First pre-flight assessment of MTG LI Level 2 performances

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GLM Science meeting 2020

Acknowledgements:
ESA, LI Mission Advisory Group, Dr Mason Quick, Dr Dennis Buechler,
Prof Kenneth Cummins, Dr William (Bill) Koshak

Introduction

The assessment of the expected (pre-flight) Level 2 performances of LI is essential from a user and application perspective

EUMETSAT employs the **LI Reference Processor** for the pre-flight end-to-end performance assessment:

1. Latest available version of the Level 0 instrument simulator and Level 1b prototype processor (delivered by industry through ESA)

2. Up-dated Level 2 prototype processor (EUMETSAT)

3. EUMETSAT developed a brand new approach for defining the input pulses and flashes following the guidelines from LI MAG meeting #9 and meetings with US experts → key observational properties of lightning drive the definition of the inputs

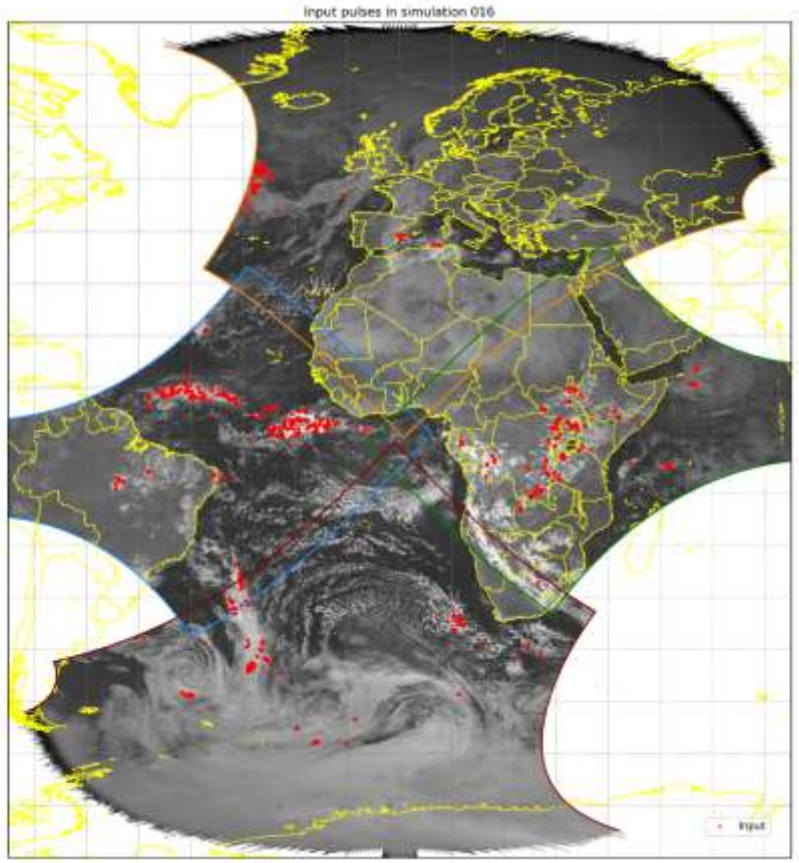
Pulse properties

I. Temporal variation/profile (FEGS)
II. Radiance (FEGS)
III. Duration (FEGS)
IV. Radius (LIS)
V. Location in space and time (from flash properties)

Flash properties

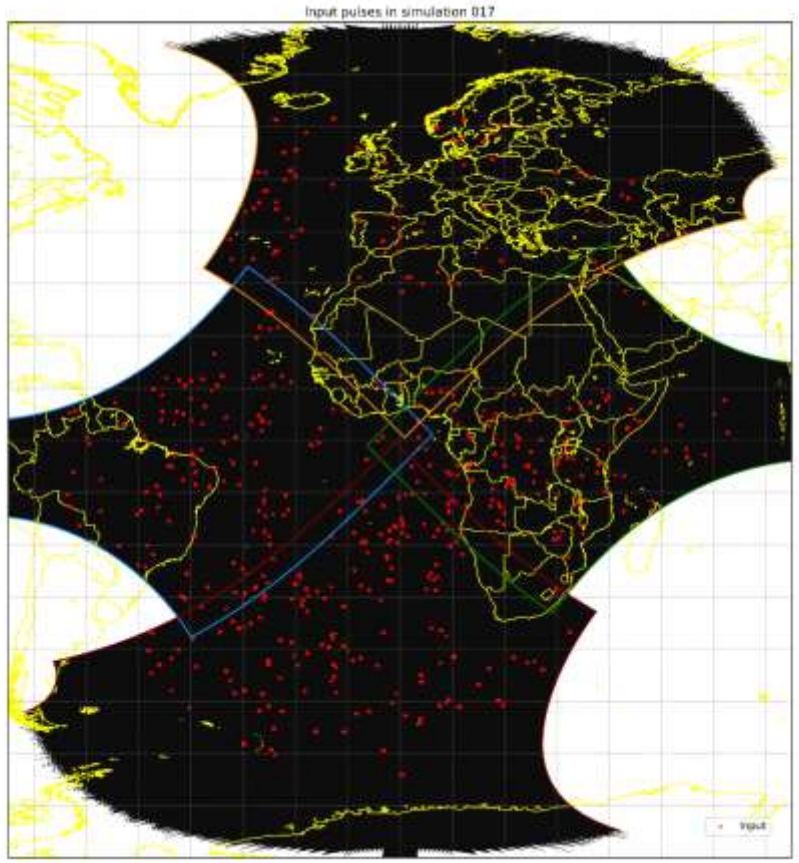
I. Location in space (SEVIRI Level 2 products)
II. Location in time (LIS)
III. Number of pulses (LIS)
IV. Time difference between pulses (LIS)
V. Location of pulses within the flash (LMA)
VI. Flash duration (set by the combination of *Number of pulses* and *Time difference between pulses*)

Method



7am 12pm 5:30pm

201110291212



7pm 12am 5:30am

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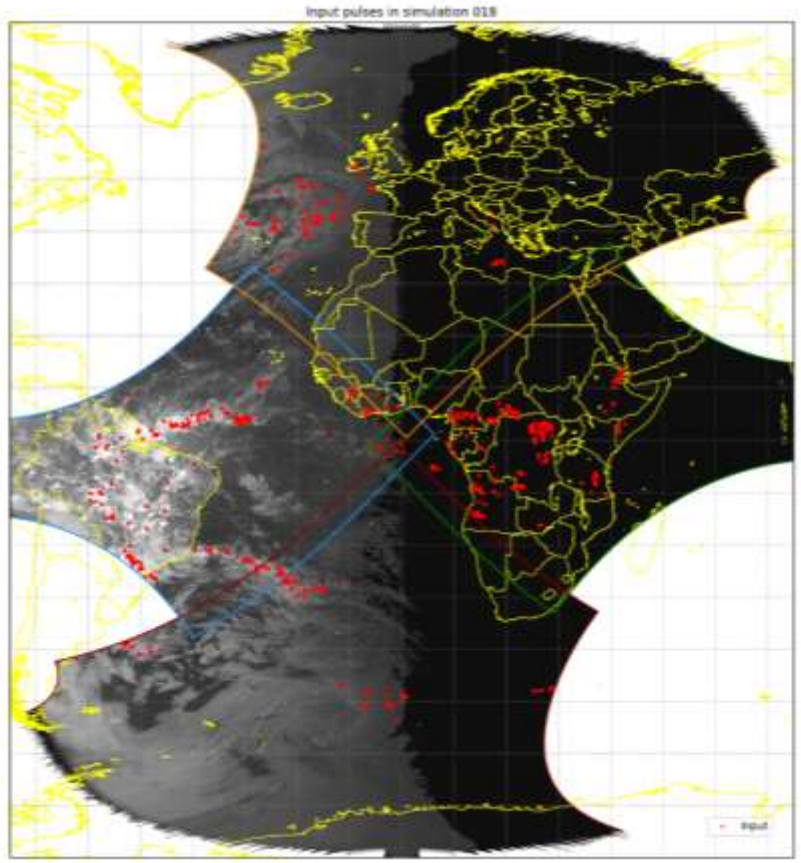
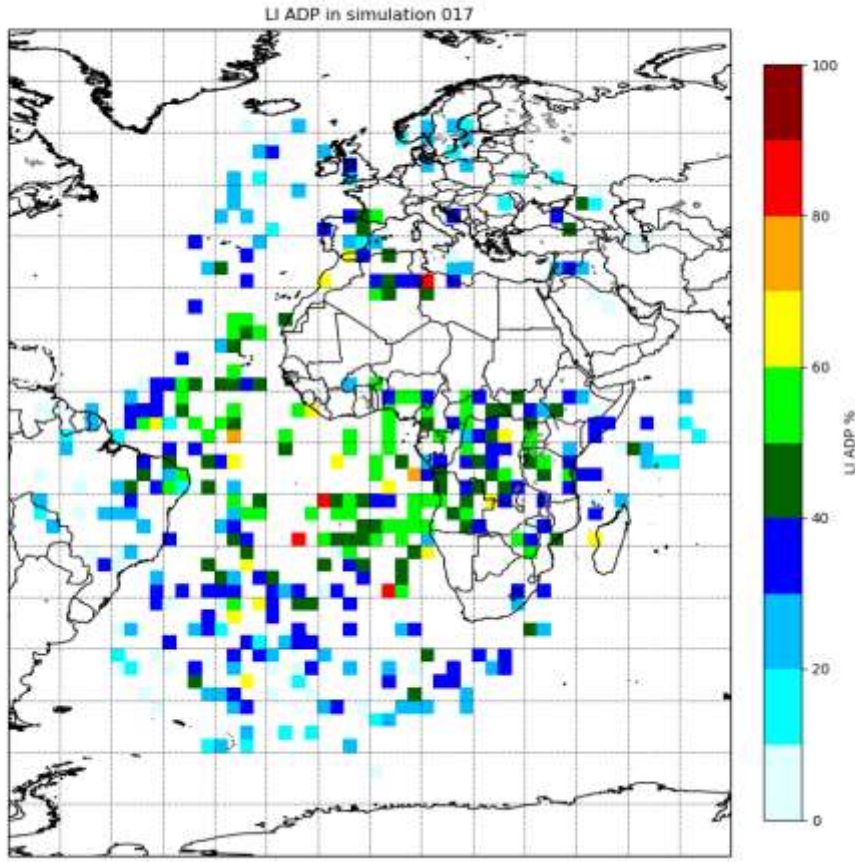


1pm 6pm 11:30pm

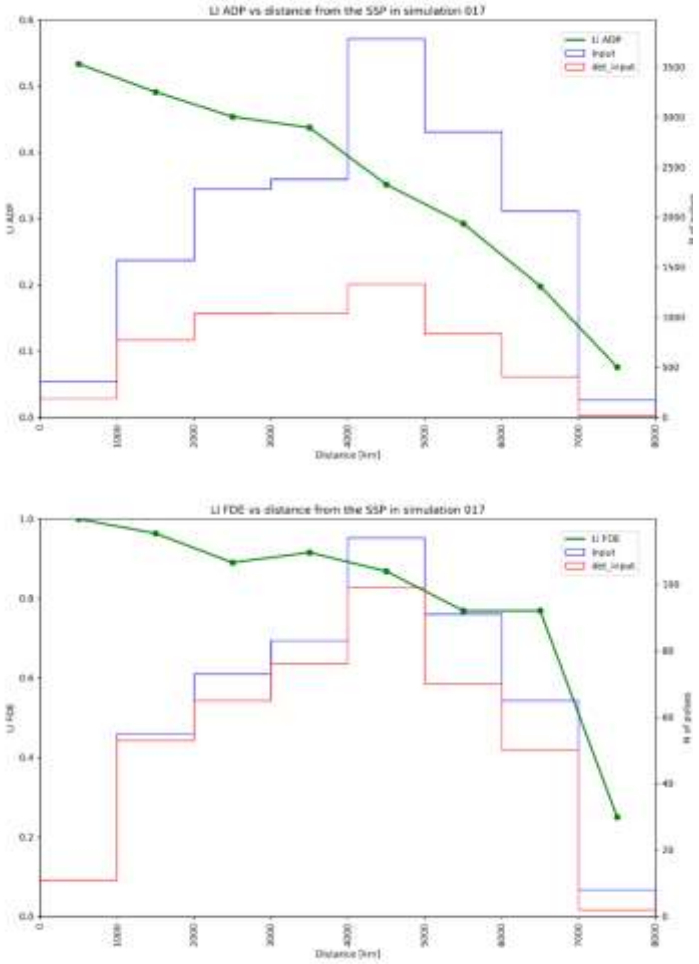
201303201812

Red dots are input flashes

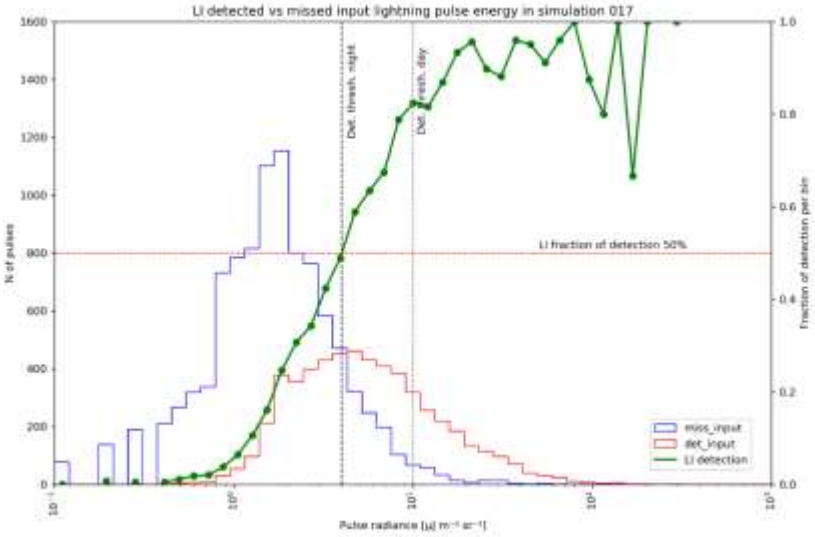
Results - night



ADP (pulse DE for GLM) as a function of the GEO location



ADP and FDE as a function of distance from SSP



Minimum detectable energy (a-la GLM wrt FEGS)

Results and conclusions

Session	Level 2 FDE	Level 2 FFAR	Level 2 det. thld.
016 day	0.56 ± 0.18	6 ± 4 1/(sec OC)	≈ 15 µJ / (sr m^2)
017 night	0.88 ± 0.10	0 ± 0 1/(sec OC)	≈ 4 µJ / (sr m^2)
018 half	0.69 ± 0.19	4 ± 3 1/(sec OC)	≈ 6.5 µJ / (sr m^2)

The simulated lightning detection performances of LI are characterized by a strong variability

The FDE varies from about 0.3 to 0.98, for a FFAR that can be as high as 24 flashes per second

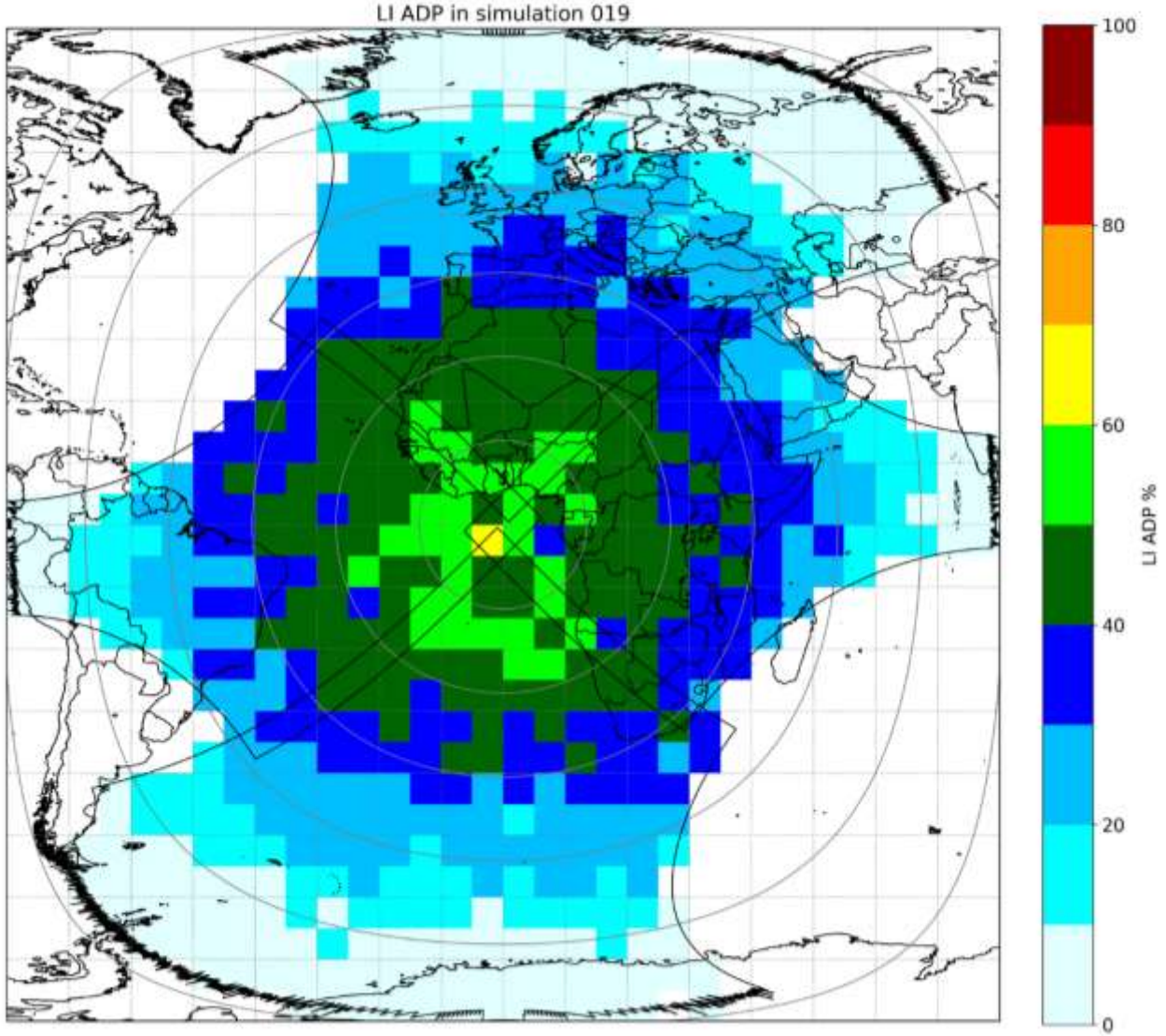
The detection threshold varies in [4, 15] µJ / (sr m^2)

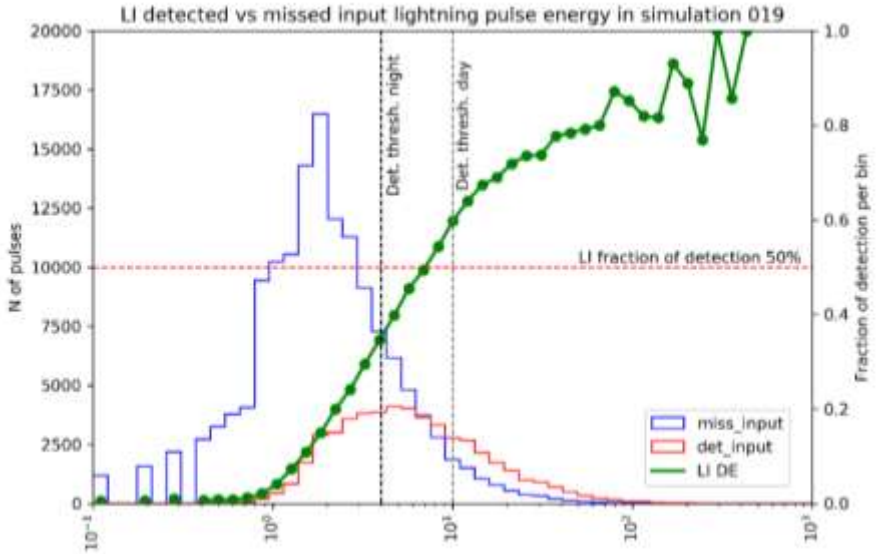
GLM performances against FEGS over the US and for 6am – 6pm local times (link to the reference):

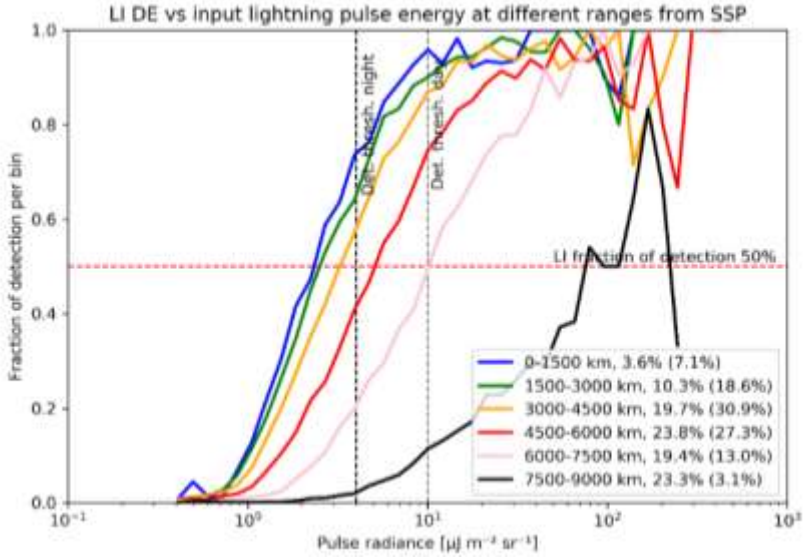
- Strong storm-by-storm variability
- The expected LI FDE over the 84% Earth disc (60% average) is comparable with the GLM FDE over its coverage area (61% average) when taking into account the fairly conservative assumptions of the analysis
- The GLM detection threshold is 10 µJ / (sr m^2) (Dr Mason Quick private communication)

Future work

PRELIMINARY RESULTS







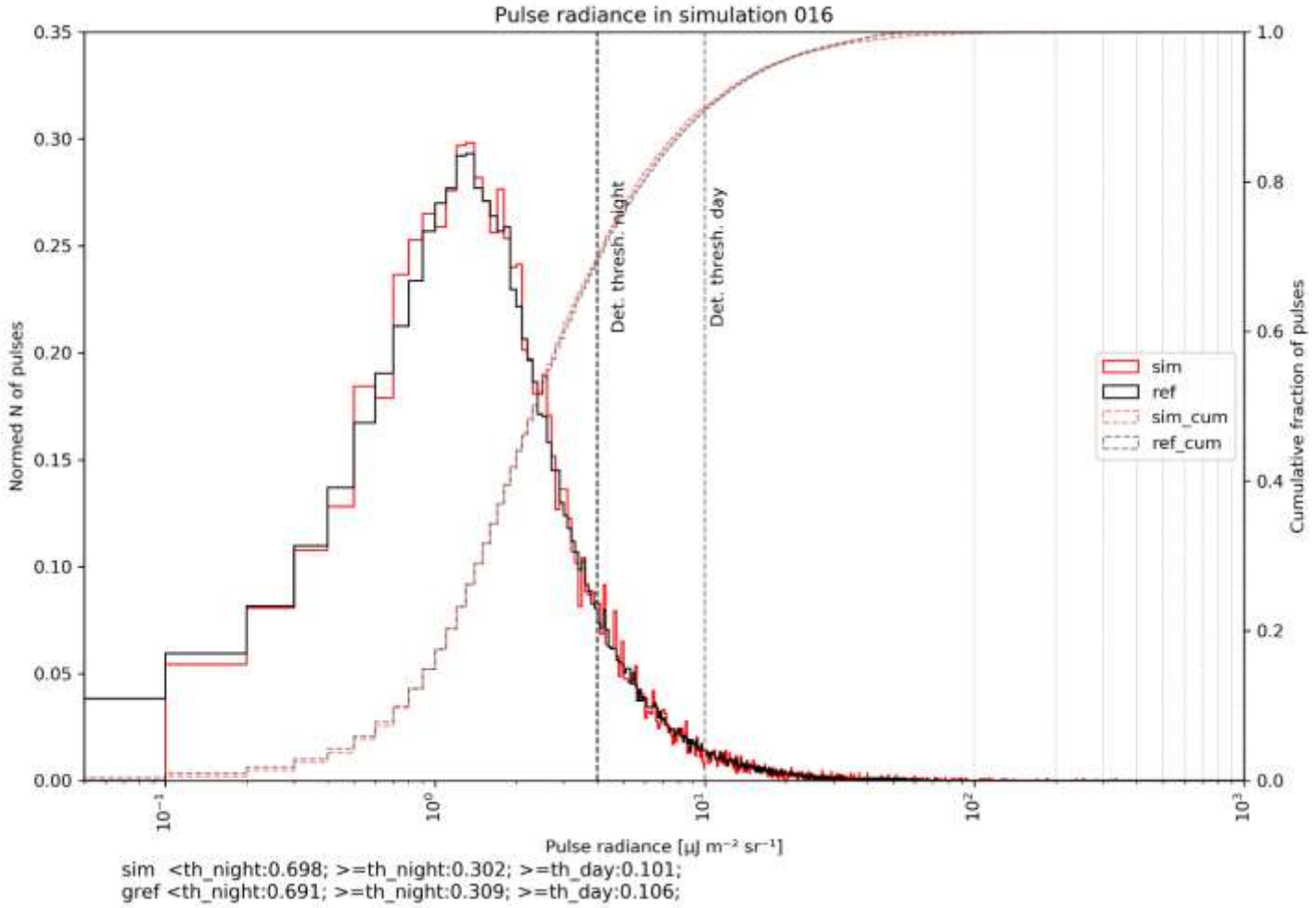
EUMETSAT

Backup slides

Analysis assumptions and inputs

Pulse property	Settings
Spatial variation	Uniform-radiance disk with size set by the radius. The pulse is "seen" at the focal plane with a smoothed spatial variation due to the convolution with the instrument spatial response and pixel response.
Temporal variation	Maxwell function with normalized integral over the pulse duration and peak reached at 1/3 of the duration → $R = k \cdot P / D$ where R is the pulse Radiance, P is the pulse Peak Radiance, and D is the pulse Duration.
Radiance (R)	From a 2D distribution derived from FEGS observations relating R; also the associated P is derived from the random draws
Duration (D)	Stems from the relation $R = k \cdot P / D$, i.e., D is consistent with the properties of the pulse
Radius	Derived from the LIS distribution of the group size as $r = (16 \cdot \#_{DT} / \pi)^{1/2}$
Location in space and time	Stem from the flash properties

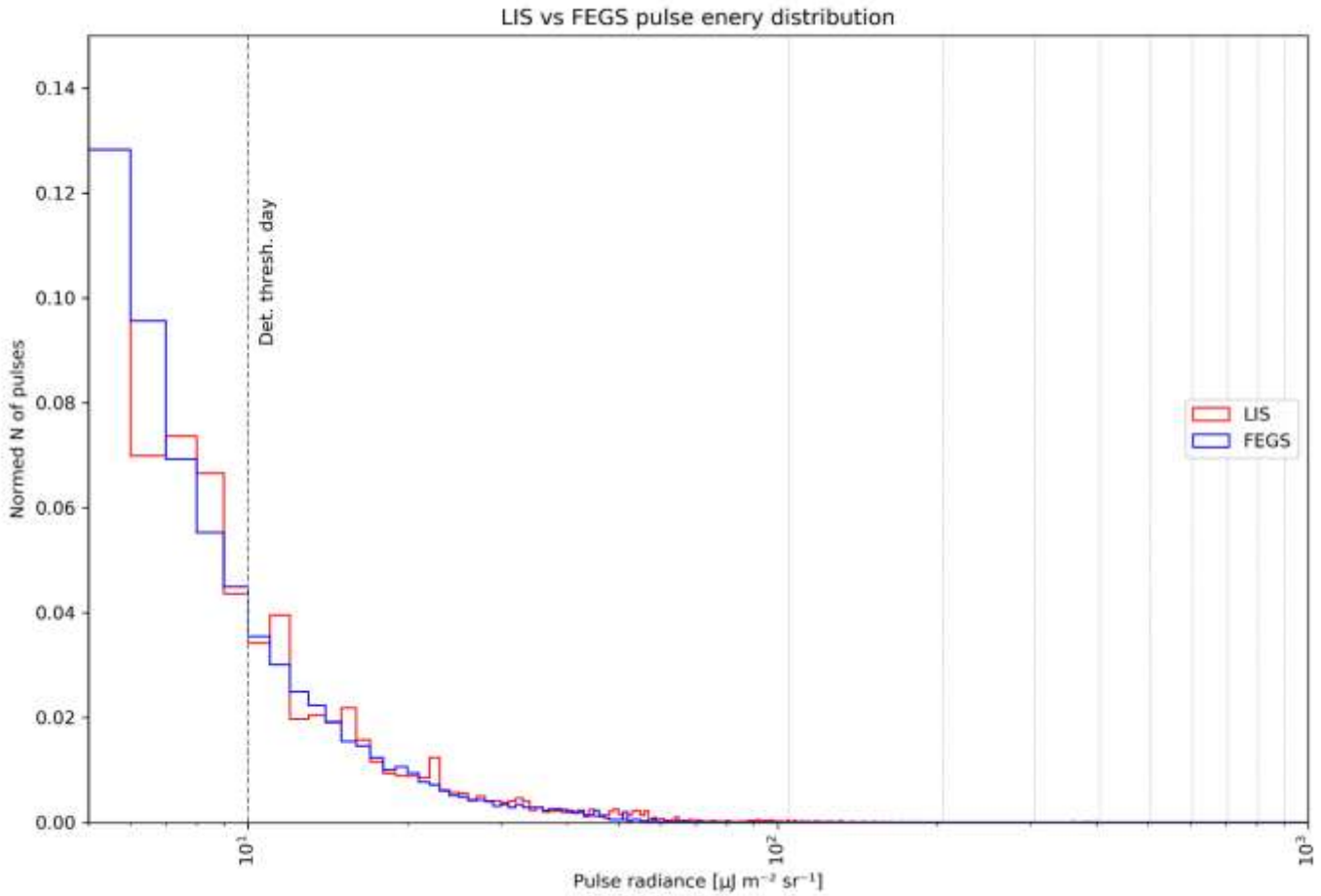
Analysis assumptions and inputs



The pulse radiance distribution from FEGS was compared against the one from LIS:

1. Forced match at the peak of the LIS distribution to check the high-end behaviour
2. Evaluated the mismatch at the low end

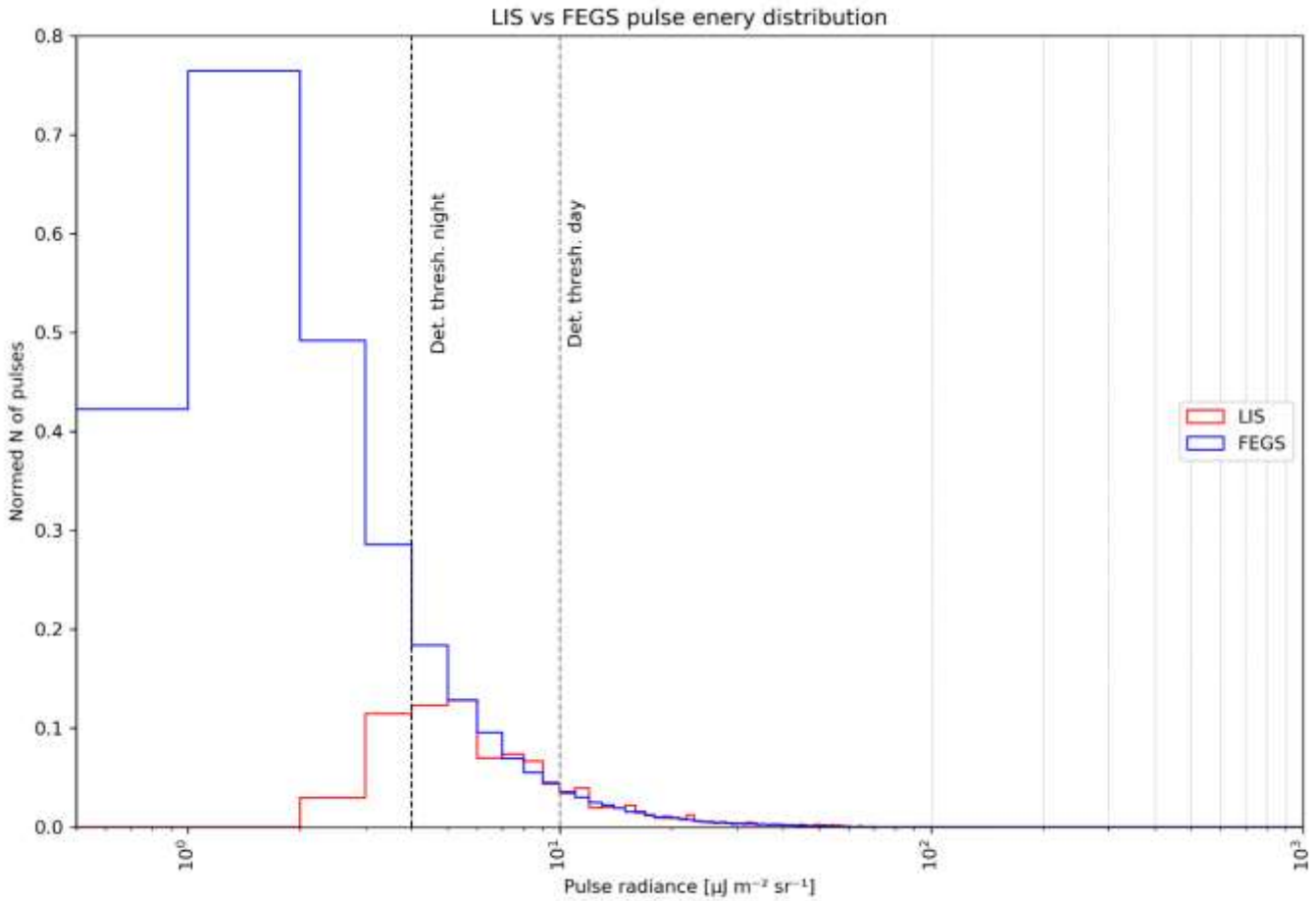
Analysis assumptions and inputs



The pulse radiance distribution from FEGS was compared against the one from LIS:

1. Forced match at the peak of the LIS distribution to check the high-end behaviour → **very good match**
2. Evaluated the mismatch at the low end

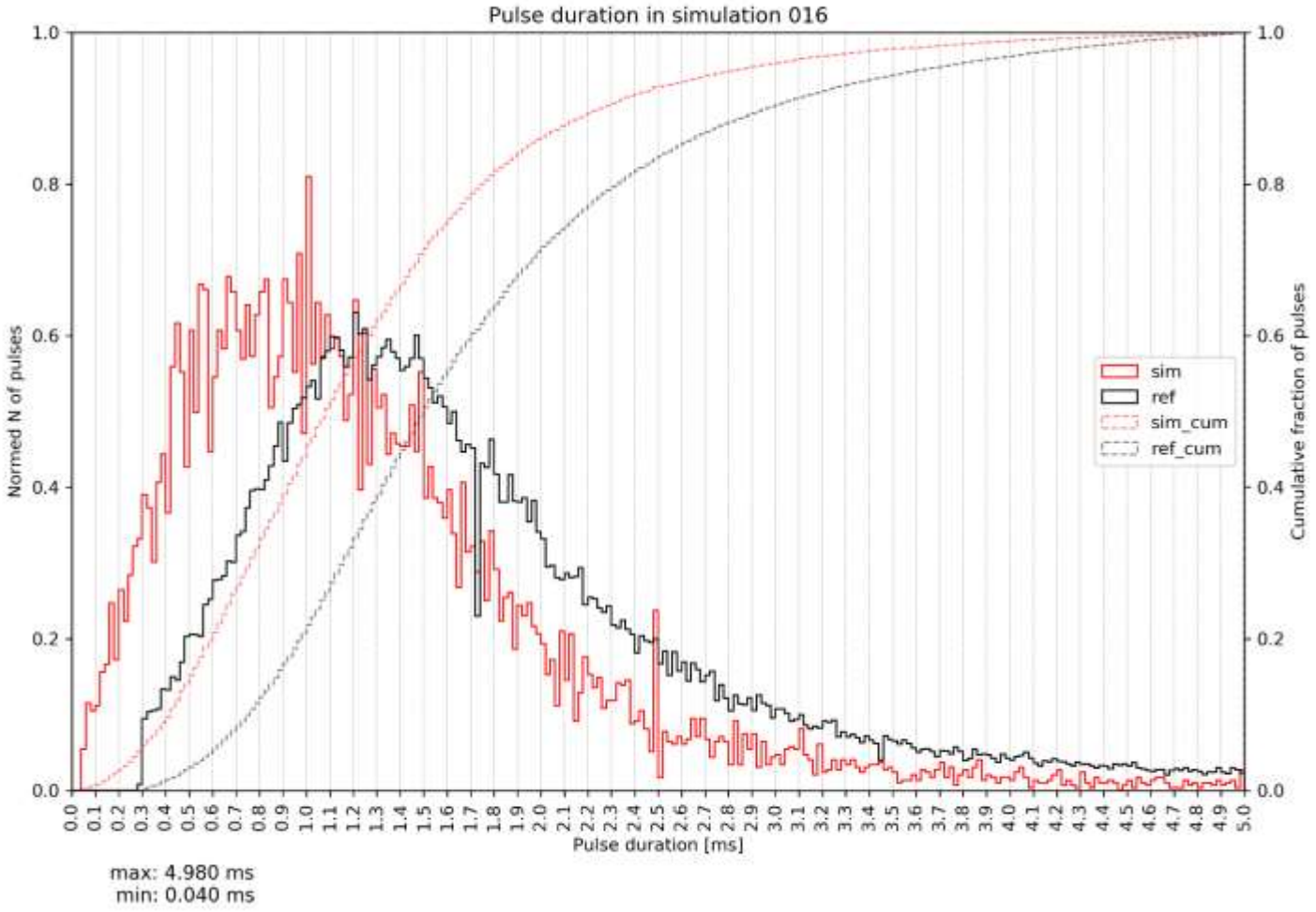
Analysis assumptions and inputs



The pulse radiance distribution from FEGS was compared against the one from LIS:

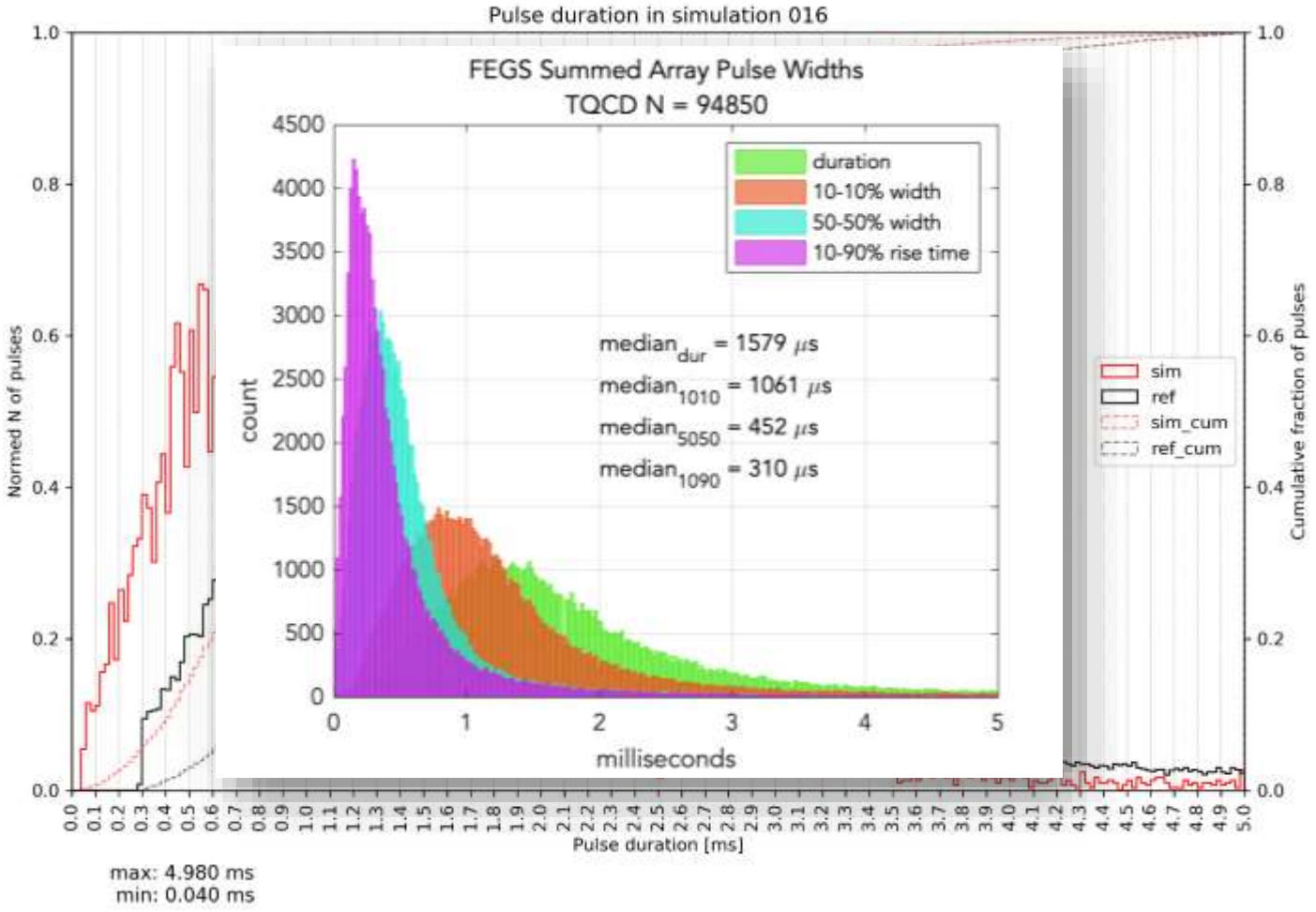
1. Forced match at the peak of the LIS distribution to check the high-end behaviour → **very good match**
2. Evaluated the mismatch at the low-end → **FEGS contains 8 times more information than LIS below 5 µJ / (sr m²)**

Analysis assumptions and inputs



The pulse duration distribution is peaked at lower values than the pulse duration distribution derived from the analysis of FEGS pulse profiles

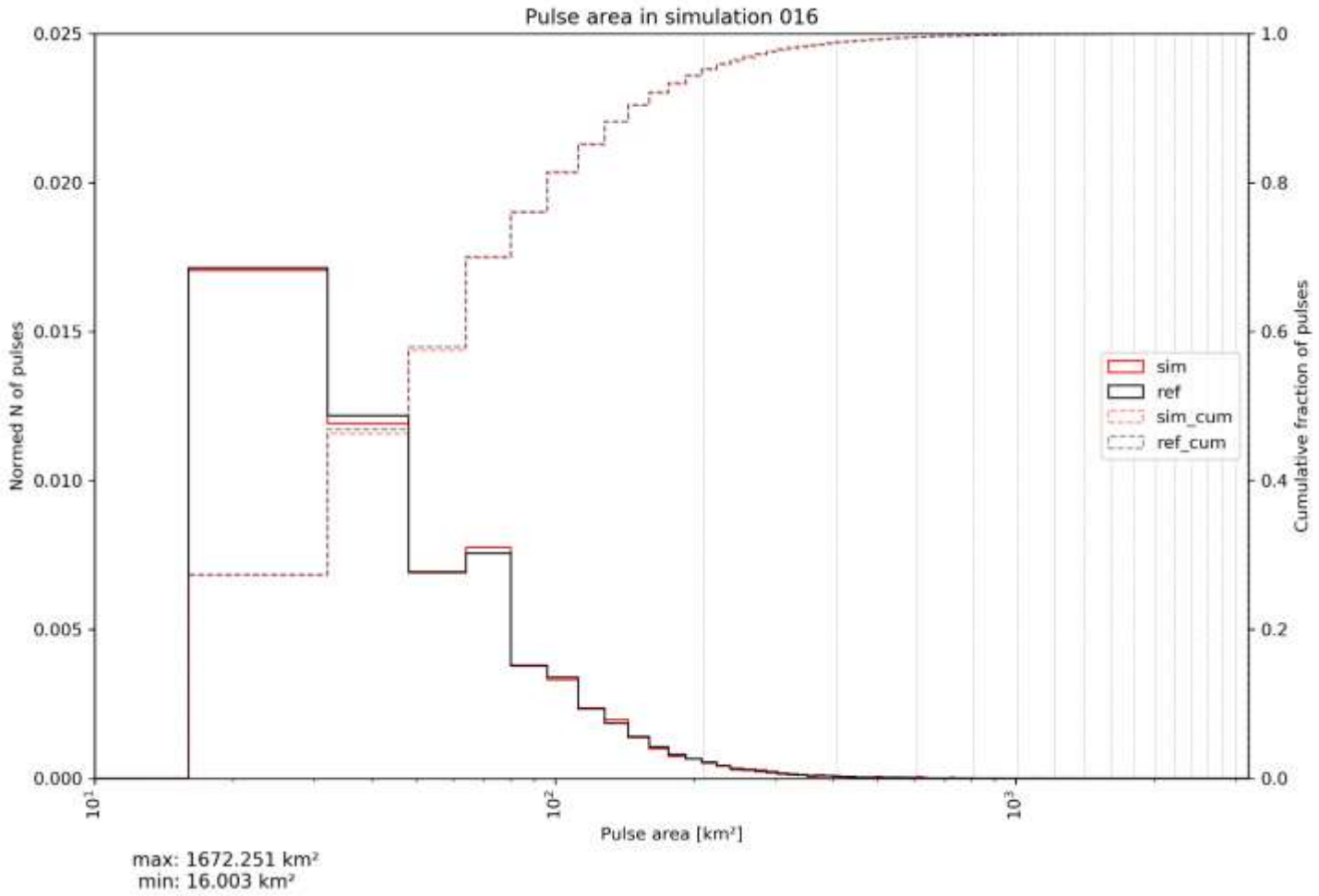
Analysis assumptions and inputs



The pulse duration distribution is peaked at lower values than the pulse duration distribution derived from the analysis of FEGS pulse profiles

Well within the families of pulse duration distributions derived from FEGS (e.g., very close to the 1010 case; Dr M. Quick private communication)

Analysis assumptions and inputs



The pulse area distribution from the distribution of number of events in groups from LIS

Open issue:

1. Most of the pulses smaller than the LIS pixel (link)
2. The typical pulses missed by GLM as derived from FEGS are faint, but not smaller than LIS pixel (link)

Analysis assumptions and inputs

Flash property	Settings
Location in space	Random within two types of masks: 1. Multi-sensor precipitation rate estimate product 2. Cloud mask product (only for totally dark scenes)
Location in time	All flashes start at the same time, i.e., at frame 1 of the simulation
Number of pulses	From the distribution of number of groups per flash **boosted by a factor 3**
Time difference between pulses	From the distribution of time differences between groups in flashes from LIS data
Location of pulses within the flash	Randomly located around the flash location within the distance from the flash area derived with the Ebro LMA by adopting the convex-hull method; the flash is assumed to be round in shape
Flash duration	Stems from the number of pulses and time difference between pulses; the maximum flash duration is 2 sec

Analysis assumptions and inputs

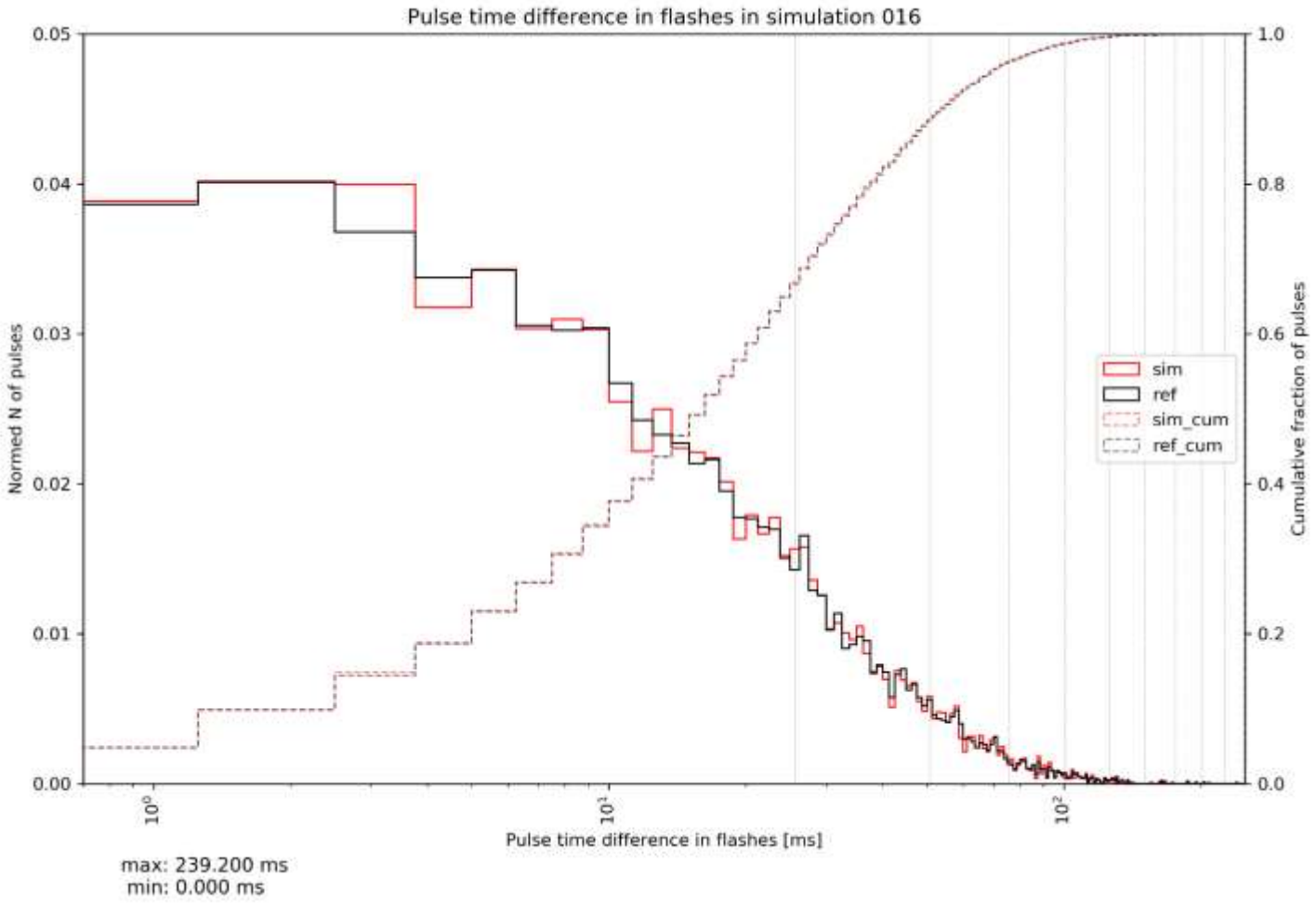
The pulse radiance distribution from FEGS was compared against the one from LIS:

1. Forced match at the peak of the LIS distribution to check the high-end behaviour → **very good match**
2. Evaluated the mismatch at the low-end → **FEGS contains 8 times more information than LIS below 5 µJ / (sr m^2)**

About 30% of the information in LIS statistics is below 5 µJ / (sr m^2)

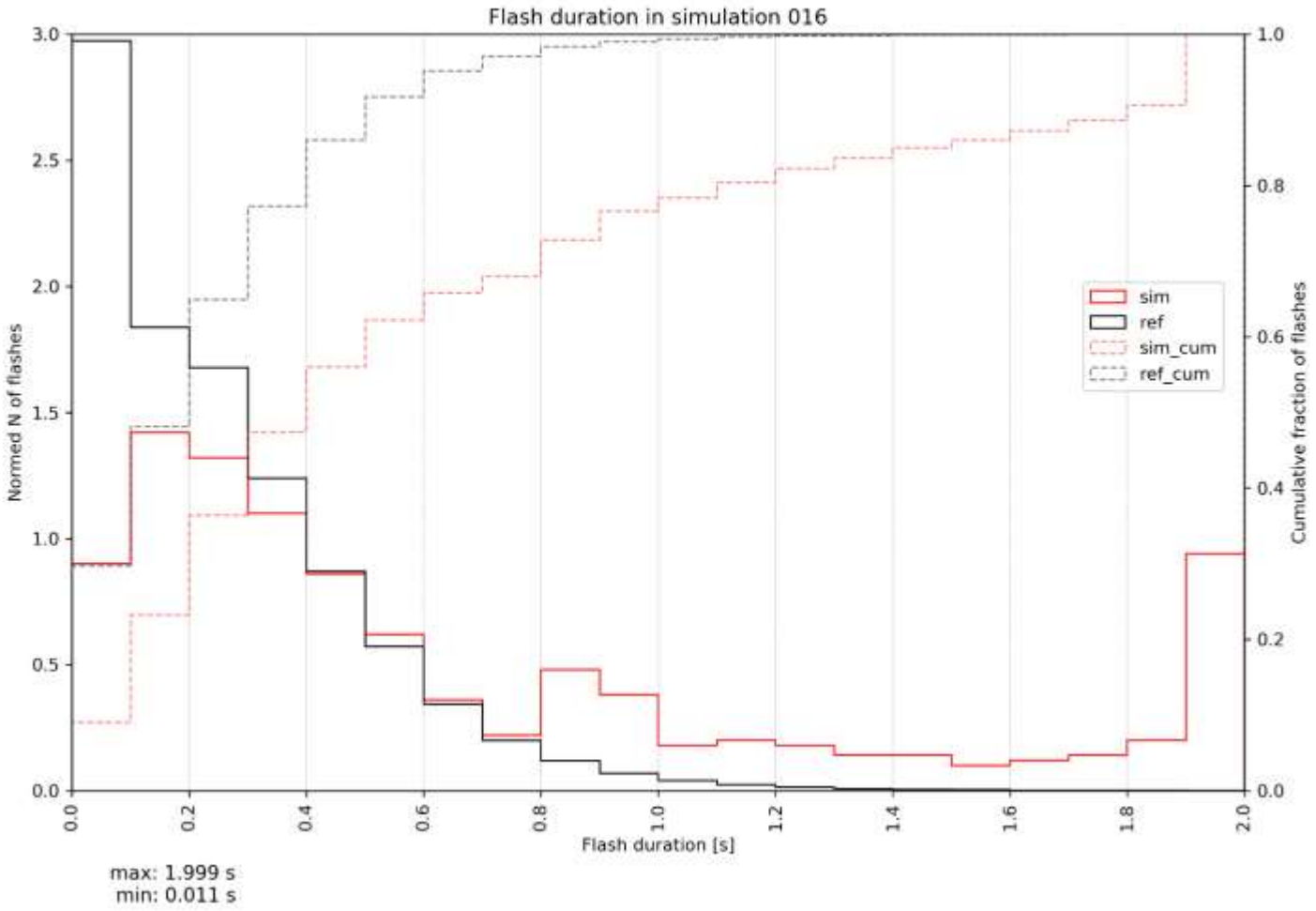
The boosting factor to the number of pulses is computed as $8 \times 0.3 + 0.7 = 3.1$

Analysis assumptions and inputs



The distribution of the time difference between pulses in flashes is not modified since it is anyway dominated by short intervals

Analysis assumptions and inputs



The distribution of the flash duration is characterized by longer flashes than in the LIS distribution (here ref) with an artificial peak at 2 millisecond

It is known that LIS is underestimating the flash duration as a consequence of its limited sensitivity (see link1 and link2)