

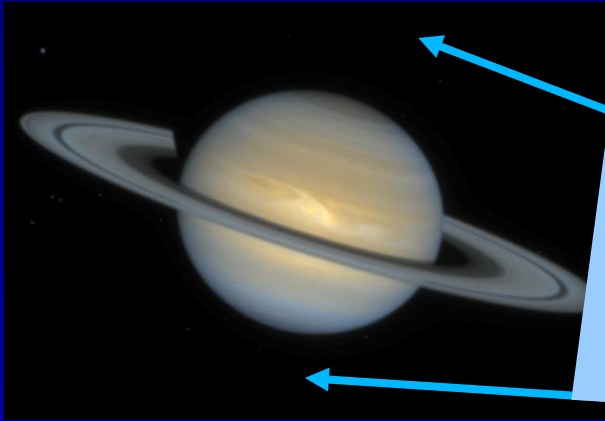
# Ground based study of Saturn Electrostatic Discharges

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and the Radio-Exopla collaboration

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# What do we see?

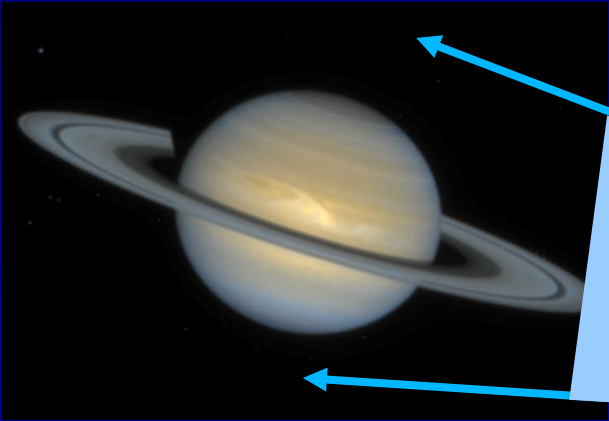


Saturn

UTR-2



# What do we see?

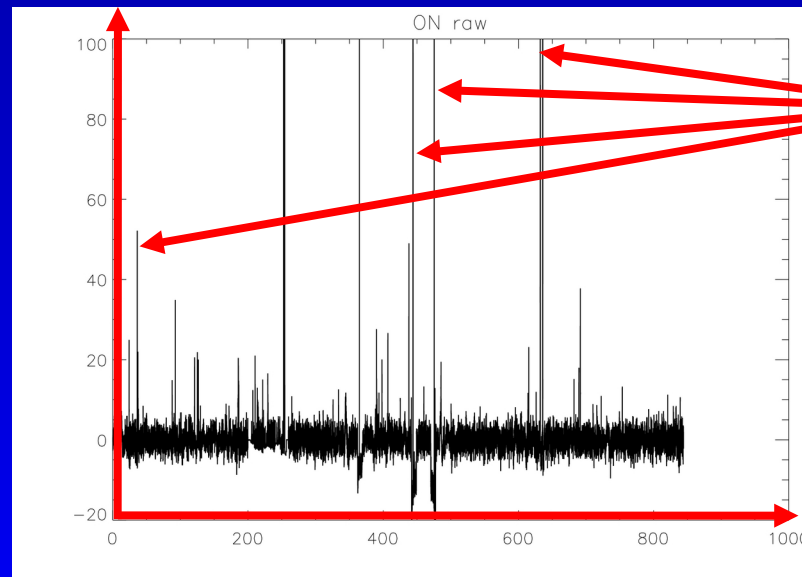


Saturn

UTR-2



Intensity  
(12-28  
MHz)



The signal  
(“Saturn  
Electrostatic  
Discharges”  
)

time

# What is the source?

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The source: lightning activity in corotating storm system

How do we know?

- ⇒ we see the storms in IR (e.g. “Dragon storm”, 2004)
- ⇒ episodes repeat after one planetary rotation

# What is the source?

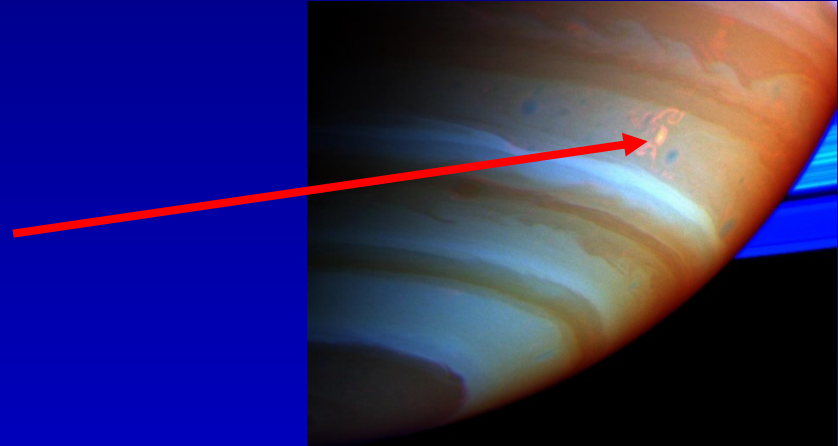
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⇒ episodes repeat  
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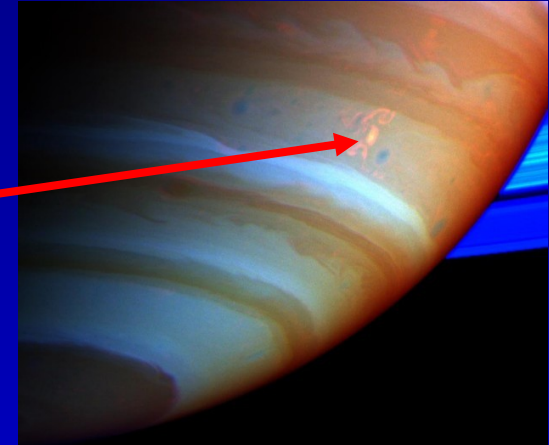


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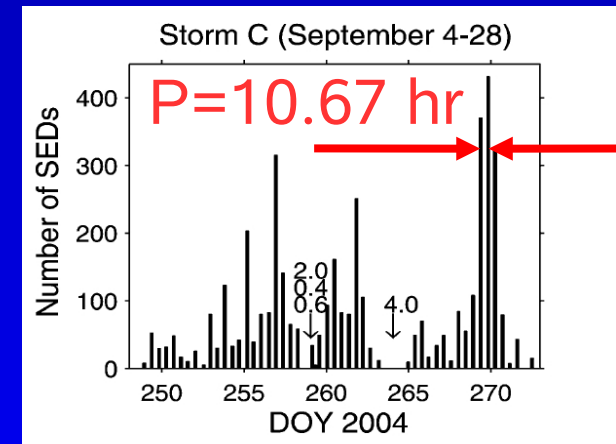
The source: lightning activity in corotating storm system

How do we know?

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



⇒ episodes repeat after one planetary rotation



# Radio search motivation

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## Why to study SEDs?

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

# SED observations

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## Satellite observations:

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

## Ground observations:

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

# SED observations

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## Satellite observations:

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

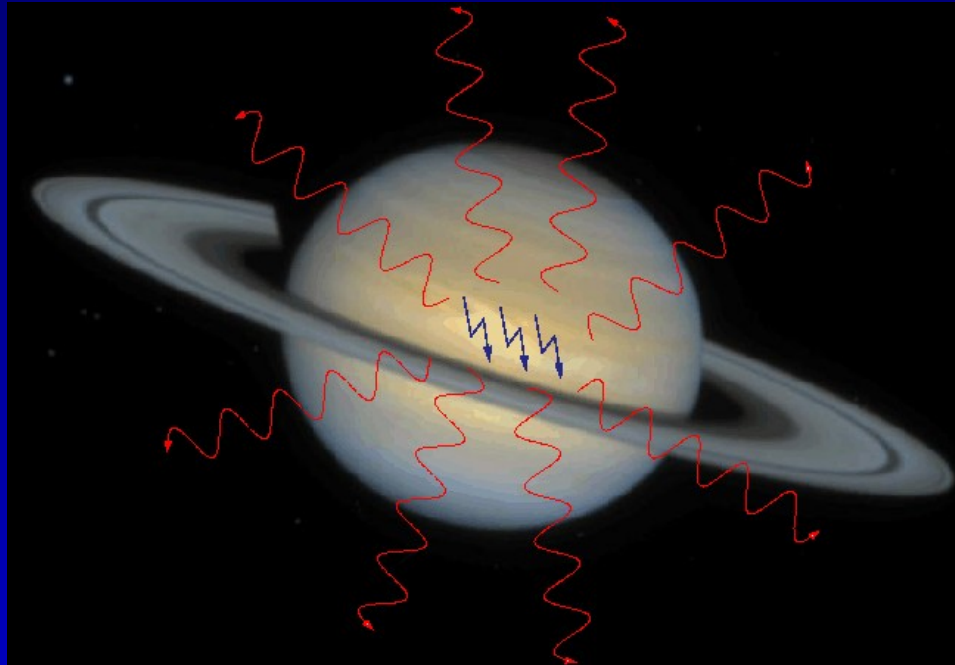
10<sup>5</sup> km  
instead of  
1.5\*10<sup>9</sup> km,  
i.e. signal  
10<sup>8</sup> times  
stronger

## Ground observations:

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

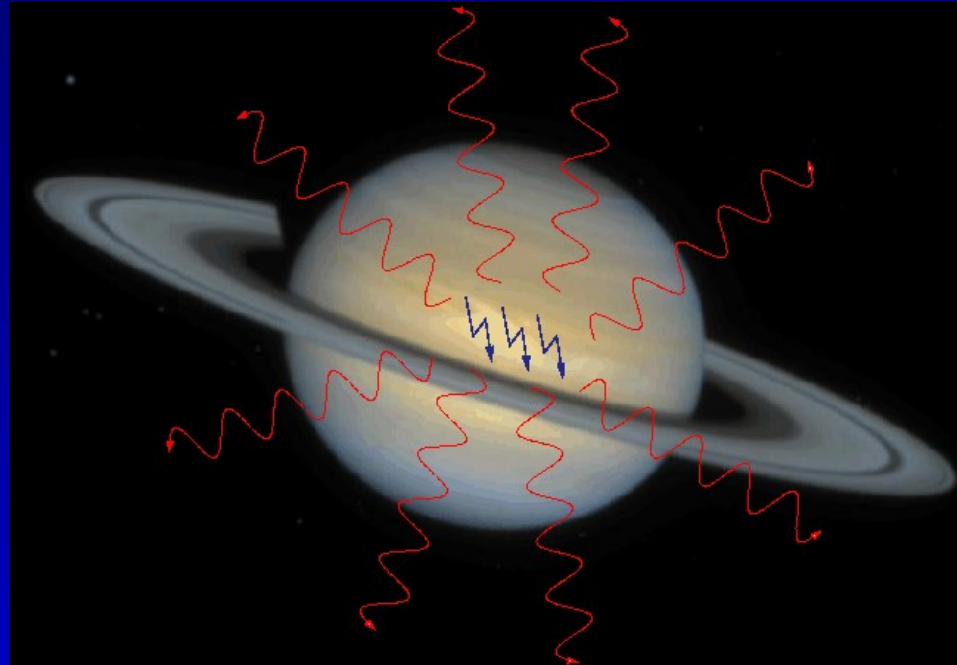
modern  
receivers,  
Cassini as  
trigger

# Ground-based observation: Challenges



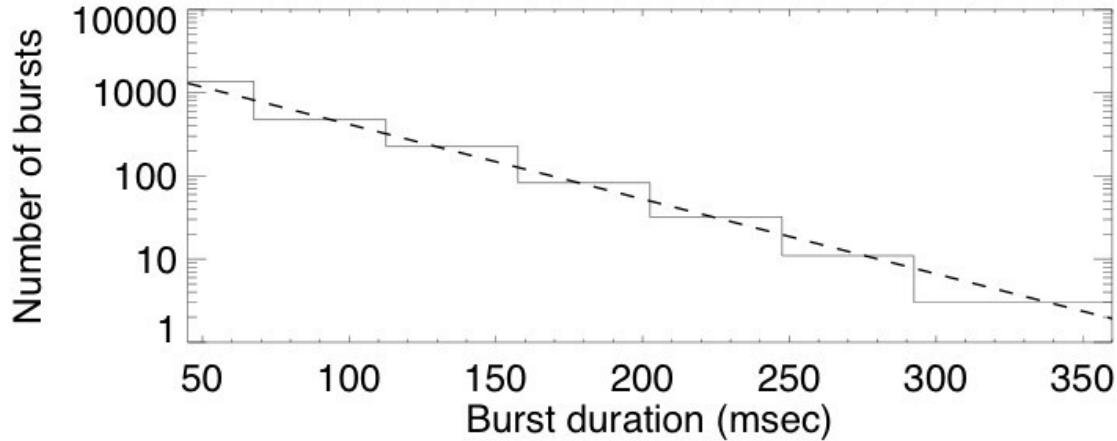
- high flux density, but **short** integration time ( $\sim 10$  msec)
- **sporadic** emission (low occurrence rate:  $\sim 30$  d/year)
- **low frequency** (known: 20 kHz-40 MHz)

# Ground-based observation: Challenges

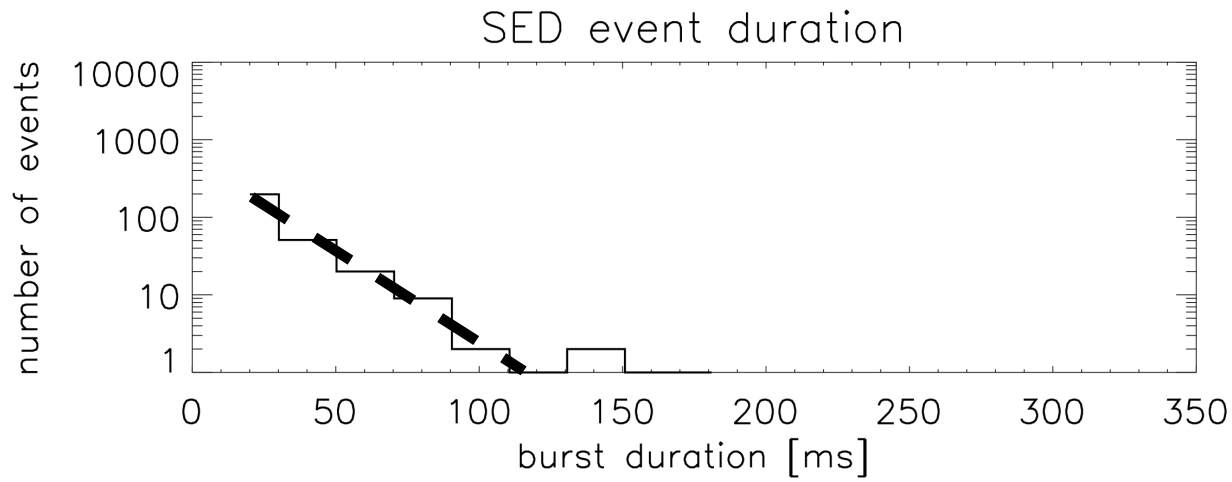


- high flux density, but short integration time (~ 10 msec)
- sporadic emission (low occurrence rate: ~30d/year)
- low frequency (known: 20 kHz-40 MHz)

# Burst duration

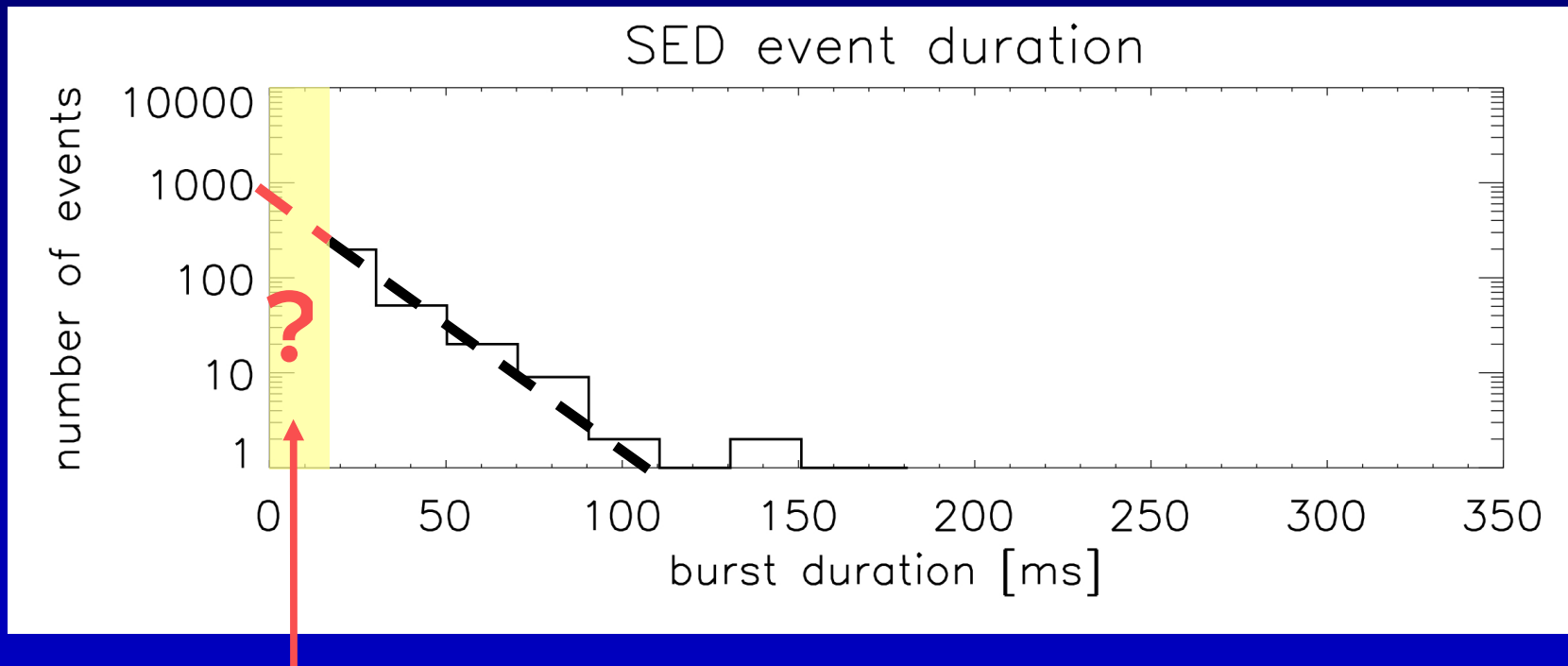


$\tau \approx 40\text{-}50$  msec  
(Voyager, Cassini)



$\tau \approx 40$  msec  
(UTR-2)

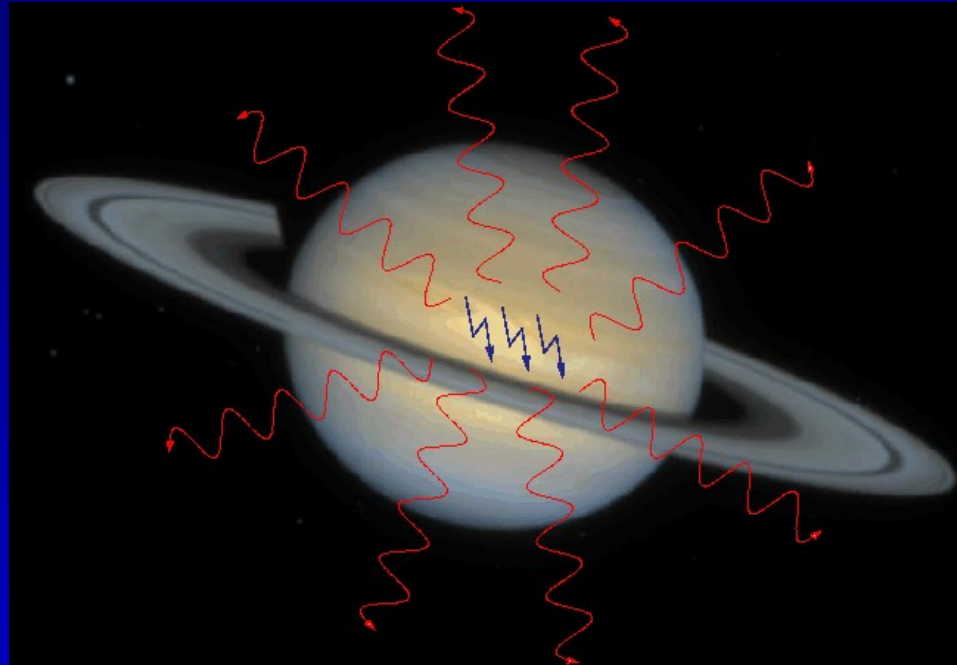
# Temporal fine structure?



Substructure < 20 msec?

(standard Cassini integration time = 40 msec,  
standard UTR-2 integration time = 20 msec)

# Ground-based observation: Challenges



- high flux density, but **short** integration time ( $\sim 10$  msec)
- **sporadic** emission (low occurrence rate:  $\sim 30$  d/year)
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# Occurrence

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- |                          |            |
|--------------------------|------------|
| • November 1980          | >8 days    |
| • August 1981            | >5 days    |
| • May 2004               | ~4 days    |
| • July 2004              | ~8 days    |
| • August 2004            | ~8 days    |
| • September 2004         | ~25 days   |
| • June 2005              | ~3 days    |
| • January/February 2006  | ~36 days   |
| • November/December 2007 | ~35 days   |
| • January-August 2008    | >240 days! |

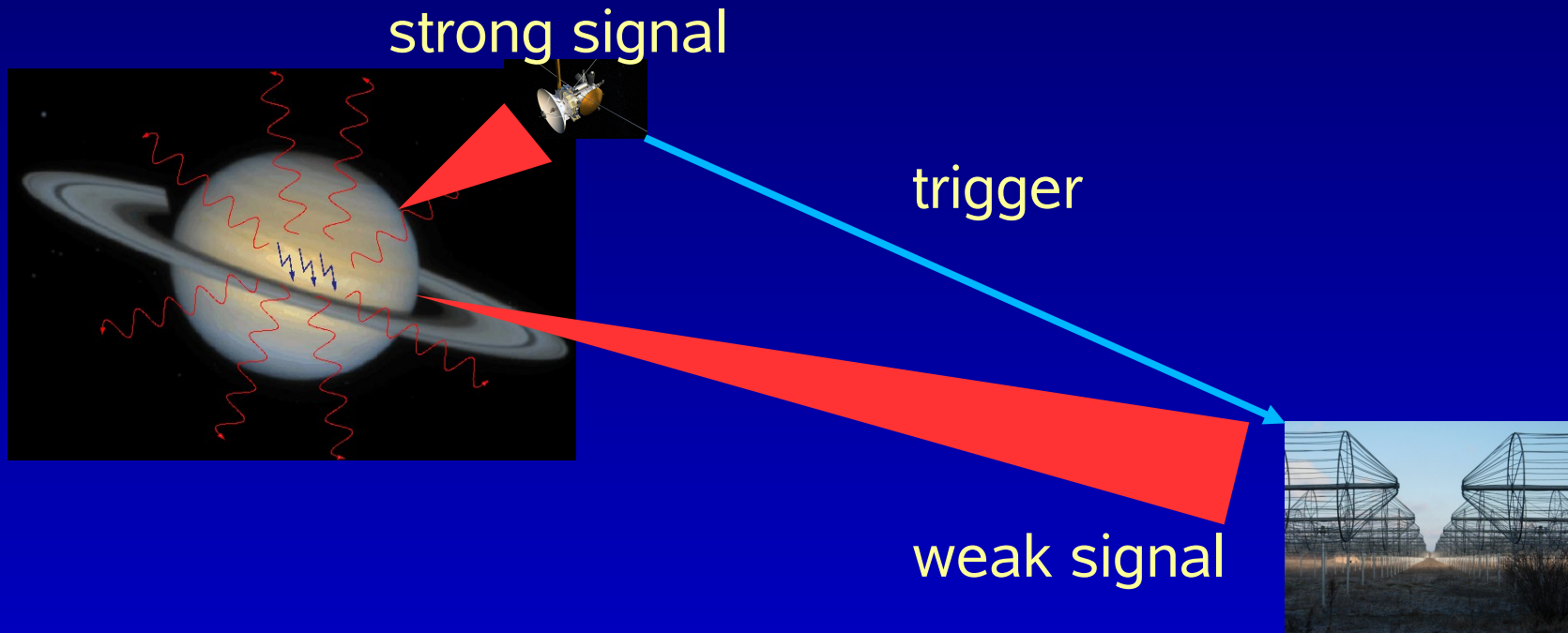
⇒ low occurrence rate

⇒ difficult to predict:

9 months **with** signal

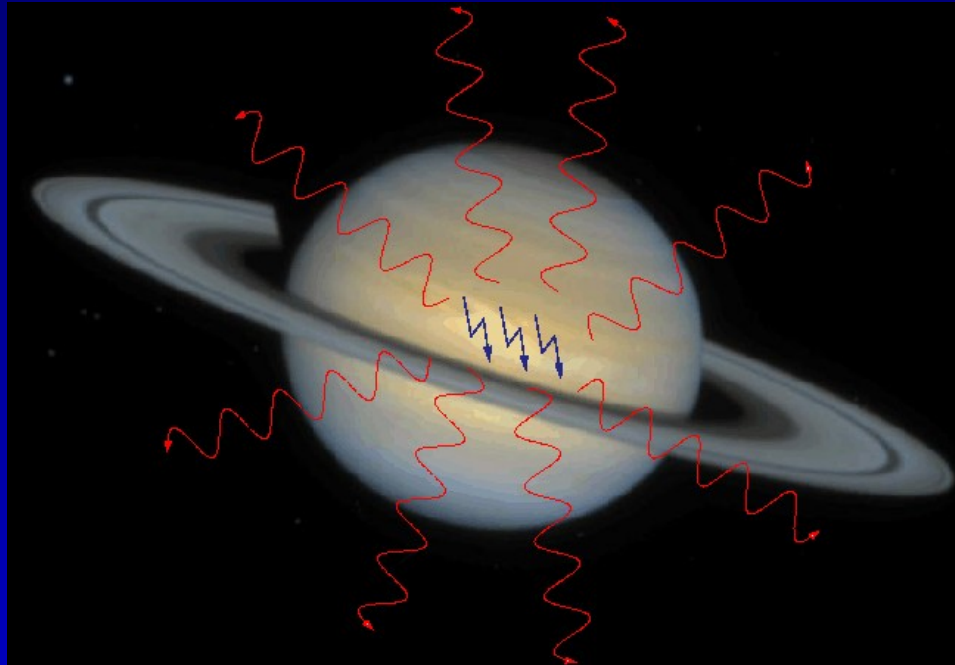
20 months **without** signal

# Ground-based observation



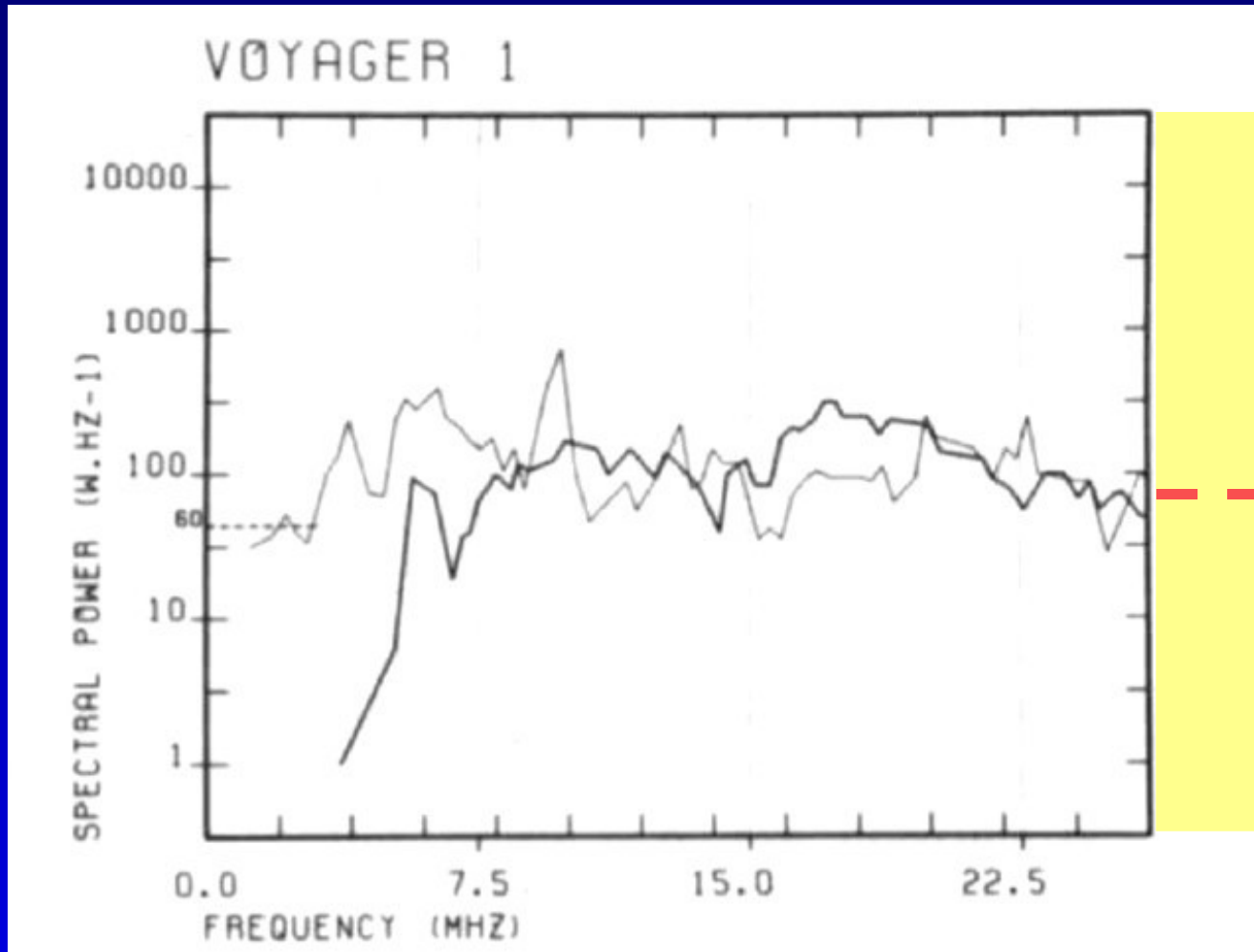
- Cassini used to trigger ground-based observations
- after Cassini (>2010)? Optical images? Monitoring?

# Ground-based observation: Challenges



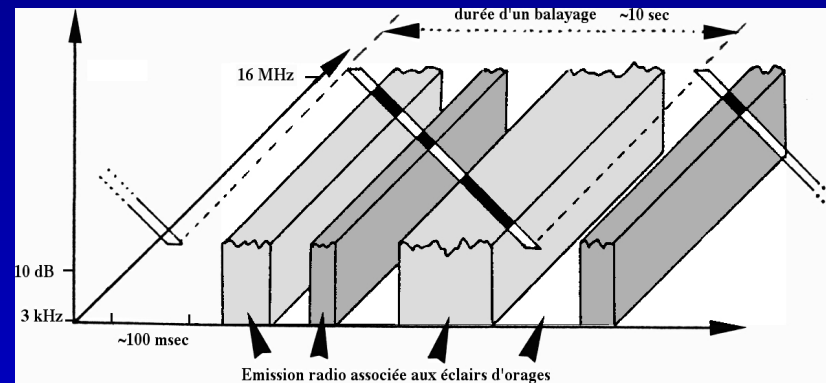
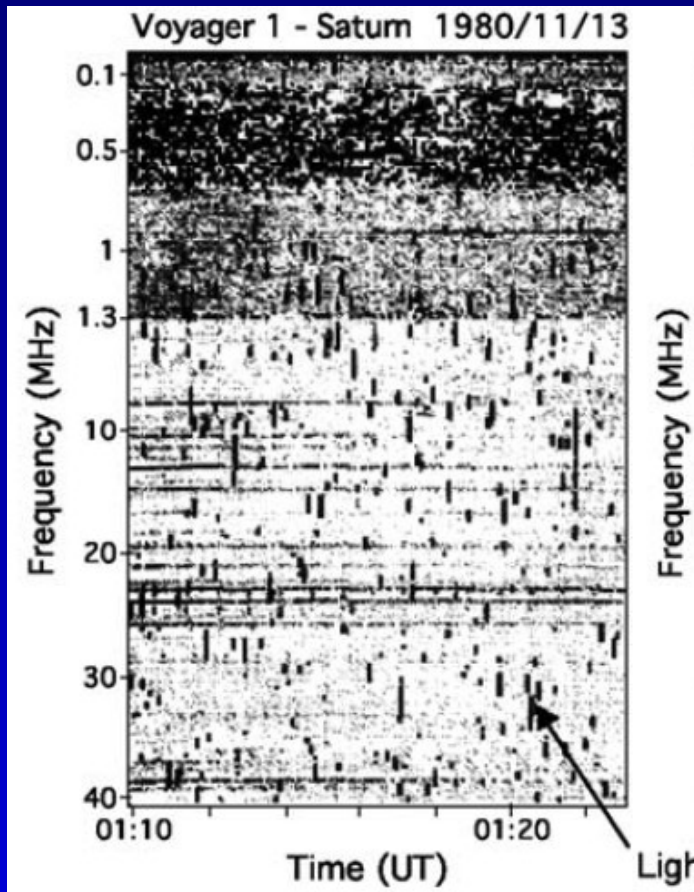
- high flux density, but **short** integration time ( $\sim 10$  msec)
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# Spectrum



average spectrum

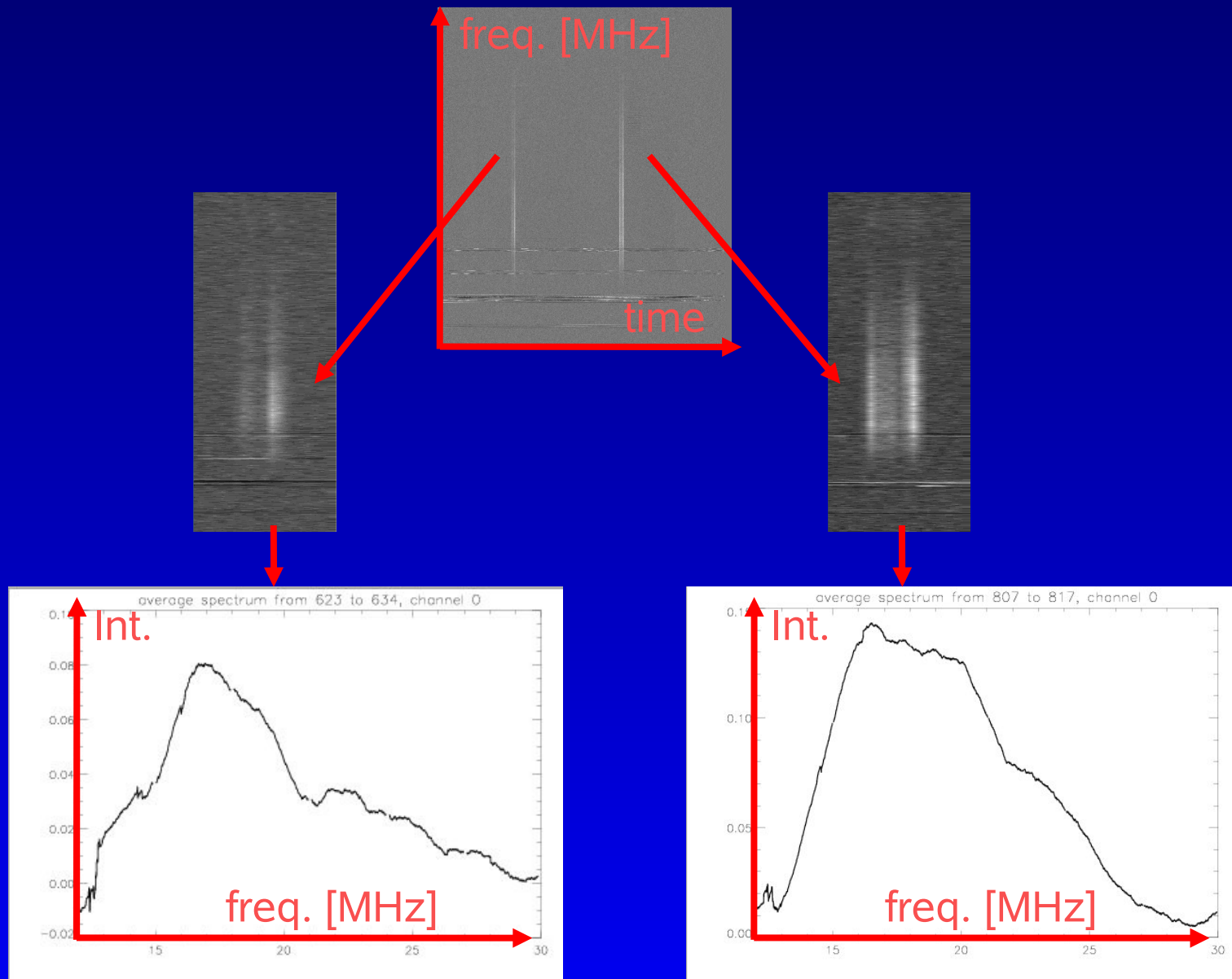
# Observation by Voyager



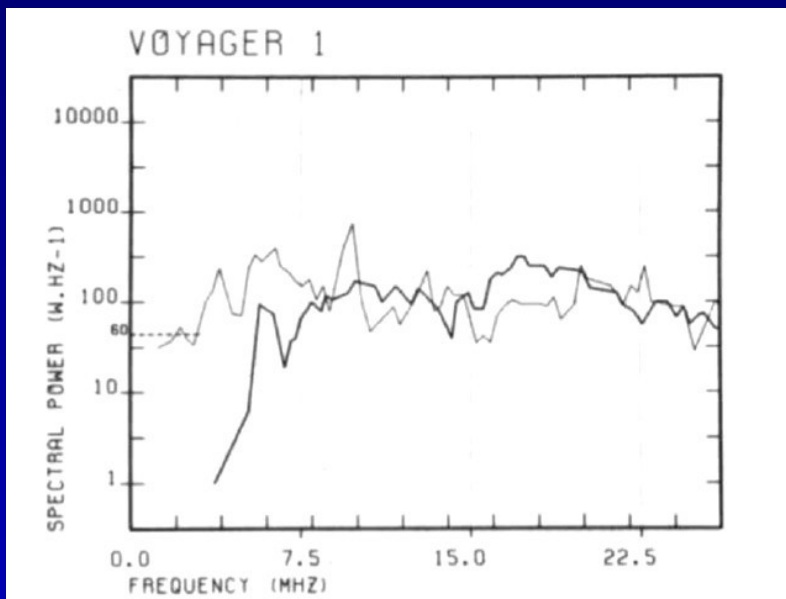
⇒ measured: **average** spectrum

⇒ spectra of **individual** events unknown!

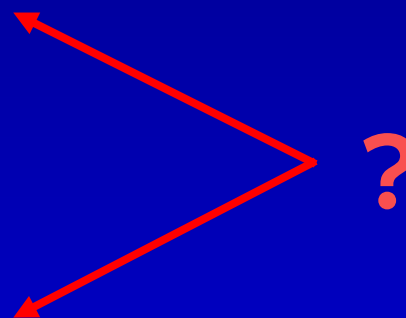
# Observations at UTR-2



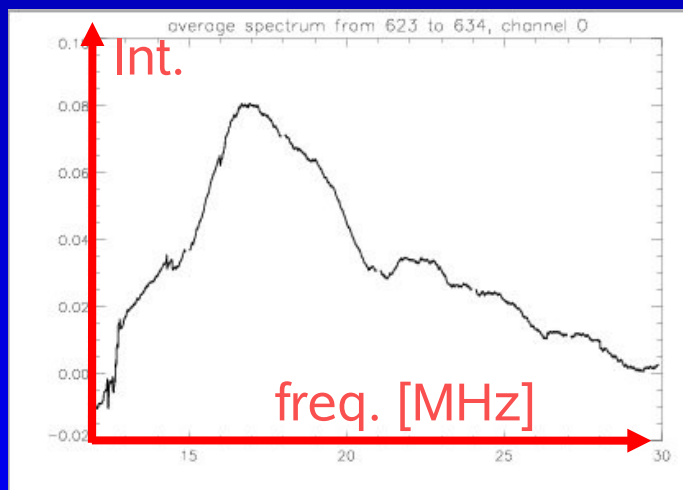
# Observations at UTR-2



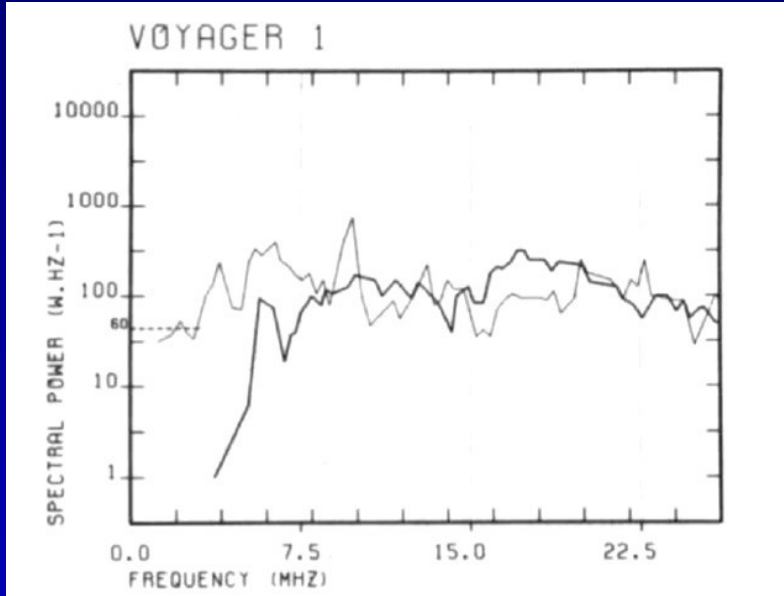
Voyager



UTR-2

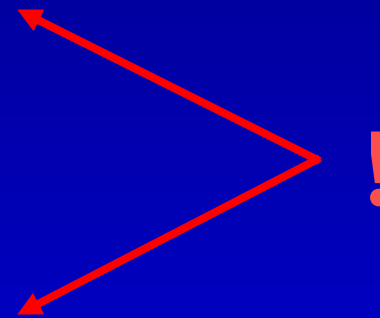


# Observations at UTR-2



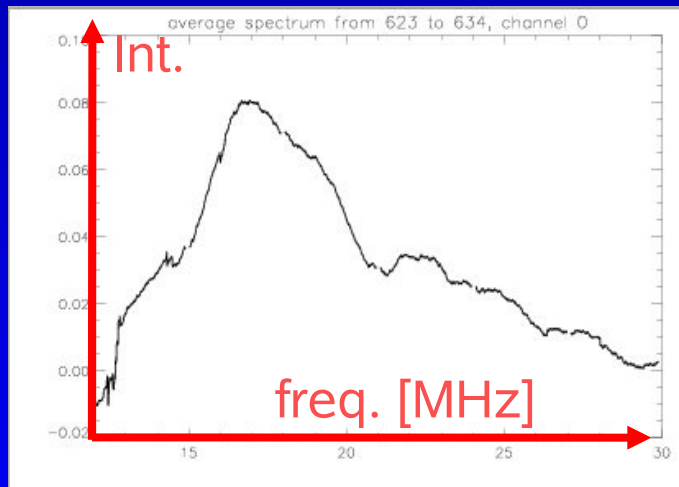
Voyager

average spectrum

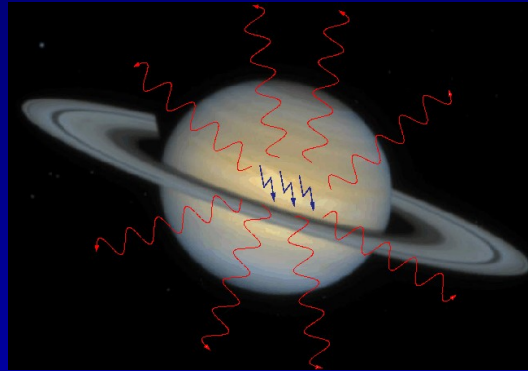


UTR-2

individual event



# Ground-based observation: Challenges



short bursts  
(~ 10 msec)

low frequency  
(0.020-40 Mhz)

sporadic emission  
(~ 30d/year)

Nancay

ok(?)

10-100 Mhz

Cassini-triggered

WSRT

ok(?)

115-175 Mhz

Cassini-triggered

UTR-2

ok!

10-30 Mhz

Cassini-triggered

LOFAR

ok!

30-240 Mhz

monitoring?

# Observations with LOFAR

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## 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

## Non-detections:

- Mars: discharges in dust clouds?