Optimisation of Instruments

Arnoud Apituley
Volker Freudenthaler
Adolfo Comeron

Outline

- Goals
- Methodology and Tools
- Progress and Status
- Conclusions

Goals

- Improving the EARLINET installed base of lidars
  1. Performance
  2. Homogeneity
  3. Operationality
- Selecting optimum technical solutions for instrumental problems
- Recommendations for implementation across the network
- Facilitate expansion of the network

Performance

- Which parameters should be optimised?

Table 1: **Measurement characteristics as required for the main application areas. Backscatter lidar (BL), Raman lidar (RL), depolarization lidar (DL), and high spectral resolution lidar (HSRL). These methods can be applied either at one or at multiple wavelengths (MBL, MRL). α= extinction, β = backscatter, δ = depolarization, S_a = lidar ratio, MPP = microphysical properties.**

Application area	Parameters required	Instrument type	Operation required	Number of stations
1.a Global climatology	α, δ, (β, S_a)	RL	fixed schedule, 3/week	20?
1.b Model evaluation	α, δ, (β, S_a, MPP)	MRL	fixed schedule + diurnal cycles	
1.c Transport and tracers	β, (α, δ, MPP)	BL	fixed schedule + on alert	50
1.d Radiation	α, β, (δ)	RL	random	20
2.a Air quality assessment	α, δ, β, MPP	RL	fixed schedule	50+
2.b Air quality forecast	B	BL	quasi-continuous	??
3. Plumes from special events	β, (α, δ, MPP)	BL	on alert	50
4.a Ground truth	α, δ, β, S_a	MRL	TBD	20
4.b Complementary information	α, δ, β, S_a	MRL	fixed schedule	20

GAW report 178, WMO/TD-No. 1443

Performance

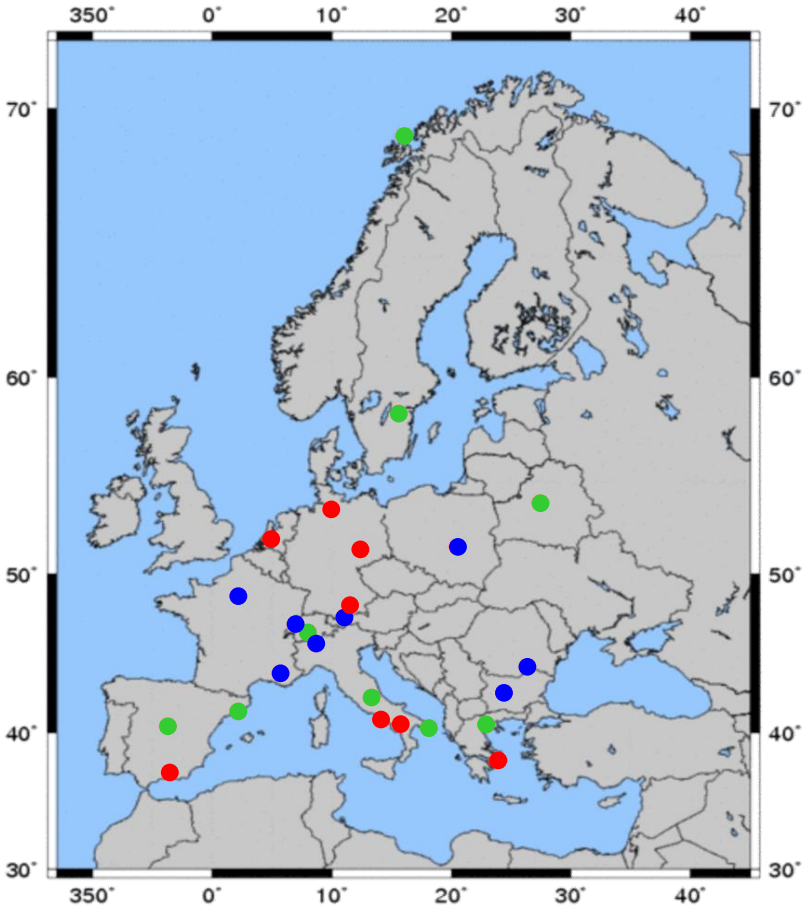
- Which lidar configurations?

Table 3: **Aerosol properties that can be derived from lidar observations. Only the simpliest lidar type that is needed to provide the product is listed. Depolarization channels (DL) are required to identify desert dust.**

Parameter (product)	Basic lidar type
Range corrected signal (colour plots of aerosol and cloud distributions)	BL
Attenuated backscatter coefficient (calibrated range-corrected signal)	BL
PBL depth	BL
Aerosol backscatter coefficient	BL+SPM
Aerosol type discrimination (dust, anthropogenic)	BL+DL
Aerosol extinction coefficient (estimate), optical depth, column lidar ratio	BL+SPM
Aerosol extinction coefficient, optical depth, lidar ratio	RL or HSRL
Ångström exponent (backscatter-related)	MBL
Ångström exponent (extinction-related)	MRL
Aerosol type determination (dust, maritime, fire smoke, urban haze)	MRL+DL
Aerosol microphysical properties (volume and surface conc., refractive index)	MRL
Single scattering albedo (aerosol)	MRL

GAW report 178, WMO/TD-No. 1443

Homogeneity?

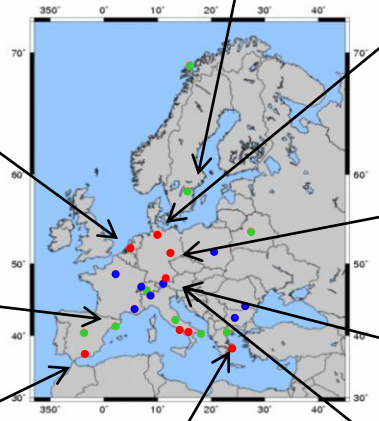


- Multi-wavelength Raman (3+2)
- Raman
- Backscatter

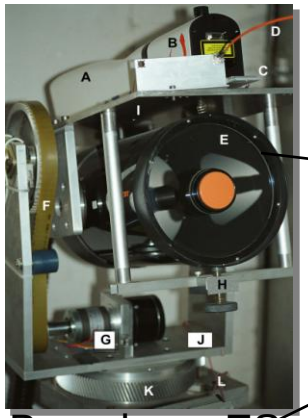
Bilthoven/Cabauw, NL

Linkoping, SE

Hamburg, DE



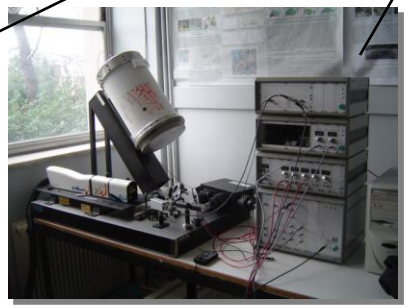
Leipzig/Meltpiz, DE



Barcelona, ES

München, DE

Granada, ES



Athens, GR

Garmisch-Partenkirchen, DE

Operationality

- Increase level of automation
  - e.g. measurement start-up procedures
  - Full autonomous operation
- Decrease need for operator controlled measurements
  - e.g. safety and control

Expected Results

- Enhanced homogeneity of performance over the network
  - Quantitative data products
- Better coverage of vertical range
  - Including the boundary layer
- Increased temporal coverage
  - Improved Raman daytime performance
  - Increased level of automation (capture events)
- Facilitate expansion of the network
- Possible: spin-off to SME for production of standardised components
-

Expected Results

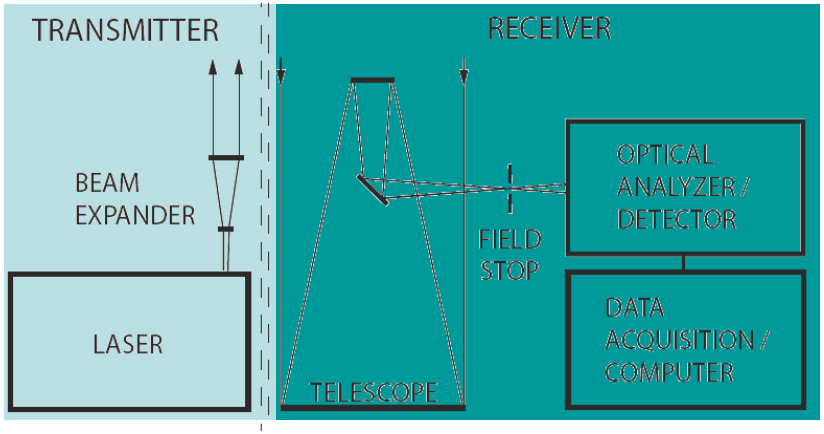
- Enhanced homogeneity of performance over the network
  - Quantitative data products
- Better coverage of vertical range
  - Including the boundary layer
- Increased temporal coverage
  - Improved Raman daytime performance
  - Increased level of automation (capture events)
- Facilitate expansion of the network
- Possible: spin-off to SME for production of standardised components
- Expansion of deliverable data products
  - Cloud products, ash, faster data delivery

Methodology and Tools

- Handbook of Instruments
  - Extensive set of system parameters
  - Exploitation of handbook data
- Repository of techniques
  - Solutions for technical problems
- Analysis tools
  - Optical configuration (ray-tracing)
  - Electronics recommendations and testing procedures

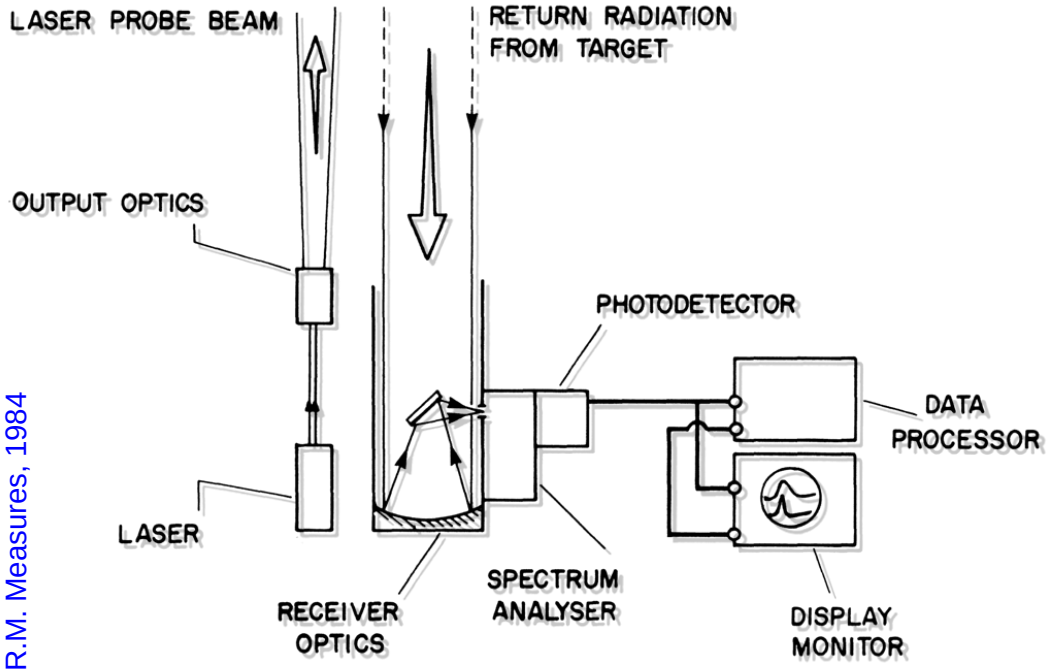
Handbook of Instruments

- Detailed description of each individual station
- Generic format to allow wide variety of designs
- Blocks of information
  - Station information (location, name, etc.)
  - Emitter description (wavelengths, control systems)
  - Optical receiver
  - Wavelength separation
  - Detectors
  - Data acquisition
  - Ancillary station information (nearest sonde, sunphotometer)

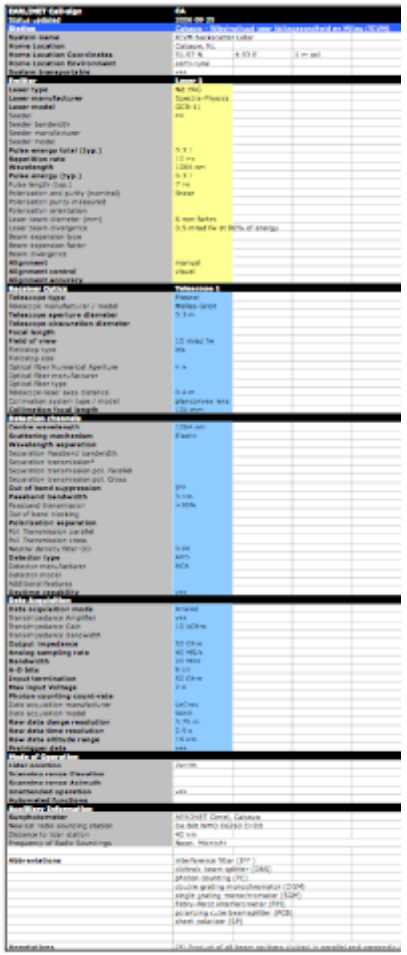


Handbook Example

- 1-lambda Backscatter lidar

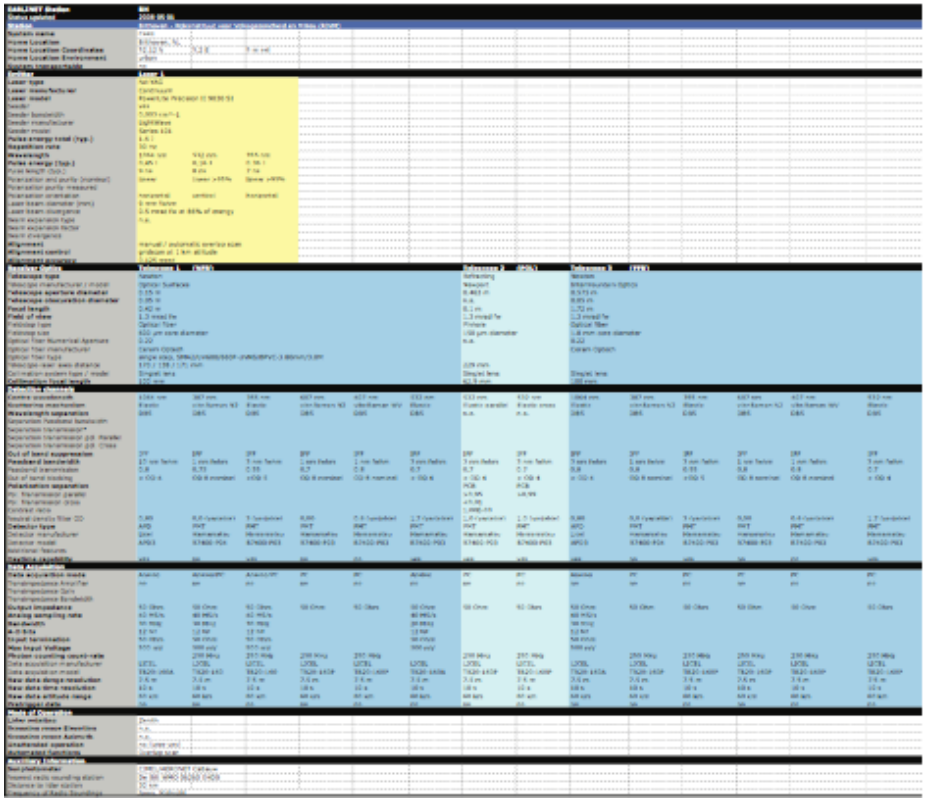


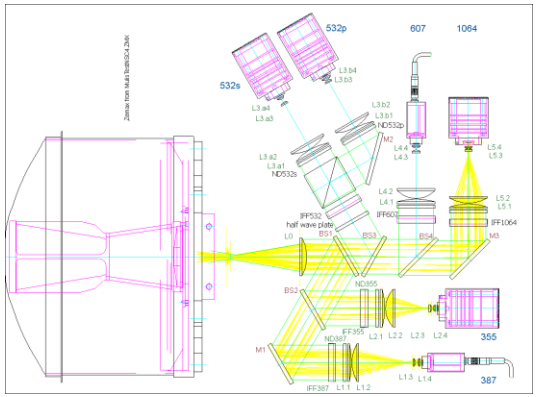
R.M. Measures, 1984



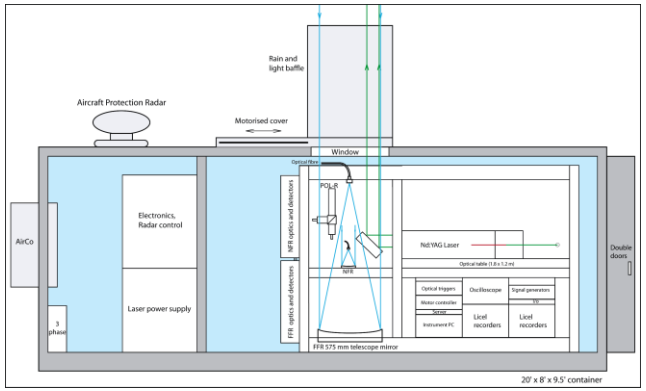
Handbook Example

- Multi-wavelength Raman Lidar





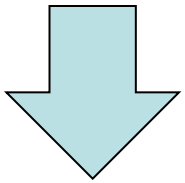
MULIS, V. Freudenthaler



CAELI, A. Apituley

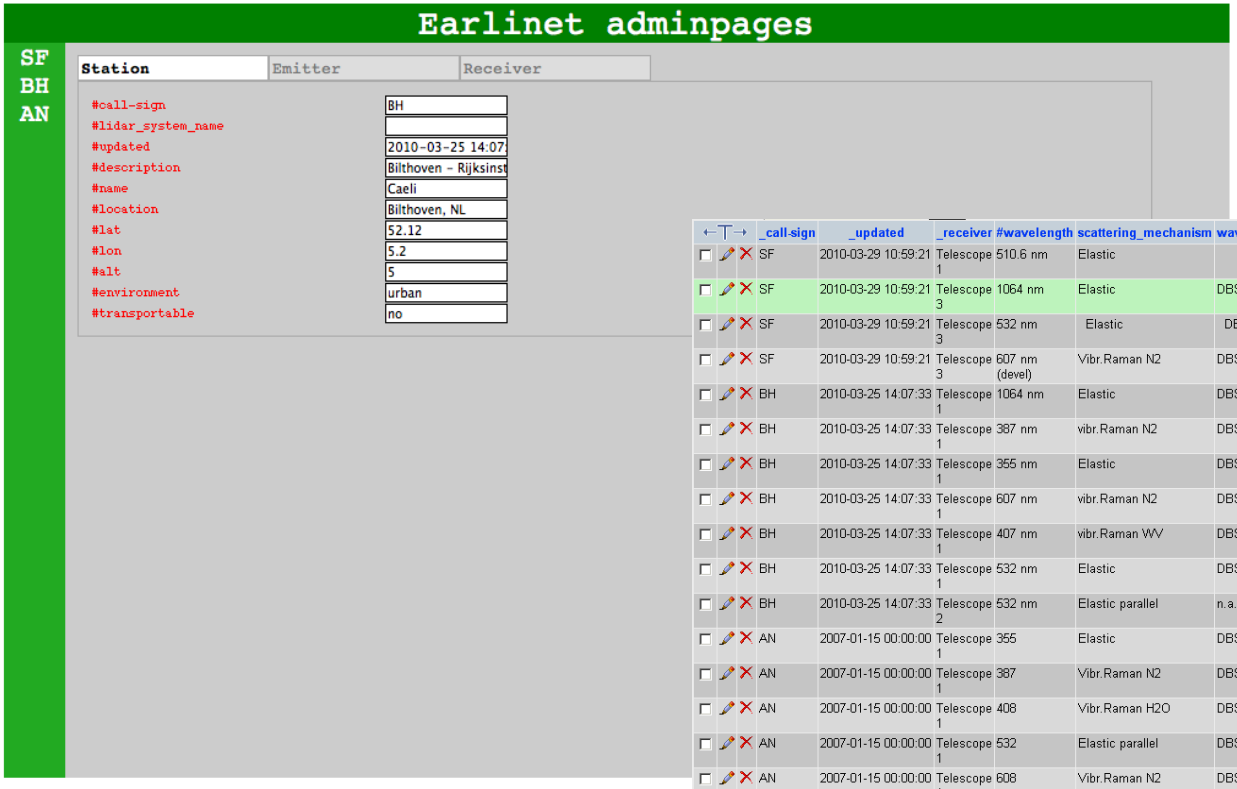
Handbook Updating

- Spreadsheet
  - Tedious updating process
  - Difficult to couple to profiles in database



- Database with admin-access via web
  - Easier to maintain
  - System configuration traceable to specific date
  - Automatic access (data processing purposes)
  - Public interface for general overview

Handbook Updating



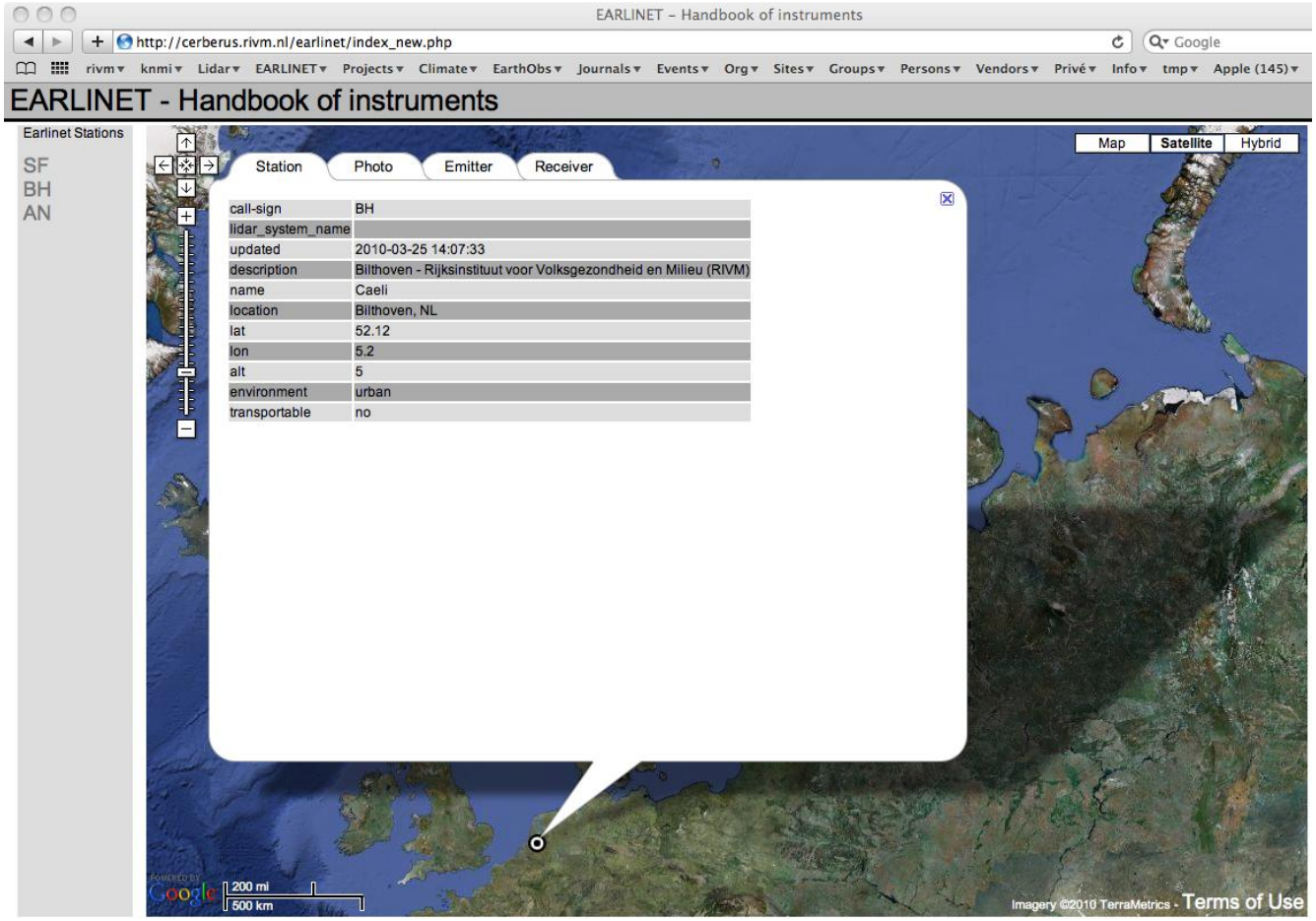
_call-sign	_updated	_receiver	#wavelength	scattering_mechanism	wavelength_separation	separation_passband_bandwidth	separation_transmiss
SF	2010-03-29 10:59:21	Telescope 1	510.6 nm	Elastic			
SF	2010-03-29 10:59:21	Telescope 3	1064 nm	Elastic	DBS		
SF	2010-03-29 10:59:21	Telescope 3	532 nm	Elastic	DBS		
SF	2010-03-29 10:59:21	Telescope 3	607 nm (devel)	Vibr.Raman N2	DBS		
BH	2010-03-25 14:07:33	Telescope 1	1064 nm	Elastic	DBS		
BH	2010-03-25 14:07:33	Telescope 1	387 nm	vibr.Raman N2	DBS		
BH	2010-03-25 14:07:33	Telescope 1	355 nm	Elastic	DBS		
BH	2010-03-25 14:07:33	Telescope 1	607 nm	vibr.Raman N2	DBS		
BH	2010-03-25 14:07:33	Telescope 1	407 nm	vibr.Raman WV	DBS		
BH	2010-03-25 14:07:33	Telescope 1	532 nm	Elastic	DBS		
BH	2010-03-25 14:07:33	Telescope 2	532 nm	Elastic parallel	n.a.		
AN	2007-01-15 00:00:00	Telescope 1	355	Elastic	DBS	0.2	
AN	2007-01-15 00:00:00	Telescope 1	387	Vibr.Raman N2	DBS	0.2	
AN	2007-01-15 00:00:00	Telescope 1	408	Vibr.Raman H2O	DBS	0.2	
AN	2007-01-15 00:00:00	Telescope 1	532	Elastic parallel	DBS	0.35	
AN	2007-01-15 00:00:00	Telescope 1	608	Vibr.Raman N2	DBS	0.2	
AN	2007-01-15 00:00:00	Telescope 1	660	Vibr.Raman H2O	DBS	10	
AN	2007-01-15 00:00:00	Telescope 1	1064	Elastic	DBS	0.2	

http://cerberus.rivm.nl/earlinet/earlinet.php

Handbook Public View

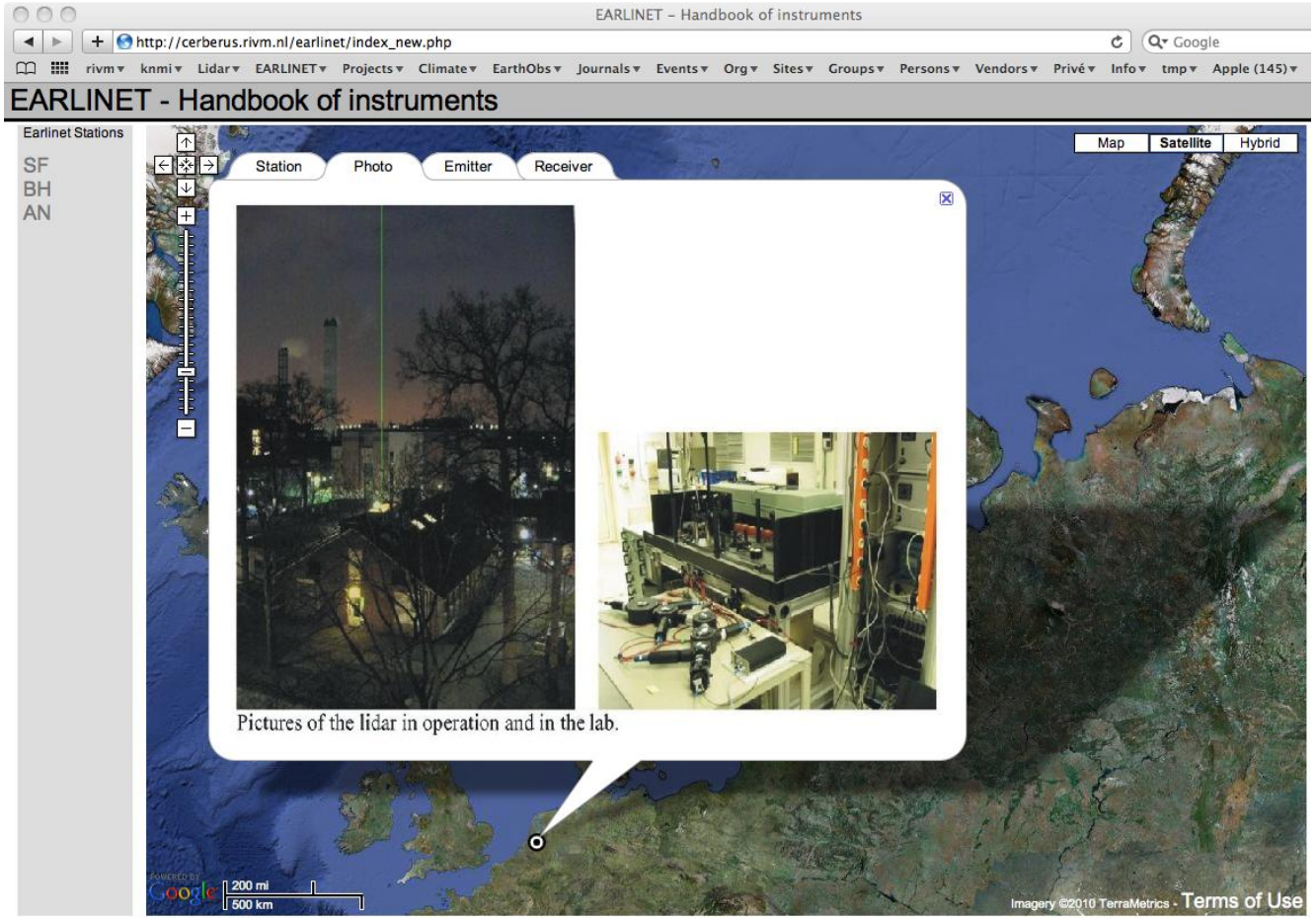
http://cerberus.rivm.nl/earlinet/index_new.php

Handbook Public View



http://cerberus.rivm.nl/earlinet/index_new.php

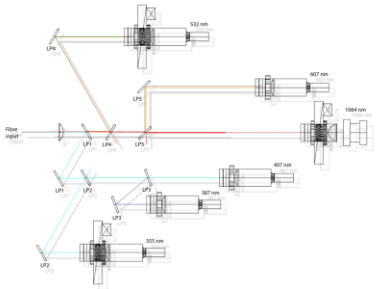
Handbook Public View

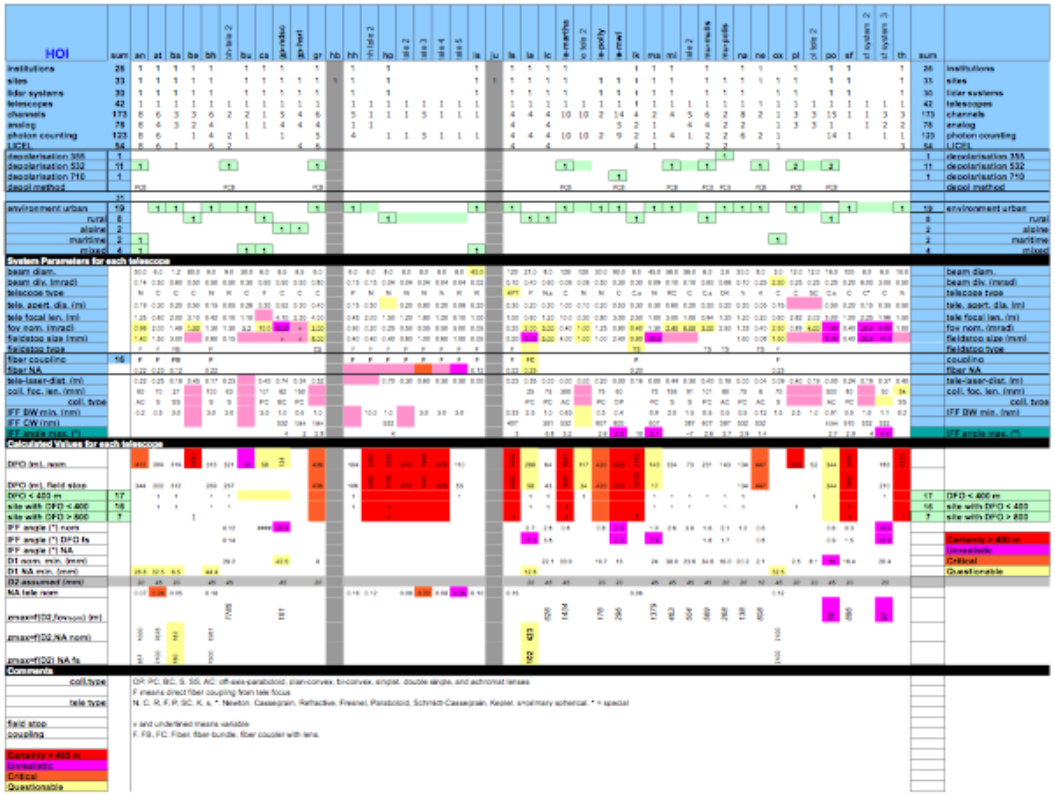


http://cerberus.rivm.nl/earlinet/index_new.php

Analysis Tools

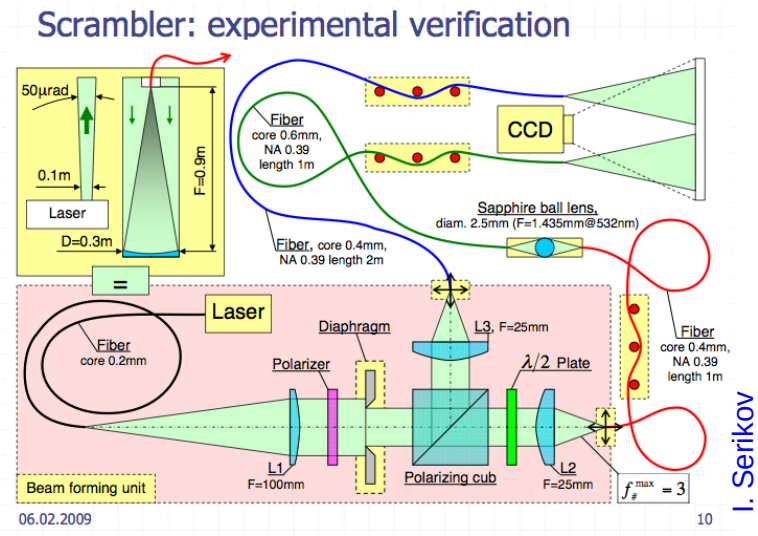
- Optics
  - Calculate validity of configuration based on Handbook data
  - Raytracing individual instruments

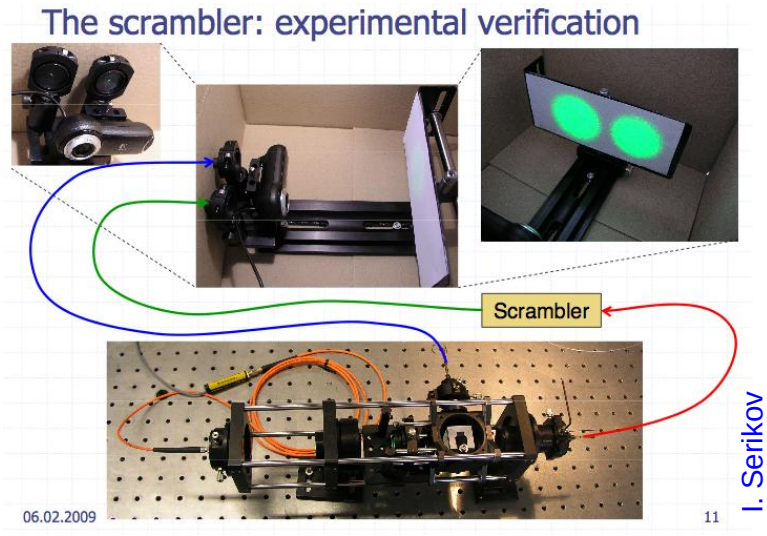




Repository of Techniques and Solutions

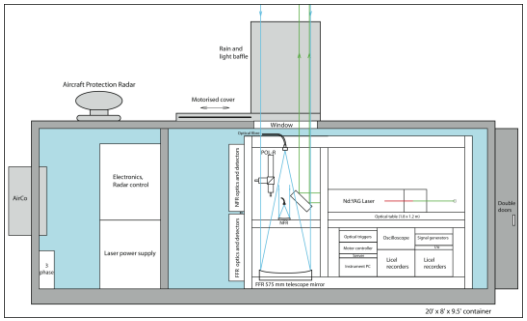
- Techniques are presented and discussed during workshops
- Documentation materials made accessible

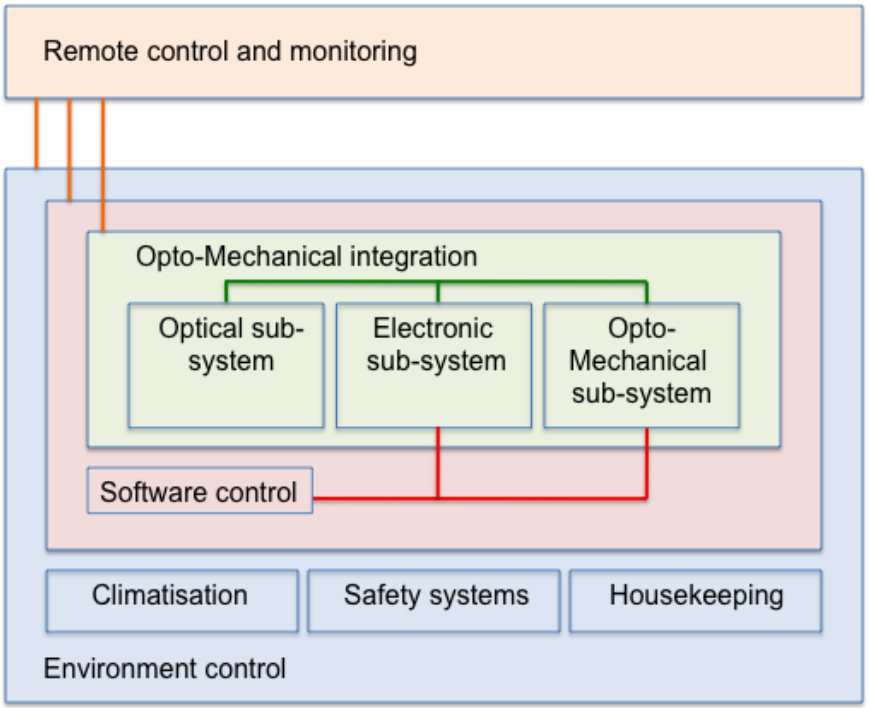




System Integration and Automation

- Recommendations to put sub systems together
  - Serviceable (modular, replaceable, upgradable)
  - Instrument control software integration
  - Electrical connections to avoid problems
  - Computer Interfacing
  - Remote control





Commercial Systems

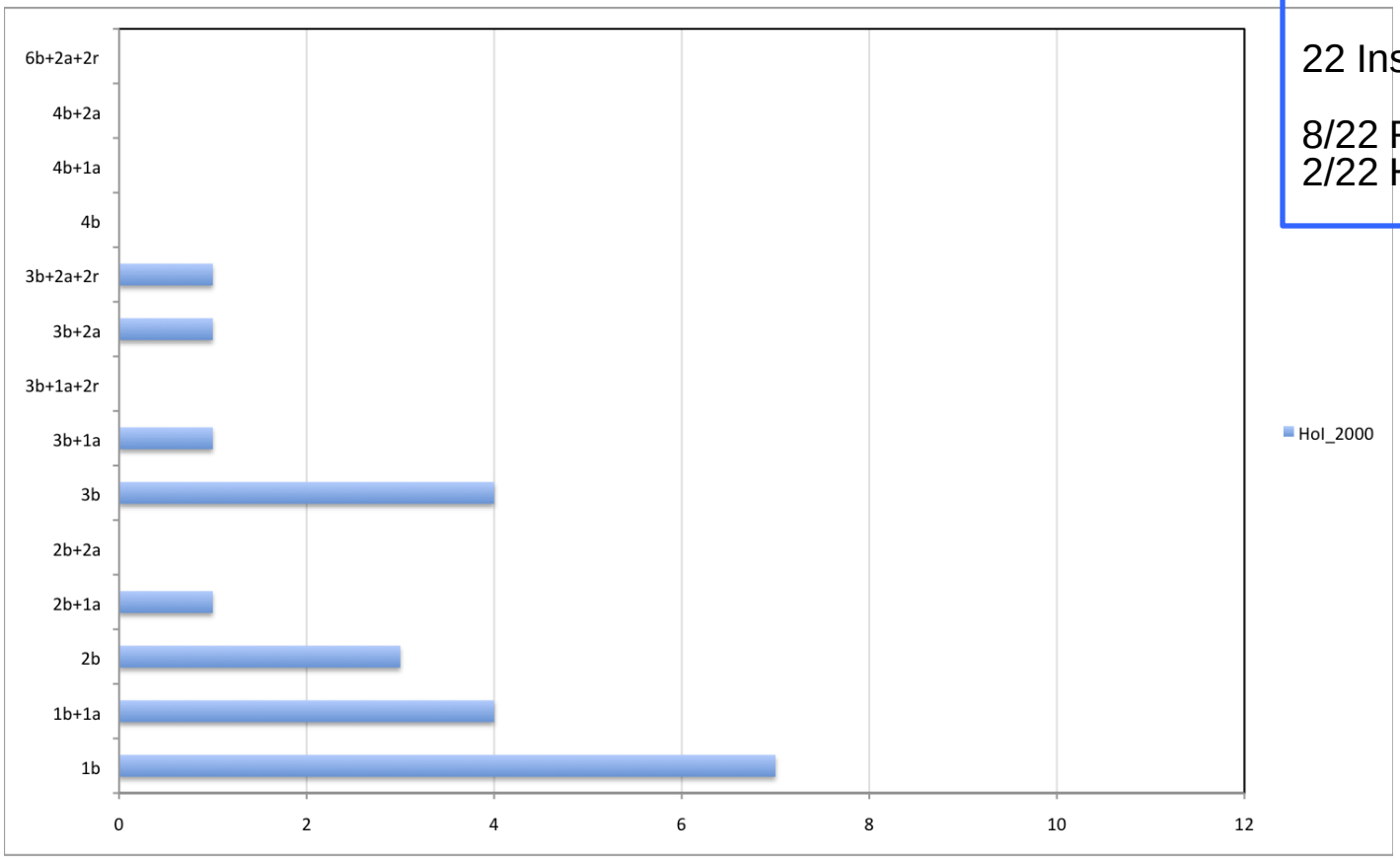
- Commercially available systems are available
  - In use in Granada, Leipzig, Evora, Bucharest, Ispra, Palaiseau
  - Instruments have to pass through network QA/QC procedures before data can be accepted in the database
- Common parts
  - Interact with suppliers for common specifications and custom configurations

Progress and Status

- Instrument installed base development since 2000

Station	Country	System name	Lat	Lon	2000	2006	2010
Abastumani	GE		41.75 N	42.82 E	-	-	-
Aberystwyth	GB		52.4 N	4.06 W	1b+1a	-	-
Andenes	NO	ALOMAR Troposphere Lidar	69.278 N	16.008 E	-	3b+2a	3b+2a
Athens	GR	EOLE	37.9716 N	23.7875 E	1b	3b+2a	3b+2a
Barcelona	ES	UPCLidar	41.393 N	2.120 E	1b	2b	2b+1a
Belsk	PO		51.5 N	20.47 E	3b	2b	3b
Bucharest	RO	LISA	44.348 N	26.029 E	-	2b	-
		RALI			-	-	3b+2a
Cabauw	NL	RBL	51.97 N	4.93 E	-	1b	-
		Caeli			-	-	3b+2a
Cork	IR				-	-	-
Evora	PT		38.568 N	7.912 W	-	-	3b+2a
Garmisch-Partenkirchen	DE		47.476 N	11.063 E	3b	-	-
		NDSC lidar			-	2b	2b
		HSRL			-	2b+1a	2b+1a
Granada	ES	Raymetrics LR321 - D400	37.164 N	3.605 W	-	3b+1a	3b+2a
Hamburg	DE	ARL2	53.568 N	9.973 E	1b+1a	3b	3b+1a+2r
Ispra	IT	CIMEL	45.811 N	8.621 E	-	1b	1b
Kühlungsborn	DE		54.1167 N	11.7667E	3b+2a	-	-
L'Acquila	IT		42.344 N	13.327 E	1b+1a	1b+1a	1b+1a
Lausanne	CH	EPFL-MeteoSwiss	46.5481 N	7.9839 E	3b+1a	2b+2a	-
Lecce	IT	UniLe	40.33 N	18.10 E	1b+1a	1b+1a	1b+1a
Leipzig	DE	Martha	51.35 N	12.43 E	3b+2a+2r	3b+2a+2r	3b+2a+2r
		Bertha			-	6b+2a+2r	6b+2a+2r
		Polly			-	1b+1a	1b+1a
		Polly-XT			-	-	3b+2a
Linköping	SE	FOI UV Lidar	58.392 N	15.575 E	1b	2b+2a	2b+2a
Lisbon	PT		37 N	8.5 W	1b	-	-
Ljubljana	SI		46.0 N	14.5 E	1b	-	-
Madrid	ES	LIDAR-CIEMAT	40.456 N	3.726 W	-	1b+1a	1b+1a
Maisach	DE	POLIS	48.209 N	11.258 E	-	1b+1a	1b+1a
Minsk	BY	MSTL-2	53.917 N	27.383 E	2b	4b+1a	4b+2a
München	DE	MULIS	48.15 N	11.57 E	3b	3b+2a	3b+2a
Napoli	IT		40.833 N	14.183 E	1b	3b+2a	2b+2a
Ness-Ziona	IL	IIBR	31.55 N	34.47 E	-	-	2b
Neuchatel	CH	MAL-ground	47.001 N	6.955 E	3b	1b	1b
Oxylithos	GR	EOLE-OXY	38.55 N	24.13 E	-	-	-
Palaiseau	FR	LNA	48.42 N	2.16 E	2b	2b	-
		ALS450			-	-	1b
Payerne	CH	RALMO	46.812 N	6.943 E	-	-	1b+1a
Potenza	IT	PEARL	40.6 N	15.733 E	2b+1a	3b+2a	3b+2a
		MUSA			-	-	3b+2a
Saint-Michel (HP)	FR	LTA-LOR	43.935 N	5.712 E	-	1b+1a	1b+1a
Sofia	BU	Sofia-EARLINET station IE	42.65 N	24.38 E	2b	3b+1a	3b+1a
Thessaloniki	GR	AUTH	40.5N	22.9 E	1b	3b	2b+2a

Network Development

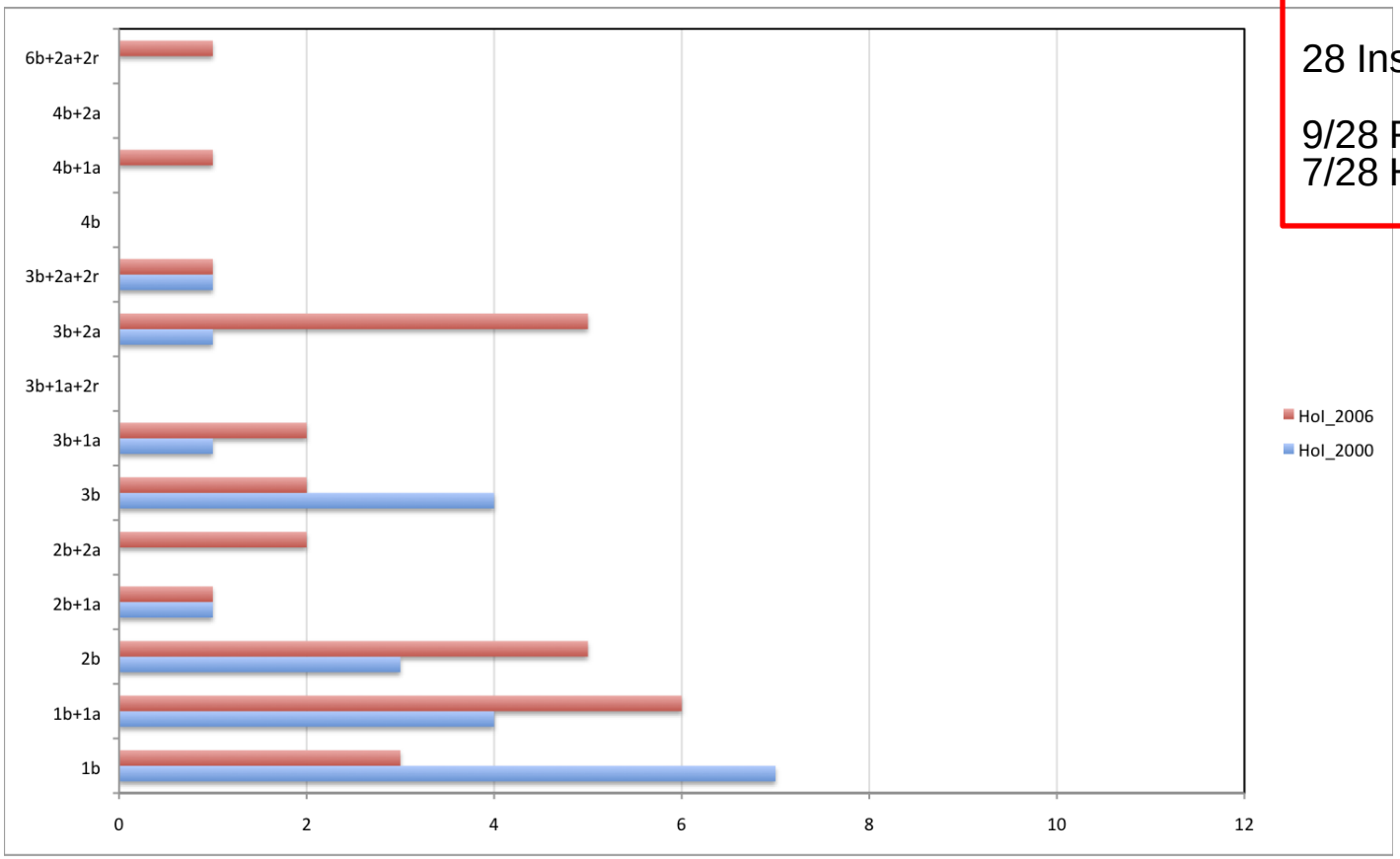


2000

22 Instruments

8/22 Raman capable
2/22 High performance

Network Development

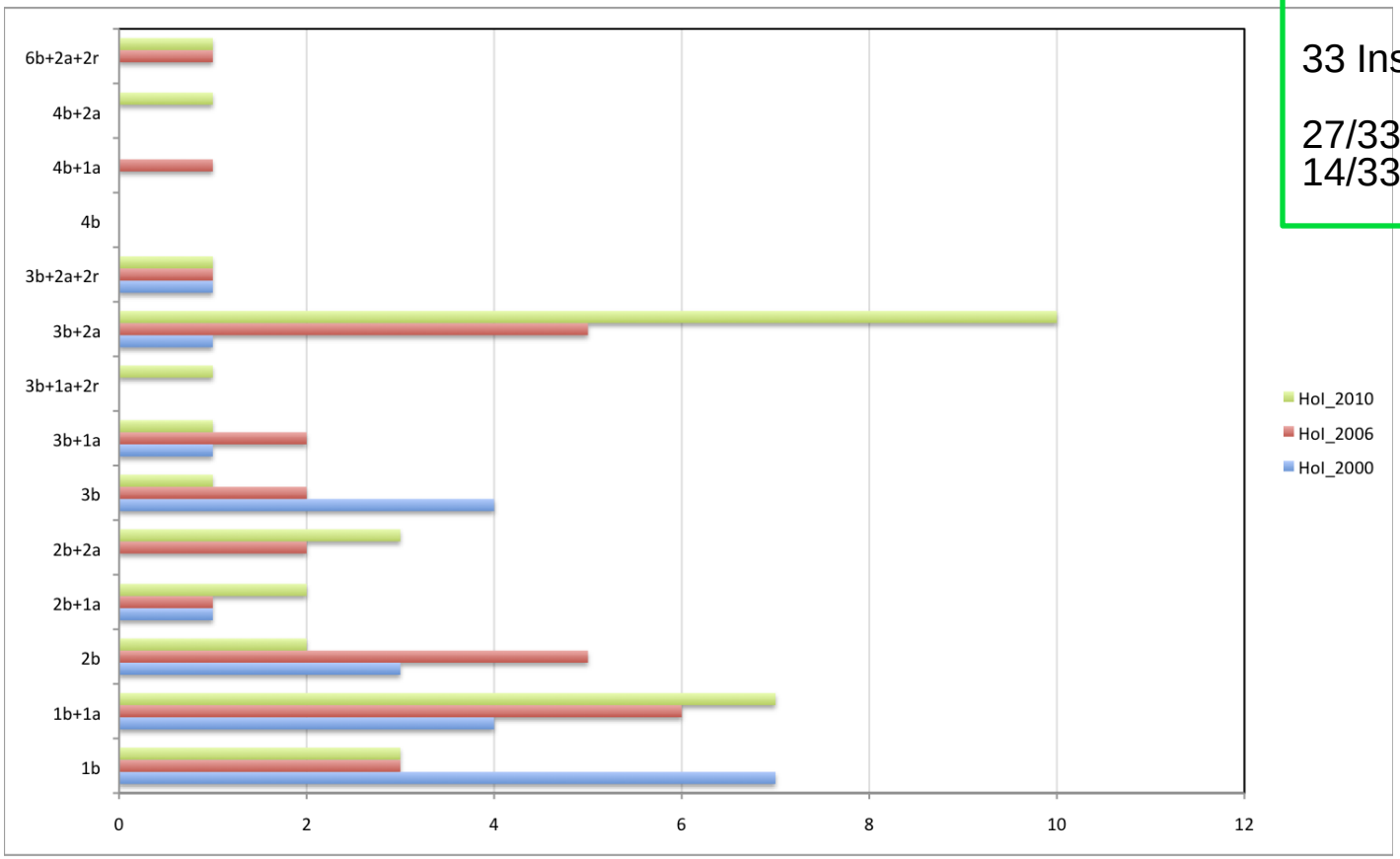


2006

28 Instruments

9/28 Raman capable
7/28 High performance

Network Development



2010

33 Instruments

27/33 Raman capable
14/33 High performance

Conclusions

- Tools exist for keeping track of the development and quality of the installed base of instruments in the network
- Recommendations and techniques for network participants and aspiring partners available
- Improvement of tools and repository of recommendations is ongoing
- Commercial systems are becoming part of the network
- Network has expanded and performance in terms of network objectives has increased