EXACT:
Experiment for X-Ray Characterization and Timing

Speaker
Ryan Vogt

Contributors
Dr. Demoz Gebre Egziabher, Dr. Lindsay Glesener, Hannah Weiher, Joel Runnels, Trevor Knuth, Tim Kukowski, Jeffrey Chaffin, Maxwell Yurs, Kendra Bergstedt

University of Minnesota
Astrophysical Sources of High Energy Radiation

• Solar Eruptive Events
  – Solar Flares
  – Coronal Mass Ejections

Figure 1: (Right) X-ray image of solar flare (NASA). (Left) Image of Pulsar (NASA)

• Non-Solar Astrophysical Radiation Sources
  – Gamma Ray Bursts
  – Pulsars
Solar Eruptive Events

• Solar Flares and Solar Cycle

Figure 2: (Left) Sunspot numbers and flare activity in Solar Cycles 23 and 24. (Right) Standard Solar Flare Cartoon (Both Steven Christe, 2007)
Solar Eruptive Events

- Coronal Mass Ejections (CME)

Figure 3: Coronal Mass Ejection and Earth’s Magnetic Field
(thewatchers.adorraeli.com)
Solar Eruptive Events: Still Unknown

• Energy Transfer
  – Magnetic fields to kinetic energy
  – Hard X-Ray signature

• Hard X-Ray Emission
  – Solar surface
  – Corona
  – CME cores
Navigation in Space

- **Gamma Ray Bursts**
  - Large, distant, high-energy EM events
- **Pulsars**
  - Periodic X-ray radiation source
- **Precision timing of events**
- **Relative timing to give relative position**
- **Similar to GPS**

Figure 4: Determination of timing and position using X-Ray and Gamma Ray sources
EXACT: One Project, Two Missions

Shared Requirements:
- Energy ranges
- Timing requirements
- Sensor requirements

Shared Resources:
- Project funding
- Expertise and experience
- Two departments

Figure 5: UMN EXACT Project Logo
EXACT Team Structure

Aerospace Engineering (9) Space Physics (10)

- PI: Dr. Demoz Gebre Egziabher
  - Sub-system design
  - Component assembly and installation
  - Spacecraft ranging

- PI: Dr. Lindsay Glesener
  - Solar activity research
  - Detector testing and development
  - Solar flare characterization
EXACT Team Structure

Undergrad Executive Team:
- Project Manager (PM)
- Chief Engineer (CE)
- Document Specialist

Senior Executive Team:
- Dr. Gebre and Dr. Glesener
- Executive PM
- Executive CE
The EXACT Satellite: GRID

- Gamma Ray Incidence Detector
  - Scintillator Detector with 4 CsI(Tl) crystals
  - Student designed
  - Inexpensive and replicable

Figure 6: Image of GRID Detector
The EXACT Satellite: GRID

• GRID Detector
  – Redesign in progress
    • Time precision
    • Energy resolution

  – Continued Testing
    • At UMN
    • High Altitude Student Platform (HASP)

Figure 6: Image of GRID Detector
The EXACT Satellite: Sun-Pointing

- Solar Panels
  - Power generation
  - Attitude determination

- Magnetorquers
  - Attitude control

Figure 7: Image of EXACT with Solar Panels
EXACT Research and Testing

• Solar Flare Analysis
  – Predicted photon counts for each flare class
  – Used to predict data volume for detector

<table>
<thead>
<tr>
<th>Flare Class</th>
<th>Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>230,000</td>
</tr>
<tr>
<td>B5</td>
<td>935,000</td>
</tr>
<tr>
<td>B9</td>
<td>1,853,000</td>
</tr>
<tr>
<td>C1</td>
<td>3,370,000</td>
</tr>
<tr>
<td>C5</td>
<td>32,000,000</td>
</tr>
<tr>
<td>C9</td>
<td>58,000,000</td>
</tr>
</tbody>
</table>

Table 1: Solar flare counts by class

Figure 9: Image of Solar Flare (NASA)
EXACT Research and Testing

• GRID Tests and Calibration
  – Testing with various radioactive sources
  – Discovered errors in current setup

Figure 10: Sample radioactive sources (imagesco.com)
EXACT Research and Testing

High Altitude Student Platform (HASP):

- Component Testbed
  - Detector
  - Communications
  - Power system
- Integration - August
- Flight - September

Figure 11: HASP Vehicle (stratocat.com.ar)
The Future and EXACT

- Inexpensive Hard X-Ray detector for solar observation
- Spacecraft ranging technique for positioning data in space
- Solar and space research at UMN