



Kiruna Atmospheric- and Geophysical Observatory (KAGO)

ALIS_4D — status, possibilities and future plans

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Csilla Szasz¹ Tima Sergienko¹ Peter Sköld²
Lars-Göran Vanhainen¹ Masatoshi Yamauchi¹ ...

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²University of Umeå (Physics, EMG, ArcUm)

³KTH Royal Institute of Technology



Swedish Institute of Space Physics

New organisation from 2018

- ▶ PAF + STP \Rightarrow STAR, Solar Terrestrial and Atmospheric Research (Head: Johan Kero)
- ▶ KGO \Rightarrow KAGO Kiruna Atmospheric and Geophysical Observatory: Urban Brändström (head), Daria Mikhaylova, Lars-Göran Vanhainen and Uwe Raffalski
- ▶ Uwe Raffalski is responsible for atmospheric measurements within KAGO
- ▶ Ozone radiometer (KIMRA) became observatory instrument 2018.



KAGO

Kiruna Atmospheric and Geophysical Observatory

- ▶ Magnetometers, 1950–
- ▶ Allsky cameras, 1956–
- ▶ Ionosondes, 1952–
- ▶ Riometers, 1958–
- ▶ Infrasound, 1973– (In observatory since 2015)
- ▶ Ozone radiometer (KIMRA), 2001– (In observatory since 2018)
- ▶ ALIS_4D (Observatory measurements from fall 2019)
- ▶ (Weather station, ALIS, guest instr.)



Geomagnetic observations

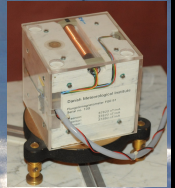
Kiruna, Lycksele and Tormestorp

- ▶ **PI: Masatoshi Yamauchi**
- ▶ **Kiruna:** timeseries 1950–
 - ▶ 2 Variometers (DMI-FGE91) and EDA (backup)
 - ▶ 2 Proton magnetometers (Gemsys)
 - ▶ 2 DI-flux teodolites
 - ▶ Plans for 2018
 - ▶ Solve baseline issues
 - ▶ Solve noise issues with new proton magnetometer
 - ▶ Upgrade observatory to INTERMAGNET 1 s standard.
 - ▶ Replace at least one variometer with a more modern 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)



Geomagnetic observatory

Kiruna





Geomagnetic observations

FGE-91 cal. in Nurmijärvi





Riometers

Kiruna and Lycksele

- ▶ PI/Project leader: Tima Sergienko/Daria Mikhaylova
- ▶ IRFs first scientific publication on polar cap absorption.
- ▶ Instruments: La Jolla Sciences (“blue box”)
- ▶ **Kiruna**: timeseries since 1958
 - ▶ 30 MHz and 38 MHz
 - ▶ New SDR-riometer during 2018 (RF-Shamaanit)
- ▶ **Lycksele**: timeseries since 1958
 - ▶ 38 MHz
- ▶ GloRiA <http://spears.lancs.ac.uk/gloria/>
- ▶ Delivers data to Aviation Civile, France, ICAO 24/7 service (2018–)



Ionosondes

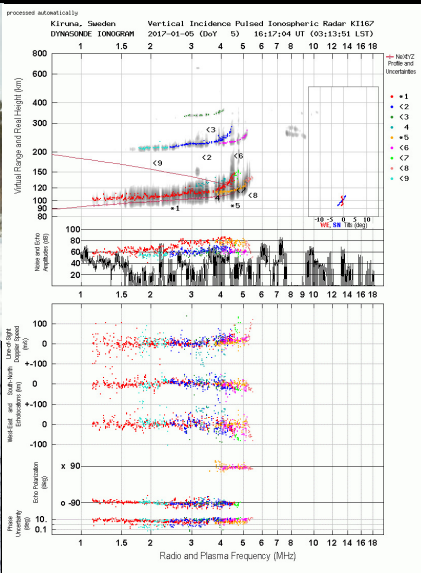
Kiruna, Lycksele and Uppsala

- ▶ **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. Urgent need for new instruments
 - ▶ **New ionosonde procured during 2018**



Ionosondes

Kiruna





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)



Infrasound





All-sky cameras

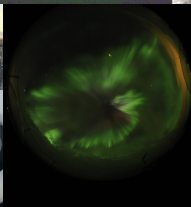
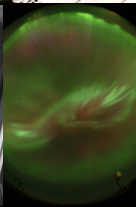
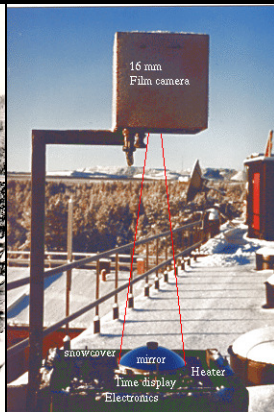
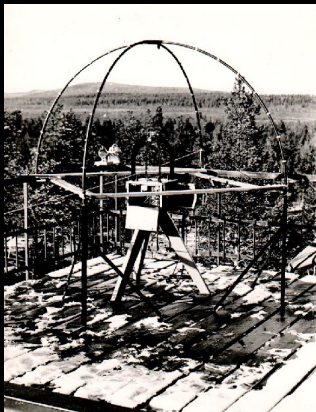
Kiruna and Abisko

- ▶ **PI: Urban Brändström**
- ▶ **Objective:** Sky overview during dark hours. (Colour imaging each minute during dark periods).
- ▶ **Kiruna:** timeseries 1956–2004 (film) 2001– (digital)
 - ▶ Nikon D700, Nikkor 8mm.
 - ▶ To be replaced with a Sony $\alpha 7s$
- ▶ **Abisko (STF tourist station)**
 - ▶ Guest instrument from Hiroshima University, (Nishi-san)



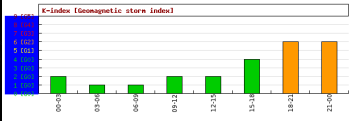
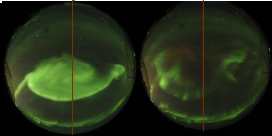
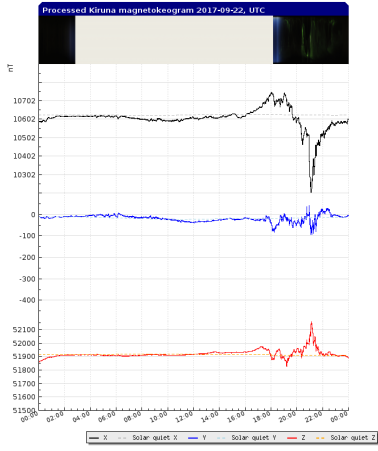
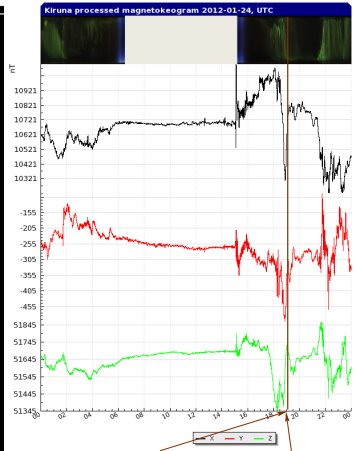
All-sky cameras

Kiruna





IRF Magnetokeogram





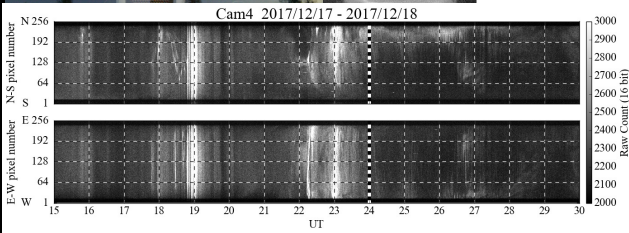
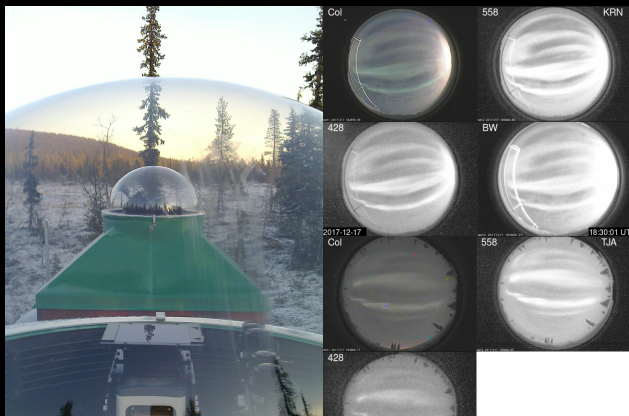
Meteor cameras

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

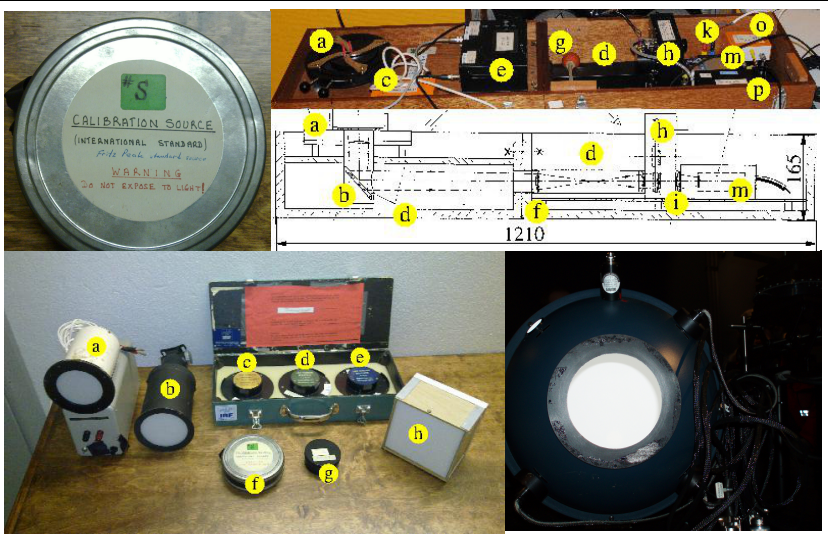


ISEE/NIPR





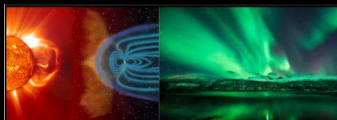
Optical absolute calibration





ALIS_4D

A Swedish contribution to complementary instruments for EISCAT_3D



EISCAT_3D Science Case

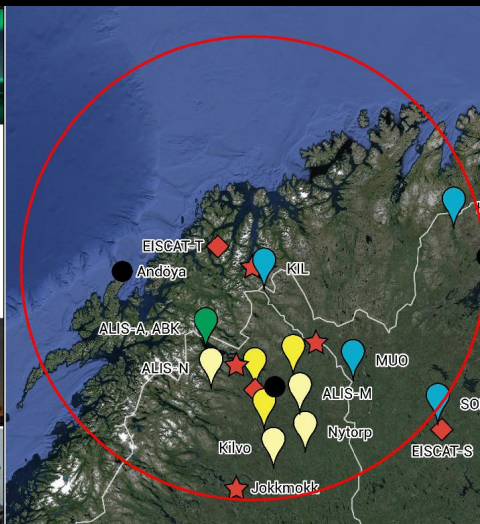
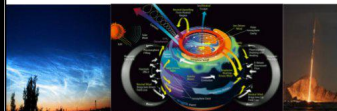
Anita Aikio¹, Ian McCrea²,
and the EISCAT_3D Science Working Groups

¹University of Oulu, Finland

²STFC Rutherford Appleton Laboratory, United Kingdom

EISCAT_3D Preparatory Phase Project WP3

Version 3.0, July 2014





ALIS_4D

A Swedish contribution to complementary instruments for EISCAT_3D

- ▶ 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!



AILS_4D

A Swedish contribution to complementary instruments for EISCAT_3D

- ▶ High-time resolution (> 25 FPS)
- ▶ Continuous operation (observatory modes)
- ▶ Status
 - ▶ 2016: (summer) Funding application (granted in November)
 - ▶ 2017: Procurement procedures, four imagers delivered, optics ordered
 - ▶ 2018: Optics delivery (April) Main development work. Tests in fall.
 - ▶ 2019: Continuous operations from fall. Ground support for SPIDER2 rocket.
- ▶ Funded by *Kempestiftelserna*, Department of Physics at UmU and IRF.
- ▶ PIs Urban Brändström (IRF), Asta Pellinen-Wannberg (UmU)

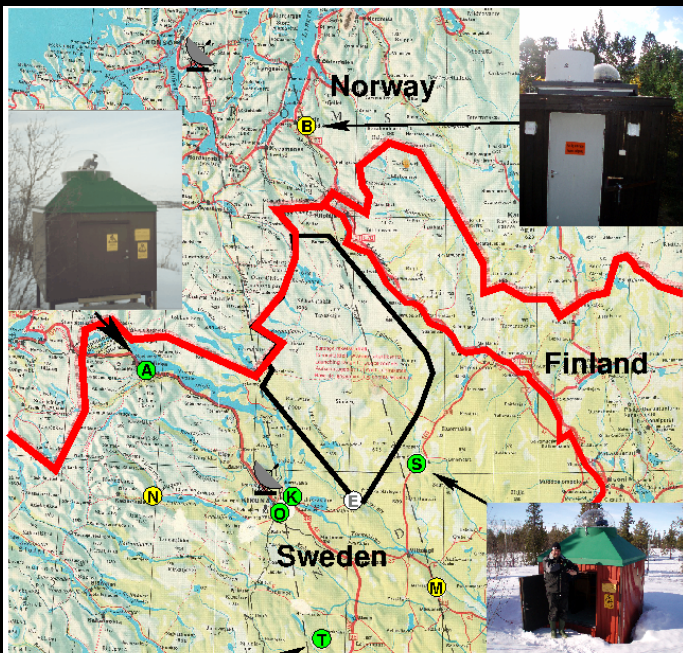


INSTITUTET FÖR RYMDFYSIK
Swedish Institute of Space Physics



Umeå universitet

ALIS_4D sites





ALIS/ALIS_4D

Comparison

	ALIS	ALIS_4D phase II
FoV	4 CCD $\approx 60^\circ$ 1 EMCCD $\approx 30^\circ$ (1 EMCCD $\approx 15^\circ$)	4 EMCCD $\approx 150^\circ$ 1 EMCCD $\approx 30^\circ$ (1 EMCCD $\approx 15^\circ$)
Res	$1024^2 \approx 100\text{m}$ $256^2 \approx 500\text{m}$	$1024^2 \approx 750\text{m}$ $512^2 \approx 1.5\text{km}$
Time	12 FPM	> 25 FPS
Mode	Campaign only	monitoring/campaign

Sort of an Àttje





ALIS/ALIS_4D

Available filters

λ [Å]	$\Delta\lambda$ [Å]	Line	Remarks	#
3950	92	Ca, Fe	Meteors	1
4227	280	Ca, Fe, H ₂ O, ...	Meteors	1
4340.5	25	H $_{\gamma}$, Balmer series	Meteors	1
4278	50	N ₂ ⁺ 1Neg.	Aurora/Airglow	6
4861.3	25	H $_{\beta}$, Balmer series	Meteors	1
5100	40		Background	4
5577	40	O(¹ S)	Aurora/Airglow	6
5893	200	Na, ...	Meteors	1
6230	40		Background	4
6300	40	O(¹ D)	Aurora/Airglow	6
6562	70	H $_{\alpha}$	SPIDER	4
6562.8	25	H $_{\alpha}$, Balmer series	Meteors	1
6750	200	N ₂ 1P	SPIDER/LEEWAVES	4
8000	1000	OH Meinel	Airglow LEEWAVES	4
8446	40	O(3p ³ P)	Aurora/Airglow (O(3p ³ P))	4



ALIS_4D

Sensitivity and speed



	Res.	Hz	R/count	λ_c
ALIS (CCD)	1024 ²	0.04	13.4	5577Å
ALIS (CCD)	256 ²	0.2	0.78	5577Å
ALIS (CCD)	256 ²	0.2	1.74	4278Å
ALIS_4D (EMCCD)	1024 ²	16.5	6	5577Å
ALIS_4D (EMCCD)	1024 ²	25	0.5	5577Å

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



Summary

- ▶ ALIS_4D will be a powerful Swedish contribution to complementary instruments for EISCAT_3D.
- ▶ Extensive upgrades of the observatory instrumentation underway at IRF. New Ionosonde (Uppsala), Riometer and variometer Kiruna (Also including atmospheric measurements)
- ▶ We have a very nice collaboration with Umeå University!
- ▶ ...and of course also with KTH, SPIDER2 coming up!