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Jodrell Bank Observatory

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Advertising!

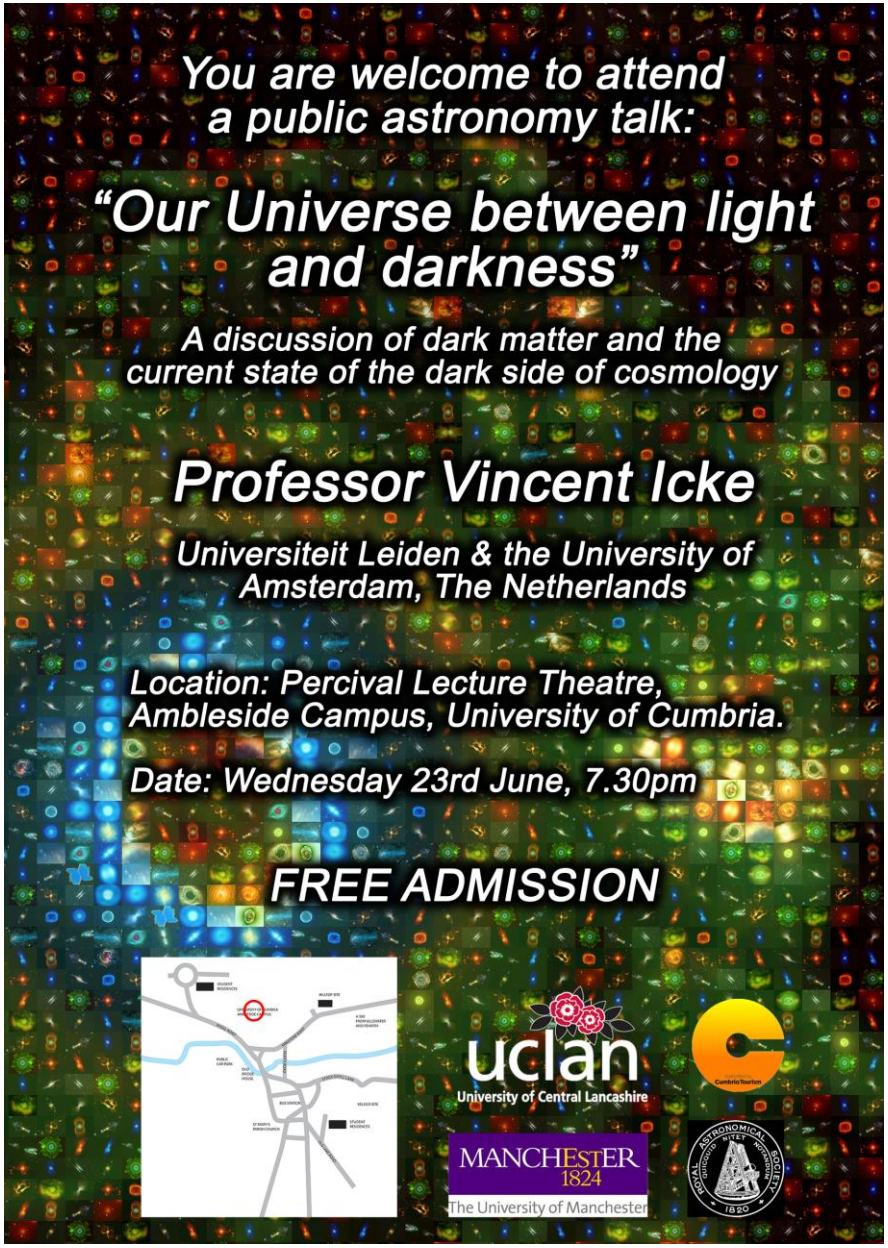
Big Bangs and Black Holes

Professor Carole Mundell
Liverpool John Moores University

Thursday 15th July
Jodrell Bank Observatory

£7 per person

Tickets available from
Jodrell Bank Visitor Centre
or by calling 01477 571 339



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Lost into Space

The Fate of our Sun

or 'Revealing the mass-loss history of a star'

Dr Chris Wareing
Jodrell Bank Visitor Centre

14th June 2010 – West Didsbury Astronomical Society

Overview

- Where's our Sun going in life?

- Modelling evolved stars:-
  - planetary nebula and their progenitors
  - mira stars
  - neutron stars

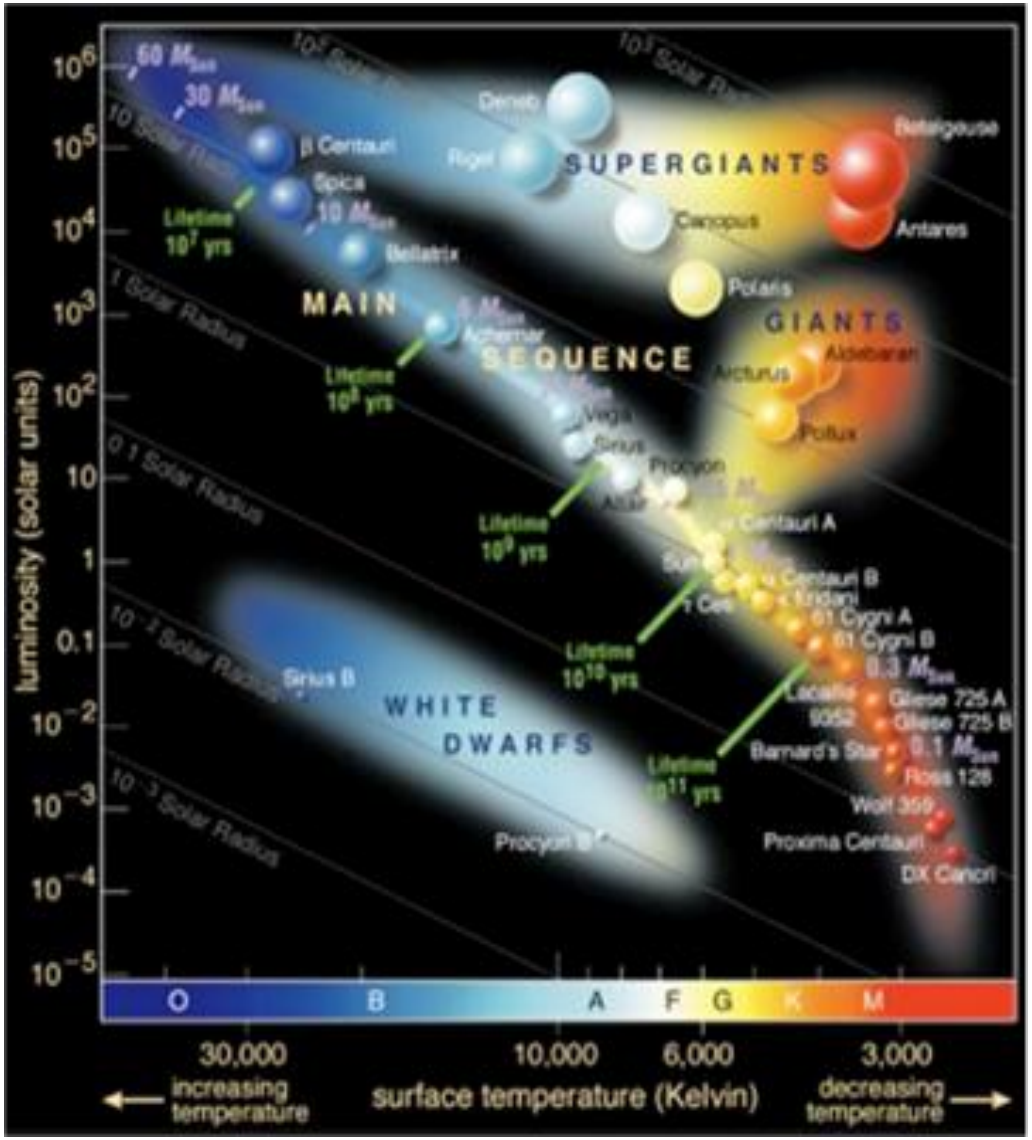
Motivations

- What's my motivation?

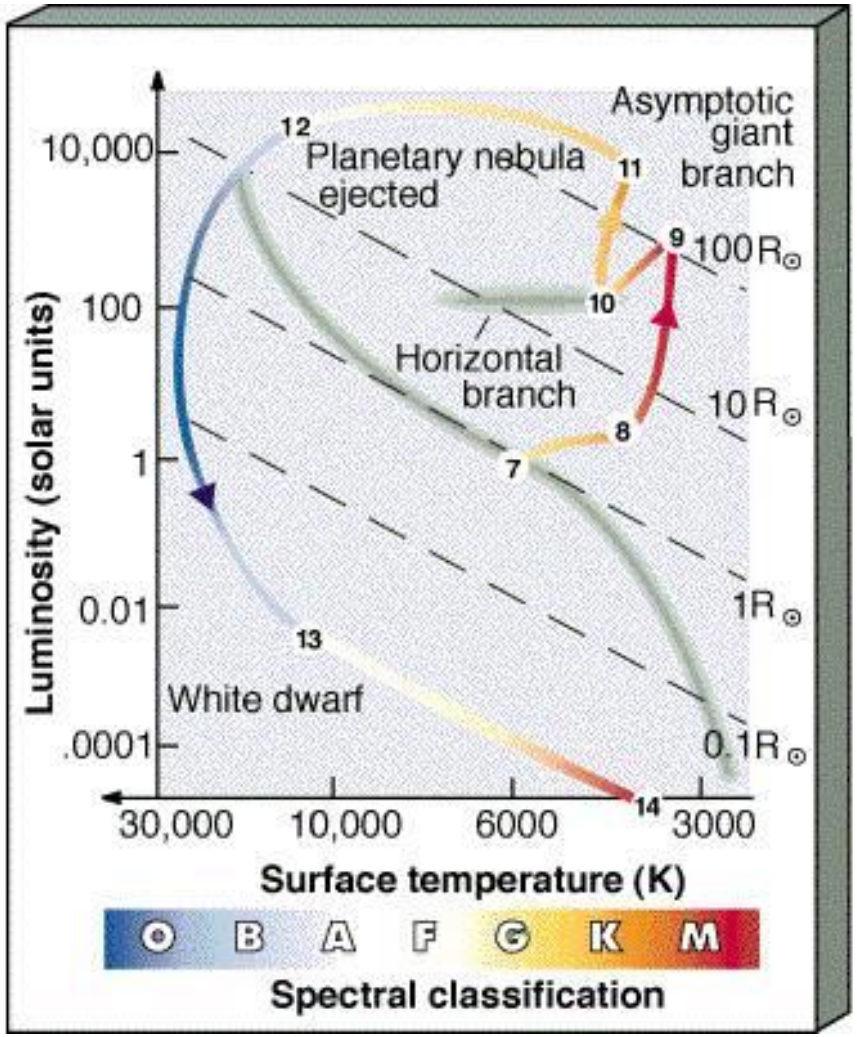
- Towards understanding the evolution of our Sun…
  - will our Sun explode in a giant fireball?
  - or will it fizzle out and fade into obscurity?
  - or is it something in between?
  - what will happen to the Earth?

- Stellar mass-loss is the motor that makes stars and galaxies change over time.
  - If only we could see how it changed over time!
  - Could we disentangle the effects of the surrounding interstellar space and reveal the mass-loss history of a star for the first time!

Where are we now…

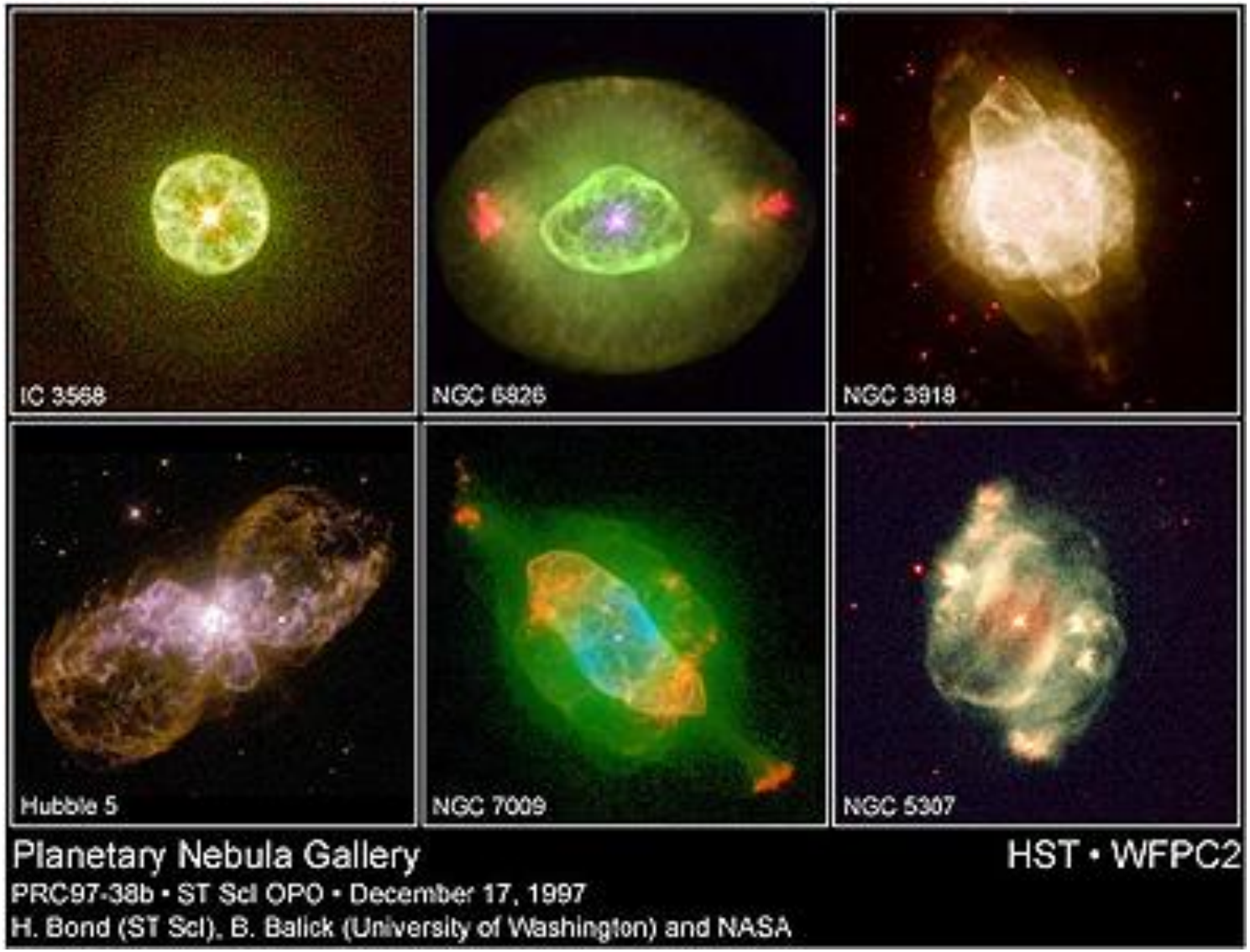


...and where are we going?

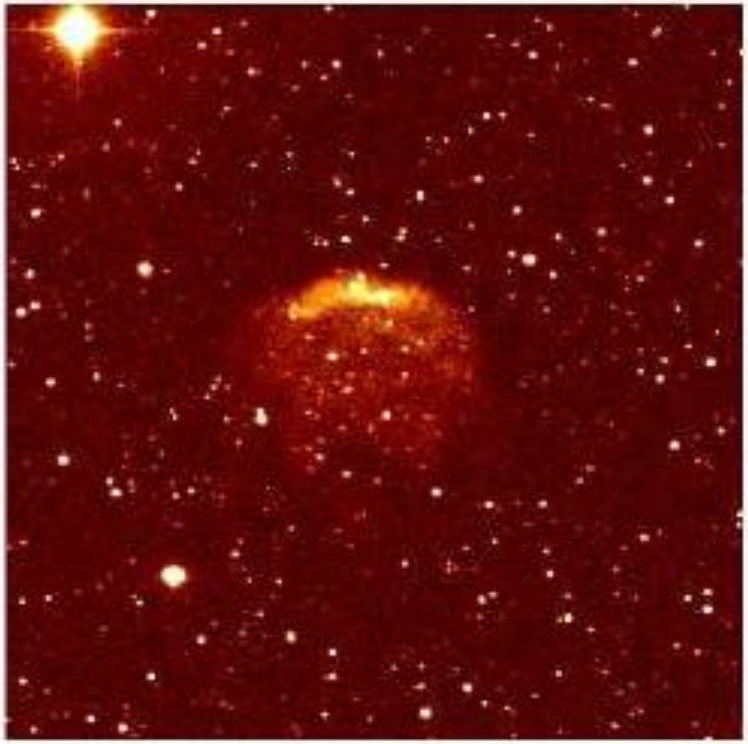


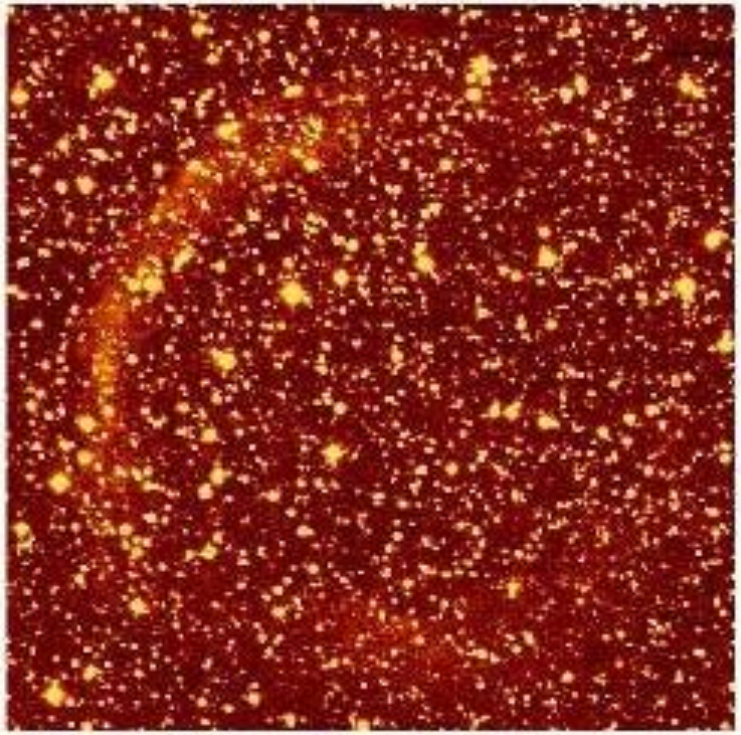
To answer these questions, astronomers must study planetary nebulae

Some of the beautiful images…



PNe from the recent IPHAS survey

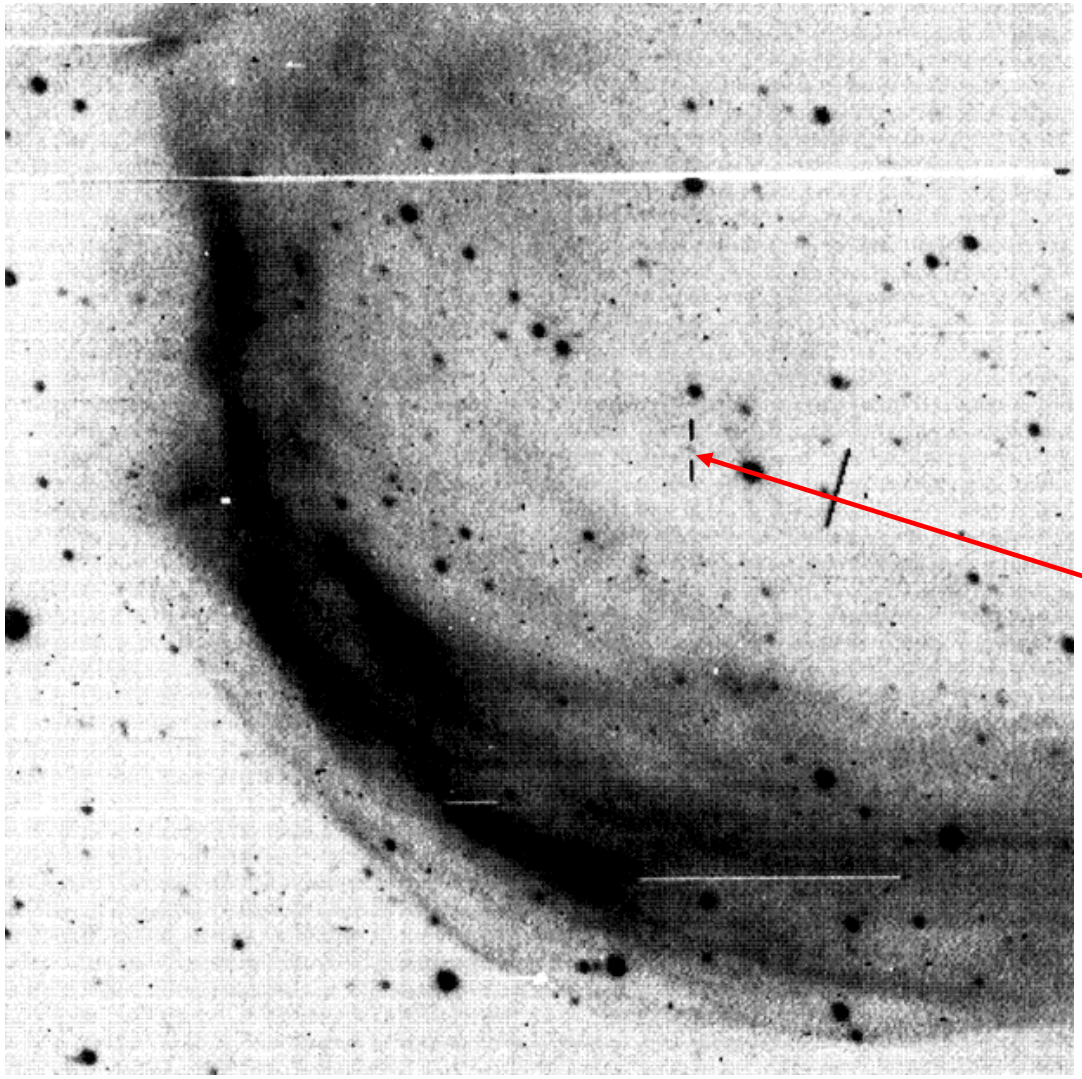




- Some PNe show only interactions at their extreme edges.

What are they interacting with?
Where has this material come from?
Might this material contain details of mass-loss history?

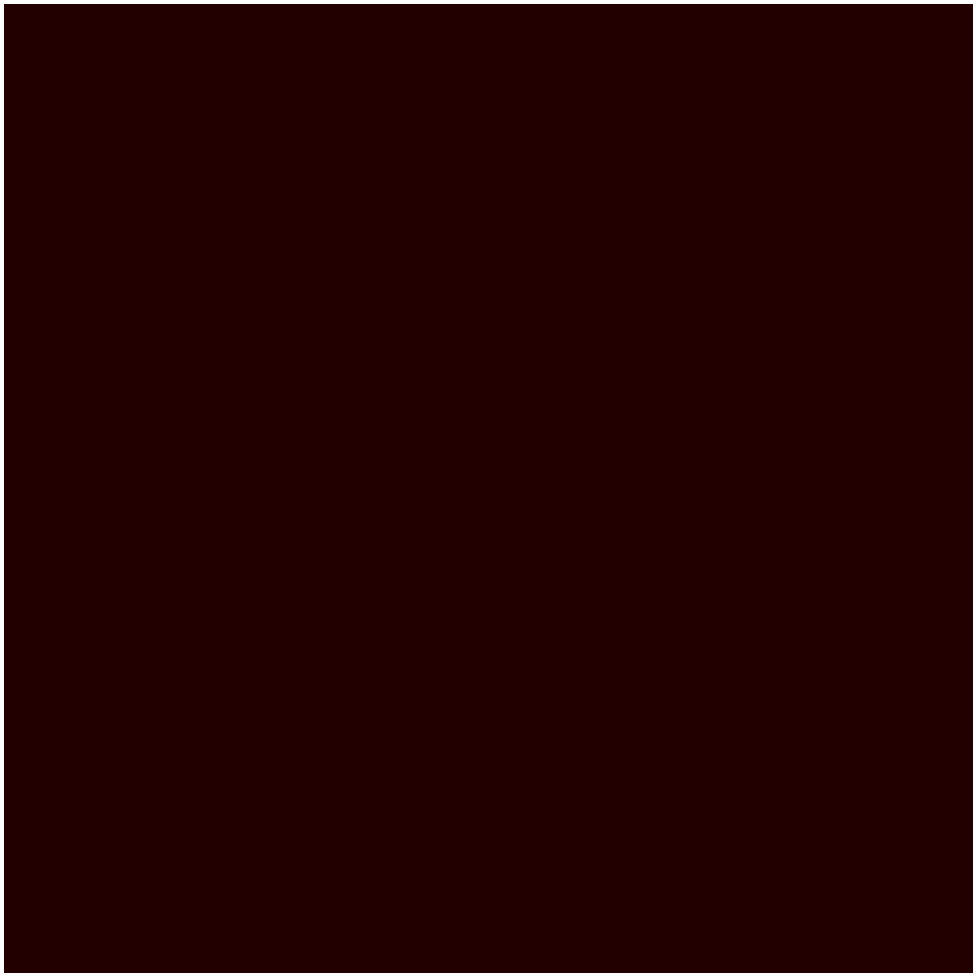
The planetary nebula Sh 2-188



- Filamentary one-sided nebula.
- Central star candidate.

Sh 2-188: new observations

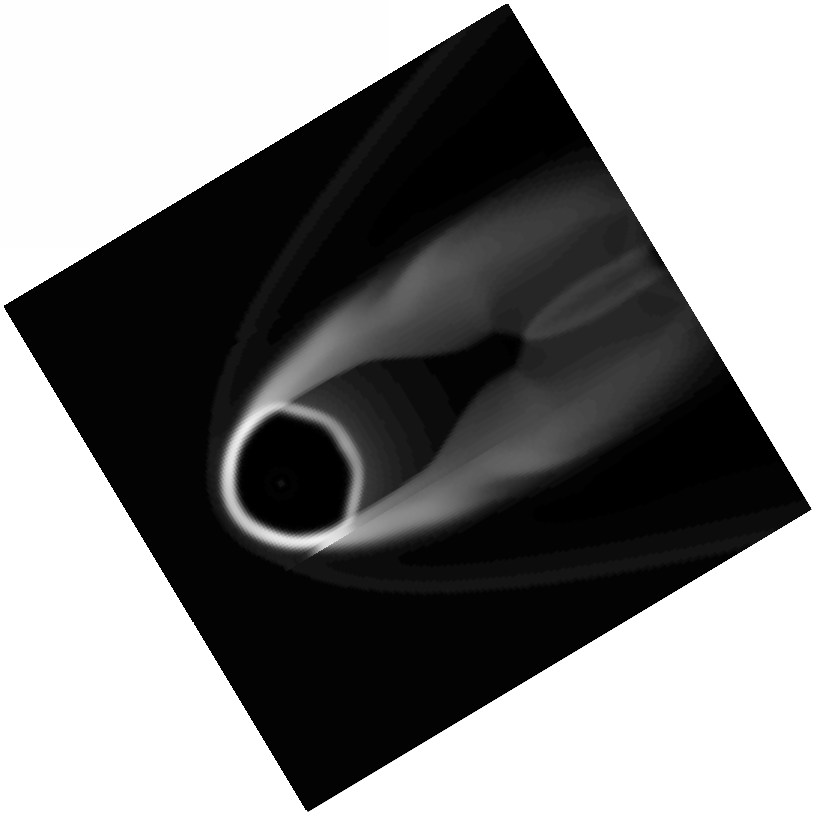
Hydrodynamic simulations



- space isn't empty, albeit very close.
- we simulate space as a very low density fluid
- the equations for the motion of fluids are well known (if still unsolved!)
- we use an approximation and a model like a boat passing through water; we move a star through the fluid

N.B. – there are 5 times more frames per unit time during the post-AGB phase

Sh 2-188: post-AGB evolution

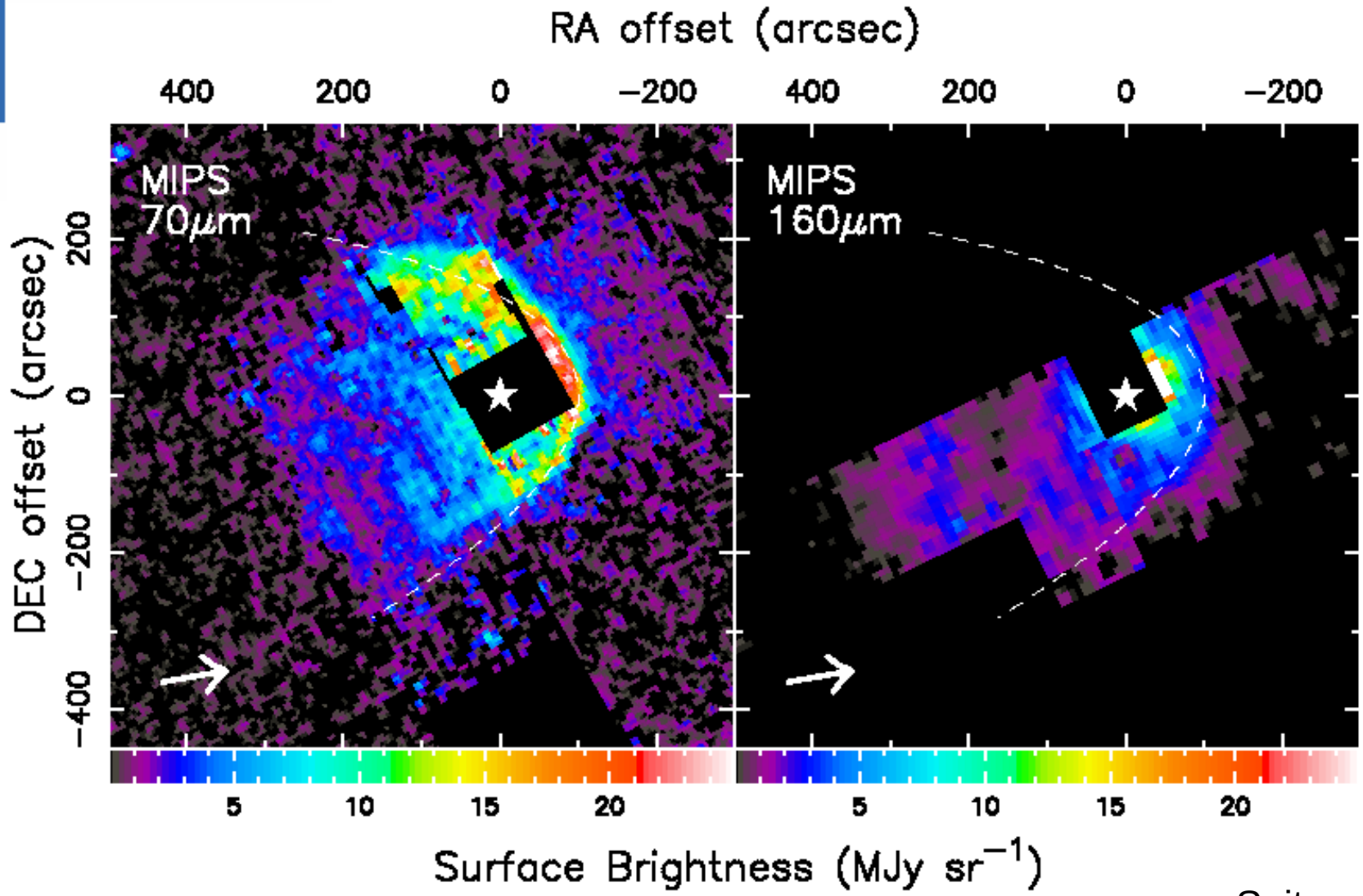


Best fit of model implies a velocity of 125 kilometres per second!

Prediction 1

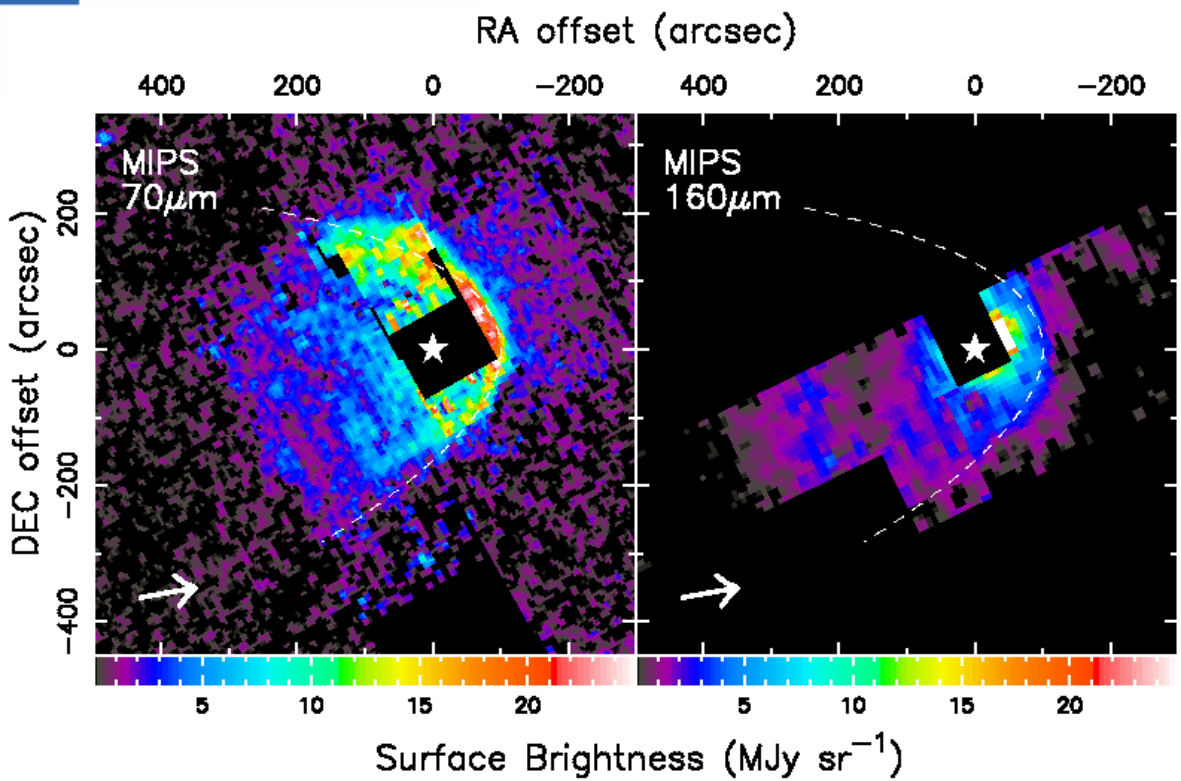
There must exist bow shocks around the *progenitors* of planetary nebulae.

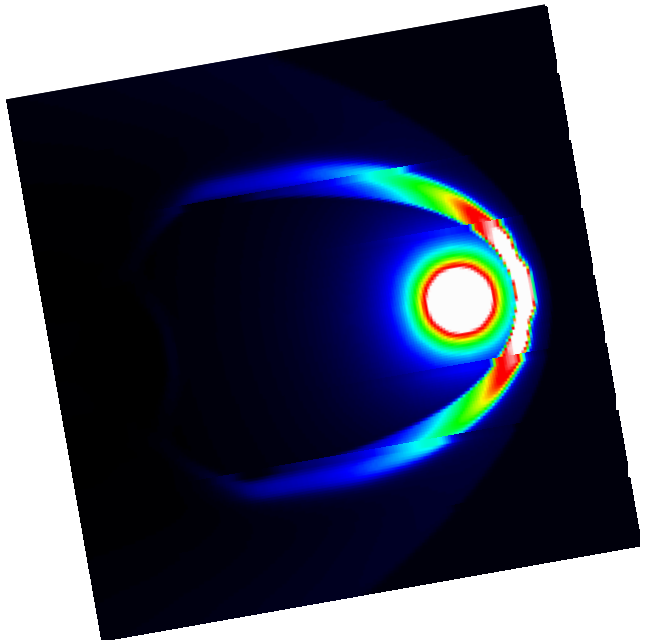
New observations of R Hydrae



Spitzer data

New observations of R Hydrae



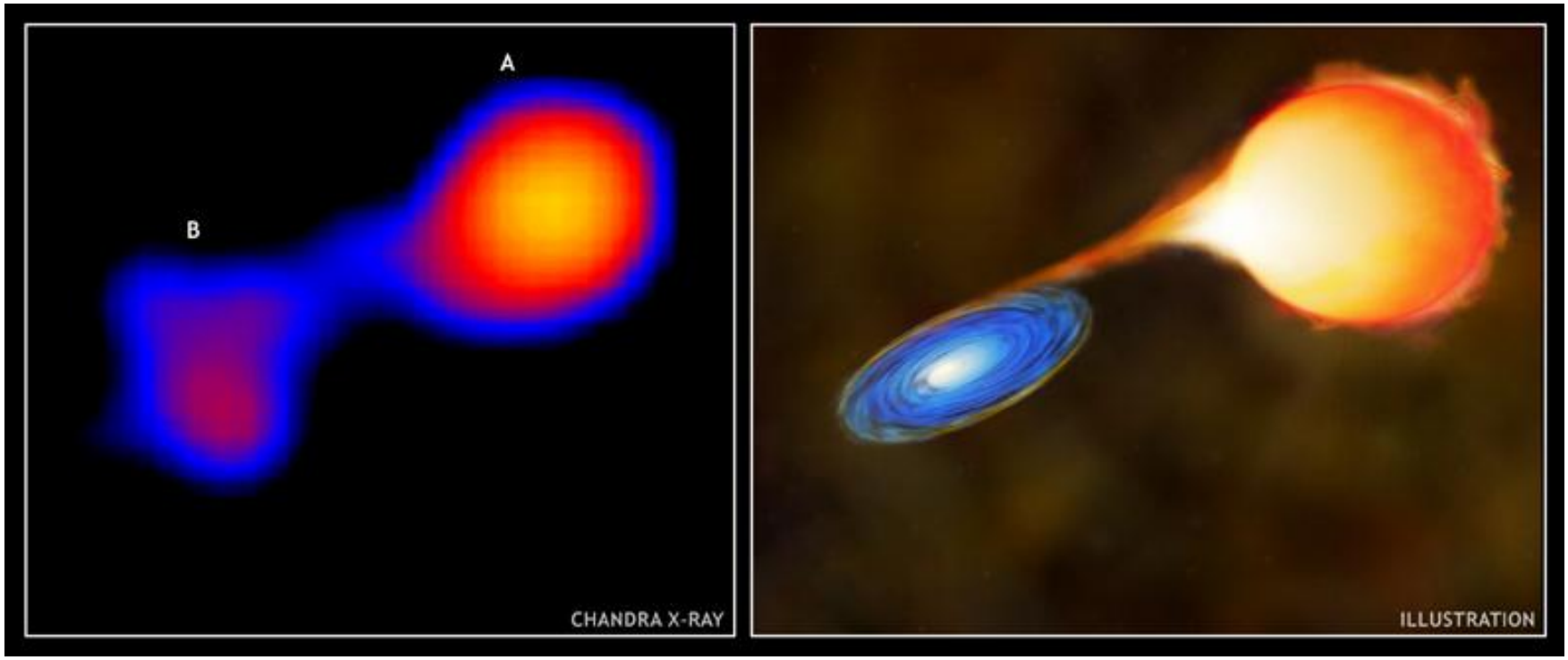


Motion of the star is in the right direction for the arc-like structure ahead of the star being a bow shock.

Prediction 2

If bow shocks exists around the progenitors of planetary nebulae, *tails* of material must also exist.

The binary star system Mira



- Mira A: planetary nebulae progenitor.
- Mira B: possibly a white dwarf.

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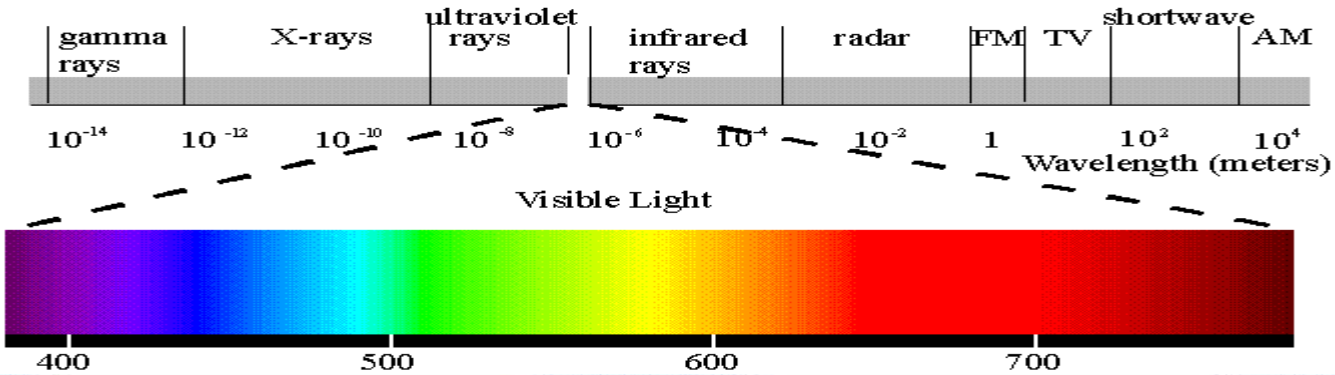
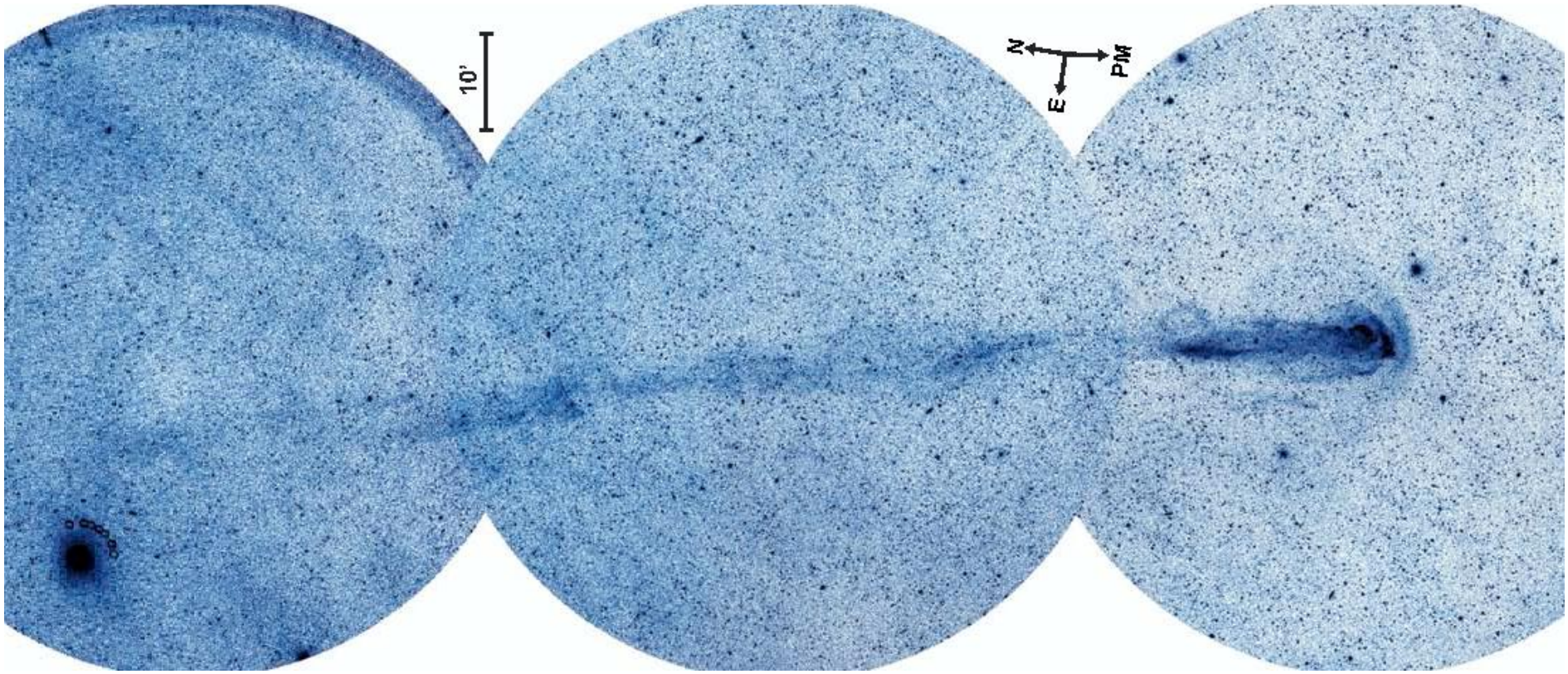
Ultra-violet GALEX observation





Ultra-violet vs. visible light

Ultra-violet

Visible light

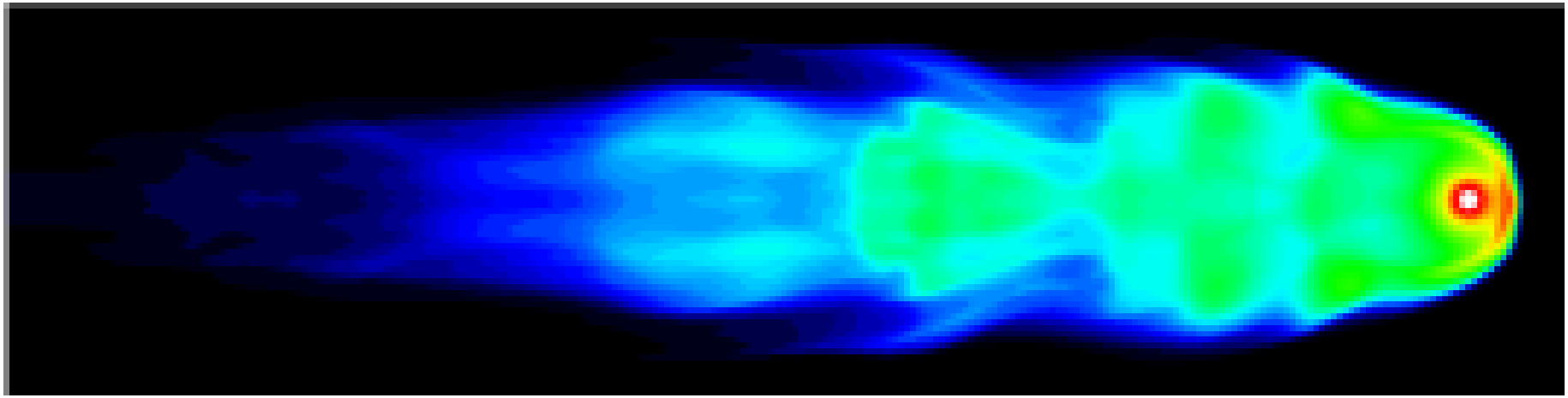
Mira

An animation of Mira's movement through the ISM
Credit: NASA/JPL-Caltech

The mass loss history of Mira

- Martin et al concluded:-
  - the structures are a bow shock and ram-pressure-stripped tail of material.
  - directionality is in agreement with the proper motion of the system.
  - spatial extent of the tail is 4parsec implying the tail represents 30,000 years of mass-loss history.
  - density variations along the tail are the result of mass-loss variations.

Simulations



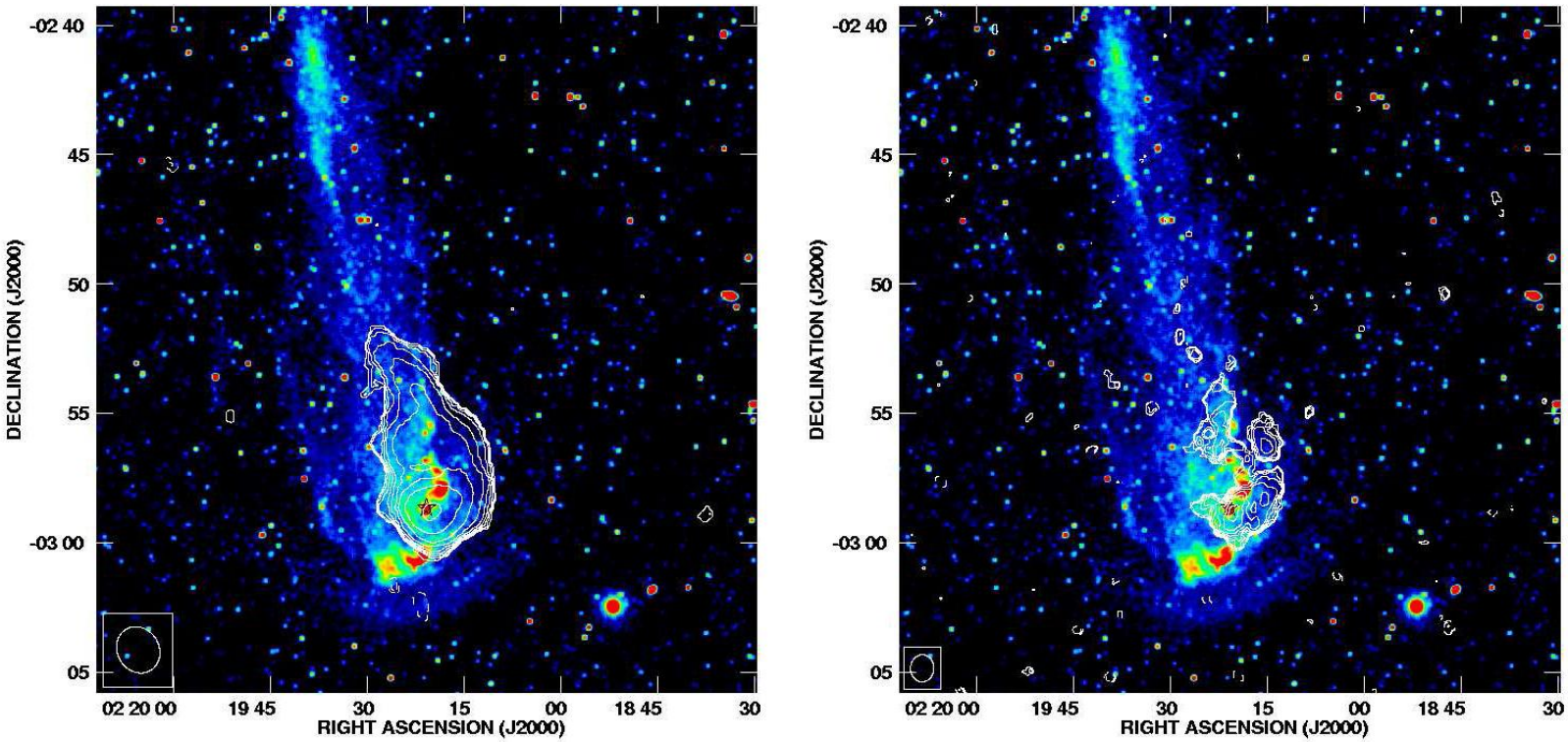
450,000 years to form a 4pc tail!

Prediction 4

Material entering the tail behind Mira does not immediately deccelerate to zero, instead it gradually deccelerates along the tail.

Much older material 'keeps up' with Mira and the tail is in fact far older than 30,000 years.

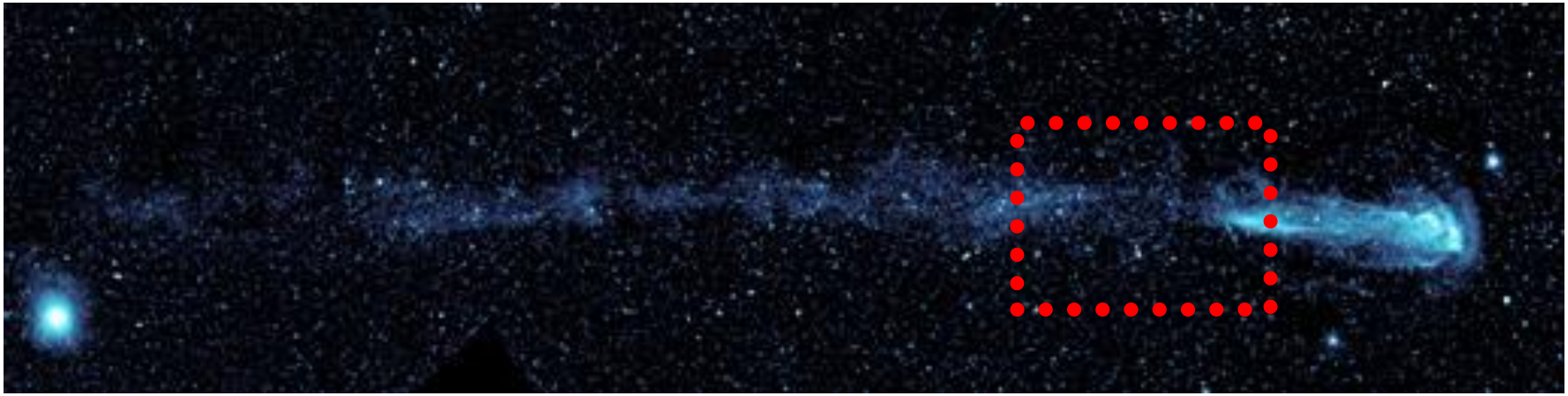
Radio observations



- H1 emission (VLA observation) overlaid on GALEX observation.

Further radio mapping with Nancay Radio Telescope reveals a clear slowing-down of the material in the tail with increasing distance from Mira.

Gaps in the tail?



Why is there a recent gap in the tail?

- Mira is in the right direction at the right distance to have possibly recently enetered the local bubble.
- Ueta et al recently estimated the cometary astropause to be around 40,000 years old (ApJ **687** L33 (2008)).
- Agrees with our theoretical prediction of the shock reestablishment time after Mira entered the local bubble.

Mira… a Rosetta stone of astrophysics

- The tail of Mira represents almost half a million years of mass-loss history – the entire lifetime on the AGB.

- Current understanding of mass-loss during this stage of evolution is sketchy at best:-
  - AGB winds are symmetric, how do asymmetric PNe form?
  - how do helium flashes etc alter the circumstellar structure?

There is no clear picture!

If we can disentangle the effects of ISM interaction…

we can reveal the mass-loss history of a star for the first time…

a Rosetta stone of astrophysics!

This is the next exciting stage of the project,
I am currently applying for funding to continue this.

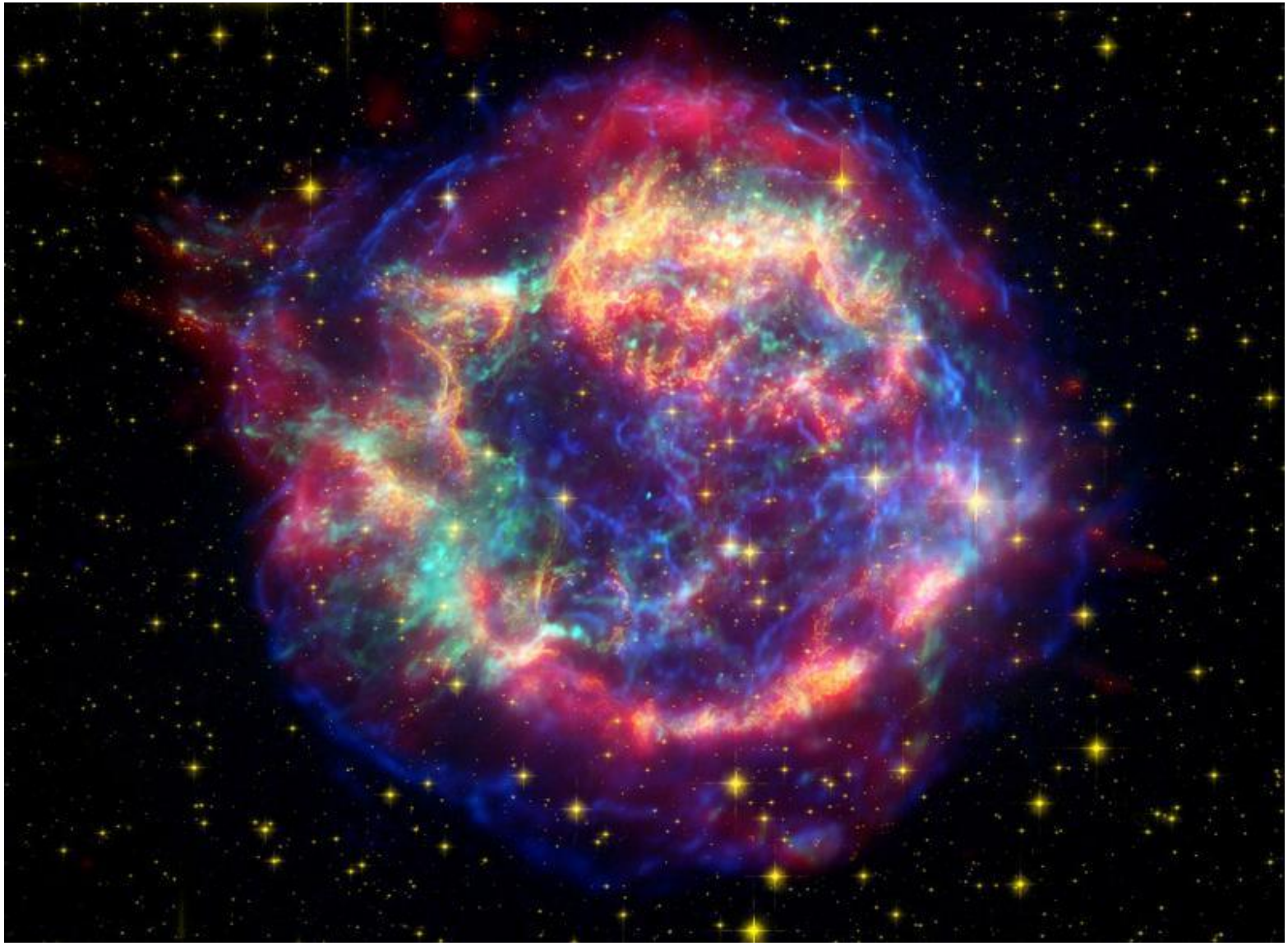
Let’s get back down to Earth…

What might happen to our Earth when the Sun goes through this stage of evolution?

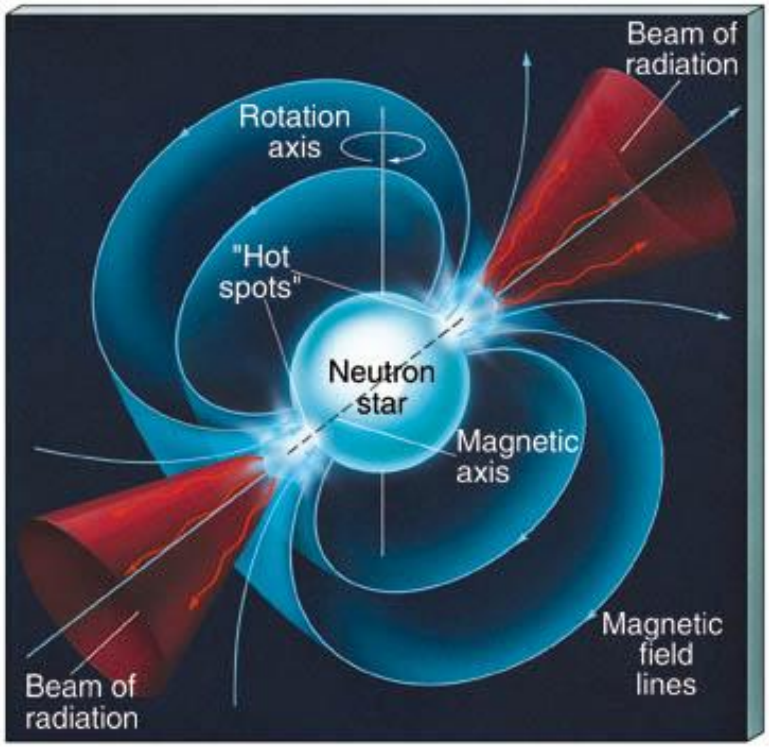
The short answer is complete destruction!

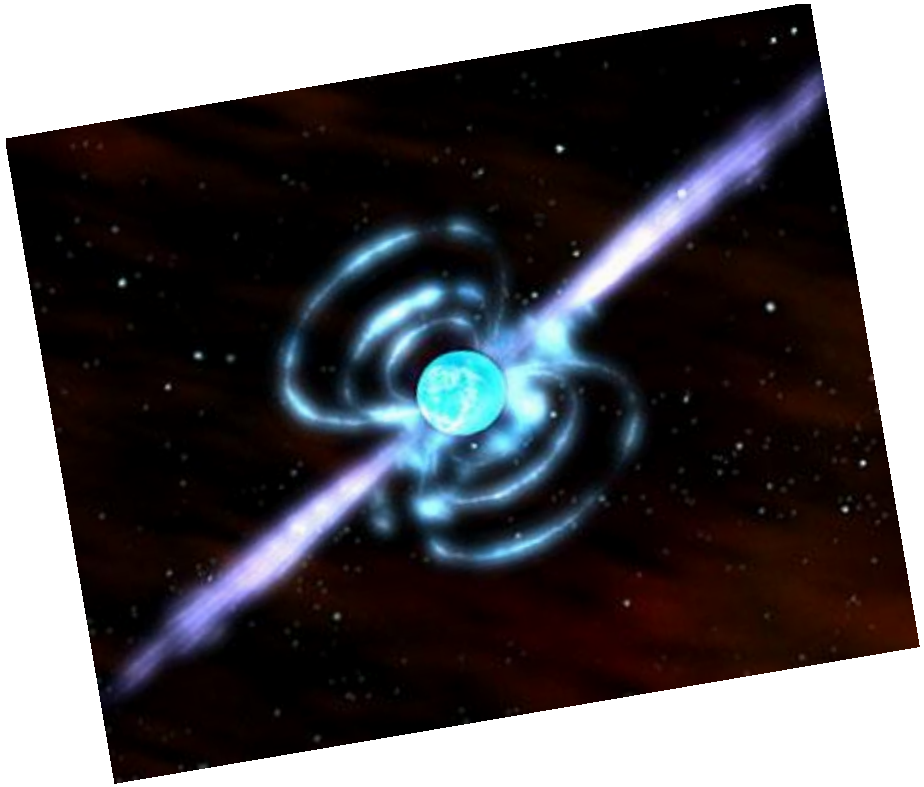
But this won't happen for another 5 billion years, so no need to worry just yet.

Supernovae



Neutron stars





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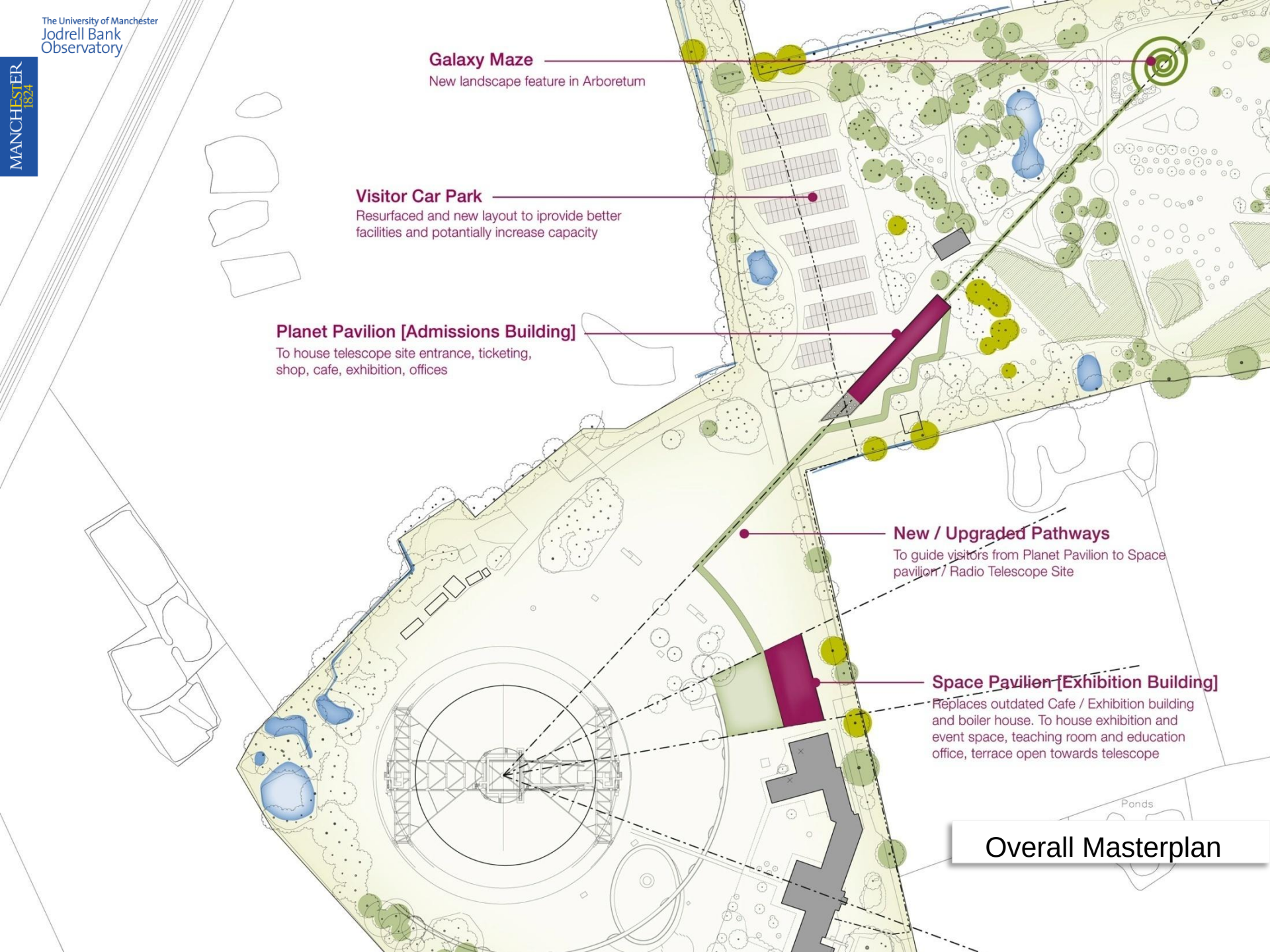

Overall Masterplan

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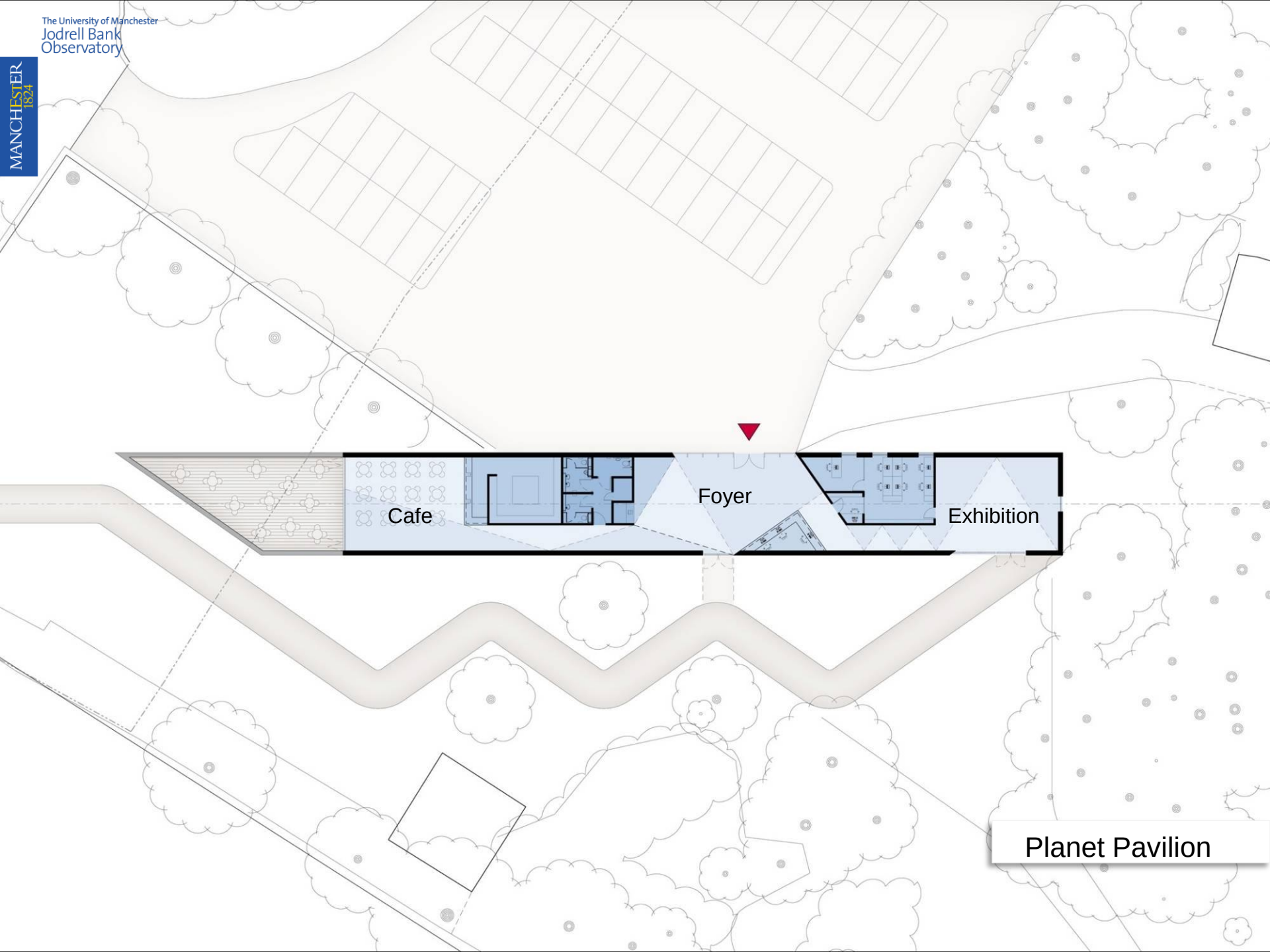

Planet Pavilion

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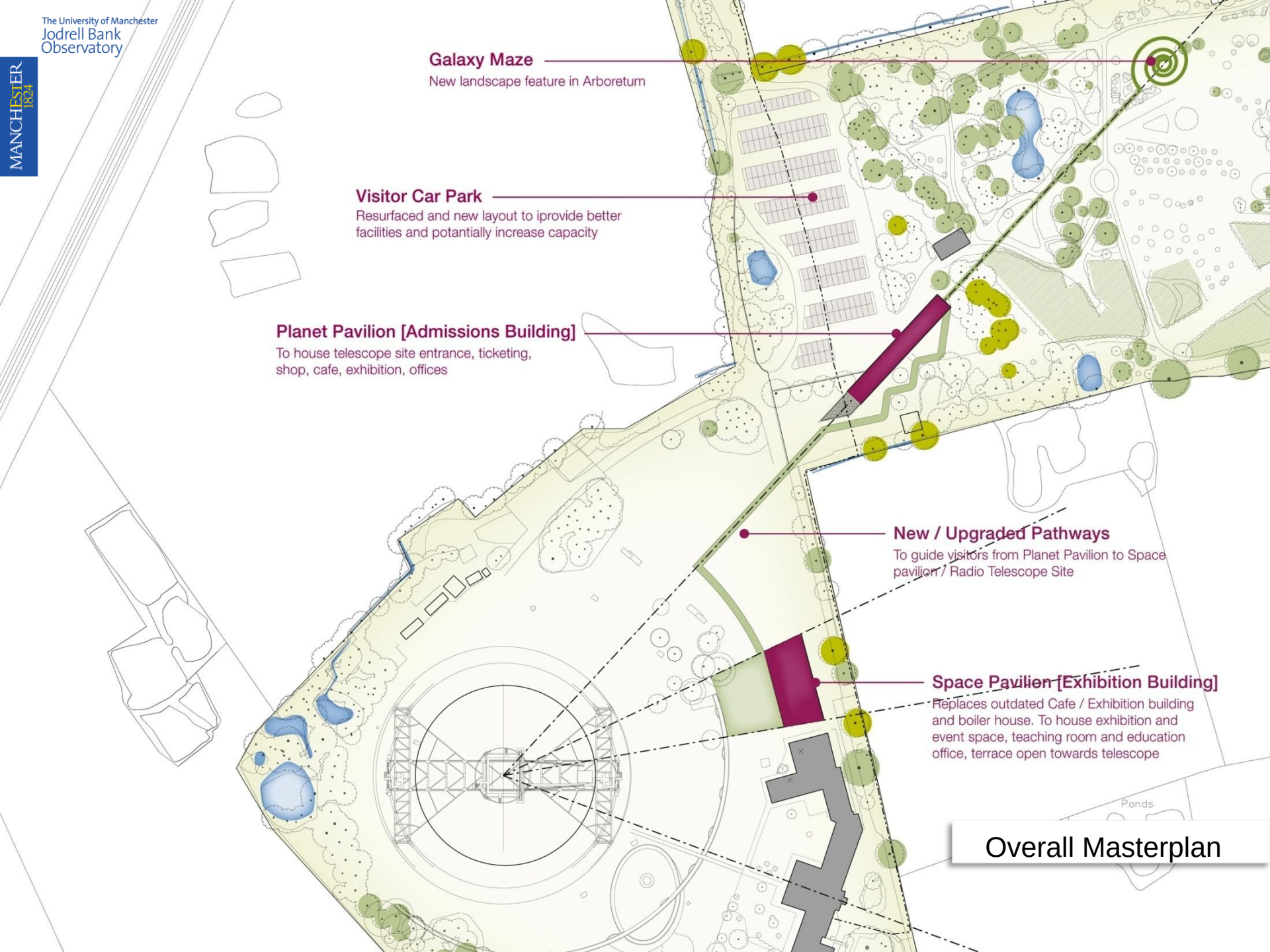

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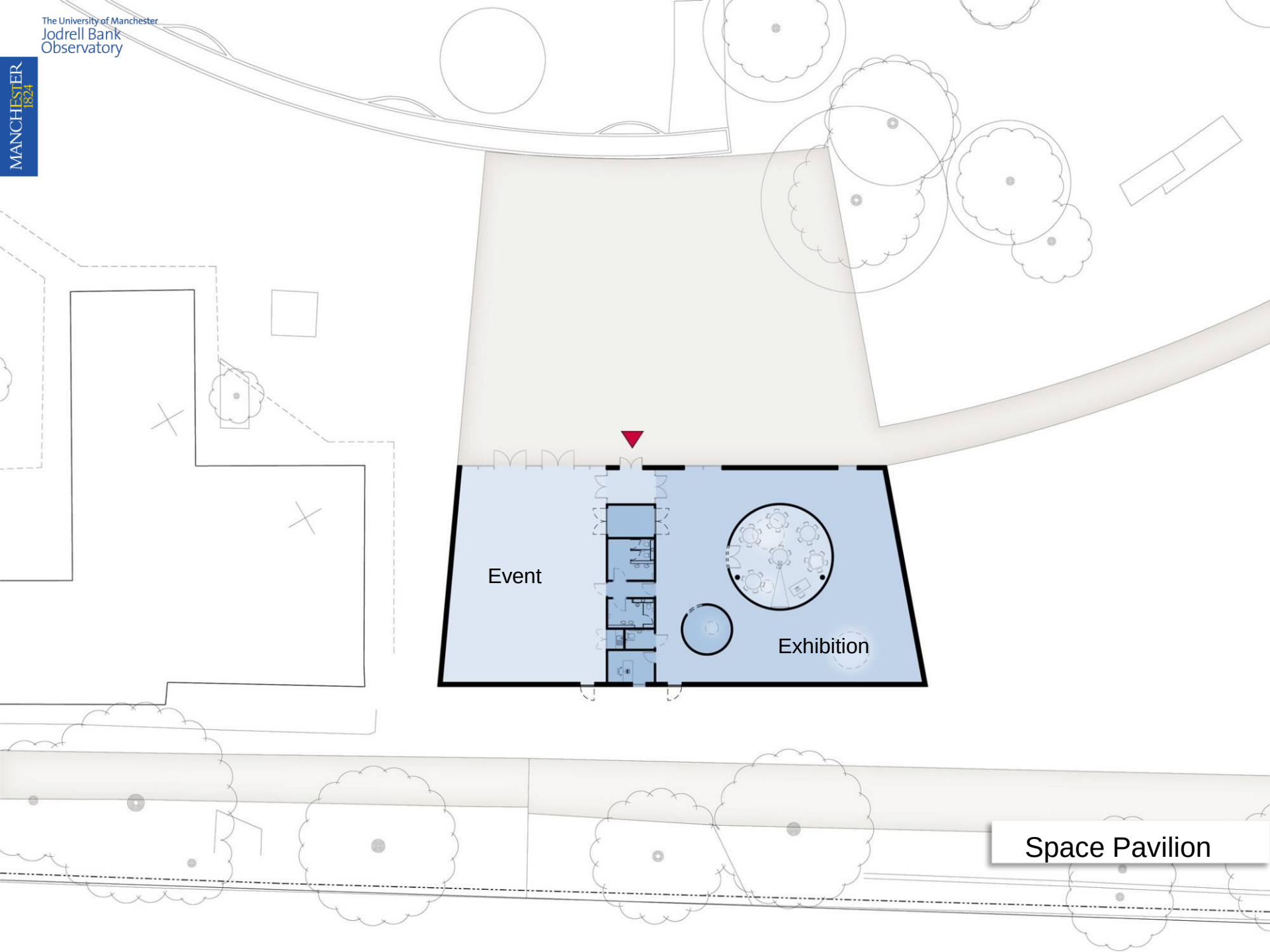

Space Pavilion

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Artist’s Impression of Planet Pavilion

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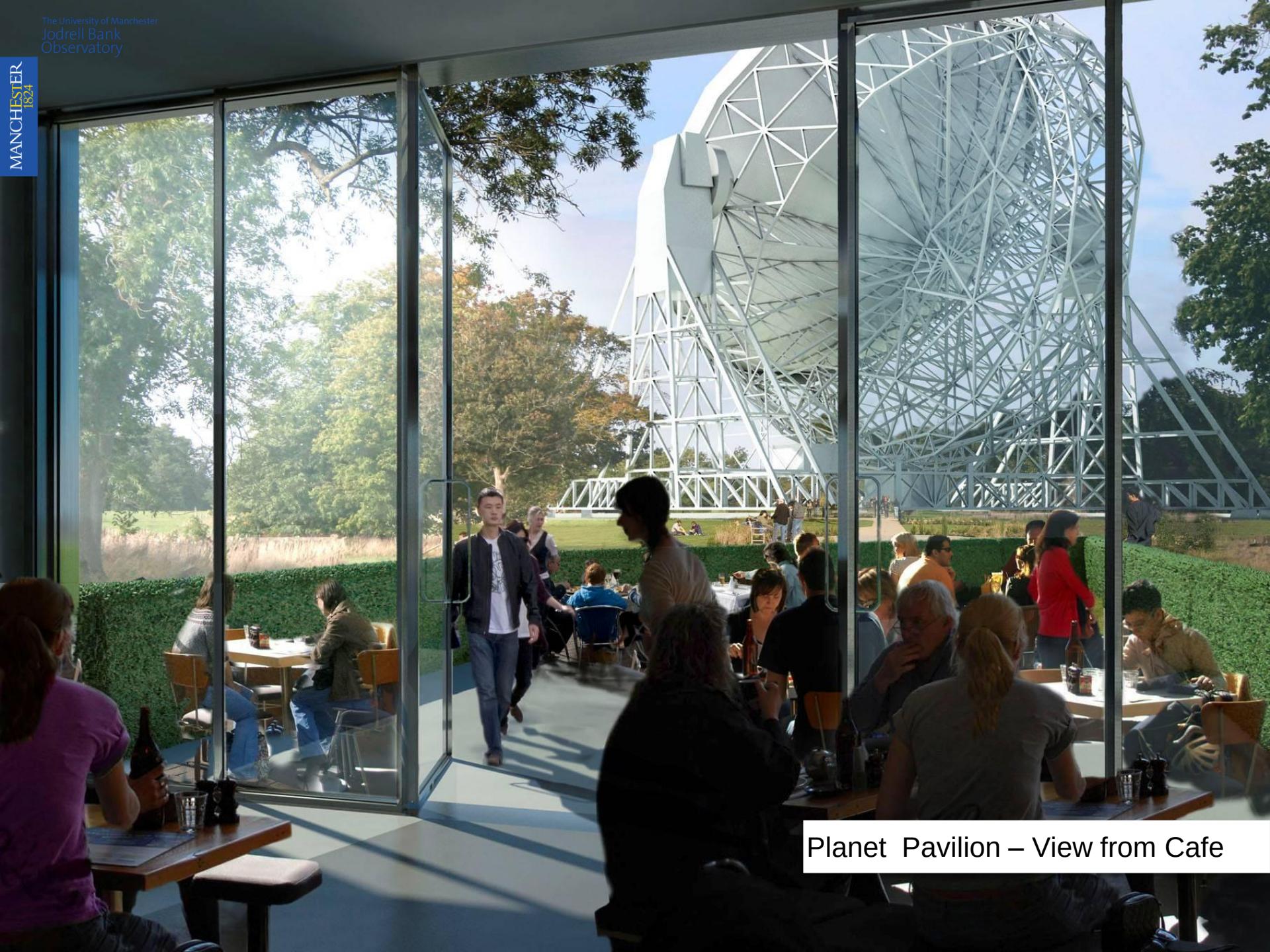

Planet Pavilion – View from Cafe