Australian Government | ANSTO

Application of the CORIS360 Gamma-ray Imager at a Light Source

Y. E. Tan, D. Boardman, L. Chartier, M. Guenette, J. Ilter, G. Watt

ANSTO

14/09/2021

Science. Ingenuity. Sustainability.

Gamma-ray Imager

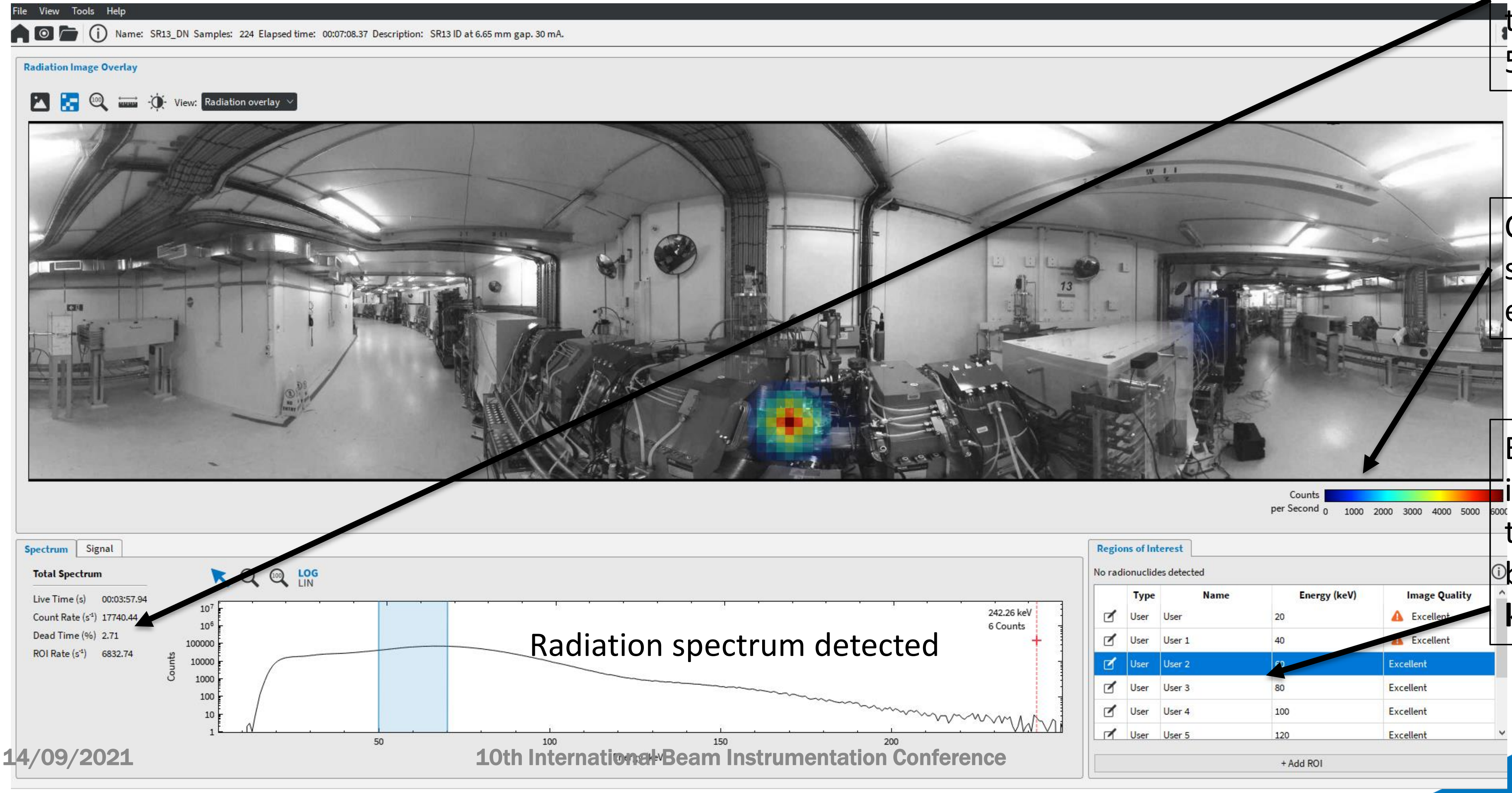
- Single CLLBC Scintillator as the detector.
- Compressed sensing
- Radiation image reconstruction by intensity measurements through the use of internal rotating masks.

CORIS360®

Introducing the world's most advanced radiation imaging solution

Fast, 360° × 90° gamma-ray imaging across the full energy range, for improved decision making

Interpreting Data



Detector stats. Dead time on the detector. > 50% is bad…

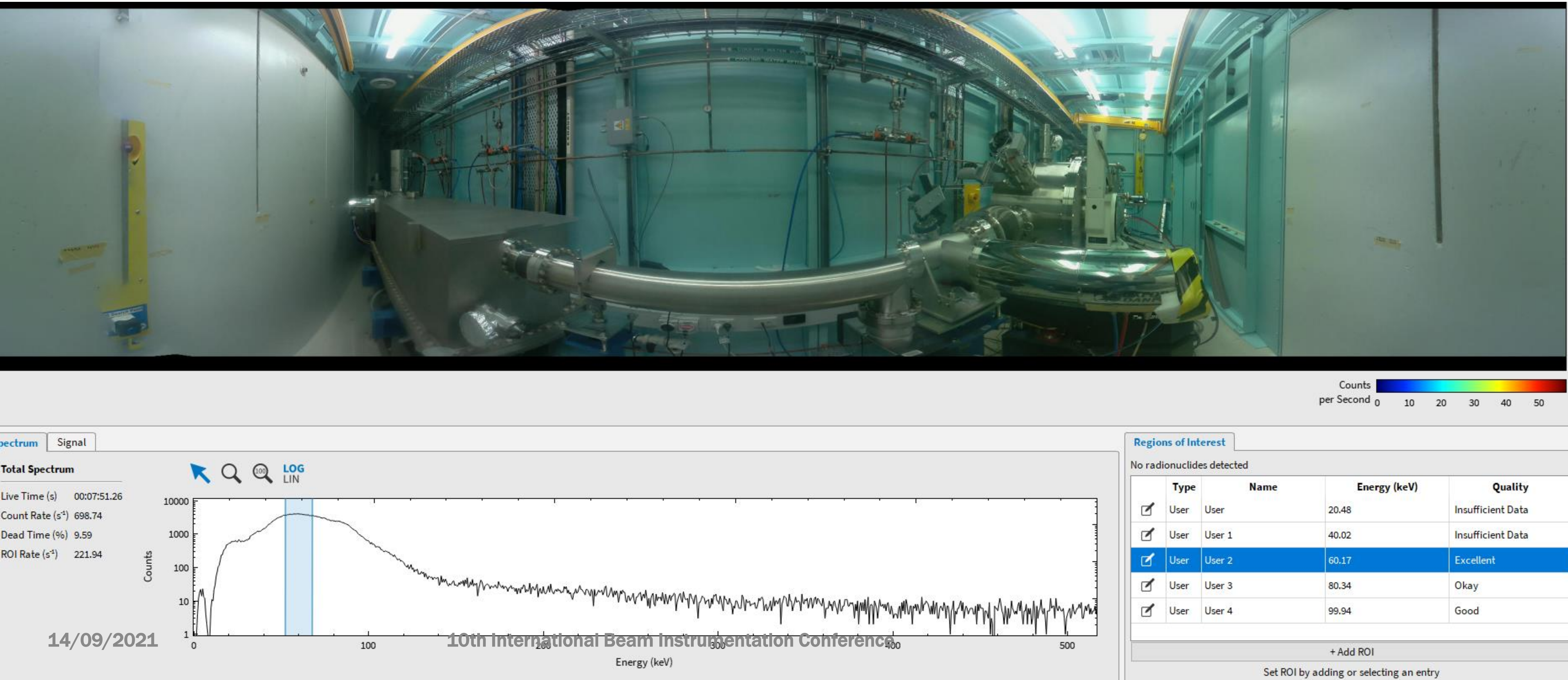
Counts per second in the energy ROI.

Energy region of interest (ROI), for this experiment bandwidth is **±10 keV.**

Dipole Source ($B = 1.25T$; $E_c = 8$ keV)

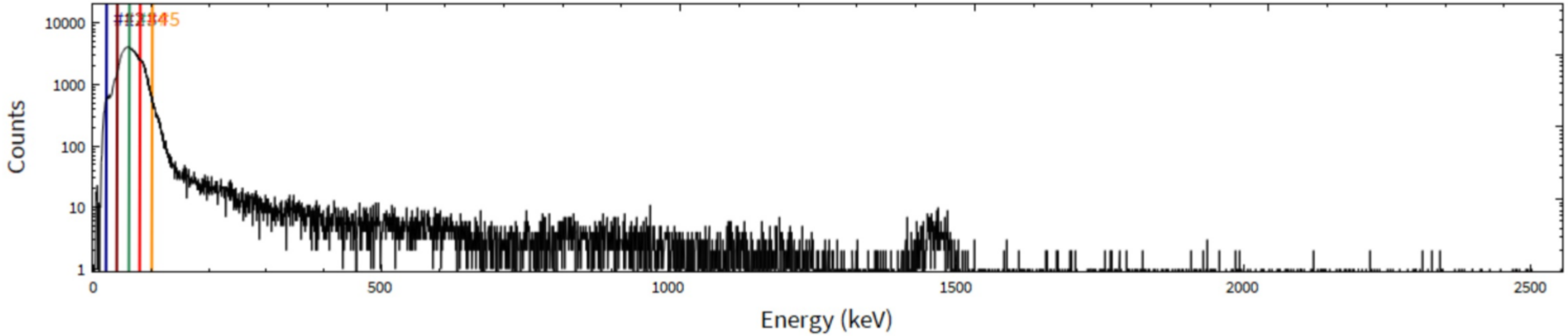
PD BEAMLINE

Dipole source – PD (E_c = 8 keV)



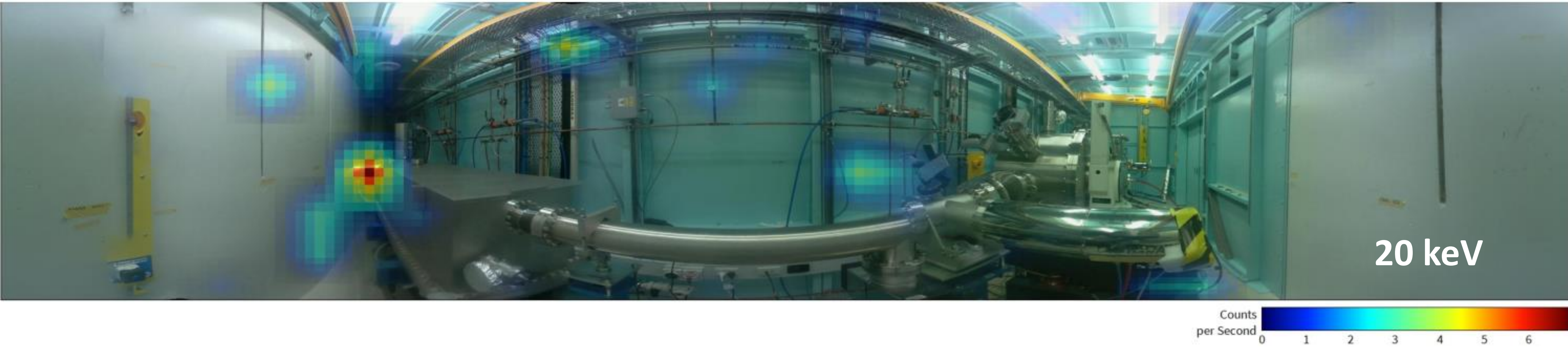
Dipole source - PD

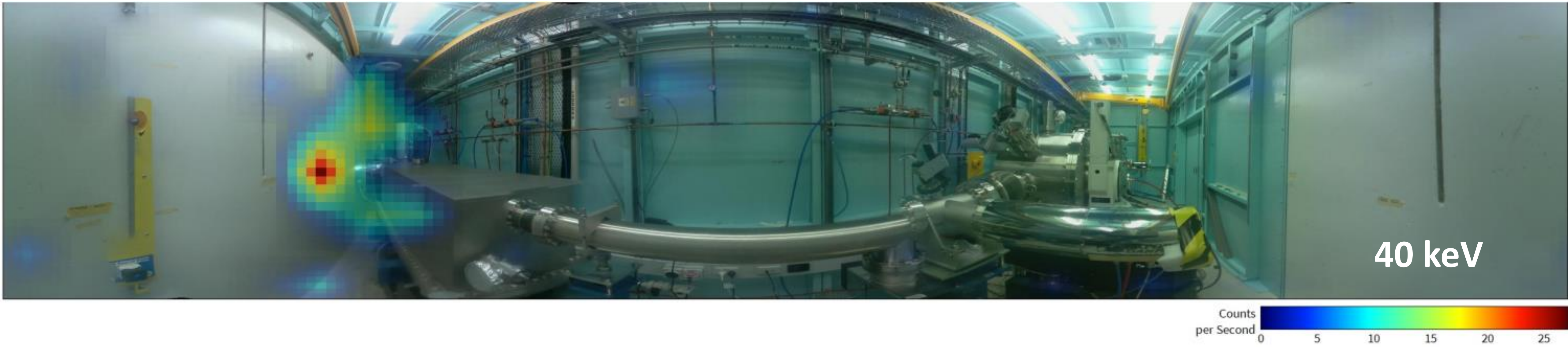
Energy Spectrum

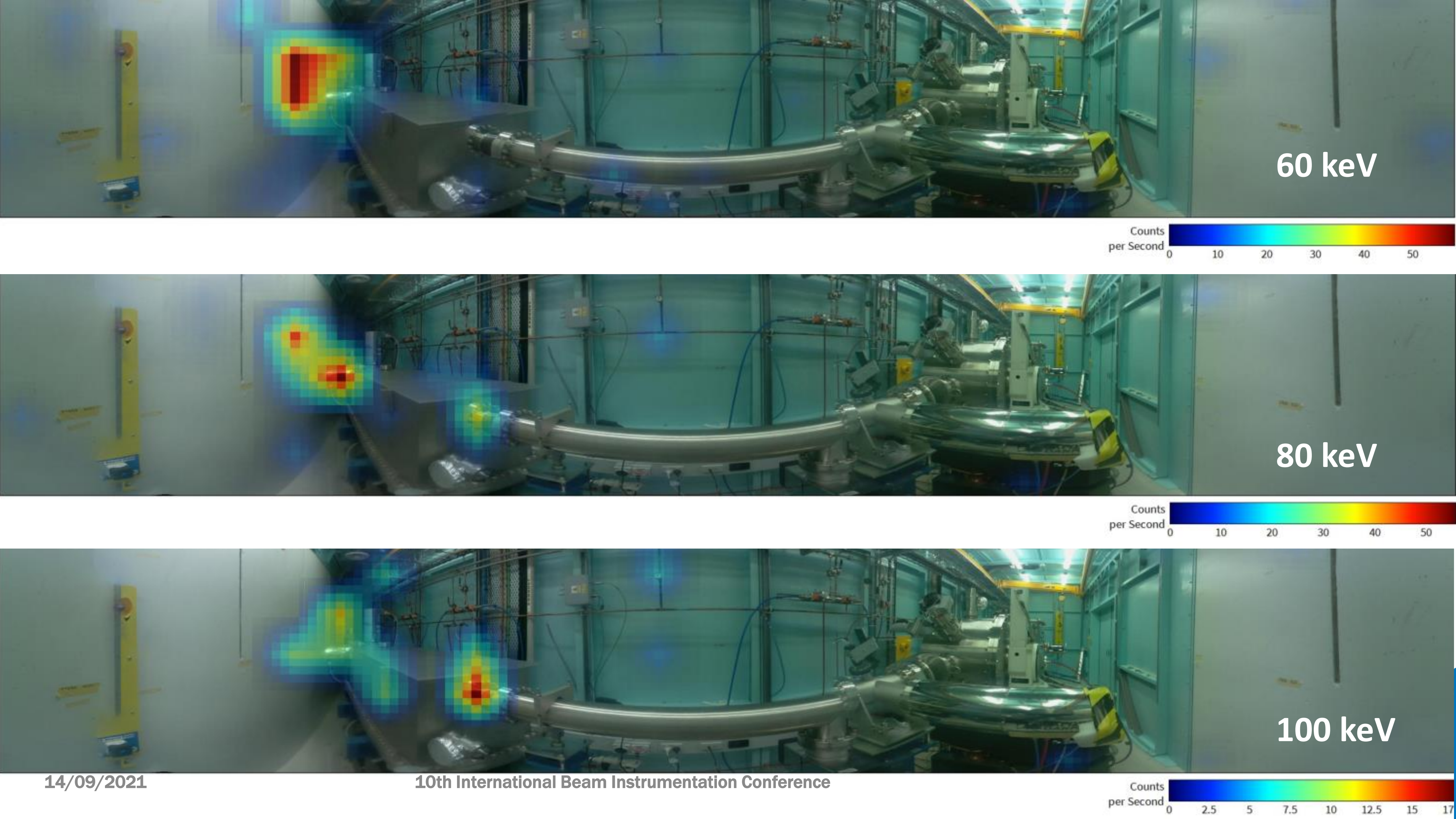


Regions of Interest

	Type	Name	Energy (keV)	Range (keV)	Counts	Rate (cps)	Quality	Page
#1	User	User	20.48	13.4 - 27.6	10704	22	Insufficient Data	2
#2	User	User 1	40.02	32.9 - 47.1	41973	89	Insufficient Data	3
#3	User	User 2	60.17	52.5 - 67.9	104555	221	Excellent	4
#4	User	User 3	80.34	72.0 - 88.7	75055	159	Okay	5
#5	User	User 4	99.94	91.6 - 108.3	21540	45	Good	6


20 keV
Counts
per Second
0
1
2
3
4
5
6


40 keV
Counts
per Second
0
5
10
15
20
25

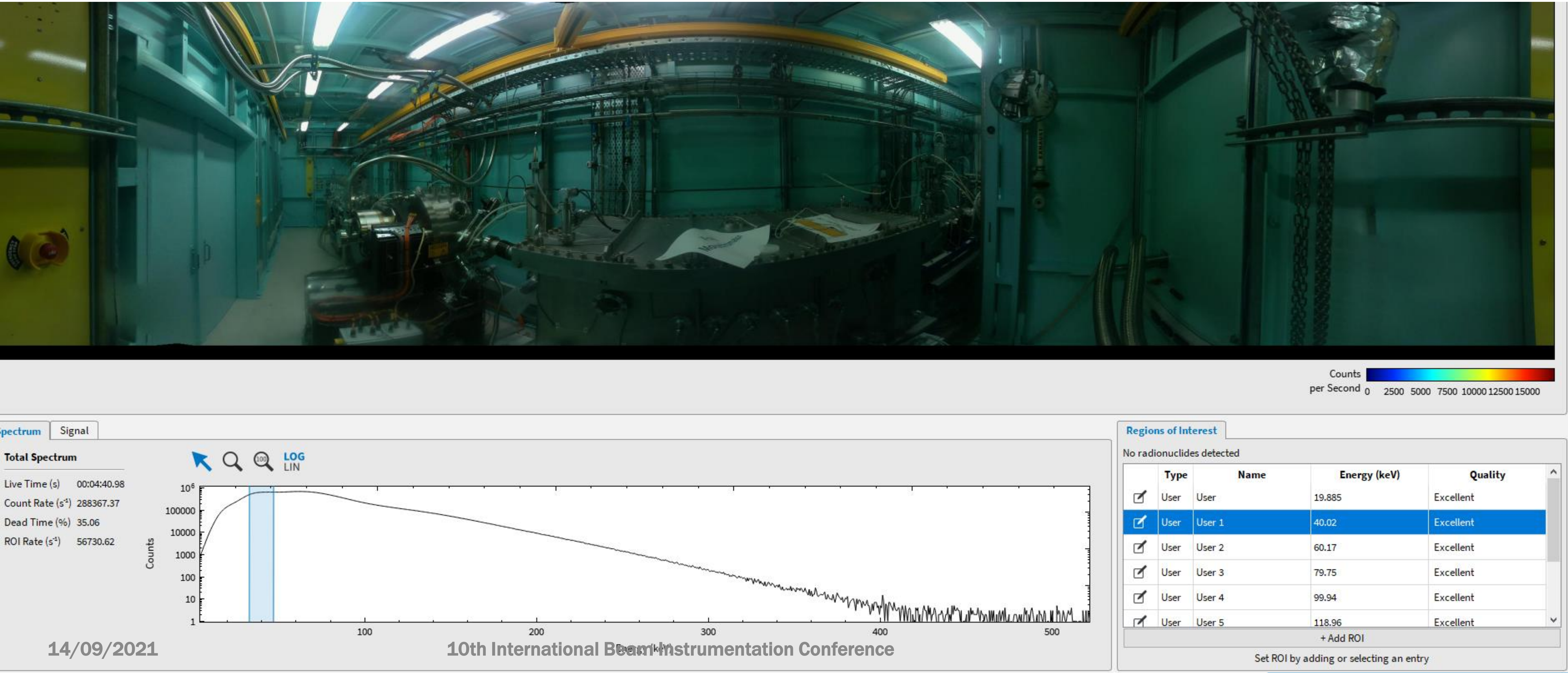

60 keV
Counts per Second
0 10 20 30 40 50
80 keV
Counts per Second
0 10 20 30 40 50
100 keV
Counts per Second
0 2.5 5 7.5 10 12.5 15 17

Permanent Magnet Multipole Wiggler (B = 1.6T @ 18.2mm; E_c = 11.4 keV)

XAS BEAMLINE

PMW - XAS

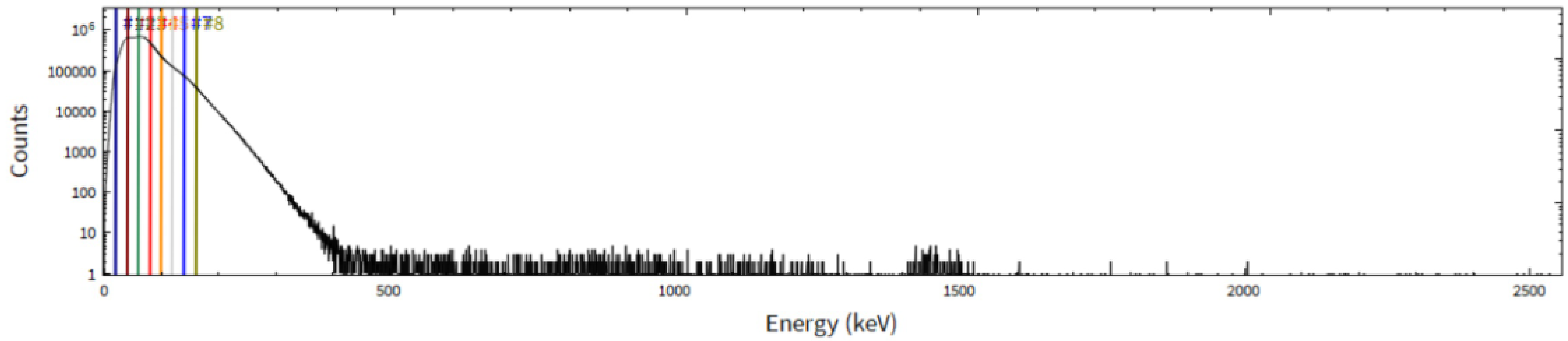
PMW - XAS



Counts per Second
0 2500 5000 7500 10000 12500 15000
pectrum
Signal
Total Spectrum
Live Time (s) 00:04:40.98
Count Rate (s⁻¹) 288367.37
Dead Time (%) 35.06
ROI Rate (s⁻¹) 56730.62
LOG
LIN
Counts
10⁶
100000
10000
1000
100
10
1
100
200
300
400
500
Regions of Interest
No radionuclides detected
Type Name Energy (keV) Quality
User User 19.885 Excellent
User User 1 40.02 Excellent
User User 2 60.17 Excellent
User User 3 79.75 Excellent
User User 4 99.94 Excellent
User User 5 118.96 Excellent
+ Add ROI
Set ROI by adding or selecting an entry

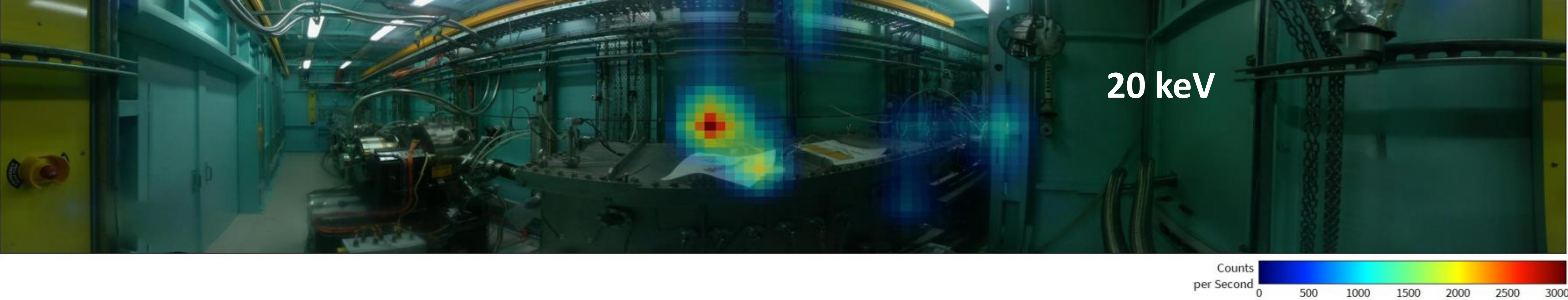
PMW - XA

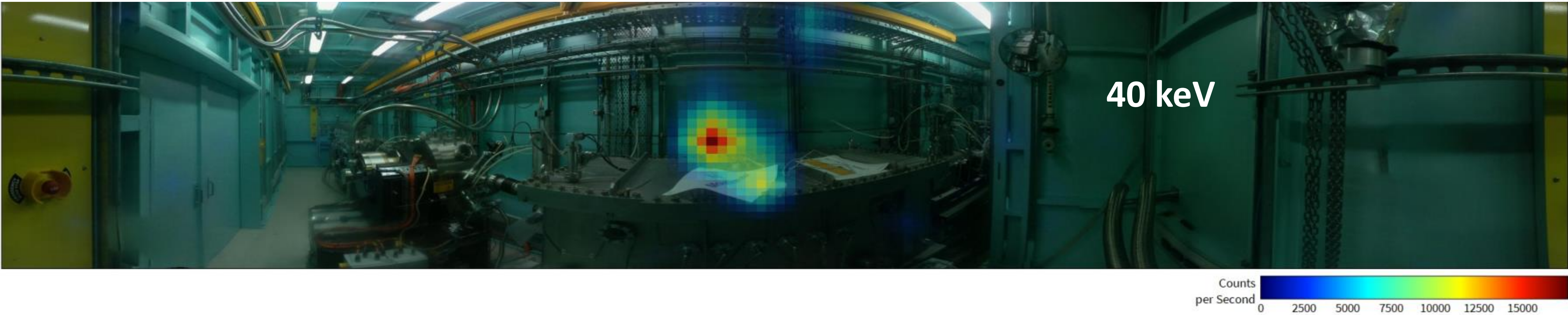
Energy Spectrum

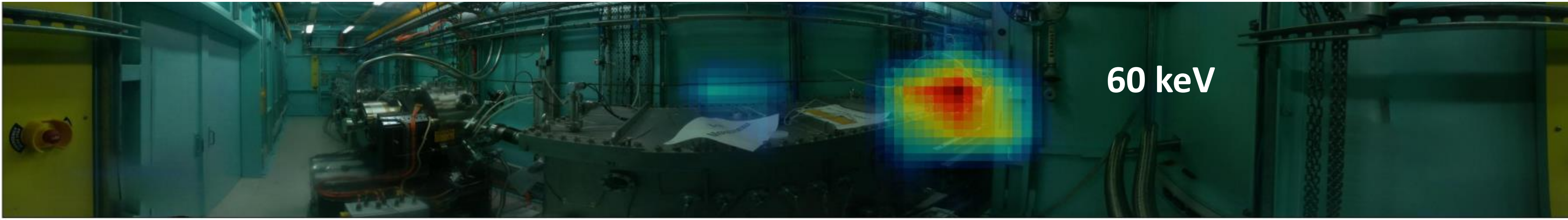


Regions of Interest

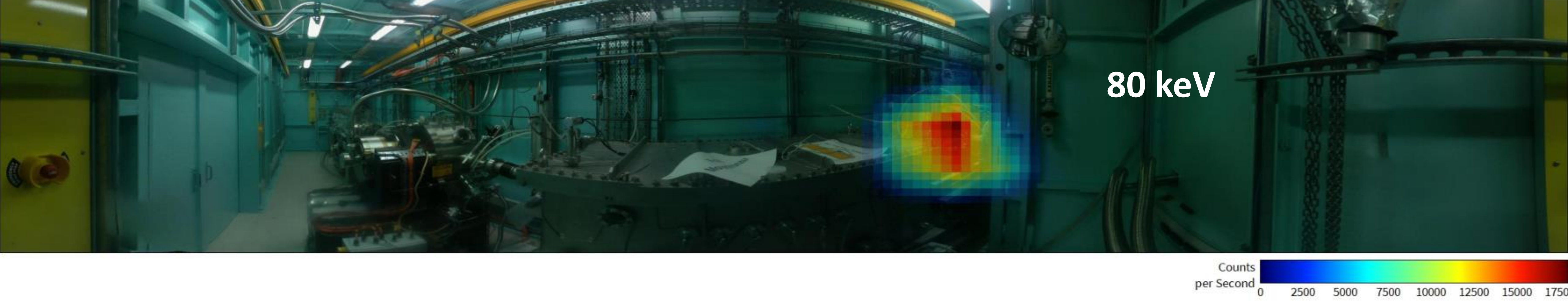
	Type	Name	Energy (keV)	Range (keV)	Counts	Rate (cps)	Quality	Page
#1	User	User	19.885	12.8 - 27.0	3651557	12995	Excellent	2
#2	User	User 1	40.02	32.9 - 47.1	15940396	56730	Excellent	3
#3	User	User 2	60.17	52.5 - 67.9	18321722	65205	Excellent	4
#4	User	User 3	79.75	71.4 - 88.1	14387378	51203	Excellent	5
#5	User	User 4	99.94	91.6 - 108.3	6658978	23698	Excellent	6
#6	User	User 5	118.96	110.0 - 127.9	3919191	13948	Excellent	7
#7	User	User 6	139.785	130.3 - 149.3	2503472	8909	Excellent	8
#8	User	User 7	160.03	150.5 - 169.6	1252546	4457	Excellent	9

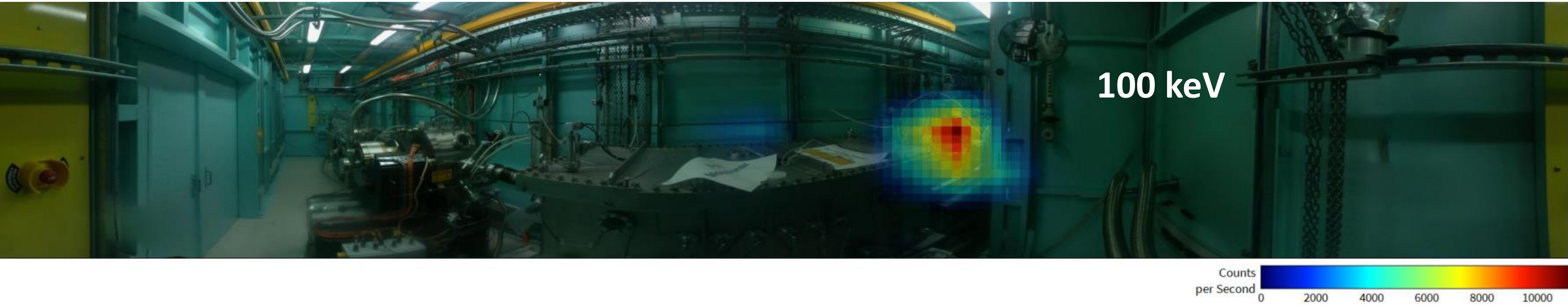

20 keV
Counts
per Second
0
500
1000
1500
2000
2500
3000

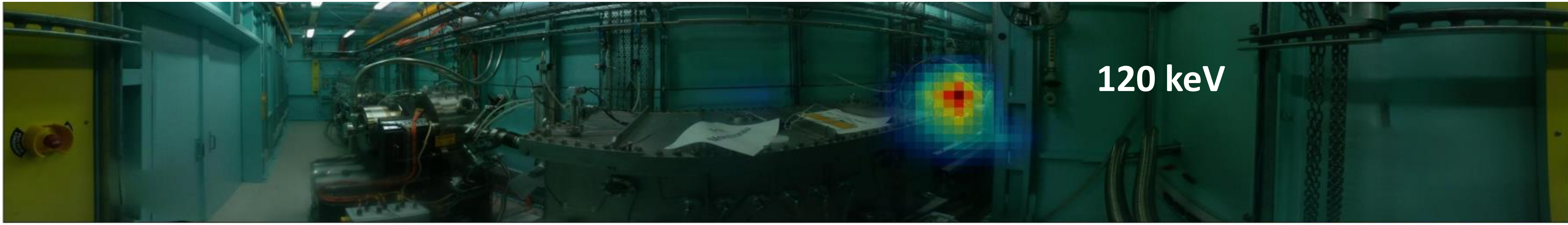

40 keV
Counts
per Second
0
2500
5000
7500
10000
12500
15000

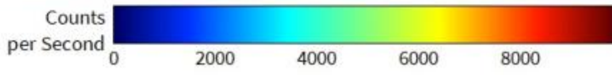

60 keV

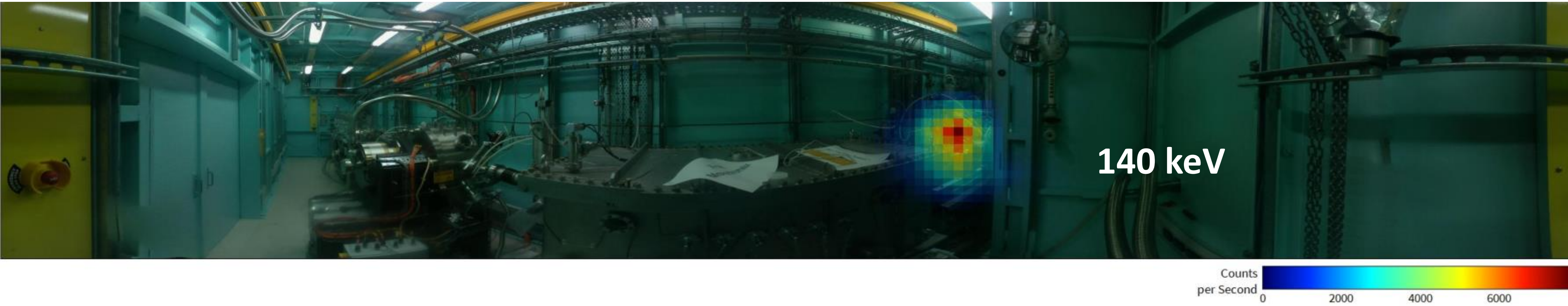

Counts
per Second
0
2500
5000
7500
10000
12500

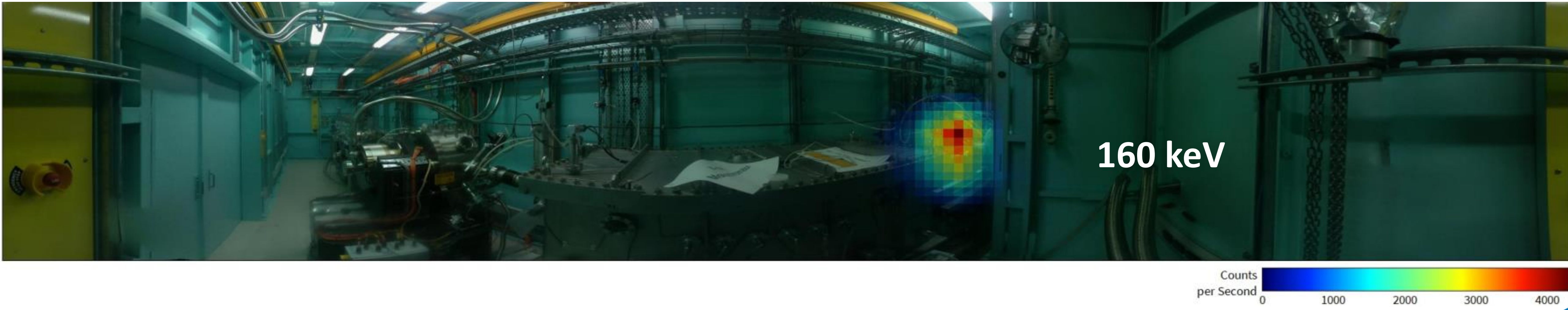

80 keV
Counts per Second
0 2500 5000 7500 10000 12500 15000 1750


100 keV
Counts per Second
0 2000 4000 6000 8000 10000


120 keV


Counts per Second
0 2000 4000 6000 8000


140 keV
Counts
per Second
0
2000
4000
6000

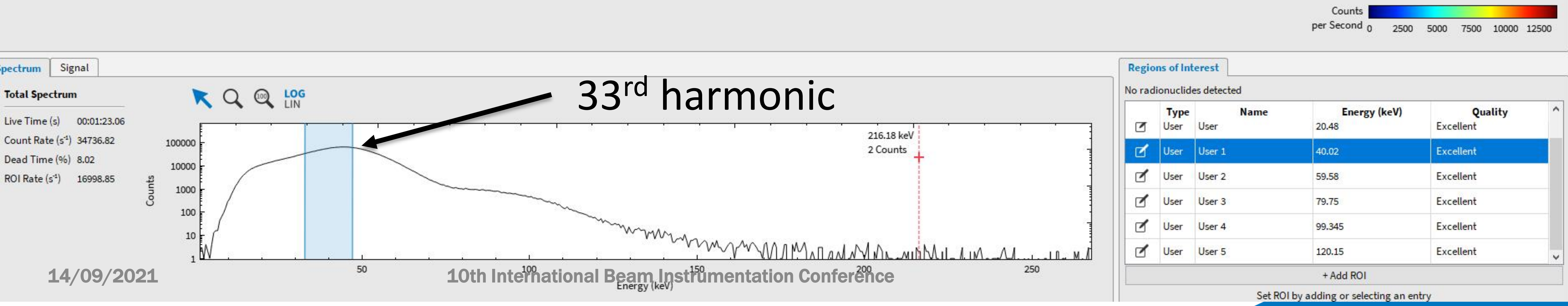

160 keV
Counts
per Second
0
1000
2000
3000
4000

In-vacuum Undulator (22mm; $K = 1.77$; $E_{1st} = 1550$ eV)

MX2 BEAMLINE

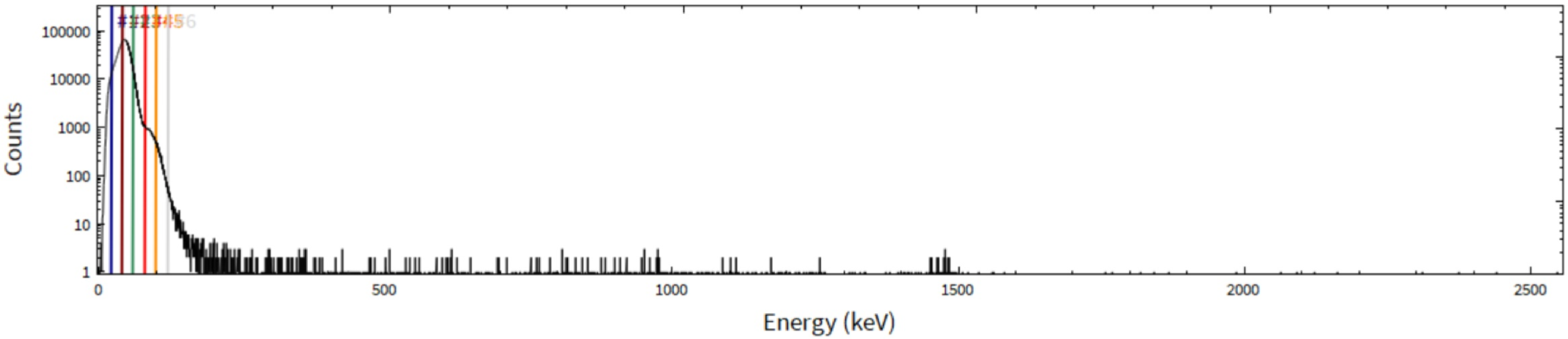
MX2 – IVU

MX2 – IVU (22mm; K = 1.77; E_{1st} = 1550 eV)



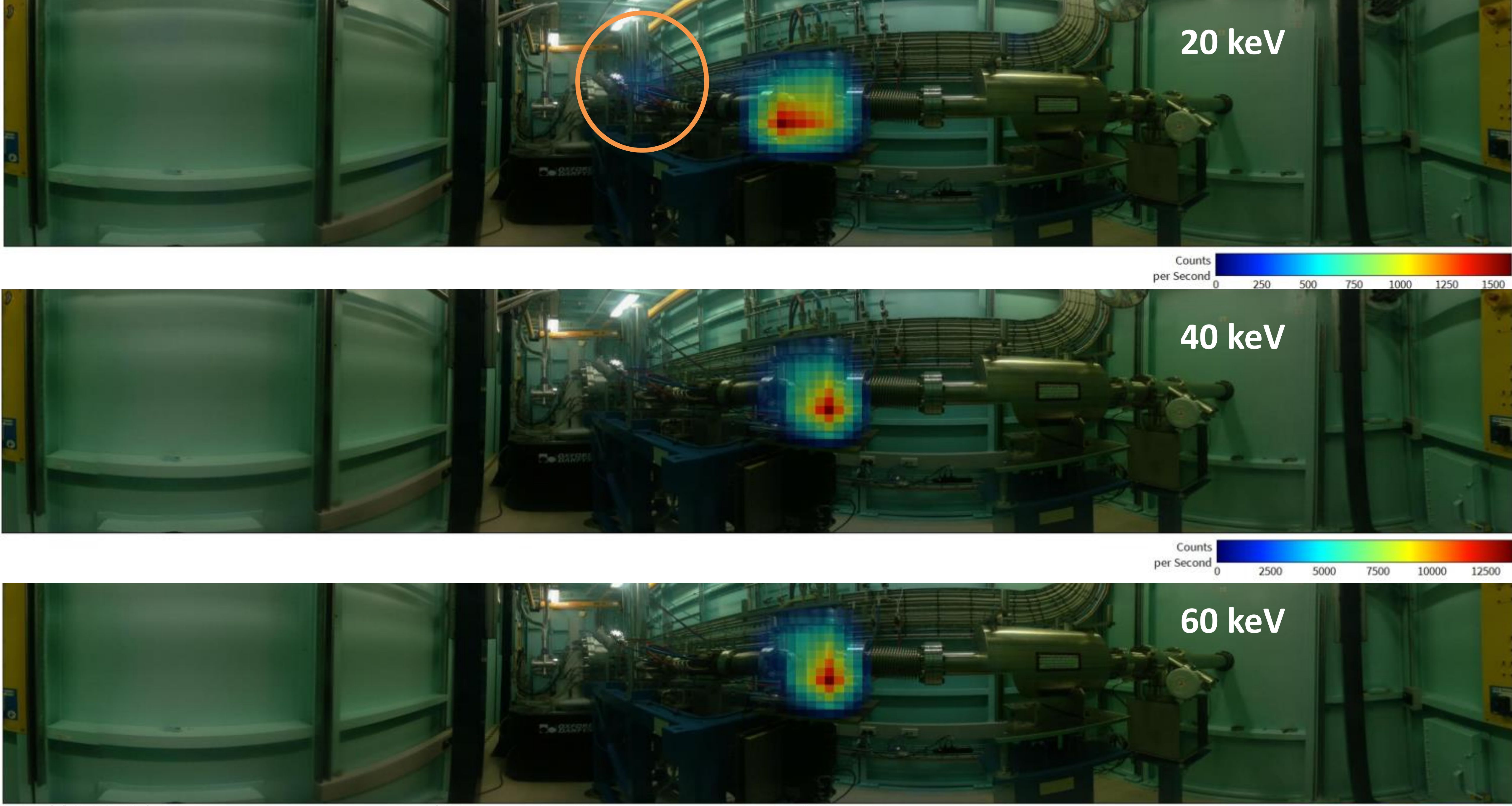
MX2 – IVU (22mm; K = 1.77; E_{1st} = 1550 eV)

Energy Spectrum



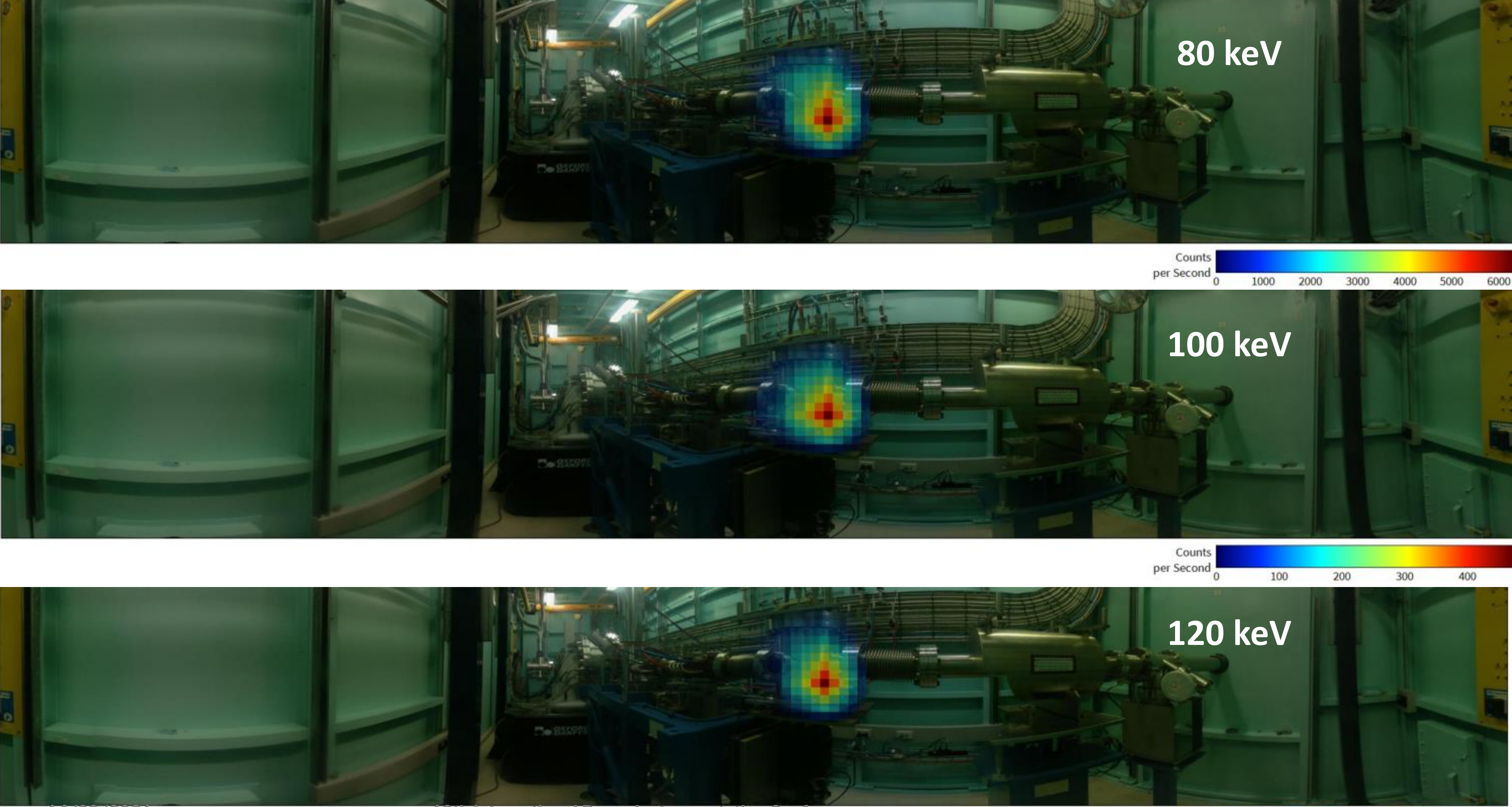
Regions of Interest

	Type	Name	Energy (keV)	Range (keV)	Counts	Rate (cps)	Quality	Page
#1	User	User	20.48	13.4 - 27.6	278165	3348	Excellent	2
#2	User	User 1	40.02	32.9 - 47.1	1411409	16992	Excellent	3



20 keV
Counts
per Second
0
250
500
750
1000
1250
1500
40 keV
Counts
per Second
0
2500
5000
7500
10000
12500
60 keV

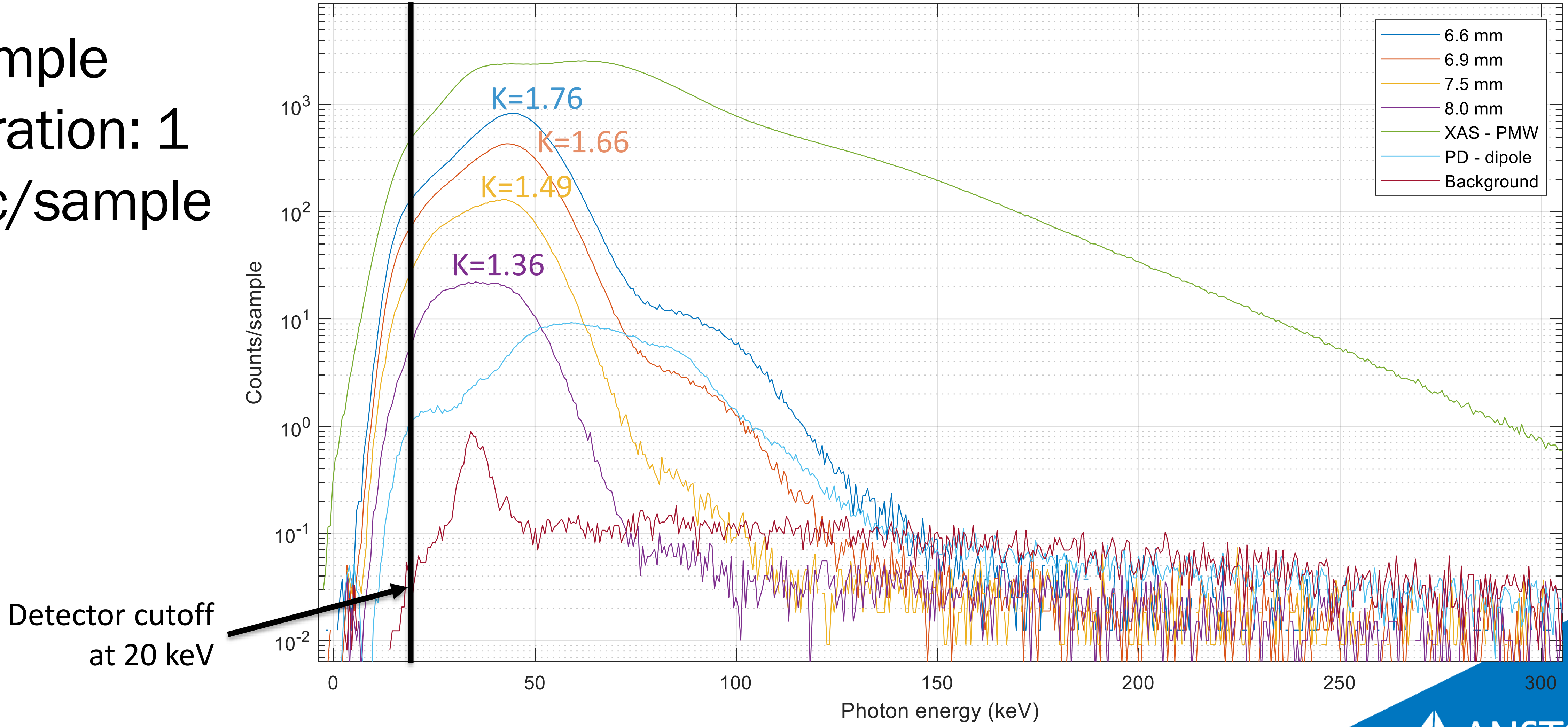
Counts
per Second
0
1000
2000
3000
4000
5000
6000


80 keV
Counts
per Second
0
1000
2000
3000
4000
5000
6000
100 keV
Counts
per Second
0
100
200
300
400
120 keV


Counts
per Second
0
50
100
150
200
250

Spectra Comparison

- Sample duration: 1 sec/sample



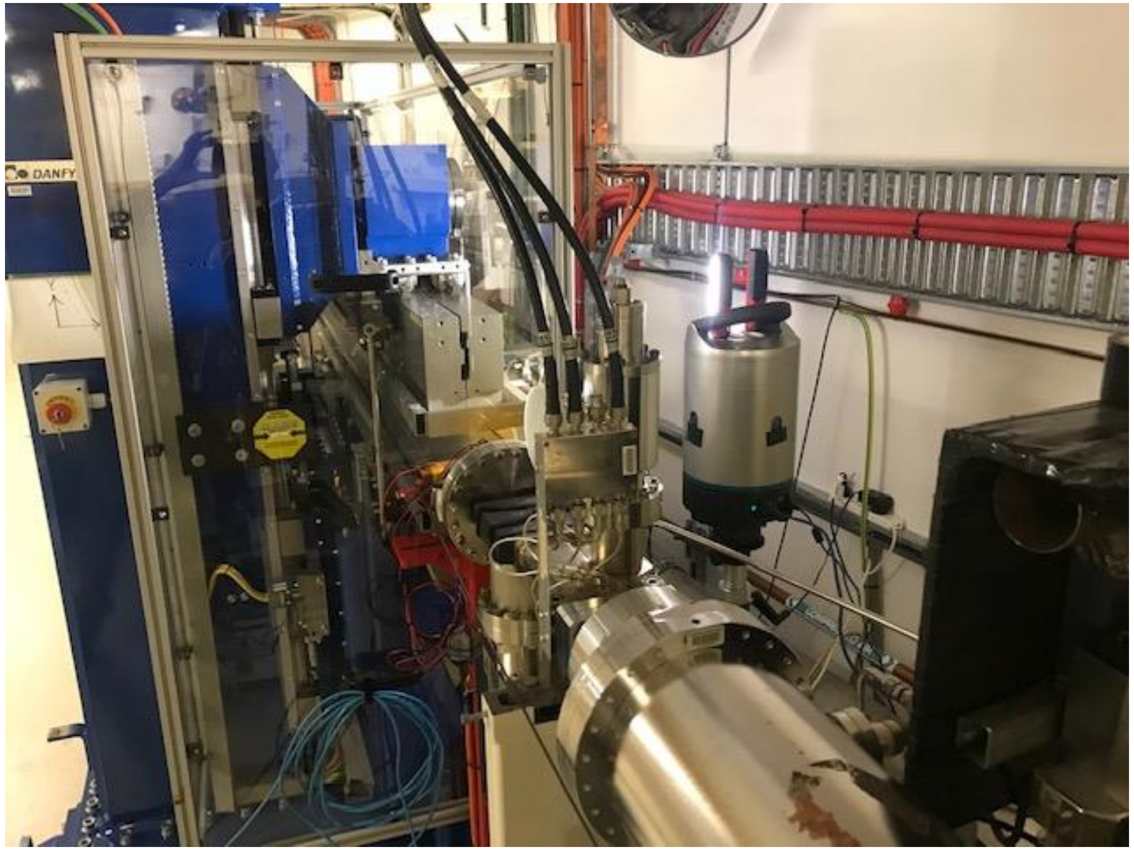
STORAGE RING

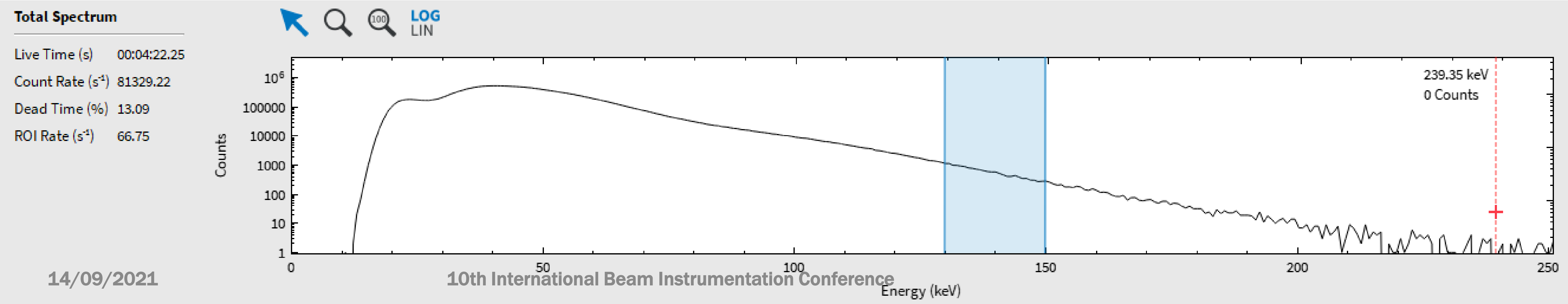
ANSTO

Radiation damage downstream of the EPU vacuum chamber

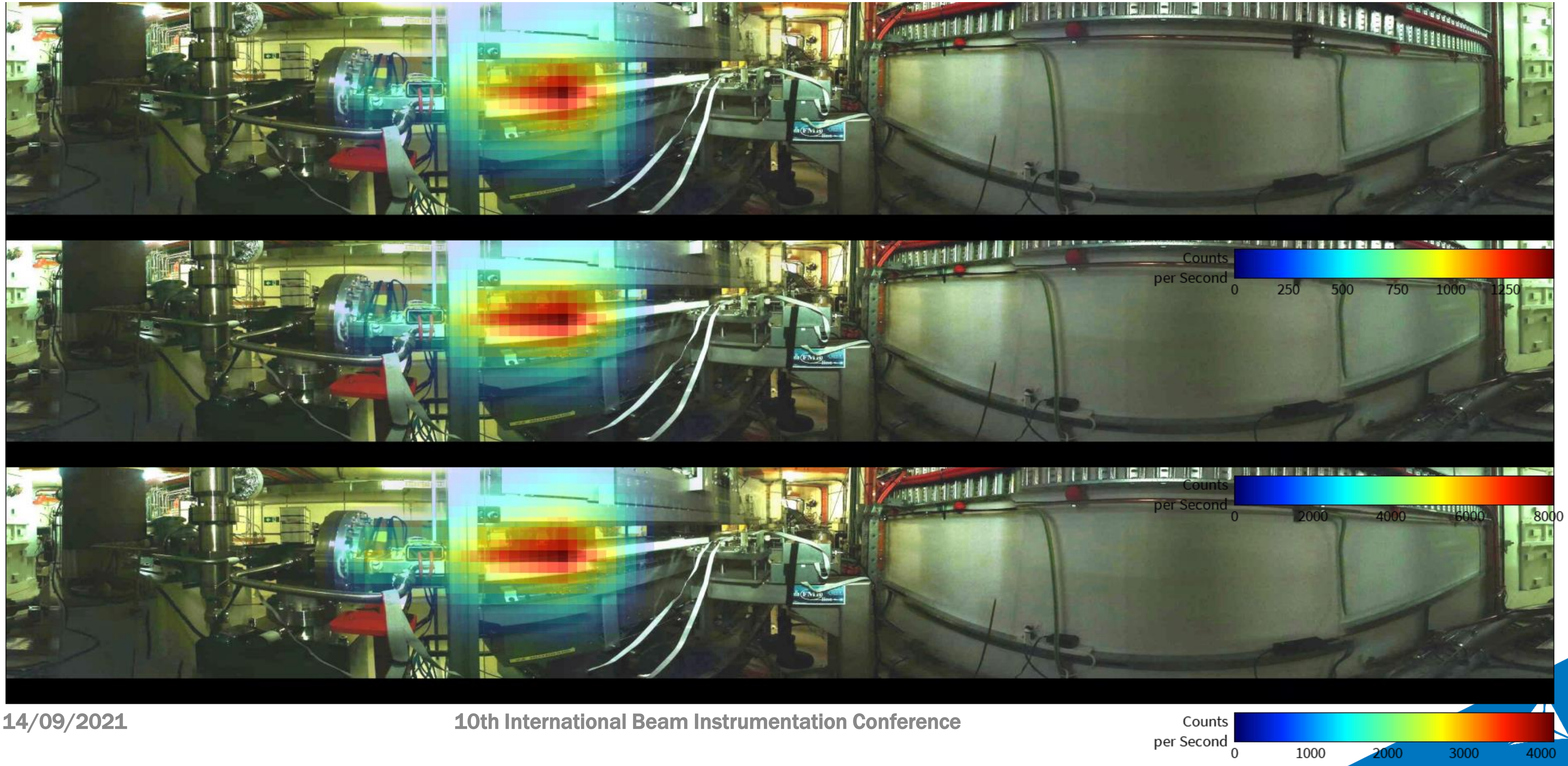
SECTOR 14

Location and Spectrum





SR14 EPU Vacuum Chamber Images

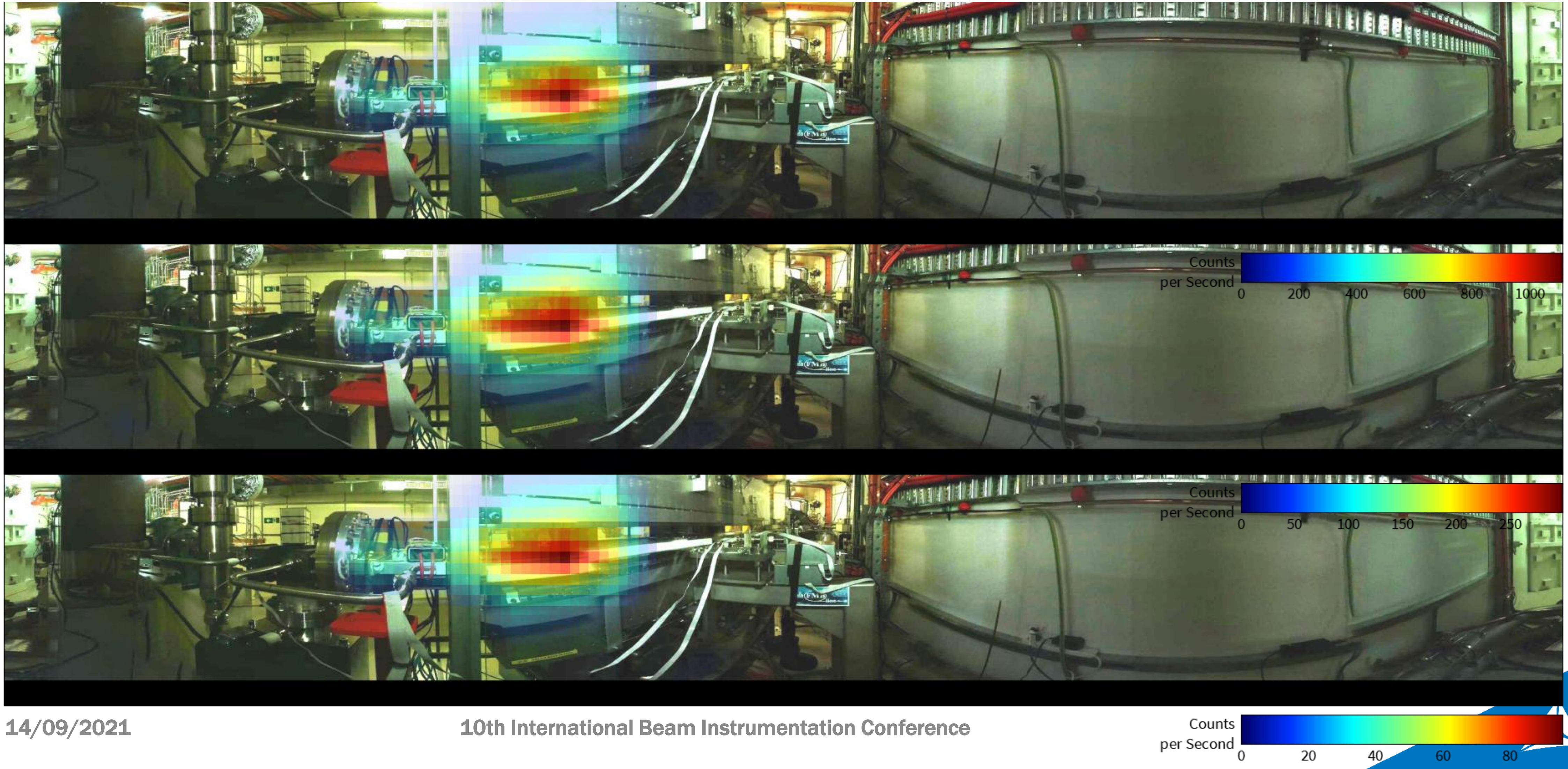


20 keV

40 keV

60 keV

SR14 EPU Vacuum Chamber Images



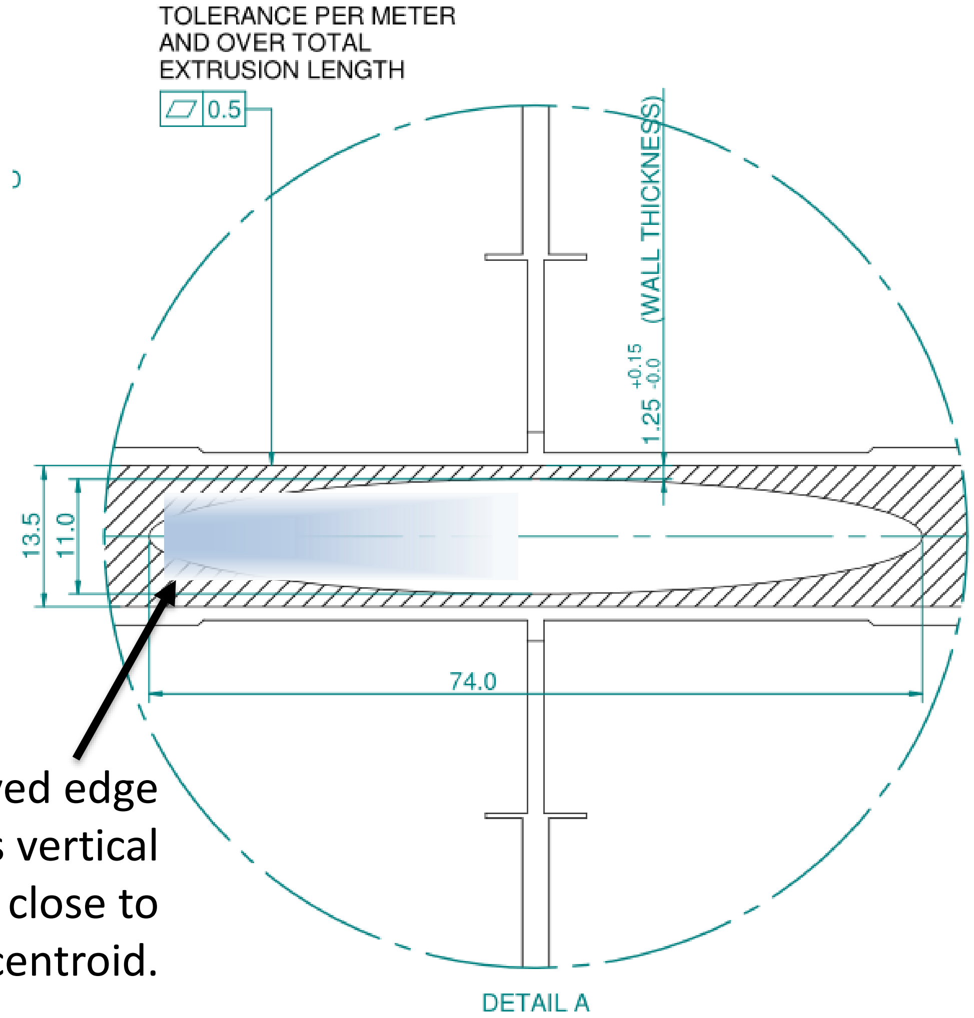
80 keV

100 keV

120 keV

SR14 EPU Vacuum Chamber Conclusions

- 2 mA!
- Spectrum shows essentially the dipole spectrum.
- Result of upstream dipole radiation illuminating the end of the narrow gap Aluminium vacuum chamber.
- Occurs in the last 300 mm of the ID vacuum chamber.
- Could be upstream mask is insufficient or a design imperfection.

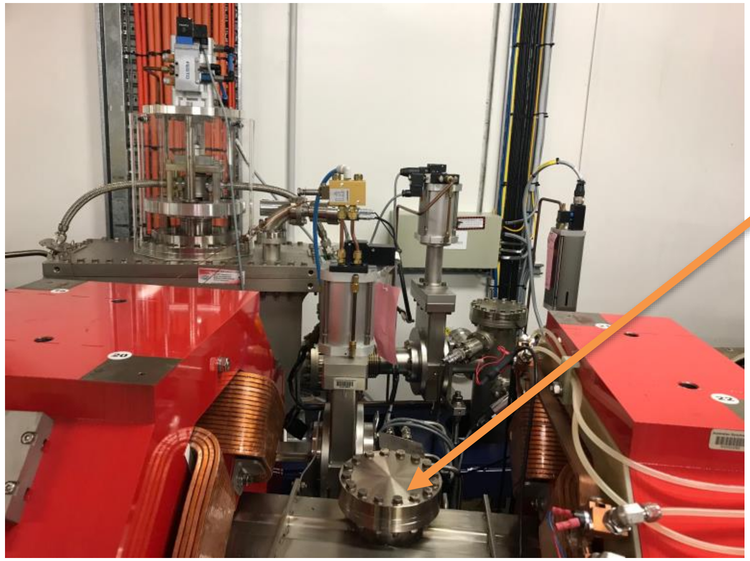


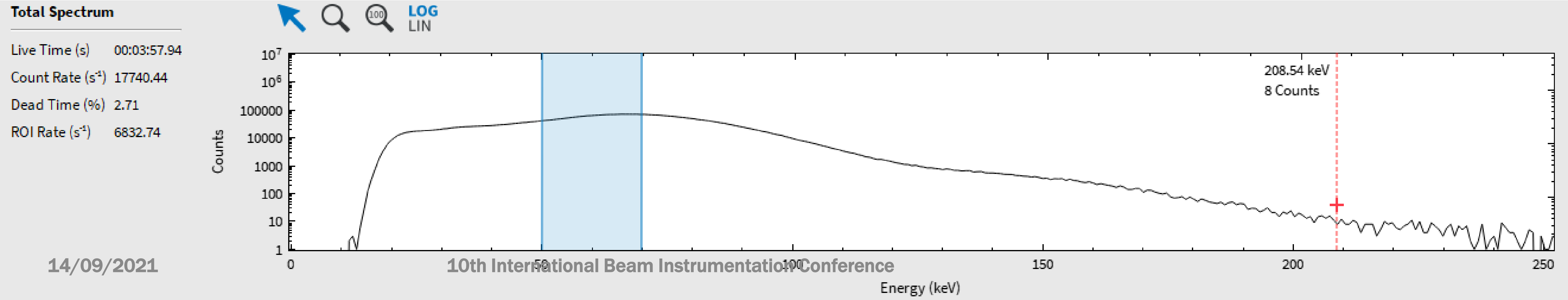
Curved edge clips vertical fan close to centroid.

Middle Long Girder, Dipole crotch absorber

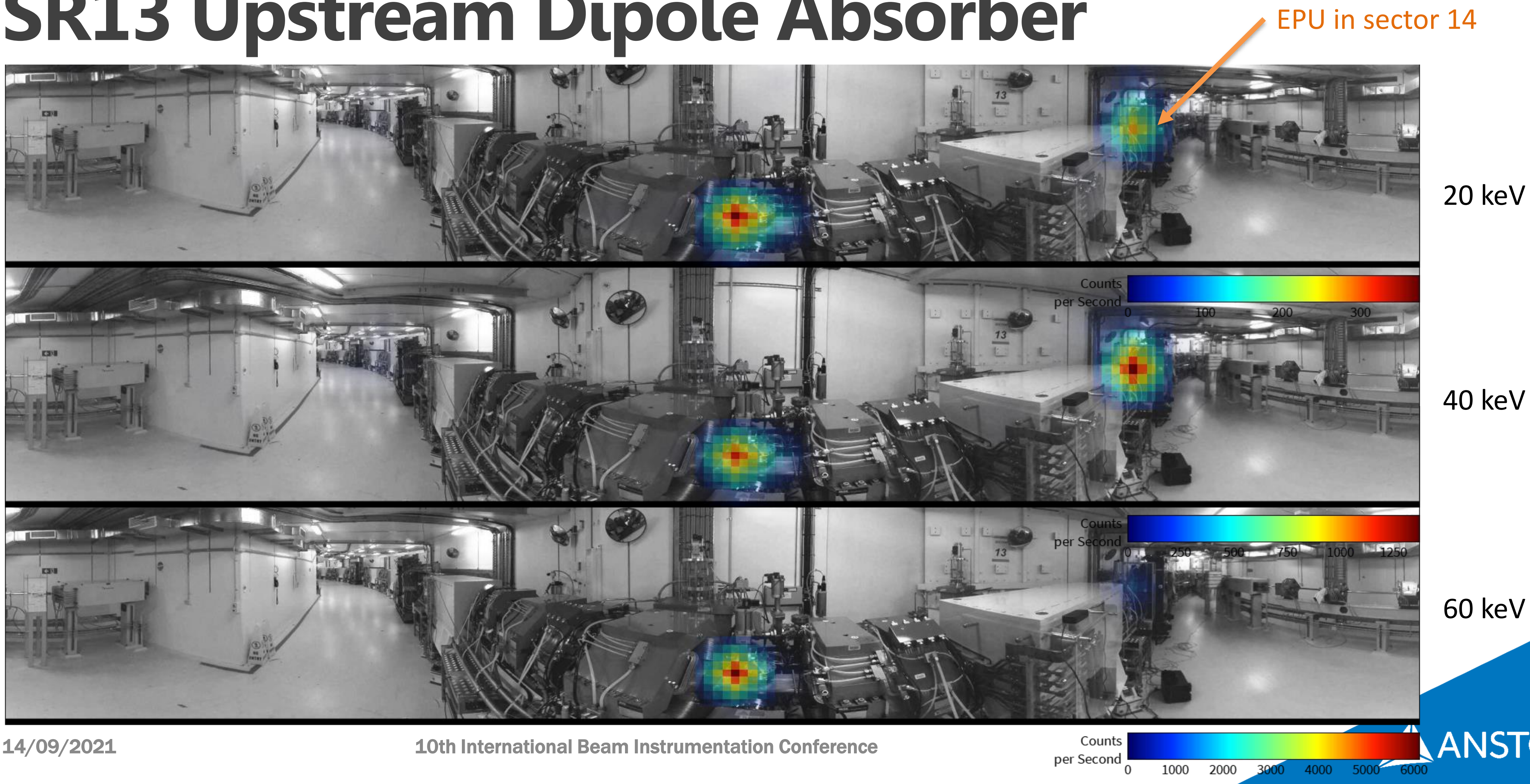
SECTOR 13

Location and Spectrum

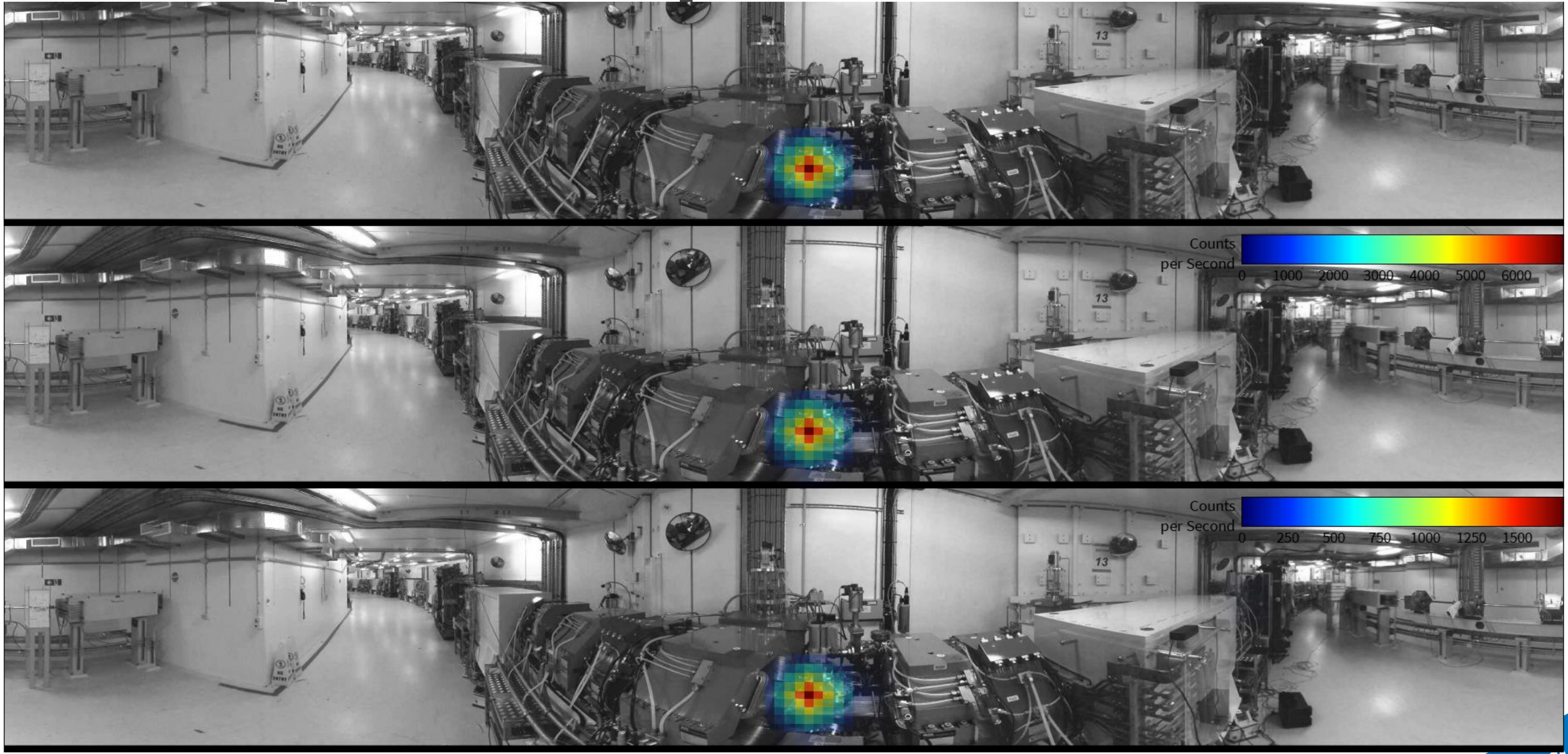




SR13 Upstream Dipole Absorber



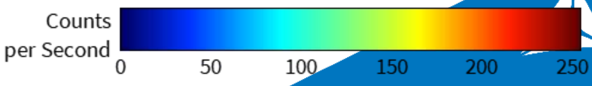
SR13 Upstream Dipole Absorber



80 keV

100 keV

120 keV



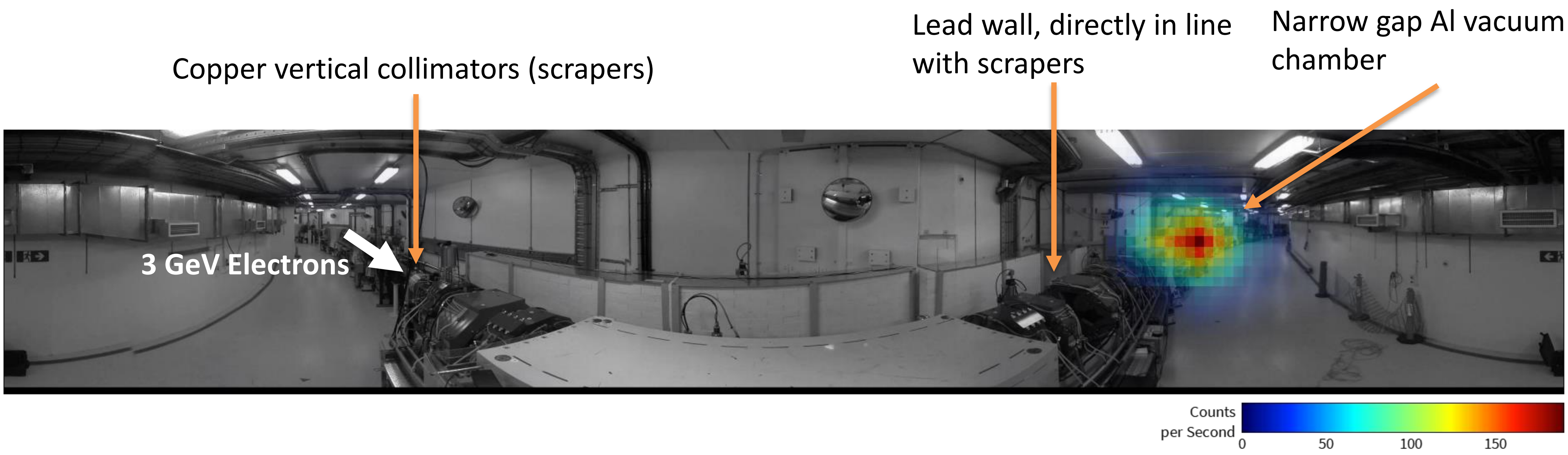
SR13 Conclusions

- Still see radiation from the EPU.
- Scattered radiation from the dipole crotch absorber can penetrate the 2mm vacuum vessel resulting in the observed spectrum.

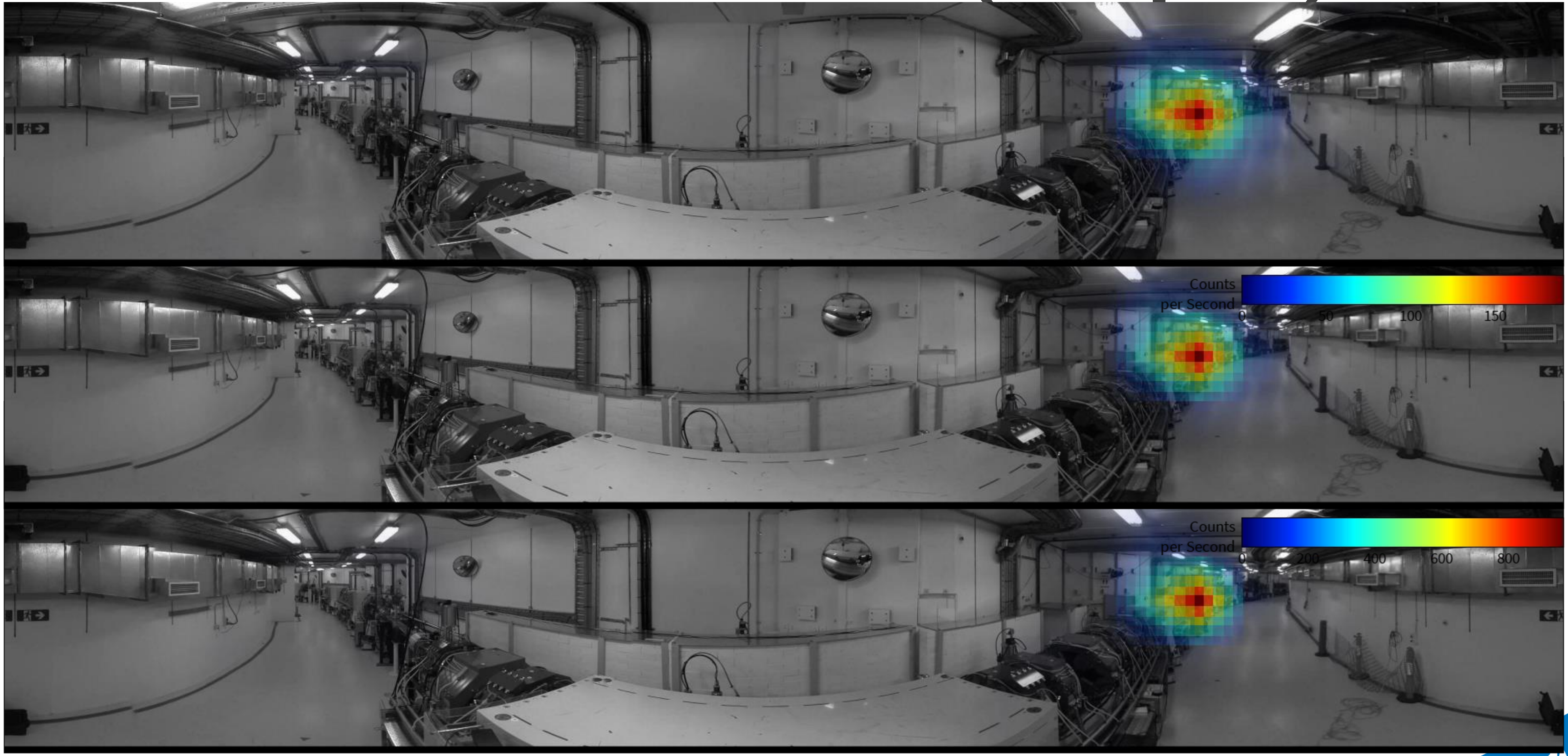
Upstream dipole – vertical collimators (scrapers)

SECTOR 11

SR11 Vertical Collimators (Scrapers)



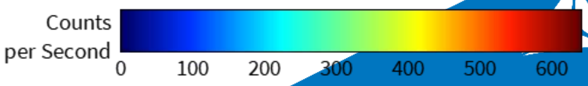
SR11 Vertical Collimators (Scrapers)



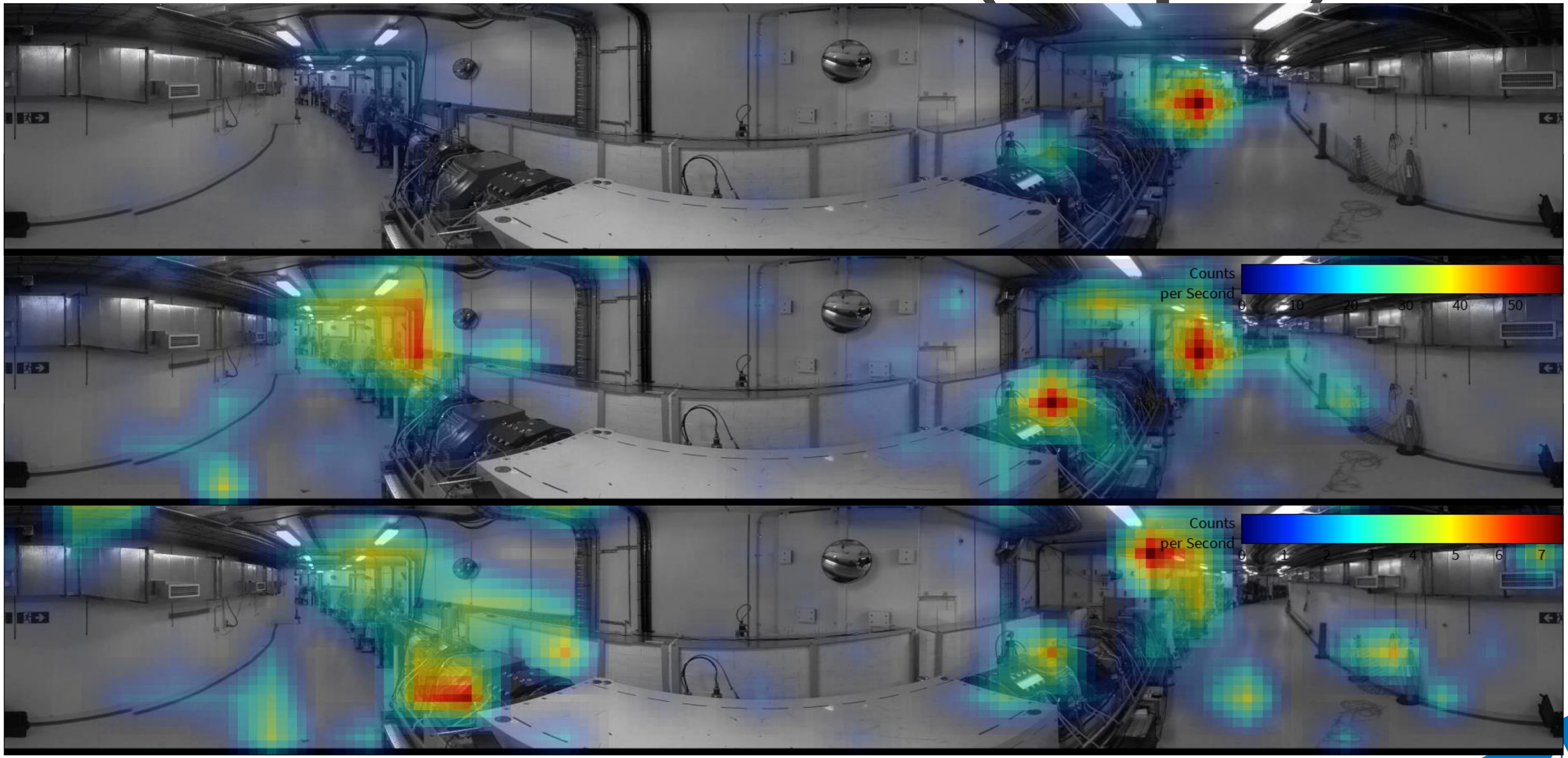
20 keV

40 keV

60 keV



SR11 Vertical Collimators (Scrapers)



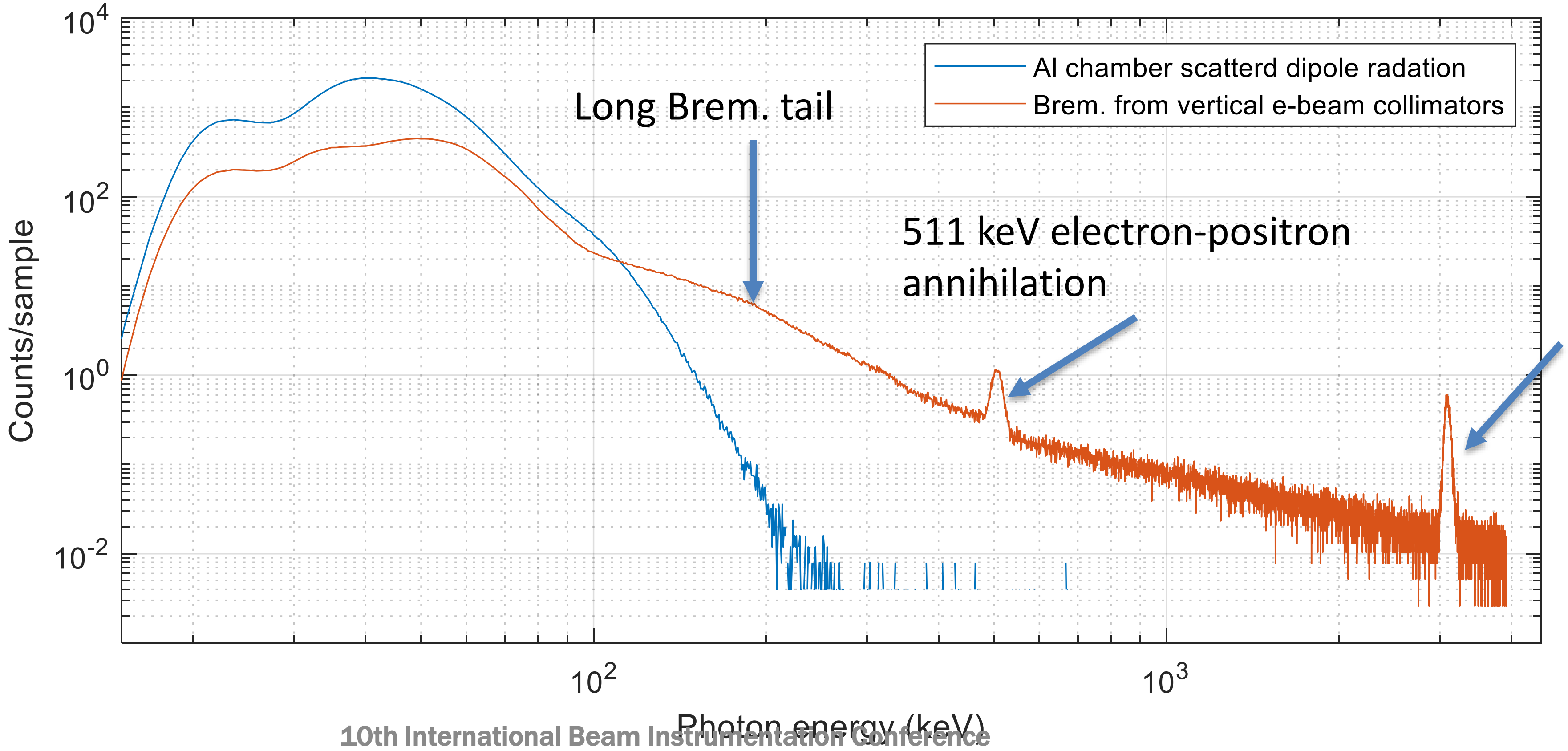
80 keV

100 keV

120 keV

SR11 Vertical Collimators (Scrapers)

Vertical scrapers closed to reduce lifetime to 6 hours.



SR11 Scraper Conclusions

- Below 100 keV, the radiation spectrum is dominated by the dipole radiation from downstream wiggler which has the same Aluminium chamber as the EPU.
- Above 100 keV, we are observing the effects of Bremsstrahlung radiation from electrons colliding with the copper scrapers.
- The radiation is scattered everywhere creating a “cloud” or sources around the scrapers and at the lead wall where the Bremsstrahlung radiation hits.

CONCLUSION

Strengths

- Will be valuable in identifying the best locations for locating and subsequently measuring local hotspots.
- Used to define where local shielding should be implemented.
- Useful where synchrotron radiation is involved.
- Can be used to isolate potential obstructions to the synchrotron radiation in the front-ends or beamline optics.

ANSTO

Weaknesses

- Weighing in at ~20 kg it is heavy
- Cannot reconstruct images if the source intensity cannot be held constant for more than a few minutes.
- Cannot be used in the injector where there is a very low duty factor (150 ns over a 1 second injection rate).

Future Plans

- Developing solutions for Aluminium chamber problems.
- Using imager to design local shielding around SCW photon absorber and reduce incidence of sensor failures around it.
- Will be working with the team that developed CORIS360 to investigate:
  - Low energy (and lighter) version of the detector
  - Optional adapters
    - like an external sensor for background measurements to help with variable intensity sources
    - Lighting options (was pretty dark in the tunnels)