Kiruna Atmospheric and Geophysical Observatory (KAGO)

Status of ALIS_4D

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2020-12-08

KAGO Instrument overview

Kiruna Atmospheric and Geophysical Observatory

- Magnetometers, 1950–: IRF [PI: Yamauchi]: Kiruna, Lycksele, Tormestorp;
  SGU[Schwarz]: Abisko, Uppsala and operation of Lycksele
- Ionosondes, 1952– [PI: Leyser]: Kiruna, Lycksele, Uppsala.
- Allsky cameras, 1956– [PI: Brändström]: Kiruna, Abisko, Tjautjas
- Riometers, 1958– [PI: Sergienko]: Kiruna, Lycksele
- Infrasound, 1973– [PI: Kero]: (In observatory since 2015) (Kiruna, Jämtön, Lycksele, Sodankylä)
- Ozone radiometer (KIMRA), 2001– [PI: Raffalski]: (In observatory since 2018) (Kiruna)
- ALIS_4D [PI: Brändström] (Observatory measurements from late 2020) Abisko, Kiruna, Silkkimuotka, Tjautjas
- (Weather station, ALIS, guest instruments, etc.)

AILS_4D timeline

A Swedish contribution to complementary instruments for EISCAT_3D

- Funded by *Kempestiftelserna*, Faculty of Science and Technology at UmU and IRF.
- High-time resolution (> 25 FPS)
- Continuous operation (observatory modes)
- Timeline:
  - 2016: (summer) Funding application (granted in November)
  - 2017: Procurement procedures, four Andor imagers delivered, optics ordered
  - 2018: Optics delivery (April) Main development work.
  - 2019: first light, first campaign (October 2020)
  - 2020: SPIDER2 campaign Continuous operations from end 2020.
  - 2021: Regular operations begin

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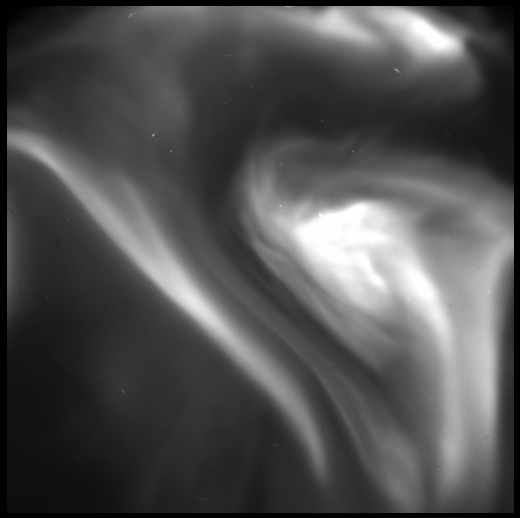
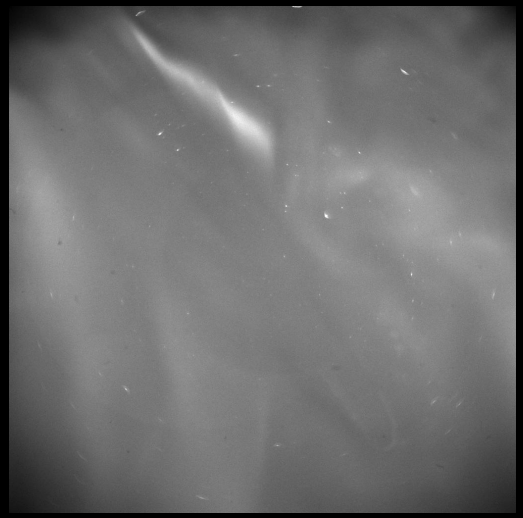
ALIS_4D

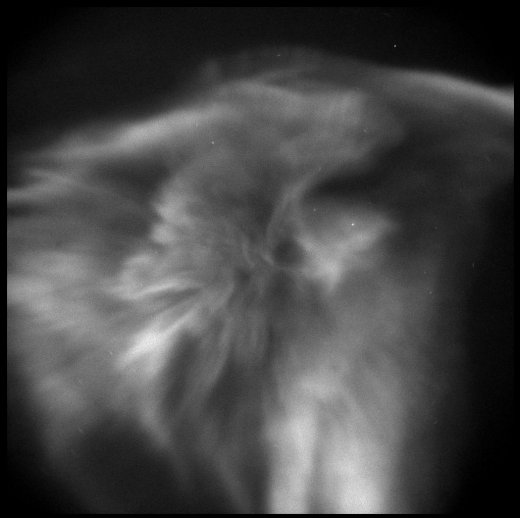
First light 2019-02-28 18:38:00.005608 11.006 s 6750 Å

6750 Å

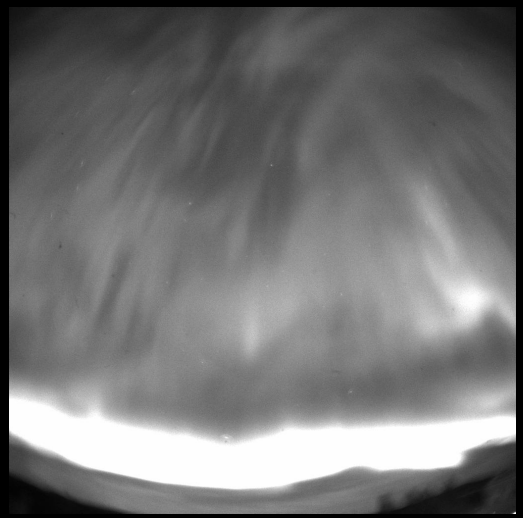


6562 Å



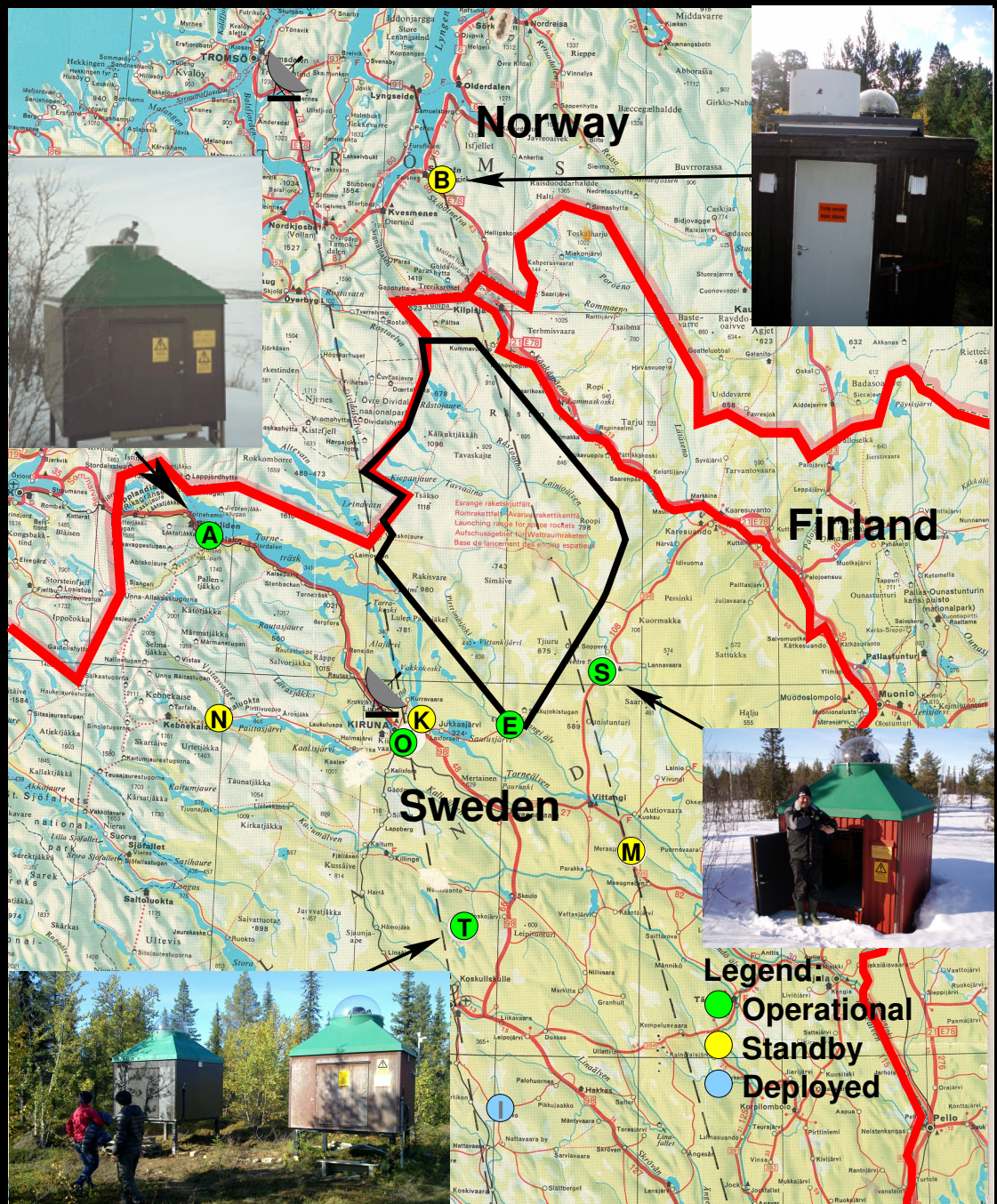


4278 Å



6562 Å

ALIS_4D sites



ALIS_4D

Overview

- Design goal: to be compatible with EISCAT_3D and similar efforts (in particular optical) in Norway, Finland (and Russia?).
- Both long-time monitoring and campaign mode observations
- Much to explore regarding operating modes, observatory vs. campaign modes, interoperability, etc.
- More or less on schedule (knock on wood)

ALIS/ALIS_4D

Comparision of some key specifications

	ALIS	ALIS_4D phase II
FoV	6 CCD $\approx 60°$ 1 EMCCD $\approx 30°$ (1 EMCCD $\approx 15°$)	4 (5) EMCCD $\approx 136°$ 1 EMCCD $\approx 30°$ (1 EMCCD $\approx 15°$)
Spatial resolution	$1024^2 \approx 100\mathrm{m}$ $256^2 \approx 500\mathrm{m}$	$1024^2 \approx 750\mathrm{m}$ $512^2 \approx 1.5\mathrm{km}$
Temporal	0.2 Hz	> 25 Hz
Mode	Campaign only	monitoring/campaign

ALIS/ALIS_4D

Preliminary absolute calibration

Dynamic range.	Res.	Hz	low R/count	high R/count	λ_c
ALIS (CCD)	256^2	0.2	1.74		4278Å
ALIS_4D (EMCCD)	1024^2	25	2.9	10	4278Å
ALIS (CCD)	1024^2	0.04	13.4		5577Å
ALIS (CCD)	256^2	0.2	0.78		5577Å
ALIS_4D (EMCCD)	1024^2	25	0.4	2.5	5577Å
ALIS_4D (EMCCD)	1024^2	25	0.4	1.7	6300Å

ALIS_4D

Some components inherited from ALIS

- Station huts:
- Camera mounts (refurbished)
- Filterwheels (refurbished) and filters
- Aniara (Software) (Major rewrite done)

Sort of an Àttje

Normal

Pessimal case

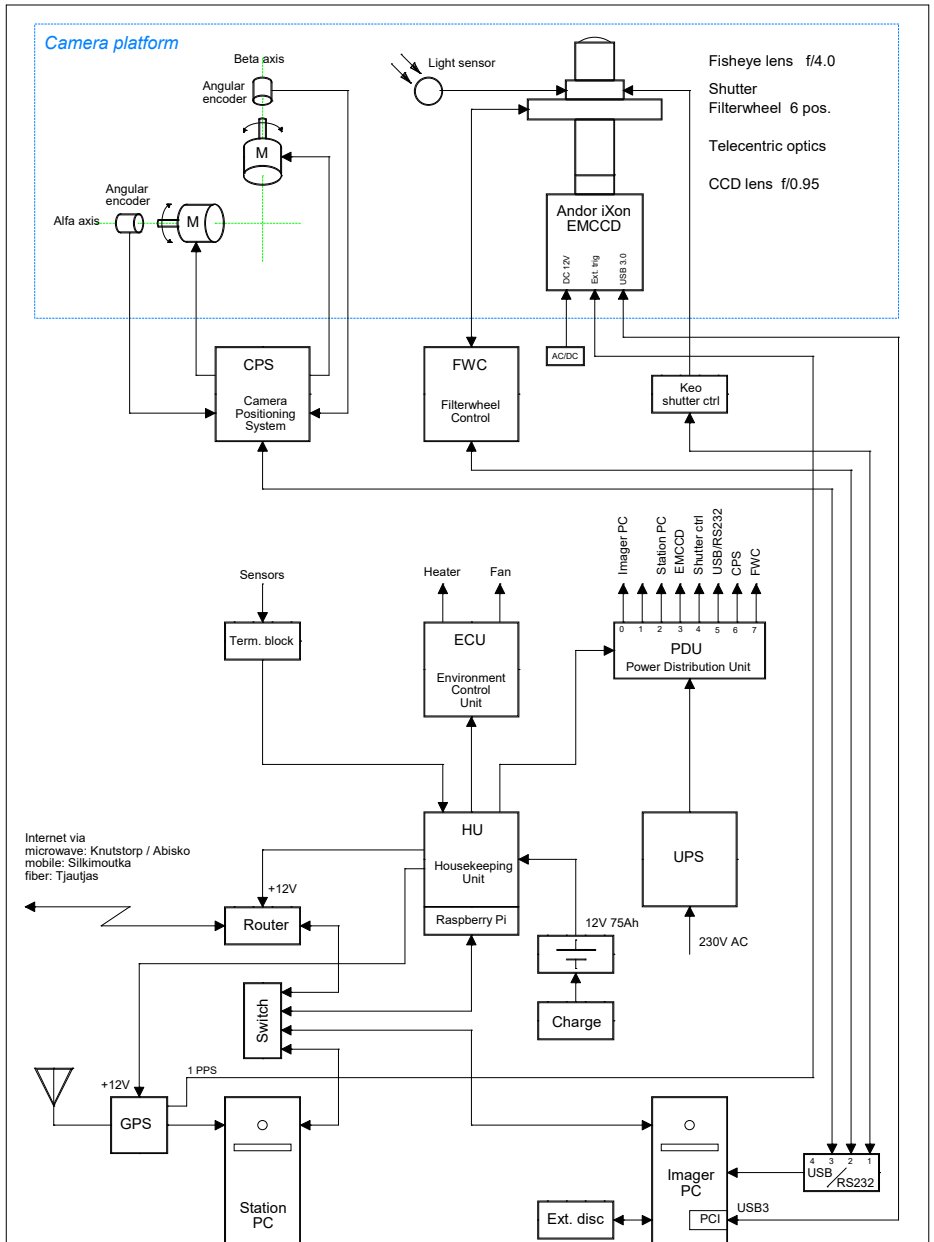
ALIS/ALIS_4D

Filters inherited from ALIS

λ [Å]	$\Delta\lambda$ [Å]	Line	Usage	#
3950	92	Ca, Fe	Meteors	1
4227	280	Ca, Fe, H_2O, ...	Meteors	1
4340.5	25	H_γ, Balmer series	Meteors	1
4278	50	N_2^+ 1Neg.	Aurora/Airglow	6
4861.3	25	H_β, Balmer series	Meteors	1
5100	40		Background	4
5577	40	$O(^1S)$	Aurora/Airglow	6
5893	200	Na, ...	Meteors	1
6230	40		Background	4
6300	40	$O(^1D)$	Aurora/Airglow	6
6562	70	H_α	SPIDER	4
6562.8	25	H_α, Balmer series	Meteors	1
6750	200	$N_2 1P$	SPIDER/LEEWAVES	4
8000	1000	OH Meinel	Airglow LEEWAVES	4
8446	40	$O(3p^3P)$	Aurora/Airglow ($O(3p^3P)$)	4

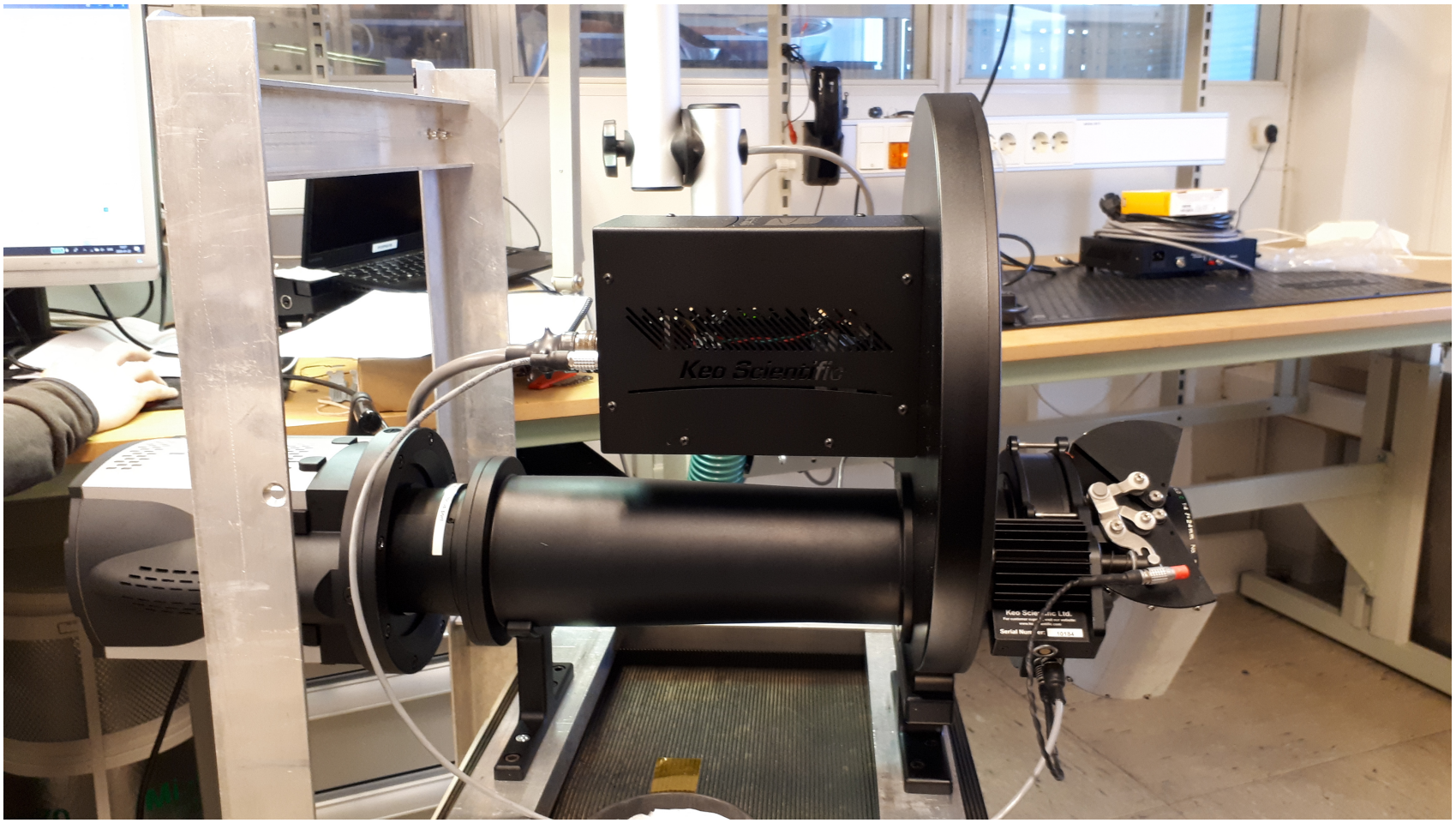
ALIS_4D

Station block diagram



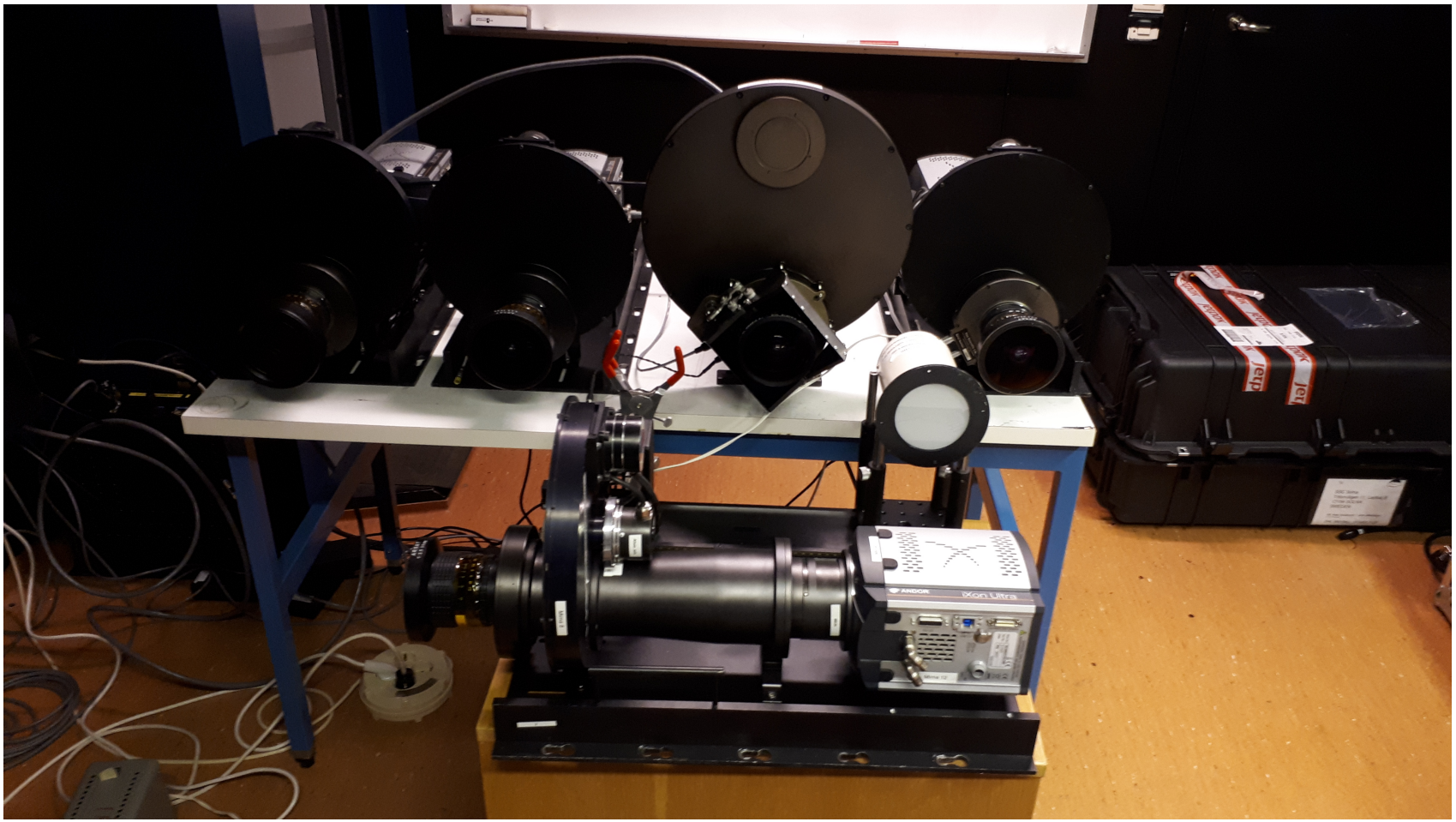
ALIS_4D

ESRANGE imager



ALIS_4D

All imagers



ALIS_4D

Software summary 2020-11-26

Aniara Software suite for ALIS/ALIS_4D written in C (GPL, Brändström and co-authors)

- **mima** Imager site daemon
- **saba** Positioning daemon
- **ud** "universal daemon" uses dynamic libraries (modules) for interfacing to various hardware (housekeeping unit, etc.)
- **fonoglob** Text-based user interface and interfacing daemon (web-interface, other things]

ql4d Quicklooks, movies and more (GPL, Peje Nilsson)

Not yet Keograms.

AIDA_tools Gustavsson, Sergienko (Matlab, Scilab) main analysis software for ALIS/ALIS_4D, etc. Python port!

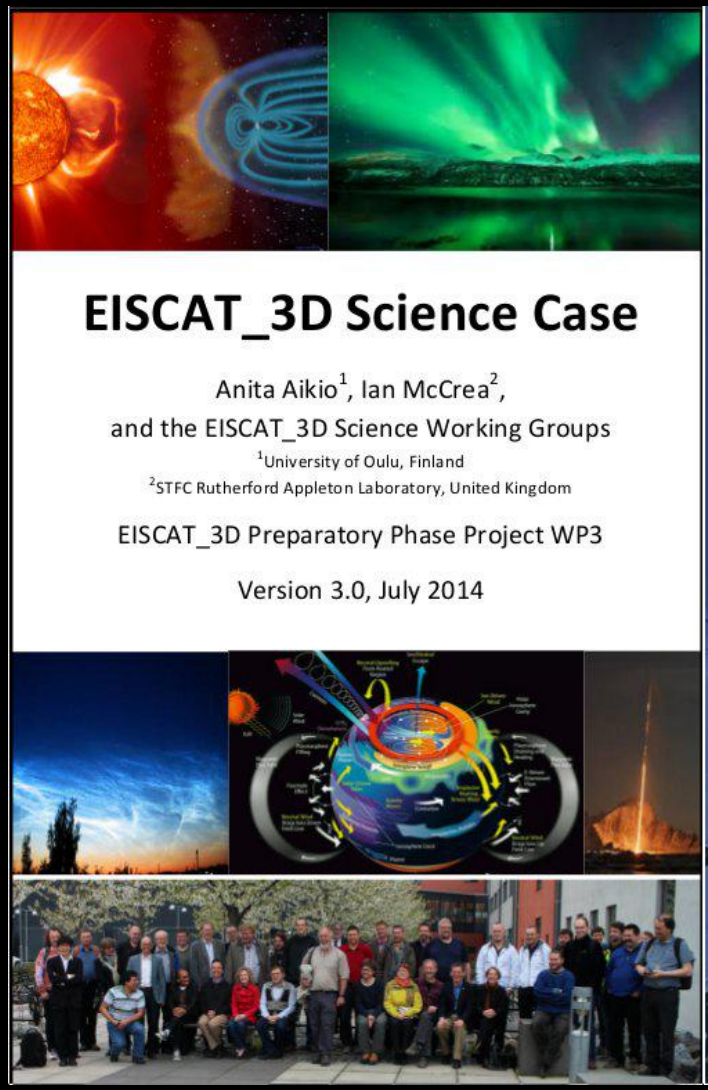
Data production

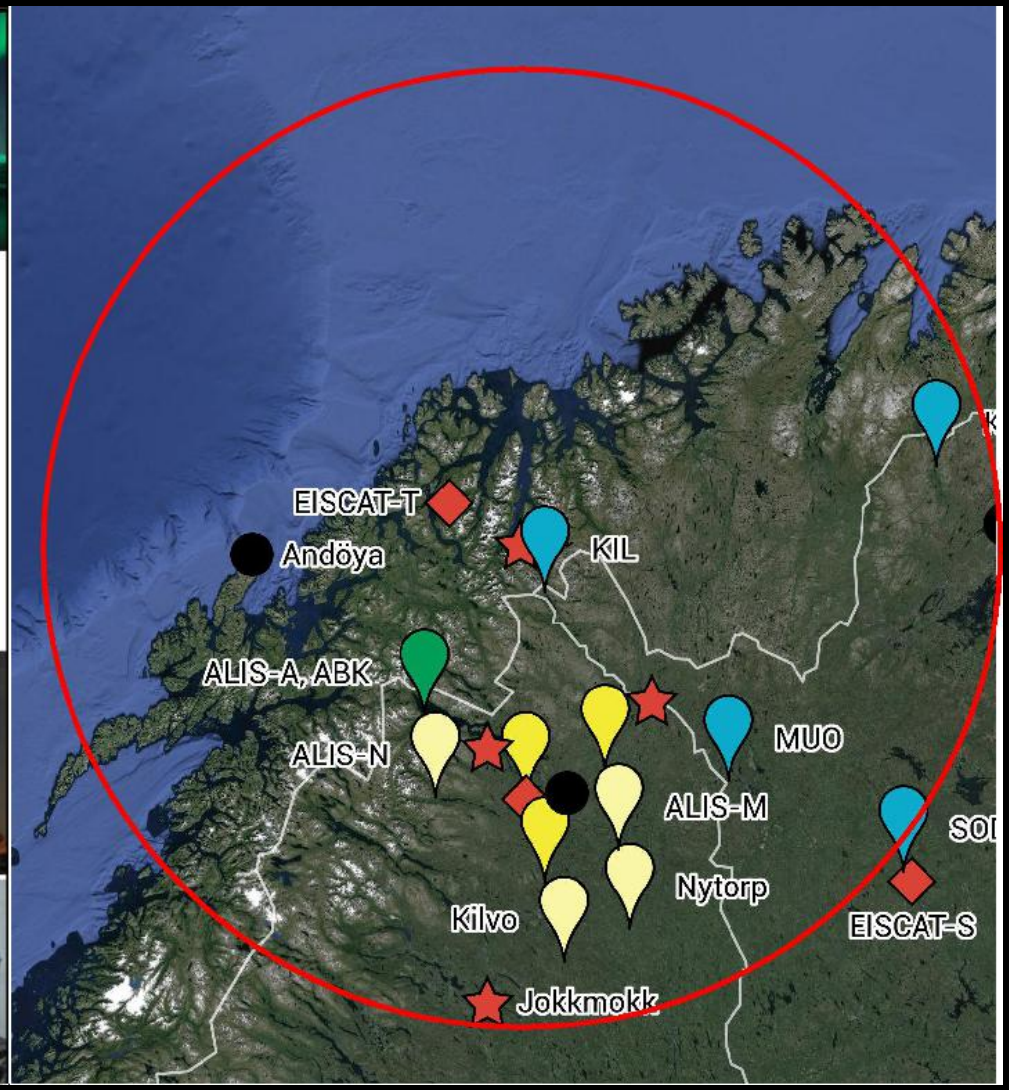
"Harddisks are either new or full" Gustavsson

Hz	resolution	GiB/h	total GiB/h	GiB/night
0.1	256^2	0.02	0.09	1
0.1	512^2	0.09	0.4	6
0.1	1024^2	0.35	14.1	22
1	256^2	0.22	0.88	14
1	512^2	0.9	3.51	56
1	1024^2	3.5	14.06	225
25	256^2	11	44	352
25	512^2	44	176	1406
25	1024^2	176	703	5625

EISCAT_3D science case

Infrastructures and geographical advantages





ALIS_4D

Do EISCAT_3D need optics?

- High-speed narrow-band imaging of aurora, RIOE, meteor trails, . . .
- Observatory modes (long-time monitoring)
- The string “optic” occurs 46 times in 122 pages
- Table 1 “EISCAT_3D radar performance requirements” p. 107–109: Optics required in 70 % (16 of 23) science topics .

Optical measurements are a requirement for EISCAT_3D!

new-moon periods are popular! (Gustavsson, present EISCAT)

There are many clear solid scientific objectives for optical instruments!

Complementary experiences

ALIS/EISCAT campaigns 1990-present

- Many instruments lacks (proper) user interfaces
- Many combinations of operating systems, platforms and software.
- Realtime data access has improved over the years
- Observations missed as many experimenters assumed continous operation (ALIS)
- No common data license but many groups moving in that direction.
- Many of us re-invent the wheel several times
- No joint scheduling of EISCAT and complementary instruments, many PIs to contact
- Increasing Nordic collaboration on these matters (NOMx)

Towards a common interface specification

Some thoughts regarding design requirements

- Platform independent (Everyone must be able continue to use their favourite operating systems and tools)
- Interoperability with other systems such as EISCAT_3D
- Possibility of combining several national infrastructures and instruments into larger units. One such example: BIFROST/ALIS_4D/MIRACLE

ALIS_4D

data levels

Level	Usage	Archived	Metadata
Level 0	N/A	N/A	N/A
Level 1	Binary dumps (technical tests only)	yes	no
Level 2	Unprocessed (raw) data stored as FITS-files	yes	yes
Level 3	Processed data in physical units	yes?	yes
Level 4	Higly processed data in physical units (e.g. 3D volume emission rate from tomography)	yes?	yes
(Level 5)	Final scientific results (e.g. publications)	yes	yes

Suggested levels of control

	Level of control	For example
C0	Not controllable, data only	Magnetometer, simple riometer
C1	Basic control ability	Simple ASC
C2	Advanced configuration and control abilities	ALIS/ALIS_4D Modern Ionosondes
C3	Realtime analysis capabilites capable of bidirectional command and control	Not yet
C4	As C3 but autonomous bidirectional decision-making and control	Not yet

Suggested layers of instrument control

Layer	Description	For example (ALIS_4D)
7	Top level interfaces	EISCAT_3D user interface
6	Translation	Between native interface(s) and other systems via a common interface specification (CIS)
5	Native user interface or API	web- and/or text-based user interfaces
4	Communication	`fonoglob -d` ("concentrator" daemon)
3	Instrument software	(`mima` imager daemon)
2	Internal firmware	(Imager firmware)
1	Hardware	(Imager, filterwheel, etc.)

ALIS_4D

SPIDER2 launch

ALIS_4D

Ongoing scientfic studies

- Data-analysis/publications
  - G. Giono, N. Ivchenko, T. Sergienko and U. Brändström: "Multi-point measurements of the plasma density and temperature from the Langmuir probe onboard the SPIDER sounding rocket Free Falling Units." (SPIDER, ALIS, SNSA)
  - Sergienko, et al.: data-analysis (SNSA ongoing) Quicklook-movie 2020-02-19 SPIDER2 launch at 23:14 UTC
  - Sergienko, et al.: Orbit determination from ALIS_4D images (ongoing, SNSA/NRFP)
- Future projects
  - Several scientific campaigns 2020/2021
  - BROR (Sergienko, SNSA Approved yesterday!)
  - Orbit determinations (SNSA/NRFP, TBC)

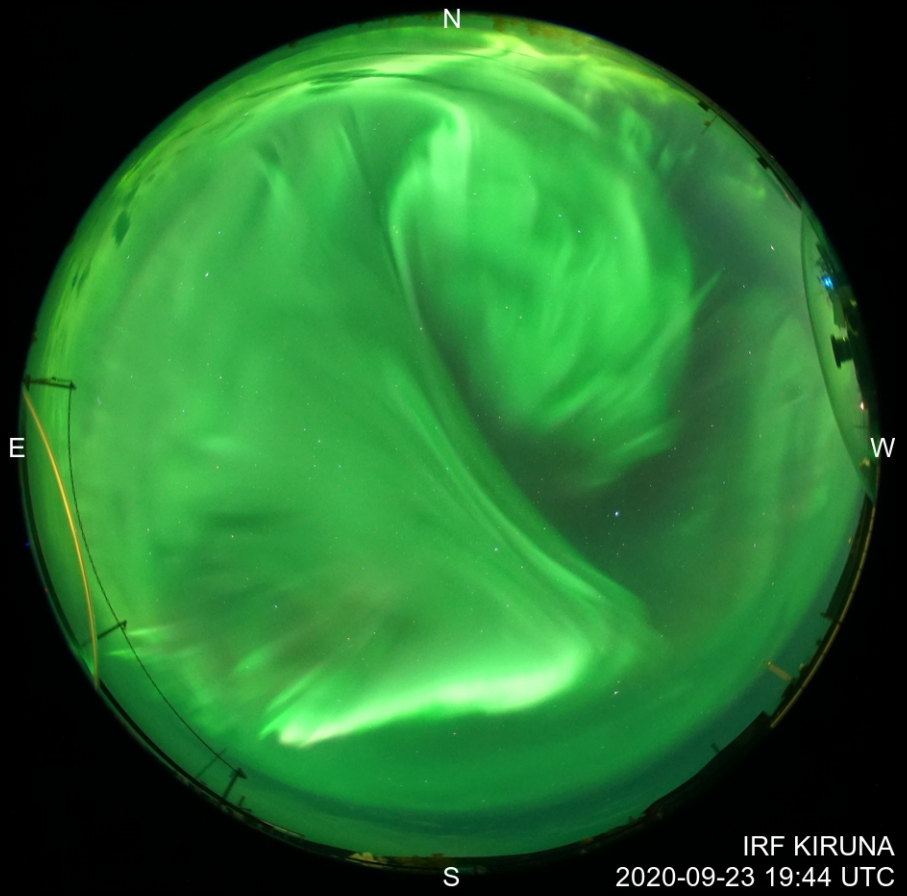
ALIS_4D

PI: Urban Brändström

- Operational with four stations (Abisko, Kiruna, Silkkimuotka and Tjautjas) since fall 2019.
- ESRANGE since spring 2020. SPIDER2
- BROR: barium release rocket mission (if funded)
- Optical support for EISCAT_3D
- Andor DU-888 EMCCD-imagers (1024×1024, up to video rates)
- Narrow band interference filters with six position filter-wheel
- Absolute calibrated.
- Long-time monitoring starts soon (2020, hopefully MIRACLE compatible) Delayed mainly because of cloudy skies.
- Raw-data (FITS), gif quicklooks and daily movie.
- Quicklook-movie 2020-09-23

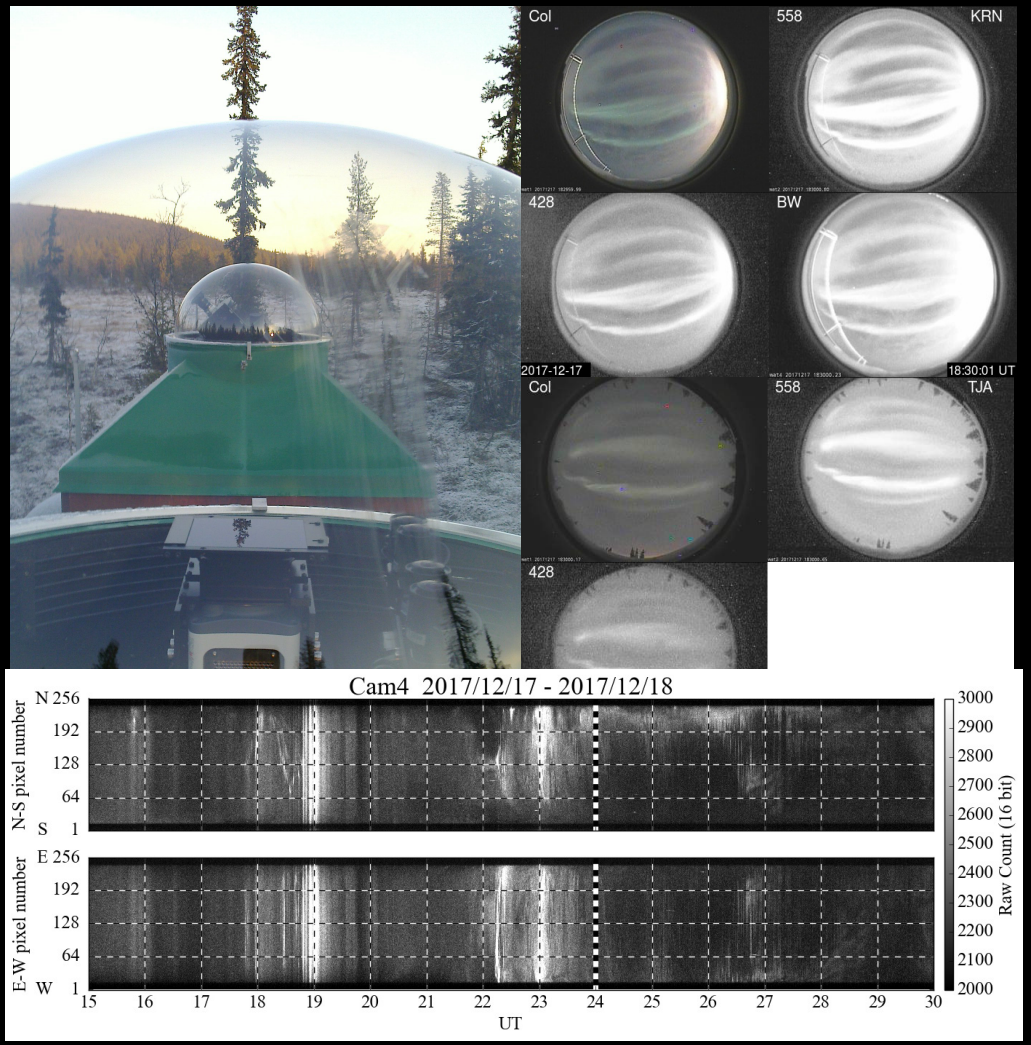
New allsky camera (Sony α7S)

PI: Urban Brändström



- Normally 1 exp. / min. but campaign modes available
- Keograms, movie and three resolutions (up to 4K available)
- Quicklook-movie 2020-09-23

ISEE/NIPR



PI: Yasunobu Ogawa (watec), Keisuke Hosokawa (100 Hz)

Summary

- Operational but some more work remains. . .
- ALIS_4D long-time monitoring of selected emissions starts "RaISoonNow(tm).
- BROR mission (Funded by SNSA)
- New allsky-camera in Kiruna, (open-source)
- The pandemic makes things go slower, but so far no major problems as long as nobody gets covid-19
- A lot of work, we are under-staffed but situation more or less under control as long as all are healthy
- ALIS_4D example quicklook movie at http://alis.irf.se/stdnames/2020/09/23/2020-09-23.mp4
- Corresponding movie from new allsky-camera: https://www.irf.se/alis/allsky/krn/2020/09/23/movie20200923.mp4

References I