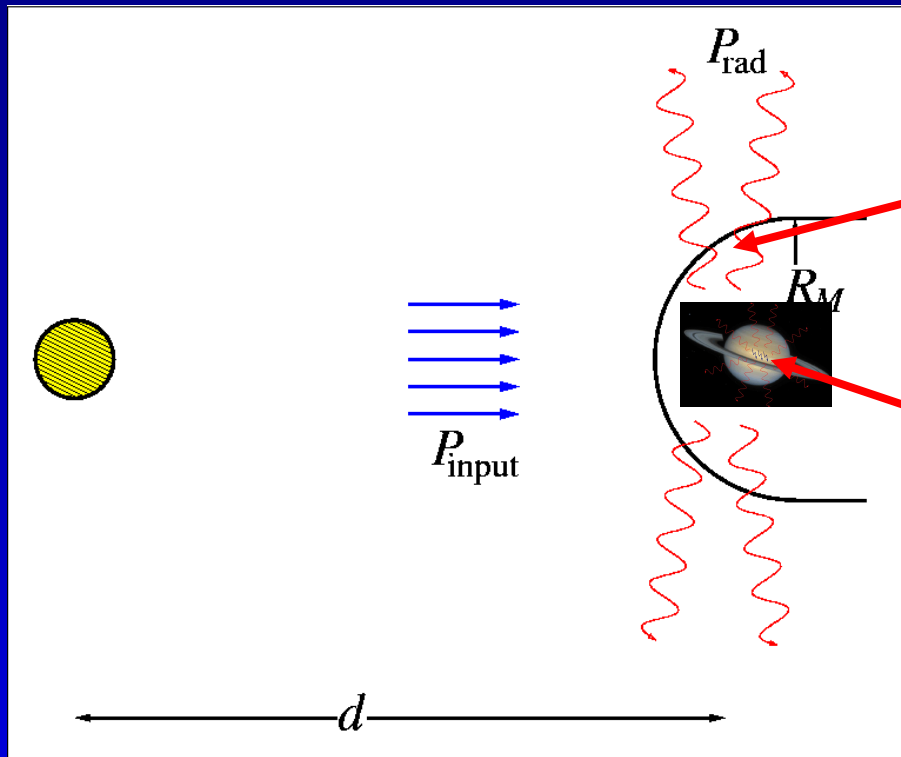


Radio bursts from Saturn lightning

Jean-Mathias Grießmeier

with: P. Zarka, A. Konovalenko, G. Fischer, B. Ryabov,
D. Vavriv, V. Ryabov, H. Rucker, P. Ravier, M. Sidorchuk
and the Radio-Exopla collaboration

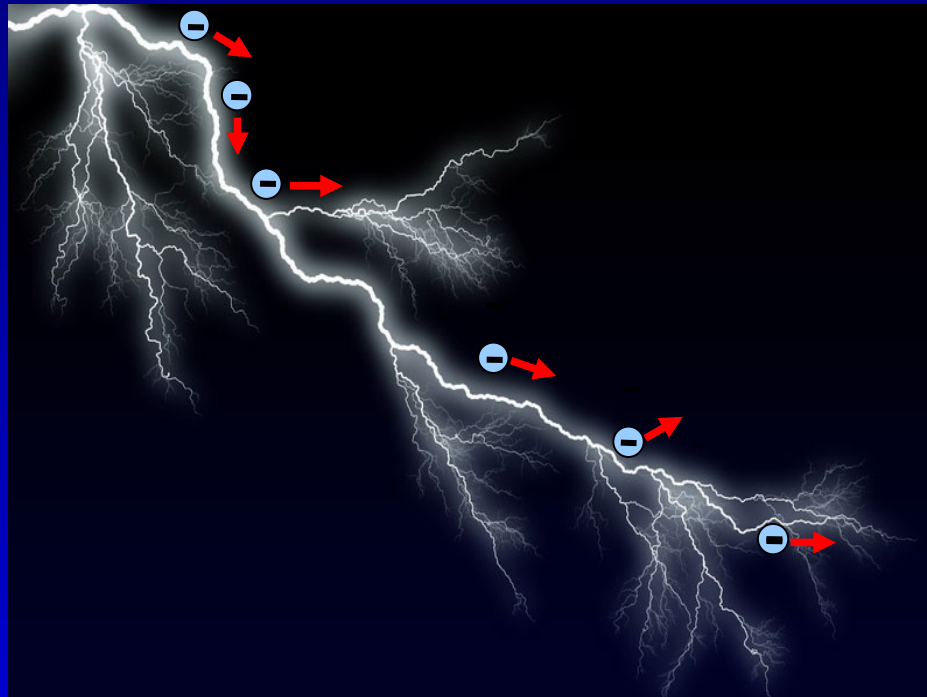
Lightning



magnetospheric emission

atmospheric emission (lightning)

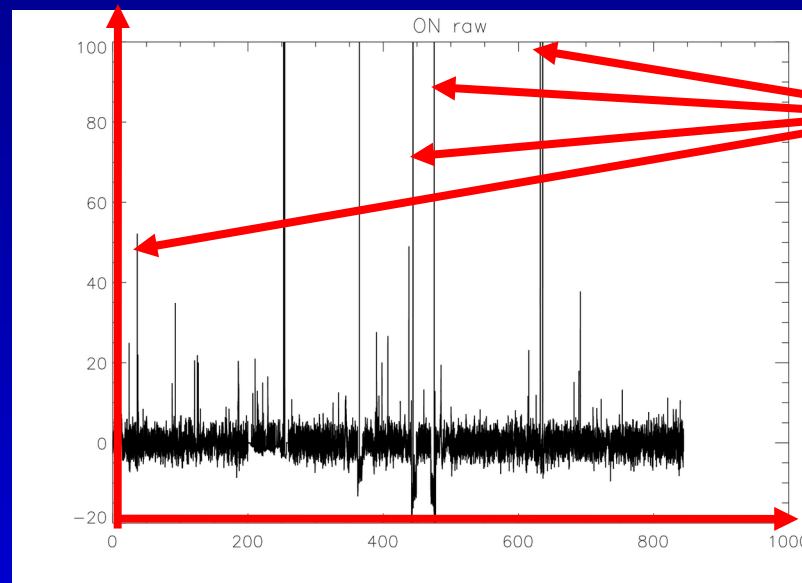
Lightning



acceleration of charges \Rightarrow electromagnetic radiation

Planetary lightning

Intensity
(12-28
MHz)



Lightning as a radiosource

Radiosource: **lightning activity** in corotating storm system

How do we know?

⇒ episodes repeat
after one planetary
rotation

⇒ we even see the
storms in IR
(e.g. “Dragon
storm”, 2004)

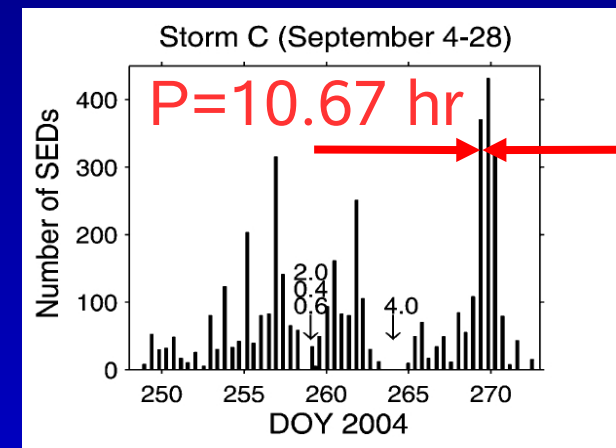
Lightning as a radiource

Radiource: lightning activity in corotating storm system

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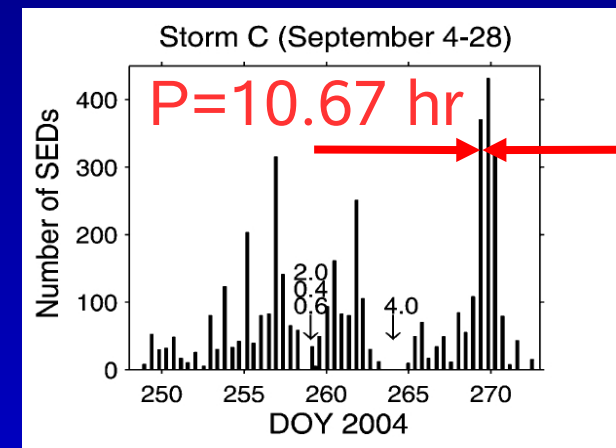


Lightning as a radiource

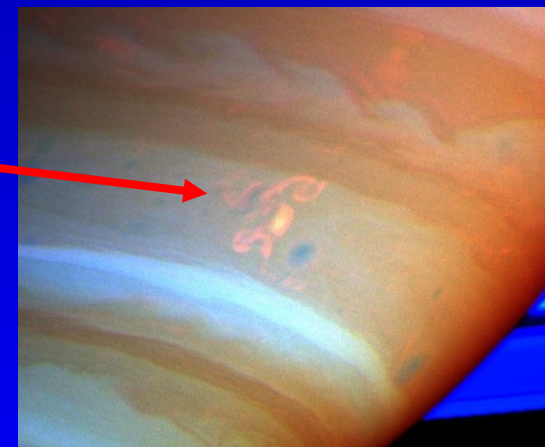
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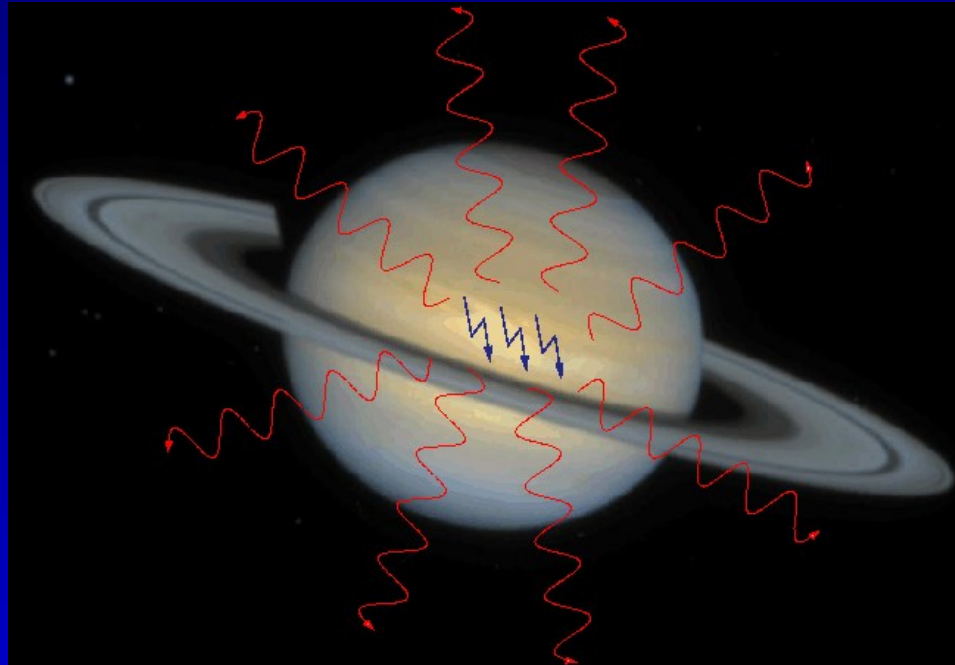


Saturn lightning

Why to study Saturn lightning?

- existence of lightning
- electrification processes
- atmospheric dynamics and composition
- geographical and seasonal variations
- correlation with optical/IR observations (clouds)
- comparison to Earth processes

Observational challenges



Radiobursts are:

- faint signal (no ground detection until 2006)
- transient signal (≤ 2 ms)
- sporadic emission (low occurrence rate: ~ 30 d/year)
- low frequency (≤ 20 kHz to ≥ 40 MHz)

Saturn lightning observations

Satellite observations:

- Voyager 1 & 2: 1980 & 1981
- Cassini: 2004-now

Ground observations:

- UTR-2 & Nancay: 2006
- UTR-2: 2007 & 2008

Saturn lightning observations

Satellite observations:

- Voyager 1 & 2: 1980 & 1981
- Cassini: 2004-now

10⁵ km
instead of
1.5*10⁹ km,
⇐ i.e. signal
10⁸ times
stronger

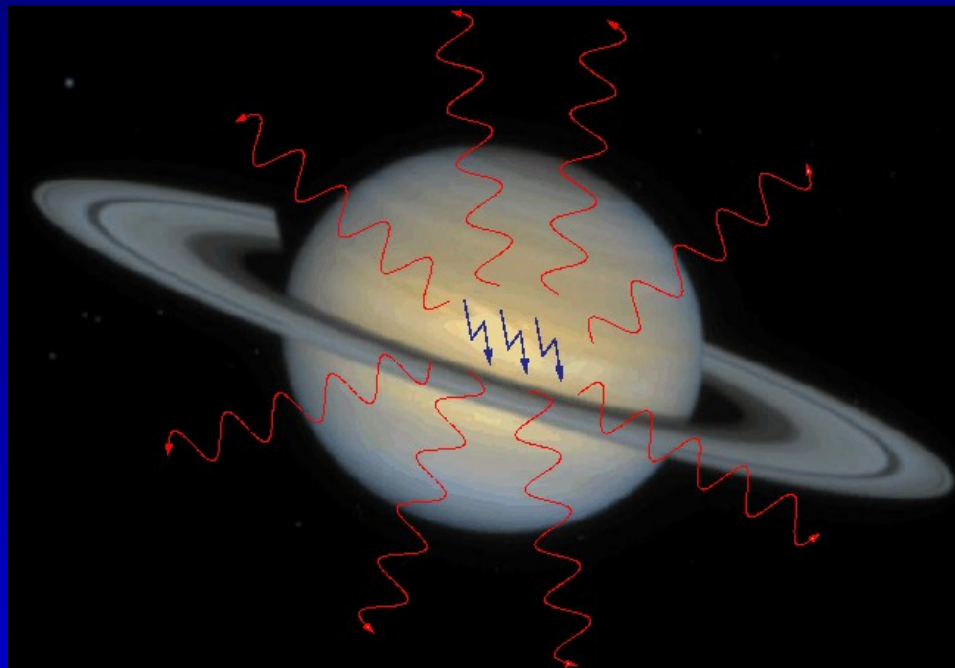
Ground observations:

- UTR-2 & Nancay: 2006
- UTR-2: 2007 & 2008

modern
receivers,
⇐ Cassini as
trigger

⇒ large collecting area required

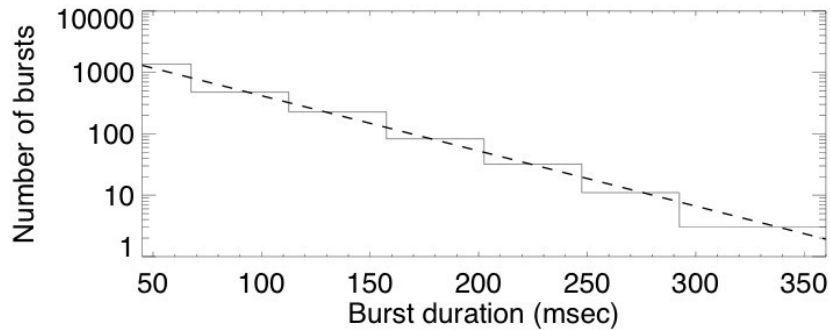
Observational challenges



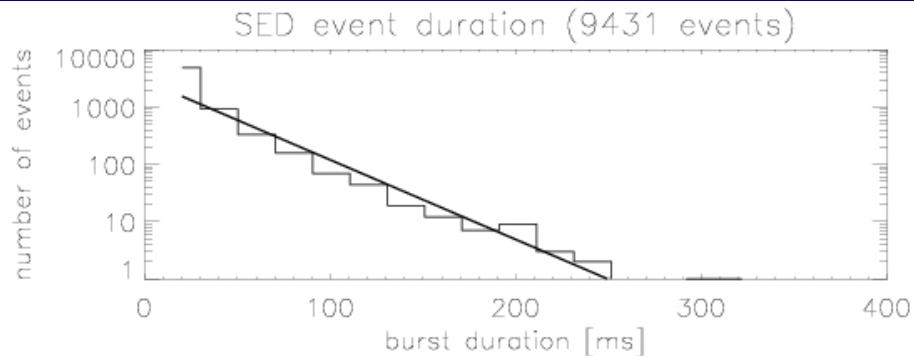
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Burst duration

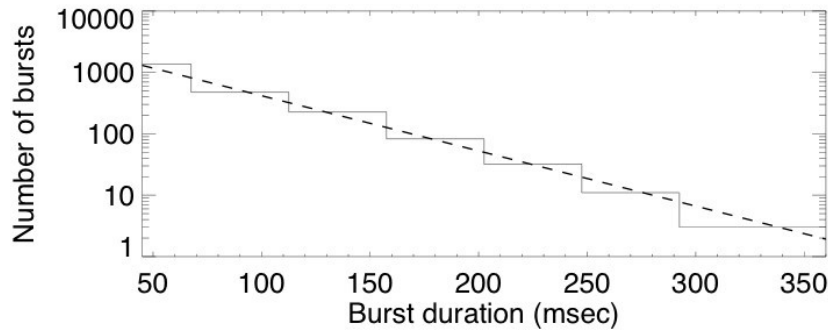


$\tau \approx 40\text{-}50\text{ ms}$
(Voyager, Cassini,
 $\Delta t = 40\text{ ms}$)

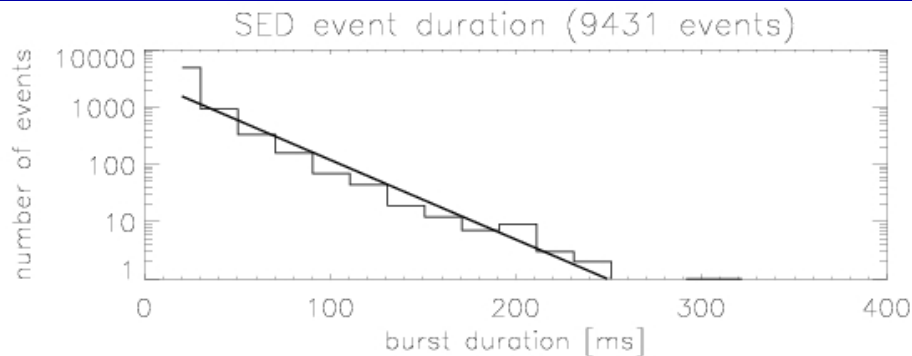


$\tau \approx 30\text{ ms}$
(UTR-2,
 $\Delta t = 20\text{ ms}$)

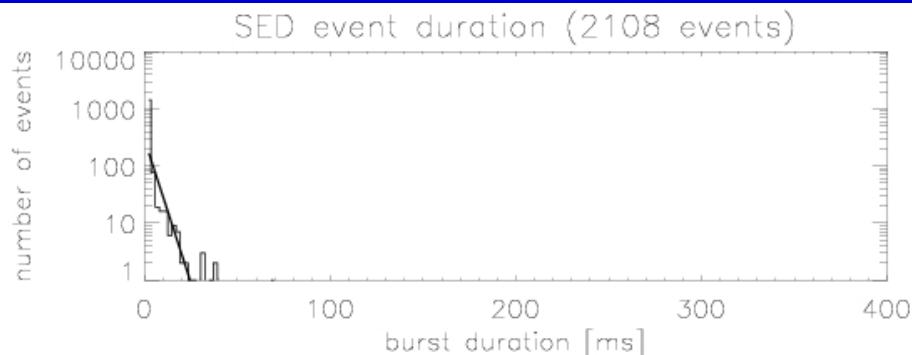
Burst duration



$\tau \approx 40\text{-}50$ ms
(Voyager, Cassini,
 $\Delta t = 40$ ms)



$\tau \approx 30$ ms
(UTR-2,
 $\Delta t = 20$ ms)



$\tau \approx 4.3$ ms
(UTR-2,
 $\Delta t = 2$ ms)

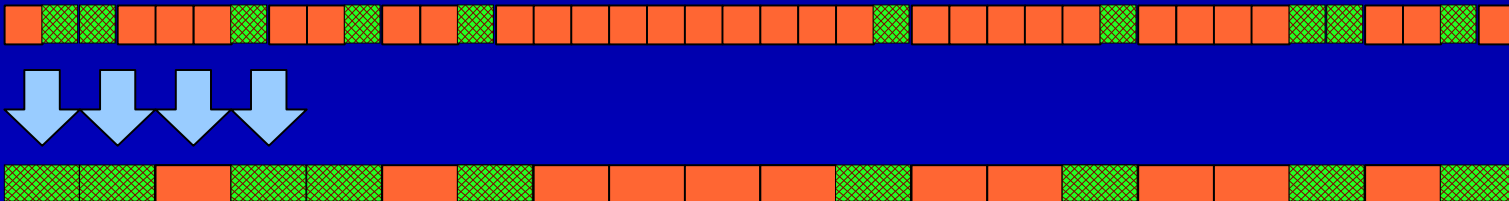
Not enough time resolution!

dt=10 ms



Not enough time resolution!

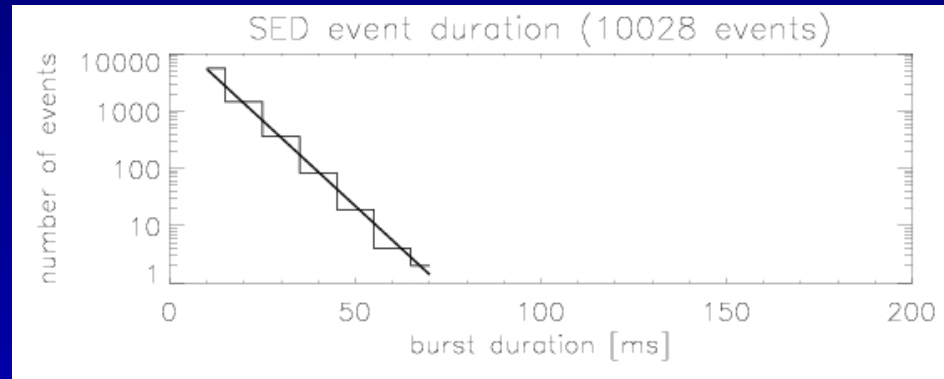
dt=10 ms



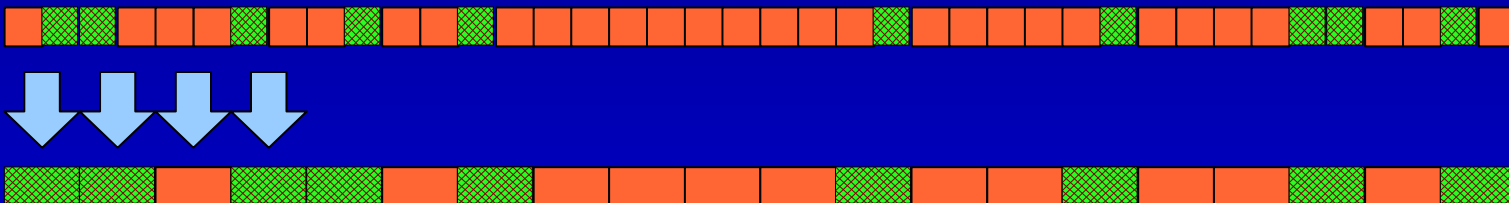
dt=20 ms

Not enough time resolution!

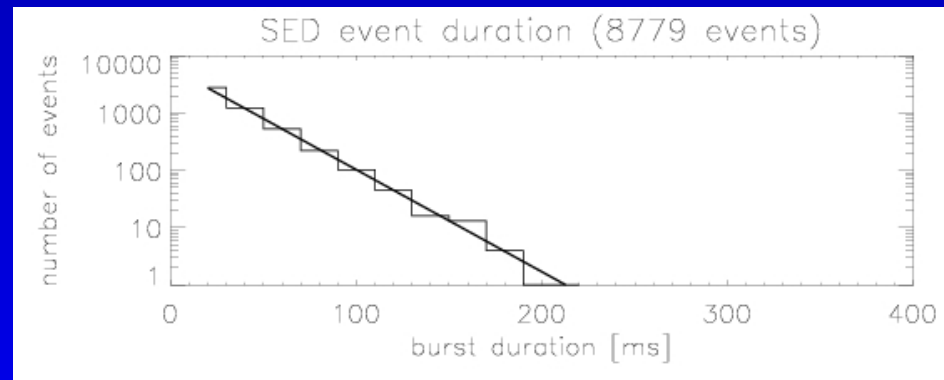
dt=10 ms



$\tau = 7.3$ ms



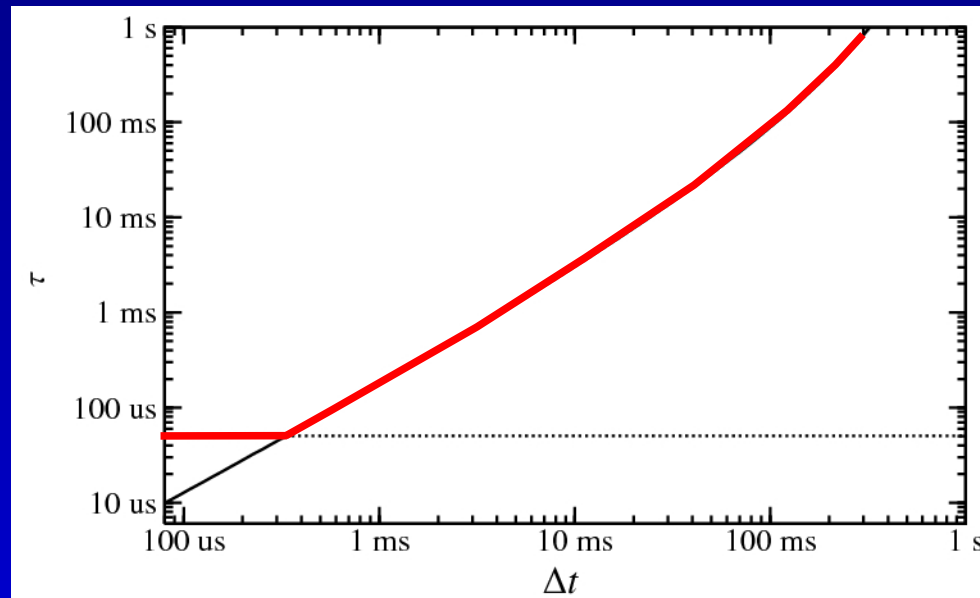
dt=20 ms



$\tau = 24.4$ ms

e-folding time as a function of Δt

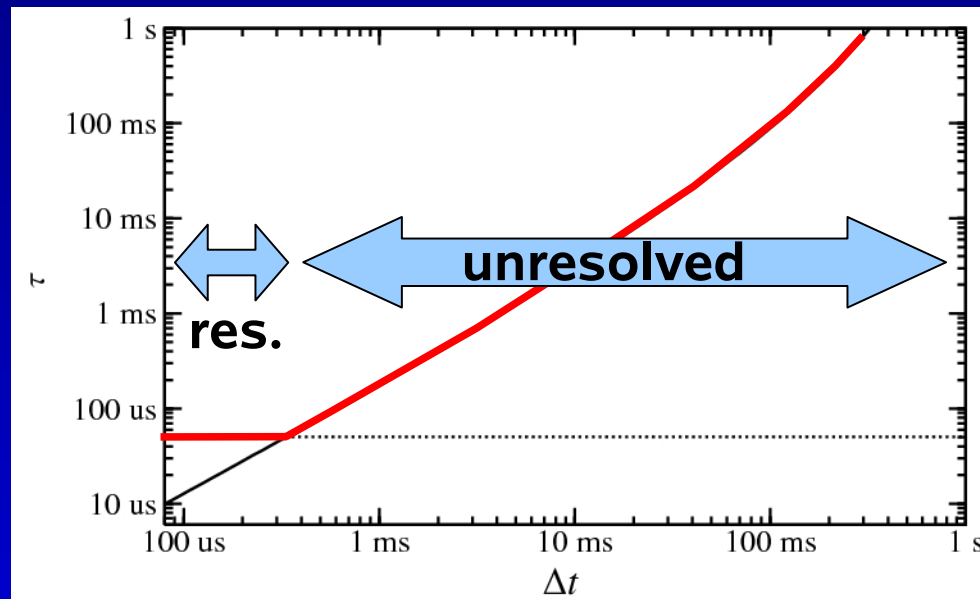
measured
e-folding
time



sampling time

e-folding time as a function of Δt

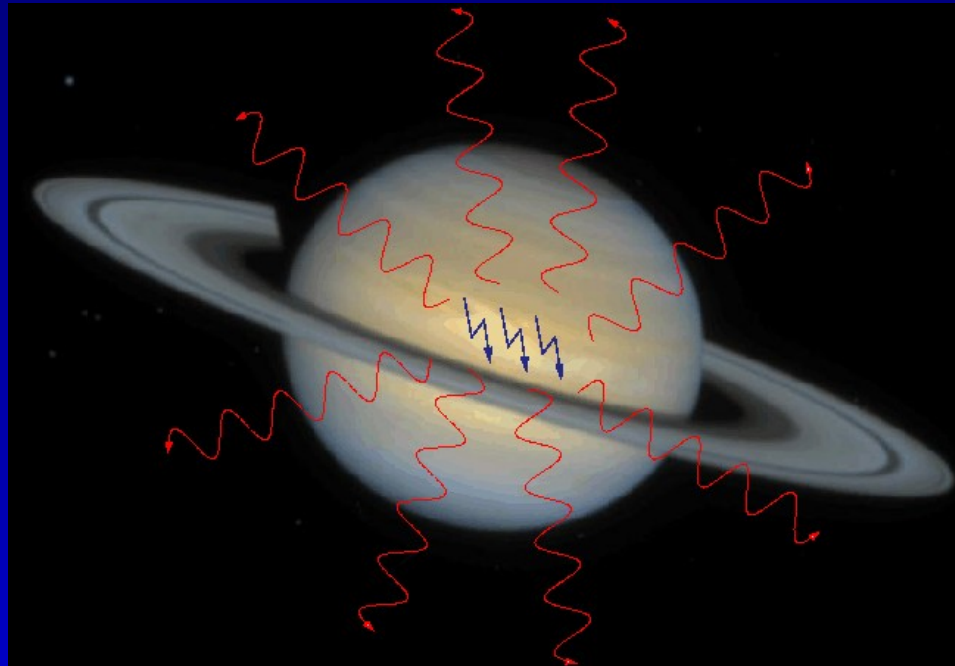
measured
e-folding
time



sampling time

\Rightarrow high time resolution required

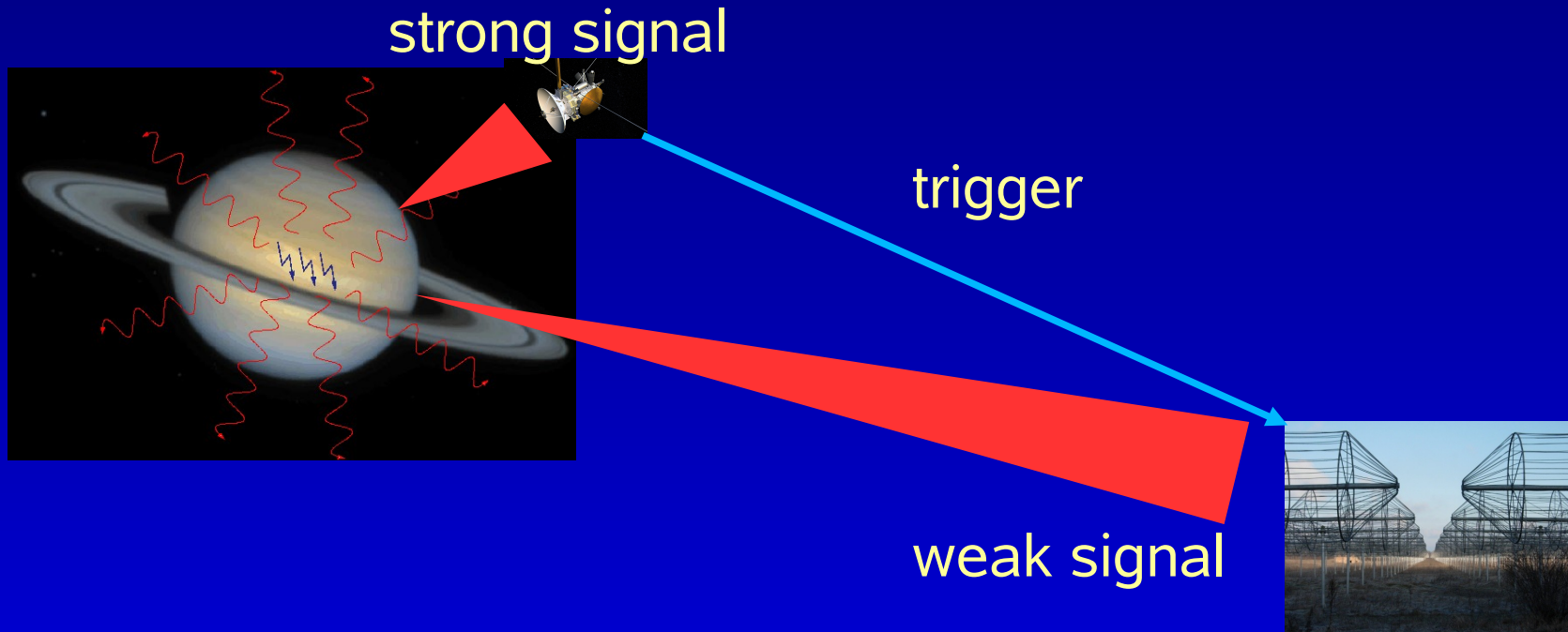
Observational challenges



Radiobursts are:

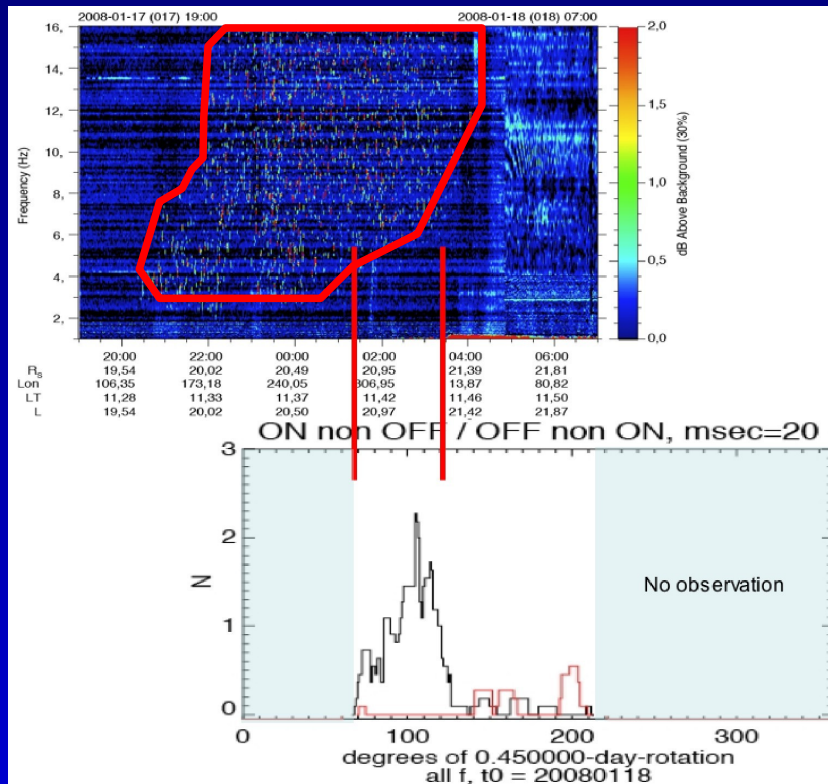
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Ground-based observation



Cassini triggers ground-based observations

Ground-based observation



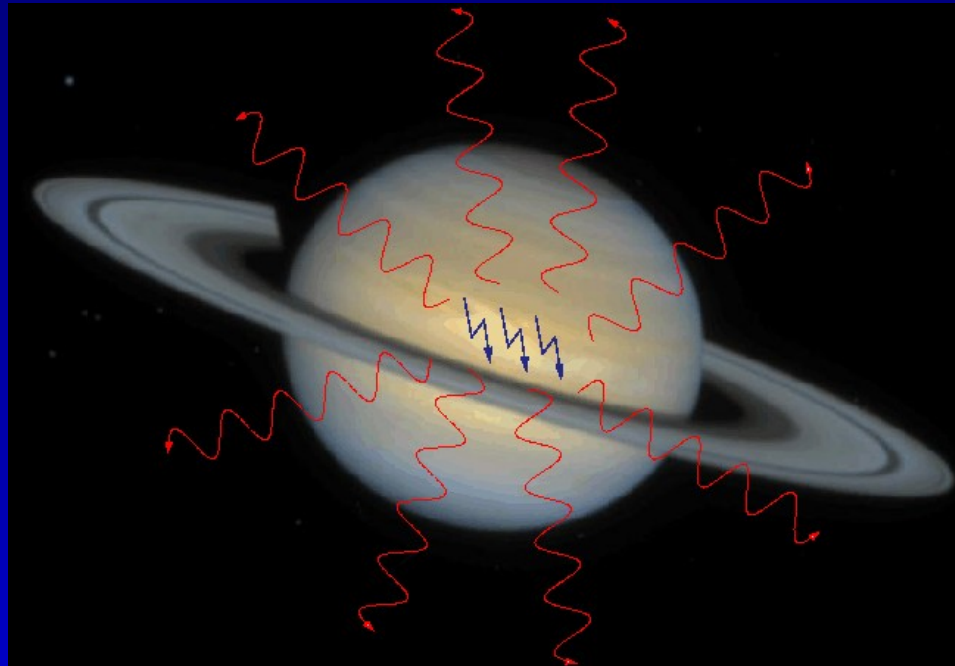
← Cassini

← UTR-2

- now: Cassini triggers ground-based observations
- after Cassini (>2010)?

⇒ monitoring required

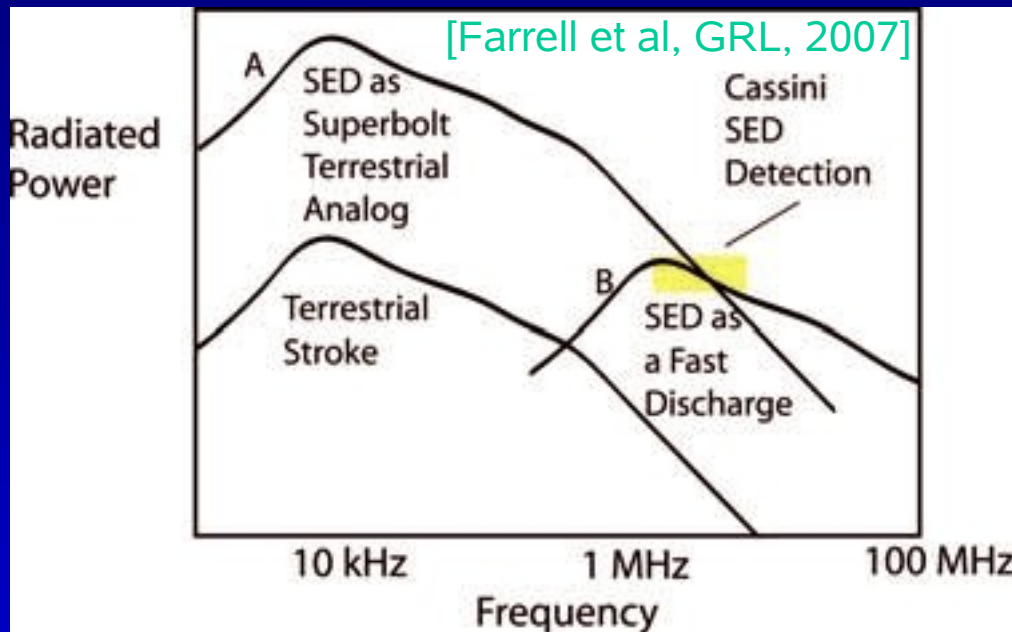
Observational challenges



Radiobursts are:

- **faint** signal (no ground detection until 2006)
- **transient** signal (≤ 2 ms)
- **sporadic** emission (low occurrence rate: ~ 30 d/year)
- **low frequency** (≤ 20 kHz to ≥ 40 MHz)

Spectrum

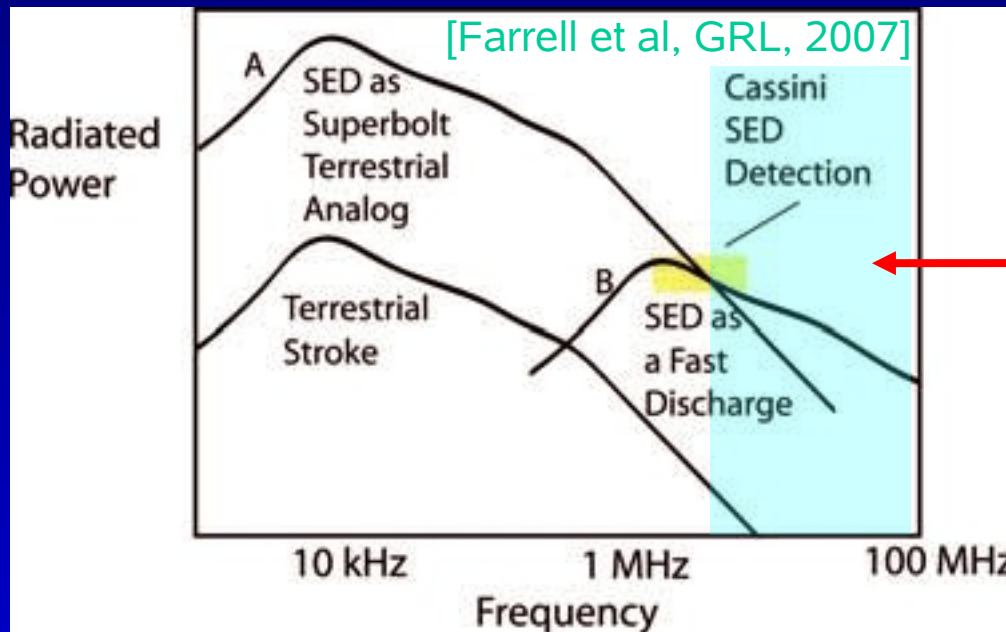


with the currently known spectrum, Saturn lightning could be

- (A) 10000 times **stronger** than on Earth
- (B) 10000 times **weaker** than on Earth

⇒ spectrum needed in wide band

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Observational challenges

Radiobursts are:

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Observational challenges

Radiobursts are:

- **faint** signal (no ground detection until 2006)

LOFAR has a large collecting area

- **transient** signal (short duration)

LOFAR has a high time resolution

- **sporadic** emission (low occurrence rate: ~30d/year)

LOFAR can monitor

- **low frequency** (≤ 20 kHz to ≥ 40 MHz)

LOFAR can observe up to 240 MHz

Observations:

- Saturn: geographical variation
seasonal variation
correlation to optical surveys
- Uranus: spectrum
discharge timescale

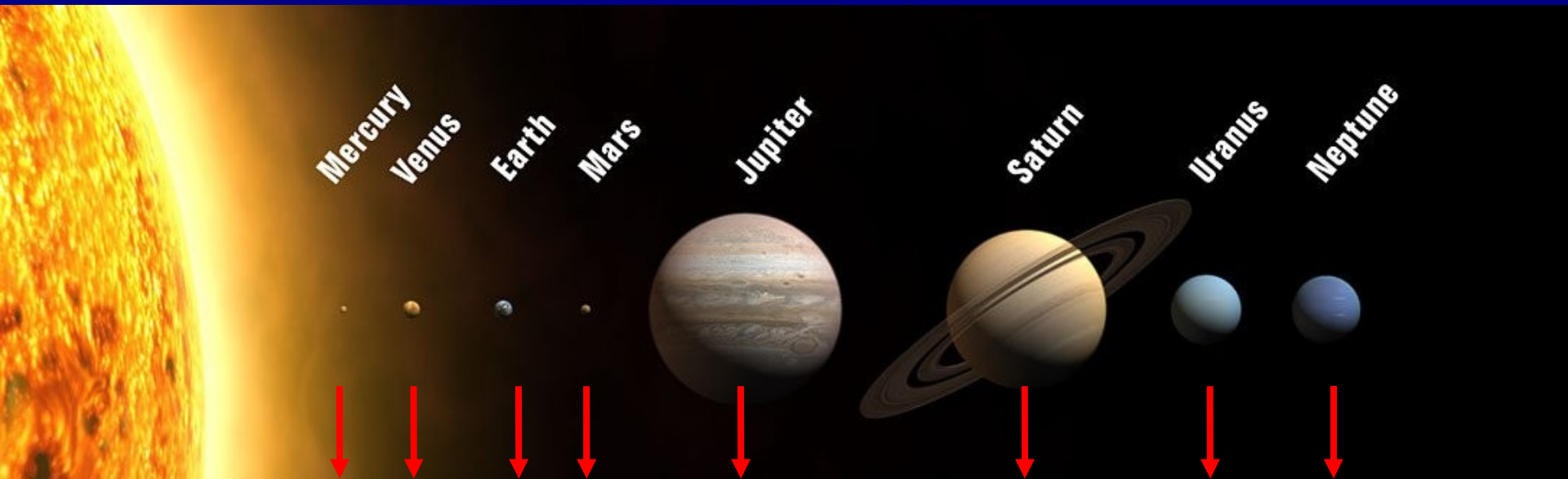
Tentative detections:

- Neptune: follow-up tentative detections
- Venus: follow-up tentative detections

Predicted:

- Mars: discharges in dust clouds?

Lightning on other planets?



observed

? ■ ■ ■ ■ ?

to be
observed
(LOFAR)

■ ■ ■ ■ ■ ■ ■

The End