

# REVERBERATION MAPPING THE NUCLEAR DUST EMISSION IN AGN FROM MODELING TO LARGE SURVEYS

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# MODELING AGN DUST EMISSION

## Collaborators:

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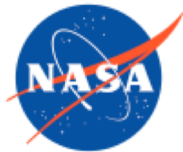
Jack Gallimore

Sebastian Hönig

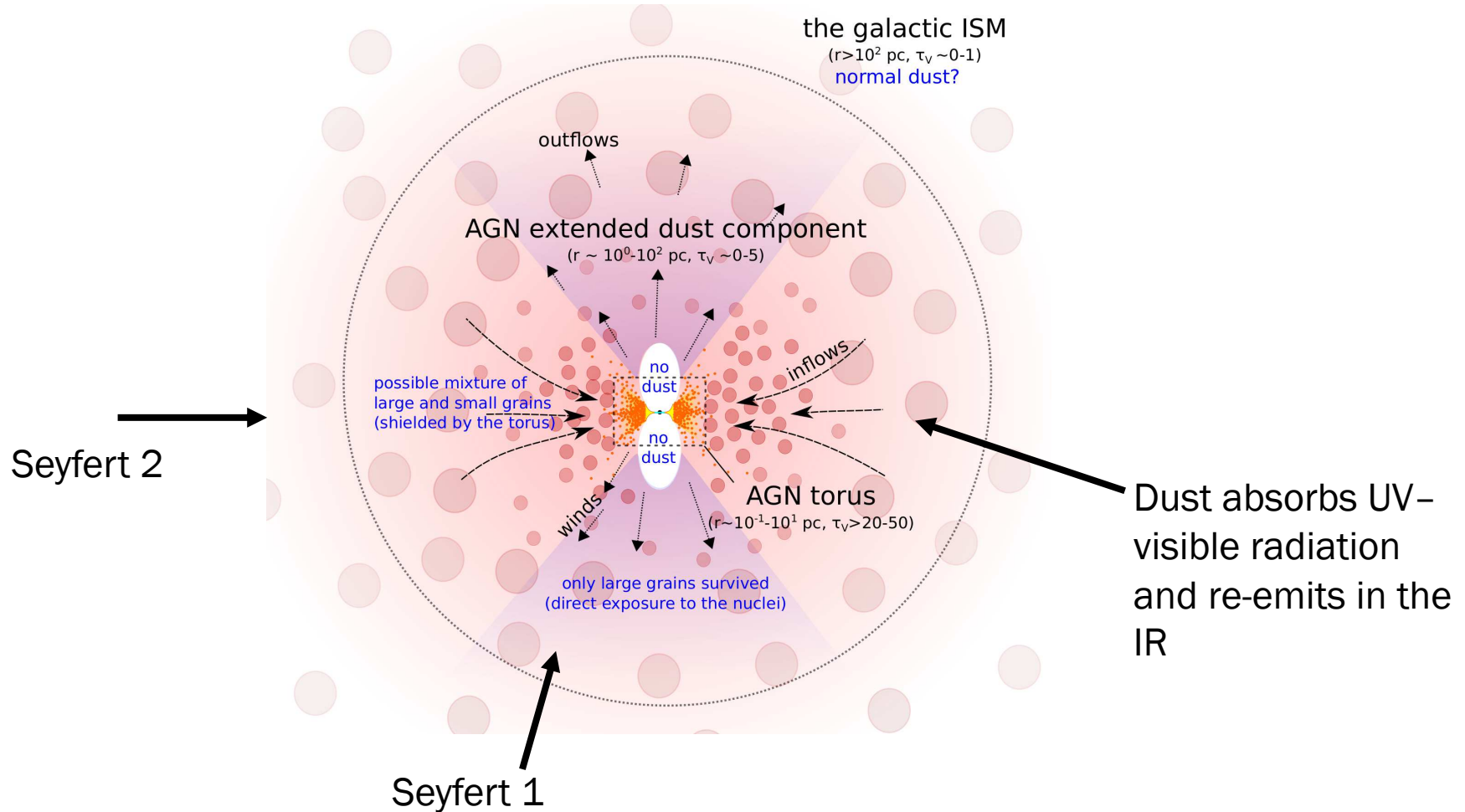
Supported by:

NASA/ATP NNX12AC68G

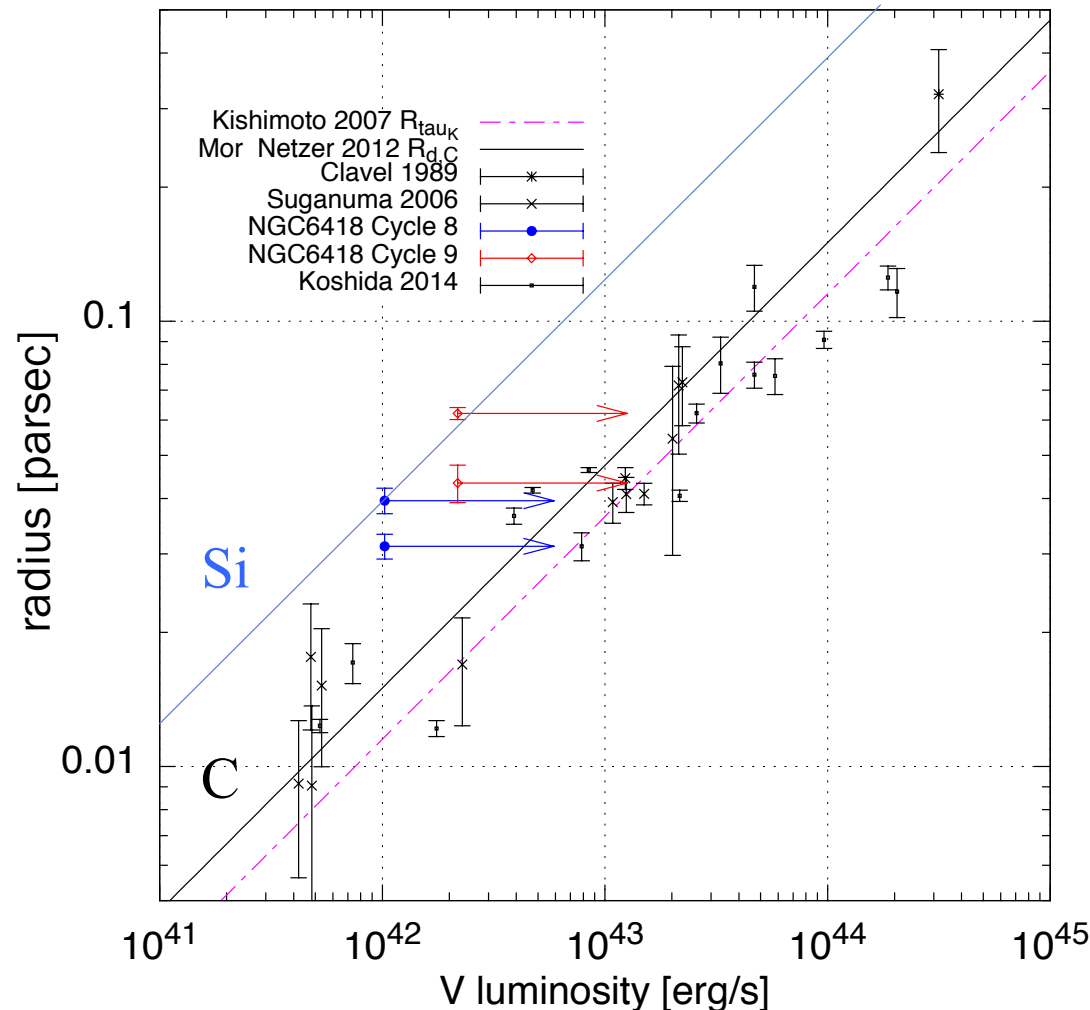
NASA/ADAP NNX16AF42G



# Dust in AGN



# Radius Luminosity Relationship



Observed radii are  
~2 time smaller  
than theoretical dust  
sublimation radius

(Kishimoto et al. 2007,  
Vazquez et al. 2015)



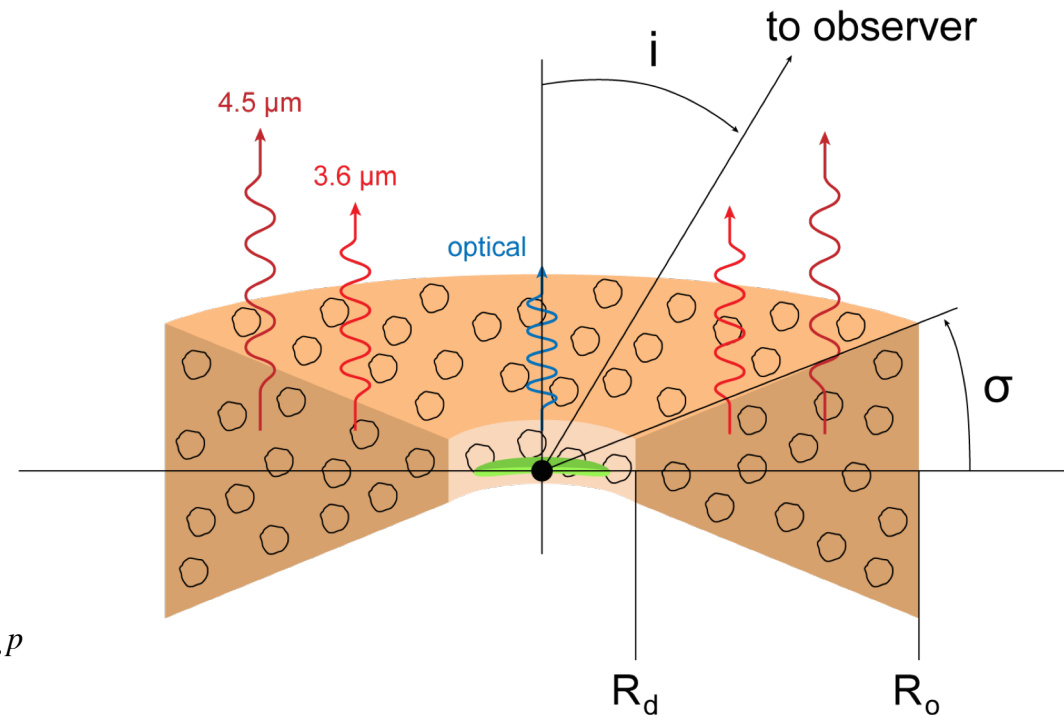
# TORMAC: Torus Reverberation Mapping Code

## Model Features:

- Inner Radius set to Dust Sublimation Radius
- Sharp or “fuzzy” boundary
- Isotropic or anisotropic illumination,  $s$
- ISM dust composition

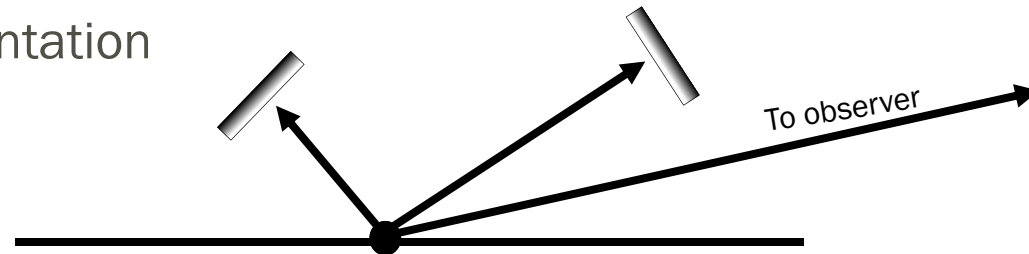
## Free Parameters:

- Spherical or disk,  $\sigma=0-90^\circ$
- Inclination,  $i=0-90^\circ$
- Radial distribution of clouds,  $\propto r^p$
- Radial depth,  $Y=R_o/R_d$
- Optical depth,  $\tau_V$
- Volume filling factor,  $\Phi$

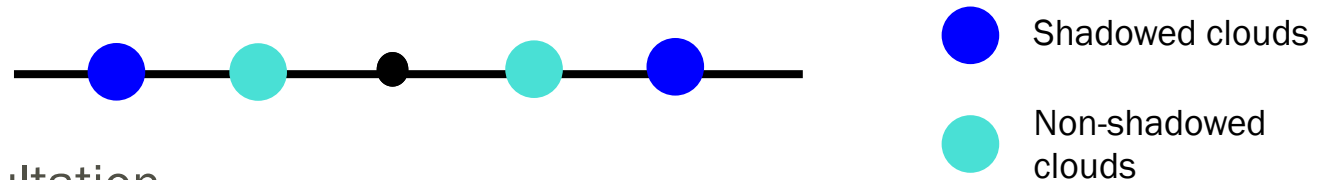


# Radiative Transfer Effects

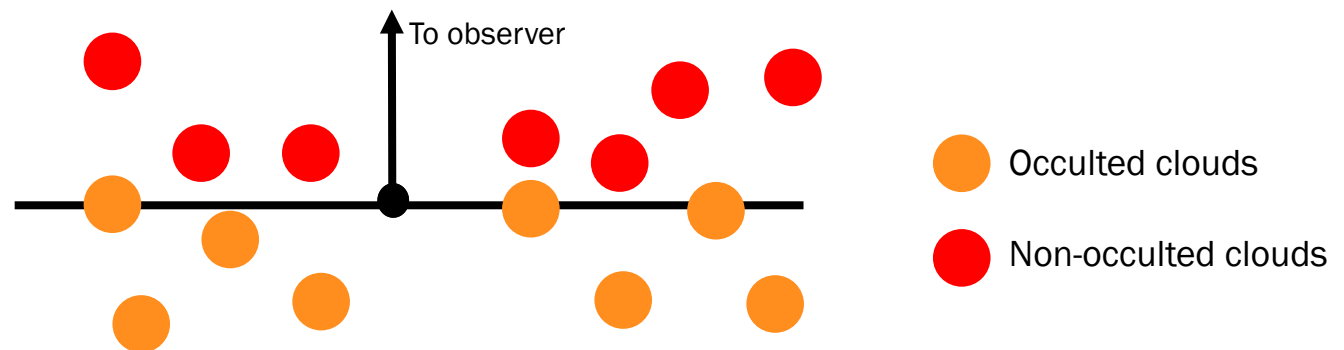
- Cloud orientation



- Cloud shadowing



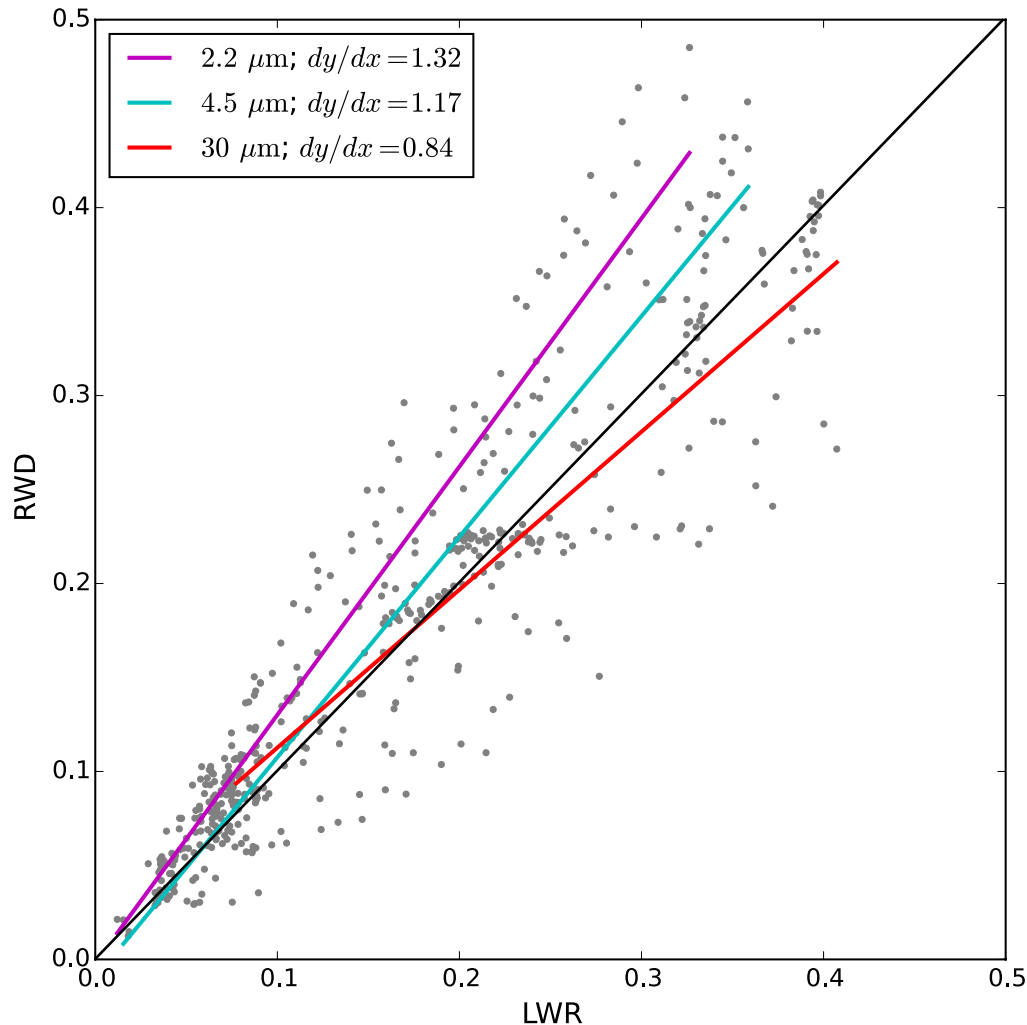
- Cloud occultation



# Descriptive Parameters

- Response Weighted Delay (RWD)
  - *Characteristic lag of transfer function*
- Luminosity Weighted Radius (LWR)
  - *Effective radius of the torus*
- When torus is composed of isotropically emitting clouds,  
RWD=LWR
  - True for both sphere and disk

# RWD vs LWR

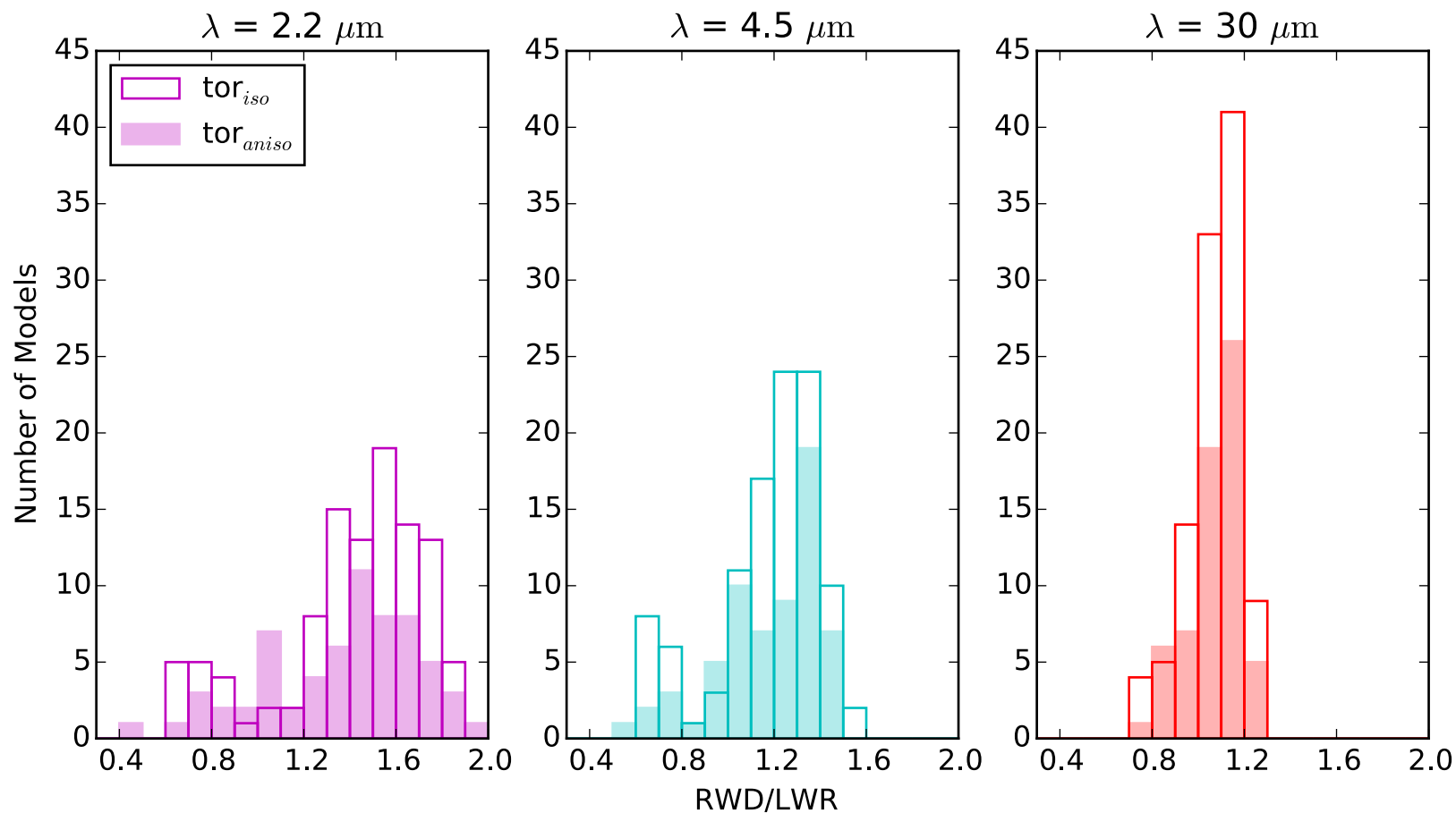


## ► Model Parameters:

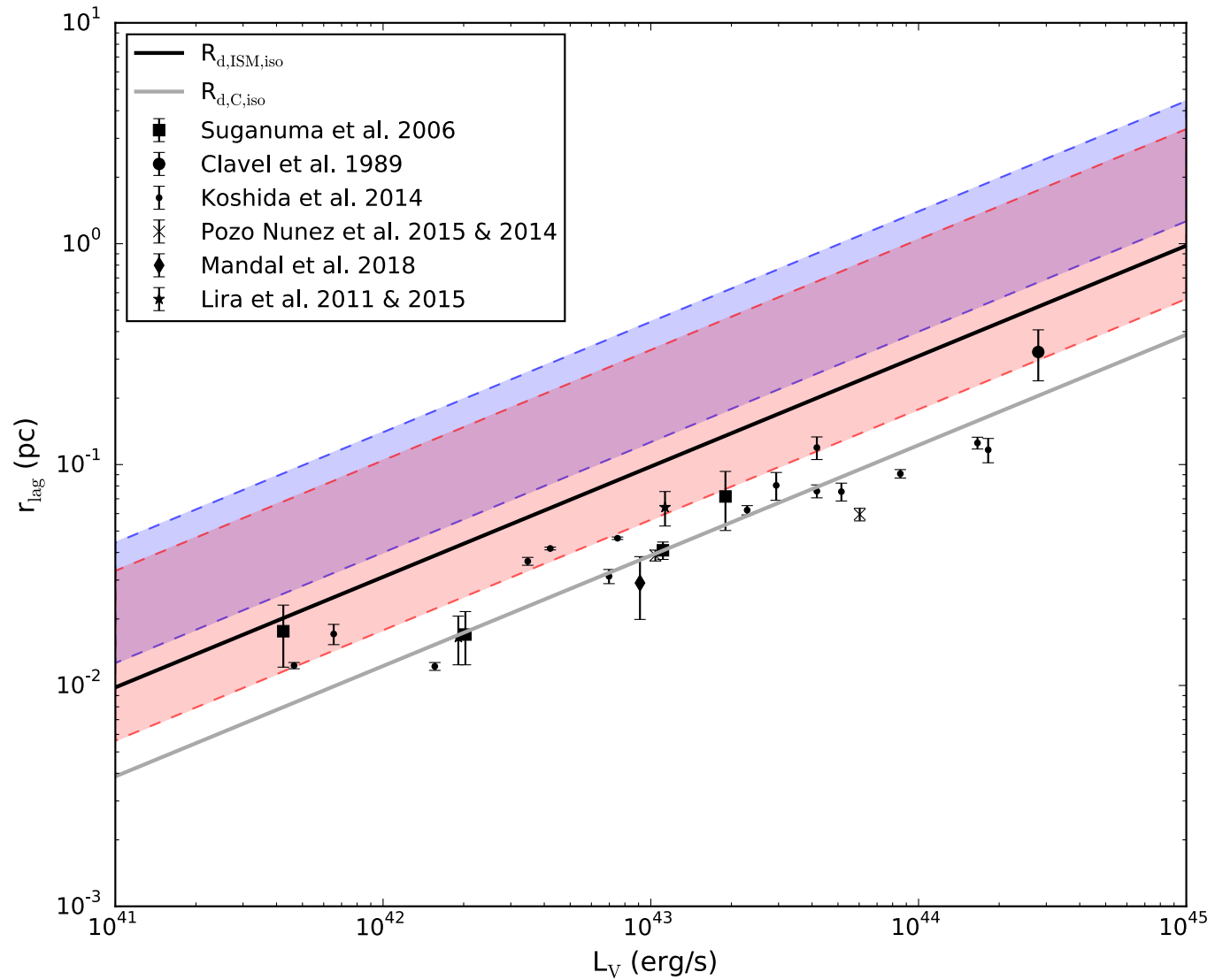
- $\propto r^p$ ;  $p = -2$  to  $-4$
- $Y = R_o/R_d = 2$  to  $50$
- $i = 0$  to  $90^\circ$
- $\sigma = 15$  to  $60^\circ$
- $s = 0.01$  to  $1$
- $\tau_v = 5$  to  $100$
- $\Phi = 0.0001$  to  $0.1$
- Sharp and fuzzy

$$0.4LWR < RWD < 1.8LWR$$

# RWD vs LWR



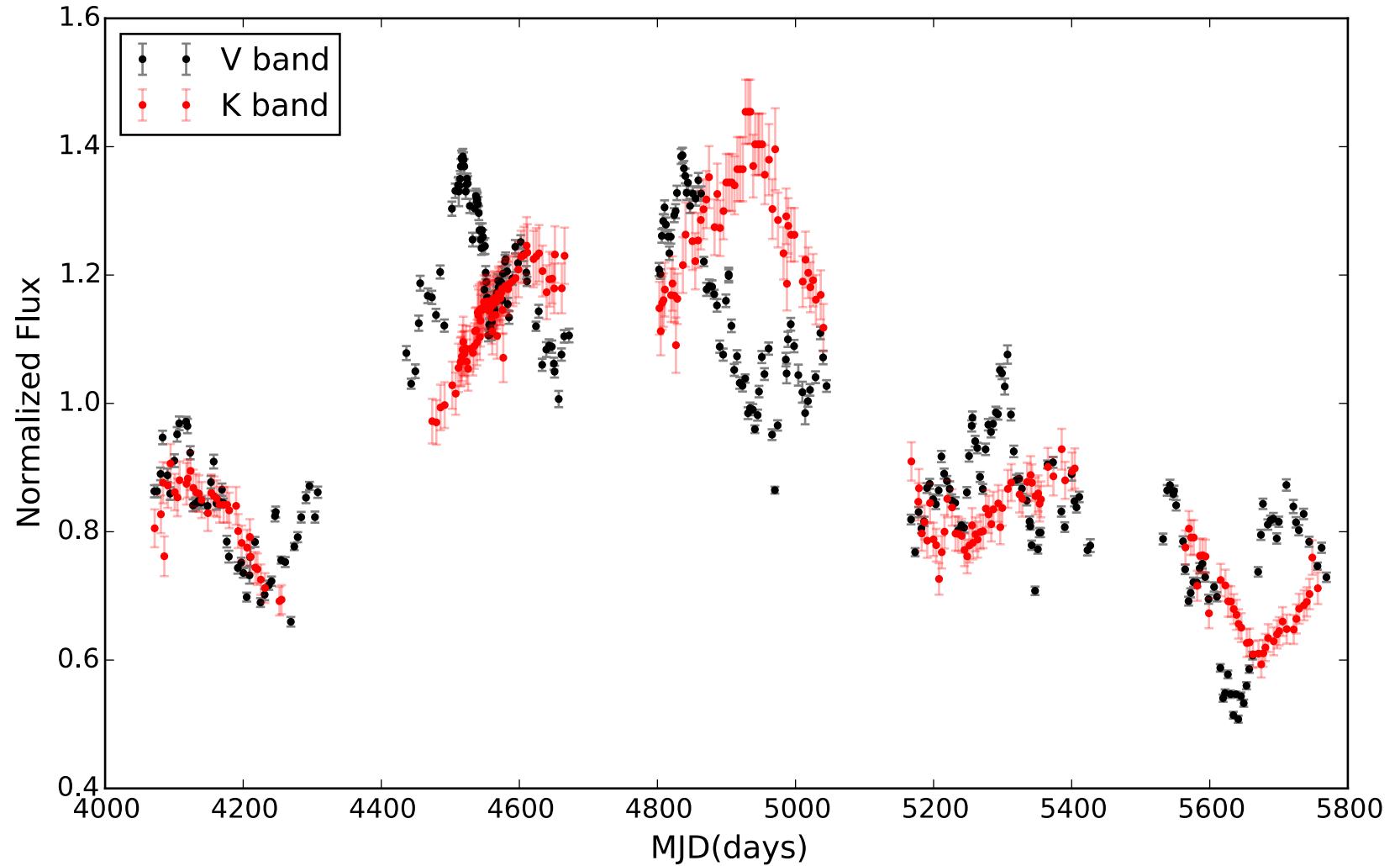
# R-L Relationship



# Current Capabilities

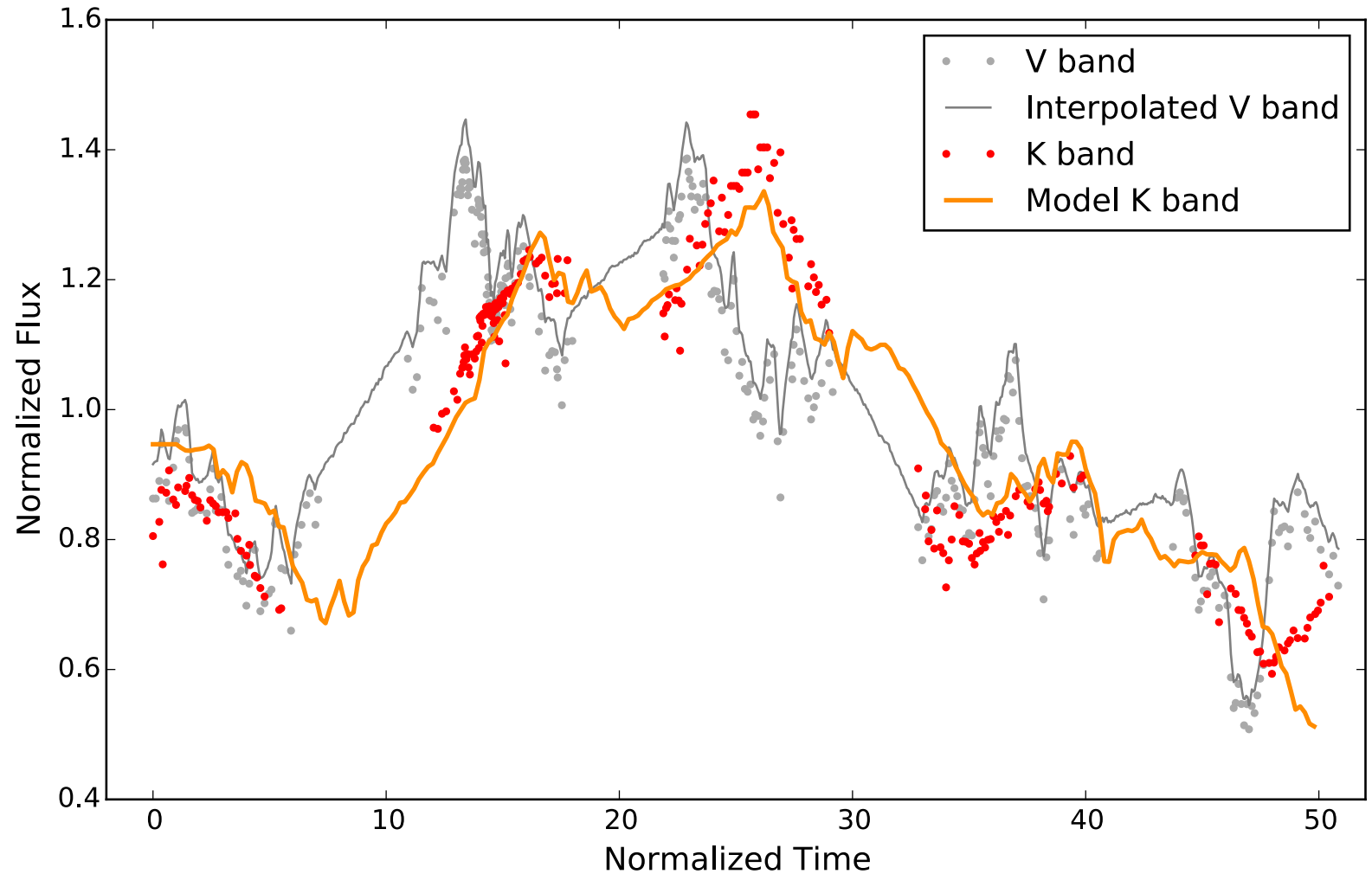
- TORMAC compatible with any radiative transfer grid/database
- Polar dust distribution
- “hot dust” component
- *Gradient in composition of clouds from Carbon-dominated to full ISM composition*
- \*<http://cat3d.sungrazer.org/>
- Dust emission response light curves


# NGC 3783





# NGC 3783: Models






# CURRENT WORK: VEILS+VOILETTE

**Collaborators:**

Sebastian Hönig

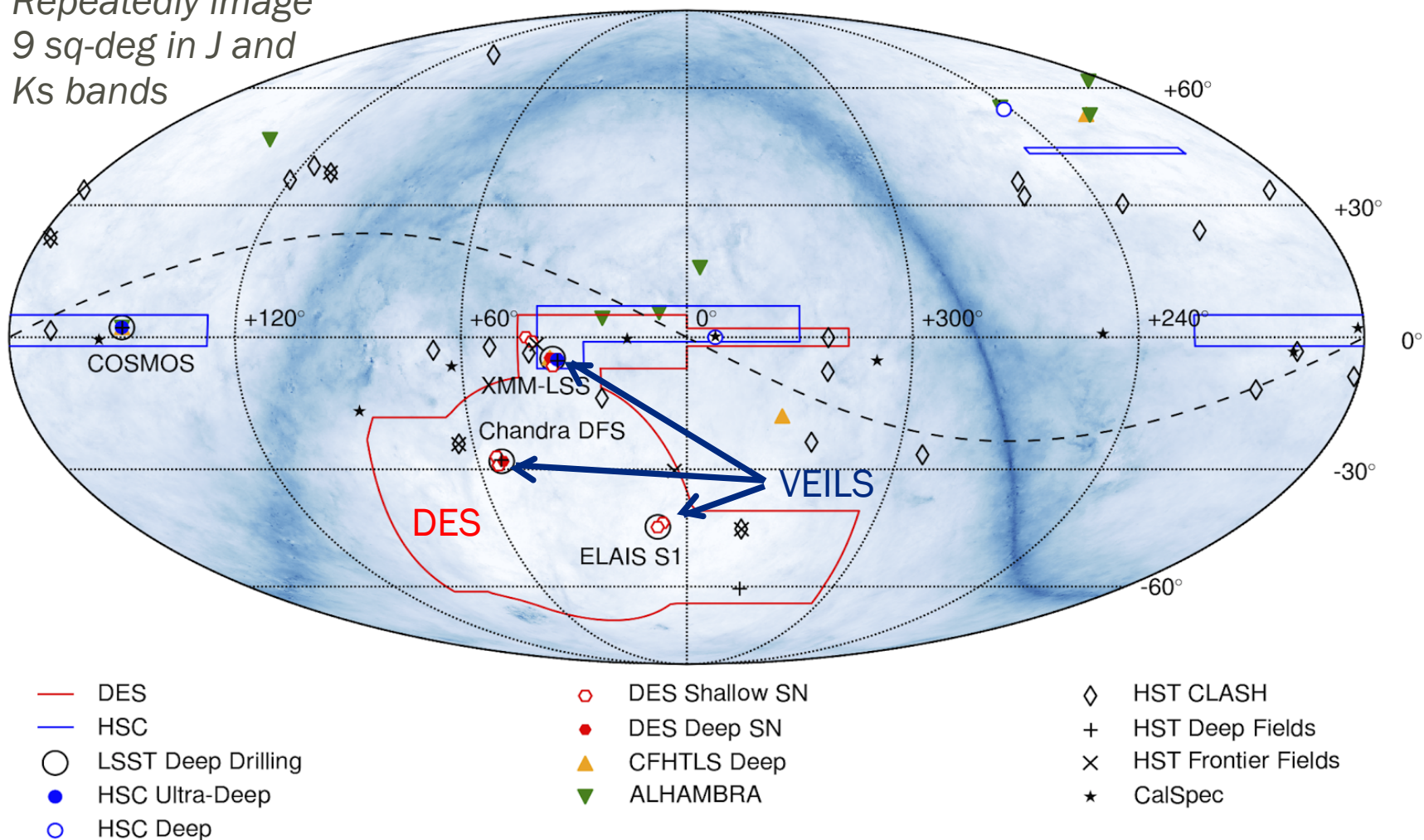
Bella Boulderstone (see talk at 5pm)

Ella Guise (see poster)



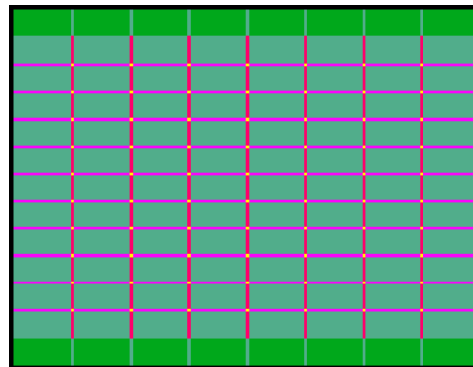
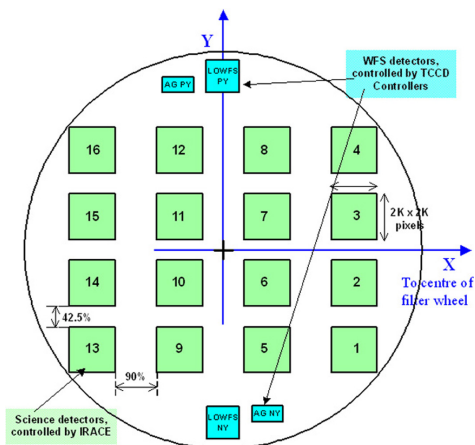
# VEILS: VISTA Extragalactic Infrared Legacy Survey

*Repeatedly image  
9 sq-deg in J and  
Ks bands*



# VISTA

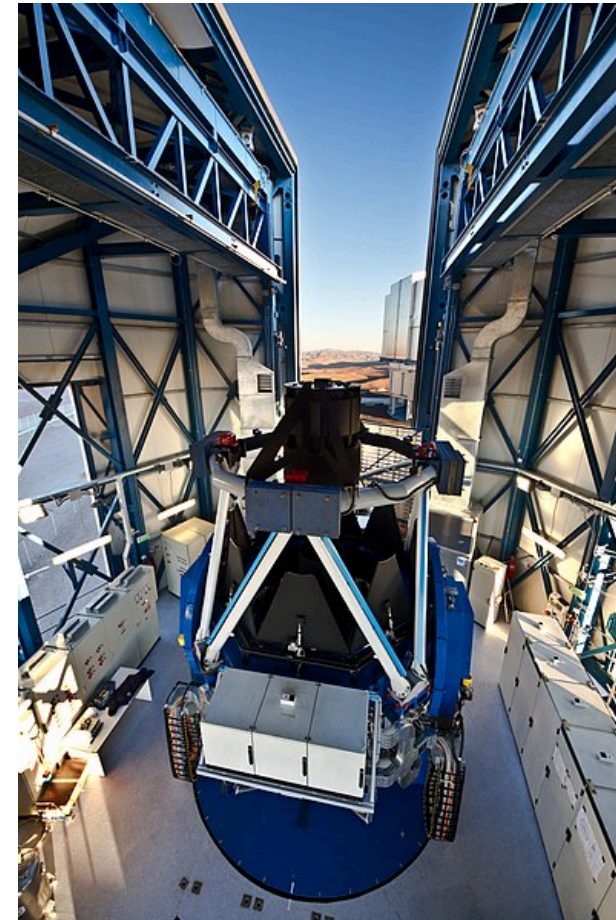
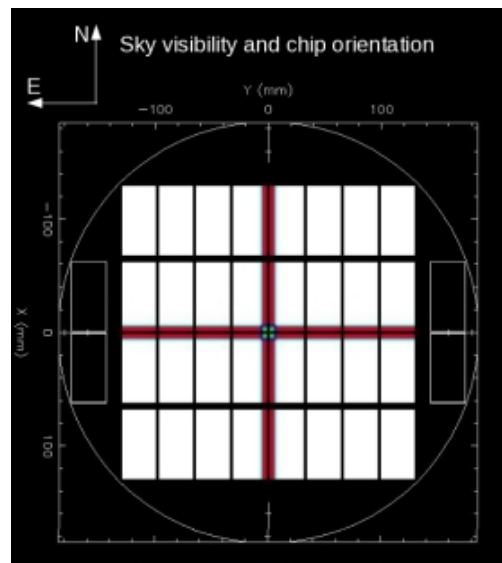
- 4.2m wide field survey telescope
- 1.5deg diameter field of view
- VIRCAM Infrared camera: 16 2Kx2K detectors



6 offset 'pawprints' gives a  
1.5 x 1.0 sq-deg tile

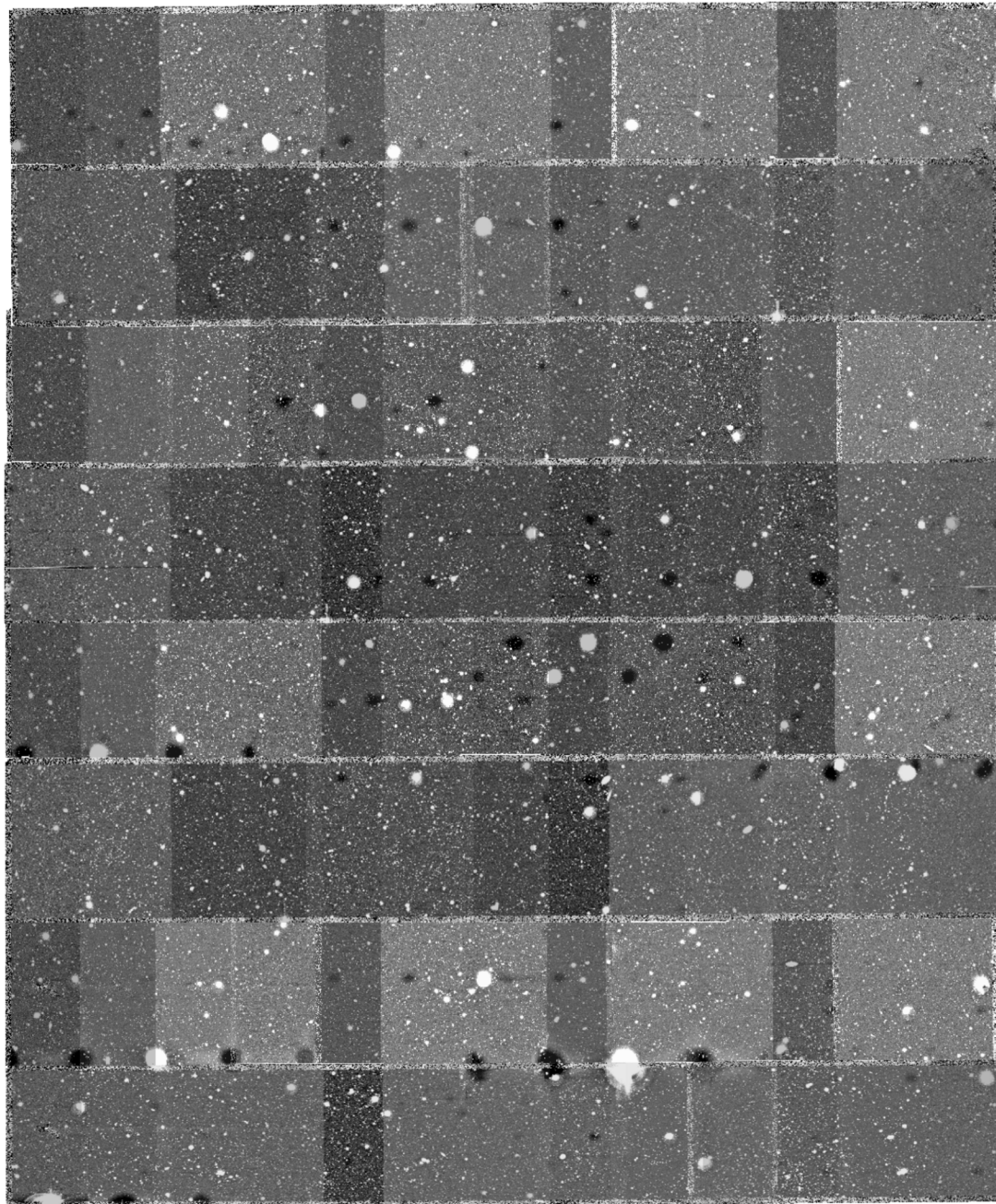
# VOILETTE

- VEILS Optical Lightcurves of Extragalactic Transient Events
- OmegaCAM on the VST
  - 32 – 2K x 4K pixel detectors
  - 1deg field of view



<https://www.eso.org/public/images/>

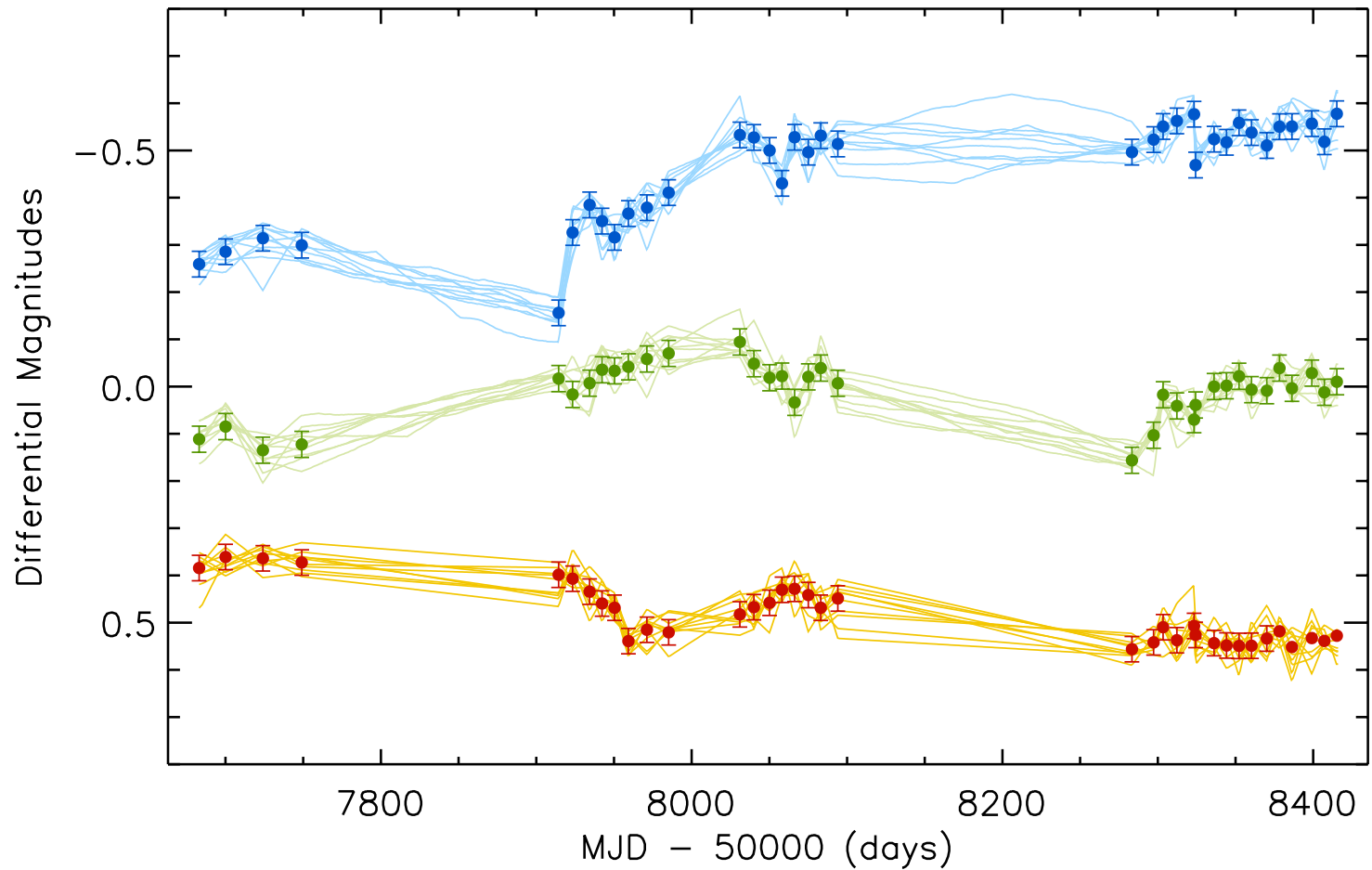






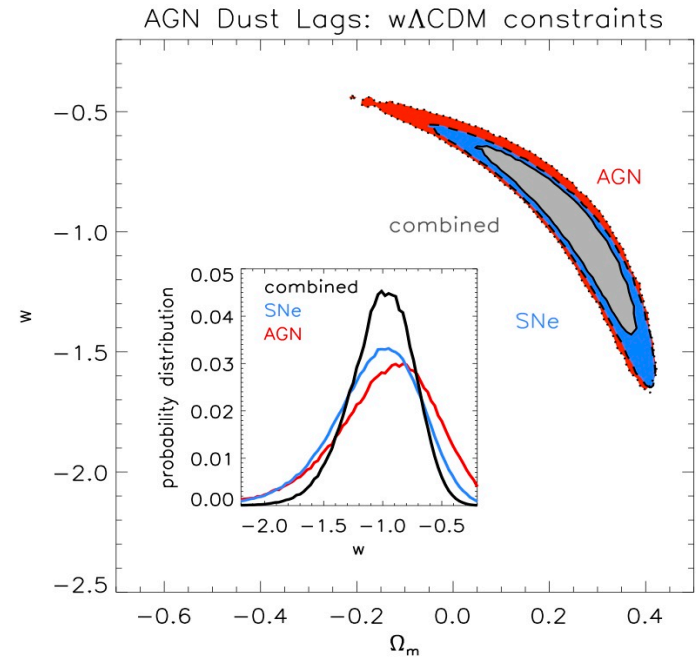
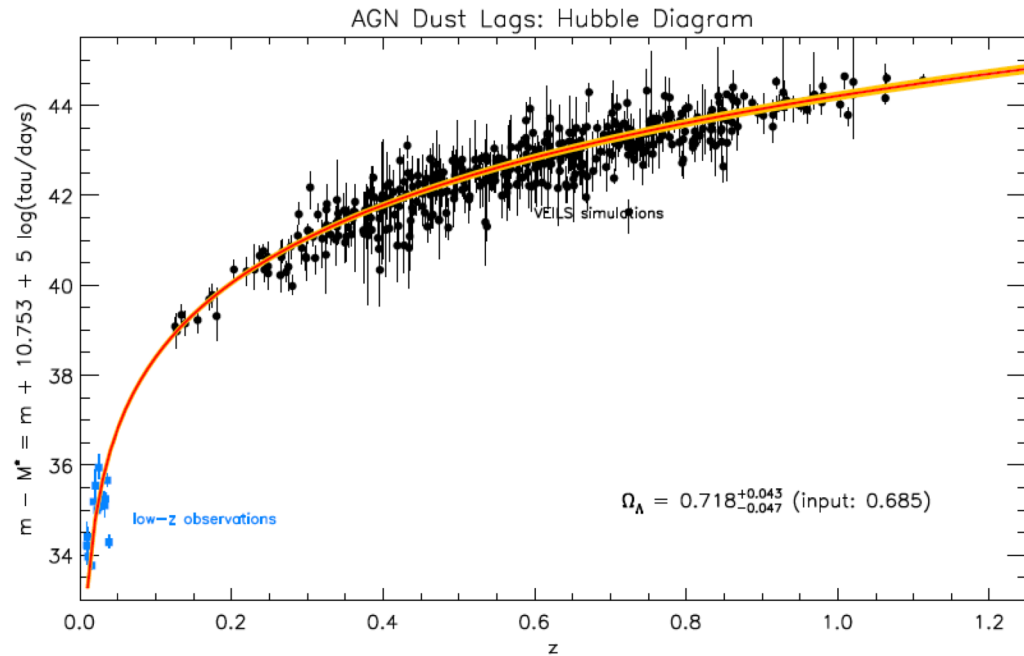


# Preliminary IR Light Curves





# VEILS: Cosmology with AGN Dust



# Summary

- TORMAC capabilities
  - *Multiwavelength dust emission response for cloud ensemble using radiative transfer models*
  - *Simulate IR response LC given any driving LC*
  - *Incorporates anisotropic illumination, global opacity effects*
  - *$0.4LWR < RWD < 2LWR$*
- VEILS
  - *Increase IR reverberation mapped AGN by orders of magnitude*
  - *Establish AGN as an independent cosmological standard candle*