HiSPARC: Introducing Python

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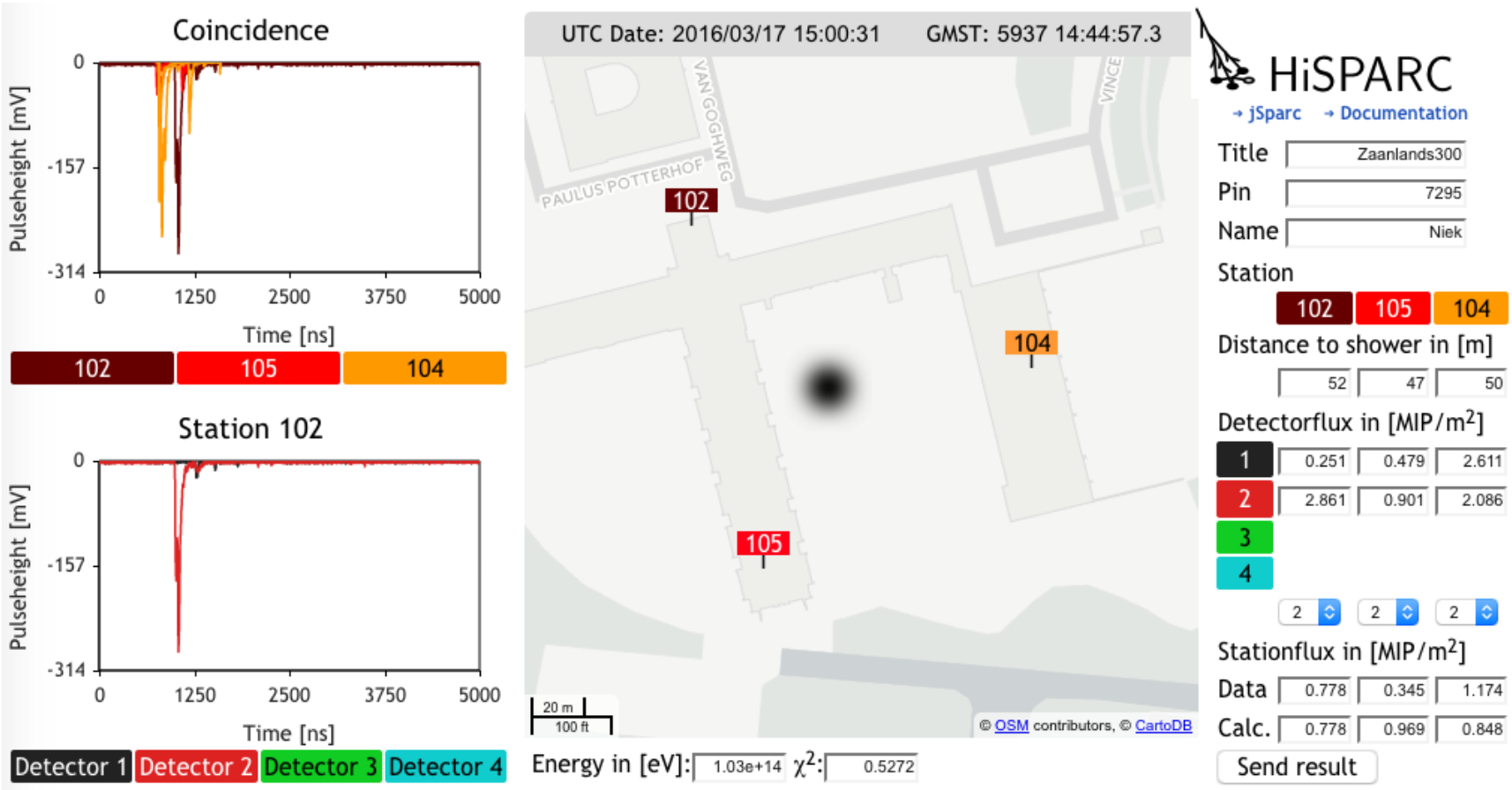
Outline

Targets

The reconstruction game can be used from an age of 12 to 14 years and:

- Shows capabilities of HiSPARC.
- Facilitates interactive reconstruction of energie.
- Presents detector data.

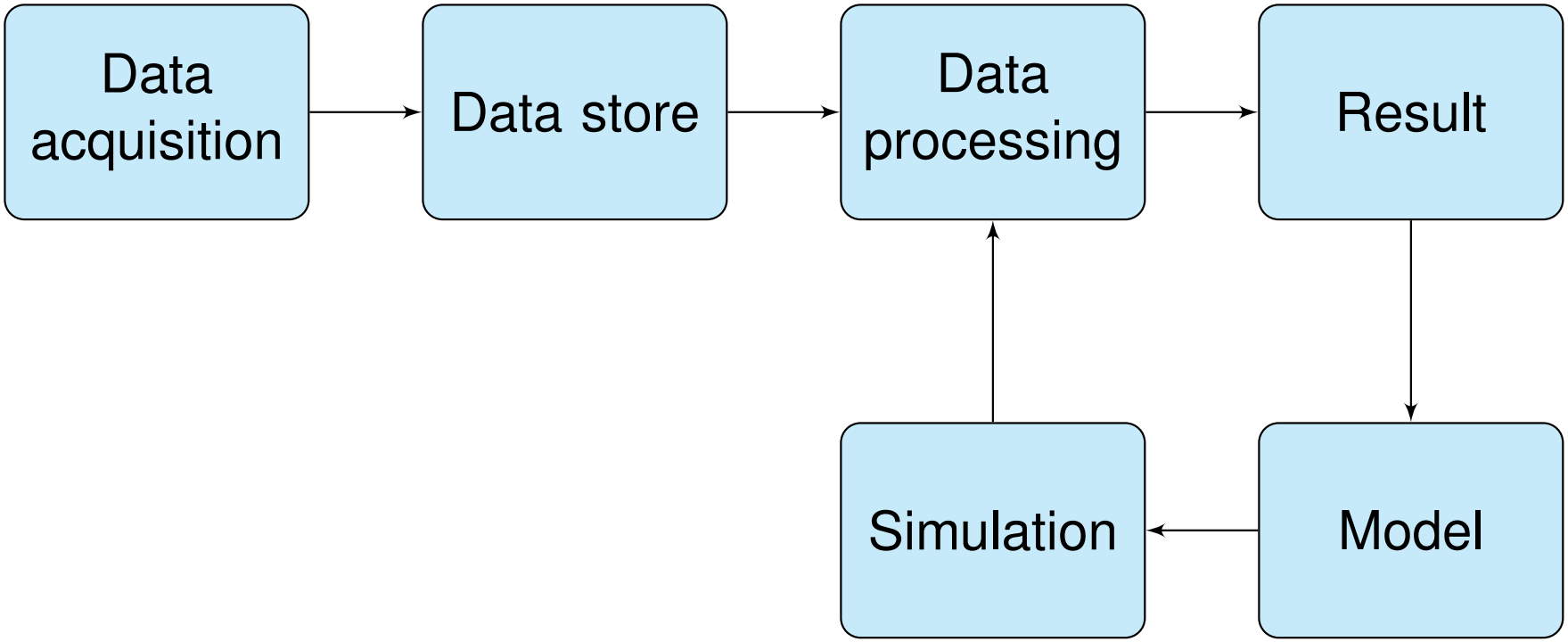
jSparc


Coincidence
Pulseheight [mV]
0
-157
-314
0
1250
2500
3750
5000
Time [ns]
102
105
104
Station 102
Pulseheight [mV]
0
-157
-314
0
1250
2500
3750
5000
Time [ns]
Detector 1
Detector 2
Detector 3
Detector 4
UTC Date: 2016/03/17 15:00:31
GMST: 5937 14:44:57.3
VAN GOGHWEG
PAULUS POTTERHOF
VINCE
102
104
105
20 m
100 ft
© OSM contributors, © CartoDB
Energy in [eV]: 1.03e+14
χ²: 0.5272
HiSPARC
→ jSparc
→ Documentation
Title Zaanlands300
Pin 7295
Name Niek
Station
102
105
104
Distance to shower in [m]
52
47
50
Detectorflux in [MIP/m²]
1 0.251 0.479 2.611
2 2.861 0.901 2.086
3
4
2
2
2
Stationflux in [MIP/m²]
Data 0.778 0.345 1.174
Calc. 0.778 0.969 0.848
Send result

Python

- Software is used both for Science and Outreach.
- The interpretation of HiSPARC cosmic ray data needs a lot of number crunching.
- This proces is automated using the Python programming language.
- The introduction of Python should be as easy as possible in the class room. This is realised with interactive Jupyter Notebooks.
- The flexibility of these notebooks enables pupils to discover self formulated solutions and interpretation methods.

Data Flow


Data acquisition
Data store
Data processing
Result
Simulation
Model

HiSPARC Library Packages

- Data processing uses SAPPHiRE (Simulation and Analysis Program Package for HiSPARC Research and Education).
- Packages like NumPy, SciPy and Healpy are used too.
- These packages can be imported in Jupyter Notebooks and thus be used for outreach.

Local Installation

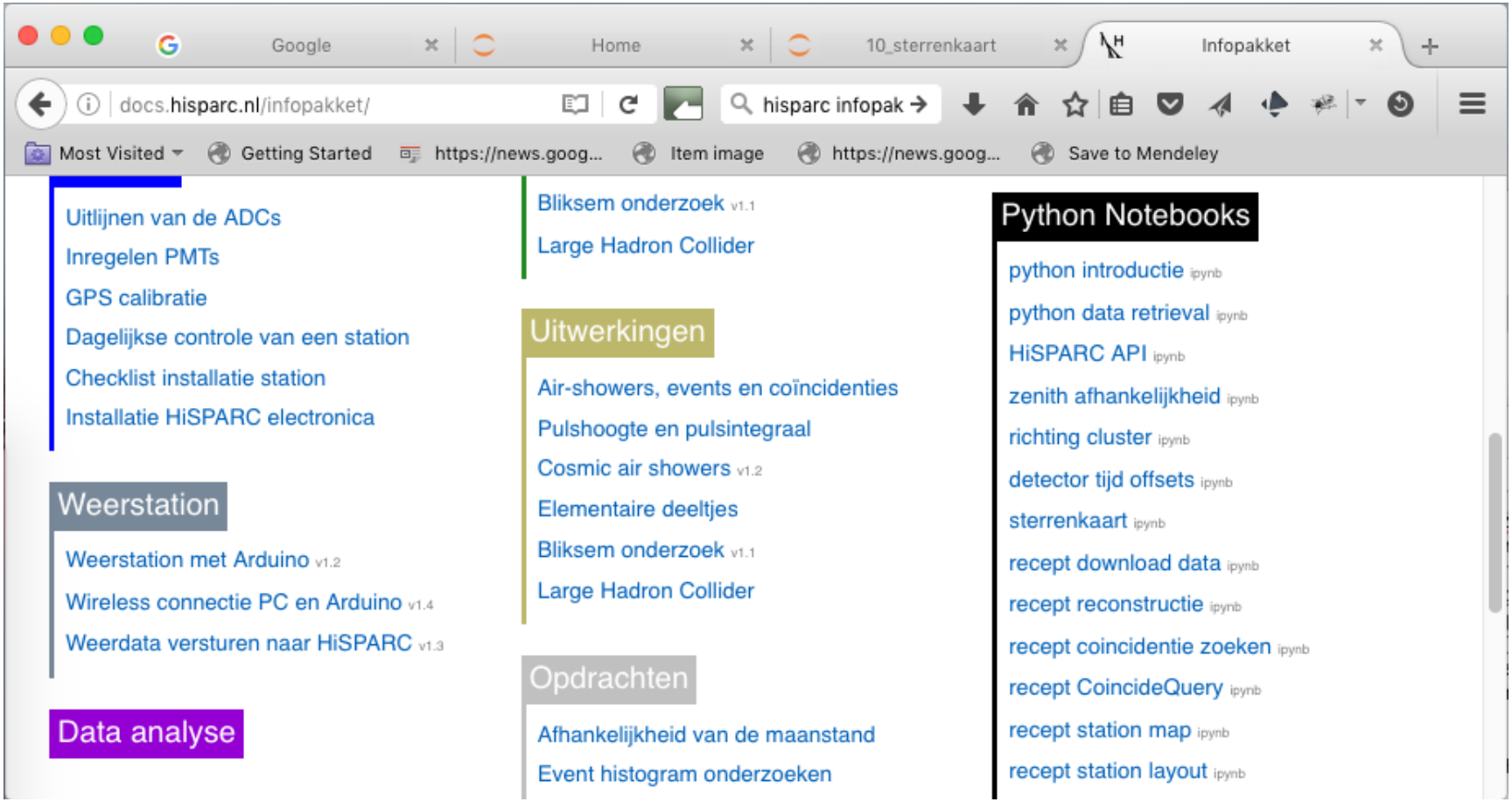
- Advantage: Jupyter is installed on your local machine using Anaconda. The Windows operating system does not support Healpy. Using Linux or OSX no problems have been encountered. Possibilities are huge.
- Disadvantage: A set of computers with Anaconda / Jupyter and HiSPARC modules is required.

Cloud Computing

HiSPARC started a cooperation with SURFsara for cloud computing.

- Advantage: Cloud computing is possible using a browser. Only a set of client-computers with a browser and an internet connection with the cloud server is needed.
- Disadvantage: However the server does not run under Windows, possibilities are limited. Only packages installed by SURFsara can be used. Installed notebooks can be edited.

Notebook Examples



Targets

From an age age of about 15 years.

- Show simple programming examples, pupils develop programming skills form scratch.
- Introduction of lists, dictionaries and arrays.
- Modelling using functions.
- Creating plots and histograms of data.
- Editing notebook templates.

Example

Python Introductie

Dit is een zeer incomplete python introductie, waarin een aantal belangrijke aspecten van de scripttaal `python` worden toegelicht, bedoeld voor lezers met redelijk wat ervaring in een taal als `Java` of `C\C++\C#`.

Het is zeker niet bedoeld als een complete introductie van `python` voor beginners.

Andere bronnen:

- Een zeer leesbaar boek over Python 2.7 is `Think Python` (gratis downloadbaar in PDF en HTML): http://greenteapress.com/wp/think-python/
- Een online interactieve basis introductie van Python: https://www.codecademy.com/learn/python
- **Aanrader**: Het UvA practicum "Programmeren voor Natuur- en Sterrenkunde" heeft zeer bruikbare (natuurkundige) opdrachten in Python: https://progns.mprog.nl/ (klik bovenaan op Archive)

Hello, World!

In `python 2.7` ziet deze klassieker er zo uit: (Druk Ctrl-Enter in de cel hieronder)

```
In [1]: print 'Hello, World!'
        Hello, World!
```

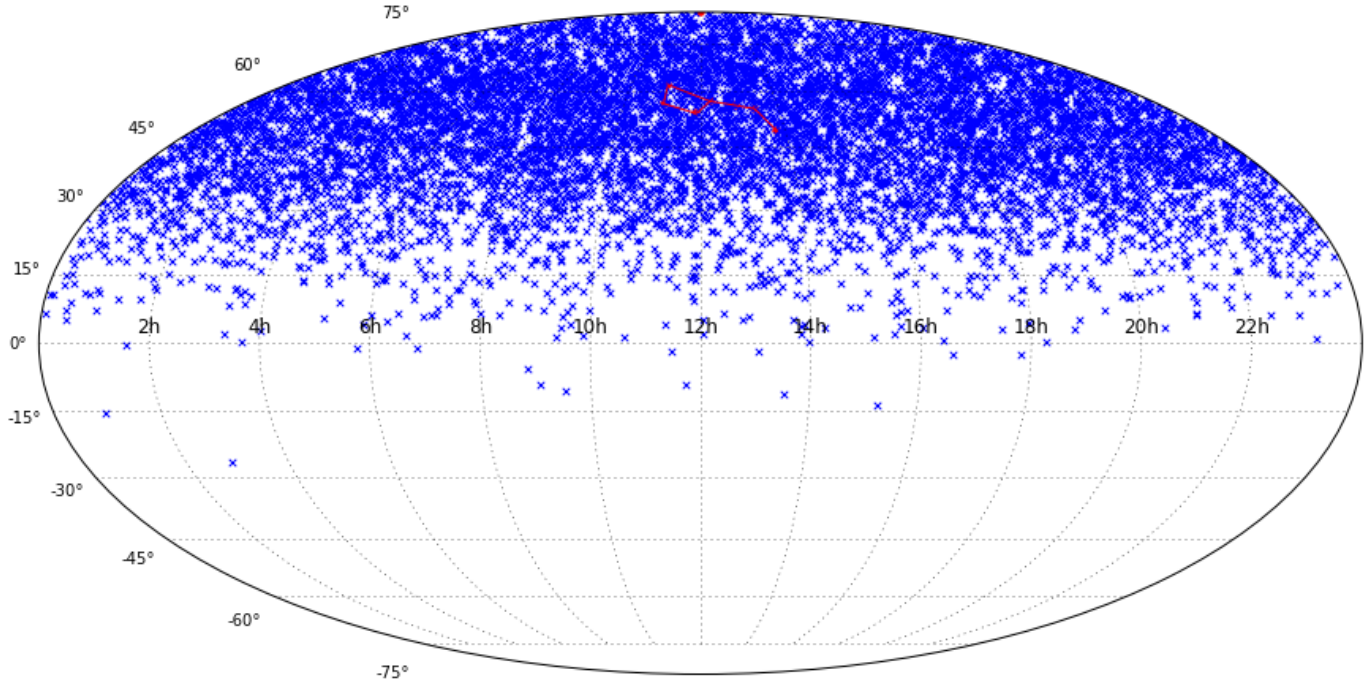
Targets

- Retrieving detection data.
- Retrieving detector data.
- Examples of reconstructions.
- Writing notebooks.

Example: Reconstruction of shower directions.

```
In [18]: plot_events_on_mollweide(events, filename='noordelijke hemel.png')
```

```
/usr/local/lib/python2.7/site-packages/matplotlib/projections/geo.py:489: RuntimeWarning: invalid value encountered
in arcsin
  theta = np.arcsin(y / np.sqrt(2))
/usr/local/lib/python2.7/site-packages/matplotlib/collections.py:571: FutureWarning: elementwise comparison failed;
returning scalar instead, but in the future will perform elementwise comparison
  if self._edgecolors == str('face'):
```



Targets

Pre university level.

- Creating *.py files from notebooks. Building specialised modules / classes.
- Writing test procedures.
- Publishing specialised modules via HiSPARC by mail.
- HiSPARC publishes specialised modules after approvement in a student repository.

Good practices

- Software packages tent to grow and evolve. Functions and classes therefore should be paired to test-functions and test-classes to ensure a stable performance.
- Updates should not be uploaded before a test has been performed.
- Notebooks developed by pupils are welcome at HiSPARC (inclusive tests). We perform the upload.

Experiments by teachers in research.

The unique geometry of HiSPARC facilitates unique experiments:

- Correlations of singles rate (1 detector), events (1 station / 2 or 4 detectors), local coincidences (1 (sub-)cluster, several stations) and long distance correlations (within the network) are possible, GZ!
- Air-shower development depends on atmospheric parameters: weather. Weather-data is availlable.
- Detection on the Earth depends on magnetic fields in the solar system: Massive Solar Flares.
- Ionisations due to air-showers triggers lightning discharges.

Summary and Outlook

- Notebooks are succesfully introduced at teachers workshops.
- HiSPARC data is interpreted using tested python modules.
- HiSPARC notebooks, based on these modules, are used for research within Nikhef and at schools from 2015.
- Software is available at HiSPARC Github.

Useful links

`http://docs.hisparc.nl/infopakket/pdf/notebook_installatie.pdf(dutch)`
`https://www.codecademy.com/learn/python`
`http://jupyter.org/install.html`
Python gives a comment if a command does not work. Python discriminates between lists, dicts and numpy-arrays. Operations work different on these datatypes! A numpy-array passed into a function returns a numpy-array. A list added to a list returns a longer list. Dicts can contain data that can be retrieved using dict['parameterName'] or dict['otherParameterName']