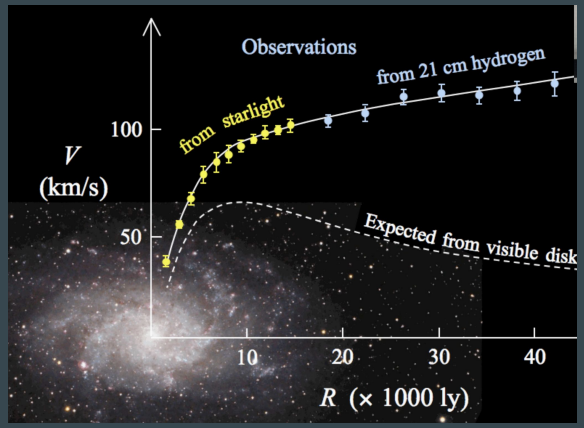
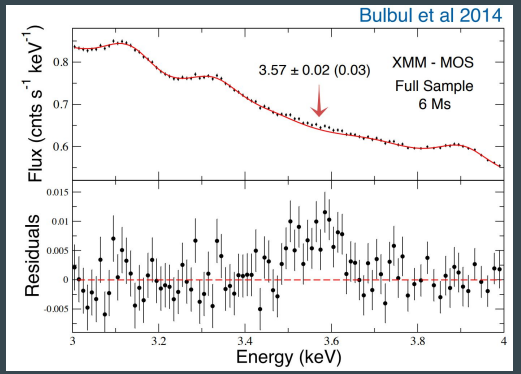

Heat Management
Solutions in the CubeSat
By: Brody Oleson

Dark Matter

- Rotation curves for galaxies have unexpected velocity results
- Velocity results give reason to believe that there is more matter than the visible stars and gas in the galaxy.
- Some models suggests that the dark matter emits x-rays when it decays, recent observations have some hints of these X-ray signal.

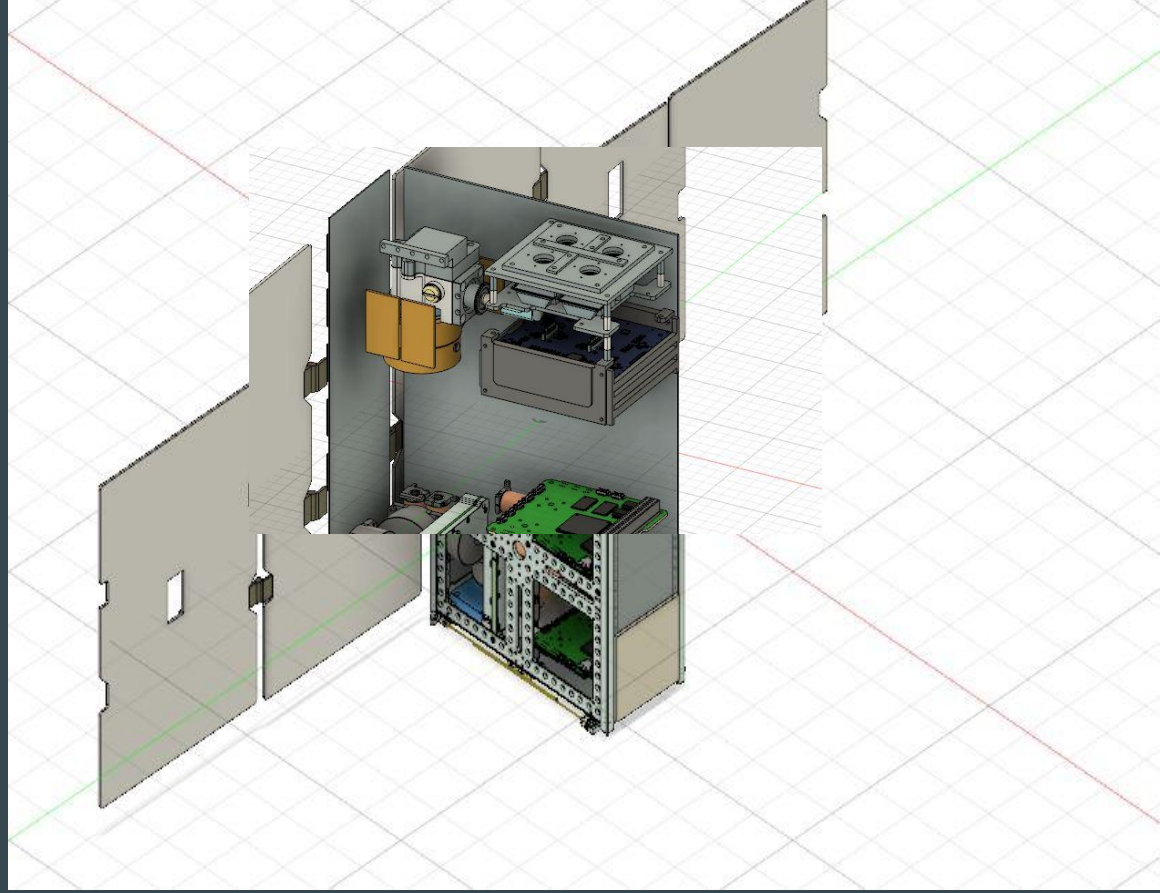




$$\Gamma = \frac{9\alpha G_F^2 m_s^5 \sin^2 2\theta}{1024\pi^4}$$

CubeSat

- Fermilab, UIUC LASSI, and CU Aerospace
- Takes wide image of X-Rays in the galaxy
- Mini-Satellite that is more affordable than similar projects
- 1.27 Kg limit



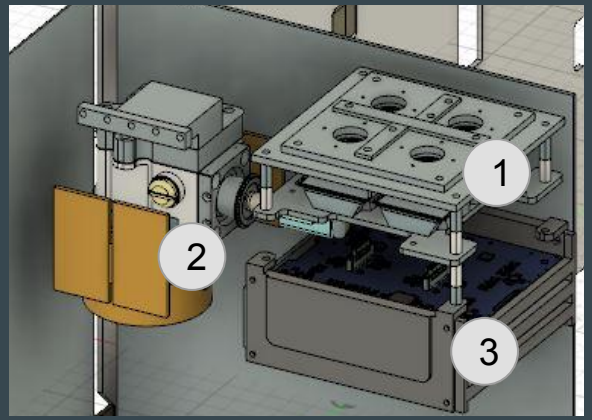
Hitomi + XMM-Newton X-Ray Space Telescope

- Japanese X-ray satellite that takes a wide perspective image, similar to the CubeSat
- Software error leading to the separation of solar panels

- Large telescope that was built to take images of a specific point, usually used for other galaxies

Darkness thermal load from Fermilab's payload

- For X-rays we want to use scientific CCDs (1).
- The designed instruments needs a cryocooler to keep the CCDs at 170K, these cryocooler(2) uses 10W of electrical power that we need to dissipate in space.
- The CCDs are controlled with FNAL's custom electronics(3), that dissipates another 10W.
- How do we move this heat away from the payload and into outer space without the use of convection?



Heating Solutions-Thermal Straps

- Aluminum vs Copper
- By determining the surface area needed for proper conductivity, we were then able to solve for the masses for each material. Copper requires a smaller surface area as having a greater thermal conductivity. However, Aluminum can produce the same thermal conductivity at a smaller mass.

Aluminum

Q(d)/(Dt(K)) = A

By taking the amount of heat transfered (Q) which is 10W and the distance between the isothermal planes in meters which is .2M you can solve for the numerator of the equation used to find the surface area we are looking for

We will find our denominator by multipying the change in temperature (60K) by the thermal conductivity.

$$= \frac{10W \times .2M \ mK}{60K \times 239W} = \frac{2m^2}{1430} = .00014 \ m^2$$

We now have to solve for the mass of the thermal strap.

Mass=Volume x Density

The density of aluminum is

while the volume is (1.2cm X 1.2cm) 20 cm

V= 28.8 cm^3
D=2.7 g/cm^3
Mass=77.76 g

Aluminium / Density

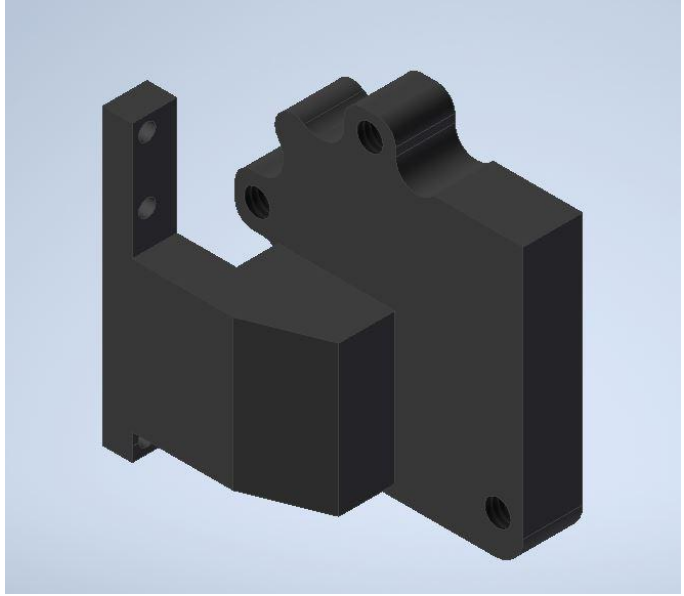
2.7 g/cm³

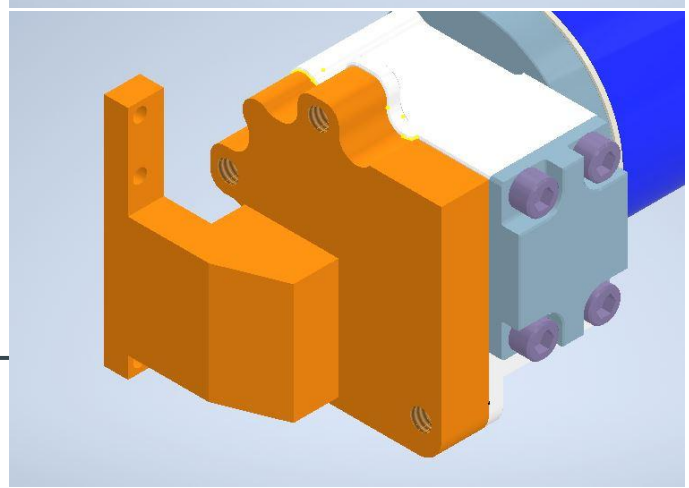
Work done by Shivam Gaind, Saint Charles East High School

Cryocooler

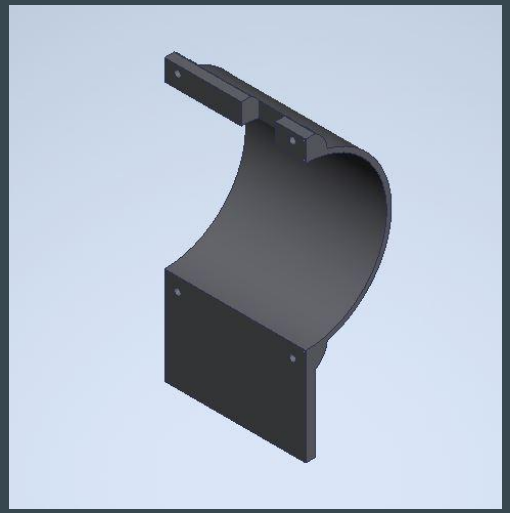
- Commercial cryocooler with 1W cooling capacity.
- Small size, cooling range of 65K-150K
- 10W electrical power needed to cool
- Front grip to attach the thermal straps
- Back attachment for stability of the component

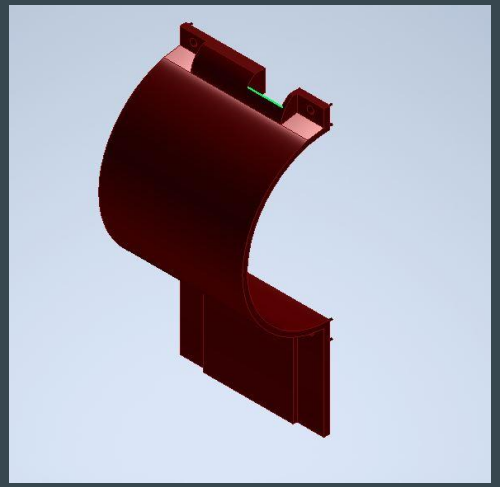
Back Attachment

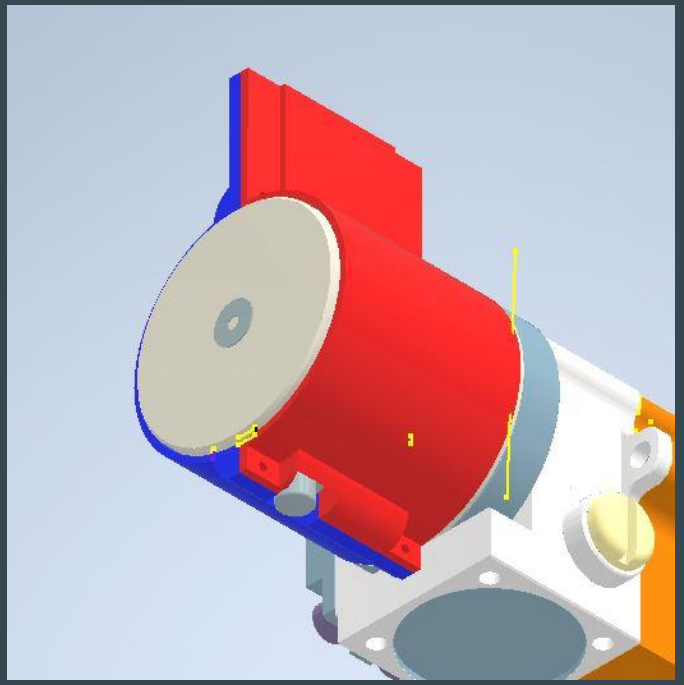




Thermal Straps

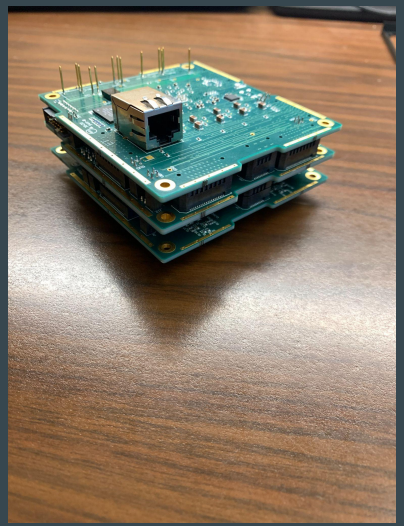






Electronic Readout Boards

- 10W needed to cool
- Clamps to connect to circuit boards as well as thermal straps connecting to the clamps



Work done by Shivam Gaind, Saint Charles East High School

Future

Due to the short time frame, in the future the team will use the parts created to test the thermal conductivity of all the printed parts.

The project will move on to the critical design stage

Plans to launch the satellite in two years

Questions?