



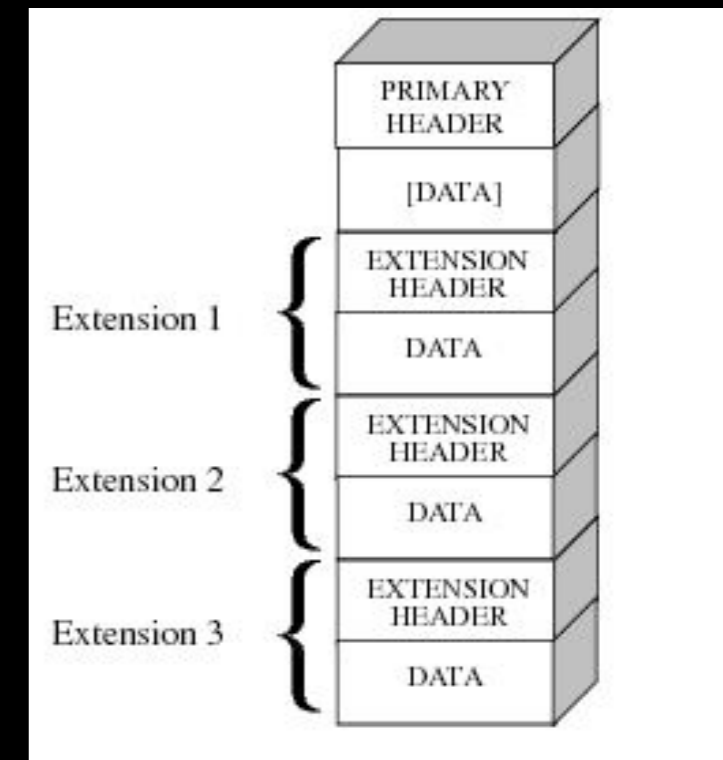
OIFITS tools

Xavier Haubois



OIFITS format (1)

- OIFITS are FITS files, HDU: headers, extensions, tables...
- OIFITS 1.0 (Pauls et al., 2005, PASP): traditional format
- OIFITS 2.0 (Duvert et al, 2017, A&A) is the new standard:
 - > improved description in the headers (data mining)
 - > more tables (polarisation measurements more explicit)
 - > better description of measurement errors and their correlations
 - > libraries available in C (<https://github.com/jsy1001/oifitslib>)





OIFITS format (2)

Select FITS file extension - /Users/xavierhaubois/Desktop/Projets/VLTI_SS/ATs/Configurations/Northern_baselines/comm5/data_15_05_16/reduced/G...

	Extension	Header	Type	Size	#5	#6	#7	#8	#9
	PRIMARY	...	IMAGE	1 x 1					
1	OI_ARRAY	...	BINARY TABLE	6 x 4	STAXYZ	MNTSTA			
2	OI_TARGET	...	BINARY TABLE	17 x 1	DECEPO	RA_ERR	DEC_ERR	SYSVEL	VELTYP
3	OI_WAVELENGTH	...	BINARY TABLE	2 x 210					
4	OI_WAVELENGTH	...	BINARY TABLE	2 x 210					
5	OI_WAVELENGTH	...	BINARY TABLE	2 x 5					
6	OI_WAVELENGTH	...	BINARY TABLE	2 x 5					
7	OI_VIS	...	BINARY TABLE	18 x 6	VISDATA	VISERR	VISAMP	VISAMPERR	VISPHI
8	OI_VIS2	...	BINARY TABLE	10 x 6	VIS2DATA	VIS2ERR	UCOORD	VCOORD	STA_INDEX
9	OI_T3	...	BINARY TABLE	14 x 4	T3AMP	T3AMPERR	T3PHI	T3PHIERR	U1COORD
10	OI_FLUX	...	BINARY TABLE	8 x 4	FLUX	FLUXERR	STA_INDEX	FLAG	
11	OI_VIS	...	BINARY TABLE	18 x 6	VISDATA	VISERR	VISAMP	VISAMPERR	VISPHI
12	OI_VIS2	...	BINARY TABLE	10 x 6	VIS2DATA	VIS2ERR	UCOORD	VCOORD	STA_INDEX
13	OI_T3	...	BINARY TABLE	14 x 4	T3AMP	T3AMPERR	T3PHI	T3PHIERR	U1COORD
14	OI_FLUX	...	BINARY TABLE	8 x 4	FLUX	FLUXERR	STA_INDEX	FLAG	

Cancel Read All



Tools

Data reduction

Visualization

Libraries

OIFITS

Data modeling

Image reconstruction

Database



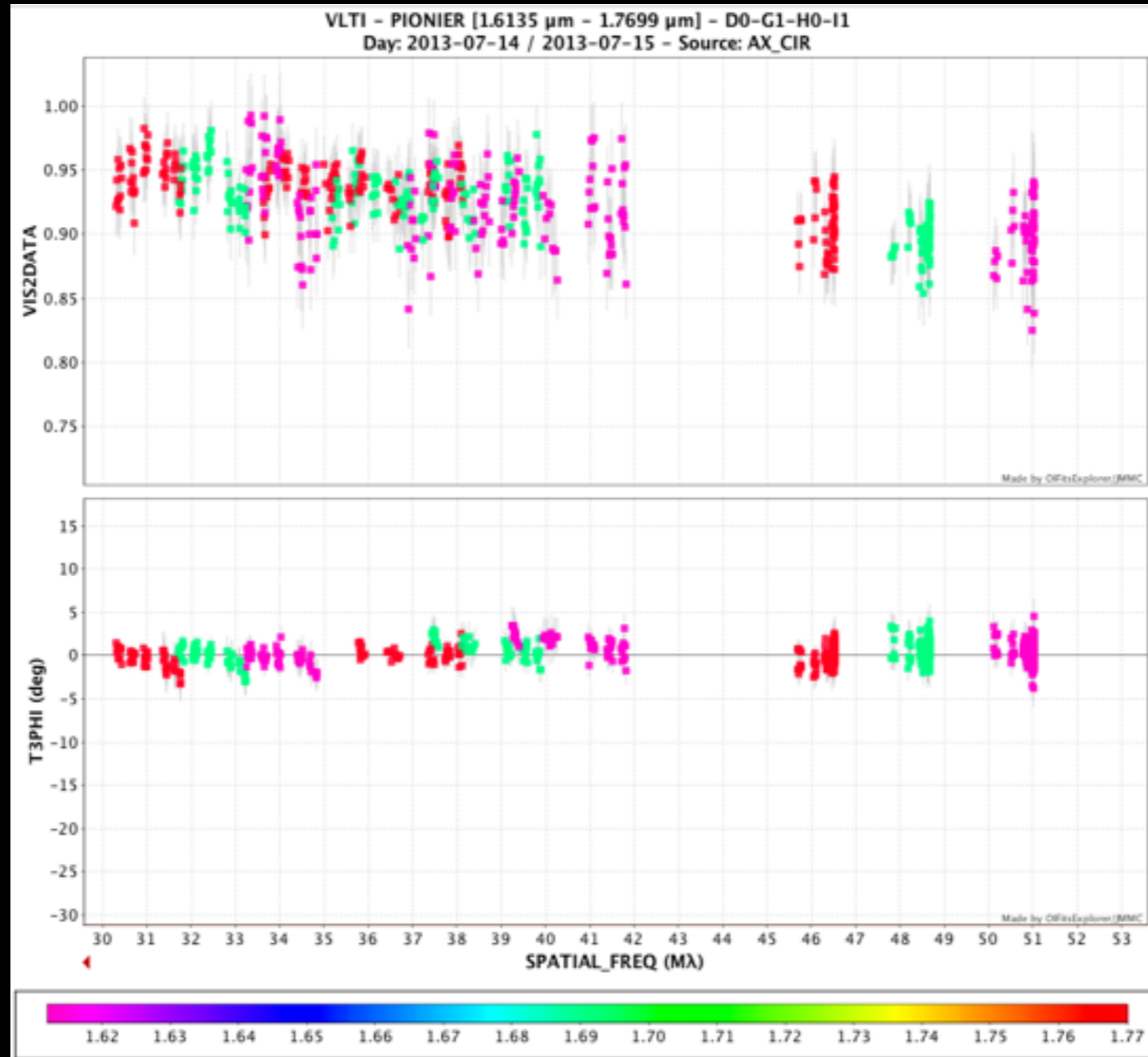
Data Reduction

- Data Reduction pipelines for AMBER, PIONIER and GRAVITY produce OIFITS
- OIFITS can be uncalibrated/calibrated
- Routines to manipulate OIFITS are developed within these pipelines
- Particularly interesting functions: reading, selecting, averaging, stacking, writing, etc...



Visualization tools (1)

- Fv, any fits reading SW that can make plots
- OiFits Explorer (JMMC, www.jmmc.fr)





Visualization tools (2)

- quicklook for GRAVITY, (A. Mérand): <https://github.com/amerand/GRAVIQL>

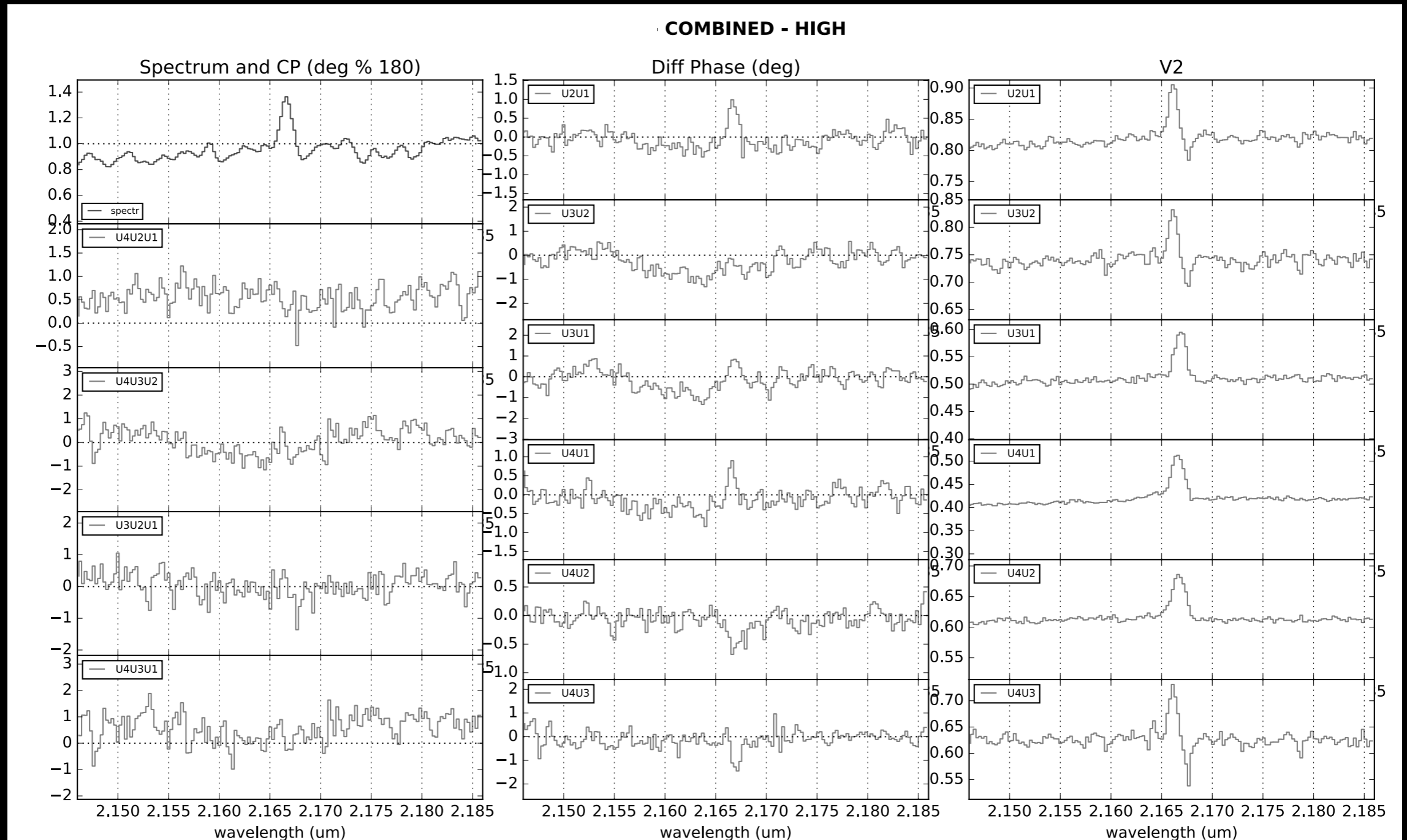
The screenshot shows the 'GRAVITY Spectro-Interferometric Quick Look' window. At the top, there are several tabs for different spectral lines: 'Full Range', 'HeI 2.058um', 'MgII 2.140um', 'Brg 2.166um', 'NaI 2.206um', 'NIII 2.249', and 'CO bands'. Below these are buttons for 'Show CP, dPhi, V2', 'Show Spectrum', 'Change directory', 'Reload file list', and a red 'QUIT' button. The main area displays a table of observation data for the directory '/diskc/PrivateData/GRAVITY/2016-06-17/'.

Object	Prog ID	Contain.	Disp	Wollast	Baseline	Seei	Tau0	FT	SC	Date-Obs
<input type="checkbox"/> HR_Car	60.A-9172(A)	1380002	HIGH	COMBINED	A0-G1-J2-K0	0.78"	8.1ms	99%	100%	2016-06-18T00:03:19
<input type="checkbox"/> HR_Car	60.A-9172(A)	1380002	HIGH	COMBINED	A0-G1-J2-K0	0.55"	8.1ms	99%	100%	2016-06-18T00:14:22
<input type="checkbox"/> HIP50644	60.A-9172(A)	1380002	HIGH	COMBINED	A0-G1-J2-K0	0.45"	7.2ms	100%	100%	2016-06-18T00:34:31
<input type="checkbox"/> HIP50644	60.A-9172(A)	1380002	HIGH	COMBINED	A0-G1-J2-K0	0.51"	6.0ms	99%	100%	2016-06-18T00:45:34
<input checked="" type="checkbox"/> HD93206	60.A-9175(A)	1380275	HIGH	COMBINED	A0-G1-J2-K0	0.57"	8.9ms	90%	90%	2016-06-18T01:04:40
<input checked="" type="checkbox"/> HD93206	60.A-9175(A)	1380275	HIGH	COMBINED	A0-G1-J2-K0	0.54"	7.4ms	82%	80%	2016-06-18T01:35:28
<input type="checkbox"/> HD94776	60.A-9175(A)	1380275	HIGH	COMBINED	A0-G1-J2-K0	0.80"	7.6ms	98%	96%	2016-06-18T01:57:37
<input type="checkbox"/> HD94776	60.A-9175(A)	1380275	HIGH	COMBINED	A0-G1-J2-K0	0.65"	11.2ms	98%	96%	2016-06-18T02:07:27
<input type="checkbox"/> HD139664	60.A-9165(A)	1380111	HIGH	COMBINED	A0-G1-J2-K0	0.32"	15.8ms	100%	100%	2016-06-18T03:48:55
<input type="checkbox"/> HD139664	60.A-9165(A)	1380111	HIGH	COMBINED	A0-G1-J2-K0	0.37"	11.0ms	100%	100%	2016-06-18T04:00:04
<input type="checkbox"/> HD139664	60.A-9165(A)	1380111	HIGH	COMBINED	A0-G1-J2-K0	0.38"	10.8ms	98%	98%	2016-06-18T04:11:13
<input type="checkbox"/> HD137730	60.A-9165(A)	1380111	HIGH	COMBINED	A0-G1-J2-K0	0.47"	7.5ms	100%	100%	2016-06-18T04:26:50
<input checked="" type="checkbox"/> HD148937	60.A-9168(A)	1380404	HIGH	COMBINED	A0-G1-J2-K0	0.61"	6.6ms	100%	100%	2016-06-18T04:51:05
<input checked="" type="checkbox"/> HD148937	60.A-9168(A)	1380404	HIGH	COMBINED	A0-G1-J2-K0	0.44"	8.8ms	100%	100%	2016-06-18T05:02:06
<input type="checkbox"/> HD149835	60.A-9168(A)	1380404	HIGH	COMBINED	A0-G1-J2-K0	0.34"	13.1ms	100%	100%	2016-06-18T05:14:53
<input type="checkbox"/> HD149835	60.A-9168(A)	1380404	HIGH	COMBINED	A0-G1-J2-K0	0.64"	4.8ms	100%	100%	2016-06-18T05:25:58
<input type="checkbox"/> Altair	60.A-9164(A)	1377965	HIGH	SPLIT	A0-G1-J2-K0	0.60"	7.8ms	100%	100%	2016-06-18T06:06:52
<input type="checkbox"/> Altair	60.A-9164(A)	1377965	HIGH	SPLIT	A0-G1-J2-K0	0.69"	6.5ms	100%	100%	2016-06-18T06:14:54
<input type="checkbox"/> Altair	60.A-9164(A)	1377965	HIGH	SPLIT	A0-G1-J2-K0	0.45"	7.9ms	100%	100%	2016-06-18T06:22:57
<input type="checkbox"/> HD188310	60.A-9164(A)	1377965	HIGH	SPLIT	A0-G1-J2-K0	0.40"	10.8ms	100%	100%	2016-06-18T06:40:44
<input type="checkbox"/> HD188310	60.A-9164(A)	1377965	HIGH	SPLIT	A0-G1-J2-K0	0.45"	8.9ms	100%	100%	2016-06-18T06:48:36
<input type="checkbox"/> HD188310	60.A-9164(A)	1377965	HIGH	SPLIT	A0-G1-J2-K0	1.14"	3.5ms	100%	100%	2016-06-18T06:56:30
<input checked="" type="checkbox"/> IRC_10420	60.A-9166(A)	1380657	HIGH	COMBINED	A0-G1-J2-K0	0.73"	4.4ms	100%	100%	2016-06-18T07:17:57
<input checked="" type="checkbox"/> IRC_10420	60.A-9166(A)	1380657	HIGH	COMBINED	A0-G1-J2-K0	0.80"	4.1ms	99%	100%	2016-06-18T07:27:26
<input type="checkbox"/> HD190073	60.A-9170(A)	1380739	HIGH	COMBINED	A0-G1-J2-K0	0.50"	7.0ms	88%	80%	2016-06-18T08:36:05
<input type="checkbox"/> HD190073	60.A-9170(A)	1380739	HIGH	COMBINED	A0-G1-J2-K0	0.52"	10.9ms	99%	100%	2016-06-18T08:50:06



Visualization tools (2)

- quicklook for GRAVITY, (A. Mérand): <https://github.com/amerand/GRAVIQL>





Libraries 1: IDL

http://dept.astro.lsa.umich.edu/~monnier/oi_data/

Filename	Purpose
read_oidata.pro	Routine to read oidata FITS files
write_oidata.pro	Routine to write oidata FITS files
define_oisArray.pro	Defines OI-ARRAY data structure
define_oiTarget.pro	Defines OI-TARGET data structure
define_oiwavelength.pro	Defines OI-WAVELENGTH data structure
define_oivis.pro	Defines OI-VIS data structure
define_oivis2.pro	Defines OI-VIS2 data structure
define_oiT3.pro	Defines OI-T3 data structure
define_vis2data.pro	Defines VIS2DATA structure
define_t3data.pro	Defines T3DATA structure
extract_vis2data.pro	Extract OI-VIS2 data into more usable IDL variables (no pointers)
extract_t3data.pro	Extract OI_T3 data into more usable IDL variables (no pointers)
merge_oidata.pro	Allows combination of oidata.fits files with no info loss
concat_oitable.pro	Used to concatenate like structures (workaround for IDL v5.1). updated in 2013 for compatibility with devlarx update in astrolib.
copy_oitable.pro	Used with concat_oitable.pro for compabiility with updated astrolib.
testdata.fits	A very basic test FITS file distributed by J. Young
make_testfits.script	IDL script to create bigtest.fits
bigtest.fits	Test FITS file containing full richness of OI-data format



Libraries 2: python, yorick, julia

Python:

- astropy.io.fits <http://docs.astropy.org/en/stable/io/fits/>
- Paul Boley: <http://astro.ins.urfu.ru/pages/~pboley/oifits/>
- Python tools for GRAVITY (merge, analysis, etc)
svn co https://145.238.154.30/repos/DRS_gravity/python_tools
- Yorick (E. Thiébaud): <https://github.com/emmt/YOIFITS>
- Julia (E. Thiébaud): <https://github.com/emmt/OIFITS.jl>

Summary of OIFITS tools and libraries:

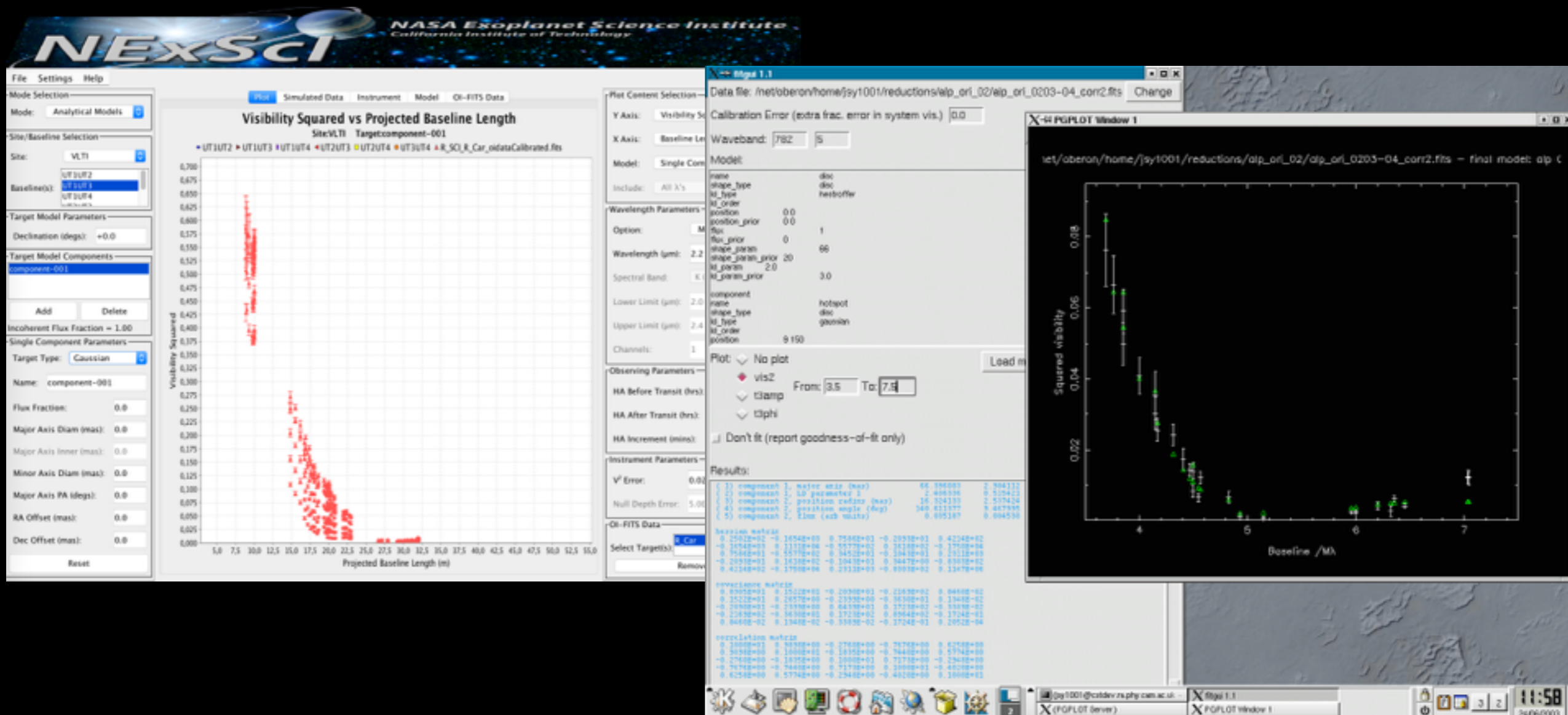
- <http://www.astro.phy.cam.ac.uk/research/ResearchFacilities/software-for-astrophysics/oifits>



Model-fitting (1): VMT and mfit

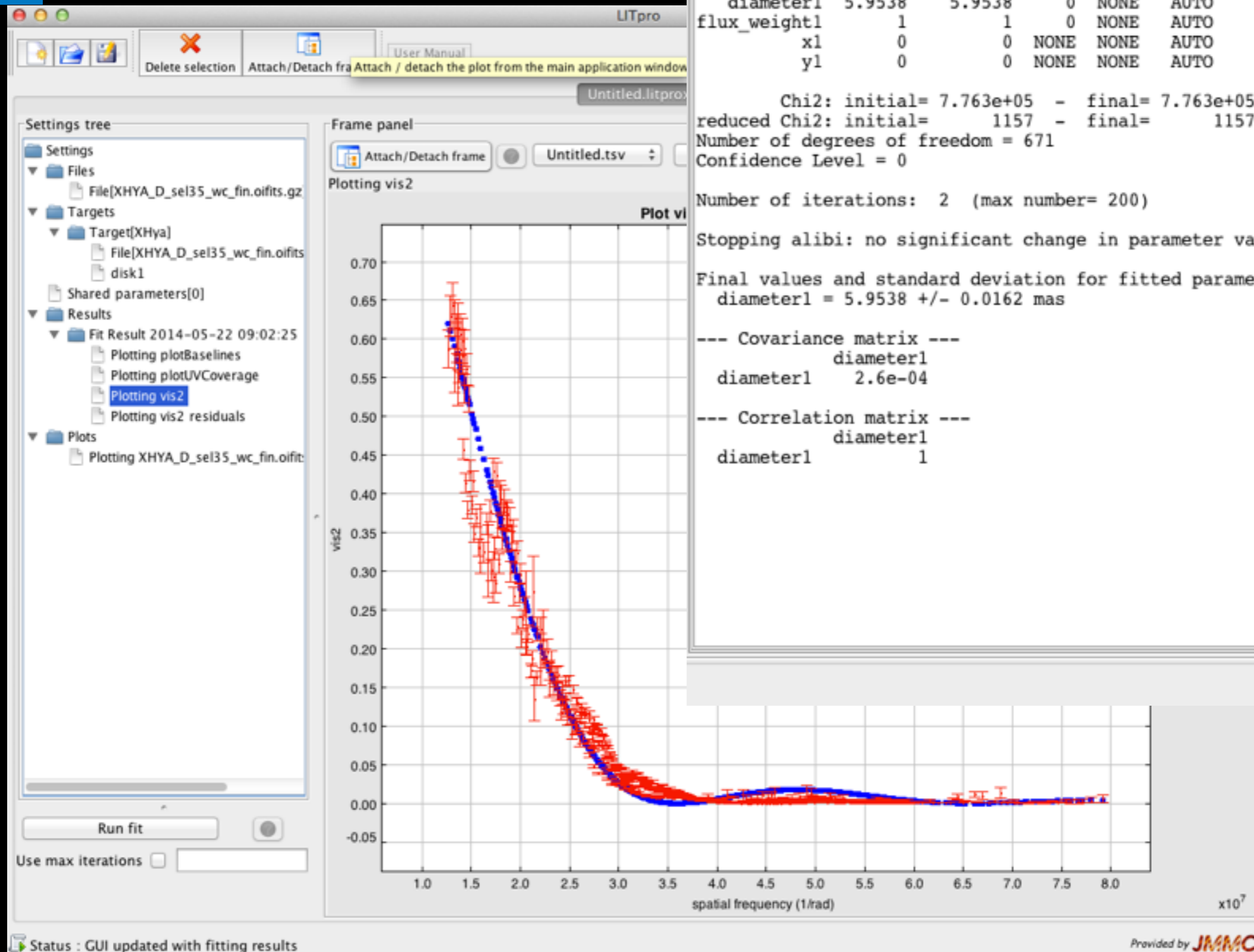
- Visibility Modeling Tool, (NExSci), 2 T, limited sets of models (Keck,PTI)
<http://nexsciweb.ipac.caltech.edu/vmt/vmtWeb/>

- mfit (John Young): multi-component (with asymmetries) models + GUI
<http://www.mrao.cam.ac.uk/~jsy1001/mfit/>





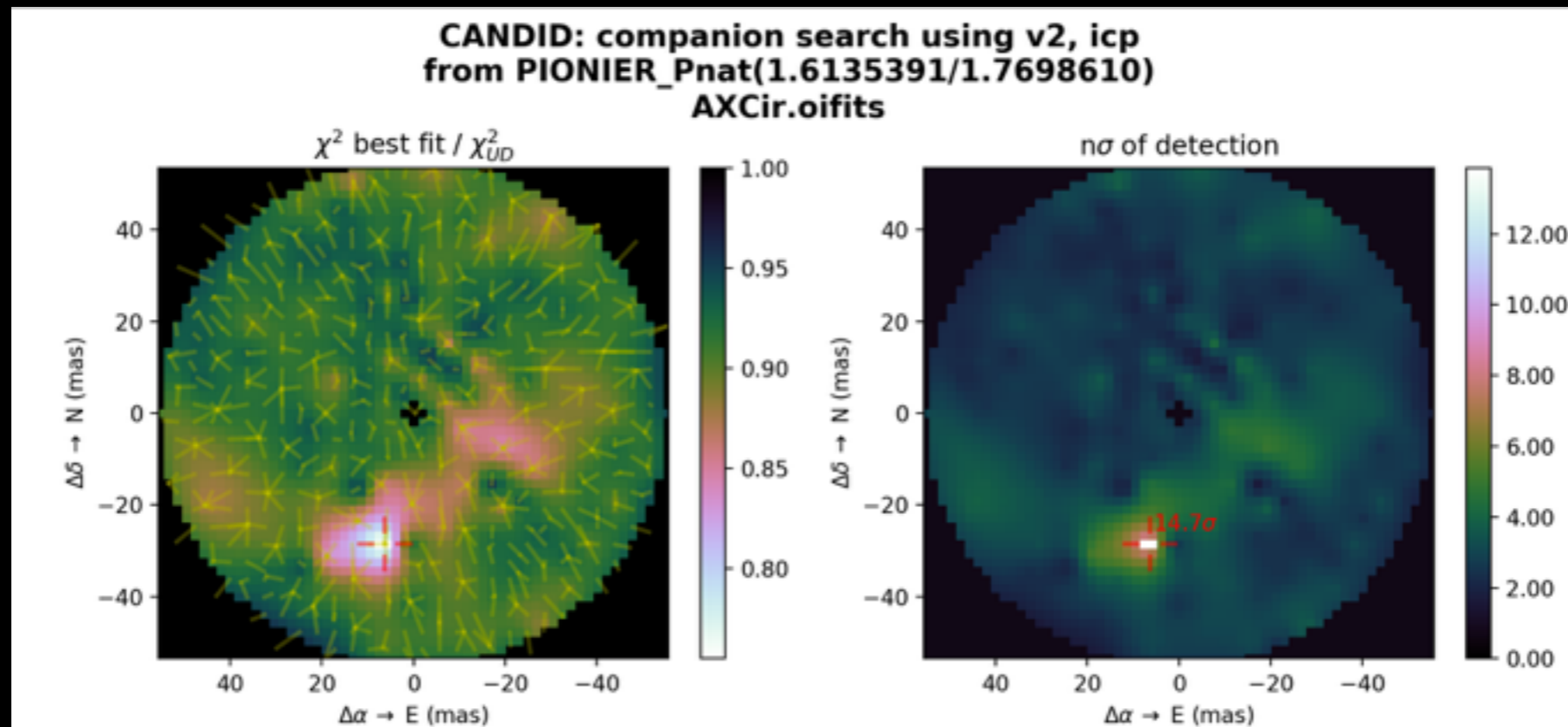
Model-fitting (2): LITpro (Tallon-Bosc et al. 2008), www.jmmc.fr



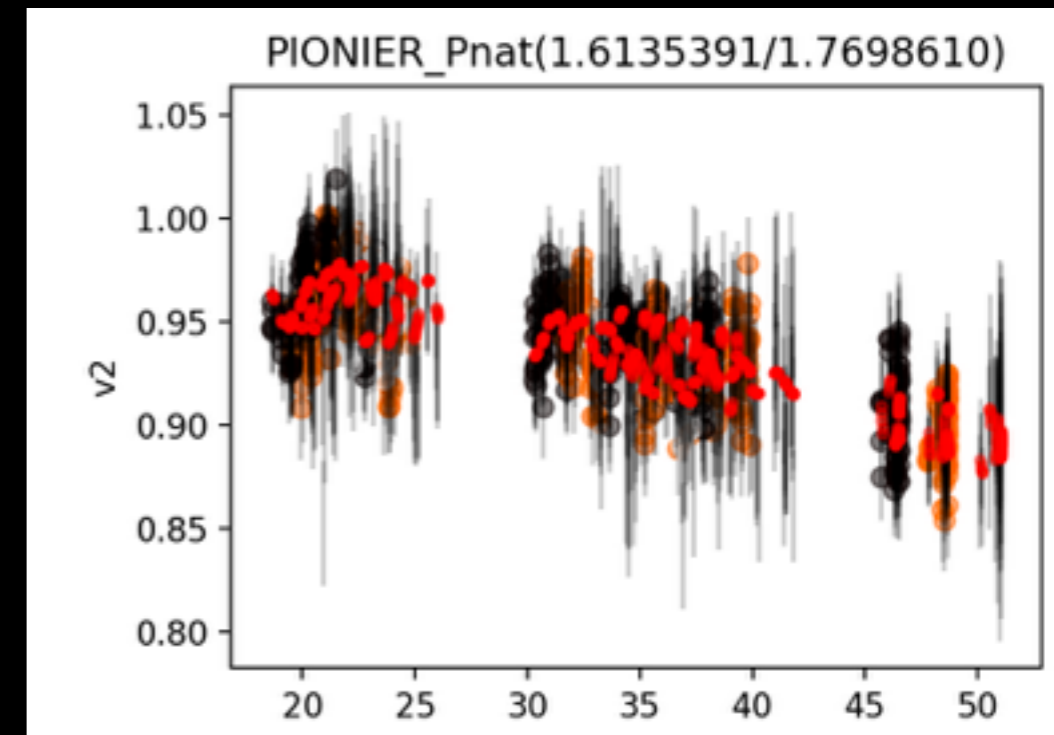


Model-fitting (3): CANDID (Gallenne et al. 2015)

<https://github.com/amerand/CANDID>



- Fit, chi2 maps
- Injection of synthetic companion \rightarrow detection limit
- Fast, simple sets of commands
- Bandwidth smearing taken into account





Model-fitting (4): SIMTOI

<http://www.chara.gsu.edu/observers/data-analysis-software/3-simtoi>

The screenshot displays the SIMTOI software interface. On the left is a parameter table, and on the right is a 3D model rendering window.

Name	Free	Value	Min	Max	Step
Feature					
Uniform Spot					
theta	<input type="checkbox"/>	60	0.1	180	0
phi	<input type="checkbox"/>	45	0	360	0
radius	<input type="checkbox"/>	15	0.1	6	0
delta_T	<input type="checkbox"/>	1000	-2000	2000	0
Model					
Sphere					
Pos. Angle	<input type="checkbox"/>	0	0	360	0
Inclination	<input type="checkbox"/>	0	0	360	0
Rotation	<input type="checkbox"/>	0	0	360	0
Color	<input type="checkbox"/>	0	0	1	0
Di	<input type="checkbox"/>	0	0	1	0
Position					
XY					
N	<input type="checkbox"/>	-9	-1	1	0
E	<input type="checkbox"/>	-9	-1	1	0
Shader					
LDL - Power Law					
alpha	<input type="checkbox"/>	0.5	0.1	1	0
Model					
Flared Disk (Pascucci 2004)					
Pos. Angle	<input type="checkbox"/>	30	0	360	0
Inclination	<input type="checkbox"/>	89	0	360	0
Rotation	<input type="checkbox"/>	0	0	360	0
Color	<input type="checkbox"/>	0	0	1	0
r_in	<input type="checkbox"/>	0.1	0.1	10	0
radial cutoff	<input type="checkbox"/>	20	0.1	10	0
height cutoff	<input type="checkbox"/>	5	0.1	10	0
n rings (int)	<input type="checkbox"/>	200	1	100	0
Position					
XY					
N	<input type="checkbox"/>	-13	-1	1	0
E	<input type="checkbox"/>	-4	-1	1	0
Shader					
Pascucci 2004 Disk					
rho0	<input type="checkbox"/>	2.39	0.1	100	0
kappa	<input type="checkbox"/>	5000	0.1	10	0
r0	<input type="checkbox"/>	2.39	0.1	6	0
h0	<input type="checkbox"/>	0.04	0.1	10	0
alpha	<input type="checkbox"/>	11	0.1	10	0
beta	<input checked="" type="checkbox"/>	2	0.1	10	0

Annotations on the 3D model rendering:

- Live Parameter Updating & Rendering
- Spots!
- Smooth edges via. multi-sample anti-aliasing
- Roche Lobe Geometry w/ Healpix tessellation
- Limb darkening
- Obscuration
- Animation



Database 1: OiDB, Optical Interferometry Database

oidb.jmmc.fr

- Goals:

- > Promote, preserve OI data and centralise its access
- > Connect data users with observing teams
- > Interoperability with the VO tools
 - Direct feed to LitPro and OiFitsExplorer (among other tools)

- Contents:

- Already ~5000 calibrated science-ready OIFITS
- Including all calibrated PIONIER data since 2011
- Weekly updated observation logs from CLIMB, CLASSIC and VEGA (since 2006)
- + your data!





Database 2: ESO-Phase 3 for VLTI data products

- PIONIER science-ready OIFITS released soon,
- GRAVITY/MATISSE in the future (OIFITS 2.0)



Image reconstruction softwares

- PAINTER: <http://www-n.oca.eu/aferrari/painter/>
- WISARD: http://www.jmmc.fr/wisard_page.htm
- MACIM: <http://www.physics.usyd.edu.au/~mireland/MACIM/>
- MIRA: <http://cral.univ-lyon1.fr/labo/perso/eric.thiebaut/?Software:MiRA>
- BSMEM
 - ftp://ftp.eso.org/pub/general/VLT12017_School
 - www.mrao.cam.ac.uk/research/optical-interferometry/bsmem-software/
- SQUEEZE: <https://github.com/fabienbaron/squeeze>
- IRBIs:
 - > Binary image to be used with VirtualBox(www.virtualbox.org/):
 - ftp ftp.eso.org
 - login: anonymous password: your email address
 - > cd pub/general/VLT12017_School
 - > binary
 - > get ubuntu14_matisse_18012017.ova
- The OI imaging beauty contest (proceedings SPIE 2016, Sanchez+17)