クエーサーペア位相補償観測によるVERAの精度検証

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Pradel N、Hideyuki Kobayashi, VERA group

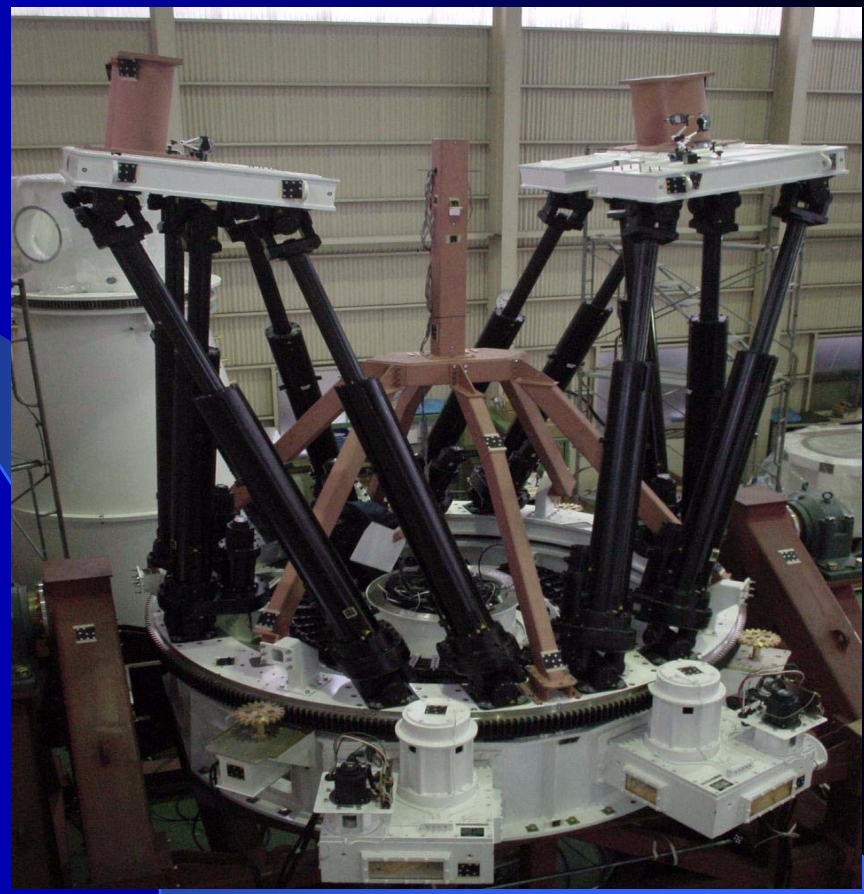
Why the verification?

1, Dual beam system

2, New VERA terminal

(Recorder, Correlator)

1 Gbit recorder(VERA terminal)



Dual beam system

QSOペア selection

- Flux density >1Jy@22GHz
- VCSによりペアを組む天体を探す
- 9 組のQSOペアを観測
- 以下の4組は3回以上の観測
  - OU+401ペア（3回）
  - OJ038ペア（3回）
  - 3C446ペア（5回）
  - 3C345ペア（20回）

中川さんポスター

Pradelさん

•異なる2ビーム離角（0.3-2.2度）や赤緯など、様々な条件下でペアを観測

Pair	天体名	RA	Dec	離角[°]	Flux[Jy]	ν[GHz]	SNR	検出
1	J0831+0429	08h31m48.876953s	+04d29'39.08534"	2.00	1.83	22	~20	△
	OJ038	08h25m50.338356s	+03d09'24.52014"		1.44	22	30-40	○
2	J1808+4542	18h08m21.885902s	+45d42'20.86621"	2.03	0.46	8	0	×
	OU+401	18h01m32.314854s	+44d04'21.90031"		1.23	24	~40	○
3	J0830+2410	08h30m52.086193s	+24d10'59.82046"	1.39	1.08	24	~40	○
	OJ259	08h37m40.245673s	+24d54'23.12149"		0.67	8	0	×
4	3C446	22h25m47.259293s	-04d57'01.39073"	2.20	4.80	22	60-70	○
	J2218-0335	22h18m52.037724s	-03d35'36.87941"		2.80	31	~50	○
5	0202+149	02h04m50.413902s	+15d14'11.04346"	1.79	2.04	22	~20	△
	J0209+1352	02h09m35.998322s	+13d52'00.75182"		0.47	8	0	×
6	1510-089	15h12m50.532940s	-09d05'59.82950"	1.12	1.28	22	60-70	○
	J1513-1012	15h13m44.893444s	-10d12'00.26435"		0.90	8	~40	○
7	1633+382	16h35m15.492973s	+38d08'04.50060"	1.93	1.31	22	70-80	○
	J1640+3946	16h40m29.632771s	+39d46'46.02854"		1.20	8	~30	△
8	2145+067	21h48m05.458679s	+06d57'38.60422"	0.87	1.60	22	~100	○
	J2151+0709	21h51m31.429317s	+07d09'26.78376"		0.25	8	0	×
9	0923+392	09h27m03.013916s	+39d02'20.85195"	1.99	1.88	24	~80	○
	J0916+3854	09h16m48.904556s	+38d54'28.14650"		0.62	8	0	×
10	OU+401	18h01m32.314854s	+44d04'21.90031"	1.47	1.23	24	~40	○
	J1753+4409	17h53m22.647902s	+44d09'45.68608"		0.90	8	~20	△
11	4C31.56	20h23m19.017351s	+31d53'02.30595"	1.87	0.30	24	~20	△
	TXS2023+335	20h25m10.842097s	+33d43'00.21454"		1.50	24	~45	○

3C446 & J2218-0035(2.195度離角)

- 3C446

  z = 1.4 (Wright et al 1983)

  type = OVV, BLLAC

  flux = 3-4 Jy

- J2218-0035

  z = 0.9 (Wright et al 1983)

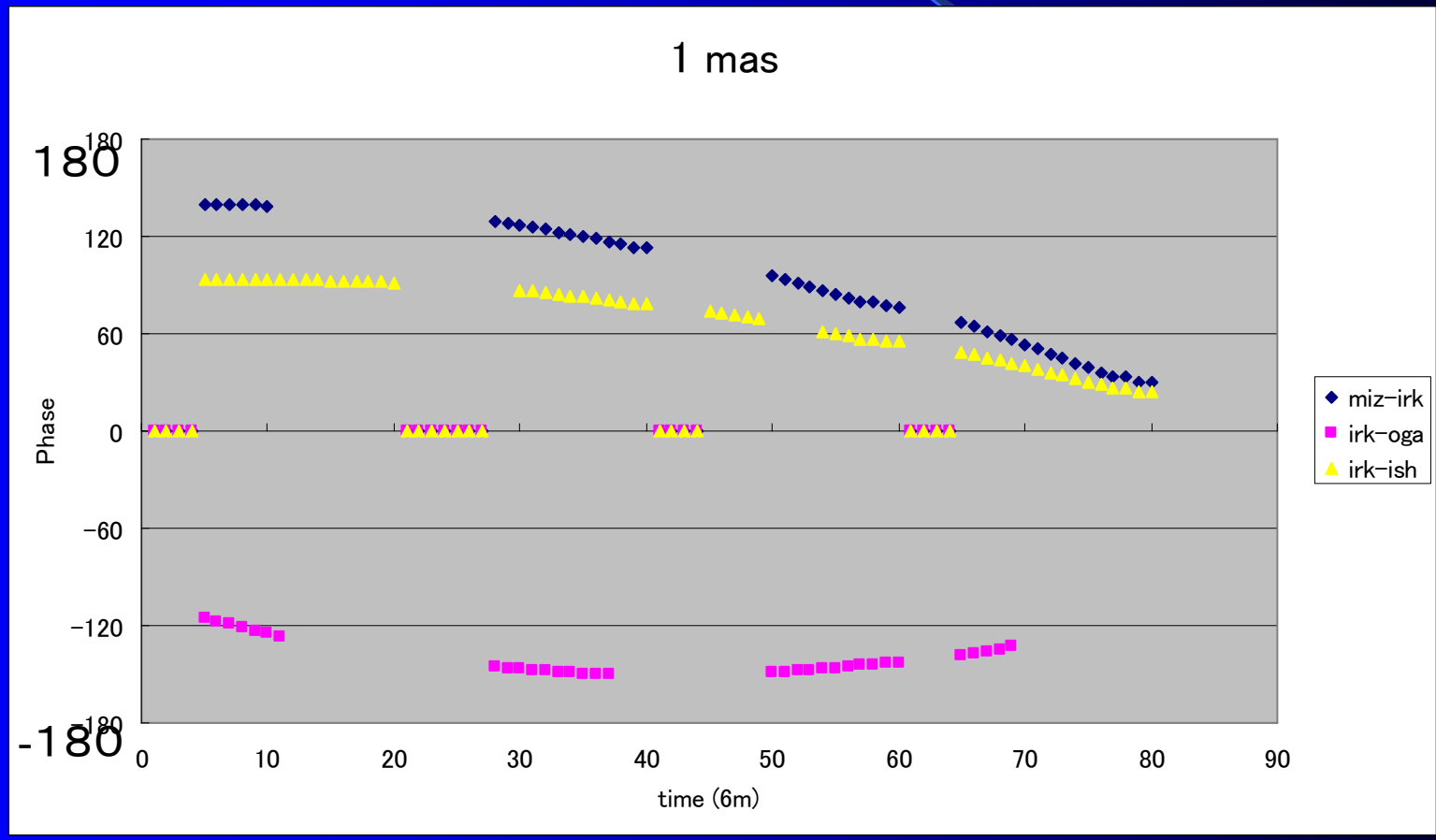
  type = QSO

  flux = 2 Jy

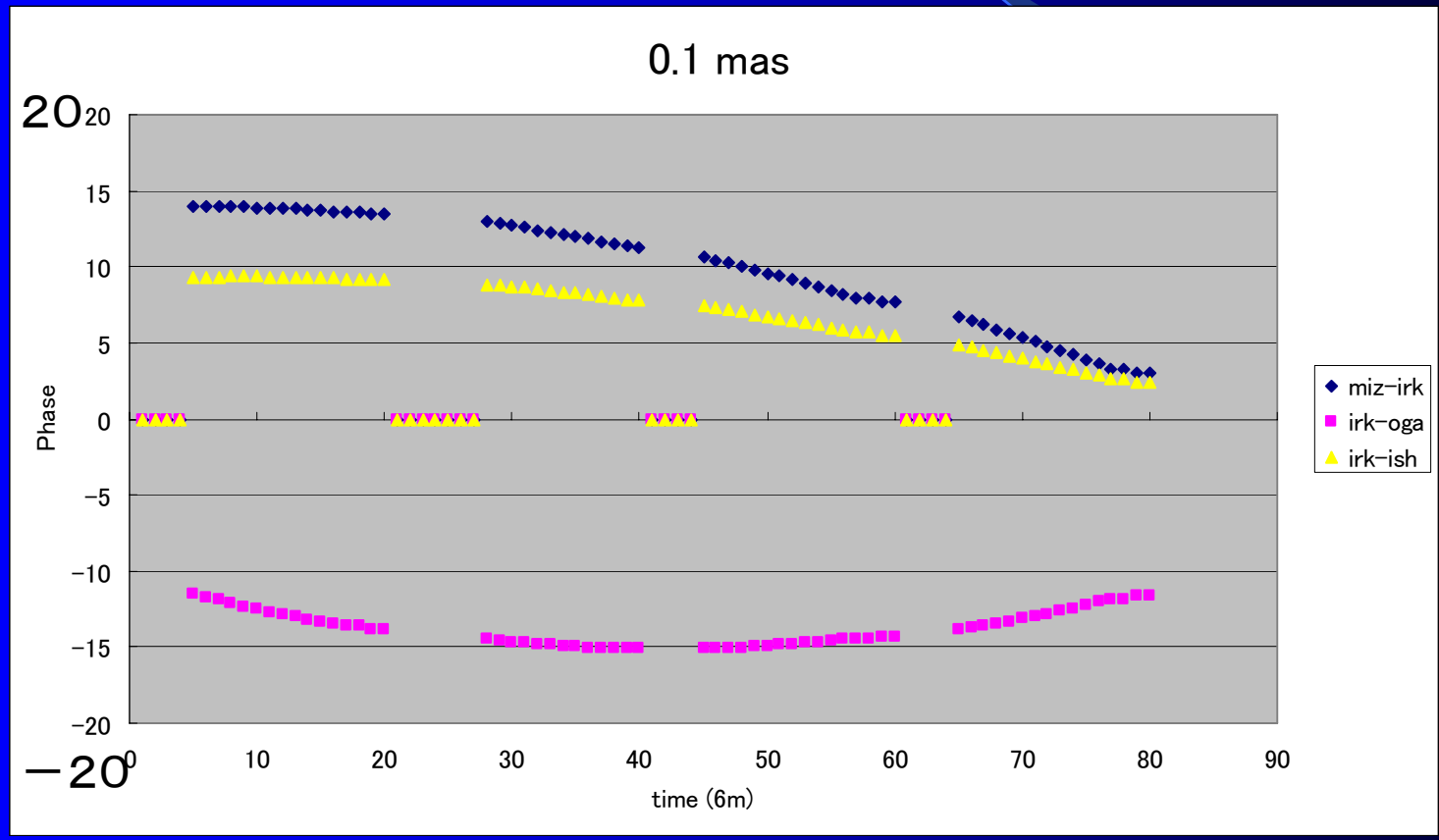
Observations

- Date 2004/11/24、2005/2/24、2005/4/13、2005/5/24, 2005/11 5 epoch
- Band K band
- DIR2000(1Gbps, 16MHz*16) (all epoch) – VERA terminal
- DIR1000(128Mbps, 16MHz*2) (2005/5/24) – VSOP terminal

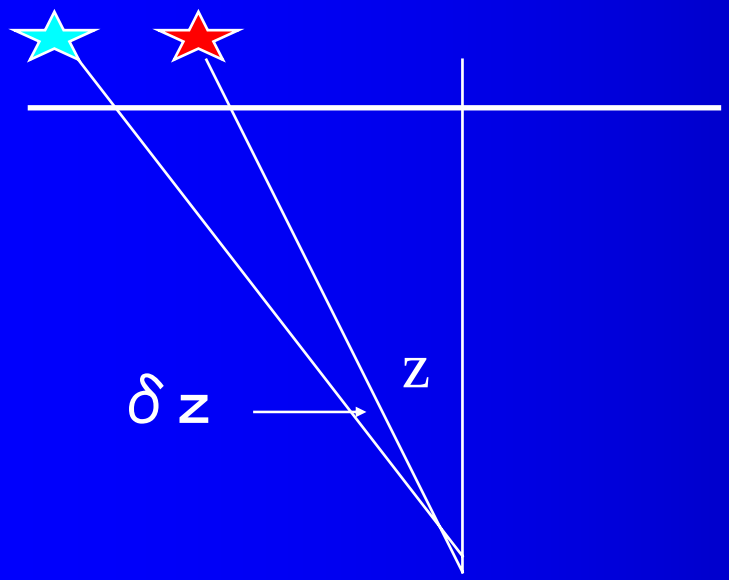
Example(source position offset)



Example


0.1 mas
20
15
10
5
0
−5
−10
−15
−20
Phase
0
10
20
30
40
50
60
70
80
90
time (6m)
miz−irk
irk−oga
irk−ish

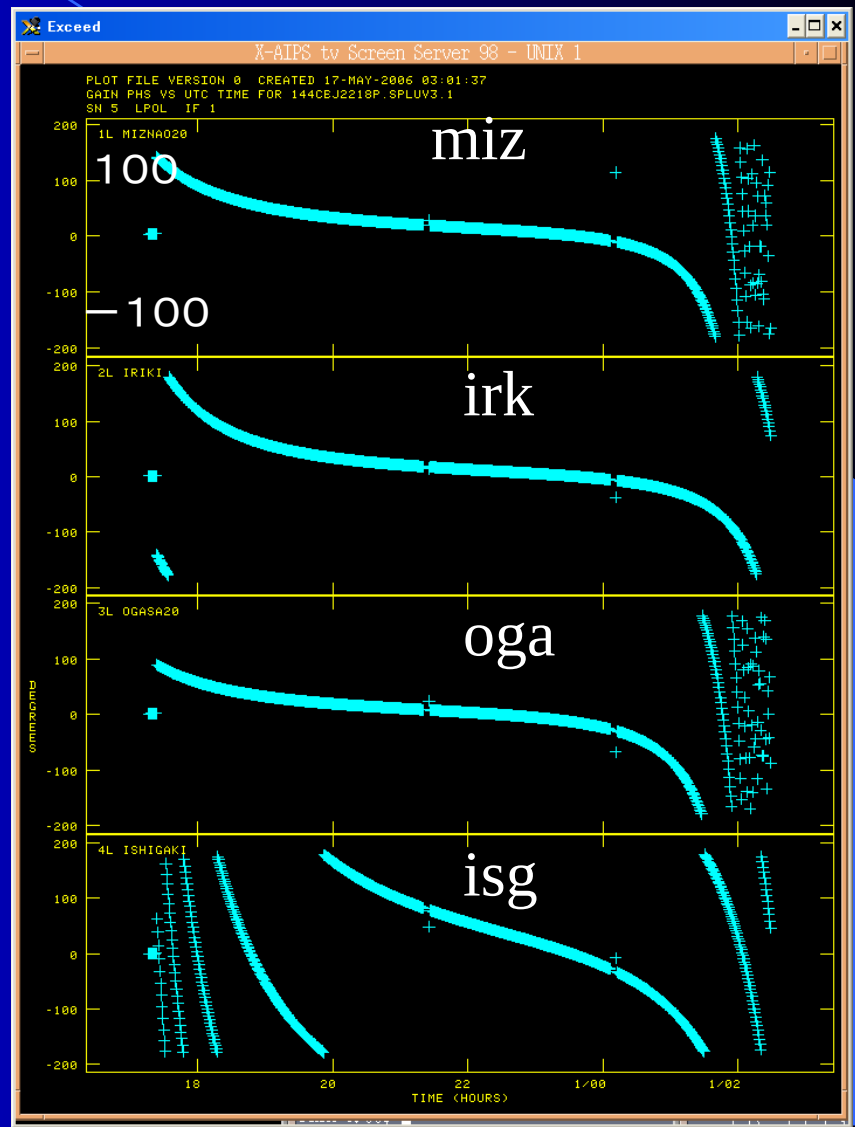
Example (Zenith delay)



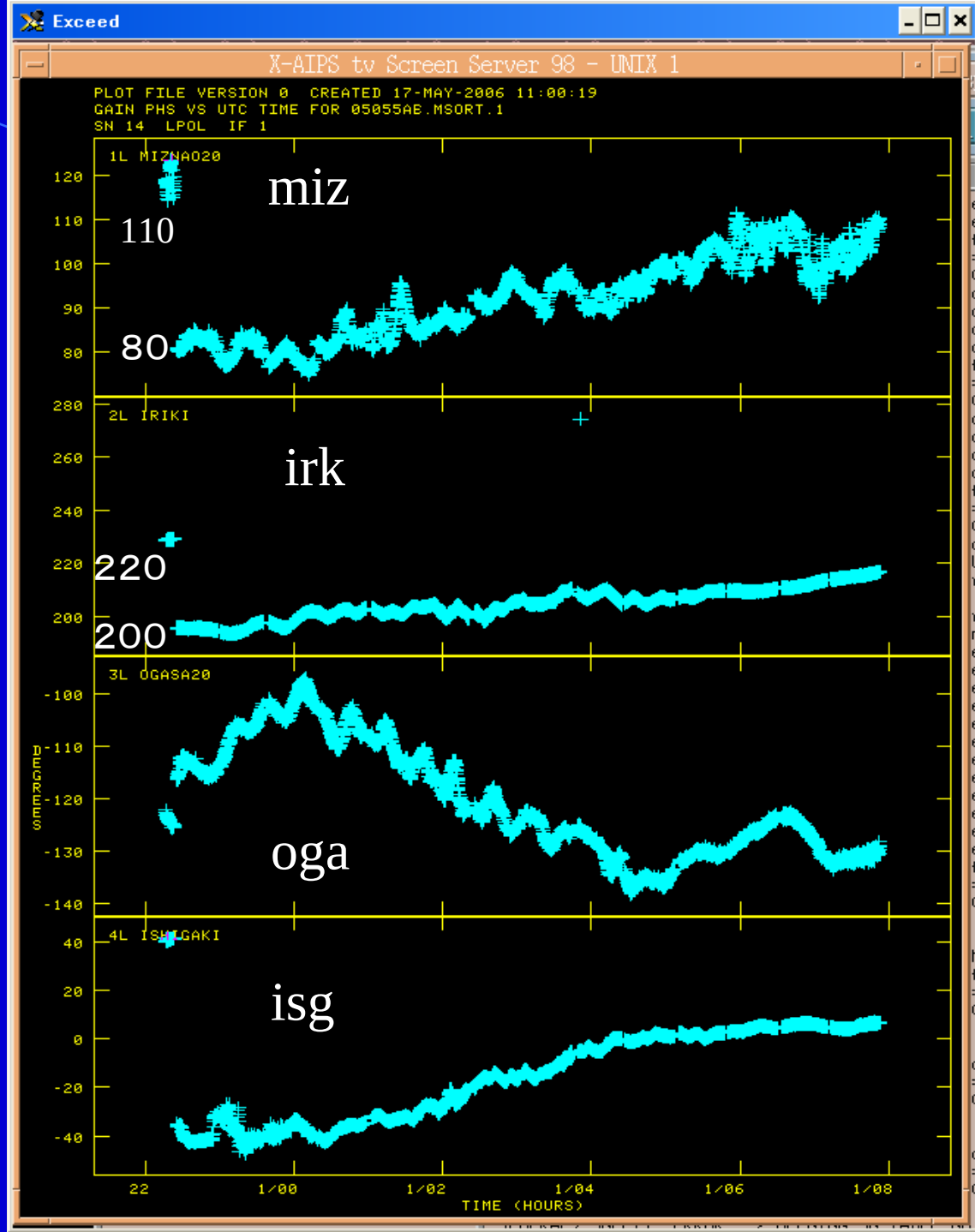
$$\phi_{\sec z} = \delta\phi_0 \sec z' \delta_z = \delta\phi_0 \sec z \tan z \delta_z$$

0.1nsec=3cm(miz,irk,oga) ⟶

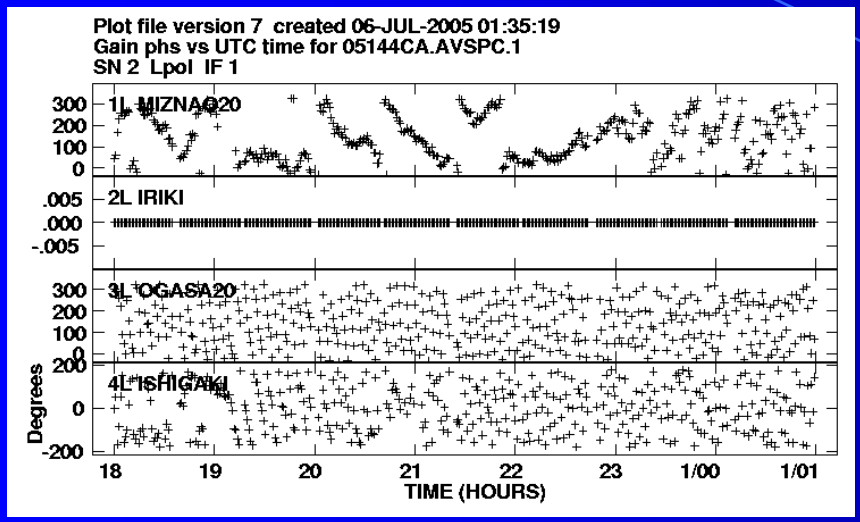
0.5nsec (isg)



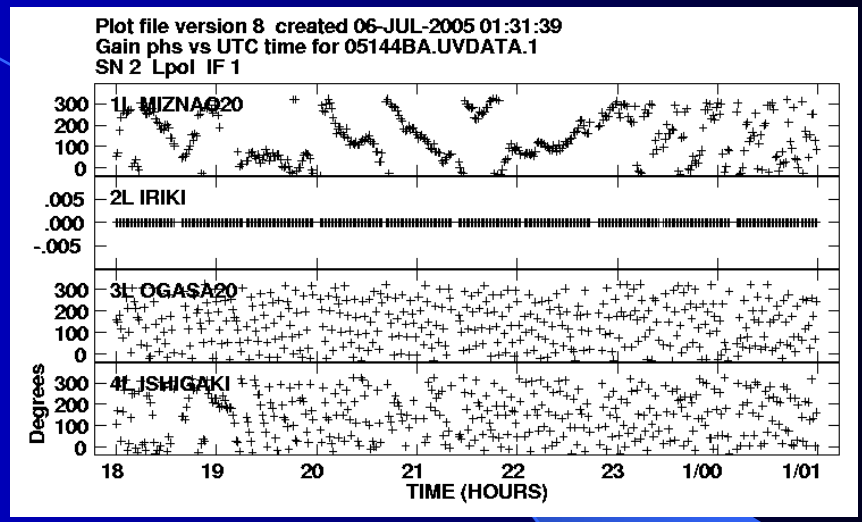
Example (2B cal phas



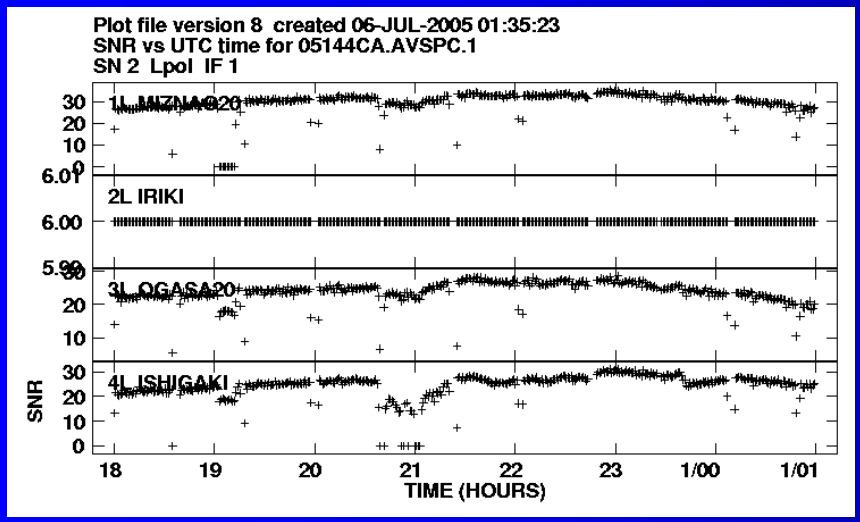
VSOP terminal VS VERA terminal



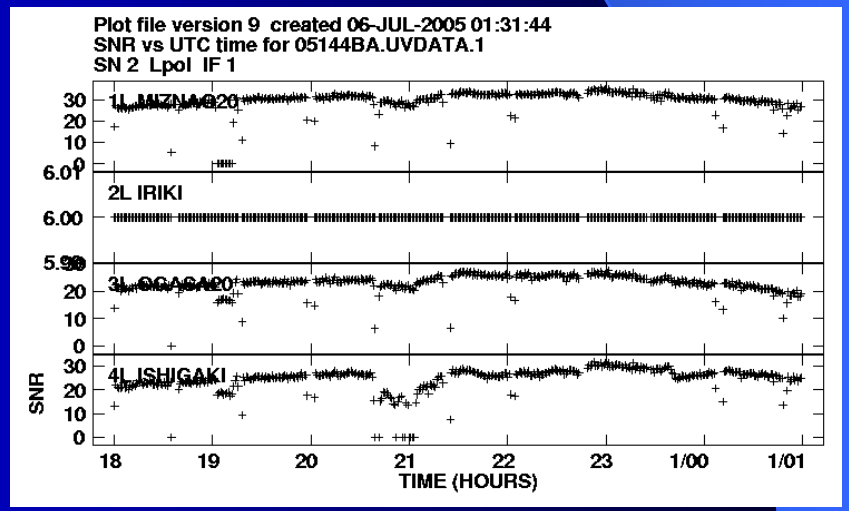
DIR1000 A-beam(Phase)



DIR2000 A-beam(Phase)

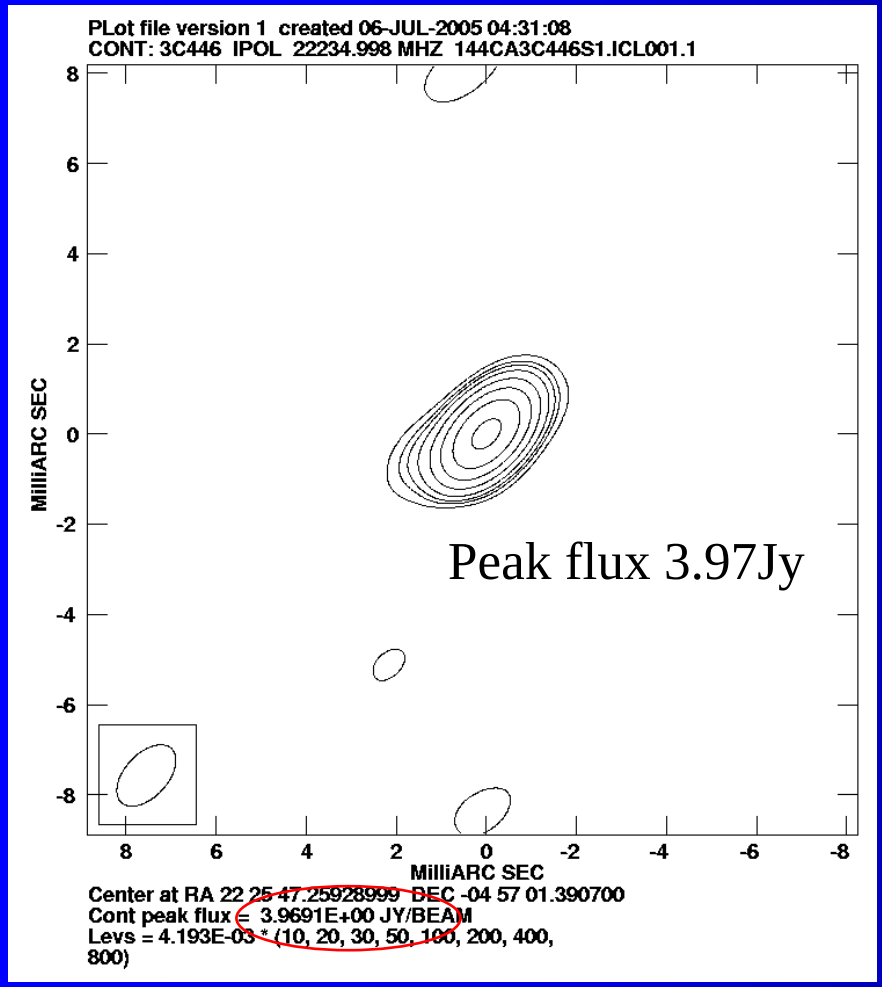


DIR1000 A-beam(SNR)

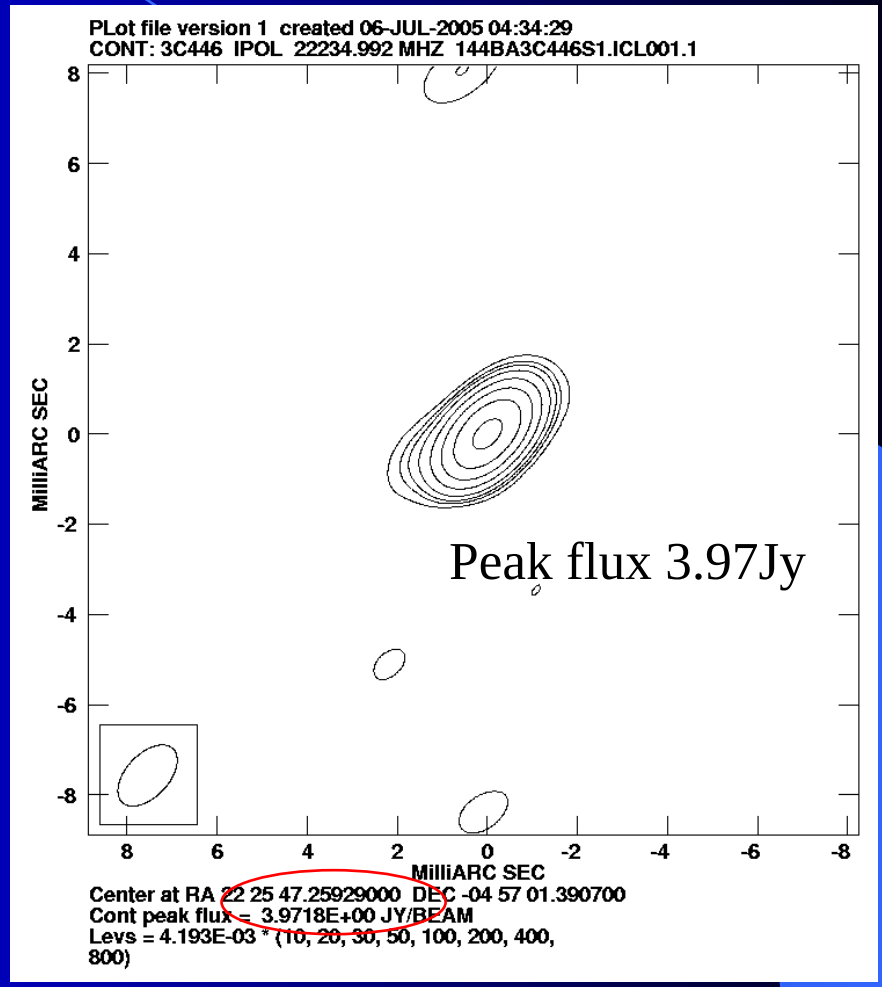


DIR2000 A-beam(SNR)

A comparison of images

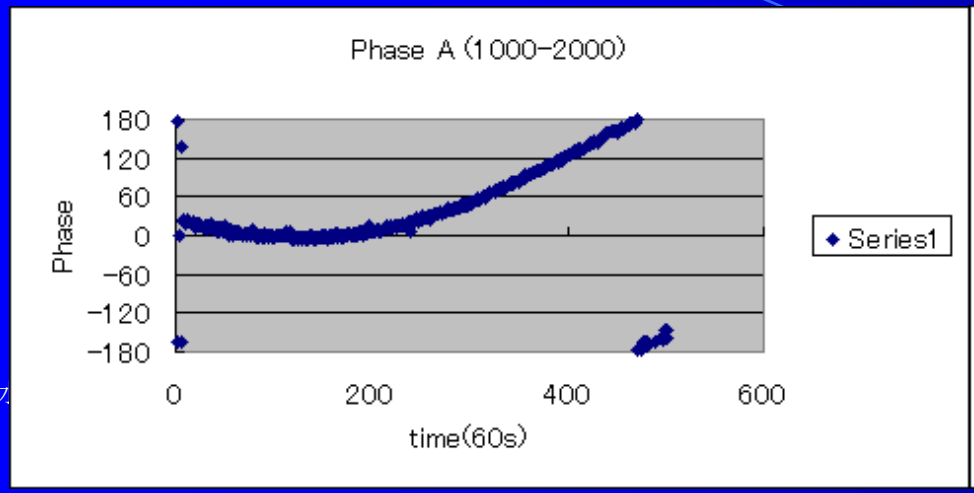


DIR1000(128Mbps) 3C446

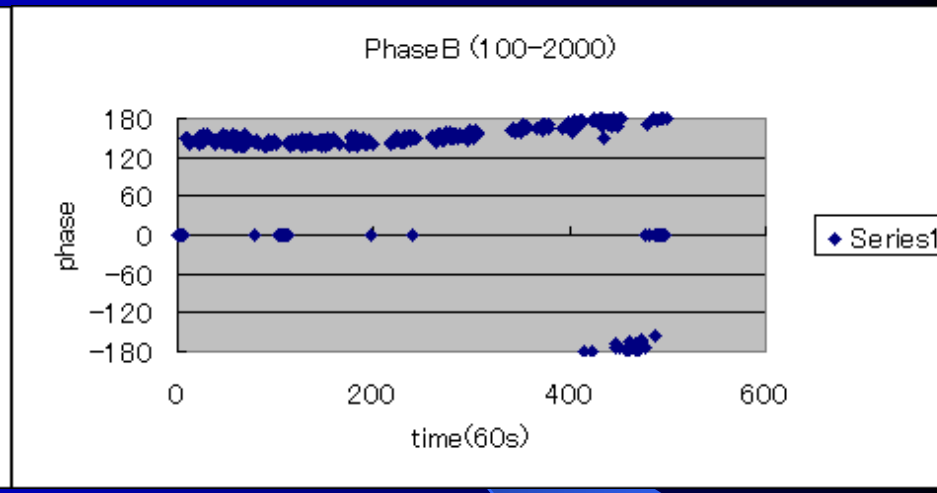


DIR2000(1Gbps) 3C446

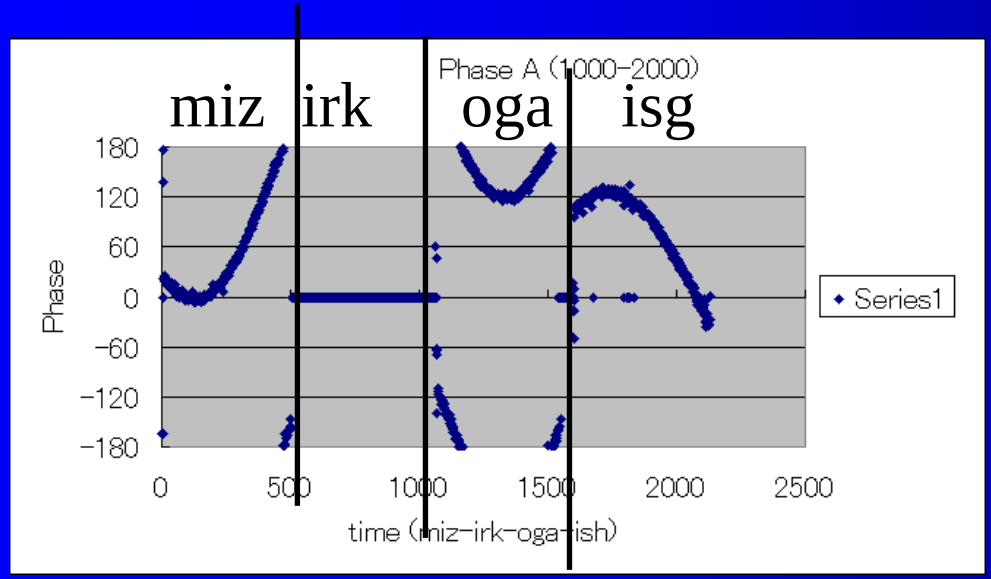
VSOP terminal VS VERA terminal



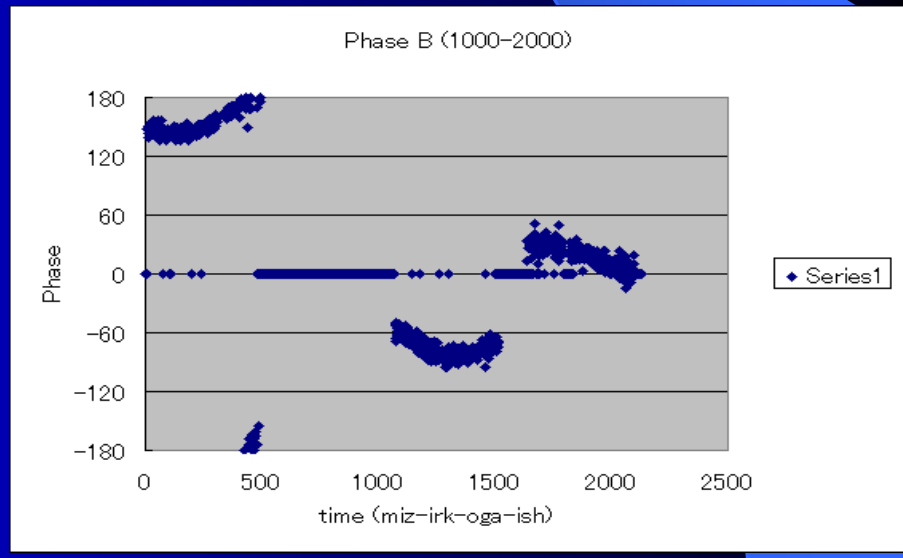
Phase A (1000-2000) at MIZ



Phase B (1000-2000) at MIZ

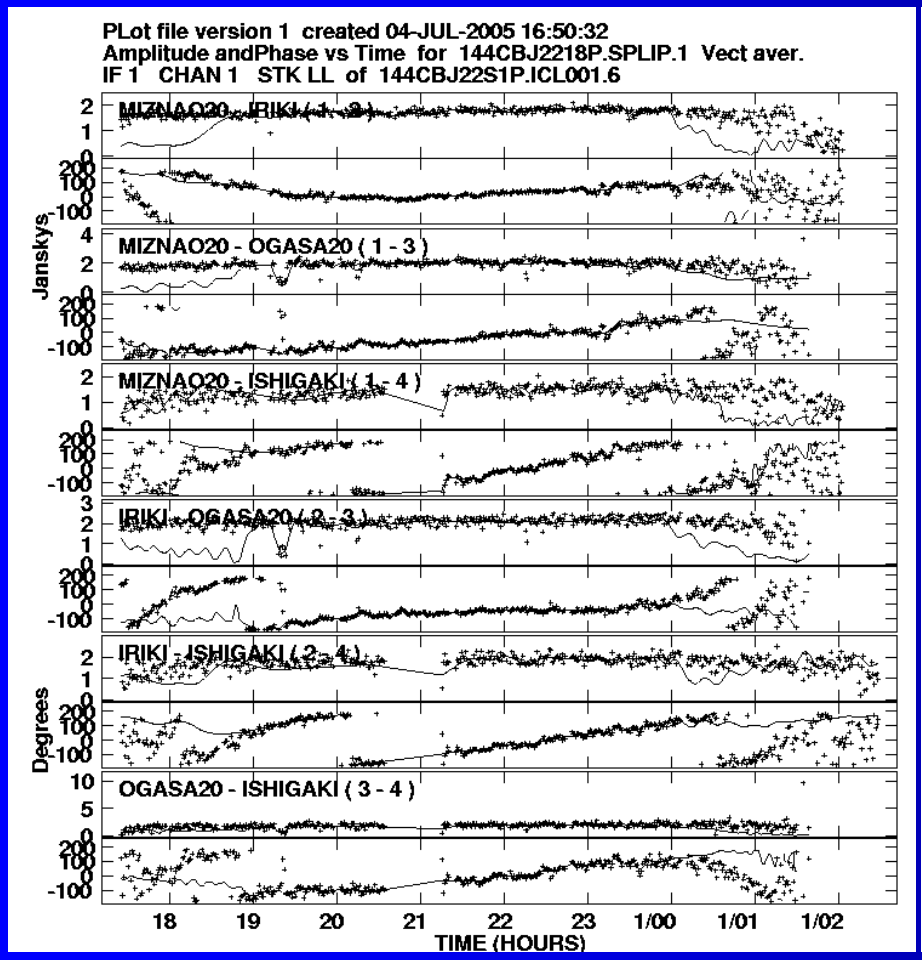


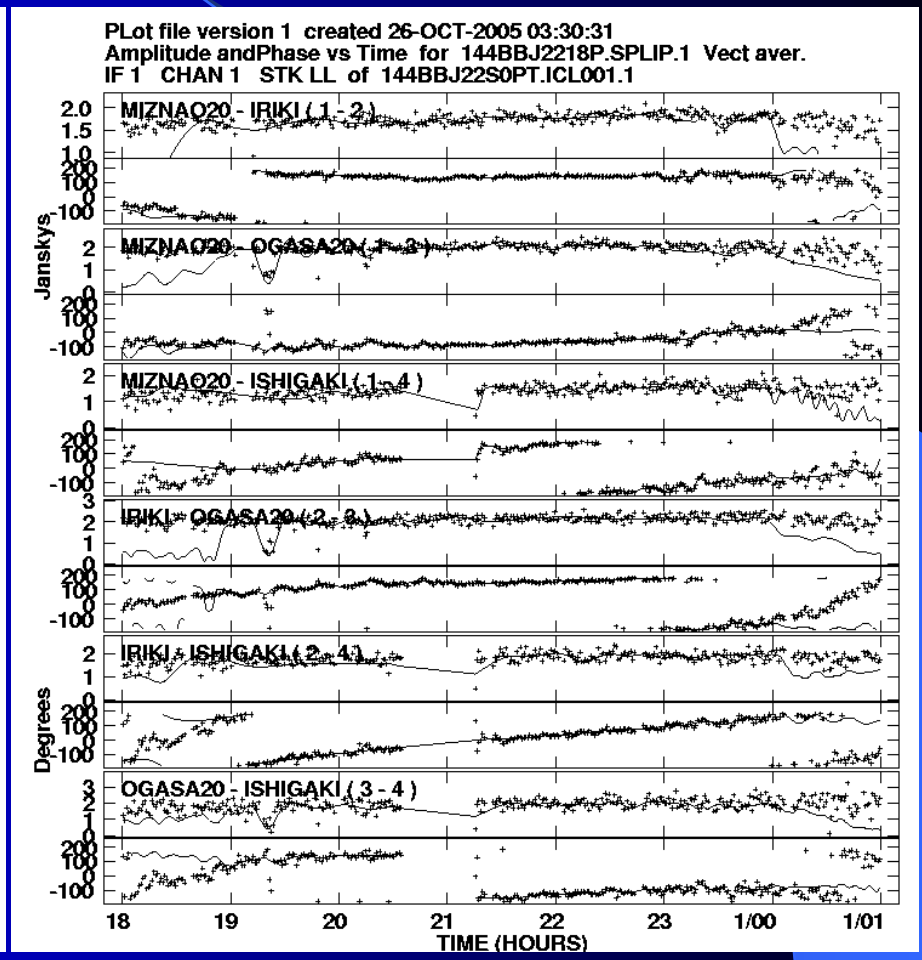
Phase A (1000-2000) at all stations



Phase A (1000-2000) at all stations

Comparison between DIR1000 and DIR2000 for phase referencing

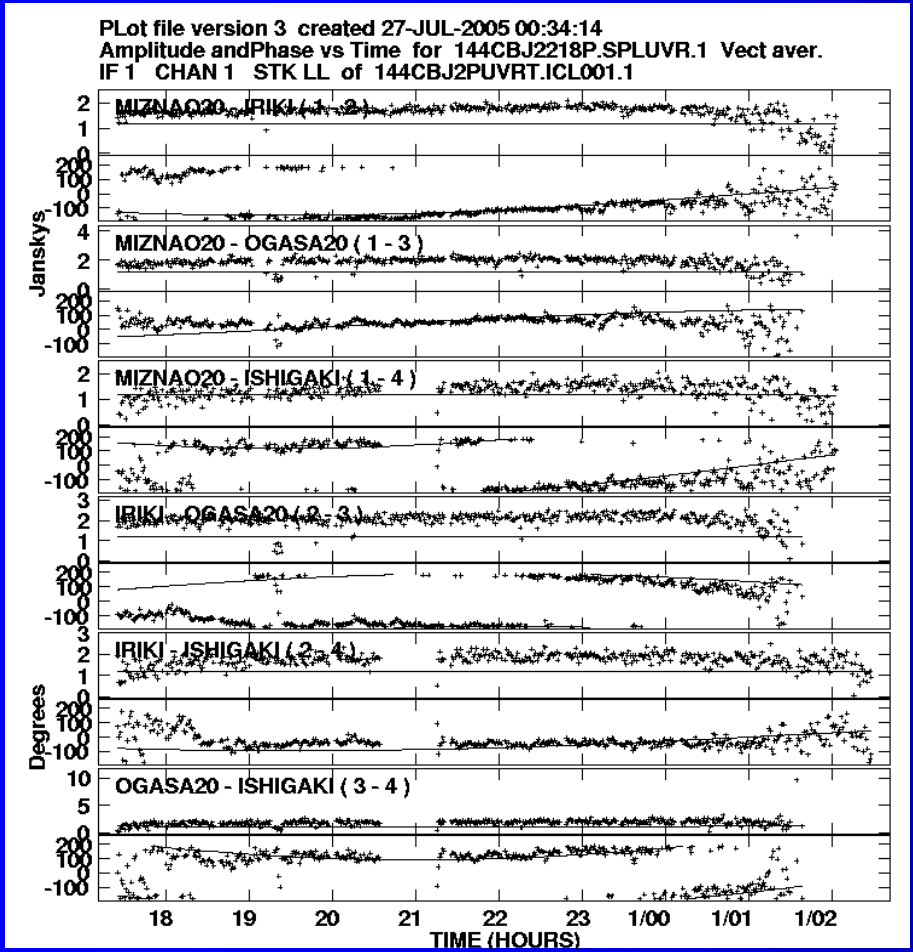




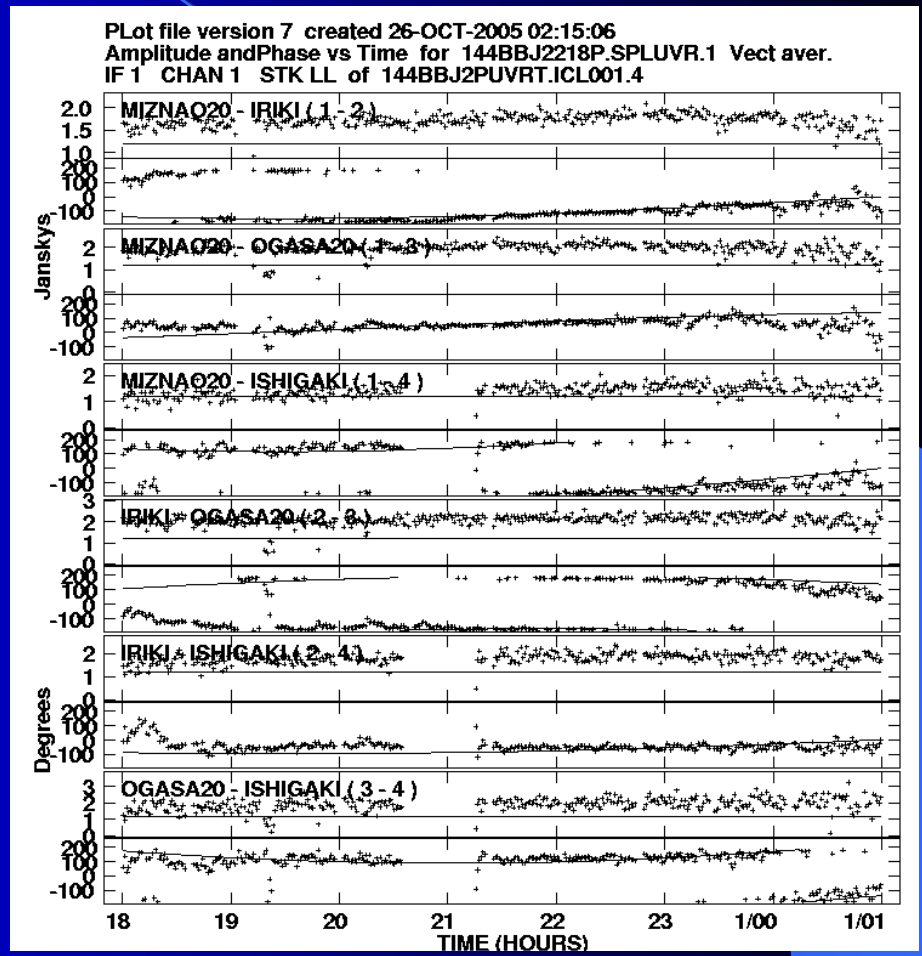
No apriori compensation DIR1000

No apriori compensation DIR2000

Comparison between DIR1000 and DIR2000 for phase referencing(using new dap by honma、hirota)

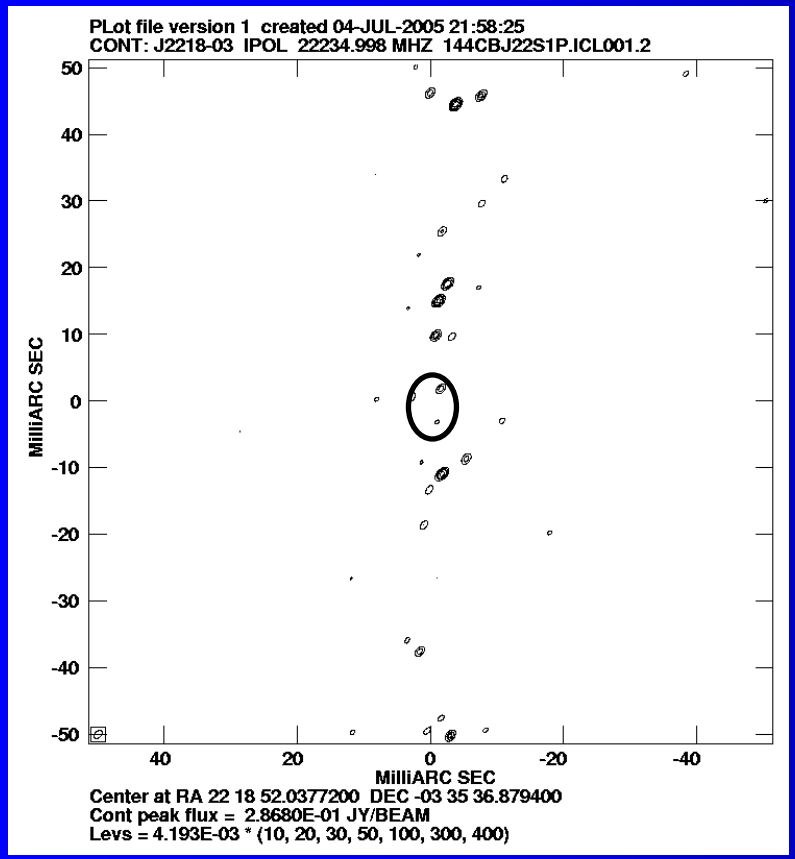


dap compensation DIR1000

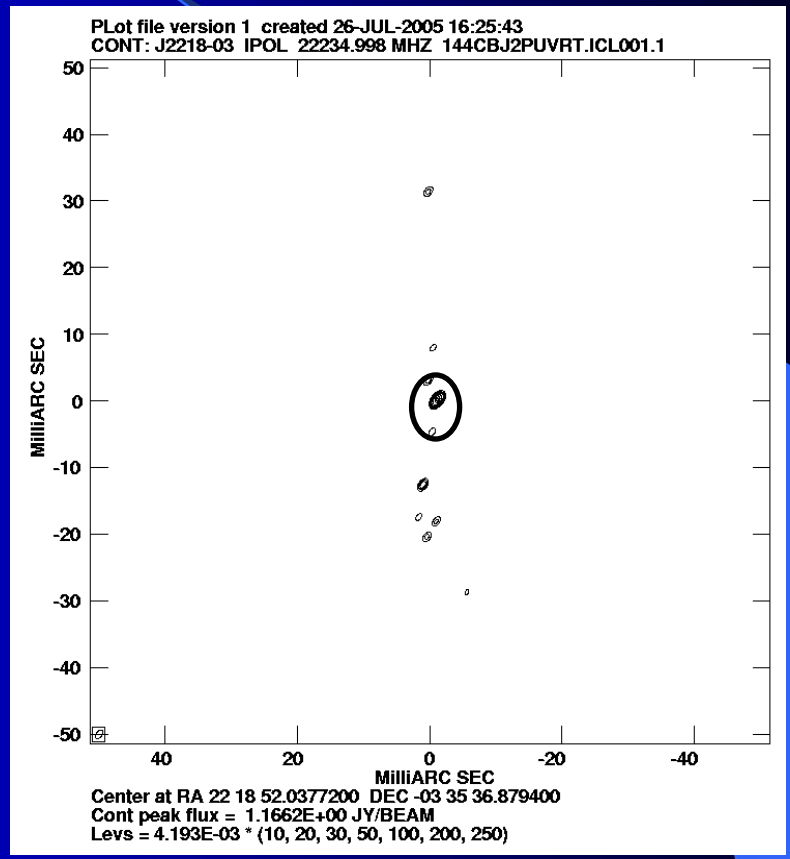


Dap compensation DIR2000

Comparison between before and after compensation (images)

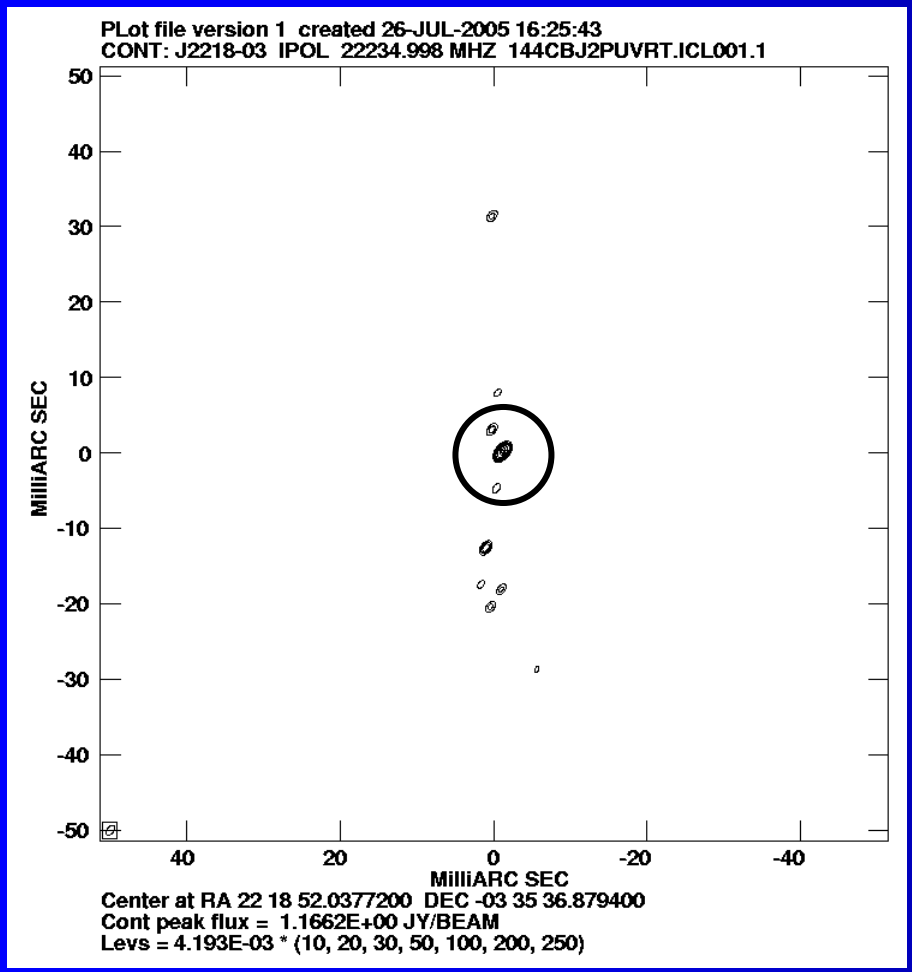


アプリ補正なし

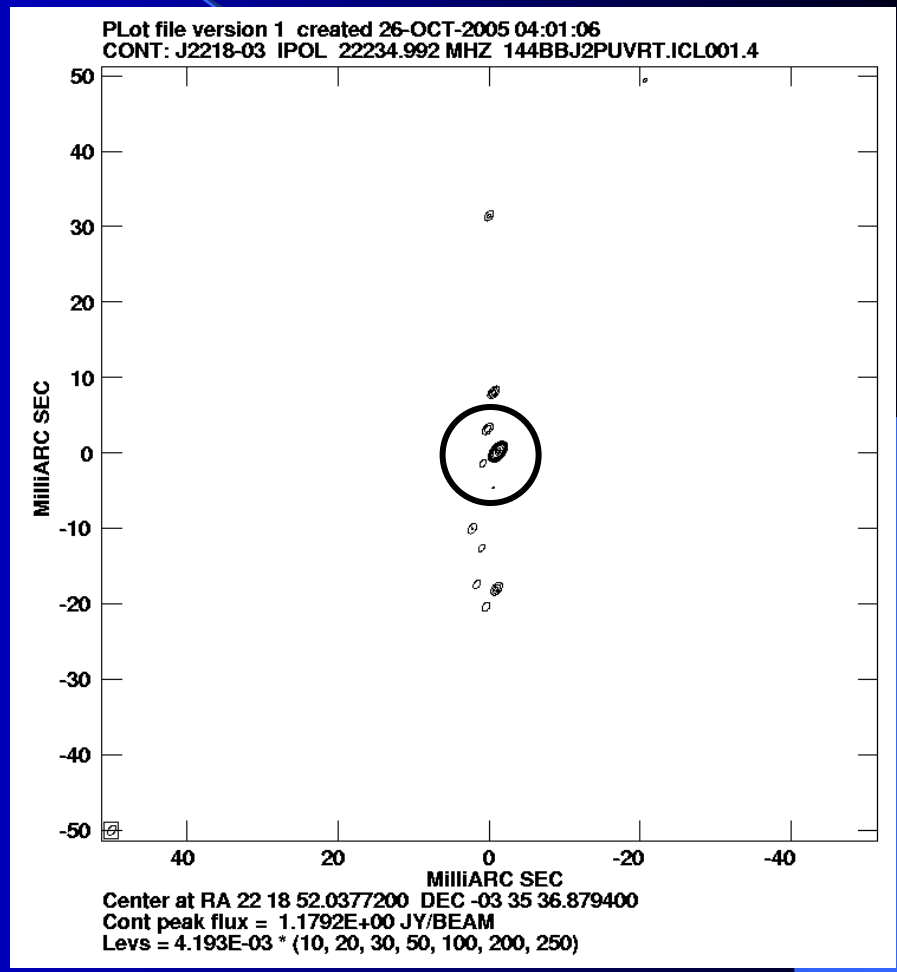


補正あり（2000系）

Comparison between DIR1000 and DIR2000 for phase referencing(using new dap by honma、hirota)

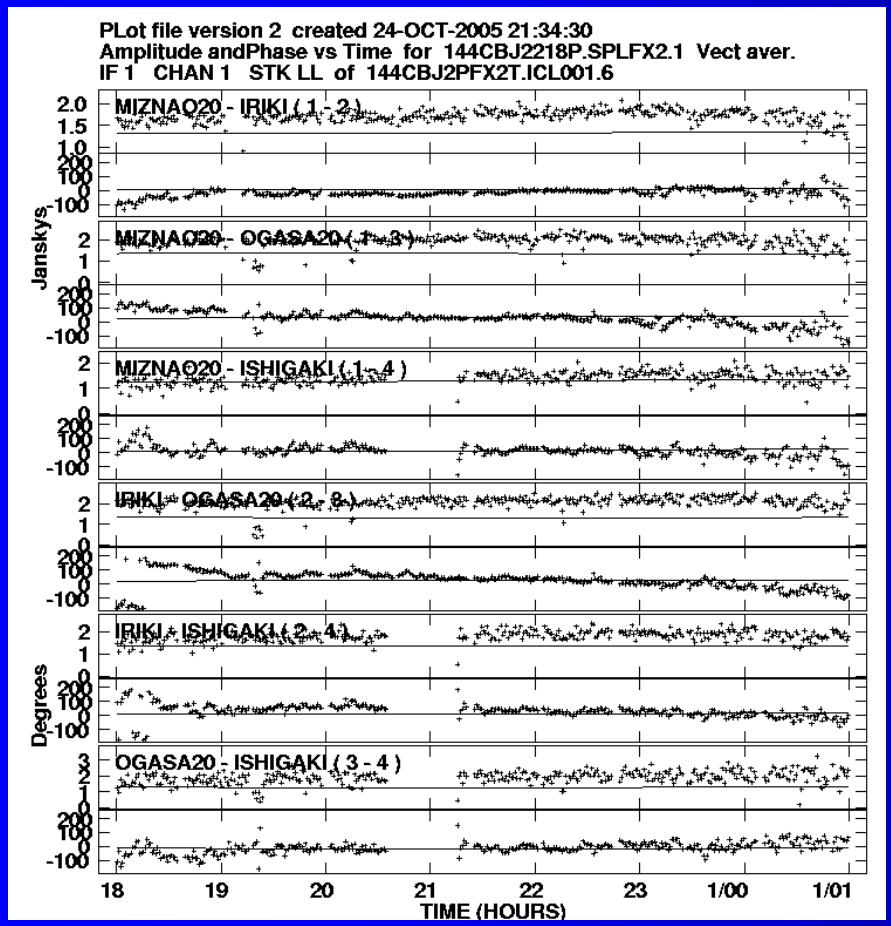


補正あり（Dap） DIR1000

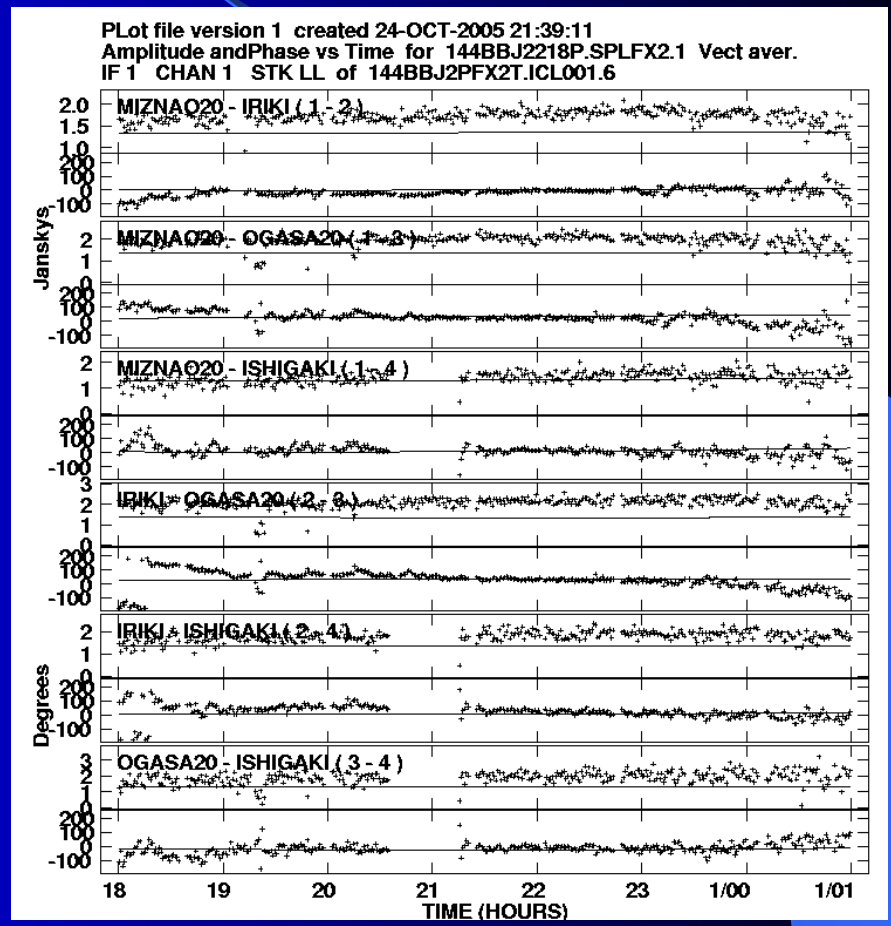


補正あり（Dap） DIR2000

Comparison between DIR1000 and DIR2000 for phase referencing (using fxcalc by Jike、Kurayama)

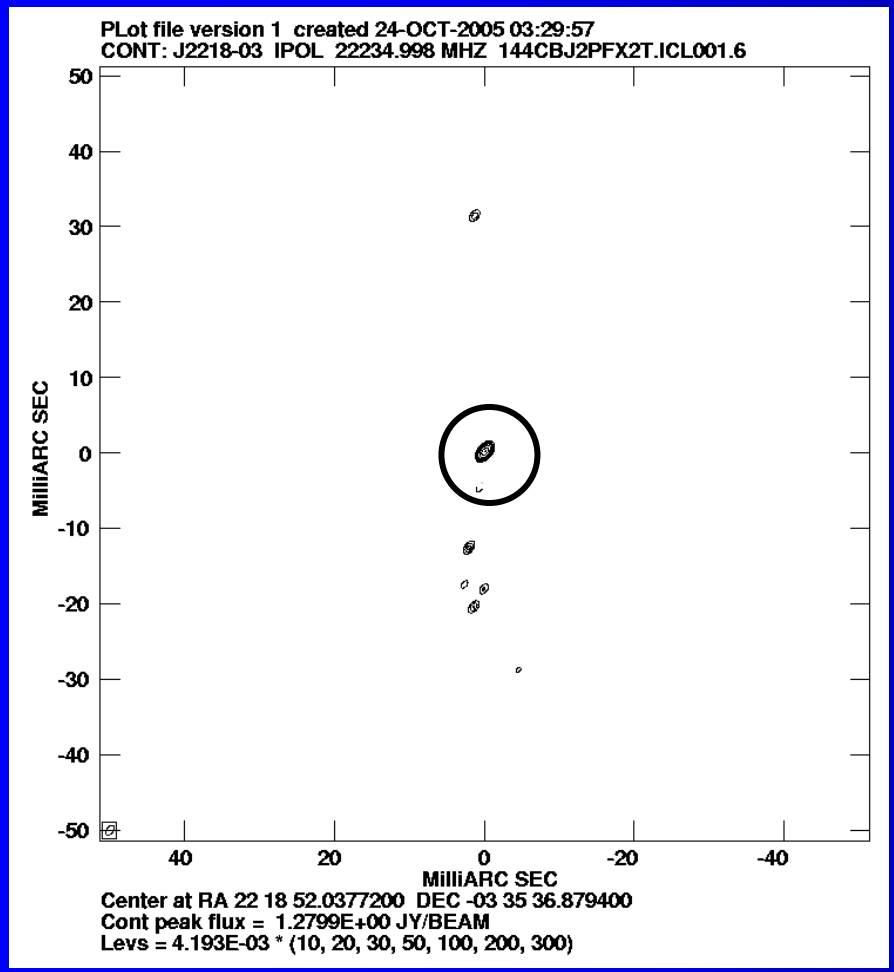


補正あり（fxcalc） DIR1000

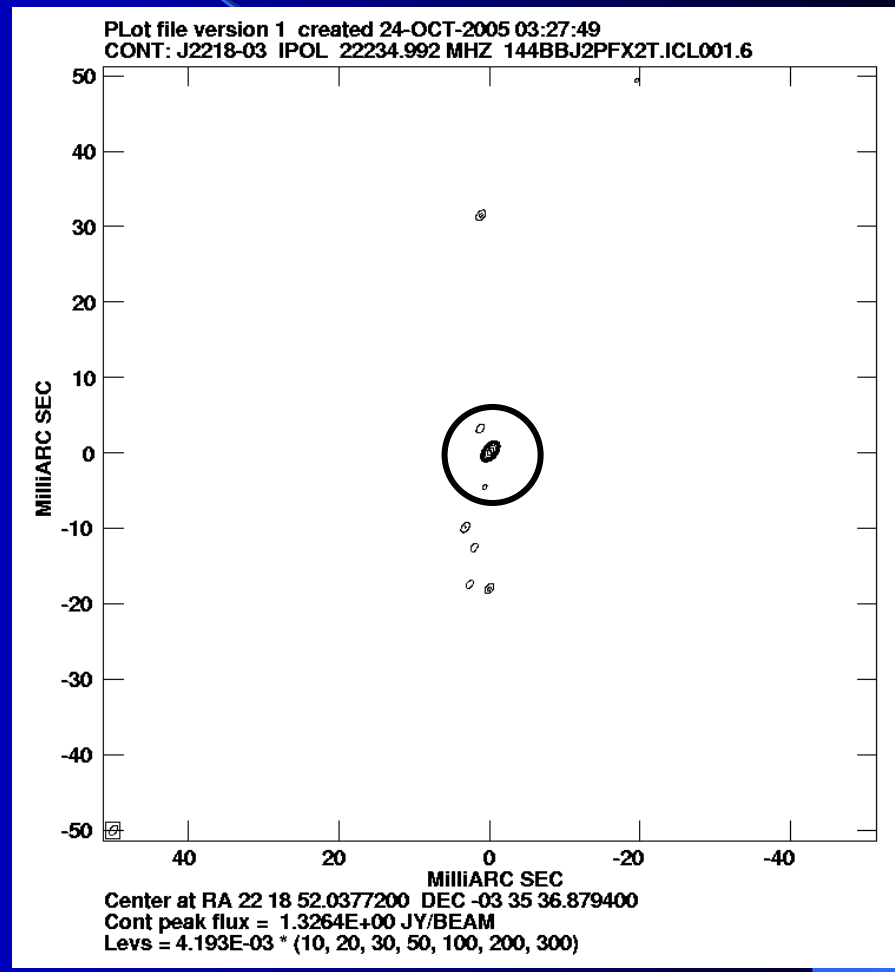


補正あり（fxcalc） DIR2000

Comparison between DIR1000 and DIR2000 for phase referencing(using fxcalc)



fxcalc compensation DIR1000



fxcalc compensation DIR2000

Results

J2218-035	ΔR.A(mas)	r m s （μ sec)	ΔDec （mas)	r m s （μ sec)
dap 1000	1.15305	1.28	0.1397	1.45
dap 2000	1.1654	1.315	0.14545	1.485
fxcalc 1000	0.0980	1.085	0.1635	1.225
fxcalc 2000	0.11275	1.145	0.1728	1.295
dap(1000-2000)	-0.01235		-0.00575	
fxcal(1000-2000)	-0.0147		-0.0093	
dap-fxcalc(1000)	1.05		-0.0238	
Dap-fxcalc(2000)	1.0526		-0.02735	

Offset from correlator apriori position

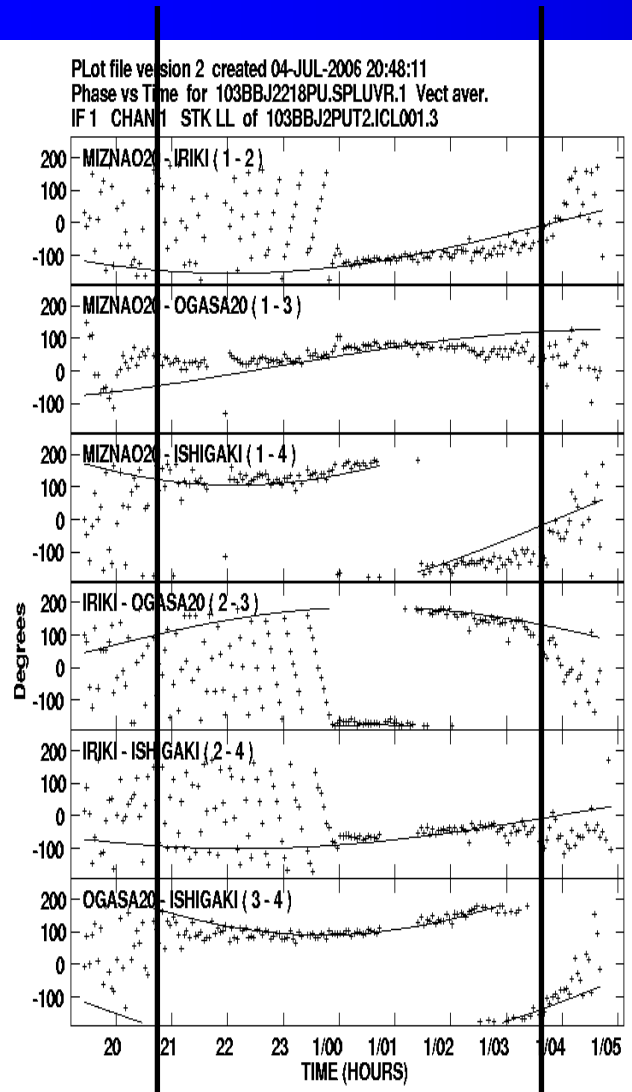
R.A～12-14μas and Dec～5-9μas (peak to peak)

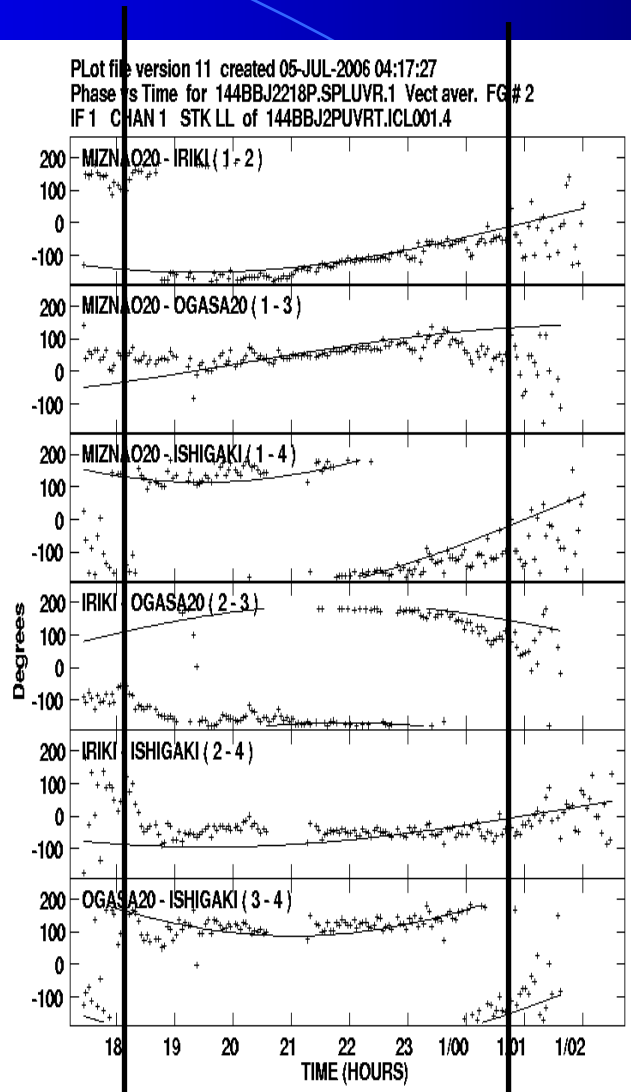
Multi epoch analysis

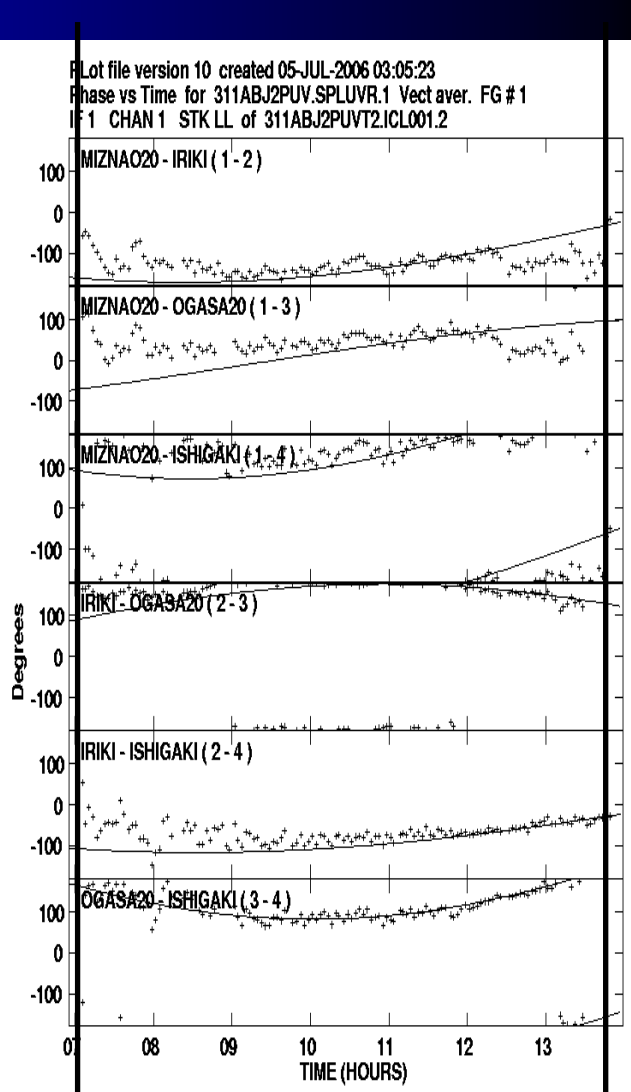
観測（今回報告する）：R05103b、R05144b、R05311A
解析　：修正DAP、
　　：天頂大気遅延補正（Sec Z補正のみ）

- 1）GPSの天頂大気遅延値の固定オフセットの性質（系統誤差or熱雑音or季節変動、その他？）は何か？
- 2）Fluxを乱す可能性のある数10度/数10分の位相変動の原因は何か？
- 3）Dec方向の位置の100 μ asレベルの不確定性は何か？（大気、アプリオリ精度、or 解析手法。。？）

Multi epoch analysis(Amp & Phase)







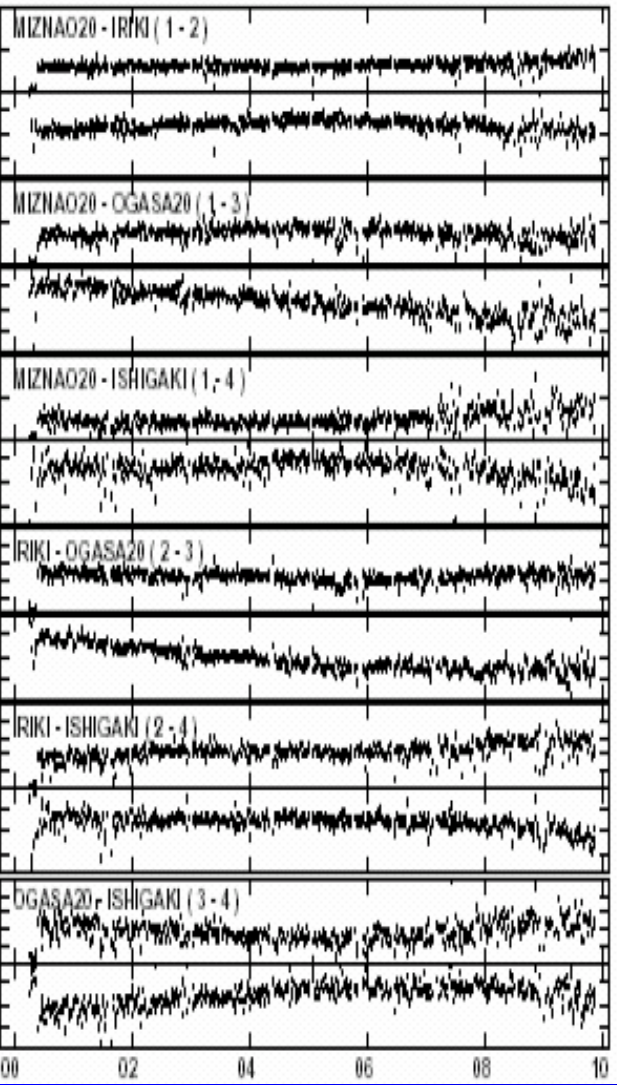
R05103b R05144b R05311a

Phase referenced visibility

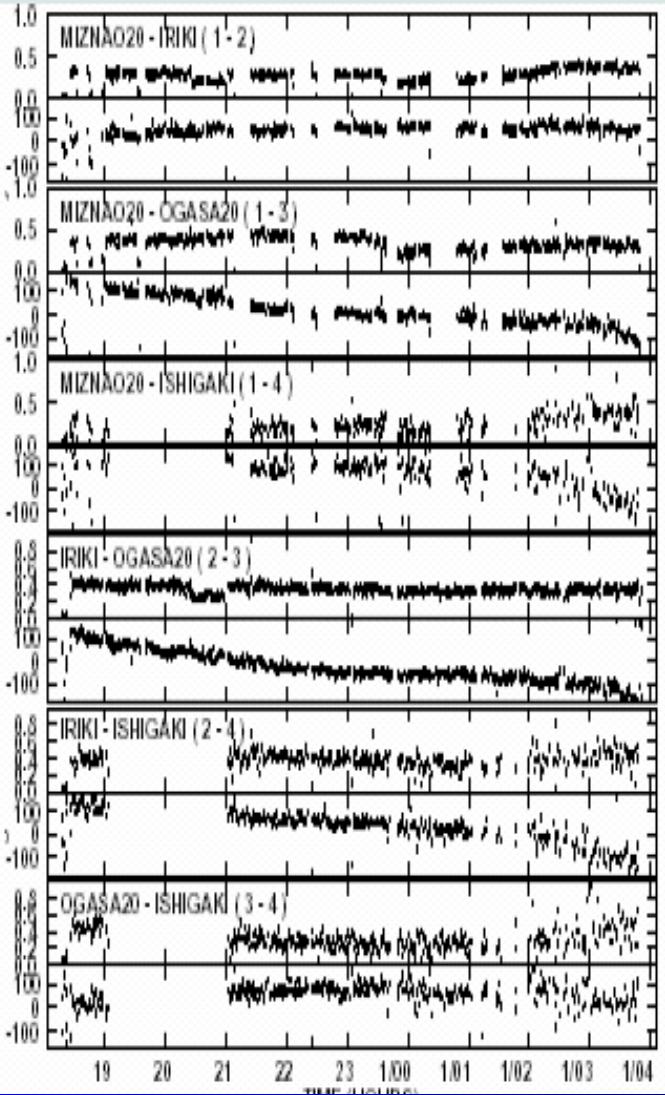
・J1753+4409の位相補償後Visibility

By 中川さん

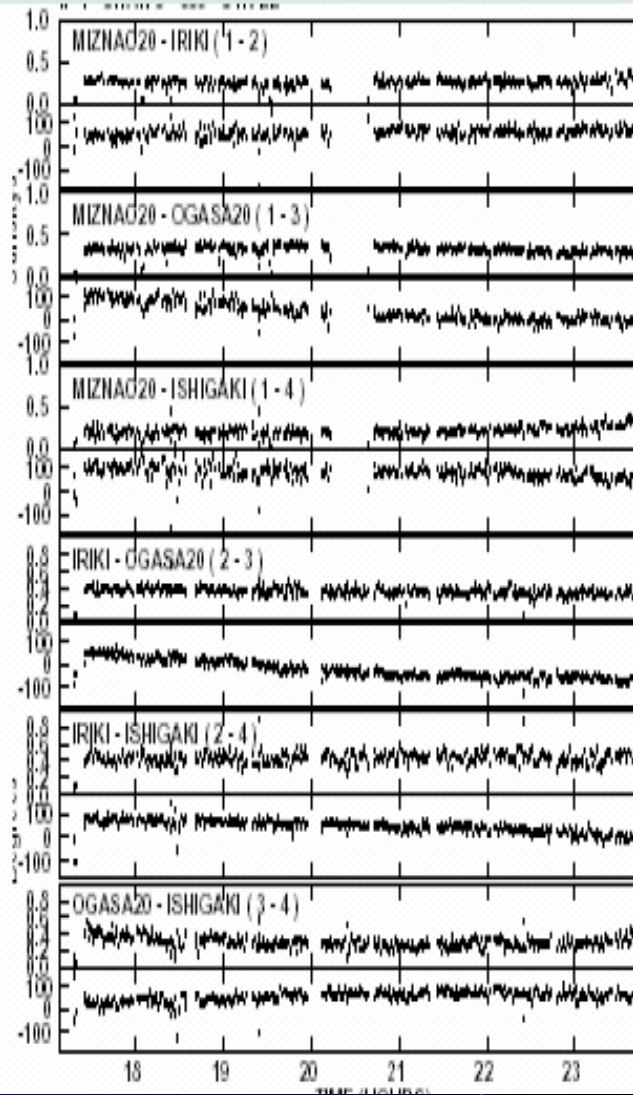
r04322a



r05056a



r05085a

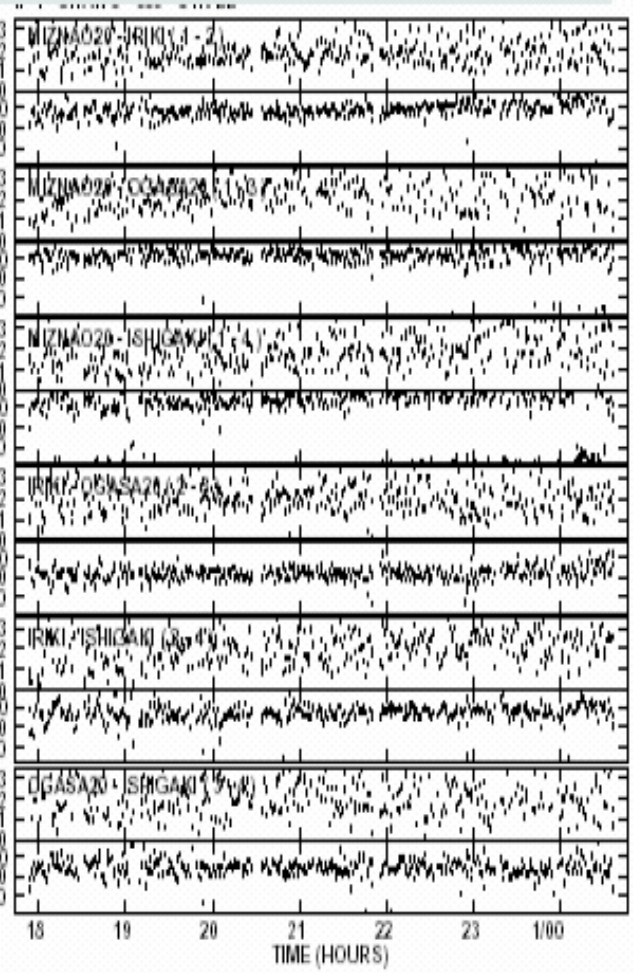


Phase referenced visibility

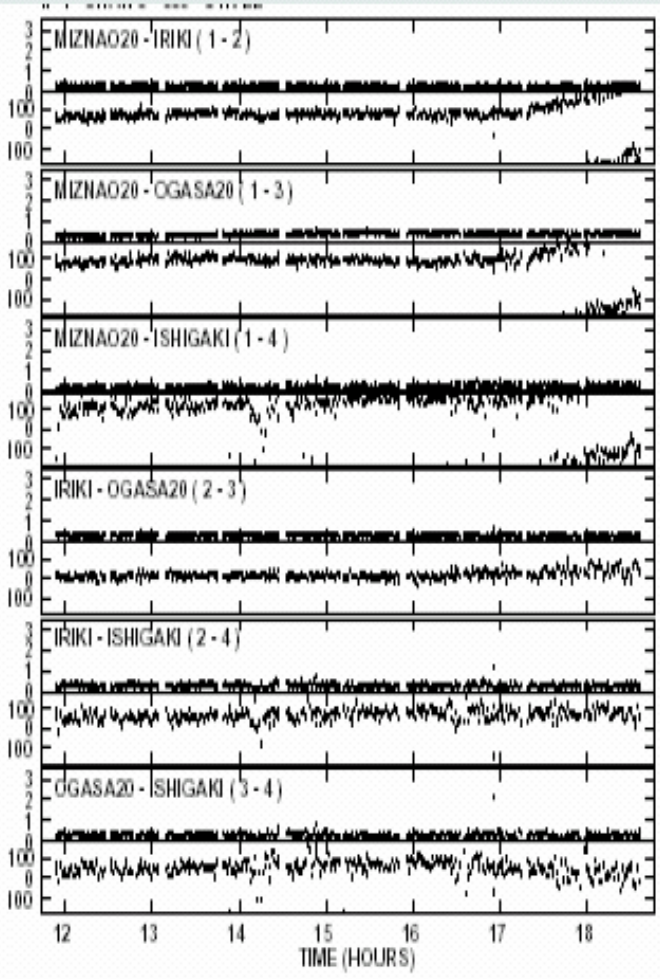
By 中川さん

・J0831+0429の位相補償後Visibility

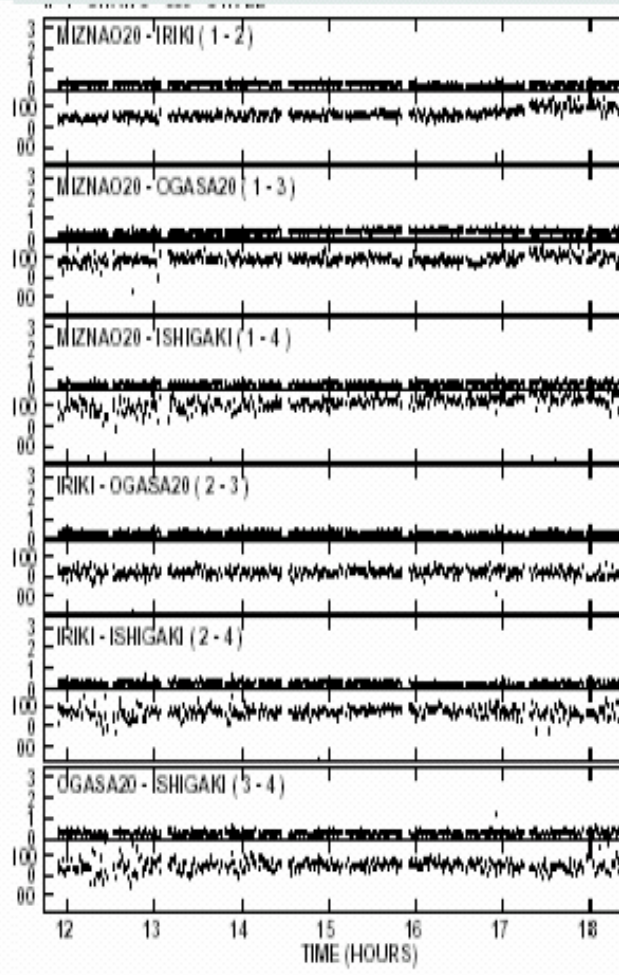
r05300c



r06028d

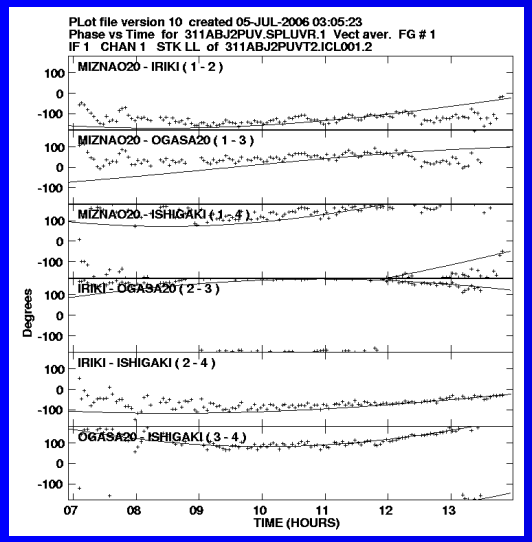


r06029a

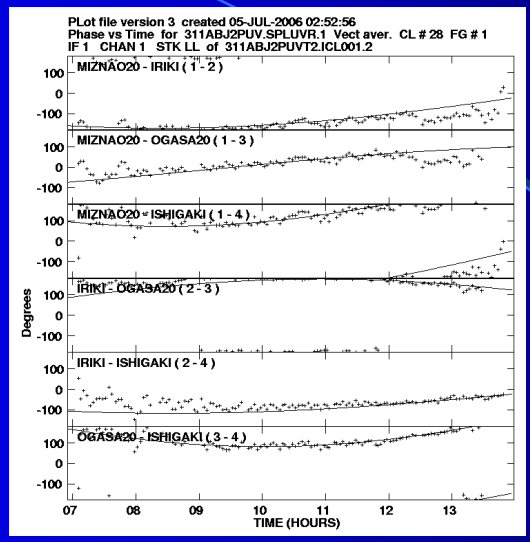


・Amplitude補正に問題

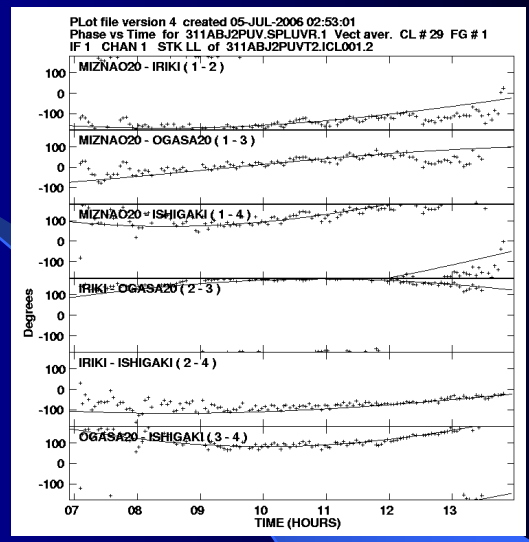
Search for zenith atmosphere delay offset
(天頂大気遅延オフセットサーチ、R05311A)



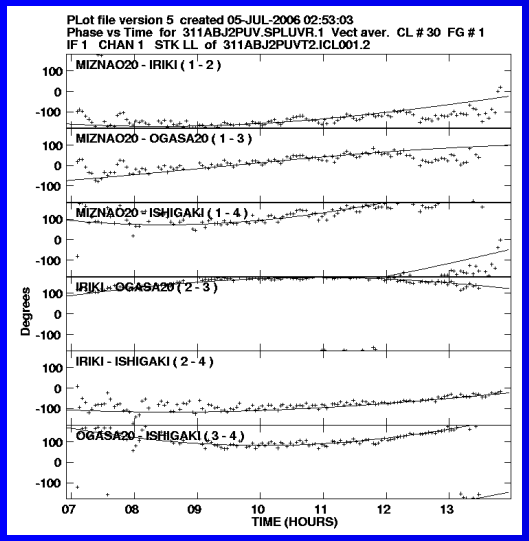
No offset



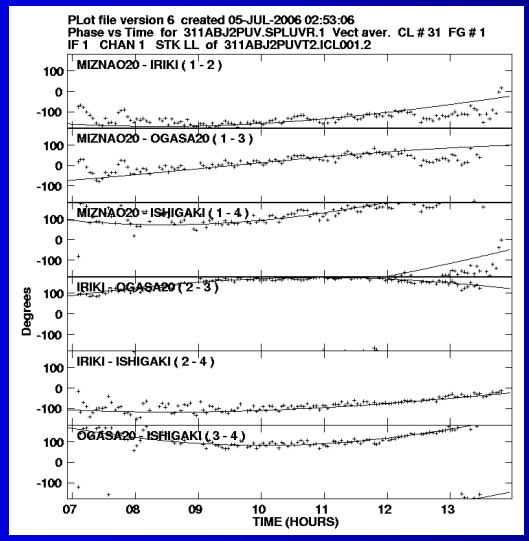
MIZ 0.1 nsec offset



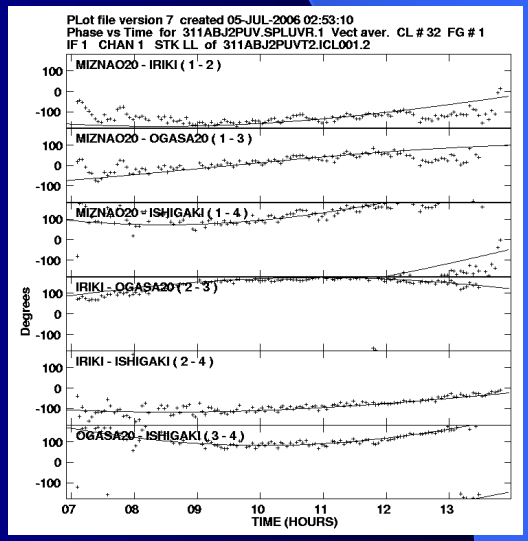
MIZ 0.1nsec +IRK 0.02nsec



MIZ 0.1 nsec + IRK 0.04 nsec

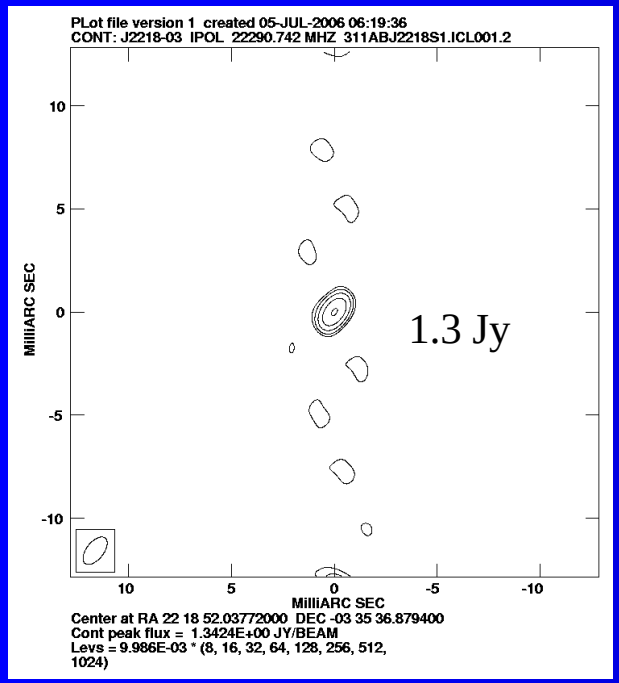


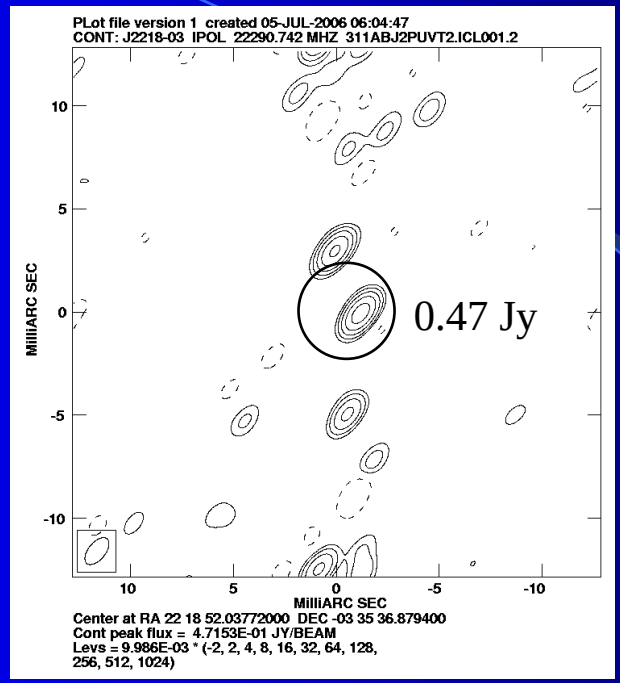
MIZ 0.1 nsec +IRK 0.06 nsec

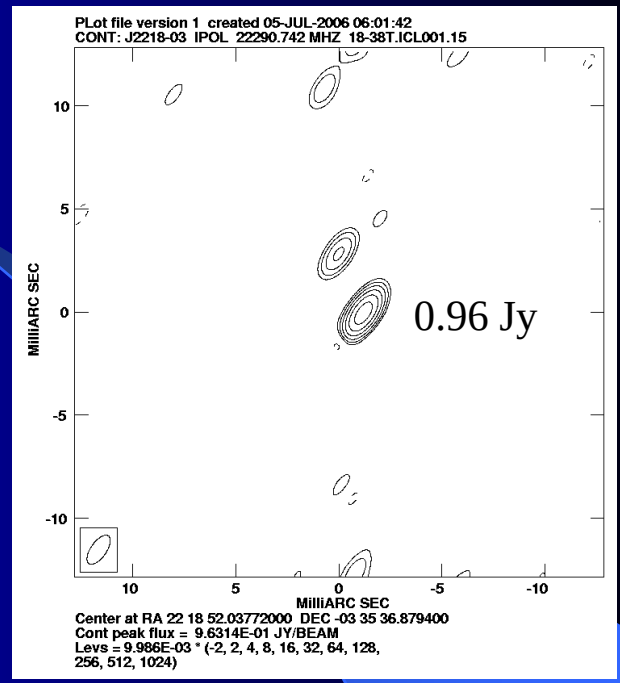


MIZ 0.1 nsec + IRK 0.08 nsec

Target Images (J2218-0035、R05311A)







Only Fring search

Zenith atm delay offset is not applied

MIZ 0.1nsec、IRK 0.06nsec offset

1）天頂大気遅延残差一定？（水沢は0.1nsec、観測開始時の水沢―入来基線の位相で１００度程度）
すべてのエポックで小笠原、石垣は比較的安定？）
→GPSの測定にはある系統誤差が入っている（例えば水沢に0.1nsecとか）？（疑問１）

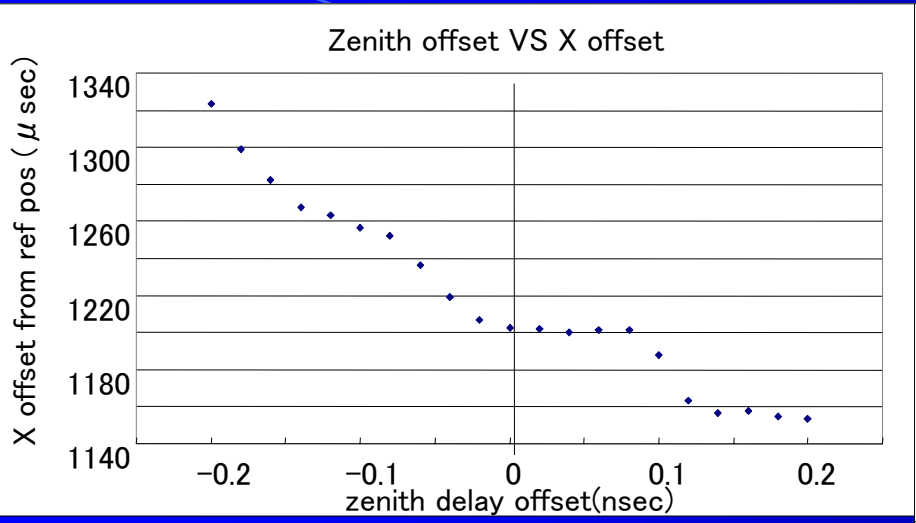
2）この初期モデルの与え方は正しい？モデルに合わせ込めてしまうかもしれない。要検討
（次々章で整合性一応チェック）

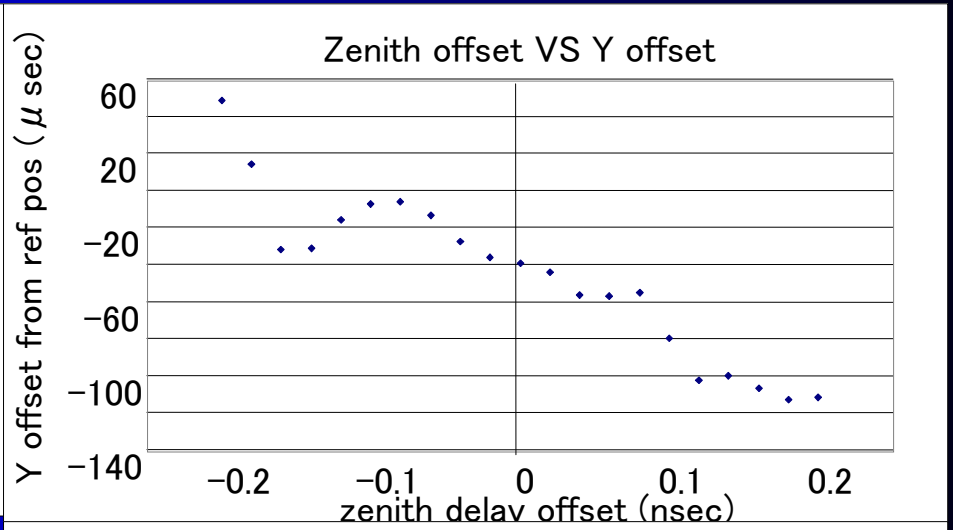
3）大気補正をする事によりpeak fluxは2倍に改善するが、self calibrationに比べると70%
→先に述べた水沢の0.02nsec程度のオフセットを入れれば多少改善する可能性あり（独立でない！）

天頂大気オフセットによる、位置、fluxの変移

・上記天頂大気オフセットサーチ法妥当性チェックが目的
（中心モデルとvisibility phaseを合わせる事でfluxがピークにくる？）

・MIZ 0.1nsec、入来0.06nsecのoffsetは妥当か？



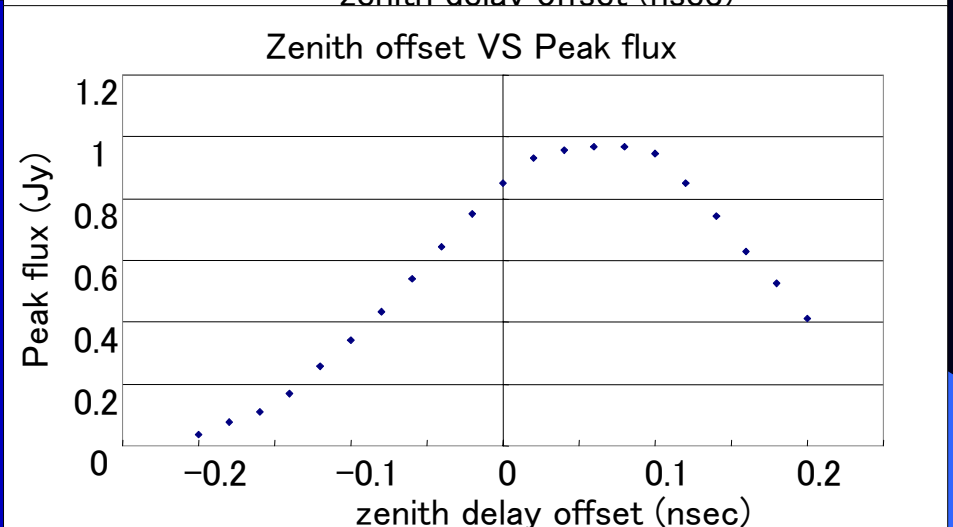


水沢0.1nsec固定+入来　-0.25～0.25nsecまで変化

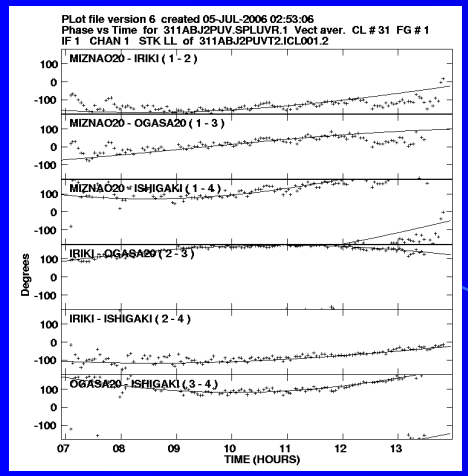
1、入来 0.0 6 nsec近辺でfluxがピークになり、位置もX,Y方向共に、0.06nsec近辺で安定　OK？

2、小笠原、石垣サーチ必要？

3、天頂大気遅延オフセットで動かせる位置は数10μas程度？



Fluxの収束と位相安定度

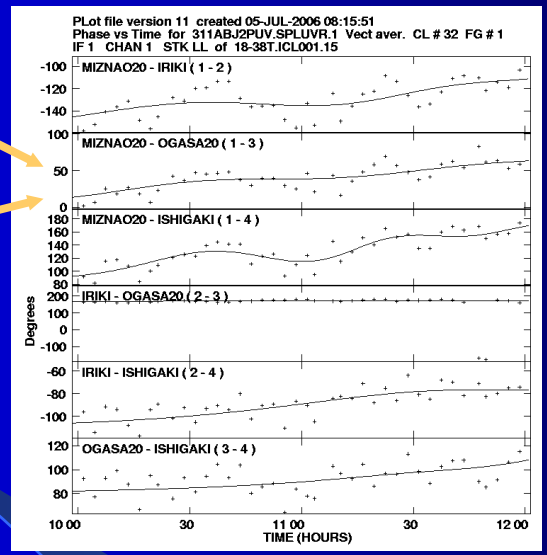


MIZ 0.1nsec+IRK 0.06 nsec

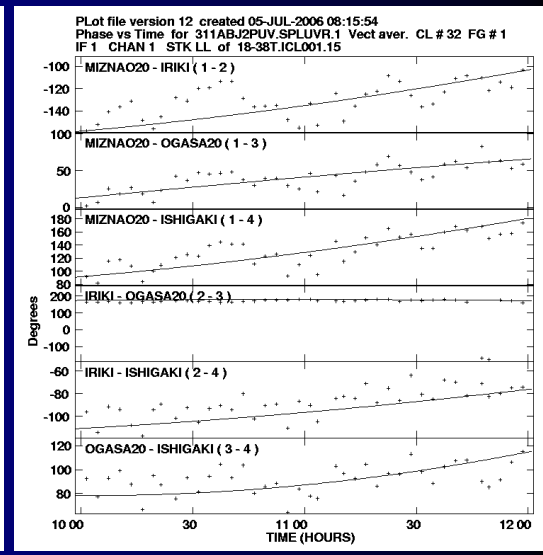
10:00-12:00
を拡大

50

0



Model = all components



Model = only center

1、数10度/数10分の位相変動が
Fluxの分散に影響？

2、1ビーム解析での位相安定度＝数度
→フリンジサーチ精度不足ではない？

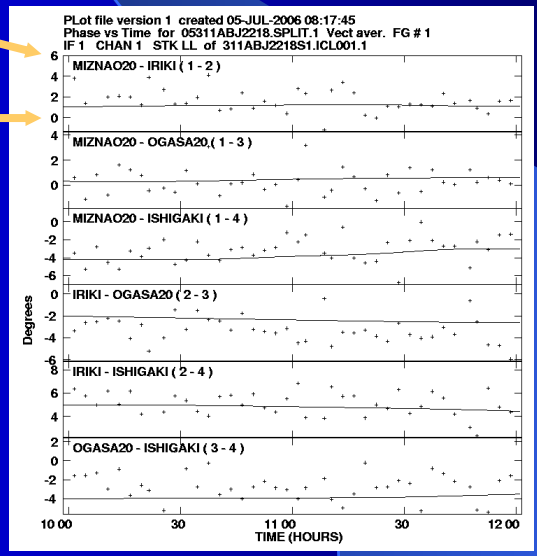
3、位相校正テーブル安定

4、短時間数10度/hourの位相変動を天頂大気遅延オフセットで補正するのは不可能
（前述の議論により位置にはあまり影響しない）

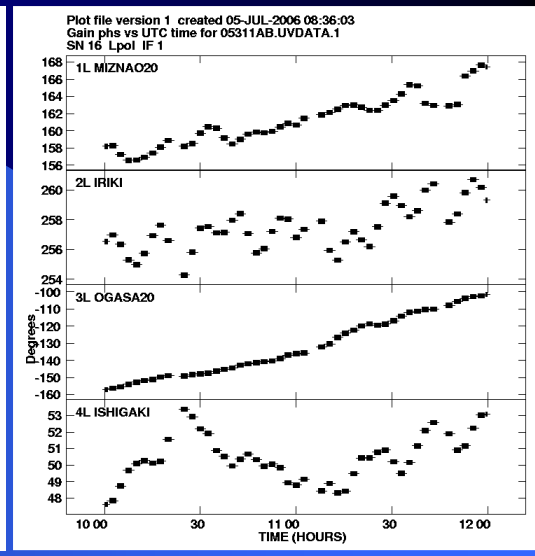
5、　→原因は何？、フリンジサーチの時間間隔？、CLCALでの校正テーブル補間ミス？
天頂大気遅延オフセットの変動？、解析ミス？・・・(疑問２)

5

0

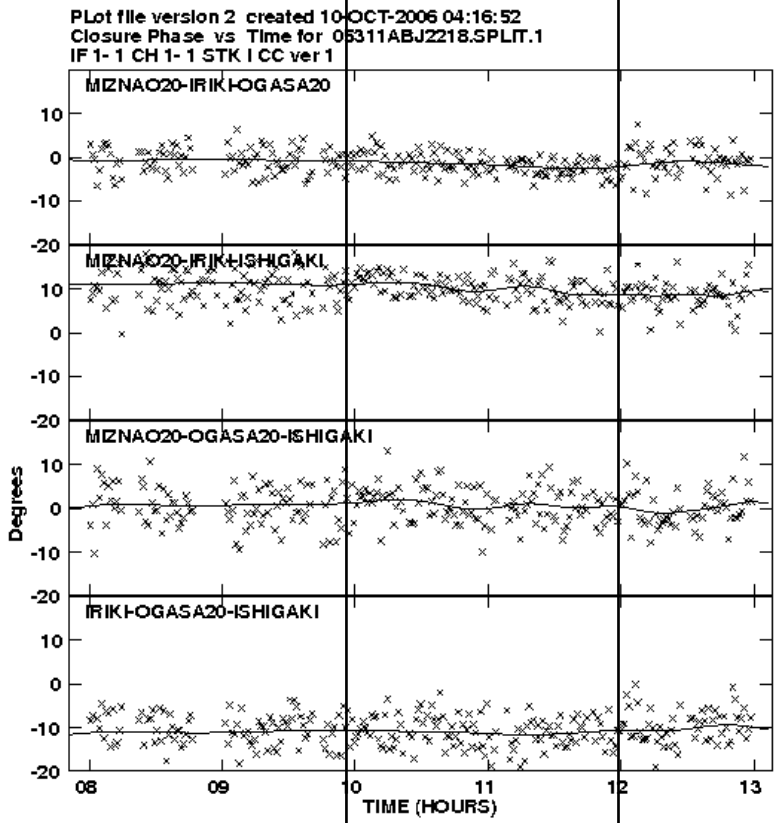


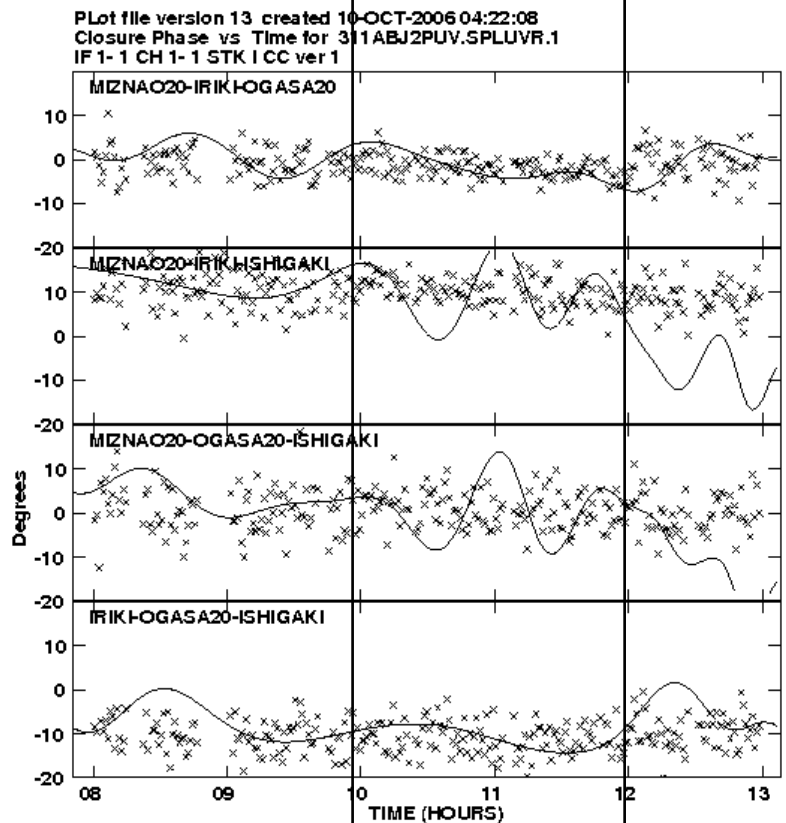
Only fringe search (1beam)



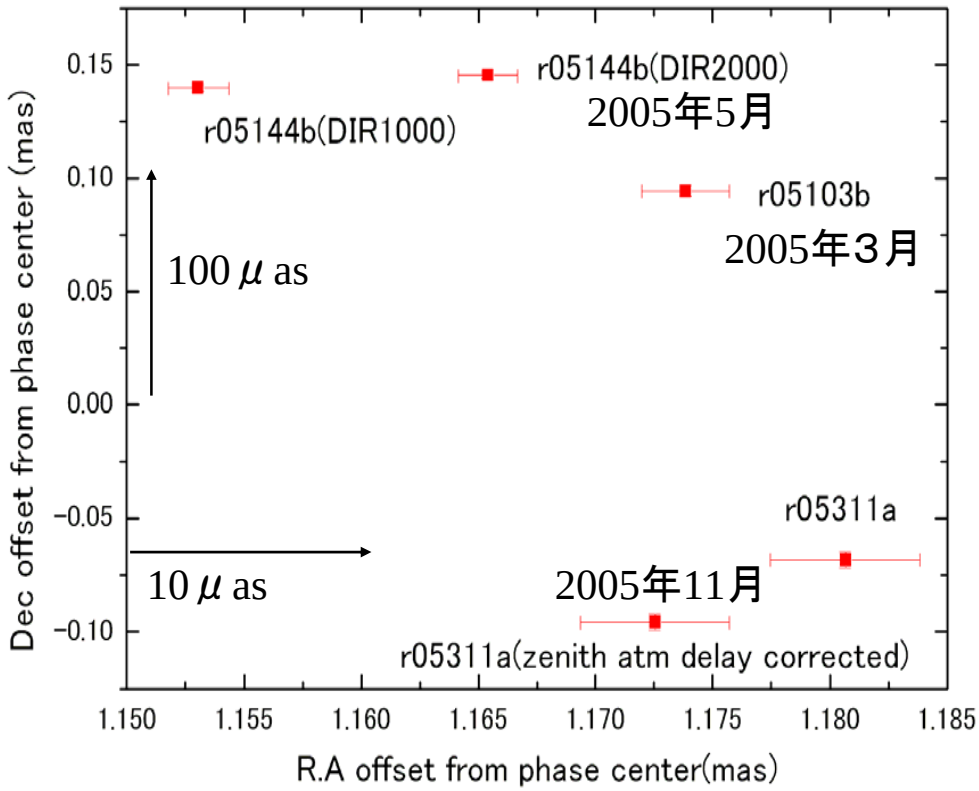
2 Bcal table

Closure phase





3エポックでの相対位置変化
(QSOペアの離角安定度

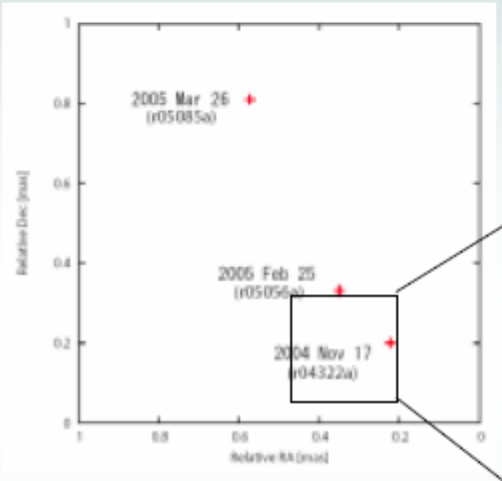


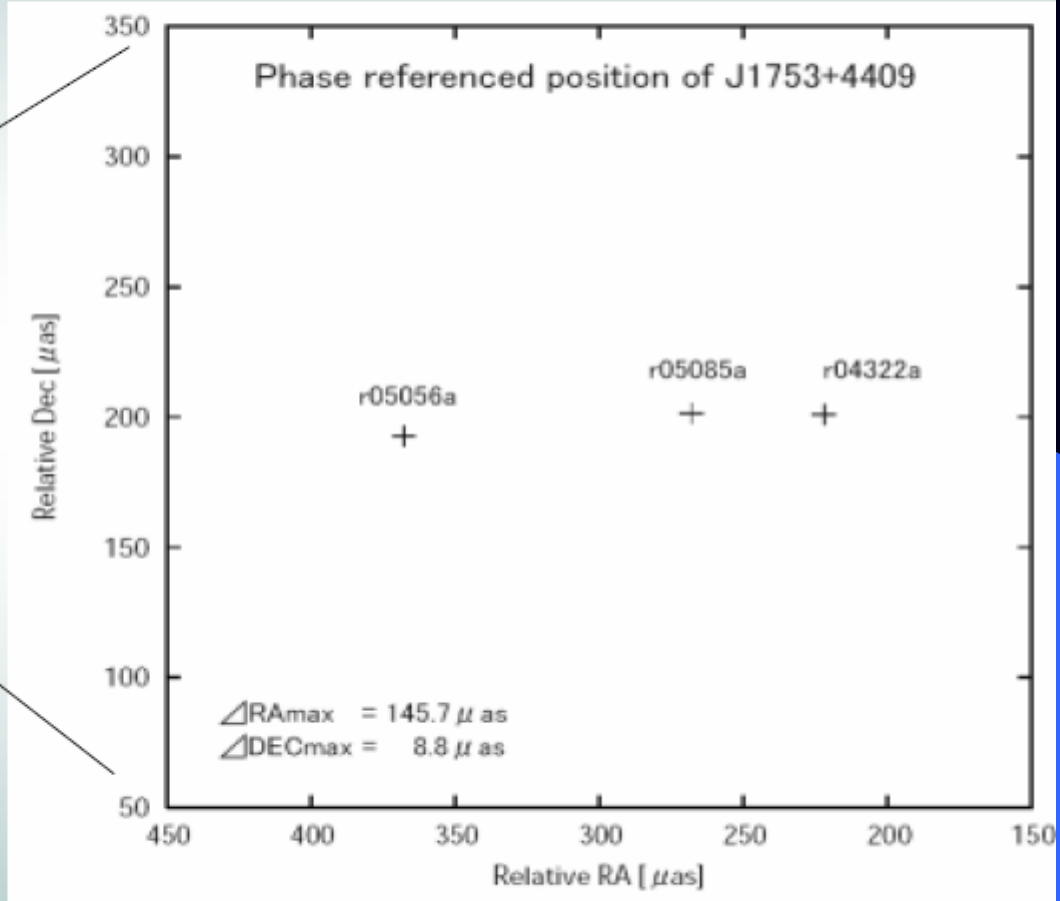
	ΔR.A (mas)	Δdec (mas)
R05311a	1.18065	−0.0682
R05311a	1.17255	−0.09565
R05144c	1.15305	0.13975
R05144b	1.1654	0.14545
R05103b	1.17385	0.0943

R.A　8.45 μ as 、 Dec　241.1 μ as (peak to peak)　200日

J1753+4409の位置再現性

※Gaussian fit した成分のピーク位置





	Peak [Jy/beam]	rms [Jy/beam]	D/R
r04322a	0.302	0.013	23.6
r05056a	0.202	0.024	8.4
r05085a	0.292	0.013	22.5

東西に大きなひらき

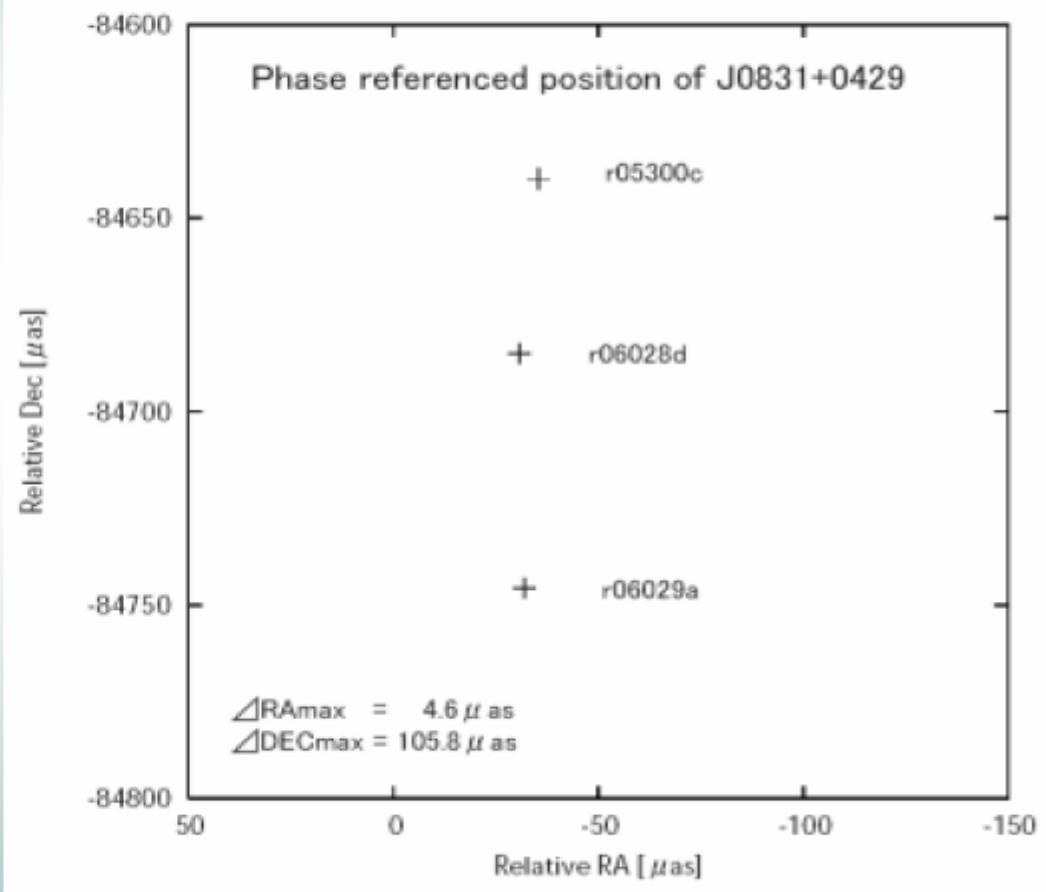
By nakgawa

J0831+0429の位置再現性

※Gaussian fit した成分のピーク位置

南北方向に大きなひらき

・ペアの位置角は42°



By nakgawa

Summary

- 1000系、2000系比較

  R.A～12-14 μ and Dec～5-9 μ . （peak to peak）

- 多エポック解析

  3C446 R.A 8.45 μ as 、 Dec 241.1 μ as (peak to peak) 200日間隔

  OJ038 R.A 4.6 μ as、 Dec 105.8 μ as (pp） 90日間隔

  OU+401 R.A 145.7 μ as、 Dec 8.8 μ as 90日間隔

- １） GPSの天頂大気遅延値の固定オフセットの性質（系統誤差or熱雑音or季節変動、その他？）は何か？

- ２）Fluxを乱す可能性のある数10度/数10分の位相変動の原因は何か？

- ３） Dec方向の位置の100 μ asレベルの不確定性は何か？（大気、アプリオリ精度、or 解析手法。。？）

- ４）ペアによる位置再現性の相違は何？