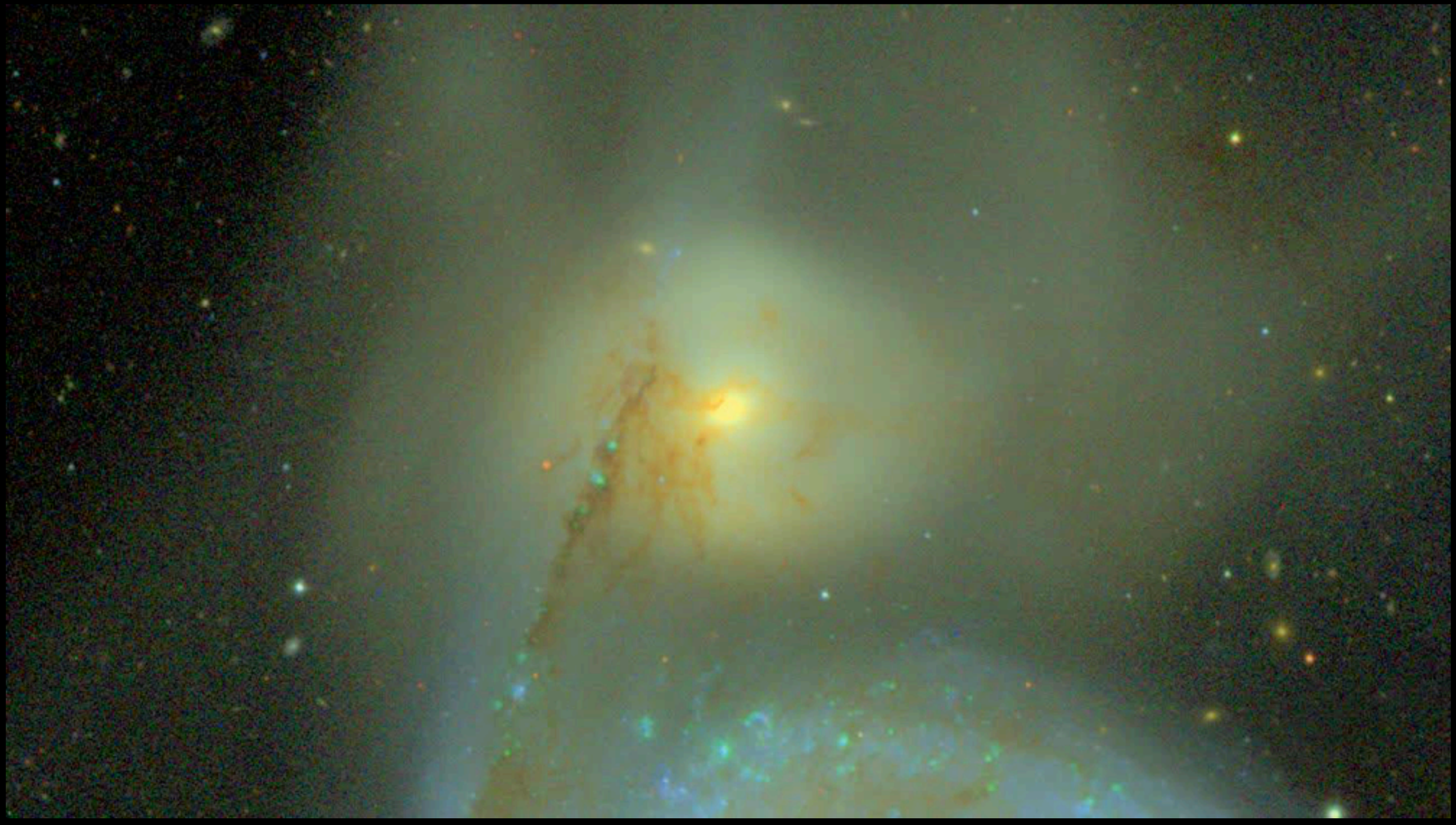
Sloan Digital Sky Survey III:
mapping the Universe on the largest scales

1. The largest multicolor image of the night sky
   (Michael R. Blanton, New York University)
2. The largest 3-D map of the Universe
   (David J. Schlegel, Lawrence Berkeley Labs)
3. The largest map of the outer Milky Way
   (Constance Rockosi, UC Santa Cruz)
4. A resource to astronomers and the public
   (Michael R. Blanton, New York University)

SDSSIII

Zoom credit: David W. Hogg

http://www.youtube.com/watch?v=HyMnSyYE1b0



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SDSSIII

The largest multicolor image

1. Covers one-third of the sky (14,555 square degrees)
2. Greatest in terms of pixels: 1.2 trillion in each of 5 bands
3. Half a billion detected stars and galaxies:
   a. *260 million stars*
   b. *210 million galaxies*
4. Not just really big but also really useful:
   a. *images are uniformly excellent quality*
   b. *easily accessible public distribution*

SDSSIII

A milestone in astronomy

1. SDSS-III imaging completes 11-year mission of SDSS camera
2. Builds on the legacy of SDSS-I and -II
3. compare it to National Geographic's Palomar Survey (1958), which is still an important astronomical reference
4. SDSS provides a *digital* rather than photographic image
5. A unique reference for the next decade and beyond

Jim Gunn

Connie Rockosi

SDSSIII

Messier 33

NGC 604

SDSSIII

Southern Galactic Cap

Northern Galactic Cap

regular galaxies

minor mergers

major mergers

serious train wrecks!

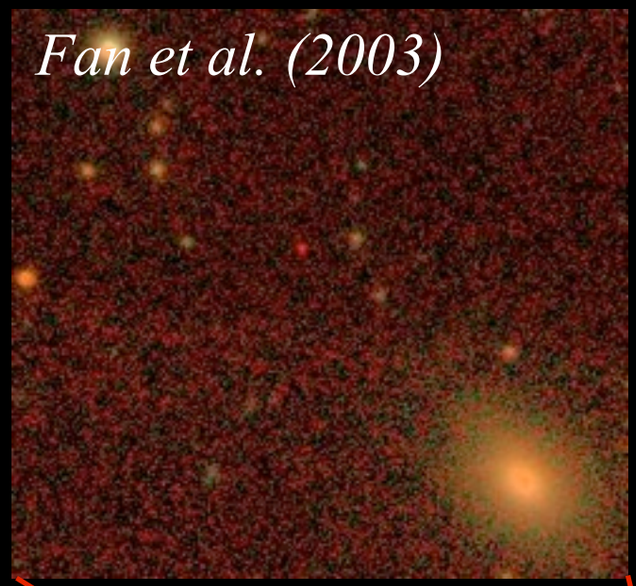
SDSSIII

Needles in a haystack

With DR8, people will now be able to go and search an entirely new area of the haystack

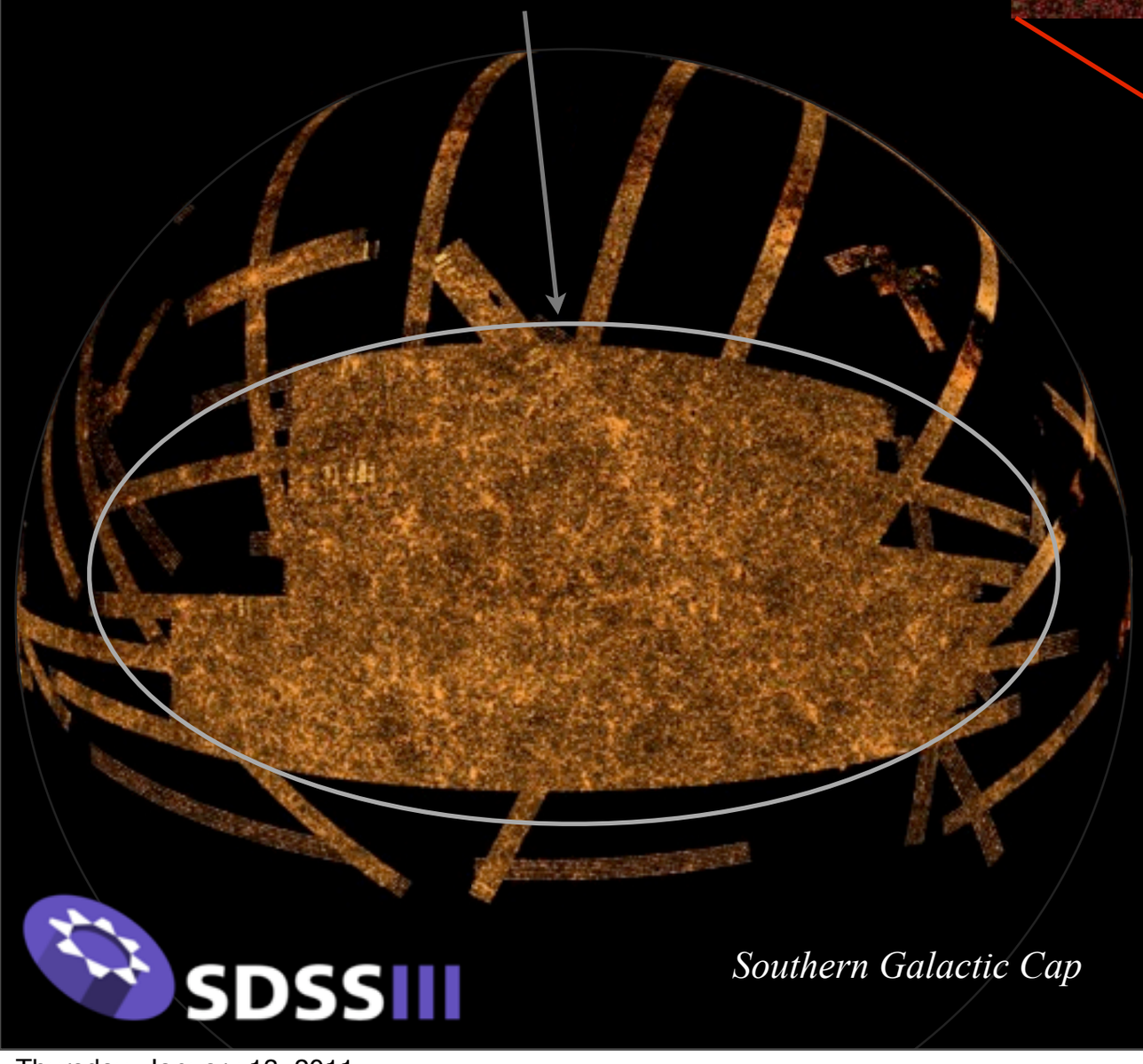
one of the most distant objects known

Fan et al. (2003)

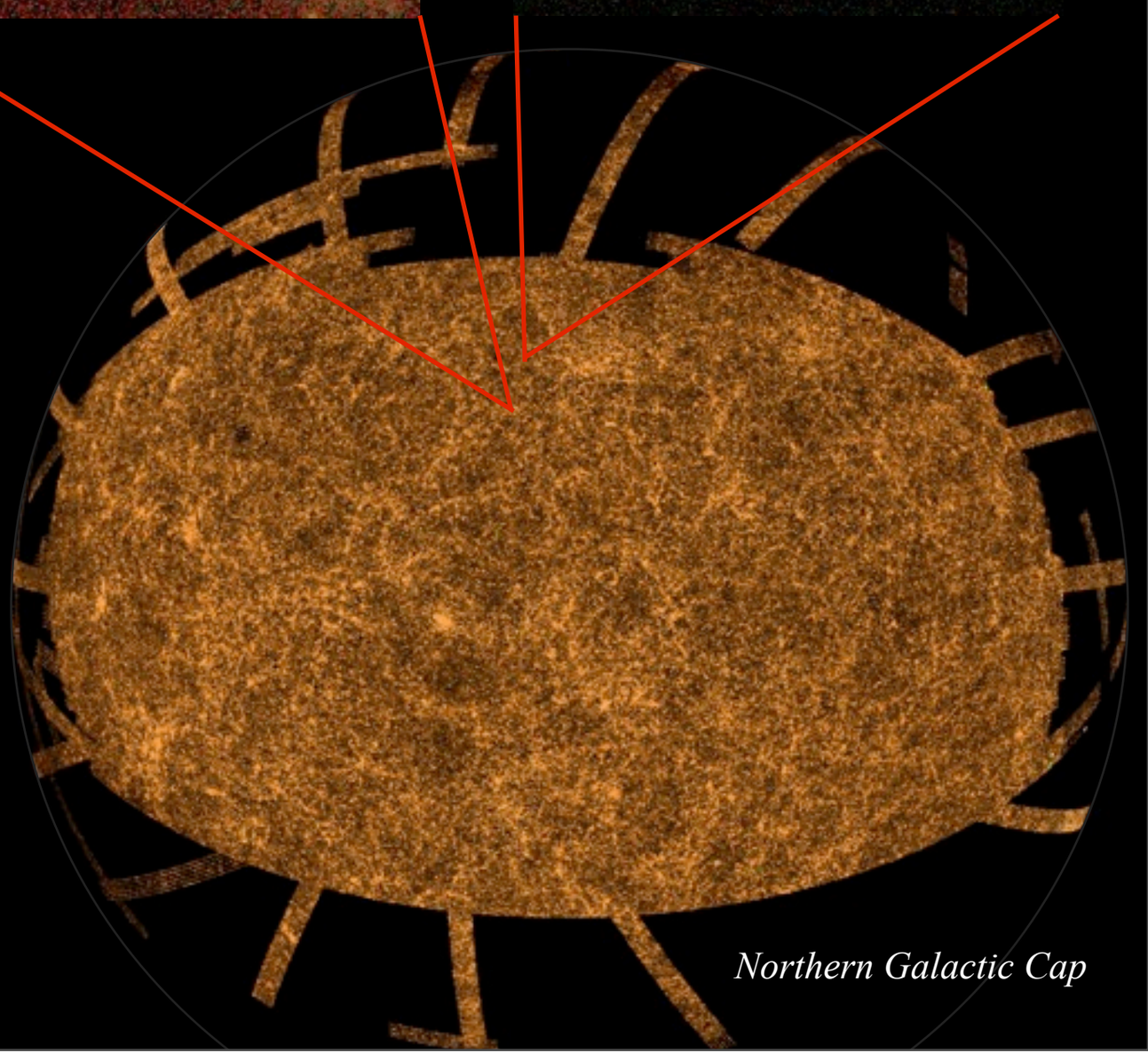


a gravitational lens

Lin et al. (2008)



Southern Galactic Cap



Northern Galactic Cap

SDSSIII

SDSS-III continues through 2014 as a *spectroscopic* program

1. The distant Universe with BOSS
   (D. J. Schlegel, PI)
2. The outer Milky Way with SEGUE
   (C. Rockosi, PI)

SDSSIII

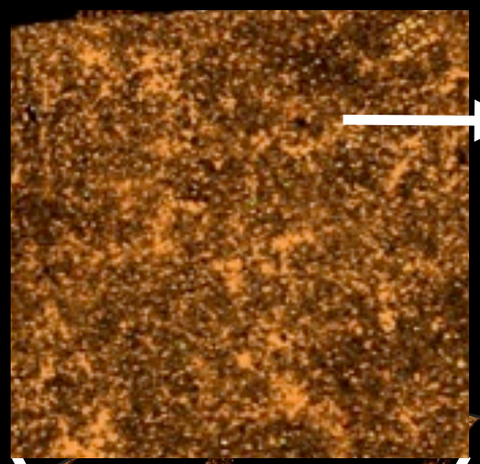
BOSS in Sloan Digital Sky Survey III
2-D → 3-D maps

David Schlegel for the SDSS
Lawrence Berkeley National Lab

1. SDSS mapped million brightest galaxies (done!)
2. SDSS-III mapping more distant Universe (2009-2014)
3. On track for new measurements of dark energy

SDSSIII

20% of SDSS telescope time used to make these 2-D maps



Each point is a galaxy

Southern Galactic Cap

Northern Galactic Cap

SDSSIII

80% of SDSS telescope time used to make these 3-D maps

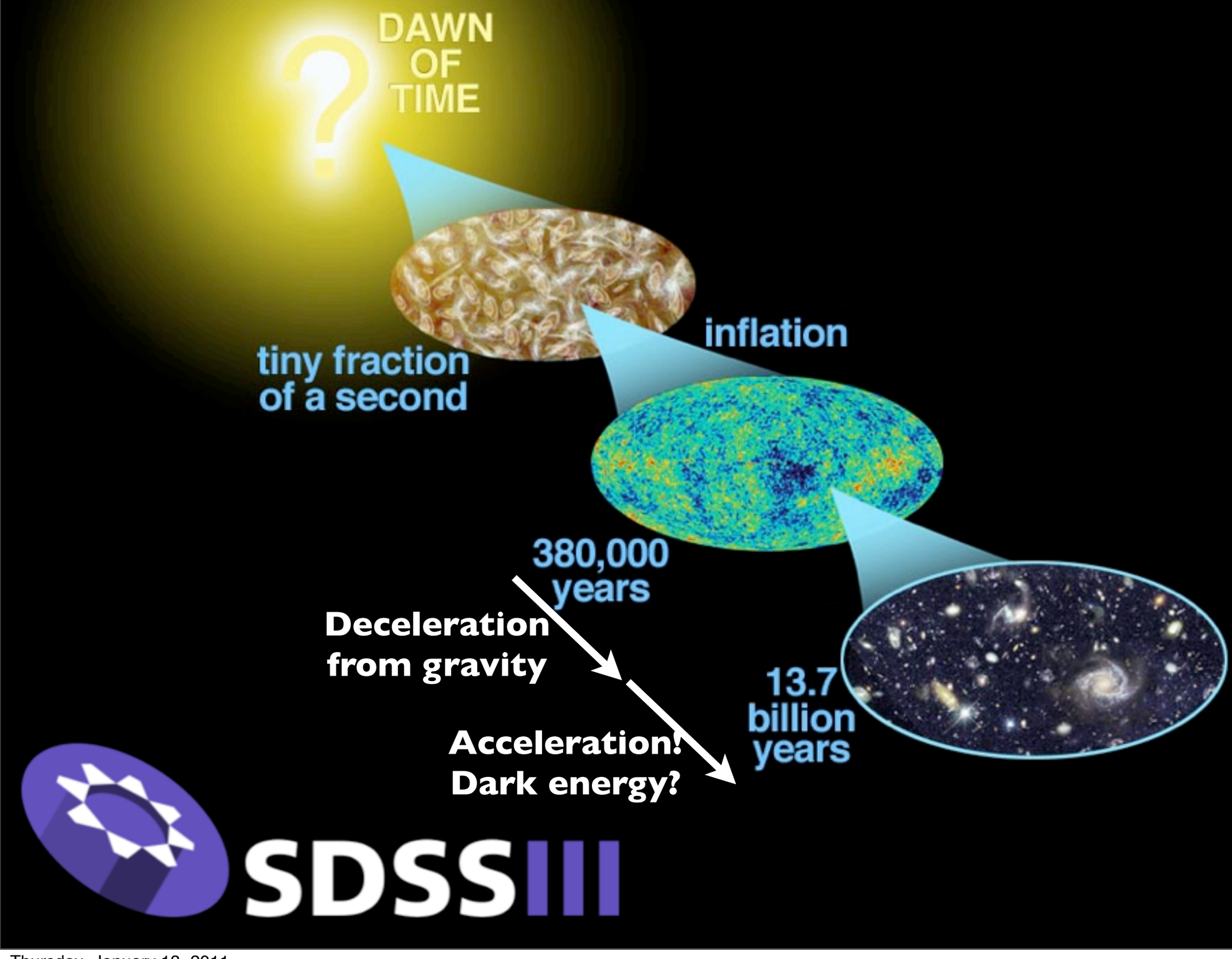
Movie credit: Dinoj Surendran & Mark Subbarao, U Chicago and Adler Planetarium for the SDSS

80% of SDSS telescope time used to make these 3-D maps

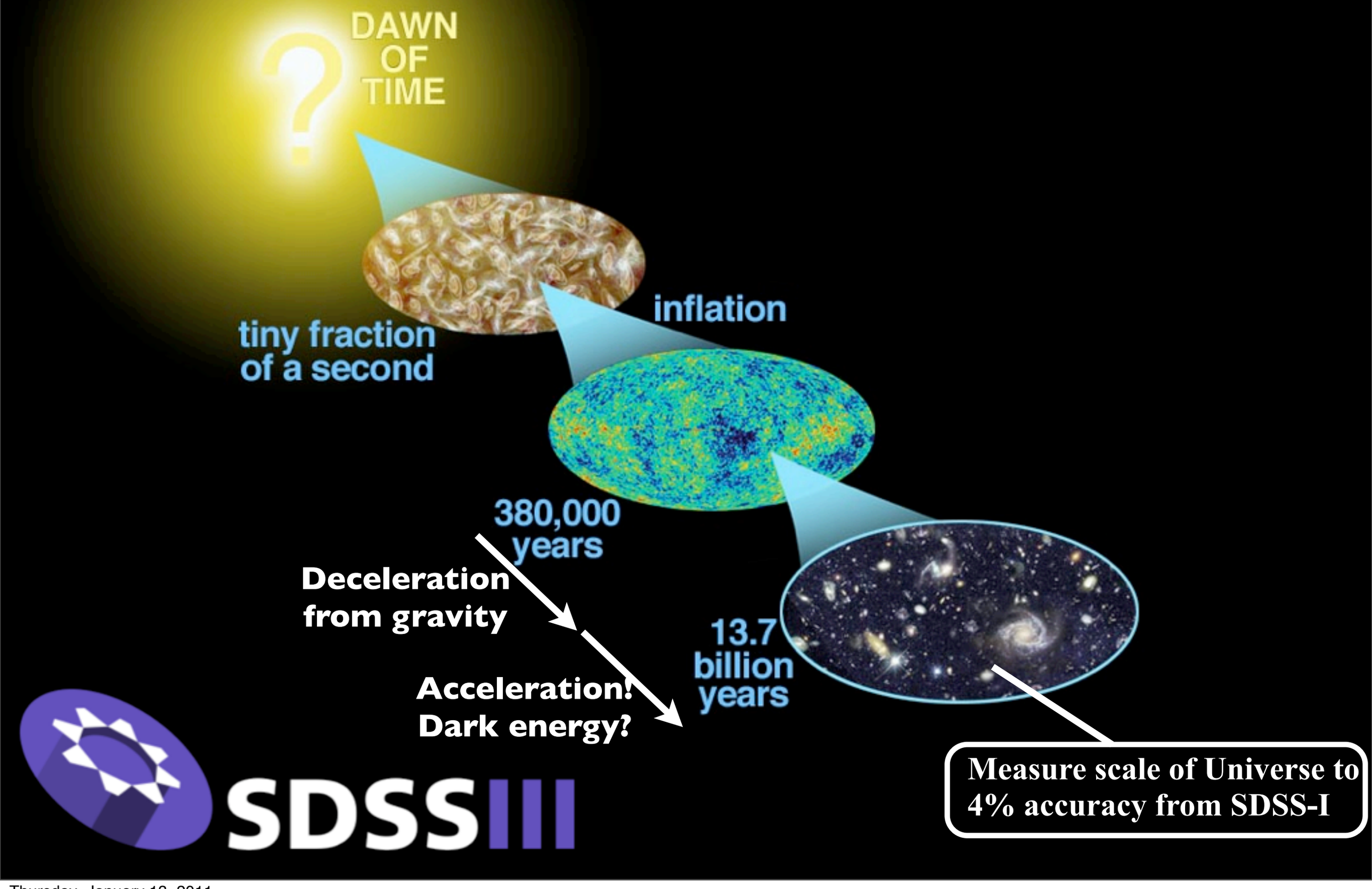
... but this is the “nearby” Universe

Movie credit: Dinoj Surendran & Mark Subbarao, U Chicago and Adler Planetarium for the SDSS

Effect of dark energy on the history of the Universe



Effect of dark energy on the history of the Universe



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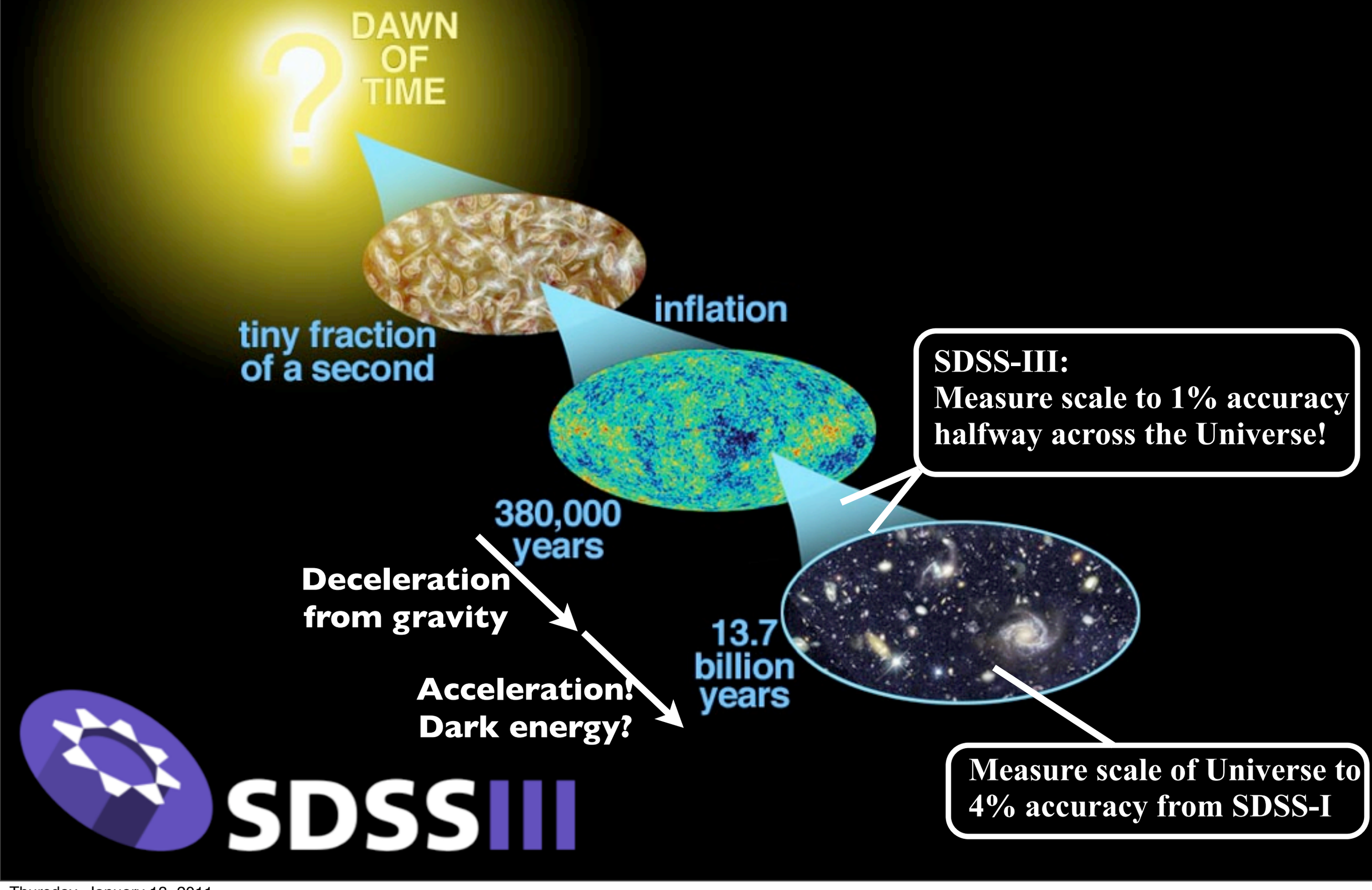

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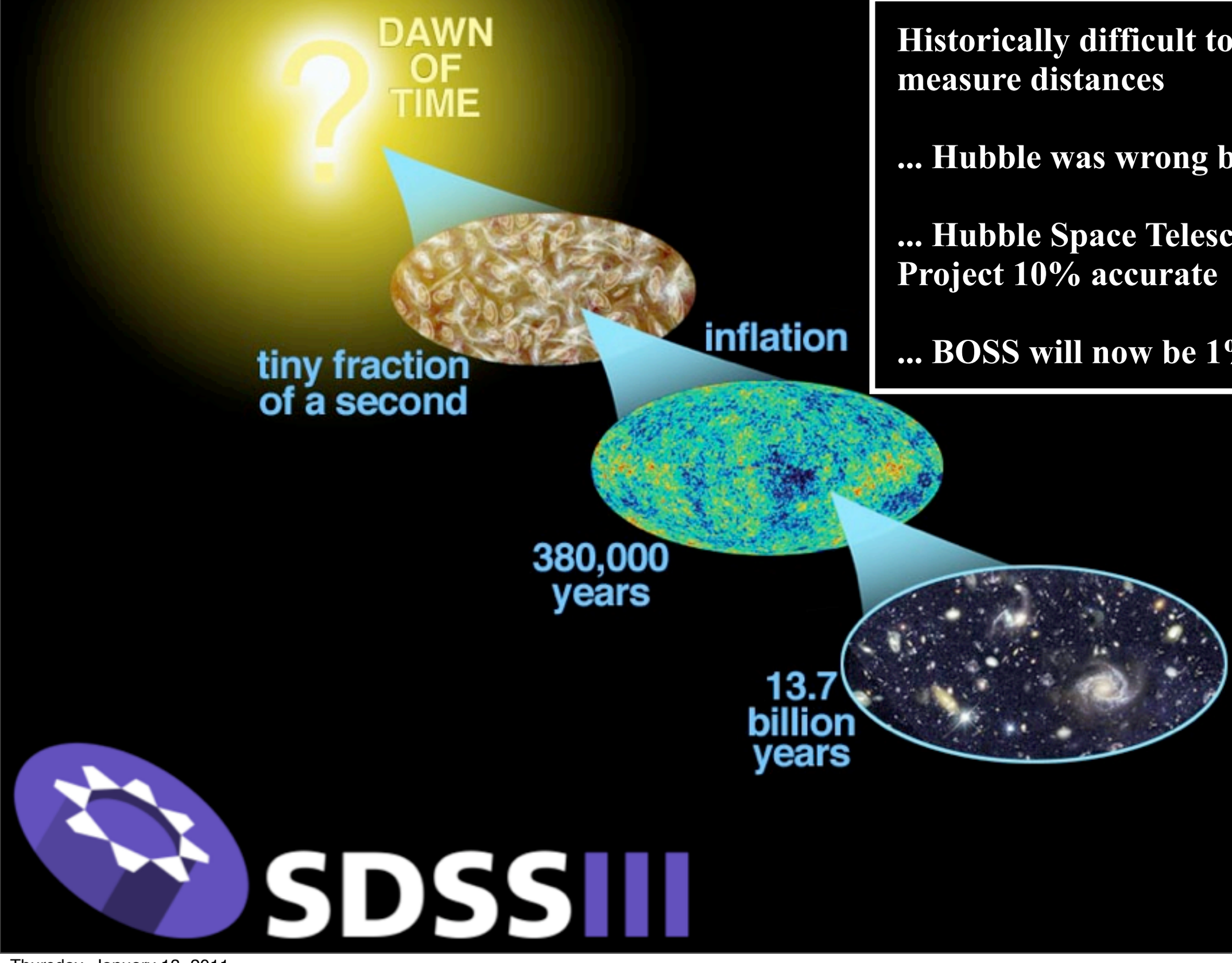


Historically difficult to accurately measure distances

... Hubble was wrong by 700% in 1929

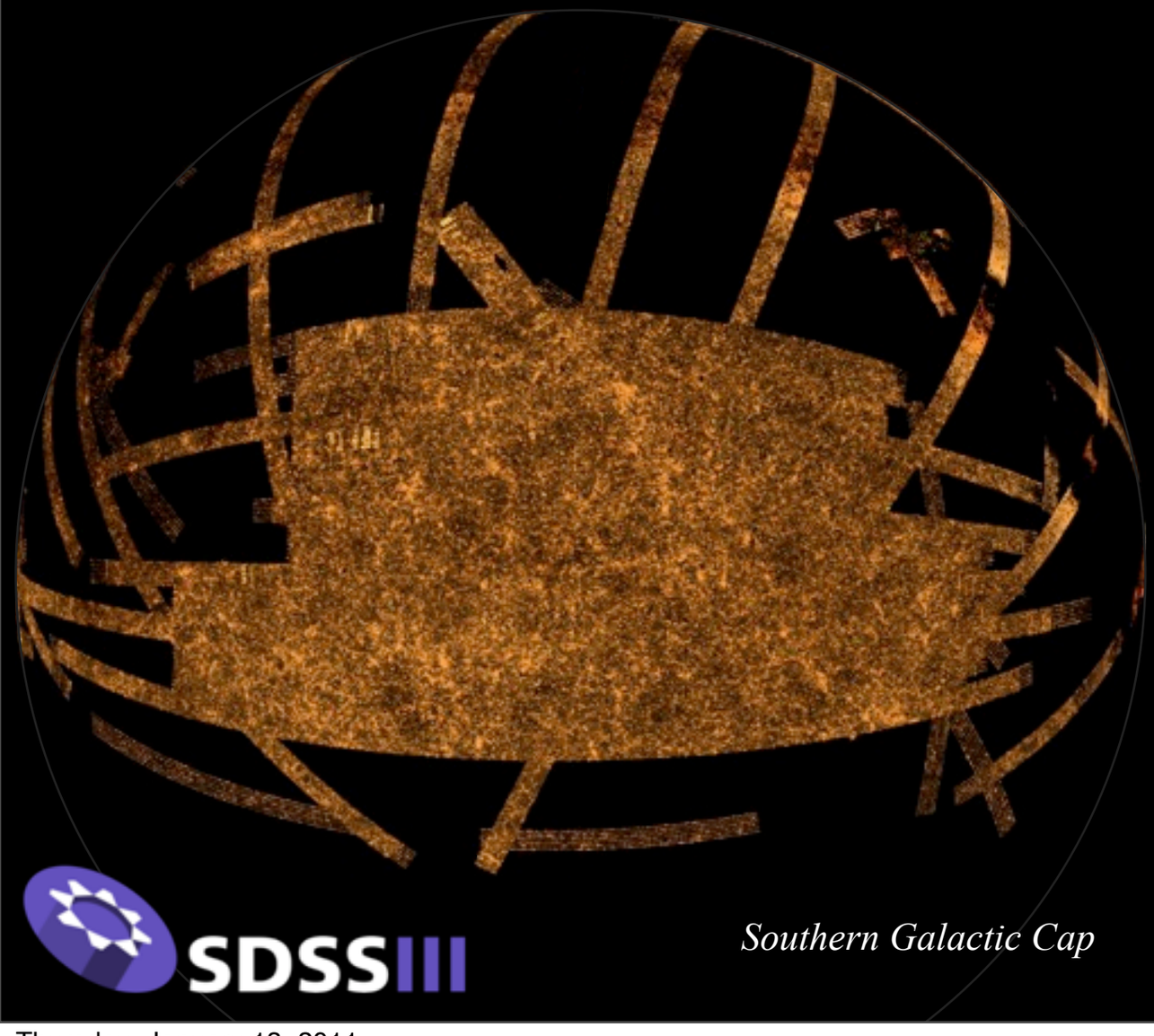
... Hubble Space Telescope Key Project 10% accurate

... BOSS will now be 1% accurate

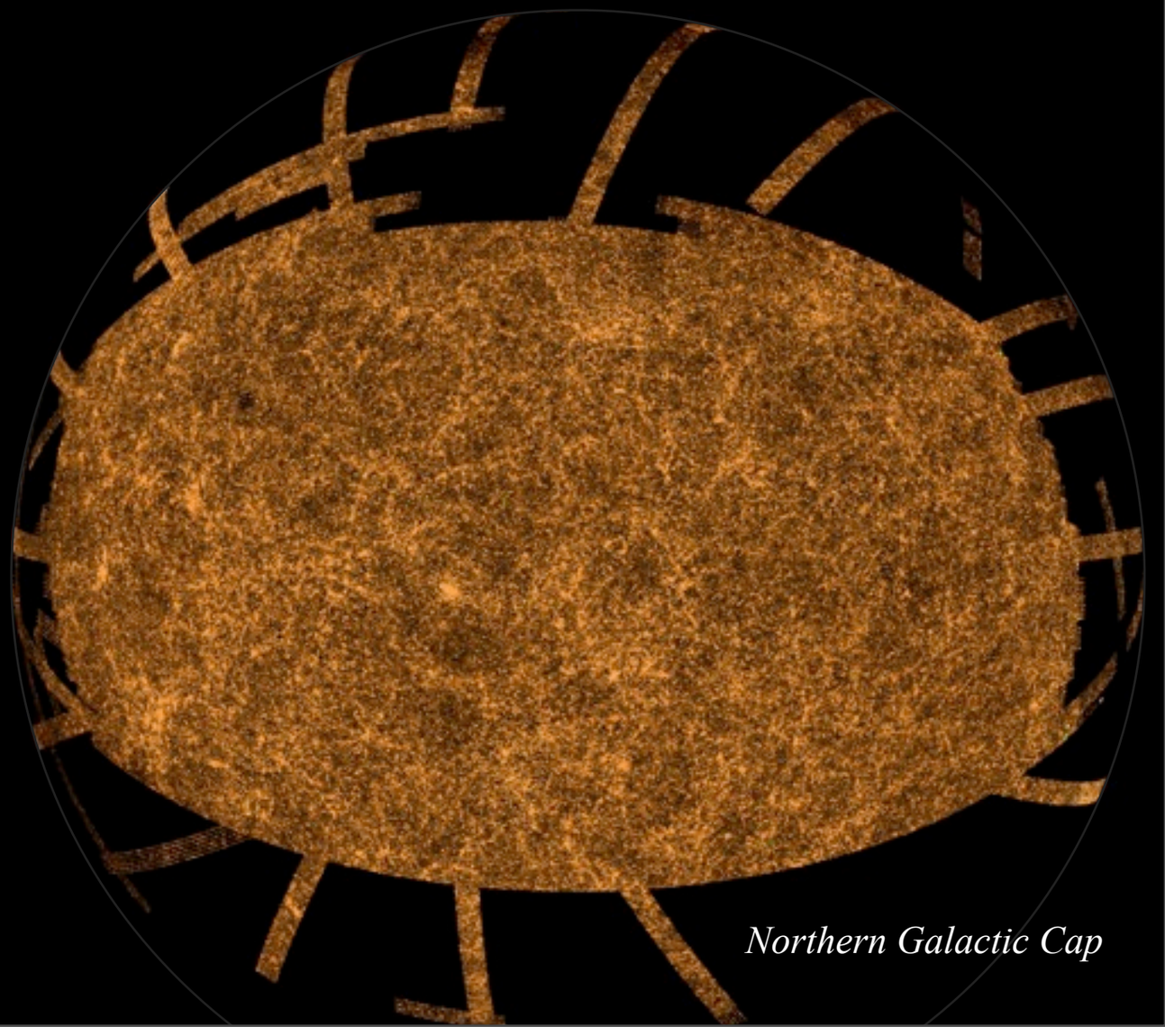
SDSS-III 3-D map:

From the 2-D image, select the 1% reddest galaxies...

take a spectrum... get a distance



Southern Galactic Cap



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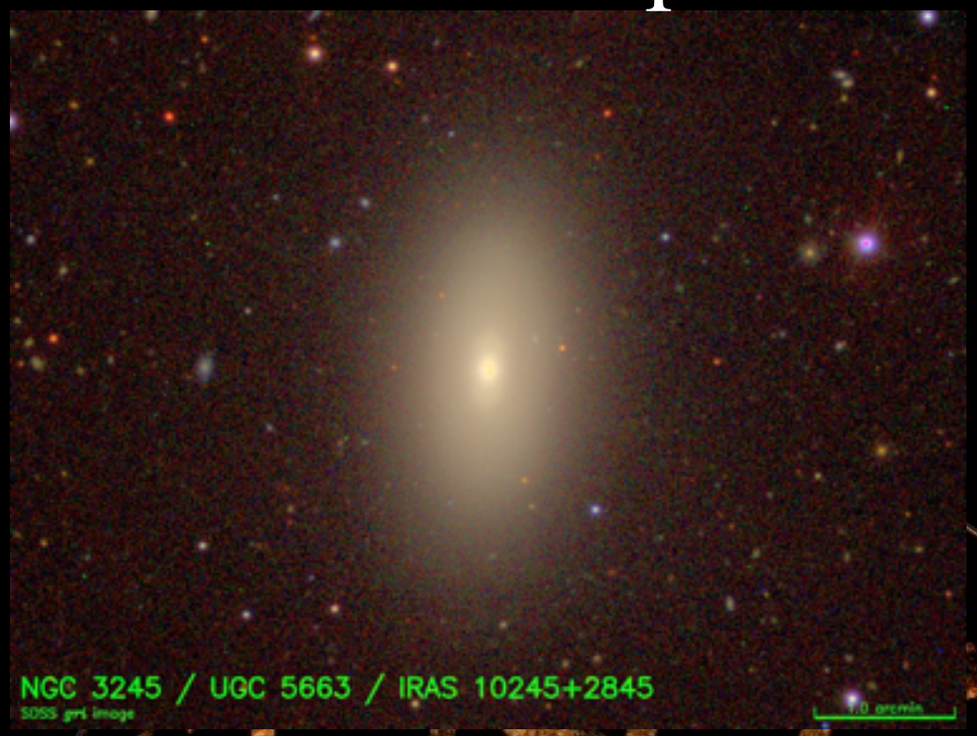

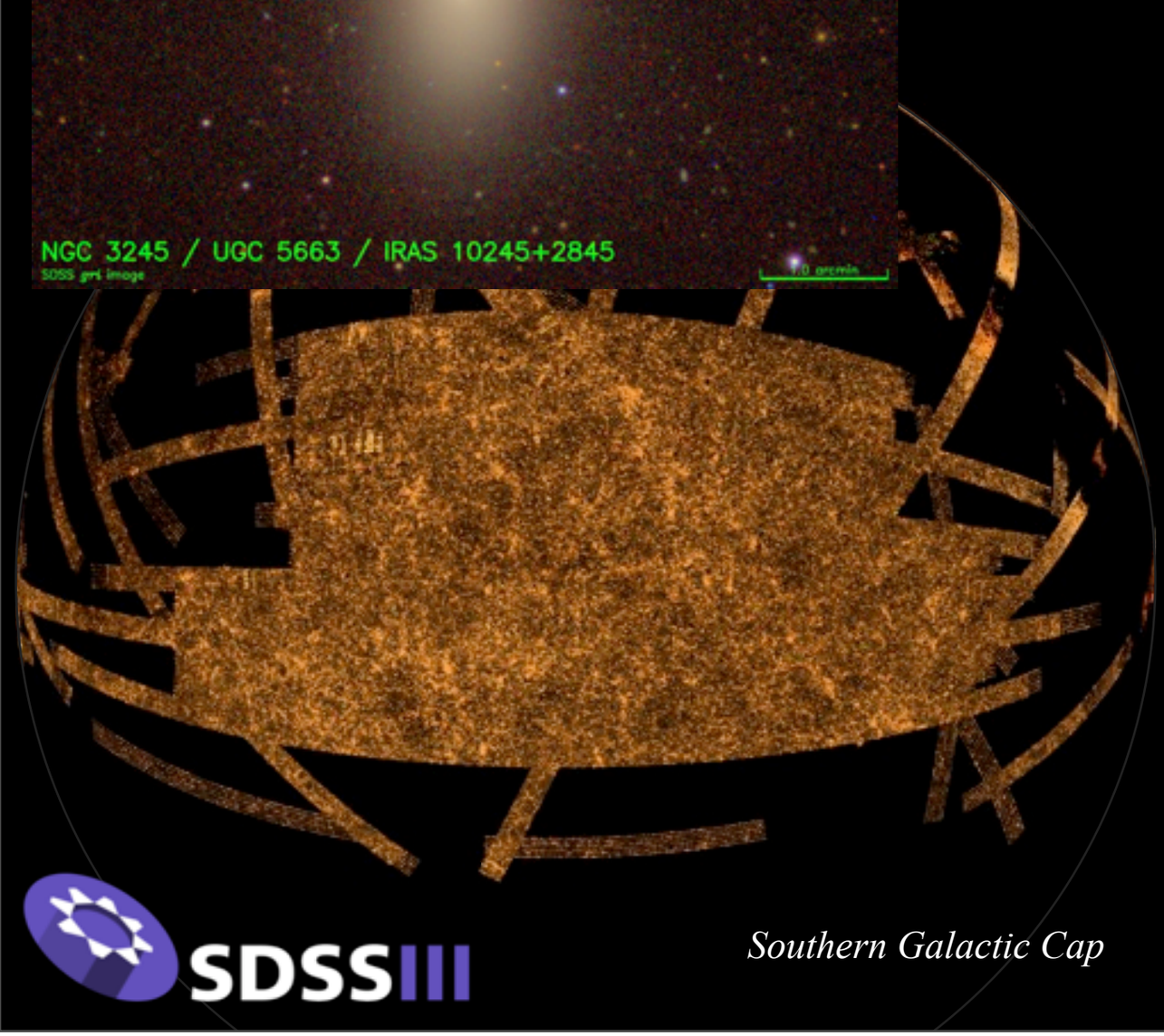

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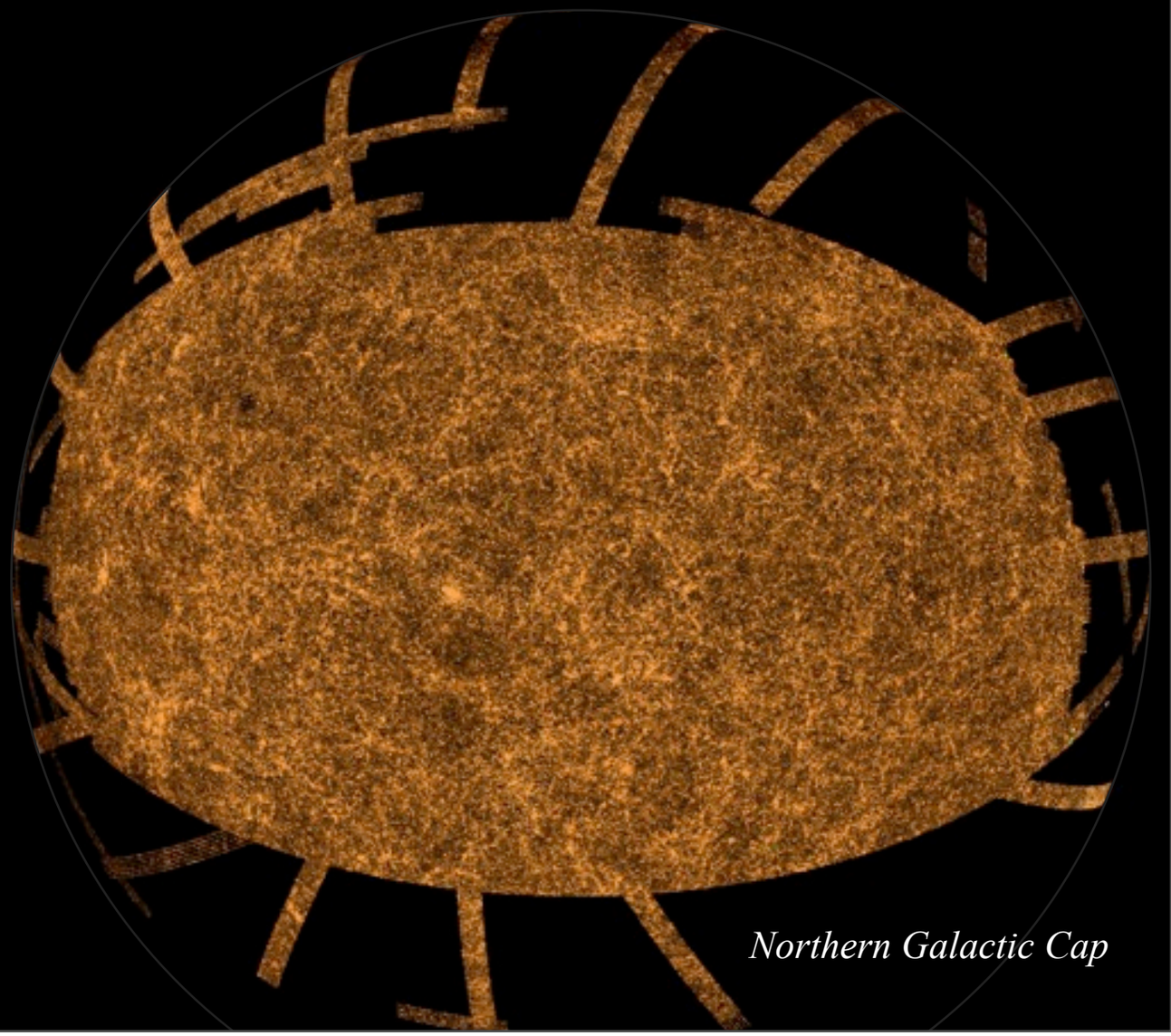

Northern Galactic Cap

SDSSIII

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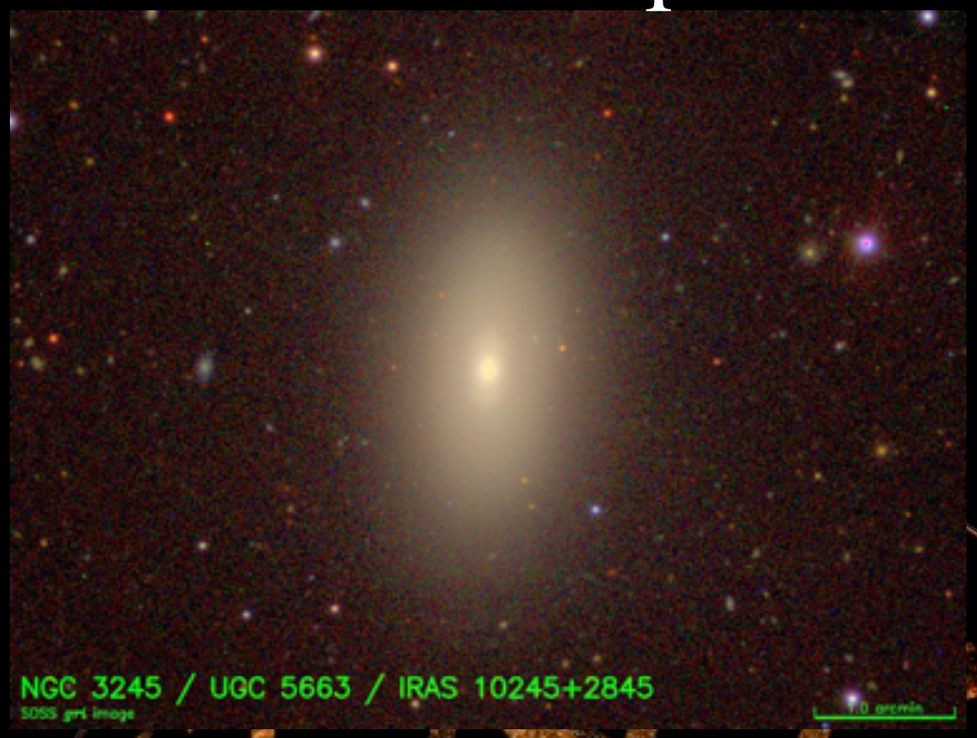

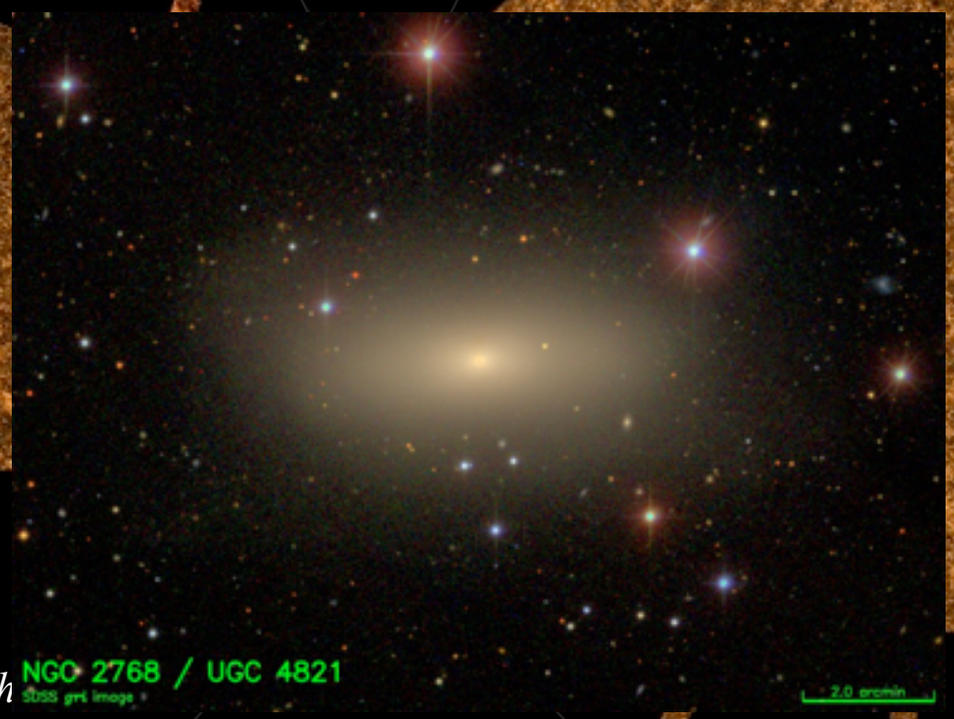

South *Northern Galactic Cap*

SDSSIII

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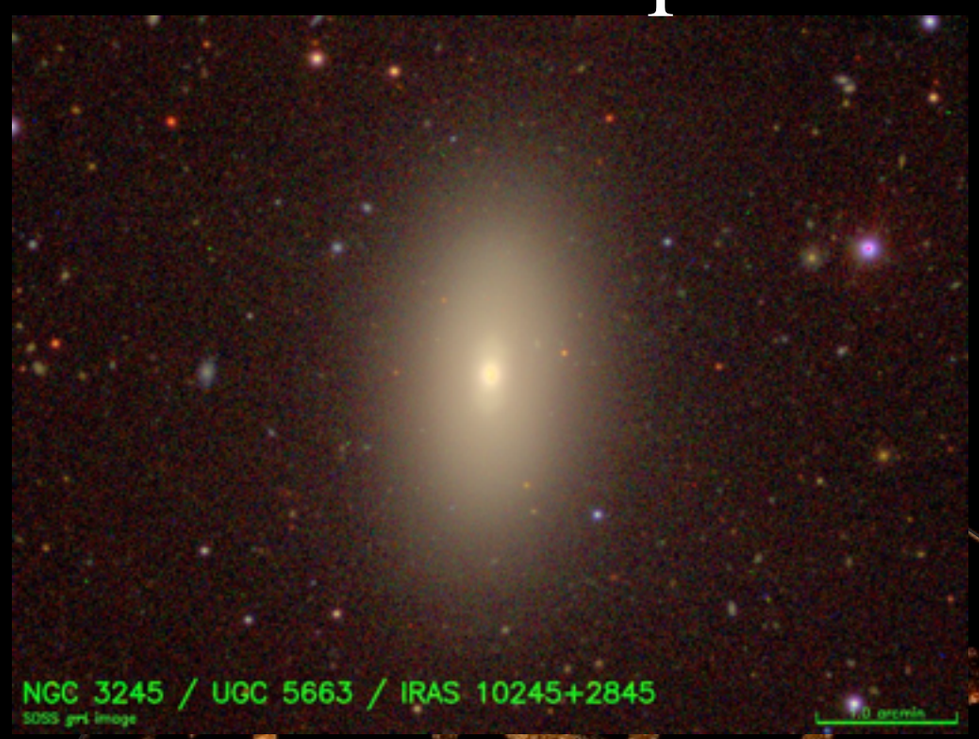
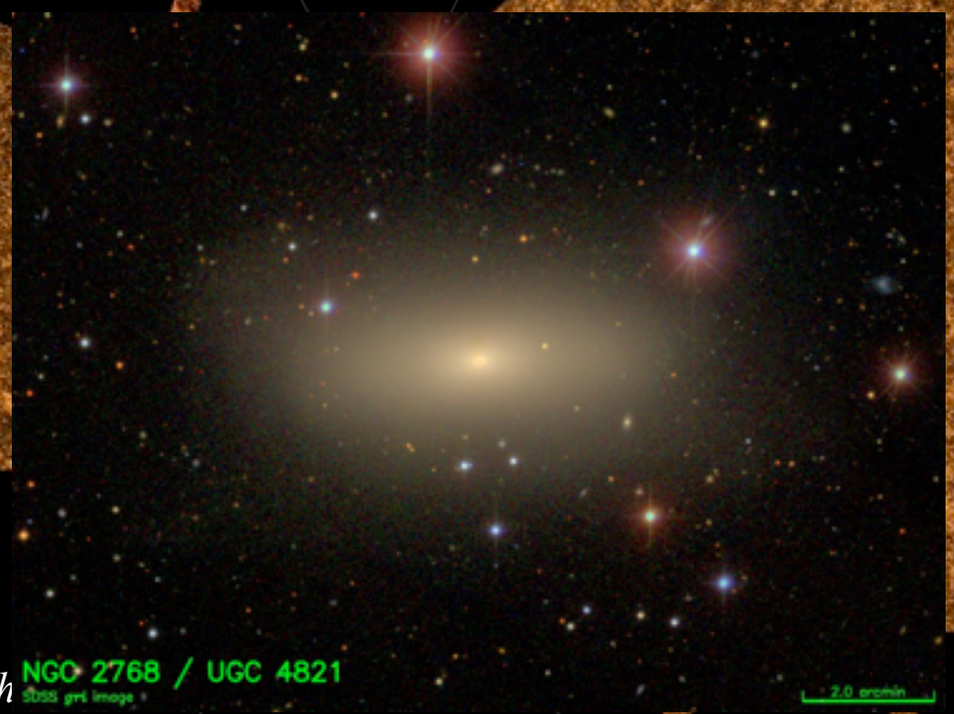
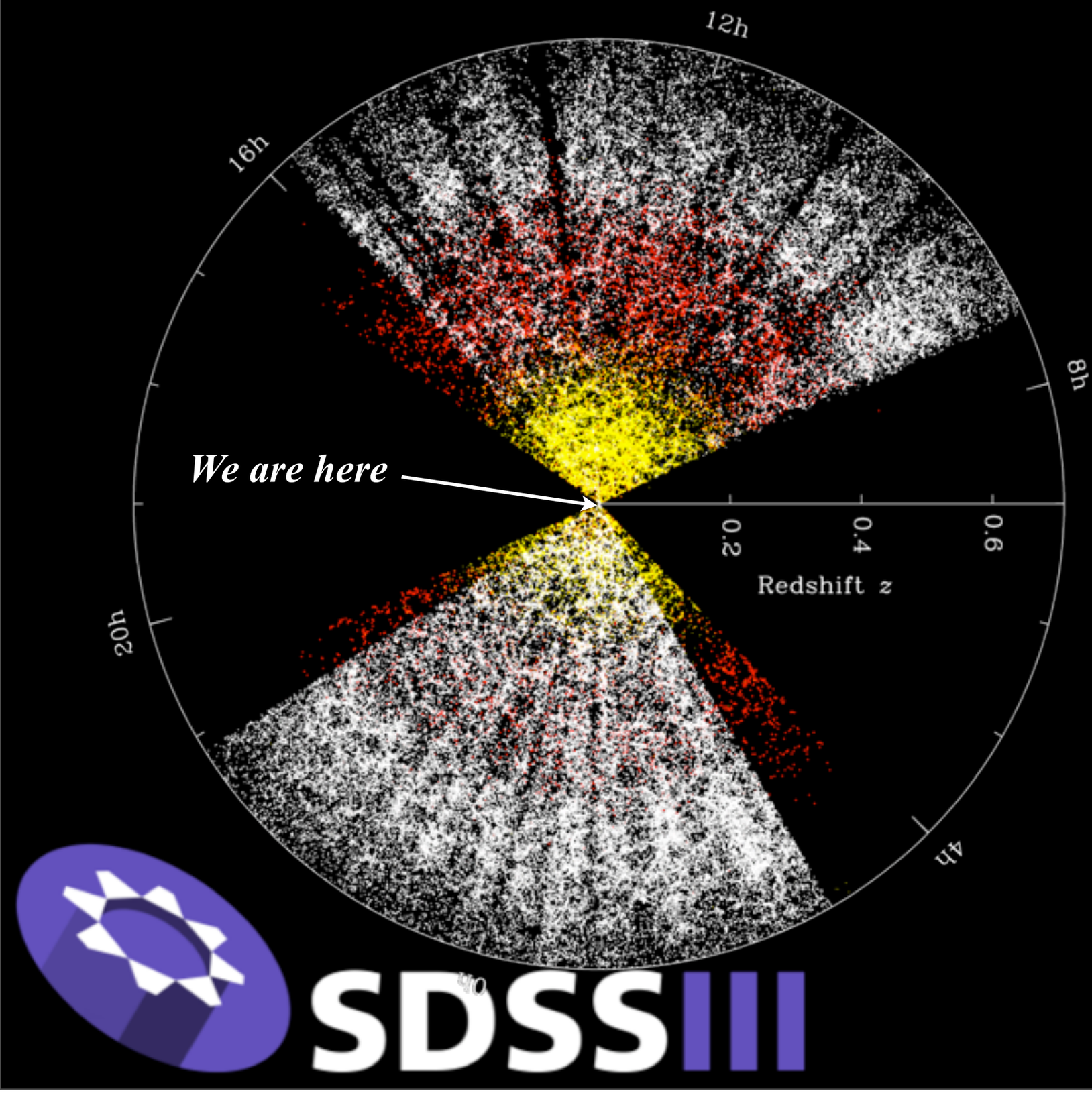




South *Northern Galactic Cap*

SDSSIII

SDSS-III 3-D map:
Extend from 1 billion (“nearby”) to 7 billion light-years



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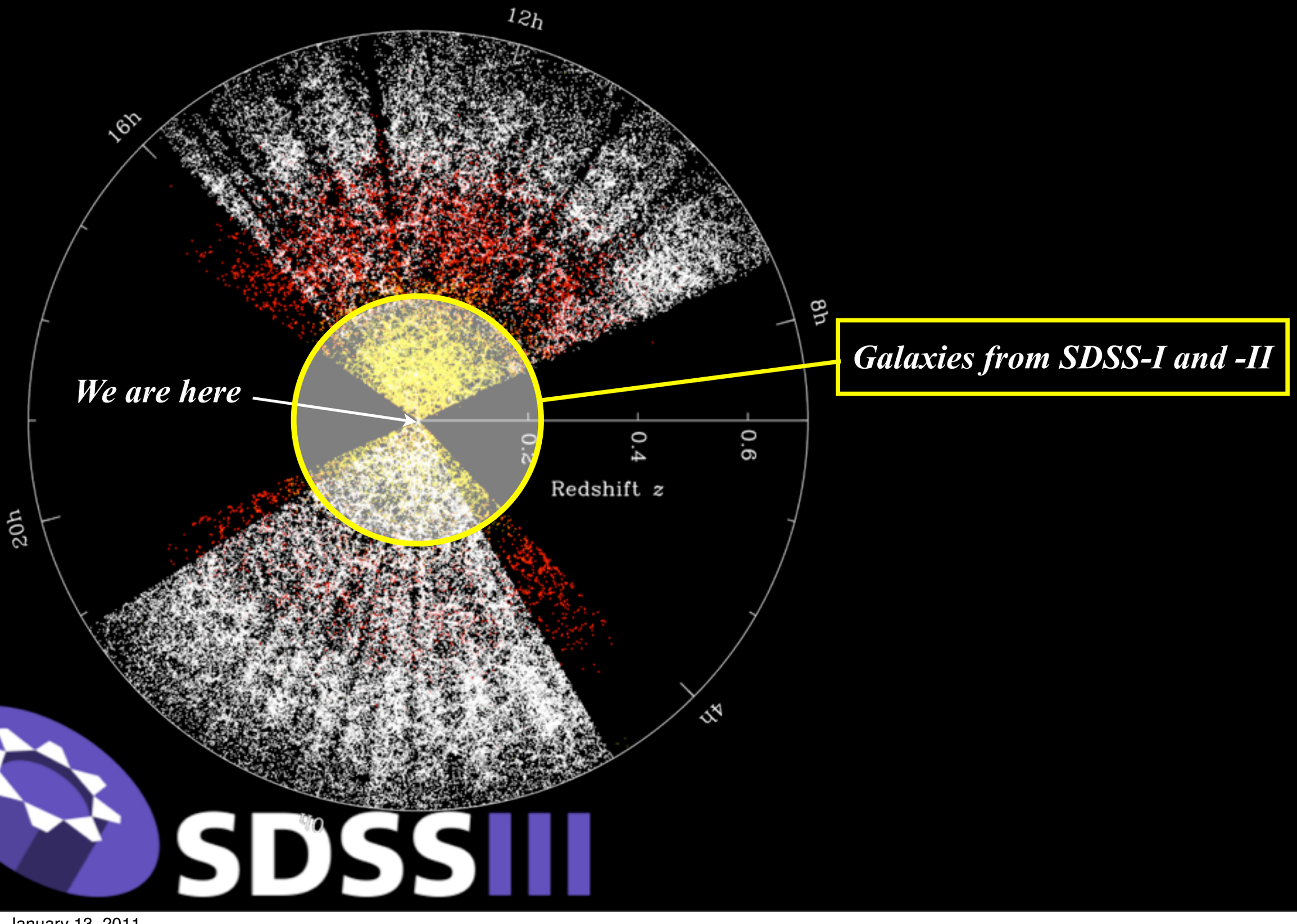

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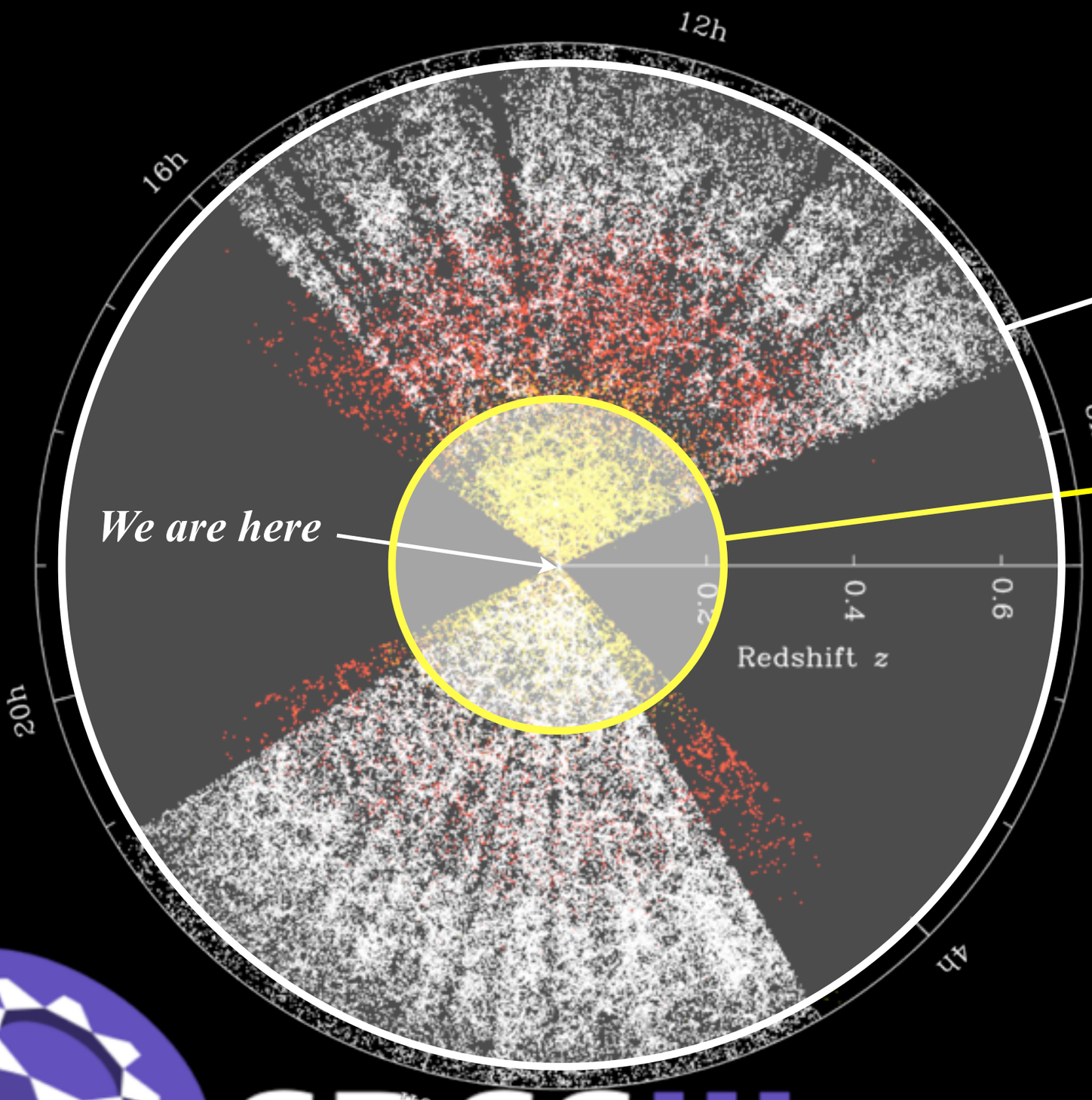


Red galaxies from SDSS-III

Galaxies from SDSS-I and -II

SDSS III

SDSS-III as of today:

- *After 1 year, larger than all galaxy surveys (except SDSS-I !)*

Coming soon!

- *Precision measures of dark energy from 3-D galaxy maps*

SDSS-III completion in 2014:

- *Largest 3-D map of 1.5 million galaxies*
- *1% accurate probe of dark energy in distant Universe*

SEGUE-2
Mapping the Distant Milky Way

Constance Rockosi

University of California, Santa Cruz
UCO/Lick Observatory

Largest Map of the Outer Galaxy

A picture of our Galaxy

from the inside looking out

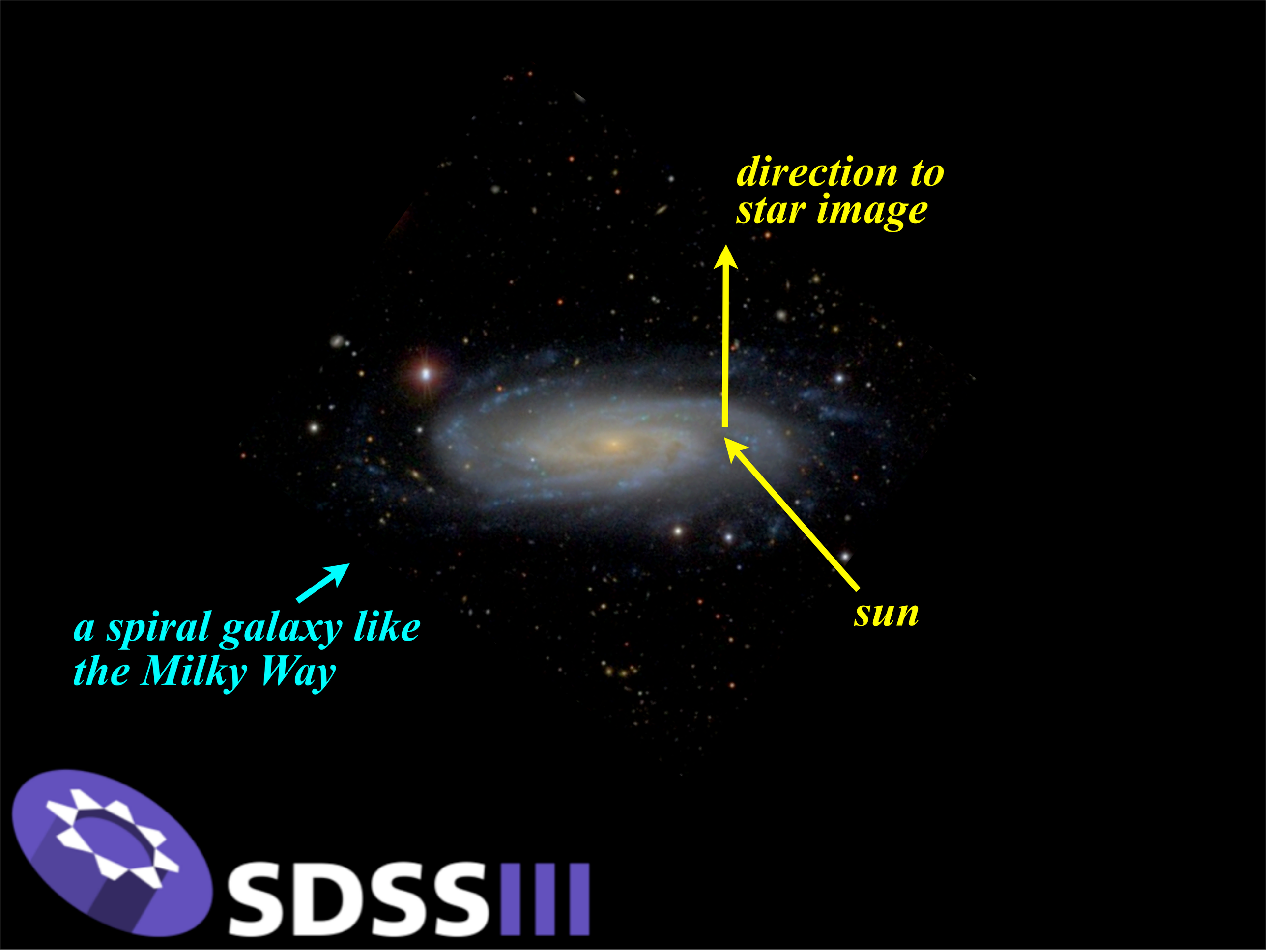
made by selecting old stars as identified in the SDSS-III multicolor image

blue: nearby stars
red: farther away

bright: lots of stars close together
faint: few stars

Image credit: V. Belokurov

SDSSII


direction to
star image
sun
a spiral galaxy like
the Milky Way
SDSSIII

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SDSSIII

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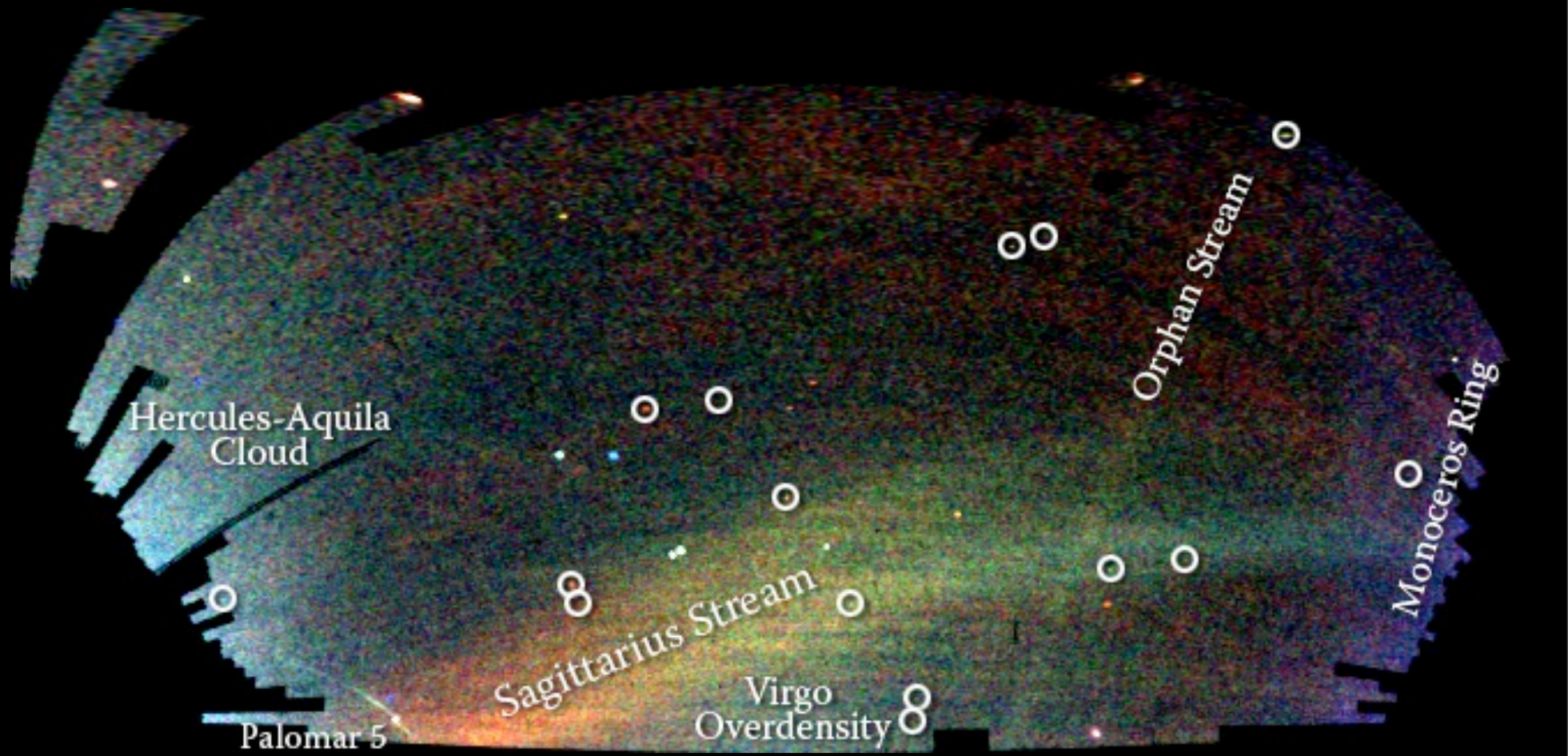
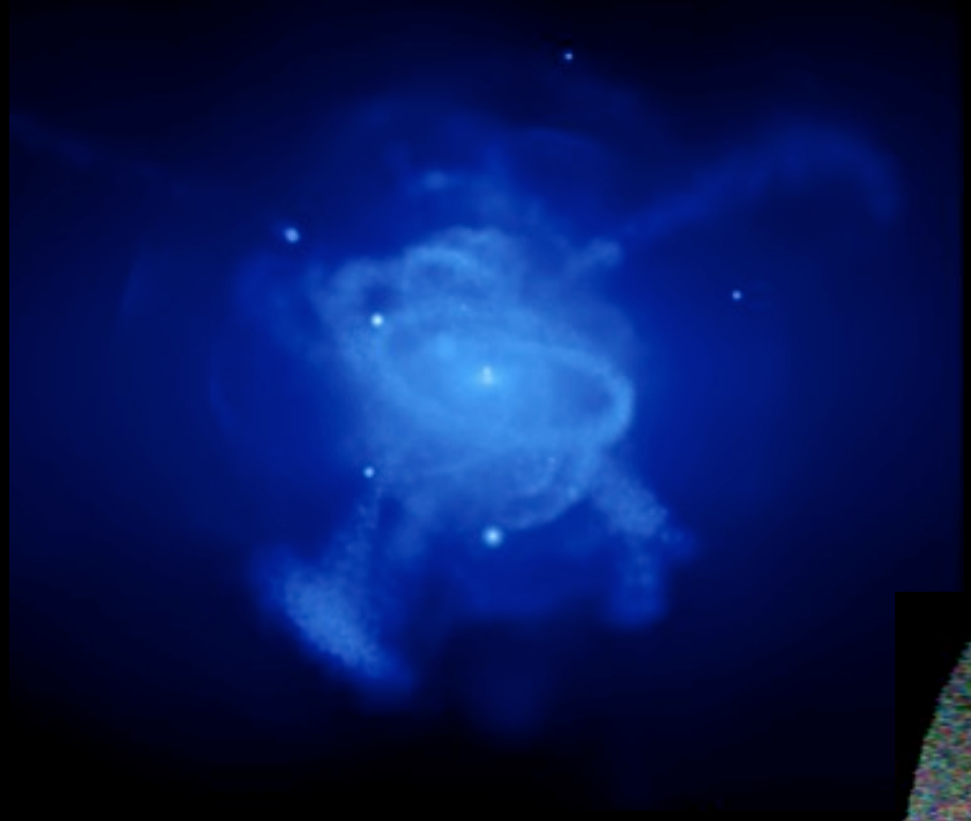


Image credit: V. Belokurov

SDSSIII

Learning How Galaxies Grow



A "theoretical galaxy" like the Milky Way. Image credit: Sandip Sharma from computer models by K. Johnston and J. Bullock

Cosmology predicts: satellite galaxies fall in to grow a galaxy like the Milky Way

Satellites fall in, stars are pulled out along streams and become part of the galaxy.

Confirmation of this picture motivated the SEGUE survey in SDSS-III to learn more about these stars and how galaxies grow.

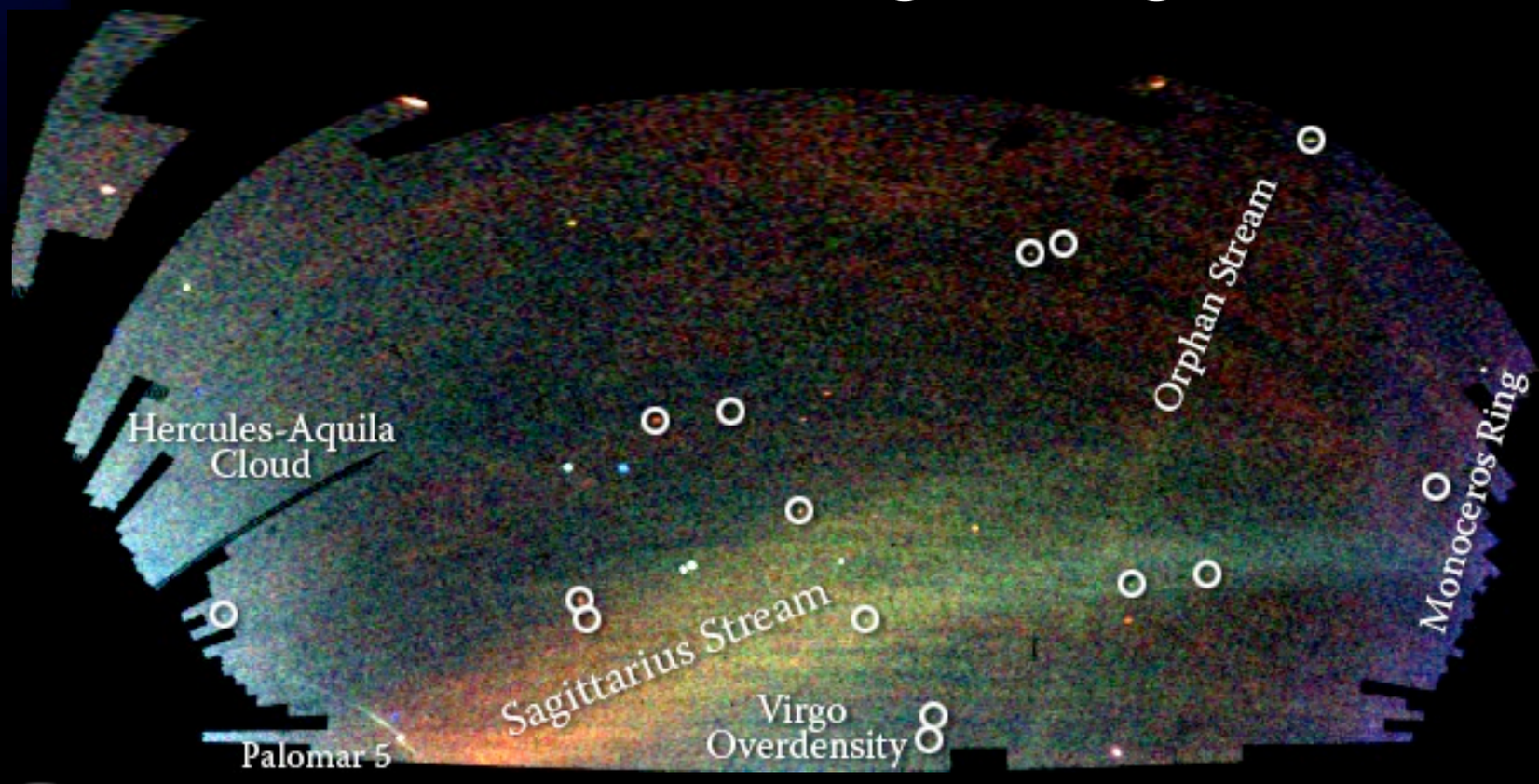
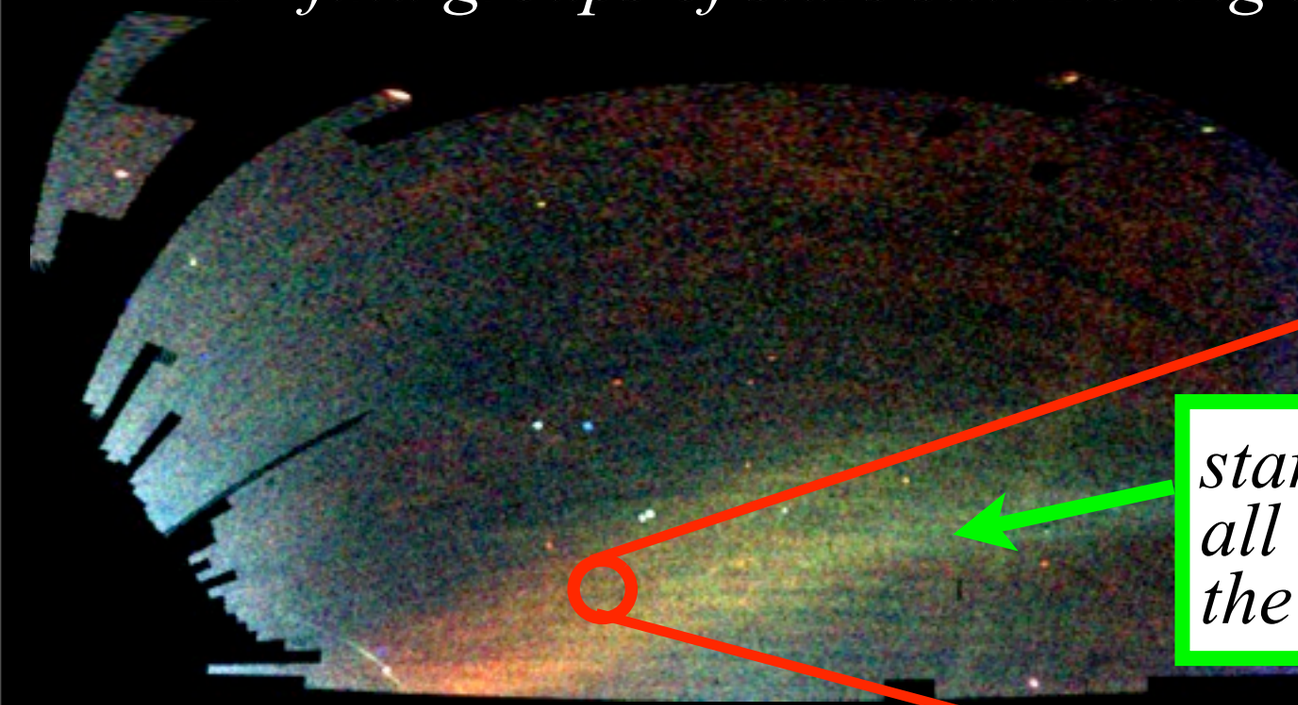


Image credit: V. Belokurov

SDSSIII

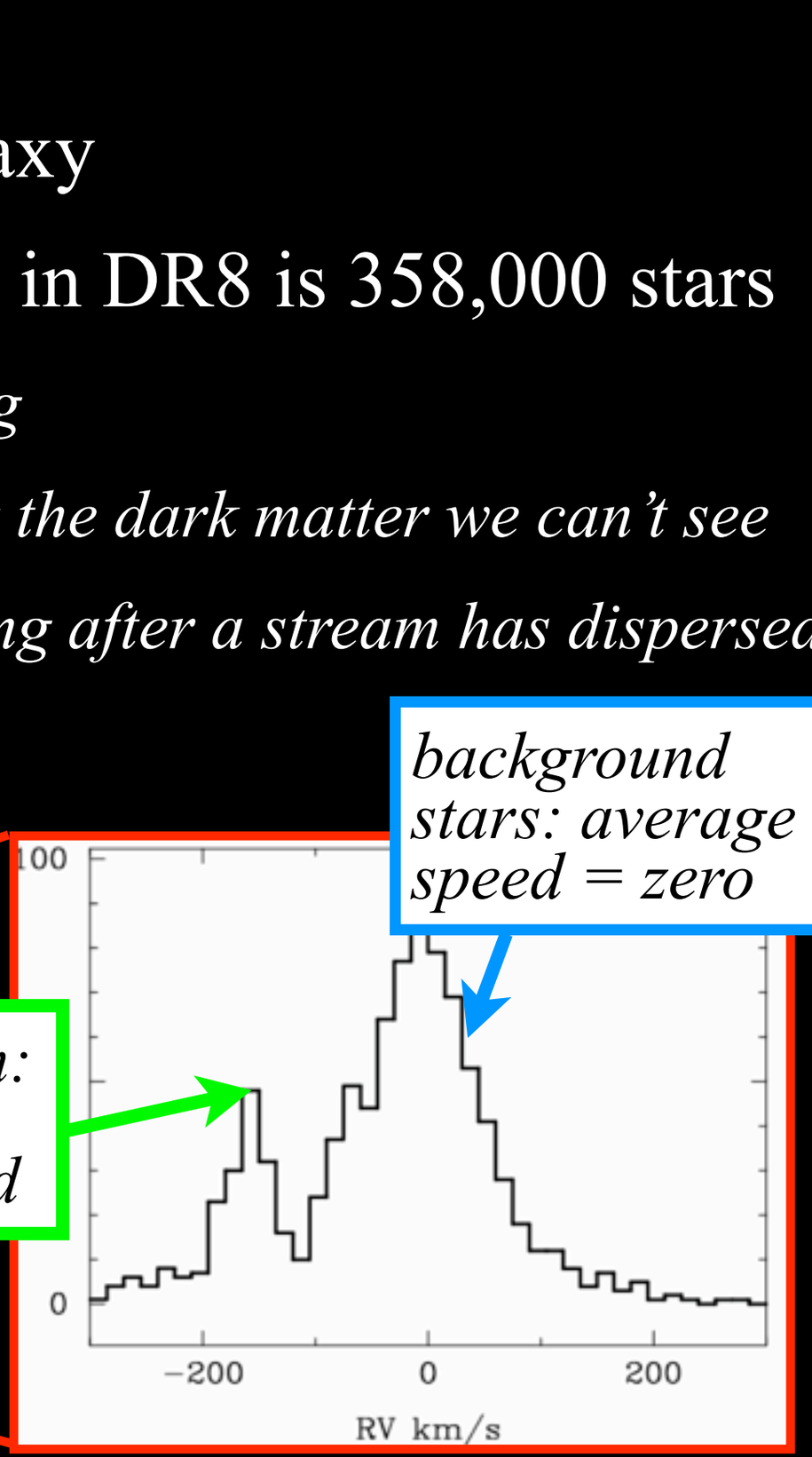
SEGUE-2

1. Spectroscopy of 118,000 stars in our Galaxy
2. With SEGUE-1, the total SEGUE sample in DR8 is 358,000 stars
   a. *Doppler velocity: how fast the stars are moving*
      i. *measure total mass of the Galaxy, including the dark matter we can't see*
      ii. *find groups of stars still moving together long after a stream has dispersed*



stars in stream: all moving at the same speed

background stars: average speed = zero



SEGUE star speeds in stream region

SDSSIII

SEGUE-2

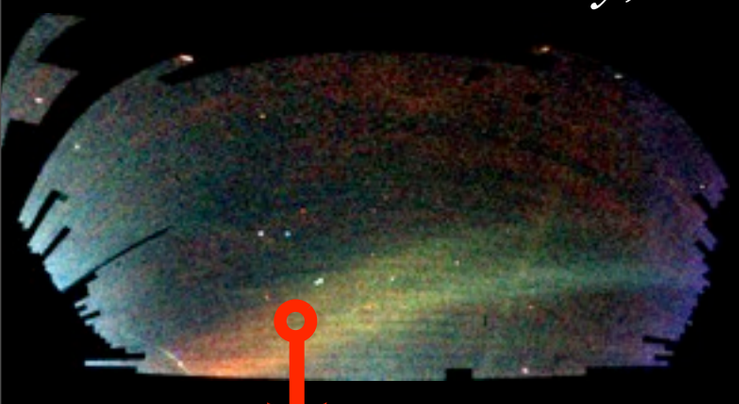
b. Learn what stars are made of

i. identify chemical elements in stars

ii. fingerprint the environments in which the stars were born

iii. identify different kinds of satellites that fell in to the galaxy: big, small; recently, long ago

Credit: Schlaufman (323.02D)



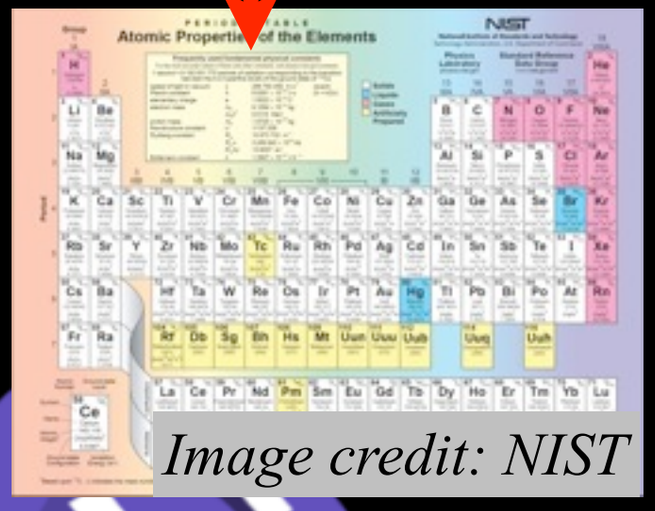
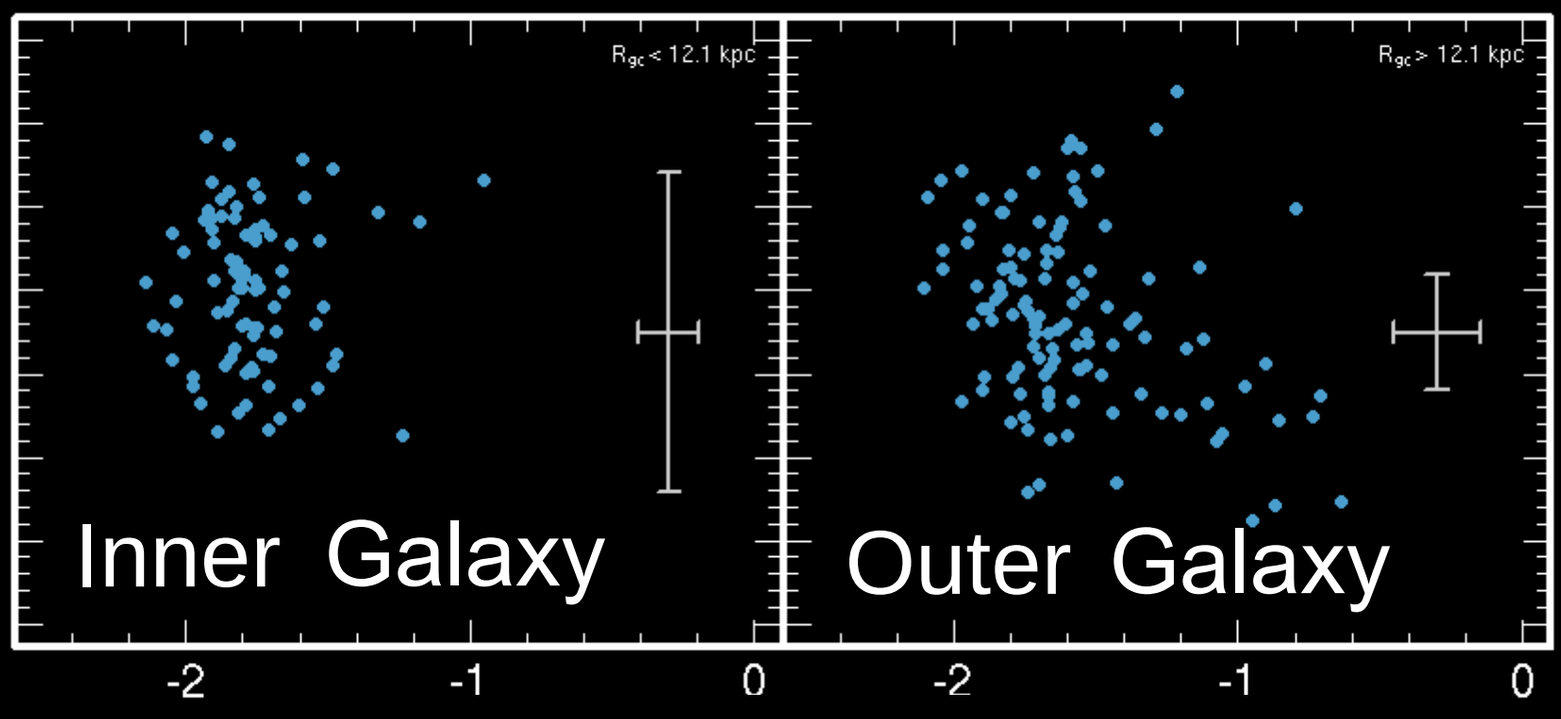


Image credit: NIST



SDSSIII

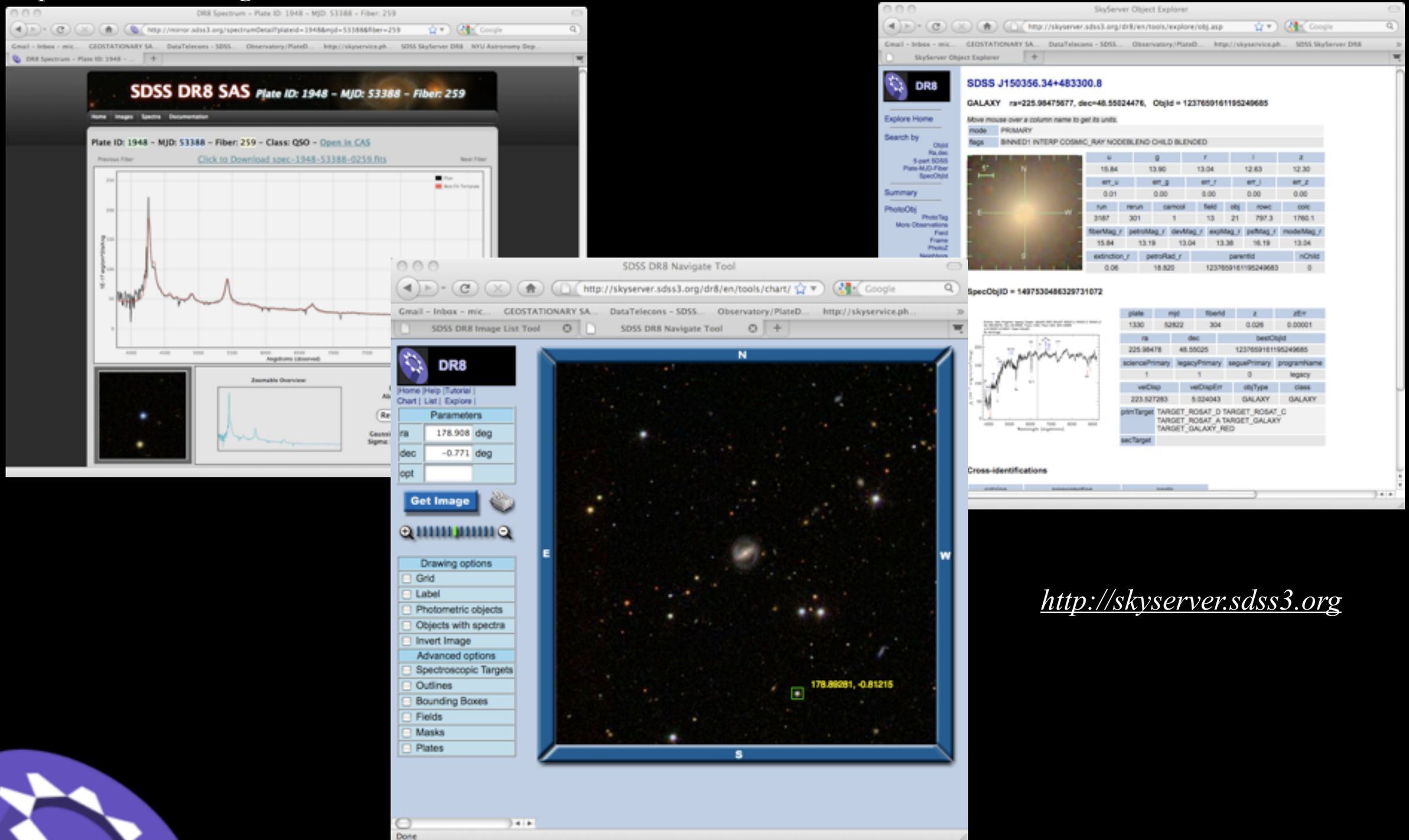
Data Release 8

1. 30 terabytes of images total
2. 470 million stars and galaxies cataloged
3. 1.8 million spectra
4. Uniformly good quality
5. Results accessible to professionals and amateurs alike

SDSSIII

SkyServer and Science Archive

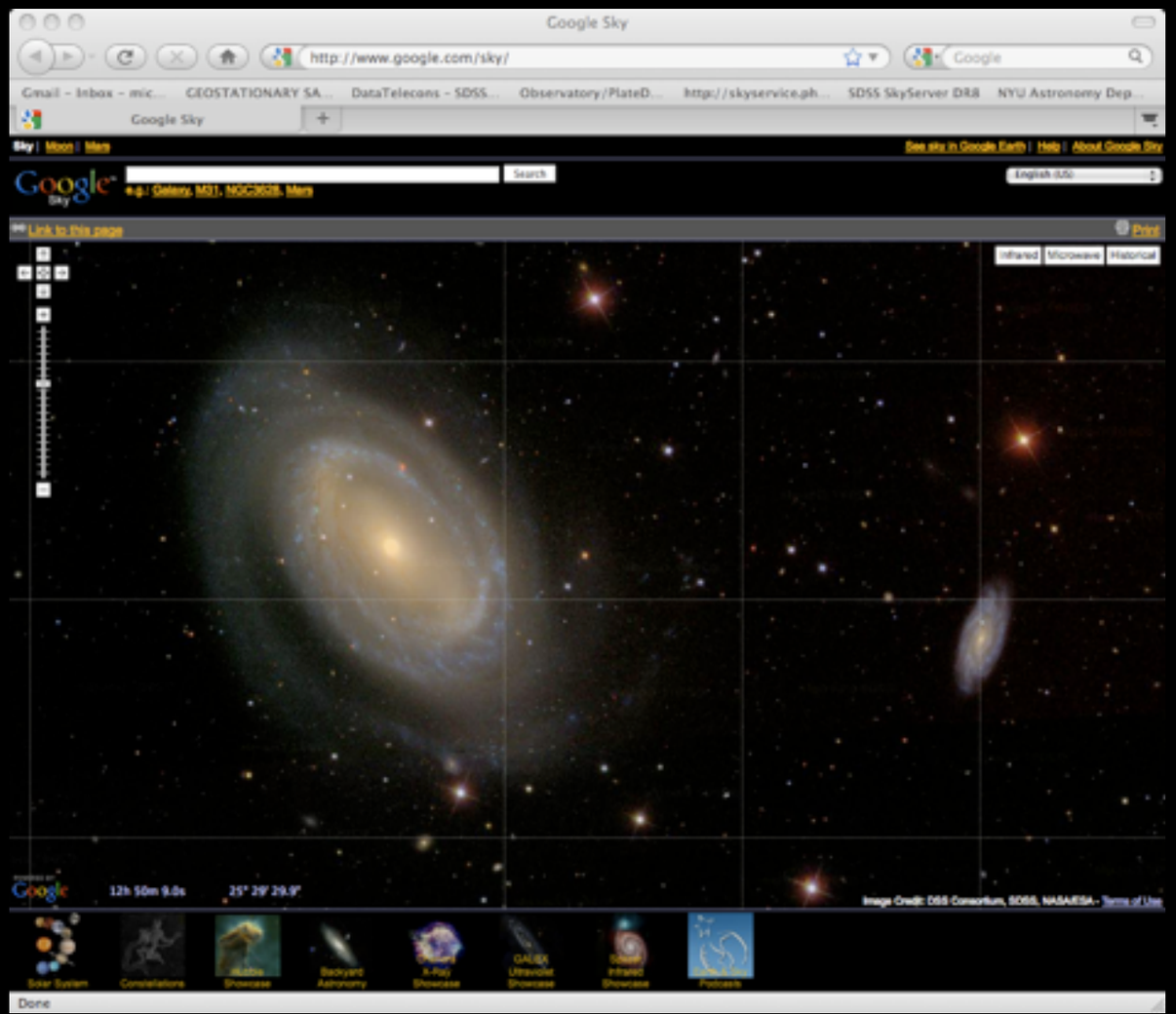
http://data.sdss3.org



http://skyserver.sdss3.org

SDSSIII

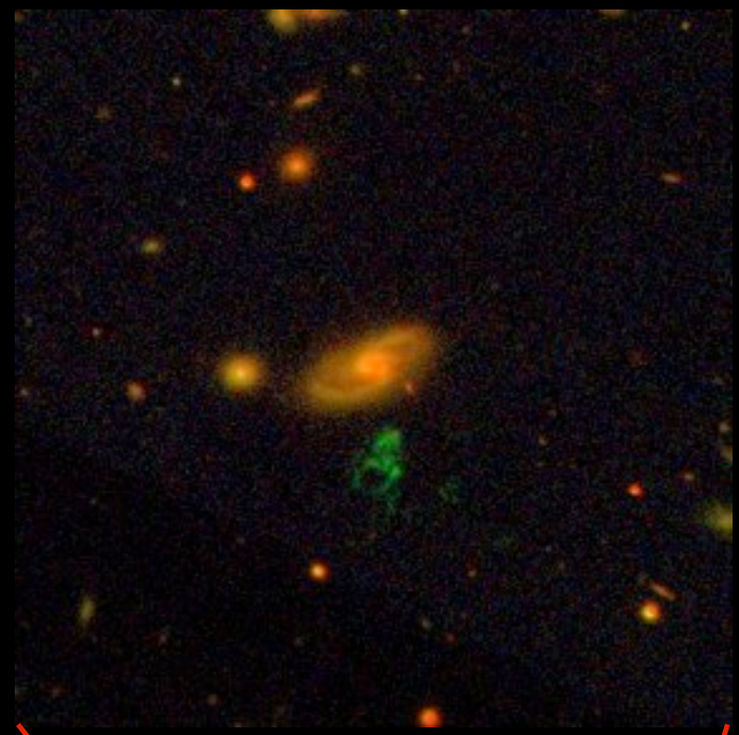
Primary data source for:
Google Sky, World-Wide Telescope, Galaxy Zoo

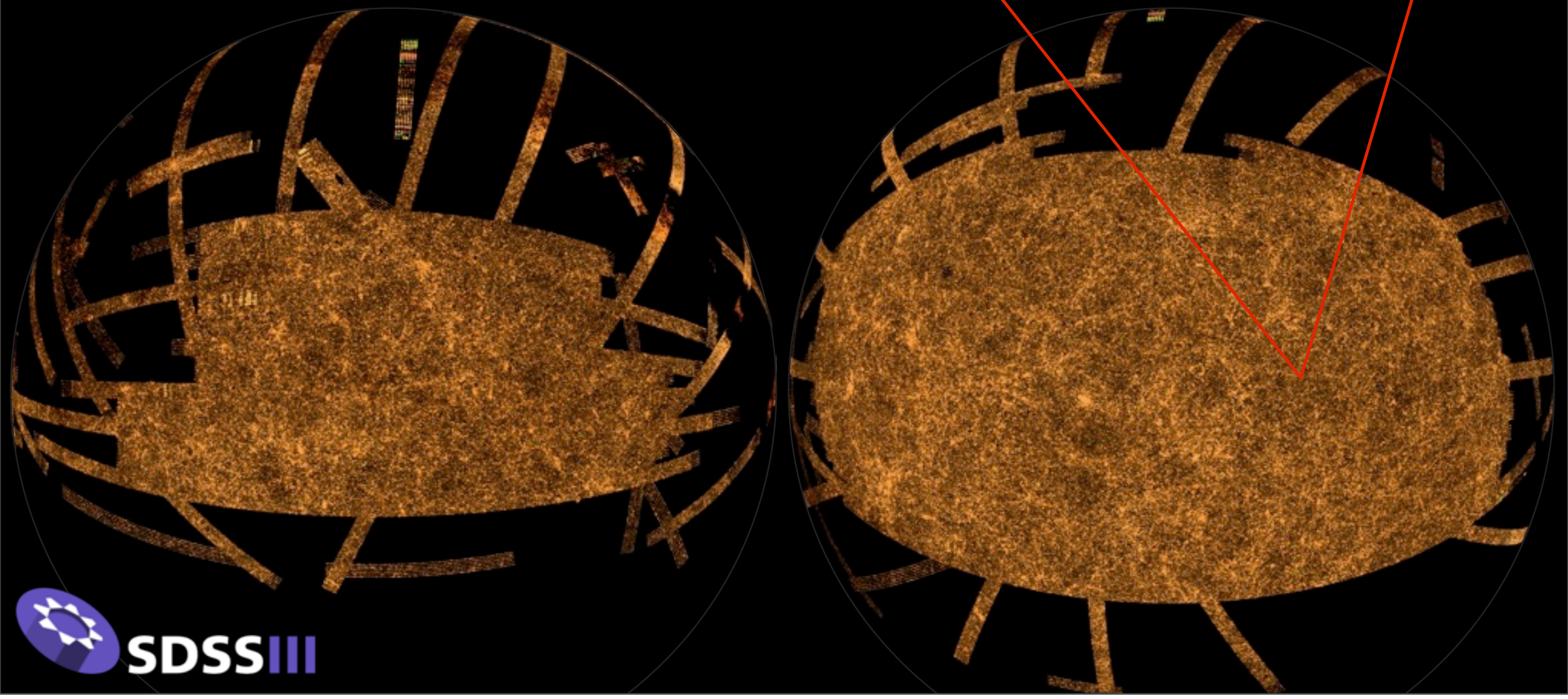


SDSSIII

Distribution lets public into the act

e.g. Hanny's Voorwerp, which you heard about yesterday: discovered in 2007 by an amateur using SDSS imaging in GalaxyZoo





Future data releases through 2014

1. BOSS: *three-dimensional maps*
2. MARVELS: *a search for planets around other stars*
3. APOGEE: *Milky Way studies using infrared light*

literally thousands of papers based on public SDSS data so far: a few dozen being presented this week, on the very smallest stars as well as the most massive black holes

SDSSIII

Many people, many years

Funding for SDSS-III has been provided by the Alfred P. Sloan Foundation, the Participating Institutions, the National Science Foundation, and the U.S. Department of Energy. The SDSS-III web site is http://www.sdss3.org/.

SDSS-III is managed by the Astrophysical Research Consortium for the Participating Institutions of the SDSS-III Collaboration including the University of Arizona, the Brazilian Participation Group, Brookhaven National Laboratory, University of Cambridge, University of Florida, the French Participation Group, the German Participation Group, the Instituto de Astrofisica de Canarias, the Michigan State/Notre Dame/JINA Participation Group, Johns Hopkins University, Lawrence Berkeley National Laboratory, Max Planck Institute for Astrophysics, New Mexico State University, New York University, Ohio State University, Pennsylvania State University, University of Portsmouth, Princeton University, the Spanish Participation Group, University of Tokyo, University of Utah, Vanderbilt University, University of Virginia, University of Washington, and Yale University.

SDSSIII