Kiruna Atmospheric and Geophysical Observatory (KAGO)

Status report 2020-11-26 with focus on ALIS_4D

Urban Brändström, Johan Kero, Thomas Leyser, Daria Mikhaylova, Peje Nilsson, Uwe Raffalski, Fredrik Rutqvist, Tima Sergienko, Lars-Göran Vanhainen, Masatoshi Yamauchi

Swedish Institute of Space Physics (KAGO, STAR)

2020-11-26

Outline

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.)

KAGO news

Kiruna Atmospheric and Geophysical Observatory

- ALIS_4D operational. Observatory measurements starting soon.
- New Allsky camera (Sony α7S) in Kiruna.
- New suspended variometer and major refurbishment of magnetic observatory.
- RfS spectroriometer in Kiruna disturbed by Kiruna ionosonde. Relocation planned. (Nikkaluokta, Silkkimuotka or Tjautjas?)
- New low-cost ionosondes (after Juha Vierinen) are under investigations

Outline

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 fall.
  - 2021: Regular operations begin

INSTITUTET FÖR RYMDFYSIK
Swedish Institute of Space Physics

Umeå universitet

AILS_4D

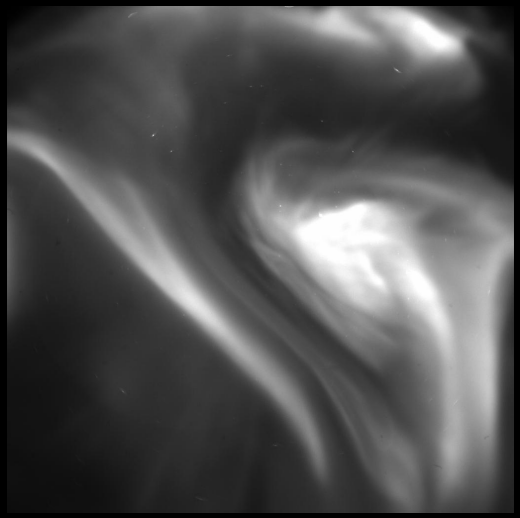
People involved

- IRF/KAGO core team:
  - Urban Brändström, PI
  - Lars-Göran Vanhainen, Engineer
- IRF/STAR, core team:
  - Peje Nilsson, Software engineer
  - Tima Sergienko, CoI
- International collaborators
  - Yasunobo Ogawa, NIPR
  - Yoshimasa Tanaka, NIPR
  - Takanori Nishiyama , NIPR
  - Keisuke Hosokawa, ISEE
  - Shin-ichiro Oyama (ISEE & U. Oulu)
  - ...
- Umeå University, Physics

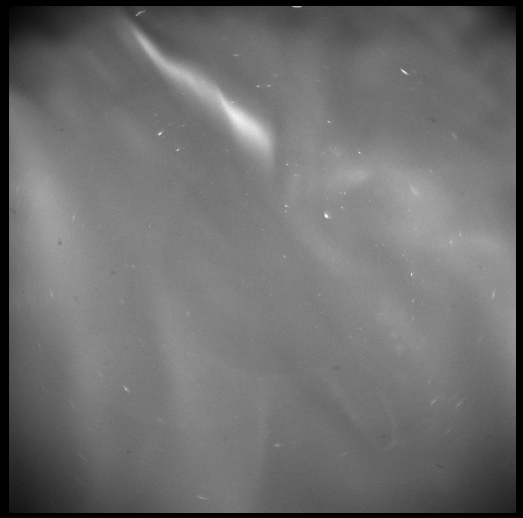
ALIS_4D

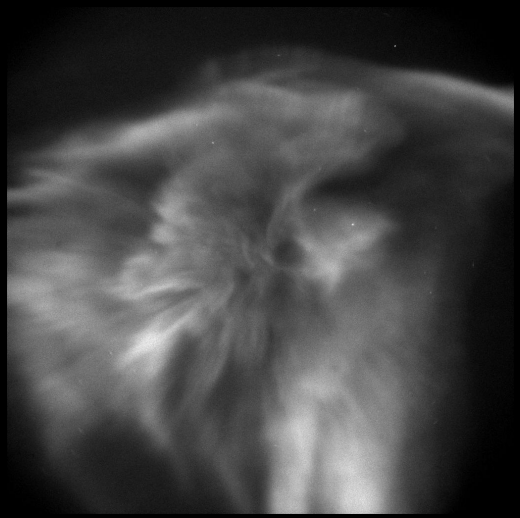
First light 2019-02-28 18:38:00.005608 11.006 s 6750 Å

6750 Å

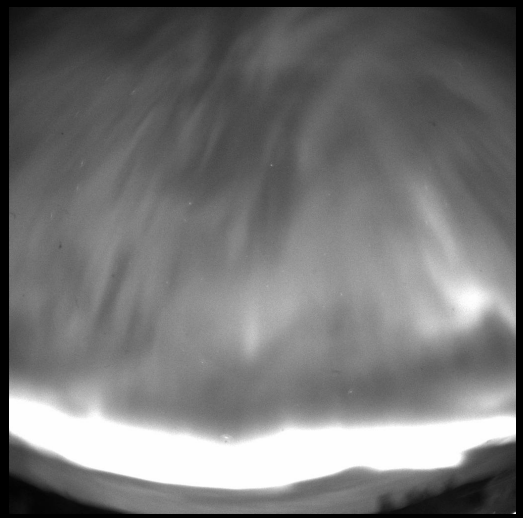


6562 Å



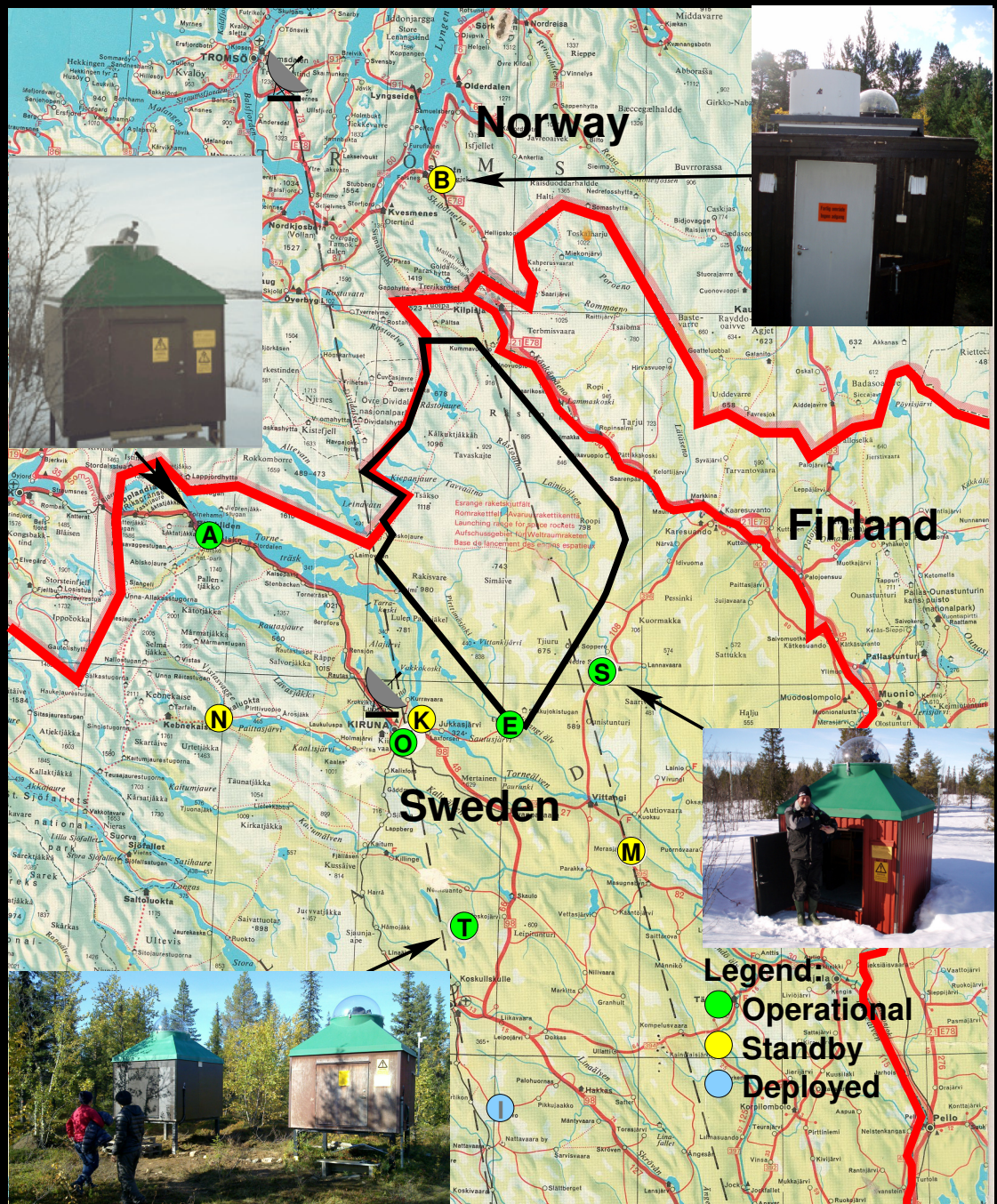


4278 Å



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

What is a Rayleigh?

$$4\pi L_\gamma = \int_0^\infty \epsilon(l, t, \lambda) dl \tag{1}$$

This quantity is the column emission rate, which *Hunten et al.* [1956] proposed as a radiometric unit for the aurora and airglow. In SI-units the Rayleigh becomes [*Baker and Romick*, 1976]:

$$1\ [\mathrm{Rayleigh}] \equiv 1\ [\mathrm{R}] \triangleq 10^{10} \left[\frac{\mathrm{photons}}{\mathrm{s\ m^2\ (column)}}\right] \tag{2}$$

Radiance:

$$L_\gamma = \frac{\lambda}{hc} L_E \left[\frac{\mathrm{photons}}{\mathrm{s\ m^2\ sr}}\right]$$

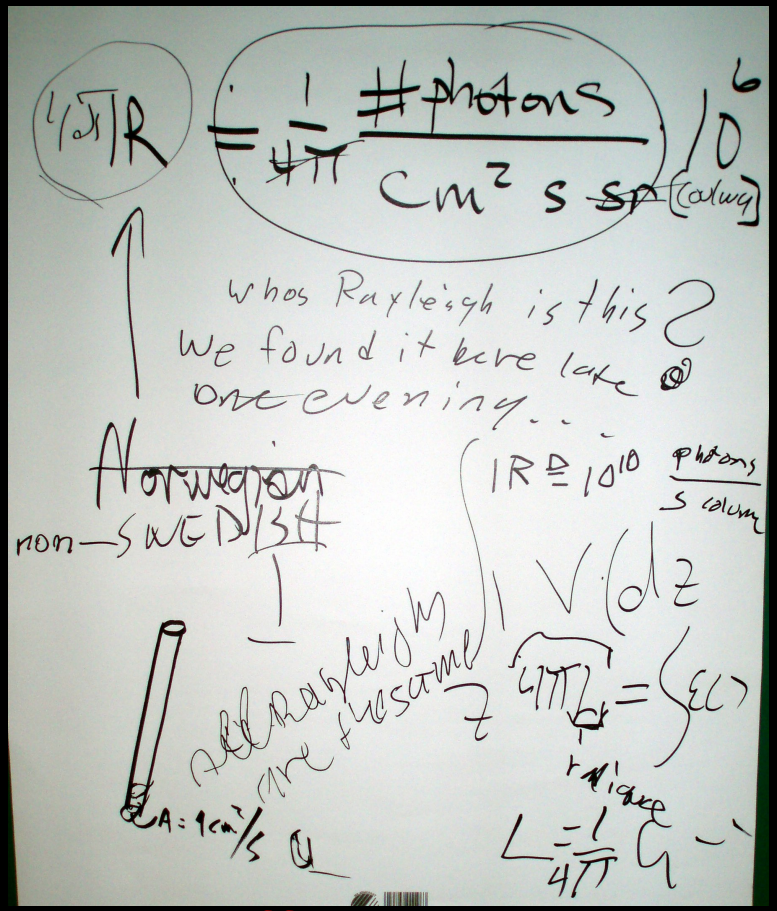
Rayleigh to radiance [*Baker and Romick*, 1976]:

$$L_\gamma = \frac{10^{10} I}{4\pi} \left[\frac{\mathrm{photons}}{\mathrm{s\ m^2\ sr}}\right] \tag{3}$$

He said the R-word!!!

This seminar is getting silly, STOP IT NOW!

—My brain hurts!



—This is a topic for a completely different seminar!

—Besides I talked about this in 2015... they should remember.

—Should we say the G-word to SSPT? Geometrical factor!!!

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

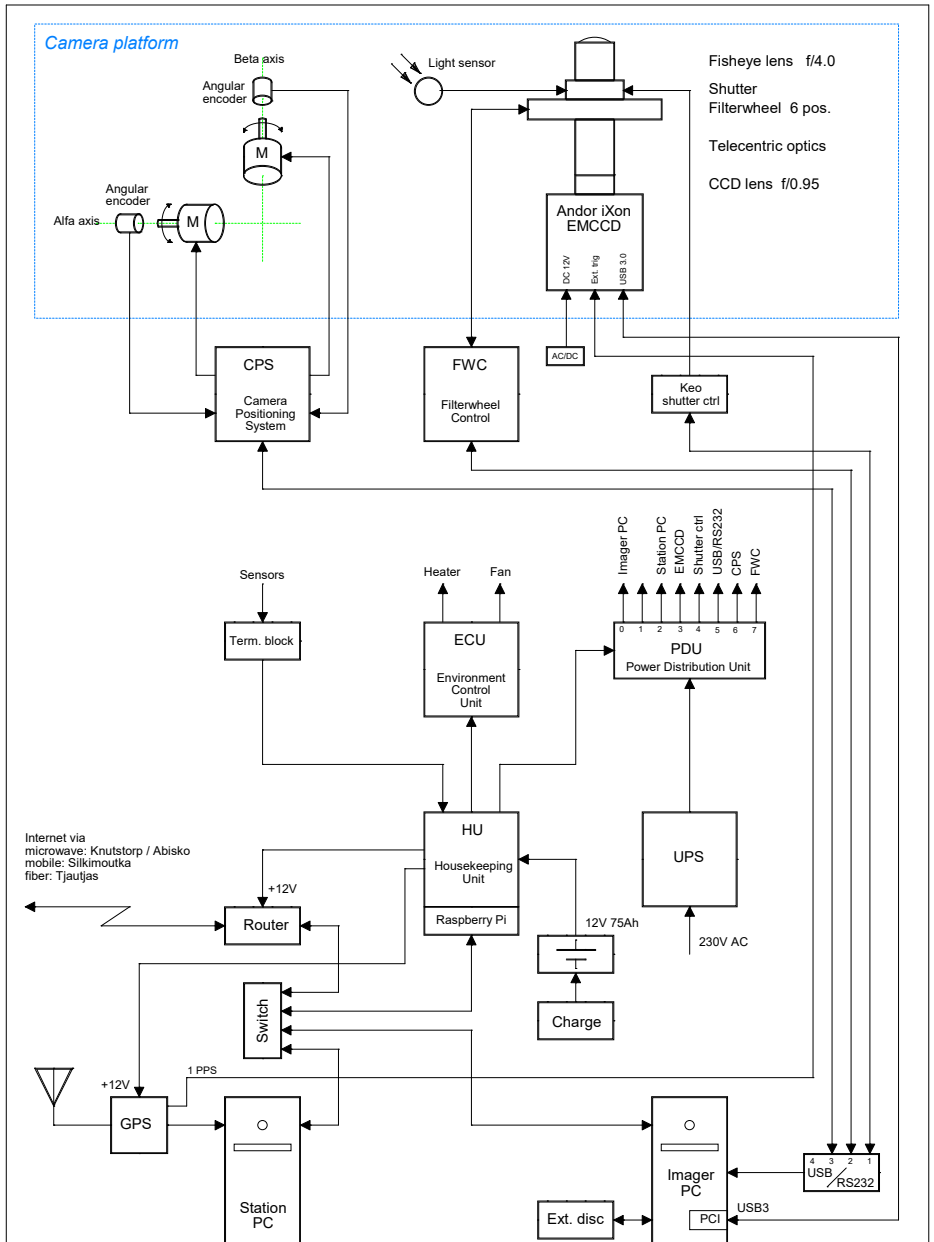
ALIS/ALIS_4D

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

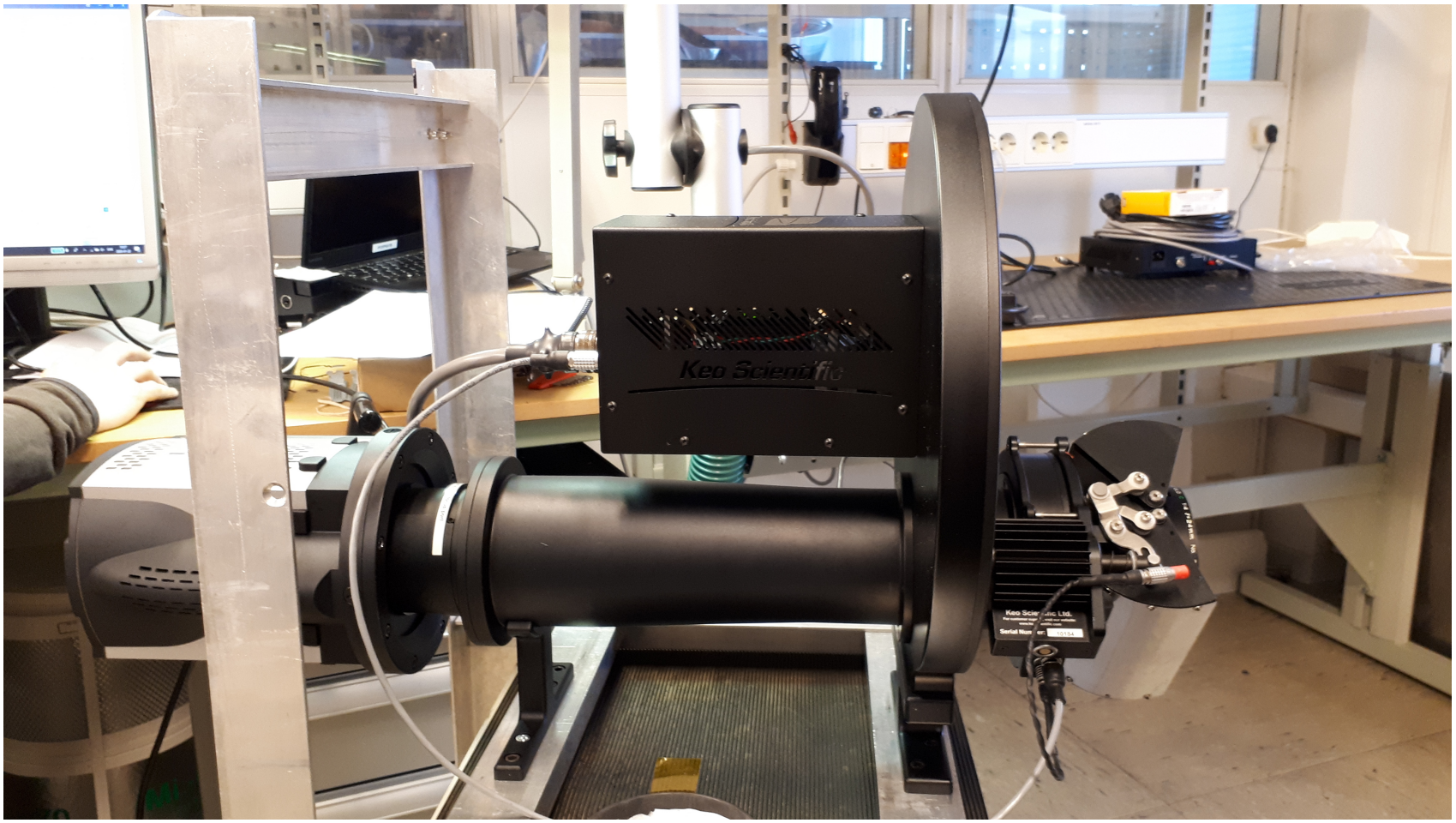
ALIS_4D

Station block diagram



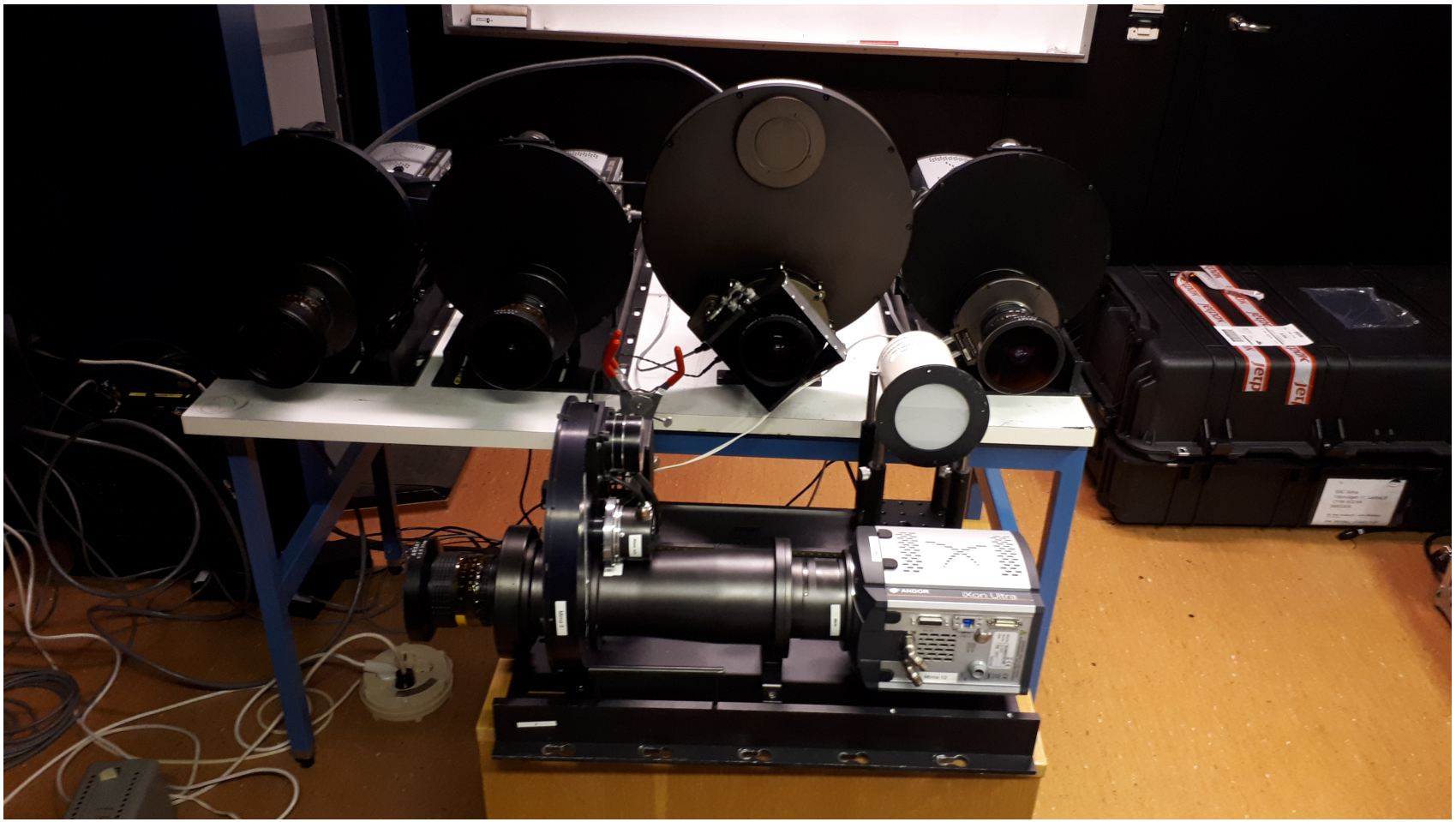
ALIS_4D

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!

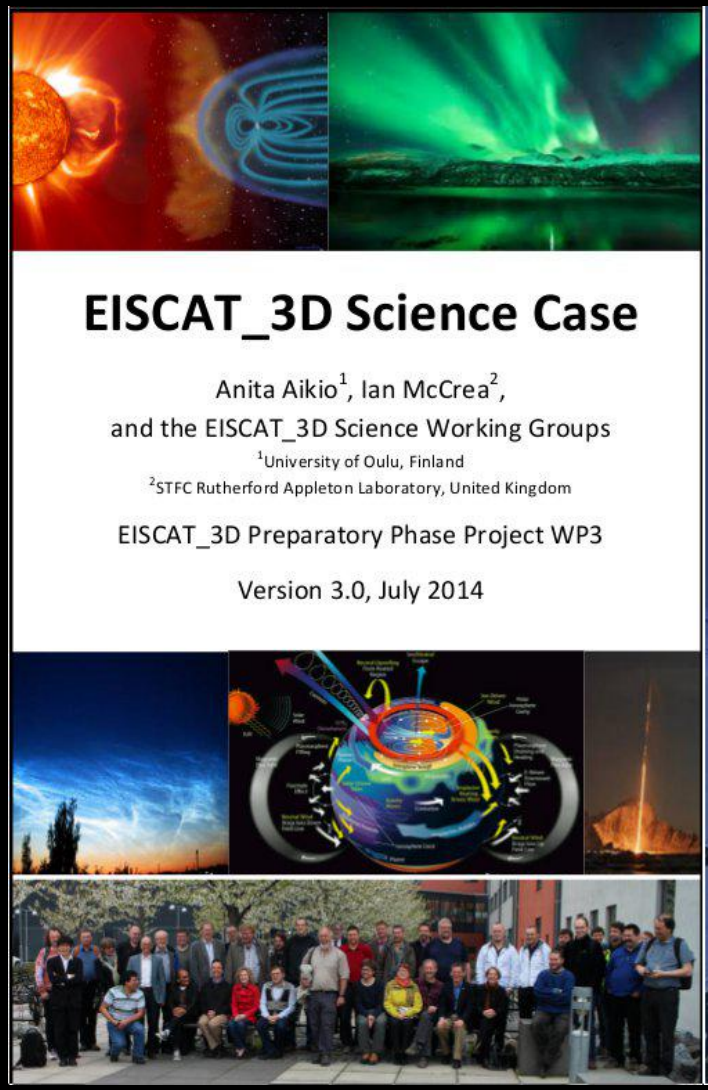
Data production

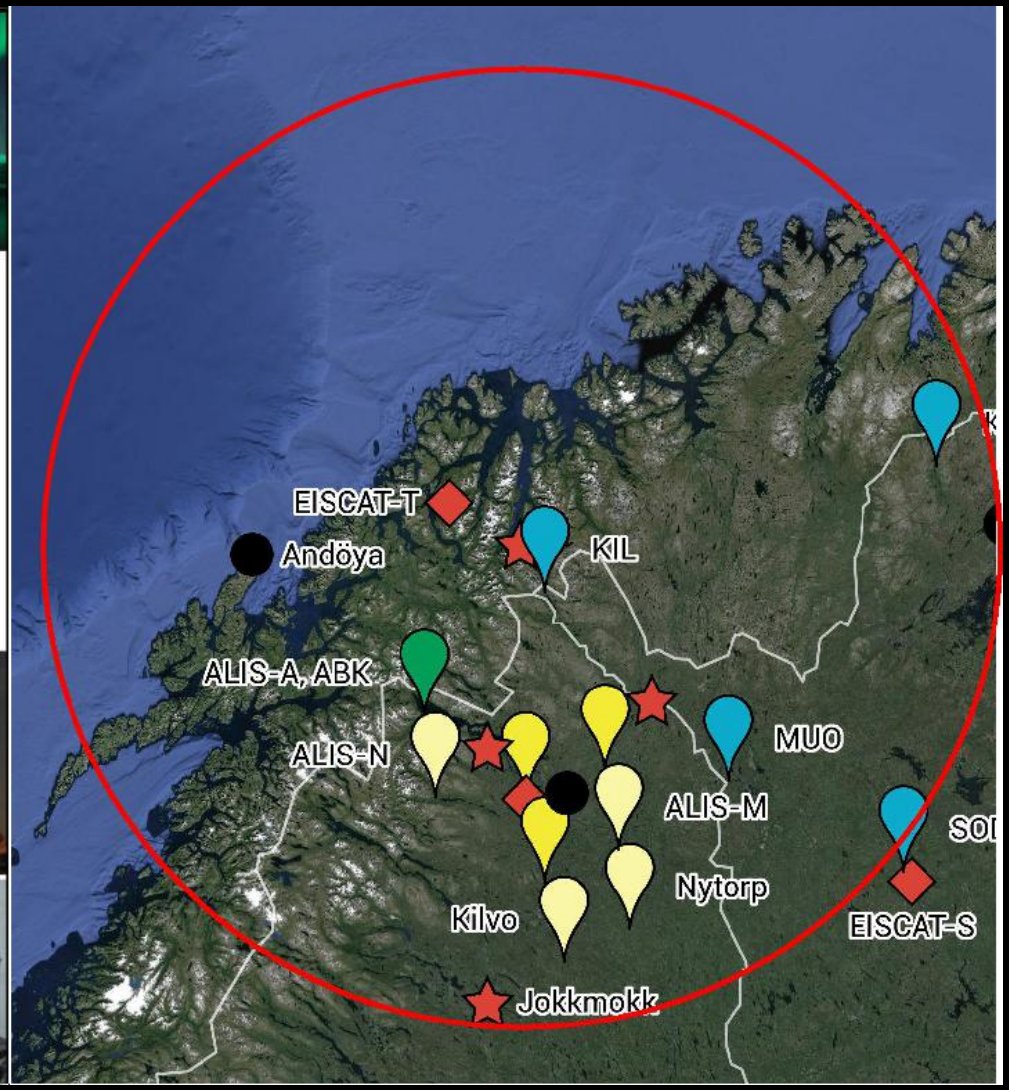
"Harddisks are either new or full" Gustavsson

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

The Open Systems Interconnection model

OSI (Open Source Interconnection) 7 Layer Model

Layer	Application/Example		Central Device/ Protocols		DOD4 Model
Application (7) Serves as the window for users and application processes to access the network services.	**End User layer** Program that opens what was sent or creates what is to be sent Resource sharing • Remote file access • Remote printer access • Directory services • Network management		**User Applications** SMTP	GATEWAY Can be used on all layers	Process
Presentation (6) Formats the data to be presented to the Application layer. It can be viewed as the "Translator" for the network.	**Syntax layer** encrypt & decrypt (if needed) Character code translation • Data conversion • Data compression • Data encryption • **Character Set Translation**		JPEG/ASCII EBDIC/TIFF/GIF PICT		
Session (5) Allows session establishment between processes running on different stations.	**Synch & send to ports** (logical ports) Session establishment, maintenance and termination • Session support - perform security, name recognition, logging, etc.		**Logical Ports** RPC/SQL/NFS NetBIOS names		
Transport (4) Ensures that messages are delivered error-free, in sequence, and with no losses or duplications.	**TCP** Host to Host, Flow Control Message segmentation • Message acknowledgement • Message traffic control • Session multiplexing	PACKET FILTERING	TCP/SPX/UDP		Host to Host
Network (3) Controls the operations of the subnet, deciding which physical path the data takes.	**Packets** ("letter", contains IP address) Routing • Subnet traffic control • Frame fragmentation • Logical-physical address mapping • Subnet usage accounting		**Routers** IP/IPX/ICMP		Internet
Data Link (2) Provides error-free transfer of data frames from one node to another over the Physical layer.	**Frames** ("envelopes", contains MAC address) [NIC card — Switch — NIC card] (end to end) Establishes & terminates the logical link between nodes • Frame traffic control • Frame sequencing • Frame acknowledgment • Frame delimiting • Frame error checking • Media access control		**Switch Bridge WAP** PPP/SLIP	Land Based Layers	Network
Physical (1) Concerned with the transmission and reception of the unstructured raw bit stream over the physical medium.	**Physical structure** Cables, hubs, etc. Data Encoding • Physical medium attachment • Transmission technique - Baseband or Broadband • Physical medium transmission Bits & Volts		**Hub**		

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 TBC)
  - Orbit determinations (SNSA/NRFP, TBC)

ALIS_4D

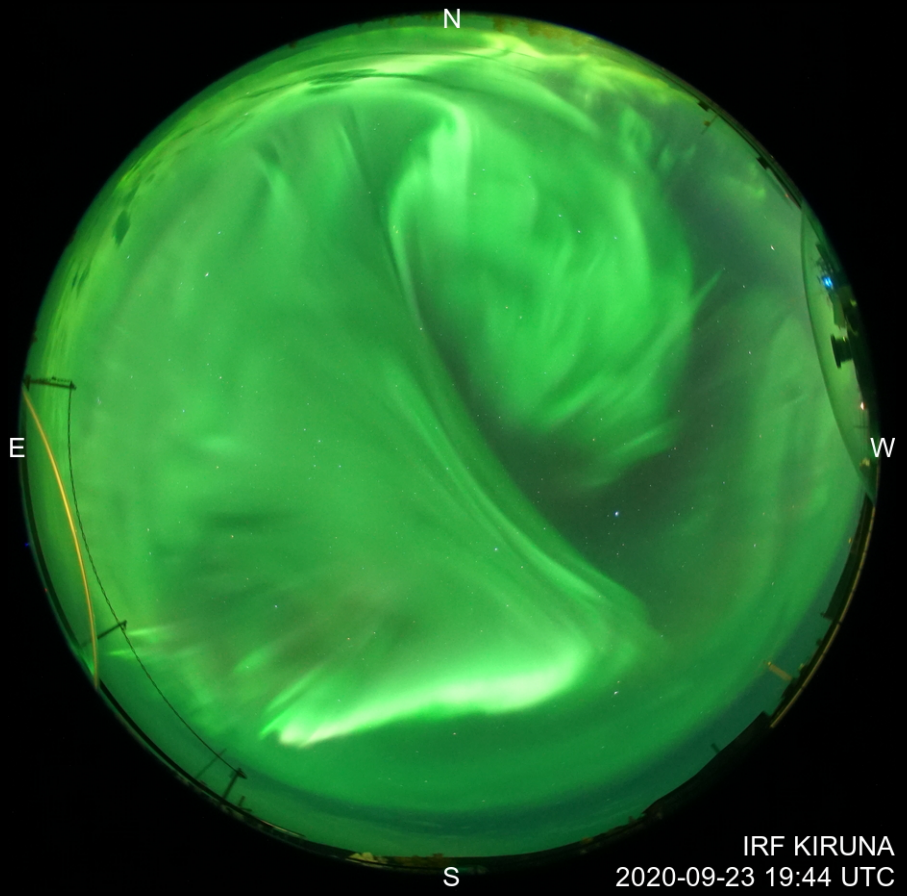
PI: Urban Brändström

- 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

Outline

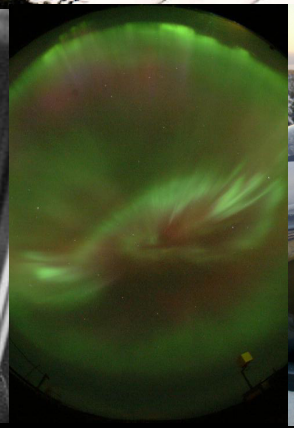
New allsky camera (Sony α7S)

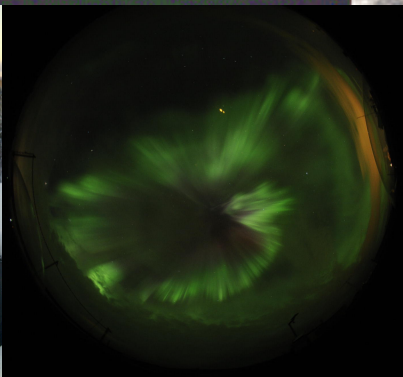
PI: Urban Brändström



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

Older all-sky cameras





All-sky cameras

- Objective: Sky overview during dark hours. (Colour imaging each minute during dark periods). Absolute measurements: ALIS during campaigns
- Kiruna instrument: Nikkor 8mm objective lens and a Sony $\alpha 7s$ (Nikon D700 until spring 2020)
- Time-series: 1956–2004 (film) 2001– (digital)
- Related: Meteor cameras All-sky camera at Abisko turiststation (Nishi-san)
- ISEE 100Hz camera (Tjautjas)
- More cameras planned (Hopefully Lycksele)
- PI: Urban Brändström

Meteor cameras

Abisko, Kiruna, Sodankylä and Umeå

- PI: Eric Stempels (UU) (IRF: Johan/Urban)
- Objective: Sky overview. (B/W video imaging 24/7) meteor detection
- Kiruna and Abisko part of Swedish Meteor Imaging network
- Abisko:
- Kiruna:
- Sodankylä:
- Umeå: (UmU)
- Time-series: 2015–
- More cameras planned

Bolid

2019-09-24 23:19:01 UTC

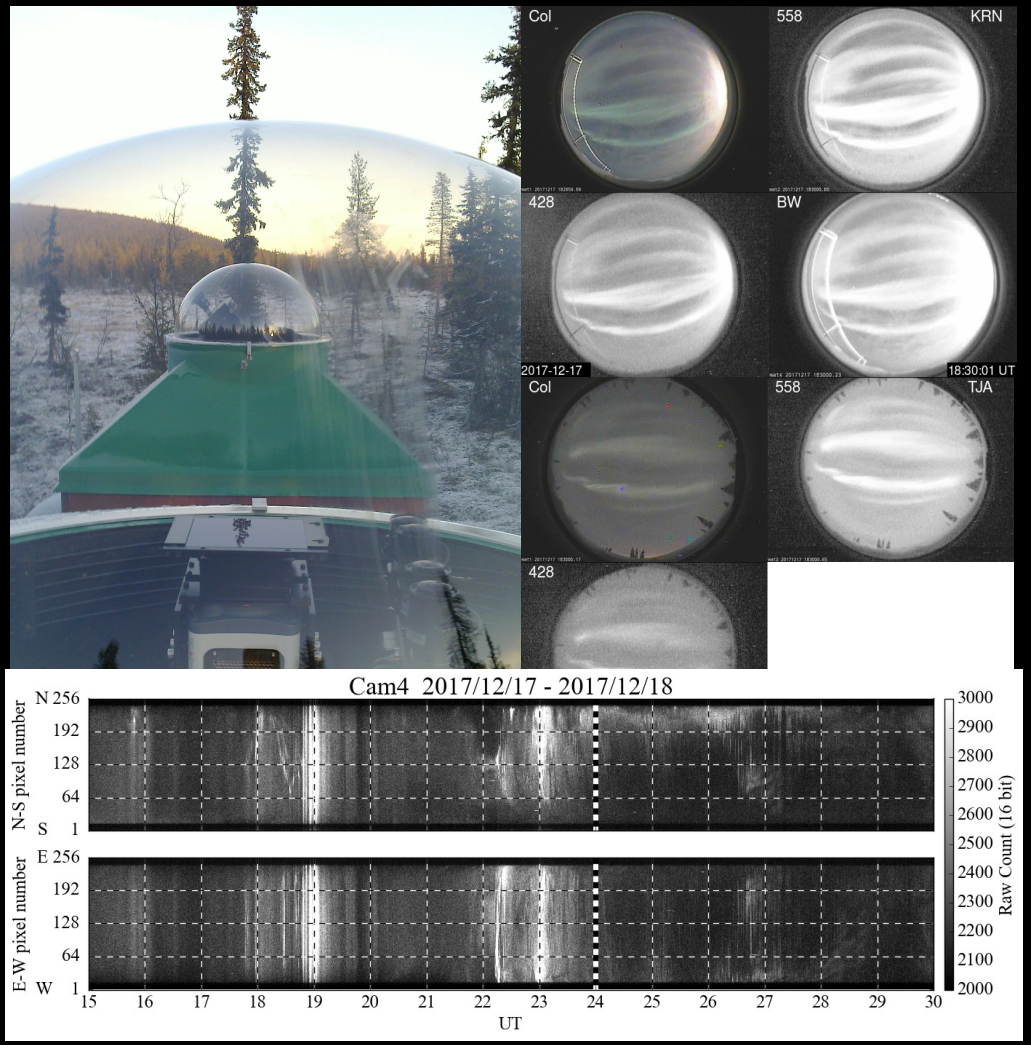
Kiruna

(Abisko)

ISEE/NIPR cameras

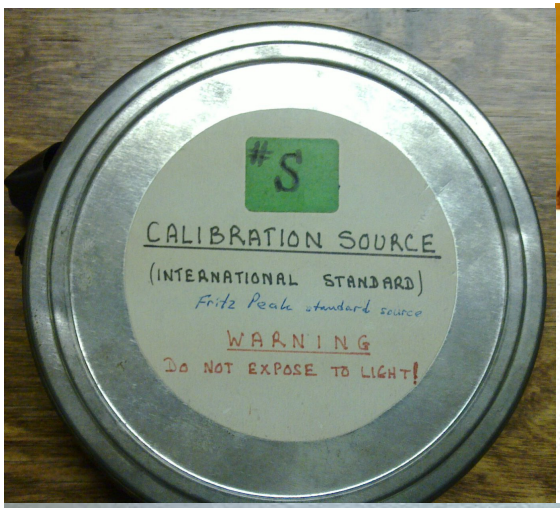
100 Hz EMCCD and four channel auroral imagers

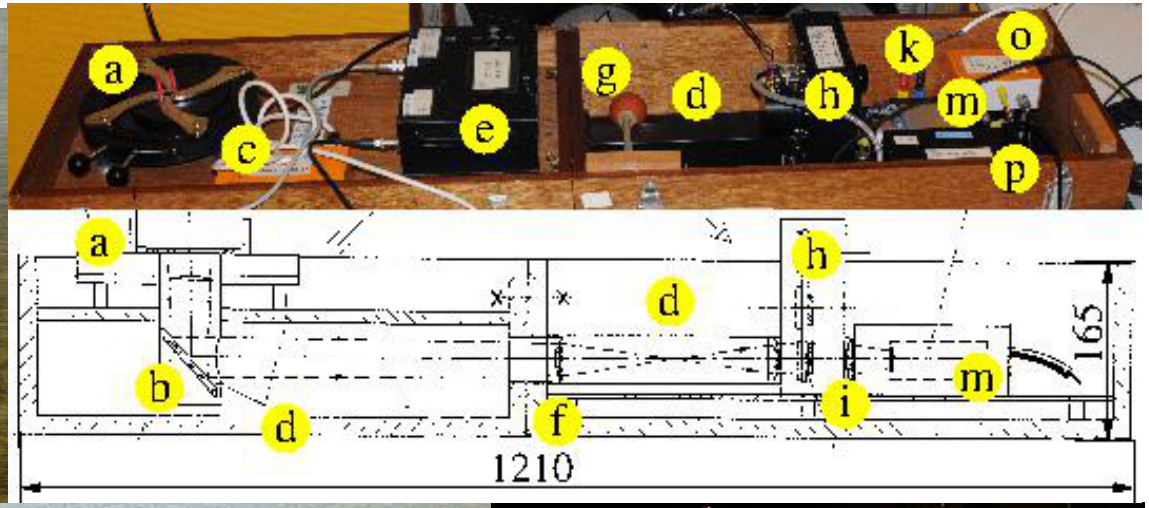
ISEE/NIPR

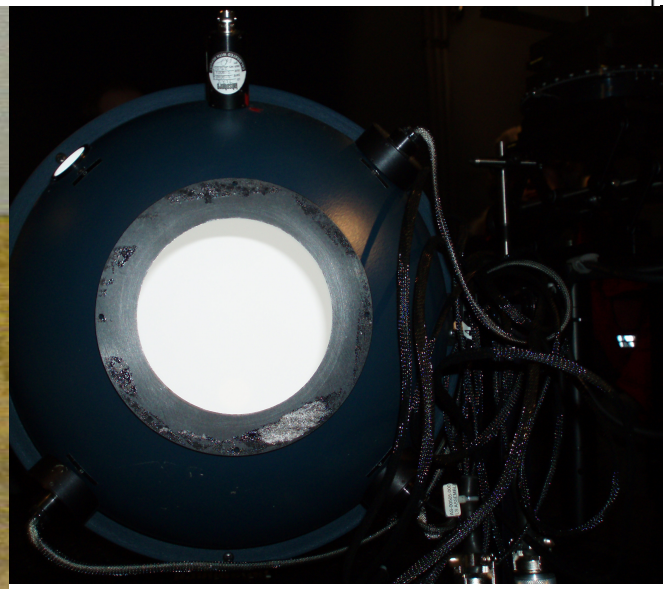


PI: Yasunobu Ogawa (watec), Keisuke Hosokawa (100 Hz)

Optical absolute calibration







Geomagnetic observations

PI: Masatoshi Yamauchi

Geomagnetic observations

Kiruna, Lycksele and Tormestorp

- PI: Masatoshi Yamauchi
- Kiruna: timeseries 1950–
  - 2 Variometers primary (DTU FGE suspended) and secondary(DMI-FGE91)
  - 2 Proton magnetometers (Gemsys)
  - 2 DI-flux teodolites
  - 2020:
    - Major upgrade of the observatory to INTERMAGNET 1 s standard.
    - Replaced one variometer with a modern suspended instrument
- Lycksele (in cooperation with SGU): timeseries 1957–
  - 2 Variometers
  - Proton (Gemsys) -
  - DI-flux teodolite
- Tormestorp (Hässleholm): variometer (DTU-FGE) 2018–
- Abisko and Uppsala PI Gerhard Schwarz (Owned and operated by SGU)

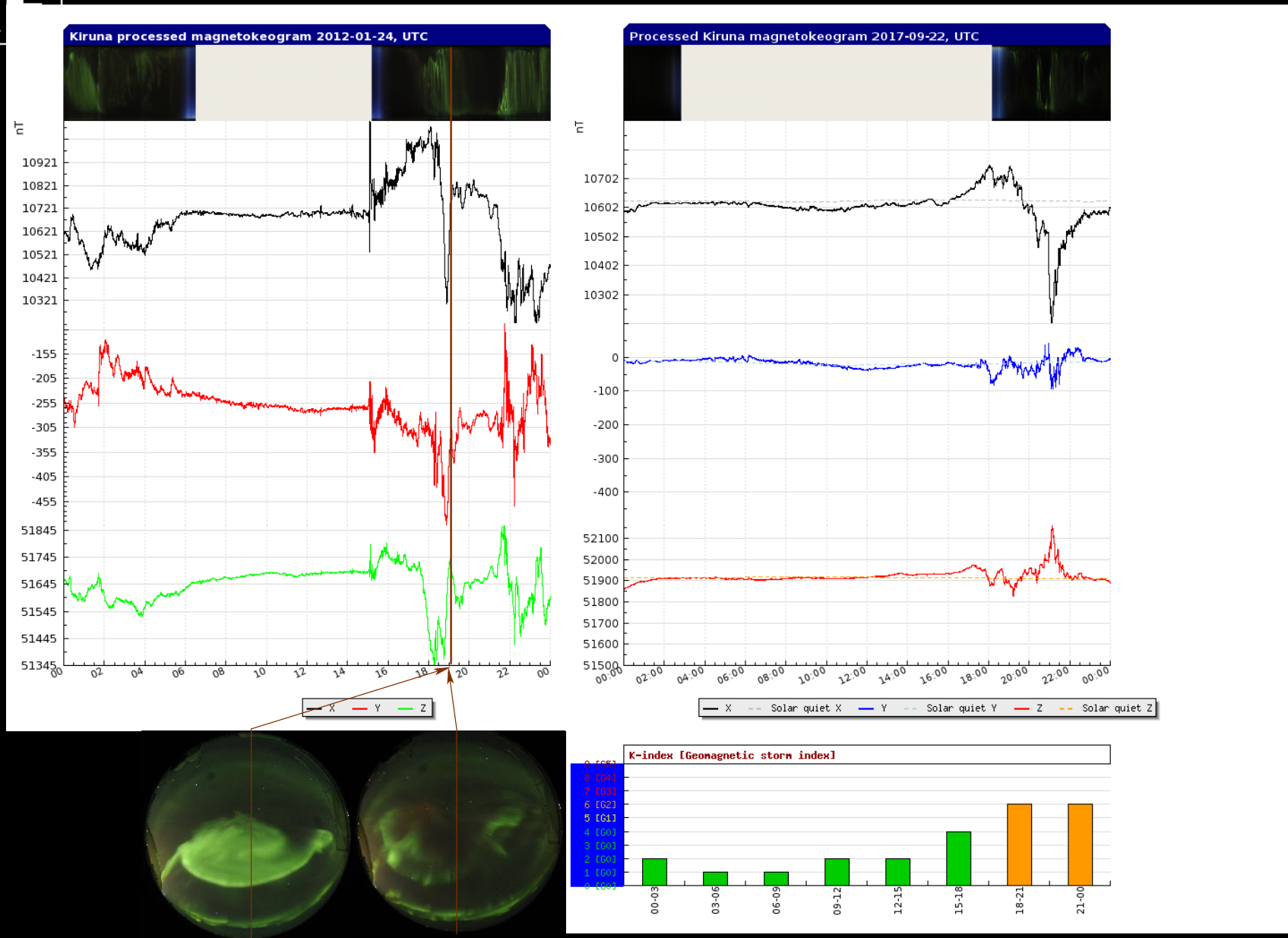
New variometer

Lantmäteriet

Swedish land survey measured geographic north

Photos: Daria Mikhaylova

IRF Magnetokeogram



Riometers

Kiruna and Lycksele

- PI/Project leader: Tima Sergienko/Daria Mikhaylova
- IRFs first scientific publication on polar cap absorption.
- Kiruna: timeseries since 1958
  - 30 MHz and 38 MHz derived from spectroriogram
  - New SDR- spectroriometer installed (RF-Shamaanit)
- Lycksele: timeseries since 1958 Instrument: La Jolla Sciences ("blue box")
  - 38 MHz
- GloRiA http://spears.lancs.ac.uk/gloria/
- Delivers data to Aviation Civile, France, ICAO 24/7 service (2018–)

Ionosondes

PI: Thomas Leyser (Photo L-G Vanhainen)

Ionosondes

Kiruna, Lycksele and Uppsala

- PI: Thomas Leyser
- Kiruna: timeseries since 1957 (first ionograms 1948!)
  - Vertical Incidence Pulsed Ionospheric Radar, (VIPR) delivered fall 2016. Running since December 2016.
- Lycksele: timeseries since 1957
  - Old ionosonde 4 ionograms/hour.
- Uppsala: timeseries: since 1952
  - Old ionosonde 4 ionograms/hour. Broken beyond repair! Urgent need for new instruments
- New ionosondes (after Vierinen) built at IRF start 2021

Infrasound

PI Johan Kero

Infrasound

Kiruna, Jämtön, Lycksele and Sodankylä

- PI: Johan Kero
- Objective: Infrasound detection and triangulation
- Kiruna: Timeseries since 1973
  - Kiruna: microphones (old and new)
  - Four microbarographs from CEA, France
- Jämtön:
  - Microphones (old and new)
- Lycksele:
  - Microphones (old and new)
- Sodankylä (moved from Uppsala)
  - Microphones (old to be upgraded)

Outline

Summary

- Some work remains. . .
- ALIS_4D long-time monitoring of selected emissions.
- BROR mission (if funded by SNSA)
- New allsky-camera in Kiruna, (open-source)
- Move spectroriometer?
- New IRF-built ionosondes in Uppsala and Lycksele?
- 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

References I

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