

2010/7/15 Kiso symp.

2KCCDによる 古い散開星団の観測

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古い散開星団と銀河考古学

- 銀河系の中期の歴史の星形成史を反映
- 銀河系の構造の進化の研究
 - 金属量の進化 $[\text{Fe}/\text{H}] = [\text{Fe}/\text{H}](t, r_{\text{GC}})$
(Friel 1995; Twarog 1997; Chen 2003)
 - 速度場のトレーサー (Chen 2003)
- 銀河系の合体史の手がかり (Frinchaboy 2004)
- 星の進化理論の実験場

単独星より年齢, 距離, 金属量, 速度が正確

金属量 (Chen 2003)

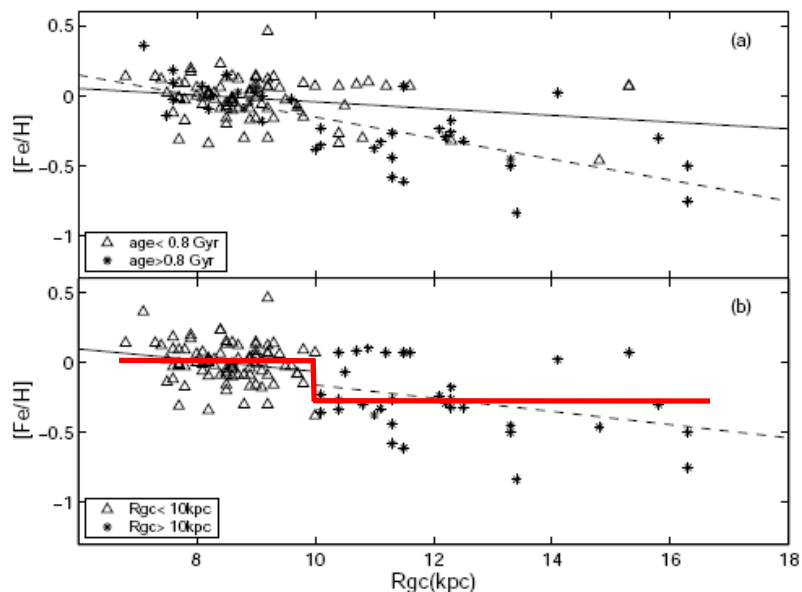


FIG. 9.—(a) Time evolution of the iron gradient. Triangles show clusters with age less than 0.8 Gyr, stars show clusters with age greater than 0.8 Gyr. The gradients are -0.024 and -0.075 dex kpc^{-1} , respectively. (b) Gradients for inner disk (within 10 kpc) and out disk clusters. The corresponding gradients are -0.040 and -0.047 dex kpc^{-1} , respectively.

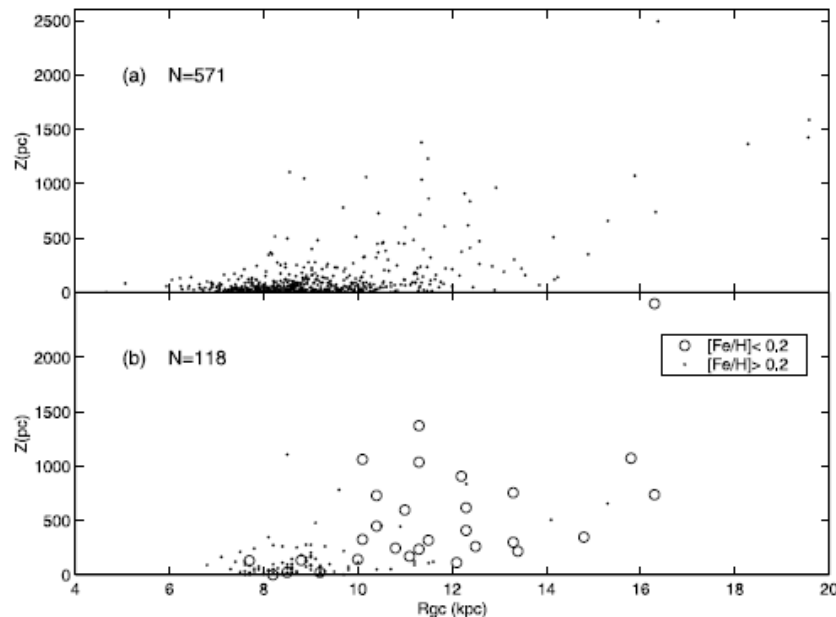


FIG. 5.—(a) Height from the Galactic plane vs. Galactocentric distance, for all 571 clusters with data available. (b) Same as (a), but for only 118 OCs that also have iron abundance data. It can be seen that the most metal poor clusters are located in the outer part of the Galactic disk.

若い星団の金属量勾配は小さい？
10kpc外は傾きが浅い

Stepwise distribution (Twarog)
PN, Chepeid, HII regionとも整合

金属量の少ない星団は銀河面から
離れたところに多い

速度場 Chen (2003)

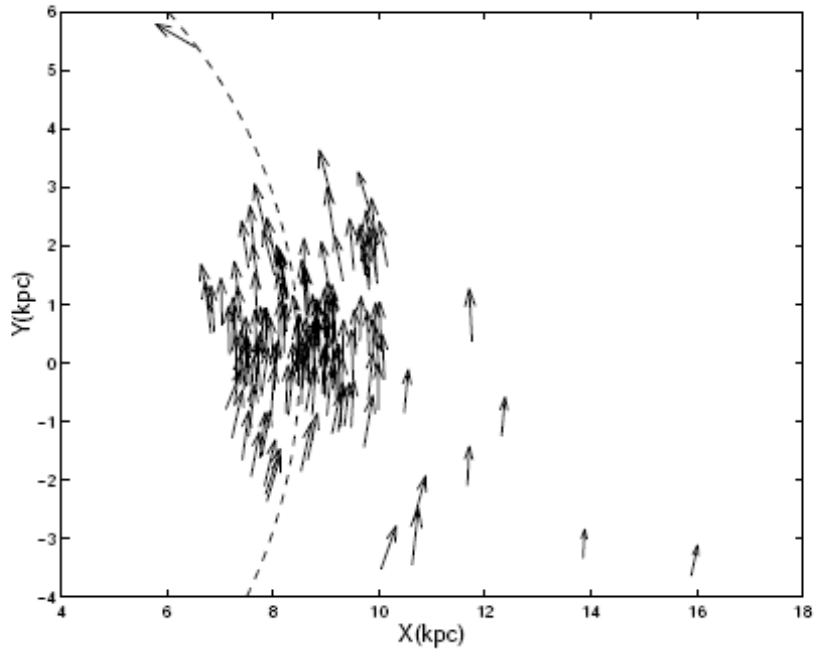
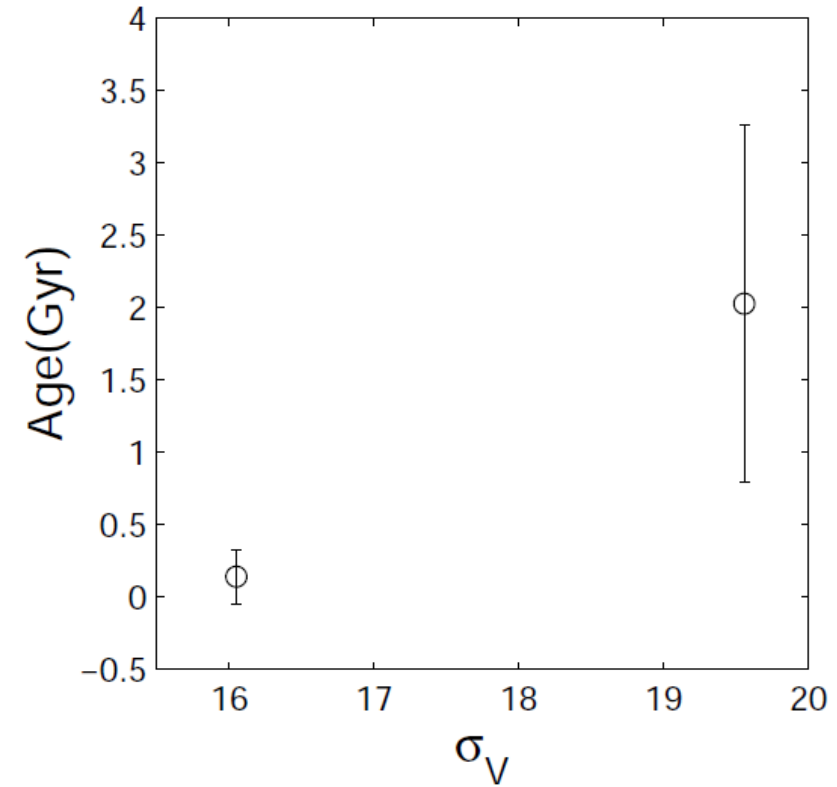
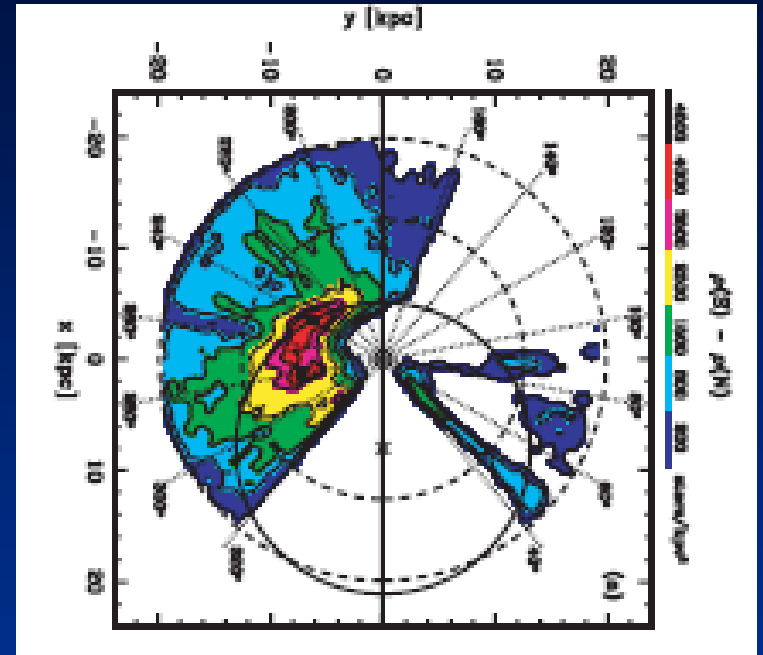


FIG. 3.—Velocity projection on the Galactic plane for 144 clusters, which have both radial velocity and mean proper motion available. The Sun is located at $X = 8.5$ kpc, $Y = 0$ pc.



おおいぬ座(CMa)矮小銀河

- 2MASS / RC stars
(Bellazzini 2004)
 - $r_{GC} = 13.5 \pm 2$ kpc
 - 銀河面内 40° 以上広がり
- diskのwarpか?
(Carraro et al. 2007)
- もっと離れた星団やSiO₂メーザーも
運動学的には、同じ起源?
(Frinchaboy 2004; Deguchi 2007)



古い散開星団

- 年齢 0.6~10 Gyr

- 代表的なサンプル

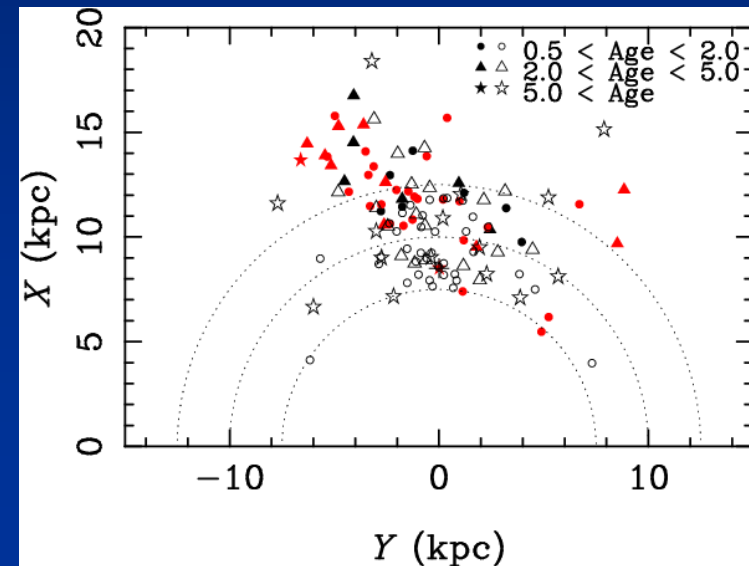
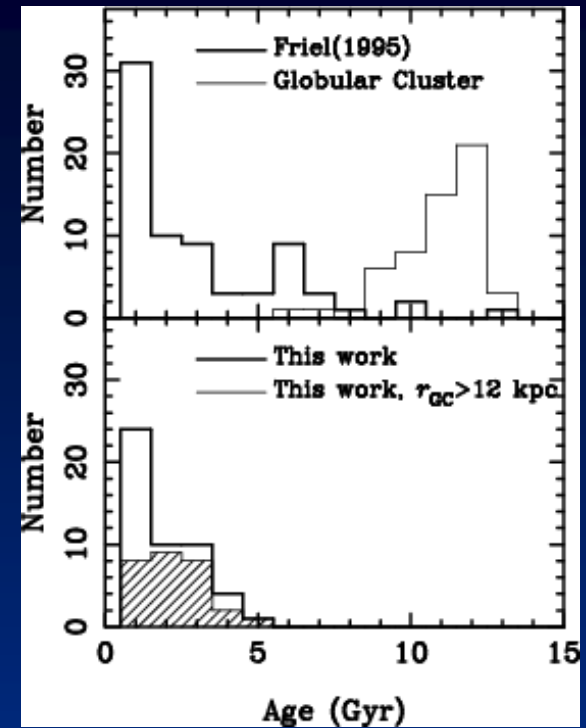
- Friel (1995) 73 clusters
- Hasegawa et al. (2004, 2008) 50 clusters
- Chen (2003) (p.m., compilation)
- Mermilloid (WEBDA) 227 clusters

cf. Comprehensive list of clusters

- Lynga (COCD, 1930) 1100 clusters
- Dias (2002) (compilation) 1537 clusters
- Mermilloid (WEBDA) increasing...

測光観測@GAO65cm

- 観測期間 2000～2007
- サンプル数 50天体
 - selection
 - Trumplerの形態パラメーター
 - $\delta \geq -20^\circ$
- 65cm望遠鏡 + 水冷CCD + B, V, I
 - $V_{\text{lim}} \sim 20, I_{\text{lim}} \sim 18.5$
- DAOPHOT & CMD & Isochrone
- Age = 0.6 ~ 5.0 Gyr (except one)
 - destruction time scale ~ 0.2 Gyr
 - 球状星団とは重複しない
- $R_{\text{GC}} = 7.5 \sim 15.0$ kpc
 - **outerdiskの研究に適したサンプル**



さて。。。

Schmidt short program
& open cluster ???

木曾ショートプログラム＋散開星団？

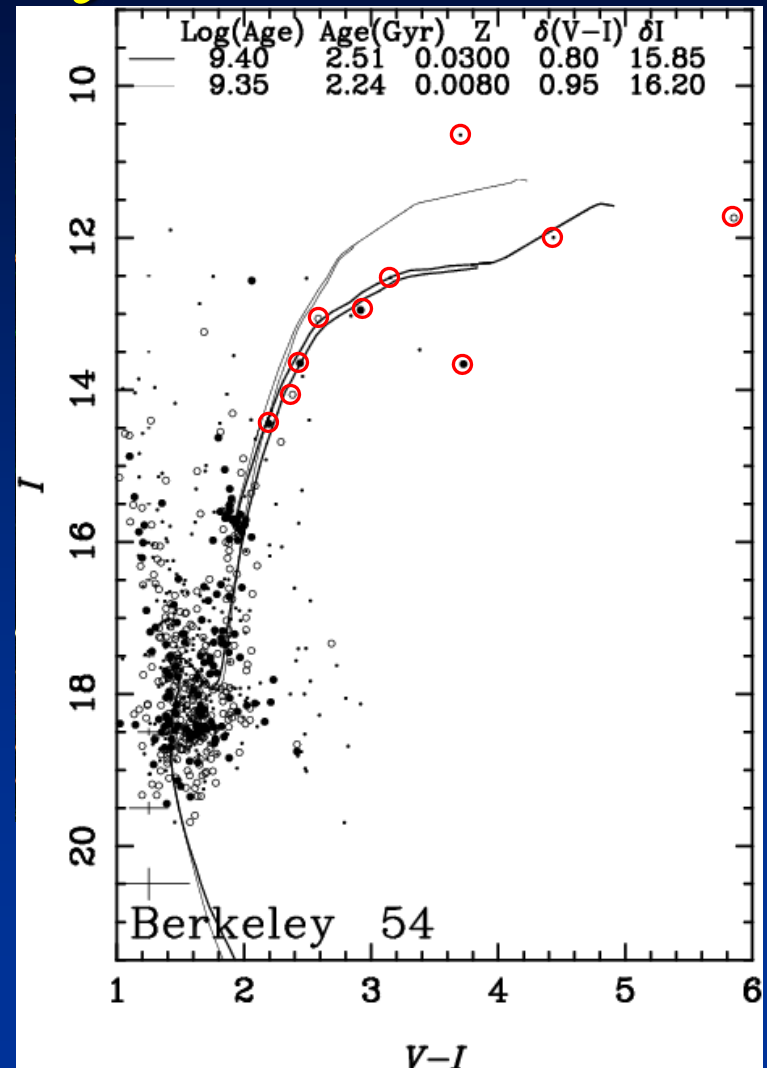
- Mass segregation
 - あるとされているが。。。
 - Harwarden (1975)??, Pandey et al ?
 - 木曾シュミットの広視野に適、相対測光で十分
- 連鎖的星形成？
- 降着星団があればそのtailを検出できるか
 - NGC6791は降着矮小銀河という説もあり、それを確かめられるどうかで方法論を検証
 - SDSS like: 広視野観測に適
- Berkeley 54
 - Unusual mixture of population as a OC ?

Berkeley 54

a rare cluster with many evolved stars?

• 晩期型星の大都会

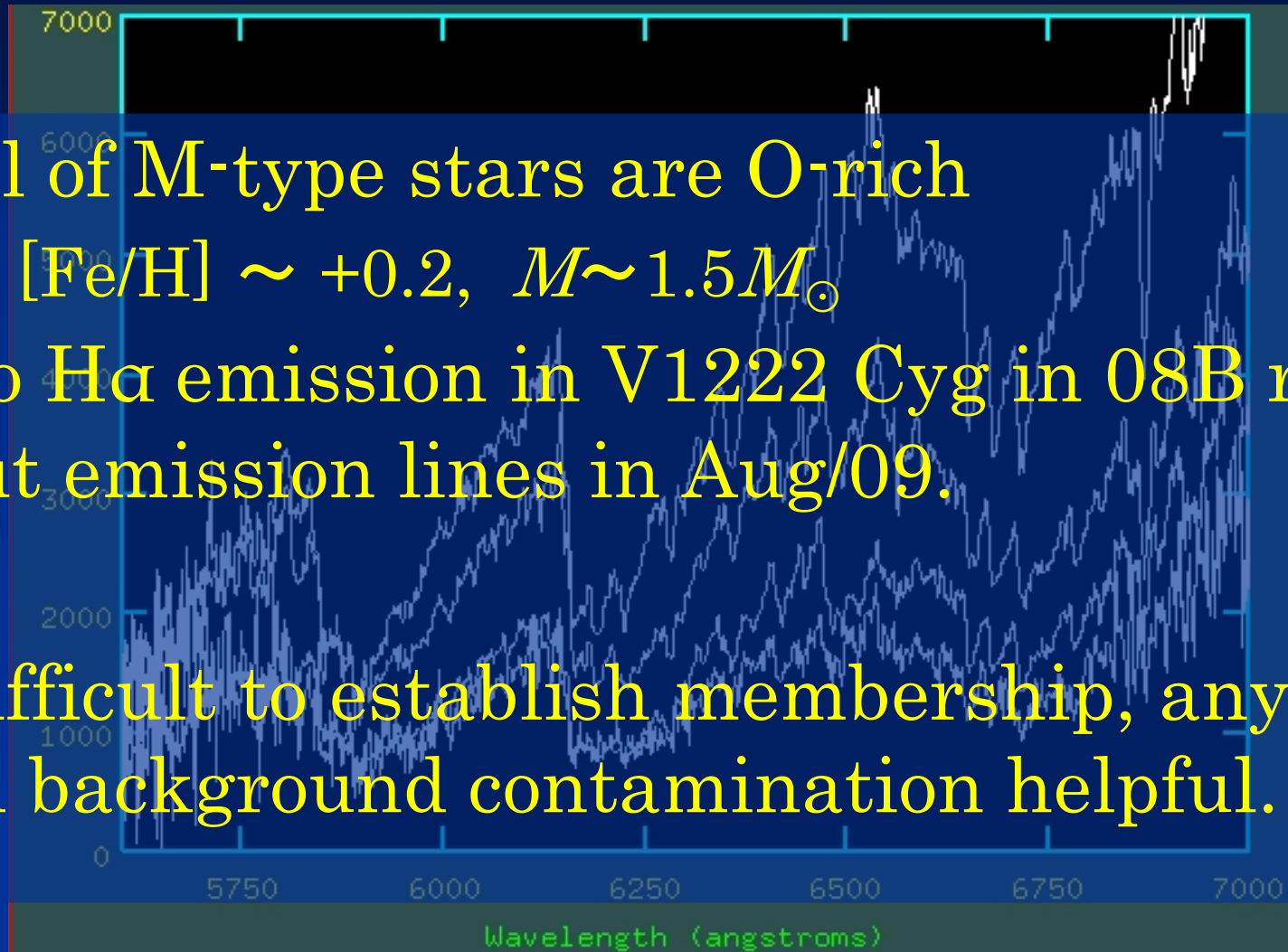
- 変光星 V1222 Cyg
 - 非対称のnebulosity
 - O-rich Mira, emission lines
- 複数のAGB星候補
- 多数のRGB/RC
- 年齢や金属量が主系列から正確にわかる希少サンプルで、mass-lossモデル等に貢献可?
- 一般にovershoot model
 - 1~3 Gyrの不定性



Berkeley 54 (08B)

a rare cluster with many evolved stars

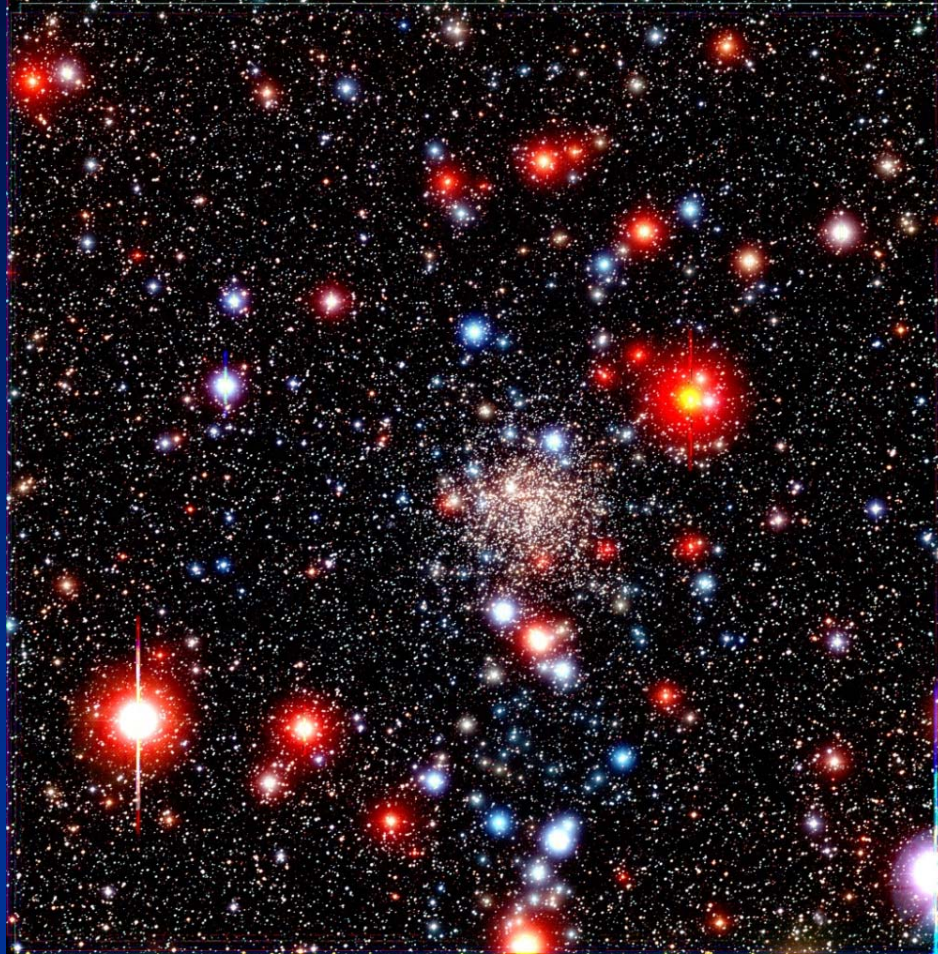
- All of M-type stars are O-rich
 - $[\text{Fe}/\text{H}] \sim +0.2$, $M \sim 1.5M_{\odot}$
- No H α emission in V1222 Cyg in 08B run, but emission lines in Aug/09.
- Difficult to establish membership, any hint on background contamination helpful.



観測諸元

日時	2009年11月5～7日
装置	Kiso Schmidt + 2KCCD
フィルター	<i>B</i> 、 <i>V</i> 、 <i>R</i> 、 <i>I</i> 、 <i>Hα</i>
Seeing	2.7～4.0 arcsec ?
天候	(おおむね)晴れ
対象	NGC 6791, Berkeley 54/36
標準星	分散 0.08mag(I) ???? cf. $\geq 0.02\text{mag}$ (I) at GAO

So far, so good...

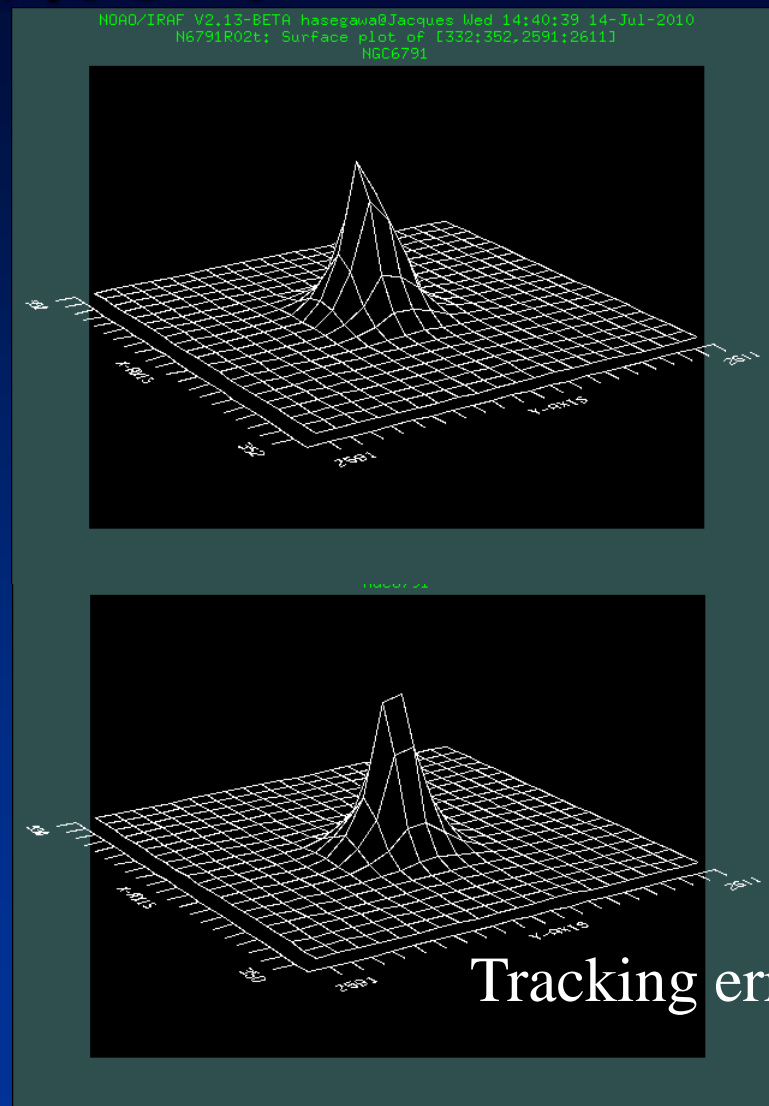
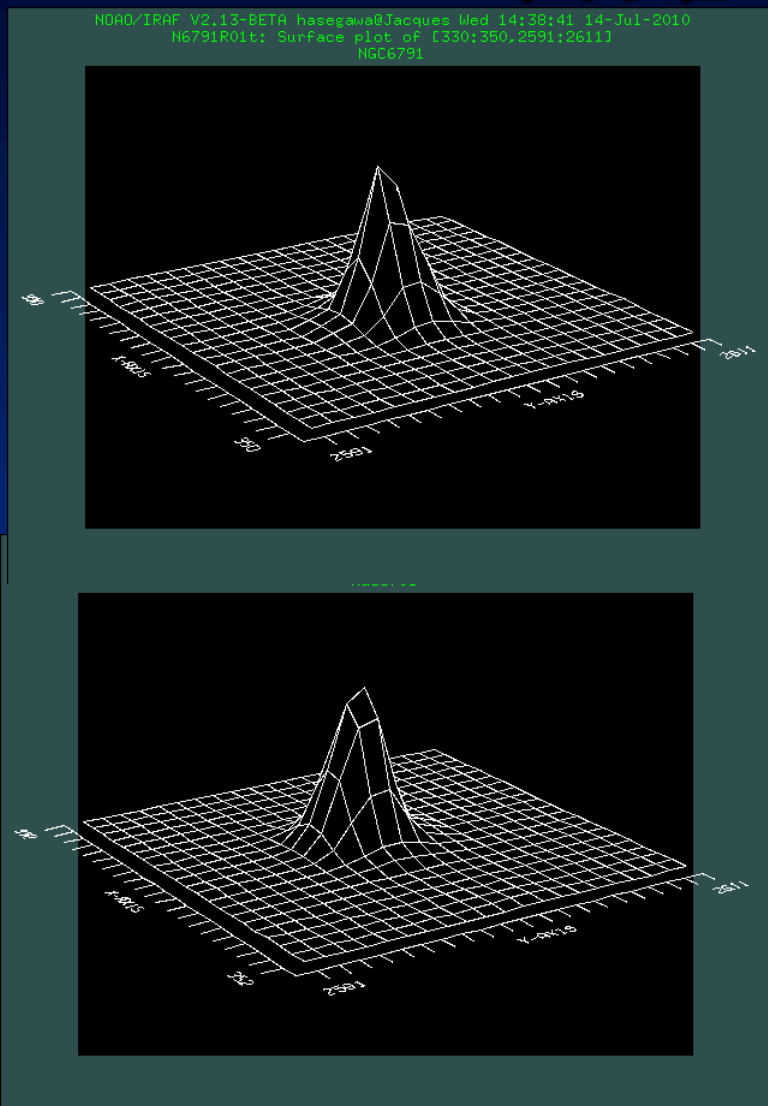


NGC 6791



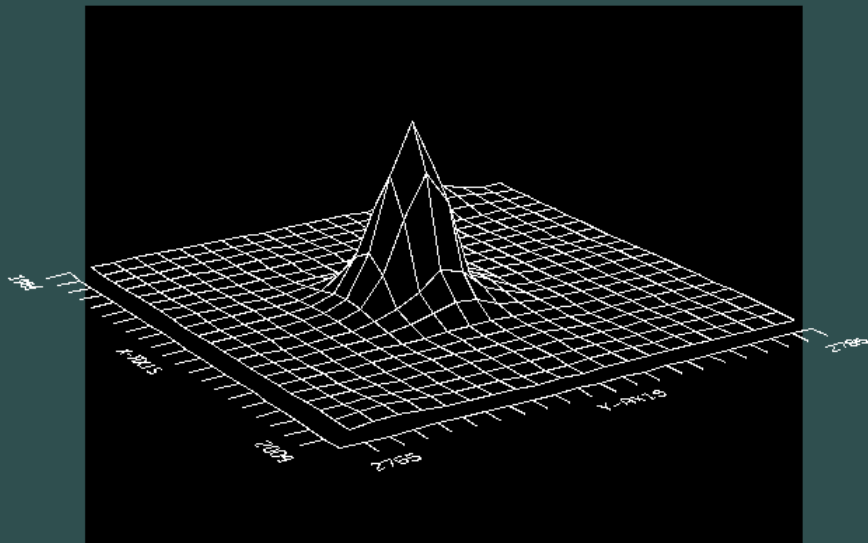
Berkeley 54

苦難の始まり

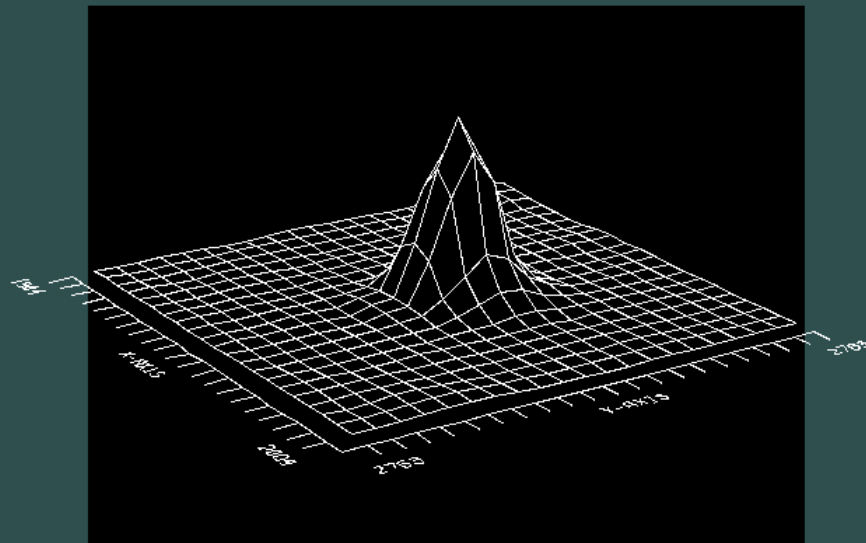


The same star on 4 exps with R-band, no saturation.

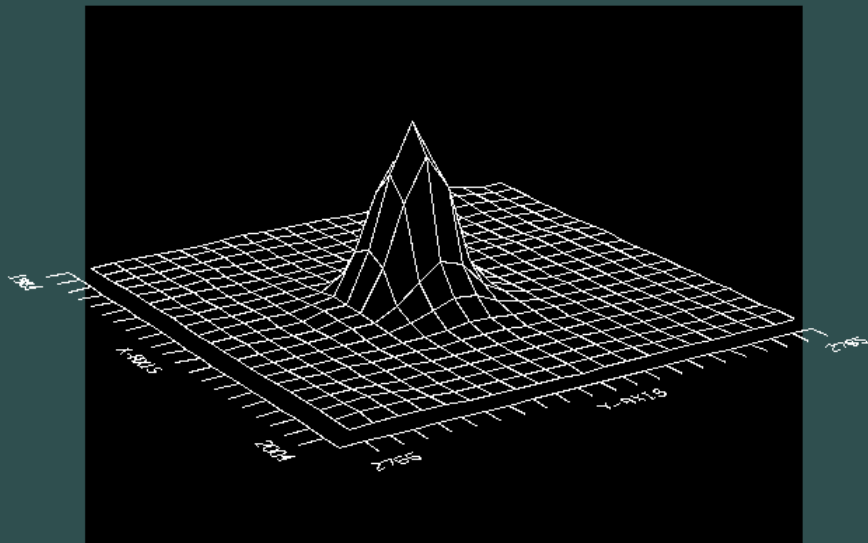
NOAO/IRAF V2.13-BETA hasegawa@Jacques Wed 14:43:55 14-Jul-2010
N6791R01t: Surface plot of [1984;2004.2765;2785]
NGC6791



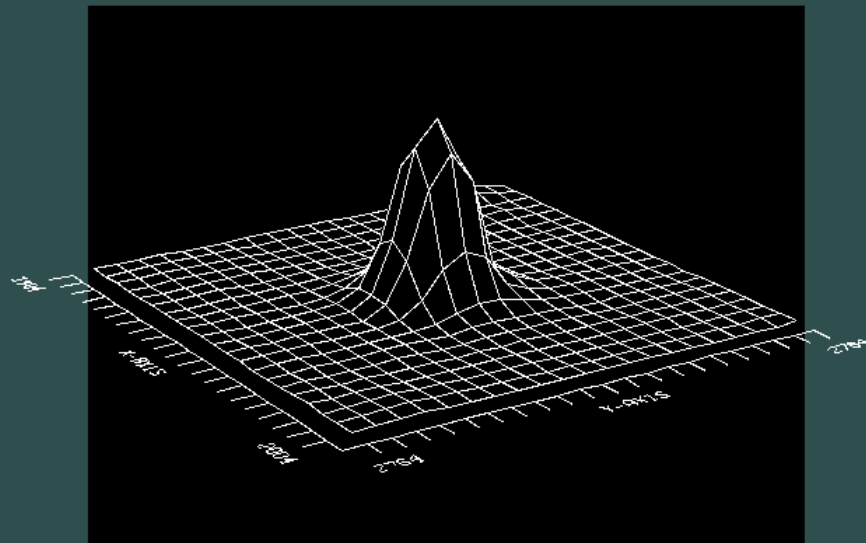
NOAO/IRAF V2.13-BETA hasegawa@Jacques Wed 14:46:04 14-Jul-2010
N6791R02t: Surface plot of [1984;2004.2763;2783]
NGC6791



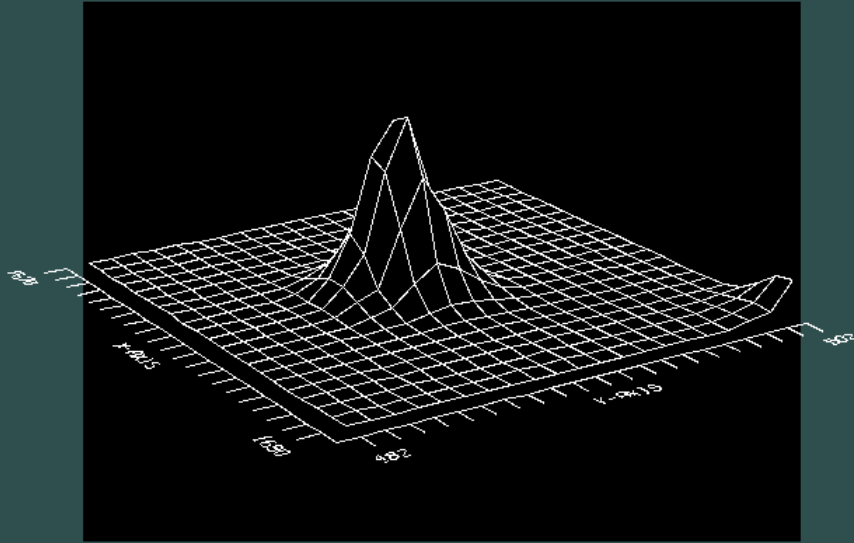
NOAO/IRAF V2.13-BETA hasegawa@Jacques Wed 14:44:33 14-Jul-2010
N6791R02t: Surface plot of [1984;2004.2765;2785]
NGC6791



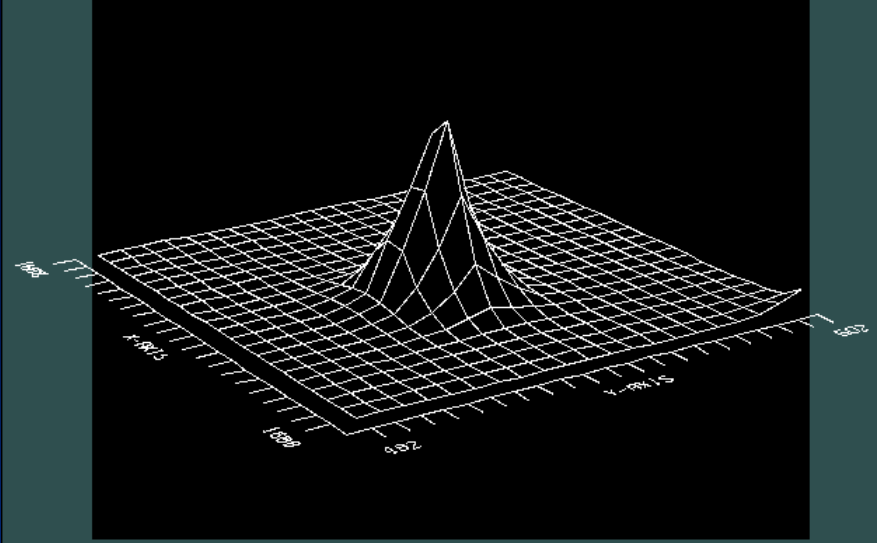
NOAO/IRAF V2.13-BETA hasegawa@Jacques Wed 14:42:59 14-Jul-2010
N6791R04t: Surface plot of [1984;2004.2764;2784]
NGC6791



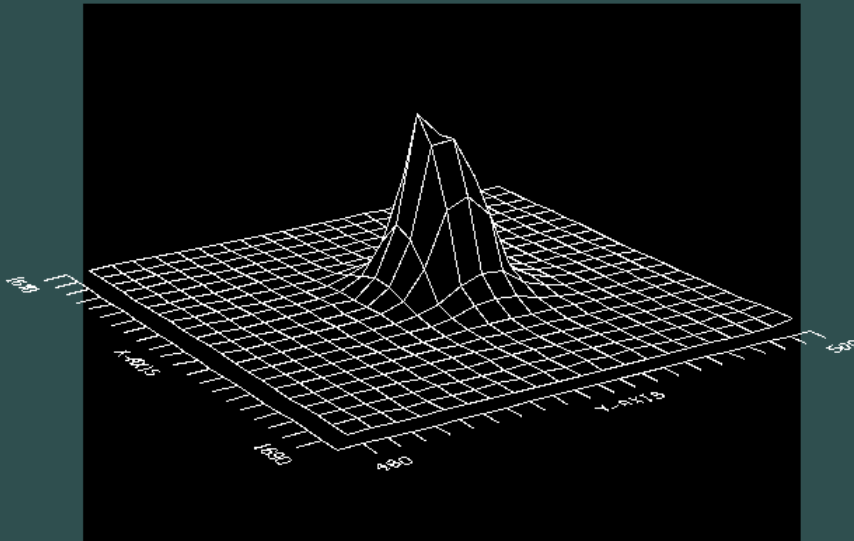
NOAO/IRAF V2.13-BETA hasegawa@Jacques Wed 14:53:53 14-Jul-2010
N6791R01t: Surface plot of [1670:1690,482:502]
NGC6791



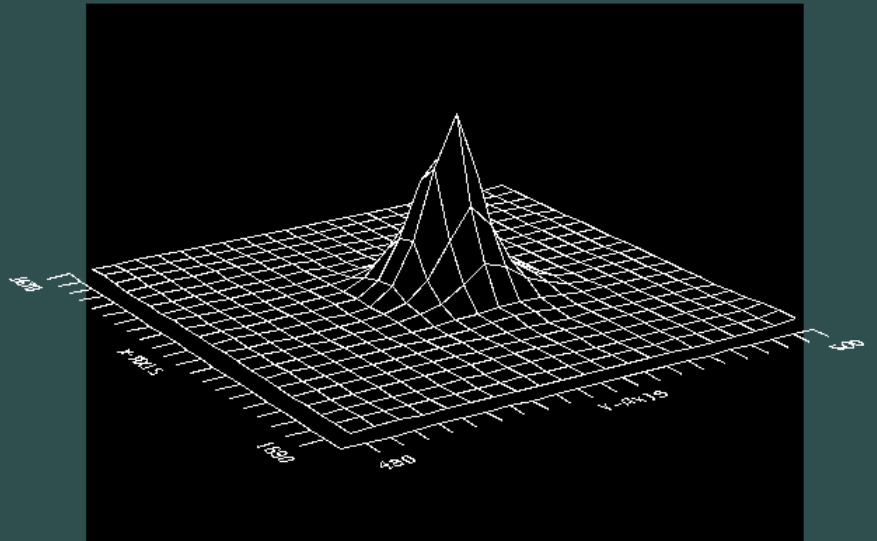
NOAO/IRAF V2.13-BETA hasegawa@Jacques Wed 14:54:26 14-Jul-2010
N6791R02t: Surface plot of [1668:1688,482:502]
NGC6791



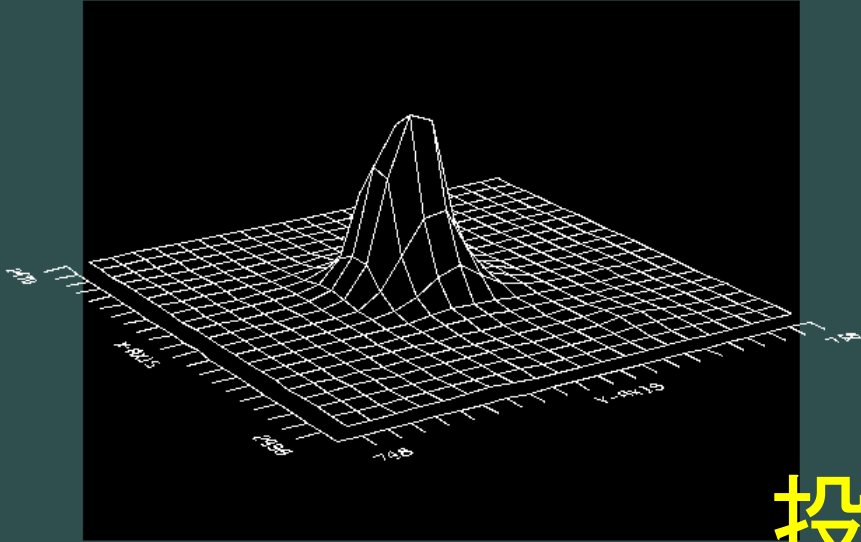
NOAO/IRAF V2.13-BETA hasegawa@Jacques Wed 14:52:35 14-Jul-2010
N6791R03t: Surface plot of [1670:1690,480:500]
NGC6791



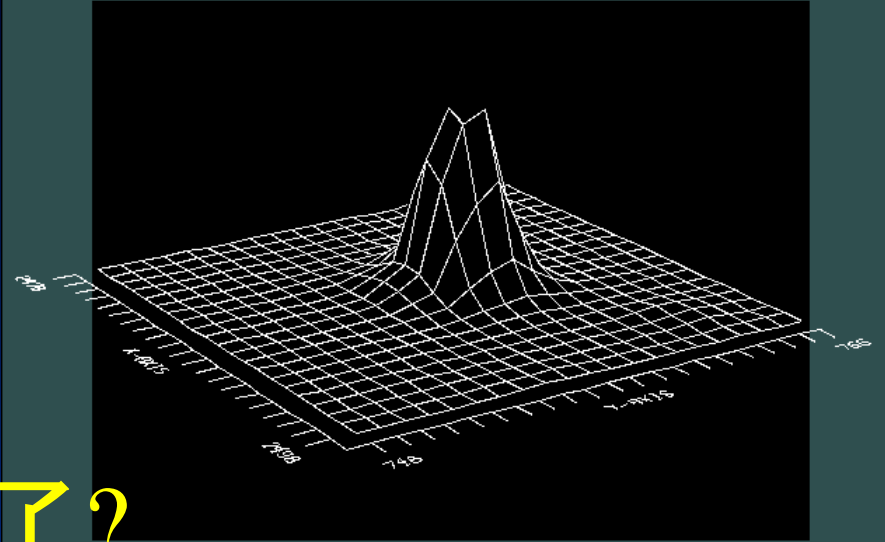
NOAO/IRAF V2.13-BETA hasegawa@Jacques Wed 14:55:08 14-Jul-2010
N6791R04t: Surface plot of [1670:1690,480:500]
NGC6791



NDAO/IRAF V2.13-BETA hasegawa@Jacques Wed 14:57:02 14-Jul-2010
N6791R01t: Surface plot of [2478:2498,748:768]
NGC6791

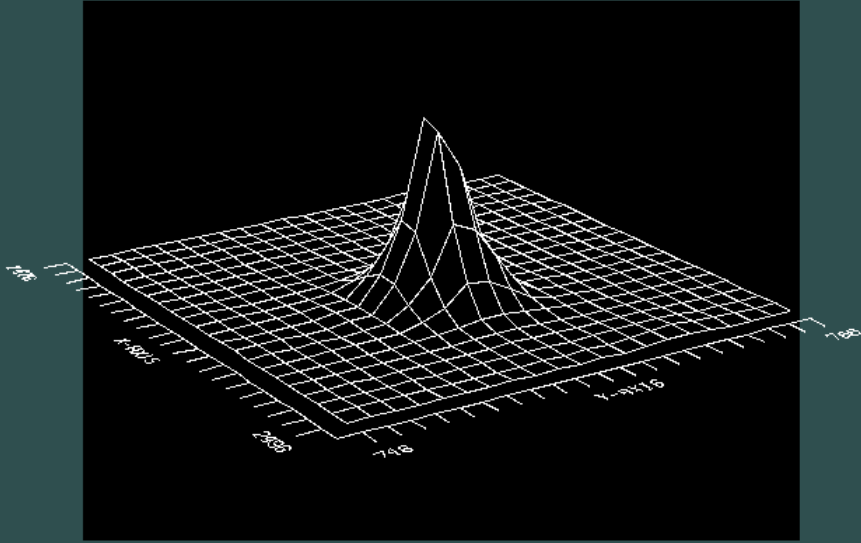


NDAO/IRAF V2.13-BETA hasegawa@Jacques Wed 15:09:46 14-Jul-2010
N6791R02t: Surface plot of [2478:2498,746:766]
NGC6791

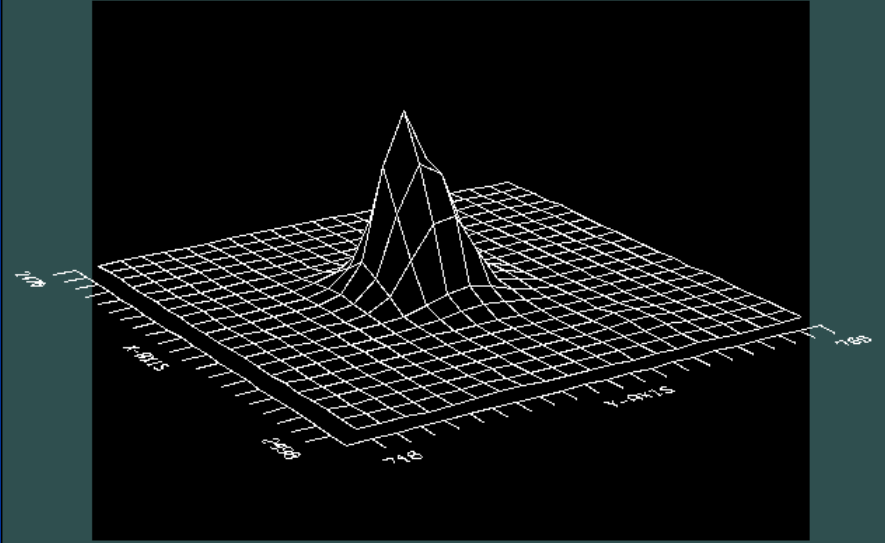


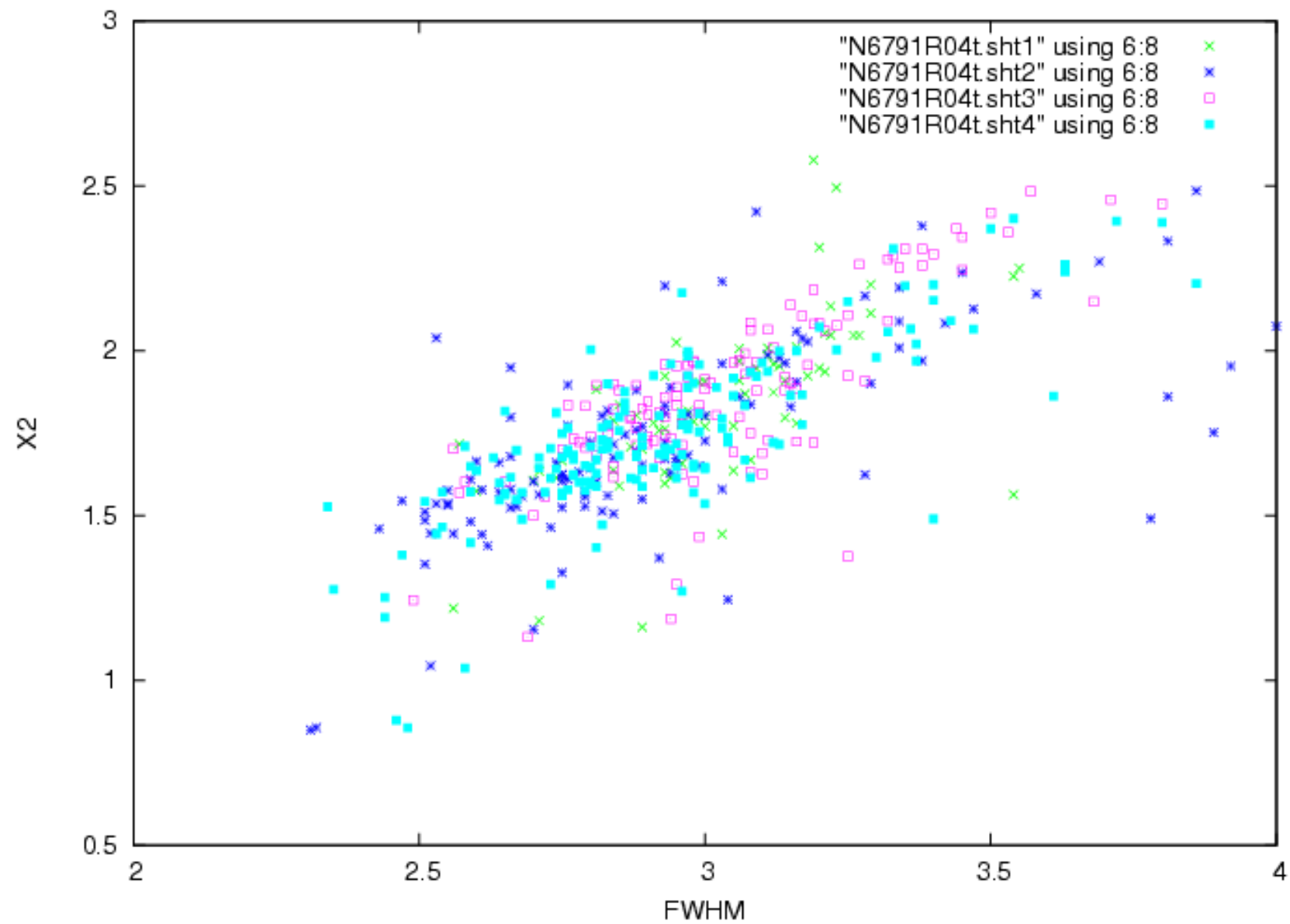
投了?

NDAO/IRAF V2.13-BETA hasegawa@Jacques Wed 15:10:16 14-Jul-2010
N6791R03t: Surface plot of [2476:2496,748:768]
NGC6791

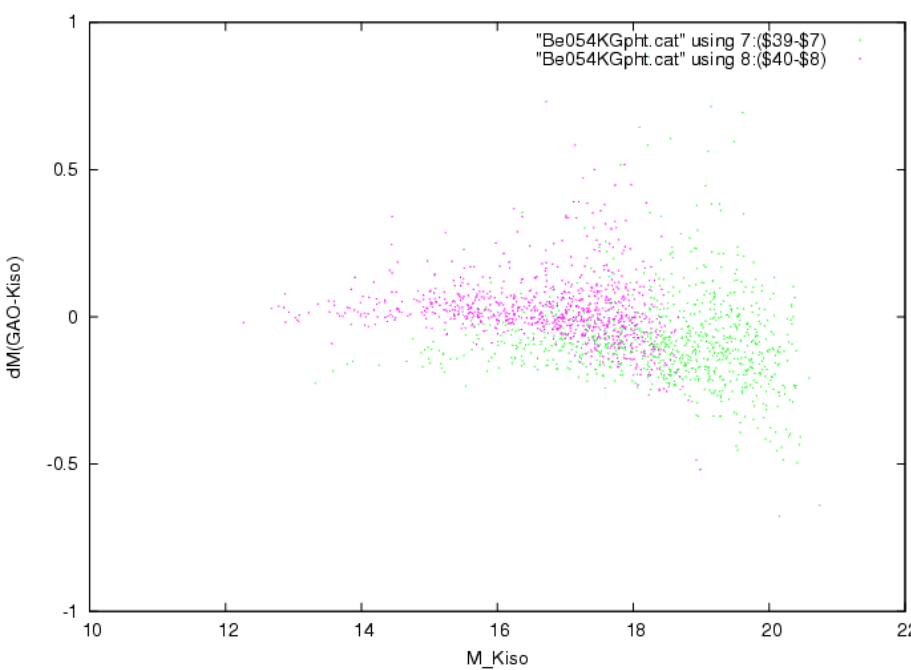
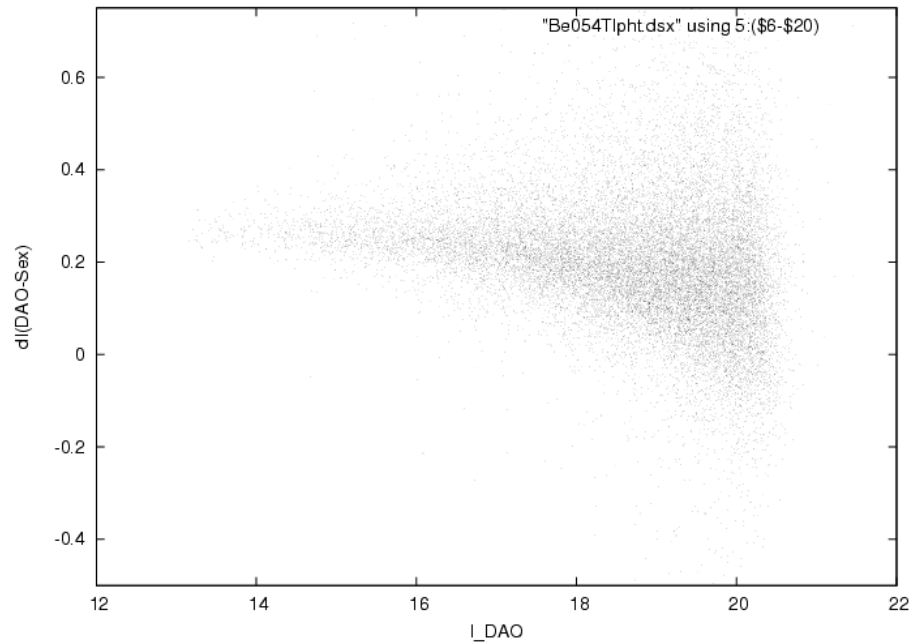
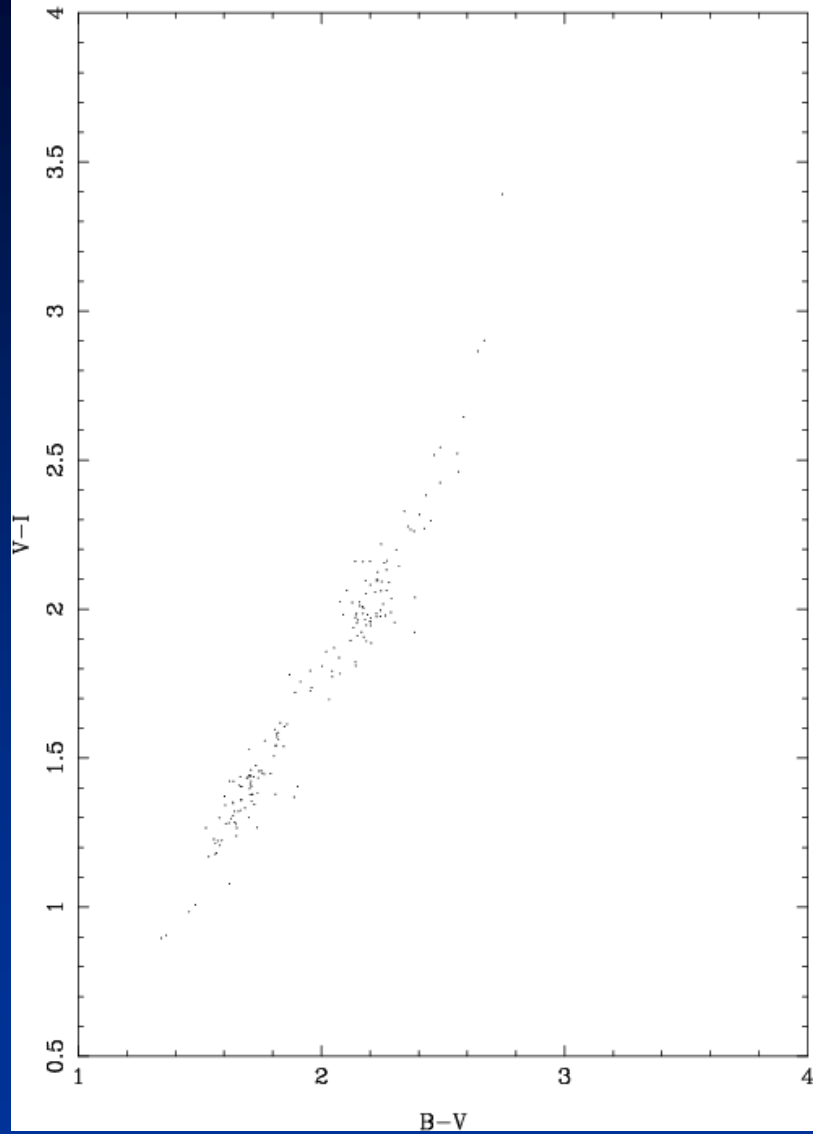


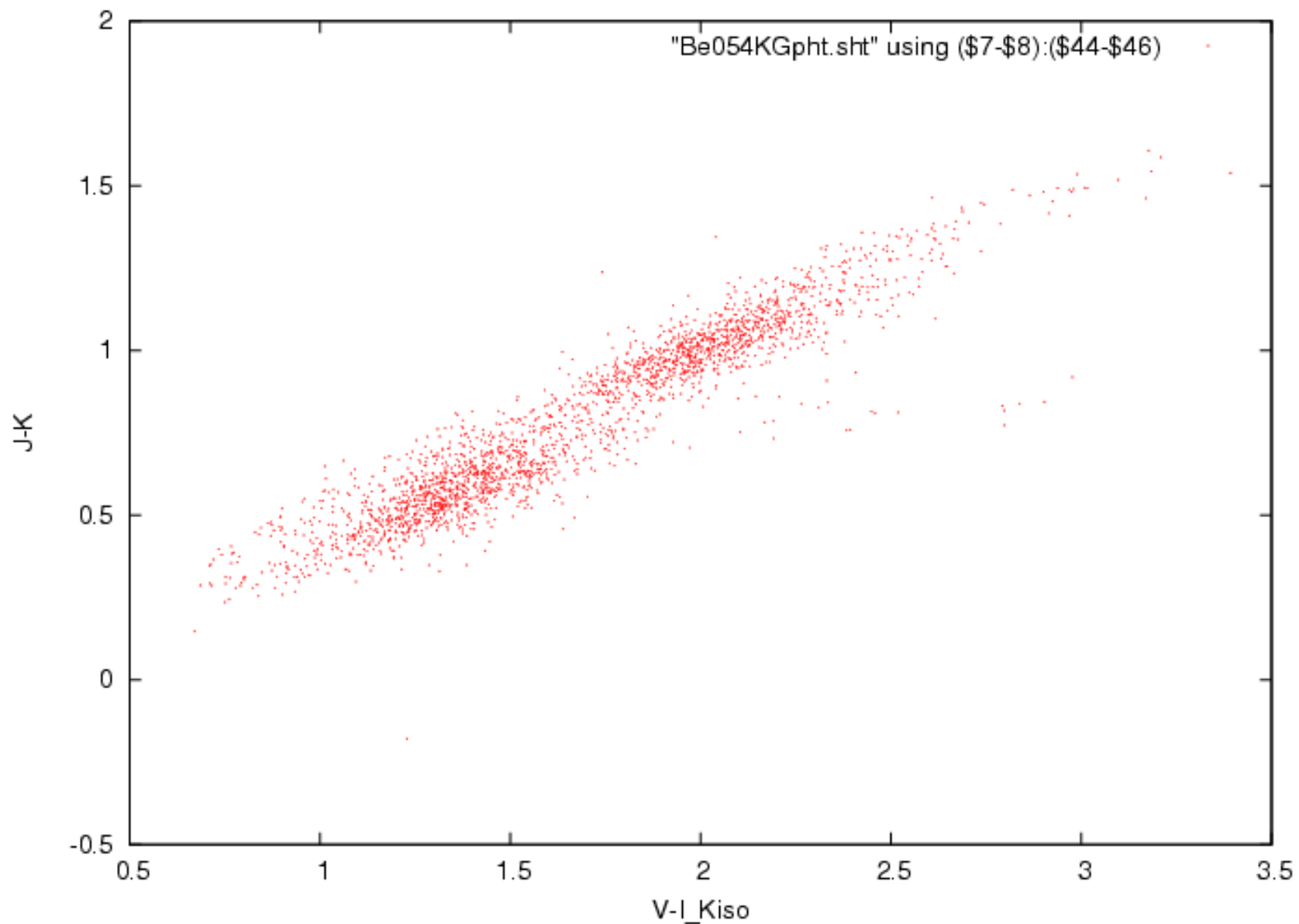
NDAO/IRAF V2.13-BETA hasegawa@Jacques Wed 14:56:02 14-Jul-2010
N6791R04t: Surface plot of [2478:2498,748:768]
NGC6791

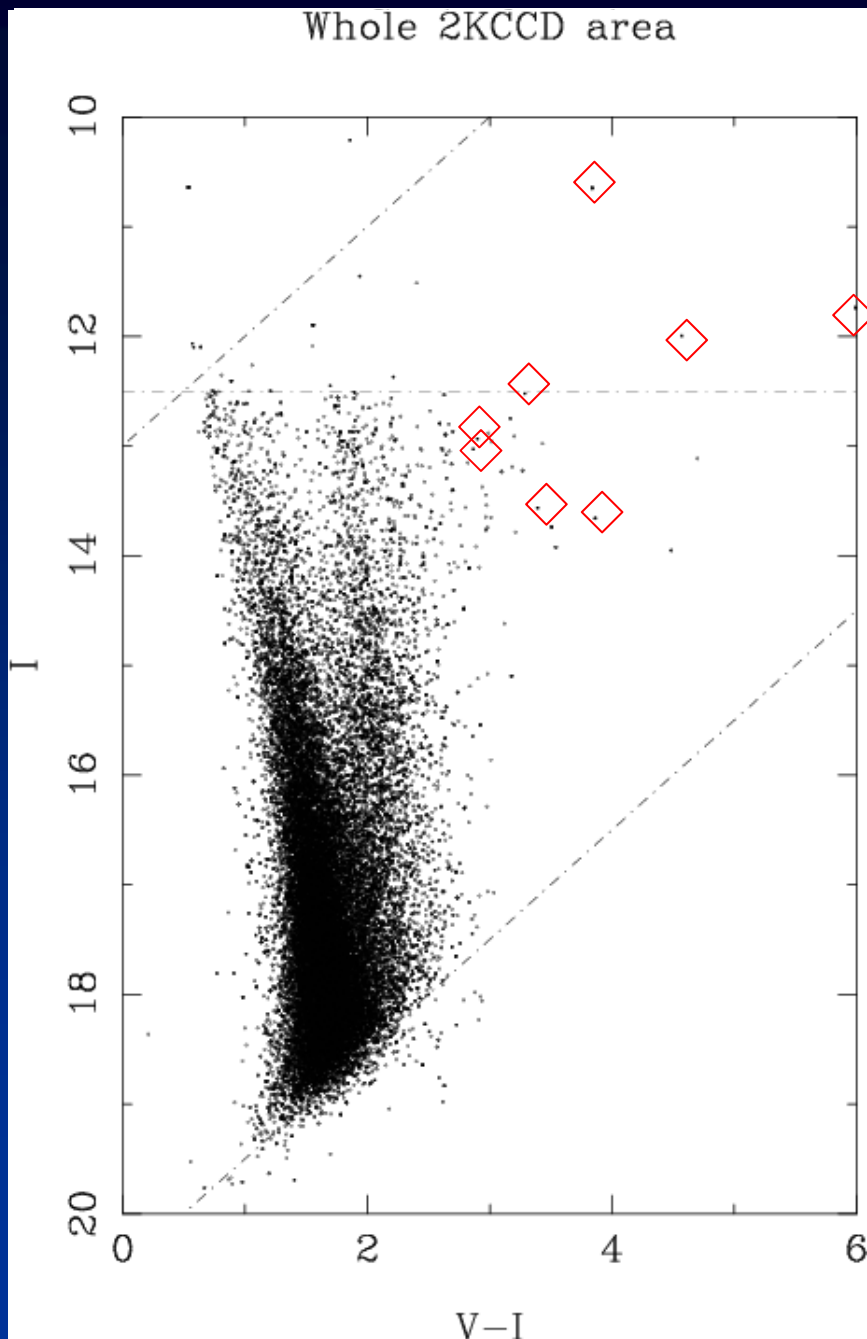




Central part





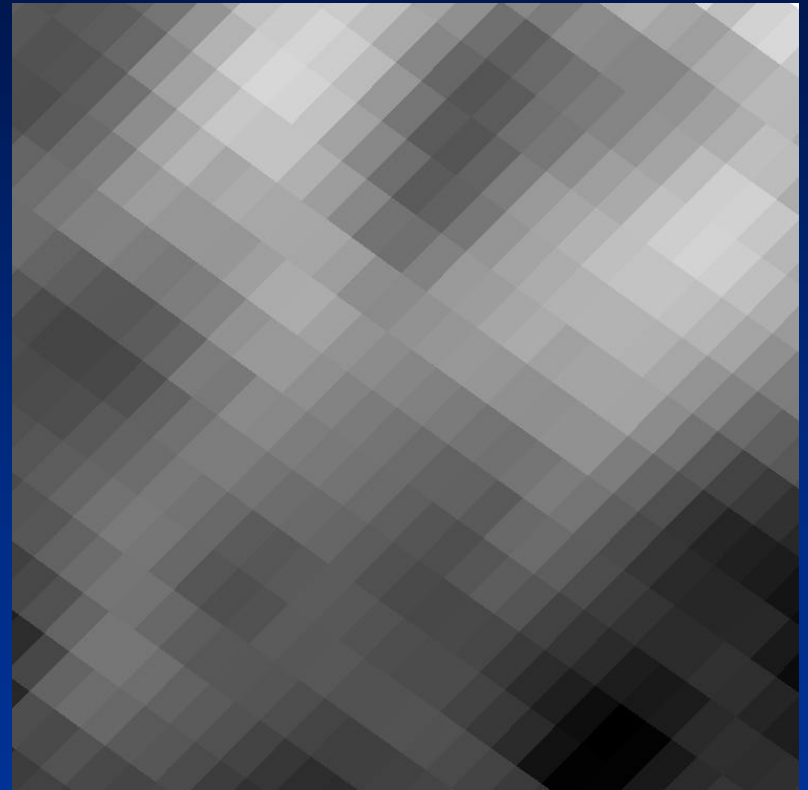


- 25倍広い視野でも $V-I > 2.75$ の星はほとんどない。
- Be54 のAGB領域の contaminationは非常に少ない。
 - Almost free from the photometric error
 - 深さはGAOとほぼ同じ
 - Clock pattern ?
- すぐ南の領域も観測。後日検証。
- ショートが必要？

Differential reddening



$$E(B-V) = 1.1 \sim 1.2$$



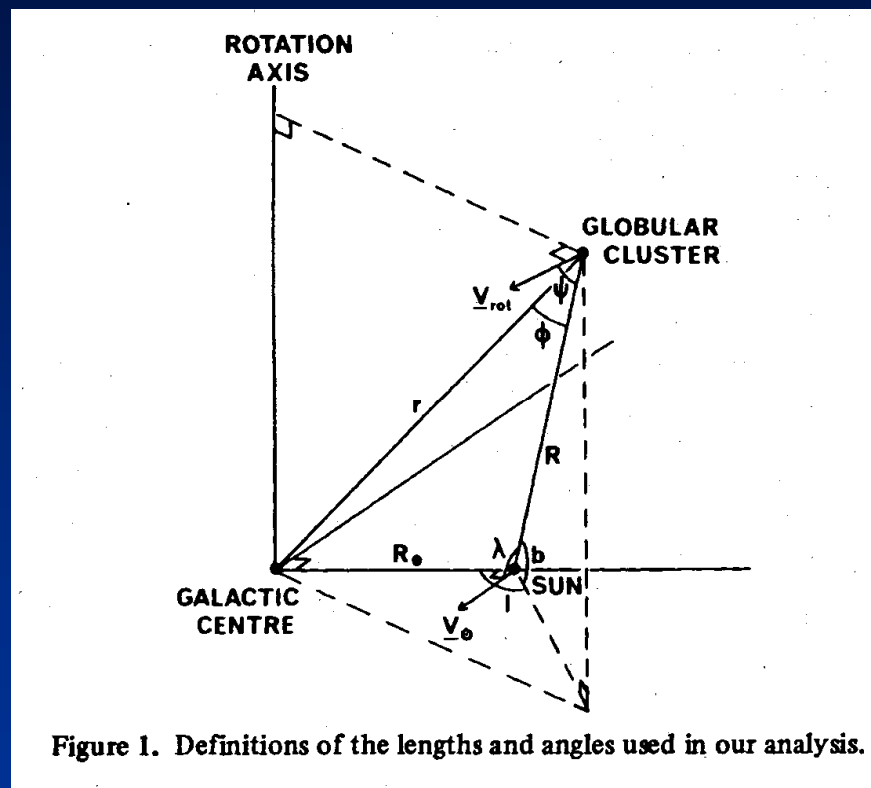
$$(45 \times 45 \text{ arcmin}^2)$$

What's Going on about Be 54

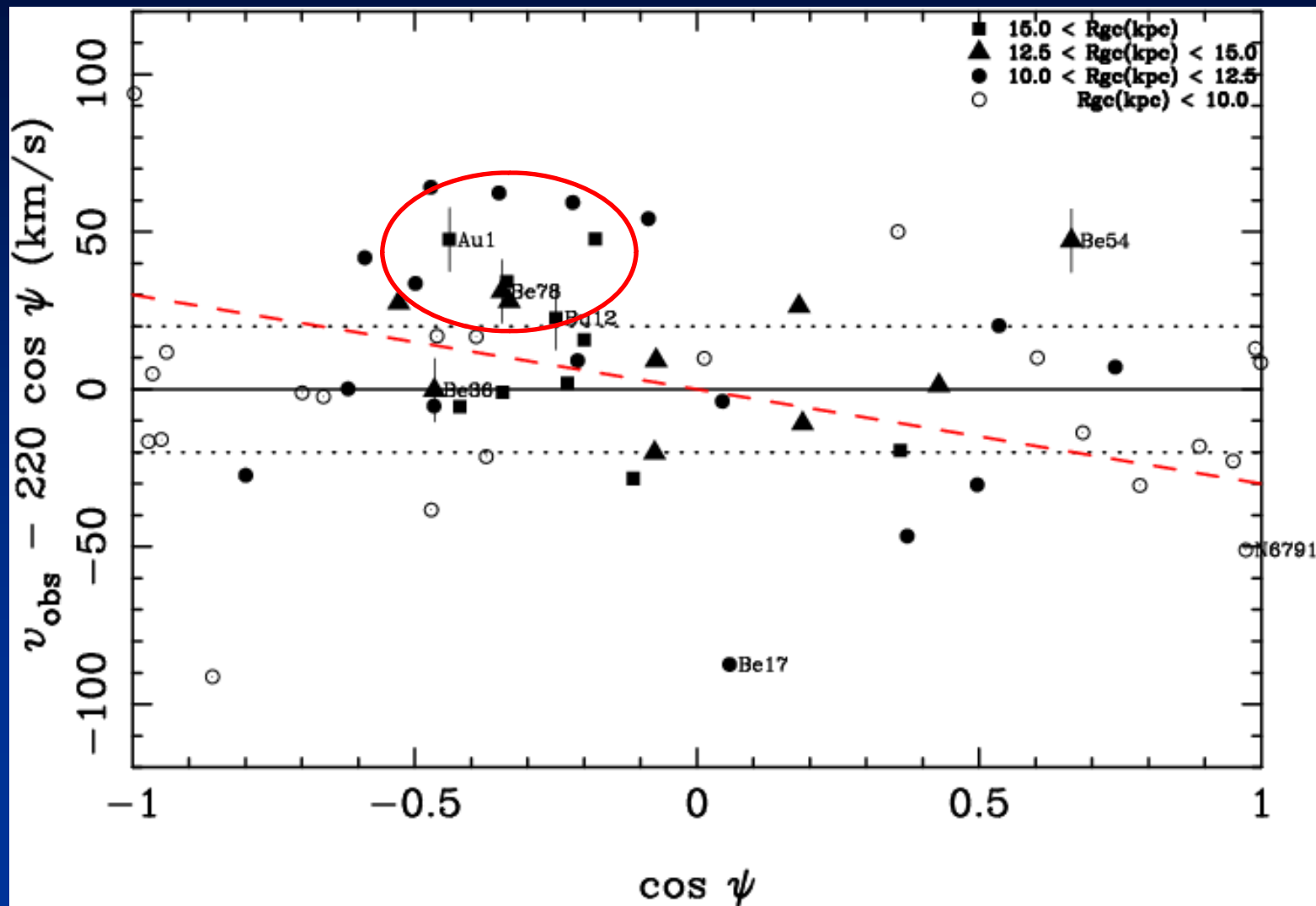
- 変光星の光度曲線
- 視線速度の測定
 - K-giants w/OAO-KOOLS
 - M-giants w/OAO-KOOLS+Lick-KAST
- V1222 Cygの「あかり」衛星による観測
- SiOメーザー観測(1回目、受からず)

銀河回轉

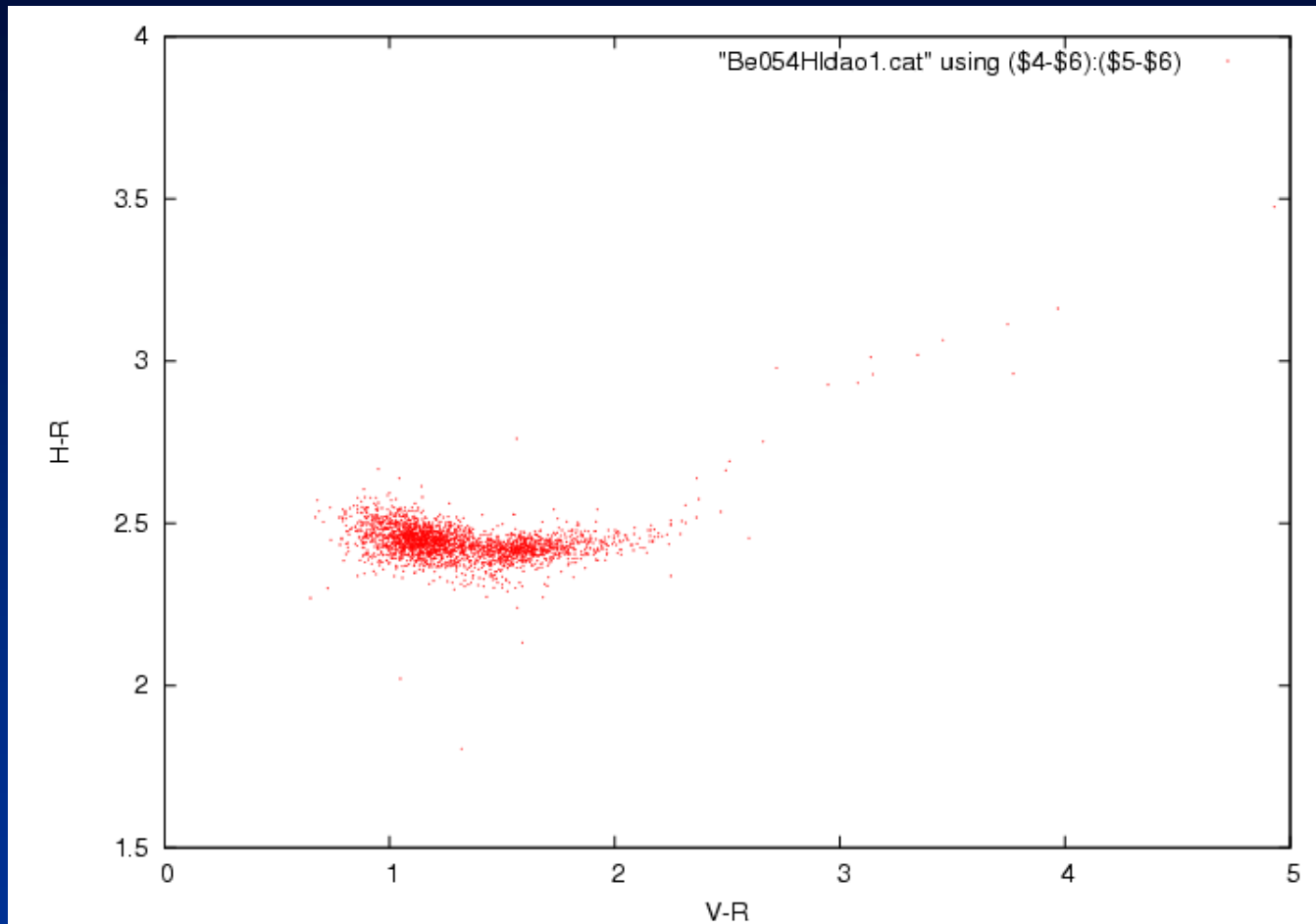
- $V_{\text{obs}} = V_{\text{rot}} \cos \psi$
(Frenk & White 1980)
 - originally devised for globulars
- Friel (1989)
 - $v_{\text{rot}} = 190 \text{ km/s}$ (23 old OCs)
 - slow rotation ?
- Scott (1995)
 - $v_{\text{rot}} = 210 \text{ km/s}$ (35 old OCs)
 - consistent with young clusters in Hron (87) ?



Dynamics of selected clusters



付録: H α 輝線星



- 思ったより(期待したより)少ない？
- 銀河面カタログの参照。。。後日。