DEVELOPING AN OPEN SOURCE SOFTWARE:

THE PYACTIGRAPHY JOURNEY

OPEN SCIENCE DAY 2025

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Section of Chronobiology

THERE AND BACK AGAIN

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Christina Schmidt

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ACTIGRAPHY

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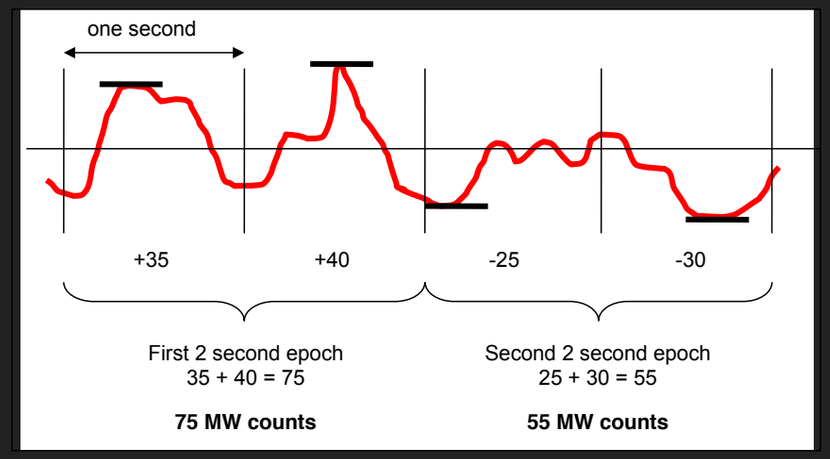

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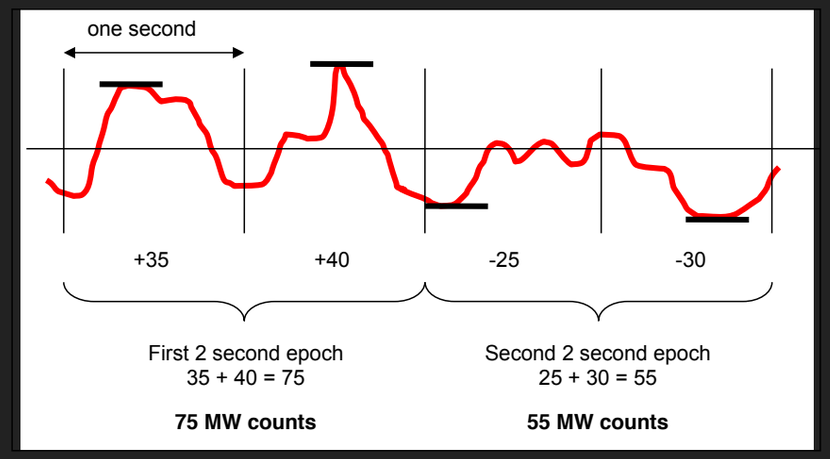

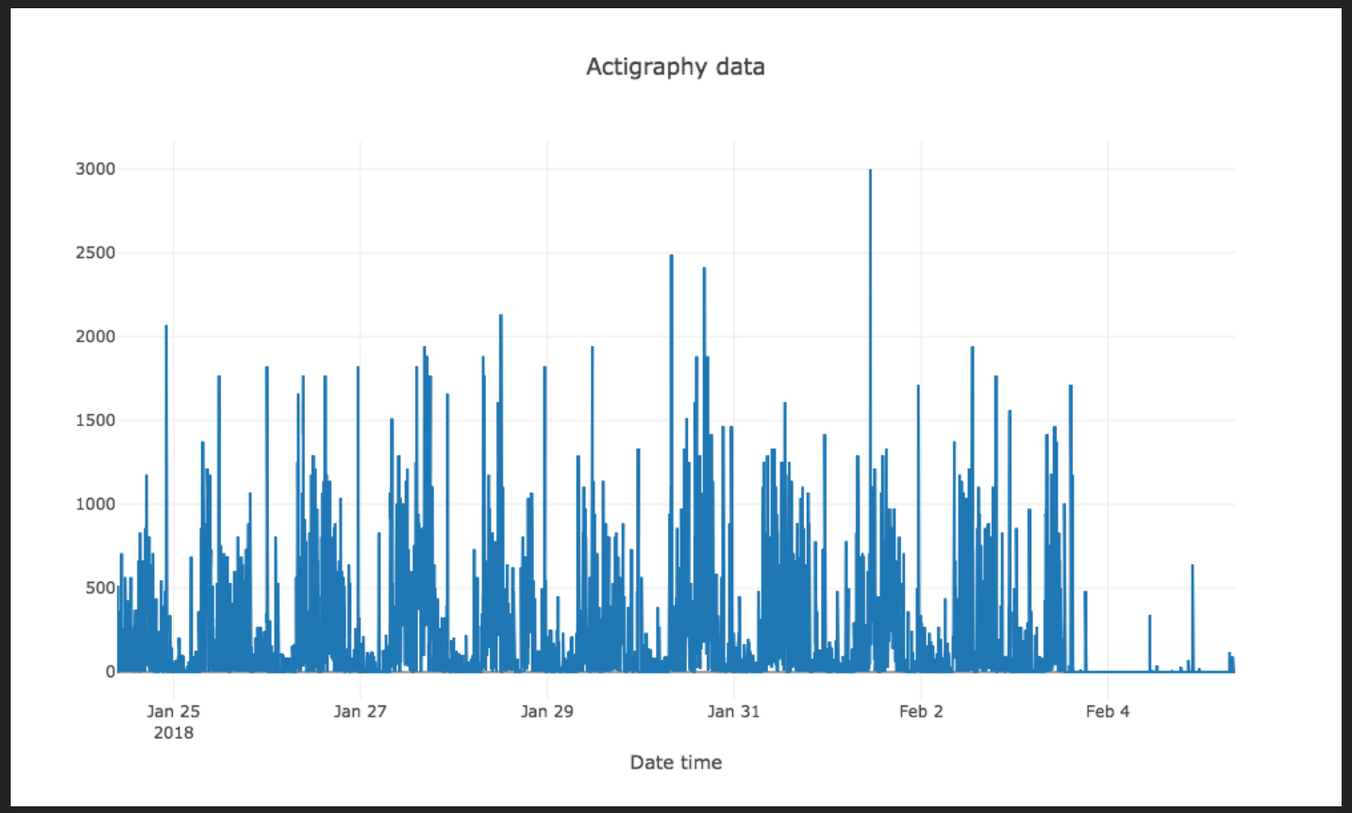

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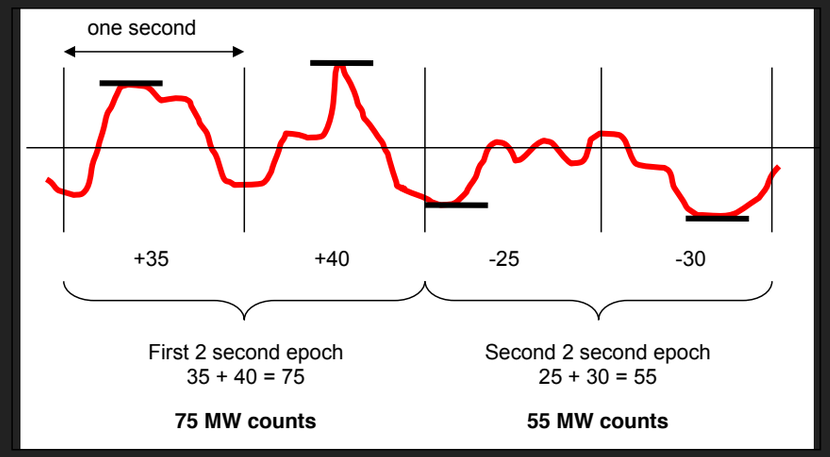

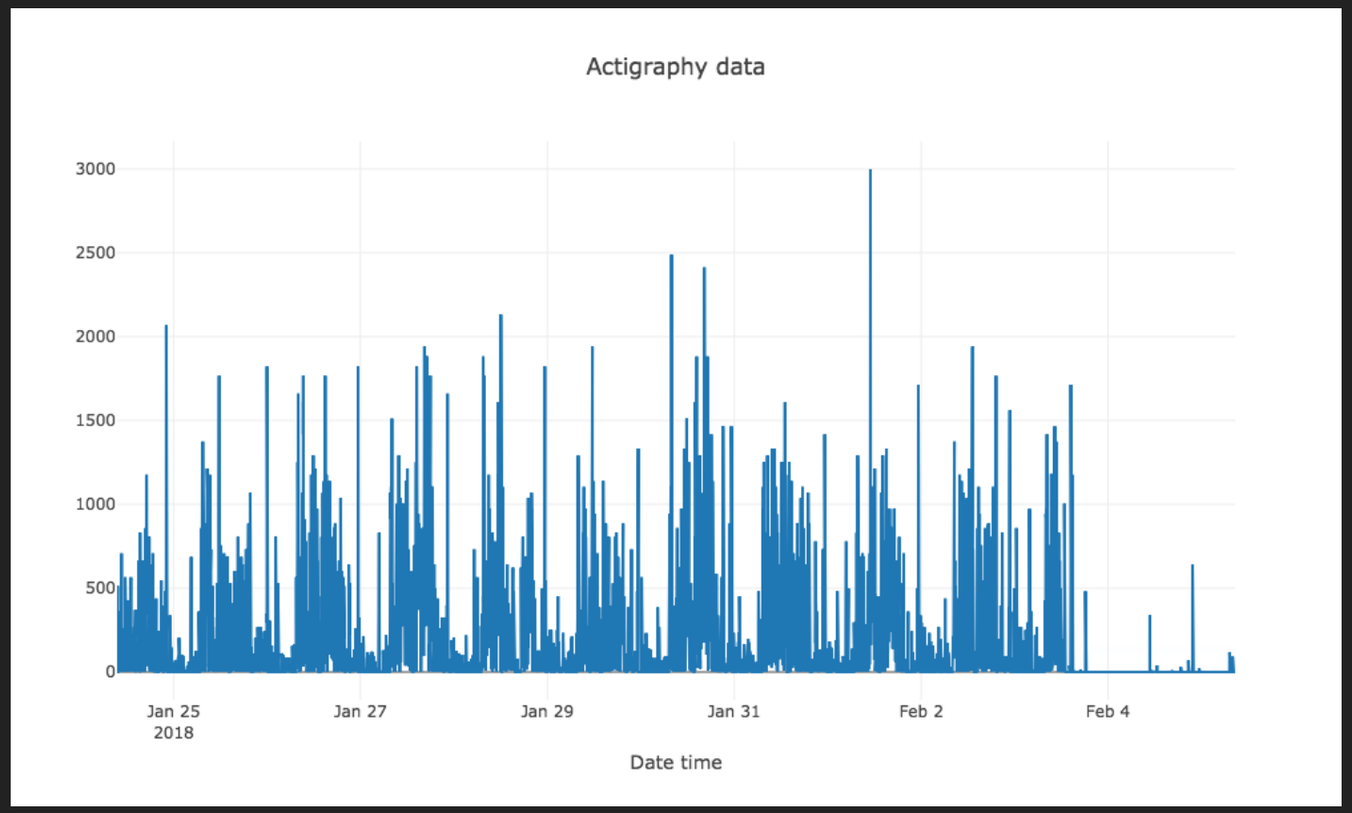

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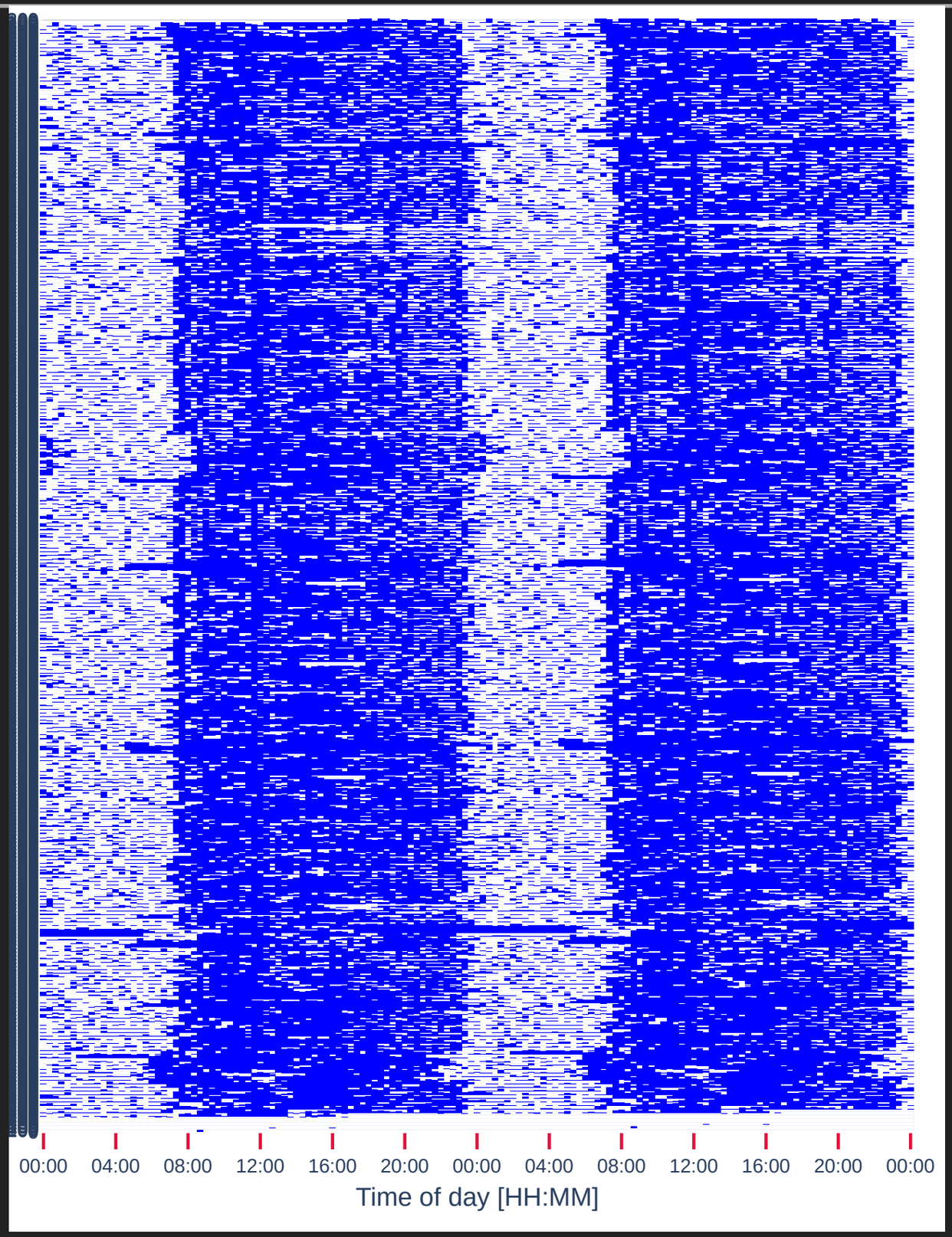

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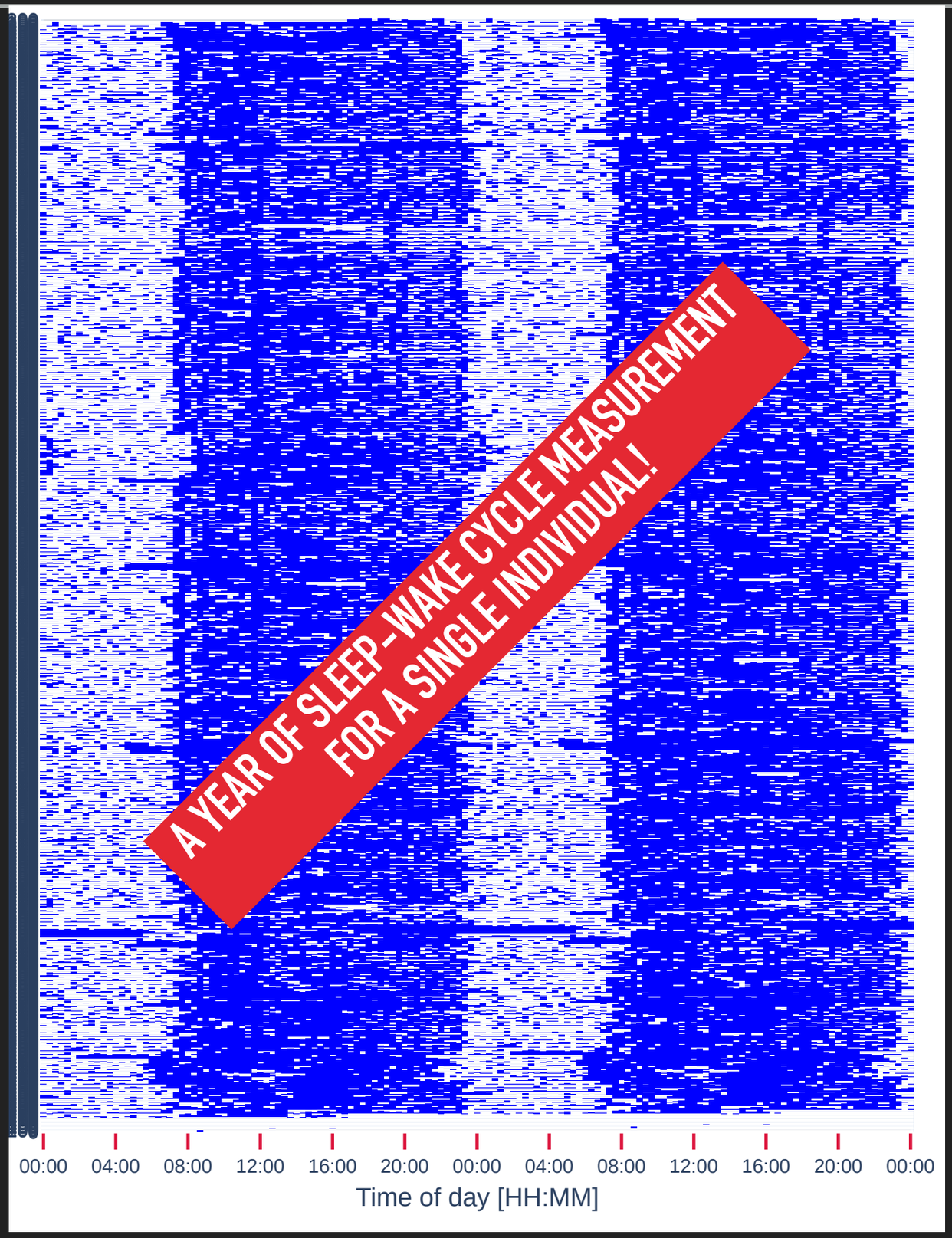

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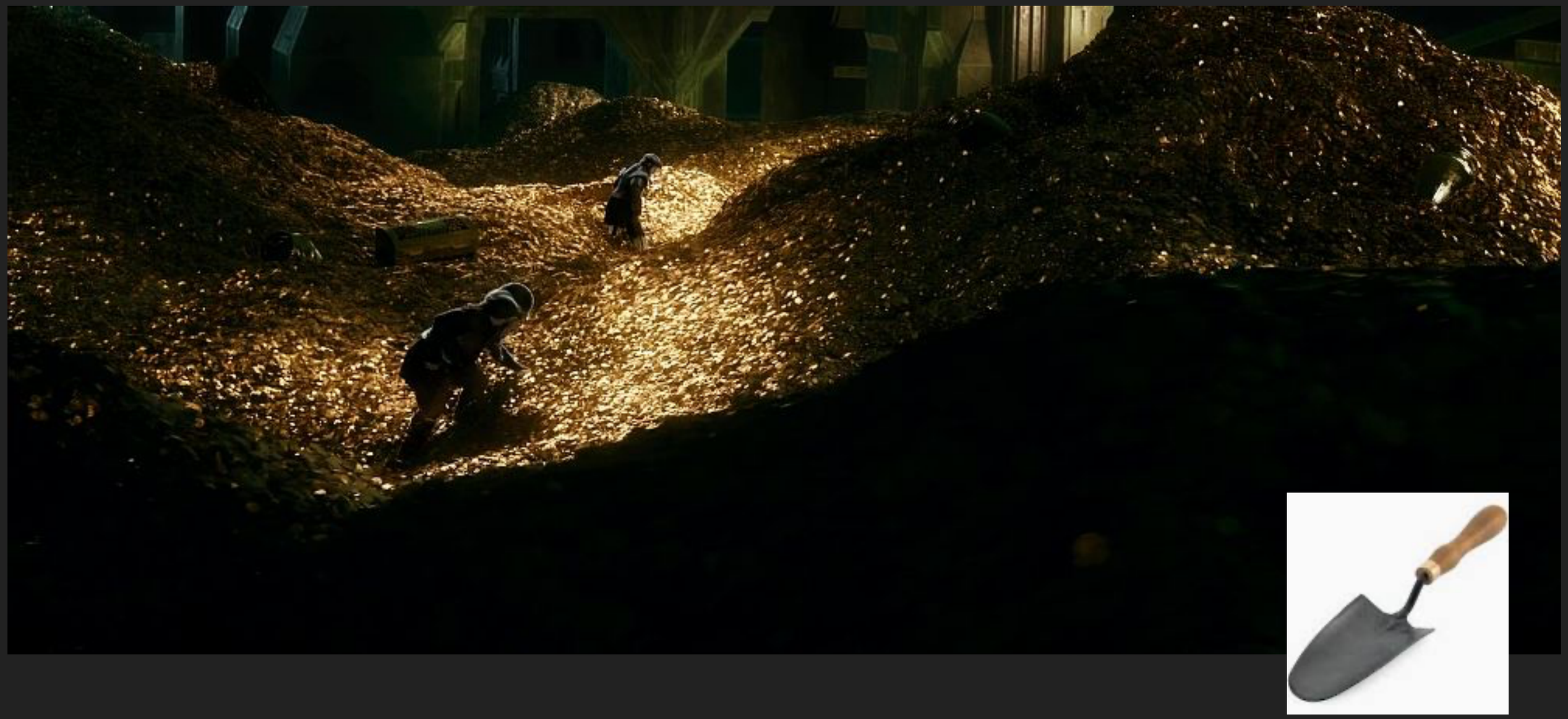

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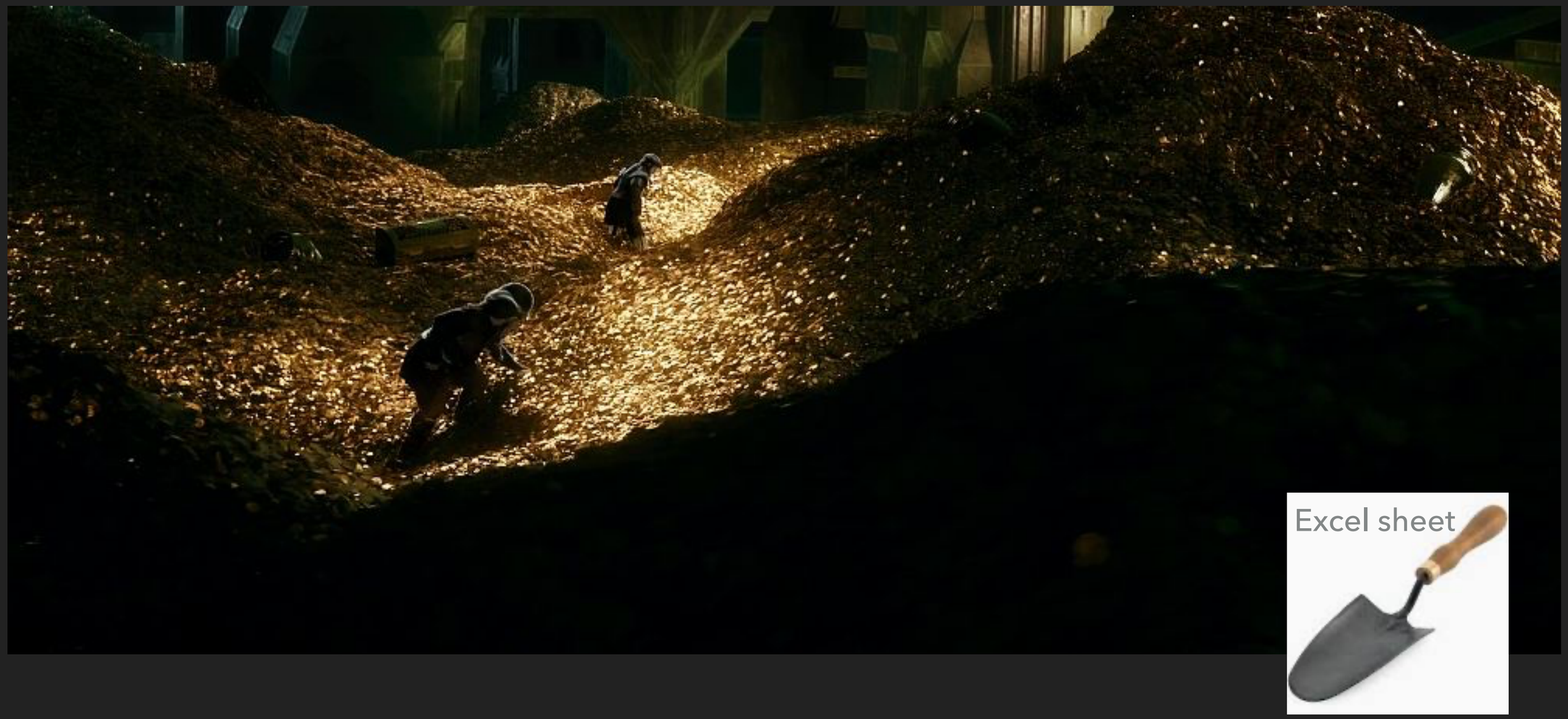

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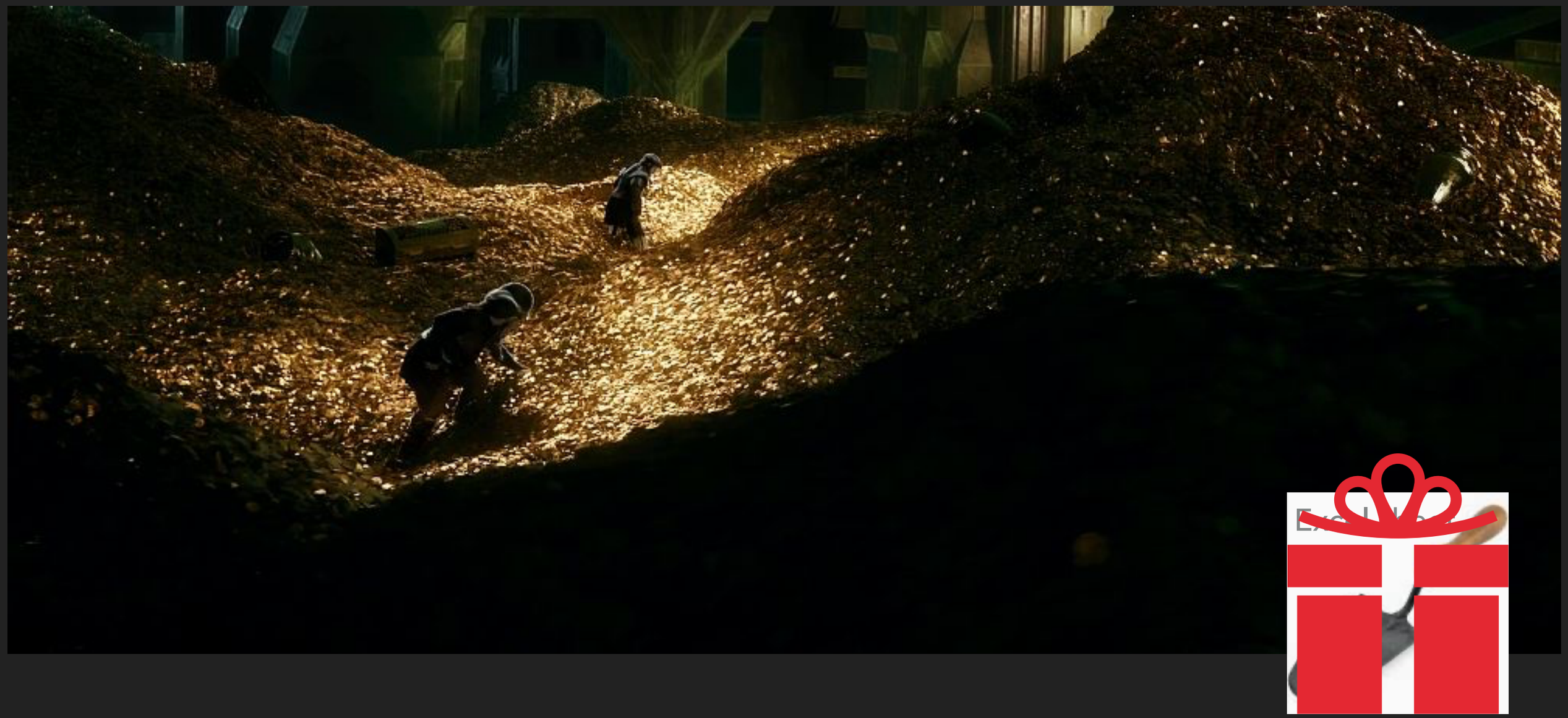

PYACTIGRAPHY

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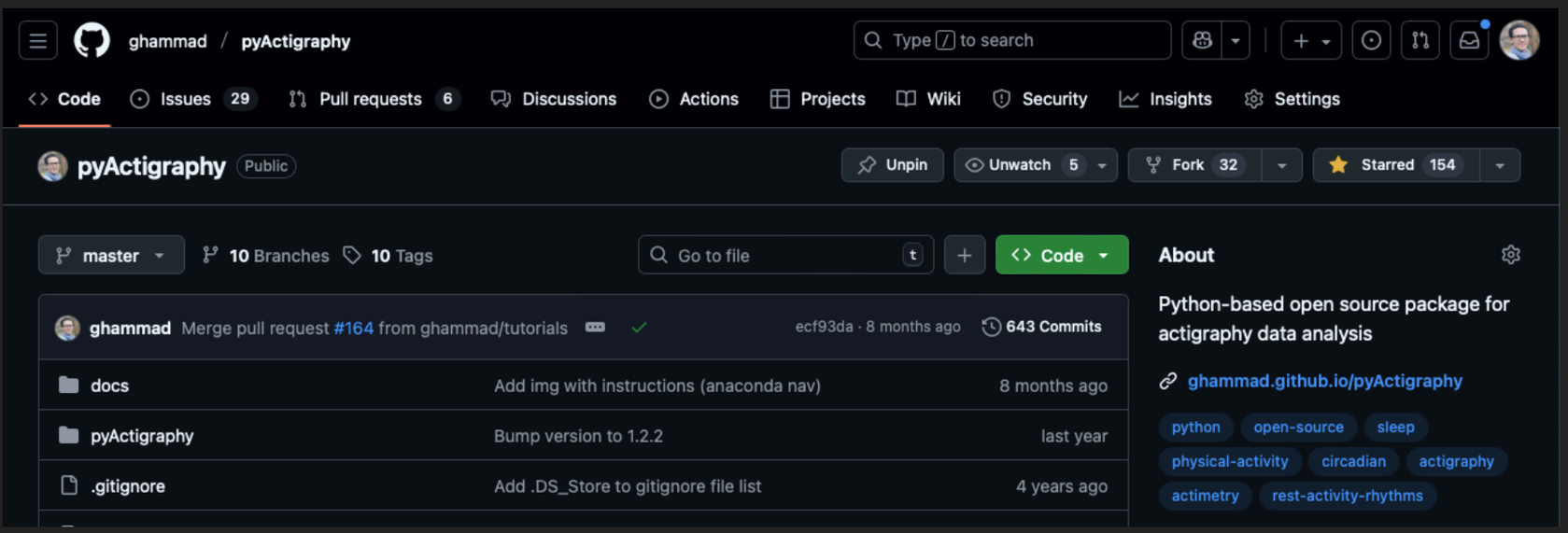

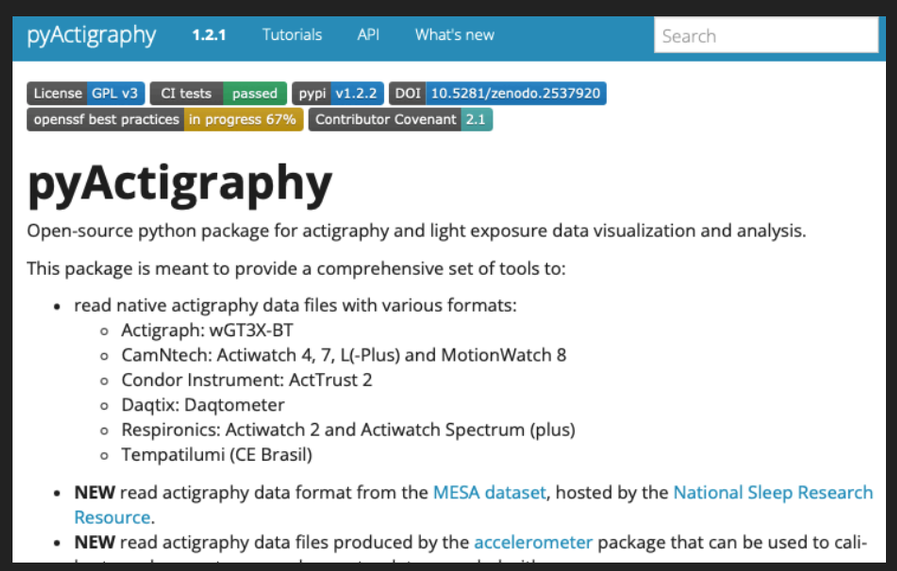

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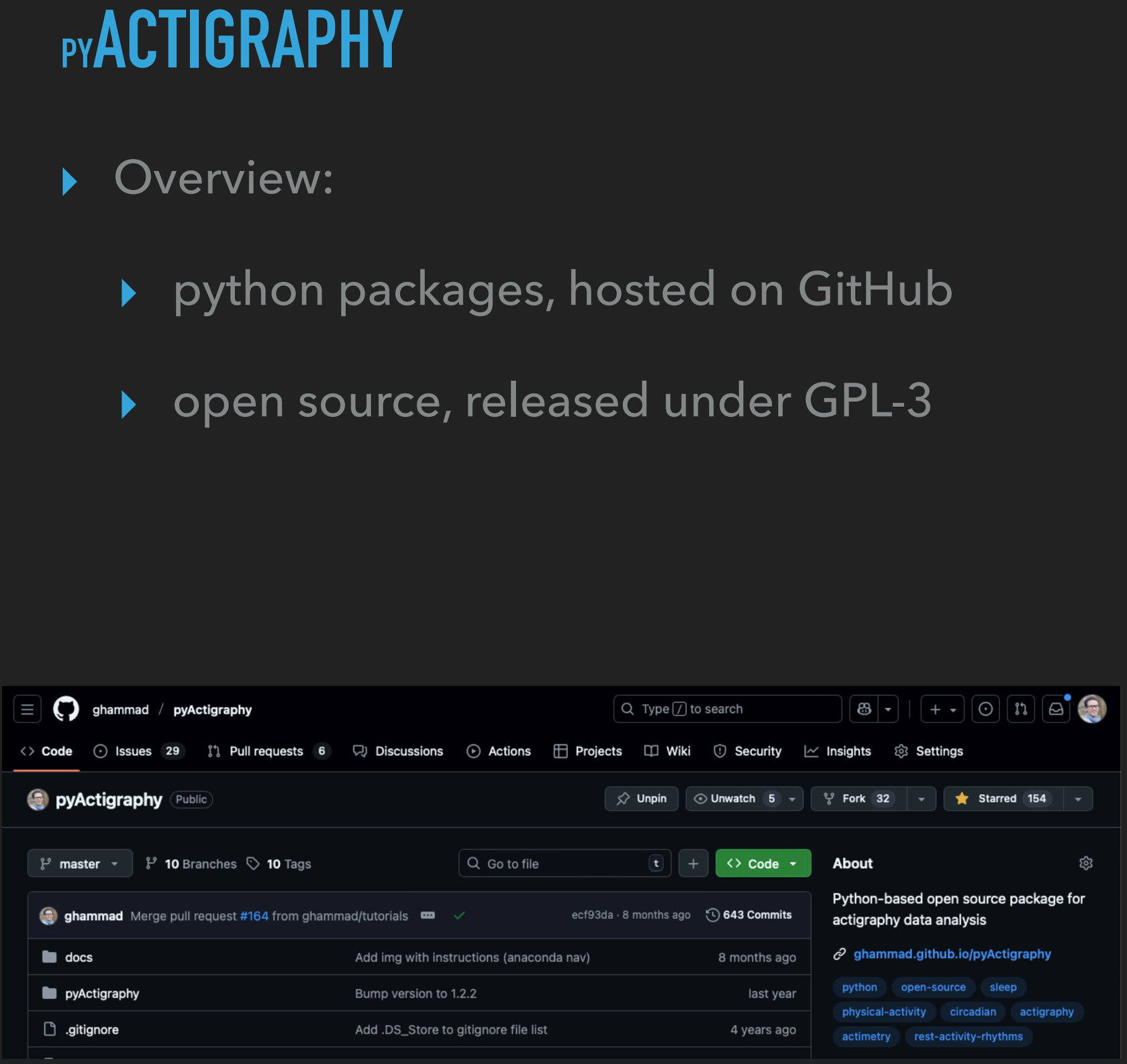

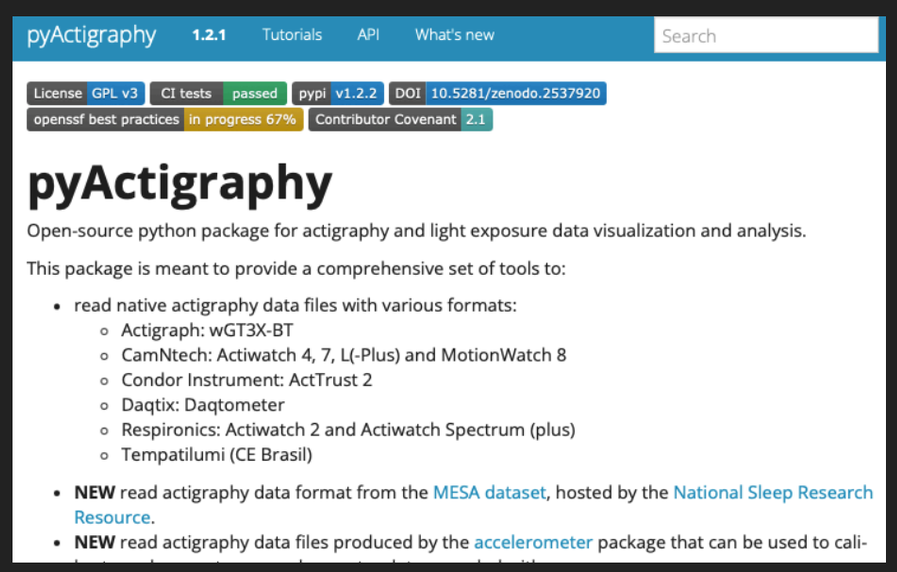

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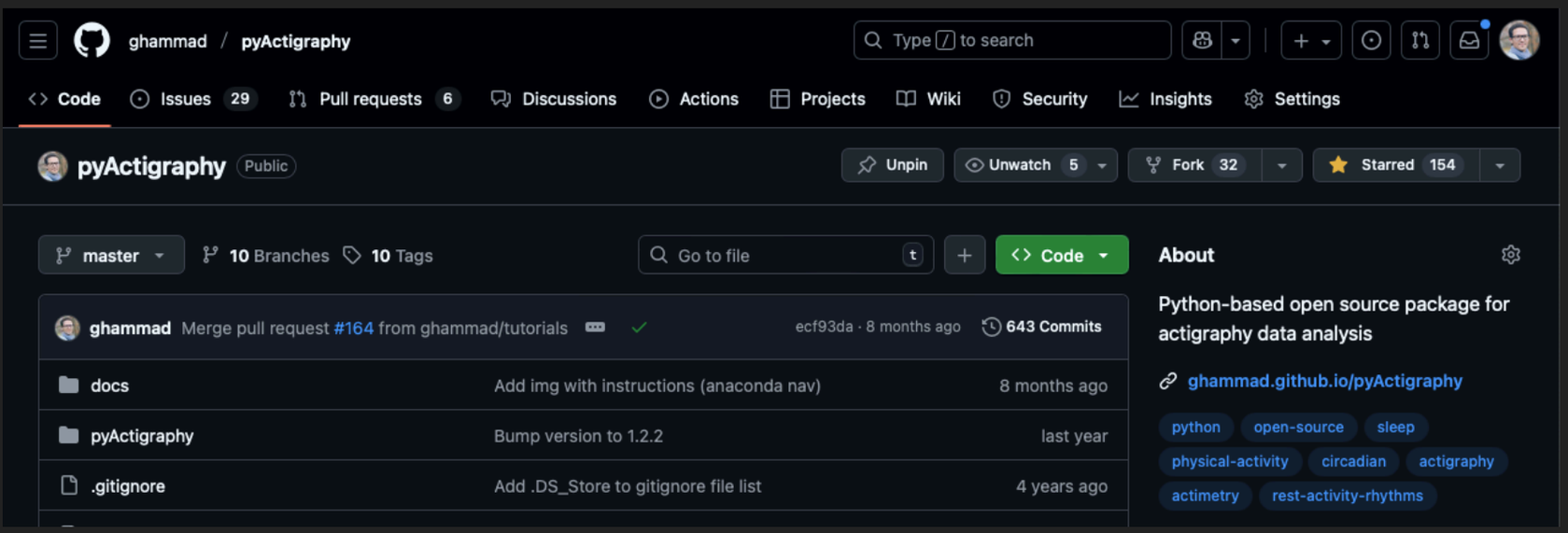

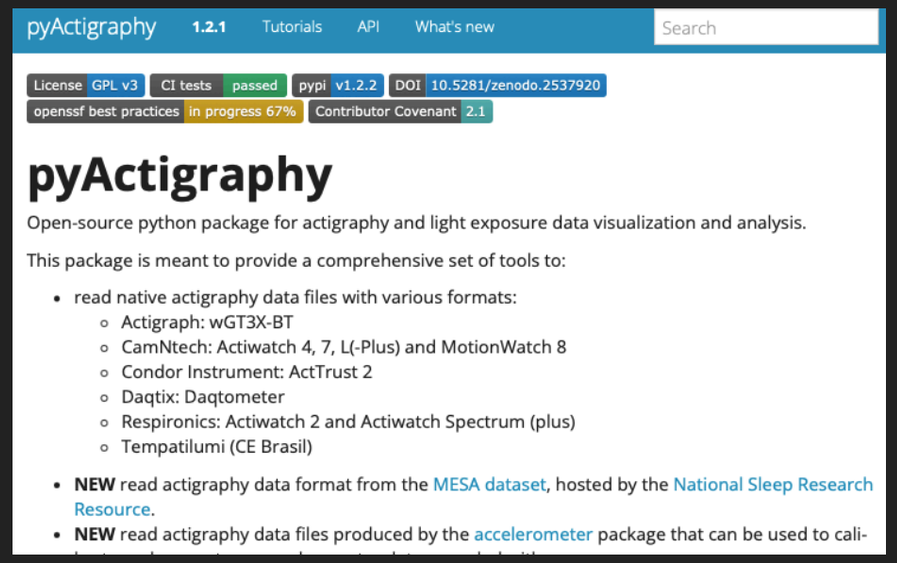

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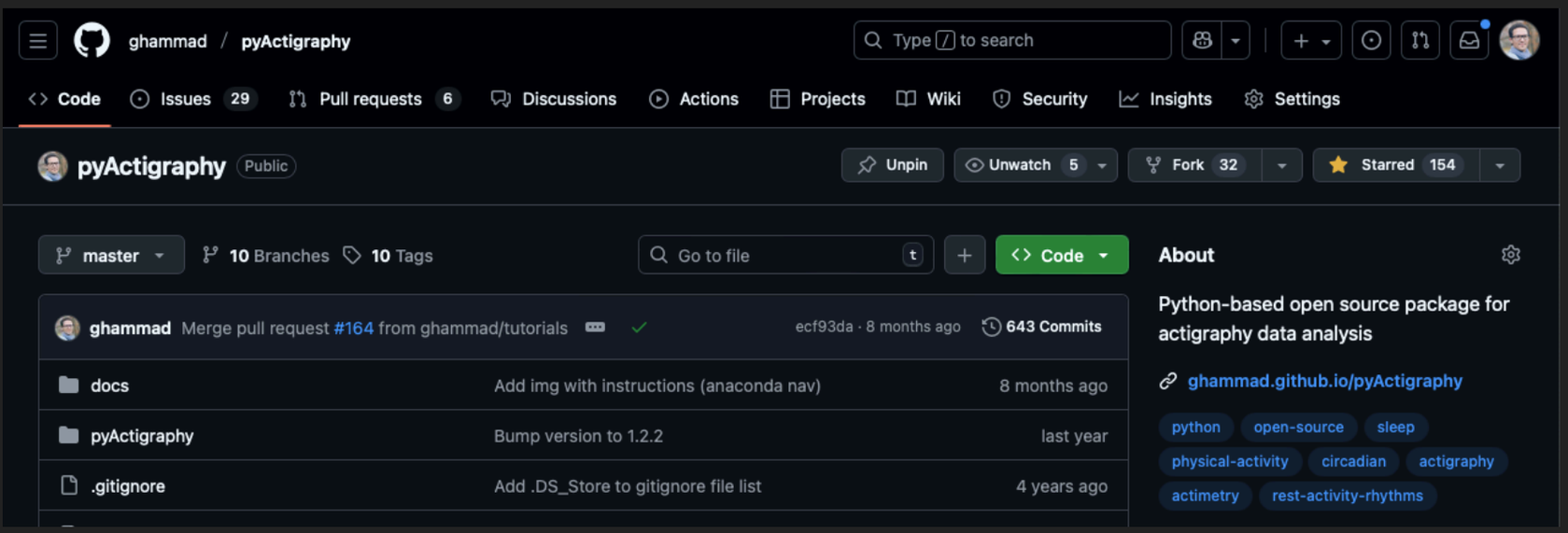

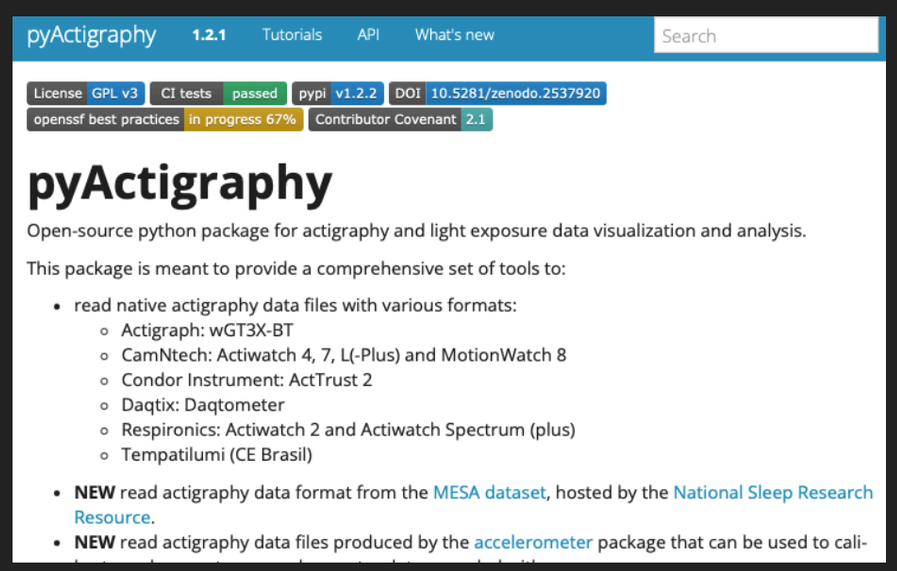

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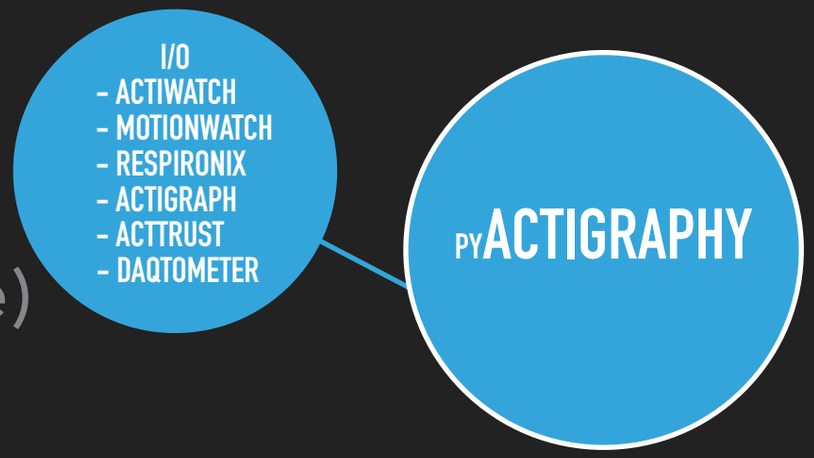

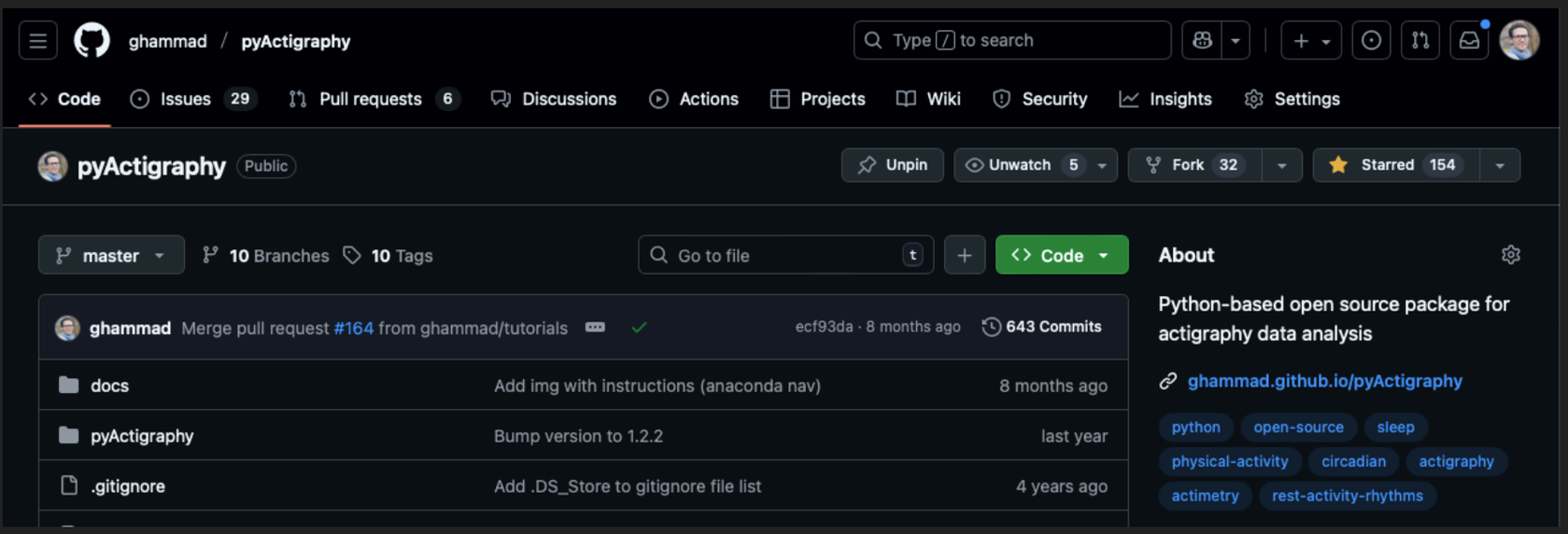

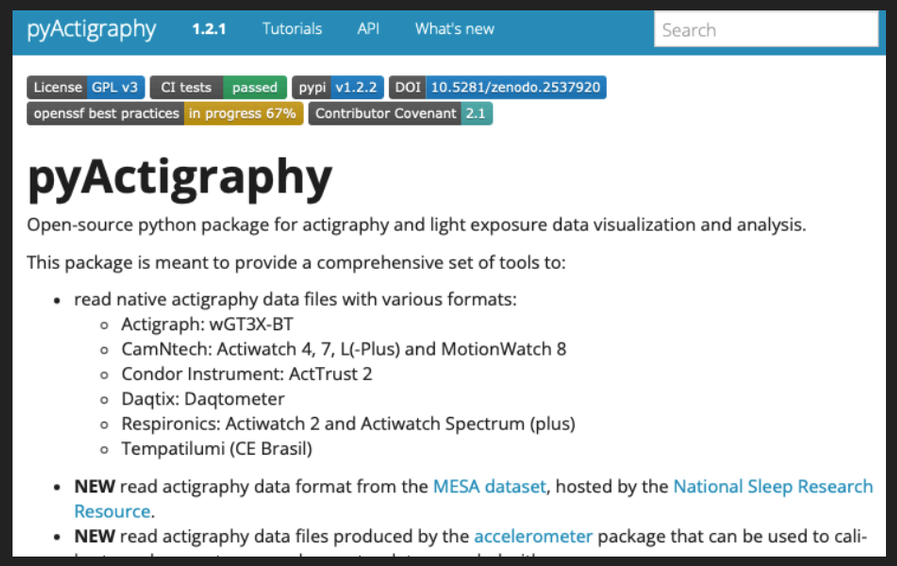

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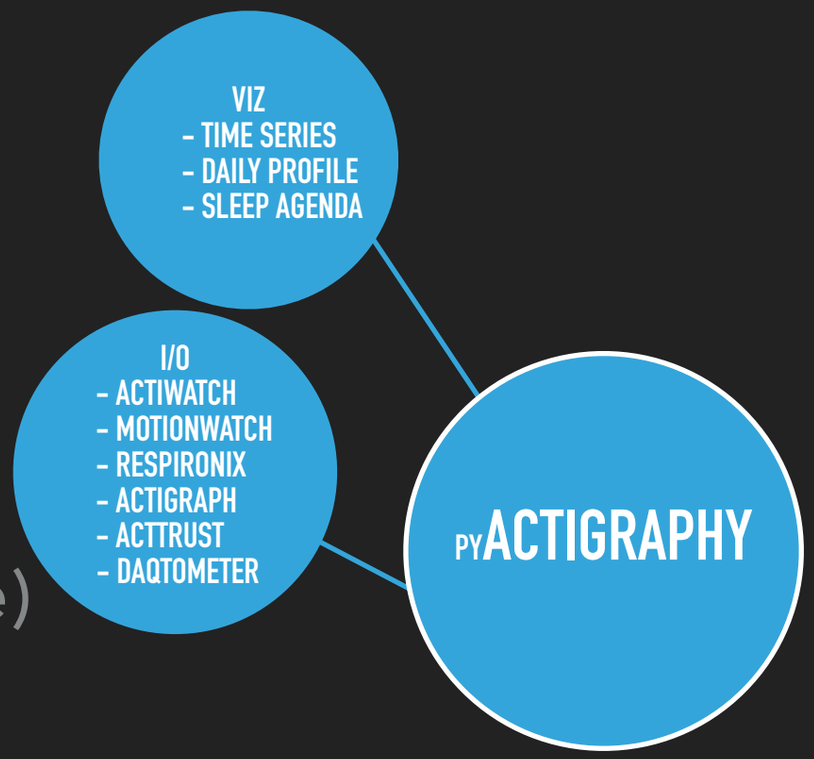

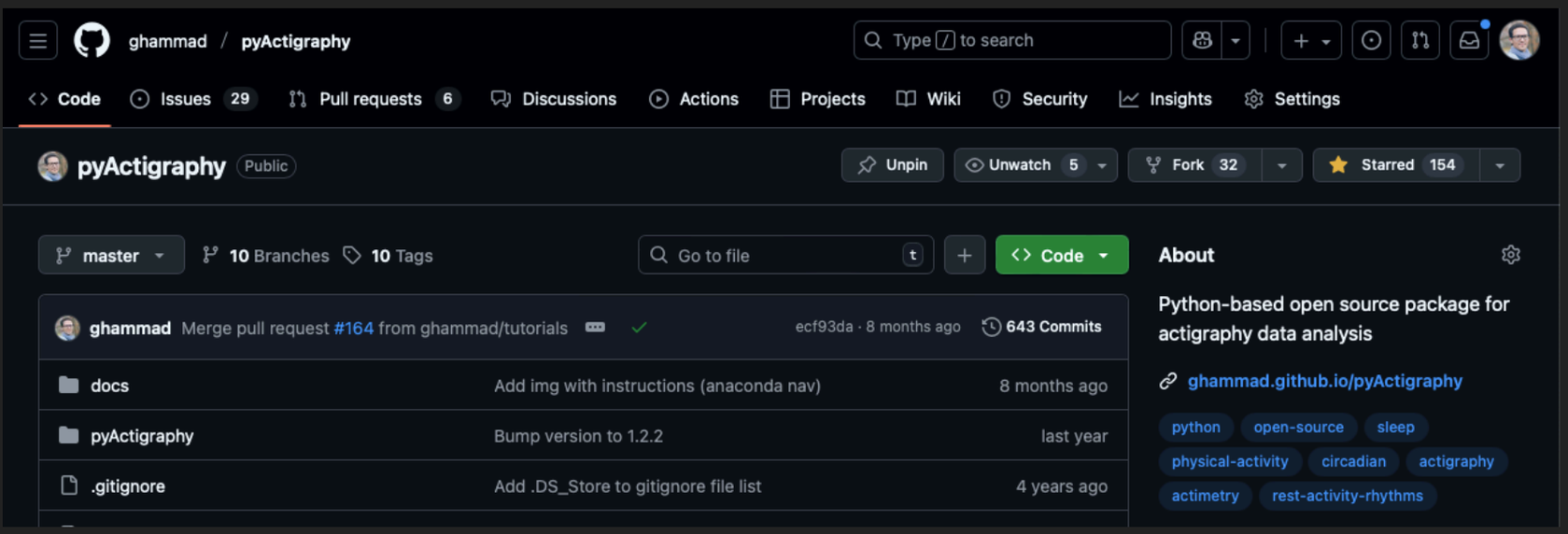

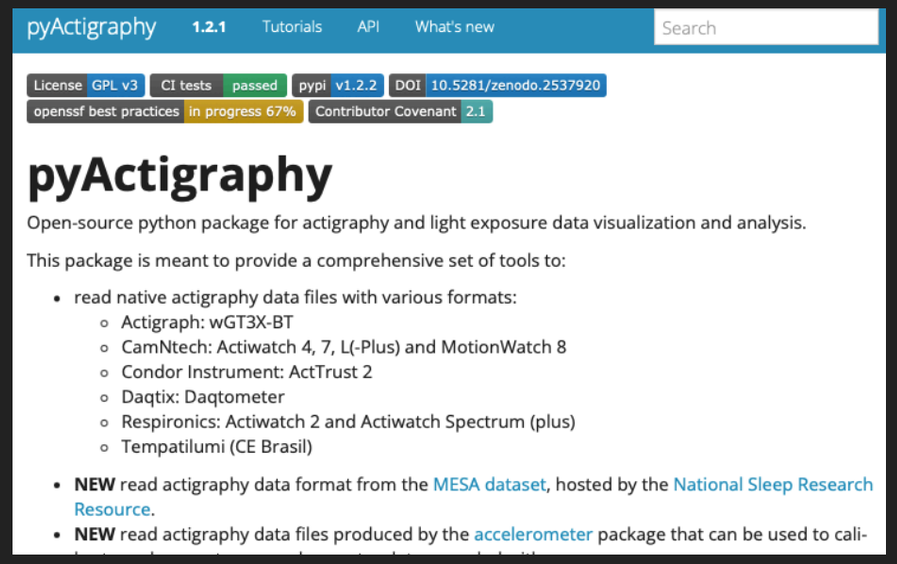

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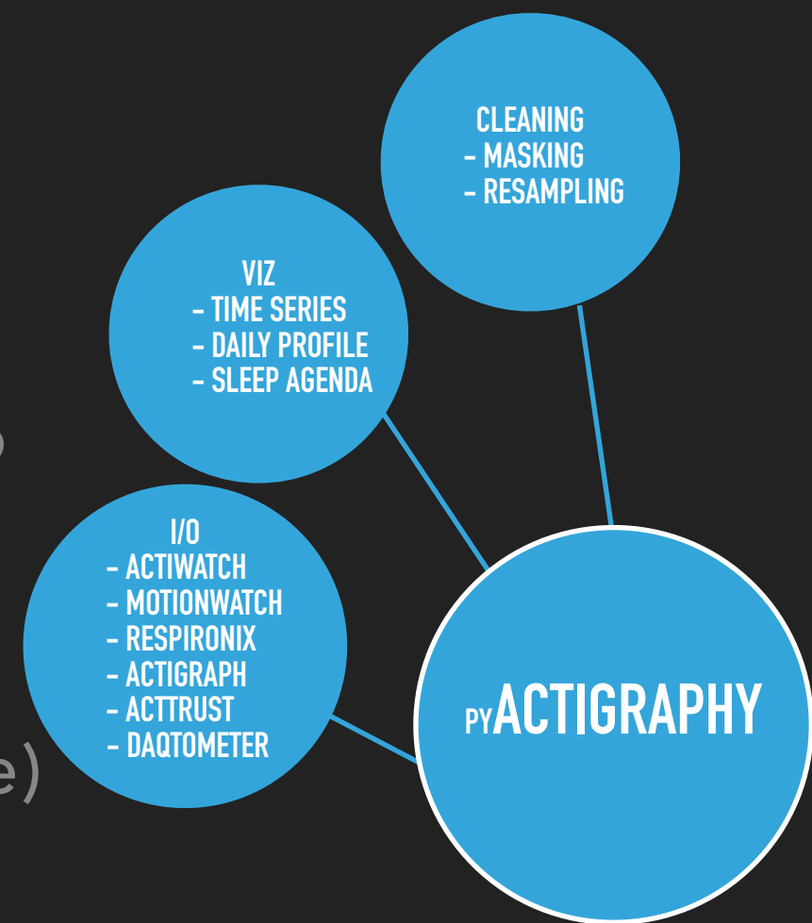

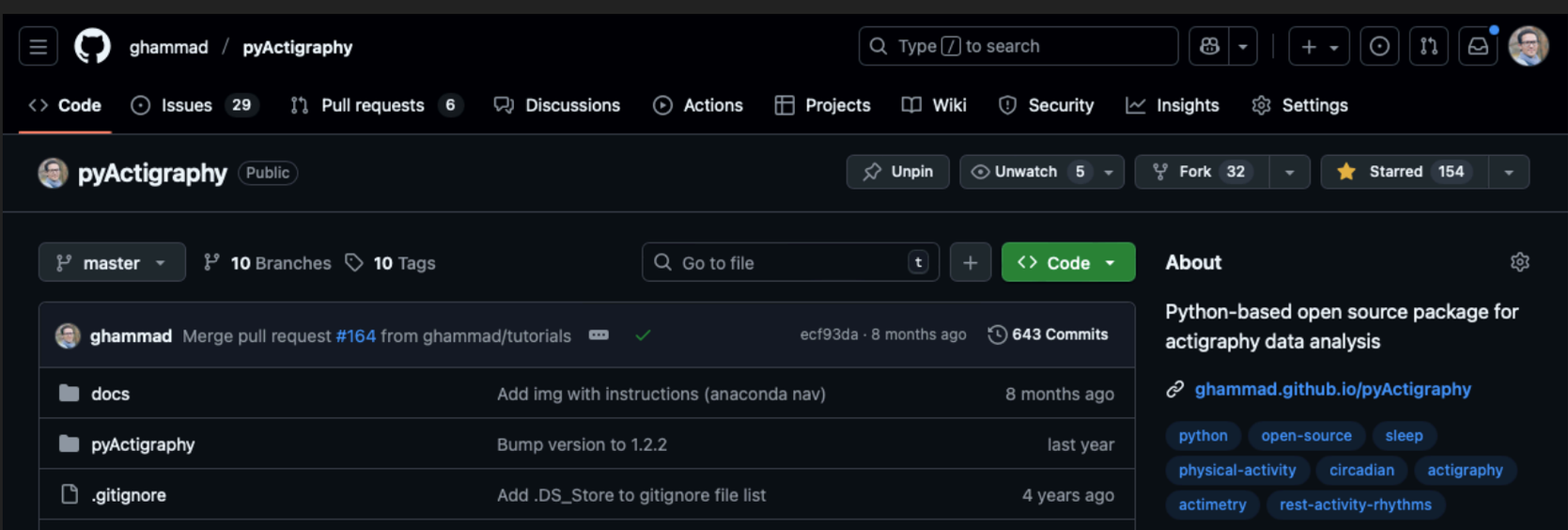

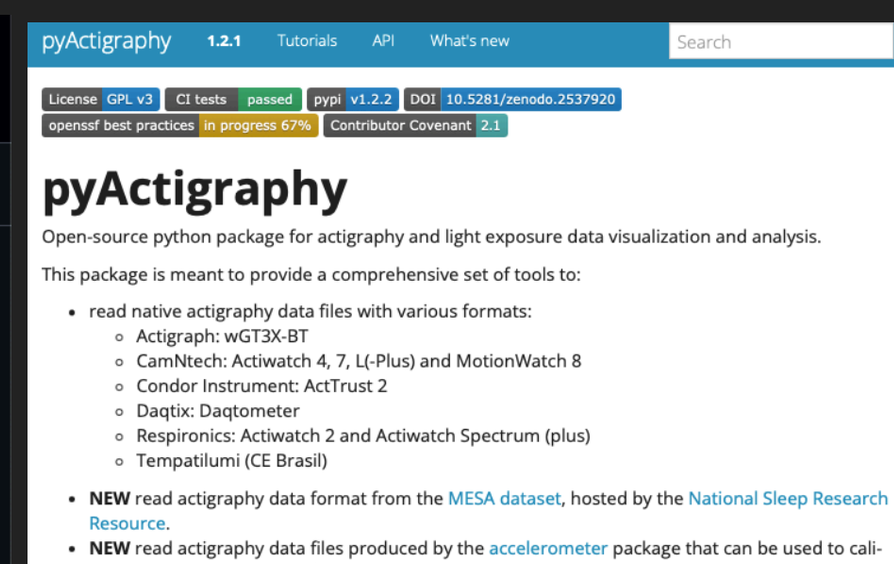

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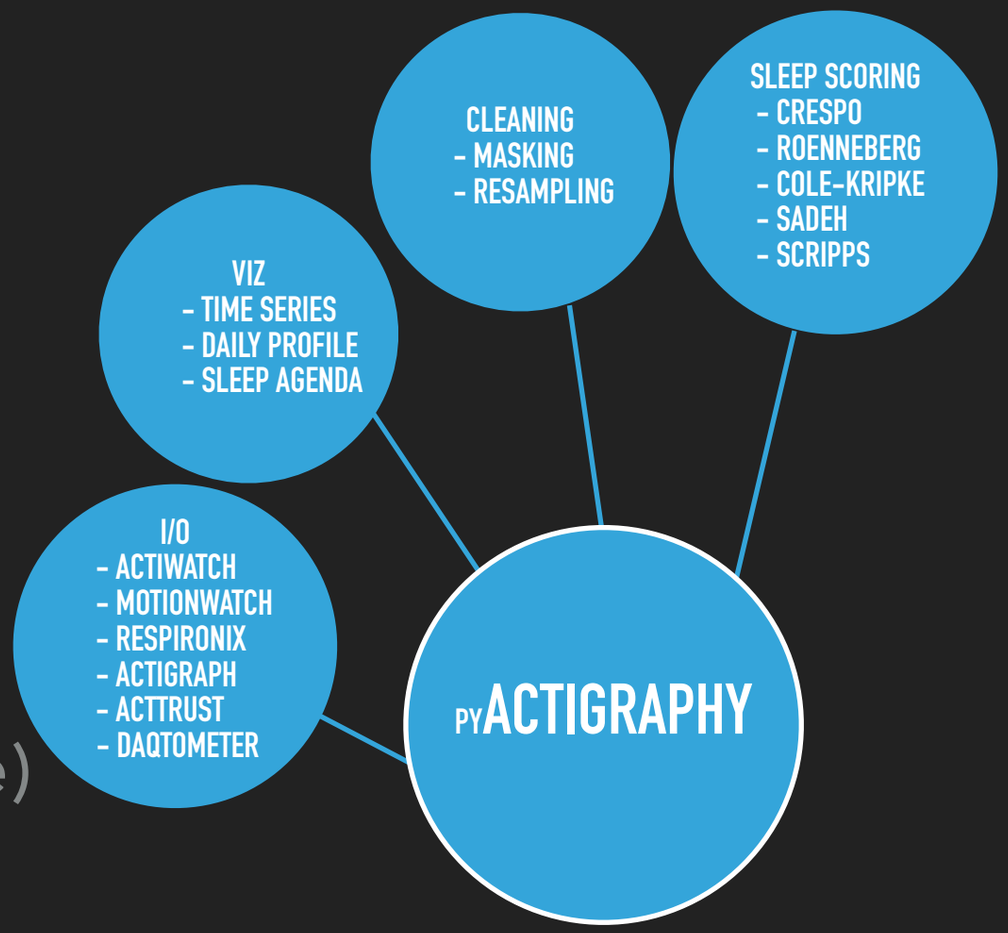

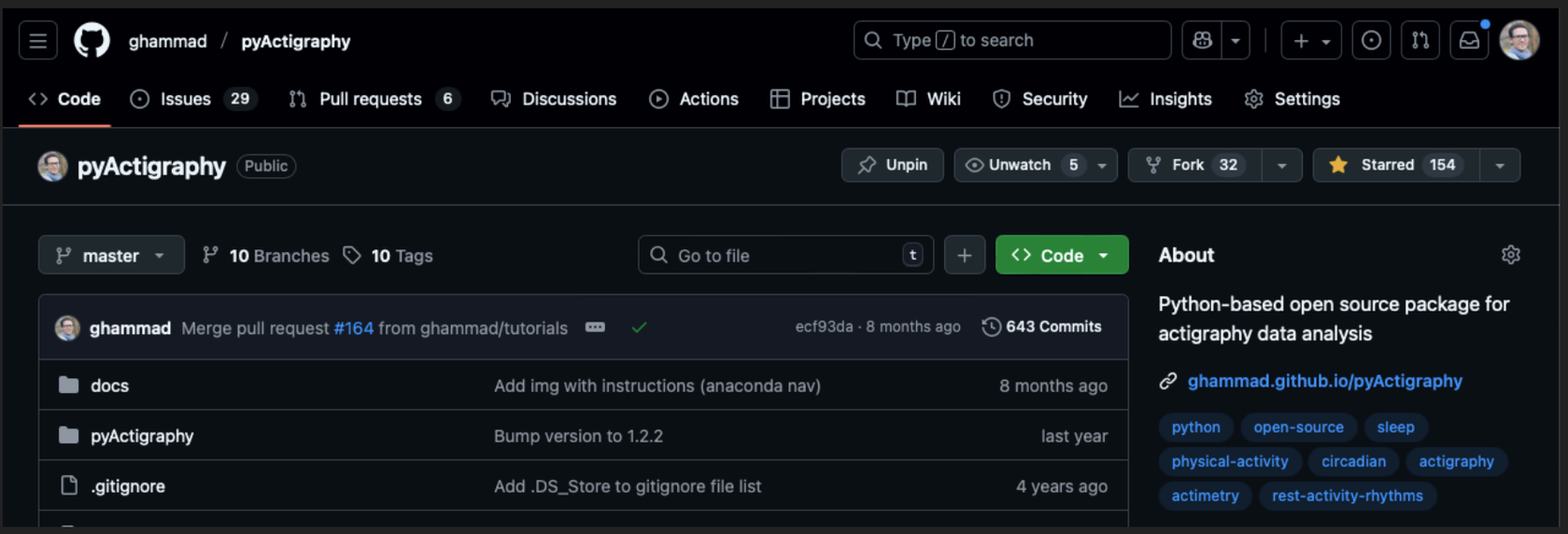

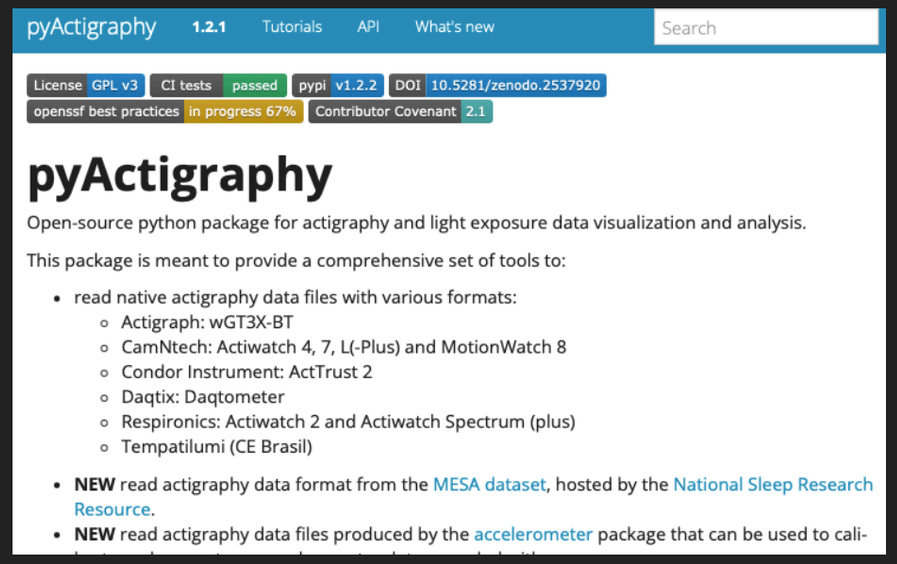

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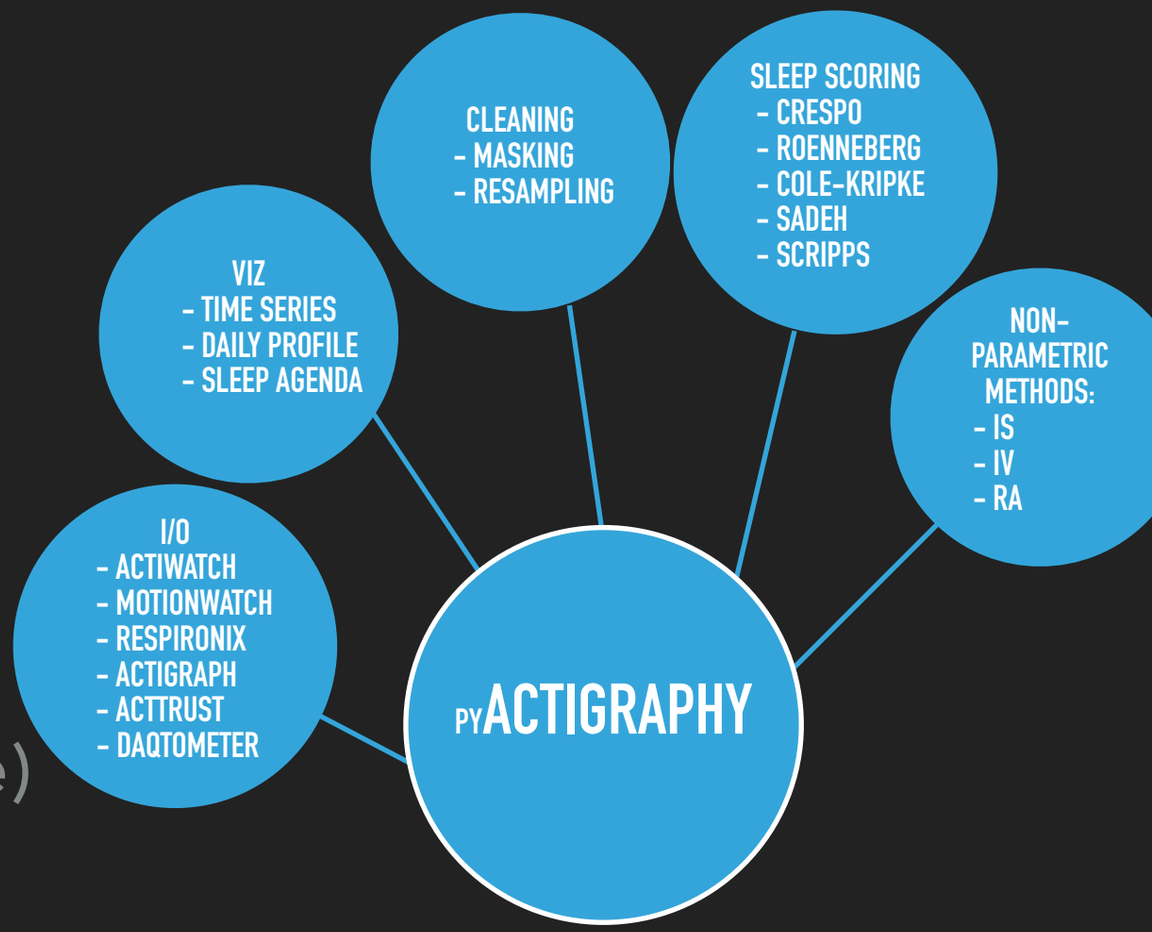

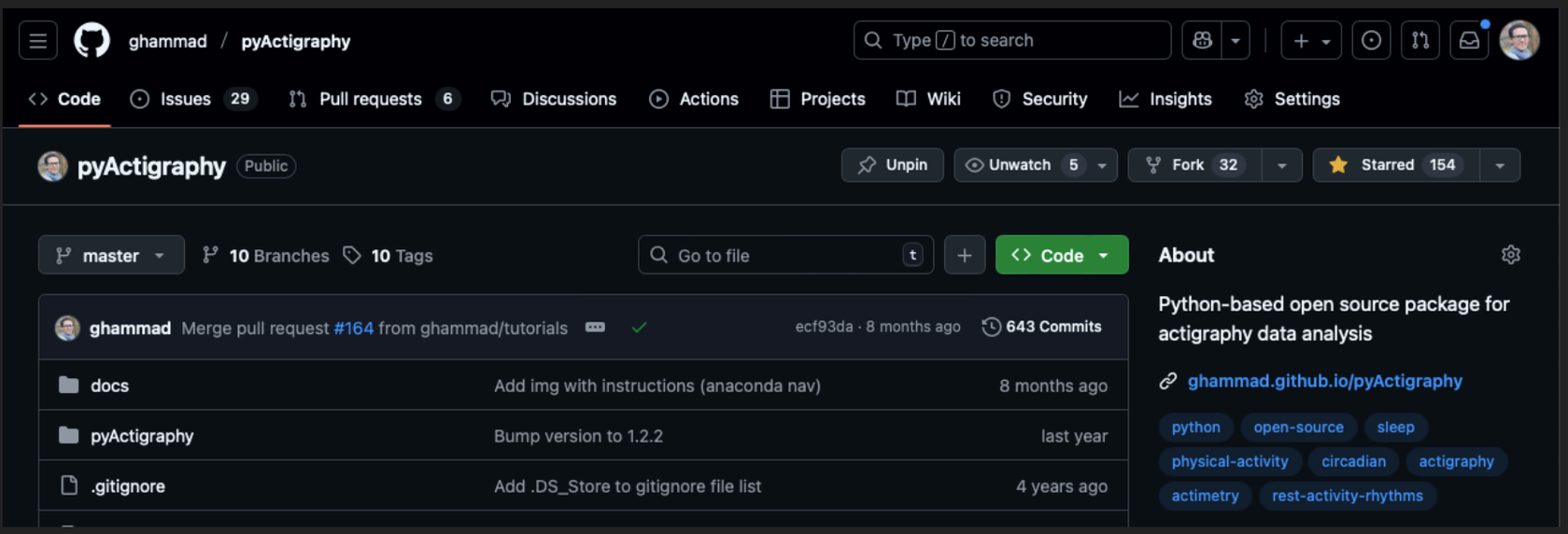

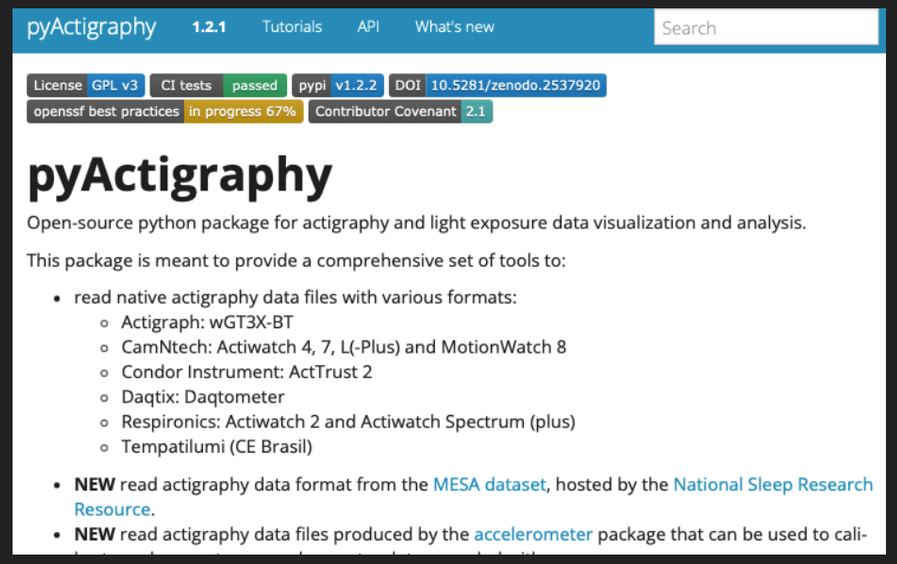

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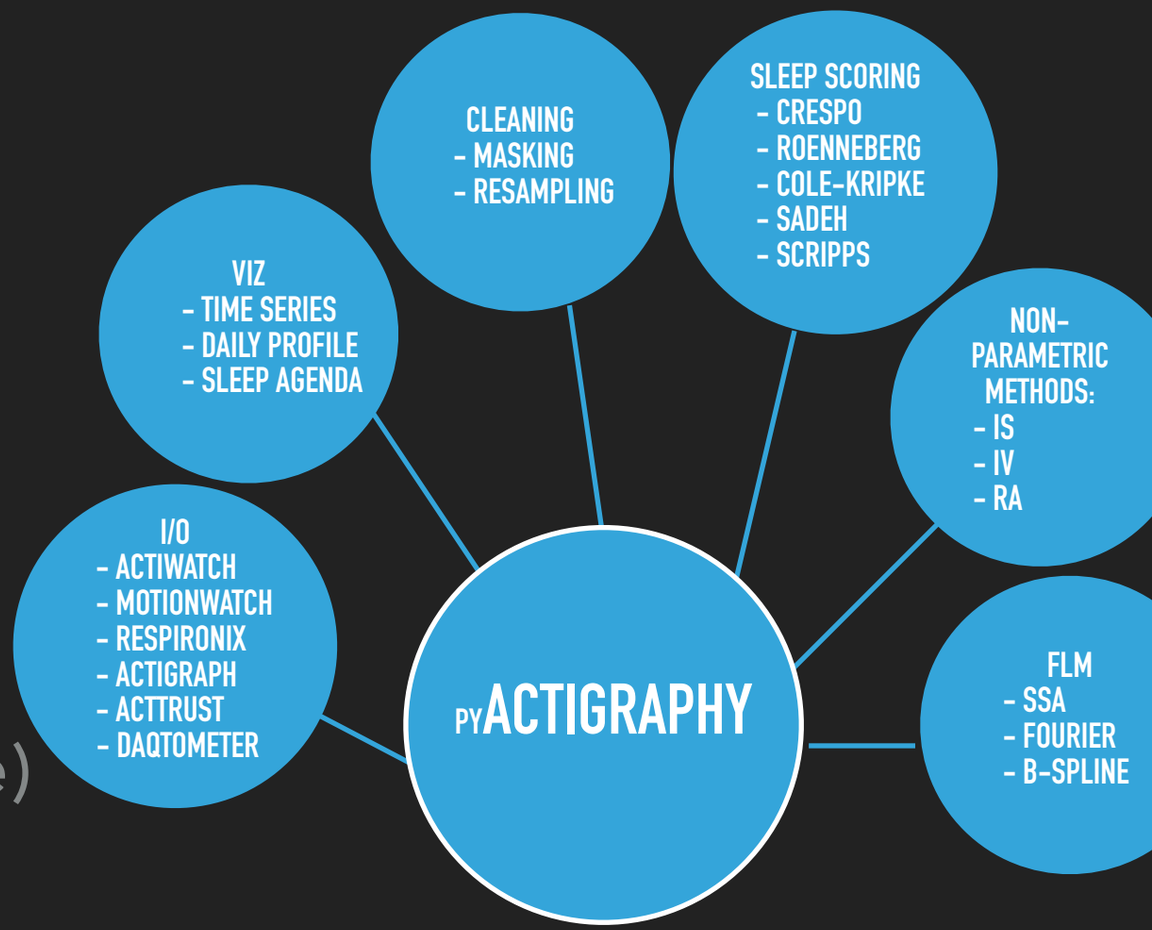

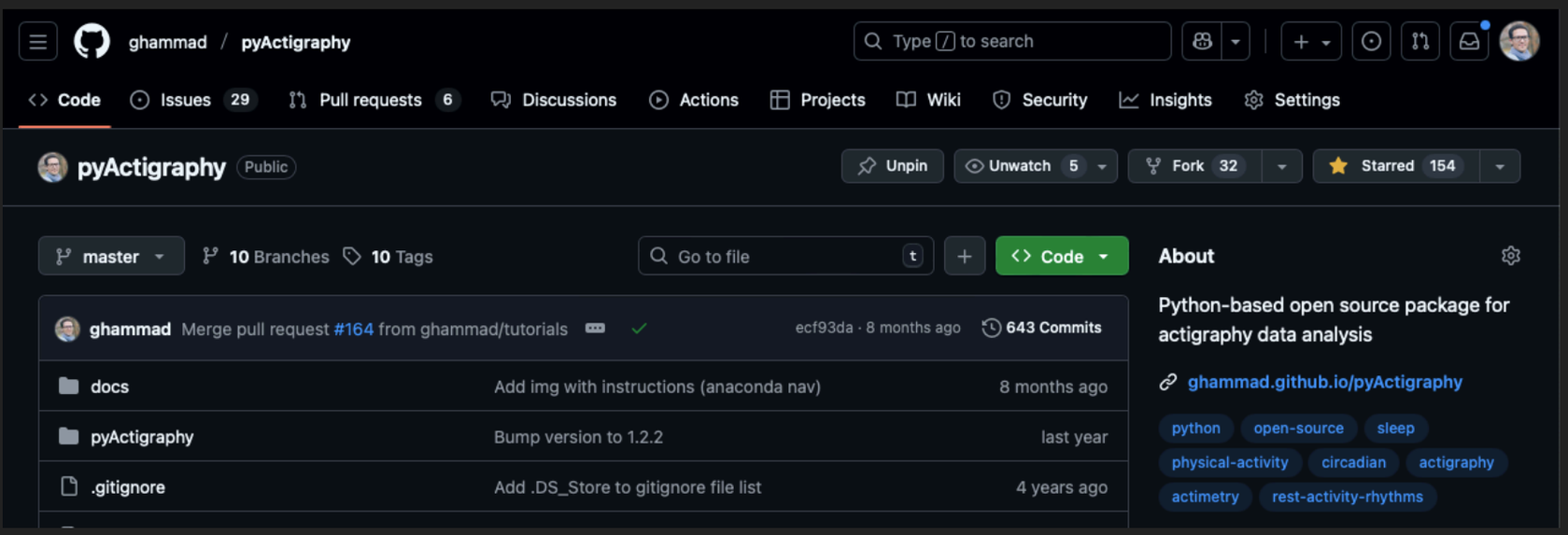

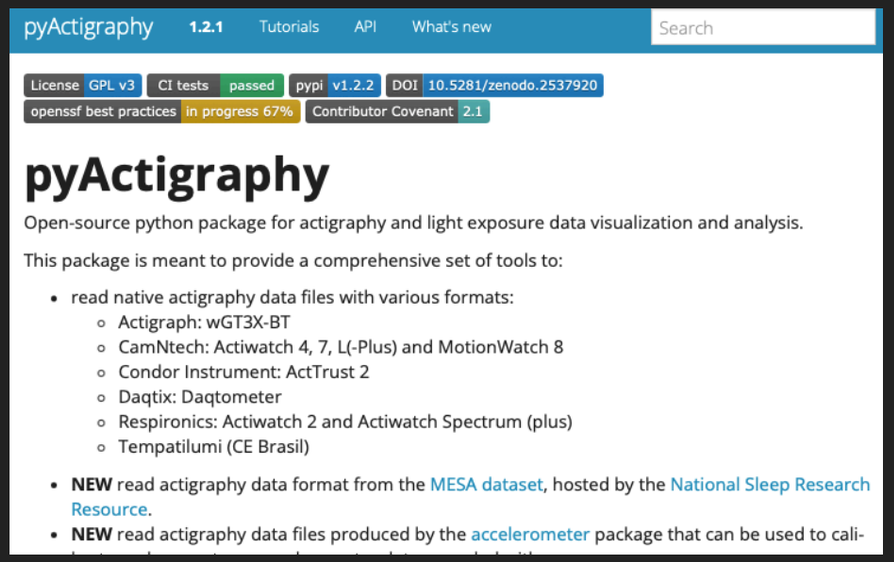

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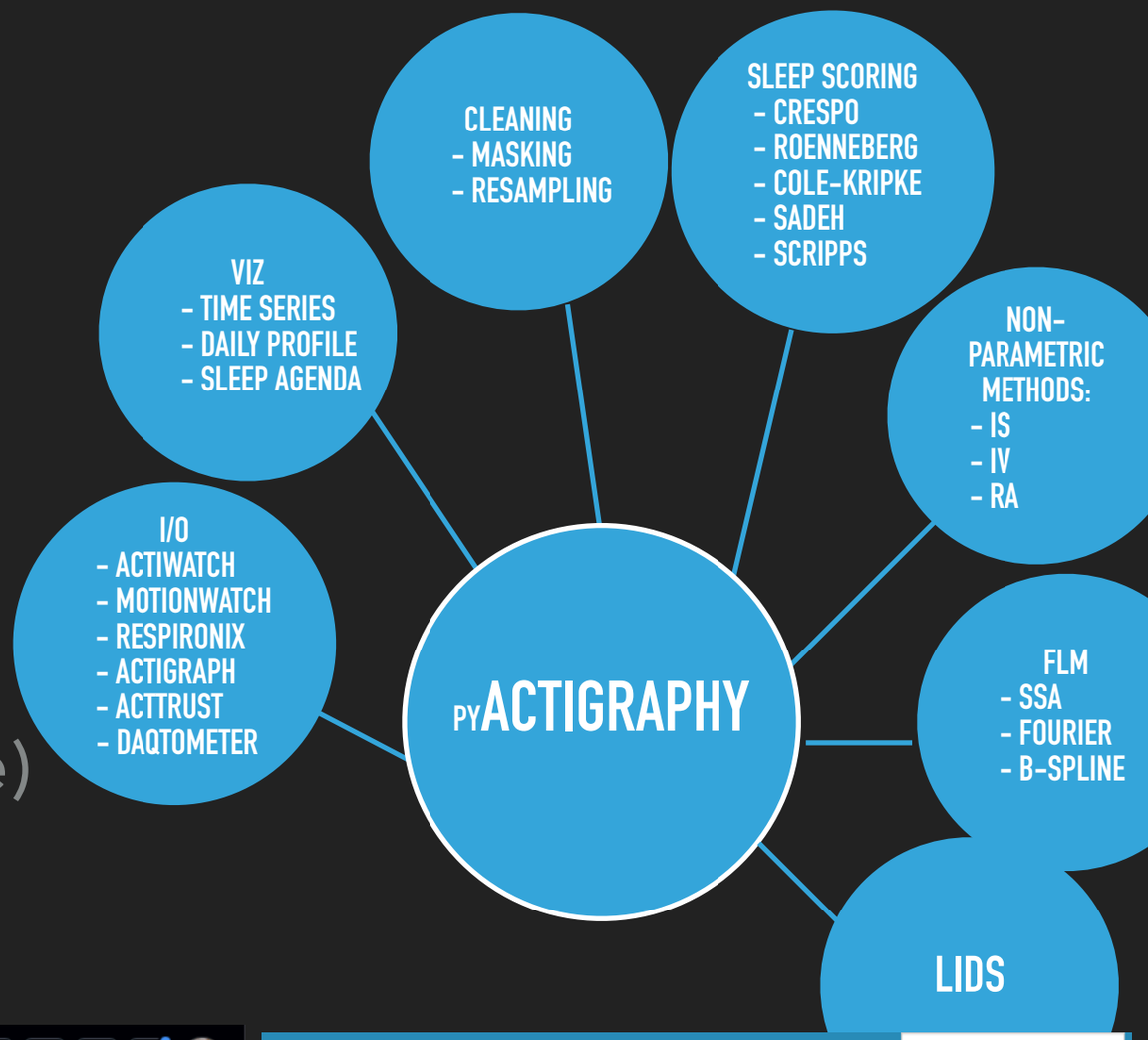

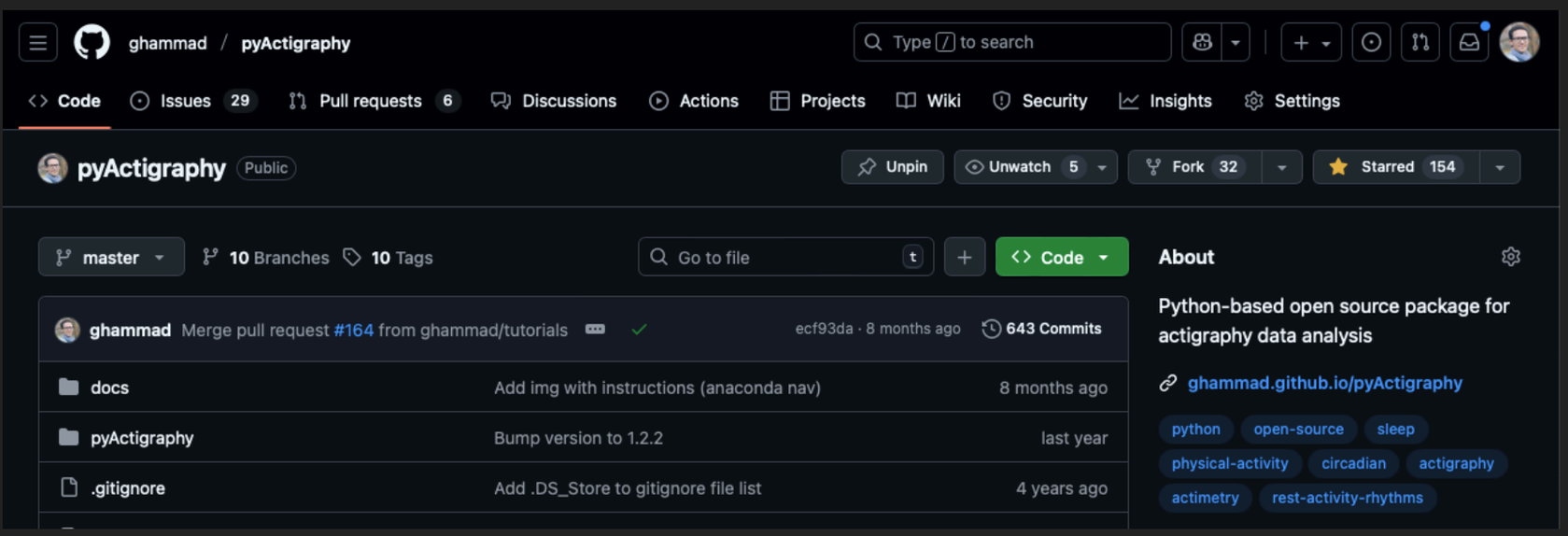

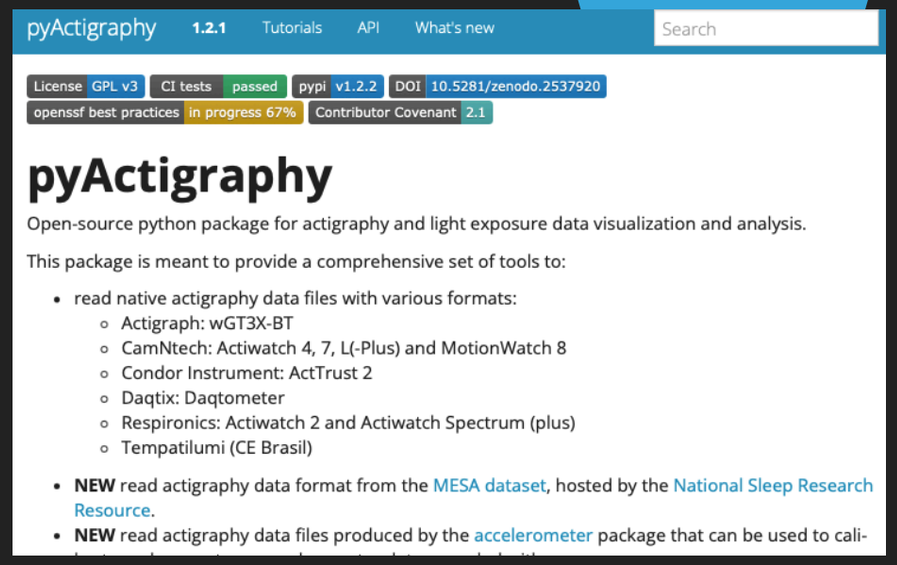

PYACTIGRAPHY: FEW LESSONS LEARNT ALONG THE WAY

TAKE THE USER BY THE HAND…

TAKE THE USER BY THE HAND…

- Tutorials:

pyActigraphy 0.2 Documentation API Source Search

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  - 1.1 Changing the resampling frequency
  - 1.2 Changing the threshold
  - 1.3 Without binarizing the data
- 2 Relative amplitude
- 3 Mean IS and IV
- 4 IS, IV and RA per period

Non-parametric variables with pyActigraphy

Non-parametric variables such as:

- Interdaily stability (IS)
- Intradaily variability (IV)
- Relative amplitude (RA)

can easily be calculated with the pyActigraphy package.

First import the pyActigraphy package and read your favorite actigraphy data file:

```
In [1]: import pyActigraphy
In [2]: import os
        fpath = os.path.join(os.path.dirname(pyActigraphy.__file__),'tests/data/')
```

pyActigraphy 0.2 Documentation API Site Search

Introduction to data masking with pyActigraphy

This introduction notebook illustrates how to mask potentially spurious inactivity periods.

First, load the pyActigraphy package:

```
In [1]: import pyActigraphy
```

As well as your favourite plotting package:

```
In [2]: import plotly.graph_objs as go
```

Read an individual actigraphy file

As an example, let's read a .awd file located in the test directory of the pyActigraphy package:

```
In [3]: import os
        fpath = os.path.join(os.path.dirname(pyActigraphy.__file__),'tests/data/')
In [4]: raw = pyActigraphy.io.read_raw_awd(fpath+'example_01_mask.AWD')
```

Plot the data

```
In [5]: layout = go.Layout(title="Actigraphy data", xaxis=dict(title="Date time"), yaxis=dict(title="Counts/period"), showlegend=Fals
In [6]: go.Figure(data=go.Scatter(x=raw.data.index.astype(str), y=raw.data), layout=layout)
```

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Sleep fragmentation via state transition probability

"Quantification of the Fragmentation of Rest-Activity Patterns in Elderly Individuals Using a State Transition Analysis"

Andrew S.P. Lim, MD, Lei Yu, PhD, Madalena D. Costa, PhD, Aron S. Buchman, MD, David A. Bennett, MD, Sue E. Leurgans, PhD, (

Sleep, Volume 34, Issue 11, 1 November 2011, Pages 1569–1581, https://doi.org/10.5665/sleep.1400

```
In [1]: import pyActigraphy
In [2]: import plotly.graph_objs as go
In [3]: # create objects for layout and traces
        layout = go.Layout(title="",xaxis=dict(title=""), showlegend=False)
```

Read an individual actigraphy file

```
In [4]: # retrieve path to example files
        import os
        fpath = os.path.join(os.path.dirname(pyActigraphy.__file__),'tests/data/')
In [5]: raw = pyActigraphy.io.read_raw_awd(fpath+'example_01.AWD', period='7 days')
```

Quantify the Rest-to-activity transition probability

help(raw.kRA)

Rest to activity (kRA)

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Automatic detection of rest/activity periods with pyActigraphy

The **pyActigraphy** package implements several rest/activity detection algorithms.

Broadly speaking, they can be divided in two categories:

- Epoch-by-epoch rest/activity scoring (inspired by PSG):
  - Cole-Kripke's, Sadeh's, Scripps' algorithms
- Detection of consolidated periods of similar activity patterns
  - Crespo's, Roenneberg's algorithms

All algorithms have been implemented to return a binary time serie (0 being rest or activity depending on the definition made in the original article...)

```
In [1]: import pyActigraphy
In [2]: import plotly.graph_objs as go
In [3]: import os
        fpath = os.path.join(os.path.dirname(pyActigraphy.__file__),'tests/data/')
In [4]: raw = pyActigraphy.io.read_raw_rpx(fpath+'test_sample.csv', period='6 days', language='FR')
```

Epoch-by-epoch rest/activity scoring algorithms

All based on the same idea;

- use a rolling window over the data and convolute them with a "gaussian"-like kernel.
- if the resulting data is above a predefined threshold, classify as activity. Rest otherwise...

My opinion regarding these algorithms

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Usage of sleep diary with pyActigraphy

Sleep diary is usually given with an actimeter to allow participants to report the subjective evaluation of their sleep episodes. A sleep diary is the easiest and least invasive way to get information about sleep episodes from participants. It allows comparison between data recorded by an actigraph and the real-life.

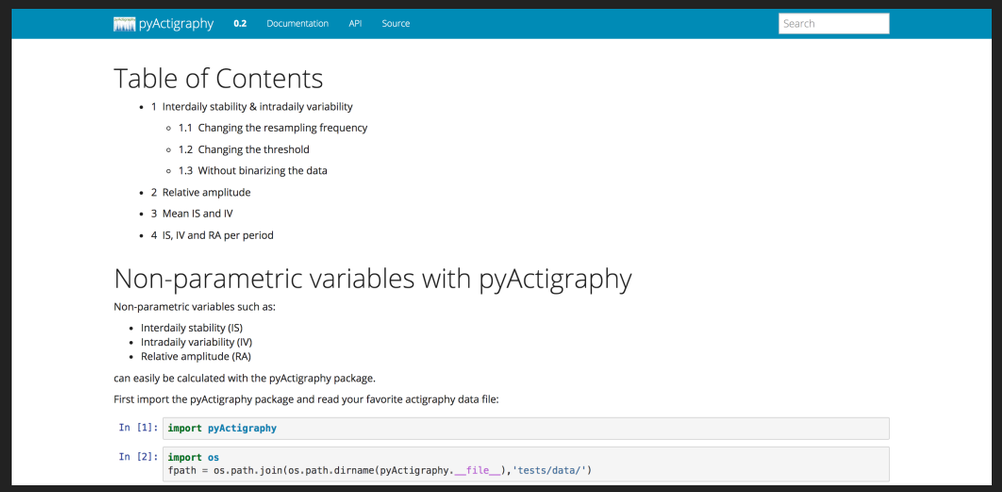
In medical fields, sleep diary is commonly recommended in order to help doctors in the diagnosis and treatment of sleep-wake cycle disorders.

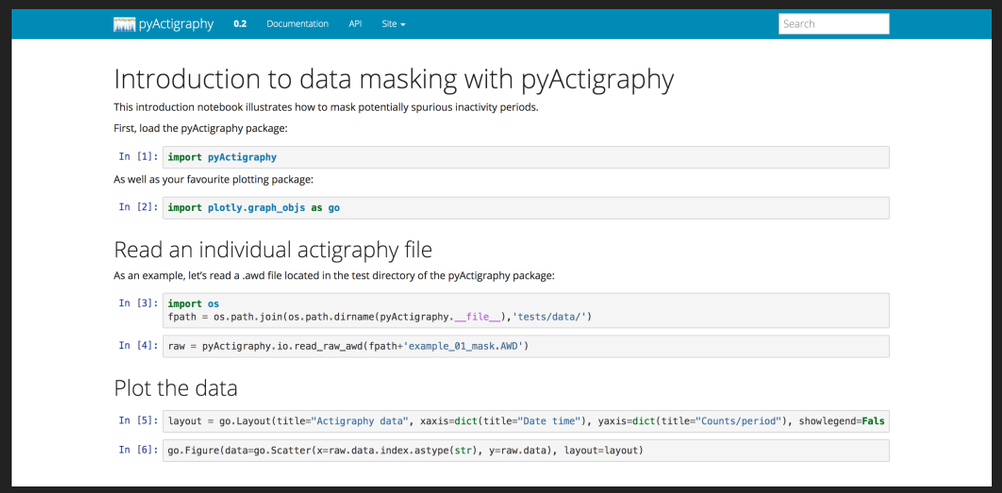
```
In [1]: import pyActigraphy
In [2]: import os
In [3]: import plotly.graph_objs as go
In [4]: # Retrieve path to example files
        fpath = os.path.join(os.path.dirname(pyActigraphy.__file__),'tests/data/')
In [5]: # Read test file
        raw = pyActigraphy.io.read_raw_awd(fpath+'example_01.AWD')
In [6]: # Check the start time of the actigraphy recording
        raw.start_time
Out[6]: Timestamp('1918-01-23 13:58:00')
In [7]: # Check the duration of the recording
        raw.duration()
Out[7]: Timedelta('12 days 18:41:00')
```

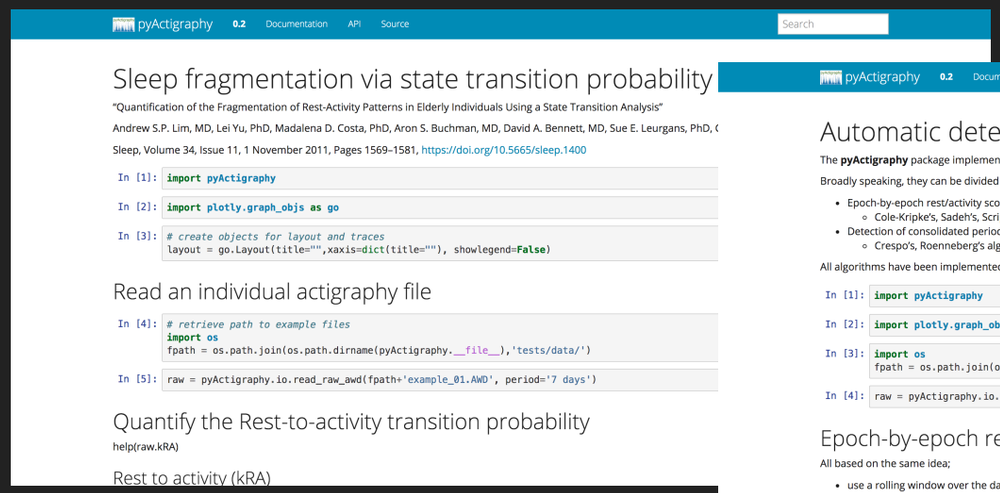
Read a sleep diary

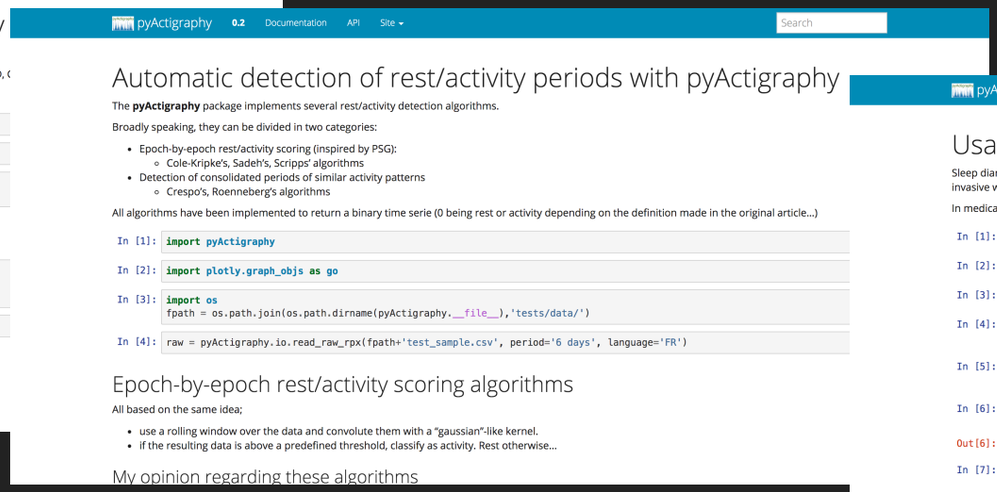
TAKE THE USER BY THE HAND…

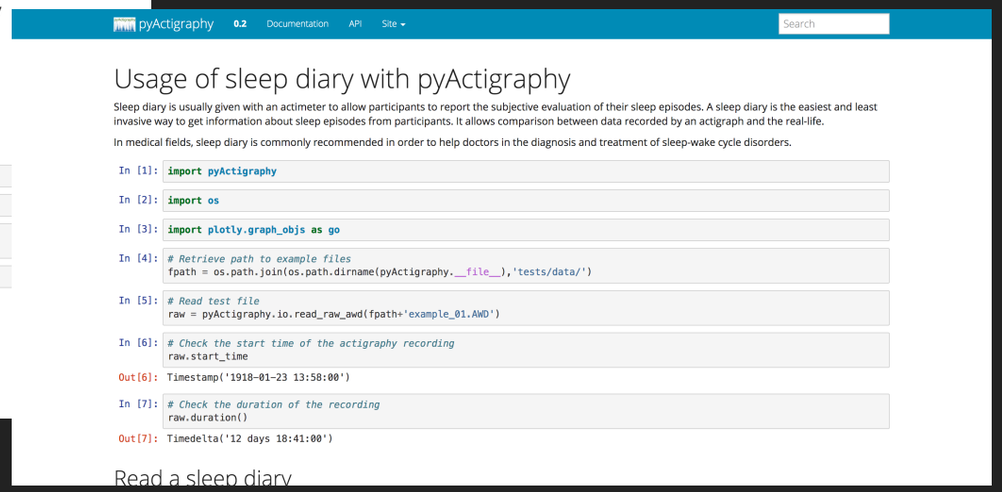
- Tutorials:
  - Available online: https://ghammad.github.io/pyActigraphy/documentation.html





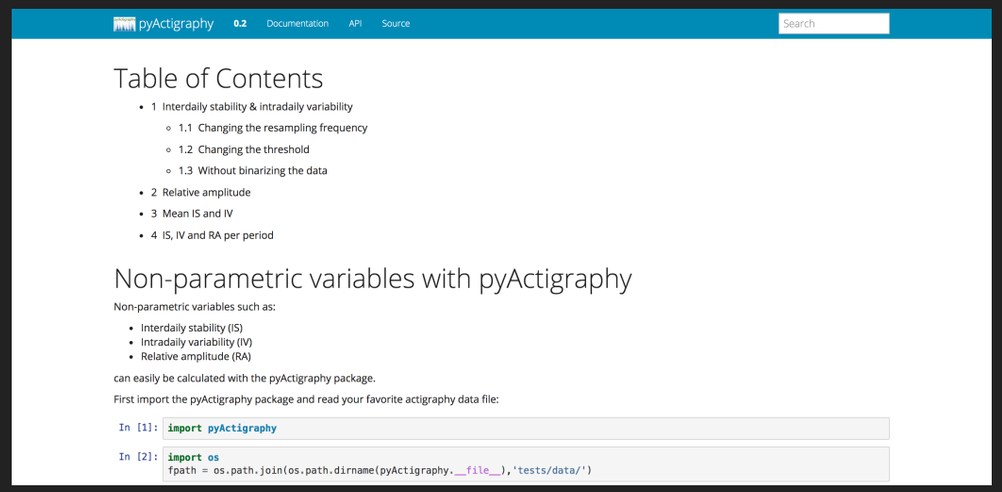


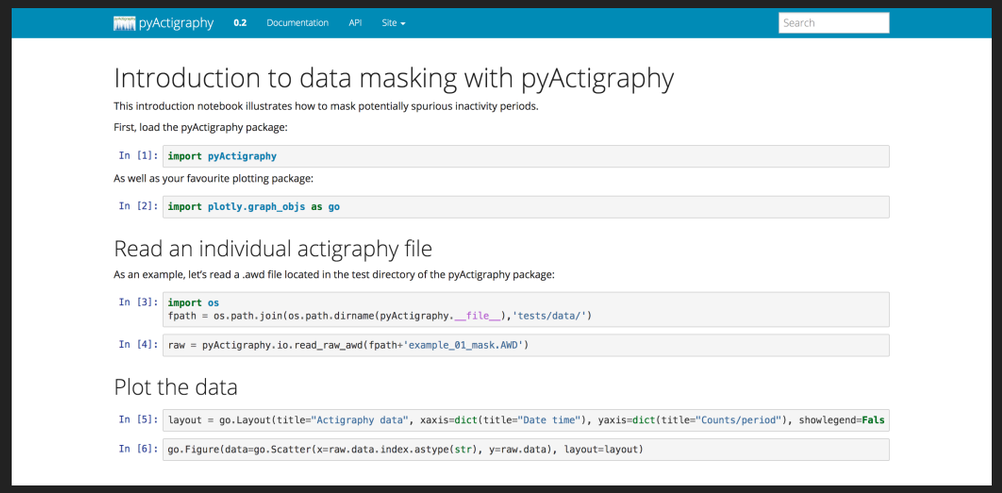


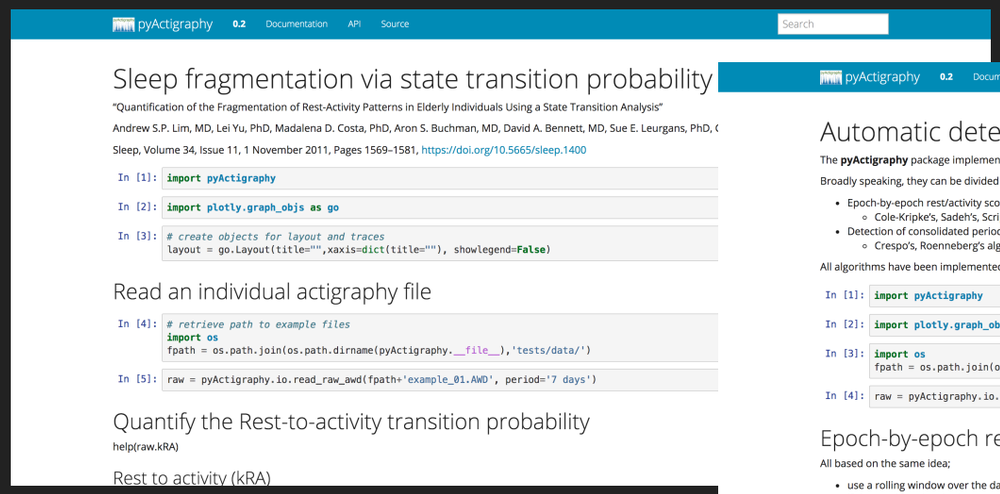


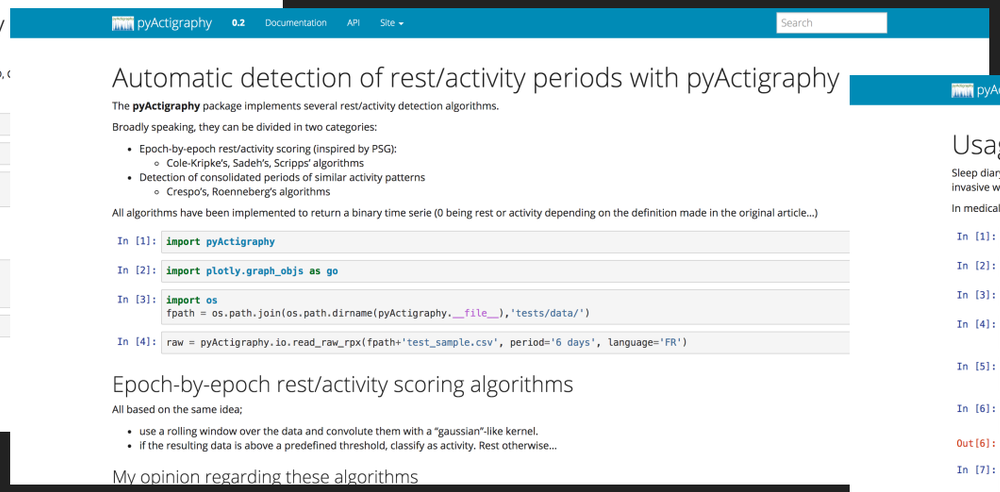
TAKE THE USER BY THE HAND…

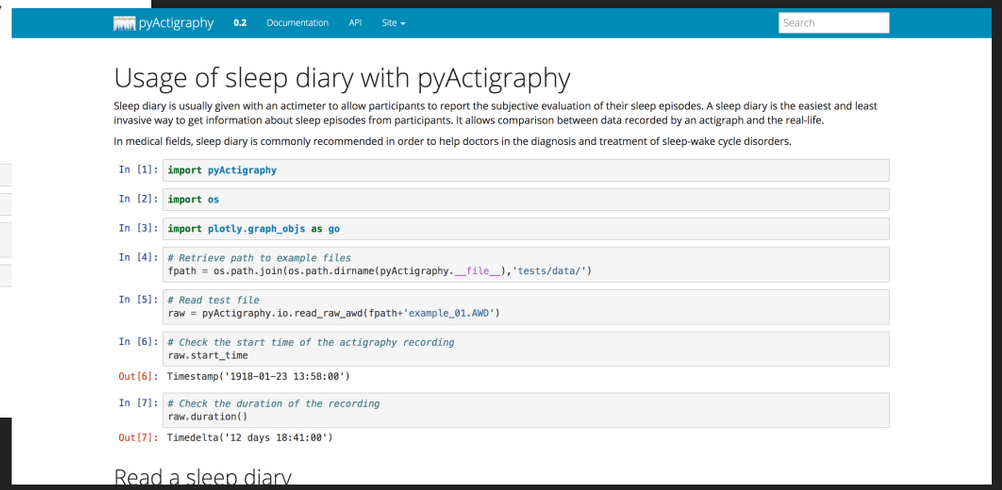
- Tutorials:
  - Available online: https://ghammad.github.io/pyActigraphy/documentation.html
  - Interactive and friendly





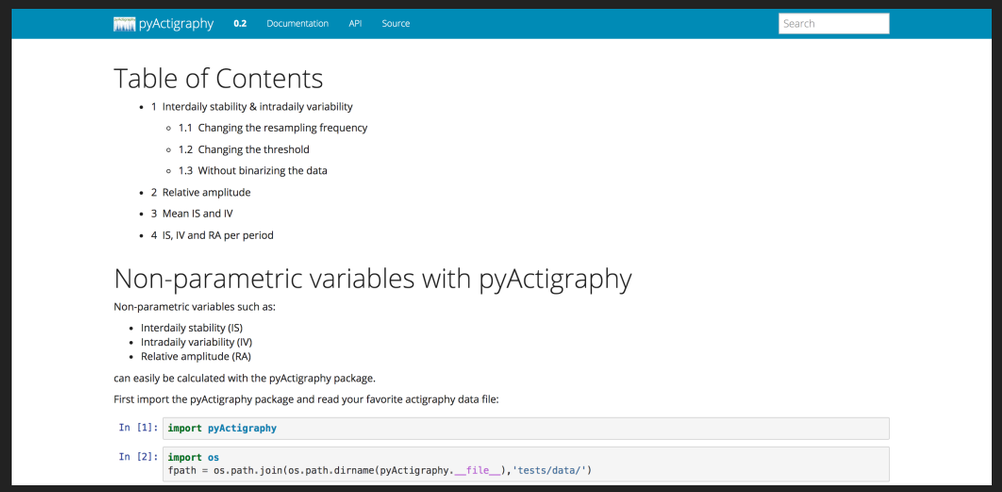


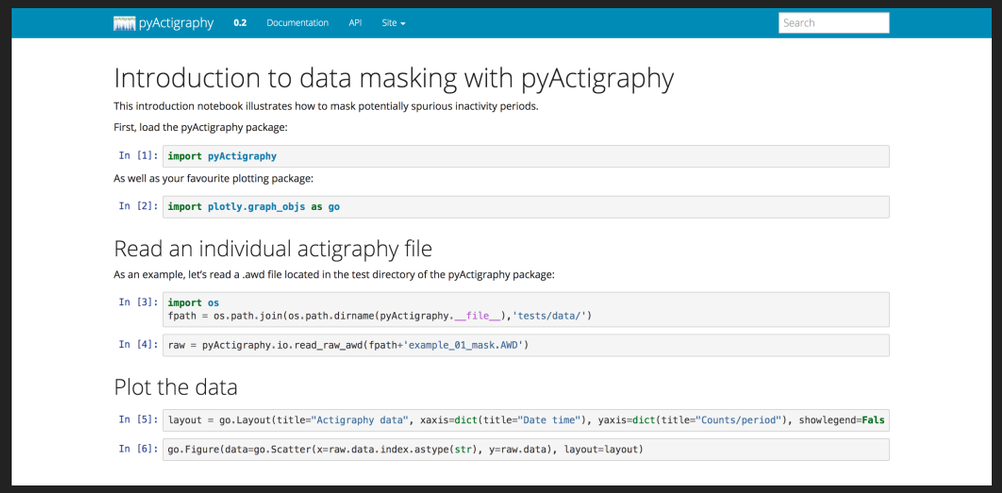


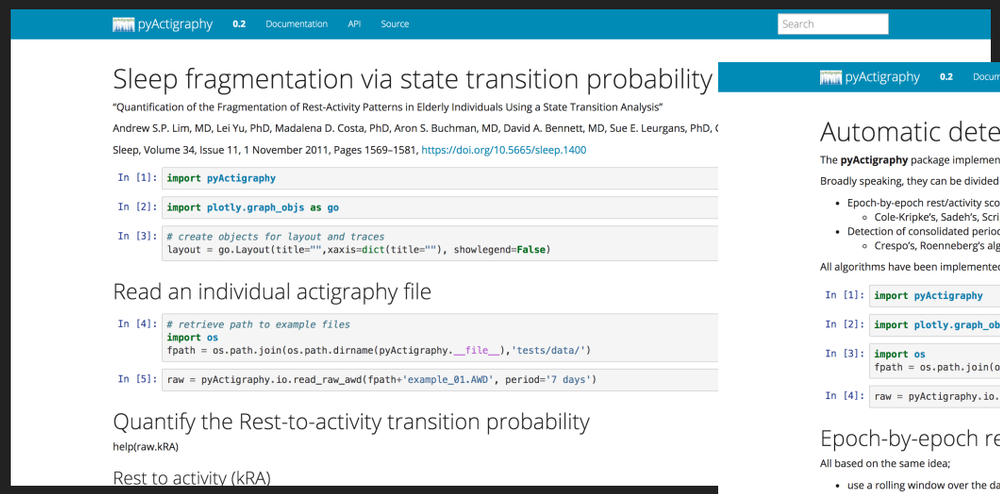


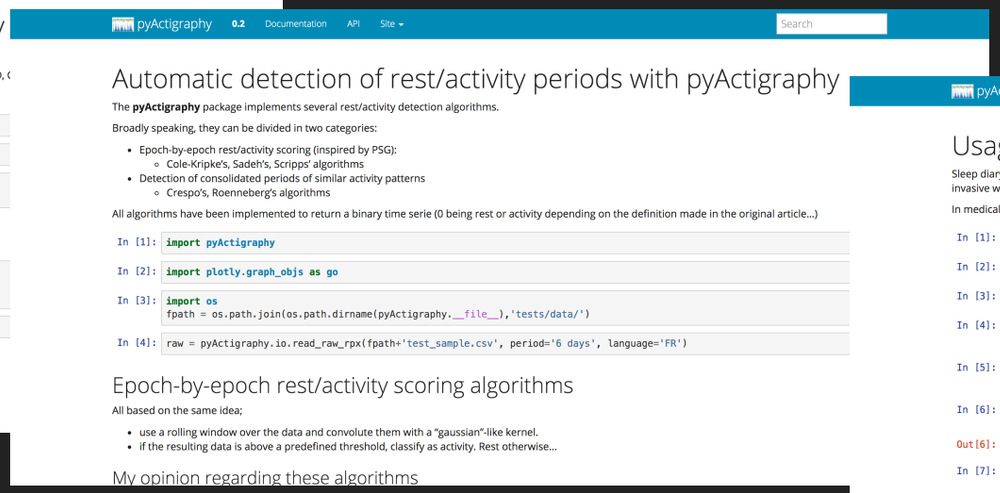
TAKE THE USER BY THE HAND…

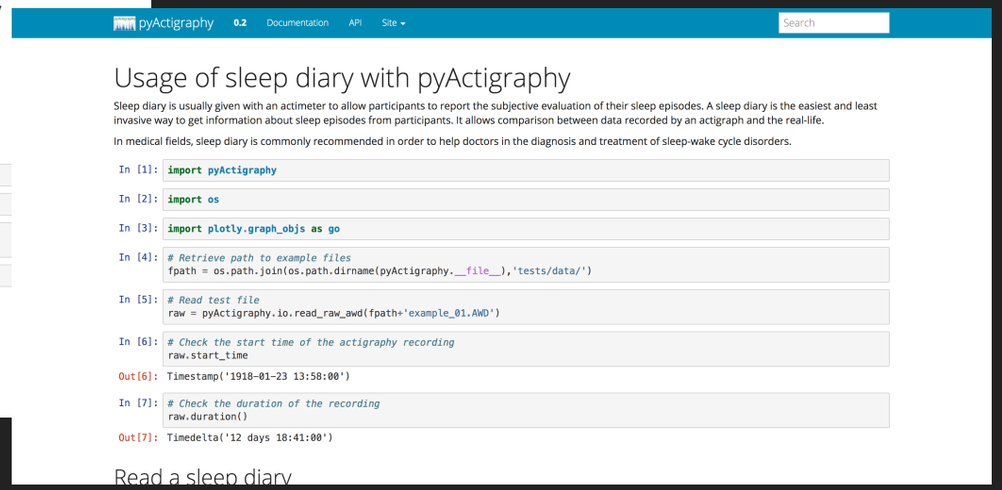
- Tutorials:
  - Available online: https://ghammad.github.io/pyActigraphy/documentation.html
  - Interactive and friendly
  - Covers the main functionalities











. . . BUT NOT TOO MUCH.

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- Jupyter notebooks

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- Jupyter notebooks
  - included in the package itself

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pyActigraphy 1.0 Tutorials API Source Search

Introduction to data masking with pyActigraphy

This introduction notebook illustrates how to mask potentially spurious inactivity periods.

First, load the pyActigraphy package:

In [1]:
```
import pyActigraphy
```

```
/usr/local/lib/python3.7/site-packages/statsmodels/tools/_testing.py:19: FutureWarning: pandas.util.testing is deprecated. Us
  import pandas.util.testing as tm
```

As well as your favourite plotting package:

In [2]:
```
import plotly.graph_objs as go
```

Read an individual actigraphy file

As an example, let's read a .awd file located in the test directory of the pyActigraphy package:

In [3]:
```
import os
fpath = os.path.join(os.path.dirname(pyActigraphy.__file__),'tests/data/')
```

In [4]:
```
raw = pyActigraphy.io.read_raw_awd(fpath+'example_01_mask.AWD')
```

Plot the data

In [5]:
```
layout = go.Layout(title="Actigraphy data", xaxis=dict(title="Date time"), yaxis=dict(title="Counts/period"), showlegend=Fals
```

In [6]:
```
go.Figure(data=go.Scatter(x=raw.data.index.astype(str), y=raw.data), layout=layout)
```

BUILD TRUST!

BUILD TRUST!

- Unit tests:

BUILD TRUST!

- Unit tests:
  - test if function output is conform to expectations

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- Unit tests:
  - test if function output is conform to expectations
  - Implemented using pytest
- Integrated in the Github CI/CD pipeline:

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- Unit tests:
  - test if function output is conform to expectations
  - Implemented using pytest
- Integrated in the Github CI/CD pipeline:
  - Run automatically when modifications are pushed on Github.

```
========================================================================== test session starts ==========================================================================
platform darwin -- Python 3.7.0, pytest-3.8.0, py-1.6.0, pluggy-0.7.1 -- /Users/ghammad/.virtualenvs/pyActigraphy/bin/python
cachedir: .pytest_cache
rootdir: /Users/ghammad/Work/CRC/pyActigraphy, inifile:
collected 51 items

pyActigraphy/tests/test_agd.py::test_instance_agd PASSED                                                                                                          [  1%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_name PASSED                                                                                                     [  3%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_uuid PASSED                                                                                                     [  5%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_start_time PASSED                                                                                               [  7%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_frequency_header PASSED                                                                                         [  9%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_data PASSED                                                                                                     [ 11%]
pyActigraphy/tests/test_agd.py::test_read_raw_agd_data_frequency PASSED                                                                                           [ 13%]
pyActigraphy/tests/test_atr.py::test_instance_atr PASSED                                                                                                          [ 15%]
pyActigraphy/tests/test_atr.py::test_read_raw_atr_name PASSED                                                                                                     [ 17%]
pyActigraphy/tests/test_atr.py::test_read_raw_atr_uuid PASSED                                                                                                     [ 19%]
pyActigraphy/tests/test_atr.py::test_read_raw_atr_start_time PASSED                                                                                               [ 21%]
pyActigraphy/tests/test_atr.py::test_read_raw_atr_data PASSED                                                                                                     [ 23%]
pyActigraphy/tests/test_awd.py::test_instance_awd PASSED                                                                                                          [ 25%]
pyActigraphy/tests/test_awd.py::test_read_raw_awd_name PASSED                                                                                                     [ 27%]
pyActigraphy/tests/test_awd.py::test_read_raw_awd_uuid PASSED                                                                                                     [ 29%]
pyActigraphy/tests/test_awd.py::test_read_raw_awd_start_time PASSED                                                                                               [ 31%]
pyActigraphy/tests/test_awd.py::test_read_raw_awd_data PASSED                                                                                                     [ 33%]
pyActigraphy/tests/test_dqt.py::test_instance_dqt PASSED                                                                                                          [ 35%]
pyActigraphy/tests/test_dqt.py::test_read_raw_dqt_name PASSED                                                                                                     [ 37%]
pyActigraphy/tests/test_dqt.py::test_read_raw_dqt_uuid PASSED                                                                                                     [ 39%]
pyActigraphy/tests/test_dqt.py::test_read_raw_dqt_start_time PASSED                                                                                               [ 41%]
pyActigraphy/tests/test_dqt.py::test_read_raw_dqt_duration PASSED                                                                                                 [ 43%]
pyActigraphy/tests/test_dqt.py::test_read_raw_dqt_length PASSED                                                                                                   [ 45%]
pyActigraphy/tests/test_kra.py::test_kra_sequences PASSED                                                                                                         [ 47%]
pyActigraphy/tests/test_kra.py::test_kra_logit PASSED                                                                                                             [ 49%]
pyActigraphy/tests/test_kra.py::test_kar_sequences PASSED                                                                                                         [ 50%]
```

DO NOT LET USERS IN THE DARK

DO NOT LET USERS IN THE DARK

- Code documentation:

DO NOT LET USERS IN THE DARK

- Code documentation:
  - Implemented using Sphinx:

```python
    def IS(self, freq='1H', binarize=True, threshold=4):
        r"""Interdaily stability

        The Interdaily stability (IS) quantifies the repeatibilty of the
        daily rest-activity pattern over each day contained in the activity
        recording.

        Parameters
        ----------
        freq: str, optional
            Data resampling `frequency string
            <https://pandas.pydata.org/pandas-docs/stable/timeseries.html>`_.
            Default is '1H'.
        binarize: bool, optional
            If set to True, the data are binarized.
            Default is True.
        threshold: int, optional
            If binarize is set to True, data above this threshold are set to 1
            and to 0 otherwise.
            Default is 4.

        Returns
        -------
        is: float


        Notes
        -----

        This variable is defined in ref [1]_:

        .. math::

            IS = \frac{d^{24h}}{d^{1h}}

        with:
```

DO NOT LET USERS IN THE DARK

- Code documentation:
  - Implemented using Sphinx:
    - from reStructuredText sources included in the source code…

```
818     def IS(self, freq='1H', binarize=True, threshold=4):
819         r"""Interdaily stability
820
821         The Interdaily stability (IS) quantifies the repeatibilty of the
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823         recording.
824
825         Parameters
826         ----------
827         freq: str, optional
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844         Notes
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851             IS = \frac{d^{24h}}{d^{1h}}
852
853         with:
```

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- Code documentation:
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    - from reStructuredText sources included in the source code…
    - … to HTML pages, hosted on Github (gh-pages)

```
818     def IS(self, freq='1H', binarize=True, threshold=4):
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842
843
844         Notes
845         -----
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847         This variable is defined in ref [1]_:
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849         .. math::
850
851             IS = \frac{d^{24h}}{d^{1h}}
852
853         with:
```

pyActigraphy 1.0 Tutorials API Source Search

pyActigraphy.metrics.MetricsMixin.IS

MetricsMixin. **IS** (*freq='1H', binarize=True, threshold=4*) [source]

Interdaily stability

The Interdaily stability (IS) quantifies the repeatibilty of the daily rest-activity pattern over each day contained in the activity recording.

Parameters:
- **freq** (*str, optional*) – Data resampling frequency string. Default is '1H'.
- **binarize** (*bool, optional*) – If set to True, the data are binarized. Default is True.
- **threshold** (*int, optional*) – If binarize is set to True, data above this threshold are set to 1 and to 0 otherwise. Default is 4.

Returns: is
Return type: float

Notes

This variable is defined in ref [1]:

$$IS = \frac{d^{24h}}{d^{1h}}$$

with:

$$d^{1h} = \sum_{i}^{n} \frac{(x_i - \bar{x})^2}{n}$$

where x_i is the number of active (counts higher than a predefined threshold) minutes during the ith period, $\bar{x}$ is the mean of all data and n is the number of periods covered by the actigraphy data and with:

$$d^{24h} = \sum_{i}^{p} \frac{(\bar{x}_{h,i} - \bar{x})^2}{p}$$

where $\bar{x}^{h,i}$ is the average number of active minutes over the ith period and p is the number of periods per day. The average runs over all the days.

For the record, tt is the 24h value from the chi-square periodogram (Sokolove and Bushel1 1978).

References

[1] Witting W., Kwa I.H., Eikelenboom P., Mirmiran M., Swaab D.F. Alterations in the circadian rest–activity rhythm in aging and Alzheimer's disease. Biol Psychiatry. 1990;27:563–572.

Examples

```
>>> import pyActigraphy
>>> rawAWD = pyActigraphy.io.read_raw_awd(fpath + 'SUBJECT_01.AWD')
>>> rawAWD.IS()
0.6900175913031027
>>> rawAWD.IS(freq='30min', binarize=True, threshold=4)
0.6245582891144925
>>> rawAWD.IS(freq='1H', binarize=False)
0.5257020914453097
```

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Guest blogger: Grégory Hammad, Ir, PhD GIGA-CRC in vivo imaging, University of Liège, Liège, Belgium, Chair of Neurogenetics, Faculty of Medicine, Technical University of Munich, Munich, Germany

PyActigraphy is an open-source Python software for actigraphy and light data analysis. Keep reading

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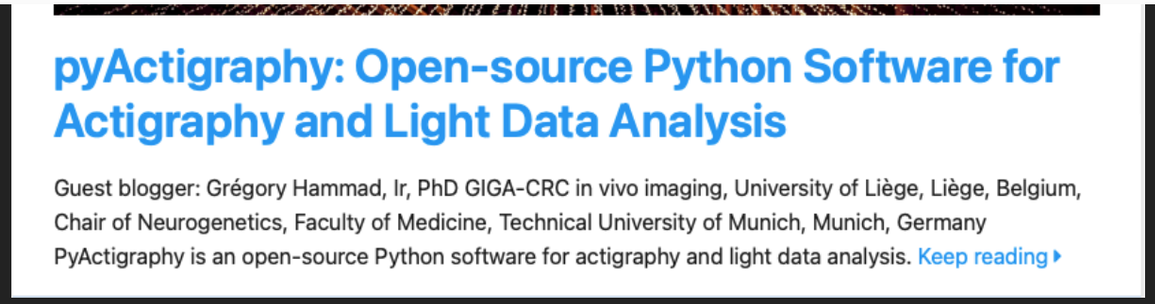
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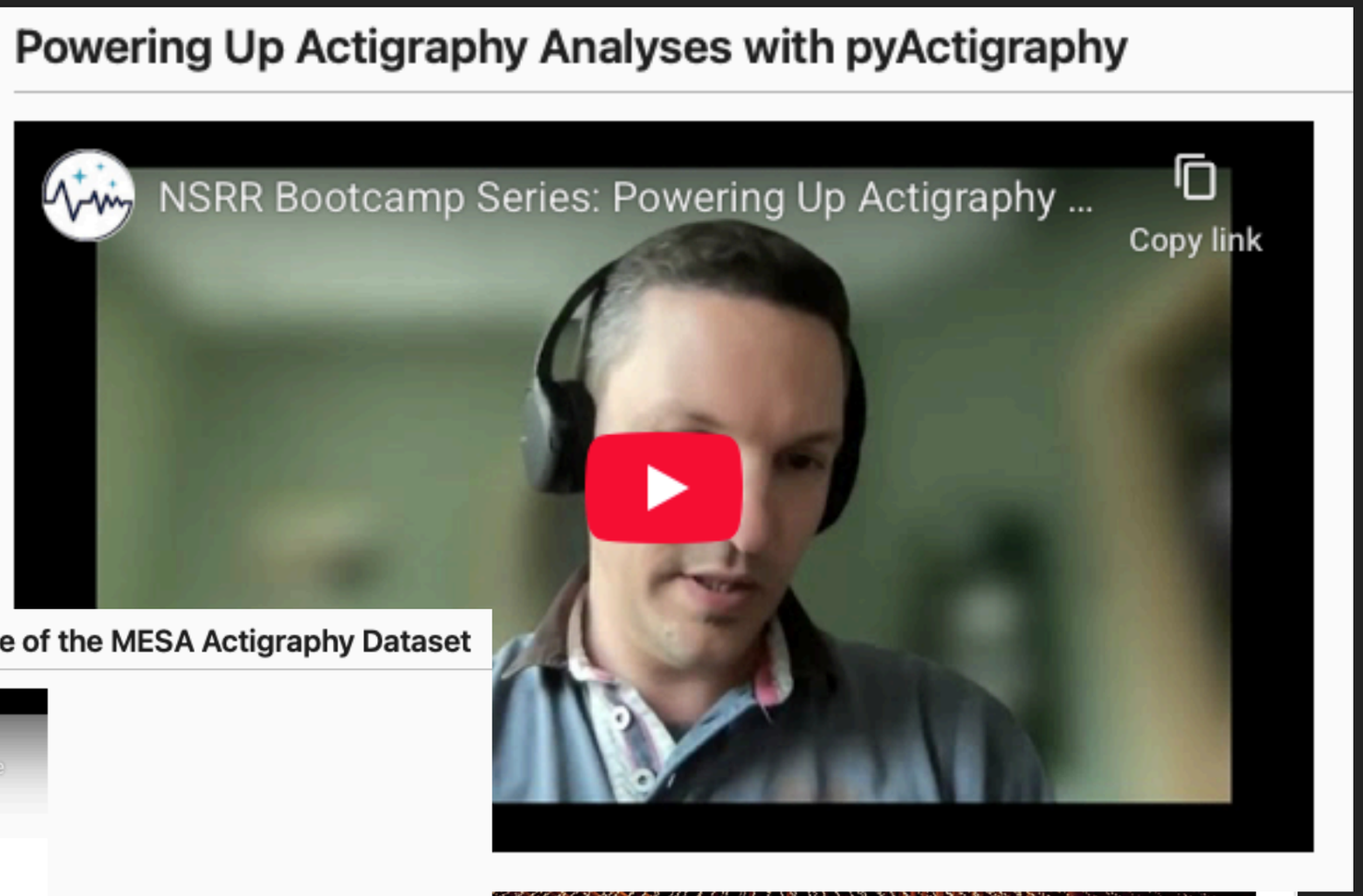
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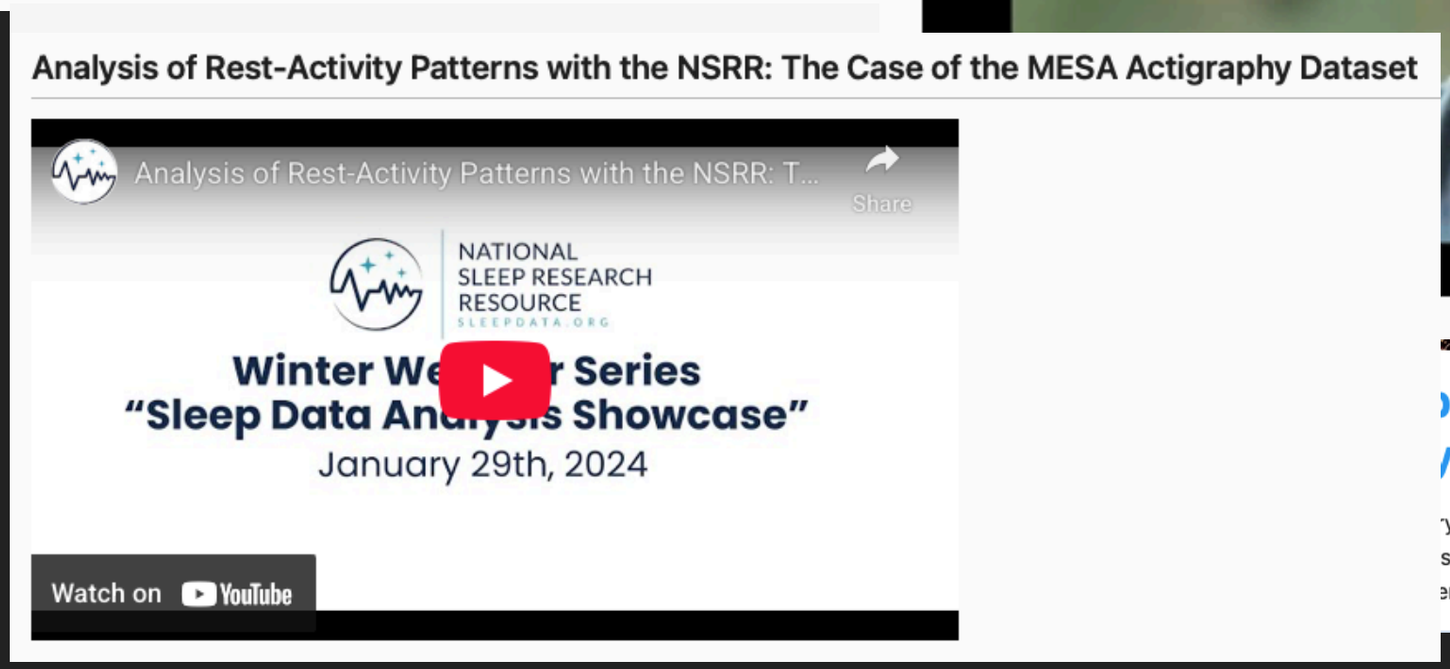
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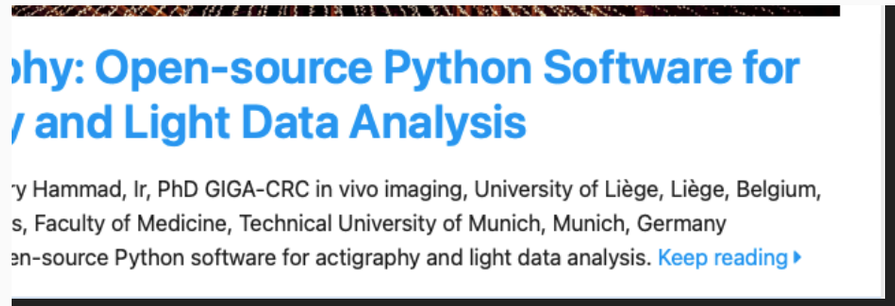
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WEALTH OF OPEN DATA

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WEALTH OF OPEN DATA

OPEN SOFTWARES?

DATA BANKING IS HAPPENING!

WEALTH OF OPEN DATA  OPEN SOFTWARES?

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THANK YOU ALL!

Special thanks to:

- Eva Winnebeck (University of Surrey, Guildford) for advices, data&code sharing on the LIDS
- Andrew Lim (Sunnybrook Research Institute, Toronto) for sharing his code on state-transition probability

gregory.hammad@uliege.be - GIGA-CRC - ULiège

IS THE JOURNEY OVER?

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How do we sustain openness?

THANK YOU.
QUESTIONS?

gregory.hammad@uliege.be - GIGA-CRC - ULiège

WHAT IS SHARING?

WHAT IS SHARING?

- And what it is not…

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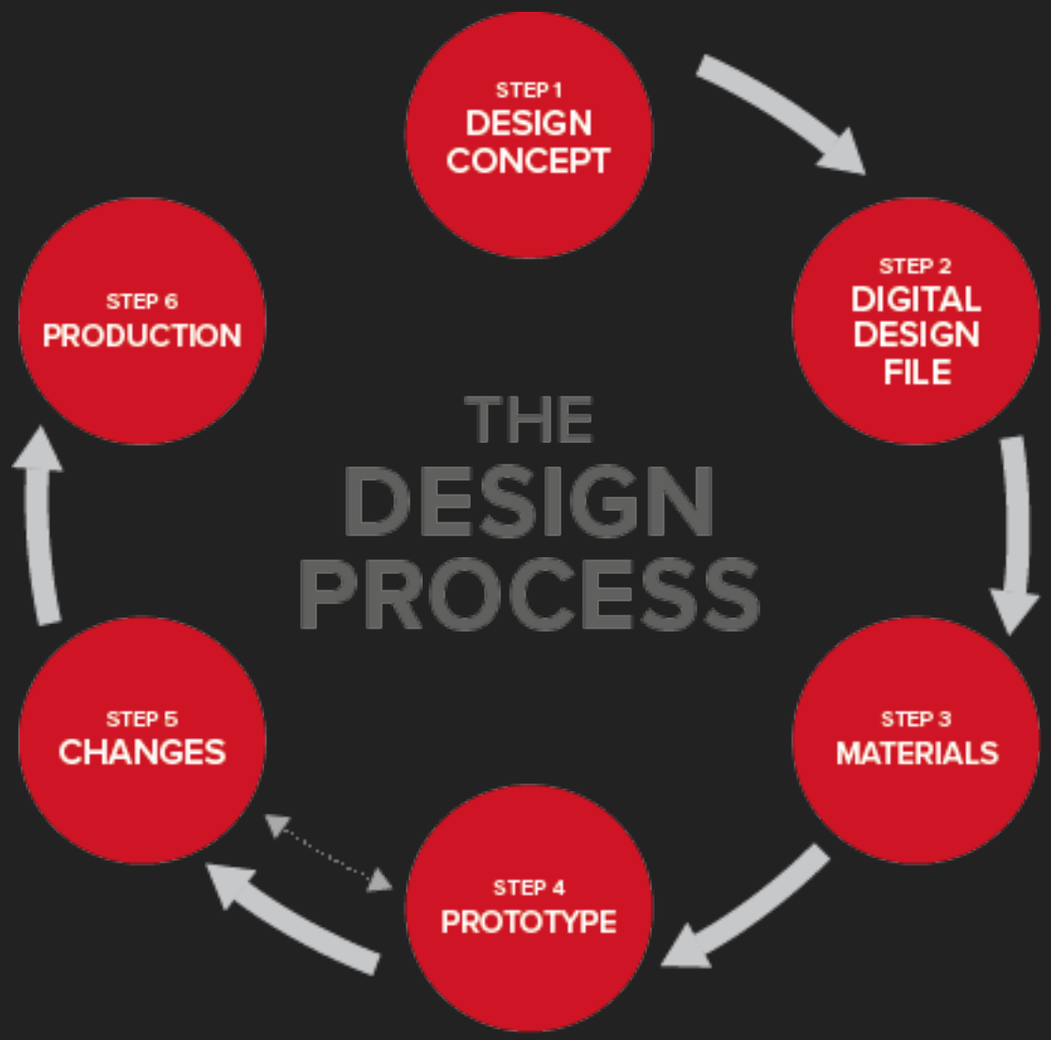

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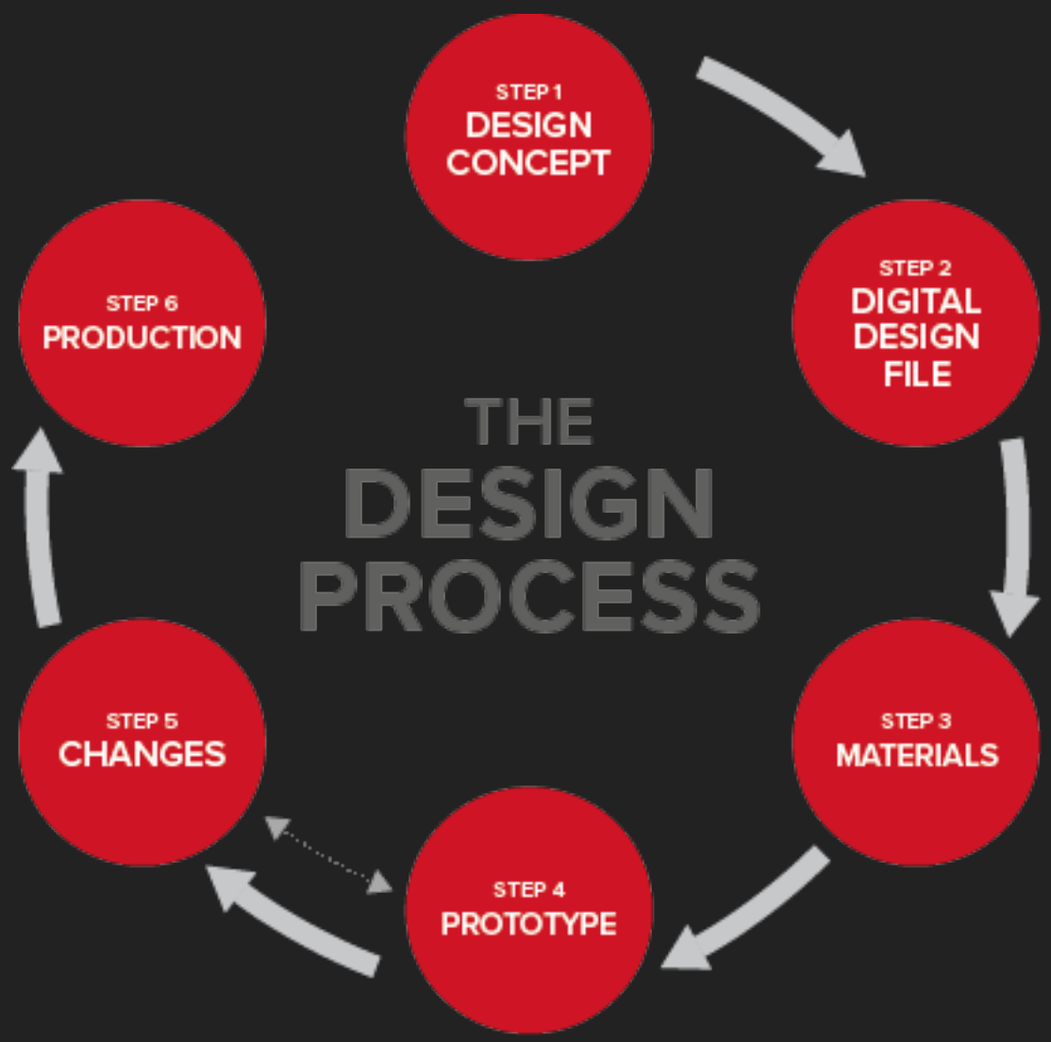

Hum…

Where is the documentation?

CONTEXT: RESEARCH LAB ACTIVITIES

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- Use of actigraphy in a Sleep and Chronobiology lab:

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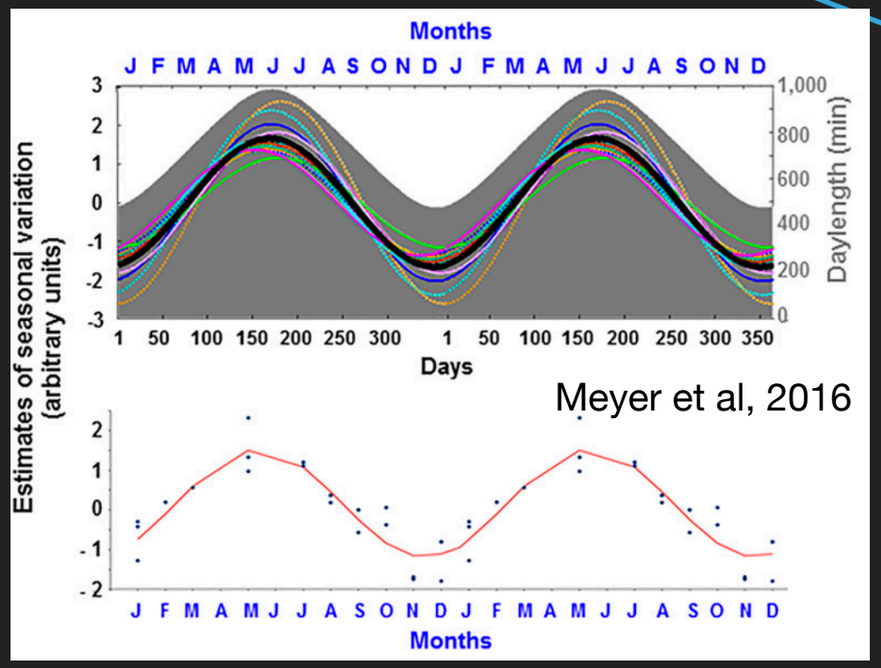
- Use of actigraphy in a Sleep and Chronobiology lab:

From circannual….

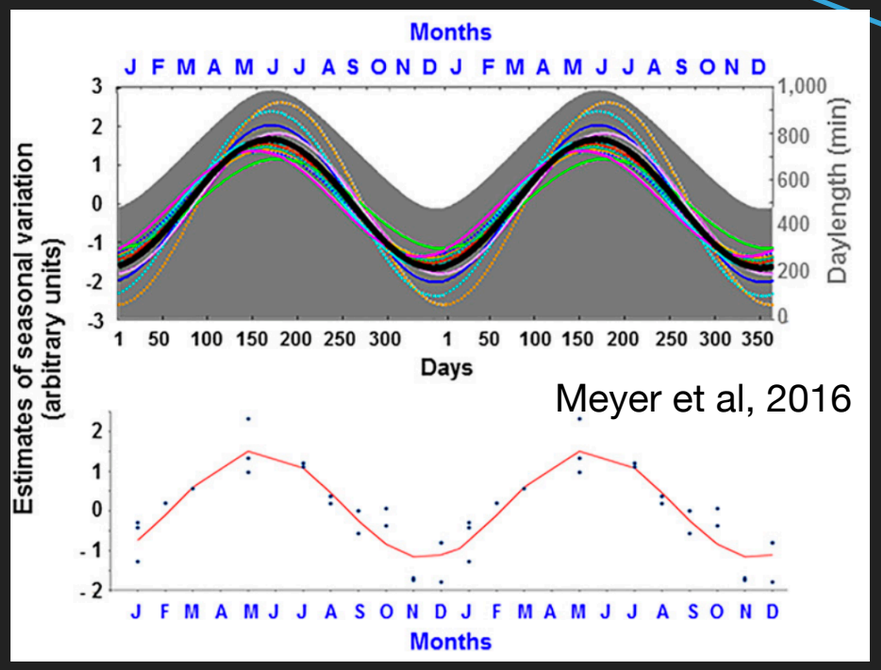


Meyer et al, 2016

CONTEXT: RESEARCH LAB ACTIVITIES

- Use of actigraphy in a Sleep and Chronobiology lab:

From circannual….



Meyer et al, 2016

Original Articles

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Christina Schmidt, Fabienne Collette, Christian Cajochen & Philippe Peigneux

Pages 755-789 | Received 05 Dec 2006, Accepted 16 Oct 2007, Published online: 05 Dec 2007

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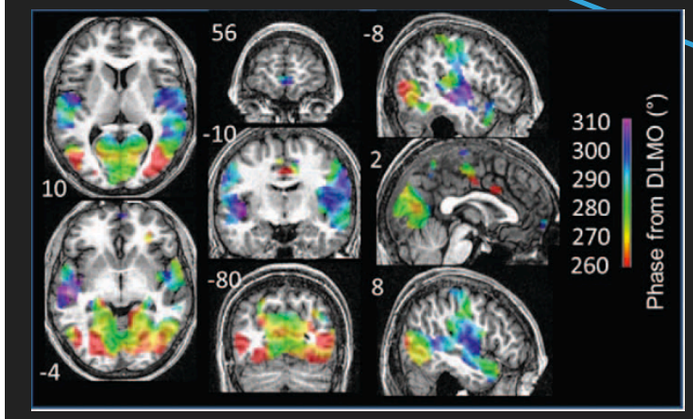

Muto et al, 2016

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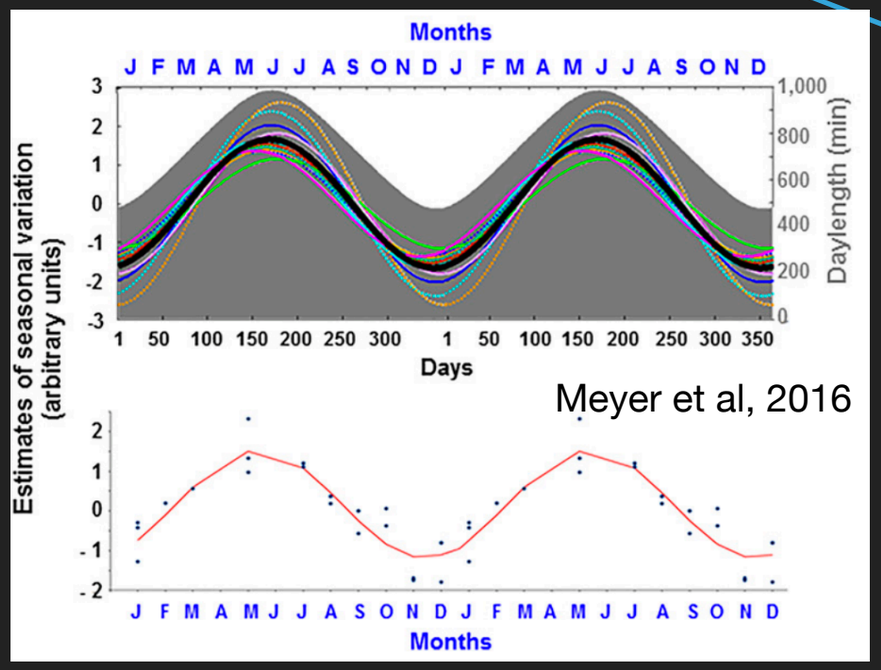
CONTEXT: RESEARCH LAB ACTIVITIES

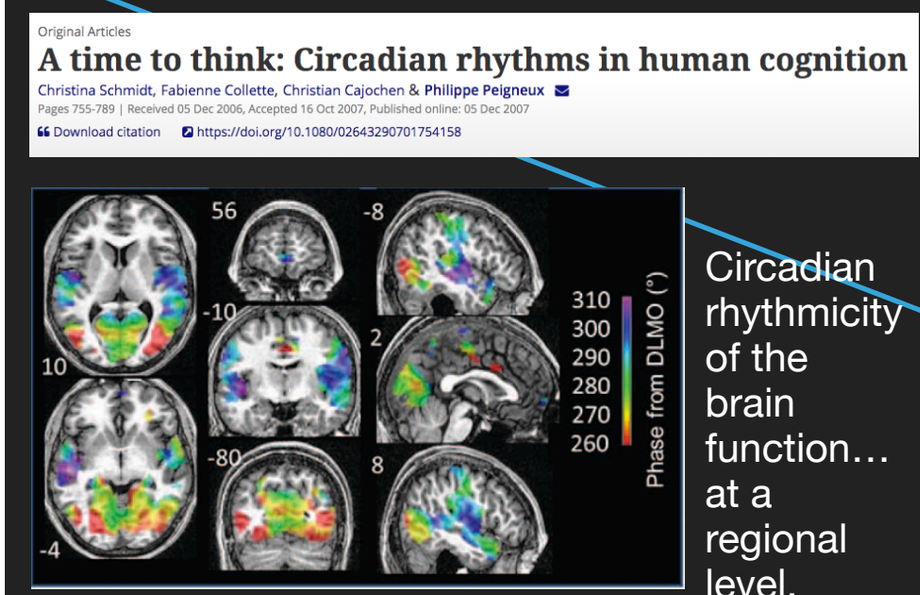
- Use of actigraphy in a Sleep and Chronobiology lab:

… to circadian rhythms…

From circannual….



Meyer et al, 2016



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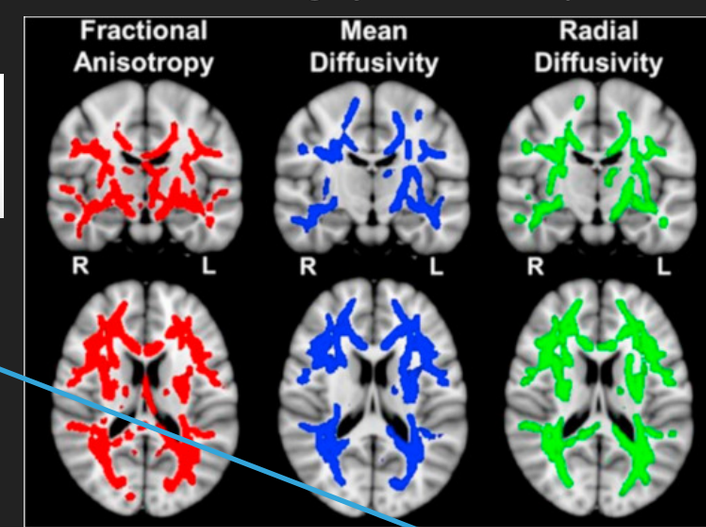

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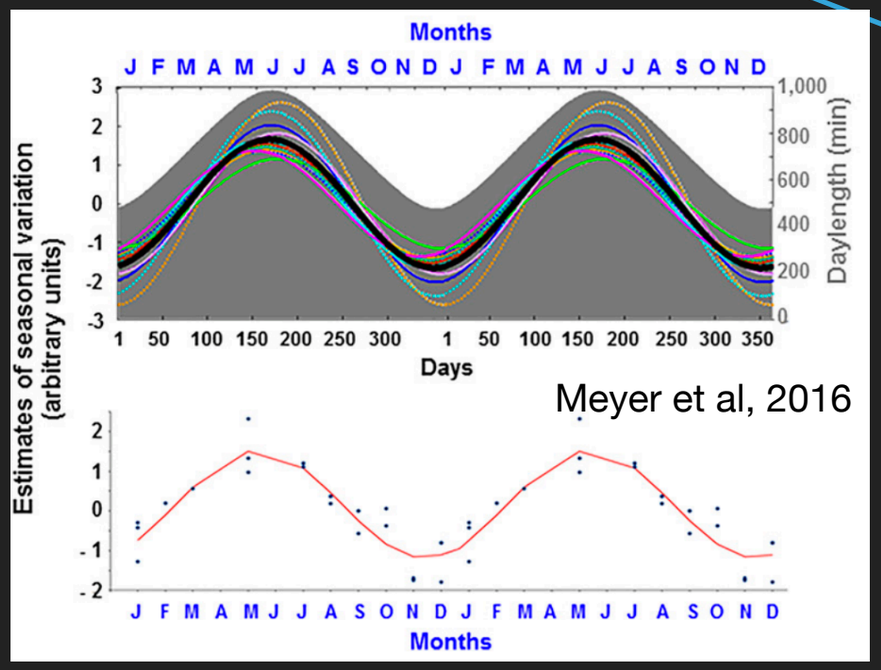

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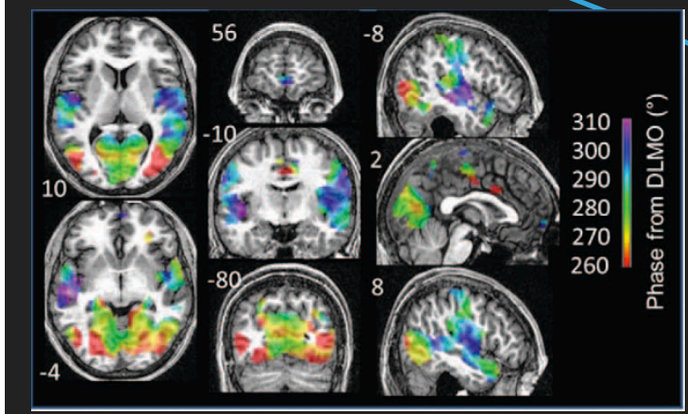

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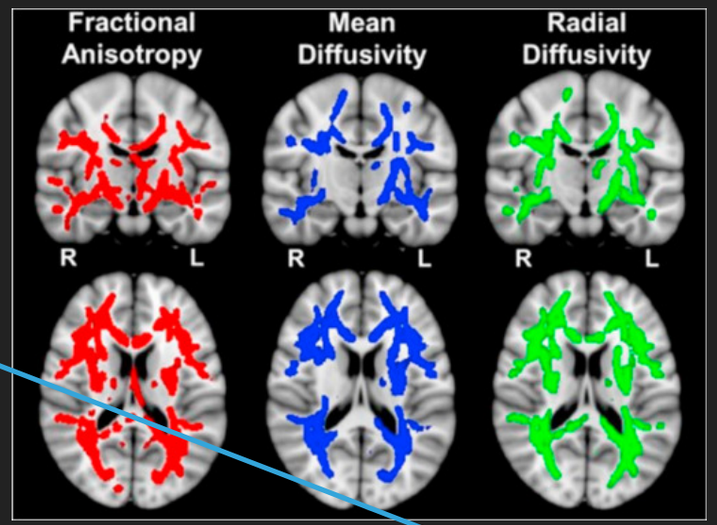

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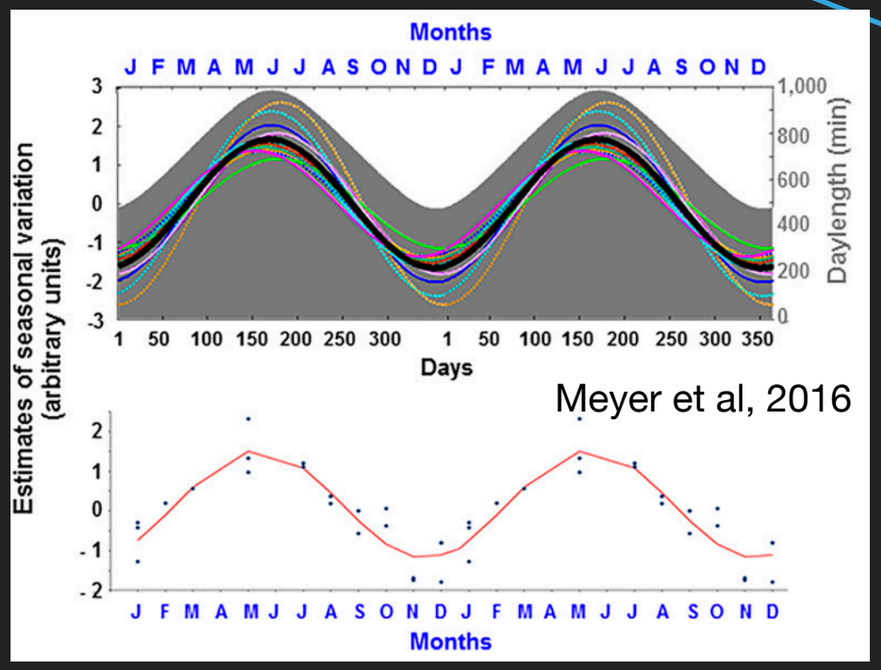

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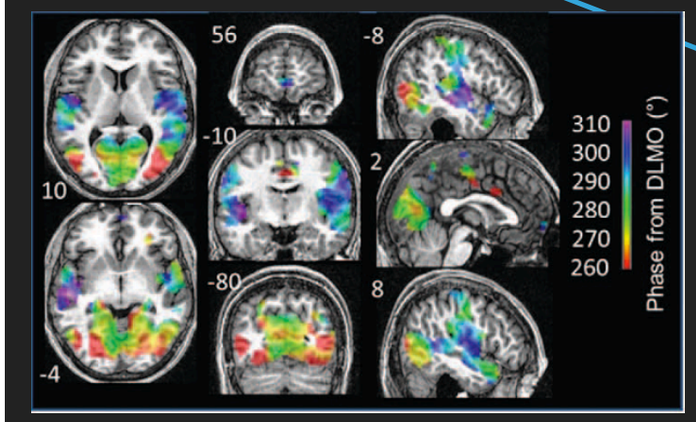

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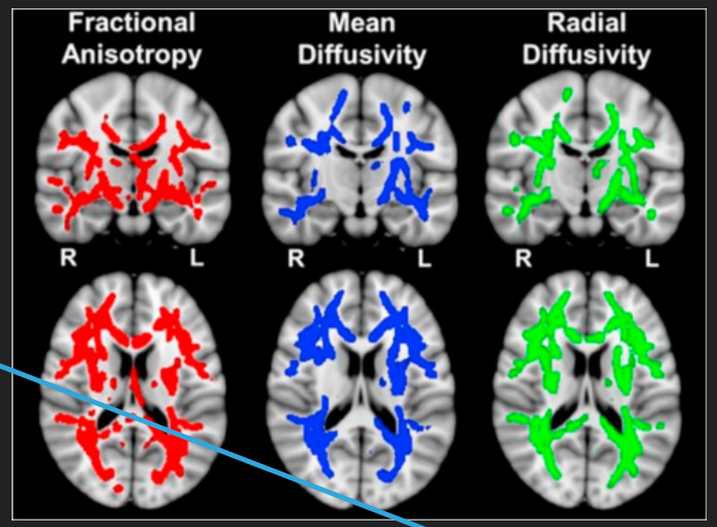

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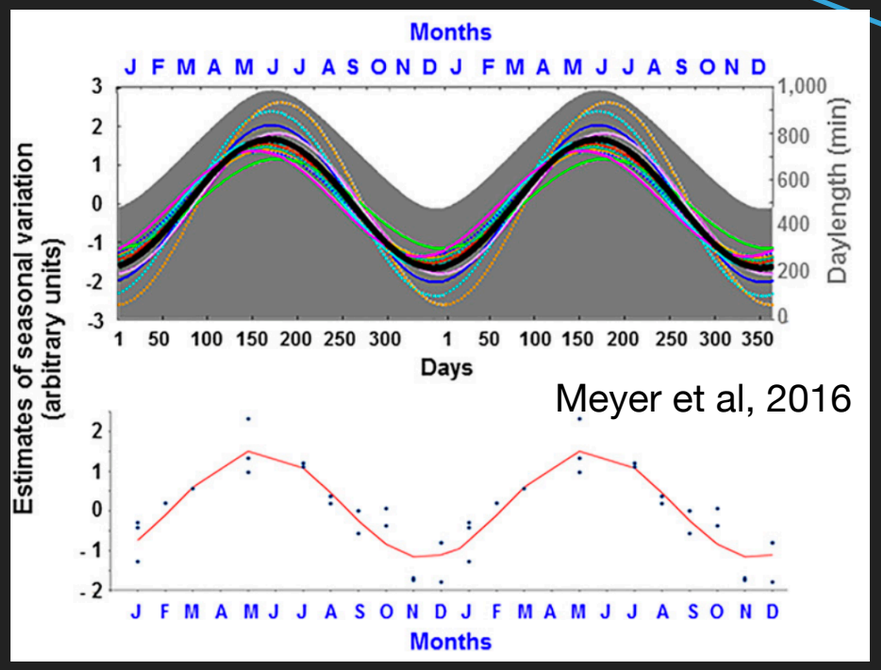

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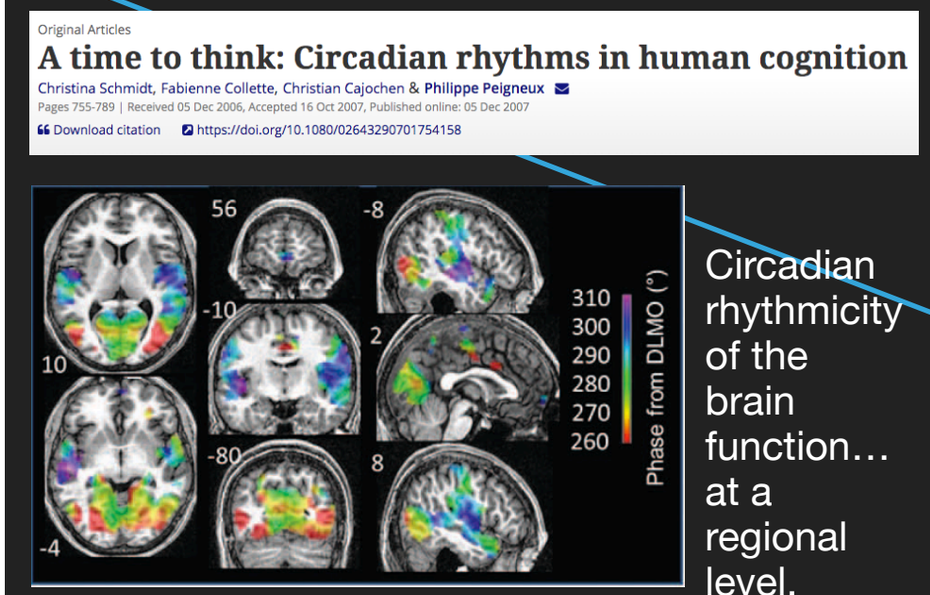

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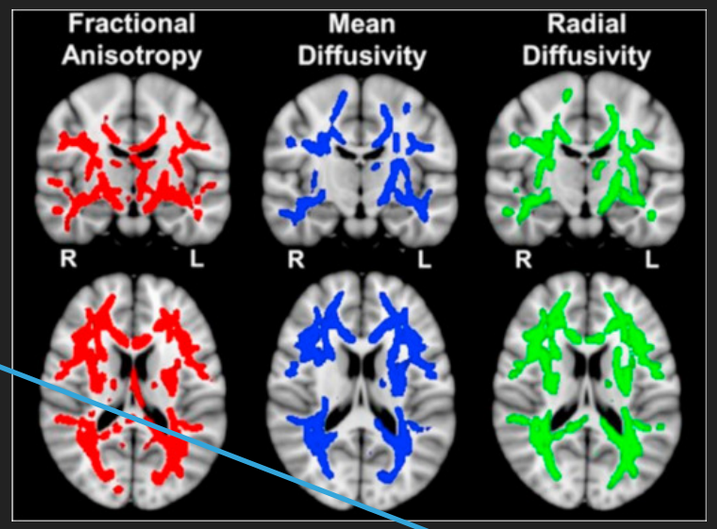

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… to ultradian rhythms!

- Confounding factors (cognition, brain structure/response, sleep architecture)
- System dynamics (complexity, fractality, etc)

CONTEXT: RESEARCH LAB ACTIVITIES

Personal view

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- Use of actigraphy in a Sleep and Chronobiology lab:

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  - Underused / (un)reused …

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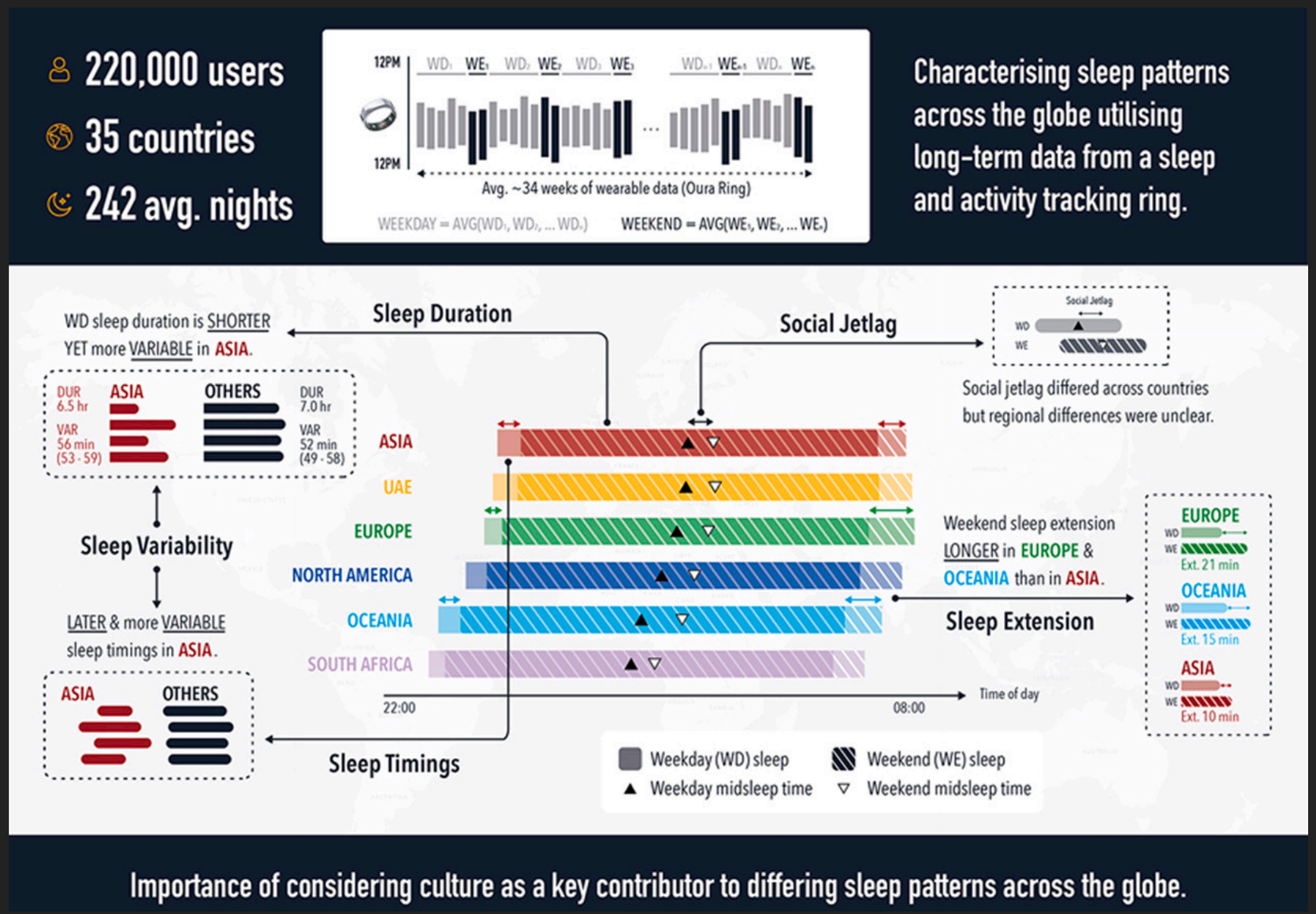
This motivated the development of an open-source toolbox !

FROM SLEEP AT LARGE…



Willoughby et al., 2023

FROM SLEEP AT LARGE…

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Article | Open access | Published: 05 April 2019

Genetic studies of accelerometer-based sleep measures yield new insights into human sleep behaviour

Samuel E. Jones, Vincent T. van Hees, Diego R. Mazzotti, Pedro Marques-Vidal, Séverine Sabia, Ashley van der Spek, Hassan S. Dashti, Jorgen Engmann, Desana Kocevska, Jessica Tyrrell, Robin N. Beaumont, Melvyn Hillsdon, Katherine S. Ruth, Marcus A. Tuke, Hanieh Yaghootkar, Seth A. Sharp, Yingjie Ji, Jamie W. Harrison, Rachel M. Freathy, Anna Murray, Annemarie I. Luik, Najaf Amin, Jacqueline M. Lane, Richa Saxena, … Andrew R. Wood + Show authors

Nature Communications **10**, Article number: 1585 (2019) | Cite this article

Abstract

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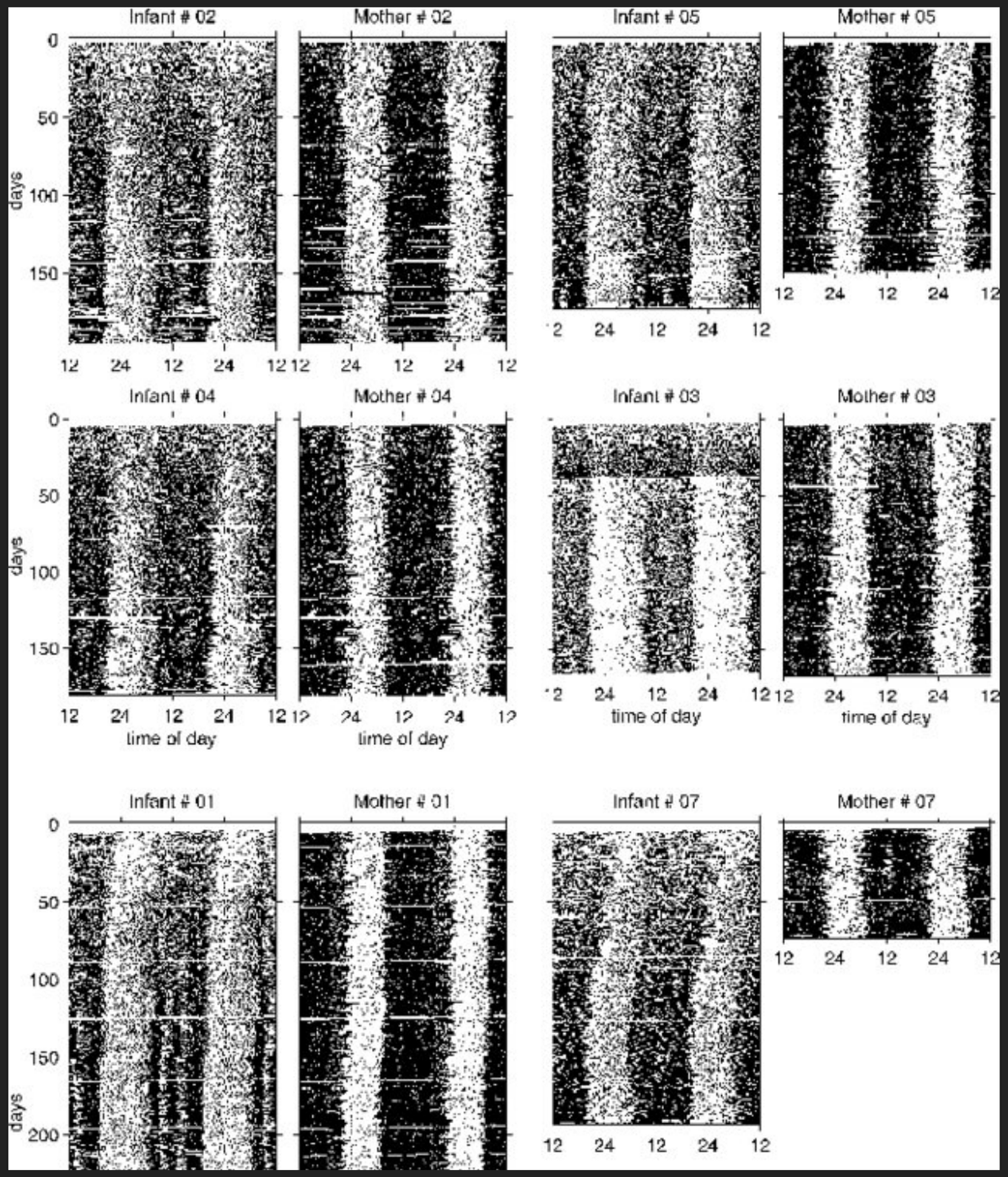

Jenni et al., 2006