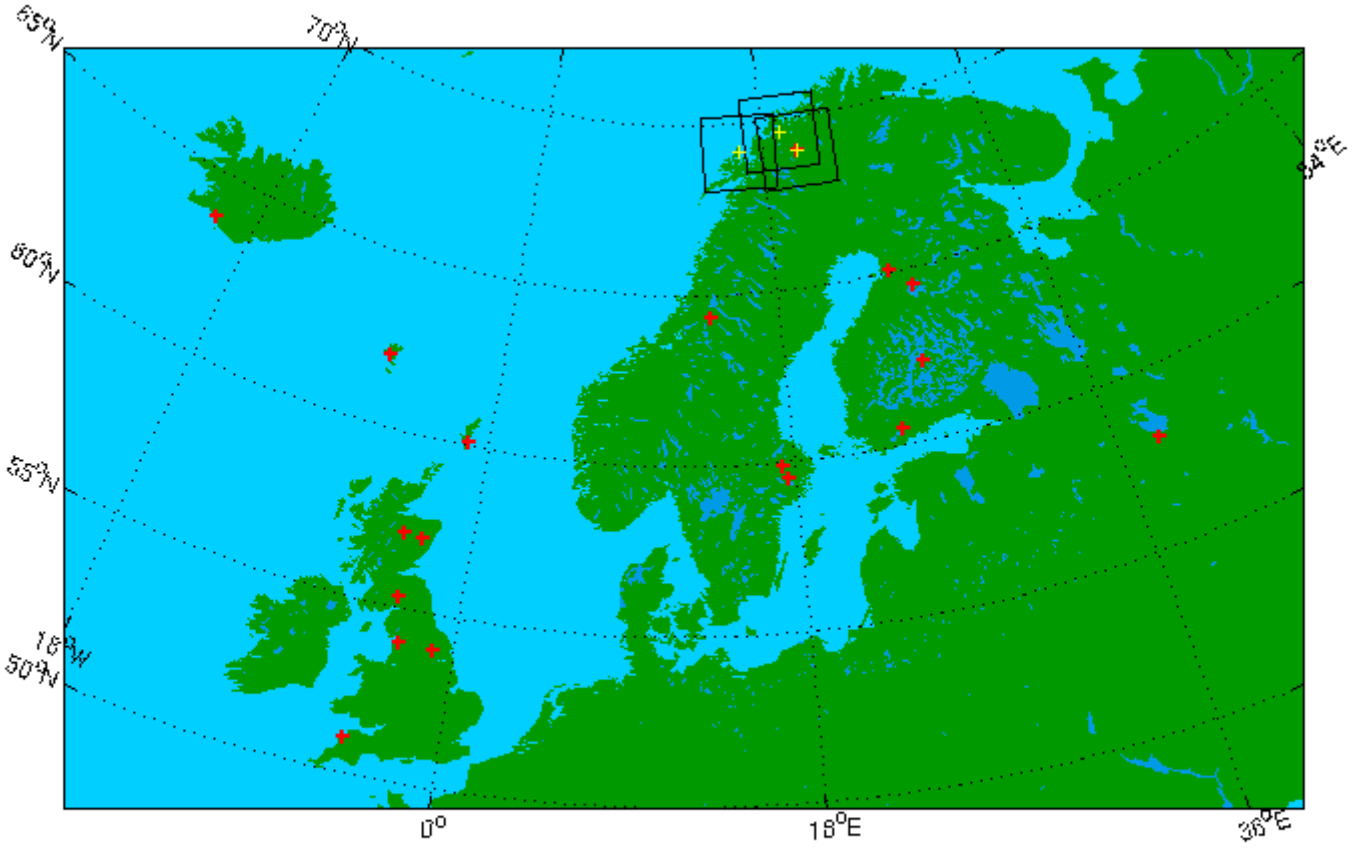
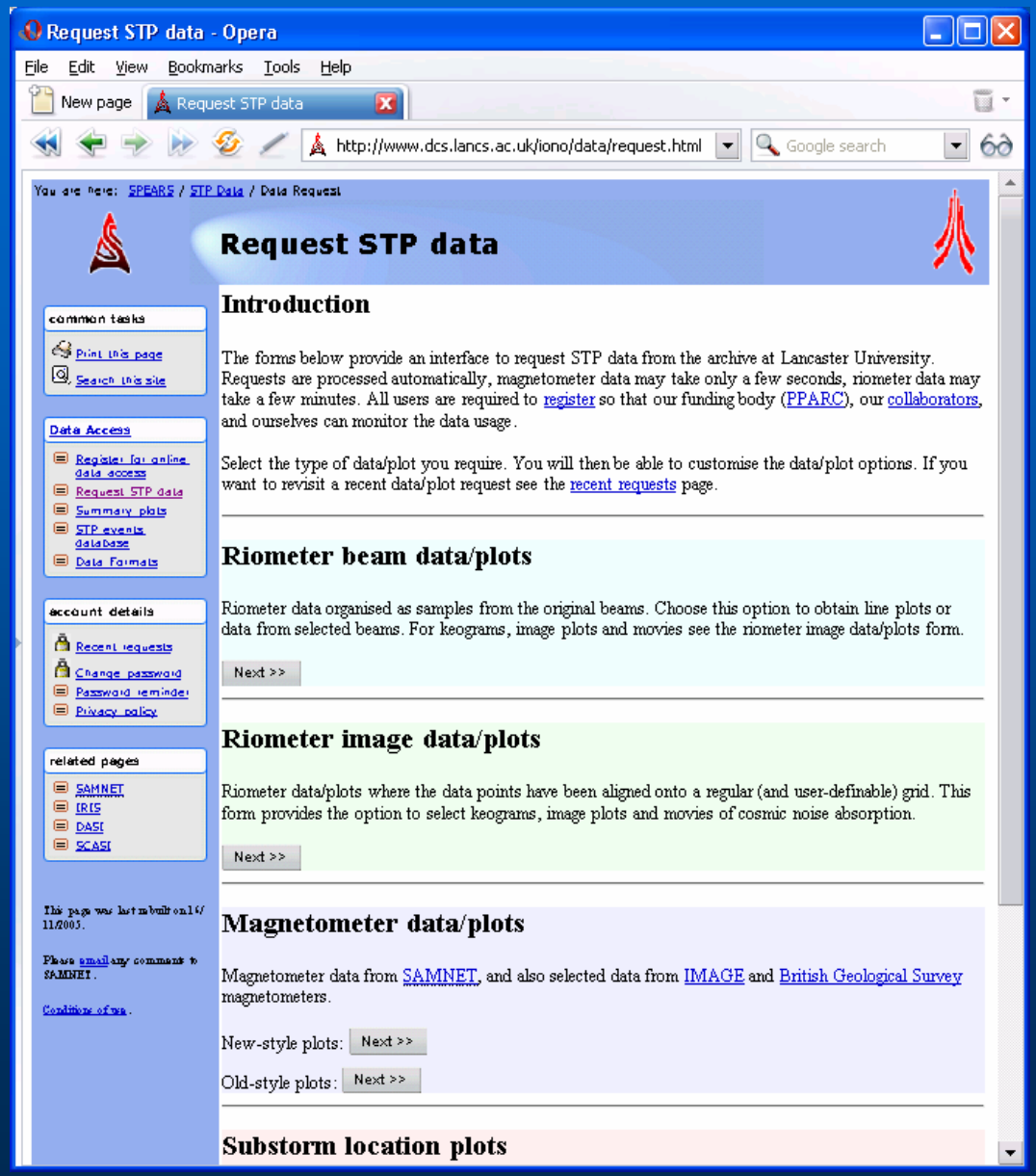
Riometer data from a Lancaster perspective

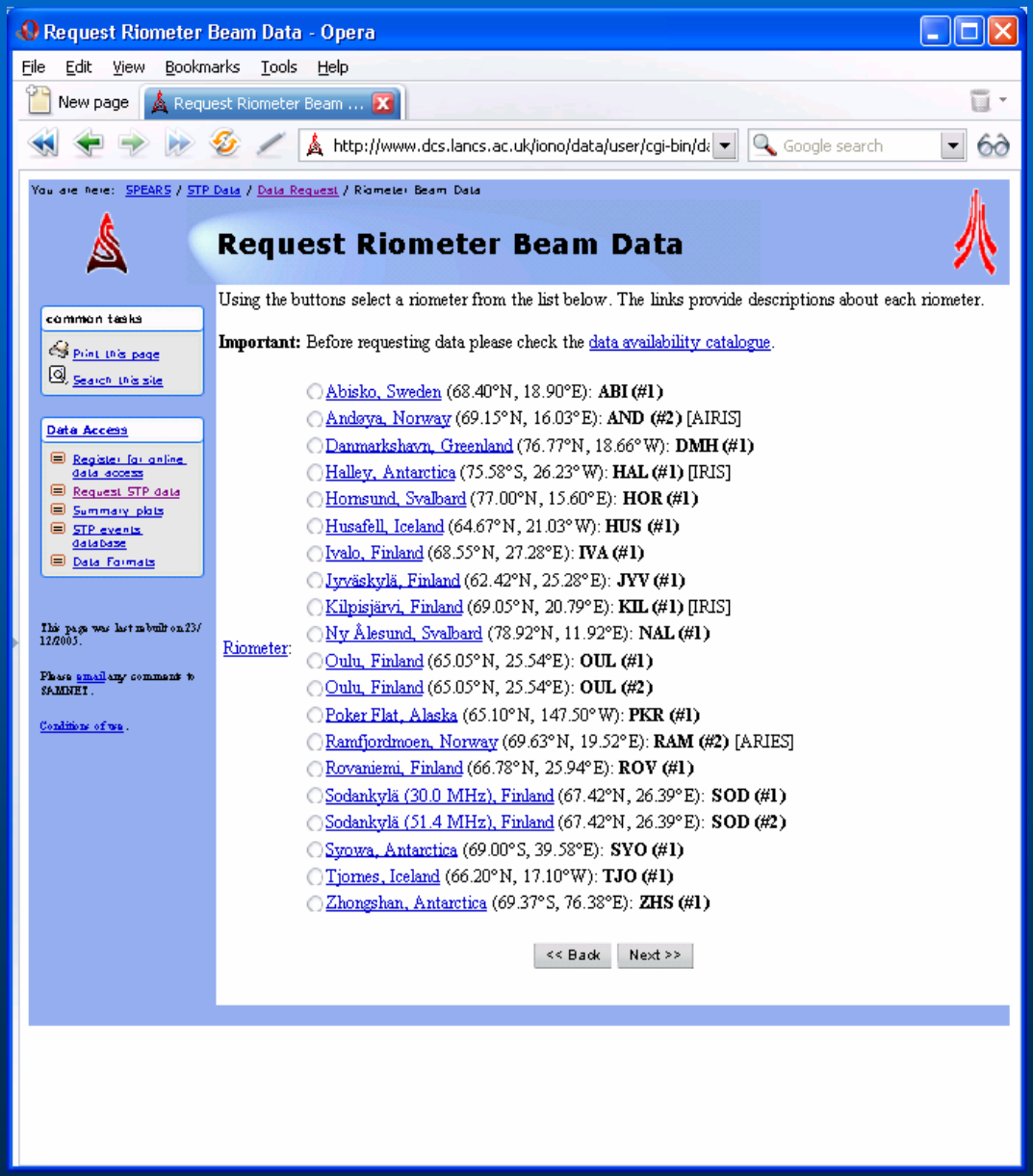
Steve Marple
Farideh Honary

Lancaster data sources



http://www.dcs.lancs.ac.uk/iono/data/request.html

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Please email any comments to SAMNET.
Conditions of use.
Using the buttons select a riometer from the list below. The links provide descriptions about each riometer.
Important: Before requesting data please check the data availability catalogue.
Riometer:
Abisko, Sweden (68.40°N, 18.90°E): ABI (#1)
Andøya, Norway (69.15°N, 16.03°E): AND (#2) [AIRIS]
Danmarkshavn, Greenland (76.77°N, 18.66°W): DMH (#1)
Halley, Antarctica (75.58°S, 26.23°W): HAL (#1) [IRIS]
Hornsund, Svalbard (77.00°N, 15.60°E): HOR (#1)
Husafell, Iceland (64.67°N, 21.03°W): HUS (#1)
Ivalo, Finland (68.55°N, 27.28°E): IVA (#1)
Jyväskylä, Finland (62.42°N, 25.28°E): JYV (#1)
Kilpisjärvi, Finland (69.05°N, 20.79°E): KIL (#1) [IRIS]
Ny Ålesund, Svalbard (78.92°N, 11.92°E): NAL (#1)
Oulu, Finland (65.05°N, 25.54°E): OUL (#1)
Oulu, Finland (65.05°N, 25.54°E): OUL (#2)
Poker Flat, Alaska (65.10°N, 147.50°W): PKR (#1)
Ramfjordmoen, Norway (69.63°N, 19.52°E): RAM (#2) [ARIES]
Rovaniemi, Finland (66.78°N, 25.94°E): ROV (#1)
Sodankylä (30.0 MHz), Finland (67.42°N, 26.39°E): SOD (#1)
Sodankylä (51.4 MHz), Finland (67.42°N, 26.39°E): SOD (#2)
Syowa, Antarctica (69.00°S, 39.58°E): SYO (#1)
Tjornes, Iceland (66.20°N, 17.10°W): TJO (#1)
Zhongshan, Antarctica (69.37°S, 76.38°E): ZHS (#1)
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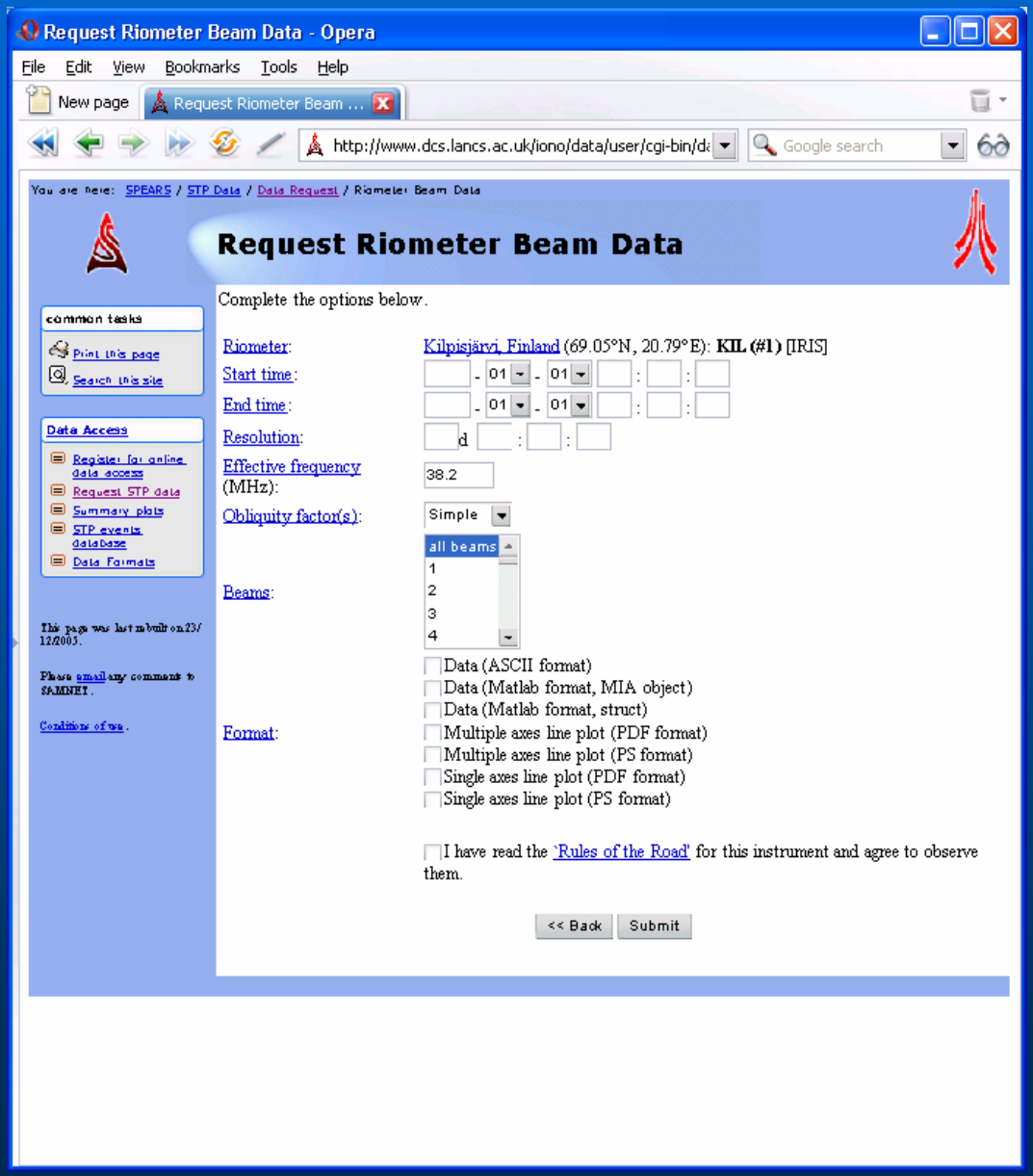
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Complete the options below.
Riometer: Kilpisjärvi, Finland (69.05°N, 20.79°E): KIL (#1) [IRIS]
Start time:
End time:
Resolution:
Effective frequency (MHz):
38.2
Obliquity factor(s):
Simple
Beams:
all beams
1
2
3
4
Format:
Data (ASCII format)
Data (Matlab format, MIA object)
Data (Matlab format, struct)
Multiple axes line plot (PDF format)
Multiple axes line plot (PS format)
Single axes line plot (PDF format)
Single axes line plot (PS format)
I have read the 'Rules of the Road' for this instrument and agree to observe them.
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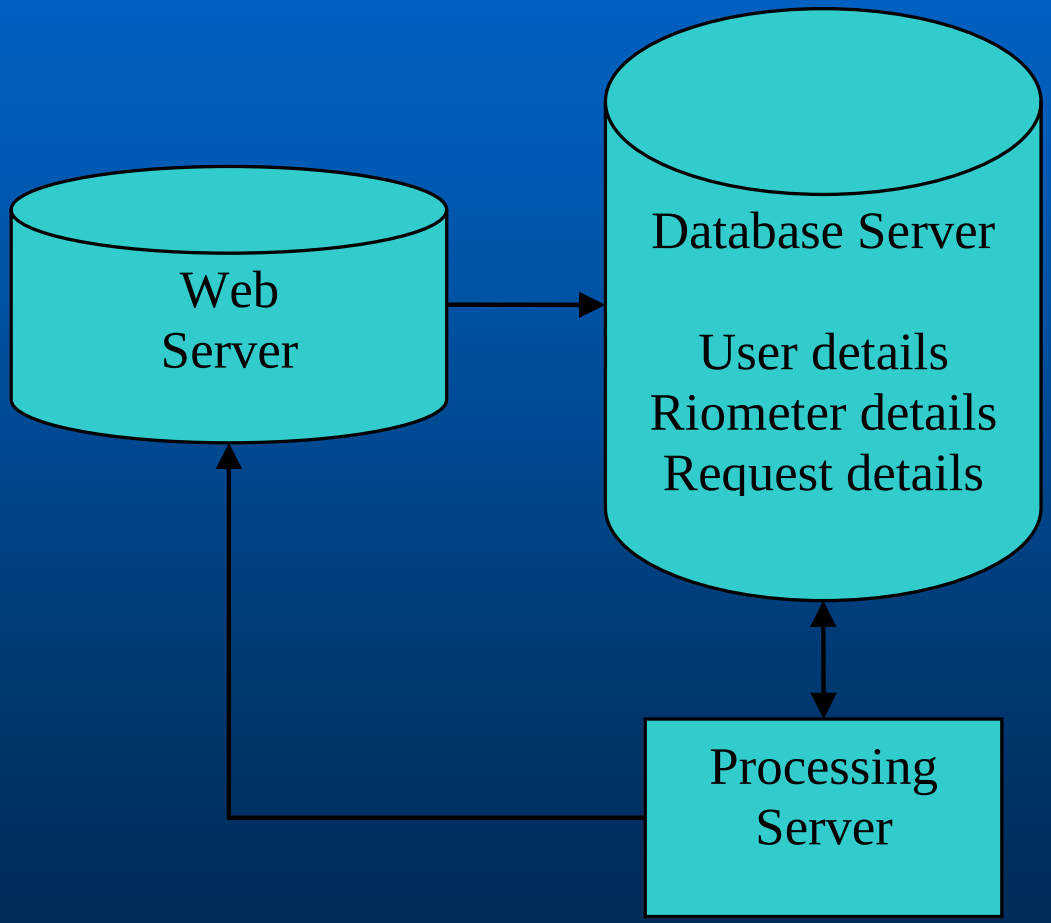
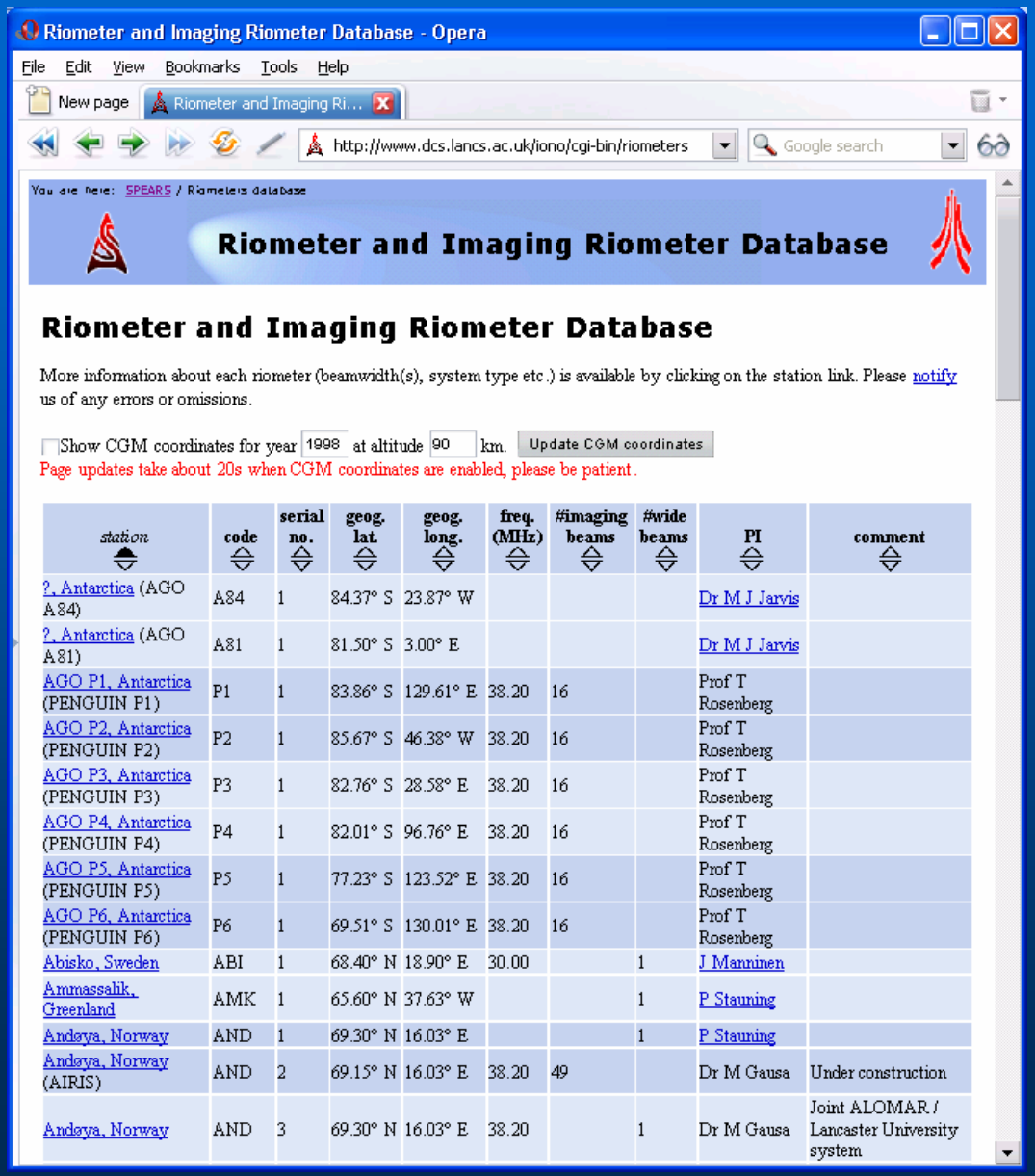
Recent requests for STP data by Dr Steve Marple <s.marple@lancaster.ac.uk>
request details | ID | start time | requested | status
STP events | 31 | not available | 2005-12-22 14:00:47 | processing completed (results deleted)
riometer beam data | 1507 | 2006-02-01 00:00:00 | 2006-02-18 15:47:40 | processing completed (results deleted)
riometer beam data | 1508 | 1999-04-02 00:00:00 | 2006-02-19 15:45:48 | processing completed (results deleted)
riometer beam data | 1521 | 2006-02-03 00:00:00 | 2006-03-05 09:36:19 | processing completed (results deleted)
riometer beam data | 1522 | 2006-02-03 00:00:00 | 2006-03-05 14:23:01 | processing completed (results deleted)
riometer image data | 1205 | 2006-02-03 00:00:00 | 2006-03-17 13:39:42 | processing completed
riometer image data | 1206 | 2006-02-03 00:00:00 | 2006-03-17 14:06:48 | processing completed
Use the links in the table above to see the requested data.
Administrator functions
Requests: [recent | all | terminated | completed]
User list.
See requests by other users:

Data request flowchart



http://www.dcs.lancs.ac.uk/iono/cgi-bin/riometers



Riometer and Imaging Riometer Database

More information about each riometer (beamwidth(s), system type etc.) is available by clicking on the station link. Please notify us of any errors or omissions.

Show CGM coordinates for year 1998 at altitude 90 km. Update CGM coordinates

Page updates take about 20s when CGM coordinates are enabled, please be patient.

station	code	serial no.	geog. lat.	geog. long.	freq. (MHz)	#imaging beams	#wide beams	PI	comment
?, Antarctica (AGO A84)	A84	1	84.37° S	23.87° W				Dr M J Jarvis	
?, Antarctica (AGO A81)	A81	1	81.50° S	3.00° E				Dr M J Jarvis	
AGO P1, Antarctica (PENGUIN P1)	P1	1	83.86° S	129.61° E	38.20	16		Prof T Rosenberg	
AGO P2, Antarctica (PENGUIN P2)	P2	1	85.67° S	46.38° W	38.20	16		Prof T Rosenberg	
AGO P3, Antarctica (PENGUIN P3)	P3	1	82.76° S	28.58° E	38.20	16		Prof T Rosenberg	
AGO P4, Antarctica (PENGUIN P4)	P4	1	82.01° S	96.76° E	38.20	16		Prof T Rosenberg	
AGO P5, Antarctica (PENGUIN P5)	P5	1	77.23° S	123.52° E	38.20	16		Prof T Rosenberg	
AGO P6, Antarctica (PENGUIN P6)	P6	1	69.51° S	130.01° E	38.20	16		Prof T Rosenberg	
Abisko, Sweden	ABI	1	68.40° N	18.90° E	30.00		1	J Manninen	
Ammassalik, Greenland	AMK	1	65.60° N	37.63° W			1	P Stauning	
Andøya, Norway	AND	1	69.30° N	16.03° E			1	P Stauning	
Andøya, Norway (AIRIS)	AND	2	69.15° N	16.03° E	38.20	49		Dr M Gausa	Under construction
Andøya, Norway	AND	3	69.30° N	16.03° E	38.20		1	Dr M Gausa	Joint ALOMAR / Lancaster University system

Riometer details - Opera

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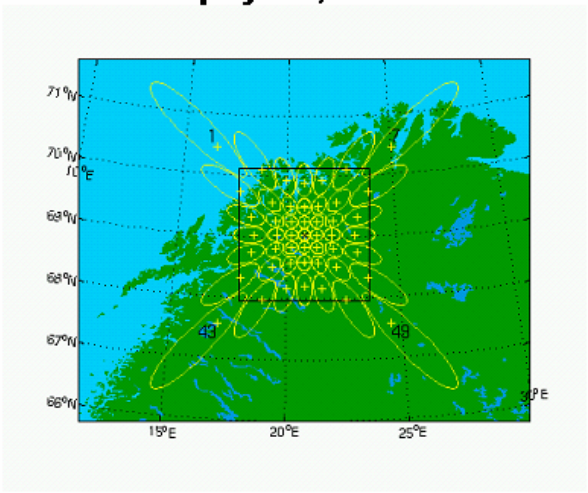
http://www.dcs.lancs.ac.uk/iono/cgi-bin/riometers?he

Google search

Riometer details for Kilpisjärvi, Finland



Riometer beam projection for Kilpisjärvi. Note that any beams which have multiple lobes stronger than -3dB are not shown. The map is also available in EPS and PDF formats. You are welcome to use the maps in publications but please credit them to Steve Marple.

CGM coordinates for year 1998 at altitude 90 km. Update CGM coordinates

CGM and *L* values in the table are computed for 1998 at an altitude of 90km using a modified version of the GEO-CGM (Jan. 2001) code downloaded from NASA's National Space Science Data Center, and embedded into PostgreSQL.

Location:	Kilpisjärvi, Finland
Name:	IRIS
Abbreviation:	KIL
Serial number:	1
Geographic coordinates:	69.05° N 20.79° E (Google Map)
CGM coordinates:	65.85° N 104.30° E
L value:	6.06
URL:	http://www.dcs.lancs.ac.uk/iono/iris/
Facility:	

Multi-instrument Analysis (MIA) - Overview

Designed to process different STP data types:

- Riometer processing and visualisation tools
- Magnetometer processing and visualisation tools
- All-sky camera processing and visualisation tools

Advantages of a Common Approach

By using a common approach tools common to different data formats can be shared:

- Image plots
- Keograms
- Line plots
- Movies
- Map overlays
- Shape / movement analysis

Riometer data types

Data types:

Beam data:

- Raw power (not linearised, ADC units)
- Power (linearised, possibly in dBm)
- Quiet day curve (QDC) [raw and linearised versions]
- Absorption

- Images of the above *(image data)*

Absorption data

- Absorption data can be loaded in two ways:
  - Create on-the-fly:

    Absorption = (QDC – received power) / obliquity factor
  - Load directly from disk

Creating when requested is more complex but much more flexible. The quality of the QDC can be checked, alternative QDCs can be substituted and different obliquity factors can be used (eg effective obliquity factors)

MIA is Object-oriented

- Object-oriented programming uses classes to implement different objects (eg., a riometer).
- Classes can have a hierarchy to represent similar types of object
- Implemented in Matlab, which supports object-oriented programming

MIA classes

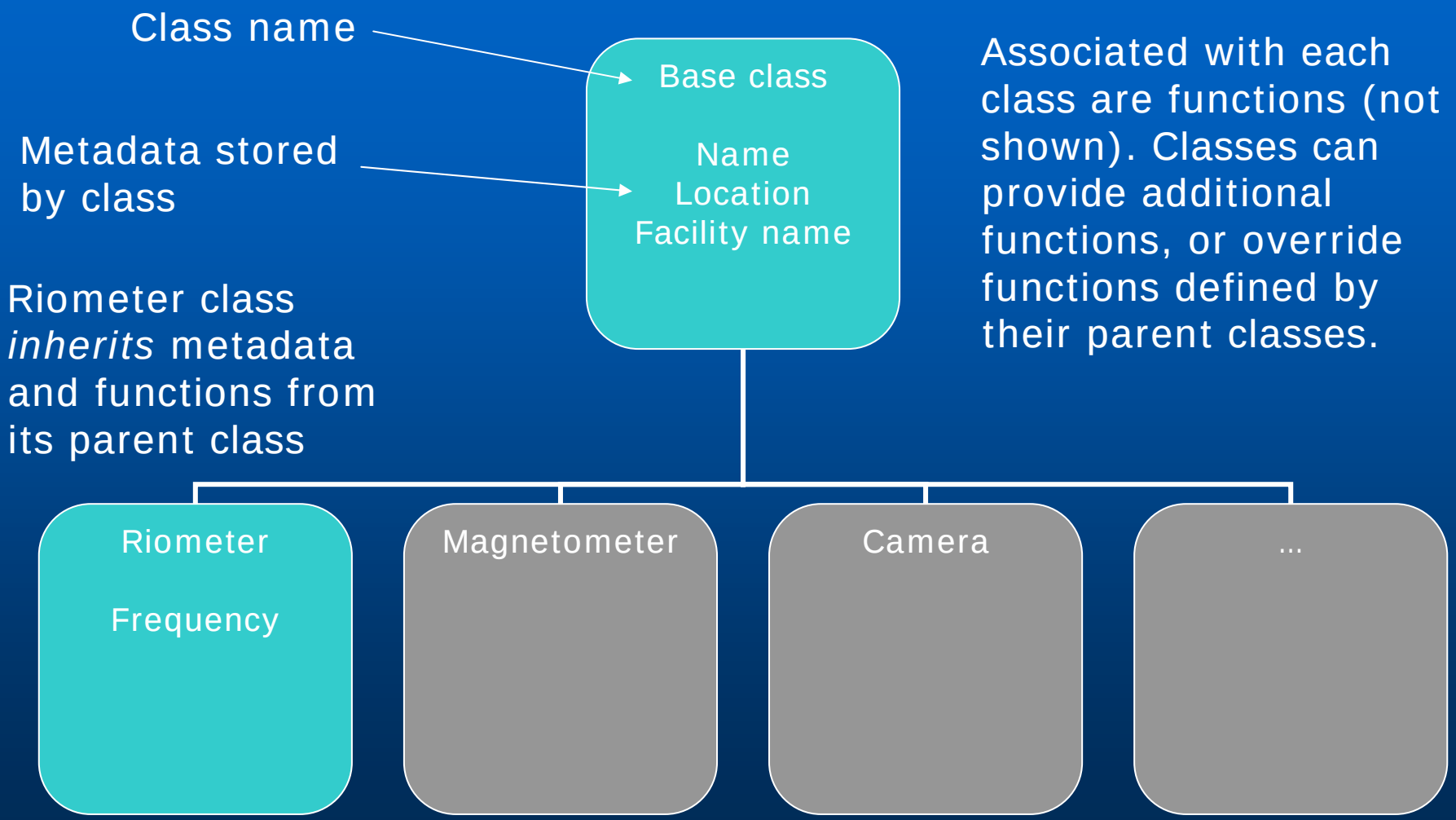
- Time/duration classes
- Instrument classes
  - Riometer
  - Magnetometer etc
- Data classes

  For riometers this includes:
  - Received power
  - Quiet day curve
  - Absorption etc

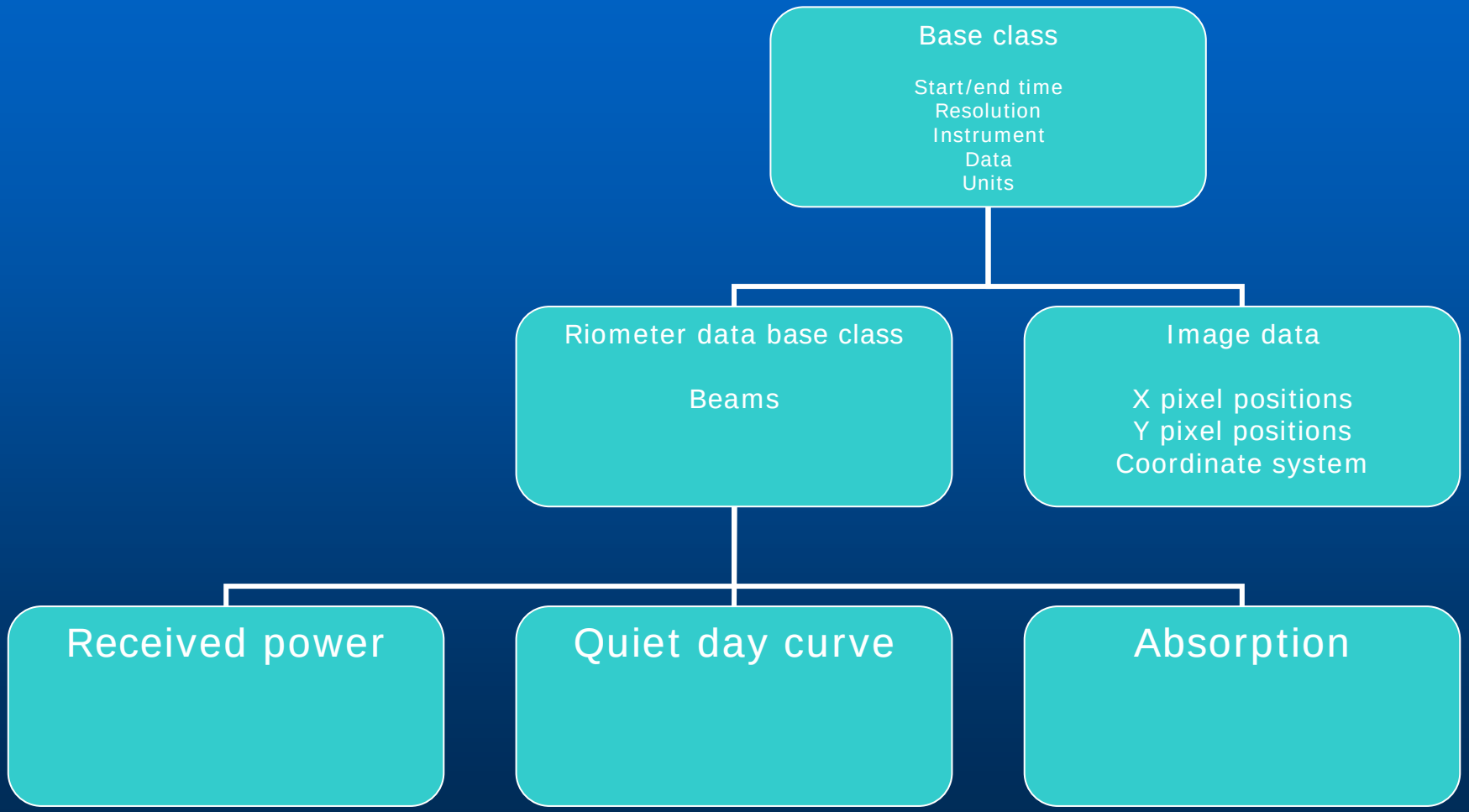
Also:

- Filter classes (in C++ terminology these are implemented as *functors*)
- GUI classes (*widgets* for time boxes, beam boxes etc. are implemented as classes)

Instrument classes



Data classes



Requirements for successful data sharing

To share data with the minimum of effort we need to agree on:

- Sufficient metadata
- Common file format
- How/where to access data
  - FTP/HTTP locations need to be predictable.
  - *Suggestion:* Define locations as strftime format strings (i.e., date/time is the only variable)
- Data definitions

Metadata requirements

Too many to list here, but includes

- Start time of data
- End time of data
- Resolution of data
- Instrument which recorded the data
- Units the data is recorded in
- Offset / centred timing
- ...

List of metadata used by MIA is available as a separate document

Files formats

Various possibilities, including:

- CDF
- NetCDF
- HDF
- XML ?

Suggestion:

Chosen format should be supported by C, Fortran, IDL, Matlab, and Perl

File formats and support

	CDF	Net CDF	HDF	XML
C	Y	Y	Y	Y
Fortran	Y	Y	Y	Y?
Java	Y	Y	Y	Y
IDL	Y	Y	Y	?
Matlab	Y	Y	Y	Y?
Perl	Y	Y	Y	Y
Speed	*?*	*?*	*?*	*Slow?*

Data definitions

- Start / end time
  - Is end time the start of the last sample or the end of the last sample?
- Beam numbers
  - So many different methods! A system based on scalars is most easily implemented.
- Are data samples offset or centred
  - Doesn't matter if recorded in metadata

Other problems

- Absorption is frequency-dependent! We need to get into the habit of specifying absorption at a given frequency!
- Identifying riometers
  - Need a common method
  - Will probably need to distinguish between different riometers at the same site (even if operations did not overlap operating frequencies may be different)
- Internationalisation
  - To label plots correctly we sometimes need to deal with accented characters (e.g., Kilpisjärvi)
- Backward compatibility
  - If we change file formats / metadata definitions we need to be able to automatically convert any data saved in the old format

How can Lancaster help with data sharing?

- MIA can already handle data from most riometers (translating from the native file formats itself) but is easily configured for any others
- MIA doesn’t need processed absorption data – users could create QDCs themselves
- If datasets are accessible via FTP or HTTP MIA can process remote data as if it resided locally. The data request system can act as a data portal

Summary

- The necessary tools to enable data sharing exist
- The necessary information to use that data (mostly) exists (e.g., riometer database at Lancaster)
- Actually getting the data not always easy!

MIA API example

Get some riometer data and find the difference between each sample to locate ‘spike’ events.

First define basic parameters

```
st = timestamp([2002 10 30 20 0 0]);
et = timestamp([2002 10 30 22 0 0]);
res = timespan(10, ‘s’);
rio = rio_kil_1;
beams = [18 25 32]; % 3 different beams
```

Then create the absorption object:

```
mia = rio_abs('starttime', st, …
              'endtime', et, …
              'resolution', res, …
              'beams', beams, …
              'instrument', rio);
```

Note how we can set only the parameters we need. We could have changed the obliquity method, or used a non-standard QDC, if we had set the appropriate parameters, but the default ones are suitable.

The `mia` object contains all sorts of information (see class diagram). We can extract the information we want by calling functions. To get the absorption values for beam 25 we do this:

```
ri = getparameterindex(mia, 25); % find row index
data25 = getdata(mia, ri, ':');
```

We don't know what row the data for beam 25 is stored in, so we have to ask. We want samples for all times, but since we are calling a function, not subscripting an array we cannot use ":", we have to pass the colon as a string, `':'`.

To get the entire data matrix we could just have called:

```
alldata = getdata(mia);
```

Back to the problem of detecting spike events. The difference between succesive samples is easily calculated using Matlab's own `diff` function.

```
diffdata = diff(data25);
```

I have documented almost all of the MIA functions, so you can use the `help` command to find out how to use the function.

MIA filters

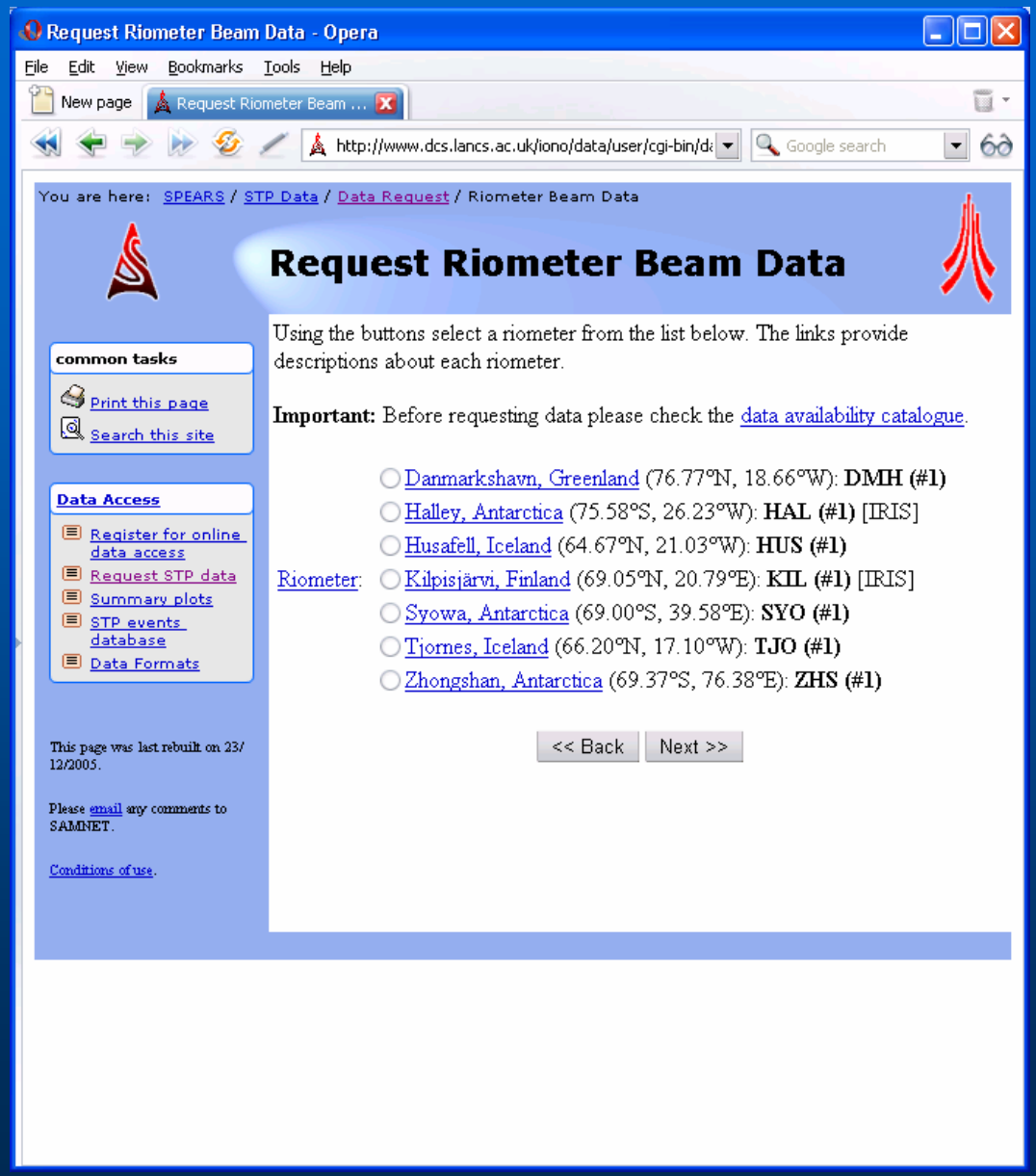
- Want a method to filter data which automatically adjusts to the type of data and resolution.
- Any method which uses filters should not have to know any special information to use the filter. (Otherwise as new filters are added all functions which use filters must be updated).
- In C++ the method I have used is called a *functor*.

  (Matlab does not have the vocabulary to describe these OOP tricks, so when necessary I borrow the terminology from C++.)

MIA filters

The technique is described below:

- Create a filter object. In a Matlab function it would normally be created with the correct parameters for your use. In a GUI environment there is a graphical configure command to allow users to adjust the parameters.
- Pass the configured filter object, and the MIA data object, to the function which needs to filter something. The called function does not have to know anything special to use that filter, all the configuration details are stored inside the filter object.
- When the called function needs to perform filtering it make a call to the `filter` method. Matlab's OOP ensures the filter method which corresponds to that filter class is called. Any information needed (e.g., window size for a sliding mean filter) is stored inside the filter object.
  - If the window size is stored as a `timespan` then the filter method should compute the actual window size by comparing the resolution of the data with the specified window size.
  - This ensures the filters work independently of the data.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Zhongshan, Antarctica (69.37°S, 76.38°E): ZHS (#1)
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Tools

- Line plots
- Images
- Keograms
- Movies
- Map overlays

- Filters to process data (remove scintillation etc)
- Functions for generating and checking QDCs
- Antenna modelling
  - Beam projections
  - Effective obliquity factors

Time classes

- Times and durations initially appear to be simple quantities to handle. Month and year boundaries, and leap years quickly escalate the complexity of dealing with times.
- MIA provides two companion classes: `timestamp` (for dates/times) and `timespan` (for durations)
- Addition of `timestamps` is not valid, but most other operations are.