

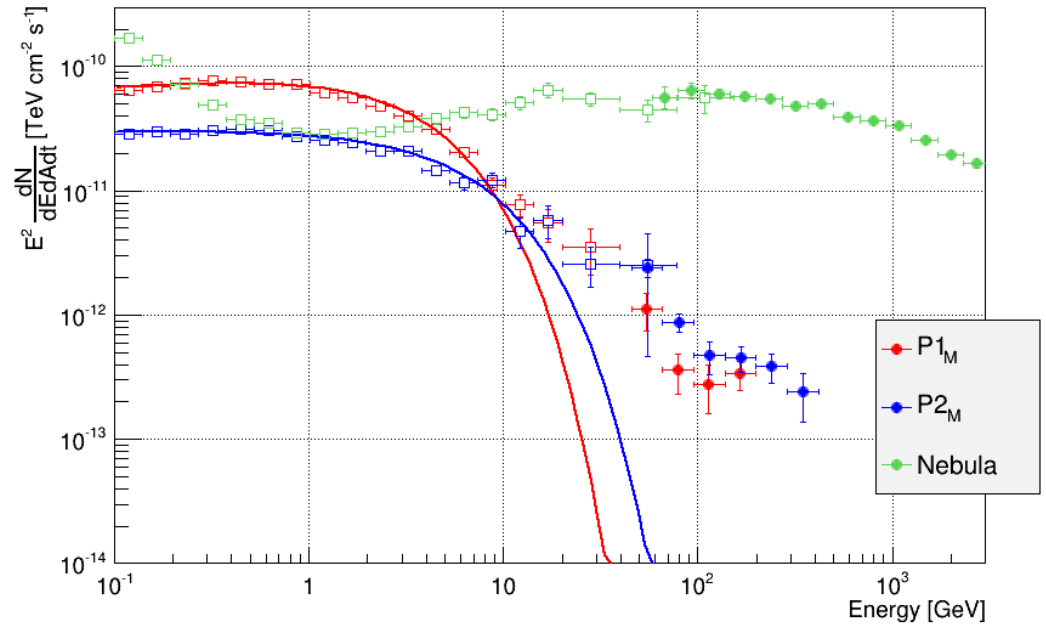
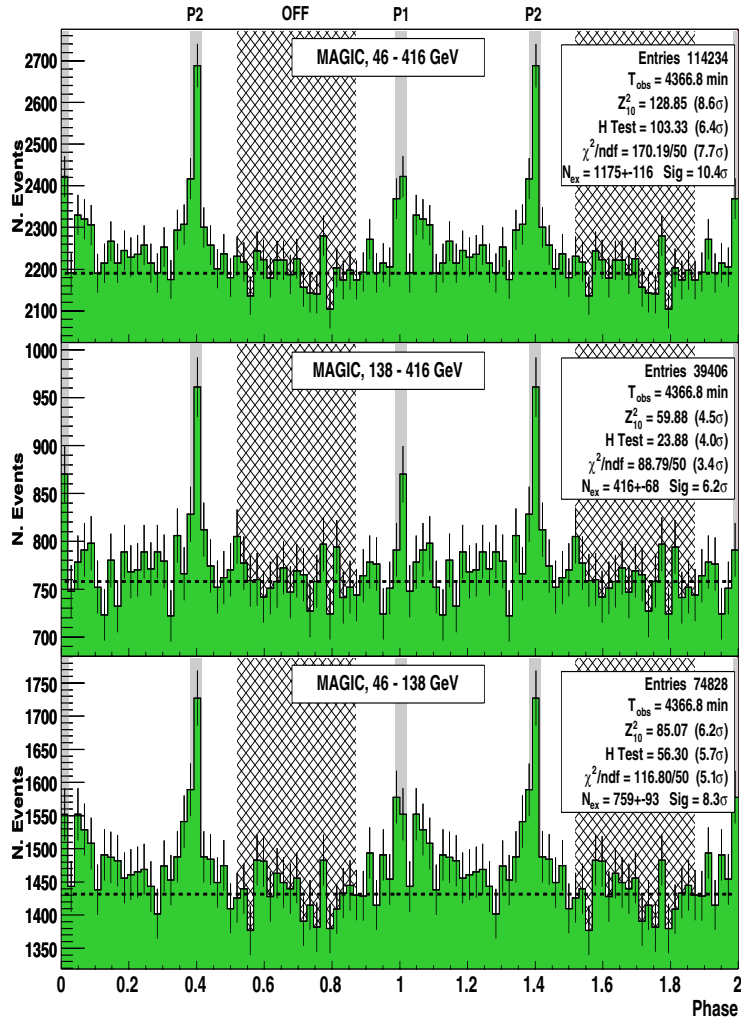


MAGIC による 最近のパルサー観測

京都大学
齋藤隆之



Crab Pulsar, latest publication



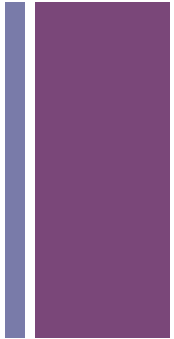
70 h, 2009-2011

Exponential cutoffからのずれ
400 GeVまでベキ関数的にのびている

+ 統計増やして、より精密に

- Crab NebulaはCalibrationソース。（さまざまなコンディションで）しょっちゅう観測される
- Moonデータや、High 天頂角まで含めると、300時間を超える観測が行われた(2009年以降の Stereo観測のみ)
- Crab Nebula観測 = Crab Pulsar観測
- Low energy 解析のため、天頂角35度、低夜光データのみを採用すると、135時間
- 2011 - 2012年のカメラのアップグレードで、Low energy の感度は向上

+ Discovery of emission!



	P1	P2
Phase	0.983- 1.026	0.377-0.422
Excess	932+-118	1511+-124
Significance	8.0 σ	12.6 σ

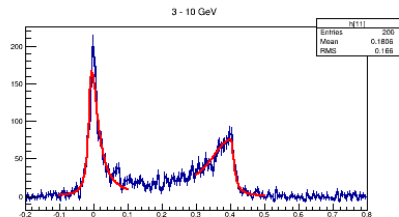
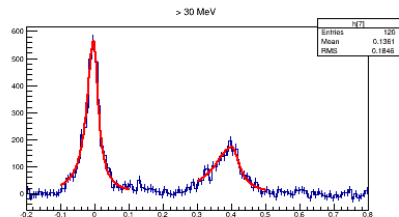
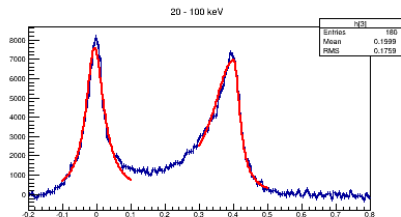
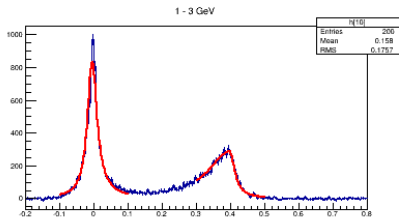
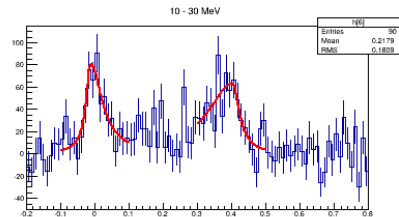
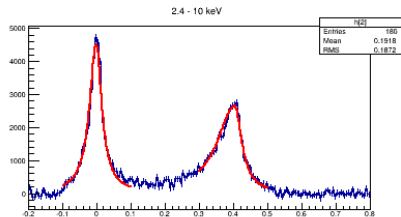
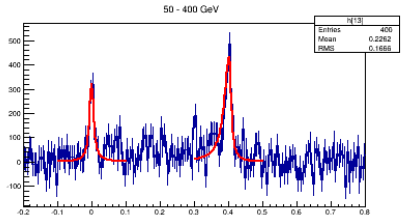
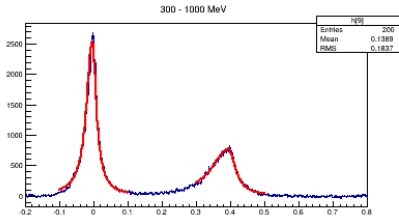
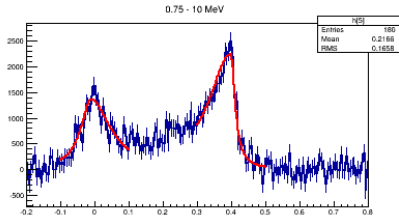
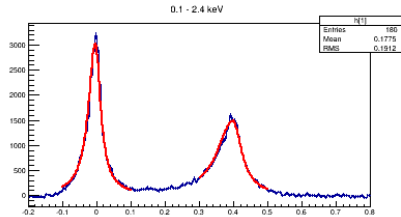
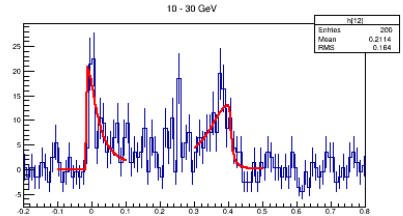
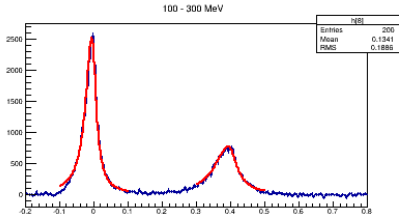
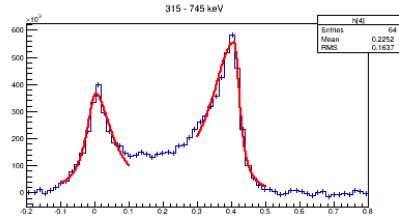
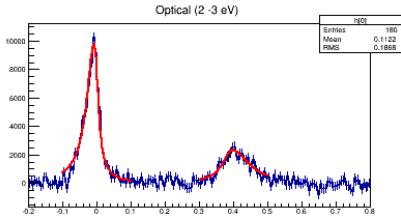


+ 他波長との比較

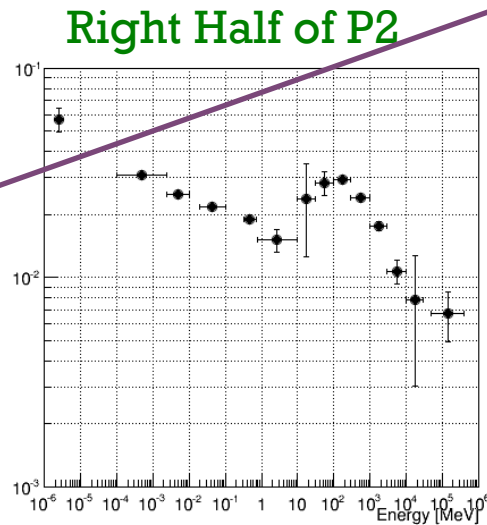
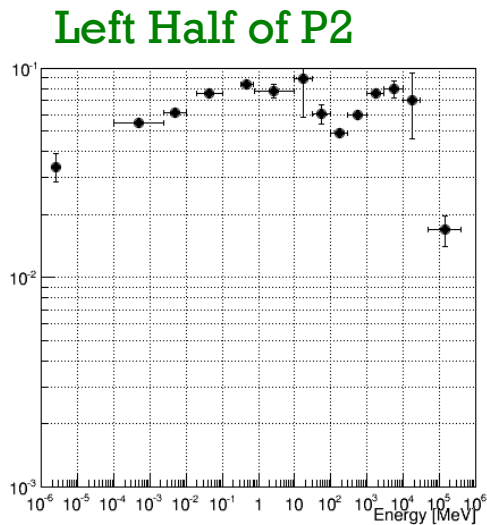
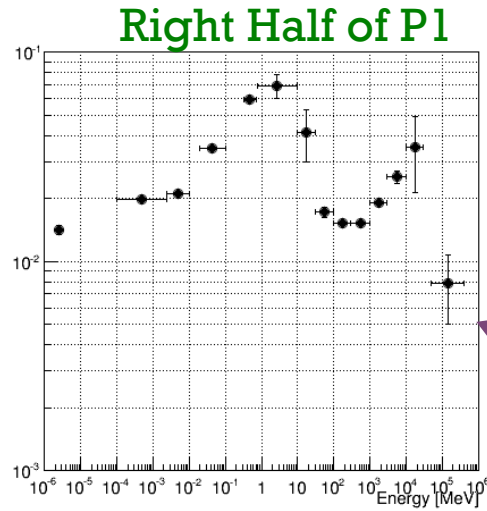
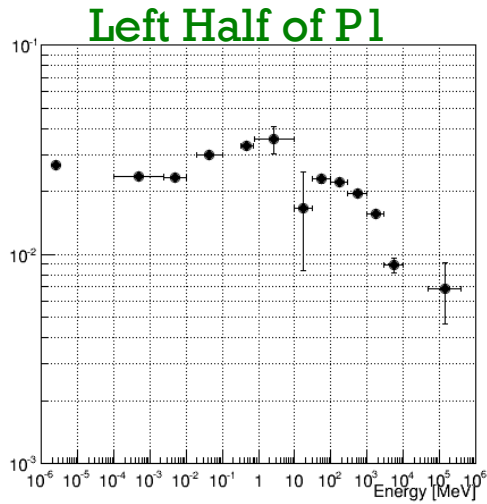




Parametrization – Lorentzian Fitting



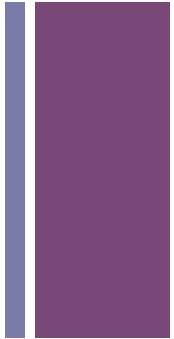
+ Half Width vs Energy



Sudden drop
In inner edges!!
(yet, bridge exist!?)

Gradual drop
In outer edges

+ P2/P1 ratio

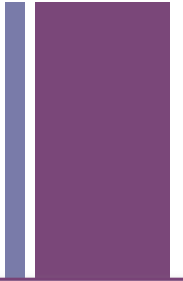


MAGIC

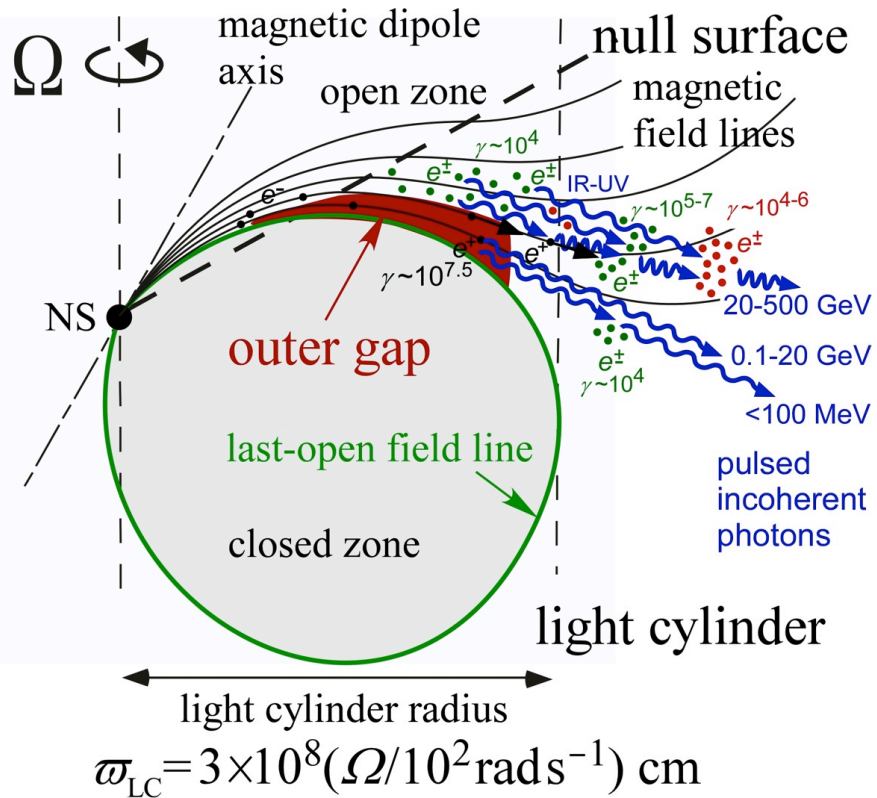


フラックスは、謎の関係式をみたしている

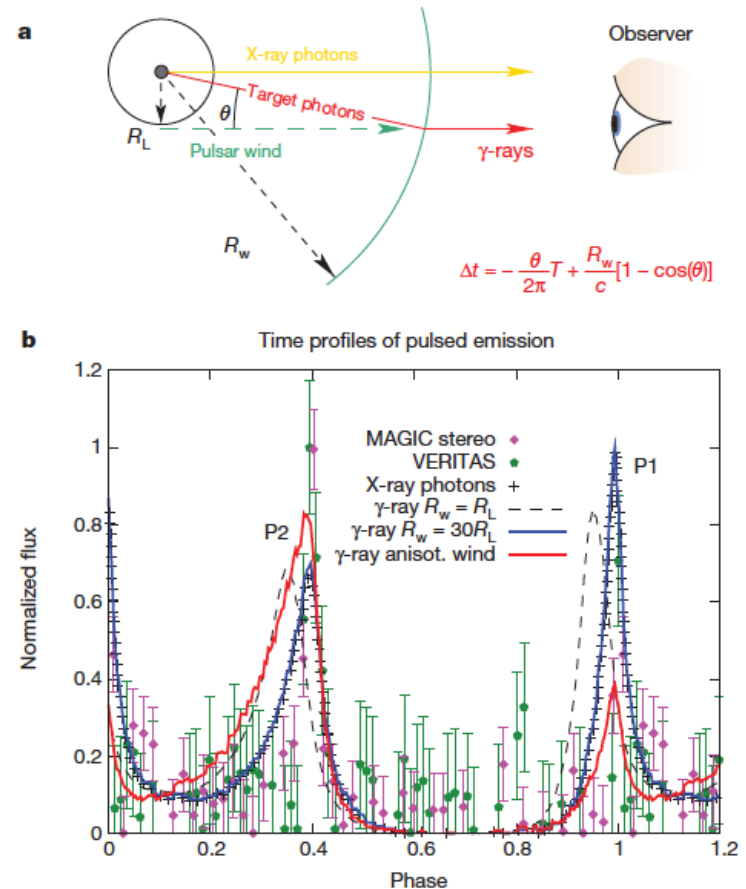
+ Spectra



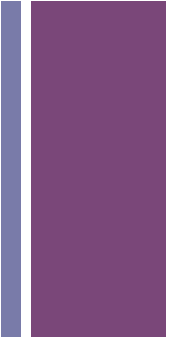
+ なにがわかったのか？



Magnetospheric Cascade model (K. Hirotani)によれば、Light Cylinder 付近の磁場のToroidal成分が強いことを示している



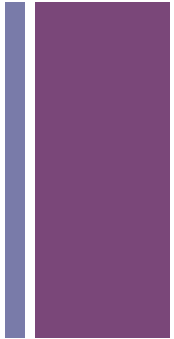
Wind scattering model (Aharonian et al., Nature 482, 2012)によれば、X線とおなじか、より“太い”波形にはず。どう説明するのか？？



Crab 以外のパーサーは見えないのか？



Fermi-LAT 2nd pulsar catalogue

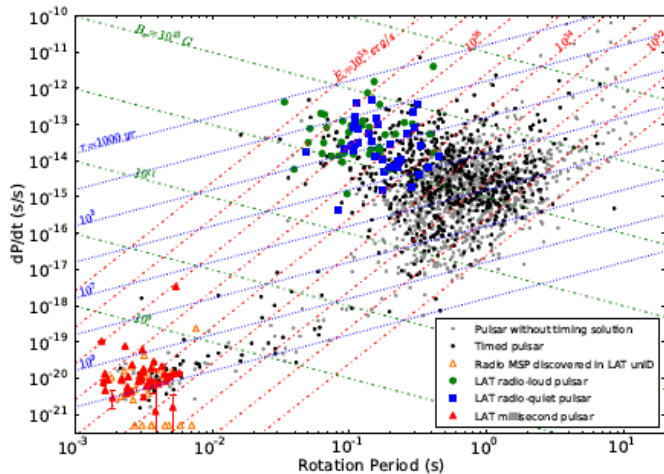


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+0200

The Second *Fermi* Large Area Telescope Catalog of Gamma-ray Pulsars

A. A. Abdo¹, M. Ajello², A. Allafort³, L. Baldini⁴, J. Ballet⁵, G. Barbiellini^{6,7},
M. G. Baring⁸, D. Bastieri^{9,10}, A. Belfiore^{11,12,13}, R. Bellazzini¹⁴, B. Bhattacharyya¹⁵,
E. Bissaldi¹⁶, E. D. Bloom³, E. Bonamente^{17,18}, E. Bottacini³, T. J. Brandt¹⁹, J. Bregeon¹⁴,
M. Brigida^{20,21}, P. Bruel²², R. Buehler²³, M. Burgay²⁴, T. H. Burnett²⁵, G. Busetto^{9,10},
S. Buson^{9,10}, G. A. Caliandro²⁶, R. A. Cameron³, F. Camilo^{27,28}, P. A. Caraveo¹³,
J. M. Casandjian⁵, C. Cecchi^{17,18}, Ö. Çelik^{19,29,30,31}, E. Charles³, S. Chaty⁵,
R.C.G. Chaves⁵, A. Chekhtman¹, A. W. Chen¹³, J. Chiang³, G. Chiaro¹⁰, S. Ciprini^{32,33},
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S. Cutini^{32,33}, F. D'Ammando⁴¹, A. de Angelis⁴², M. E. DeCesar^{19,43}, A. De Luca⁴⁴,
P. R. den Hartog^{3,45}, F. de Palma^{20,21}, C. D. Dermer⁴⁶, G. Desvignes^{47,34}, S. W. Digel³,
L. Di Venere³, P. S. Drell³, A. Drlica-Wagner³, R. Dubois³, D. Dumora⁴⁸,
C. M. Espinoza⁴⁹, L. Falletti³⁵, C. Favuzzi^{20,21}, E. C. Ferrara¹⁹, W. B. Focke³,
A. Frankowski³, P. C. Freire⁴⁷, S. Funk³, P. Frey^{20,21}, F. Gaetano²¹, D. Casanrini^{32,33}

[astro-ph.HE] 23 May 2013



	Spectrum reliable	Spectrum unreliable	All
Canonical	67	10	77
Milisecond	34	6	40
All	101	16	117



Fermi-LAT 2nd pulsar catalogue

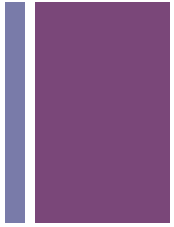
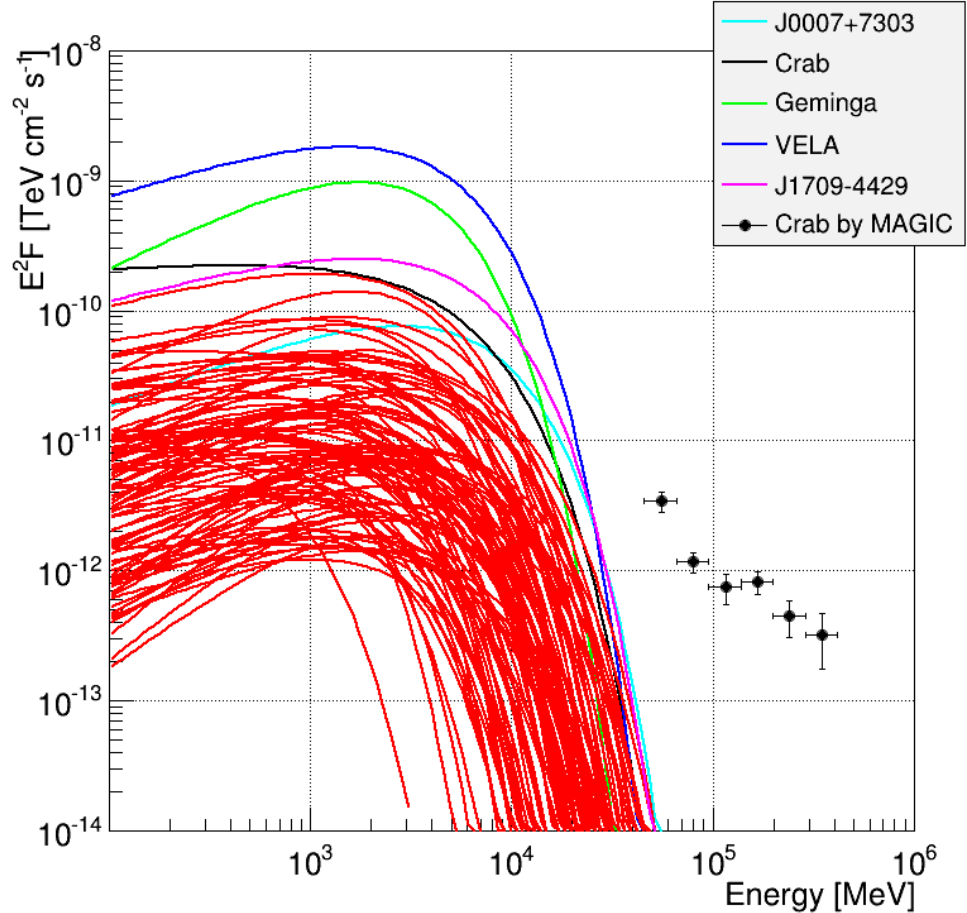


Table 9. Spectral fitting results for young LAT-detected pulsars

PSR*	Photon Flux ($\text{ph cm}^{-2} \text{s}^{-1}$) ($\times 10^{-8}$)	Energy Flux ($\text{erg cm}^{-2} \text{s}^{-1}$) ($\times 10^{-11}$)	Γ	E_{cut} (GeV)	TS	TS_{cut}	$TS_{\text{b, free}}$	Luminosity ($10^{33} \text{ erg s}^{-1}$)	Efficiency ^b (%)
J0007+7303	323 ± 0.4	40.1 ± 0.4	1.4 ± 0.1	4.7 ± 0.2	43388	1884	4	94 ± 1 ± 40	21.0 ± 0.2 ± 8
J0106+4855	1.7 ± 0.4	1.9 ± 0.2	1.2 ± 0.2	2.7 ± 0.6	544	58	2	21 ± 2 ⁺²⁰ ₋₈	71 ± 7 ⁺⁶⁰ ₋₃₀
J0205+6449	10.5 ± 0.7	5.4 ± 0.2	1.8 ± 0.1	1.6 ± 0.3	1019	86	7	24 ± 1 ± 1.0	0.09 ± 0.01 ± 0.01
J0248+6021	9.9 ± 1.3	5.2 ± 0.4	1.8 ± 0.1	1.6 ± 0.3	578	61	0	25 ± 2 ± 5	12 ± 1 ± 2
J0357+3205	9.0 ± 0.4	6.4 ± 0.2	1.0 ± 0.1	0.8 ± 0.1	3468	461	2	...	...
J0534+2200	208 ± 1	129.3 ± 0.8	1.9 ± 0.1	4.2 ± 0.2	102653	1461	13	619 ± 4 ± 300	0.14 ± 0.01 ± 0.1
J0622+3749	2.0 ± 0.3	1.4 ± 0.1	0.6 ± 0.4	0.6 ± 0.1	302	91	0	...	...
J0631+1036	6.4 ± 0.6	4.7 ± 0.3	1.8 ± 0.1	6 ± 1	621	39	1	5.6 ± 0.3 ⁺³ ₋₂	3.2 ± 0.2 ⁺² ₋₁
J0633+0632	9.7 ± 1.1	9.4 ± 0.5	1.4 ± 0.1	2.7 ± 0.3	2448	203	9	...	...
J0633+1746	416 ± 1	423.3 ± 1.2	1.2 ± 0.1	2.2 ± 0.1	906994	33861	277	31.7 ± 0.1 ⁺²⁰ ₋₂₀	97.4 ± 0.3 ⁺³⁰⁰ ₋₅₀
J0659+1414	7.1 ± 0.6	2.5 ± 0.2	1.7 ± 0.5	0.4 ± 0.2	419	33	0	0.24 ± 0.02 ± 0.05	0.62 ± 0.04 ± 0.1
J0729-1448 †	...	...	...	...	54	26	0	...	...
J0734-1559	10.8 ± 0.7	5.6 ± 0.2	2.0 ± 0.1	3.2 ± 0.9	916	39	9	...	...
J0742-2822	3.2 ± 0.6	1.7 ± 0.2	1.7 ± 0.3	1.6 ± 0.8	112	11	2	9 ± 1 ± 4	6.2 ± 0.7 ± 3
J0835-4510	1088 ± 2	906 ± 2	1.5 ± 0.1	3.0 ± 0.1	1659005	43084	916	89.3 ± 0.2 ± 10	1.3 ± 0.1 ± 0.1
J0908-4913	7.9 ± 1.3	4.4 ± 0.4	1.0 ± 0.4	0.5 ± 0.2	315	82	0	35 ± 3 ⁺³⁰ ₋₂₀	7.1 ± 0.7 ⁺² ₋₂
J0940-5428 †	...	...	...	...	14	13	8	...	...
J1016-5857	6.9 ± 2.4	5.4 ± 0.9	1.8 ± 0.2	6 ± 3	290	13	0	55 ± 9 ⁺³⁰ ₋₅₀	2.1 ± 0.4 ⁺¹ ₋₂
J1019-5749 †	...	...	...	...	21	0	0	...	...
J1023-5746	30 ± 3	19.5 ± 1.2	1.7 ± 0.1	2.5 ± 0.4	2926	162	20	...	...
J1028-5819	31 ± 2	24.3 ± 0.8	1.7 ± 0.1	4.6 ± 0.5	5096	235	28	158 ± 5 ± 40	18.9 ± 0.6 ± 5
J1044-5737	26 ± 1	15.6 ± 0.5	1.8 ± 0.1	2.8 ± 0.3	3380	202	19	...	...
J1048-5832	25 ± 2	19.6 ± 0.6	1.6 ± 0.1	3.0 ± 0.3	5389	325	30	176 ± 5 ± 40	8.8 ± 0.3 ± 2
J1057-5226	32 ± 1	29.5 ± 0.3	1.0 ± 0.1	1.4 ± 0.1	27848	2377	5	4.3 ± 0.1 ⁺⁵ ₋₃	14.4 ± 0.2 ⁺¹⁰ ₋₁₀
J1105-6107	7.8 ± 1.6	4.9 ± 0.6	1.5 ± 0.3	1.3 ± 0.6	309	42	8	150 ± 20 ± 50	5.9 ± 0.7 ± 2
J1112-6103	1.9 ± 0.9	2.0 ± 0.5	1.6 ± 0.3	6 ± 3	58	6	0	360 ± 90 ⁺⁵⁰⁰ ₋₃₀₀	8 ± 2 ⁺¹⁰ ₋₄
J1119-6127	11 ± 2	7.1 ± 0.5	1.8 ± 0.1	3.2 ± 0.8	661	37	13	600 ± 40 ± 50	26 ± 2 ± 2
J1124-5916	10 ± 1	6.2 ± 0.4	1.8 ± 0.1	2.1 ± 0.4	1058	79	6	170 ± 10 ⁺⁵⁰ ₋₇₀	1.4 ± 0.1 ^{+0.4} _{-0.6}
J1135-6055	7.4 ± 0.9	4.8 ± 0.3	1.7 ± 0.1	2.4 ± 0.5	498	61	3	...	...
J1357-6429	7.8 ± 1.1	3.4 ± 0.3	1.8 ± 0.4	0.9 ± 0.5	187	20	0	25 ± 2 ⁺¹⁰ ₋₈	0.82 ± 0.05 ^{+0.4} _{-0.3}
J1410-6132 †	3 ± 3	3 ± 1	...	...	40	9	0	800 ± 300 ⁺⁹⁰⁰ ₋₄₀₀	8 ± 3 ⁺⁹ ₋₄
J1413-6205	16 ± 2	15.7 ± 0.6	1.5 ± 0.1	4.1 ± 0.5	1795	180	1	...	...
J1418-6058	38 ± 3	30.2 ± 1.4	1.8 ± 0.1	5.5 ± 0.5	3487	172	1	92 ± 4 ⁺¹⁰⁰ ₋₈₀	1.9 ± 0.1 ⁺² ₋₁



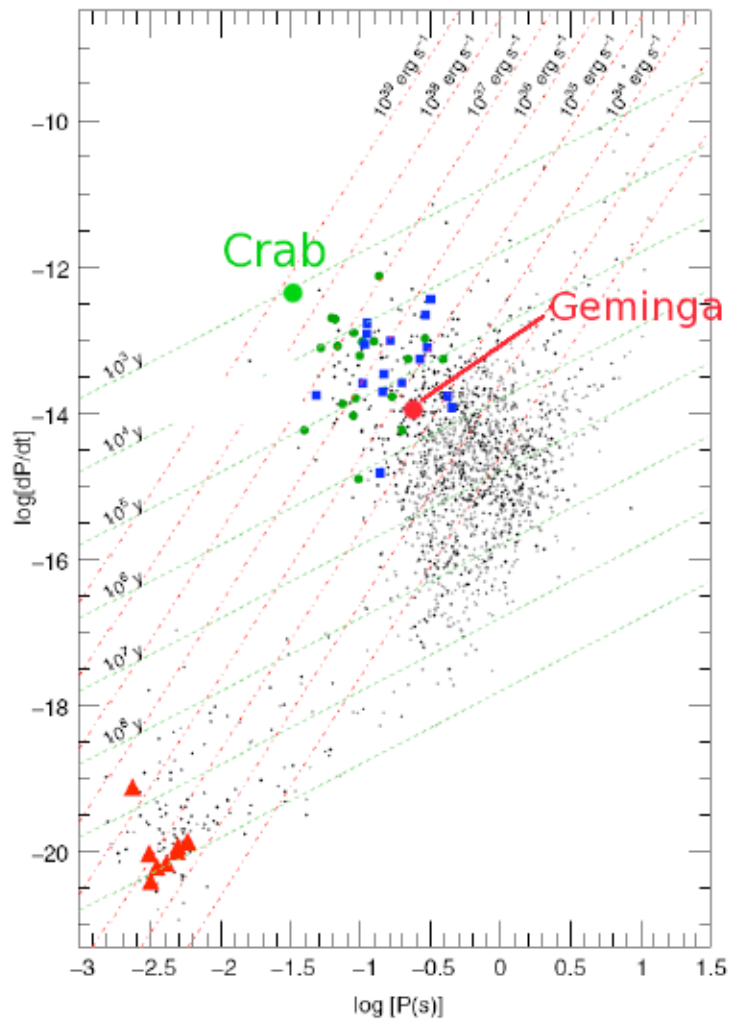
Crab: J0534+2200

Geminga: J0633+1746

Vela: J08835-4510

MAGIC で天頂角<30度で観測可能な赤緯: -2° ~ 58°
10 GeVでCrabより明るいパルサーはGemingaだけ

Geminga vs Crab

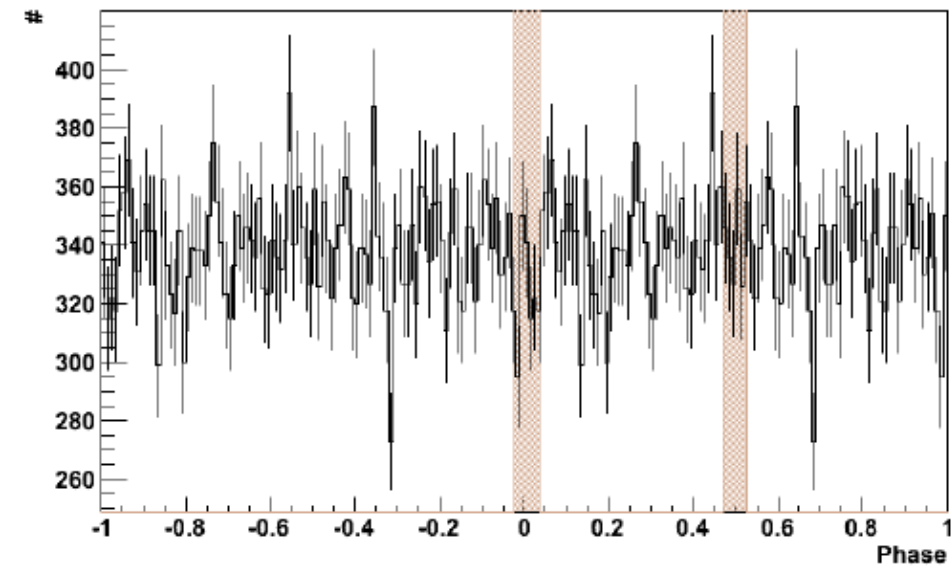


	Crab	Geminga
Period	34 ms	237 ms
$P_{\dot{}}$	4.2×10^{-13}	1.1×10^{-14}
R_{LC}	1600 km	11300 km
Age	1000 yr	3×10^5 yr
B_0	4×10^{12} G	1.6×10^{12} G
B_{LC}	950 kG	1.1 kG
$L_{SpinDown}$	5×10^{38} erg/s	3×10^{34} erg/s
Distance	2000 pc	250 pc

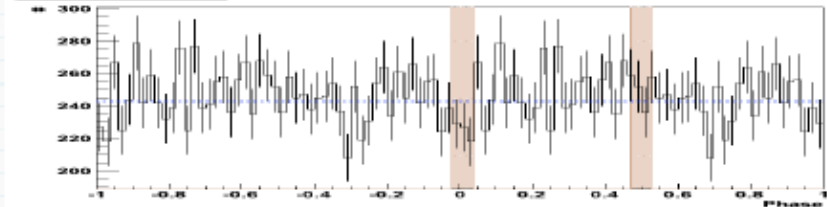
光円柱での磁場は3桁低く、Spin Down Luminosity は4桁低い。
一方で距離は1桁小さい

MAGIC 觀測結果

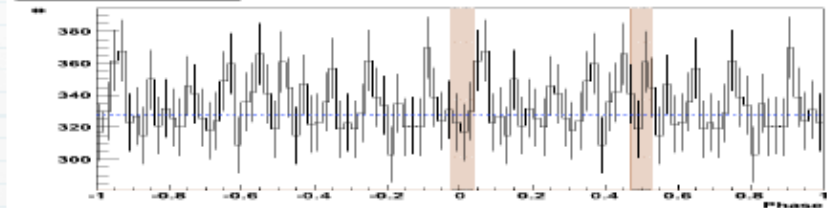
50 - 400 [GeV]



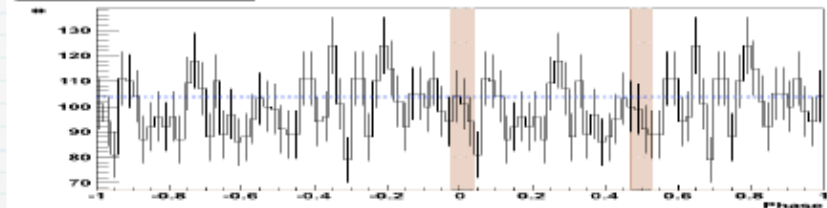
39.8 - 63.1 [GeV]



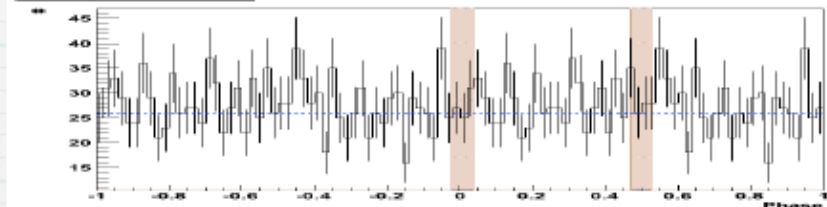
63.1 - 100.0 [GeV]



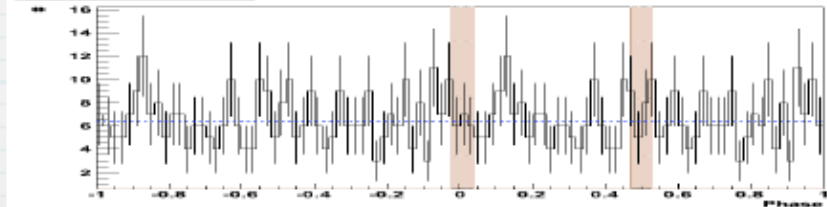
100.0 - 158.5 [GeV]



158.5 - 251.2 [GeV]



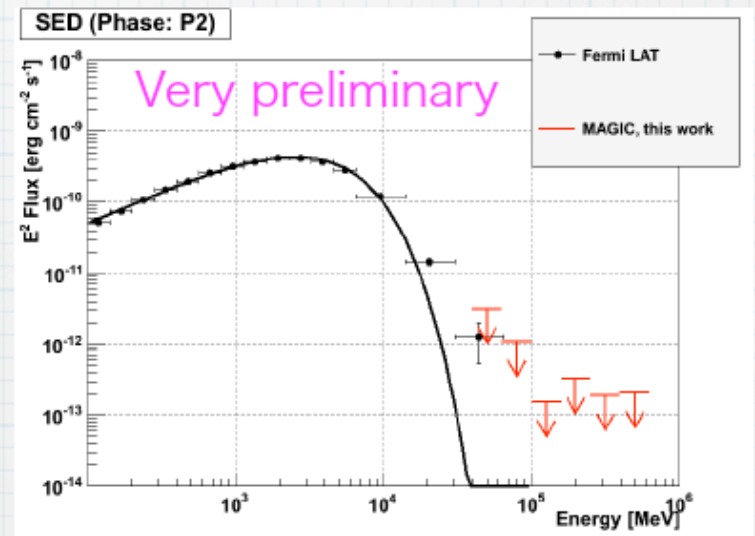
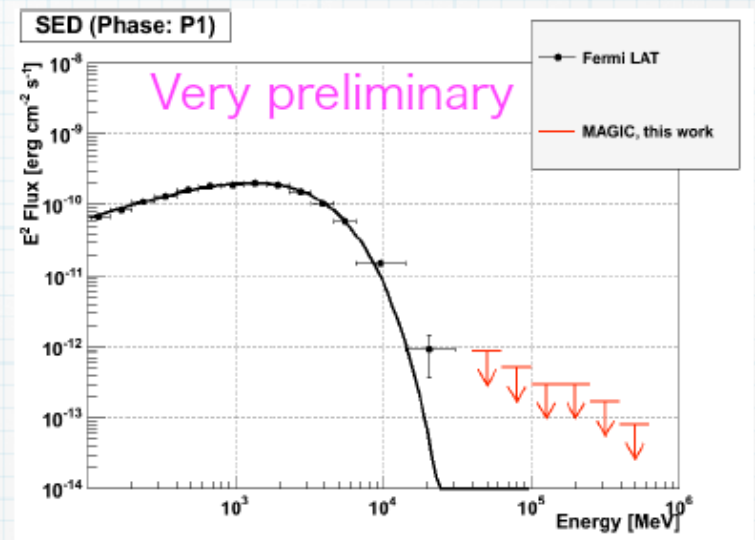
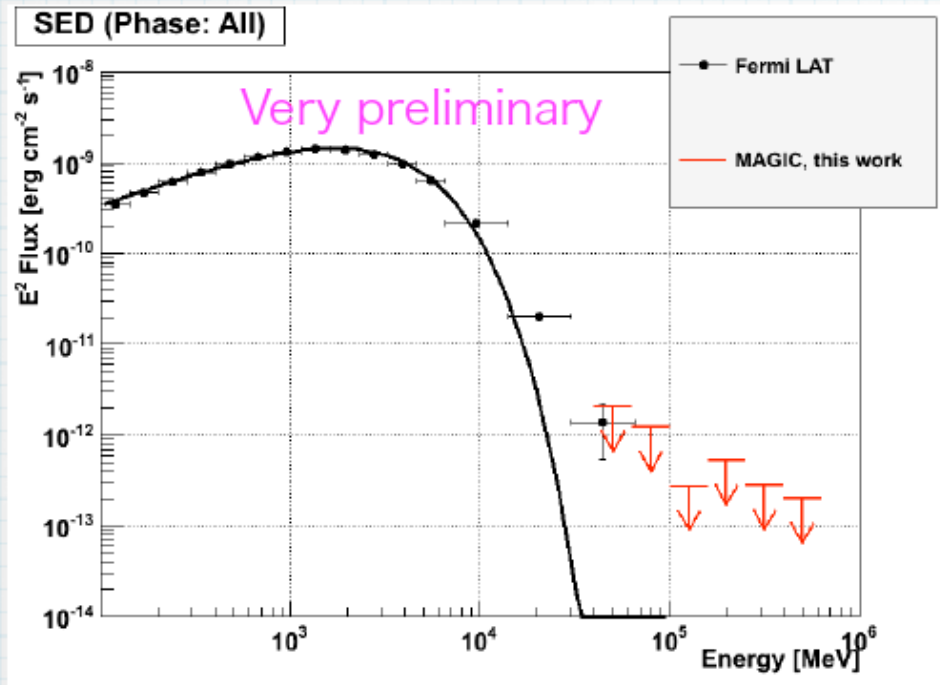
251.2 - 398.1 [GeV]



Energy [GeV]	P1	P2
50 - 400	-75.4 +- 49.2	22.8 +- 48.2
39.8 - 63.1	-60.2 +- 29.0	16.4 +- 29.1
63.1 - 100	-15.0 +- 34.7	33.6 +- 34.0
100 - 159	-8.8 +- 19.4	-33.1 +- 17.9
159 - 251	5.7 +- 10.1	7.9 +- 9.8
251 - 398	0.8 +- 5.0	2.1 +- 4.9


<超過事象数>

フラックス上限値



現状のデータ、解析からは、スペクトラムの形について議論できない

+ 結論

- Crabの精密測定 
- その物理的結論は、非常に難しい
- Fermi Catalogのスペクトラムパラメータから判断すると GemingaがCrabの次に有力なパルサー。それでもMAGICで検出できない
- パラメータでなく、10GeV以上の検出光子数で調べる必要がある。
- (MAGICではCrab以外見えないかもしれない)
- (LSTに期待)