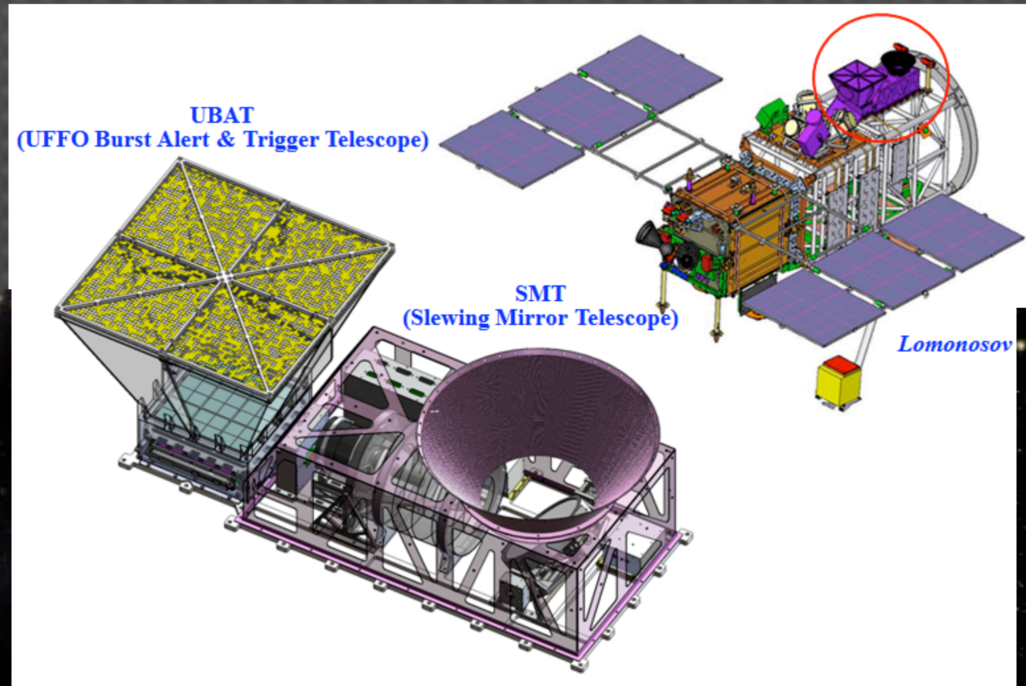
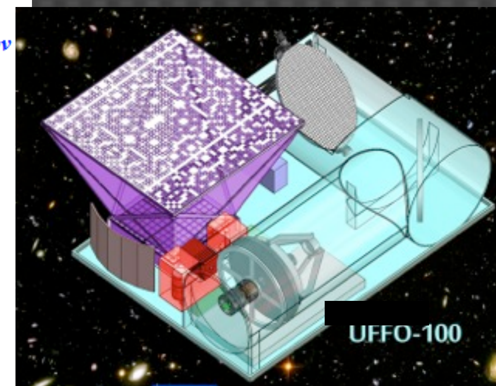




UFFO Program - Update

GRB *Optical* Response < 1 sec.

B. Grossan

SSL, EUL

EUL/Skobeltsyn Institute
MSU

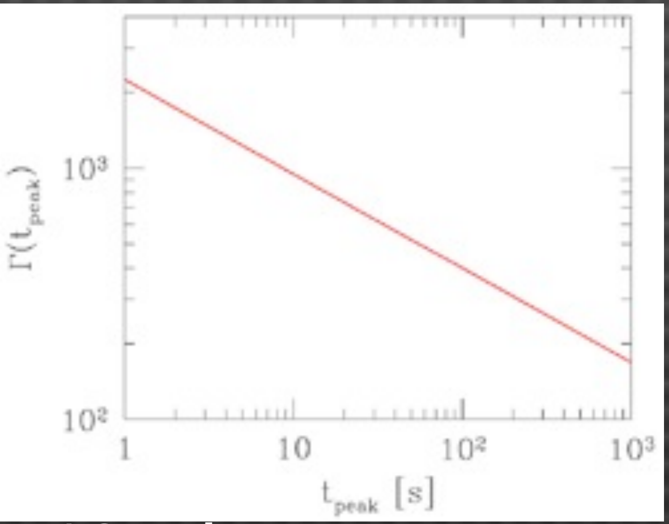
Prompt **Optical** Emisssion, the rise phase of the optical light curve,

Touches On Interesting Topics

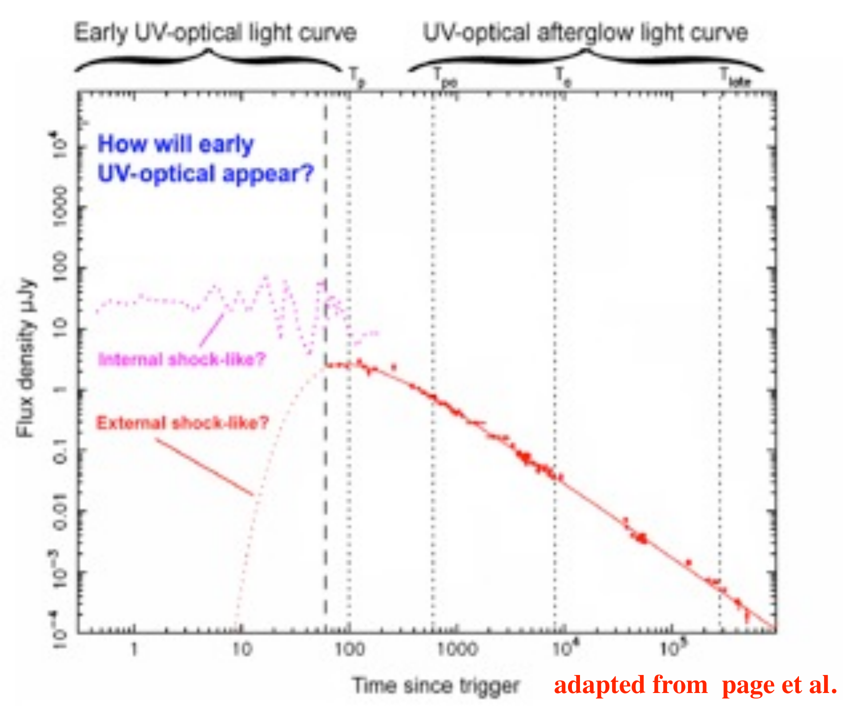
- What you could to **with faster response...**

Measurements w/Early Optical

- Measure Bulk Lorentz Factor (BLF) of Optical Emission
  - given by time of the early UV-optical emission peak[1]
    - from Molinari et al. 2007
    - Sari & Piran 1999



- For BLF = 1000, need to respond faster than 10 s !



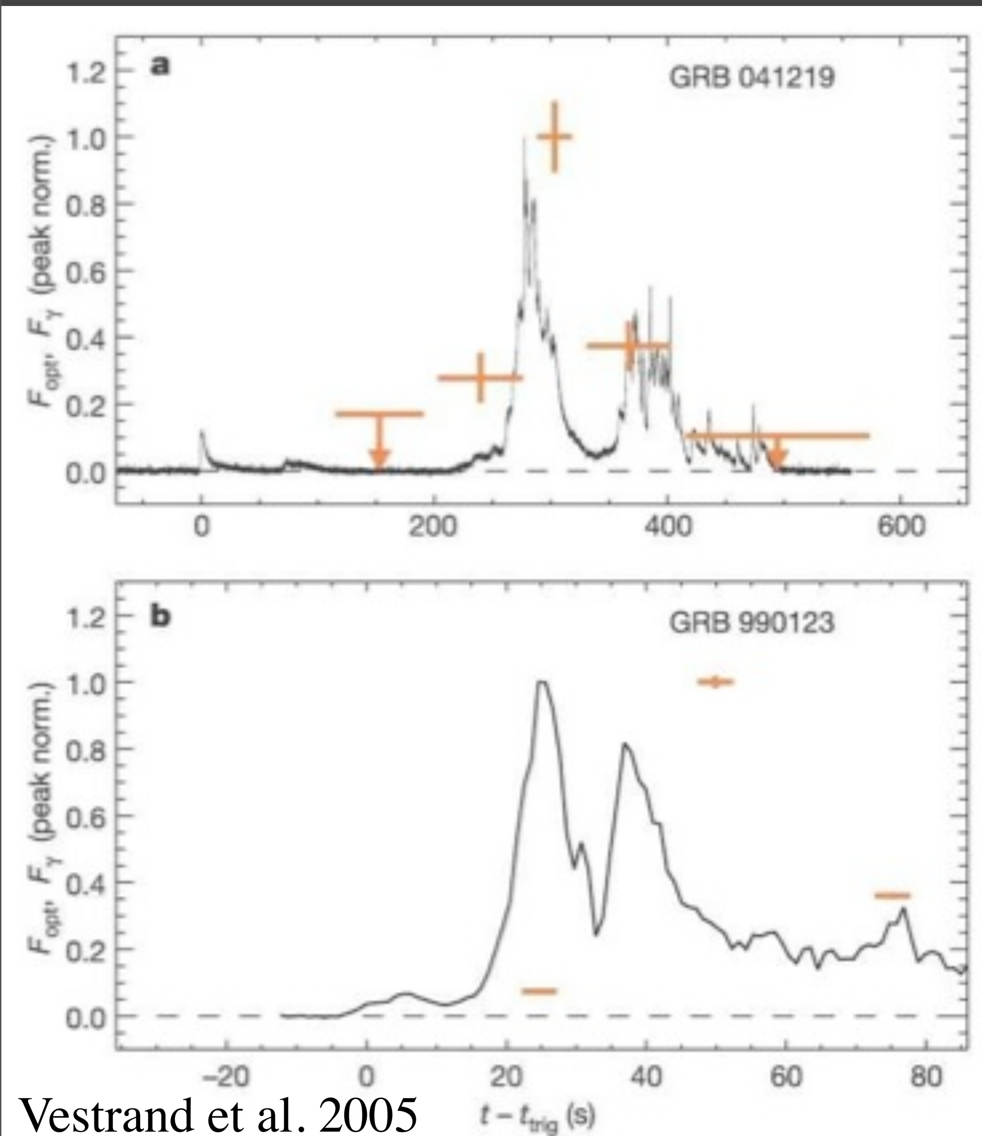
- Identify Internal Shock Emission
  - **Faster response than current, high time resolution, required.**

(1) some dependence on external density; assumes external shock

Friday, June 15, 12

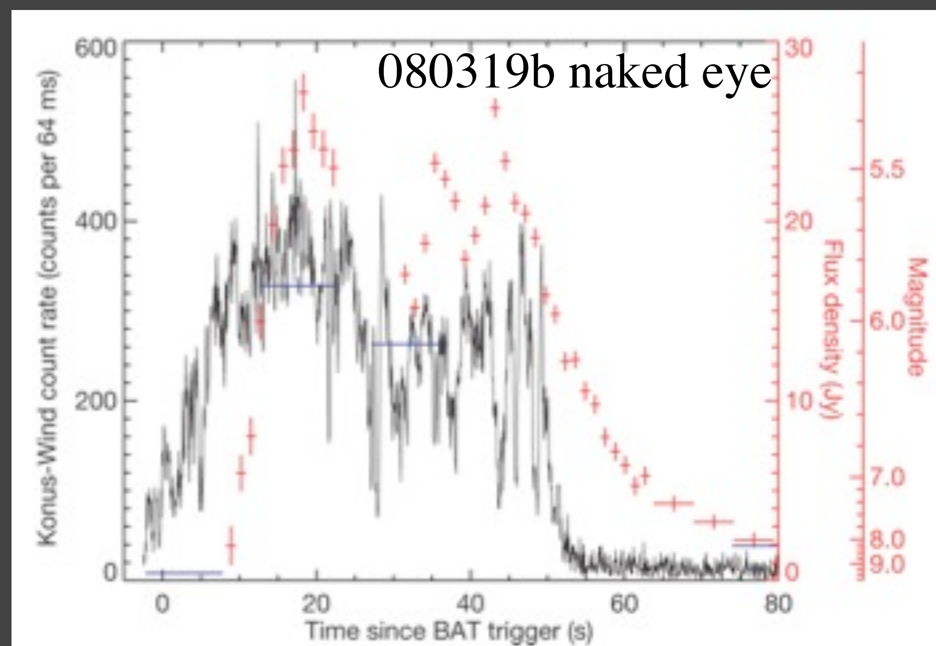
Correlation of early Opt, γ

- Both examples, and counter-examples
  - Data marginal except for 080319b
  - need faster response, resolution, to improve.



Vestrand et al. 2005

- 041219 - Probably.
- 990123- No.
- 080319b- Mostly
  - (best data)



080319b naked eye Racusin et al. 2008

"Multi-Messenger" Measurements

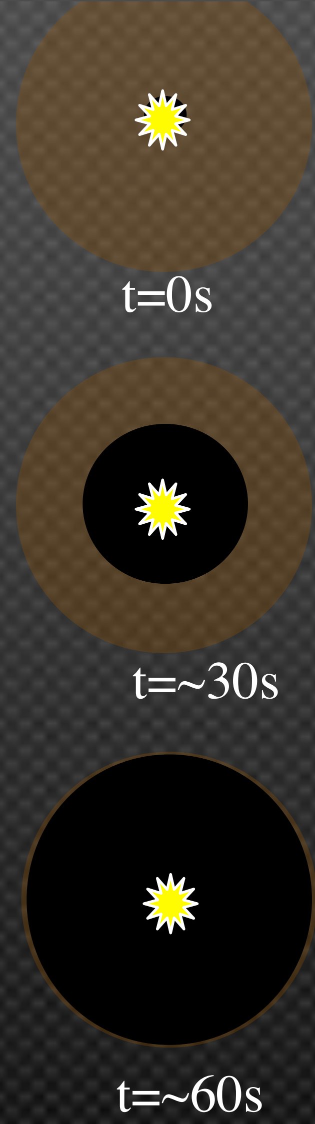
- Physics in correlation and delay for
  - Short GRB: gravitational waves vs. optical-gamma light [1]
    (depending on emission region size)
  - Neutrinos vs. optical-to-gamma prompt light
  - HE vs. Low E delay - GR alternative models (high-z vs. low-z)

... though most of these come with caveats on complex jet structure.

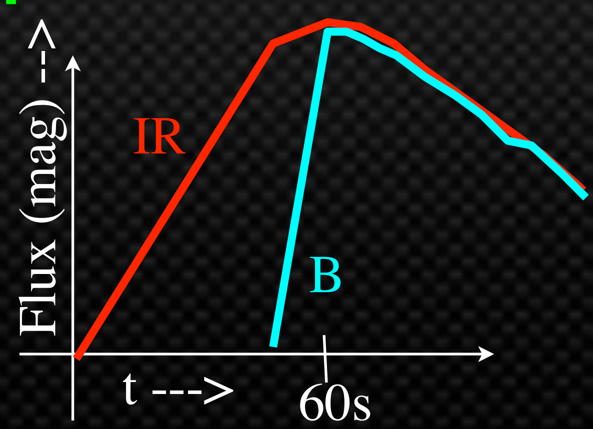
These time scales potentially very short, need faster response.

[1] e.g. Nishizawa, Taruya & Saito, cosmology with Space GW detectors also needs red shift; perhaps get many from prompt observations of SHGRB.

Probing Progenitor Environment via Dust Evaporation



- GRB have enough energetic photons to vaporize dust throughout typical dust cloud[1]
  - Typical time <~ 60 s
- *Time-dependent* extinction measurement would
  - confirm dust distribution (e.g. in cloud vs. behind dust lane), composition, evaporation models
- Need time-dependent spectral slope **with faster response** than current.

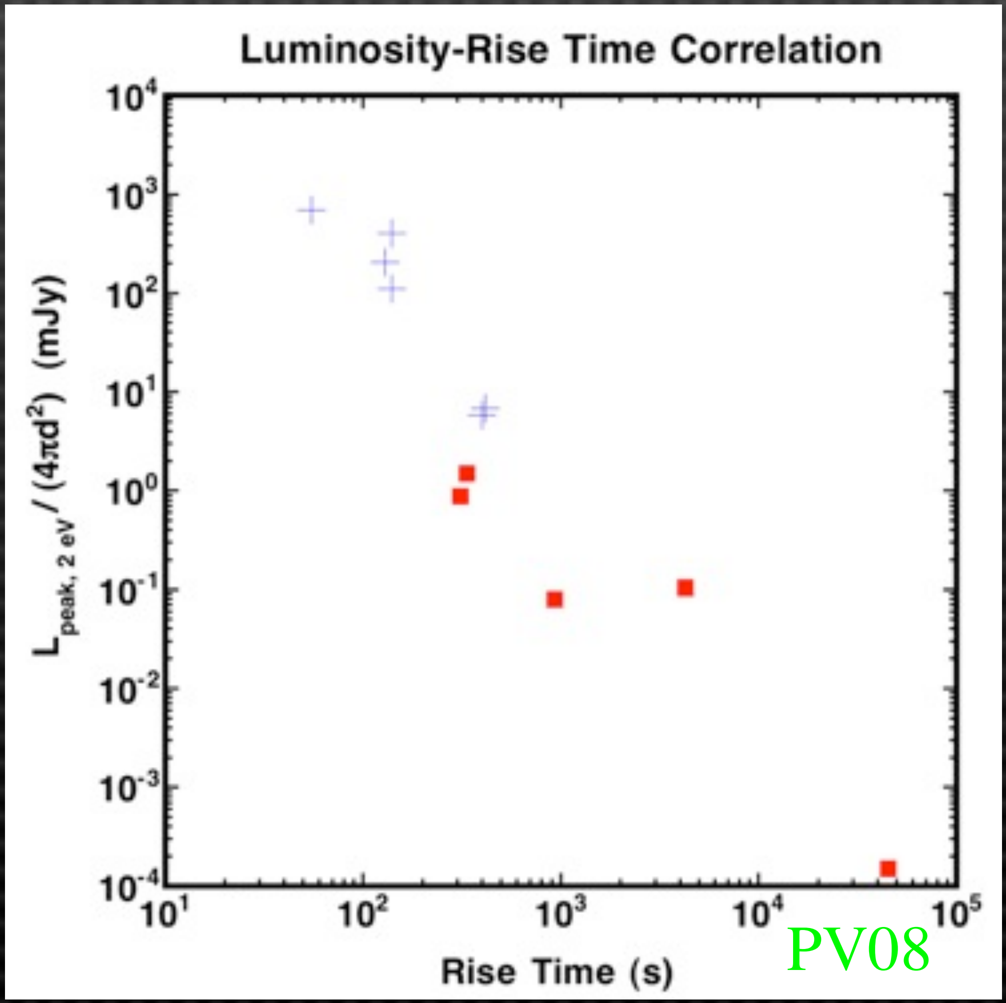


(note Fynbo talk "circumburst or other?")

(1) models: Salvaterra+09, Perna+03; >60 s too late: Oates+09, Perley+10

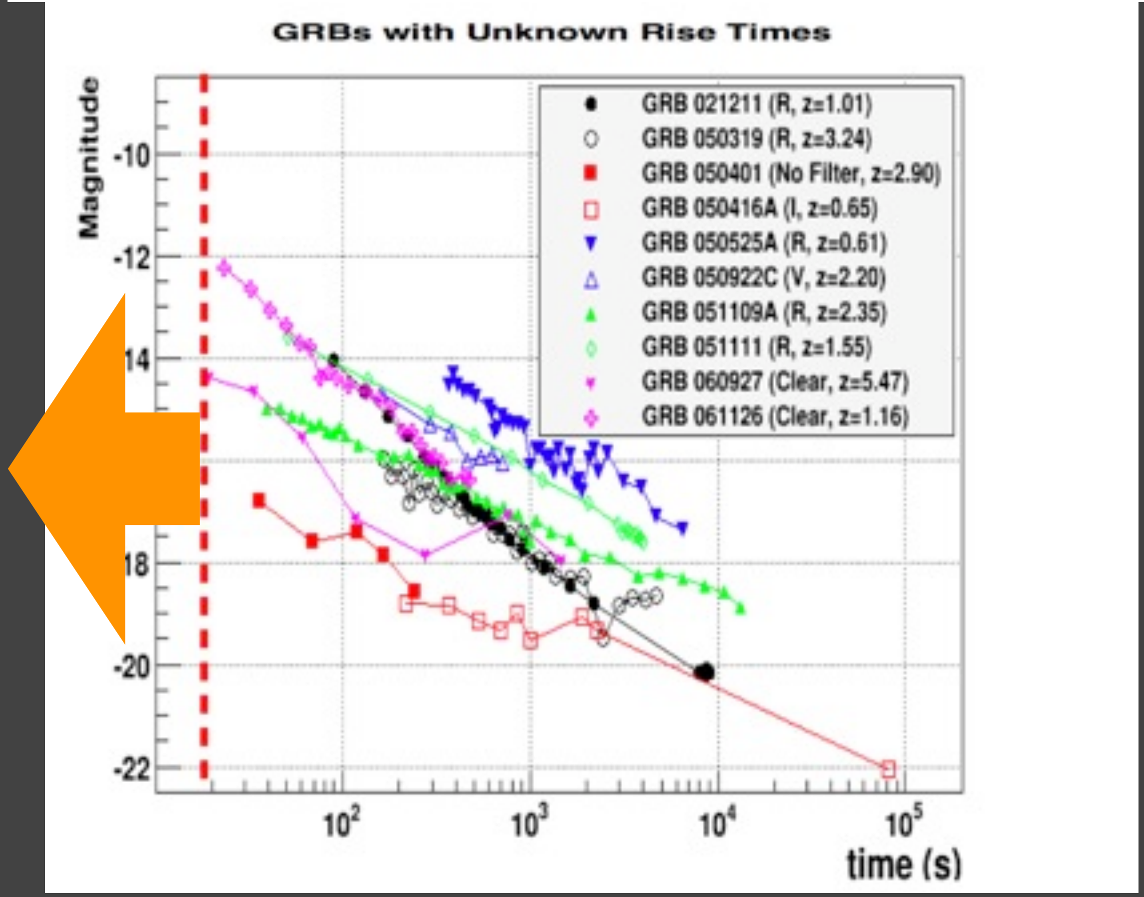
GRB Luminosity Calibration? Cosmological tool?

- PV08: calibrate L_{peak} with rise time:



Well, *those* points correlate, but ...

Same paper, but not plotted....

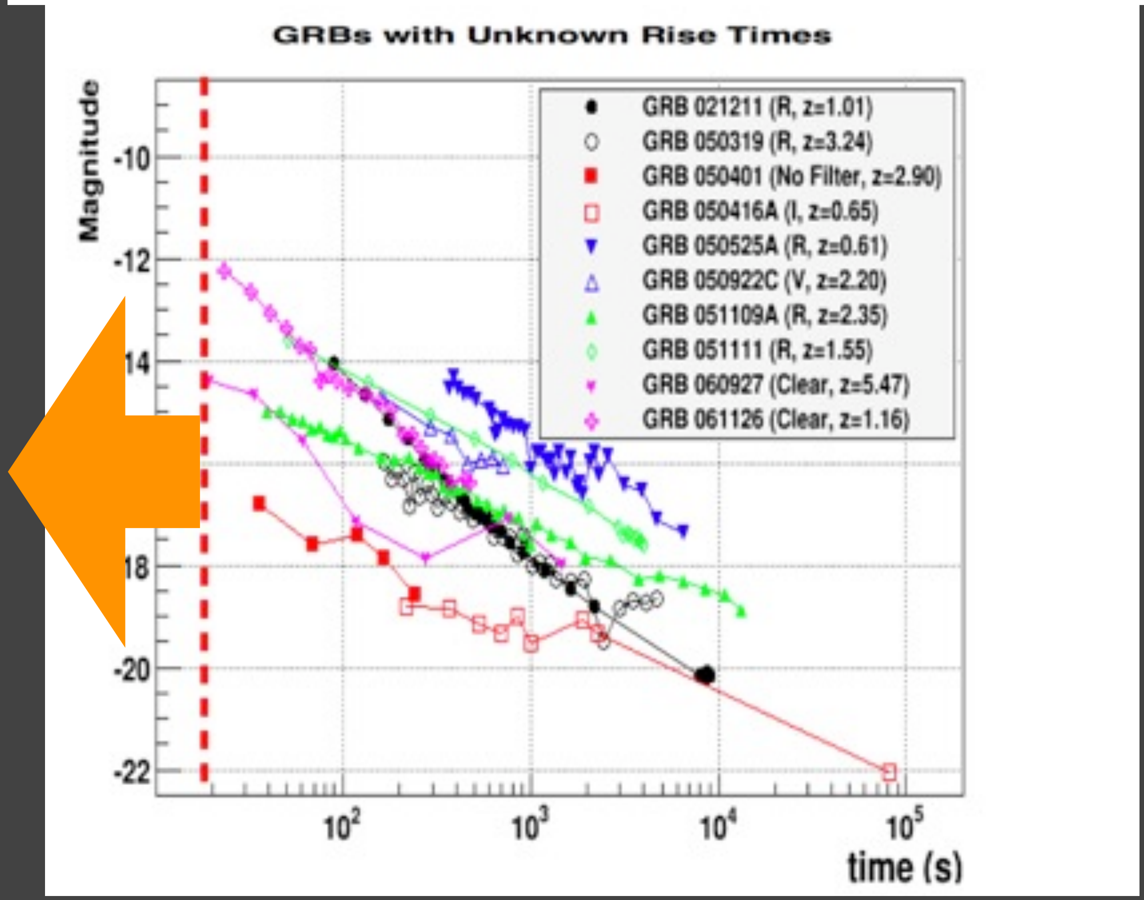


- 2/30 TOTAL in PV08 have < 60 s peak, but majority (18/30) have no clear peak.

Well, *those* points correlate, but ...

- Majority of sample data not used... **because lacking early data**...

Same paper, but not plotted....



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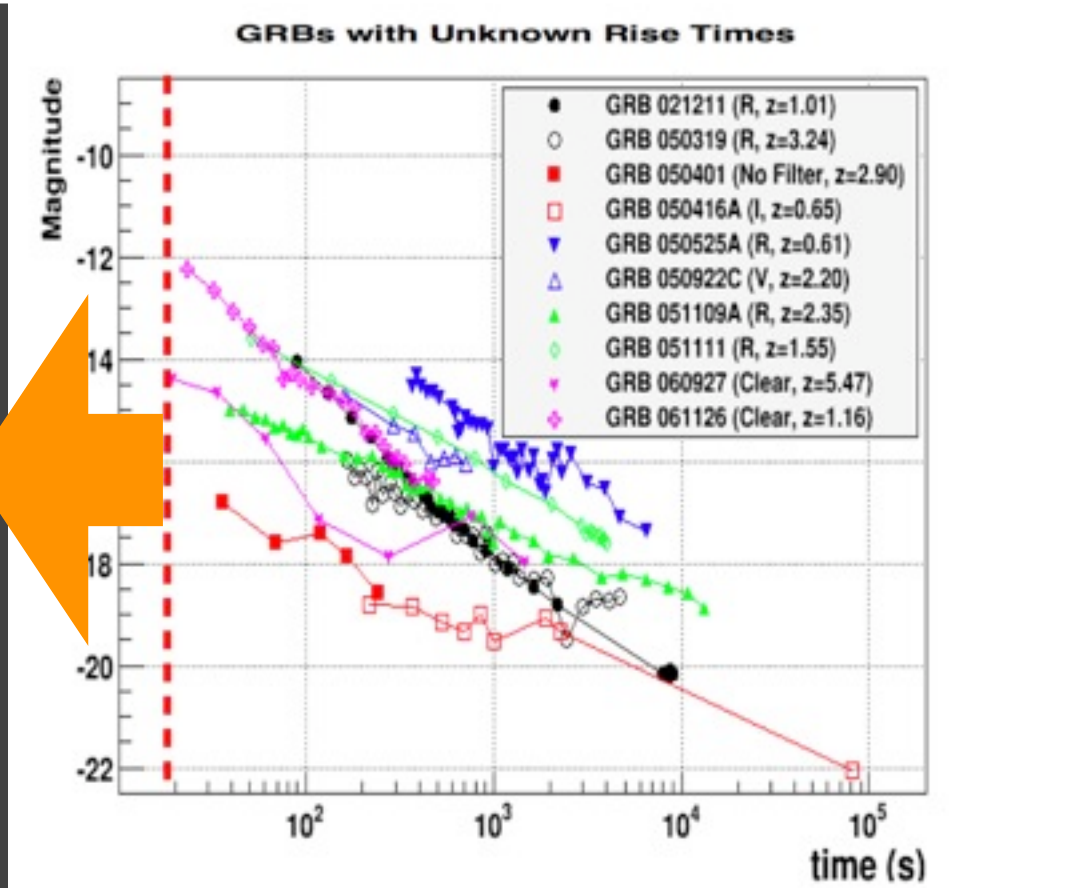
- **Need more data at earlier time!**



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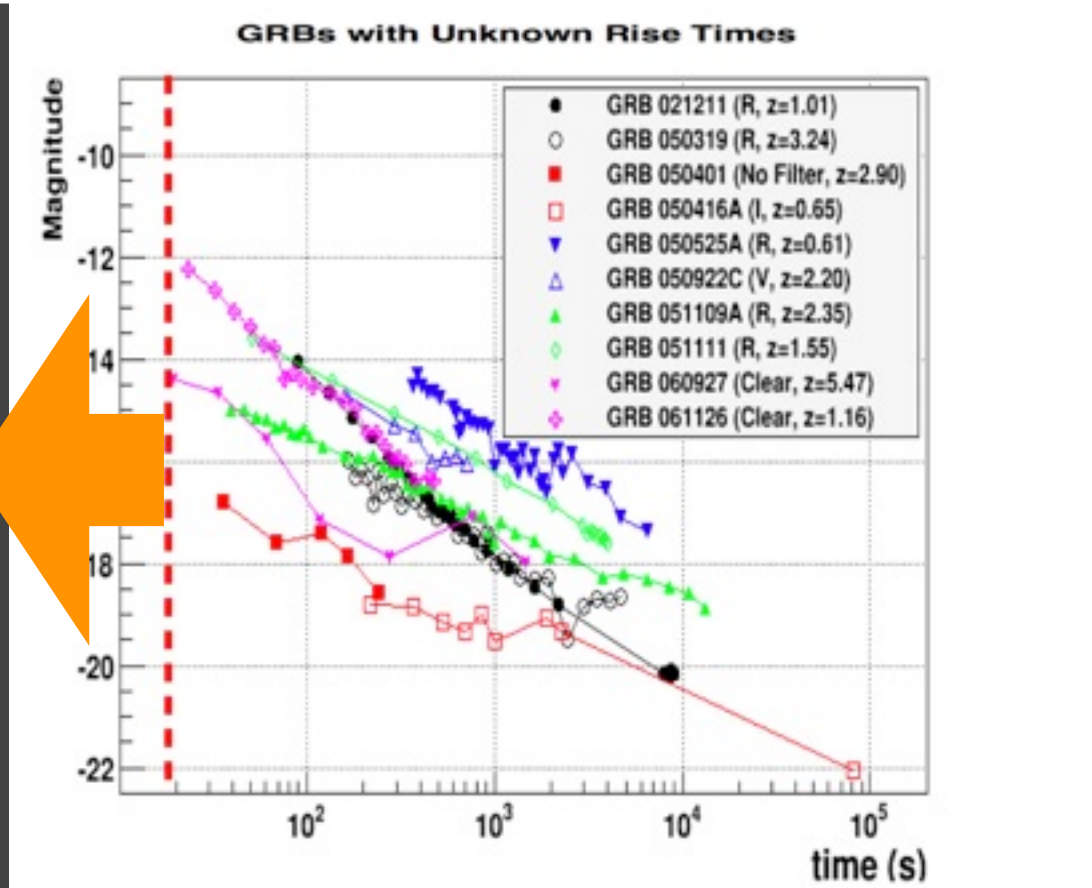


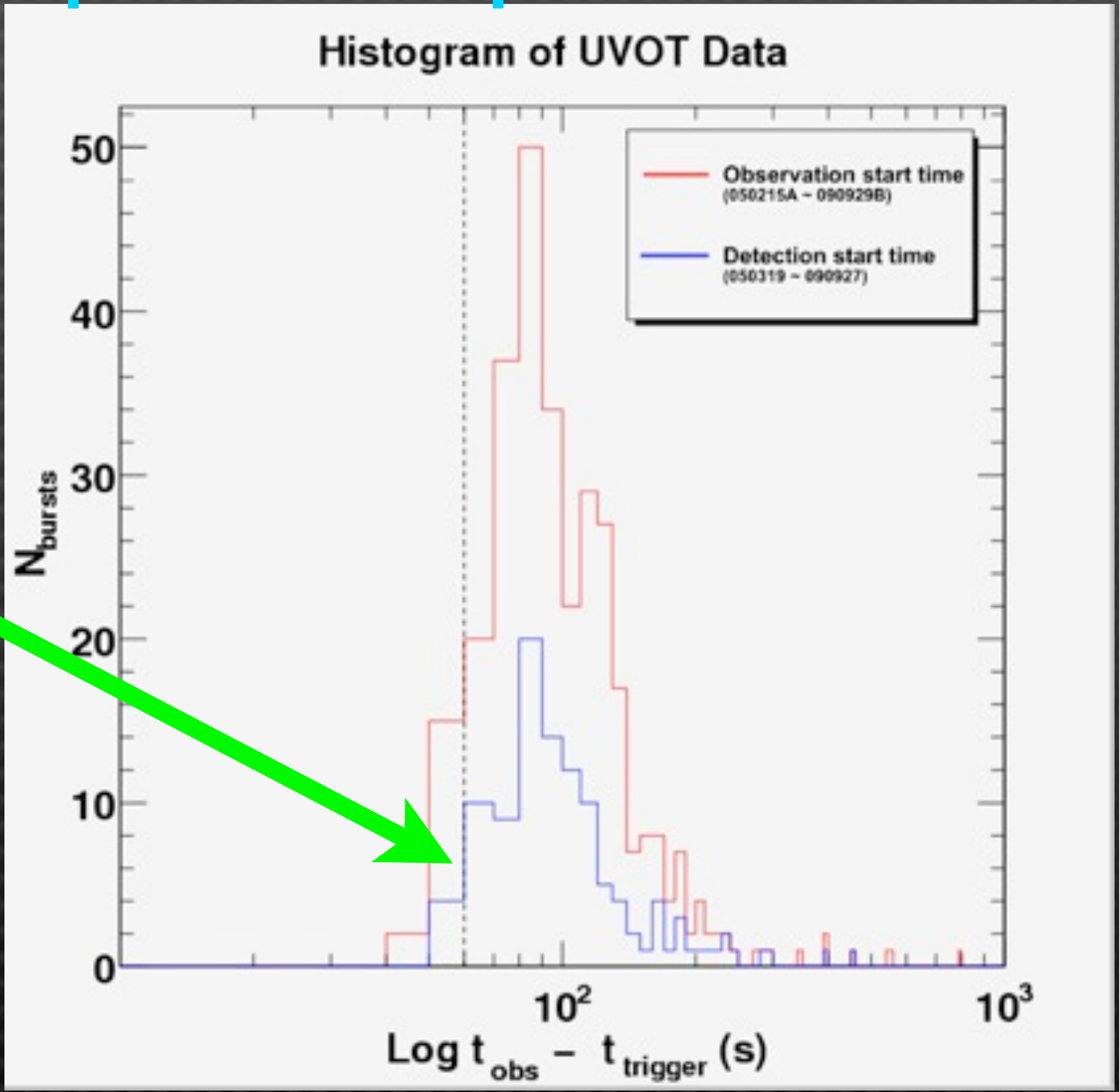
- **MOST t_{rise} unknown.**
- **Need more data at earlier time!**

- **NEED FASTER RESPONSE TO EVALUATE!**

- 2/30 TOTAL in PV08 have < 60 s peak, but majority (18/30) have no clear peak.

SWIFT response speed limited

- SWIFT has few data t < 60 s !

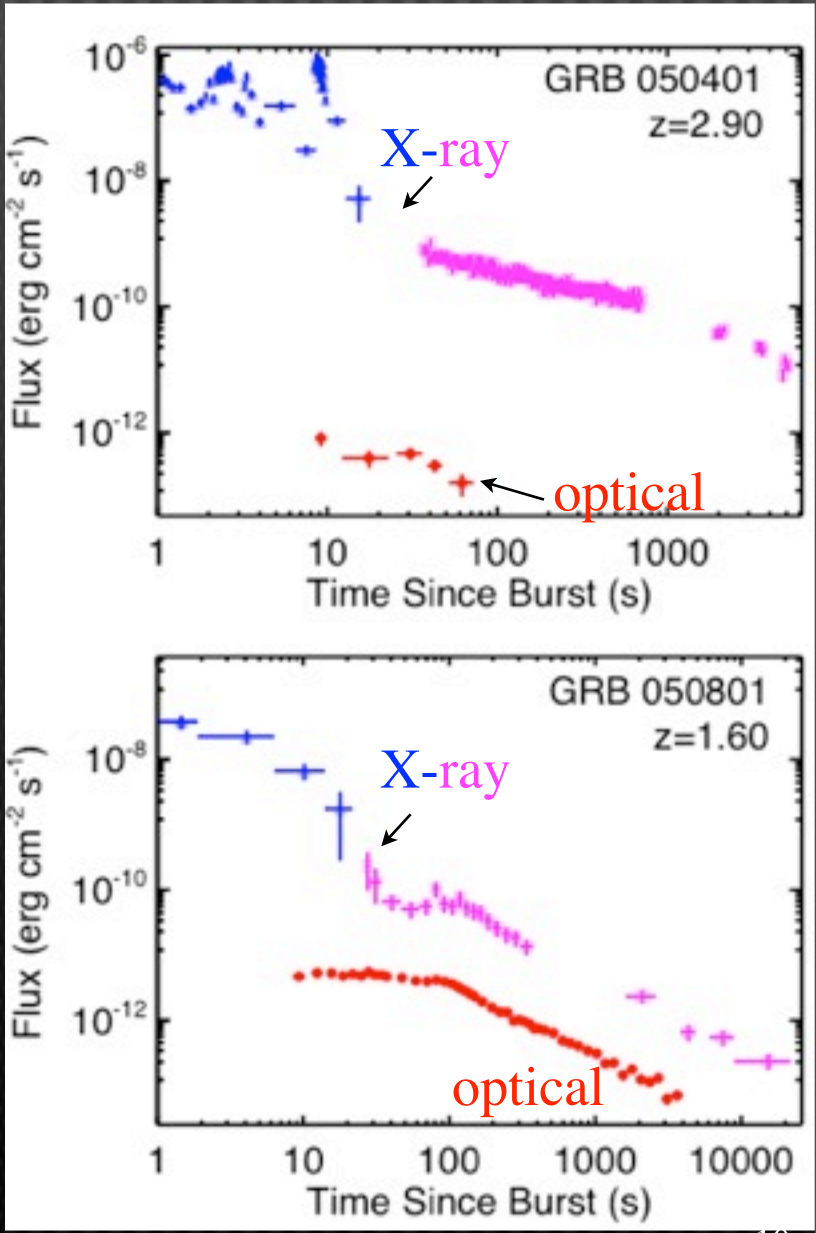


How will we ever get a large sample of rise times, shapes?

Ground-Based Telescopes: Small # of Rapid Results Very Interesting

- Fastest Responses in Rykoff+09: Too Slow for Rise
  - In all of Rykoff, < 60 s responses... ONE rise time measure.
  - Wouldn't you like to know the true distribution of optical rise times?

Rykoff+09, red points are ROTSE-IIII



...but still too slow and rare.

Future Prospects

- SIX YEARS of SWIFT+ Ground Systems-few rapid detections
  - Weather, limited sky, small aperture limit impact of ground-based *rapid* follow-up.

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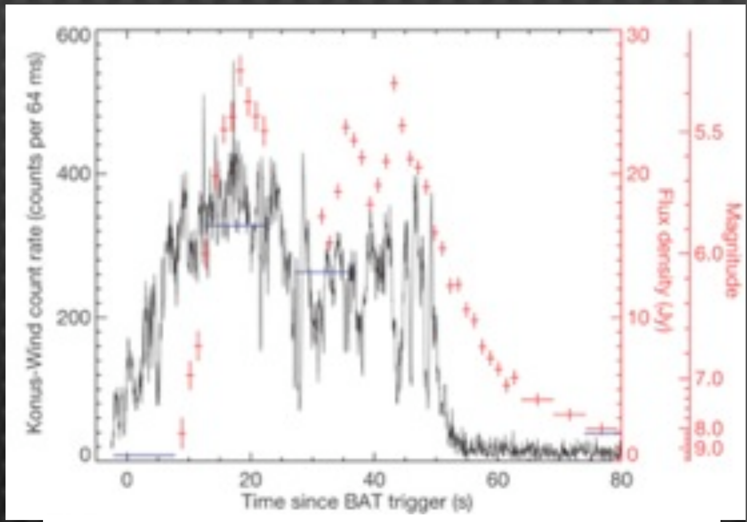
080319B is really the "Lucky" burst: 10° and 30 min. after another!



080319b naked eye Racusin et al. 2008

ONE in six years!!

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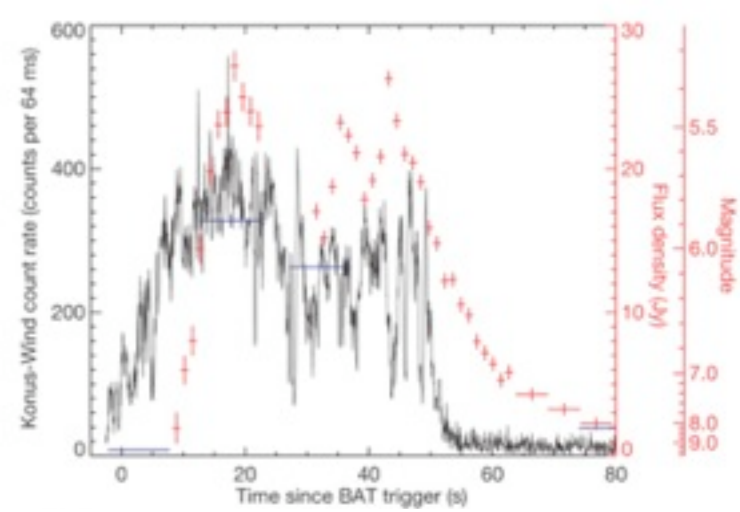


080319b naked eye Racusin et al. 2008

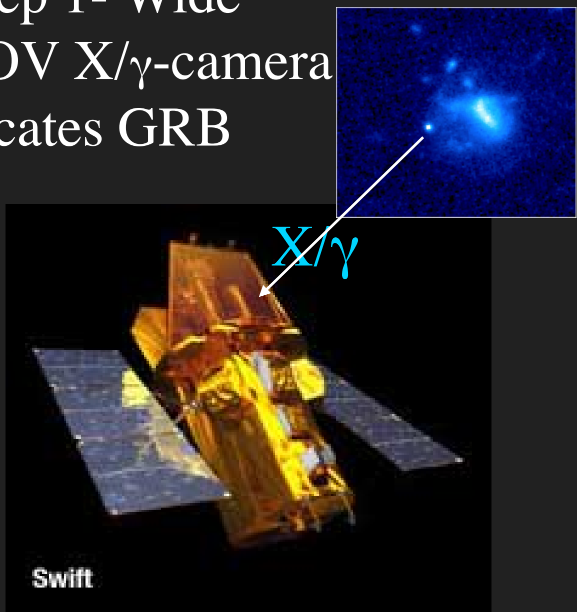
ONE in six years!!

- SWIFT life is finite; after, alerts stop!
- **NEED FASTER SYSTEM FOR GAME-CHANGING PROGRESS!**

Respond Faster?

- SWIFT rotates entire spacecraft to point opt instrument

Step 1- Wide FOV X/γ-camera locates GRB

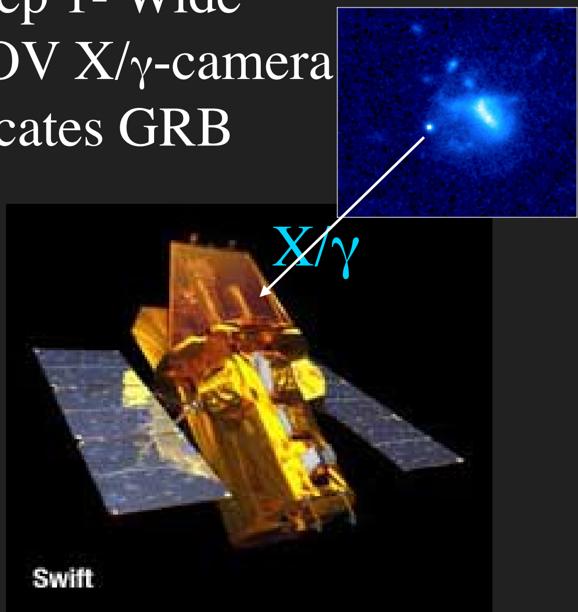


Step 2- Spacecraft rotates to point at GRB

Respond Faster?-Steer the Beam

- SWIFT rotates entire spacecraft to point opt instrument

Step 1- Wide FOV X/γ-camera locates GRB



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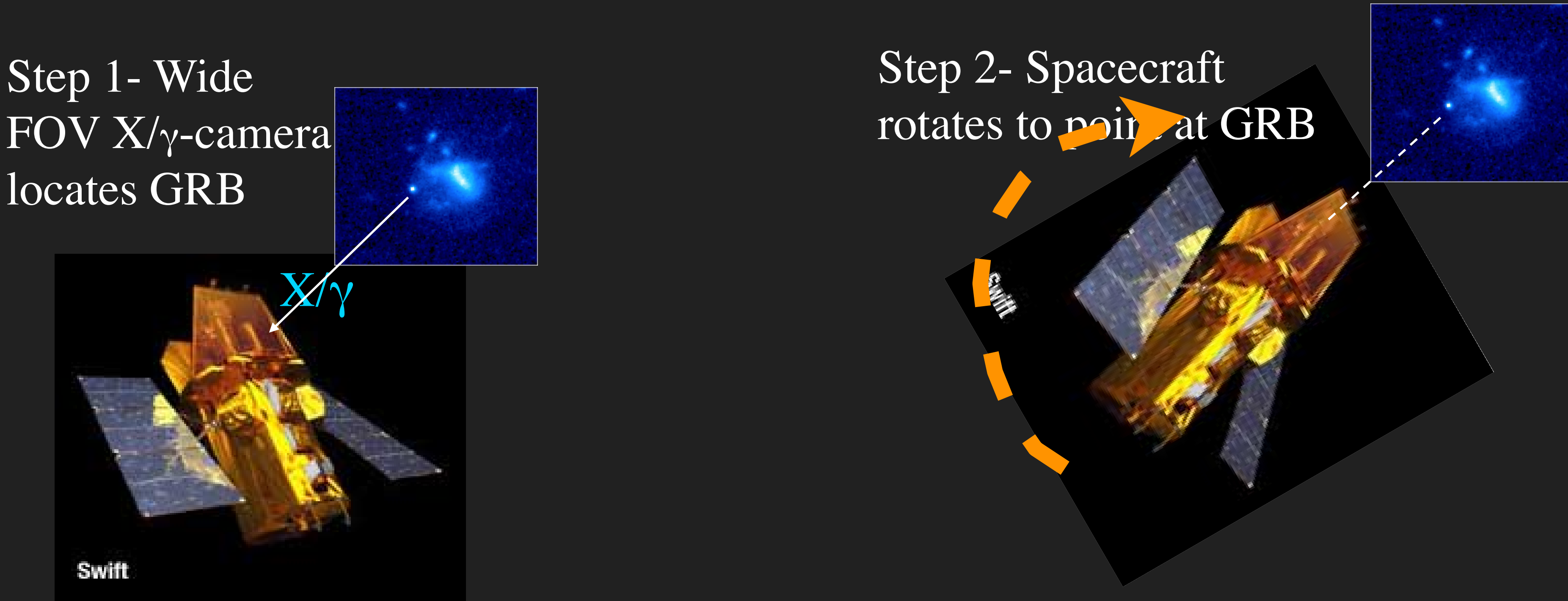
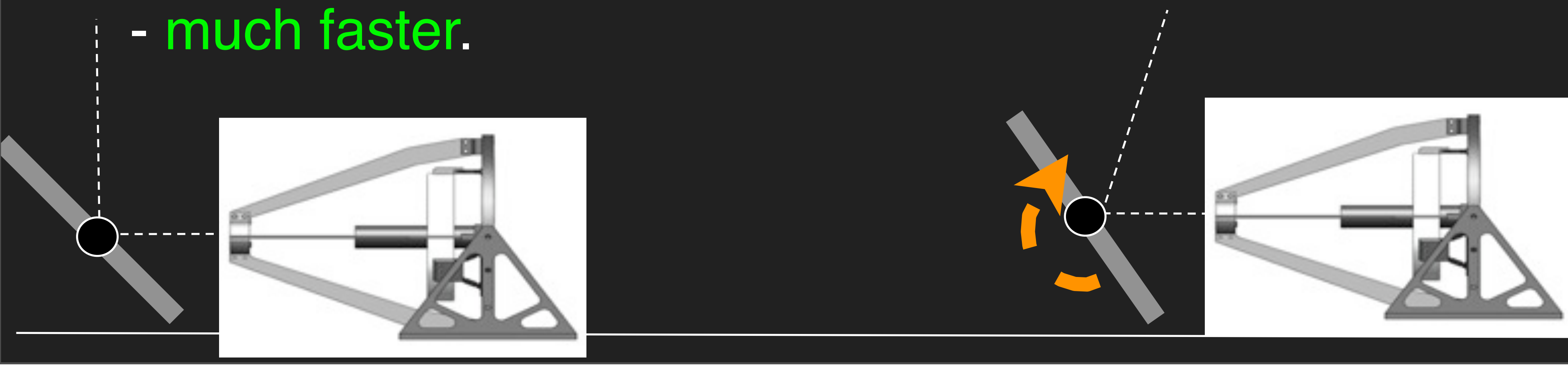


- We use mirrors to steer the *beam*, not the spacecraft - much faster.

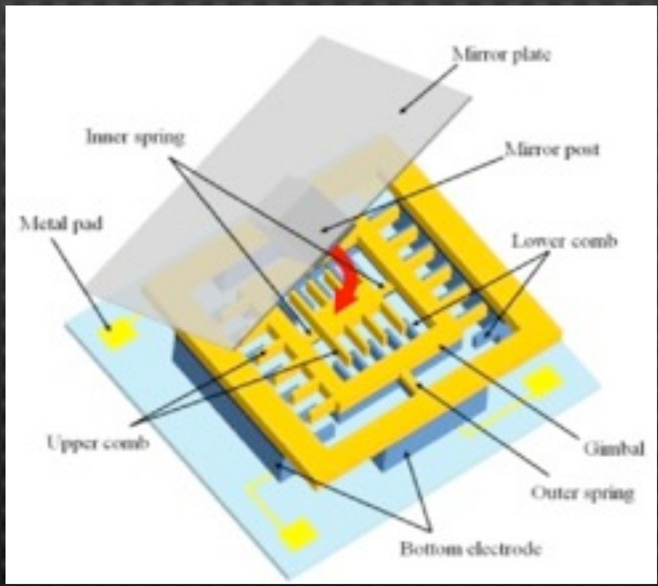


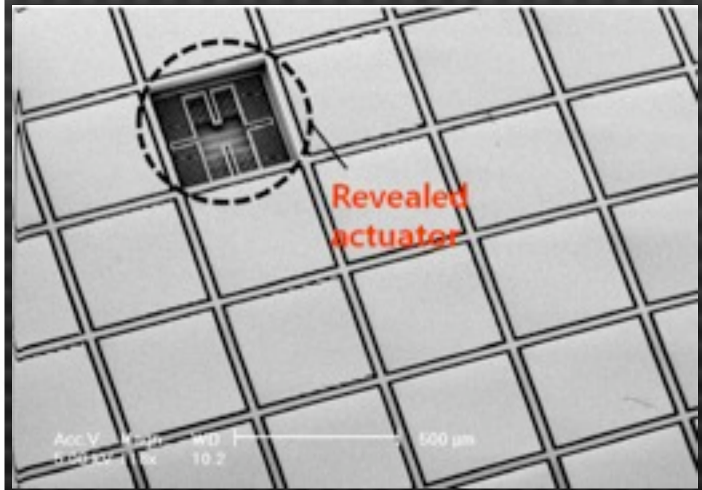
MEMS Technology

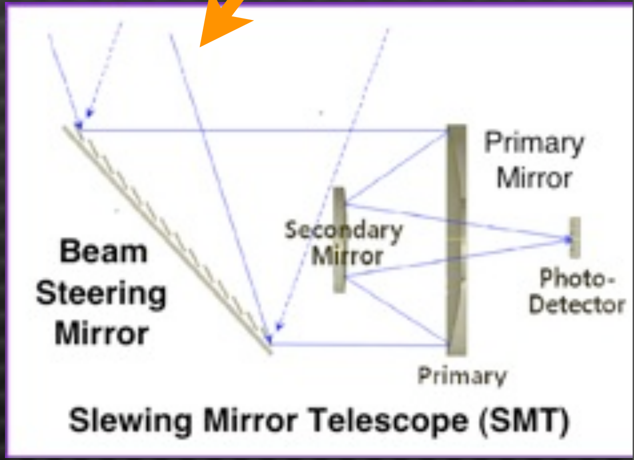
- MEMS mirror arrays @ Ewha, Seoul - **FAST**
  - from +40 deg. to -40 deg. in ~ **1 ms, point+settle**
  - negligible power, mom. of Inertia

MEMS Group, Korea
Il Park, P.I.

Steer a telescope beam with MEMS in front





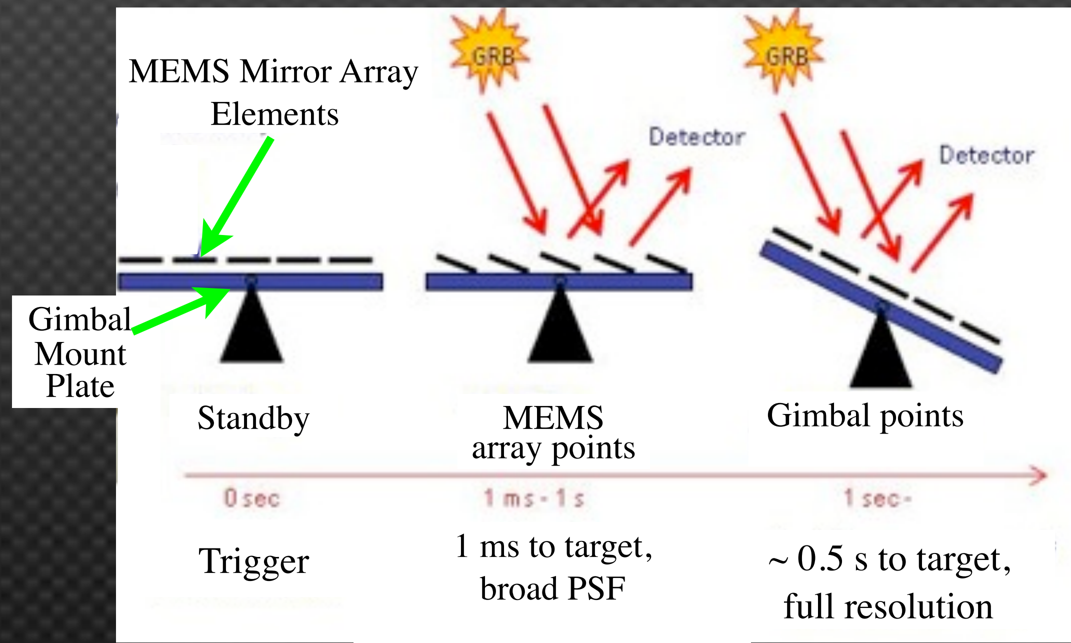


- Speed Costs:
  - limiting factor is uniformity of manufacture => **~ 2 arc minute PSF**
    - can correct? Not Yet. - any individual control greatly increases # lines on chip
    - ”grating effect” and diffraction limit also give problems

Hybrid MEMS/Gimbal Concept

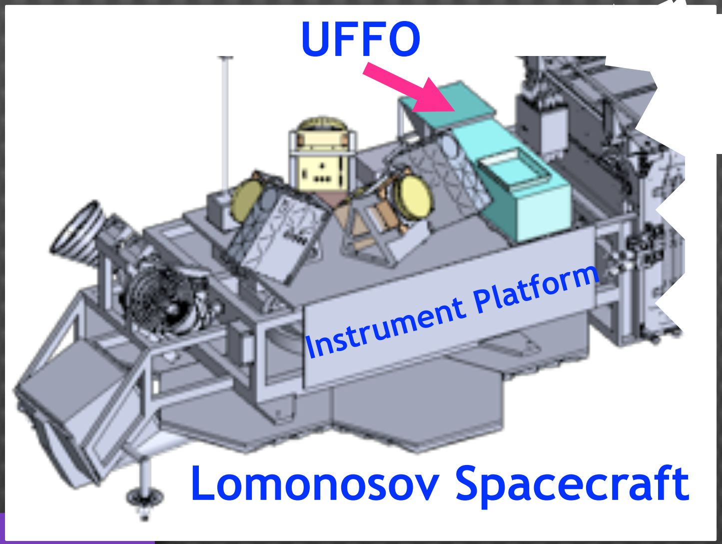
- Ultra-fast Mode:
  - MEMS array responds in ~ 10^{-3} s
    - PSF ~ up to 2 arcmin means reduced sensitivity!
      - OK for brightest bursts.

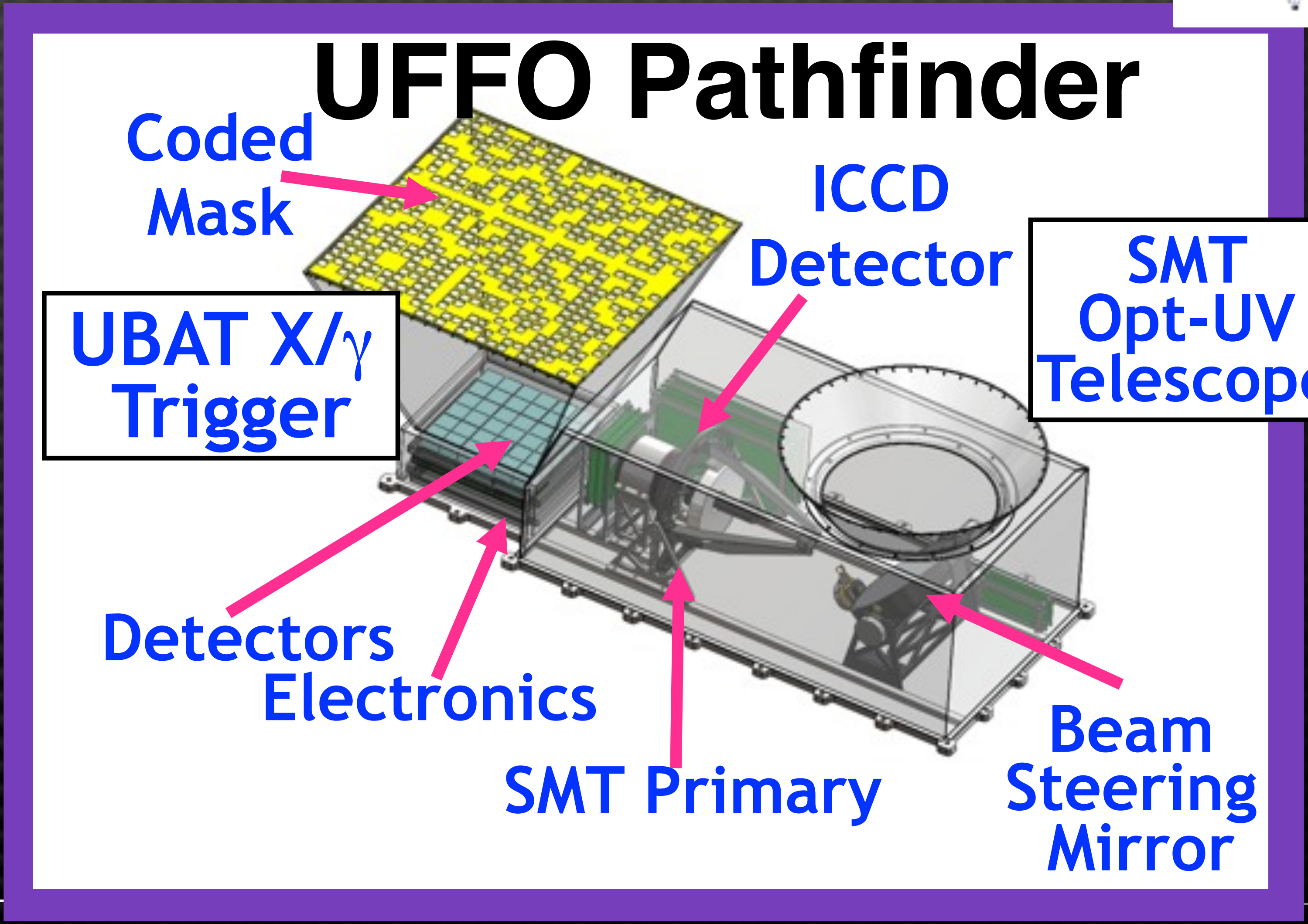
- Fast-Reponse:
  - MEMS array off. PSF now < 1 arcsec
  - Gimbals respond < 1 s over 90°field.



UFFO-Pathfinder

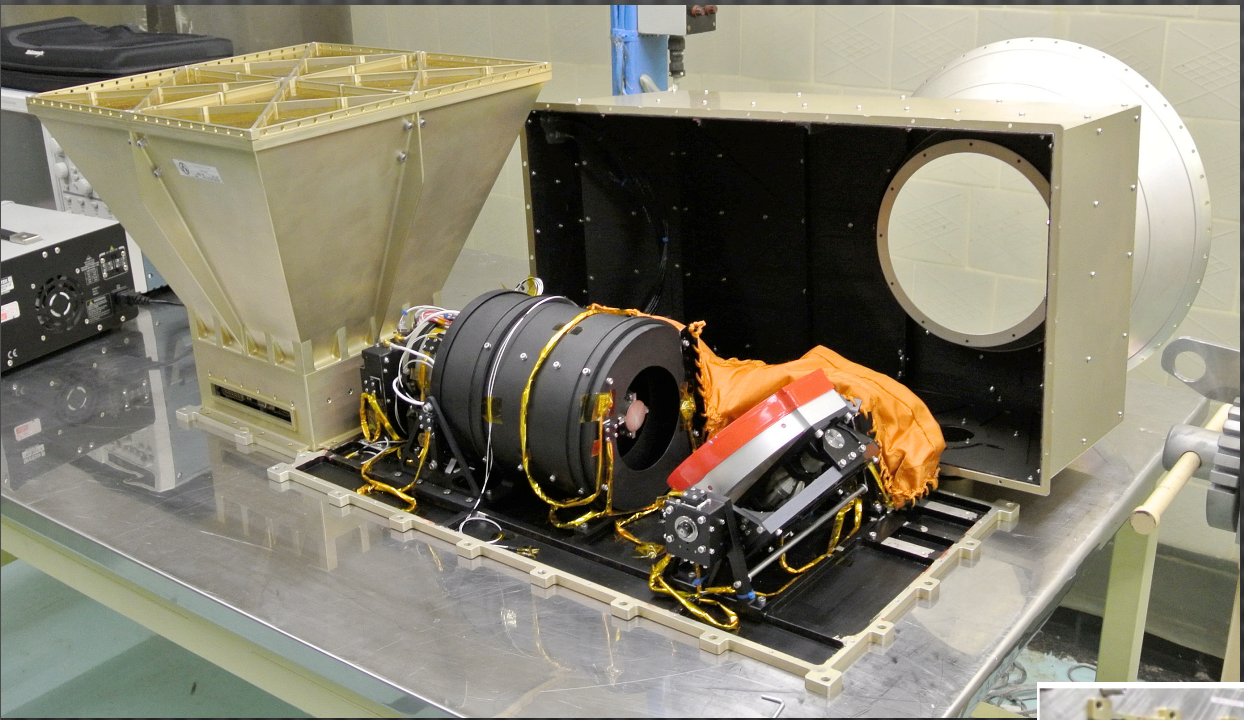
- Small! - 20 kg, 10 W only 10 cm mirror, but...
- ~ 40 triggers, 10 optical detections /yr



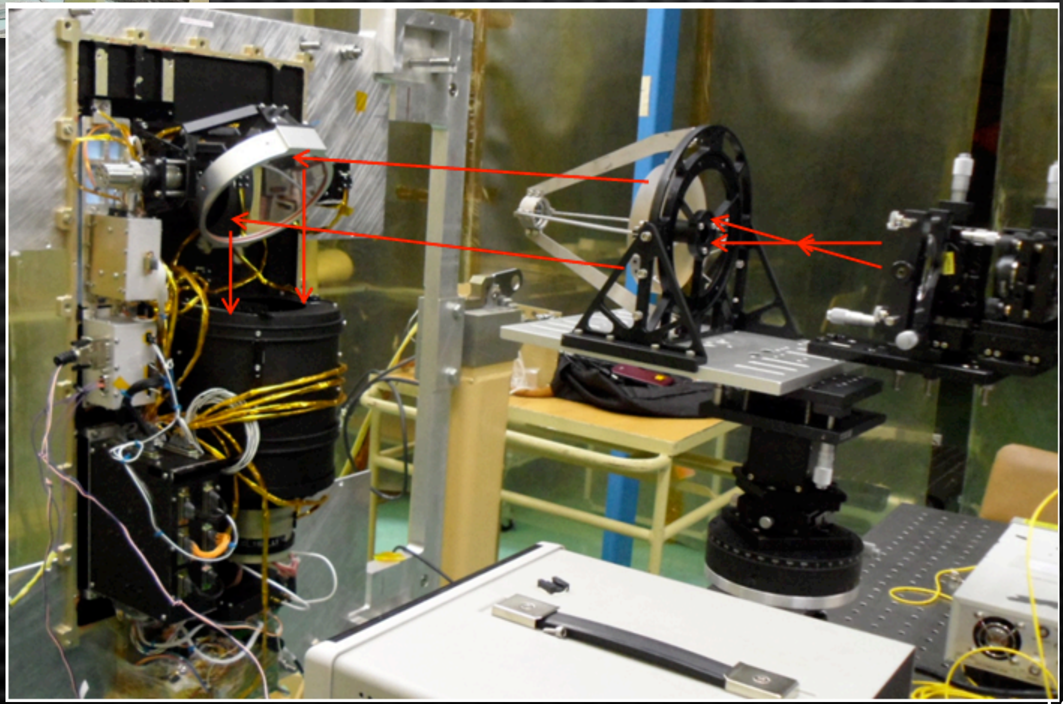


Launches April!

UFFO-Pathfinder

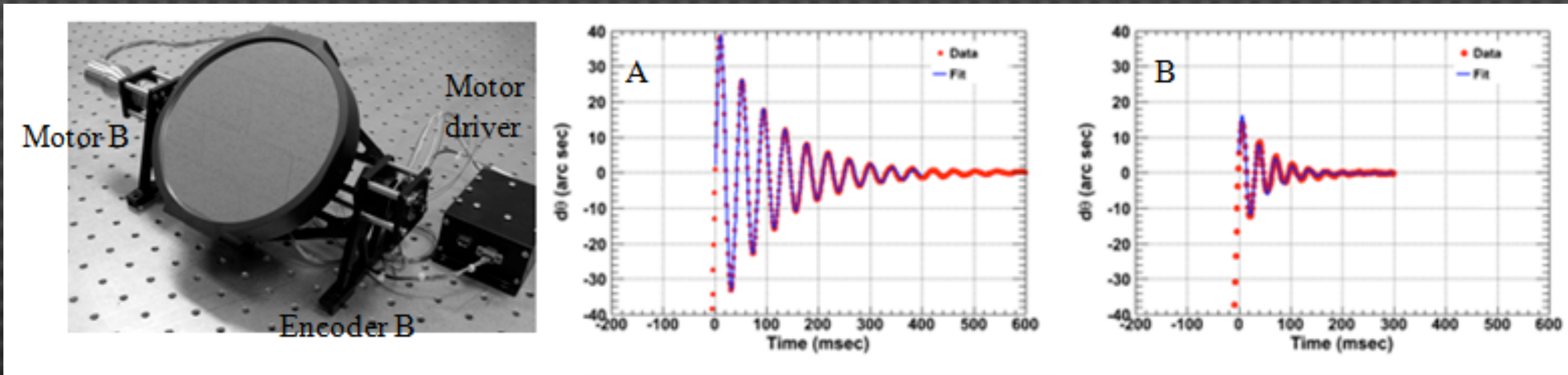


Flight model of Slewing Mirror Telescope (Flight model of UBAT is mounted together on the UFFO base-plate and final cross calibration has been done)



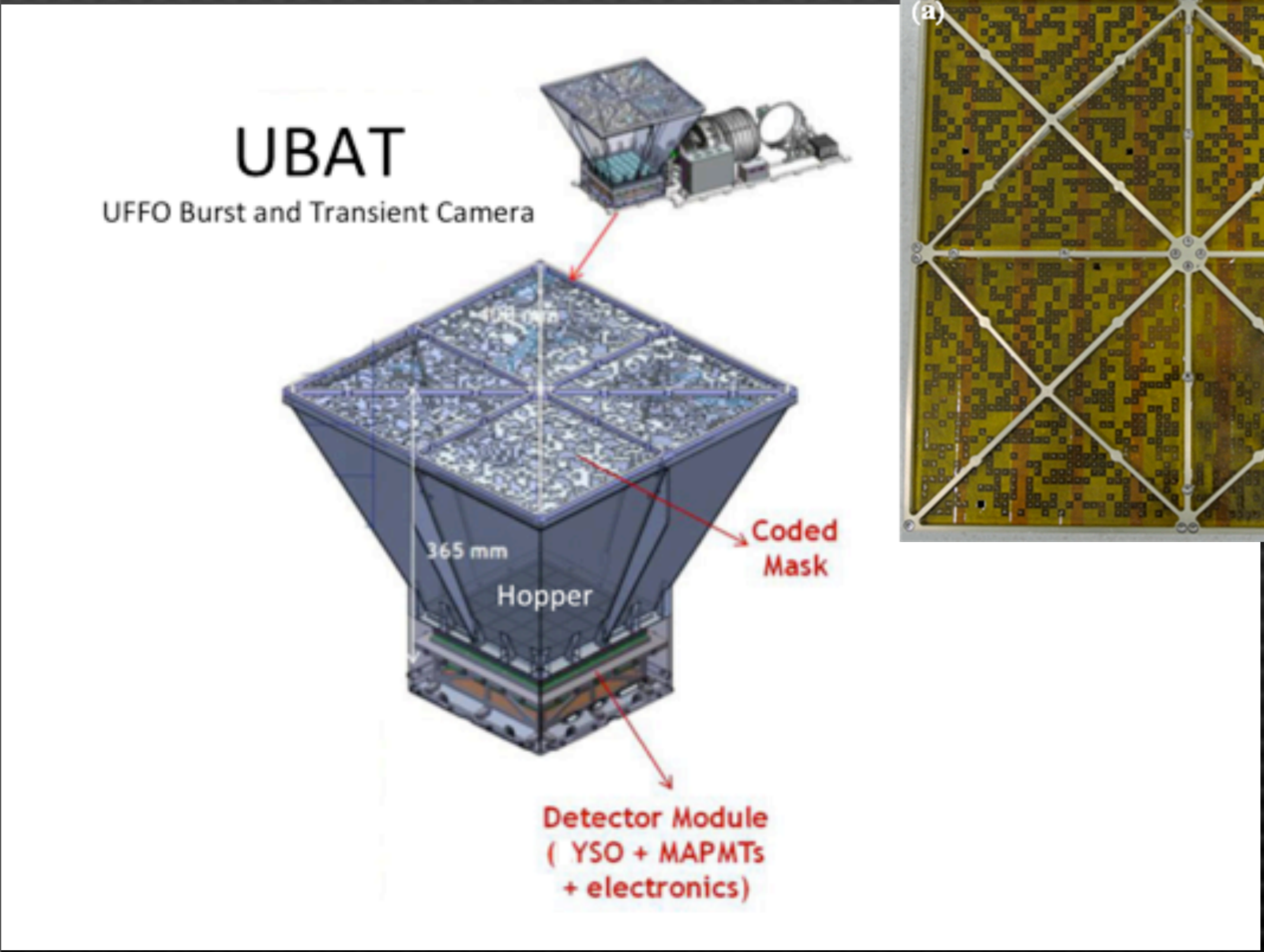
System verification during the final integration in ISTRA, Russia (Flight model of SMT is mounted vertically and parallel beam was made from pre-flight Ritchey-Chrétien telescope)

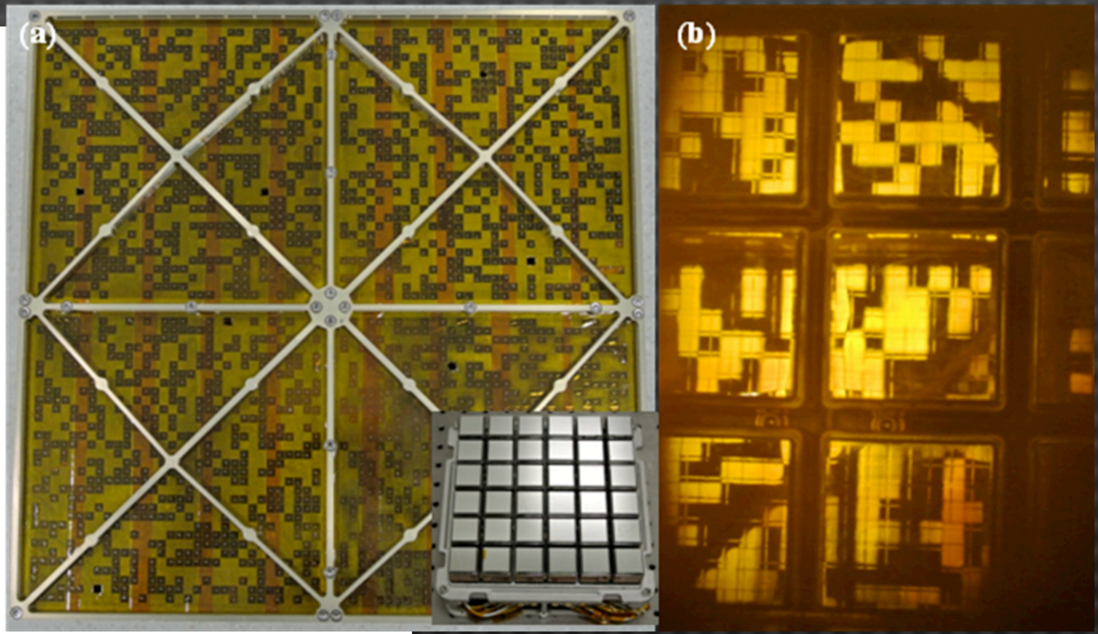
UFFO-Pathfinder Mirror Technology



- Limiting Slew time - settle time - < 400 ms

UFFO-Pathfinder Mask by U. Valencia

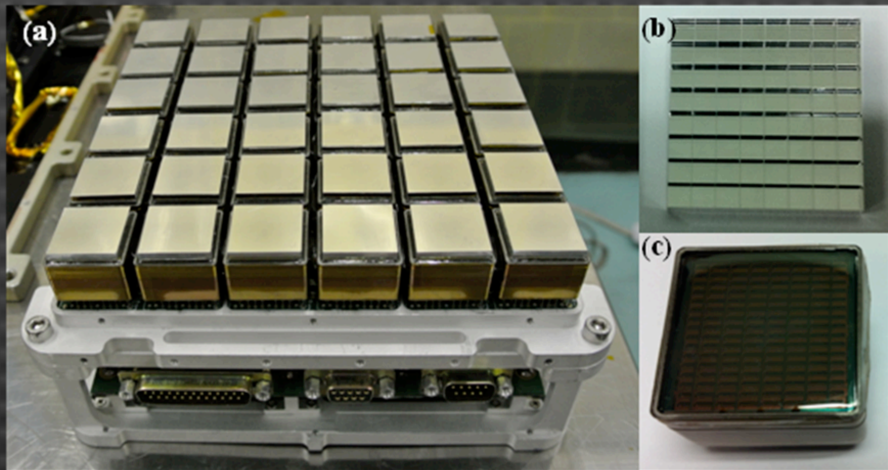




- Tungsten

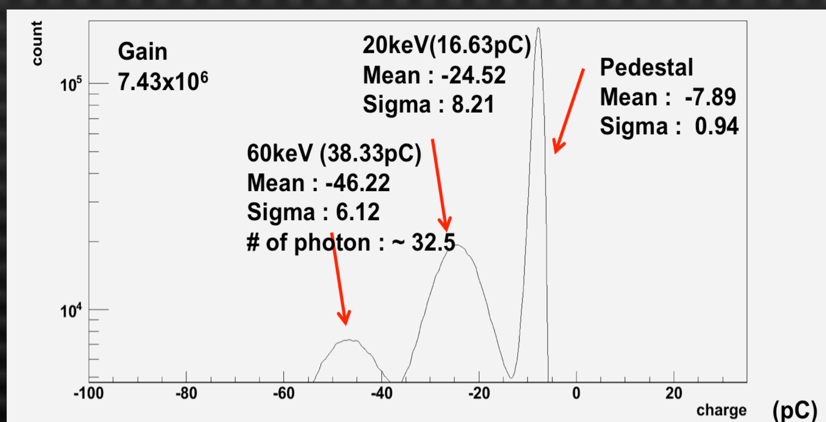
UBAT Detectors

- MAPMT read selected for re-use of JEM/EUSO ASIC



- YSO xtals primary detection
- material

UBAT Digital board. It consists of 2 FPGAs, 2 SRAMs, and a flash memory. A MCU is reserved.



UBAT Numbers

Instrument Type: Coded Mask X-Ray Camera
Mask Size: 380.16 mm square (ref BGPC1)
Mask-Detector Separation: 282 mm (ref BGPC2)
UBAT Mass: 10.0 kg (9.31 TM + .69 contingency & Harnass) (ref ubmb10)
UBAT Power: TBD
Shielding: Passive graded 2.0 mm Al + 0.1 mm W (ref ubmb10)
Half-Coded FOV: 68 deg (ref BGPC3)

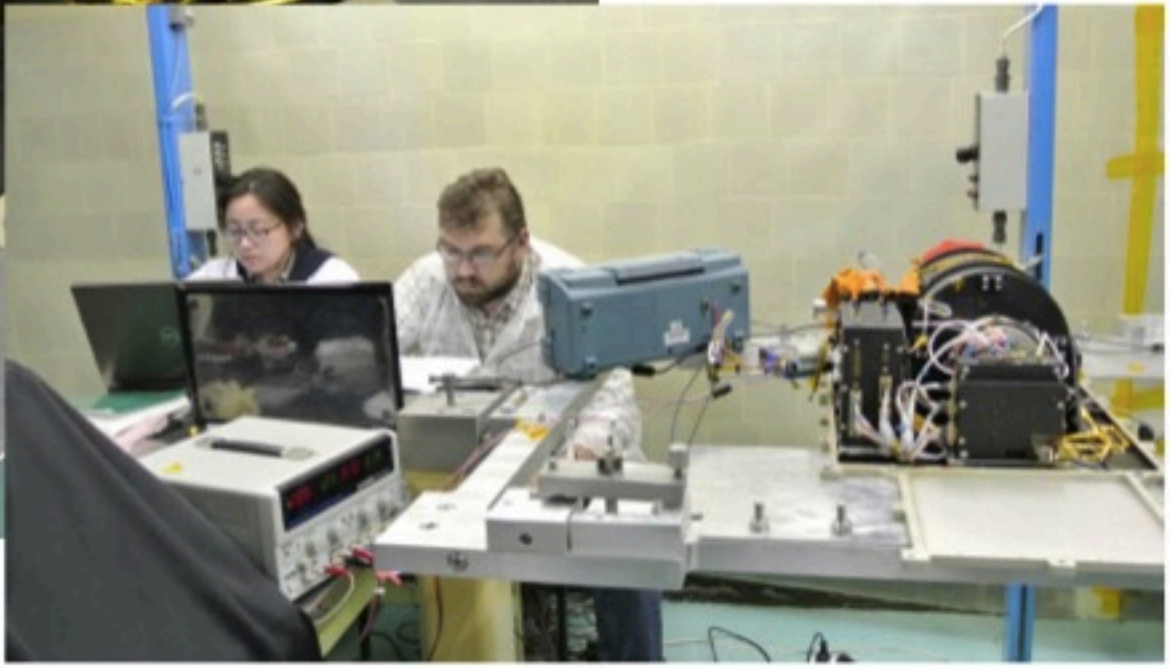
Detector Material: YSO Crystal (ref 120214)
MAPMT Anode Pitch: 2.88 mm (ref pcca)
Total Area: 191.1 cm^2 (ref ubmb10)
Electronic Detectors: Hammamatsu MAPMT (ref 111109)
Energy Range: 10-100 keV (ref bg1)
Detector Array: 9 X(2X2 MAPMT/EC Board) = 36 MAPMT, 8 channels each (ref udm3)
N_Channels: 48X48 = 2304 (ref pcca)

Imaging Frame Time = 500 ms (ref gt11)
Trigger Windows: 1, 2,4,8,16,32,64 s (ref gt11)
Maximum Integration Time: 64 s (ref gt11)

UBAT Now In Testing @ Istra

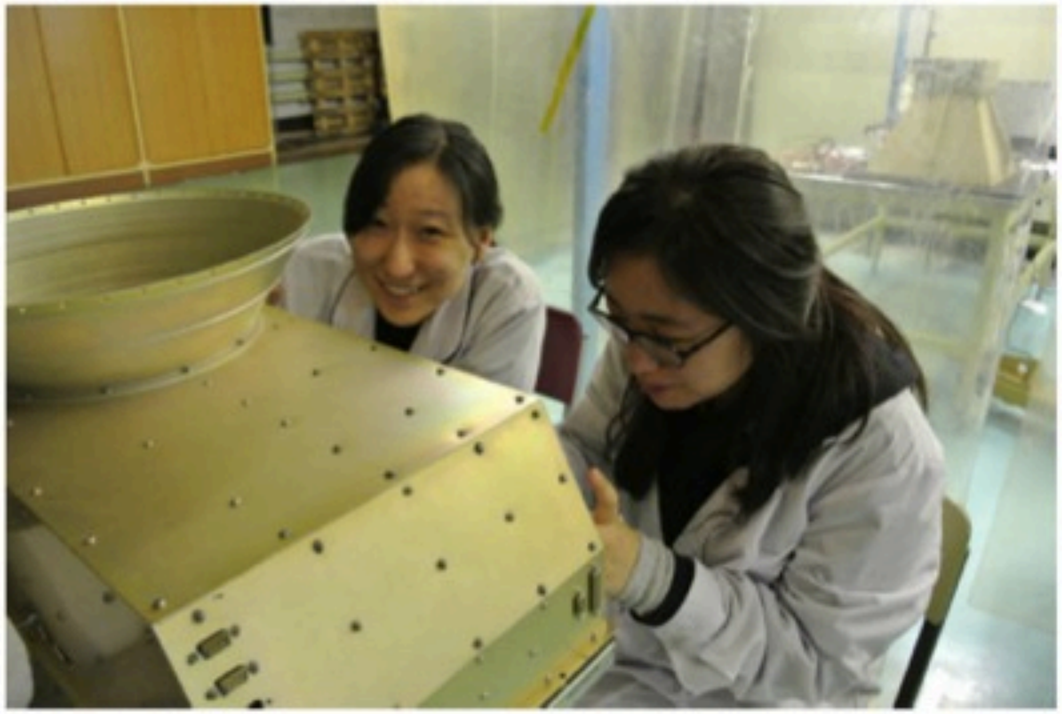
Preparation for "Input control" of UFFO-P

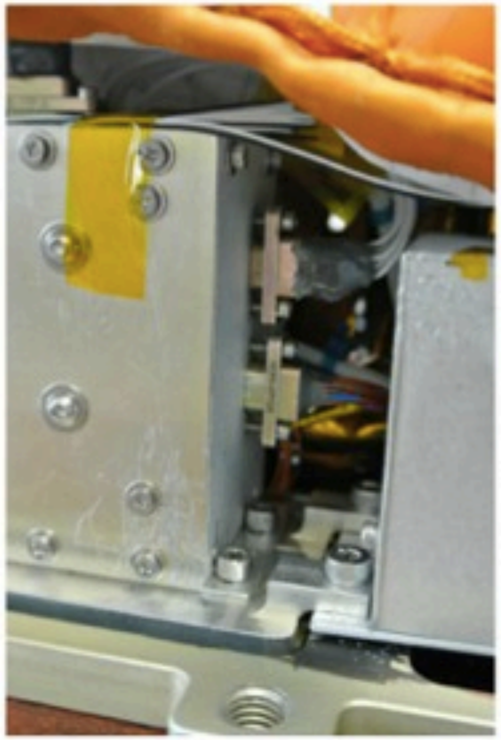
SMT Now In Testing @ Istra



Spaceflight...

3. Epoxy was put on SMT case fasteners / ICCD structures / FM RC structures / SMT readout and UDAQ/ UFFO power electronics boxes (But if we need, it can be removed)





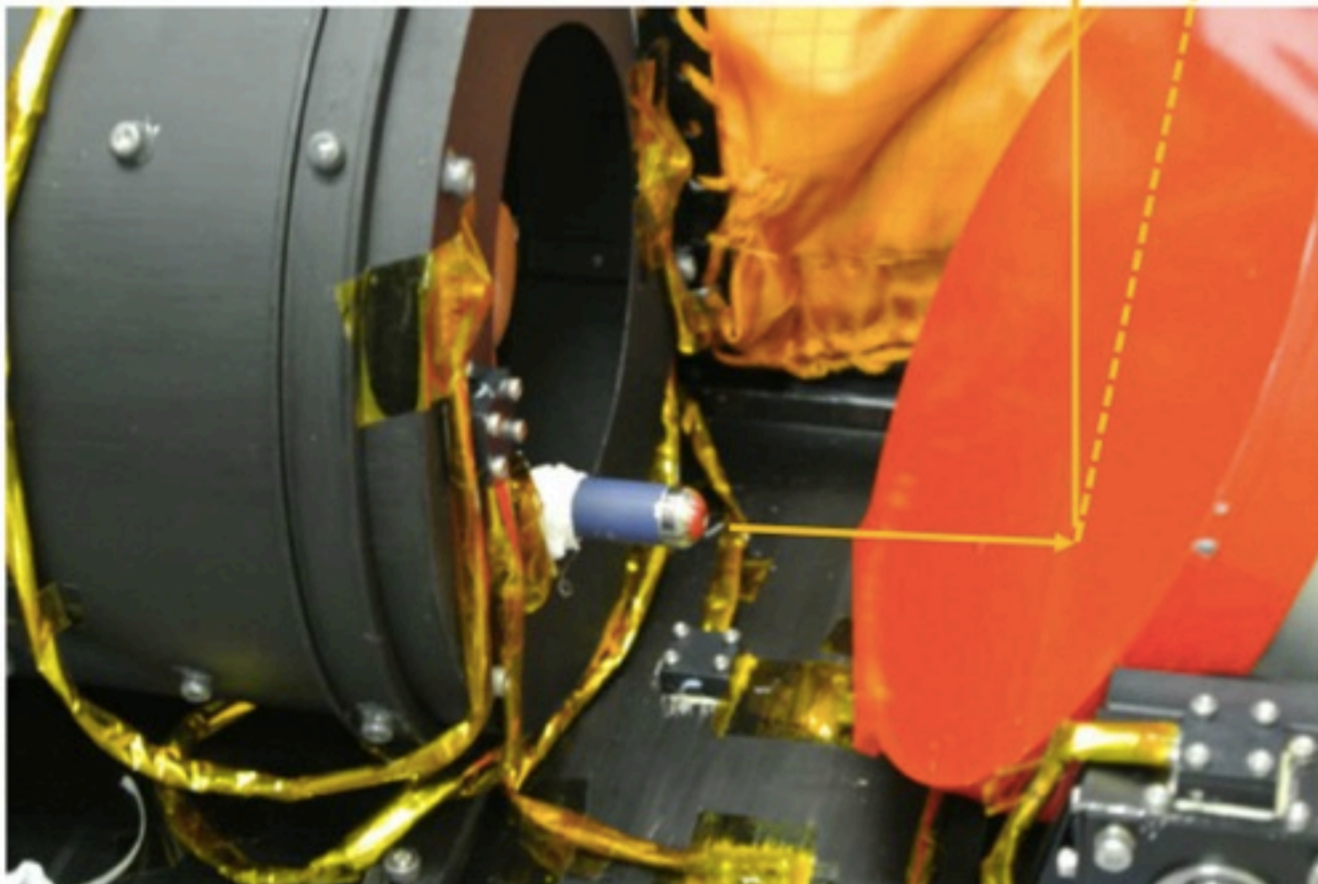
Expert Team

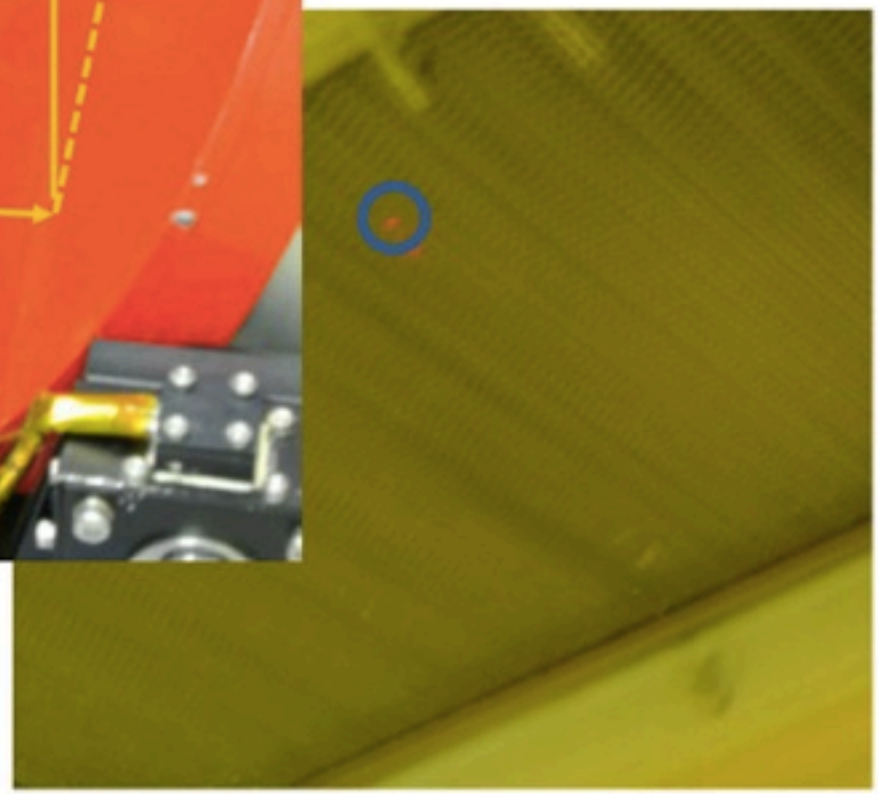
4. New UFFO-power board check with integration

Mirror Control Testing

5. 2nd version SMT logic was updated

- By Tingyun ,Jiwoo and Jieun successfully integrated 2nd version SMT logic -> Confirmed in Taiwan and ISTRA



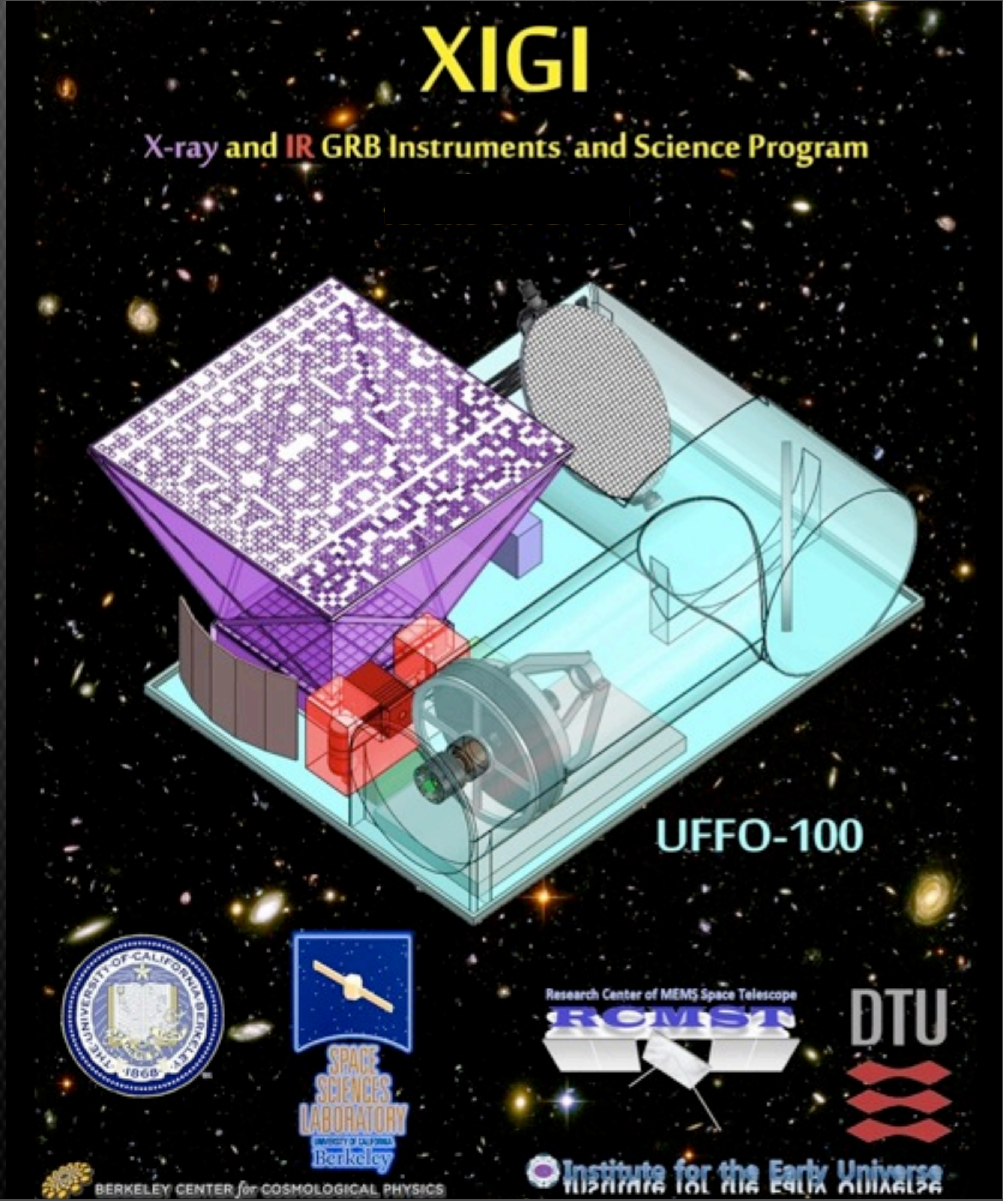


-As following the current test setup -> Repeatability and accuracy : less than ~10 arcmin

Schedule Update

- ~2 weeks : "Table test" will be done & FM BI "input control" will be done
- Early July : UFFO attached to payload frame
- Early July: Integration tests on frame / calibration between BDRG and SMT with source.
- End July : Delivery to VNIEEM
- ?Cross-Calibration UBAT/SMT?
- Best Launch Estimate 2013 April

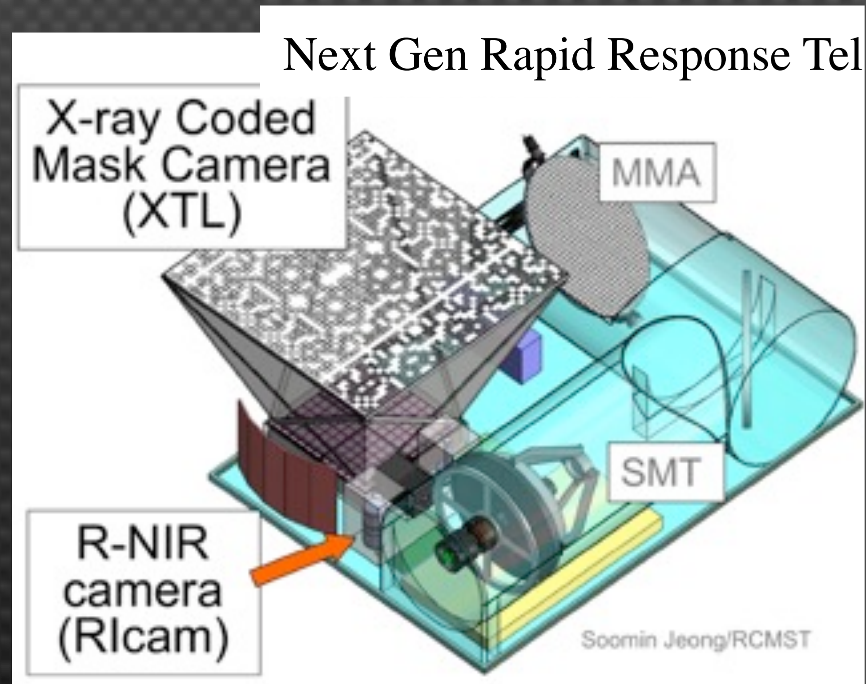
NASA "Partner Mission of Opportunity" Proposal



Next Generation

30 cm Slewing Mirror Telescope (SMT)

- 120 kg, ~ 1 m^3
- 30 cm aperture R-C telecsope
- Smaller, less massive, faster than SWIFT
  - smaller X-ray detector, 1024 cm^2 CZT
  - Design taken from ASIM MXGS instrument, thanks to collaborators
  - Faster because beam-steered, not spacecraft steered.

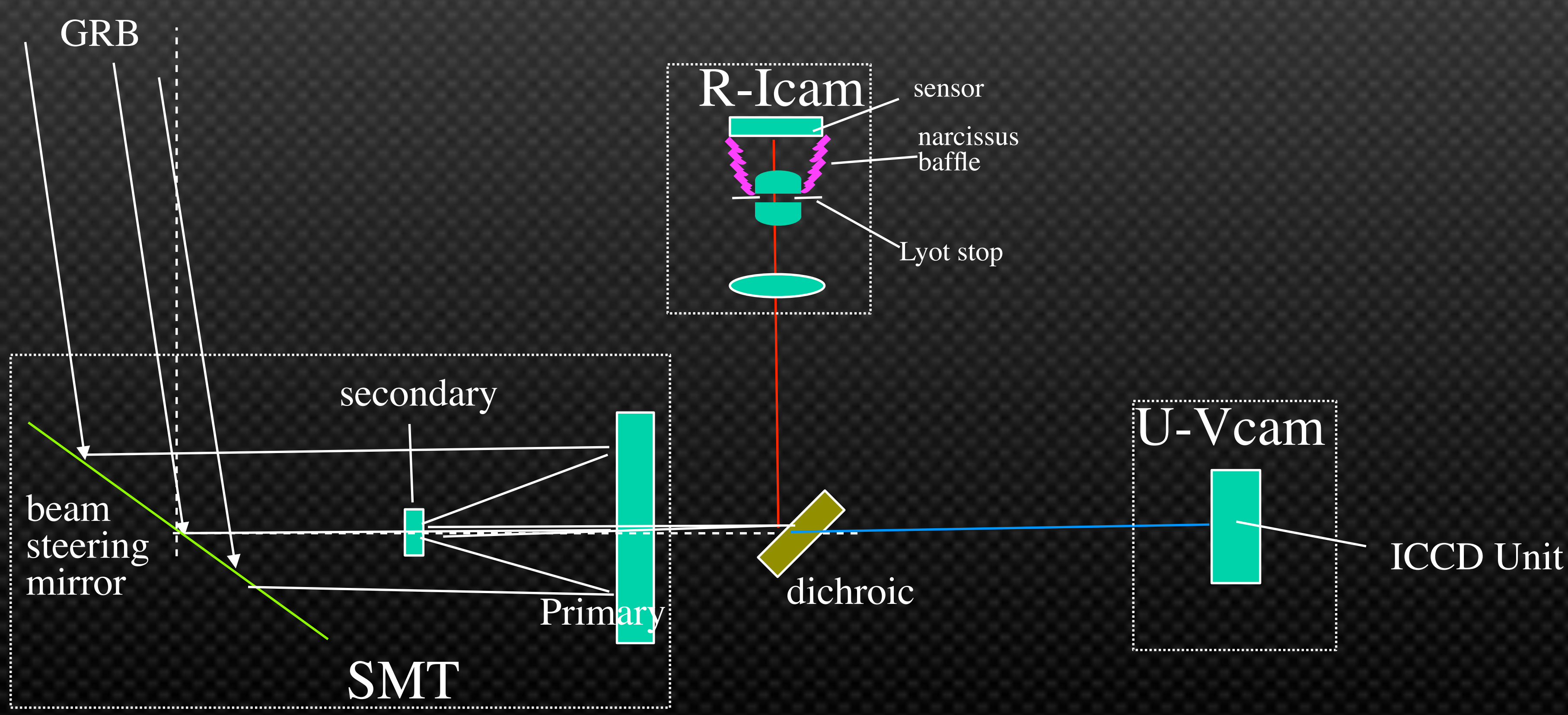


Preliminary artist rendering of one concept (compact package) only.

Lots of work on this by RCMST, MSU, U Valencia, Berkeley SSL

Separate UV, IR cameras for telescope

- Dichroic splits beam to...
- U-Vcam - just like ICCD in UFFO-Pathfinder 0.2-0.57 μm
- R-Icam - HgCdTe array 0.57-1.7 μm <- SSL/Berkeley



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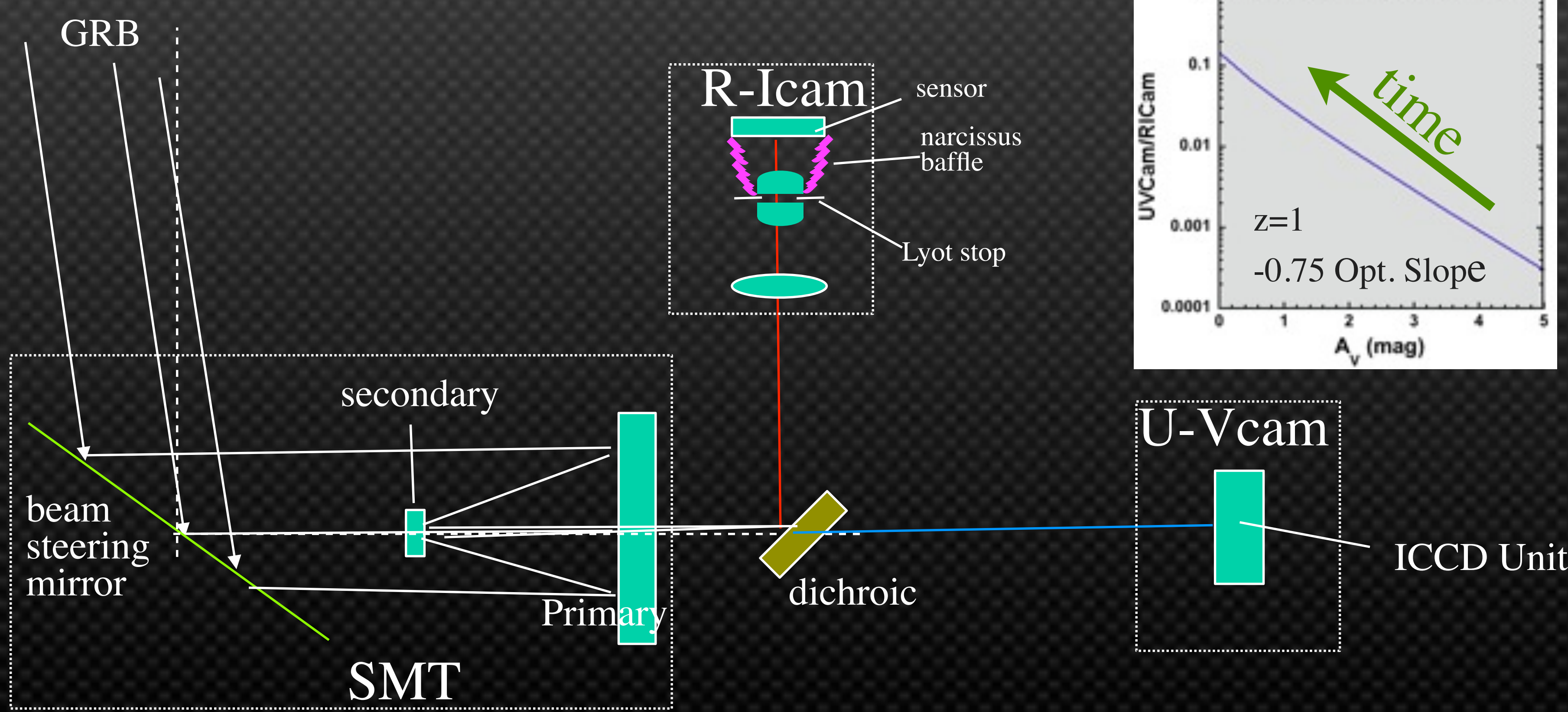
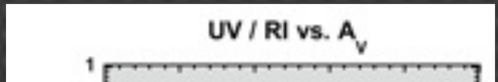
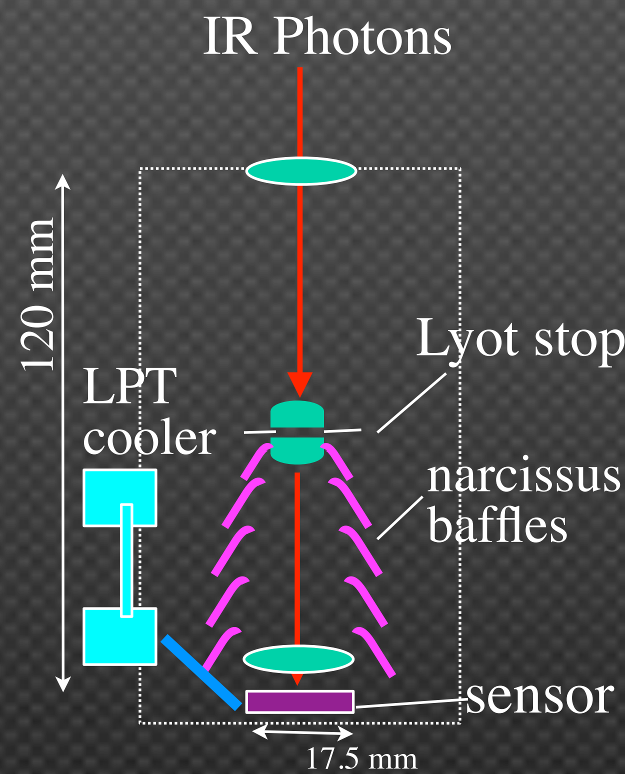




R-Icam Design



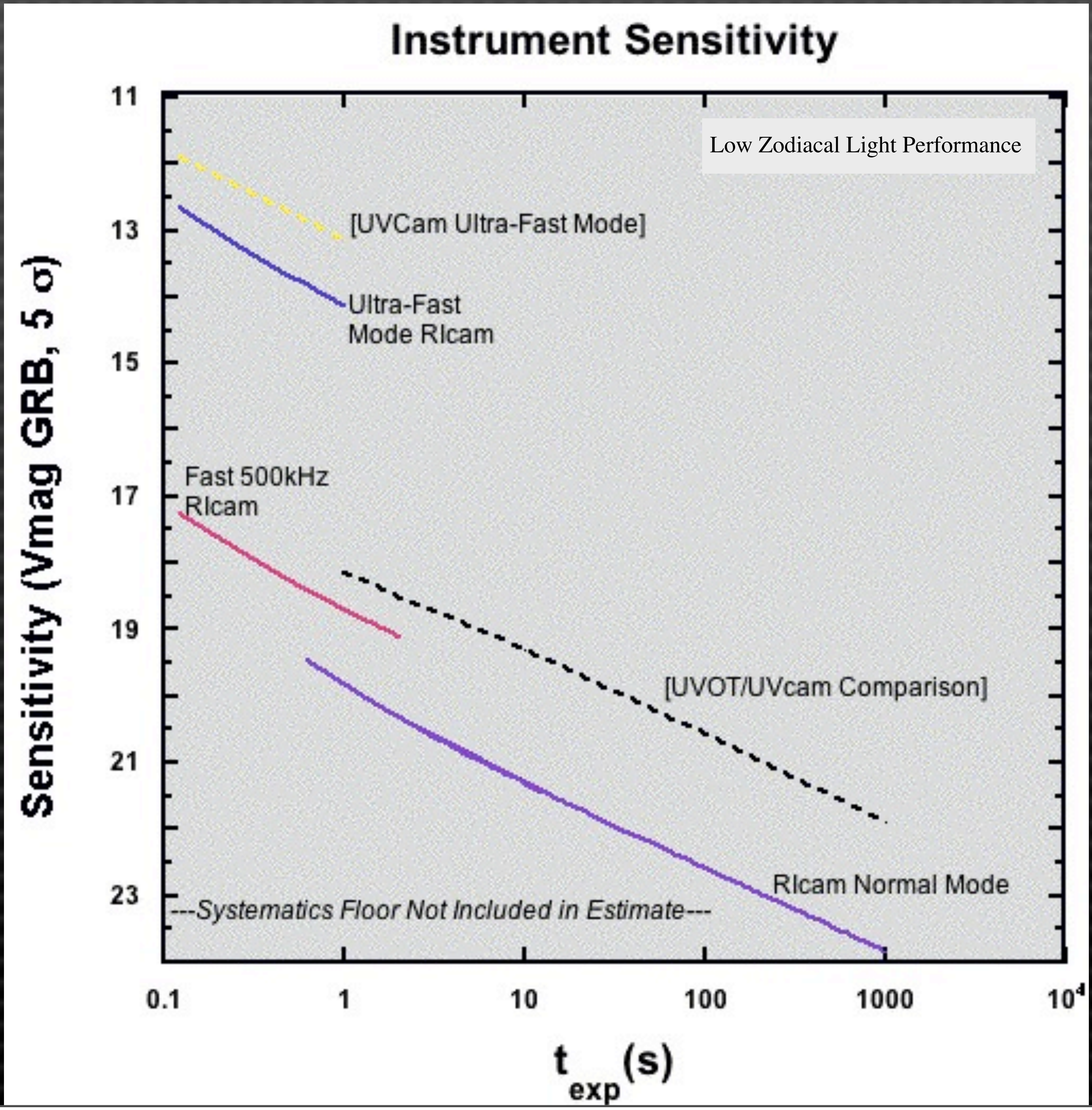
- HgCdTe Sensor H2RG 1.7 μm cutoff
  - short cutoff -> little thermal background
- Optics Design
  - Lyot stop, narcissus baffles reduce thermal background
    - by Brian Sutin
- Big, Wide Band 0.6 -1.7 μm
  - get more photons in NIR

Wide Band • Low Space Background • Steep Object in IR

This is a winning combination!

RIcam Sensitivity

- **Equivalent V-mag shown**
  - GRB opt slope= -0.75 assumed (compare to UVOT)
  - Optimistic Zodi,etc.
  - About two mag more sensitive than SWIFT UVOT
  - Good because: (1)wide band, (2) low-bgnd, (3)steep spec. target



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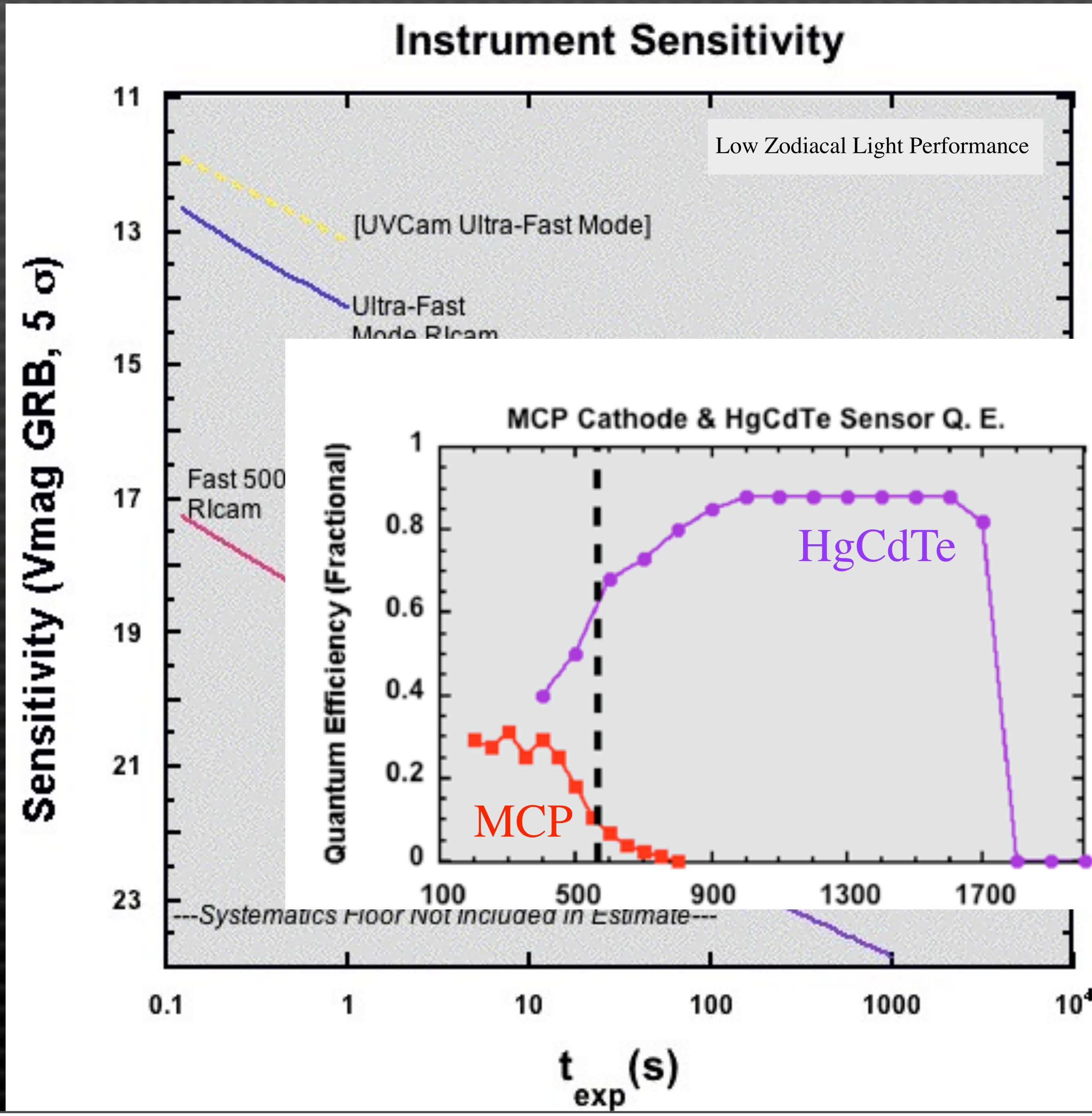


Followup

- Will broadcast on GCN via Globalstar SMS
- BOOTES[1] + ...? Ground-based follow-up
- GCN broadcast enables more sensitive X-follow-up
  - Fermi - lots of sky coverage for additional "prompt" coverage to higher-E
  - pointed X-ray observations by other operational narrow-field instruments
    - SWIFT & Suzaku, for now, hopefully they will ”sign up”
- YOUR FOLLOW-UP INSTRUMENT HERE
  - Spectroscopy especially welcome.

(1) Thanks to Collborator - Alberto Castro-Tirado

UFFO-100 Estimates

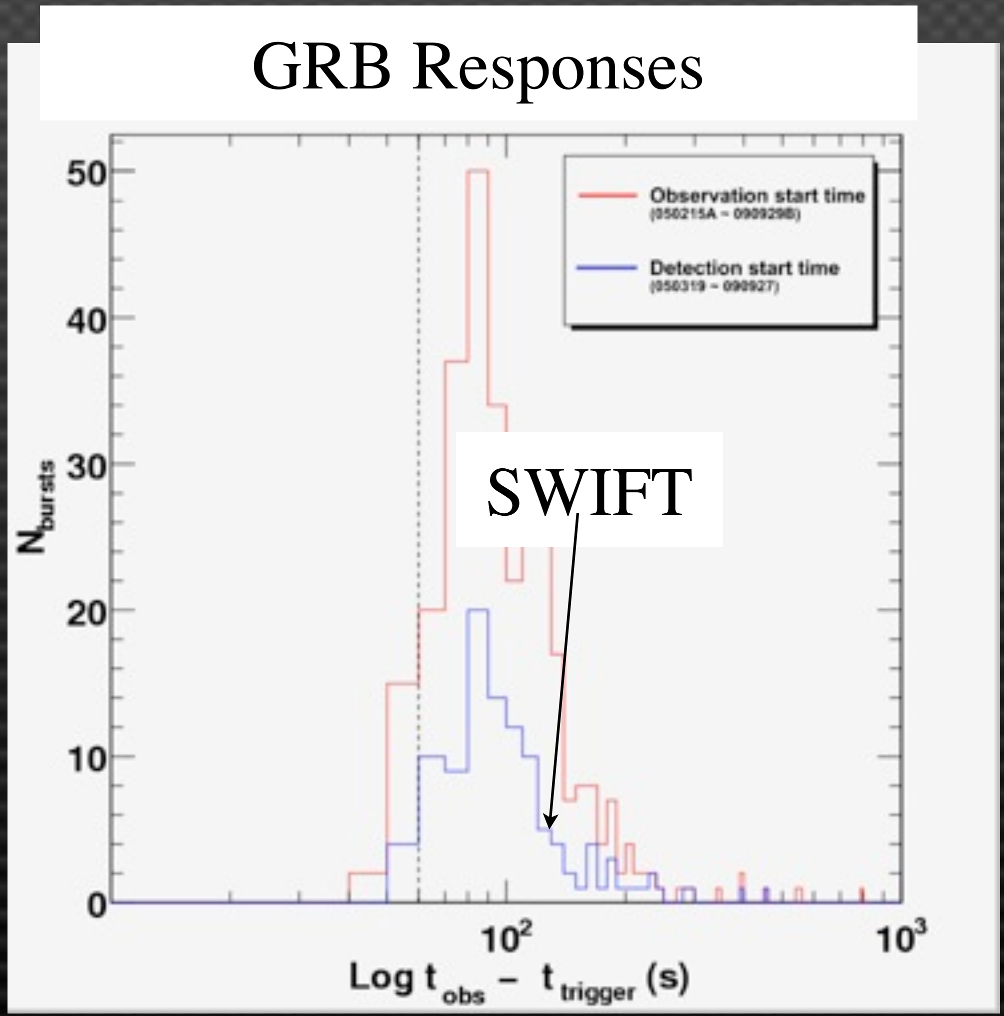
	SWIFT BAT	UFFO XTL
Area (cm^2)	5200	1024
Triggers/yr	77	64
SHGRB/yr	6.9	~ 5 (uncertain)

- Approximate: Scales SWIFT, Uses fluence histo, assumes duty cycle

	UVOT[1]	**UVcam**	**RIcam[1]**
sensitvity (Vmag,5σ) 1/10/100 s	18.1/19.3/20.5	<--- ~ same	14.3 ultra/ 19.3 fast t=1s Normal:.../ 21.9/ 23.2
N_{detect} / yr	27	> 15 10s (> for early peaks, because we are faster!)	≥ 29 (including extinguished) more via sensitivity? Most SHGRB?

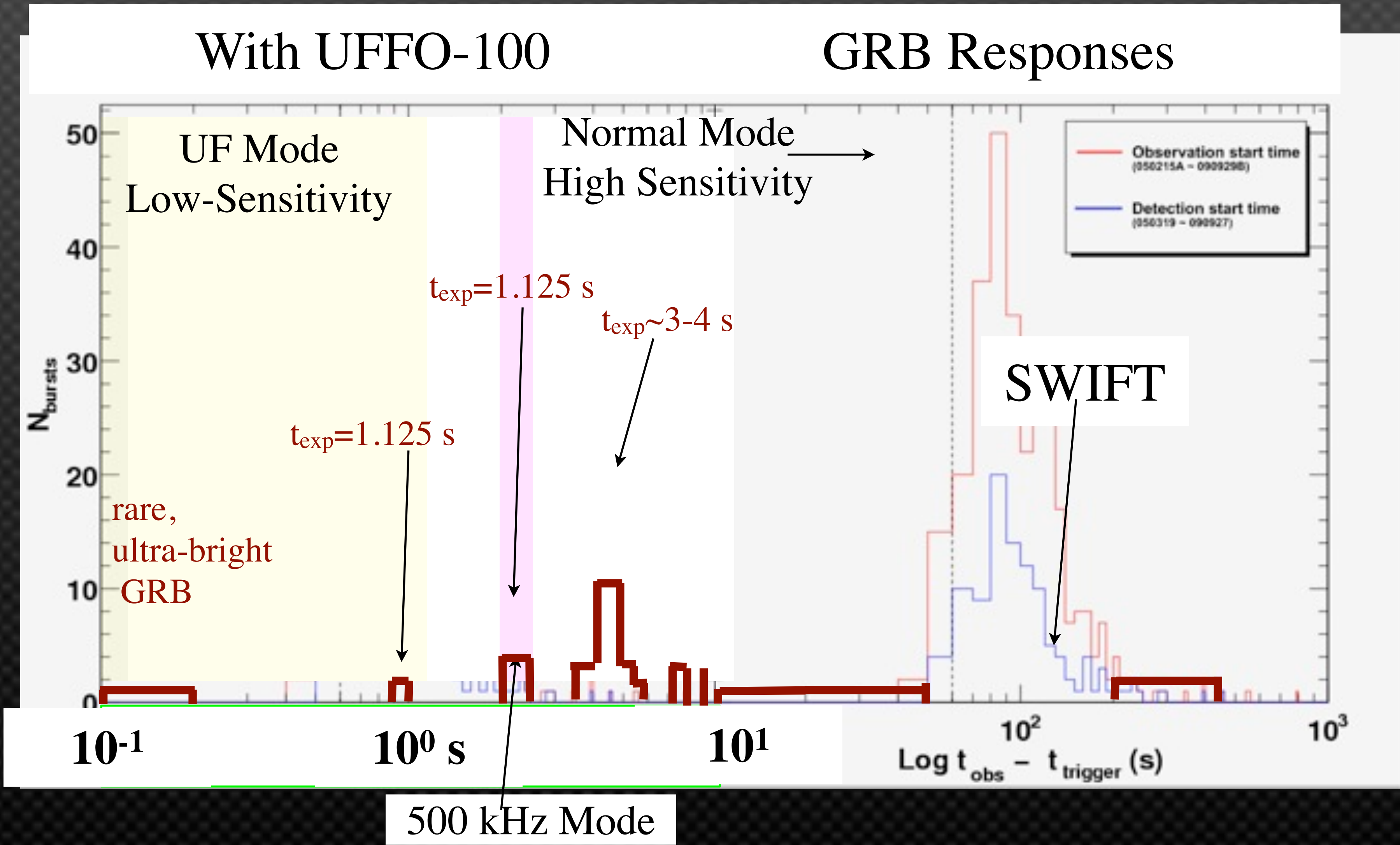
- Approximate: assume fixed fraction detectable, 1.3X for RIcam due to extinguished bursts
- (1)UVOT Sens. from GCNs; RICam & UVOT both at low zodiacal light

Wouldn't you like to see this?*



- Response time function of mode/sensitivity + true t_{peak}

Wouldn't you like to see this?*



(* Please note this plot is grossly unprofessional conjecture.)

- Response time function of mode/sensitivity + true t_{peak}

Summary

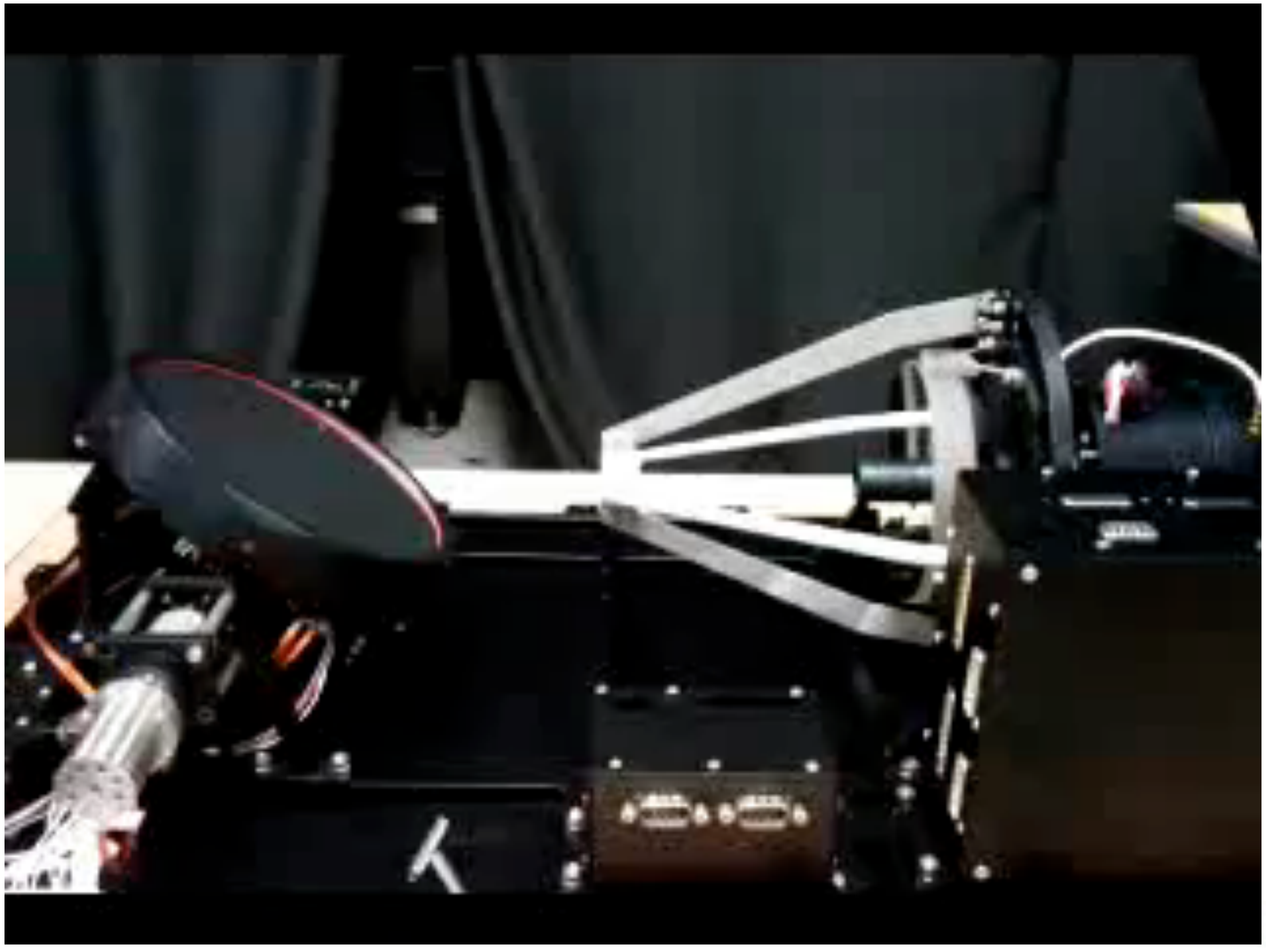
- Project Objectives:
  - Significant sample of GRB rise phase light curves
  - some 0.1-1 s measurements
  - Bulk Lorentz factors, rise times, X-opt correlations, possible multi-messenger measurements
- UFFO-Pathfinder D=10 cm Nov. 2011 on Lomonosov
- Next Generation D=30 cm proposed
- All projects open to follow-up & other contributions

Collaborators (Thanks!)

- RCMST Seoul: Il Park, Jiwoo Nam, Heuijin Lim, Soomin Jeong ... and Many others
- M. Panasyuk, A. Iyudin, S. Svertilov, etc. etc. MSU/SINP/EUL
- Kevin Hurley, Henry Heetderks, (SSL)
- Søren Brandt, Carl Budtz-Jorgens (DTU)
- Alberto Castro-Tirado, Chris Eyles, Paul Connell (IAA)
- Nikolai Østgaard, Kjetl Ulluland (UBergen)
- Enrico Ruiz-Ramirez, UCSC
- George Smoot, IEU, UCB, PCCP, EUL...+many more

GCN alerts after April!

-Thank You-



UFFOConsortium

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... and many more

http://uffo.ewha.ac.kr/

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Thank You