TARANIS mission

T. Farges
with the collaboration of J-L. Pinçon, J-L. Rauch, P-L. Blelly, F. Lebrun, J-A. Sauvaud, and E. Seran

Joint MTG LI & GOES-R GLM workshop – 27-29 May 2015 - Roma

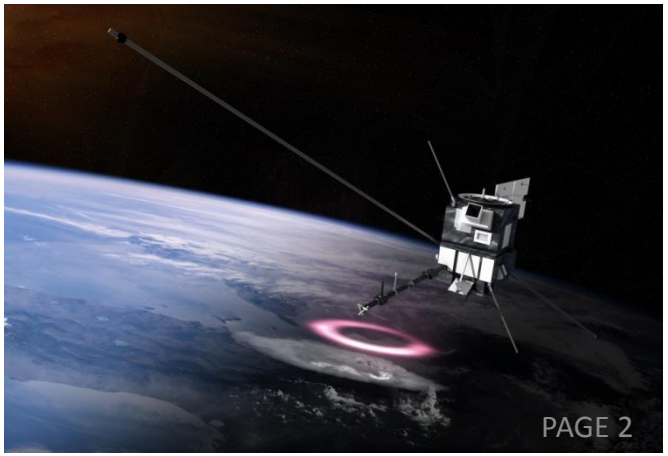
TARANIS scientific objectives

TARANIS (Tool for the Analysis of RAdiation from lightNIng and Sprites) is a **CNES satellite** mission dedicated to the study of impulsive energy transfers between the atmosphere of the Earth and the space environment. Its main objectives are :

- To advance the physical understanding of the links between TLEs, TGFs and environmental conditions *(lightning activity, geomagnetic activity, atmosphere/ionosphere coupling, occurrence of Extensive Atmospheric Showers, etc).*

- To identify the signatures associated with these phenomena *(electron beams, associated electromagnetic or/and electrostatic fields)* and to provide inputs to test generation mechanisms.

- To provide inputs for the modelling of the effects of TLEs, TGFs and bursts of precipitated and accelerated electrons *(lightning induced electron precipitation, runaway electron beams)* on the Earth's atmosphere.



TARANIS main characteristics

Mission lifetime: ≥ 2 years

Dimensions: ~ 1m³

Mass: ~200 kg

Orbit:

- Sun-synchronous
- Inclination : **98°**
- Altitude: **700 km**

Subsystems:

- mass memory: **16 Gbits**
- X band telemetry: **16.8 Mbits/s**
- Data: 4 GB/day

Time accuracy:

- relative: **10 µs**
- absolute: **±1 ms**

Pointing accuracy:

- localization: **5 km**

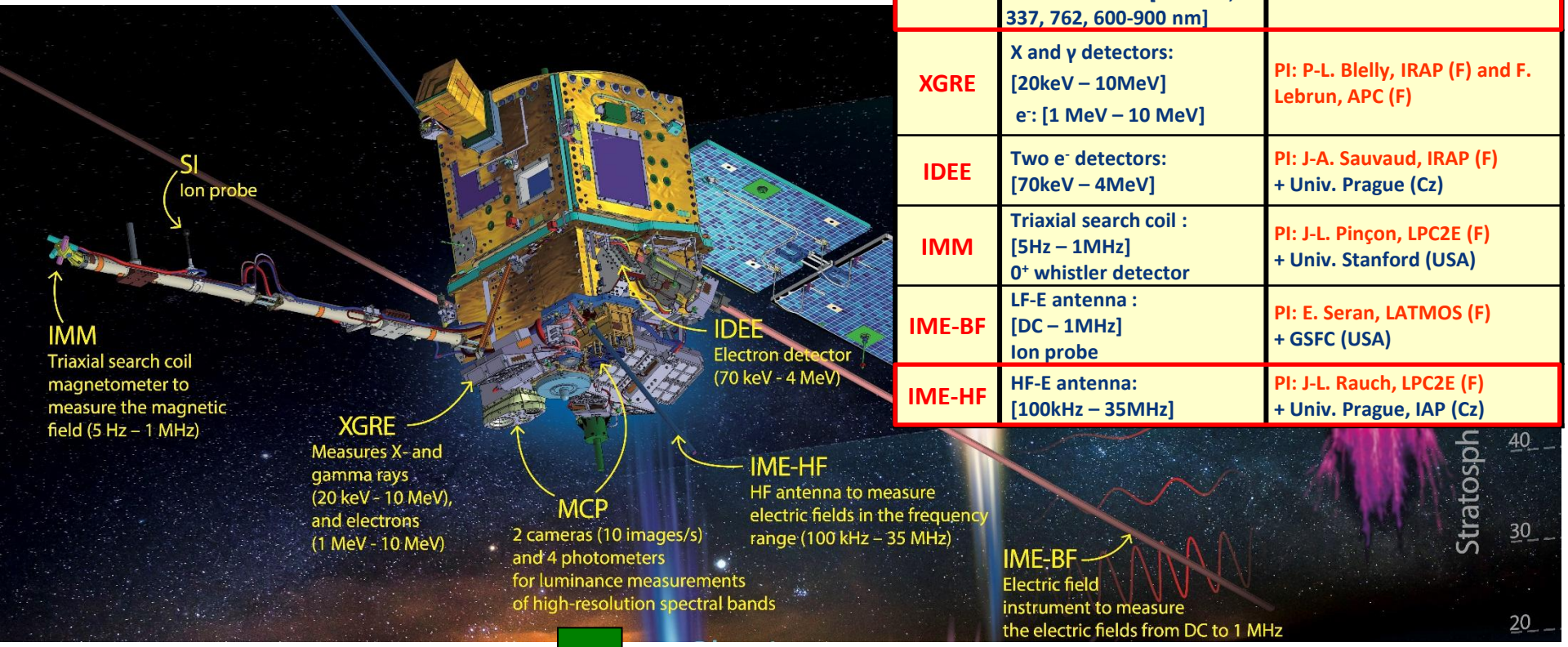
Main scientific challenge is to measure these phenomenon with all the instruments in high resolution:

- **Combined Nadir observations of TLEs and TGFs.**
- **Energetic electrons measurements**
- **Wave field measurement over the frequency range [DC - 35 MHz].**

TARANIS scientific payload

PI Mission : JL Pinçon (LPC2E)
Scientific co-I : E. Blanc (CEA)

MCP	Lightning micro-camera TLE micro-camera 4 Photometers [170-260, 337, 762, 600-900 nm]	PI: Th. Farges (CEA)
XGRE	X and γ detectors: [20keV – 10MeV] e^-: [1 MeV – 10 MeV]	PI: P-L. Blelly, IRAP (F) and F. Lebrun, APC (F)
IDEE	Two e^- detectors: [70keV – 4MeV]	PI: J-A. Sauvaud, IRAP (F) + Univ. Prague (Cz)
IMM	Triaxial search coil : [5Hz – 1MHz] 0^+ whistler detector	PI: J-L. Pinçon, LPC2E (F) + Univ. Stanford (USA)
IME-BF	LF-E antenna : [DC – 1MHz] Ion probe	PI: E. Seran, LATMOS (F) + GSFC (USA)
IME-HF	HF-E antenna: [100kHz – 35MHz]	PI: J-L. Rauch, LPC2E (F) + Univ. Prague, IAP (Cz)



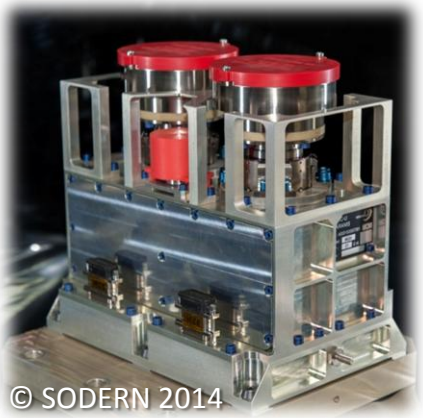
TOWARDS THE EARTH

MCP instrument

MCP-MC | **Only during night time** | **MCP-PH**

2 cameras

MCS
lightning + TLE
762 ± 5 nm



MCE
lightning
777 ± 5 nm

Radius at ground: 276 km
Frame rate: 10.3 s^{-1}
Dynamic: 12 bits/pixel
Synchronous camera

Mass: 2.4 kg
Size: 124 x 179 x 165 mm
Power: 11.5 W
Spatial resolution: 1.08 km at nadir

4 photometers

PH1 (TLE)
160-260 nm

PH2 (TLE)
337 ± 5 nm

PH3 (TLE)
762 ± 5 nm

PH4 (lightning)
600 - 900 nm

Radius at ground: 276 km,
except PH4 700 km
Sampling freq: 20 kHz
Dynamic: 12 bits / sample

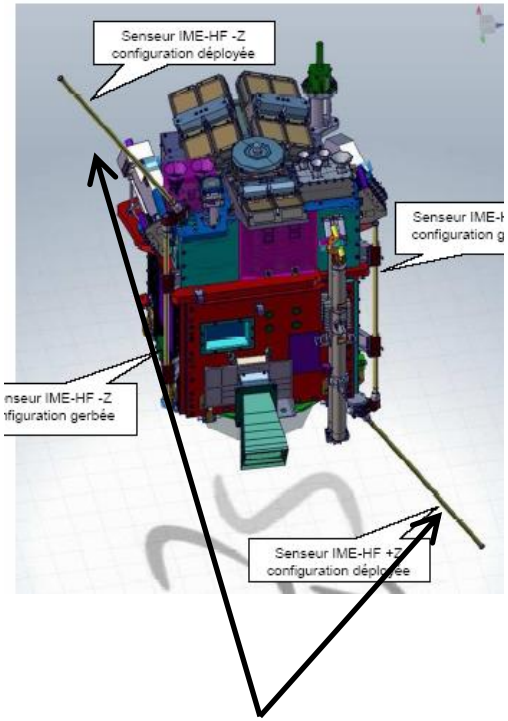
Mass: 2.5 kg
Size: 185 x 127 x 200 mm
Power: 5.6 W

Event mode : 3 full resolution images per camera and 410 ms waveforms per photometer

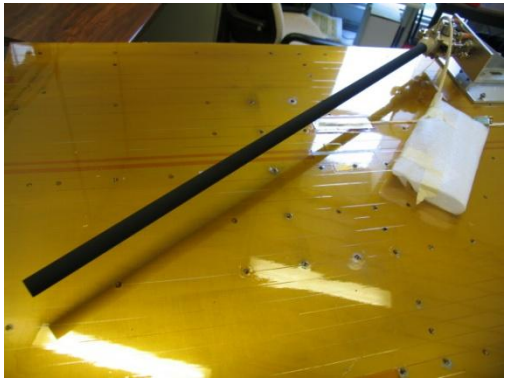
Scientific objectives:

- Provide identification, dating and localization of TLEs
- Provide dating and localization of lightning
- Provide spectroscopic (FUV/ UV /NIR) information
- Alert generation (if TLE or strong lightning occurrence detected on board)

IME-HF instrument



unfold HF antennas



- 2 antennas along a satellite diagonal, on the opposite side of the solar panels to measure fluctuation of the HF electric field : 100 kHz – 35 MHz
- Alert generation
- Data sampling: 80 MHz
- Event data per half orbit:
  - up to 3 waveform data (full sampling frequency, 41 ms)
  - and narrowband-filtered waveforms (filterbank of 12 frequencies, time resolution of 12 µs, 41 ms)

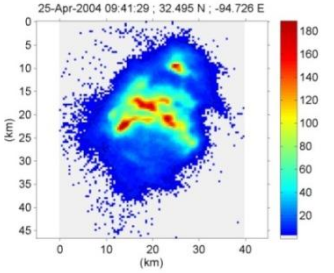
Scientific objectives:

- Identification of waves and signatures associated to transient luminous phenomena during storms
- Characterization of lightning flashes from their HF electromagnetic signatures, association with TLEs and TGFs
- Detection of precipitated and accelerated particles (including runaway electron beams and very high energy cosmic rays) from their HF electromagnetic or/and electrostatic signatures
- Identification of characteristic frequencies of the medium from cut-off frequencies and polarization (ordinary or extraordinary mode)

TARANIS measurements for lightning studies

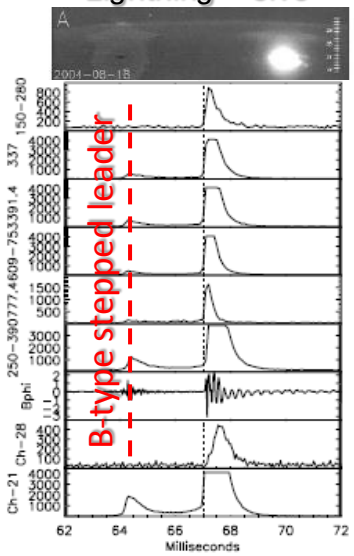
Contribution to lightning physics studies

- Image:
  - Lightning localization
  - Filament structure (1 km spatial resolution)
  - (Relative) cloud top height
- Photometer waveforms :
  - Physical mechanism: different wavelength
- HF waveforms:
  - IC/CG discrimination capability (Davis, JGR, 2012)
  - identification of lightning phase: preliminary breakdown, stepped leaders, return strokes, …
  - TIPPs: altitude of discharges determination
- Comparison of measurements:
  - Image/photometer: better localization
  - Photometer/HF waveforms: diffusion by clouds

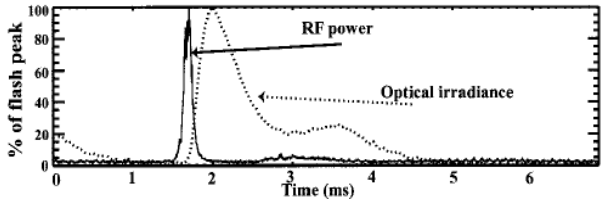


LSO data
Farges et al., 2014

Lightning + elve



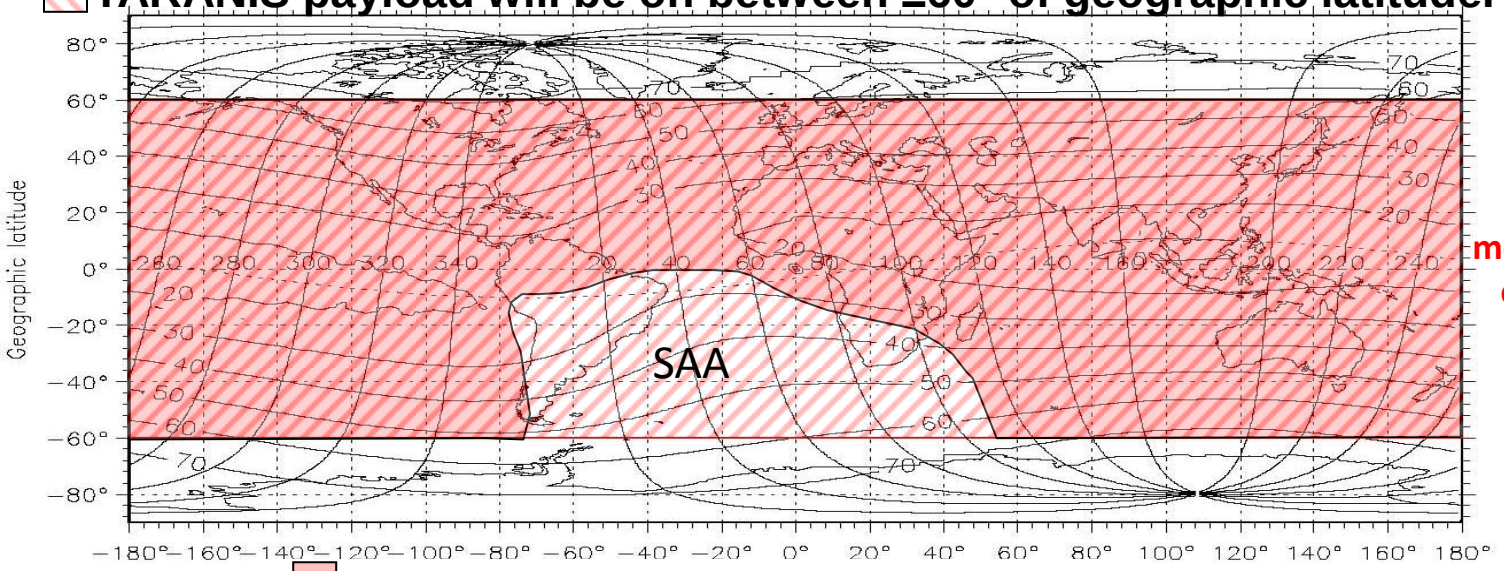
ISUAL data *Frey et al., 2005*



FORTE data *Light et al., 2001*

TARANIS operating modes

TARANIS payload will be on between ±60° of geographic latitude.



X and Gamma measurements outside SAA.

Optical measurements only during night.

Survey data:

Continuous monitoring of the background conditions.

2 GB of low resolution data per day!

Event data:

Triggered: when a priority event is detected (TLE, TGF, electron beam, burst of electromagnetic/electrostatic waves), then all instruments record and transmit high resolution data.

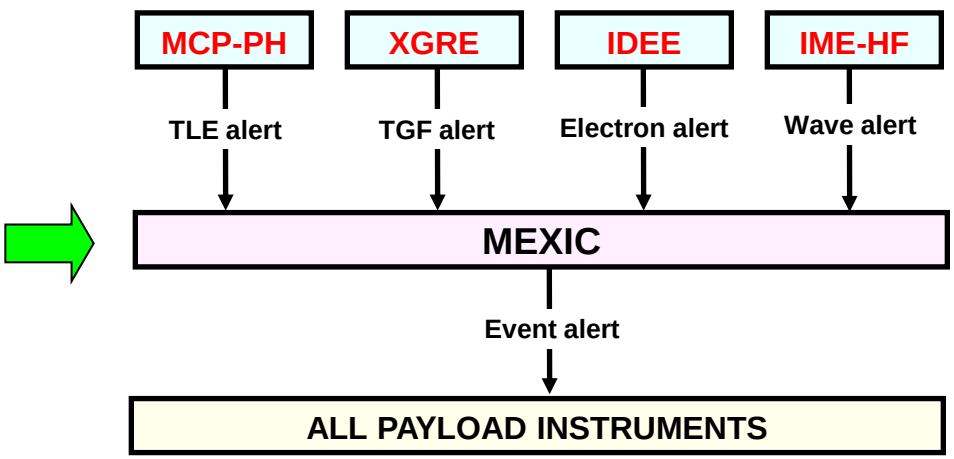
2 GB of high resolution data per day!

TARANIS event data

TARANIS

Mass memory: 16 Gbits
X-band telemetry: 16.8 Mbits/s

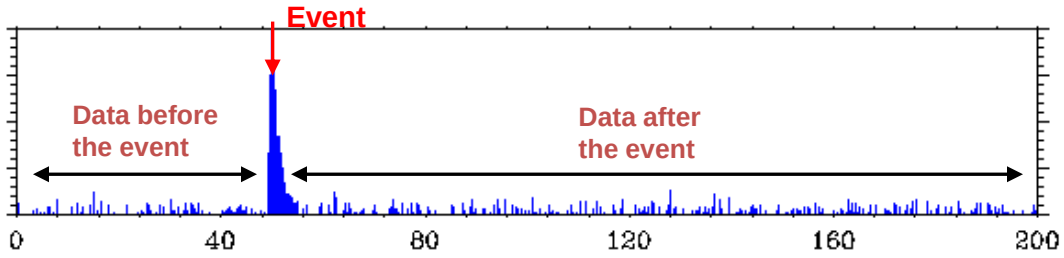
2 GBytes of event data per day
- On average 12 events per half-orbit (T=100mn)
- A maximum of 36 events per half-orbit



4 triggering instruments

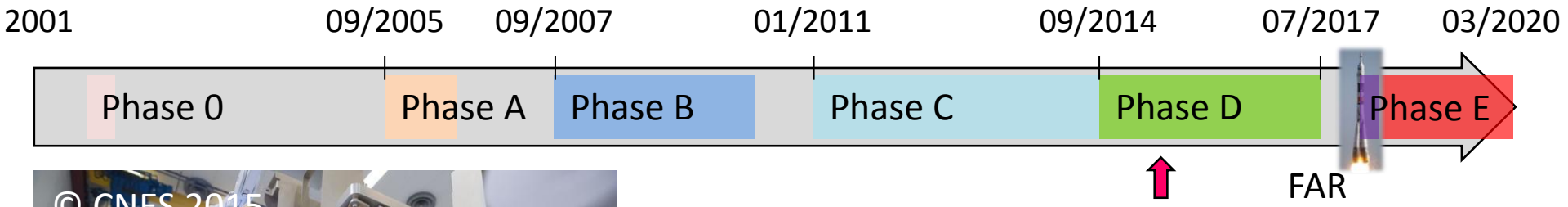
Multi EXperiment Interface Controller to power and to manage the whole scientific payload.

On-board analyzers will include event buffer memory sized to record high resolution data both before and after the trigger



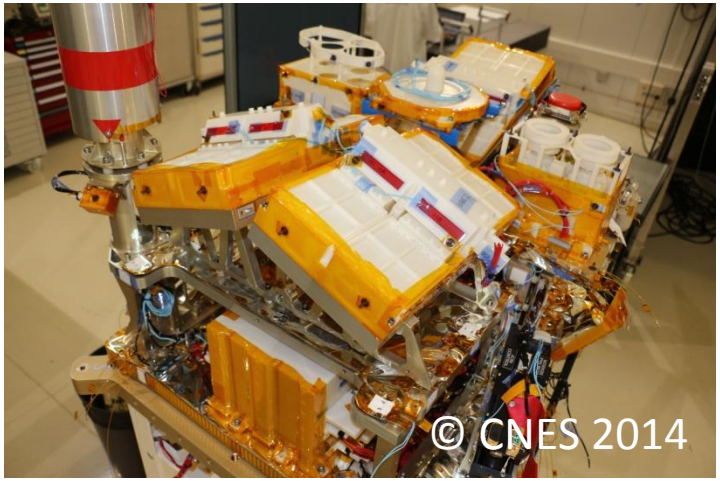
Time window depends on instrument time resolution

TARANIS status & launch



Now: platform integration, instrument qualification
Next step: instrument integration on the payload

Platform integration



Scientific payload with 3D models

Launch: late 2017, from Kourou with Soyuz as a piggyback of ESA EarthCare satellite

TARANIS data server and data policy

Guest investigators will have access to:

- Calibrated Survey and Event data
- Quickviews (Survey & Event)
- Auxiliary data

after TARANIS scientific committee agreement.

TARANIS data will be available via the TARANIS data server

T+24H : TARANIS data server (access via login)

T+18 months : CDPP data server (no login needed)

MCP data for GEO LIs validation

Comparison of LEO and GEO satellites is not a new problem but:

- Comparing concurrent MCP and LIS/GLM/LI records requires to take into account the instrument characteristics (e.g. wavelengths, time exposure, radiometric sensitivity) and condition of observations (e.g. spatial resolution, viewing angle)
- Cross-validation at the group scale, flash scale and storm scale during MCP viewing period

	MCP/TARANIS	LI/MTG	GLM/GOES-R	LIS/ISS
Timing accuracy	± 1 ms	GPS?	GPS?	GPS?
Time exposure	97 ms	1 ms	2 ms	2 ms
Spatial resolution at 10 km altitude	1.08 km at nadir	4.5 km at nadir (more in oblique)	8 km at nadir ~14 km at the edge of FOV	4 km at nadir
Filter bandwidth (FWHM)	11.3 nm	1.5-2.0 nm	1 nm	1 nm
Spectral sensitivity in bandwidth	radiometric characterization in progress	?	?	4.7 $\mu J.m^{2}.sr^{-1}$ (SNR > 6)
Viewing direction	nadir	nadir to oblique	nadir to oblique	nadir
Data	full resolution image (512x512)	neighboring triggered pixels in the same integration period		

Thank you for your attention

References:
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Hébert P et al., paper number 134 of 9th ICSO International Conference proceedings, October 9th-12th 2012, Ajaccio, France