100KeV以上のeventのHXRと電波のpower-law indexの比較

CDAW2010 @ NSRO
2010.10.29

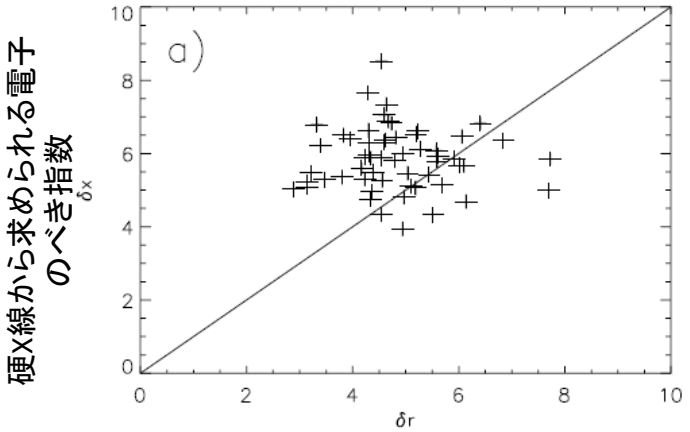
（グループ2）
中島、大山、西塚、川手、大井

動機

- 17GHz・34GHzのマイクロ波バーストは、主に数100keV-数MeV程度の電子によるジャイロシンクロトロン放射
- 100keVの硬X線バーストは100-200keV程度の電子による制動放射
- →数100keV-数MeVの硬X線は17GHzと同じ電子を見ているか？

先行研究

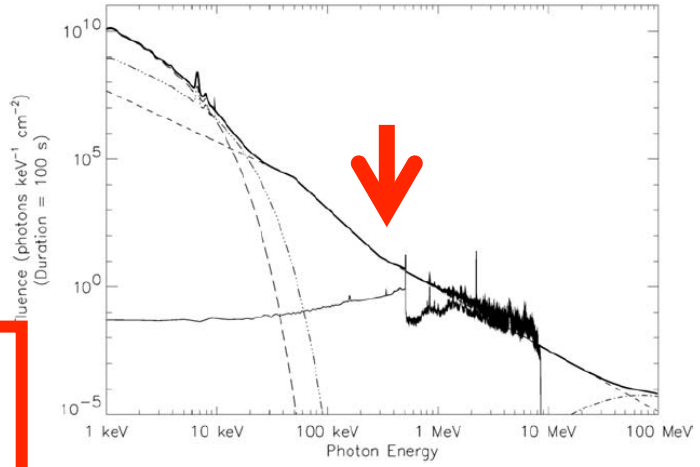
- Silva et al. (2000)
  - 硬X線から求められる電子スペクトル指数とマイクロ波から求められる電子スペクトル指数は一致しない
  - $\delta_x - \delta r \sim 1$



マイクロ波から求められる電子のべき指数

Silva et al. (2000)

- Lin et al. (2002)
  - 硬X線スペクトルに見られる数百keVにおけるべきの折れ曲がり(高エネルギー側が3程度hardening)



Lin et al. (2002)

通常観測することのできる数百keVの硬X線による電子のべき指数と、17GHzを放射する電子のべき指数は異なる場合のほうが多いのではないか？

方法

野辺山偏波計によるturn over frequency よりも大きい周波数のデータを用いて電波フラックスのべき指数を求め、対応する電子のエネルギー分布の指数を求める

$$\delta_r = (1.22 + \alpha)/0.9$$

Dulk (1985)

RHESSI front detectorを用いて100keV前後の硬X線フラックスのべき指数を求め、対応する電子のエネルギー分布の指数を求める

footpointにおけるthick target model

$$\delta_x = \gamma + 1.5$$

Tandberg-Hanssem & Emslie (1988)

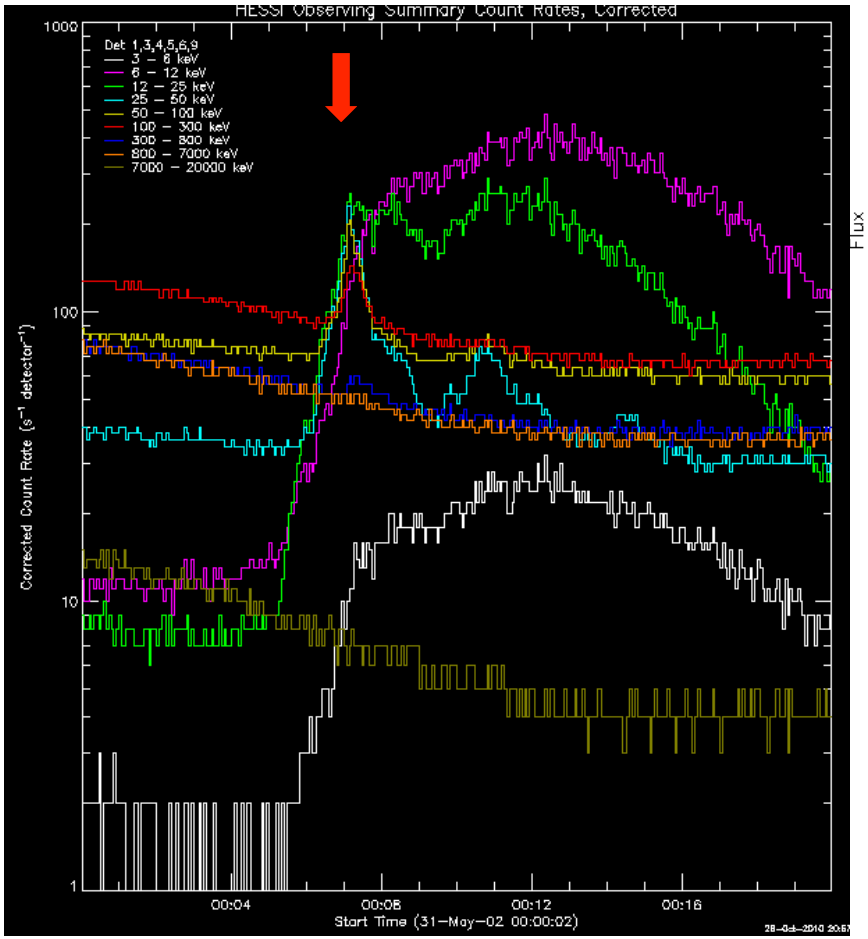
非熱的電子の輻射量が多い
フレアを選択的に解析

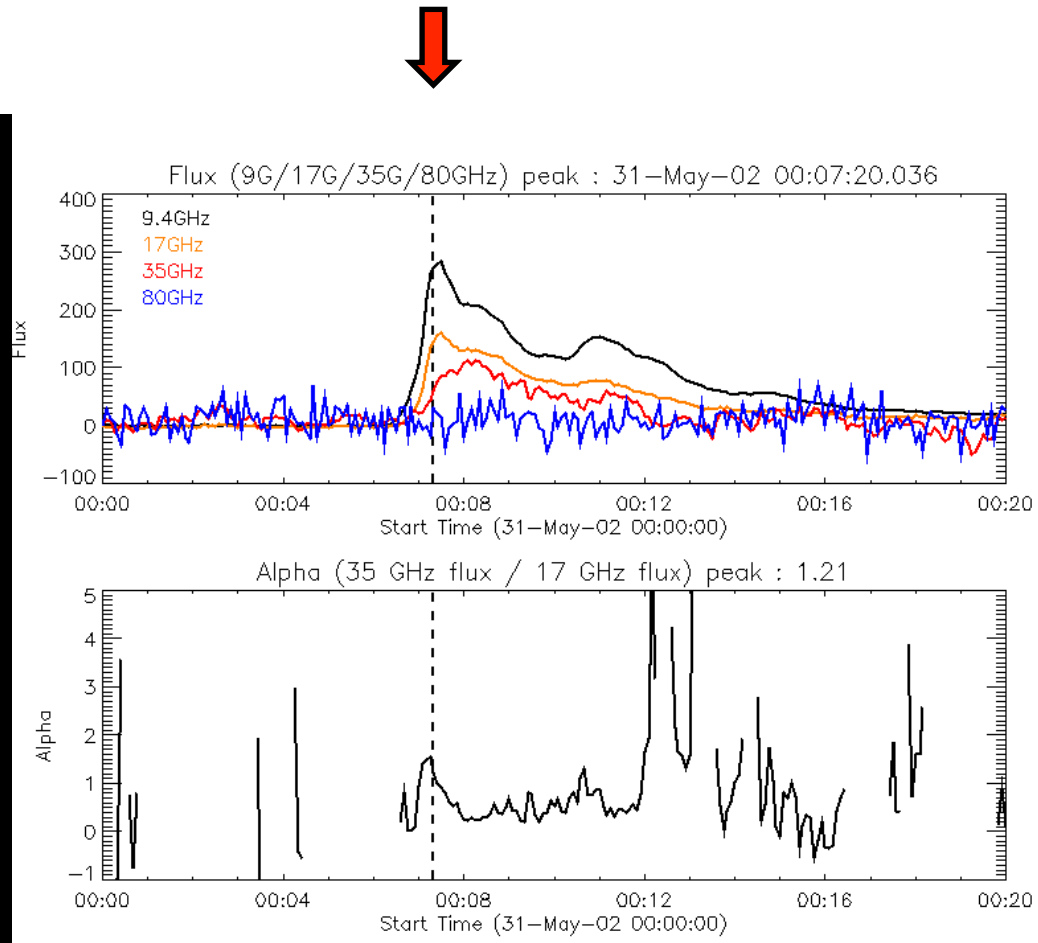
- 両者の差はどの程度存在するか
- Silva et al. (2000)とどの程度一致するか
- どのような条件で差が生じているか

イベントリスト

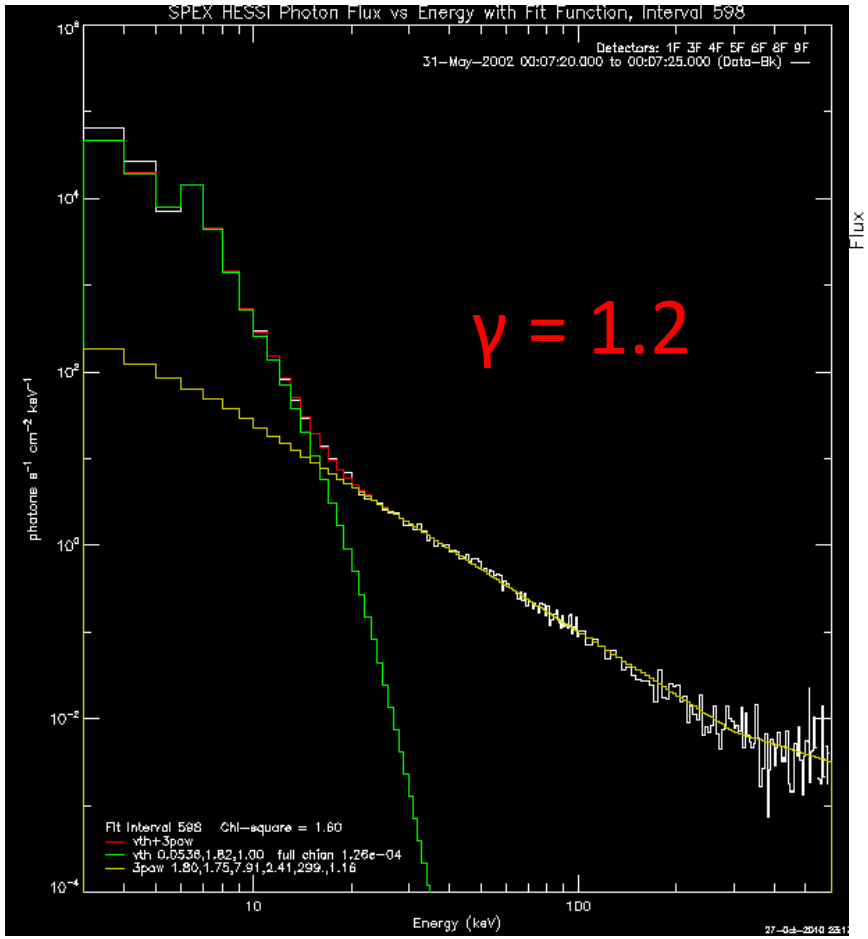
#	Date	Class	Limb/Disk	Start Time	Peak(17GHz)	End Time	position	X	Y
1	2002/5/31	M2.4	limb	0:04	00:07:20	0:25	S30E85	-825	-481
2	2002/7/20	X3.3	limb	21:04	21:28:00	21:54			
3	2002/7/23	X4.3	disk	0:18	00:30:30	0:47	S12E74	-899	-236
4	2003/5/27	X1.4	disk	22:56	23:02:00 23:05:30	23:13	S07W16	270	-108
5	2003/6/17	M6.8	disk	22:27	22:46 22:52:30	23:12	S08E58	-805	-147
6	2004/1/6	M5.8	near limb	6:13	6:22:30	6:36	N05E89	-992	93
7	2004/7/15	X1.8	disk	1:30	2:38:00	1:48	S10E52	-751	-211
8	2004/7/16	X1.3	disk	1:43	2:03:00	2:12	S10E39	-599	-236
9	2005/8/25	M6.4	near limb	4:31	4:38:10	4:45	N08E82	-943	118
10	2005/9/10	X2.1	disk	21:30	21:35:00	22:43			
11	2005/9/13	X1.7	disk	23:15	23:18:30 23:20:00	23:30	S11E00	-15	-304

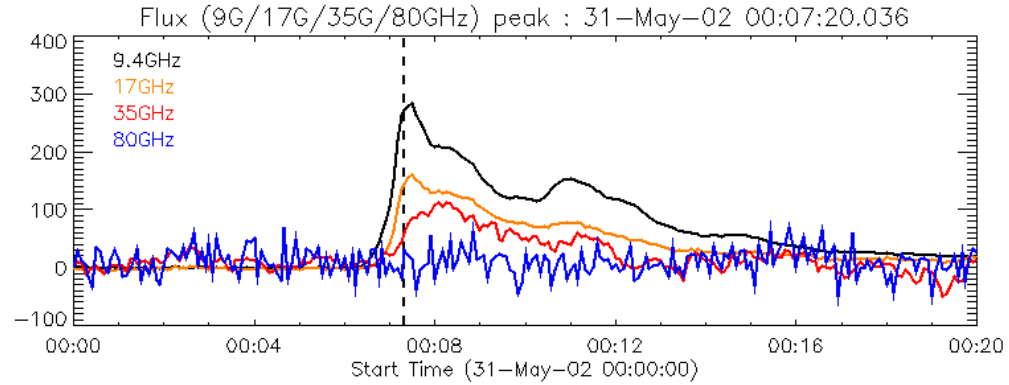
[1] 2002 May 31, 0:04 - 0:25UT M2.4
limb event

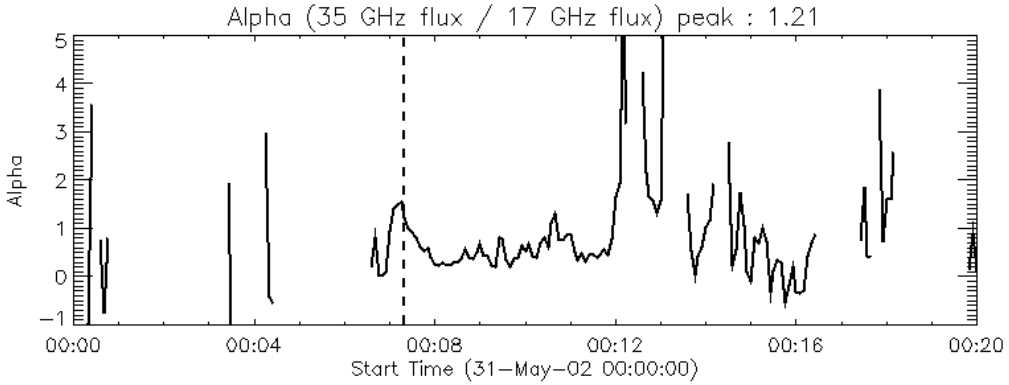




[1] 2002 May 31, 0:04 - 0:25UT M2.4
limb event



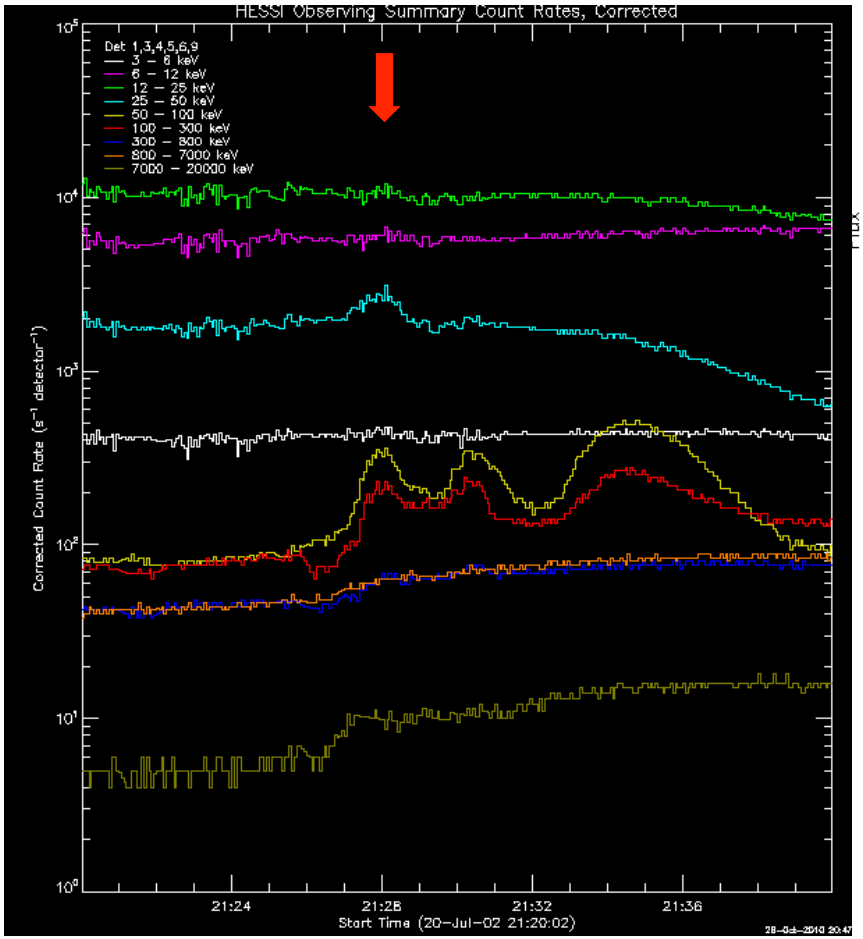


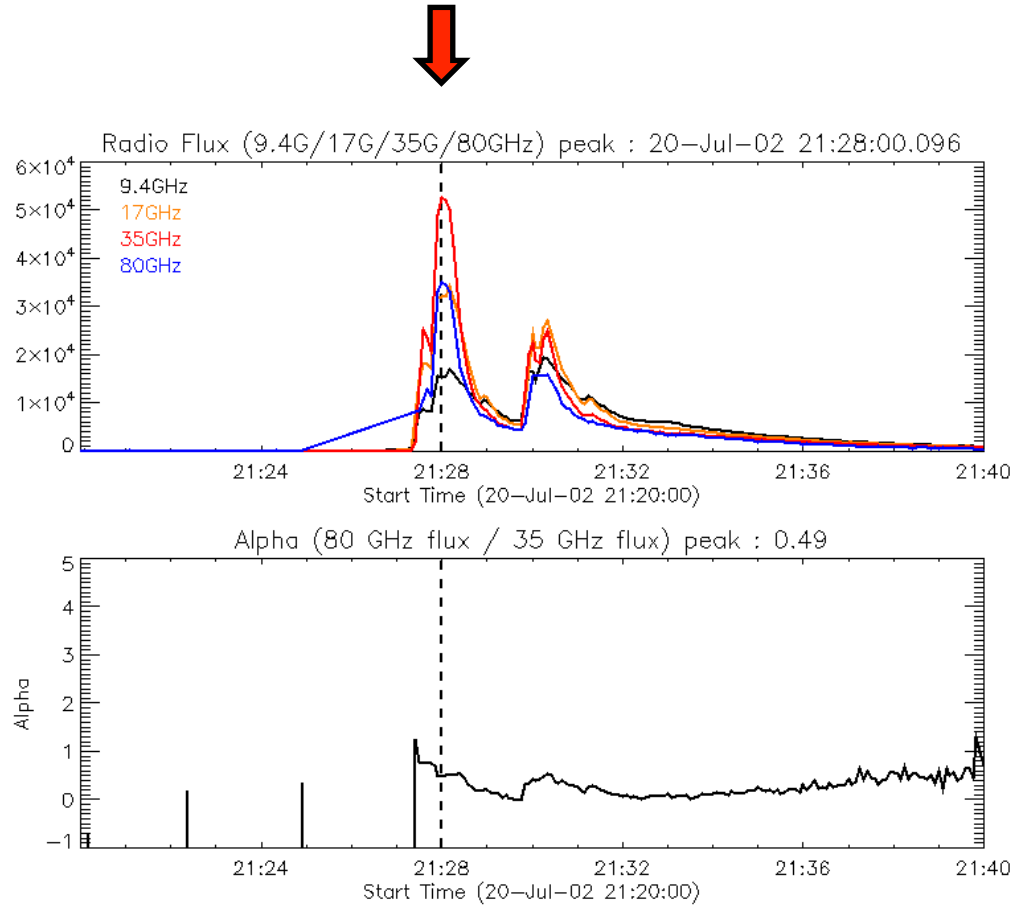


α = 1.2

[2] 2002 Jul 20, 21:04 - 21:54UT X3.3

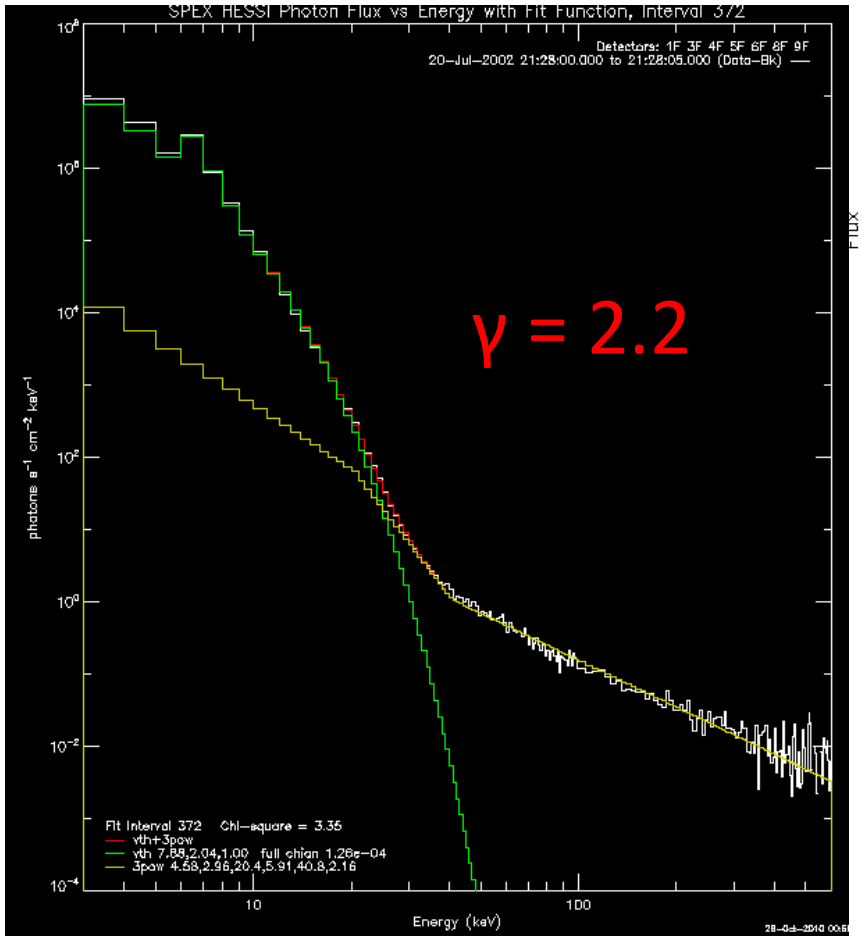
limb event

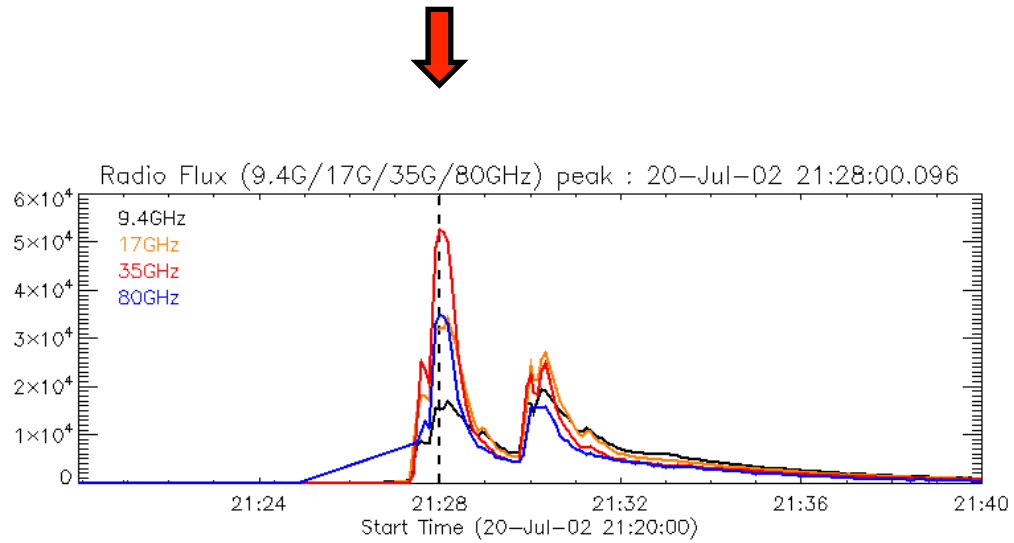


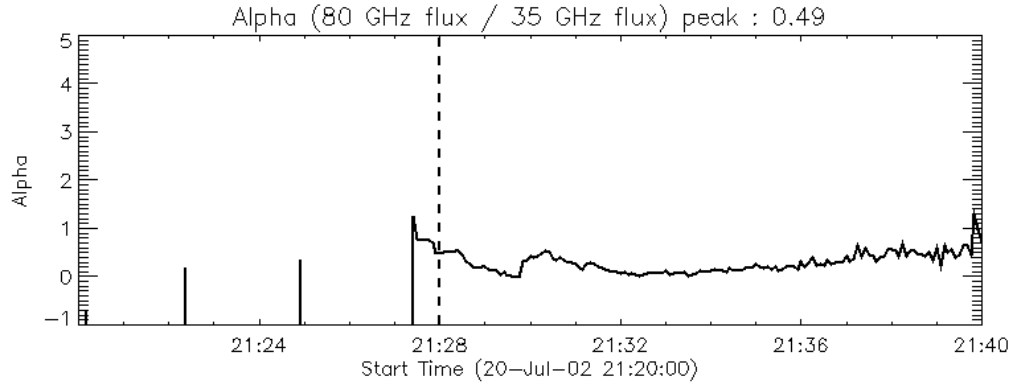


[2] 2002 Jul 20, 21:04 - 21:54UT X3.3

limb event



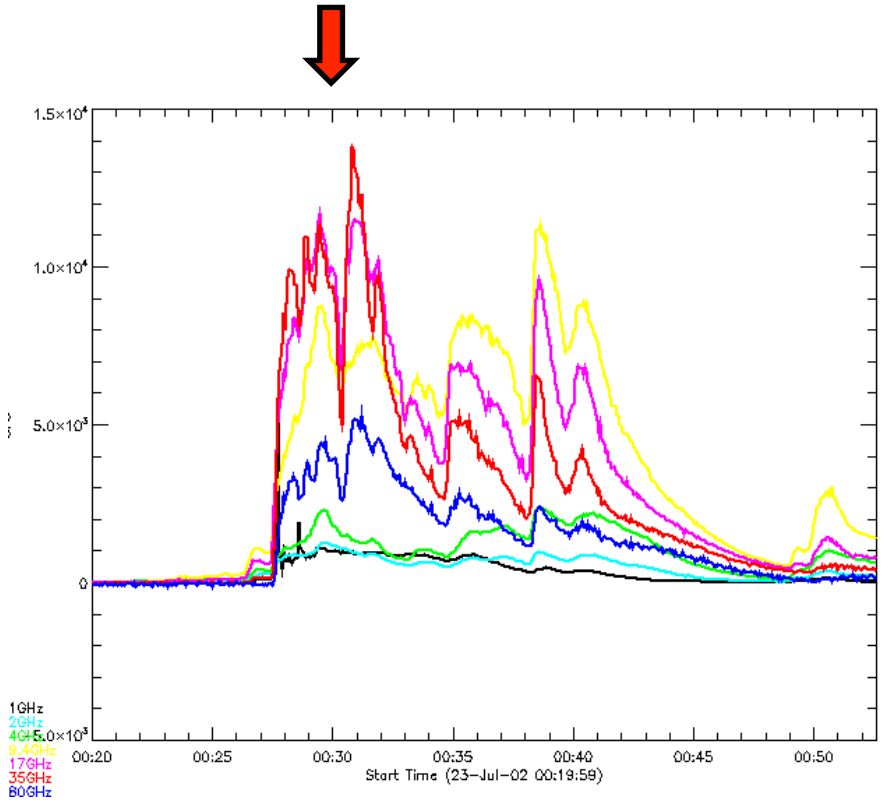


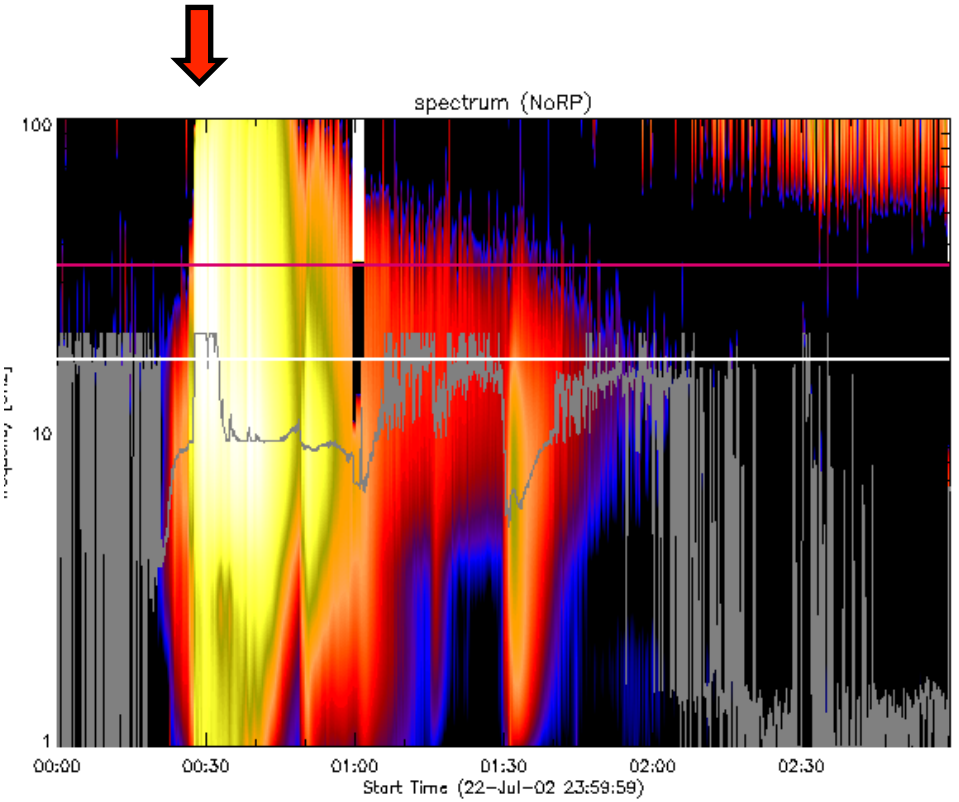


α = 0.5

[3] 2002 Jul 23, 00:18 - 0:47UT X4.3

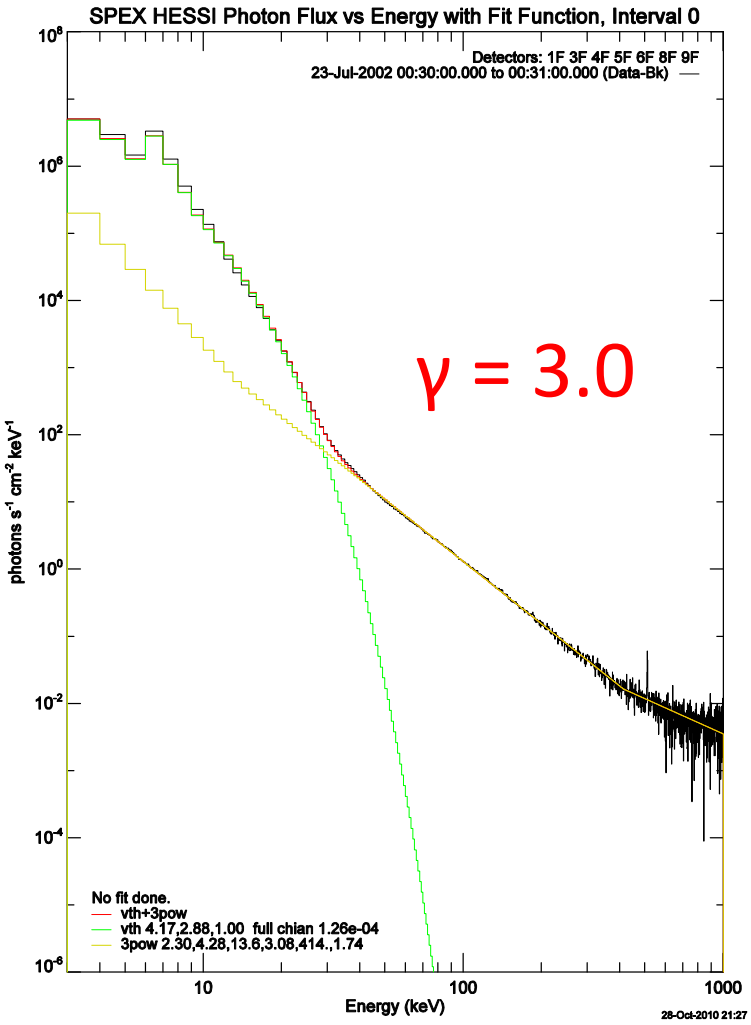
disk event

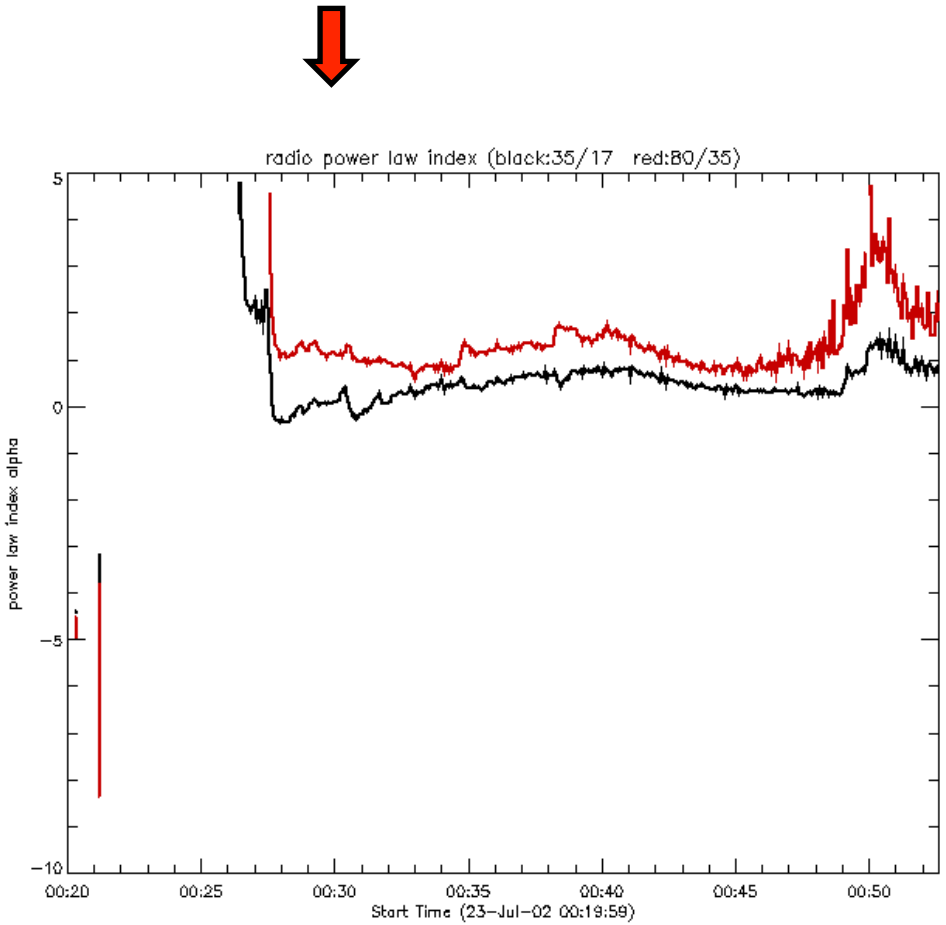




[3] 2002 Jul 23, 00:18 - 0:47UT X4.3

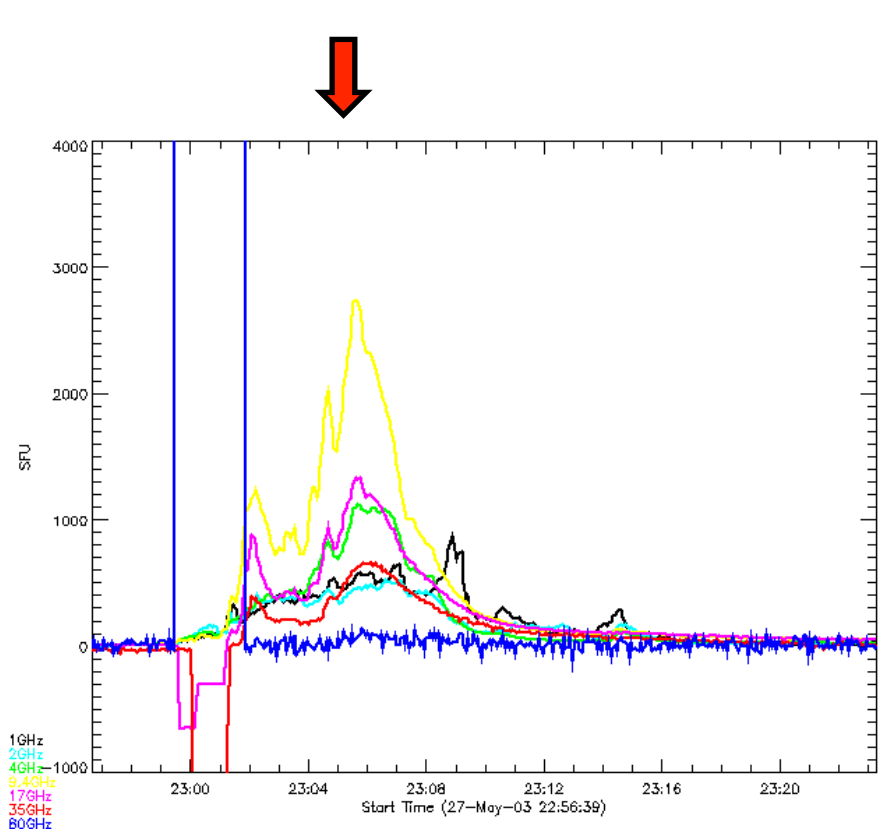
disk event

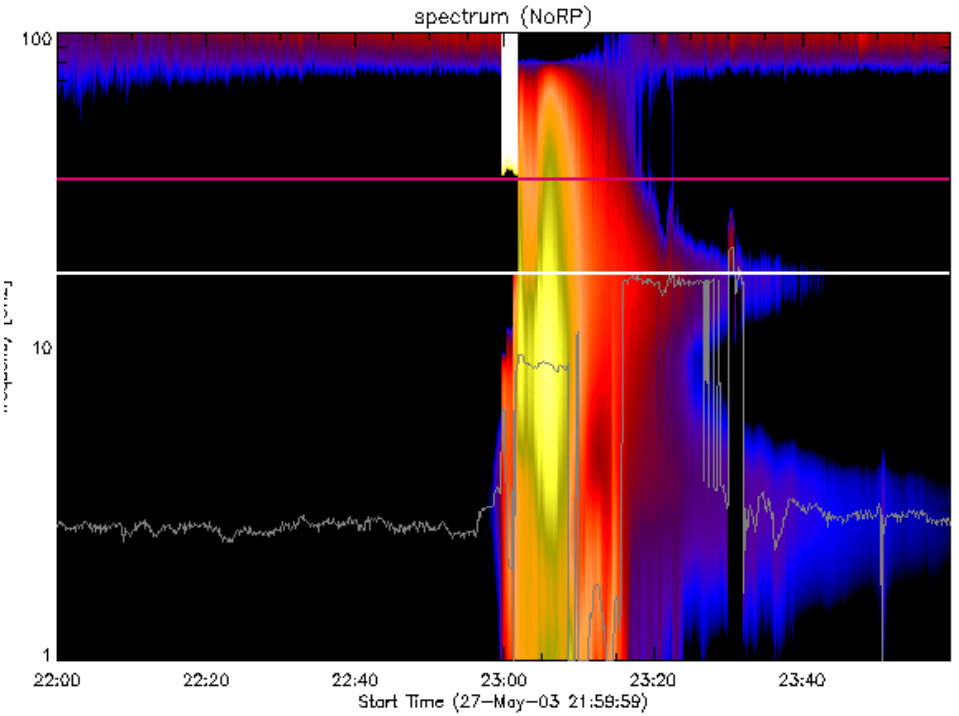




[4] 2003 May 27, 22:56 - 23:13UT X1.4

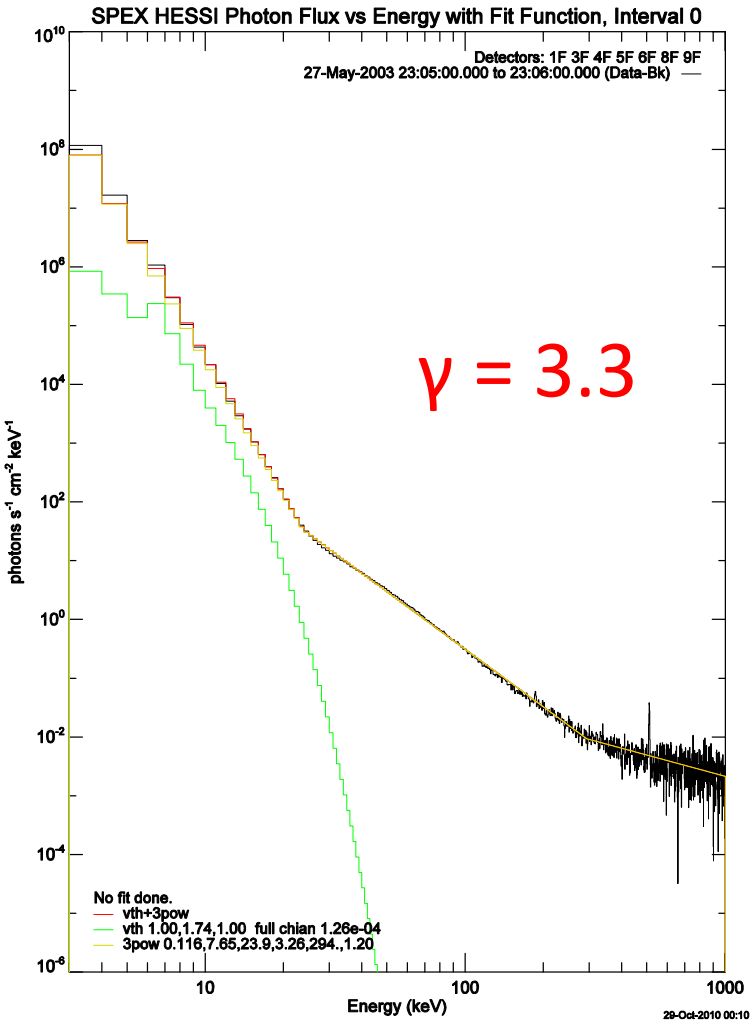
disk event

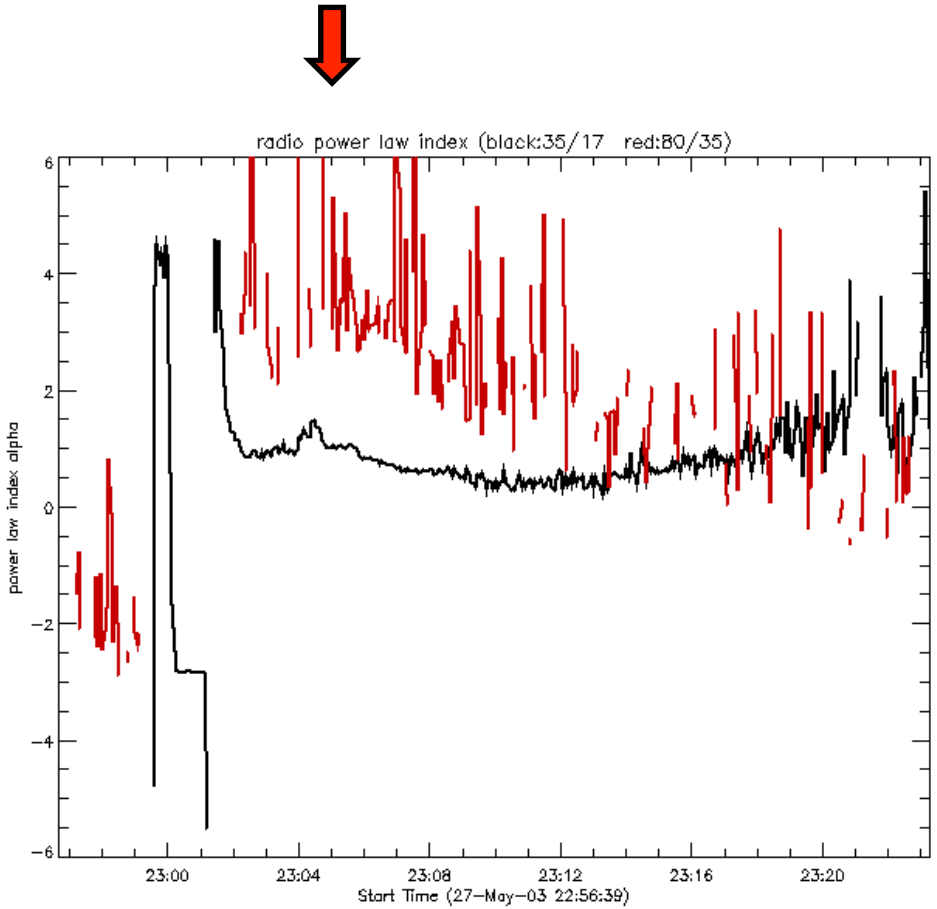




[4] 2003 May 27, 22:56 - 23:13UT X1.4

disk event

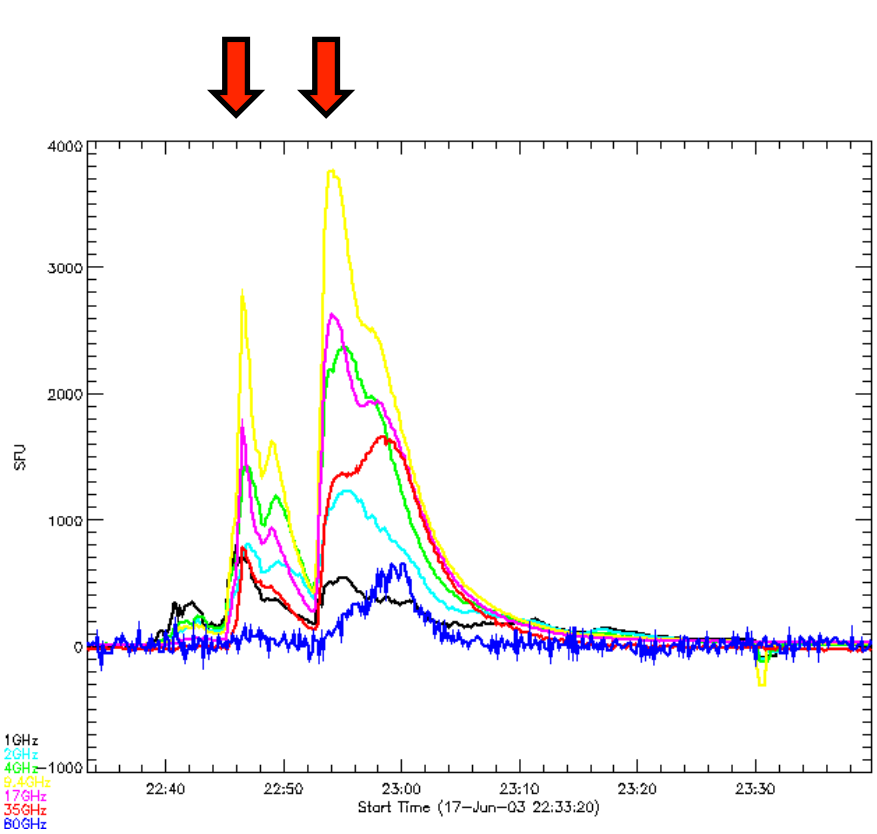


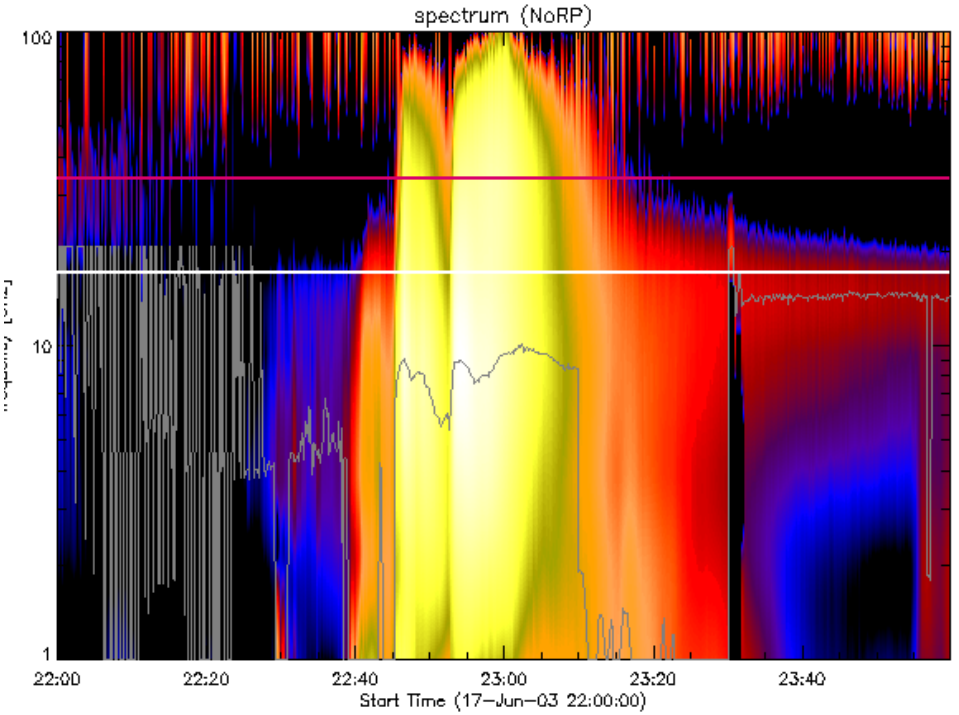


α = 2.0

[5] 2003 Jun 17, 22:27 - 23:12UT M6.8

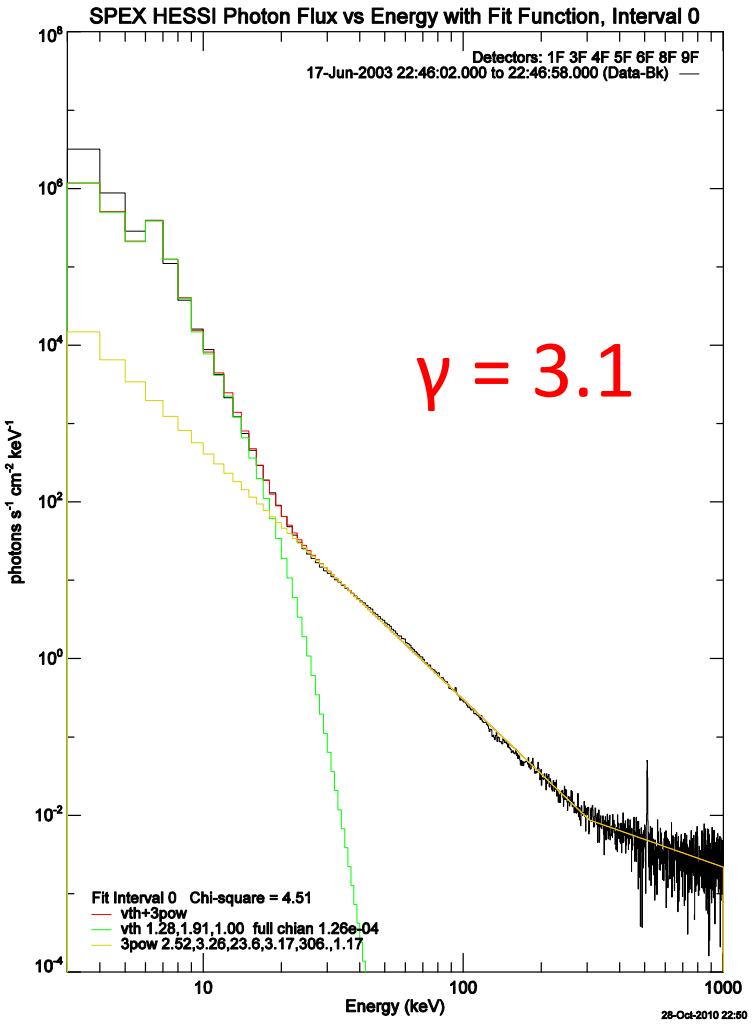
disk event

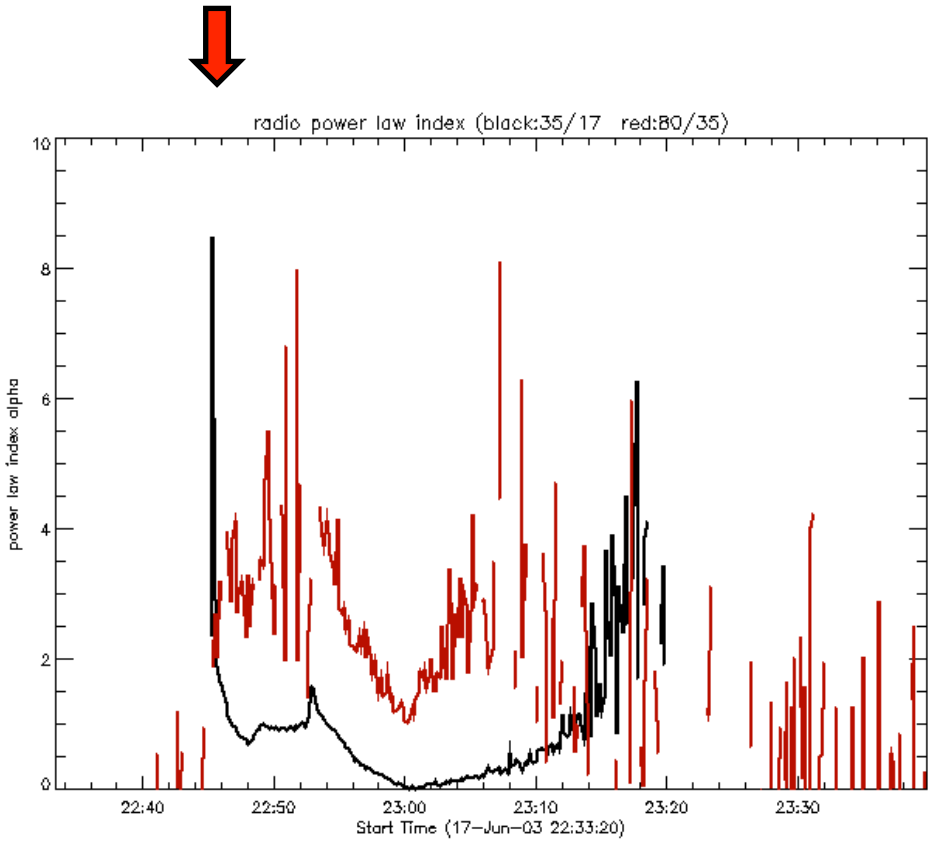




[5] 2003 Jun 17, 22:27 - 23:12UT M6.8

disk event (peak 1 at 22:46UT)

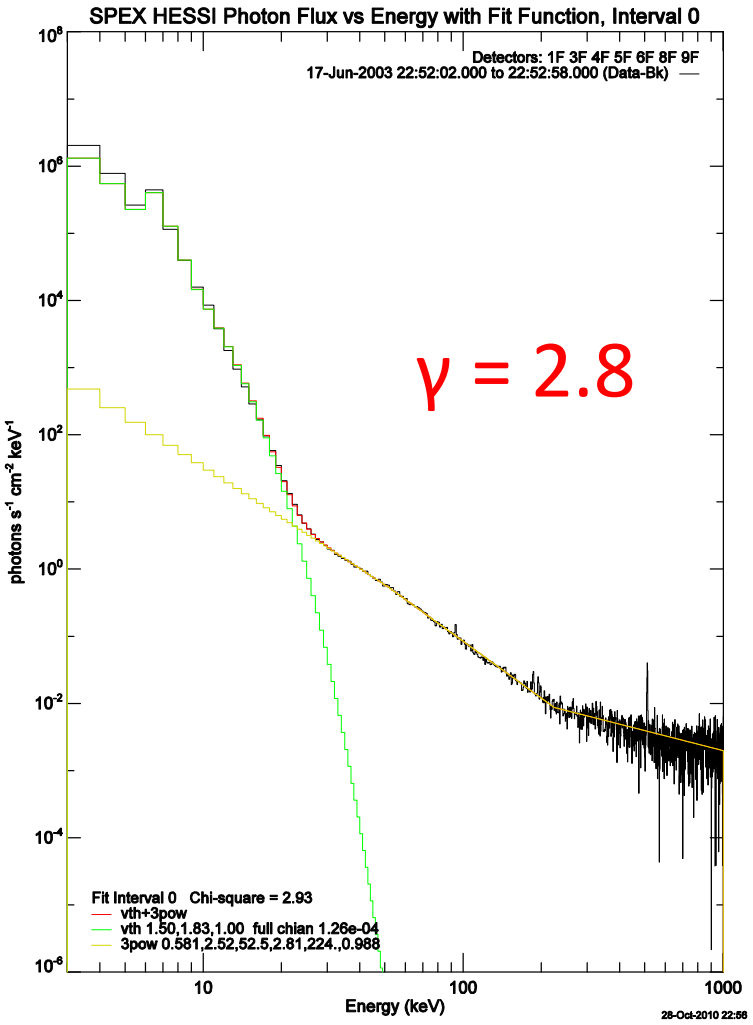




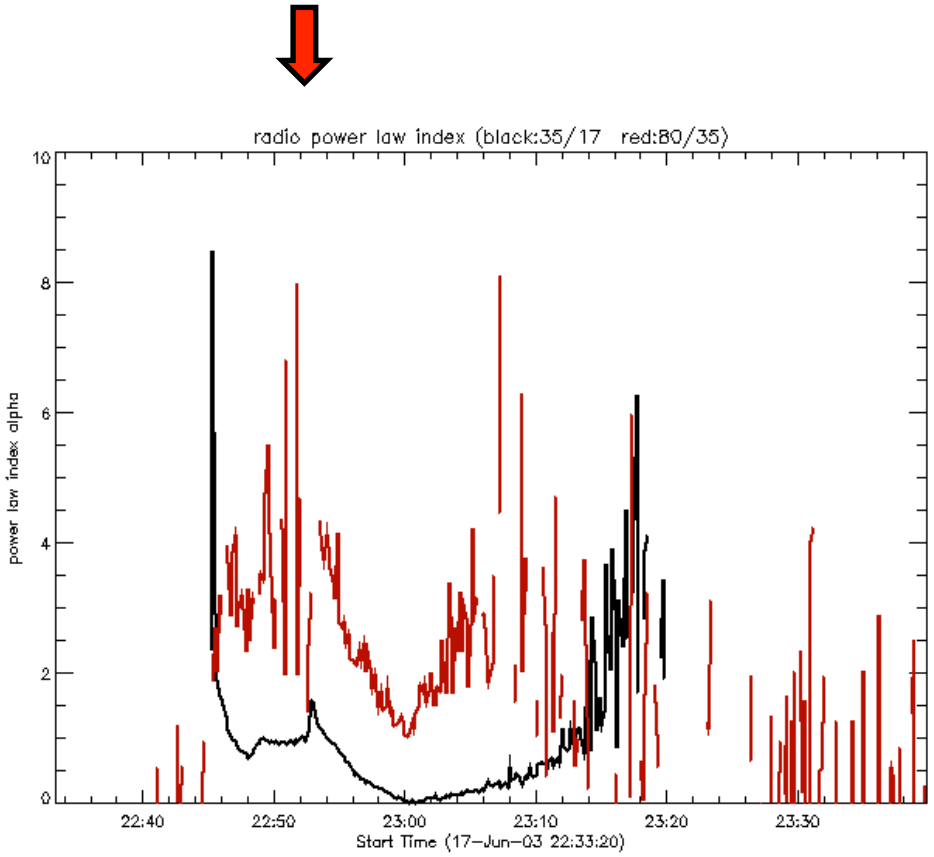
α = 1.0

[5] 2003 Jun 17, 22:27 - 23:12UT M6.8

disk event (peak 2 at 22:52UT)



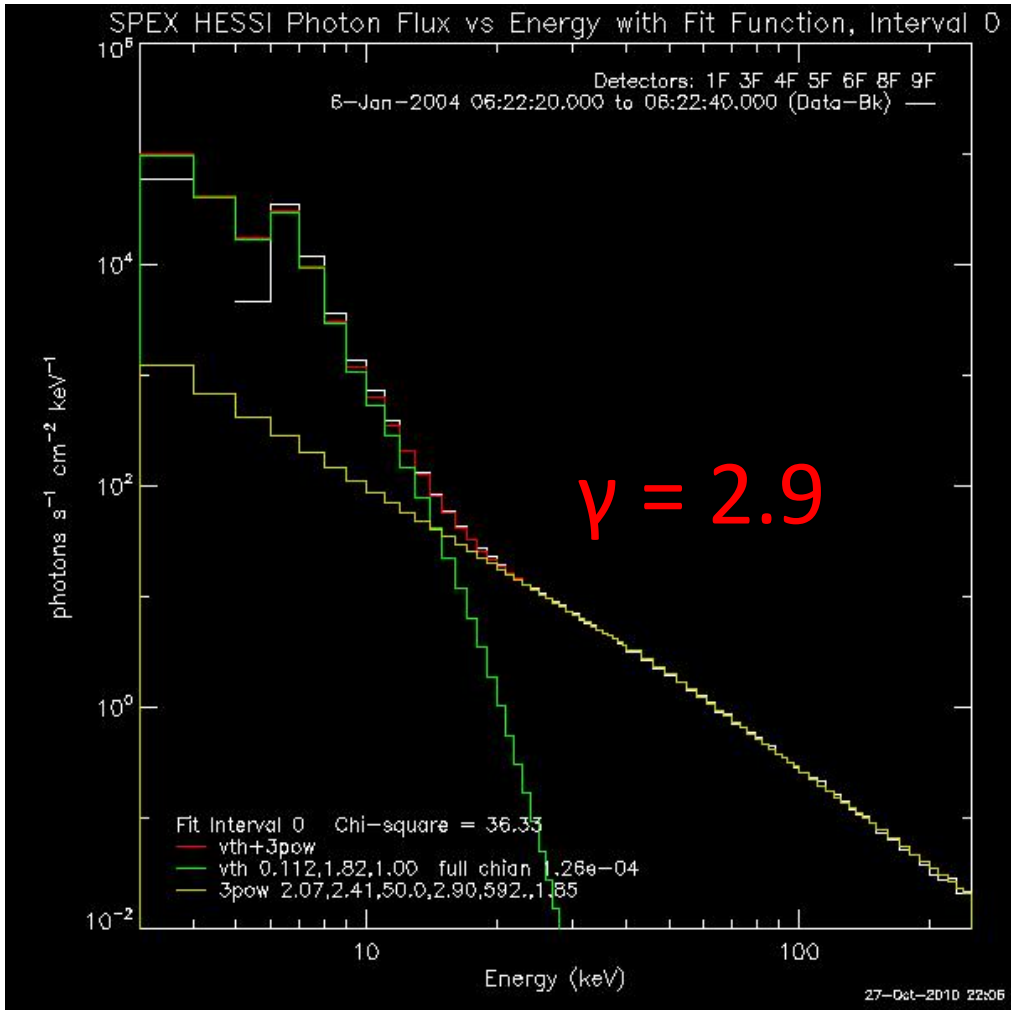
γ = 2.8

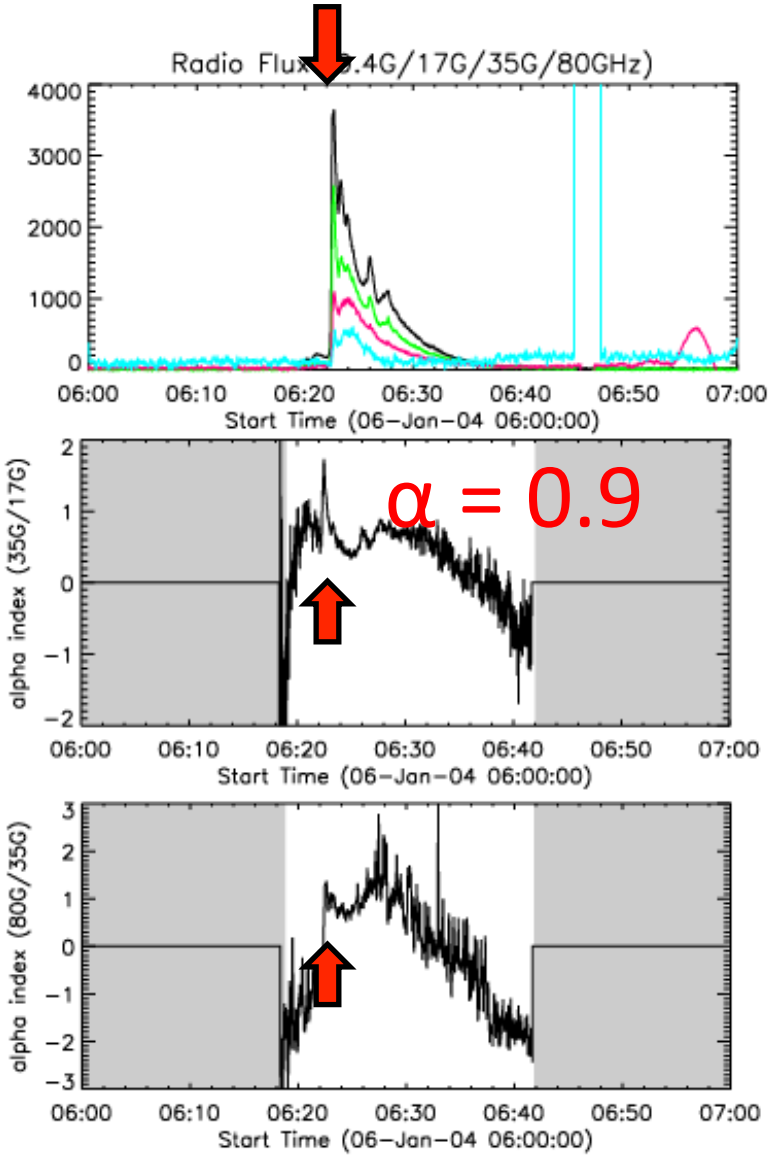


α = 1.0

[6] 2004 Jan 6, 06:13-06:36UT M5.8

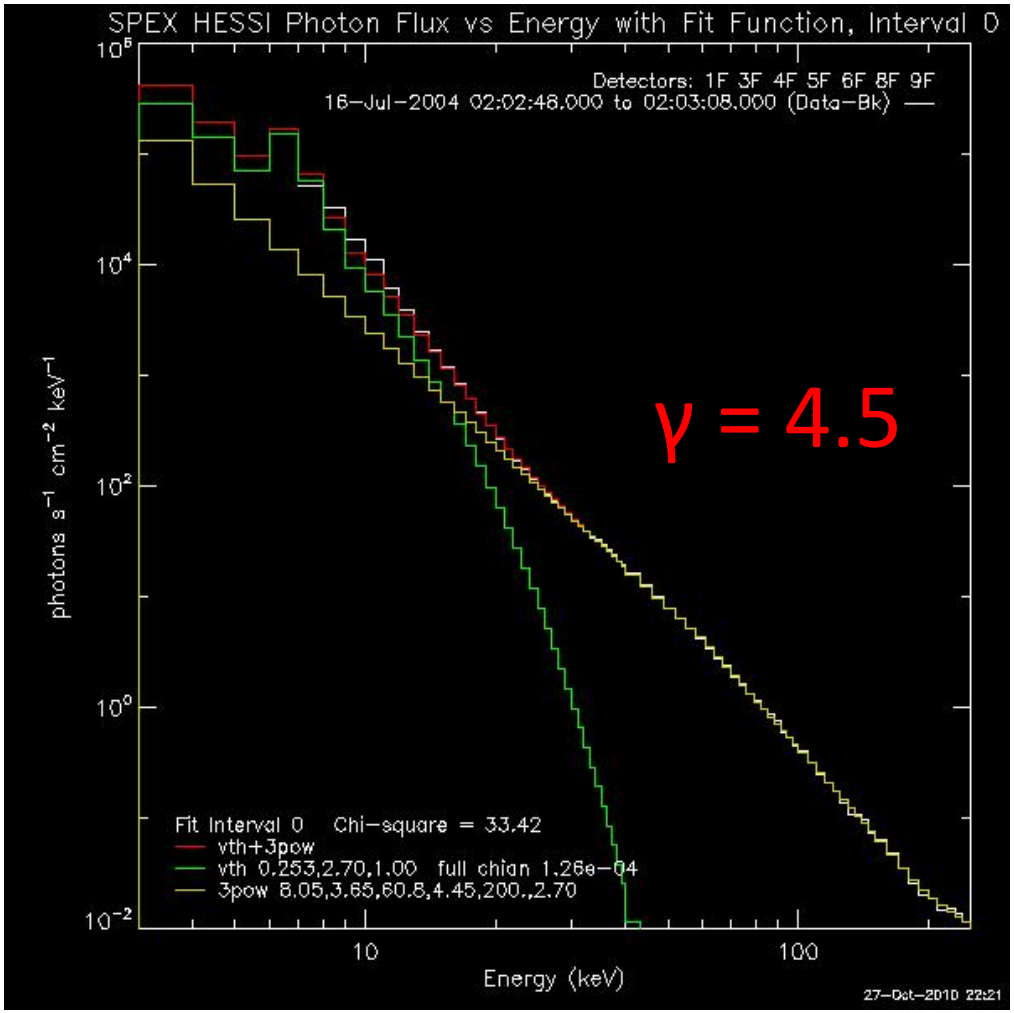
near limb event



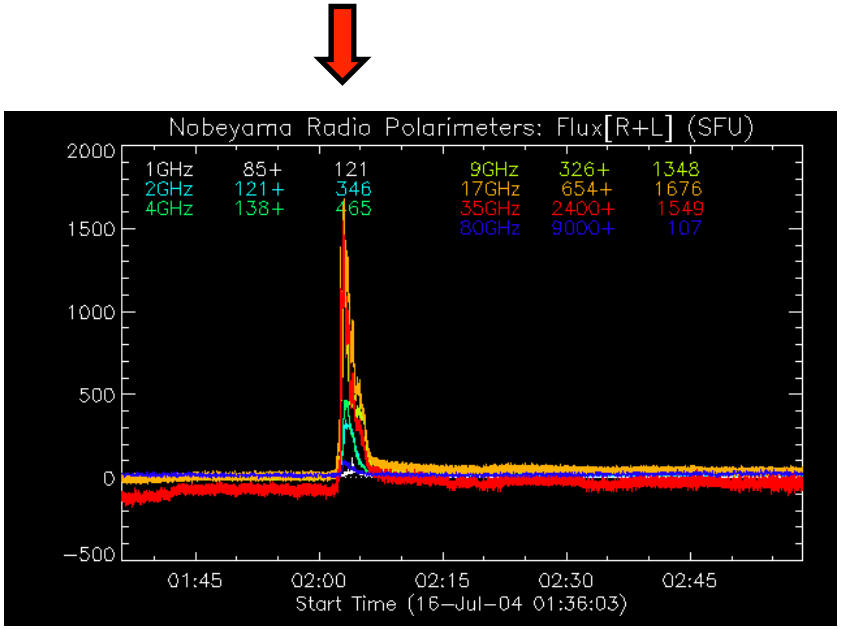


[8] 2004 Jan 6, 06:13-06:36UT M5.8

near limb event



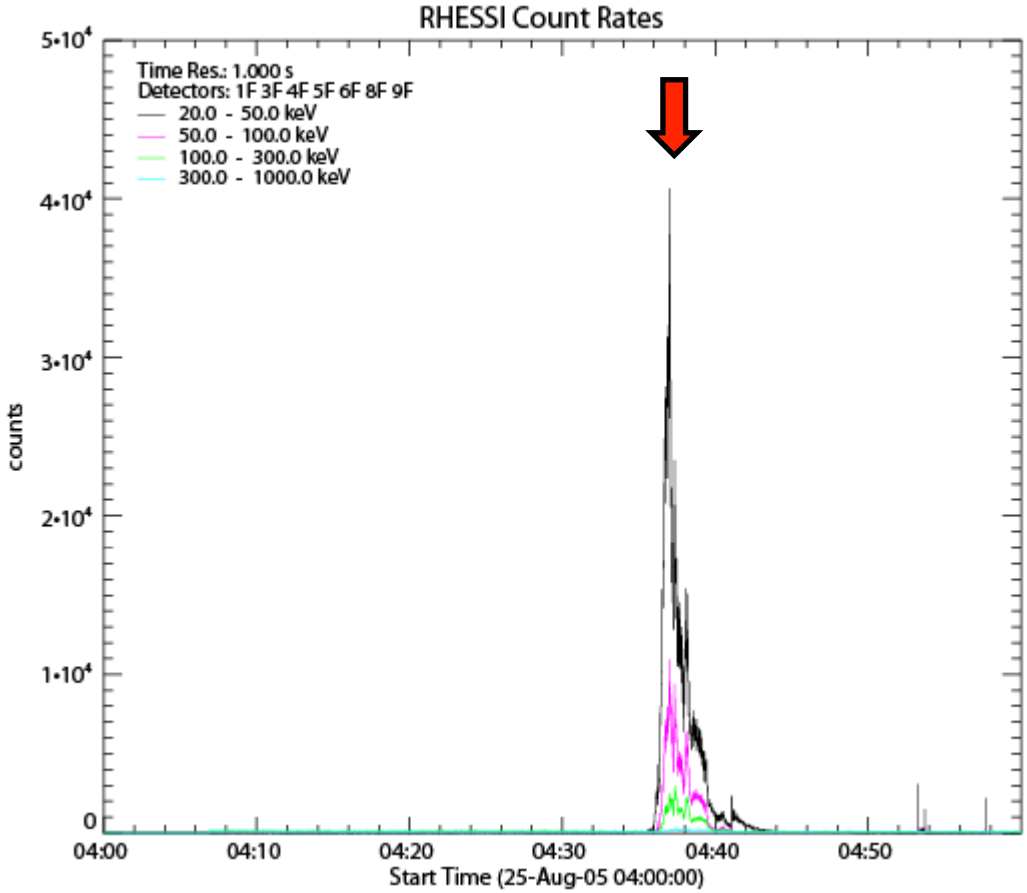
γ = 4.5

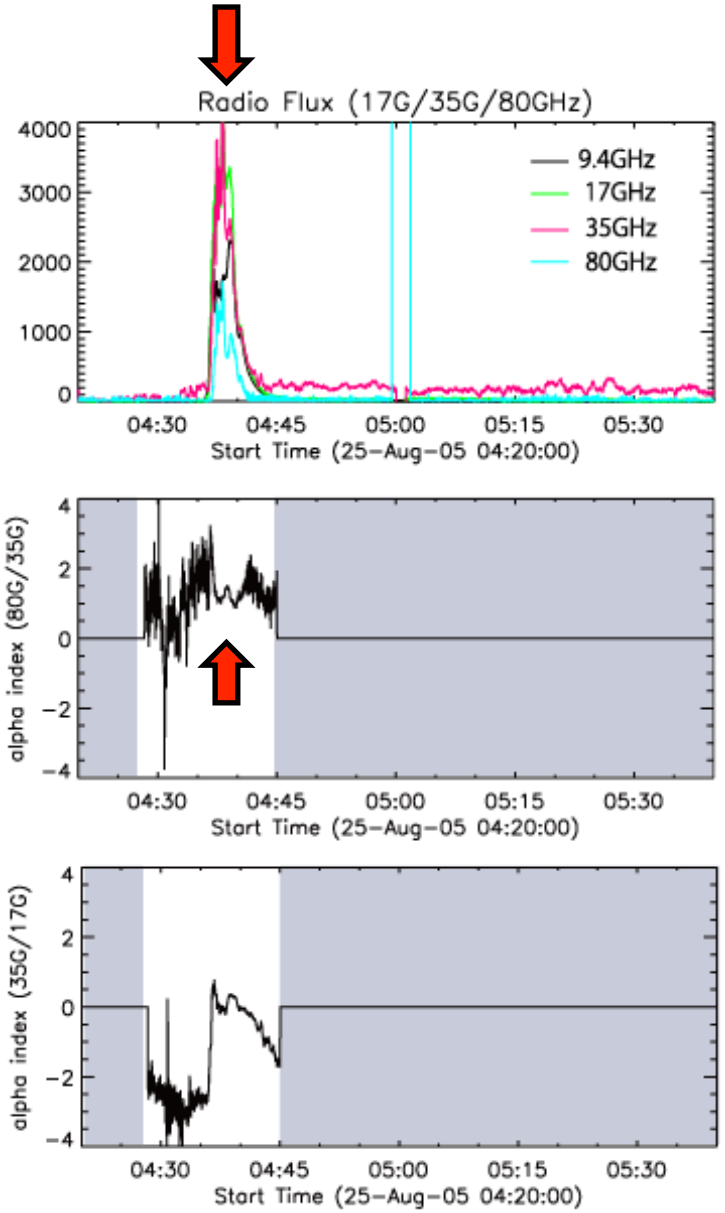


α = 0.3

[9] 2005 Aug 25, 4:31-4:45UT M6.4

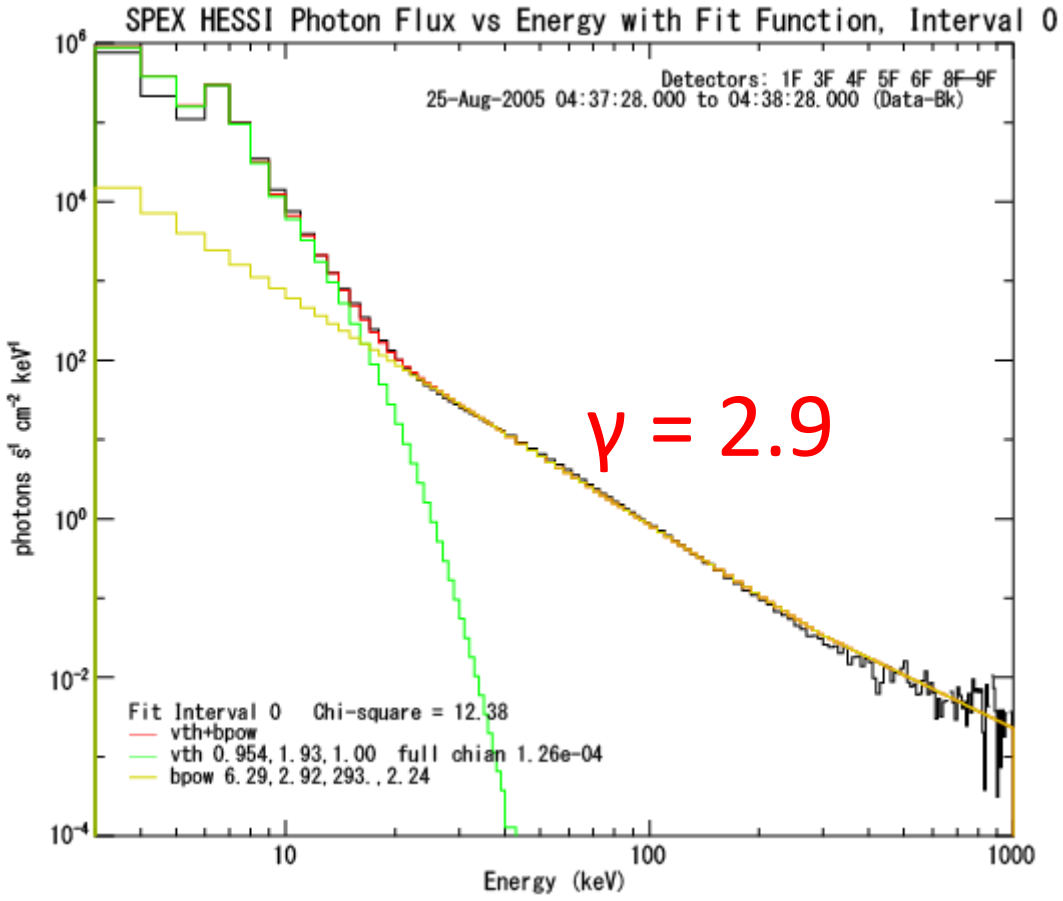
near limb event

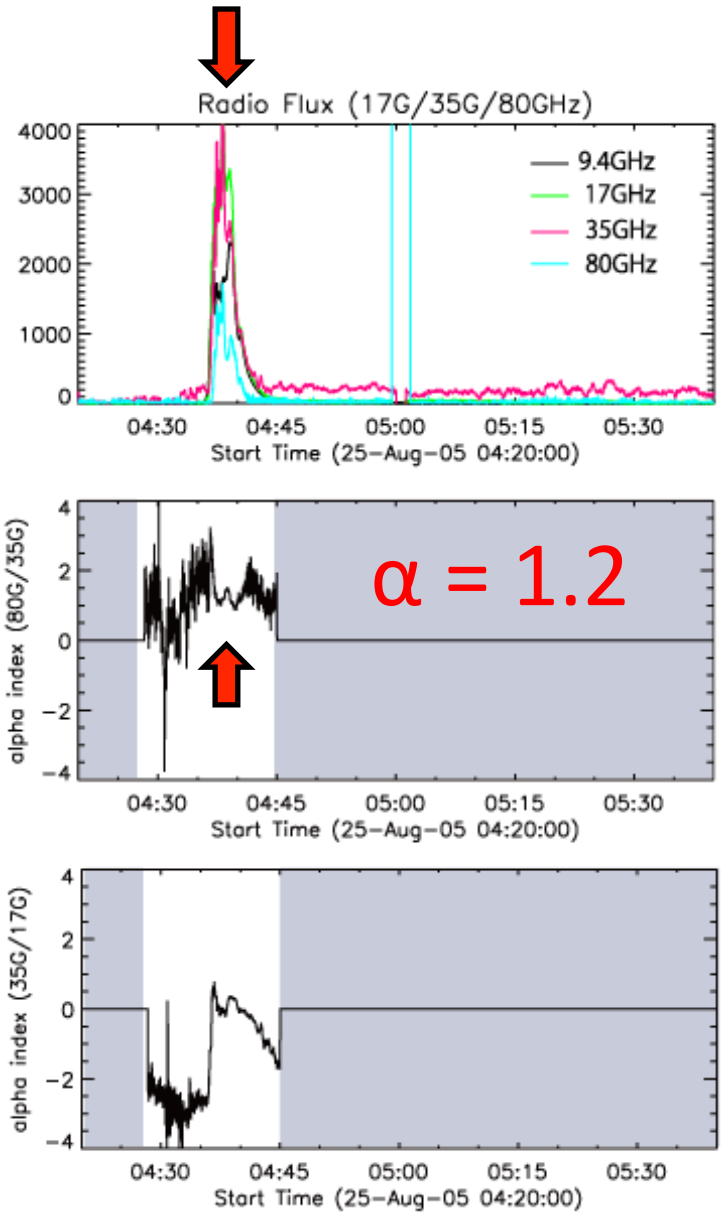




[9] 2005 Aug 25, 4:31-4:45UT M6.4

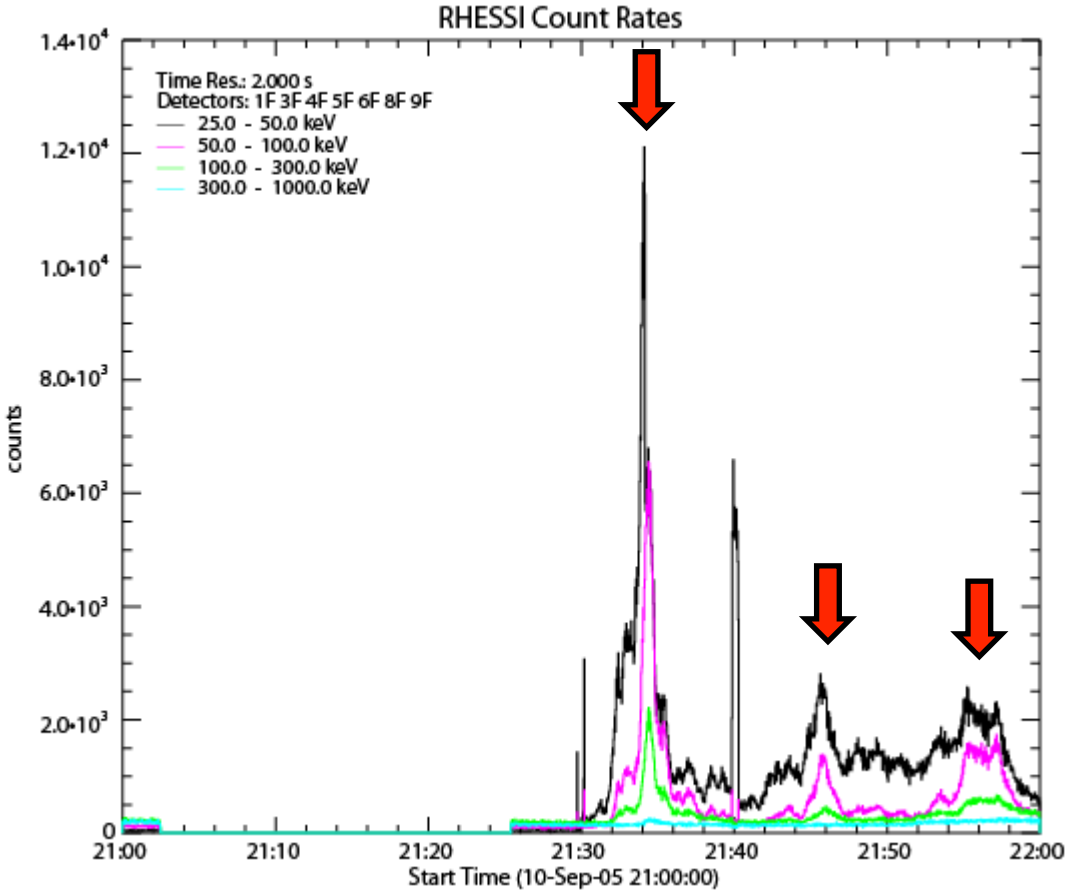
near limb event

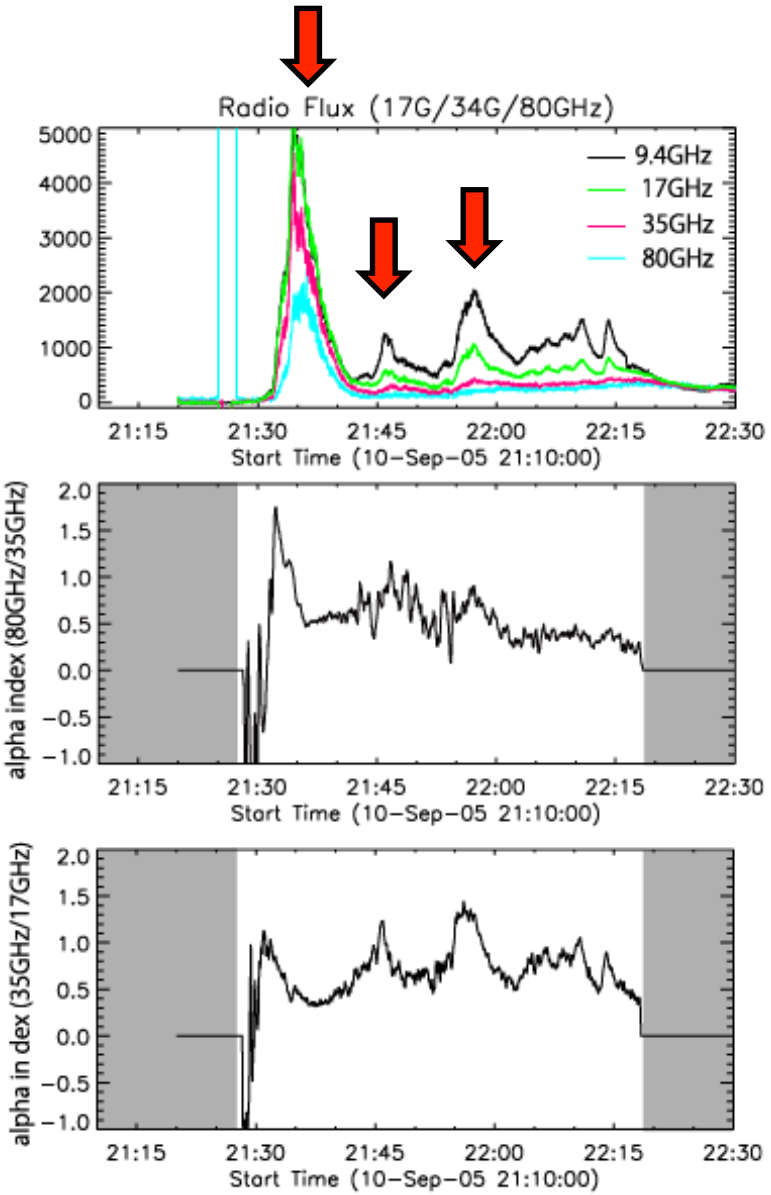




[10] 2005 Sep 10, 21:30-22:43UT X2.1

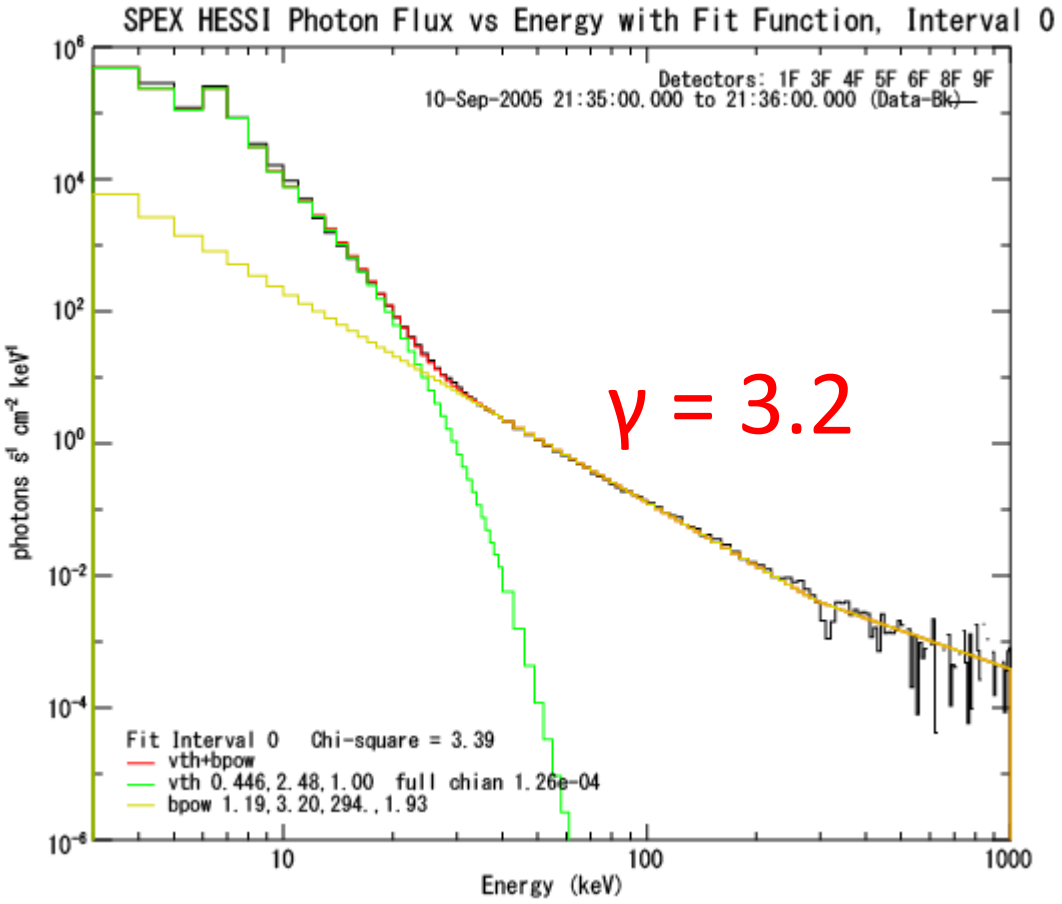
disk event

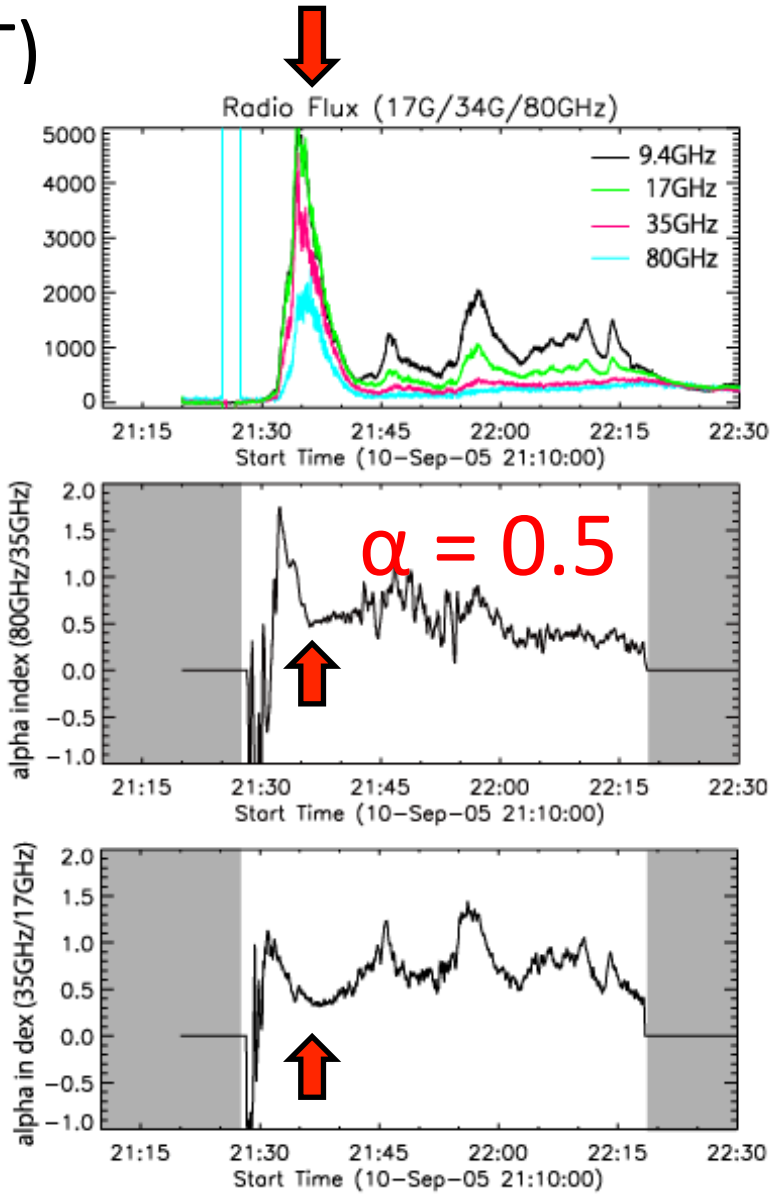




[10] 2005 Sep 10, 21:30-22:43UT X2.1

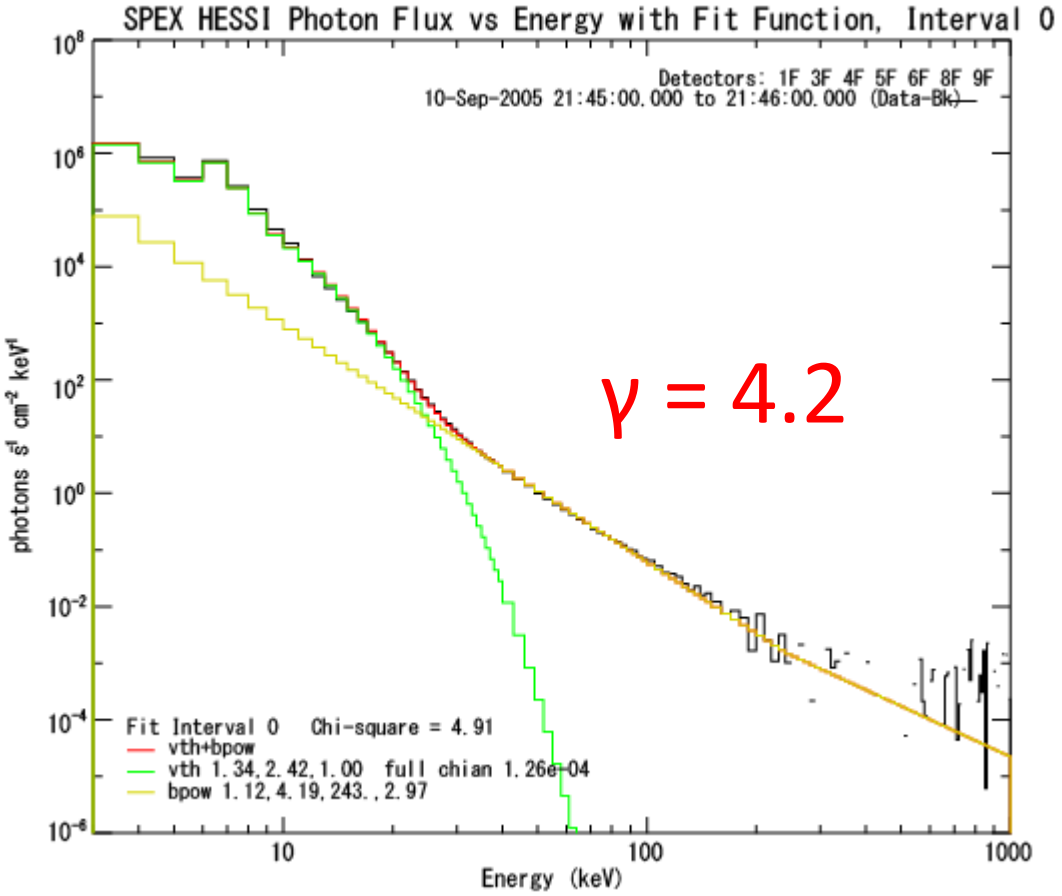
disk event (peak 1 at 21:36UT)

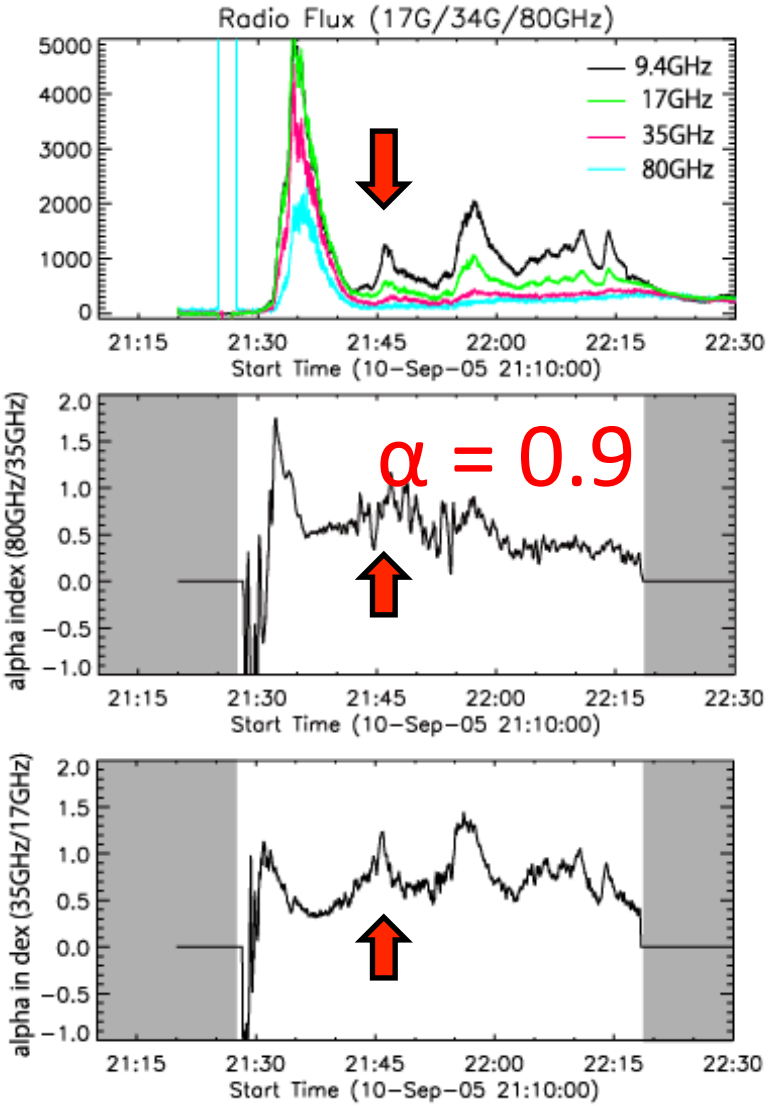




[10] 2005 Sep 10, 21:30-22:43UT X2.1

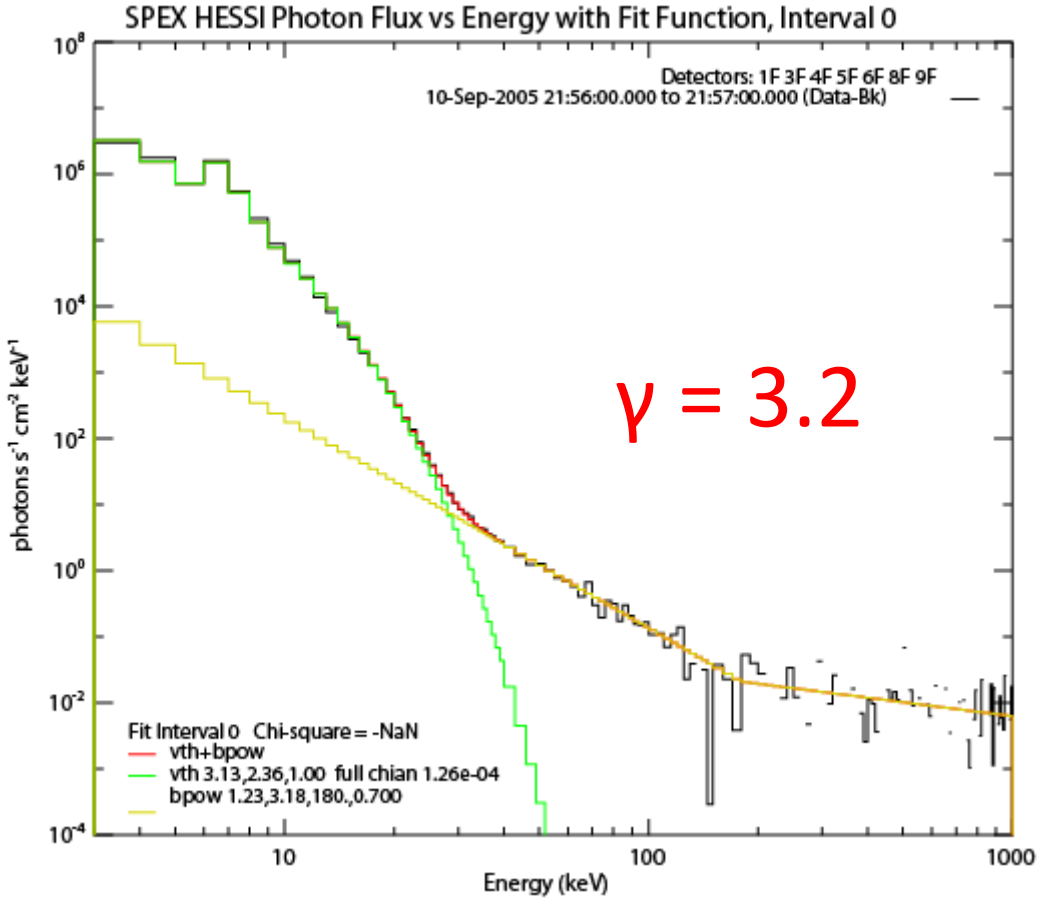
disk event (peak 2 at 21:45UT)

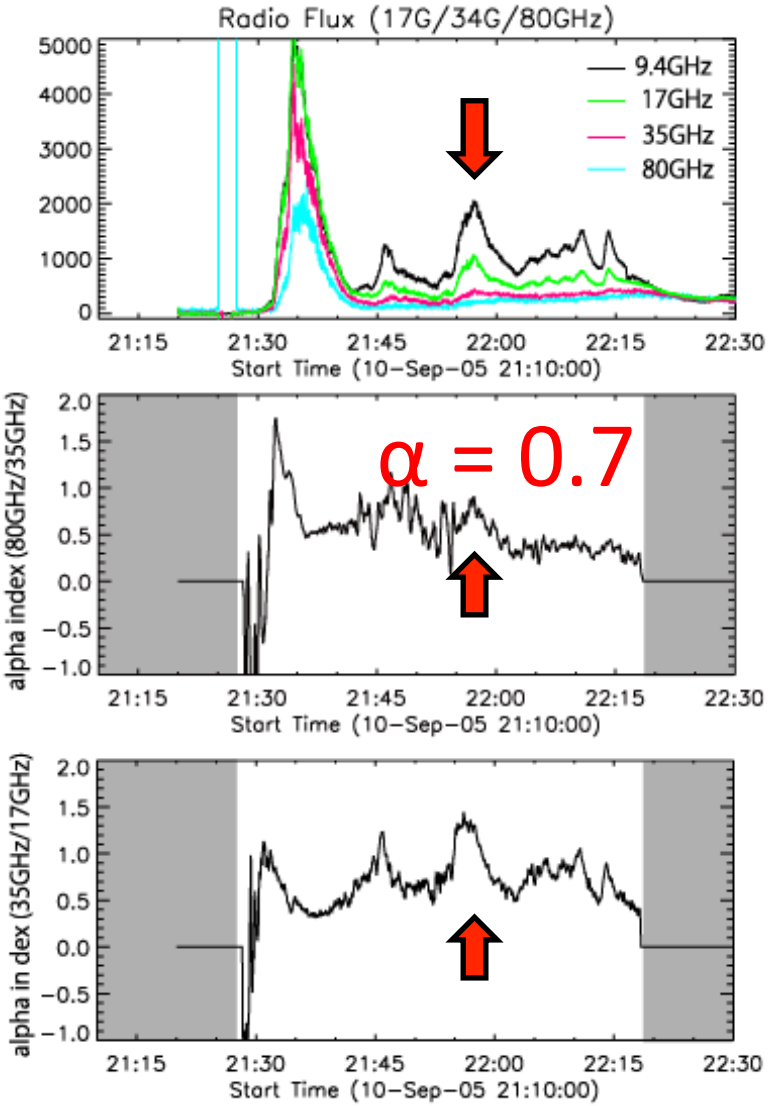




[10] 2005 Sep 10, 21:30-22:43UT X2.1

disk event (peak 3 at 21:56UT)

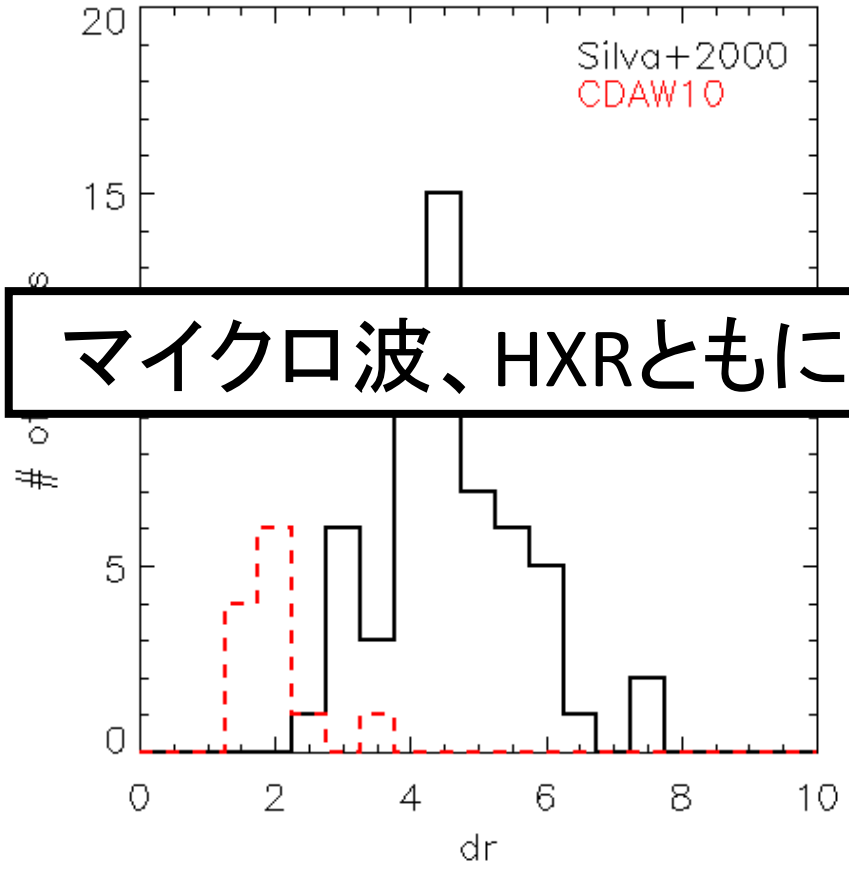


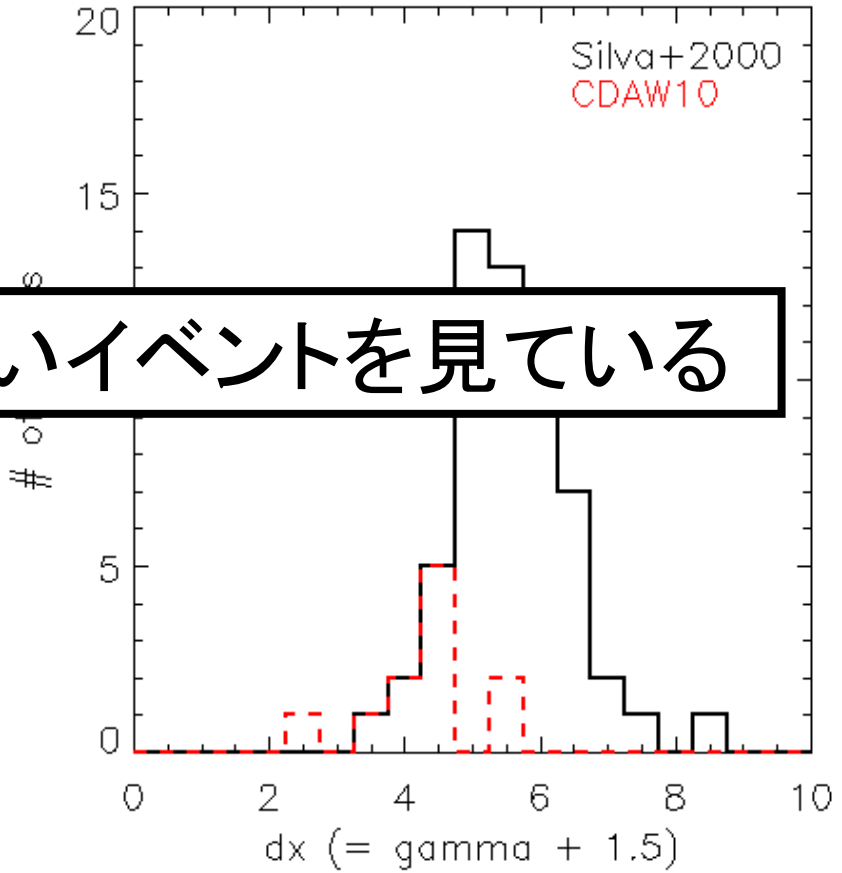


結果

#	Date	Class	Limb/Disk	Peak(17GHz)	gammma	alpha
1	2002/5/31	M2.4	limb	00:07:20	1.2	1.2
2	2002/7/20	X3.3	limb	21:28:00	2.2	0.5
3	2002/7/23	X4.3	disk	00:30:30	3.0	0.5
4	2003/5/27	X1.4	disk	23:02:00 23:05:30	3.3	2.0
5	2003/6/17	M6.8	disk	22:46 22:52:30	3.1 2.8	1.0 1.0
6	2004/1/6	M5.8	near limb	6:22:30	2.9	0.9
7	2004/7/15	X1.8	disk	2:38:00		
8	2004/7/16	X1.3	disk	2:03:00	4.5	0.3
9	2005/8/25	M6.4	near limb	4:38:10	2.9	1.0
10	2005/9/10	X2.1	disk	21:35:00 21:45 21:56	3.2 4.2 3.2	0.5 0.9 0.7
11	2005/9/13	X1.7	disk	23:18:30 23:20:00		

Silva+(2000)との比較





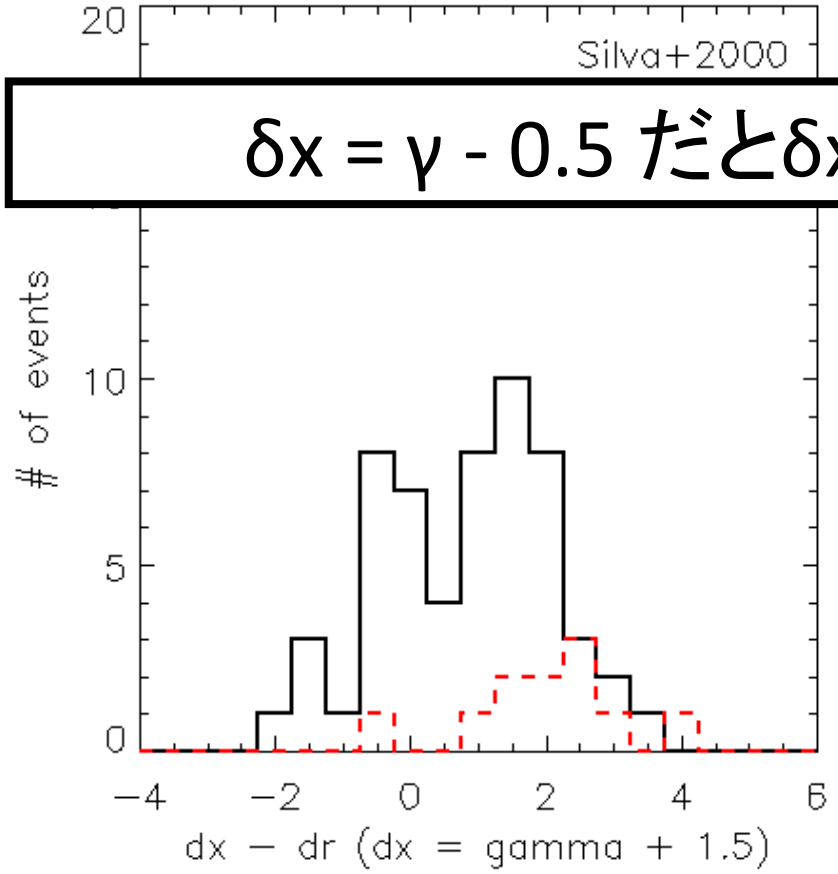
マイクロ波、HXRともに硬いイベントを見ている

マイクロ波から求められる電子のべき指数

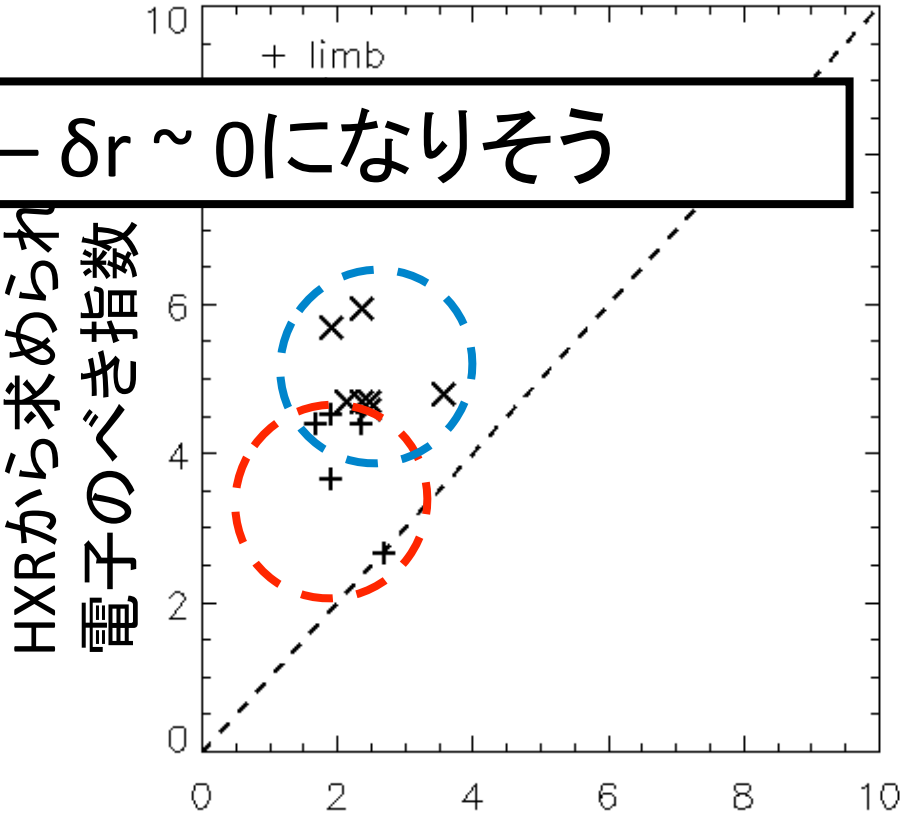
HXRから求められる電子のべき指数

Silva+(2000)との比較

$\delta x = \gamma - 0.5$ だと$\delta x - \delta r \sim 0$になりそう



HXRべき指数
−マイクロ波べき指数



マイクロ波から求められる電子のべき指数

考察

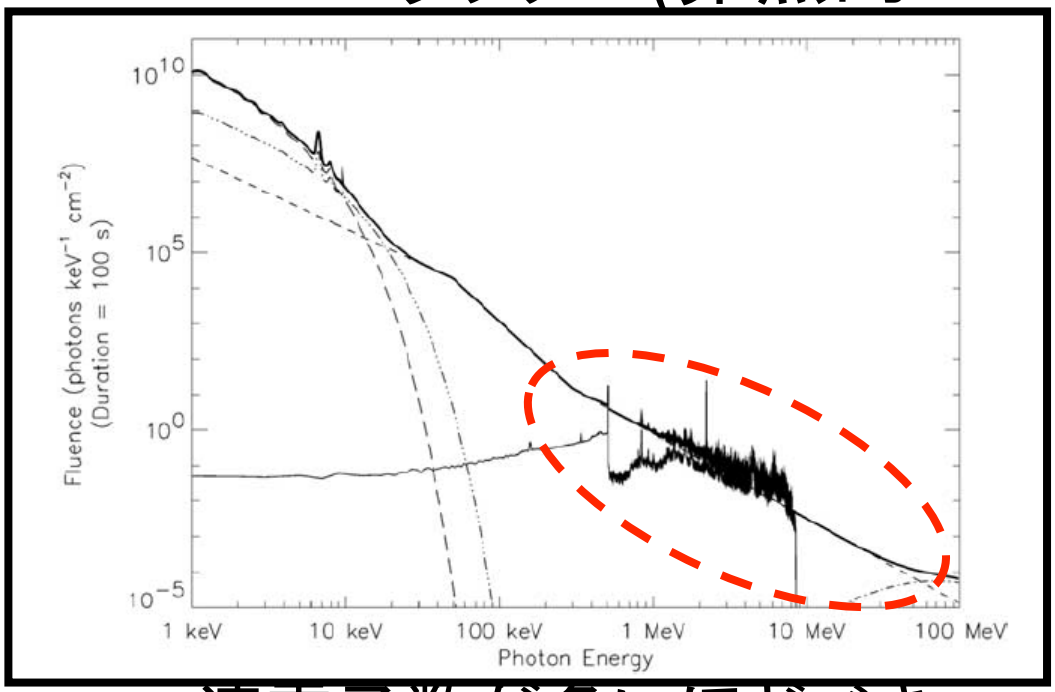
- 数百keVのknee以上のエネルギーを電子で見ているとすると、何がkneeを作っているのか

center-to-limb variationが存在する
→footpoint電波源とlooptop電波源とで差が生じる

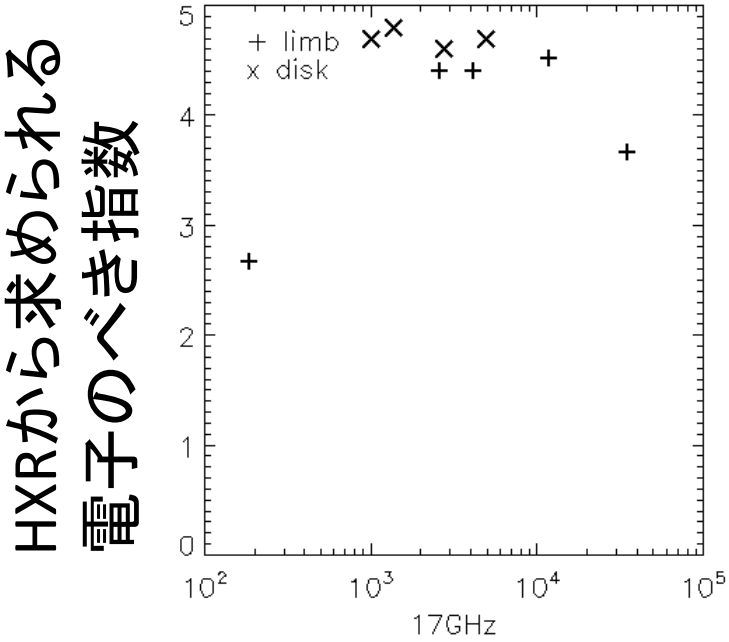
limb eventの方がべきが柔らかい
→磁場の強い場所、低エネルギーを見ると、べきが柔らかい

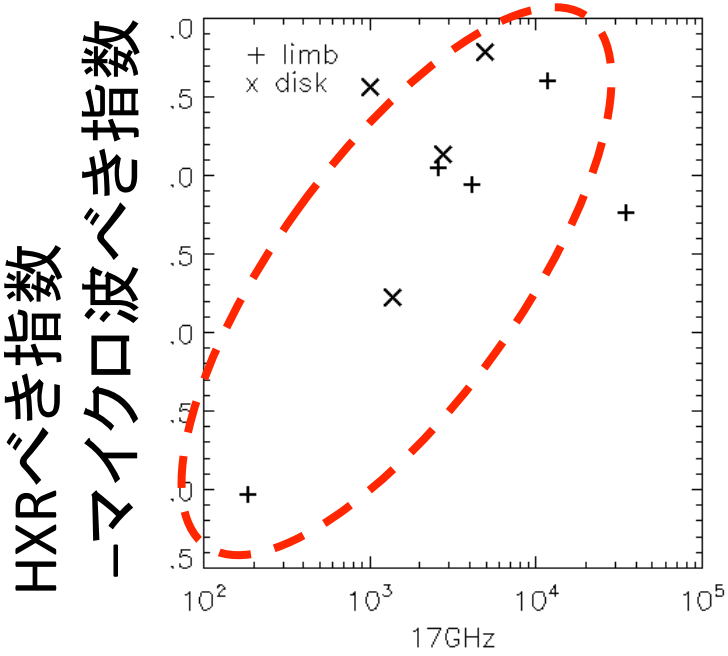
結果その2

- 17GHzフラックス(非熱的



速電子数が多いほどべき
指数は硬くなる





まとめ

- モデルとしたγ+1.5は正しいか
  -> 空間構造を考慮した追解析が必要
  ->各イベント毎の特徴を抽出する

- 今回はsilva+(2000)と比べて強いイベントであり、べきは硬い
  -> 数百keVで非熱的輻射の強いイベントを選択的に解析