Mixing And Matching Sensor Format With Lens Coverage

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Electrical & Computer Engineering

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Film Formats

- Many film formats common, 16mm to 4x5”, but 135 cartridge 24x36mm dominated
- In 1996, Advanced Photo System (APS 240) allowed programmable cropping:
  - H (High Definition) 30.2x16.7mm
  - C (Classic) 25.1x16.7mm
  - P (Panoramic) 30.2x9.5mm
- Digital camera sensors have been smaller...

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Sensor Formats... Are Also Lens Formats

- "Full Frame" digital cameras are ~36x24mm
  - Lens must cover 43.3mm diameter
- Square crop of full frame is ~24x24mm
  - Lens must cover 33.9mm diameter (78%)
- Digital APS-C is ~23.7x15.6mm (1.52x crop)
  - Lens must cover 28.4mm diameter (66%)

    ... about 6% undersize from film APS C
- *Canon* APS-C is ~22.3x14.9mm (1.61x crop)
  - Lens must cover 26.8mm diameter (61%)

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Format Mismatch

- FF : APS-C (or smaller) format availability
  - 1:**2.9** body sales (CIPA, 2014)
  - **7.4**:1 used lenses (KEH, Nov. 28, 2015)
  - Upgrade path from APS-C to FF...
- Focal Reducers (FR) reduce focal length, coverage, and f/number; increase resolution
- Teleconverters (TC) increase focal length, coverage, and f/number; decrease resolution
- Does coverage change balance resolution?

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E.g., APS-C Fisheye On FF + TC

- Opteka 6.5mm APS-C “rectangular” fisheye... on FF using 1.5x (1.56x measured) FF TC

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Lens Mount Compatibility

- Within a camera brand, often compatible
- At least 90 different mounts (Wikipedia)
- Can convert a lens mount... usually not easy
- Can add an adapter:
  - Glassless adapter (still focus to infinity?)
    - Mirrorless short-flange-distance helps
    - Many available for under $10
    - Can cheaply 3D-print custom adapters
  - Glass adapters (low-magnification TCs)
  - TCs and FRs

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Adapters & Converters Used

Adapter or Converter	Format	Magnification		Notes
		Market	Actual	
Metabones Speed Booster ULTRA	APS-C	0.71	0.71	can correct data
Zhongyi Lens Turbo	APS-C	0.726	0.73	
Zhongyi Lens Turbo II	APS-C	0.726	0.74	rectangular masking
glassless adapters	FF	-	1.00	
Kenko alpha-AF 1.4x Teleplus MC4 DGX	FF	1.4	1.39	8-pin data corrected
Rokunar 1.4x M/AF Tele-converter	FF	1.4	1.45	5-pin data corrected, "no lens" on E-mount
Kenko Mx-AF 1.5x Teleplus SHQ	FF	1.5	1.39	8-pin pass-through
Kenko N-AFd 1.5x Teleplus SHQ	FF	1.5	1.56	Nikon F mount

- Note that APS-C is 1.52x – 1.61x crop... which would be undone by 0.66x – 0.62x
- ±1 stop f/number change is +0.71x or -1.41x

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A Bit About TCs...

- TCs can handle lens electronics 3 ways:
  1. No electronics nor wiring
  2. Pass-through wiring
  3. Processor actively translates lens signals
- Sony does not make E/FE-mount TCs and says their LA-EA1/2/3/4 A-mount adapters will not work with TCs
- Only the Kenko 1.4x was fully functional (type 3) on Sony E/FE via LA-EA1/2/3/4 adapters

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Lenses Used

Lens Make, Designation	Format	Focal Length		*f*/number		Notes
Opteka Fish-Eye CS	APS-C	6.5		3.5		removable shade Samyang 8mm?
Sigma DC HSM	APS-C	8	16	4.5	5.6	zoom
Sigma EX DC	APS-C	10	20	4	5.6	zoom
Spiratone YS	FF	18		3.5		
Sony AF DT (SAL-1870)	APS-C	18	70	3.5	5.6	zoom
Mir 20	FF	20		3.5		KMZ
Spiratone Plura-Coat	FF	24		2.8		
Vivitar Auto Wide-Angle	FF	28		2.5		Kiron
Super-Takumar	FF	28		3.5		
Super-Multi-Coated Takumar	FF	35		2		
Super-Takumar	FF	50		1.4		
Auto Mamiya/Sekor	FF	55		1.4		
Sony AF DT (SAL-55200)	APS-C	55	200	4	5.6	zoom
Zenit MC Helios 44M-7	FF	58		2		

- Just the lenses discussed here...

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MTF Measurement Procedure

- All measurements made using Sony 24MP – APS-C: **NEX-7**, FF: **A7** – at base ISO (100), "A" mode +1EV, *aligned* using manual focus, tripod & self-timer & electronic first curtain
- Modulation Transfer Function at 50% contrast (MTF50) cycles/pixel measurements:
  - Used free **MTF mapper** software
  - Slanted-edge target, inkjet "E" semi-gloss
  - **`edge_mtf_values.txt`** median-filtered in 5% diagonal radius off-axis bins

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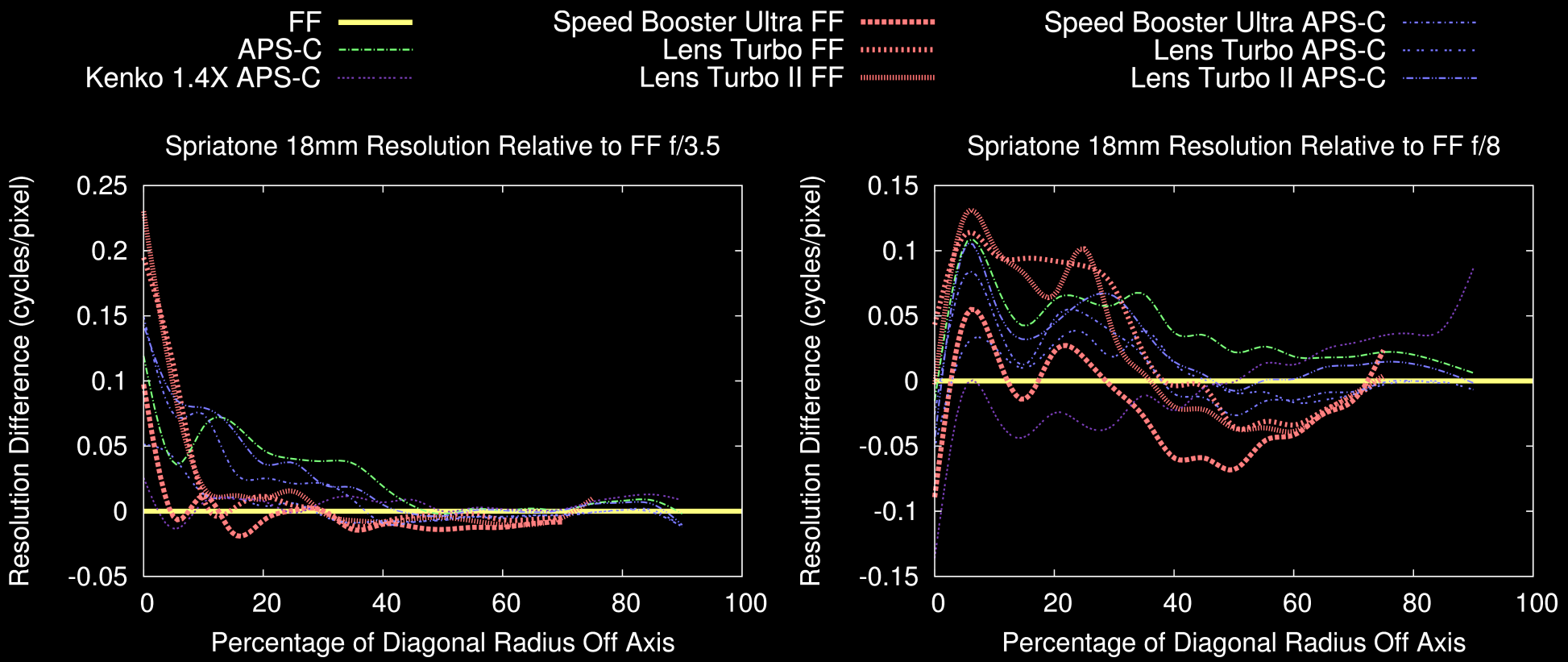
FF Lens: 18mm f/3.5 Spiratone



- Lens not good off axis... APS-C crop best

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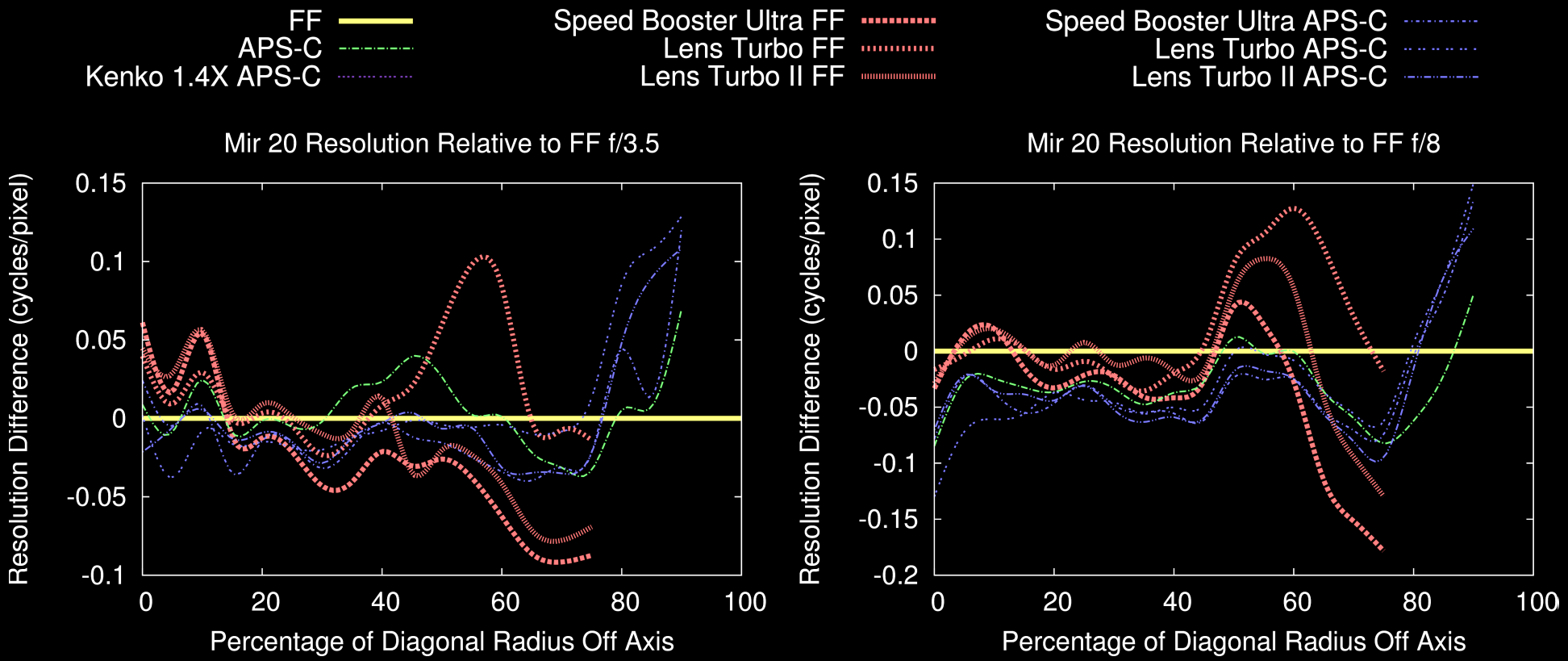
FF Lens: 20mm *f*/3.5 Mir 20



- No clear winner here...

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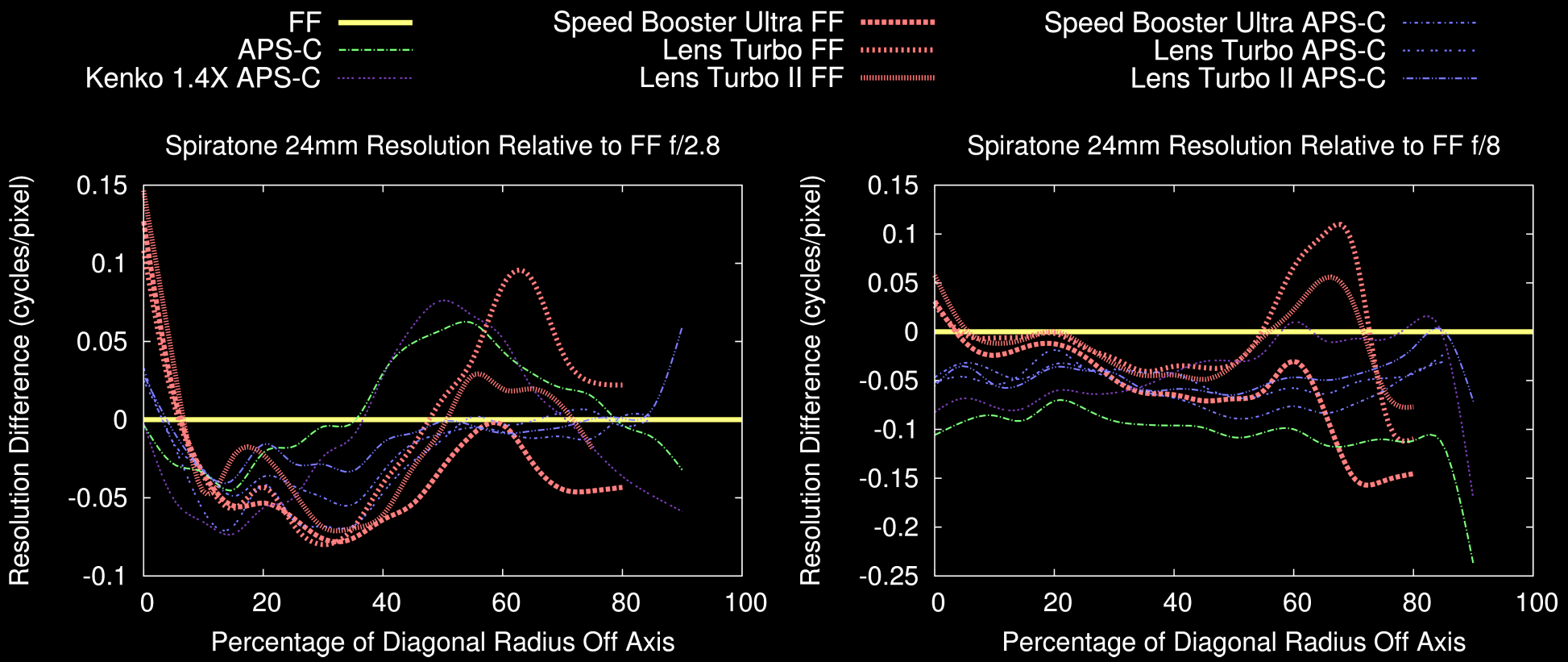
FF Lens: 24mm f/2.8 Spiratone



- No clear winner here... maybe native FF?

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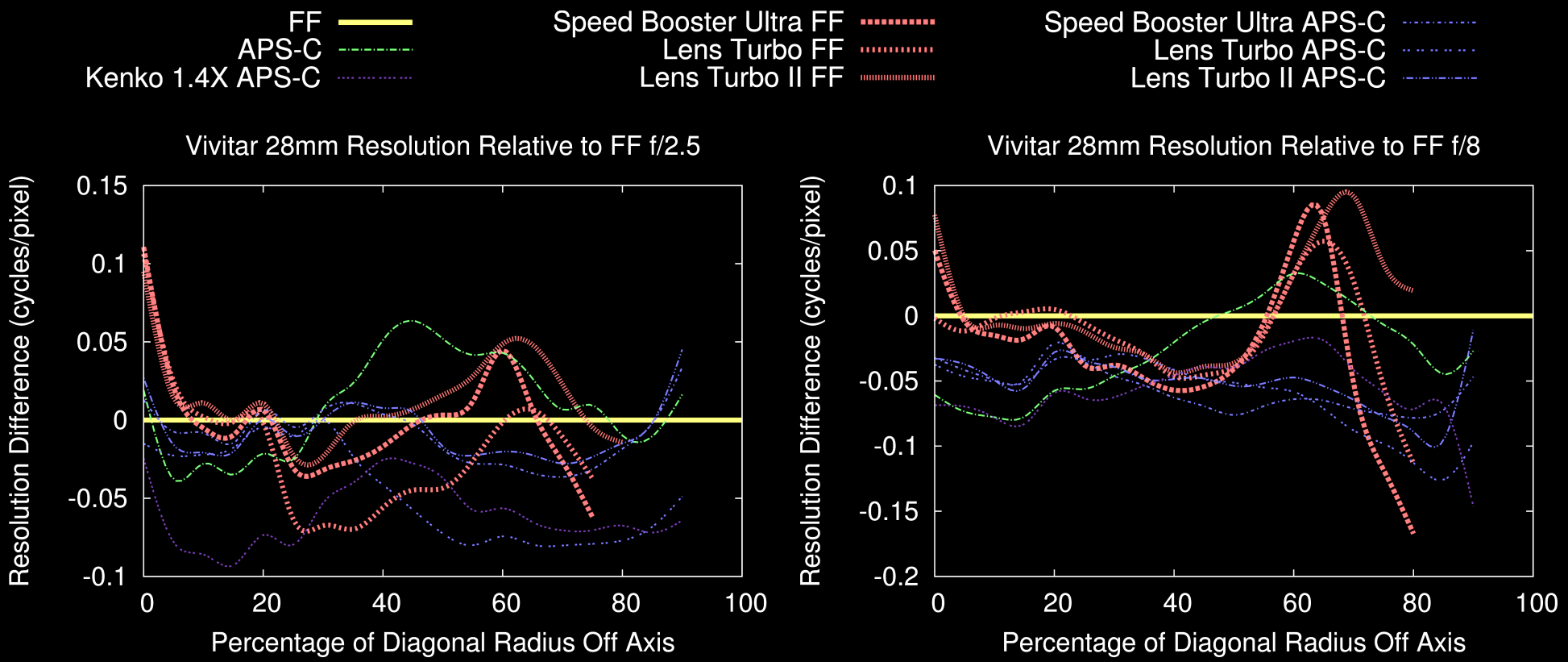
FF Lens: 28mm *f*/2.5 Vivitar



- No clear winner here... maybe native FF?

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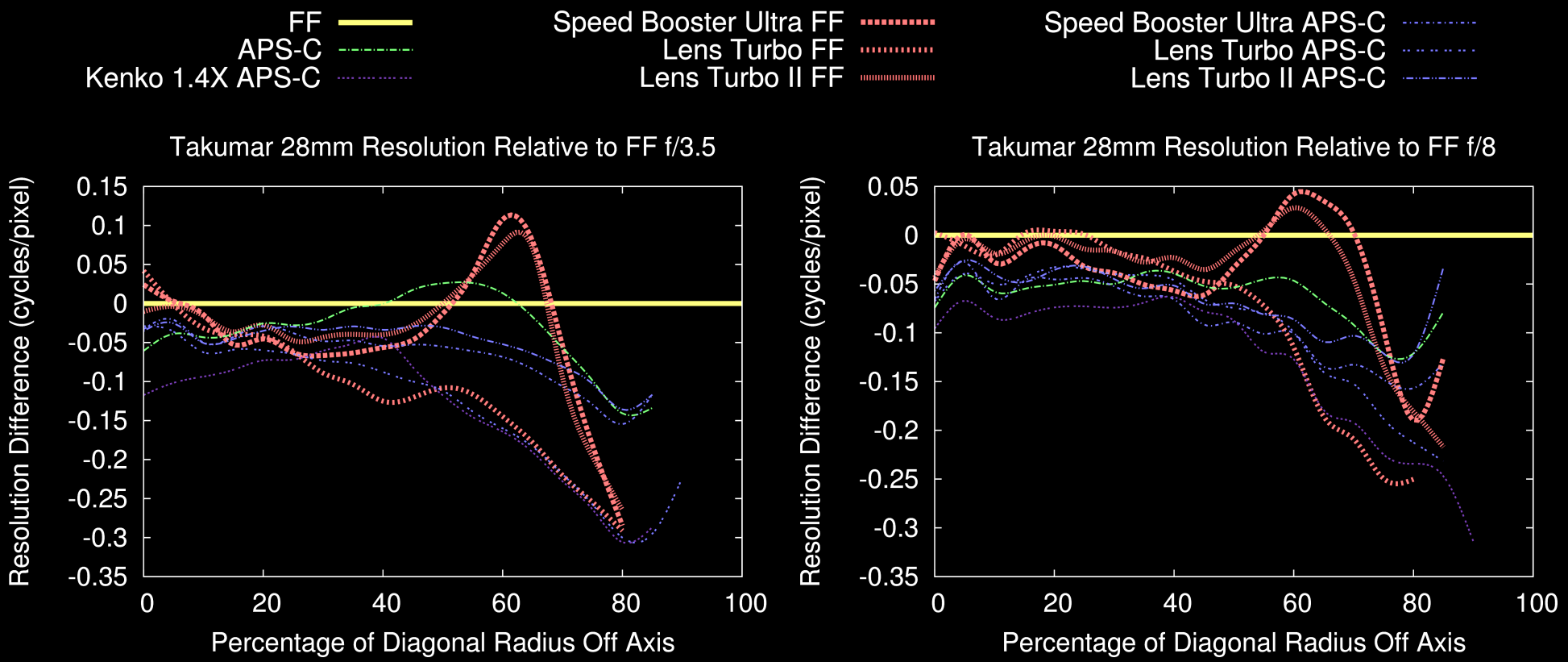
FF Lens: 28mm *f*/3.5 Takumar



- Very close until edges, but native FF is best

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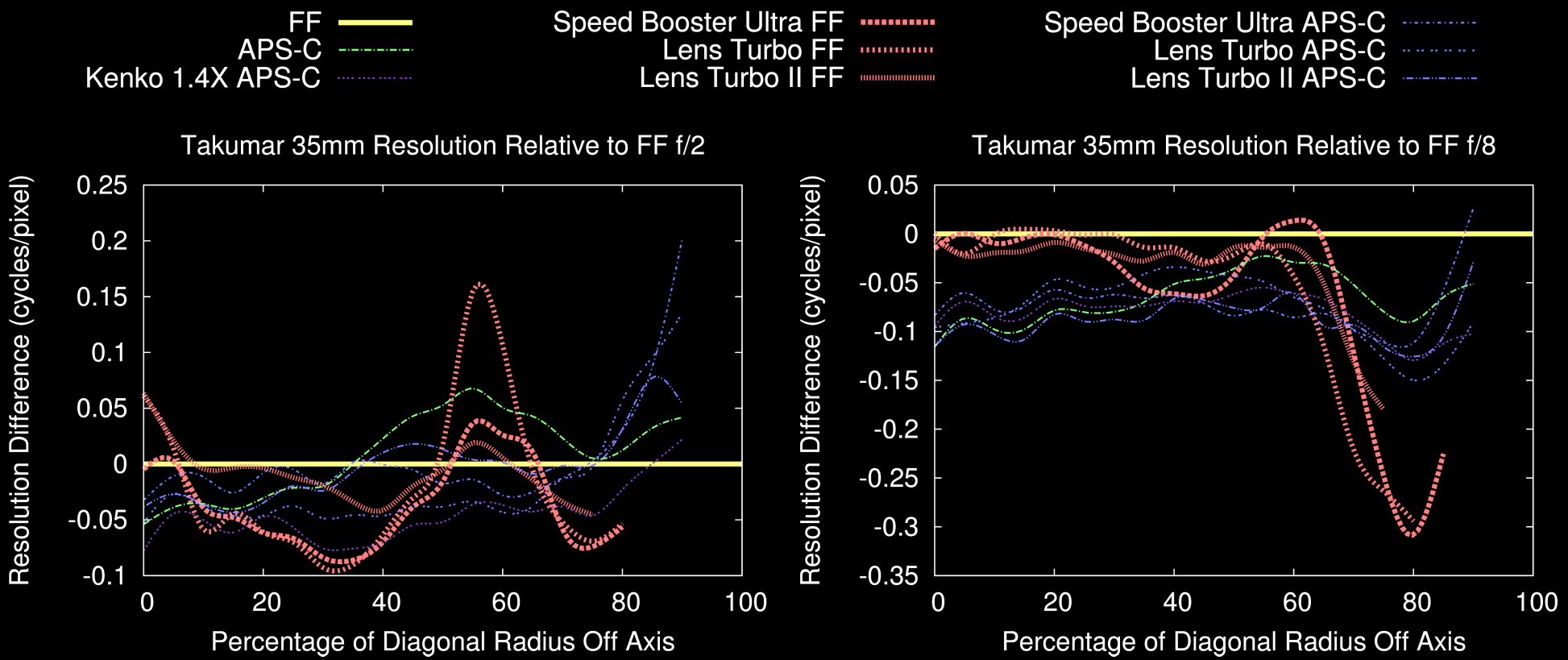
FF Lens: 35mm *f*/2 Takumar



- No clear winner here... maybe native FF?

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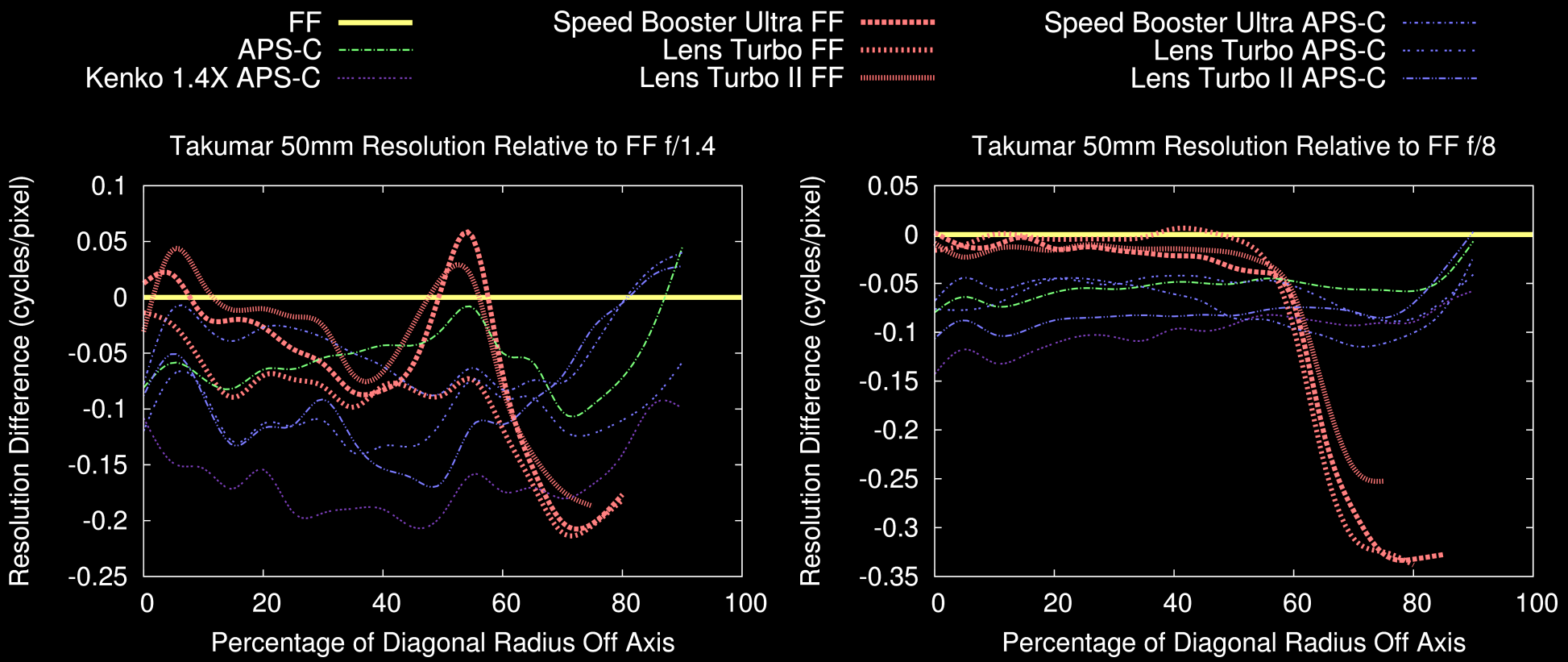
FF Lens: 50mm *f*/1.4 Takumar



- Native FF wins, but not by a huge margin

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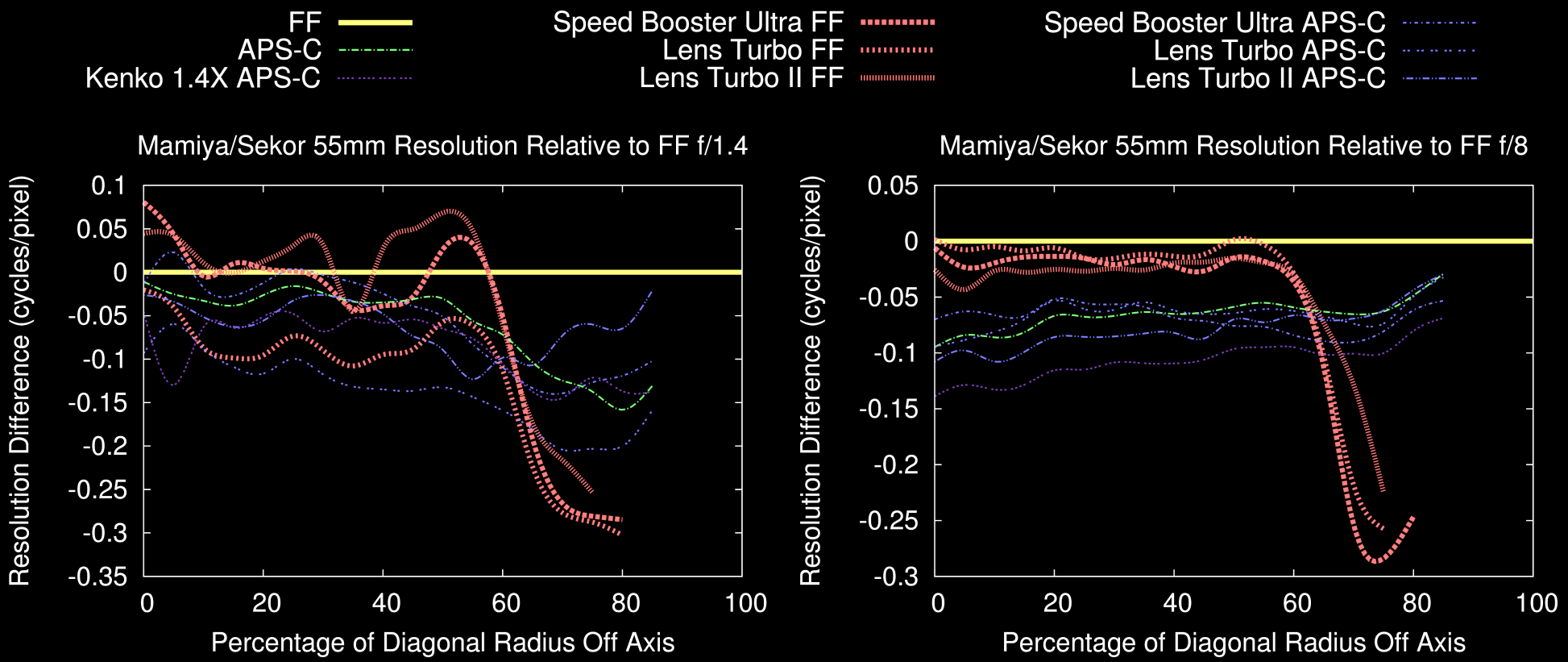
FF Lens: 55mm *f*/1.4 Mamia/Sekor



- Native FF wins, but not by a huge margin

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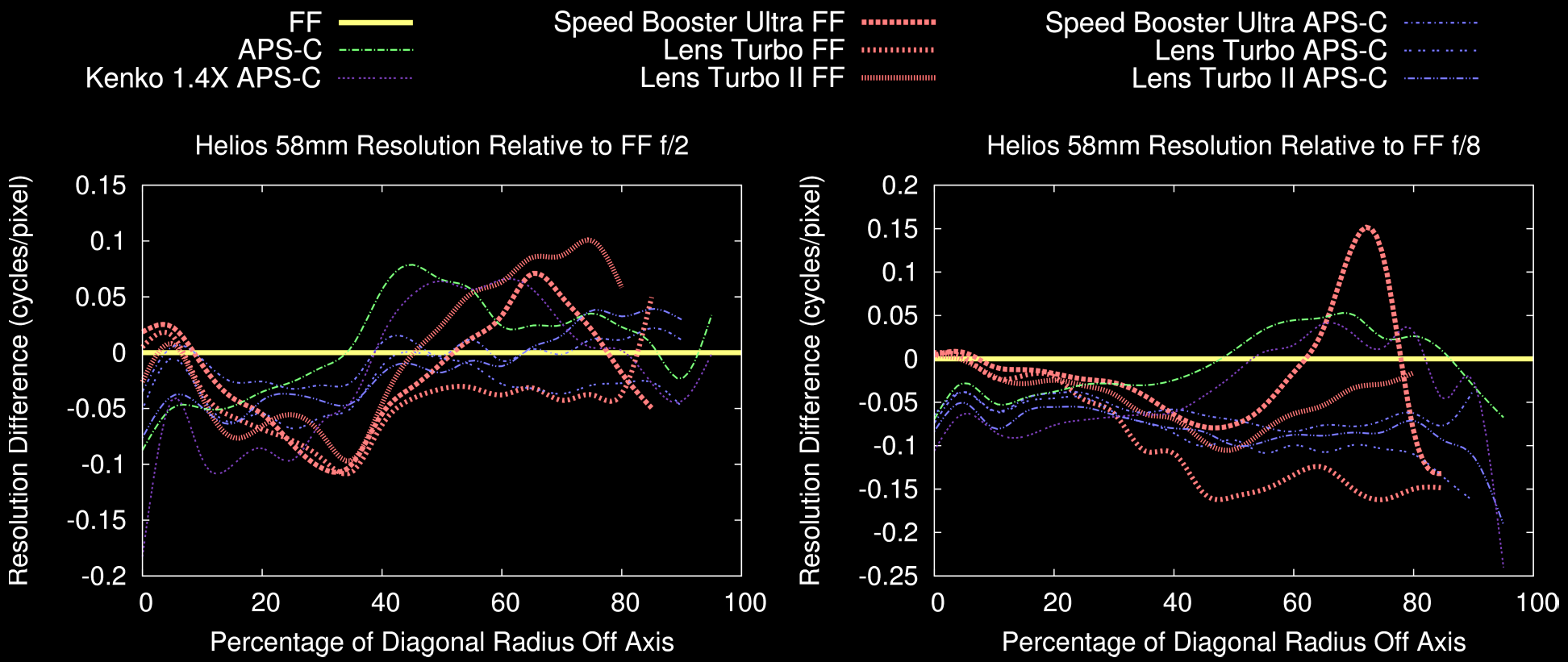
FF Lens: 58mm *f*/2 Helios



- No clear winner here... maybe FF or APS-C?

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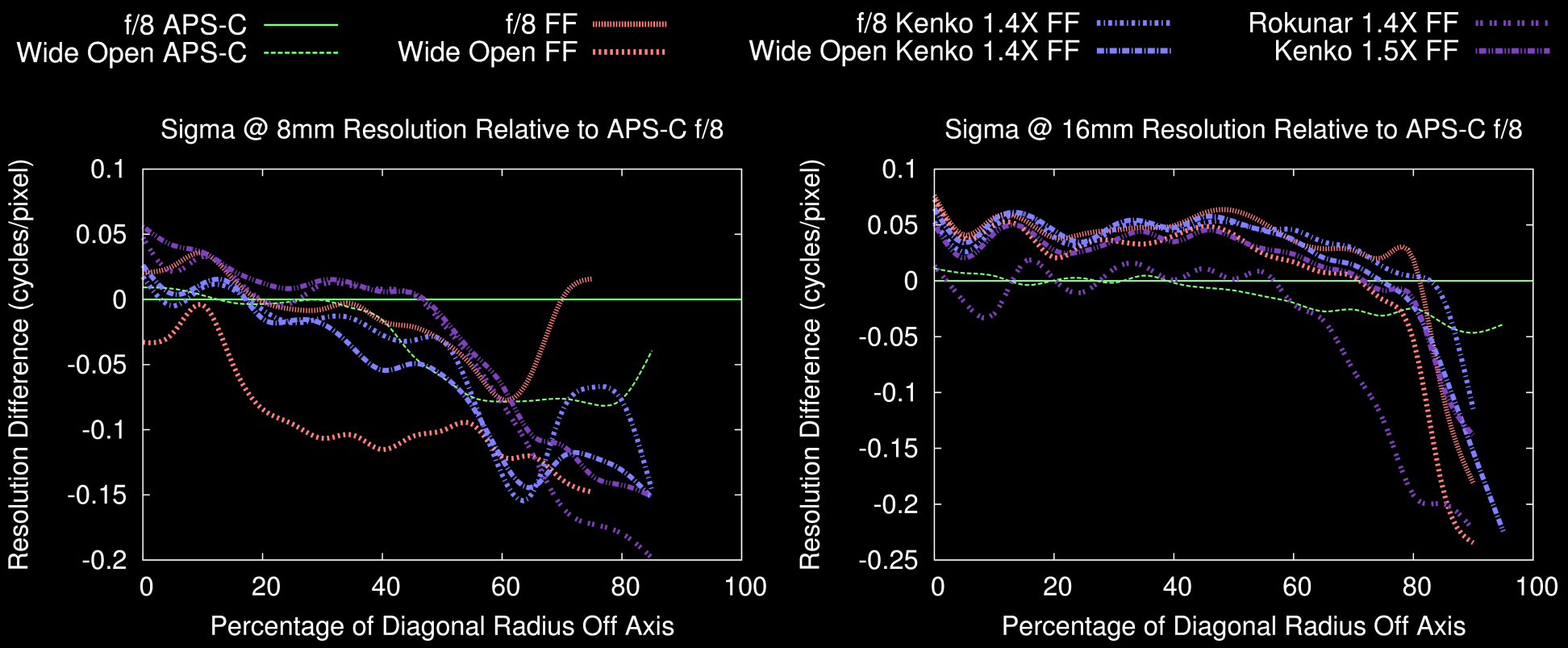
APS-C: 8-16mm *f*/4.5-5.6 Sigma



- Really too close to call except @ 8mm *f*/8

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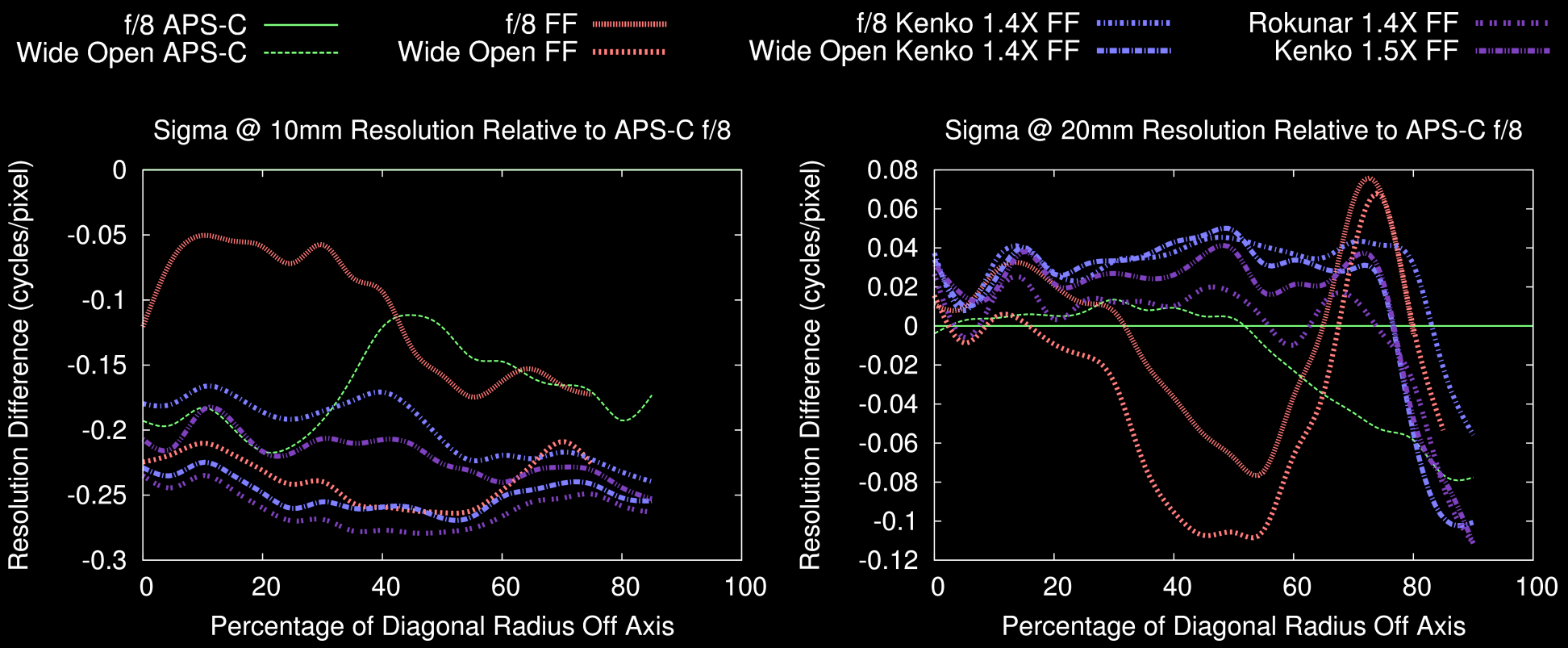
APS-C: 10-20mm *f*/4-5.6 Sigma



- Focus problem @ 10mm; only APS-C *f*/8 ok
- @ 20mm, FF TC did very well

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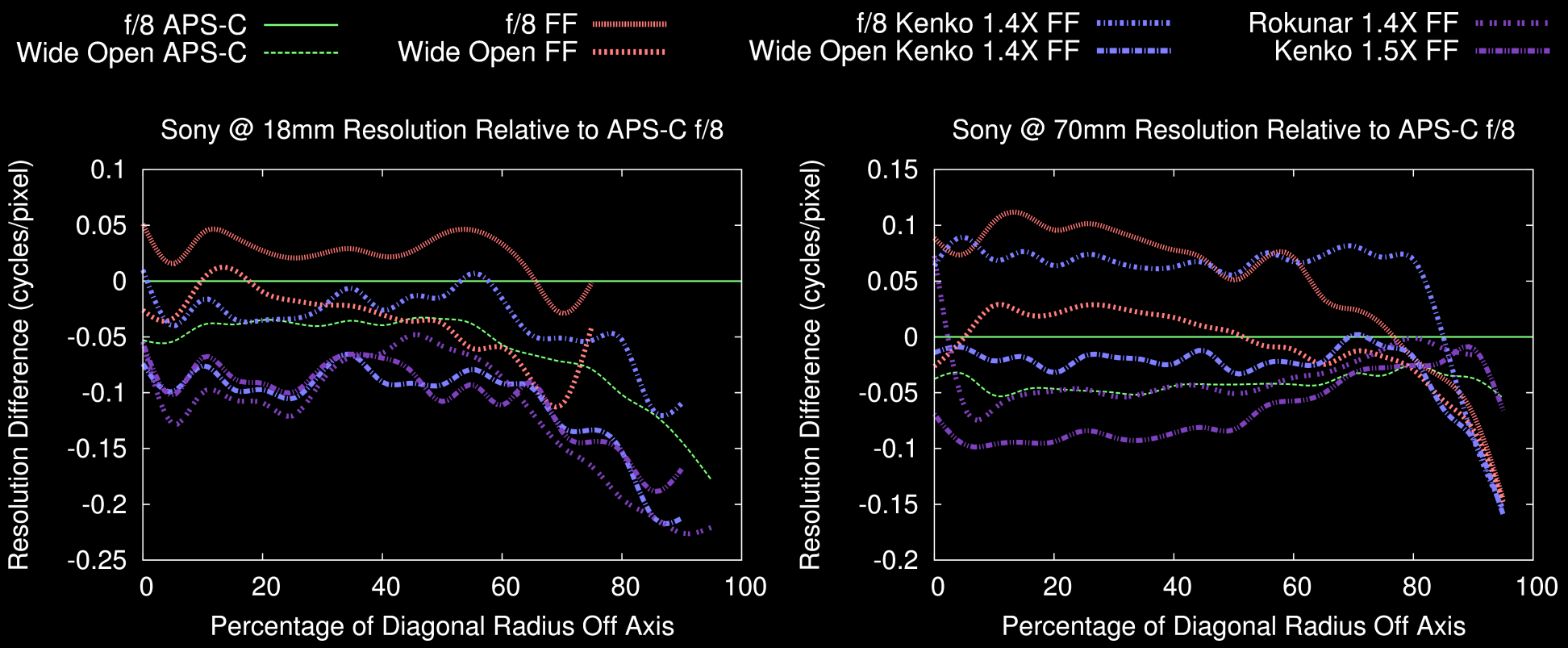
APS-C: 18-70mm *f*/3.5-5.6 Sony



- FF and *f*/8 best until vignetting
- FF with TC and *f*/8 also better than native

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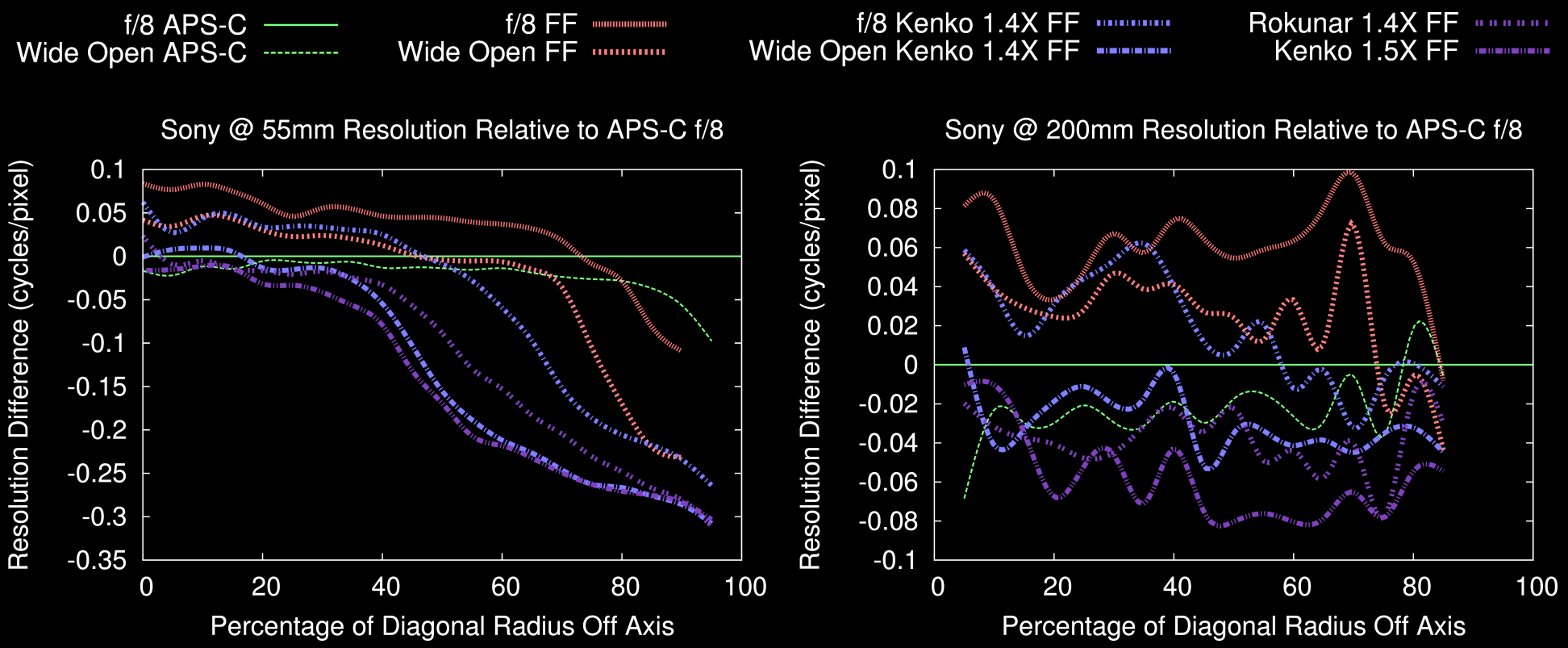
APS-C: 55-200mm *f*/4-5.6 Sony



- FF best overall
- FF with TC and *f*/8 mostly better than native

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What Did All Those MTF50 Measurements Tell Us?

- CA, SA, coma, field curvature, etc., will reduce MTF → resolution approximates image quality
- FF lenses:
  - Resolution generally was good for FF, but usually comparably good adapted
  - FRs often improve center resolution
- APS-C lenses:
  - Resolution on FF with TC often *beats* native
  - Direct use on FF helped mediocre centers

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Vignetting Measurement Procedure

- All measurements made using Sony **A7**
- Same settings as for MTF50 measurement, and same target
- Lighting was adjusted to improve evenness
- Absolute amount of darkening matters less than gradient in perception of vignetting, so results were presented primarily as images; problem cases were obvious
- Native FF vignette is shown wide open

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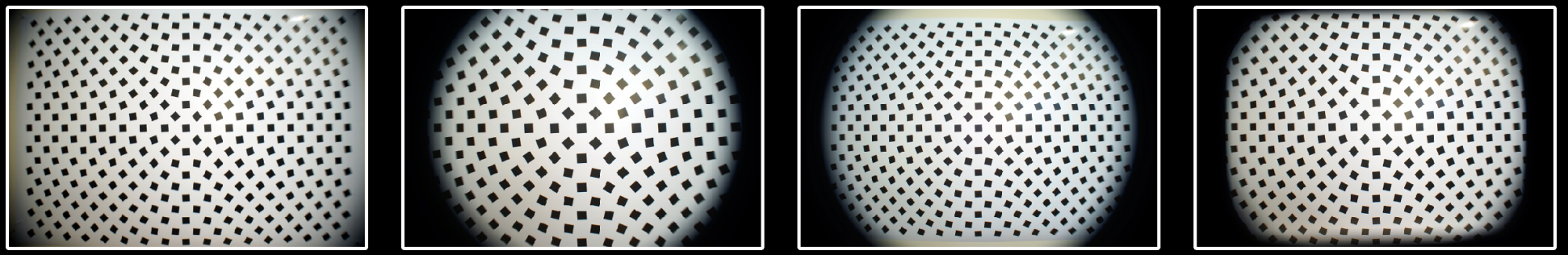
FF Lens Vignette:
18mm *f*/3.5 Spiratone

Spiratone 18mm Usable Area

Full–Frame, f/3.5 | Speed Booster Ultra FF, f/8 | Lens Turbo FF, f/8 | Lens Turbo II FF, f/8



- Heavy vignetting on native FF
- FR avoids worst in APS-C or 23mm square

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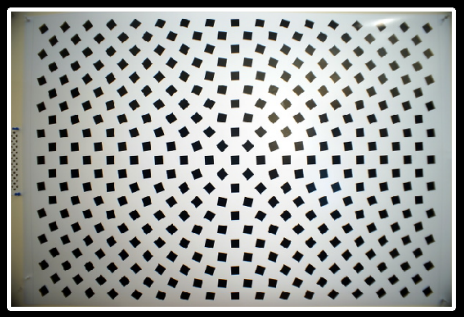
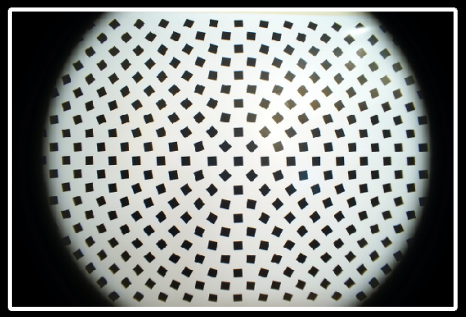
FF Lens Vignette:
20mm *f*/3.5 Mir 20

Mir 20 20mm Usable Area

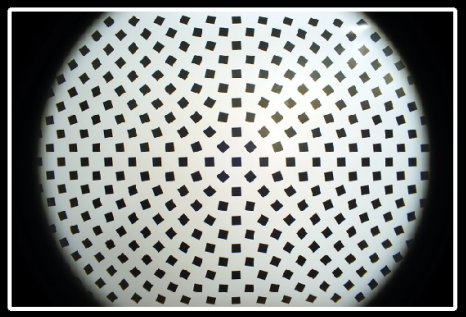
Full–Frame, f/3.5



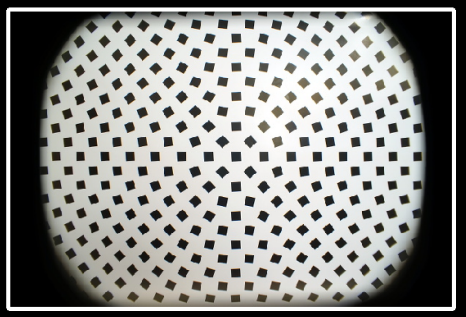
Speed Booster Ultra FF, f/8



Lens Turbo FF, f/8



Lens Turbo II FF, f/8



- Sharp vignetting >2EV in FF extreme corners
- FR is fine in APS-C or 23mm square crop!

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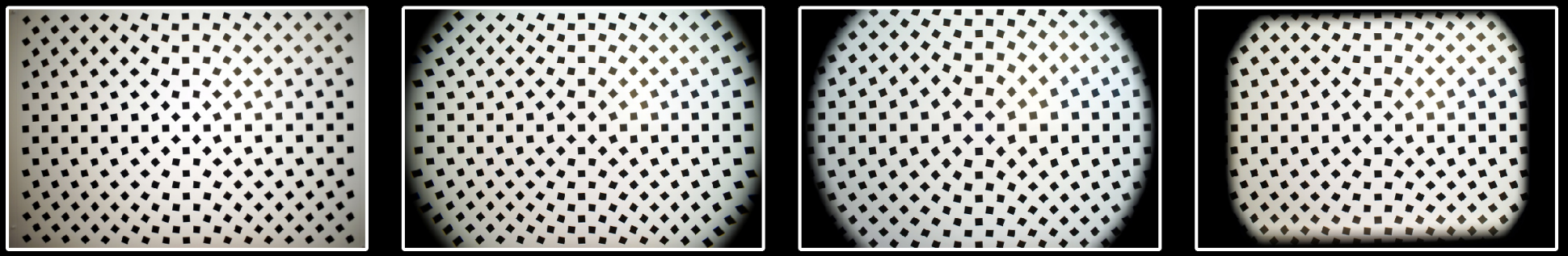
FF Lens Vignette:
35mm *f*/2 Takumar

Takumar 35mm Usable Area

Full–Frame, f/2 | Speed Booster Ultra FF, f/8 | Lens Turbo FF, f/8 | Lens Turbo II FF, f/8



- Gentle vignetting gradient in FF

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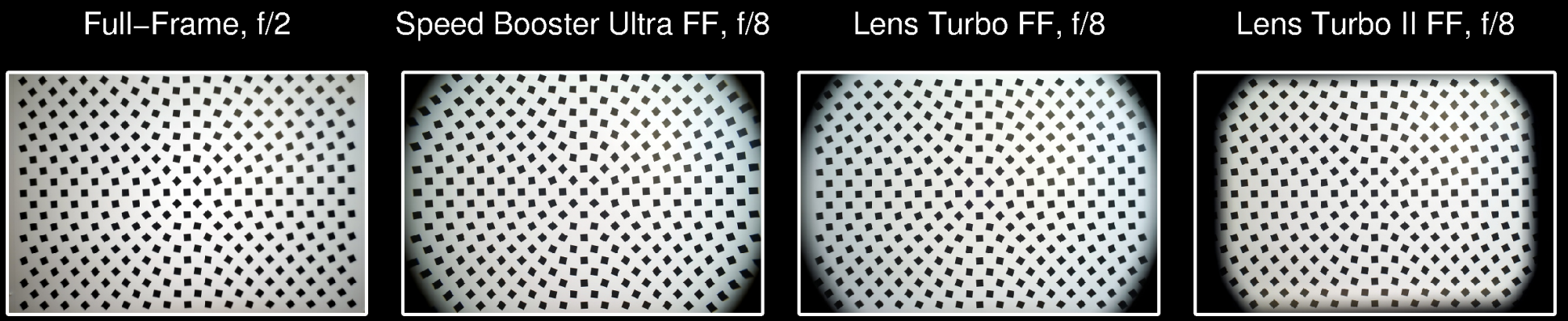
FF Lens Vignette:
58mm *f*/2 Helios

Helios 58mm Usable Area



- Gentle vignetting gradient in FF

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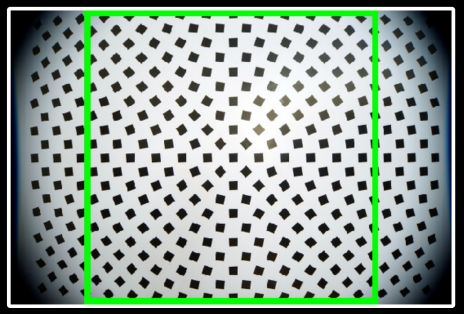
APS-C Lens Vignette:
8-16mm f/4.5-5.6 Sigma

Sigma @ 8mm Usable Area

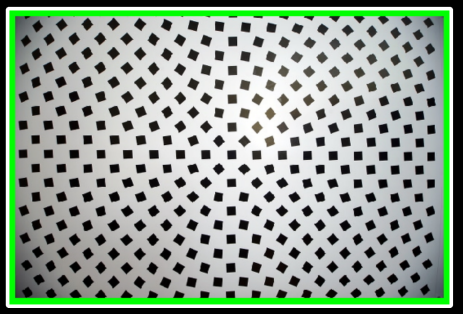
Full–Frame, f/8

Kenko 1.4X, f/8

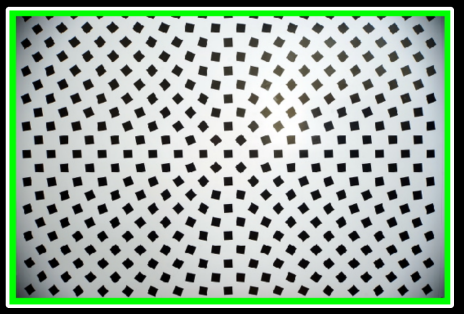


Sigma @ 16mm Usable Area

Full–Frame, f/8



Kenko 1.4X, f/8



- @ 8mm, 23mm square with trimmed hood?
- @ 8mm, good 24mm square with FR
- @ 16mm, covers FF even without FR

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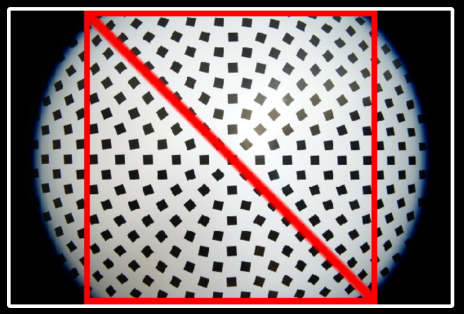
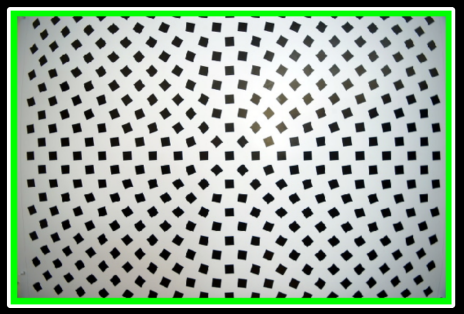
APS-C Lens Vignette:
10-20mm *f*/4-5.6 Sigma

Sigma @ 10mm Usable Area

Full–Frame, f/8

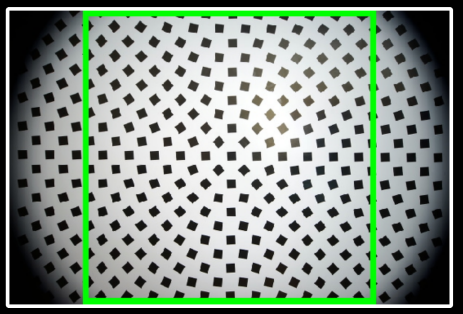


Kenko 1.4X, f/8

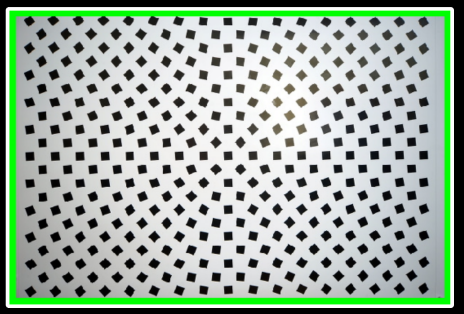


Sigma @ 20mm Usable Area

Full–Frame, f/8



Kenko 1.4X, f/8



- @ 10mm, 23mm square without TC
- @ 20mm, covers 24mm square without TC
- With FR, FF covered well at all focal lengths!

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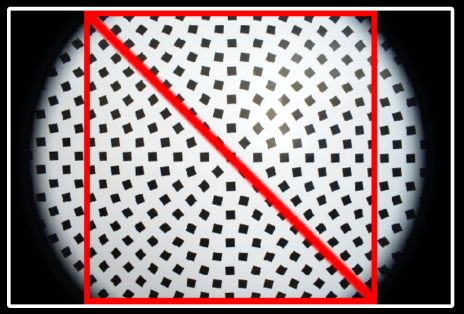
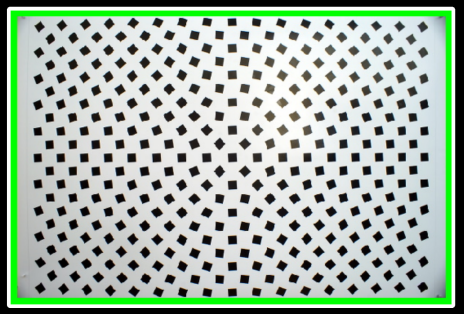
APS-C Lens Vignette:
18-70mm *f*/3.5-5.6 Sony

Sony @ 18mm Usable Area

Full–Frame, f/8

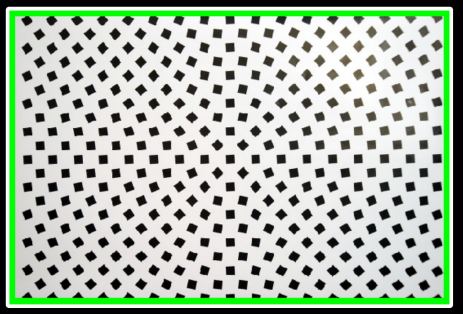


Kenko 1.4X, f/8

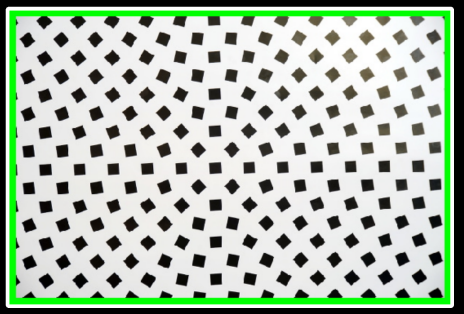


Sony @ 70mm Usable Area

Full–Frame, f/8



Kenko 1.4X, f/8



- @ 18mm, 23mm square without TC
- @ 18mm, extreme corners are dark with TC
- @ 70mm, even coverage with/without TC

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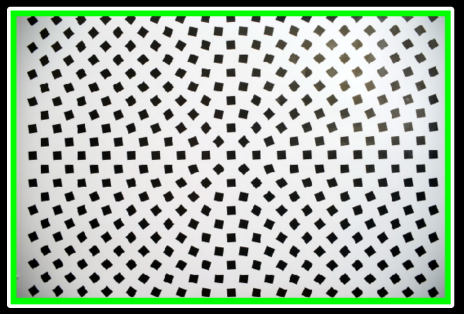
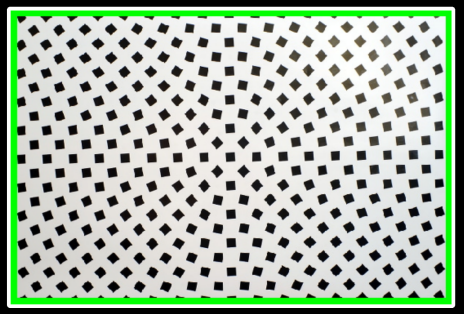
APS-C Lens Vignette:
55-200mm *f*/4-5.6 Sony

Sony @ 55mm Usable Area

Full–Frame, f/8

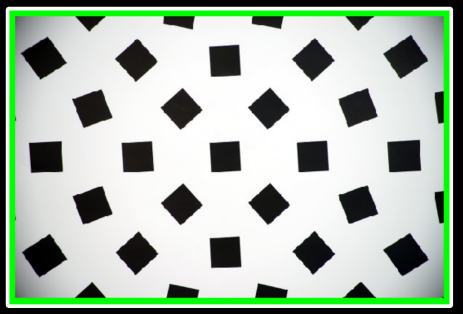


Kenko 1.4X, f/8

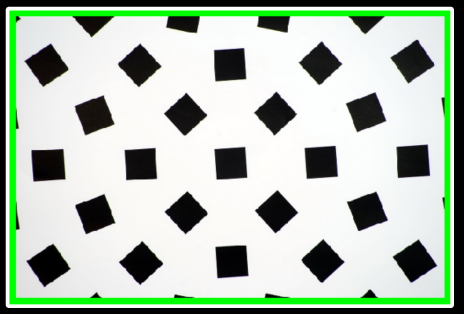


Sony @ 200mm Usable Area

Full–Frame, f/8



Kenko 1.4X, f/8



- @ 200mm, extreme corners dark without TC
- Covers FF with/without TC

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APS-C 10-20mm *f*/4-5.6 Sigma On APS-C Vs. FF + TC

- Left: @ 10mm native APS-C
- Right: @ 10mm on FF using 1.4x TC

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Conclusions

- IQ of adapted lenses often >= native format
  - FRs often improve central resolution
  - TCs used to expand coverage also “”
  - Some APS-C lenses cover FF natively
- Biggest FF problem: vignetting (even native!)
- FF FR allows at least 23mm square crops

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