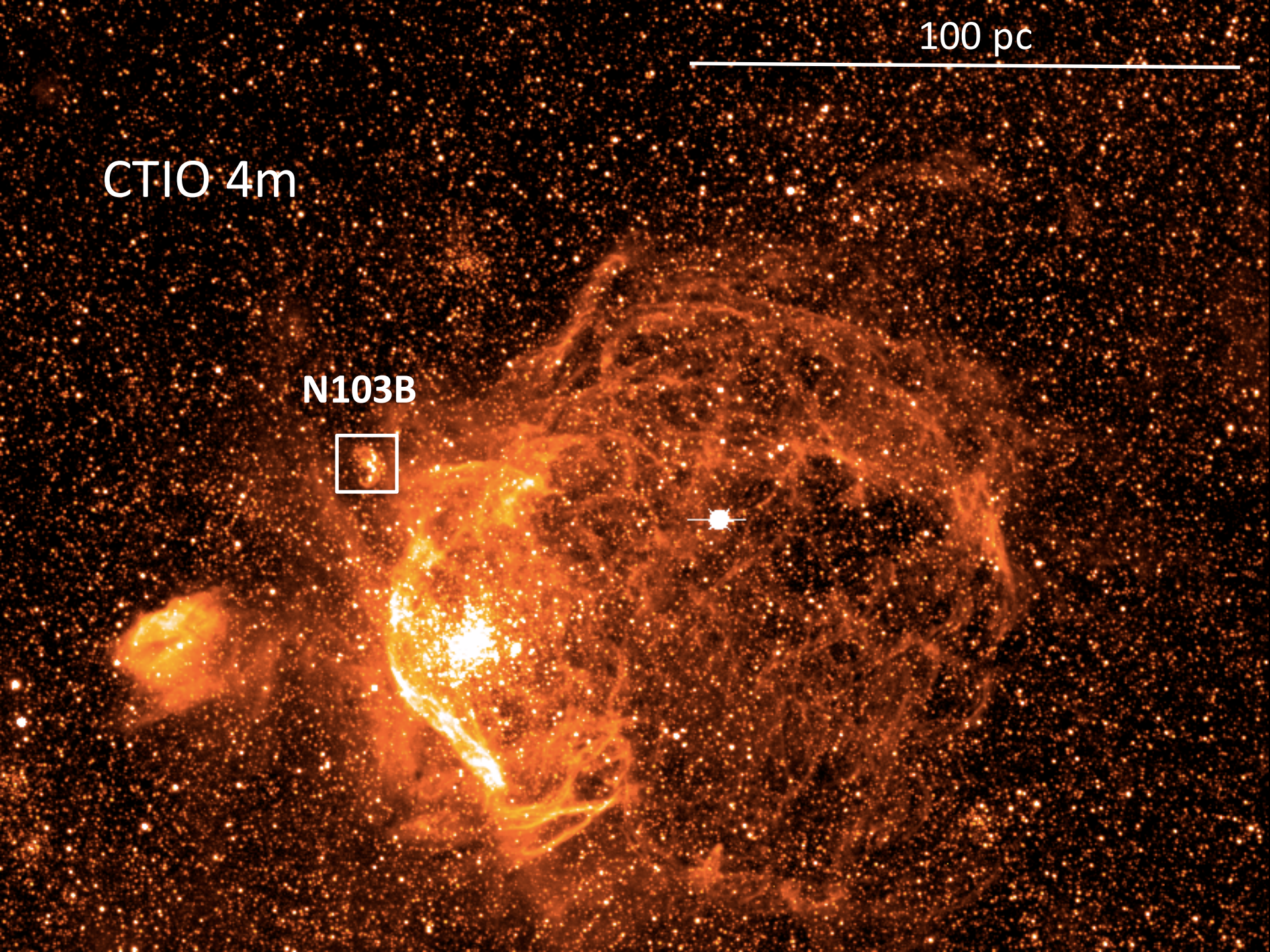


Large Magellanic Cloud

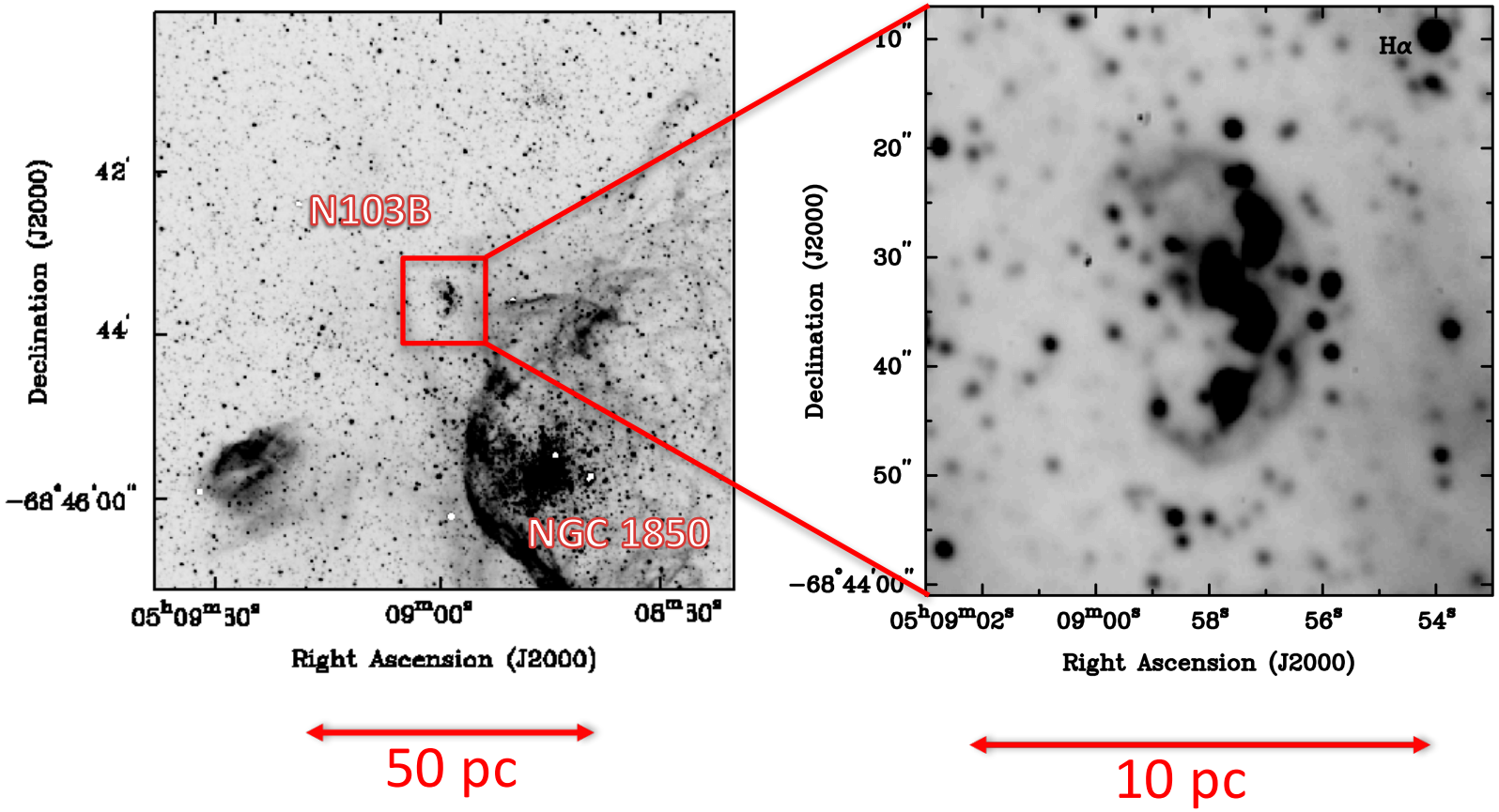
C. Smith, S. Points, the MCELS Team
and NOAO/AURA/NSF


MCELS

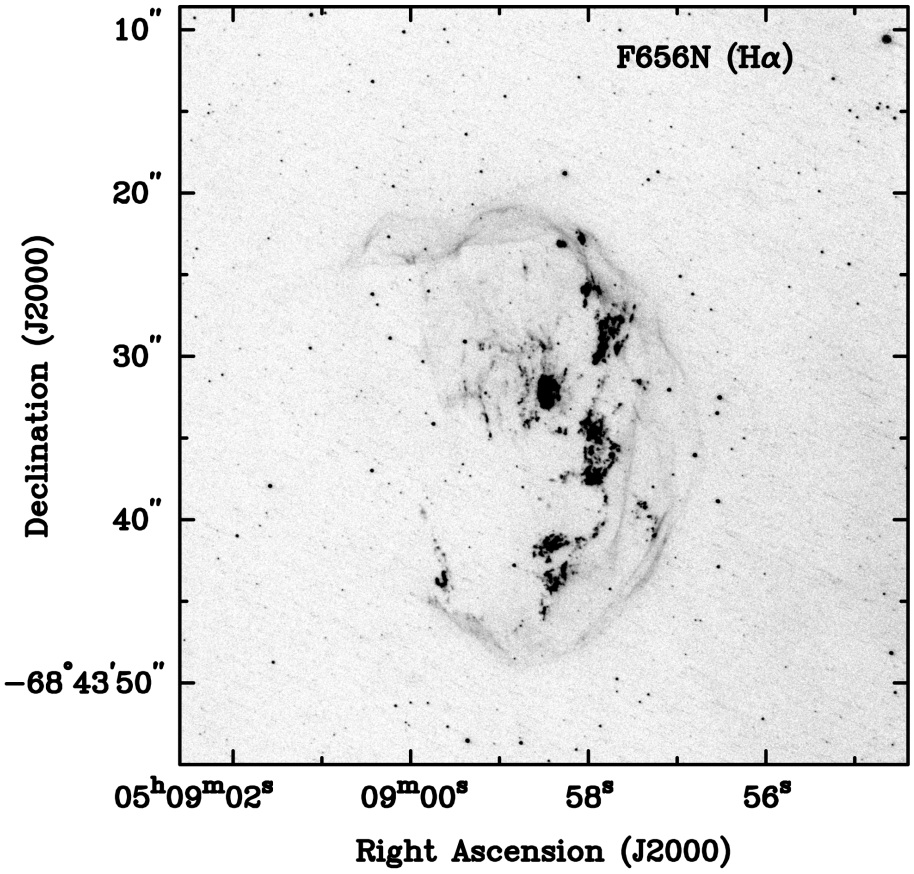

100 pc
CTIO 4m


100 pc
CTIO 4m
N103B

4m Hα Image of N103B

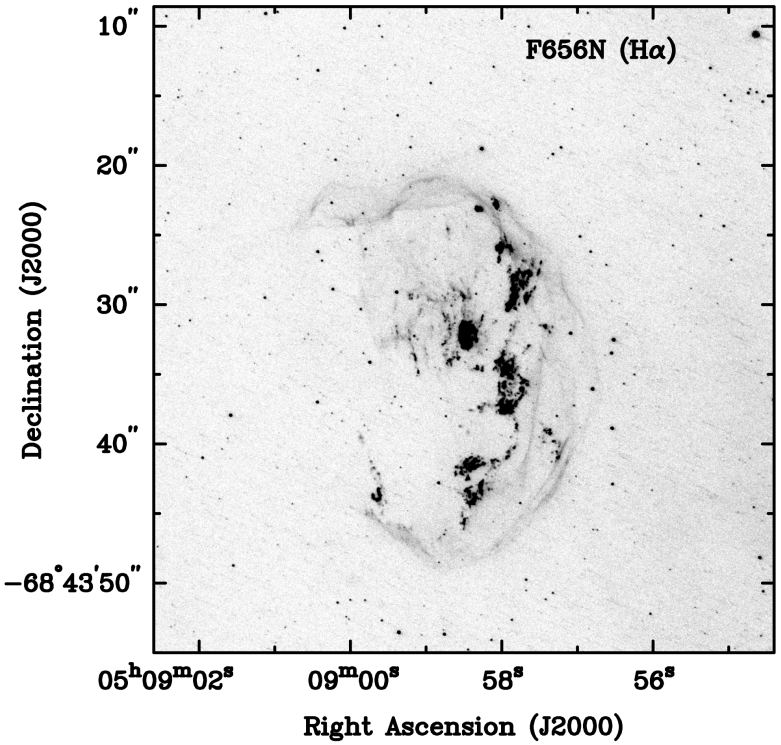


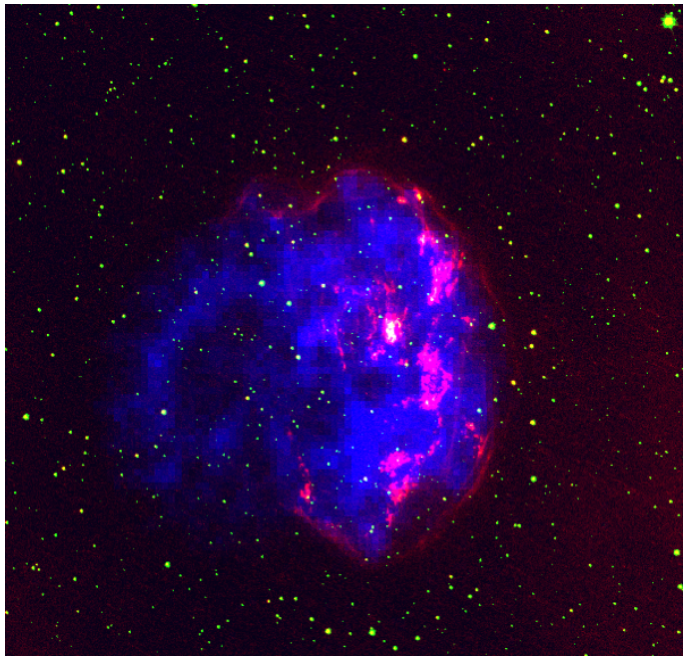
HST Hα Image of N103B



- Known distance
  ~50 kpc (LMC)
- Young ~860 yr
  - light echo (Rest+2005)
- Type Ia
  - X-ray spec (Hughes+1995)
  - light echo (Rest+2005)

HST and Chandra images of N103B





Left: *HST* Hα image

Right: *HST* Hα (R) + F475W (G) + Chandra X-ray (B)

Environment and Physical Structure

1. N103B is projected in the outskirt of the superbubble around the rich cluster NGC1850.

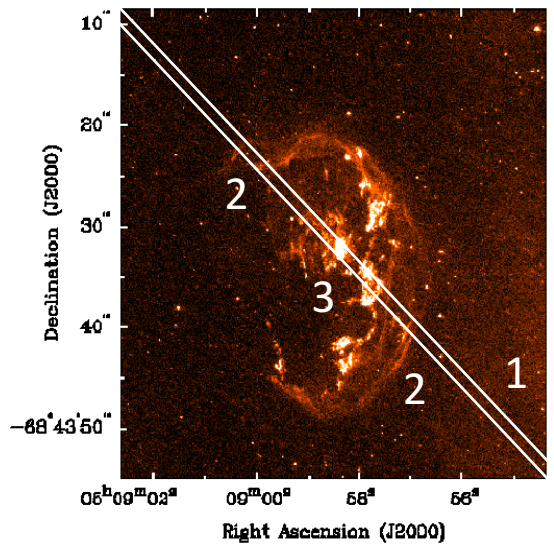
2. The Hα shell is open to the east where X-ray and radio emission extends further out (Lewis et al 2003).

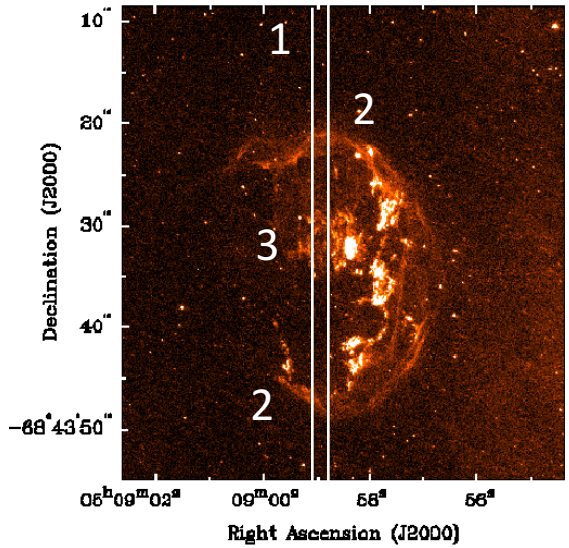
3. Four prominent groups of knots
   - rms electron densities up to $2250 \pm 300\ cm^{-3}$
   - electron densities ~ $5300\ cm^{-3}$ ([S II] 6716/6731)
   - ***High-density knots => circumstellar medium.***

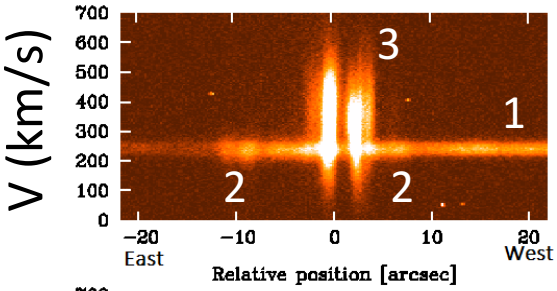
Outline

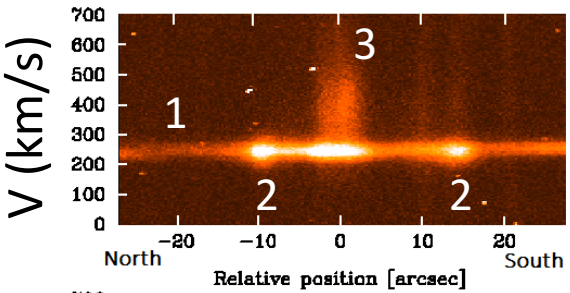
- Environment and physical structure
- Spatiokinematically differentiate SNR and background components
- Proposed model and surviving companion candidates

CTIO 4m long-slit echelle spectra

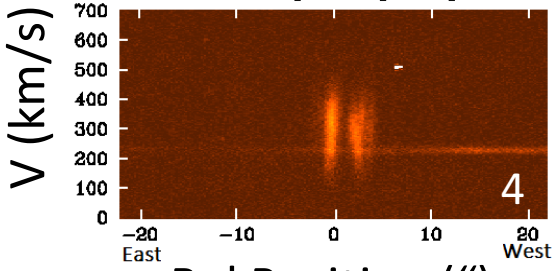


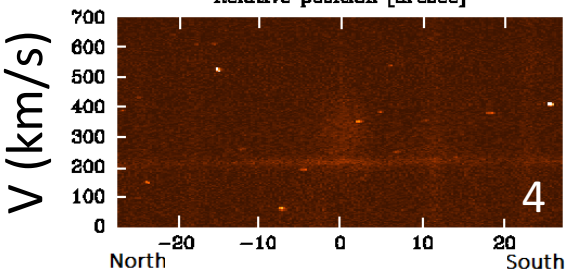






Hα



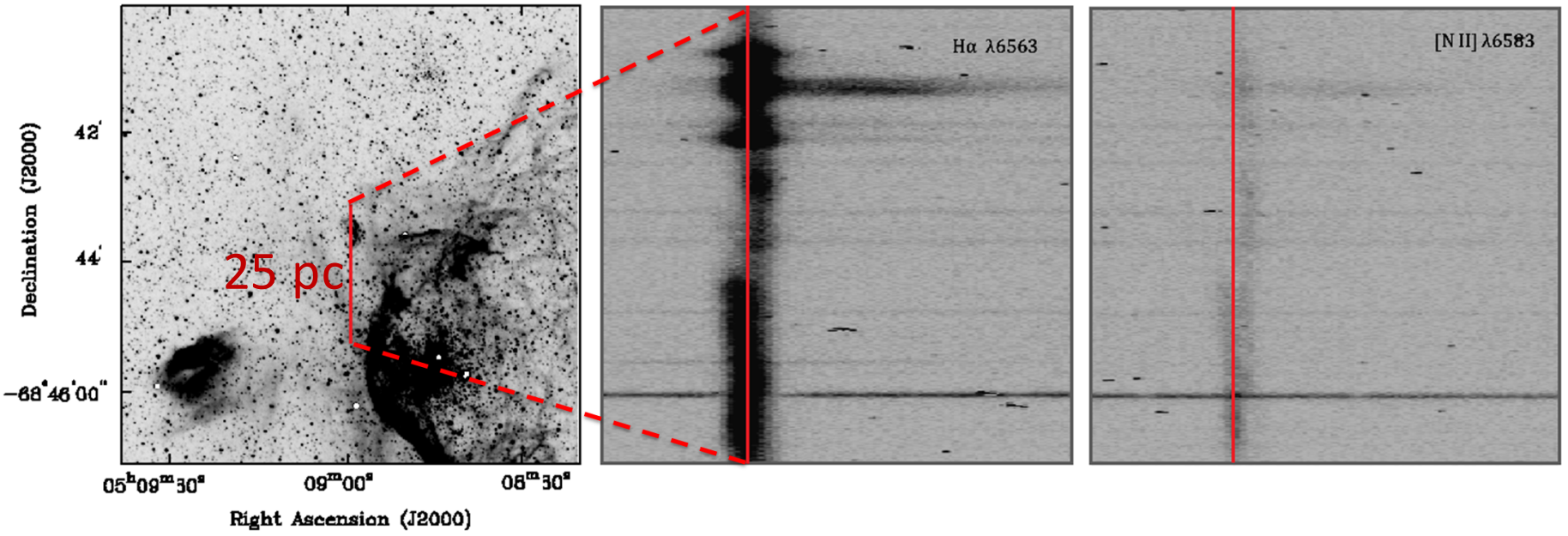


[N II]

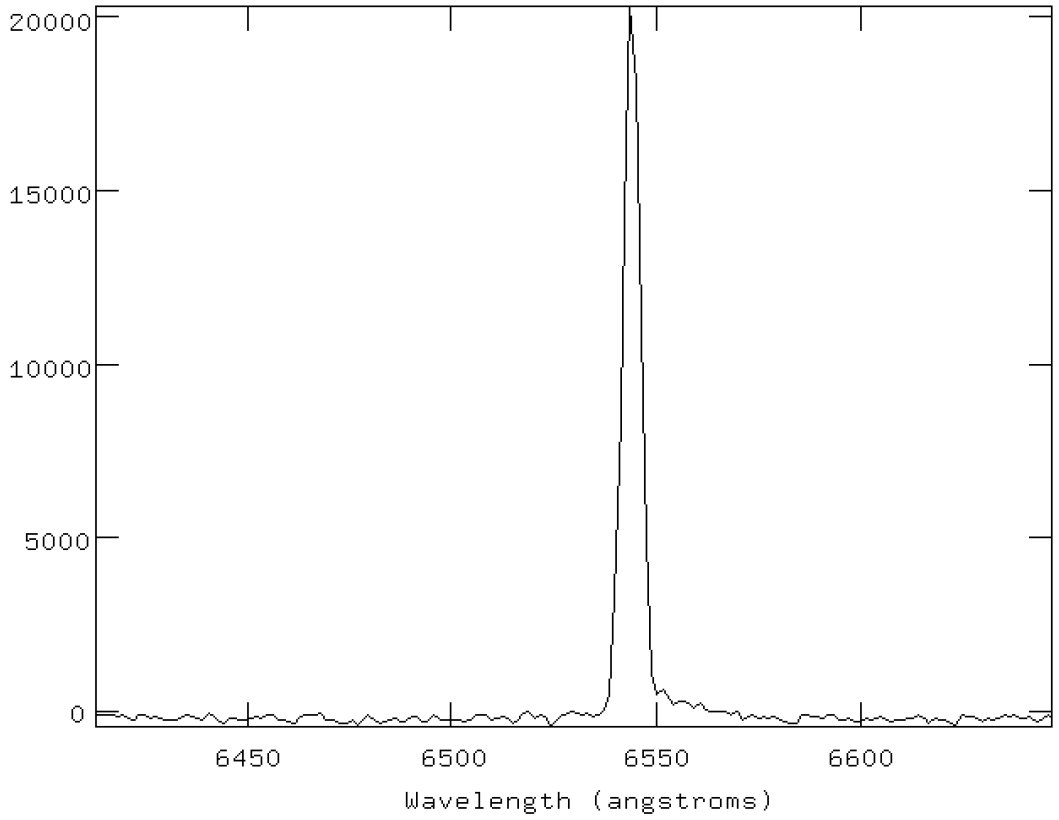
Rel Position (“)

Rel Position (“)

Large 25 pc Expanding Shell



Balmer shell: Narrow component with Broad component on receding side



Taken with SOAR 4m Goodman Spectrograph

Spatiokinematically Differentiate SNR and Background Components

1. Background interstellar gas
2. Balmer-dominated SNR shell
   (core + broad wing on receding side)
3. Shocked nebular knots ($\Delta V \sim 500$ km s^{-1})
4. Large interstellar shell in background

Outline

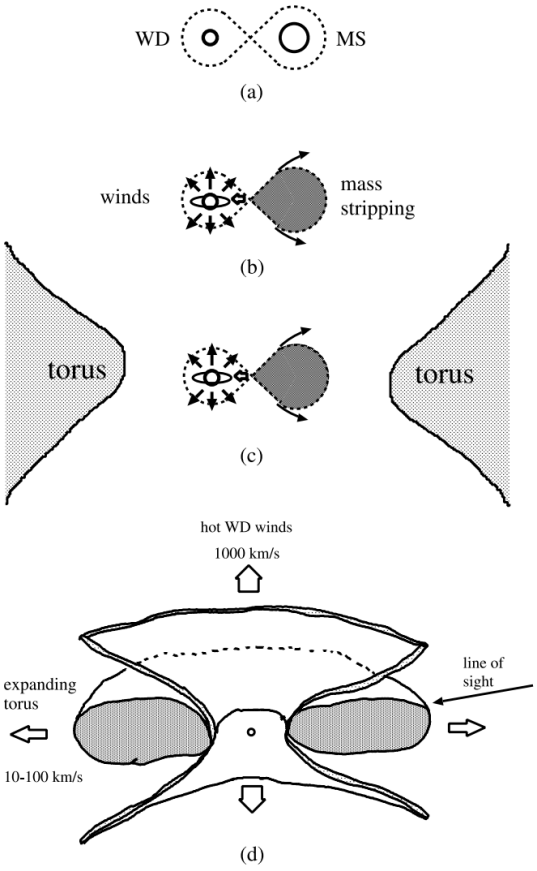
- Environment and physical structure
- Spatiokinematically differentiate SNR and background components
- Proposed model and surviving companion candidates

Proposed Model

We need to explain:

- Apparently elliptical Balmer-dominated shell
- Dense knots
- The eastern diffuse X-ray and radio emission does not have optical counterparts

Proposed Model

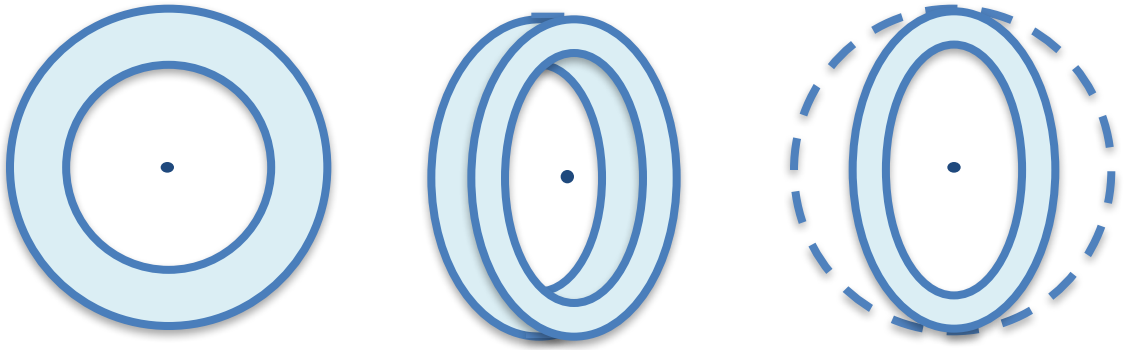


(Hachisu et al. 2008)

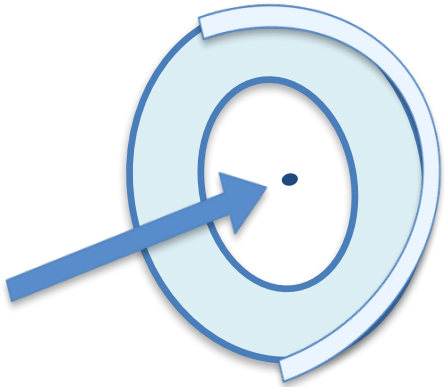
Top view

45° side view

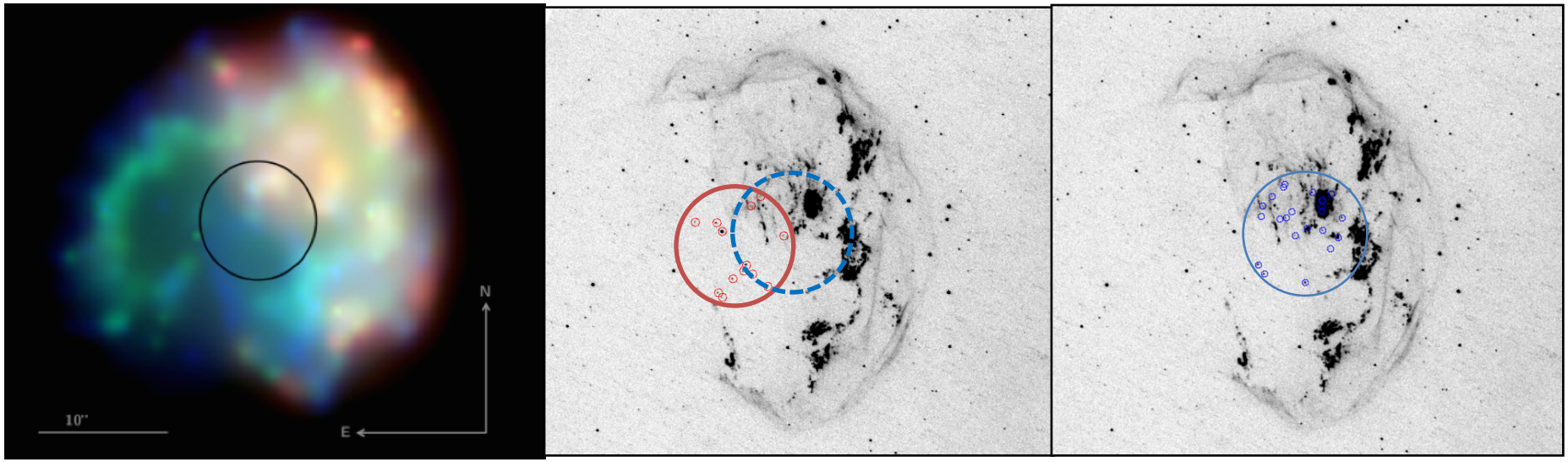
Projection



Proper motion through ISM



Surviving Companion candidates

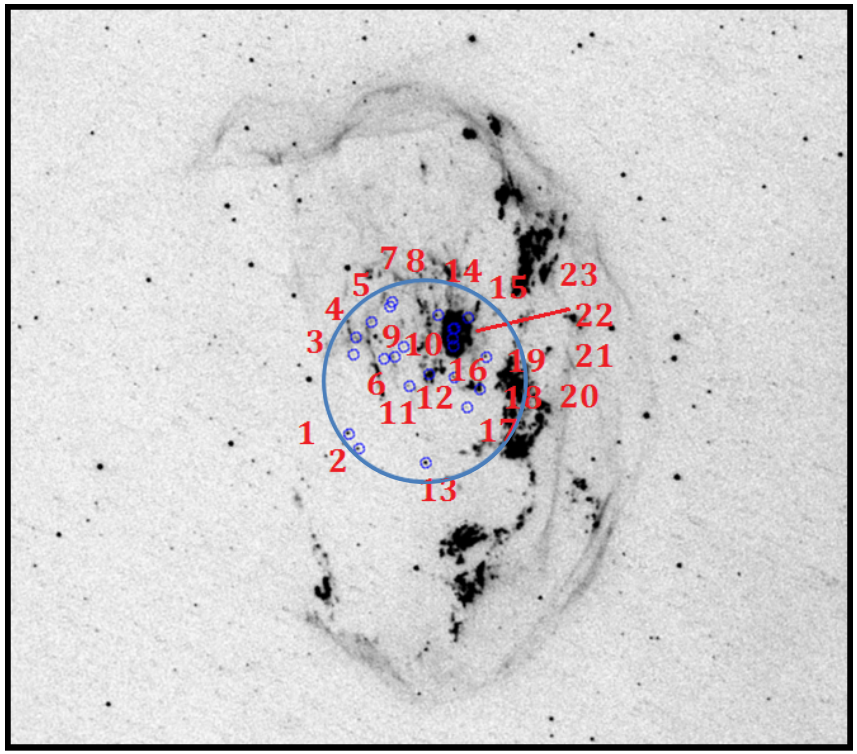


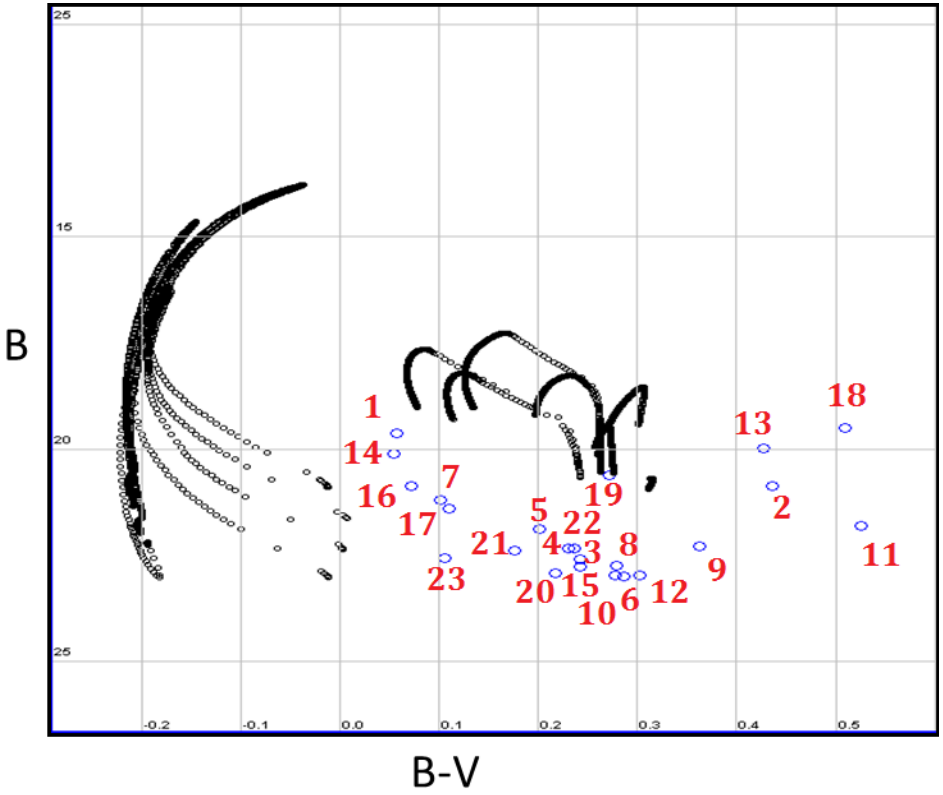
Comparison

Explosion center determined from radio and X-ray emissions.
(Pagnotta & Schaefer 2015)

Explosion center determined from the Balmer shell boundaries.
(Li , Chu, et al. in preparation)

Surviving companion candidates





Li , Chu, et al. in preparation

Pan, et al. 2014

Proposed Model and Surviving Companion Candidates

1. Progenitor's proper motion to west => compression on the leading side and low-density in the trailng side.
2. Progenitor's ejecta => incomplete torus.
3. Explosion center ~ Balmer shell center
4. No obvious surviving companion candidates

Summary

- N103B consists of a filamentary Balmer-dominated shell and dense nebular knots.
- The Balmer shell results from **collisionless shocks**, indicating the N103B is *projected* near the ionized superbubble around NGC 1850.
- The prominent nebular knots consist of shocked circumstellar material ejected by the SN progenitor, thus indicating a SD origin of this Type Ia SN.
- We are using the *HST* photometric data to search for surviving companion candidates, nothing obvious. Model needs improvements.