

Megapřehledky oblohy

Jak vypadá Petabyte dat

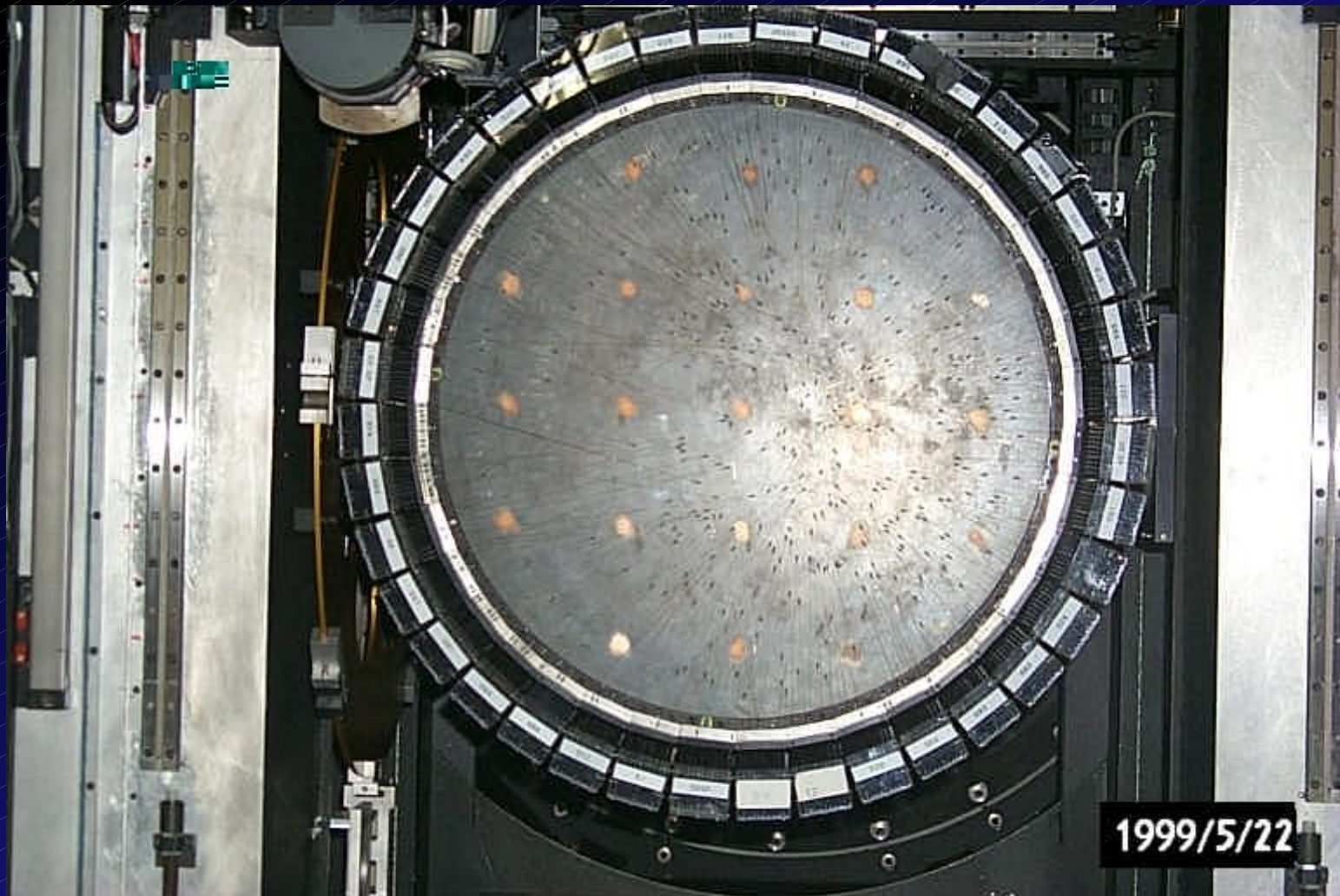
Petr Škoda
Astronomický ústav AVČR

Nové přístroje na pointované pozorování

- MOS
 - vlákna (2dF, 6dF, Hydra, Octopus)
 - Mikrostěrbiny – vypálené laserem, MMD
- IFU (Gemini, JWT, VIMOS) – slitlety, mikročočky
- Hvězdné koronografy
- Optické Interferometry
- Ešeletové spektrografy a Fly-Eye kamery
- AO a LGS

Two degree field 2dF (AAT)

Robot
2 desky
400 vláken



2dF (AAT)

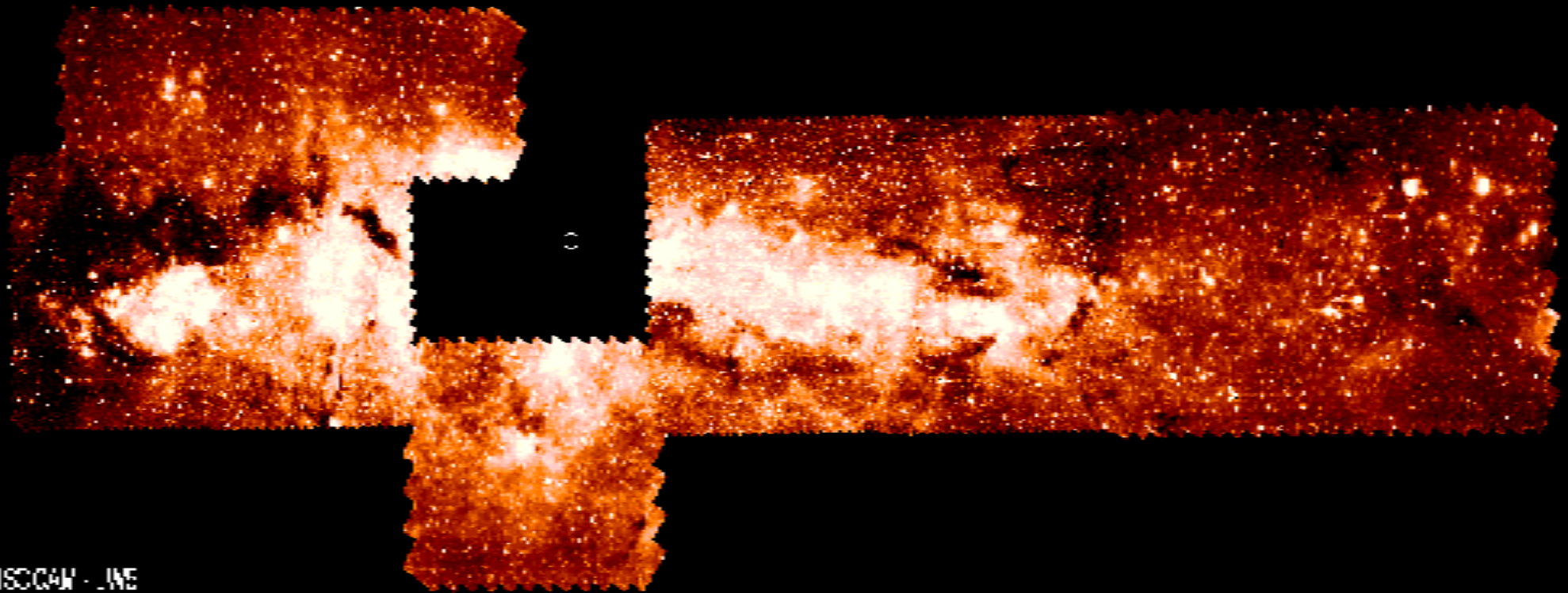


Družice

- Chandra
- XMM-Newton
- HST
- SOHO
- Hipparcos
- Rosat, FUSE, EUVE, IUE
- Mnoho jiných
- Velká datacentra – SW před startem, simulace

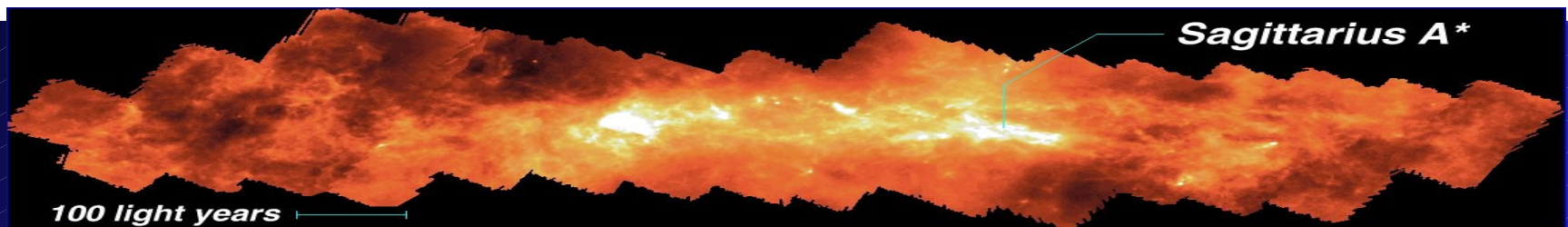
Thermal IR and Sub-mm surveys: new tools for huge complex data sets and maps are already essential

Infrared Space Observatory image of the Inner Galaxy at 7micron wavelength



ISOGAL - IWE

S Ganesh, A Omont & the ISOGAL Collaboration, 1999

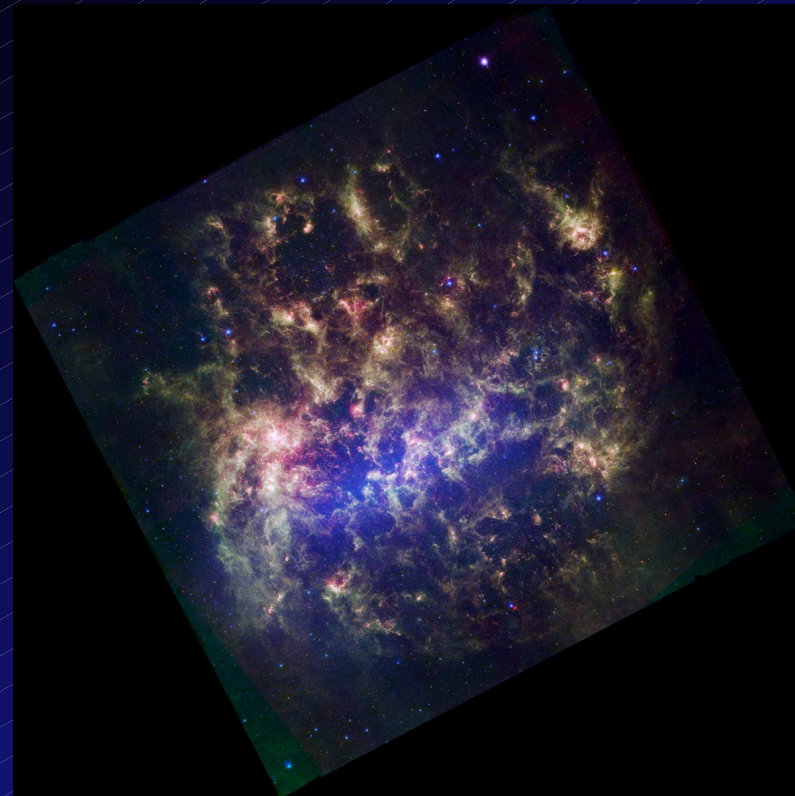
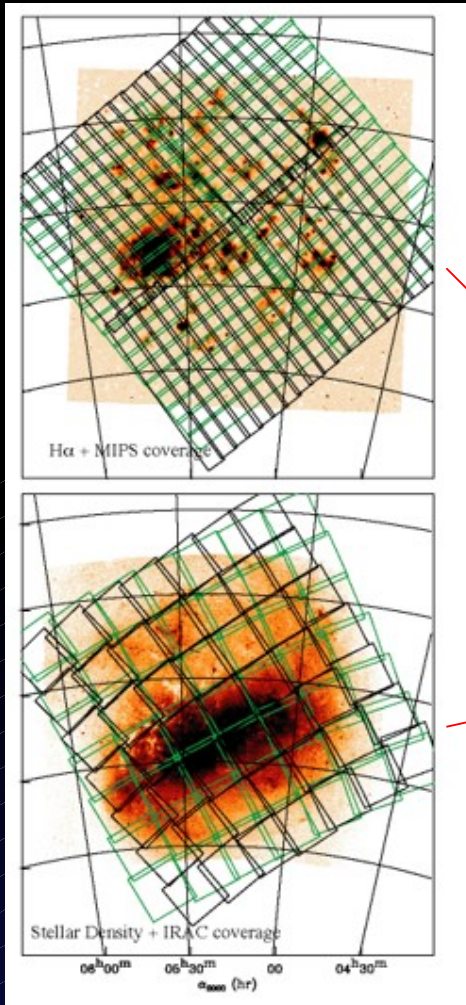


*Sagittarius A**

100 light years

SAGE: Spitzer Survey of the Large Magellanic Cloud

Instrument	Bands (μm)	Field-of-View (arcmin)
IRAC	3.5, 4.5, 5.8, 8.0	5.2. x 5.2
MIPS	24	5.4 x 5.4
	70	5.25 x 2.6
	160	0.5 x 0.5



IRAC 3.6 μm

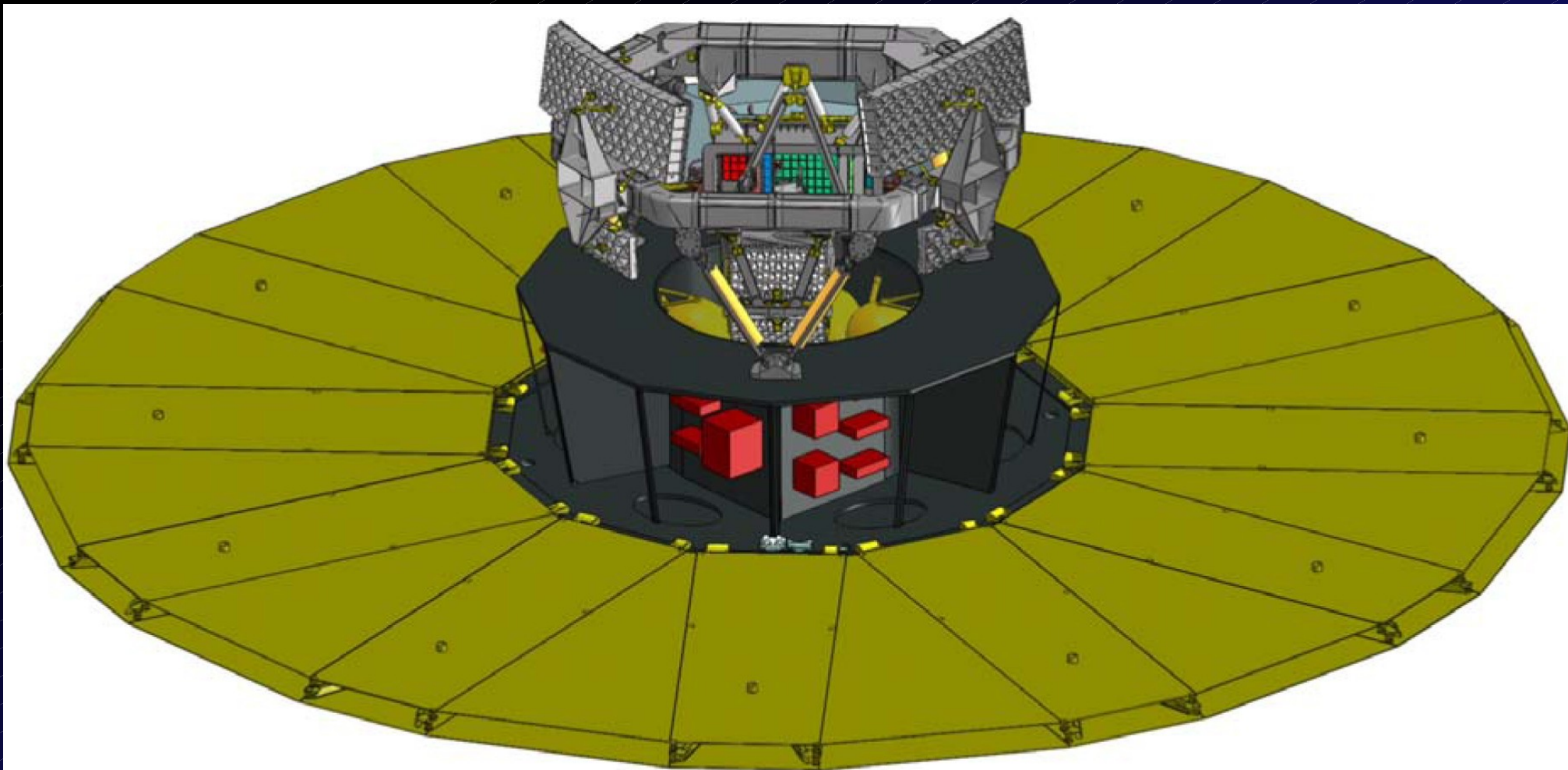
IRAC 8.0 μm

MIPS 24 μm

Two epochs:
Jul/Aug 05 & Oct/Nov 05

*Images Courtesy Margaret Meixner
(PI)*

GAIA (2012)

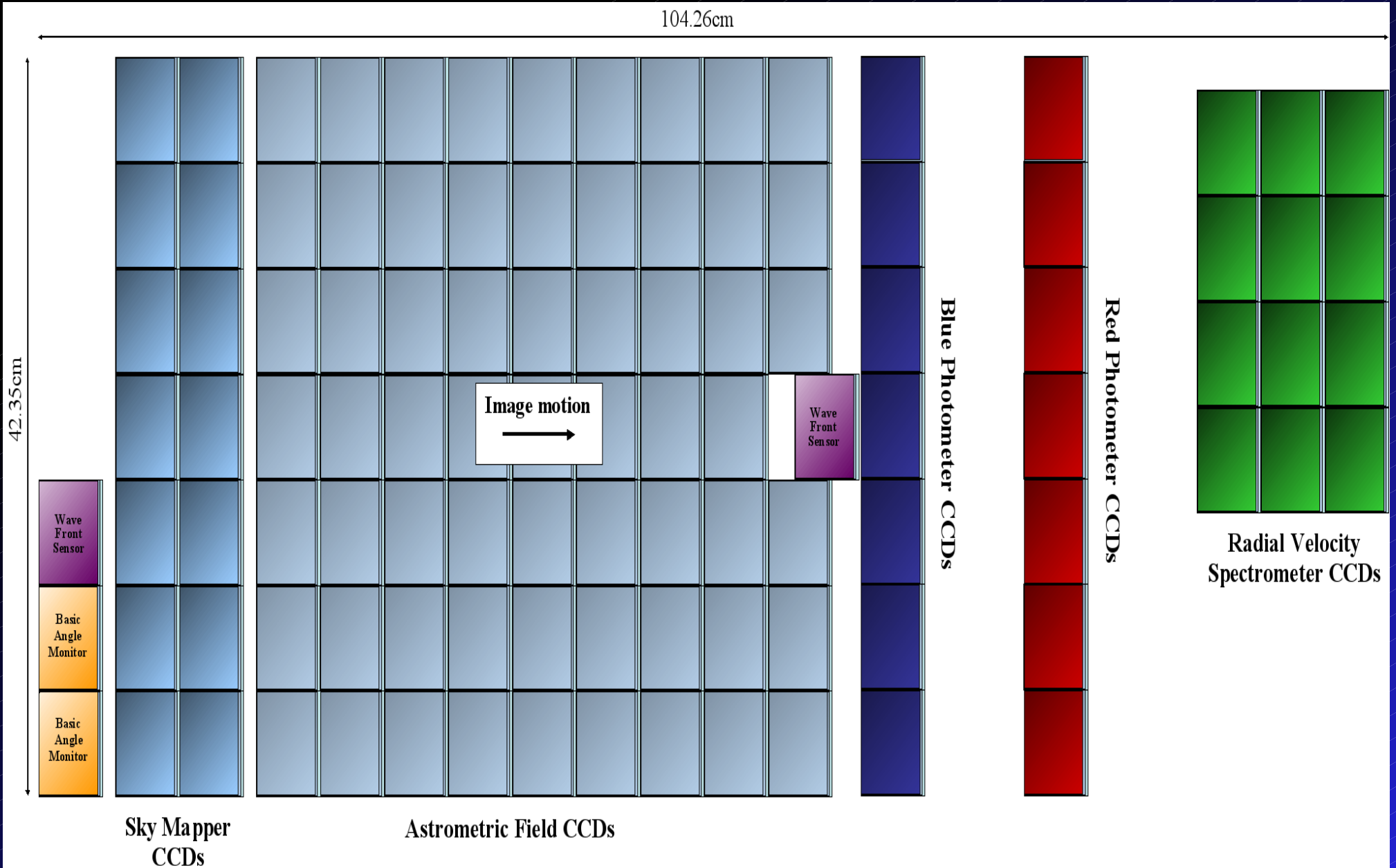


GAIA CCDs

106 CCDs

938 Mpix

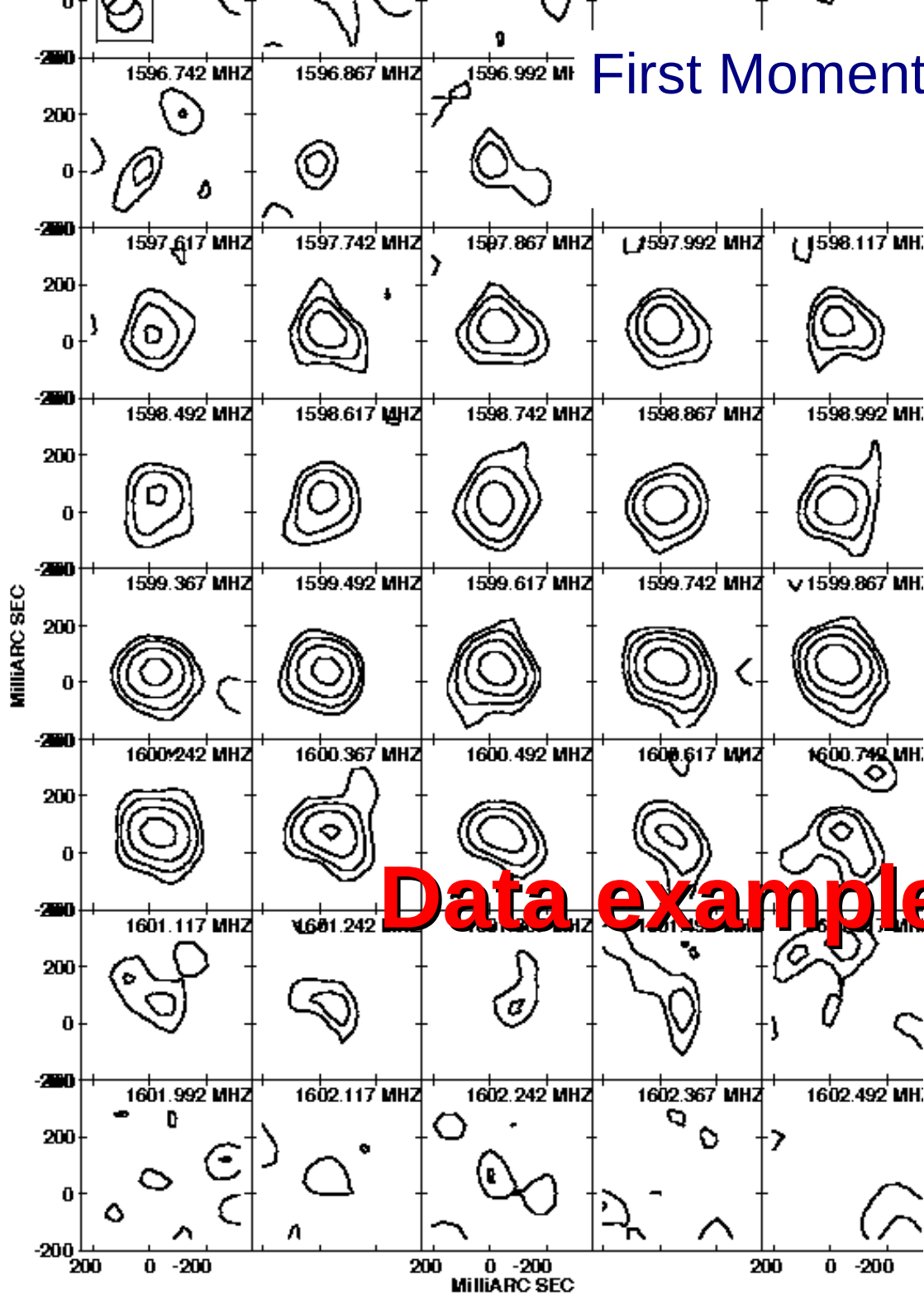
2800cm²



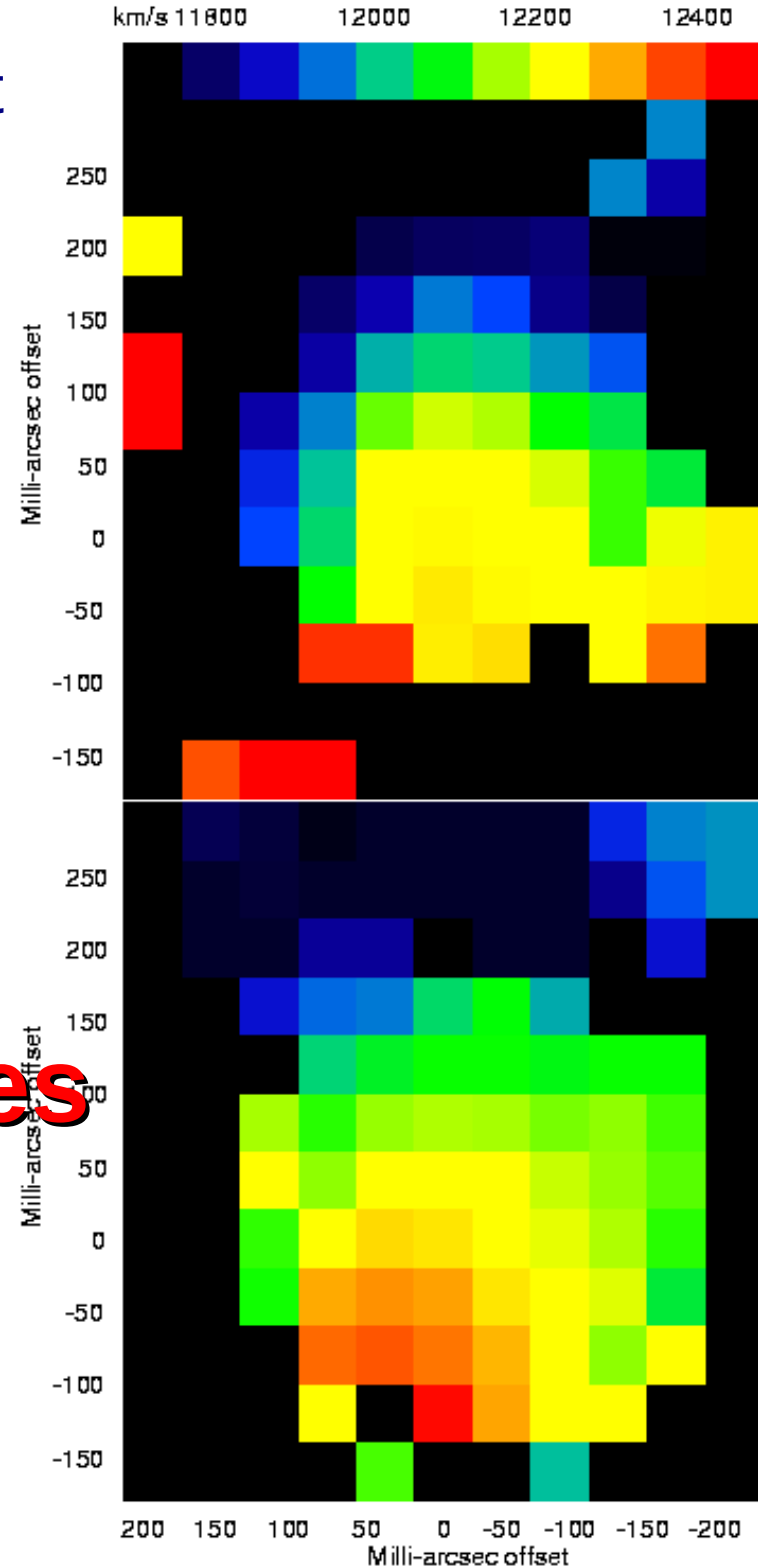
Radioteleskopy

- Nejvíce dat – FITS, 3D
- Datacube
- Kontinuální toky
- Složitá redukce
- Klíčové pro strukturu vesmíru (HI)
- Speciální chipy - korelátory
- Nutno masivně paralelní clustery - FFT
- Přesný čas, synchronizace (VLBI)
- ALMA, SKA = datový oříšek

DECLINATION (J2000)



Data examples



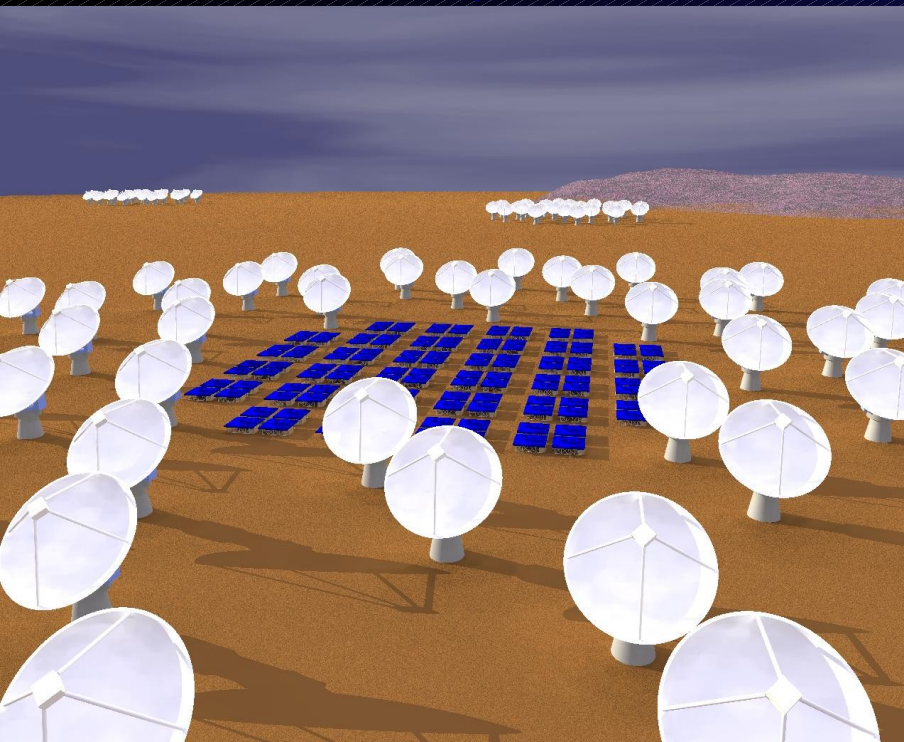
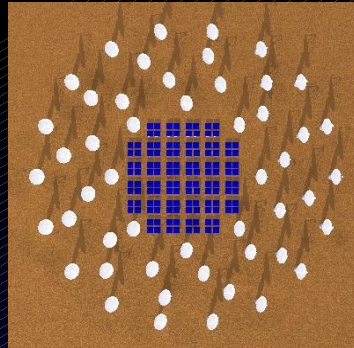
Atacama Large Milimeter Array ALMA

64 antén 12m
Chajnator 5000m
Chille
2008-2012

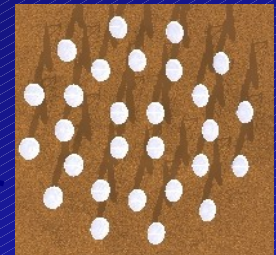


SKA (2011-2018)

Inner core



Station



Wide-angle radio camera +
radio “fish-eye
lens”

Velké (opt) přehledky oblohy

- Automatické pozorování (systemicky)
- On-line předzpracování – alerty SN
- Finání redukce komplikovaná = superpočítače a GRID (OmegaCam-Montage-Terapix)
- SW je také nástroj (30%-50% ceny projektu)
- Stomiliony objektů
- Velké databáze (stovky TB)

Palomar Observatory Sky Survey

- POSS-I (1950-57)
 - Cover the sky of $\delta > -30$
 - Blue (400nm) and Red (650nm)
 - 936 photographic plates
- POSS-II (1987-1999)
 - Finer grain and fast emulsions
 - 103aO $\rightarrow$ IIIaJ, 103aE $\rightarrow$ IIIaF
 - Install achromatic corrector
 - 897 plates



Southern Surveys

- UK Schmidt
 - SERC(J) (1974-87) 606 plates
 - AAO(R) (1989-) 606 plates
- ESO Schmidt
 - ESO(B) (1973-78)
 - ESO(R) (1973-88)



2MASS

2 * 1.3m telescopes

Arizona & Chile

1997-2001

J, H, K'

1.25, 1.65, 2.17 μm

471 10^6 point sources

Scale = 2"/pixel

1054 asteroids (2000)

12219 asteroids (2006)

DENIS

1m telescope

Chile

1995-2001

I, J, K'

0.82, 1.25, 2.16 μm

355 10^6 point sources

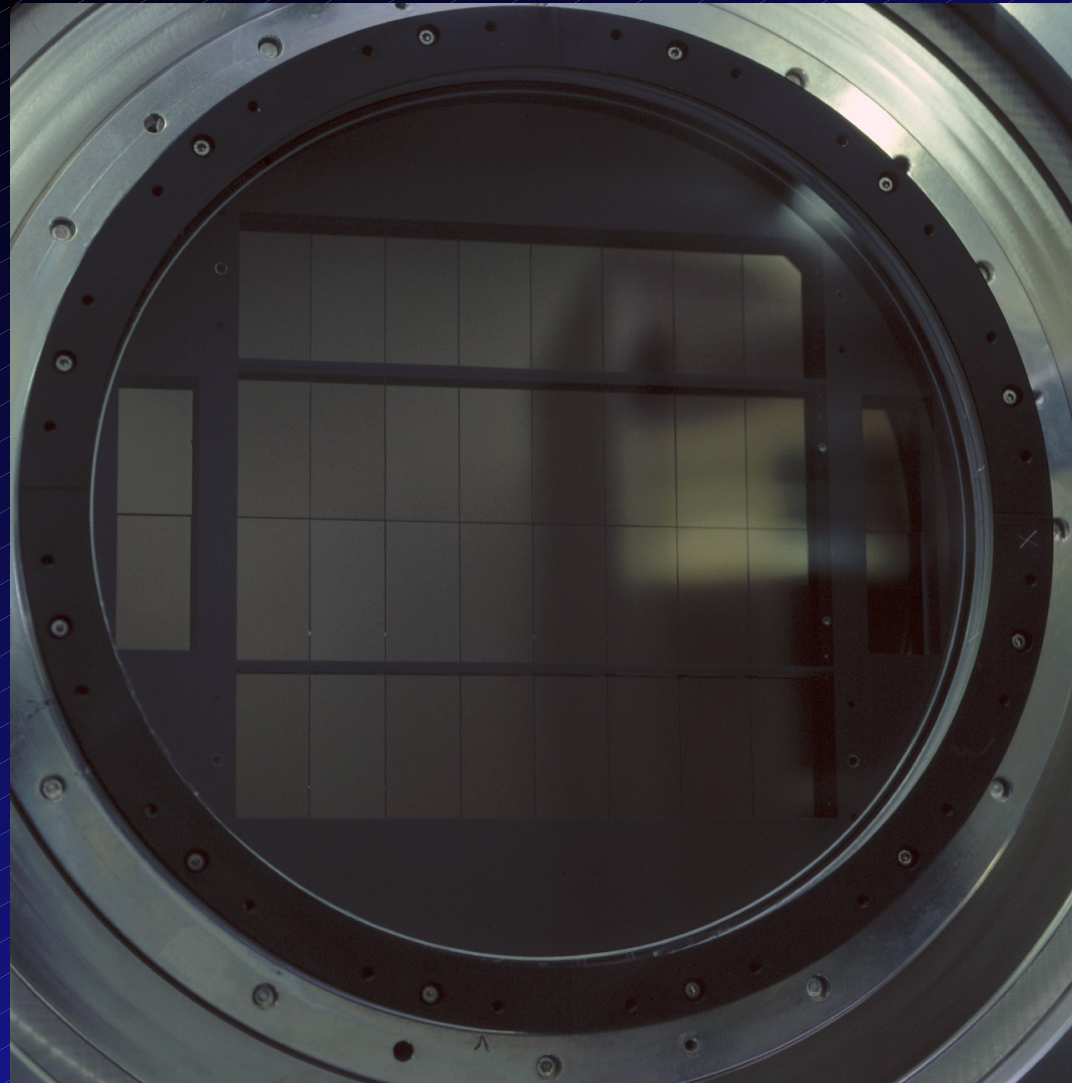
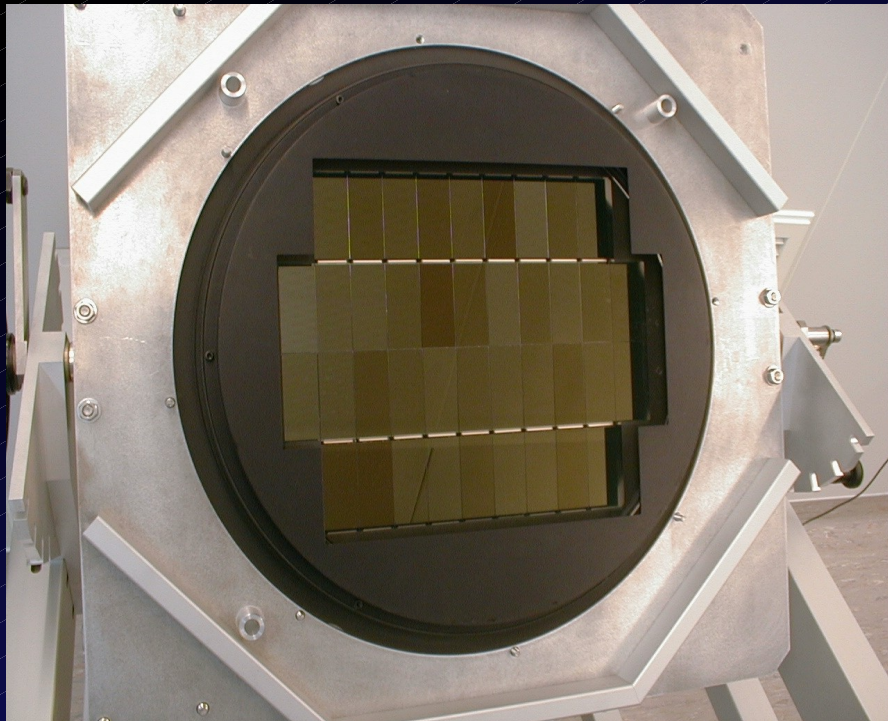
Scale = 1", 3" & 3"/pixel

767 asteroids (2001)

1931 asteroids (2004)

OMEGACAM (CFHT)

36 (40) CCD 4.6kx2k
770 MB na expozici
77 GB za noc
Montage - Terapix





Mosaic of M42
created on
TeraGrid

B. Berriman,
J. Good
(Caltech)
J. Jacob, D.
Katz (JPL)

G. Singh, M.
Su, E.
Deelman (ISI)

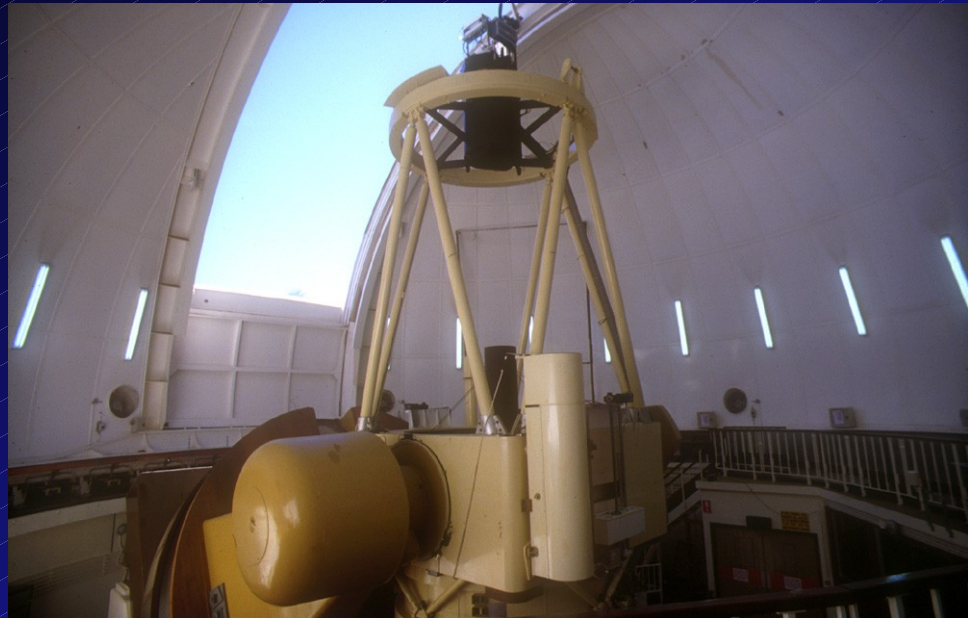
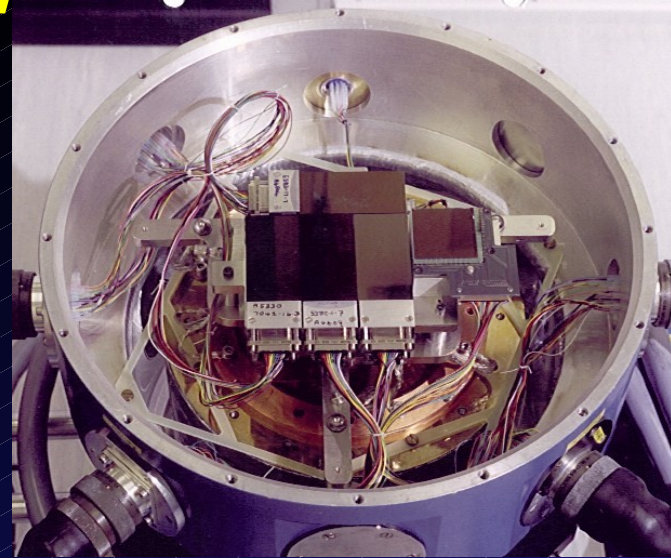


IPHAS Key Goals

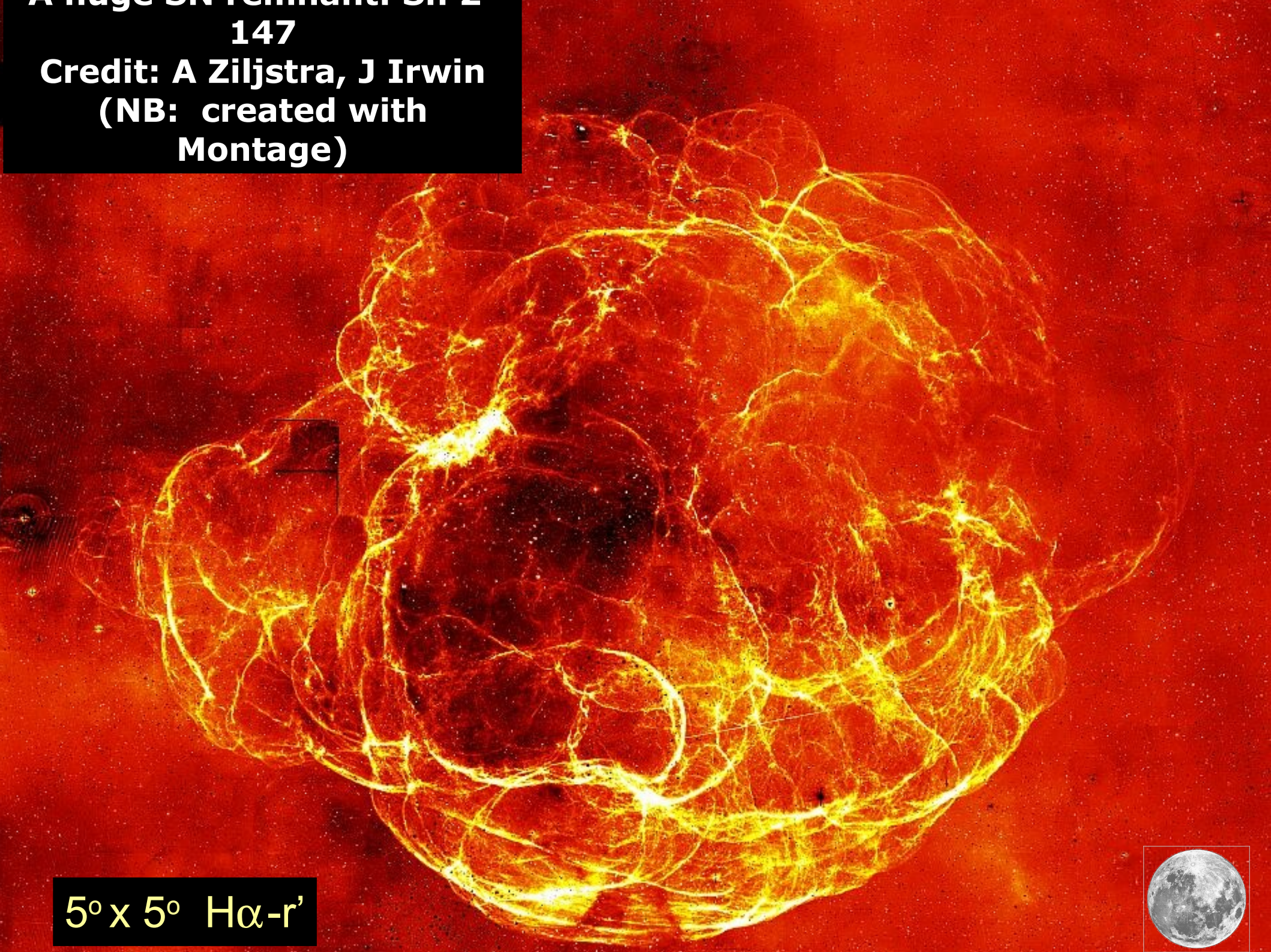
Large scale Milky Way structure and study of early and late type populations (preferentially selected via H-alpha emission line properties):

- (Compact) planetary and symbiotic nebulae
- luminous blue variables (P Cygni and eta Car like objects)
- OBA extreme supergiants
- rapidly evolving post-AGB stars
- Be stars of all types (including young Herbig stars)
- good statistics on clusters of T Tau stars
- a range of interacting binary stars (symbiotics, 'supersoft' compact binaries, WD/NS/BH accreting binaries generally)

IPHAS data source: 2.5-m INT + WFS



A huge SN remnant: SN 1994E
147
Credit: A Zijlstra, J Irwin
(NB: created with
Montage)

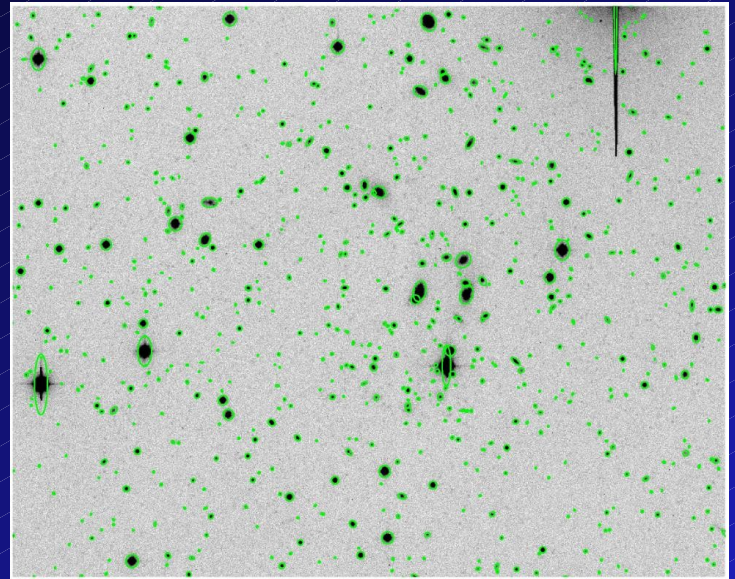
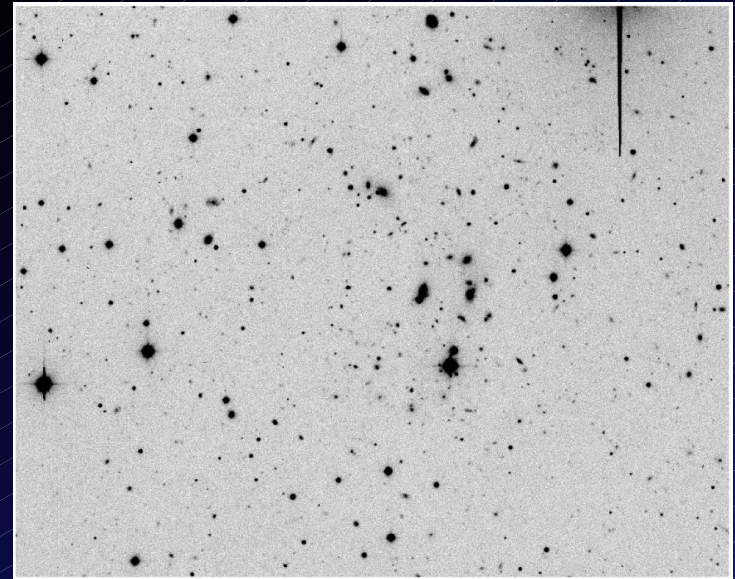
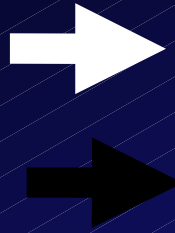
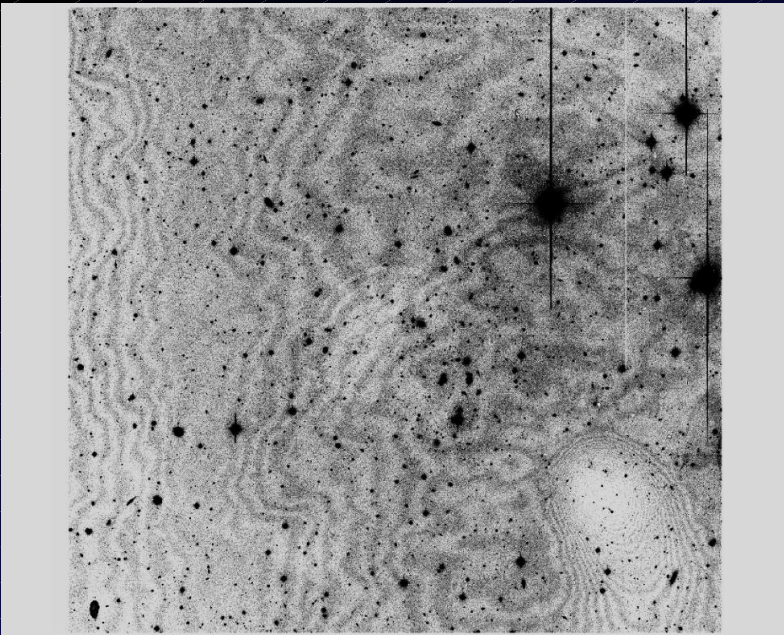


5° x 5° H α -r'



Survey Products

- Photometric catalogue
~100 million objects
- Detection of ~50000 H α -
emitting objects



Sloan digital sky survey = SDSS

- Initial goals

- - Imaging 10,000 square degree of northern sky down to 23mag in 5 optical band (3900-9200Å)
 - 7×10^7 stars
 - 5×10^7 galaxies
 - 1×10^6 quasars
 - Measure redshifts for 10^6 galaxies and 10^5 quasars
 - Create largest, homogeneous, and high-quality catalog of galaxies and quasars

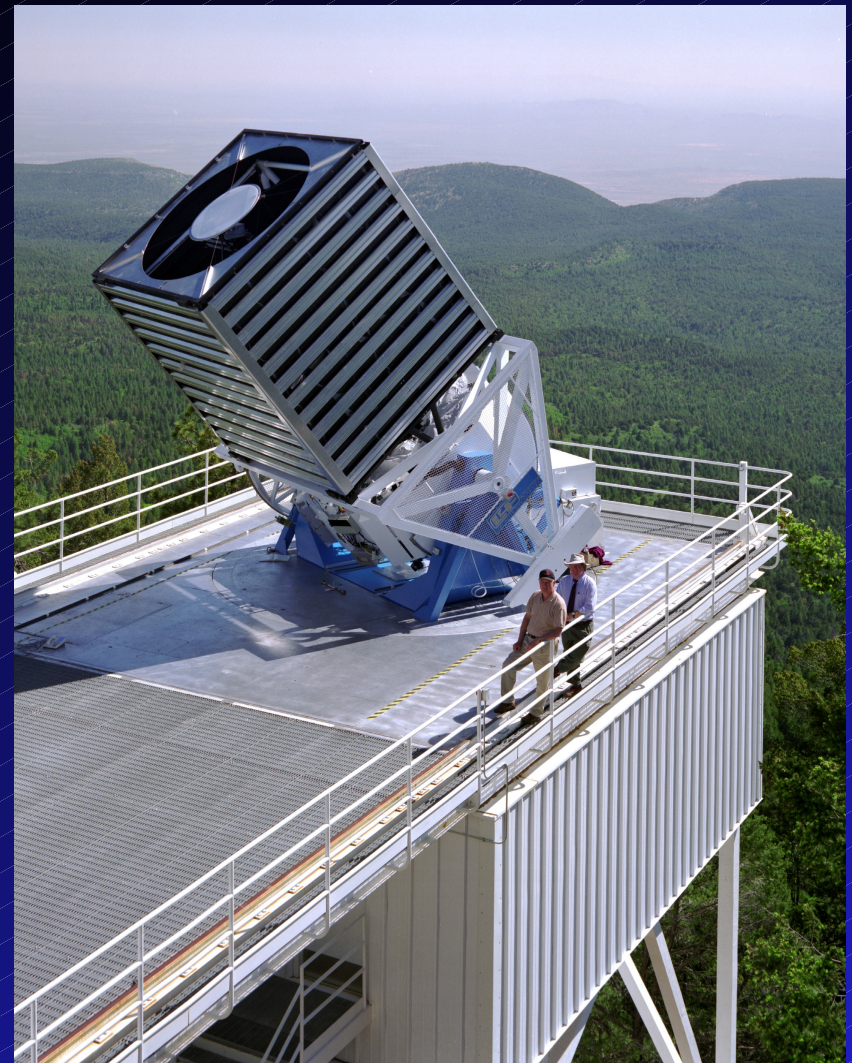
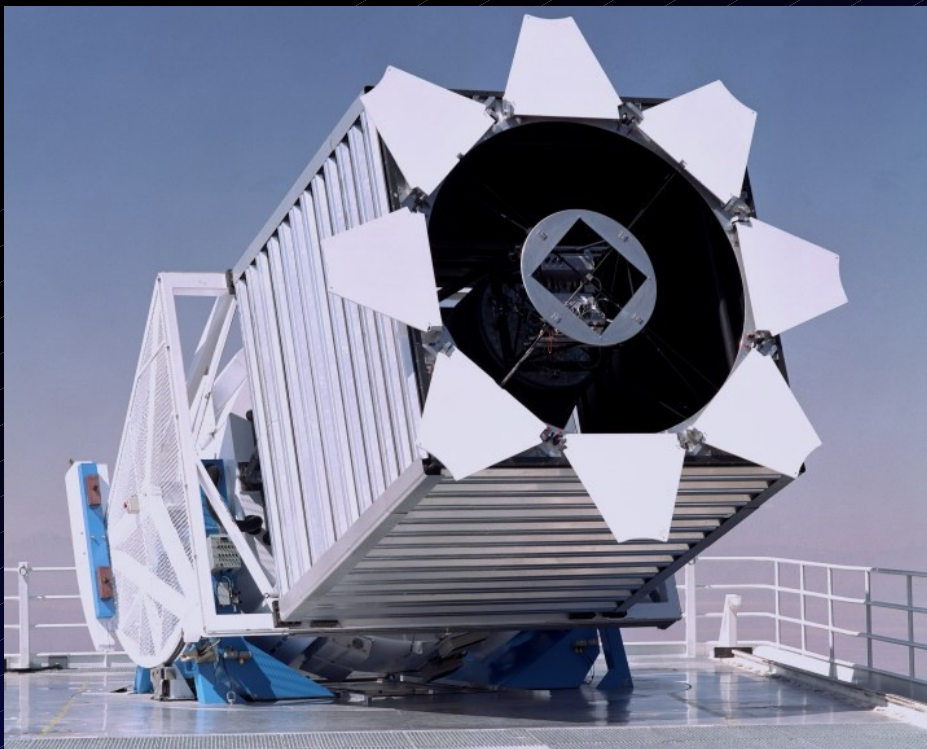
SDSS



Apache point observatory – New Mexico

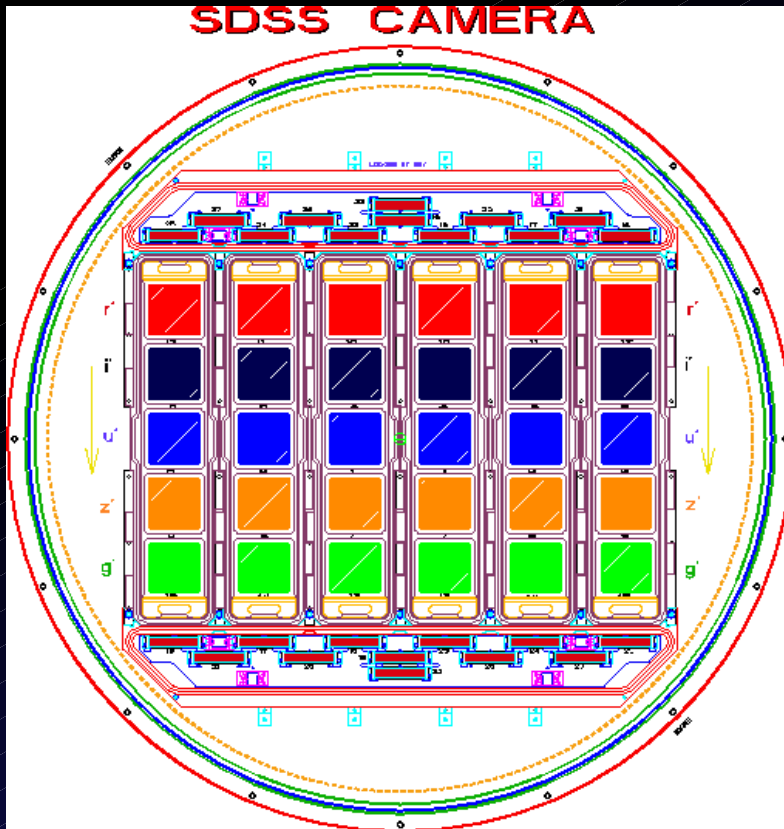


SDSS 2.5m teleskop

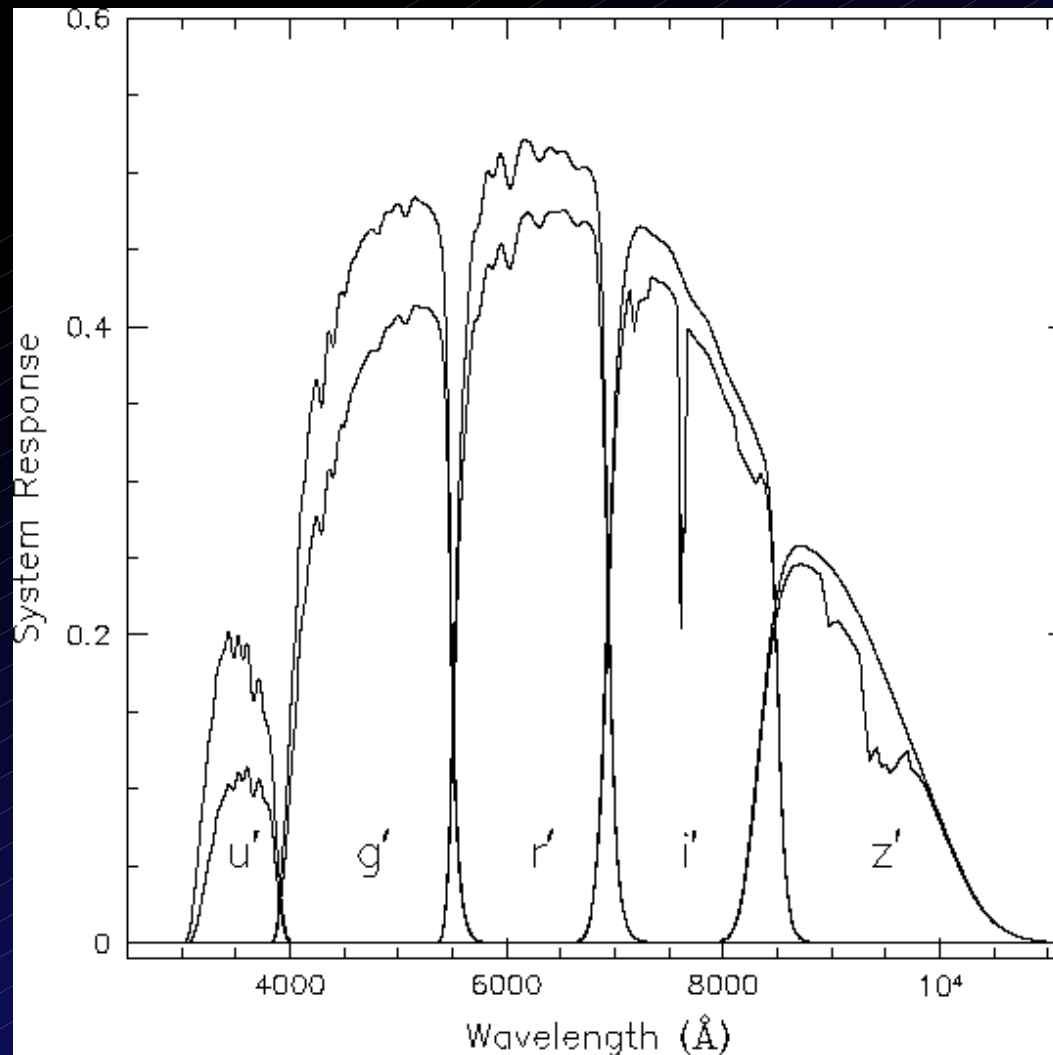


SDSS CCD

30x CCD 2kx2k

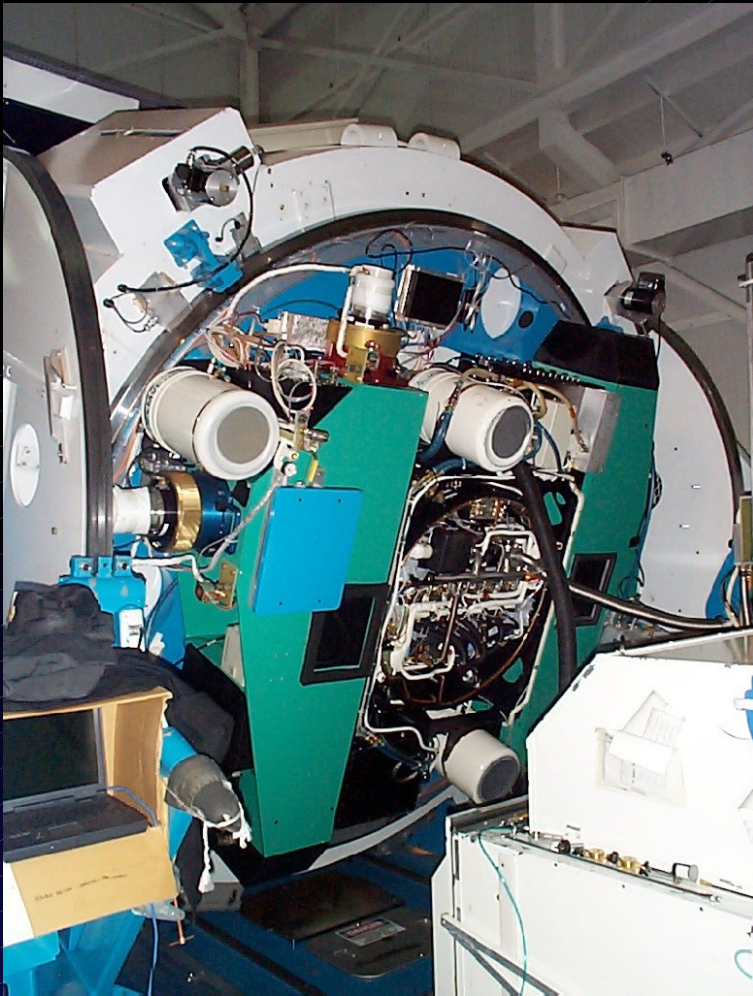


Filter System

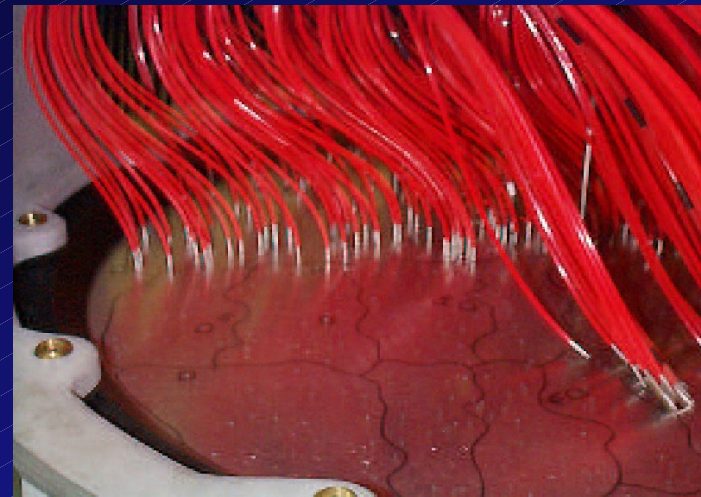


AB system based on 4 primary standards

SDSS spektrograf



2 spektrografy 3800-9200 Å
640 vláken
beamsplitter – červený a modrý
desky až 6-9 za noc (5000 objektů)



Data Archives

- Main page
 - <http://www.sdss.org/dr5/index.html>
 - Describe data products, instruments, and algorithms
- Data Archive Server
 - <http://das.sdss.org/DR5-cgi-bin/DAS>
 - Serve flat files (FITS format)
- Catalog Archive Server
 - <http://cas.sdss.org/astrodr5/en/>
 - Search tools for SDSS catalogs
- Casjobs
 - <http://casjobs.sdss.org/casjobs/>
 - Batch job server for SQL searches

SDSS Data Release

<u>release</u>	<u>Area deg²</u>	<u>spectra</u>	<u>when</u>
EDR:	462	54,000	6/2001
DR1:	2099	186,000	4/2003
DR2:	3324	367,000	3/2004
DR3:	5282	529,000	10/2004
DR4:	6670	850,000	7/2005
DR5:	8000	1,490,000	6/2006

SDSS DR5 Archiv

- Obrázky

- 8000 deg sq
- 215 milionů objektů
- 9 TB obrázků
- 1.8 TB katalog

–	u	g	r	i	z
•	3551Å	4686Å	6165Å	7481Å	8931Å
•	22.0	22.2	22.2	21.3	20.5mag

SDSS DR5 Archiv

- Spektra (60GB 2D -170GB z,měření)
 - 5740 sq. deg.
 - 3800-9200 Å resolution 1800, SNR>4 g=20.2
 - 1,048,960 spectra, classified into
 - 674,749 Galaxies
 - 79,394 Quasars (redshift <2.3)
 - 11,217 Quasars (redshift >2.3)
 - 154,925 Stars
 - 60,808 M stars and later
 - 12,312 Unknown class

End of SDSS-I

- SDSS-I has finished on June 2006
- Imaging : ~ 8900 deg² (unique N&S)
detected 210 million objects
7800 deg² (footprint N&S)
7300 deg² (footprint N)
- Spectroscopy :
 - ~ 1880 plates
 - ~ 1150 N ~ 5800 deg²
 - 160 S
 - ~570 special
 - 1.14 million spectra of celestial objects

Spectrum Services for the VO - Microsoft Internet Explorer

Back

Search

Favorites

File

Edit

View

Favorites

Tools

Address

http://voservices.net/spectrum/search_list.aspx?search=cone&view=graph&page=0

Go



Spectrum Services

home

docs

search

MySpectrum

collections

webservice

user

not logged in
[login](#) | [register](#)

National Virtual Observatory

Search Results

Found 12 objects. Displaying from 1 to 3

List mode

Image mode

First

Prev

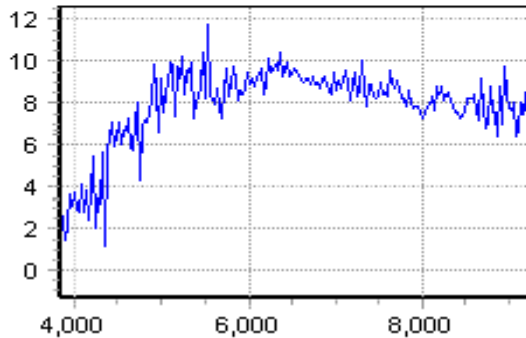
Next

Last

☐ 1. SDSS J115944.85+000000.00

ivo://jhu/sdss/dr4#80443408212033536 |
ivo://sdss/dr4/spec#80443408212033536

class: Galaxy , Z = 0.1009
ra = 179.936874 , dec = 0.941241

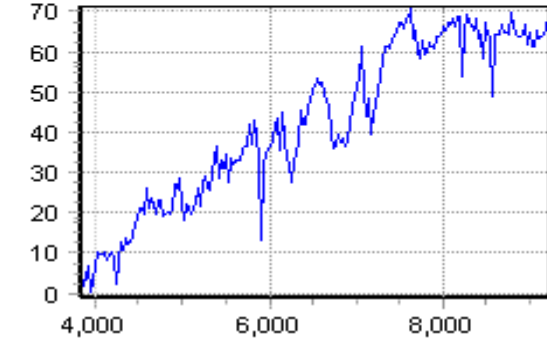


[details](#)

☐ 2. SDSS J120008.29+016000.00

ivo://jhu/sdss/dr4#80443408262365184 |
ivo://sdss/dr4/spec#80443408262365184

class: Galaxy , Z = 0.0000
ra = 180.034561 , dec = 1.146855

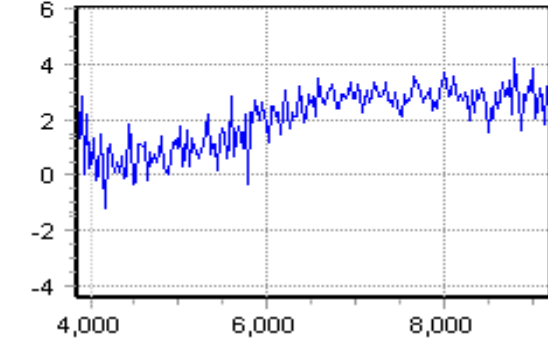


[details](#)

☐ 3. SDSS J115923.80+000000.00

ivo://jhu/sdss/dr4#80443407863906304 |
ivo://sdss/dr4/spec#80443407863906304

class: Galaxy , Z = 0.4517
ra = 179.849167 , dec = 0.984768



[details](#)

Select All

Clear All

What do you want to do with the results?

Download data

Download data

Save to MySpectra

Plot on a graph

Calculate composite

Calculate synthetic magnitudes

Fit continuum & lines

<< Results

< Back

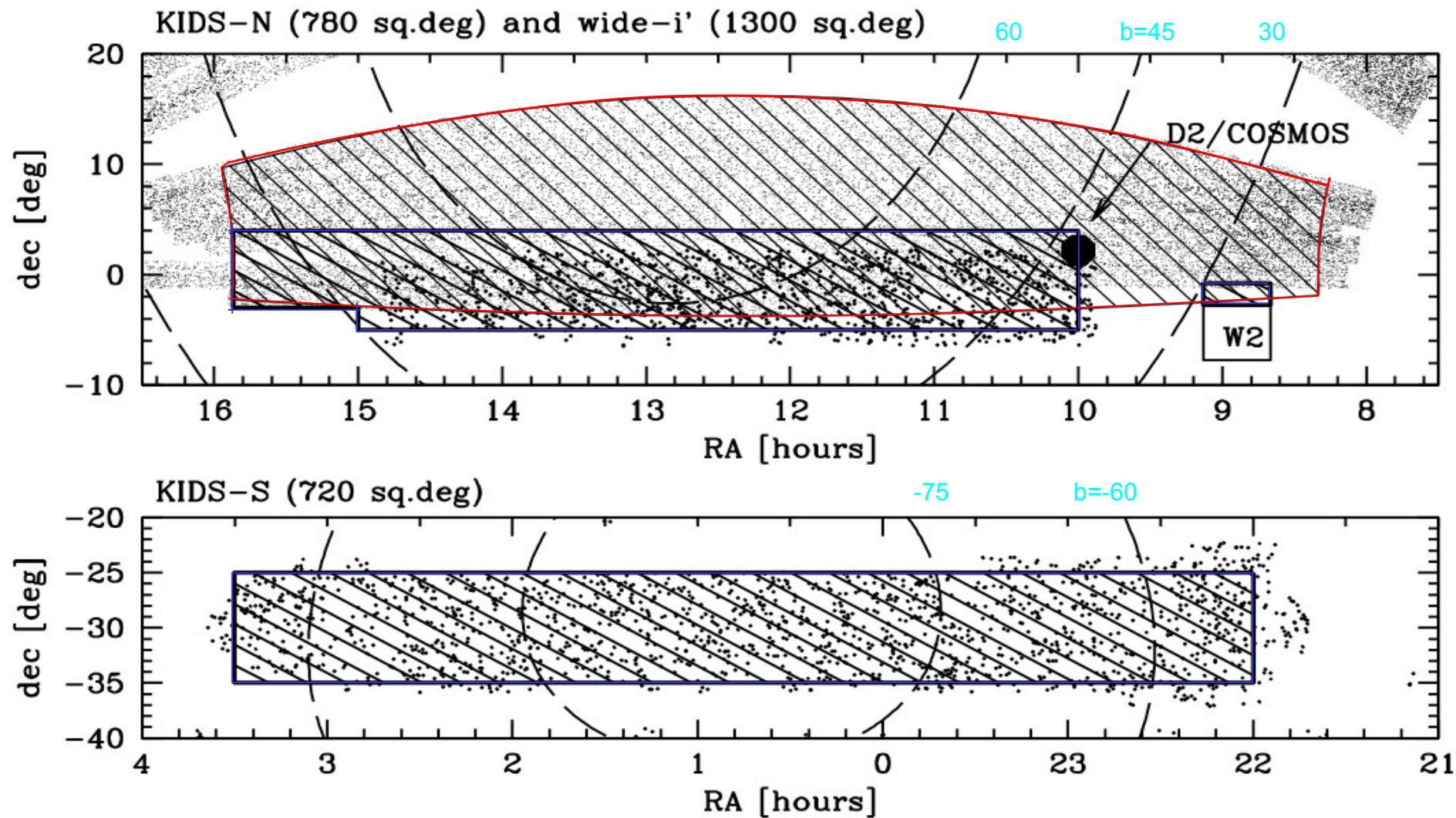
Next >

Finish >>

Internet

Merging of surveys

- KIDS (optical) + VIKING (near-IR) + 2dfGRS (spectra) + UKIDSS (near-IR) + SDSS (optical+spec) + ...
 - Data processed and archived in different places
 - Visualization of combined survey
 - Combined analysis:
 - eg, detect mass overdensities from lensing in optical, then check the IR data for red sequence galaxies
 - Check whether objects move, vary
 - Many tools in hand, but VO addresses similar questions and will be very useful



1500 sq.deg. in ugriZYJHK
+2000 sq.deg. in i (+UKIDSS YJHK)

Shapelets

- Gaussian x polynomials

Orthonormal basis: Gauss-hermite series

Nice transformation properties (little mixing)
under

Translation

Rotation

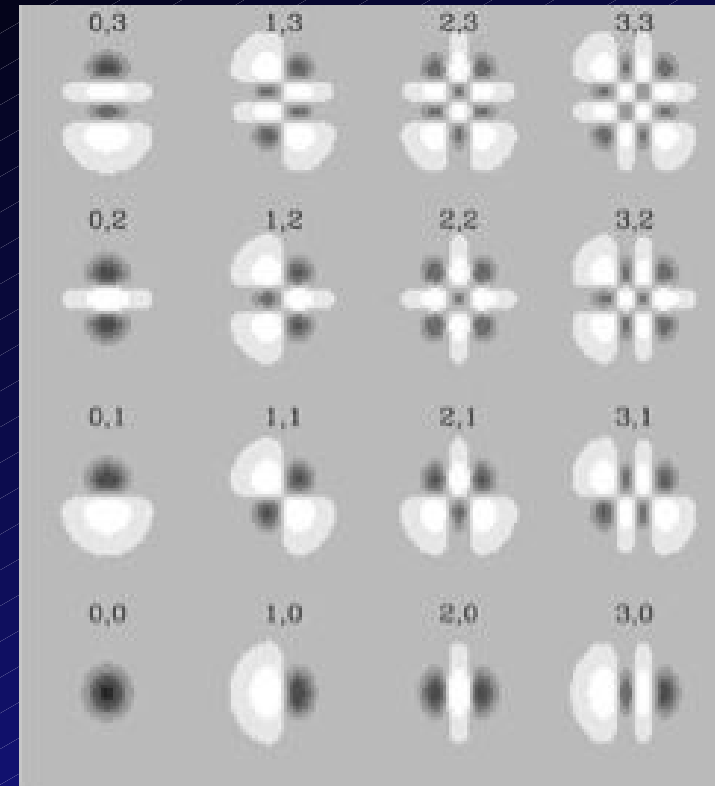
Shear

Magnification

...

- Reasonable approximations to PSF & galaxies
(?)

- Closed-form expressions for convolutions



(Refregier 2003)

Specializované – Mikročočky

- MOA
 - NZ, Mt John Observatory, 4 CCD 2kx2k
- OGLE
- MACHO
- WASP (Sutherland, La Palma) – 8 kamer 2x2k
- KIDS
- Zpracování on-line statisíce objektů
- Mikročočky jen zlomek potenciálu – proměnné hvězdy a pod.



VISTA

4m telescope

0.6 sq.deg. IR camera

16 2kx2k detectors

0.35" pixels



VST

2.6m telescope

1 sq.deg. optical camera
(OmegaCAM)

32 2kx4k detectors

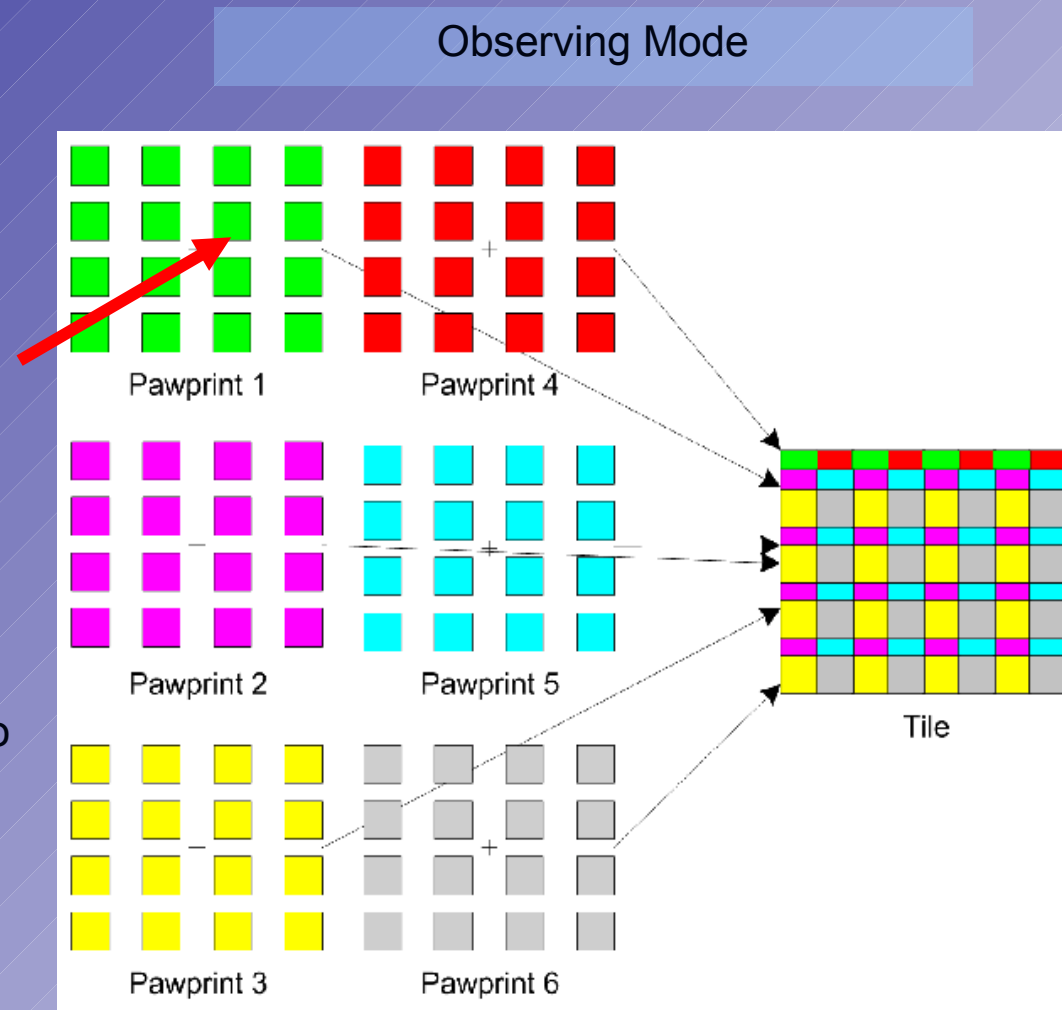
0.21" pixels

Visible and Infrared Survey Telescope for Astronomy VISTA

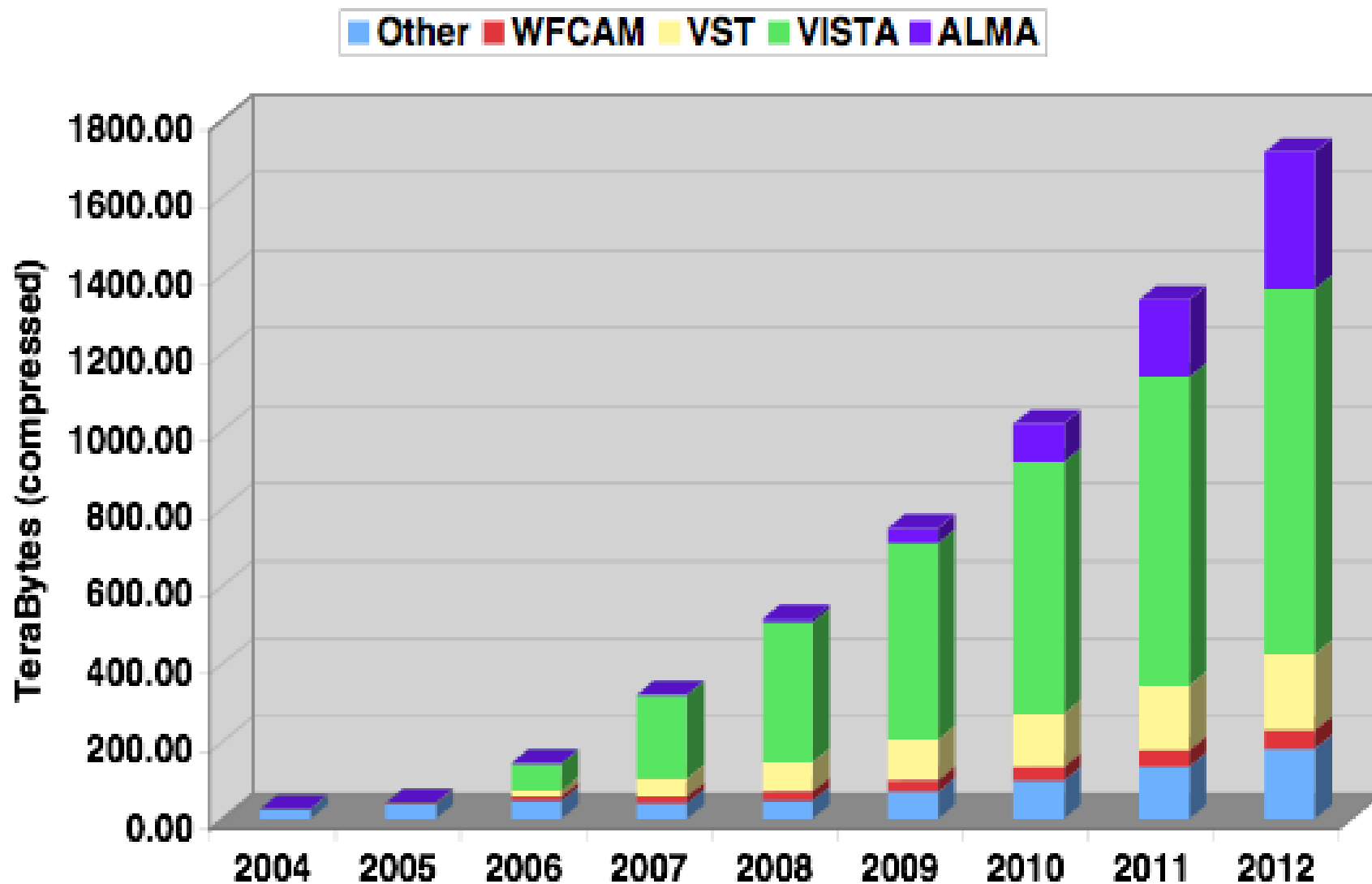
- 4-m class imaging survey telescope in Chile
- 2007
- 1.6 deg FoV
- 16 2kx2k CCD

Evaluation of Montage

- Six stepped exposures fill a "Tile" with at least two exposures
- Automated pipeline processes each "pawprint",



The ESO Archive



Large Synoptic Survey Telescope LSST

Cerro Pachón, Chile

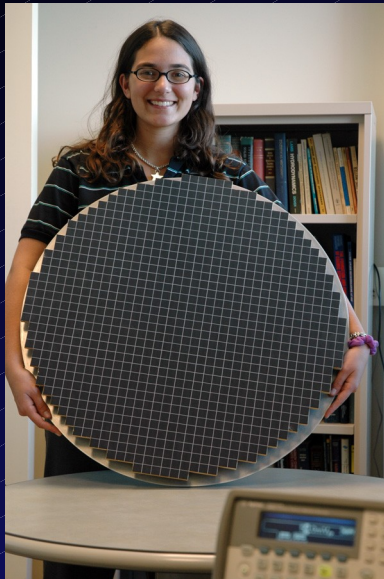
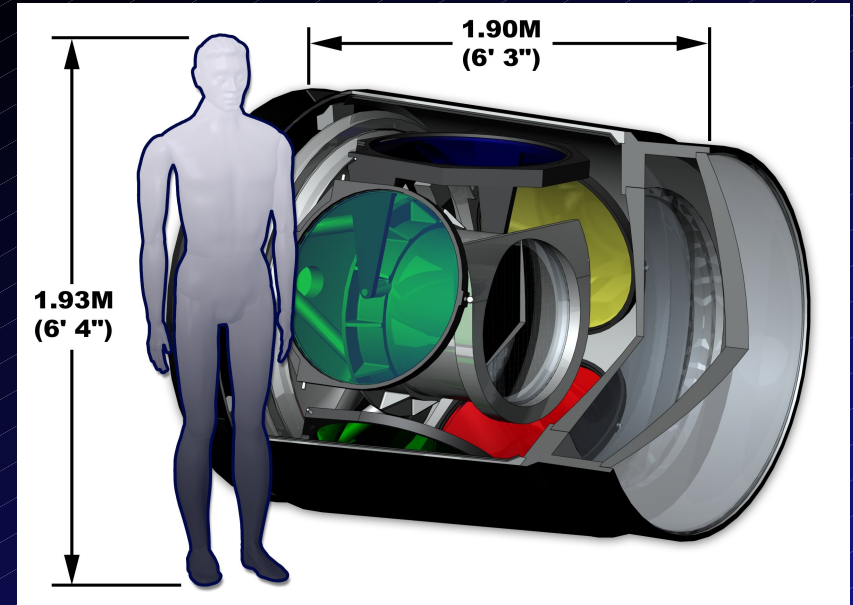
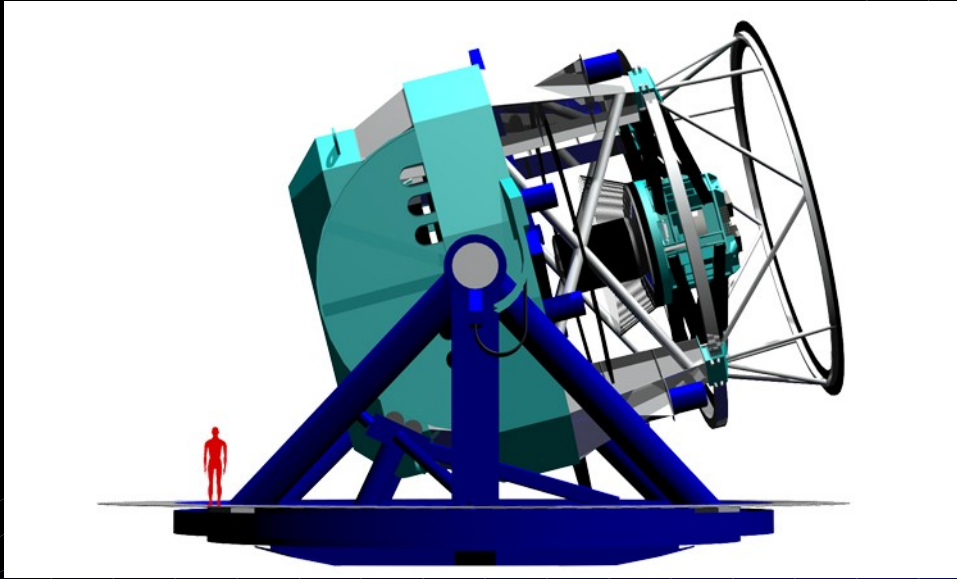
SOAR

Gemini South

El Peñón
Future site of the LSST



LSST (8.4m)



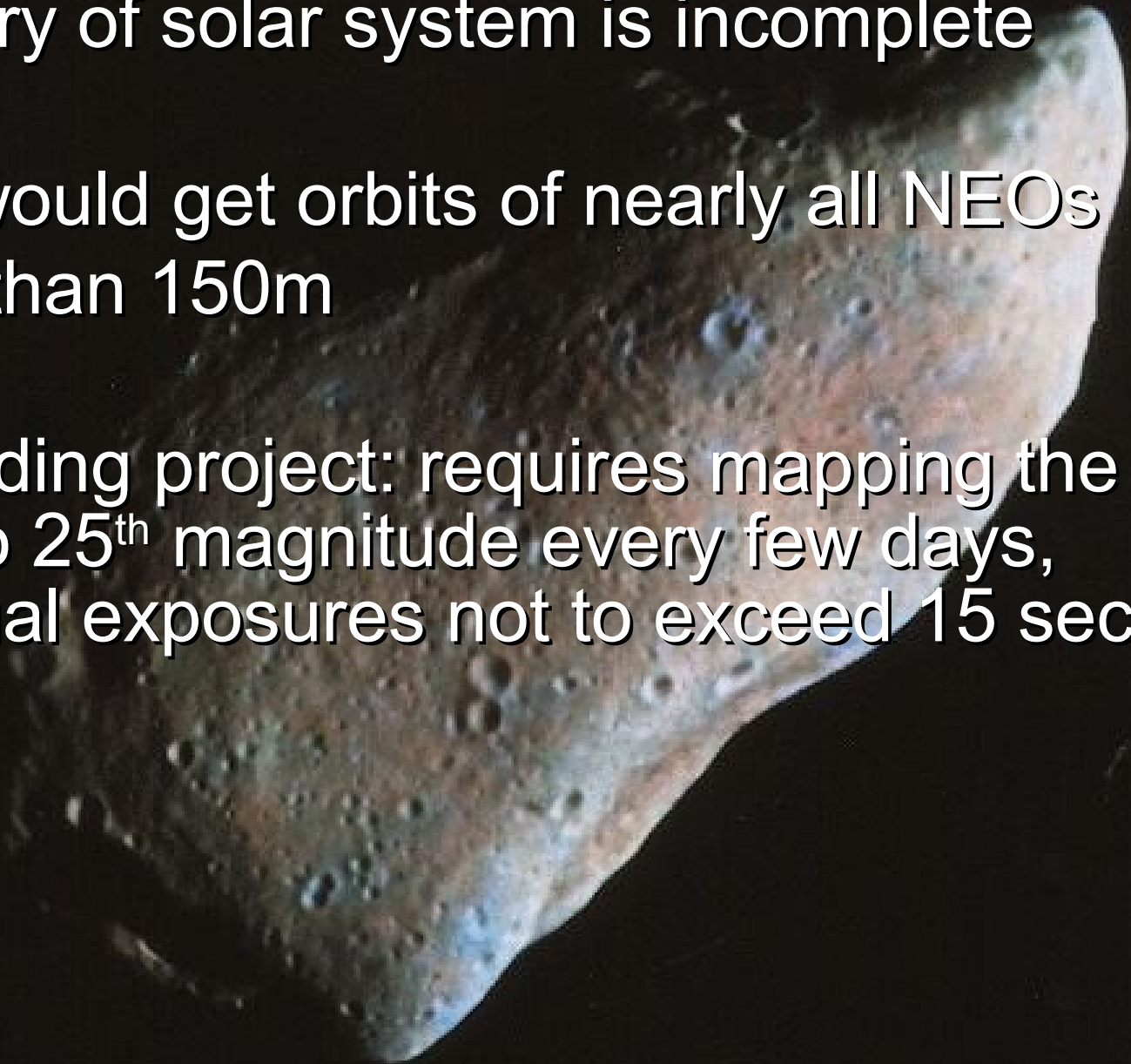
200 CCD 4kx4k,
32 kanálů (6400)
3.2 Gpix za 2 sec
64cm průměr
3.5 deg FOV
30 TB/noc
2 TFLOPS
detekce změn do 60sec

LSST survey of $>20,000$ sq deg

- 4 billion galaxies with redshifts
- Time domain:
 - 100,000 asteroids
 - 1 million supernovae
 - new phenomena

Near Earth Objects

- Inventory of solar system is incomplete
- LSST would get orbits of nearly all NEOs larger than 150m
- Demanding project: requires mapping the sky down to 25th magnitude every few days, individual exposures not to exceed 15 sec



LSST Survey

- 6-band Survey: *ugrizy* 320–1050 nm
NEO frequent revisits: *grizy*
- Sky area covered: >20,000 deg²
0.2 arcsec / pixel
- Each 10 sq.deg FOV revisited ~2000 times
- Limiting magnitude: 26.5 AB magnitude @10 σ
25 AB mag /visit = 2x15 seconds
- Photometry precision: 0.01 mag requirement,
0.001 mag goal

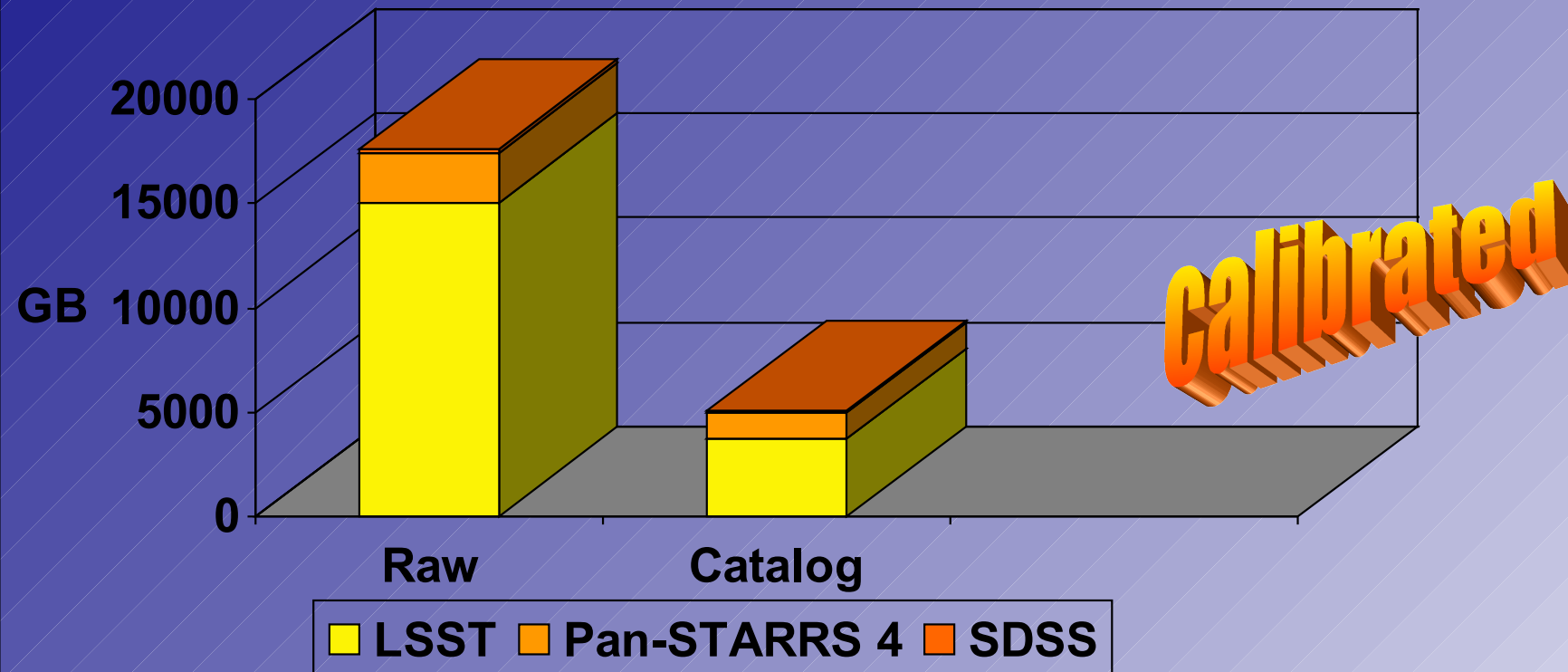
LSST

Processing pipeline generates 108TB of 32-bit floating point temporary image data, not archived

**Calibrated images at 8 Gbps (36 TB/24 hours) +
Noise maps at 8 Gbps (36 TB/24 hours) +
Subtracted images at 8 Gbps (36 TB/24 hours) = 108TB/24 hours**

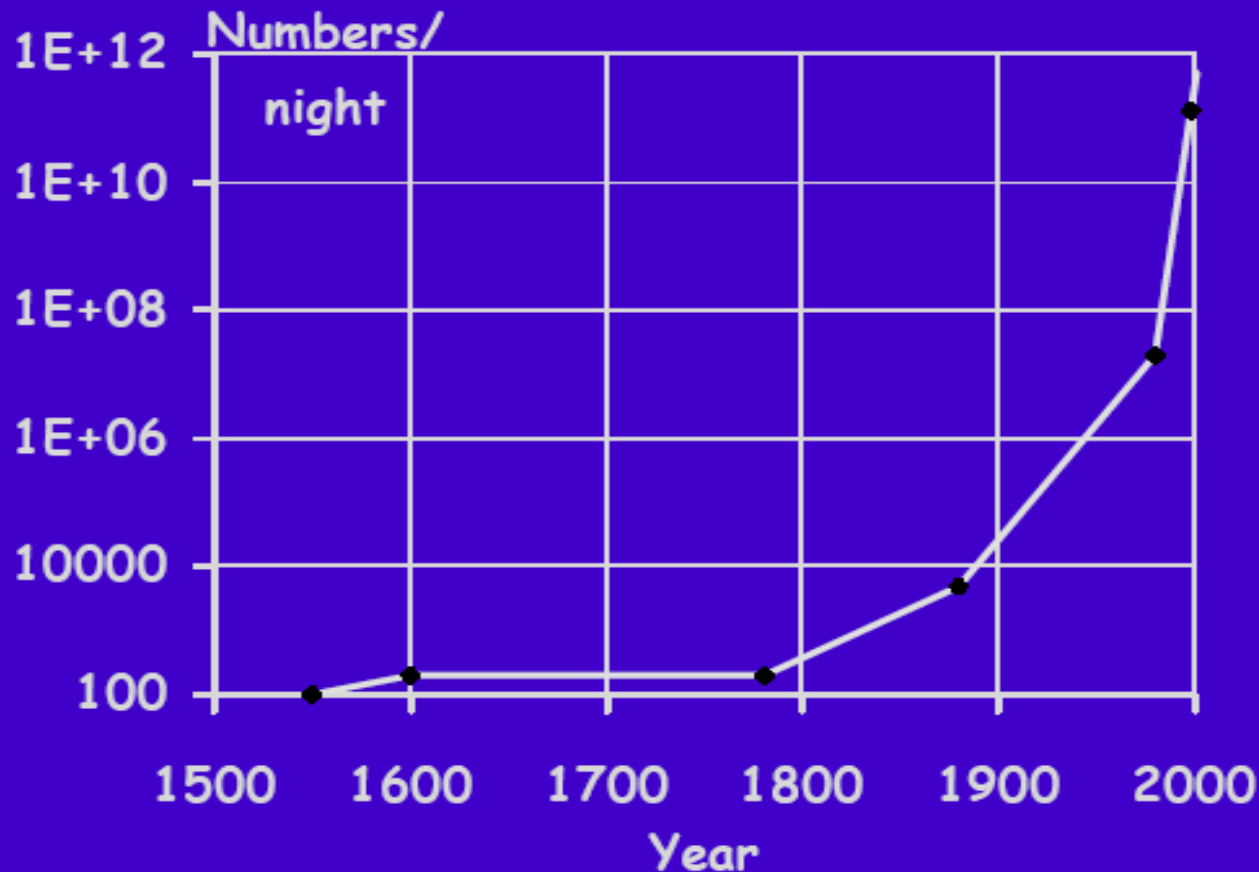
Unprecedented Astronomy Data Volumes

Estimated Nightly Data Volumes



Lavina dat

- Moorův zákon chipy – zdvojení 1.5 roku (1000/10 let)
- Data v astronomii – zdvojení < 1 rok !



$T_2 < 18 \text{ mths}$
1990-2000

Lavina dat

