CCD vs. CMOS: Which is better?

A brief summary of camera bench testing

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Introduction

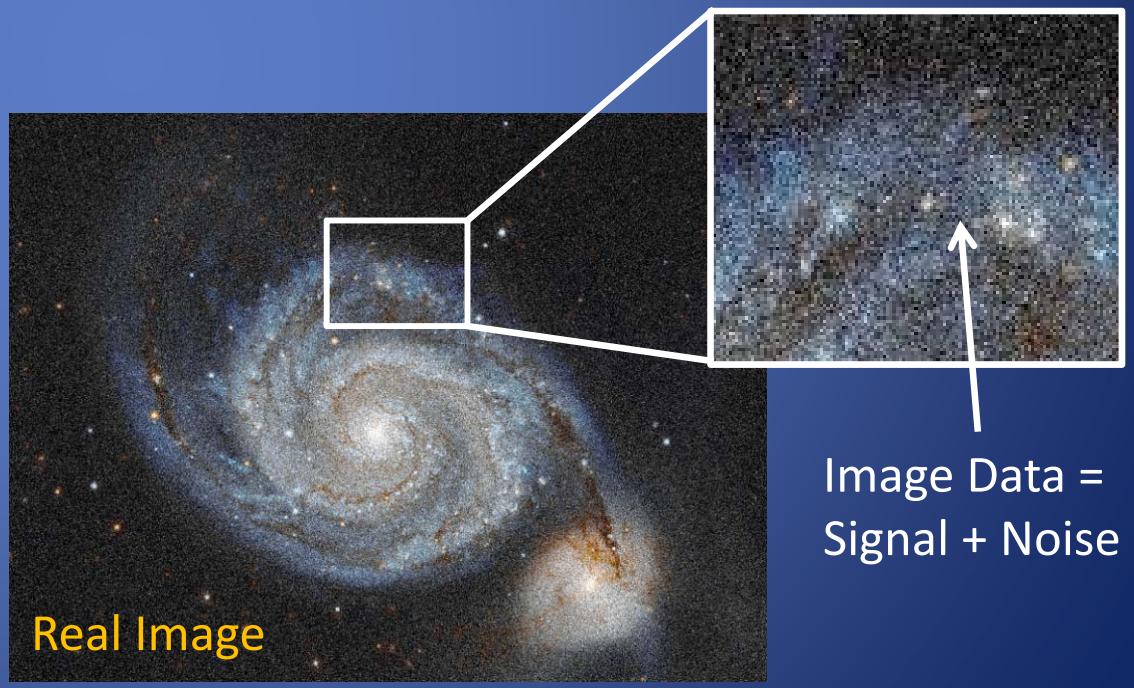
- Number of astro-camera choices has exploded in the past couple years
- New camera offerings have CMOS sensors
- CMOS sensors are the latest technology so they're better right?...
- …Not necessarily! Comparison testing needed

Camera Testing Project

- Started in late 2013
- Impetus - excess of narratives on camera performance, lack of actual unbiased test results
- Final straw - Astro-Video Systems & related CN berating of MC
- On my own develop a test method & start testing cameras
- Many new cameras since 2013 – 21 tested so far

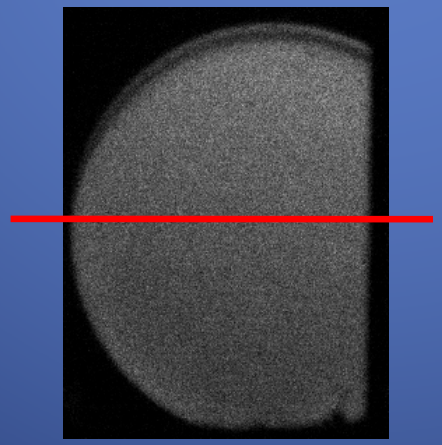
Evaluating Camera Performance

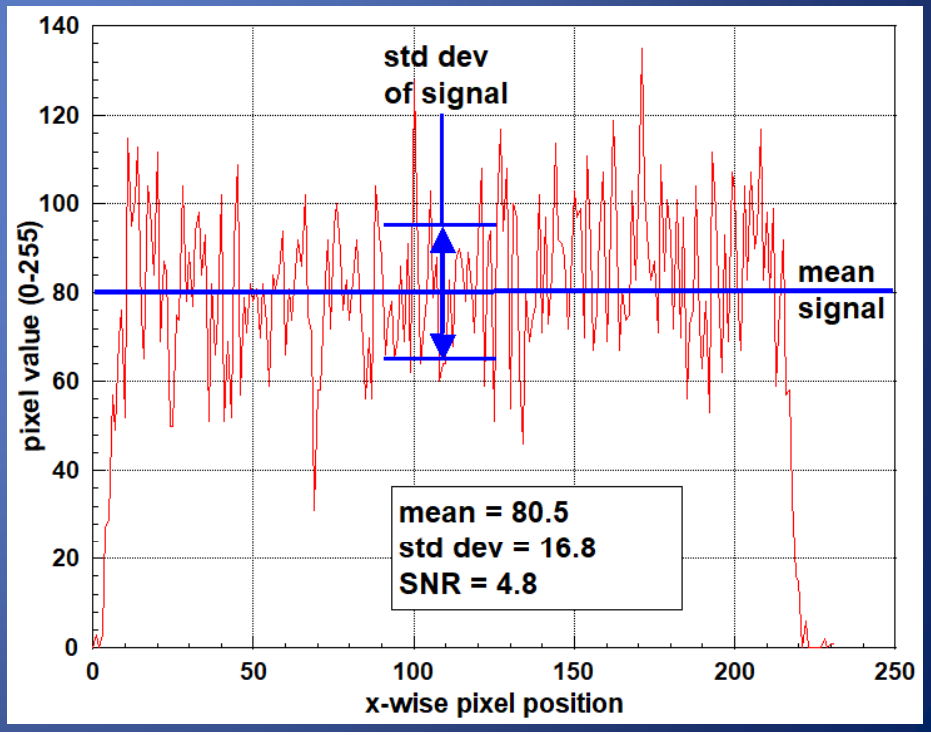
- Sensitivity & Noise → Observable Image
- Most common figure of merit is Signal to Noise Ratio (SNR)



Evaluating Camera Performance

- SNR = Mean Signal / RMS Noise → signal standard deviation
- SNR can be improved in several ways:
  - exposure time $SNR \propto \sqrt{\text{exposure time}}$
  - stack frames $SNR \propto \sqrt{\#\text{frames}}$
  - binning $SNR \propto \#\text{bin}$
- Measuring SNR accurately & repeatably → bench test





My Test Method

Representative Light Source

Opal Glass Diffuser

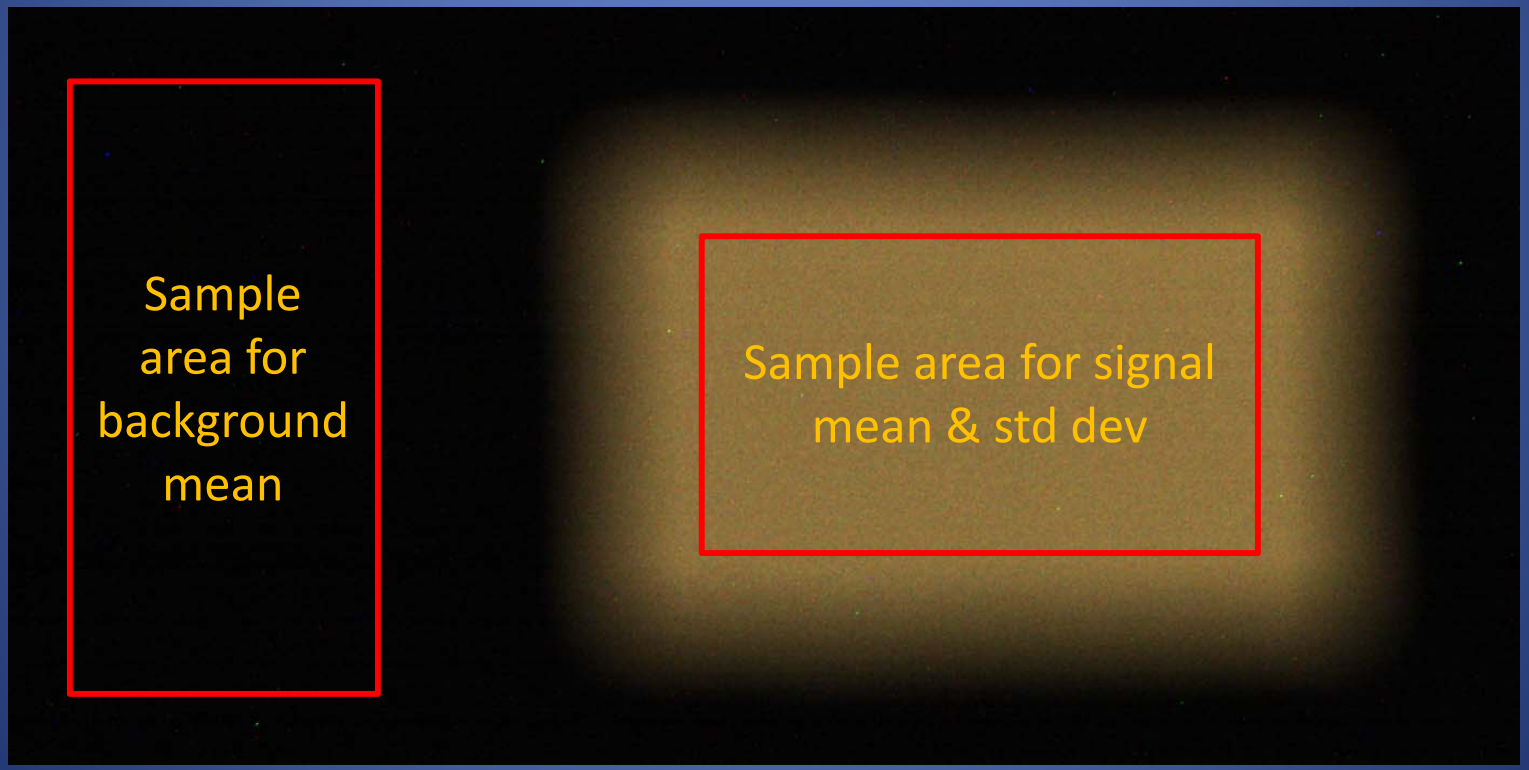
All other light sources in room off

FLT98 @ f/6.3 + ND4.8

Small Rectangular Opening

My Test Method

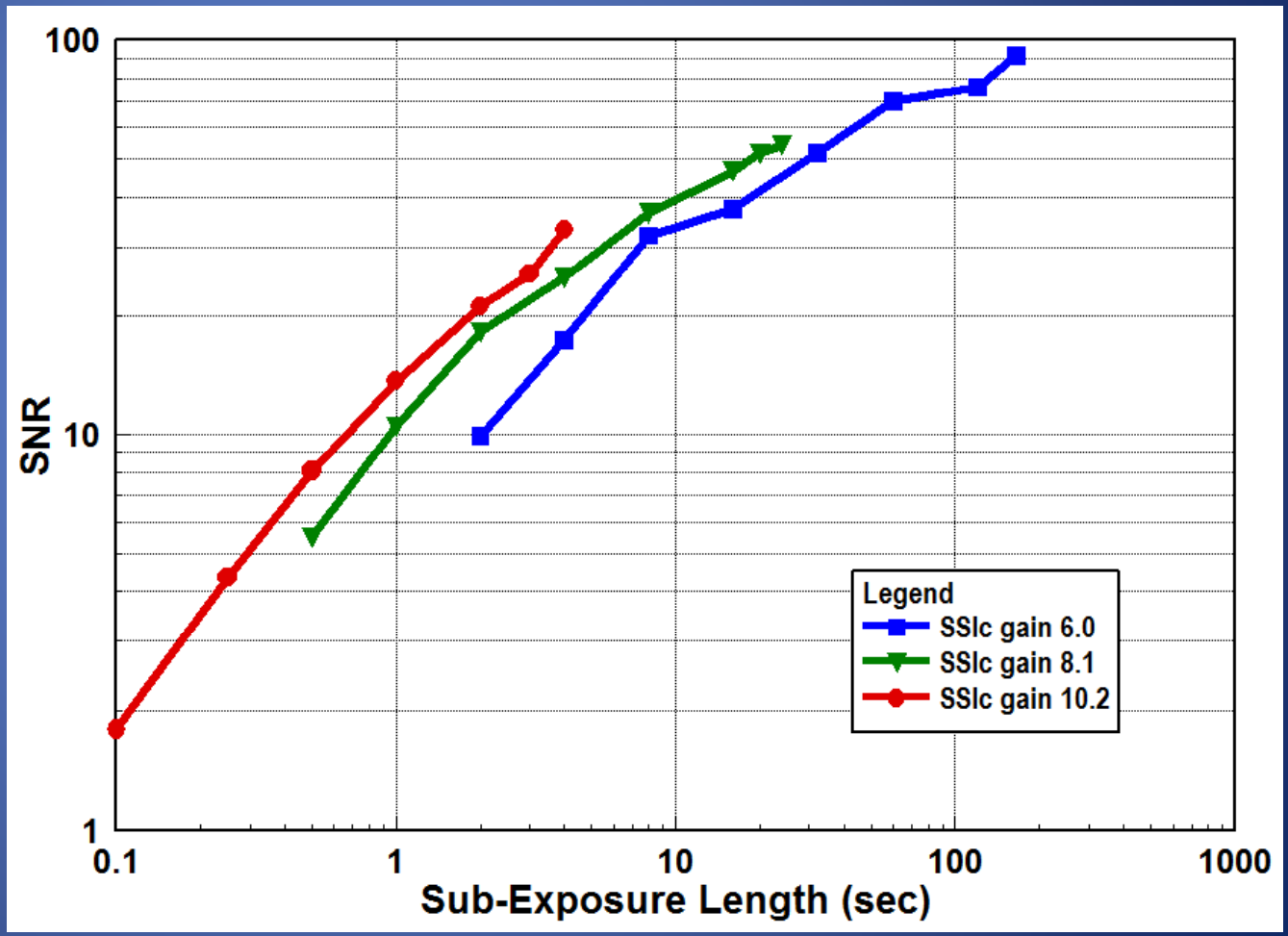
- Capture images at different exposure times and gain settings, all other settings at default
- Analyze images using ImageJ – mean & std dev



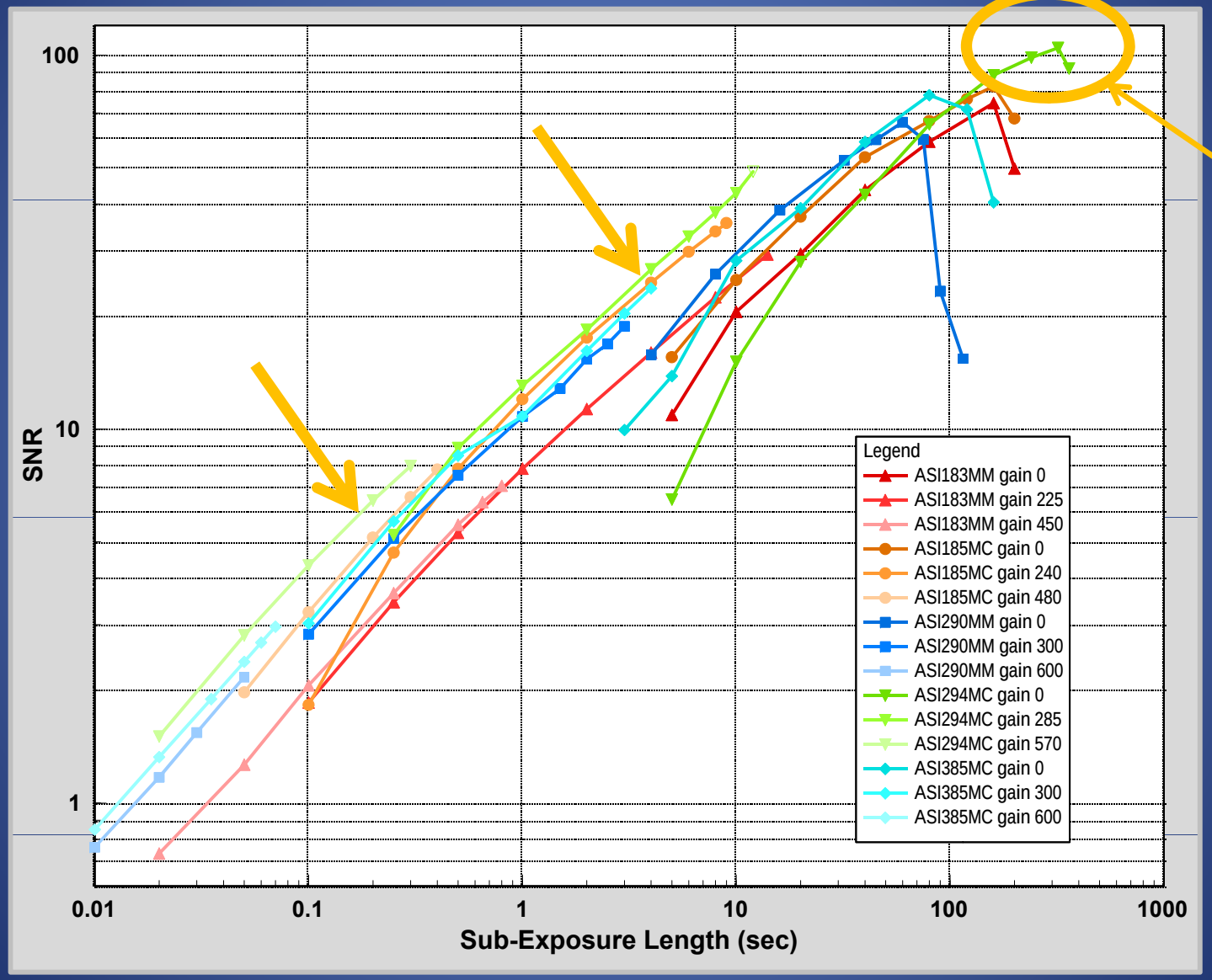
Sample image: DS2.3+, Gain 50, Exp 1s

Sample SNR Result

- SNR increases with exposure (as expected)
- Gain shifts curve left (higher SNR for same exposure)
- Gain also reduces max exposure & max SNR (due to image saturation)
- **How quickly can I see my image?**



SNR – ZWO ASI

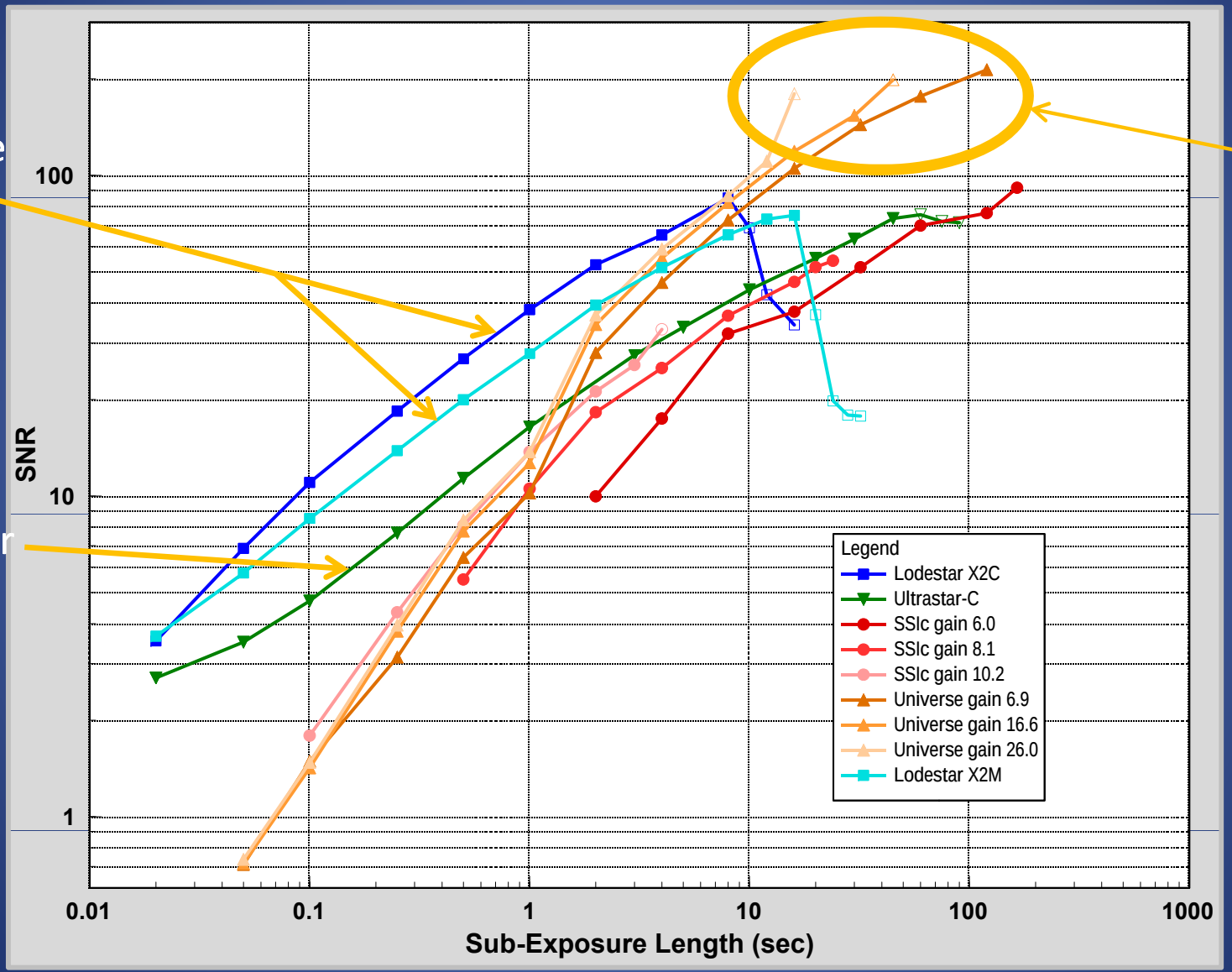


IMX294 sensor performs best

SNR – Miscellaneous

Monochrome not better than colour (?)

ICX825 camera rather noisy

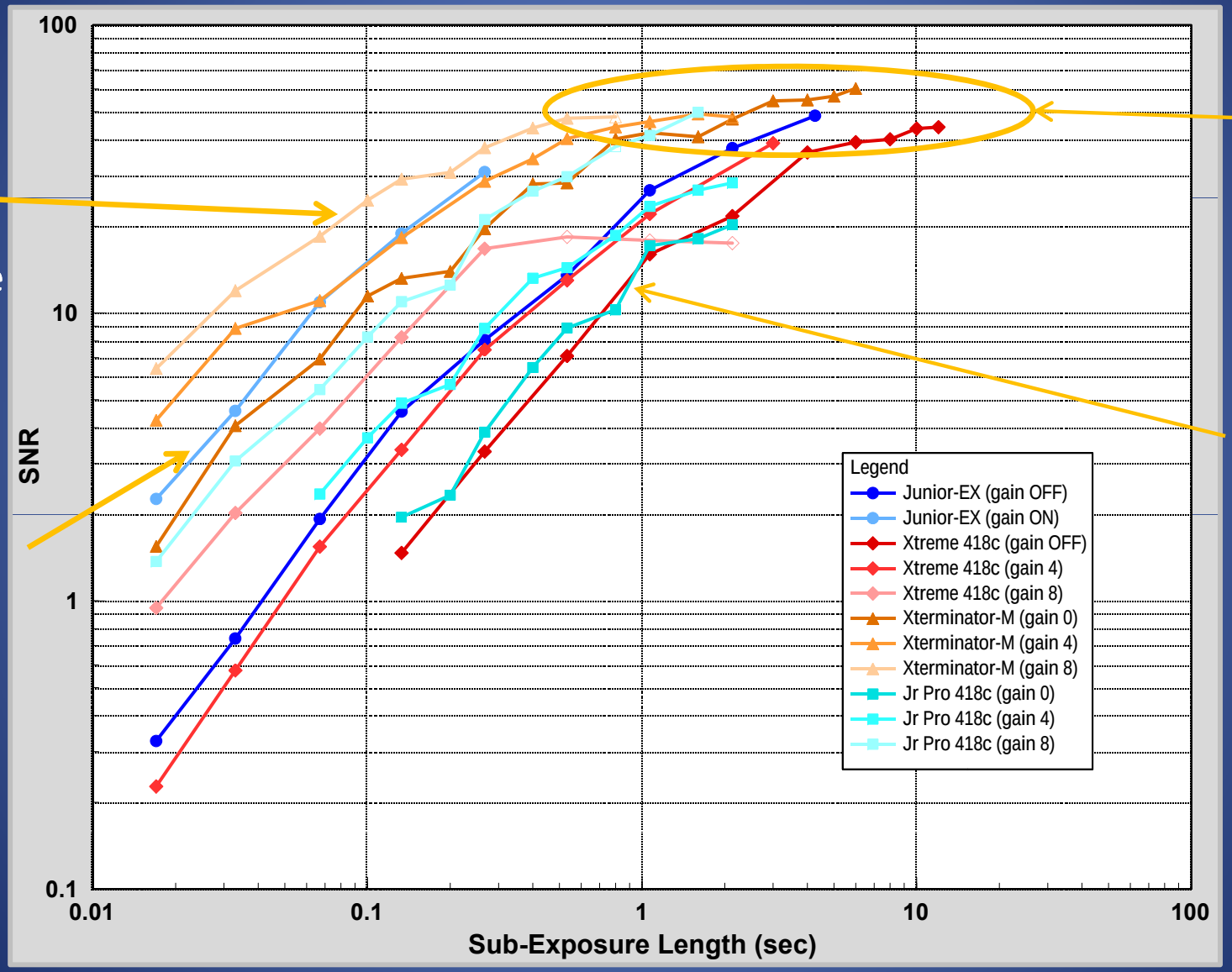


Universe capable of very high SNR

SNR – Mallincam Video

Xterminator gives high SNR in shortest time

surprisingly old Junior-EX also very good



all analog video cam's seem to level out at around SNR=40

Xtreme & Jr Pro very similar as expected (same sensor)

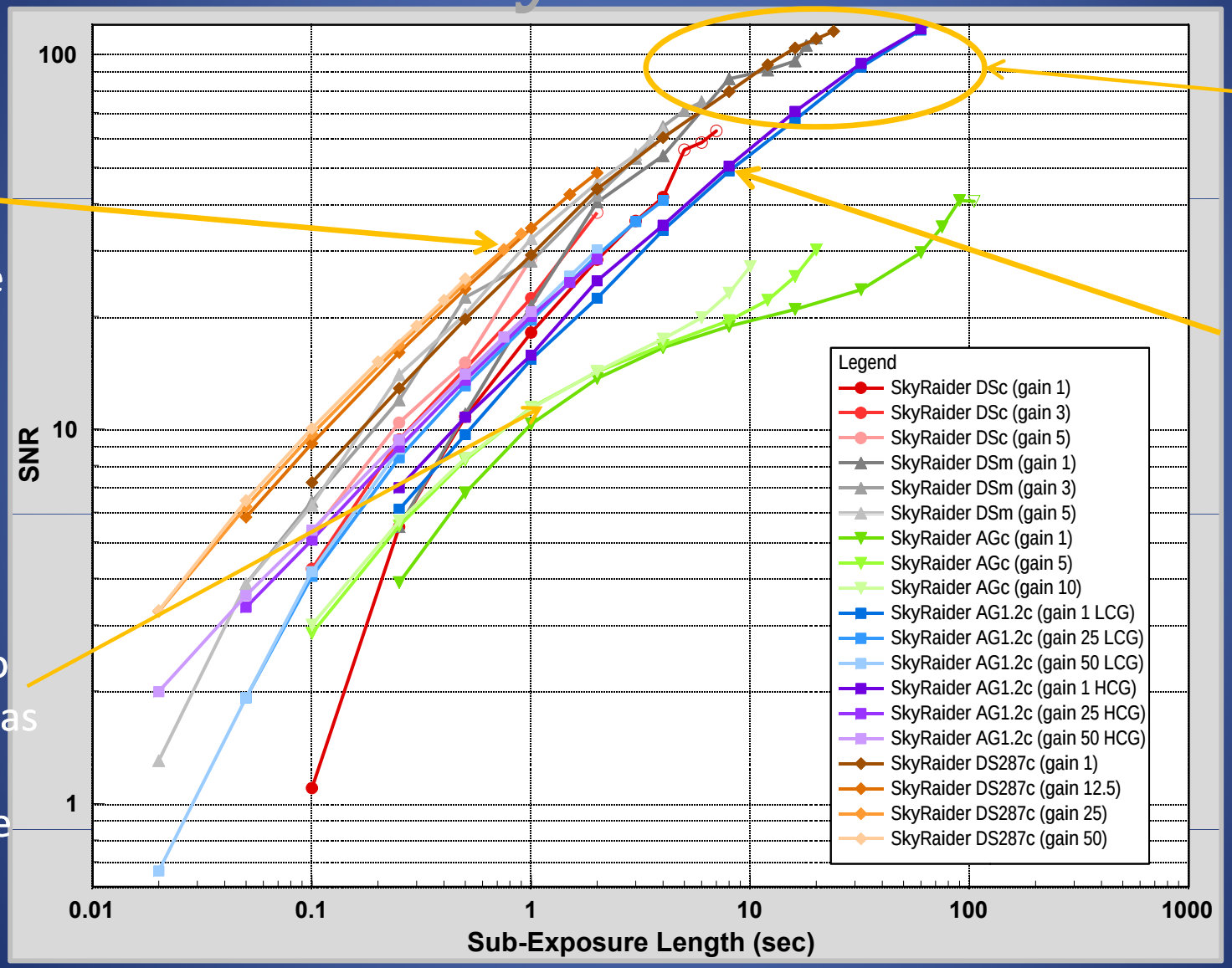
SNR – SkyRaider Small

DS287c gives high SNR in shortest time

compared to other cameras AGc lacking performance

high SNR achieved with AG1.2c, DSm, & DS287c

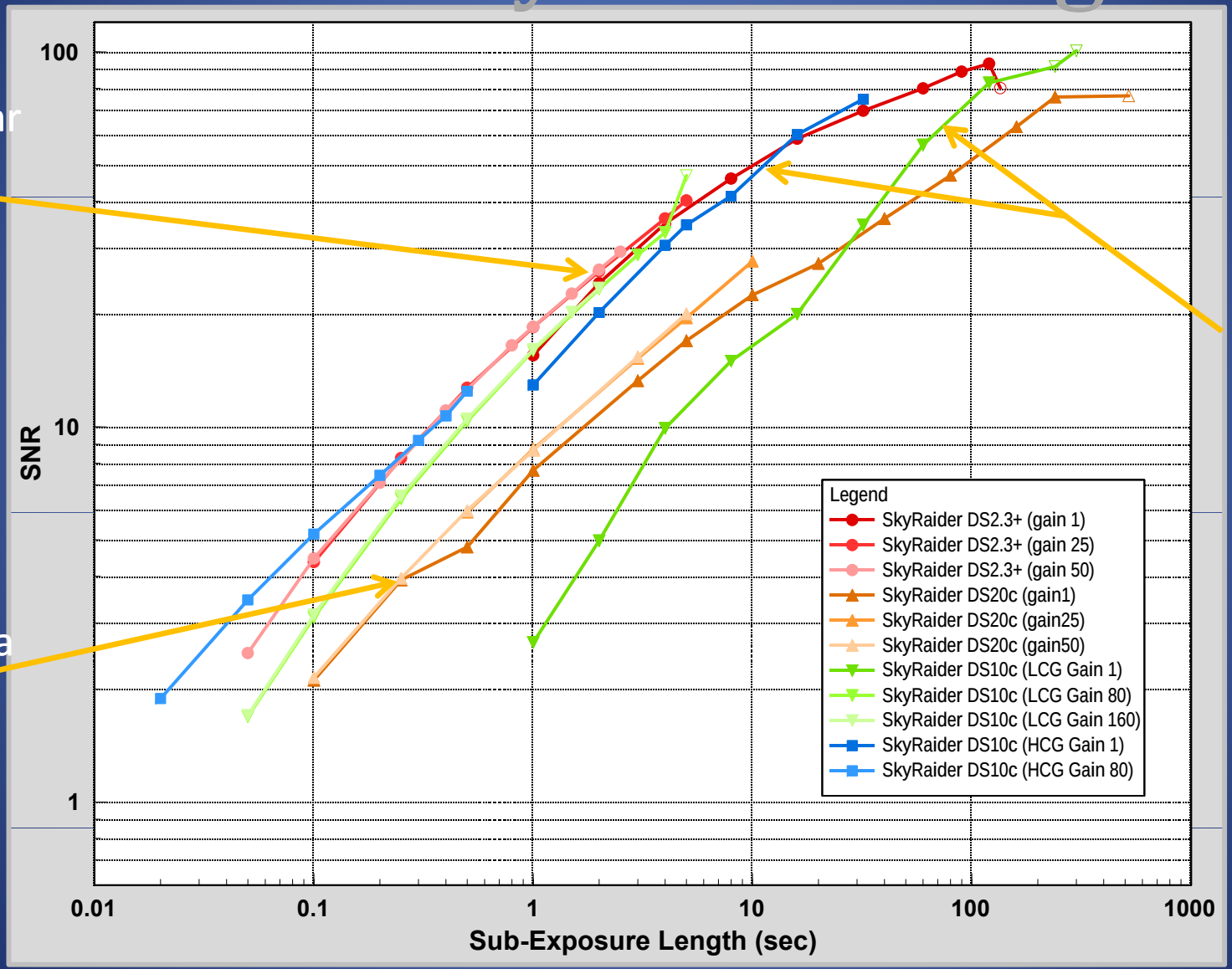
no difference in SNR using HCG on AG1.2c



SNR – SkyRaider Large

DS2.3+ similar or slightly better performance than DS10c

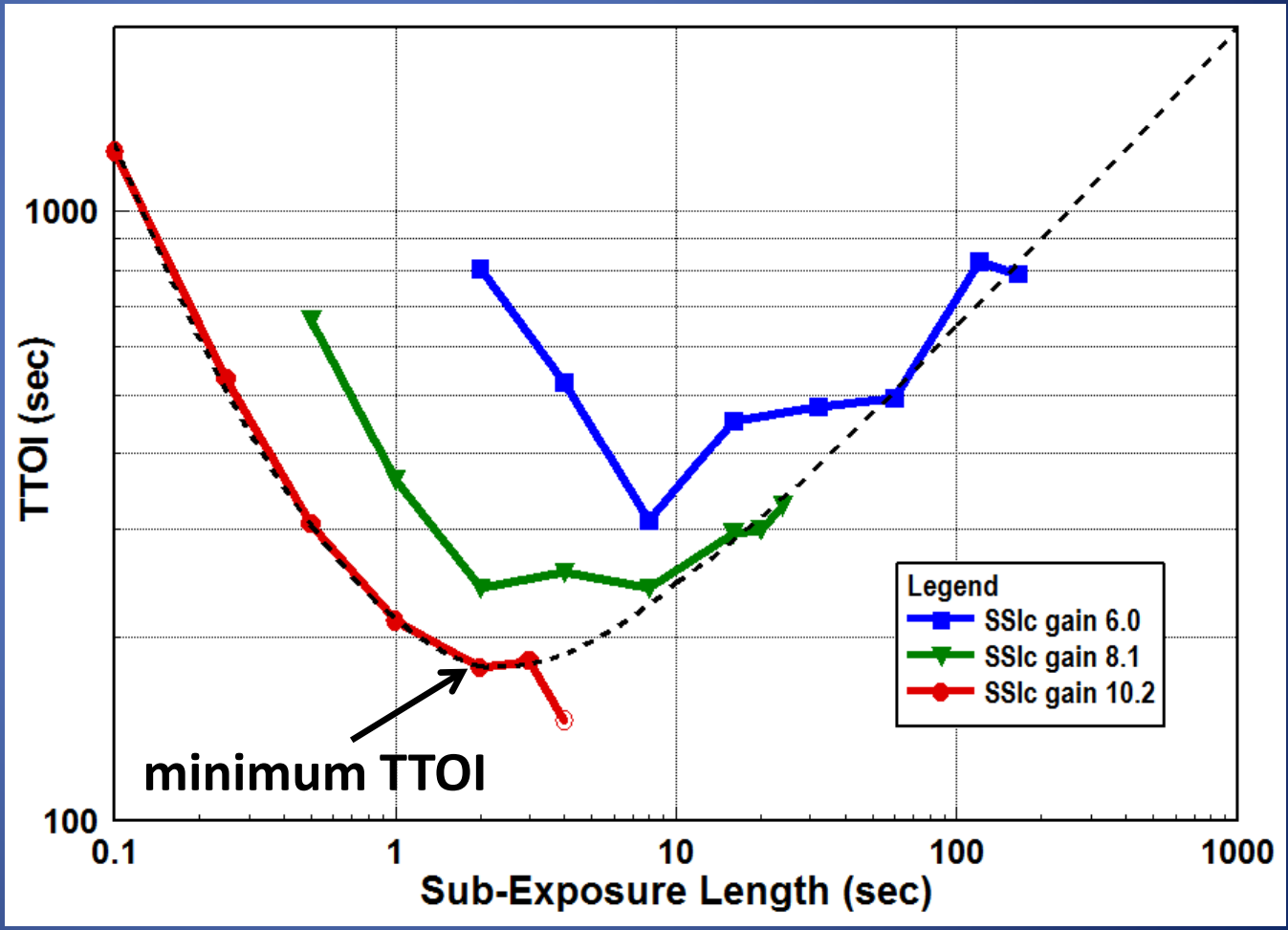
prototype 20MP camera low SNR, not likely to become a product



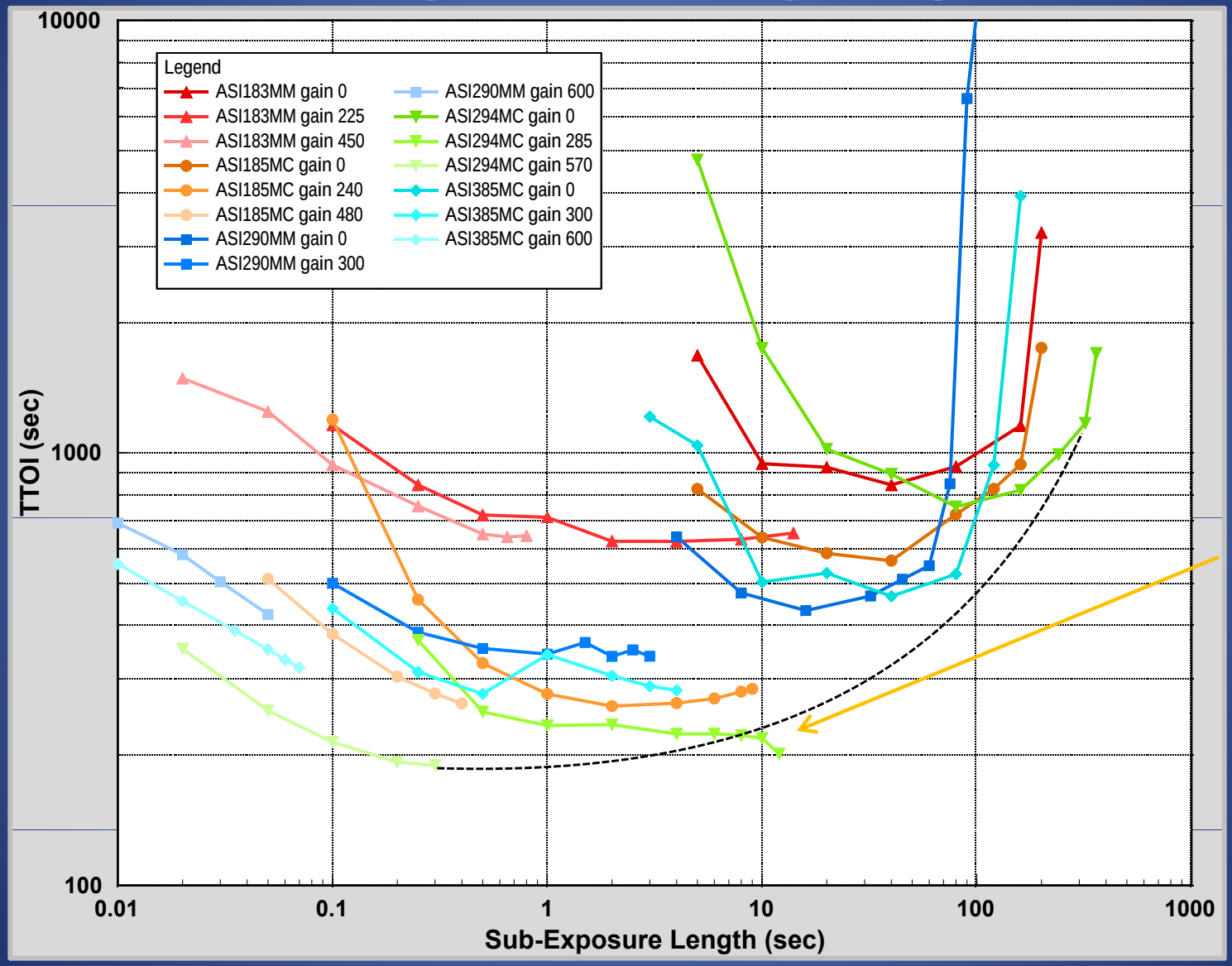
HCG has big impact on DS10c performance

Time To Observable Image

- By changing exposure, gain, and/or stacking frames, how long to get SNR=200?
- Compare cameras using TTOI

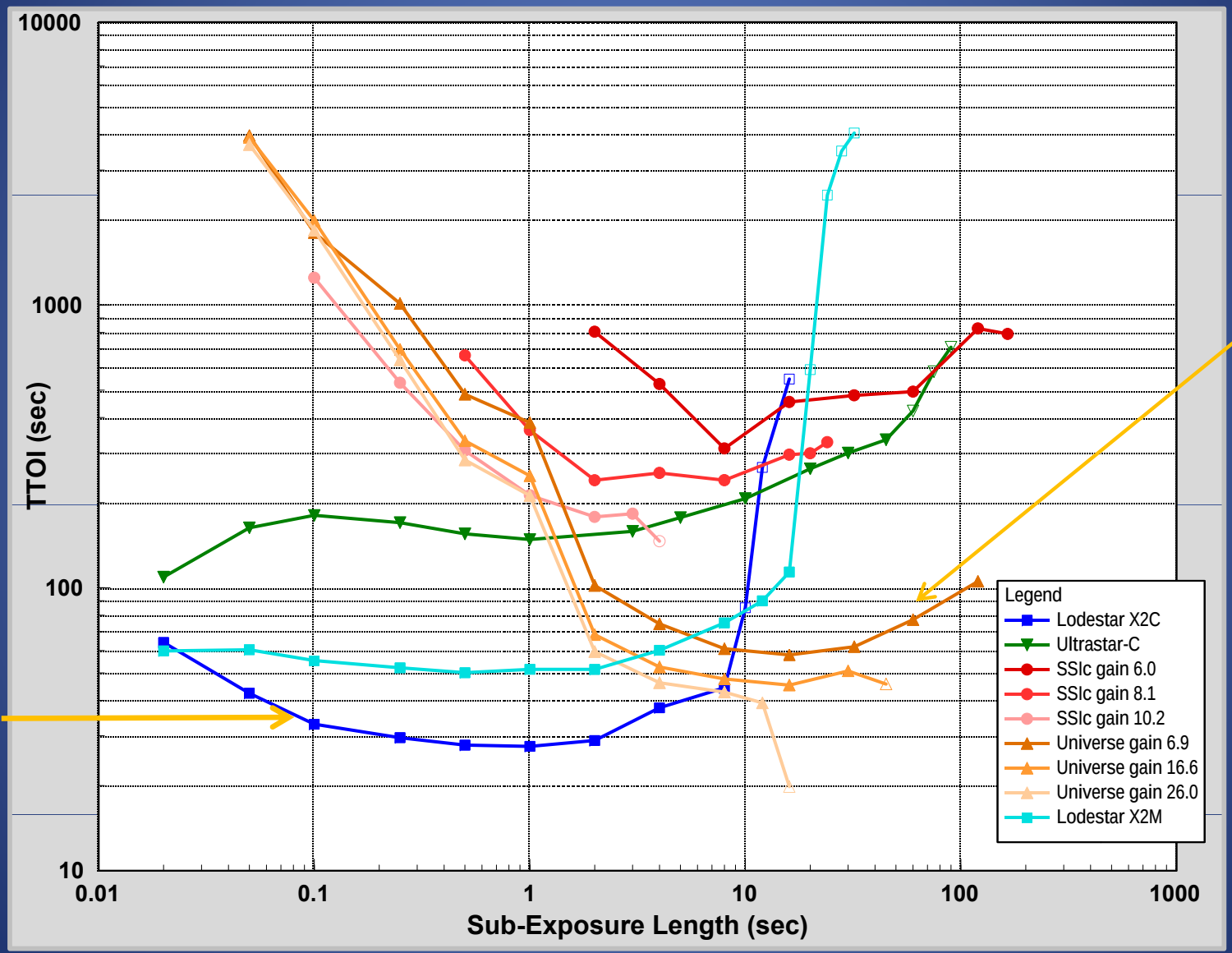


TTOI – ZWO ASI



IMX294 sensor gives best TTOI ~ 190s

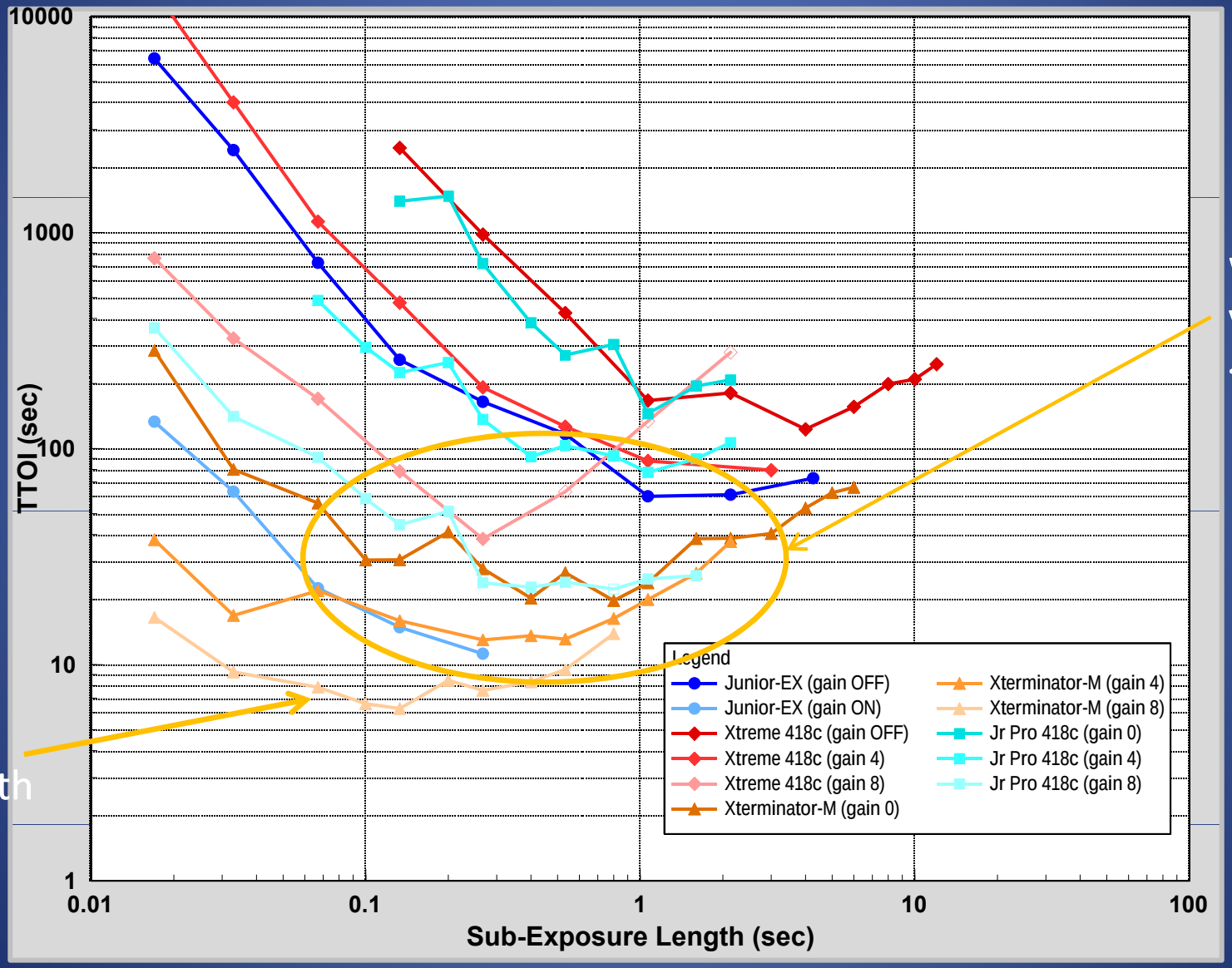
TTOI – Miscellaneous



ICX828 camera very good ~ 27s

Universe also very good ~ 42s

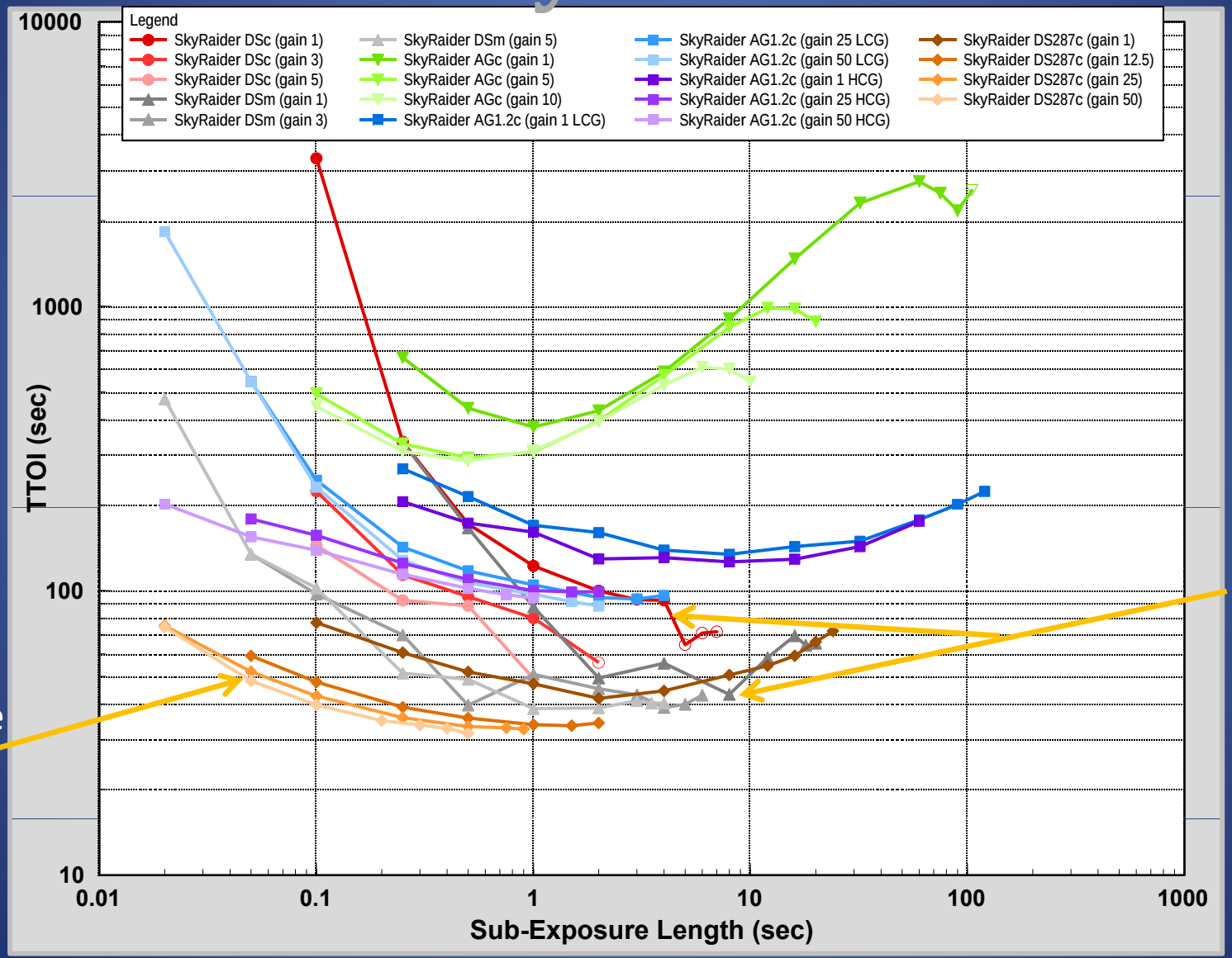
TTOI – Mallincam Video



with gain all video cams << 100s

Xterminator is a beast with TTOI < 10s !

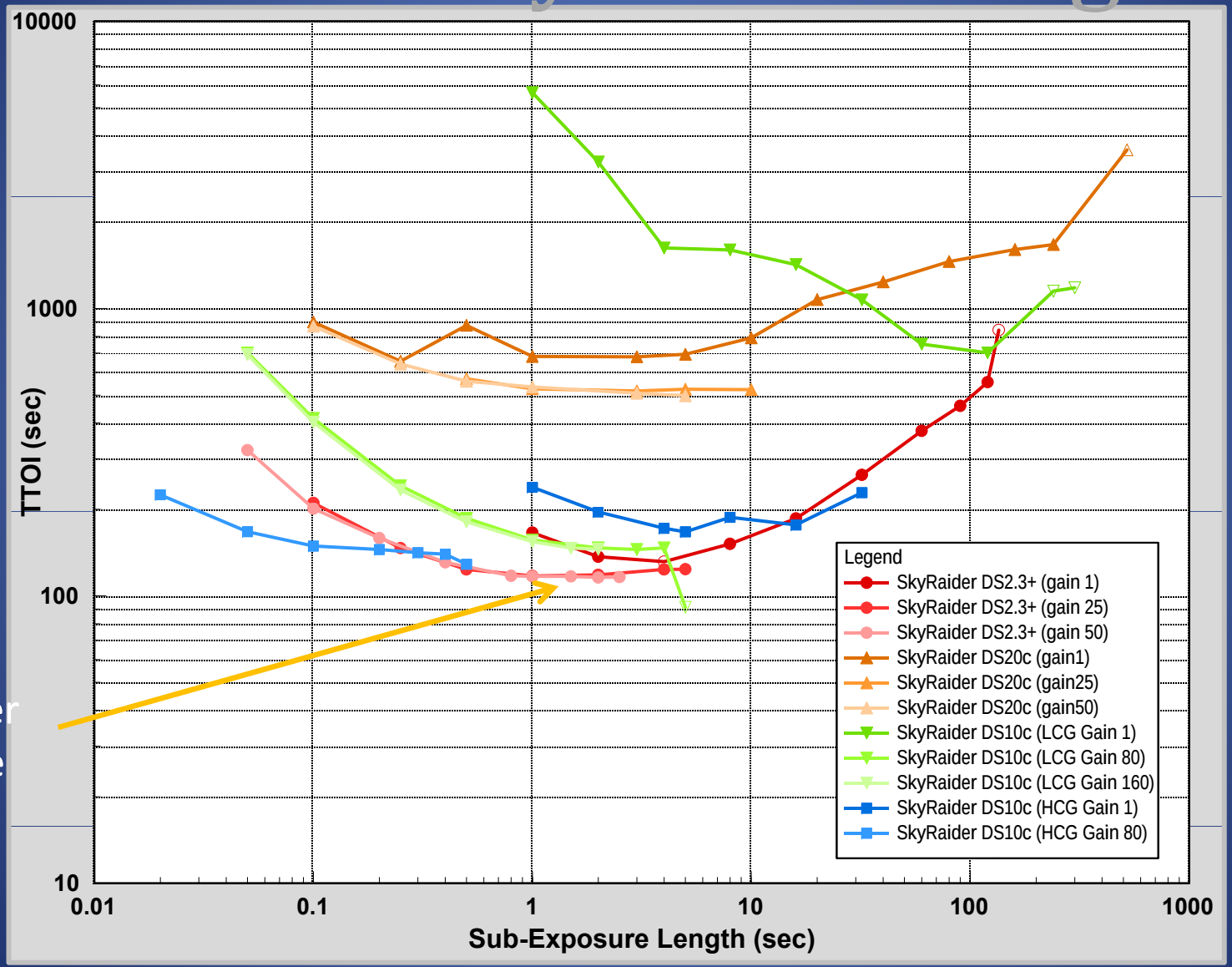
TTOI – SkyRaider Small



DS287c gives performance better than DSm (TTOI~32s)

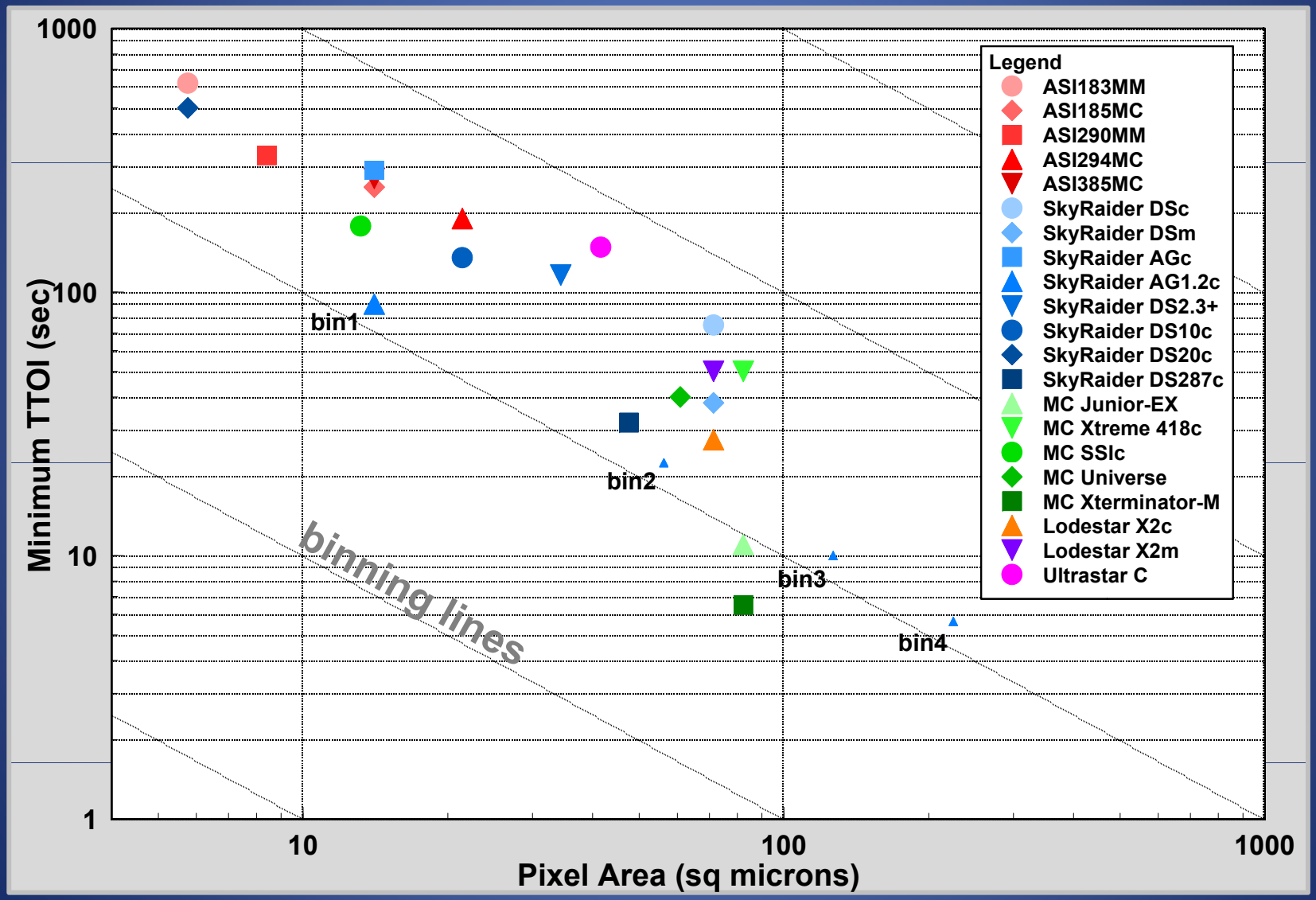
DSm much better than DSc

TTOI – SkyRaider Large



DS2.3+ slightly better performance than DS10c

Min. TTOI Comparison



Conclusions

- In general, CCD-based cameras still have TTOI much shorter than CMOS-based (x10+)…but DS287 is coming close!
- SkyRaider series out performs comparable ZWO cams
- DS1.2c & DS287c lead CMOS cameras for performance vs. pixel size

Conclusions

- Caveat for using stacking: single frame SNR must be good enough for aligning frames (>10?)
- Must consider other camera properties too: amp glow, resolution, sensor size
- Cameras remaining to be tested: MC Micro, vintage video cams (Samsung, Stellarcam), Astro-Video Systems

Questions?