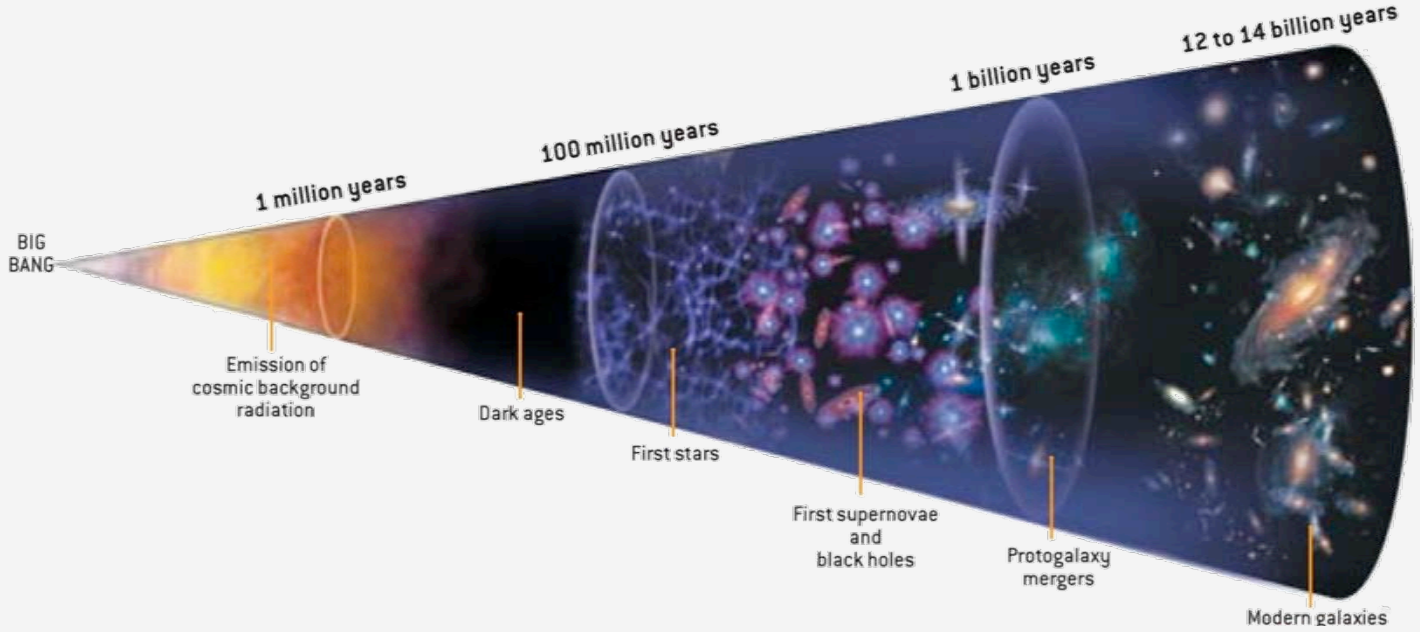
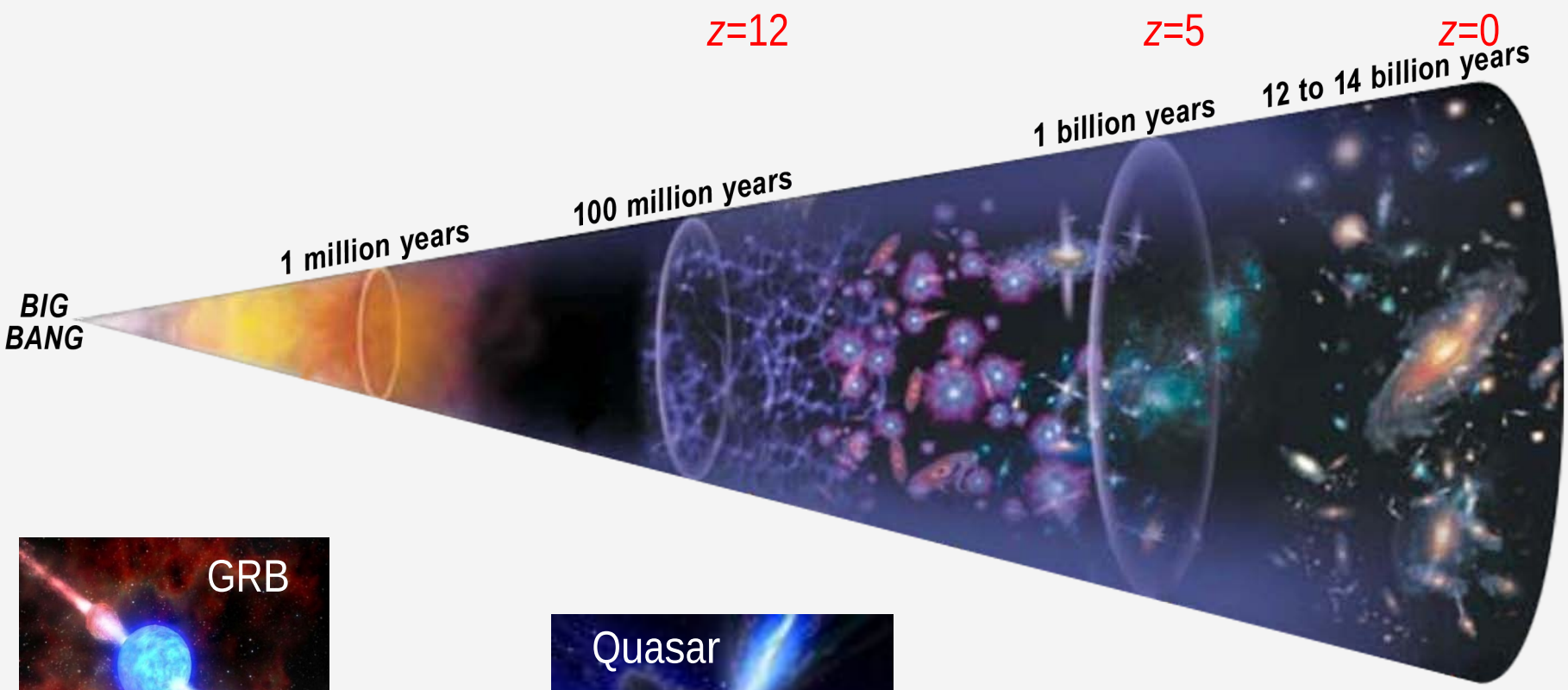

Joint Astrophysics Nascent Universe Satellite:
OBSERVING the ILLUMINATION of the UNIVERSE
JANUS
JANUS
Pete Roming

The Illumination of the Universe

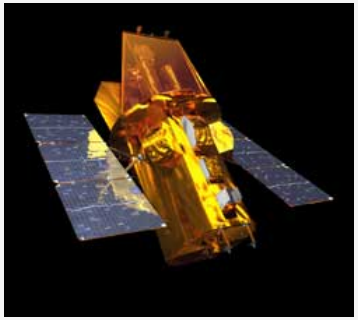


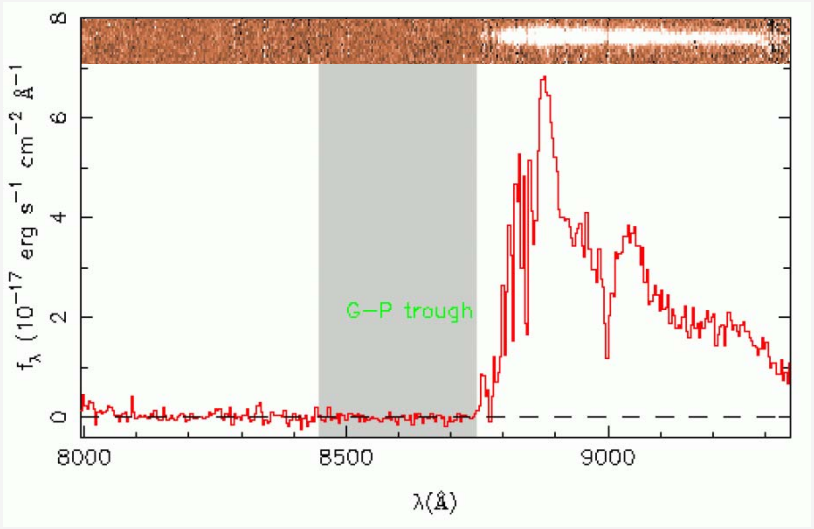
- Cosmic plasma becomes neutral gas at +380,000 years
- Cosmic Dark Ages: Dark matter and neutral gas collapse
- 1st stars, galaxies, & quasars are born – reionization begins
- Reionization complete by z=5.8

Cosmic Beacons

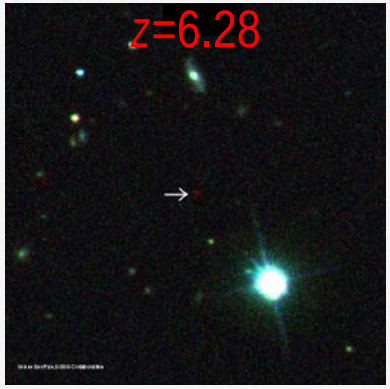


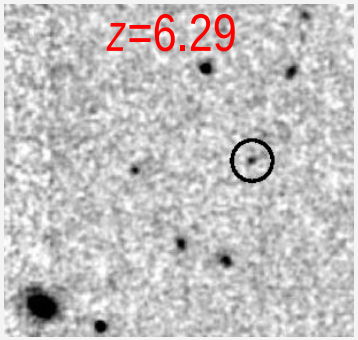
Quasars & GRBs from the Infant Universe



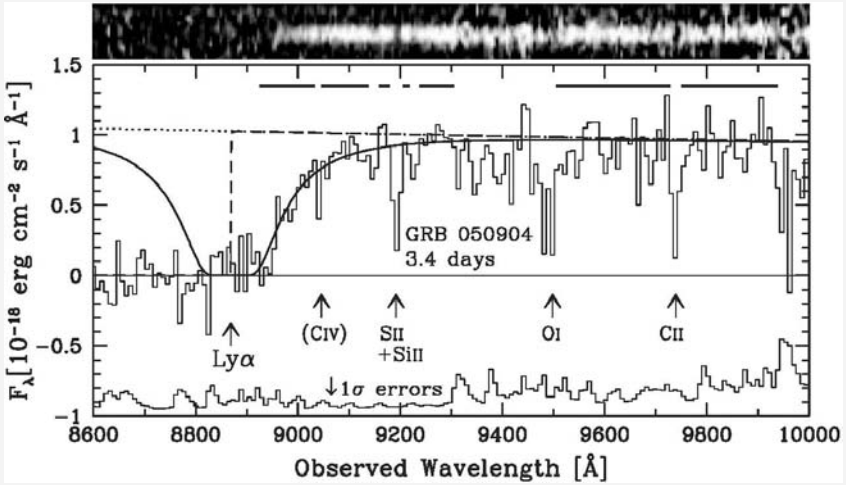


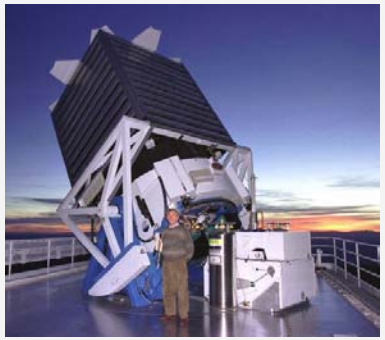
SDSS Quasar





GRB 050904

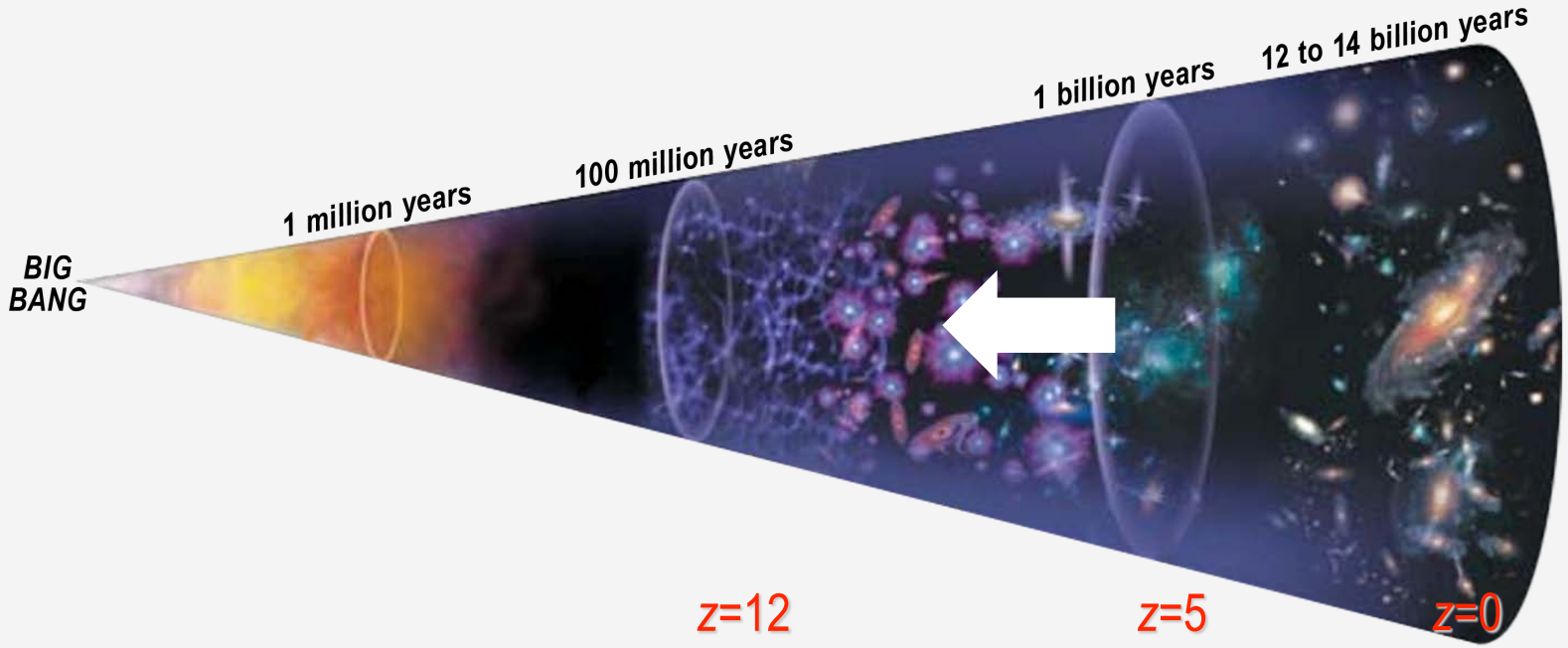




From Discovery to Exploitation

- Current capabilities for pursuing these high-z beacons are limited
- Need to probe further back
- ~10x larger samples
- Faster spectral redshifts

GRB	$t_{Photo-z}$	$t_{Spectra-z}$	z
050904	10 hrs	3.5 dys	6.3
080913	10 hrs	11 hrs	6.7
090423	7 hrs	24 hrs	8.2



From Discovery to Exploitation

- Large field-of-view instruments required
  - Finds large number of high-z quasars and GRBs
  - Breadth is more important than depth in this case
- Reducing contamination
  - Near-IR quasar survey unaffected by atmosphere
  - High-*z* quasar spectra highly distinctive at R≈14
- Provide rapid GRB redshifts in ~30 minutes

The JANUS Observatory

X-ray Coded Aperture Telescope:

Detects & localizes high-z GRBs

Near InfraRed Telescope:

Low-resolution spectroscopy of high-z GRBs & quasars

Spacecraft:

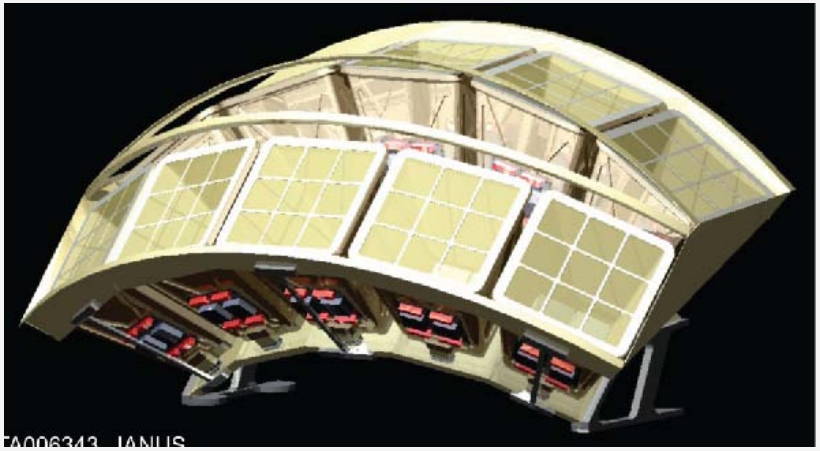
Rapid slewing and communications with the ground

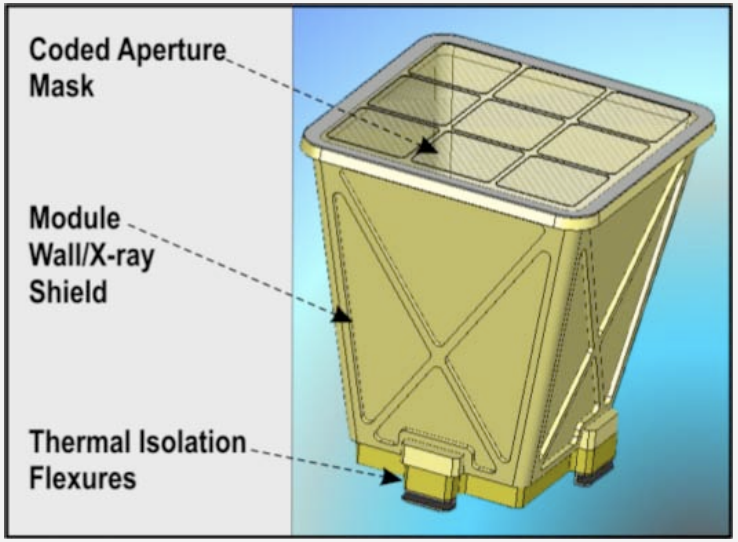
Gamma-RAy Polarizing Experiment or High Energy Monitoring Instrument:

γ-ray spectroscopy

X-ray Coded Aperture Telescope (XCAT)

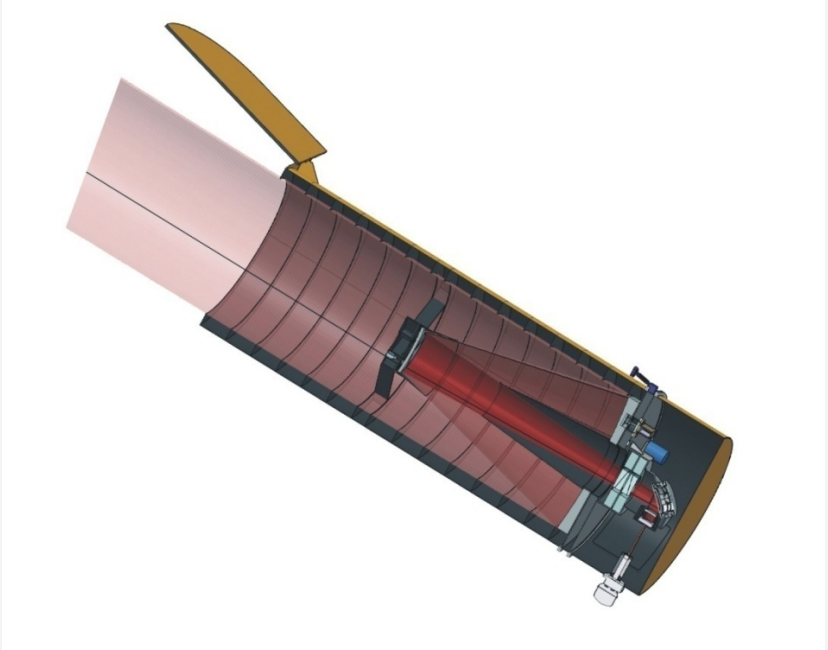
- Dave Burrows, Lead
- Coded aperture “shadow mask” telescope
- Hybrid CMOS detectors (Si)
  - Energy range is 1–20 keV
- 10 modules arranged in 2x5 “caterpillar” format
- ~4 sr field-of-view
- Localizations to 40”-70”
- Triggering algorithm similar to *Swift* BAT





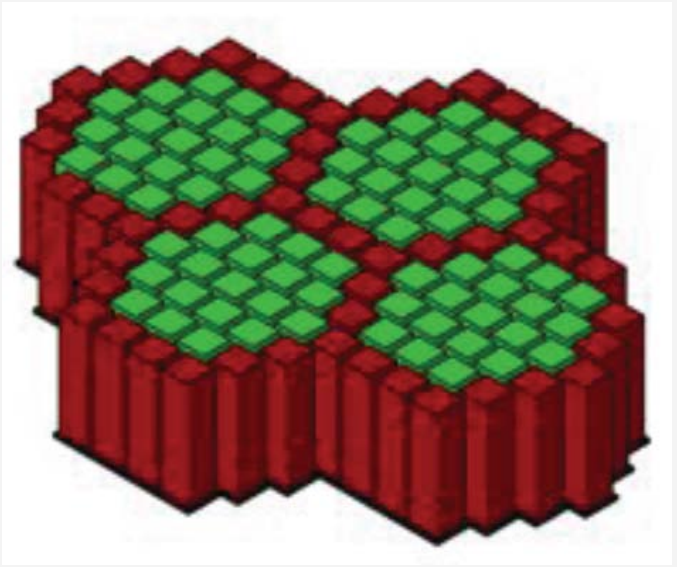
Near-InfraRed Telescope (NIRT)

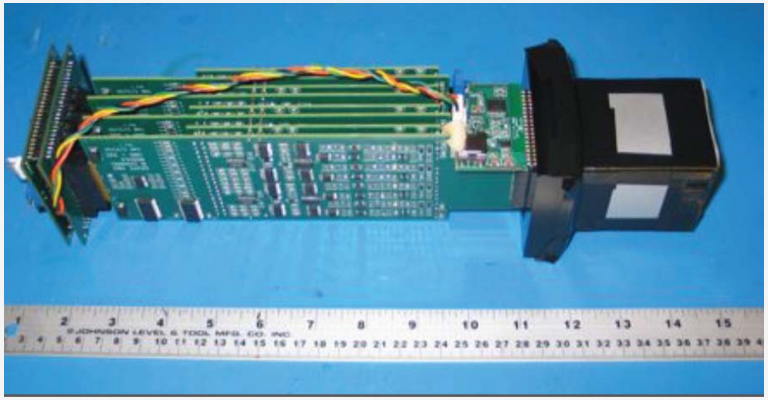
- Terry Herter, Lead
- Ritchey-Chrétian design
  - 55 cm aperture
- 2k x 2k MCT detectors
  - 0.7–1.7 μm
  - Lyman-alpha over $5 < z < 13$
- 0.36 deg^2 field-of-view
  - Allows extragalactic all sky survey during baseline mission
- Sub-arcsecond localizations
- Direct imaging and low-resolution (objective prism) spectroscopy



Gamma-RAy Polarimetry Experiment (GRAPE)

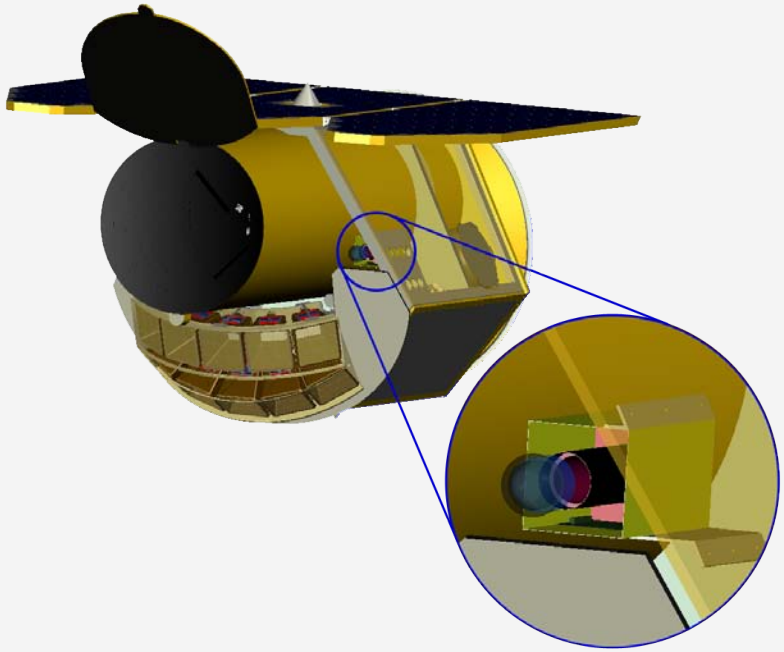
- Mark McConnell, Lead
- Polarimetry
  - 60-500 keV
- Spectroscopy
  - 15 keV – 1.0 MeV
  - Photon counting
- 120 degree field-of-view
  - Co-pointed w/ XCAT
- Captures peak energies of bright GRBs
- Student Collaboration
- Precursor instrument already flown on balloon



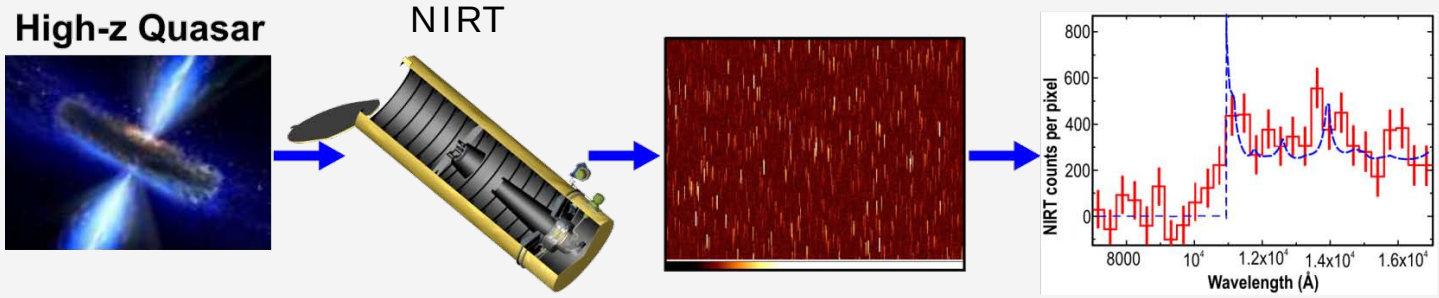


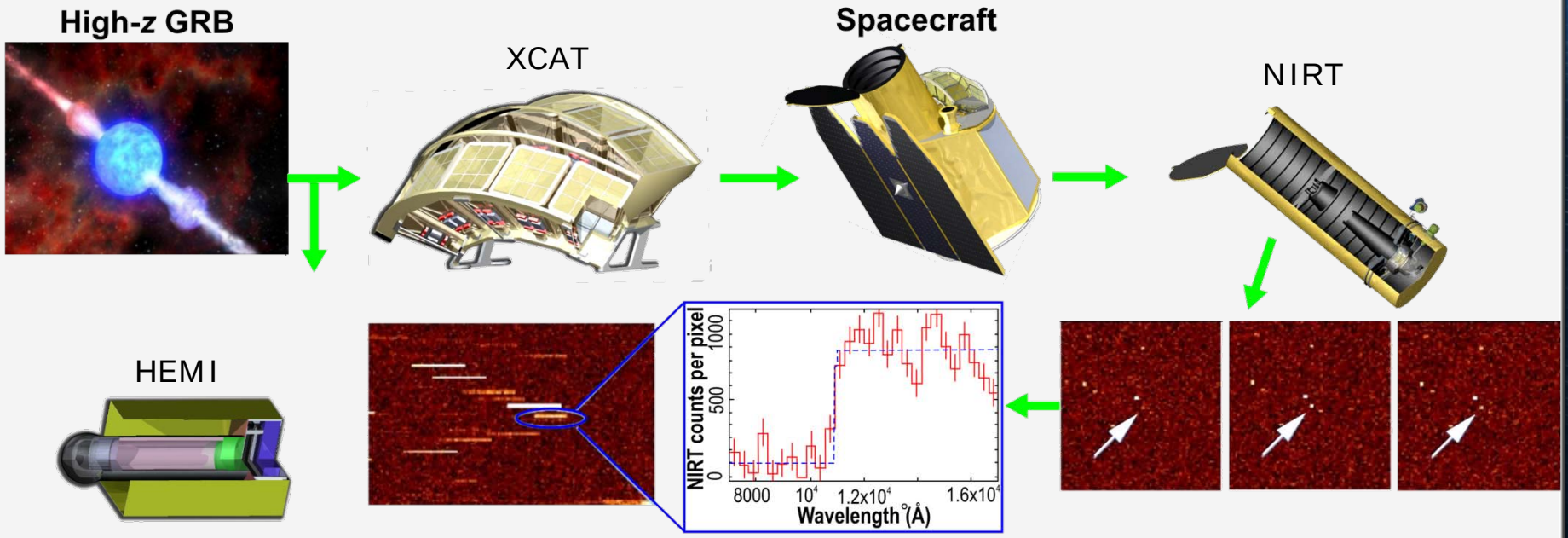
High Energy Monitoring Instrument (HEMI)

- Sven Bilen, Lead
- Non-imaging spectroscopy
- NaI photomultiplier tube
  - 20 keV – 1.5 MeV
  - Photon counting
- 6 sr field-of-view
- Captures peak energies of bright GRBs
- Student Collaboration
- Precursor instrument already flown on balloon



Performing the Investigation

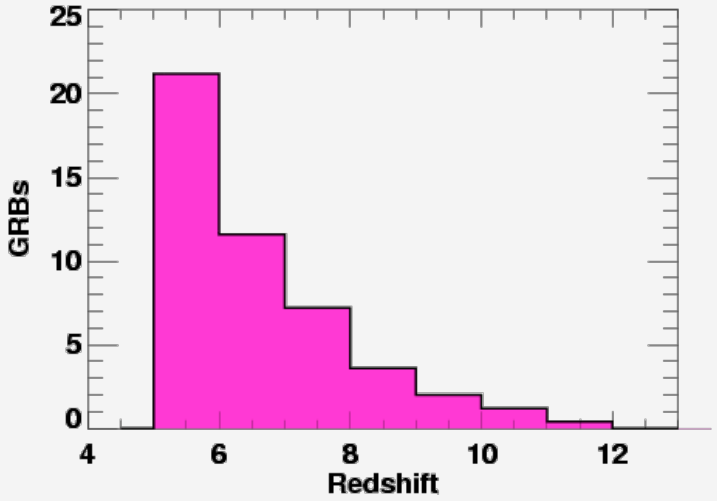


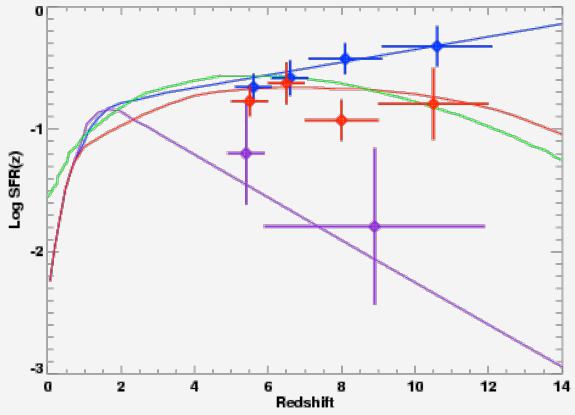


JANUS Science: Objective 1

Measure the cosmic star formation rate over 5<z<12 by detecting and observing high-redshift gamma-ray bursts and their afterglows.

- JANUS to detect ~40 bursts (z>5) over two-year mission
- Position, flux, and redshift derived from XCAT and NIRT data
- Redshifts will reveal cosmic star formation rate over 5<z<12
- Stellar light was likely the dominant cause of reionization
- Star formation estimates are crucial to constructing a full picture of reionization

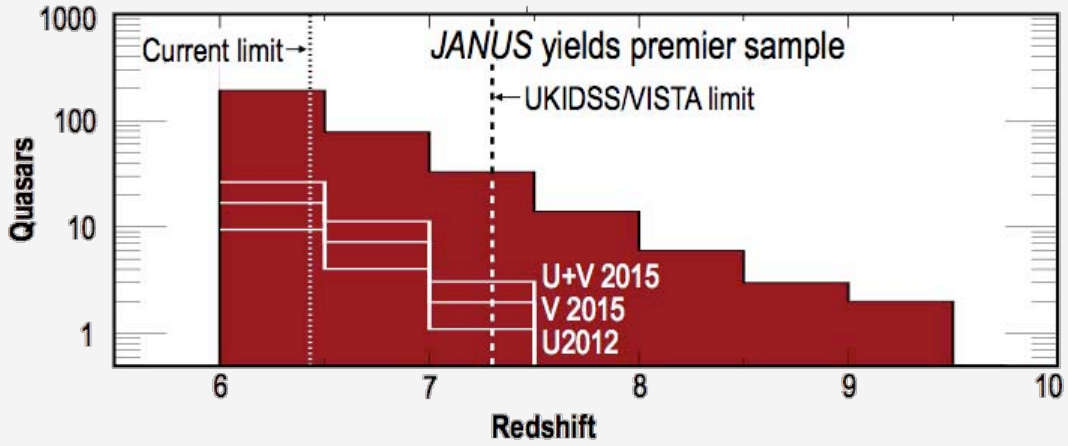




JANUS Science: Objective 2

Map the growth of massive black holes that seed galaxy formation at z>6 .

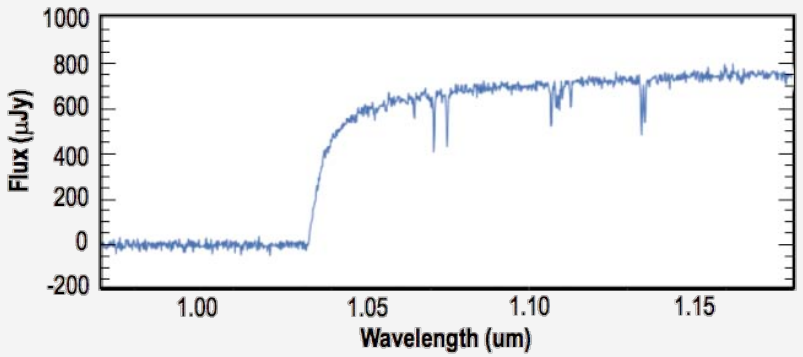
- JANUS will carry out a 20,000 deg^2 objective-prism survey (0.7–1.7 μm)
  - ½-billion spectra in survey
- Reaching *J*~20 mag in the continuum (4σ) with resolution *R*≈14
- ~200 quasars (*z*>6), well beyond capabilities of ground-based surveys
- Redshift & ionizing flux of each quasar measured directly from NIRT data

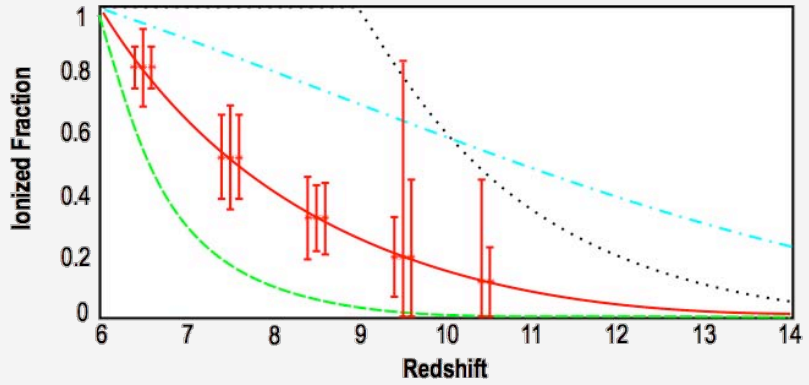


JANUS Science: Objective 3

Enable detailed studies of the history of reionization and metal enrichment in the early Universe.

- Every JANUS GRB and quasar will be bright enough for observations with current facilities
- Burst alerts reported in real time
- JANUS bursts will be used to measure the ionized fraction in the intergalactic medium
- Quasar catalog updated at 3-month intervals
- Each quasar is a target for upcoming satellite and ground-based observatories



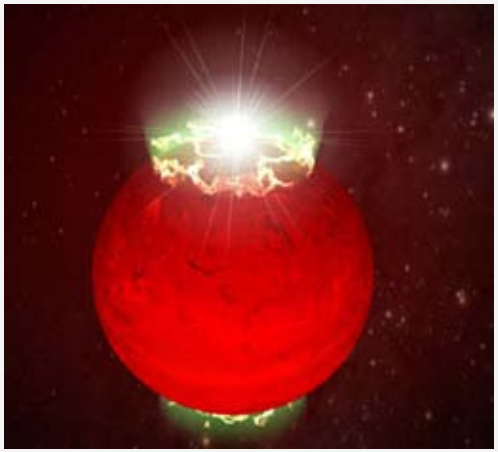


JANUS GCN Data Products

Data Product to GCN	Time Since Burst (seconds)
X-ray Position & Fluence	40
Initial X-ray Light Curve	100
Gamma-ray Spectrum	120
X-ray Light Curves	160-880 (Every 60 seconds)
NIR Finding Chart & Spectrum	1140
GRB Redshift	1200

JANUS Science for "Free"

- GRB-SNe connection
  - GRB060218/SN006aj & GRB100316D/SN2010bh like
  - 3-11/year
- X-ray All-Sky Monitor
  - Super-flares from solar-type stars
  - Supergiant fast X-ray transients
  - Tidal Disruption Events
- Brown Dwarf studies
  - 4,000,000 late M dwarfs
  - 70,000 L dwarfs
  - 8000 T dwarfs
  - 300 Y dwarfs



Impact On Cosmology

- JANUS Direct High-Impact Results
  - Evolution of the star formation rate in the infant Universe
    - *Precision of <15% for z>5*
  - Role of high mass stars on reionization
  - Quasar contribution to reionization
    - *Precision of 10% for 4 redshift bins between 6<z<10*
  - The 1st quasars and their rapid growth rate
  - Ancillary science, i.e. coolest BDs, GRB-SNe connection
- JANUS-Facilitated High-Impact Results
  - Help localize faint galaxies (cf. talk by Yamada)
  - Metal enrichment in early Universe star-forming regions
  - Pop III stars explode as GRB/PISn (cf. talks by Suwa/Whalen)

Timeline

- NASA Explorer ($200M) class mission
- Final AO out ~Oct-2010
- Phase A Selections ~Jun-2011
- Mission Selections ~Jun-2012
- Launch ~Apr-2016
- 2-year prime mission
- 3-4 year extended mission

Stay Tuned!!