Towards Kazakhstani Virtual Observatory

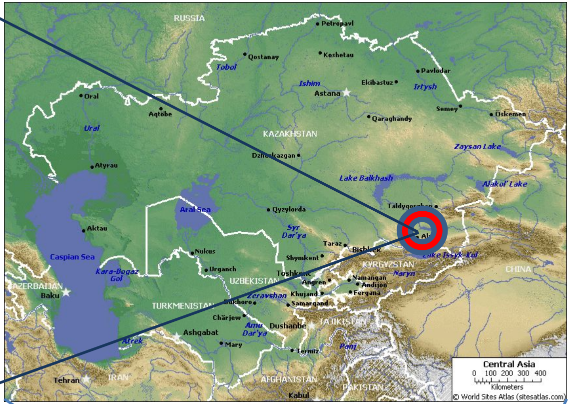
Yerlan AIMURATOV and Chingis OMAROV
[Fesenkov Astrophysical Institute, Almaty, Kazakhstan]
for
IVOA Exec Meeting, Zoom, October 11th, 2022

OUTLINE:

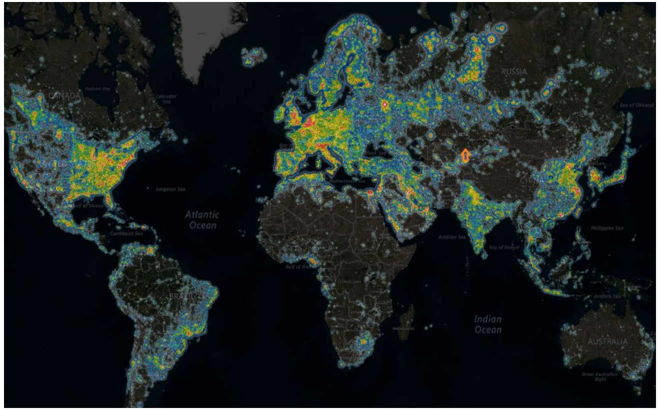
1. Who we are?
2. Project: a basis for Kazakhstani Virtual Observatory
3. Project Aims
4. Project Objectives
5. Current progress
6. What next? Further plans and funding
7. Supervision in VO via mentoring and internship
8. Conclusion

Fesenkov Astrophysical Institute

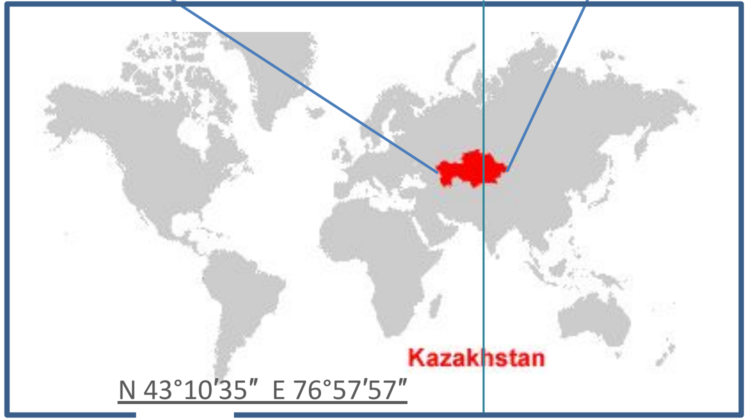
FAI main building



Almaty

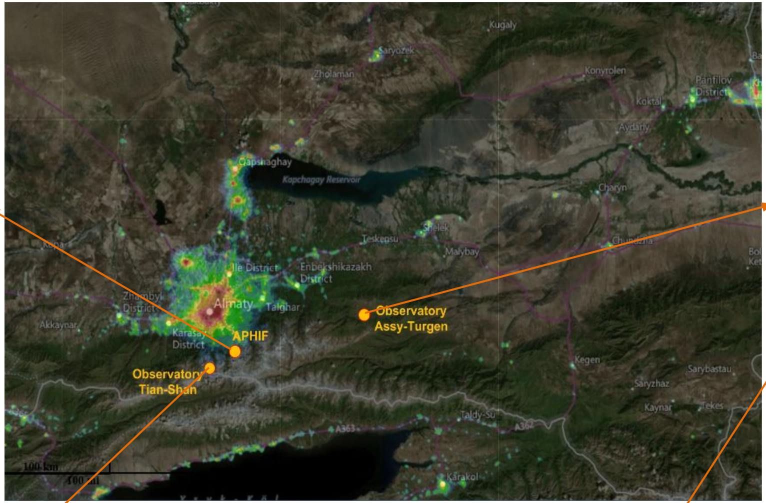


World light pollution map



Three observational bases

Kamenskoye Plateau Observatory (1450 m)

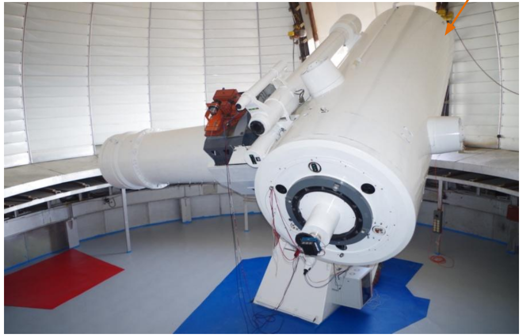


Light pollution map

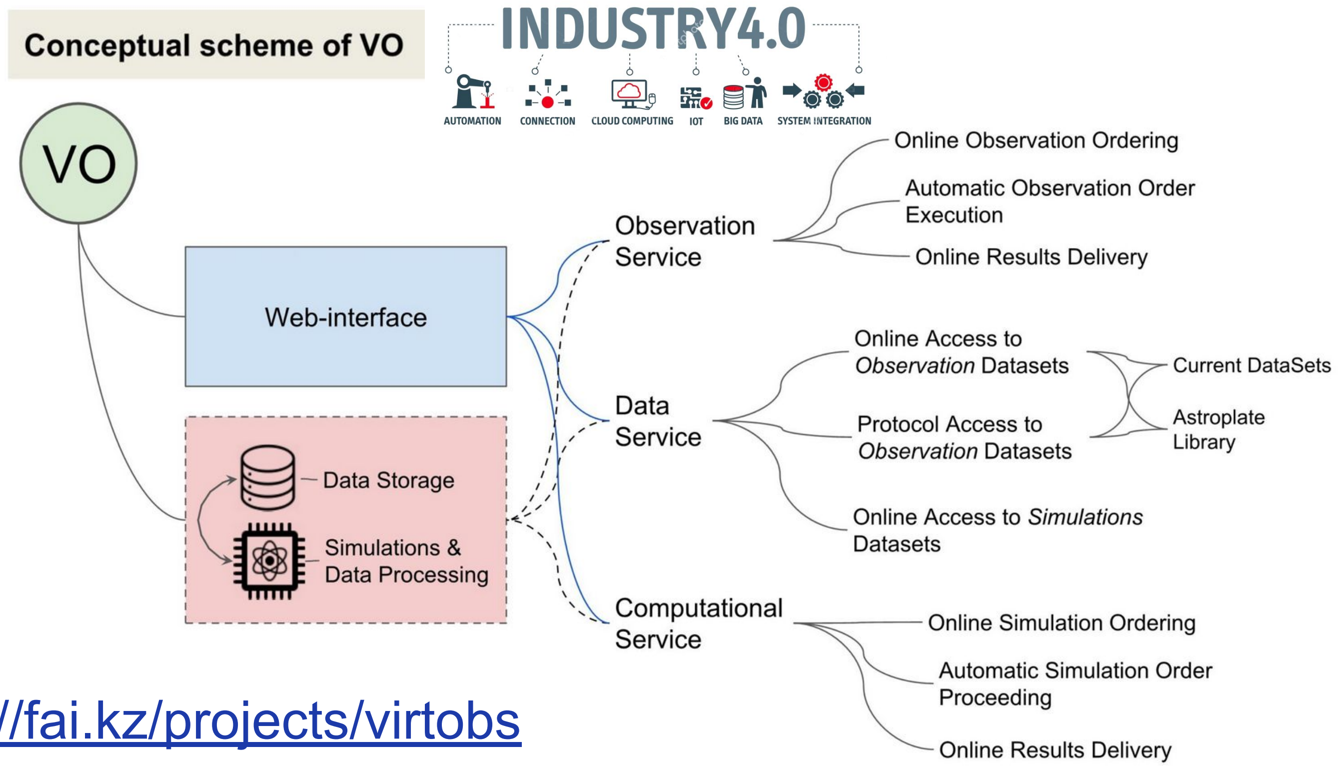
Assy-Turgen Observatory (2750 m)

NU special fast-opening dome telescope CDK700

Tien-Shan Astronomical Observatory (2840 m)



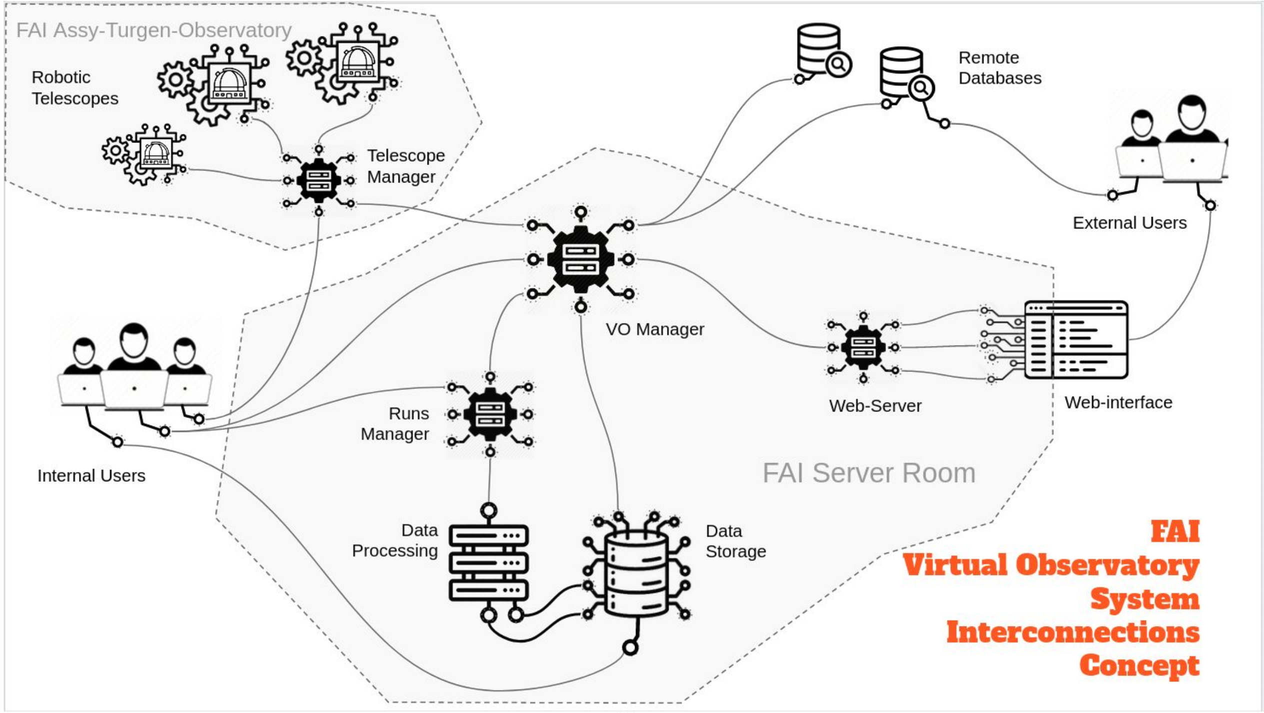
Project: Development of the national Virtual Observatory based on robotic telescopes, Big-Data technologies, and high-performance computing (No. BR10965141)



https://fai.kz/projects/virtobs

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.



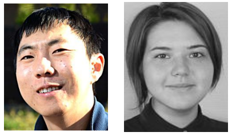
General tasks for FAI VO

National Virtual Observatory

- **Telescopes automation** — python, Radmin

- **Construction of system for data storage and processing** — Synology, SQL

- **Interface design** — SQL, HTML, CSS, JS



- **Digitization of astroplates** — Nova.Astrometry.net, Aladin, IRAF, Source Extractor

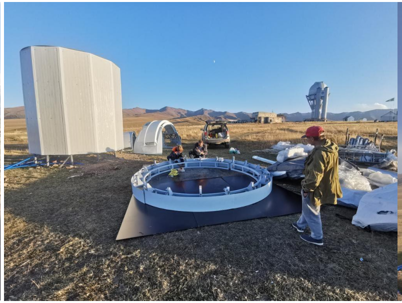
- **Computing automation** — slurm workload manager

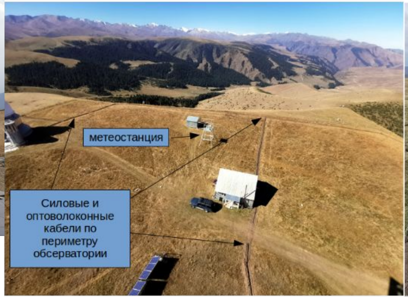
- **Data Mining** — AstroConda, The Astropy Project, python, ANACONDA, IRAF

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]

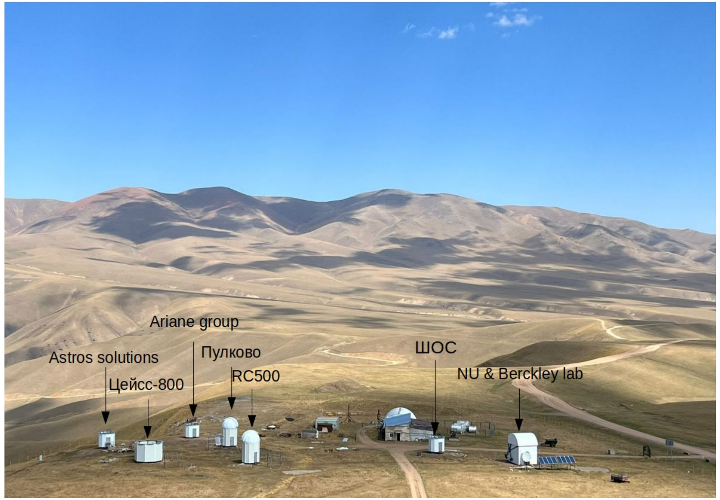


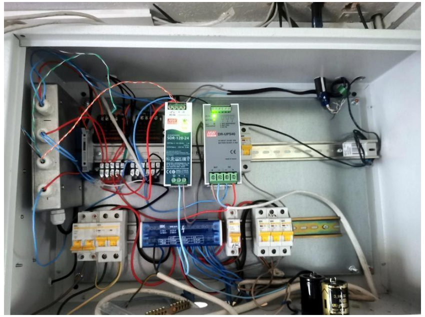


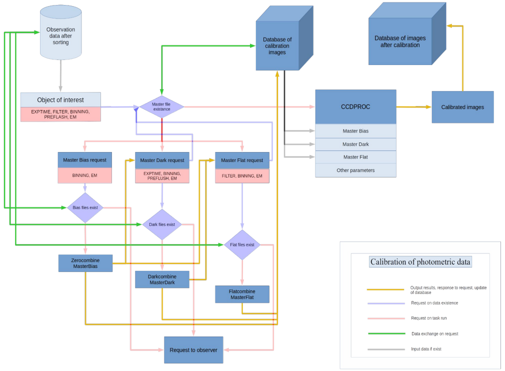
Task 1: Development of control system for remotely operational optical telescopes

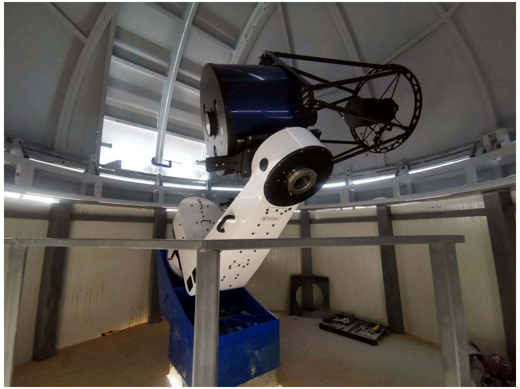
Results in **2022**:

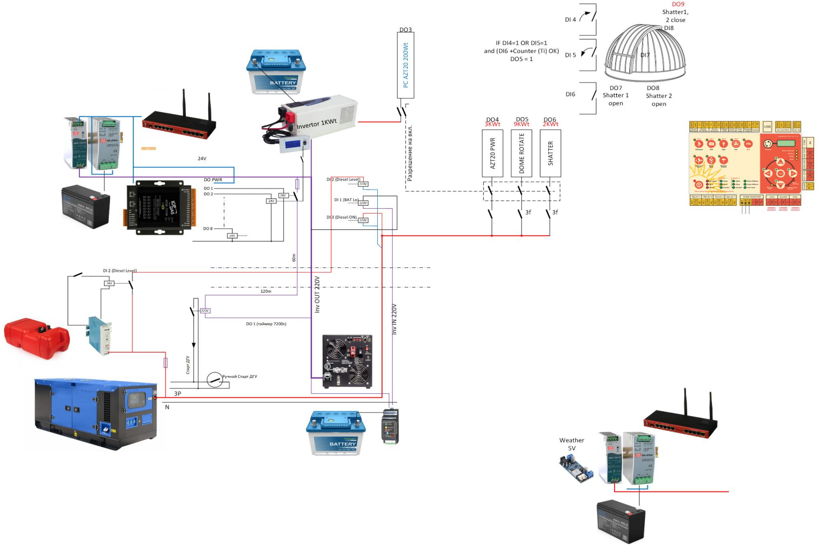
1. Observatory infrastructure development [complete]
2. Telescopes and equipment automation [in progress]
3. Data reduction software development [complete]









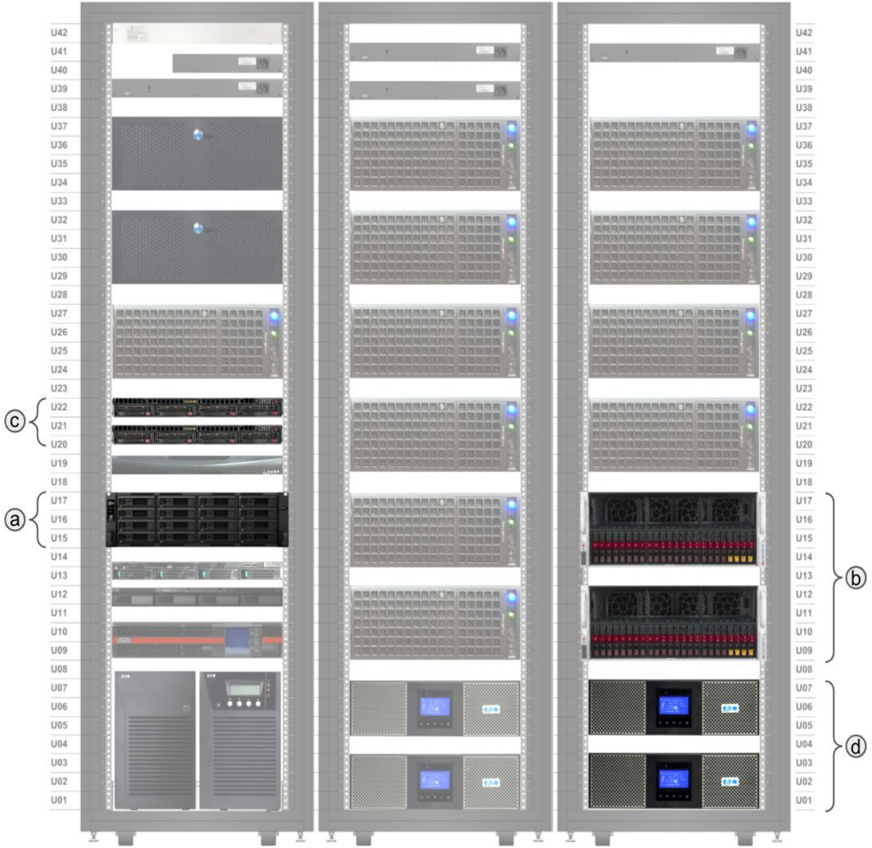


Task 2: Expansion of computational resources for storage, processing and analysis of Big Data

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) uninterrupted 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

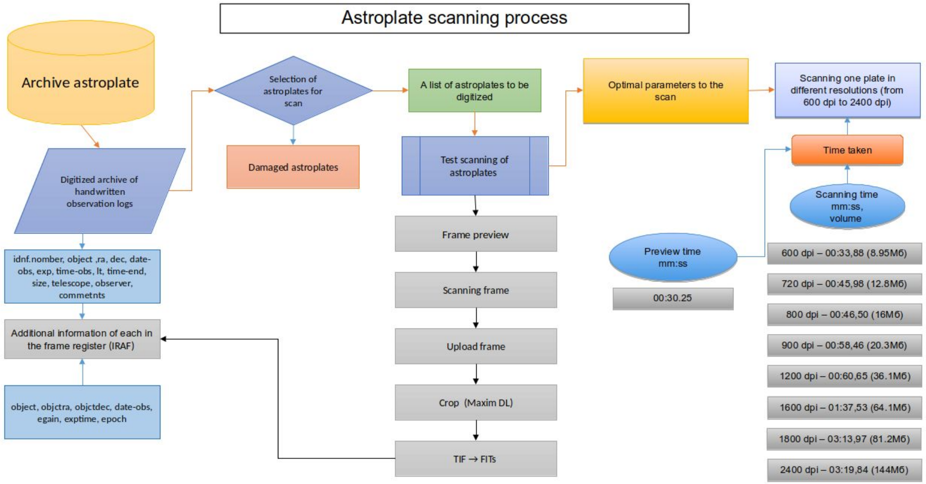
Results in **2022**:

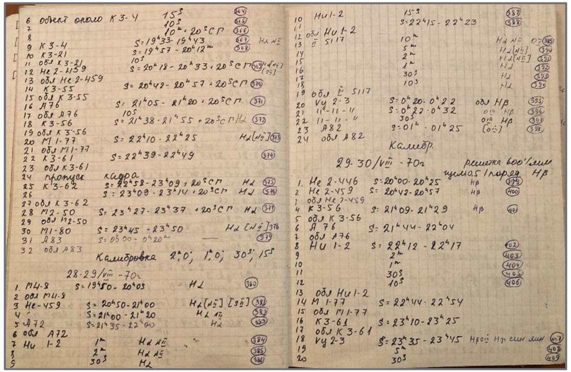
1. Acquisition, assembly and configuration of the big-data storage system [complete]
2. Acquisition, assembly and configuration of computational nodes for big-data processing [in progress]

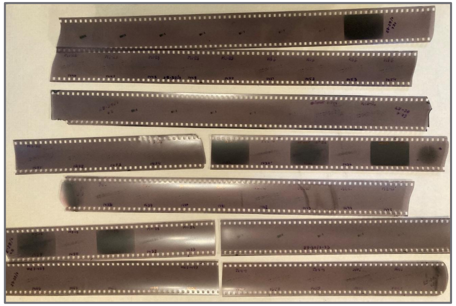
Task 3: Digitization of the FAI astroplates library and its use in conjunction with modern photometric and spectral data

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]



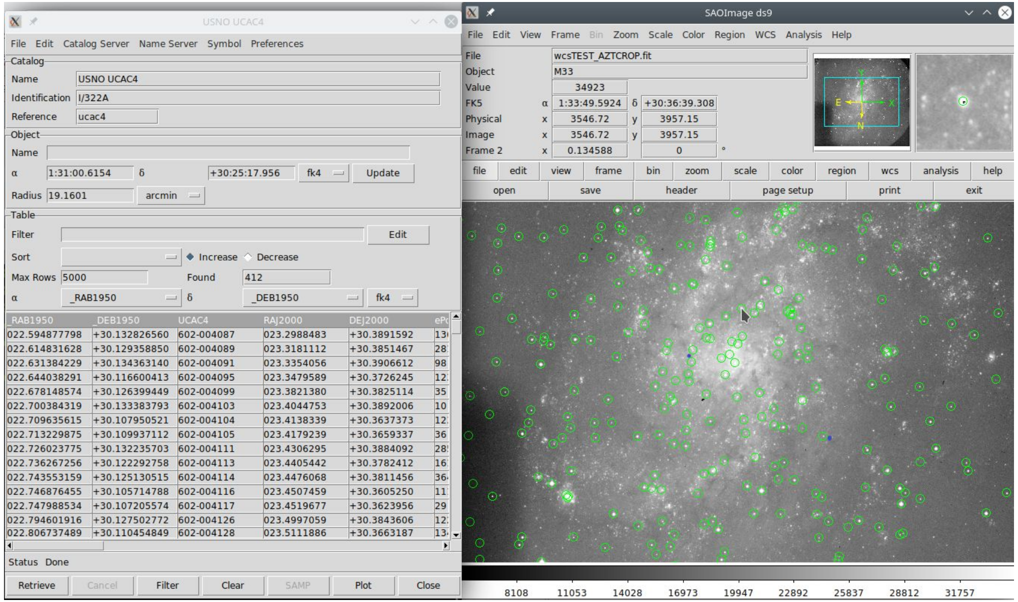


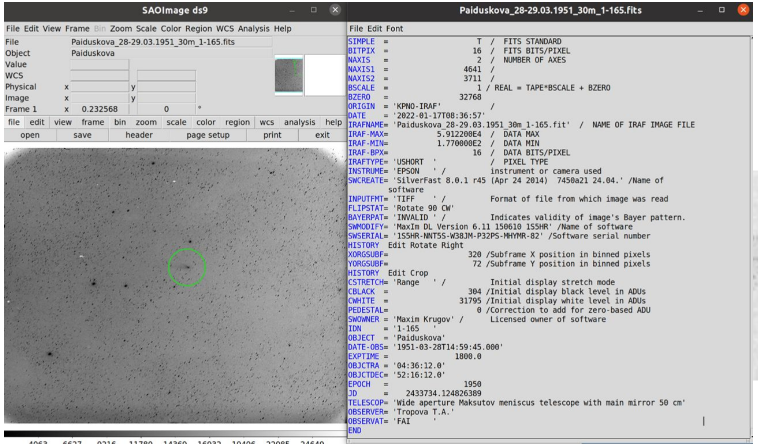


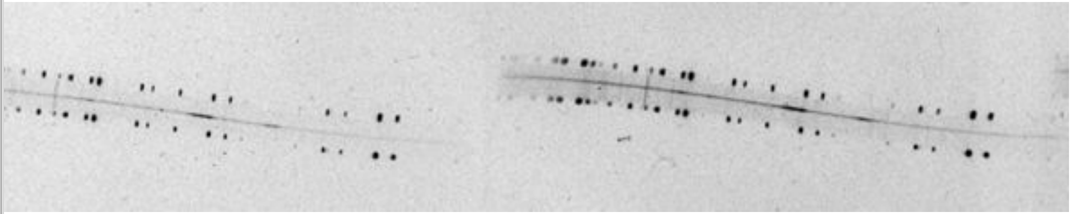
Task 3: Digitization of the FAI astroplates library and its use in conjunction with modern photometric and spectral data

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]





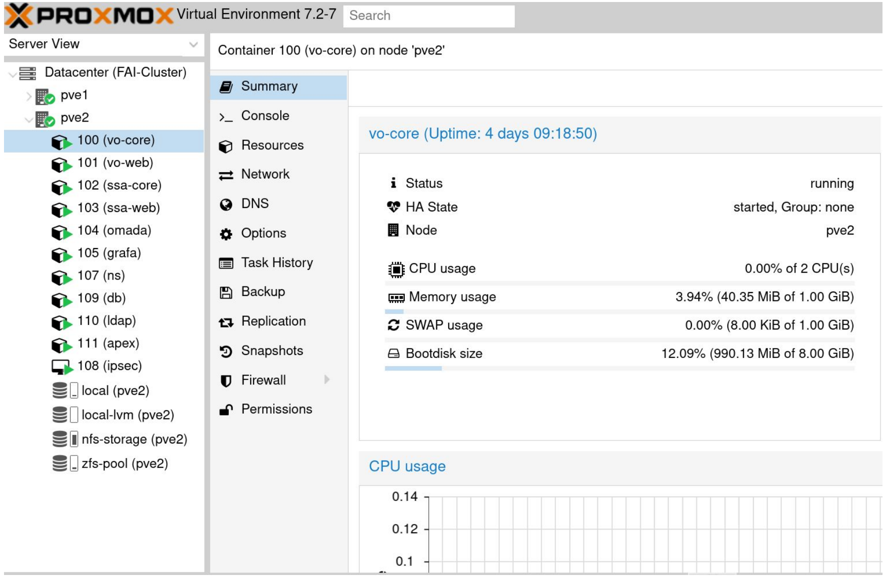


Task 4: Automation of the computational resources usage

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**:

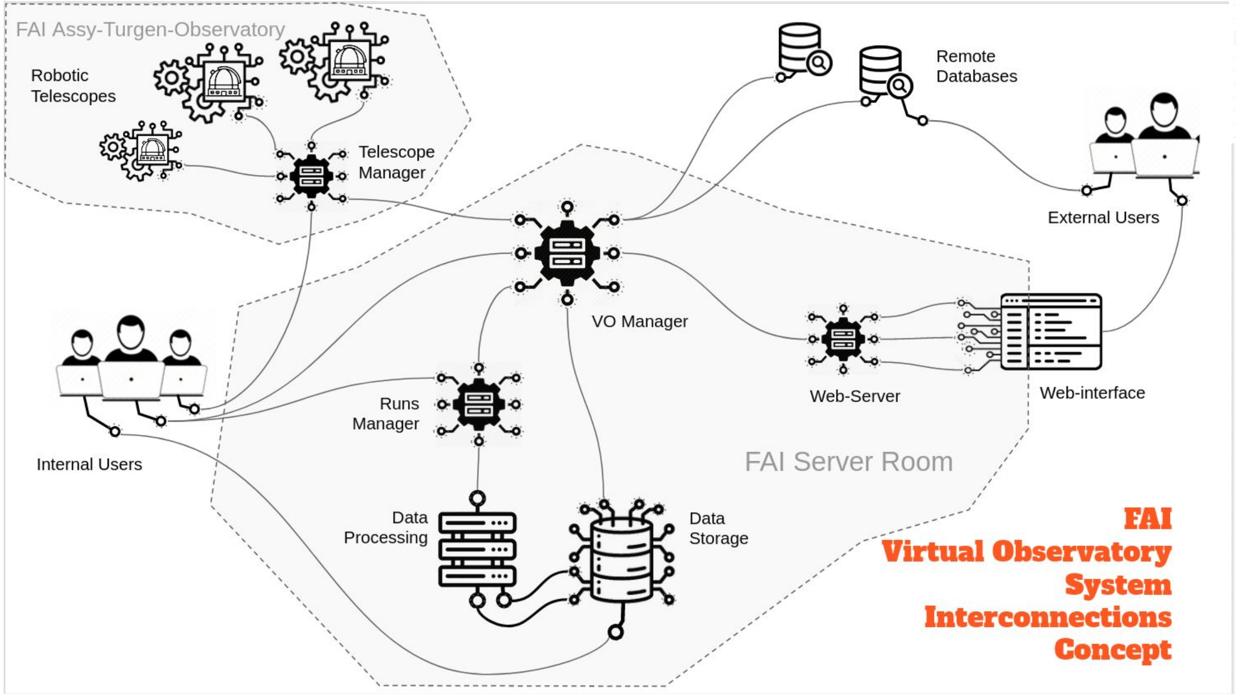
1. Installation and configuration of the job scheduler and all associated software packages for automated usage of the computational resources [in progress]

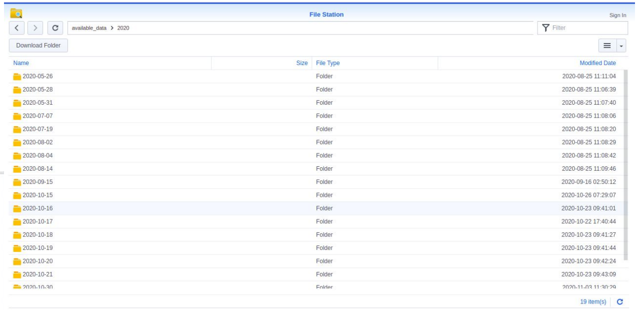
Figure on the left - Snapshot of the web-interface of the tuned virtual environment Proxmox. On the left is a list of active LXC-containers.

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

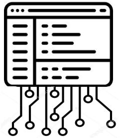
Results in six months of **2021**:

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



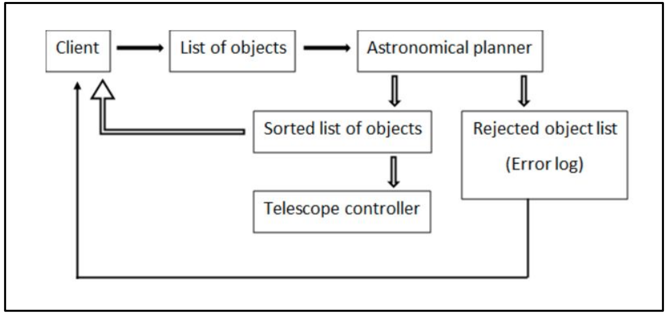


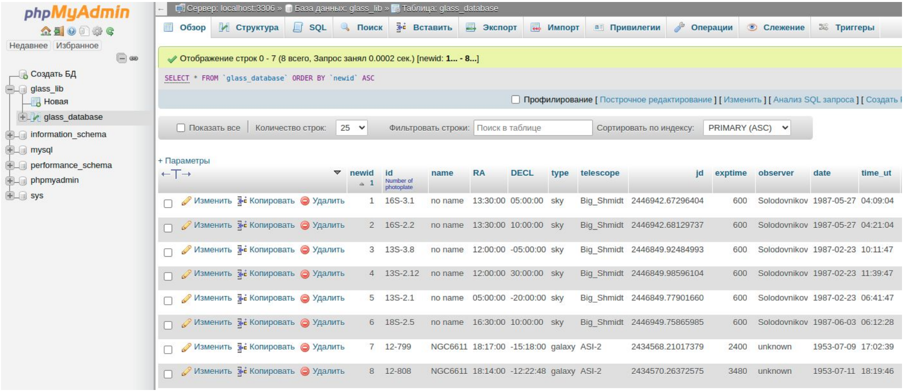
Task 5: Integration of computational and astronomical data from ground-based telescopes and computing facilities, and providing access to them

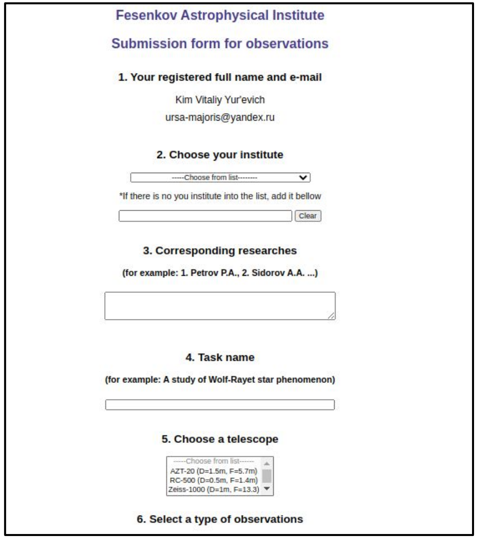


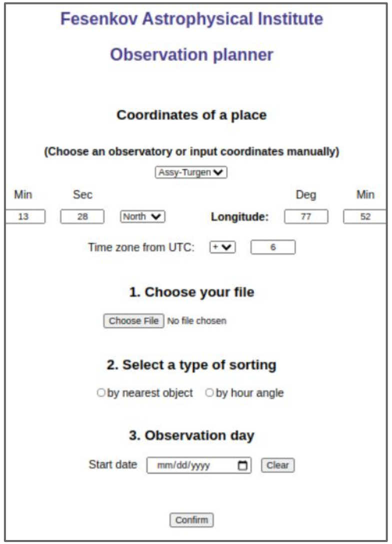
Results in **2022**:

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]









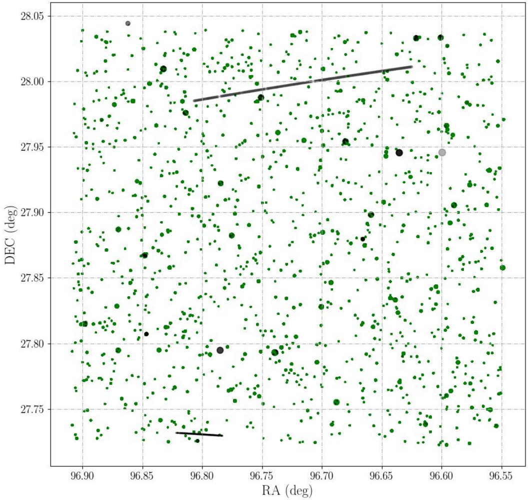
Task 6: Development of Big Data and data mining methods, algorithms and tools for the investigation of space objects

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**

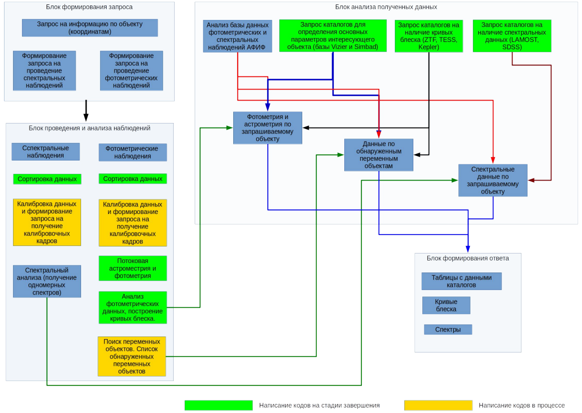


Results in **2022**:

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 of the 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★]
[1] *Fesenkov Astrophysical Institute, Observatory 23, 050020 Almaty, Kazakhstan*
[2] *Al-Farabi Kazakh National University, 050040 Almaty, Kazakhstan*

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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 $T_{eff} \approx 3830$ K and $M_\star = 0.45\ M_\odot$. 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 ($R_\star$) from the star. The boundary of the dust-free zone for graphite grains is closer to the star, $\sim 1.5 R_\star$, and is represented confidently only for larger grains with radius > 0.5 µm. 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 ≥ 300 µm 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 μm–5 cm.

computation MDPI

Article
Evaluation of Pseudo-Random Number Generation on GPU Cards

Tair Askar [1,2,*], Bekdaulet Shukirgaliyev [2,3,4], Martin Lukac [5] and Ernazar Abdikamalov [2,6]

1 School of Engineering and Digital Sciences, Nazarbayev University, Nur-Sultan 010000, Kazakhstan
2 Energetic Cosmos Laboratory, Nazarbayev University, Nur-Sultan 010000, Kazakhstan; bekdaulet.shukirgaliyev@nu.edu.kz (B.S.); ernazar.abdikamalov@nu.edu.kz (E.A.)
3 Fesenkov Astrophysical Institute, Almaty 050020, Kazakhstan
4 Department of Solid State Physics and Nonlinear Physics, Faculty of Physics and Technology, Al-Farabi Kazakh National University, Almaty 050040, Kazakhstan
5 Department of Computer Science, Nazarbayev University, Nur-Sultan 010000, Kazakhstan; martin.lukac@nu.edu.kz
6 Department of Physics, Nazarbayev University, Nur-Sultan 010000, Kazakhstan
* Correspondence: tair.askar@nu.edu.kz

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Acta Astrophysica Taurica
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Studies of active galactic nuclei in Kazakhstan

I. Izmailova
Fesenkov Astrophysical Institute, Observatory 23, Almaty 050020, Kazakhstan
e-mail: izmailova@aphi.kz

Submitted on October 31, 2021

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journal homepage: www.elsevier.com/locate/newast
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Hunting for overlooked eccentric eclipsing binaries from ASAS-3 survey

A.V. Khalikova [a,*], E.R. Gaynullina [a], A.V. Serebryanskiy [b]
[a] *Ulugh Beg Astronomical Institute, Astronomicheskaya str., 33, Tashkent 100052, Uzbekistan*
[b] *Fesenkov Astrophysical Institute, Observatory 23, Almaty 050020, Kazakhstan*

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

S. Shomshekova [*], I. Izmailova, A. Umirbayeva, Ch.Omarov
Fesenkov Astrophysical Institute, Observatory 23, 050020 Almaty, Kazakhstan

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УДК 520.43
МРНТИ 41.51.41

С.А. Шомшекова*, И.М. Измайлова, С.Г. Мошкина, А. Ж. Умирбаева

Астрофизический институт имени В.Г. Фесенкова, Алматы, Казахстан.
E-mail: shmshekva-saule@mail.ru

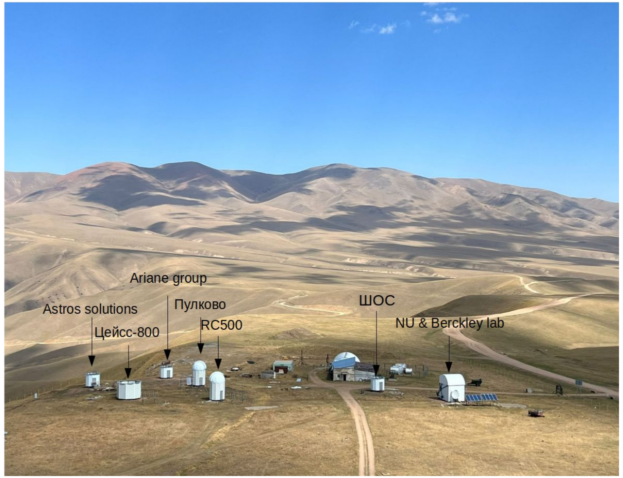
ОЦИФРОВКА КОМЕТ ФОТОМЕТРИЧЕСКИХ АСТРОНЕГАТИВОВ АСТРОФИЗИЧЕСКОГО ИНСТИТУТА ИМЕНИ В.Г. ФЕСЕНКОВА

Further VO plans and funding

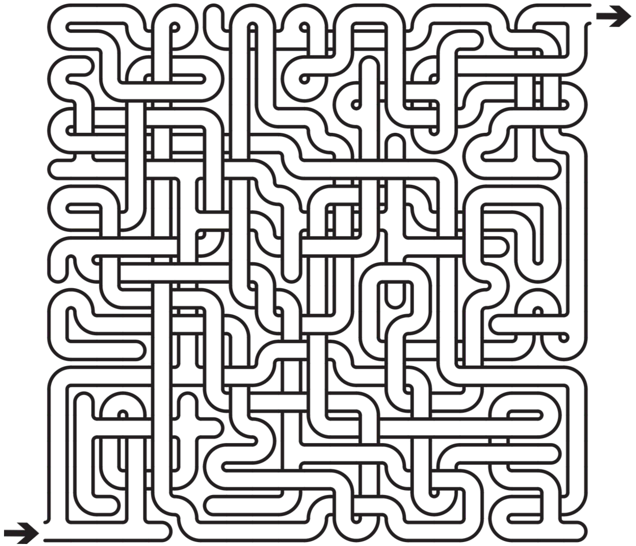
1. Development of the Assy-Turgen Observatory within the scope of VO
2. Active International collaboration on various topics (incl. Kaz-VO developing)
3. Implementing F.A.I.R. principles for observational and simulation data

Funding will be provided by two Ministries:

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



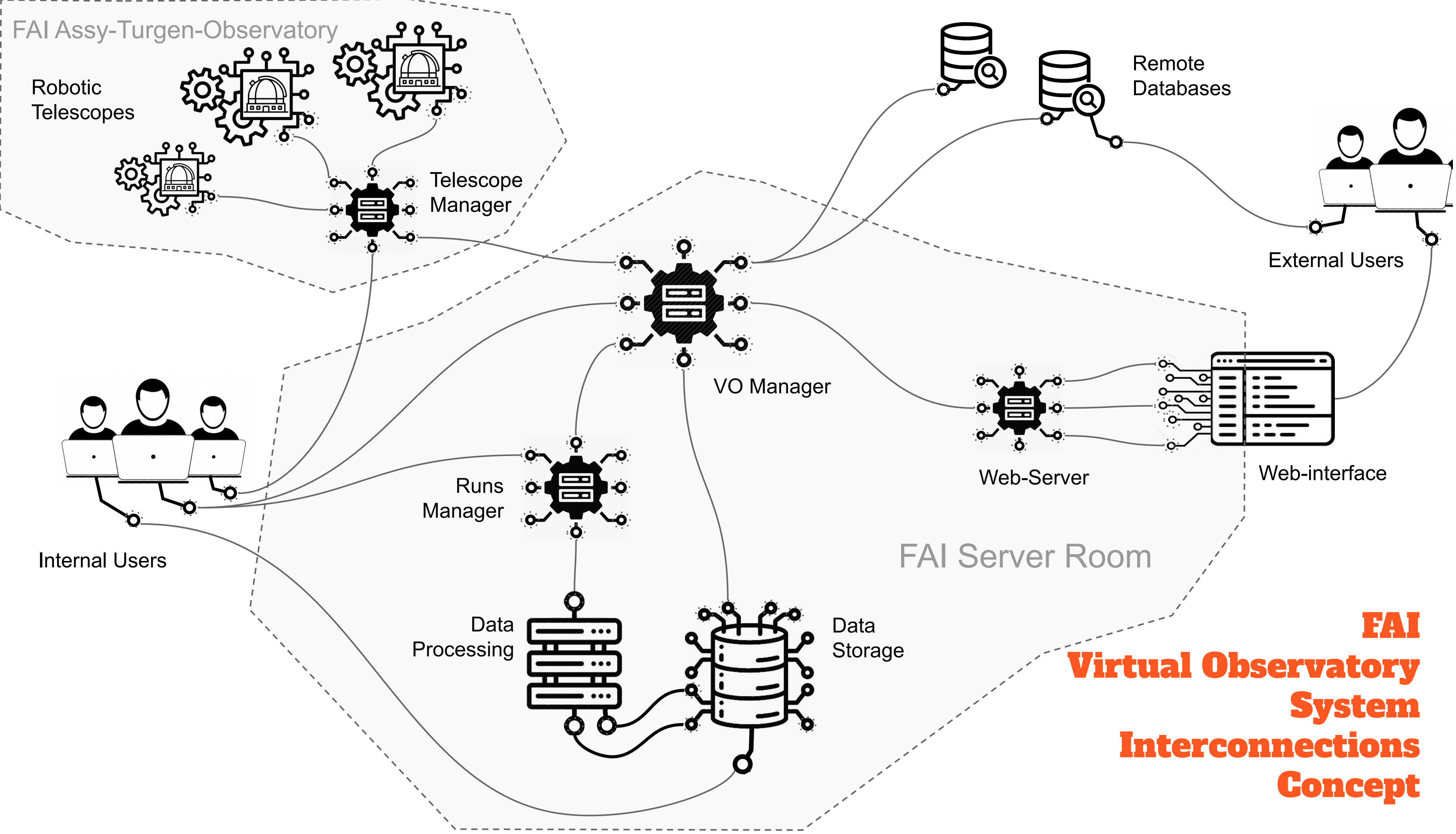
Supervision in VO



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