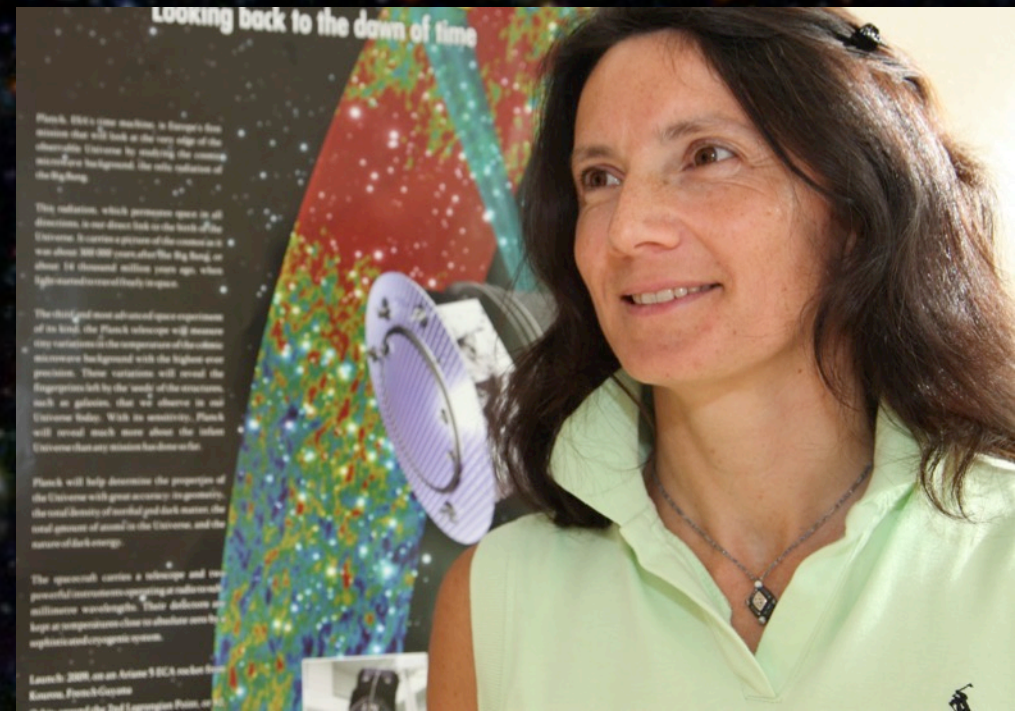


# Research In cosmology

Nathalie Palanque-Delabrouille

Physics Division Director  
Berkeley Lab

Quarknet, June 2022



# Brief curriculum

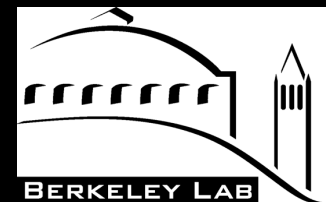
Engineering school in Paris, France (in telecommunications)

PhD in physics jointly between  
University of Chicago, USA  
University Paris, France

Researcher in cosmology for over 25 years  
at CEA (Agency for atomic energy and alternative energies, France)



Physics Division Director  
at Lawrence Berkeley National Laboratory





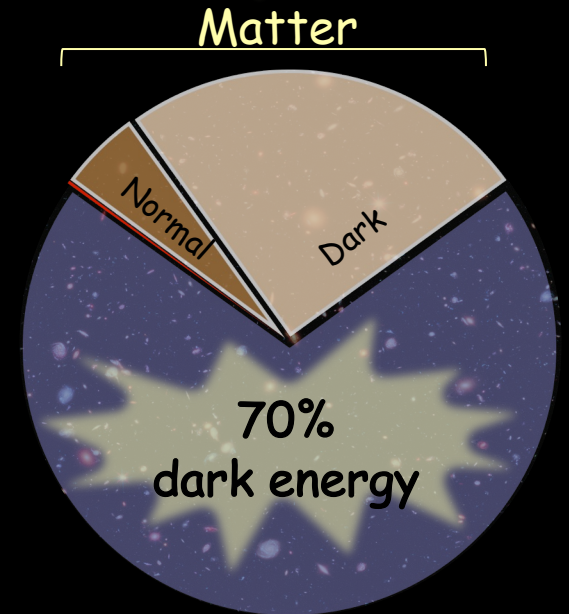
# Why research ?

- I love puzzles; the cosmos is a mystery  
What is it made of? How does it evolve?
- Leading investigations and solving mysteries is exciting  
Finding clues, testing hypotheses

This is exactly what research is !



85% is unknown  
dark matter



# Research in cosmology

Using the Canada-France-Hawaii telescope in Hawaii (4200m elevation)

Studying stellar explosions (supernovae) to investigate dark energy



(Type Ia) supernovae allow to determine

- their distance
- age of the Universe at explosion

→ allow us to measure expansion rate of the Universe at different epochs (dictated by dark energy)

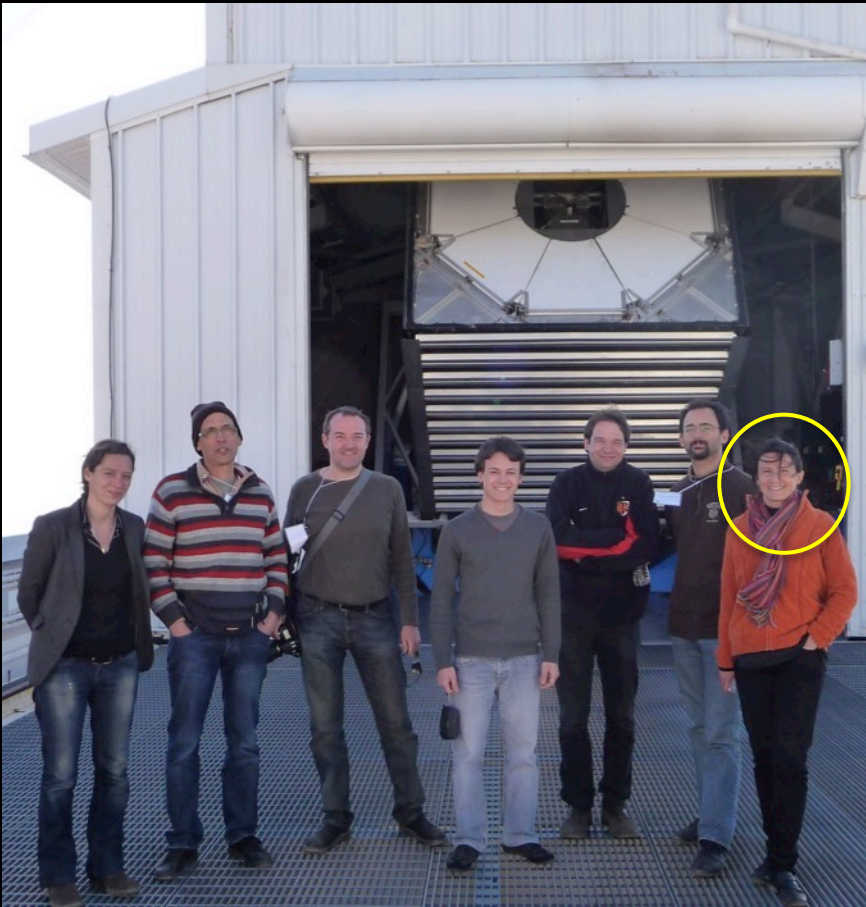




# Research in cosmology

Using the Sloan Digital Sky Survey telescope (SDSS) in New Mexico (2800m elevation)

To probe the distribution of galaxies ( $\rightarrow$  expansion rate of the universe  $\rightarrow$  dark energy)

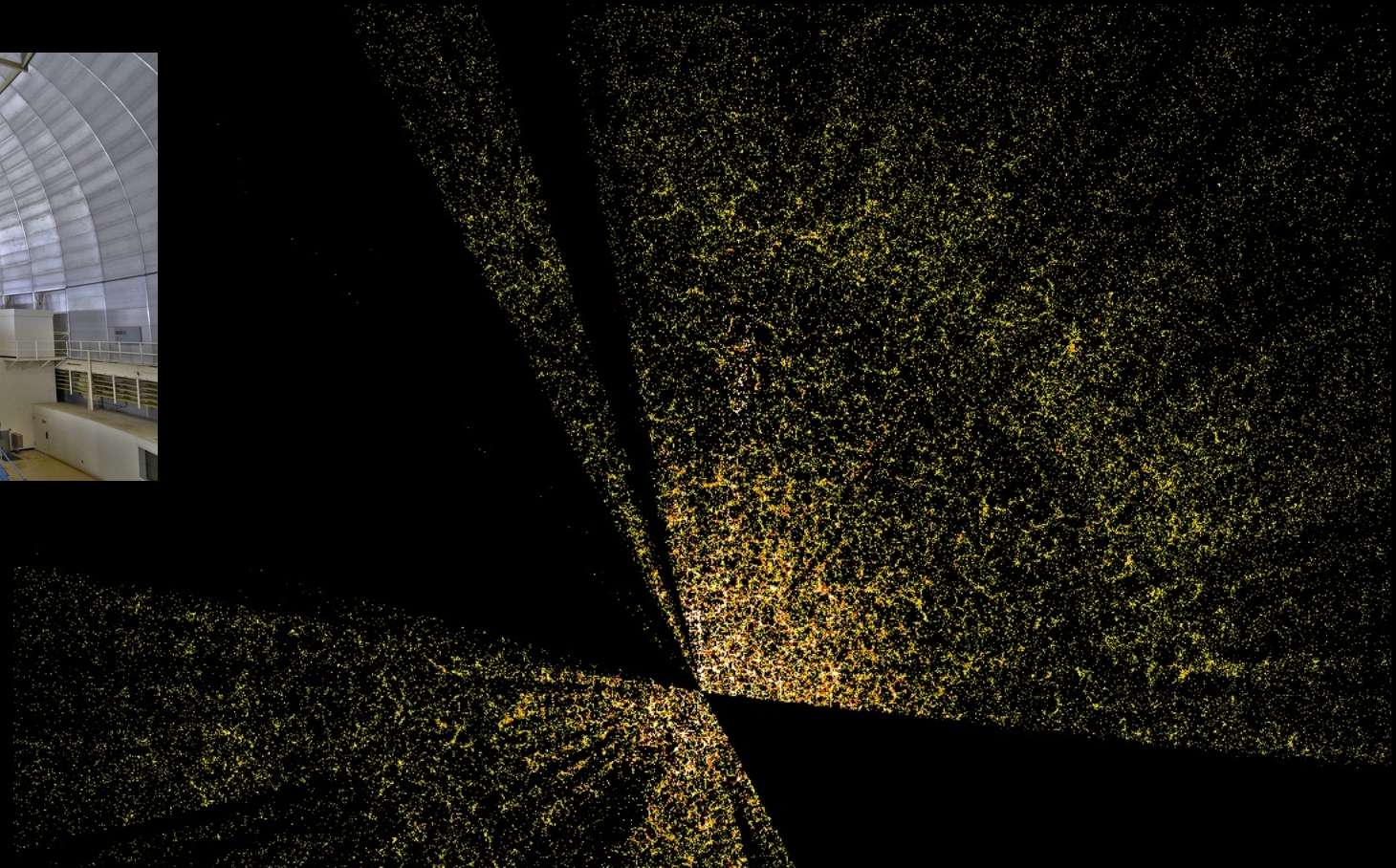




# Research in cosmology

And now the Dark Energy Spectroscopic Instrument (DESI) in Arizona (2200m elevation)

To probe the distribution of galaxies ( $\rightarrow$  expansion rate of the universe  $\rightarrow$  dark energy)



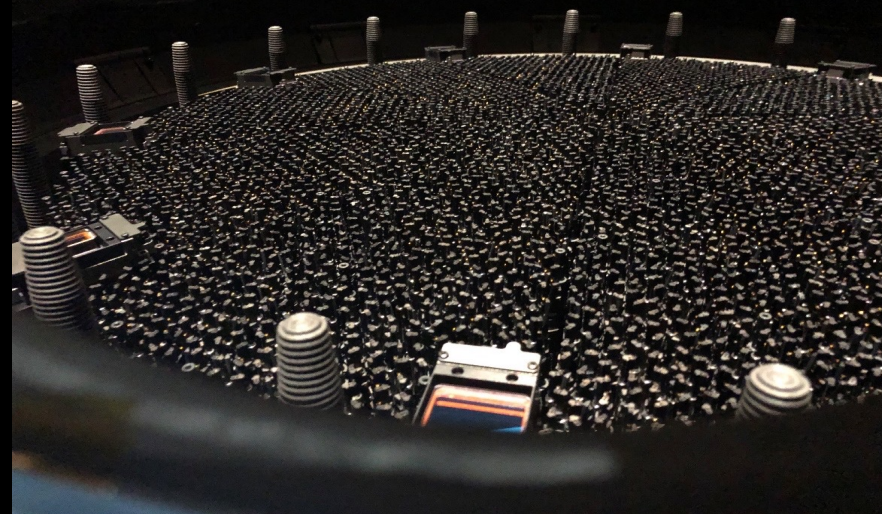
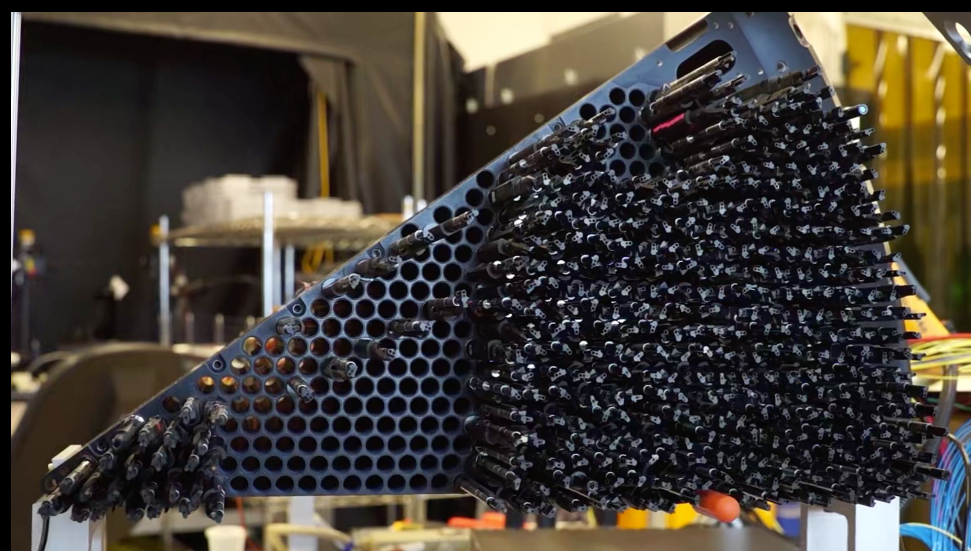
Led by Berkeley Lab



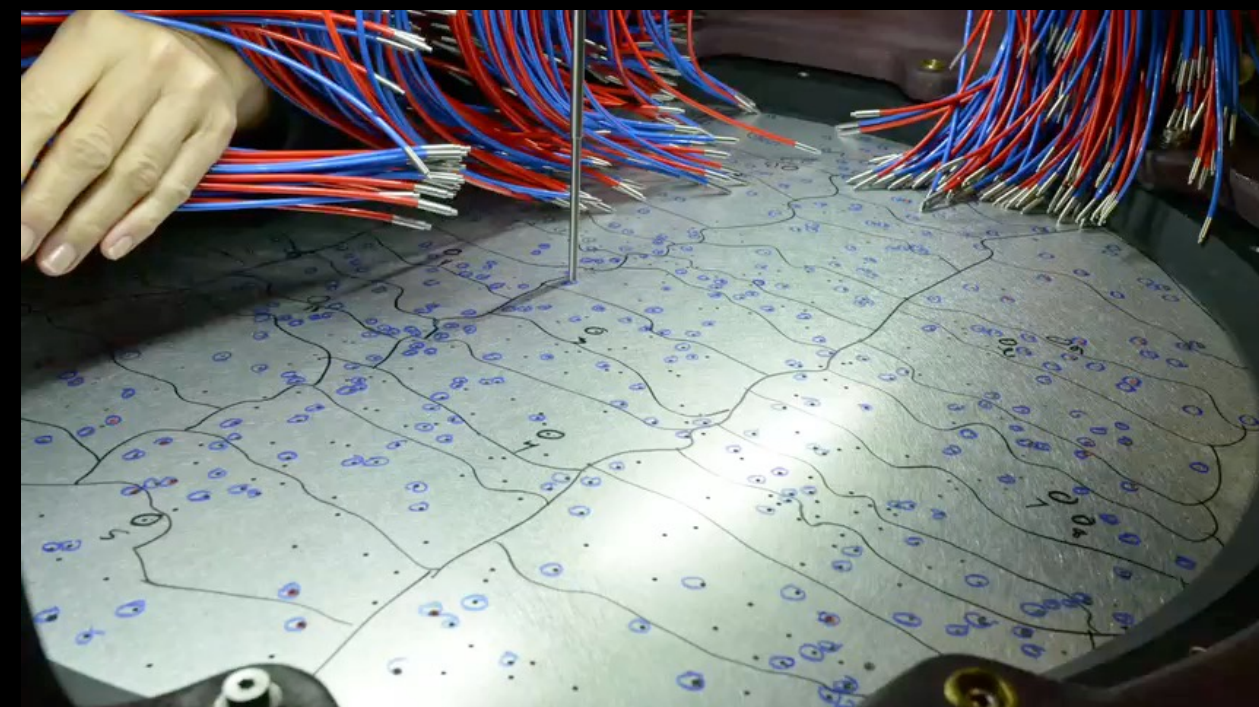


# New technologies

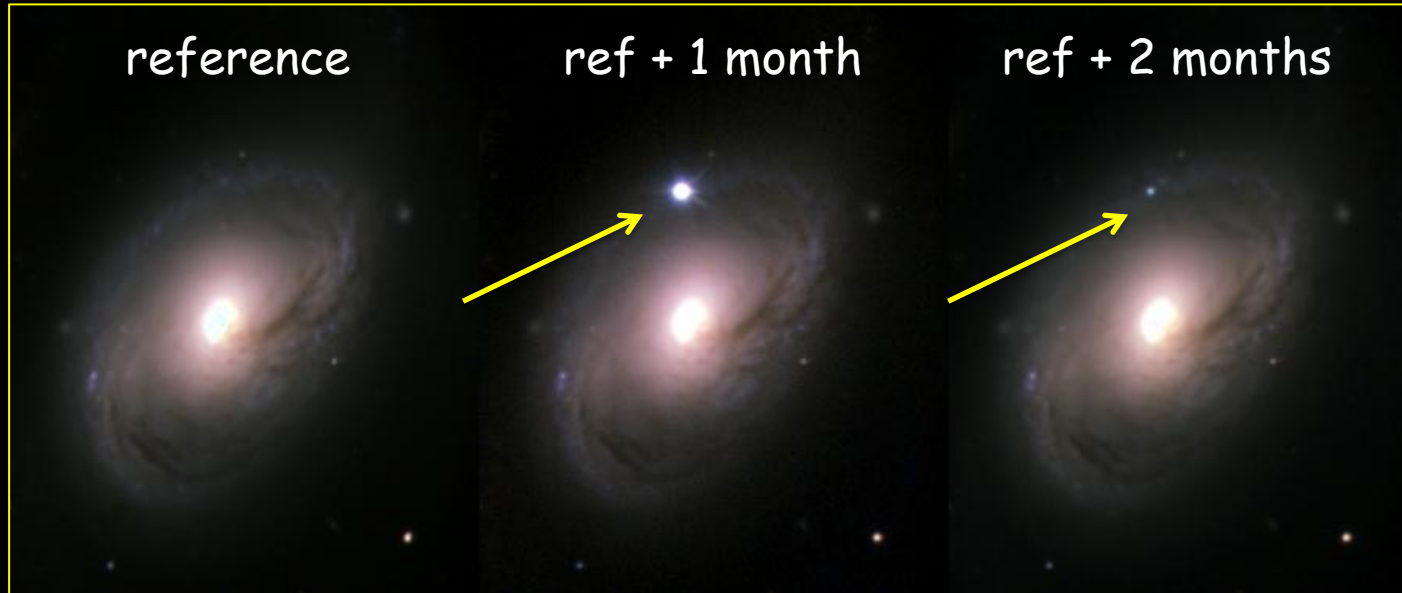
2020 (DESI):  
Robotic positioners  
positioned to  
micron-precision  
in 1 minute



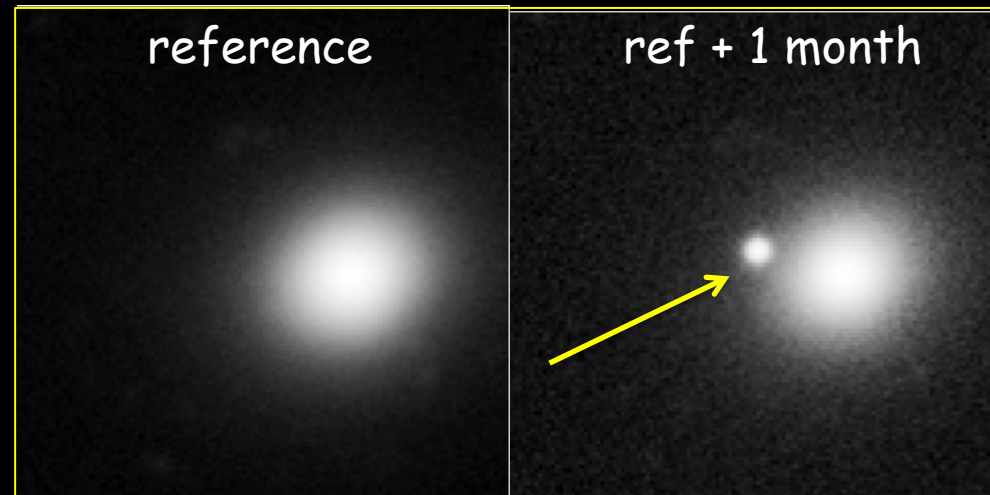
2010 (SDSS):  
Several hours of  
daytime work  
To prepare for  
Night observations



# New analysis methods



Where are the supernovae?

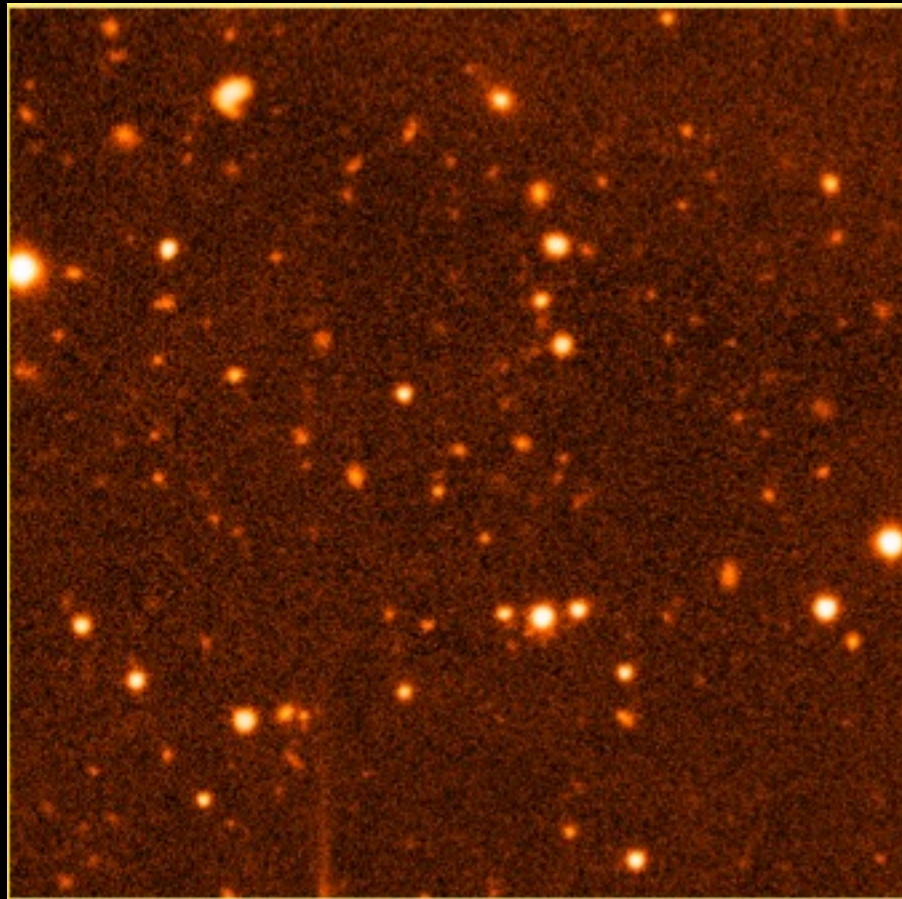




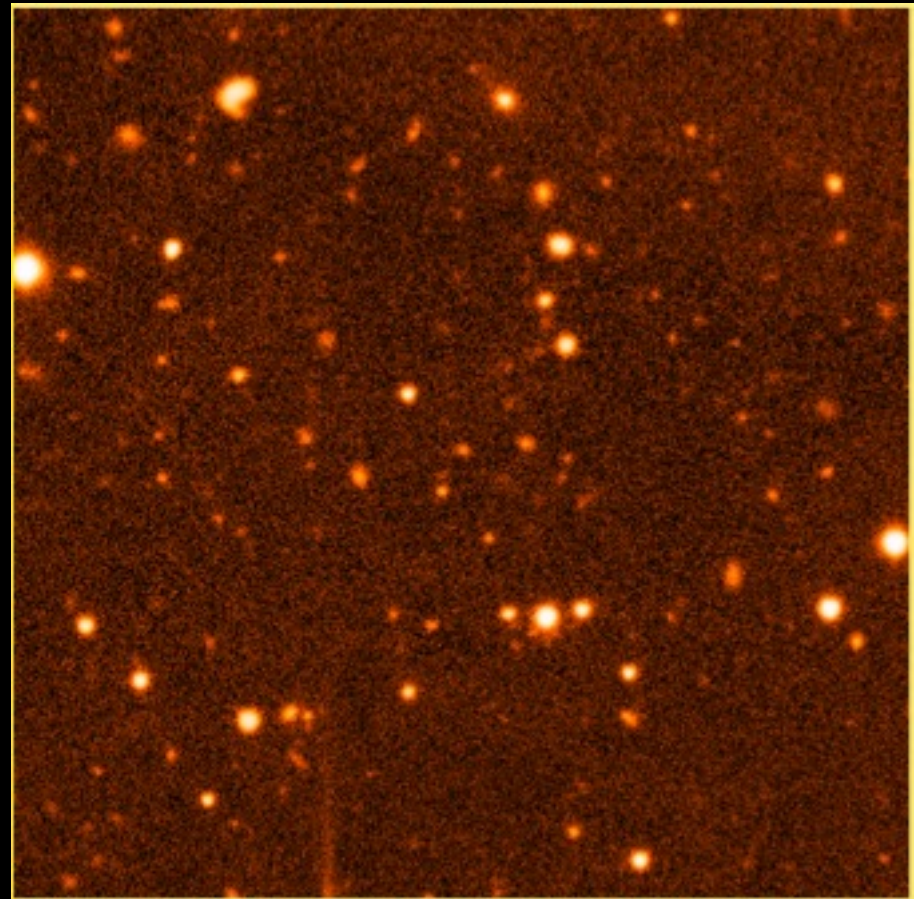
# New analysis methods

Where are the supernovae?

Reference image



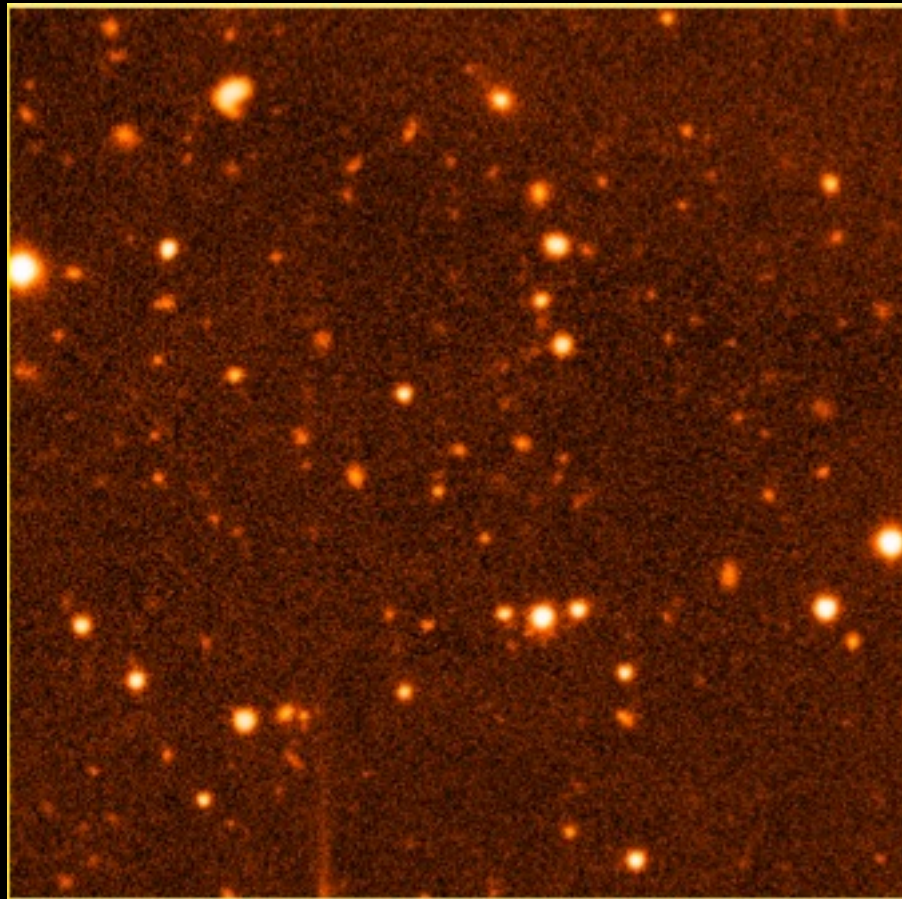
New image



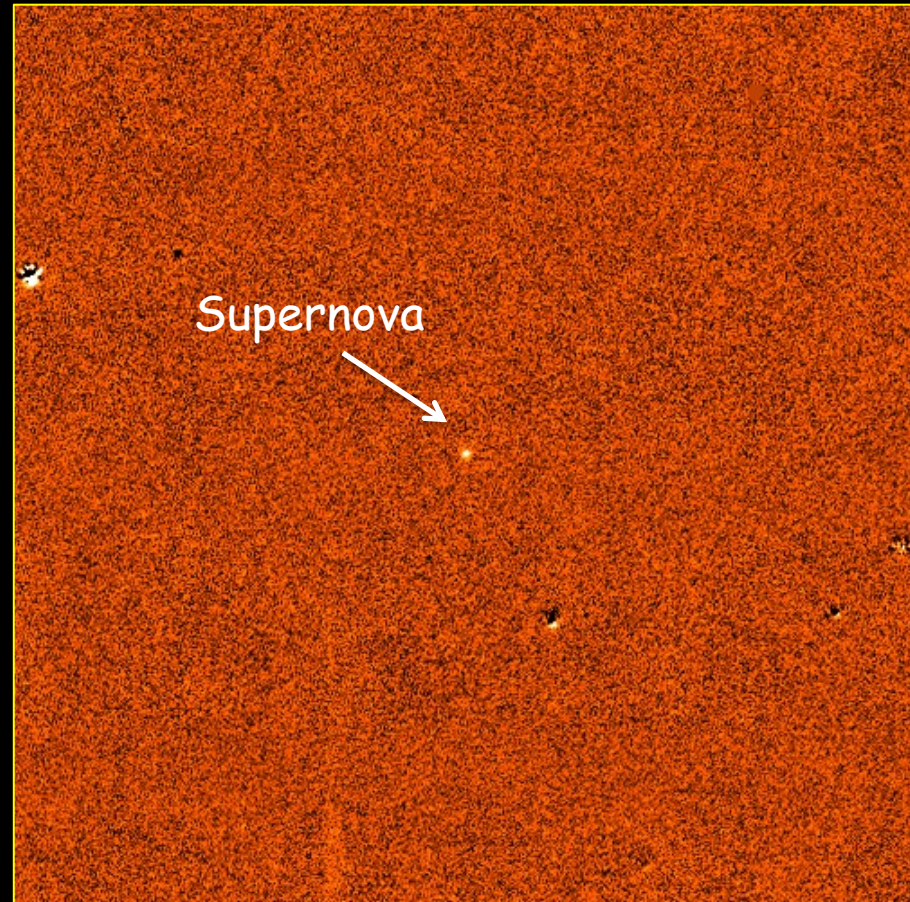
# New analysis methods

Where are the supernovae?

Reference image



New image



Subtraction

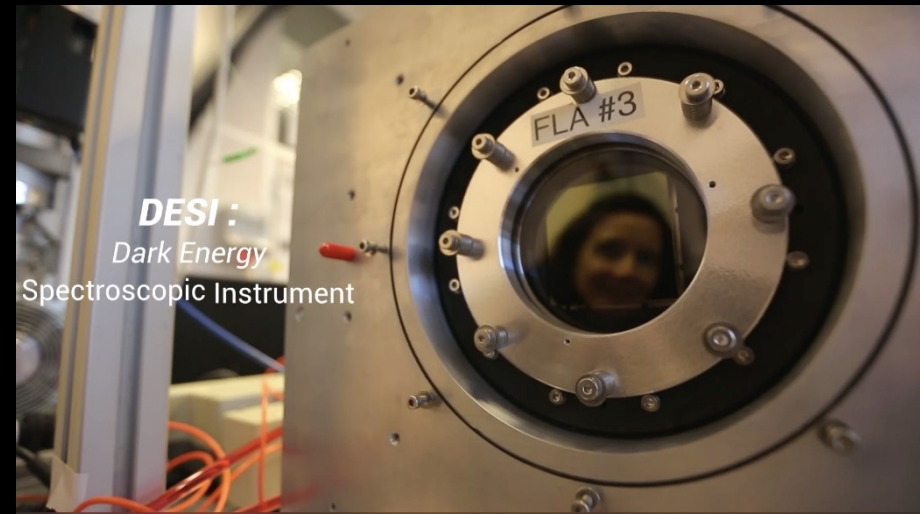
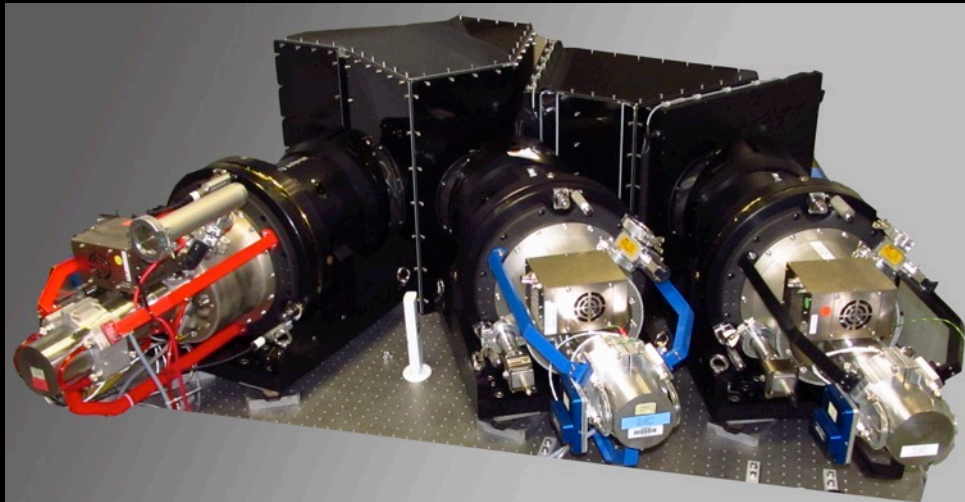
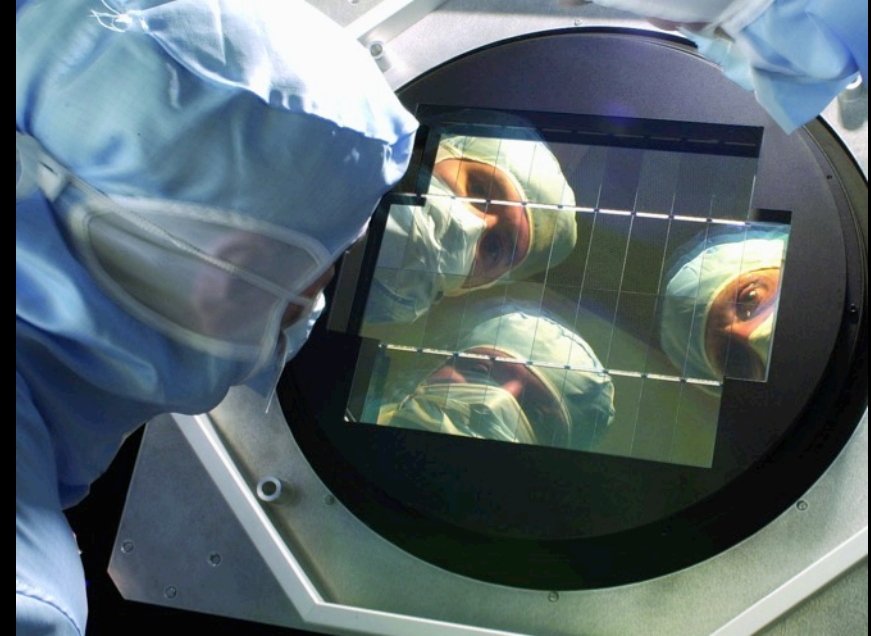


# Cutting-edge detectors

## CCD cameras

In the public: millions of pixels  
0.5 inch on a side

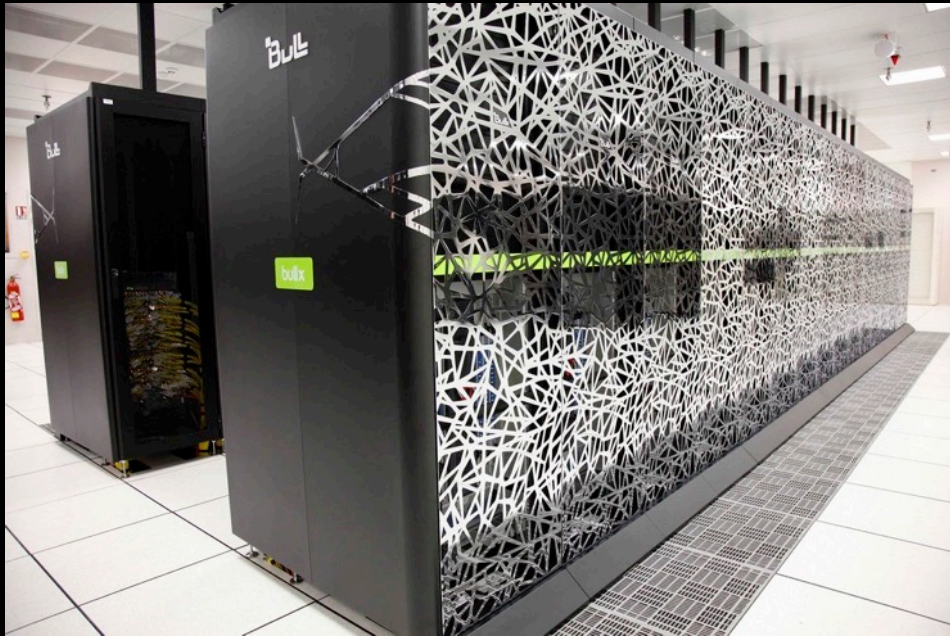
In research: billions of pixels  
1 ccd up to 2.5 inches on a side  
mosaics ~16 inches on a side



# High performance computing to model the the Universe

Reproducing the evolution of the Universe over 13.7 billion years requires **millions of hours (100 years!)** on a single-core computer!

Run on over 2000-8000 processors simultaneously (**supercomputers**)  
→ ~ 2 weeks



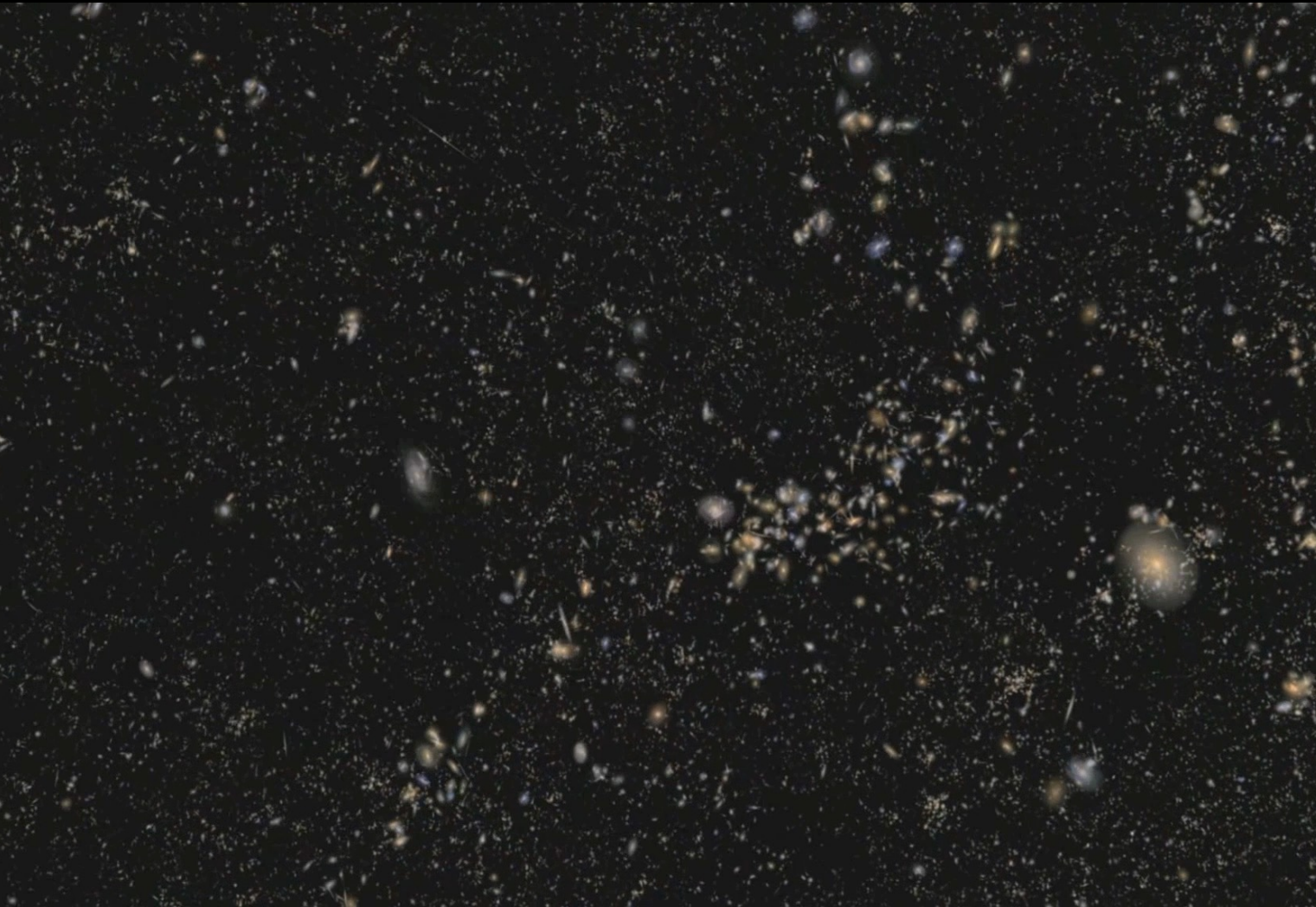
2022 Supercomputer @ LBNL



# Use of High Performance Computing

To compare observations of the Universe to models

The Universe contains  
100 to 200 billion galaxies





# Do Science !

Science is a place for men and women as well

Research is exciting

Research is both a scientific and a human adventure

## There is room for you

