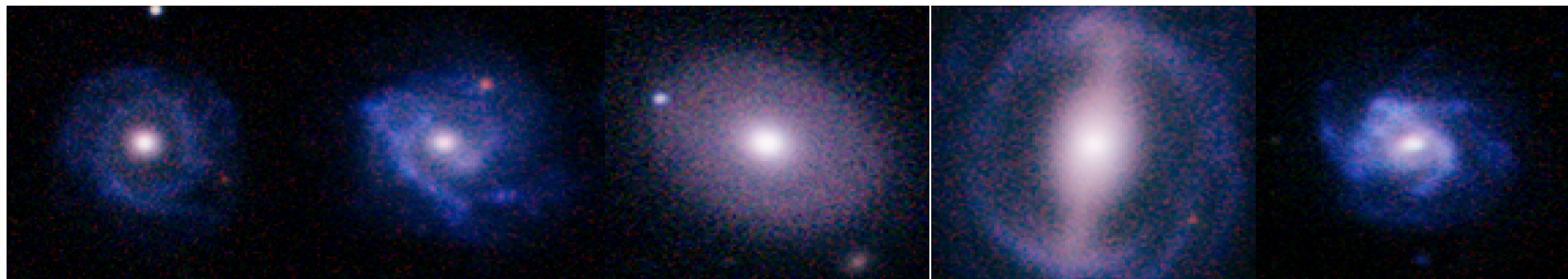




Galaxy And Mass Assembly (GAMA) & WAVES

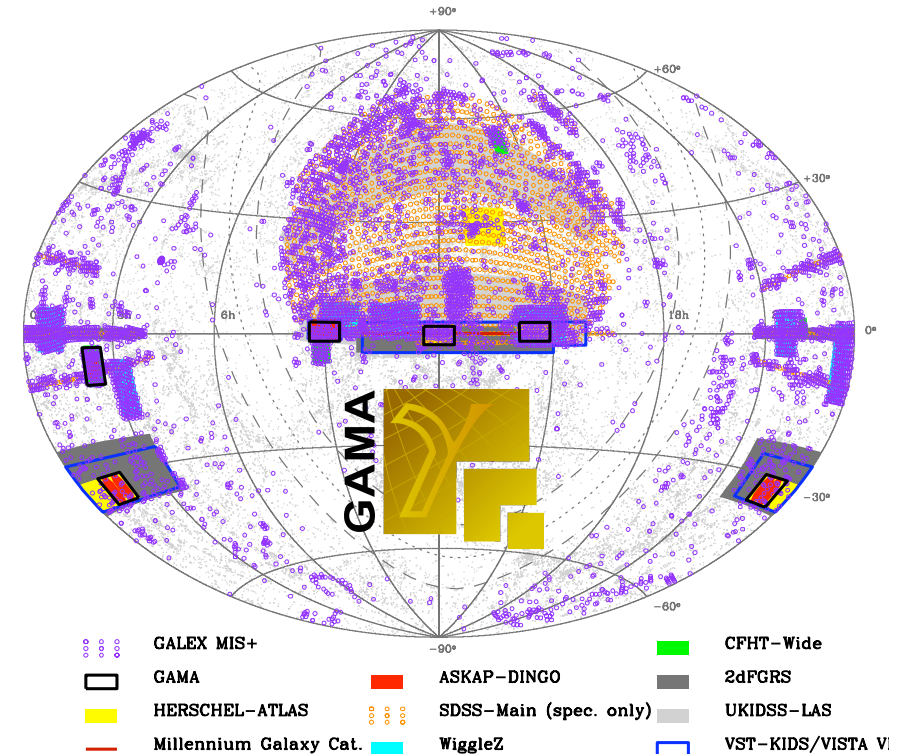
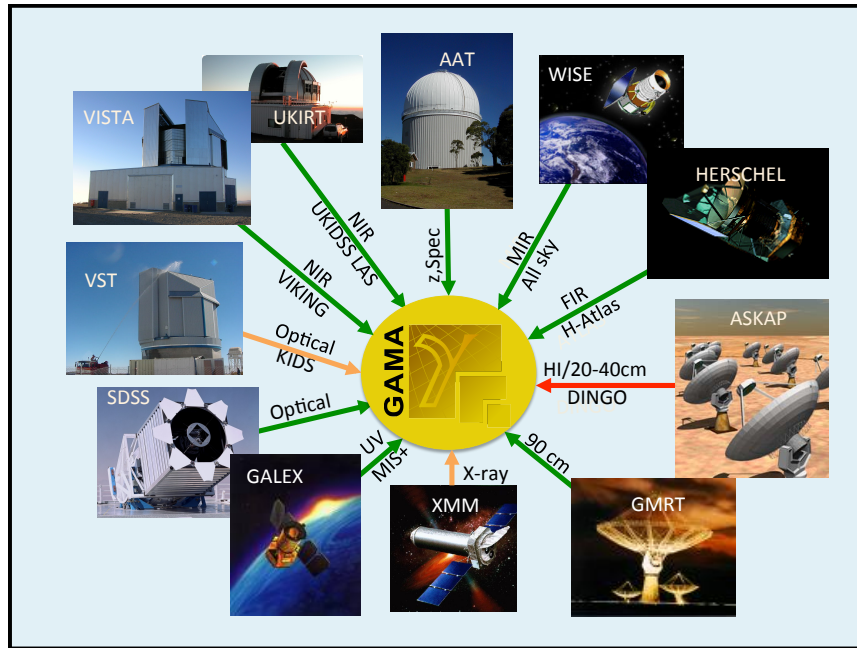
Simon Driver

International Centre for Radio Astrophysics Research,
University of Western Australia
and
The University of St Andrews





Galaxy And Mass Assembly (GAMA)



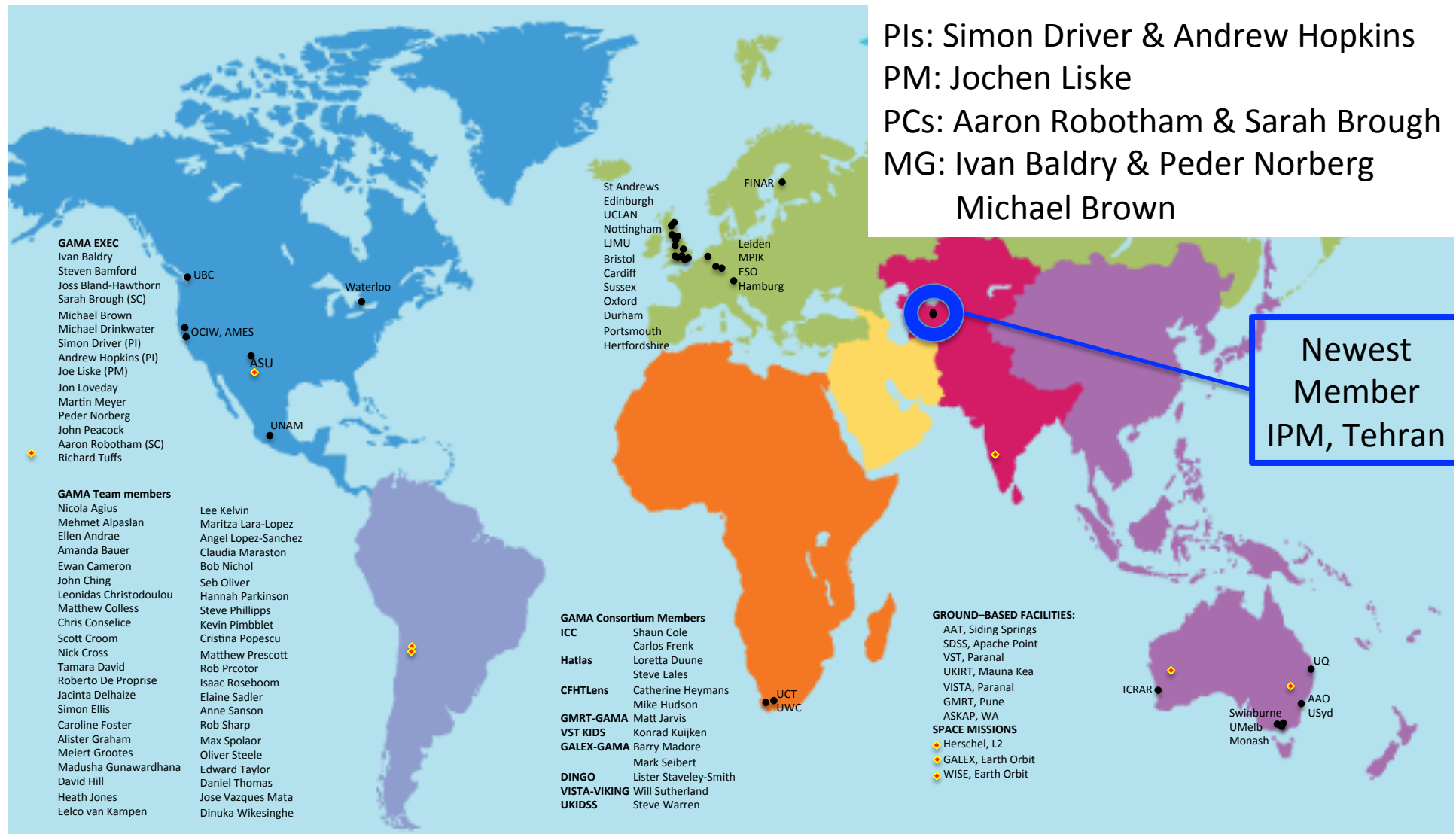
250,000 galaxies to $r < 19.8$ mag over five 60 sq deg ($\sim 98\%$ complete, selected from SDSS)

- catalogue of 25,000 groups (halos) to $10^{12} M_{\odot}$
- 21 band photometry + gas (ASKAP) [GALEX+VST+VIKING+WISE+Herschel]
- *mass, energy and structure* on 1kpc to 100Mpc scales to $z \sim 0.25$
- Website <http://www.gama-survey.org/> Community Data Releases (DR1,DR2,PDR)



The GAMA Team

Team now includes: 97 scientists (including 14 PhD students) across 39 institutions, 4 continents





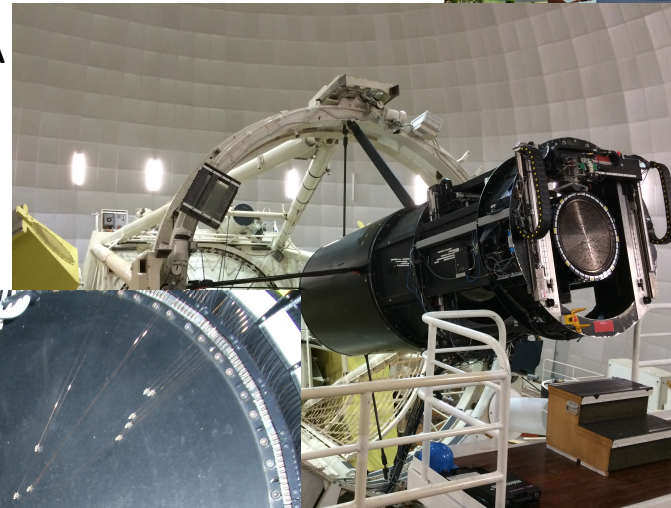
200 nights over 7 years
 (top speed due to RA range!)
 ~300k spectra



Most productive 4m class telescope
 in the world: 2dFGRS, 6dF, WiggleZ, GAMA

~30% of all known redshifts from AAO

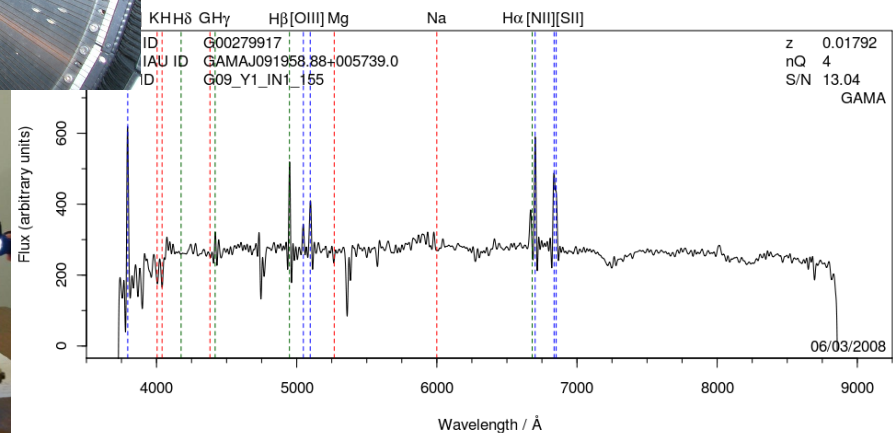
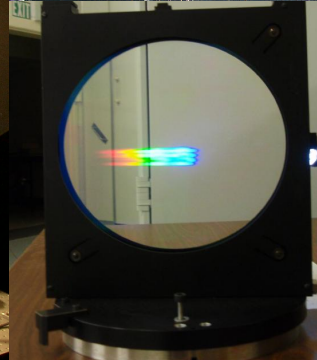
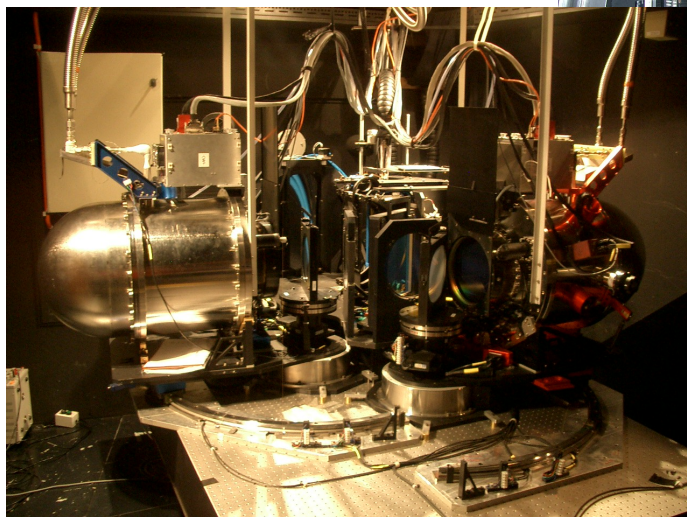
3.9m but 1.5'' seeing
 and 50% cloudy =
 dedicated spectroscopy



Entire Process
 Automated:

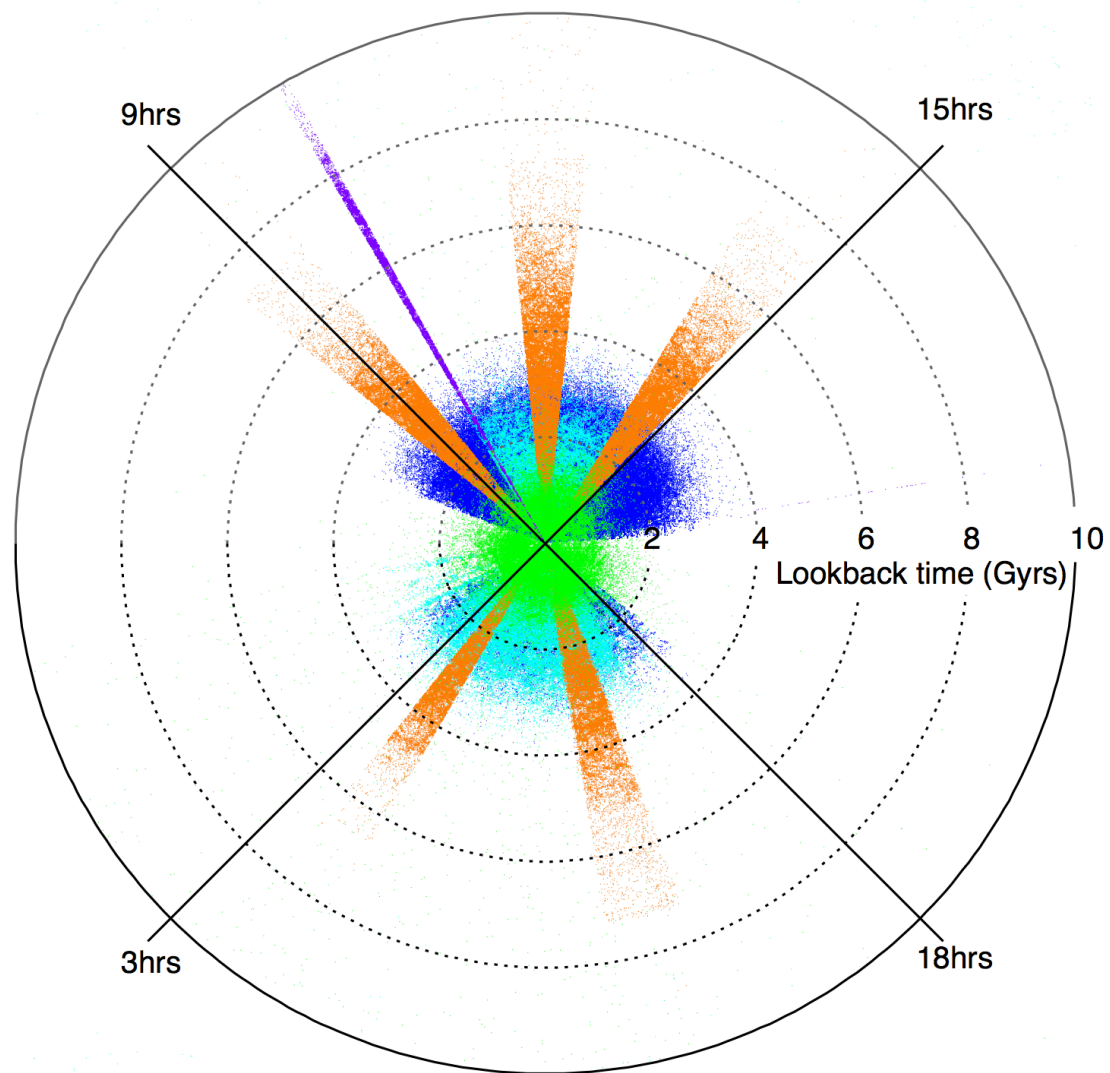
- Tiling
- Data reduction
- Redshifting

2500z/night



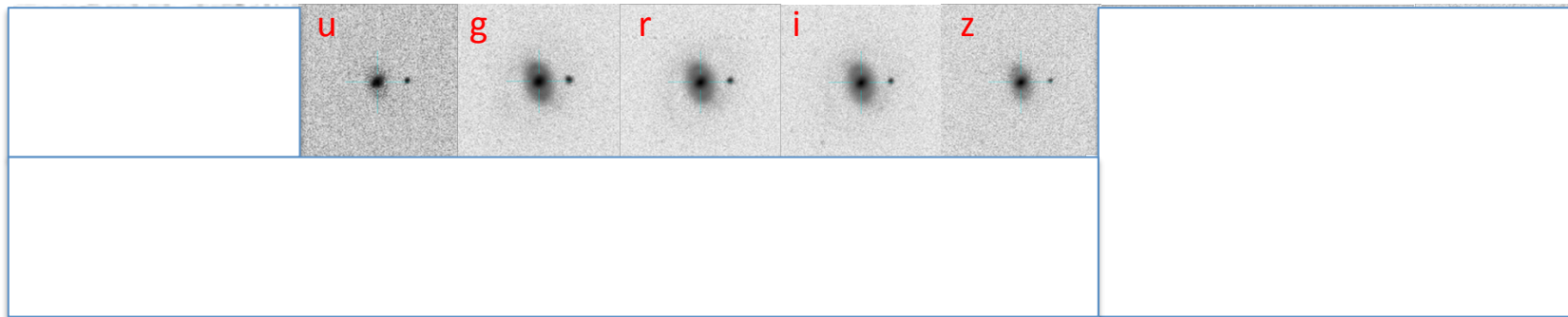
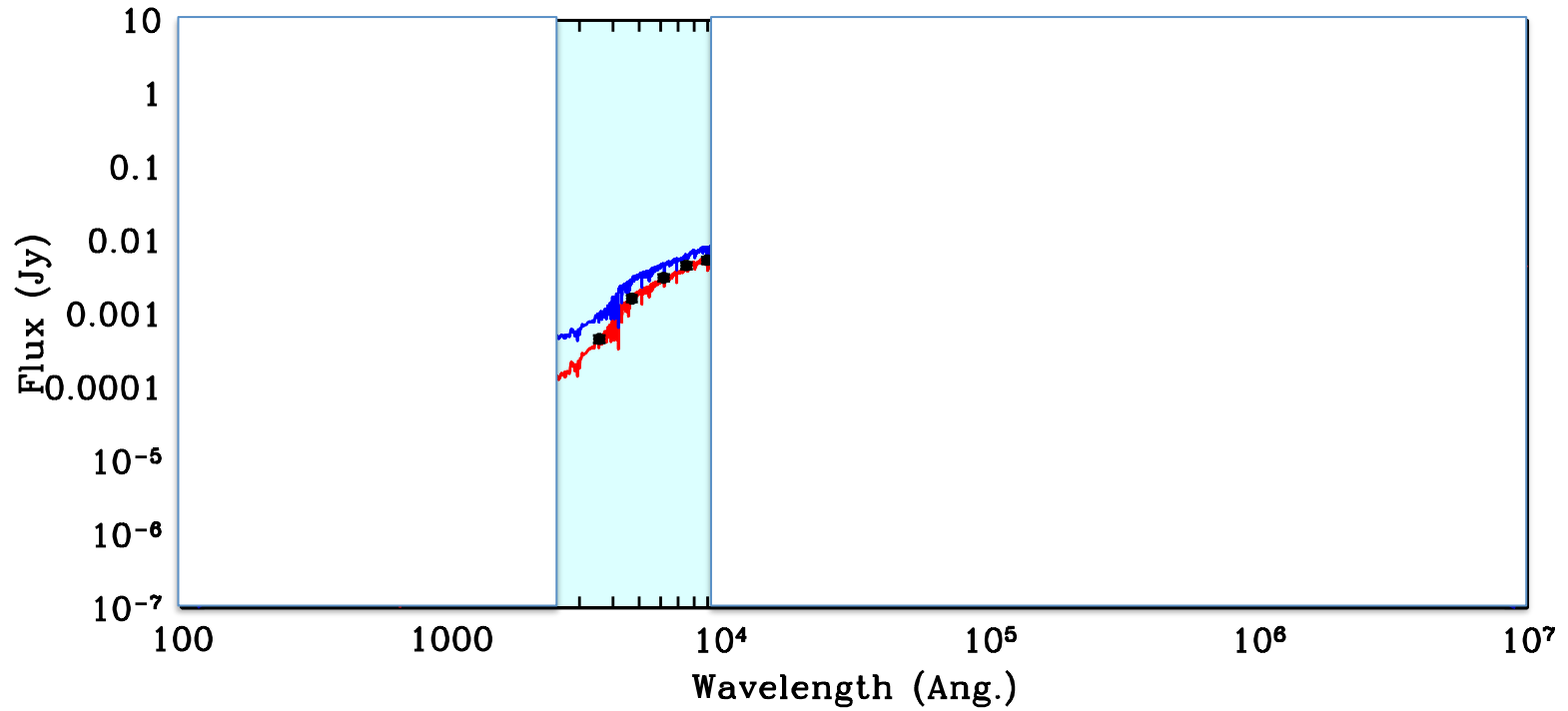


Unbiased galaxy redshift surveys:

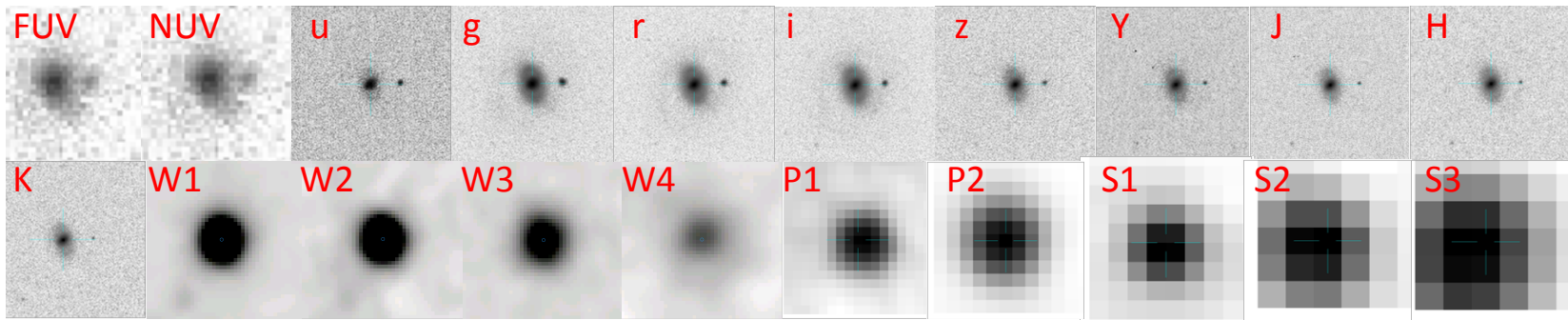
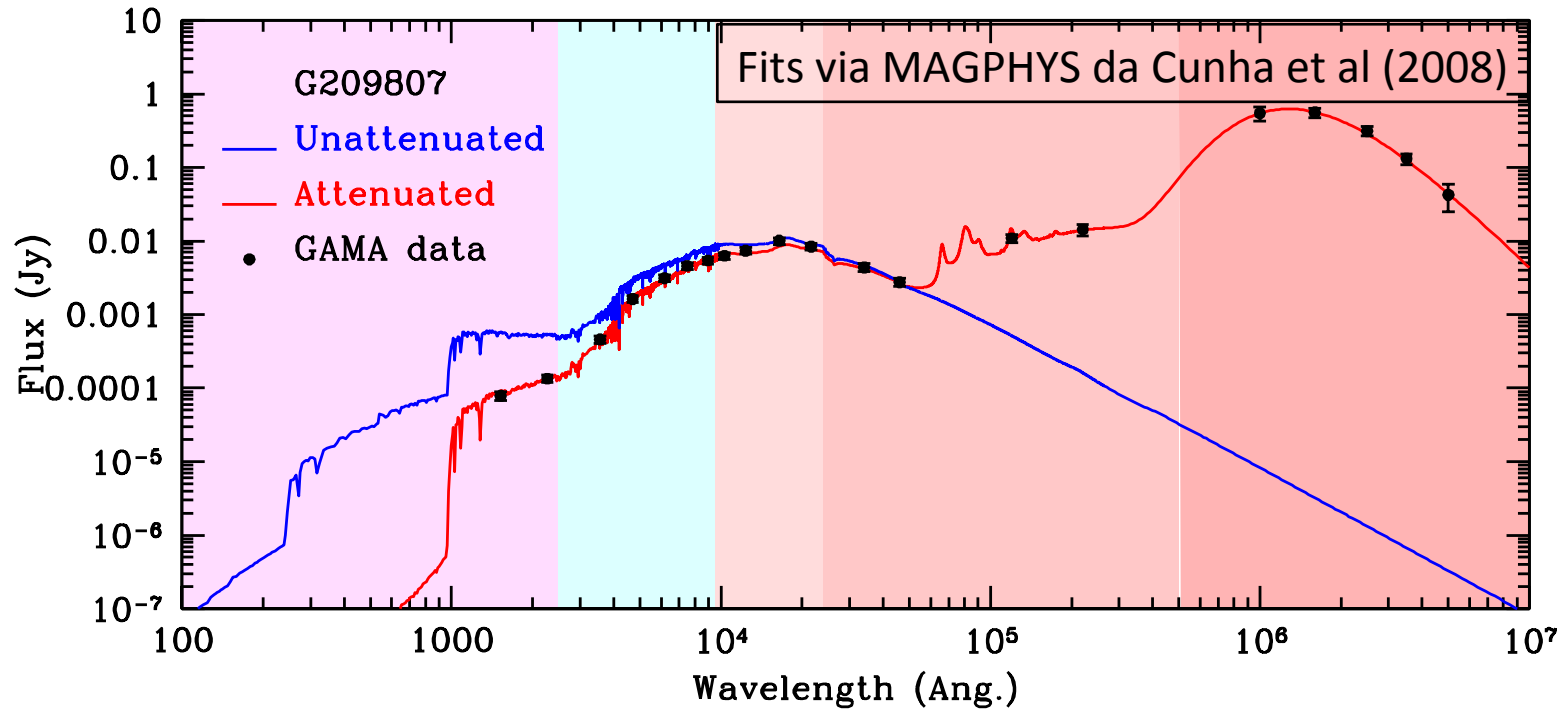


| 6dfGRS | SDSS DR9 | 2dFGRS | GAMA | zCOSMOS |

Panchromatic photometry



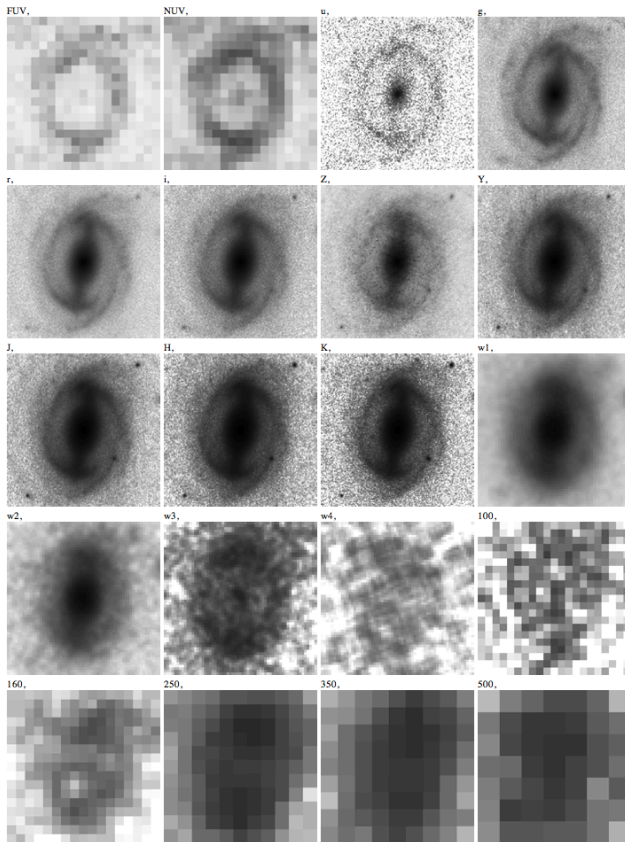
Panchromatic photometry



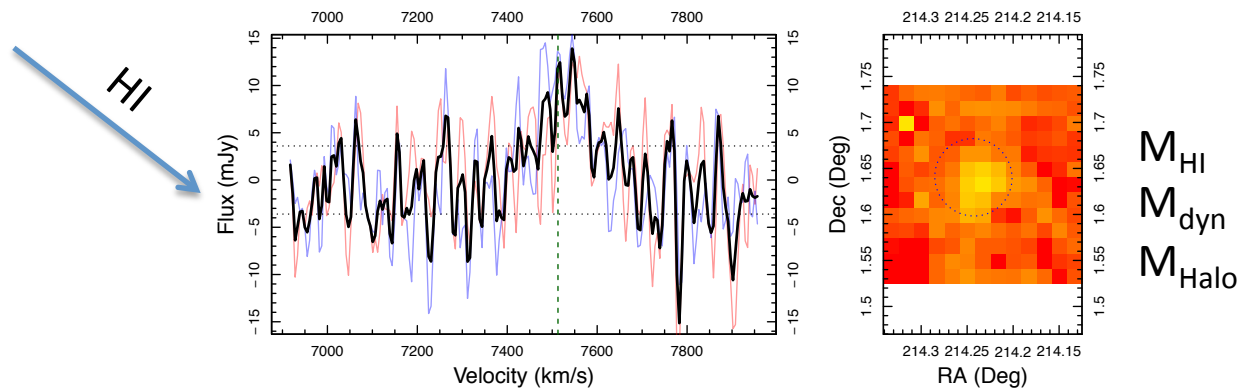
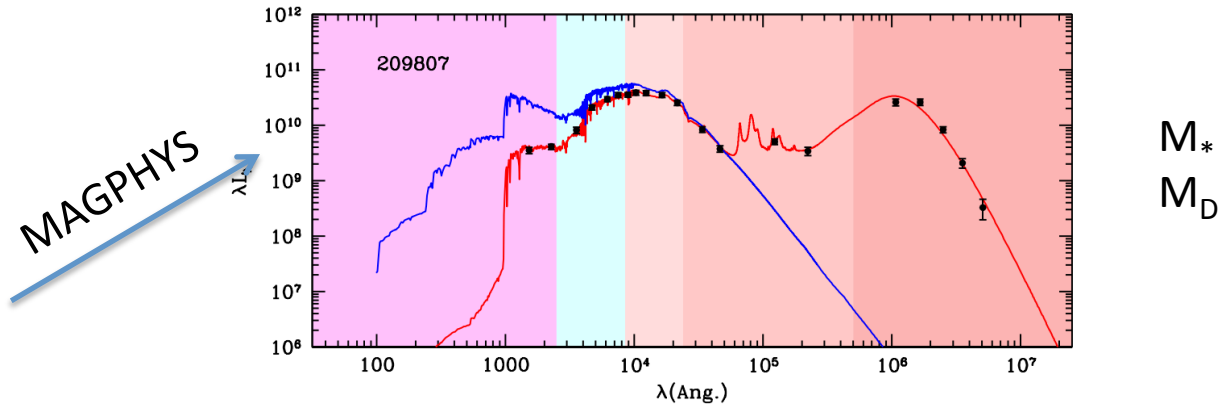


Energy & masses for 250k galaxies

20 band photometry
FUV-Opt-NIR-MIR-FIR



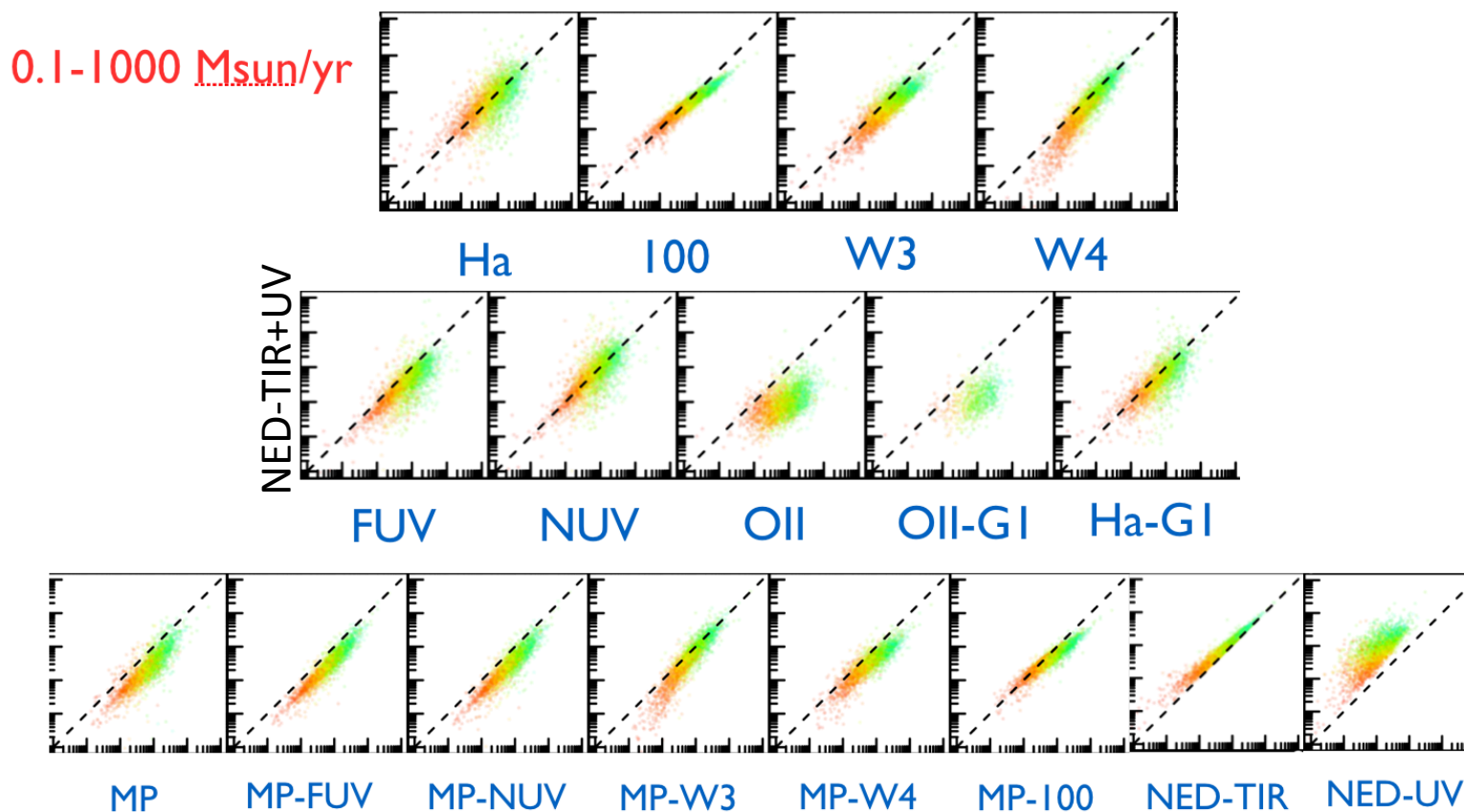
LAMBDAAR software developed to cope with mismatched PSFs
use r-band aperture and convolve, deblend, deconfuse etc



+ spectral line diagnostics + structural decomp + halo properties
+ IFU follow-up (SAMI) + HI (ASKAP)

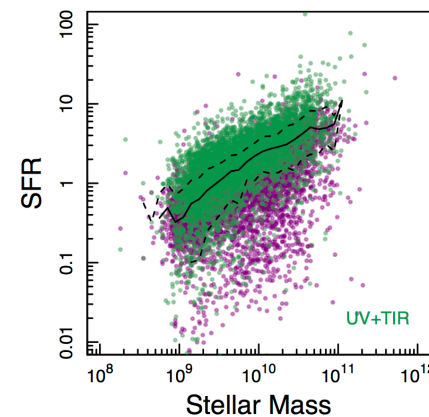
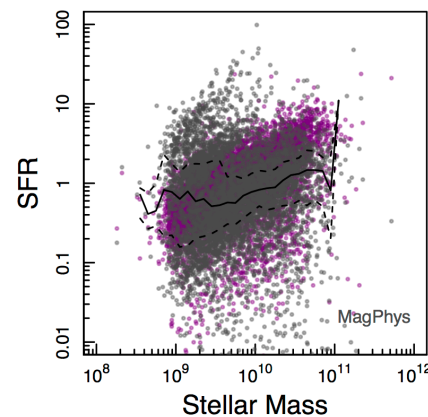
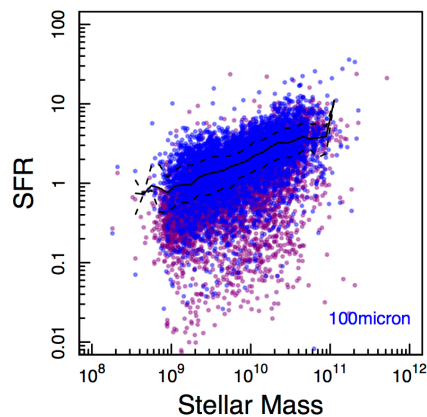
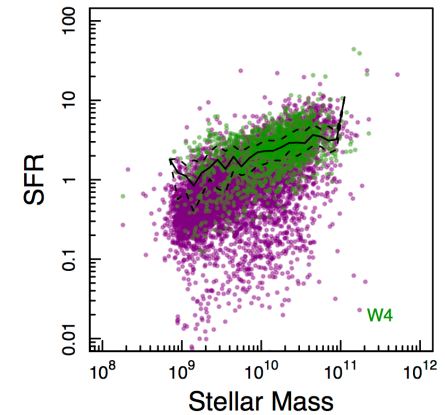
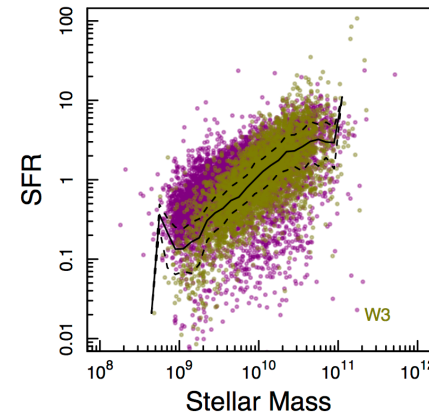
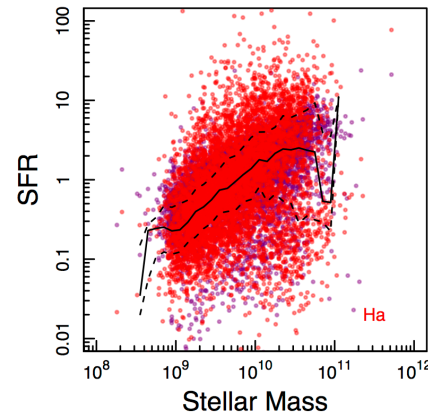
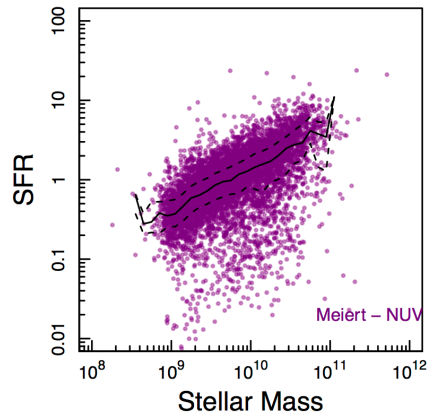
GAMA SF indicators

- GAMA measures multiple SFR indicators
 - NUV/FUV, H α , OII, W3/W4, 100micron, UV+FIR, MagPhys (various)



GAMA SF indicators

- GAMA measures multiple SFR indicators
 - NUV/FUV, H α , OII, W3/W4, 100micron, UV+FIR, MagPhys (various)
 - E.g., galaxy main sequence

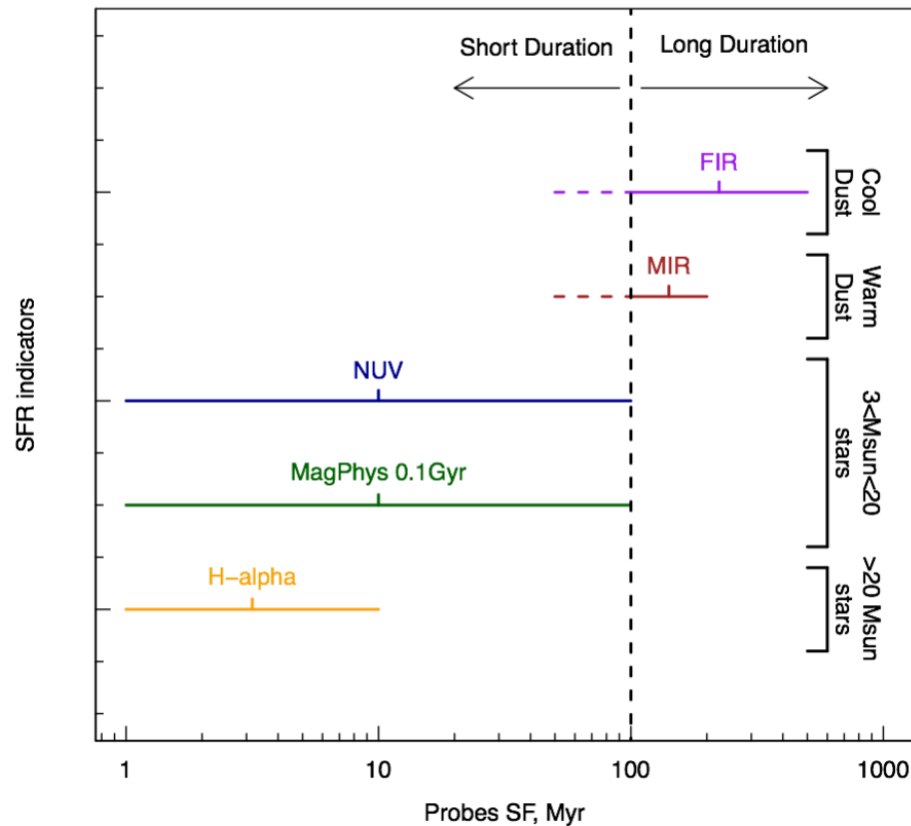


Luke Davies
Davies et al, in prep

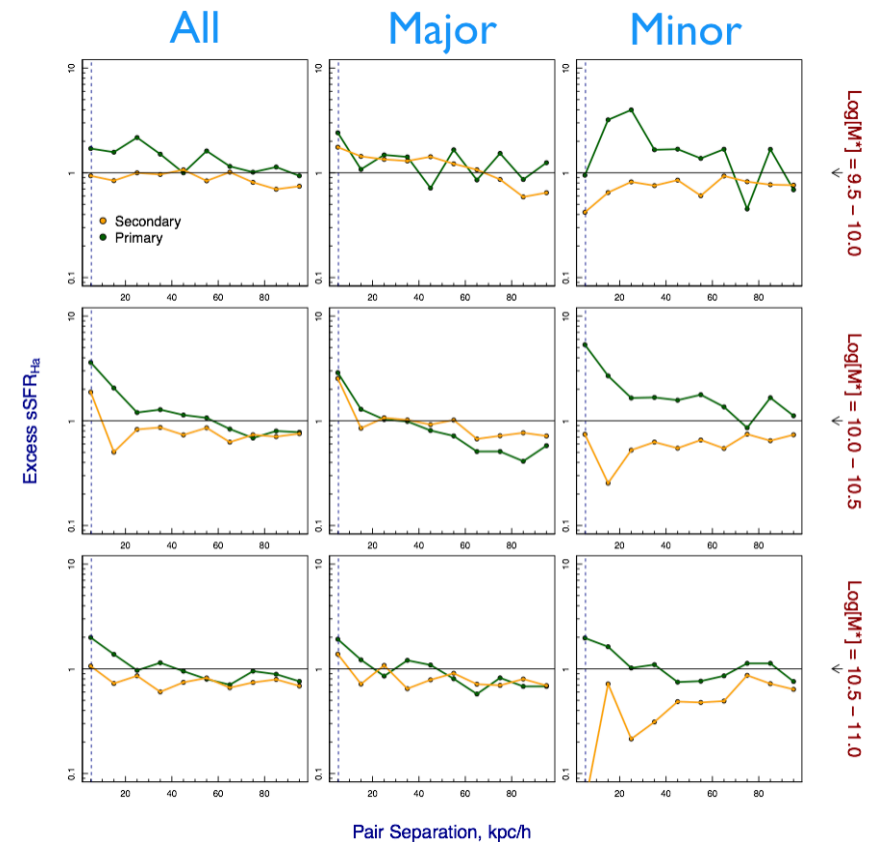
GAMA SF indicators

- GAMA measures multiple SFR indicators
 - Different indicators trace different timescales
 - Can measure increase/decrease of SF
 - with e.g., pair separation etc

Luke Davies
Davies et al, in prep



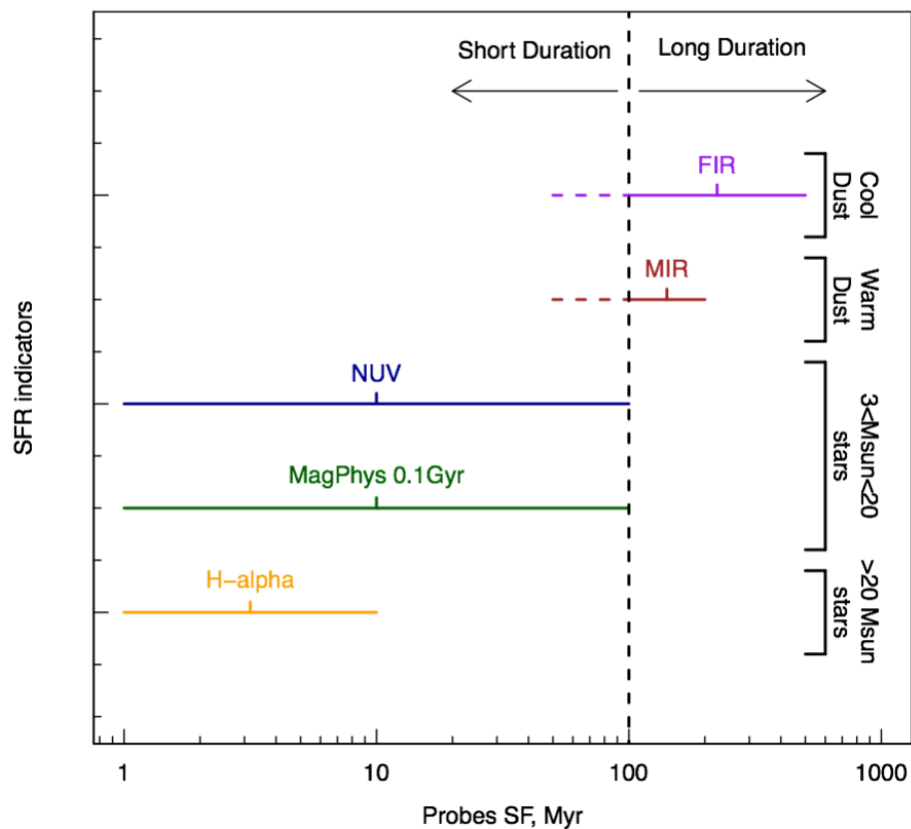
H α



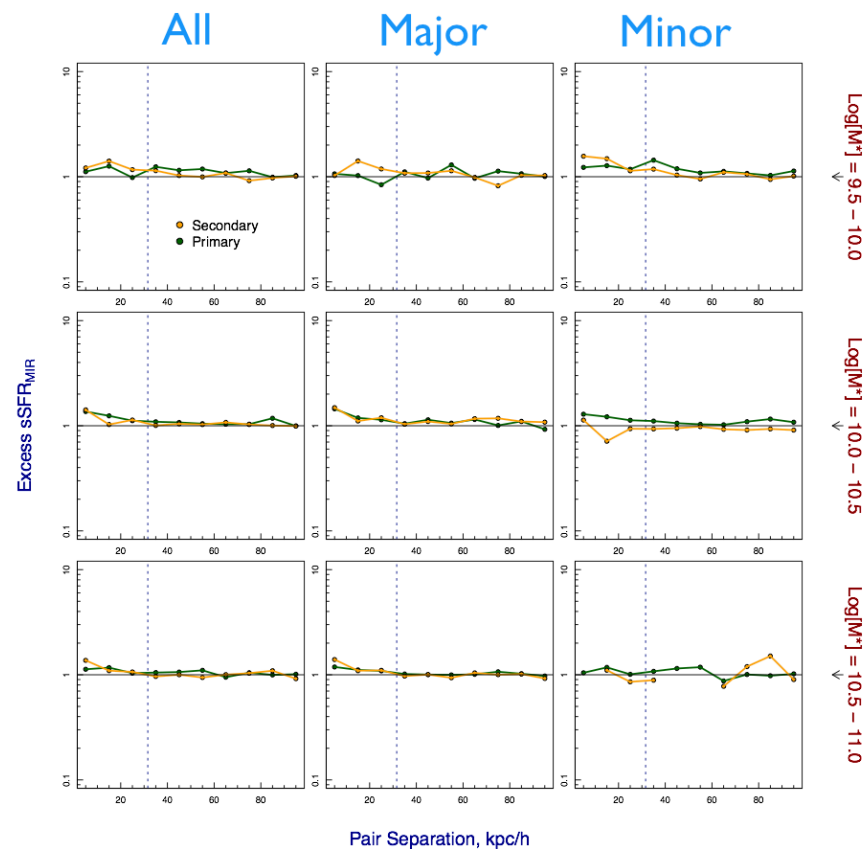
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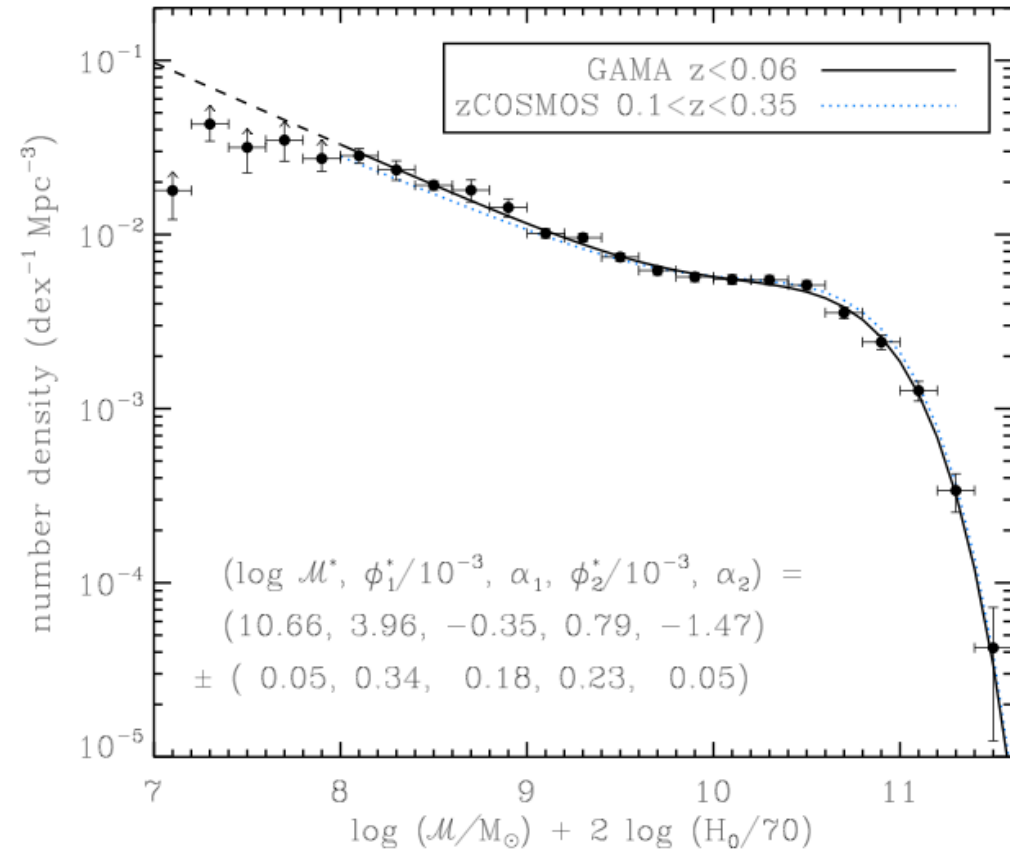
Luke Davies
Davies et al, in prep



W4

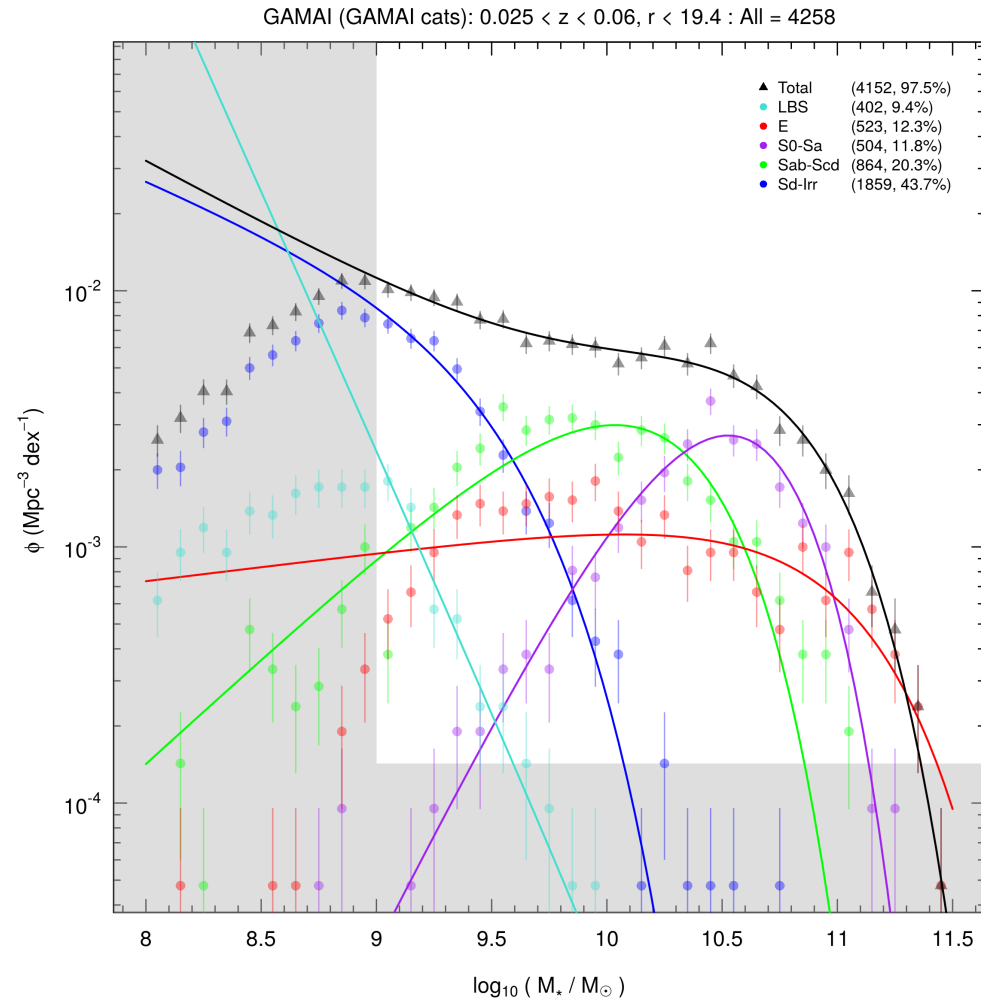


- Mass:
 - GSMF (Baldry et al)
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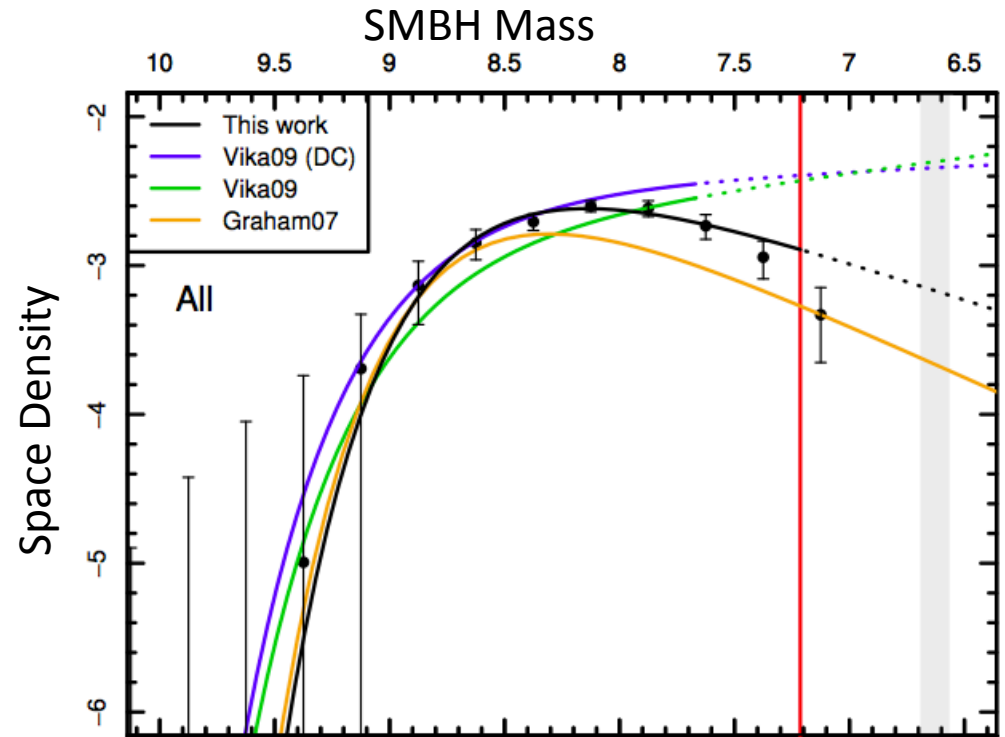


Science ($z < 0.1$)

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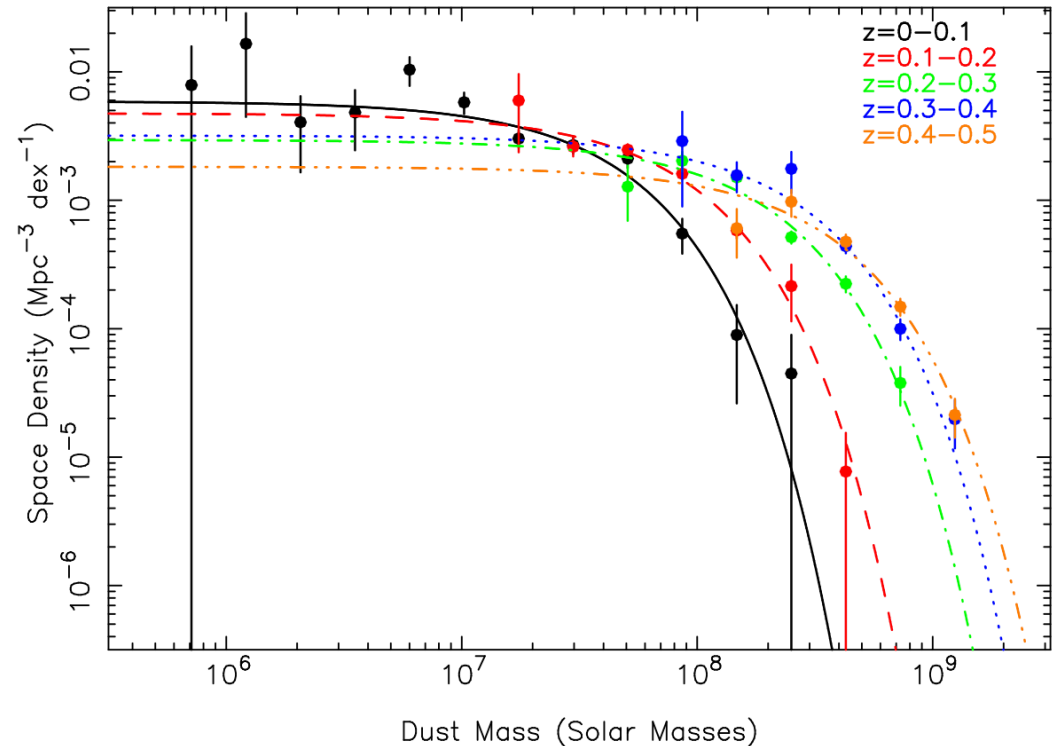


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SMBHs derived using near-IR $M_{\text{BH}}-L_{\text{BULGE}}$ relation
Graham et al., (2013)

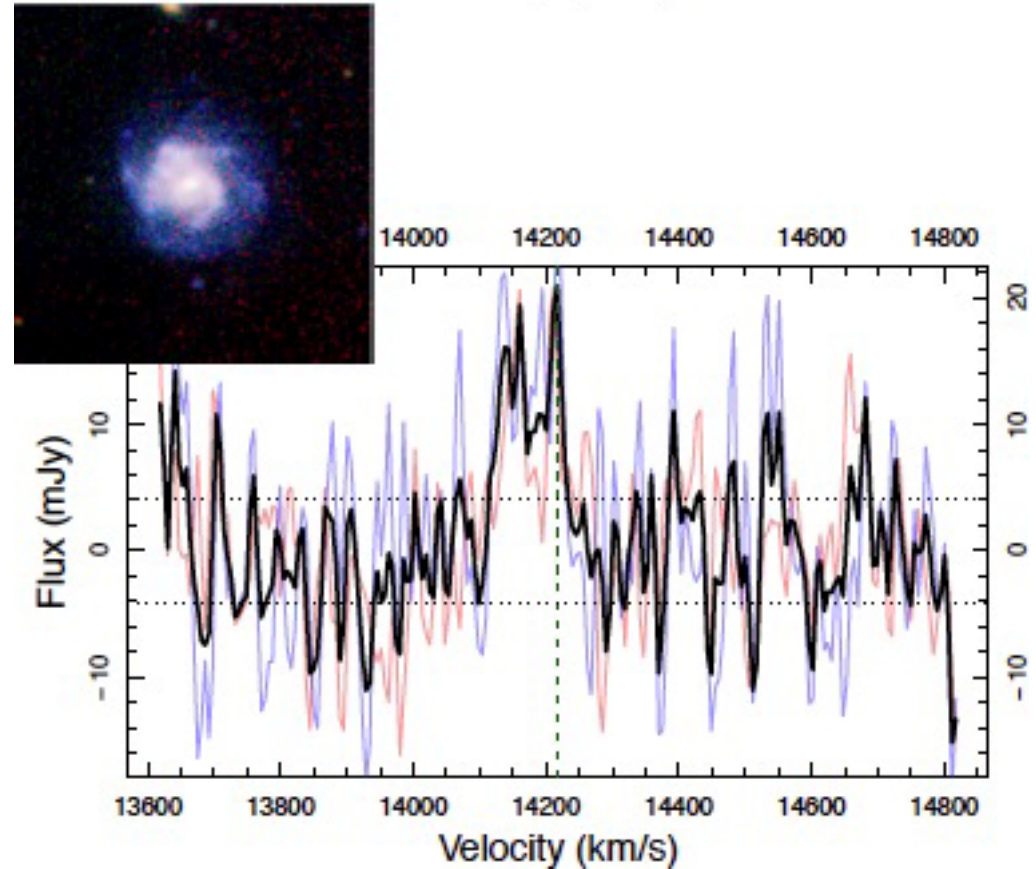
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Very strong evolution seen in dust mass
(collaboration paper with Herschel-Atlas)

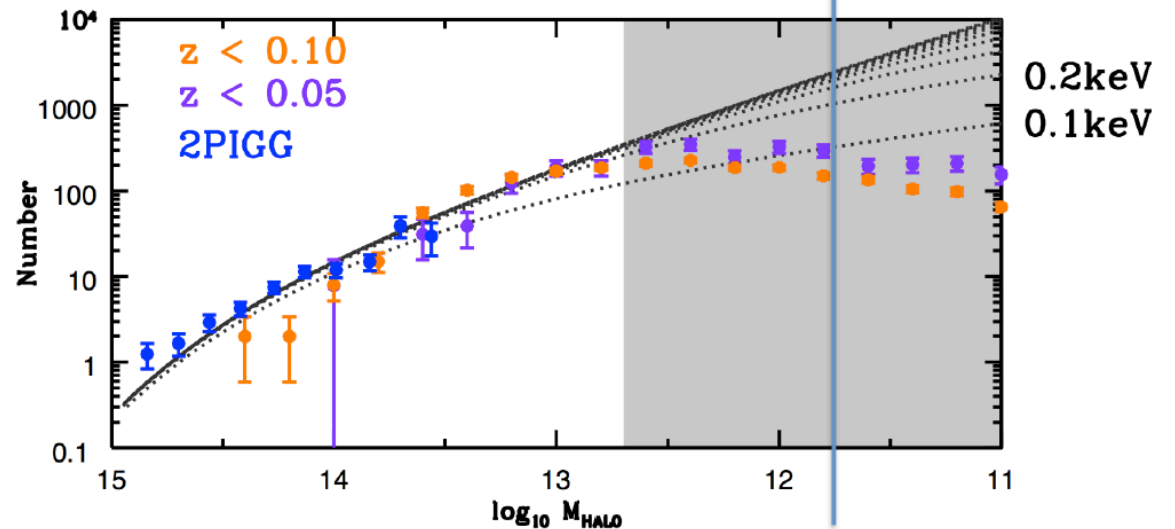
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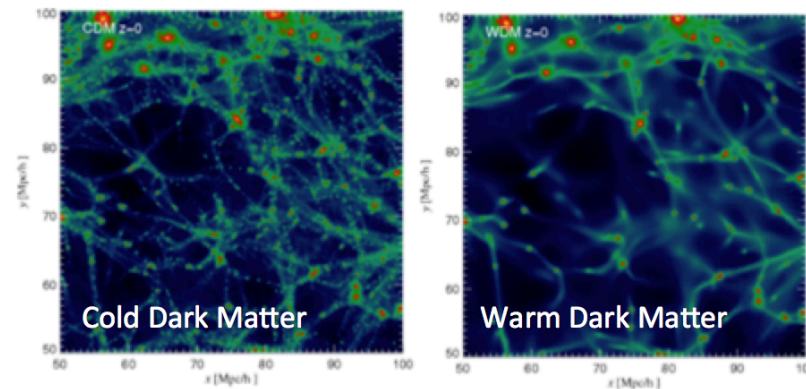


Science ($z < 0.1$)

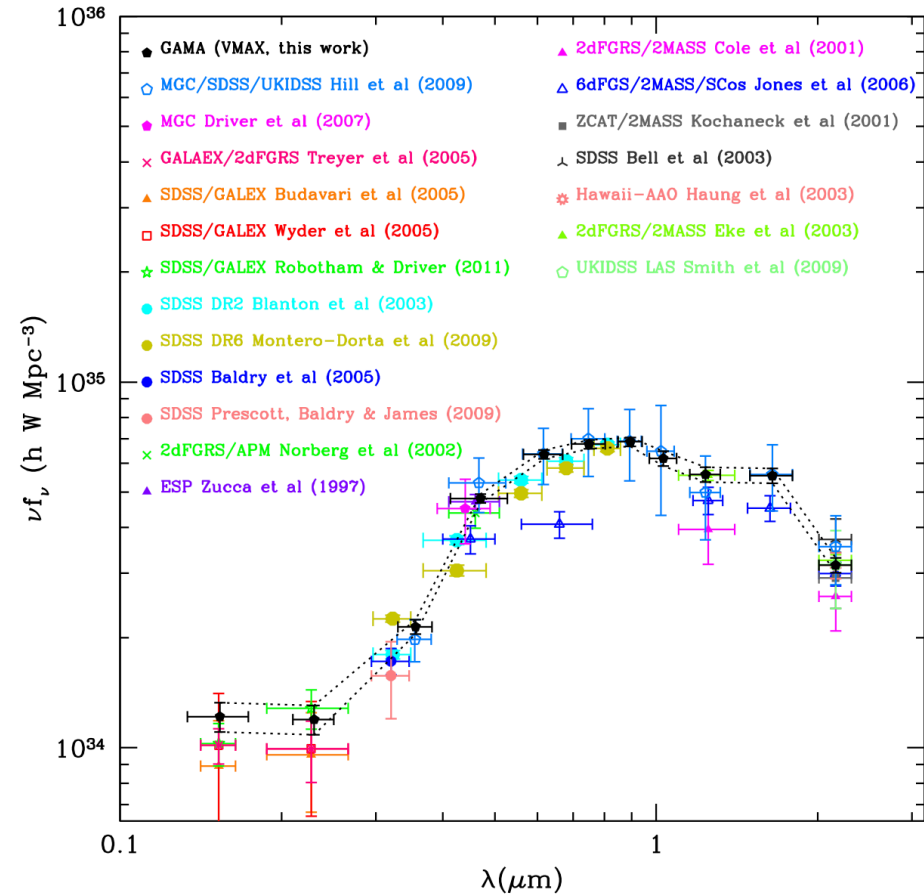
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Final limit around here.

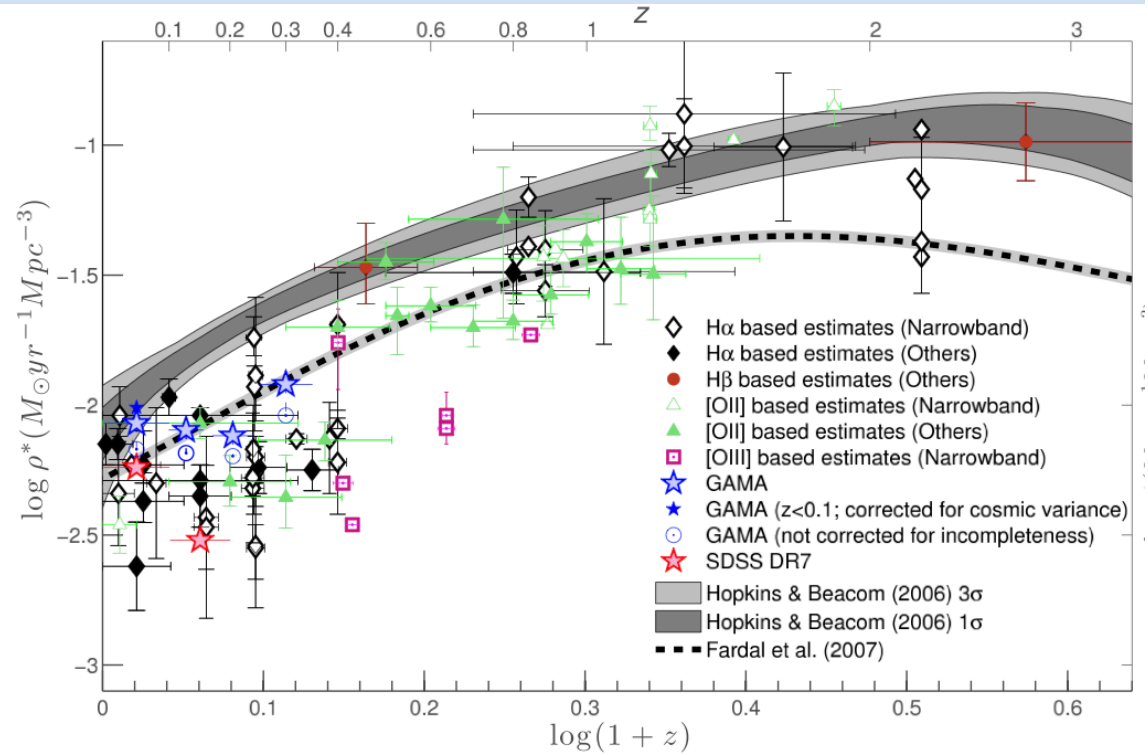


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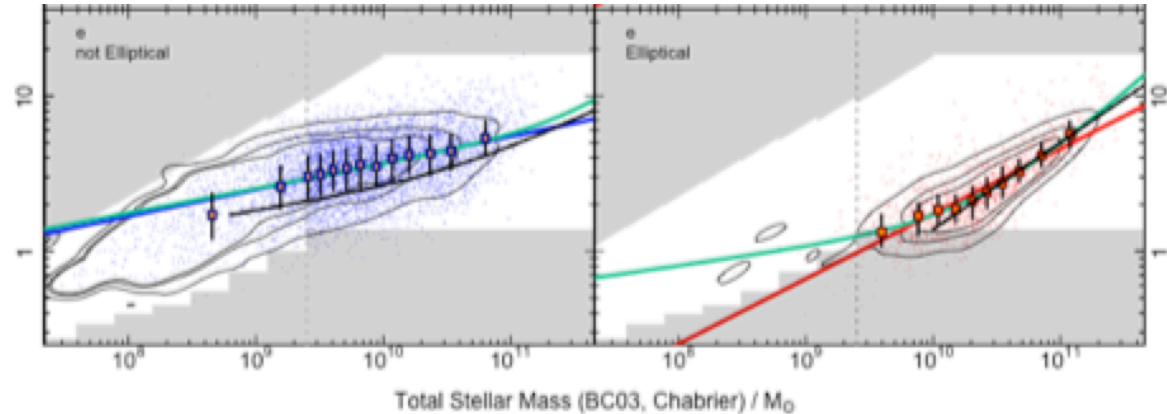
Science ($z < 0.3$)

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 - GSMF (Baldry et al)
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Science ($z < 0.1$)

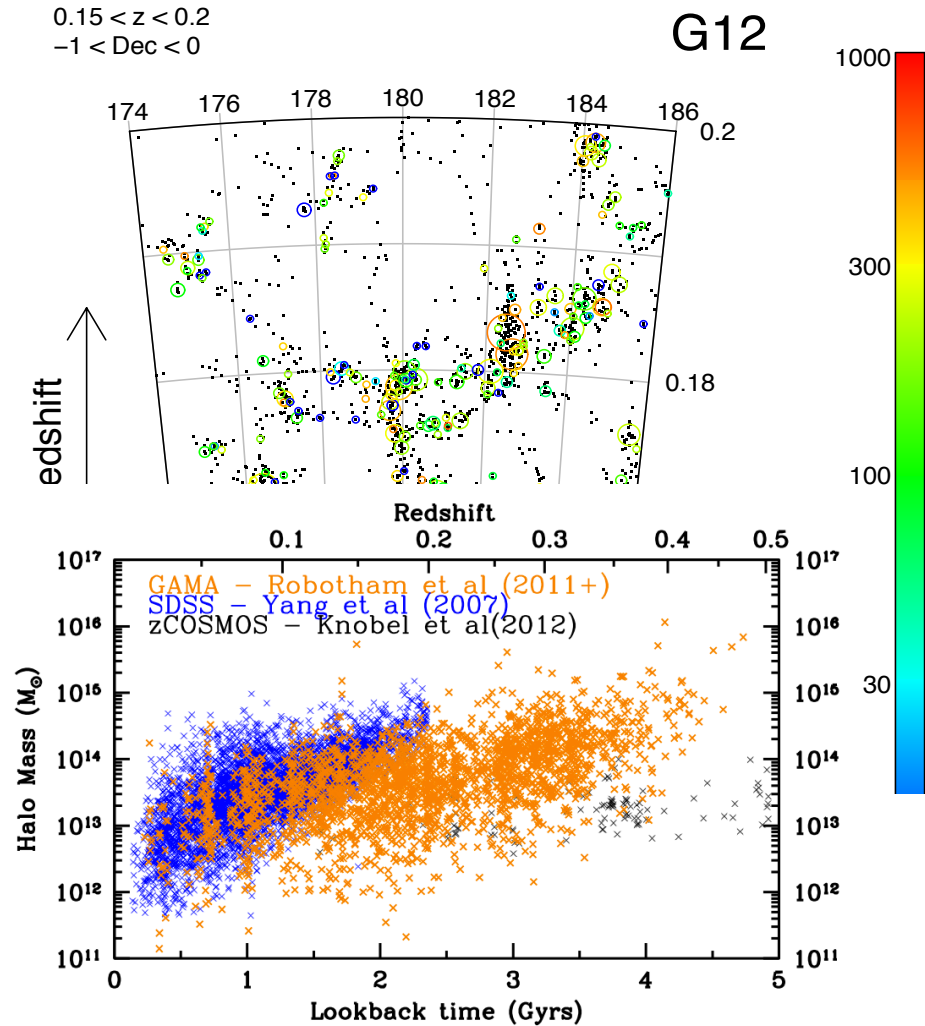
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Mass-size relation by component coming

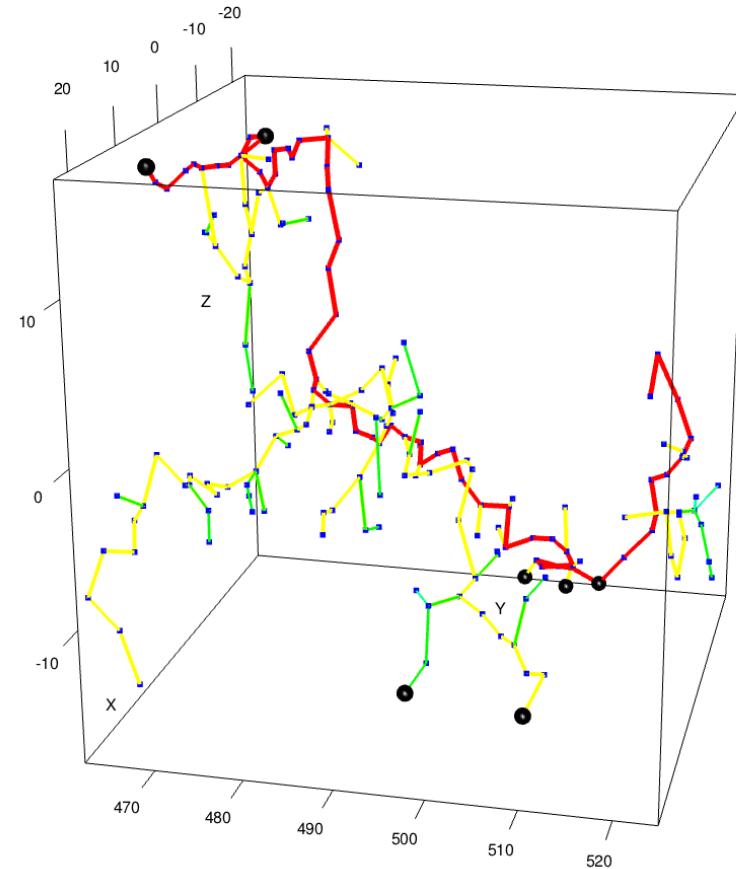
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25,000 GAMA groups

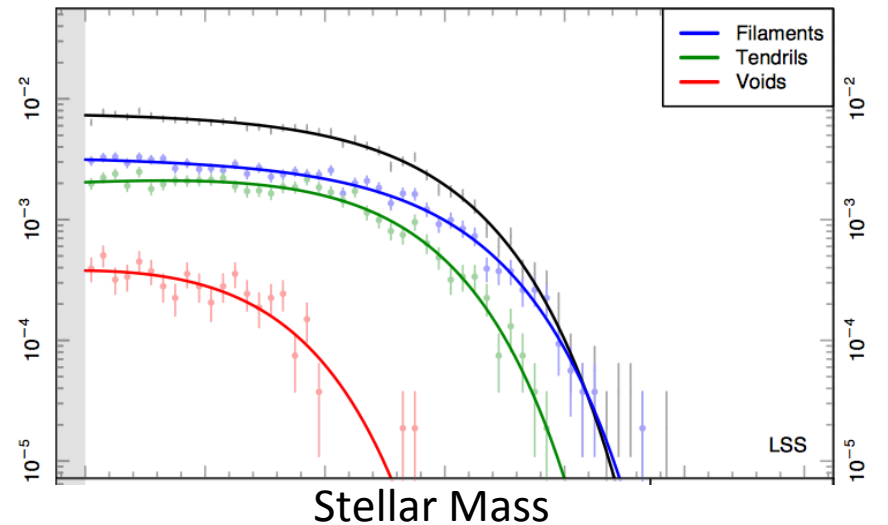
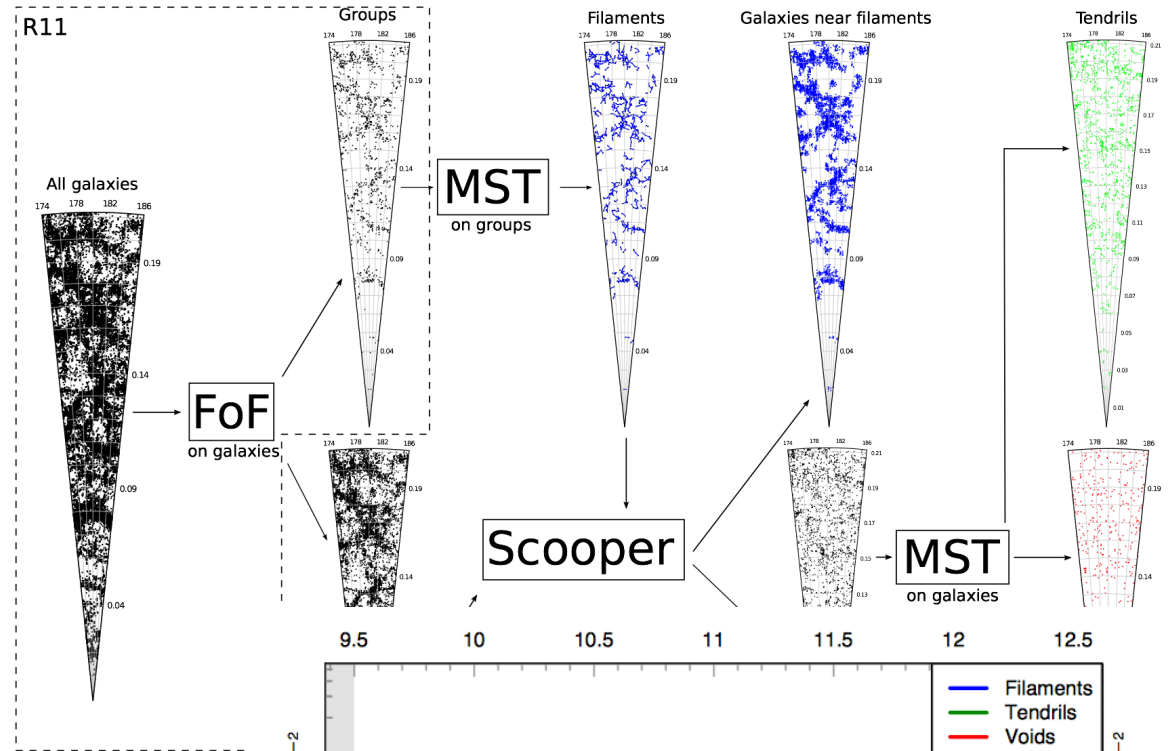
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Minimal spanning trees used to derive
Backbones, filaments and tendrils

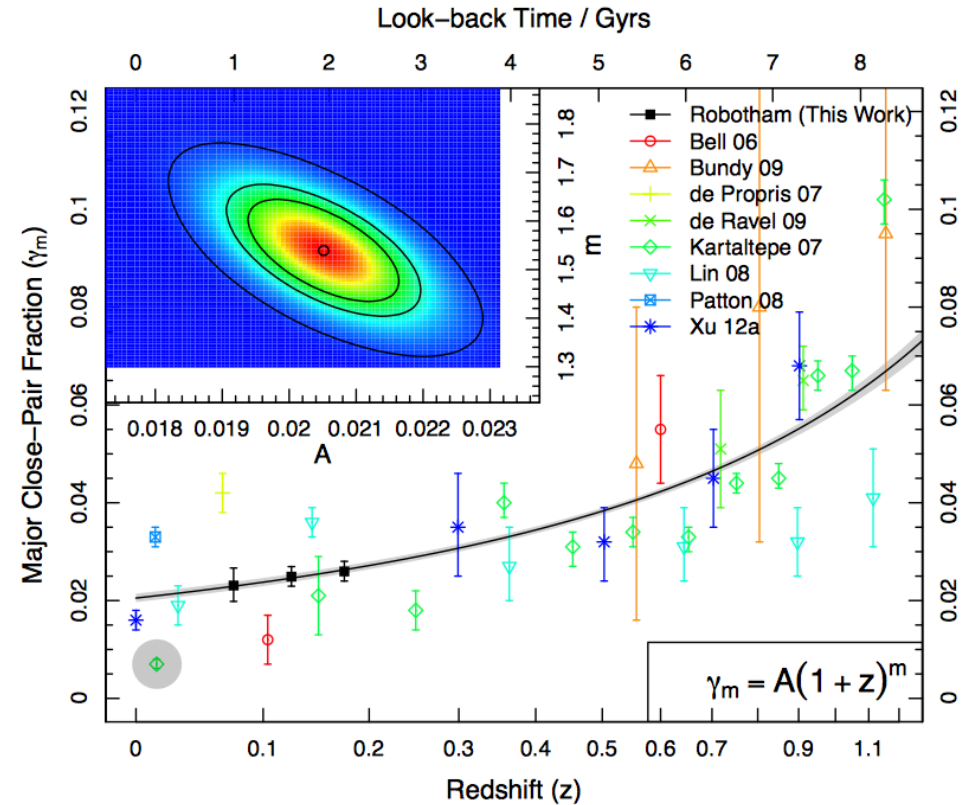
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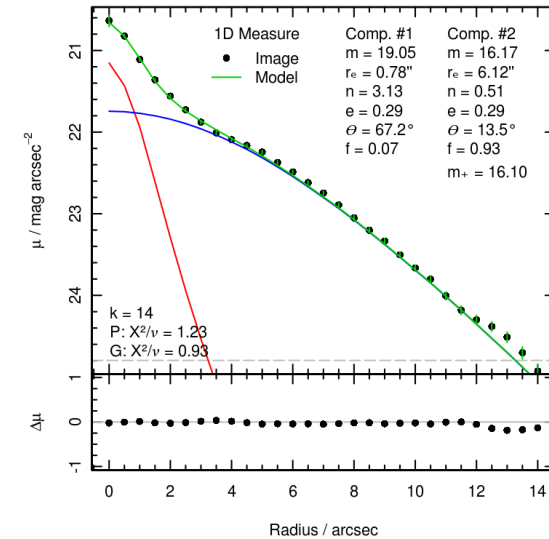
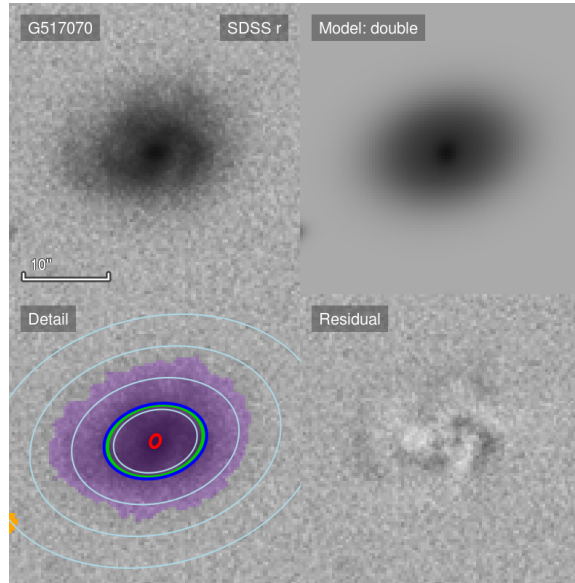


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 - Tendrils (Alpaslan et al)
 - Pairs (Robotham et al)
 - **Bulge-disc decomposition (Lange et al, Haussler et al)**



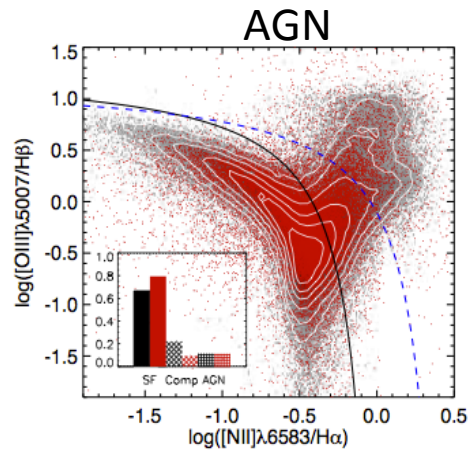
Stellar Mass Budget

- 50% in spheroids = hot mode evolution
- 50% in discs = cold mode evolution

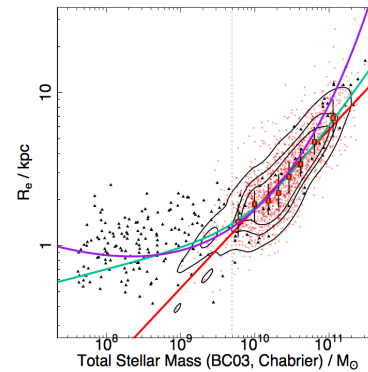


and so much more...

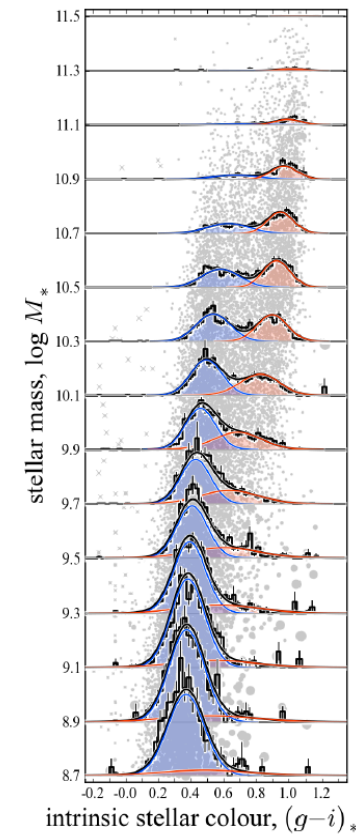
72 papers in press, 200 more in progress: GAMA/Hatlas, GAMA/XXL, GAMA/SAMI, GAMA/KiDS
[Proposal 272 approved yesterday!]



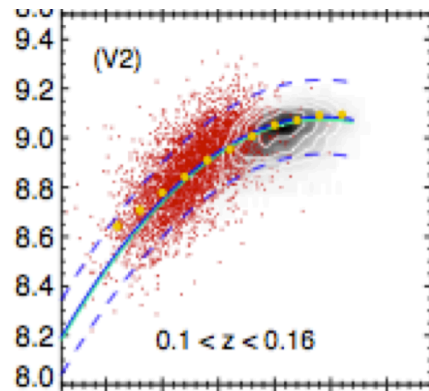
Mass-size relation



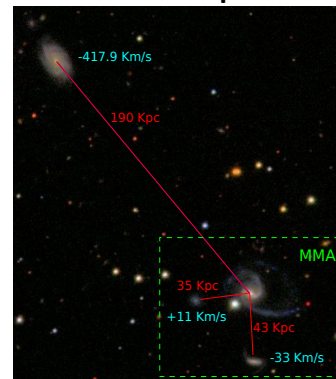
Bimodality



MASS-METALICITY



Local Group Analogs



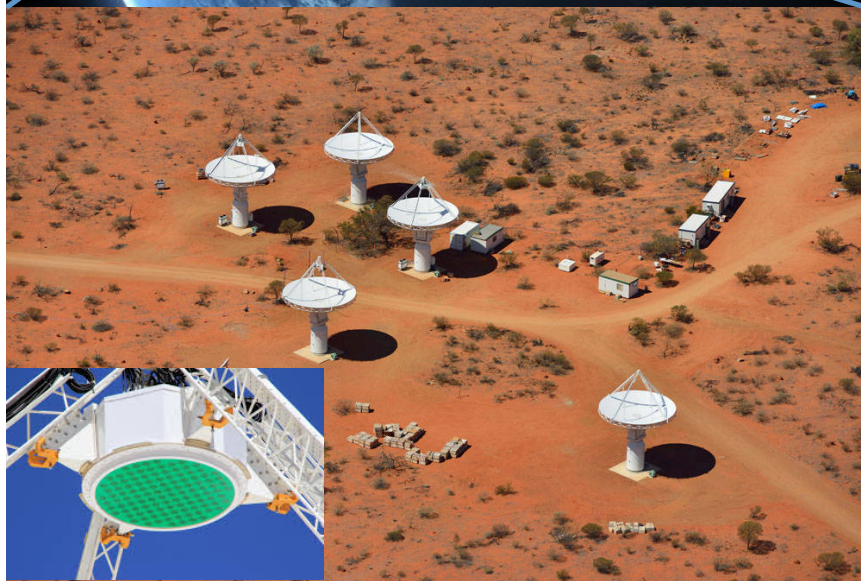
But best still to come.....→



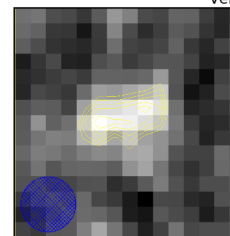
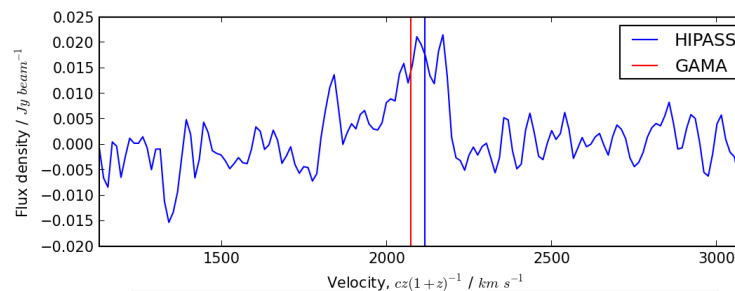
HI gas and dynamics via ASKAP



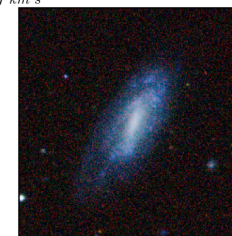
Australian-SKA Pathfinder
Thirty-six 12m antennas with phase array feeds
30 sq deg field of view
GAMA23 region primary deep target
Operations with 12 antennas commence mid-2015
HI to $z=0.45$



GAMA ID: 220687, HI RA: 12:11:12.0, HI Dec: +01:28:23
GAMA RA: 12:11:19.9, GAMA Dec: 1:29:33.0, Separation: 0:2:17.6



HIPASS zero-moment map



GAMA image



Moving out in z.

GAMA = one hand clapping

Will redefine $z=0$ but ideally want to bridge the $0.1 < z < 1$ gap

Only currently available dataset is COSMOS

Hence lets *GAMIfy* COSMOS, i.e.,
Use identical software/techniques:

- pairs, groups
- stellar masses
- SFRs
- panchromatic photometry
- bulge-disc decomposition
- test two-phase model predictions:
energy, Z , M_* (Driver et al 2013)

G10(zCOSMOS+)

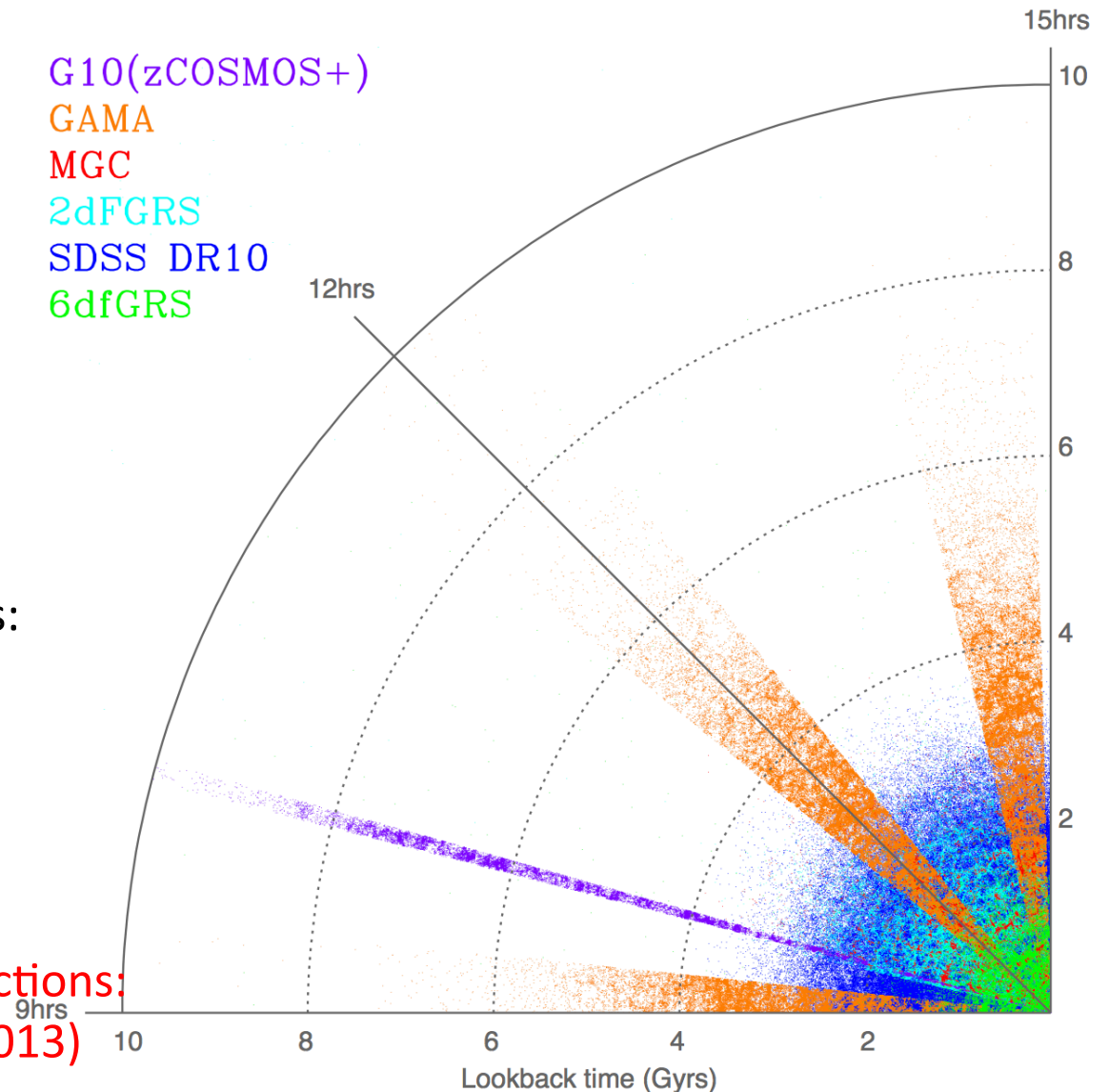
GAMA

MGC

2dFGRS

SDSS DR10

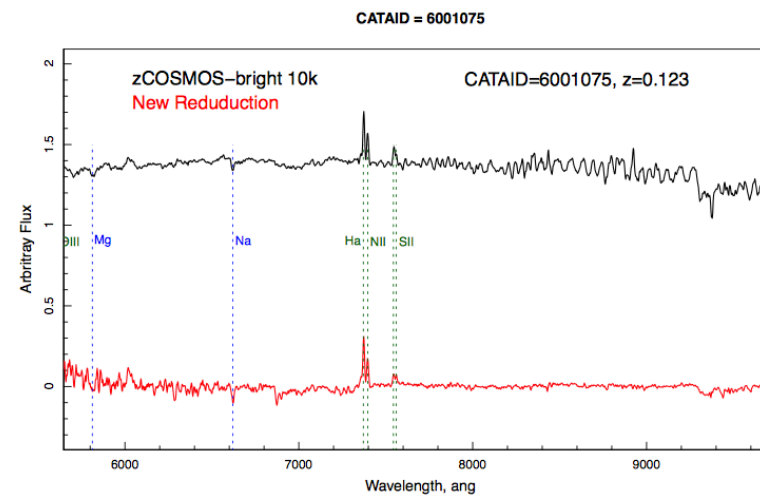
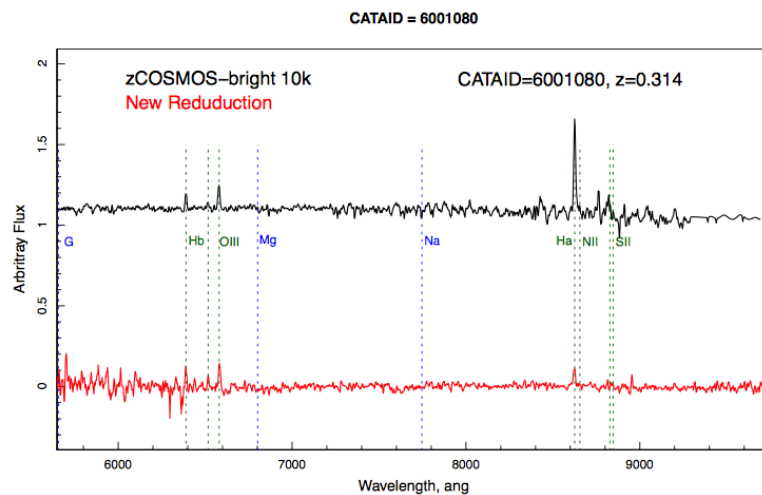
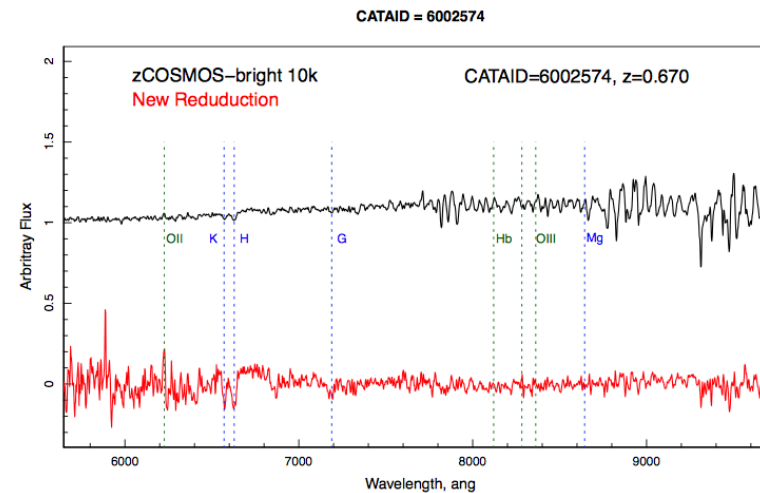
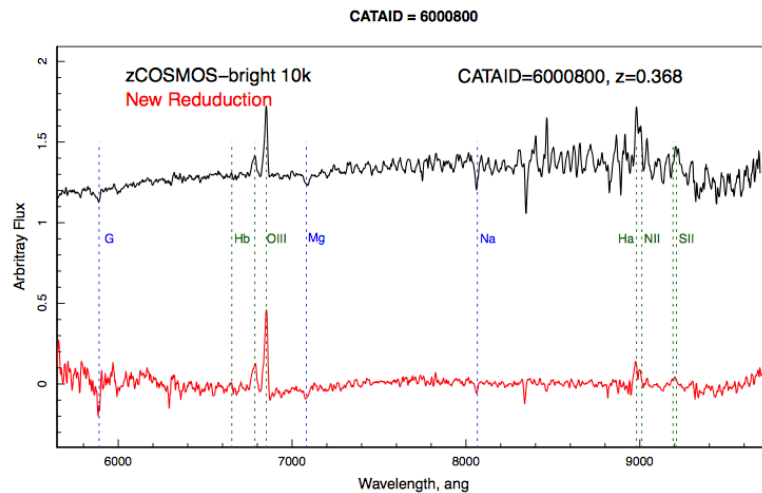
6dfGRS





Introducing G10 aka zCOSMOS

Complete analysis from ESO archive of the zCOSMOS 20k sample + PRIMUS + VVDS + SDSS
Available at: <http://ict.icrar.org/cutout/G10/> see Davies et al (2015, astro-ph:1409.3574)



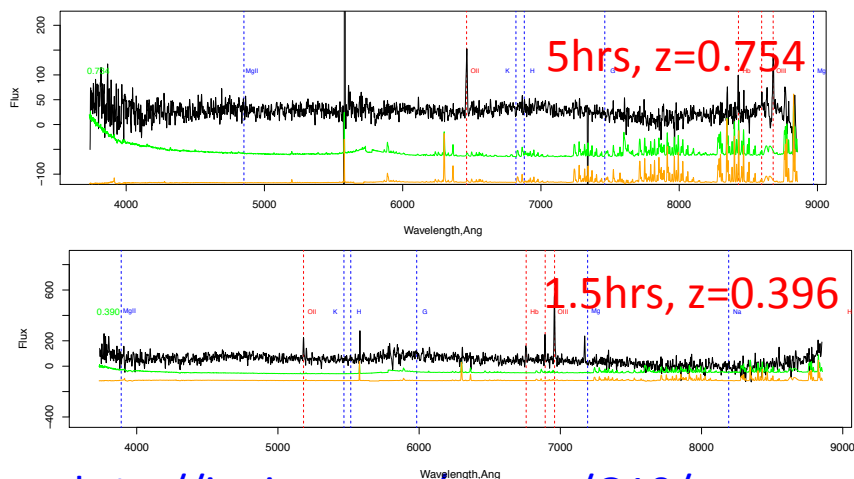


Z-COS: Finishing (z)COSMOS

Spectroscopic completeness across the unique COSMOS field is actually poor (~50%)
Photo-z's are great but not for pair or group studies

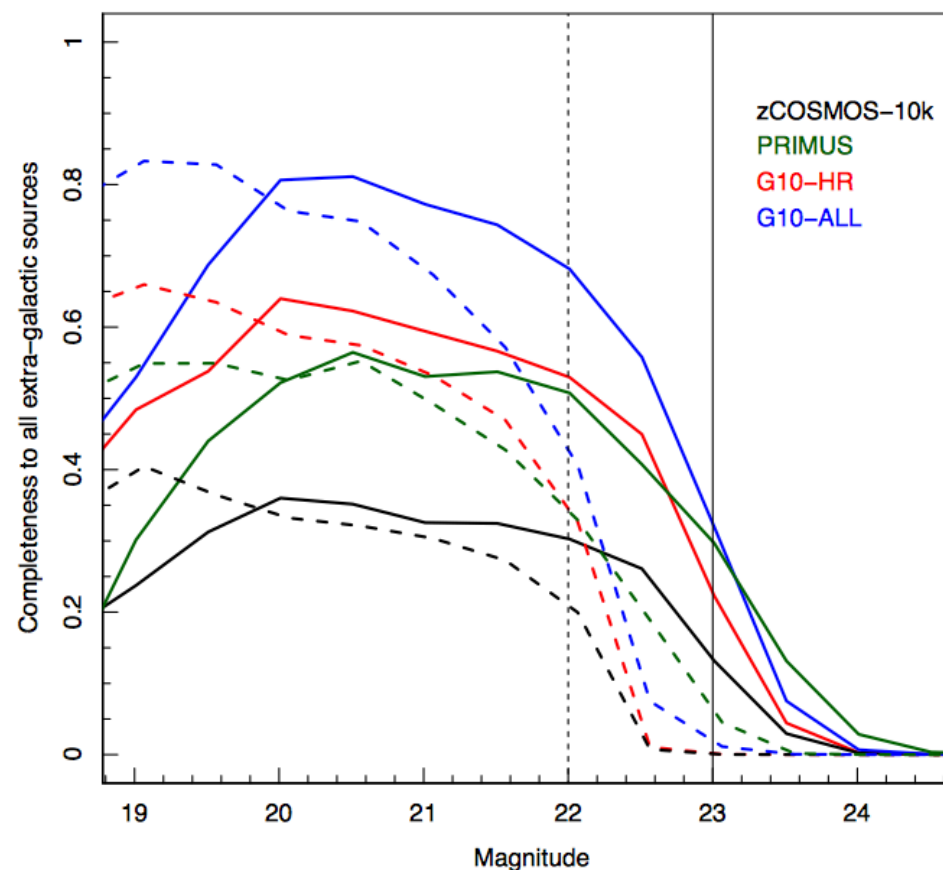
With 15 nights of AAT/AAOmega time can complete COSMOS to >90% completeness

Demonstrated from deep ($r < 22$ mag) observations in G15 field following AAOmega detector upgrades



<http://ict.icrar.org/cutout/G10/>

Davies et al (2015, astro-ph:1409.3574)





WAVES

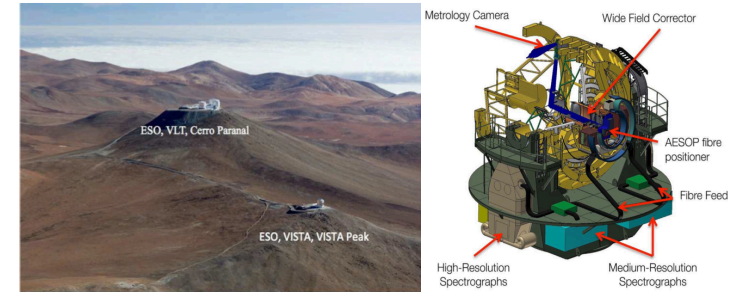
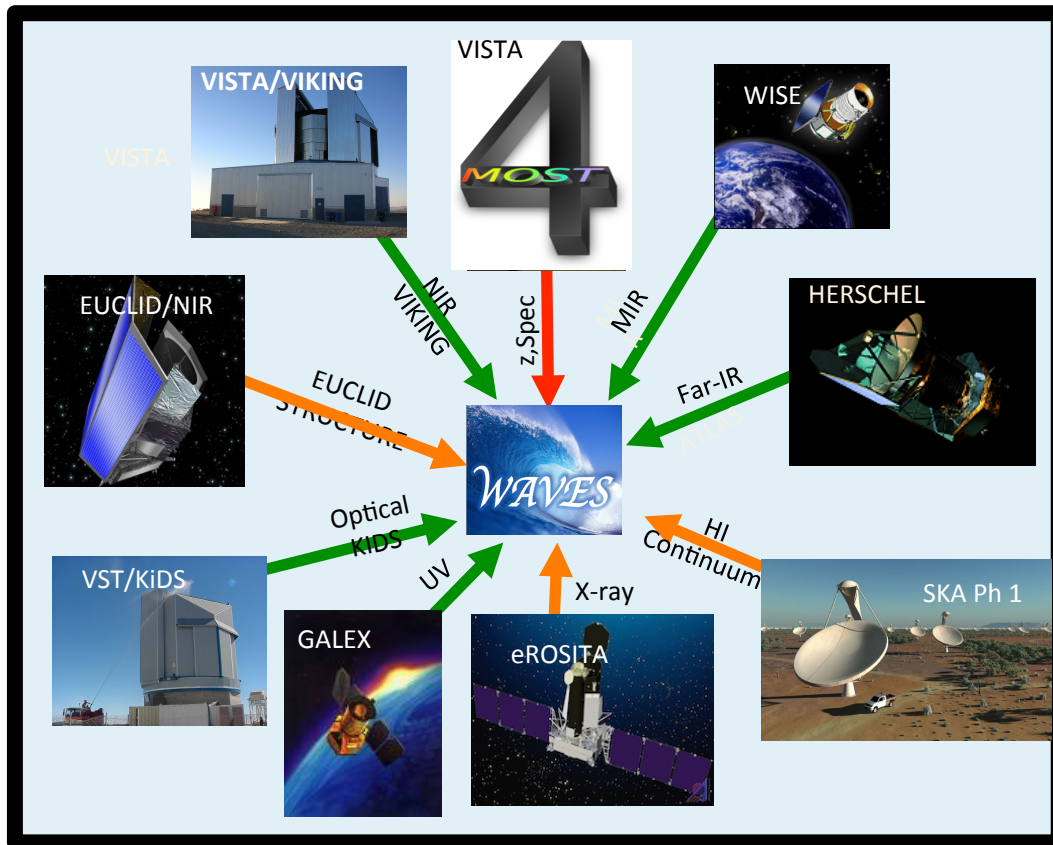
wide area VISTA
extra-galactic
survey

WAVES OUTLINE

Simon Driver ICRAR/UWA

WAVES
wide area VISTA
extra-galactic
survey

Wide Area VISTA Extra-galactic Survey



A 4MOST Design Reference Survey

2-4 million galaxies

WIDE (700 sq deg):

$r < 22$ (photo- $z < 0.2$)

VST KiDS South

DEEP (100 sq deg):

$r < 22$

GAMA23 (VST KiDS)

CDM v WDM

85,000 groups (Wide)

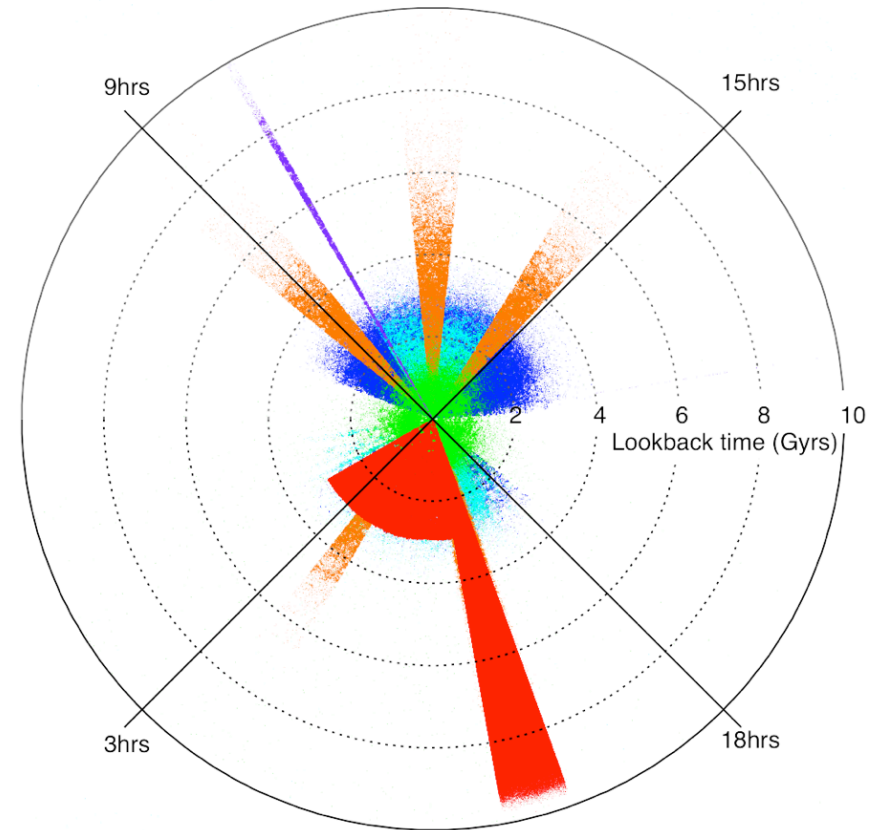
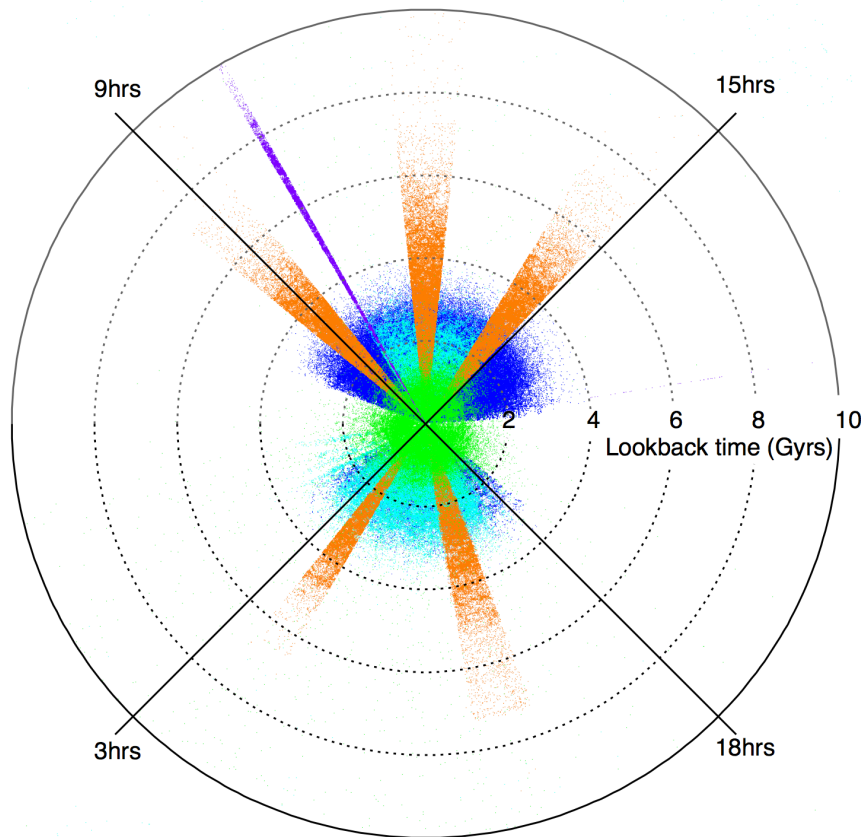
50,000 groups (Deep)

Mass, Energy, Structure to $z=1$

Deep = 75x zCOSMOS

WAVES cone plot

SDSS scale project locally to very low mass AND out to $z \sim 0.8$



| 6dfGRS | SDSS DR9 | 2dFGRS | GAMA | zCOSMOS | | 6dfGRS | SDSS DR9 | 2dFGRS | GAMA | zCOSMOS | WAVES |

WAVES survey area

Input Cat:

KiDs+VIKING

Optimised for overlap with:

Herschel

EUCLID

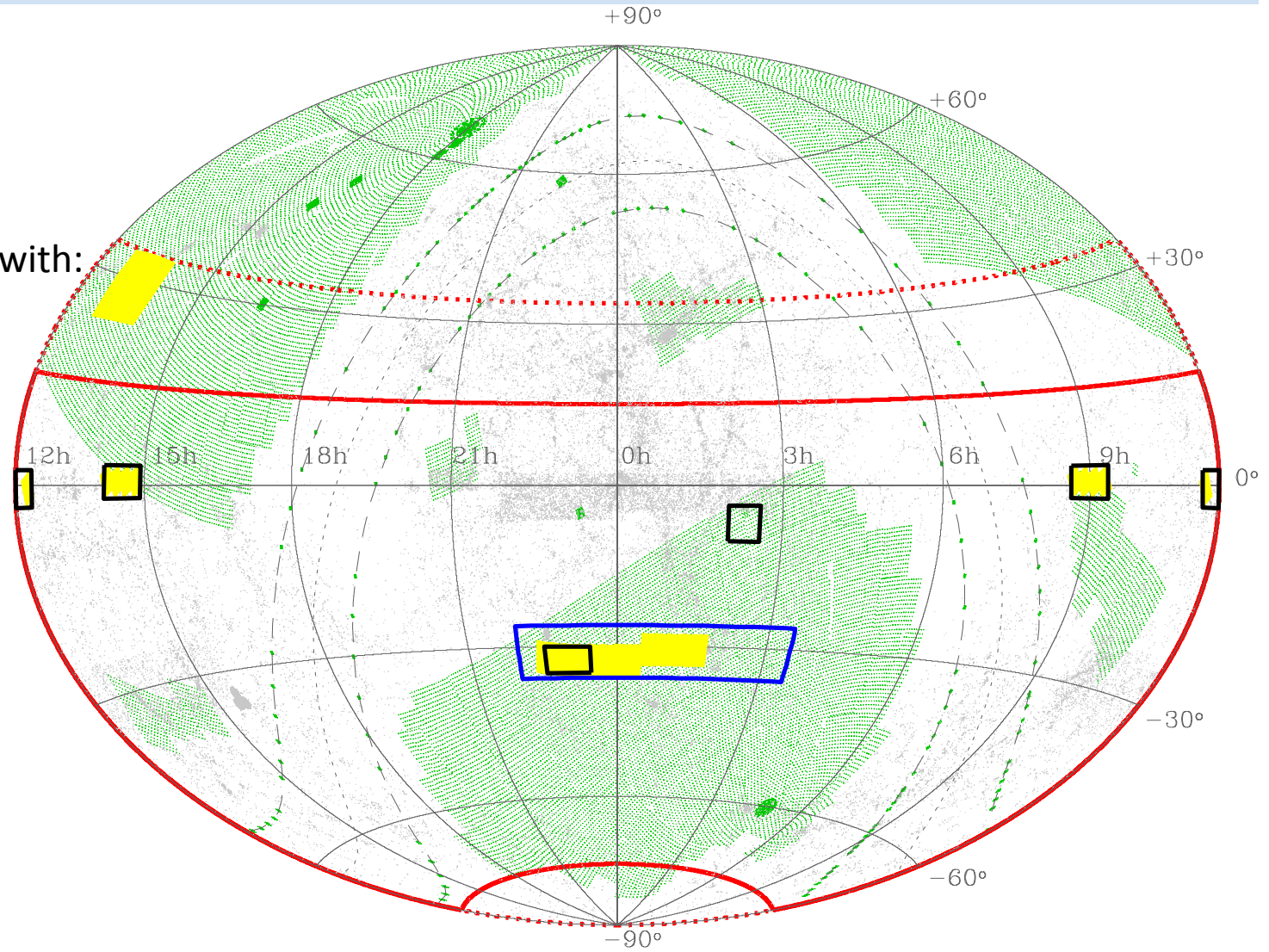
SKA

LSST

VLT/ELT

Hector

WAVES-DEEP to
be located inside
WAVES-WIDE area



GAMA



LSST (airmass<1.4)



EUCLID



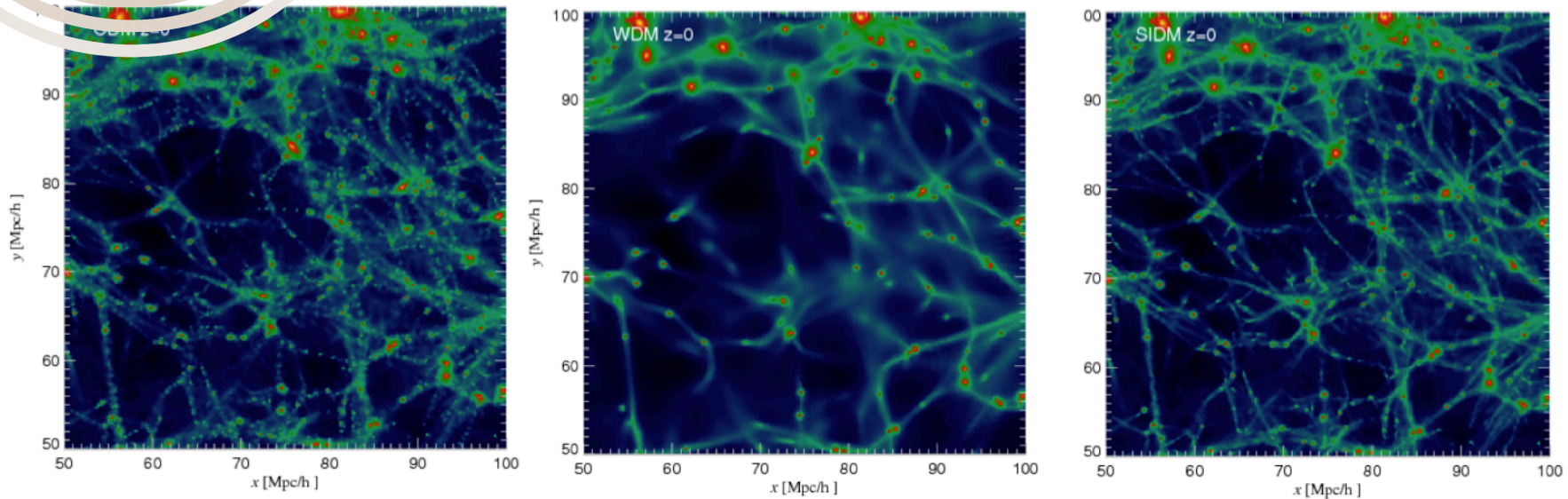
HERSCHEL-ATLAS



LSST (airmass<2.2)

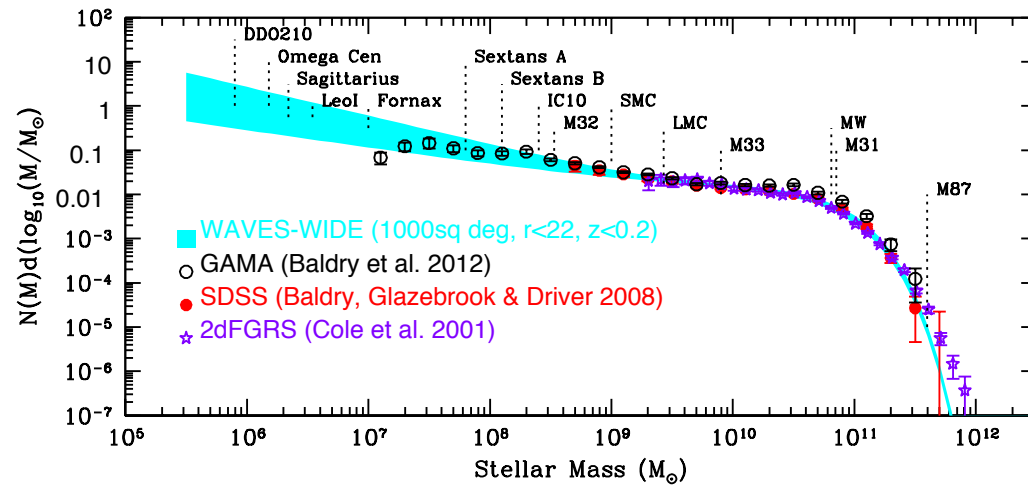


WAVES-WIDE

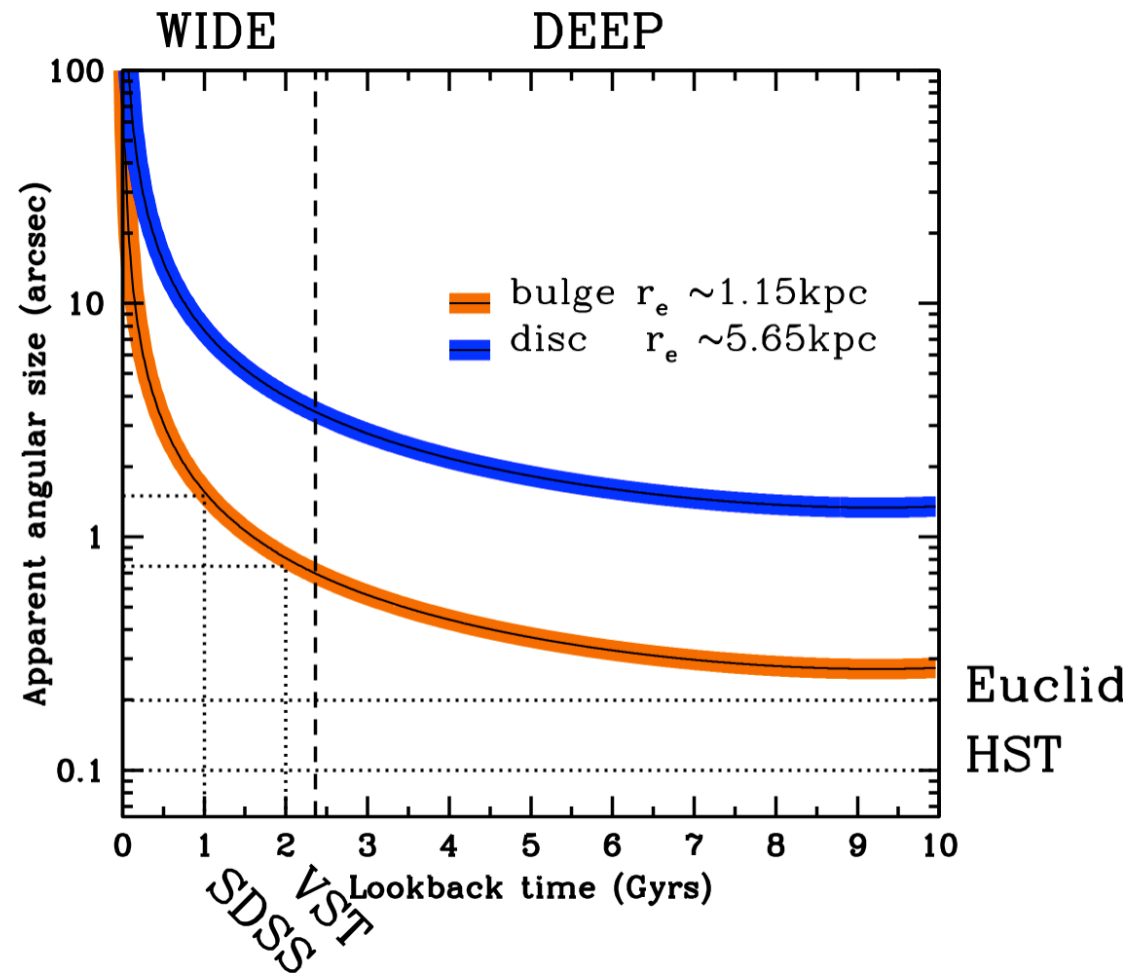
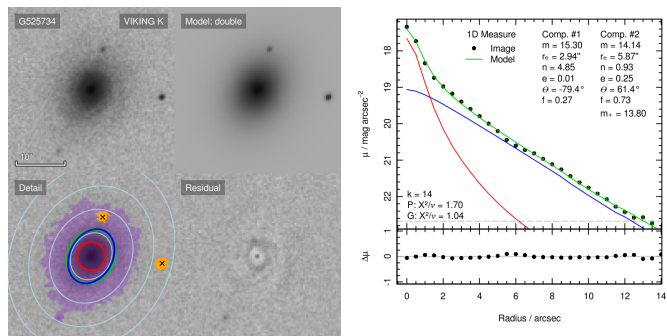
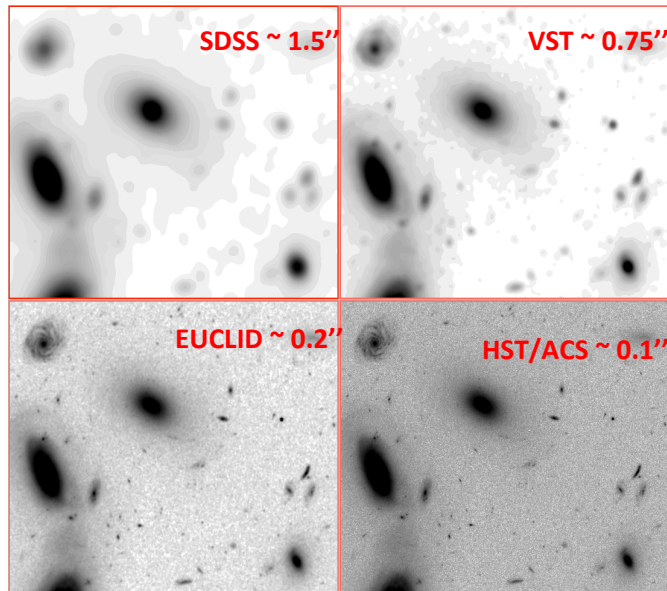


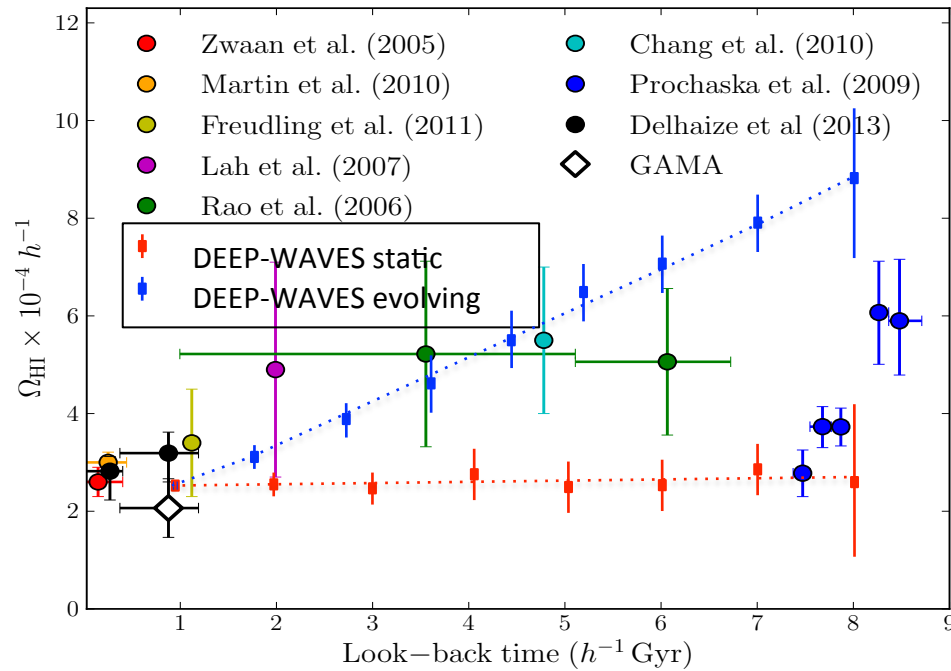
Comprehensive test of CDM/WDM on kpc-Mpc scales

- Halo Mass Function
- Halo Occ. Stats.
- High-order statistics
- Pair frequency
- etc



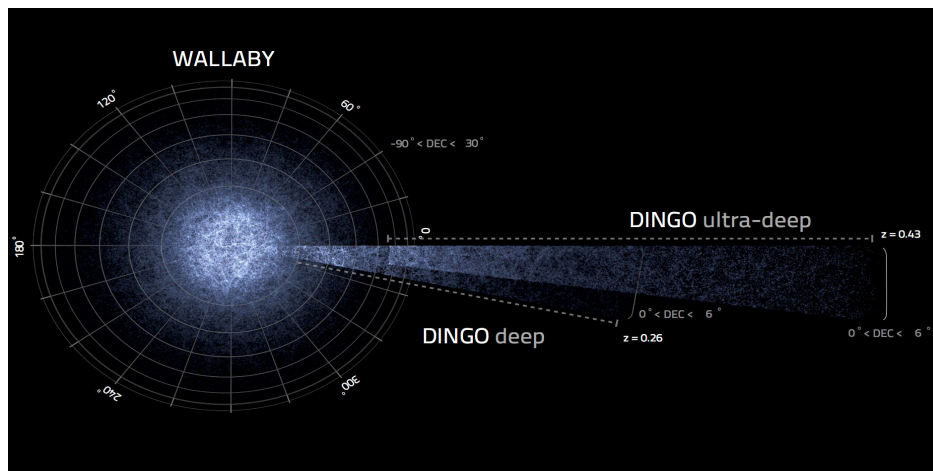
Bulge-disc decomposition of 1million galaxies to $z=1$





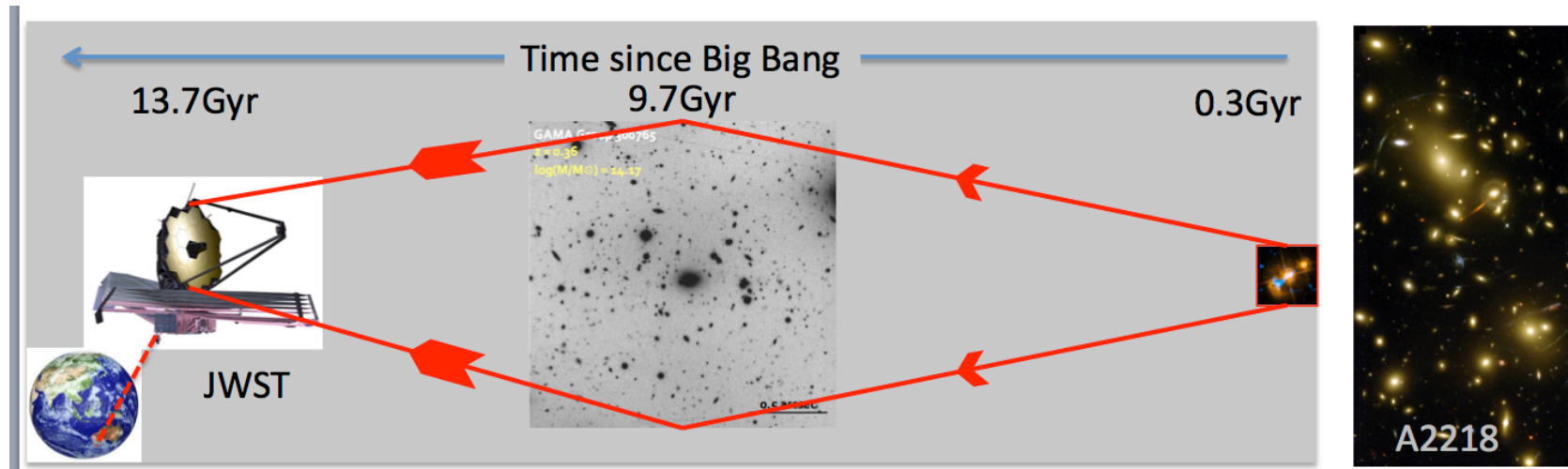
A deep 100 sq deg SKA-mid survey:

- HI detections of massive systems
 - HI masses
 - HI dynamics
- Optically motivated source finding
 - Expand sample x3
- HI stacking using WAVES selection
 - galaxy type
 - halo mass
 - SFR
- Continuum
 - SFR estimates



A wide 700 sq deg SKA-mid survey

- As above by shallower
- Similar to WALLABY & DINGO but to $z \sim 1$



JWST = mid-IR optimal for studying $z > 10$ galaxies but how to detect them?

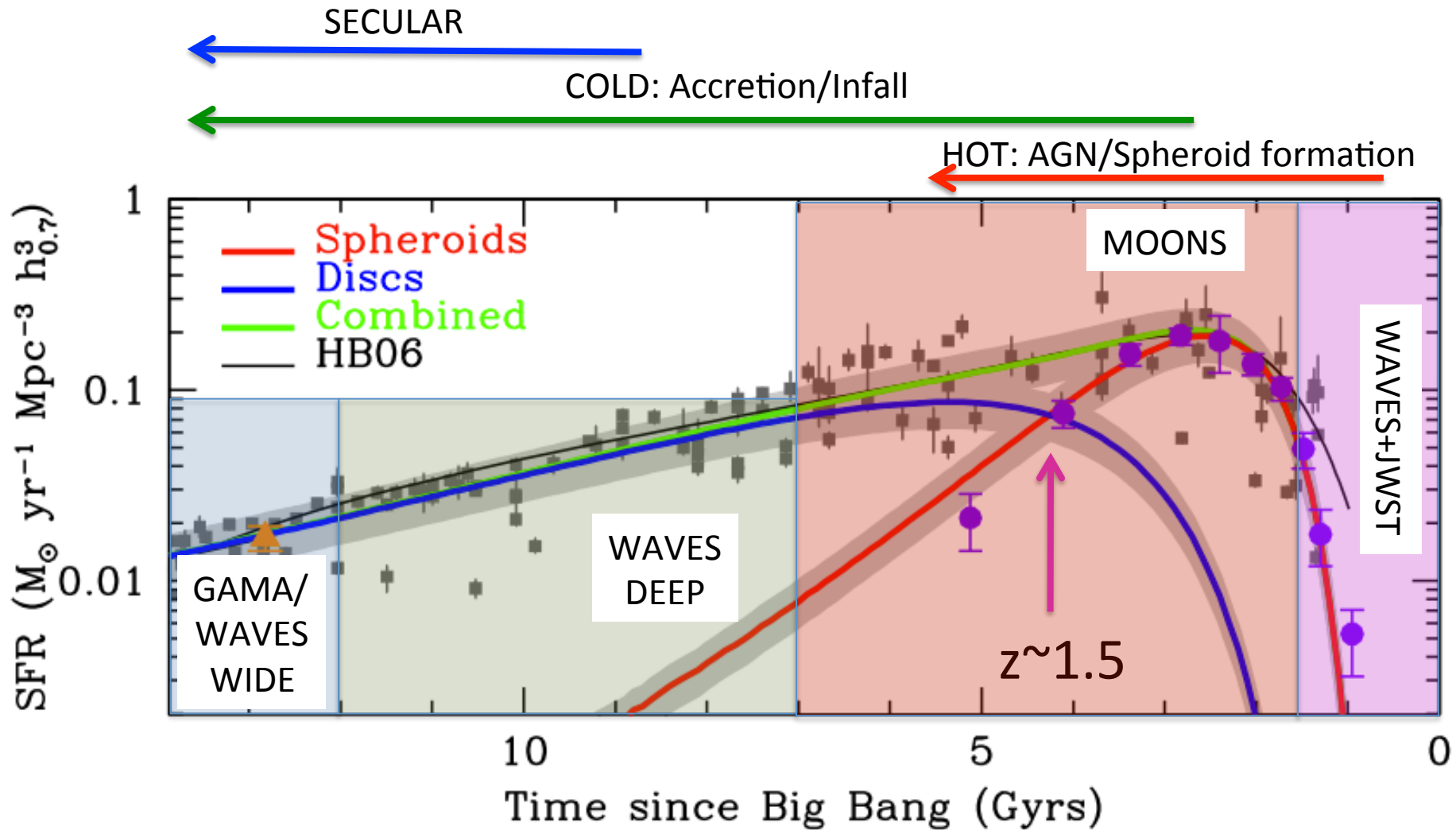
$z \sim 0.7$ compact groups are the best foreground lenses to probe the $z > 10-12$ Universe

Initially use GAMA groups as gravitational lenses and switch to WAVES groups later

- 110hrs GTO time (Windhorst ILS campaign)

Legacy surveys

WAVES = Era of primary disc growth





Key message

Synergy,

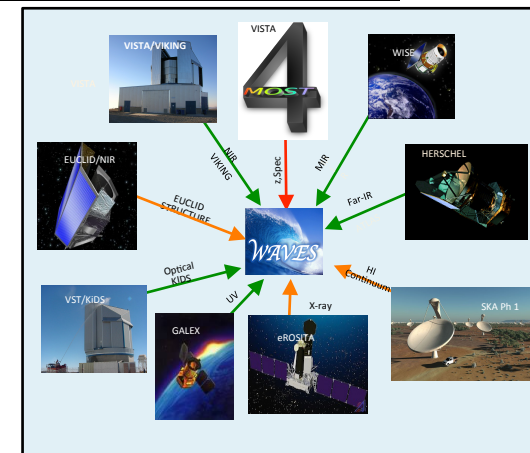
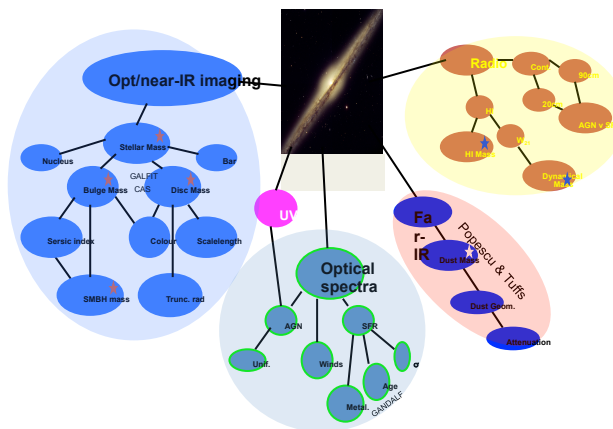
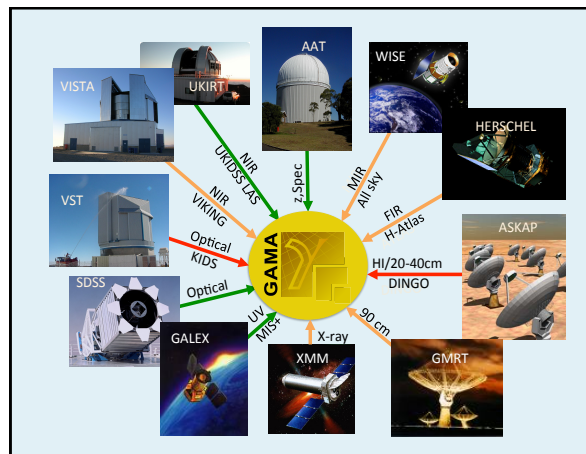
synergy,

synergy



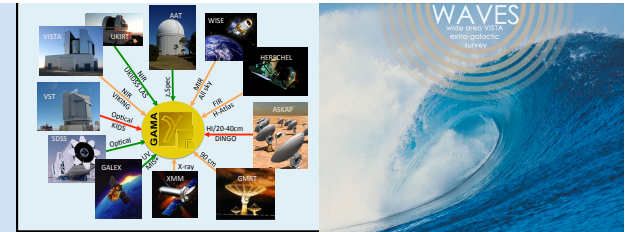
(+ stringent QC and a great database, e.g., SDSS, GAMA etc.)

Gone are the days of single facility surveys

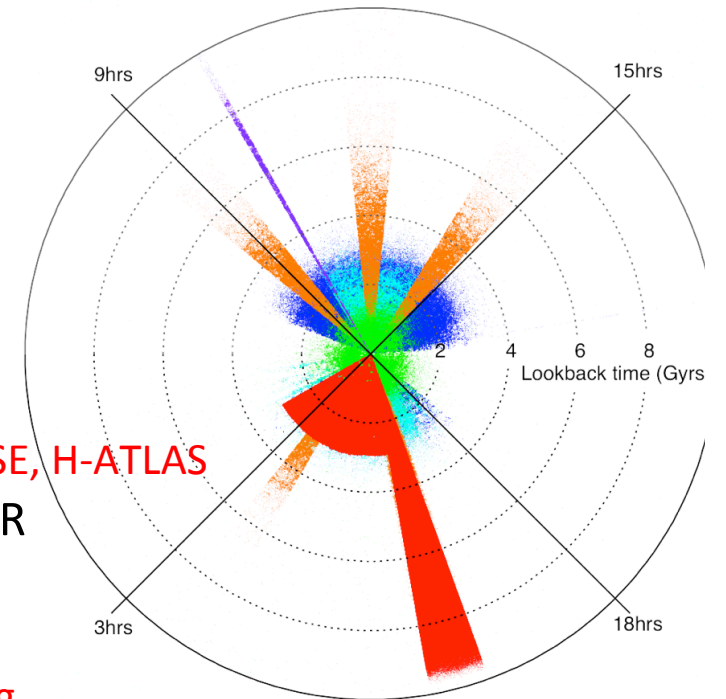




Thank-you:



- AAT/AAO, SDSS, UKIRT
- ESO (VST, VLT, VISTA)
- ESA (HERSCHEL)
- NASA (GALEX, WISE)
- UK Wide-Field Centres: **CASU, WFSU**
- Teams:
 - 2dFGRS, SDSS, MGC, 6df GS, zCOSMOS
 - GALEX, SDSS, VST KiDS, UKIDSS LAS, VISTA VIKING, WISE, H-ATLAS
- Software: SExtractor, SWARP, PSFex, Aladin, Topcat, R
- Funding: SUPA, STFC, ARC, ERC, RS, SIEF, ICRAR
- GAMA Team: 97 Scientists but in particular:
 - Joe Liske, Ivan Baldry, Aaron Robotham, Peder Norberg



| 6dfGRS | SDSS DR9 | 2dFGRS | GAMA | zCOSMOS | WAVE

- GAMA DR2: <http://www.gama-survey.org/DR2>
- GAMA PDR: <http://ict.icrar.org/cutout>
- zCOSMOS/G10: <http://ict.icrar.org/cutout/G10/>
- WAVES: <http://www.wave-survey.org/>
- CompareYourFacility: <https://asgr.shinyapps.io/ganttshiny/>
- Online cosmology calculator <https://asgr.shinyapps.io/cosmocalc/>