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Brief Report on ALIS (Auroral Large Imaging System), a New All-Sky Camera in Kiruna and Auroral Imaging Using a Mini-DV Camcorder.

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Abstract. This paper briefly describes the current status of three auroral imaging projects: ALIS (Auroral Large Imaging System), the developement of a new all-sky camera in Kiruna, and the use of a mini-DV camcorder for auroral visualisation.

ALIS consists of six unmanned imaging stations in northern Sweden and was initially intended mainly for auroral studies, however, the use of the system has grown to also incorporate studies of: artificially generated aurora, polar-stratospheric clouds and possible future studies of differential ablation phenomena in meteor trails, among other things.

A new all-sky camera is beeing designed in Kiruna. The camera is based on commercially available components and produces digital colour images available on the world-wide web.

The new generation of semi-professional video cameras are sensitive enough for recording of auroral phenomena. Image quality is good enough for TV-broadcasting and auroral visualisation for the general public.

1 ALIS

ALIS (*Auroral Large Imaging System*) was conceived in 1989 suggesting a net in Northern Scandinavia of 28 stations, with a baseline of 100 km, with a medium field of view of 90° (Steen, 1989). The number of stations was later reduced to 14 within Sweden and possible expansions into the surrounding countries (Steen et al., 1990). Due to limited funding, the number of stations were finally reduced to six.

The present six stations consists of a high-performance camera, which is a thinned, backside illuminated 1024×1024 pixels CCD (Charge Coupled Device) imager, with quad. readout channels. The detector is attached to a telecentric lens-system equipped with a six position filter-wheel intended for 3-inch narrow-band (40 Å) interference filters (Table 1).

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Table 1. Available filters at the various ALIS stations. The stations are numbered as follows: 1 Kiruna, 2 Merasjrvi, 3 Silkkimuotka, 4 Tjautjas, 5 Abisko, 6 Nikkaluokta (see also figure 1)

pos.	line. [Å]	use	stations
0	5577	$O(^1S)$	all
1	6300	$O(^1D)$	all
2	4227	Ca	1
2	5893	Na	4
2	6230	bg.	2,3,5,6
3	white		all
4	8446	OI	1,4,5,6
4	5320	lidar	3
5	4278	N_2^+	all

The front lens has a moderate field-of-view of $54^\circ \times 54^\circ$ at four stations and $90^\circ \times 90^\circ$ at the remaining two stations.

Each camera is mounted in a camera positioning system (CPS), making it possible to individually direct any camera to image any desired region of the sky.

The main scientific objective of ALIS was aimed at spectroscopic reconstruction of the three-dimensional auroral signal, by the use of tomographic inversion techniques (Gustavsson, 1998; Aso et al., 1998a,b, 1999; Sergienko et al., 2001; Rydesäter and Gustavsson, 2001). Another important issue were to expand absolute measurements of the auroral signal, traditionally made by scanning or imaging photometers to two dimensions (Gustavsson et al., 2000b). It is important to stress that the ALIS detector is a *spectroscopic imager* and not a traditional camera.

Other scientific objectives expanded to studies of polar-stratospheric clouds (Steen et al., 1997; Enell et al., 1999, 2000), artificially generated aurora (Brändström et al., 1999; Gustavsson et al., 2000a; Leyser et al., 2000), daytime aurora (Rees et al., 2000), studies of differential ablation phenomena in meteor trails (Brändström et al., 2002), image processing of auroral data (Rydesäter, 2001), etc.

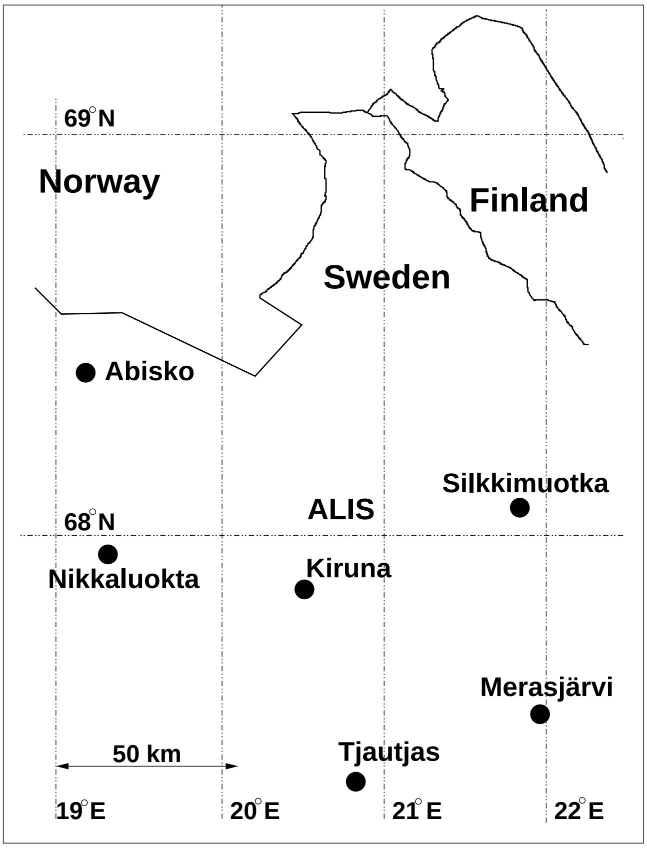

Fig. 1. Layout of the ALIS system located in northern Sweden.

1.1 calibration

Calibrating an imager is a considerably more difficult task as compared to calibrating a photometer, which is a difficult task in itself. The calibration procedures for ALIS are found in (Aso et al., 1999; Brändström et al., 1997; Urashima et al., 1999; Gustavsson, 2000). During this optical-meeting most of the ALIS cameras were intercalibrated against various sources and instruments.

1.1.1 Summary of calibration steps

- Bias (on-chip overscan strips)
- Intercalibration, C14 sources, FMI sphere, etc. 28AM, Oulu
- Flat-field, cannot be properly done yet
  (requires big $r \approx 1m$ integrating sphere)
- Geometric corrections, optical transfer function, direction of optical axis, etc. using the star background (Gustavsson, 2000).

1.2 Summary

Key features of ALIS:

- Six imaging stations, separated ≈ 50 km.
- Non-intensified thinned, back-side illuminated CCD-cameras 1024×1024 pixels, 16 bits ADC, quad. readout system.
- Telecentric lens system (FoV $54° \times 54°$ or $90° \times 90°$)
- Steerable camera positioning system (CPS).
- Narrow-band (40 Å) interference filters (see table 1).
- Fully automated and remote-controlled operation over Internet.
- ALIS is a unique facility which still has a high scientific potential in many fields of optical studies of the upper atmosphere.
- The infra-structure has worked well for about ten years and is open to other instruments.
- More information at `http://alis.irf.se`.
- ALIS data-archive directly available on Internet. (`http://petrydpc.itm.mh.se/alis/`)
- The system is currently put into hibernation. See the web-sites above for the most recent information on ALIS.

2 A new all-sky camera in Kiruna

An all-sky camera has been operating in Kiruna since the International Geophysical Year in 1957 (Stoffregen, 1962). In 1977 the camera was replaced with a new more automated type (Hypönen et al., 1974). This camera is still in operation, however a replacement is strongly needed since the data storage medium is 16 mm colour film, which is expensive and difficult to put on the world-wide web. The advanced new Finnish all-sky cameras (Syrjäsuo, 2001) are based on intensified CCD:s with filter-wheels and narrow band interference filers like ALIS. Here we present a much simpler approach, based on a commercial digital camera with replaceable optics. It is our intention that this camera will produce digital data, of better, or at least similar quality, as compared to the color films produced by the old camera. After testing a number of cameras, we found a camera with a suitable sensitivity and noise level fulfilling our requirements.

2.1 Design

The camera (Fuji FinePix S1Pro, cost ≈ 30000 SEK) is equipped with a Nikon Nikkor 8 mm 1:2.8 giving almost $180°$ field-of-view. Figure 2 shows the prototype camera mounted in a dome. The final version will be mounted in an insulated box together with all necessary equipment.

The camera is controlled by a camera control computer (Figure 3), and the image data is transferred to an archiving computer (running Linux), where it is made available to the world-wide web. Monitoring and control of the camera can be done remotely using an ordinary web browser. Data is archived on writeable DVD:s.

Fig. 2. The prototype camera with lens mounted on a tripod.

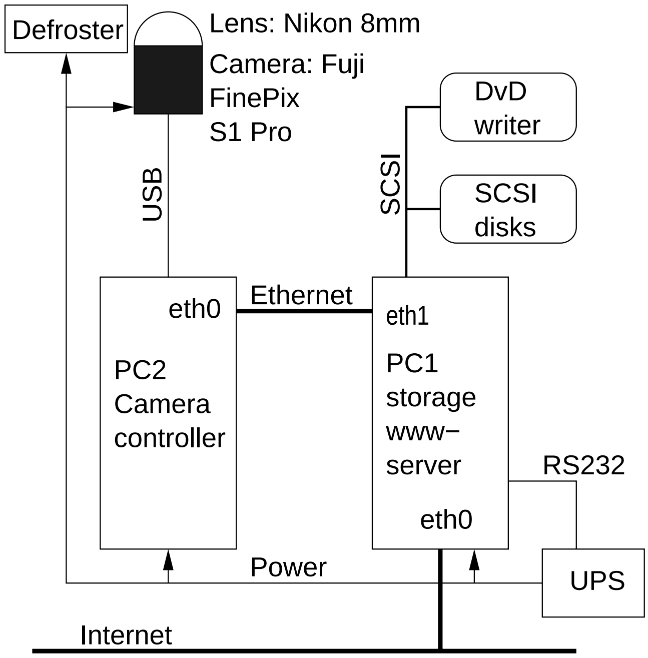

Fig. 3. Block diagram of the new all-sky camera under development. The camera is a Fuji FinePix S1pro with a Nikon 8mm lens. The camera is controlled via an USB interface. Images (quicklooks and full-resolution images) are downloaded to a webserver, where it is made available to the general public. Archiving of data is made using a DVD writer. The solution with two computers increases accessibility of data while servicing the camera.

3 Auroral imaging with a commercial video camera

The new generation of semi-professional digital video (DV) camcorders has been found to be sensitive enough for semi-live ($\approx 3-4$ frames/second) color recording of auroral phenomena. At these framerates, it is possible to record even weak diffuse, pulsating and black aurora with an acceptable signal to noise ratio (comparable to monochrome ISIT TV-recordings). These cameras could therefore be a good tool for studies of auroral morphology. The quality is good enough for TV-broadcasting and auroral visualisation intended for the general public. Another interesting future possibility is to use this type of camera together with methods for automated image analyses as described by Rydesäter (2001); Syrjäsuo (2001) for automated control of a more complex system like ALIS.

3.1 Sony DCR VX-2000E PAL.

- 3 CCD ≈ 450 kpixels.
- Optics: $f = 6 - 72$ mm 1:1.6-2.4
- $12\times$ Optical zoom, $48\times$ digital zoom.
- miniDV tapes (and memorystick for still-images)

Fig. 4. Example image from the new all-sky camera prototype 2001-03-19 19:10 UTC. A larger colour version of this image can be downloaded from: `http://www.irf.se/~urban/28am`

Fig. 5. Sample frame from a auroral video obtained with a commercial mini-DV camcorder displaying green, red and blue aurora. A meteoroid trail is also seen in the lower middle part of the image. A larger colour version of this image can be downloaded from:
http://www.irf.se/~urban/28am
Photo ©2001 Urban Brndstrm

– IEEE-1394 "firewire" capture directly to a computer.

– Color auroral imaging possible from about 3 images per second up to video rate, depending on auroral intensity.

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