EXACT: Experiment for X-Ray Characterization and Timing

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Astrophysical Sources of High Energy Radiation

- Solar Eruptive Events
  - Solar Flares
  - Coronal Mass Ejections

- Non-Solar Astrophysical Radiation Sources
  - Gamma Ray Bursts
  - Pulsars

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