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SNe and GRBs Conference @RIKEN

Polarimetric observations of GRB afterglows

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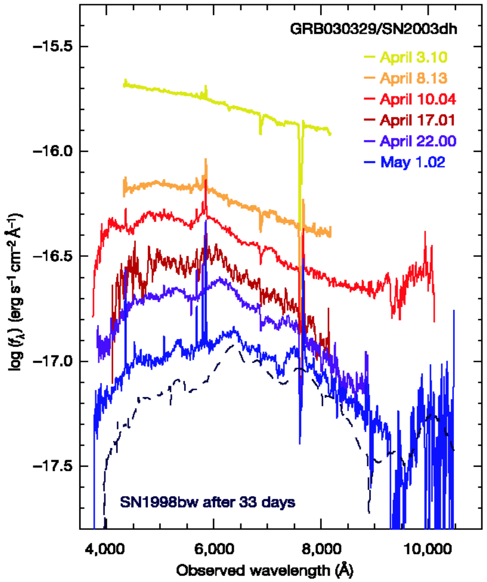
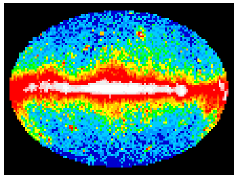
What is GRB ?

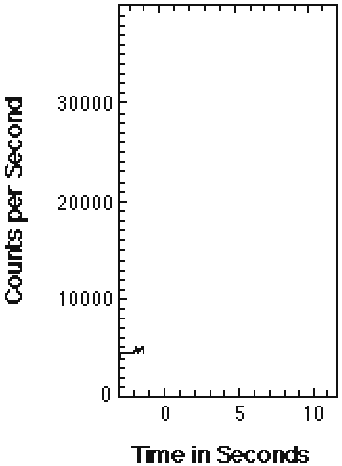
Gamma-ray Burst; GRB

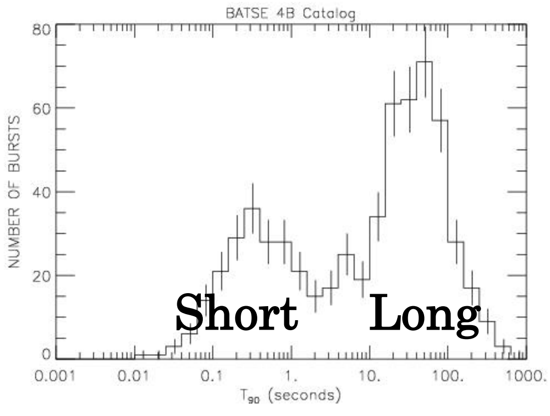
- Most energetic explosion in the universe (~ 10^{52} erg)
- Occurring at cosmological distance
- Gamma-ray arises in the form of relativistic jet.
  We observe it along the axis of the jet.
- Long GRB (> 2s) and short GRB (< 2s)
- A part of long GRBs associate with SNe Ic

Spectral evolution becoming SNe Ic









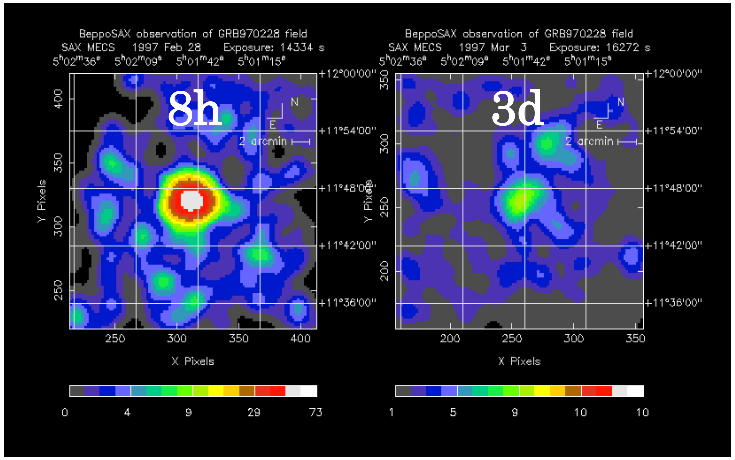
http://www.batse.msfc.nasa.gov/batse/grb/duration/

(Hjorth+ 03)

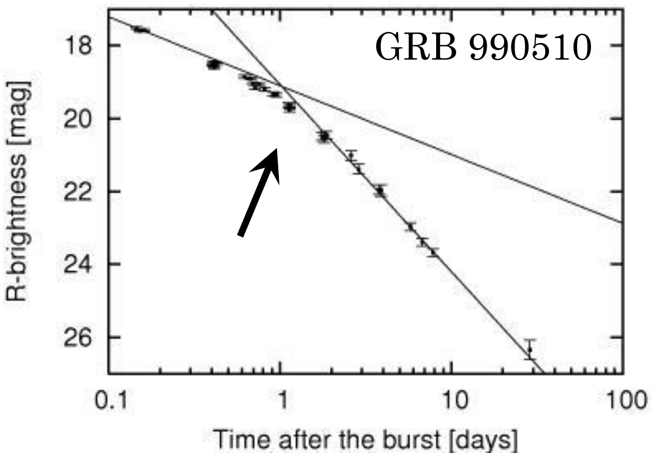
GRB afterglow

- A considerable fraction of GRBs show afterglows, in **X-ray, optical, NIR, and radio** wavelength.

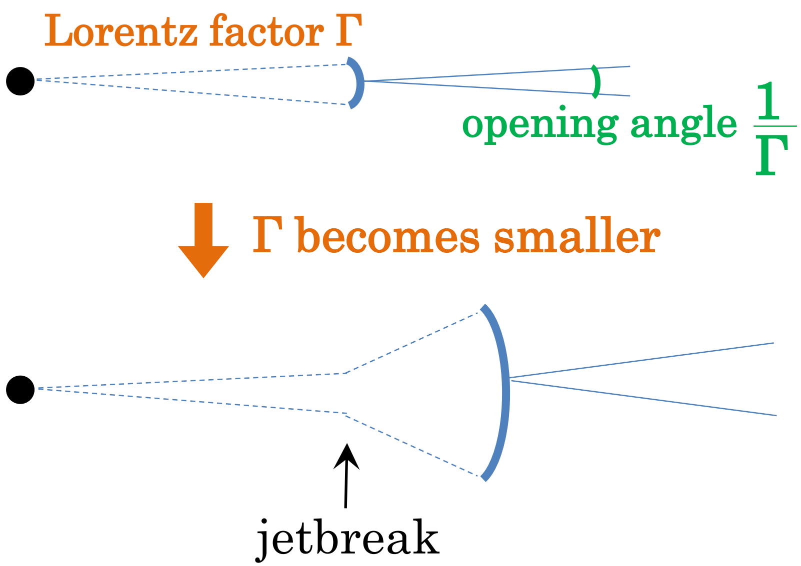
- GRBs are relativistic events. “ jetbreak ” ~1d after the burst.



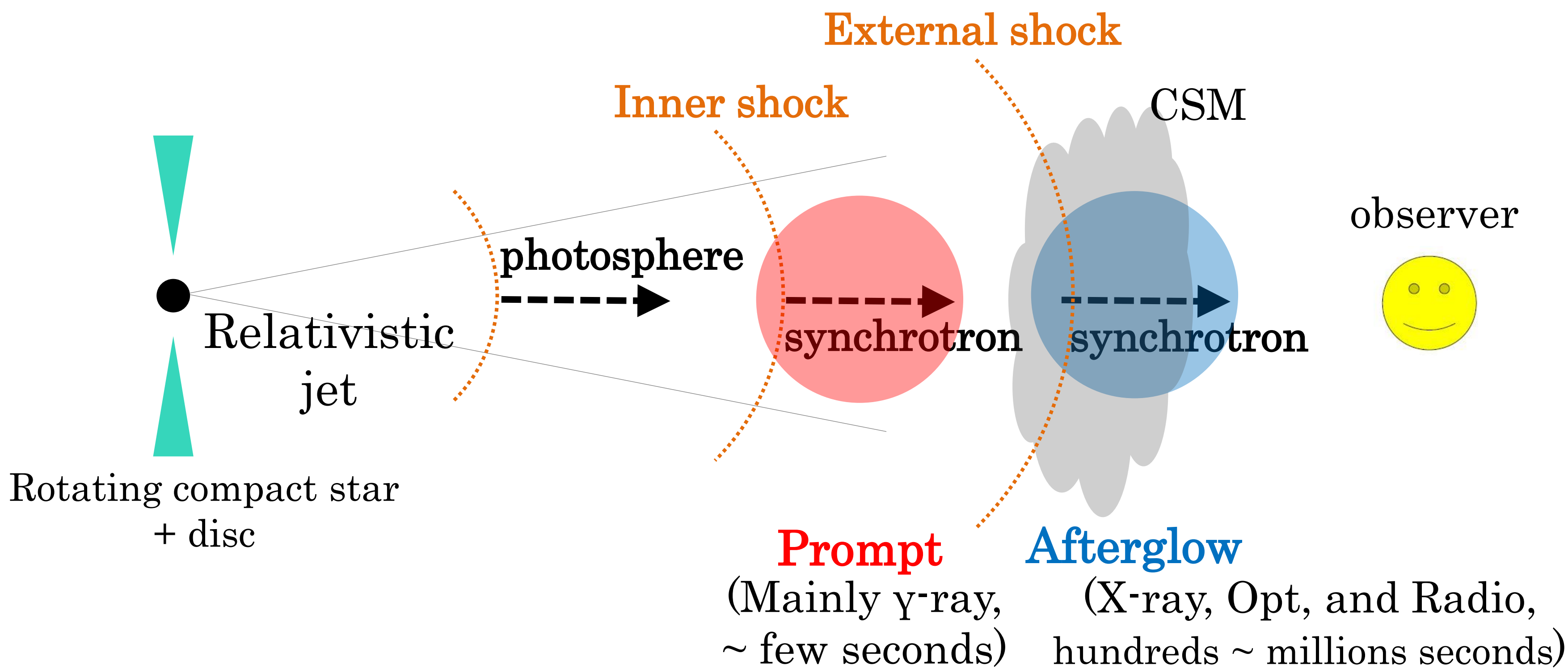
http://spiff.rit.edu/classes/phys240/lectures/grb_pres/grb_pres.html



(Wei+ 02)



Standard emission model



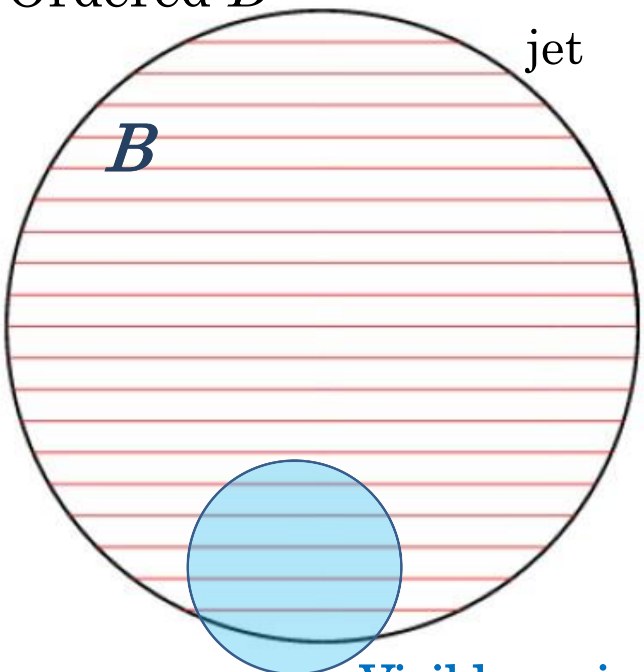
<u>Synchrotron Radiation</u> is most likely as prompt and afterglow

reasons ・consistent with non-thermal SED

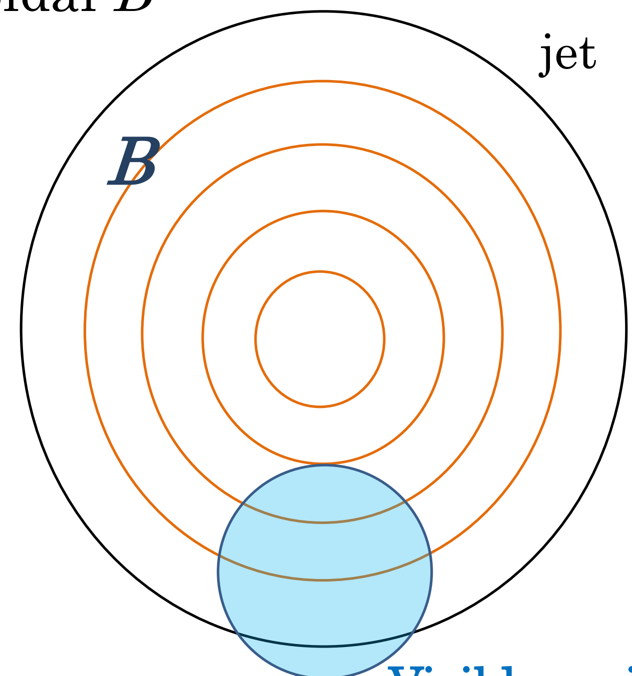
・easy to explain γ-ray LC

Basic ideas of GRB polarization

Ordered B



Troidal B



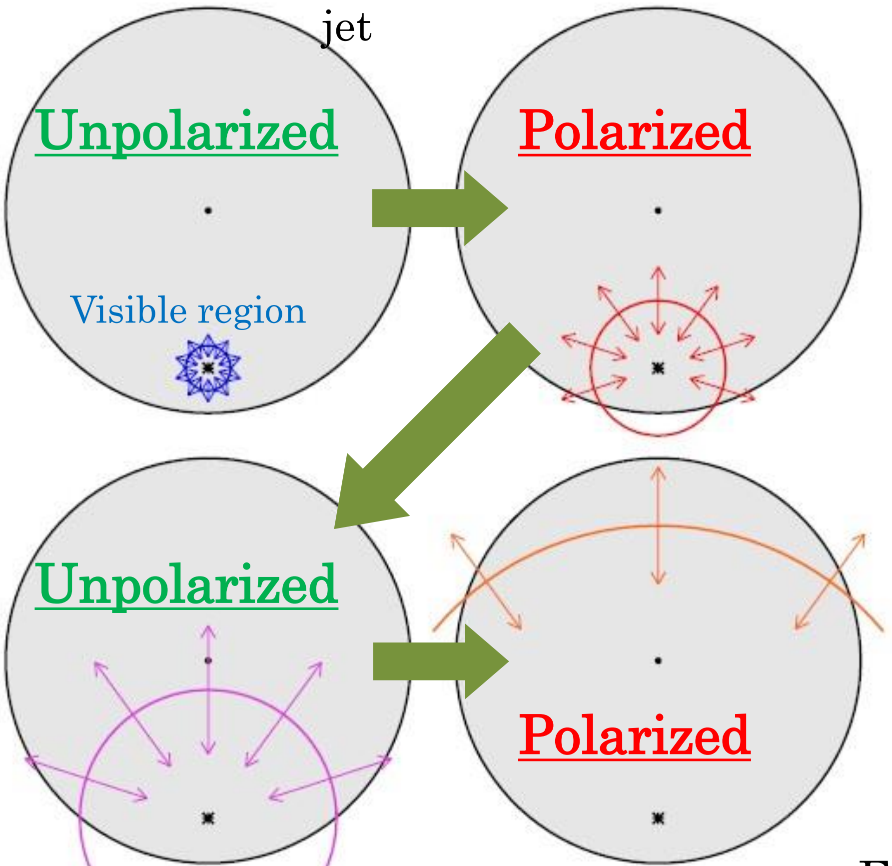
- P.D. ~ max 70%
- no time variability

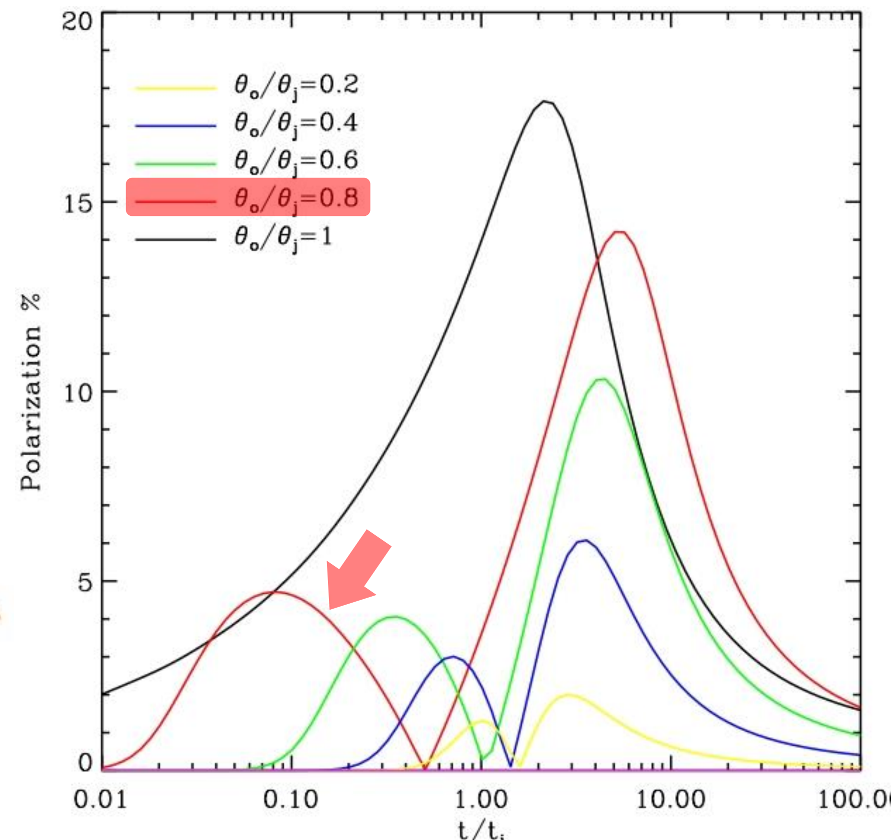
- local P.D. ~ max 70%
- P.D. become smaller with time

Important model 1

Random B-field in micro-scale + off-axis jet beaming effect

(Sari +99 ; Rossi +04 ; Granot +99 etc.)





P.D. once becomes zero with jetbreak (at ~1day ?)

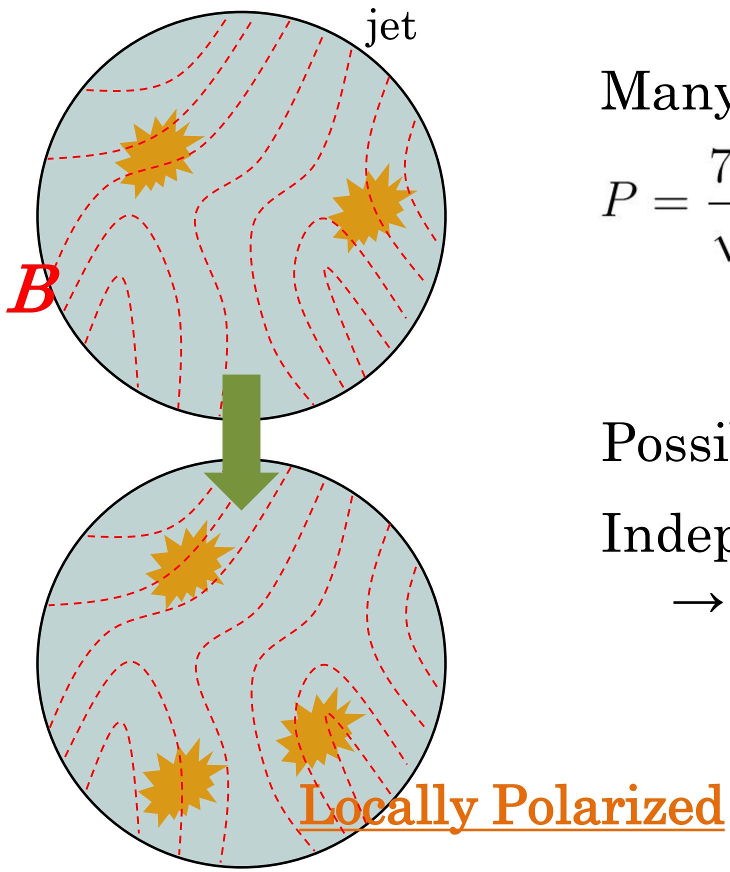
From jet edge

- P.D. becomes zero at early time
- large P.D. amplitude

Important model 2

Group of independent patches having coherent B-field

(Gruzinov & Waxman +99)



Many coherent patches (N~50)

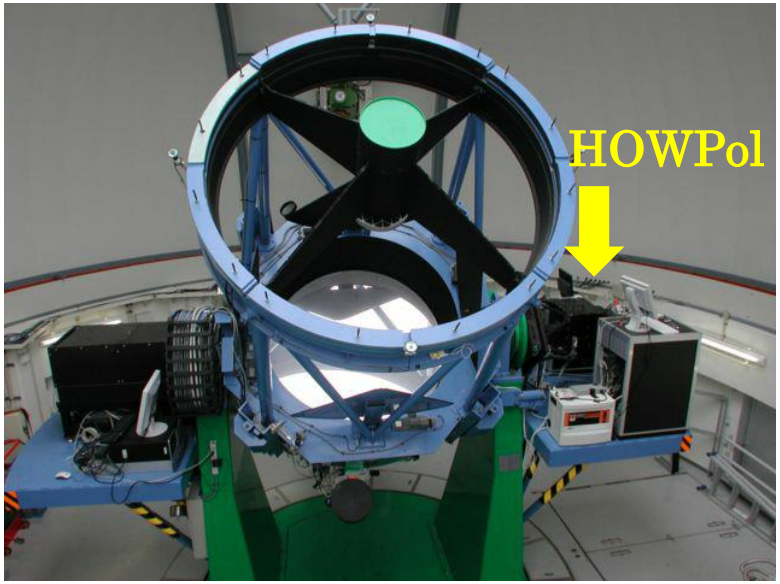
$$P = \frac{70\%}{\sqrt{N}} \sim 10\%$$

not canceled out completely

Possible to produce complicated P.D.

Independent from jetbreak
→ high P.D. at early epoch ?

Kanata telescope + HOWPol



Kanata telescope

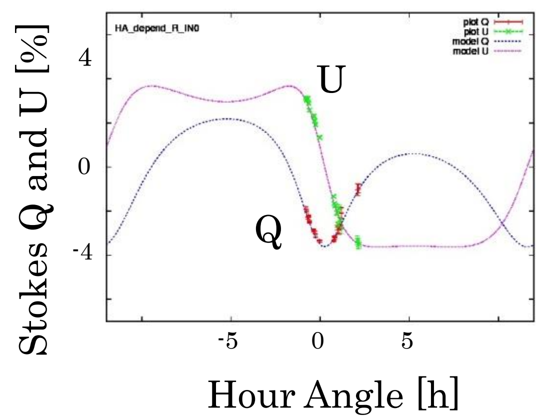
- Located Higashi-Hiroshima
- Effective aperture 1.5 m
- Fair weather ratio ~50%
- Moving speed
  Azimuth axis 5 degree / s
  Altitude axis 2 degree / s
  Extremely fast as 1m-class

HOWPol

(Hiroshima One-shot Wide-field Polarimeter)

Polarization obs. **with one exposure**

Tertiary mirror makes polarization
→ HA-depending model correction
(σ ~ 0.5%)



GRB auto-observation system

Kanata telescope → Appropriate for GRB polarization observation ← HOWPol

Kanata telescope:
- Auto observation system
- High moving speed

HOWPol:
- Only one exposure

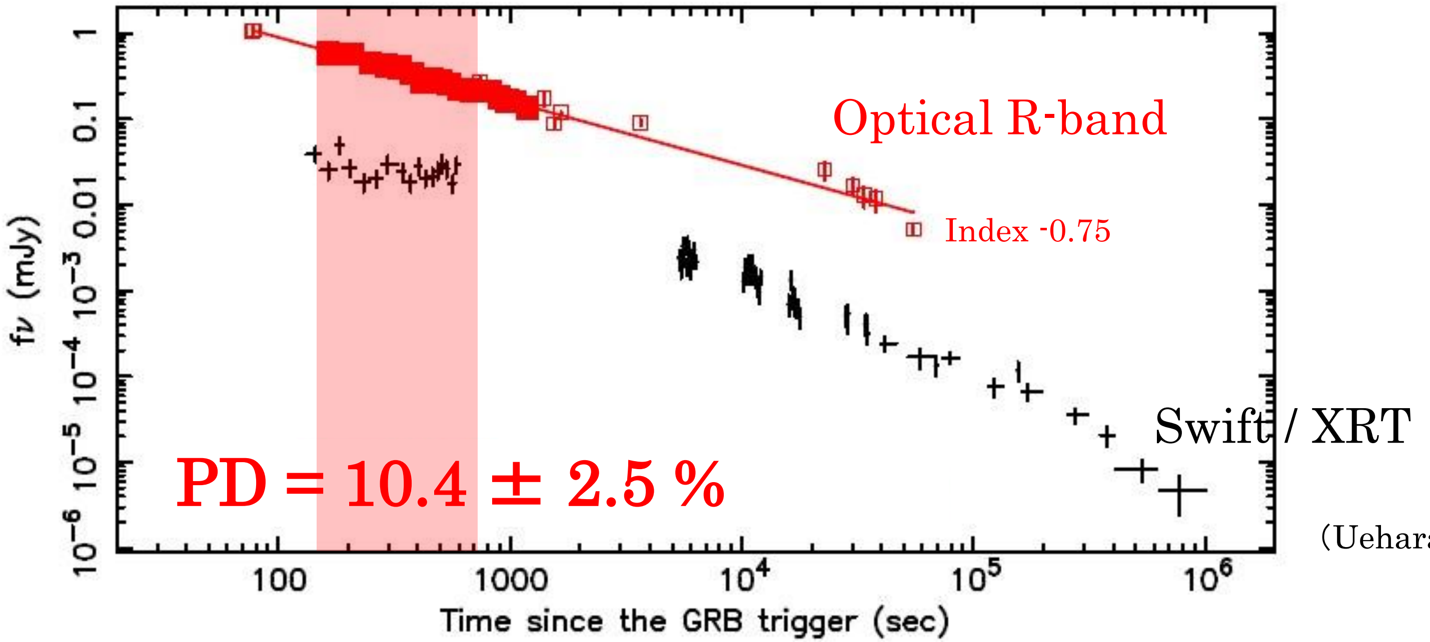
Appropriate for GRB polarization observation

Since 2009, ∼60 GRB with auto-observation system

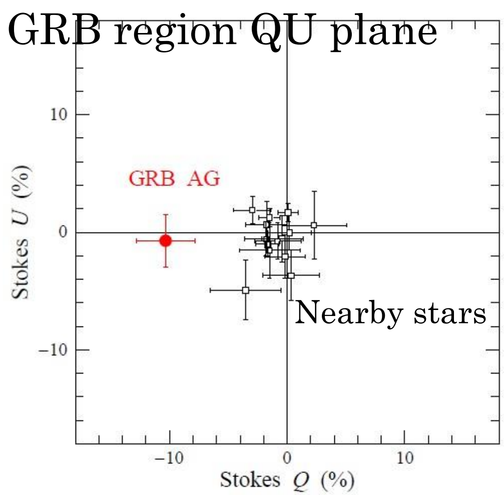
ID	Time [s]	Publication
GRB 091208B	149 ∼ 1286	Uehara +12, ApJL
GRB 111228A	163 ∼ 19000	Takaki+ in prep.
GRB 121011A	92 ∼ 5241	
GRB 130427A	10000 ~ 30000	
GRB 130505A	~10000	
GRB 140629A	73 ∼ 12000	Takaki+ in prep.

GRB 091208B

$z = 1.063$, $T_{90} = 14.9 \pm 3.7$ s



(Uehara+ 12)

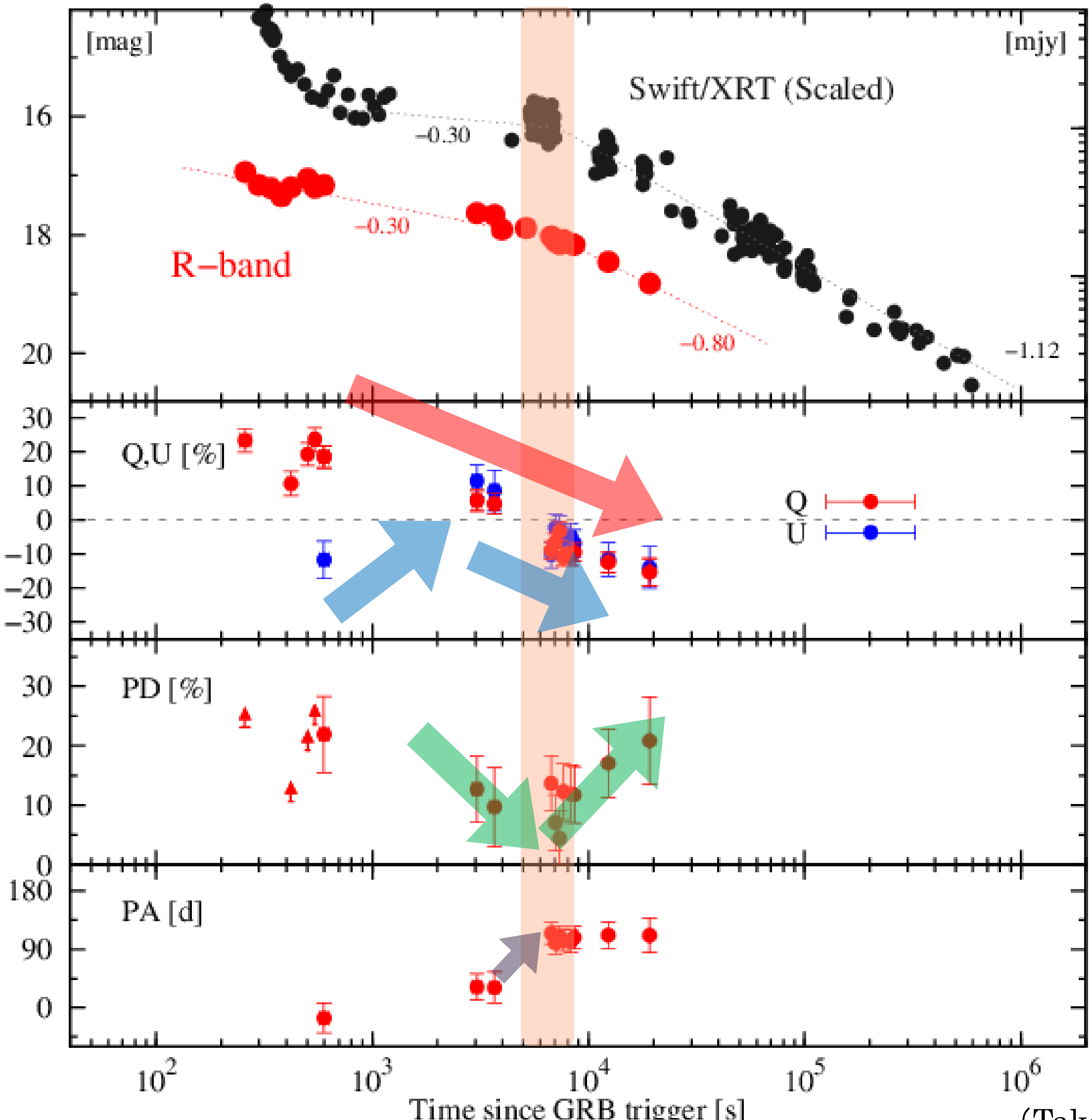


- Standard Afterglow
- Forward shock emission
- High PD is **inconsistent with model 1**

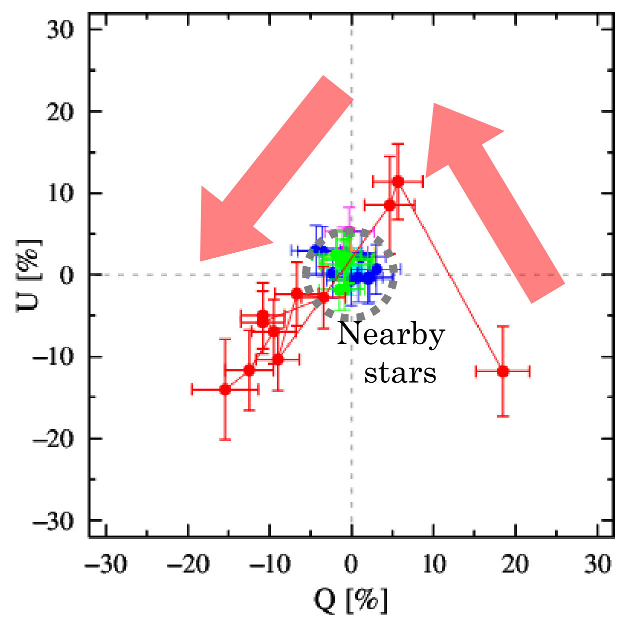
See Uehara et al. 2012 for detail.

ii GRB 111228A

z = 0.714, T_{90} = 101.2 ± 5.4 s



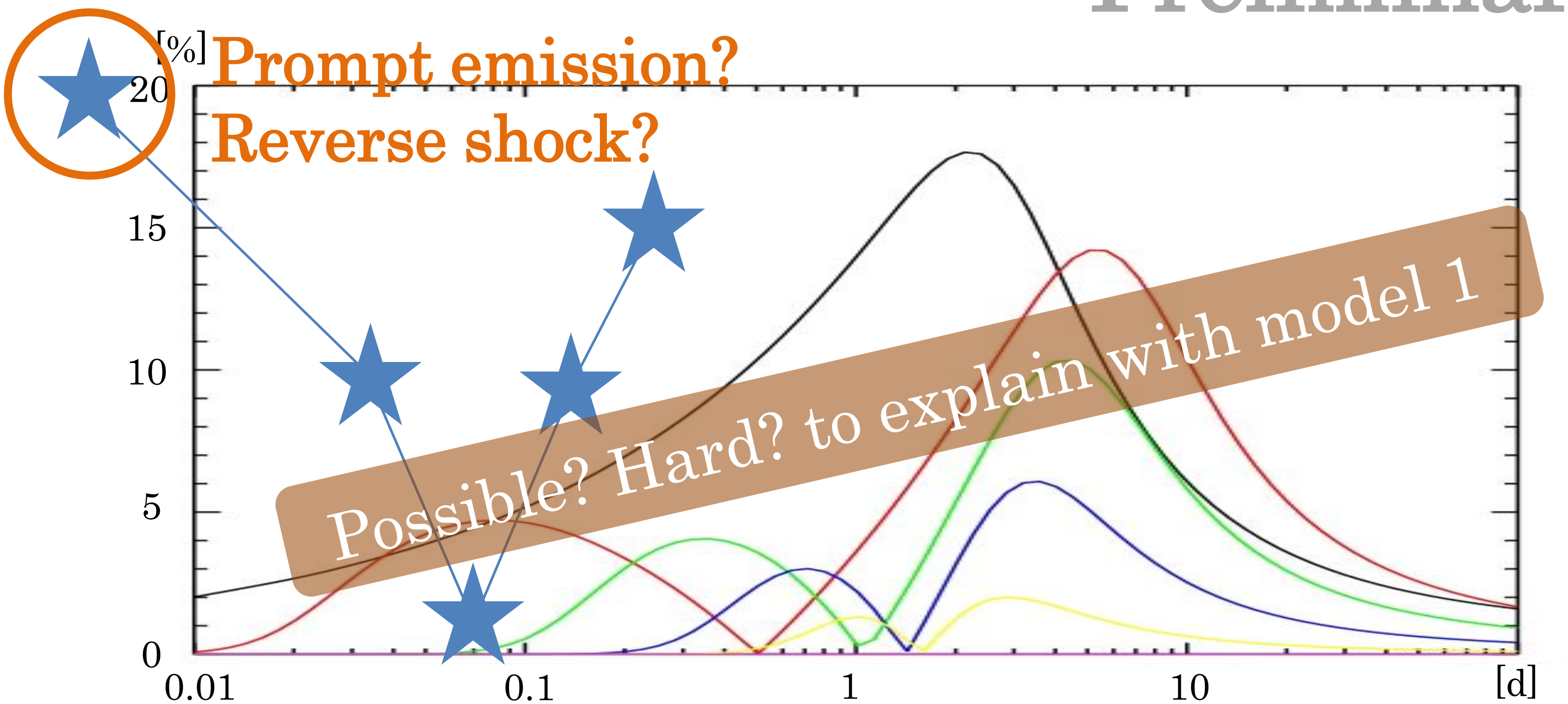
- PD evolution
  - >20% at ~ 500 s
  - ~0% at ~ 6000 s
  - >10% at ~15000 s
- PA rotated 90d (across origin in QU-plane)



(Takaki+ in prep.)

GRB 111228A Discussion

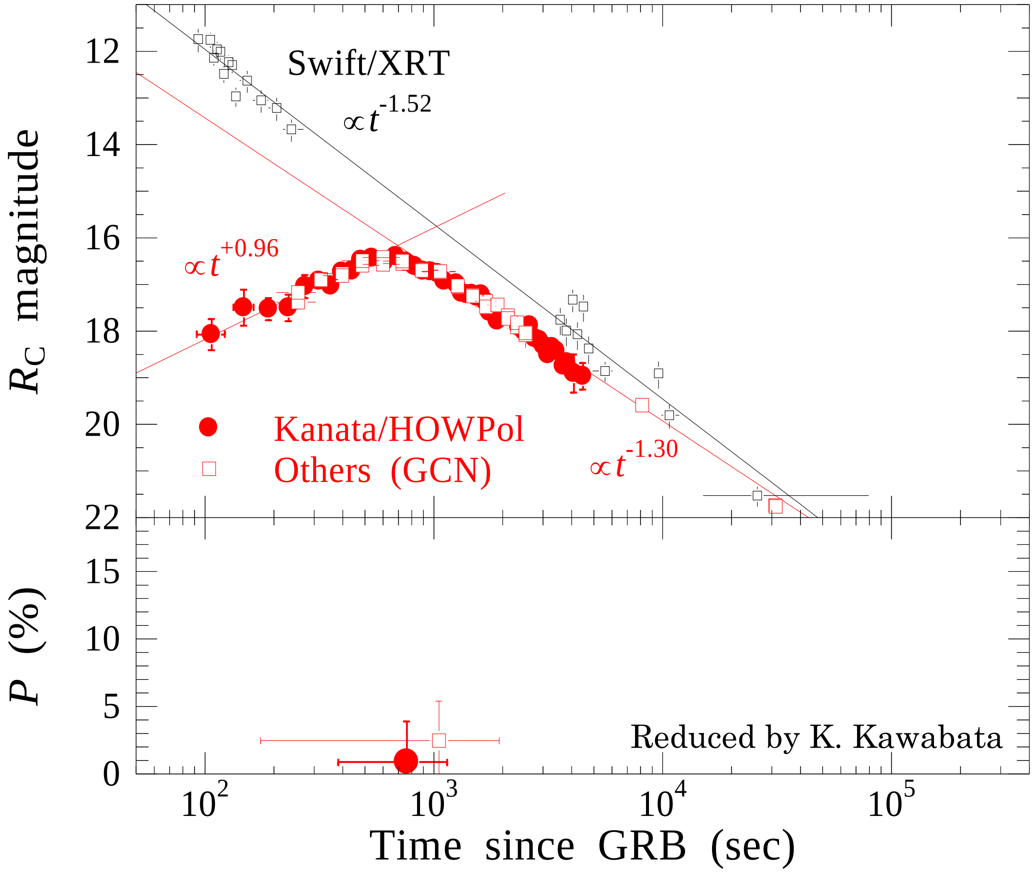
Preliminary



- Zero-PD at very fast timing
  - Most possible due to jetbreak
  - Viewing angle? Jet surface size?
  - Not standard optical LC shape → More complicated?
- X-ray shallow decay is just geometric effect?

GRB 121011A

z = unknown, T_{90} = 75.6 ± 12.7 s

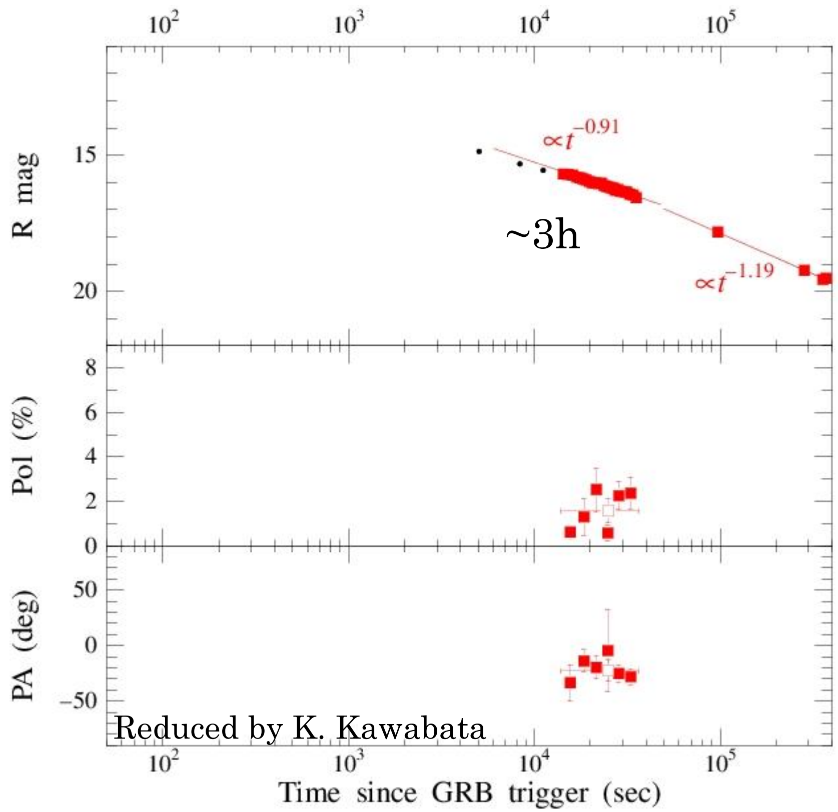


- Started observation from very early (t = 92 s)
- Standard Afterglow
- nearly zero PD (< 4%)

iv GRB 130427A & 130505A

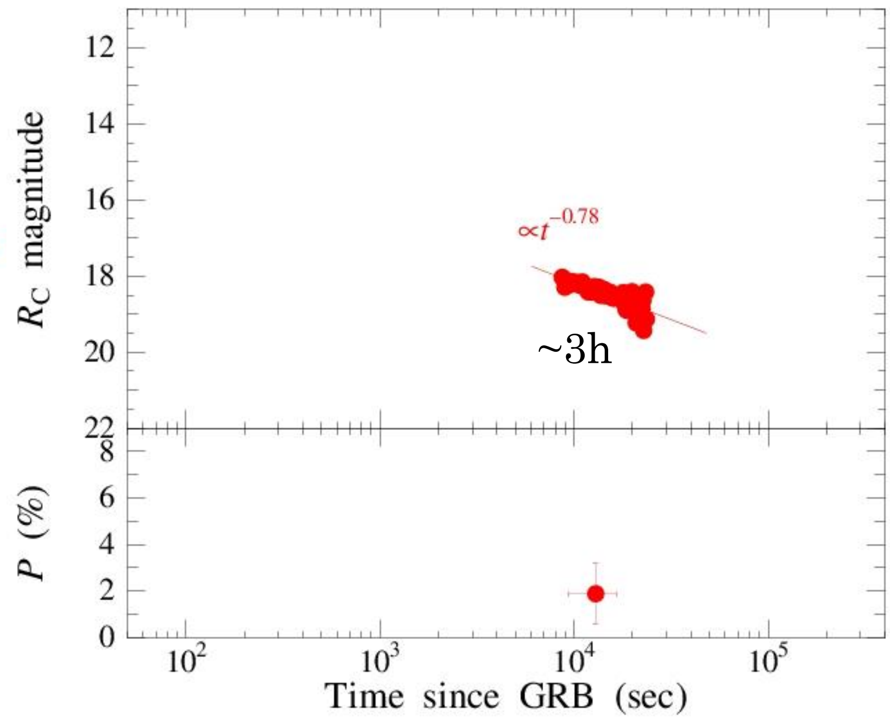
GRB 130427A

$z = 0.34$, $T_{90} = 162.8 \pm 1.4$ s



GRB 130505A

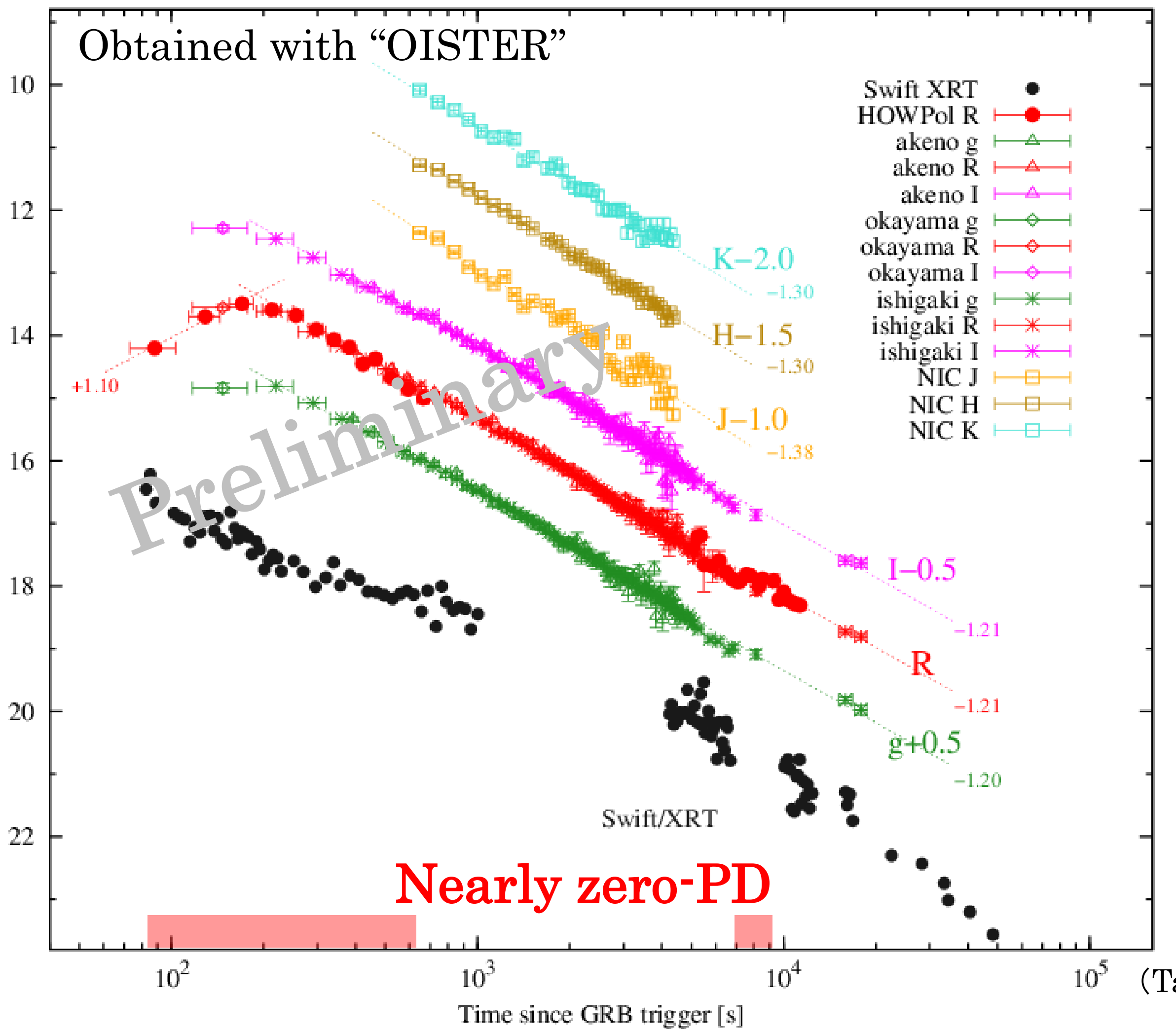
$z = 2.27$, $T_{90} = 88 \pm 10$ s



Both GRBs are **small PD at ~10^4 s**

V GRB 140629A

z = unknown, T_{90} = 75.6 ± 12.7 s

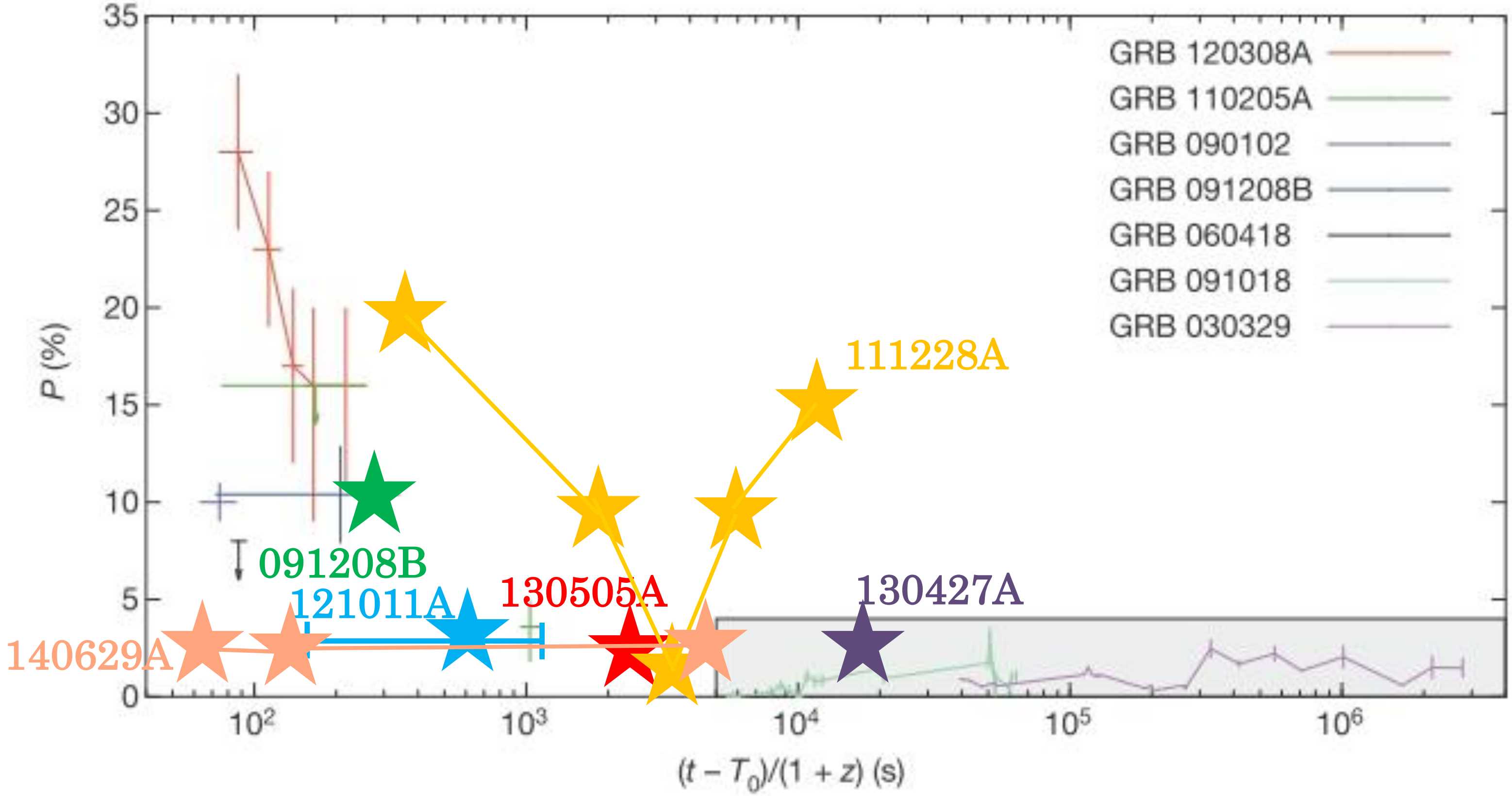


(Takaki+ in prep.)

- ❒ Multi-band LC
- ❒ Very standard AG
- ❒ Small PD

Sumarry

(Mundell+ 13)



- GRB polarization : 1 event / yr
- Still unclear, no uniformed picture
- More observation samples, especially early phase.