Origin of > 100 GHz radio emission

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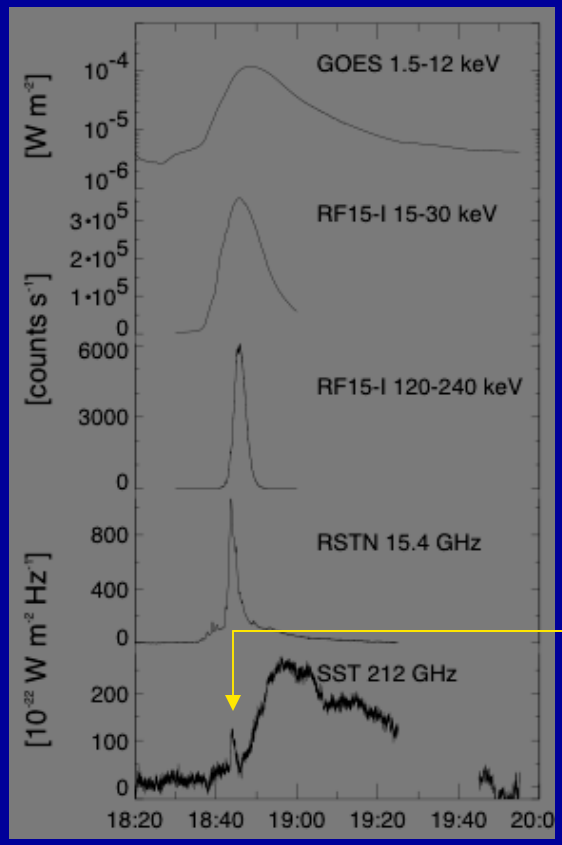
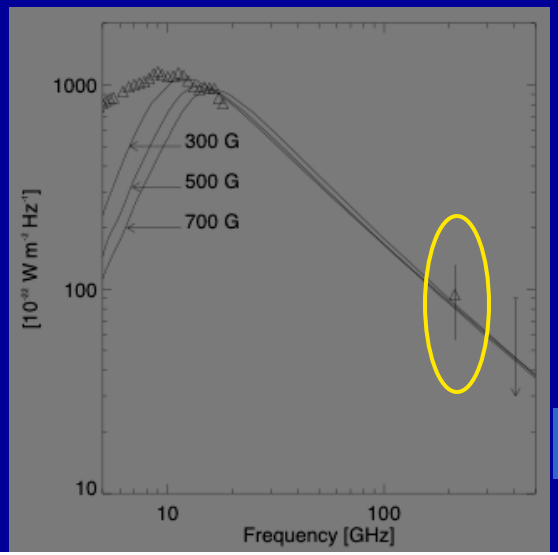
First observations of solar flares at $\lambda \leq 1$ mm (SST)





- X and cm-λ: typical impulsive flare impulsive
- 202 GHz (SST): HF of the synchrotron spectrum = HE part of the e^- spectrum

  $\nu \approx \gamma^2 \nu_{ce}$

  ($\Rightarrow$ HF spectrum= measure of the extent of the e^- energy spectrum)
- time-extended phase (thermal ?)

Trottet et al. 2002 A&A

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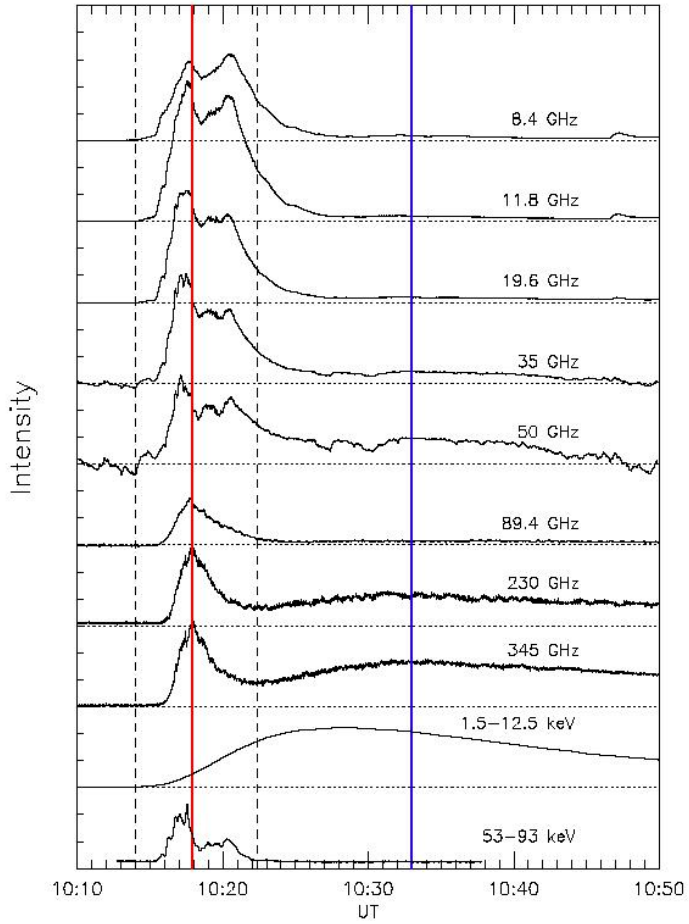
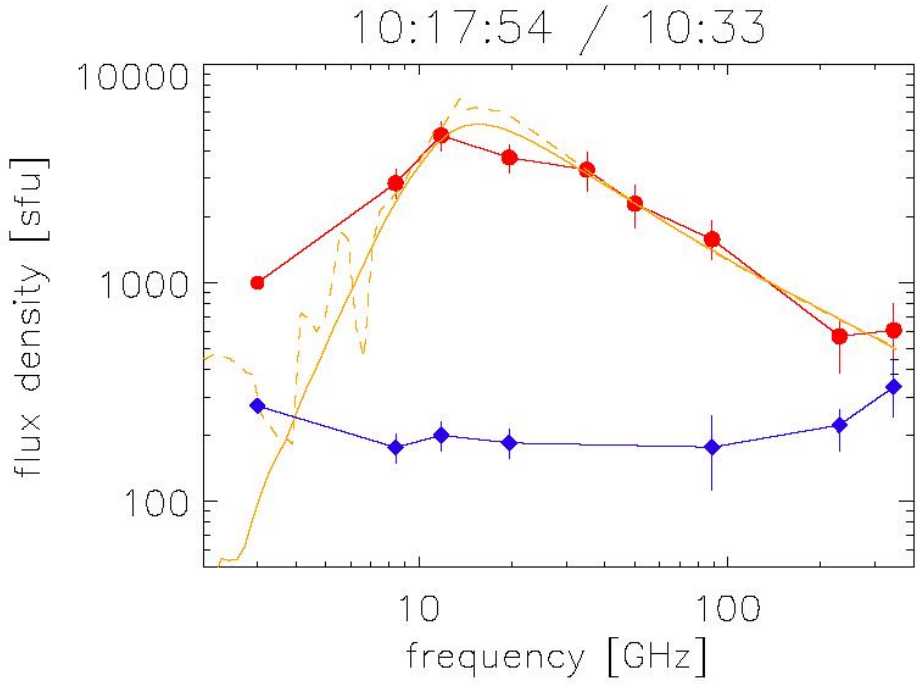
12.04.2001: First Observation of a Solar Flare in the Submillimeter Range with KOSMA





T. Lüthi et al., A&A, **415**, *1123–1132, 2004*

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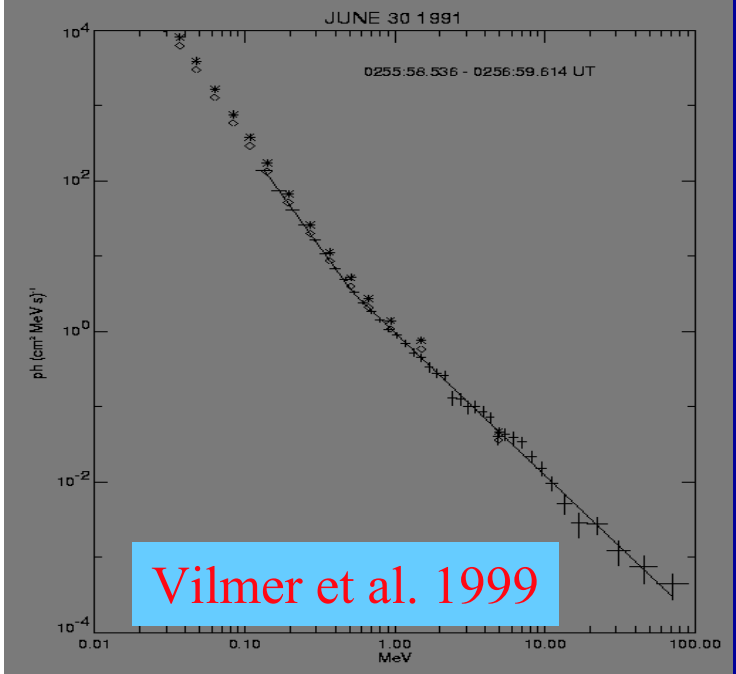
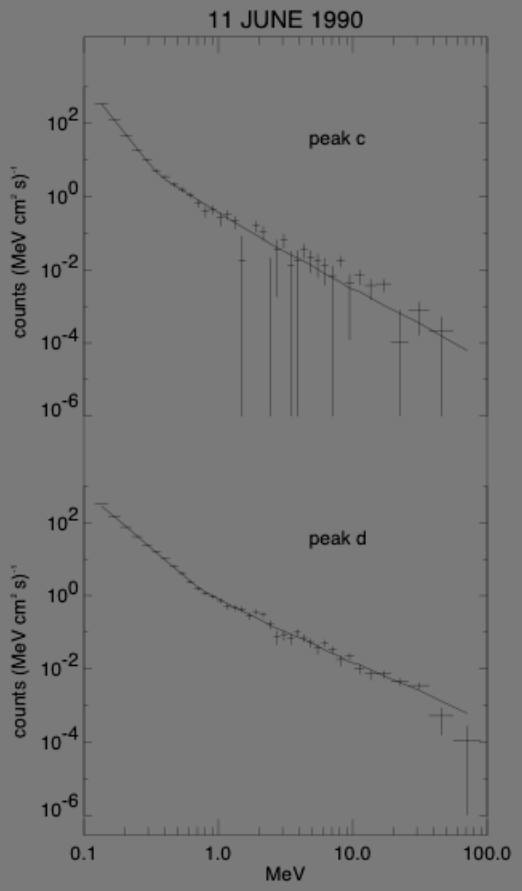


Vilmer et al. 1999

Trottet et al. 1998



Spectral index > 1 MeV:
~1.5 - 2.2 with <1.9>
No longitude effect
Rieger et al. 1998

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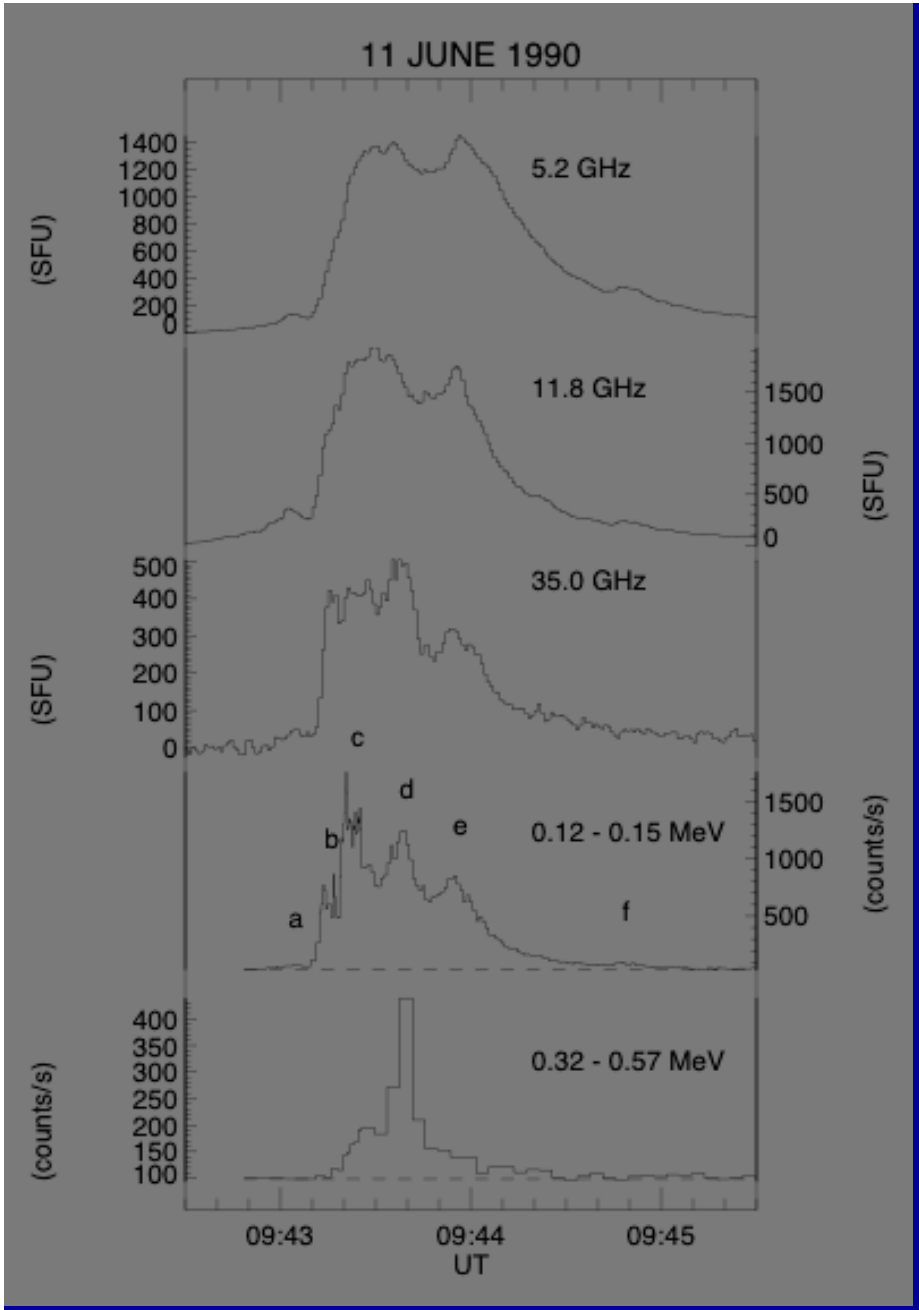

Trottet et al. 1998

Peak c

from HXR/GR

$\alpha = 4.1$ for E<Eb

$\alpha = 1.5$ for E>Eb

-observed

$\alpha = 1.5$

Peak d

- from HXR/GR

$\alpha = 2.7$ for E<Eb

$\alpha = 1.2$ for E>Eb

-observed

$\alpha = 1.3$

Peak a

$\alpha = 1.5$

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> 0.4-1 MeV GR continuum and cm-mm radio emission produced by the same population of relativistic e- (e.g. Trottet et al. 1998, 2000). Radio is thus a sensitive diagnostic of relativistic e-:

- relativistic electrons are produced even in small flares (BIMA, Kundu et al.)

- consistent with production of relativistic electrons since the very beginning of a flare

- sub-second time structures correlated at HXR and mm wavelengths: fast acceleration of both non relativistic an relativistic e- (Kaufmann et al. 2000)

HOWEVER !

2003 Nov 4

Kaufmann et al. 2003

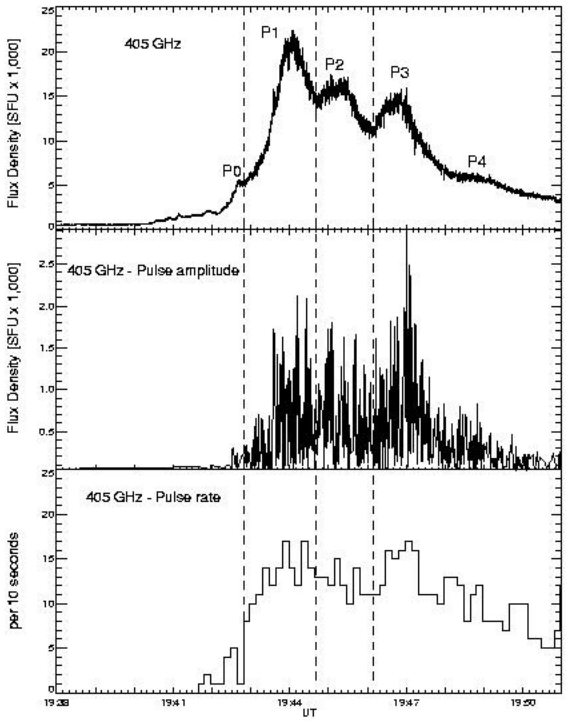

Figure 4

Kaufmann et al. 2003

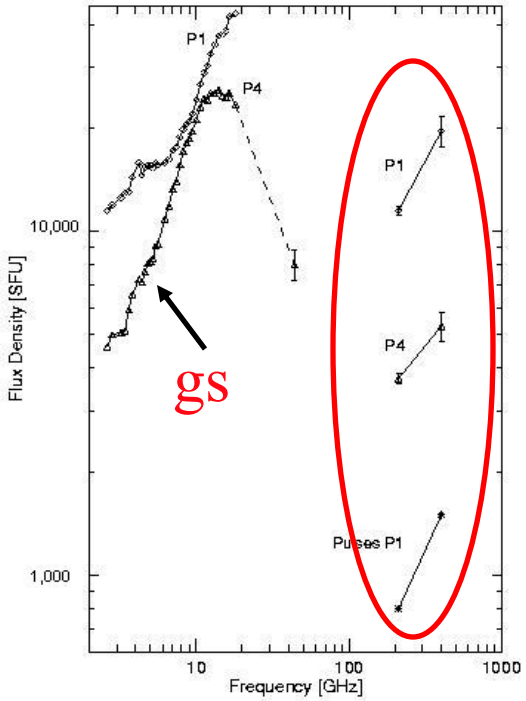

Figure 3

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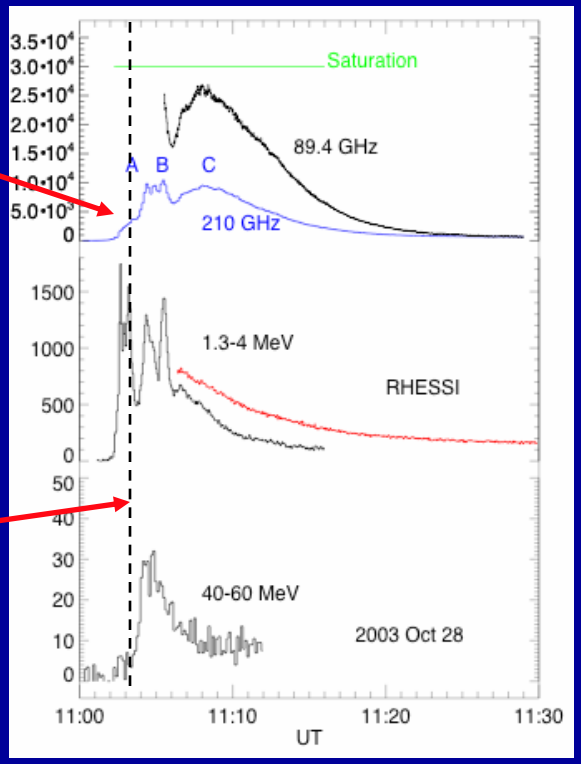
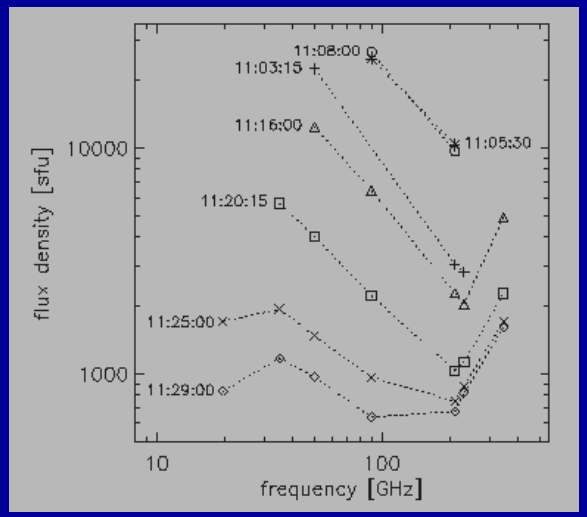
2003 Oct 28

Gs spectr. ➢ 345 GHz

Impulsive burst B at 210 starts when the > 10 MeV GR spectrum hardens

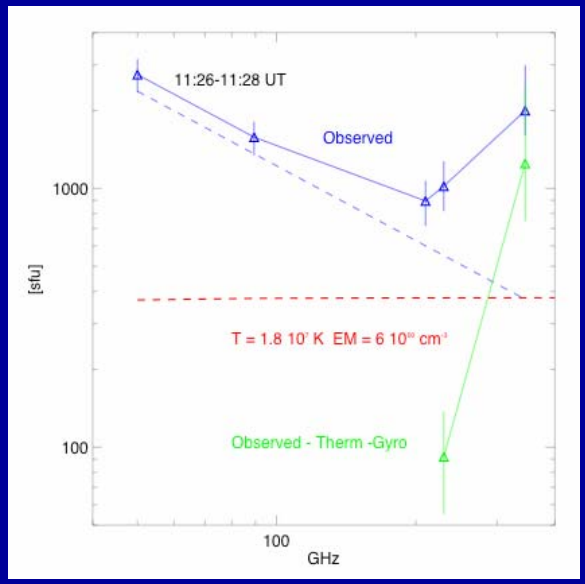
Above 210 GHz The radio spectrum Increases with freq.





Luethi et al. 2004 A&A

Gs+term (corona) up to ≈ 200 GHz but increasing spect. at higher freq. ?



Trottet et al. 2005

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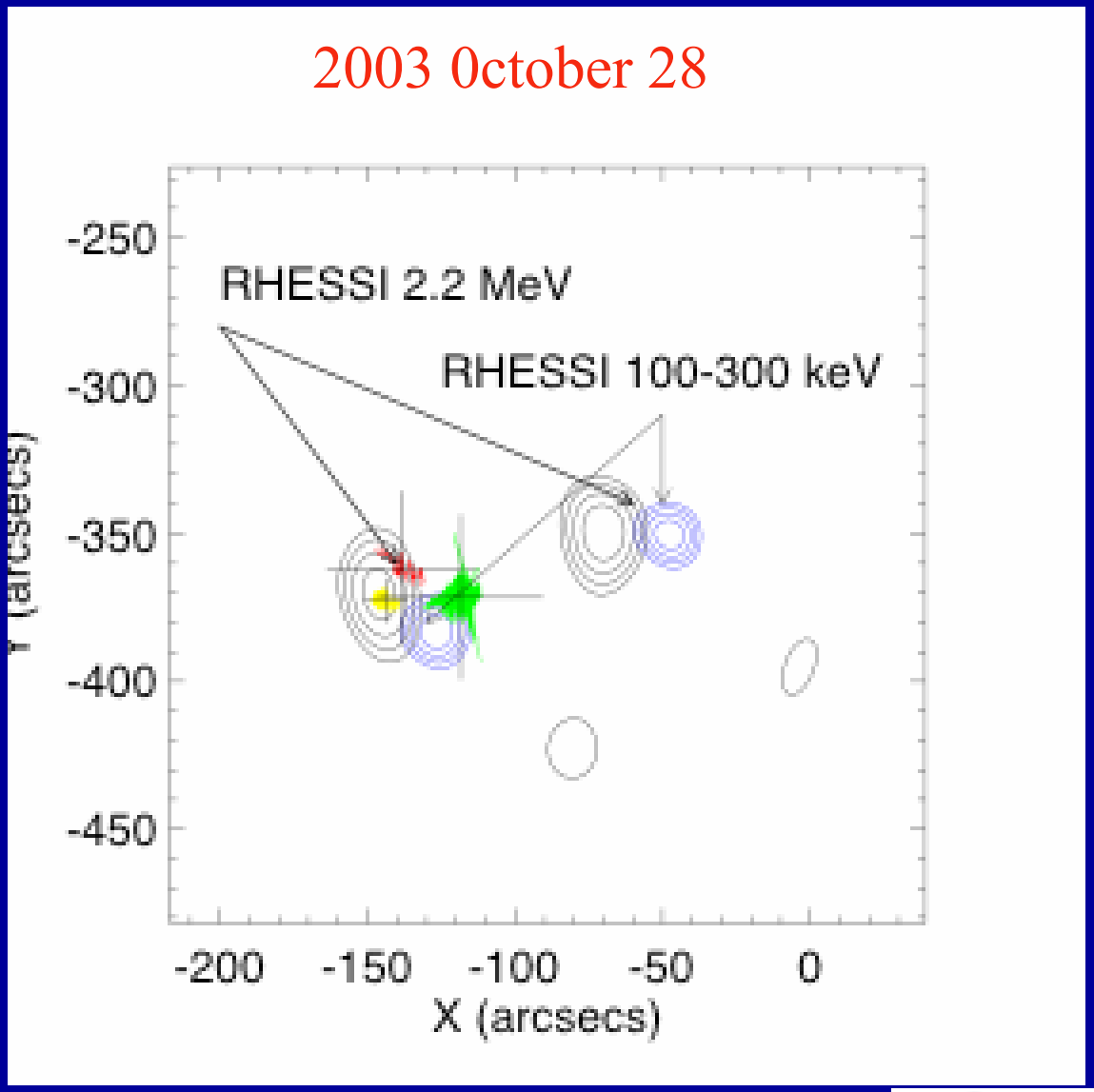
Increasing spectra above 200 GHz ?

- Optically thick gs. From $e^- \Rightarrow$ compact and very dense sources with high magnetic field: **unrealistic numbers of high energy electrons!**
- gs. from positrons (Lingenfelter & Ramaty 1967)
- Inverse Compton/gs (Kaufmann et al. 1986)
- Thermal: optically thick free-free emission: **energy deposition in the chromosphere by particles or conduction fronts**

Trottet et al. 2006

2003 0ctober 28



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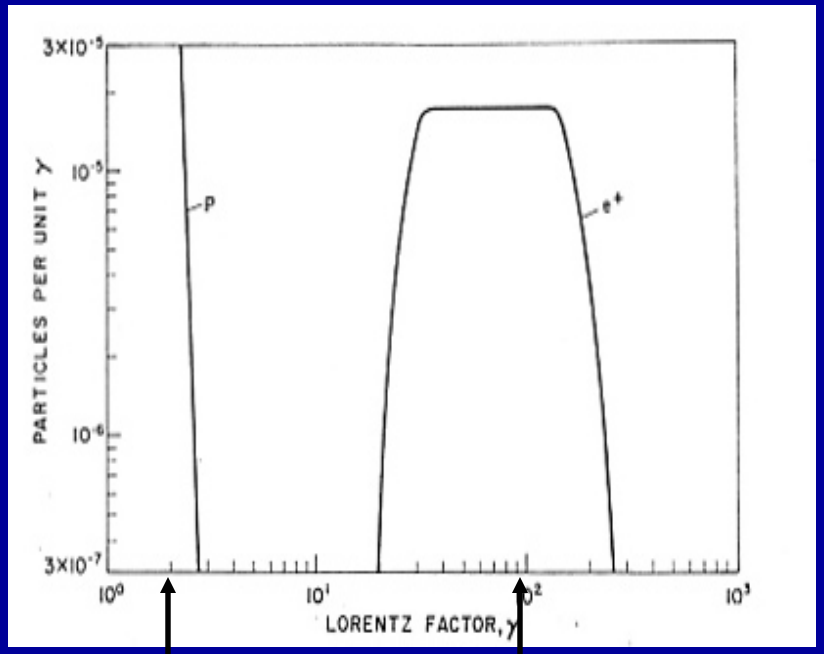
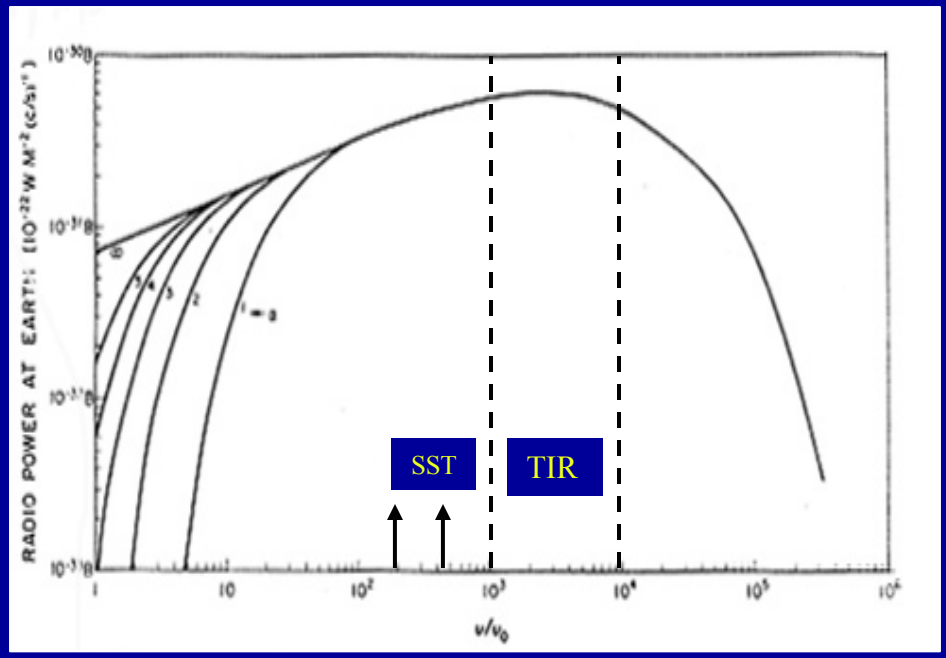
Example of gs from positrons (Lingenfelter & Ramaty 1967)



200 MeV

50 MeV



B=400 G

←B→

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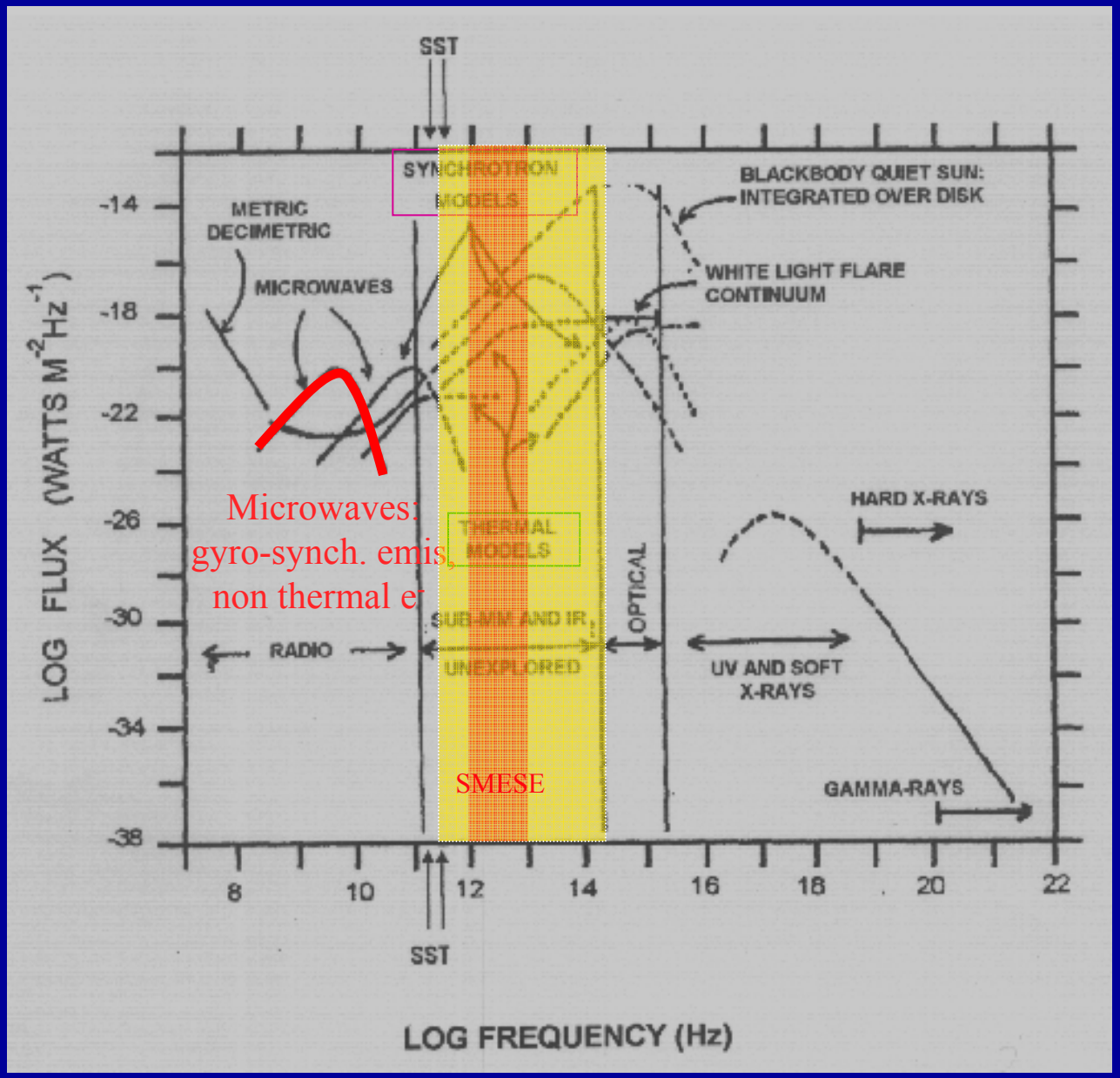
SST
SYNCHROTRON MODELS
METRIC DECIMETRIC
MICROWAVES
BLACKBODY QUIET SUN: INTEGRATED OVER DISK
WHITE LIGHT FLARE CONTINUUM
Microwaves:
gyro-synch. emis
non thermal e
THERMAL MODELS
HARD X-RAYS
SUB-MM AND IR
OPTICAL
RADIO
UNEXPLORED
UV AND SOFT X-RAYS
SMESE
GAMMA-RAYS
LOG FLUX (WATTS M^{-2}Hz^{-1})
-14
-18
-22
-26
-30
-34
-38
8
10
12
14
16
18
20
22
SST
LOG FREQUENCY (Hz)