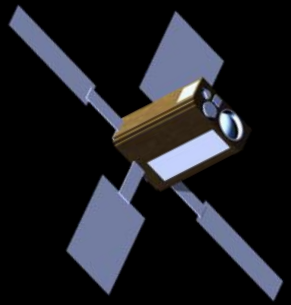

HIBARI (“skylark”)

a wide-field near UV transient monitor in a 6U CubeSat

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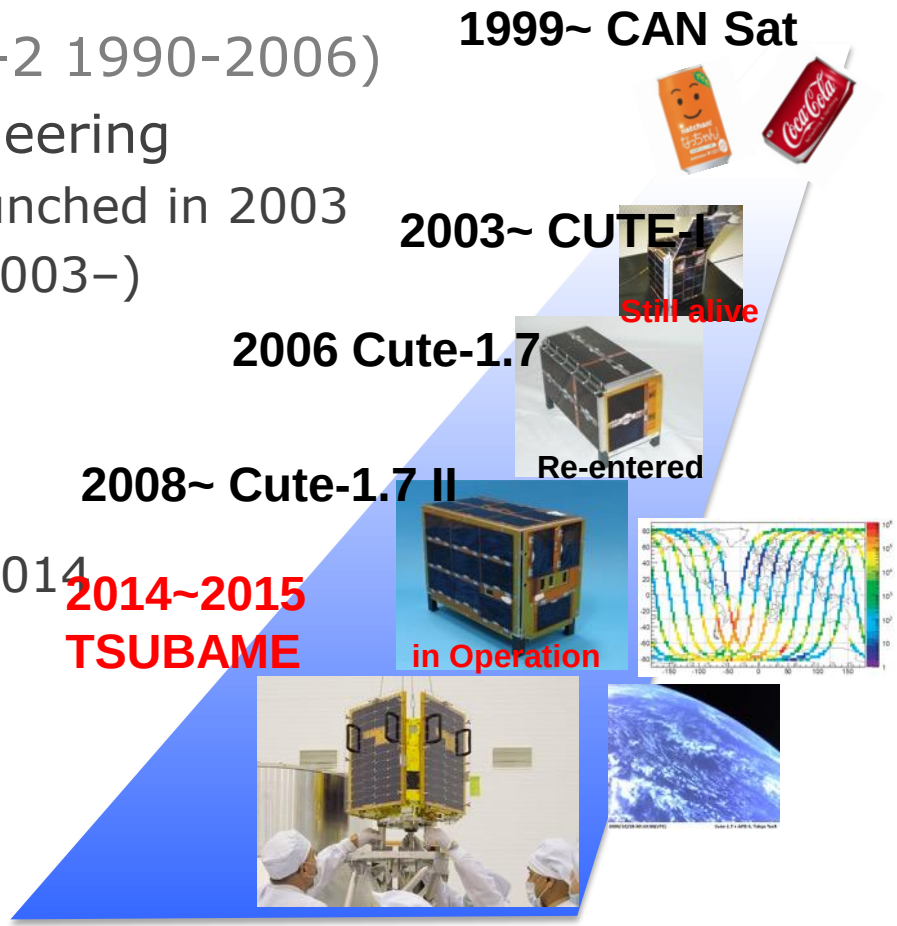
on behalf of TokyoTech Small Sat team

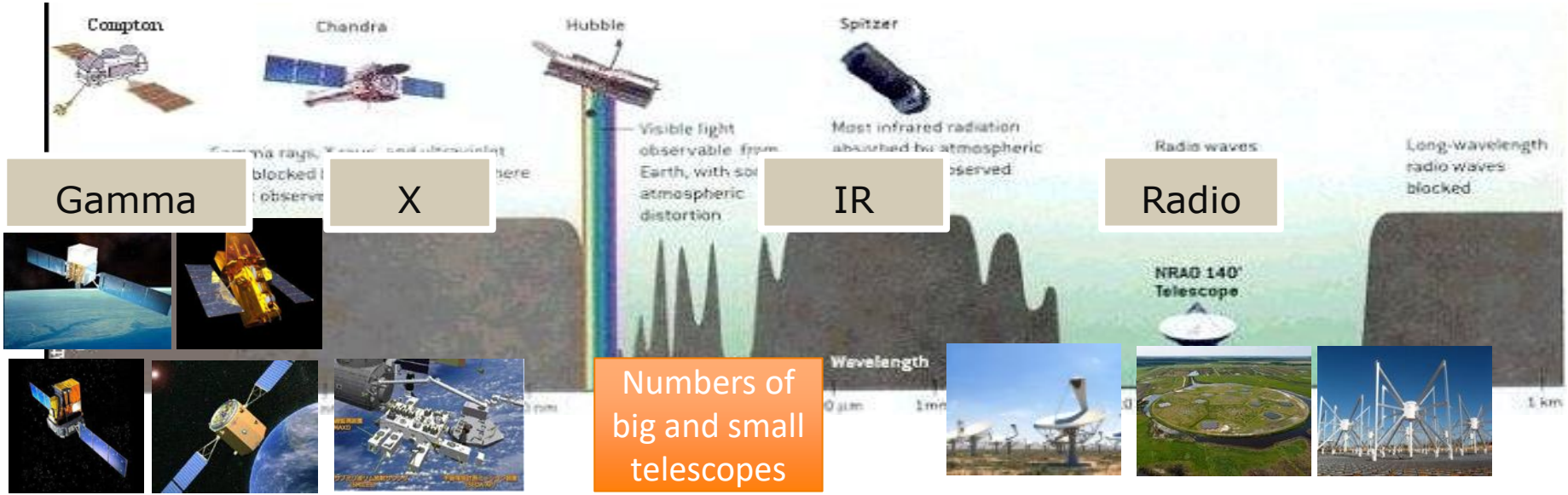
Very small satellite heritage at Tokyo Tech

- (NK's involvement in HETE, HETE-2 1990-2006)
- Started in Dept. Mechanical Engineering
- CUTE-1: one of the first CubeSats launched in 2003
- Science + Engineering partnership (2003–)
- Cute-1.7: First Science Instrument
  - First APD in space as radiation detector
    - temperature-compensation gain control
  - CPU failure in 2003, success in 2006
- TSUBAME (50 kg class) launched in 2014
  - GRB polarimetry in hard X-ray
  - Autonomous repointing
  - Lost due to RF failure



Motivation: Why UV?

- Wide-field telescopes are already working in gamma, X, Opt/IR, and Radio.

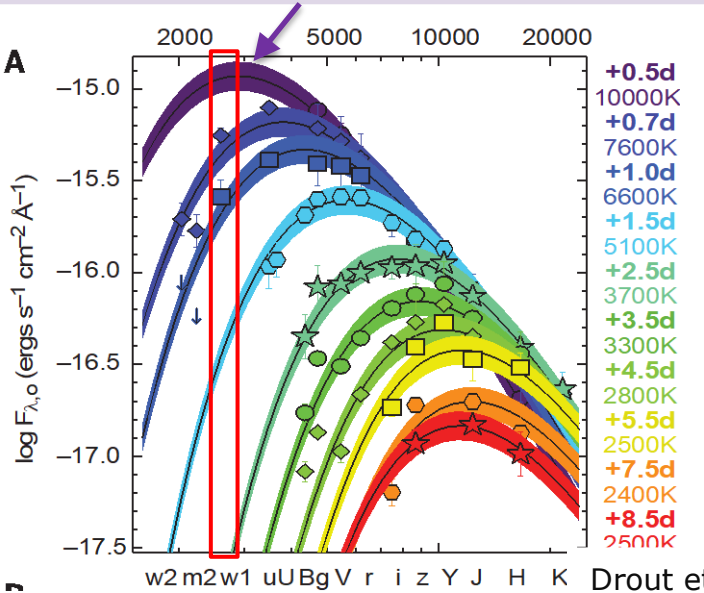


There is no wide-field instrument in UV band.

Early UV emission from double NS merger

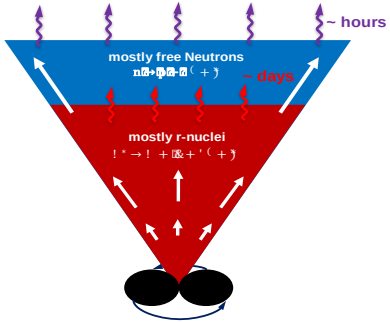
- Radioactive decay of main ejecta

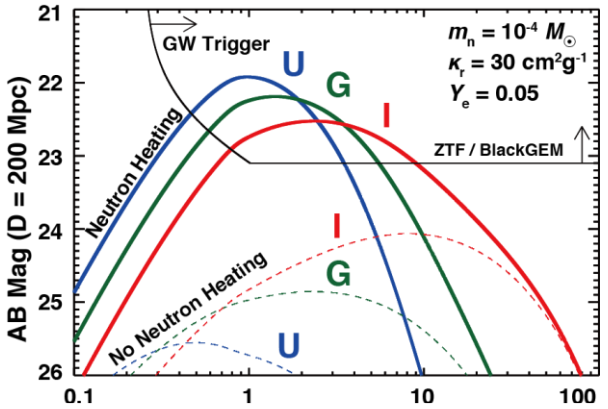
Spectrum at 0.5d (not observed yet)



Drout et al. 17

- Free neutron decay (< 10hr)
  - (Metzger et al. 2015)



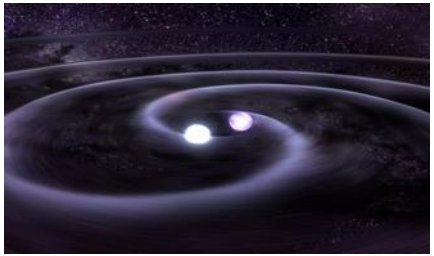


Very early phase afterglow can be much brighter.

- UV light comes earlyer than optical light
- Low number density of stars in UV band

Wide-field UV telescope is useful for GW follow-up.

Possible Targets and Expected Event Rate



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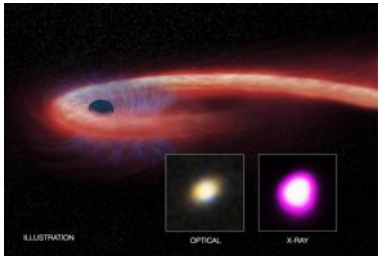


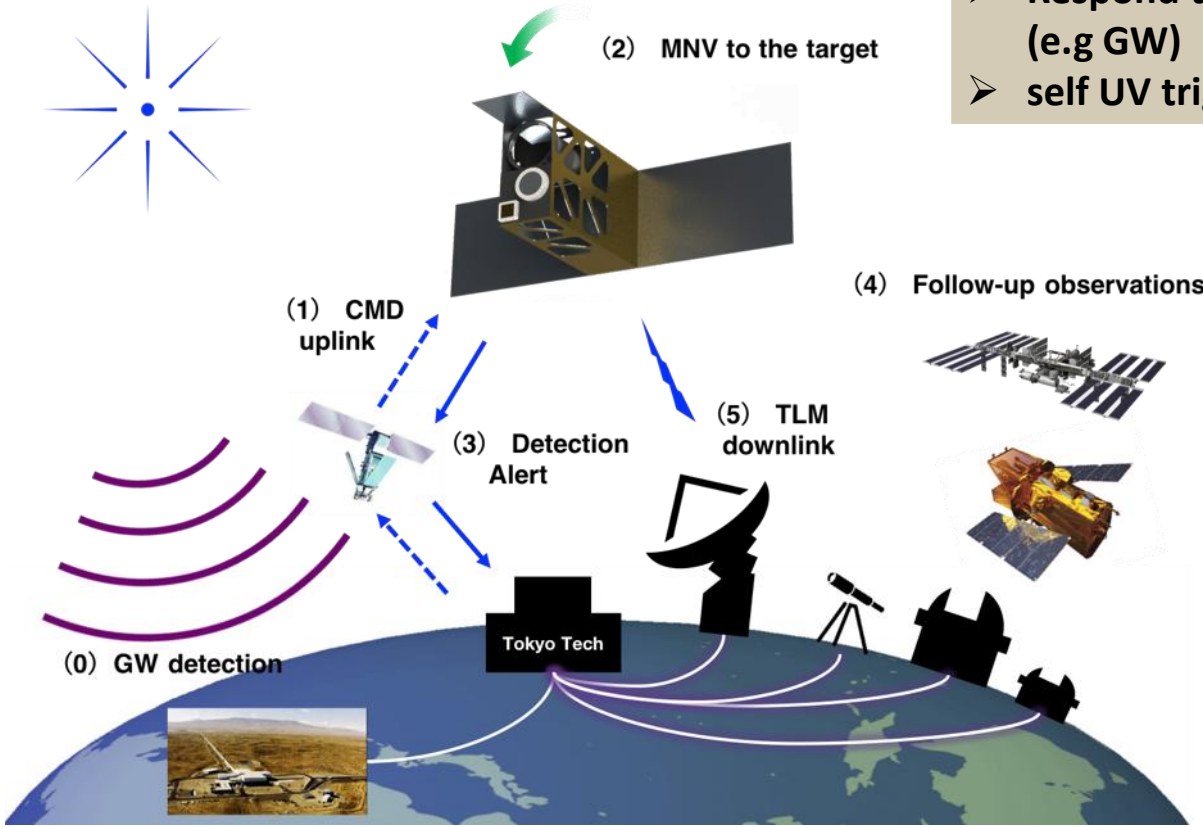
© CXC/M. Weiss

Target	Position uncertainty	Duration	Magnitude
GWs (NS-NS)	**~100 deg^2**	**0.5**~10 hr?	**unknown**
Shock Breakouts	Unpredictable	**~0.5 hr?**	**~3 yr^{-1} 100 str^{-1}**
Tidal Disruption Events	Unpredictable	~ a few weeks	**~2 yr^{-1} 100 str^{-1}**

- Type-Ia SNe (and their UV flashes), Stellar Flares can be observed as well.

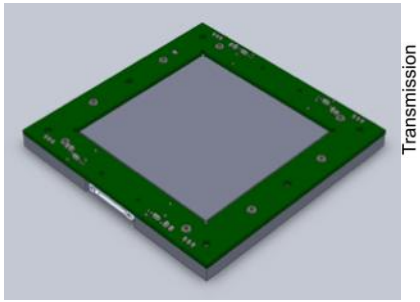
Mission Sequence

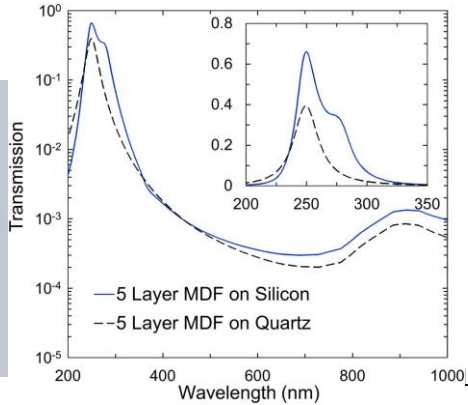
- **Respond to external trigger (e.g GW)**
- **self UV trigger**



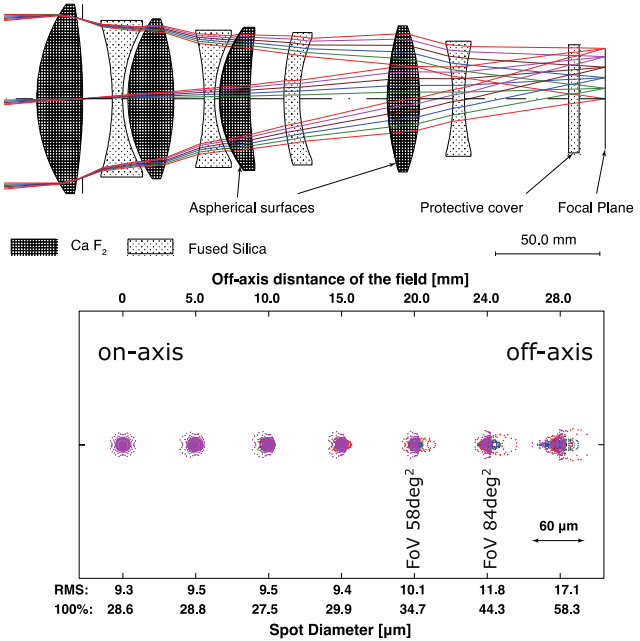
Detector and Optics

- Baseline: CMOS image sensor
  - short readout time
  - low readout noise
  - Enables short exposure frames needed for poor attitude stability
- JPL's BI-CMOS
  - "delta-doped" CMOS (Nikzad+)
  - directry deposited AR coarting (Hennesy+)
    - (Solar-blind bandpass filter for 230~280nm)



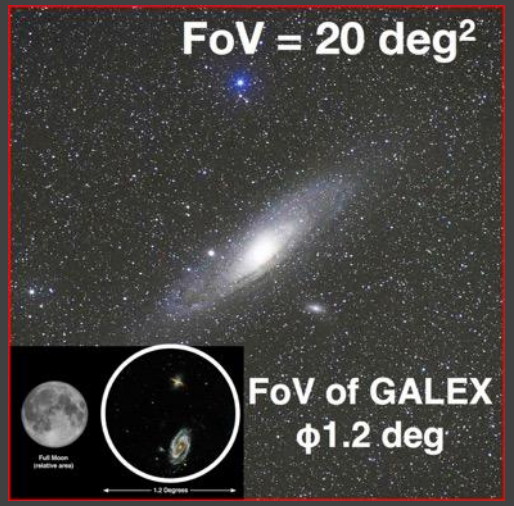


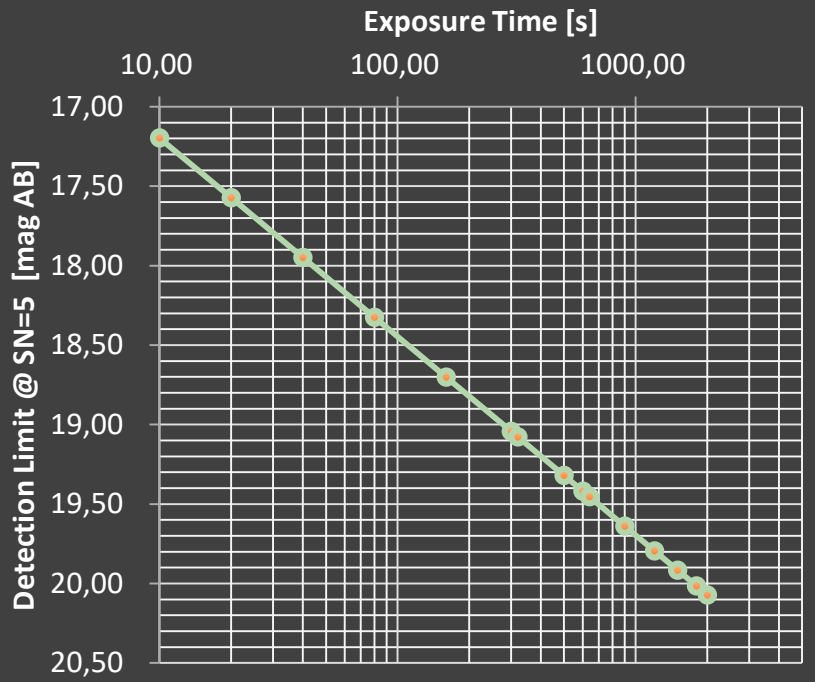
- Optics design mostly completed
  - image circle ≥ ø48mm, FoV ≥ 84 deg^2
  - focal length: temperature-sensitive
  - PSF 12 μm rms at 9° off-center



106 deg² (JPL CMOS)

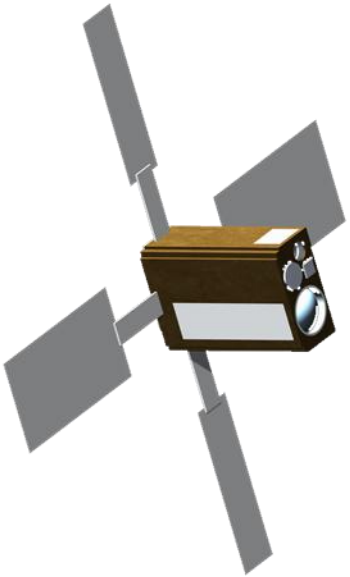
84 deg² (PSF < 1 pixel)

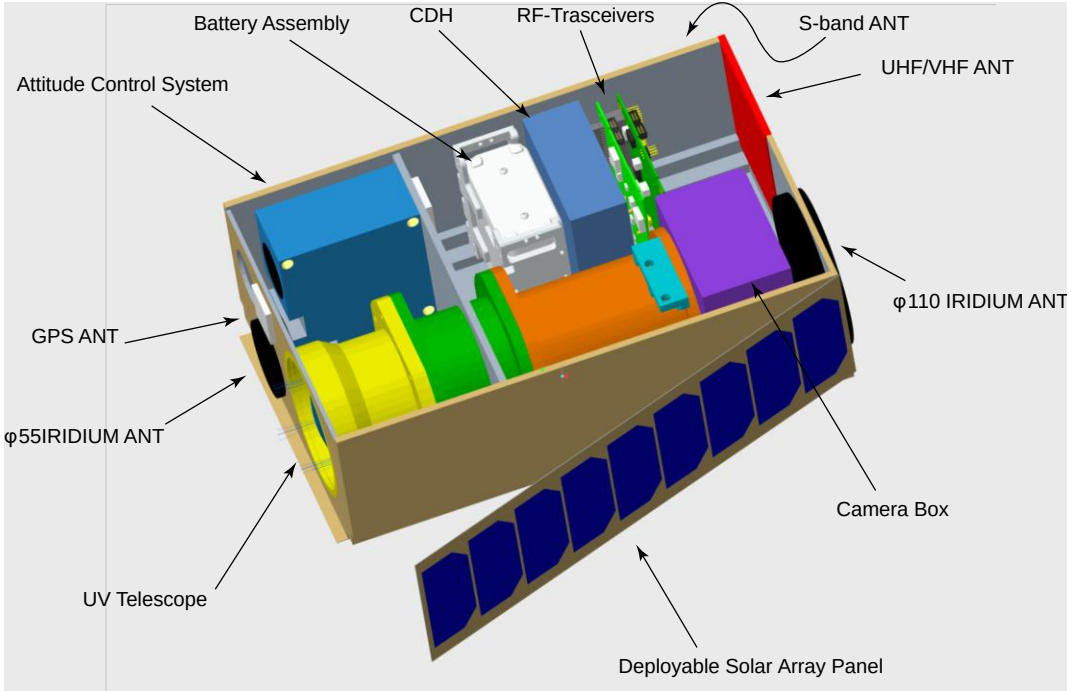




20 mag (5σ) in 1800 s

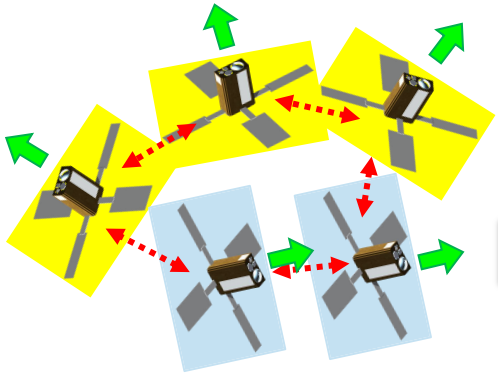
Satellite bus and instrument accommodation





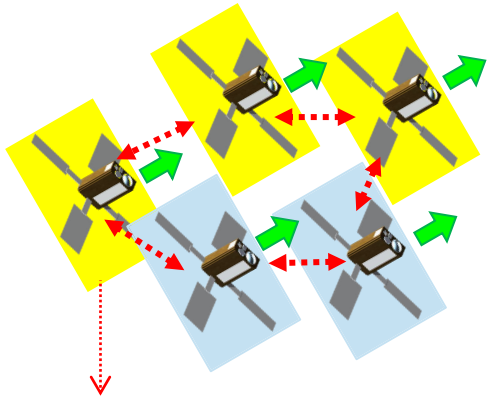
System design is still ongoing.

A concept: multimode nanosatellite squadron



Monitor + Pointing

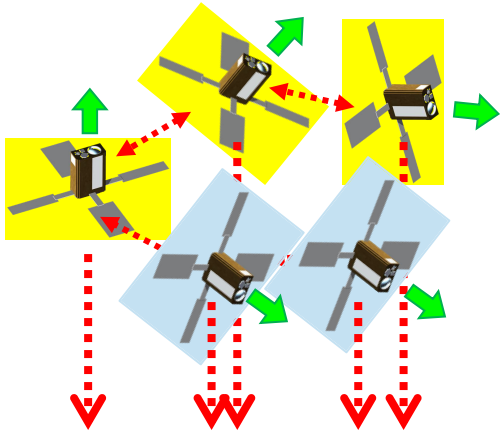
- Consisting of specialized satellites
  - Wide-field Monitors (optical, UV, X-ray, gamma-ray)
  - Narrow-field detectors (timing, spectra, polarimetry, etc.)



Alert

Follow-up observations

- Autonomous repointing
- Continuous inter-satellite communication (e.g. WiFi)
- Keep satellites within the WiFi range
  ➔ orbit control mechanism (propulsion or aerodynamic)



Science Data

Monitor + Pointing

- Downlink
  - real-time alert
    - VHF, Iridium, TDRS, …
  - Delayed downlink – Hub or dustrubyted RF

Technical Challenges for the Squadron

- Build member satellites cheap and fast
  - Standard bus
  - COTS subsystems (Power, RF, ACDS)
- Keep it within WiFi (or similar) range
  - orbit control mechanism (propulsion or aerodynamics)
- Launch
  - add member satellites to the existing squadron
- Ground stations
  - real-time alert
  - delayed science data

Summary

- A 6U cubesat for wide-field UV survey is proposed.
  - Possible targets are
    - GW counterparts
    - SN Shock breakouts (~3/yr)
    - Tidal disruption Events (~2/yr)
    - Type-Ia SNe, Stellar flares etc
  - Status
    - Concept Design, optical system design —mostly done
    - Can be built and launched in 4 years
    - Demonstration of Attitude Sensors (will be launched in 2018)
- Multimode nanosatellite squadron concept is proposed
  - Some technical issues, probably solvable
  - Coordination may be more challenging