

Towards Kazakhstani Virtual Observatory

Yerlan AIMURATOV and Chingis OMAROV

[Fesenkov Astrophysical Institute, Almaty, Kazakhstan]

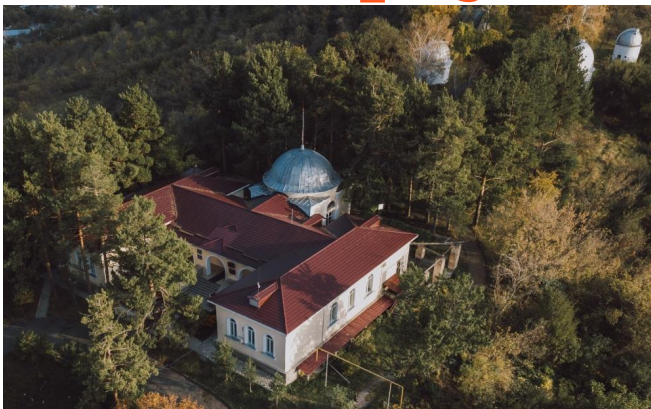
for

IVOA Exec Meeting, Zoom, October 11th, 2022

OUTLINE:

1. Who we are?
2. Project: a basis for Kazakhstani Virtual Observatory
3. Project Aims
4. Project Objectives
5. Current progress
6. What next? Further plans and funding
7. Supervision in VO via mentoring and internship
8. Conclusion

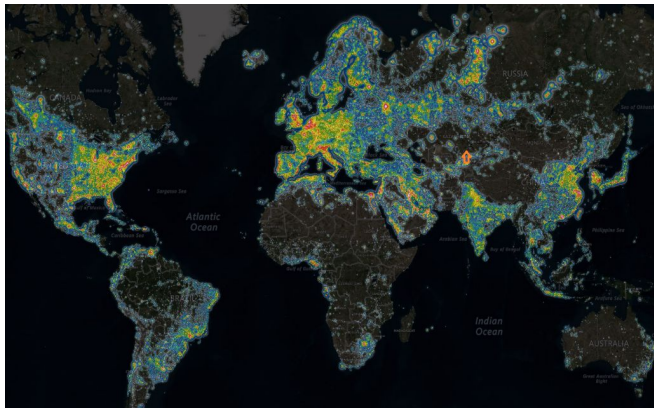
Esenkov Astrophysical Institute



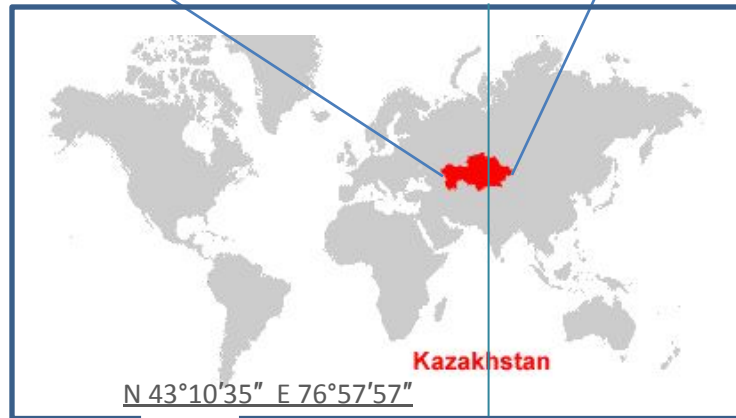
FAI main building



Almaty



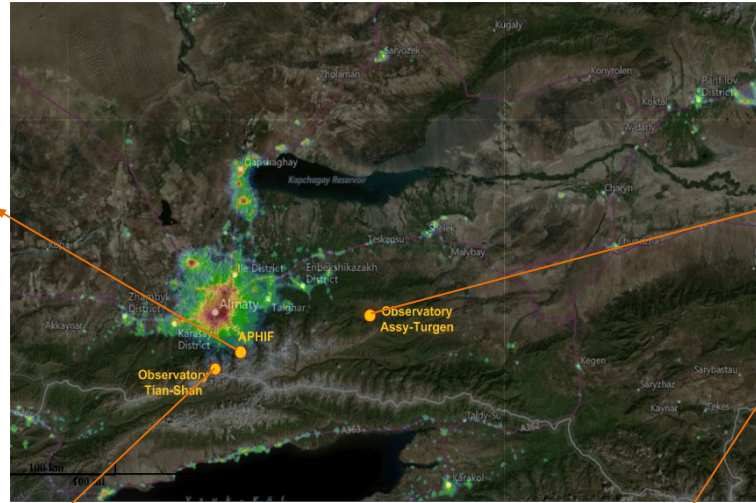
World light pollution map



Three observational bases



Kamenskoye Plateau Observatory (1450 m)



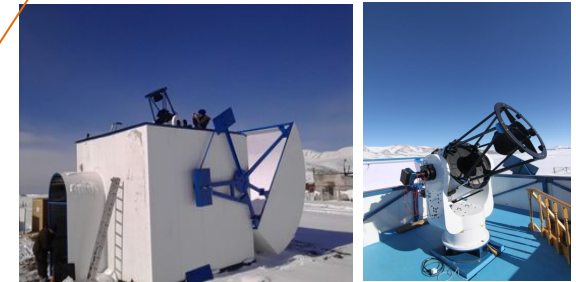
Light pollution map



Assy-Turgen Observatory (2750 m)



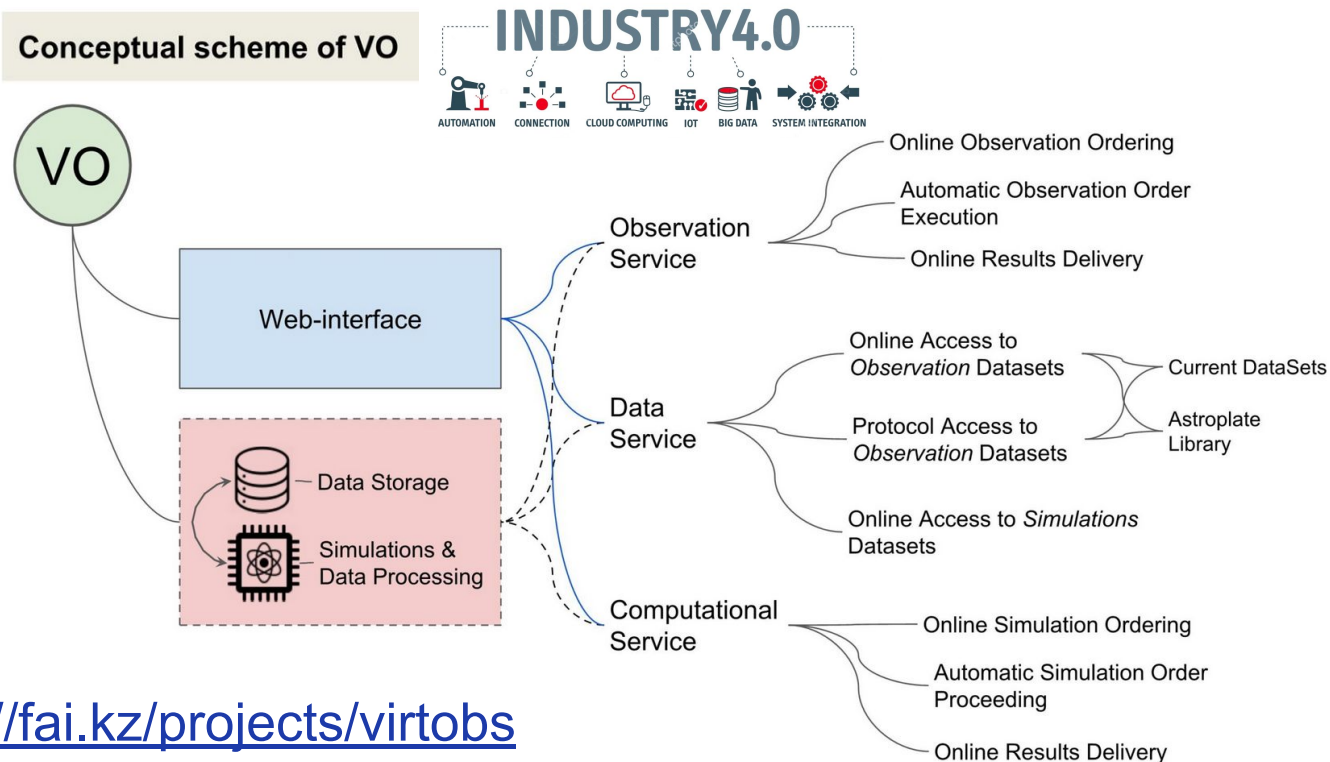
Tien-Shan Astronomical Observatory (2840 m)



NU special fast-opening dome telescope CDK700

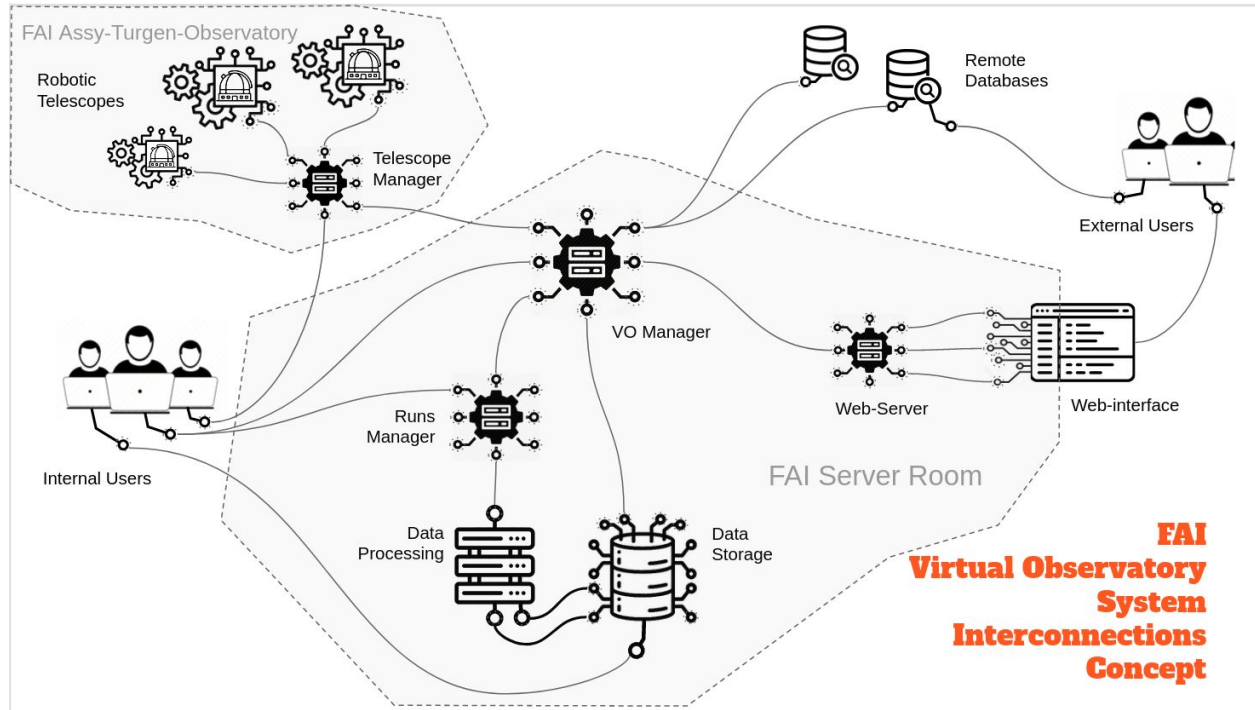
Project: Development of the national Virtual Observatory based on robotic telescopes, Big-Data technologies, and high-performance computing (No. BR10965141)

Conceptual scheme of VO

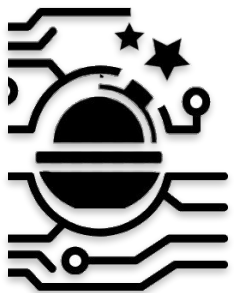


The goal and general conception of the program:

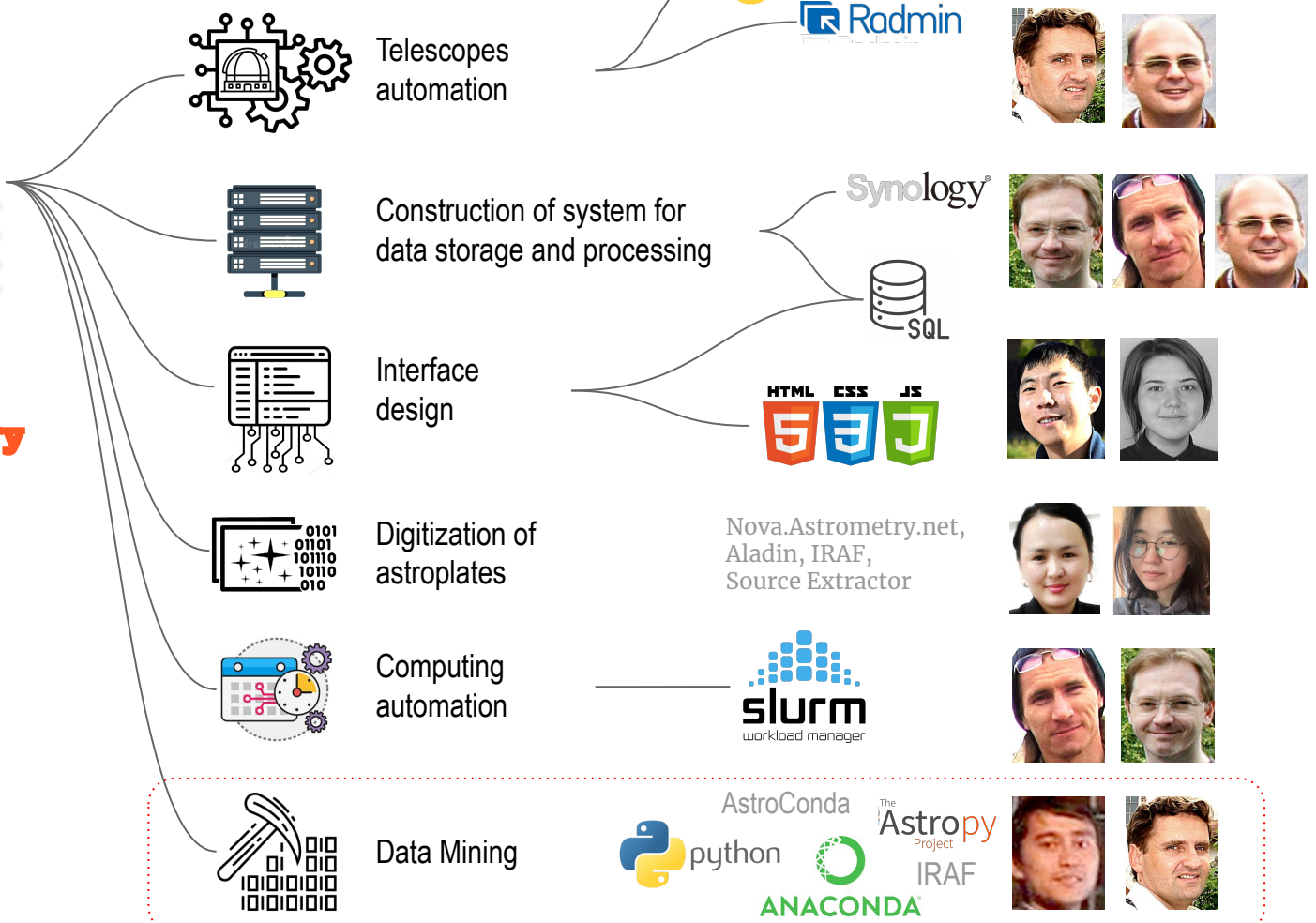
Creation and development of the National Virtual observatory to enhance the capabilities of astronomical research and provide services to external users. Development of the methods to process, store and analyze Big Data in astronomy for the investigation of near-Earth and deep space objects.



General tasks for EAI VO



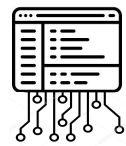
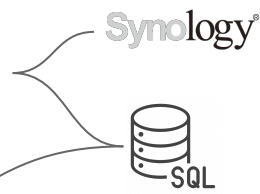
National Virtual Observatory



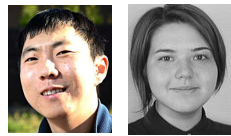
Telescopes automation



Construction of system for data storage and processing



Interface design



Digitization of astroplates

Nova.Astrometry.net, Aladin, IRAF, Source Extractor



Computing automation



Data Mining

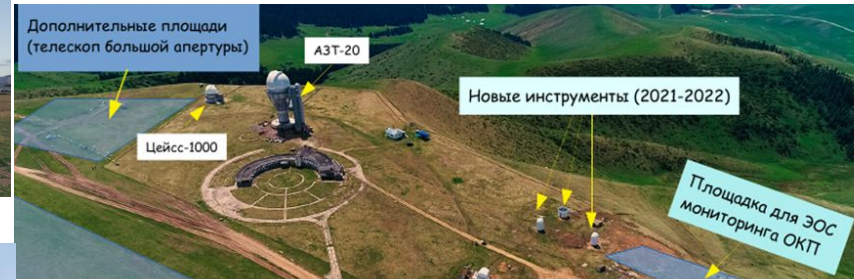
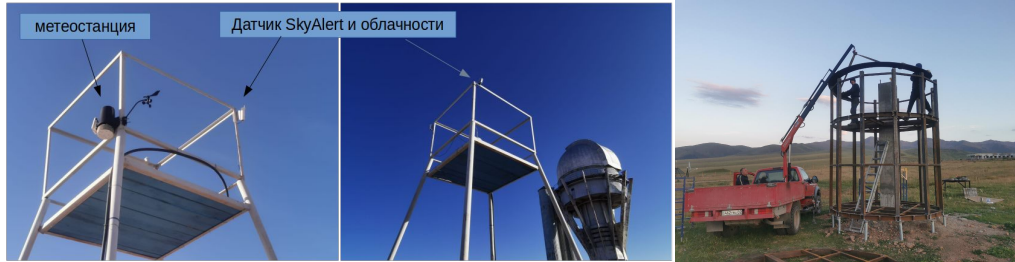


Task 1: Development of control system for remotely operational optical telescopes



Results in six months of **2021**:

1. Observatory infrastructure development [in progress]
2. Telescopes and equipment automation [in progress]
3. Data reduction software development [in progress]

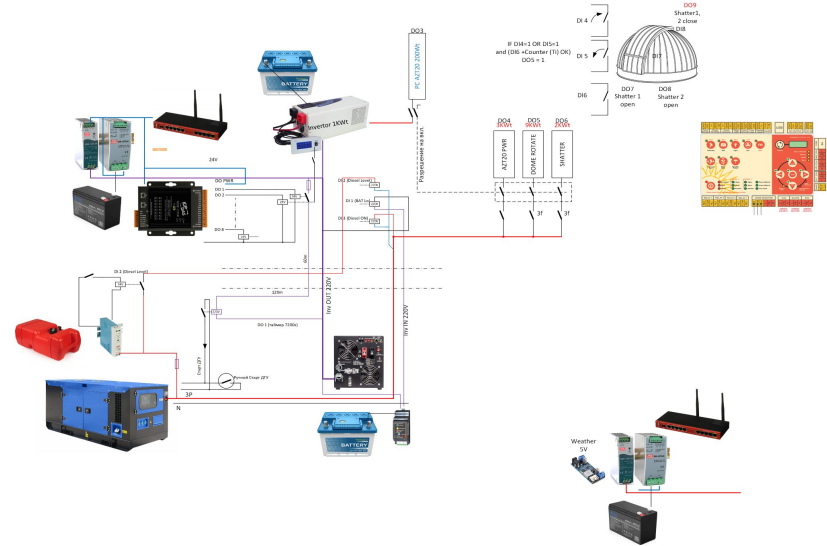
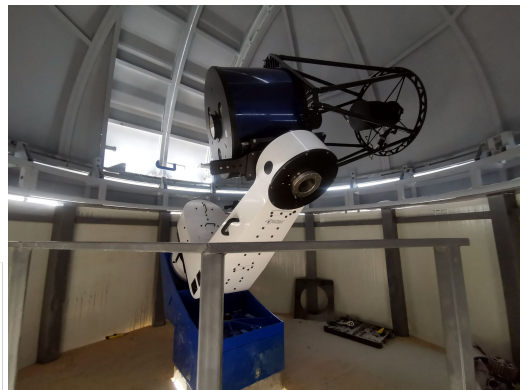
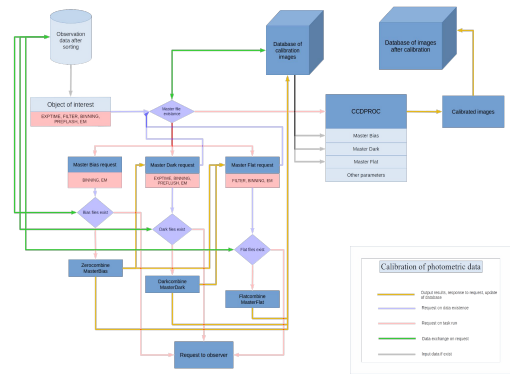
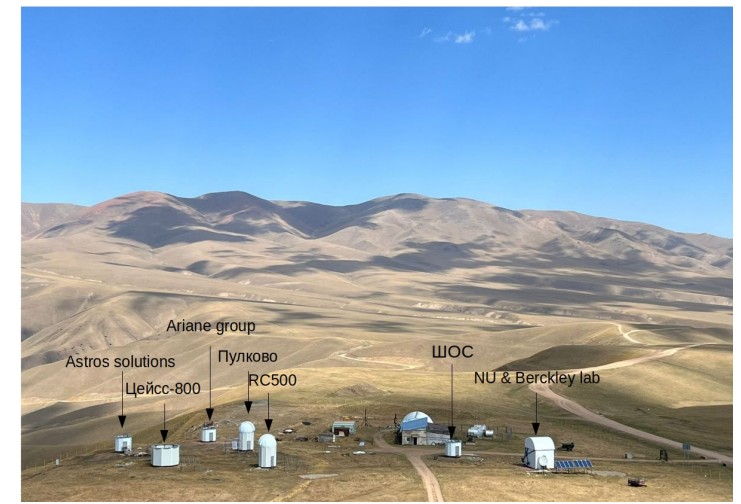
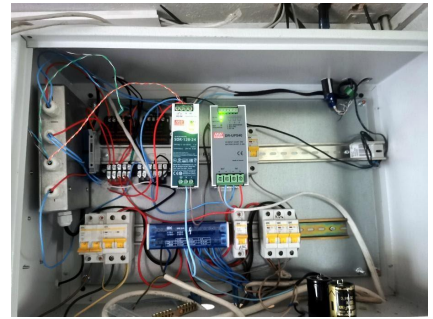


Task 1: Development of control system for remotely operational optical telescopes



Results in 2022:

1. Observatory infrastructure development **[complete]**
2. Telescopes and equipment automation **[in progress]**
3. Data reduction software development **[complete]**



Task 2: Expansion of computational resources for storage, processing and analysis of Big Data

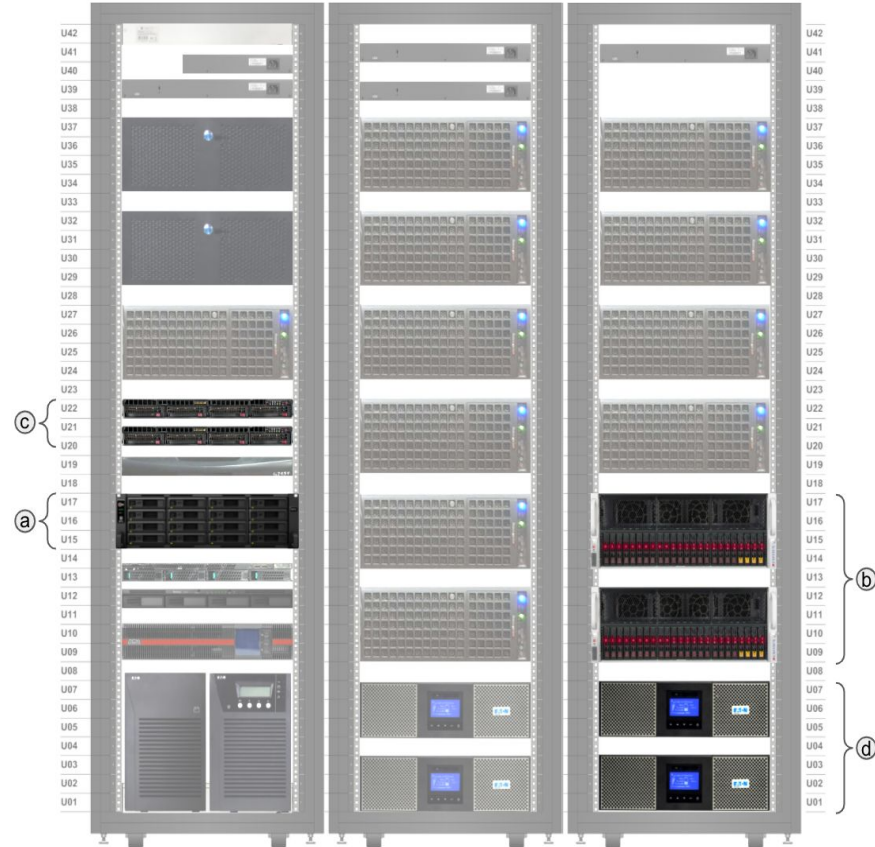
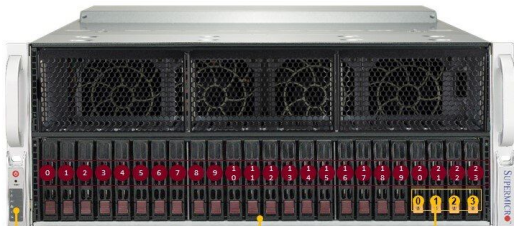


Results in six months of **2021**:

1. Acquisition, assembly and configuration of the big-data storage system **[complete]**
2. Acquisition, assembly and configuration of computational nodes for big-data processing **[in progress]**

Figure - Expanded computer cluster in FAI

- (a) system for big-data storage,
(b) computational servers for numerical simulations and big-data processing,
(c) general-purpose servers for the hosting of the VO digital core and job scheduler, as well as other required services and processes,
(d) uninterruptible power supplies for the protection of the servers and their autonomous work in case of electricity failure

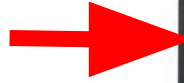


Task 2: Expansion of computational resources for storage, processing and analysis of Big Data



Results in 2022:

1. Acquisition, assembly and configuration of the big-data storage system **[complete]**
2. Acquisition, assembly and configuration of computational nodes for big-data processing **[in progress]**



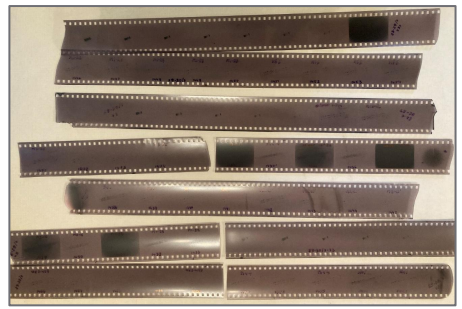
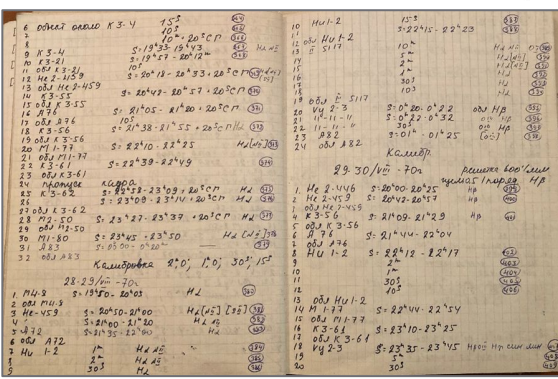
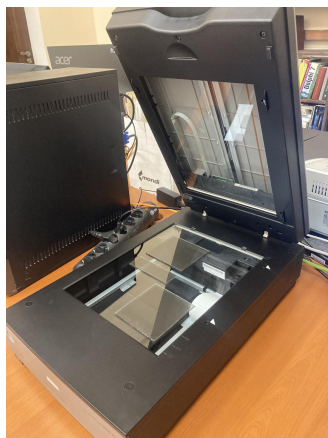
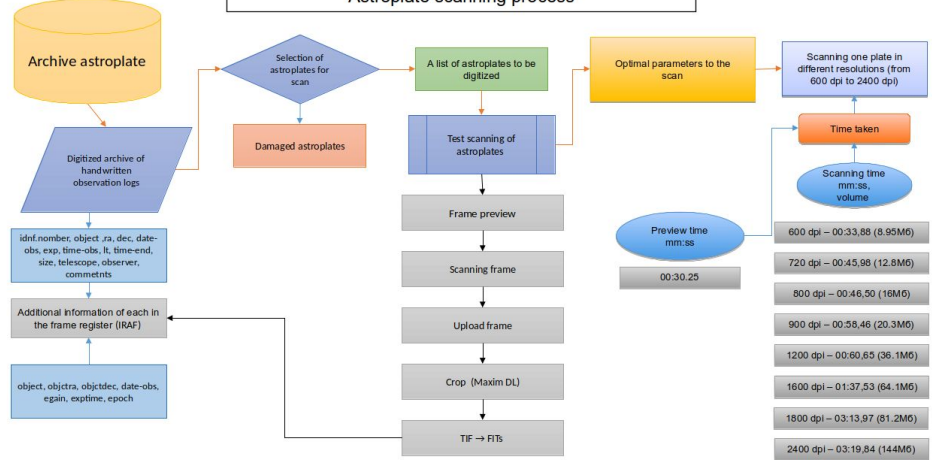
Task 3: Digitization of the FAI astroplates library and its use in conjunction with modern photometric and spectral data



Results in six months of 2021:

1. Analysis of the total amount of archived data stored on different media: plates and films. Checking up the safety and quality of archived data, sorting them up. **[complete]**
2. Test scanning of samples of astroplates and selecting the necessary parameters for scanning the entire data archive. **[complete]**
3. Catalog analysis and selection of the most suitable algorithms for astrometric reduction **[complete]**

Astroplate scanning process



Task 3: Digitization of the FAI astroplates library and its use in conjunction with modern photometric and spectral data



Results in 2022:

1. Digitization of the photometric and spectral astroplates library, archiving data in the FITS format. Filling out the information into an electronic journal from archival handwritten observation logs **[in progress]**
2. Provide a unified identification system to bring the virtual observatory's astronomical databases up to standard **[complete]**
3. Provide additional individual information for each frame by its identification number **[in progress]**

USNO UCAC4

File Edit Catalog Server Name Server Symbol Preferences

Catalog Name: USNO UCAC4
Identification: J322A
Reference: ucac4

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Radius: 19.1601 arcmin

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SAOImage ds9

File Edit View Frame Bin Zoom Scale Color Region WCS Analysis Help

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M33
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FK5 α: 1:33:49.5924 6 +30:36:39.308
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Image x: 3546.72 y: 3957.15
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open save header page setup print exit

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SAOImage ds9

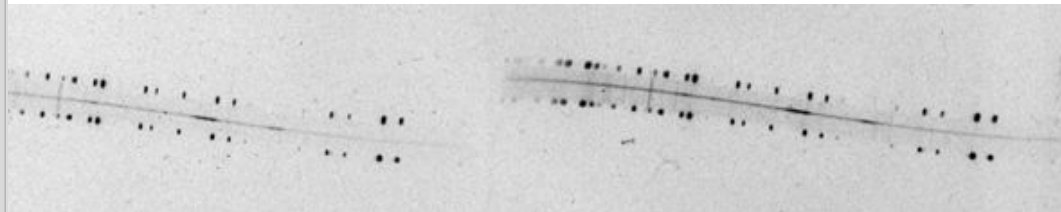
File Edit View Frame Bin Zoom Scale Color Region WCS Analysis Help

File Edit Font

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Value:
WCS:
Physical x: y:
Image x: y: 0
Frame 1 x: 0.232568 y: 0

file edit view frame bin zoom scale color region wcs analysis help
open save header page setup print exit

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BITPIX = 16 / FITS BITS/PIXEL
NAXIS = 2 / NUMBER OF AXES
NAXIS1 = 4641
NAXIS2 = 3711
BSCALE = 1 / REAL = TAPE=BSCALE + BZERO
BZERO = 32768
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DATE = '2002-01-17T08:36:57'
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TRAF-NAME = 5.912206E4 / DATA MAX
TRAF-NUM = 1.779000E2 / DATA MIN
TRAF-BPIX = 16 / DATA BITS/PIXEL
TRAF-TYPE = / PIXEL TYPE
INSTRUME = 'USHORT' / Instrument or camera used
INSTRUME = 'EPSON' / Instrument or camera used
SWHREATE = 'SilverFast 8.0.1 r45 (Apr 24 2014) 7450a21.24.04.' /Name of software
INSTRUME = 'TIFF' / Format of file from which image was read
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BAYERPAT = 'INVALID' / Indicates validity of image's Bayer pattern.
SWHDLVER = 'Maxim DL Version 6.11.198010 IS9H' /Name of software
SERIALNUM = 'ISS9H-MNTSS-W383M-P325P-MYMR-82' /Software serial number
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VORGSI0P = 320 /Subframe X position in binned pixels
VORGSI1P = 72 /Subframe Y position in binned pixels
HISTORY: Edit Crop
ESTRETCH = 'Range' / Initial display stretch mode
COLLCK = 394 /Initial display black level in ADUs
SMWITE = 31795 /Initial display white level in ADUs
PEDESTAL = 0 /Correction to add for zero-based ADU
SWHNER = 'Maxim Krugov' / Licensed owner of software
ION = '-1-165'
OBJECT = 'Palduskova'
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EXPTIME = 1800.0
VELCTRA = '04:36:12.0'
OBJCTDEC = '52:16:12.0'
EPOCH = 1950
JD = 2433734.124826389
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OBSERVAT = 'Tropna T.A.'
OBSERVAT = 'FAI'
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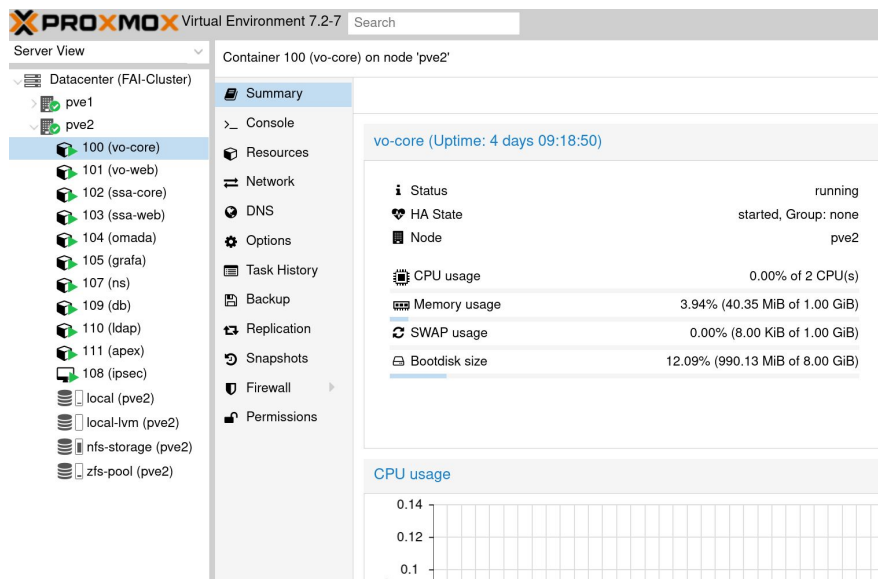
Task 4: Automation of the computational resources usage



Results in six months of **2021**:

1. Analysis of existing job schedulers for automated usage of computational resources, and of the associated software packages **[complete]**

Figure on the right - Monitoring of the parameters of the VO computer cluster (nodes caslake1-caslake5) with the configured Grafana system



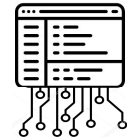
Results in **2022**:

1. Installation and configuration of the job scheduler and all associated software packages for automated usage of the computational resources **[in progress]**



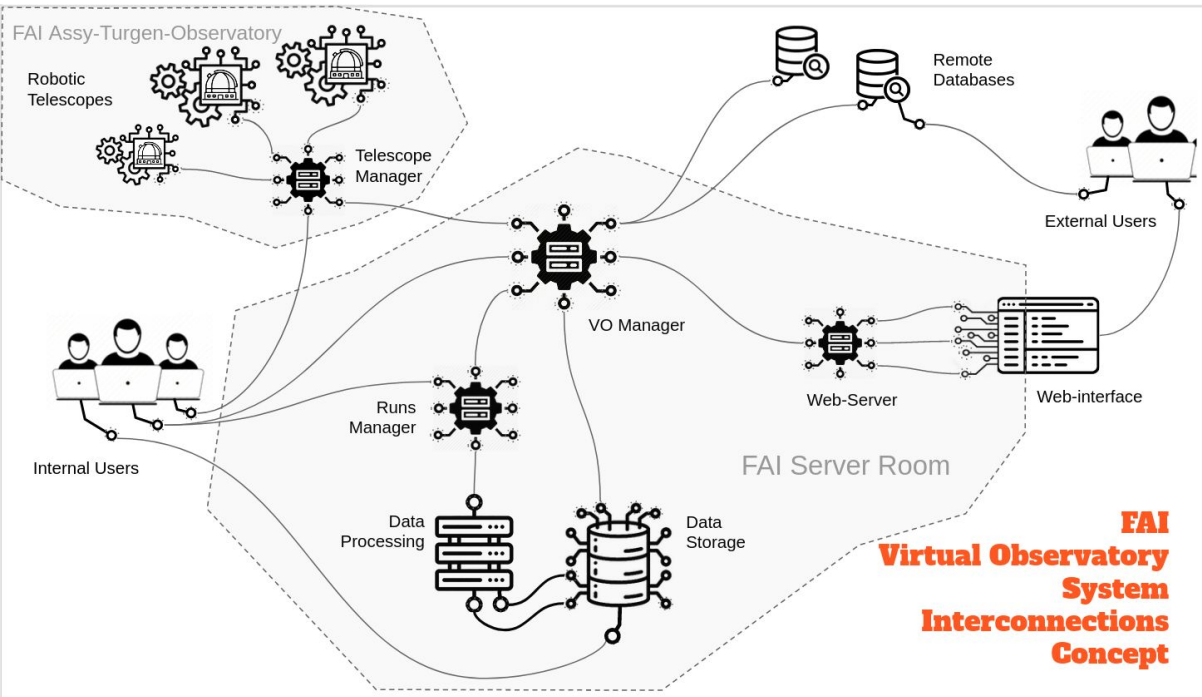
Figure on the left - Snapshot of the web-interface of the tuned virtual environment Proxmox. On the left is a list of active LXC-containers.

Task 5: Integration of computational and astronomical data from ground-based telescopes and computing facilities, and providing access to them



Results in six months of 2021:

1. Development of the blueprint for the digital core of the virtual observatory and its interfaces for the interaction with other VO modules **[complete]**



FAI
Virtual Observatory
System
Interconnections
Concept

File Station

Download Folder

Name	Size	File Type	Modified Date
2020-05-26		Folder	2020-09-25 11:21:04
2020-05-28		Folder	2020-08-25 11:06:39
2020-05-31		Folder	2020-08-25 11:07:40
2020-07-07		Folder	2020-08-25 11:08:06
2020-07-19		Folder	2020-08-25 11:08:20
2020-09-02		Folder	2020-08-25 11:08:29
2020-09-04		Folder	2020-08-25 11:08:42
2020-08-14		Folder	2020-08-25 11:08:46
2020-09-15		Folder	2020-08-25 11:08:52
2020-10-15		Folder	2020-10-22 09:41:07
2020-10-16		Folder	2020-10-22 09:41:01
2020-10-17		Folder	2020-10-22 17:40:44
2020-10-18		Folder	2020-10-22 09:42:27
2020-10-19		Folder	2020-10-22 09:42:44
2020-10-20		Folder	2020-10-22 09:42:24
2020-10-21		Folder	2020-10-22 09:41:09
2020-10-20		Folder	2020-11-05 11:30:36

FESENKOV ASTROPHYSICAL INSTITUTE
 Aerospace Committee of the Ministry of Digital Development, Innovations and Aerospace Industry
 National Center for Space Research and Technology

Project members

- Omarov, Chingiz, Dr. Program leader
- Akmalbekov, Yerlan, PhD. Task leader
- Kim, Vitaliy, PhD. Task leader
- Melikhanov, Maxim, Sp. Task leader
- Serebryanskiy, Alexander, Dr. Task leader
- Shornikova, Saule, PhD. Task leader
- Noris, Denis, PhD. Task leader
- Almasova, Gulshat, Dr.
- Akayev, Chingiz, M.Sc.
- Dubovichenko, Sergei, Post. Dr.

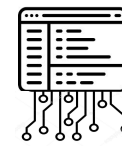
Development of the national Virtual Observatory based on robotic telescopes, Big-Data technologies, and high-performance computing

Funding
 Science Committee of Kazakhstan
 August 2021 - December 2023

Project publications

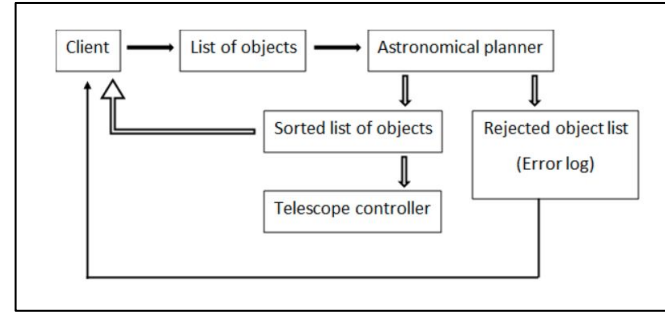
- Shornikova S., Ibratova I., Umarbayeva A., Omarov C. A method for digitization of archival catalogs of the Fesenkov Astrophysical Institute. *New Astronomy*, 97, 103181, November 2022. [arXiv]
- Savilev V. I., Mublit T. Two-particle Kinetic Equation for Pairs of Quasiparticles. *Physics of Plasmas*, August 2022. [arXiv]
- Shelkova L. I., Kuznetsova A. I., Serebryanskiy A. V. On survival of dust grains in the habitable zone of cool white dwarfs. *Monthly Notices of the Royal Astronomical Society*, 514, 901-9025, May 2022. [arXiv]
- Umarbayeva C. A., Ibratova I. M., Almasova G. S., Zhelezova A. M. *Chigirganyn kometi qorlarynyq quramynan* [arXiv]

Task 5: Integration of computational and astronomical data from ground-based telescopes and computing facilities, and providing access to them



Results in 2022:

1. Assembly of fail-safe server to host the digital core of the virtual observatory **[complete]**
2. Development of the interoperability interface between the digital core and the database **[complete]**
3. Development of the interoperability interface between the digital core and the automated telescopes **[complete]**
4. Development of the interoperability interface between the digital core and the computational cluster **[complete]**



newid	id	name	RA	DECL	type	telescope	jd	exptime	observer	date	time_ut
1	165-3.1	no name	13:30:00	05:00:00	sky	Big_Smidt	2446942.67296404	600	Solodovnikov	1987-05-27	04:09:04
2	165-2.2	no name	13:30:00	10:00:00	sky	Big_Smidt	2446942.68129737	600	Solodovnikov	1987-05-27	04:21:04
3	135-3.8	no name	12:00:00	-05:00:00	sky	Big_Smidt	2446849.92484993	600	Solodovnikov	1987-02-23	10:11:47
4	135-2.12	no name	12:00:00	30:00:00	sky	Big_Smidt	2446849.98596104	600	Solodovnikov	1987-02-23	11:39:47
5	135-2.1	no name	05:00:00	-20:00:00	sky	Big_Smidt	2446849.77901660	600	Solodovnikov	1987-02-23	06:41:47
6	185-2.5	no name	16:30:00	10:00:00	sky	Big_Smidt	2446949.75865985	600	Solodovnikov	1987-06-03	06:12:28
7	12-799	NGC6611	18:17:00	-15:18:00	galaxy	ASI-2	2434568.21017379	2400	unknown	1953-07-09	17:02:39
8	12-808	NGC6611	18:14:00	-12:22:48	galaxy	ASI-2	2434570.26372575	3480	unknown	1953-07-11	18:19:46

Fesenkov Astrophysical Institute
Submission form for observations

1. Your registered full name and e-mail
Kim Vitaliy Yurevich
ursa-majoris@yandex.ru

2. Choose your institute
---Choose from list---

*If there is no your institute into the list, add it below
[Clear]

3. Corresponding researches
(for example: 1. Petrov P.A., 2. Sidorov A.A. ...)
[Text area]

4. Task name
(for example: A study of Wolf-Rayet star phenomenon)
[Text area]

5. Choose a telescope
---Choose from list---
AZT-20 (D=1.5m, F=5.7m)
RC-500 (D=0.5m, F=1.4m)
Dima-1000 (D=1m, F=13.3)

6. Select a type of observations

Fesenkov Astrophysical Institute
Observation planner

Coordinates of a place
(Choose an observatory or input coordinates manually)
[Assy-Turgen]

Min Sec Deg Min
13 28 North Longitude: 77 52

Time zone from UTC: [6]

1. Choose your file
[Choose File] No file chosen

2. Select a type of sorting
 by nearest object by hour angle

3. Observation day
Start date [mm/dd/yyyy] [Clear]

[Confirm]

Task 6: Development of Big Data and data mining methods, algorithms and tools for the investigation of space objects

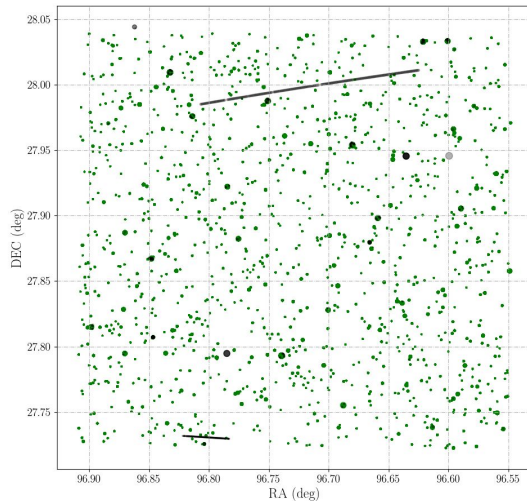


Results in six months of **2021**:

1. Development of software packages for the analysis of observational data and catalogs involving data mining algorithms **[in progress]**

Software & codes:

- Basic version of the computer code for **query and analysis** of astronomical catalogs
- Basic version of the program code for **pipeline astrometry and photometry**

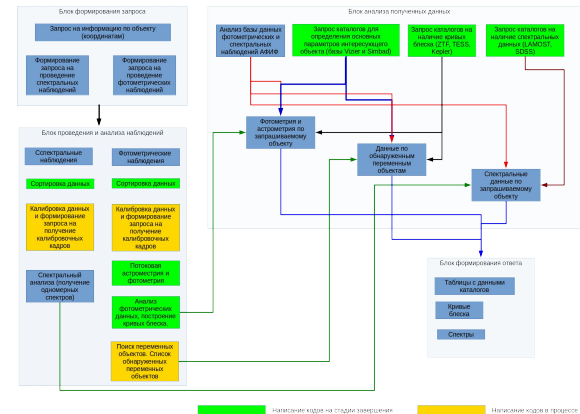


Results in **2022**:

1. Development of software packages for the analysis of observational data and catalogs involving data mining algorithms **[in progress]**
2. Development of methods, algorithms and tools for Big Data for effective analysis of astronomical data **[in progress]**

Software & codes, algorithms:

- block diagram of the analysis software
- code for header compilation of the digitized astroplates
- code for primary reduction of the digitized spectra



Project expected results in 2023

Task 1. Upgraded **experimental infrastructure** for near-Earth and deep space research. Automated control of optical telescopes for remote access observations. Optical telescopes remote access control system for images and spectra acquisition of space objects.

Task 2. Computing cluster to provide a service for **storing, processing, and analysis** of astronomical Big Data

Task 3. Photometric and spectral databases of the **digitized astroplates library** of astronomical objects integrated into VO's digital environment

Task 4. **Digital infrastructure** in computational cluster automating the usage of its resources

Task 5. **Digital core of the virtual observatory** integrated with all other VO components and providing a **unified user interface** to interact with those components, integrated database, informational web-resource

Task 6. **Software packages** for processing and analyzing large multi-dimensional arrays of astronomical data

Project publications

Monthly Notices
ROYAL ASTRONOMICAL SOCIETY
MNRAS 514, 997–1005 (2022)



<https://doi.org/10.1093/mnras/stac1405>

On survival of dust grains in the sublimation zone of cold white dwarfs

Lyubov I. Shestakova,^{1*} Akmaral I. Kenzhebekova^{2*} and Aleksander V. Serebryanskiy^{1*}

¹Fesenkov Astrophysical Institute, Observatory 23, 050020 Almaty, Kazakhstan
²Al-Farabi Kazakh National University, 050040 Almaty, Kazakhstan

Accepted 2022 May 13. Received 2022 May 13; in original form 2021 September 24

ABSTRACT

We consider a mechanism for the deposition of dust grains on to the surface of cold white dwarfs (WDs). Calculations show that grains can fall on to a cold WD directly, without reaching the phase of complete evaporation, if the parent bodies and the grains orbit on elongated, close to parabolic, orbits. To this end, we calculated the dynamics of evaporating silicate and graphite dust grains moving in circular and parabolic orbits around the white dwarf WD J1644–0449 with $T_{\text{eff}} \approx 3830$ K and $M_* = 0.45 M_{\odot}$. The calculations accounted for the influence of radiation pressure and Poynting–Robertson drag on the grain dynamics. The results show that silicate grains of all sizes considered that leave the parent bodies on circular orbits evaporate completely at a distance of ~ 3 stellar radii (R_*) from the star. The boundary of the dust-free zone for graphite grains is closer to the star, $\sim 1.5 R_*$, and is represented confidently only for larger grains with radius $> 0.5 \mu\text{m}$. We determined the lower limits of the radius for grains capable of reaching the stellar surface. For comparison, we analysed the dependences of lower size limits for infalling silicate grains for a set of WDs within the temperature range 3000–5000 K. We conclude that silicate grains with an initial size $\geq 300 \mu\text{m}$ can reach the surface of WD J1644–0449. For stars with temperatures in the range 3000–5000 K, the corresponding grain size range is $0.016 \mu\text{m} - 5 \mu\text{m}$.

computation



Article

Evaluation of Pseudo-Random Number Generation on GPU Cards

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Open Access Online Journal on Astronomy and Astrophysics

Acta Astrophysica Taurica

www.astrophysicatauricum.org

Acta Astrophys. Tau. 3(1), 35–38 (2022)

doi:10.31059/aaet.vol3.iss1.pp35-38

Studies of active galactic nuclei in Kazakhstan

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Submitted on October 31, 2021

New Astronomy 97 (2022) 101875



Contents lists available at ScienceDirect

New Astronomy

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Hunting for overlooked eccentric eclipsing binaries from ASAS-3 survey

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New Astronomy 97 (2022) 101881



Contents lists available at ScienceDirect

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A method for digitization of archival astroplates of the Fesenkov Astrophysical Institute

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Reports of the Academy of Sciences of the Republic of Kazakhstan

REPORTS OF THE NATIONAL ACADEMY OF SCIENCES

OF THE REPUBLIC OF KAZAKHSTAN

ISSN 2224-5227

Volume 1, Number 341 (2022), 137-143

<https://doi.org/10.32014/2022.2518-1483.143>

УДК 520.43

МРНТИ 41.51.41

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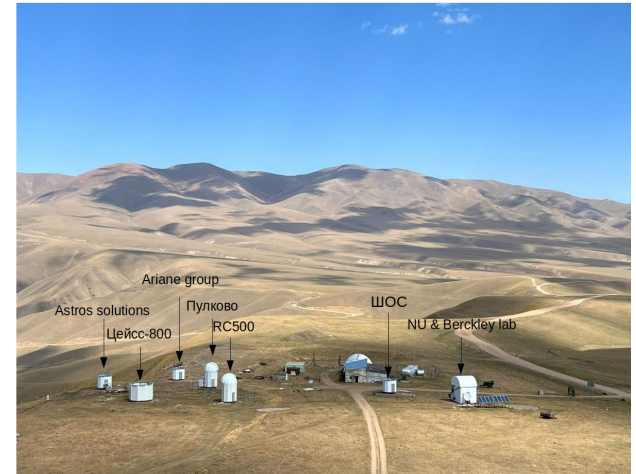
ОЦФРОВКА КОМЕТ ФОТОМЕТРИЧЕСКИХ АСТРОНЕГАТИВОВ
АСТРОФИЗИЧЕСКОГО ИНСТИТУТА ИМЕНИ В.Г. ФЕСЕНКОВА

Further VO plans and funding

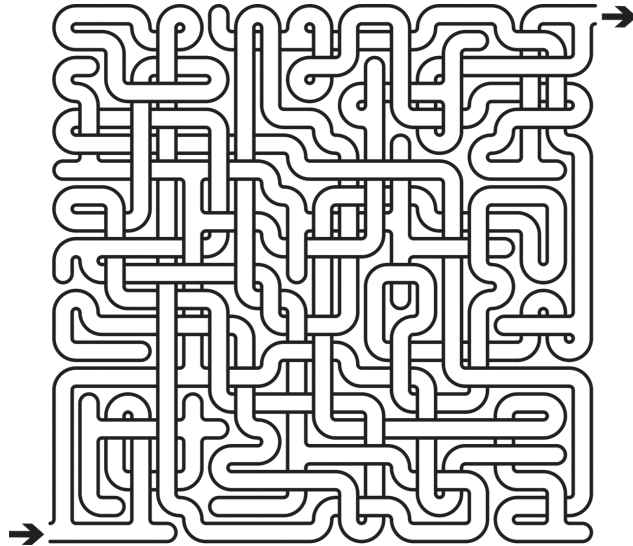
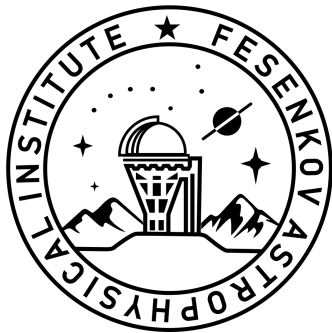
1. Development of the Assy-Turgen Observatory within the scope of VO
2. Active International collaboration on various topics (incl. Kaz-VO developing)
3. Implementing F.A.I.R. principles for observational and simulation data

Funding will be provided by two Ministries:

- Ministry of Digital Development, Innovation and Aerospace Industry
- Ministry of Science and Higher Education



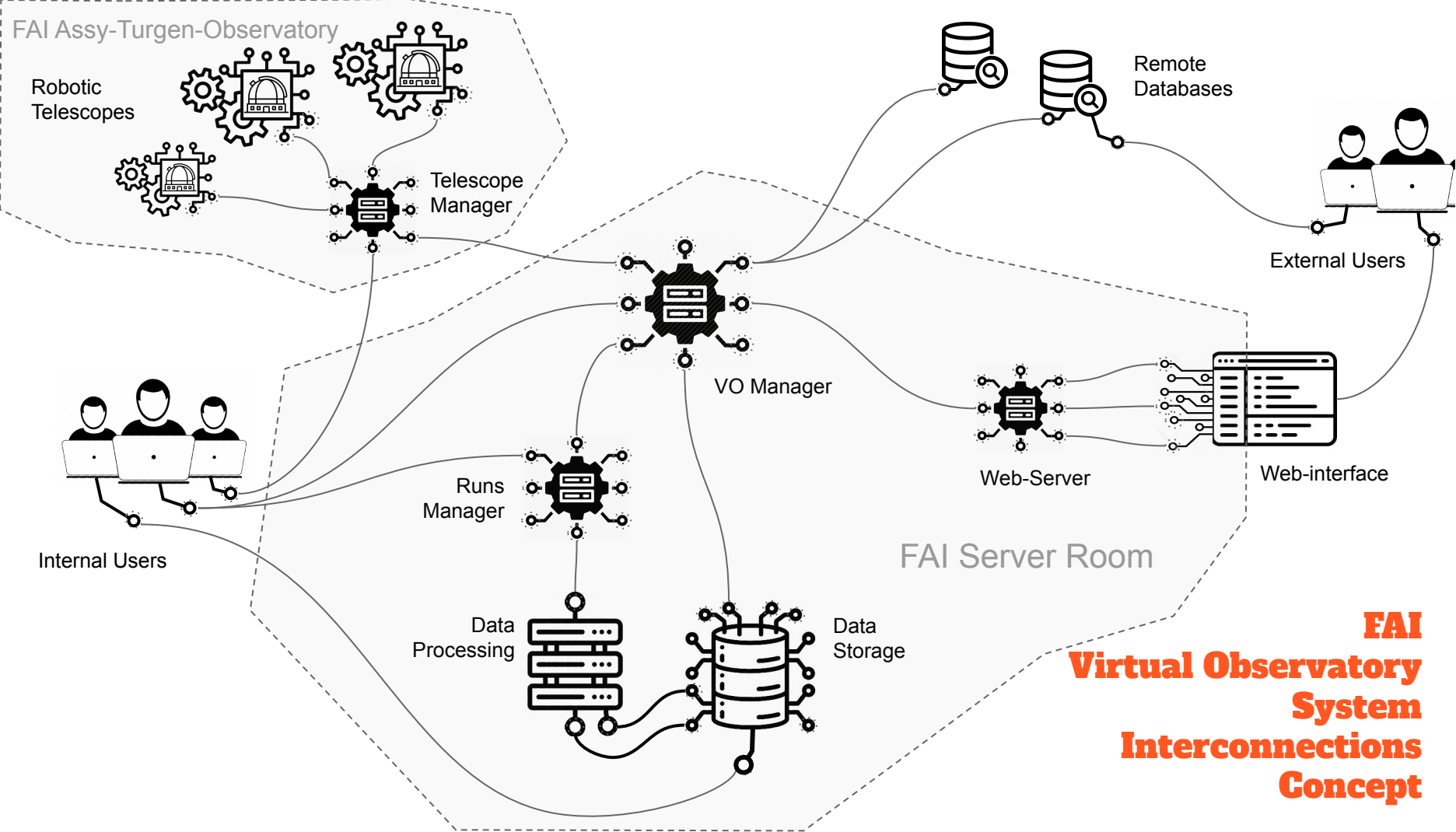
Supervision in VO



Cooperation, training and conferences

1. IVOA Interops
2. Second ESCAPE School on VO
3. Local conferences
4. Internal seminars
5. Internships

Cooperation agreement with **Astronomisches Rechen-Institut** - August 2022



**FAI
Virtual Observatory
System
Interconnections
Concept**