The BAQUNIN project
an overview

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**IDEAS+ WP**

2015 Pandora #115 + CIMEL at ESRIN  
2015 WRF Model at ESRIN  
2016 Laser+chiller for MWL at Sapienza University  
2016 Pandora #115 moved to CNR-ISAC, CIMEL moved to Sapienza University  
2017 Second Pandora #117 at Sapienza  
2018 Pyranometer + Sky-camera  
2018 Third Pandora #138 at CNR-IIA (still under refurbishment!)

**BAQUNIN Project**  
2019 (March) KO
The project activities are structured into two phases, **Phase-1** and **Phase-2**.

The time duration of the two phases is:
- **Phase-1**: from Mar-2019 to Feb-2020
- **Phase-2**: from Mar-2020 to Feb-2022

During **Phase-1**, only a subset of all potential activities will be activated, as this start-up period will be considered as a pilot and demonstrator.

The full activity realisation will be achieved during **Phase-2** of the project.
APL support instrumentation

1) HeNe Cw lasers
2) NdYag pulsed lasers (1064nm, 532 nm, 355 nm)
3) Jarrel Ash spectrometer (f=0.5 m)
4) Jobin Yvon U1000 double spectrometer (f=1 m)
5) Jobin Yvon LHT30 VUV spectrometer (f=0.3 m)
6) Optical tables
7) Spectral and Xenon lamps
8) Narrow- and large-band filters in the UV-Vis-NIR range
9) Set of mirrors, lenses, beam-splitters and dichroics
10) Optomechanics
11) Light sensors
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Owner</th>
<th>Site</th>
<th>Operation Conditions</th>
<th>Range (m.a.s.l.)</th>
<th>Dz (m)</th>
<th>Spectral Range / wavelengths</th>
<th>Observables</th>
<th>Since</th>
</tr>
</thead>
<tbody>
<tr>
<td>SODAR</td>
<td>APL</td>
<td>APL</td>
<td>Day/Night</td>
<td>100 – 900</td>
<td>15</td>
<td>4450.75, 4650.75, 4840.75 Hz</td>
<td>PBL winds and turbulence</td>
<td>1990</td>
</tr>
<tr>
<td>Brewer MKIV</td>
<td>APL</td>
<td>APL</td>
<td>Day</td>
<td>Column</td>
<td>N/A</td>
<td>286.5 – 363 nm</td>
<td>Radiance, trace gases</td>
<td>1992</td>
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<tr>
<td>MFRSR</td>
<td>APL</td>
<td>APL</td>
<td>Day</td>
<td>Column</td>
<td>N/A</td>
<td>940, 870, 673, 615, 500, 415 nm</td>
<td>Radiance, aerosols, trace gases</td>
<td>2004</td>
</tr>
<tr>
<td>POM</td>
<td>CNR-ISAC</td>
<td>APL CNR-IIA</td>
<td>Day</td>
<td>Column</td>
<td>N/A</td>
<td>1600, 940, 870, 670, 500, 440, 380, 340 nm</td>
<td>Radiance, aerosols, water vapour</td>
<td>2010</td>
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<tr>
<td>Meteo station</td>
<td>Climate Consulting</td>
<td>APL CNR-IIA</td>
<td>Day/Night</td>
<td>In situ</td>
<td>N/A</td>
<td>n/a</td>
<td>Air temperature and humidity</td>
<td>2014</td>
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<tr>
<td>LIDAR</td>
<td>APL ESA</td>
<td>APL</td>
<td>Day/Night</td>
<td>300 – 20000</td>
<td>7.5</td>
<td>Elastic: 1064, 532, 355 nm, Polarised: 532 nm</td>
<td>Aerosols, water vapour, clouds</td>
<td>2015</td>
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<tr>
<td>WRF</td>
<td>Sard. Clim. ESRIN</td>
<td>Day/Night</td>
<td>0-20000</td>
<td>39 levels</td>
<td>N/A</td>
<td>n/a</td>
<td>Meteorological variables</td>
<td>2015</td>
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<tr>
<td>Pandora-2S</td>
<td>ESA APL CNR-ISAC CNR-IIA</td>
<td>Day/Night (Moon)</td>
<td>Column</td>
<td>N/A</td>
<td>290-520 and 400-900 nm</td>
<td>Radiance, trace gases, aerosols</td>
<td>2016</td>
<td></td>
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<td>Sun-photometer</td>
<td>Univ. Lille APL</td>
<td>Day</td>
<td>Column</td>
<td>N/A</td>
<td>1640, 1020, 870, 675, 500, 440, 388, 340 nm</td>
<td>Aerosols, water vapour</td>
<td>2016</td>
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<tr>
<td>All Sky Camera</td>
<td>ESA APL</td>
<td>Day/Night</td>
<td>N/A</td>
<td>N/A</td>
<td>RGB</td>
<td>n/a</td>
<td>Clouds</td>
<td>2018</td>
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<td>Pyranometer</td>
<td>ESA APL</td>
<td>Day</td>
<td>Column</td>
<td>N/A</td>
<td>285 – 3000 nm</td>
<td>Radiance, clouds</td>
<td>2018</td>
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<td>ceilometer</td>
<td>APL APL</td>
<td>Day/Night</td>
<td>100 – 6000</td>
<td>N/A</td>
<td>Elastic: 904 nm</td>
<td>Clouds, aerosols</td>
<td>2019</td>
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<td>Disdrometer</td>
<td>APL APL</td>
<td>Day/Night</td>
<td>In situ</td>
<td>N/A</td>
<td>N/A</td>
<td>n/a</td>
<td>Rain</td>
<td>2019</td>
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<td>FTIR EM-27</td>
<td>CNR-ISAC APL</td>
<td>Day/Night</td>
<td>Slant Column</td>
<td>N/A</td>
<td>700 – 2200 cm¹ (4.5 – 14 mm)</td>
<td>PBL GHG</td>
<td>2019</td>
<td></td>
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</tbody>
</table>
Example of **synergistic use** of different remote sensing instruments/products:

**Pandora + SODAR**

Pandora operated in MaxDOAS mode

SODAR provides wind profiles

\[ \text{SC} = \text{Pandora NO2 Surface Concentration (µg m}^{-3}\text{)} \]

\[ \text{TC} = \text{Pandora NO2 Tropospheric Column (Dobson)} \]

\[ \text{U} = \text{SODAR Inertial Sublayer wind speed (m s}^{-1}\text{)} \]

\[ \text{TC} \propto U^{-2/3} \]

\[ \text{SC} \propto U^{-1/2} \]

No significant dependency on wind direction
Urban Boundary Layer (UBL)
Mixed Layer (ML)
Inertial Sublayer (IS)
Surface Layer (SL)
Roughness Sublayer (RS)
Urban Canopy Layer (UCL)

The Pandora TC does not include the SL contribution
The Pandora SC refers to the Roughness sublayer
NO2 production layer (UCL) is not probed

In low wind conditions, the NO2 produced in the UCL is lifted by turbulent updrafts and becomes detectable by Pandora.

In moderate to strong wind conditions (> 4 m/s) the NO2 bottom-up fluxes are suppressed and only a fraction of the NO2 profile is detectable.
Significant impact on interpretation of TROPOMI NO2 validation

What is Pandora retrieving?
What is TROPOMI retrieving?
Creative approach to atmospheric monitoring
Seagull Borne Atmospheric Monitoring

Set-up of instrumentation
Installation on the platform
Take off count down
Take off successful! (almost)
A first test, a GPS was mounted on the platform, in order to follow its trajectory with sufficient accuracy. The next phase of the experiment (if the platform survives and comes back in a reasonable time) we will install P, T, CO2 and CO sensors on the platform in order to explore the Urban PBL in a 3D fashion!

The only applicable restriction is on the weight of the payload, which must not exceed 3% of the mass of the platform.

That is, Pterodactyls (250 kg) could fly 7.5 kg of instruments.

The project is run in collaboration with Lega Italiana Protezione Uccelli (LIPU)
Same as the Royal Society for the Protection of Birds (RSPB)

This means that

Seagulls are not physically offended (not sure about their pride)

We did not show how the platform has been convinced to collaborate

We cannot control the Seagull brain yet (research ongoing)
SBAM
BAQUNIN Platform position from 3 to 9 May
(ANSA) - Rome, December 11 2018 - A large fire broke overnight at a waste facility managed by Rome municipal trash company AMA. The fire at the 2,000-square-metre rubbish centre produced thick smoke on via Salaria, in the north of the historic capital, and the smell of smoke reached the centre. The city council has advised people in the area to keep their windows closed and refrain from outdoor activities.

The local authority said Lazio's ARPA environmental agency had not registered air-pollution levels outside the permitted parameters.
532 nm

1064 nm

wvl (nm)

340
400
500
675
870
1020
Tropospheric NO2 doubled during the event!

Data analysis in progress
Pandora Formaldehyde
FTIR (horizontal measurements)
Sky-Camera images
WRF trajectories
What’s still missing?

Essential for GHG validation (e.g. EDAP => GOSAT, TANSAT)
Cost: 90 kUSD (*0.89= 80 kEuro)

Essential for Tropospheric Species and aerosol validation (e.g. S5p, S4, S5, 3MI, IASI)
Cost: 130 kEuro
Conclusions
• Good example of IDEAS+ WP evolution into an ESA project
• Operate instruments, collect, harmonise and distribute data
• Support/perform validation of atmospheric composition satellite missions
• Synergistic use of active/passive atmospheric probes
• Lot of instruments => lot of data => lot of work

Outlook
• Phase 1 just started: web site to be launched before summer (data, docs)
• Participation in scientific campaigns: not limited to Tiber Valley (e.g. Etna)
• Attract other scientific institutions operating in Rome area (e.g. ENEA, INGV)
• Extend the instrumental suite => T&Q profiles, GHG columns