Collaboration with X-ray Observations

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THE NOBEYAMA cm-λ RADIOHELIOGRAPH

- ★ dedicated telescope for solar studies
- ★ daily routine observations
- ★ wide FOV covering the whole Sun
- ★ R- & L-circular polarization
- ★ 2-d spatial resolution of ~10"
- ★ temporal resolution of 1s/50ms

X-RAY OBSERVATIONS in early '90s

☆ SOLAR-A: coordinated whole Sun instruments

- ★ HXT: hard X-ray (15-100keV) imaging
  ~5", 0.5s, 4 energy bands
- ★ SXT: soft X-ray imaging (mirror)
  2.5", 2(0.5)s, 6 filters
- ★ WBS: wide-band spectroscopy (X-γ)
- ★ BCS: high-dispersion spectroscopy

☆ GRO, CORONAS's, MAX'91 balloons, etc.

Prehistory to the RADIOHELIOGRAPH

★ 8-cmλ Radioheliograph (1974; TYKW)
2-d, 2', scanning type
⇨ correlator type (1984)

★ 17-GHz Interferometer (1978; NBYM)
1-d, 50", 0.8s, correlator type
⇨ spatial resolution to 25" (1981)

★ Radio Polarimeters
1, 2, 3.75, & 9.4 GHz (TYKW)
17, 35, 80 GHz (NBYM)

★ provision of basic flare data
★ science objectives
comparison with X-ray/γ-ray emissions,
general characteristics of MW sources,
impulsive vs gradual hard flares,
preflares, correlated flares, etc.

SOLAR-A/RADIOHELIOGRAPH COLLABORATION

ACCELERATION MECHANISMS IN FLARES

Correlation between HXR/MW Emissions

- ★ HXR/MW flux correlation
- ★ HXR/MW time profiles (timing)
- ★ HXR/MW source location

Types of HXR/MW sources

- ★ impulsive, gradual hard, & super-hot
- ★ delayed gradual sources

Repetition of Pulses

- ★ HXR/MW source characteristics

MAGNETIC FIELD CONFIGURATION

Preflare Conditions

Changes before/during/after the Flare

Impulsive Flares

(1) Structures

i) HXR / MW / EUV correlation (flux, time profile)
→ sources deeply related

ii) HXR stereo observations (ISEE-3/PVO ; by Kane)
→ height ≤ 2,500 km

iii) HXR double-source structure (SMM, Hinotori)
→ a pair of loop footpoints ?

iv) MW bipolar structure
1978/09 – 1980/07 (NRAO 17 GHz Interferometer)

Total	19
Double-source events	12
Bipolar sources	9
Two same pol. sources	2
Pol. + Unpol. sources	1
More-than-two source events	2

?? Beam Precipitation

(2) Multiply Impulsive Bursts

ensemble of ELEMENTARY FLARE BURSTS

or

repeated ACCELERATION PULSES at a single site

- correspondence to individual type III's
- regularity of time profiles

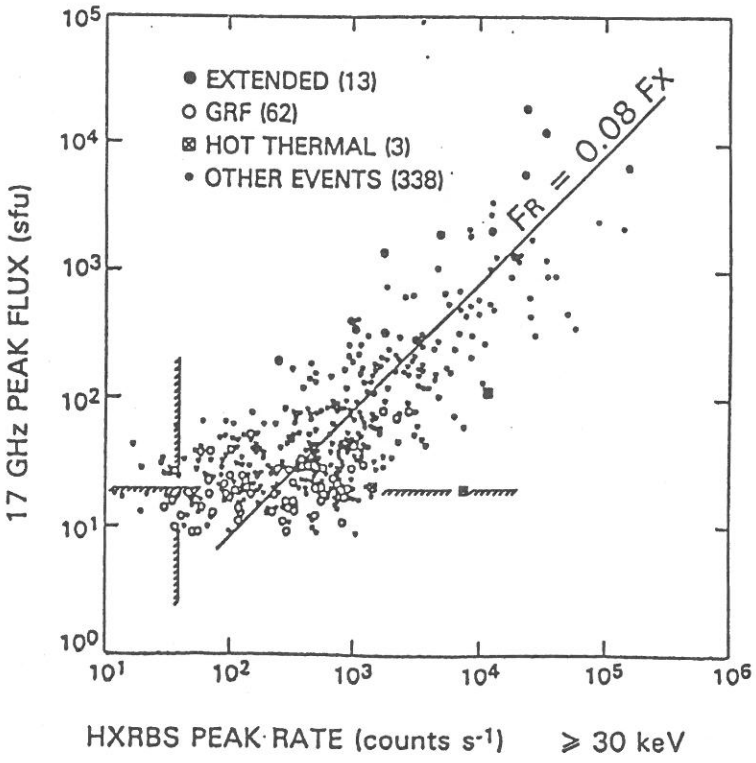
case study : 1980 June 7 / 1983 May 12

(3) Other topics to be solved

- Peak delay of MWs w.r.t. HXRs
- " " of higher-energy HXRs w.r.t. lower-energy HXRs
- discrepancy of SOURCE LOCATION between HXR and MW
  (SMM / VLA observations)
  (Hinotori/NBYM ; by Nakajima)

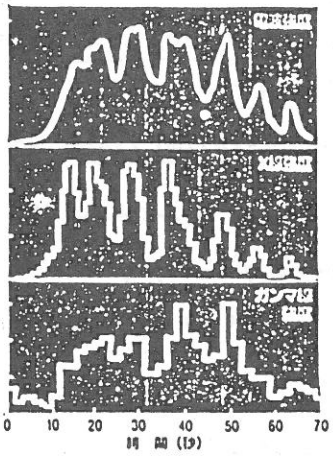
Then,

* WHY DO HXR AND MW CORRELATE SO WELL WITH EACH OTHER !?

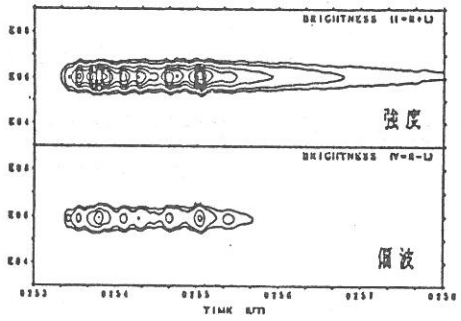


超高速のフレア粒子加速とその脈動

1980年
6月7日



マイクロ波　　1983年5月12日



Gradual Hard ("Extended" or "N_μ") flares

i) purely coronal HXR events (Hudson)

ii) height of MW N_μ events (17 GHz, NOYM)

→ height ≥ 20,000 km

iii) coronal HXR sources (Hiratori ; by Tsuneta et al.)

→ height ≥ 20,000 km
(1991 May 13)

(Thick-target) TRAP

- acc. duration ≥ 100 s
- spectral hardening with time
- efficient trap

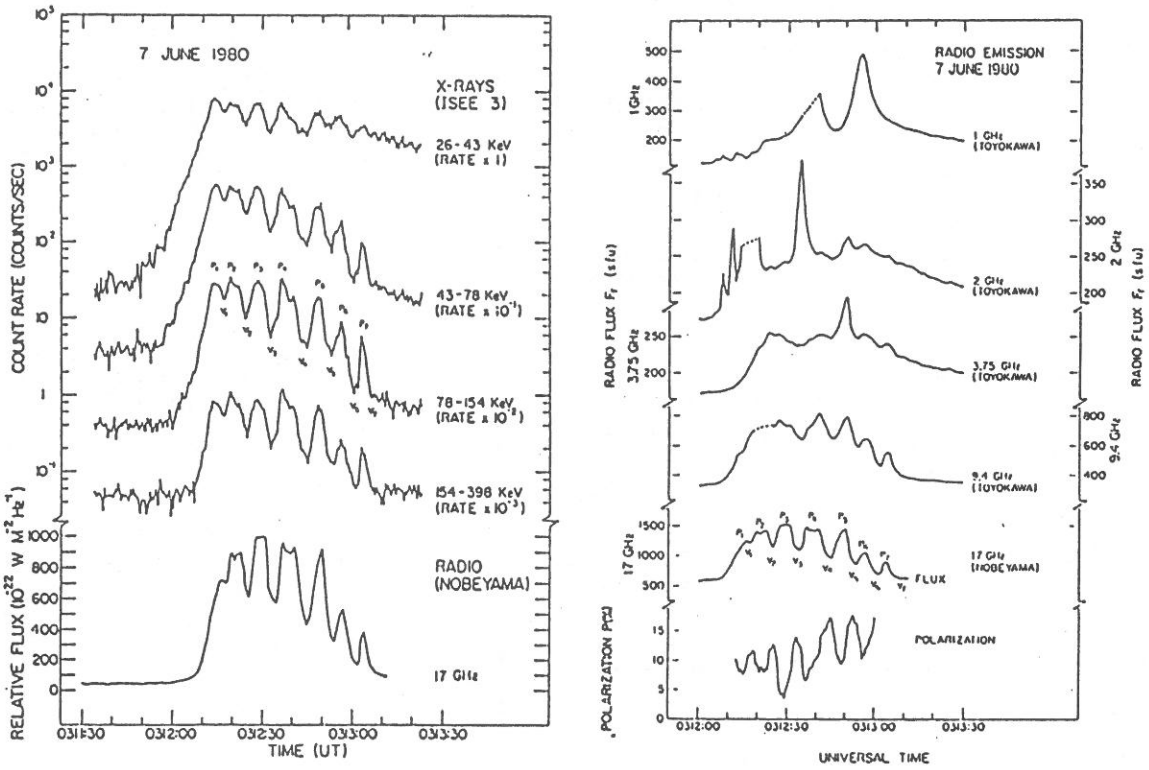
Case studies

1981 Apr. 1 (Kawabata et al., Nakajima et al.)
"Delayed Enhancement Events"

Two different acceleration processes ?
(one for IMPULSIVE, the other for GRADUAL HARD)

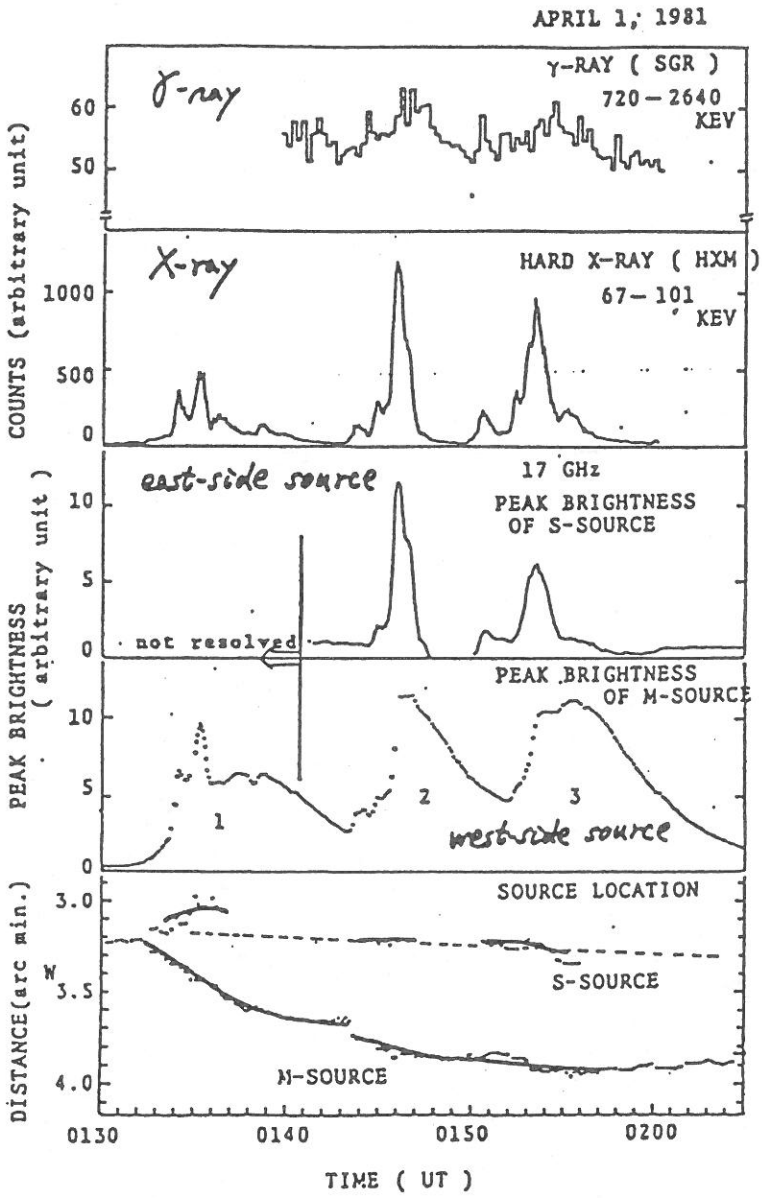
- Both accelerate electrons & ions
- Beam vs Trap { Flare size / Pitch angle distribution

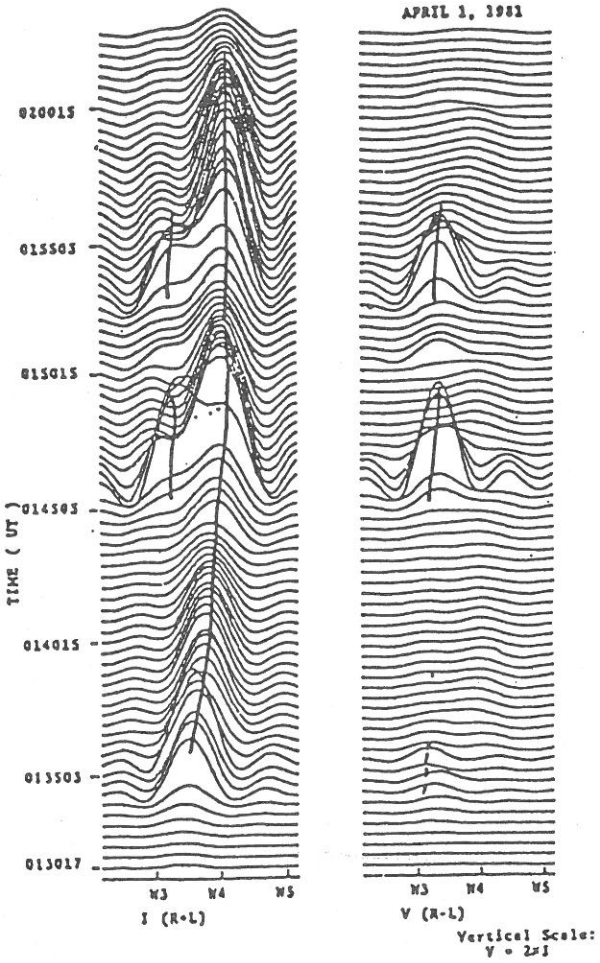
海外の研究者も
野辺山・豊川のデータを活用



S. R. Kane et al. (UCSD; 1983)

衛星によるX線・ガンマ線観測とマイクロ波観測は、粒子加速解明の車の両輪



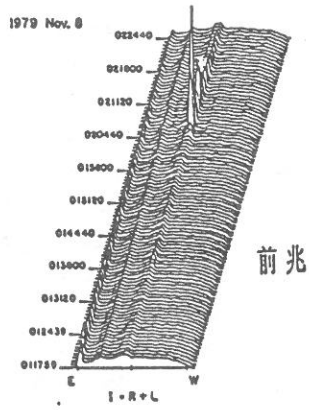


Flare Triggering

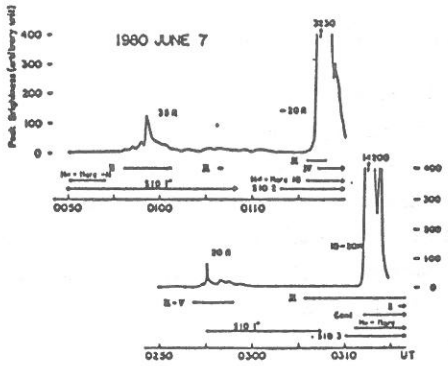
* Taking-off of CME's
* Preflare MW activities / Type III's
* Hα activities prior to the Main Energy Release.

* Correlated flares

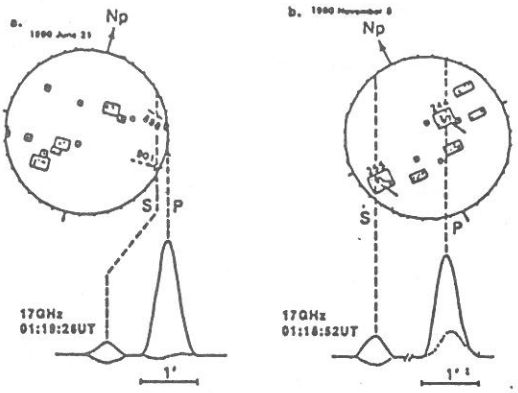
マイクロ波フレアの＜前兆現象＞

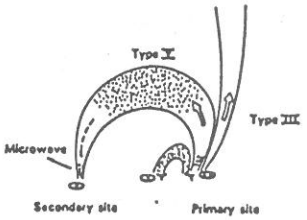


前兆



フレア粒子の伝播が
もうひとつのフレアを励起





フレア衝撃波の伝播による励起は知られていましたが、粒子による励起は新発見