



Accelting

Advancing movement & sleep research

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GGIR training: Session 2

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BEFORE WE START

- Focus of this course
- Questions
- Slides + Documentation + Example data:
<https://www.accelting.com/ggir-training-materials/>

Day 1: questions?

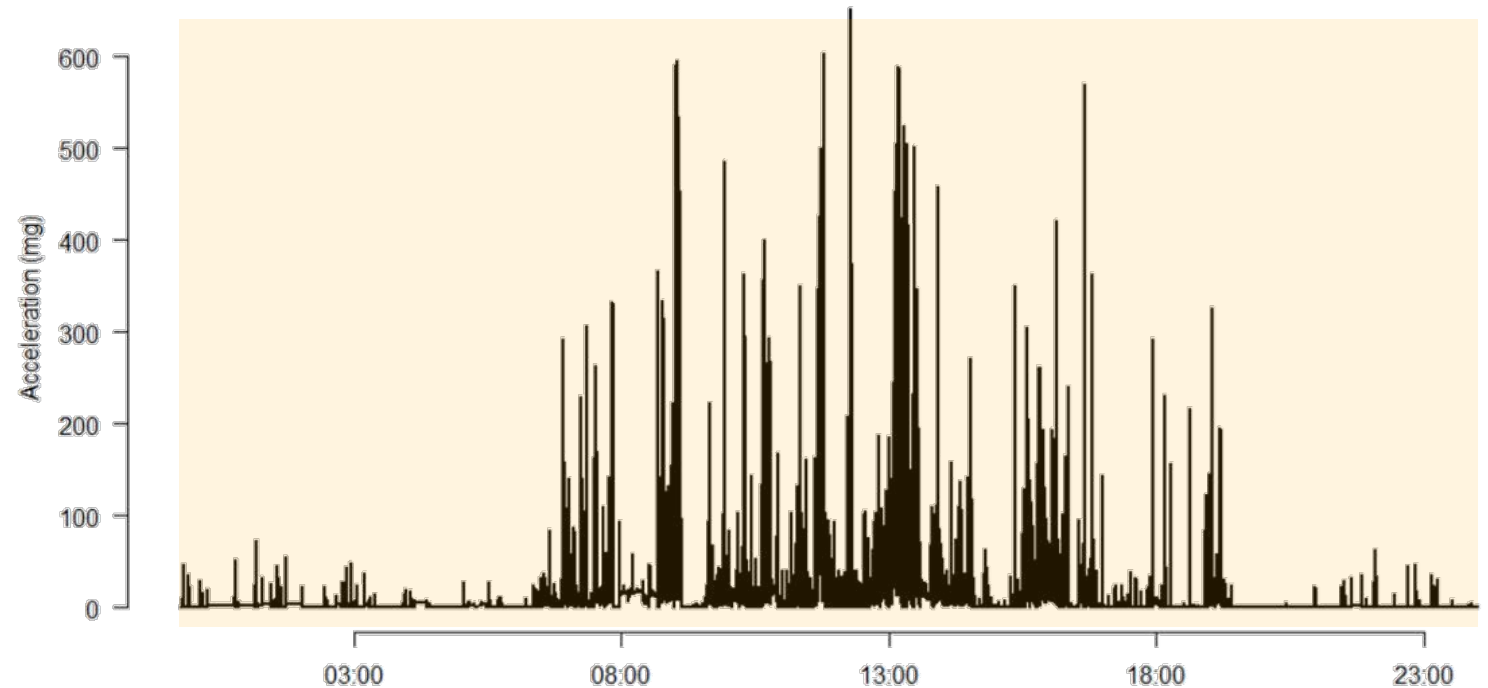


Day segment analysis

The argument **qwindow**

Numeric or character (default = c(0, 24)).

```
GGIR(  
  [...]  
  qwindow = c(0, 24),  
  [...])
```

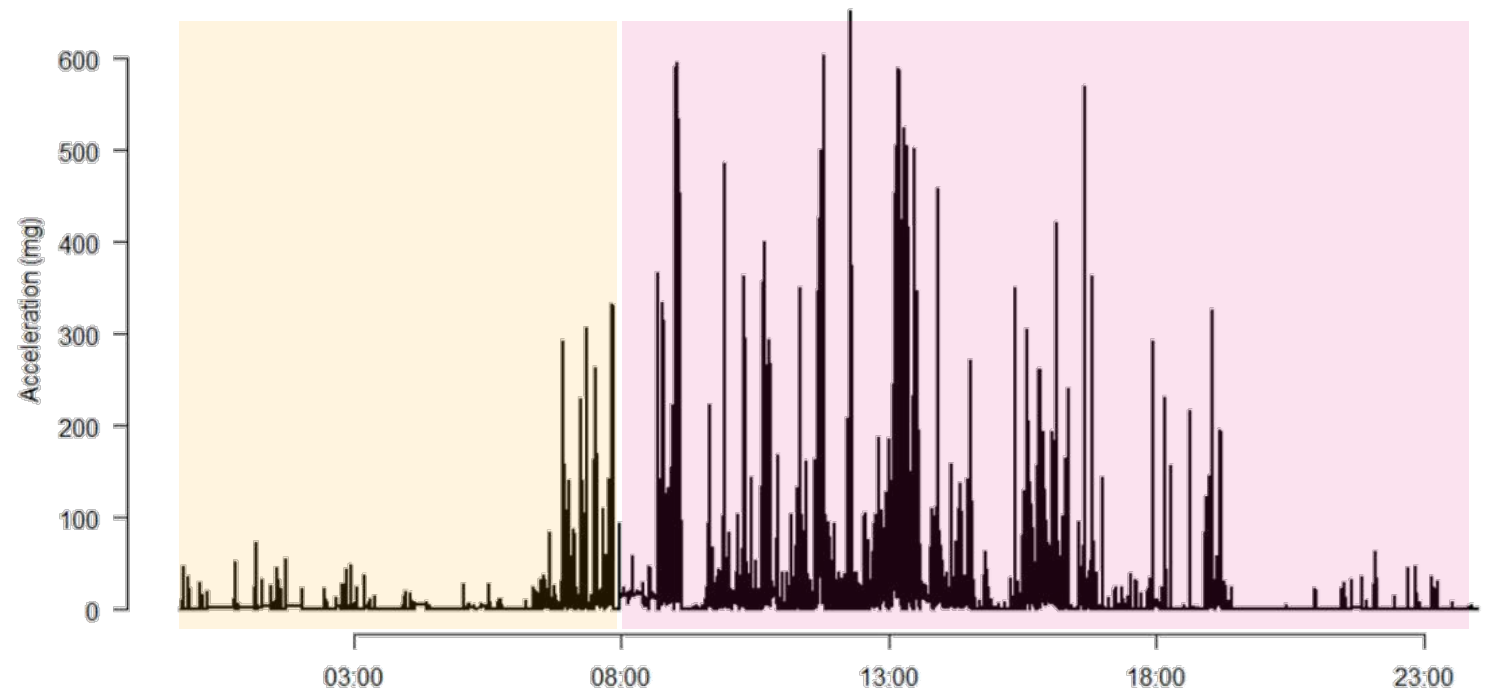


Day segment analysis

The argument **qwindow**

Numeric or character (default = c(0, 24)).

```
GGIR(  
  [...]  
  qwindow = c(0, 8, 24),  
  [...])
```



Day segment analysis

The argument **qwindow**

Numeric or **character**.

If you want to use a day specific segmentation, then you can set qwindow to be the **full path to activity diary file (csv file)**.

```
GGIR(  
  [...]  
  qwindow = "C:/mystudy/activitylog.csv",  
  [...])
```

ID	Date	PE_1	PE_2	Date	PE_1	PE_2
ID01	20-01-2022	09:00:00	10:00:00	21-01-2022		
ID02	22-01-2022	11:30:00	12:30:00	23-01-2022	09:00:00	10:00:00
ID03	02-02-2022			03-02-2022	10:00:00	11:00:00
ID04	15-01-2022	09:00:00	10:00:00	16-01-2022		
ID05	04-02-2022			05-02-2022	11:30:00	12:30:00

Will only get the 24h indicators

Learning goals for this session

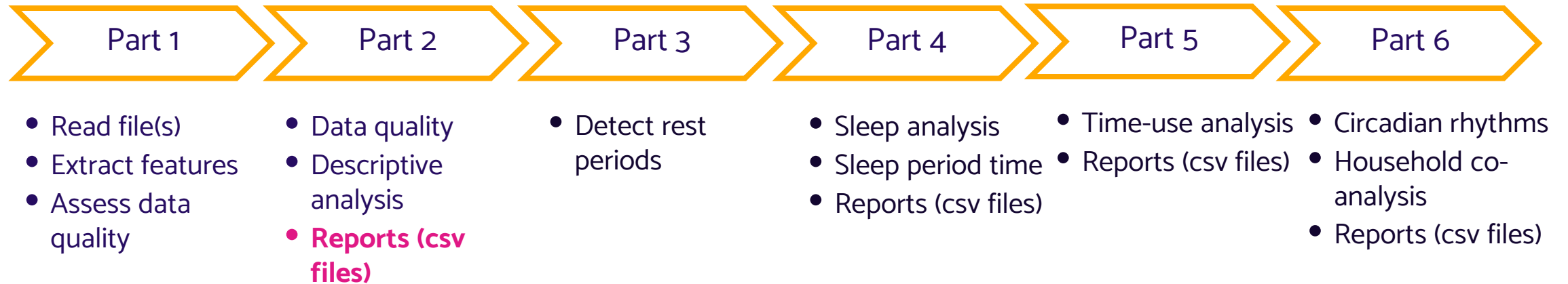
- Understand the Part 2 Output.
- Learn about basics of sleep detection with GGIR:
 - Understand how it works
 - Know how to use it yourself



Part 2 Output



The GGIR pipeline



For documentation of all variable names see:

<https://wadpac.github.io/GGIR/articles/GGIRoutput.html#ggir-part-2>

Part 2

Output

- meta
 - csv
 - ID01.csv
 - ...
- results
 - QC
 - data_quality_report.csv
 - plot_to_check_data_quality.pdf
 - part2_daysummary.csv
 - part2_daysummary_longformat.csv
 - part2_summary.csv

Part 2

Output

- meta
 - csv
 - ID01.csv
 - ...
- results
 - QC
 - data_quality_report.csv
 - plot_to_check_data_quality.pdf
 - **part2_dayssummary.csv**
 - **part2_dayssummary_longformat.csv**
 - part2_summary.csv

Output from Part 2

Note: Are all values in the first Excel column? Check out GGIR parameters `sep_reports` and `dec_reports`

Day-level features (wide)

`do.report = 2`

part2_daysummary.csv

ID	filename	calendar_date	N valid hours	N hours	weekday	measurementday	qwindow_timestamps	qwindow_names
11	011_45400.cwa	2019-03-28T00:00:00+0100	24	24	Wednesday	2	0_8_24	0_8_24
11	011_45400.cwa	2019-03-29T00:00:00+0100	24	24	Thursday	3	0_8_24	0_8_24
11	011_45400.cwa	2019-03-30T00:00:00+0100	24	24	Friday	4	0_8_24	0_8_24
11	011_45400.cwa	2019-03-31T00:00:00+0100	23	24	Saturday	5	0_8_24	0_8_24
11	011_45400.cwa	2019-03-31T00:00:00+0100	10	24	Sunday	6	0_8_24	0_8_24

Output from Part 2

Day-level features (wide)

do.report = 2

```
GGIR(  
  [...]  
  # Data cleaning  
  includedaycrit = 16,  
  [...])
```

part2_daysummary.csv

ID	filename	calendar_date	N valid hours	N hours	weekday	Measurement day
11	011_45400.cwa	2019-03-28T00:00:00+0100	24	24	Wednesday	2
11	011_45400.cwa	2019-03-29T00:00:00+0100	24	24	Thursday	3
11	011_45400.cwa	2019-03-30T00:00:00+0100	24	24	Friday	4
11	011_45400.cwa	2019-03-31T00:00:00+0100	23	24	Saturday	5
11	011_45400.cwa	2019-03-31T00:00:00+0100	10	24	Sunday	6


Output from Part 2

Day-level features (wide)

`do.report = 2`

Only if qwindow is defined, e.g.
`qwindow = c(0, 8, 24)`

`part2_daysummary.csv`



ID	Measurement day	qwindow_ timestamps	mean_ENMO_ mg_0-24hr	MVPA_E5S_T100_ ENMO_0-24hr	mean_ENMO_ mg_0-8hr	MVPA_E5S_T100_ ENMO_0-8hr	mean_ENMO_ mg_8-24hr	MVPA_E5S_T100_ ENMO_8-24hr
11	2	0_8_24	50.297	146.833	5.368	2.167	72.762	144.667
11	3	0_8_24	16.099	51.833	4.024	3.417	22.136	48.417
11	4	0_8_24	38.232	170.417	7.903	8.5	53.396	161.917
11	5	0_8_24	15.085	41.25	7.393	4.167	18.932	37.083
11	6	0_8_24						

Output from Part 2

Day-level features (long)

Only if qwindow is defined, e.g.
qwindow = c(0, 8, 24)

do.report = 2

part2_daysummary_longformat.csv

ID	filename	calendar_date	N_valid_hours	N_hours	N_valid_hours_in_window	N_hours_in_window	weekday	measurement_day	qwindow_timestamps	qwindow_name
11	011_45400.cwa	2019-03-28T00:00:00+0100	24	24	8	8	Wednesday	2	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-29T00:00:00+0100	24	24	8	8	Thursday	3	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-30T00:00:00+0100	24	24	8	8	Friday	4	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-31T00:00:00+0100	23	23	8	8	Saturday	5	00:00-8:00	0-8hr
11	011_45400.cwa	2019-03-28T00:00:00+0100	24	24	16	16	Wednesday	2	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-29T00:00:00+0100	24	24	16	16	Thursday	3	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-30T00:00:00+0100	24	24	16	16	Friday	4	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-31T00:00:00+0100	23	23	15	15	Saturday	5	08:00-24:00	8-24hr
11	011_45400.cwa	2019-03-28T00:00:00+0100	24	24			Wednesday	2	00:00-24:00	0-24hr
11	011_45400.cwa	2019-03-29T00:00:00+0100	24	24			Thursday	3	00:00-24:00	0-24hr
11	011_45400.cwa	2019-03-30T00:00:00+0100	24	24			Friday	4	00:00-24:00	0-24hr
11	011_45400.cwa	2019-03-31T00:00:00+0100	23	23			Saturday	5	00:00-24:00	0-24hr

Output from Part 2

Note: There is no `part2_summary_longformat.csv` regardless of whether `qwindow` is used.

Person-level features

`do.report = 2`

`part2_summary.csv`

ID	device_sn	bodylocation	filename	start_time	startday	samplefreq	device	meas_dur_dys
11	45400	not extracted	011_45400.cwa	2019-03-27T00:00:00+0100	Tuesday	50	axivity	6.99

All days

ID	N valid WEdays	N valid WKdays	AD_mean_ENMO_mg_0-24hr	AD_mean_ENMO_mg_0-8hr	AD_mean_ENMO_mg_8-24hr
11	2	5	28.809	6.222	40.102

Only if `qwindow` is defined, e.g. `qwindow = c(0, 8, 24)`

Weekdays

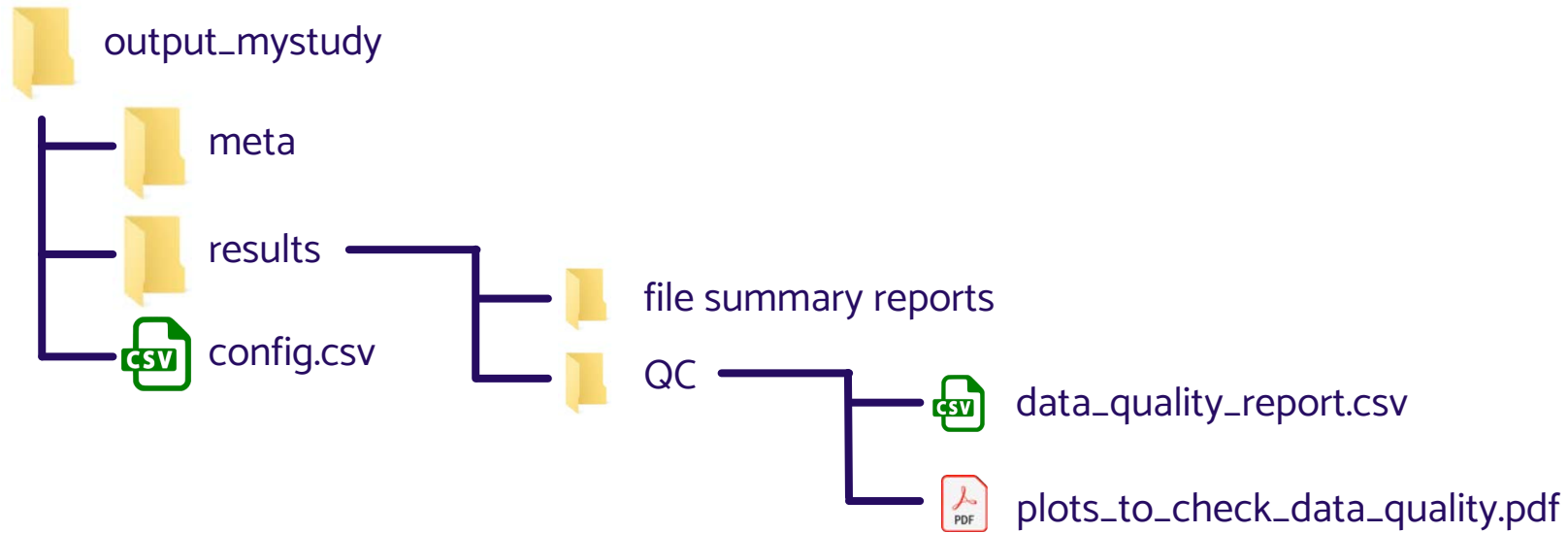
ID	N valid WEdays	N valid WKdays	WD_mean_ENMO_mg_0-24hr	WD_mean_ENMO_mg_0-8hr	WD_mean_ENMO_mg_8-24hr
11	2	5	33.197	5.471	47.06

Weekend days

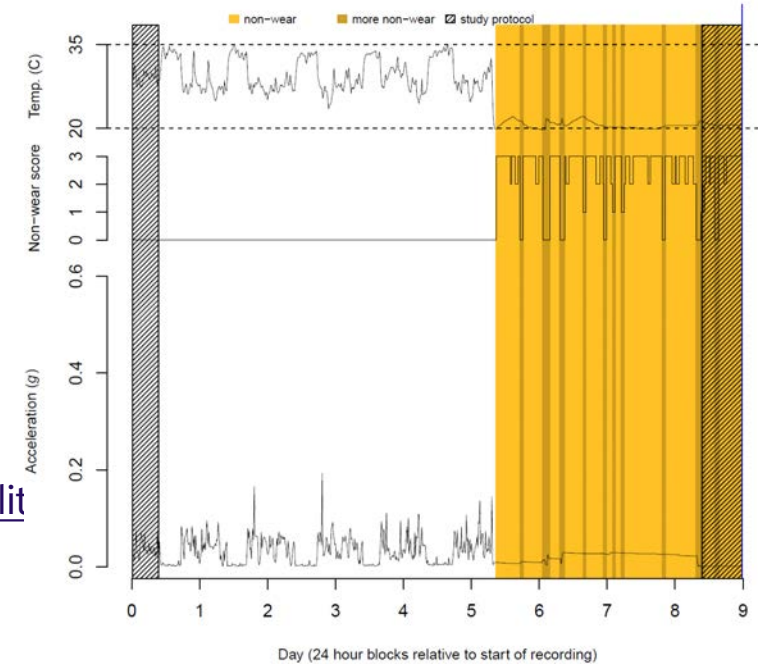
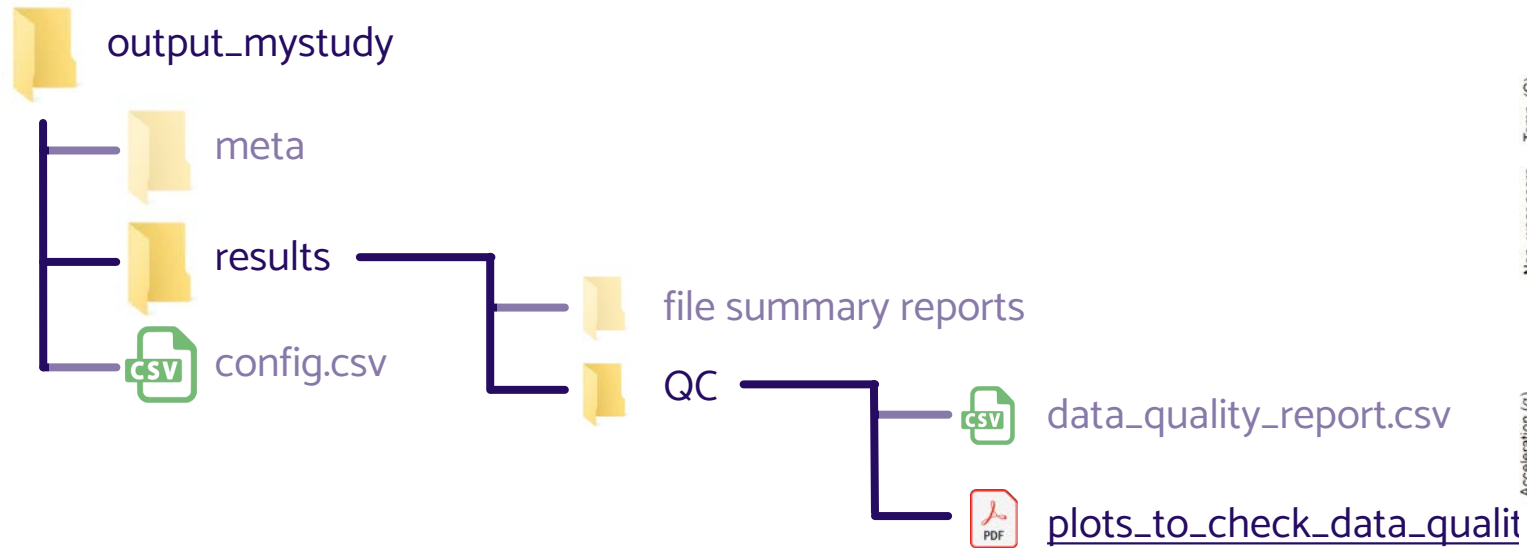
ID	N valid WEdays	N valid WKdays	WE_mean_ENMO_mg_0-24hr	WE_mean_ENMO_mg_0-8hr	WE_mean_ENMO_mg_8-24hr
11	2	5	17.838	8.099	22.707

AD_ = all days
WD_ = weekdays
WE_ = weekend days
WWD_ = weighted weekdays
WWE_ = weighted weekend days

The GGIR pipeline (output folder)



The GGIR pipeline (output folder)



Output from Part 2

Epoch-level features

`epochvalues2csv = TRUE` *# default = FALSE!!*

output_axivity > meta > csv		
<input type="checkbox"/> Name	Status	Date modified
<input checked="" type="checkbox"/> 011_45400_cwa.cwa.RData.csv	🔄	6/2/2022 9:46 AM
<input checked="" type="checkbox"/> 013_42151_cwa.cwa.RData.csv	✅	6/2/2022 9:46 AM
<input checked="" type="checkbox"/> 015_44944_cwa.cwa.RData.csv	✅	6/2/2022 9:46 AM
<input checked="" type="checkbox"/> 017_42151_cwa.cwa.RData.csv	✅	6/2/2022 9:46 AM

Signal metrics only!

For time series of sleep and bout classification, see GGIR part 5 (as discussed on day 4)

	A	B	C
1	timestamp	anglez	ENMO
2	2019-03-27T00:00:00+0100	-25.347	0.0022
3	2019-03-27T00:00:05+0100	-25.3816	0.0017
4	2019-03-27T00:00:10+0100	-25.342	0.0025
5	2019-03-27T00:00:15+0100	-24.8968	0.0027
6	2019-03-27T00:00:20+0100	-25.3328	0.0027
7	2019-03-27T00:00:25+0100	-25.4124	0.0024
8	2019-03-27T00:00:30+0100	-25.2169	0.002
9	2019-03-27T00:00:35+0100	-25.7494	0.0023
10	2019-03-27T00:00:40+0100	-25.5495	0.0024
11	2019-03-27T00:00:45+0100	-26.3225	0.0021
12	2019-03-27T00:00:50+0100	-25.4574	0.0022
13	2019-03-27T00:00:55+0100	-25.2172	0.0028
14	2019-03-27T00:01:00+0100	-24.6724	0.0025
15	2019-03-27T00:01:05+0100	-25.0957	0.0023
16	2019-03-27T00:01:10+0100	-24.5152	0.0026
17	2019-03-27T00:01:15+0100	-24.996	0.0033
18	2019-03-27T00:01:20+0100	-26.0688	0.0019
19	2019-03-27T00:01:25+0100	-25.278	0.0028
20	2019-03-27T00:01:30+0100	-25.5993	0.0023
21	2019-03-27T00:01:35+0100	-25.8586	0.0024



Sleep & accelerometers

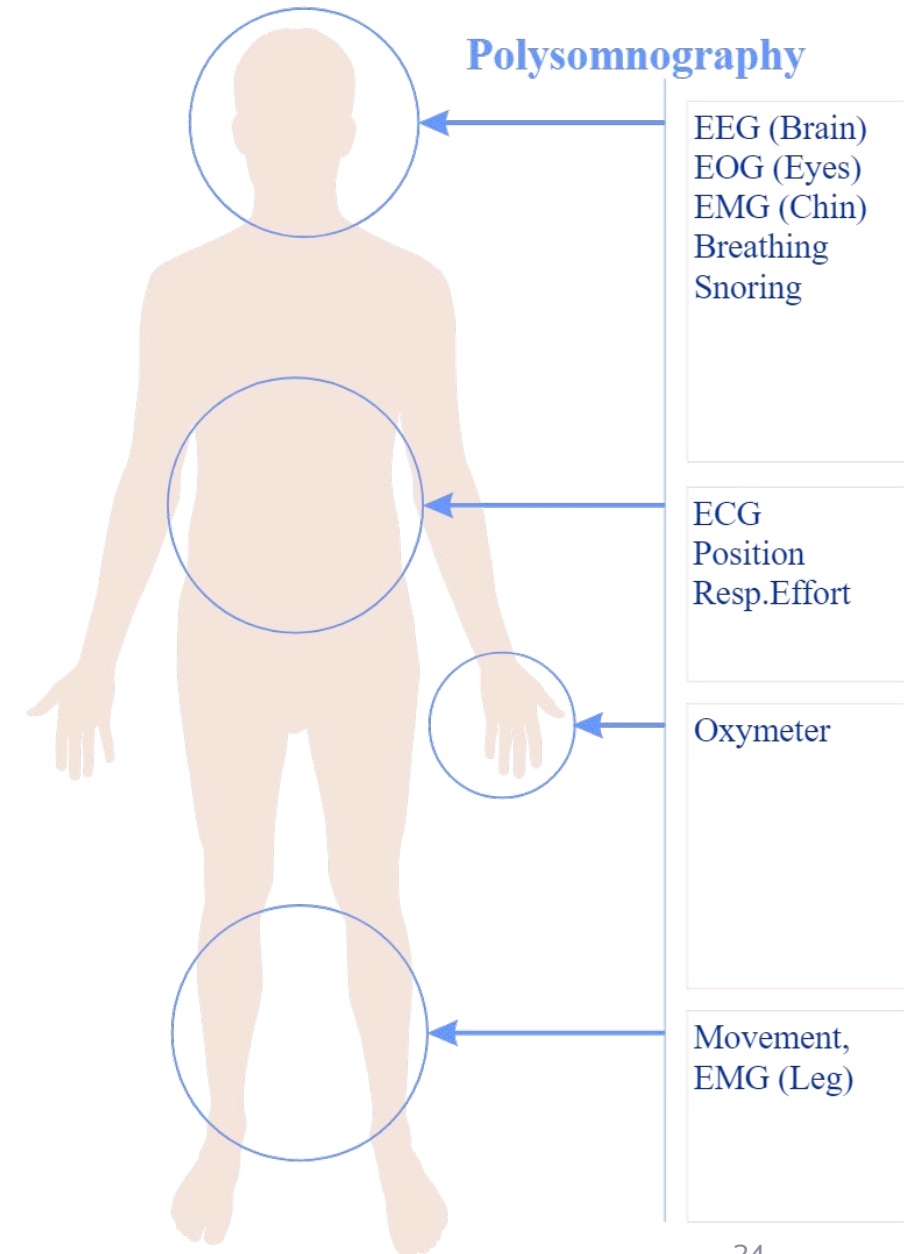


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Polysomnography

Lab-based

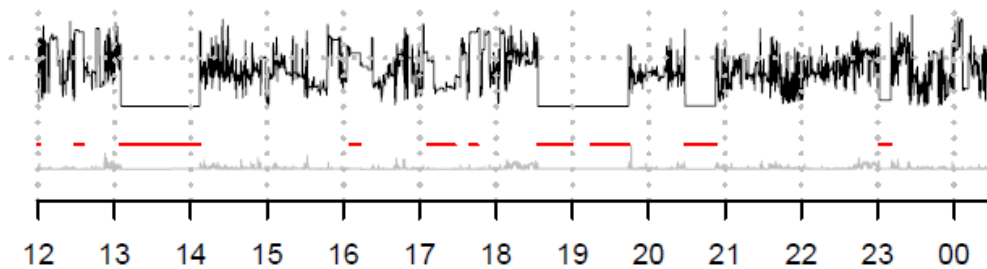
- Reference method for sleep assessment
- Combination of monitors:
 - EEG
 - Heart rate
 - Gases exchange
 - Blood oxygen levels
 - Others
- Specialist go over the signal and classify 30-sec epochs into **sleep stages**



Accelerometer-based sleep assessment

Free living

- **Challenge 1:** distinguish sleep, wake, and non-wear

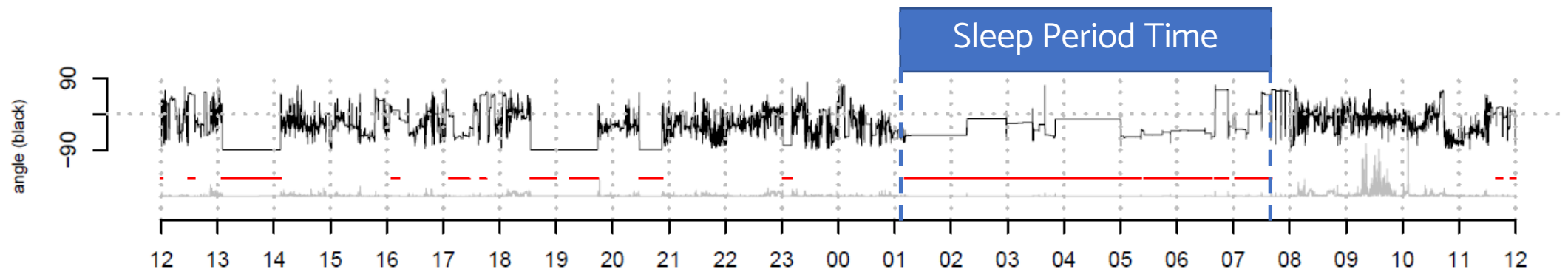


- Term: Sustained Inactivity Bout, abbreviated as SIB

Accelerometer-based sleep assessment

Free living

- **Challenge 2:** separate daytime and nighttime (**Sleep Period Time**)



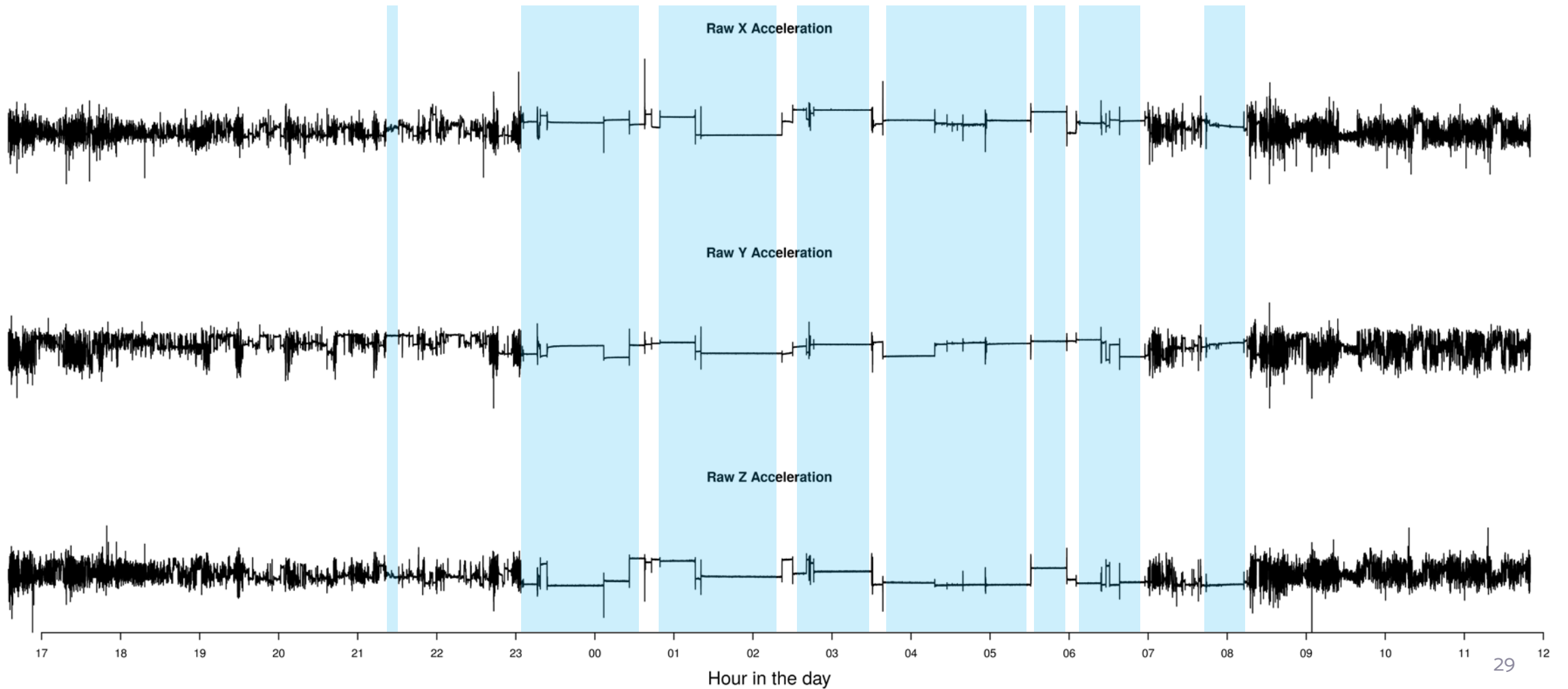
Challenge 1: wake/rest



The GGIR pipeline



Rest/Wake detection



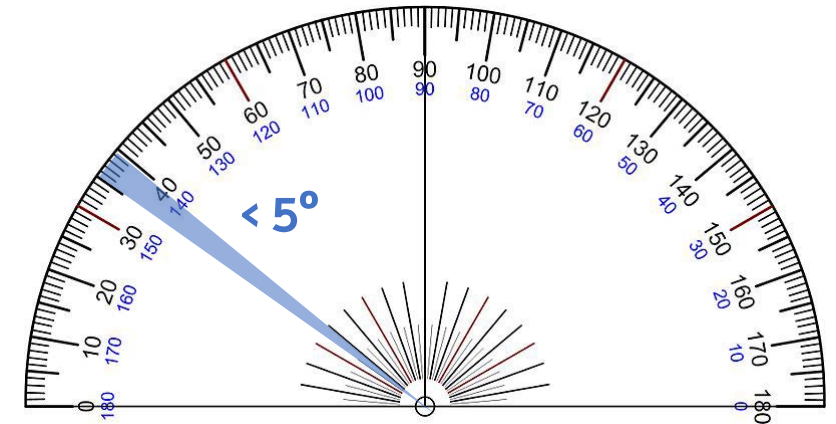
vanHees2015

- Interpretable as lack of posture change and lack of movement, regardless of agreement with neurological sleep
- Angle is a more visual concept than magnitude of acceleration

Angle of z-axis (independent of attachment orientation across brands)



> 5 minutes

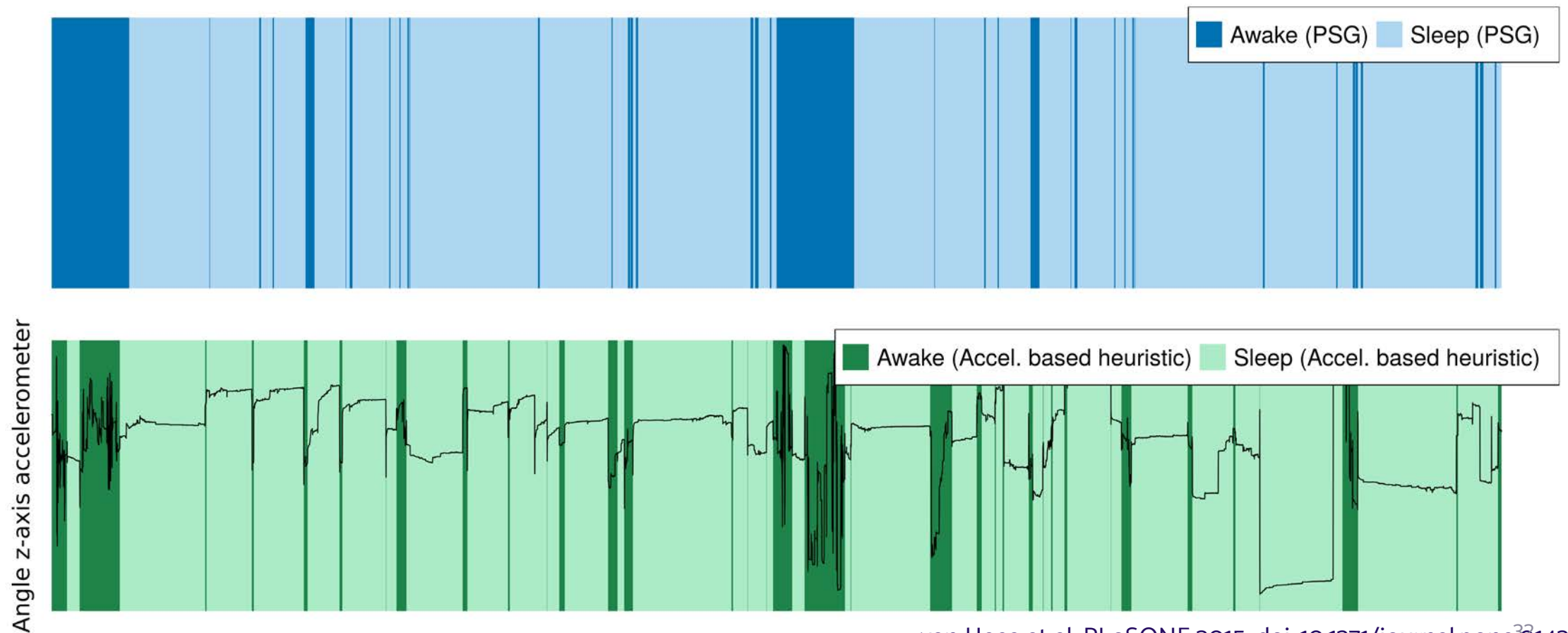


[This Photo](#) by Unknown Author is licensed under [CC BY-SA](#)

vanHees2015: How it works

1. Calculate z-angle for each 5 second epoch
2. Calculate change in z-angle between 5 second epochs
3. Identify segments where change is less than 5° for at least 5 minutes
4. Label those segments as sustained inactivity bouts (sib)

vanHees2015



The GGIR()

Sleep analysis

```
GGIR(  
  [...]  
  # Acceleration metrics  
  do.anglez = TRUE,  
  # Sleep analysis  
  HASIB.algo = "vanHees2015",  
  anglethreshold = 5,  
  timethreshold = 5,  
  [...])
```

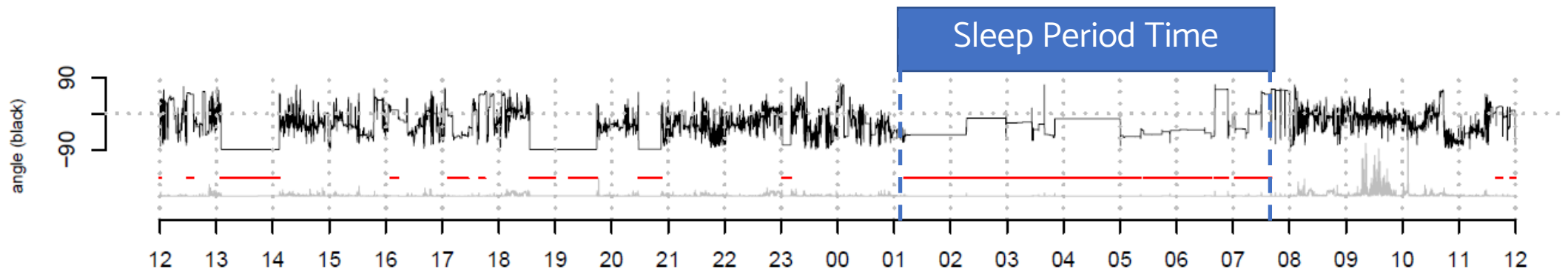
Challenge 2: Sleep Period Time



Accelerometer-based sleep assessment

Free living

- **Challenge 2:** separate daytime and nighttime (**Sleep Period Time**)

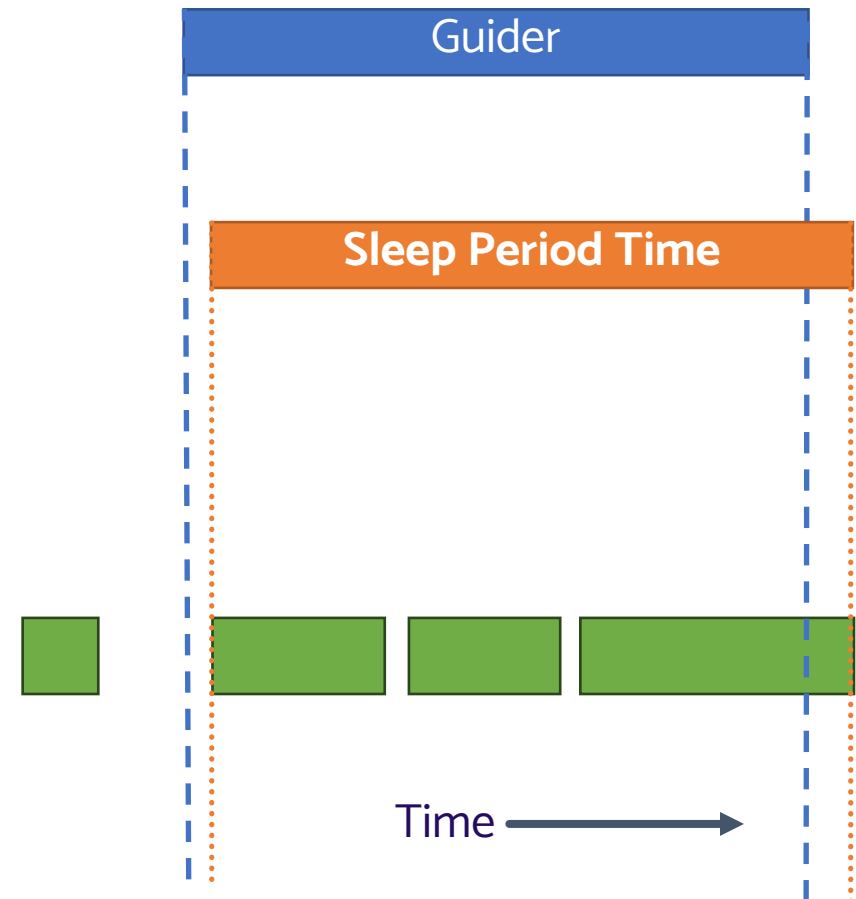


The GGIR pipeline



“Guiders” to guide SPT window detection

Sustained Inactivity Bouts:



HDCZA algorithm

- No convincing gold standard exists for free-living conditions
- Heuristic method, 'trained' with unlabeled data from 20 random individuals.

Change in wrist angle over time invariant to sensor orientation

5 second rolling medians of raw signals x, y, z

$$\text{angle}_z = \left(\tan^{-1} \frac{a_z}{\sqrt{a_x^2 + a_y^2}} \right) \cdot 180/\pi$$

Consecutive 5 second averages

Absolute difference between successive values

Rolling median using 5 minute window

Detect when values < (10th percentile of values in day* · 15)

Keep blocks > 30 minutes

Include time gaps < 60 minutes

Longest block in day*

Guider-window

Threshold per individual

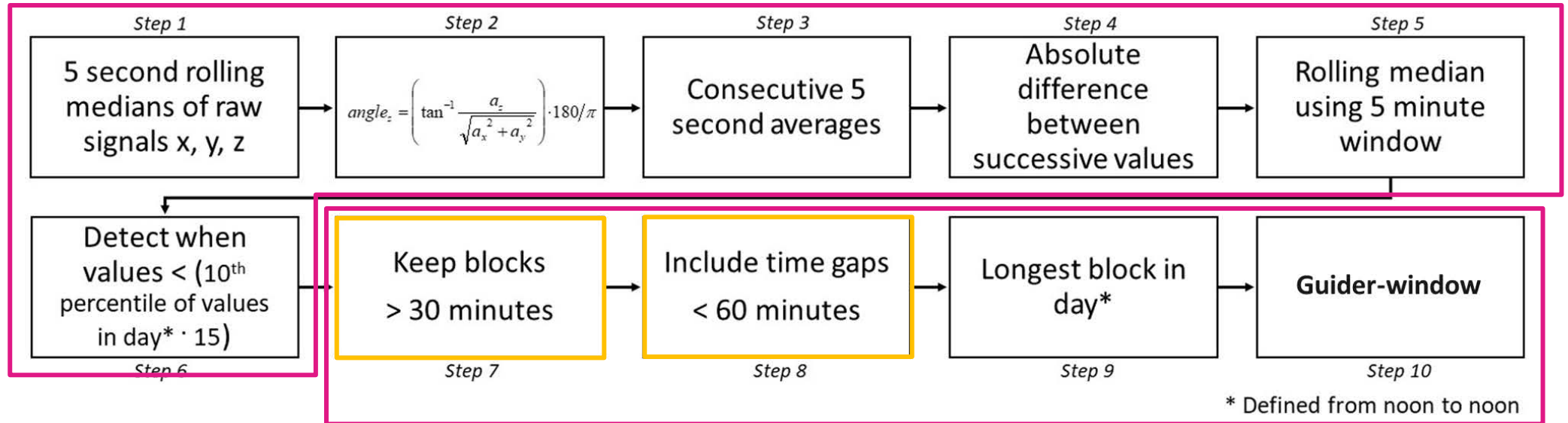
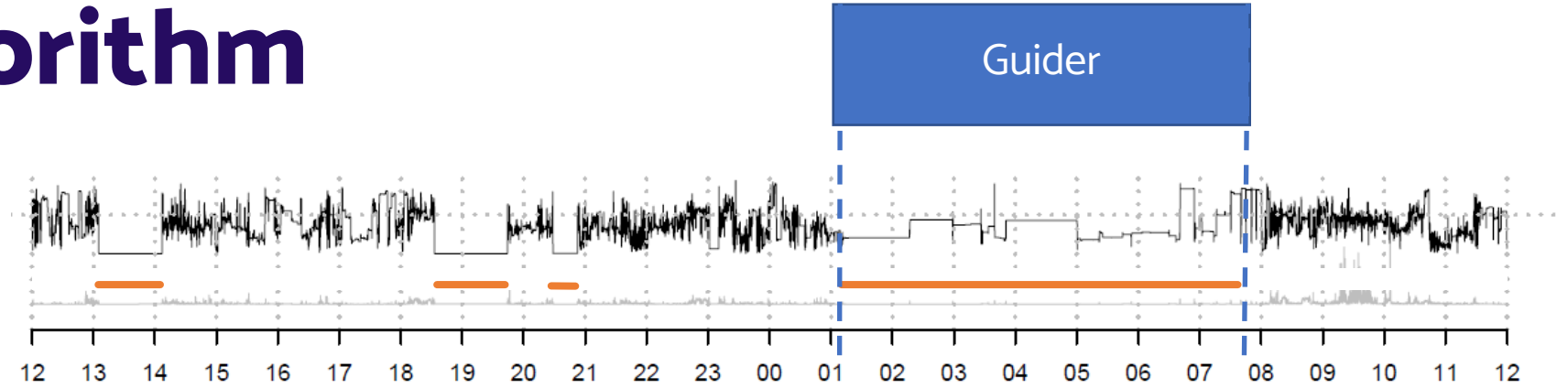
My assumptions about what a sleep period is

Step 10

* Defined from noon to noon

HDCZA algorithm

HDCZA algorithm



How Guiders deal with Non-wear

- Parameter **HASPT.ignore.invalid** allows to indicate whether invalid time segments should be ignored in the guider detection.

- **FALSE** (default), invalid but imputed time segment are used.

Assumption that imputation takes care of missing data

- **TRUE**, invalid time segments are ignored.

Sensor not worn during day

- **NA**, then invalid time segments are considered to be no movement segments in the guider detection.

Sensor possibly not worn during night or concern about accidentally detecting sleep as non-wear

Sleeplog

```
GGIR(  
  [...]   
  # Sleep analysis  
  loglocation = "C:/mystudy/mysleeplog_basic.csv",  
  [...])
```

NOTE: If night is not available, built-in algorithms will be used

Basic format sleeplog

colid = 1



coln1 = 2



ID	Onset_n1	Wakeup_n1	Onset_n2	Wakeup_n2	Onset_n3	Wakeup_n3	Onset_n4	Wakeup_n4
01	23:00:00	07:00:00	23:45:00	08:20:00	23:15:00	08:00:00	00:30:00	
02	22:30:00	07:30:00	22:35:00	07:00:00	23:45:00	09:05:00	23:44:00	09:00:00
03	23:45:00	07:10:00	00:02:00	08:30:00	22:50:00	07:25:00	23:00:00	07:38:00
04	00:10:00	09:00:00				07:30:00	00:25:00	09:10:00

Advanced format sleeplog

colid = 1



Note: parameter coln1 is not needed and ignored

ID	D1_date	D1_wakeup	D1_inbed	D1_nap_start	D1_nap_end	D1_nonwear1_off	D1_nonwear1_on	D2_date
01	2022-06-24	07:00:00	23:15:00	15:00:00	15:45:00	13:35:00	14:10:00	2022-06-25
02	2022-06-26	07:30:00	23:45:00			09:05:00	10:30:00	2022-06-27
03	2022-07-24	07:10:00	22:50:00	13:02:00	13:30:00	18:00:00	19:10:00	2022-07-25
04	2022-06-14	09:00:00	00:50:00			20:30:00	21:00:00	2022-06-15

Advanced format sleeplog

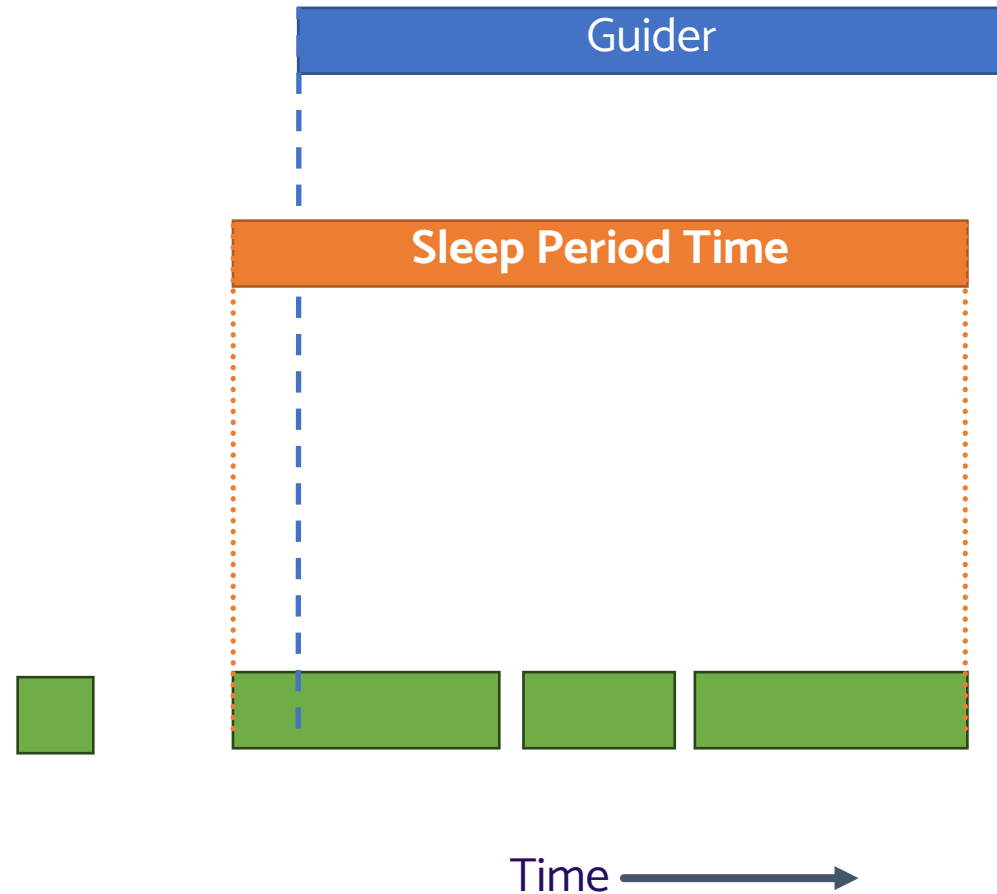
- Date columns → “date”
- Wakeup – Sleep onset columns → “wakeup”, “onset”
- Time in bed columns → “inbed”, “tobed”, “lightsout”, “lightson”
- Napping columns → “nap”
- Nonwear columns → “nonwear”

ID	D1_date	D1_wakeup	D1_inbed	D1_nap_start	D1_nap_end	D1_nonwear1_off	D1_nonwear1_on	D2_date
01	2022-06-24	07:00:00	23:15:00	15:00:00	15:45:00	13:35:00	14:10:00	2022-06-25

Guider & SIB => SPT

Default behaviour

```
GGIR(  
  [...]  
  # Sleep analysis  
  sleepwindowType = "SPT",  
  [...])
```



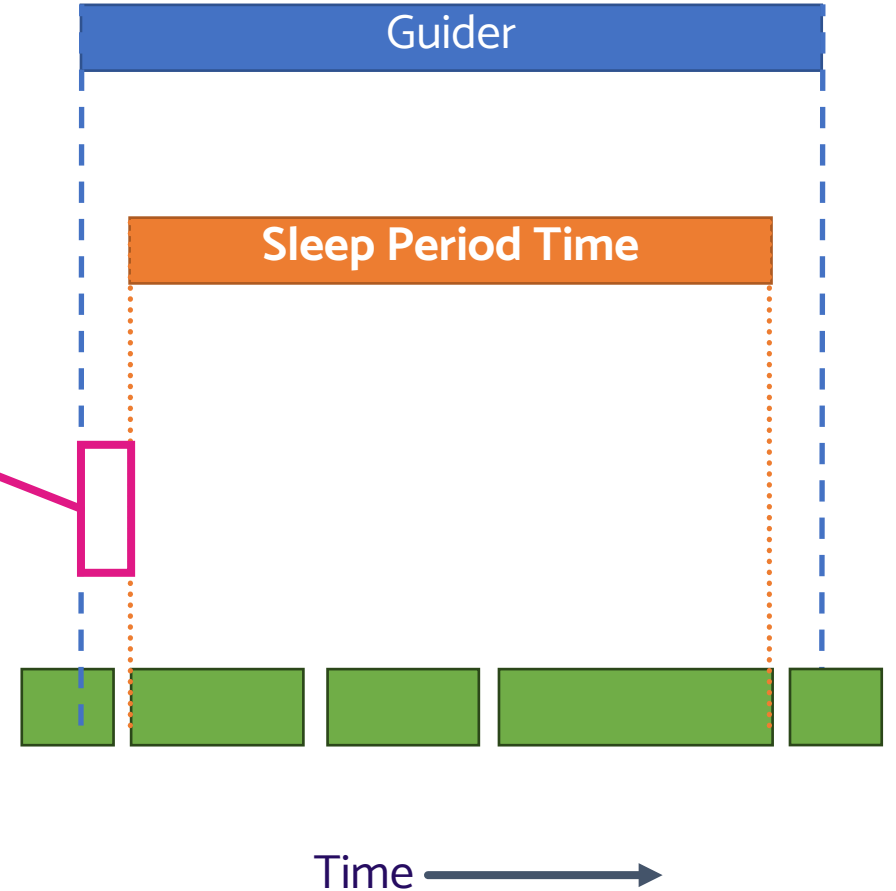
Guider & SIB => SPT

Sleeplog: time in bed or lights out

```
GGIR(  
  [...]  
  # Sleep analysis  
  sleepwindowType = "TimeInBed",  
  [...])
```

Only relevant for
sleeplog as guider

Sleep latency
Sleep efficiency



The GGIR()

Sleep analysis guided by sleeplog

GGIR(

[...]

Sleep analysis with basic sleeplog

`loglocation` = "C:/mystudy/mysleeplog_basic.csv",

`colid` = 1, `coln1` = 2,

`sleepwindowType` = "SPT", **OR** `sleepwindowType` = "TimeInBed",

[...])

GGIR(

[...]

Sleep analysis with advanced sleeplog

`loglocation` = "C:/mystudy/mysleeplog_advanced.csv",

`colid` = 1,

`sleepwindowType` = "SPT", **OR** `sleepwindowType` = "TimeInBed",

[...])

Other input parameters

GGIR(
[...]

[...]

Data cleaning

do.report = 4,

includenightcrit = 16,

[...])



16 hours available from noon-to-noon or from 6pm-to-6pm



Individual assignment 1

Preparation:

- Get the example data from <https://www.accelting.com/ggir-training-materials/>
- Open a new R script in RStudio

Task:

- Process the data files with GGIR part 1 and 2:
 - Specify idloc = 2 to ensure the ID is correctly extracted
 - Treat the first day as not trustworthy
 - Extract time spent in intensity levels.
- Compare part2_summary.csv and part2_daysummary.csv, can you see the relationship and differences?
- Look at the part2_summary.csv column names, can you figure out what they mean?

Hint: The following page provides some guidance

<https://wadpac.github.io/GGIR/articles/GGIRoutput.html#ggir-part-2>

Individual assignment 2

Preparation:

- Use the same script as in assignment 1.

Task:

1. Update your R script to analyse the data for sleep with GGIR part 3 and 4 with the sleeplog as provided.
2. Note that ID 4 does not have a sleeplog. Can you spot this in the output and can you see how GGIR handles this?
3. Look at the part4_nightsummary.csv column names, can you figure out what they mean?

Hint: The following page provides some guidance

<https://wadpac.github.io/GGIR/articles/GGIRoutput.html#ggir-part-4>

Group assignment

Task:

- Prepare a mini-presentation where you explain how you would process part 1 and 2 for your own study
- Groups of around 4

What do we expect:

- Research question of interest (ideally related to PA distribution)
 - Including population and variables of interest that you would require
- Details about the study protocol
 - Accelerometers configuration, body attachment site, recording duration, start and end times of the recording,...
- How you would approach the data processing to get your variables of interest from GGIR parts 1 and 2
 - GGIR parameters and how you would configure them (e.g., metric selection, study protocol,...)

Day Evaluation