

# ExtraGalactic Science 2

Eric Gawiser (Rutgers)

MOSAIC-2 image: MUSYC E-HDFS UBR composite



# ExtraGalactic Science 2: "2 Fast 2 Furious?"

Eric Gawiser (Rutgers)



# ExtraGalactic Science 2: "The Wrath of Photons?"

Eric Gawiser (Rutgers)



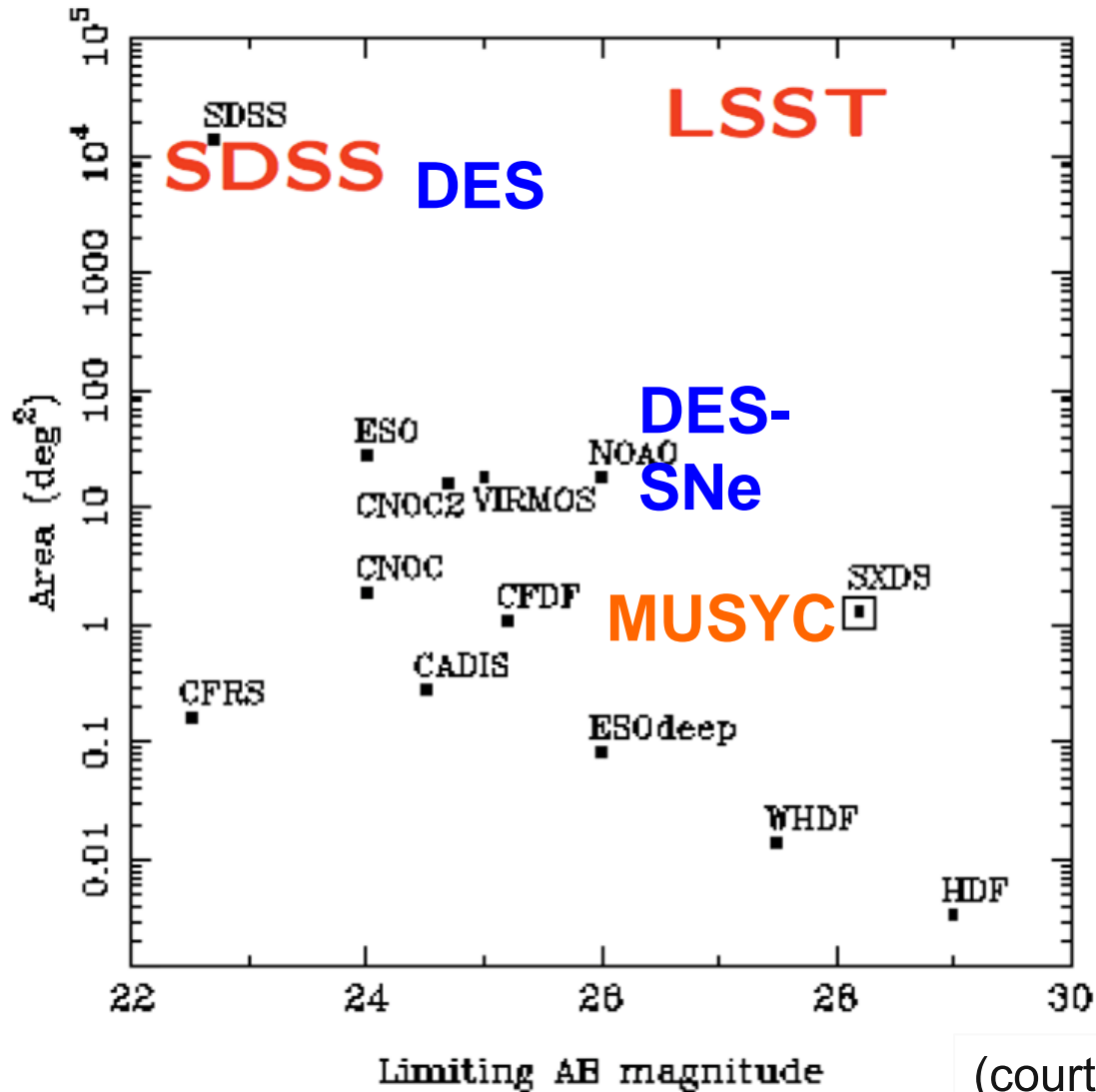
# ExtraGalactic Science 2: "The DECam Strikes Back"

Eric Gawiser (Rutgers)

# Extragalactic Surveys with DECam

- Galaxy evolution & Galactic science with DES data
- Parameter space available – what you cannot do with DES data but can achieve in a few-to-many Blanco nights
- View DECam as intermediate between existing MOSAIC surveys (e.g., NDWFS, DLS, MUSYC) and LSST
- Science drivers – you name it!

# Area vs. Depth



(courtesy Z. Ivezić)

# Parameter space for DECam surveys vs. existing data/DES

- Time domain – large etendue, fast readout means much of LSST science can be started now!

# Relevant Chapters from LSST Science Book

- 5 The Solar System
- 6 Stellar Populations
- 7 Milky Way and Local Volume Structure
- 8 The Transient and Variable Universe
- 9 Galaxies
- 10 AGN
- 11 Supernovae
- 12 Strong Lenses
- 13 Large Scale Structure
- 14 Weak Lensing

**429 pages of science ideas for DECam!**

**LSST Science Collaborations need pilot data**

# Parameter space for DECam surveys vs. existing data/DES

- Time domain – fast readout means much of LSST science can be attempted now!
- More area at same depth
  - DES covers a lot of area, but can add filters to DES area, target Galaxy, etc.

# Parameter space for DECam surveys vs. existing data/DES

- Time domain – fast readout means much of LSST science can be attempted now!
- More area at same depth
  - DES covers a lot of area, but can add filters to DES area, target Galaxy, etc.
- More depth
  - DES SNe fields cover 30 square degrees, but can add filters, target other fields, go deep in Year 1, go deeper in single field

# What filters are worth adding?

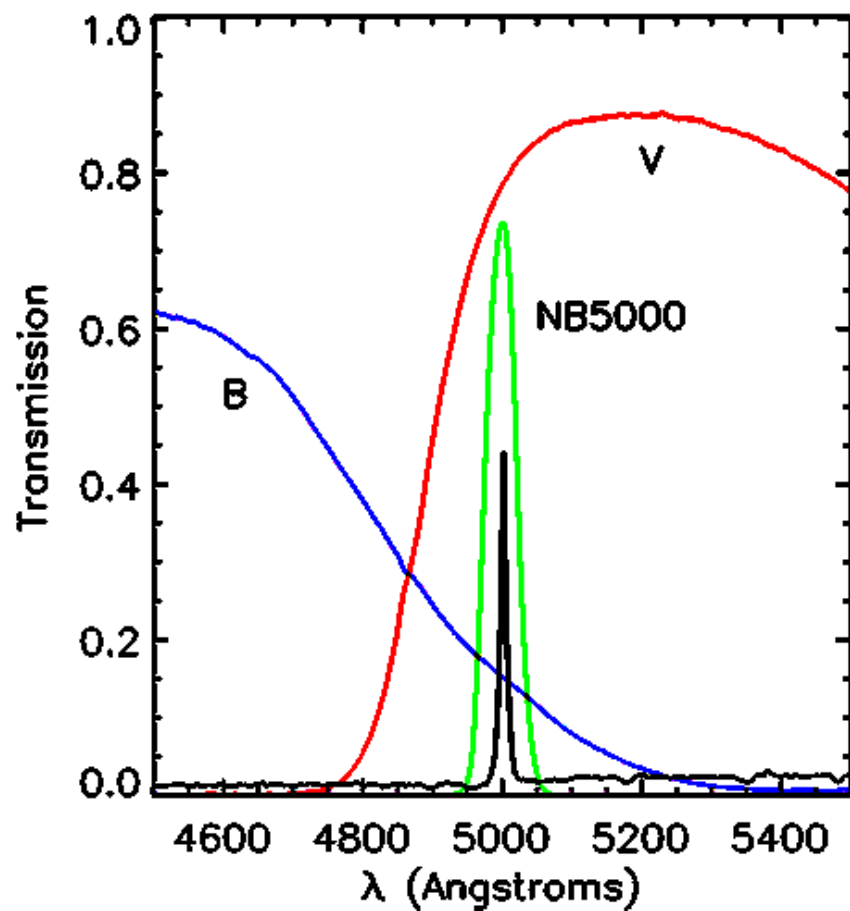
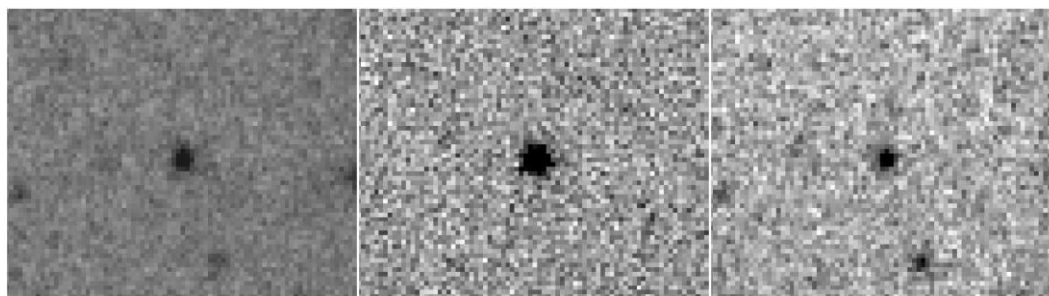
- u-band! Improve photo-z, study low-z SF, select tens of thousands of  $z=3$  LBGs
- very broad red (izy?) filter for NEOs etc.
- medium-band set – expensive but technically feasible & great for photo-z
- narrow-band???

# Lyman $\alpha$ Emitting (LAE) Galaxy

B

NB5000

V



# Are narrow-band filters useful for DECam?

**Concerns: Central wavelength will vary with radius  
Bandpass will not be uniform**

**Solutions: Embrace the first, calibrate the second**

**For emission-line galaxy (LAE) selection, just changes the shape of the survey volume**

**Could you build a single H $\alpha$  filter that works in MW, MCs & Local Group? (put a target with given radial velocity a corresponding radius from field center; you lose FOV)**

# Multiwavelength Coverage for DECam Deep Fields

**Can put Deep Fields on existing survey fields of  
GALEX/WFC3, VISTA (JHK), Akari, Warm Spitzer Mission,  
etc.**

**Advantage in defining fields soon and coordinating  
coverage ahead of time (e.g., with LSST Deep Fields)**

**We need a World-Access Wiki for Astronomy to  
coordinate the next generation of deep-wide  
multiwavelength surveys – who wants to host it?**

# MUSYC

(Multiwavelength Survey by Yale-Chile)

Eric Gawiser (Rutgers, P.I.)  
Pieter van Dokkum (Yale)  
Paulina Lira (U. Chile)  
Meg Urry (Yale)  
Viviana Acquaviva (Rutgers)  
Michael Berry (Rutgers)  
Nicholas Bond (NASA GSFC)  
Carie Cardamone (MIT)  
Robin Ciardullo (Penn State)  
John Feldmeier (Youngstown State)  
Harold Francke (P.U. Católica)  
Marijn Franx (Leiden)  
Lucia Guaita (Stockholm)  
Caryl Gronwall (Penn State)  
Minh Huynh (Western Australia)  
Leopoldo Infante (P.U. Católica)  
Sheila Kannappan (UNC)  
Sugata Kaviraj (Imperial College)  
Mariska Kriek (Harvard-CfA)  
Peter Kurczynski (Rutgers)  
Danilo Marchesini (Tufts)  
Ana Matkovic (Penn State)  
Nelson Padilla (P.U. Católica)  
Ryan Quadri (OCIW)  
Kevin Schawinski (Yale)  
Ezequiel Treister (Hawaii)  
Carlos Vargas (Rutgers)  
Jean Walker Soler (Rutgers)



**Public Data Release and 60 Refereed  
Publications available at:**

**<http://physics.rutgers.edu/~gawiser/MUSYC>**

**(see also Gawiser et al 2006a, ApJS 162, 1)**

# MUSYC survey design

- Square degree comprised of four 30'x30' fields (ECDF-S, EHDF-S, SDSS1030+05, Castander's Window 1255+01)
- Deep UBVRIzJHK + NB3727, NB5000Å imaging (to  $5\sigma$  depths of U,B,V,  $R_{AB}=26$ ,  $K_{AB}=23$ , NB3727=24.5, NB5000=25)
  - 25 nights with MOSAIC for UBVRIz, 50 more for narrow-band
  - 6 nights with DECam would cover 3X the area to this depth
- Public Spitzer/HST/GALEX/XMM/Chandra coverage in ECDF-S (including GOODS-S), also deep sub-mm & radio imaging
- ECDF-S also imaged with 18 Medium-Band optical filters (Cardamone/Taniguchi)
- Spectroscopic follow-up with VLT+VIMOS, FORS, Magellan+IMACS, Gemini+GNIRS

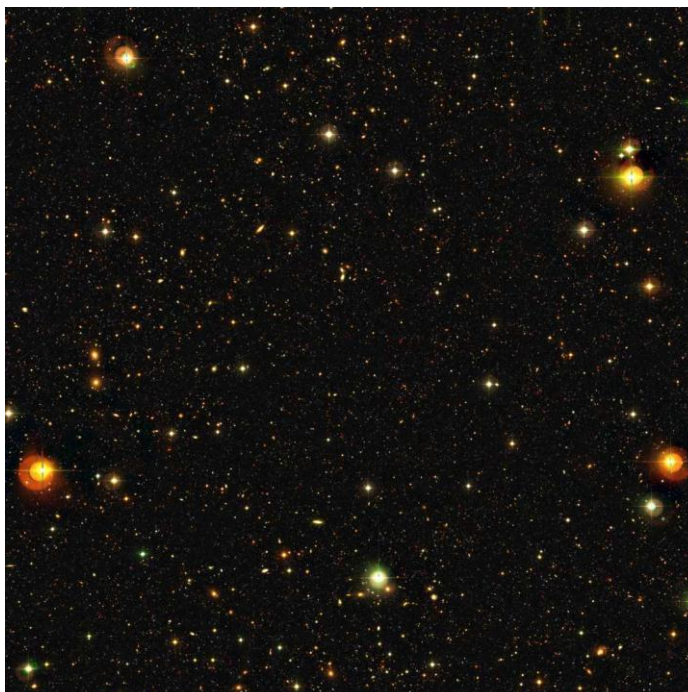
# MUSYC: A Square-degree Survey of the Formation and Evolution of Galaxies and their Central Black Holes

## Science Projects:

1. Census of galaxies at  $z=3$  (Gawiser)
  2. Evolved galaxies at  $2 < z < 3$  (van Dokkum)
  3. AGN demographics at  $0 < z < 6$  (Urry)
  4. Luminosity functions and galaxy clustering at  $z < 1$  (Christlein, Padilla)
  5. Recent star formation in ellipticals (Kaviraj)
  6. Galactic structure from colors and proper motions (Altmann)
- Etc.

U,B,R=26  
( $5\sigma$ )

*Chandra  
Deep  
Field  
South*



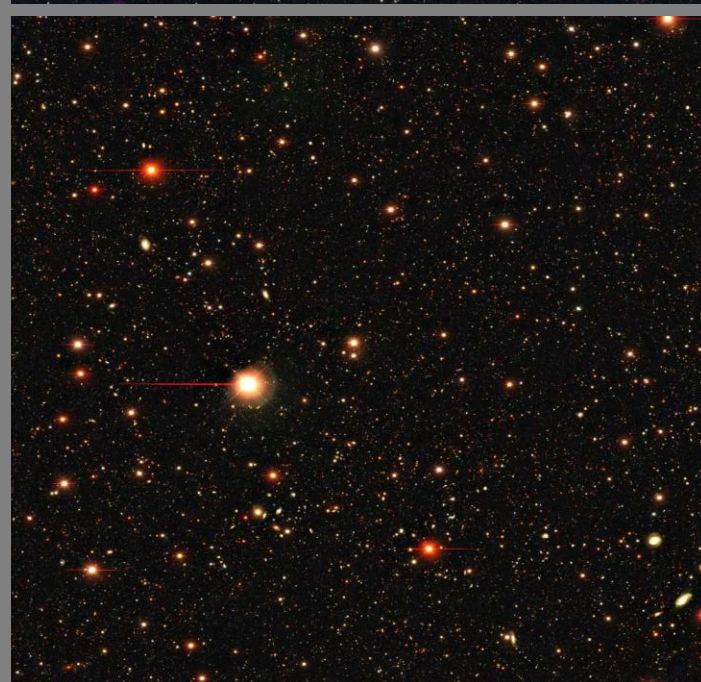
*SDSS  
1030+  
05  
 $z=6.3$   
QSO  
Field*



*Castander's  
Window  
(1256+01)*



*Hubble  
Deep  
Field  
South*

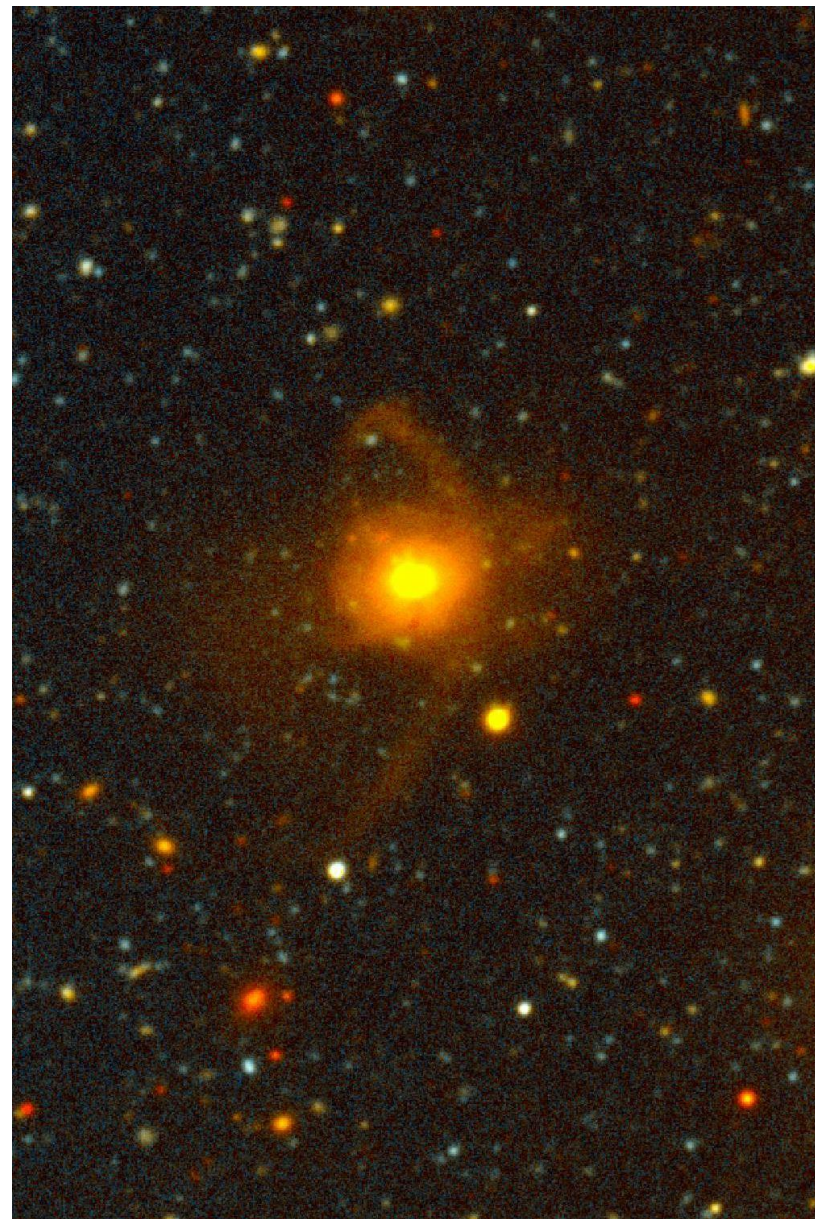


# Sloan Digital Sky Survey

**MUSYC** (100X better sensitivity)



DES (main) is intermediate  
 $\text{LSST} \approx \text{SDSS} \times \text{MUSYC}$



# Lessons for Surveys Learned from MUSYC

1. Human resources are the limiting input
2. Make friends, not war
3. Empower youth
4. S[tuff] happens – it's the response that counts
5. Survey uniformity is critical but never perfect
6. Embrace the future
7. Photometry is worth thinking about
8. Multi-wavelength coverage is important
9. Spectroscopic follow-up is critical
10. Coordination of deep fields is needed