

Byurakan spectroscopic surveys and their scientific discoveries

Areg Mickaelian

Byurakan Astrophysical Observatory (BAO)

*Large surveys with small telescopes: Past, Present, and Future (Astroplate III)
11-13 March 2019, Bamberg, Germany*

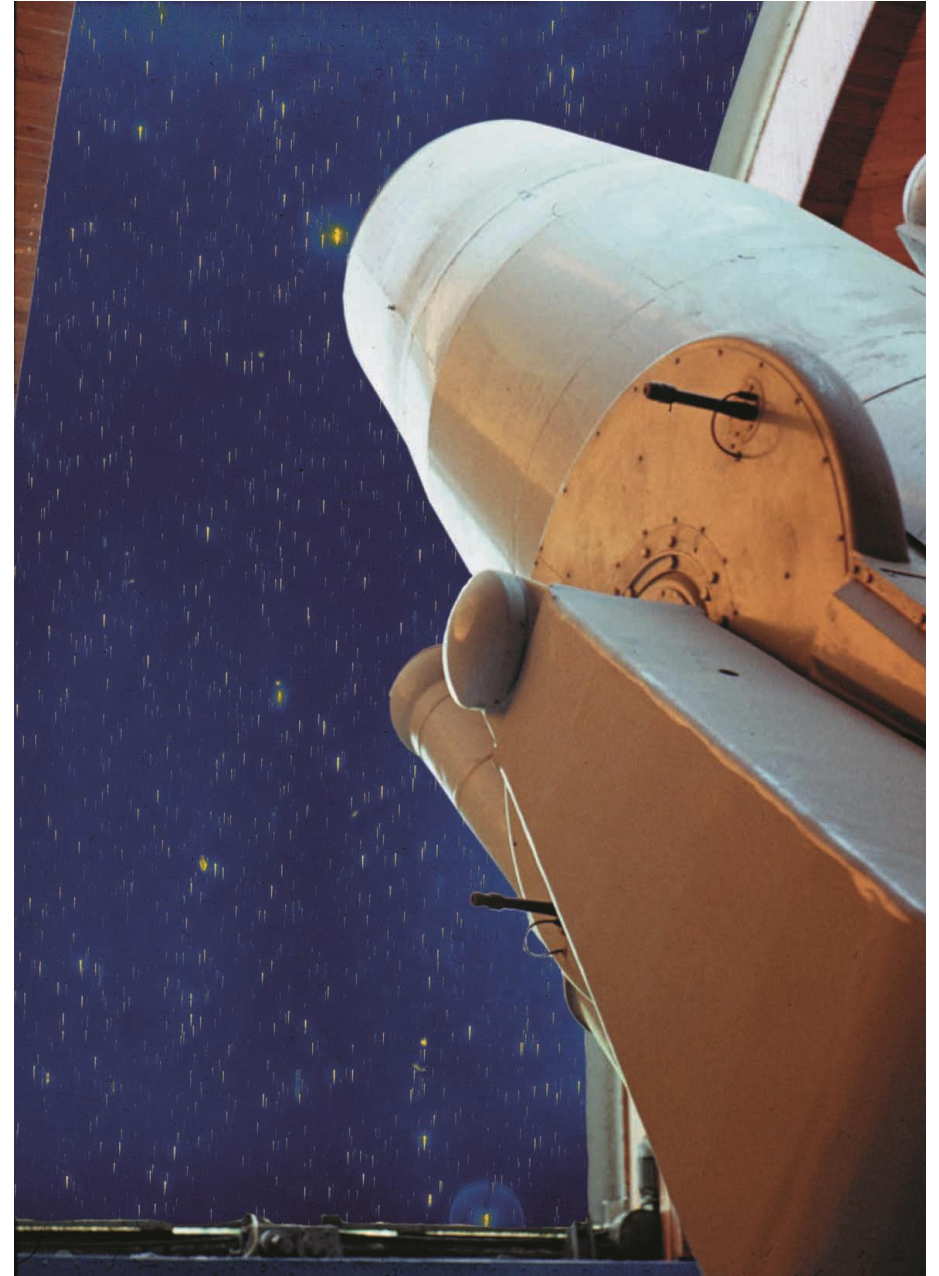
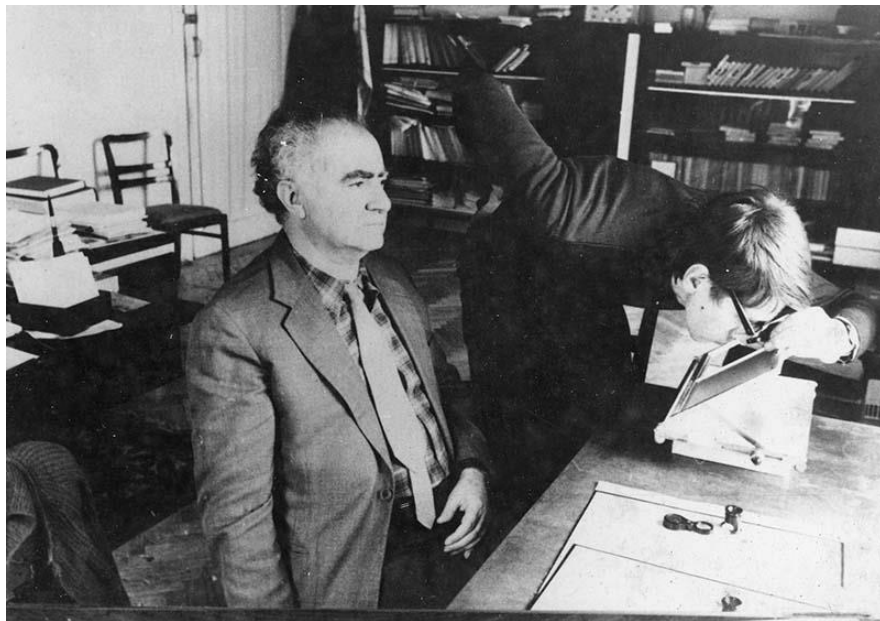
Overview

- The First Byurakan Survey (FBS or Markarian Survey)
- Famous Markarian galaxies
- Studies of Markarian galaxies, MW data
- FBS based new science projects
- Digitization of Markarian survey, DFBS
- Second Byurakan Survey (SBS)
- Other digitization projects
- BAO Plate Archive Project
- Photographic and digital data
- Small and large telescopes



Research team and the telescope

E
V
J



Markarian or First Byurakan Survey

Authors: *B.E.Markarian, V.A.Lipovetsky, J.A.Stepanian*

Years: *1965-1980*

Instruments: *102/132/213 cm Byurakan Schmidt telescope
1.5° objective prism (1800 Å/mm at H γ)*

Emulsions: *Kodak IIAF, IIaF, 103aF, IIF*

Spectral range: *3400-6900 Å with a sensitivity gap near 5300 Å*

Field: *4.1° × 4.1° (plates: 16 × 16 cm)*

Scale: *96.8 "/mm*

Region of sky: *$\delta \geq -15^\circ$, $|b| > 15^\circ$*

Total area: *17,000 sq. degree (1133 fields, more than 2000 plates)*

Limiting magn: *17^m-17.5^m ($\leq 18.5^m$)*

Main goal: *selection of UV-excess galaxies*

Selected objects: *UV gal, Sy, QSO, BLL, LINER, SB, HII, radiogalaxies, etc.*

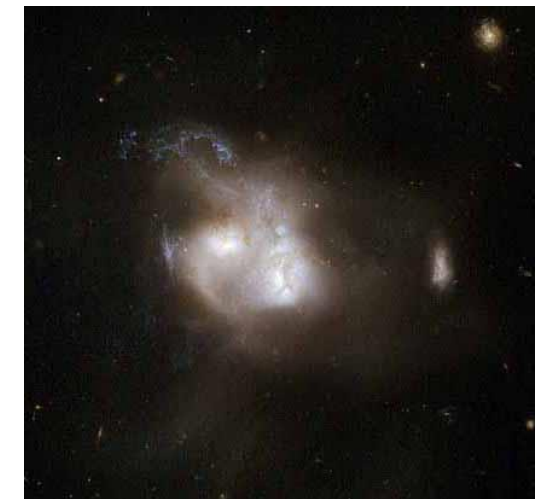
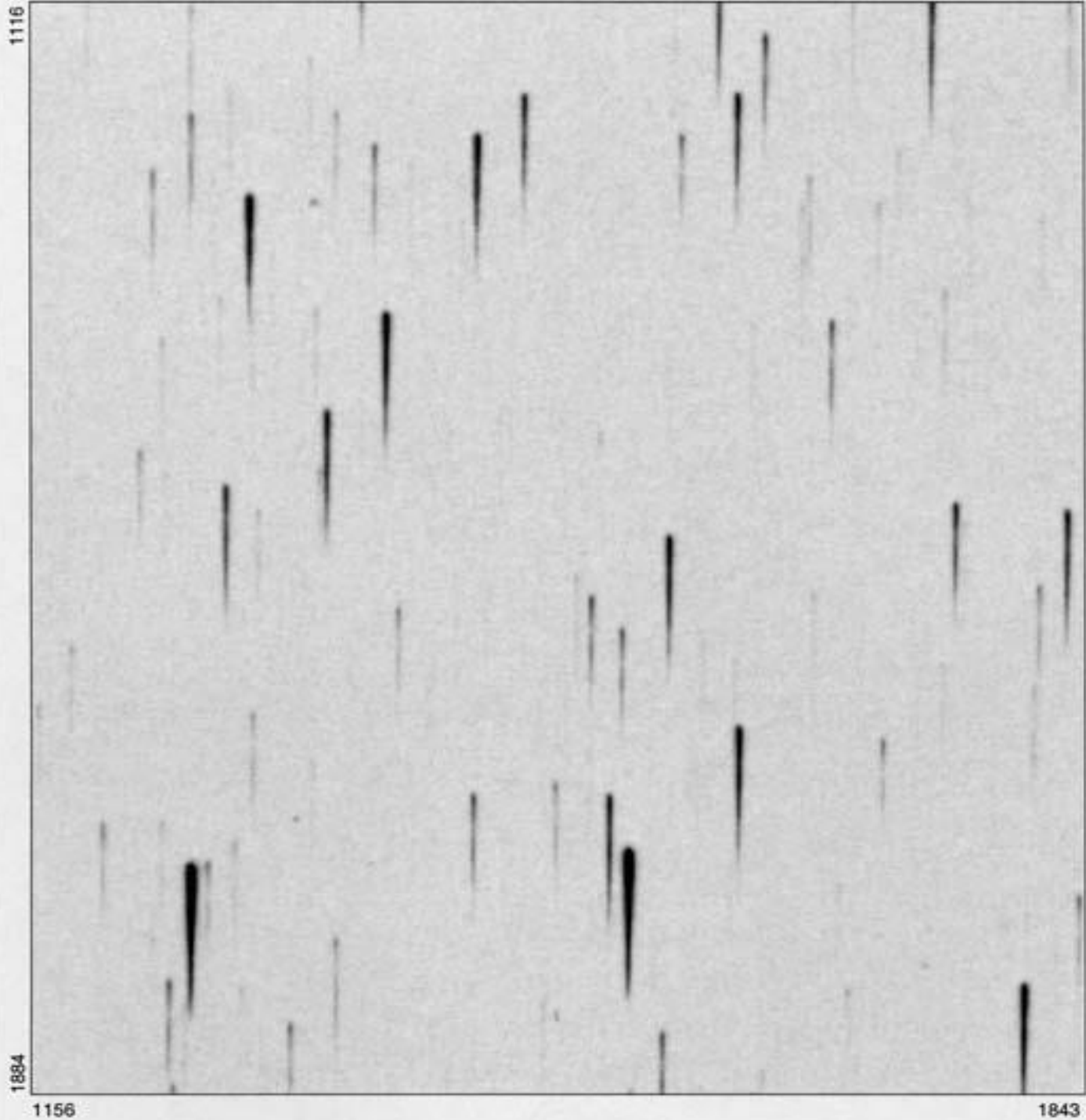
Number of objs: *1515*

Publication: *15 lists (1967-1981), 3 catalogs (Mazzarella & Balzano 1986, Markarian et al. 1989, Petrosian et al. 2007)*

The Markarian Survey

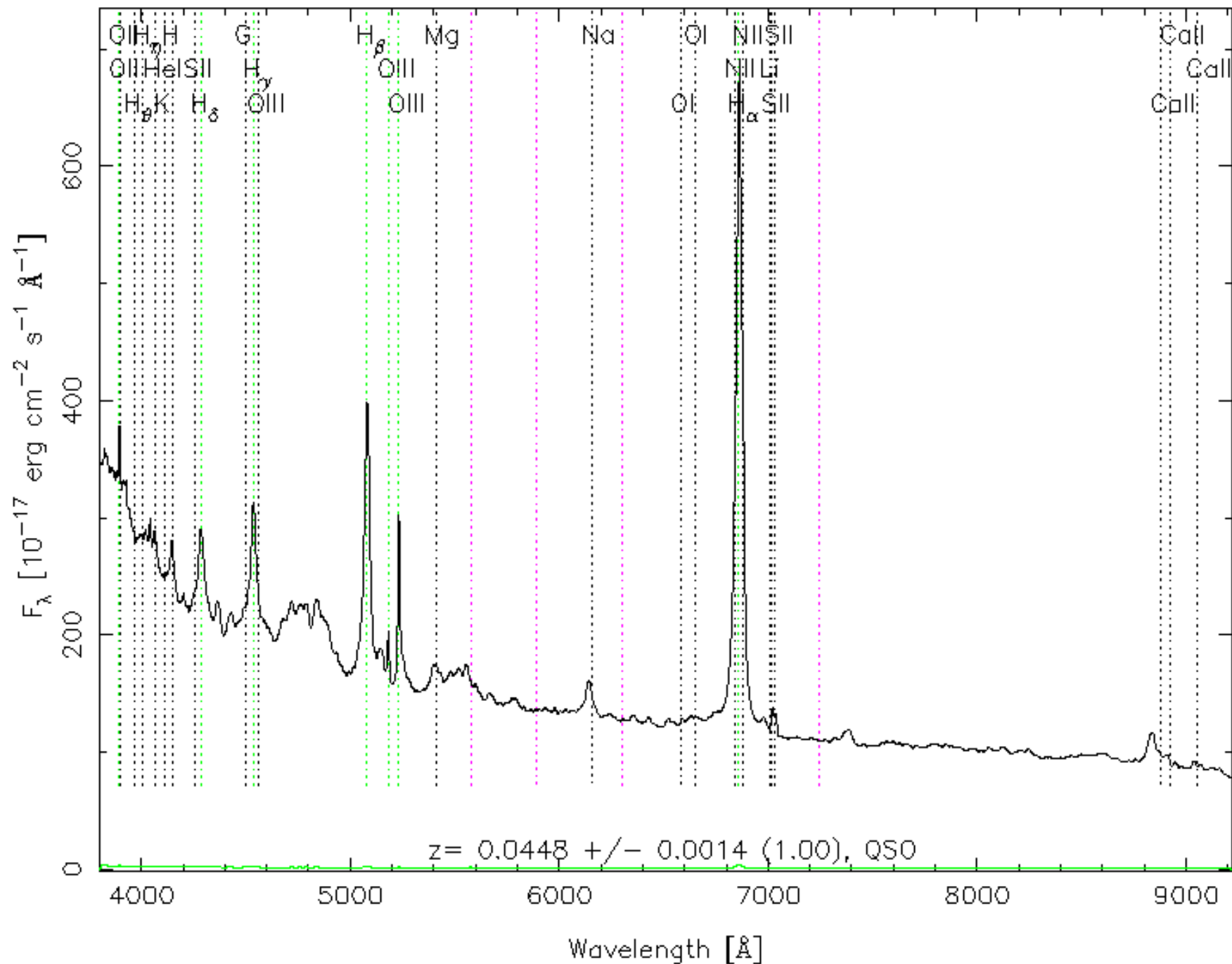


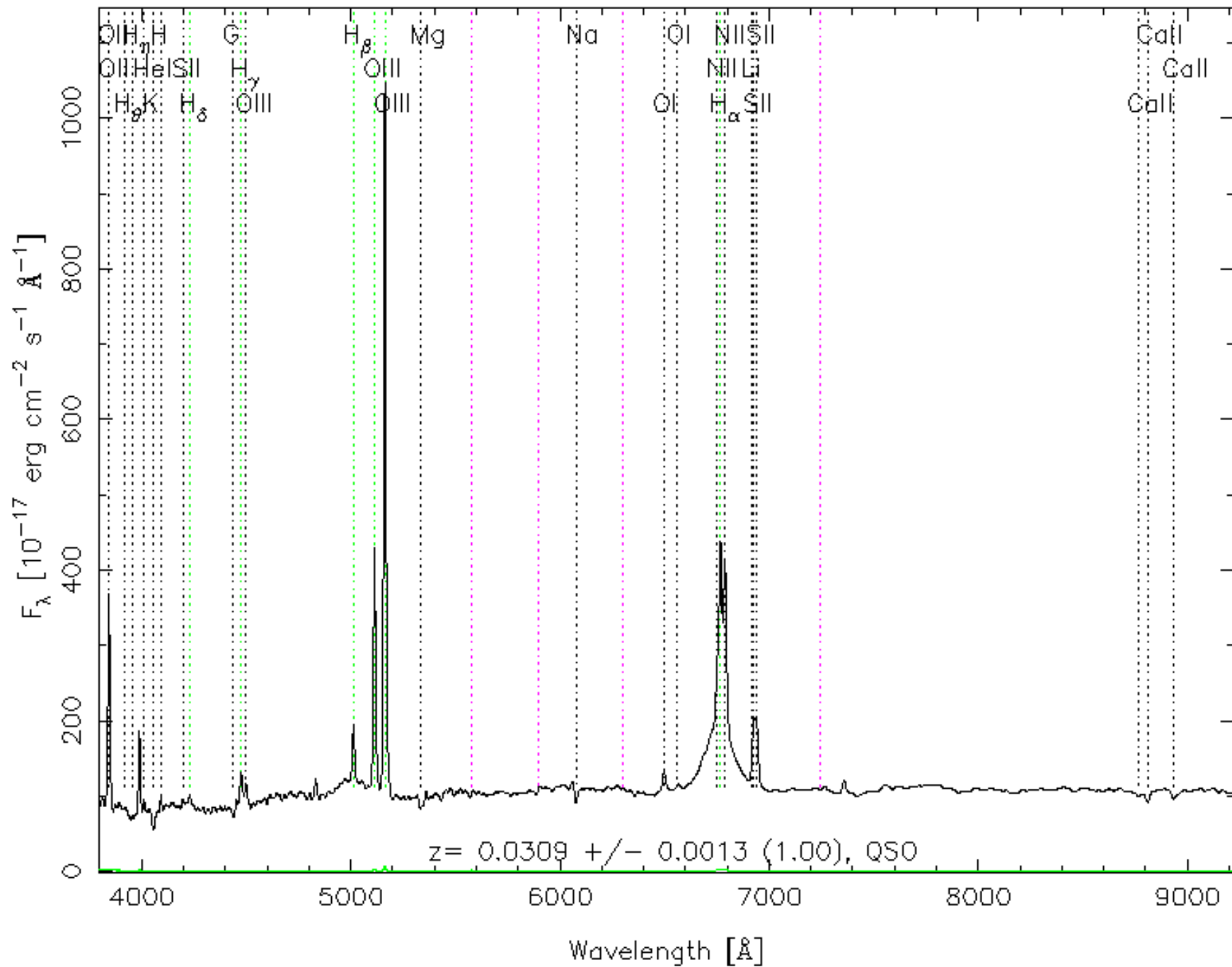
- First systematic objective-prism survey
- The largest objective-prism survey of the Northern sky (17,000 sq. deg)
- New method of search for AGNs
- 1517 UVX galaxies: 181 Seyferts, 17 LINERs, 13 QSOs, 3 BLLs, 95 Starburst, 26 HII galaxies
- Classification of Seyferts: Sy1 & Sy2 (Weedman & Khachikian)
- Definition of Starburst galaxies (Weedman)
- Other projects: FBS BSOs, RS, opt. ident. (BIG & BIS objects)



Famous Markarian galaxies

- **Mrk 231** the closest ULIRG, BAL QSO and most luminous IR galaxy in the Local Universe
- **Mrk 421, Mrk 501** are among the highest known energy sources
- **Mrk 116 (=IZw18)** the most metal-deficient (BCDG) (Mrk and SBS)
- **Mrk 938** the first dynamic merger discovered observationally
- **Mrk 110** intermediate between NLS1 and BLS1 (FWHM=4900 km/s); understanding BLS1s and NLS1s differences
- **Mrk 6** shows variations of spectral lines typical of different types of obj. (Sy2 & Sy1); very high H column density in X-rays
- **Mrk 766** one of the most important NLS1 galaxies
- **Mrk 273** a wonderful double-double nuclei galaxy
- **Mrk 266** has a multiple structure nuclear region
- **Mrk 231, Mrk 507** super strongest FeII emitters ($\text{FeII } \lambda 4570 / \text{H}_\beta > 2$)
- **Mrk 530, Mrk 993, Mrk 1018** change their spectra from Sy1.9 to Sy1.0





Mrk galaxies SDSS activity types

779 Mrk galaxies having SDSS spectra in DR7-DR9

533 HII

31 Composites (LINER/HII, Sy/HII, Sy/LINER or Sy/HII/LINER)

12 LINERs

4 Sy2.0

5 Sy1.9

8 Sy1.8

5 NLS1.5

11 Sy1.5

8 NLS1.2

21 Sy1.2

4 NLS1

4 Sy1.0

2 QSO

11 AGN (without an exact class)

52 Em (HII or AGN)

65 Abs

3 Stars

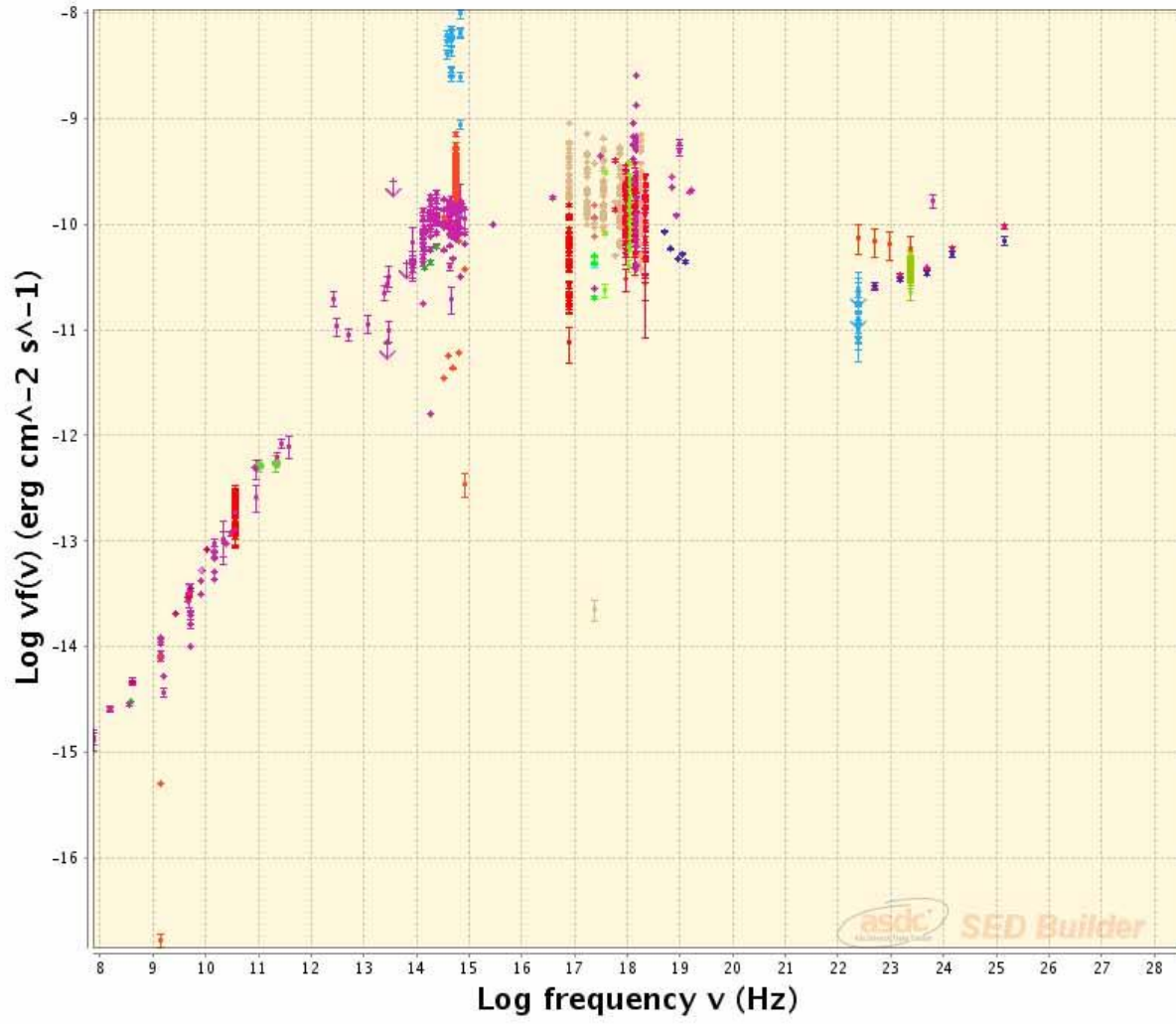


time SED tool V2.0



Version 2.1
[Login](#) [Feedback](#)
[Tutorial](#) [DATA EXPLORER](#)
[User Data](#) [Existing SEDs](#)
 Current SED Search and build new SEDs

Mrk 421 Ra=166.11381 deg Dec=38.20883 deg (NH=1.9E20 cm⁻²)



Redshift: Frame:
 X Axis: Y Axis:

+ Time Filtering

ASDC Catalogs

	Type
<input checked="" type="checkbox"/>	Radio
<input checked="" type="checkbox"/>	Infrared
<input checked="" type="checkbox"/>	Optical UV
<input checked="" type="checkbox"/>	Soft X Ray
<input checked="" type="checkbox"/>	Hard X Ray
<input checked="" type="checkbox"/>	Gamma Ray

External Catalogs

<input checked="" type="checkbox"/>	Name	Search	Options
<input checked="" type="checkbox"/>	2Mass	<input type="checkbox"/>	V U
<input checked="" type="checkbox"/>	USNO B1	<input type="checkbox"/>	V U
<input checked="" type="checkbox"/>	Catalina SS	<input type="checkbox"/>	V U
<input checked="" type="checkbox"/>	Ned	Mrk 421	V U
<input checked="" type="checkbox"/>	SDSS7	<input type="checkbox"/>	V U
<input checked="" type="checkbox"/>	USNO A2.0	<input type="checkbox"/>	V U

FBS based new science projects

FBS blue stellar objects

1103 objects: WD, sd, CV, PNN, QSO, Sy, etc.

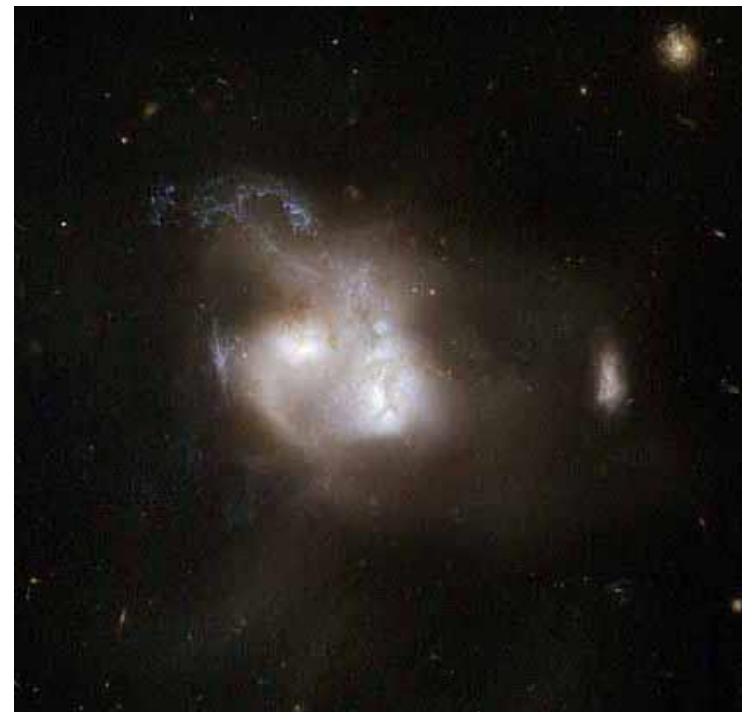
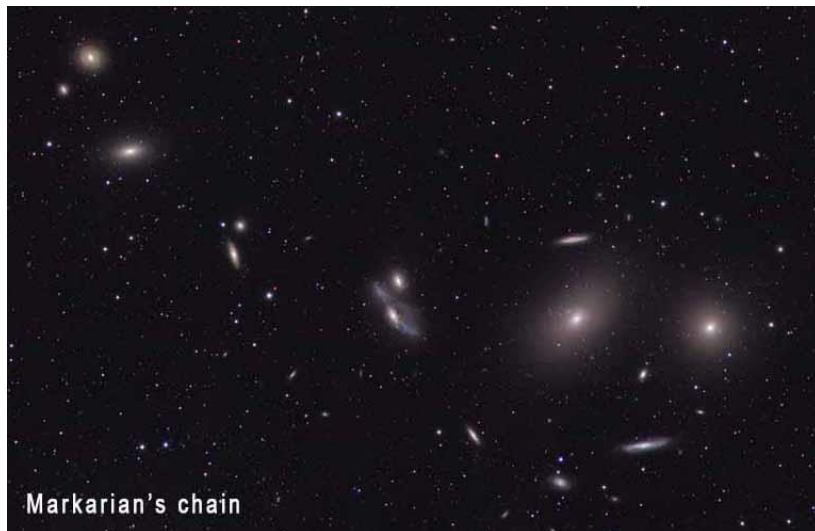
FBS late-type stars

1471 objects: C-stars, late M stars

Optical identifications of IRAS point sources

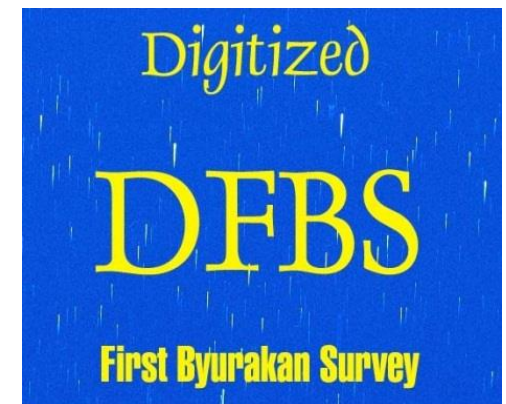
BIG objects: 1278 galaxies

BIS objects: 300 stars



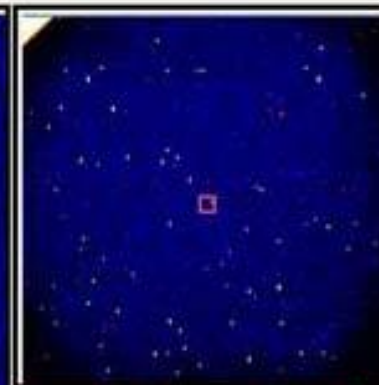
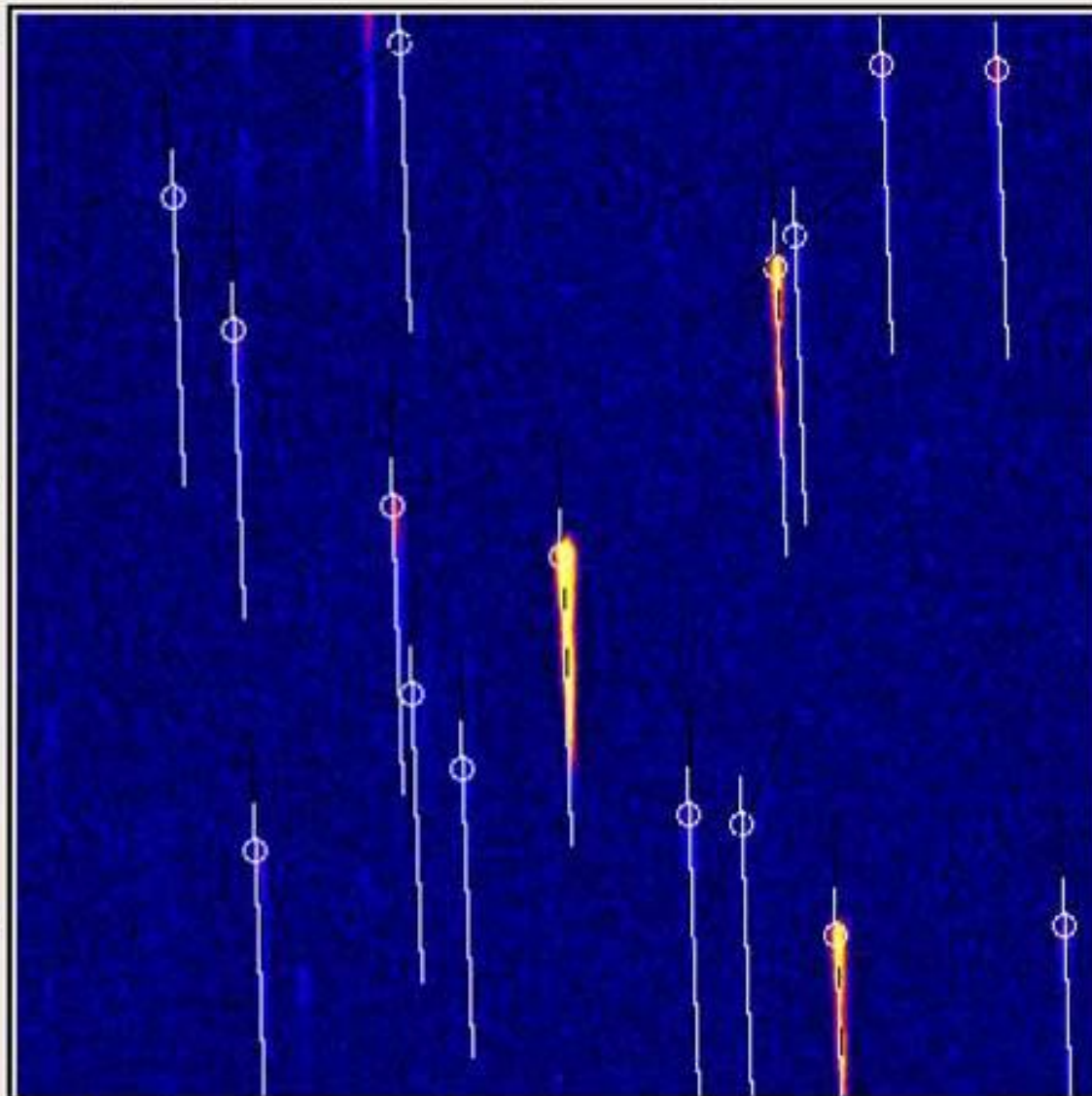
Digitized First Byurakan Survey

Teams:	<i>Byurakan Obs., Univ. Roma, Cornell Univ.</i>
Years:	<i>2002-2005+</i>
Instrument:	<i>Epson Expression 1680 Pro scanner</i>
Scanning options:	<i>1600 dpi (15.875μ pix size), 16 bit, transparency (positive) mode, "scanfits"</i>
Plate size:	<i>9601\times9601 pix, 176 MB file</i>
Spectra:	<i>107\times5 pix (1700μ in length)</i>
Dispersion:	<i>33 Å/pix average (22-60 Å/pix), 28.5 at Hγ</i>
Spectral resolution:	<i>50Å</i>
Astrometric solution:	<i>1" rms accuracy</i>
Scale:	<i>1.542 "/pix</i>
Photometry:	<i>0.3^m accuracy</i>
Data volume:	<i>1874 plates, ~400 GB</i>
Number of objs:	<i>~20,000,000 (~40,000,000 spectra)</i>



Main

image | data | Setup | log | Help | local data



Show

- Object positions
- Alignments
- Spectrum line

X: 4964 ra:14:21:13.702

Y: 5397 dec:+43:10:53.346

v: 11198

1275-08424526 <> Xlog Ylog ang: 92.30



Ell. .69

B: 12.24

B-usn 12.2

R: 11.91

R-usn 11.4

Flag: OK

s/n: 130.7

L: 120

Save List save

bck= 11057.8/1.44

1275-08424526

- name
- coords

Find>

Auto Manual | Mag | Finding |

Manual operations

Load Fits

Compute angle

Get Spectra

Fits File: /fbs/images/fbs0005_cor.fits

file dati: /fbs/usn2/fbs0005_cor.coo

Density



DFBS archive
Digitized First Byurakan Survey

[EXPLORE](#) [GET SPECTRA](#) [CREDITS](#)
[GET IMAGE](#) [TEAM](#)

Download as

Query type
single

center
Ra: 21:32:03
Dec: -12:47:42
size: 10 amin

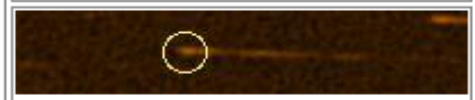
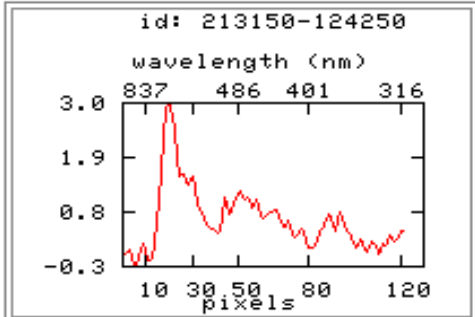
Radius Box

options
Order by: ra
and by: dec
mag range: -7. ≤ R ≤ 17
lines in table: 50

selected 31 of 31 records [Download this table](#) [log file](#)

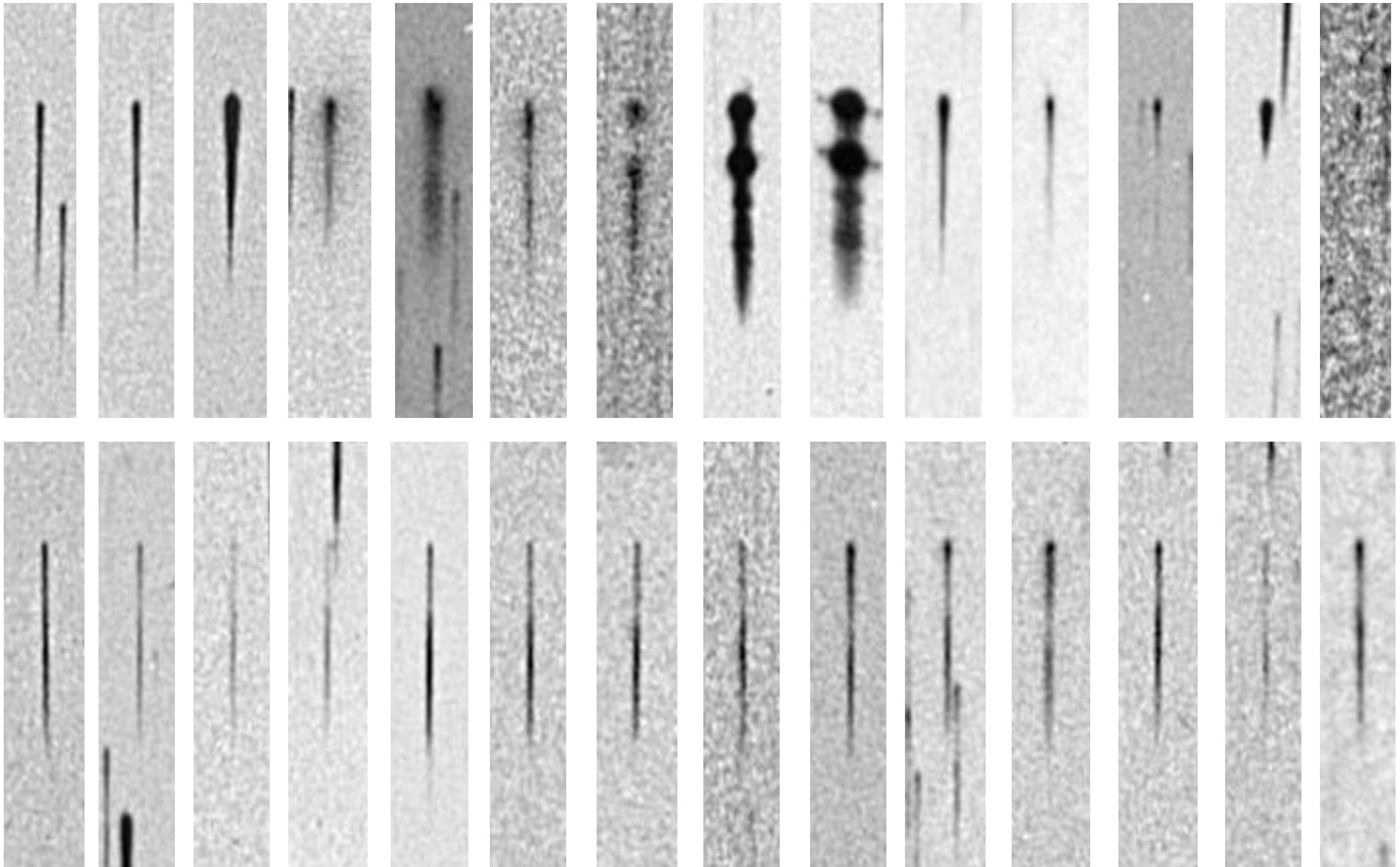
Spectra List Table

#.	id.	ra(2000)	dec(2000)	B mag	R mag	B-R
1	213143-124622	21:31:43	-12:46:22	15.38	14.29	1.09
2	213148-124541	21:31:48	-12:45:41	14.85	14.10	0.75
3	213148-125004	21:31:48	-12:50:04	16.39	15.84	0.55
4	213150-124250	21:31:50	-12:42:50	15.16	14.17	0.99
5	213150-124437	21:31:50	-12:44:37	16.84	15.92	0.92
6	213150-124714	21:31:50	-12:47:14	13.10	12.46	0.64
7	213154-124814	21:31:54	-12:48:14	14.10	12.90	1.20
8	213154-124927	21:31:54	-12:49:27	16.02	13.96	2.06
9	213155-124419	21:31:55	-12:44:19	15.52	14.30	1.22
10	213155-124400	21:31:55	-12:44:00	15.53	14.31	1.22
11	213156-124841	21:31:56	-12:48:41	14.10	12.93	1.17
12	213157-124559	21:31:57	-12:45:59	10.42	11.04	-0.62
13	213158-124307	21:31:58	-12:43:07	16.24	16.07	0.17
14	213158-124534	21:31:58	-12:45:34	10.38	11.01	-0.63
15	213200-124549	21:32:00	-12:45:49	17.09	16.73	0.36



(J2000)
ra: 21:31:50.273
(J2000)
dec: -12:42:50.61
R: 14.17
B: 15.16
Class: U
Length: 110.0
Plate: fbs1053

DFBS low dispersion spectra



DFBS and VO

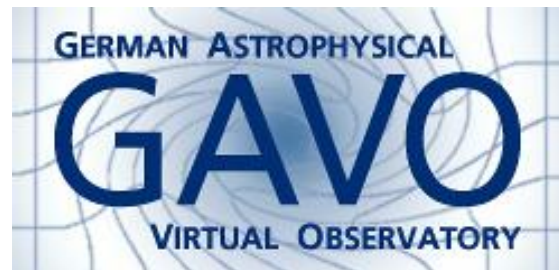
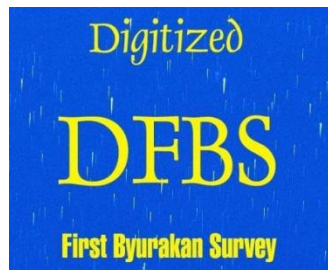
Previous attempts: **OBSPM, France; CRAL, Lyon, France**

Collaboration with **Astronomisches Rechen-Institut: Zentrum für Astronomie, Heidelberg, Germany; *Markus Demleitner, Joachim Wambsganss, Hendrik Heintz***

MES-BMBF (BAO-ARI, also IIAP, Armenia), ArVO-GAVO collaboration

Making DFBS VO compliant:

- **Data available through TOPCAT**
- Publishing in **GAVO DaCHS** service
- **SIAP and SSAP** services for DFBS images and spectra
- **Classification of spectra**; templates for QSOs, WDs, C stars, etc.



Second Byurakan Survey (SBS)

Authors: *B.E.Markarian, J.A.Stepanian, L.K.Erastova,V.H.Chavushyan*

Years: *1978-1991*

Instruments: *102/132/213 cm Byurakan Schmidt, 1.5°, 3° & 4° prisms
(1800 Å/mm, 900 Å/mm & 280 Å/mm at H γ)*

Emulsions: *Baked Kodak IIIa-J, IIIa-J+GG495, IIIa-F+RG2, IV-N*

Spectral range: *3400-5300 Å, 4950-5400 Å, 6300-6950 Å*

Field: *4.1° × 4.1° (plates: 16 × 16 cm)*

Scale: *96.8 "/mm*

Region of sky: *49° ≤ δ ≤ 61°, |b| > 30° (7^h43^m ≤ α ≤ 17^h15^m)*

Total area: *965 deg² (65 fields, 550 plates)*

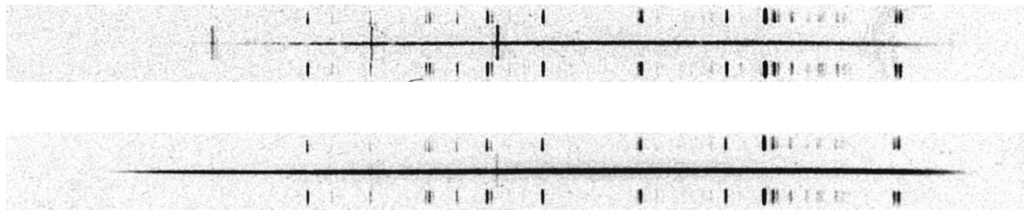
Limiting magn: *18^m-20^m in V (completeness is ≤ 17.5^m)*

Main goal: *Extension of the FBS to fainter magnitude limits*

Methods: *UVX / emission lines / SED*

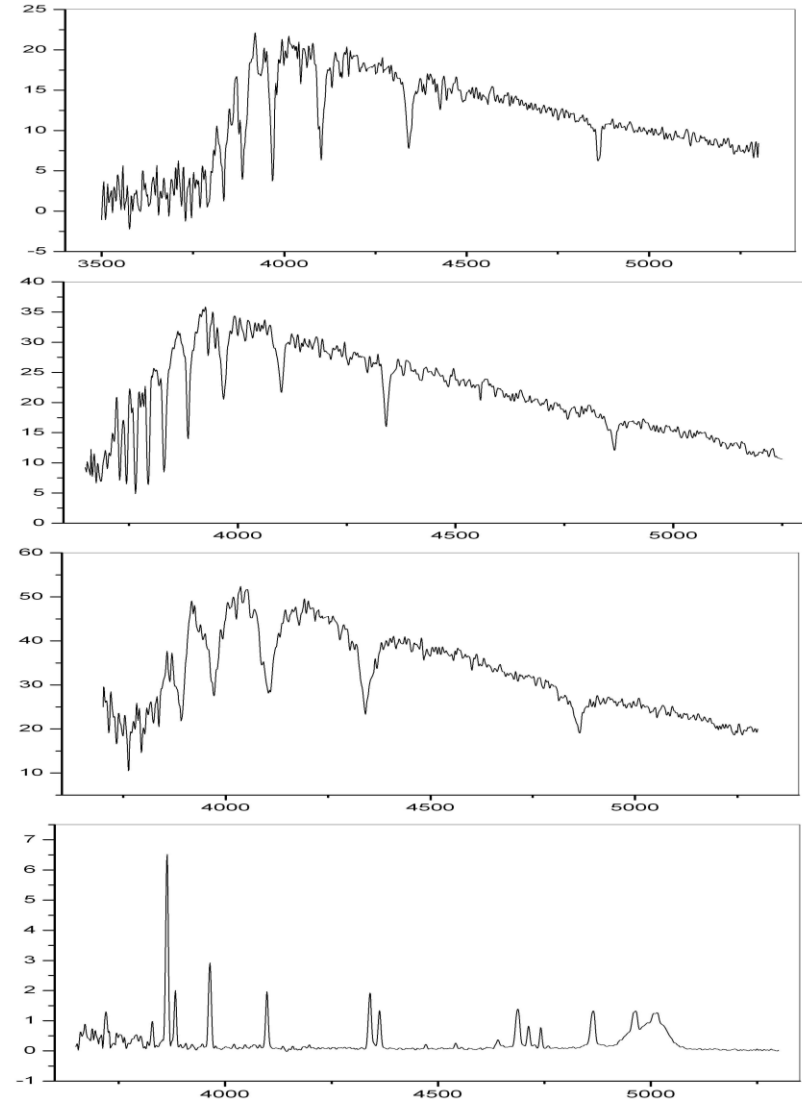
Digitization: *since 2003: 16 bit, 2400 dpi (10 μ pixel size); 180 SBS plates*

Other digitization projects: Photographic spectra of the FBS BSOs



Scanning spectra: 1600 dpi,
16 bit, 650x21 pix sizes
~700 spectra have been
digitized (FBS blue stellar
objects & late-type stars), 101
published

A new PN (FBS 2323+421), 7
white dwarfs (DA, DAB, DZ),
78 hot subdwarfs, 9 HBB stars
have been revealed.

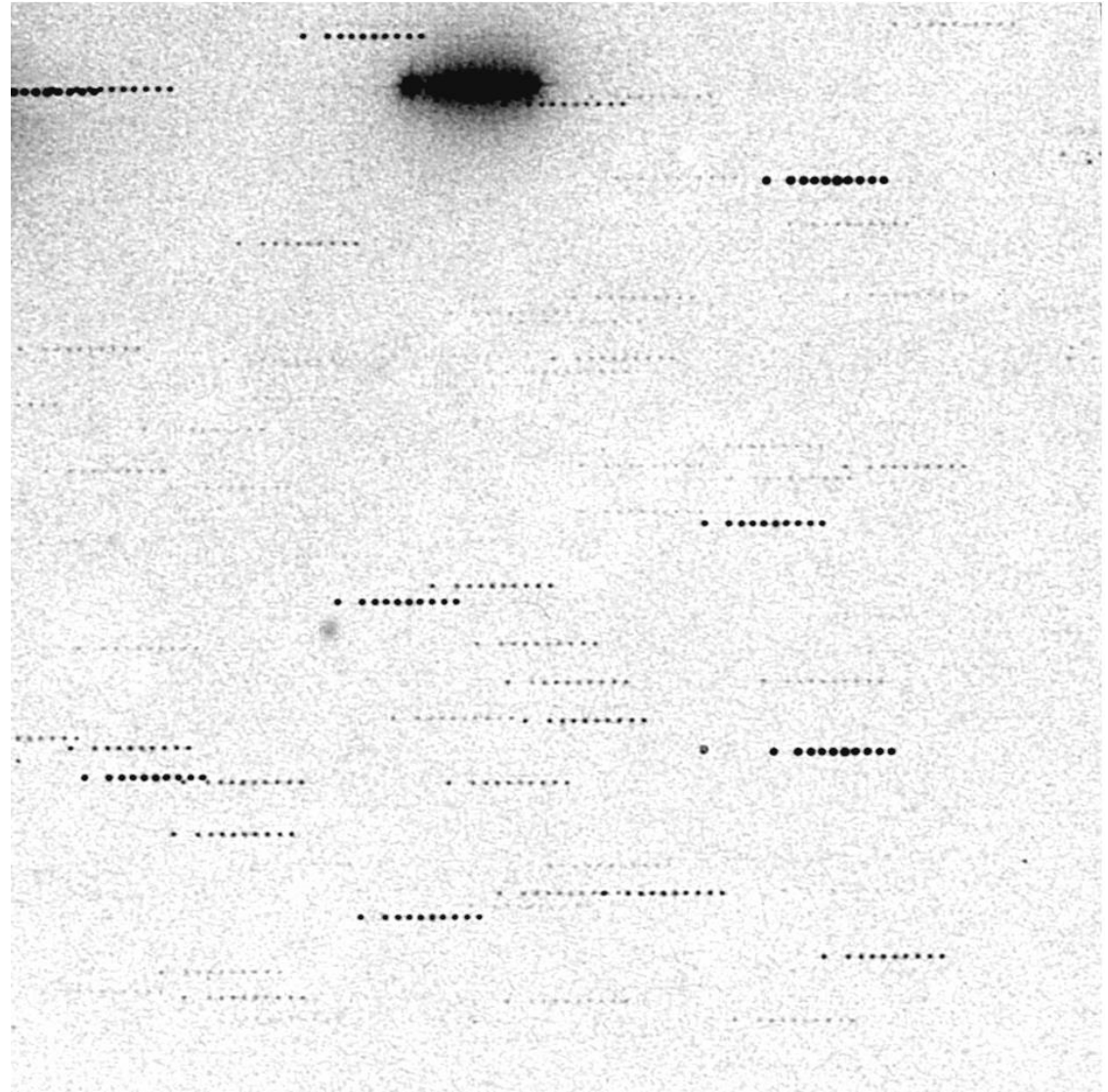
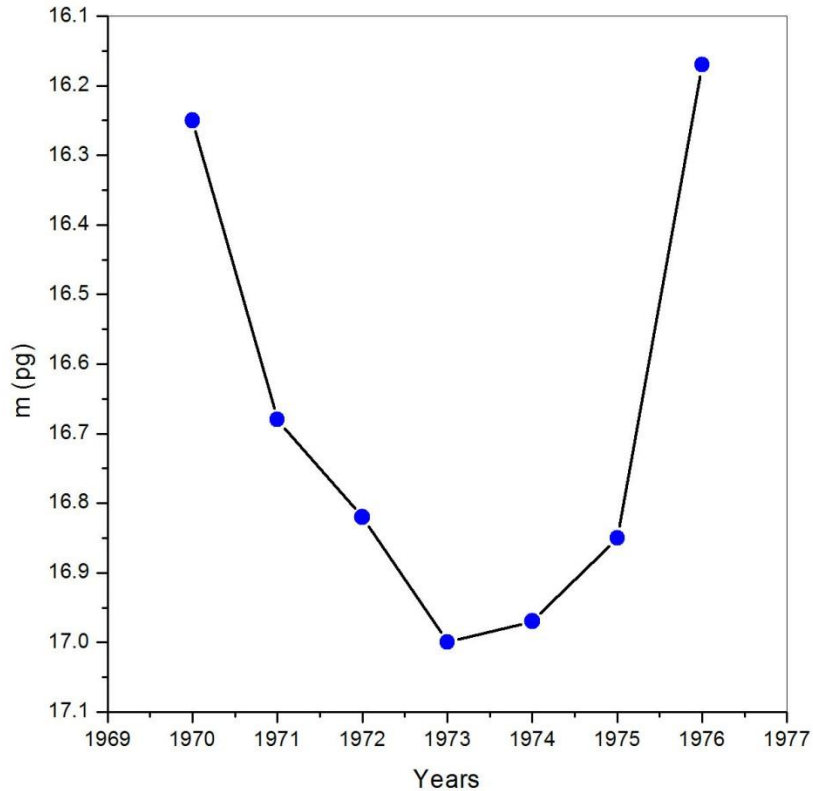


Other digitization projects:

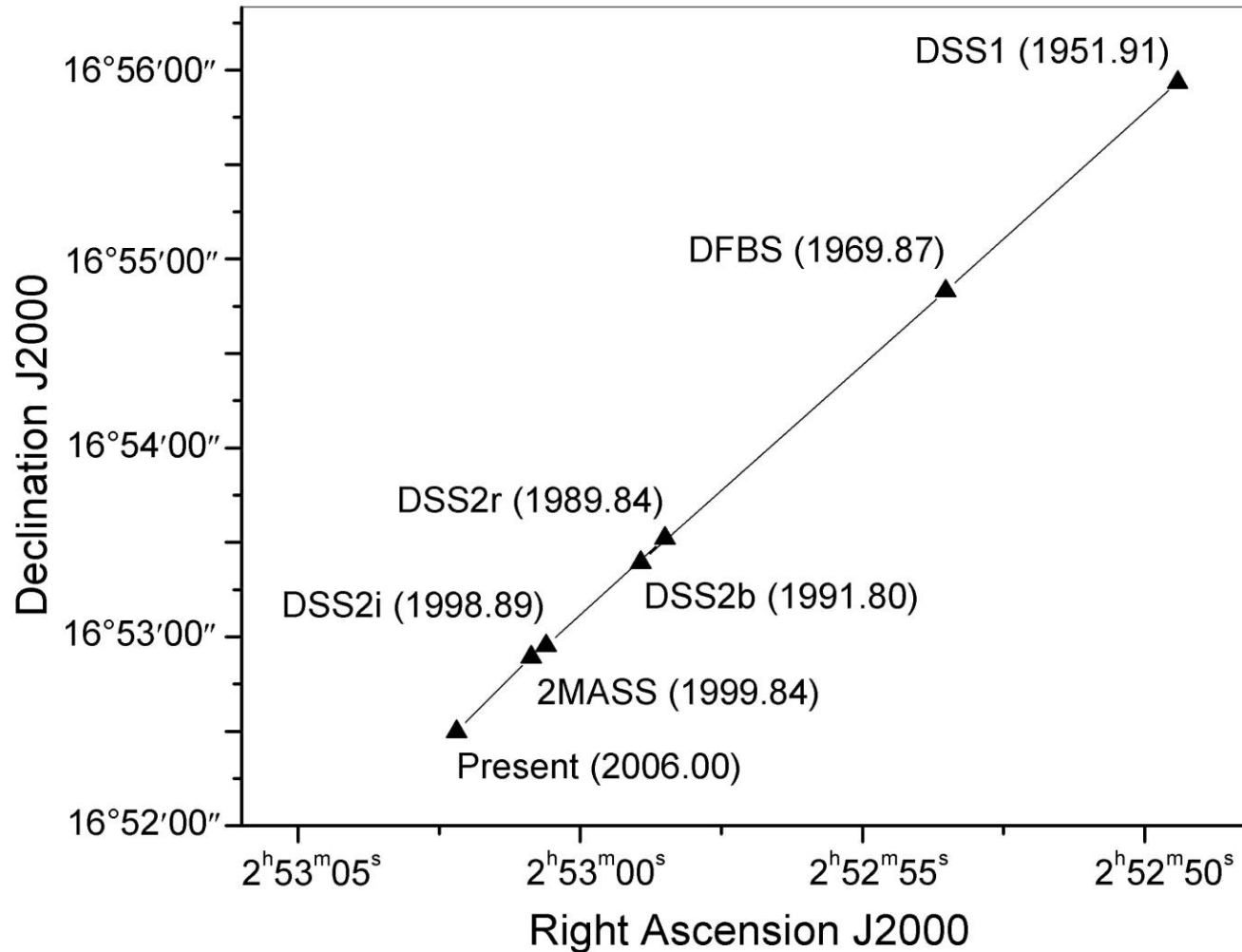
Study of long-term variability of ON 231

Photographic chains for discovery of flare stars in stellar clusters

Coma: 189 plates with a total number of more than 1200 exposures in 1965-1976 with the Byurakan 21" and 40" Schmidt

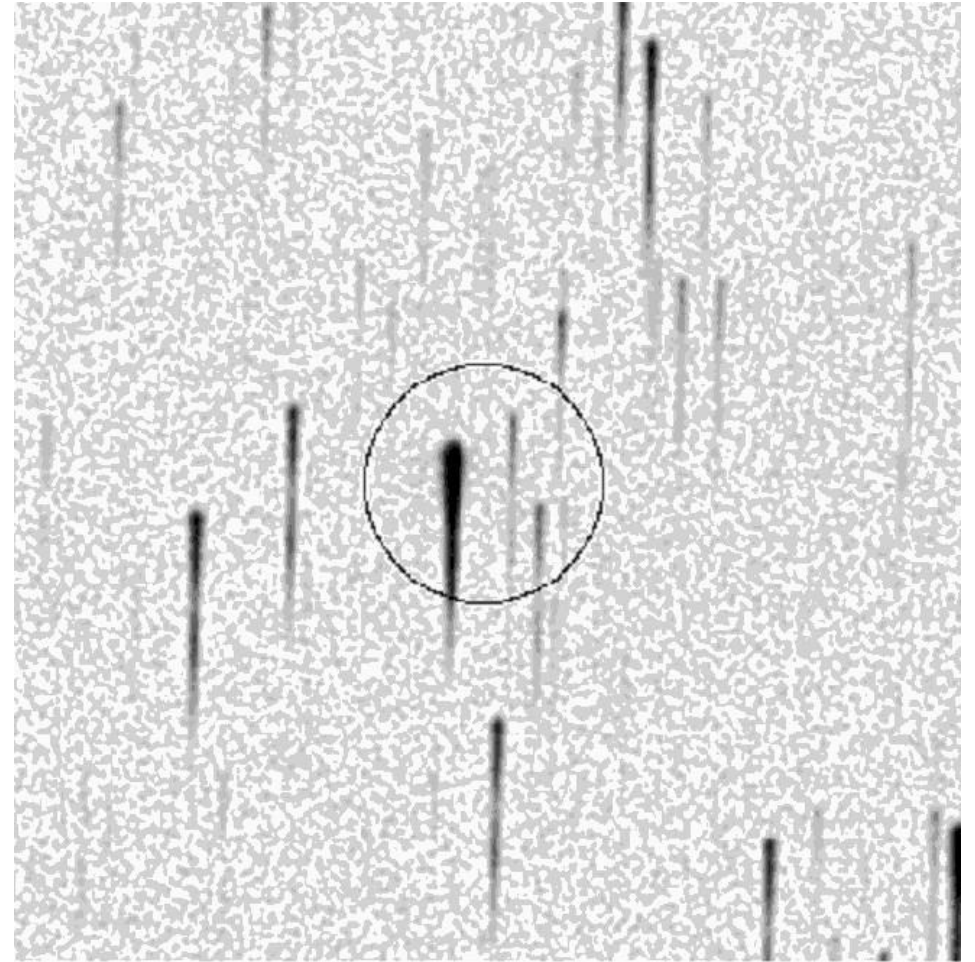
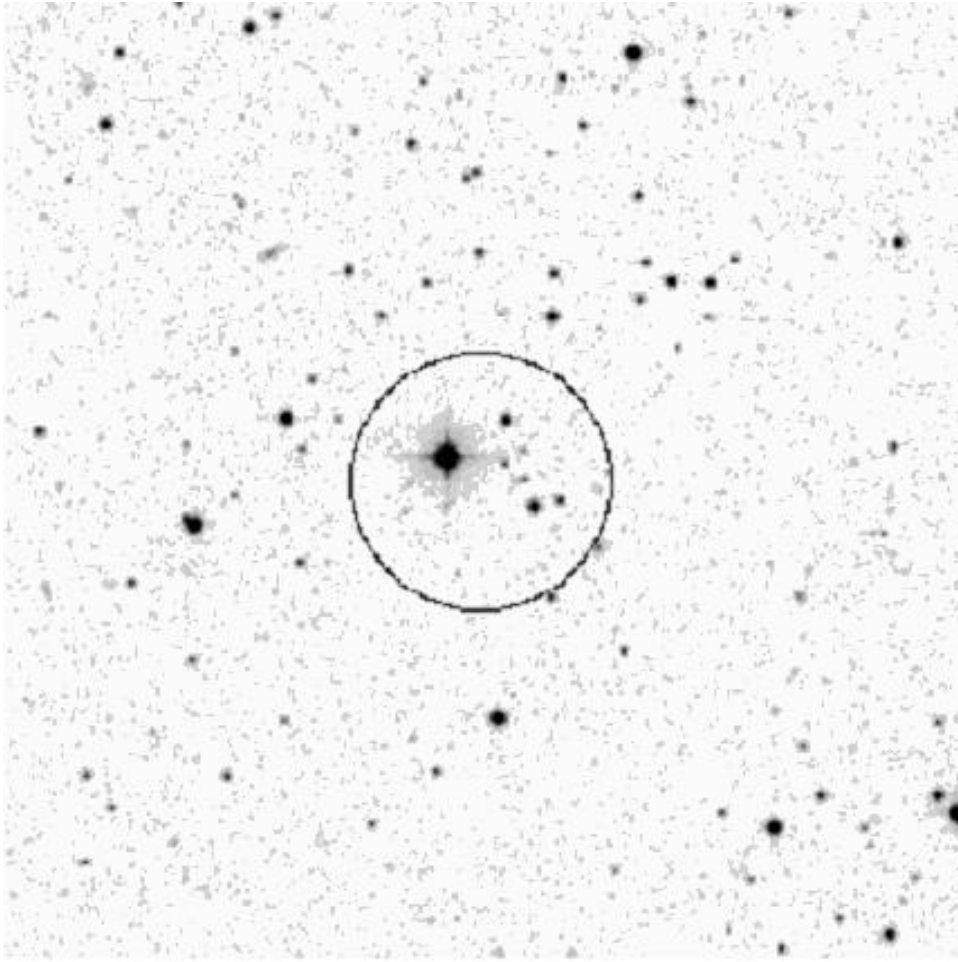


High proper motions

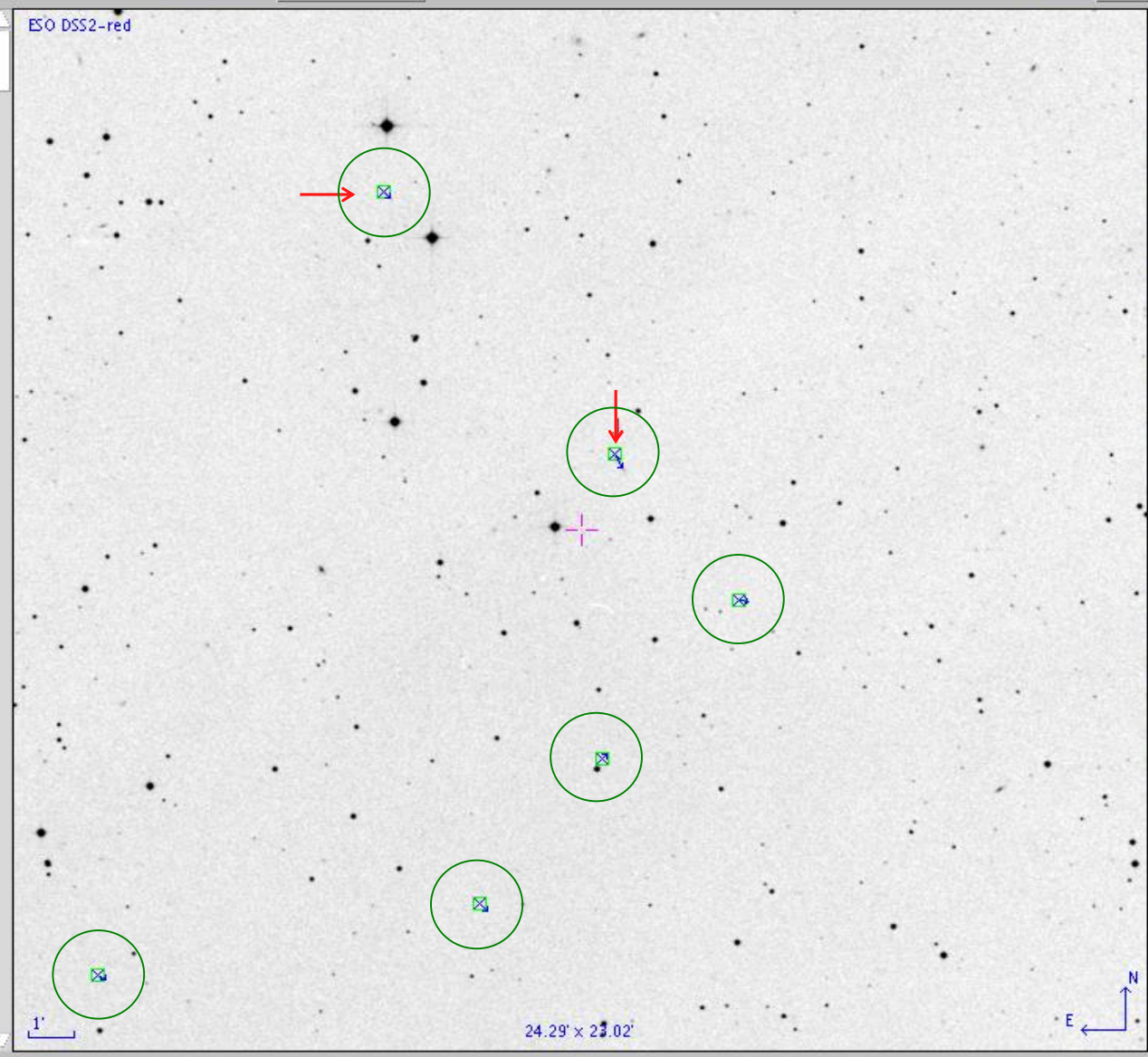


FBS 0250+167, PM=5.050 as/yr

Optical identification of X-ray, IR and radio sources



ROSAT FSC, IRAS PSC & FSC, NVSS, FIRST sources



select
dist
draw
tag
text
filter
rgb
blink
rsamp
cont
zoom
mqlss
hist
prop
del

SkyBoT 19!
ESO DSS2-

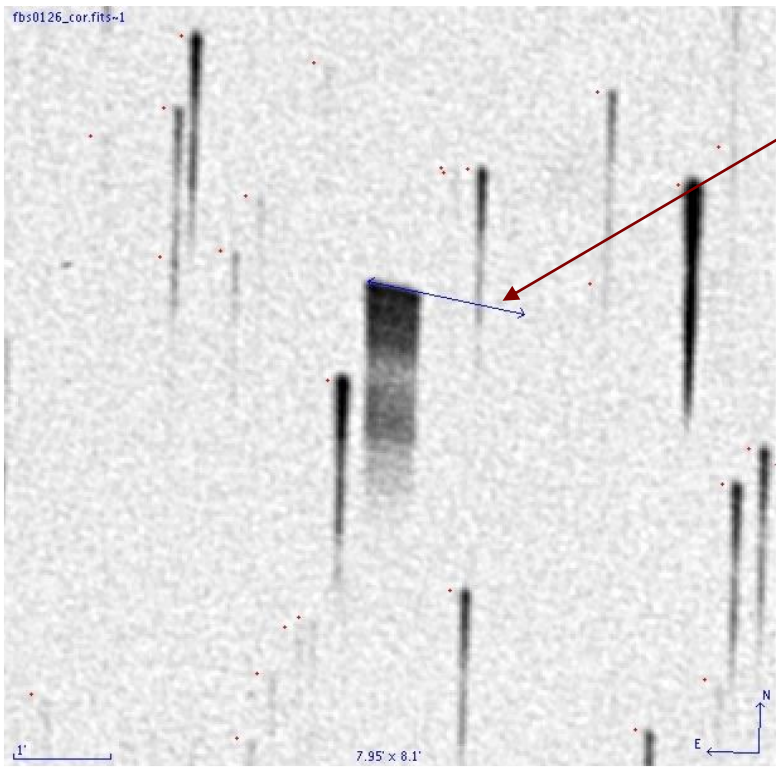
Catalogs:

- All VizieR
- Surveys
- Missions
- WMAP
- NED
- SkyBot
- Others..

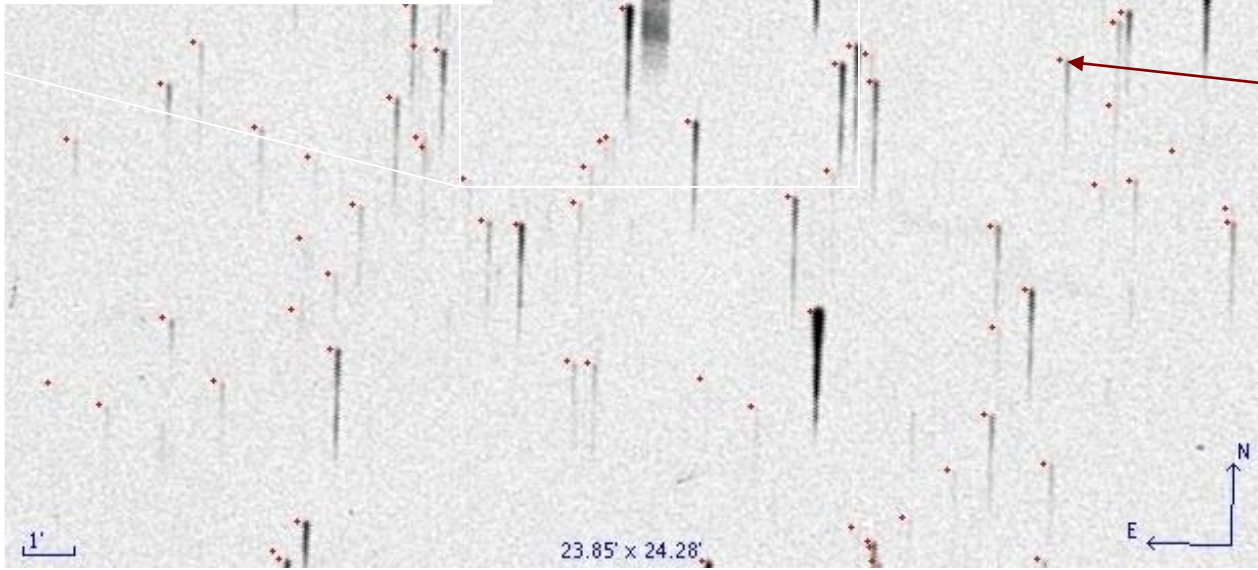
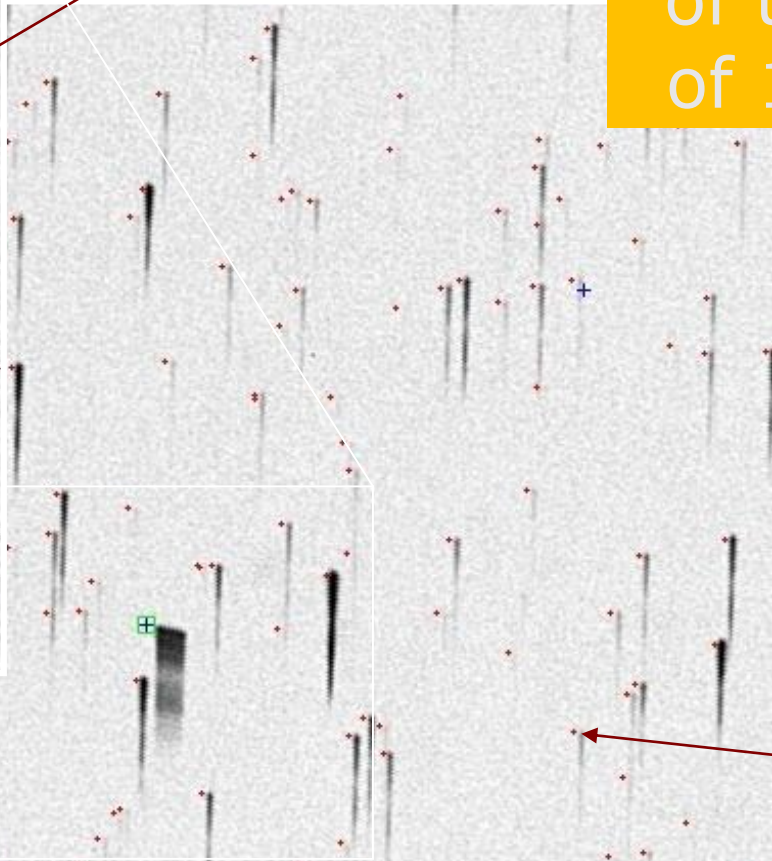
- ESO DSS2-red - provided by The Digitized Sky Survey from ESO (Garching) Zoom 1/2x

40441	Jungmann	03 22 22.2444	+12 55 12.081	MB II	18.15	3.241	18.269	-10.6767	-17.4
-	2001 UJ20	03 22 11.2982	+12 51 59.549	MB	20.27	-49.035	261.932	-12.0898	-1.2
-	2002 W28	03 22 23.3380	+12 48 30.273	MB I	19.33	-10178.050	420.180	-5.9700	5.3
12797	1995 WL4	03 22 42.4998	+13 01 00.272	MB I	18.17	-1.987	445.387	-8.2496	-7.8
-	2002 RT159	03 22 34.1425	+12 45 18.021	MB IIIb	19.87	31023.000	637.034	-11.6642	-9.4

Identification of the spectrum of 104 Klymene



Apparent velocity



USNO stars (in red)



BYURAKAN ASTROPHYSICAL OBSERVATORY PLATE ARCHIVE PROJECT



- HOME
- BAO OBSERVATIONS
- DIGITIZATION PROJECTS
- PROJECT DESCRIPTION
- PROJECT TEAMS
- DATA ACCESS
- INTERACTIVE SKY MAP
- FOLLOW-UP PROJECTS
- DELIVERABLES
- RELATED LINKS

Telescopes

Observers

Observing programs

Publications

BAO Plate Archive



Byurakan Astrophysical Observatory (BAO) Plate Archive is one of the largest astronomical archives in the world and is considered to be BAO main observational treasure. Taking into account the hard work of Armenian astronomers and the work of BAO telescopes and other expensive equipment, as well as the results of their activities, one can say that the Plate Archive is one of our national scientific values. Due to Viktor Ambartsumian's brilliant ideas and the mentioned observational work, RA Government has recognized BAO as National value.

Today BAO archive holds 37,500 astronomical plates, films or other carriers of observational data. However, previous observational and informational registration methods currently do not make it available to wide range of scientists, and especially its usage for solution of new research problems.

The digitization of astronomical plates and films pursues not only the maintenance task, but also it will serve as a source for new scientific research and discoveries, if only the digitized material runs according to modern standards and, due to its accessibility, it will become an active archive.

The project is aimed at compilation, accounting, digitization of BAO observational archive photographic plates and films, as well as their incorporation in databases with modern standards and methods, providing access for all observational material and development of new scientific programs based on this material.



Armenian Plate Archive and Digitization Projects

BAO telescopes & observational material

Telescope name	Size (cm)	Years	Observ. methods	Plates
5" double-astrograph	13	1947-1950	photometry	3000
6"	15	1947-1950	photometry	3000
8" Schmidt	20/20/31	1949-1968	photometry	4500
20" Cassegrain	51/800	1952-1991	electrophotometry	
10" tel.-spectrograph	25	1953-	spectra	
nebular spectrograph		1954-	spectra	
16" Cassegrain	41/400	1955-1991	electropolarimetry	
21" Schmidt	53/53/183	1955-1991	photometry	12000
40" Schmidt (AZT-10)	102/132/213	1960-1991	photom., spectra	7500
ZTA-2.6m	264/1016	1975-1991	photom., spectra	7000
All telescopes		1947-1991		37000

Small/medium-size and big telescopes

pros and cons

Characteristics	Small/medium-size telescopes	Big telescopes
Collecting area D^2	poor	good
Price	affordable	high
Number of telescopes	big	small
Observing time pressure	small	big
Number of objects	big	small
Mobility	no/yes	no
Resolving power $1.22 \lambda/D$	poor	good
Field of view	big	small
Equipment	portable	dedicated
Weight (deformations)	small	big
Observing costs	small	big
Maintenance costs	small	big
Collaborative projects	many	few
Software systems	standard	dedicated

Past and present observations

Numbers

Photographic era

Digital era

Telescopes

×

×

Wavelength coverage

0

×

Limiting magnitude

0

×

Spatial/spectral resolution

0

×

Total observing time

×

×

Number of exposures

×

0

Number of observed objects

×

×

Number of bytes

0

×

Time coverage

×

0

Sky coverage

×

×

Number of results

×

×

Amount of funds

×

0