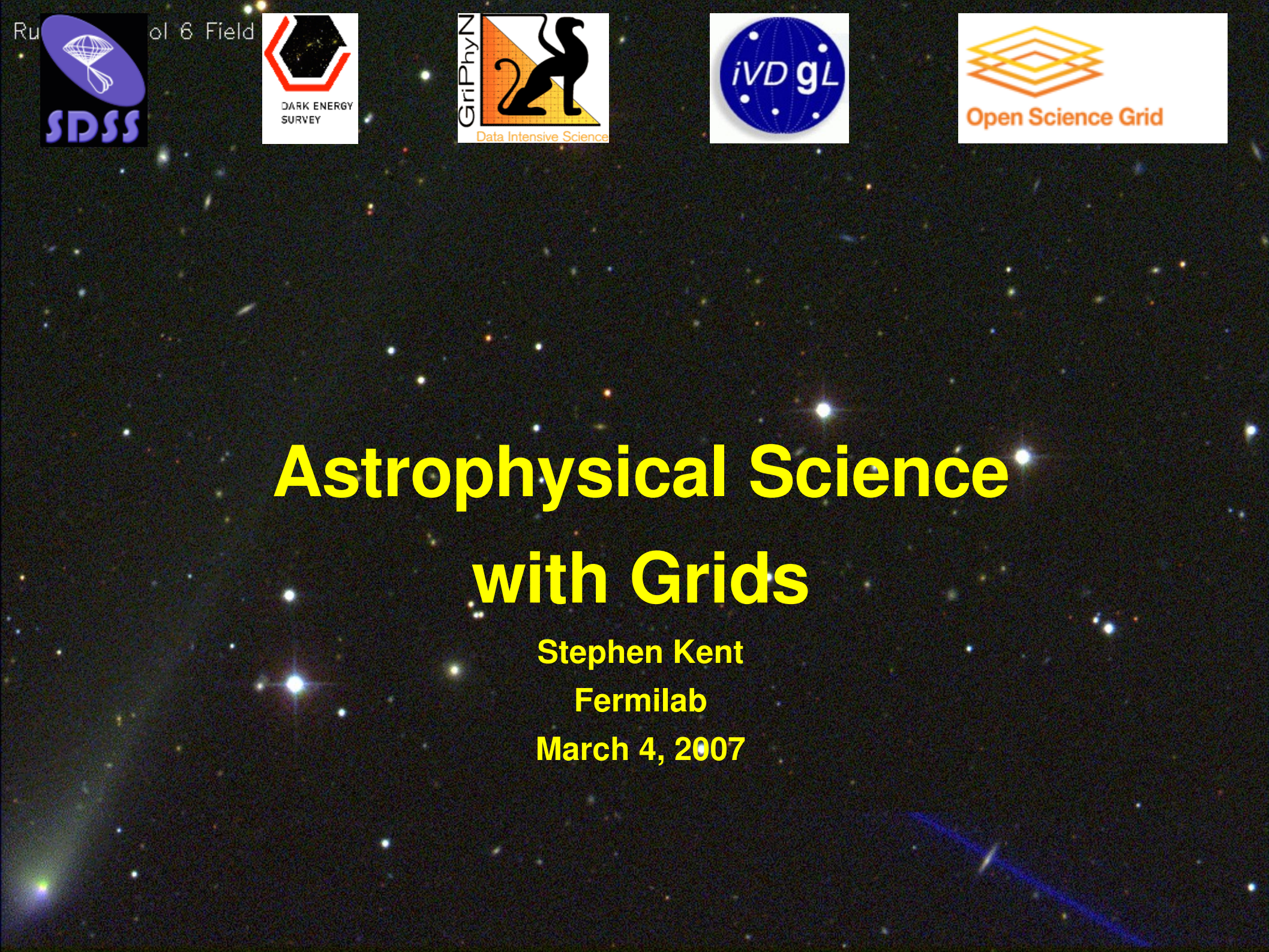


Astrophysical Science with Grids

Stephen Kent

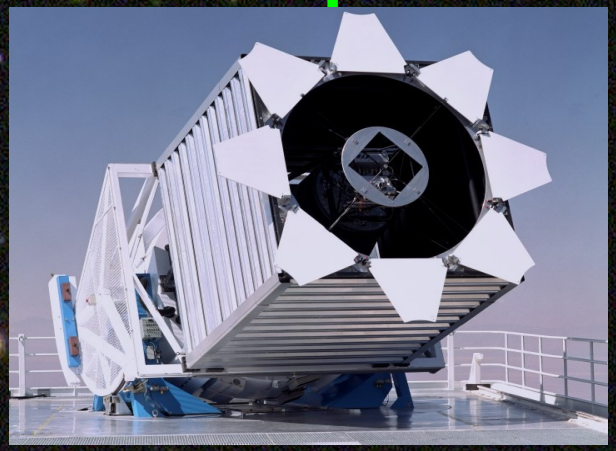
Fermilab

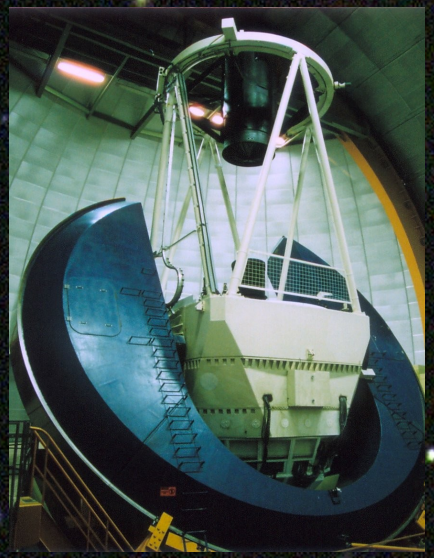
March 4, 2007

Run 125 Col 6 Field 263

Particle Astrophysics Experiments at Fermilab

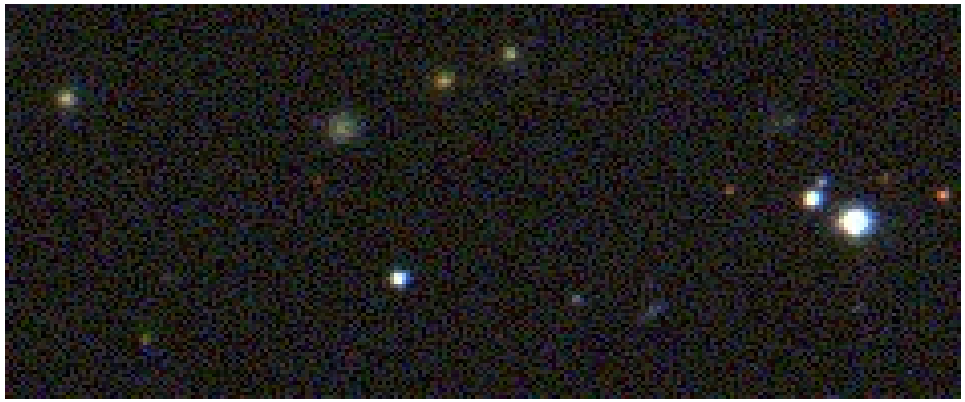
- **Current: Sloan Digital Sky Survey**
  - Color digital images of 1/4 of sky in North
  - Redshifts (velocities) of 1 million galaxies and quasars
- **Proposed: Dark Energy Survey**
  - Imaging survey like SDSS but in South
  - 4x more powerful





Types of Astronomical Data

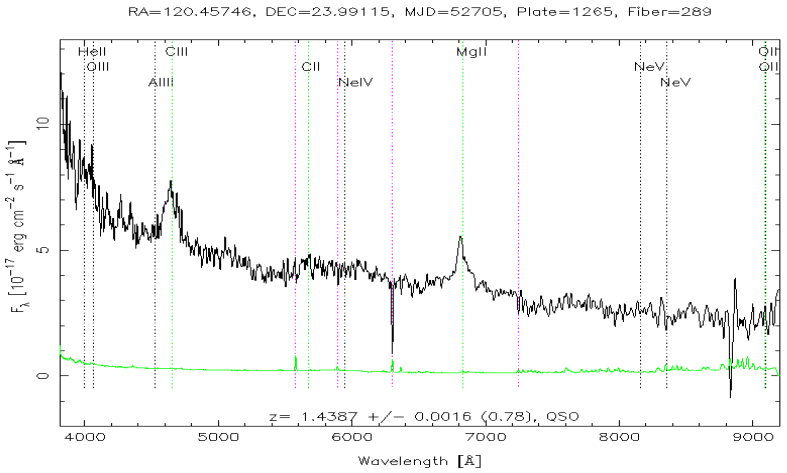
- **Two-dimensional overlapping images**
  - **1,000,000 fields in 5 colors**
  - **30 MB per field**



- **Derived object lists, calibrations ...**
  - **30 MB per field**

```
 313920 Jul 29  2003 tpM-000756-z1-0100.fit
3522240 Jul 29  2003 fpObjc-000756-1-0100.fit
  14400 Jul 28  2003 psBB-000756-g1-0100.fit
  14400 Jul 28  2003 psBB-000756-i1-0100.fit
```

- **Spectra**



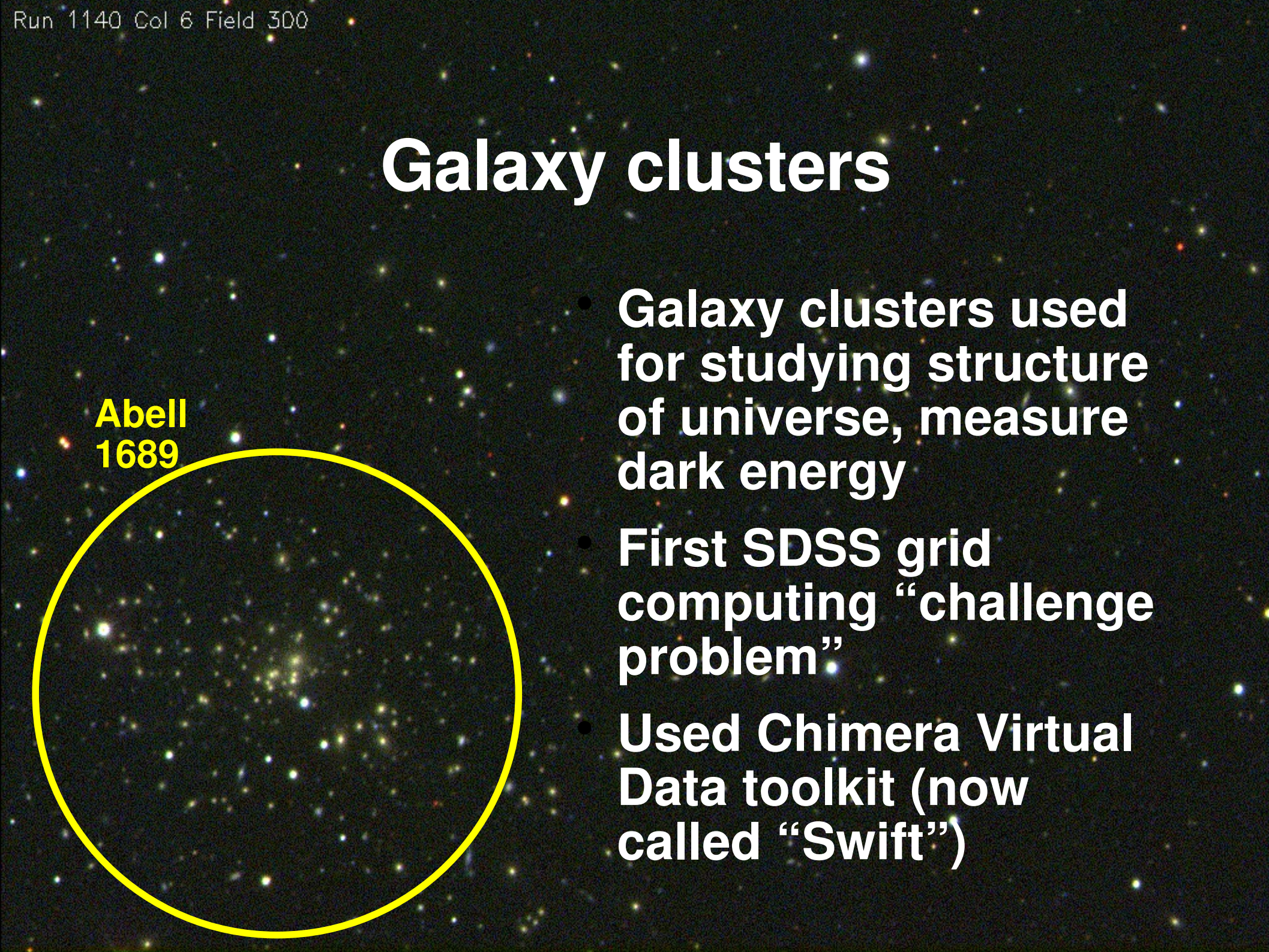
- **Object catalogs in SQL database**

```
select top 10 objid,ra,dec,u,g,r,i,z
from PhotoObj
where
    u between 0 and 19.6
    and g between 0 and 20
```

How do we use grids?

- All SDSS production data analysis
- Galaxy Cluster Finding
- Near Earth Object Search
- Quasar Spectrum Analysis
- Southern Survey Coadd
- DES Simulations for Mock Data Challenges
- Resources matched to job size
  - TAM (local SDSS grid site)
  - Fermigrid
  - Additional OSG sites (Brookhaven, U. Wisconsin, etc)

Galaxy clusters



- Galaxy clusters used for studying structure of universe, measure dark energy
- First SDSS grid computing “challenge problem”
- Used Chimera Virtual Data toolkit (now called “Swift”)

Galaxy Cluster Workflow

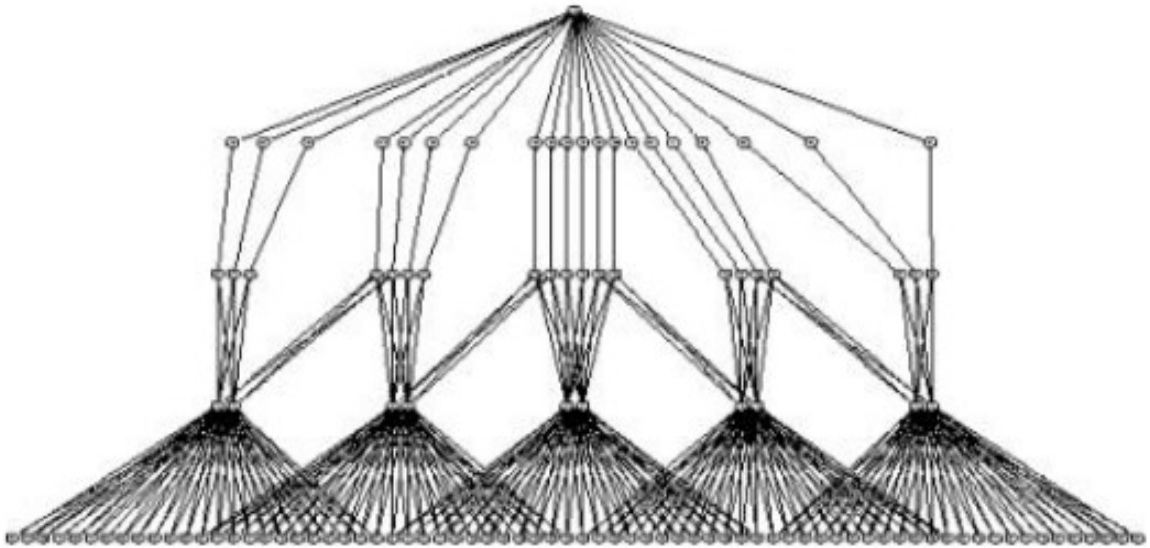


Figure 7: DAG for stripe 34 showing composition from a basic pattern.

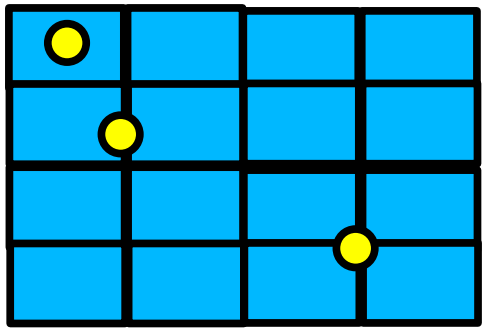


Image frame

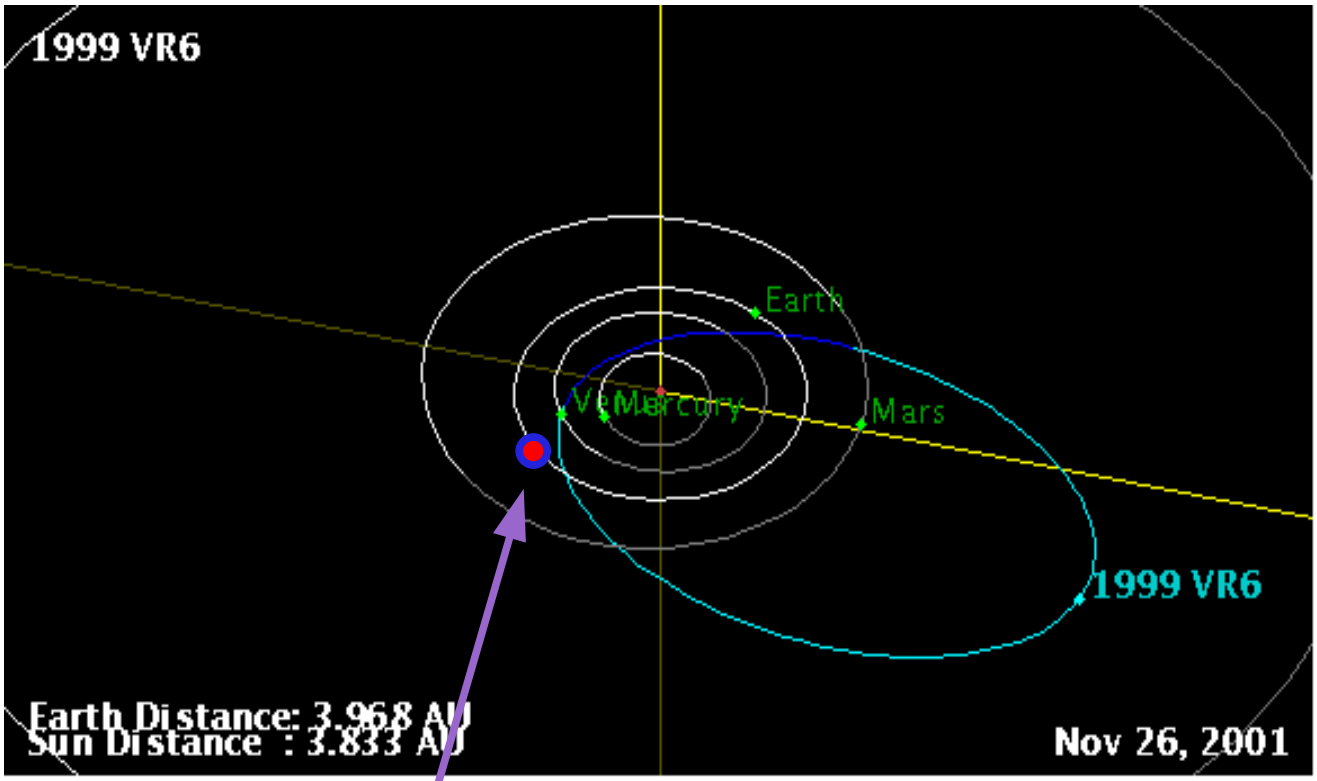
Galaxy cluster

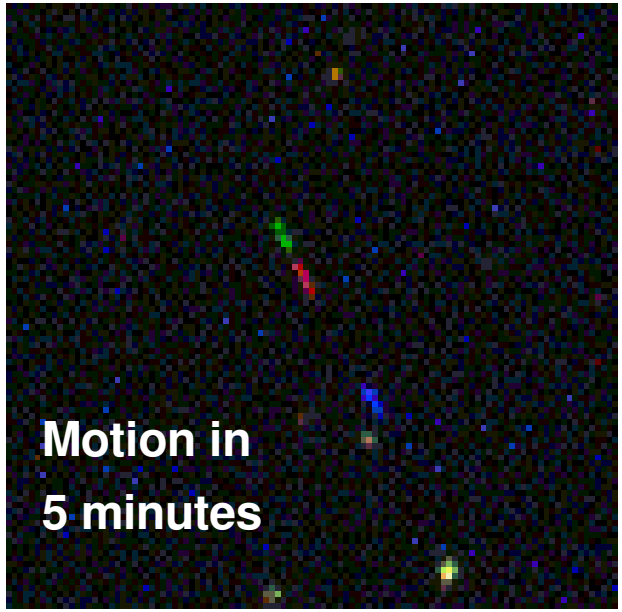
Scary workflow!

Note overlapping inputs (workflow is not fully coarse-grained parallelized).

Annis et al., 2002
Koester et al., 2007

Near Earth Object Search





1 NEO per million other SDSS objects

SDSS 2.5m Telescope

Algorithm:
- fpObjc and fpAtlas files
- Look for
  - a) elongated streaks that
  - b) move in the right direction in 2 or 3 filters

Results to Date

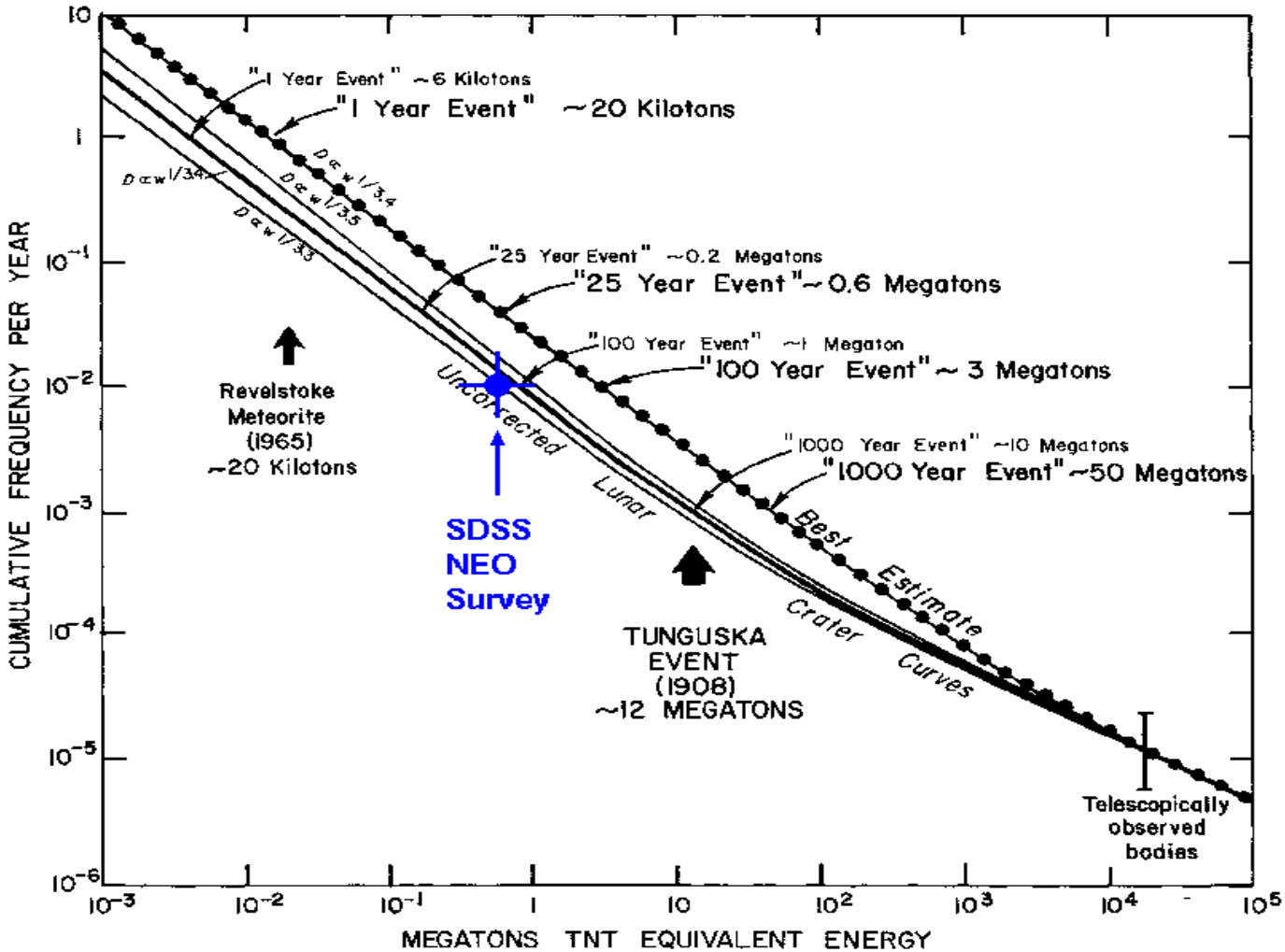


Figure 1 Estimated cumulative frequency distribution of kinetic energy of bodies colliding with the Earth.

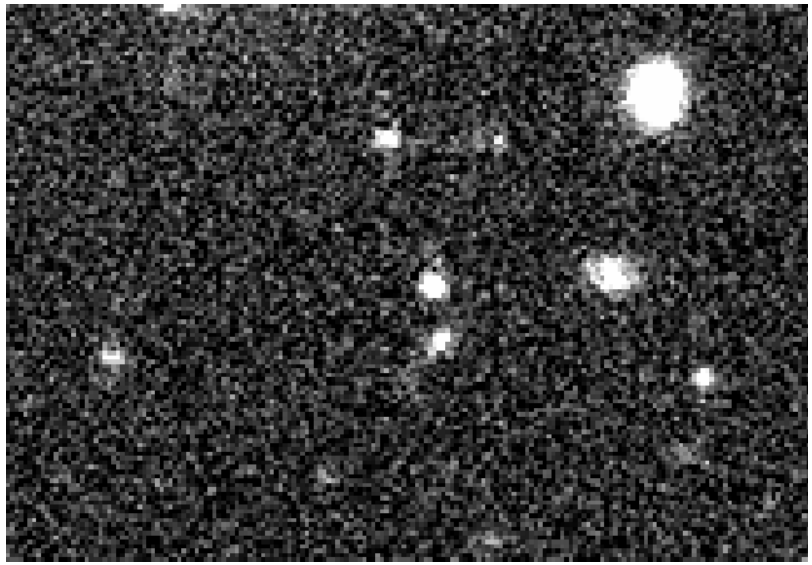
Southern Coadd

SDSS camera images a single "stripe" repeatedly

Single scans used to find supernovae, variable objects

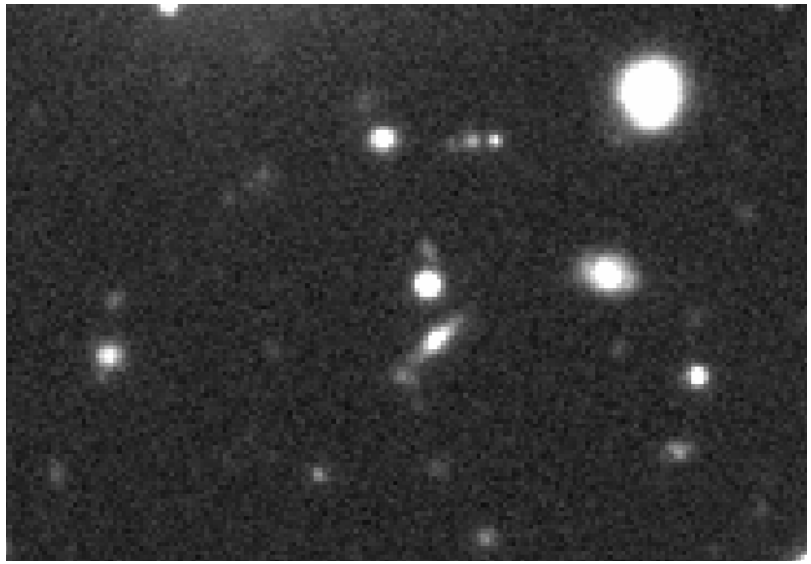
Images are added together in a "coadd"

Single Frame



35 Frames

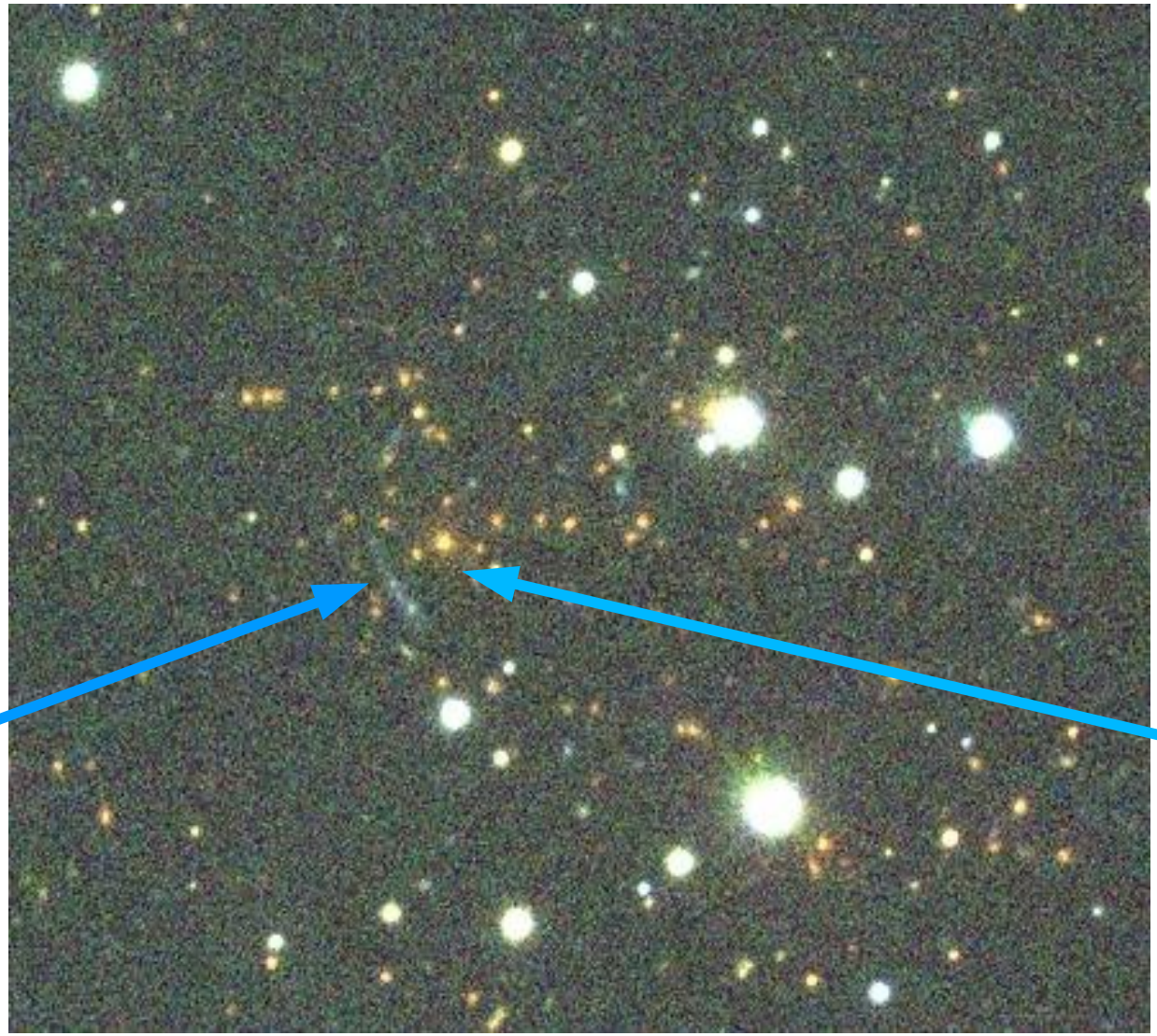
Factor 5 fainter



Gravitational Lens System

(Discovered in Coadd Data)

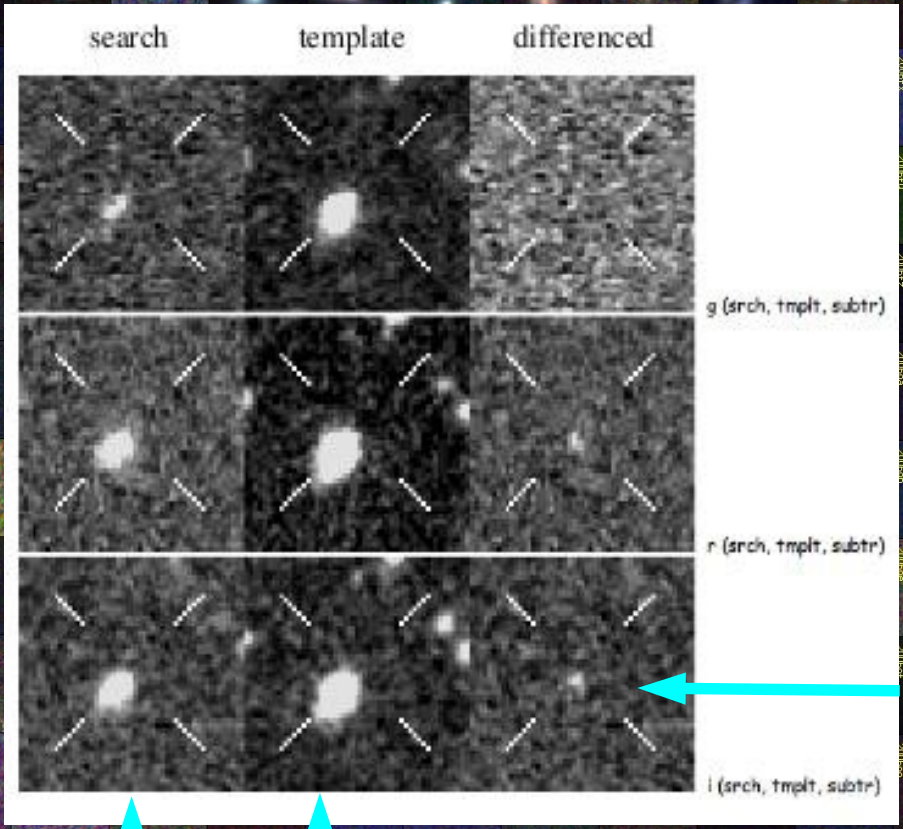
Dark Matter used as a "zoom" lens!



Distant Galaxy (Redshift unknown)

Foreground Galaxy Cluster z=0.63

SDSS II Supernova program



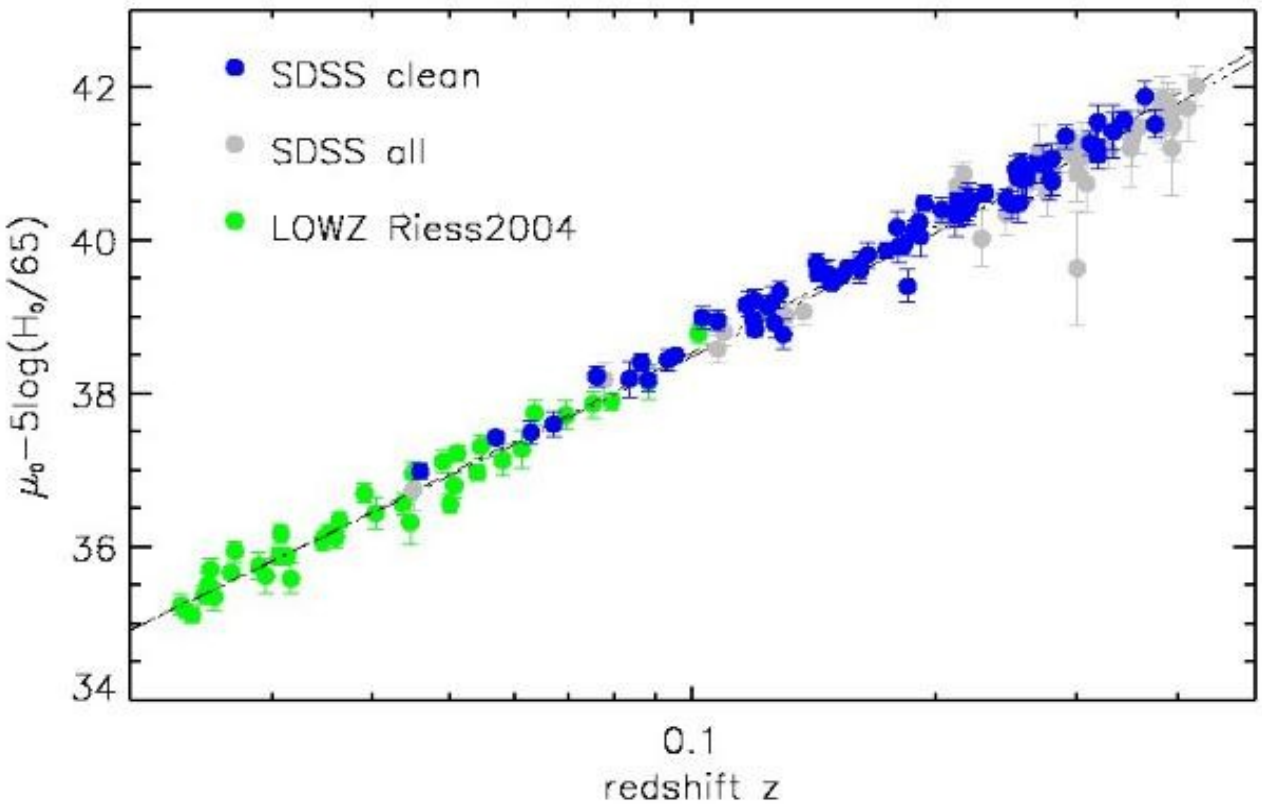
Supernovae appear as extra point of light when comparing images of a galaxy taken at two different times.

Supernova by itself

Coadd image of galaxy used as “template”

Single scan: Galaxy with extra point source of light

SDSS Supernova Survey First Results

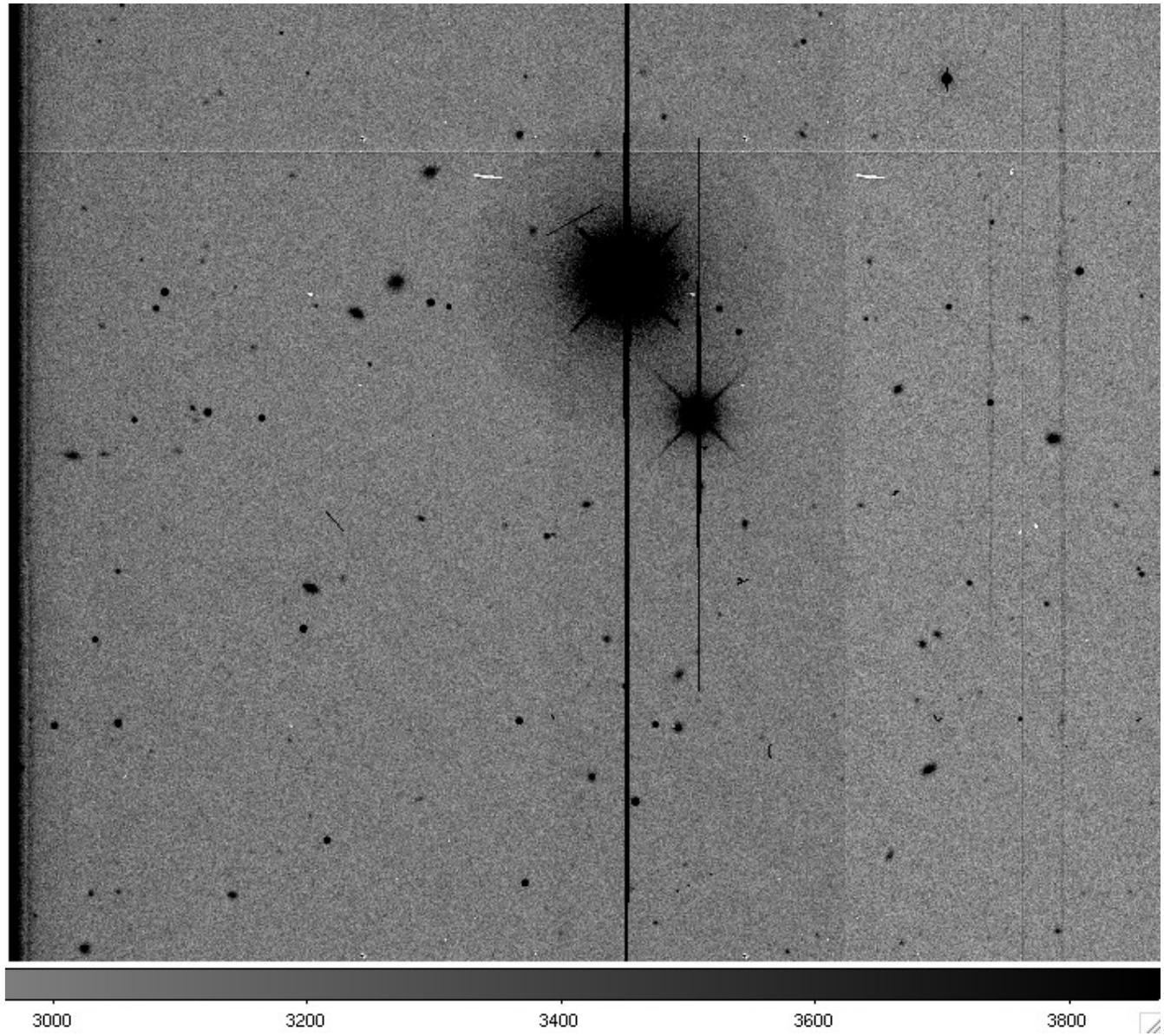


Lampeitl et al., 2007, AAS Special Session

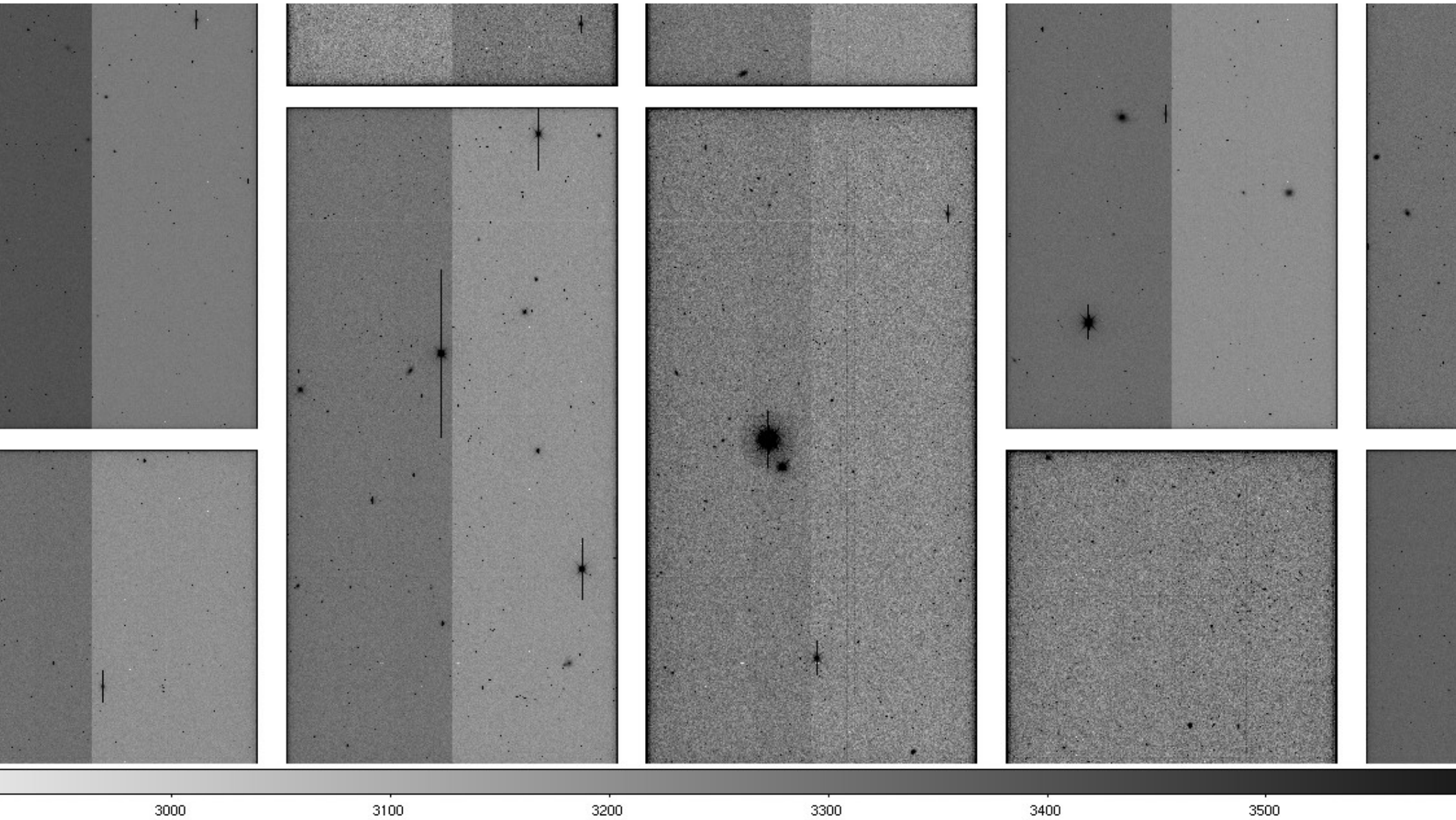
Dark Energy Survey

- DES will image 5000 square degrees of sky in the Southern Hemisphere
- Uses “data challenges” to prepare software systems for delivery of data
- ImSim 2 (completed)
  - 3.5 Terabytes
  - 15,000 CPU-hours
- ImSim 3 (planned)
  - 5X larger

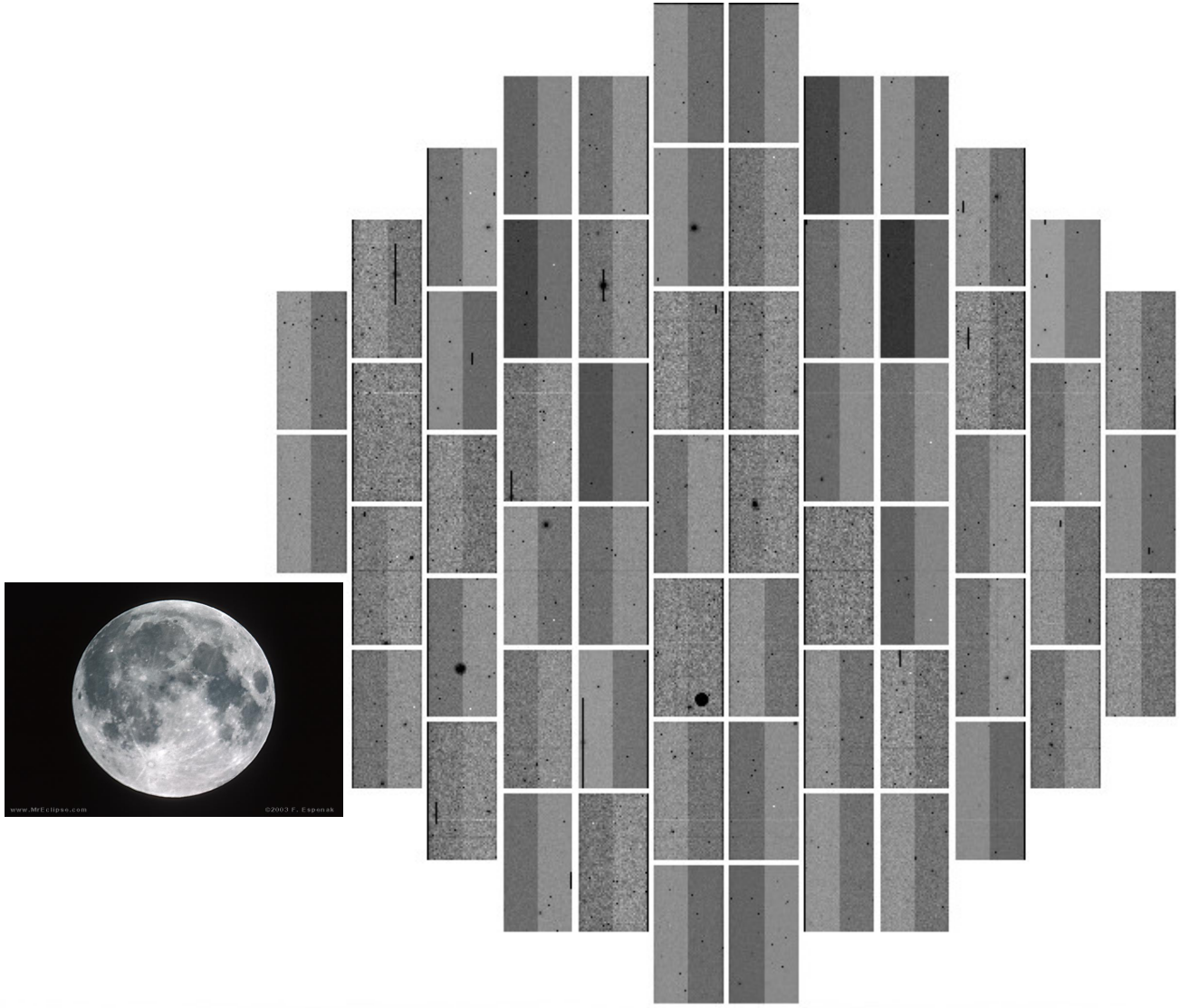
ImSim2 - detail



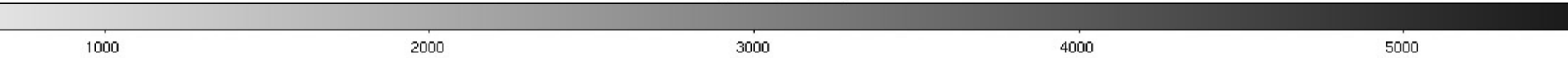
bigger ...



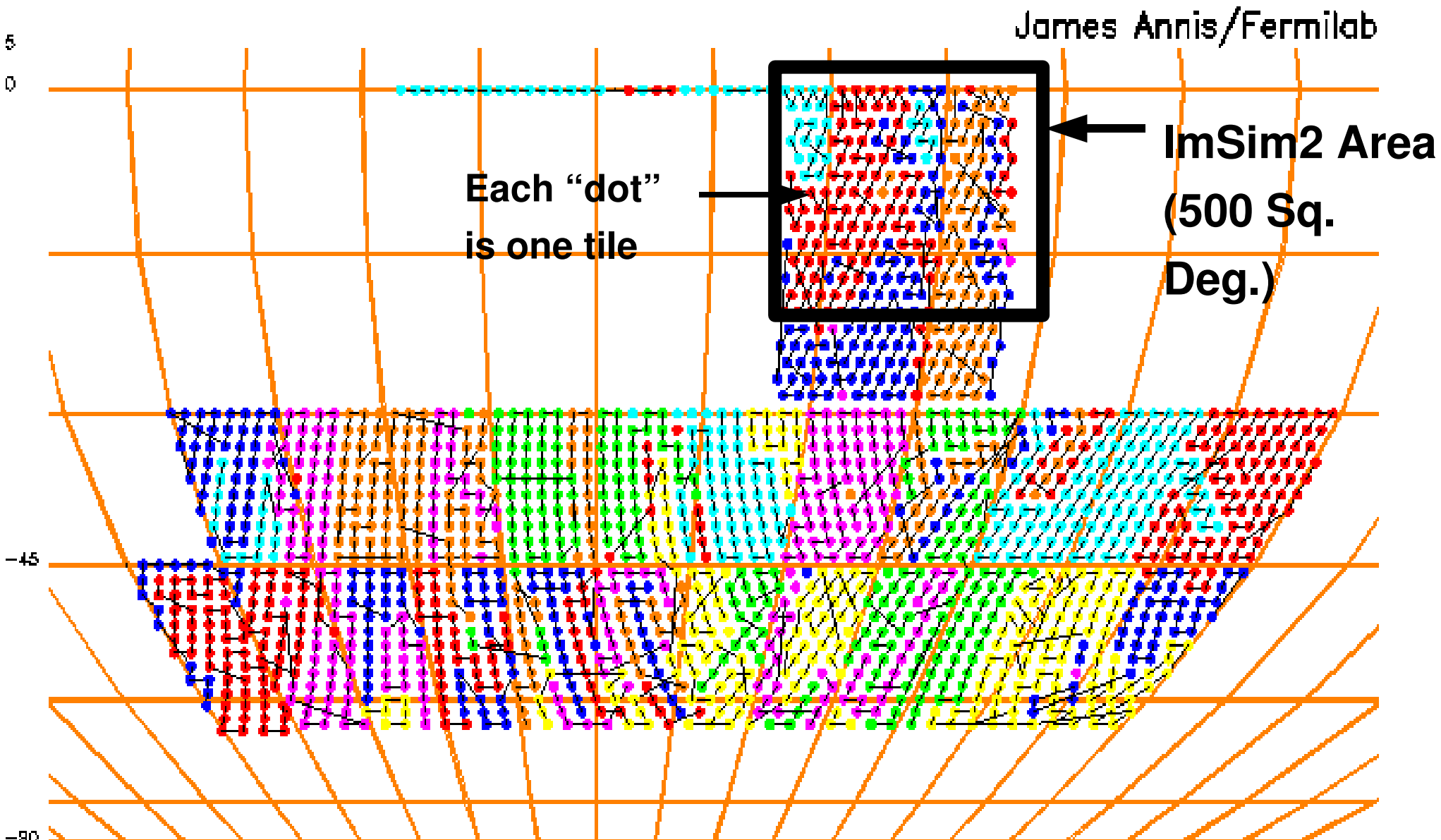
One “tile” (3 square degrees)



4 GB of data (4 filters)



Full Dark Energy Survey



Summary

- OSG is a computing resource for science analyses
- Grid computing is an integral part of current operations and plans for future astrophysics experiments.

A cautionary note
“No Silver Bullet”

“There is no single development, in either technology or management technique; which by itself promises even one order-of-magnitude improvement within a decade in productivity, in reliability, in simplicity.”

F. Brooks, “The Mythical Man-Month”