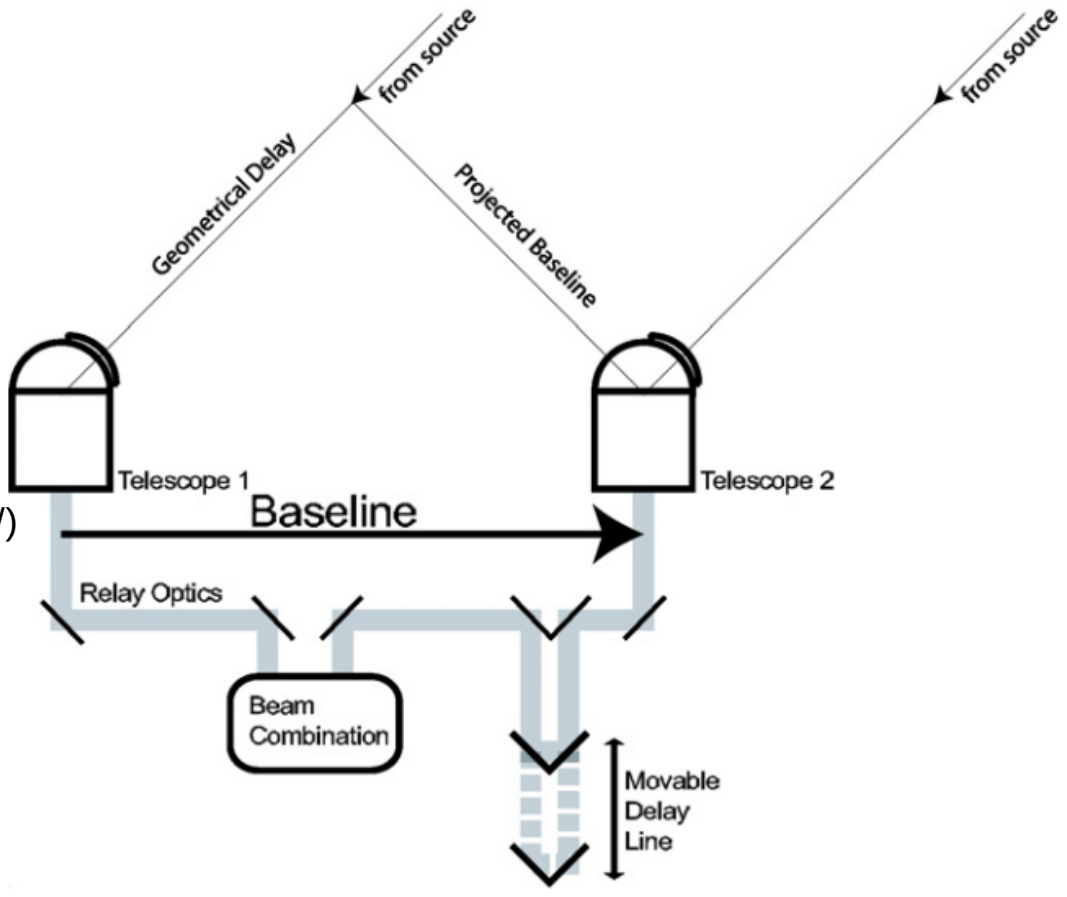
Optical Interferometry

- Lecture 1
  - Basic principles and History
  - Atmospheric turbulence and how to overcome it
  - Subsystems of an interferometric observatory – CHARA and VLTI
  - Interferometric observables
- Lecture 2
  - Science case – classical Be stars
  - OIFITS format
  - JMMC tools for interferometry (https://www.jmmc.fr/)
- **Lecture 3**
  - Parametric fitting of interferometric data with PMOIRED (https://github.com/amerand/PMOIRED)



Resources

- CHARA list of publications - https://www.chara.gsu.edu/astronomers/publications
- ESO Telescope Bibliography - https://telbib.eso.org/

Image reconstruction

- Complex process even with rich *uv* coverage
- Difficult to estimate uncertainties in the reconstructed image
- Many different codes with different applications
  - Interaction with the author of the code or an expert needed
- Many interferometric imaging programs taking place at CHARA & VLTI
  - VLTI has dedicated ‘imaging slots’ in the schedule
  - VLTI relocations can take 2 days → intermediate or non-standard configuration available for extra filling of the *uv* plane

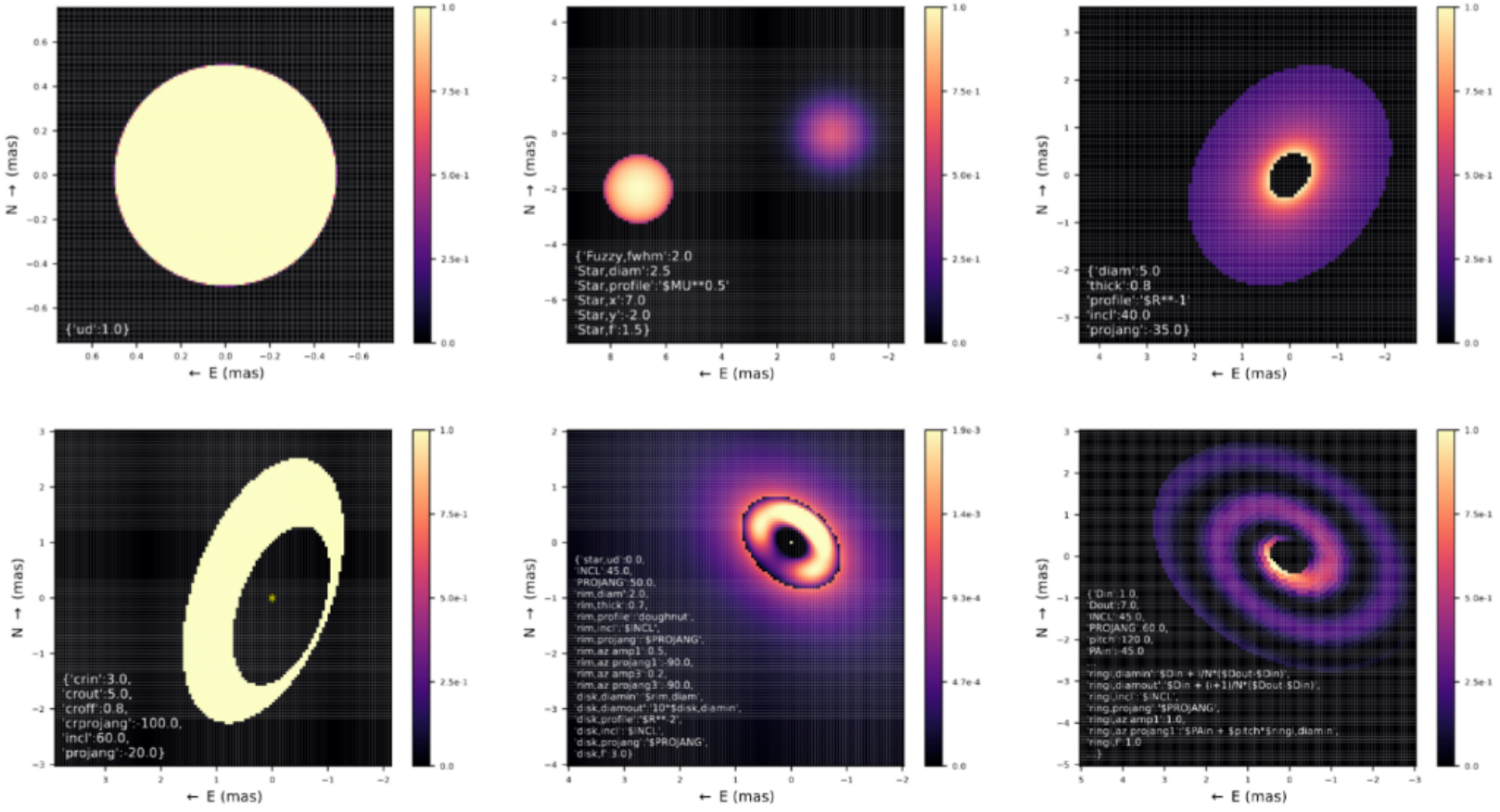
Parametric Modeling of Optical InteRferomEtric Data - PMOIRED

- **Model fitting in the *uv* plane** or image reconstruction?
- PMOIRED - python library to visualize, manipulate and model OIFITS data using simple geometric models
  - Currently the best tool for model fitting in *uv* plane
  - Fits visibility, closure phases, differential phases and normalized spectra
  - Enables combining datasets from different dates, observing modes, beam combiners, …
  - Rebinning data, manipulating error bars, …
  - Telluric correction of GRAVITY spectra
  - Parallel computing for grid searching, bootstrapping, …
  - Simulating data

Parametric Modeling of Optical InteRferomEtric Data - PMOIRED

- Analytical function defining the models
  - Disks, rings, Gaussians, … - combined linearly (complex visibility is a linear combination of the Fourier Transform of the components)
  - Using analytical visibilities much faster than using FT of synthetic images
  - Model is constructed with Python dictionaries
  - Radial and azimuthal variations of the geometrical components
  - Multi-component models need relative fluxes – can be wavelength dependent
  - Spectral lines can be defined with Gaussian or Lorentzian profiles

Parametric Modeling of Optical InteRferomEtric Data - PMOIRED



Parametric Modeling of Optical InteRferomEtric Data - PMOIRED

- Fitting the parameters
  - χ^2 minimization (*scipy.minimisation.leastsq*)– needs initial guess
  - Fixed and free parameters and enables setting priors
  - Results in best-fit parameters, uncertainties, and correlation matrix (covariance matrix)
  - Highly correlated parameters are problematic – usually need to fix one
  - *bootstrapFit* – performing fits with resampled data to get realistic uncertainties from correlated data
  - *gridSearch* – exploring parameter space using a grid or randomization in a given range
  - *detectionLimit* – detection limit e.g. for a companion

Parametric Modeling of Optical InteRferomEtric Data - PMOIRED