Scintillation Screen & Cameras at DESY Testbeam 2021

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27/10/2021

- We plan to take data using DESY-II test-beam

- No specific, accurate measurement required (yet), mostly for experience

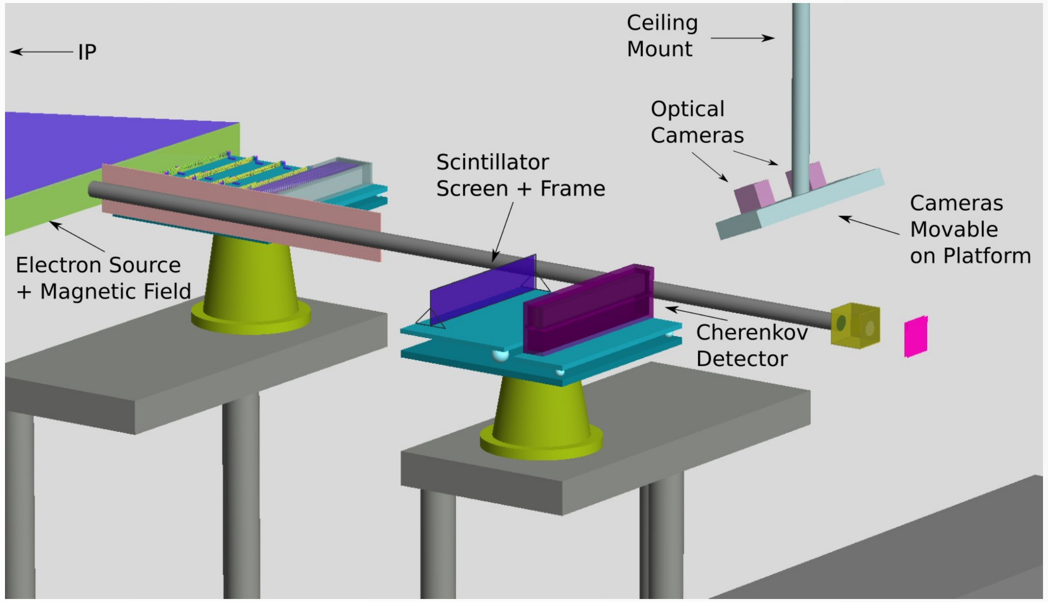
- The beam is single electron with trigger, meaning flux is lower than with LUXE

- In response place cameras closer to screen and inside dark structure (Al box-frame and thick cloth)

- testbeam rate varies highly with energy

- then use an electric trigger to isolate single-electron response as well as integrate exposure window over many

- Can veto for triggered events if triggers occur within ~5ms of one another using telescope data in post-analysis



Estimated Rates

Rates	Target 1	Target 2
Energy	3mm Cu	1mm Cu
1 GeV	~3 kHz	~1 kHz
2 GeV	~5 kHz	~1.5 kHz
3 GeV	~4.5 kHz	~1.2 kHz
5 GeV	~15Hz (6GeV in DESY II) - 600 Hz (7GeV in DESY II)	~3Hz (6GeV in DESY II) - 200 Hz (7GeV in DESY II)
6 GeV	~3 Hz (7GeV in DESY II)	~1 Hz (7GeV in DESY II)

Figures 6 and 7 show the rates vs momentum for Testbeam 21 and 24, with 6 GeV Electrons or Positrons in DESYII. Figure 8 shows a comparison of the rates for 6 GeV and 7 GeV in DESY II (measurements done 10/2008). The rates are influenced by many parameters. In practice, the maximum rate is around 5 kHz (3 GeV, 3mm Cu convert, Collimator ca. 5mm x 5mm, DESY II maximum energy at 7 GeV, no beam extraction, no DESY III ramp, single carbon wire).

Variables to Alter:

Theta – Observe relative light-level fall-off with theta; Should follow Lambertian distribution Interesting to test for 'matte' or 'glossy' screen surfaces

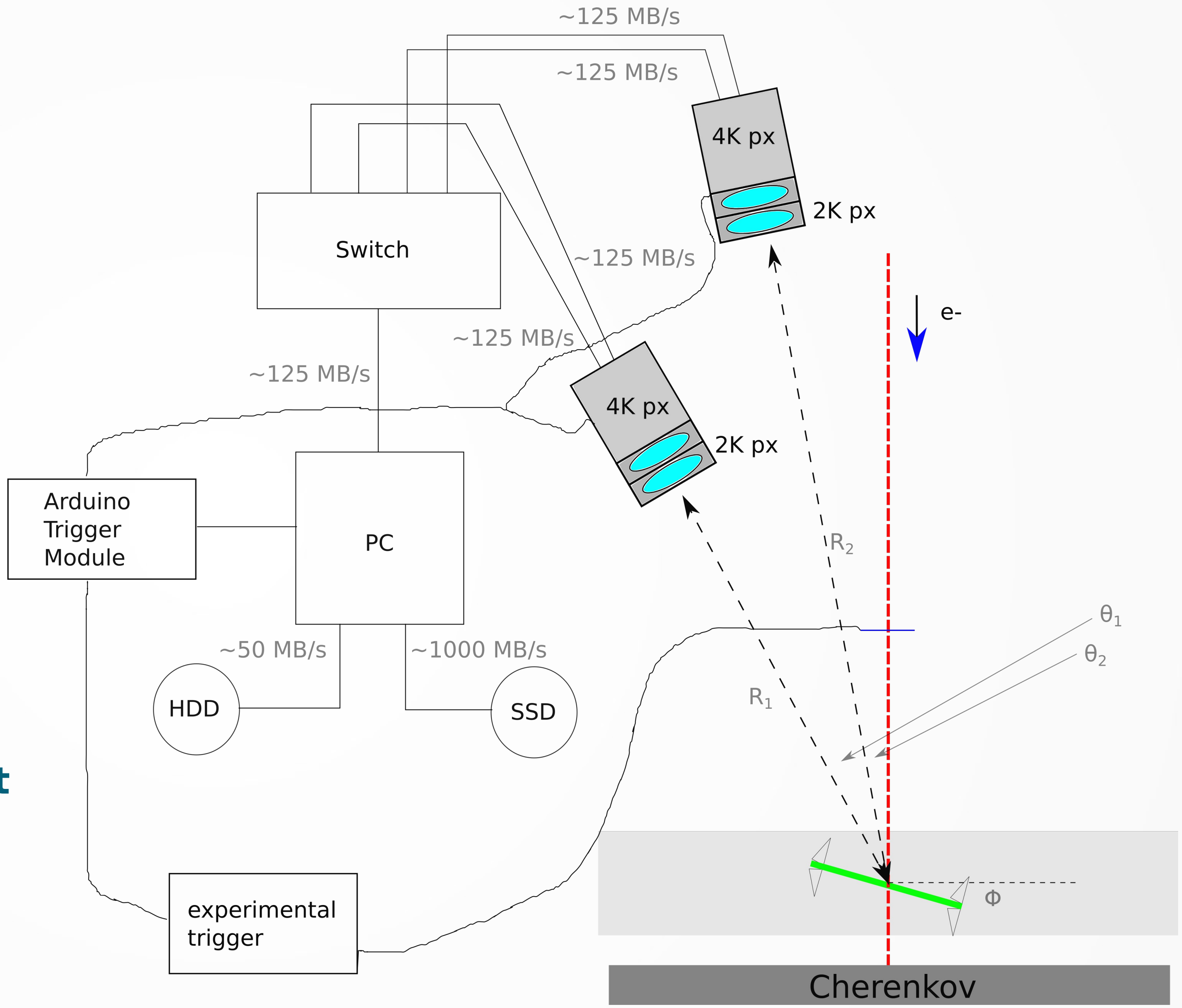
Phi – Observe relative light-level evolution screen angle to beam

Phosphor thickness – Observe increase in light levels for known phosphor layer thickness

Optical Filters – Observe signal / background light levels for several bandwidth filters

Electron Energy – Ensure consistent light levels for beam energy (1 – 6) GeV

Exposure time – In single-electron mode, vary exposure time to measure cumulative scintillation time evolution



Data & trigger

- TTL trigger generated by Testbeam 'Telescopes'

- Trigger intercepted by Arduino hardware module (Thanks Stefan!) and only transmitted if cameras are ready – all triggers are counted to relate back to telescope data

- Use lossless .tiff files, no inherent compression available from cameras

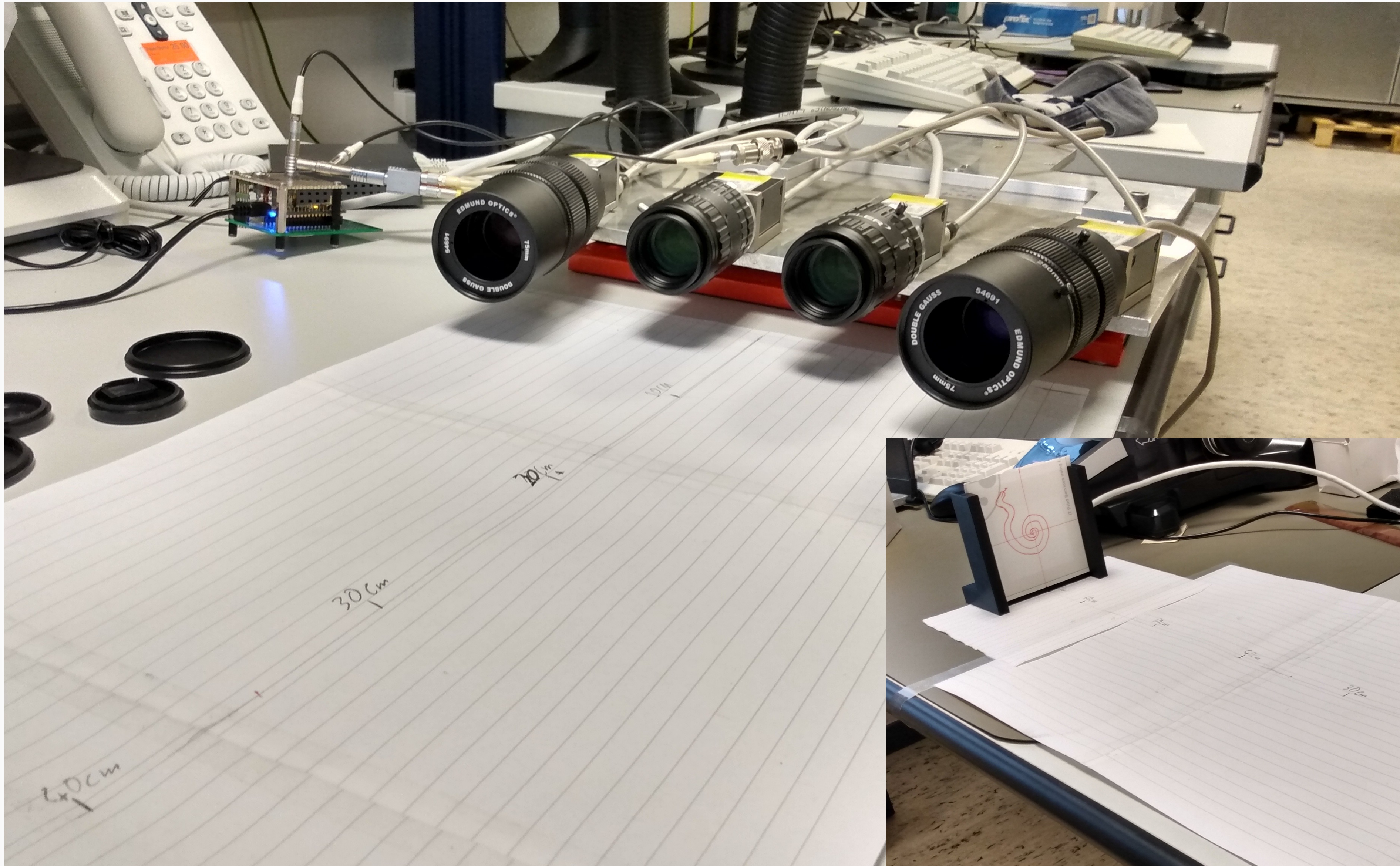
- Save directly to quick SSD, compress, then send to HDD

- We take a run then, (for longer runs sub-divide to not exceed SSD) and compress with .zip immediately after, for mostly dark images, can achieve final compression of ~97%

- Define a central part of the image in each camera as 'signal' and outside as background

- Keep a bookkeeping .txt file which should be automatically generated at the start of each run, detailing all parameters, any failed frames, and print the integral for 'signal' and 'background' regions

- Can use the images after the fact to create more usable data on the spread and intensity of the signal, maybe in ROOT format, but do this afterwards to preserve precious computation time during collection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54691
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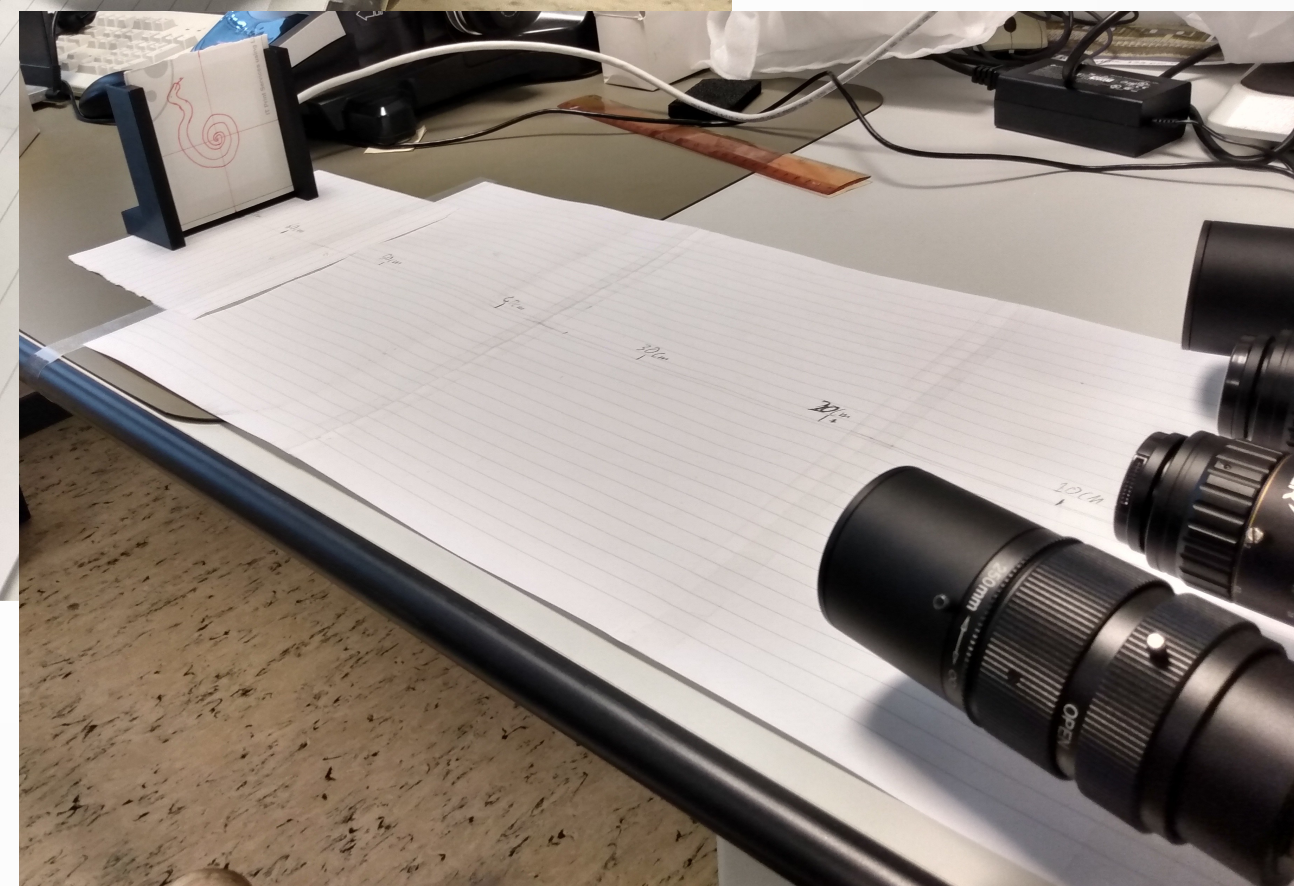
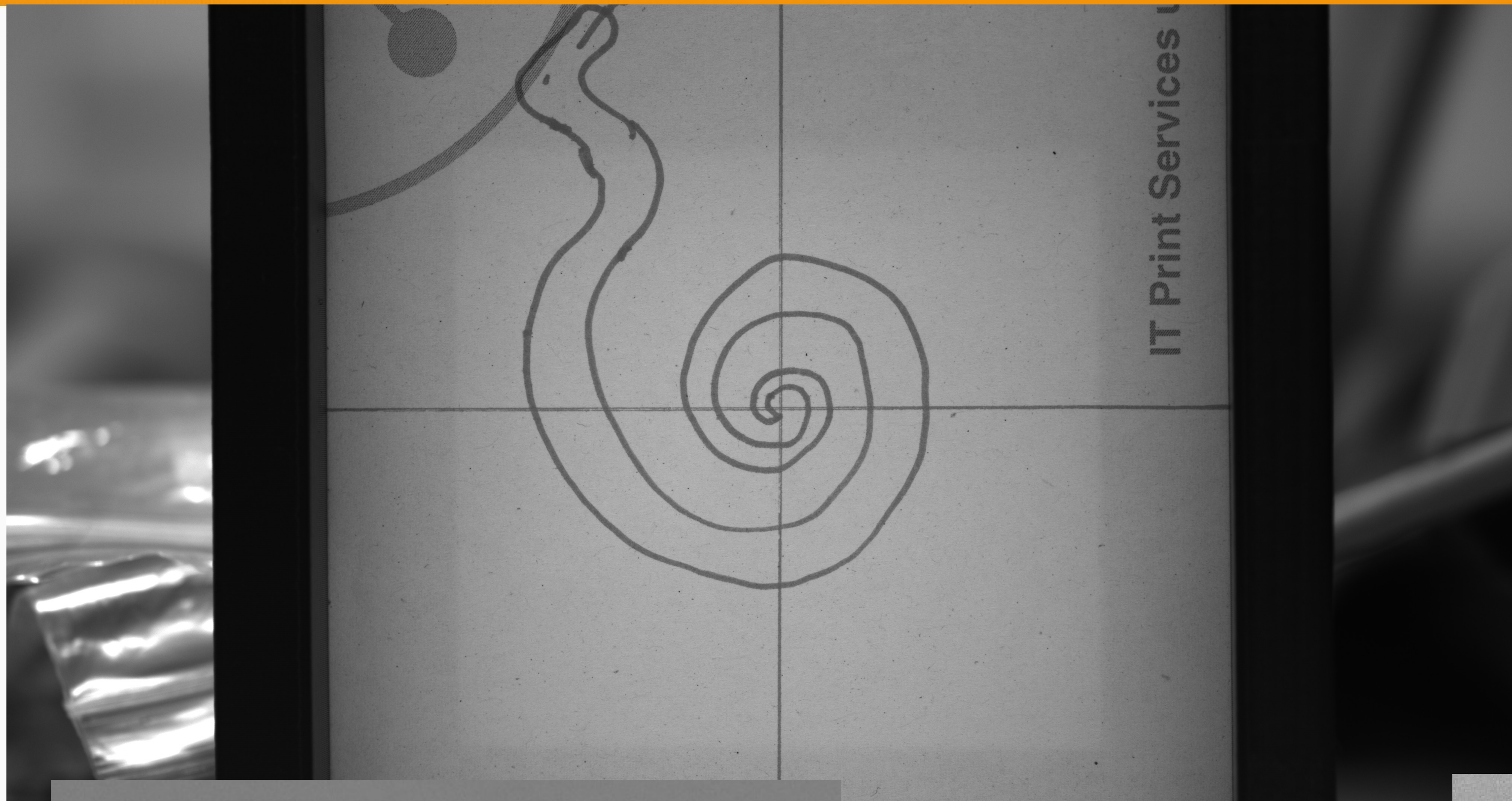
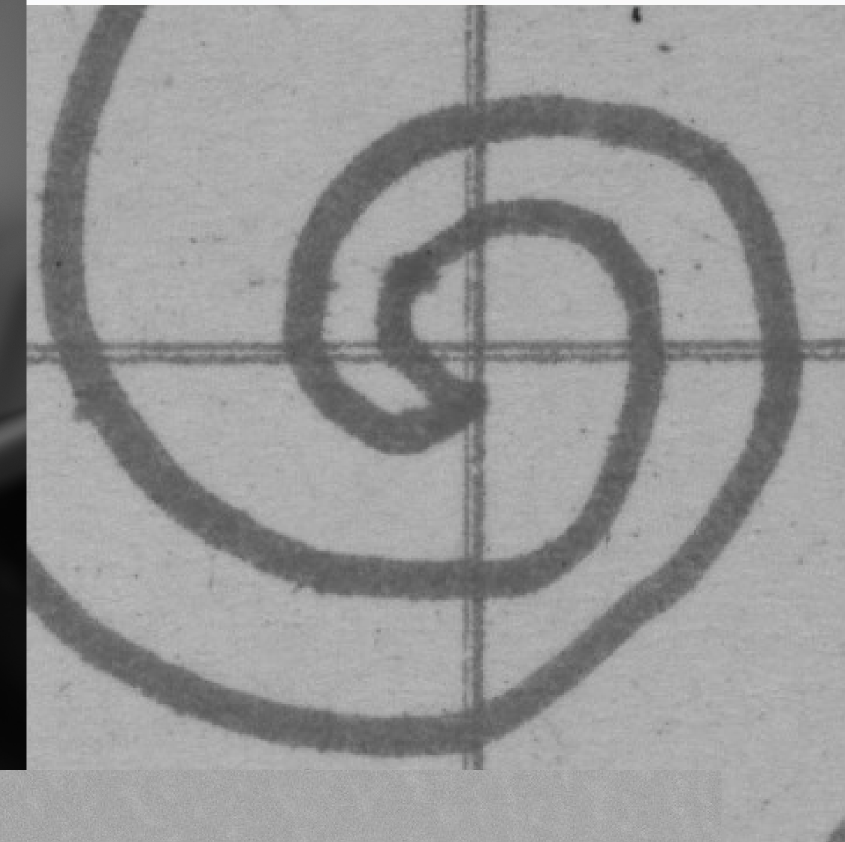
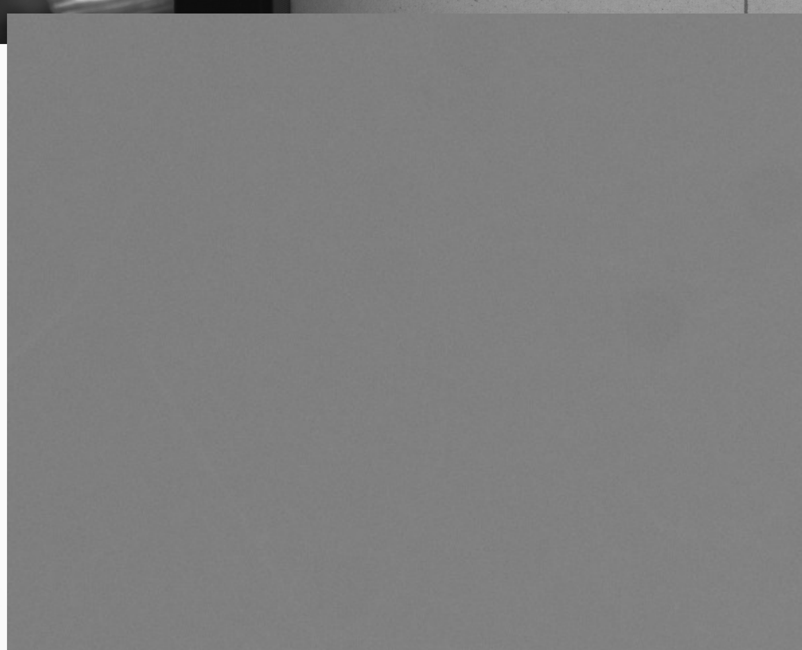








- ‘Glossy’

‘Matte’

https://docs.google.com/spreadsheets/d/1MUYqUjDCOFNoMdnNdjy7_6UkY6ORQ7WHRWiXeji-R2k/edit#gid=0

LUXE Scint Screen TB2021

File Edit View Insert Format Data Tools Add-ons Help Last edit was seconds ago

Q30 =sum(Q3:Q29)/60

Run ID	theta (deg)	phi (deg)	Screen	E_electron	t_exposure (ms)	Camera 4K_1 filter	Camera 4K_2 filter	Camera 2K_1 filter	Camera 2K_2 filter	d_screen_camera (m)	events to acquire	sqrt(S)/S	beam frequency estimate (Hz)	imaging frequency (Hz)	camera exposed as fraction time	time estimate (min)	storage estimate (GB) uncompressed	HDD usage Max 2TB 97% compressio	SSD Usage Max 240 GB
	angle betwe	angle betv	std=140µm	GadOx, plu	400 ms shor	f=50mm lens	f=75mm lens	f=50mm lens	f=75mm lens	not including orthogonal	distance from axis to		frequency take	exact for 'frame	over time	taking into account zipping transferring time for longer runs			
1	30	0	High	1 GeV	400	543 nm filter	543 nm filter	no filter	no filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
2	30	0	High	1 GeV	400	Green Filter	Green Filter	Machine Vision F	Machine Vision F	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
3	30	0	High	1 GeV	400	no filter	no filter	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
4	30	0	High	1 GeV	400	Machine Vision	Machine Vision	Green Filter	Green Filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
5	20	0	High	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
7	40	0	High	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
8	50	0	High	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
9	20	0	Plus	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
11	30	0	Plus	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
12	40	0	Plus	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
13	50	0	Plus	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
14	30	0	Standard	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
15	30	10	High	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
16	30	20	High	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
17	30	30	High	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
18	30	40	High	1 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1000	2	0.8	2.083333333	3.75	3.75	3.75
19	30	0	High	2 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1500	2	0.8	1.388888889	2.5	2.5	2.5
20	30	0	High	3 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	1200	2	0.8	1.736111111	3.125	3.125	3.125
21	30	0	High	4 GeV	400	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	100,000	0.32%	800	2	0.8	2.604166667	4.6875	4.6875	4.6875
22	30	0	High	5 GeV	3	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	50,000	0.45%	200	2	0.006	529.1666667	816	20.4	
22	30	0	Standard	5 GeV	3	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	50,000	0.45%	200	2	0.006	529.1666667	816	20.4	
22	30	0	Plus	5 GeV	3	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	50,000	0.45%	200	2	0.006	529.1666667	816	20.4	
23	30	0	High	6 GeV	3	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	25,000	0.63%	1	1	0.003	529.1666667	408	10.2	
24	30	0	High	5 GeV	1	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	50,000	0.45%	200	2	0.002	529.1666667	816	20.4	
25	30	0	High	5 GeV	1.5	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	50,000	0.45%	200	2	0.003	529.1666667	816	20.4	
26	30	0	High	5 GeV	2	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	50,000	0.45%	200	2	0.004	529.1666667	816	20.4	
27	30	0	High	5 GeV	2.5	Machine Vision F	Machine Vision F	543 nm filter	543 nm filter	0.7	50,000	0.45%	200	2	0.005	529.1666667	816	20.4	
															sum (hrs / GB)	71.20659722	6190.3125	223.3125	70.3125
															max storage at any one time [GB]			223.3125	172.3125

- Have (at least) 8 longterm runs suitable for overnight
- up to 6TB total! Can use .txt file for faster analysis
- will condense all these images to some sort of ROOT file afterwards
- total ~ 71 hours (3 days) beam time.. realistic?

To Discuss:

- Alignment in TB area? Lasers?
- TB telescopes? I have worked with the data but not sure how to set them up..
- TLU? Have successfully triggered with pulse generator.. Ruth should know
- Dark spots on images.. how to clean lenses?

backup

Scintillator Screens

Phosphor Panel for Digital Radiography

Name	Composition		X-Ray Attenuation	Brightness	Relative Brightness	MTF	
						@ 1 lp/mm	@ 2 lp/mm
DRZ-Std	Protective Layer	PET 6µm	42%	7.1	145%	0.82 (106)	0.49 (114)
	Phosphor Layer	140µm, 68mg/cm²					
	Supporting Layer	Plastic Base 250µm					
	Total	406µm					
DRZ-Plus	Protective Layer	PET 6µm	53%	8.5	173%	0.72 (93)	0.36 (83)
	Phosphor Layer	208µm, 100mg/cm²					
	Supporting Layer	Plastic Base 250µm					
	Total	464µm					
DRZ-High	Protective Layer	PET 9µm	66%	11.2	229%	0.44 (57)	0.16 (37)
	Phosphor Layer	310µm, 145mg/cm²					
	Supporting Layer	Plastic Base 188µm					
	Total	507µm					

- Acquired from MCI Optonix (USA) which get the screens from Mitsubishi Chemical

- Have 6 10cm x 10cm screens of three differing thicknesses/brightnesses

- Thicker Gadox Layer → more light, but less fine image

- Active element Terbium-doped Gadolinium Oxysulfide highly efficient in terms of light emitted/ energy deposited

- produces ~545 nm light emitted over relatively long decay time 0.6 ms (>99% emission after 3ms)

Cameras

- Two each of two models, one with double the ‘x’ resolution (1920*1200px vs 4096*2160px)

- Stream power & Data over ethernet (up to 1000Mbps), power & trigger can also come from 6-pin

- Functions with ‘Pylon’ software, C++ based, has GUI

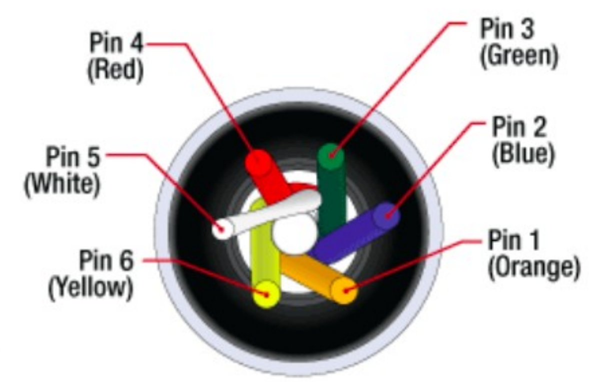
- Easy to crop image size to only desired area, streamlining data & storage

- up to 12 bits/monochrome pixel (nominal dynamic range 0 - ~4000)

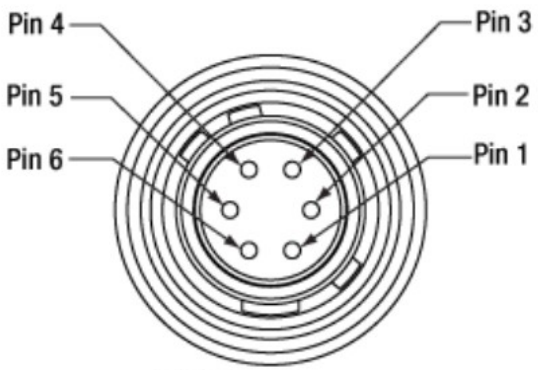
Hirose 6-pin

Wiring Information

Pin Number	Wire Color	ace GigE without GPIO	ace GigE with GPIO	aviator CL
1	Brown	Camera Power	Camera Power	Camera Power
2	Pink	Opto-isolated IN (Line1)	Opto-isolated IN (Line1)	Camera Power
3	Green	Not connected	GPIO (Line 3)	Not connected
4	Yellow	Opto-isolated OUT (Out1)	Opto-isolated OUT	Not connected
5	Gray	Opto-isolated I/O Ground	Opto-isolated I/O Ground	Camera Power Ground
6	White	Camera Power Ground	Camera Power and GPIO Ground	Camera Power Ground



Wire Diagram



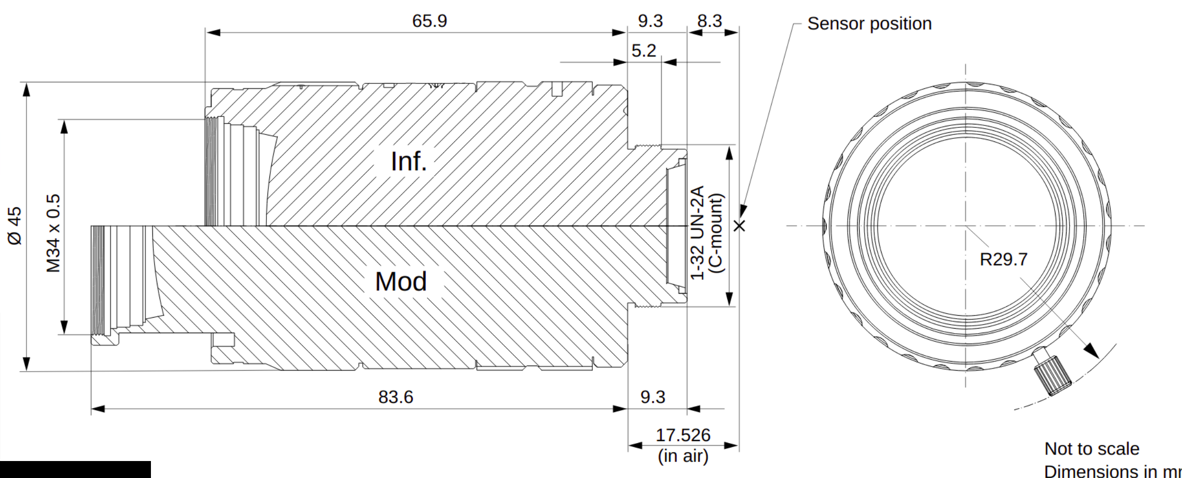
Male Hirose Connector

Have cables wired only to IO ground and line 1

Lenses

Basler Lens C11-5020-12M-P

Basler Premium C-mount lens with a fixed focal length of 50 mm, aperture range from F2.0–F16, and a resolution of 12 MP.



- Lens Focal length dictates the working distance required to image a particular object height/width

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TECHSPEC® 75mm DG Series Fixed F

75mm Focal Length, #54-691

Stock #54-691

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Qty 1-49
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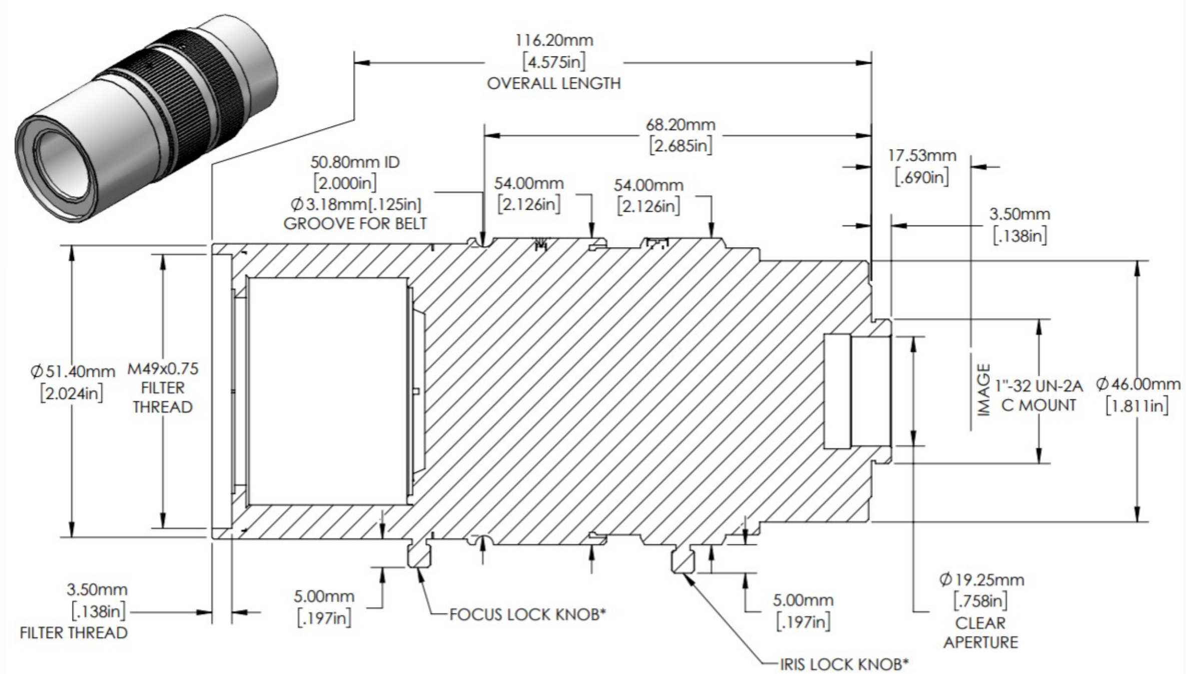
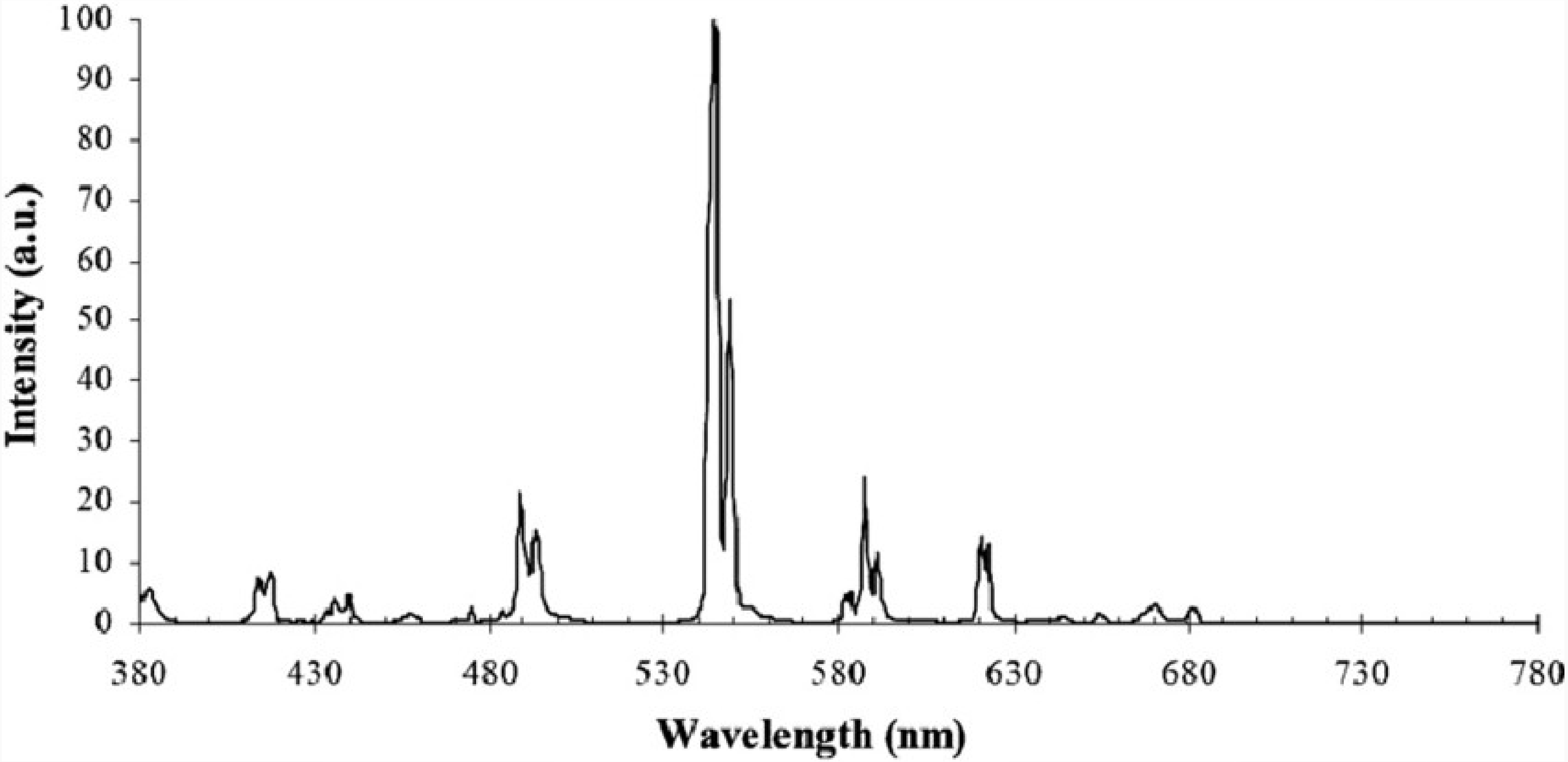


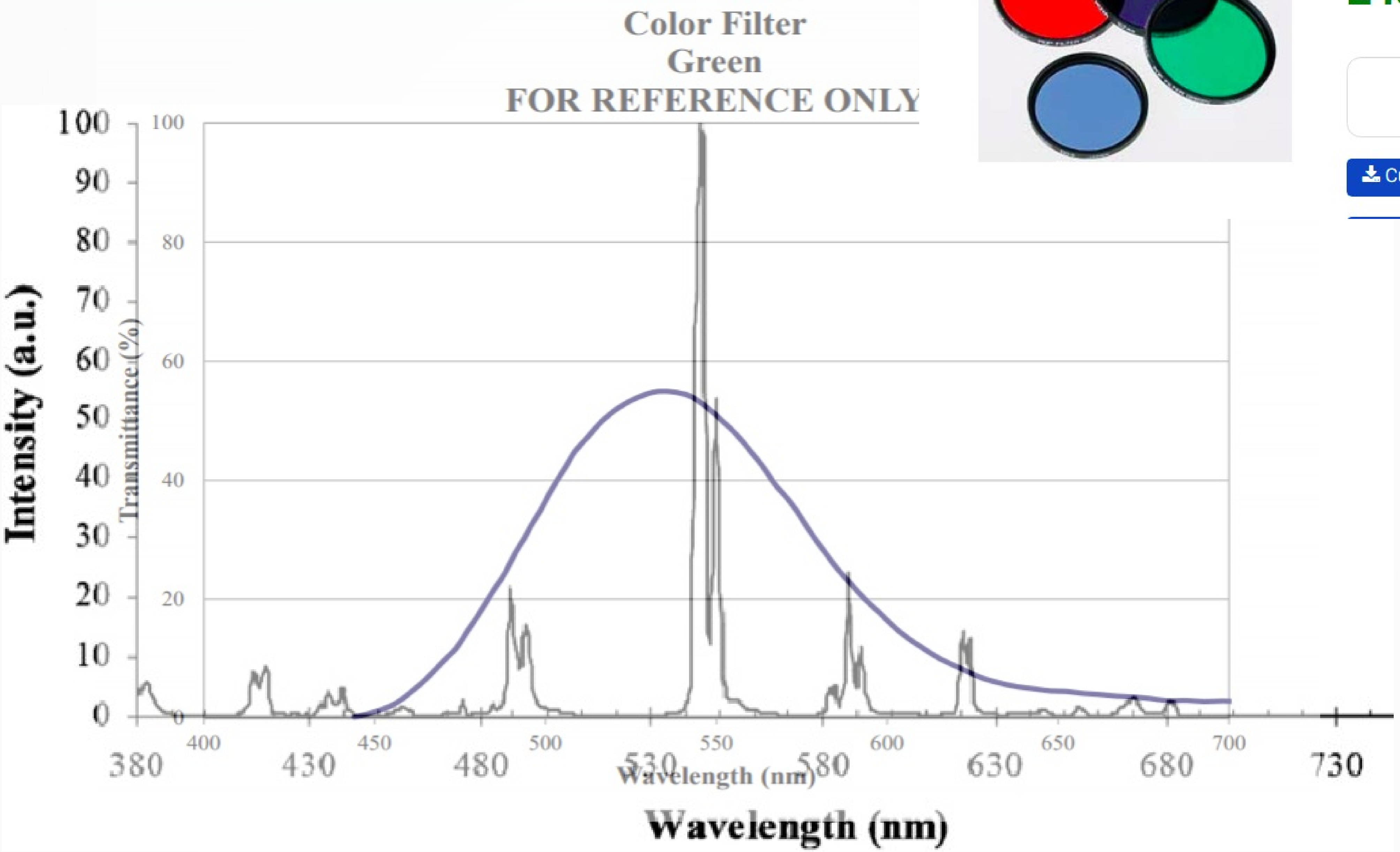
Terbium-doped GadOx emission profile



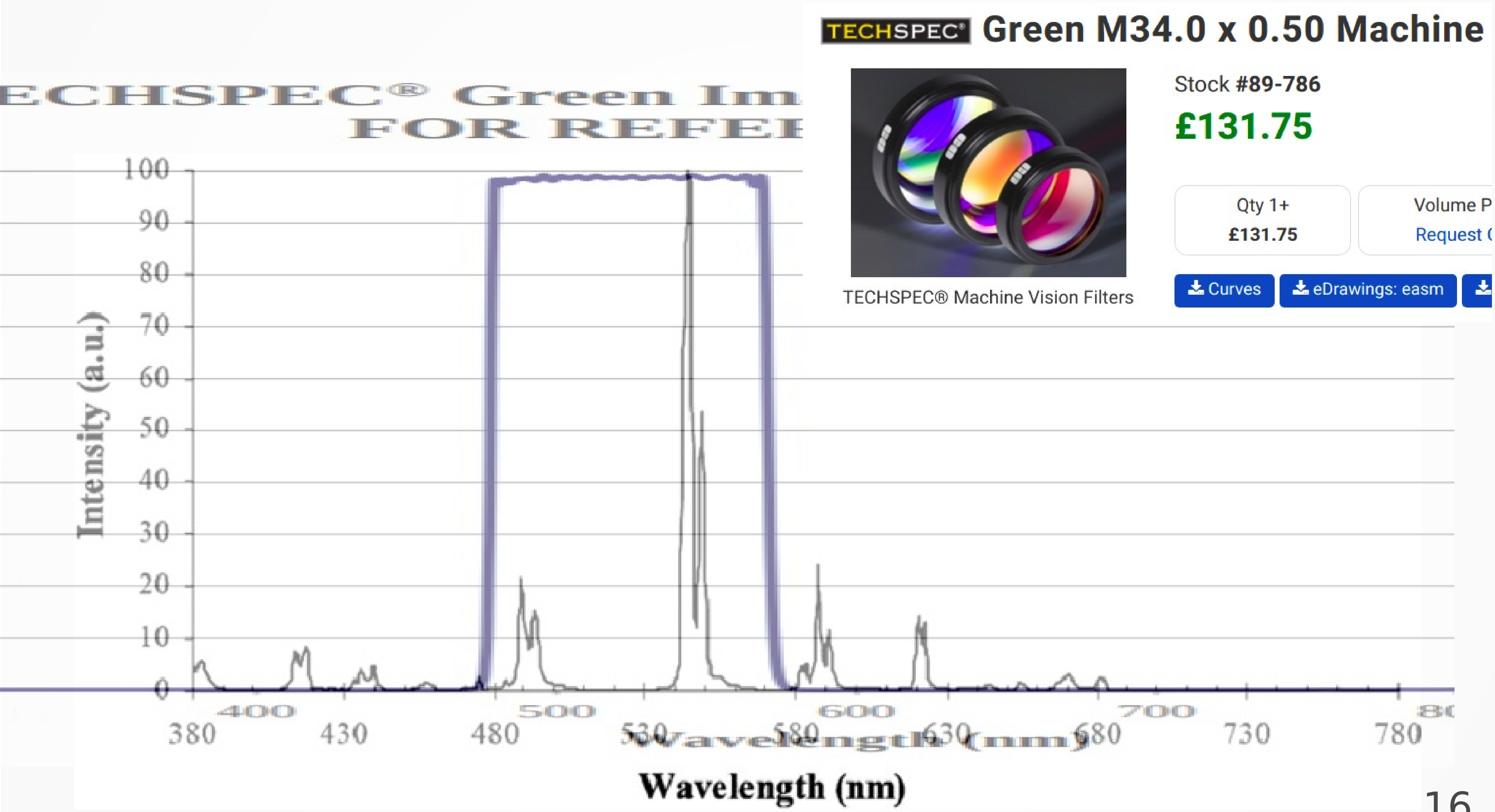
Jung, Im & Cho, Min & Lee, Sang & Bae, Kong & Jung, Phill & Lee, Chi & Lee, Jae & Yun, Seungman & Kim, Ho Kyung & Kim, Seong & Ko, Jong. (2008). Flexible Gd2O2S:Tb scintillators pixelated with polyethylene microstructures for digital x-ray image sensors. Journal of Micromechanics and Microengineering. 19. 015014. 10.1088/0960-1317/19/1/015014.

Optical Filters

A very cheap option with transmission curve:

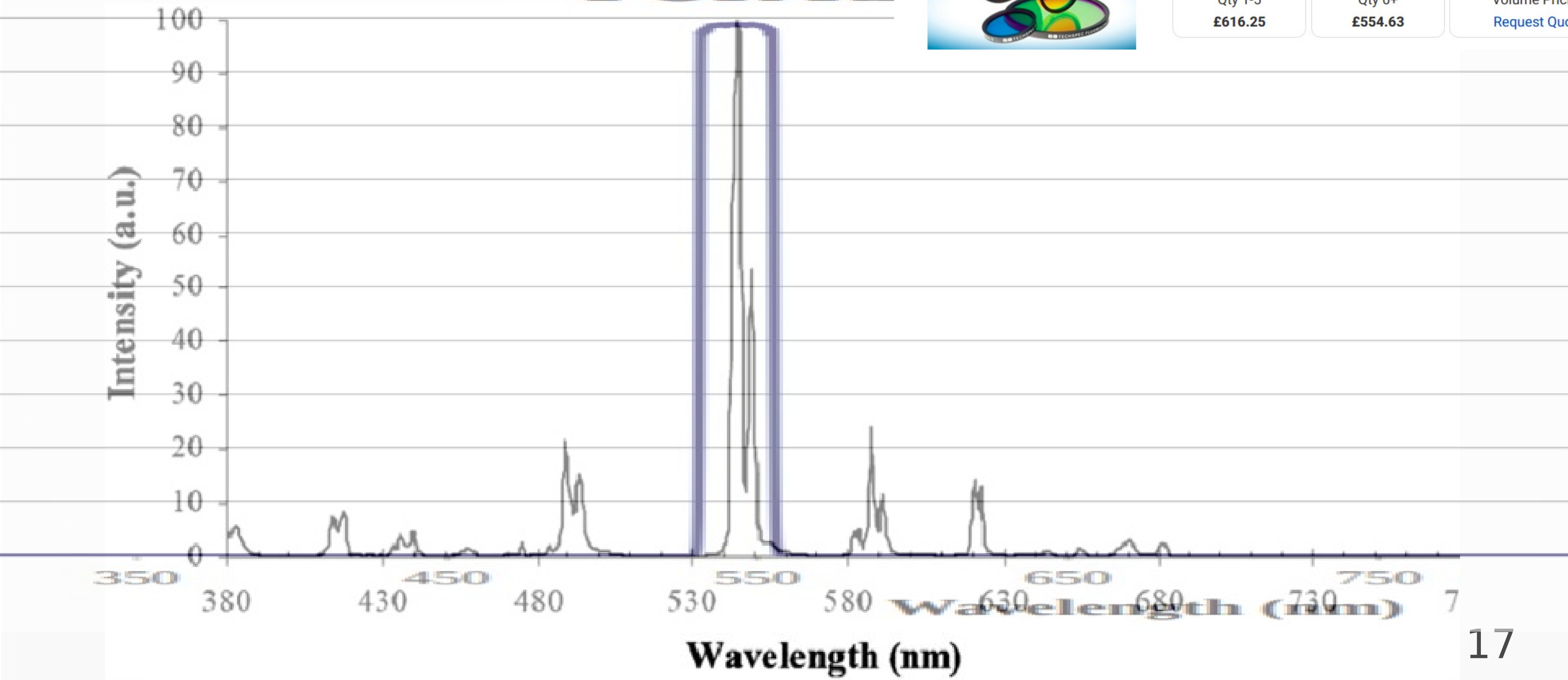


Optical Filters



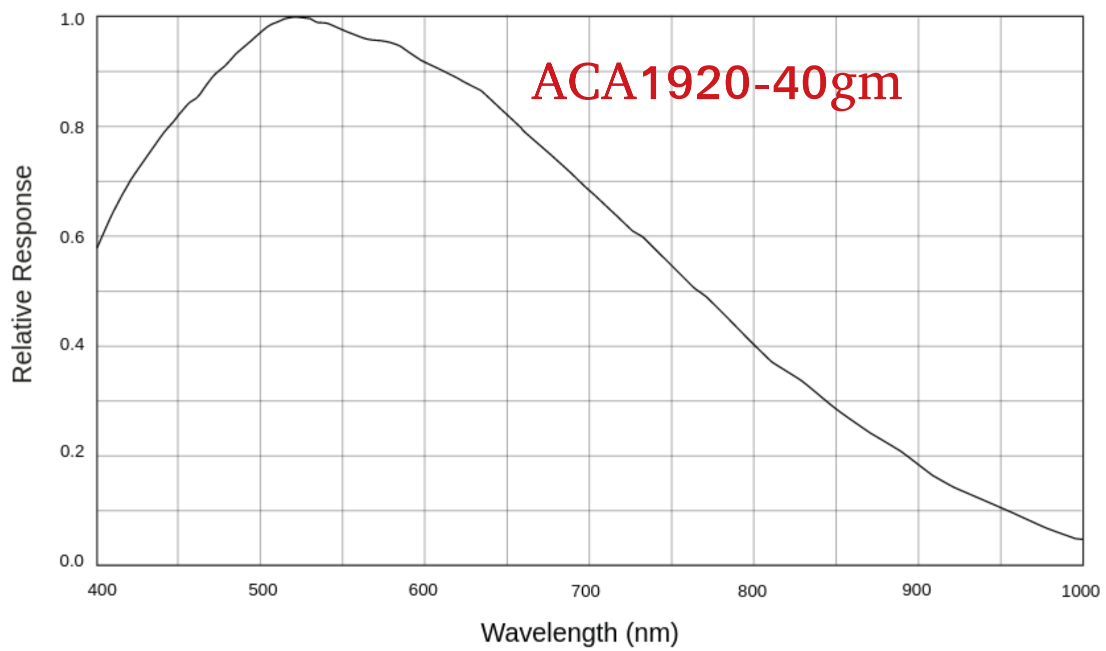
Optical Filters

There exist more expensive options with a wavelength specificity beyond what we need..

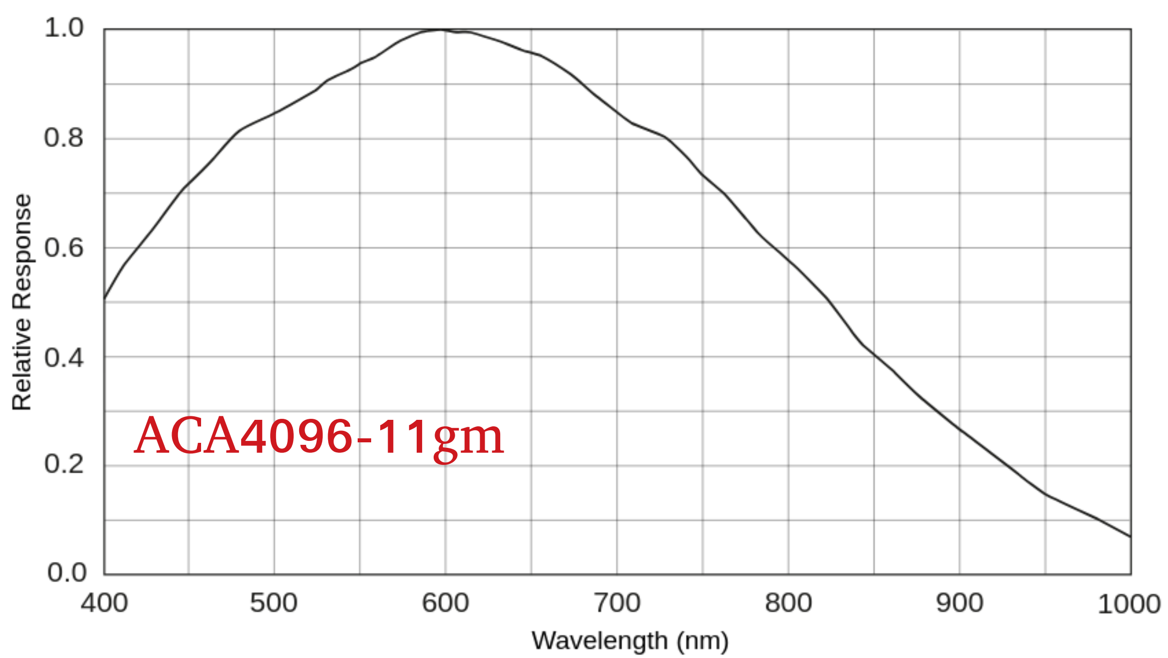


Basler Camera Quantum Efficiency

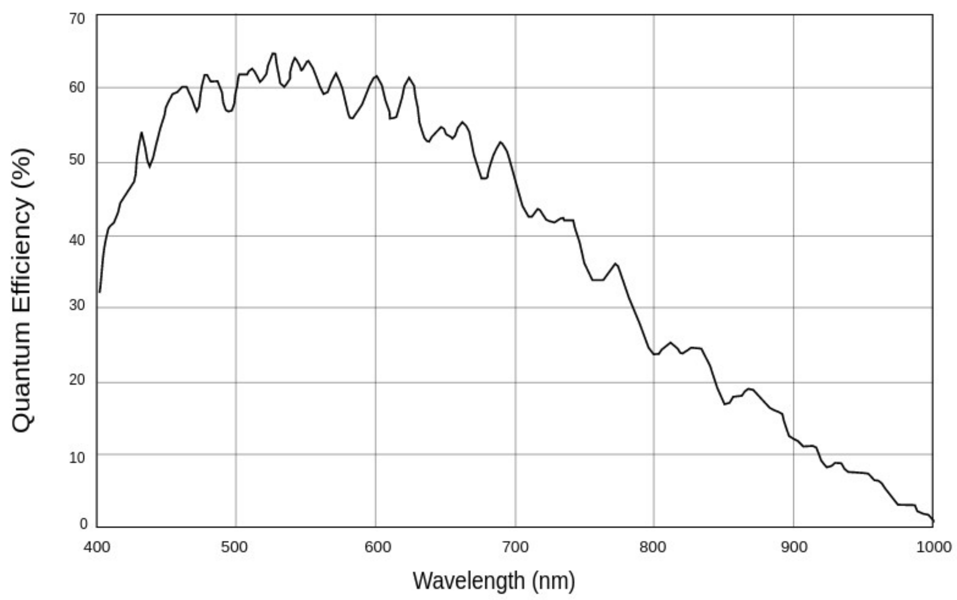
Spectral Response



Spectral Response



The spectral response curve excludes lens characteristics and light source characteristics.



← (similar model) QE ~ 60%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M49 x 0.75 Male to M52 x 0.75 Female Step-Up Adapter

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TECHSPEC® 75mm DG Series Fixed F

75mm Focal Length, #54-691

Stock #54-691

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Qty 1-49
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TECHSPEC® M34 x 0.5 Mount for 50/50.8mm Diameter Filters

M34 x 0.5 Mount for 50/50.8mm Diameter Filters, #12-785

Stock #12-785 NEW

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Qty 1-9	Qty 10+	Volume Pricing
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Basler Lens C11-5020-12M-P

Basler Premium C-mount lens with a fixed focal length of 50 mm, F16, and a resolution of 12 MP.

Mounted M49 x 0.75 Threaded ·

Stock #54-769

£43.77

Qty 1-9
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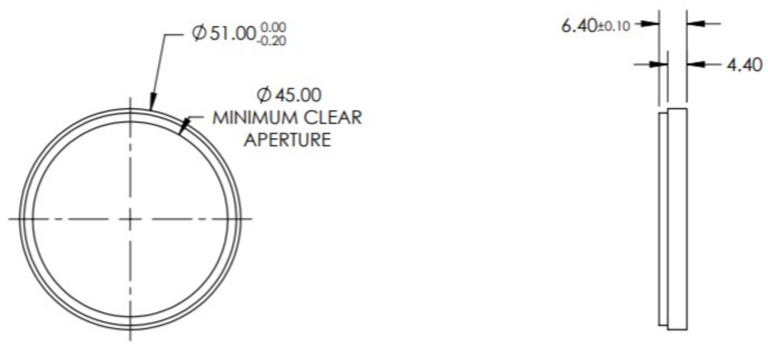

TECHSPEC® 75mm DG Series Fixed F

75mm Focal Length, #54-691

Stock #54-691

£498.95

Qty 1-49
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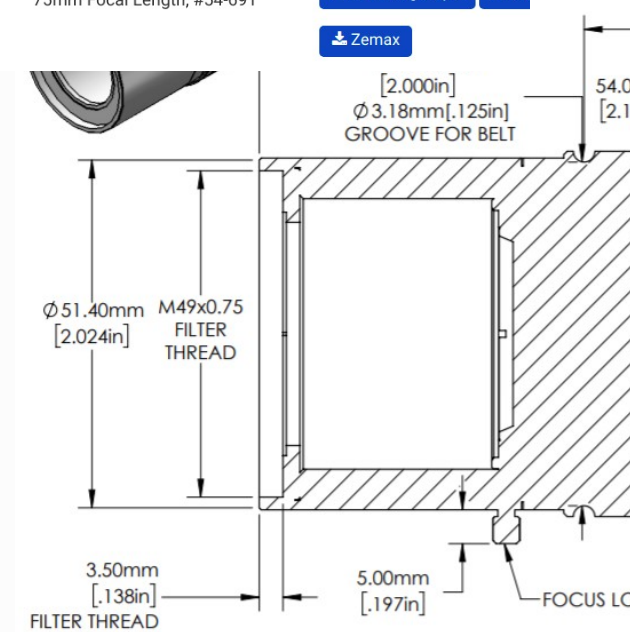

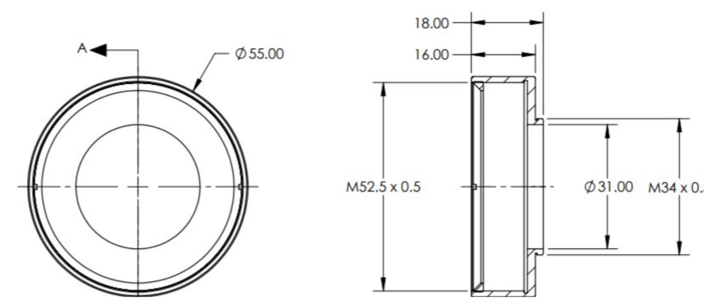

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