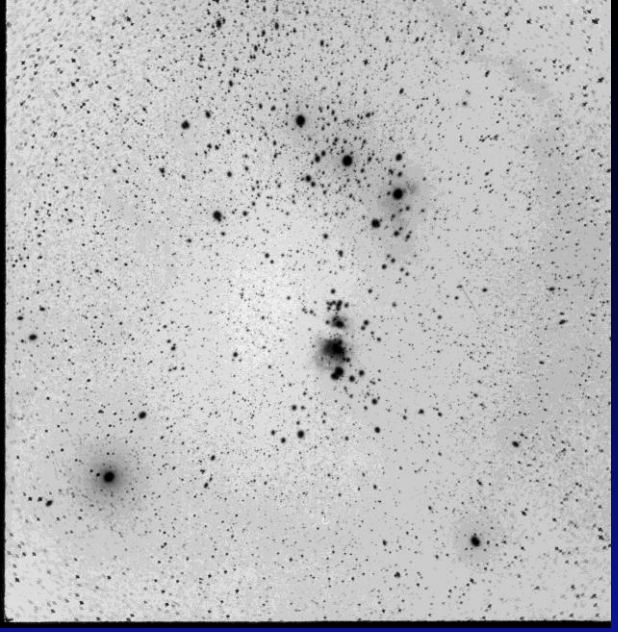
Astronomical Plate Archives: Past, Present, Future

René Hudec

Astronomical Institute, Academy of Sciences o
the Czech Republic, Ondřejov, Czech Republi

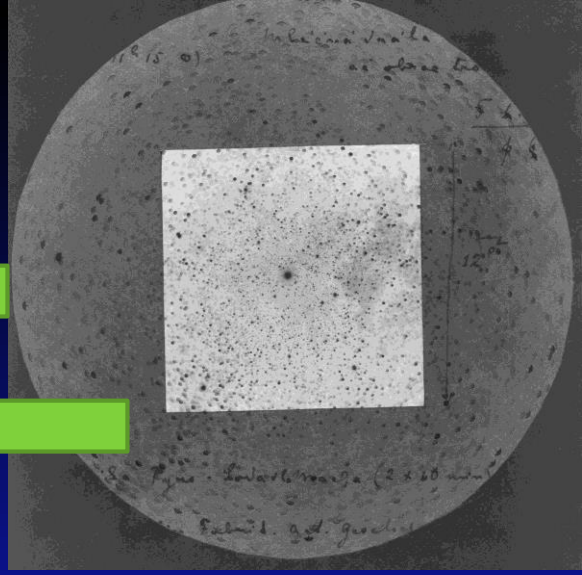
and CTU in Prague, Czech Republic



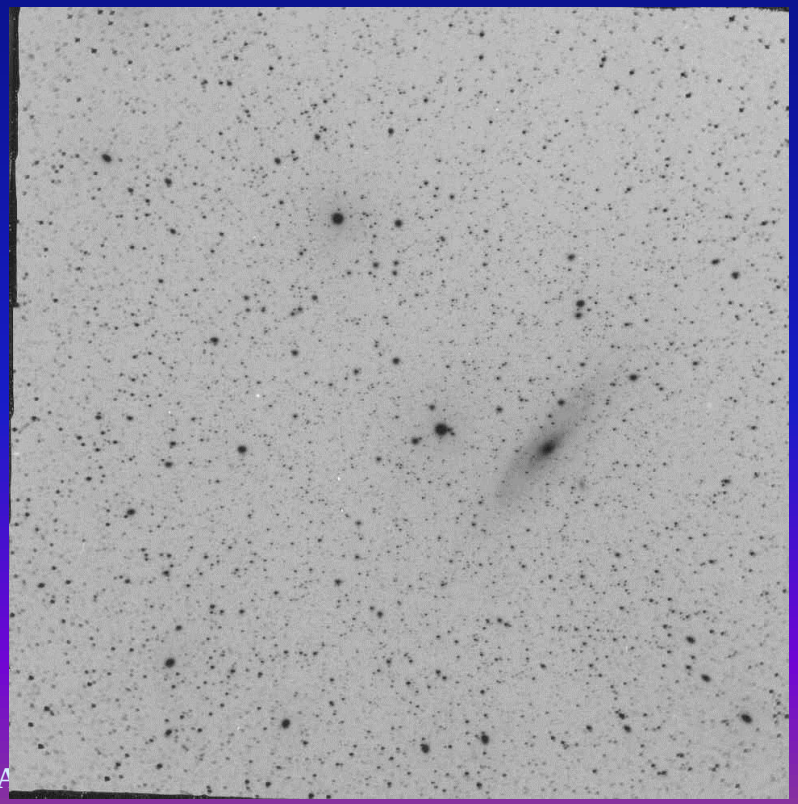
Historical photographic plates, around 1895, Ondřejov Observatory

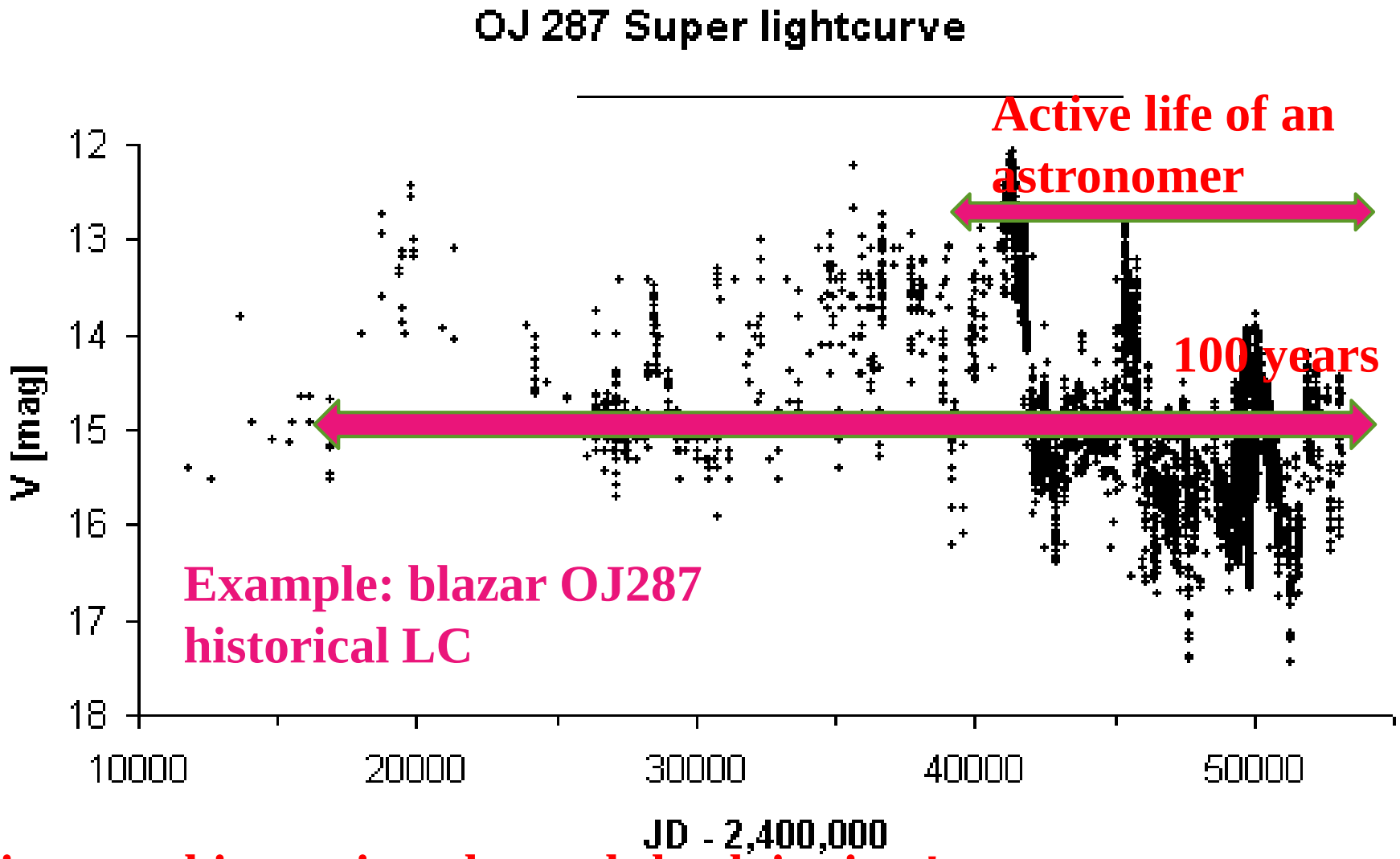
Time machine

Sky 117 years ago



Photography was used to record images for 100 years 1880 to 1980





Time machine – virtual travels back in time!

OJ287 - long term light curve (> 100 years), the only well studied case so far …. 120 years coverage

The Plate Archives

- The recording medium in astronomy (and not only astronomy) for recording images was photographic emulsion until about 1980, i.e. for about 100 years
- Hence all scientific Institutes involved in the past in imaging are expected to have archives of recorded images (as photographic negatives)

Photographic Negative Archives

- Astronomical
- Non-astronomical
- Other sciences
- National Archives
- Musea
- Others

- Glass negatives
- Plastic negatives / planfilms
- Rolfilms

Astronomical Negatives

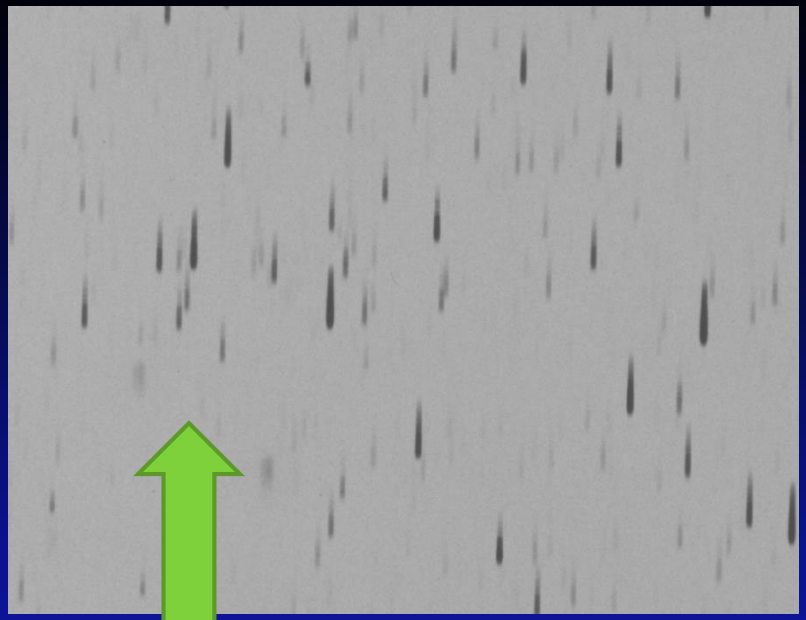
- Direct images
- Low Dispersion Spectra
- Multiple images
- Spectra

- Stars / Night Sky Images
- Meteor trailed images
- Planets
- Sun
- Moon
- Other targets

Archival sky patrol plates

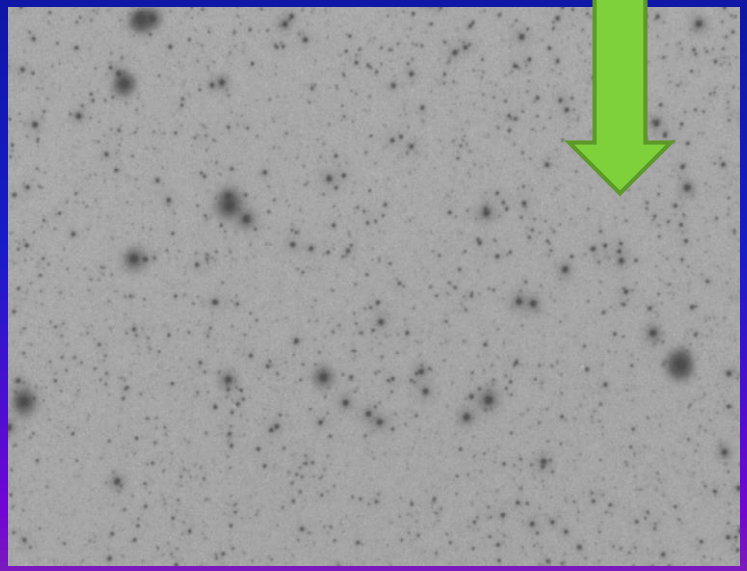
- There are more than 7 millions astronomical archival plates and negatives in the world, lim mag up to 23, > 5 x 5 deg in most cases
- Suitable for dense long-term photometry (up to 100 years, up to 2000 points, up to 23 mag)
- Suitable to detect rare events - years od CONTINUOUS monitoring easily possible
- However, the access to the data is still difficult, but:
- Recently, efforts to digitize the plates
- Use of scanners, powerful computers and innovative software allows the effective data evaluation for the first time
- 1 plate ~ 3 x 10^4 stars, 3 x 10^6 plates ……10^11 stars recorded … 10^11 photometric points

Various types of astronomical plates I. Wide Field Images

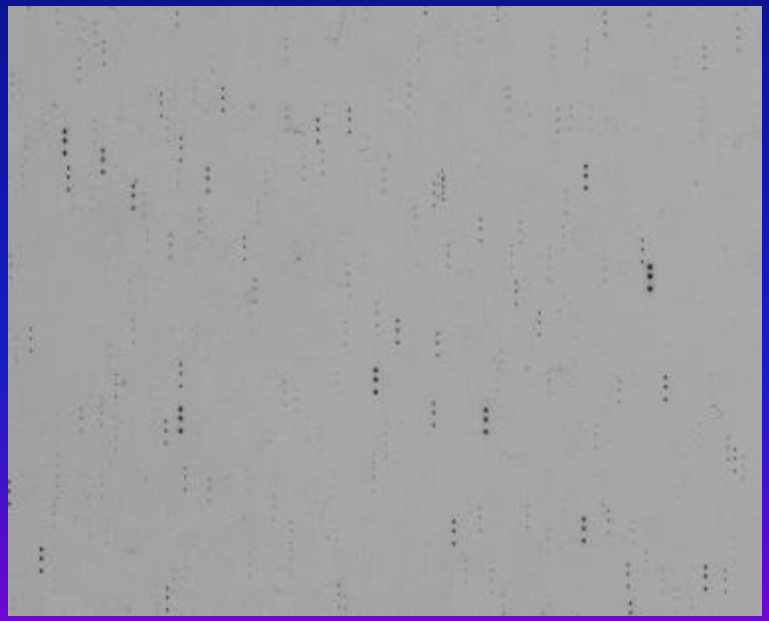


LD Spectral image

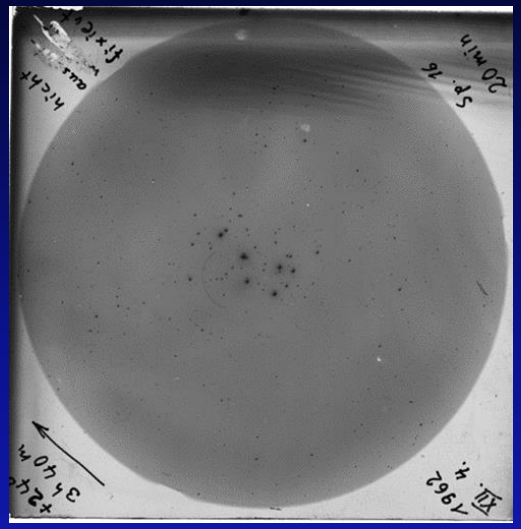
Direct Image

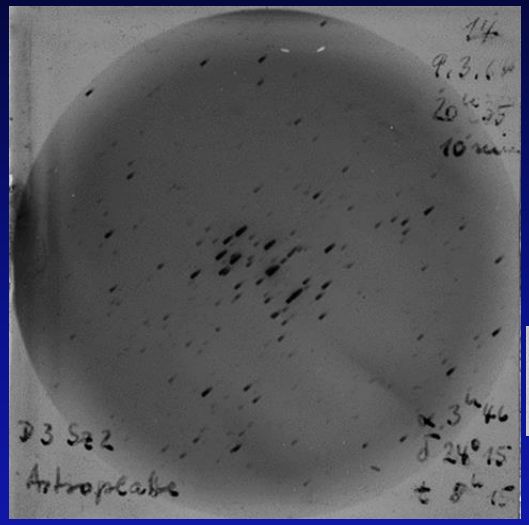


Multiple exposure

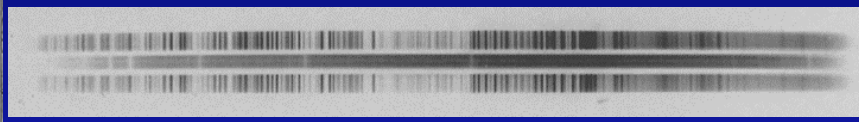


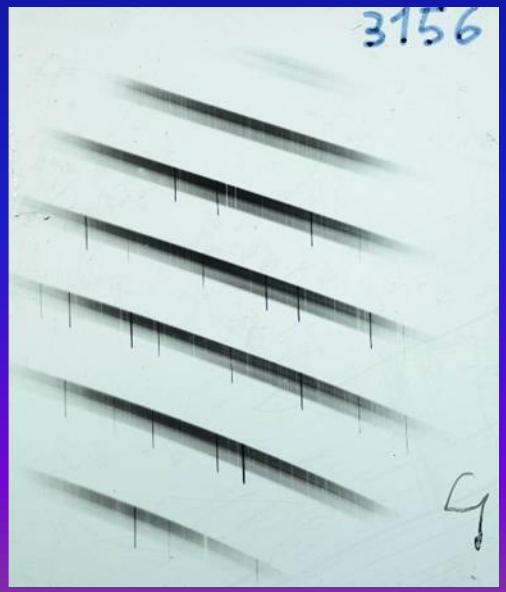
Narrow Field Astronomical Plates taken in focus of large telescopes



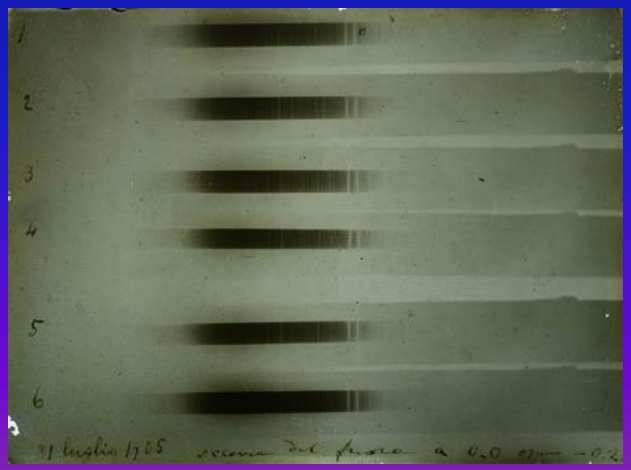


Usually small, sizes just few cm





Direct, Spectral, Single HR Spectrum



Personal visits to astronomical plate archives

- I have personally visited and evaluated the plates in more than 50 plate archives
- In numerous cases sad experience
- In few cases forbidden entry, then mostly plates badly damaged
- In most cases plates stored not in proper conditions
- Many hidden plate collections found
- Mostly scientific valuable databases
- In numerous cases no contact person, no funding, no equipment

List/Catalogue of astronomical plate archives

- Complete list does not exist
- Many are included in WFPDB (Tsvetkov et al.)
- But this is not complete
- America archives list by Wayne et al., but, again, not complete
- Examples: numerous unknown archives found by us even at those Institutions where the management was not aware that they have plate archive
- Total numbers difficult to estimate, as at many archives they do not know how many plates they have

The largest plate/negative archives (some unknown before)

- HCO USA 500 000 plates
- Carnegie Pasadena USA 500 000 plates
- Sonneberg 280 000 plates
- OHP France 250 000 plates
- Charlottesville VA USA 165 000 plates
- Swathmore Observatory PA USA 100 000 plates
- PARI USA 120 000 plates/negatives
- RGO UK 150 000 plates/negatives

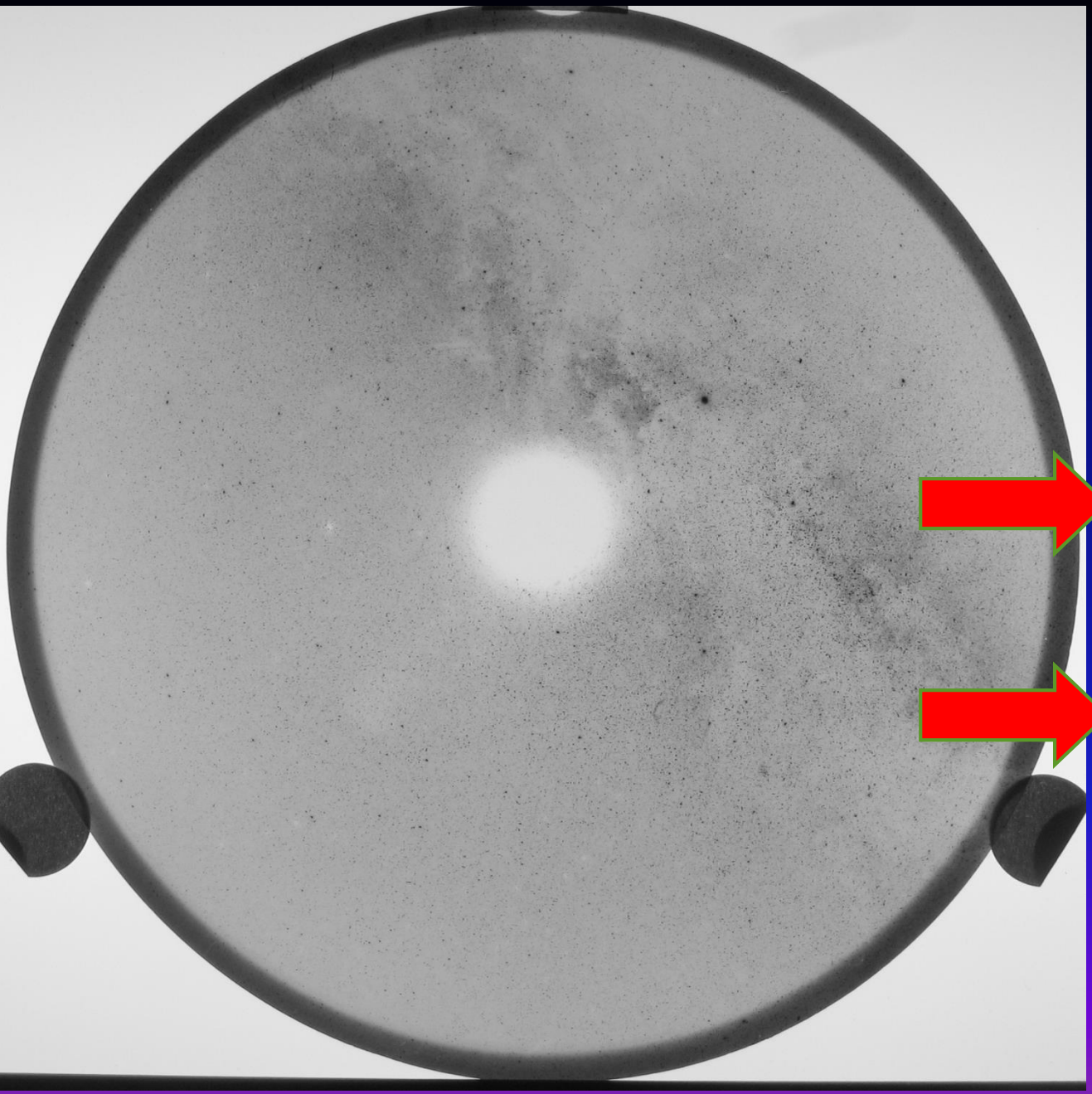
The astronomical plates taken by largest telescopes

- CFHT Hawaii USA, 3.6 m aperture
- UKSTU Siding Springs Australia
- Australia 4.0 m aperture

The astronomical negative collections with finest time resolution

- Baker-Nunn Camera networks archives, USA,
- Time resolution few seconds, FOV 5 x 30 degreees, lim mag 14-16

… and some were carefully examined dozens of years ago……



Super-Schmidt Baker Camera

About 100 000 films

Limiting magnitude 15, very sharp images

FOV 55 degrees

1950-1960

Very dense (20 minutes) sampling

Now deposited at PARI, NC

B-N Example Images

Data suitable for wide-field studies, OT searches, fast variablity

Up to 100 000 stars per 1 full frame

Extracting the information recorded in the plates:

- dedicated high quality plate scanners D very expensive
- commercially available flatbed scanners D moderately expensive
- other instruments (photometers etc.)
- by human eye
- by a CCD camera D inexpensive

- D means can be used for digitization of plates

Plate informations

- Observing logs
- In hand written form
- Some fraction transferred to files: absolutely necessary step
- Plate searches by computers
- Searchable www forms
- Goal is to find plates which include the object of interest (or given sky position)

New:

The digitisation of the astronomical plates, the novel software and the use of powerful (1 plate can represent up to 1 GB) computers allow the automated data mining and scientific evaluation of the plates for the first time

Interface between astronomy and informatics (excellent task for informatics students!)

Norbert Polko: 250 000 plates scanned: worlds record

Scanning Efforts at Sonneberg Observatory more than 250 000 plates already scanned

Plate scanning at Bamberg

Plate Digitization

- Why to digitize the plates?
- The photographic emulsions can be damaged
- To enable evaluation by dedicated software and powerful computers
- The access to the info in the plates is otherwise very difficult
- What positional accuracy is needed?
- What resolution (pixelsize in microns) is needed?

Plate Digitization II

- Very high aastrometric positional accuracy 0.1 microns only with custom made scaneres, very expensive
- Most applications do not need such high accuracy
- Pixelsize: emulsion 5 microns, Sonneberg 25 microns. Smaller pixelsize = very large size of image files = more difficult to store, to acces, and to evaluate

Plate Digitization III – Cost Factor

- Dedicated custom made accurate scanner - very expensive, difficult to move, 1 plate > 100 Euro
- Commercial flatbed scanners – moderately expensive, 1 plate >> 10 Euro
- Digital camera - inexpensive, fast – 1 plate < 1 Euro
- Cost of purchasing instrumentation not included

Transportable plate scanning device

Plate collections visited with test scanning:
Carnegie Observatories Pasadena
Lick Observatory
Yerkes Observatory
Mt Palomar Observatory
PARI NC
KPNO Tucson
CFHT Waimea, Hawaii
IfA Manoa, Hawaii
USNO Flagstaff, AZ
USNO Washington, DC & 20 more

About 3 million plates in these archives

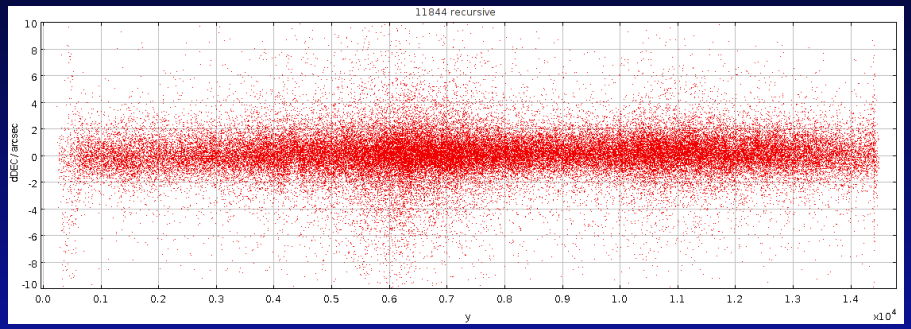
Preferences: transportable, very fast scanning, high repeability (no moving scanner parts)

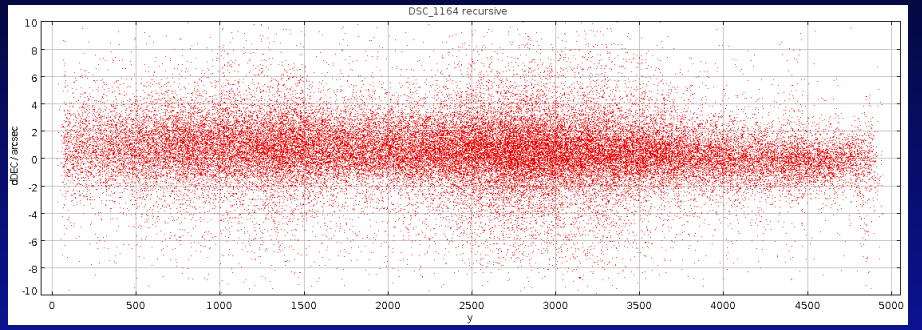
Used equipment:

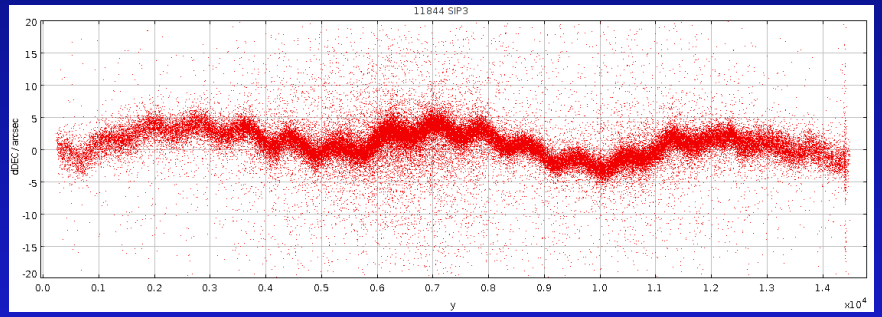
Less expensive alternative to plate scanner cost reduction > 50

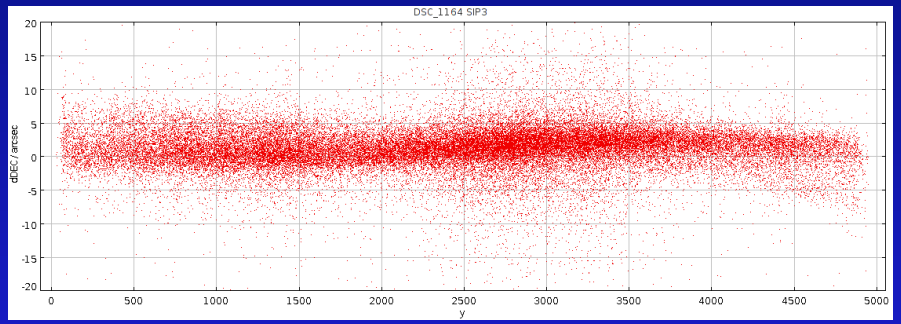
Camera: 39 Mpx high quality optics, tripod, light table, control s/w, Lens distorsion treatment etc

Comparing Camera vs. Scaner (the residual plots)









Scaner **Camera**

Bamberg Southern Sky Survey Plate NZ 11844

?

Past

Glass Plates

Recent

DVDs

Future

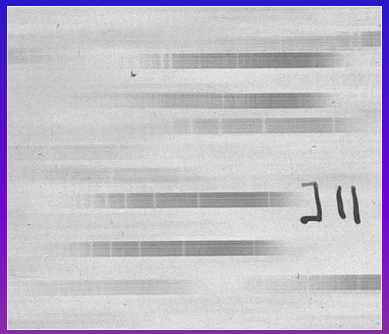
?

Creating Astronomical Plate Centres

- Storing plates which would be otherwise destroyed
- Creating centres with large number of plates and excellent equipment
- Europe: UDAPAC, no success
- USA: PARI, success
- Others? China?

PARI – US Initiative for North American Plates
PARI Institute, NC

Recently about 120 000 plates there, plans for more



Conclusions

- Astronomical Plate Archives represent valuable extended (> 7 milion) data source
- Most important: long time evolution, dense sampling, rare flares, spectral changes
- Recent wide digitization and evolution of dedicated software enables evaluation by computers, for the first time
- Storage of negatives in numerous cases is not optimal
- Need for collaboration with archivists and chemists

The End