The TAUVEX Space Observatory:

Overview

Margarita Safonova (modified by J. Murthy)

TAUVEX Science Planning/
Observer Support

TAUVEX CORE GROUP
IIA, Bangalore
http://tauvex.iiap.res.in
TAUVEX Chronology

- Proposed in 1991 for 1994 SRG flight on Russian Proton-2
- El-Op designed TAUVEX (1993)
- Project frozen at Prime Contractor 1999
- MOU signed between ISRO and ISA in 2004 to fly TAUVEX on GSAT-4
TAUVEX on GSAT4
TAUVEX-GSAT4 Orbit

- Geostationary orbit at ~ 36,000 km – outside main radiation belts
- No need for Earth avoidance
- ±90° rotation allows all sky coverage
- Scanning mode only
The Observatory

- **LAUNCH**: Dec-2009
- **3 20 cm f/8 Ritchey-Chrétien telescopes**
- **Spectral Range**: 125—350 nm
- **FOV**: 0.9°
- **Min exposure time**: 216 sec, max: 24 hrs

**Predicted Performance** *(ground calibrations ongoing, updates will be available online)*

- **Angular resolution**: 8″—10″
- **Time resolution**: 128 ms
- **Bright Limit**: $F_\lambda = 1.3 \times 10^{-11} \text{ erg cm}^2 \text{s}^{-1} \text{Å}^{-1}$
- **Point source sensitivity** *(200s, S/N=5) (O type star)*:
  - BBF: $V \sim 22^m$
  - SF1: $V \sim 20.3^m$
  - SF2: $V \sim 20.8^m$
  - SF3: $V \sim 20.2^m$
  - NBF: $V \sim 19.2^m$
- **3 year life-time** *(5 years – goal)*
TAUVEX: general design

Two units separated by ~10cm
TAUVEX: optical module

Field corrector lens group, filter substrate, and detector window all made of CaF$_2$

2 mirrors: zerodur substrate, Al+$\text{MgF}_2$ coating;
2 doublet field corrector lenses;
Detectors: 3 chain MCP with 25 mm CsTe photocathode;
Total mass = 33.5 kg;
Power consumption < 65W
TAUVEX filters

- **BBF** (blue cutoff at <200 nm)
- **SF2, NBF** (unique possibility to study interstellar dust band at 217.4 nm)

Standard mode of operation

3-band photometry:

1700±250, 2150±210, 2530±225
TAUVEX sensitivity (pre-launch)

TAUVEX Detection Limits (5 σ) with average zodiacal light background

TAUVEX filters with ranges
- BBF
- SF1
- SF2
- SF3
- NBF

5000 sec exposure
1000 sec exposure
500 sec exposure
Details in the online document:

http://tauvex.iiap.res.in/guest/documents/
Operational Constraints

Observation orientation is not user-selectable

Main constraint:
90° Sun avoidance

Additional constraints:
Moon (5°), Mars (2°), Jupiter (3°), bright stars

Scattered light – a problem
- limits the time
- restricts the orbit
- requires complicated mission planning
Operational Constraints: a year

North pole accessible

Eq.
eclipse area, Sun less than 10 degrees from equator

South pole accessible

Eq.
eclipse area, Sun less than 10 degrees from equator
Observational Windows

Based on the straylight parameters, the observable windows are decided for 15-days bins.

Observable hours (in green) from Mar 21 to Apr 6

The full description available on http://tauvex.iiap.res.in under Guest Observer
Main Science Themes

RESEARCH CATEGORIES

- The Core Science Program (TAUVEX Science Team)
- Individual Observations Program (small programs from TST)
- First Science Survey (TAUVEX Core Group)
- Archival Research Program (Once archive is open; proposals to be sent to PIs)
Main Science Themes

The Core Science Program Key Areas

- Deep Surveys
- Galactic UV Astronomy
- Studies of Supernovae
- Studies of Interstellar Dust
- Studies of AGNs
- Galaxies in UV
- Galactic and Extragalactic GCs

Submitted proposals, plans and planned surveys available on http://tauvex.iiap.res.in under Guest Observer

More on Key Areas in Pre-Launch Call for Proposals (issued online)
Special BASI issue  
(June 2007)

http://www.ncra.tifr.res.in/~basi/toc07june.htm

Papers from March 2006 TAUVEX Science meeting

Lots of proposals for TAUVEX science

• A good place to look for ideas toward Stage 3

A nearby dwarf irregular in the UV (SMC/GALEX)

M33 (FUV=blue, NUV=yellow)
Main Science Themes

First Science Survey – inaugural TAUVEX program

- Has galactic and extragalactic components. Will take place at the end of PV phase. Intended to:
  - Provide early sample of reliable UV data
  - Rapidly process data and make publicly available in time for Cycle 2
  - Plans and Proposals corrections

- Galactic Component
  
  Source counts at low $b$; to help guide Gal Plane Survey project;
  Zodiacal light; Scan through a molecular cloud

- Extragalactic Component
  
  Main Polar Survey, deep cover of the area, 4°x4°, centered on the pole;
  Verification survey, to cover small part of the Main with greater depth and
  Redundancy: concentrate on the Pole
Main Science Themes

Individual Observations Program

C Sivaram (IIA) & 2 Co-Investigators

*UV flashes from planetary collisions*

M. Safonova, C. Sivaram & J. Murthy; astro-ph/0712.3354v1

M Safonova (IIA) & 2 Co-Investigators

*UV observations of ULXs*

Gangadhara (IIA) & 1 Co-I

*Detecting pulsars in UV*
Proposed Schedule

Stage One
- Launch
- Outgassing+PV
- Calibration

Stage Two
- FSS
- Core Science Program

Stage Three
- General Observations
- Core Science Program
Observer’s Support

TAUVEX proposal planning resources:

• **Documentation:**
  • Pre-Launch Call for Proposals (**issued**)
  • TAUVEX Data Agreement and Policies (**issued**)
  • TAUVEX Observer’s Manual (TOM) (**issued; to be updated after ground calibrations, ongoing**)
  • TAUVEX Detectors and Brightness Protection (**issued**)
  • Pipeline Cookbook (**to be issued**)

• **Tools:**
  • TAUVEX ETC = Exposure Time Calculator (cps, S/N, time, background, SL)
  • Online Sky Simulator (simulates UV sky as seen by TAUVEX)
  • Stellar Flux Calculator (Kurucz model)
  • Coordinate Converter
  • Observation Planning Tool (TOP) is being developed

Questions? Contact us: tauerx@iiap.res.in
Welcome to the TAUVEX Guest Investigator Program

This is the page for scientists wishing to plan their observations with TAUVEX. Here we put out the documents and available tools (in the form of tables, graphs and online software) to help scientists to plan their observations with TAUVEX.

We would like to encourage the interested scientists to write their proposals and/or letters of intent (still possible at this stage) to us. As per our current policy, the successful proposer(s) are guaranteed exclusive right to data for a period of one year after the observation date, provided they have joined the TAUVEX Science Team.

In order to facilitate the preparation of proposals, we suggest the strategy, which is depicted in Proposal Checklist.

Strong observational constraints—the necessity to avoid Sun at 90° and only a scanning mode—limit the observable time. The solar straylight also limits the observable magnitudes by increasing the background noise and contributing to the S/N ratio, which results in differential limiting magnitude values over the sky and over the year. Observable Windows and Limiting Magnitude Maps are graphically presented on the Sky Visibility pages.
Observer’s Support

TAUVEX GUEST INVESTIGATOR PROGRAM
Science Planning and Observing Programs

- Science Planning--TAUVEX Science Team
- Core Science Program Surveys
- Submitted Proposals
- Reserved Projects
- Calibration Targets

We have identified a number of key areas with interested astronomers who will take the lead in defining the science problems and how the TAUVEX can address that problems. The general considerations in this science planning is that:

1. The observations further our understanding of front-line problems of astronomy and astrophysics.
2. The scientific goals are feasible given our observational and instrumental constraints.
3. The data are unique; i.e., they have not been better addressed by other satellite data, such as that from GALEX.
4. The problems are of interest to the Indian scientific community.

To follow these principles, TAUVEX Core Group has created the Core Science Program (CSP). The Program constitutes projects under few broad Key Science Areas defined by the TAUVEX Science Committee. These projects are distinguished by the following fundamental principles:

http://tauvex.iiap.res.in/
About 80% of observing programs was chosen to be surveys. The data from these surveys will be used by the TAUVEK Science Team to extract results useful in all the above-mentioned key science areas. The details of these surveys will be given once the Core Science Plan is finalized.

- **Deep Exposure Polar Survey (DEPS)**
  
  This survey will cover with deep exposure of 5000 sec the ~1400 square degrees around each Celestial Pole and will be repeated on the second year. The principal filters will be SF1, SF2 and SF3 in most of the orbit, and SF1, BBF and SF3 during the darkest part of the orbit. This survey will be performed during Winter and Summer Cycles of the first two years. According to the main Solar constraint (always keep TAUVEK at 90° from the Sun), TAUVEK can observe the Northern Hemisphere in winter and Southern Hemisphere in summer (in ecliptic coordinates). This decides the dates for the surveys. The schedule and other details for DEPS are given below:
  - Northern DEPS
  - Southern DEPS

- **Galactic Plane Survey (GAPS)**
  
  This survey will cover ~1500 square degrees of Galactic Plane with the average exposure time of 1000 sec. It will be conducted during each Spring and Fall Cycles for the first two years.

- **Mid-declination Galaxies Surveys (MIDGAS)**
  
  This survey is intended to investigate nearby galaxies at mid-celestial latitudes. These galaxies are so large that they cannot be observed in their entirety by an instrument such as HST with its exquisite resolution but a small field of view. This program will use the three survey principal filters, SF1, SF2 and SF3, which span the spectral region from somewhat longer than Ly a to 320 nm with three well-defined bands. These three filters define two UV colours and the combination of these measurements with data from the optical and infrared allows determination of even more colour indices.
TAUVEX Data Flow

GSAT-4

Level 0 data (telemetry, fillers)
Continuous stream, 1MBit/s

Fillers removed, required telemetry packed
Archived: 1 file per orbit

Level 1 data ~ 4.4 Gb/DVD

Pipeline

Level 2 data---Reduced data

MCF/Hassan Ground Station

Level 3 data: multiple scans, variability
p.s. catalog, jpg, gif, etc

Users
The full description available on http://tauvex.iiap.res.in under Software and in "TAUVEX Pipeline Cookbook" (to be published)
TAUVEX Final Products

- **Pipeline direct products** *(Stable Version release: end Feb ‘07)*
  
  Level 2 data: FITS images of individual scans, calibrated event lists, sky and detector images

- **Post-Pipeline products**
  
  Level 3 data: FITS images from multiple scans, light curves, point source catalogue

- **Web interface for data access**
  
  Data at all levels are archived by TCG
Monthly history

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ASTROSAT

http://meghnad.iucaa.ernet.in/~astrosat/
CONFIGURATION OF UVIT

DOORS/SUN-SHIELDS

SECONDARY MIRROR

PRIMARY MIRROR

FILTER WHEEL DETECTOR
<table>
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<th>UVIT/OPT</th>
<th>SXT</th>
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<td><strong>Detector</strong></td>
<td>UV: photon counting CCD Opt: CCD photometer</td>
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<td>Proportional Counter</td>
<td>CdZnTe detector array</td>
<td>Position-sensitive proportional counter</td>
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<td><strong>Imaging property</strong></td>
<td>imaging</td>
<td>imaging</td>
<td>non-imaging</td>
<td>imaging (&lt; 100 keV)</td>
<td>imaging</td>
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<tr>
<td><strong>Optics</strong></td>
<td>Twin Ritchey-Chretien 2 mirror system</td>
<td>Conical foil (~Wolter-I) mirrors</td>
<td>Collimator</td>
<td>2-D coded mask</td>
<td>1-D coded mask</td>
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<td><strong>Bandwidth</strong></td>
<td>130-320 nm</td>
<td>0.3-8 keV</td>
<td>3-100 keV</td>
<td>10-150 keV</td>
<td>2-10 keV</td>
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<td><strong>Geometric Area (cm²)</strong></td>
<td>1250</td>
<td>250</td>
<td>10800</td>
<td>1000</td>
<td>180</td>
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<td><strong>Effective Area (cm²)</strong></td>
<td>60 (depends on filter)</td>
<td>125@0.5 keV</td>
<td>6000@5-30 keV</td>
<td>500 (&lt;100 keV)</td>
<td>~40@2 keV (Xe gas)</td>
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<td><strong>Field of View</strong></td>
<td>0.50° dia</td>
<td>0.35° (FWHM)</td>
<td>1° x 1°</td>
<td>6° x 6° (&lt; 100 keV)</td>
<td>17° x 17° (&gt; 100 keV)</td>
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<td><strong>Energy Resolution</strong></td>
<td>&lt;100 nm (depends on filter)</td>
<td>2%@6 keV</td>
<td>9%@22 keV</td>
<td>5%@10 keV</td>
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<td><strong>Angular Resolution</strong></td>
<td>1.8 arcsec</td>
<td>3-4 arcmin (HPD)</td>
<td>1-5 arcmin in scan mode only</td>
<td>8 arcmin</td>
<td>~10 arcmin</td>
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<td><strong>Time resolution</strong></td>
<td>10 ms</td>
<td>2.6s, 0.3s, 1ms</td>
<td>10 microsec</td>
<td>1 ms</td>
<td>1 ms</td>
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<td><strong>Typical obs. time per target</strong></td>
<td>30 min</td>
<td>0.5 - 1 day</td>
<td>1 - 2 days</td>
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<td>5 min</td>
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<td><strong>Sensitivity (Obs. Time)</strong></td>
<td>21st magnitude (5σ) (1800s)</td>
<td>10 microCrab (5σ) (10000s)</td>
<td>0.1 milliCrab (3σ) (1000s)</td>
<td>0.5 milliCrab (3σ) (1000s)</td>
<td>~30 milliCrab (3σ) (300s)</td>
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THANK YOU!

TAUVEX Core Group