NIFITS: building a new **data standard** to enable the rise of **nulling interferometry**

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Interpretation of interferometric data requires **inference through the knowledge of the instrument behavior**. NIFITS defines a data standard for exchange and interpretation of nulling data. Building on lessons learned from the successful OIFITS standard and previous generations of nullers (Keck, LBTI…) we **design for the diversity** of **the coming generations** of instruments (**NOTT**, **LIFE…**) by incorporating all the necessary information for a **straightforward exploitation**.

Why is OIFITS inadequate for nulling?

Classical interferometry follows a **systematic** scheme, recording visibility for each baseline, followed by OIFITS

- OIFITS is limited to application of **ZVC theorem**
- Stores/handles **Fourier** modes **sampled by pairs of collectors**

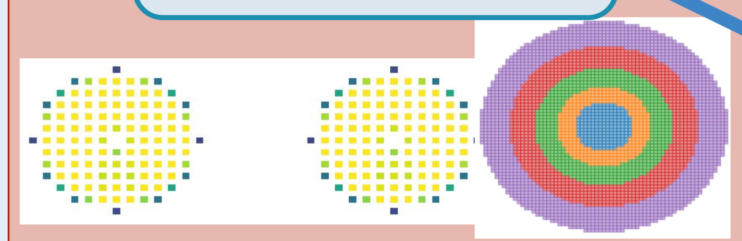
Nulling comes in a broad **variety** of schemes/ architectures requiring **ad-hoc instrument models** that DO NOT fall under the ZVC theorem.

How does NIFITS solve this problem?

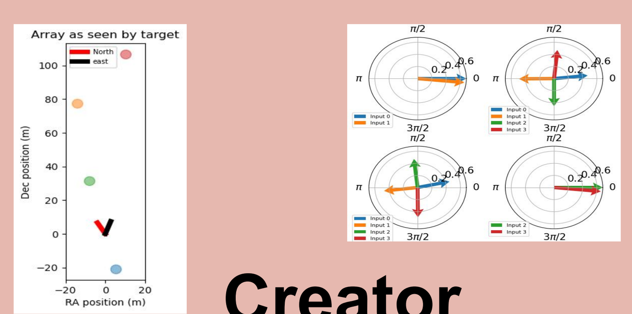
- Leave behind Fourier modes to use **instrument-specific modes**
- NIFITS contains the standardized information to build the instrument response function
- Burden of **instrument expertise** falls on the **creator of the file**, and **the user of the file can remain agnostic** to its peculiarities

The example below shows flexibility of NIFITS reproducing the response of two instruments of **extremely different architecture** using the **same operations.** The LBTI nuller implements a non-spatial filtered single Bracewell implemented in bulk optics, combining light from partially redundant apertures on a common mount. Asgard/NOTT is a long-baseline single-mode-filtered and integrated-optics, double-Bracewell nuller.

LBTI file



Asgard/NOTT file



Creator

Provides **instrument parameters** along with **data**

$$\mathbf{e}_{col} = e^{j\frac{2\pi}{\lambda}(\alpha\mathbf{x}+\beta\mathbf{y})}$$

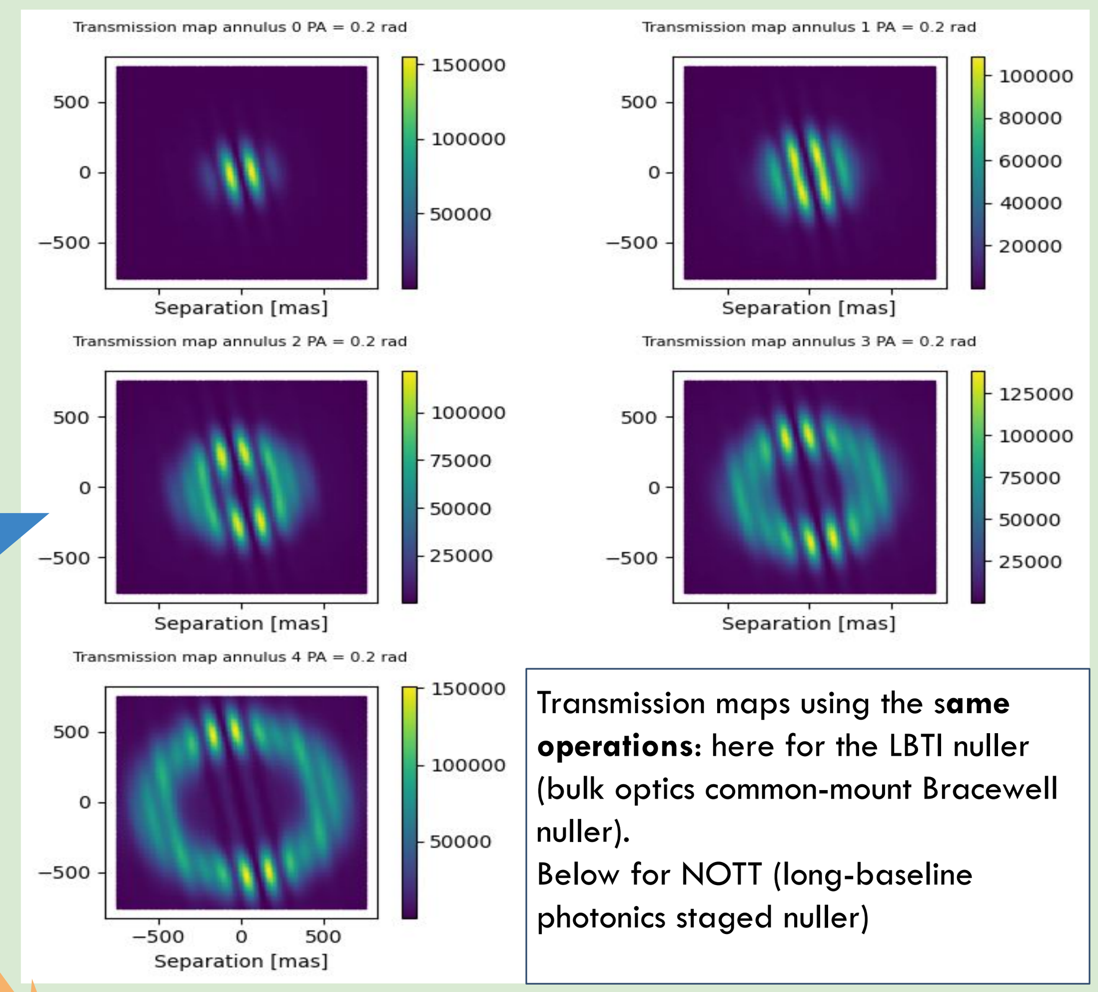
$$\mathbf{u}_{model} = \mathbf{K}\cdot|\mathbf{C}\cdot\mathbf{g}_{mod}\circ\mathbf{e}_{col}|^2$$

Library (*NIMODELER*)

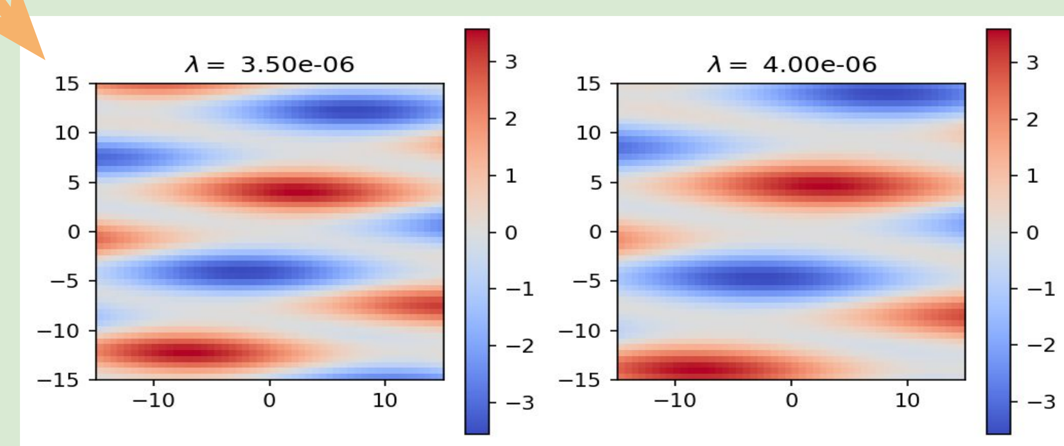
Implements simple **standard operations**

NIFITS standard

Inference



Transmission maps using the **same operations:** here for the LBTI nuller (bulk optics common-mount Bracewell nuller).
Below for NOTT (long-baseline photonics staged nuller)



User

- FoV raster -> transmission maps
- Astrophysical source model -> simulated response

By design, NIFITS is built to enable the **proliferation of advanced nulling schemes** such as proposed by Guyon (2013), Martinache & Ireland (2018), Laugier et al. (2020), Hansen et al. (2022), etc.

Extension	Required	Content
OI_ARRAY	yes	Interferometer description for compatibility with OIFITS.
NI_MOD	yes	Contains the time-varying information of the model, in particular the an interna modulation phasor vector, and the projected location of collecting apertures.
NI_CATM	referenced	The complex amplitude transfer matrix containing all static behavior of the system.
NI_KMAT	no	Identity is assumed if absent.
NI_IOUT	yes	Contains the collected output flux.
NI_KIOUT	no	Contains post-processed output fluxes.
NI_OSAMP	no	Identity is assumed if absent.
NI_FOV	referenced	Contains the complex spatial filtering function.

Item	format	unit	comment
APP_INDEX	int	NA	Index of subaperture (starts at 0)
TARGET_ID	int	d	Index of target in OI_TARGET
TIME	float	s	Backwards compatibility
MJD	float	day	
INT_TIME	float	s	Exposure time
MOD_PHAS	$n_\lambda\times$ complex		Complex phasor of modulation for the collector
APPXY	2× float	m	Projected location of subapertures in the plane orthogonal to the line of sight and oriented as (α, δ)
ARRCOL	float	m^2	Collecting area of the subaperture
FOV_INDEX	int	NA	The entry of the NI_FOV to use for this subaperture.

REFERENCES

- Pauls et al. (2005), PASP 117:1255–1262
- Duvert et a. (2017), A&A 597 A8
- Guyon et al. (2013), *PASP 125:951–965*
- Martinache & Ireland (2018), *A&A 619 A87*
- Laugier et al. (2020), *A&A 642 A202*
- Hansen et al. (2022), *A&A 664 A52*