Following up EM counterpart of GW using a new robotic telescope with 3 colours camera in Tibet

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Background

- Gravitational Wave (GW) “emits” from SN or a collapse of compact objects
- Large GW experiments are constructing and will start to find GW sources in 2017 with 100 deg$^2$ of positional accuracy.

- To confirm GW detection, important to locate counterpart phenomena.
- To understand nature of GW sources, important to monitor optical flux and variation with multi-band.

- Our approach is to construct a global optical monitoring network
Current Automatic ToO survey telescopes

- PTF
- ROTSE b
- ROTSE c
- ROTSE d
- Pi of the SKY
- LOFAR
- Liverpool
- MITSuME
- PanSTARRs
- QUEST
- TAROT S
- SkyMapper
- Zadko
- ROTSE a

Based on arxiv:1109.3498
Ali, Tibet (西蔵阿里)

- One of candidate sites developed by Prof Yao (NAOC)
Comparison with world’s class observatory

<table>
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<tr>
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<th>Subaru</th>
<th>Gar</th>
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<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Maunakea, Hawaii</td>
<td>Ali, Tibet</td>
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<tr>
<td><strong>Clear sky ratio</strong></td>
<td>74% (avg. Jan 2000-)</td>
<td>75% (Jan2013)</td>
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<td><strong>Seeing</strong></td>
<td>0.64” (avg. Jan 2000-)</td>
<td>0.8” (Oct.-Nov. 2011)</td>
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<tr>
<td><strong>Best seeing</strong></td>
<td>0.37” (Nov. 2011)</td>
<td></td>
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<tr>
<td><strong>Altitude</strong></td>
<td>4200m</td>
<td>5100m</td>
</tr>
<tr>
<td><strong>Access</strong></td>
<td>Easy</td>
<td>Near by airport</td>
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Key points of this project

- Wide field imaging capability to make survey faster
  → 50cm, F/8 RC+Corrector lens (23’x23’)
- Fine image quality to obtain high S/N
  → Introducing the compensator (spot rms < 0.7”)
- A merit of high altitude (5100m)
  → u-channel
Our telescope

- Alluna Optics, Germany
- Ritchey-Chrétien
- D=510mm, F/8
- back focus: 455, usable 350mm
- Commercial product (but custom order to extend back focus)
- Dealt in Japan
Final design of optical system layout

- Two spherical lenses perfectly correct aberrations
- Compensator is introduced
- Less bending angle as possible (~0.5deg)
- AR coating is optimised on each channel ~98-99%
Expected spot diagram

All spots are enough small compared to pixel and airy spot
u-band capability

- Usual optical glasses and atmosphere absorb UV photons
  - choose a UV enhanced CCD
  - Select Fused silica to obtain UV photons
  - Also altitude of Ali helps to collect UV photons

40% gain!
Arrived components

50cm telescope
Corrector system
Equatorial mount
Optical adjustment with Kanata

- Test on Kanata telescope
- Assembling and developing softwares
Telescope spec / performance test

- $\Delta$(Focal length) $\sim$ 1%
- $\Delta$(Backfocus) < 1%
- No significant degradation
- Hard to achieve sub arcsec
Image quality w/o corrector
Image quality w/ corrector

fwhm = 1.64(+/-)0.01 arcsec

ellipticity = 0.035(+/-)0.002
Expanding wavefront with Zernike polynomials

- Hartmann const was $\sim 0.7''$
- Spherical aberration was dominated
- must be eliminated by a pair of RC mirrors
- M2 mis-alignment along with optical axis might induce spherical aberration
- Improved const is $\sim 0.3''$
Summary

- Telescope and instrument are under testing with Kanata telescope
- Developing softwares to be “robotic”
- Maybe solved the entering problem to Tibet
- Installation work is planning in this year