Report on the

ESO Python Boot Camp — Pilot Version

held at ESO Vitacura, Santiago, Chile 13–14 October 2016

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The Python programming language is becoming very popular within the astronomical community. Python is a high-level language with multiple applications including database management, handling FITS images and tables, statistical analysis, and more advanced topics. Python is a very powerful tool both for astronomical publications and for observatory operations. Since the best way to learn a new programming language is through practice, we therefore organised a two-day hands-on workshop to share expertise among ESO colleagues. We report here the outcome and feedback from this pilot event.

The first step in launching Python at Vitacura was to hold a weekly informal coffee break centred on Python-related topics, called the ESO PyCoffee[1], which began in September 2015. Participants, from beginners to experts, shared their experience of using Python and demonstrated different applications of the language on a large diversity of astronomical problems. After a year with only presentations and discussions, we recognised a need for, and an interest in, more hands-on activities. We therefore started with the pilot version of the ESO Python Boot Camp, which took place on 13 and 14 October 2016. It was meant to be an internal event where the knowledge of more expert Python users could be shared. The main goal was to provide a basic training in Python for astronomers, telescope operators and engineers, to help them in their day-to-day tasks at the Observatory and in their own research. To achieve this goal, we placed particular emphasis on practical examples, so that trainees could leave the Boot Camp with a few scripts installed and running on their own computers.

The boot camp concept

We were not the first to organise a Python event focused on astronomy.

Figure 1. (Above) Participants attended the morning classes with their own laptops running Python and all packages required by the Boot Camp.

Figure 2. (Below) Participants and trainers working together on the proposed projects, and interacting among different groups to share good ideas.

To mention just a few cases, Berkeley[2] (the original), the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (NASA GSFC[3]) and the Institute of Astronomy, Geophysics and Atmospheric Sciences of the University of São Paulo (IAG-USP[4]), have all organised successful events similar to ours. The Python Boot Camp lasted two days, with classes during the mornings and projects in groups during the afternoons (see Figures 1 and 2). Two of the morning classes introduced the specific aspects of Python with respect to other languages, presented by the Paranal software engineer Claudio Reinero. The other classes were astronomy oriented

and introduced tools useful in processing astronomical data. In some cases the trainers proposed exercises in real time using scripts or *Jupyter Notebooks*. These tools and the knowledge and good practice learned in the morning classes were later used to work on specific observatory projects during the afternoon sessions. Outlines of these projects are presented in the next section.

The participants were from many ESO departments: students, fellows, staff astronomers, telescope operators from Science Operations, data analysts from ALMA, and Paranal/La Silla engineers from various teams. Their background in
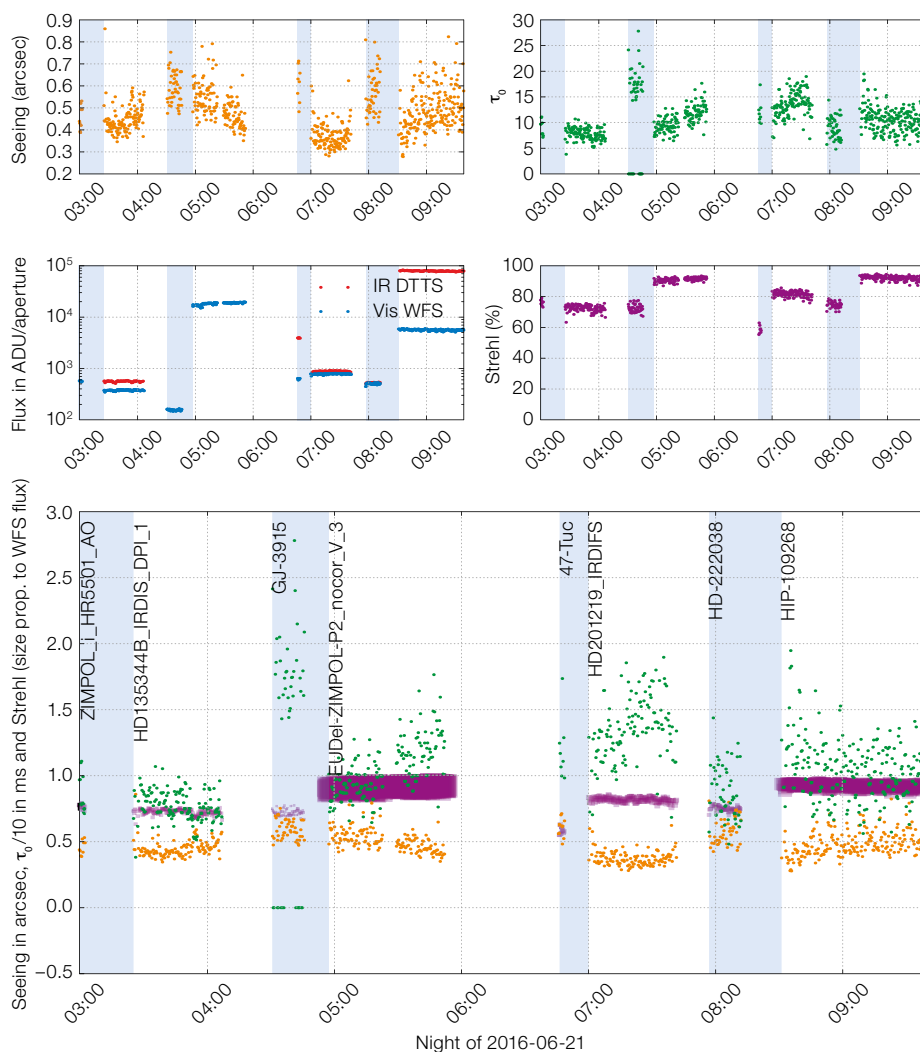
Seeing (arcsec)

τ_0

Flux in ADU/aperture

IR DTTS
Vis WFS

Strehl (%)

Seeing in arcsec, τ_0/10 in ms and Strehl (size prop. to WFS flux)

ZIMPOL_i_HR5501_AO
HD135534B_IRDIS_DPI_1
GJ-3915
EUDel-ZIMPOL-P2_nocor_V_3
47-Tuc
HD201219_IRDIFS
HD-222038
HIP-109268

Night of 2016-06-21

Figure 3. Evolution of weather conditions (seeing, coherence time [τ_0], flux and Strehl ratio), plotted in separate panels above, and combined in the large lower panel, as performed in Project 4.

Project 3 — Extracting data from the telescope log

Leader: Daniel Asmus (Fellow)

Similarly to Project 2, the participants used the telescope log files to monitor specific parameters of the SPectro-polarimetric High-contrast Exoplanet REsearch instrument (SPHERE), the Fibre Large Array Multi-Element Spectrograph (FLAMES), and the VIsible Multi-Object Spectrograph (VIMOS) in order to check the performance of the instruments at startup or the efficiency of acquisition templates. They learned how to read a large-volume text file, extract information, plot and use shell commands in Python.

Project 4 — Plotting the evolution of the Strehl ratio and atmospheric parameters using SPHERE adaptive optics data

Leader: Julien Milli (AO System Scientist)

In this group, the participants were invited to analyse the adaptive optics (AO) parameters from a SPHERE observation. They had to read the parameters from a FITS table, save them in a text file, and make quality plots (Figure 3). Advanced participants could also correlate the performance with atmospheric parameters by characterising the trends between Strehl ratio, star magnitude and coherence time. The conclusion of this project was that the Strehl ratio is sensitive to a combination of seeing and coherence time.

Project 5 — Centre the reference stars on FLAMES

Leader: Jorge Lillo-Box (Fellow)

During acquisition, three or four reference stars must be centred onto a bundle of fibres to guarantee good centring of the science targets. This advanced project aimed at automating this procedure. The participants learned how to make polar

Python ranged from complete beginners to experts. The diversity of backgrounds proved very fruitful during the interactions on the projects. The challenge, on the other hand, was to hold the attention of the more expert users without leaving the beginners behind.

Group projects

Project 1 — Focus curve of UVES

Leader: Nicolas Haddad (Paranal Instrumentation)

The participants had to analyse the differences in focus between the two chips of the Ultraviolet and Visual Echelle Spectrograph (UVES) detector and the focus evolution with time. In this project,

skills such as manipulating a FITS (Flexible Image Transport System) image and header, extracting a spectrum from a 2D image, and measuring its full width at half maximum (FWHM) were developed.

Project 2 — Tracking the Strehl ratio of SINFONI during an Observing Block

Leader: Frédéric Vogt (Fellow)

This group had to analyse the evolution of the Strehl ratio during a given Observing Block (OB) for the Spectrograph for INtegral Field Observations in the Near Infrared (SINFONI). They extracted specific information from a complex text file containing the log, manipulated strings and time variables, and learned how to make quality plots.

plots, retrieve coordinates by clicking on the plot and apply Bayesian analysis to find the centre of each star; they finally calculated the offset and rotation that should be applied for good centring.

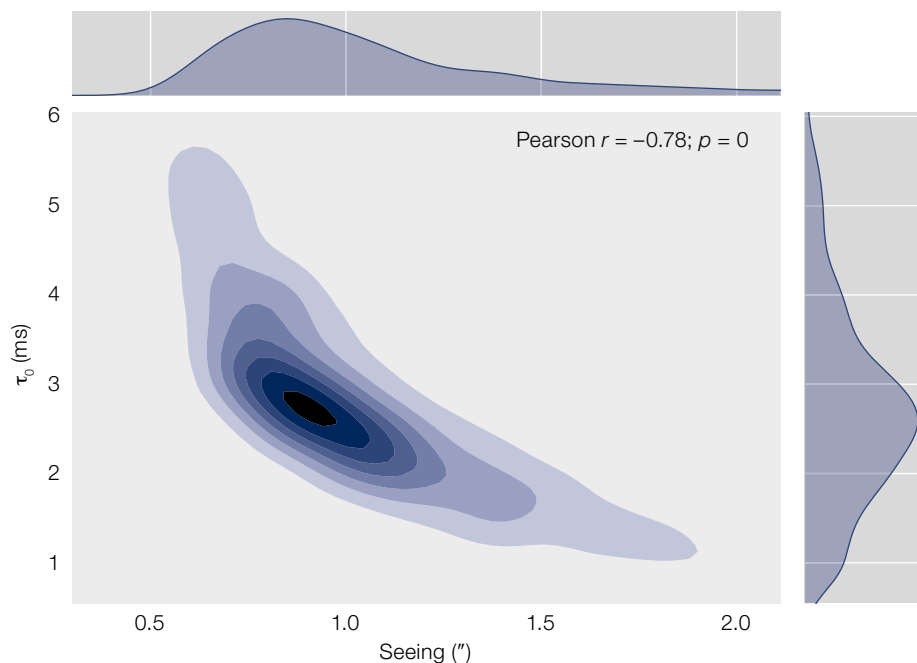### Project 6 — Reading and inspecting data using *pandas*

Leader: Ignacio Toledo (ALMA Data Analyst)

Weather conditions from Paranal are available on the ESO webpage[5] and anyone can analyse their evolution and correlations. In this project the participants were invited to explore a very large text file with observing conditions of the last 16 years in Paranal using the Python module *pandas*[6] to retrieve and manage information, and the module *seaborn*[7] for graphic inspection of trends. Figure 4 shows that, for good seeing conditions (< 0.8 arcseconds), there is a range of possible coherence time values, all suitable for AO corrections on SPHERE and NACO for example, in agreement with Figure 3.

Feedback and next workshops

After the workshop we sent a feedback form to the participants to gather their reactions to this pilot Boot Camp. On a scale of 1 to 5 where 1 is maximum, 50 % of the answers gave an overall grade 1 for the event and its length at two full days. The quality of morning classes received grades 2 and 3 in 70 % of the answers. The quality of the afternoon projects received grades 1 and 2 in 75 % of the answers. These results confirm our expectations that hands-on activities are the best way to go. Based on the comments and grades we have decided to continue with this style of training project, and we now know where to improve.

The big challenge of this event was mixing participants with different backgrounds and with different levels of Python knowledge. We proposed that the participants should study the basics of Python using the CodeCademy[8] platform and arrive at the Python Boot Camp with at least the same basic level. From this starting point, all participants learned

Figure 4. Relation between coherence time (τ_0) and Differential Image Motion Monitor (DIMM) seeing during January 2016 at Paranal as analysed in Project 6.

something new and useful. More advanced participants contributed different points of view on how to solve a given task, which highlighted the flexibility of Python.

Most of the participants reached and acknowledged the main goal of this workshop, and can now progress autonomously by self-learning, using web sources and the PyCoffee material. All of them left the event with Python scripts working on their computers and knowing how to edit and tune them for their own scientific or operational activities. Among the poll answers some people felt that the next run(s) of the Boot Camp should focus on some specific subjects, rather than cover a range of topics.

Finally, 100 % of the respondees agreed that we should continue the event. They also said we should keep the mix of people from different ESO and ALMA departments, as long as we remain a small event with around 30 participants and 10 trainers so as to be efficient during the hands-on activities and interactions. The majority of respondees agreed with maintaining the ESO Python Boot Camp as an internal training workshop for the moment. ESO and ALMA personnel change very often, and we depend on them as trainers. Therefore, we cannot offer an official training session on Python

for the external community. Nevertheless, this event proved to be very efficient in terms of sharing knowledge that is already present among our colleagues. We can recommend this type of initiative to other research institutes in astronomy. If you are struggling with a task, you might have an expert next door willing to share his/her knowledge!

Links

[1] ESO PyCoffee: www.sc.eso.org/~bdias/pycoffee/. Managed by Bruno Dias, Julien Milli, and Callum Bellhouse
[2] Berkeley Python Boot Camp: https://sites.google.com/site/pythonbootcamp/
[3] NASA GSFC Python Boot Camp: https://asd.gsfc.nasa.gov/conferences/pythonbootcamp/2016/
[4] IAG-USP Python Boot Camp: http://iagpyboot.wixsite.com/pbc2017
[5] Paranal Ambient Query Forms: http://archive.eso.org/cms/eso-data/ambient-conditions/paranal-ambient-query-forms.html
[6] Python Data Analysis Library *pandas*: http://pandas.pydata.org
[7] seaborn statistical data visualisation: http://seaborn.pydata.org
[8] CodeCademy: https://www.codecademy.com