Algorithm for data analysis of CREDO smartphone application

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CREDO Week 2018

1st – 5th October 2018

The science behind the CREDO app

$\gamma_{\mathbf{UHE}}$
(e.g. 10^{20}eV)

Citizens browse the data looking for „improbable" **time-space coincidences**

1) $\mathbf{t_n - t_1 < \sim 1\ \mu s}$
2) $\mathbf{t_1 < \ldots < t_n}$**,**

→ **indirect search for New Physics manifestations!**
→ **verification of „classic" QED predictions (preshower @ Sun)**

The science behind the CREDO app

CREDO App: *Smartphone application* to turn cameras into particle detectors
→ available on *Androïd*

top 5 users

Login	Detections
kilo	86,167
Mafia75 7	56,188
mates	33,949
Bogdan51	31,588
Krzysztof	22,295

last 5 registered users

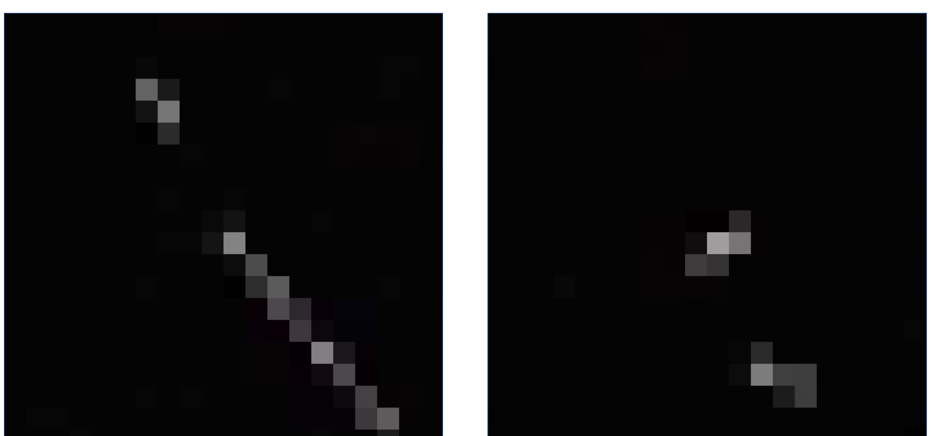
Login	Detections
filipfcb42	1
Grzegorz	0
kris	0
Hibiskus	226
prawdziwytomasz	0

Last 20 detections

sort : date by : descending Envoyer

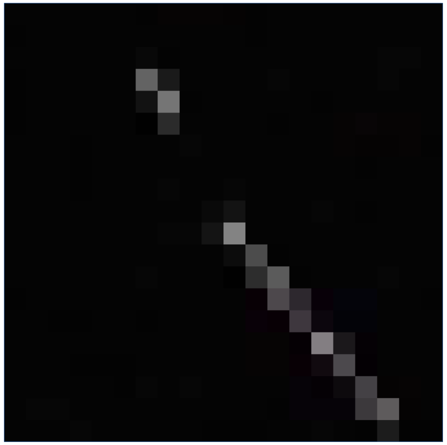
date	login	team	img
NEW 1 Hour ago	Piotr J. Piotrowski	no team	
1 Hour ago	Piotr J. Piotrowski	no team	
1 Hour ago	Piotr J. Piotrowski	no team	
4 hours ago	Piotr J. Piotrowski	no team	

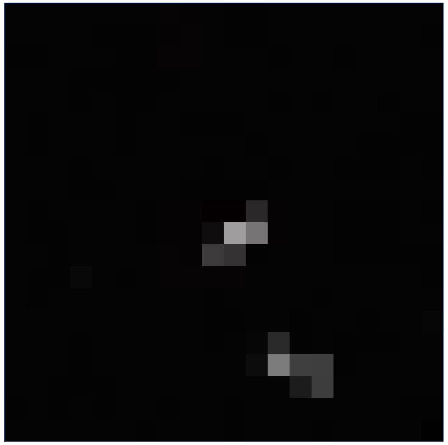
Image examples:



The science behind the CREDO app

Image examples:

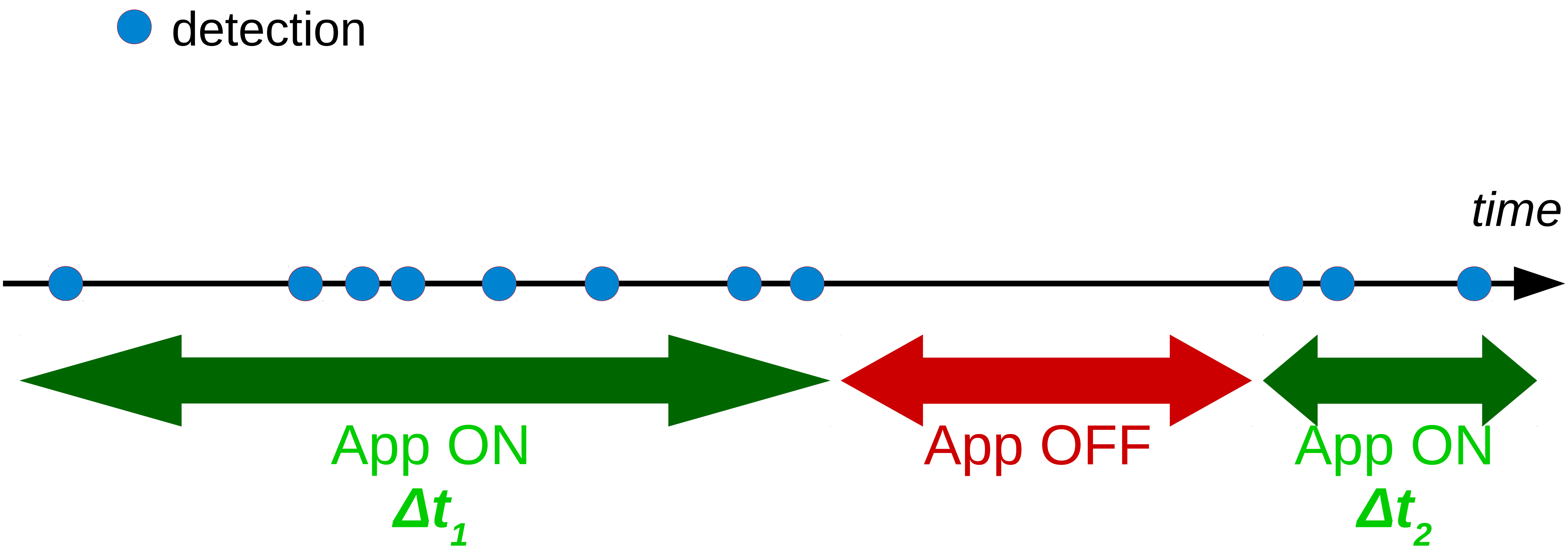




Informations obtained about the data:

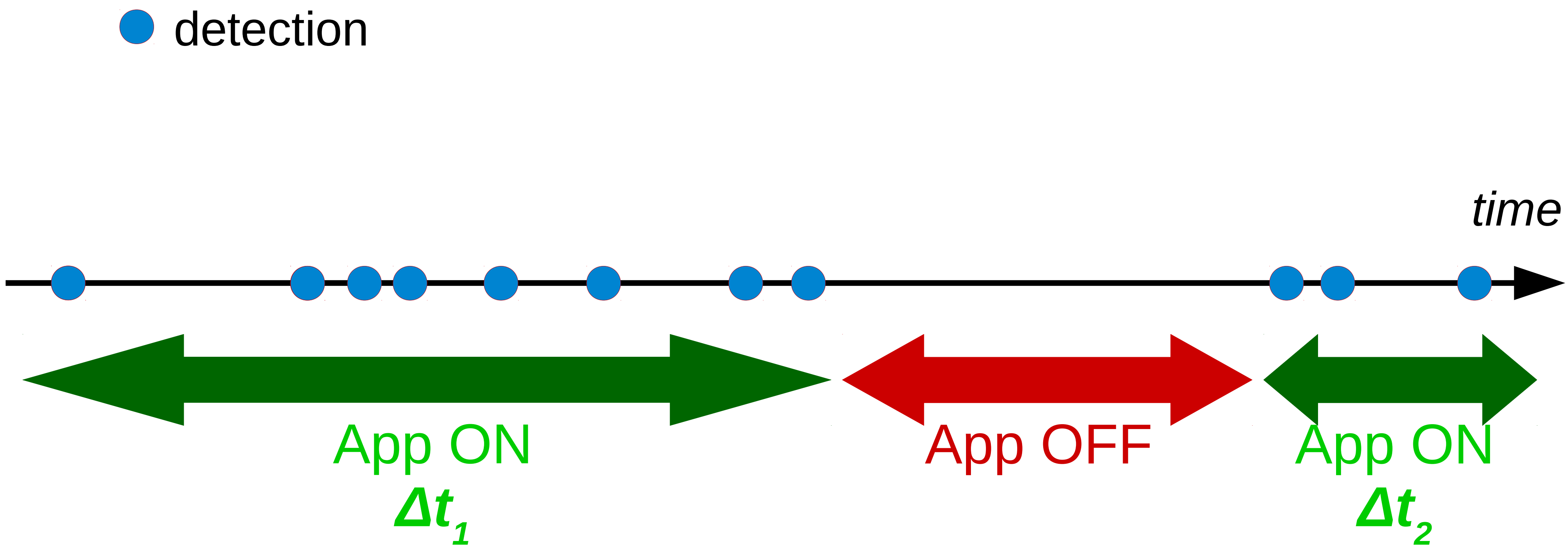
Timestamps and *GPS location*

Data acquisition and pre-processing



- If $\boldsymbol{\Delta t_1}$ + $\boldsymbol{\Delta t_2}$ + … + $\boldsymbol{\Delta t_n}$= 24h → timestamps are saved in a file.

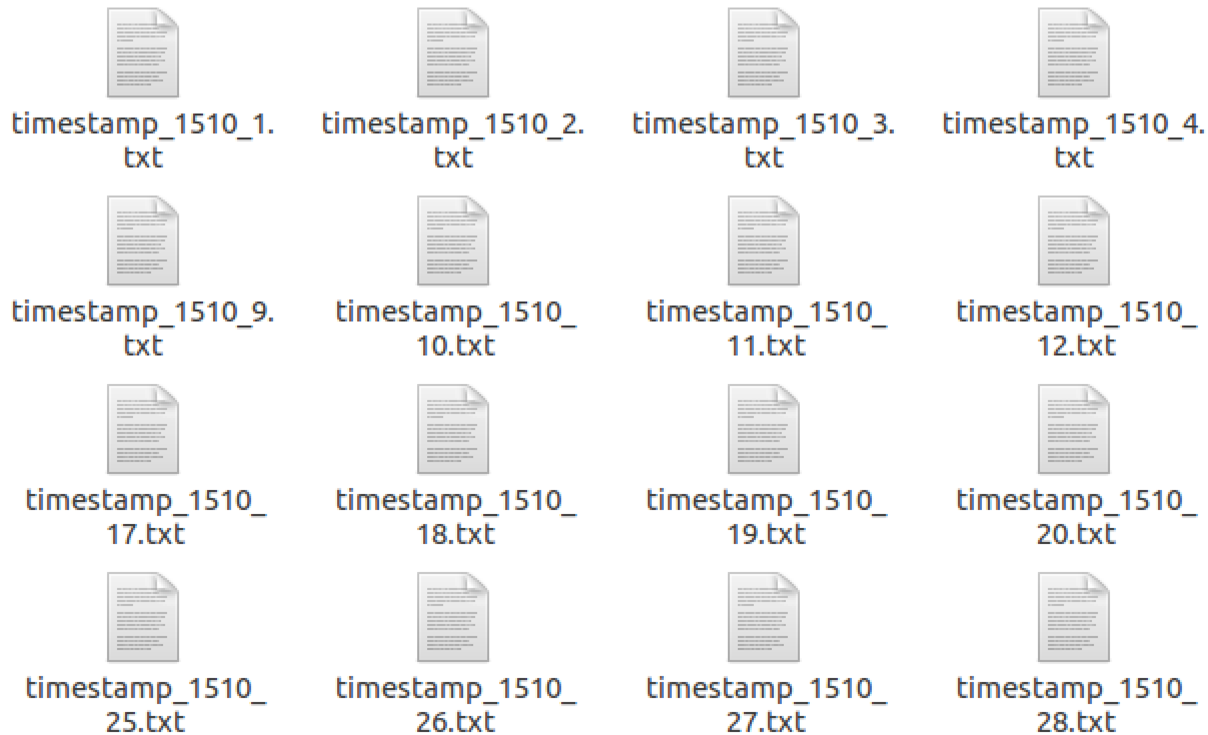
Data acquisition and pre-processing



- For each user, we obtained a file containing the timestamps for 24h periods:

  timestamps_<userID>_1.txt, timestamp_<userID>_2.txt, timestamp_<userID>_3.txt, etc...

Data acquisition and pre-processing




```
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1529325363714
1529326915006
1529326915039
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1529327799978
1529328562431
1529328592824
1529328624409
1529328729567
1529328739873
1529328784549
1529329109491
1529329940873
1529330466254
1529330595181
1529331273051
1529331883964
1529333849364
1529334153055
1529334217083
1529334217083
1529334799244
1529335003646
1529335139004
1529335139004
1529335561395
1529335561395
1529335765857
```

What are we looking for?

VOLUME 50, NUMBER 26 PHYSICAL REVIEW LETTERS 27 JUNE 1983

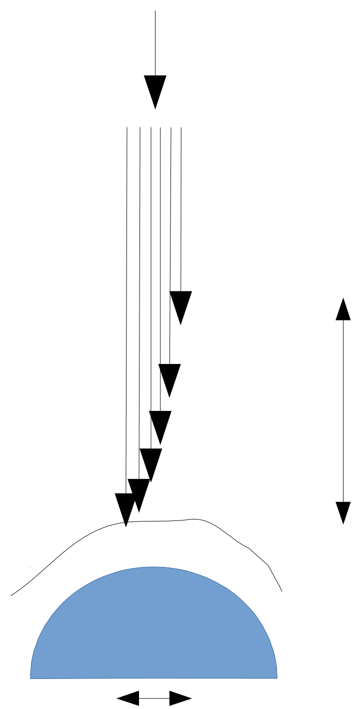
Possible Observation of a Burst of Cosmic-Ray Events in the Form of Extensive Air Showers

Gary R. Smith, M. Ogmen, E. Buller, and S. Standil
Physics Department, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada

(Received 7 April 1983)

A series or burst of 32 extensive air showers of estimated mean energy 3×10^{15} eV was observed within a 5-min time interval beginning at 9:55 A.M. (CST) on 20 January 1981 in Winnipeg, Canada. This observation was the only one of its kind during an experiment which recorded 150 000 such showers in a period of 18 months between October 1980 and April 1982.

PACS numbers: 94.40.Pa, 94.40.Rc, 95.30.-k



Year = 1981
N_{obs} = 32
N_{exp} = 1
E = 3×10^{15}eV

Δt ~5 min.

Δx >= small

What are we looking for?

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First analysis:

Looking for how many times two consecutive detections happen within 5 minutes time windows in the data and compare to background expectations!

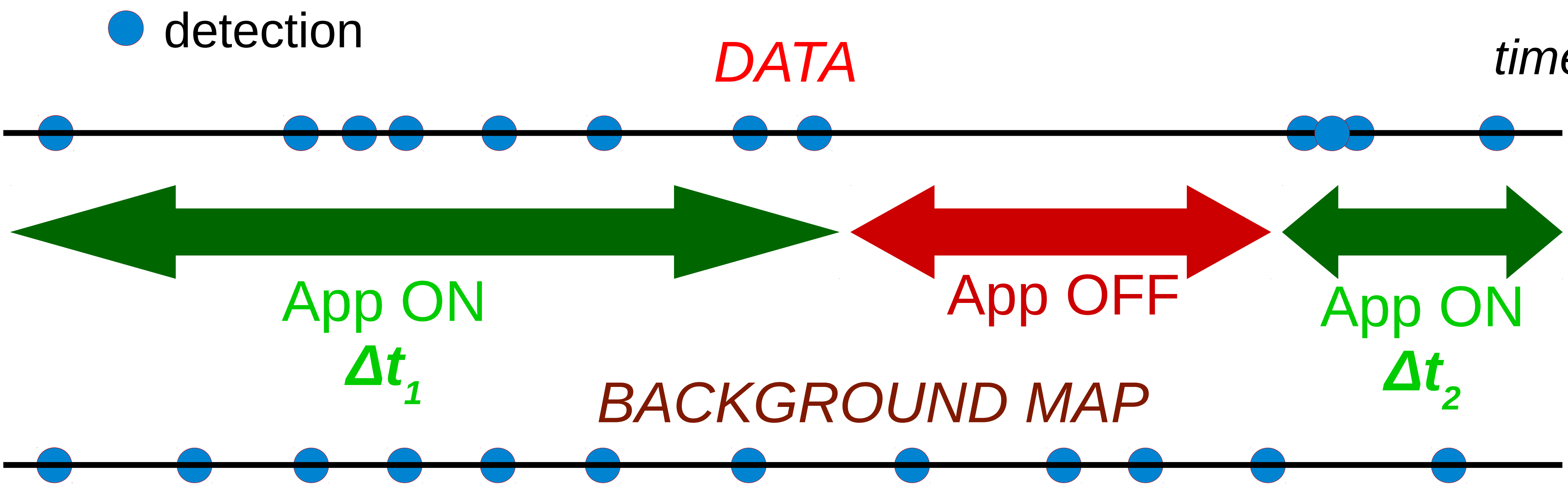
What does the algorithm look like?

1) **Extract data** from *timestamp* file.

What does the algorithm look like?

1) Extract data from *timestamp* file.

2) **Simulate MULTIPLE background maps** based on a uniform distribution of detections and the number of detections in the data.



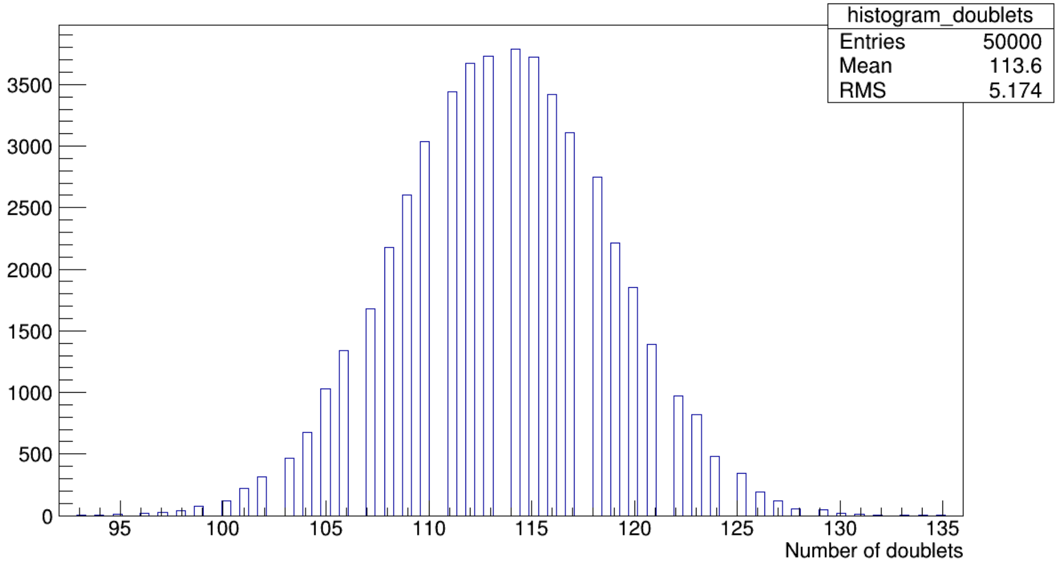
$$\Delta t_B = \Delta t_1 + \Delta t_2 = 24H$$

What does the algorithm look like?

1) Extract data from *timestamp* file.

2) Simulate multiple background maps based on a uniform distribution of detections and the number of detections in the data.

3) Count **how many times two consecutive detections happen within 5 minutes time windows in each background map** to obtain distribution and 3-sigma/5-sigma values:



What does the algorithm look like?

1) Extract data from *timestamp* file.

2) **Simulate MULTIPLE background maps** based on a uniform distribution of detections and the number of detections in the data.

3) Count how many times two consecutive detections happen within 5 minutes time windows in each background map to obtain distribution and 3-sigma/5-sigma values.

4) Count **how many times two consecutive detections happen within 5 minutes time windows <u>in data</u>** to compare do background distribution and **obtain sigma/p-value**.

What does the algorithm look like?

1) Extract data from *timestamp* file.

2) Simulate multiple background maps based on a uniform distribution of detections and the number of detections in the data.

3) Count how many times two consecutive detections happen within 5 minutes time windows in each background map to obtain distribution and 3-sigma/5-sigma values.

4) Count how many times two consecutive detections happen within 5 minutes time windows in data to compare do background distribution and obtain sigma/p-value.

5) Save **expected (background) and observed (data) values, 3 and 5 sigma bands, and significance of observed** in output file.

What does the algorithm look like?

1) Extracting data from *timestamp* file.

2) Simulate multiple background maps based on a uniform distribution of detections and the number of detections in the data.

REPEAT PROCESS FOR EACH TIMESTAMP FILE

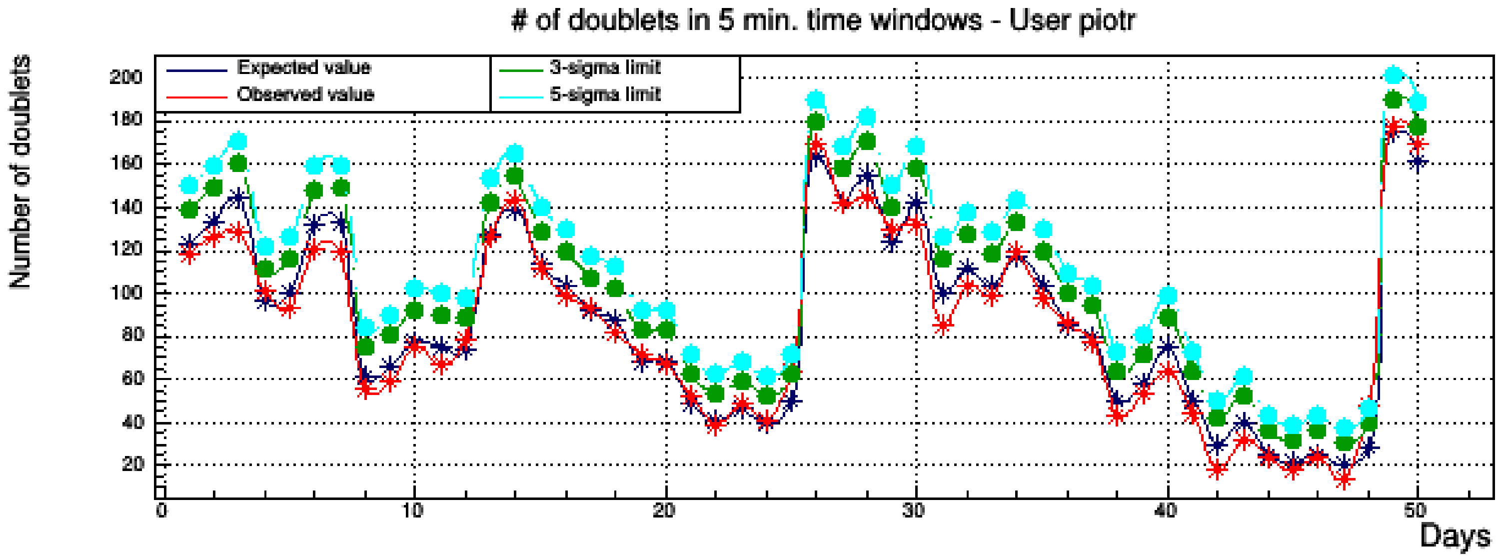
3) C … n
wi … obtain
dis …

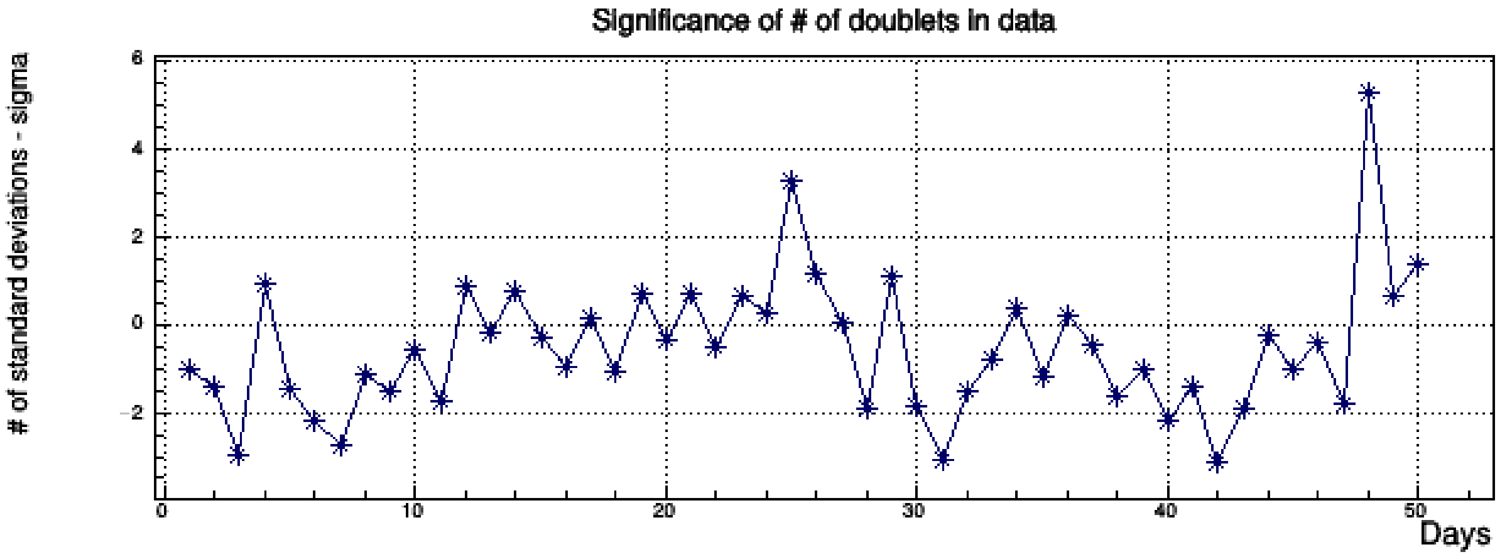
4) Count how many times two consecutive detections happen within 5 minutes time windows in data to compare do background distribution and obtain sigma/p-value.

5) Save expected (background) and observed (data) values, 3 and 5 sigma bands, and significance of observed in output file.

What do the results look like?

- Each point correspond to one timestamp file <=> one 24h period





How to run the algorithm?

- **3 FILES:**

  - *Analysis.cpp*: algorithm written in c++ performing the previously mentioned analysis.
    → OUTPUT: txt file with values used for plots.

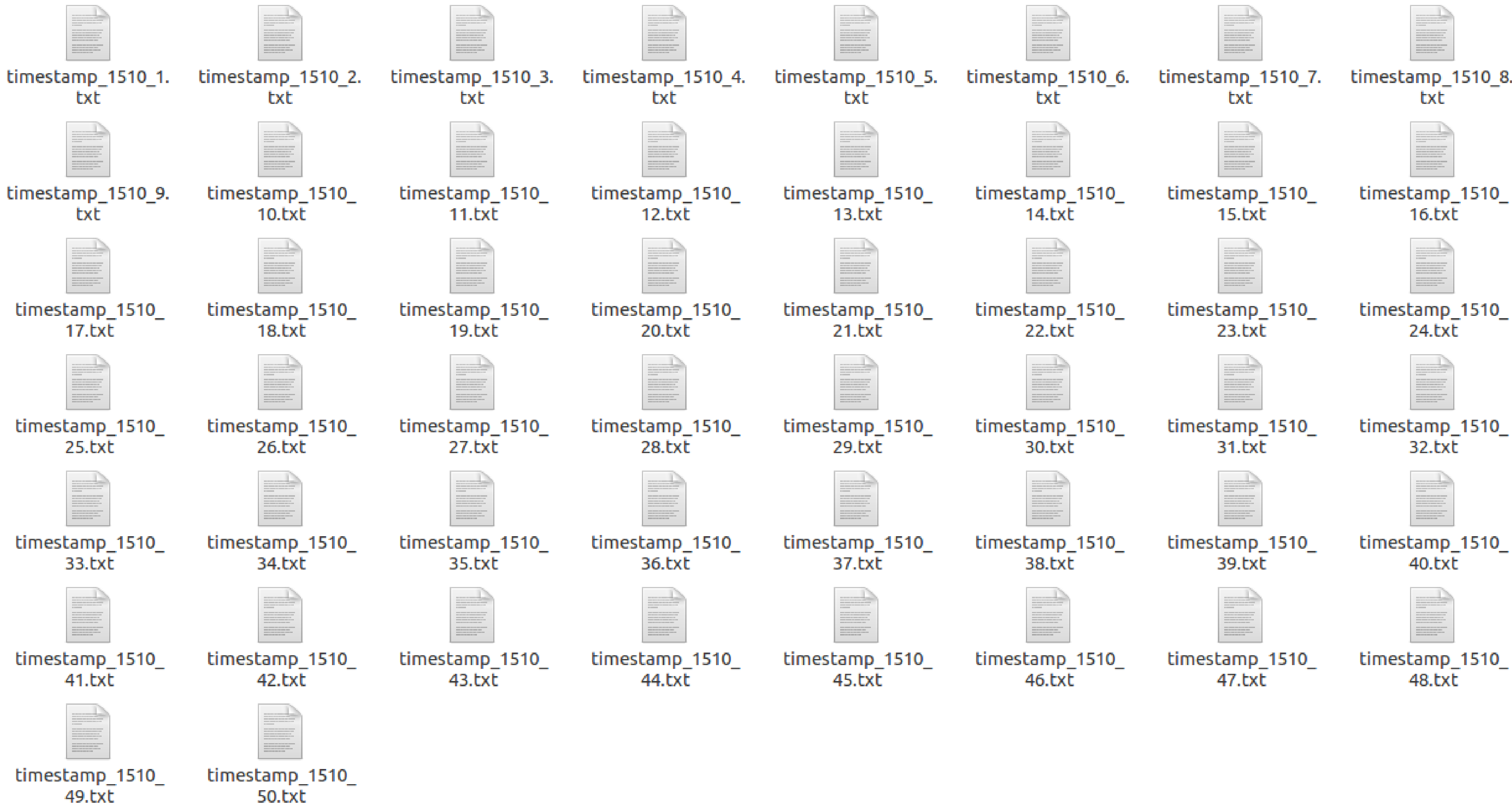
  - *Plot4user.C*: ROOT macro plotting the results obtained from the analysis.
    → OUTPUT: plots.

  - *Run.sh*: bash script compiling *analysis.cpp* file and looping over all timestamp files.

  README file contains extra informations!

PRACTICE!

Practice


timestamp_1510_1.txt
timestamp_1510_2.txt
timestamp_1510_3.txt
timestamp_1510_4.txt
timestamp_1510_5.txt
timestamp_1510_6.txt
timestamp_1510_7.txt
timestamp_1510_8.txt
timestamp_1510_9.txt
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timestamp_1510_42.txt
timestamp_1510_43.txt
timestamp_1510_44.txt
timestamp_1510_45.txt
timestamp_1510_46.txt
timestamp_1510_47.txt
timestamp_1510_48.txt
timestamp_1510_49.txt
timestamp_1510_50.txt

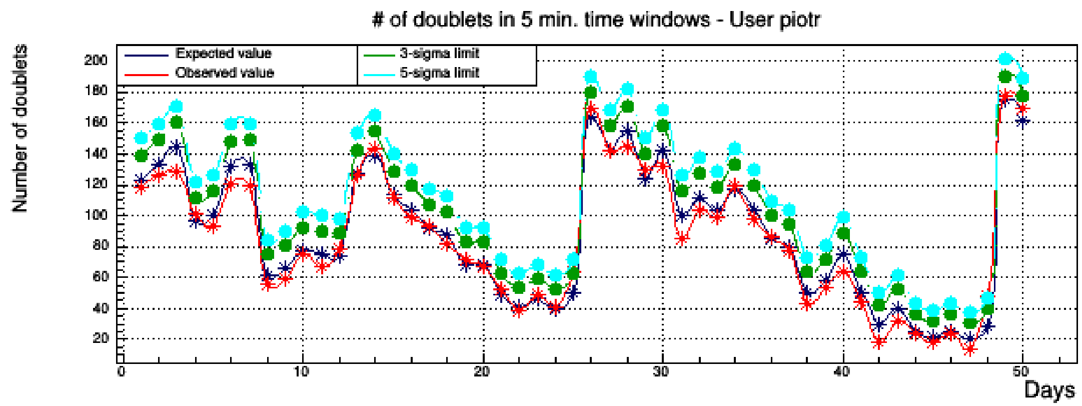
Practice

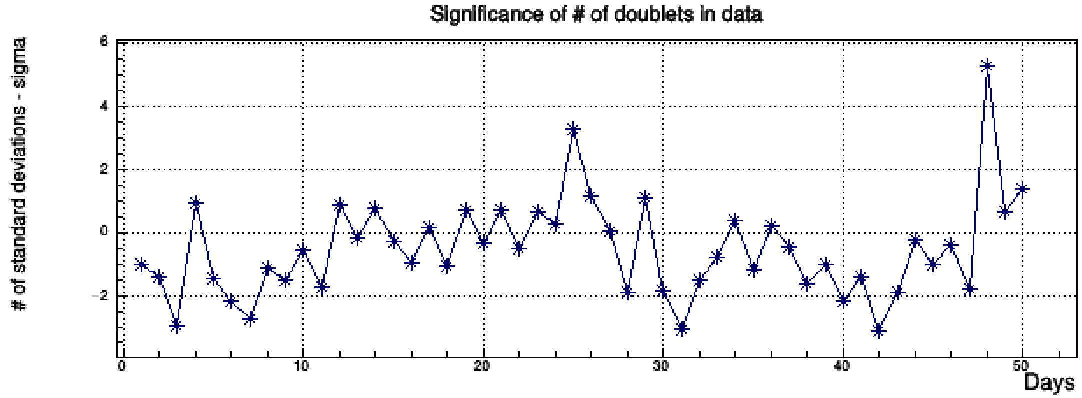
```
asava@asava-ubuntu:~/CREDO/Time_Clustering - API/v4$ bash run.sh
Processing data from user data - period 1...
Number of events in data: 252
Number of events in data after removing events with same timestamps: 227
Time covered by data = 140301.176 sec
Real ontime = 86400 sec
----- Doublet analysis -----
Expected number of doublets = 123.37118 || Number of doublets in data = 118 || pvalue = -0.694091016 || sigma = -1.023843958
3 sigma at 139.1094572 || 5 sigma at 149.601642
Elasped time is 2.00 seconds.

Processing data from user data - period 2...
Number of events in data: 278
Number of events in data after removing events with same timestamps: 238
Time covered by data = 88047.369 sec
Real ontime = 86400 sec
----- Doublet analysis -----
Expected number of doublets = 133.42482 || Number of doublets in data = 126 || pvalue = -0.8432097339 || sigma = -1.415949584
3 sigma at 149.1559309 || 5 sigma at 159.6433382
Elasped time is 1.00 seconds.

Processing data from user data - period 3...
Number of events in data: 273
Number of events in data after removing events with same timestamps: 250
Time covered by data = 99952.467 sec
Real ontime = 86400 sec
----- Doublet analysis -----
Expected number of doublets = 144.64178 || Number of doublets in data = 129 || pvalue = -0.9970569934 || sigma = -2.973629014
3 sigma at 160.4222757 || 5 sigma at 170.9426062
Elasped time is 2.00 seconds.

Processing data from user data - period 4...
Number of events in data: 216
Number of events in data after removing events with same timestamps: 196
Time covered by data = 74366.055 sec
Real ontime = 86400 sec
----- Doublet analysis -----
Expected number of doublets = 96.39774 || Number of doublets in data = 101 || pvalue = 0.635533989 || sigma = 0.9068880314
3 sigma at 111.6220891 || 5 sigma at 121.7716552
Elasped time is 2.00 seconds.
```

Practice

1	123.371180	118.000000	-1.023844	139.109457	149.601642	-5.371180
2	133.424820	126.000000	-1.415950	149.155931	159.643338	-7.424820
3	144.641780	129.000000	-2.973629	160.422276	170.942606	-15.641780
4	96.397740	101.000000	0.906888	111.622089	121.771655	4.602260

Each line corresponds to the analysis of one 24h period (one timestamp file)





Real data vs. simulated data