24th WRMISS, Athens, Greece
(Workshop on Radiation Monitoring on International Space Station)

Radiation and X-Ray Measurements in Polar Orbit by Ten-Koh 2018 Spacecraft and Comparative Assessment with ISS Data

Premkumar B. Saganti, Ph. D.

Regents Professor – Texas A&M University
Research Director - Radiation Institute for Science and Engineering (RaISE)
Professor and Coordinator of Physics - Prairie View A&M University

www.pvamu.edu/raise

RaISE
RADIATION INSTITUTE FOR SCIENCE & ENGINEERING

PRAIRIE VIEW A&M UNIVERSITY
RESEARCH TEACHING SERVICE
1876

SHARP-CPD and Ten-Koh Team

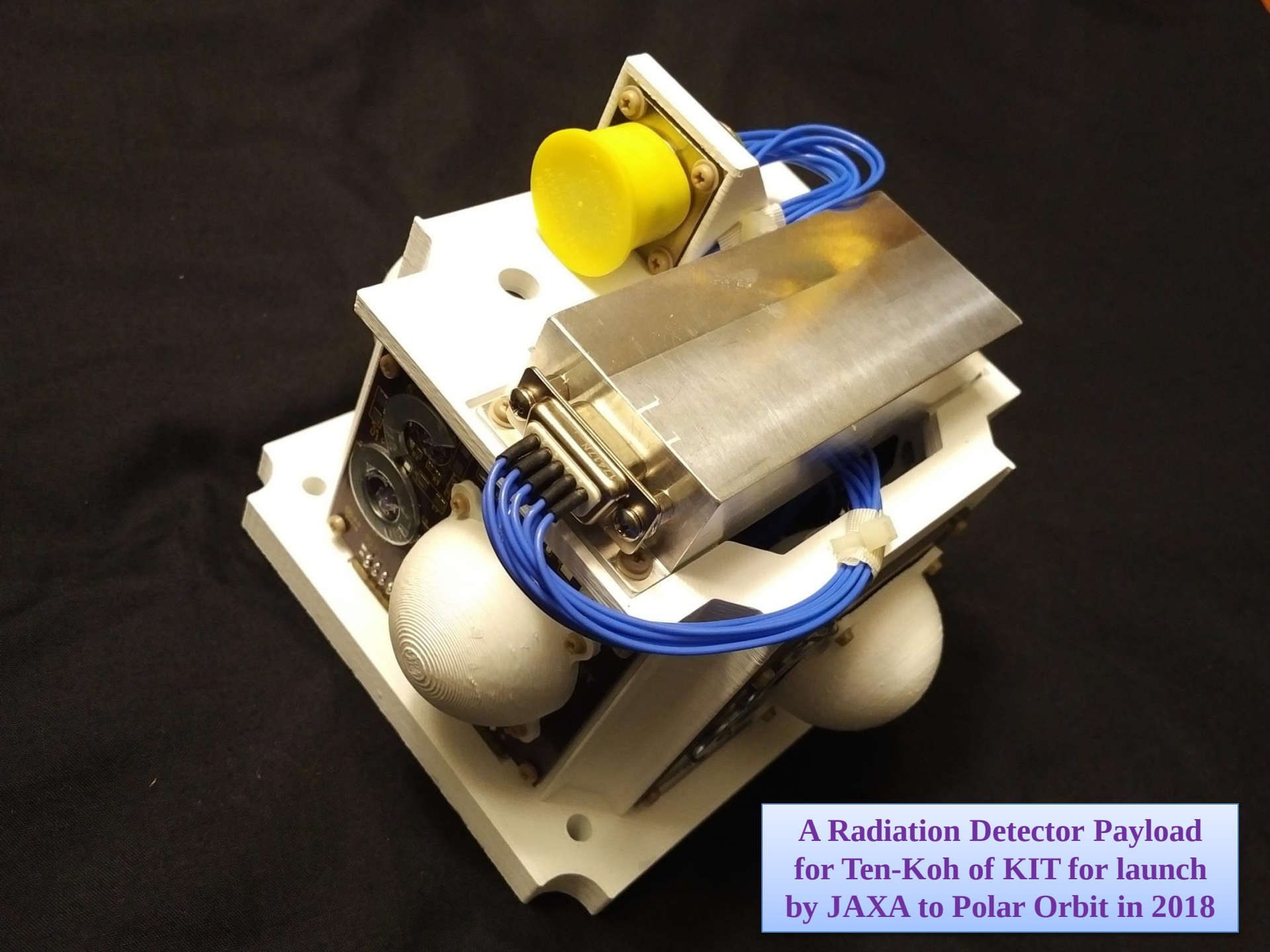
Premkumar Saganti, Gary Erickson, Mahamudur Rahman, Ramesh Dwivedi, Brain Cudnik, Seth Saganti, and Sonia Kolluri
Radiation Institute for Science and Engineering, Prairie View A&M University, TX, USA

S. Doug Holland, Richard Hagan
NASA Johnson Space Center / Holland-Space LLC, Houston TX, USA

Tsvetan Dachev, Plamen Dimitrova, Borislav Tomova, Yuri Matviichuka
Space Research and Technology Institute - Bulgarian Academy of Sciences, Bulgaria

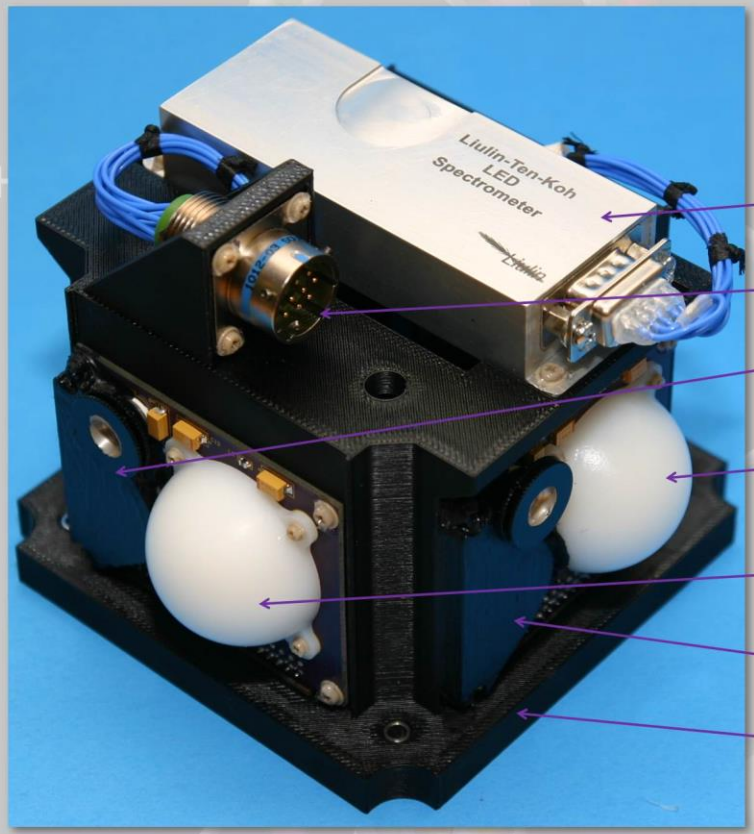
Kei-ichi Okuyama , Isai Fajardo, Jesus Gonzalez-Llorente, Rafael Rodríguez
Kyushu Institute of Technology, Kyushu, Japan

Francis A. Cucinotta
University of Nevada, Las Vegas, NV, USA



A Radiation Detector Payload for Ten-Koh of KIT for launch by JAXA to Polar Orbit in 2018

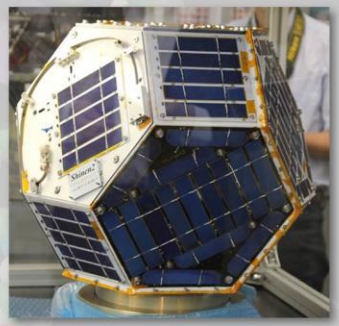
A Radiation Payload to Earth's Polar Orbit in 2018

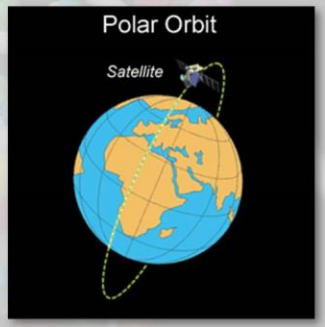


Solar and Heliospheric Assessment of Radiation Particles (SHARP) – Charge Particle Detector (CPD)

6 Radiation Sensors + 2 X-Ray Detectors + 1 Particle Spectrometer

- Liulin Spectrometer – Similar Instrument on ISS, MIR, and Chandrayaan
- Communication with In-Flight Programming Capability
- 2 Open Sensors for Ambient Radiation Measurements
- 2 Polyethylene Covered Sensors for Shielding Assessment
- 2 Polystyrene Covered Sensors for Skin Dose Assessment
- 2 X-ray Detectors
- PEKK Material for Static Guard





A radiation payload is being developed as part of efforts by the Texas A&M University (TAMU) Chancellor's Research Initiative (CRI) at Prairie View A&M University, Radiation Institute for Science and Engineering (RaISE) in collaborative partnership with NASA Johnson Space Center for the Ten-Koh spacecraft of the Kyushu Institute of Technology (KIT) for a polar orbit launch by the Japan Aerospace Exploration Agency (JAXA), Japan.

Ten-Koh Satellite of KIT-Japan will be launched by JAXA into Low Earth Polar Orbit of 93^0 and about 600 km altitude with PVAMU payload as a primary radiation science investigation instrument and in-flight command control capability.

RaISE
RADIATION INSTITUTE FOR SCIENCE & ENGINEERING

www.pvamu.edu/RaISE

This research, envisioned in part by NASA Grants (PI-Saganti) NNJ04HD93G, NNJ06JD37G, NNX07AL91G, NNX07AT25A, NNX09Q92G, and NNX10AQ14A; is currently supported through the TAMU Chancellor's Research Initiative – CRI / R aISE at PVAMU

H-II A (40) Launch on October 29, 2018 by JAXA Japan Ten-Koh Spacecraft with PVAMU Payload: SHARP-CPD

https://www.pvamu.edu/raise/space-payload/charged-particle-detector-2018/

Tracking **19431** objects as of 18-Dec-2018
HD Live streaming from Space Station
1,529 objects crossing your sky now

ISS will cross your sky
in 4h 11m 31s

Find a satellite...
N2YO.com on Facebook

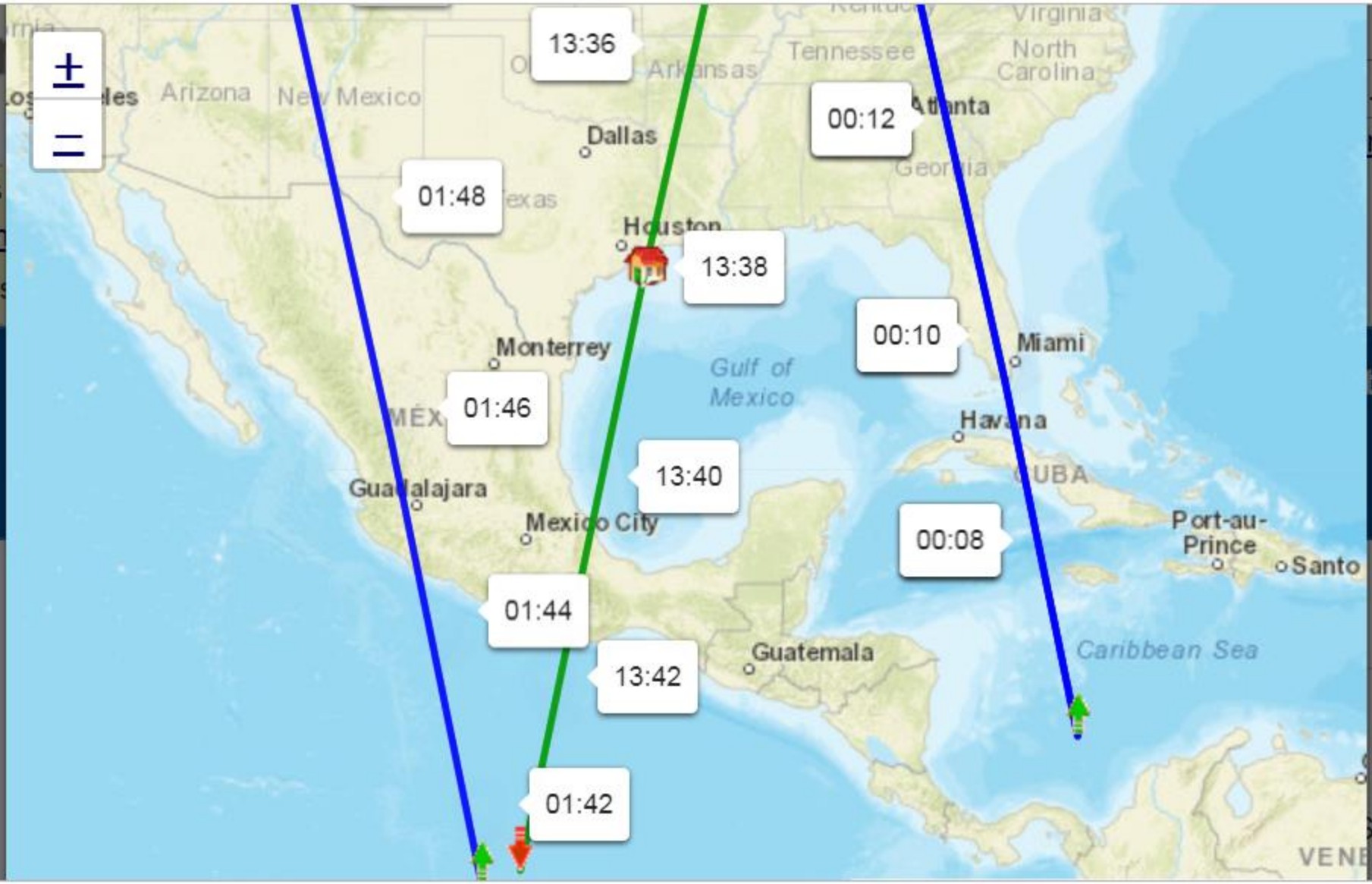
10-DAY PREDICTIONS

Object name	**TEN-KOH** Live tracking | More info
Catalog #	43677, 2018-084G
Observing location	Houston
Observing coord.	Lat: 29.76°, Lng: -95.36° Change
Local time zone	GMT -6

Uplink (MHz): 435.280
Downlink (MHz): 437.390
Beacon (MHz): 437.510
Mode: 1k2AFSK 9k6GMSK CW WSJT
Call sign: JG6YKY
Status: Active

All passes | AM/PM time | UTC | Print as PDF

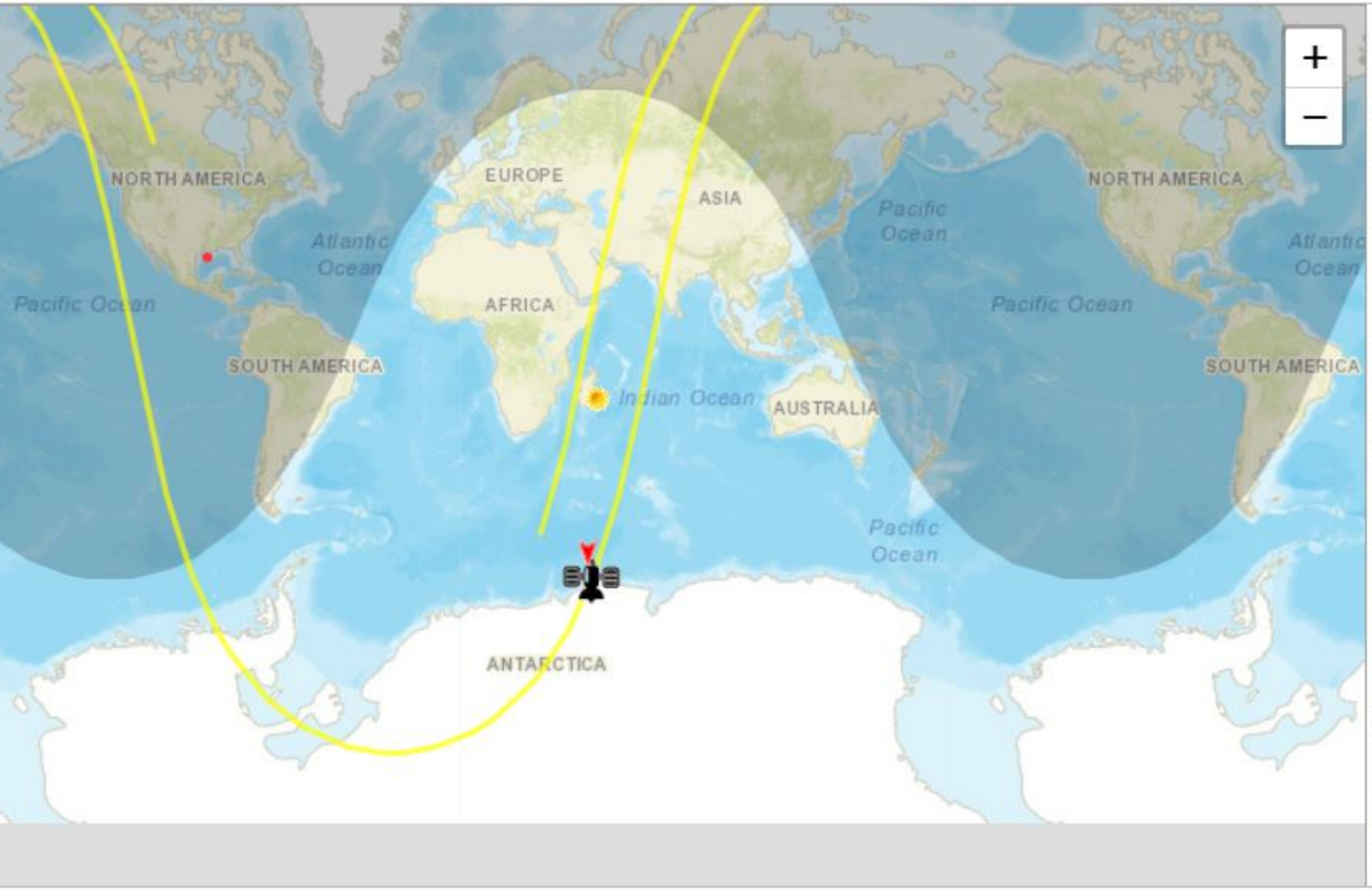
No visible pass found. Would you like to see all passes?


13:36
00:12
01:48
13:38
00:10
01:46
13:40
00:08
01:44
13:42
01:42
Dallas
Houston
Monterrey
Miami
Gulf of Mexico
Havana
Guadalajara
Mexico City
Port-au-Prince
Guatemala
Caribbean Sea
Arizona
New Mexico
Tennessee
North Carolina
Georgia

SATELLITE TRAC

https://www.n2yo.com/?s=43677

kmarks | Local Sidereal Time C | Conference Program | New Tab | NASA927 ✈ FlightAv | Louisiana Accelerator | Hello, Premkumar | CRI-RaISE – Just anot | Shandrew



TEN-KOH

NORAD ID:	43677
LOCAL TIME:	02:36:04
UTC:	08:36:04
LATITUDE:	-66.62
LONGITUDE:	48.09
ALTITUDE [km]:	622.47
ALTITUDE [mi]:	386.78
SPEED [km/s]:	7.55
SPEED [mi/s]:	4.69
AZIMUTH:	159.5 SSE
ELEVATION:	-67.6
RIGHT ASCENSION:	19h 12m 39s
DECLINATION:	-51° 12' 42"
Local Sidereal Time:	08h 02m 16s

The satellite is in day light

SATELLITE PERIOD:	97m

10-DAY PREDICTIONS FOR TEN-KOH

Make A Donation

Resources

IP2Location IP Geolocation
Find your Magnetic Declination

und P....pdf

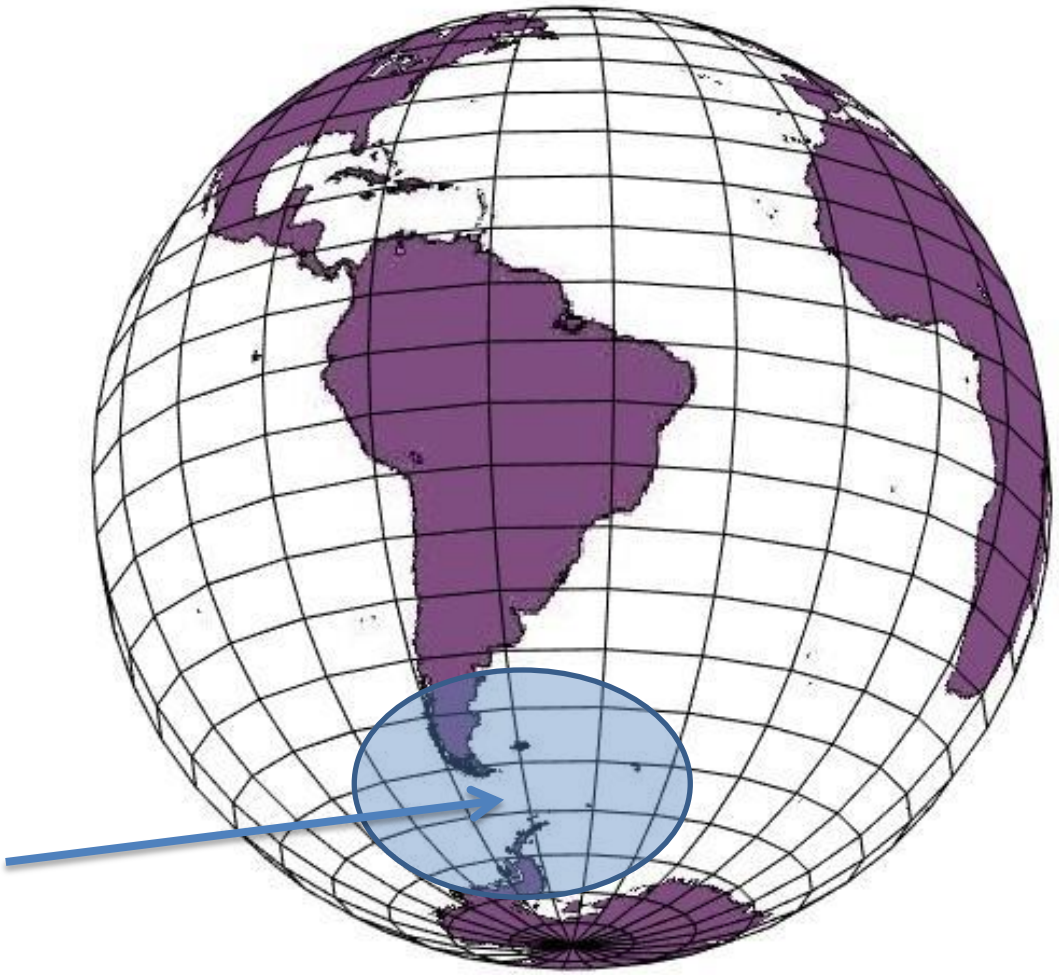
Sho

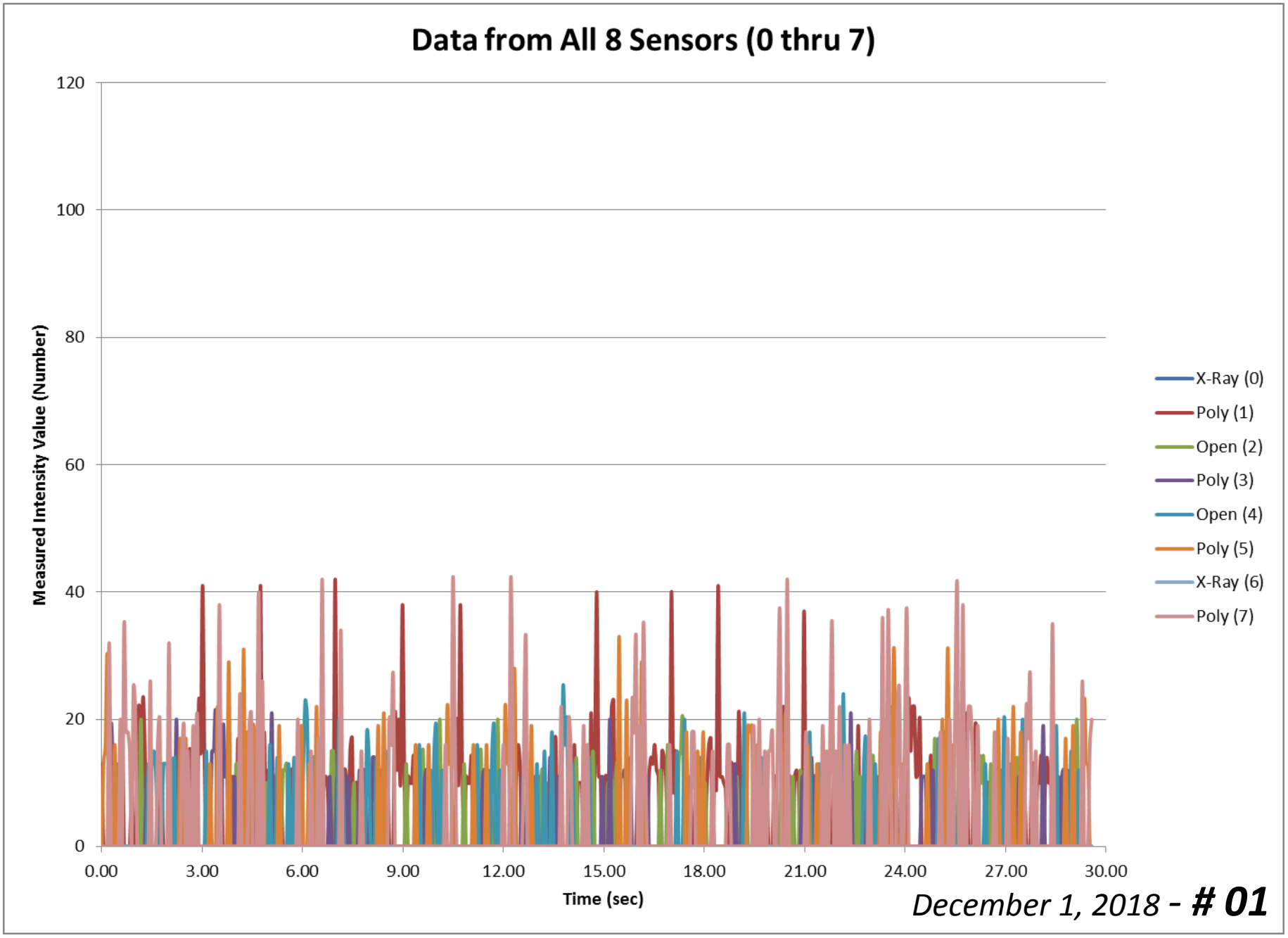
SHARP-CPD Data on December 1, 2018 from Ten-Koh thru KIT-Japan

“typical proton data and few x-rays”

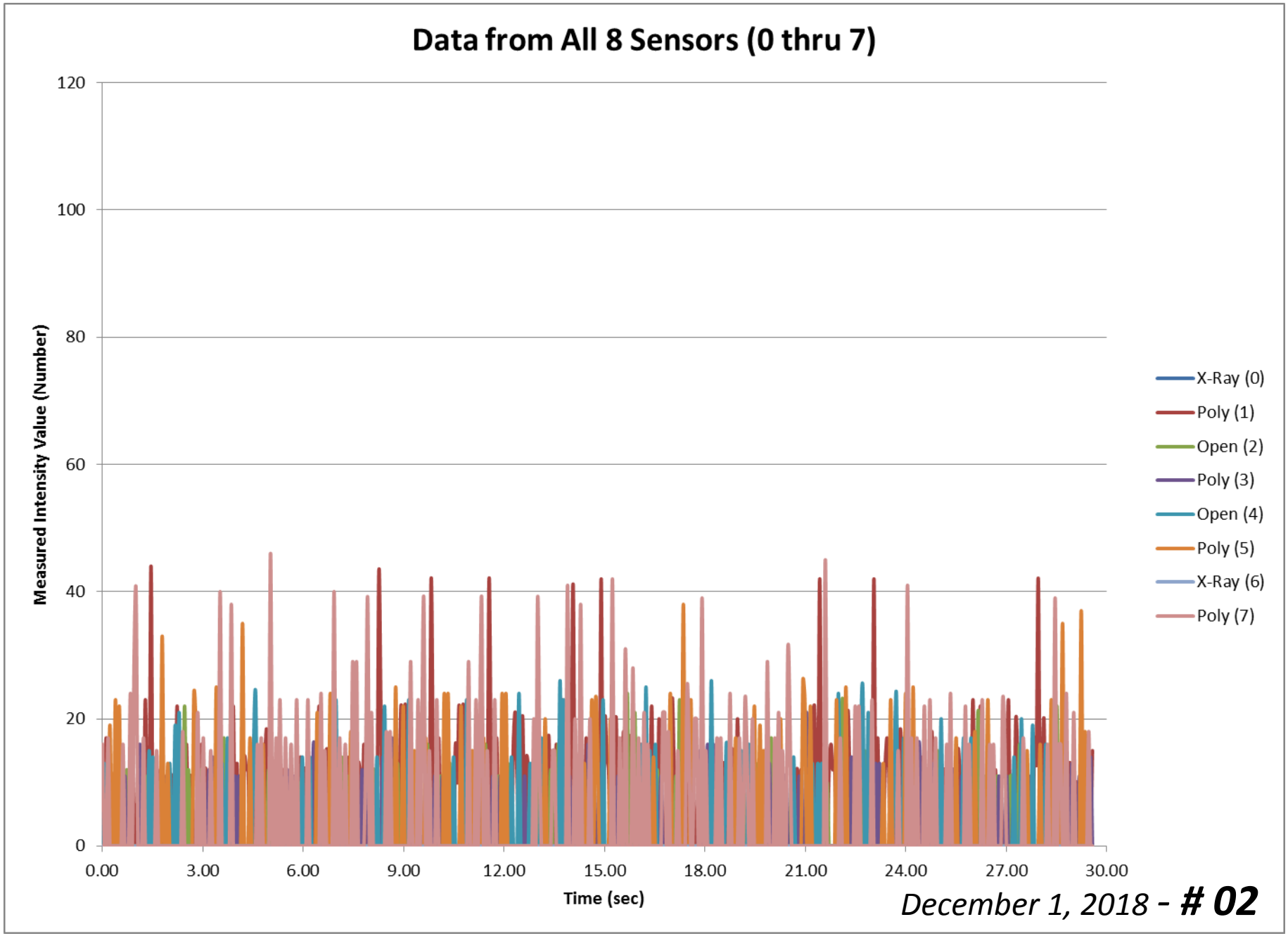
December 1, 2018 (Data)

- Date:
  - December 1, 2018
- Start Time:
  - 01:42:10 (JST)
- End Time:
  - 01:50:23 (JST)
- Number of Data Sets
  - 20
- Each Data Set
  - 30 sec (8 sensors)
- Lat / Long
  - Start Lat: -57.2905
  - Start Long: -67.3935

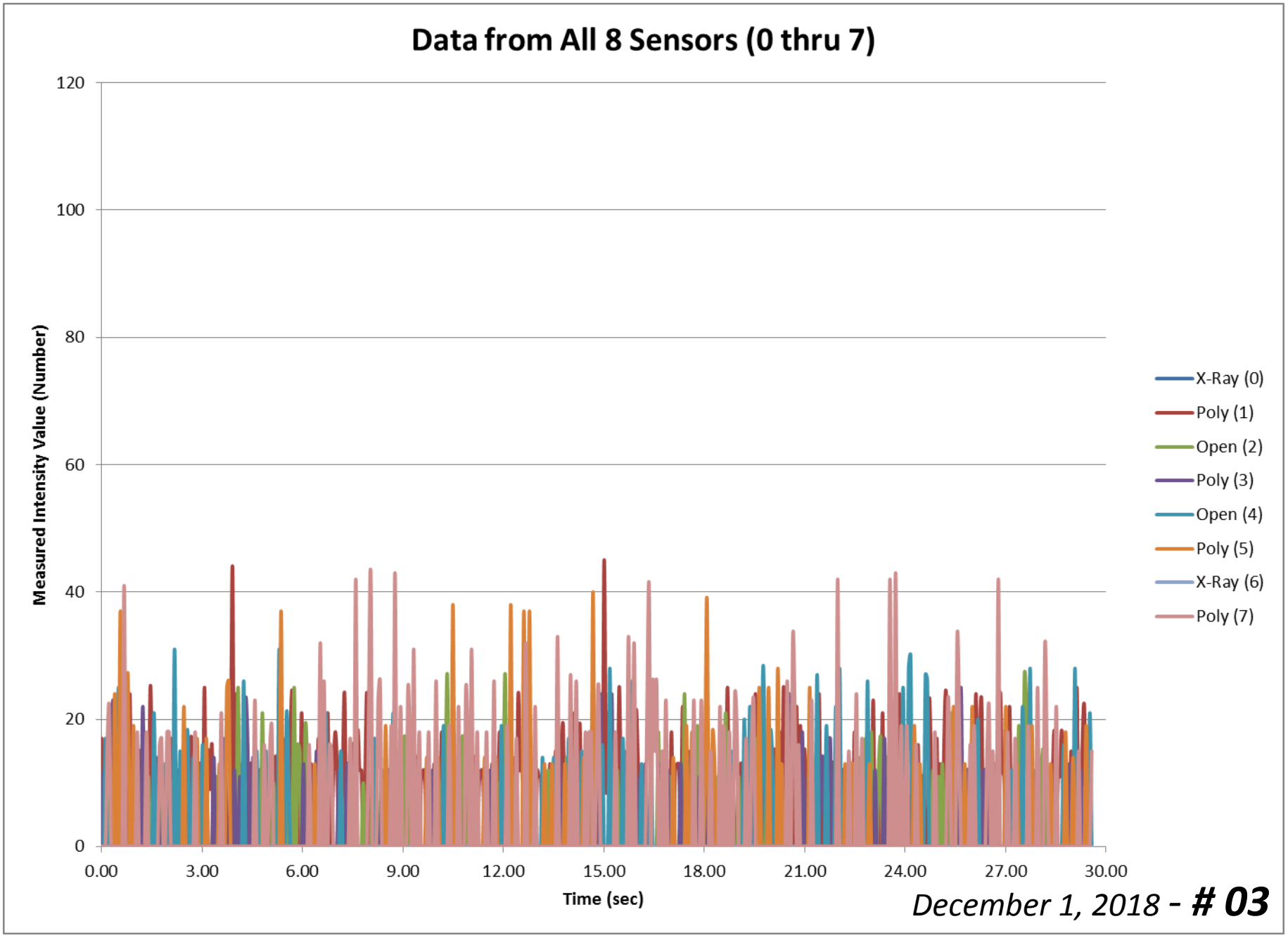


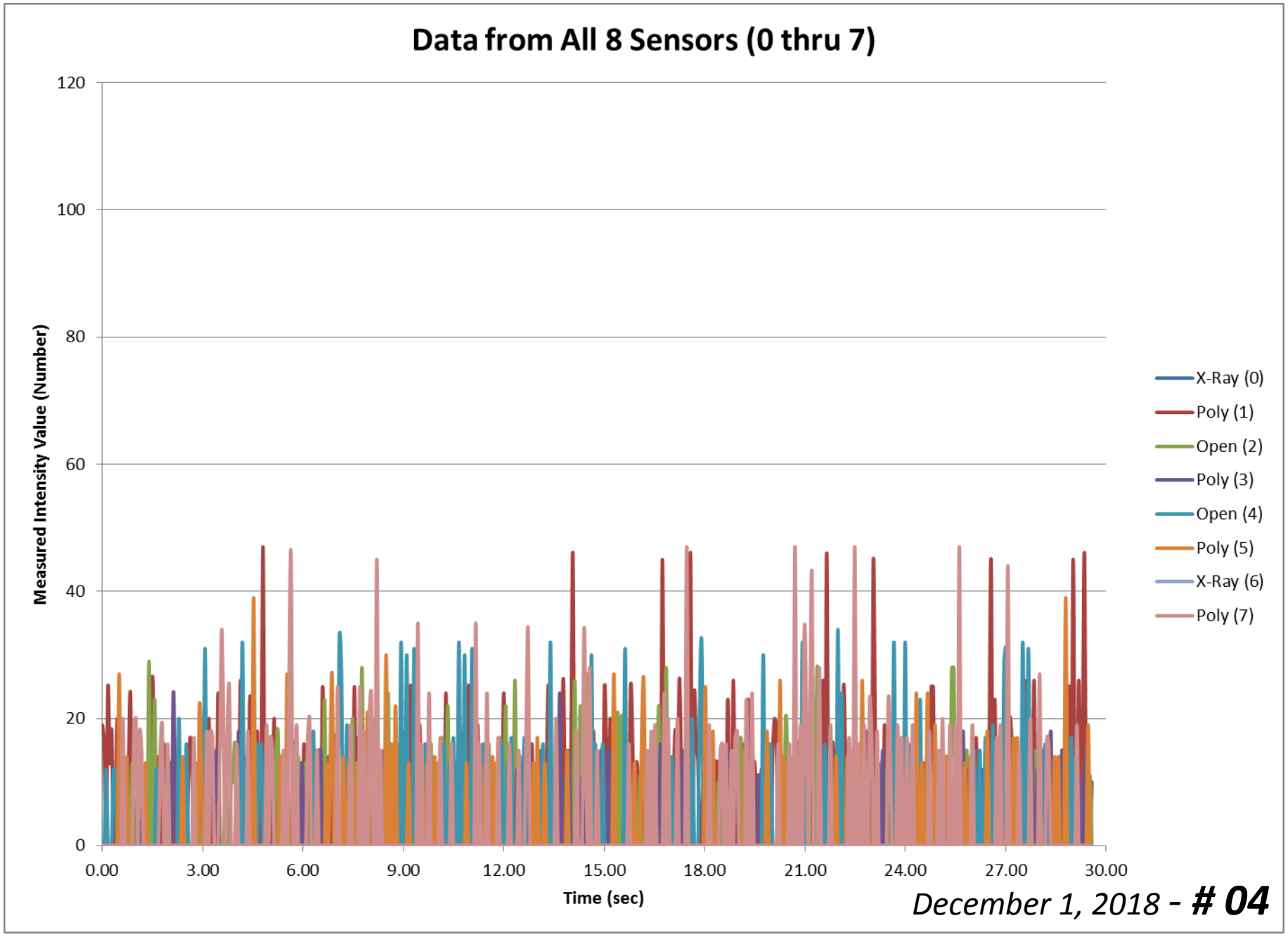


December 1, 2018 - ***# 01***

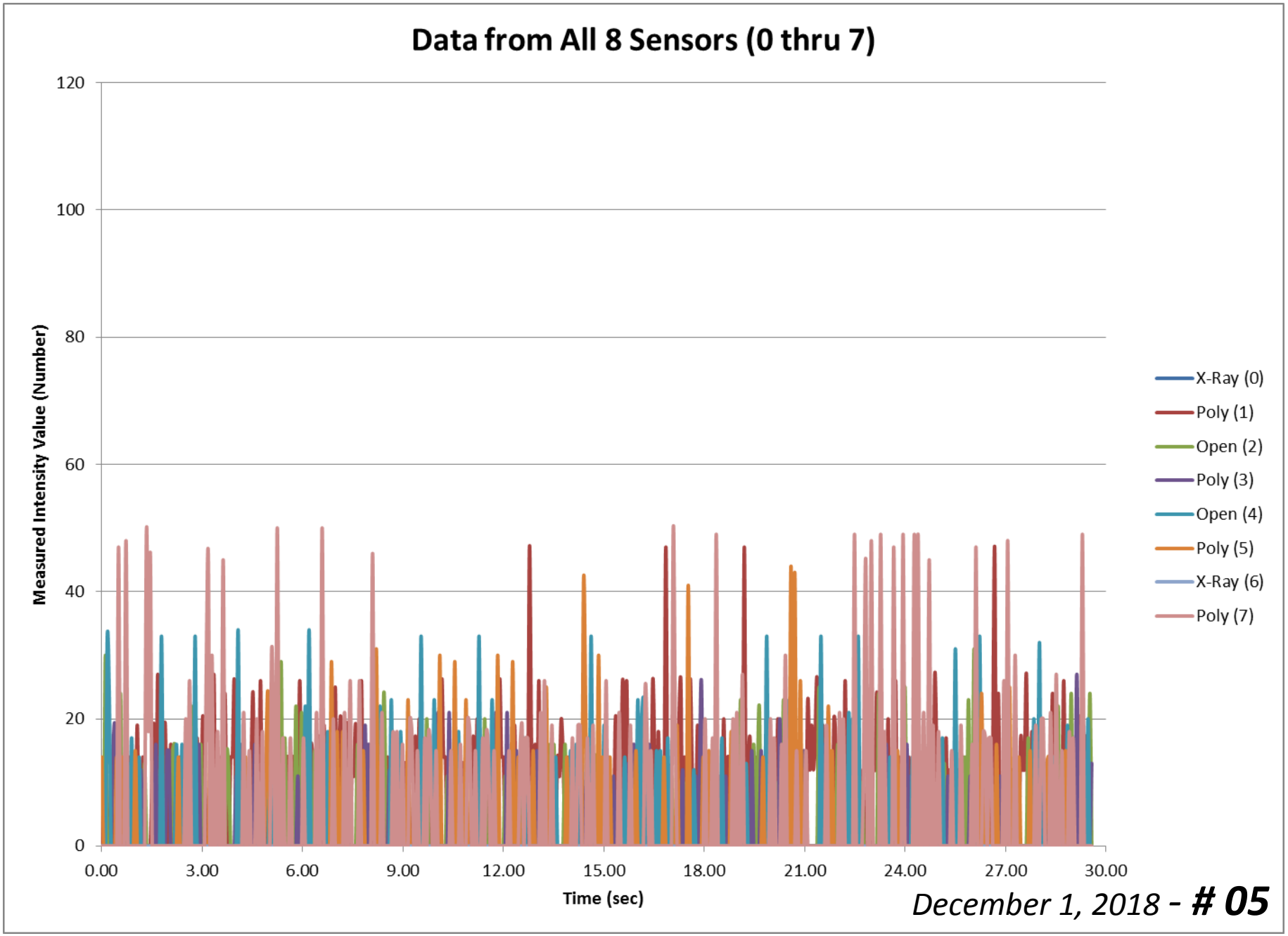


December 1, 2018 - ***# 02***

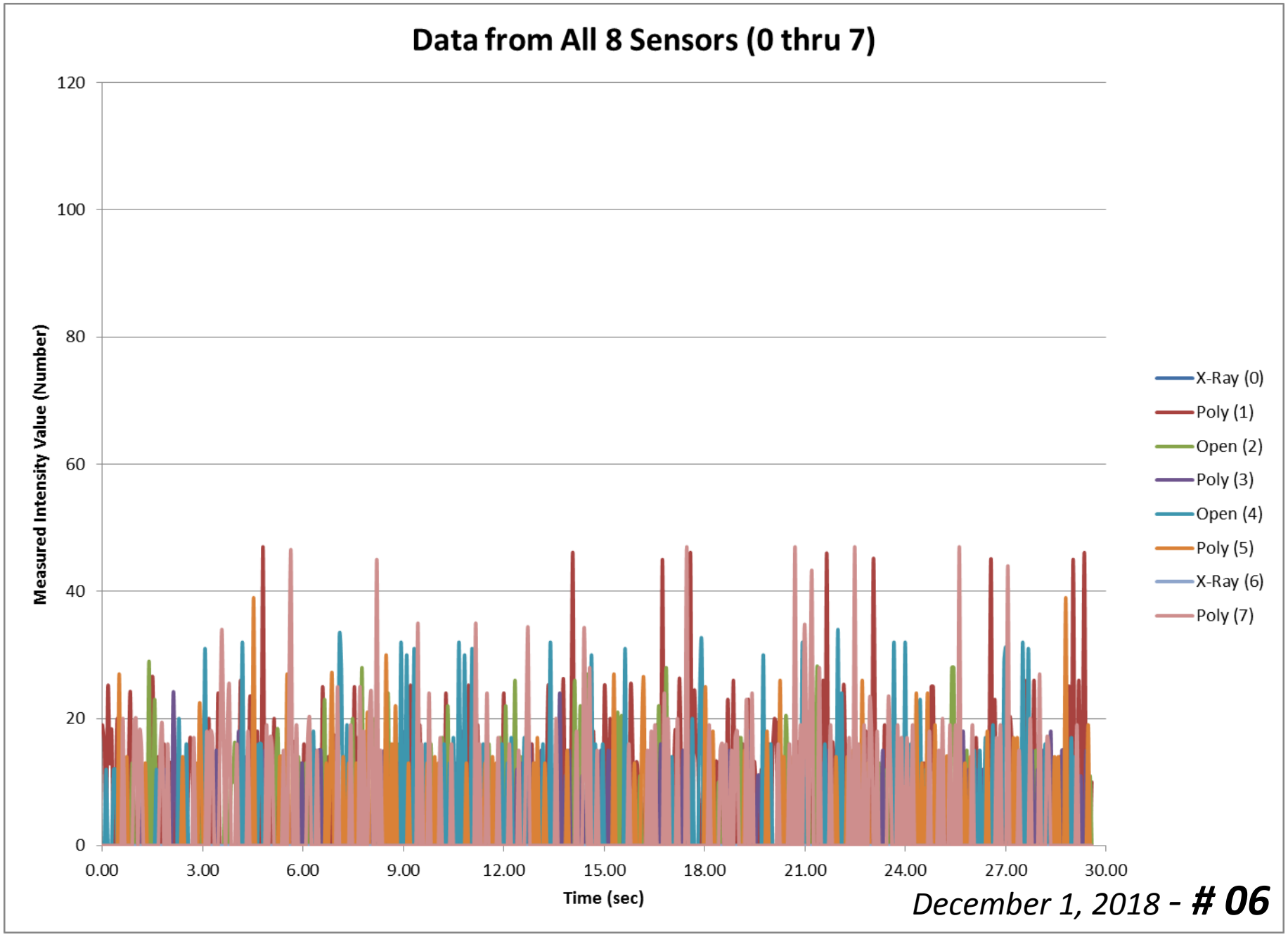

Data from All 8 Sensors (0 thru 7)
Measured Intensity Value (Number)
120
100
80
60
40
20
0
0.00
3.00
6.00
9.00
12.00
15.00
18.00
21.00
24.00
27.00
30.00
Time (sec)
X-Ray (0)
Poly (1)
Open (2)
Poly (3)
Open (4)
Poly (5)
X-Ray (6)
Poly (7)
December 1, 2018 - # 03



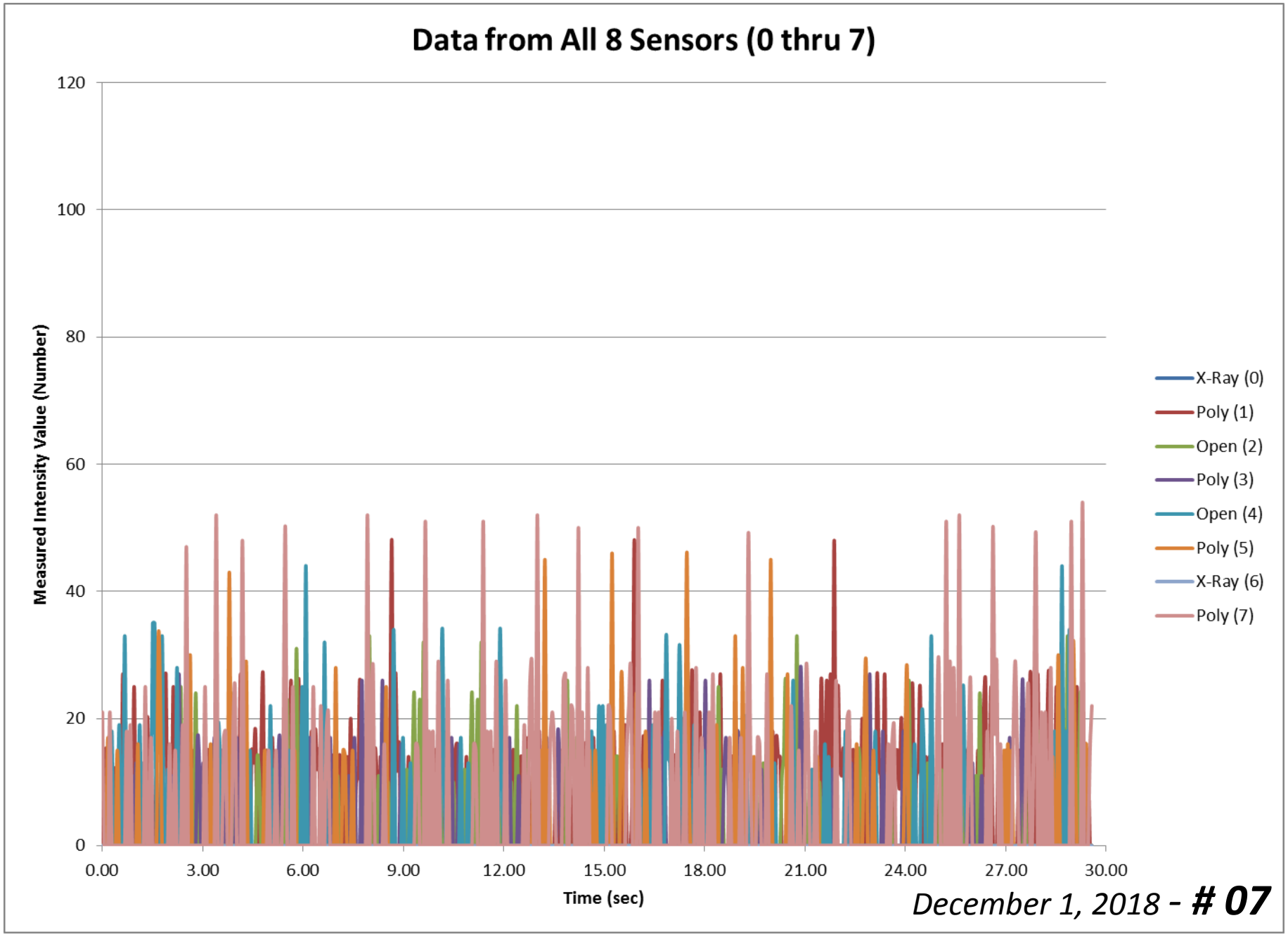
December 1, 2018 - ***# 04***



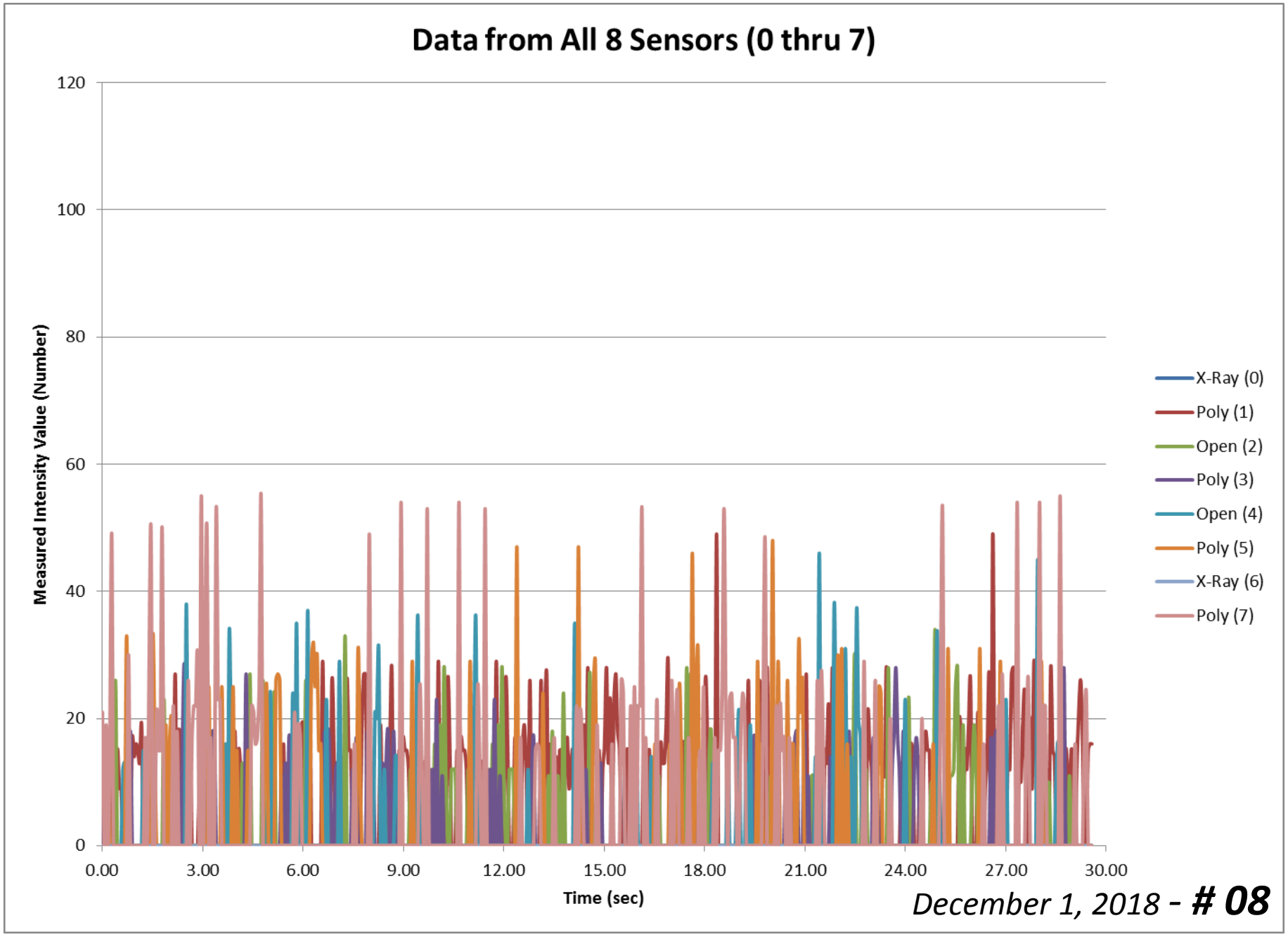
December 1, 2018 - ***# 05***



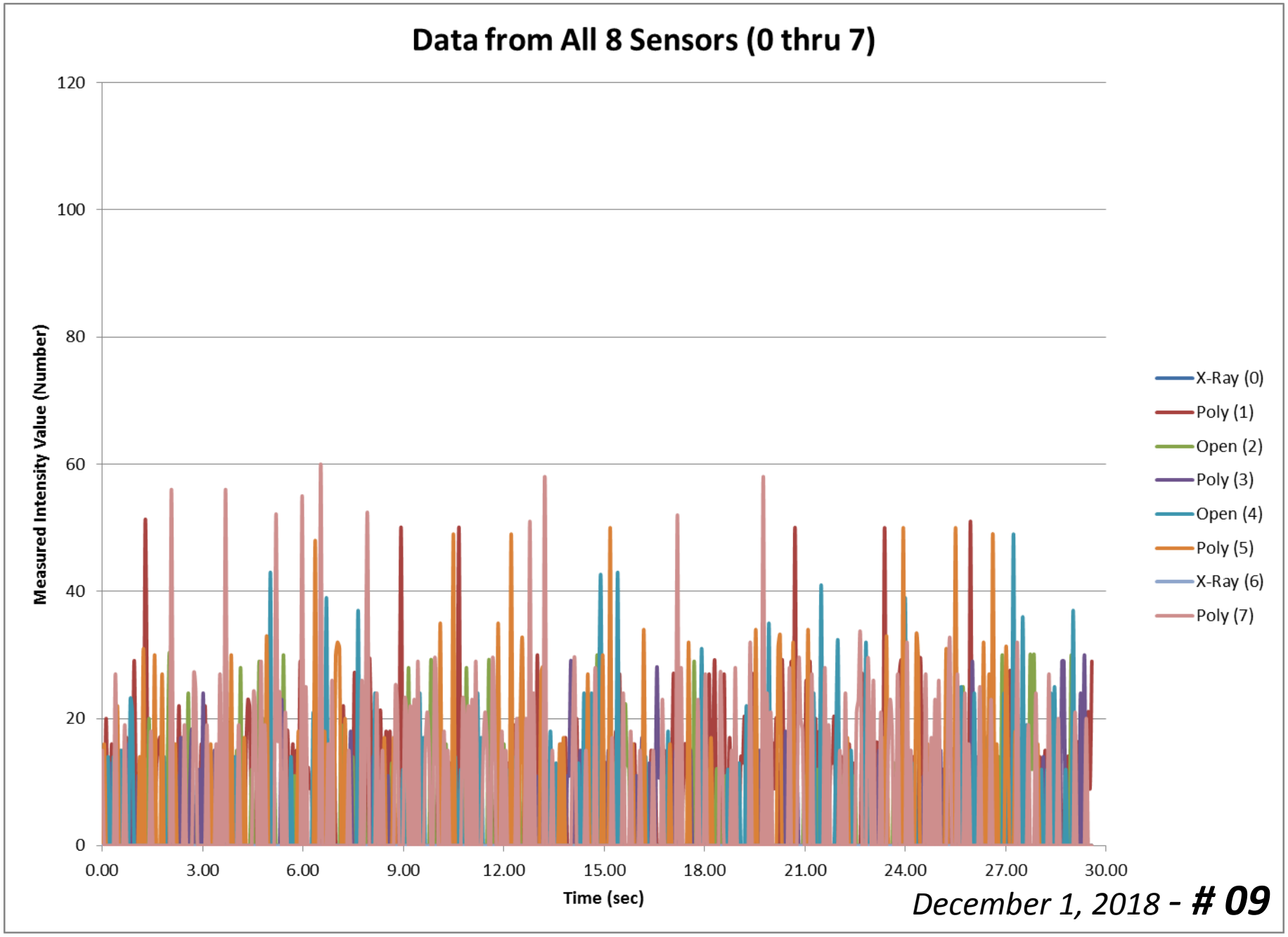
December 1, 2018 - ***# 06***



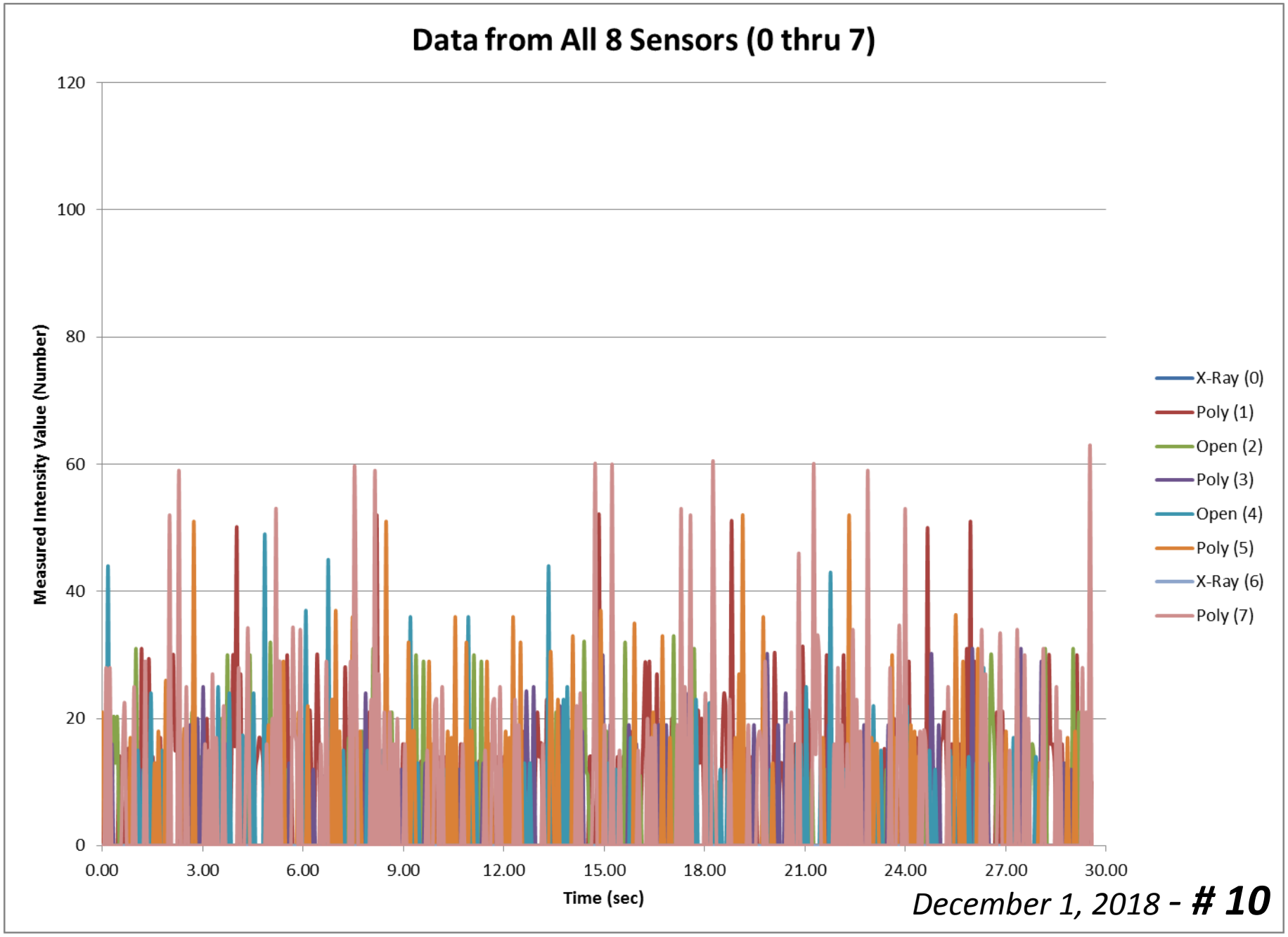
December 1, 2018 - ***# 07***



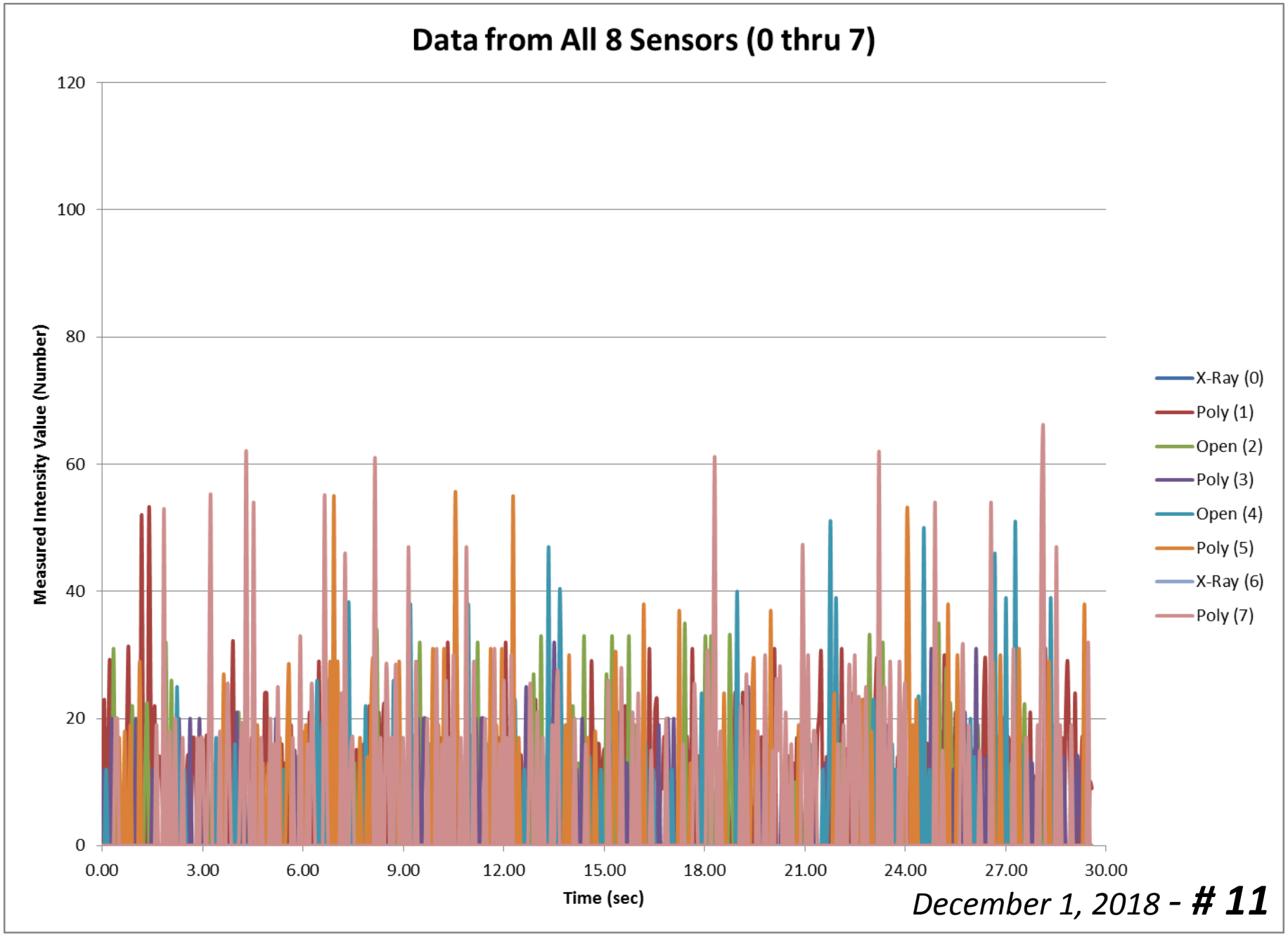
December 1, 2018 - ***# 08***



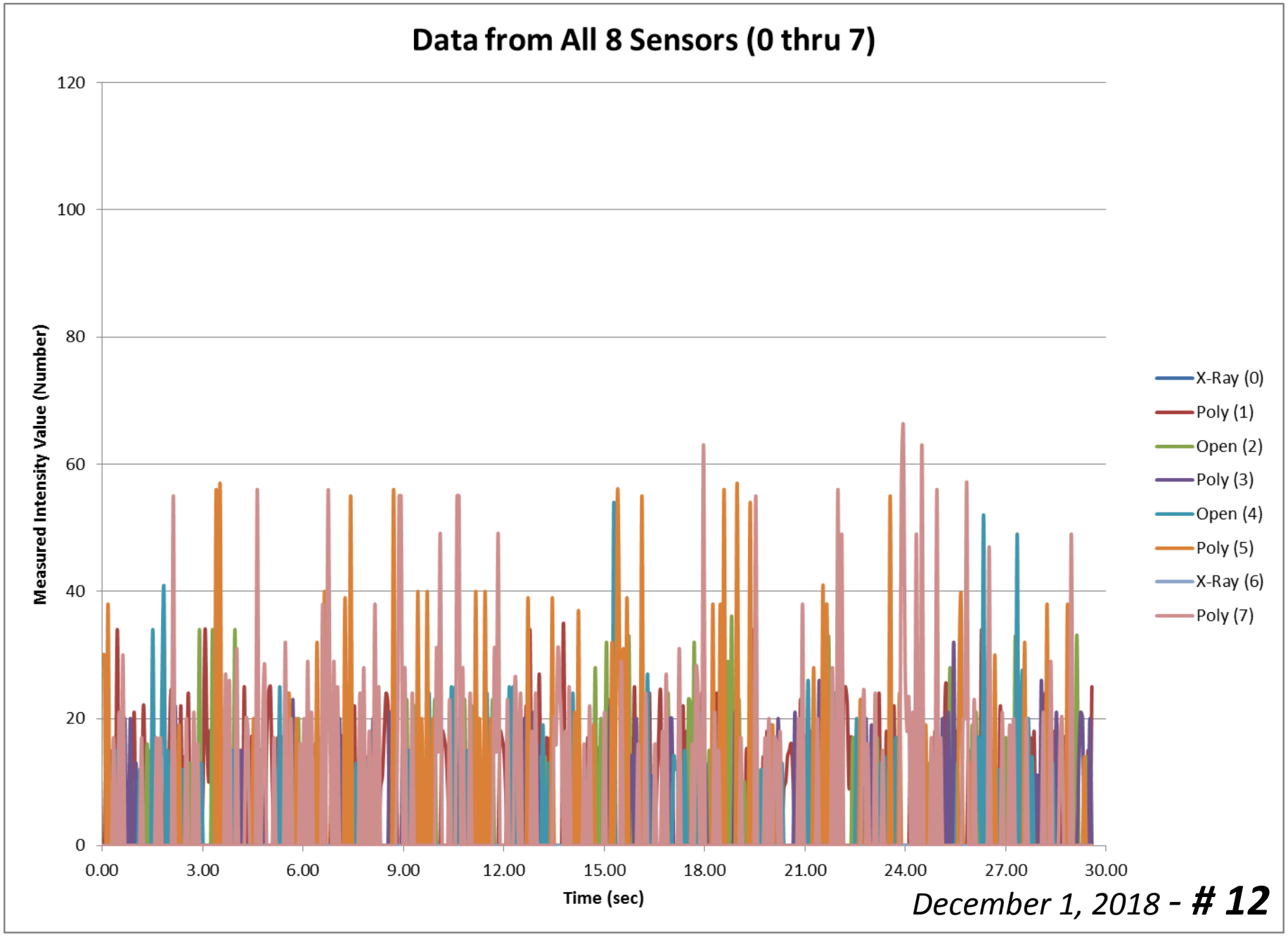
December 1, 2018 - ***# 09***



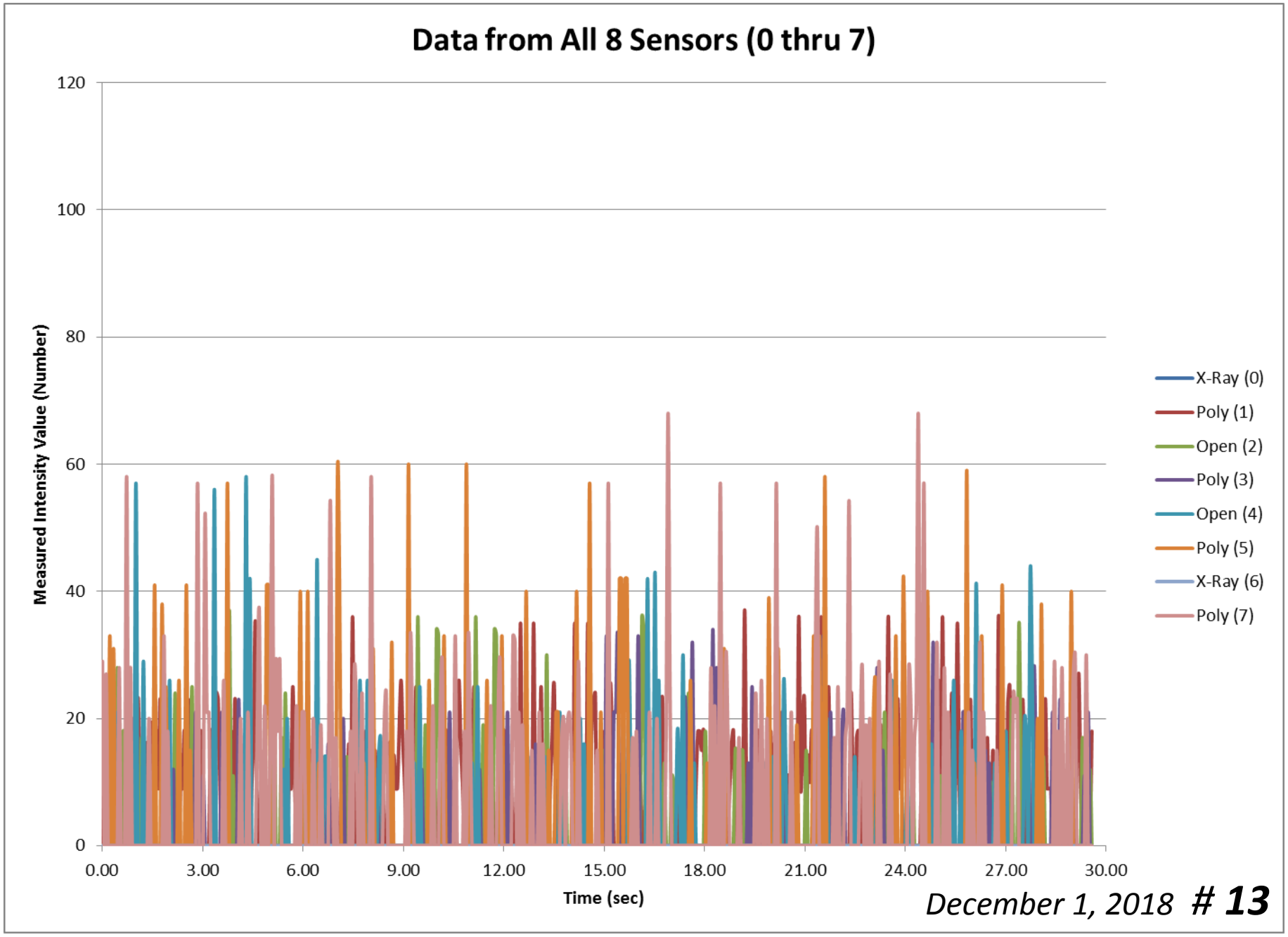
December 1, 2018 - ***# 10***



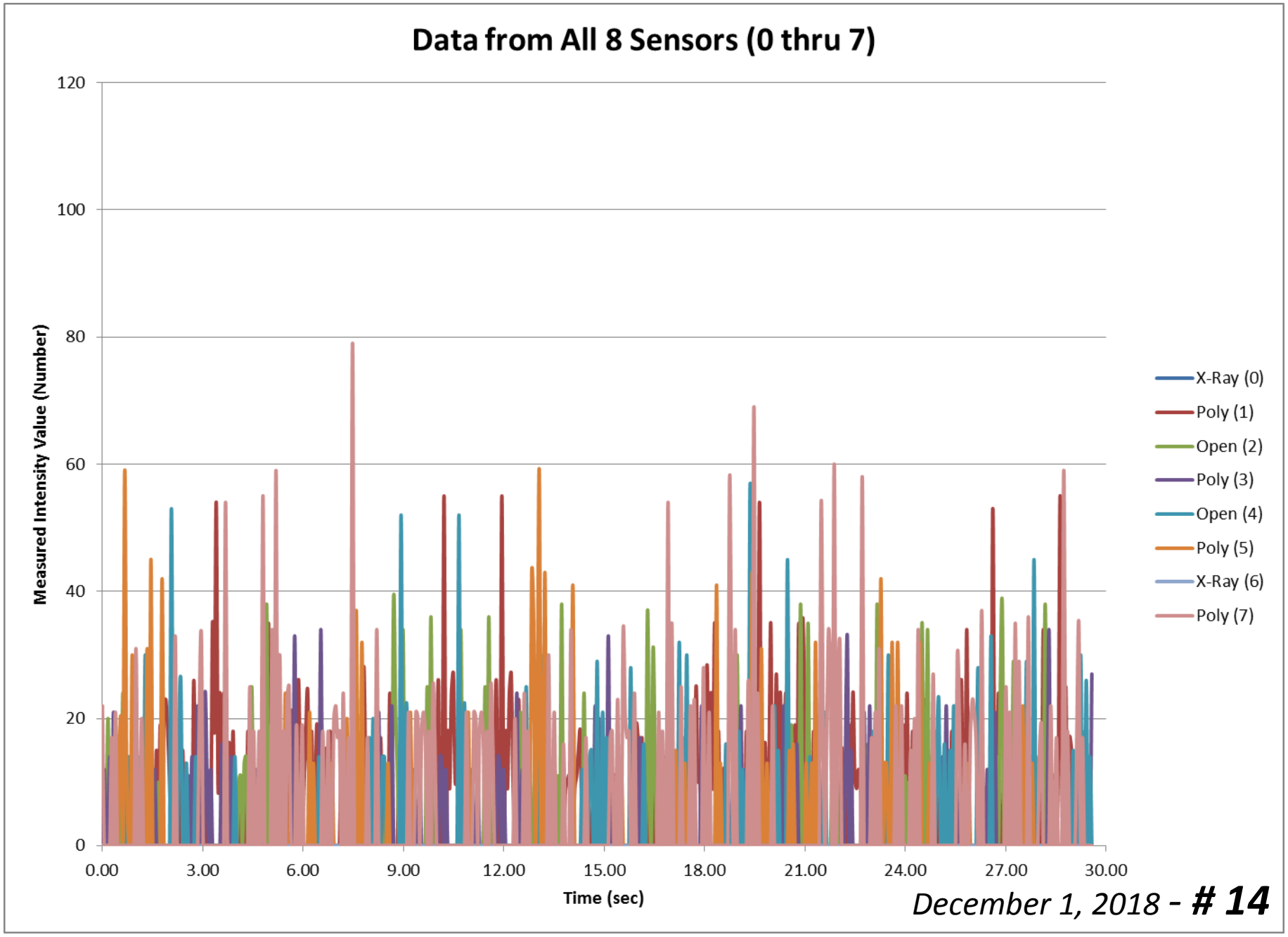
December 1, 2018 - ***# 11***



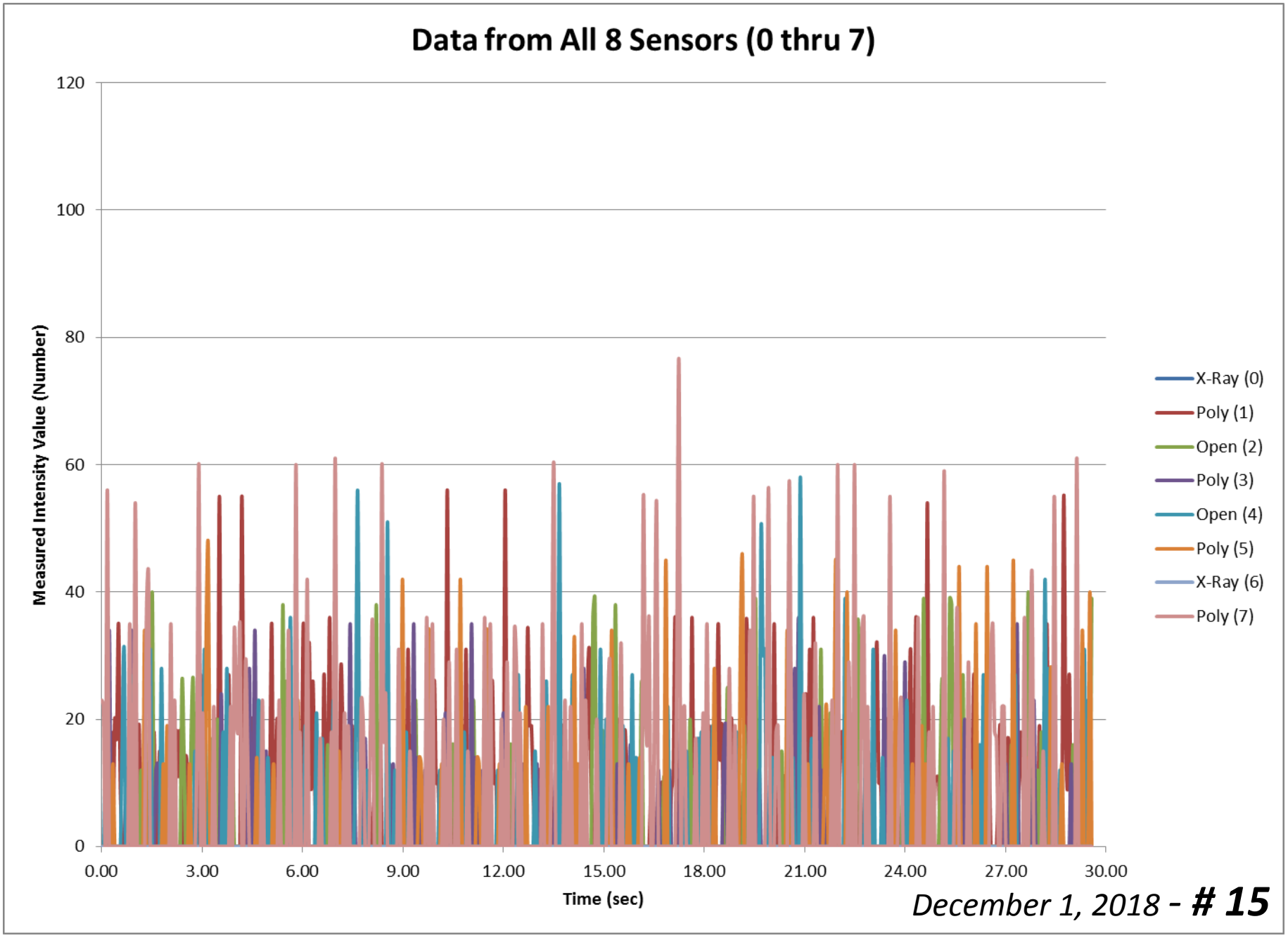
December 1, 2018 - ***# 12***



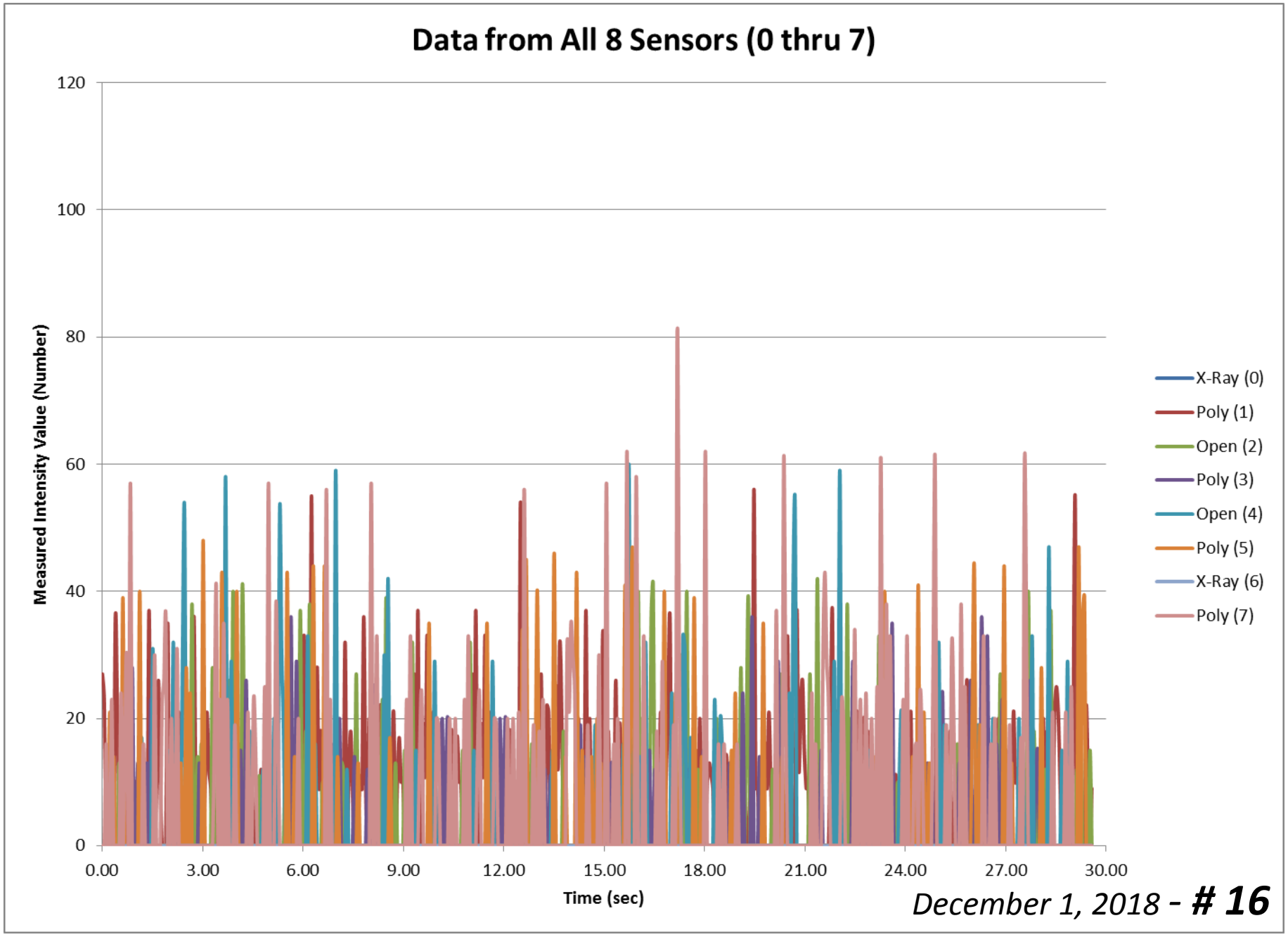
December 1, 2018 ***# 13***



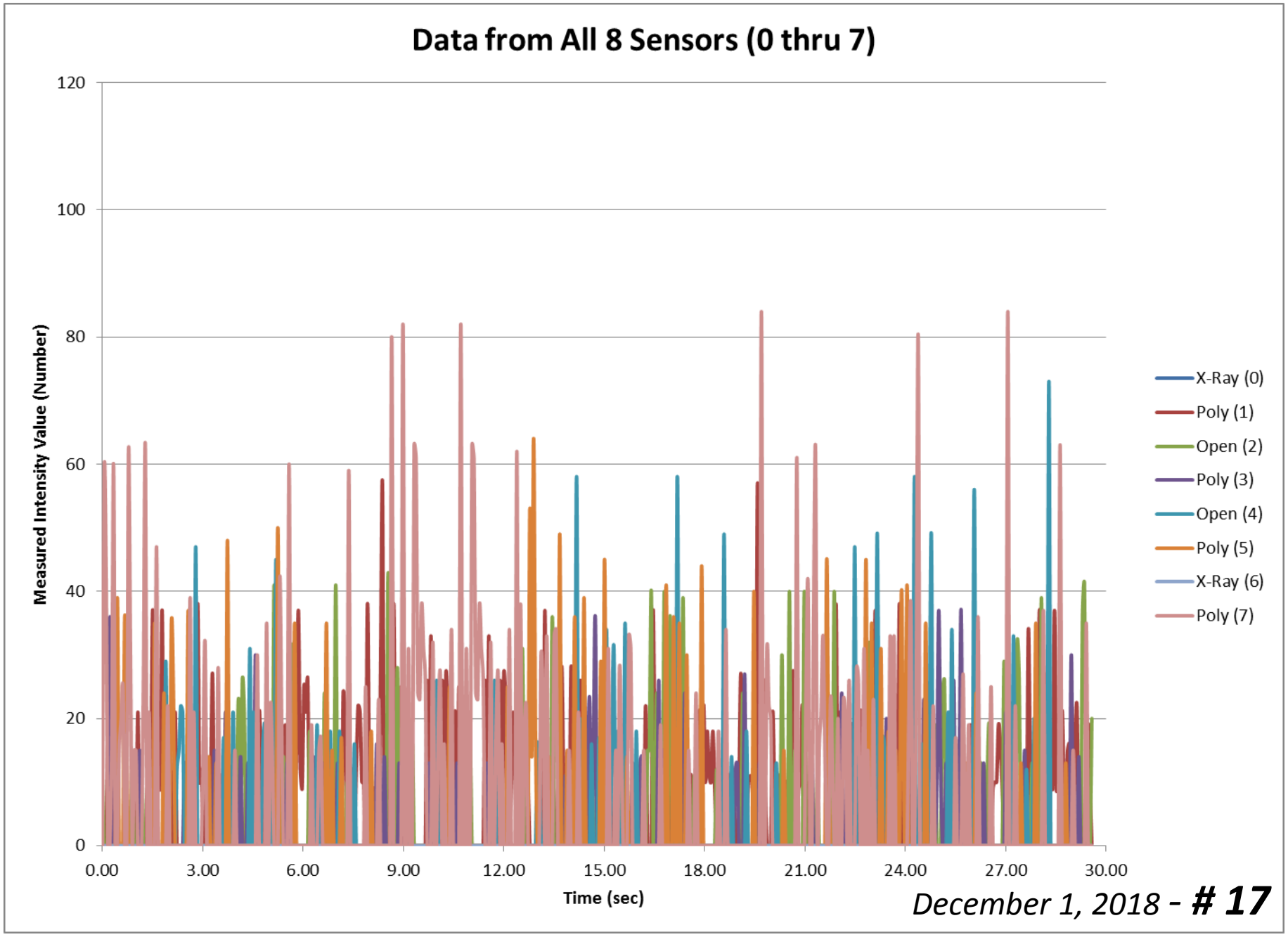
December 1, 2018 - ***# 14***



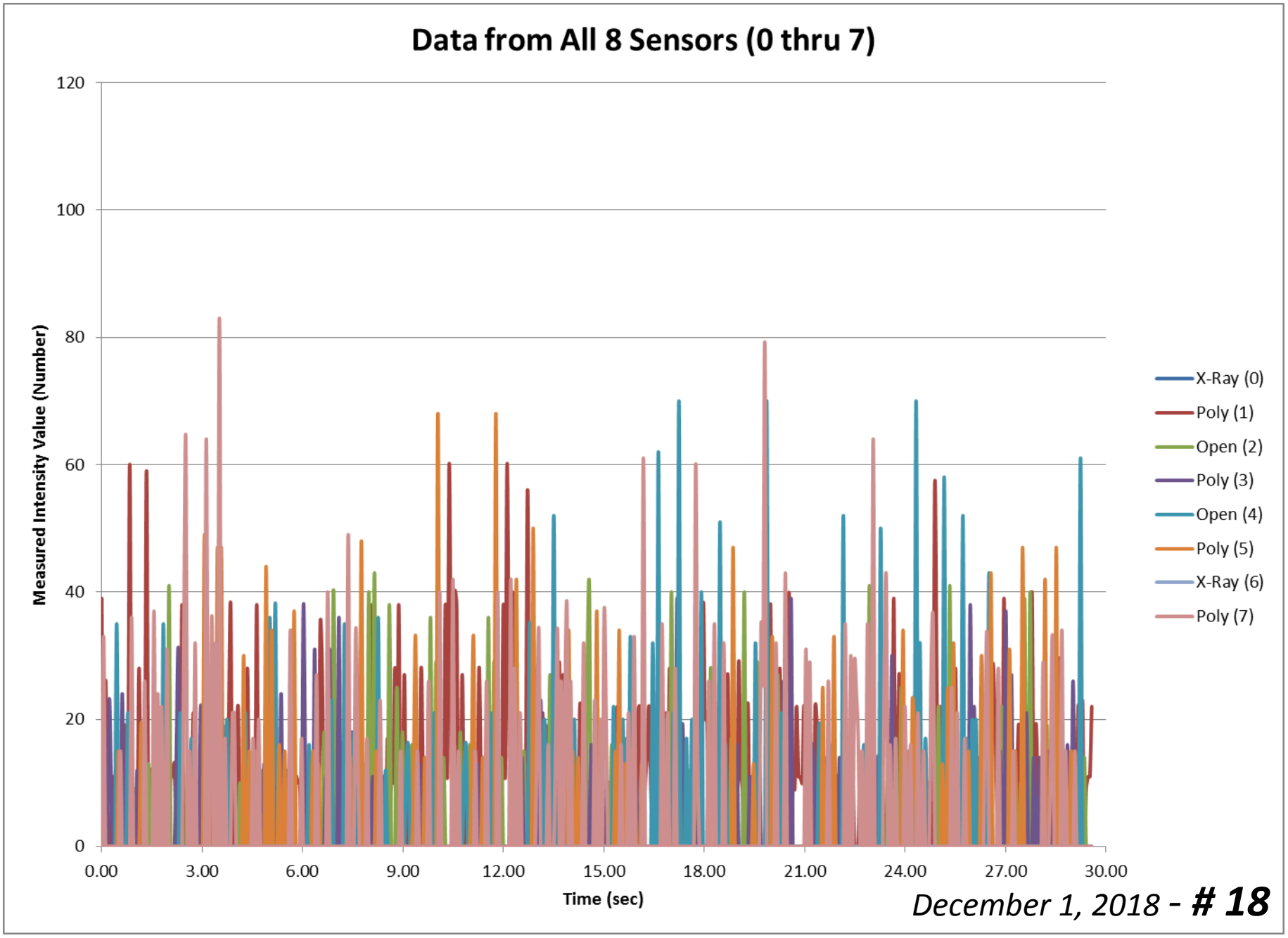
December 1, 2018 - ***# 15***



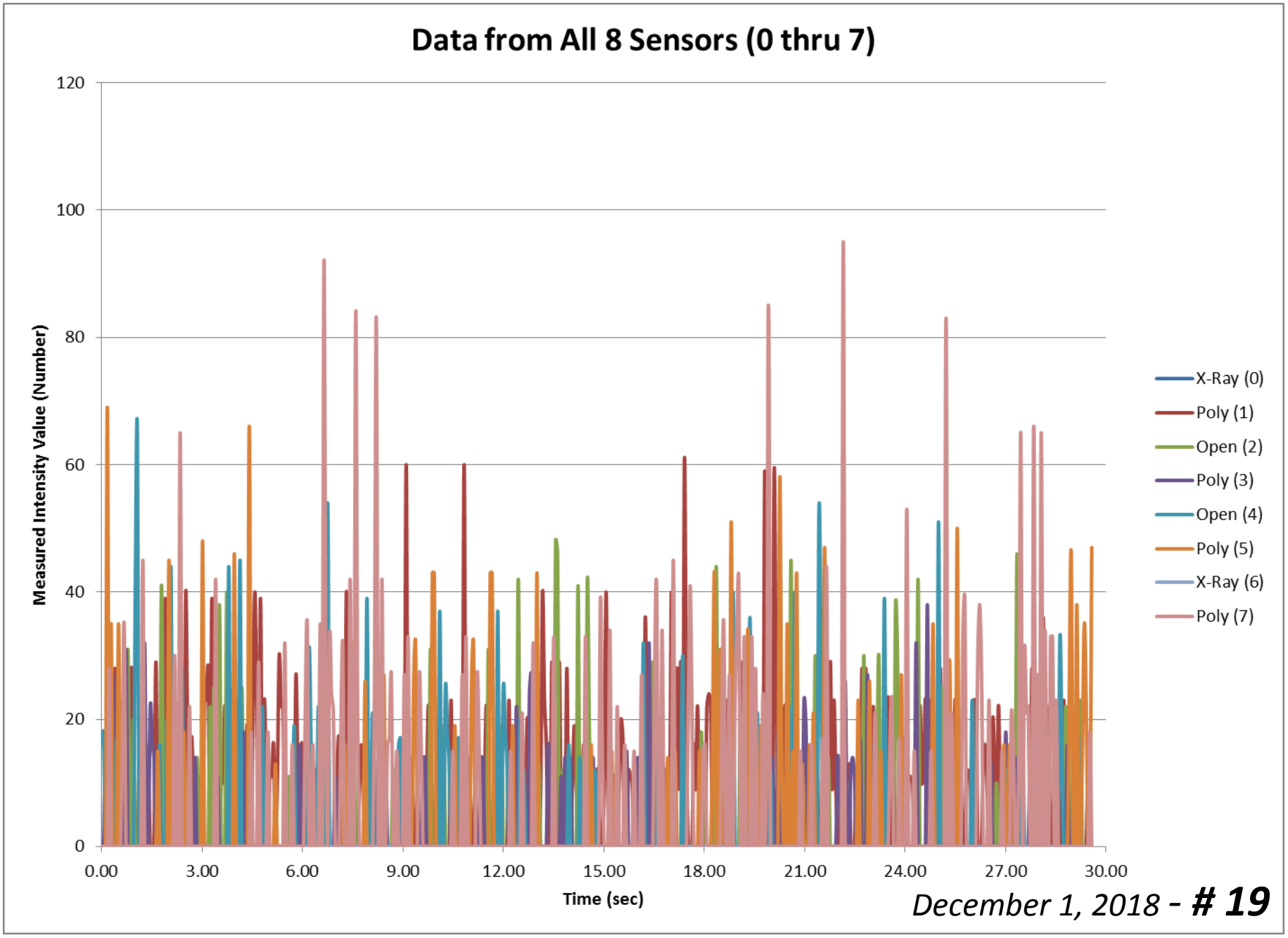
December 1, 2018 - ***# 16***



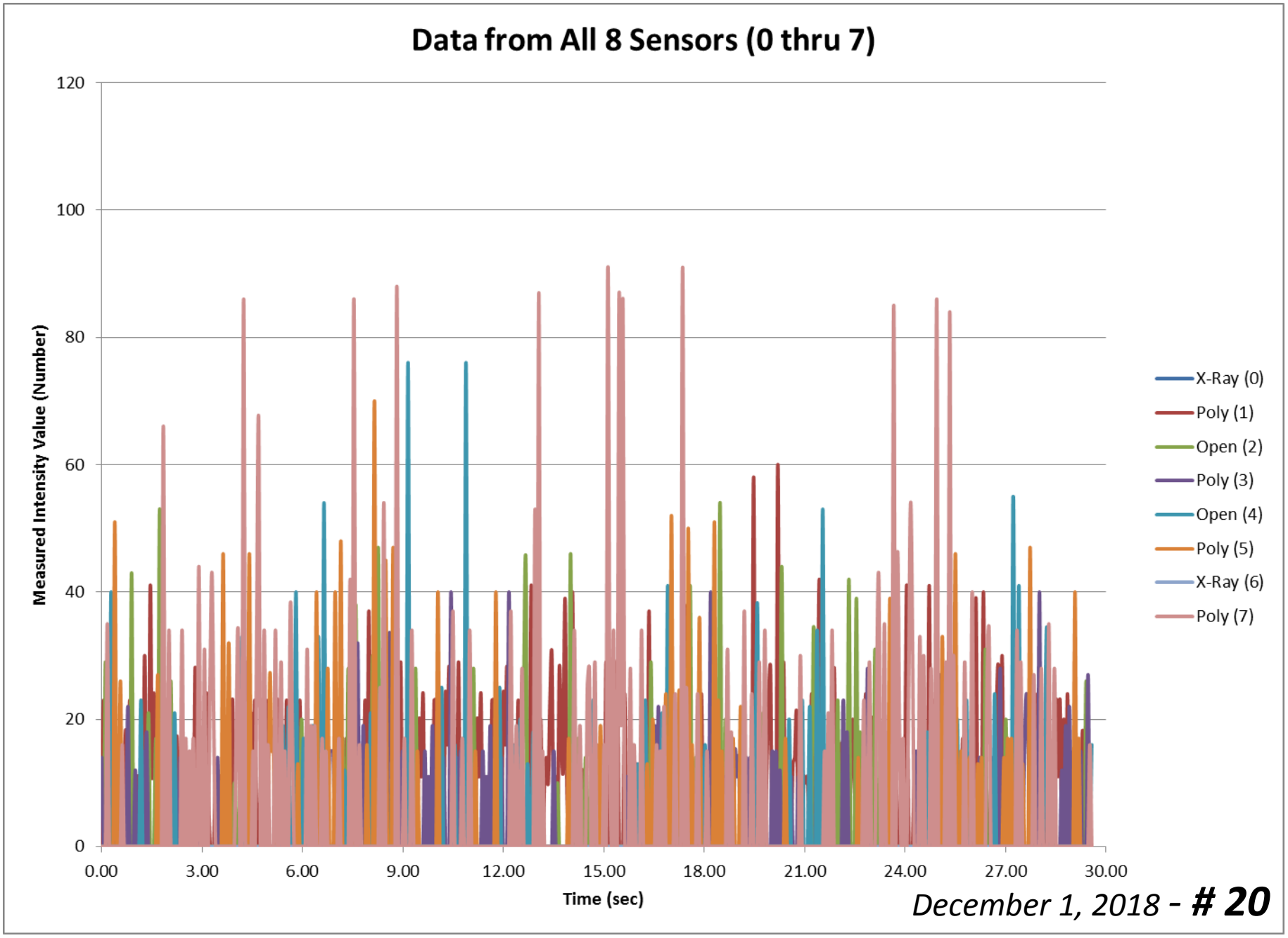
December 1, 2018 - ***# 17***



December 1, 2018 - ***# 18***

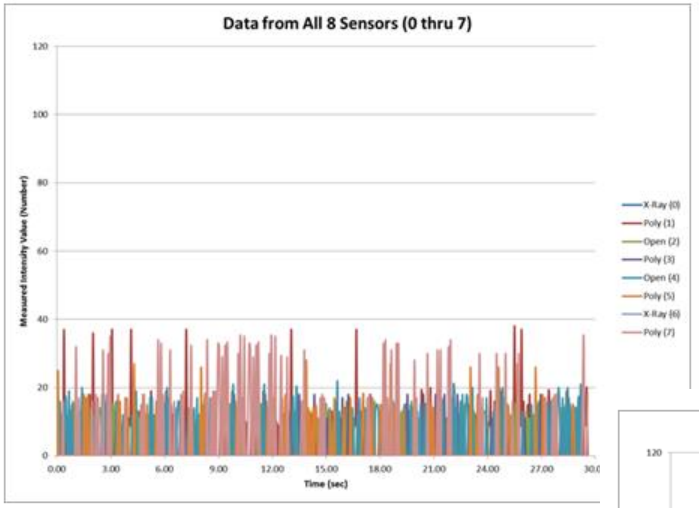


December 1, 2018 - ***# 19***

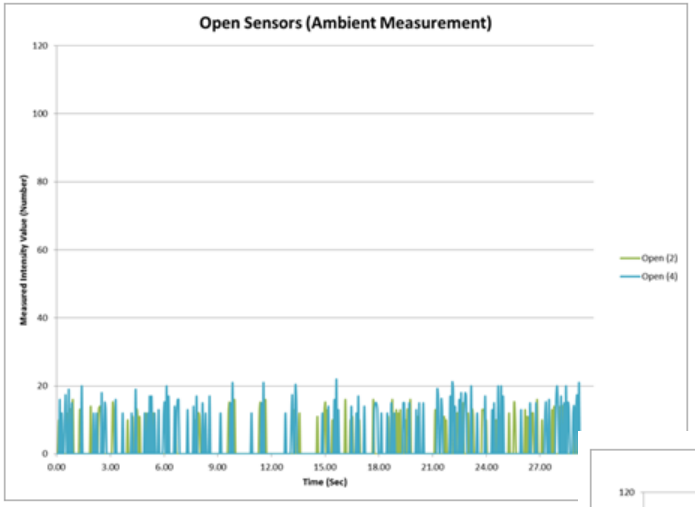


December 1, 2018 - ***# 20***

Data Set 1 of 20 (December 1, 2018)

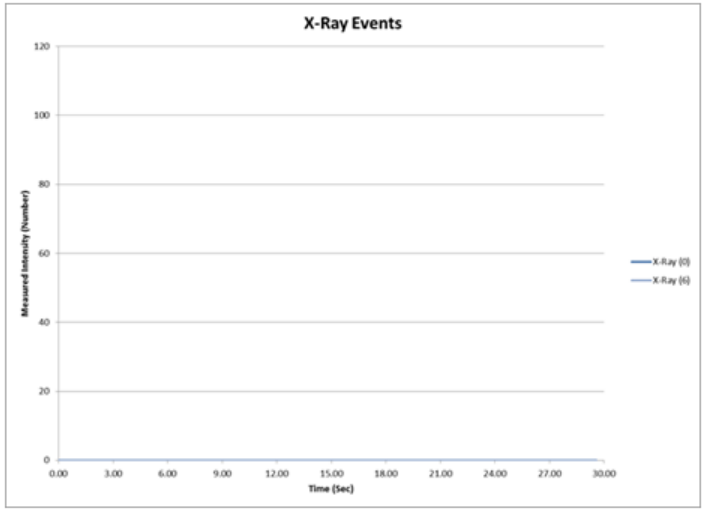


CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (MeV)	Energy-Max (MeV)
Open (2)	88	10	16	7.92	62.50	76.00
Open (4)	110	12	22	9.90	67.00	89.50

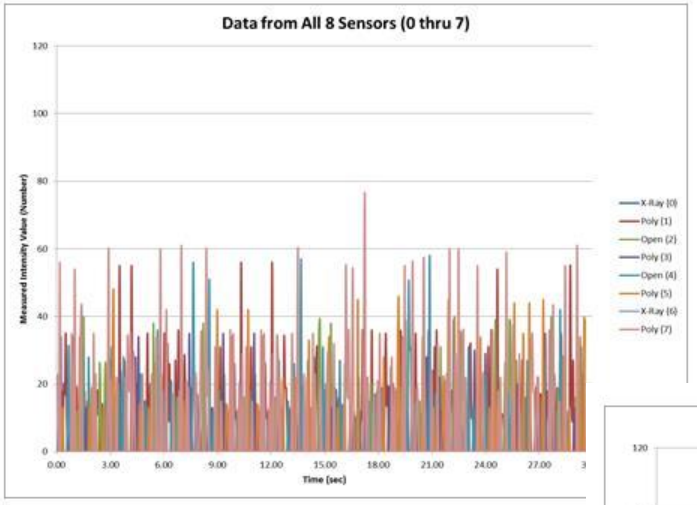


Observed – Set 1/20
Low Energy Particles
No x-ray events

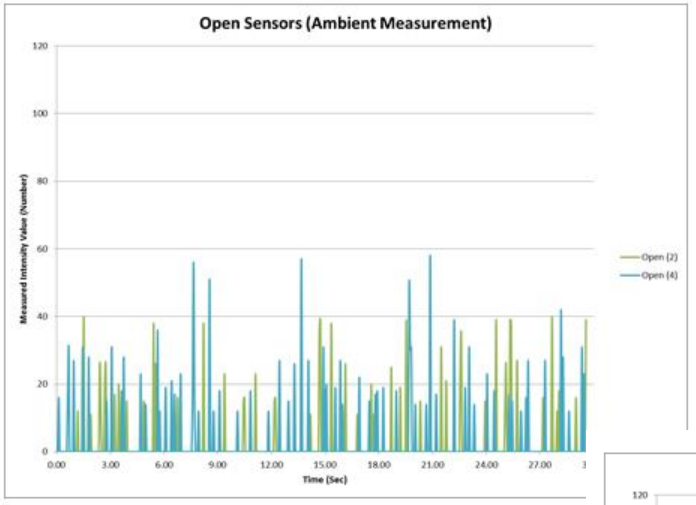
CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (kV)	Energy-Max (kV)
X-Ray (0)	0	0	0	0.00	0.00	0.00
X-Ray (6)	0	0	0	0.00	0.00	0.00



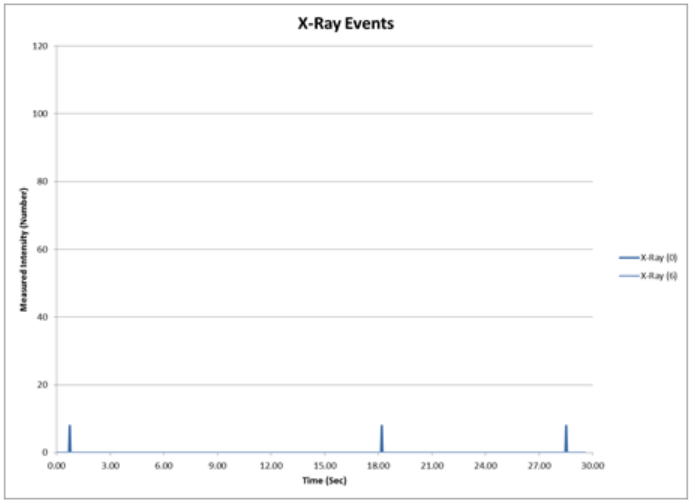
Data Set 15 of 20 (December 1, 2018)



CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (MeV)	Energy-Max (MeV)
Open (2)	53	10	40	4.77	62.50	130.00
Open (4)	68	12	58	6.12	67.00	170.50

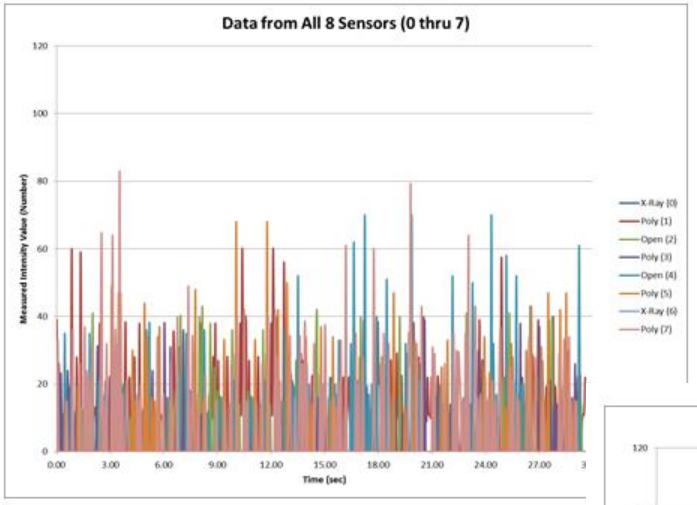


Observed – Set 15/20
Medium Energy Particles
Three x-ray events

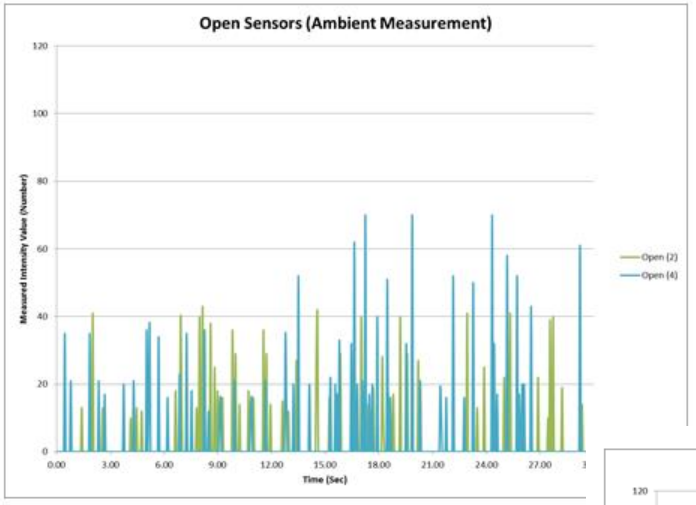


CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (kV)	Energy-Max (kV)
X-Ray (0)	3	8	8	0.27	61.60	61.60
X-Ray (6)	0	0	0	0.00	0.00	0.00

Data Set 18 of 20 (December 1, 2018)

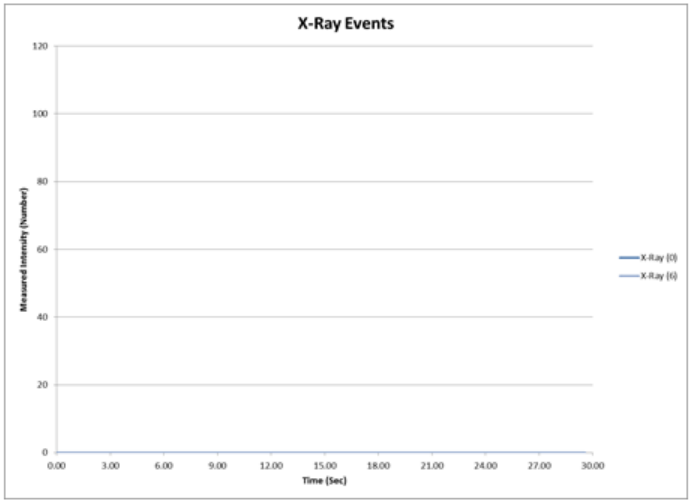


CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (MeV)	Energy-Max (MeV)
Open (2)	53	10	43	4.77	62.50	136.75
Open (4)	61	12	70	5.49	67.00	197.50



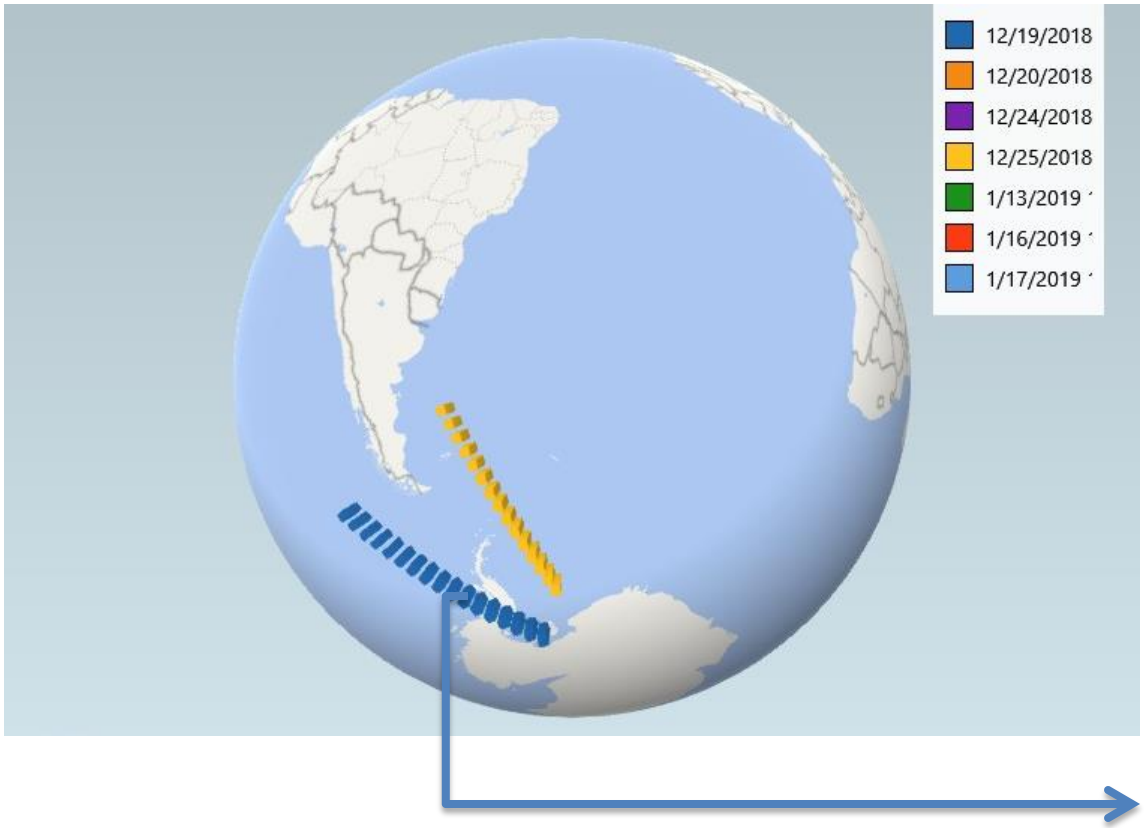
Observed – Set 18/20
High Energy Particles
No x-ray events

CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (kV)	Energy-Max (kV)
X-Ray (0)	0	0	0	0.00	0.00	0.00
X-Ray (6)	0	0	0	0.00	0.00	0.00



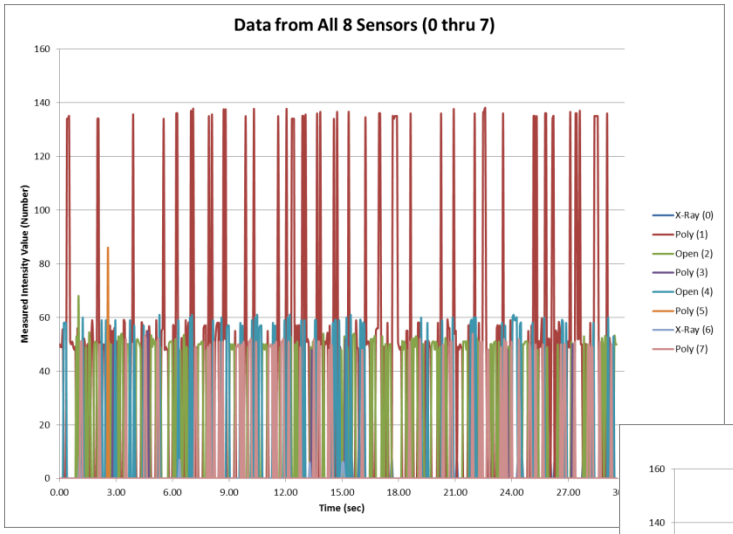
SHARP-CPD Data on December 19, 2018
from Ten-Koh thru KIT-Japan
“several x-ray events and high energy”

December 19, 2018 (Data)

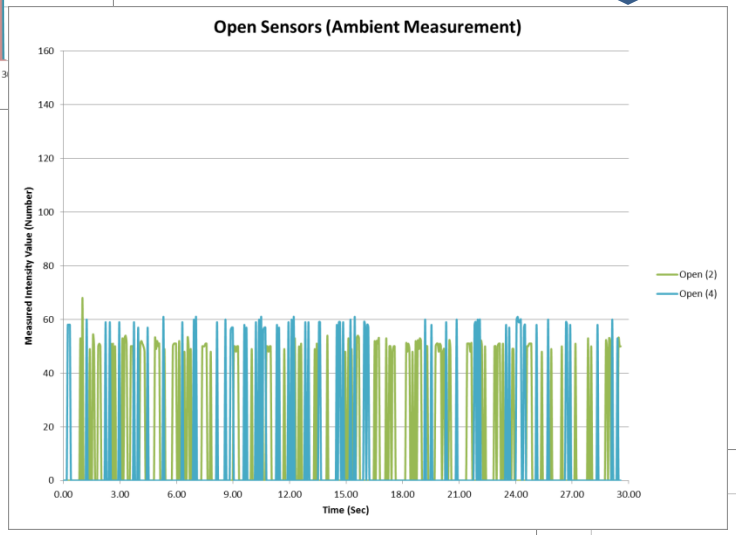


Date	Latitude	Longitude	Altitude	Data Set
19-Dec-18	-78.5317	-51.5037	631.605	6th Data
19-Dec-18	-77.172	-57.1078	631.689	6th Data
19-Dec-18	-75.6691	-61.7873	631.728	6th Data
19-Dec-18	-74.1489	-65.4859	631.719	6th Data
19-Dec-18	-72.5251	-68.6614	631.662	6th Data
19-Dec-18	-70.8623	-71.328	631.559	6th Data
19-Dec-18	-69.2265	-73.529	631.415	6th Data
19-Dec-18	-67.5114	-75.4988	631.223	6th Data
19-Dec-18	-65.8359	-77.1649	630.995	6th Data
19-Dec-18	-64.0877	-78.6894	630.719	6th Data
19-Dec-18	-62.3273	-80.0483	630.402	6th Data
19-Dec-18	-60.6158	-81.2317	630.059	6th Data
19-Dec-18	-58.8368	-82.3435	629.669	6th Data
19-Dec-18	-57.0504	-83.3589	629.243	6th Data
19-Dec-18	-55.3176	-84.2629	628.8	6th Data
19-Dec-18	-53.5195	-85.1292	628.312	6th Data
19-Dec-18	-51.7767	-85.9093	627.813	6th Data

Data Set 8 of 15 (December 19, 2018)

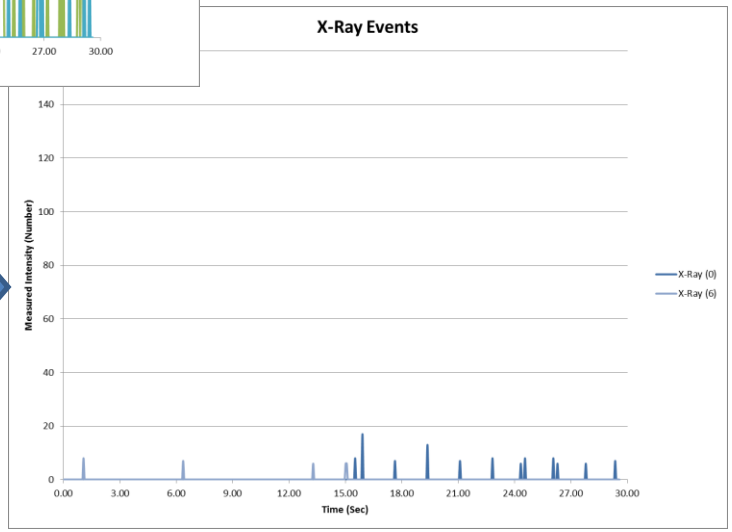


CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (MeV)	Energy-Max (MeV)
Open (2)	135	48	68	12.15	148.00	193.00
Open (4)	71	53	61	6.39	159.25	177.25

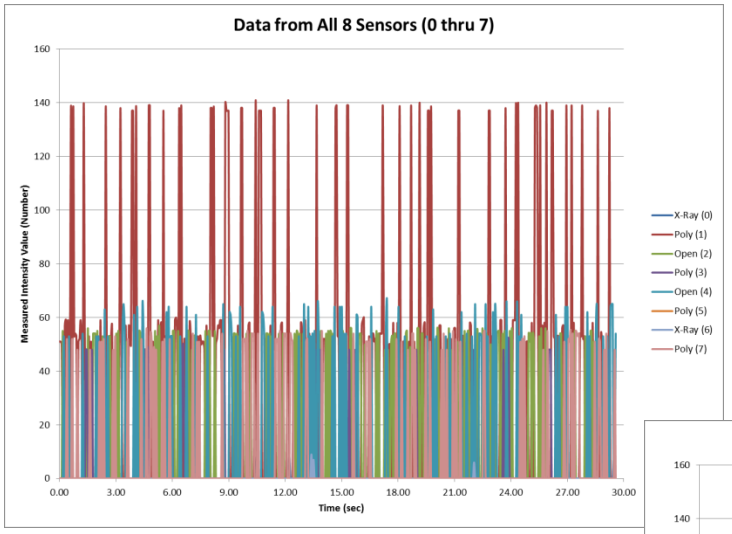


Observed – Set 7/18
More Flux of Particles …
More on one sensor…
Many x-ray events …

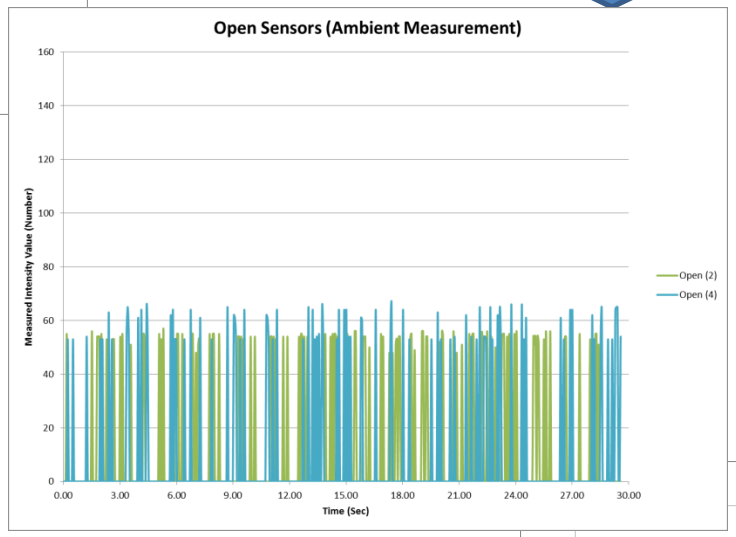
CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (kV)	Energy-Max (kV)
X-Ray (0)	12	6	17	1.08	56.20	85.90
X-Ray (6)	5	6	8	0.45	56.20	61.60



Data Set 7 of 18 (December 19, 2018)

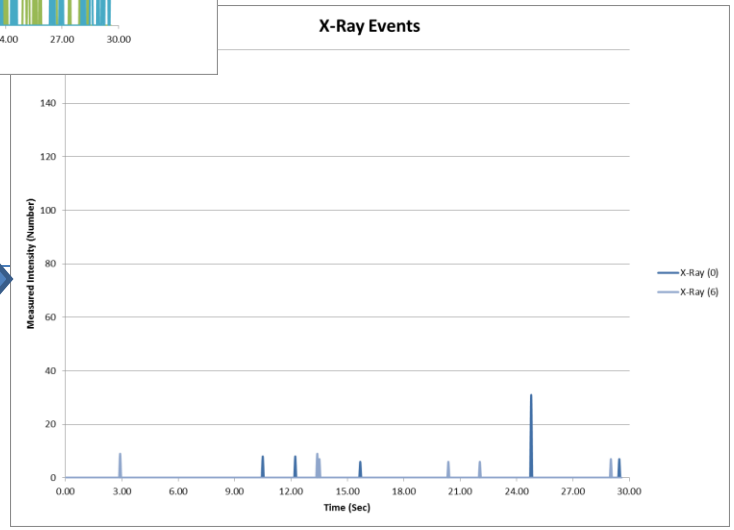


CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (MeV)	Energy-Max (MeV)
Open (2)	112	48	57	10.08	148.00	168.25
Open (4)	89	53	66	8.01	159.25	188.50

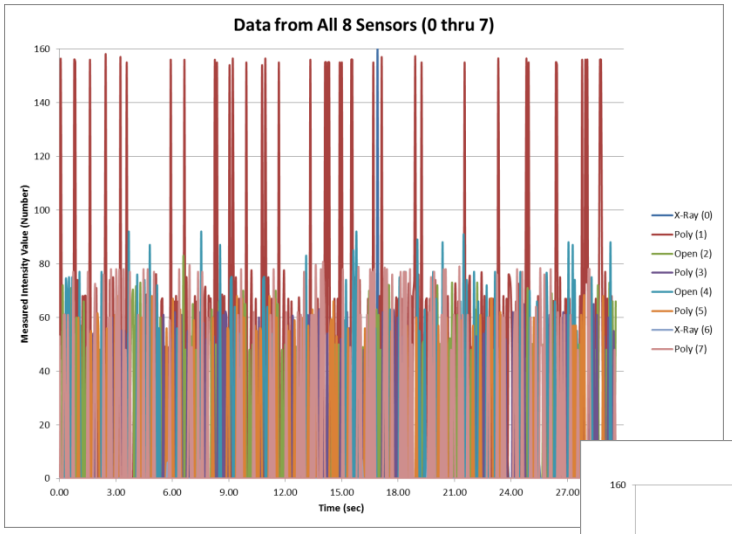


Observed – Set 7/18
High Flux of Particles …
Med Energy Particles …
Several x-ray events …

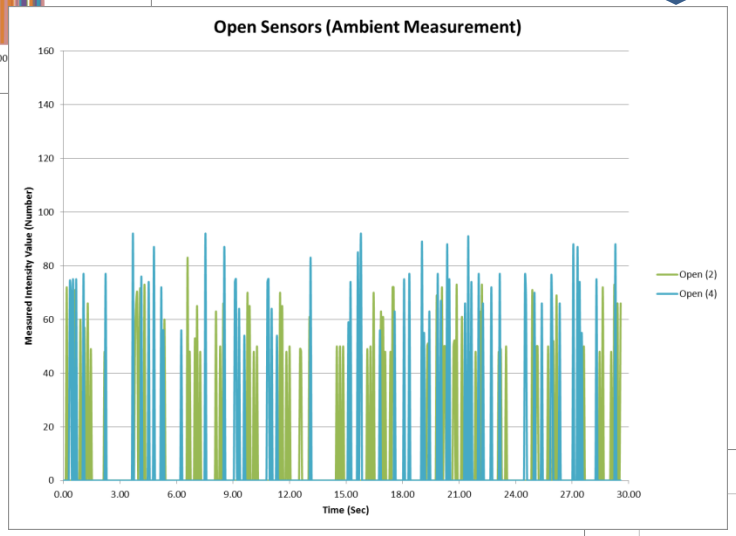
CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (kV)	Energy-Max (kV)
X-Ray (0)	5	6	31	0.45	56.20	123.70
X-Ray (6)	6	6	9	0.54	56.20	64.30



Data Set 18 of 18 (December 19, 2018)

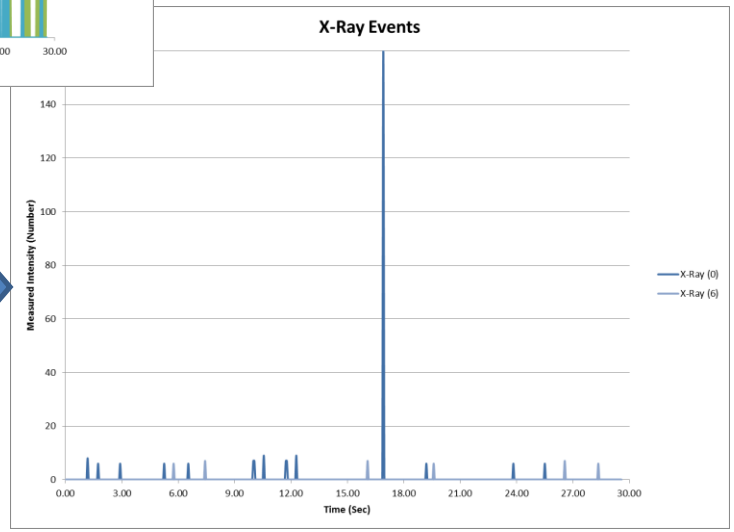


CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (MeV)	Energy-Max (MeV)
Open (2)	75	48	83	6.75	148.00	226.75
Open (4)	60	54	92	5.40	161.50	247.00



Observed – Set 18/18
High Flux of Particles …
High Energy Particles …
High x-ray ENERGY …

CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (kV)	Energy-Max (kV)
X-Ray (0)	15	6	161	1.35	56.20	474.70
X-Ray (6)	6	6	7	0.54	56.20	58.90

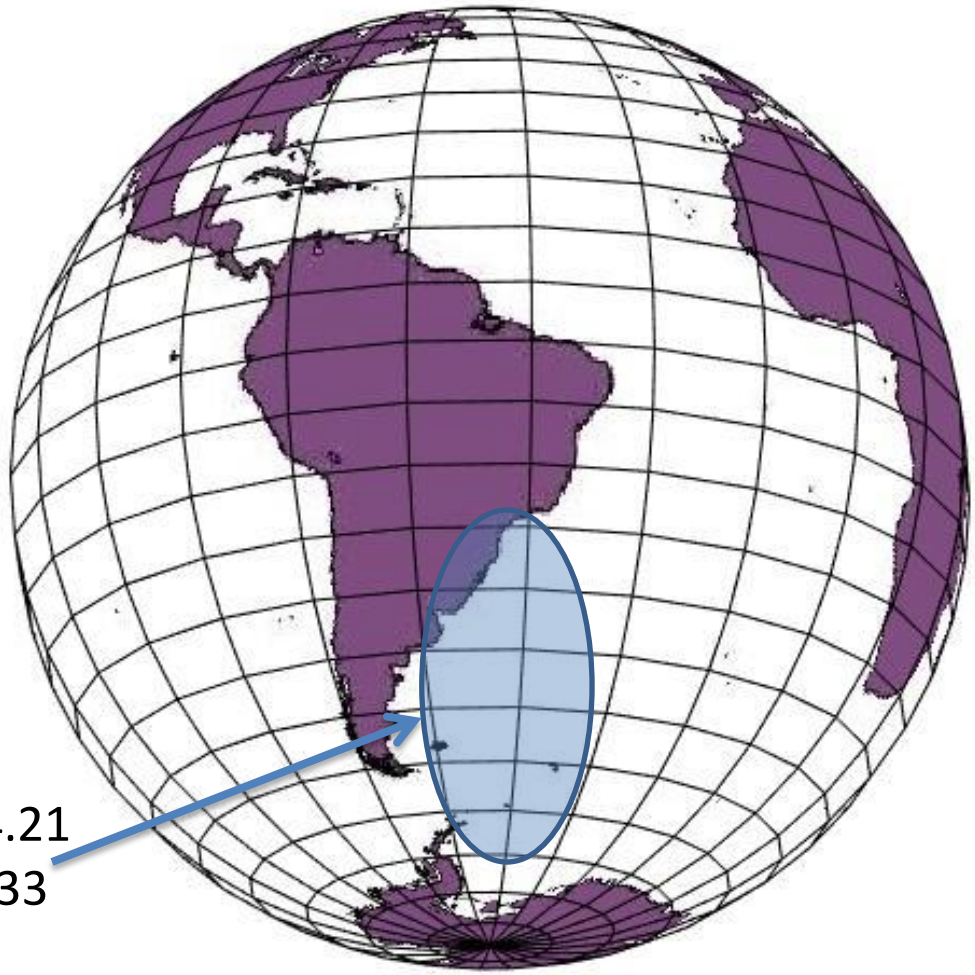


SHARP-CPD Data on December 25, 2018 from Ten-Koh thru KIT-Japan

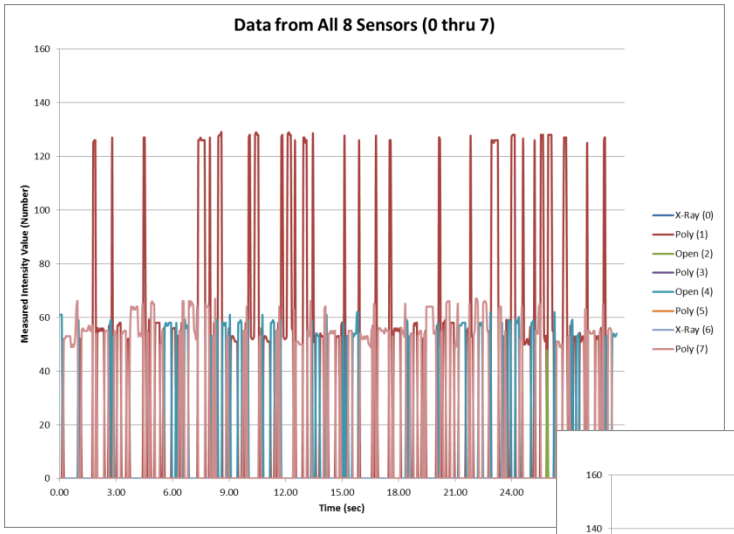
“Few x-ray events and low intensity”

December 25, 2018 (Data)

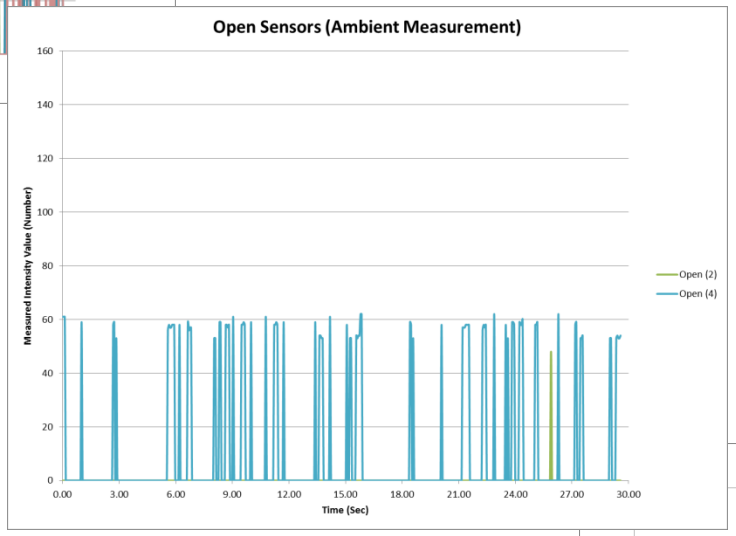
- Date:
  - December 25, 2018
- Start Time:
  - 14:09:57 (JST)
- End Time:
  - 14:16:51 (JST)
- Number of Data Sets
  - 15
- Each Data Set
  - 30 sec (8 sensors)
- Lat / Long / Alt
  - Start: -70.68 / -38.88 / 634.21
  - End: -46.22 / -55.38 / 627.33



Data Set 8 of 15 (December 25, 2018)

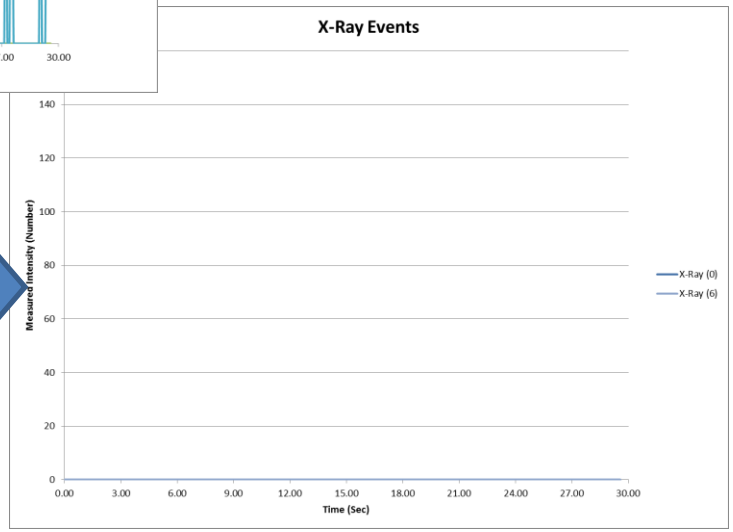


CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (MeV)	Energy-Max (MeV)
Open (2)	1	48	48	0.09	148.00	148.00
Open (4)	95	53	62	8.55	159.25	179.50

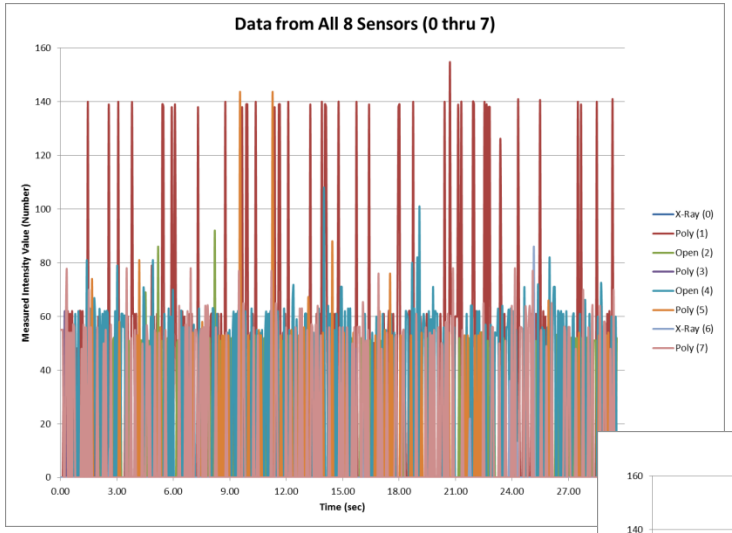


Observed – Set 8/15
More Flux of Particles …
More on one sensor…
No x-ray events …

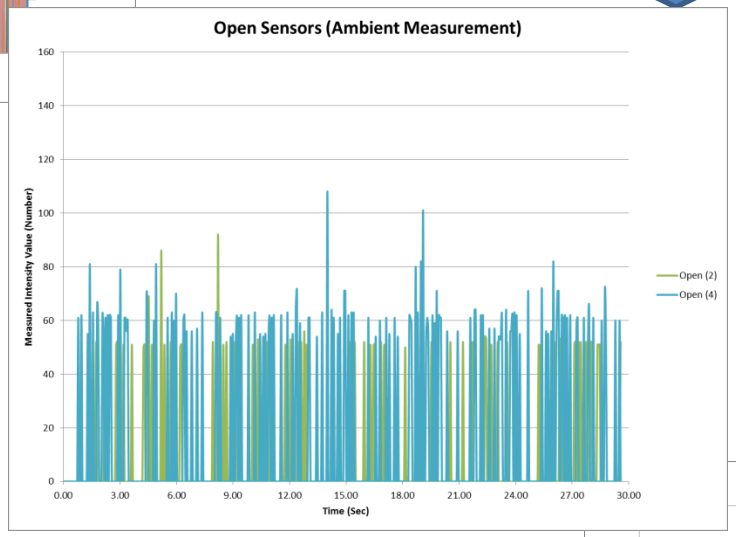
CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (kV)	Energy-Max (kV)
X-Ray (0)	0	0	0	0.00	0.00	0.00
X-Ray (6)	0	0	0	0.00	0.00	0.00



Data Set 15 of 15 (December 25, 2018)

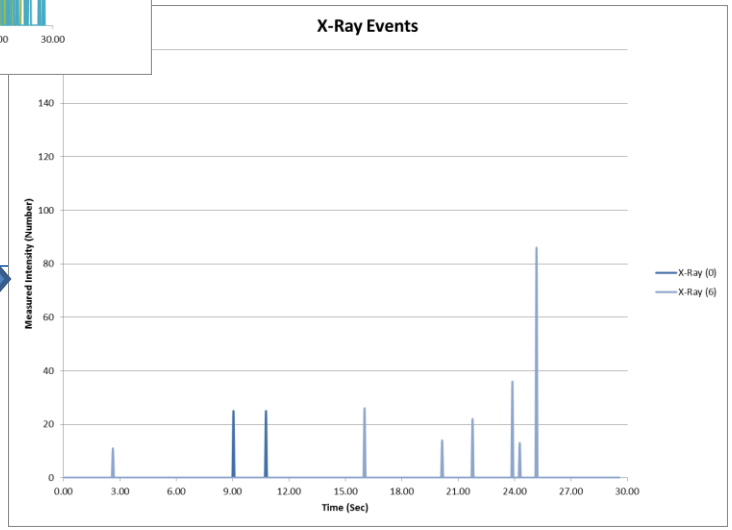


CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (MeV)	Energy-Max (MeV)
Open (2)	67	50	92	6.03	152.50	247.00
Open (4)	139	53	108	12.51	159.25	283.00



Observed – Set 15/15
High Flux of Particles …
High Energy Particles …
Several x-ray events …

CPD-Sensor	Obs Count (value)	Obs Min (value)	Obs Max (value)	Flux (#/cm^2/s)	Energy-Min (kV)	Energy-Max (kV)
X-Ray (0)	2	25	25	0.18	107.50	107.50
X-Ray (6)	7	11	86	0.63	69.70	272.20



X-Ray Data

Calibration and Assessment

X-Ray Data = Calibration

- *Glass Removal* - For our CMOS sensors, to detect the low energy florescence from x-rays, we opted the removal of the cover glass on the sensors.
  - We accomplished this with the help from PXI (Pacific X-Ray Imaging Company with their undisclosed process pertinent to their expertise).
- *Florescence Coating* - Mr Holland and his team identified the florescence material (X-Ray Phosphor Yttrium Oxysulfide).
  - Prepared a compound with required bonding capability so that a thin layer can be coated directly on to the surface wafer of the CMOS sensor.
- *X-Ray Testing* - These coated sensors are used to test the incident x-ray energy impingement from 80 kV through 320 kV in various steps.
  - Data was collected on to a sensor gadget with electronics identical to the payload data collection process system.
- *Region of Interest* – At the central region of the sensor, about 1000 x 1000 pixels are used to collect data from a collimated beam through the florescence material.
  - Data from about 100 x 100 pixel region of interest was used to develop the following interpretation.

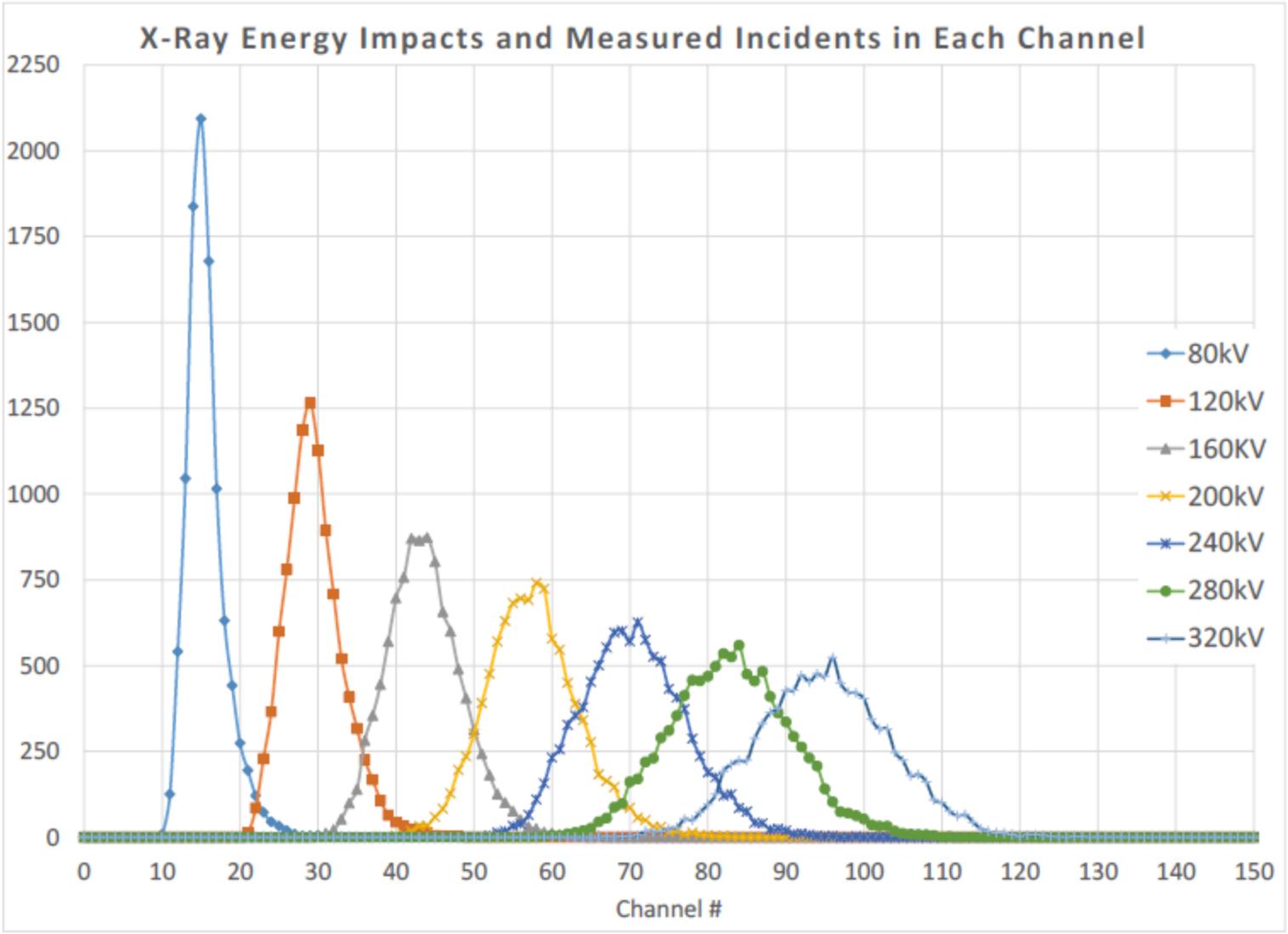


Figure-1: Seven x-ray energies are chosen to incident on the x-ray sensor at constant current (1.0 mA). Over a specific region of interest (100 x 100 pixels on the sensor), data of the observed florescence are shown in this graph as a function of CMOS channel number (#) on the x-axis and measured florescence as the number of pixels on y-axis. From this graph we recognize that the lower the x-ray energy (kV), the lower is also the florescence intensity as recognized by the channel number (#) on the sensor data as measured.

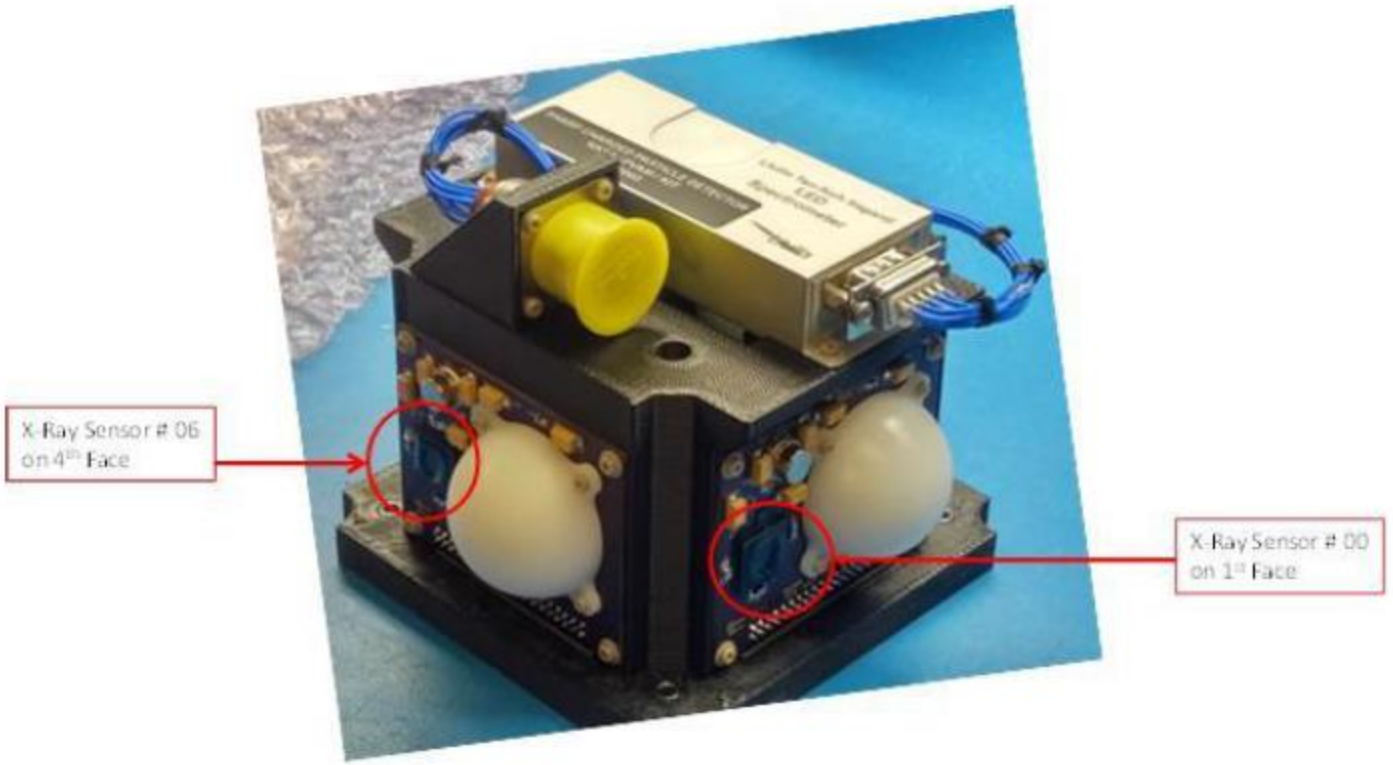


Figure-4: Depiction of the x-ray sensor locations on the SHARP-CPD payload unit on Ten-Koh spacecraft. Sensor "00" is located towards right of the image on the 1st face of the cube. Sensor "06" located on the left of the image on the 4th face of the cube structure.

IF Observed Channel Value #	THEN Estimated X-Ray Energy (kV)	IF Observed Channel Value #	THEN Estimated X-Ray Energy (kV)
5	47	20	92
6	50	40	150
7	53	60	209
8	56	80	268
9	59	100	327
10	62	120	386
11	65	140	444
12	68	160	503
13	71	180	562
14	74	200	621
15	77	220	680

Table-1: Estimated x-ray energy based on the incident florescence observed by the CMOS sensor on the Ten-Koh Spacecraft and downloaded data. An example provided as a look-up table.

Liulin Data

Estimation of Dose-Rates

Data from Liulin Ten-Koh = GCR

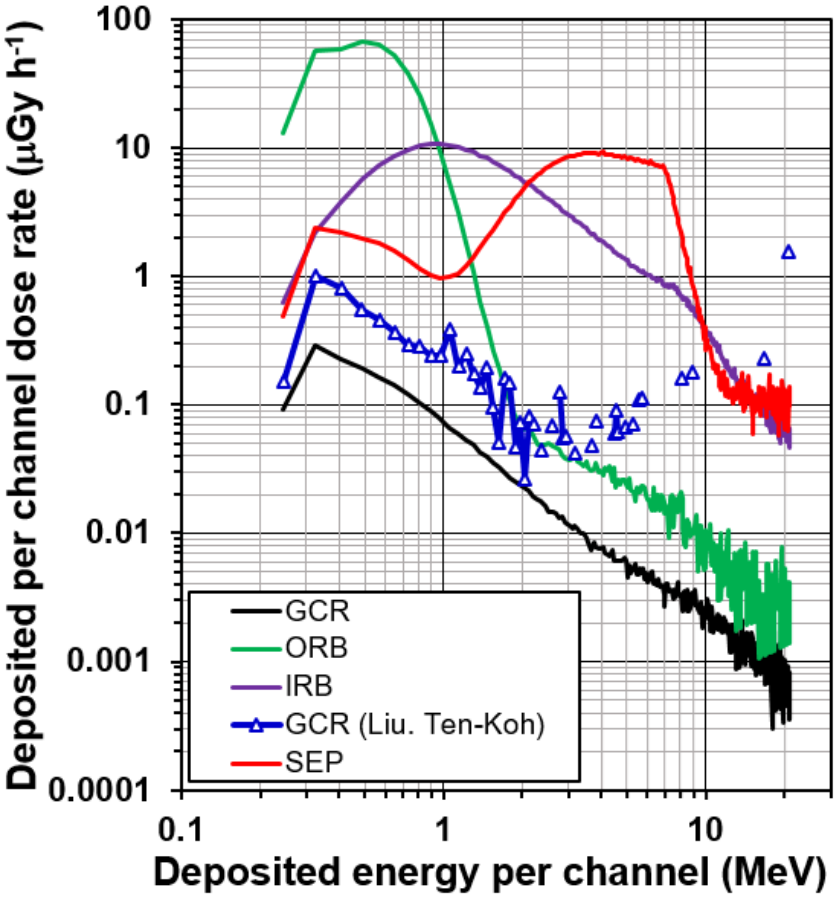
Day/Time	Exposition [sec]	Counts	Flux [cm^{-2} s^{-1}]	Dose rate [μGy h^{-1}]
08/11/2018 13:17:00	15.286	10	0.33	2.13
12/11/2018 13:59:00	15.286	11	0.39	2.35
12/11/2018	15.286	6	0.19	0.39
18/11/2018 13:33:53	15.286	8	0.26	2.79
18/11/2018	15.286	7	0.23	0.92
Aver. (Liulin Ten-Koh)			**0.28**	**1.72**
Aver. (R3DR2)			**0.46**	**1.57**

"From Table 1 it is seen that the "Liulin Ten-Koh Saganti" average dose rate is 1.72 mGy h^{-1}, while the average flux is 0.28 cm^{-2} s^{-1}. The values are typical for GCR at low latitude ~34°N at the longitude of about ~140°E. To confirm these values, we take data from the R3DR2 instrument on the ISS in the time interval 21-30 June 2015. … The obtained R3DR2 average dose rate and flux values from 46 points inside a rectangular area with coordinates between 139° and 141° geographic longitude and between 30° and 40° geographic latitude are 1.57 mGy h^{-1} and 0.45 cm^{-2} s^{-1}. These values are close to the "Liulin Ten-Koh Saganti" values and confirms our expectations that GCR particles are registered."

Prof. Dachev (BAS) - Aerospace Research in Bulgaria, 2019

Data from Liulin Ten-Koh = GCR

- Comparison of the “Liulin Ten-Koh Saganti” deposited energy spectrum shape with spectra, obtained on ISS with R3DR2 instrument for the period 21–30 June 2015.
  - – The R3DR2 spectrum represent the global GCR dose rate, which is in average 2.78 mGy h^{-1}, while the Liulin Ten-Koh average spectrum represent only high latitude doses with average value of 10.52 mGy h^{-1}.
  - – The higher altitude of the Ten-Koh satellite (~620 km) than ISS (415 km)
- *Prof. Dachev (BAS) - Aerospace Research in Bulgaria, 2019*



Conclusions / Comments

SHARP-CPD on Ten-Koh in 2018

- SHARP-CPD Payload (8+1 sensors)
  - All commands and changes to threshold values received and updated as requested
  - Data received and sent via radio frequency waves (between 435 – 437 MHz)
- Open Sensor Particle Energies
  - During the month of December 2018, we have seen the energy of the particles (primarily protons) between 60 MeV and 240 MeV
- Covered Polyethylene / Polystyrene Shielding
  - During the month of December 2018, we have seen the energy distribution behind the uniform shielding block between 20 and 120 MeV
- X-Ray Measurements
  - We have our first measurements with a simple device (luminescence from x-rays)
  - We measured x-ray energies between 10 and 120 keV (potential up to 200 keV)
- Liulin Dose-Rates
  - Polar orbit (93 deg and 600 km altitude) average dose rate is 1.72 mGy/hr
  - Compared to ISS (51.6 deg and 400 km altitude) average dose rate is 1.57 mGy/hr

PPD Payload on Shinen2 (2014)

As part of Hayabusa2 Launch by JAXA

For KIT-Japan with its Only Payload

THE SPACE RADIATION PARTICLE PIXEL DETECTOR (PPD)

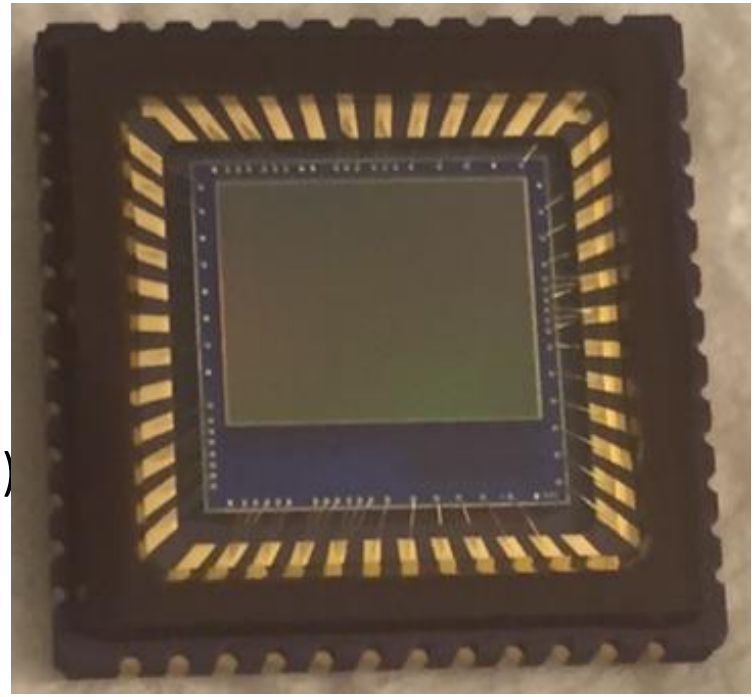
The Space Radiation Particle Pixel Detector (PPD) Payload Launched December 3, 2014 on the Shin'en-2 Spacecraft as part of the Hayabusa2 (Asteroid Explorer) Mission by JAXA, Japan. Developed by Prairie View A&M University in partnership with NASA-JSC, Jacobs, UT-Austin, UNLV, for KIT-Japan

PPD Build Restrictions

- Designed, developed, tested and delivered in six months to meet these requirements:
  - (i) low weight (~ 800 gr)
  - (ii) low power (~ 1 W)
  - (iii) high reliability over few years (~ 5+ years)
  - (iv) high tolerance in deep-space harsh radiation environment and temperatures (-50^{o} C to +50^{o} C)
  - (v) with the capability to provide data downlink over a low bit rate communication transmission via amateur radio transmission (between 2 - 5 kb/s) from deep-space. (Return highest hit over 3-minute intervals.)

Sensor Description

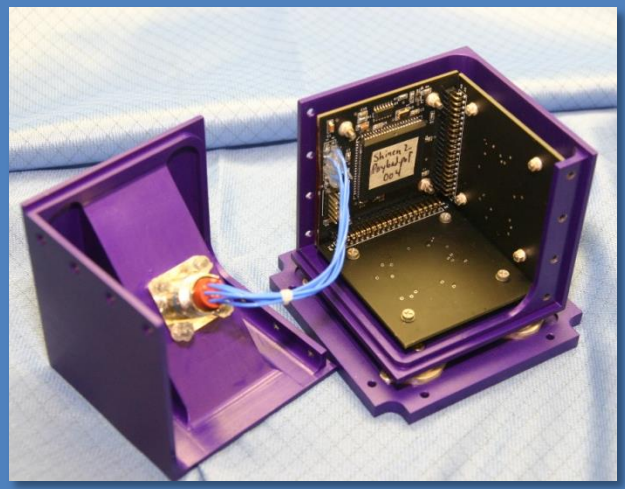
- CMOS digital image sensor
  - MT9M001(1.3 Million pixels)
- Active imager size
  - 6.66 mm (H) x 5.32 mm (V)
- Active pixels
  - 1,280 H x 1,024 V
- Pixel size
  - 5.2 µm x 5.2 µm
- Power consumption
  - 363 mW at 3.3 V (operating)
- Operating temperature
  - 0°C to +70°C
- Packaging
  - 48-pin CLCC



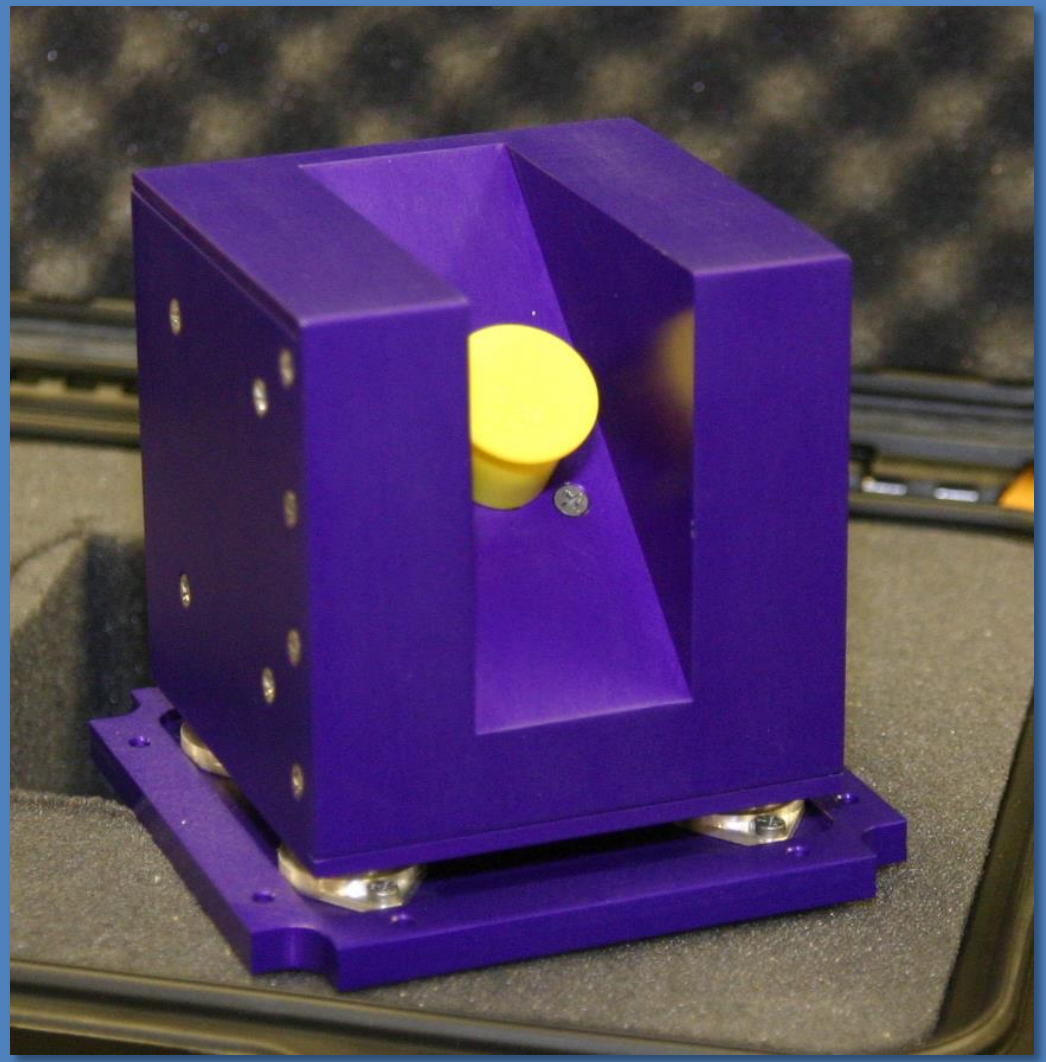
A Radiation Particle Pixel Detector for Deep-Space Exploration on Shinen2 Spacecraft of **Kyushu Institute of Technology**, *Japan*

Designed and Developed by

Prairie View A&M University with **NASA-JSC, UNLV, Jacobs Technology,** and **The University of Texas at Austin**



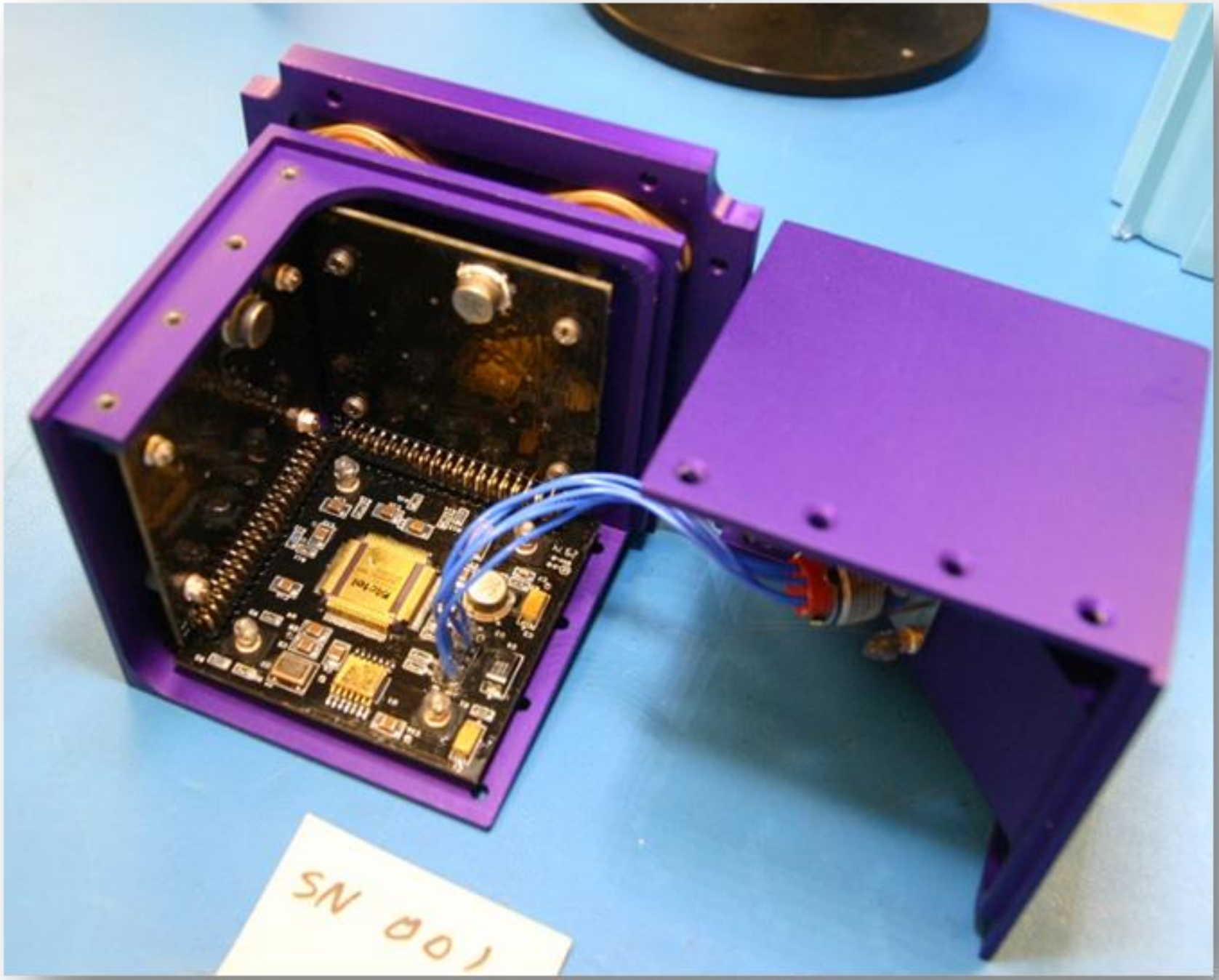
Particle Pixel Detector (PPD) -
An Engineering Unit (Prototype) Developed for Deep-Space Launch on Shinen2 as part of Hyabusa2 spacecraft from Japan in December -2014

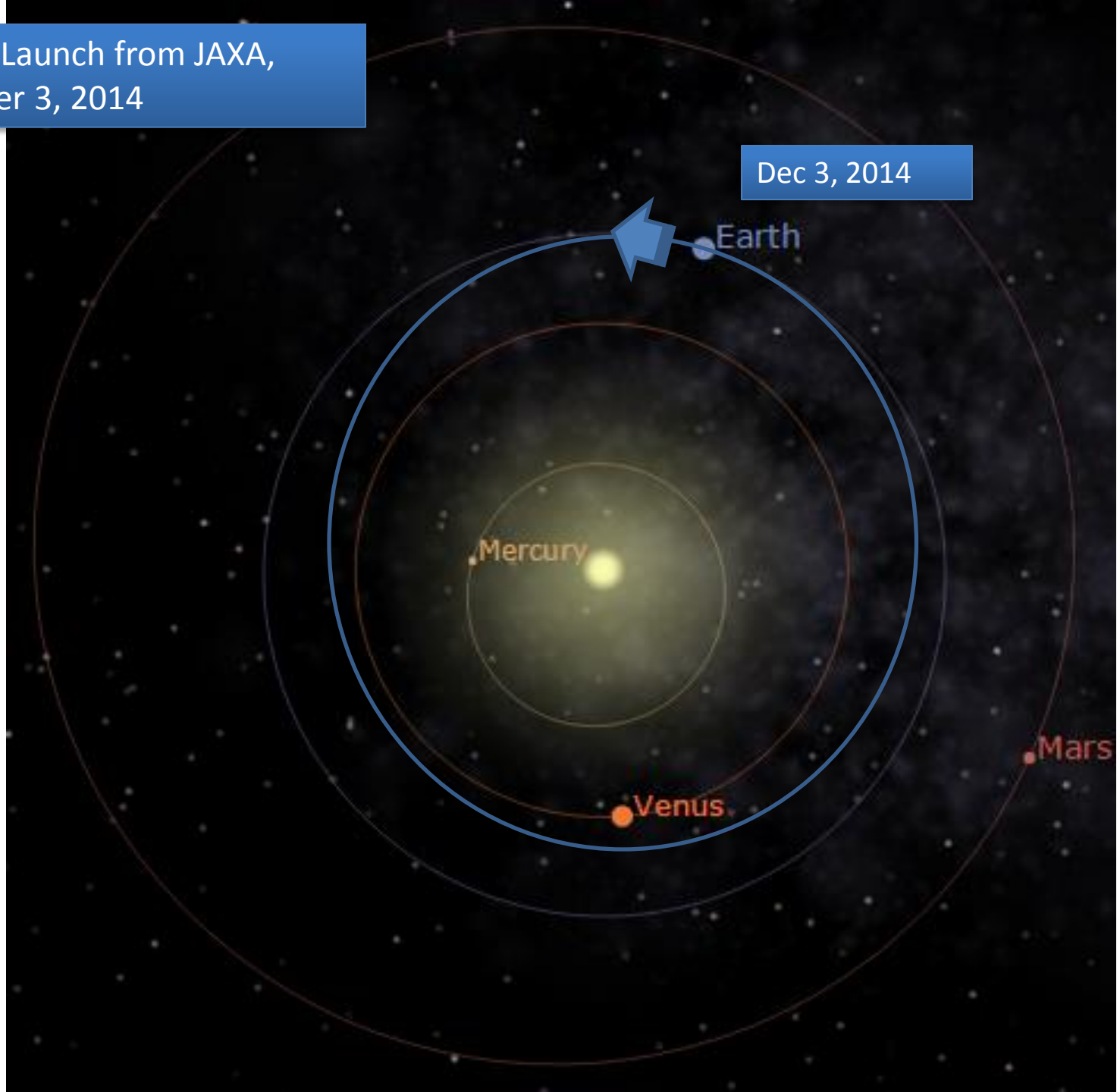


CMOS (imaging) camera system developed by Holland *et al.*, 2013.
Inset: An expanded CMOS (radiation) detector system being developed for deep-space radiation exploration by Saganti *et al.*, 2014.

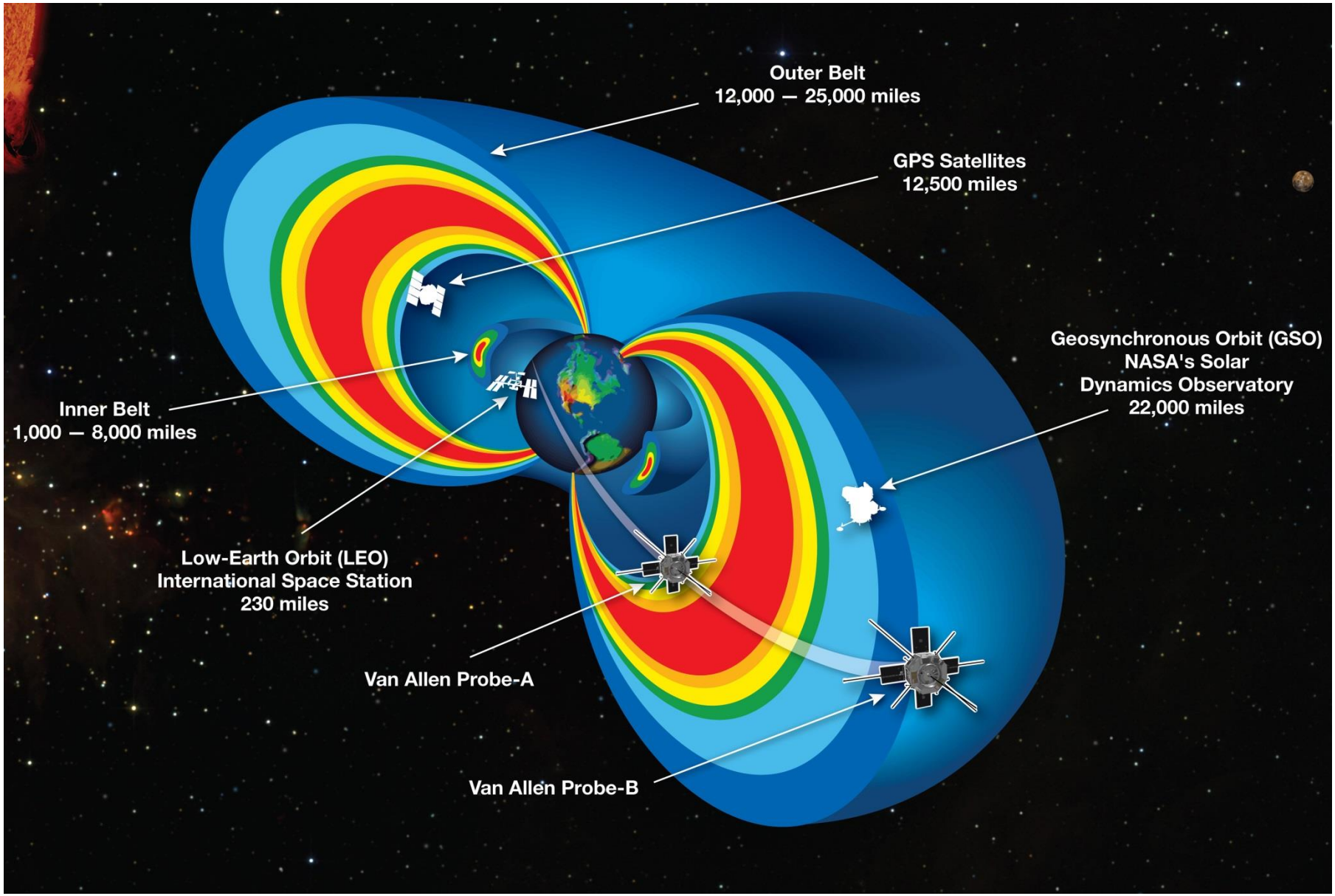
The Holland Observatory
12/23/13

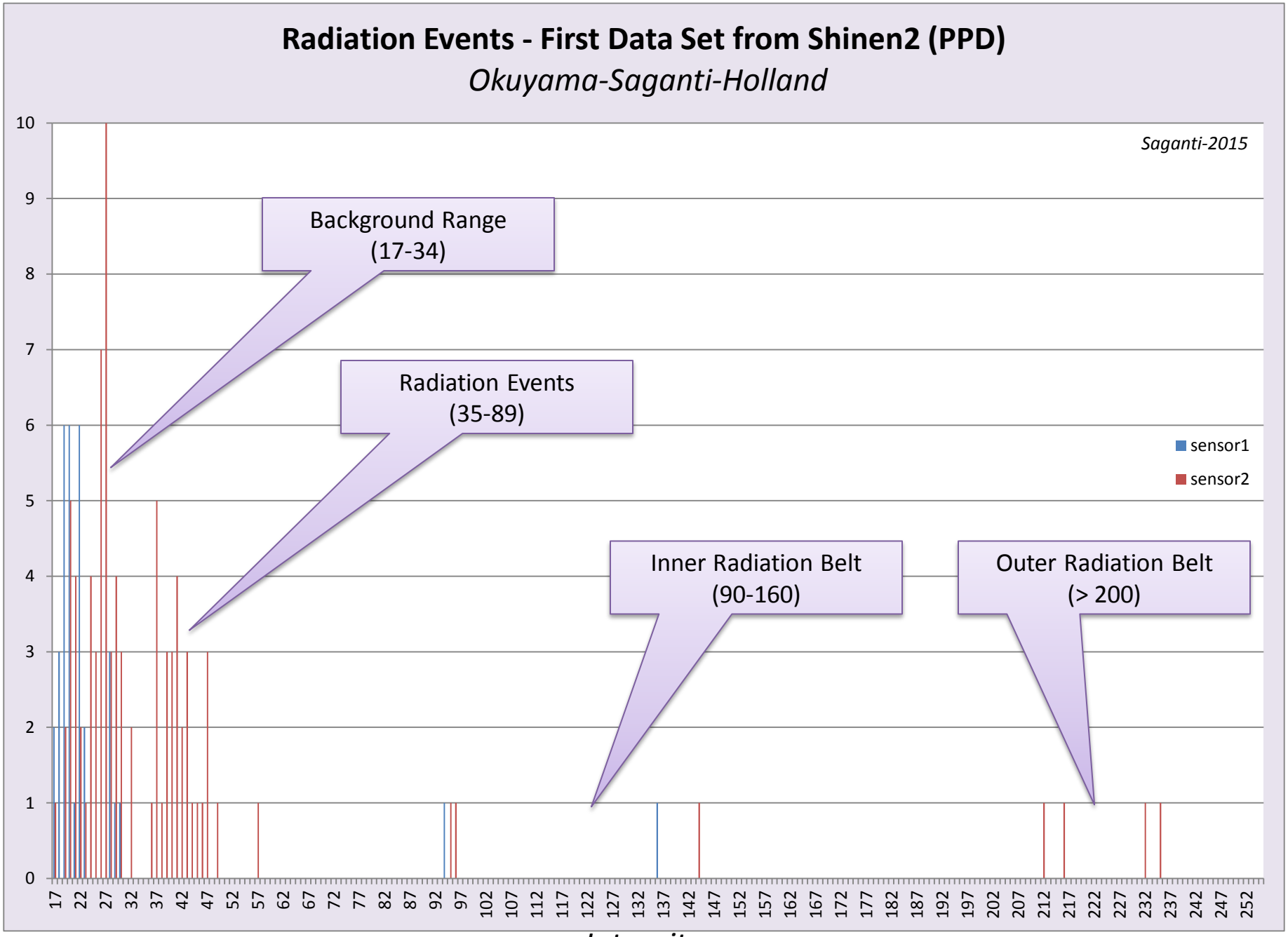
Orion's Belt Star Alnitak, Emission Nebula IC434 surrounding Dark Nebula B33 - The Horsehead Nebula, Emission Nebula NGC2024 - The Flame Nebula, Blue Reflection Nebula NGC2023 under Horsehead: all in Orion 40x5min, 200mm f/5 Newtonian, Baader MPCC, CLS Filter, Baader Filter Modified Canon 450D Camera

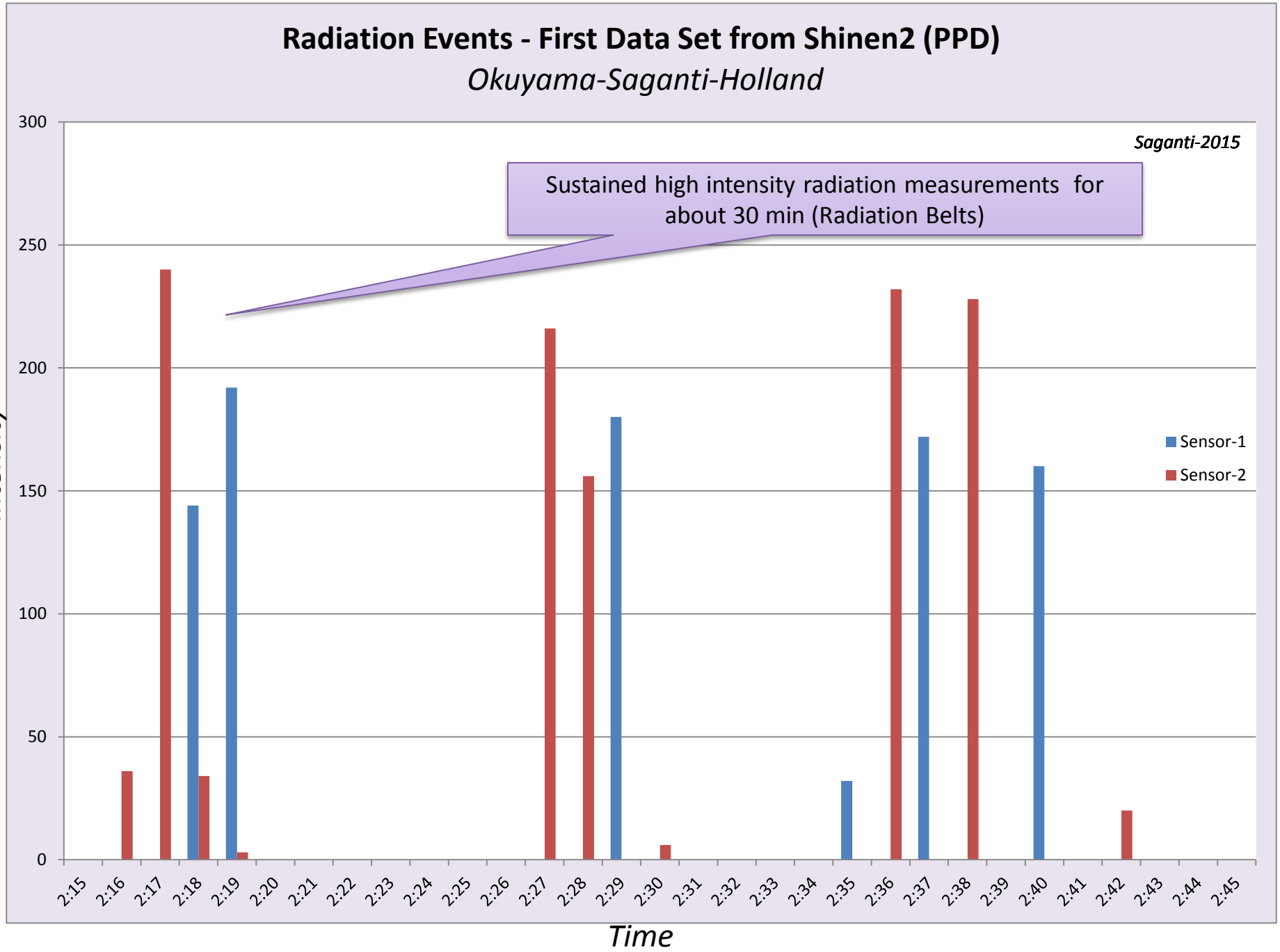

SN 001

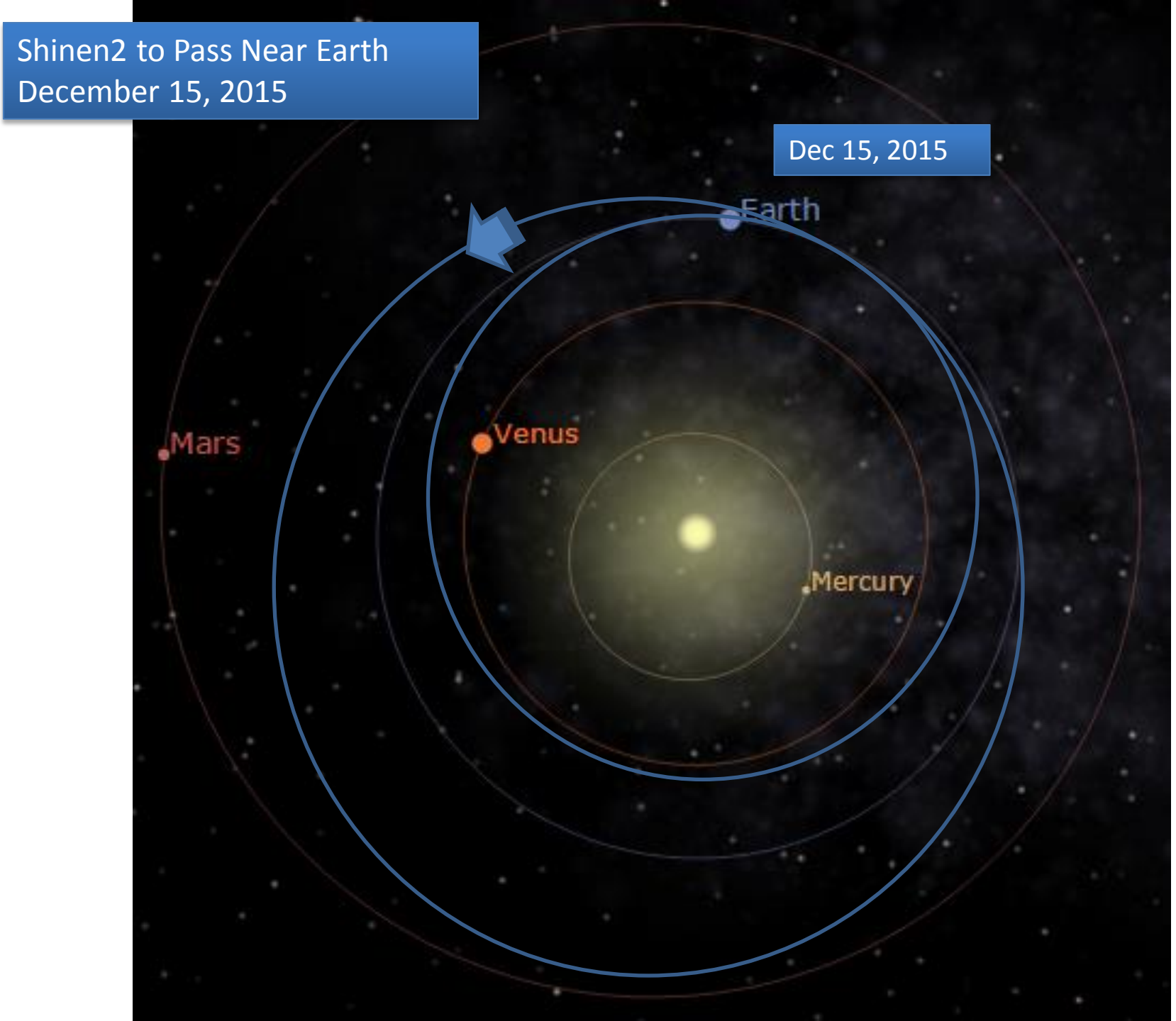

Shinen2 Launch from JAXA, December 3, 2014
Dec 3, 2014
Earth
Mercury
Venus
Mars

Radiation Belts - Illustration




Radiation Events - First Data Set from Shinen2 (PPD)
Okuyama-Saganti-Holland
Saganti-2015
Background Range
(17-34)
Radiation Events
(35-89)
Inner Radiation Belt
(90-160)
Outer Radiation Belt
(> 200)
sensor1
sensor2
Count
Intensity
0
1
2
3
4
5
6
7
8
9
10
17 22 27 32 37 42 47 52 57 62 67 72 77 82 87 92 97 102 107 112 117 122 127 132 137 142 147 152 157 162 167 172 177 182 187 192 197 202 207 212 217 222 227 232 237 242 247 252

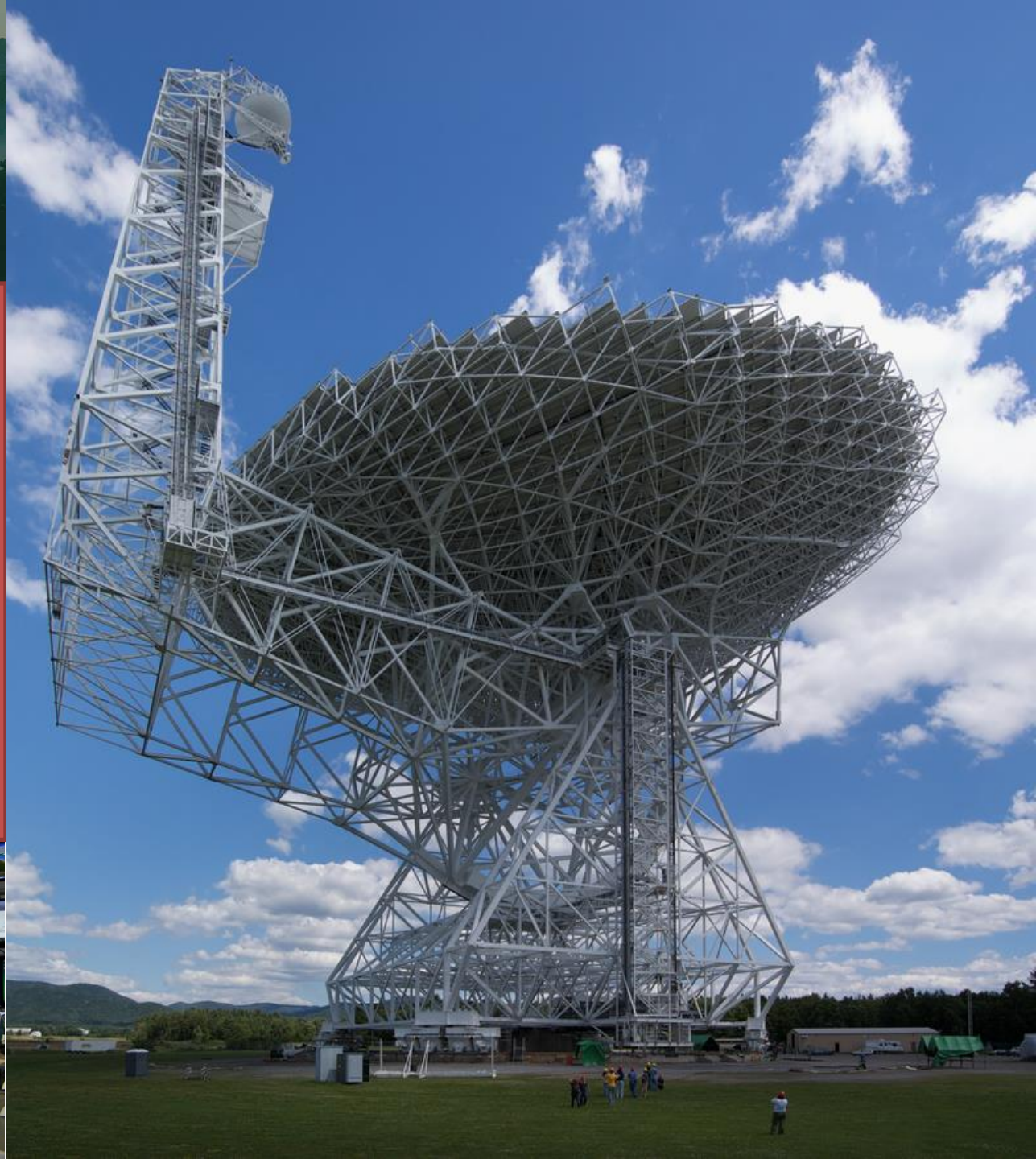

Radiation Events - First Data Set from Shinen2 (PPD)
Okuyama-Saganti-Holland
Saganti-2015
Sustained high intensity radiation measurements for about 30 min (Radiation Belts)
Sensor-1
Sensor-2
Intensity
Time
300
250
200
150
100
50
0
2:15
2:16
2:17
2:18
2:19
2:20
2:21
2:22
2:23
2:24
2:25
2:26
2:27
2:28
2:29
2:30
2:31
2:32
2:33
2:34
2:35
2:36
2:37
2:38
2:39
2:40
2:41
2:42
2:43
2:44
2:45


Shinen2 to Pass Near Earth
December 15, 2015
Dec 15, 2015
Earth
Mars
Venus
Mercury

The Robert C. Byrd Green Bank Telescope (GBT) is the world's largest fully steerable radio telescope.

National Radio Astronomy Observatory (NRAO) site at Green Bank, West Virginia.

December 3-6, 2015: NRAO GBT Team helped to collect data from Shinen2 (payload – PPD) for PVAMU.



Measurement of Space Radiation Environment with a Particle Pixel Detector (PPD): First Results

S. E. Saganti[1], M. Rahman[1], G. M. Erickson[1] , R. C. Dwivedi[1], B. M. Cudnik[1], D. Lin[1], X. Hu[1], J. R. Rhone[1],
S. D. Holland[2], K. I. Okuyama[3], F. A. Cucinotta[1], and P. B. Saganti[1]

(1) Prairie View A&M University, Prairie View, T-77446; (2) NASA Johnson Space Center, Houston, TX-77058; (3) Kyushu Institute of Technology (KIT), Fukuoka 804-8550, Japan

ABSTRACT

Space radiation beyond low-earth orbit is constantly changing due to variations in the radiation particle flux of the Galactic Cosmic Ray (GCR) environment. For future intended deep-space human explorations, beyond the protection of Earth's magnetic field lines, we need to measure and assess the radiation particle flux changes to understand and comprehend biological consequences on human explorations as well as long term radiation effects on electronic materials.

Prairie View A&M University (PVAMU), in collaboration with NASA Johnson Space Center (NASA-JSC), have been developing a radiation detector system for the Kyushu Institute of Technology (KIT) in Japan for an opportunity to launch the detector on board their Shinen2 spacecraft in 2014. This newly designed and developed instrument makes use of CMOS (Complementary Metal Oxide Semiconductor) sensors with electronics capable of identifying radiation particle trajectory through the instrument. In the present work, we show a prototype radiation particle pixel detector (PPD) with preliminary data collected making use of our own simple laboratory radiation devices and software interface developed to verify the functioning the PPD system.

INTRODUCTION

Long duration human expedition missions during the past decade have been increasing in record number of days both for male and female explorers. However, for over nearly 40 years, all of our human expeditions have been limited to Low Earth Orbit (LEO) and during the past 10 years to International Space Station (ISS). To further understand and assess radiation risk for even longer or greater radiation environment fields beyond LEO, our current knowledge and understanding needs to be drastically enhanced with more realistic long-term radiation data and the development of the needed radiation risk mitigation strategies.

The radiation particle pixel detector (PPD) was developed in a short time (6 mo) as: (i) low weight (~ 800 gr), (ii) low power (~ 1 W), (iii) reliability over few years (~ 5+ years), (iv) tolerance in deep-space harsh radiation environment (built with radiation hardened electronics) for a broad range of temperatures (-50° C to +50° C), and (v) with a unique capability to provide data downlink over a low bit rate communication transmission to Earth (few kilobytes) from deep-space. This payload makes use of CMOS (Complementary Metal Oxide Semiconductor) sensors with capability to estimate energy and particle flux.

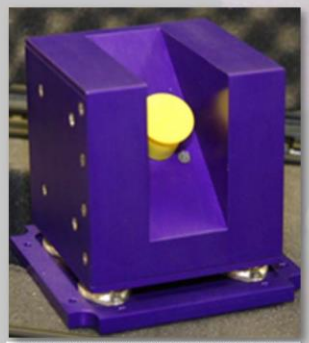
PRELIMINARY RESULTS

Several prototype PPD units were designed and were fabricated at NASA-JSC per the above requirements. To verify the operational capability of the developed unit(s), we tested with low energy laboratory radiation sources such as: Sr-90 (beta source of 0.1 μCi); Ba-133 (gamma source of 1 μCi); Co-60 (beta + gamma source of 1 μCi); and Cs-137 (beta + gamma source of 5 μCi). Initial results of the prototype space payload unit are shown for Co-60 and Cs-137.

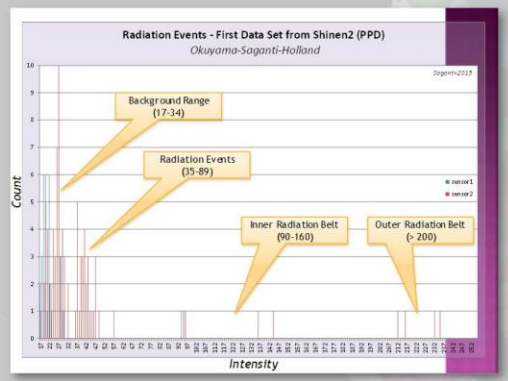
SPACE LAUNCH and DATA

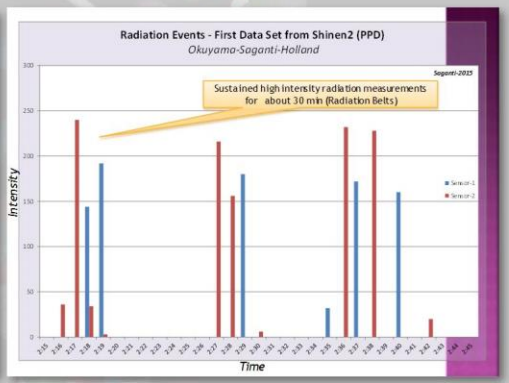
Hayabusa2 (Asteroid Explorer) launched from Japan (JAXA) on December 3, 2014 (JST) at 1:22:04 pm on a unique mission to bring a sample from an asteroid, 1999 JU3 (C-type, Near Earth Object). Planned arrival at target is 2018 and sample return to earth is expected in 2020. Hayabusa2 spun off the Shinen2 Spacecraft into an elliptical orbit around the Sun between Venus and Mars that can potentially provide radiation data for next 3 to 5 years (potentially up to 2020).

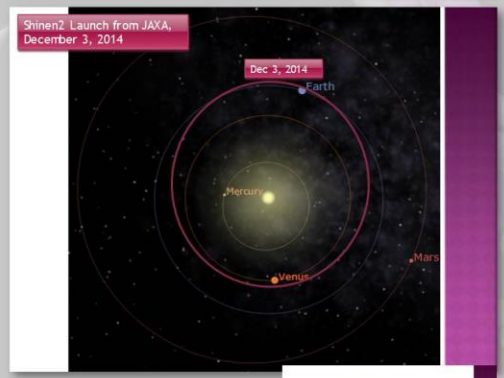
Shinen2 spacecraft, designed and built by the Kyushu Institute of Technology (KIT-Japan), is a hexagonal shaped, 15-kg, 47 x 49 x 49-cm structure built with light-weight and durable Carbon Fiber Reinforced Polymer (CFRP) with dual batteries charged by solar panels on each side of the structure and redundant UHF transmission systems at 437 MHz. Shinen2 proved its success by transmitting radiation data measured by the PPD unit from Moon orbit and up to 30 times distance from Earth to Moon.

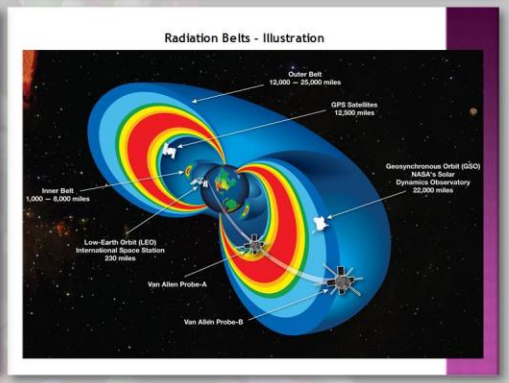


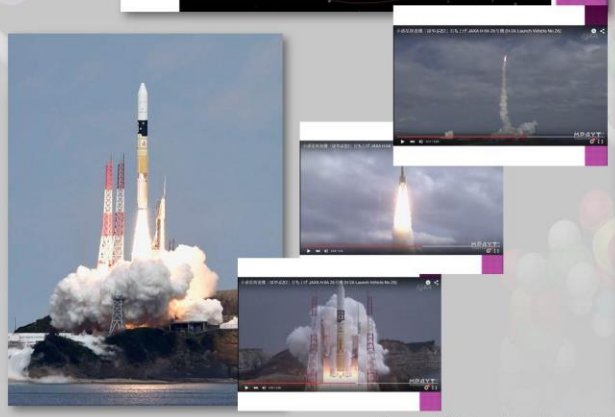
Prairie View A&M University's (PVAMU) – Radiation Particle Pixel Detector (PPD)
"A Purple and Gold Detector for Deep Space Radiation Exploration"
Developed for Deep-Space Radiation Measurement on Shinen2 Spacecraft Launched as part of Hyabusa2 (Asteroid Explorer) Mission from Japan by JAXA on December 3, 2014.

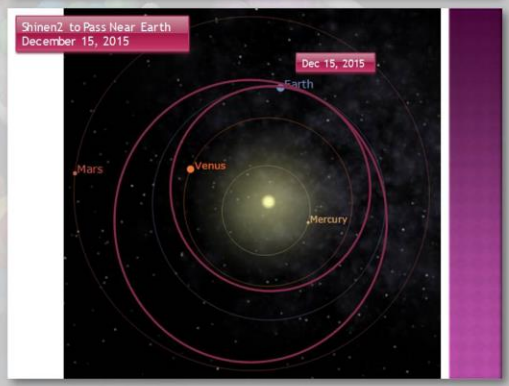




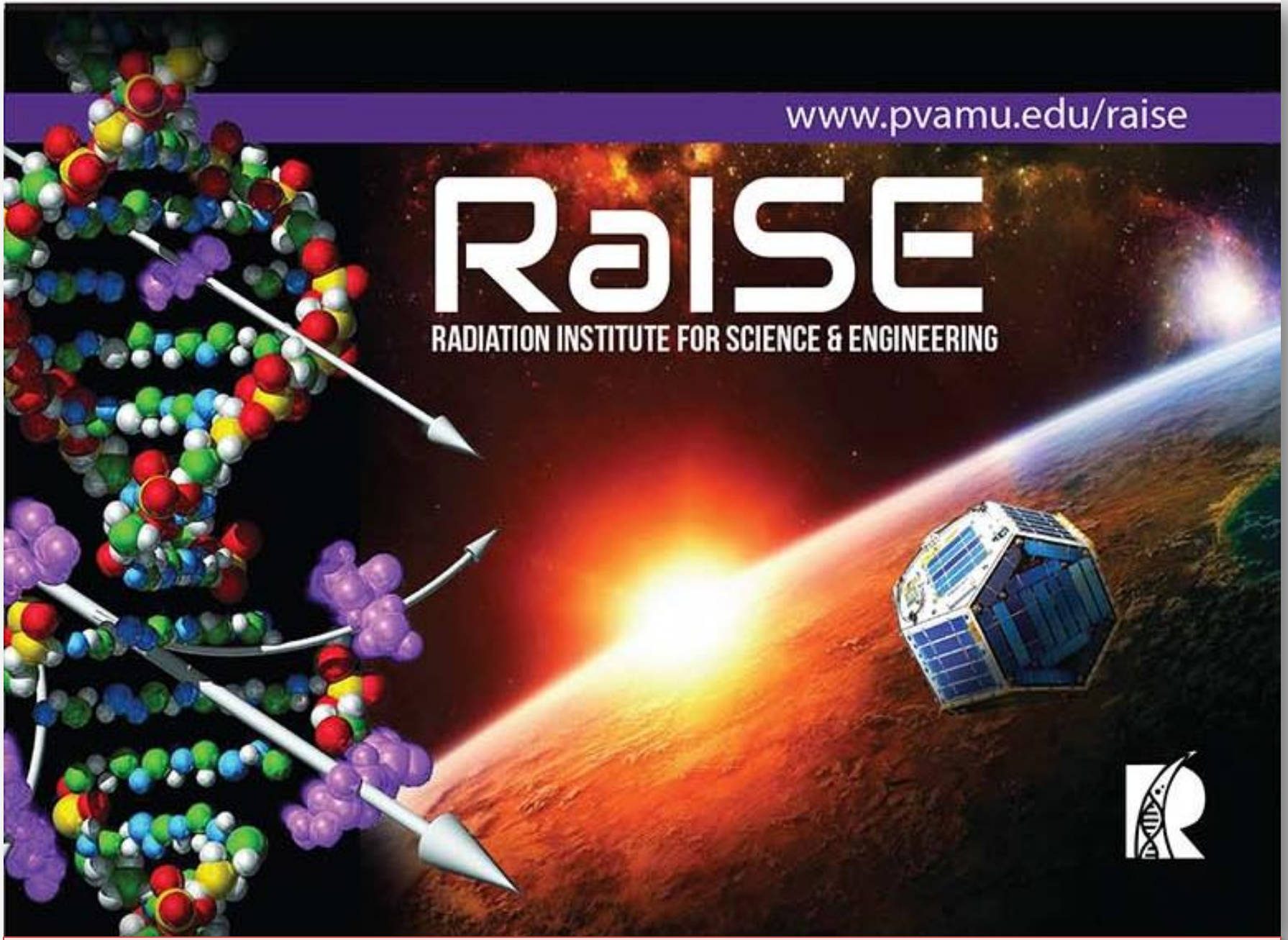








This research is being envisioned in part by NASA Grants - NNX07AT25A & NNX09Q92G, and supported through Chancellor's Research Initiative - CRI



Texas A&M University System (TAMUS) Chancellor's Research Initiative (CRI) @ Prairie View A&M University (PVAMU)