Space instrumentation II

Examples of instrument implementations
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CEO Integrated Detector Electronics AS
Outline

• Uses and users of space instruments.
• Instruments for science looking outward away from the earth:
  • Astro-particle physics.
  • Astronomy.
  • Solar science.
  • Non-earth planetary science.
• Instruments looking at the earth for:
  • science studying earth-space interactions.
  • science studying the earth's atmosphere, land and sea.
  • mapping the earth's geology, topography and geography.
  • meteorological applications.
  • defense and intelligence applications.
Uses and users of space instruments.

• A majority of instruments are used to gather data for attitude control: the humble star tracker. Almost all satellites use star trackers.

• Scientific instruments are mainly used to observe the earth and its close environment with space for governmental or commercial purposes.

• Only a tiny fraction are used for basic scientific studies in
  • Astronomy
  • Astrophysics
  • Solar physics
  • Planetary science
Satellite owner and purpose

Satellite purpose
- Communications: 49%
- Earth Observation: 28%
- Technology development: 11%
- Space Science/observation: 7%
- Navigation: 5%

Satellite owner:
- Civil: 50%
- Commercial: 25%
- Government: 23%
- Military: 2%
NGRM

- Next Generation Radiation Monitor
- Provide a measurement of the particle radiation environment around a satellite
- Flight models manufactured by Thales Alenia Space
- Thermal and radiation resistance requirents to the ASICs
- IDEAS provide IDE3465 ASICs
- NGRM presented at the RADECS 2013 conference
- IDE3465 presented at NSS/MIC/RTSD 2013
Instruments for science looking outward away from the earth

- Astronomy.
- Astro-particle physics.
- Solar science.
- Non-earth planetary science.
Missions to the Outer Planets

- Pioneer 10 & 11
- New Horizons
- Voyager 1 & 2
- Juno
- Cassini
- Galileo
Astronomy
James Webb Space Telescope
James Webb focal plane detectors

Table 1. JWST Instruments and their Detectors

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Mercury-cadmium-telluride H2RG</th>
<th>Arsenic doped silicon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6 - 2.5 μm</td>
<td>0.6 - 5 μm</td>
</tr>
<tr>
<td>NIRCam</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>NIRSpec</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>FGS/NIRISS</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>MIRI</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
Astro-particle physics
Observing the cosmic rays from space

The Alpha Magnetic Spectrometer (AMS) observatory on the ISS uses silicon microstrips detectors connected to IDEAS integrated circuits to detect cosmic rays.

The Calorimetric Electron Telescope (CALET) observatory on the ISS uses photomultiplier tubes connected to IDEAS integrated circuits to detect cosmic rays.

Images: NASA
DAMPE launched dec 17 2015

The Monkey King spacecraft, which took to the skies on 17 December, is designed to detect the high-energy particles produced by annihilating dark matter.

Dark-matter probe launches era of Chinese space science

Monkey King is first in a line of Chinese space missions focused on scientific discovery.

By Elizabeth Gibney, Celeste Biever & Davide Castelvecchi

Against a purple morning sky, in a cloud of brown smoke, the Monkey King took off. China’s first space-based dark matter detector — nicknamed Wukong (or Monkey King) after a warrior in a sixteenth-century Chinese novel — roared into the air on 17 December, marking the start of a new direction in the country’s space strategy.

From Earth’s orbit, the craft aims to detect high-energy particles and γ-rays. Physicists think that dark matter — a substance thought to make up 86% of the universe’s matter but so far observed only through its gravitational effects — could reveal itself by producing such cosmic rays as its constituent particles annihilate.

Wukong, officially called the Dark Matter Particle Explorer (DAMPE), is also notable for being the first in a series of five space-science missions to emerge from the Chinese Academy of Science’s Strategic Priority Program on Space Science, which kicked off in 2011.

China is already one of the world’s major space powers, but so far has focused on human and robotic exploration, with little investment in space science. (A notable exception is the Double Star probe launched in collaboration with the European Space Agency in 2003 to study magnetic storms on Earth.)

The DAMPE lift-off from the Jiuquan Satellite Launch Center in northern China will be followed next year by a further two missions: the world’s first quantum-communications satellite and an X-ray telescope observing in

06.09.2017

G. Maehlum (IDEAS)
X- and gamma ray telescopes and planetary spectrometers
Space based x and gamma ray Observatories

Increasing photon energy

- Compton cameras
- Gamma coded mask detectors
- X-ray telescopes

Astro-H
SWIFT
INTEGRAL
XMM Newton
Astro-H
Chandra as an example of an x-ray telescope

- Launched 1991, still active
- Chandra is sensitive to X-ray sources 100 times fainter than any previous X-ray telescope, due primarily to the high angular resolution of the Chandra mirrors. Since the Earth's atmosphere absorbs the vast majority of X-rays, they are not detectable from Earth-based telescopes, requiring a space-based telescope to make these observations.
Some components of Chandra

CCD imaging spectrometer, ACIS

High Resolution Camera, HRC
NASA’s SWIFT MISSION

Ideas XA1.2 in orbit since November 2004 and still delivering data
Swift **Burst Alert Telescope** a coded mask detector for medium energy gamma rays

**Swift Instruments**

- **Burst Alert Telescope (BAT)**
  - New CdZnTe detectors
  - Most sensitive gamma-ray imager ever

- **X-Ray Telescope (XRT)**
  - Arcsecond GRB positions
  - CCD spectroscopy

- **UV/Optical Telescope (UVOT)**
  - Sub-arcsec positions
  - Grism spectroscopy
  - 24th mag sensitivity (1000 sec)
  - Finding chart for other observers
IDEAS ASICs were used in the gamma spectrometer that mapped the moons surface

Chandrayaan-1
India’s first mission to the Moon
The University of Bergen chose the IDEAS ASIC and module for their gamma ray detector in the ASIM to be launched this year. The instrument will study gamma rays from high altitude lightings.

The Atmosphere Space Interactions monitor, ASIM on the ISS.
Particle radiation from the sun
Planetary particle detectors
IDEAS ASIC are used in 3 instruments on the BepiColombo mission to Mercury.
IDEAS ASICs are used in the RADEM instrument on JUICE.

This ASIC was custom designed for JUICE. It is designed for 8 years of operation in interplanetary coasting and at least 3 years in the tough radiation environment at Jupiter.
Conclusions

• Almost all modes of interactions between photons and matter is employed in astronomical instruments to cover a 20 order of magnitude energy range.

• Close to equally many modes are employed to detect particle radiation is space

• We are far from the end, new detectors are constantly being developed, for for space but also as spin-offs from terrestrial activities.
Thank you

We have 3 Job opportunities
contact gunnar@ideas.no

• Industrial Ph.D. position in nano electronics.
• R&D into circuits using 28nm FDSOI process
• Post doc or engineer position in nano electronics.
• R&D into circuits using 28nm FDSOI process
• engineer position in ´space engineering´.
• Development of instruments and electronics