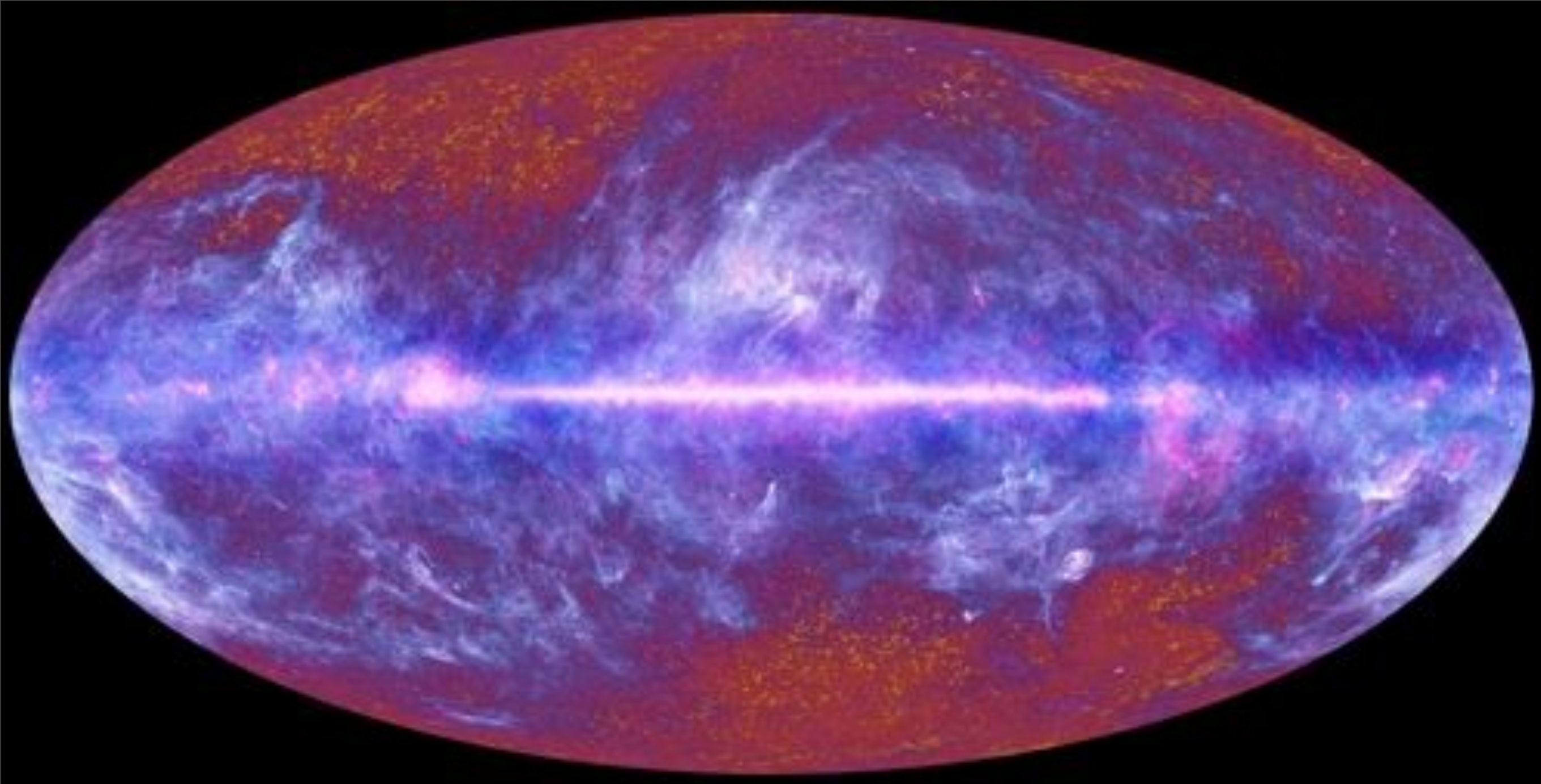


Lessons Learned From BLAST

marco viero / california institute of technology



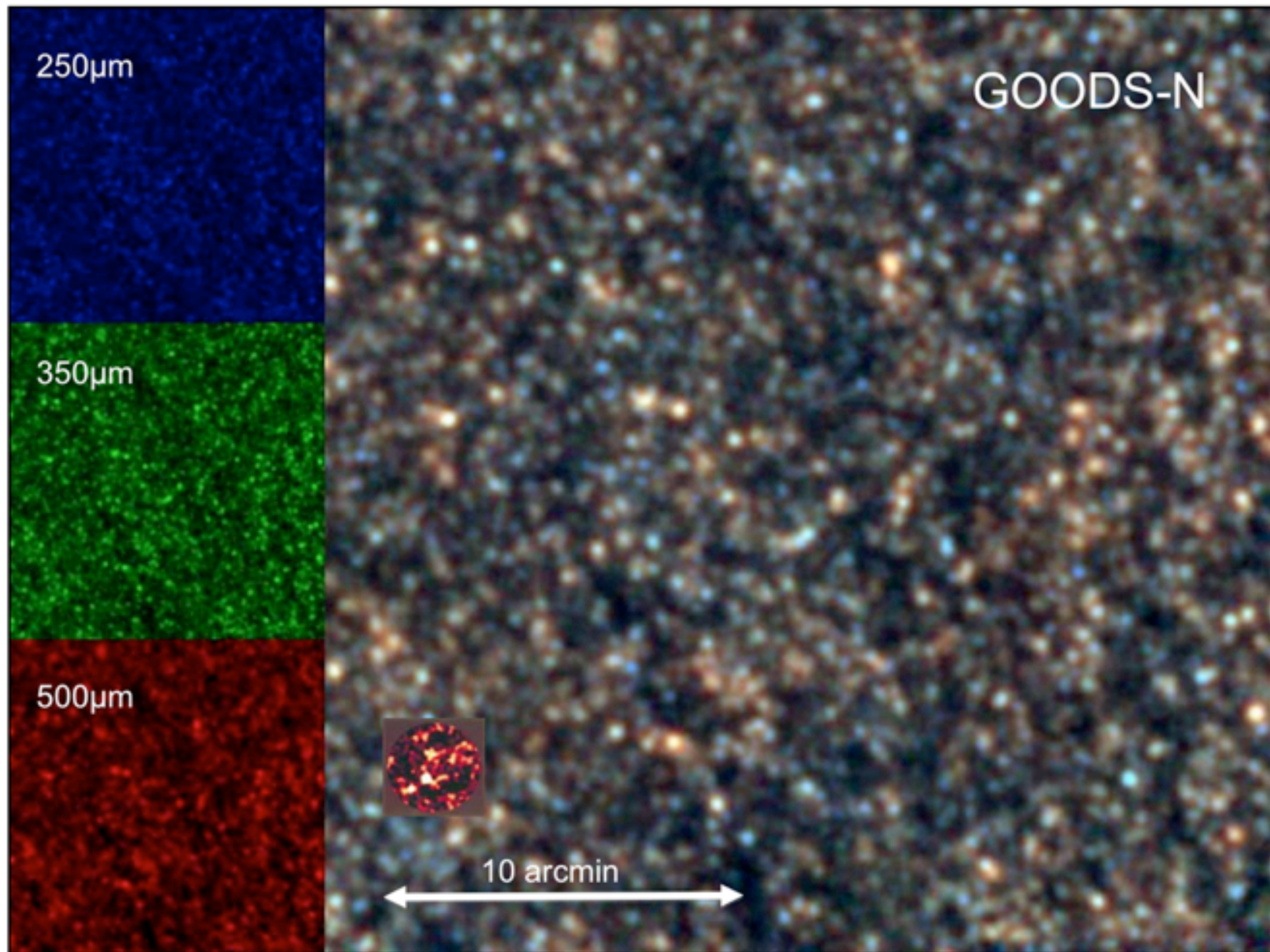
ESA, HFI & LFI consortia

motivation

marco viero



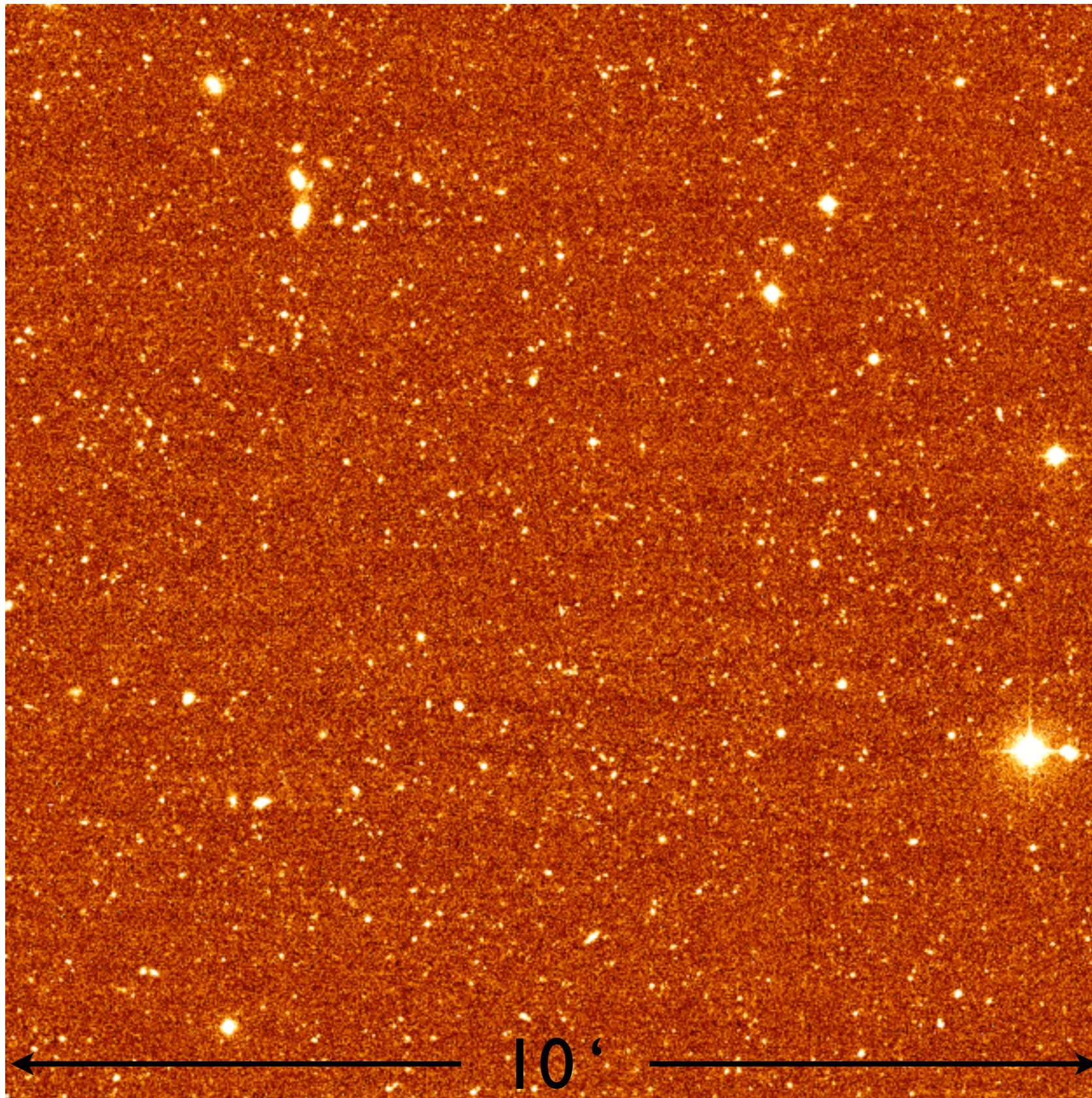
2



motivation

marco viero





U-band : MUSYC

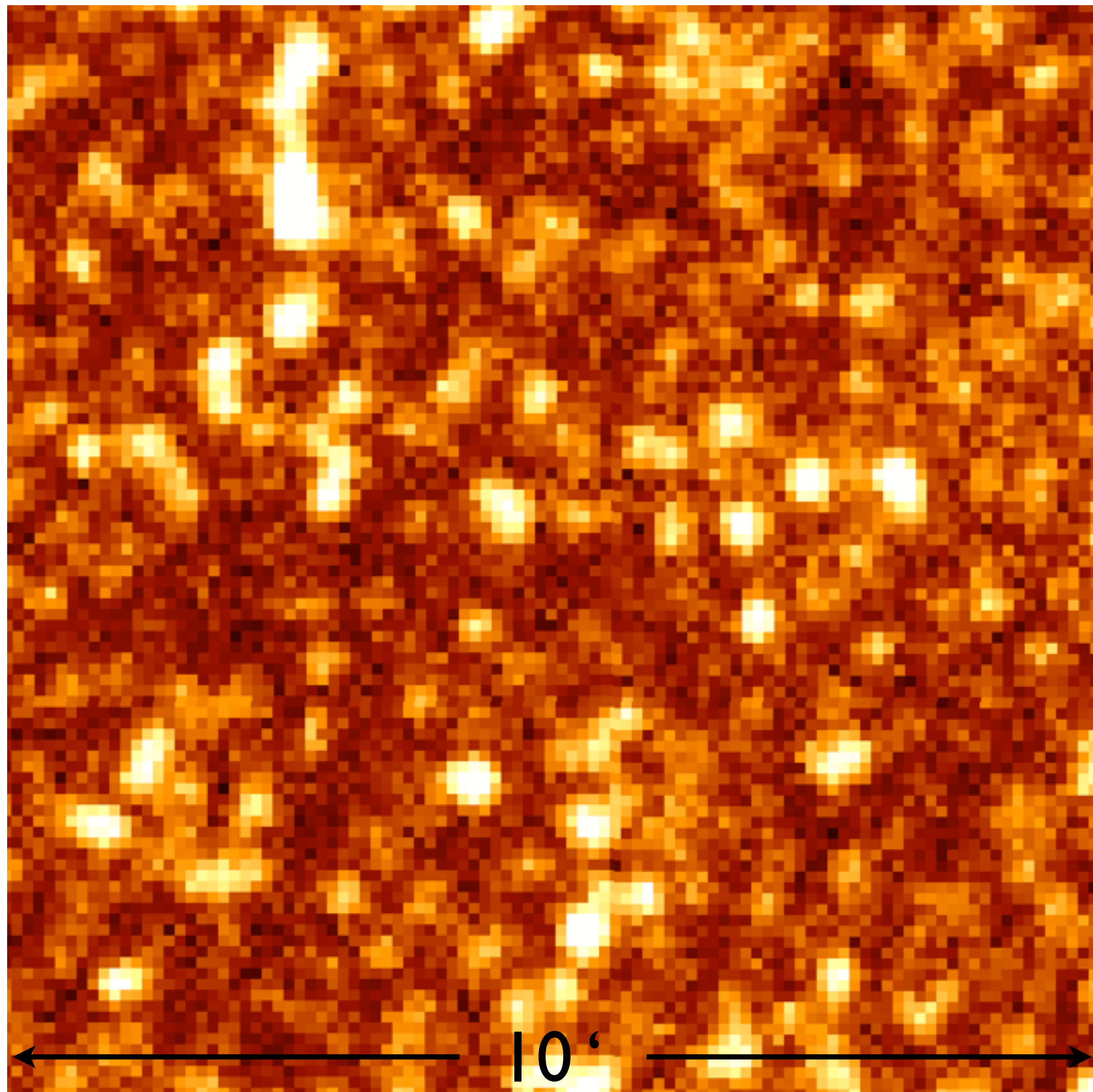
motivation

marco viero



4

Gaelen Marsden, UBC

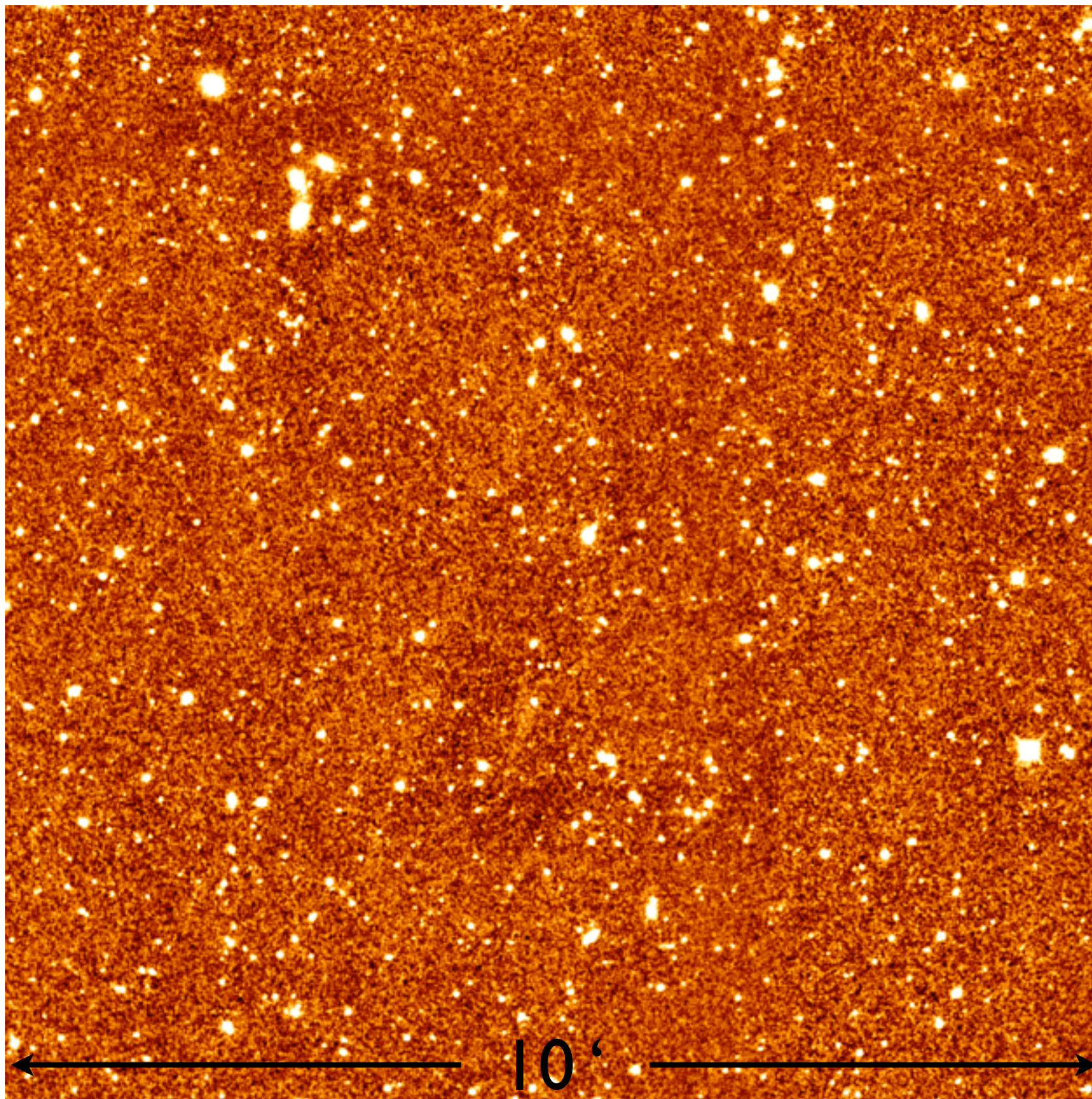


SPIRE 250 μm

motivation

marco viero





10'

K-band : MUSYC

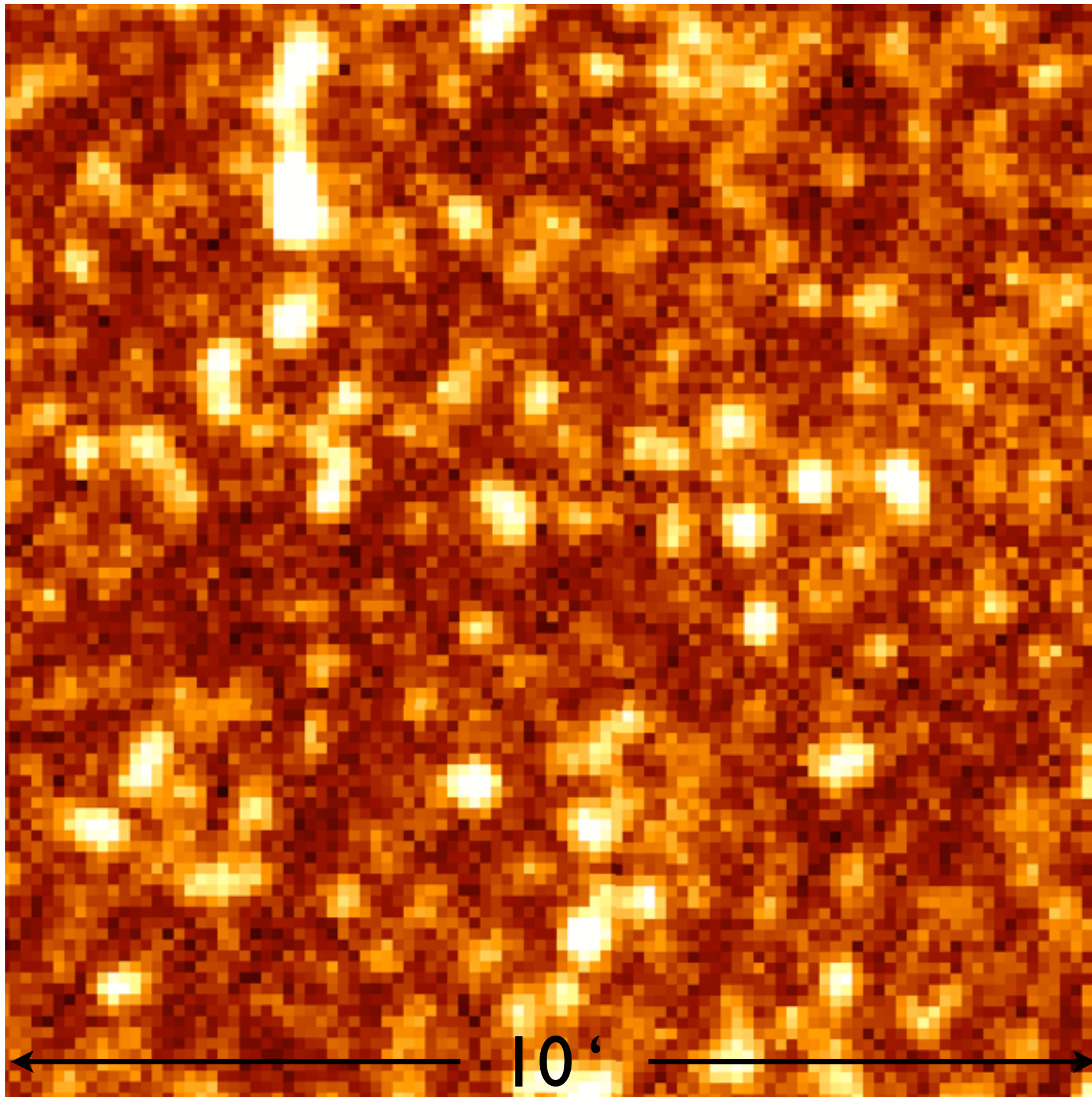
motivation

marco viero



5

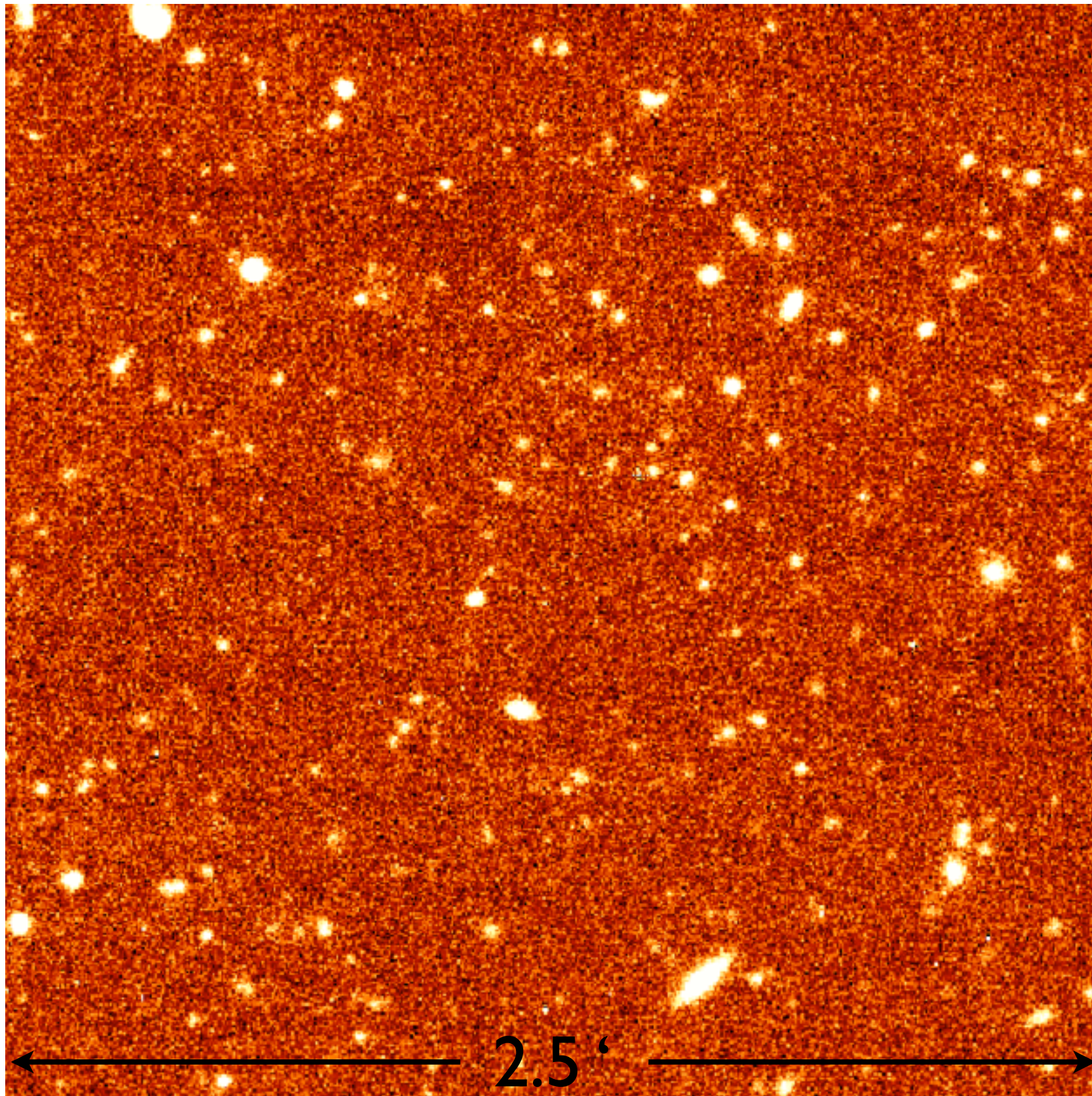
Gaelen Marsden, UBC



motivation

marco viero





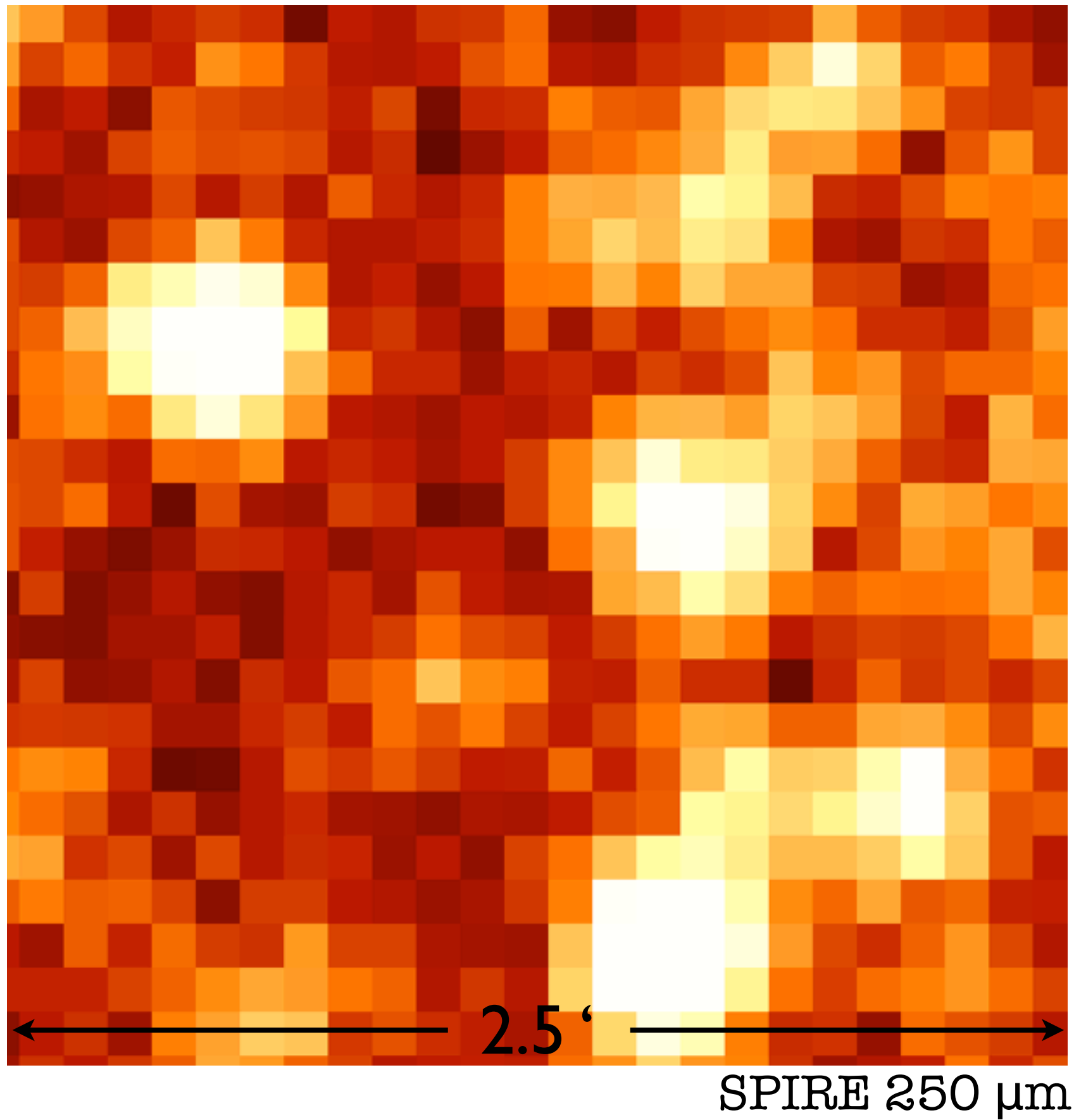
U-band : MUSYC

motivation

marco viero



Gaelen Marsden, UBC



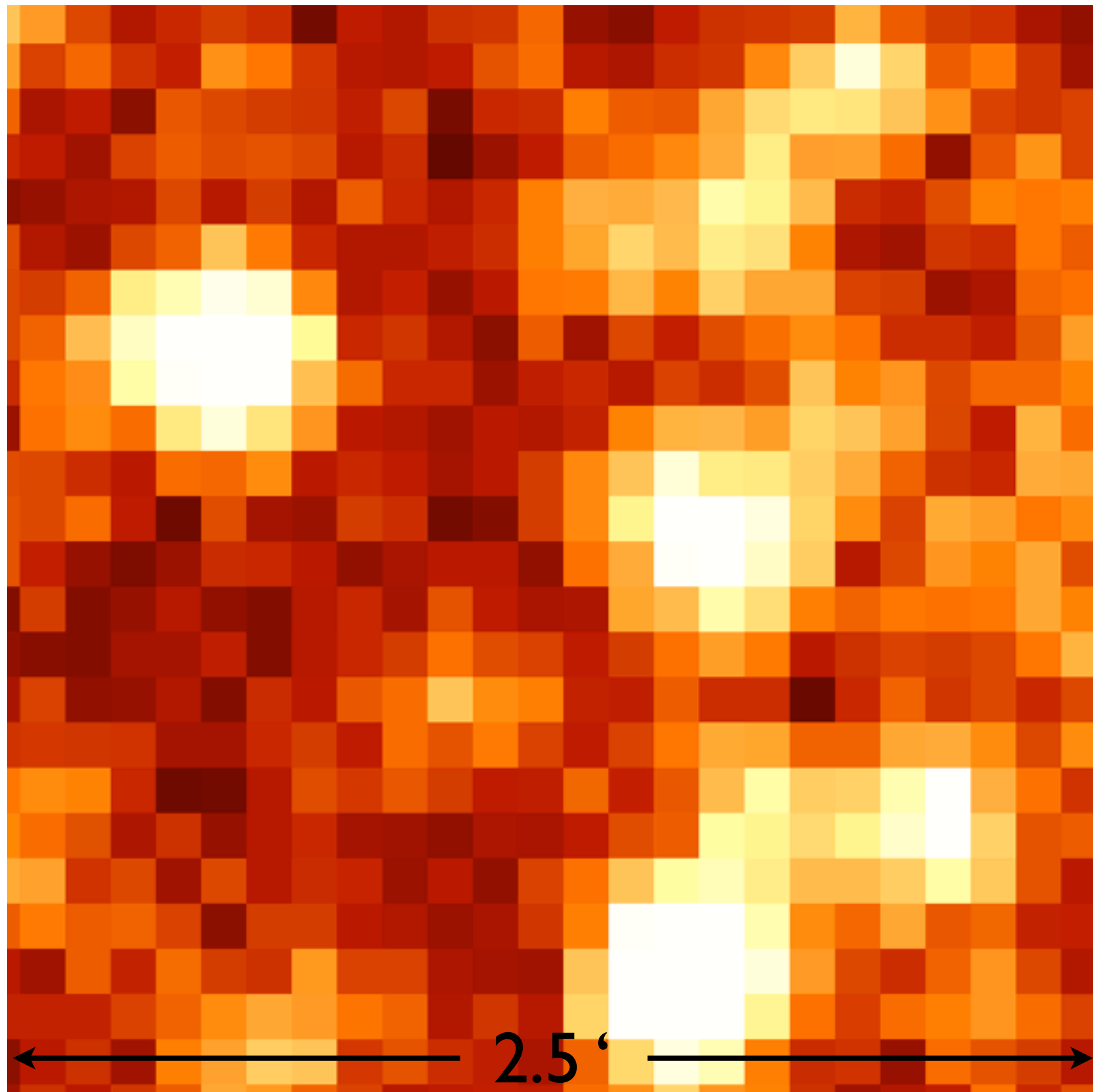
motivation

marco viero



6

Gaelen Marsden, UBC



SPIRE 250 μm

SPIRE
resolves

$\sim 250\times < \text{K-band}$

$\sim 50\times < \text{IRAC}$

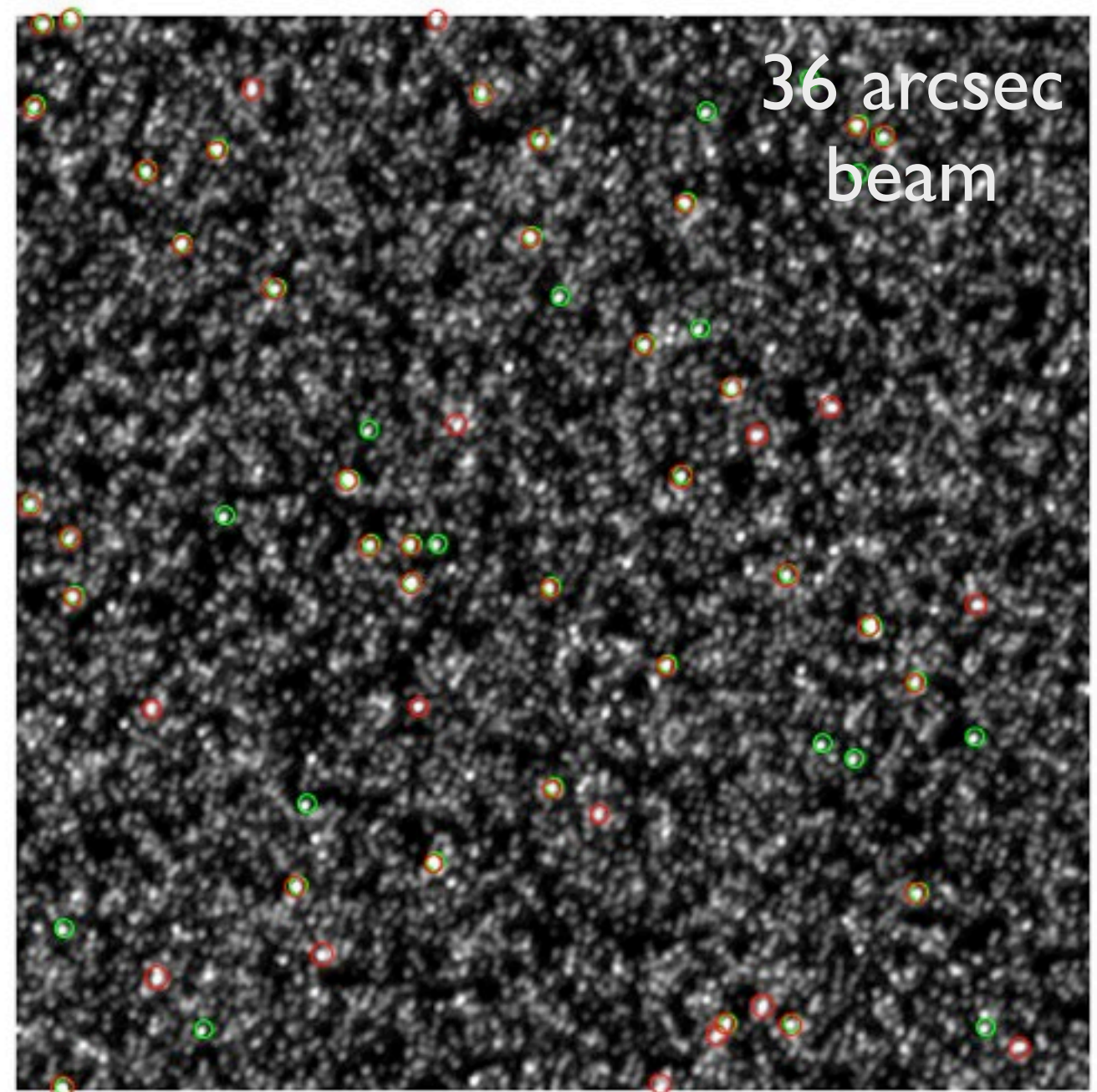
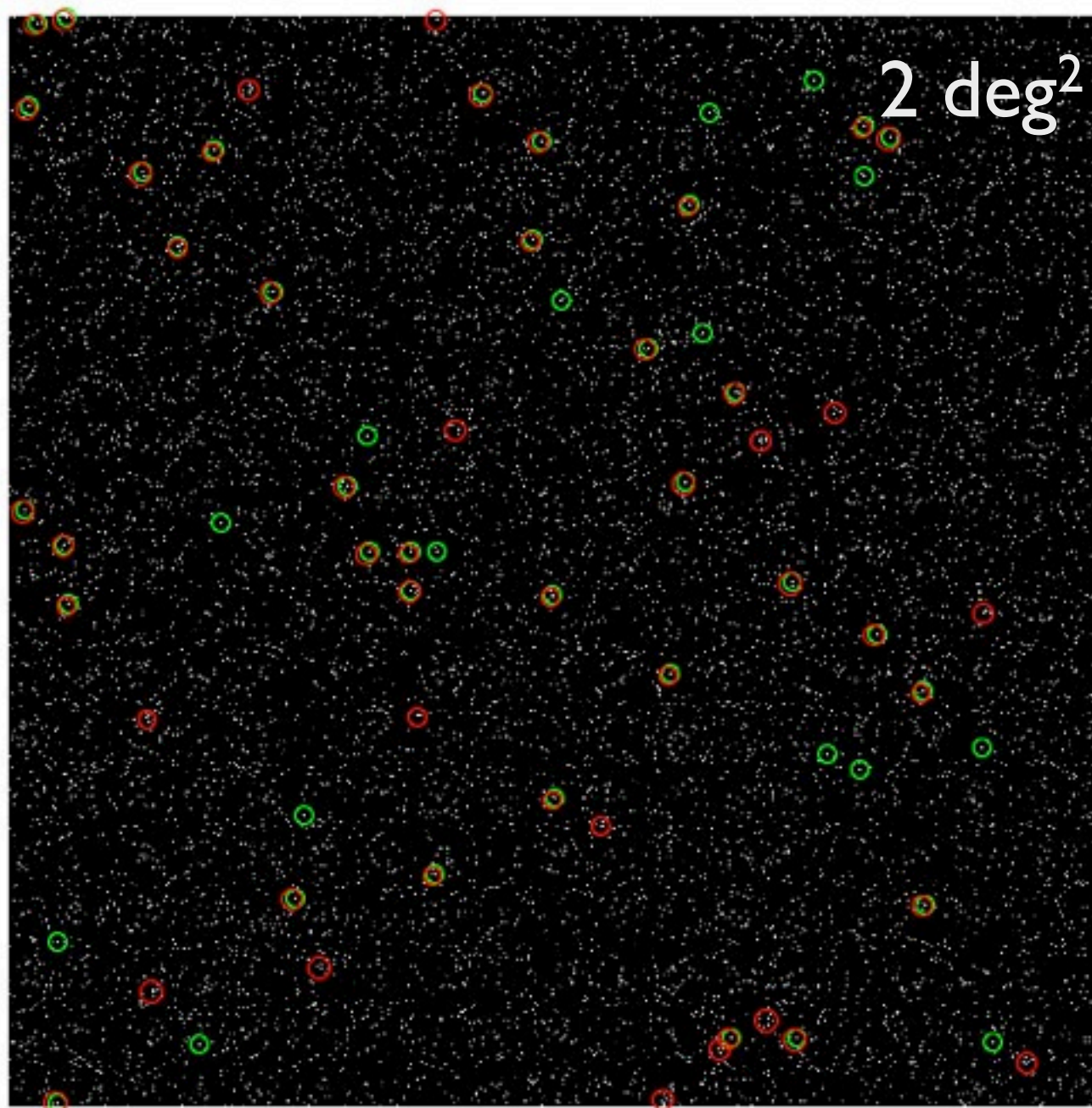
$\sim 25\times < 24 \mu\text{m}$

motivation

marco viero



6

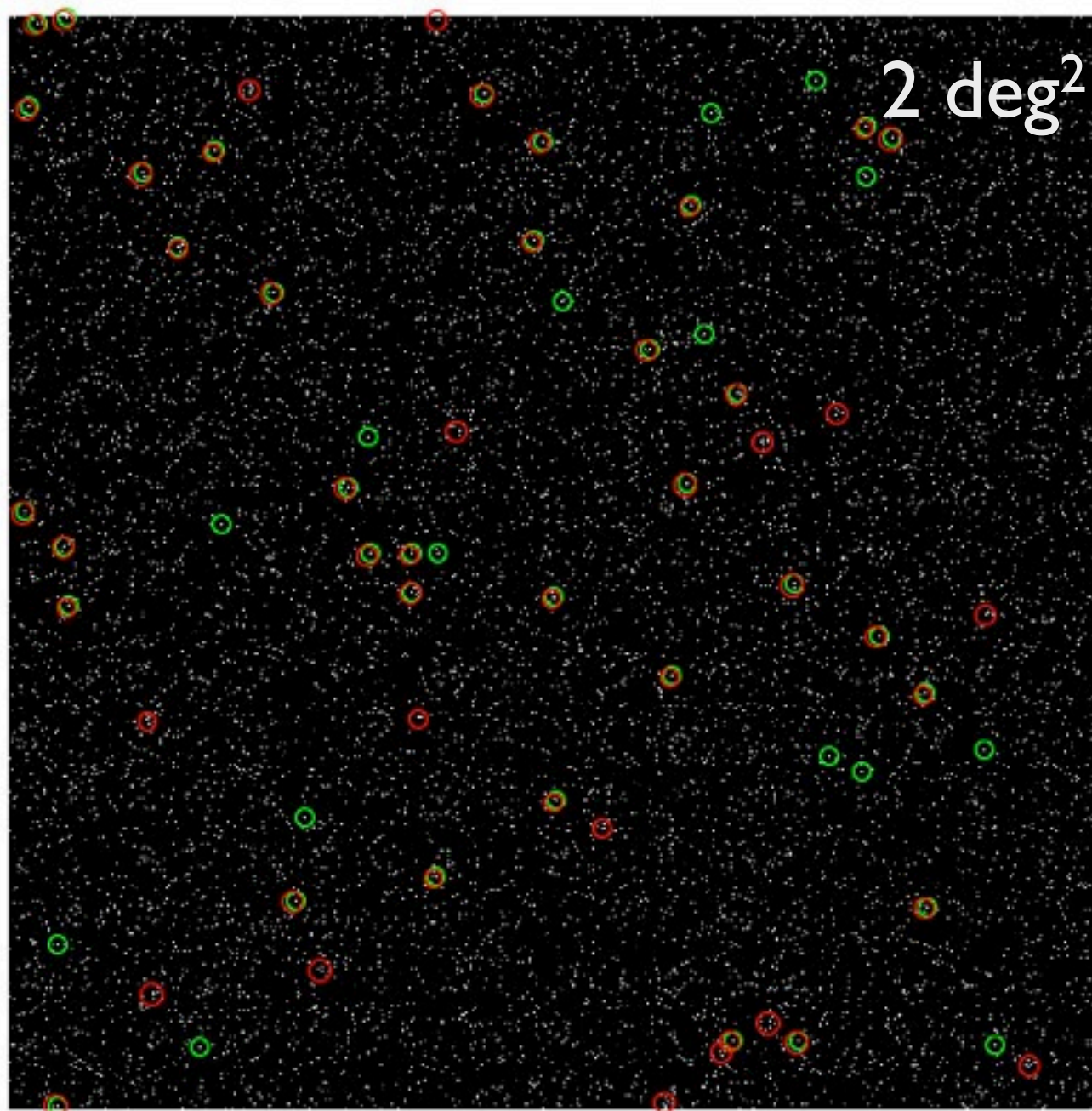


motivation

marco viero

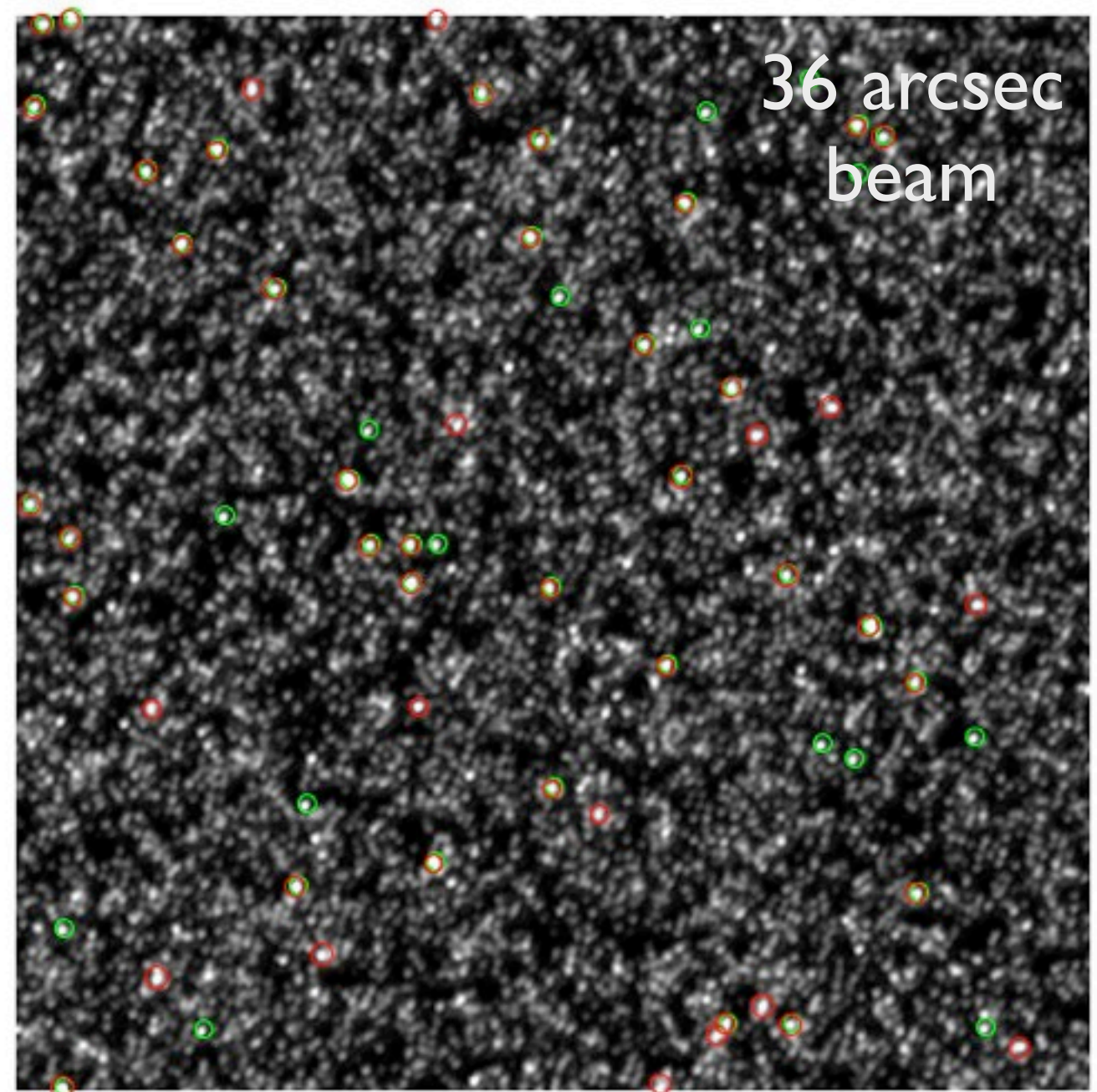


7



50 brightest
(top 0.5%)

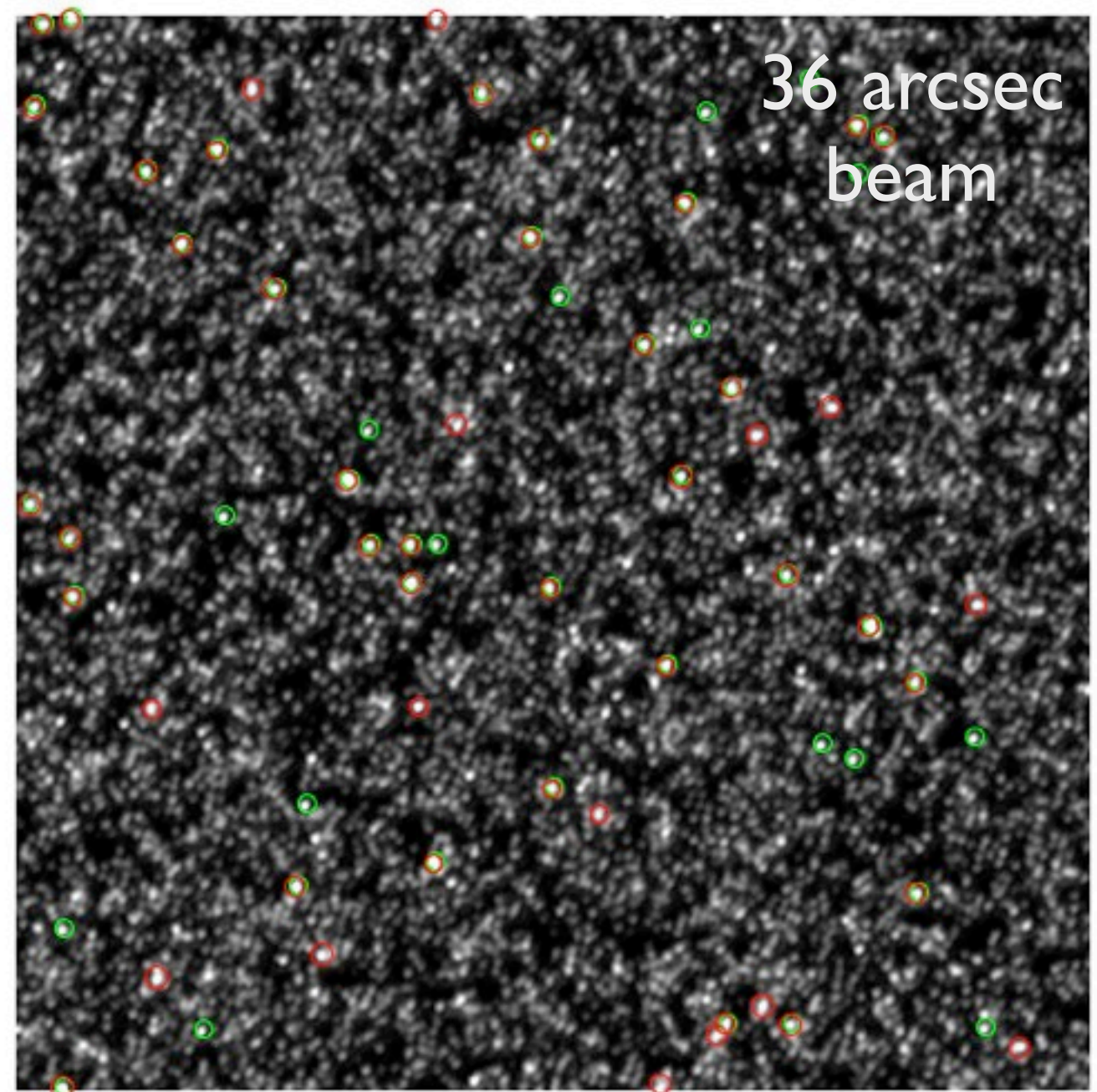
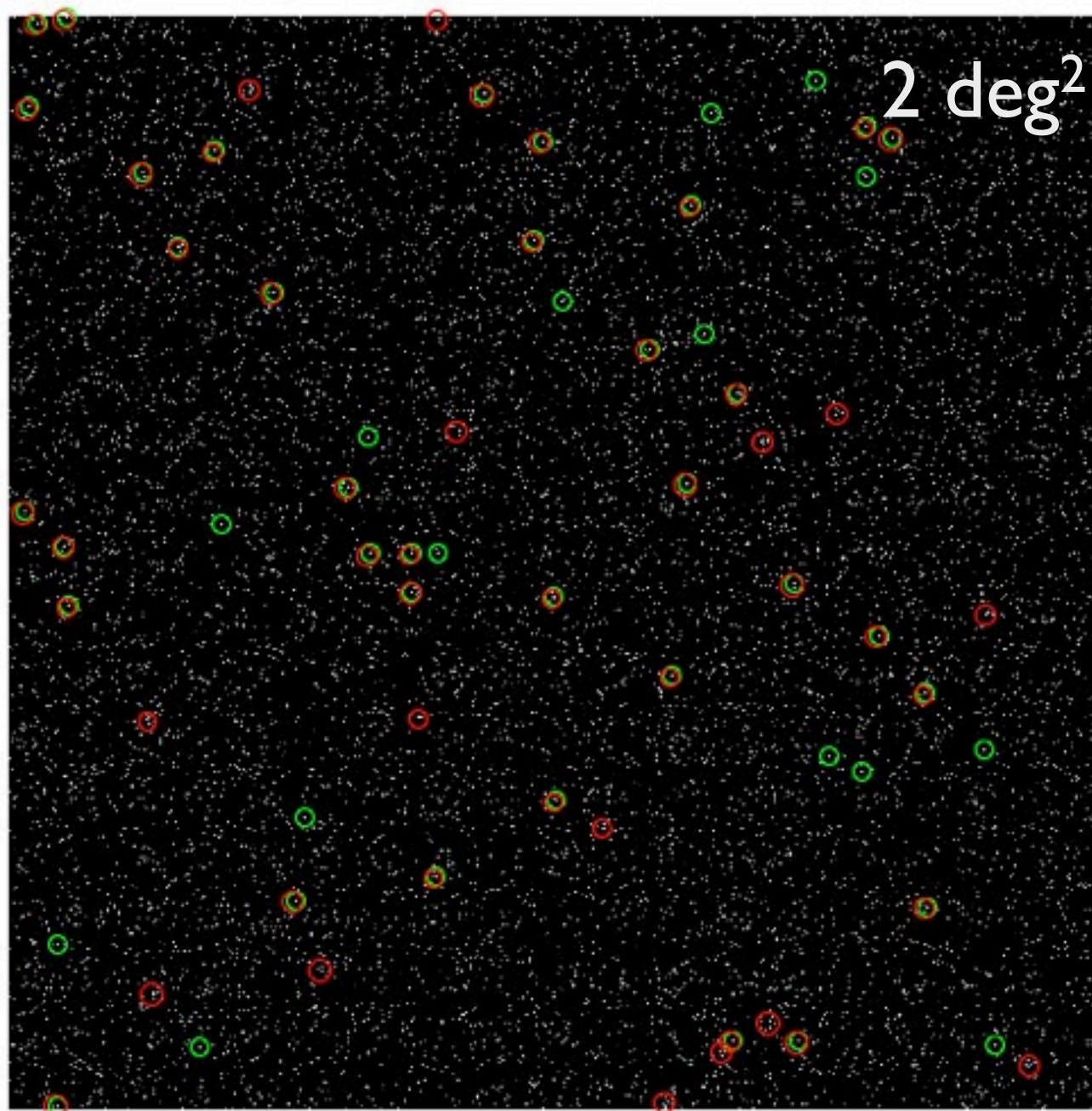
motivation



50 brightest
recovered

marco viero





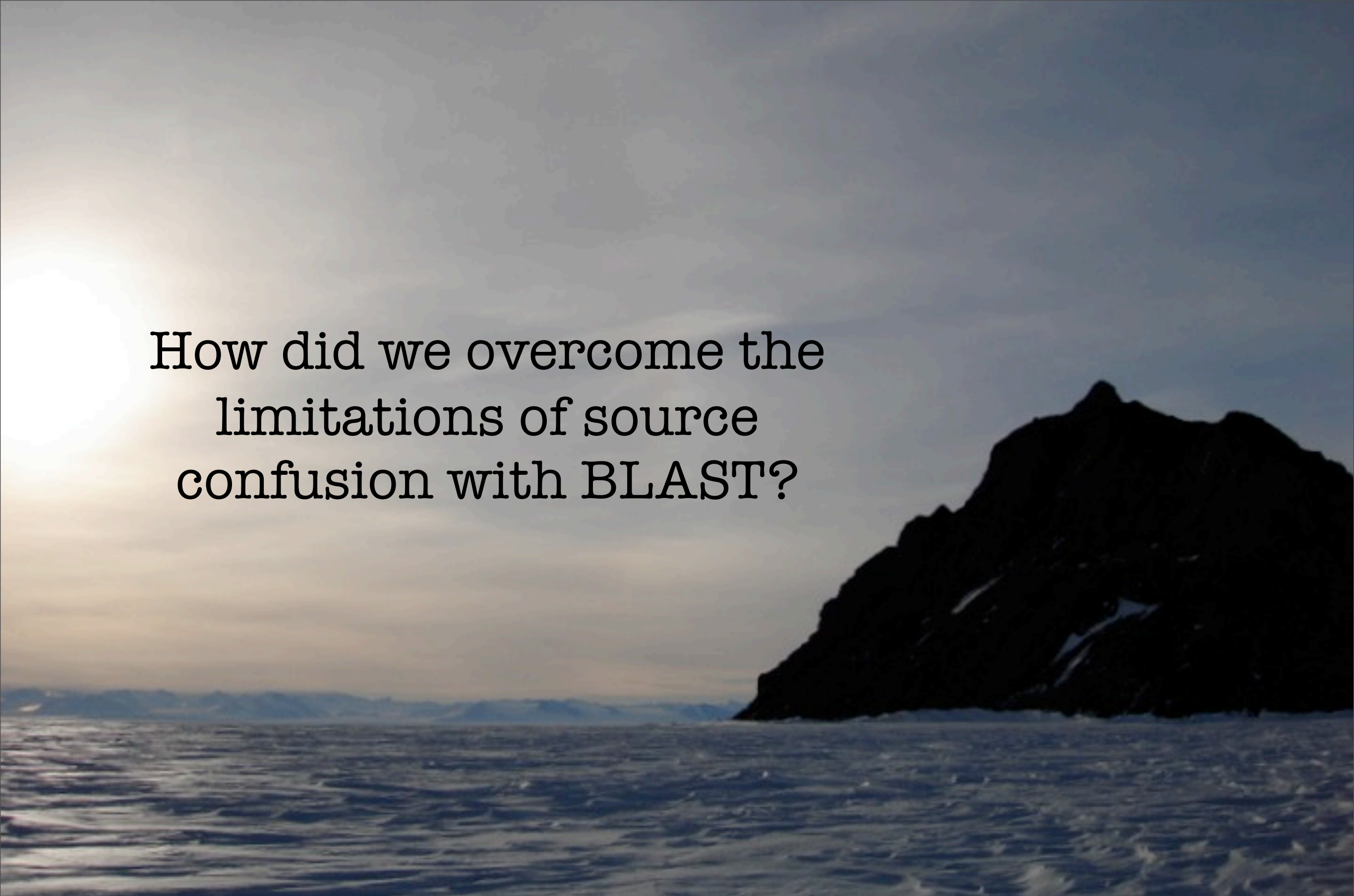
70% of top 0.5%
recovered

motivation

marco viero



7



How did we overcome the
limitations of source
confusion with BLAST?

BLAST



marco viero



BLAST TEAM



UBC

Ed Chapin
Mark Halpern
Gaelen Marsden
Douglas Scott
Don Wiebe

JPL

Jamie Bock

U of T

Peter Martin
Barth Netterfield

Brown University
Greg Tucker

CDF (France)

Guillaume Patanchon

UPenn

Mark Devlin
Jeff Klein
Marie Rex
Chris Semisch
Matt Truch

U of Miami

Josh Gundersen
Nick Thomas

INAOE (Mexico)

David Hughes
Itziar Aretxaga

Cardiff

University
Peter Ade
Matt Griffin
Peter Hargrave
Phil Mauskopf
Carole Tucker
Enzo Pascale
Lorenzo Moncelsi

Open

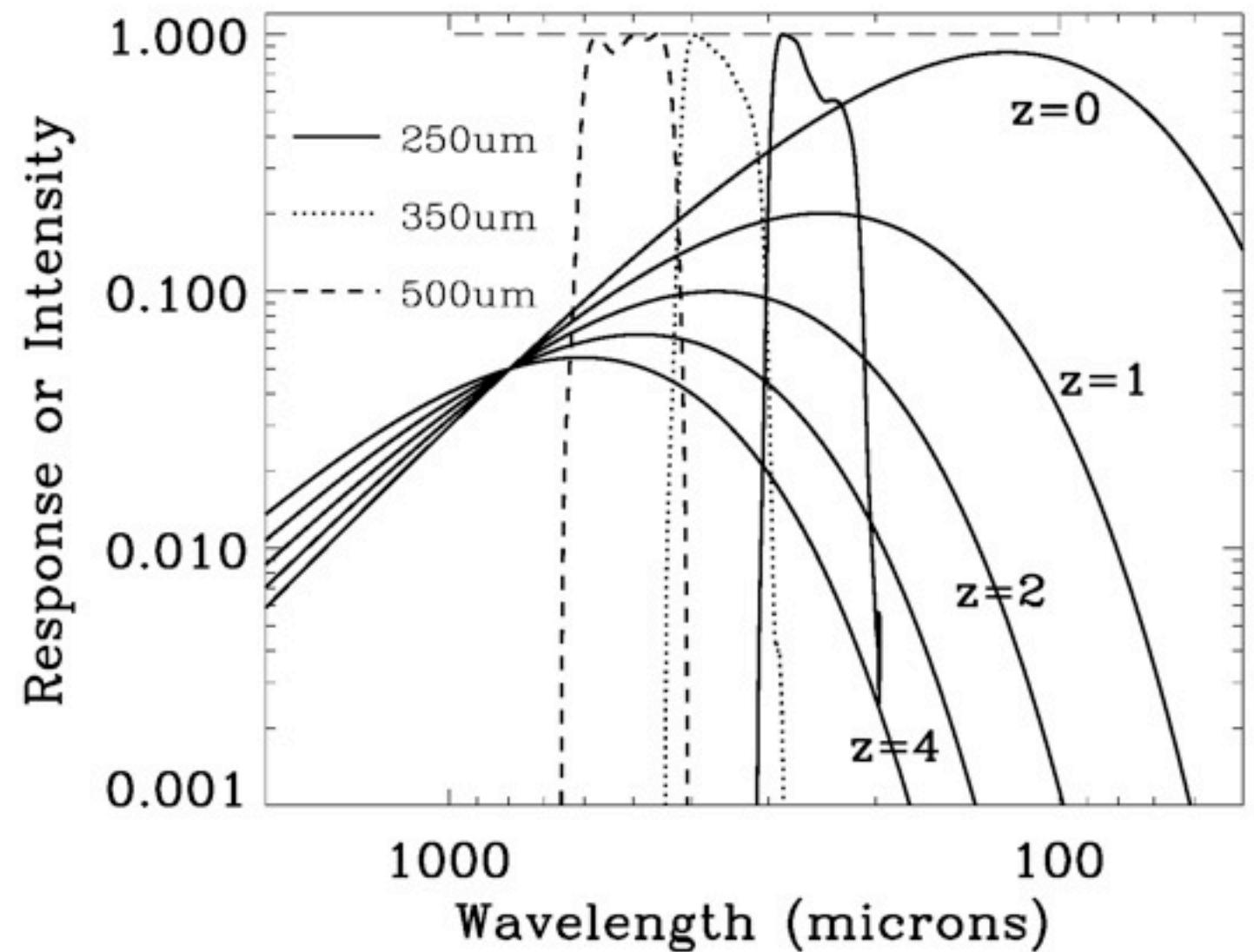
University
Mattia Negrello

CALTECH

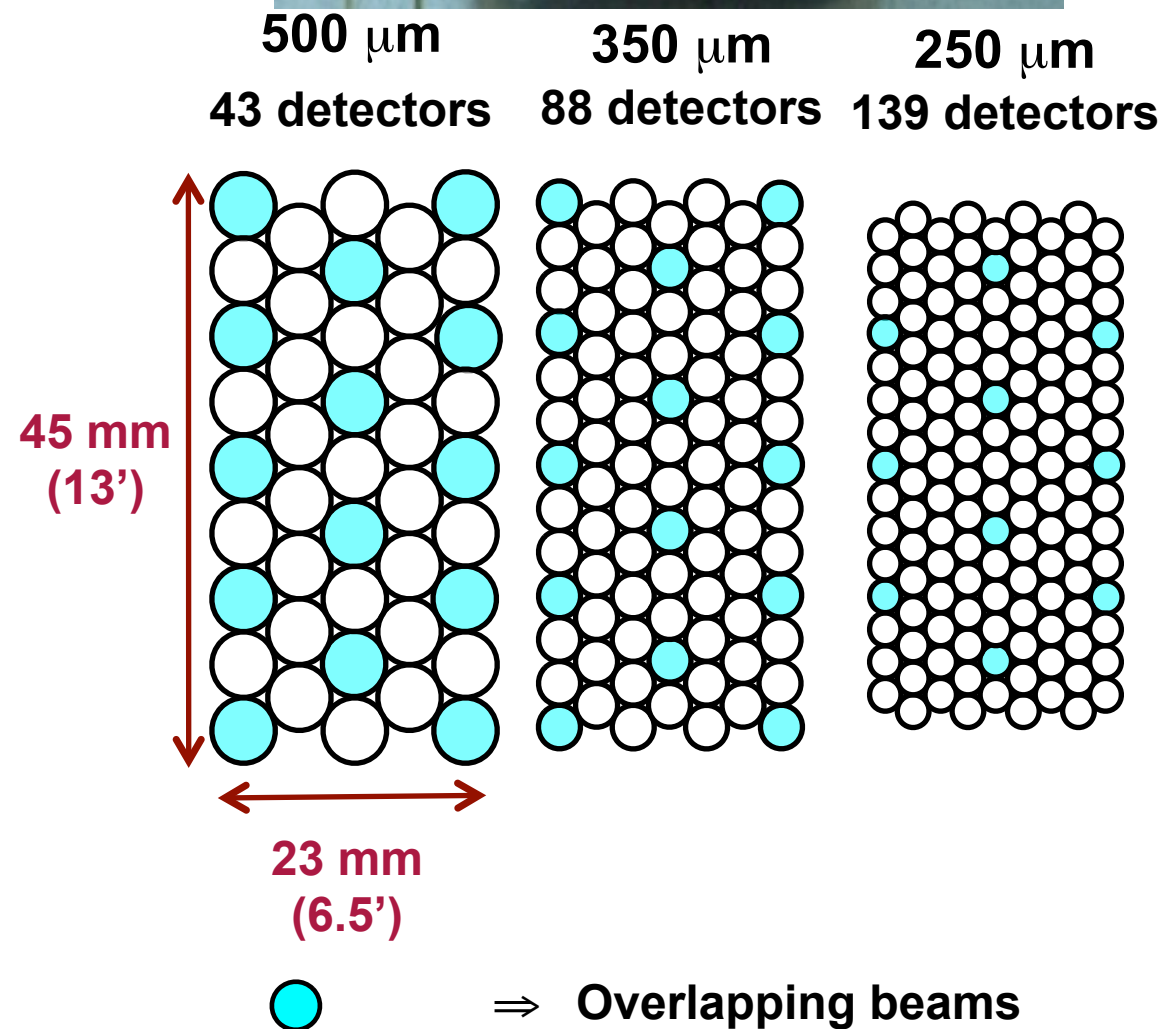
Marco Viero

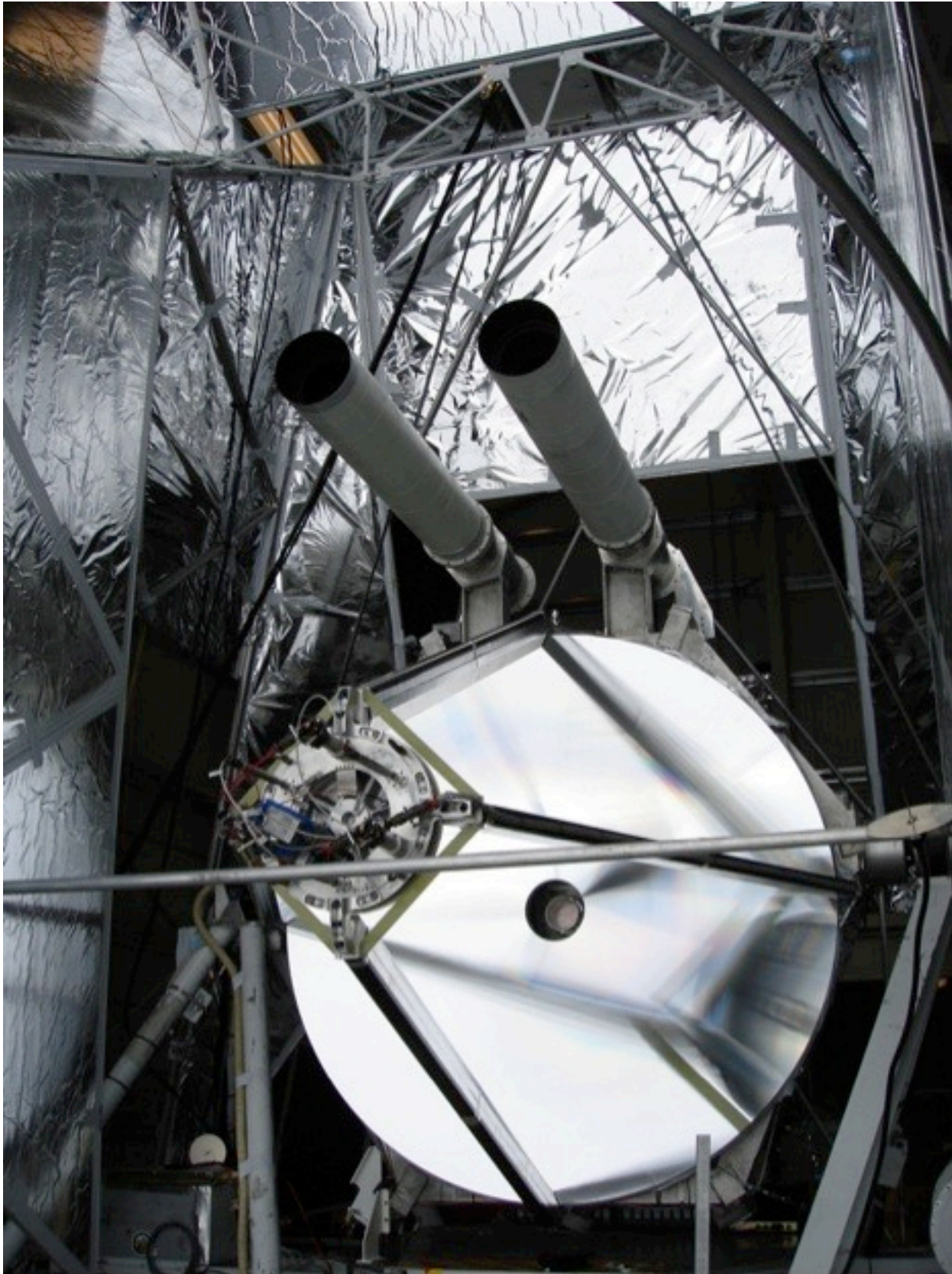


designed to bracket the
redshifted peak



SPIRE-like spider-web bolometer detector arrays...





SPIRE-like
spider-web bolometer
detector arrays...

... but a 1.8 m primary
resulting in beams:

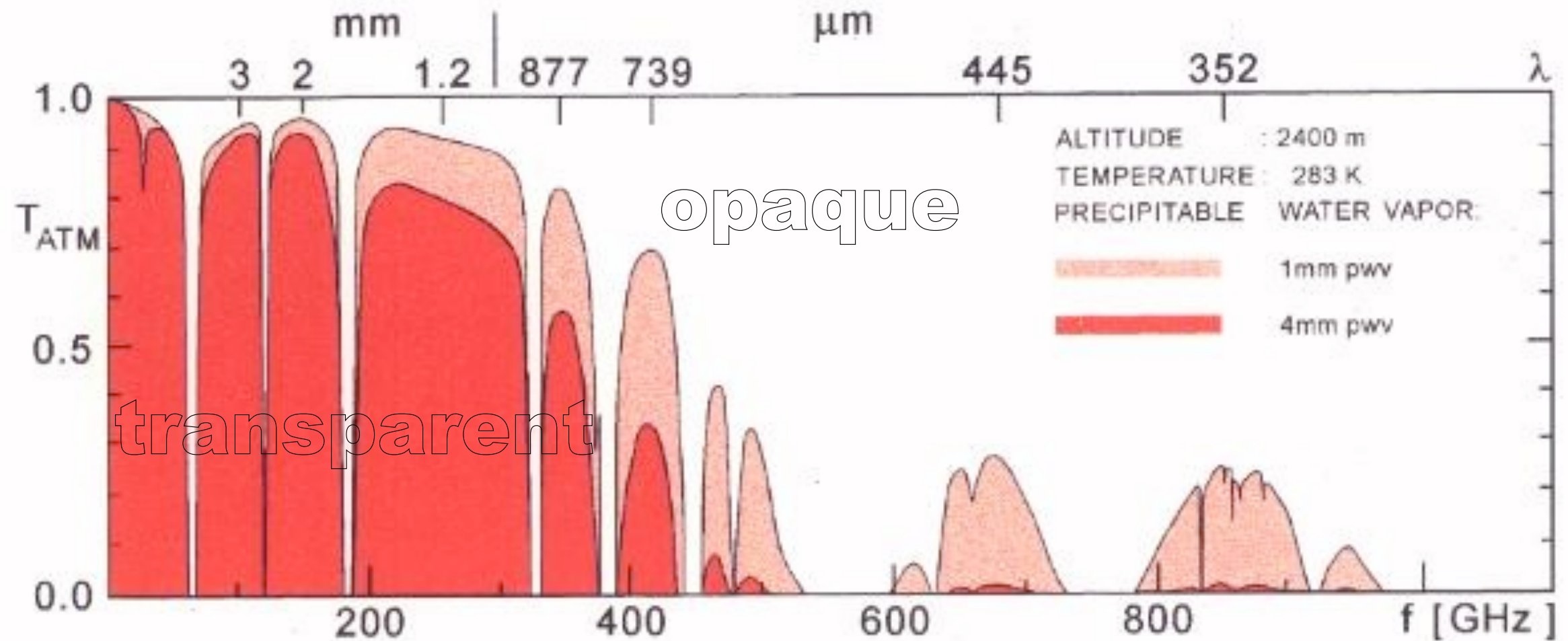
36" - 250 μm

45" - 350 μm

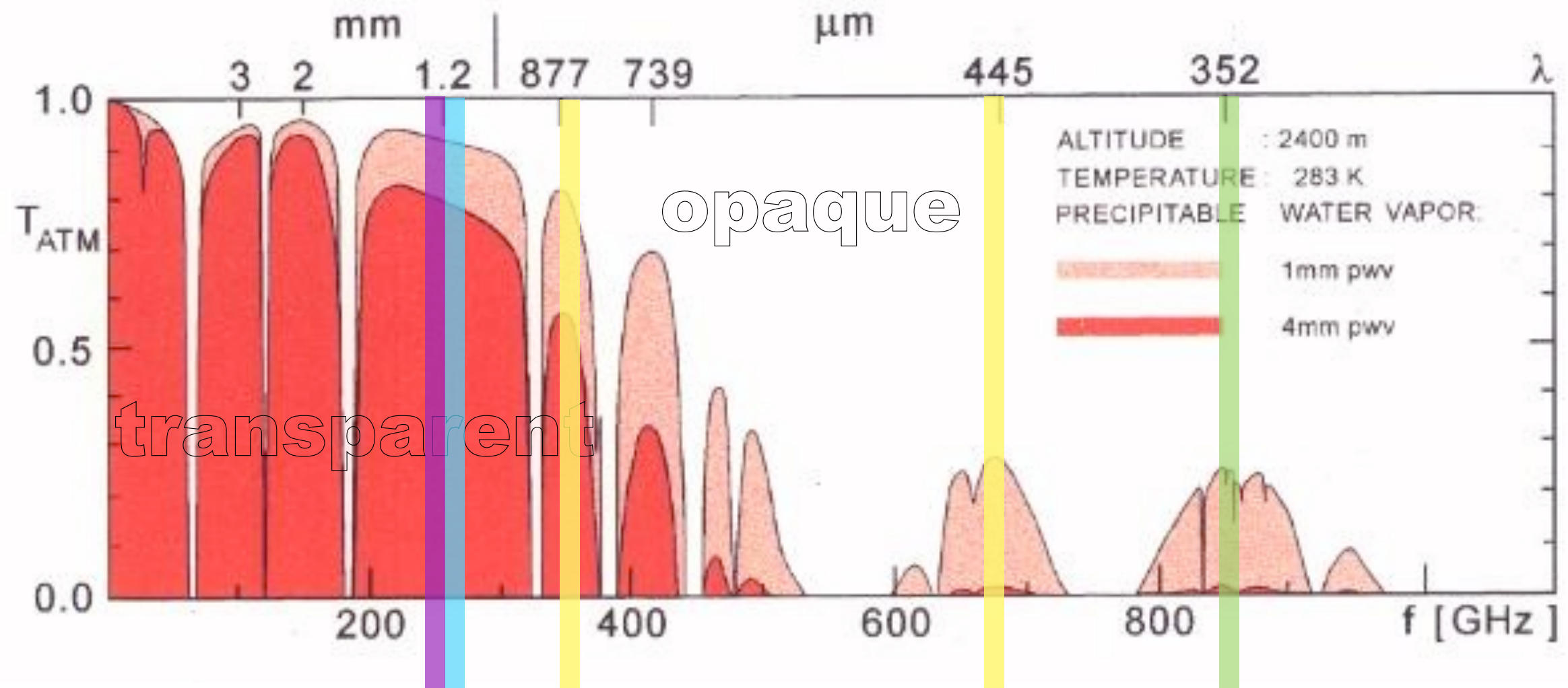
60" - 500 μm

i.e., twice the size of
SPIRE's beams

ZENITH - TRANSMISSION OF THE ATMOSPHERE IN DEPENDENCE OF THE PRECIPITABLE WATER VAPOR



ZENITH - TRANSMISSION OF THE ATMOSPHERE IN DEPENDENCE OF THE PRECIPITABLE WATER VAPOR



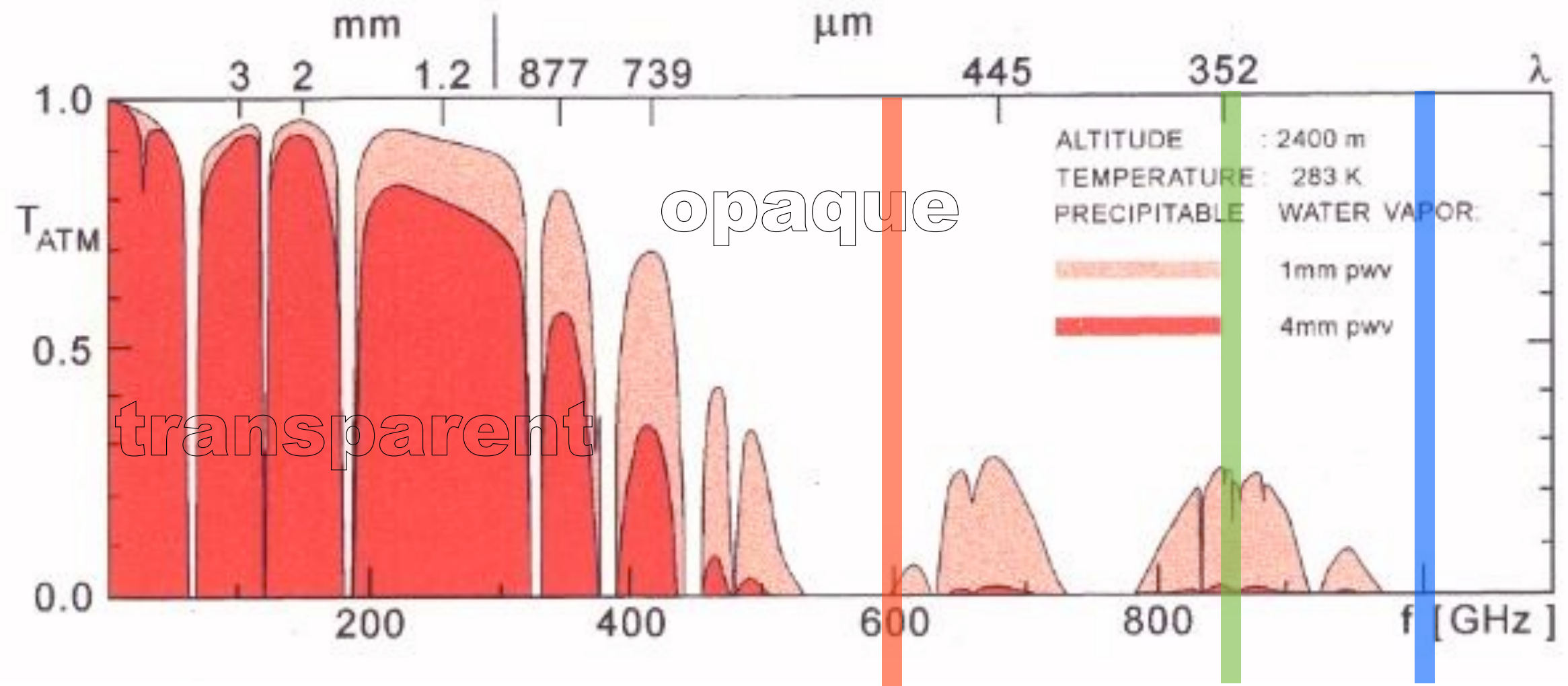
MAMBO

AzTEC

SCUBA

SHARC

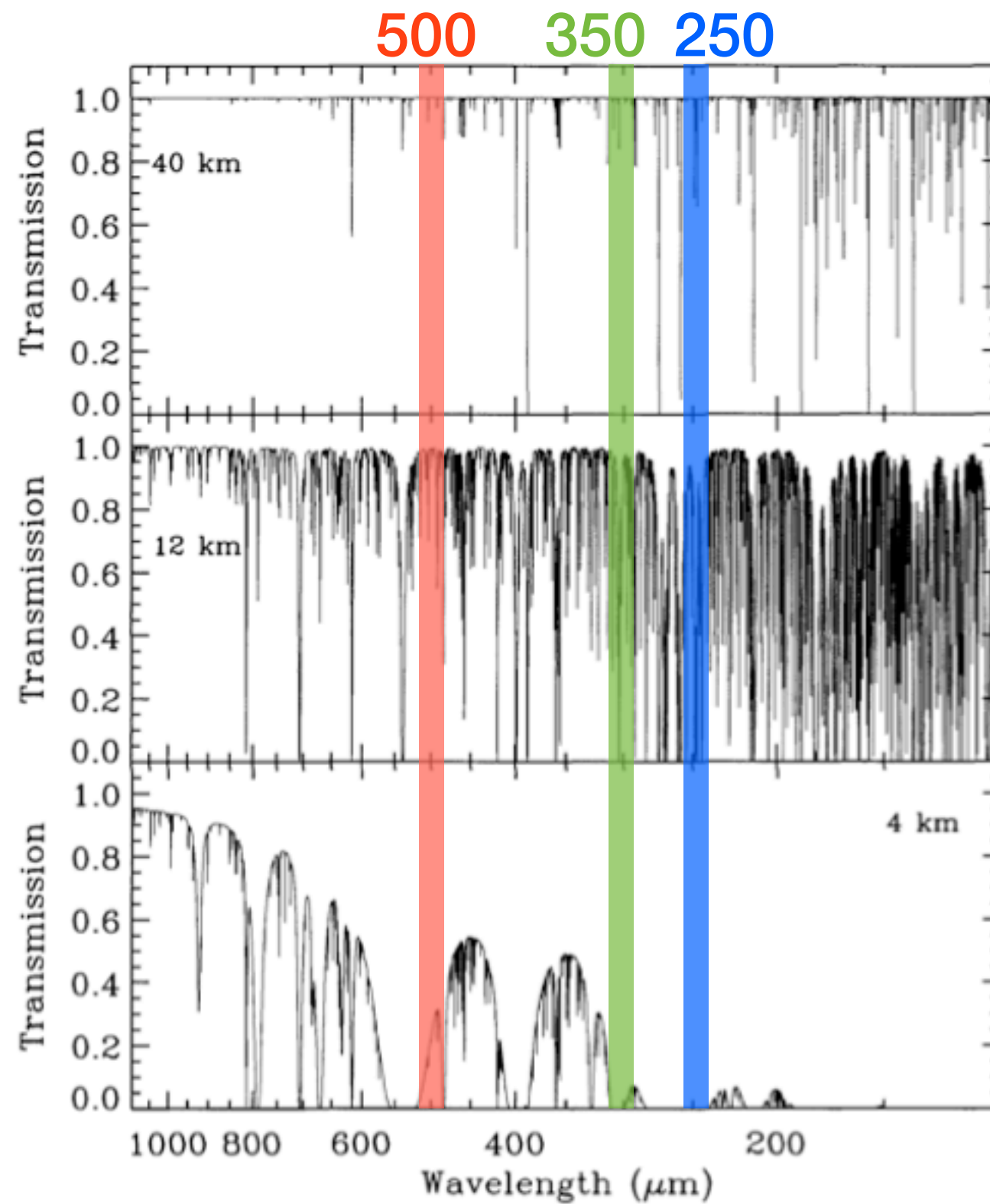
ZENITH - TRANSMISSION OF THE ATMOSPHERE IN DEPENDENCE OF THE PRECIPITABLE WATER VAPOR



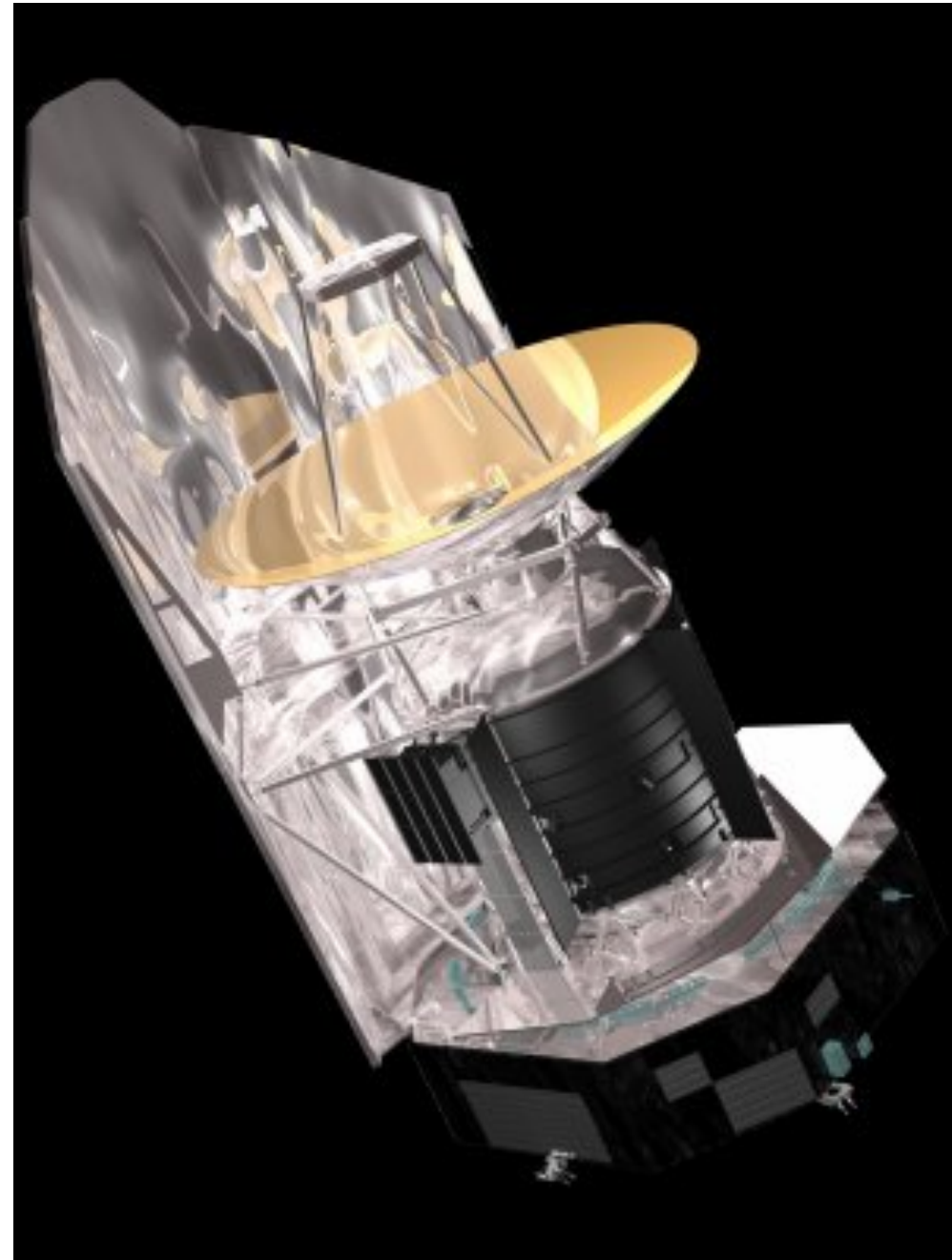
500

350

250



$\sim \$10^9$
 ~ 10 's years



BLAST

marco viero



14

$\sim \$10^9$
 ~ 10 's years
 $\sim \$10^6$
 ~ 5 ish years



train next
generation!

$\sim \$10^6$

$\sim 5ish\ years$





BLAST

marco viero



15



Wednesday, October 6, 2010



bye bye BLAST!

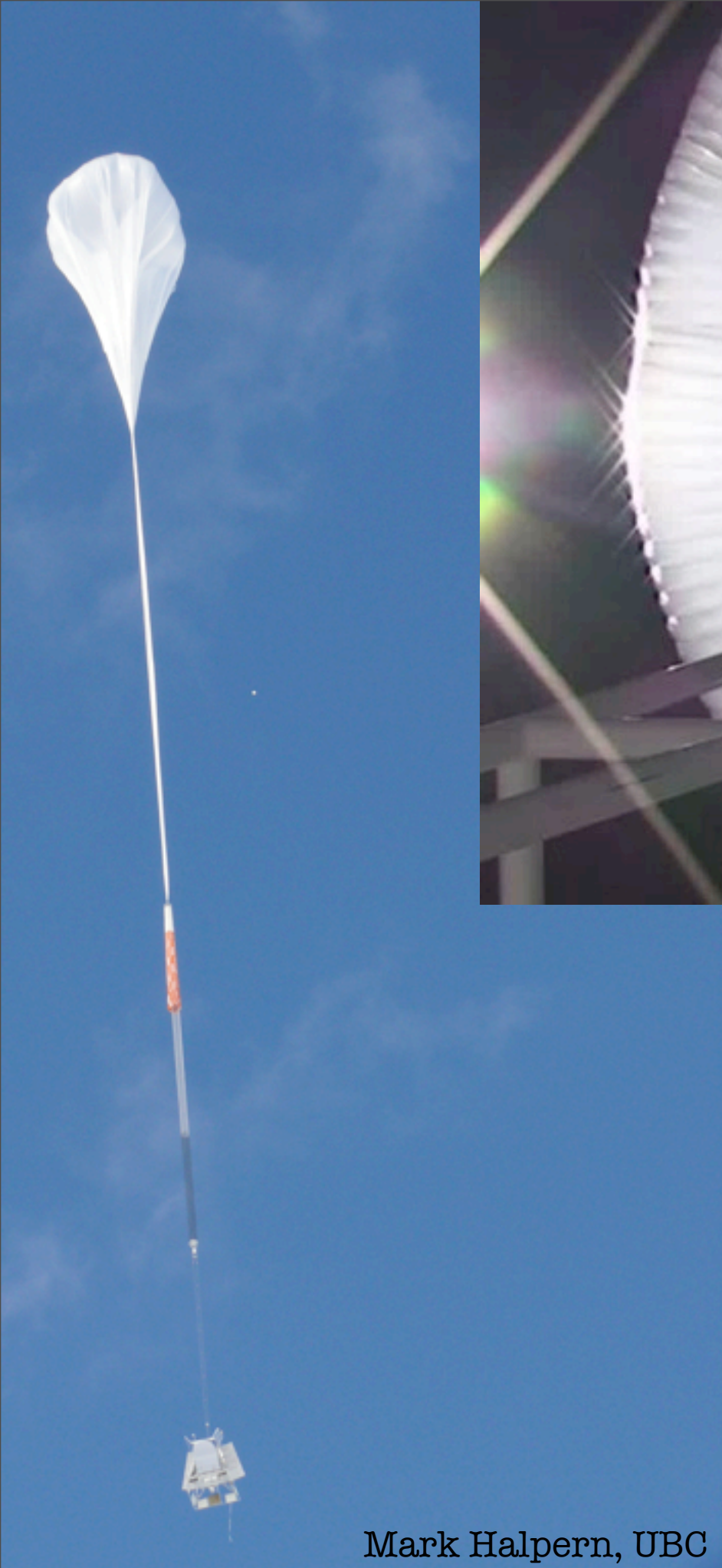


Mark Halpern, UBC

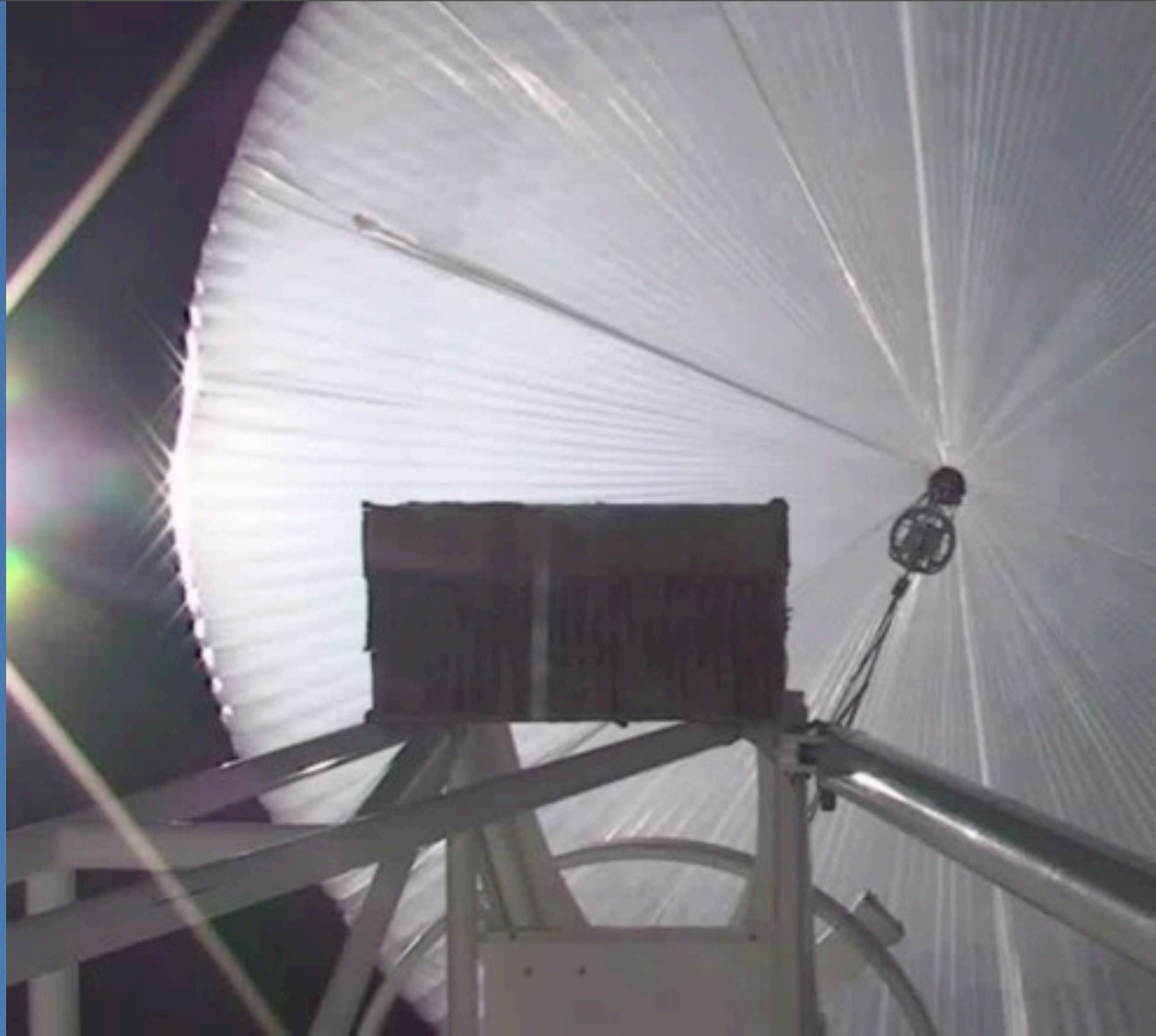


Don Wiebe, UBC

Wednesday, October 6, 2010



Mark Halpern, UBC



Perfect Flight!



Joe Martz

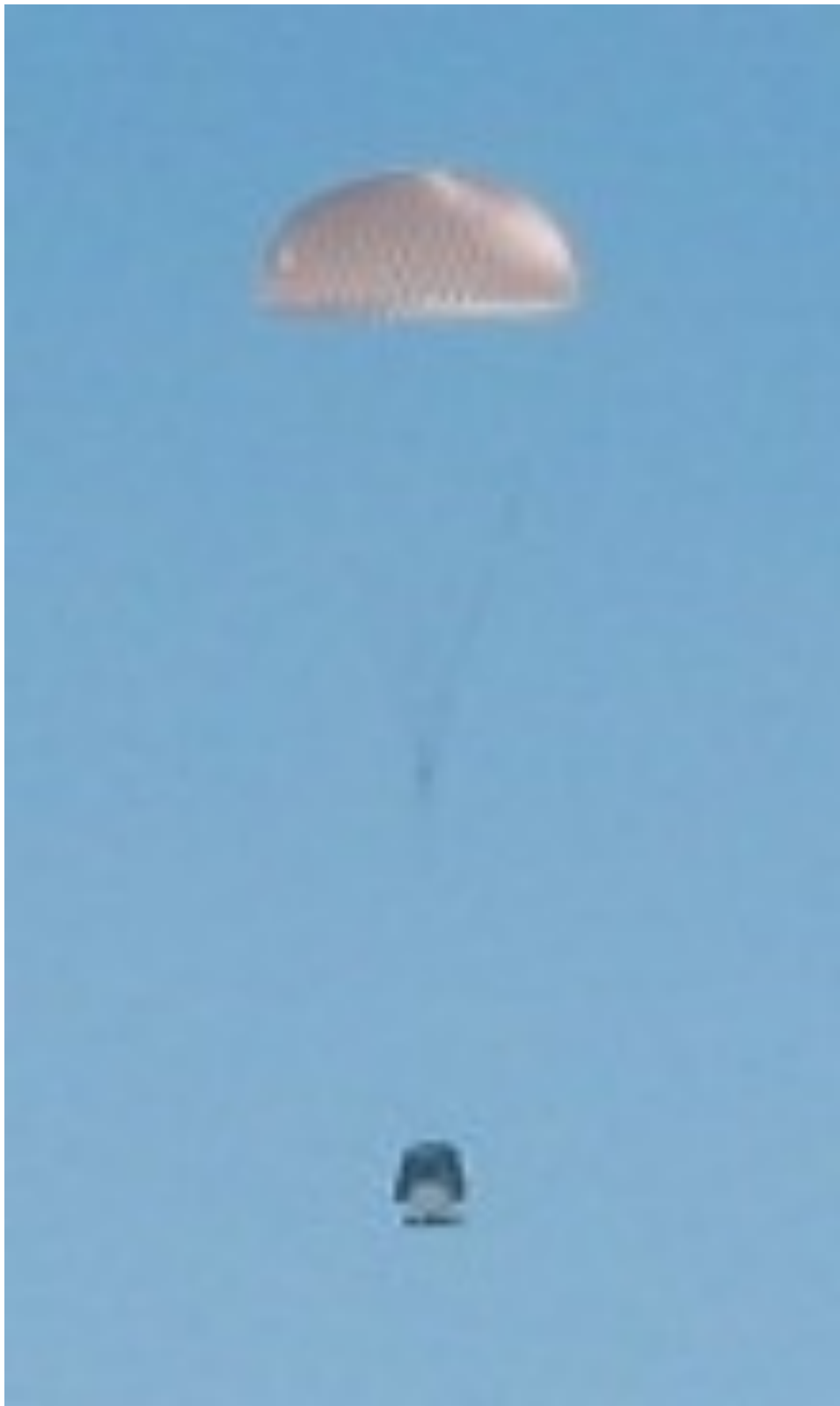
BLAST payload hanging from balloon float altitude of 120,000 ft.

marco viero



17

Perfect Landing!



BLAST

marco viero



18

Perfect Landing?



looking for
this...



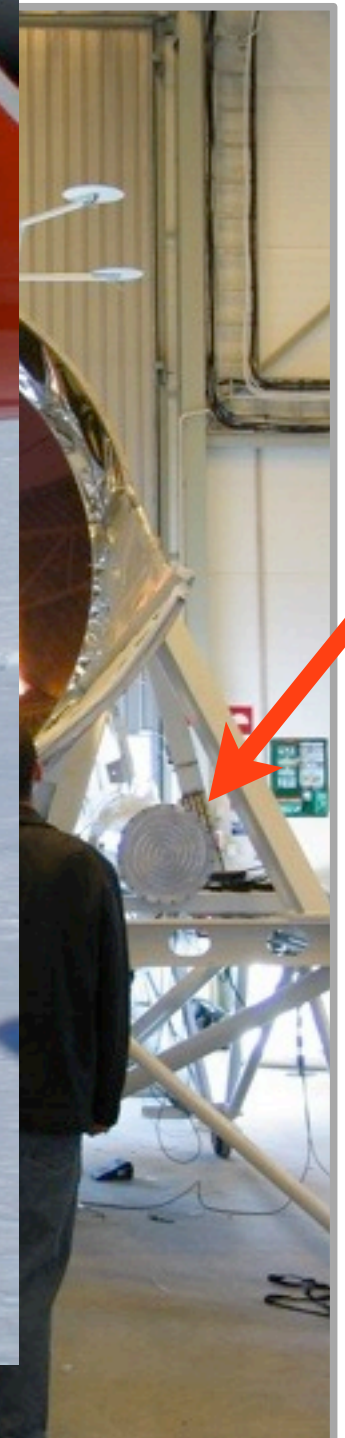
BLAST

marco viero



19

in this



BLAST

marco viero



19



BLAST

marco viero



20



BLAST

marco viero



20

see it all in
“BLAST!”
the movie

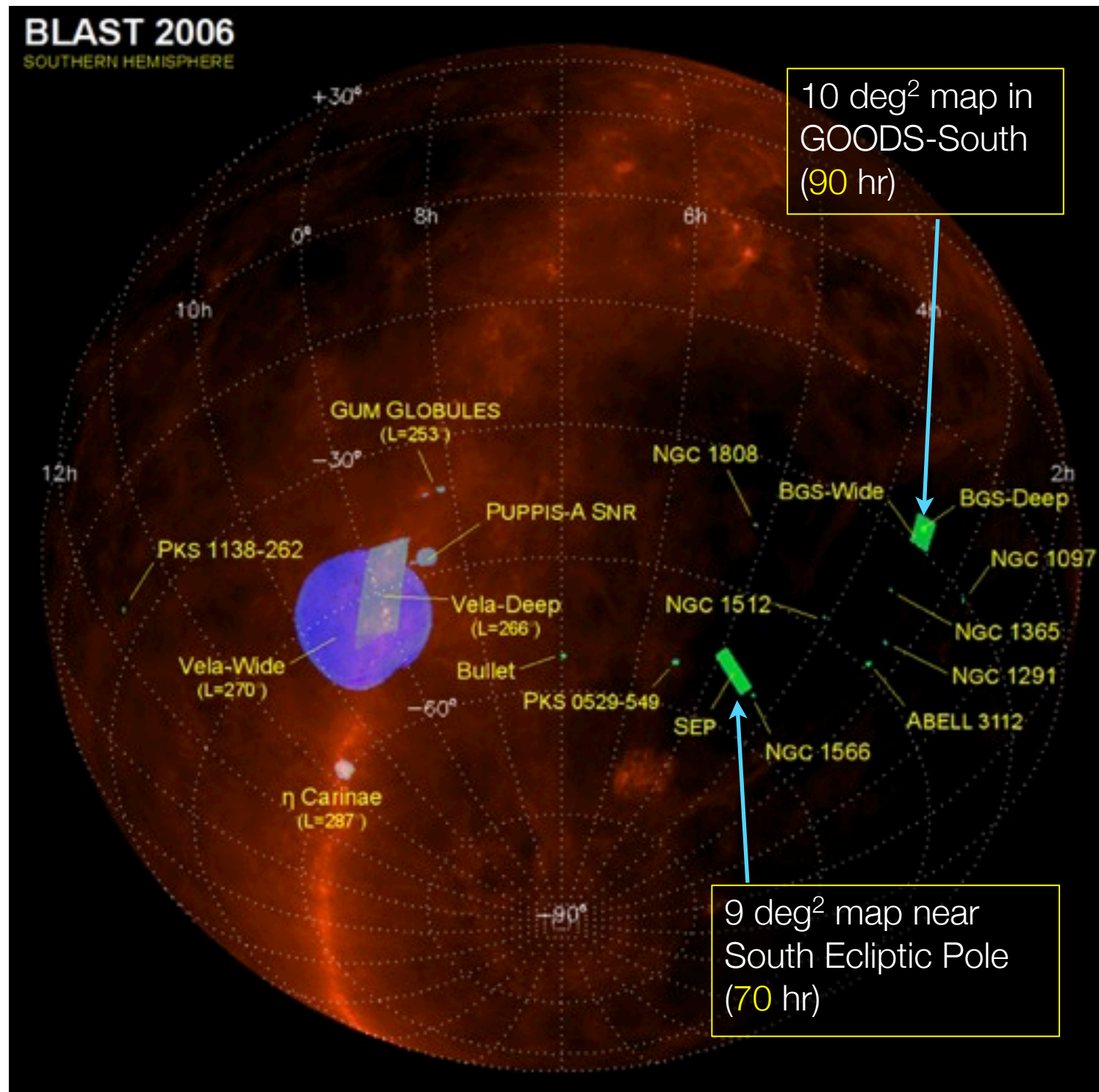


BLAST

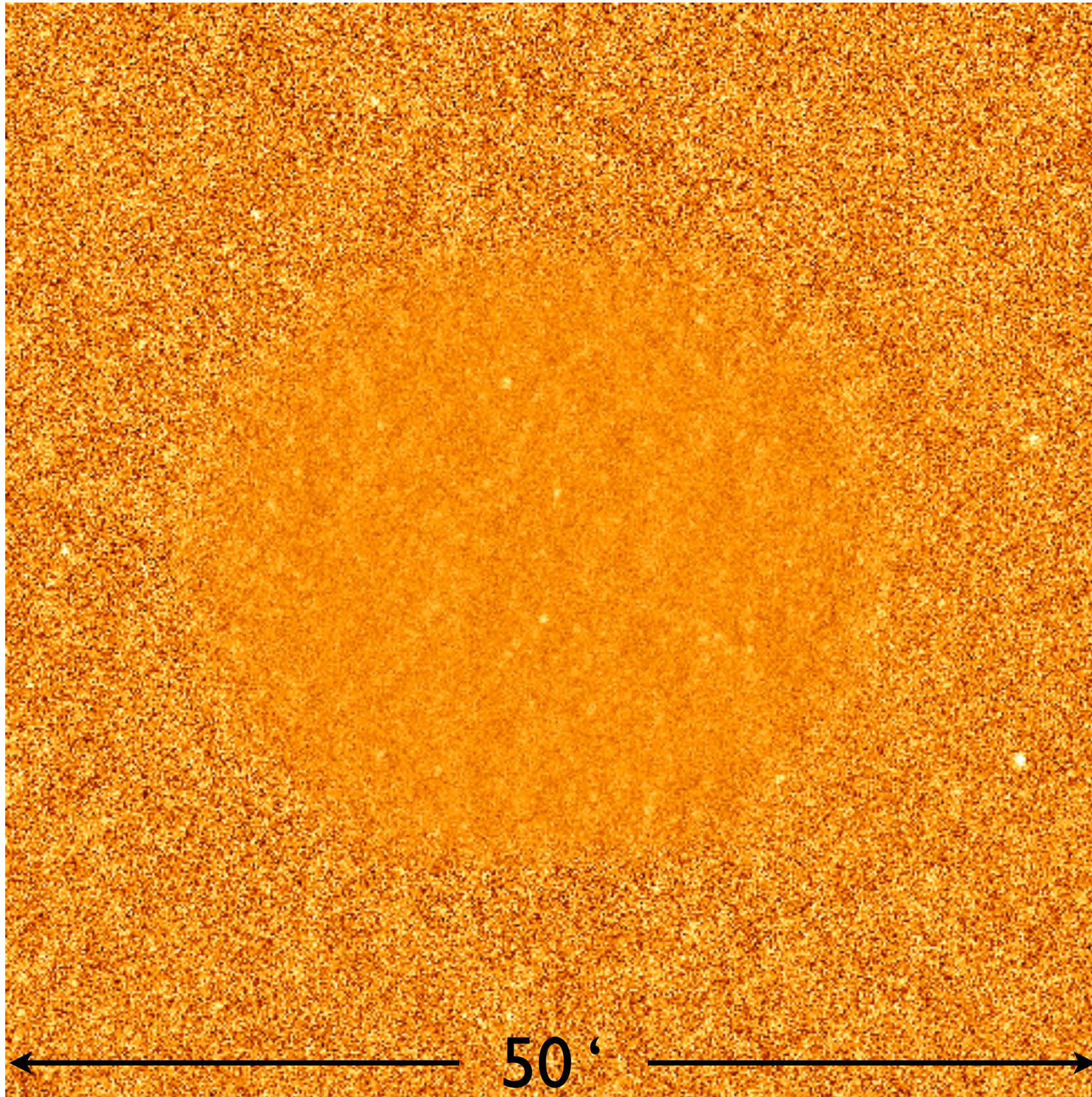
marco viero



20



~180 hours
(2/3 of flight)
on extragalactic
fields



50'

BGS deep+wide

BLAST

marco viero



1. “Over half of the far-infrared background light comes from galaxies at $z \sim 1.2$ ”, M. J. Devlin, et al. 2009, Nature, 458
2. “BLAST: Resolving the Cosmic Submillimeter Background”, G. Marsden et al. 2009, Astrophysical Journal, 707, 1766
3. “BLAST: A Far-Infrared Measurement of the History of Star Formation”, E. Pascale et al. 2009, Astrophysical Journal, 707, 1740
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5. “Submillimeter Number Counts From Statistical Analysis of BLAST Maps”, G. Patanchon et al. 2009, Astrophysical Journal, 707, 1750
6. “Radio and Mid-Infrared Identification of BLAST Source Counterparts in the Chandra Deep Field South”, S. Dye et al. 2009, Astrophysical Journal, 703, 285
7. “A Bright Submillimeter Source in the Bullet Cluster (1E0657-56) Field Detected with BLAST”, M. Rex et al. 2009, Astrophysical Journal, 703, 348
8. “BLAST: the Redshift Surveys”, S. Eales et al, Astrophysical Journal, 707, 1779
9. “The BLAST 250-micron selected galaxy population in GOODS-South”, J. S. Dunlop et al., 2009, Monthly Notices of the Royal Astronomical Society, submitted, arXiv:0910.3642
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11. “The Balloon-borne Large Aperture Submillimeter Telescope (BLAST) 2006: Calibration and Flight Performance”, M. D. P. Truch et al. 2009, Astrophysical Journal, 707, 1824
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14. “The BLAST Survey of the Vela Molecular Cloud: Physical Properties of the Dense Cores in Vela-D”, L. Olmi et al. 2009, Astrophysical Journal, 707, 1836
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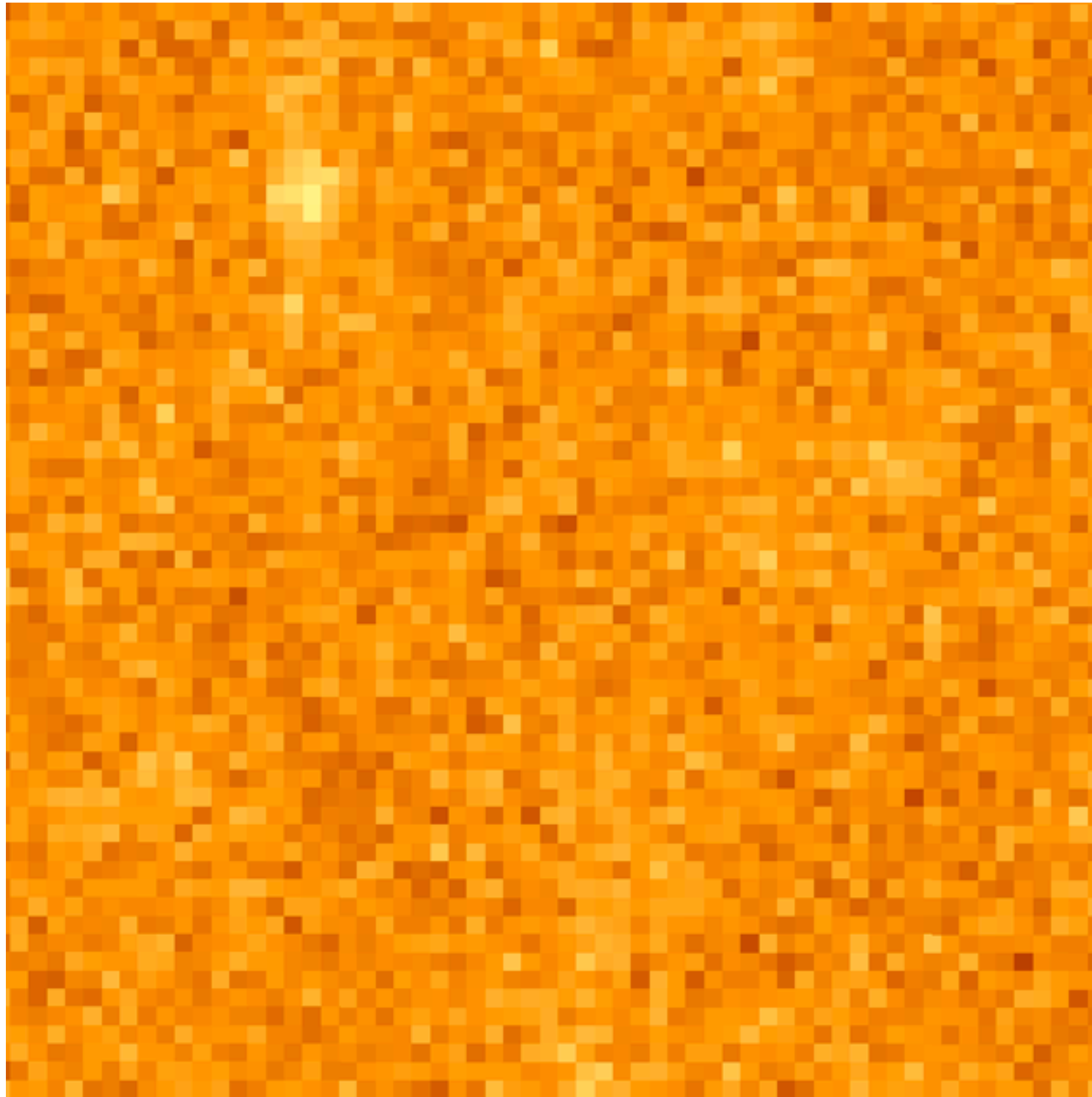
WHAT IS SO SPECIAL ABOUT BLAST?

BLAST

marco viero



24

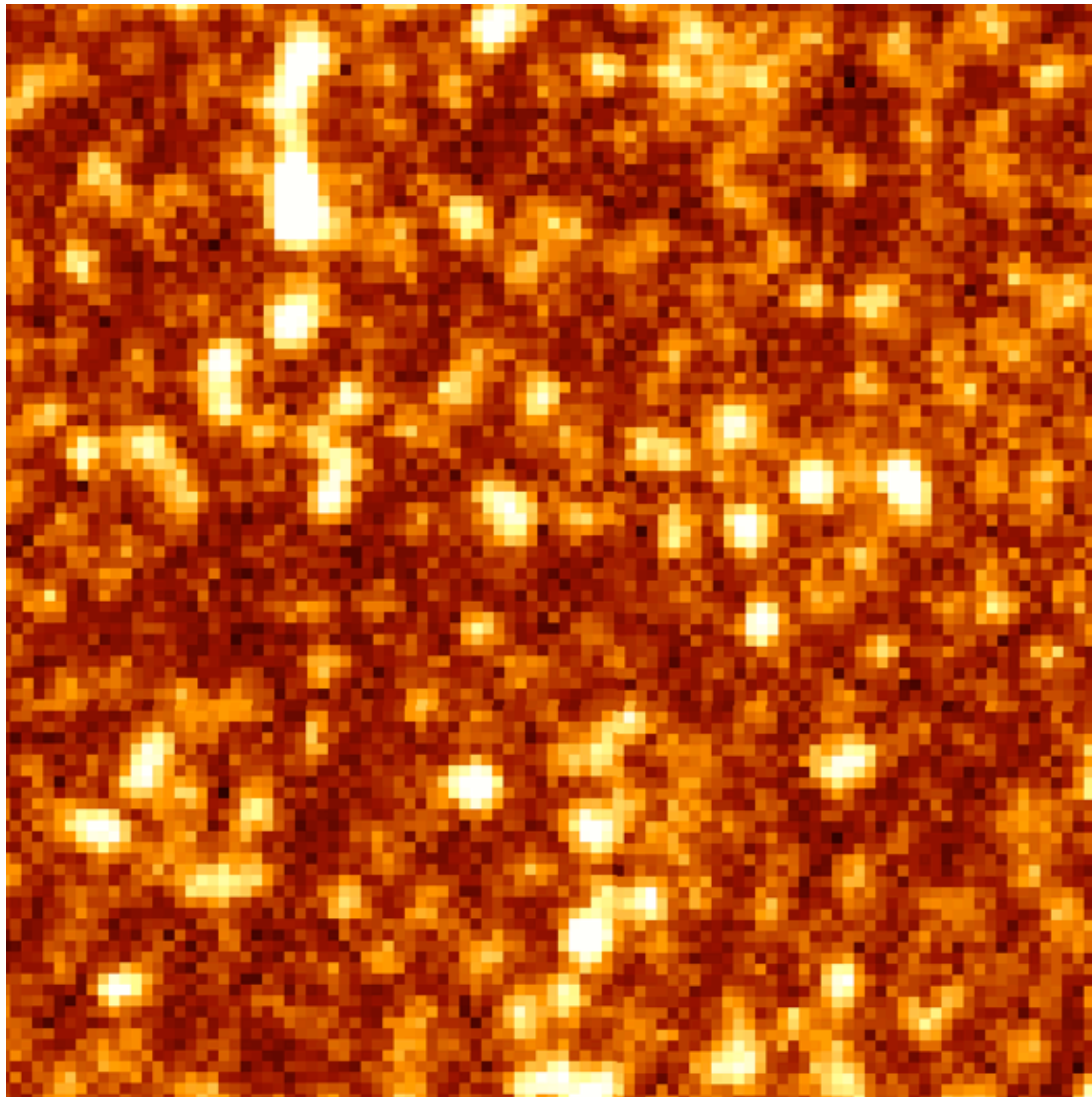


BGS deep+wide

BLAST

marco viero





SPIRE 250 μm

BLAST

marco viero





BLAST

marco viero



26

MIT balloon
Toco
Cobra
QMAP
White Dish
White Mountain
MAX
BOOMERang
QMAT
MINT
Saskatoon
Archeops
BAM
WMAP
ACT



MIT balloon
Toco
Cobra
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White Dish
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MIT balloon

Saskatoon
Archeops

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WMAP

MAX

MINT

White Dish

ACT



MIT balloon

Saskatoon
Archeops

Toco

White Mountain

BAM

QMAP

BOOMERang

Cobra

QMAT

WMAP

MAX

MINT

White Dish

ACT



Lessons Learned



Lessons Learned

- 1 - Map-based rather than catalog-based analysis better for confused maps



Lessons Learned

- 1 - Map-based rather than catalog-based analysis better for confused maps
- 2 - Deep ancillary data vital



Lessons Learned

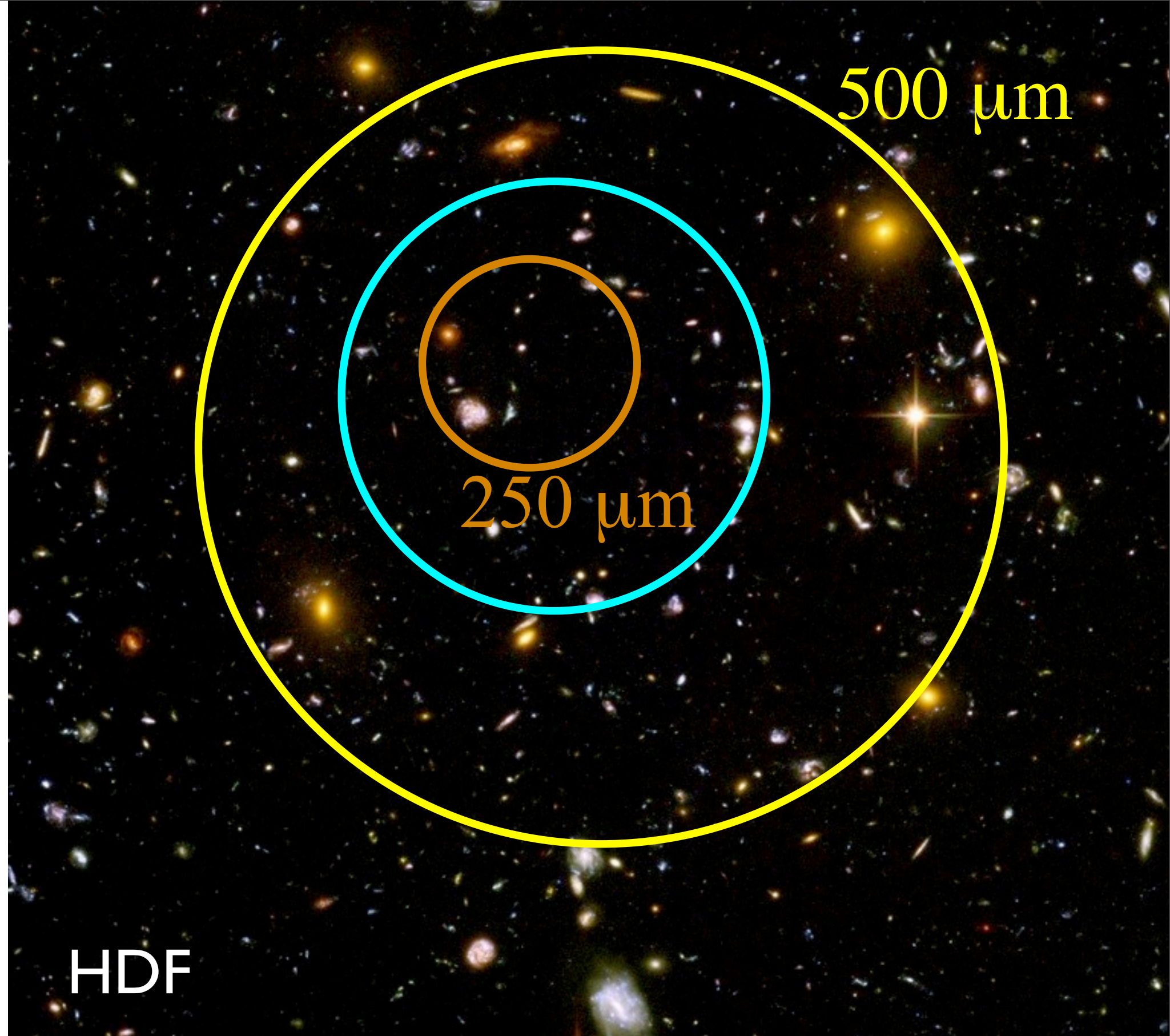
- 1 - Map-based rather than catalog-based analysis better for confused maps
- 2 - Deep ancillary data vital
- 3 - Must bring talented people (from different fields) together

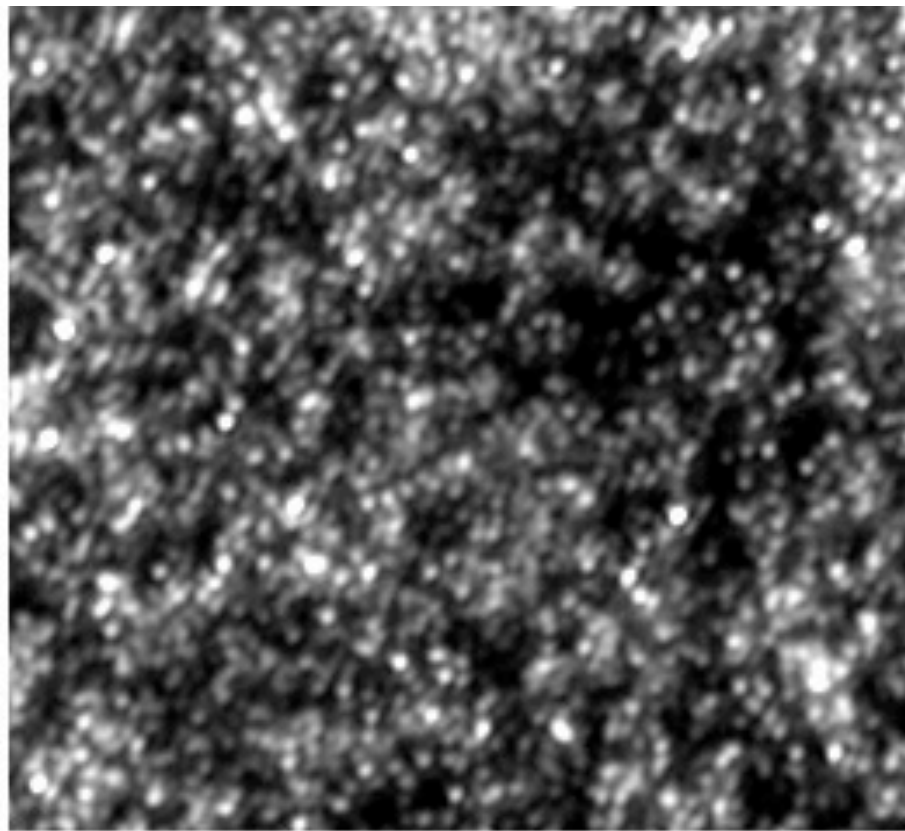
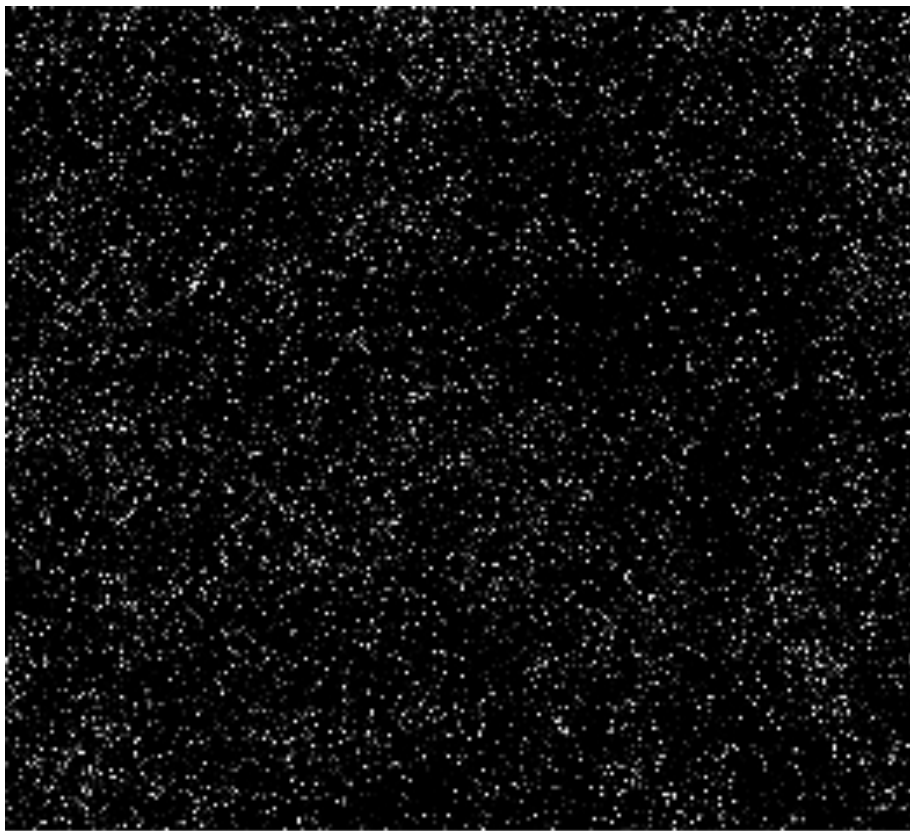


Example 1: Clustering

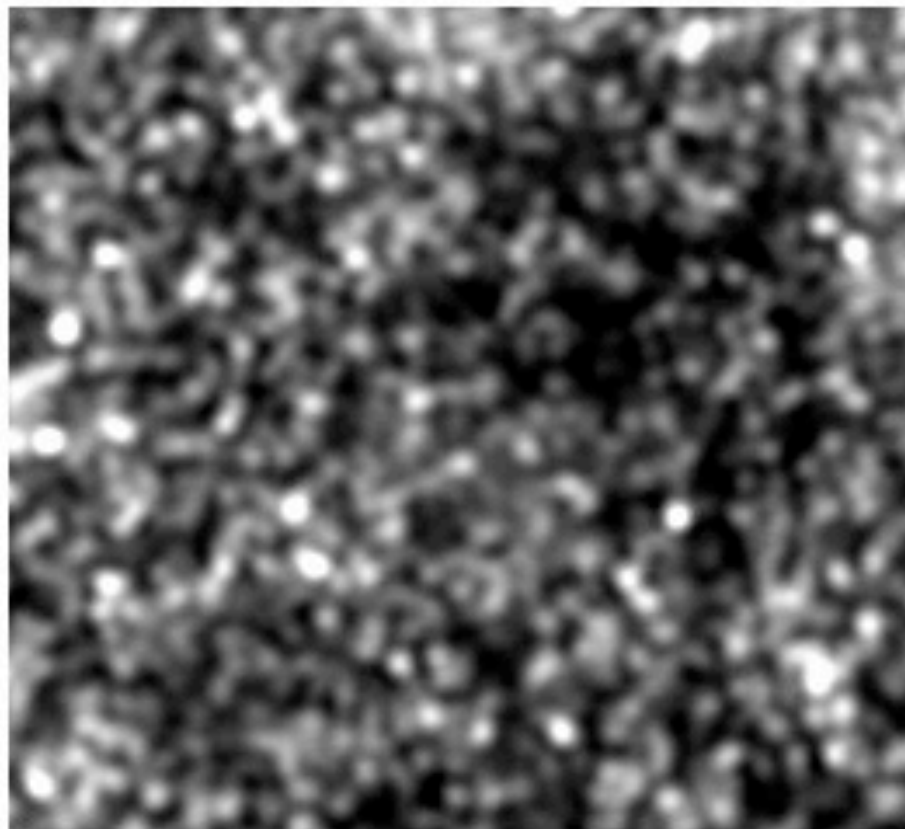
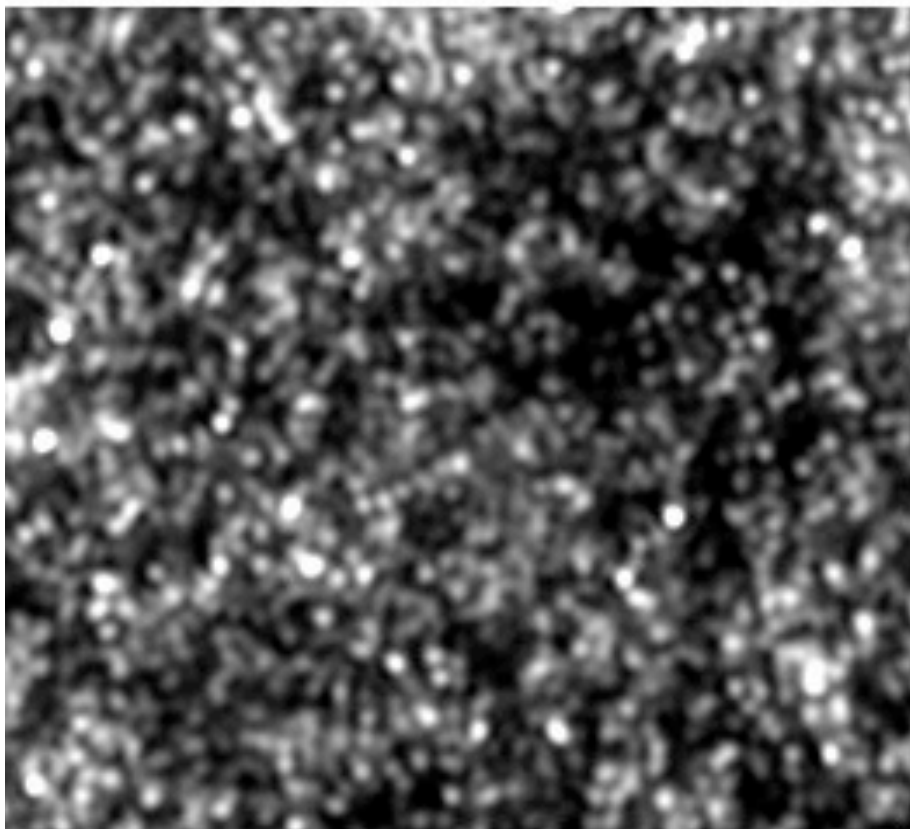
RECALL

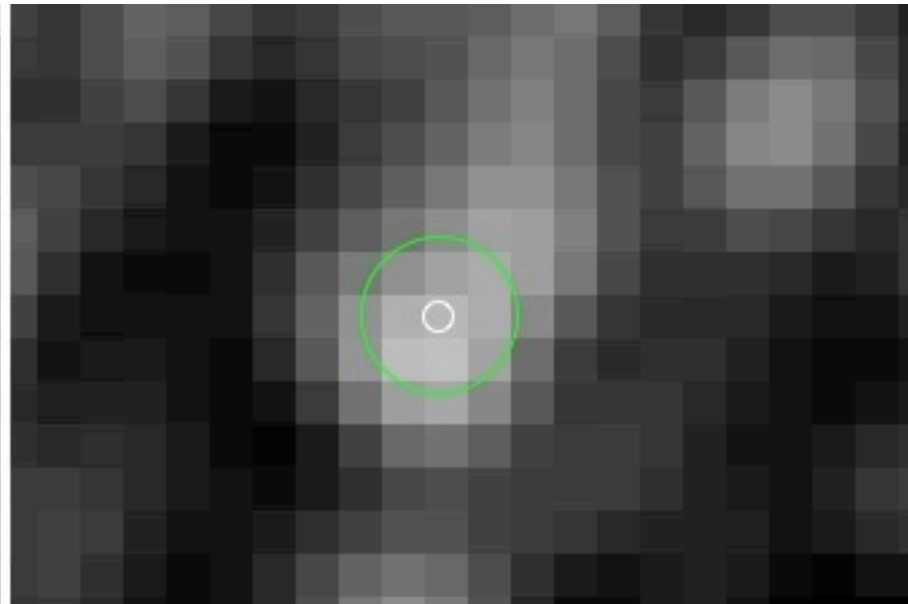
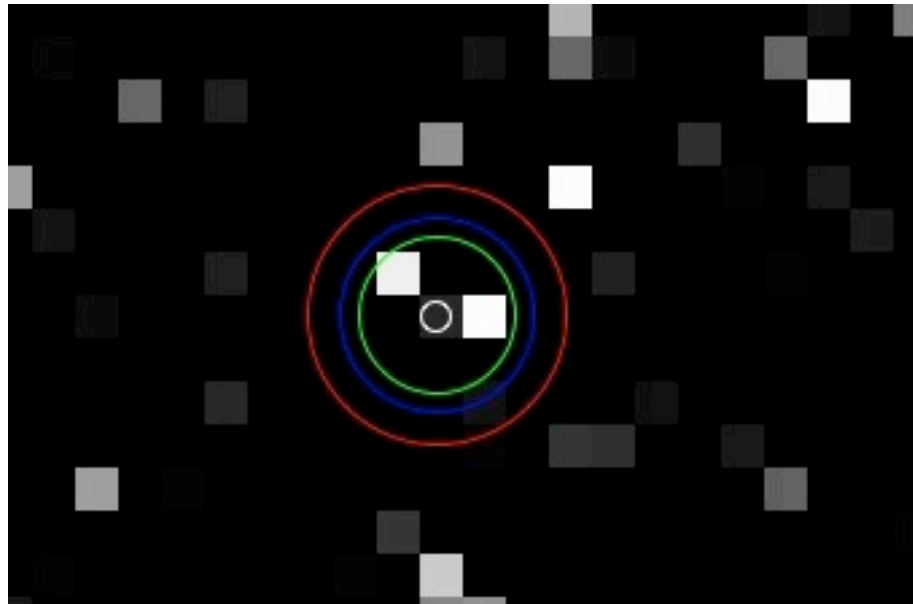
The BLAST beams are huge compared to galaxies, and even compared to the mean distance between galaxies.



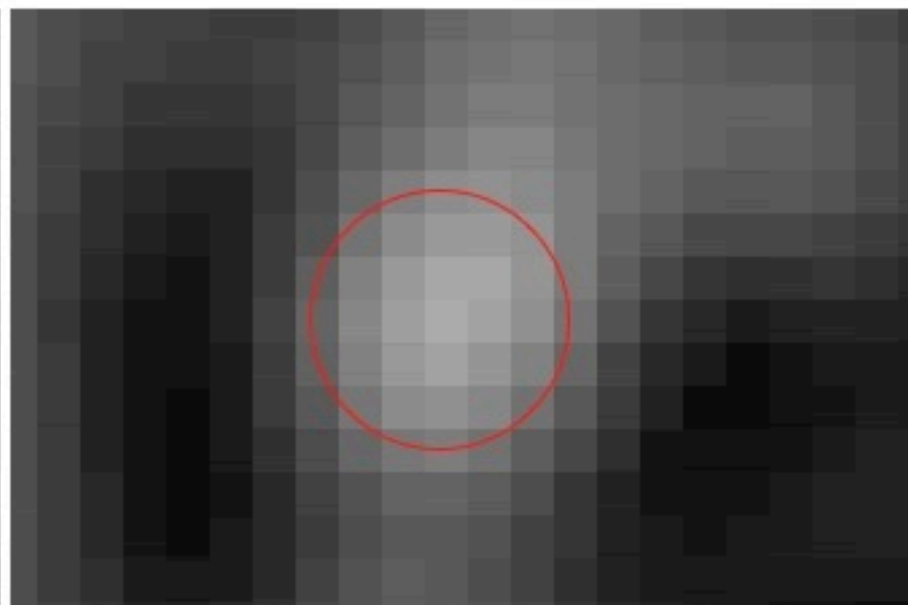
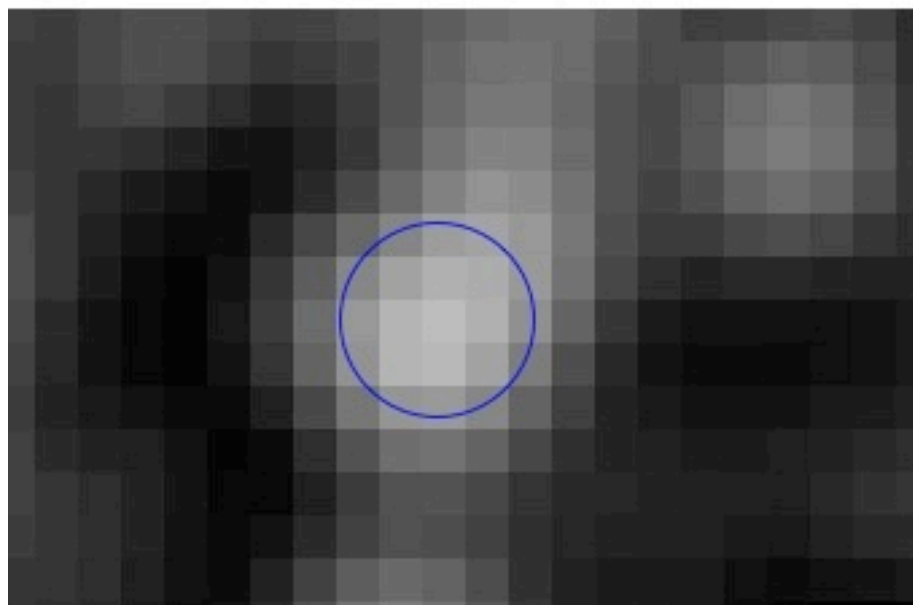


While galaxies
adequately
trace structure
on large scales.





While galaxies adequately trace structure on large scales.



On small scales, how do you even decide what is a source?

clustering

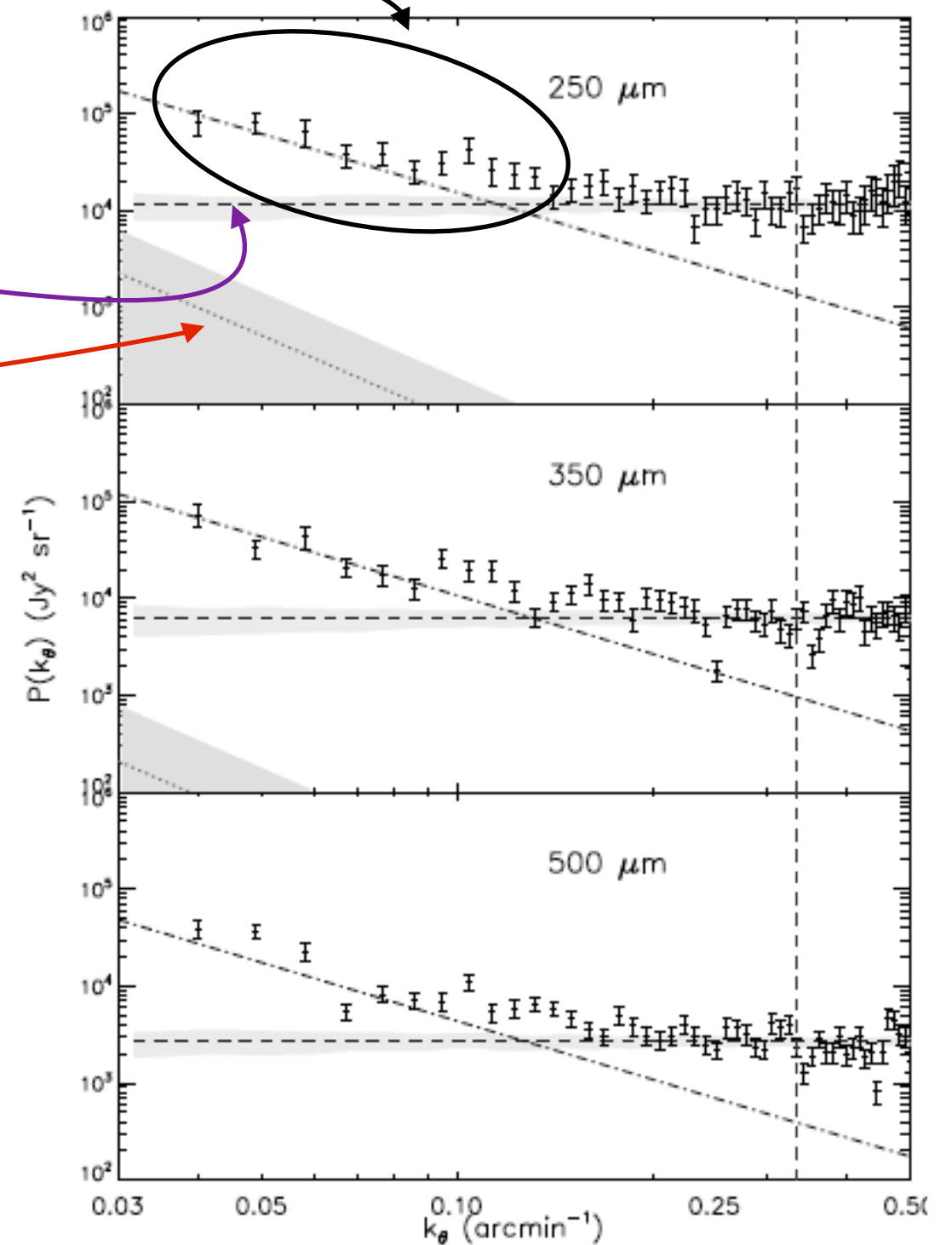
Viero et al. 0904.1200

marco viero



31

- Power Spectrum shows signal in excess of Shot Noise and Cirrus on angular scales $> 5'$



Viero et al. 0904.1200

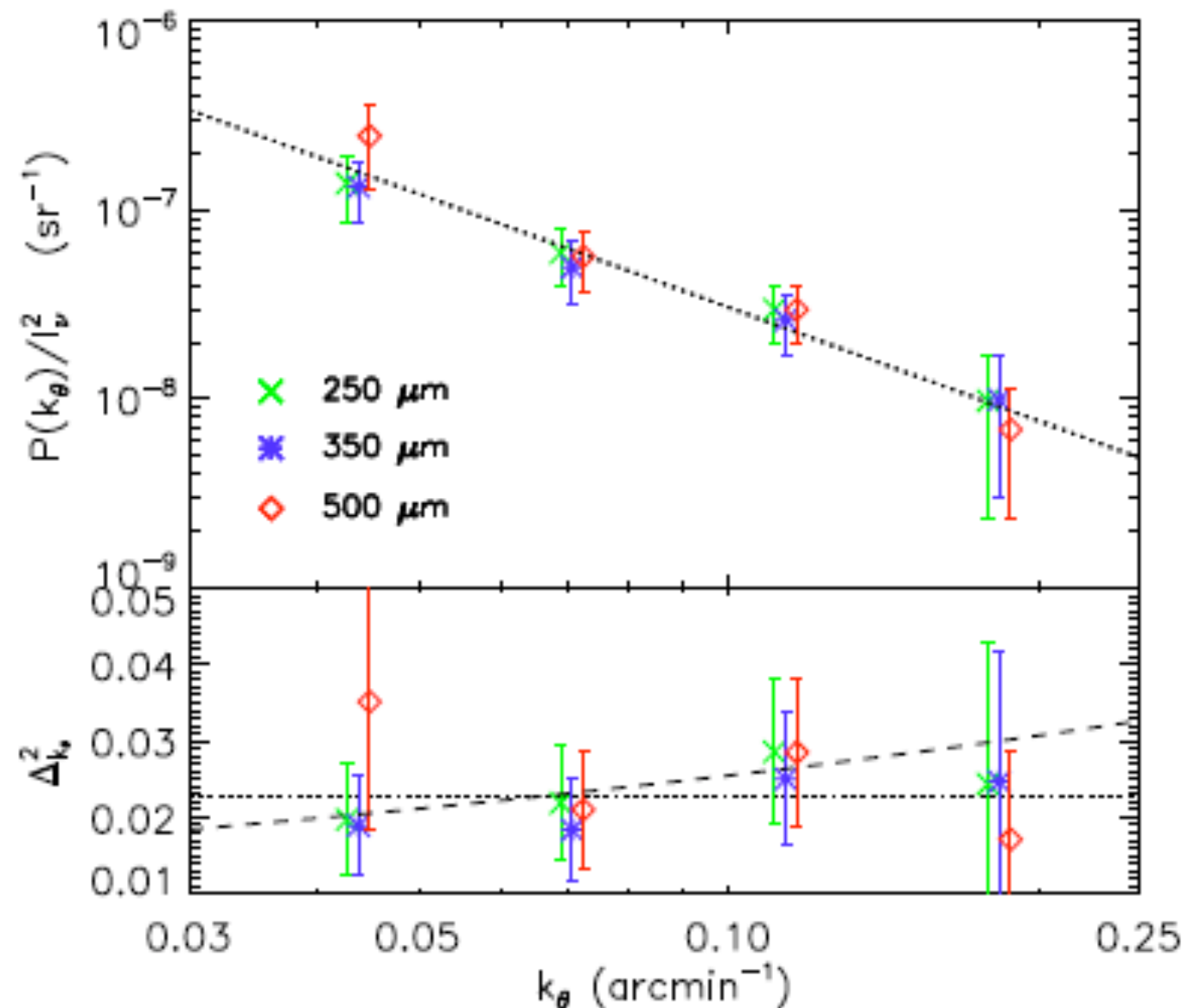
clustering

marco viero



31

- Power Spectrum shows signal in excess of Shot Noise and Cirrus on angular scales $> 5'$
- Normalized Clustering Signal well described by a power-law, with slope ≈ -2



Viero et al. 0904.1200

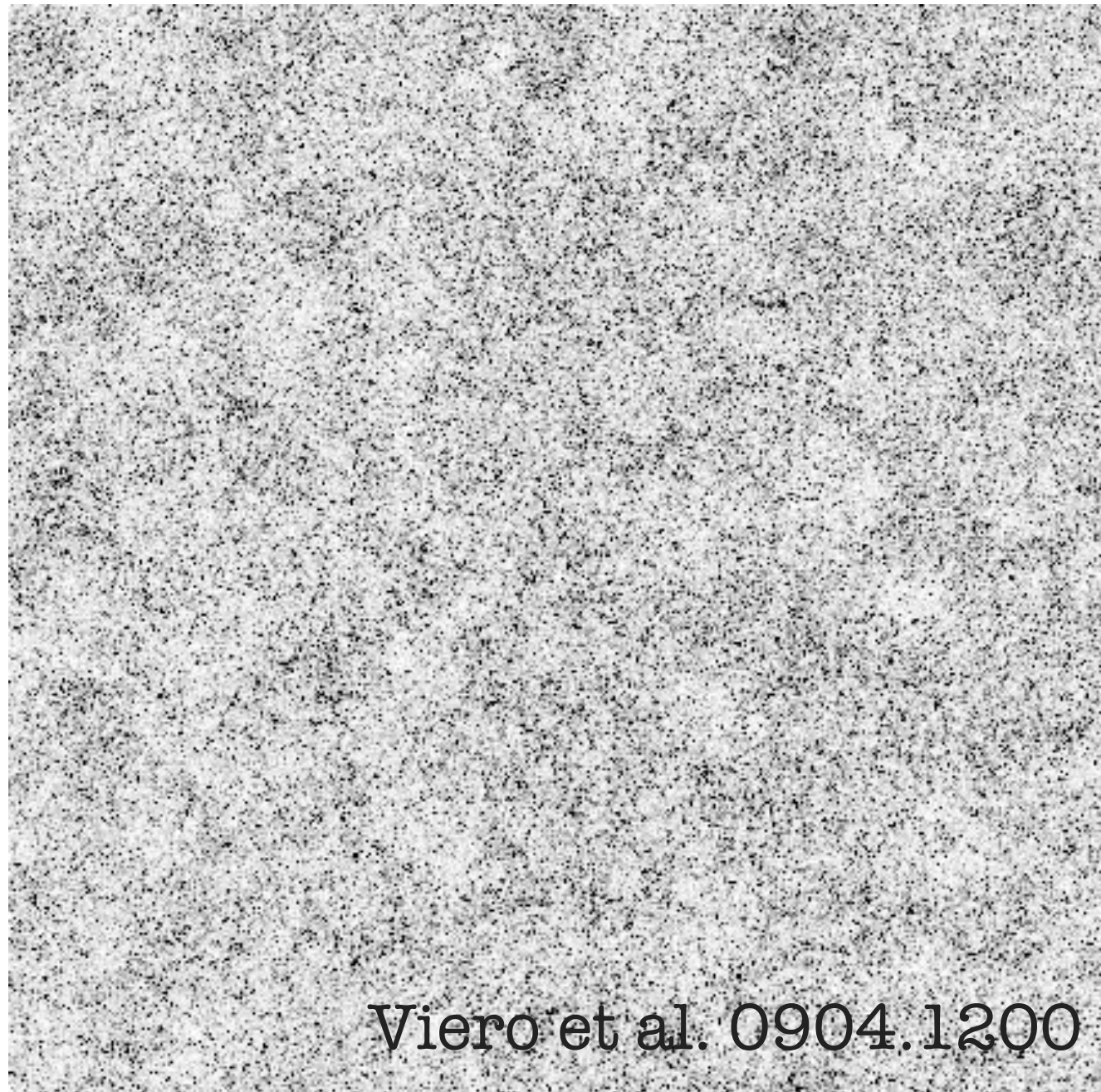
clustering

marco viero



31

BLAST predicted...



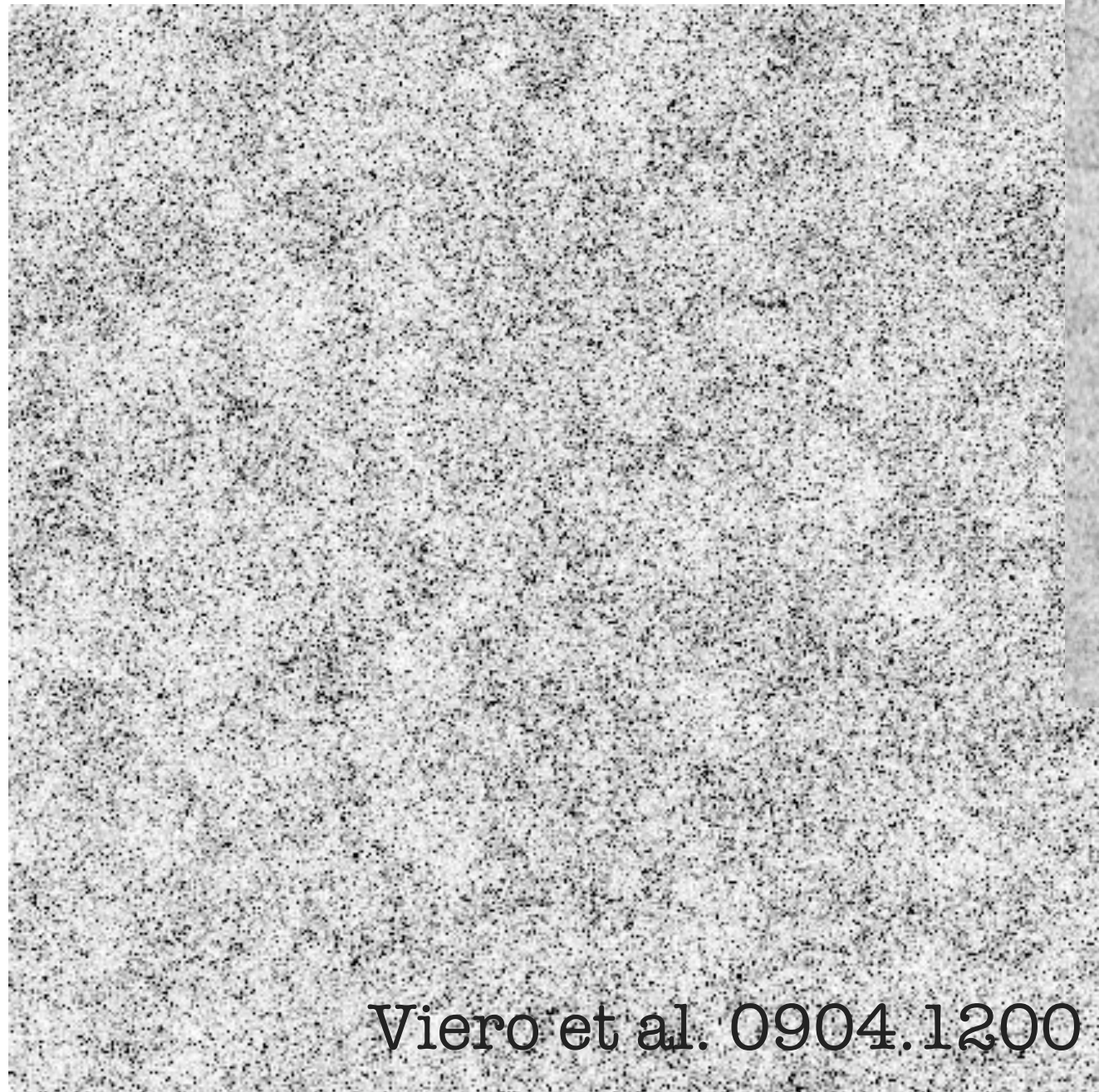
clustering

marco viero

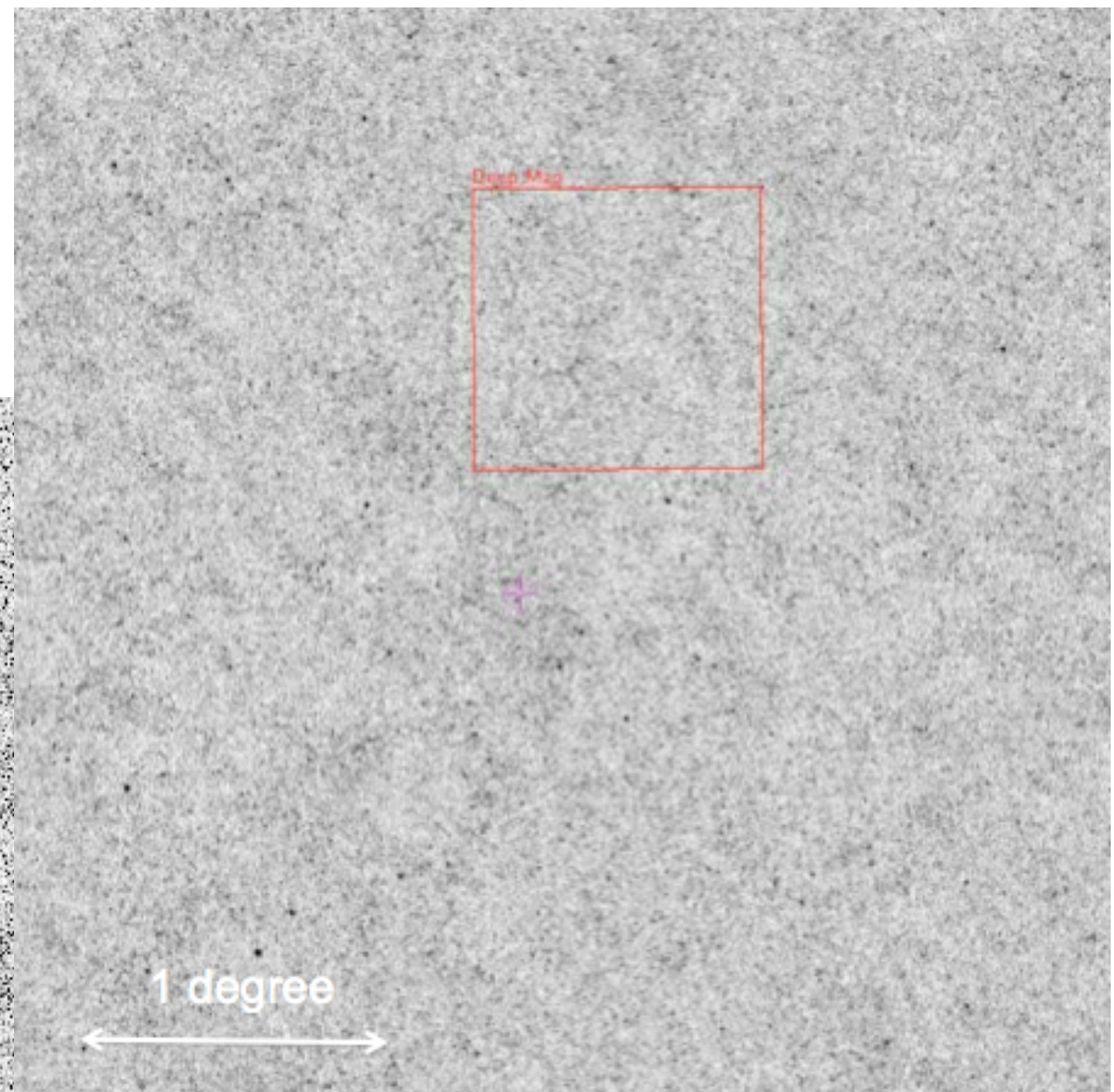


32

BLAST predicted...



Viero et al. 0904.1200



... Herschel saw

clustering

marco viero



32

clustering

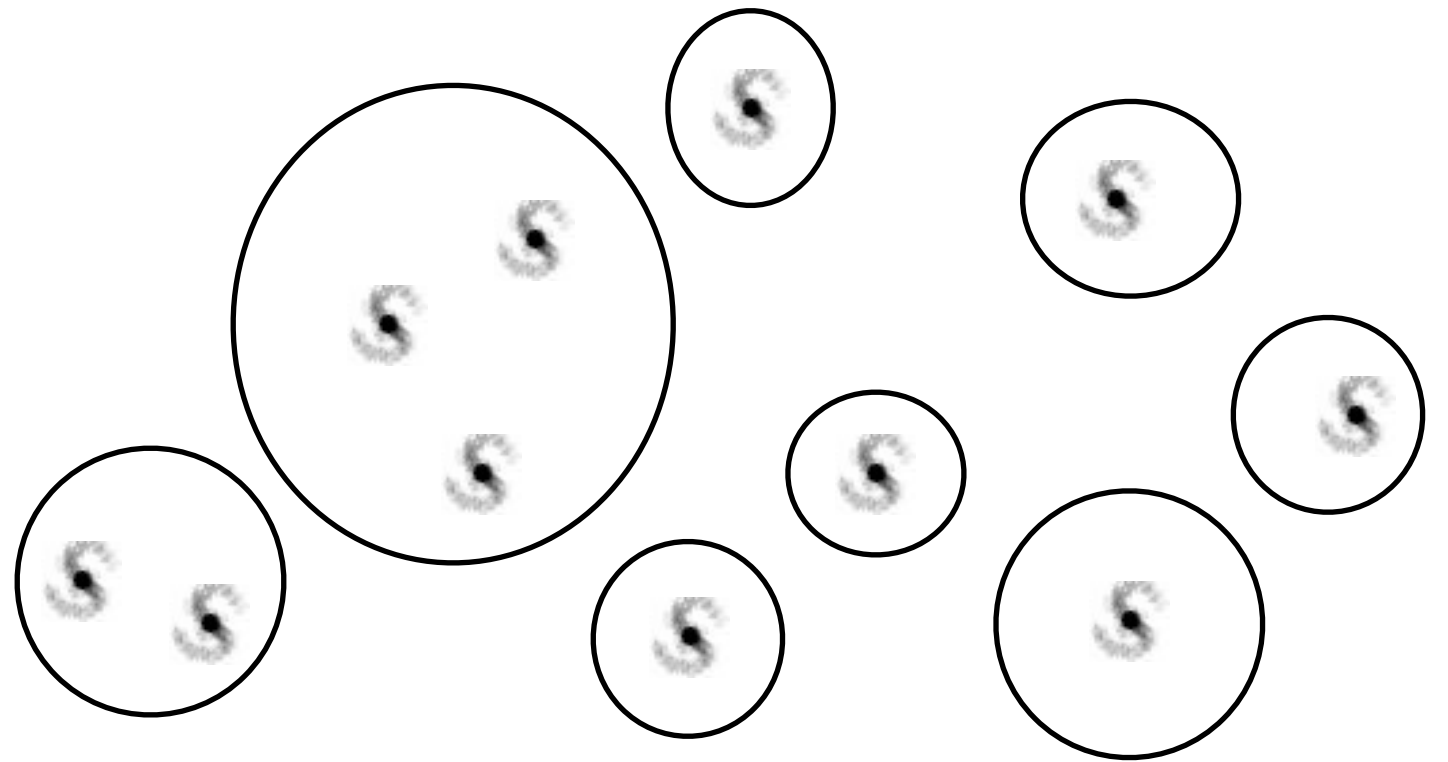
Viero et al. 0904.1200

marco viero



33

- Clustering Signal made up of two regimes



Viero et al. 0904.1200

clustering

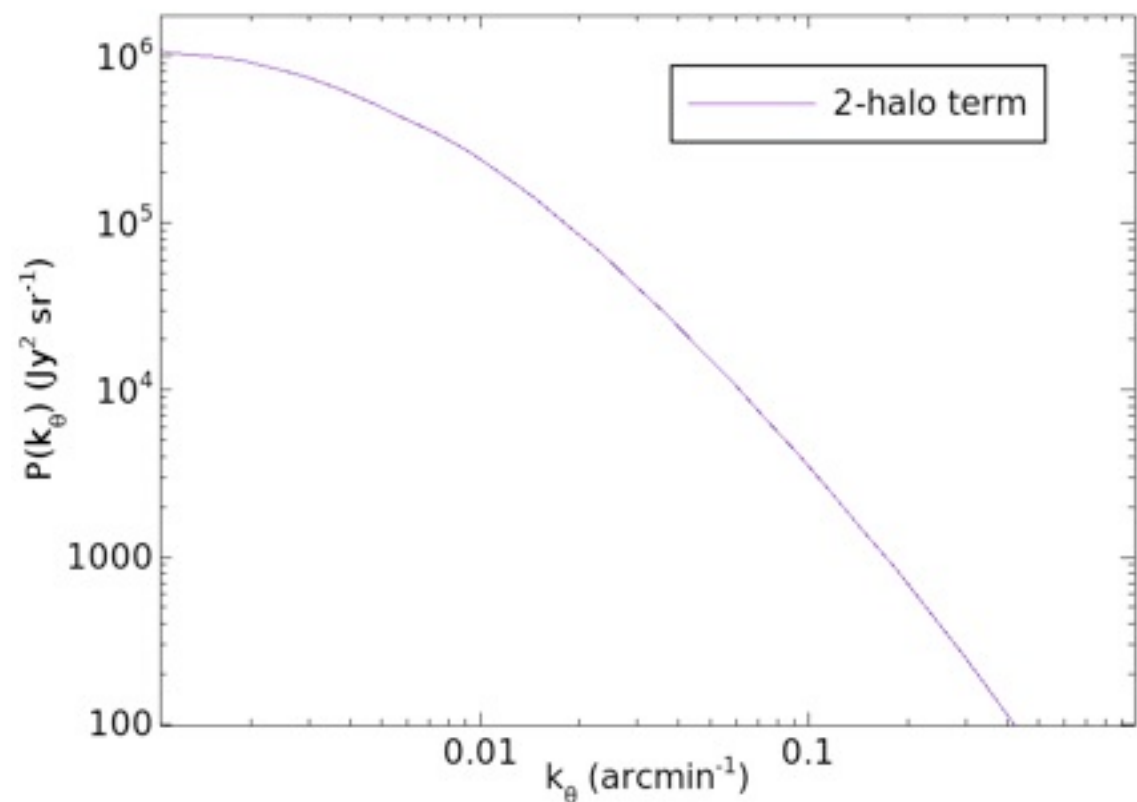
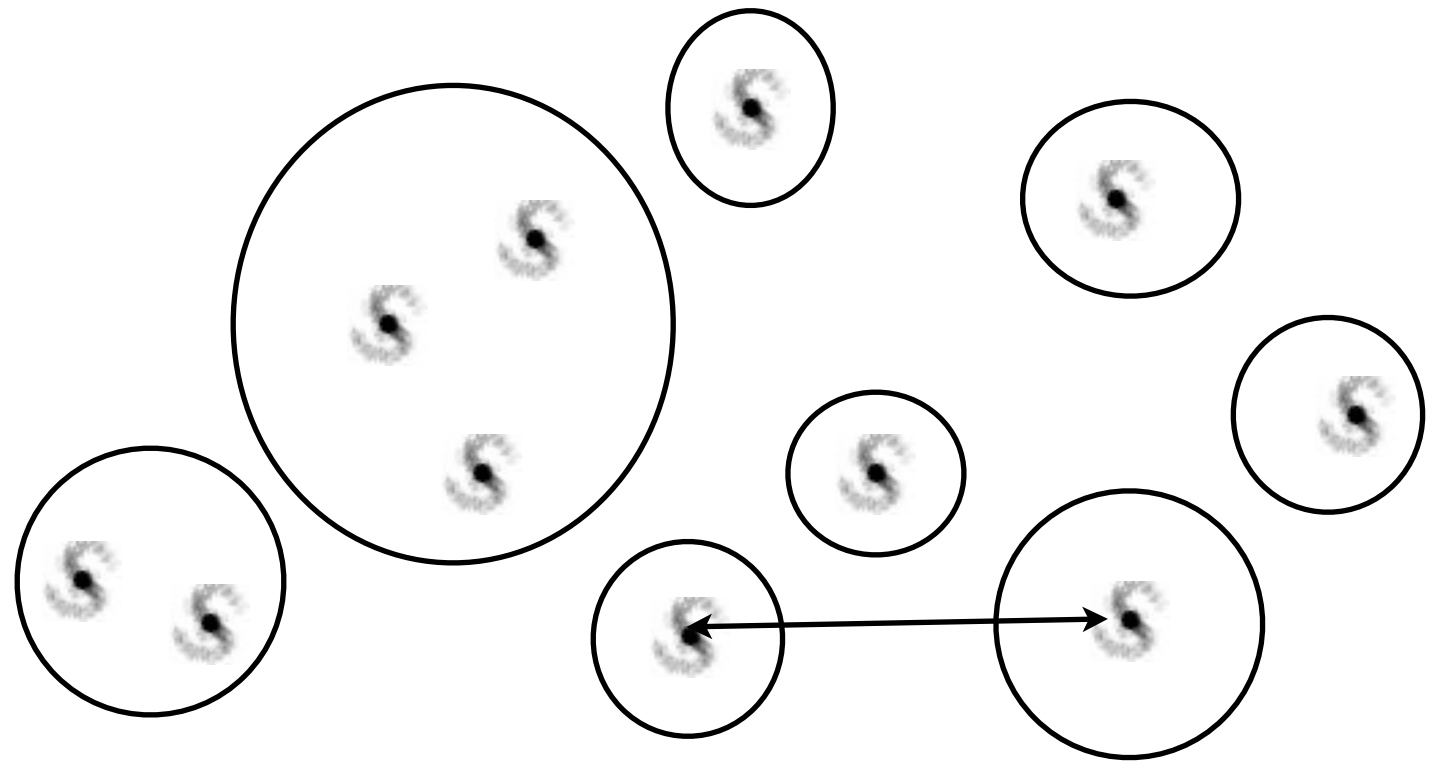
marco viero



33

- Clustering Signal made up of two regimes

- 2-halo: Linear Regime (large scales)

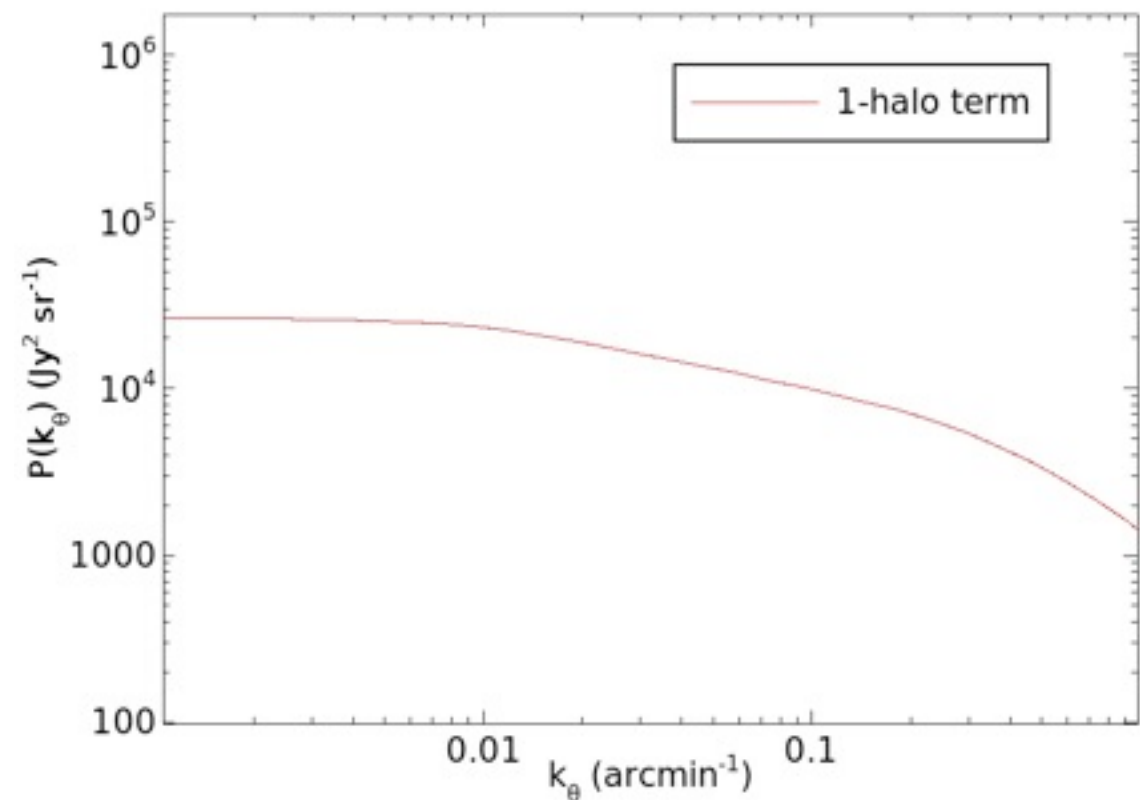
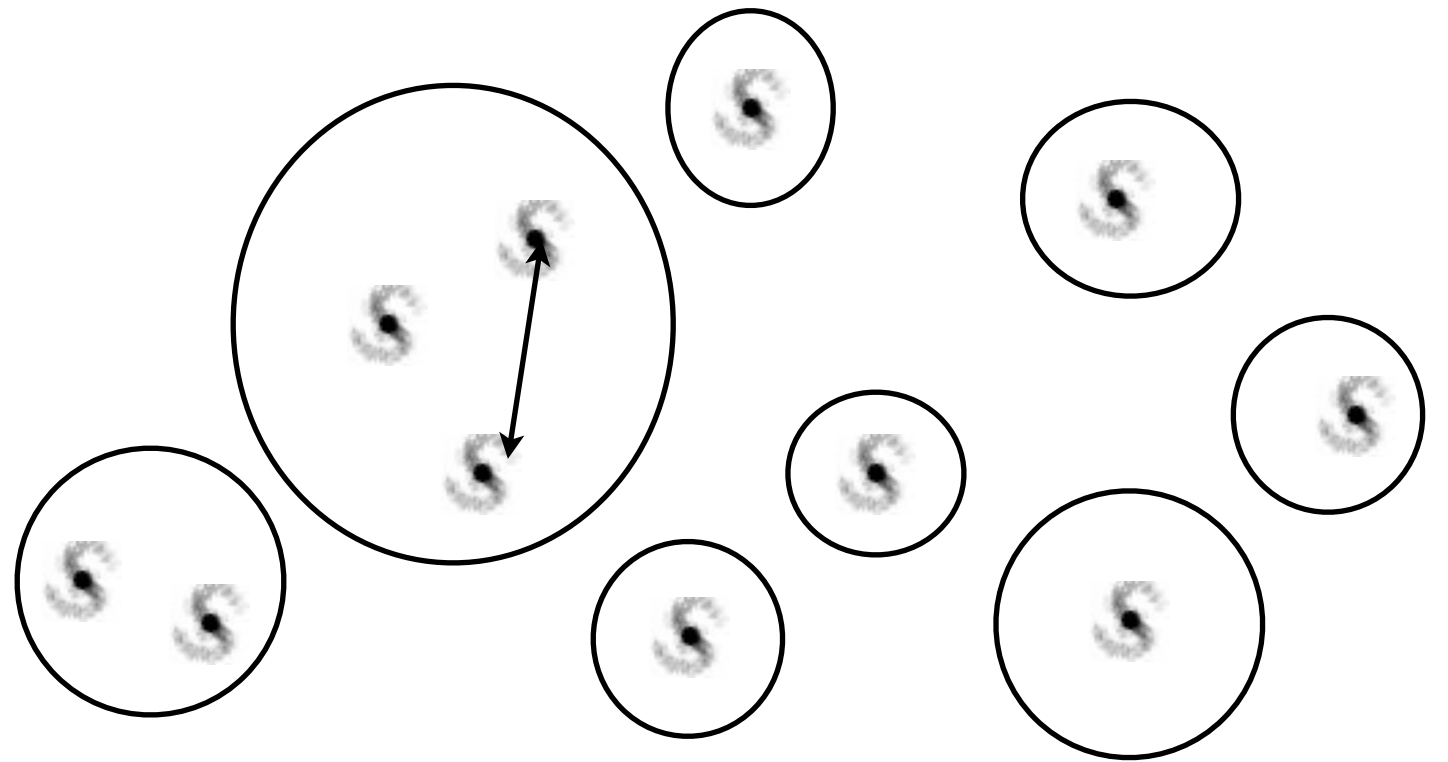


Viero et al. 0904.1200

- Clustering Signal made up of two regimes

- 2-halo: Linear Regime (large scales)

- 1-halo: Non-Linear Regime (small scales)



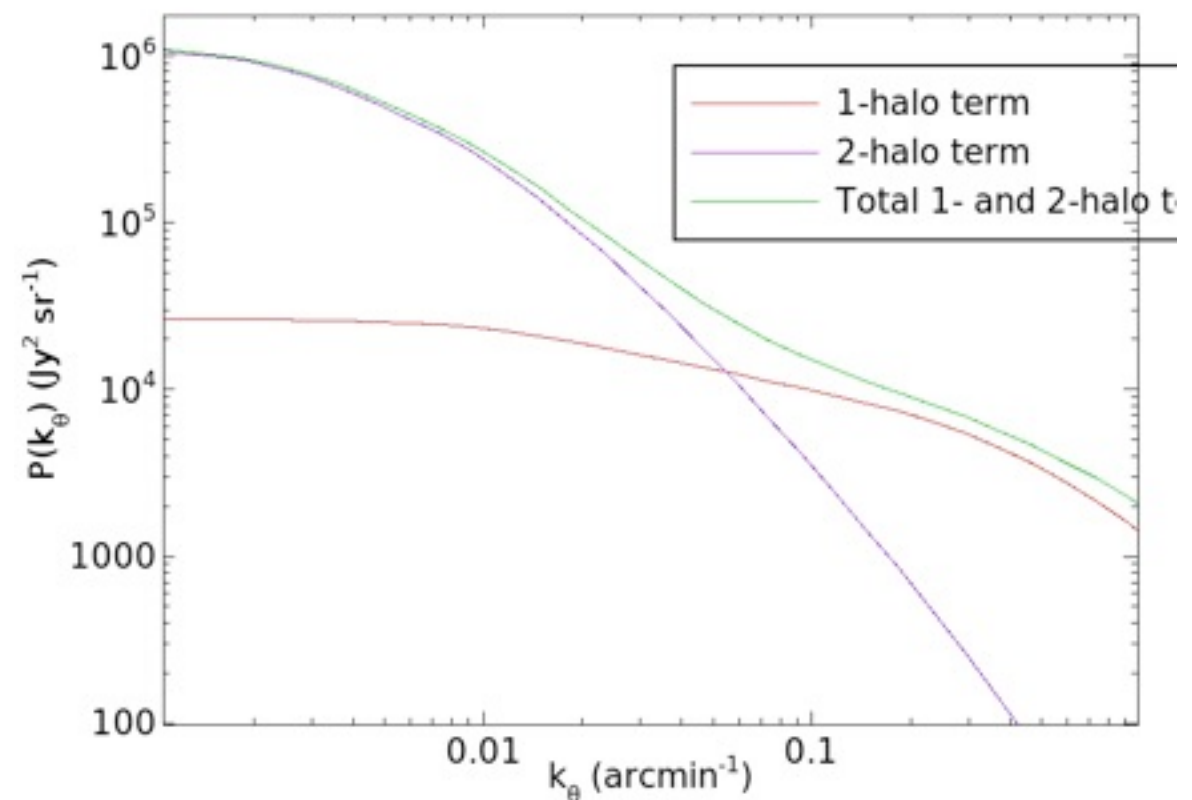
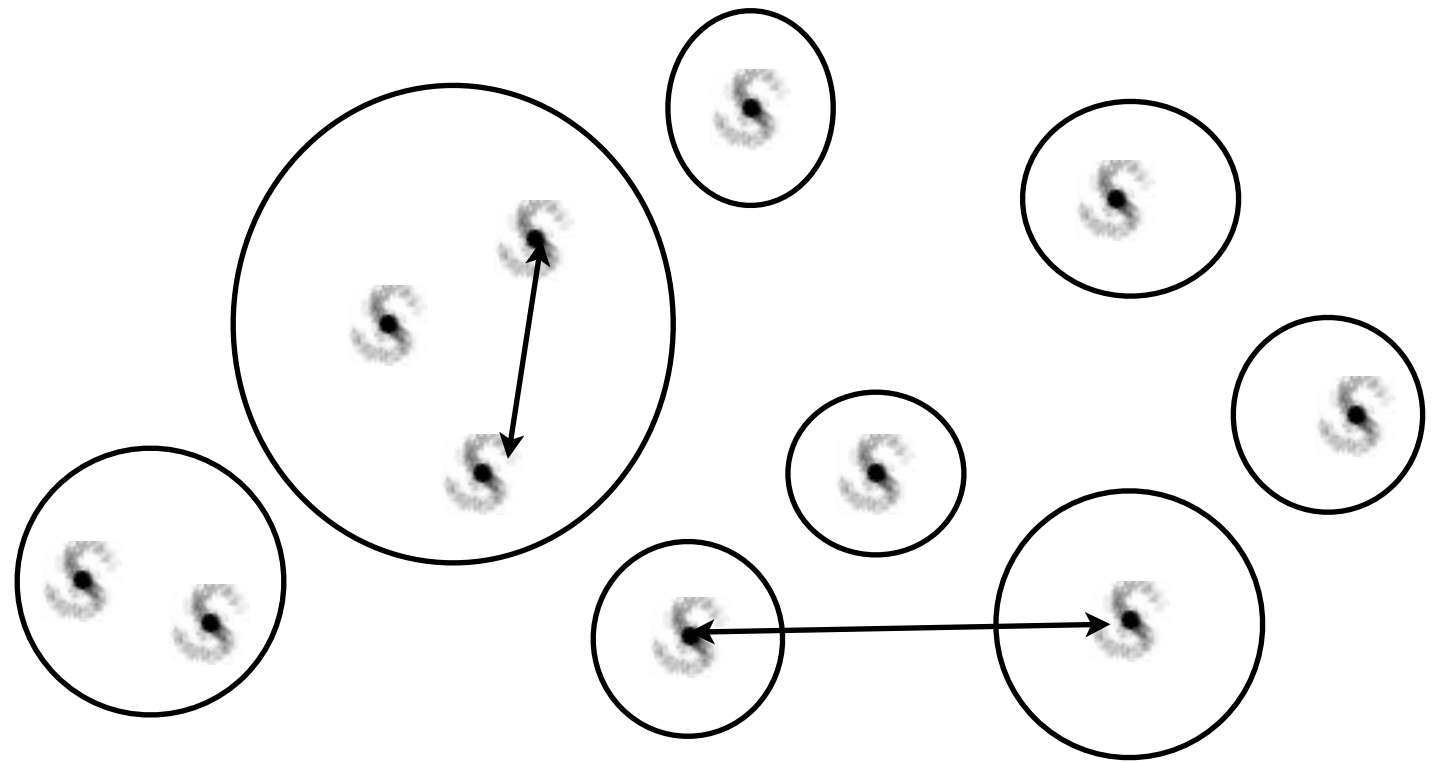
Viero et al. 0904.1200

- Clustering Signal made up of two regimes

- 2-halo: Linear Regime (large scales)

- 1-halo: Non-Linear Regime (small scales)

- Total the sum of both terms



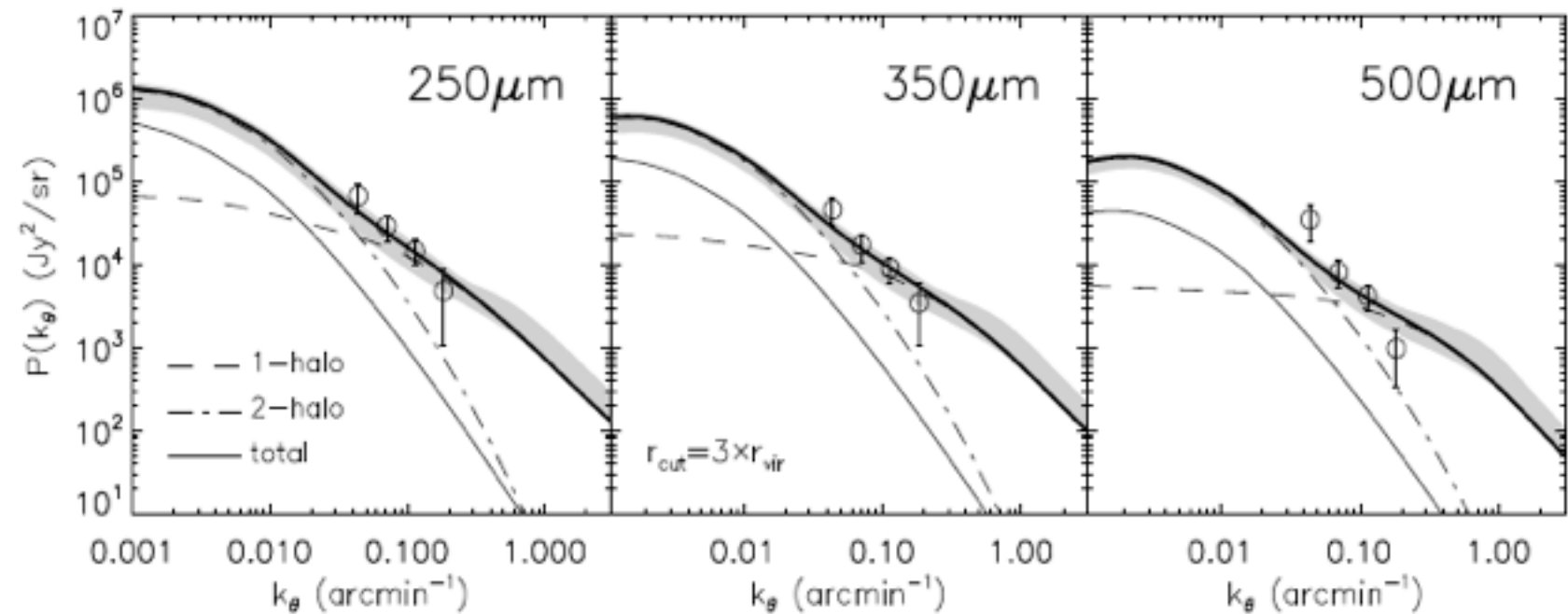
Viero et al. 0904.1200

- Clustering Signal made up of two regimes

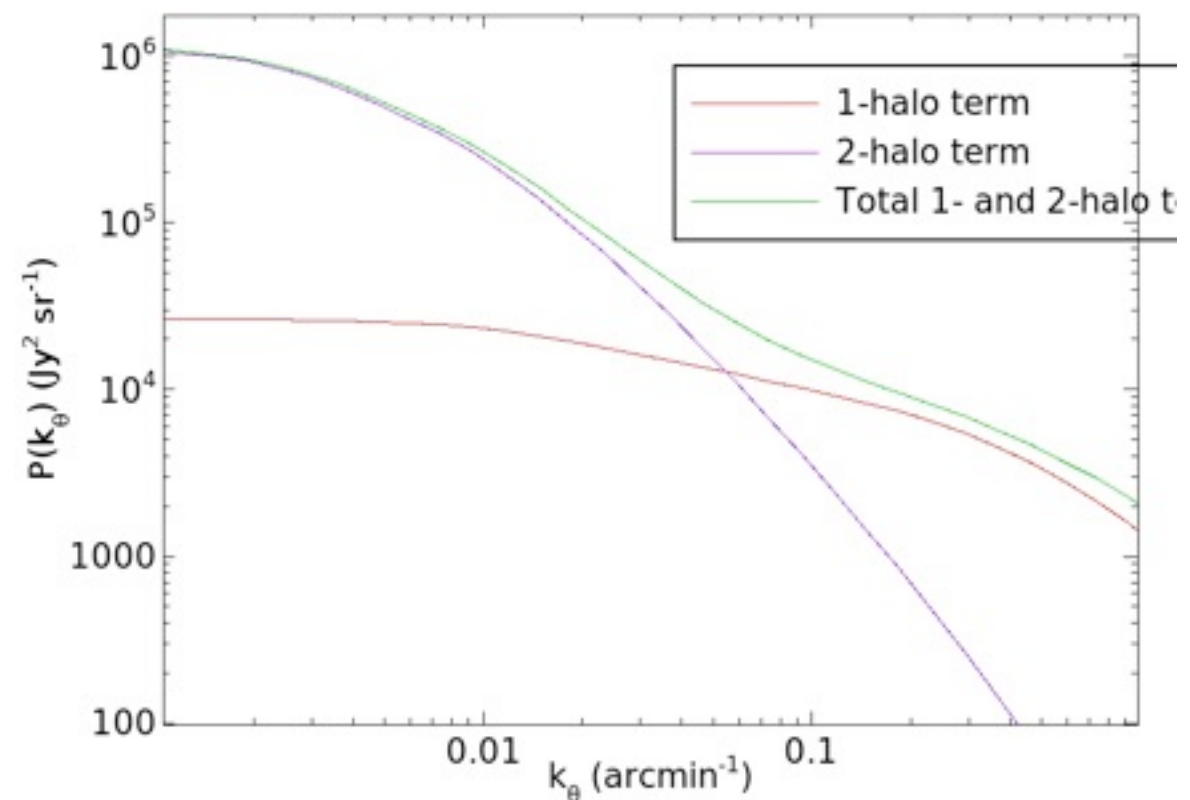
- 2-halo: Linear Regime (large scales)

- 1-halo: Non-Linear Regime (small scales)

- Total the sum of both terms



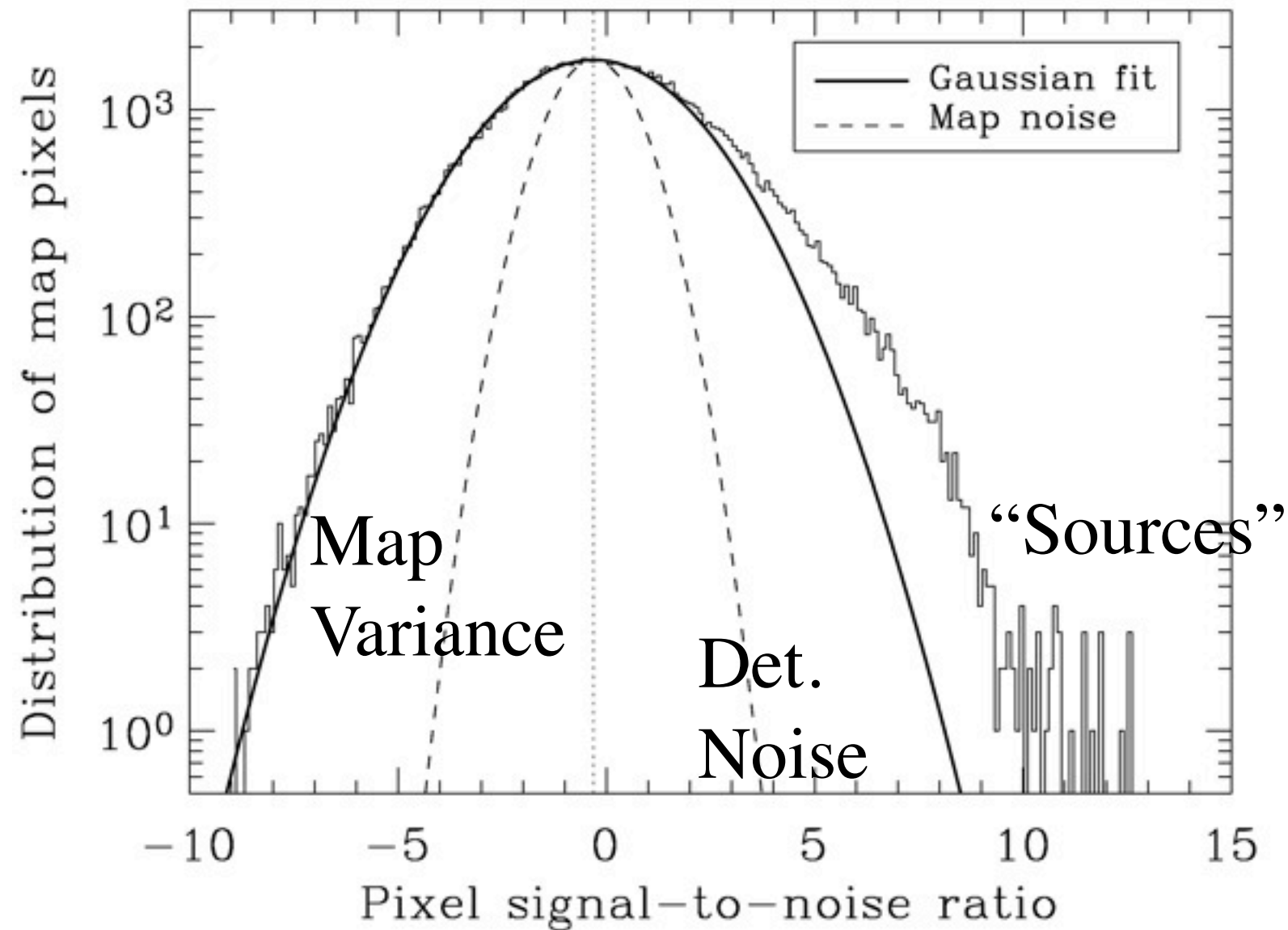
Halo Model of Mattia Negrello



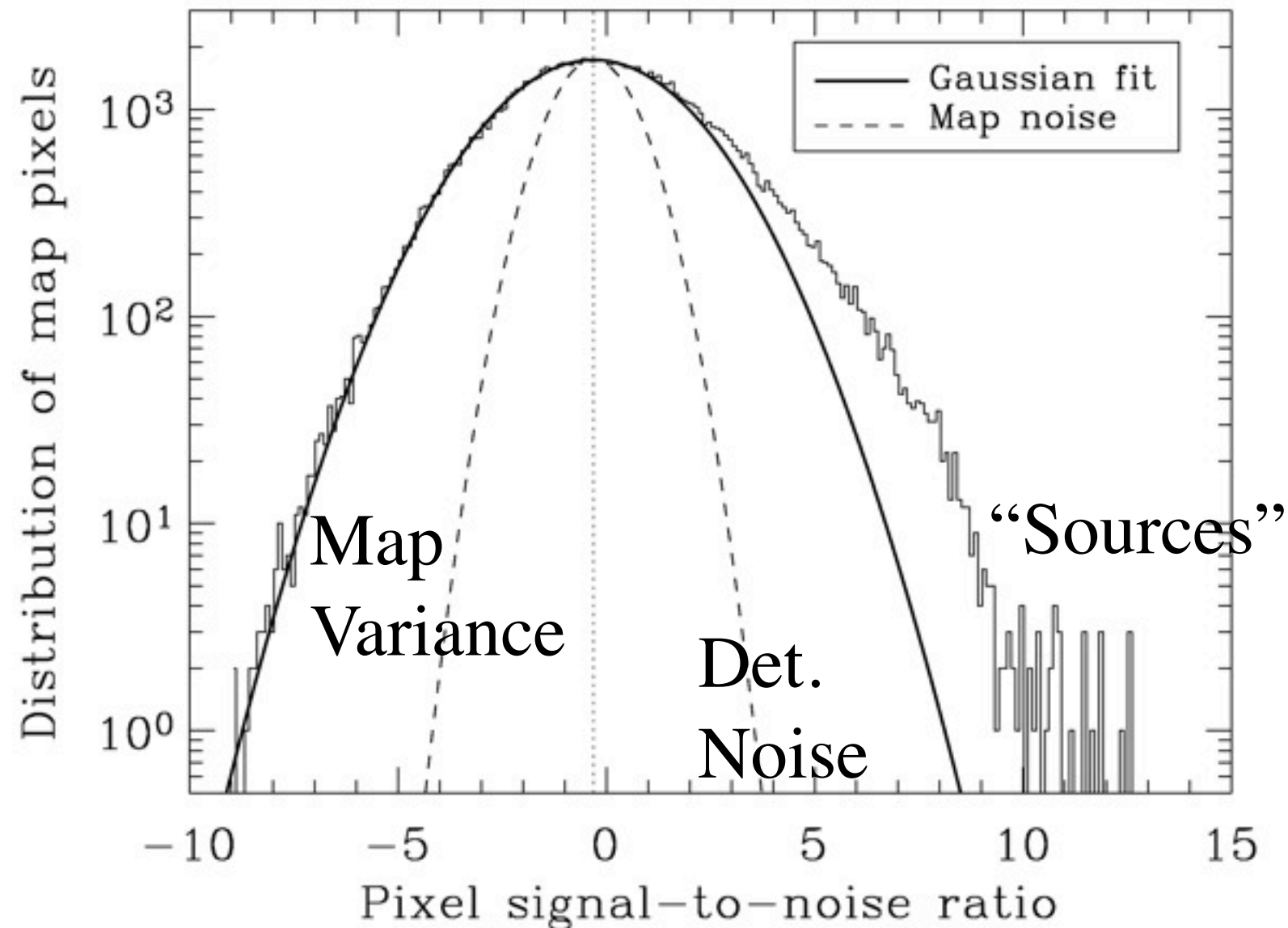
Viero et al. 0904.1200



Example 2: Number Counts

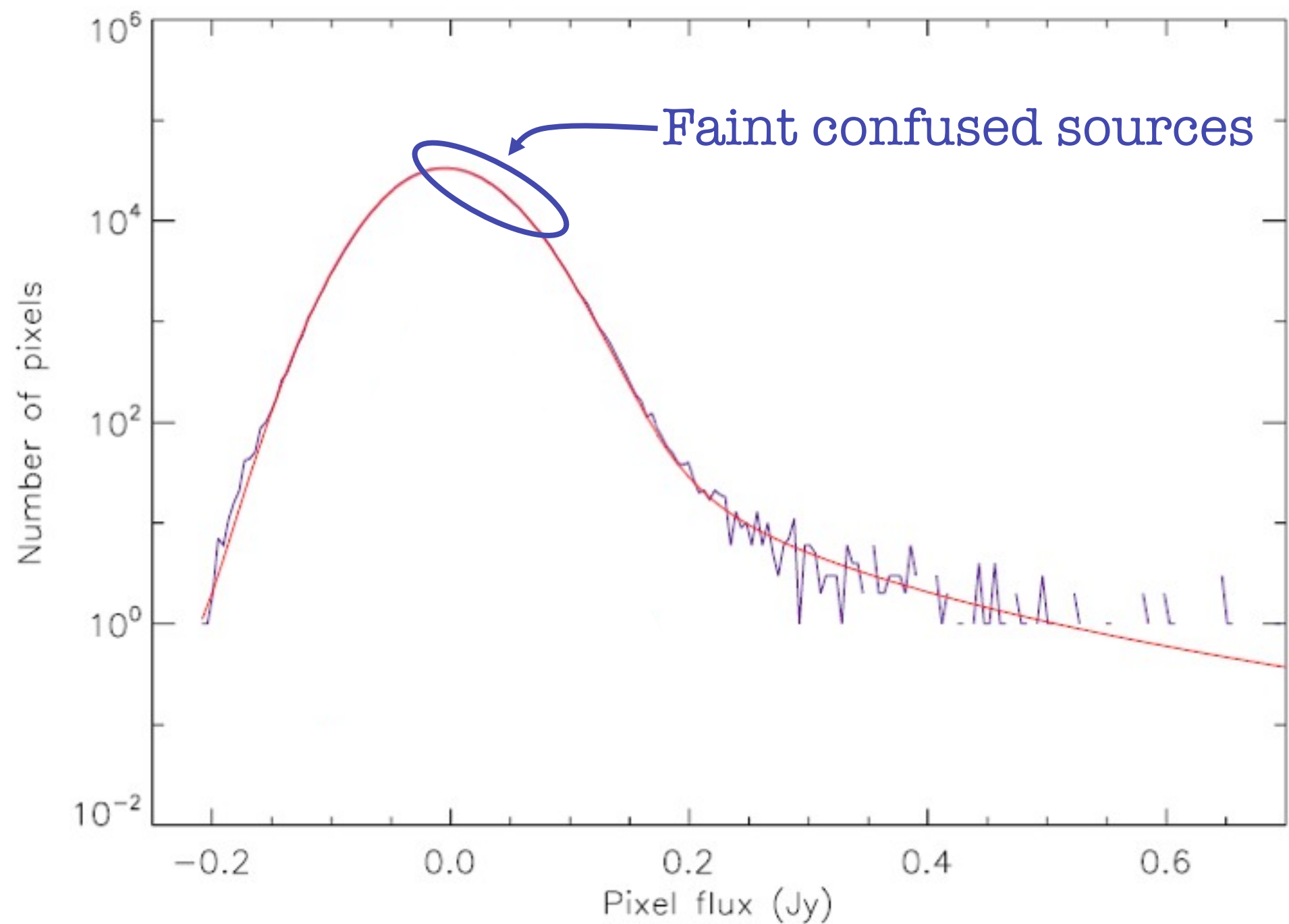


Marsden et al. 0904.1205



Marsden et al. 0904.1205

15%
of flux
resolved
into sources



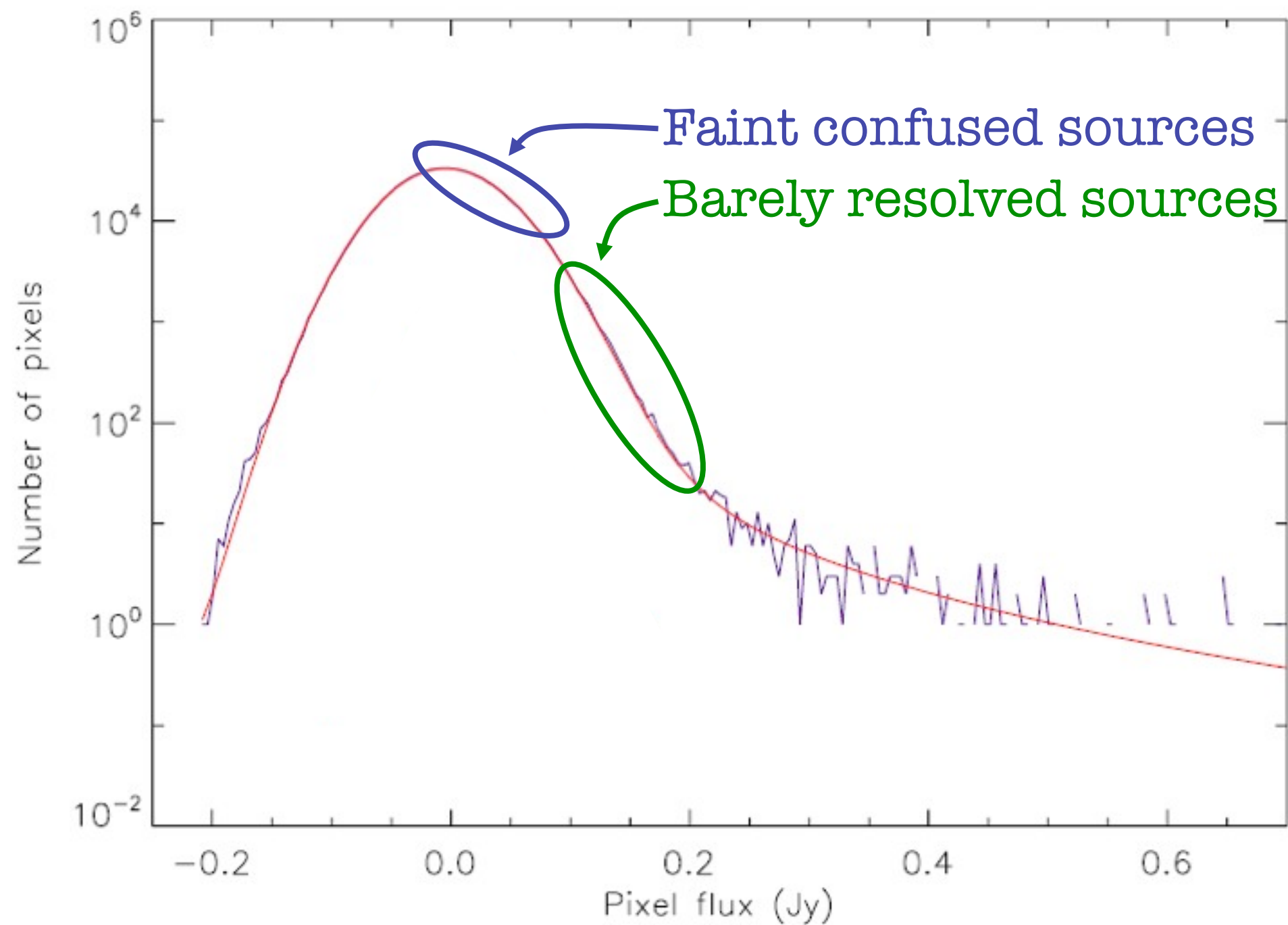
Patanchon et al. 0906.0891

number counts

marco viero



36



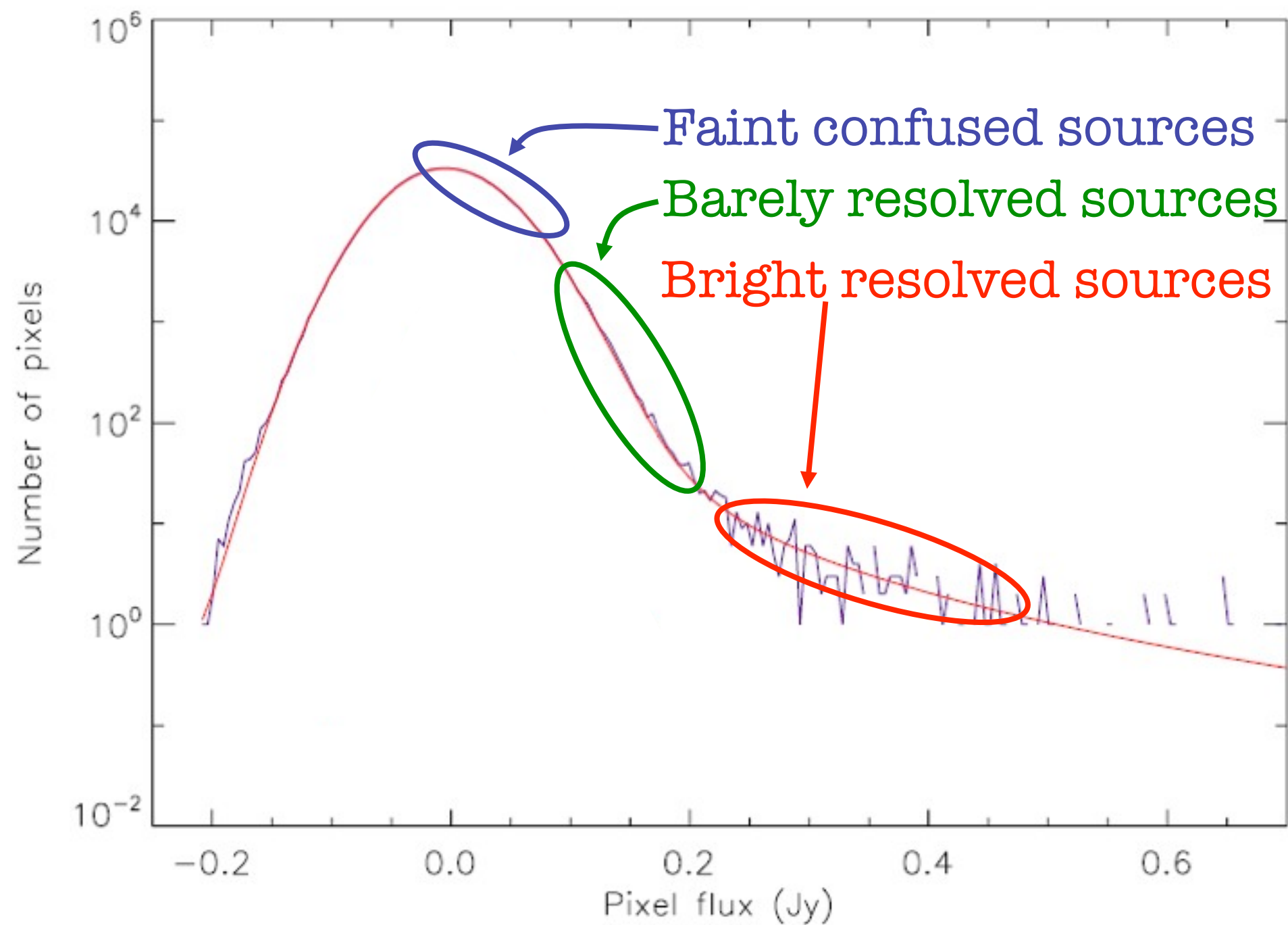
Patanchon et al. 0906.0891

number counts

marco viero



36



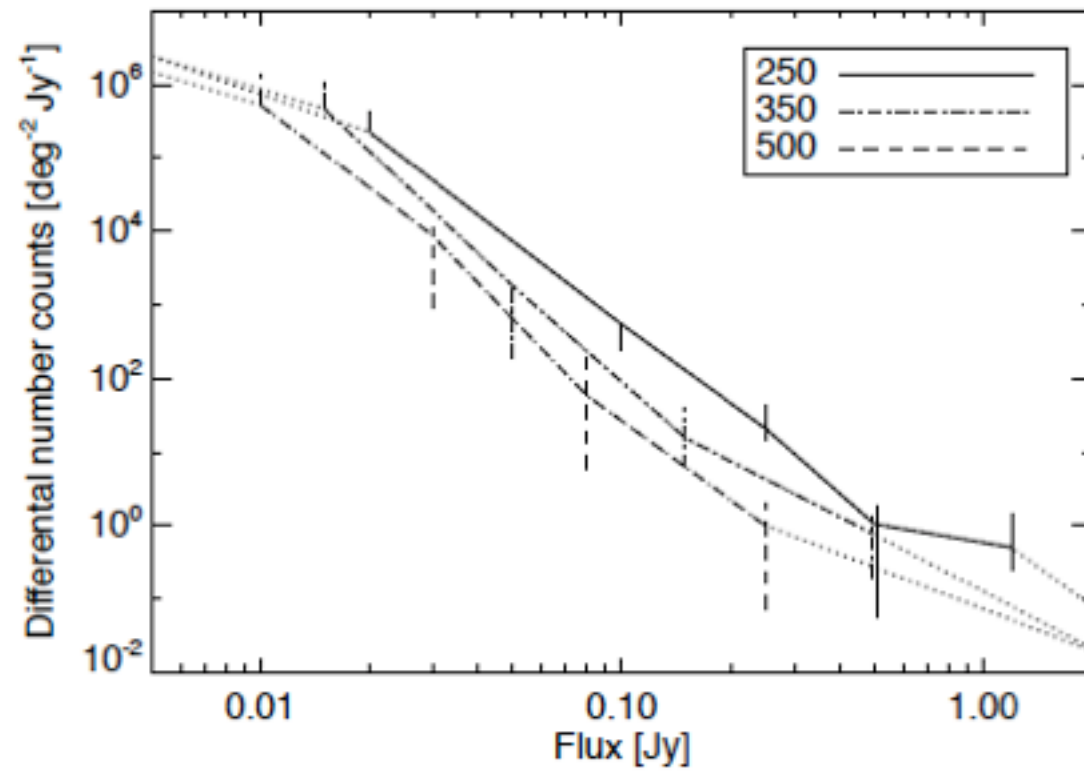
Patanchon et al. 0906.0891

number counts

marco viero



36



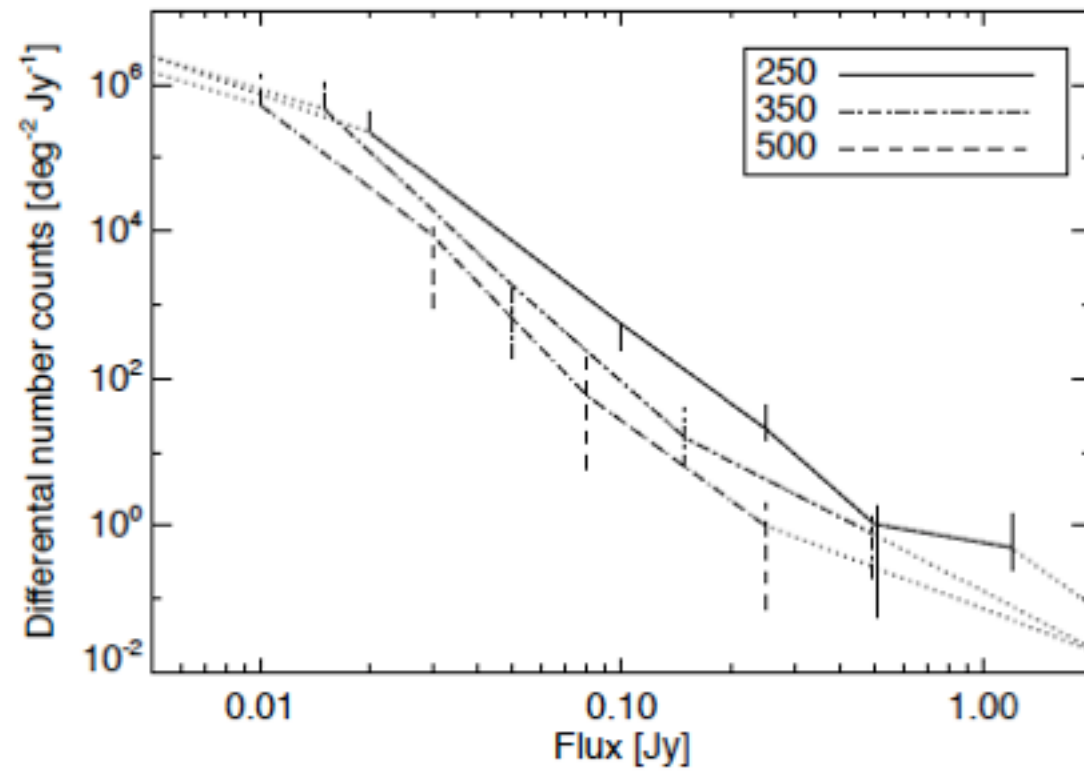
Patanchon et al. 0906.0891

number counts

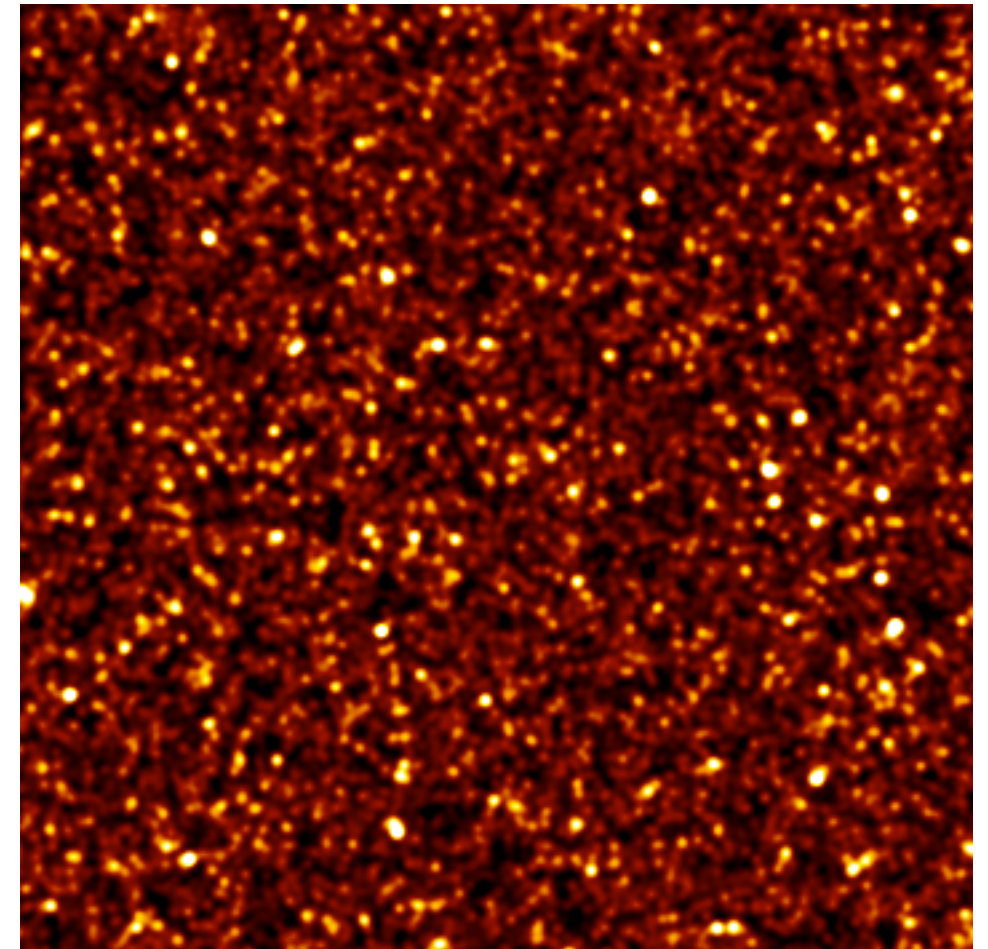
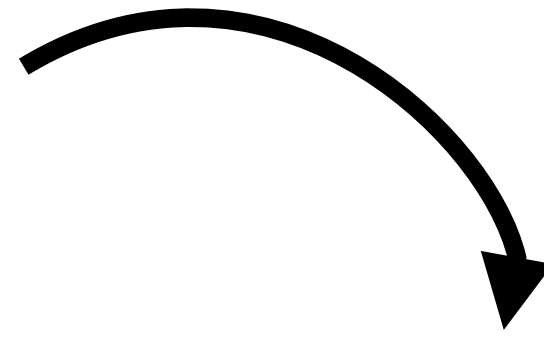
marco viero



37



Patanchon et al. 0906.0891

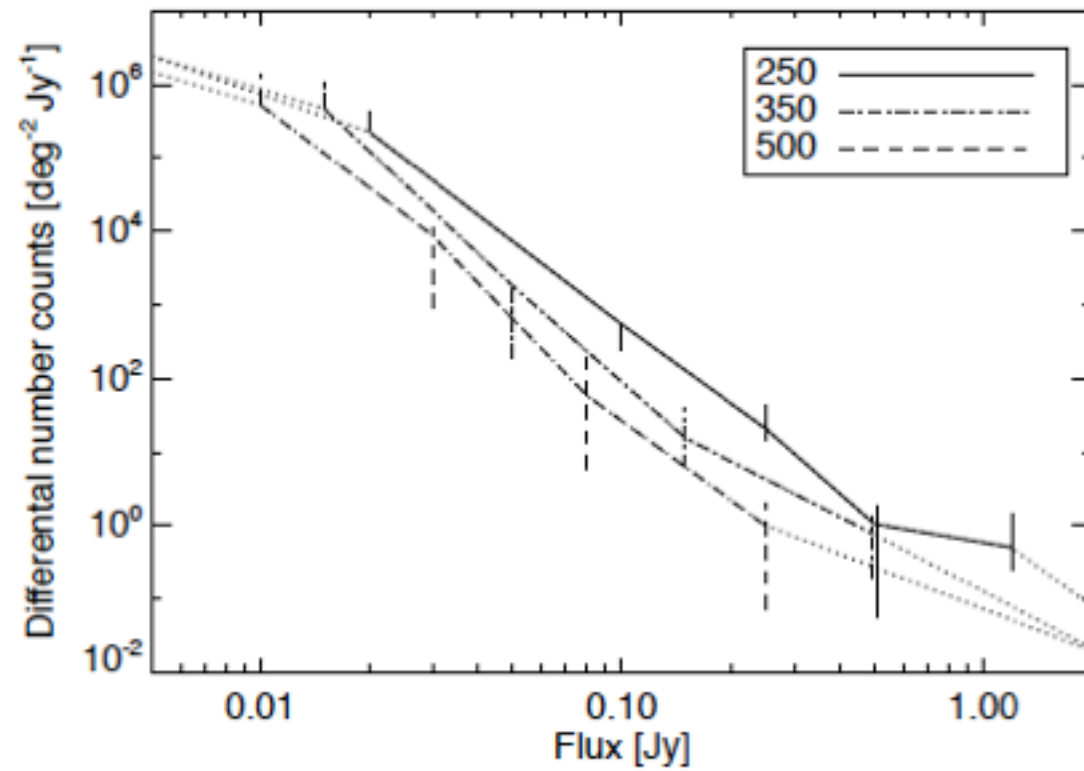


number counts

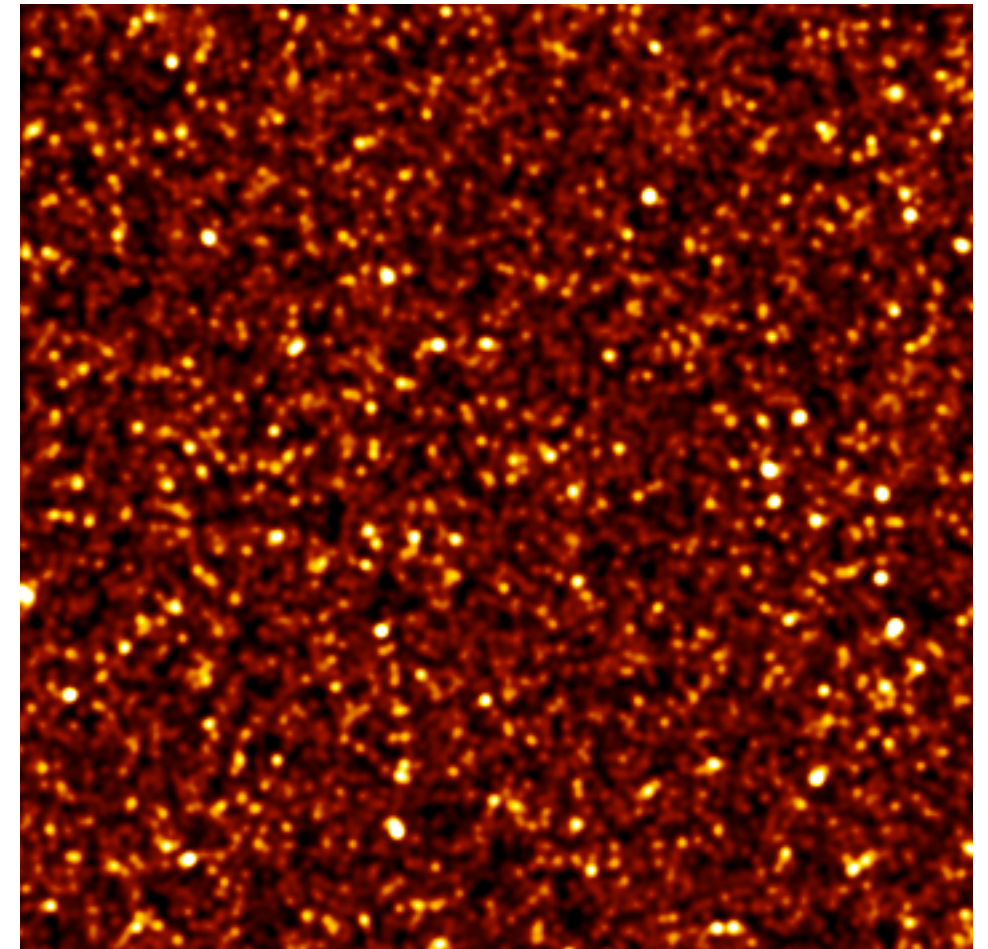
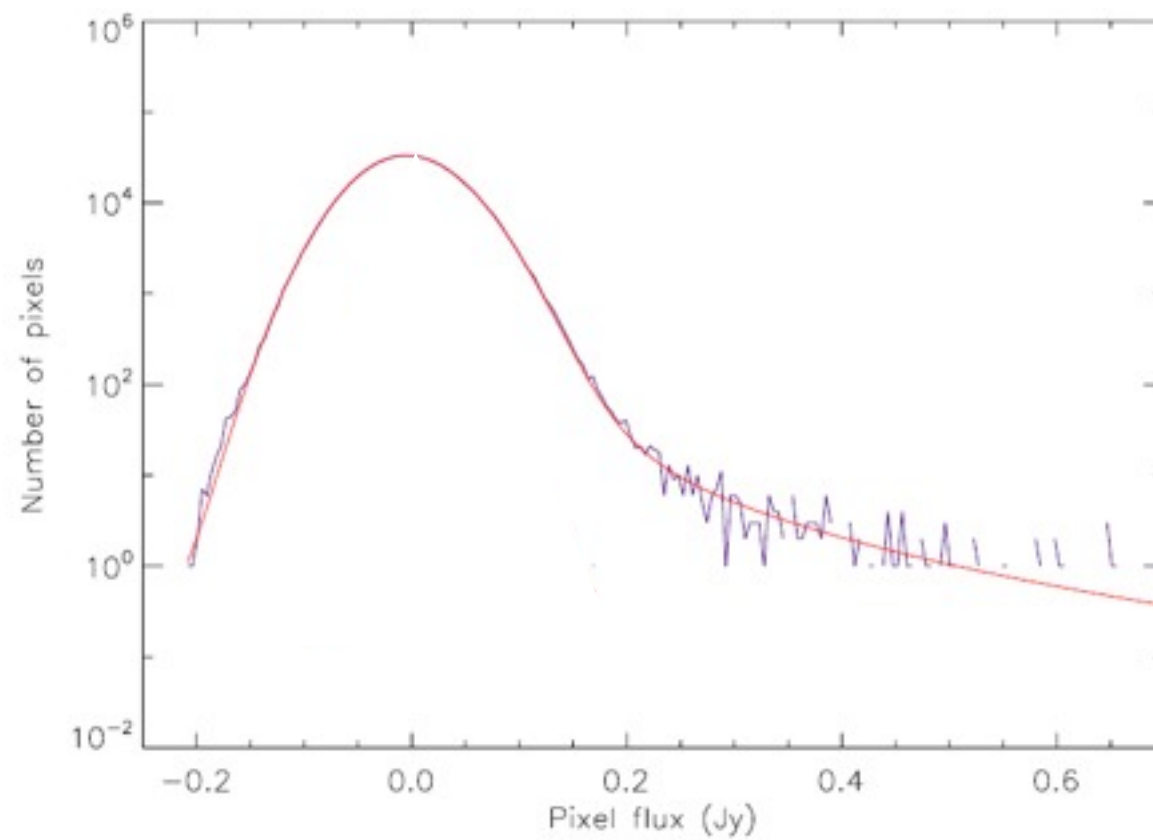
marco viero



37



Patanchon et al. 0906.0891

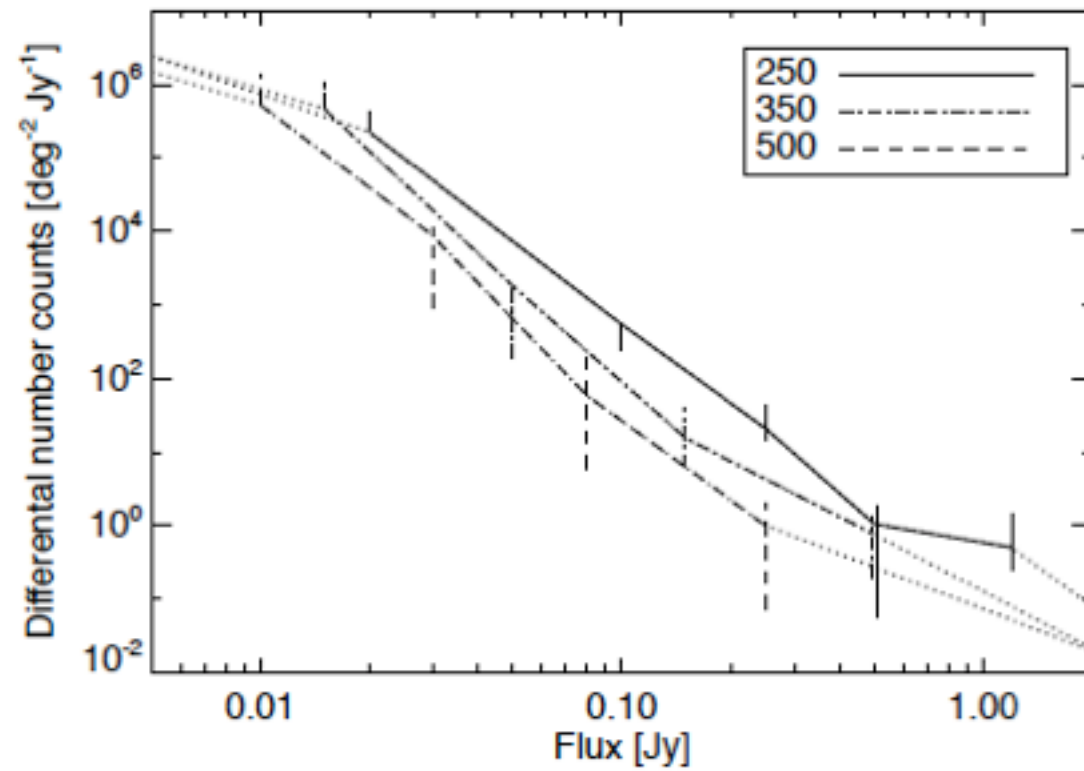


number counts

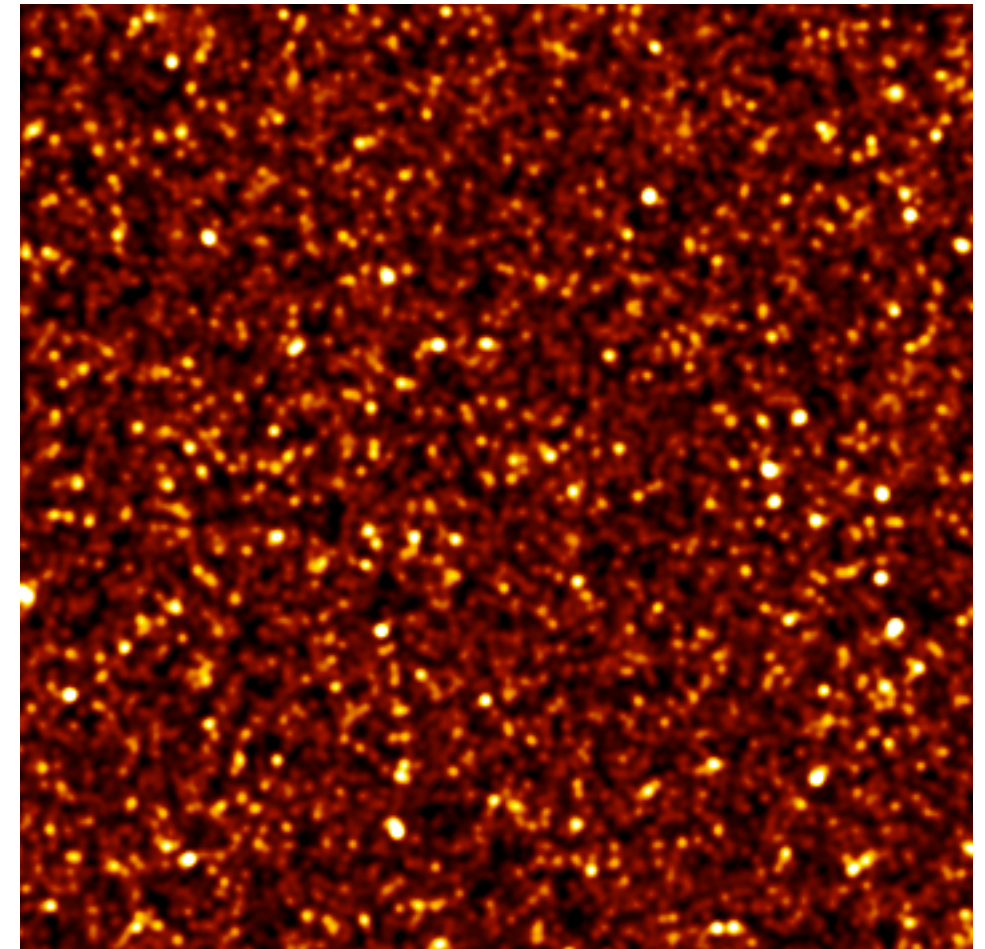
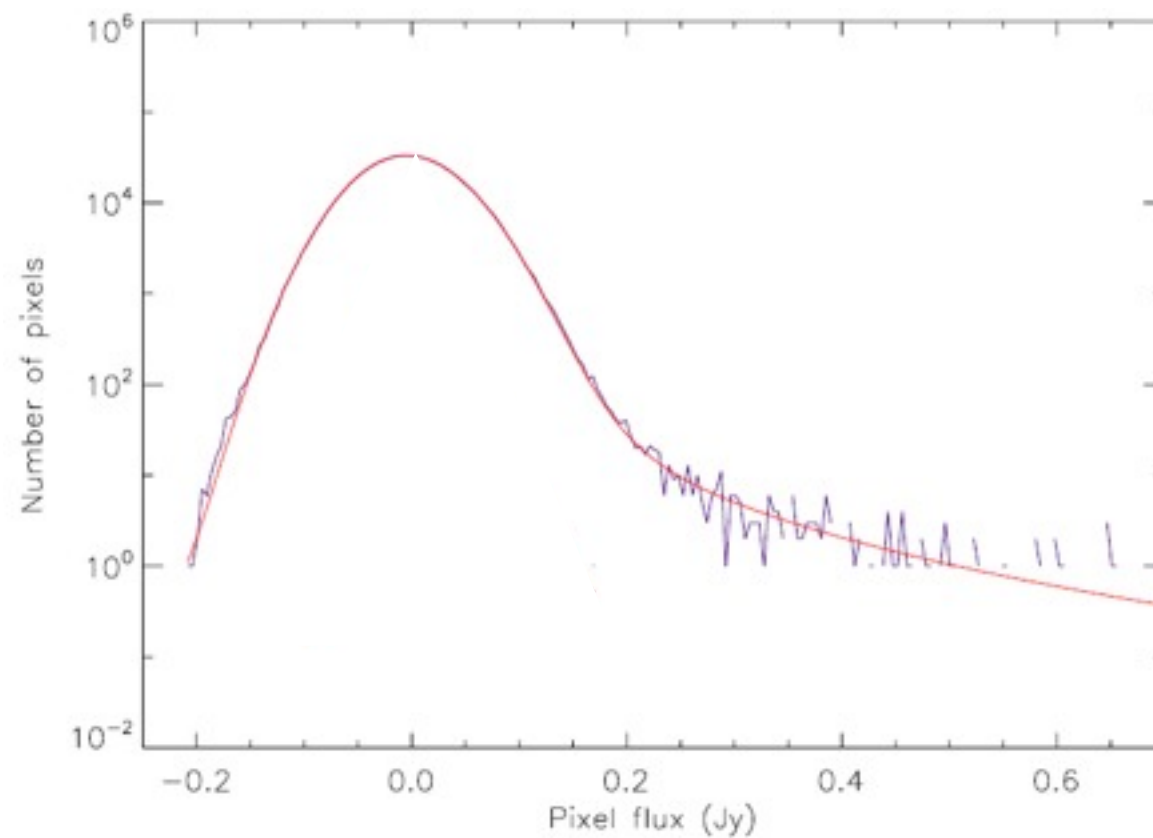
marco viero



37



Patanchon et al. 0906.0891

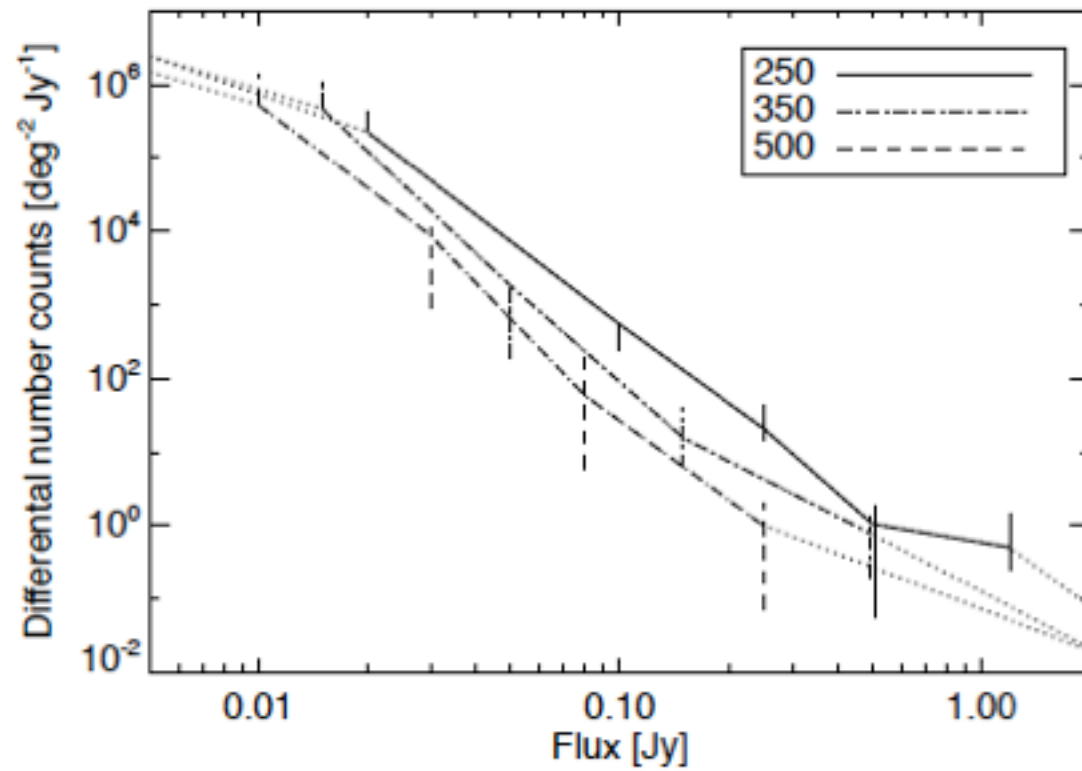


number counts

marco viero

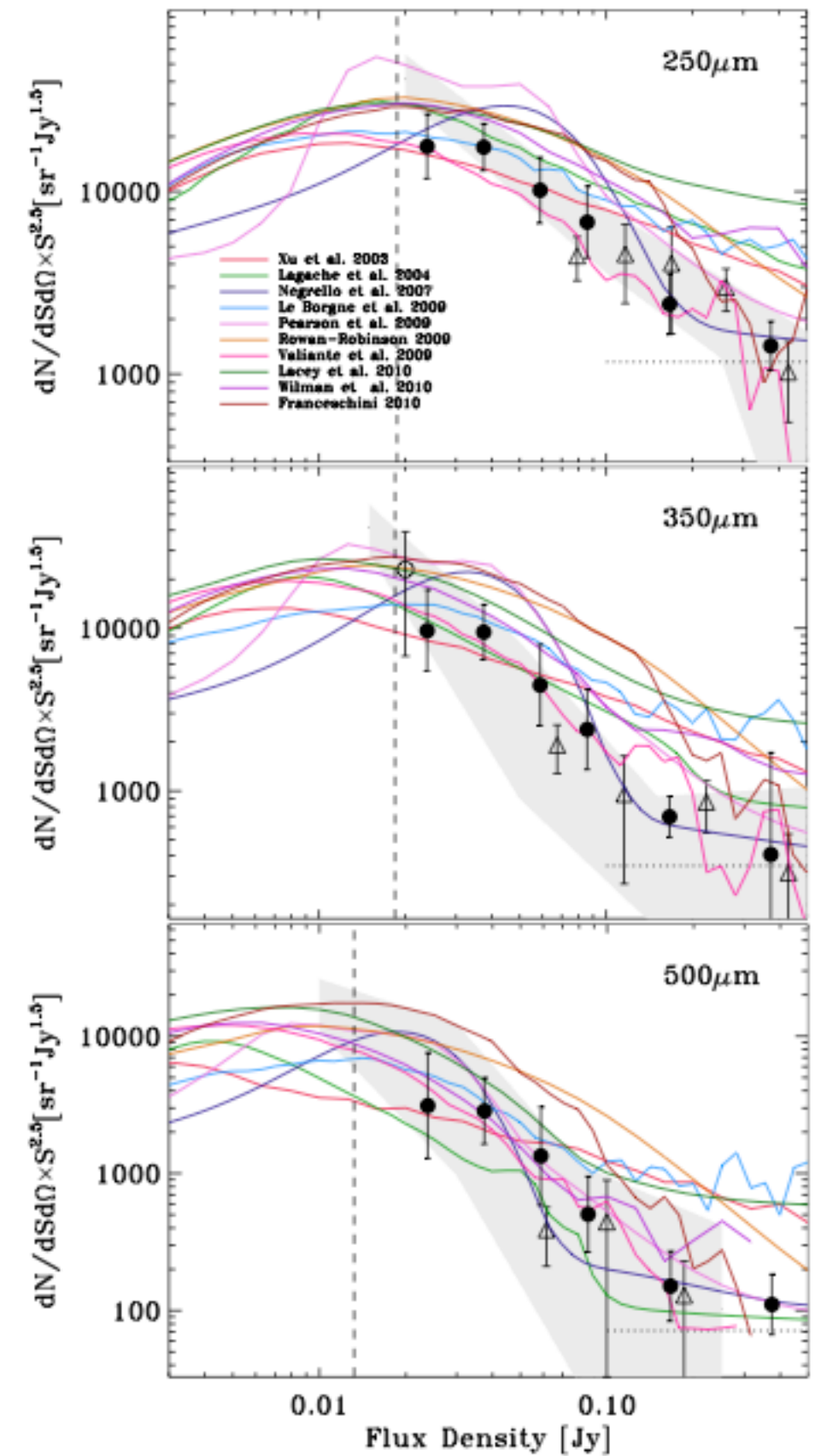


37



Patanchon et al. 0906.0891

Oliver et al. 2010



number counts

marco viero



37

dots: from
counting
sources in
BLAST maps

Patanchon et al. 0906.0891

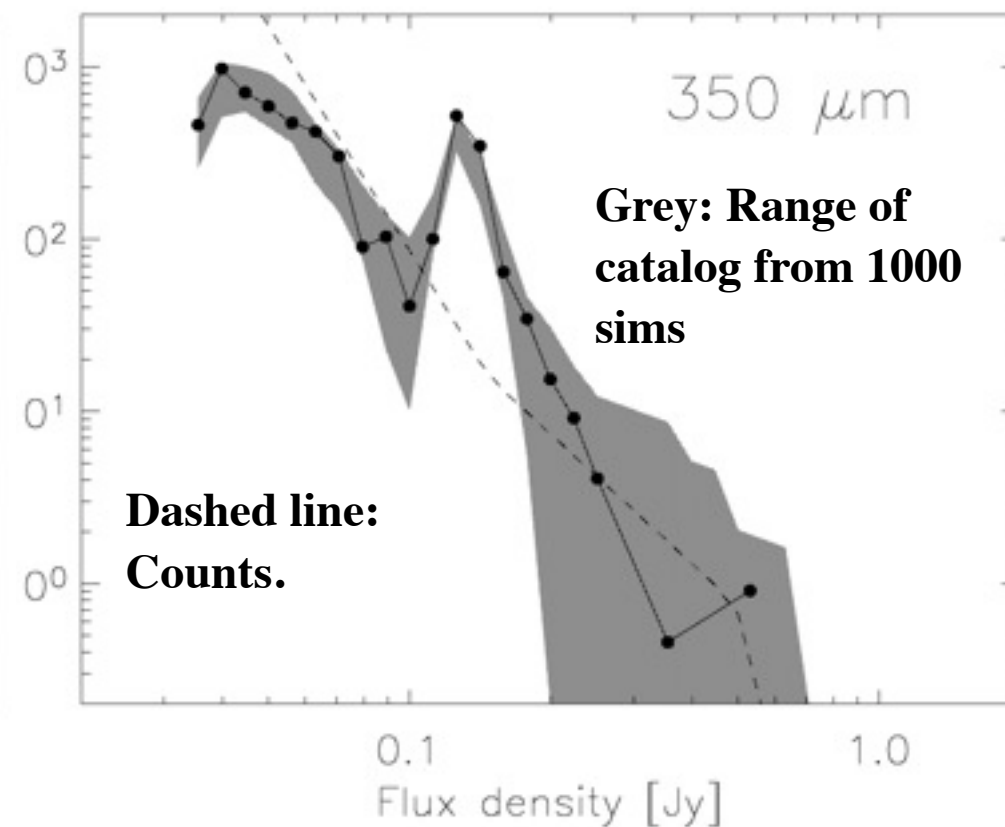
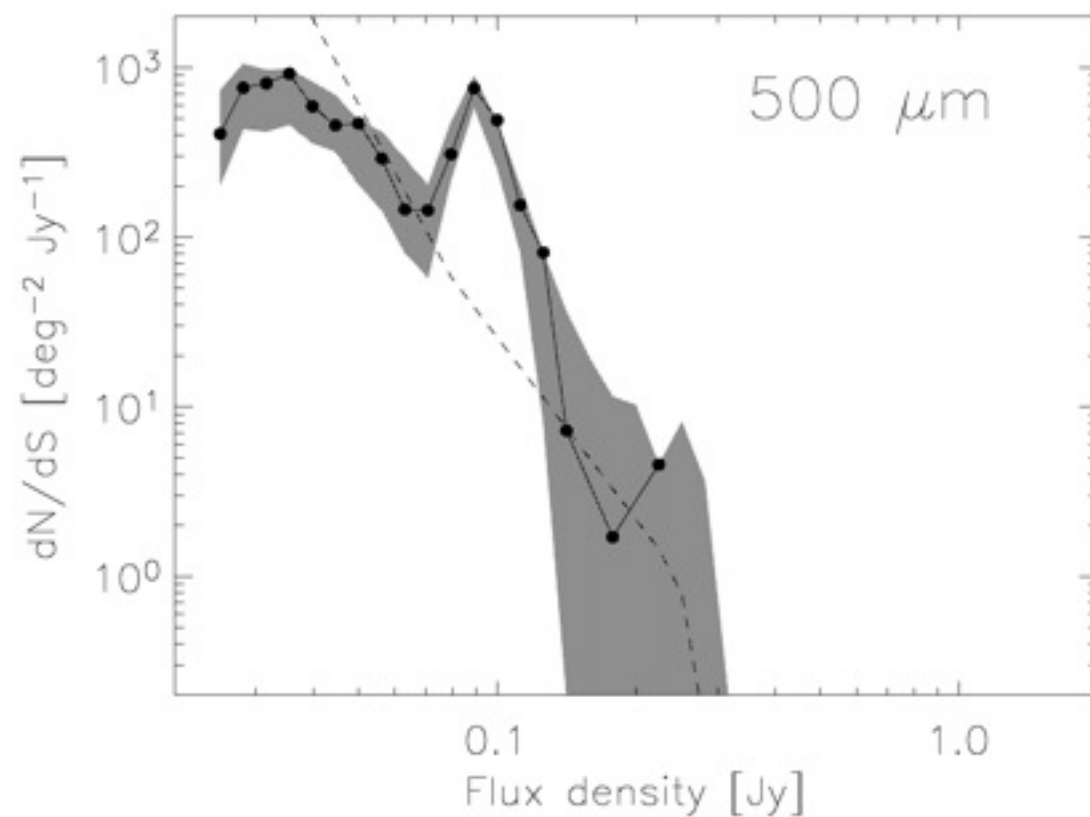
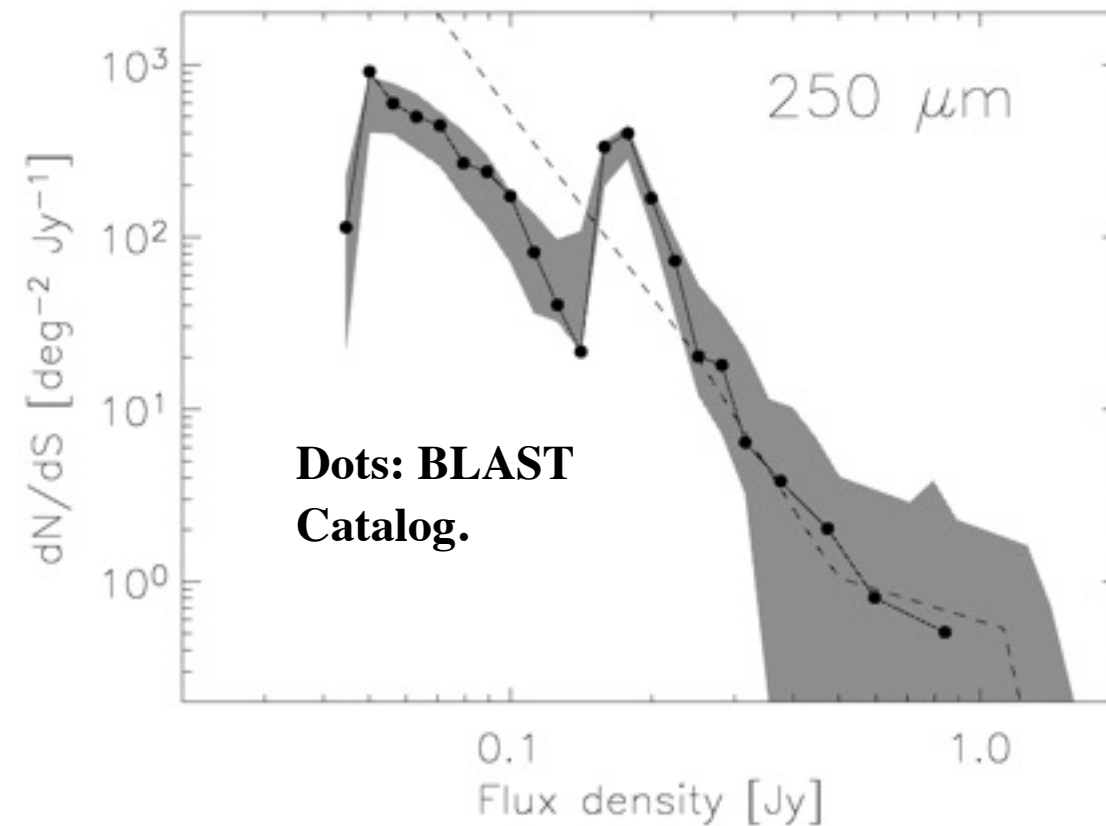
number counts

marco viero



38

dots: from
counting
sources in
BLAST maps



Patanchon et al. 0906.0891

number counts

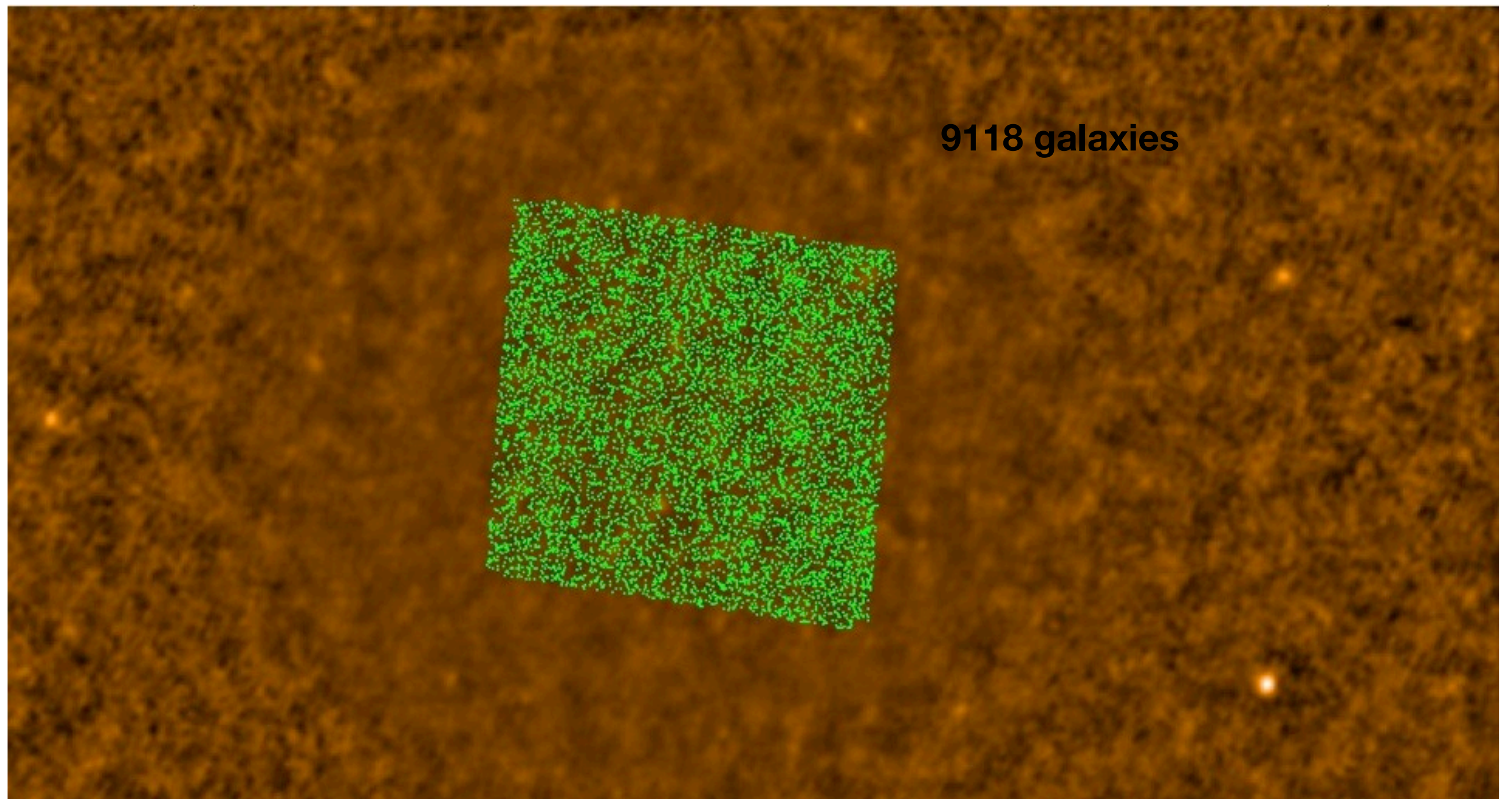
marco viero



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Example 3: Stacking





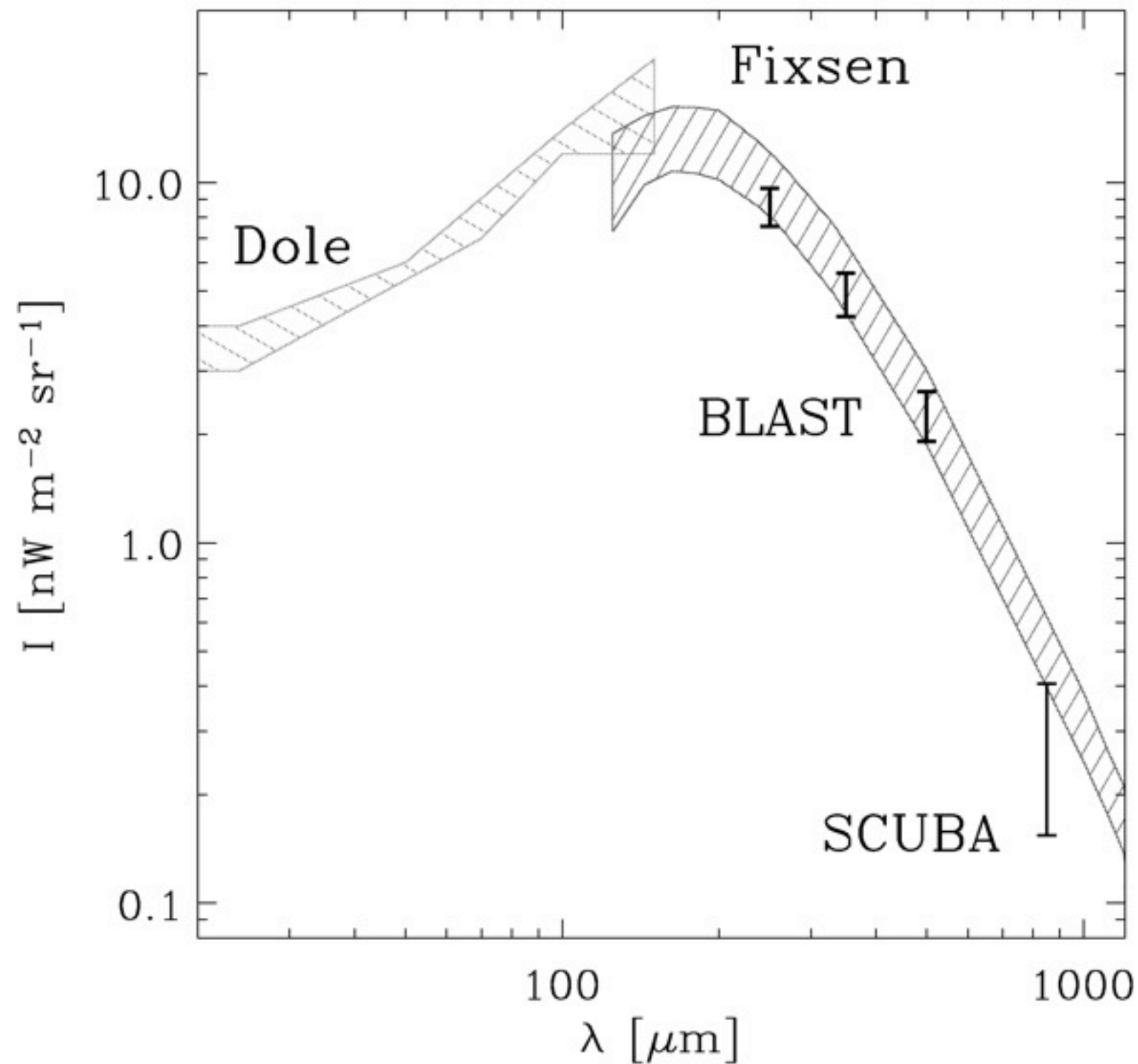
FIDEL 24 μm Catalog - Magnelli et al. 2009
 $\sim 12 \text{ sources/arcmin}^2$

stacking

marco viero



40

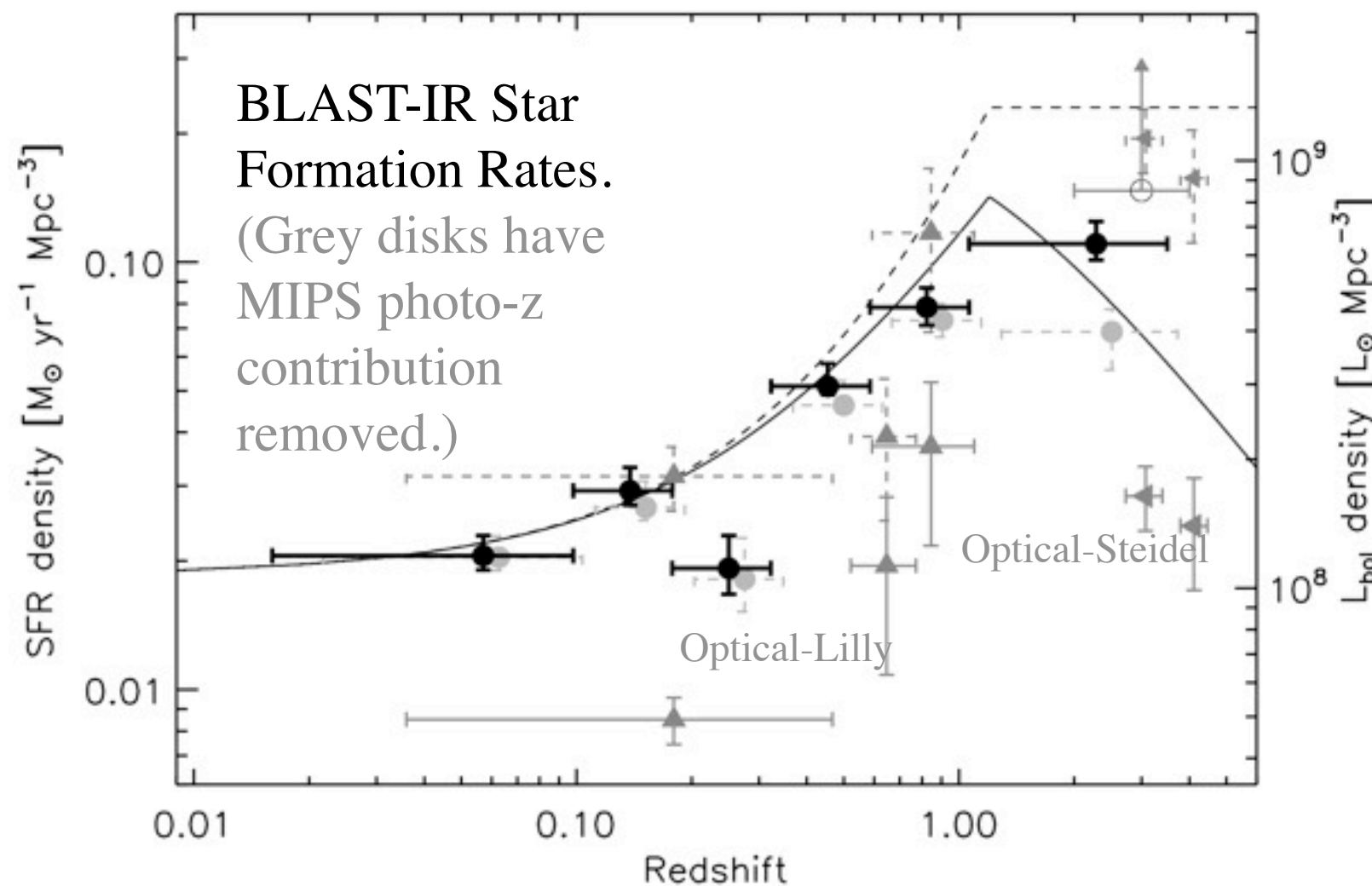


Marsden et al. - 0904.1205

The **entire** background (within errors) is made up of discrete sources i.d.'d at $24 \mu\text{m}$

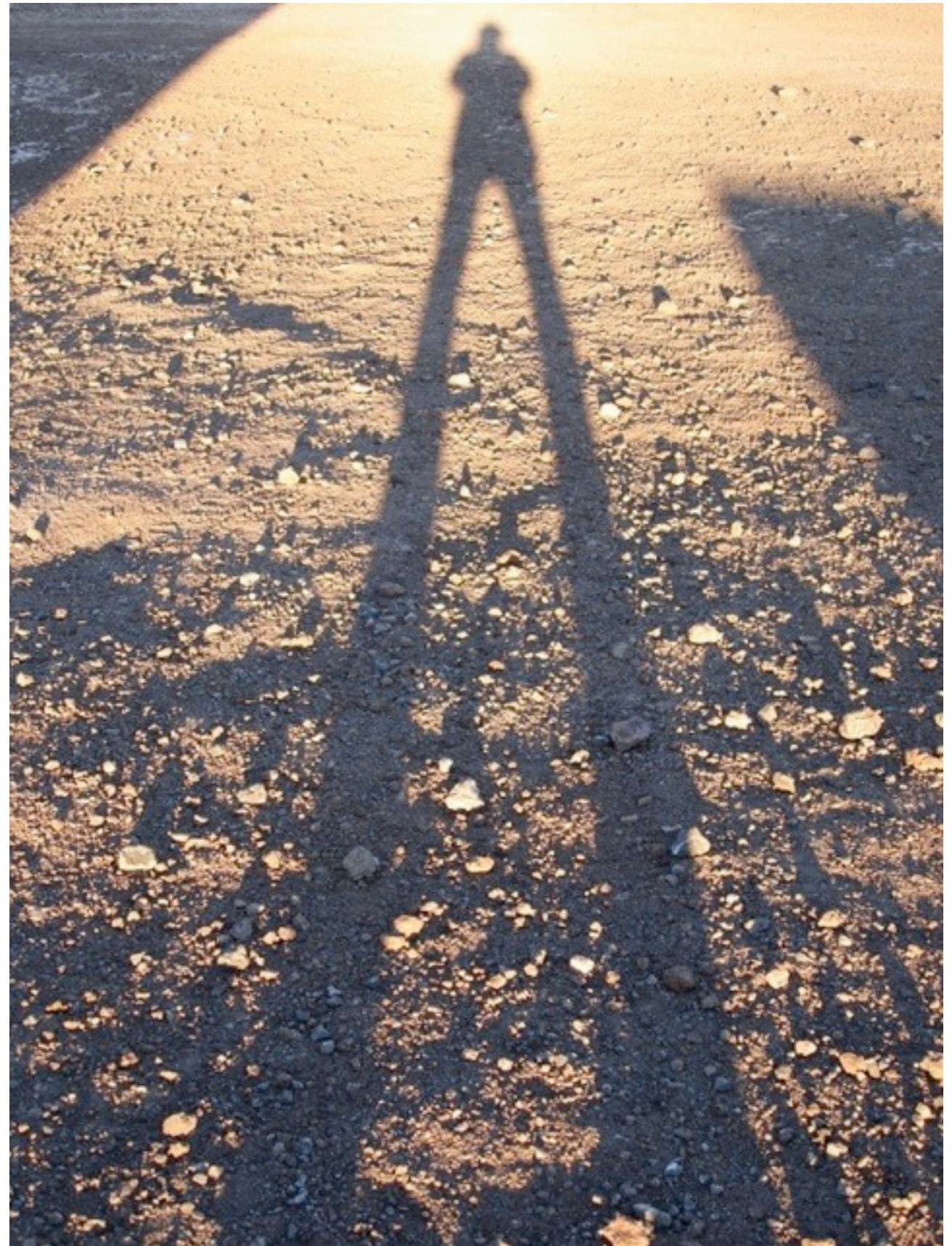
The **entire** background (within errors) is made up of discrete sources i.d.'d at $24\ \mu\text{m}$

The star-formation history of the Universe is encoded in the submillimeter



Pascale et al. 0904.1206

Lessons Learned



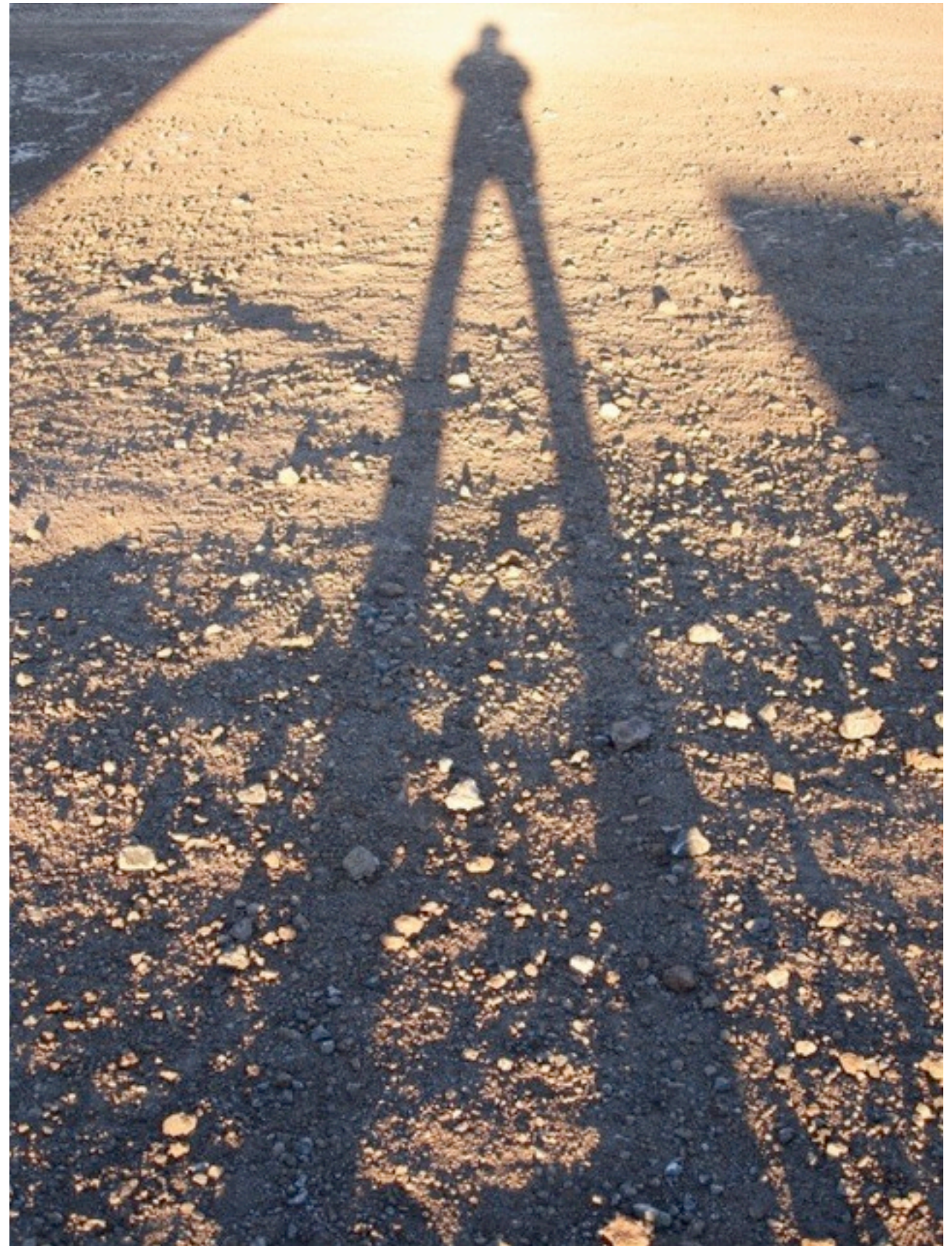
marco viero



42

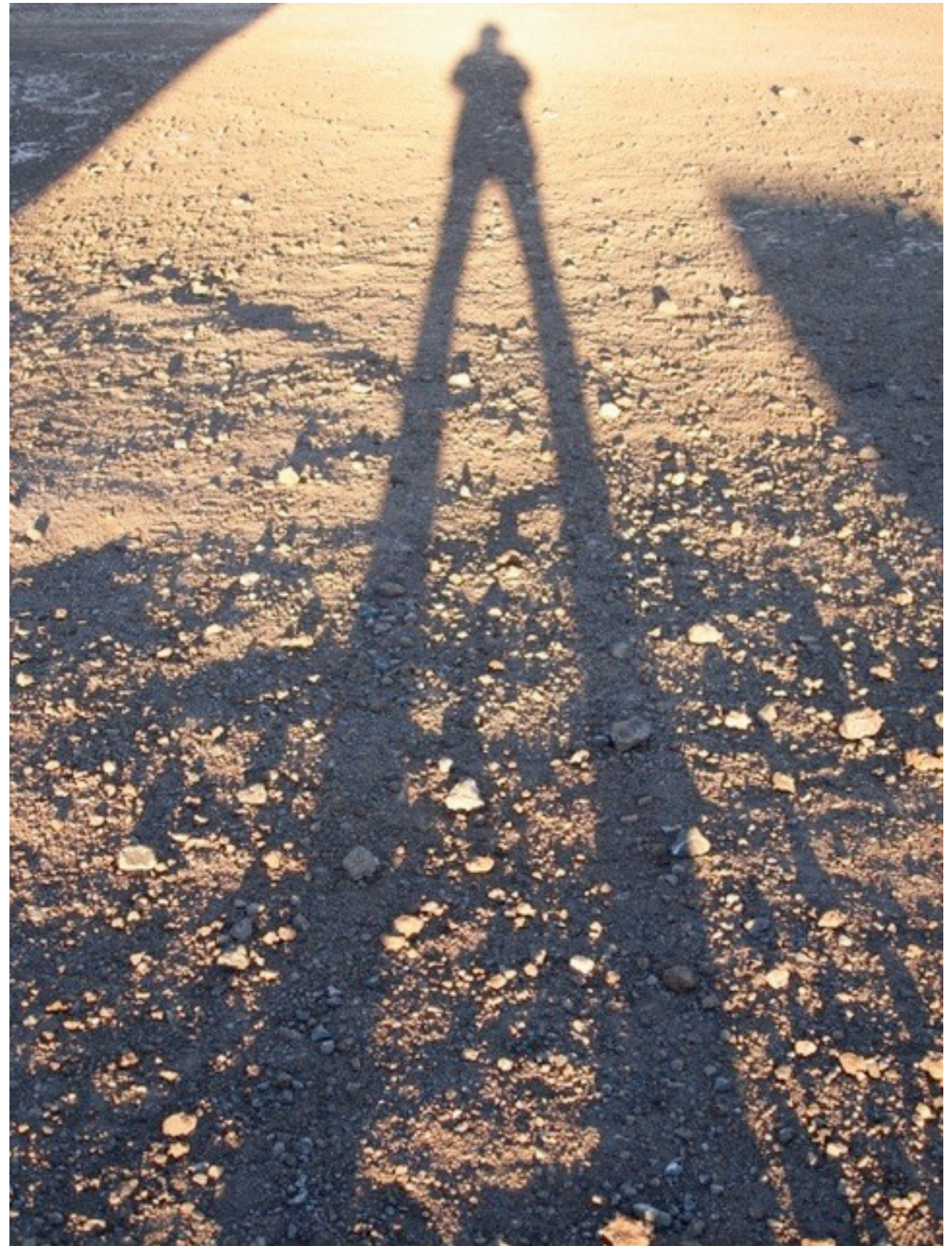
Lessons Learned

- 1 - Map-based rather than catalog-based analysis better for confused maps



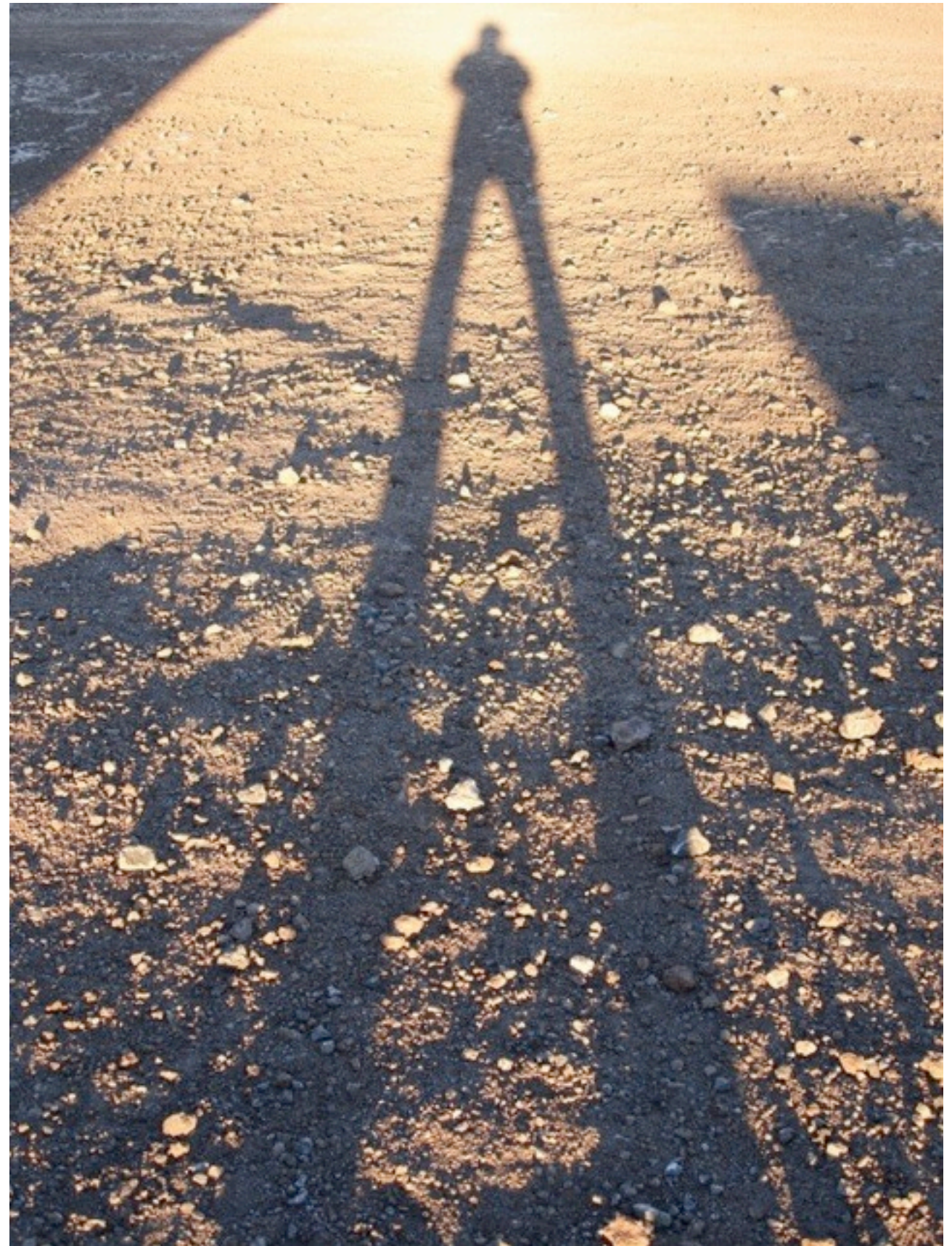
Lessons Learned

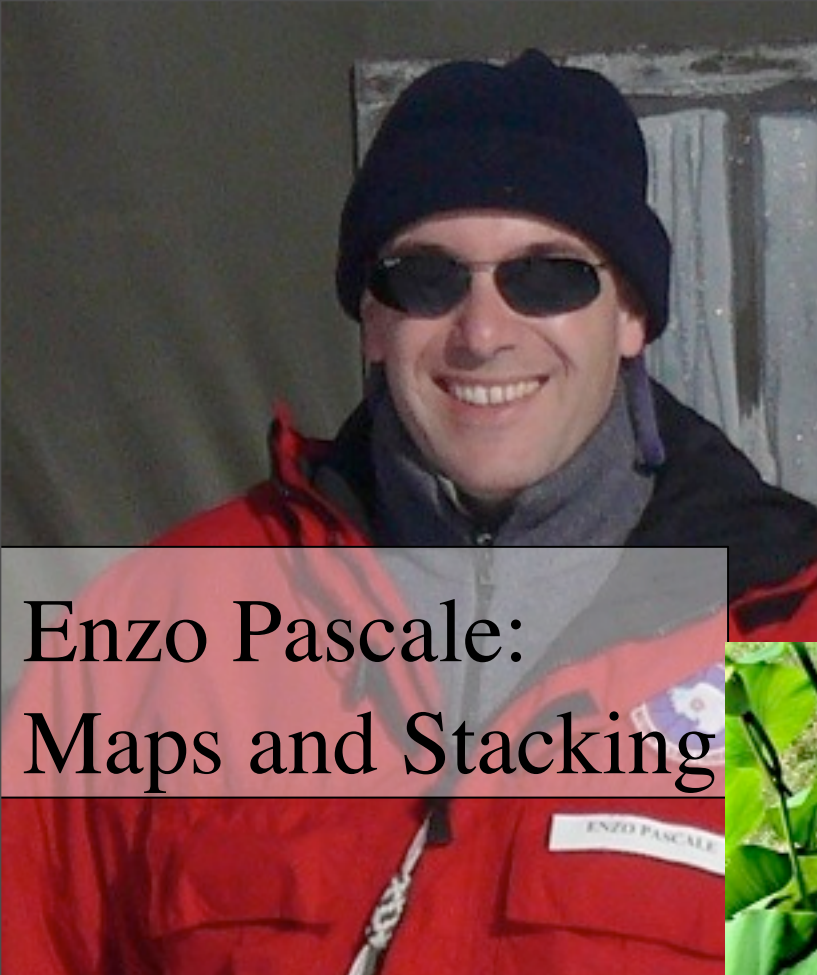
- 1 - Map-based rather than catalog-based analysis better for confused maps
- 2 - Deep ancillary data vital



Lessons Learned

- 1 - Map-based rather than catalog-based analysis better for confused maps
- 2 - Deep ancillary data vital
- 3 - Must bring talented people (from different fields) together





Enzo Pascale:
Maps and Stacking



Ed Chapin: Modelling

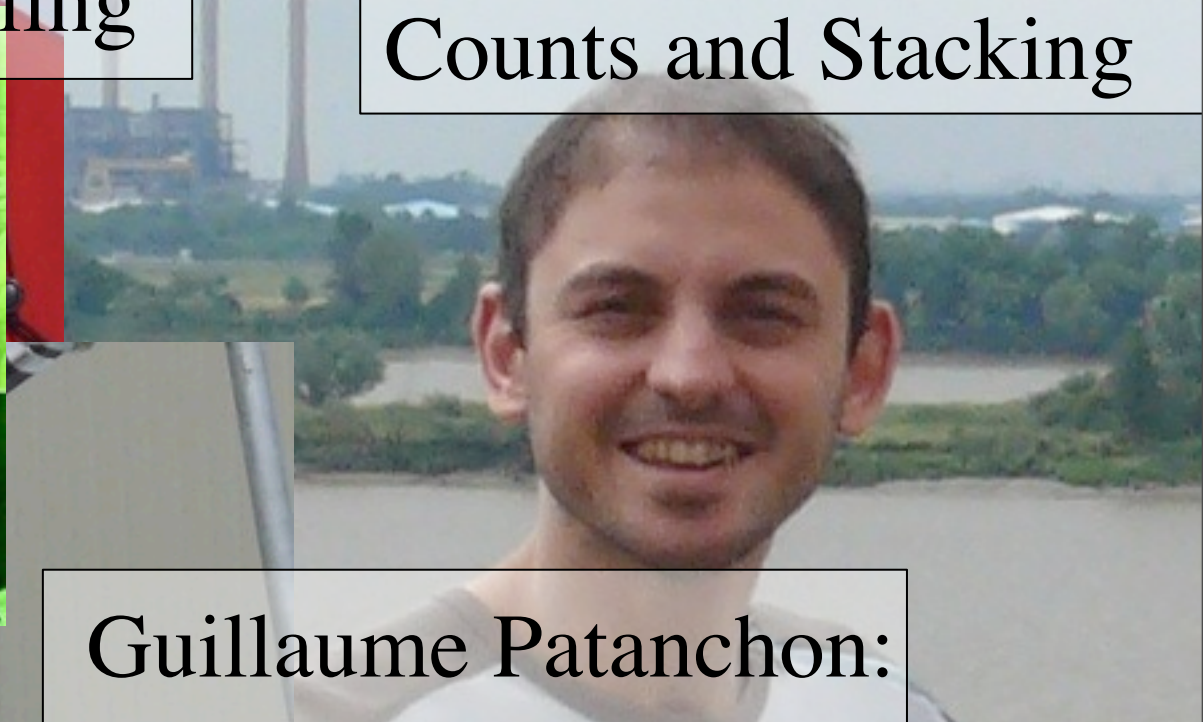


Gaelen Marsden:

Counts and Stacking



Mattia Negrello:
Halo Model



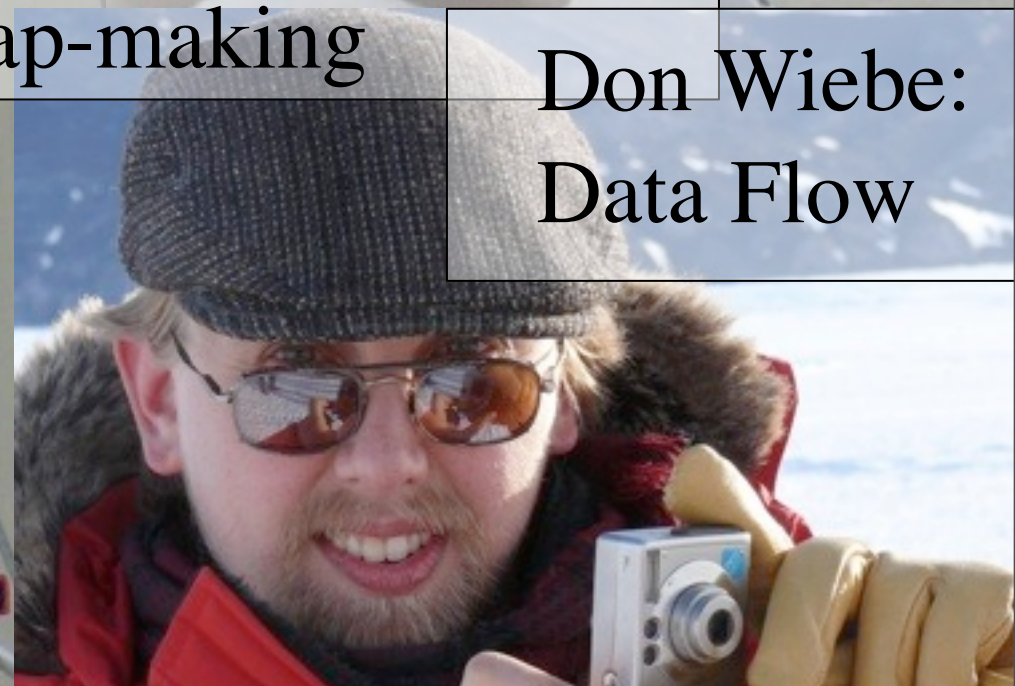
Guillaume Patanchon:
Map-making



Marco Viero:
Clustering

Marie Rex:
Lensing

Matt Truch:
Calibration



Don Wiebe:
Data Flow



Science & Technology
Facilities Council



BLAST

Balloon-borne Large-Aperture Sub-millimeter Telescope



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Science & Technology
Facilities Council



Maps, Papers and more at:
<http://blastexperiment.info>

BLAST
Balloon-borne Large-Aperture Sub-millimeter Telescope



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CRSNG**



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**COLUMBIA SCIENTIFIC
BALLOON FACILITY**