Galaxy And Mass Assembly (GAMA) & WAVES

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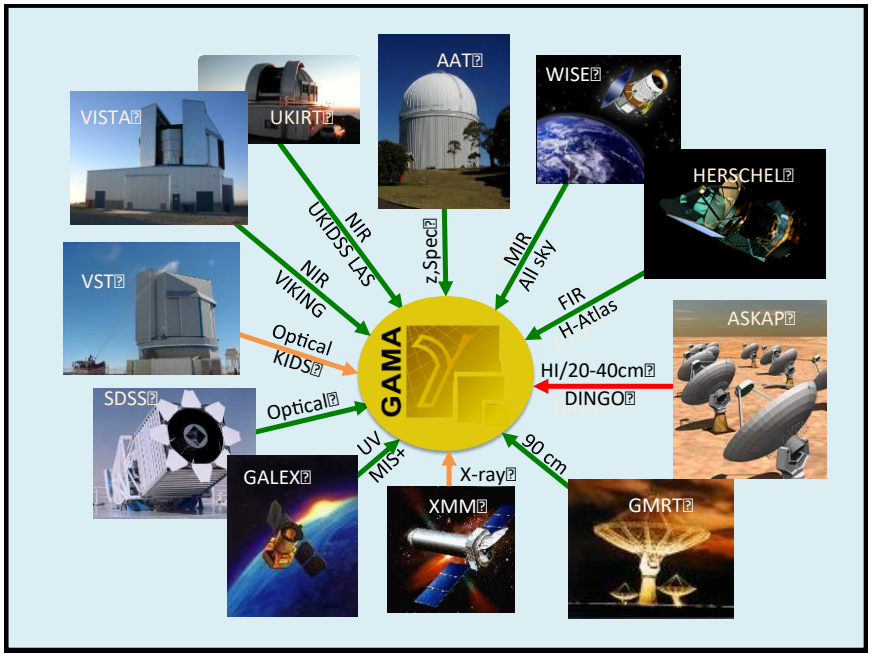
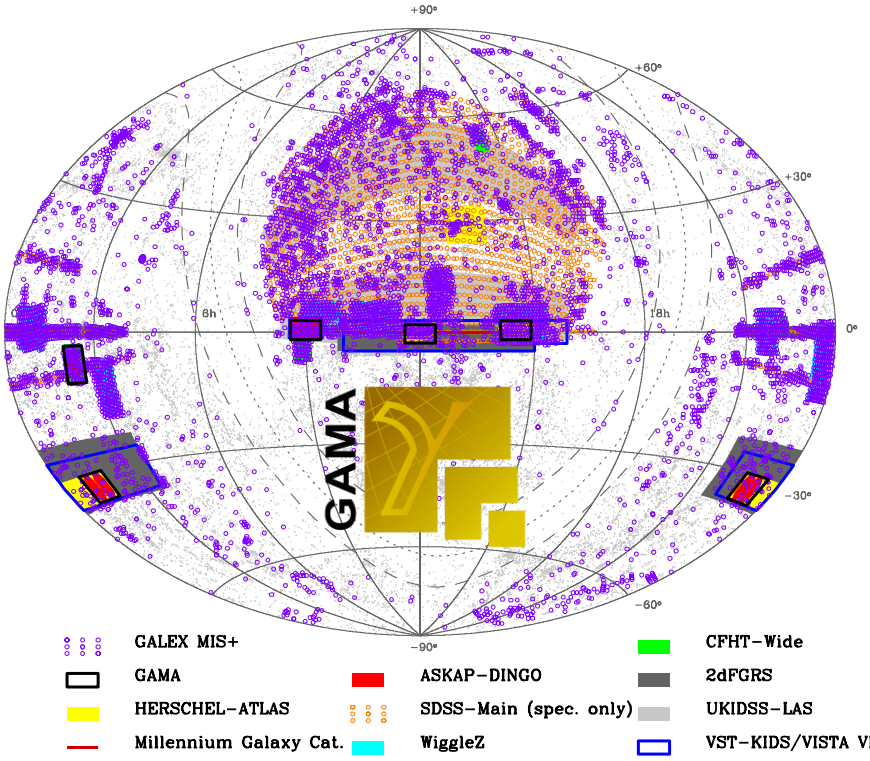
Galaxy And Mass Assembly (GAMA)





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

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

The GAMA Team

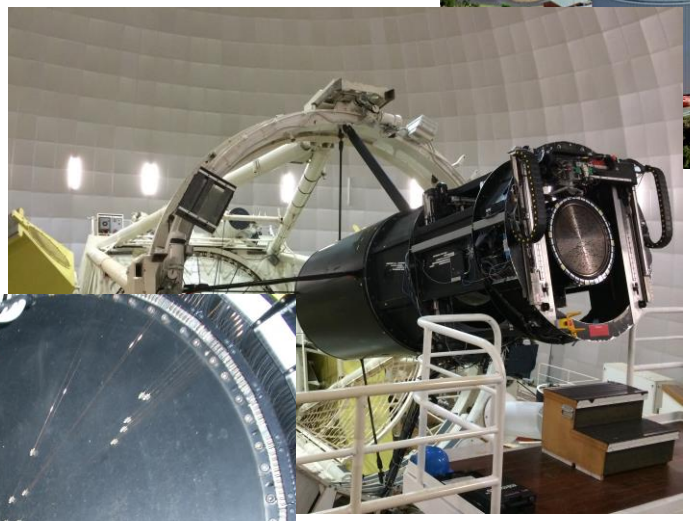
Team now includes: 97 scientists (including 14 PhD students) across 39 institutions, 4 continents

GAMA

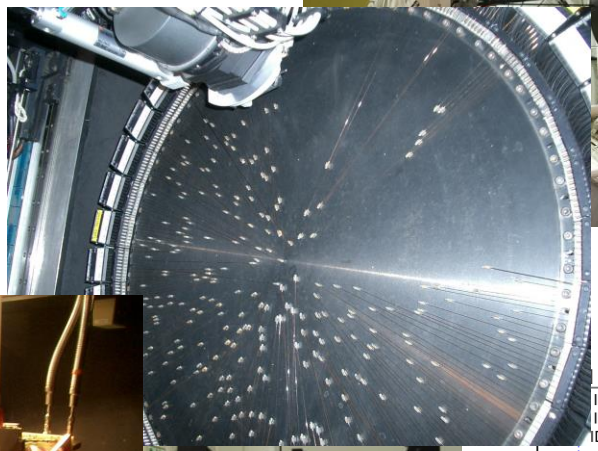
200 nights over 7 years
(top speed due to RA range!)
~300k spectra

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

~30% of all known redshifts from AAO

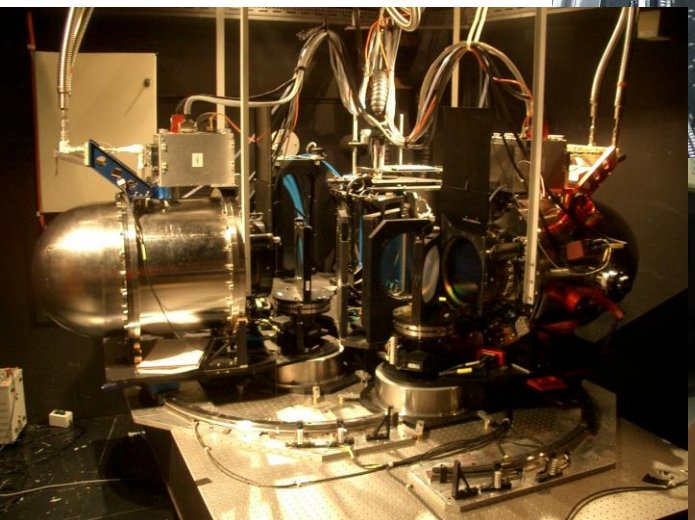


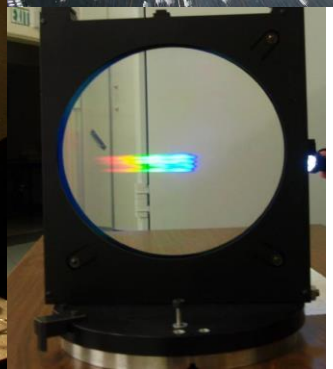
3.9m but 1.5'' seeing
and 50% cloudy =
dedicated spectroscopy

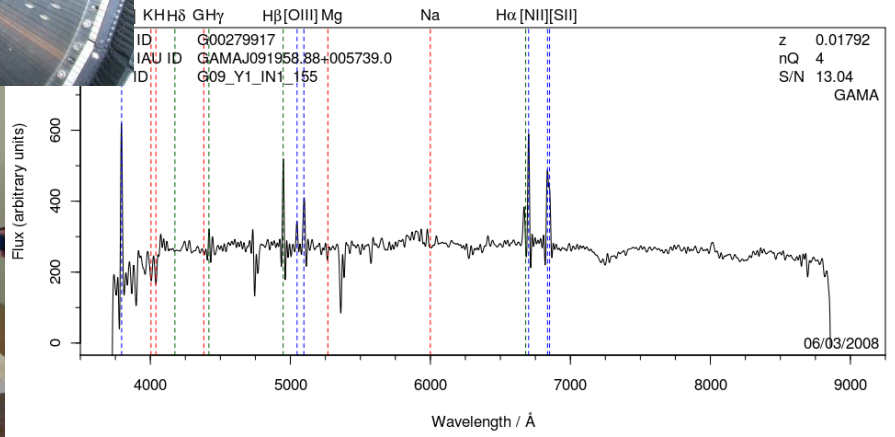


Entire Process
Automated:
- Tiling
- Data reduction
- Redshifting

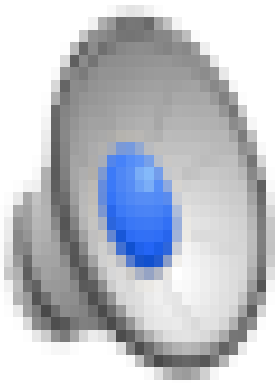
2500z/night

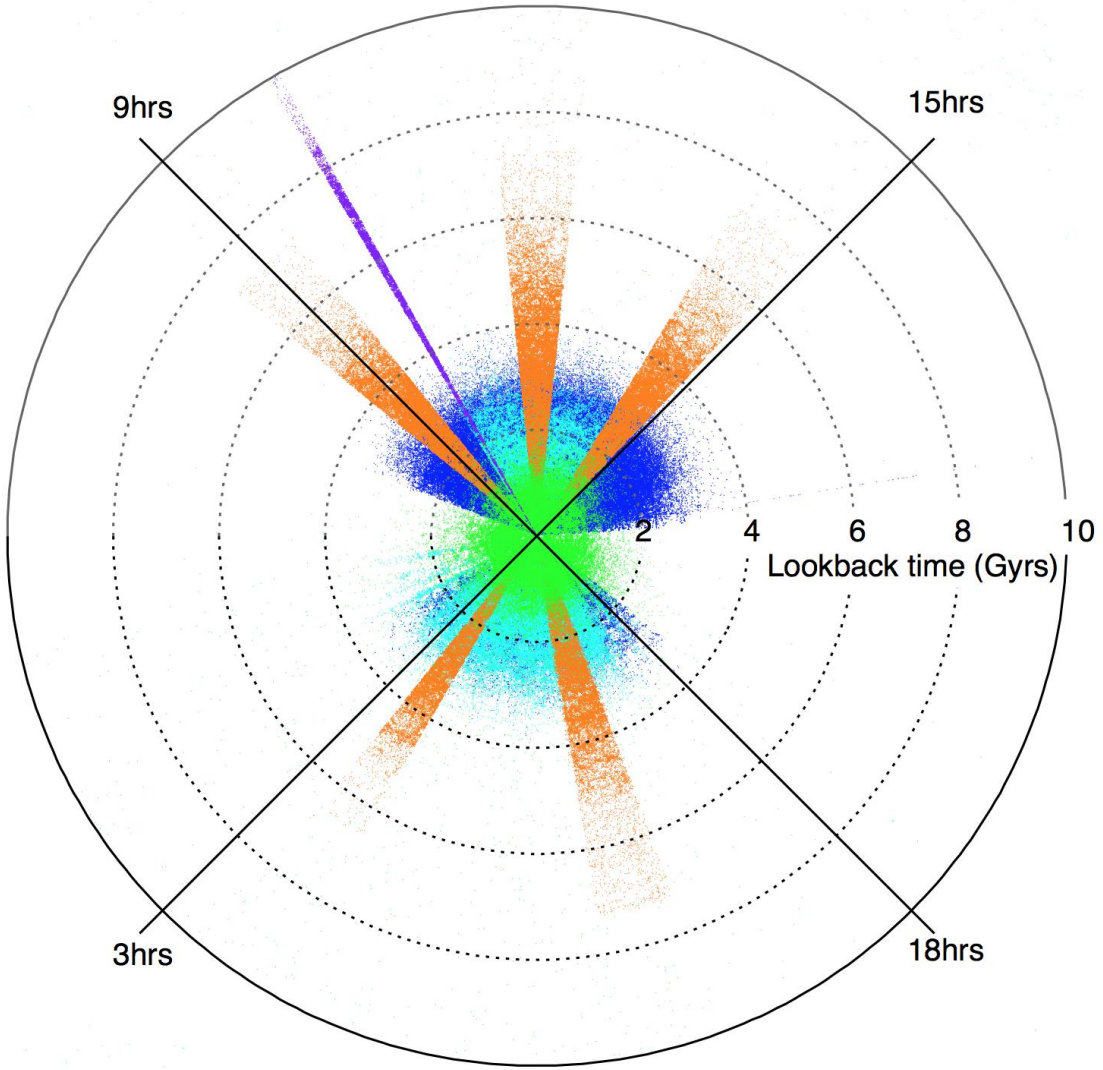






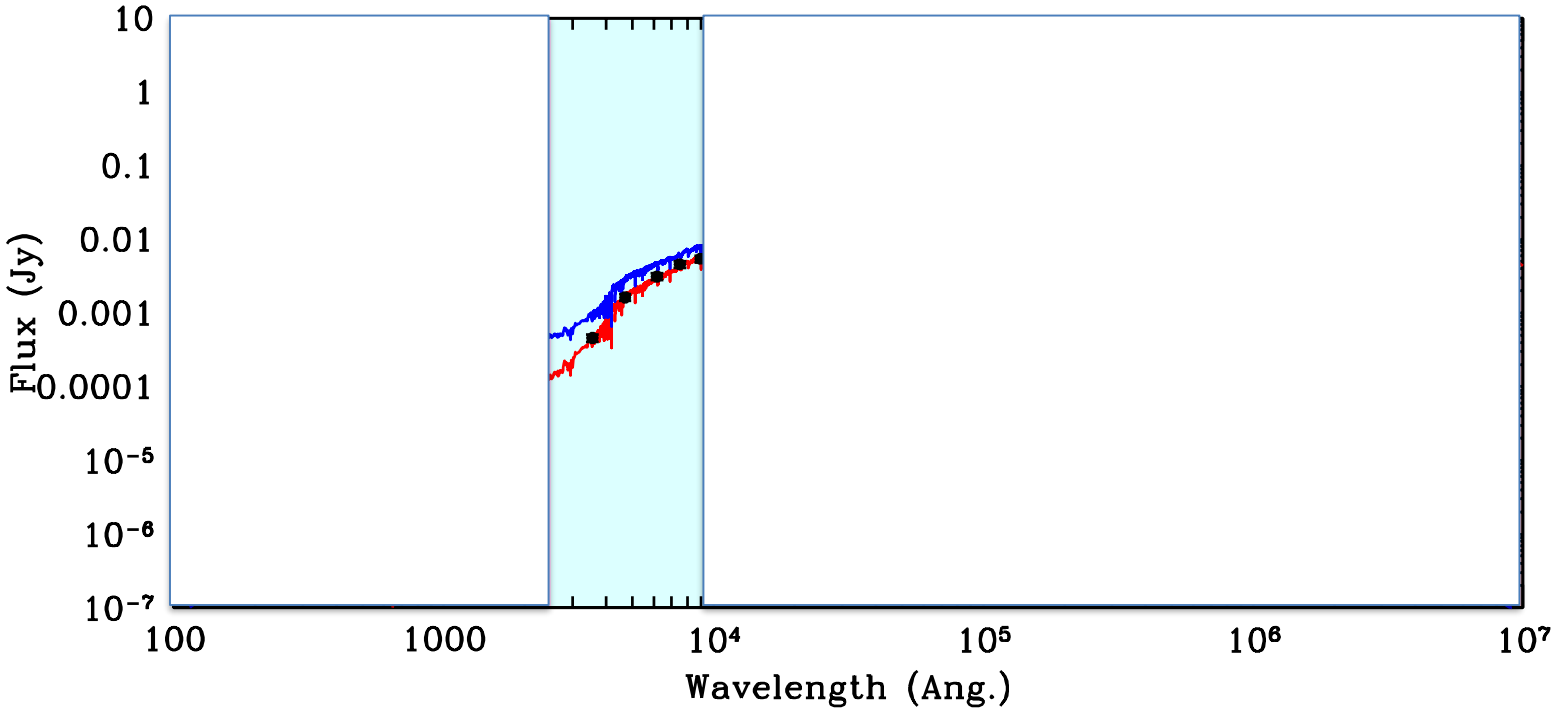
Unbiased galaxy redshift surveys:

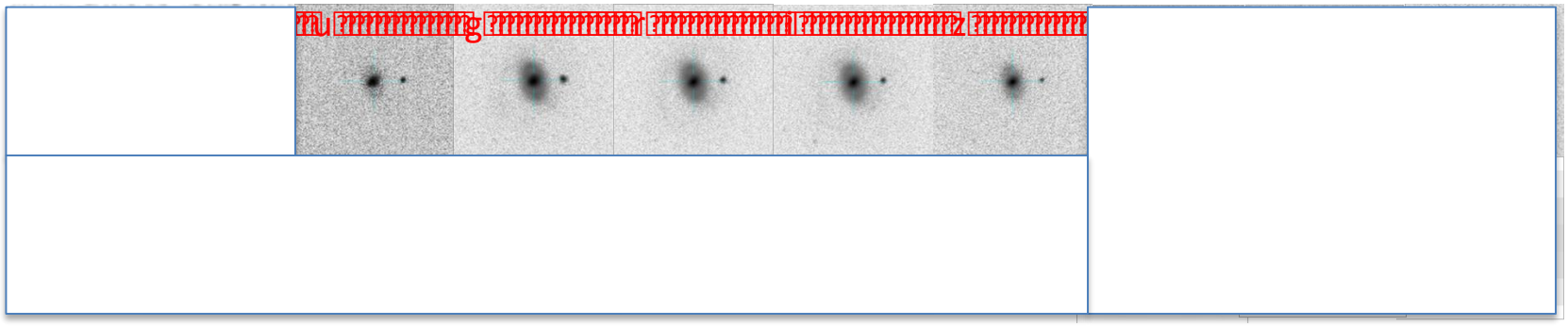




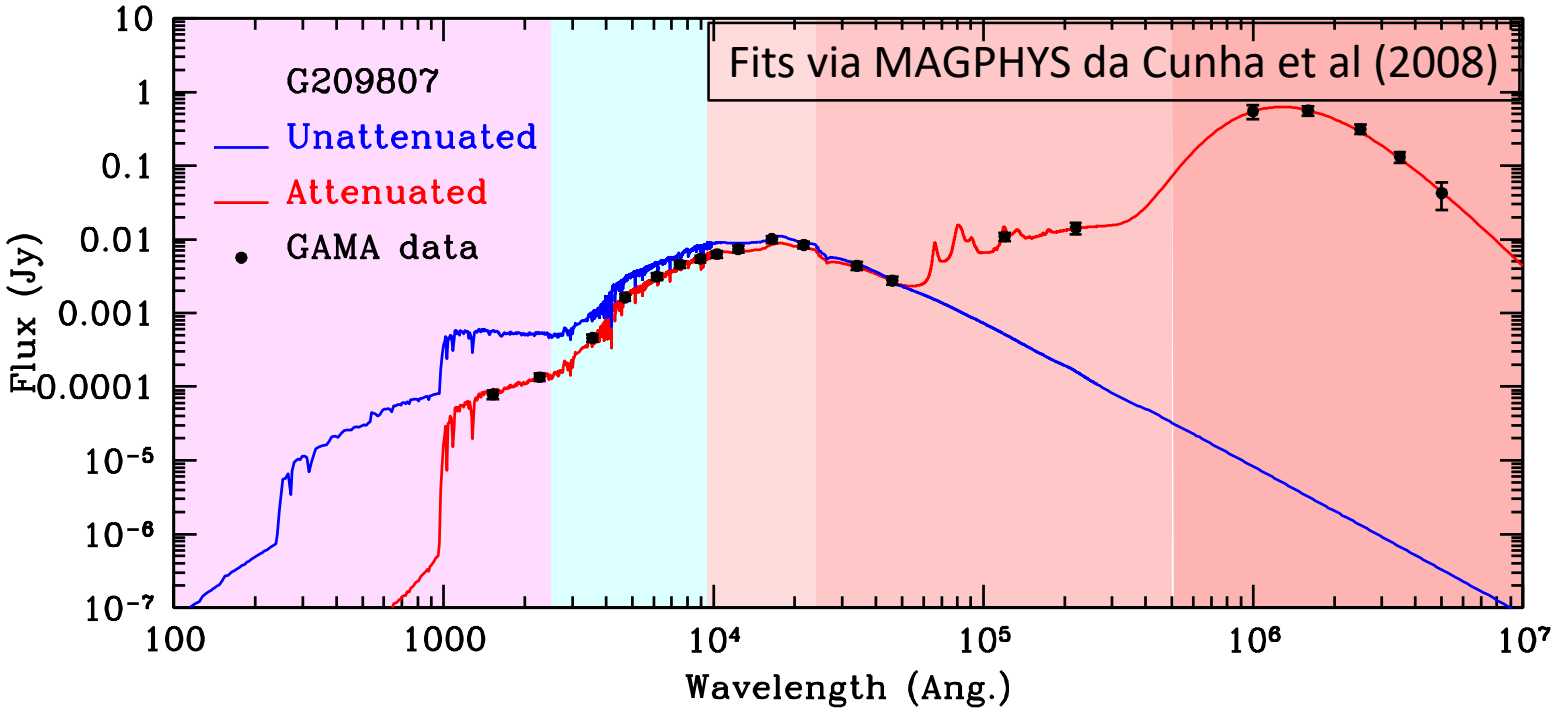
| 6dfGRS | SDSS DR9 | 2dFGRS | GAMA | zCOSMOS |

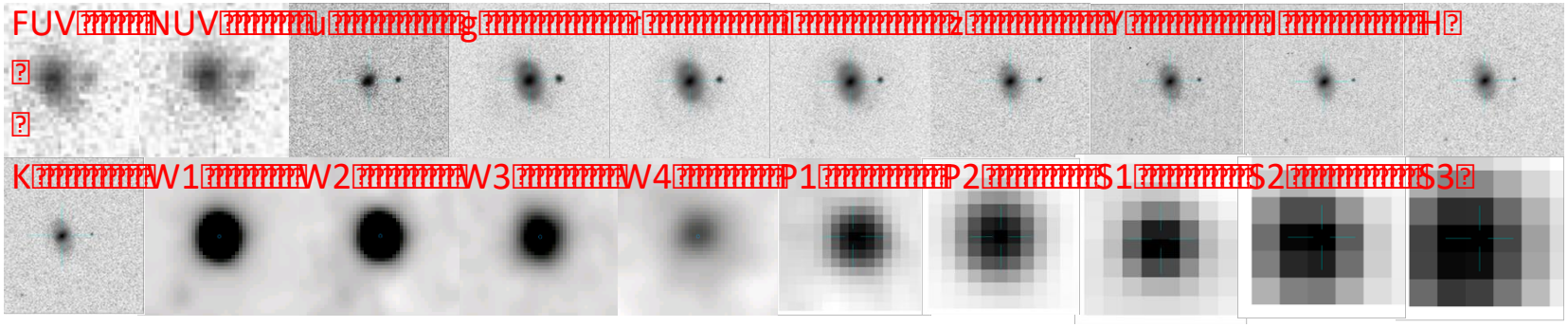
Panchromatic photometry





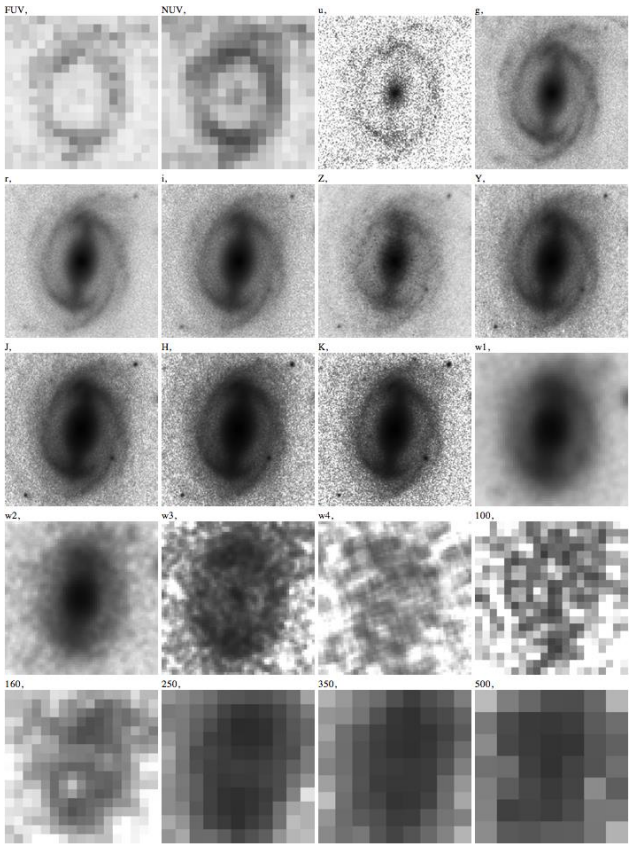
Panchromatic photometry





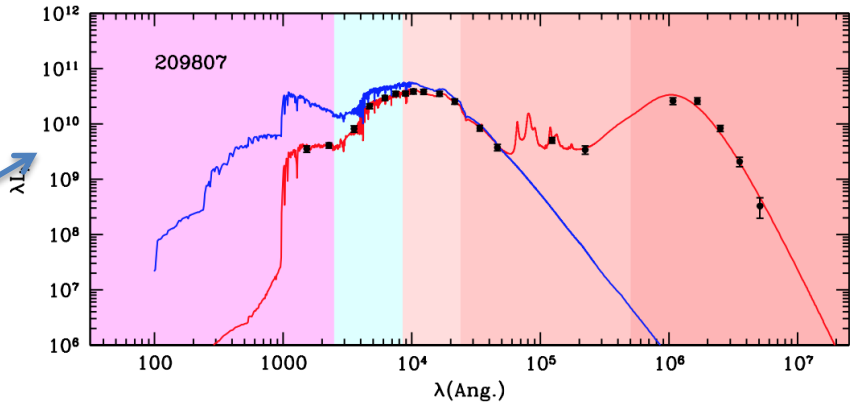
Energy & masses for 250k galaxies

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



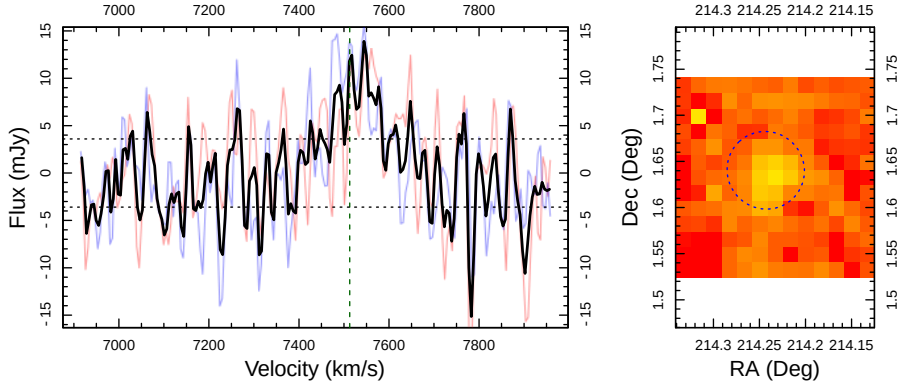
LAMBDAR software developed to cope with mismatched PSFs
use r-band aperture and convolve, deblend, deconfuse etc

MAGPHYS



M_*
M_D

HI

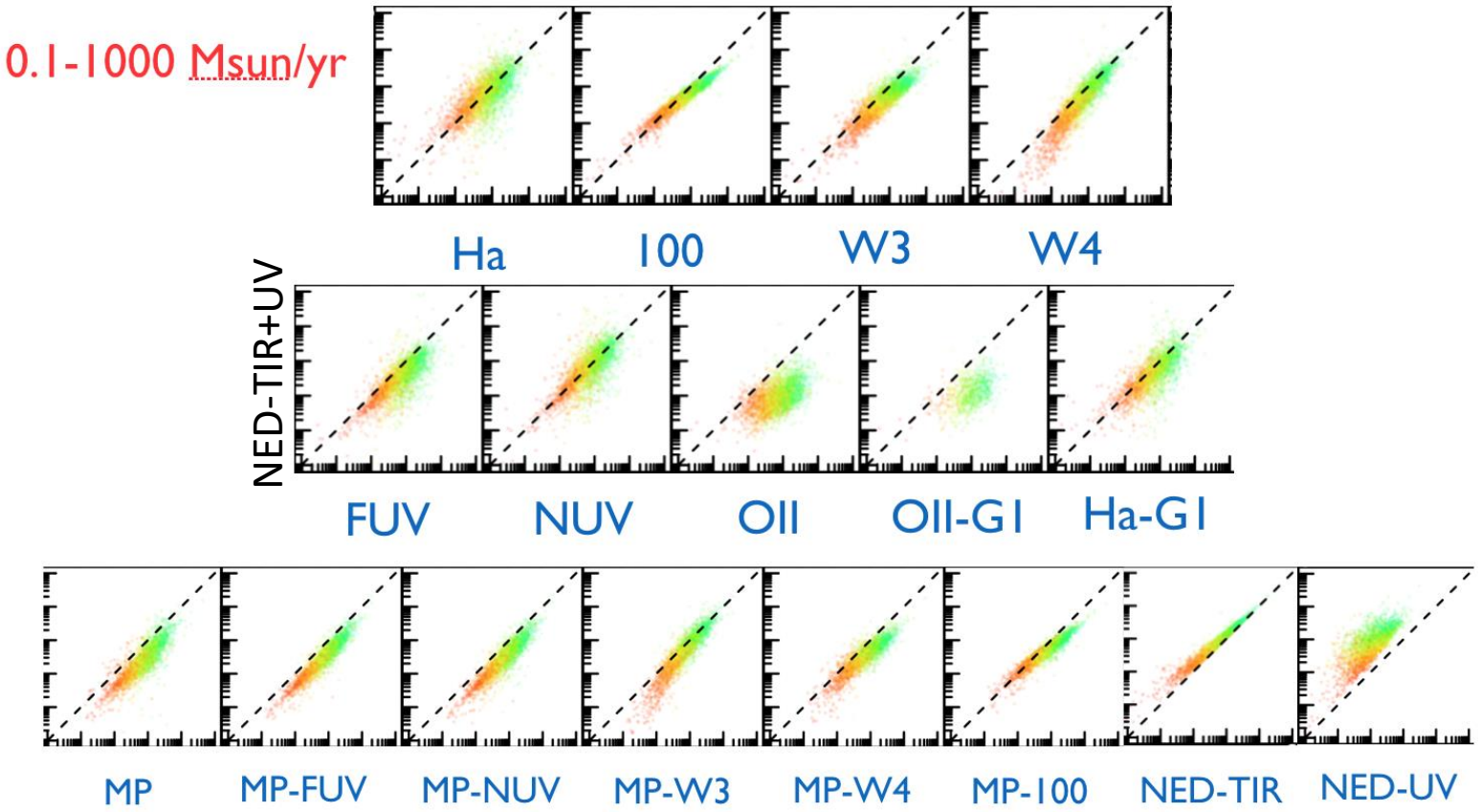


M_{HI}
M_{dyn}
M_{Halo}

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

GAMA SF indicators

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



Luke Davies

Davies et al, in prep

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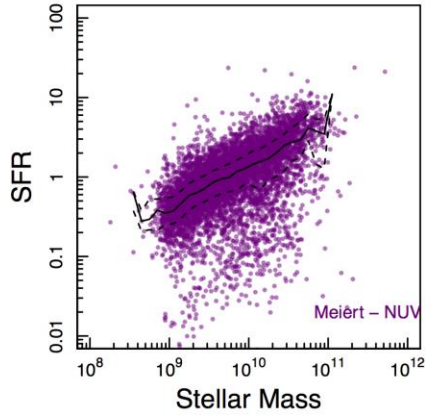
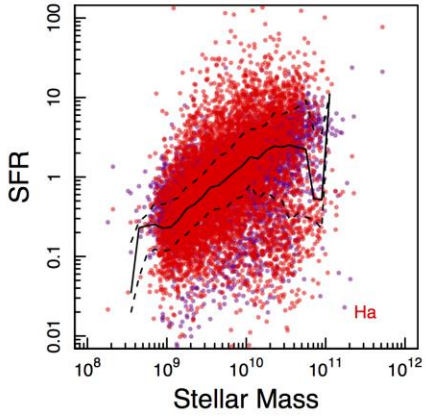
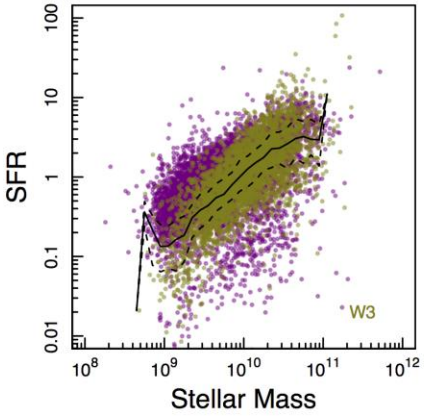
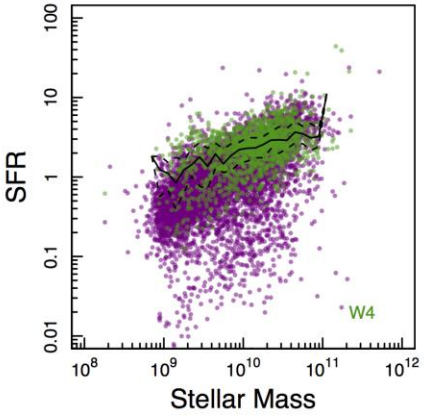
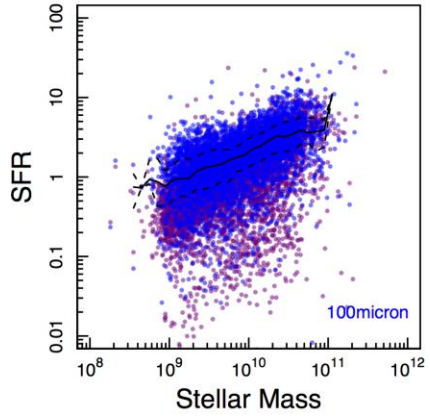
  - E.g., galaxy main sequence

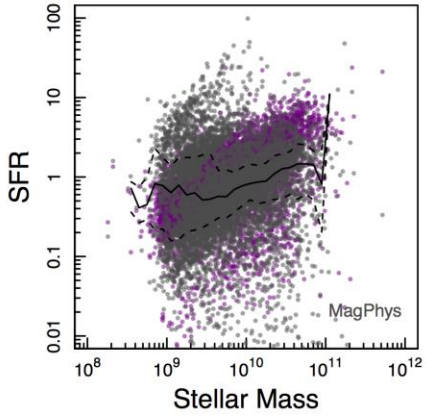


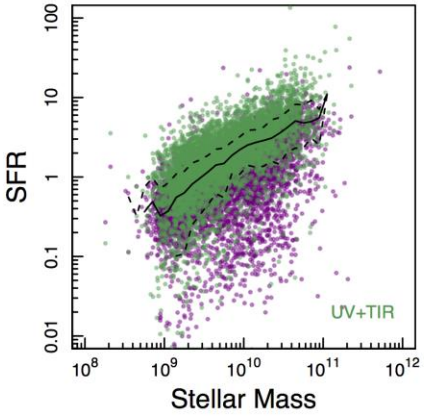












Luke Davies
Davies et al, in prep

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

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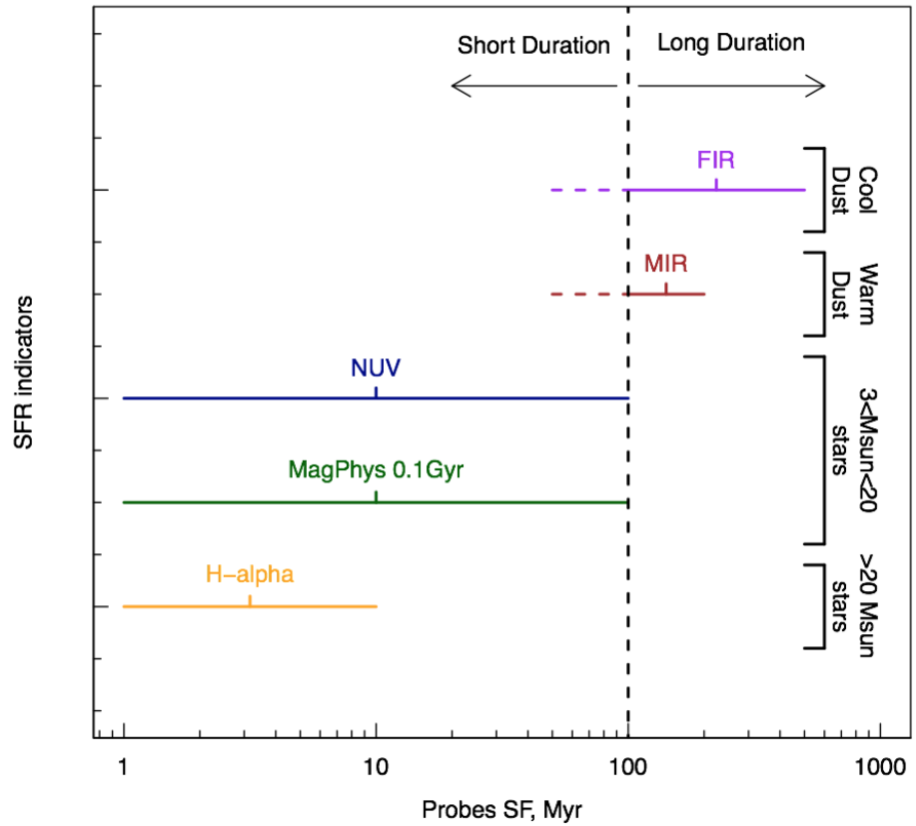
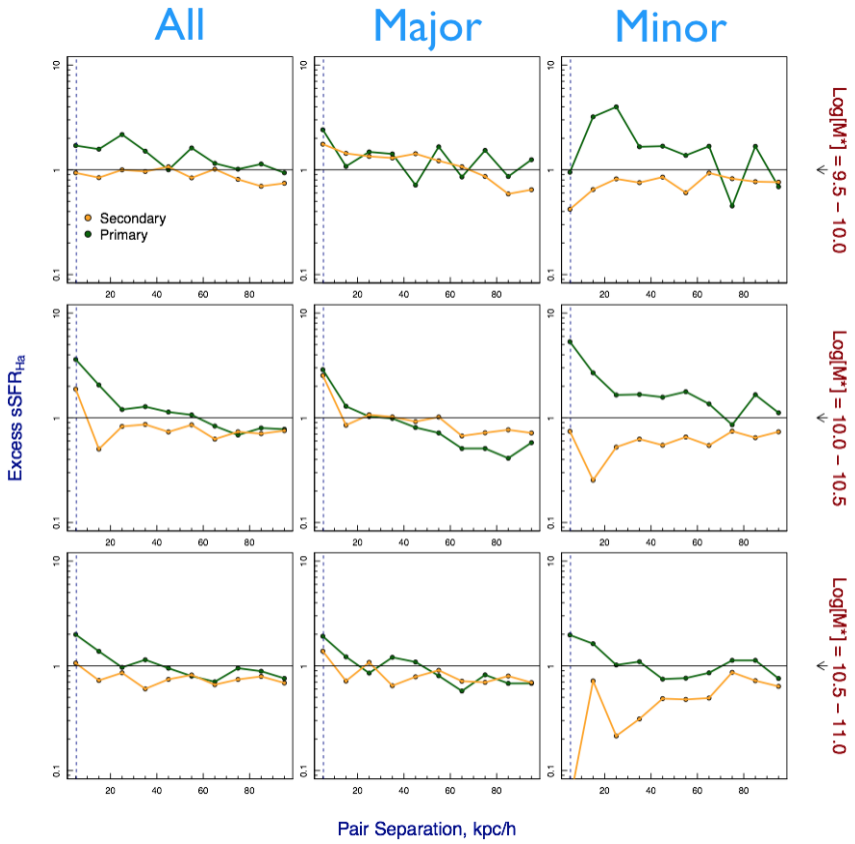
Davies et al, in prep

Hα





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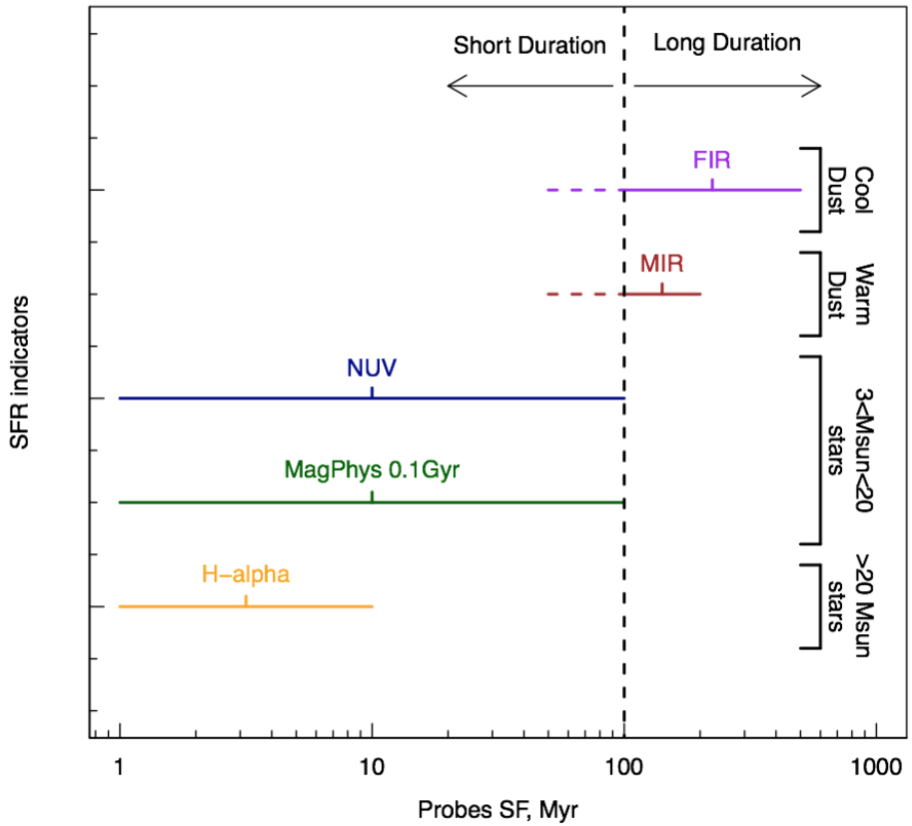
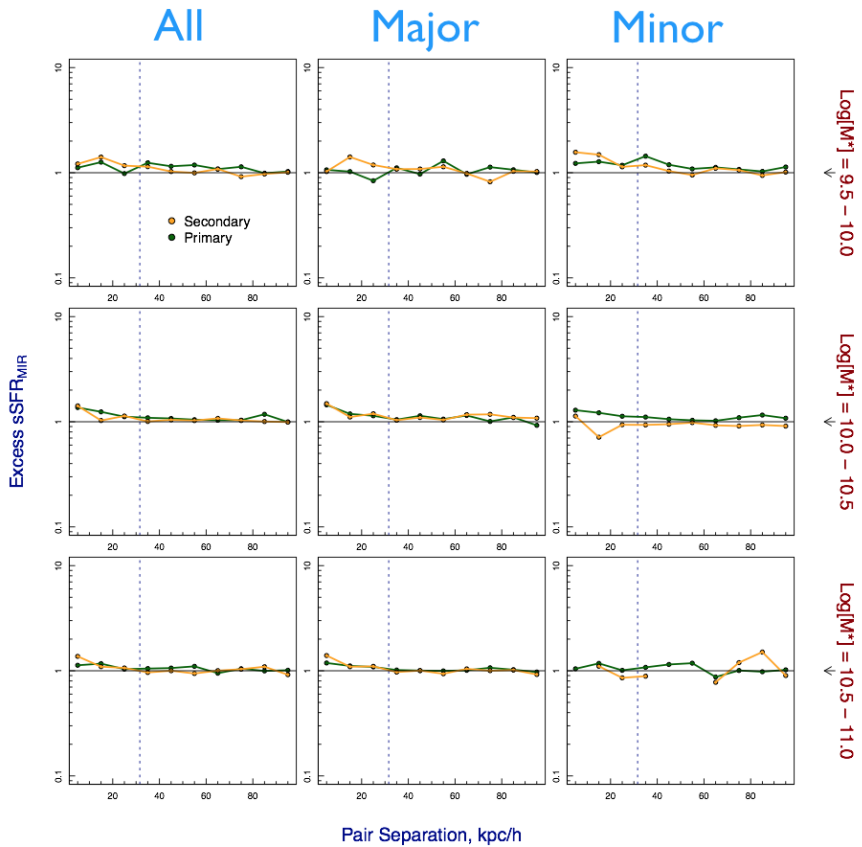


W4



Science (z<0.06)

- Mass:
  - GSMF (Baldry et al)
  - GSMF by type (Kelvin et al)
  - SMBH MF (Andrews et al)
  - DUST MF (Dunne et al)
  - HI MF (Wright et al)
  - DM HMF (Robotham et al)
- Energy:
  - CSED (Driver et al)
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- Structure:
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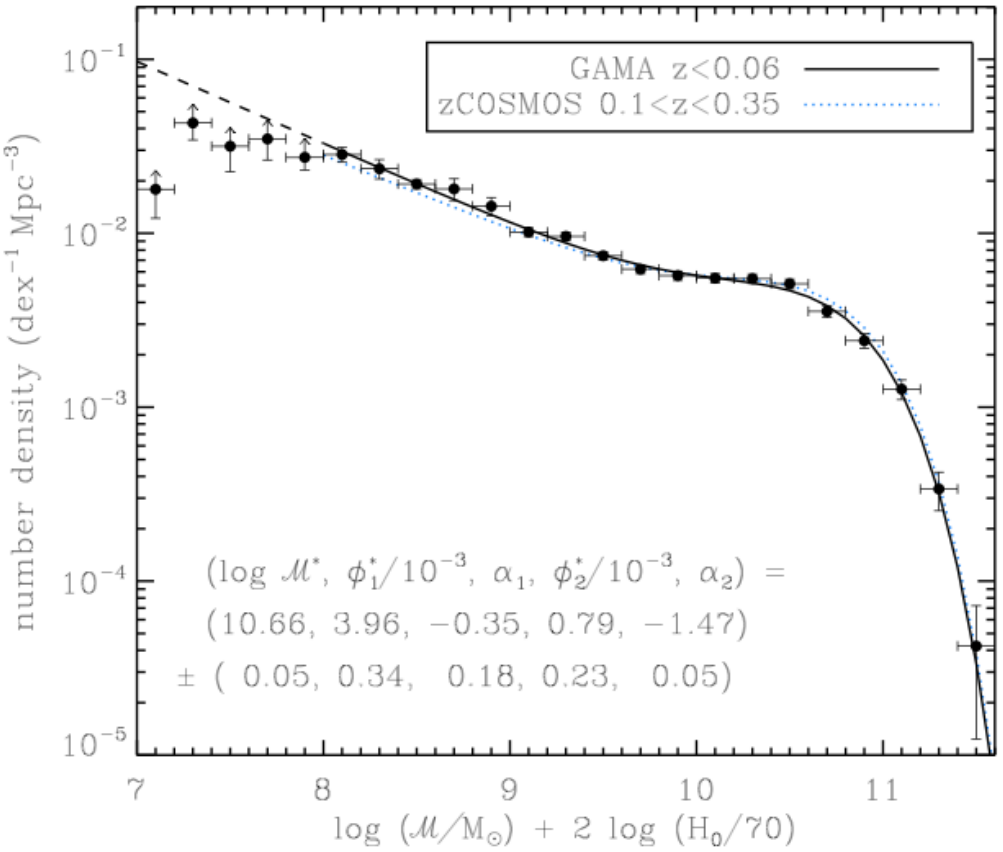

Science (z<0.1)

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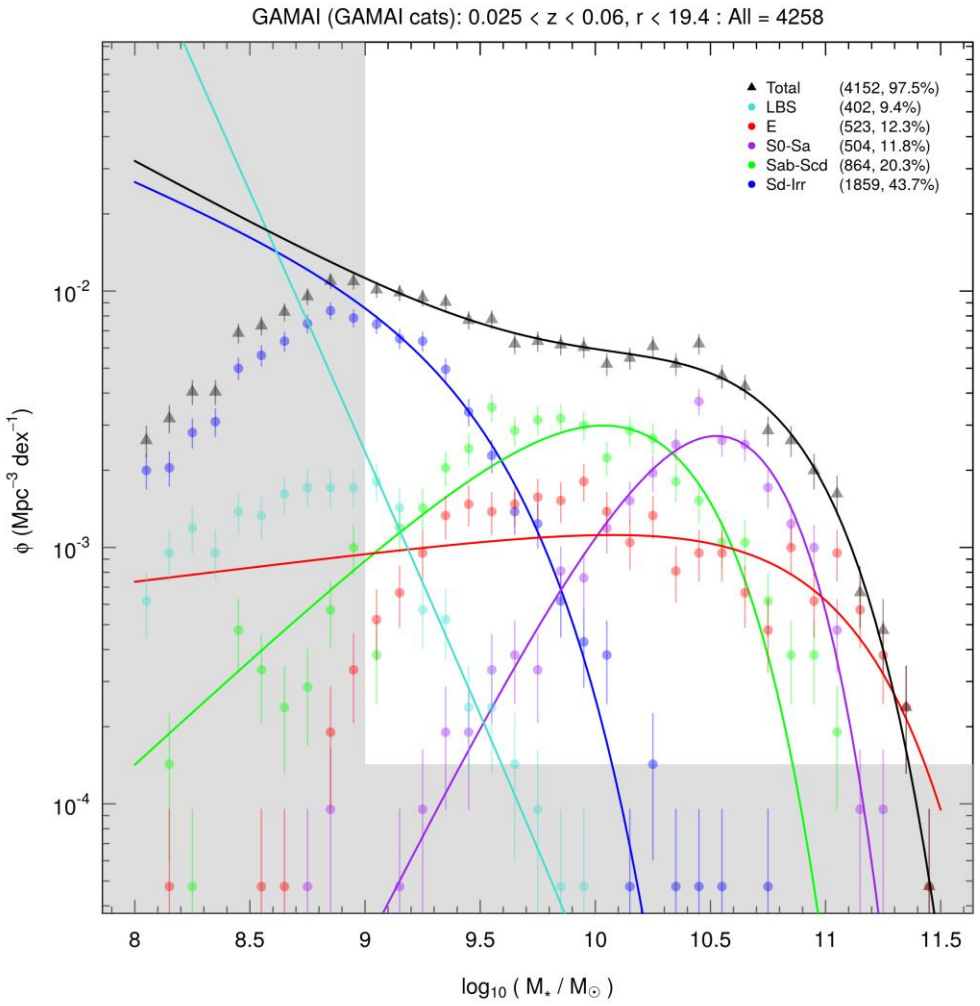

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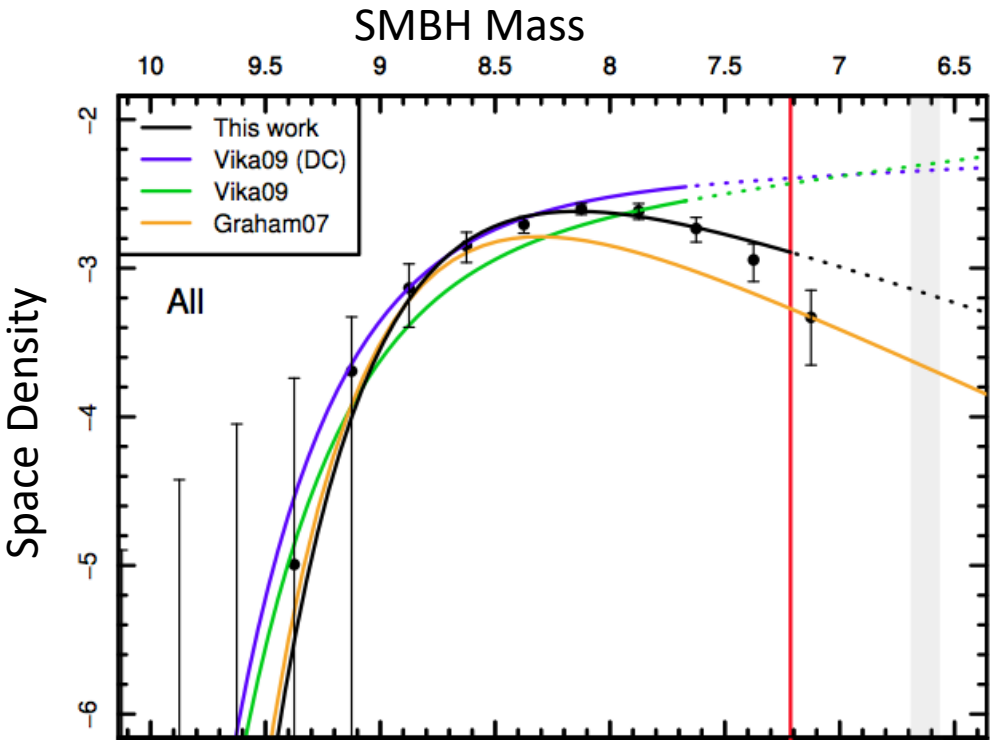

SMBHs derived using near-IR M_{BH}-L_{BULGE} relation
Graham et al., (2013)

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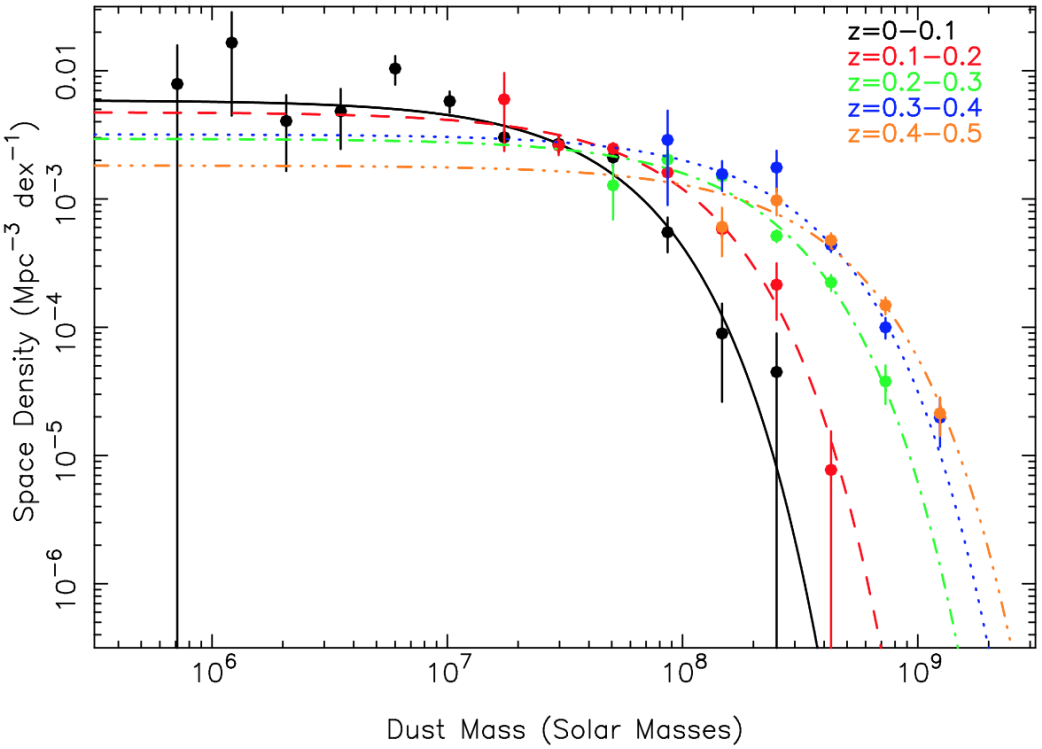

Very strong evolution seen in dust mass (collaboration paper with Herschel-Atlas)

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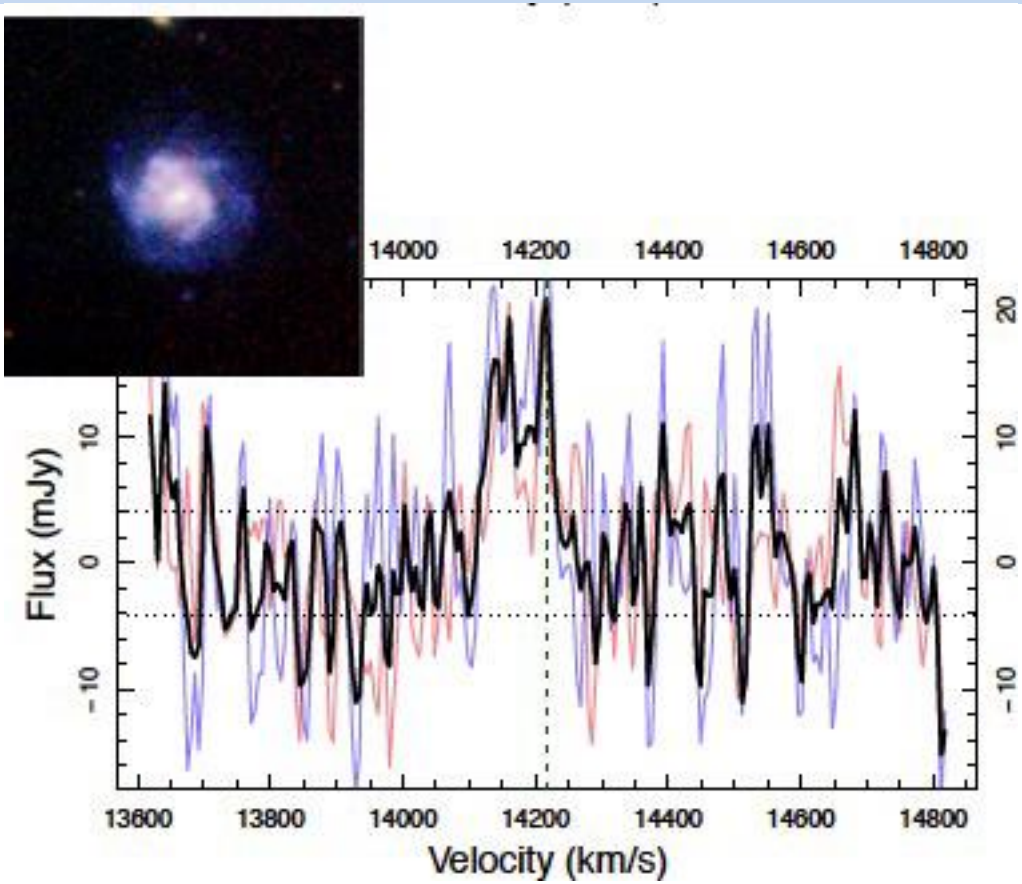

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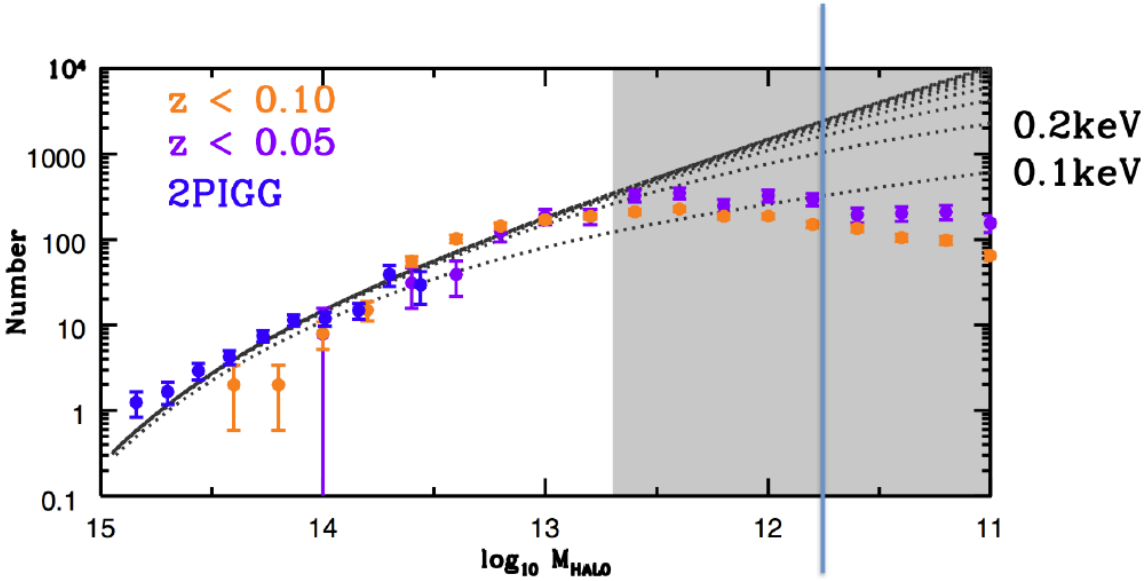
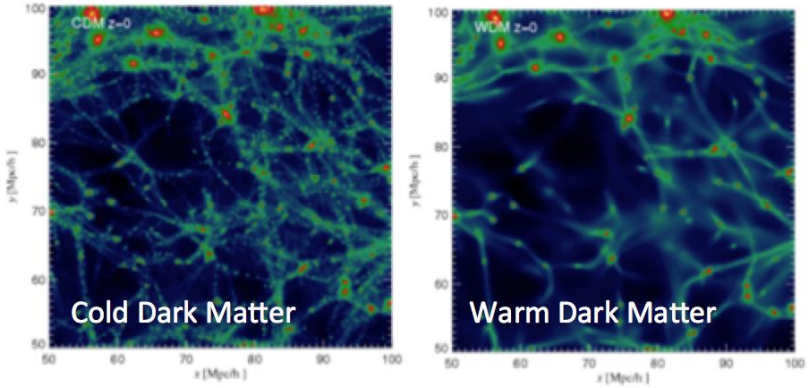


Final limit around here.



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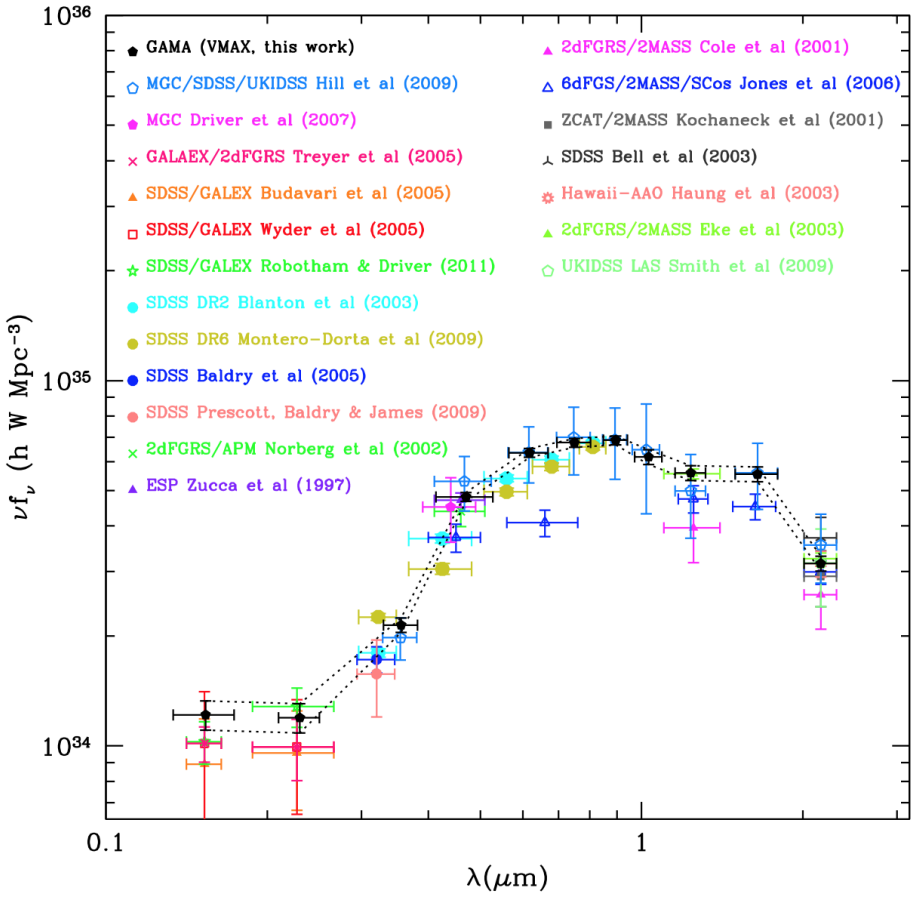

Science (z<0.3)

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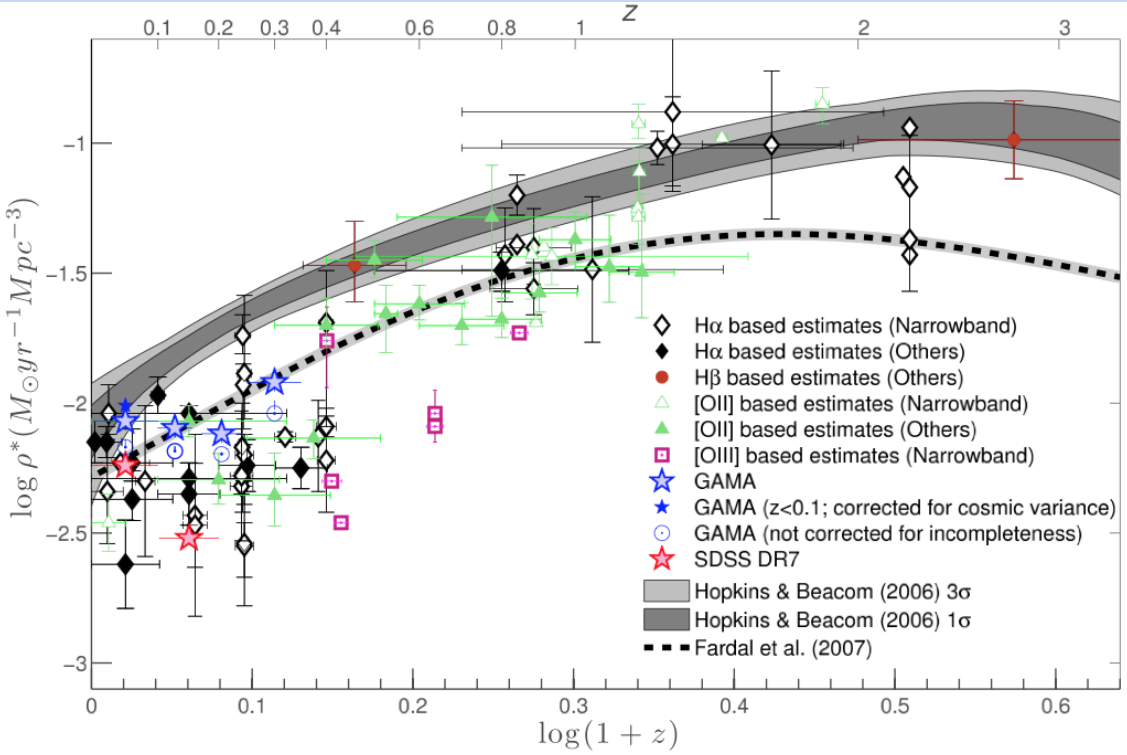

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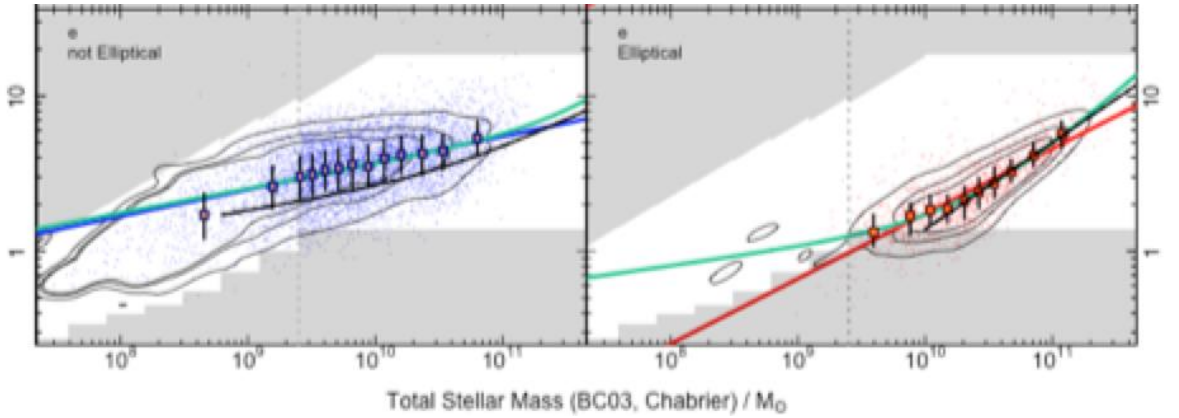

Mass-size relation by component coming

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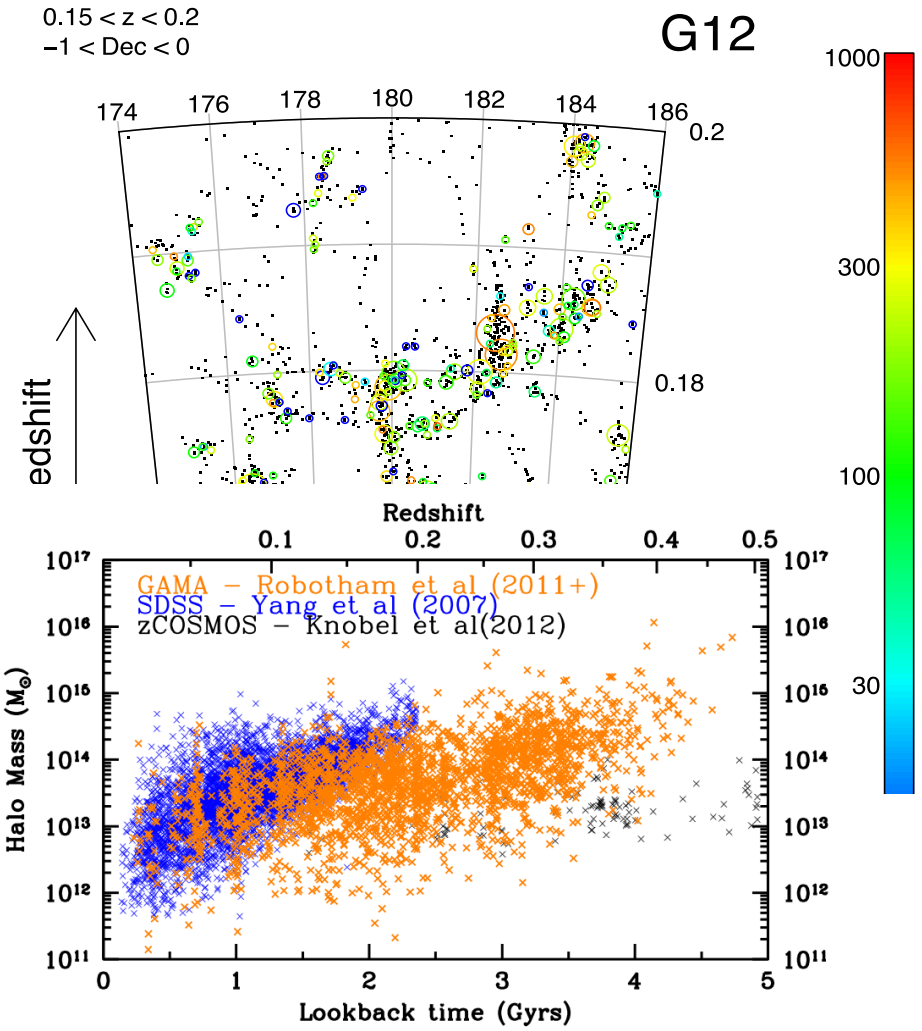

25,000 GAMA groups

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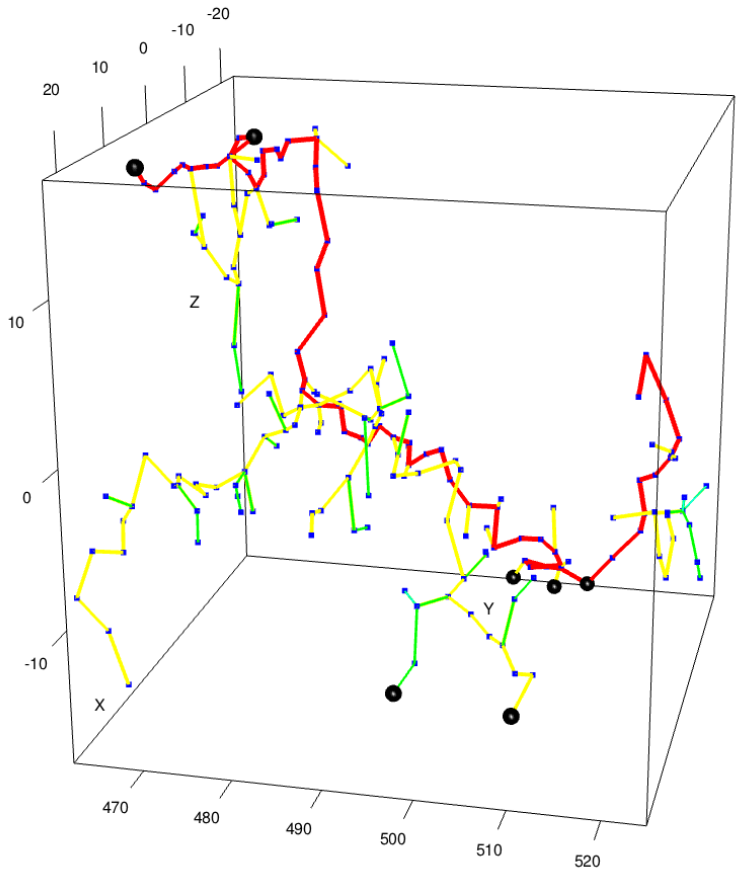
  - DM HMF (Robotham et al)
- Energy:
  - CSED (Driver et al)
  - CSFH (Gunawardhana et al)
- Structure:
  - Mass-size relations (Lange et al)
  - Groups (Robotham et al)
  - Filaments (Alpaslan et al)
  - Tendrils (Alpaslan et al)
  - Pairs (Robotham et al)
  - Bulge-disc decomposition (Lange et al, Haussler et al)



Minimal spanning trees used to derive Backbones, filaments and tendrils

Science (z<0.1)

- Mass:
  - GSMF (Baldry et al)
  - GSMF by type (Kelvin et al)
  - SMBH MF (Andrews et al)
  - DUST MF (Dunne et al)
  - HI MF (Wright et al)
  - DM HMF (Robotham et al)
- Energy:
  - CSED (Driver et al)
  - CSFH (Gunawardhana et al
- Structure:
  - Mass-size relations (Lange
  - Groups (Robotham et al)
  - Filaments (Alpaslan et al)
  - Tendrils (Alpaslan et al)
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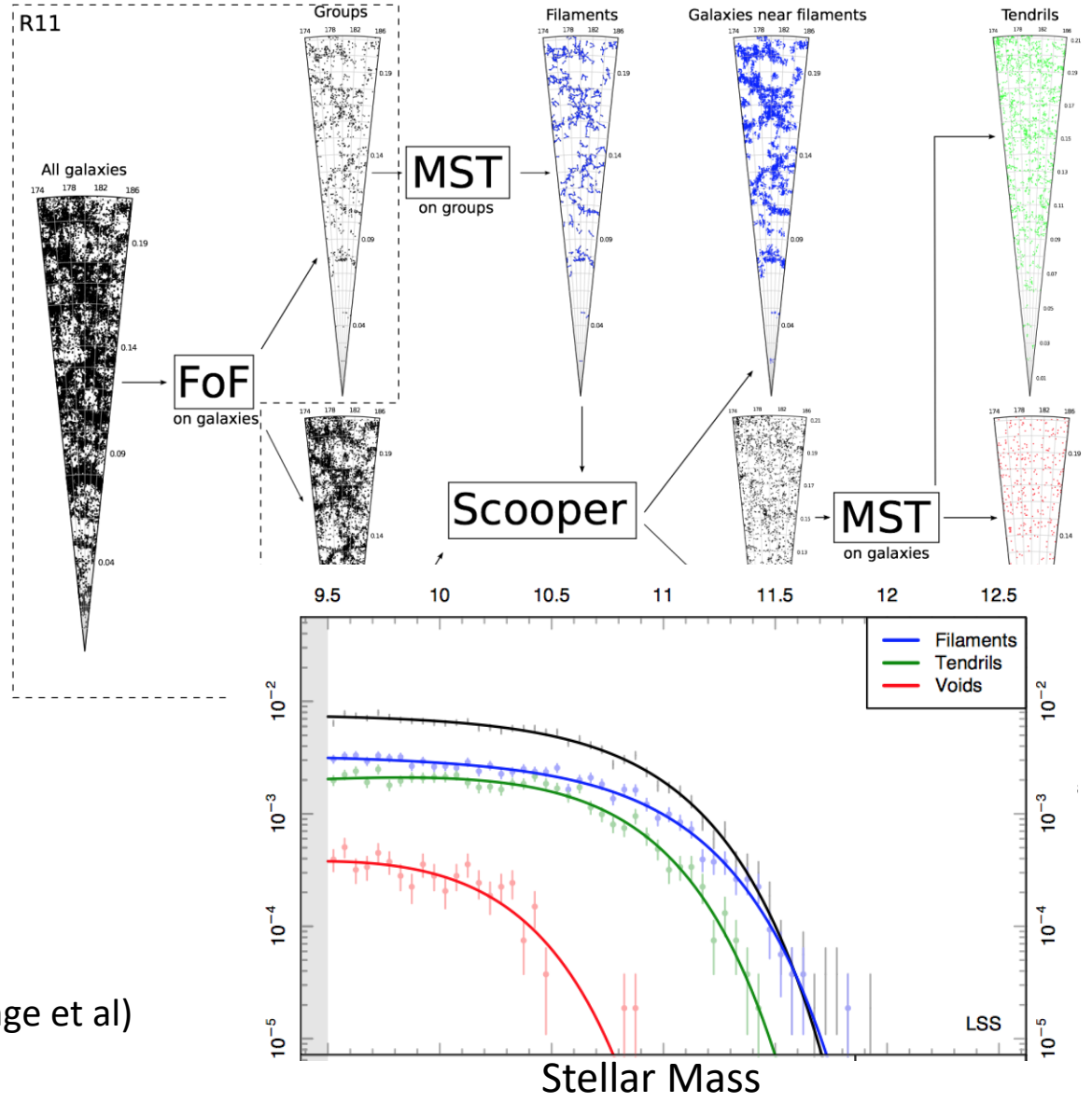

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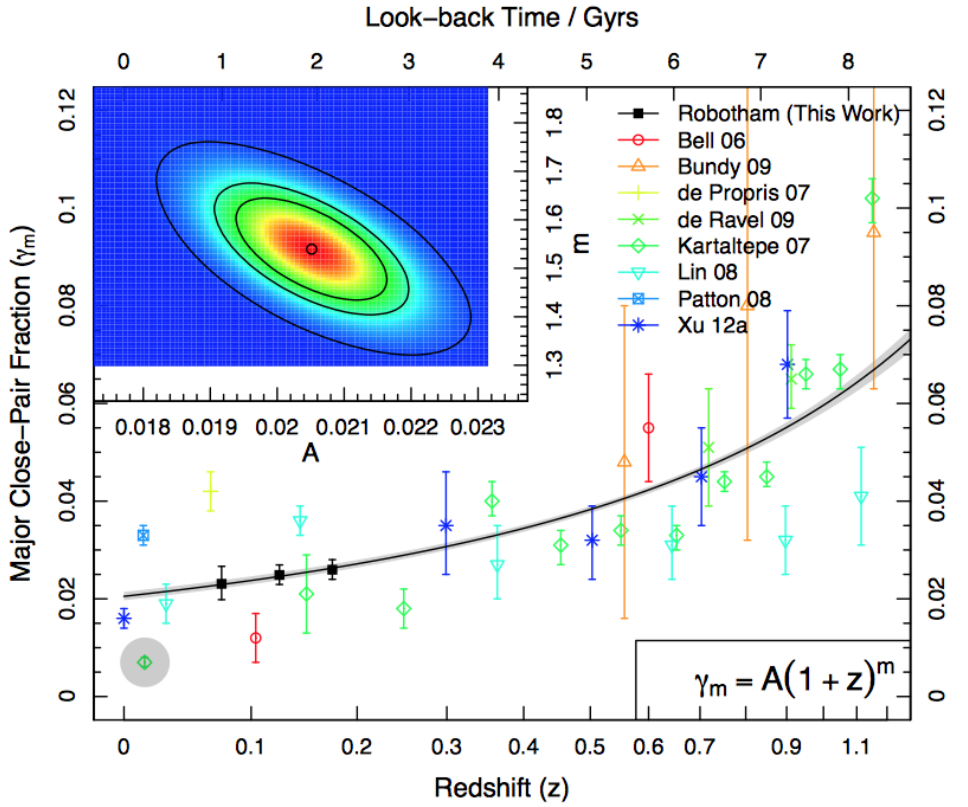

Science (z<0.1)

- Mass:
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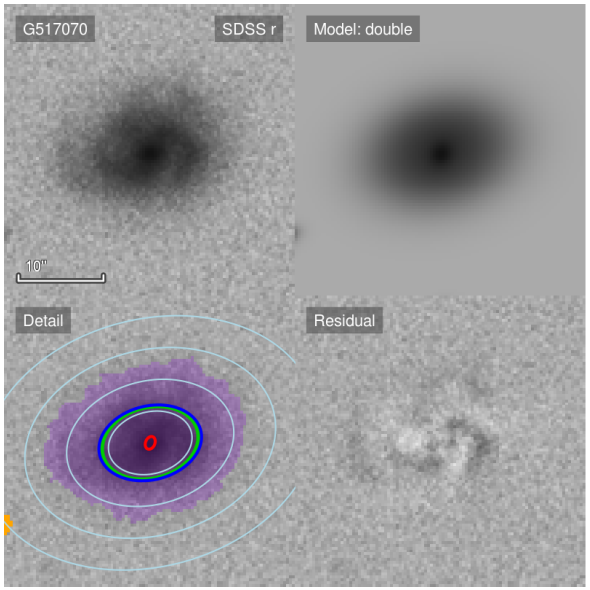
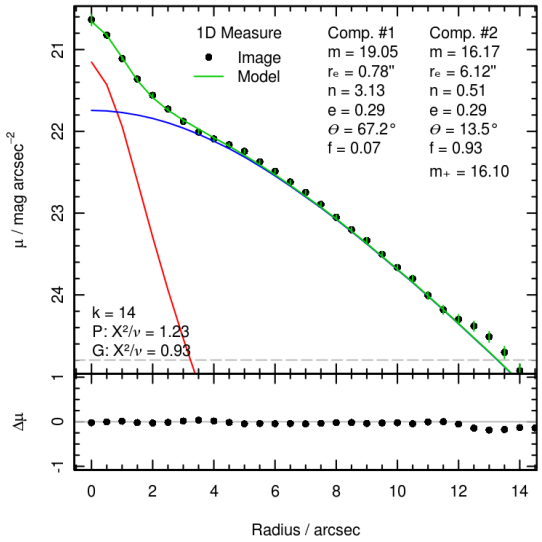
  - Bulge-disc decomposition (Lange et al, Haussler et al)





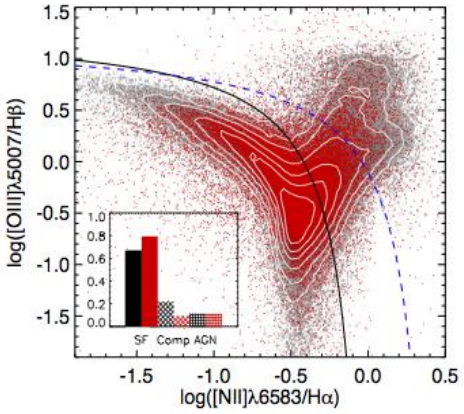
Stellar Mass Budget

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

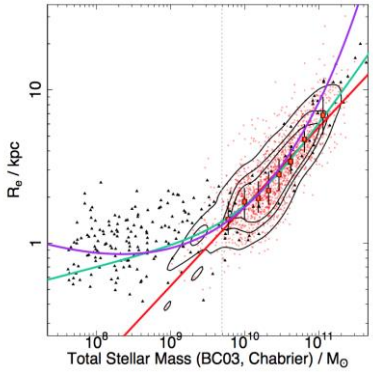
and so much more…

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

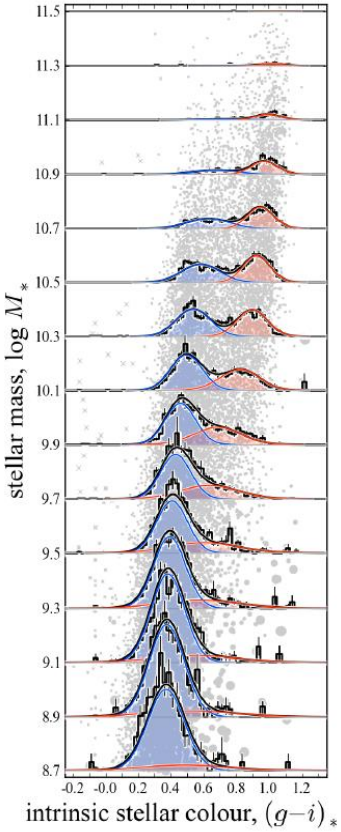
AGN



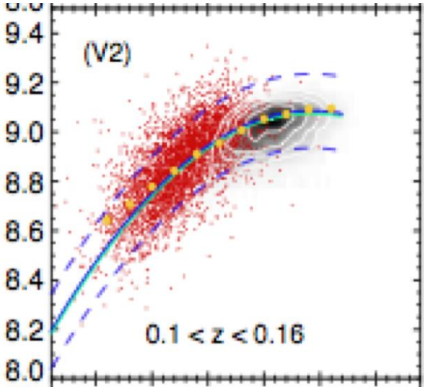
Mass-size relation



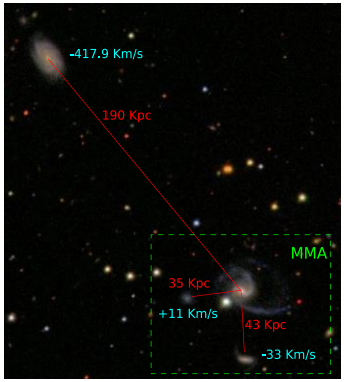
Bimodality



MASS-METALICITY

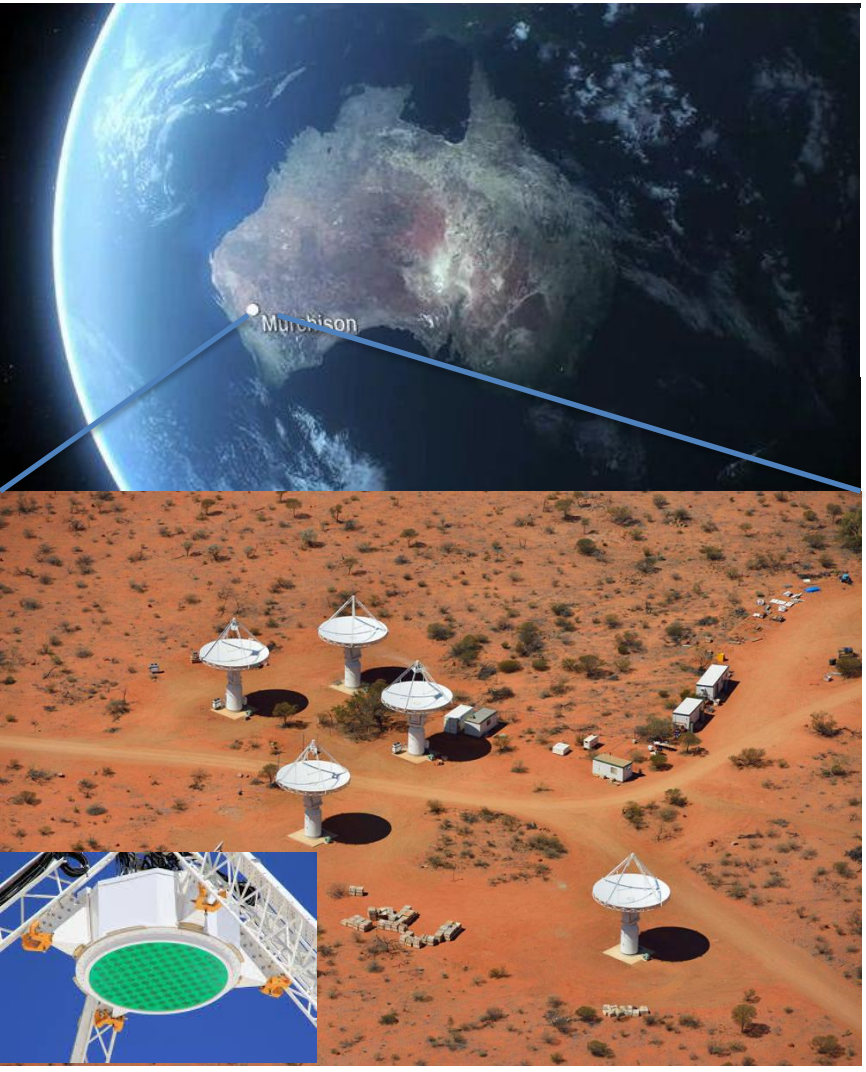


Local Group Analogs

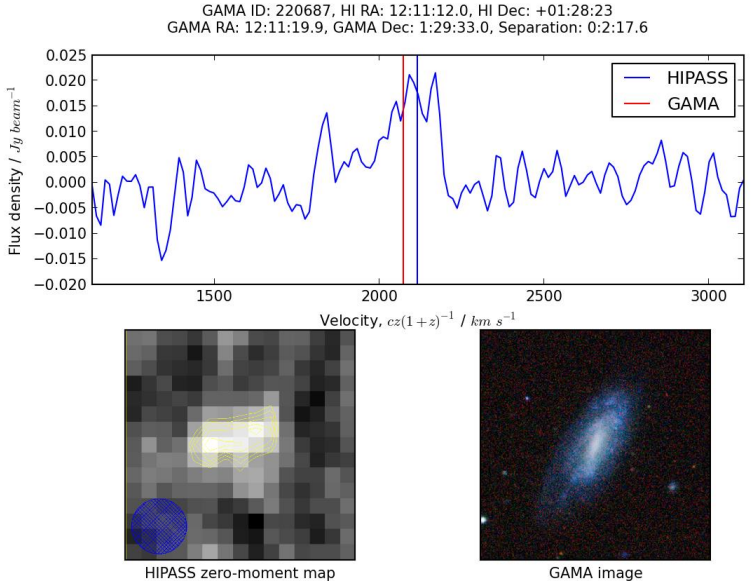


But best still to come……→

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



Moving out in z.

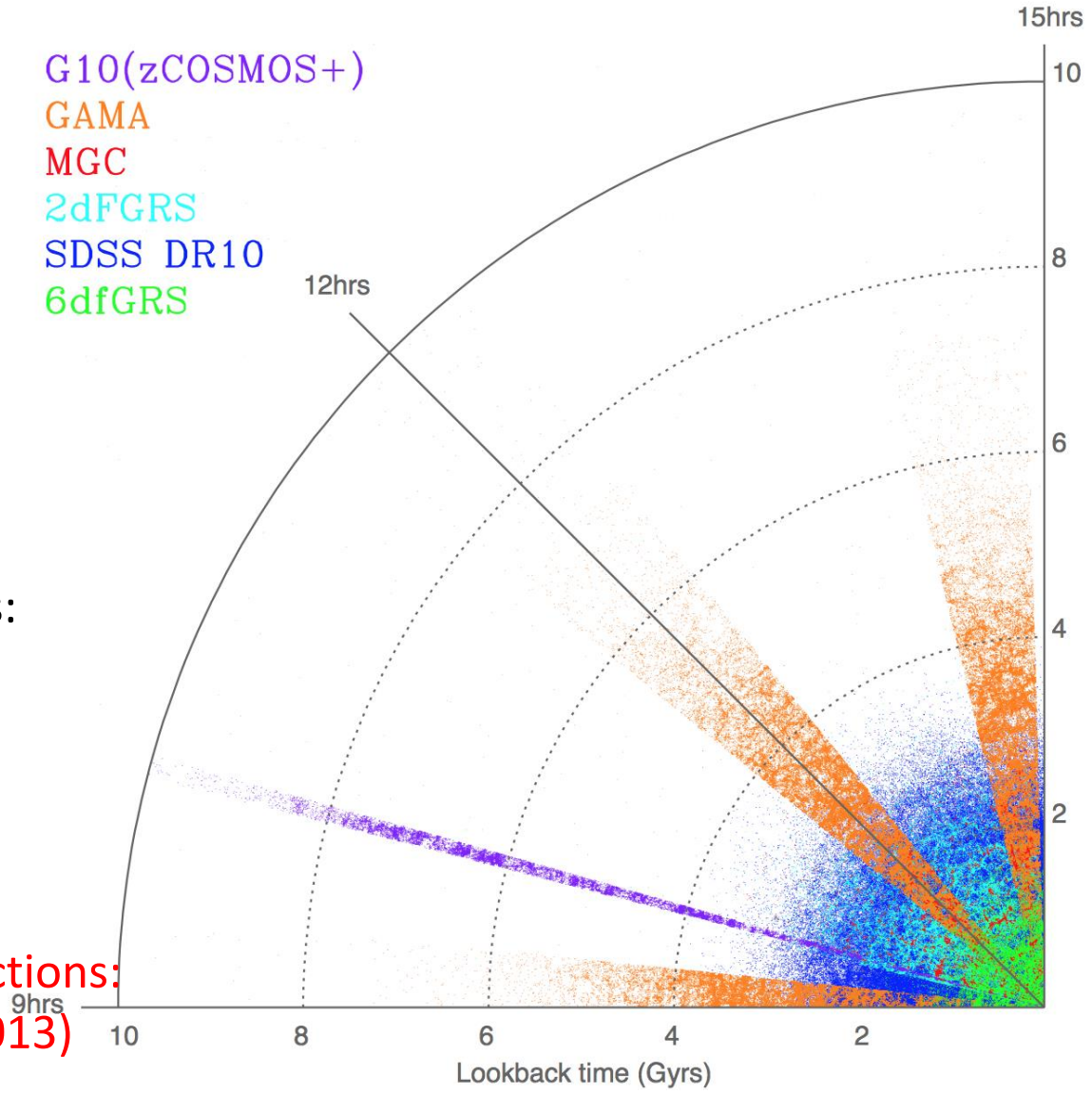
GAMA = one hand clapping

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

Only currently available dataset is COSMOS

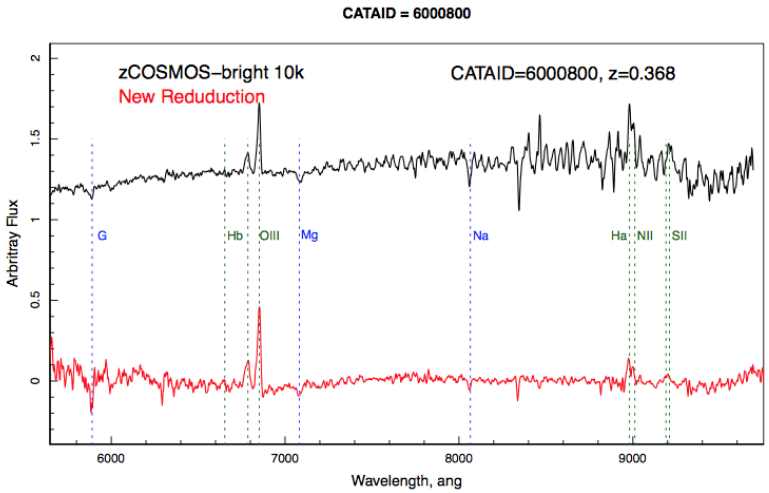
Hence lets *GAMIfy* COSMOS, i.e., Use identical software/techniques:

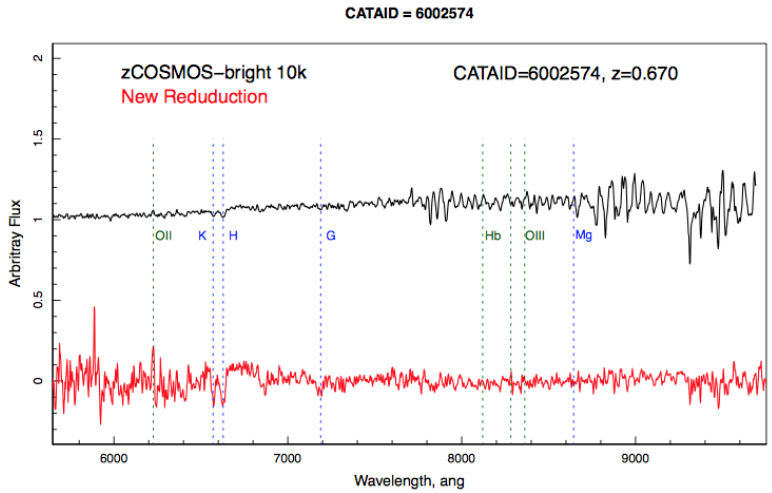
- pairs, groups
- stellar masses
- SFRs
- panchromatic photometry
- bulge-disc decomposition
- test two-phase model predictions: energy, Z, M_* (Driver et al 2013)

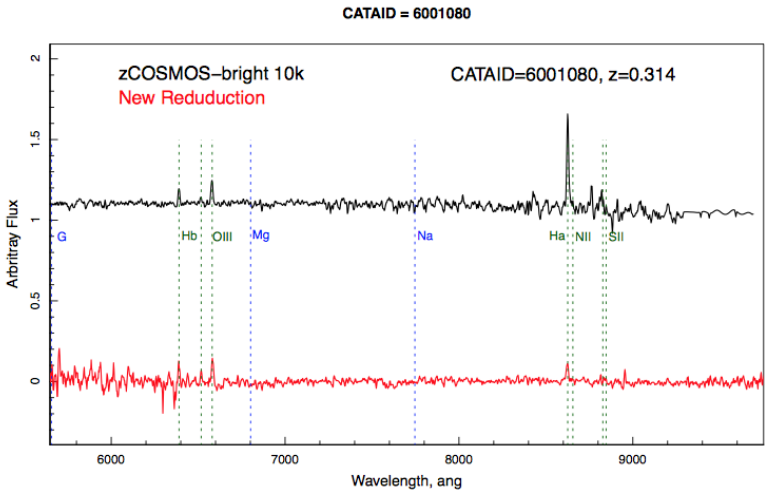


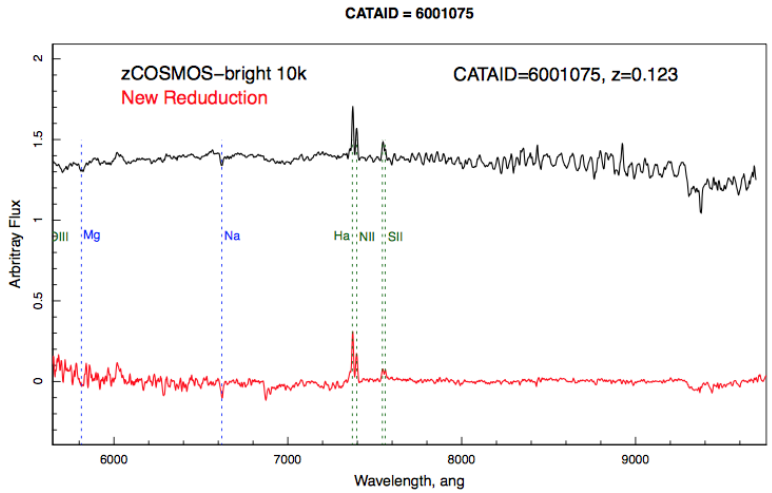
Introducing G10 aka zCOSMOS

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)







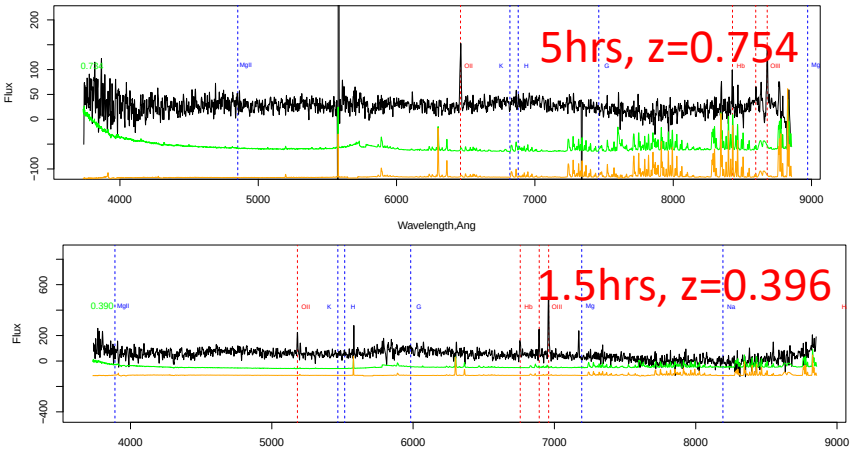


Z-COS: Finishing (z)COSMOS

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

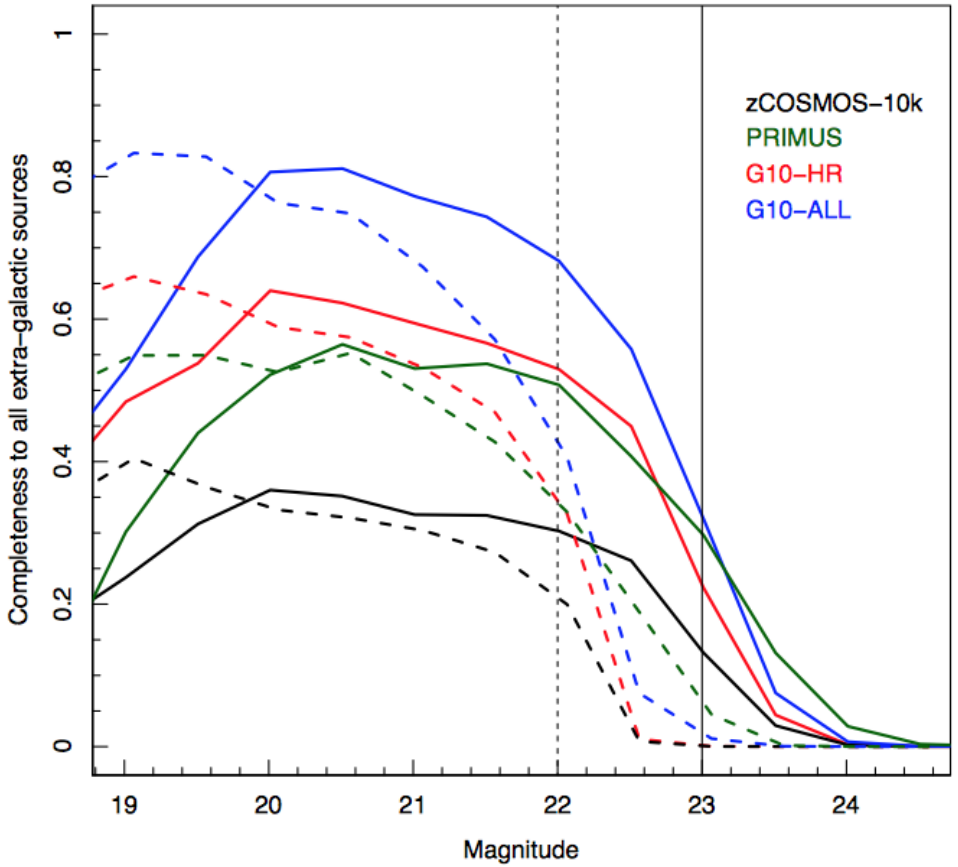
With 15 nights of AAT/AAOmega time can complete COSMOS to >90% completeness

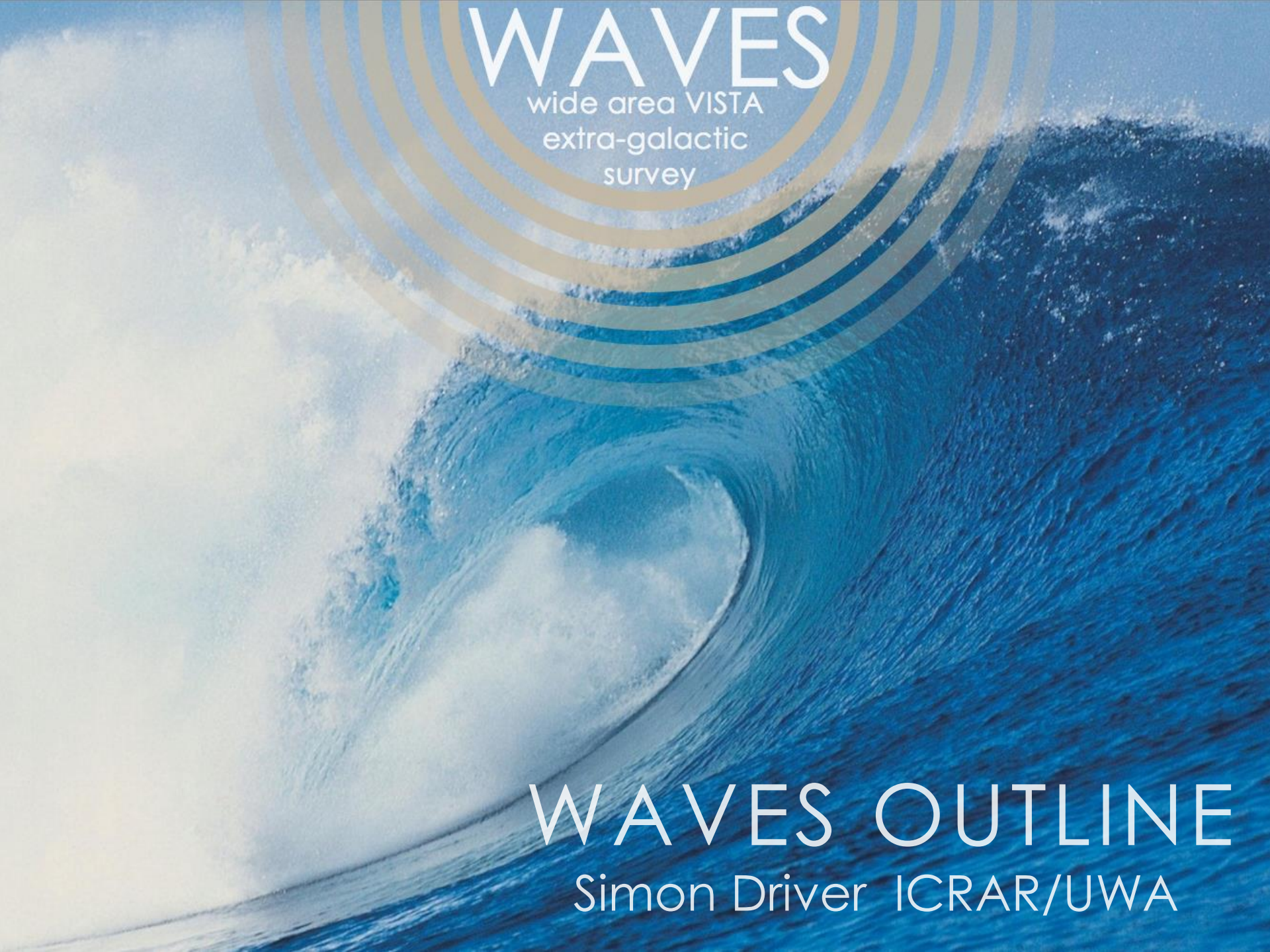
Demonstrated from deep (r<22 mag) observations in G15 field following AAOmega detector upgrades



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

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



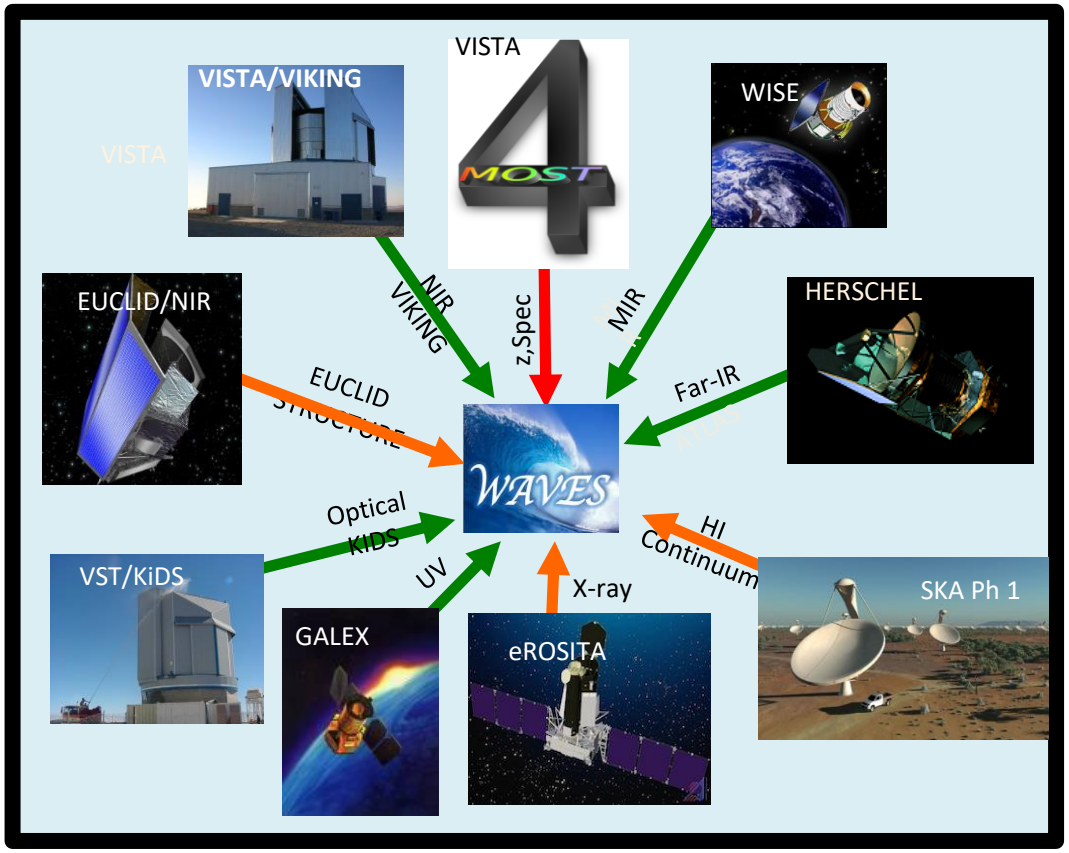


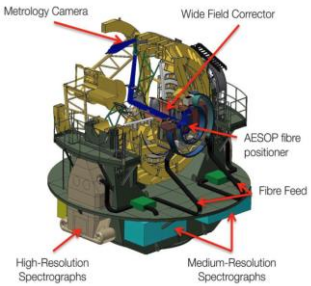
WAVES OUTLINE

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)

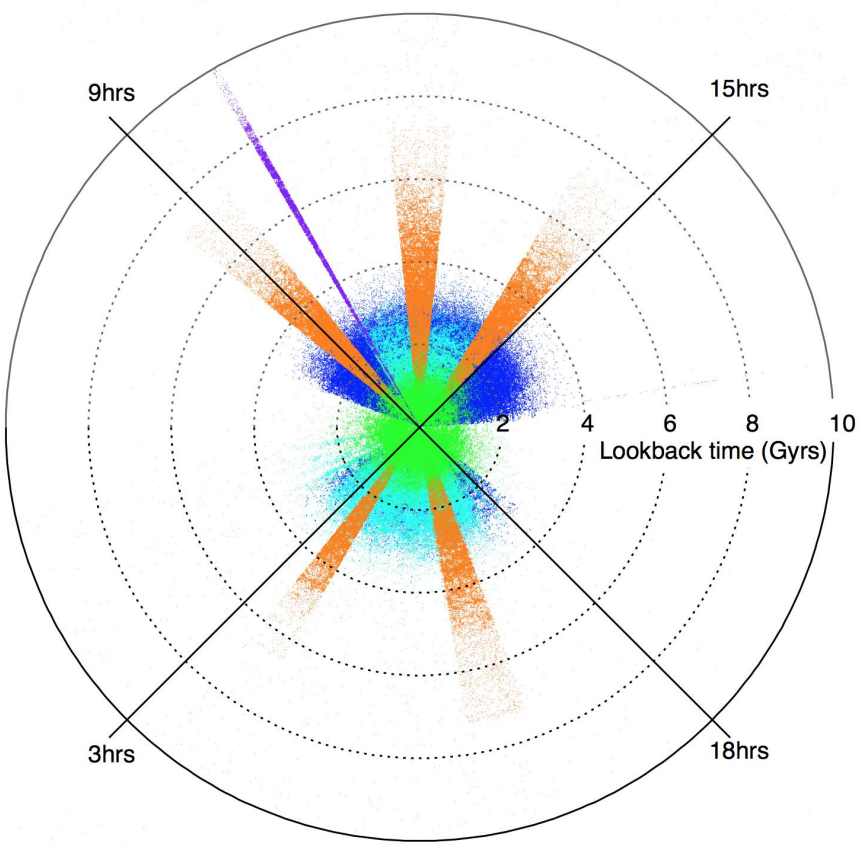
Mass, Energy, Structure to z=1

Deep = 75x zCOSMOS

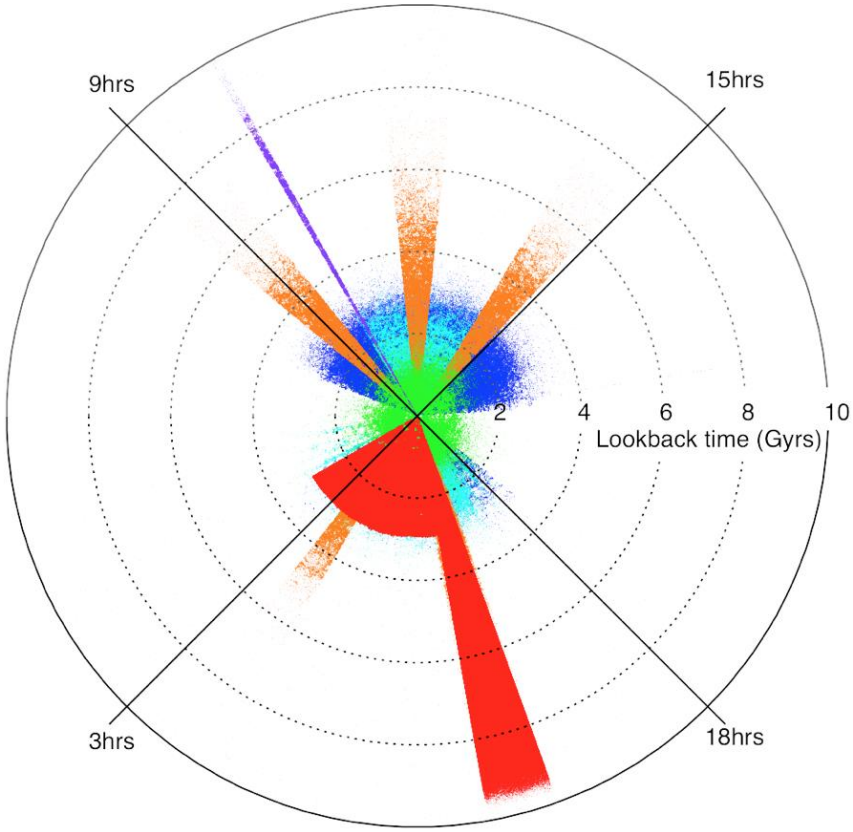
WAVES
wide area VISTA
extra-galactic
survey

WAVES cone plot

SDSS scale project locally to very low mass AND out to z~0.8



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



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

WAVES
wide area VISTA
extra-galactic
survey

WAVES survey area

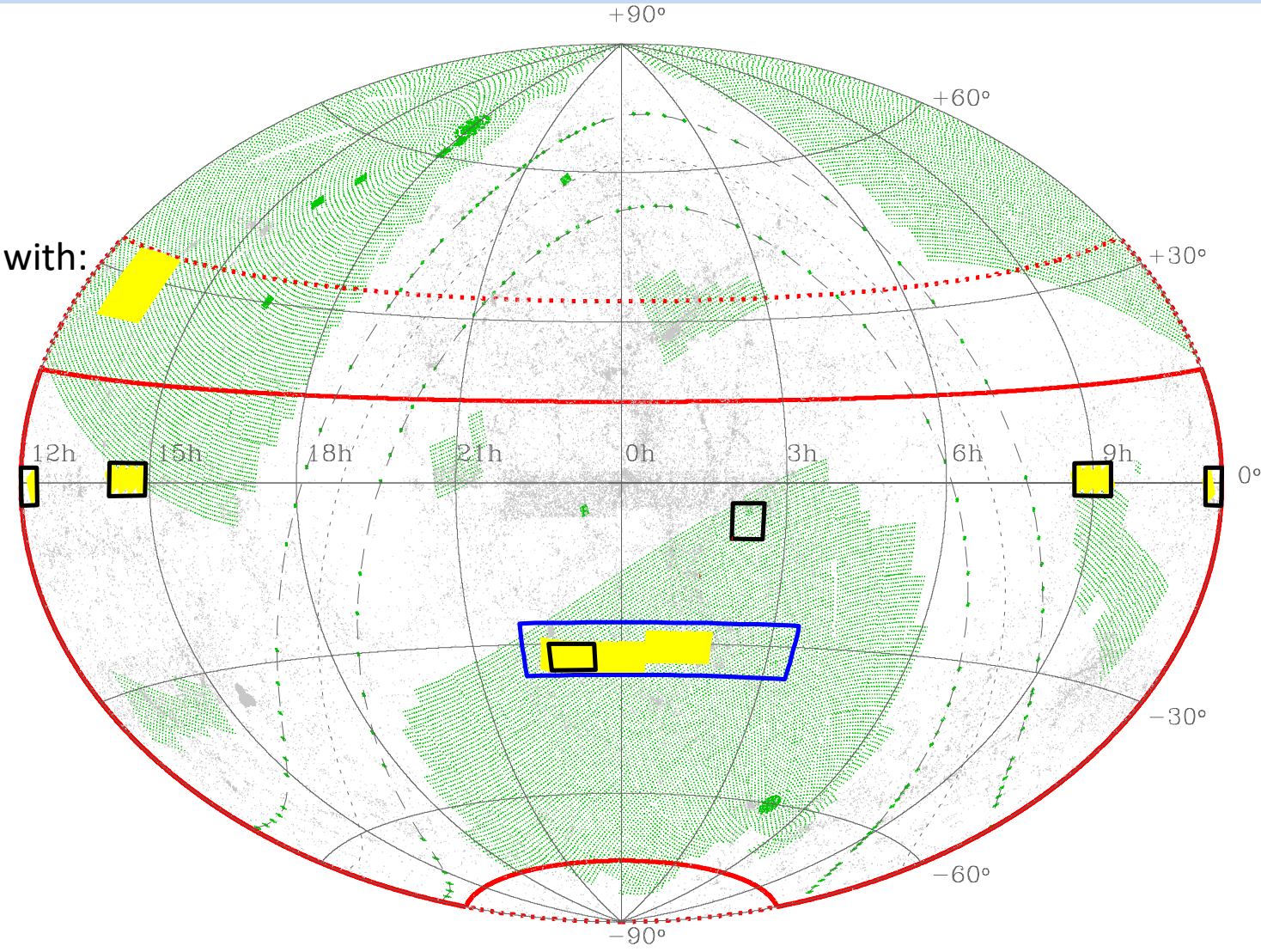
Input Cat:

KiDs+VIKING

Optimised for overlap with:

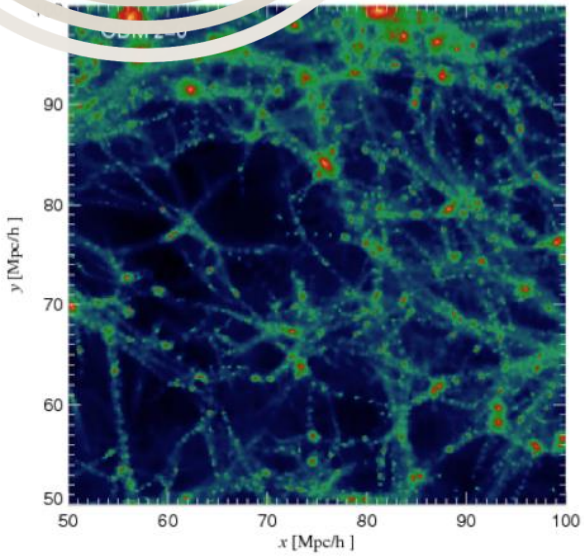
Herschel
EUCLID
SKA
LSST
VLT/ELT
Hector

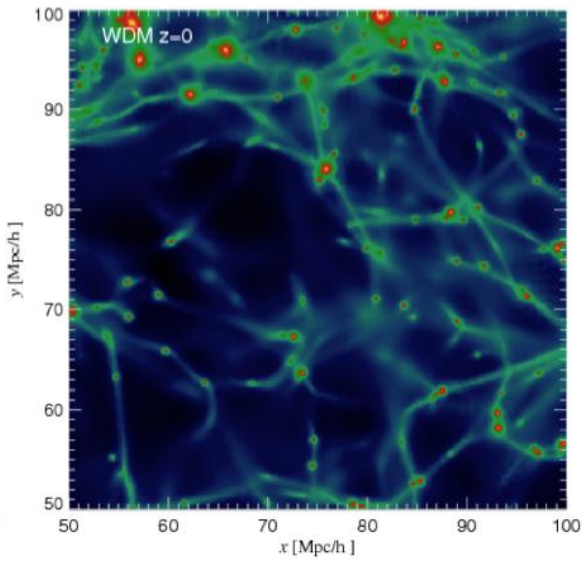
WAVES-DEEP to be located inside WAVES-WIDE area

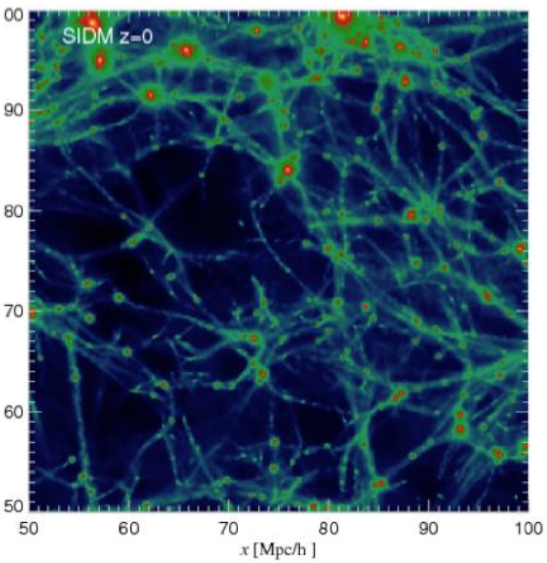


WAVES
wide area VISTA
extra-galactic
survey

Headline science

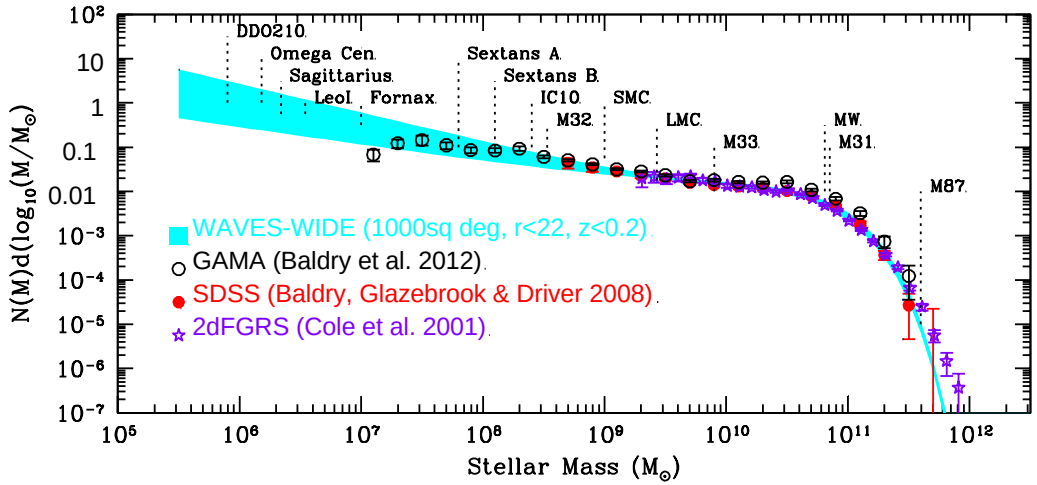






Comprehensive test of CDM/WDM on kpc-Mpc scales

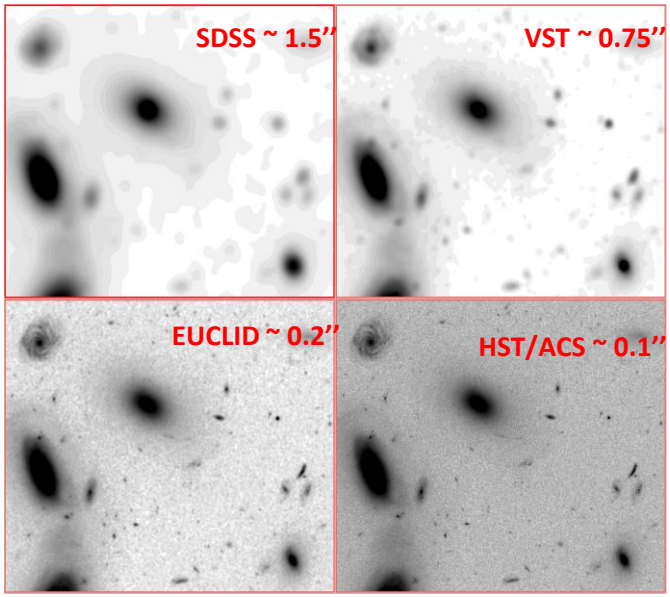
- Halo Mass Function
- Halo Occ. Stats.
- High-order statistics
- Pair frequency
- etc

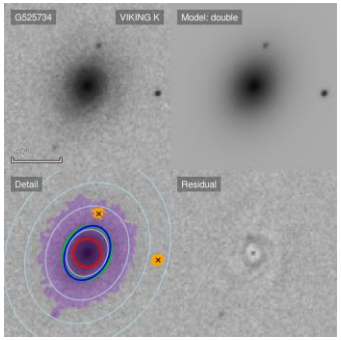


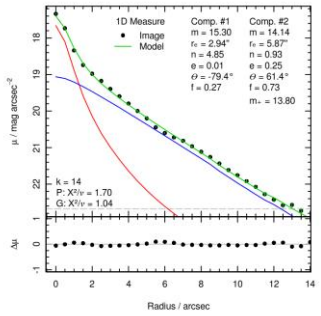
WAVES
wide area VISTA
extra-galactic
survey

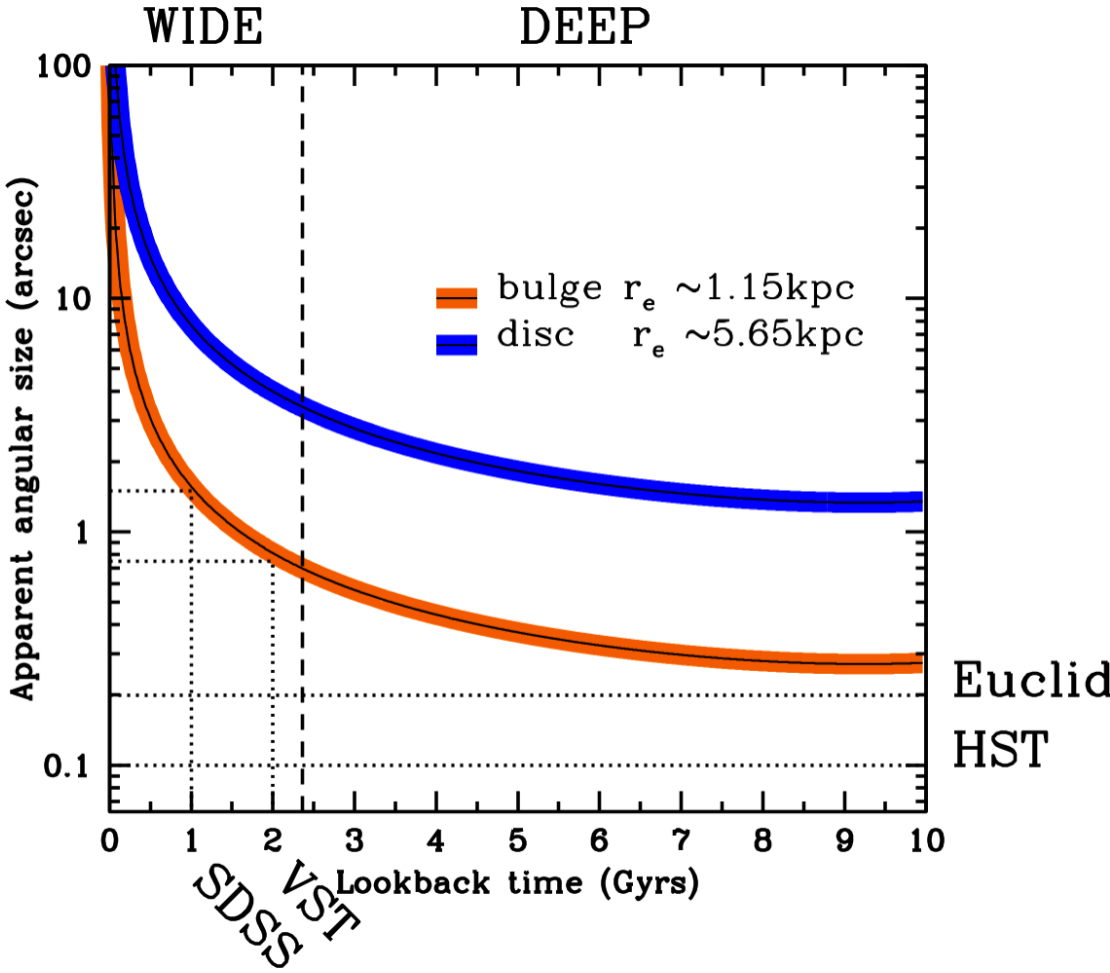
Synergy with EUCLID

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



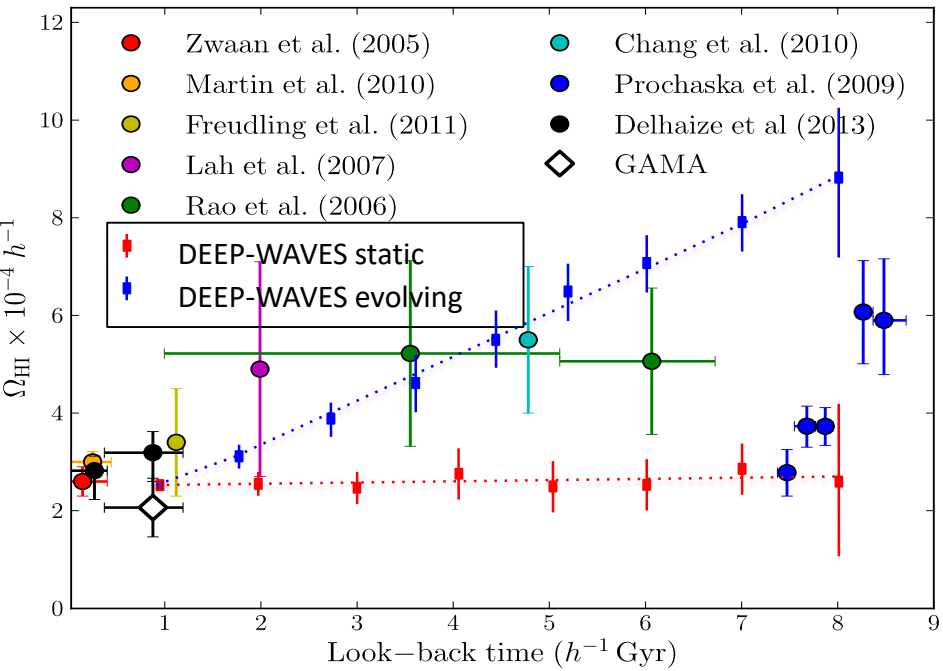


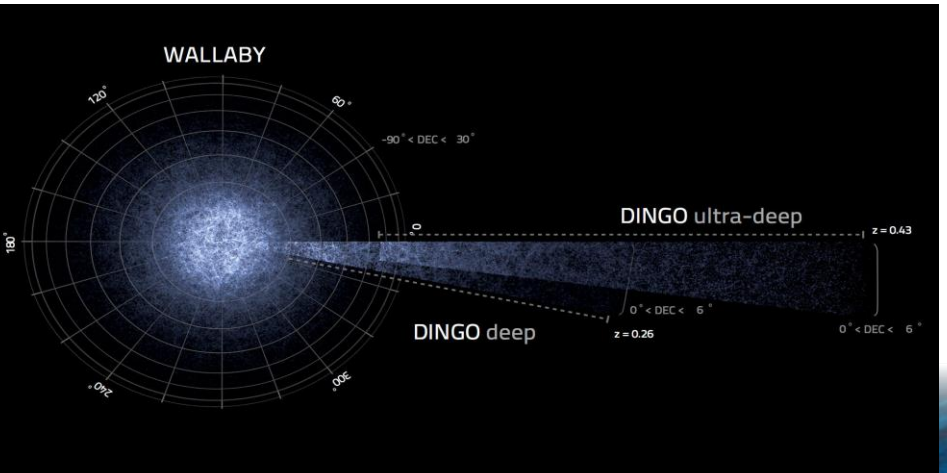




WAVES
wide area VISTA extra-galactic survey

Synergy with SKA





A deep 100 sq deg SKA-mid survey:

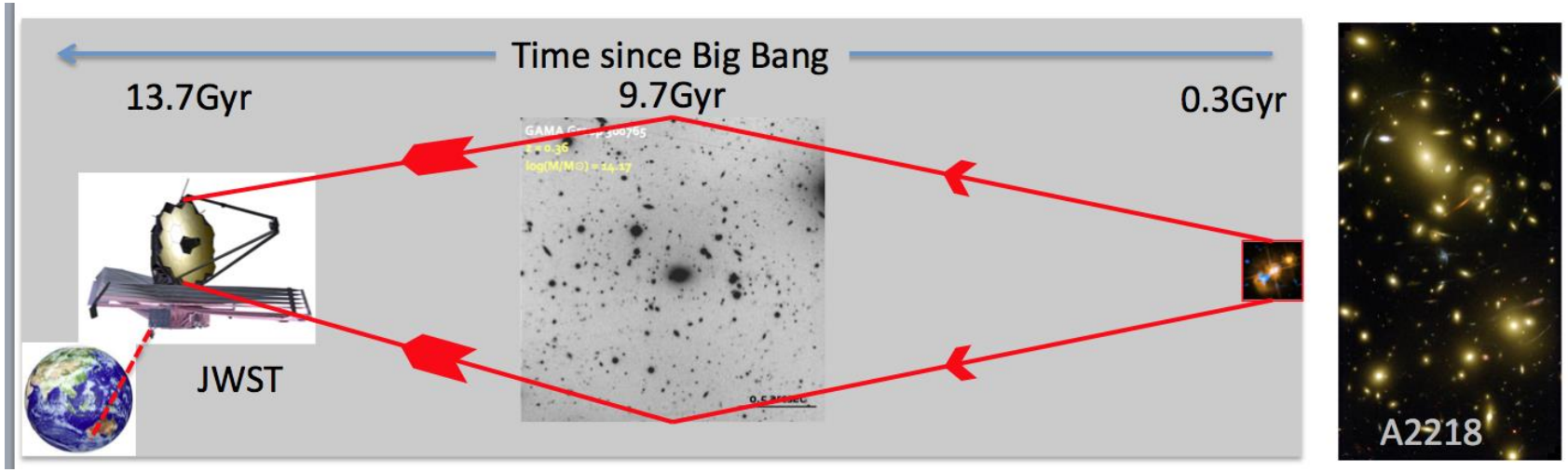
- HI detections of massive systems
  - HI masses
  - HI dynamics
- Optically motivated source finding
  - Expand sample x3
- HI stacking using WAVES selection
  - galaxy type
  - halo mass
  - SFR
- Continuum
  - SFR estimates

A wide 700 sq deg SKA-mid survey

- As above by shallower
- Similar to WALLABY & DINGO but to z~1

WAVES
wide area VISTA
extra-galactic
survey

Synergy with JWST



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

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

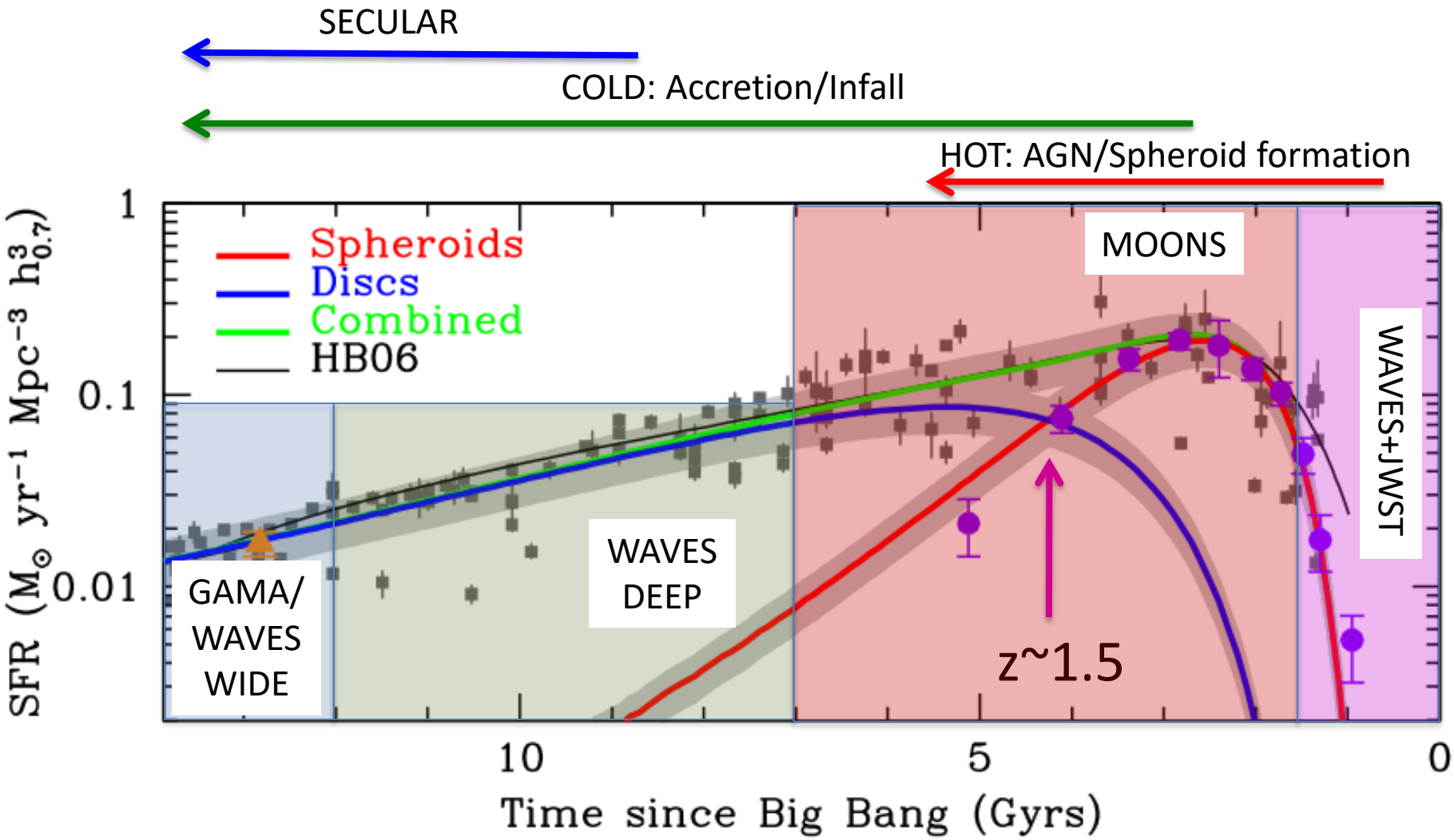
Initially use GAMA groups as gravitational lenses and switch to WAVES groups later

- 110hrs GTO time (Windhorst ILS campaign)

WAVES
wide area VISTA
extra-galactic
survey

Legacy surveys

WAVES = Era of primary disc growth

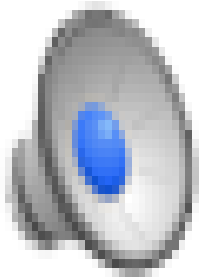


Key message

Synergy,

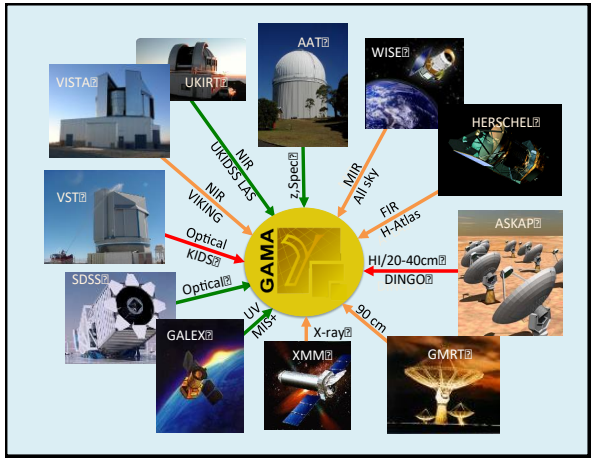
synergy,

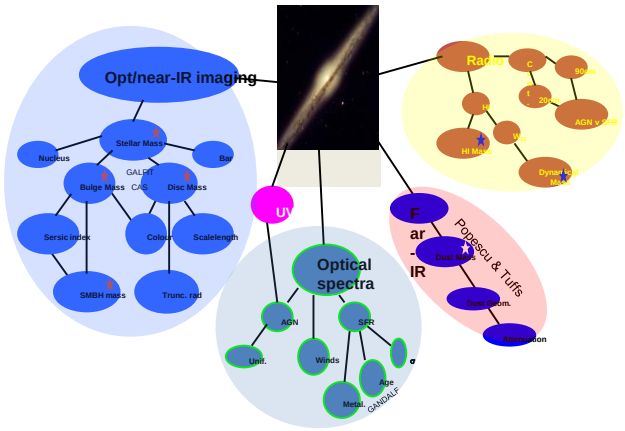
synergy

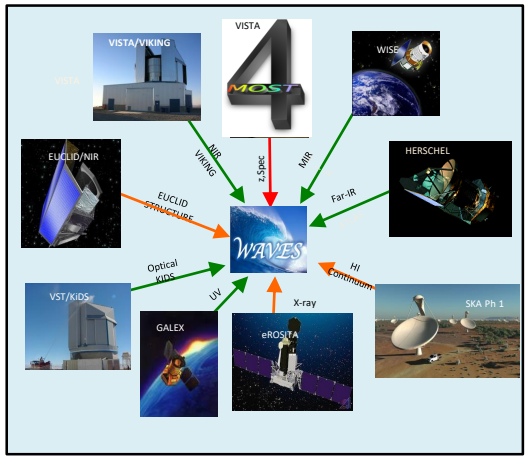


(+ stringent QC and a great database, e.g., SDSS, GAMA etc.)

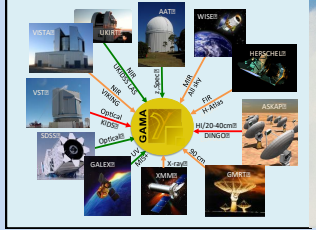
Gone are the days of single facility surveys

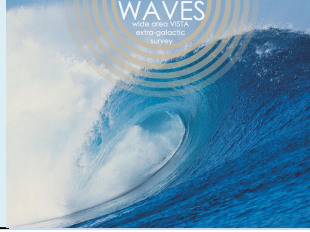




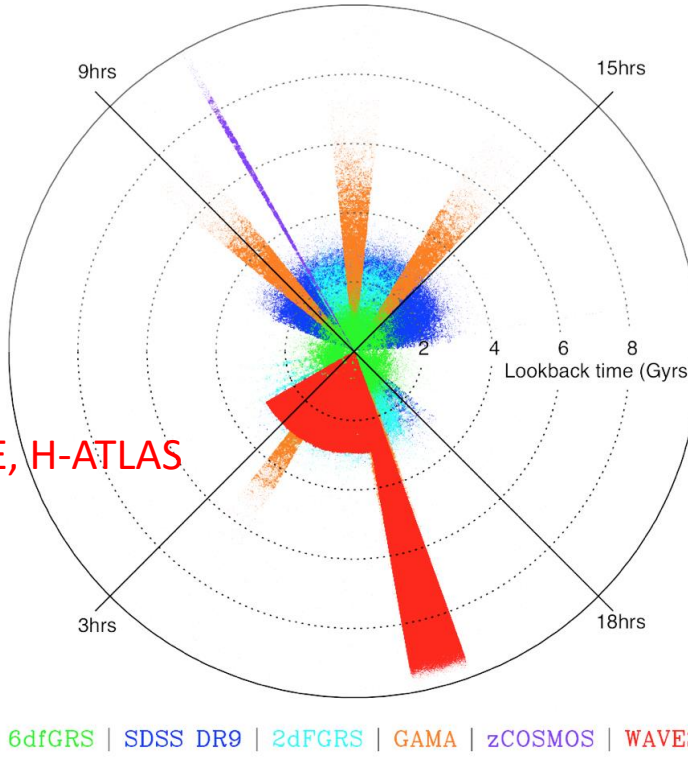


Thank-you:





- 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



- 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/

GAMAs strengths

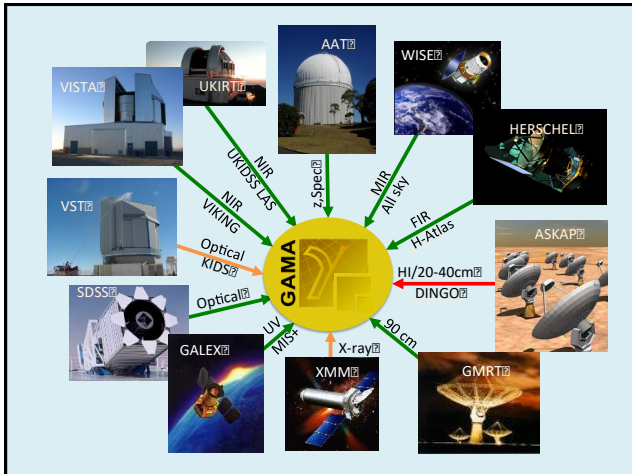
- Simple selection function (e.g., SDSS MS; 2dFGRS):
  - r<19.8 + star-gal separation using optical/near-IR colours
  - A legacy survey not a limited survey, be clever *or* versatile
  - No amount of statistics can recover what you select out

- High and uniform spatial completeness (96.7% complete, unbiased):
  - Vital for robust pair statistics and group studies
  - If galaxies evolve via merging and accelerated by halo mass, high spatial completeness is critical

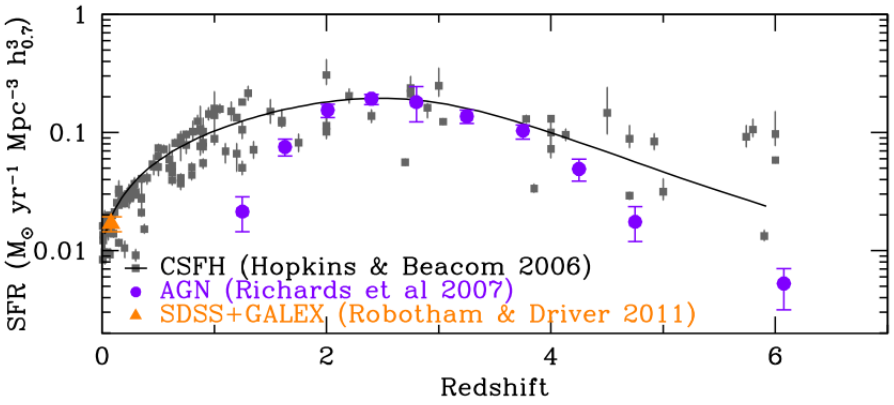
- Multi-wavelength coverage (FUV to far-IR + continuum + HI):
  - AGN (X-ray/UV/MIR/radio), Young stars (UV/opt), old stars (NIR), warm dust (mid-IR), cold-dust (far-IR), and gas (radio)
  - Panchromatic = blinkers off, don't be a backward survey!

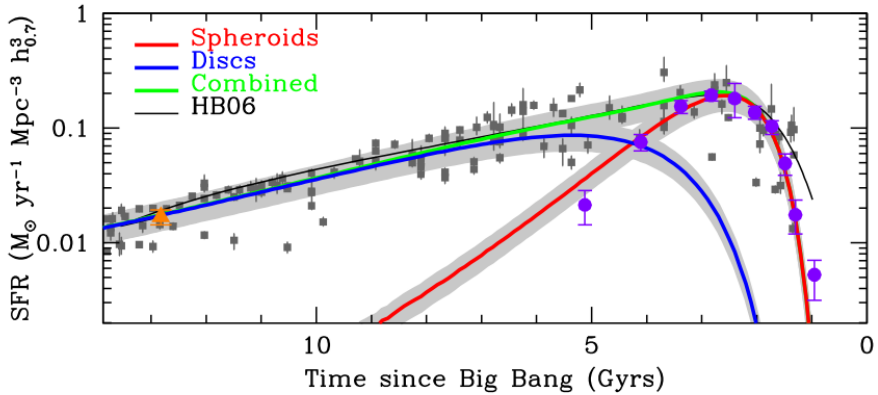
- Database and database procedures:
  - DMU process, strict QC, high standards, versatile database
  - Your data is only as good as your ability to access it (n-D)

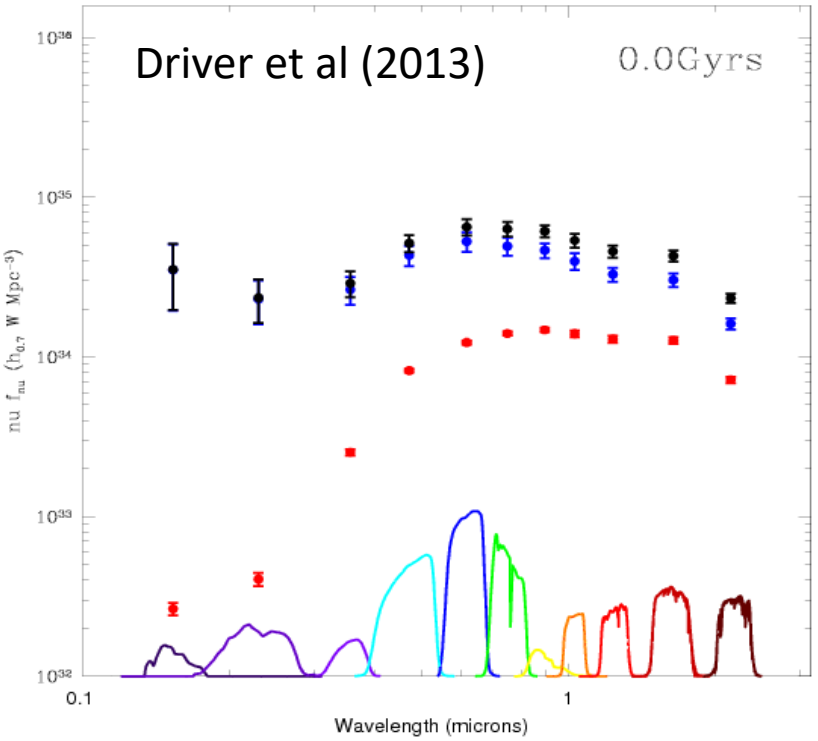
http://www.gama-survey.org/



Two phase evolution?



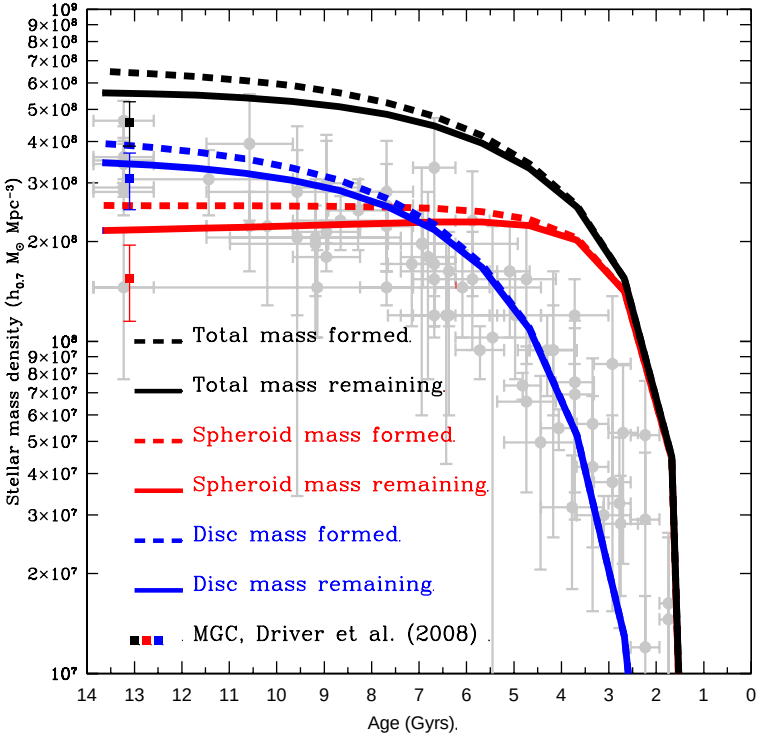


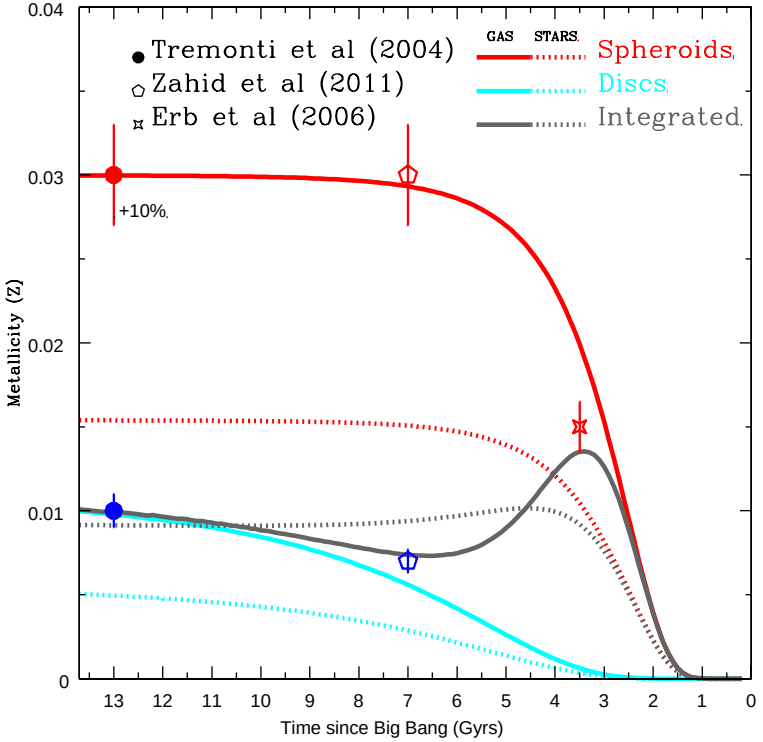


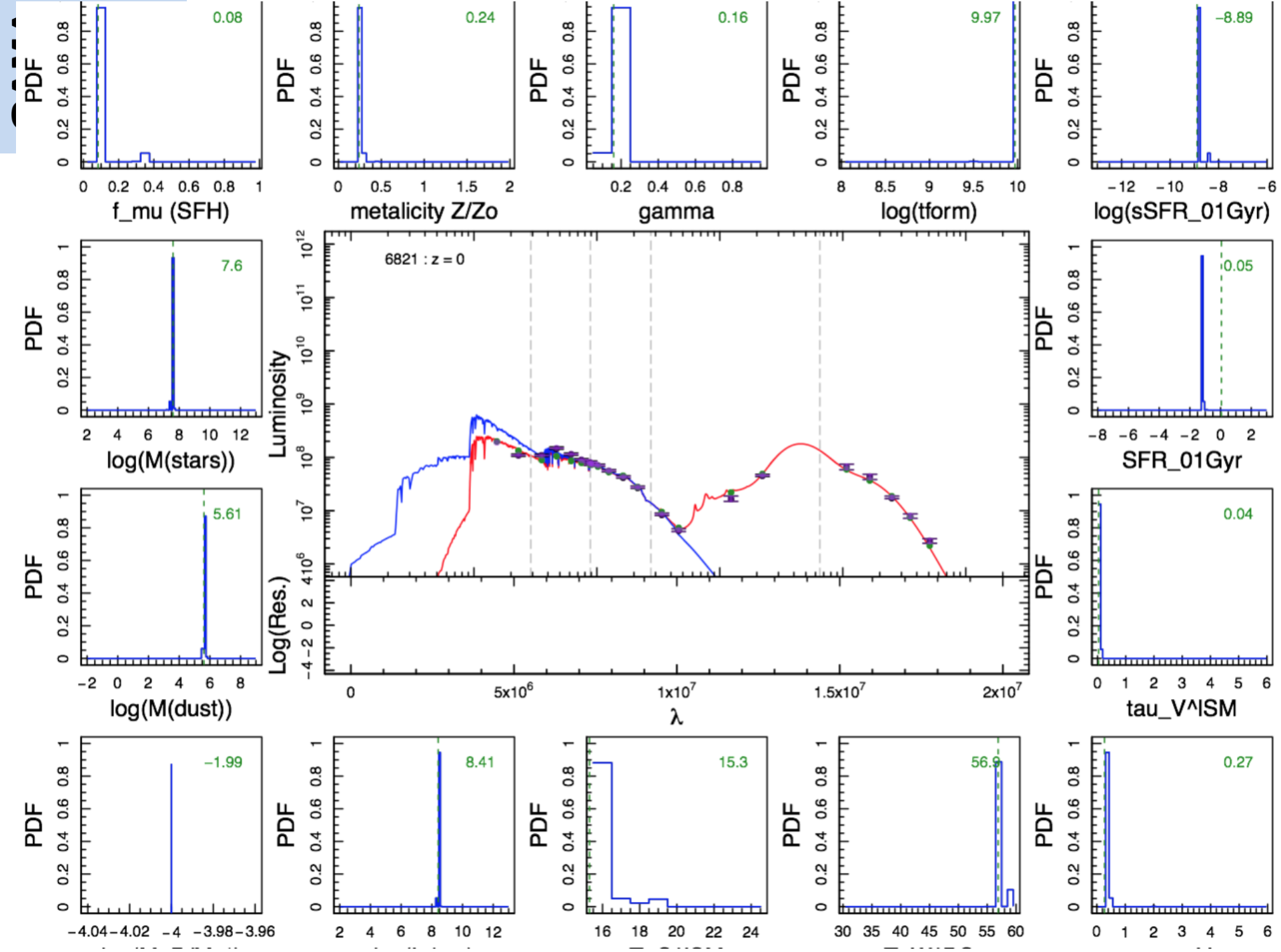
Predictions

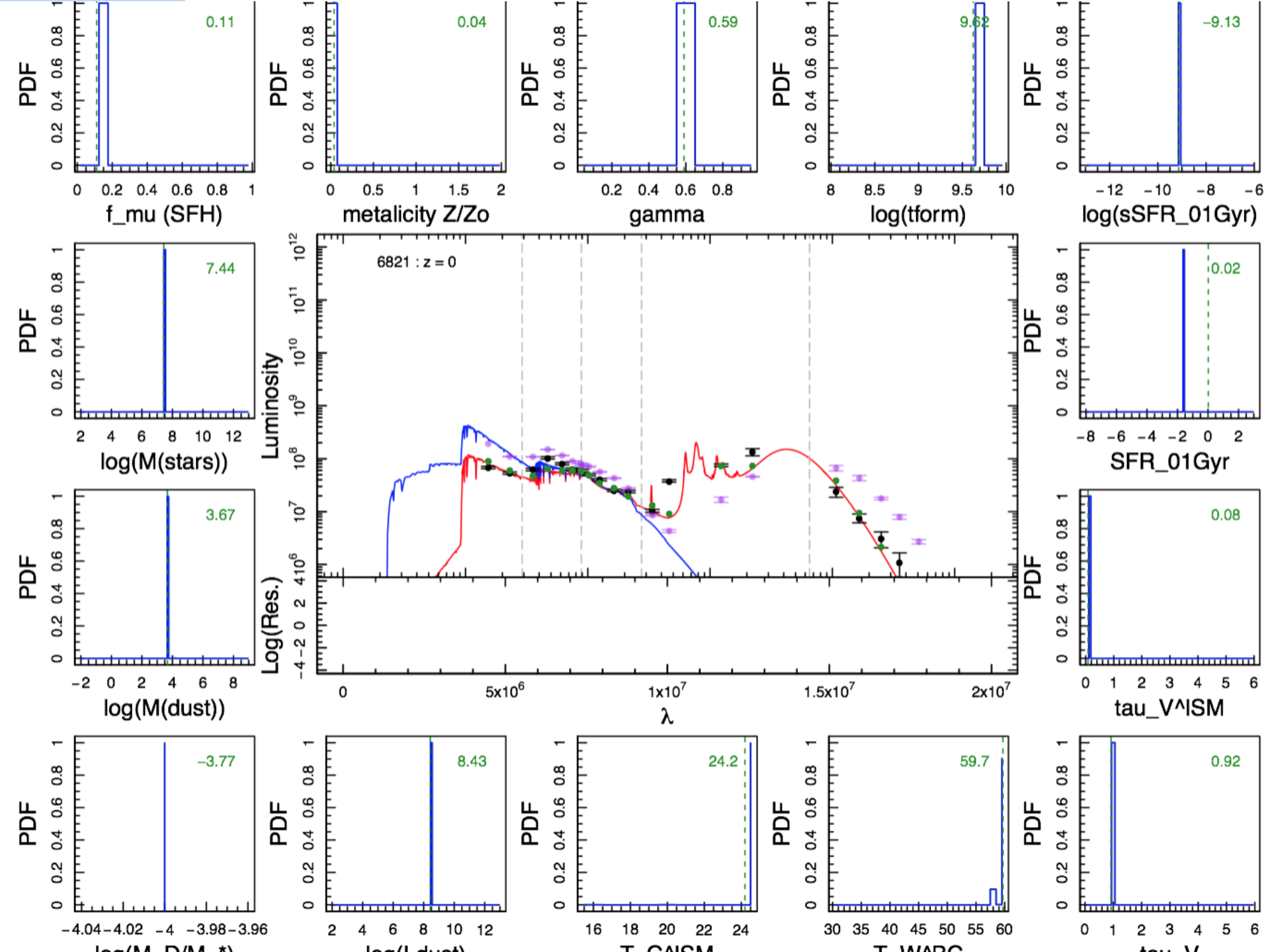
As well as a complete energy description models provides a complete prediction
Of the stellar mass build-up in spheroids and discs and their metallicity evolution

Driver et al (2013)






PDF
0.08
f_mu (SFH)
0.24
metalicity Z/Zo
0.16
gamma
9.97
log(tform)
−8.89
log(sSFR_01Gyr)
7.6
log(M(stars))
6821 : z = 0
Luminosity
Log(Res.)
λ
0.05
SFR_01Gyr
5.61
log(M(dust))
0.04
tau_V^ISM
−1.99
8.41
15.3
56.9
0.27


PDF
0.11
f_mu (SFH)
0.04
metalicity Z/Zo
0.59
gamma
9.62
log(tform)
−9.13
log(sSFR_01Gyr)
7.44
log(M(stars))
6821 : z = 0
Luminosity
Log(Res.)
λ
0.02
SFR_01Gyr
3.67
log(M(dust))
0.08
tau_V^ISM
−3.77
8.43
24.2
59.7
0.92