SpaceWire Application for the X-ray Microcalorimeter Instrument onboard the Astro-H Mission

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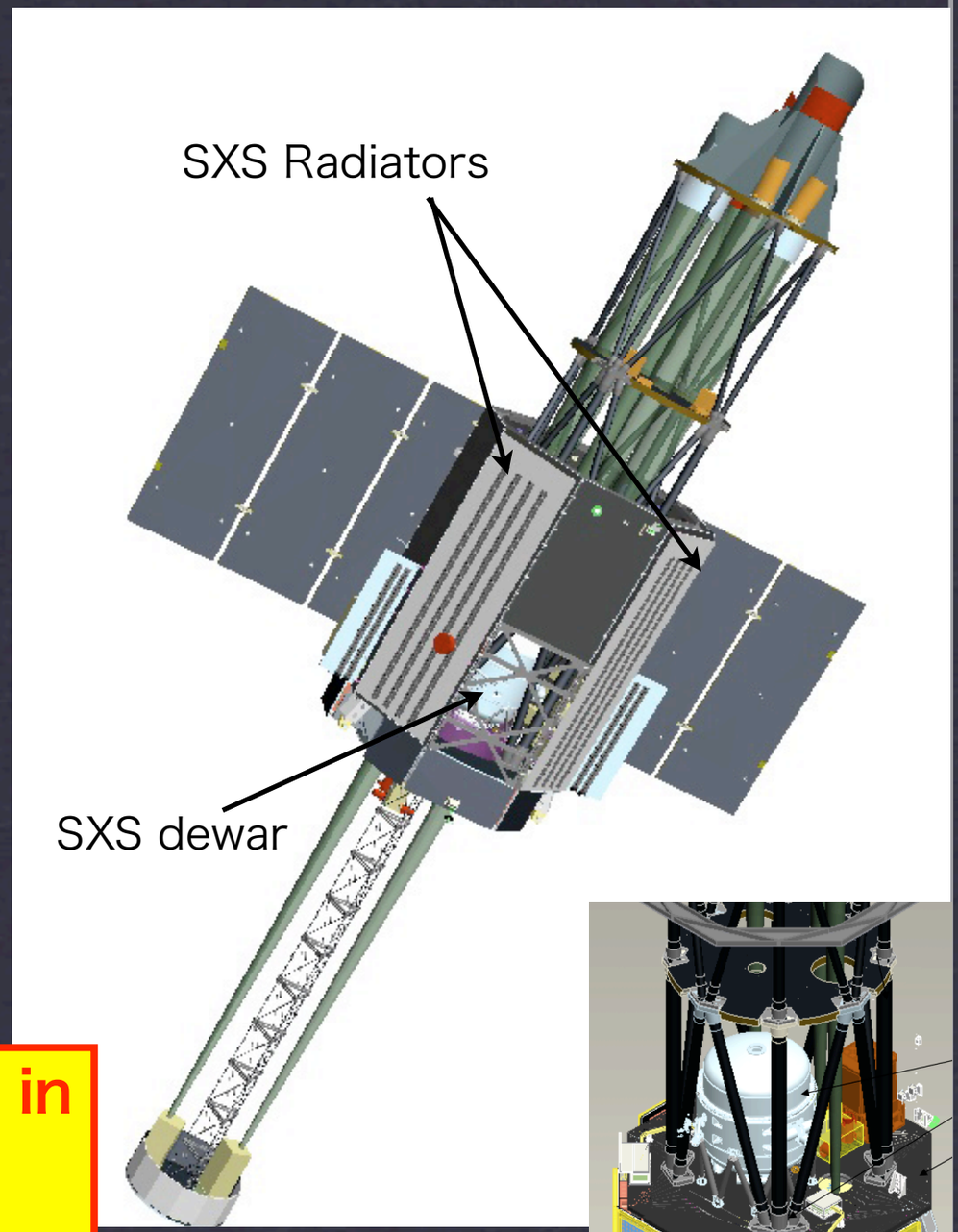
Astro-H SXS

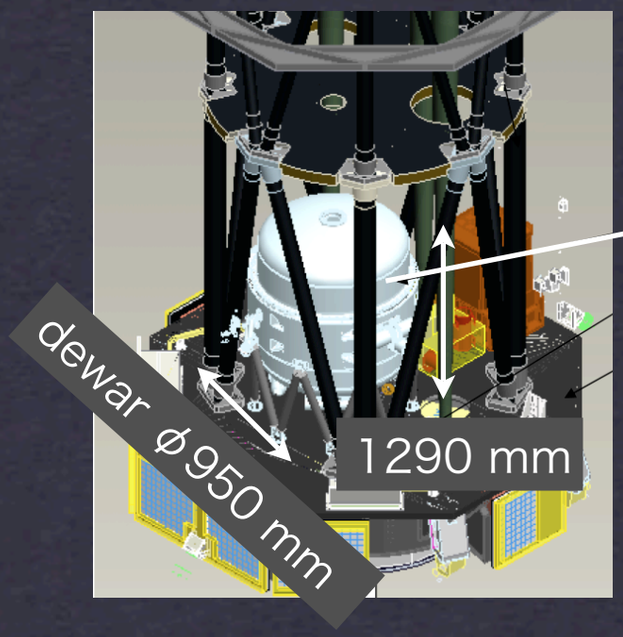
- Astro-H is the sixth Japanese X-ray observatory (2013, PI : Prof. Takahashi).
  - Astro-H :
    - Mass: 2400 kg
    - Orbit: LEO 550 km
    - Launch Vehicle: Japanese H-IIA
    - 4 instruments covering 0.3-600 keV
  - SXS (Soft X-ray Spectrometer): 0.3-10 keV
    - X-ray microcalorimeter
      - heat pulse by an X-ray photon (~fJ)
      - measure a temperature rise (~mK)
    - 50 mK cooling system
    - <7 eV FWHM energy resolution @ 6 keV
    - 210 cm^2 effective area @ 6 keV



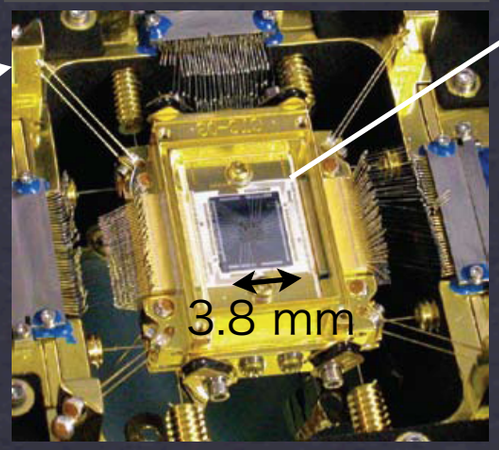
SXS will make groundbreaking discoveries in the formation and evolution of galaxies, strong gravity environments, and cosmology

SXS System

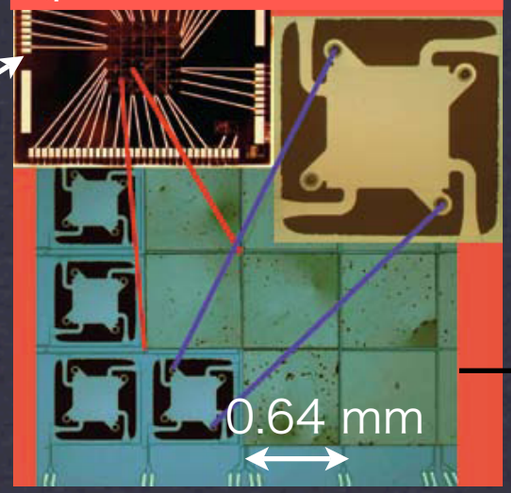
- Mass : 300 kg (dewar + mechanical coolers 230 kg)
- Power : 600 W (mechanical coolers + their electronics boxes 460 W)
- Cooling System :
  - 50 mK 2-stage adiabatic demagnetization refrigerator (ADR) x 1
  - 1.3 K liquid He x 36 litter
  - 1.7 K Joule-Thomson cooler (JT) x 1
  - 2-stage Stiring coolers (2ST) x 2 for dewar shields + 2 for JT precoolers
  - dewar
- Detector : 6x6 (goal 8x8) pix, Si thermistor + $Hg_{1-x}Cd_xTe$ absorber

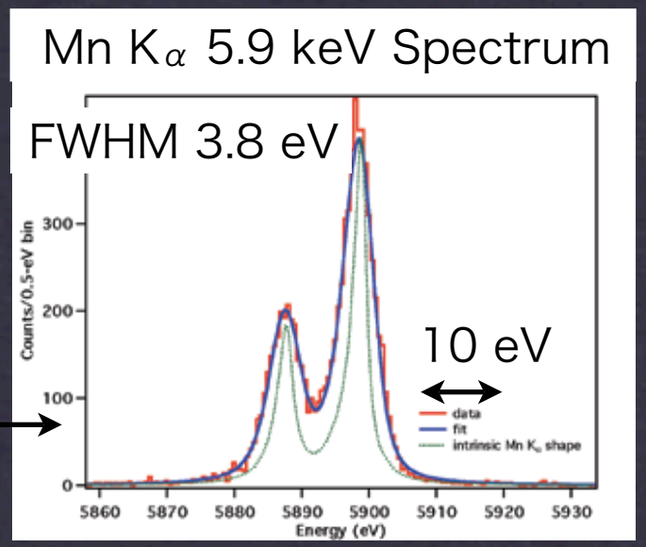


Front End Assembly
(photo Suzaku XRS)

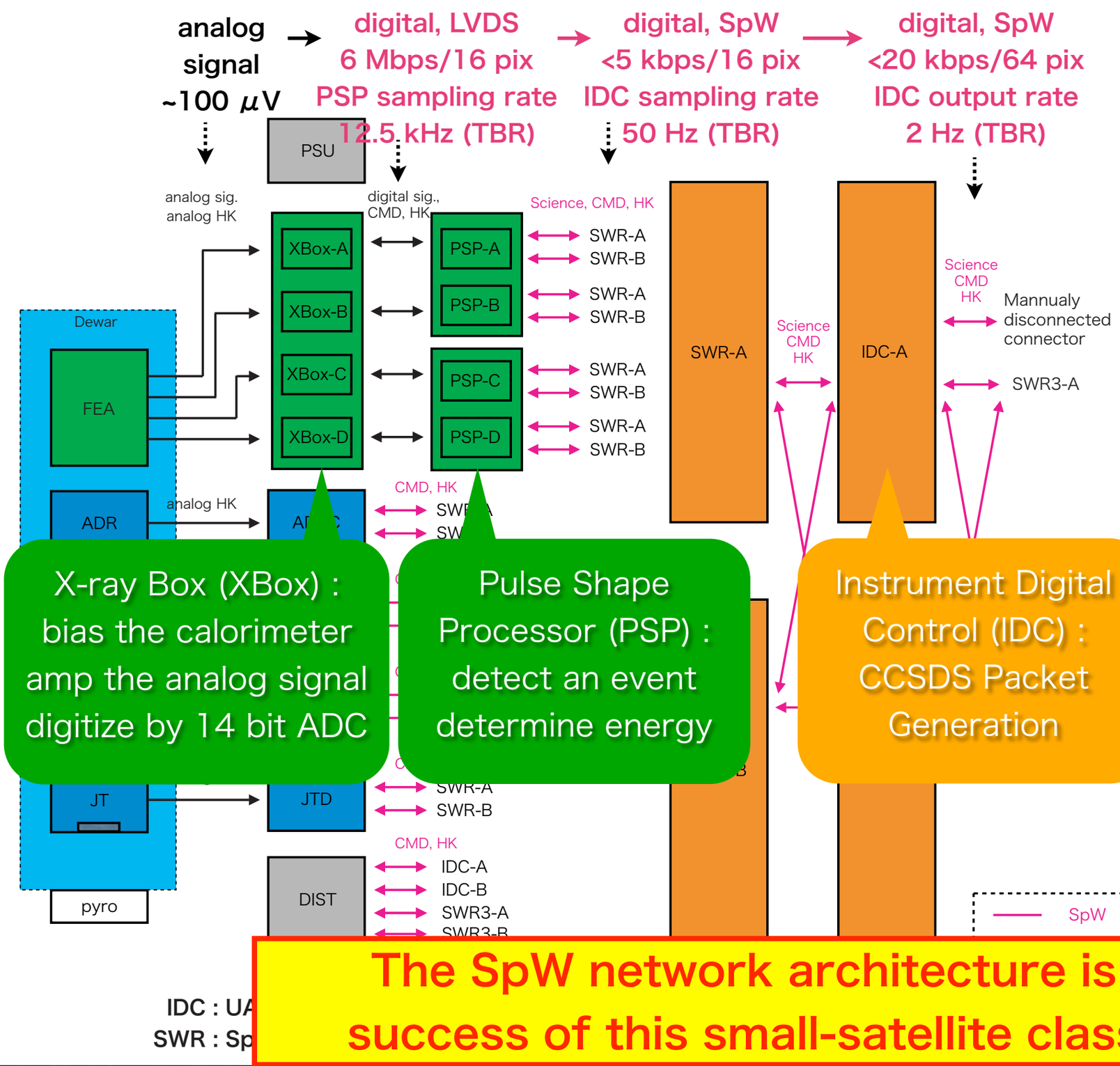


Calorimeter Array
(photo Suzaku XRS)





Data Block Diagram



- Four subsystems
- Expected data rate : <20 kbps (science), 1.5 kbps (HK)
- IDC-B and SWR-B are cold redundant
- All units have two SpW connections to IDC- or SWR-A and B.
- Every command and telemetry goes through IDC (except DIST).
- IDC-A has one SpW port and DIST has one power port for ground support equipment.

The SpW network architecture is key for success of this small-satellite class system

IDC (Instrument Digital Control)

- Functions
  - Satellite bus & GSE communication
    (CMD/TLM handling,
     CCSDS packet generation)
  - Control SXS units
    (Collect HK and science data,
     Send CMDs, Cooler limit check,
     Automatic JT control)
  - and so on
    (Time assign/management w/
     XBox and PSP, Write EEPROM to
     update IDC software, etc...)
- Development
  - BBM : Space Cube 2/C (NEC)
  - We would like to start software development within this year

- Design baseline
  - NEC's SpaceCube 2 Hihara-san's talk

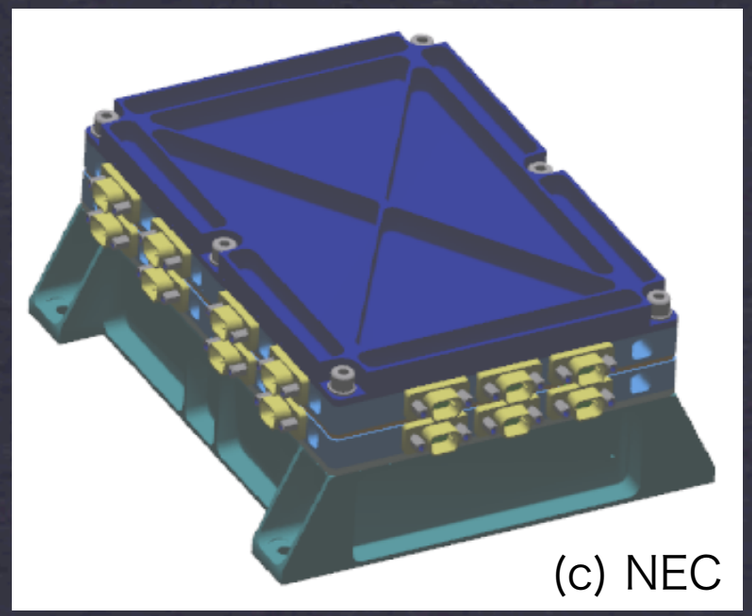
(c) NEC

Size : W71D211H180 mm
Mass : 2.1 kg
Power (32-50 V) :
ON 14±1 W @ 50 Mbps
OFF 0W
SpW link rate :
2/10/50/100/150/200 Mbps
Port : 6 SpW/router
2 RS422

CPU	**HR5000 (64 bit, 32 MHz Operation)**
Space Wire I/F	**3ch**
System Memory	**2 MB Flash Memory**
	4 MB Burst SRAM
	4 MB Asynchronus SRAM
Data Recorder Memory	**1 GB Asynchronus SDRAM**
	1 GB Flash Memory

SWR (Space Wire Router)

- Function
  - SpW router
- Design
  - Size : W150D110H60 mm (A6 size)
  - Mass : 1.2 kg
  - Power (32-50 V):
    ON 5±1 W @ SpW link rate 10 Mbps
    OFF 0 W
  - SpW link rate :
    2/10/50/100/150/200 Mbps
  - Port : 14 SpW/router
- Development
  - The same hardware will be used in
    Astro-H S/C system
  - We will take PFM approach


(c) NEC

PSP (Pulse Shape Processor)

- Functions
  - sample the data from XBox via LVDS by 12.5 kHz
  - detect an event & determine PH, event time, and rise time
  - provide an event grade considering pile-up and anti-co flags
  - sends the data to IDC via SpW for later transmission to the ground
  - Check the next talk by Hagihara for our SpW-based data processing (PreBBM)
- Design
  - One PSP box (A & B or C & D consists of two MHI's MIOs (Mission I/O board, FPGA) and two SpaceCards (CPU)
  - Size, Mass, Power : TBD
  - Port : 40 LVDS, 4 SpW
- Development
  - Pre BBM : SpW DIO board + Shimafuji's SpaceCube 1
  - BBM : 2009 Apr

Box 1: PSP-A & B

MIO-A [3 SpW, 20 LVDS]
SpaceCard-A [2+2 SpW]
MIO-B
SpaceCard-B
DC/DC

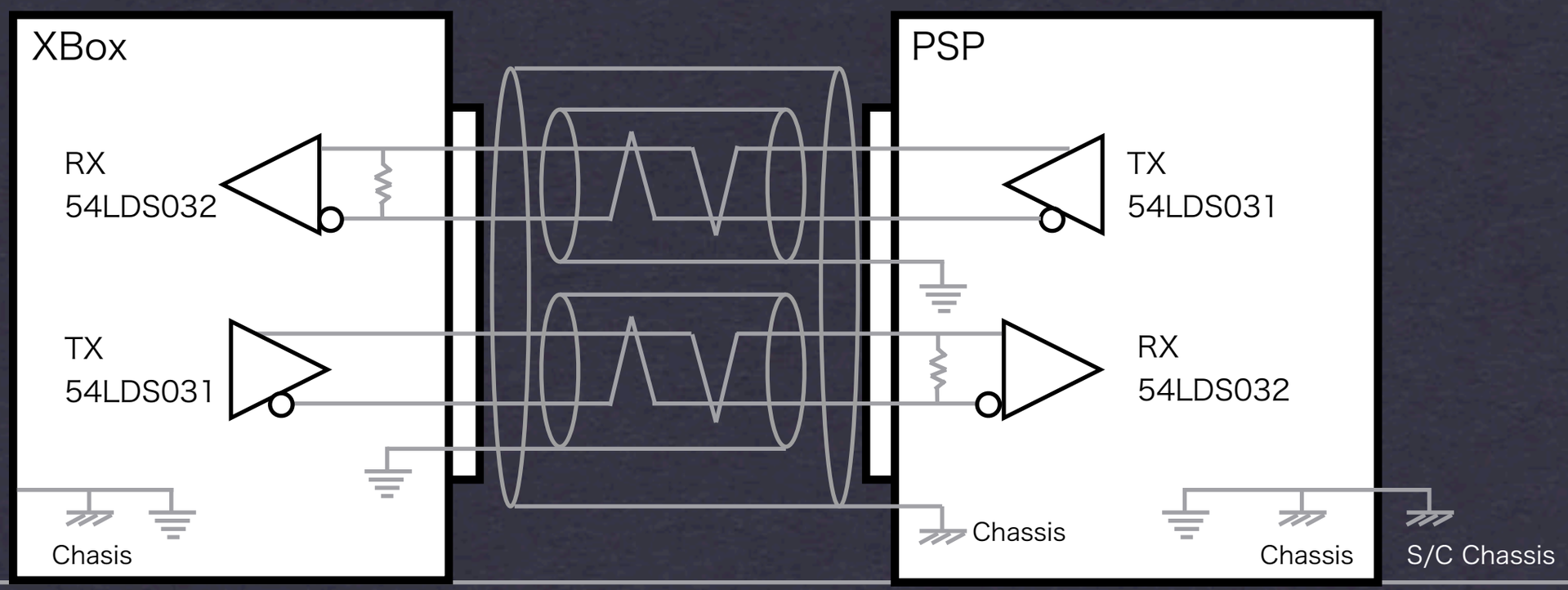
Box 2 : PSP-C & D

MIO-A [3 SpW, 20 LVDS]
SpaceCard-A [2+2 SpW]
MIO-B
SpaceCard-B
DC/DC

2 box, 4 x (MIO+SpaceCard)
16 pix/(MIO+SpaceCard)

Issue on the Grounding

- Grounding
  - LVDS chips cannot communicate correctly (can be broken), when GND levels of transmitter and receiver are different more than ±1 V
  - Chassis of XBox (analog) and PSP (digital) must be connected ?
  - In Suzaku XRS, we electrically floated the CAP (XBox) chassis from that of CDP (PSP) and also the S/C panel. It was connected to a single point ground (the dewar).
  - We would like to tie the shield around each twisted-pair only to the transmitter side and tie the outer shield only to PSP (TBD)



Summary

- We are carrying out development of SpaceWire network for the Astro-H SXS.
- The SXS data system is designed to avoid a single point failure as possible as we can (cable connections, data handling units, etc ...)
- Design baseline of IDC (CMD/TLM handling unit) will be NEC's Space Cube 2. BBM study will start soon using NEC's Space Cube 2/C.
- PSP (Pulse Shape Processor) will use a MHI's MIO board and SpaceCard. Pre BBM study is under going using MHI's Space Wire DIO board and Shimafuji's Space Cube 1. BBM will be fabricated till 2009 Apr.
- Grounding of SpW I/F LVDS chips can be an issue b/w XBox and PSP.