FLIGHT MECHANICS LAB

DIPARTIMENTO DI CHIMICA
«G. CIAMICIAN»

Aerosols and clouds formation research in A5-Unibo experiment on-board BEXUS 18 Lessons learned

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1° Symposium on Space educational activities

Padova, 10th December 2015

REXUS/BEXUS Programme

- **Realised under a bilateral Agency Agreement between the German Aerospace Center (DLR) and the Swedish National Space Board (SNSB)**
- **The Swedish share of the payload has been made available to students from other European countries through a collaboration with the European Space Agency (ESA)**

A5-Unibo

Advanced Atmospheric Aerosol Acquisition and Analysis

EUROLAUNCH
A DLR and SSC cooperation

FLIGHT MECHANICS LAB

MORABA
MOBILE RAKETENBASIS

SSC

DLR

ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

RYMDSTYRELSEN
Swedish National Space Board

esa

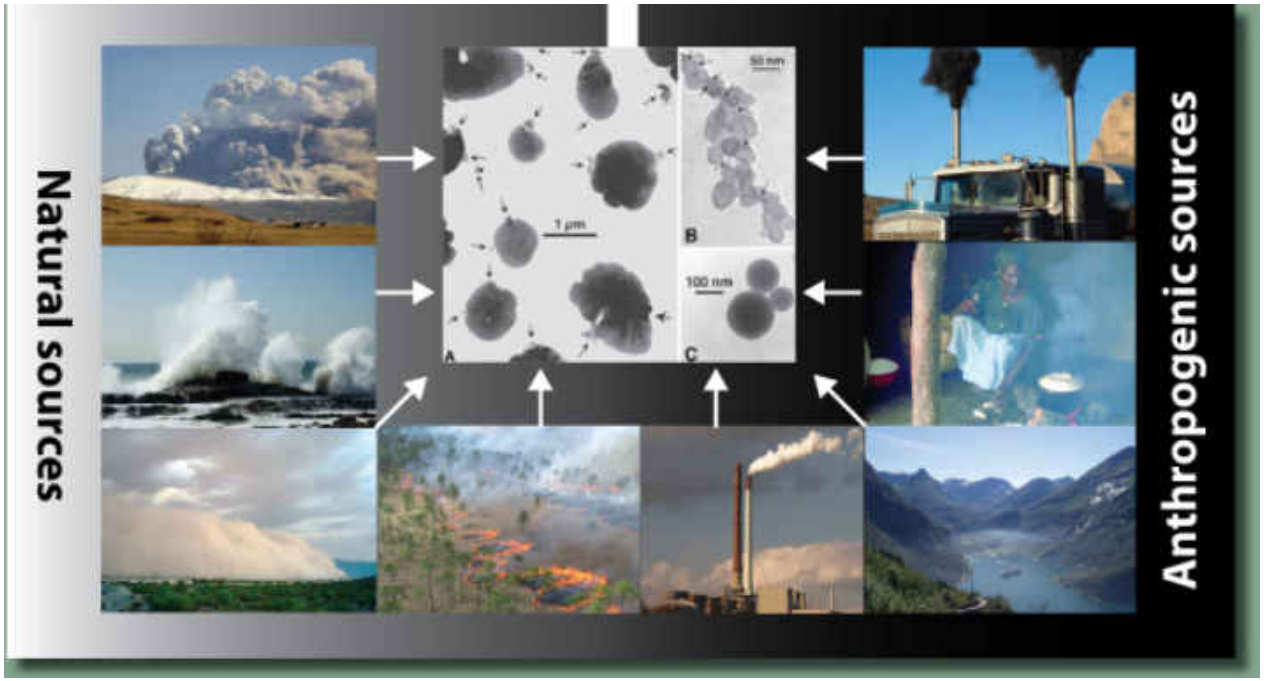
ZARM

Introduction: AEROSOLS

«Atmospheric aerosols» *(or particulate matter)* = solid and/or liquid that lie suspended in air having diameters between about 1-2 nm to about 100 µm

Sources:

- Natural
- Anthropogenic



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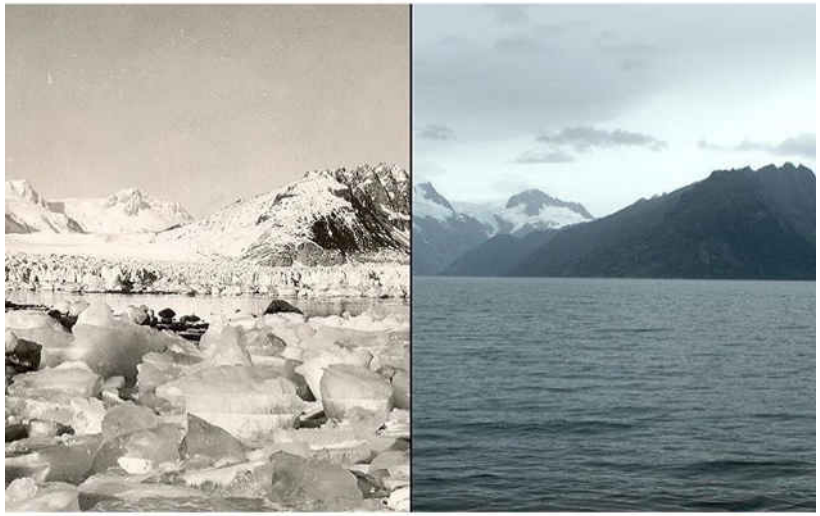
whitehouse 7h



11.985 likes

whitehouse Right now, carbon pollution in our atmosphere is higher than at any point in human history. Glaciers are melting, sea levels are rising, and unprecedented heat waves, superstorms and wildfires are delivering serious challenges for people around the world. But we're doing something about it: America is leading global efforts to combat climate change, with more than 180 countries representing nearly 95% of global emissions having recently announced their own targets to #ActOnClimate. Learn more at go.wh.gov/ChartOfTheWeek. #COP21

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unicef #PhotooftheWeek: A boy in the Tillabéri Region of #Niger makes his way through floodwaters. #Climatechange is increasing the threat of severe weather events and posing grave risks to children's survival. Over half a billion children worldwide currently live in flood-prone areas. #COP21 #UNICEF © UNICEF/UNI192350/Gilbertson


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83%
MOST RECENT
#COP21
shmritiz
Dailekh
+ FOLLOW
gabrielleagostini
3m
shmritiz Most parts of the #agricultural fields which were supposed to have wheat saplings planted on them have turned dry hit by #drought this season. #Farmers are desperately waiting for rain! This is not only the condition of #Dailekh rt now, but various parts of #Nepal while #COP21 is happening in #Paris. Also, some world leaders still are denying #ClimateChange exists! #facepalm #travel


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natgeo
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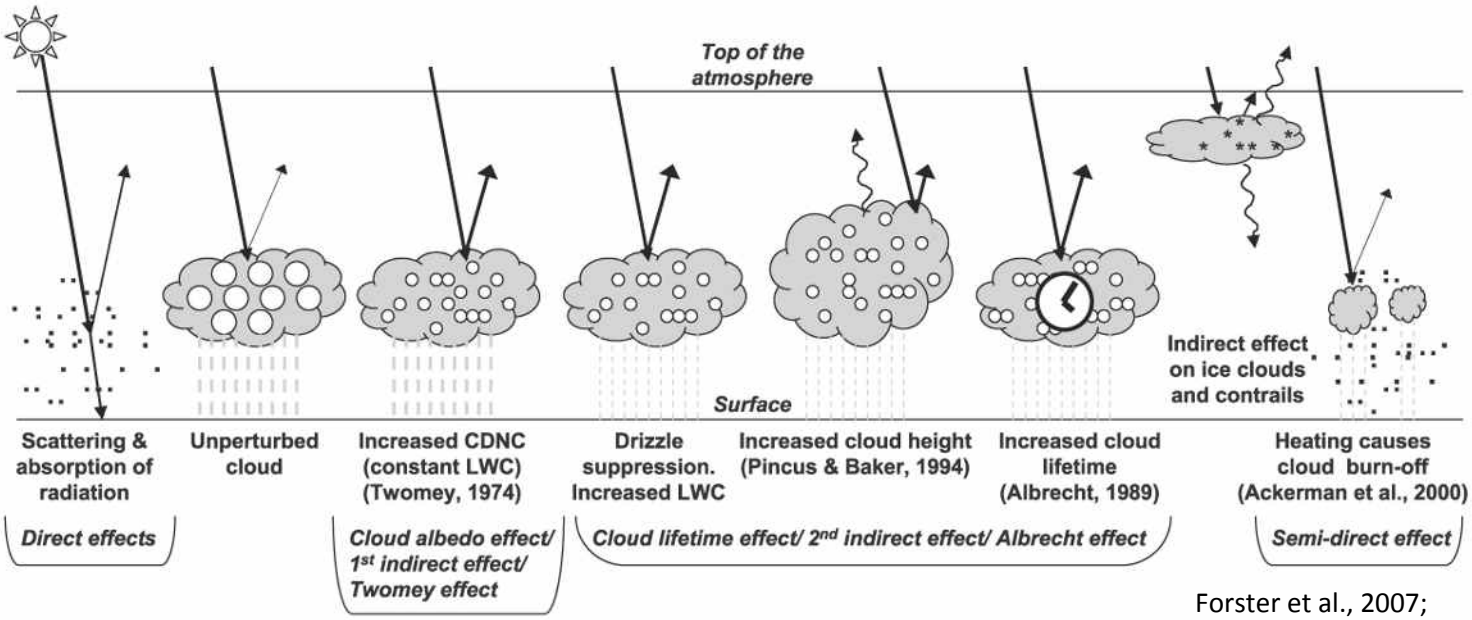
65.283 likes
natgeo Photo by @mattiasklumofficial
Afternoon light at the glacial lake Jökulsárlón on the edge of Vatnajökull National Park. This lake quite recently became the largest on Iceland since glacial retreat extended its boundaries.

Aerosols effects on climate



Forster et al., 2007;
Boucher et al., 2013

- Direct effect: effect exerted by aerosols on the radiative balance of the Earth through a combination of scattering and absorption of radiation
- Indirect effect: suite of possible impacts of aerosols on cloud properties (reflectivity, lifetime,…), due to the action as CCN (Cloud Condensation Nuclei)
- Aerosols and clouds still continue to contribute the largest uncertainties to the current estimates of Earth's changing energy budget

Scientific Objectives

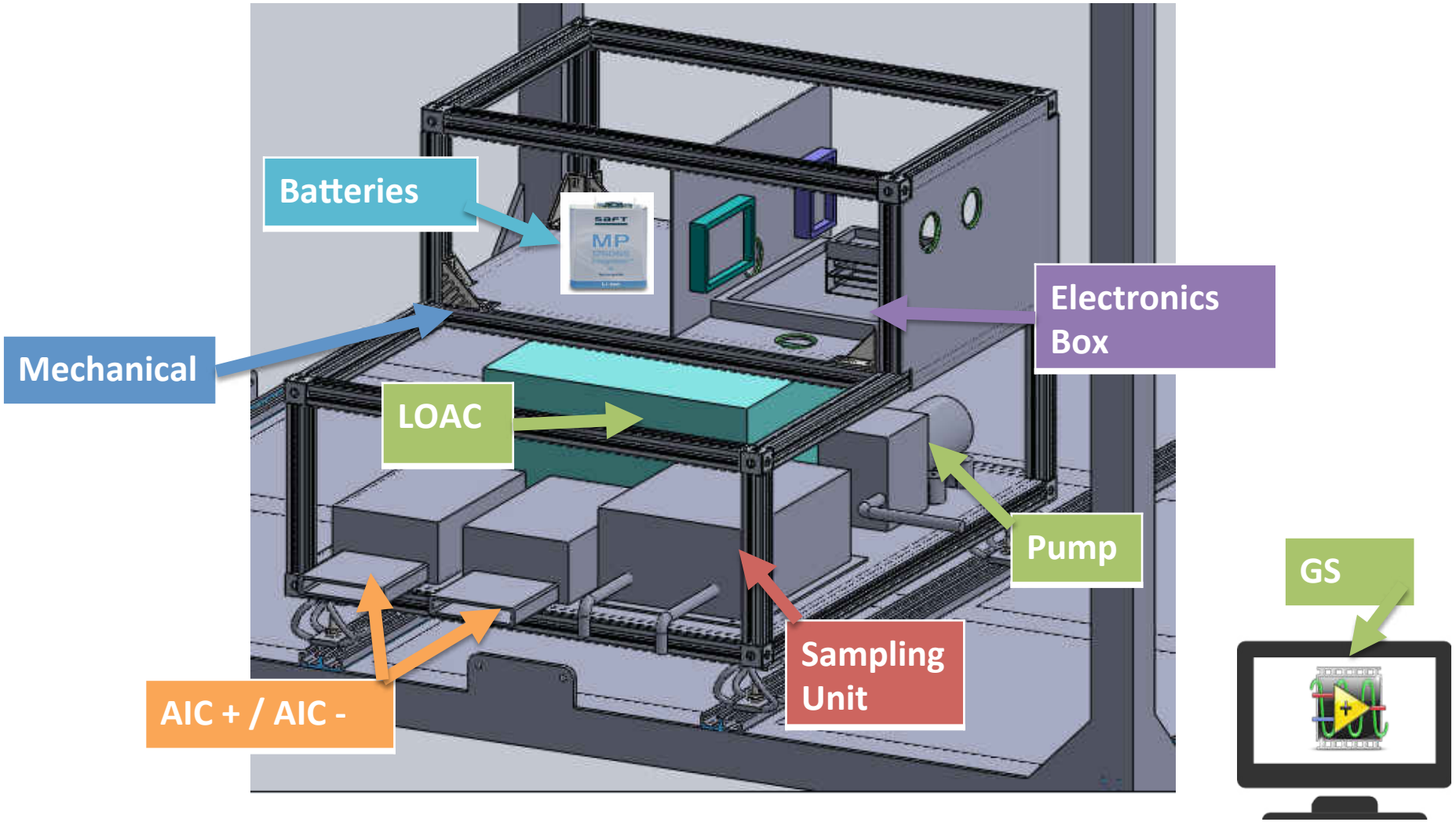
Primary Objectives

- **Study cloud formation processes and IIN**
  Investigate the **correlation** between ionization and nucleation rates
- Vertical profiles of key atmospheric parameters (temperature, humidity, pressure), particle size distributions and Ion (positive and negative)densities

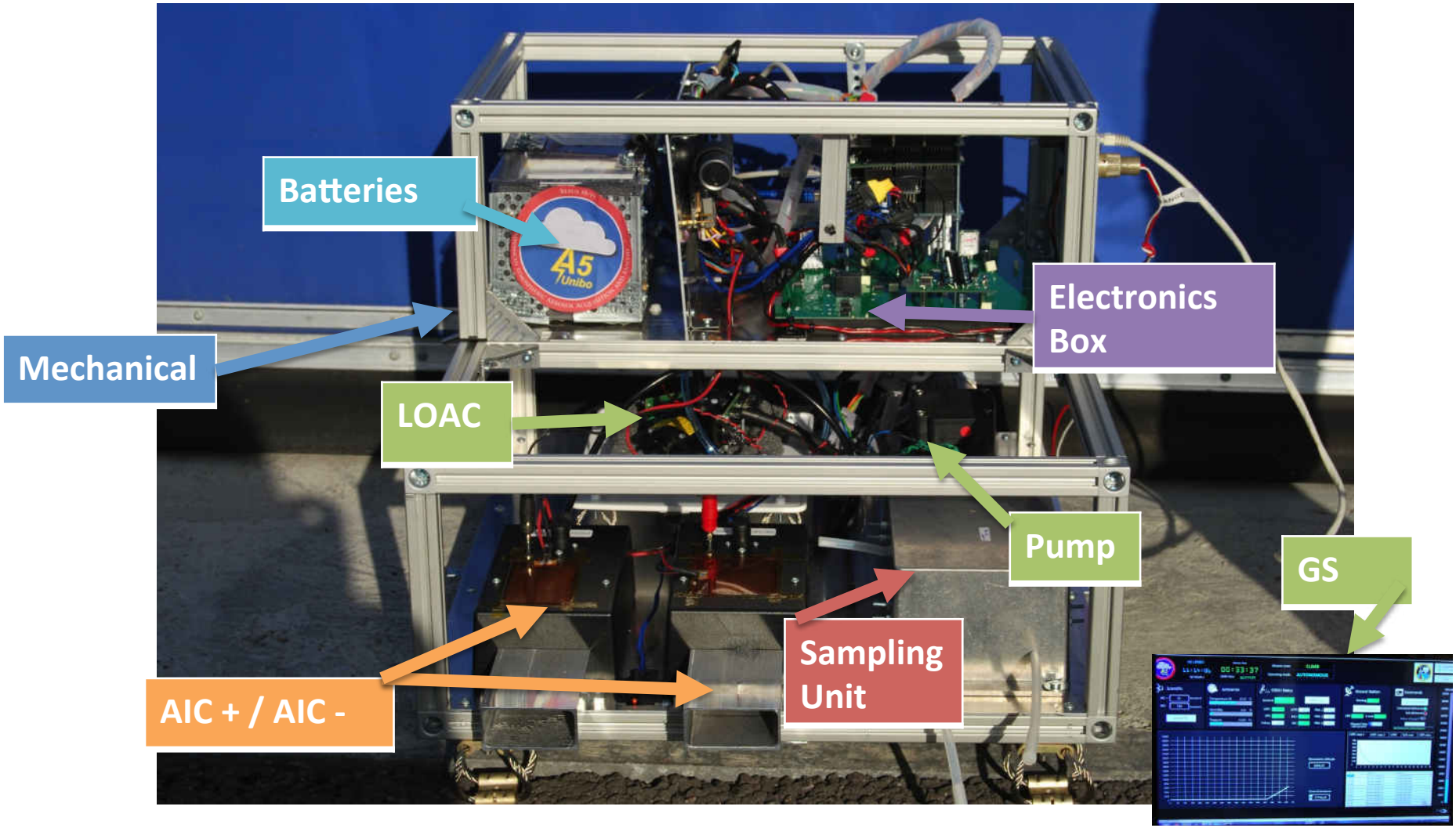
Secondary Objectives

- Retrieve aerosol samples and analyze them to determine aerosol composition and morphology
- Create a reliable simple concept for future atmospheric measurements

A5 Unibo SYSTEM Design



A5 Unibo SYSTEM Design

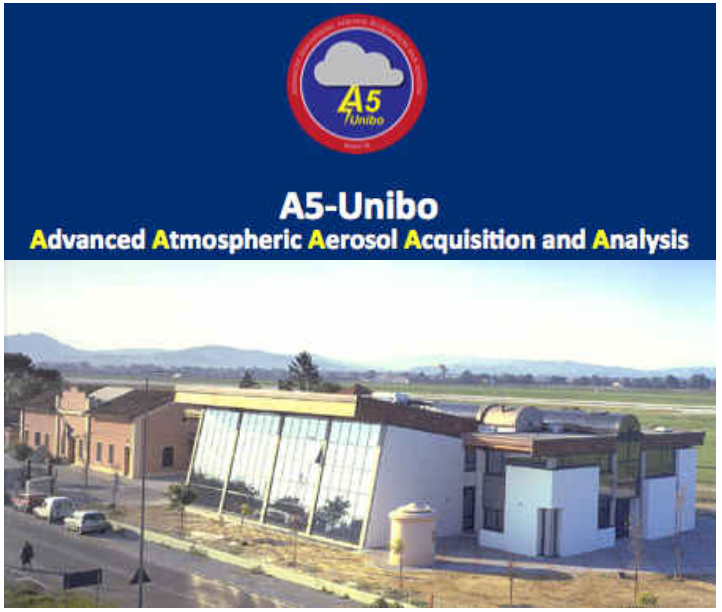


How the educational challenge started

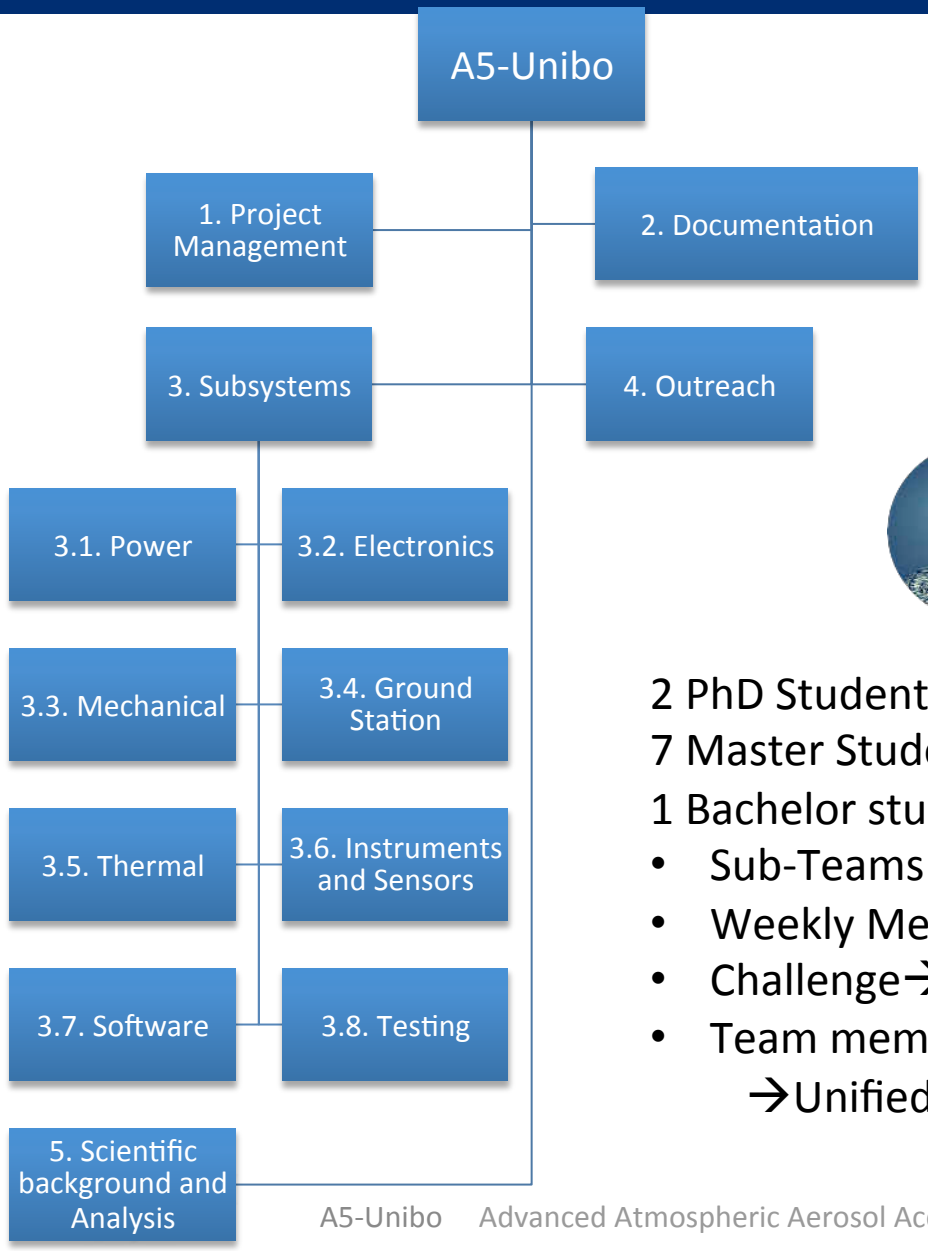
Team

Team WBS

Scientific Idea



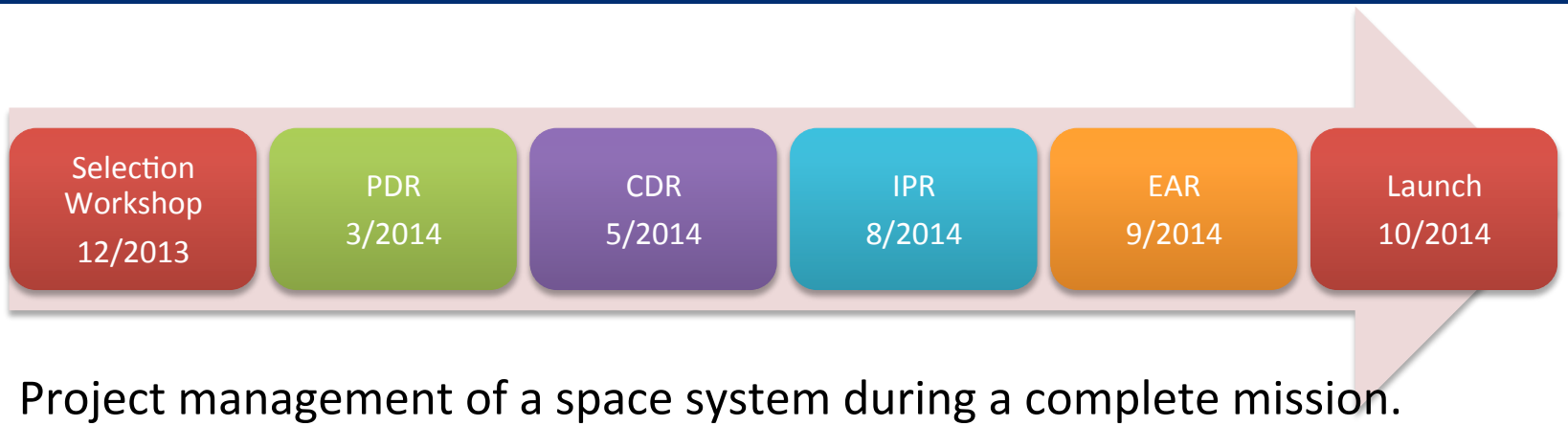
A5Unibo Team – Project Management



2 PhD Students → different backgrounds
7 Master Students
1 Bachelor student

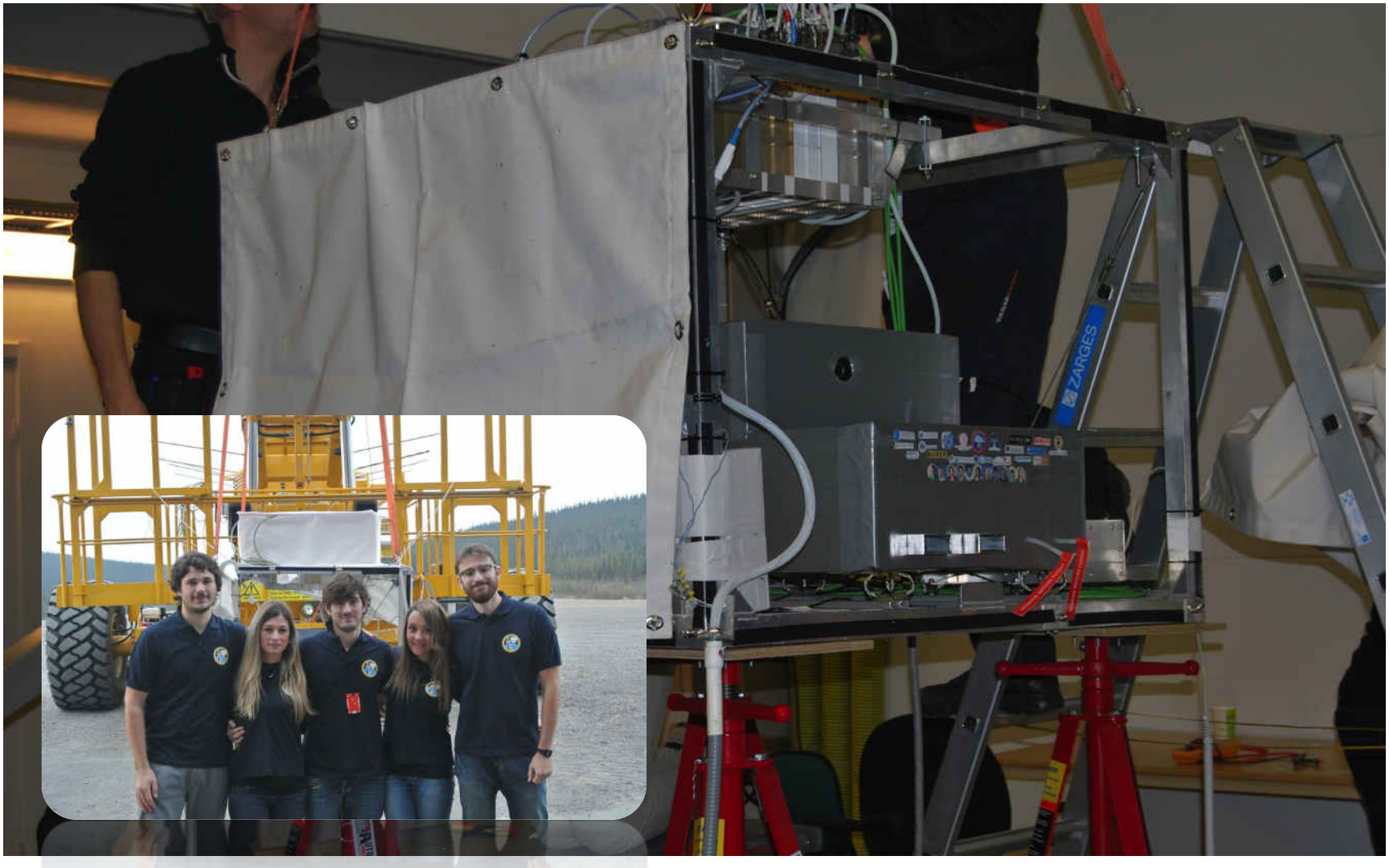
- Sub-Teams
- Weekly Meetings
- Challenge→ Students from different faculties
- Team members: Responsibility, adaptability
  →Unified Commitment to a Goal

Millestones and Reviews – Lessons Learned

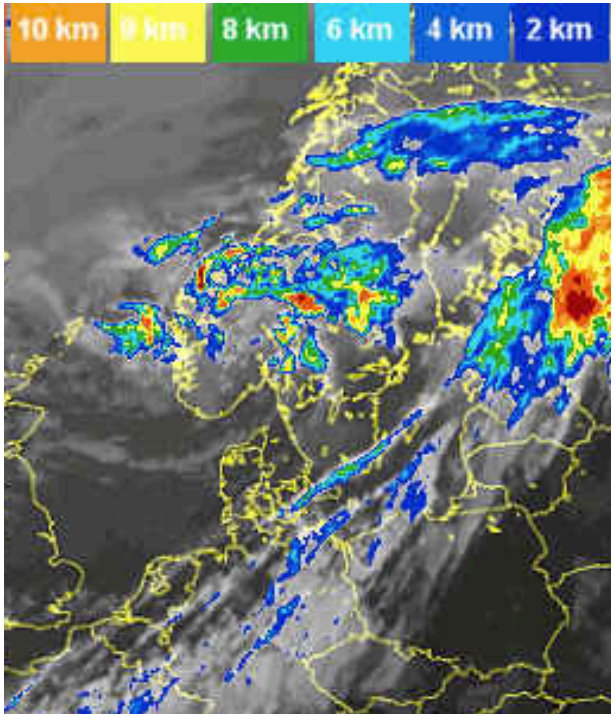


- Project management of a space system during a complete mission. Hands-on experience.
- ESA standards, ECSS (European Cooperation and Space Standardization)
- Adapting to schedules within the framework of an International Space Agency by working in a project environment respecting deadlines, milestones and passing reviews from experts.
- Problem solving strategies
- Gantt Chart +WBS (Work Breakdown Structure)

Ready for Flight



Launch Day 10th October 2014



FLIGHT EVENTS

Following table describes the Bexus 18 flight from the pilot point of view:

Time (UTC)	Event	Altitude (m)	Notes
08:48:30	Release of balloon	335	Released from Hercules launch vehicle.
08:51:51	Armed the load sensor	1123	Stabile reading on load sensor: 157 kg
10:51:31	Balloon stops ascending Avg. float level ~27200 m	27248	Average ascending velocity during climb: 3.5 m/s
11:58:06	Arming of flight termination device	27112	Preparations for flight termination
12:00:00	Cut-down	27091	Flight terminated on pilot command
12:28:30	Loss of signal	2322	Latitude: 68° 03,508 ´ Longitude: 26° 05.468´

Landing and recovery

Lessons Learned of different subsystems

Project Management

- Fundraising and communication with companies is fundamental, one person should be dedicated entirely to this task.
- Consider big time margins for purchasing and delivering.
- Consider and respect internal deadlines - team work responsibilities

Power

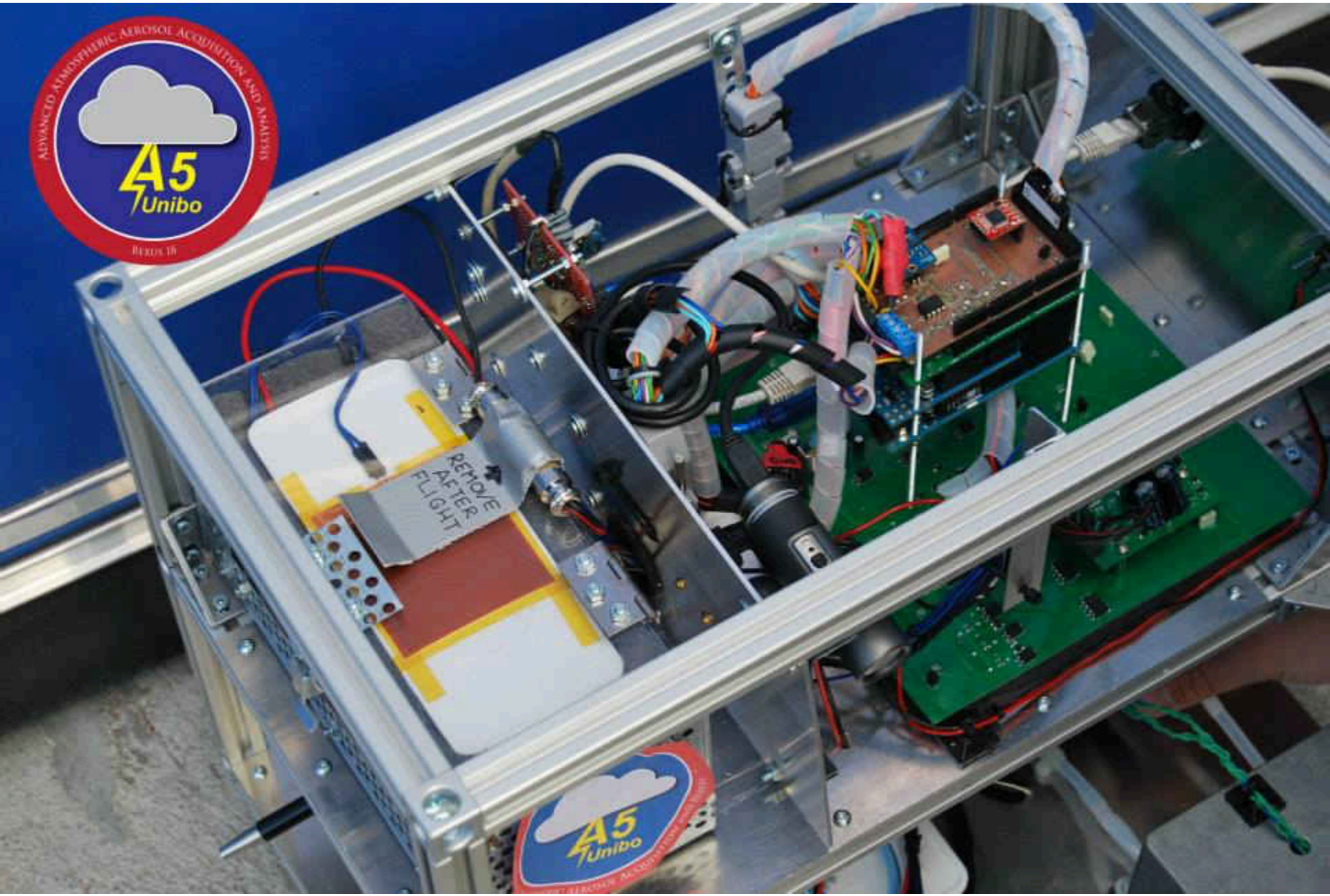
- Margins: Power budget was too conservative.
- Harnessing strategy –early phases.

Electronics

- To avoid late modifications of the boards or unexpected behaviors, the design of the boards should start very early in the project.
- Communication between software and electronic subsystem is essential.
- Grounding scheme.

Testing

- Fundamental to start thinking about tests, procedures, and facilities as soon as possible.


REMOVE
AFTER
FLIGHT

Lessons Learned of different subsystems

Mechanical

- optimize weight and size, the mechanical fixation and housing of the instruments

Thermal

- Un-direct control
- Testing of the thermal subsystem was also not sufficient→ oversizing of the battery pack

Ground Station

- Labview software environment

Instruments and sensors and scientific subsystem

- Industrial use for the instruments. →hard to adapt to the system

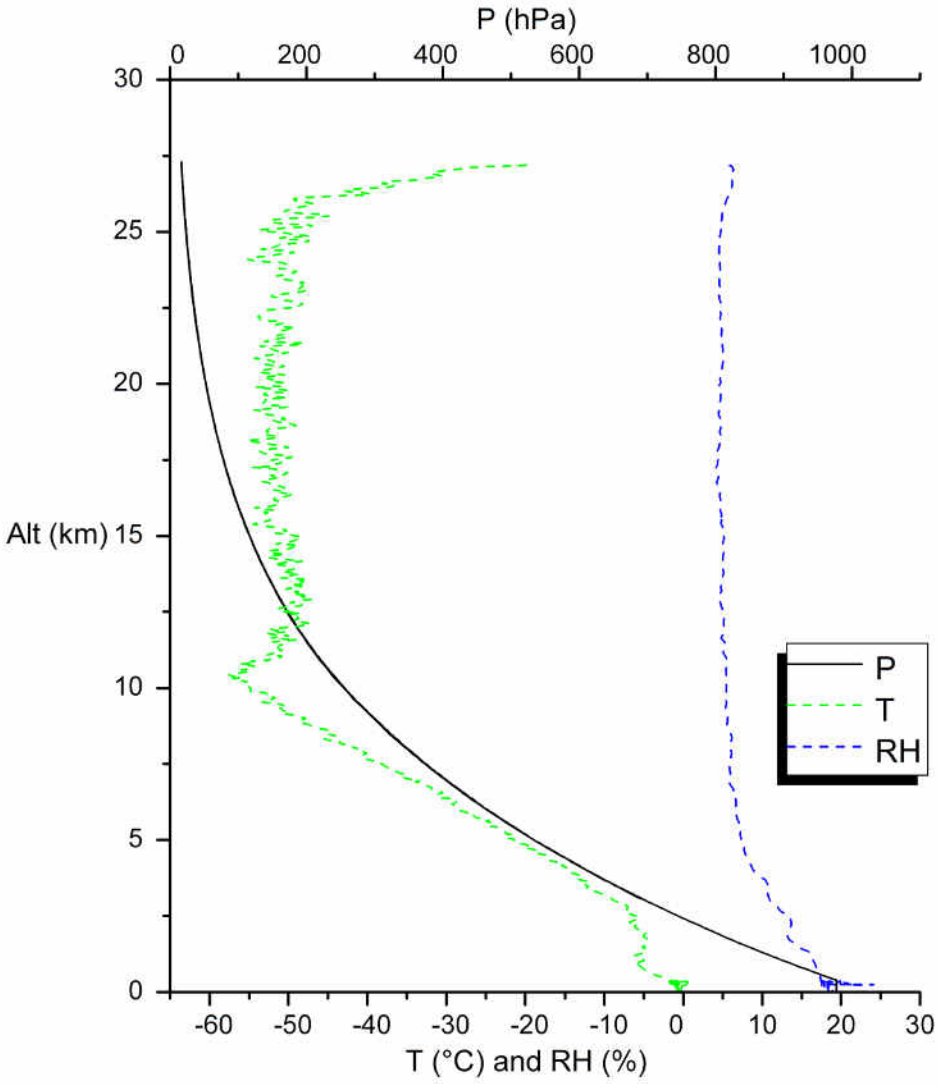
Software

- Check compatibility of the communication protocols between sensors – early phases
- Different operating modes were implemented and the mission was divided into different mission states → successful

Data Analysis
Results

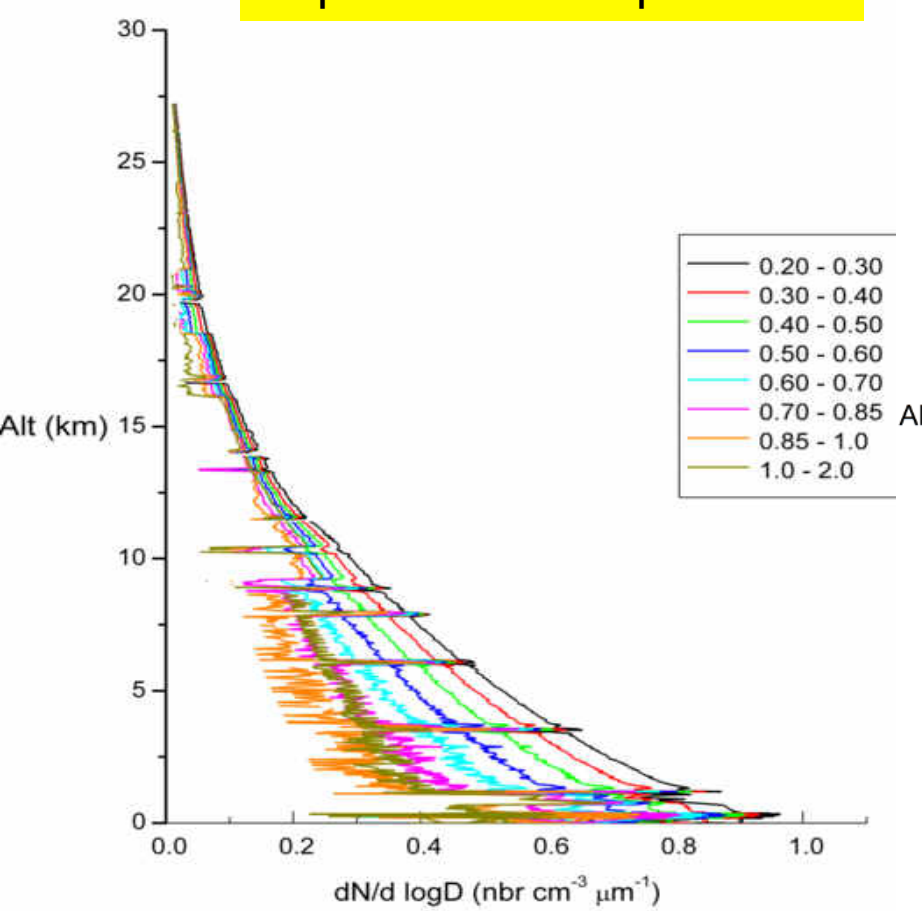
Vertical profiles: atmospheric parameters

- Exponential drop of pressure with height
- Low relative humidity: air dry at ground level, decrease until about 5 km, then more or less constant, slight increase at about 26 km
- Tropopause level ≈ 11 km extending until ≈ 25 km = stratosphere



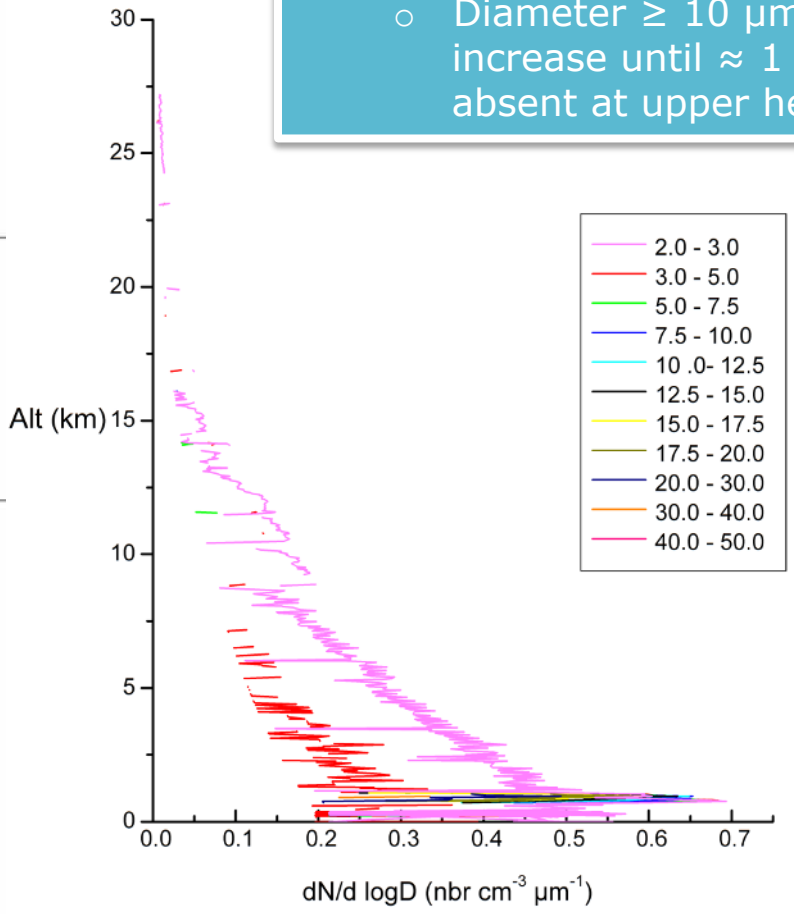
Vertical profiles: particles size distribution

Fine particles (≤ 2 µm): exponential drop



Coarse particles (> 2 µm)

- 2 µm < diameter < 10 µm: present at ground level and then at tropopause level
- Diameter ≥ 10 µm: linear increase until ≈ 1 km, absent at upper heights

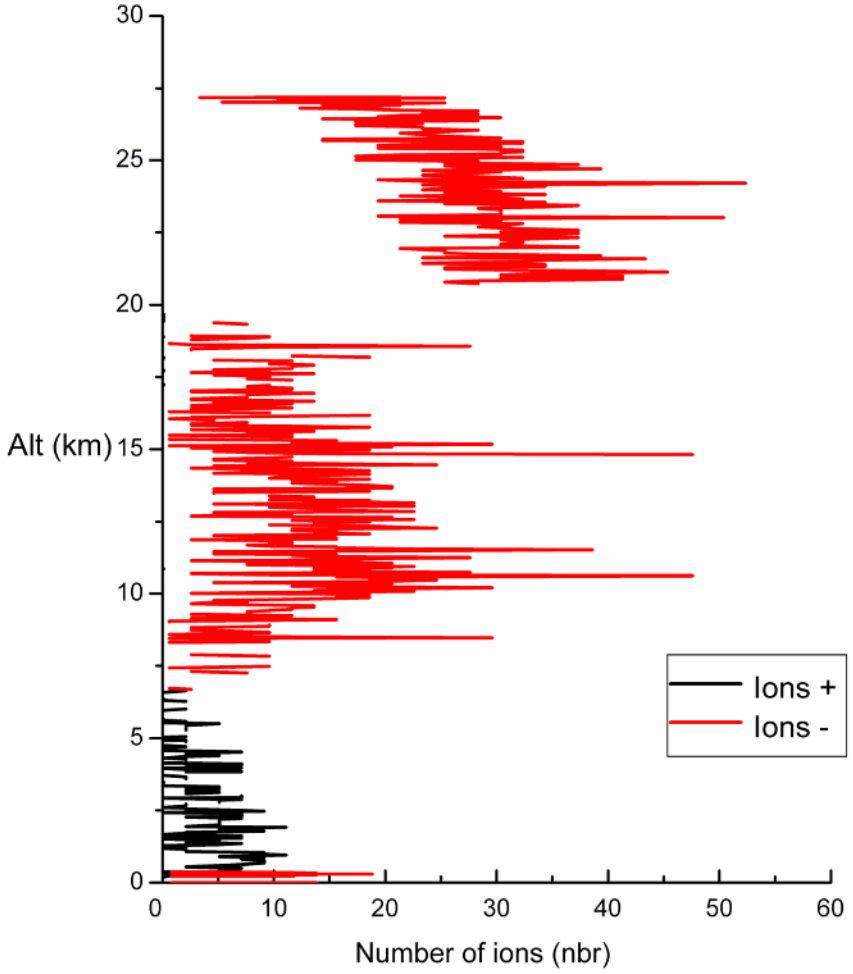


Vertical profiles: ion densities

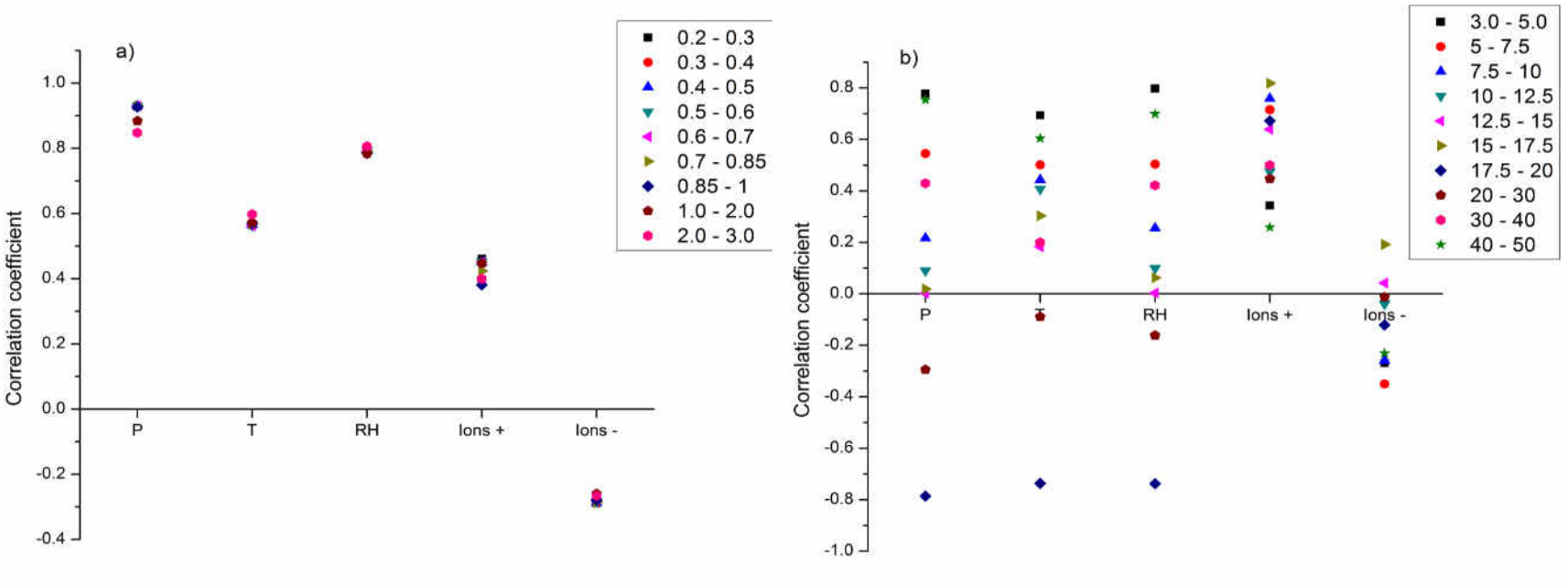
1. When present, negative ions ≫ positive ions

3. Charged particles intermittent:
   - positive ions until ≈ 6.5 km
   - negative ions at ground level and > 7 km, with maximum at ≈ 22 km

4. Behaviour consistent with previous observations



Correlations



- Positive correlation ions – particles
- Correlation particles - positive ions >: both particles and positive ions higher at ground level (lower troposphere)
- At altitudes > 9 km (upper troposphere – lower stratosphere) correlation particles – negative ions
- Correlation particles - relative humidity > temperature
- Role of ions further confirmed applying a multilinear regression model

Conclusions

A5-Unibo experiment was **successful**: vertical profiles were correctly measured and every component worked properly

Positive **correlation** ions – particles

Relative humidity more correlated than temperature (potential effect radiation/nucleation)

New software analysis

A5Unibo educational activities

Aerospace Engineering Faculty Open Days (03/04/2014) Elementary School Activities (60 children) in Flight Mechanics Laboratory (14/04/14)

Presentation to the Advance Science Institute of the University of Bologna (Nov-2014)

Seminar: March2015, 26th – Science week. Liceo Scientifico Fulcieri Paolucci diCalboli. Seminar: "A clouds physics research: Forlì flies through the stratosphere"

Inspiring new generations

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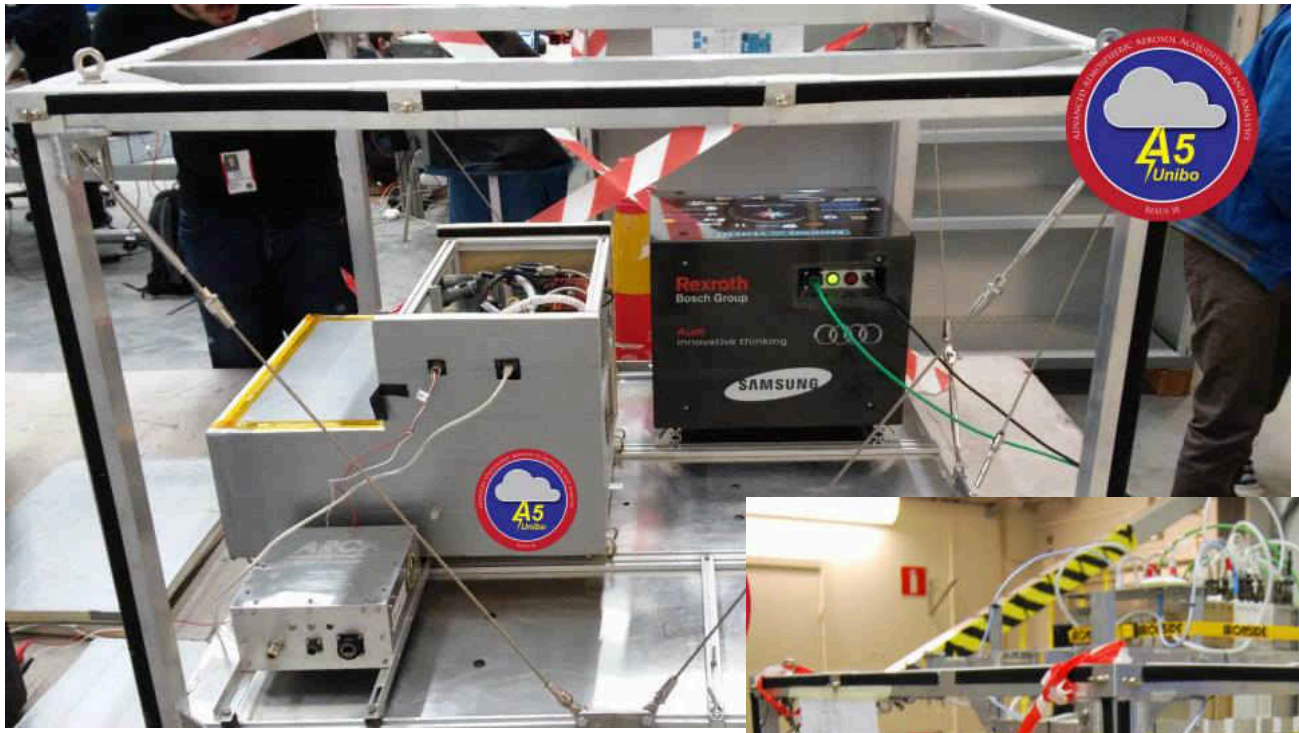
A5
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Rexroth
Bosch Group
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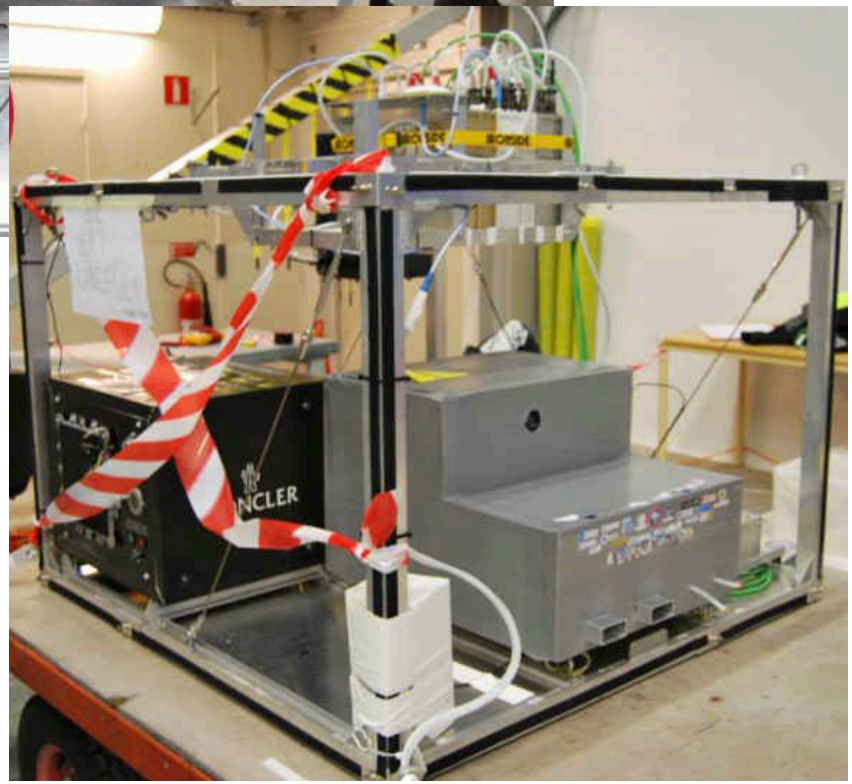

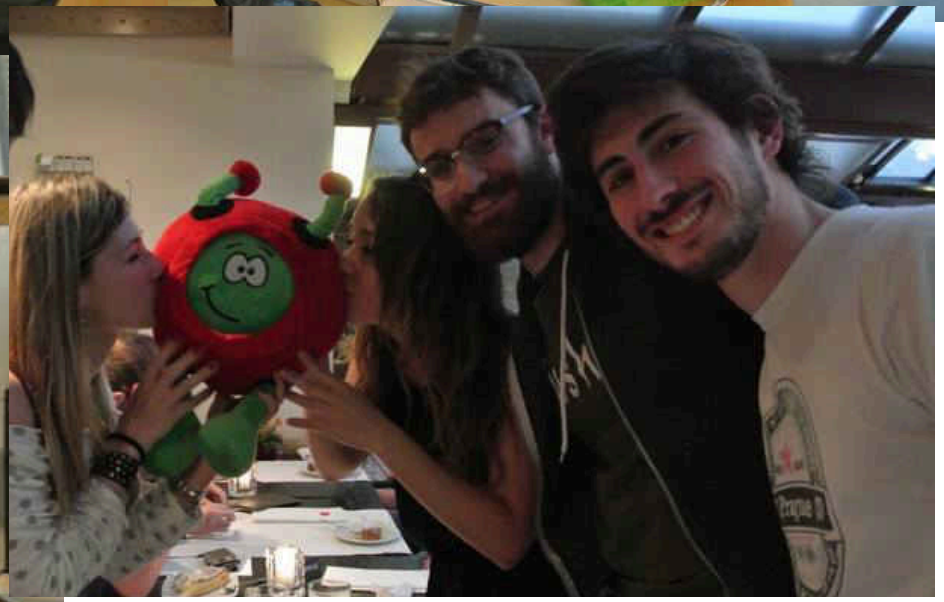

ACKNOWLEDGEMENTS

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THANK YOU QUESTIONS

A5-Unibo

Advanced Atmospheric Aerosol Acquisition and Analysis

Video

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A DLR and SSC cooperation

ZARM

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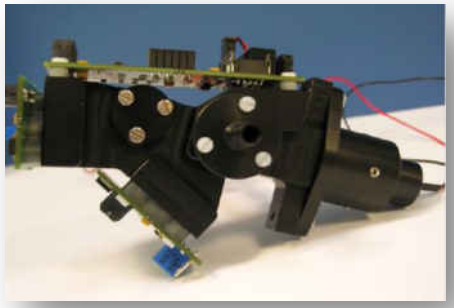
Experiment Components

Light Optical Particle Counter



LOAC	Meteomodem
Performance (FR1,PR1)	0.2 to 50 µm (19 channel bins) 0 to 2000 particles/ cm3 10 s Laser diode 25 mW @ 635 nm
Operating Range	-20° to 25° C
Power	7,2 VDC 450 mA ± 30 mA
Weight	250 g
Size	250 x 180 x 100 mm

Air Ion Counter

Air Ion counter	Alphalab
Performance (FR2,PR2)	2 million / 10 (ions per cc) Sampling time: 2s Accuracy:+/- 25%
Operating Range	-50 to +50 C
Power	Internal batteries (9V alkaline). 8 hours life at maximum drain
Weight	0.42 Kg
Size	165.1 x 93.98 x 76.2 mm

5. Experiment Components

BOXER Pump

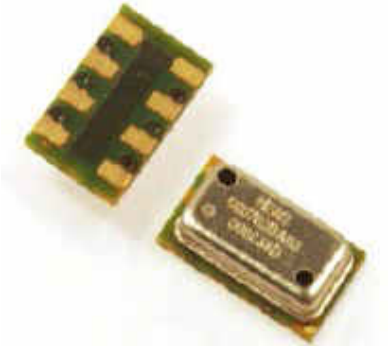
Pump BOXER 7502	Boxer Pumps
Performance	Flow rate up to 32 l/m
Operating Range	-50 to +50 C
Power	12 V DC Max current 3 A
Weight	1.1 Kg
Size	168*86*83 mm

Sioutas Sampler

Sioutas Sampler	
Sizes	Stage A: 2.5 µm Stage B: 1.0 µm Stage C: 0.50 µm Stage D: 0.25 µm
Operating Range	Any
Wind Velocity	< 5 mph
Weight	0.159 Kg
Size	8.6 x 5.5 cm

5. Experiment Components

Absolute pressure sensor



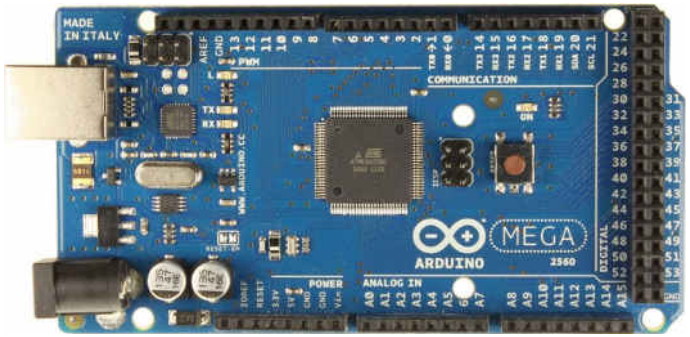
MS5607 Barometric pressure sensor	MEAS Switzerland
Operating pressure Operating temperature	10 to 1200 mbar -40 to +85 C
Pressure accuracy at 25°C, 700..1100 mbar at -20..85°C, 300..1100 mbar	 ± 0.5 mbar ± 2 mbar
Temperature accuracy at 25°C -20..85°C	 ± 0.8 C ± 2 C
Supply Voltage	1.8 to 3 V
Size	5x3x1 mm

Relative Humidity sensor

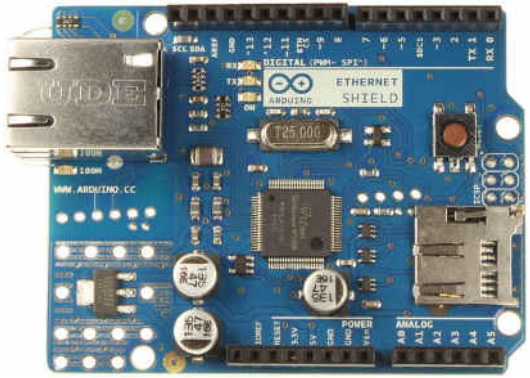
HIH9120-021	Honeywell
Operating RH **Operating temperature**	0 to 100% RH -40 to +125 C
RH accuracy (at 25°) **Temperature accuracy**	± 1.7 % RH ± 0.6
Supply Voltage	2.3 to 5.5 V (3.3 V nominal)
Supply current	0.6 mA (1mA max)

5. Experiment Components

Micro-controller Arduino MEGA 2560



Arduino Ethernet Shield



Operating Voltage	5V
Input Voltage	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (15 PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz