

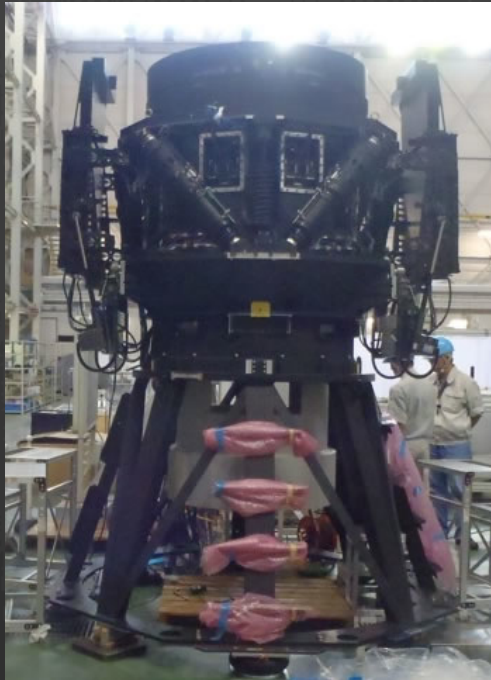
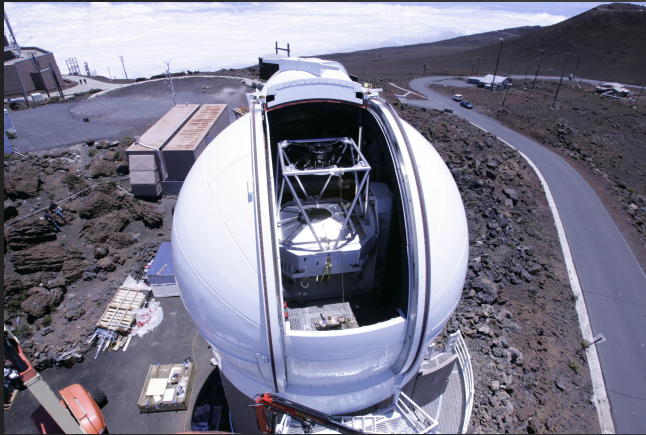
Orphan GRBs & Unusual Transients

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Time Domain Sciences @Taiwan

- ❁ Pan-STARRS-1 (国立中央大学) 2005~
 - ❁ Solar-system, variable stars, **Transients**
- ❁ SUBARU/HSC (ASIAA + Universities) 2006~
 - ❁ **Transients**, variable stars, weak lensing, galaxies...
- ❁ 台湾ローカル望遠鏡@鹿林山観測所(1m, 0.5m)
 - ❁ GRB afterglow, SNe follow-up, Fermi unID objects(新種パルサー, AGN), AGN monitoring, Solar-system, variable stars etc



Transients as High-z probes

0. Pair Instability Supernova

1. Orphan GRBs (so no quick follow-ups)

理論的に予想された天体现象

まずは発見. (Subaru HSCで初検出? !)

WISH で統計とhigh-z

2. Unusual Energetic Optical Transient

新種のイベント? (SDF05-M05)

3. Ultra-Luminous optical transients (or SNe)

既知の天体 (正体はまだ不明)

Pan-STARRS-1 (2m) で $z \sim 2$ まで検出

Pan-STARRS MDS 1 event / month

Subaru SC/HSC で $z=4 \sim 6$ まで検出予定

4. Luminous Type IIIn SNe

既知の天体

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挑戦的

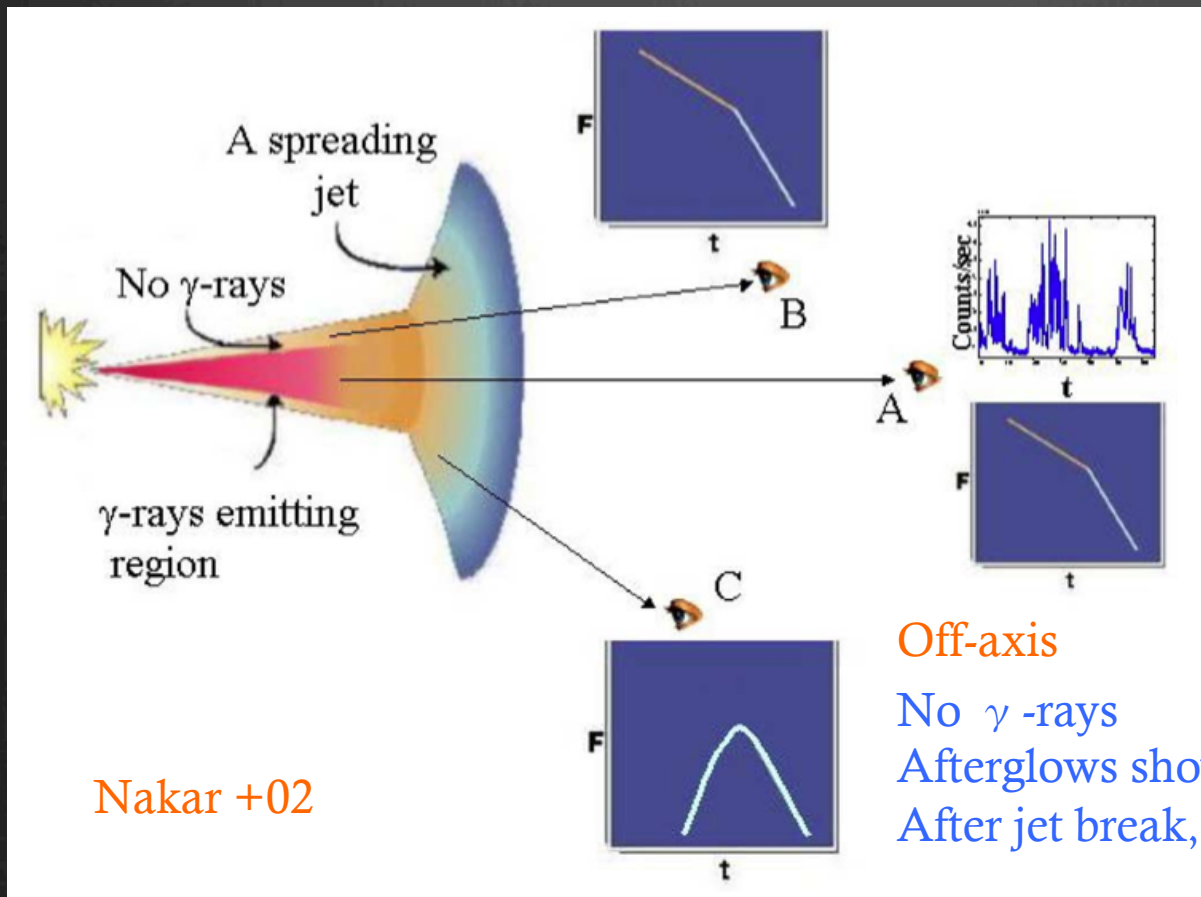


確実性が高い

1. Orphan GRB afterglow

GRB collimated Jet

Energetics $E_{\text{iso}} \sim 10^{53-54} \rightarrow$ Jet corrected $\sim 10^{51}$
Achromatic temporal break in afterglow light curves



(but Chromatic breaks,
no jet breaks....)

On-axis Orphan
(Nakar+02)
Failed GRBs
(Huang+02)
Short GRBs

Off-axis

No γ -rays

Afterglows show rise and fall

After jet break, the properties are similar

Nakar +02

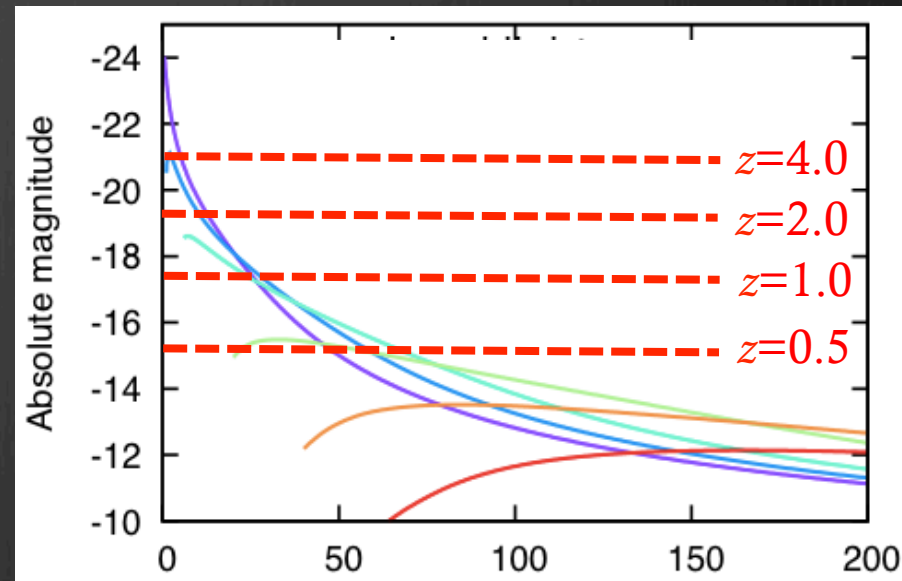
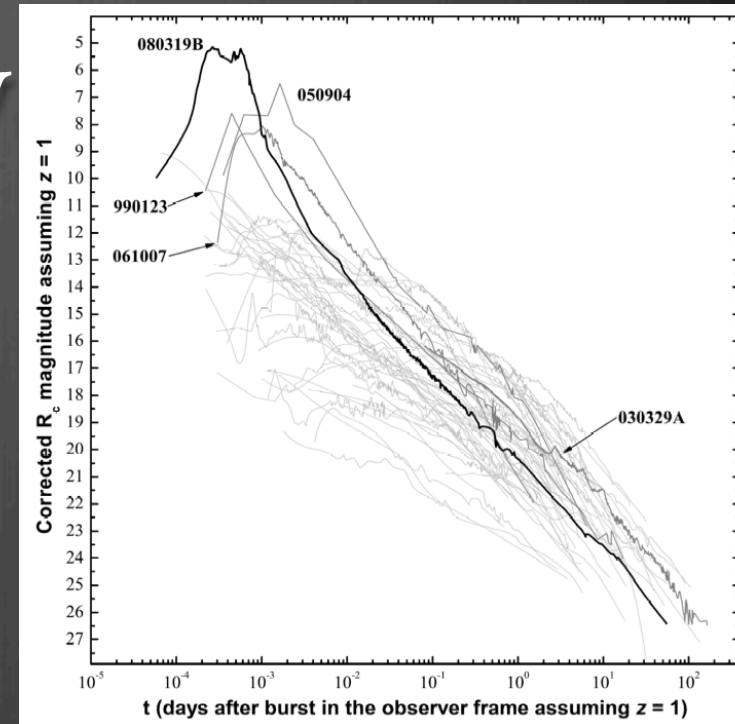
Off-axis orphan GRB afterglow = direct evidence of jet collimation

1. Orphan afterglow

- 広視野サーベイ
 - ガンマ線観測 : Swift/BAT 120 x 90 deg :
 - ~ 100 events / year
- Deep imaging (~ 26.5 mag)
median redshift $z \sim 2$
- Cadence of the survey (days scale)
- 多色観測 (monthly~ year)



HSC, WISH



Orphan GRB surveys

- 発見は、HSC?!
- 統計と発生率 @ $z < 1\sim 2$ with WISH
- On-axis orphan GRB at high- z ($z=7\sim 10$) with WISH

3. Planned HSC Survey

- ☉ Three layer (wide, deep ultra-deep) survey with grizy
- ☉ Aiming 300 nights survey over 5 years (2013 – 2018)

Table 3.1: A quick summary of HSC-wide, deep and ultra-deep surveys

Survey	Area [sq. deg.]	Depth [AB, 5σ , 2'']	Key Sciences
Wide	1500-2000	<i>grizy</i> ($i \sim 25.8$)	Cosmology, Clusters, QSOs
Deep	~ 30	<i>grizy</i> +NBs ($i \simeq 27.2$)	Galaxies, QSO/AGN, Clusters, SNe
Ultra-Deep	~ 2 HSC FoVs	<i>grizy</i> +NBs ($i \simeq 28$)	high- z galaxies (LAEs, LBGs), SNe

Time Domain Survey

Limit for 1 visit

Filter	Limit (5σ)
g	26.9
r	26.6
i	26.6
z	25.7

	HSC Deep	HSC Ultra-Deep
FOV (sq. deg)	30	4
Epoch (each filter)	12	28
Totani and Panaitescu(2002)	35	9
Nakar&Piran (2002)	5	2
Rossi+08	1	0.14

Expected

1- 44 events
(Total)

350 SNIa (180@ $z>1$)

Orphan GRB surveys

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- ❷ 統計と発生率 @ $z < 1\sim 2$ with WISH
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WISHで捉えられるであろう光度曲線を計算

Relativistic hydrodynamic simulation code

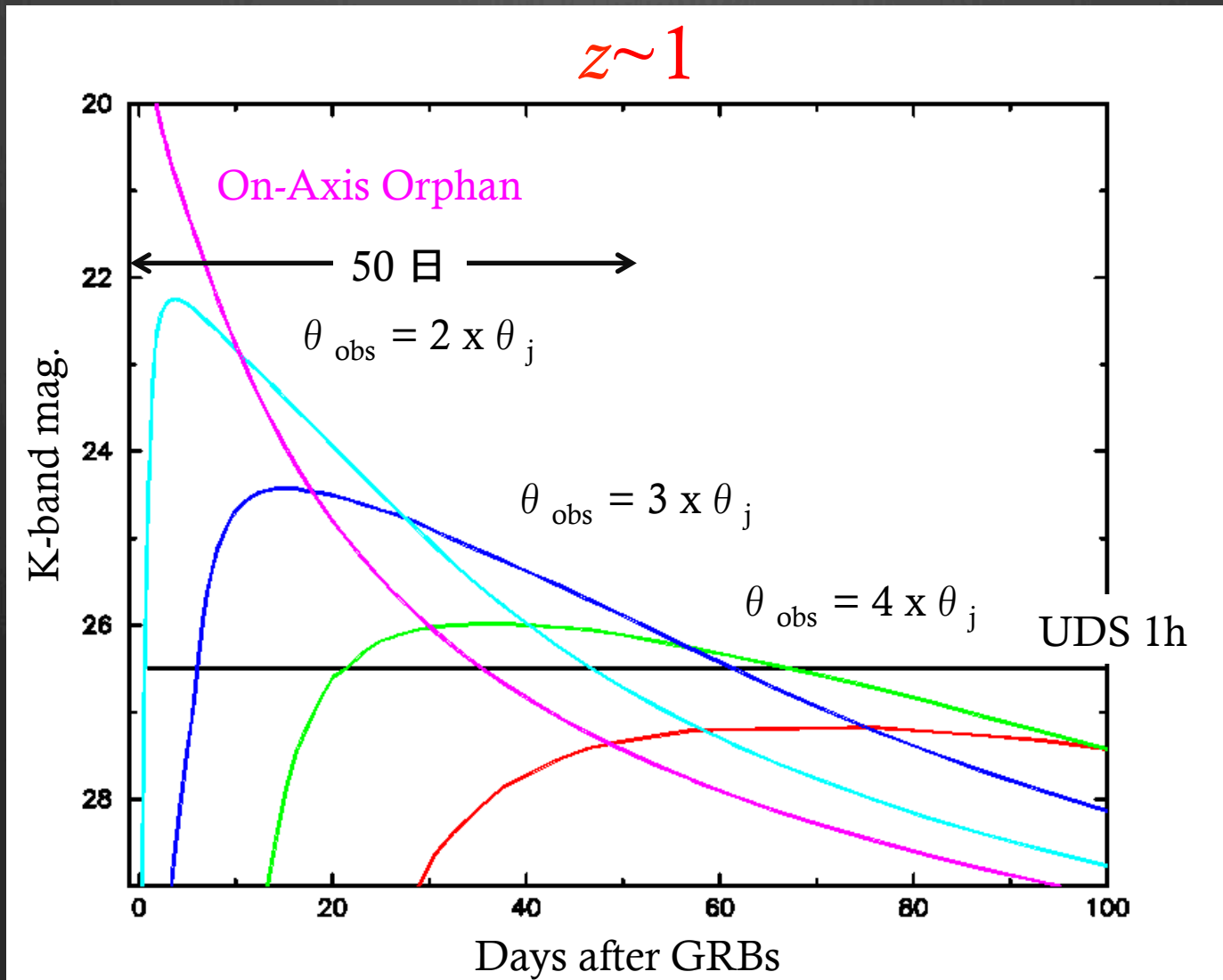
(Zhang & MacFadyen, 2006, ApJS, 164, 255, Van Eerten et al. 2012, ApJ, 749, 44)

ジェットの開き角 10 deg

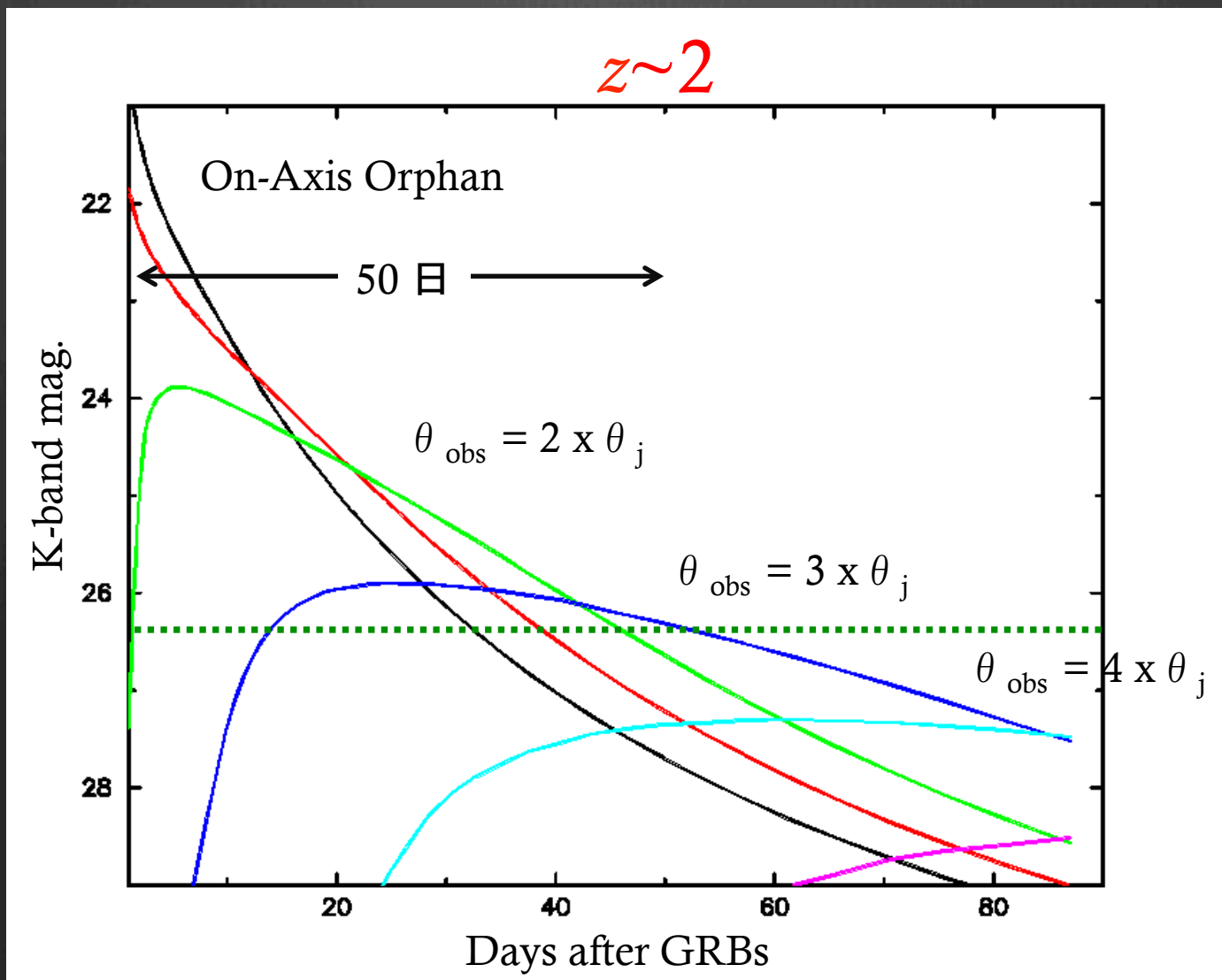
$E_{\text{total}} = 1 \times 10^{53} \text{ erg}$

ISM density 1 cm^{-3}

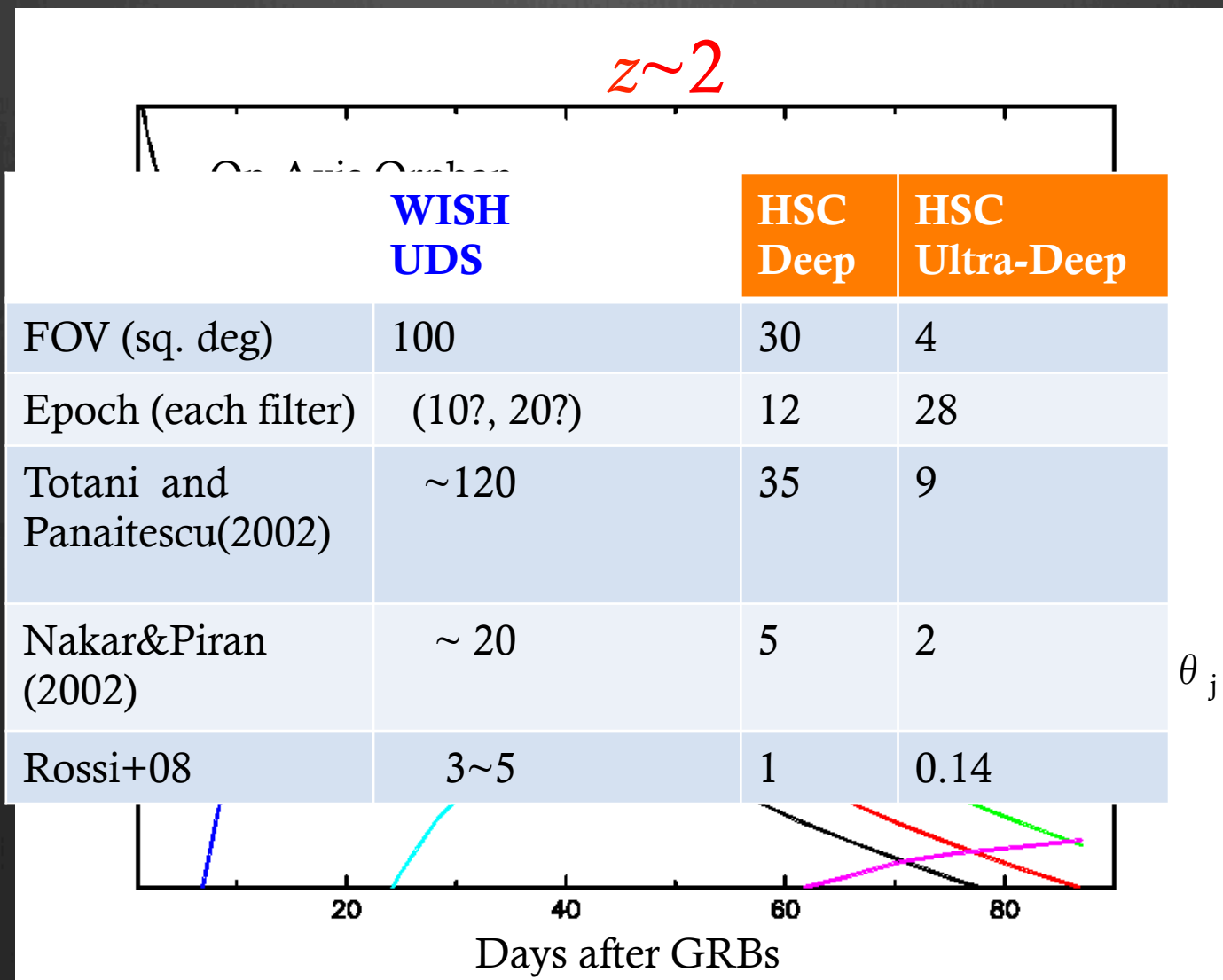
予想されるK-band光度曲線 (z=1)



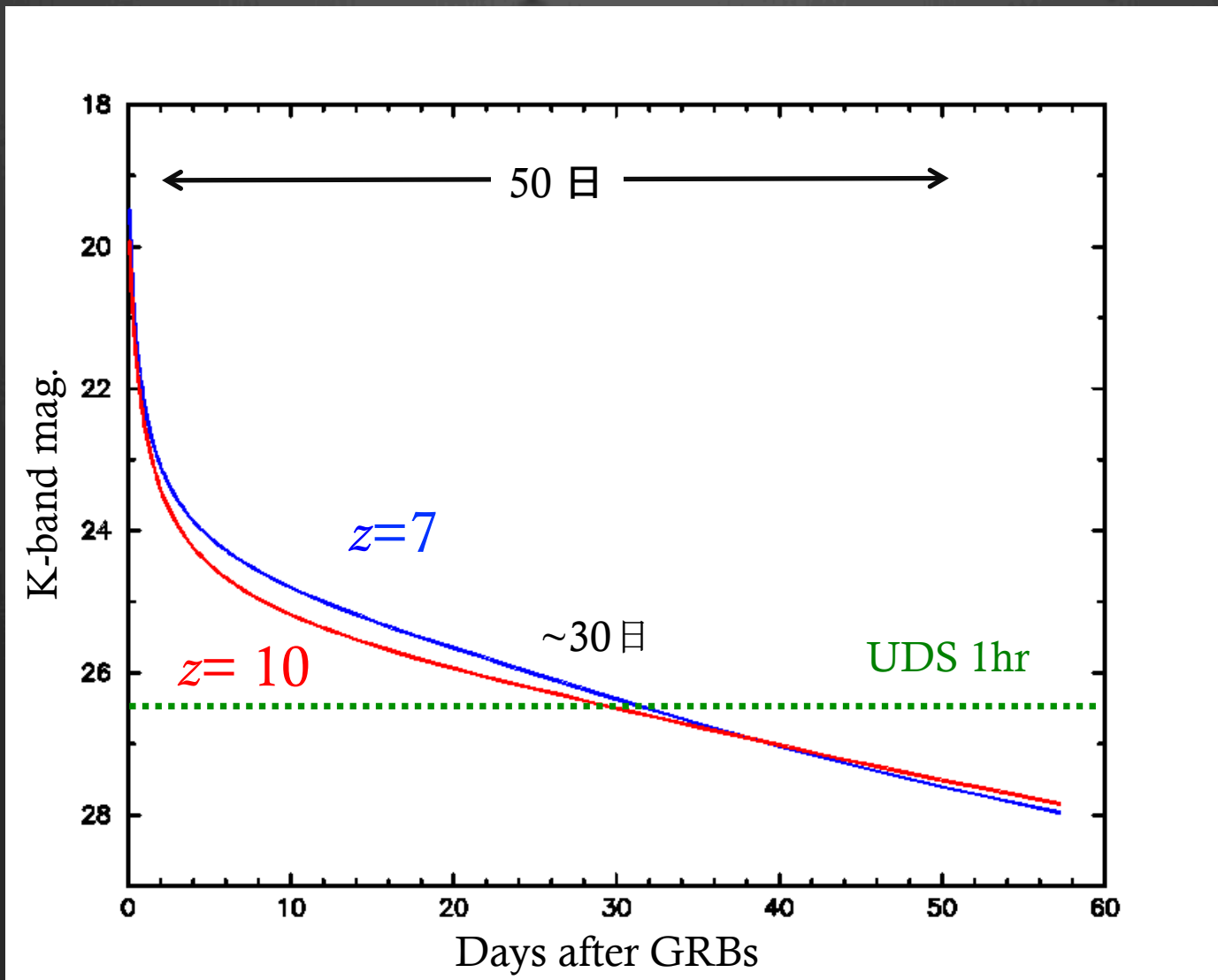
予想されるK-band光度曲線 (z=2)



予想されるK-band光度曲線 ($z=2$)



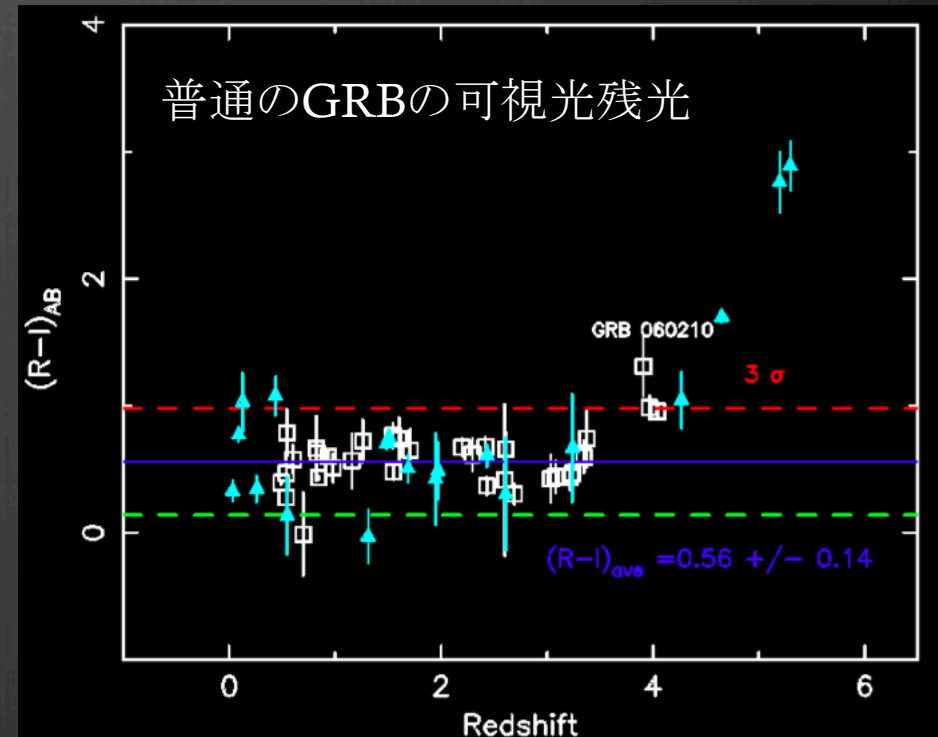
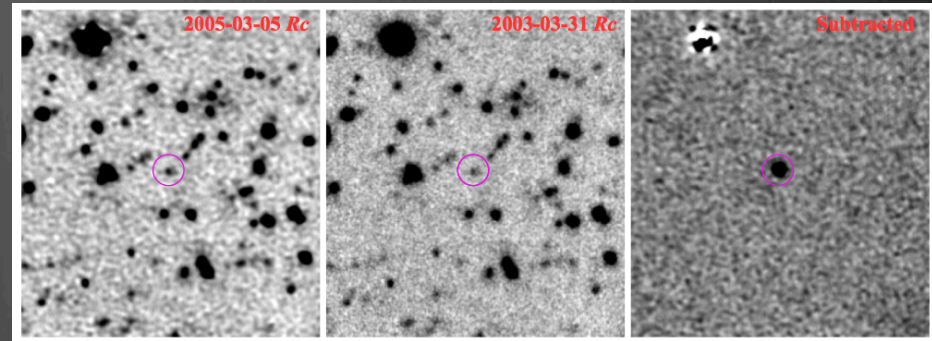
On-Axis Orphan at $z=7, 10$



検出数の期待値は.....

探査方法

- ❶ PSF 合わせた画像引き算
- ❷ 変動天体の多色の光度曲線
- ❸ 母銀河の同定
- ❹ Redshift 測定
 - ❶ Photometric redshift (host)
 - ❷ 分光観測 (母銀河、変動天体)
- ❺ Absolute mag
- ❻ 突発天体の分類 (AGN, SNe, 変光星、etc)
 - ❶ 光度曲線、色、母銀河
 - ❷ TMT, ALMA etc



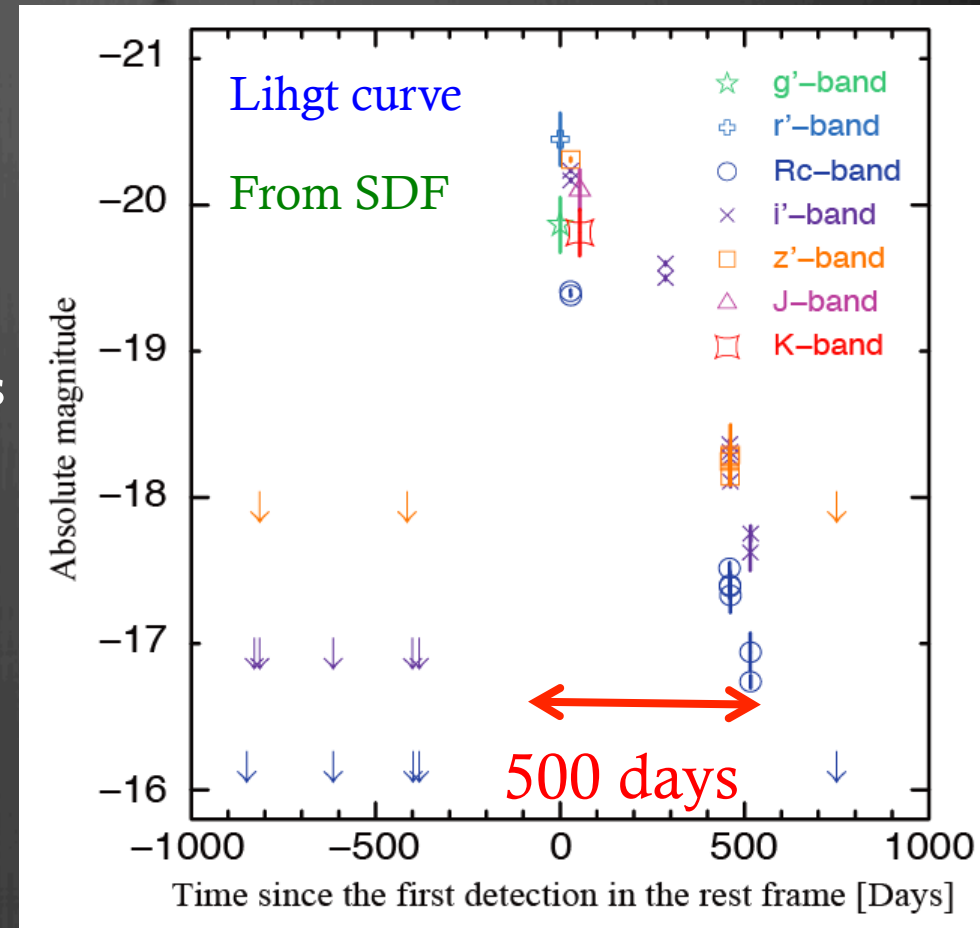
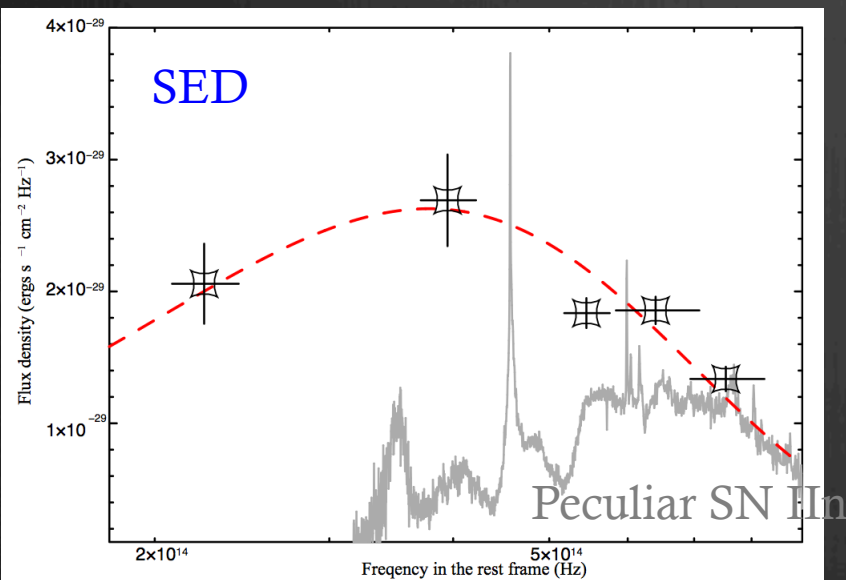
HSCサーベイに向けて、SDF & SXDSをもとに試験中

2. Unusual Energetic Optical Transient

Long and Luminous

- Duration > 500 days in the rest
> 800 days in the obs
- $z_{\text{phot}} \sim 0.65 (+0.02 -0.03)$
- Maximum absolute mag -20 mag
- Total radiated energy during our obs
 $\sim 2 \times 10^{52}$ erg
- Faint Host $M_V = -16.3$ mag
(similar to SMC)

新種の突発天体 or SNe ? !

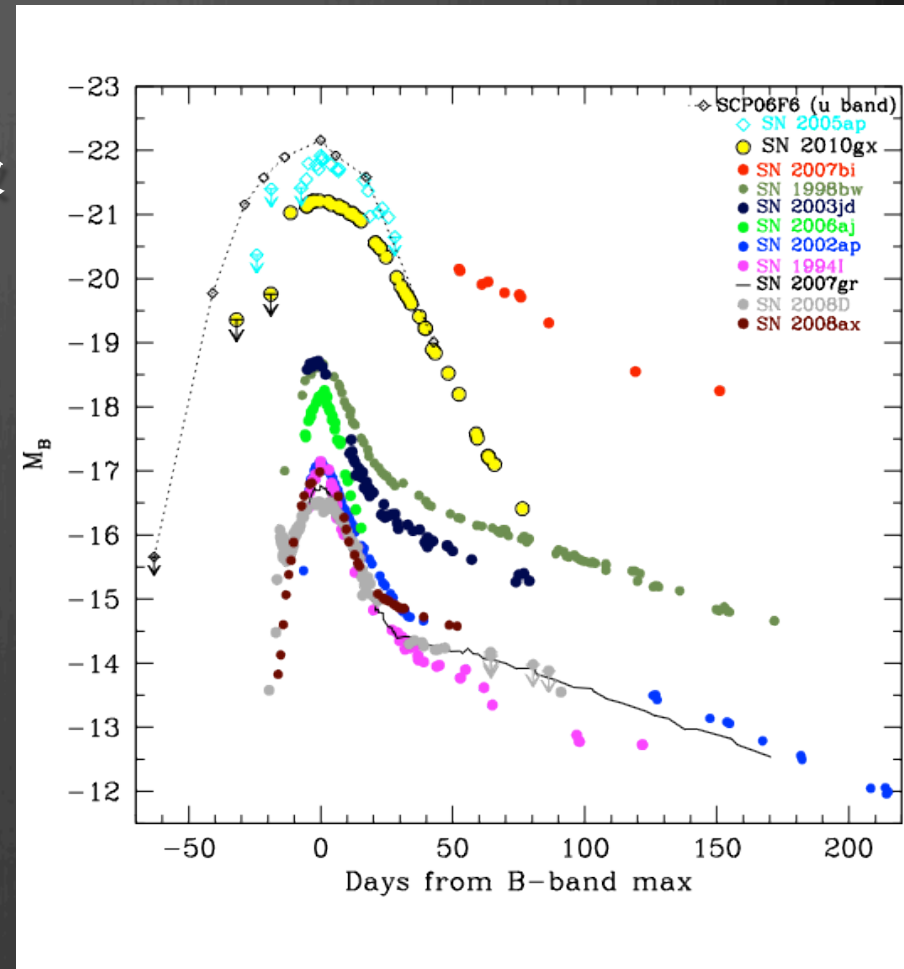


Urata et al. 2012 submitted

WISH: $z \sim 10$ くらいまで見えそう? !
(3000日くらいで1等級暗くなる
フラットな光度曲線)

3. Ultra Luminous Transient

- 新種のTransient (in 2006)
- Peak absolute magnitude -22等級
- ゆるやかな変動 (~50日)
- 明るい期間が長い
-21 mag for ~100 days
- Host less/faint
(probably metal poor host)
- おそらく超新星の一部(Ib/c, IIn)
- Pan-STARRS MDSの発見率
~ 1 event / month ($z < \sim 2$)
- $z \sim 2$ まで発見 HSCで $z=4\sim 6$ まで



Pastorello et al. 2010 ApJL 724, 16

WISH $z \sim 10$!?

長期モニター(>100~1000)が必要

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WISH で統計とhigh-z ($z \sim 10$)

Higher cadence

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Long monitoring

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