Science Ground Segment (SGS)
Organizational Unit `Shear'

OU-SHE

Martin Kilbinger, CEA Saclay

Journées Euclid France
Lyon, Dec 2014

OU-SHE

Edinburgh: Andy Taylor, Alex Hall, Bryan Gillis, David Harvey, Keith Noddle — Management, systematics, lead

Oxford: Lance Miller, Giuseppe Congedo, Niraj Welikala — shapes, PSF

UCL-MSSL: Tom Kitching, Mark Cropper, Sami Niemi

Durham: Richard Massey, Holger Israel, Mathilde Jauzac — CTI

Bonn: Tim Schrabback, Reiko Nakajima, Ole Marggarf, Edo van Uitert, Patrick Simon — HST, co-lead

UPenn: Gary Bernstein, Marisa March

Carnegie Mellon: Rachel Mandelbaum

Leiden: Henk Hoekstra, Konrad Kuijken, Massimo Viola — flexion

Lausanne: Frederic Courbin, Marc Gentile, Thibault Kuntzerm, Remy Joseph, Danka Paraficz, Nicolas Cantal — simulations, strong lensing, co-lead

Saclay: Martin Kilbinger, Simon Bekouche, Koryo Okumura, Fred Ngole, Stephane Paulin-Hendriksson, Sandrine Pires — validation

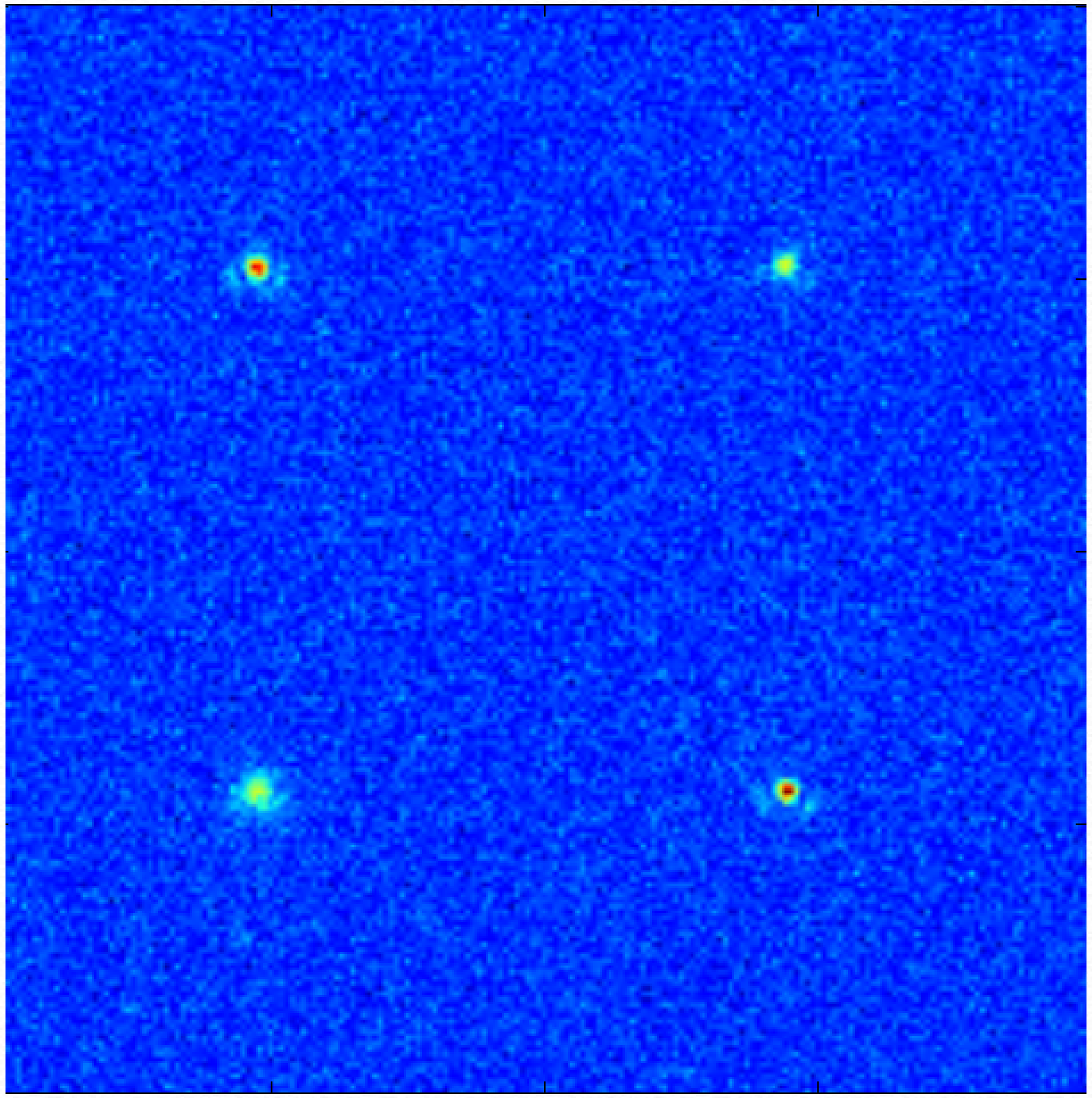
IAP: Emmanuel Bertin, Raphael Gavazzi

Marseille: Eric Jullo, Marcel Limousin

OU-SHE recent activities

- Image simulations for calibration:
  - great3
  - Euclid SHE Benchmarking Exercise (SBE)
  - simulation requirements to OU-SIM
- Stellar blends and PSF
- PSF from telescope model
- Created documents for SRR (RSD - requirement specification document) & validation plan
- Lance Miller's PSF code being inserted into SDC
- HST work: PSF & CTI modeling, code development

Image simulations for SHE



Galaxy shear g_i:

$$g_i^{\mathrm{obs}} - g_i^{\mathrm{true}} = m_i g_i^{\mathrm{true}} + c_i$$

m: multiplicative bias
c: additive bias

Euclid requirements:
$|\Delta\ m| < 2 \cdot 10^{-3}$
$|\Delta\ c| < 10^{-6}$

Use image simulations for
- Calibration: measure m, c
- Validation: check |Δ m|, |Δ c|

Further calibration and validation using
- Euclid science data (null tests)
- Deep (HST) data
- Euclid calibration data (deep survey, stellar fields)
- Emulated data (Euclid Deep → Wide)

Any shear method can be calibrated to meet Euclid Requirements with *sufficiently* good calibration data.

But calibration will fail if it requires:

- Too large a calibration set (large N_{cal}).
- Too extreme a calibration set (too high-res, depth).
- Cannot interpolate calibration to data (insufficient sample).

E.g. Size of calibration data (X=image properties)

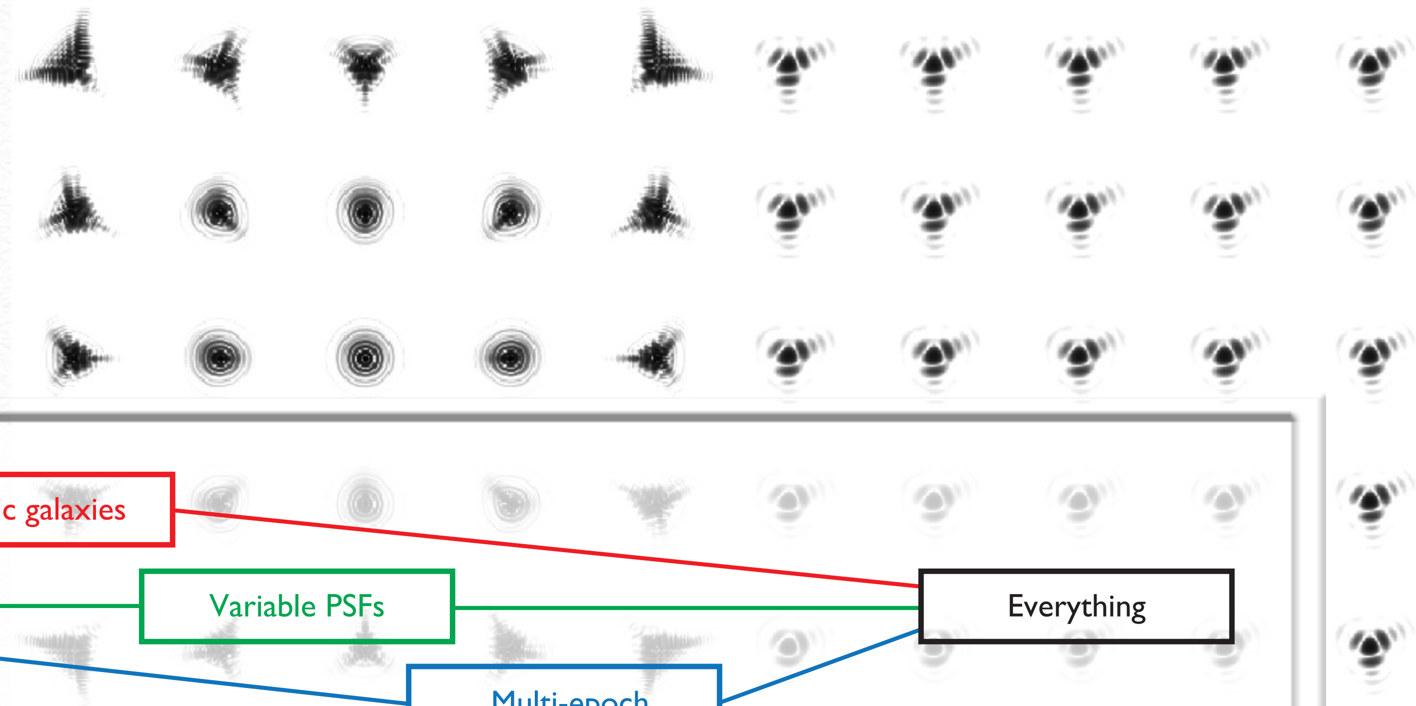
$$N_{cal} \gtrsim 10^7\, m^2 \,(\partial \ln m / \partial \ln X)^2$$

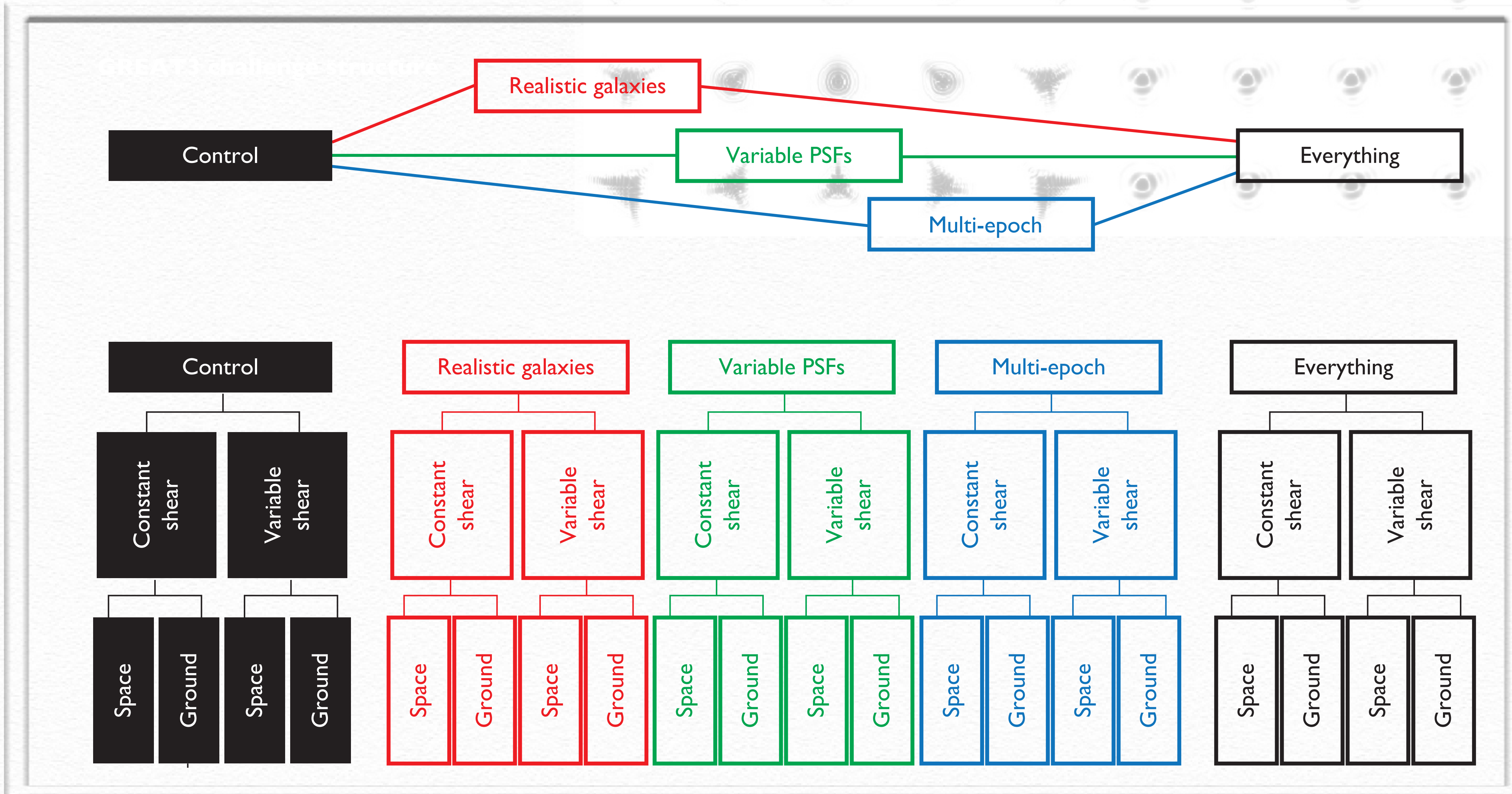
Want methods which are *insensitive* to calibration.

Andy Taylor, Edinburgh

The great3 challenge

Blind challenge to measure weak-lensing galaxy shears from simulated images.
Mid-2013 to April 2014.





Rachel Mandelbaum (CMU), Barnaby Rowe (UCL/JPL)

great3 leaderboard

Branch Leaderboards

Leaderboard	Space-based	Varying shear	Winning team	Winning score	Winning entry
control-ground-constant	N	N	CEA-EPFL	1211.4	gfit_sf_12_CGC
control-ground-variable	N	Y	CEA-EPFL	1068.0	gfit_sf_8_CGV_pca_
control-space-constant	Y	N	Amalgam@IAP	1516.2	A_SP_12.8
control-space-variable	Y	Y	Amalgam@IAP	1198.8	A_SP_v3.4
full-ground-constant	N	N	sFIT	800.2	basic_cal_fgc6
full-ground-variable	N	Y	sFIT	379.1	basic_cal_fgv7
full-space-constant	Y	N	sFIT	1184.3	basic_cal_fsc9
full-space-variable	Y	Y	sFIT	856.2	basic_cal_fsv11
multiepoch-ground-constant	N	N	sFIT	1017.1	basic_cal_mgc7
multiepoch-ground-variable	N	Y	MegaLUT	1131.3	Bonn_MegaLUT_M(
multiepoch-space-constant	Y	N	sFIT	841.4	basic_cal_msc9
multiepoch-space-variable	Y	Y	CEA-EPFL	1605.0	gfit_sf_5_MSV
real_galaxy-ground-constant	N	N	Amalgam@IAP	1121.0	A_SP_10.2
real_galaxy-ground-variable	N	Y	CEA-EPFL	790.9	gfit_RGV_pca_s55_
real_galaxy-space-constant	Y	N	Fourier_Quad	1918.5	Fourier_Quad_S6
real_galaxy-space-variable	Y	Y	MegaLUT	1667.2	Bonn_MegaLUT_RS
variable_psf-ground-constant	N	N	sFIT	883.5	basic_cal_vgc4
variable_psf-ground-variable	N	Y	Amalgam@IAP	229.8	A_SPvp_0_7v
variable_psf-space-constant	Y	N	Amalgam@IAP	1182.6	A_SPvp_1_1
variable_psf-space-variable	Y	Y	sFIT	1275.6	basic_cal_vsv

Great3 Overall Leaderboard

great3.jb.man.ac.uk/leaderboard/team

	Name	Notes	Score	Number of entries
Davis	sFIT	Modified DLS stackfit algorithm	80001	162
IAP	Amalgam@IAP	Some fellows developing software based around SExtractor and PSFex for real-life shape measurements.	80000	215
CEA, EPFL	CEA-EPFL	The team wants to investigate if we could improve shear estimation by combining gfit with sparse representation methods.	72000	340
Bonn	MegaLUT	Evolutions of the MegaLUT technique : how far can we go with SExtractor + Machine Learning ?	52000	234
Shanghai	Fourier_Quad	Our team uses the quadrupole moments of the spectral density of galaxy images in Fourier space to measure shear.	32000	36
	EPFL_gfit	Using the gfit shear measurement method, testing how far one can go by using forward model fitting + new approaches for bias calibration	24000	124
lensfit	MaltaOx	Malta-Oxford GREAT3 team. We aim to test shear measurement by likelihood fits to individual galaxies, using lensfit, and without using simulations to calibrate bias.	3001	15
Japan	E-HOLICs	E-HOLICs method is developed for aim of precise and fast shear analysis. E-HOLICs method is moment method like KSB method , but use elliptical weight function for avoiding one of systematic errors.	3000	58
US	MBI	Team members:Lang CMU, Hogg NYU, Schneider LLNL, Dawson LLNL, Bard SLAC, Marshall SLAC, Meyers Stanford, Boutigny SLAC	1000	51
Manchester	COGS	Capitalizing On Gravitational Shear Team based primarily at University of Manchester and University College London, and lead by Sarah Bridle. Most entries will use the im3shape code described in http://arxiv.org/abs/1302.0183.	•	38
	GREAT3_EC	GREAT3 executive committee - submissions using example scripts.	•	10
	EPFL_lensfit	Testing a multi-processor version of lensfit 7.2 (Miller et al., 2007, Kitching et al., 2008)	0	0
Bonn	FDNT	Fourier Domain Null Test method (Bernstein 2010) with additional m+c bias calibration	•	36
	ess	Various pipelines by Erin S. Sheldon	0	13
	DeepZot	Team members: Daniel Margala and David Kirkby at UC Irvine	0	0
CMU	CMU experimenters	This is a team for Rachel Mandelbaum's group at CMU to experiment with some crazy ideas that probably won't work, but are kind of fun to think about.	•	4
	miyatake-test	Test for GREAT3 data by the HSC pipeline.	•	4
	CEA_denoise	Moment correction on denoised images.	0	25
Ohio	MetaCalibration	This team is testing how well we can extract the shear response by shearing the images themselves, and modifying the psf accordingly.	•	3
UPenn	BAMPenn	Bernstein, Armstrong & March, University of Pennsylvania.	0	8
	HSC/LSST-HSM	A sanity check of the bookkeeping in the obs_great3 package written to allow HSC/LSST pipeline algorithms to be run on the GREAT3 simulations, using an old implementation of the HSM code.	•	4
	EPFL_MLP_FIT	multilayer perceptron, fitted data as input	0	1
EPFL	EPFL_KSB	From quadrupole moments to shear, based on the KSBf90 (Heyamans et al. 2005).	0	39
	EPFL_HNN	Hopfield Neural Network	0	32
	EPFL_MLP	MLP	0	51
	Wentao Luo	A modified method based on both BJ02(Bernstein & Jarvis 2002) and HS03(Hirata & Seljak 2003)	0	25

great3 France

- IAP:
  Annamaria Donnarumma, Emmanuel Bertin, Raphael Gavazzi

- CEA:
  Florent Sureau, Stéphane Paulin-Henriksson, Martin Kilbinger, Fred Ngolé Mboula, Jean-Luc Starck

  (+ EPFL: **Marc Gentile**, Frédéric Courbin, Huanyuan Shan, Guldariya Nurbaeva)

great3 notes (cf Euclid)

- Undersampled PSF
- Realistic galaxy models
- Realistic, spatially varying PSF
- Multi-exposure dithered images

- No star/galaxy selection, no blended objects (galaxies on a grid)
- No chromatic effects
- No instrumental effects (CTI, cosmics, bad pixels, …)
- No very low S/N galaxies (< 12 - 20)

great3 conclusions

- Model bias ~ 1-2%
- Many successful methods did model-fitting
- Simulation volume (20 - 100 GB per branch) not large enough to make very accurate performance estimation ($\Delta Q \sim 200$ for $Q \sim 1000$)
- Public scores led to feedback of making choices

Why blind tests? At Euclid accuracy, any method shapes will have to be calibrated anyway.

- Gain confidence in shape measurement + calibration
- Calibration error depends on calibration amplitude

great3 legacy

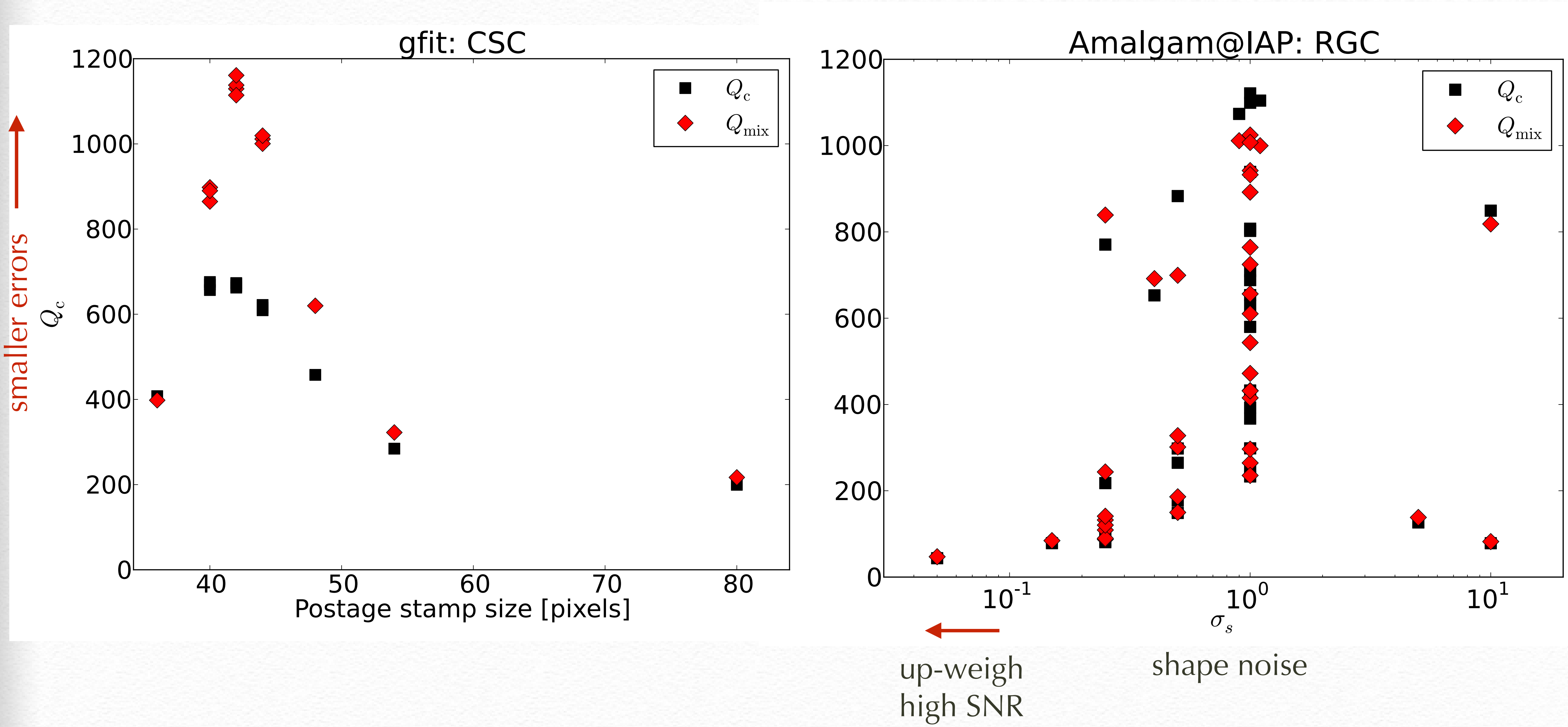
GALSIM: The modular galaxy image simulation toolkit

Barnaby Rowe[a,b,c,*], Mike Jarvis[d,*], Rachel Mandelbaum[e,*], Gary M. Bernstein[d], James Bosch[f], Melanie Simet[e], Joshua E. Meyers[g], Tomasz Kacprzak[a,h], Reiko Nakajima[i], Joe Zuntz[h], Hironao Miyatake[f,j], Jörg P. Dietrich[k,l], Robert Armstrong[f], Peter Melchior[m], Mandeep S. S. Gill[n]

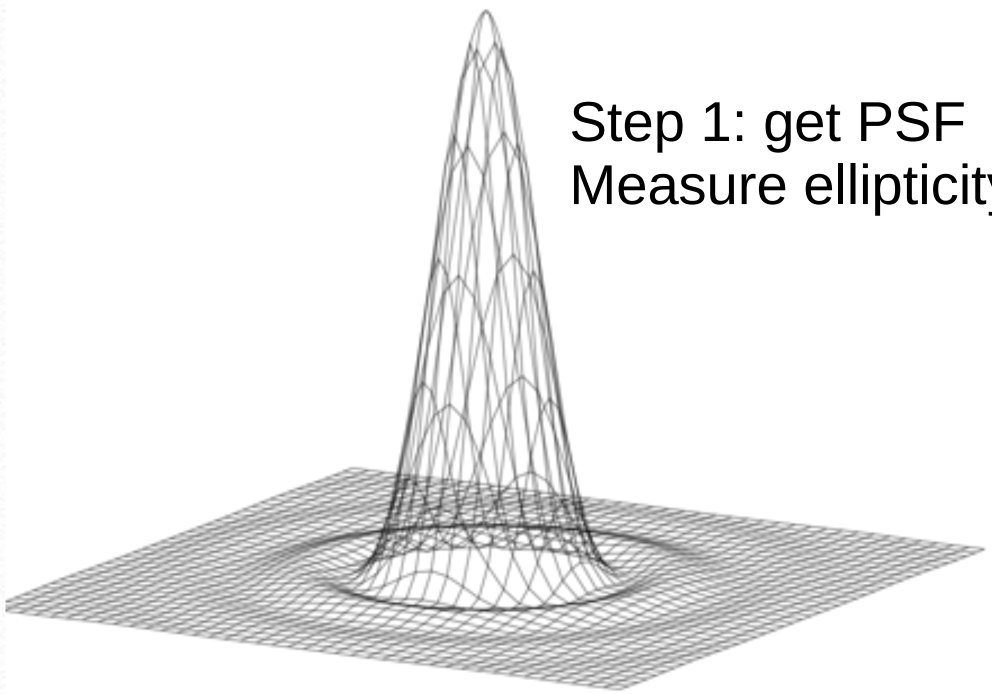
https://github.com/GalSim-developers/GalSim

- Broad range of objects: PSFs, galaxy profile models, simulated or from input data, e.g. HST
- Weak-lensing shear
- PSF convolution, different methods/accuracies
- Realistic noise including correlated noise
- Shape estimation, e.g. KSB, Hirata & Seljak (2003), Bernstein & Jarvis (2002)
- Colors

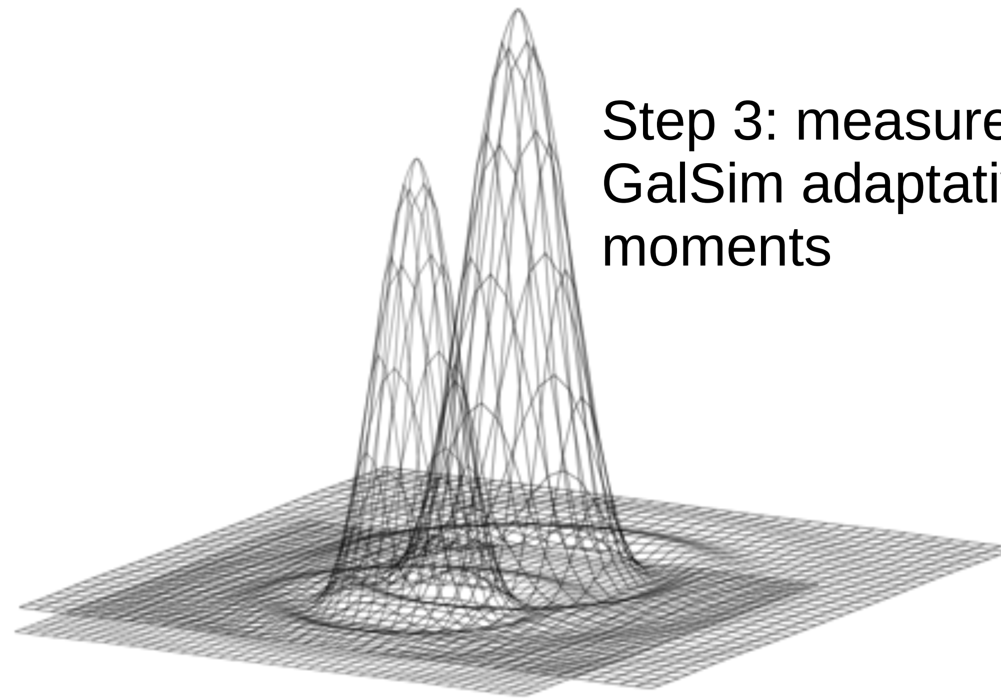
great3 analyses examples



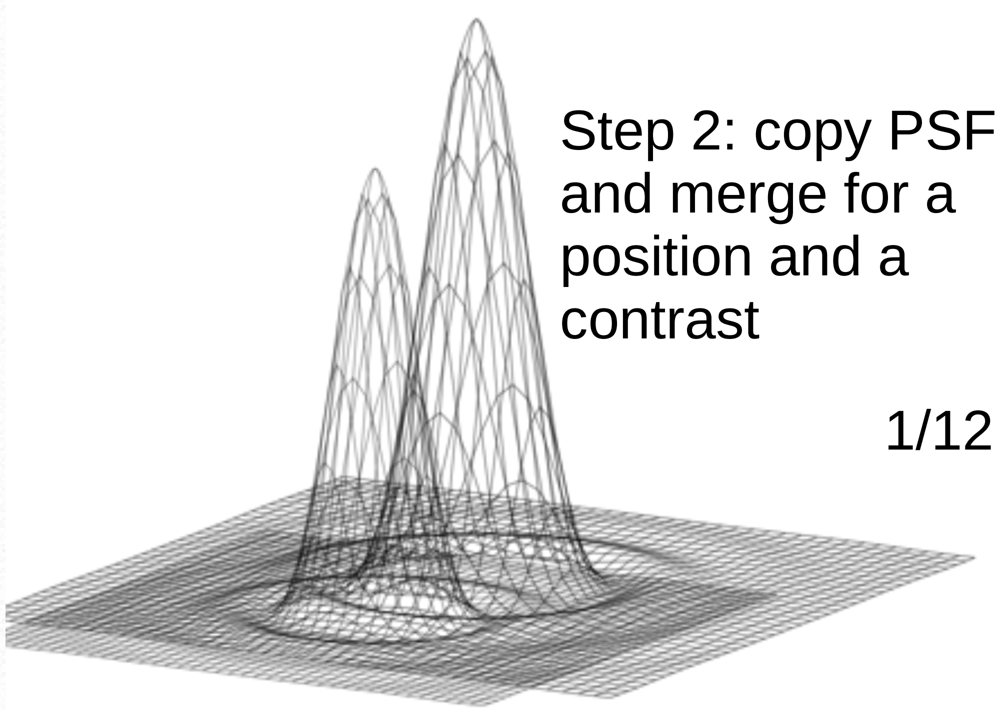
Measuring ellipticity of stellar blends



Step 1: get PSF
Measure ellipticity



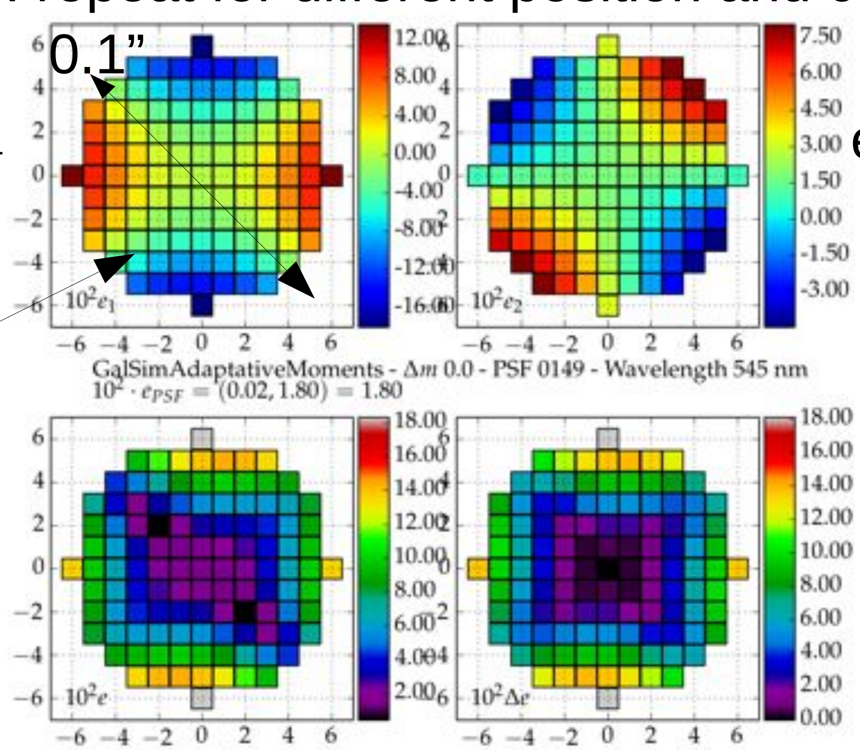
Step 3: measure with GalSim adaptative moments



Step 2: copy PSF and merge for a position and a contrast

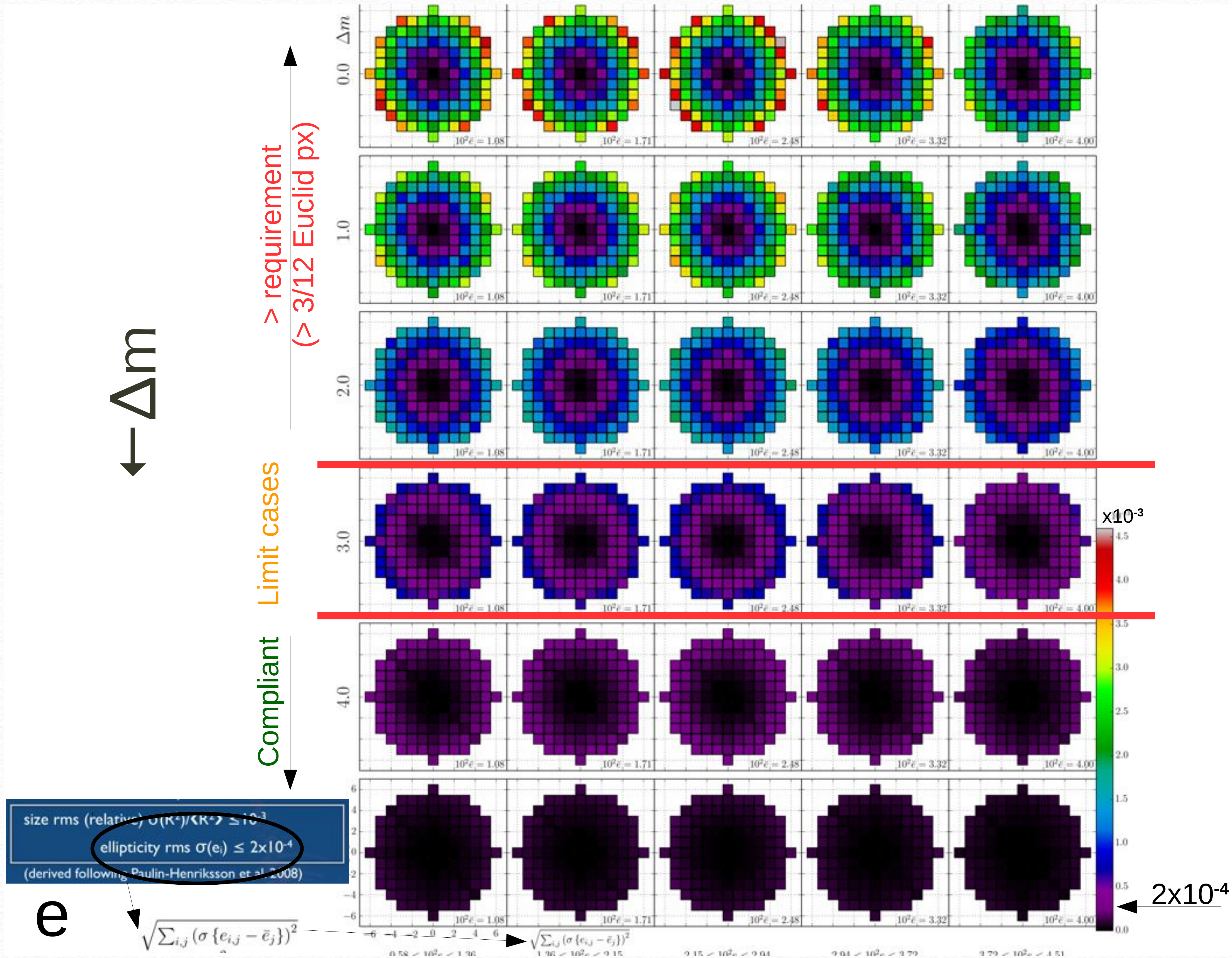
Step 4: repeat for different position and contrasts

Resolution
1/12 px EUCLID



Thibault Kunzer, Frédéric Courbin, EPFL

Ellipticity of stellar blends



Thibault Kunzer, Frédéric Courbin, EPFL

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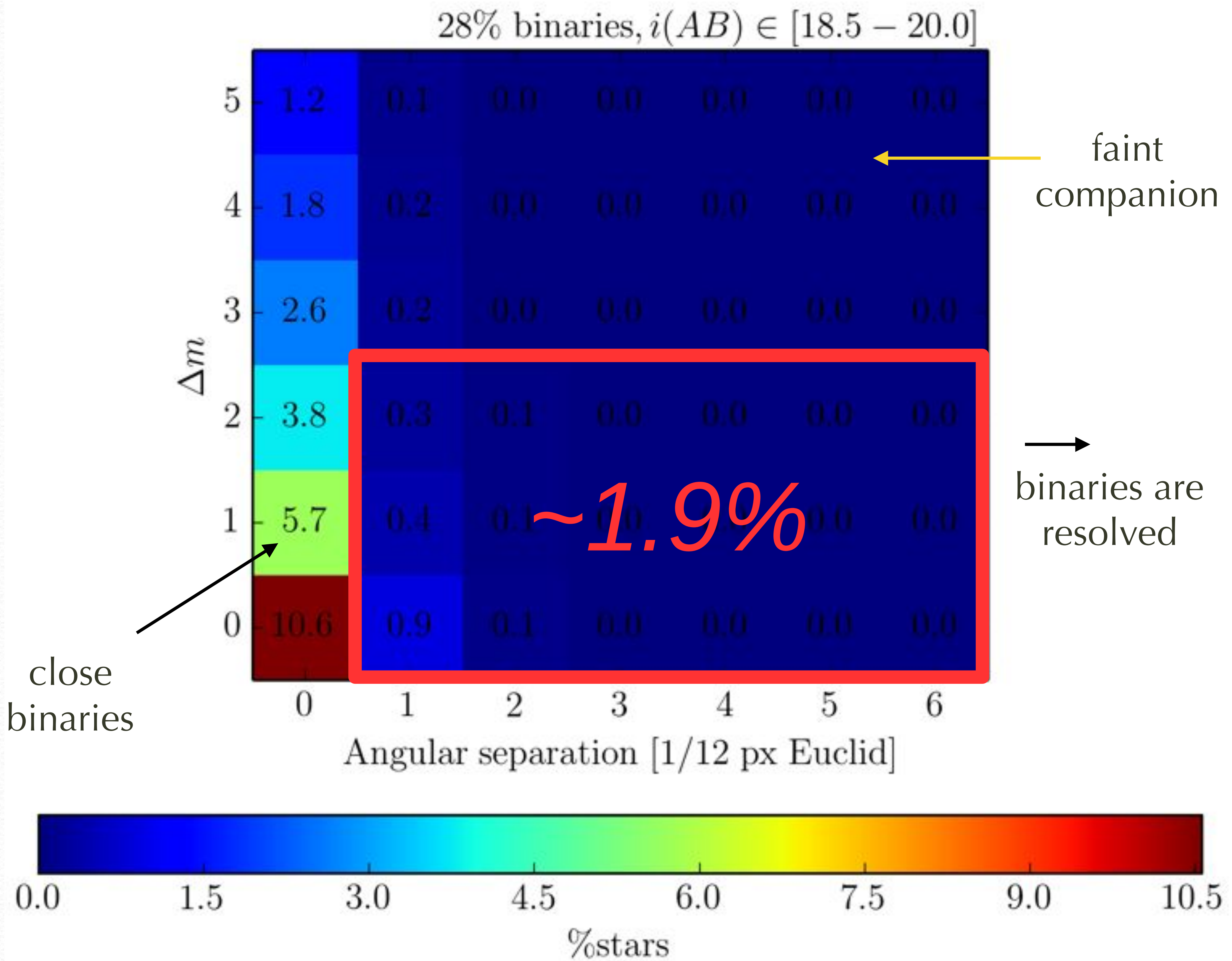
Ellipticity of stellar blends



Thibault Kunzer, Frédéric Courbin, EPFL

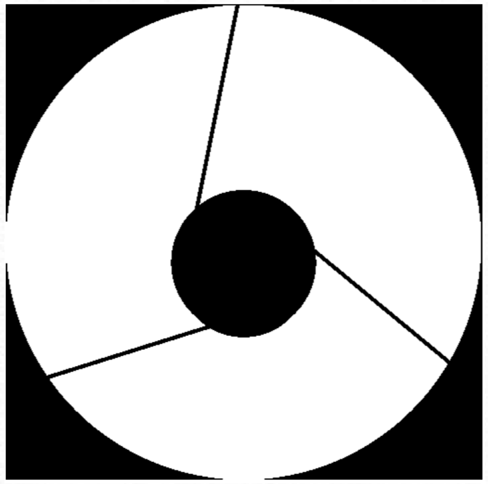
Ellipticity of stellar blends

Summary

- VIS saturates at i(AB)=~18.5.
- Star-star blending ellipticity measurement marginally non-compliant with requirement for Δm=0-2 and separation (1-3)/12*0.10”.
- Star-star blending will impact ~2% of stars with i(AB)>18.5.
- Binaries with period ~ Euclid lifetime, ellipticity(time)?
- Look also at size

Thibault Kunzer, Frédéric Courbin, EPFL

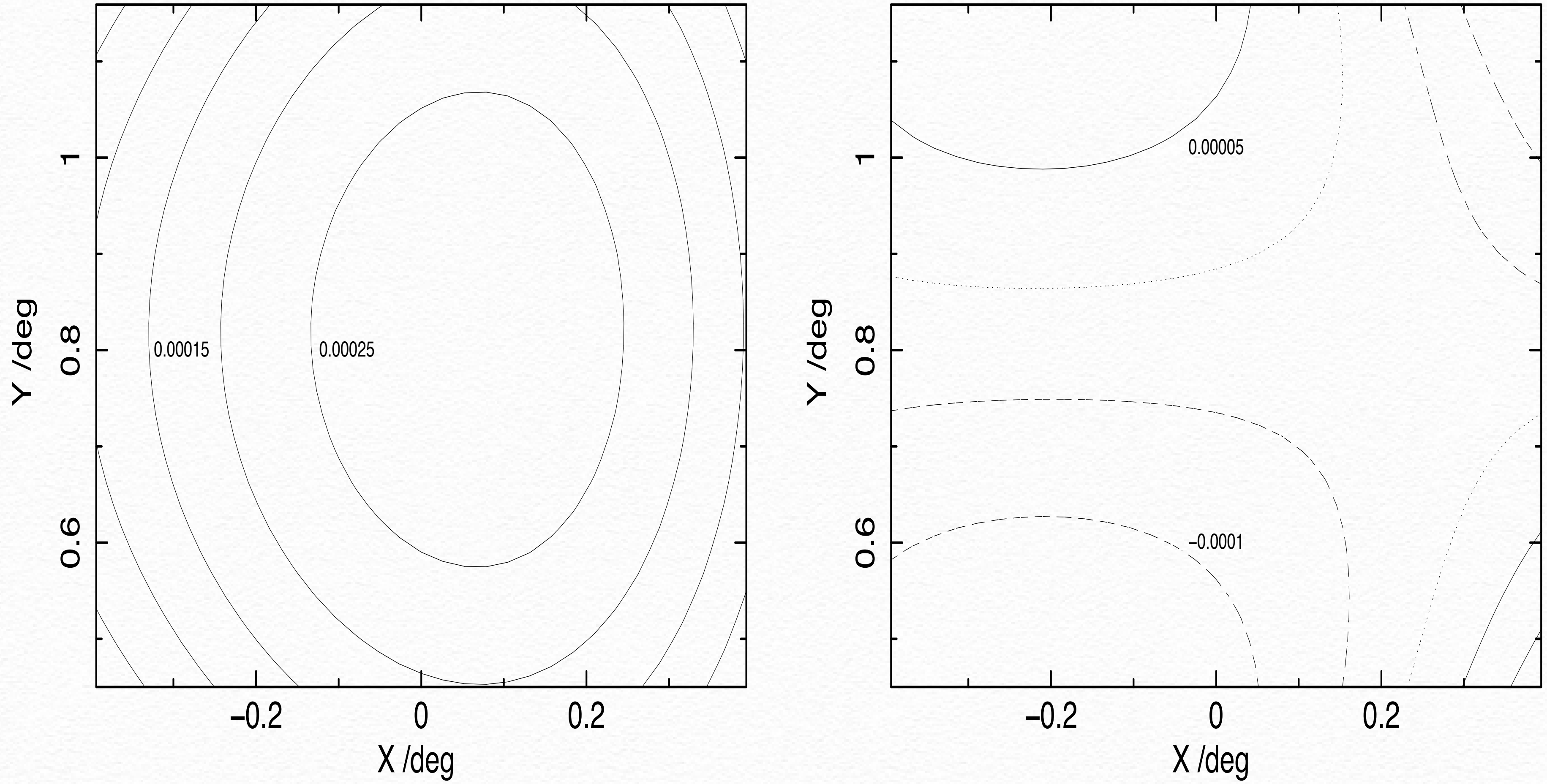
PSF modeling



Obtain PSF from wavefront at exit pupil.

Two methods (both implemented in Zemax):

- Fourier Transform of exit pupil wavefront images — faster
- Huygens direct diffraction calculations — more accurate



$\Delta e \sim 10^{-4}$

Lance Miller (Oxford), Koryo Okumura (CEA), Samuel Royanette (CEA)

France in shear

- Lot of expertise with shape measurement, PSF modeling, strong lensing, weak-lensing quality image production. Experience with data (CFHT, …). Participated in great08, great10, great3.
- Under-represented at OU-SHE WP leads.
- Attempts for more F+CH contribution to shape measurement and PSF modeling+corrections.
- Other subjects: systematics testing, morphometry, strong lensing (legacy!)