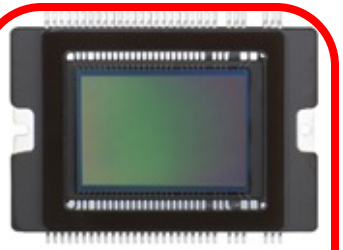
The Photogrammetric Process

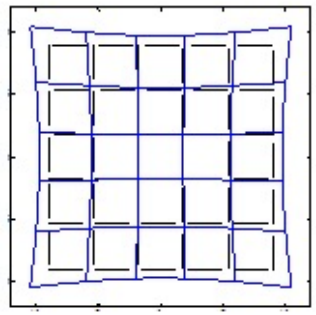



EMR → Atmosphere → Optics → Sensor → Measurements

Measurements → Corrections ← *Calibration*

Corrections → Orientation → Mapping products

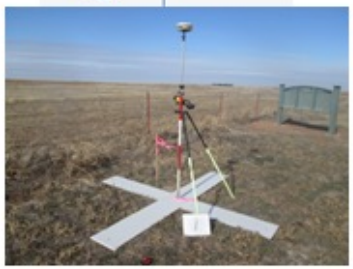




Image sources

http://blogs.mcgill.ca/osscontributors/tag/sun/
http://www.dcmtechservices.com/Targets.htm
http://www.theguardian.com/environment/2011/jan/28/europe-air-quality-pollution
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http://www.rpsurveying.com/img/proj/ControlPoint.Full.png
http://www.3dcadbrowser.com/download.aspx?3dmodel=20756

All Slides Courtesy of:

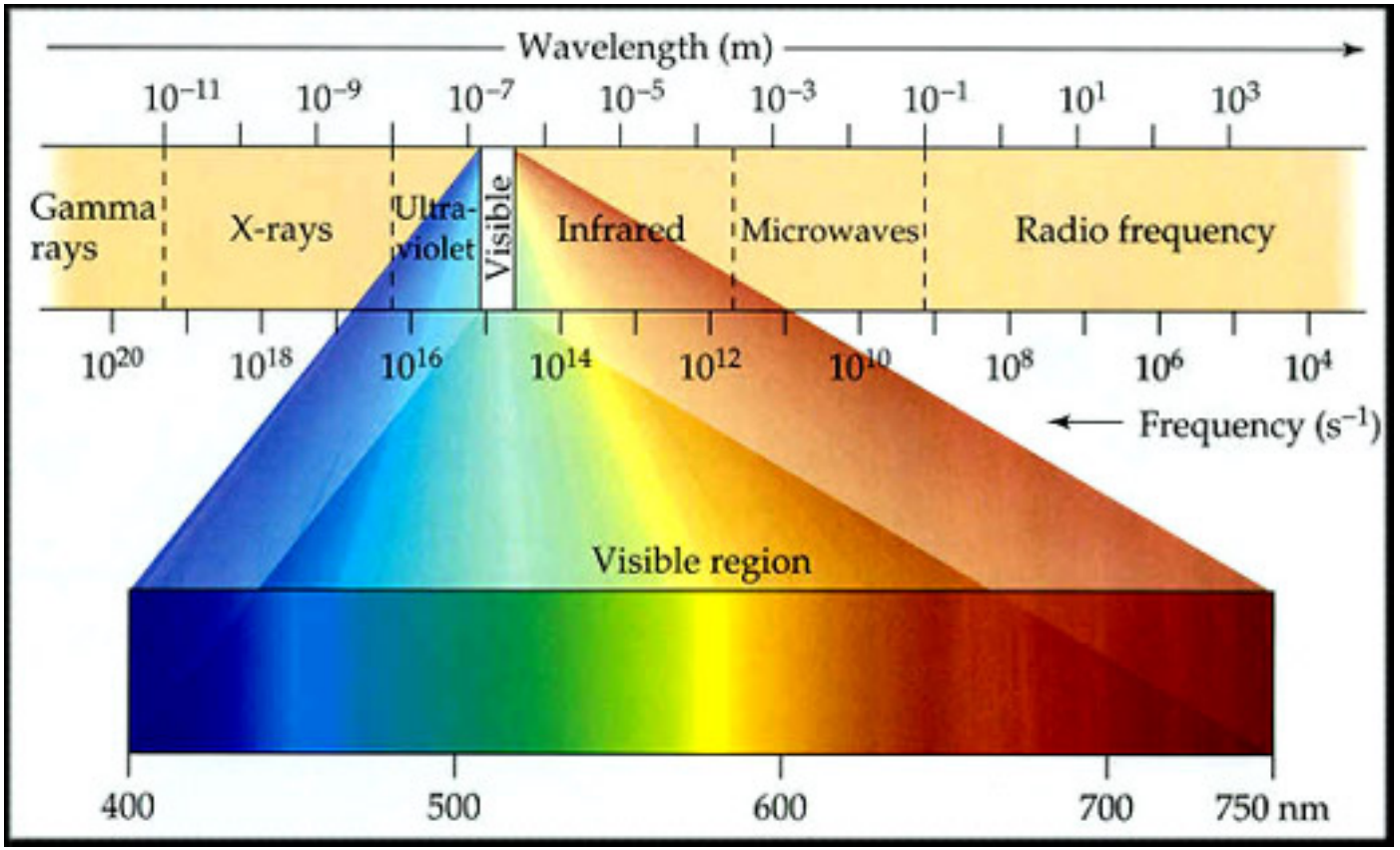
Dr. Derek Lichti
University of Calgary

EMR and Sensors

- Electromagnetic radiation (EMR)
  - Only the portions of the spectrum used by different photogrammetric sensors will be mentioned here
- Sensor types
  - Operational principles of solid-state sensors and film not covered in detail
  - More application examples presented

EMR Wavebands

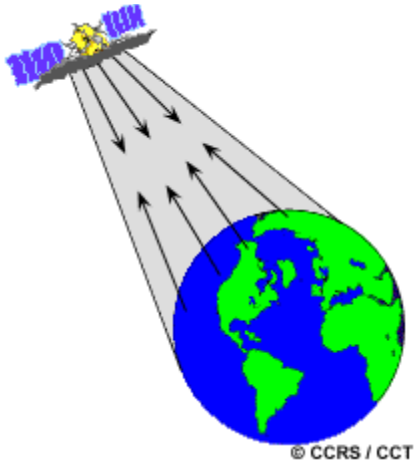
- Question for discussion: which wavebands are used for photogrammetric imaging?



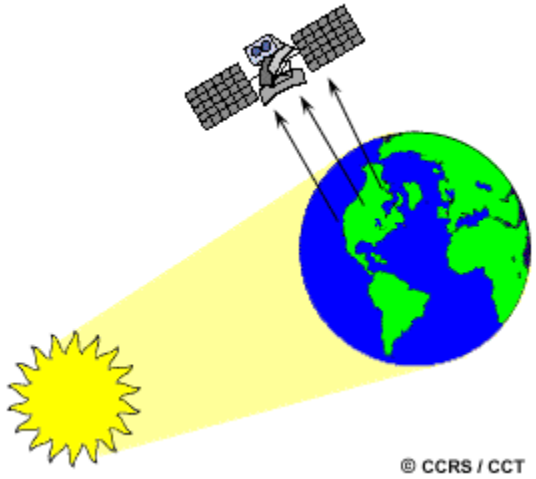
http://scioly.org/wiki/index.php/Remote_Sensing

Active vs. Passive Sensors

- Active sensors emit an EMR signal that is backscattered and received to form an image
- Examples: RADAR, LIDAR, (CIVE 6382)



- Passive sensors receive a reflected or an emitted EMR signal from the surrounding environment
- Examples: digital camera, thermal camera



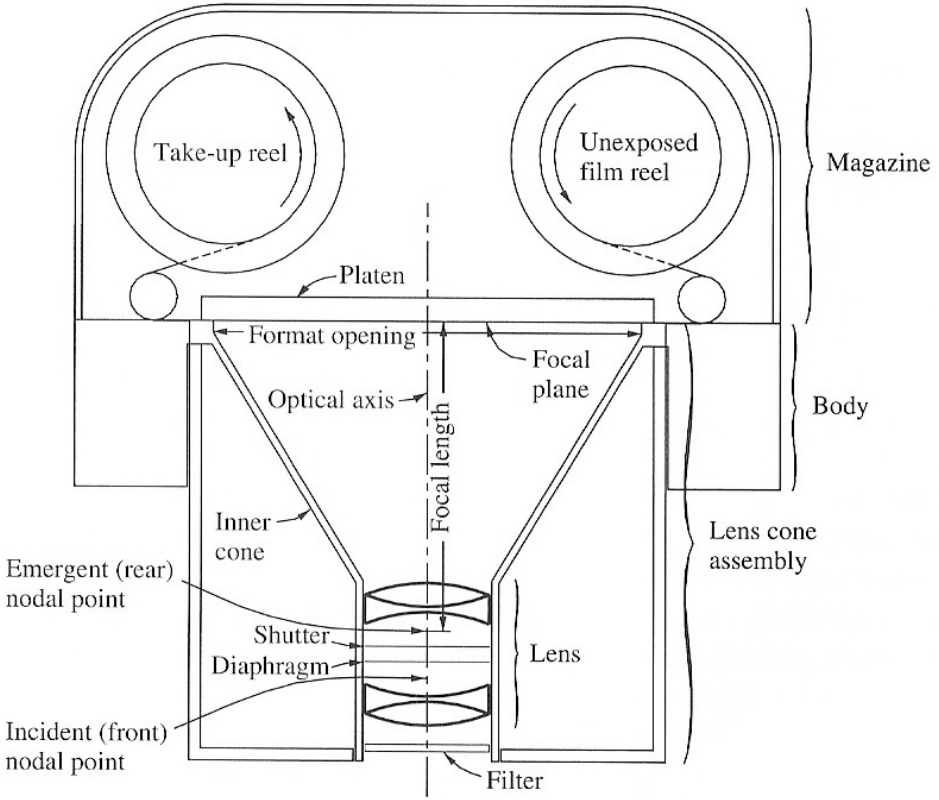
http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/14639

Passive Sensors

- Analogue (film) aerial frame camera—RC 30

http://www.leica-geosystems.us/en/Leica-RC30_57632.htm

- Schematic of a film aerial camera



Wolf, P R and B A Dewitt (2000) Elements of Photogrammetry. 3rd edition. McGraw Hill: Boston.

Passive Sensors (cont'd)

Full Frame Single Digital Camera

Applanix DSS 580
7752 x 10320 pixels
(80 Mpixels)

Multiple (5) Full Frame Digital Camera

Leica DMC III
26 112 x 15 000 pixels

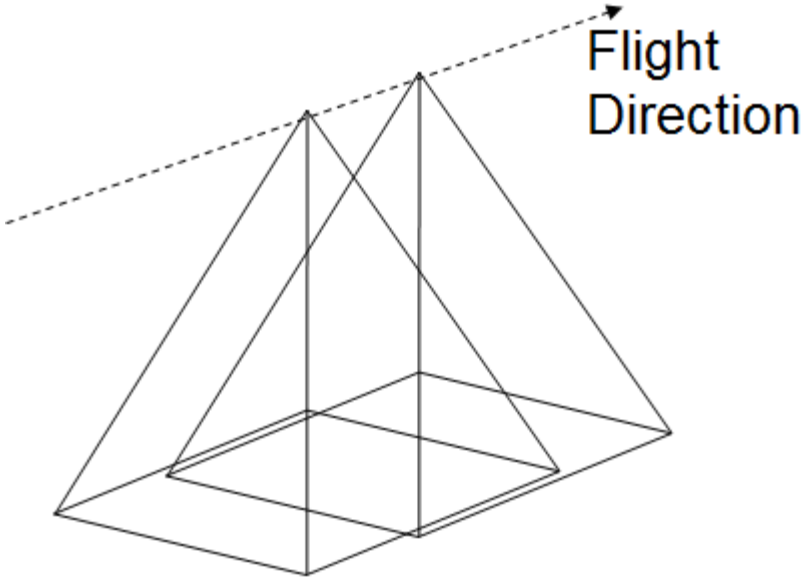
Multiple Line Pushbroom Digital Camera

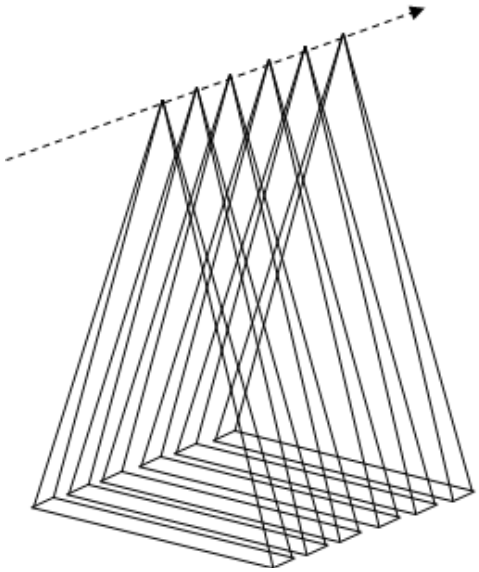
Leica ADS 100
13 lines, 20 000 pixels each

http://www.applanix.com/media/downloads/products/specs/DSS-500-Fact-Sheet.pdf
http://leica-geosystems.com/downloads123/zz/airborne/dmc_III/brochures-datasheet/Leica_DMCIII_DS_en.pdf
http://leica-geosystems.com/downloads123/zz/airborne/ADS100/brochures-datasheet/Leica_ADS100_DS_en.pdf

Frame vs. Pushbroom Imaging

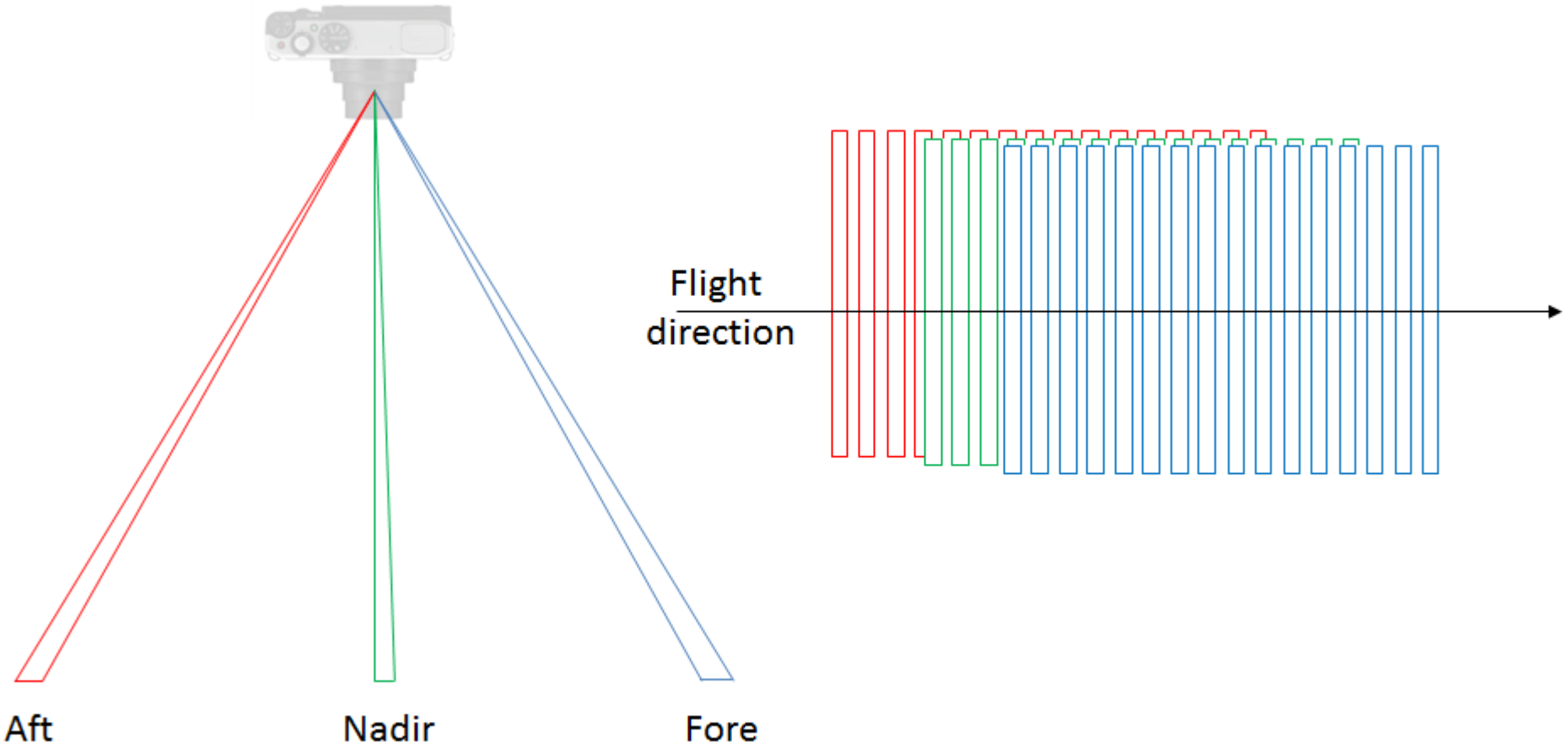
- Frame image acquisition
  - Set of overlapping frames
  - Each frame has its own perspective centre (PC)
- Pushbroom acquisition
  - Image is built up from a series of linear images
  - Each line has its own PC





Pushbroom Imaging

- Stereo coverage achieved with the overlap of the fore, nadir and aft channels



Passive Sensors (cont'd)

- Analogue terrestrial camera

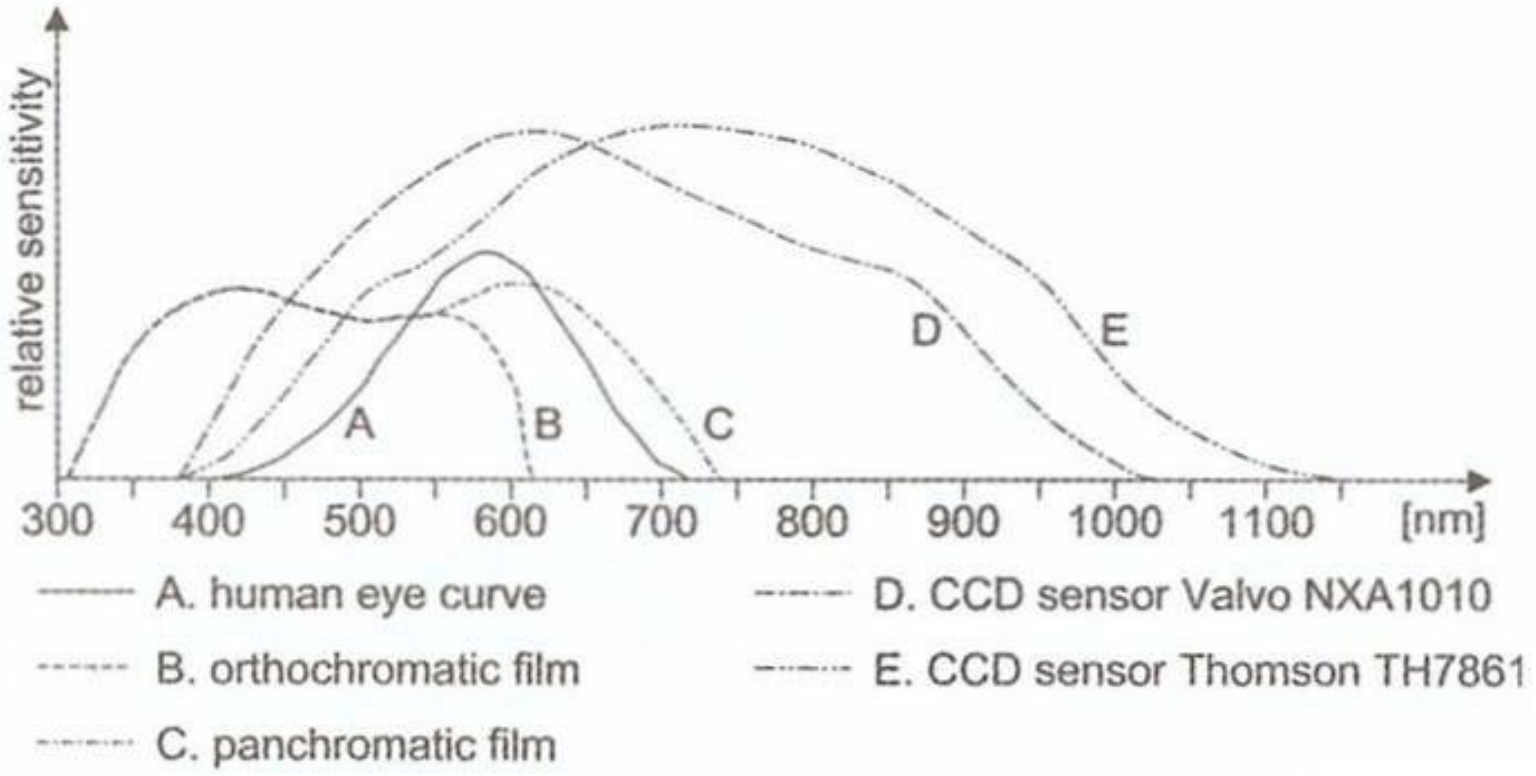
- Digital cameras

http://foto.hut.fi/opetus/260/luennot/8/mittakamera_Wild_P31.jpg
https://research.ncl.ac.uk/geospatial/research/remotesensingandphotogrammetry/researchthemes/closerangephotogrammetry/
http://www.rcgroups.com/forums/showthread.php?t=2391450

Passive Sensors (cont'd)

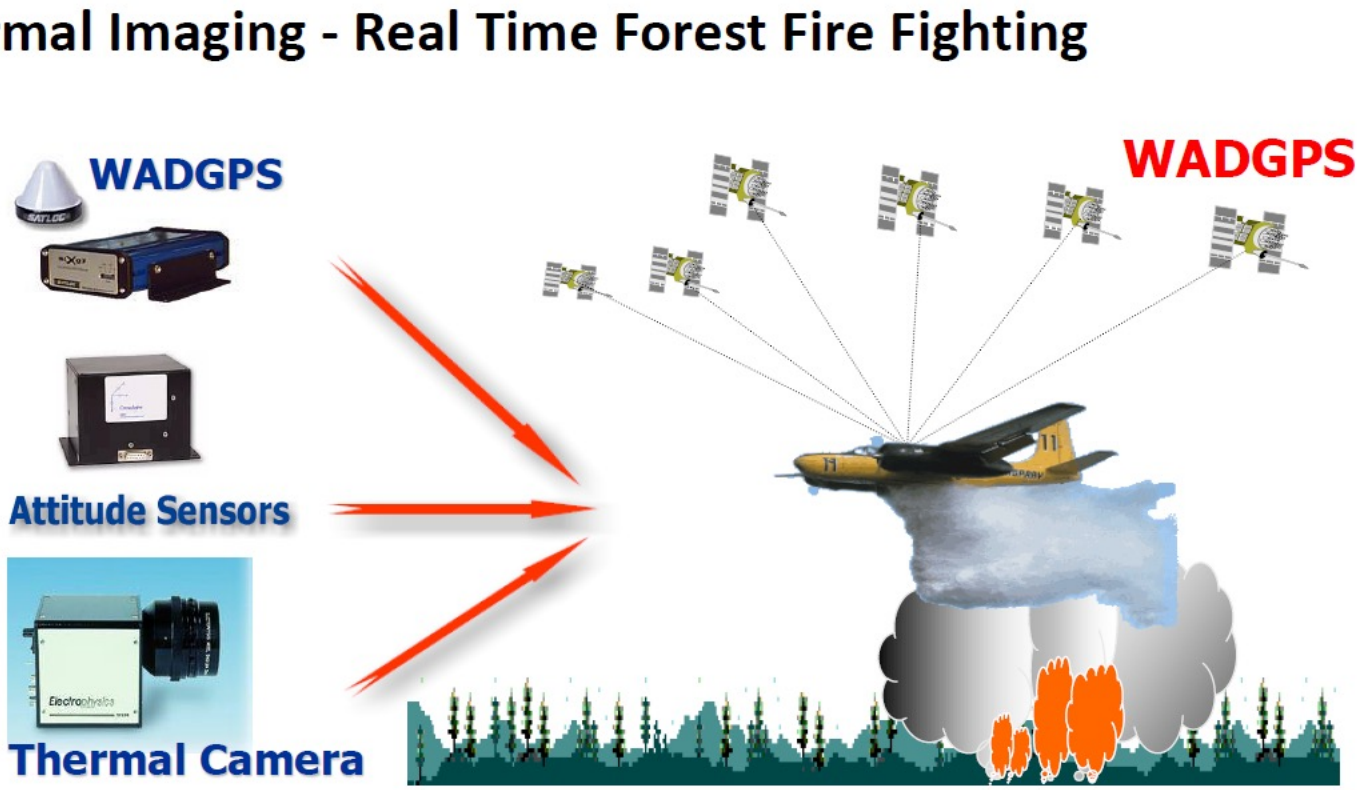
- Other passive sensors used for photogrammetry
  - Smart phones
  - GoPro
  - High-resolution (< 1m) satellite imagery: GeoEye, WorldView

Passive Optical Detector Sensitivity



Luhmann, T, Robson, S, Kyle, S and Harley, I, 2006. Close Range Photogrammetry: Principles, Techniques and Applications. Whittles Publishing, Caithness, Scotland.

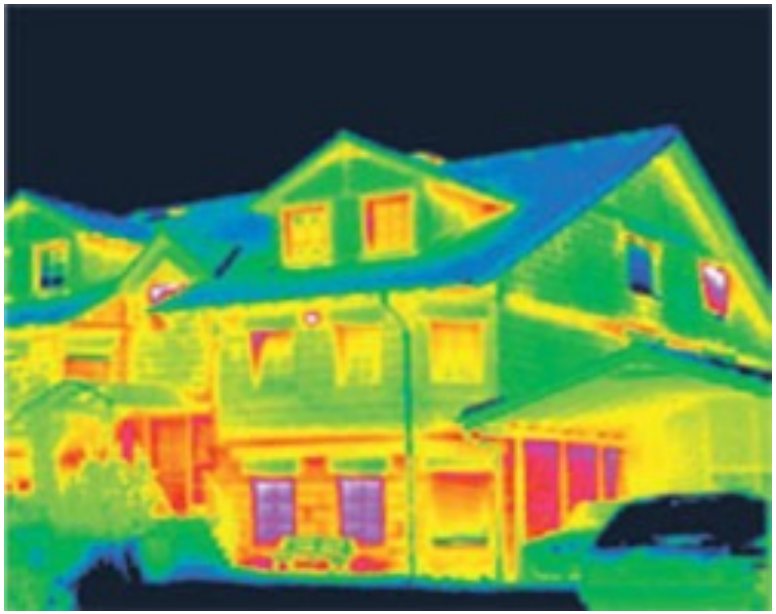
Thermal Imaging (Passive)



- Real-time reporting of the exact situation of fires
- Assisting the Forest Fire Information Centers in accurately assessing the fire
- Precisely directing water-bombers and fire-fighting crews

Image courtesy Naser El-Sheimy

Thermal Imaging (cont'd)

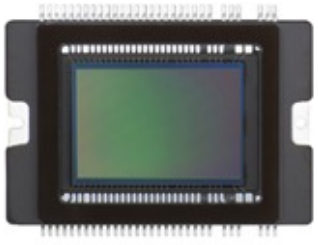


http://img.directindustry.com/images_di/photo-g/thermal-imaging-camera-handheld-7692-4046662.jpg
http://www.gwhomeinspections.com/ServicesDetail.aspx?Title=Thermal%20Imaging

The Photogrammetric Process





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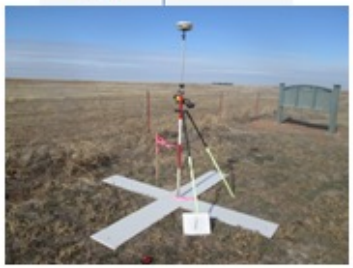
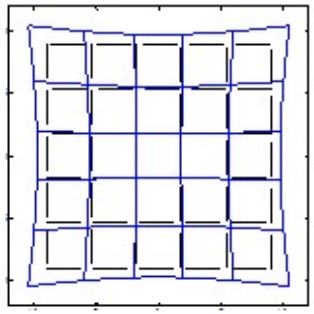

Image sources

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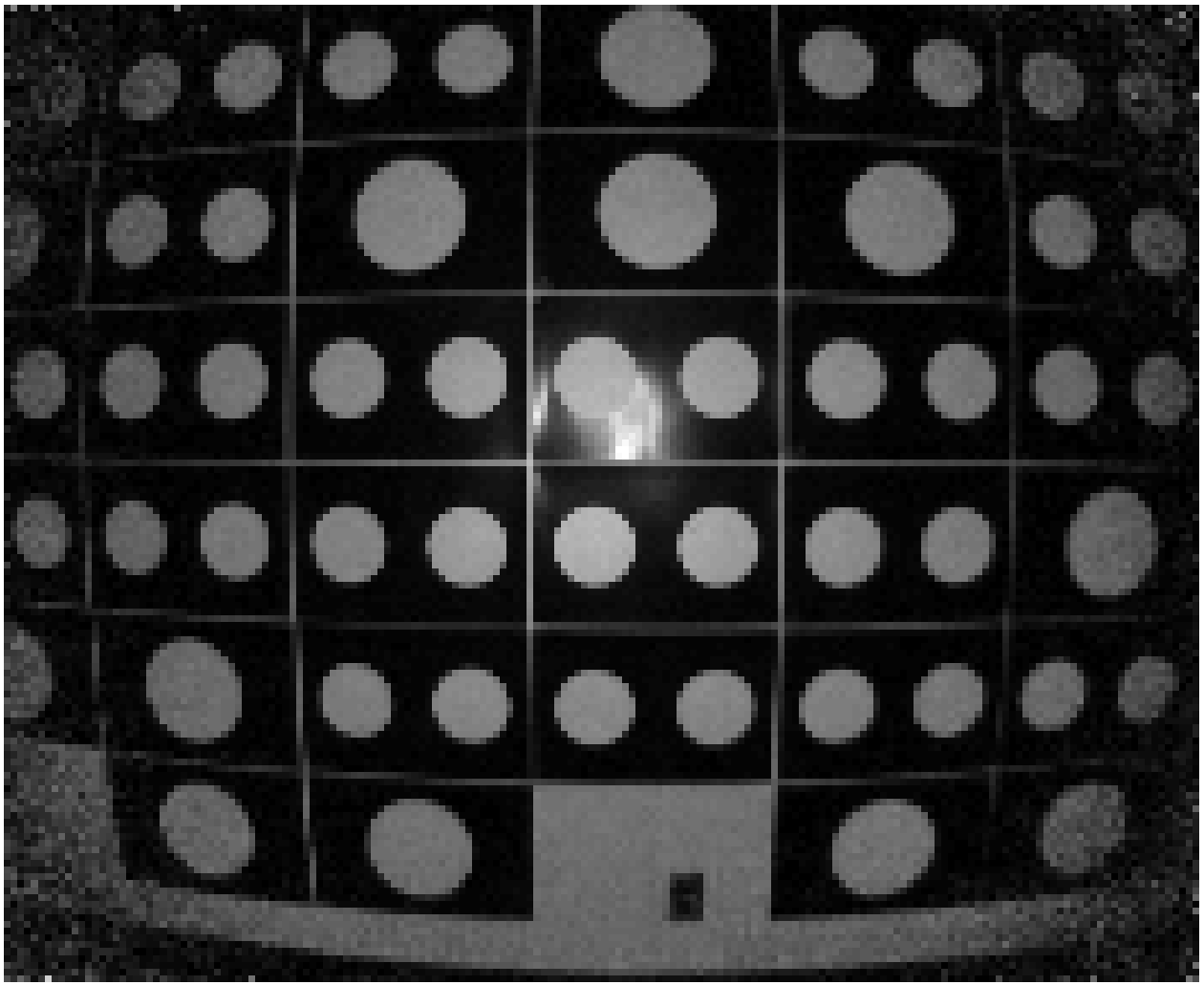
http://www.3dcadbrowser.com/download.aspx?3dmodel=20756

Aim of Photogrammetry

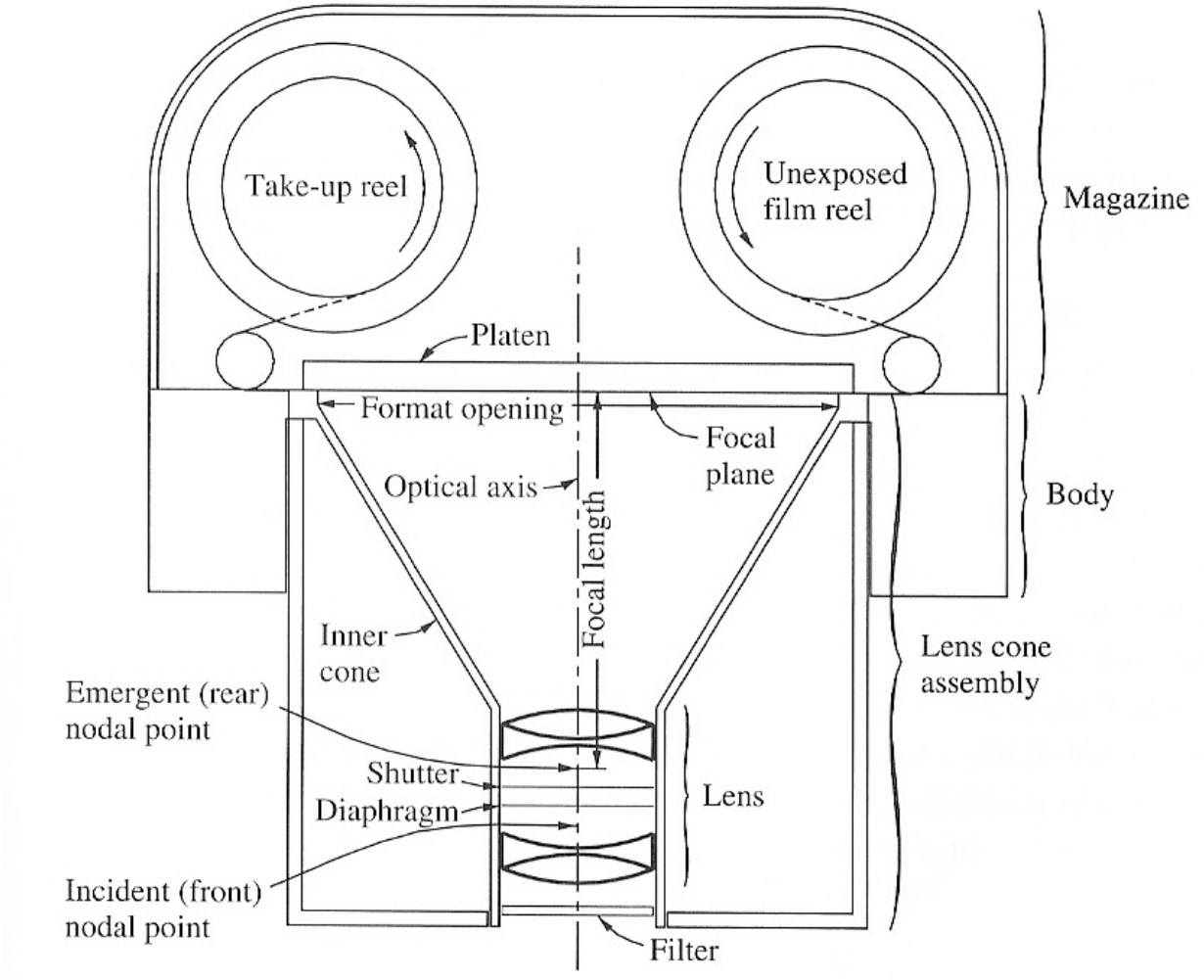
- To reconstruct the 3D world from 2D images
- Precise x,y image point co-ordinate measurements are needed
- Question: what factors might preclude our ability to make accurate measurements?

- Example on the next page
  - SR4000 range camera amplitude image
  - Aim: precise target centre measurement by least-squares ellipse fitting
  - Question: What degrading factors are evident in the image?

Image Measurement Problems

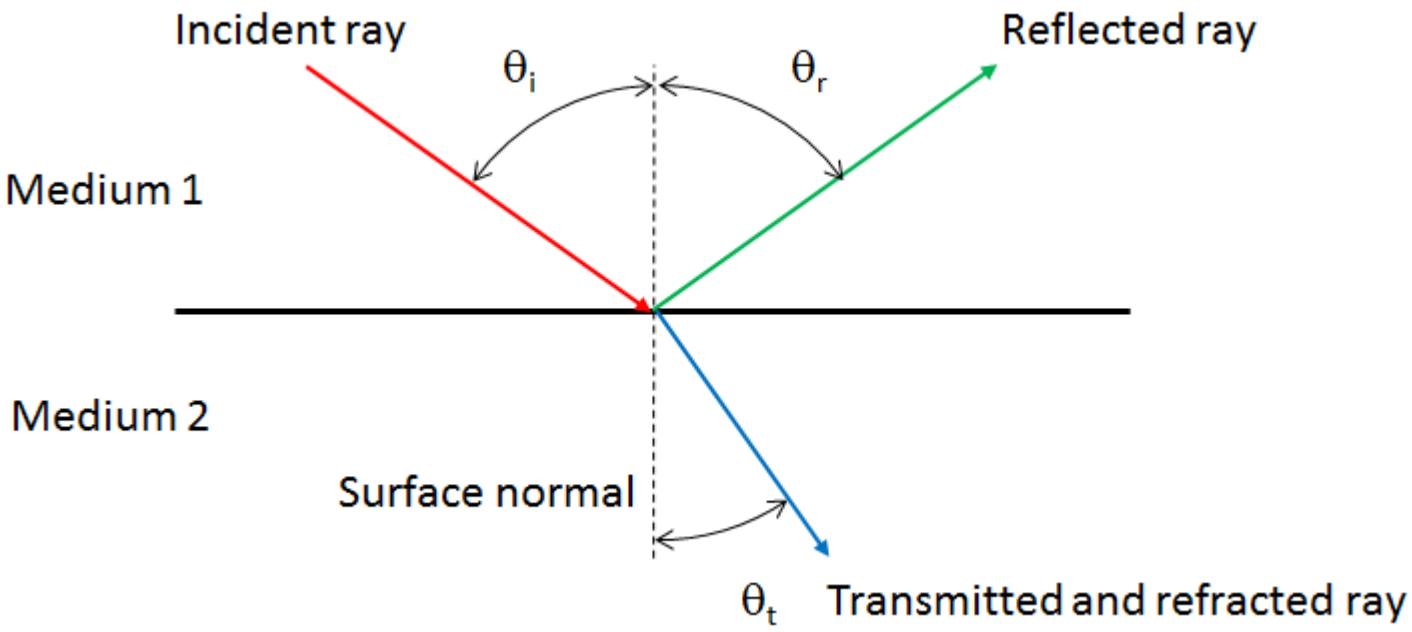


Analogue Photogrammetric Camera

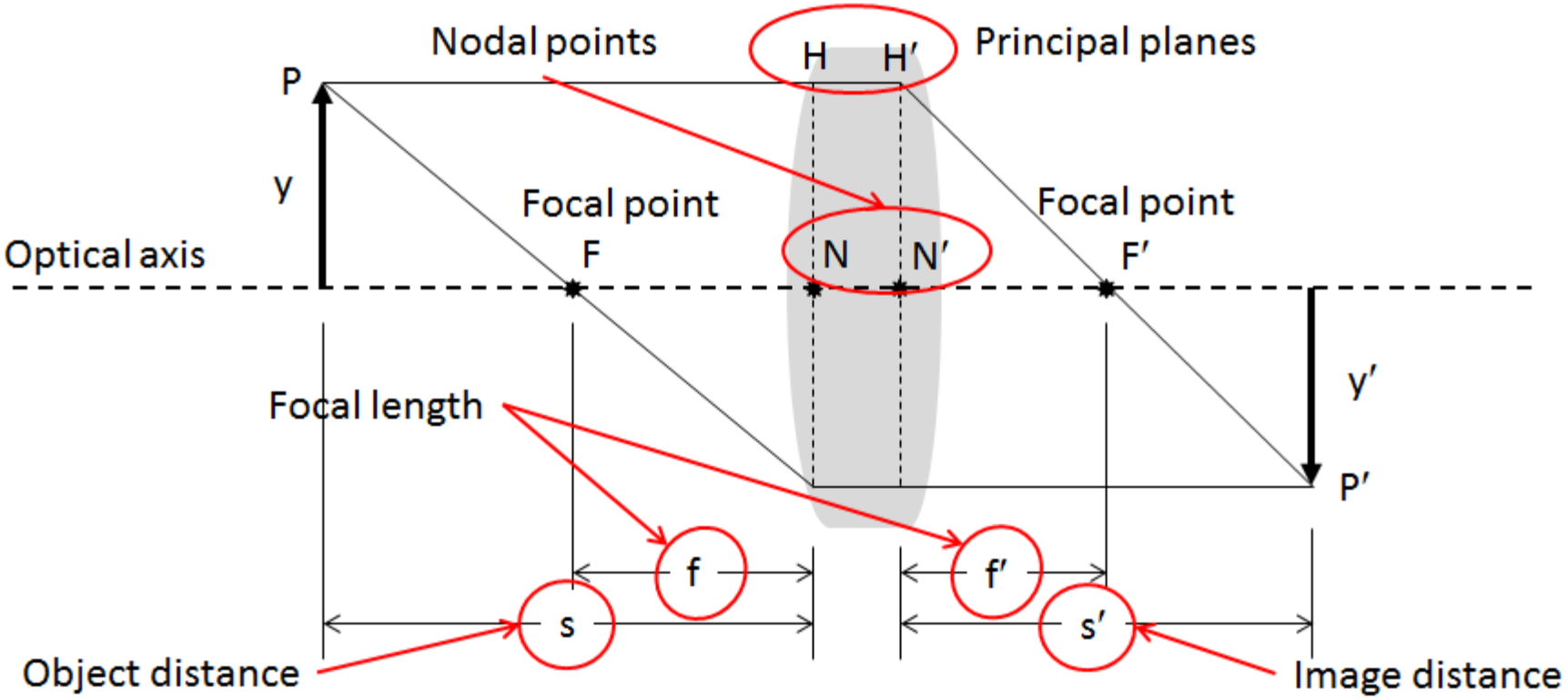


Wolf, P R and B A Dewitt (2000) Elements of Photogrammetry. 3rd edition. McGraw Hill: Boston.

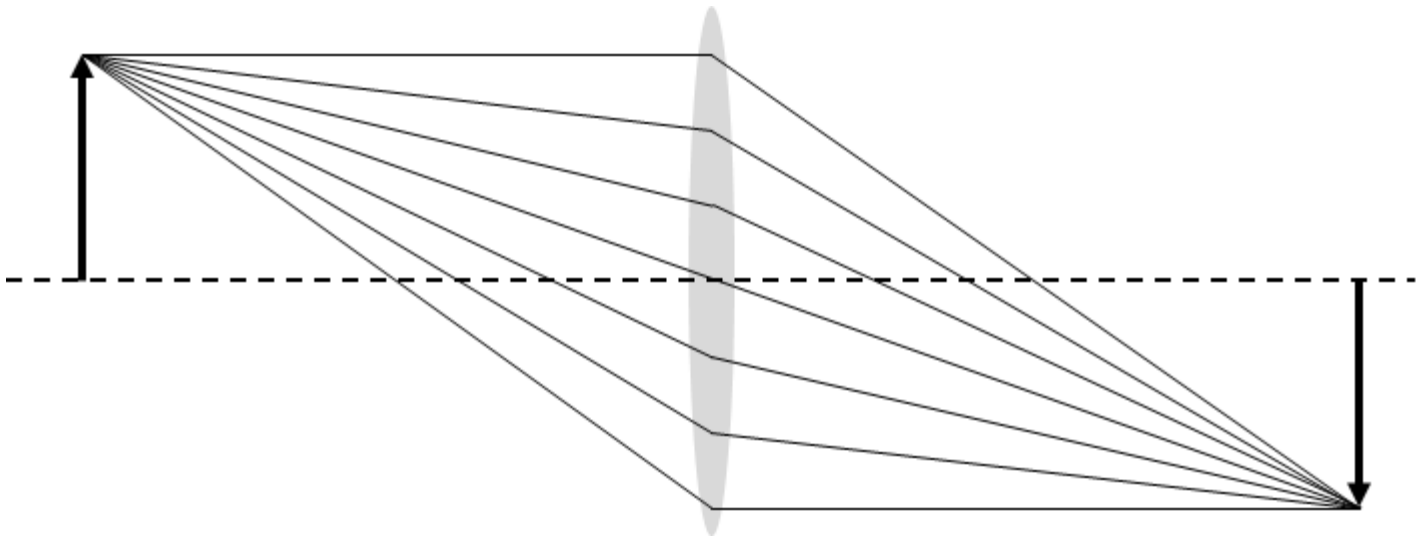
Geometric Optics



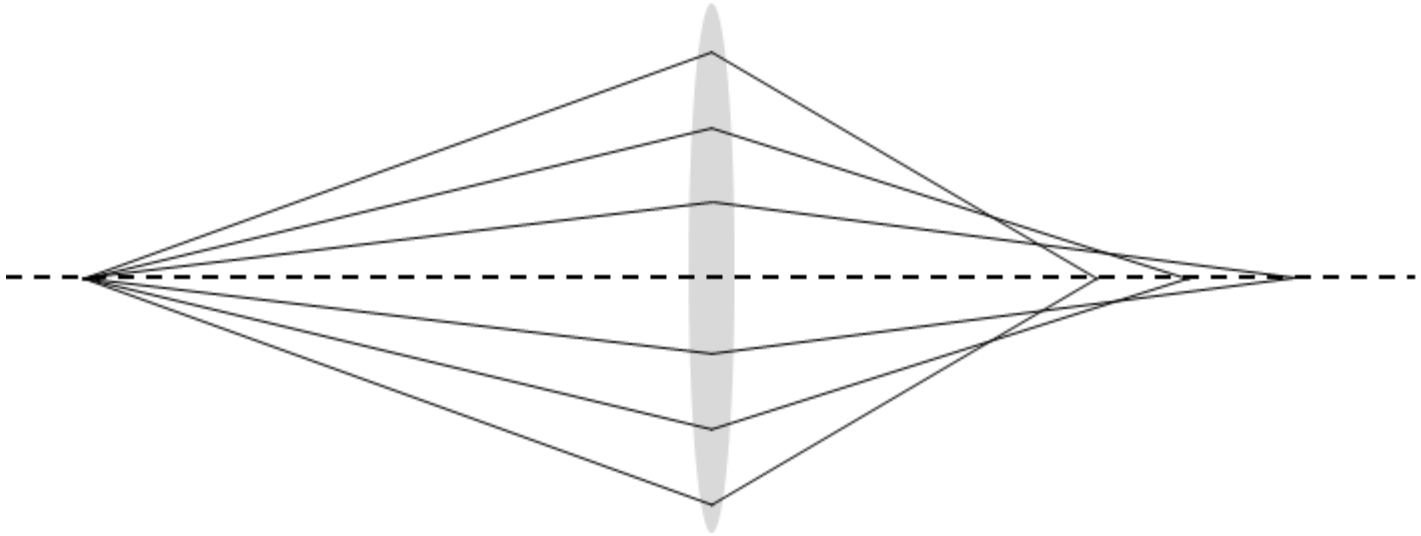
Basic Lens Definitions



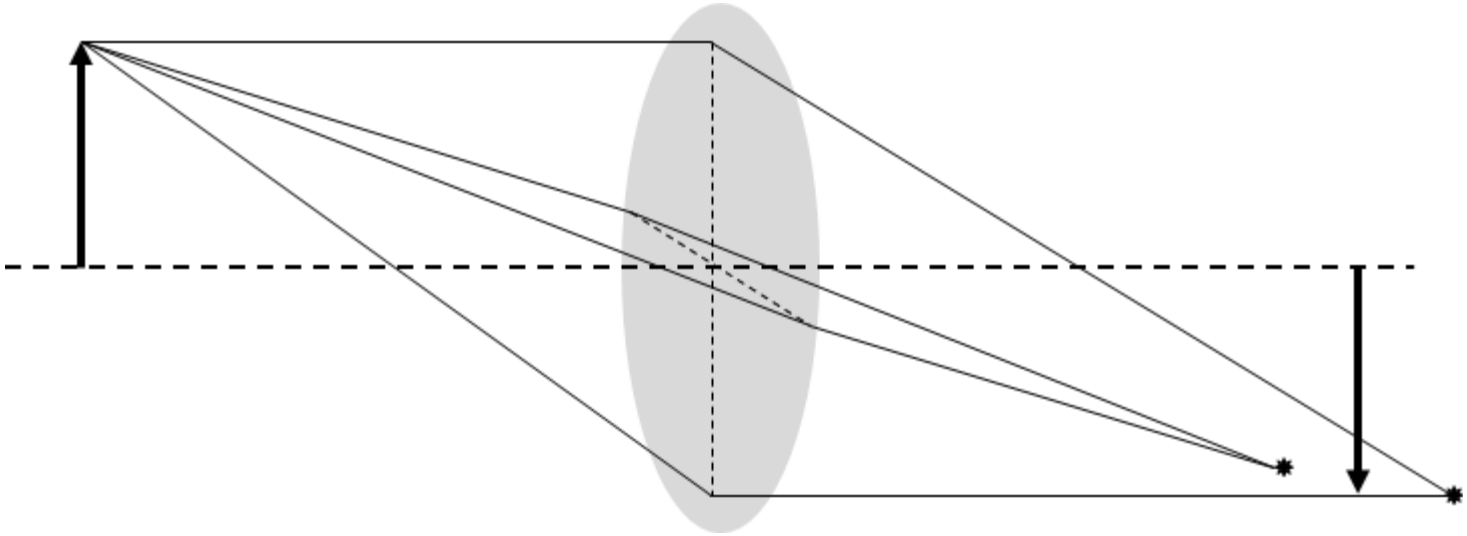
Aberration-Free Lens



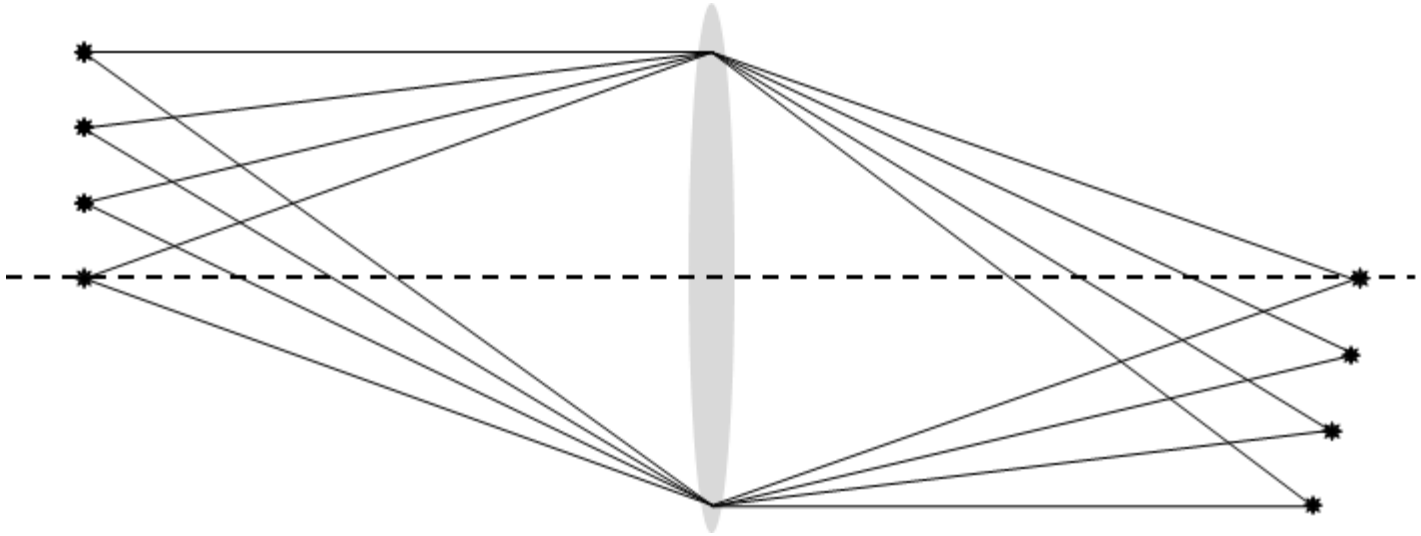
Spherical Aberration



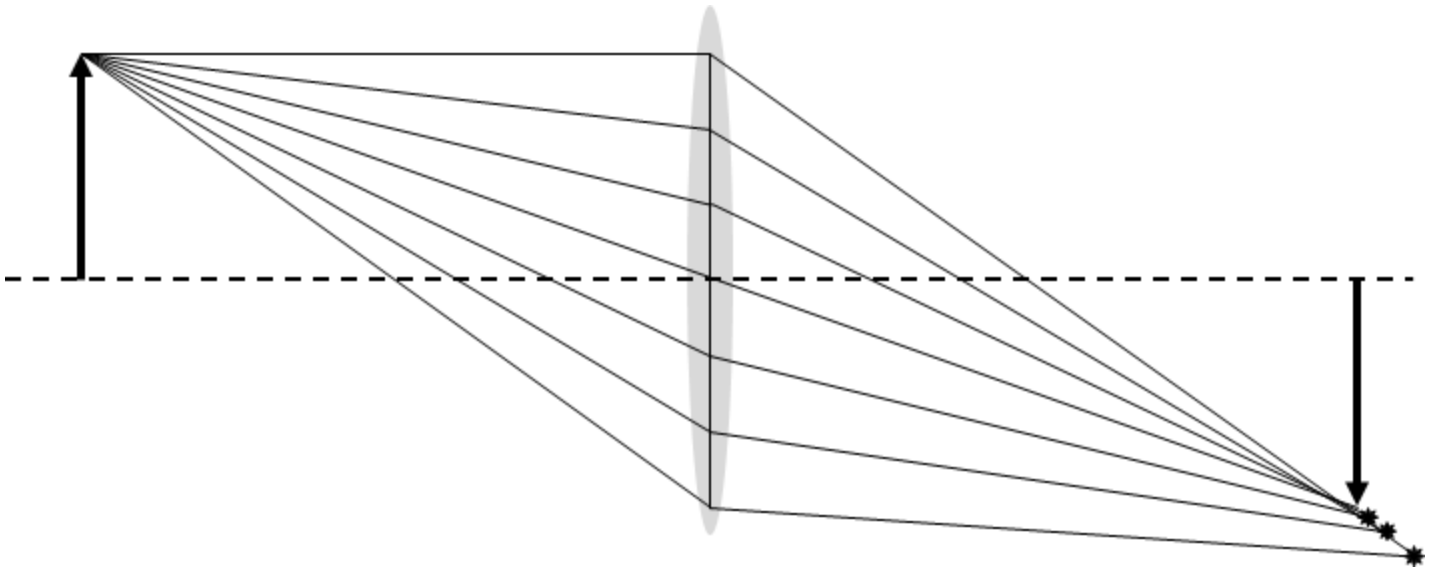
Astigmatism



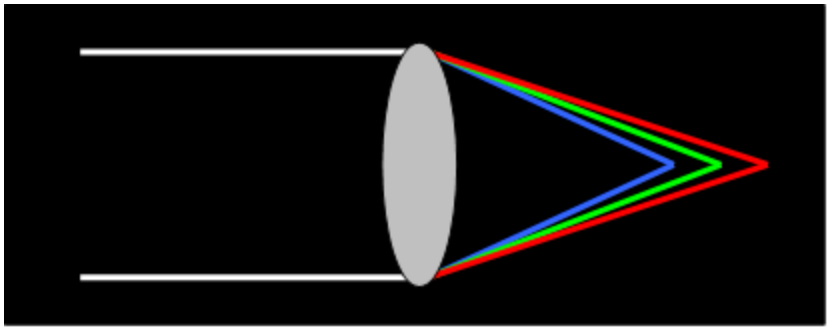
Curvature of Field



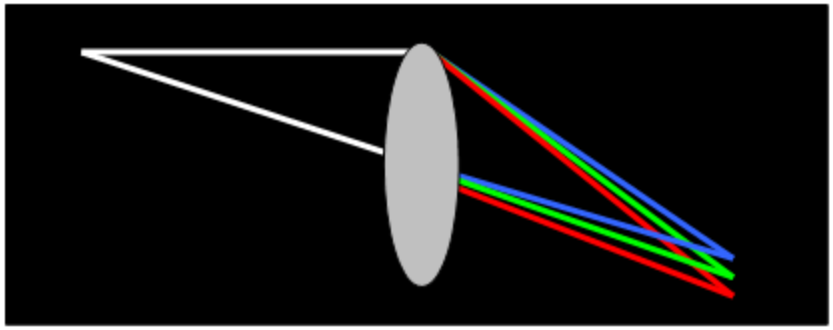
Coma



Chromatic Aberration



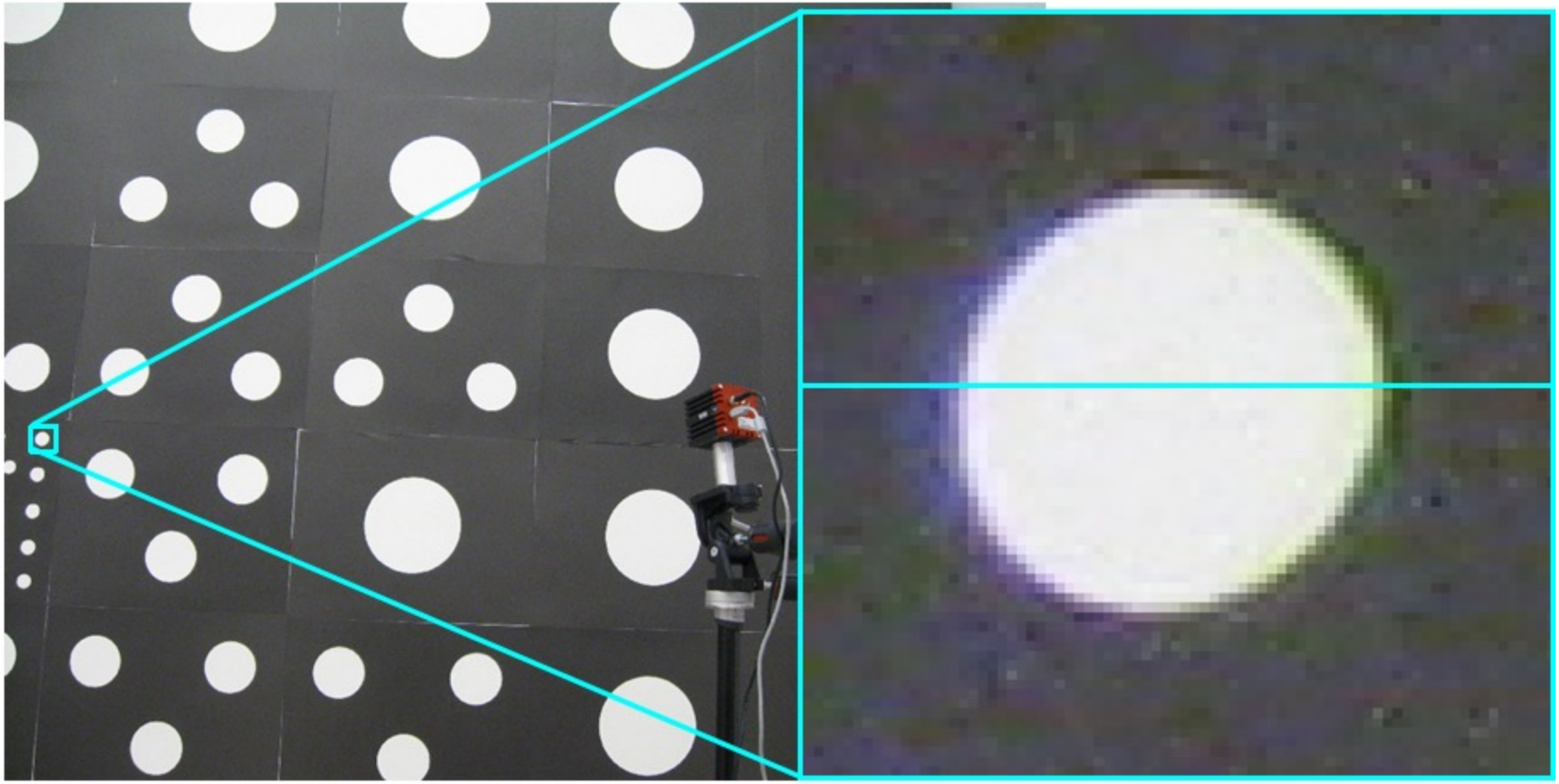
Longitudinal



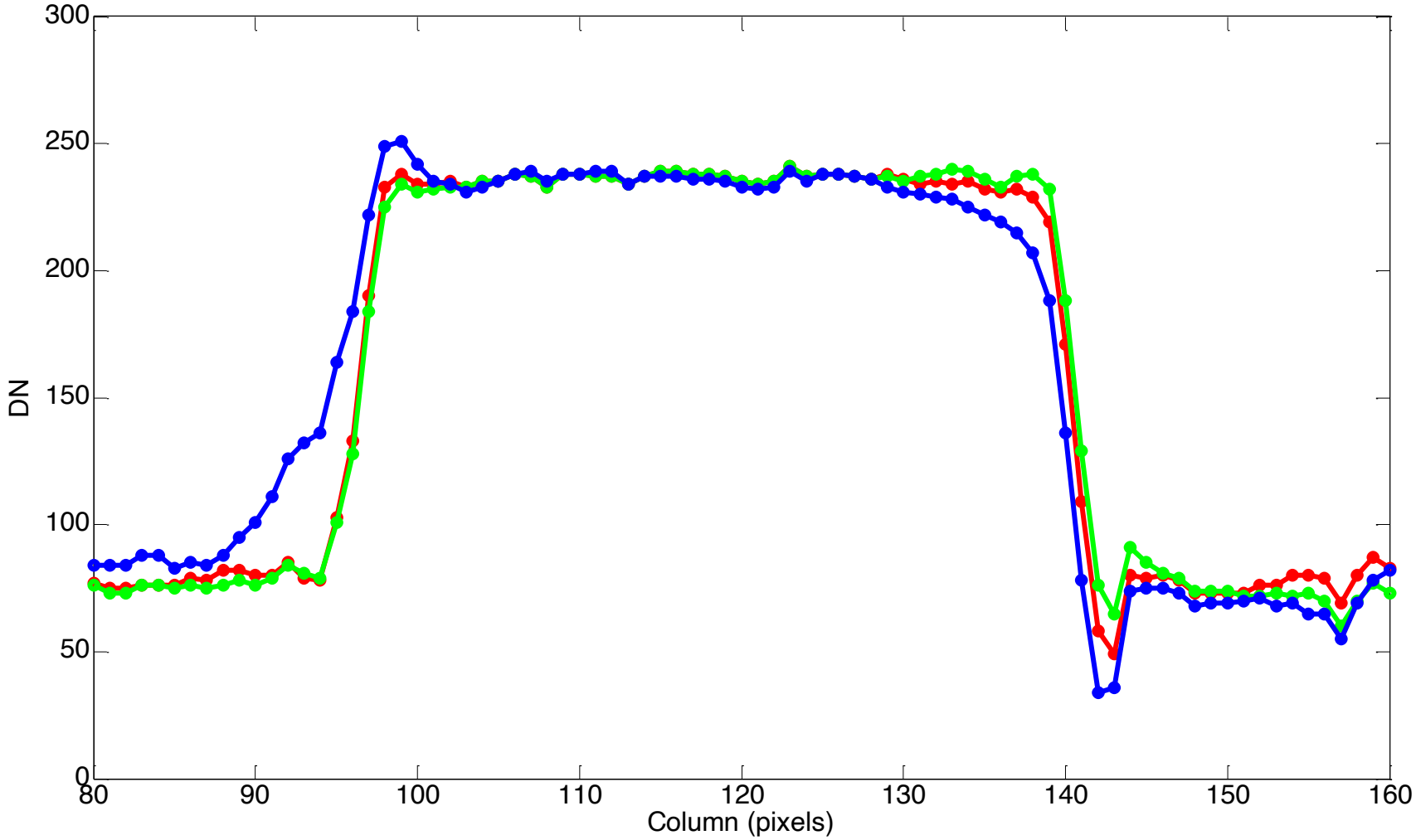
Lateral

Chromatic Aberration Example

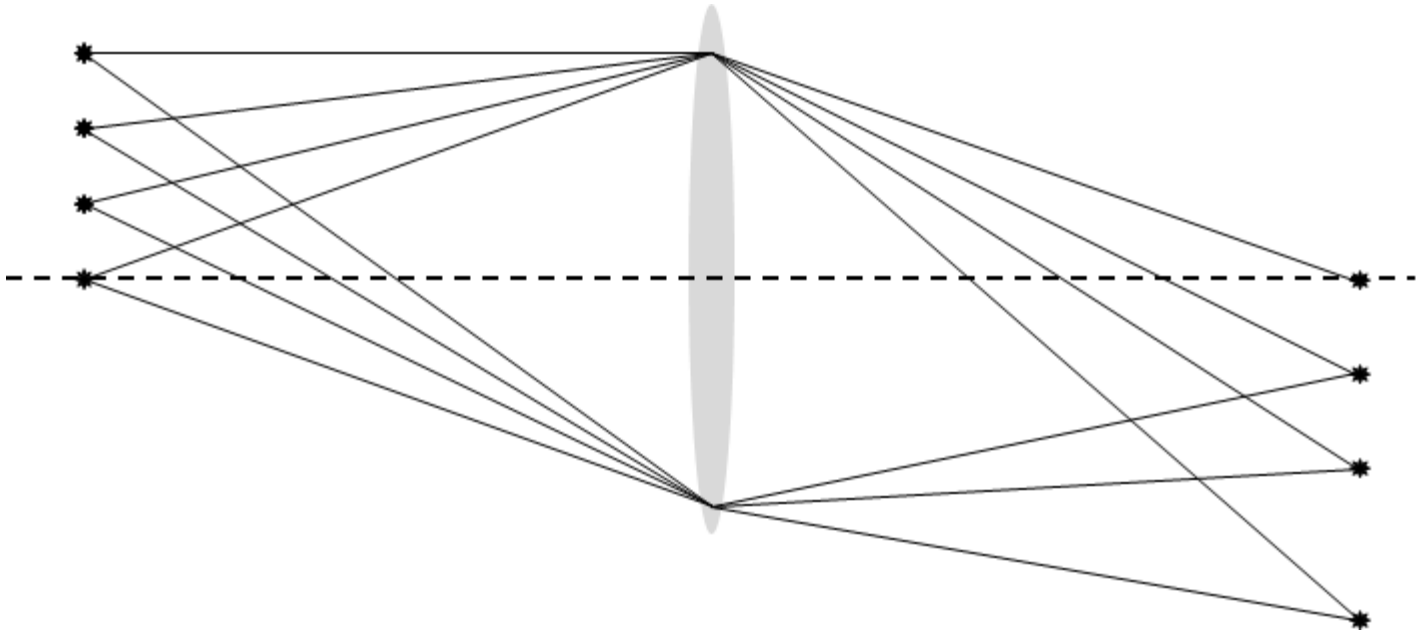
- Canon A590is 8 Mpix camera



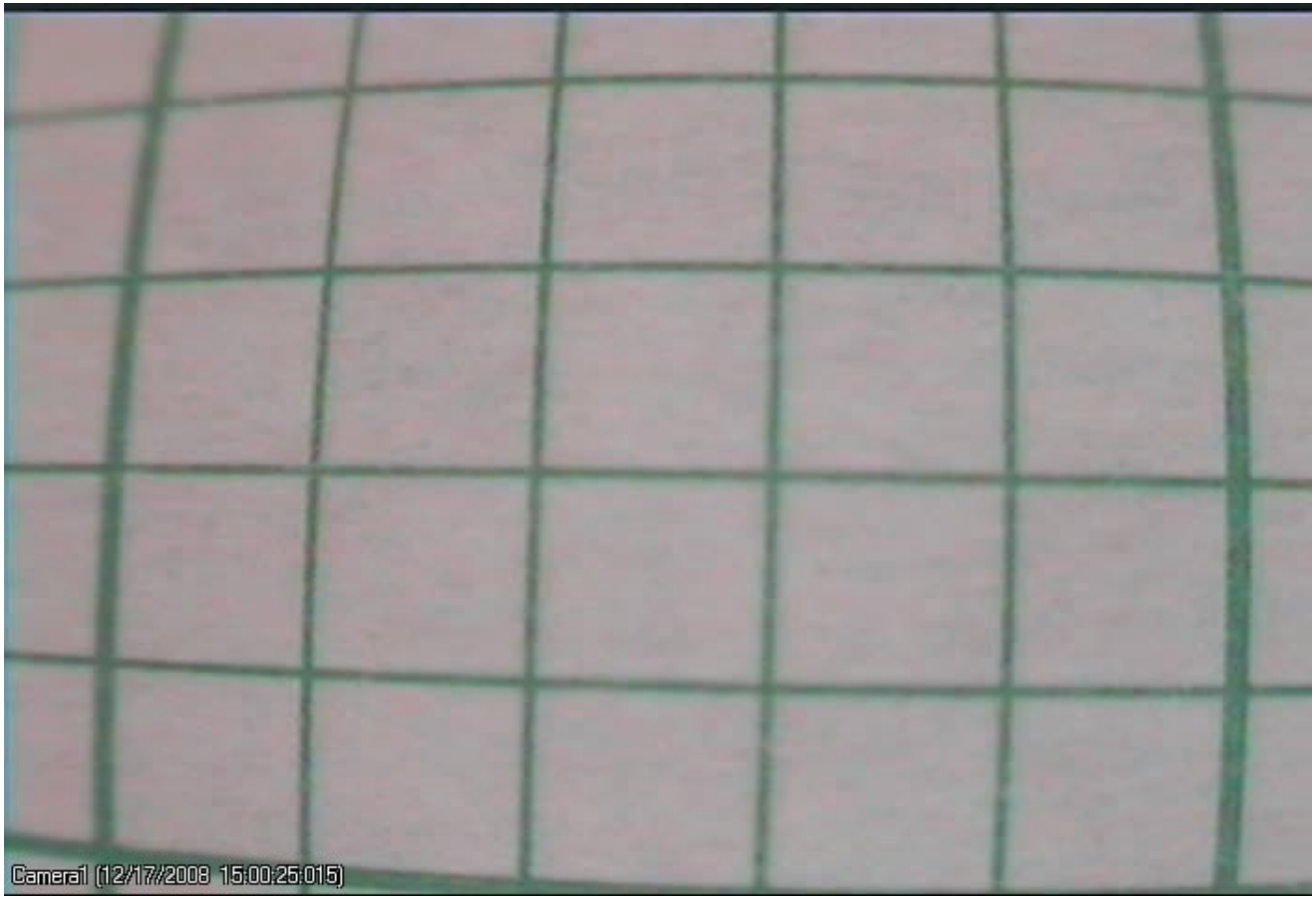
Chromatic Aberration Example (cont'd)



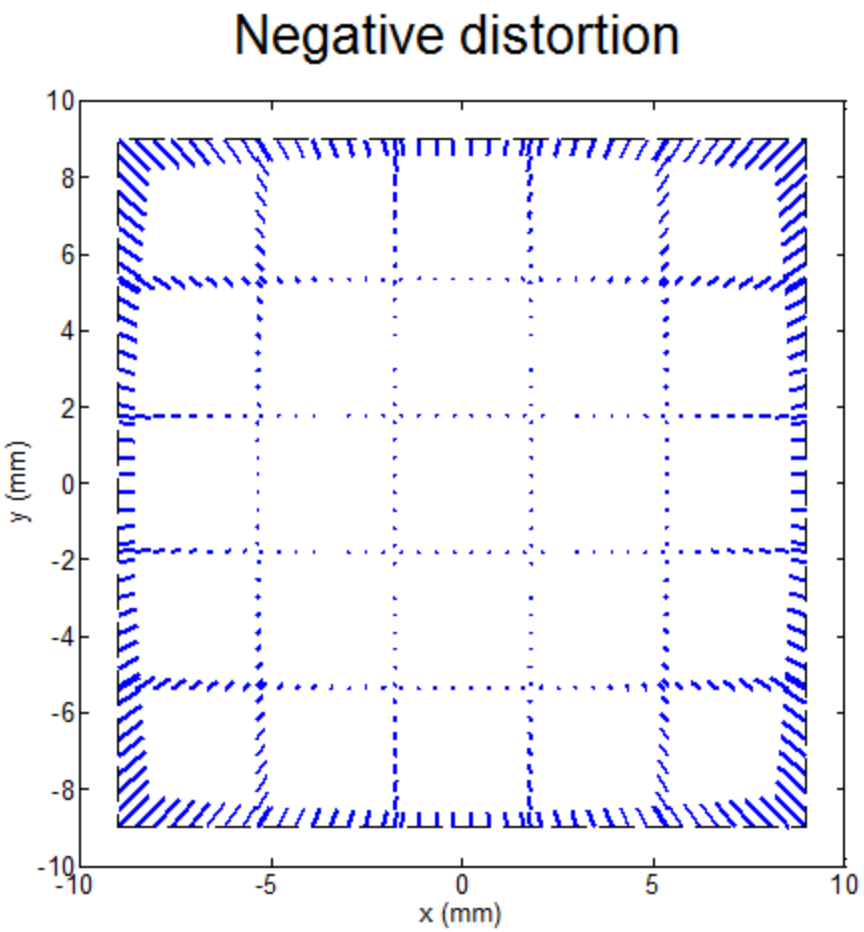
Distortion

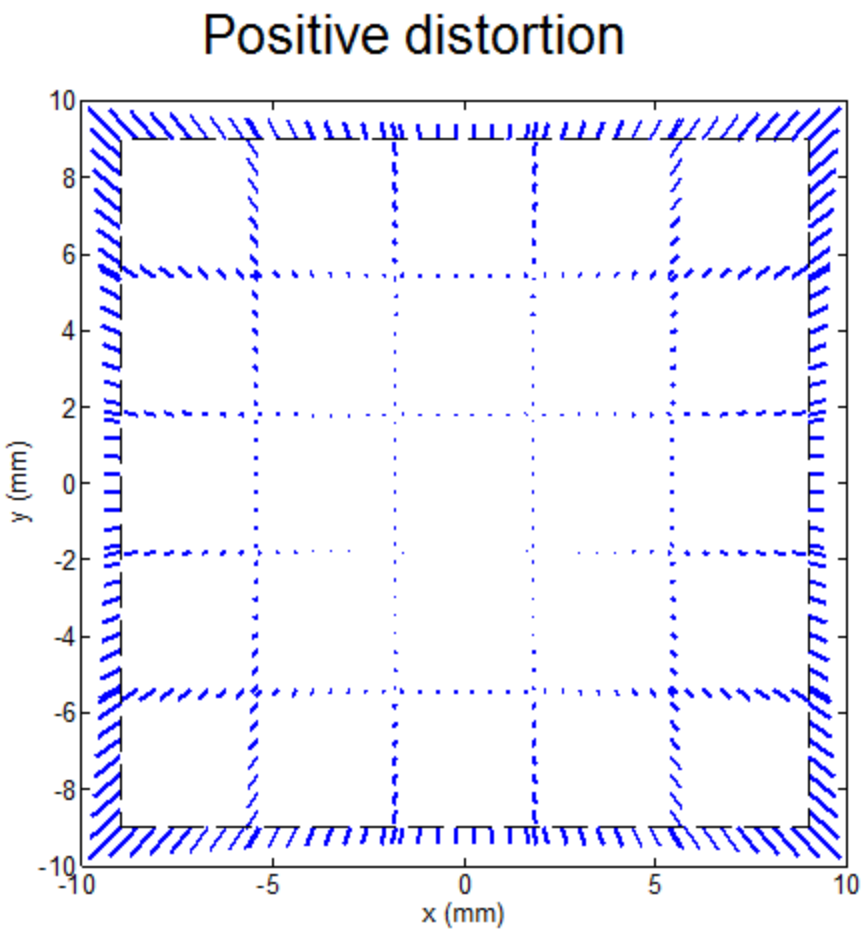


Radial Lens Distortion

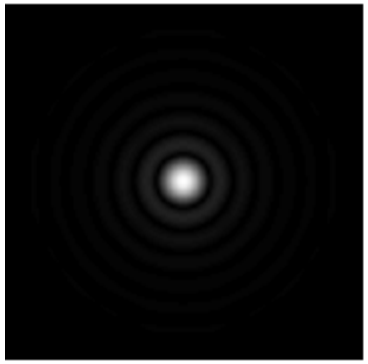


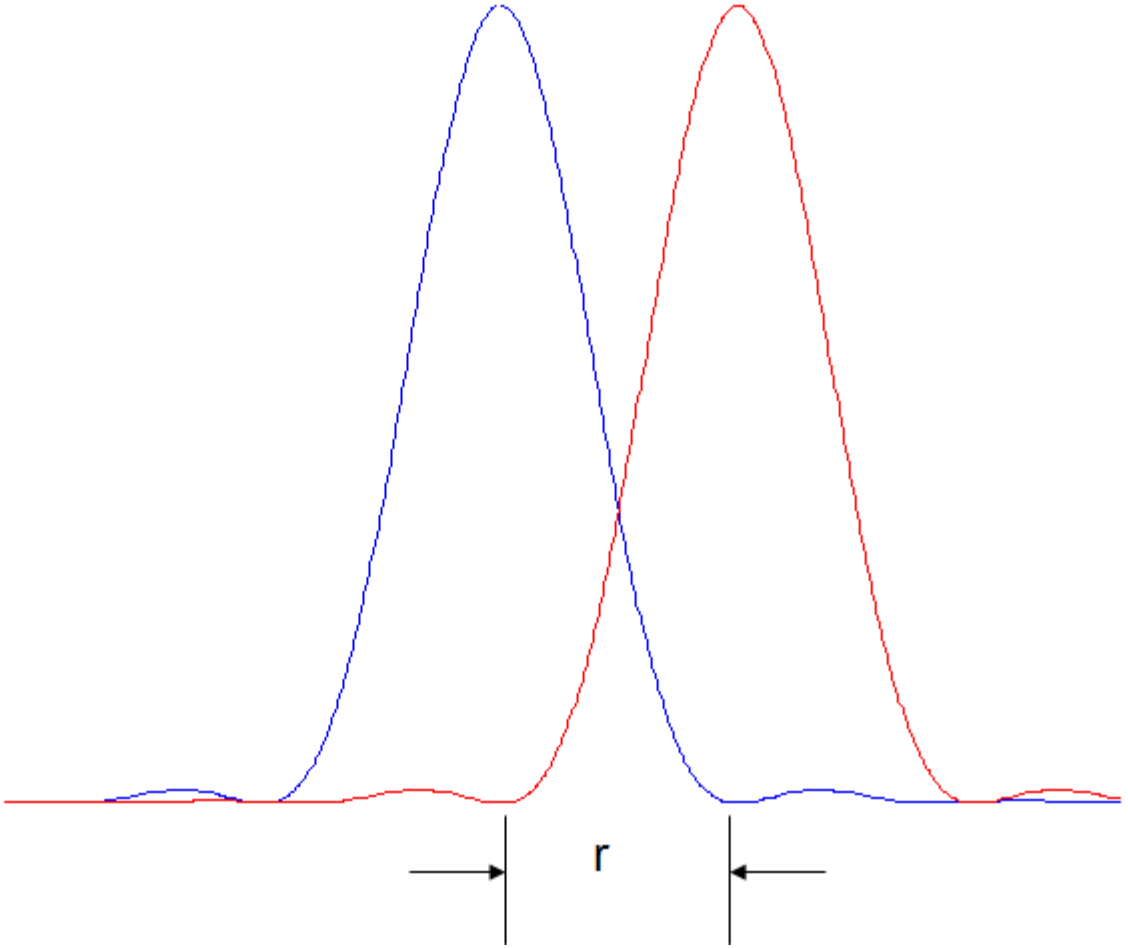
Radial Lens Distortion (cont'd)



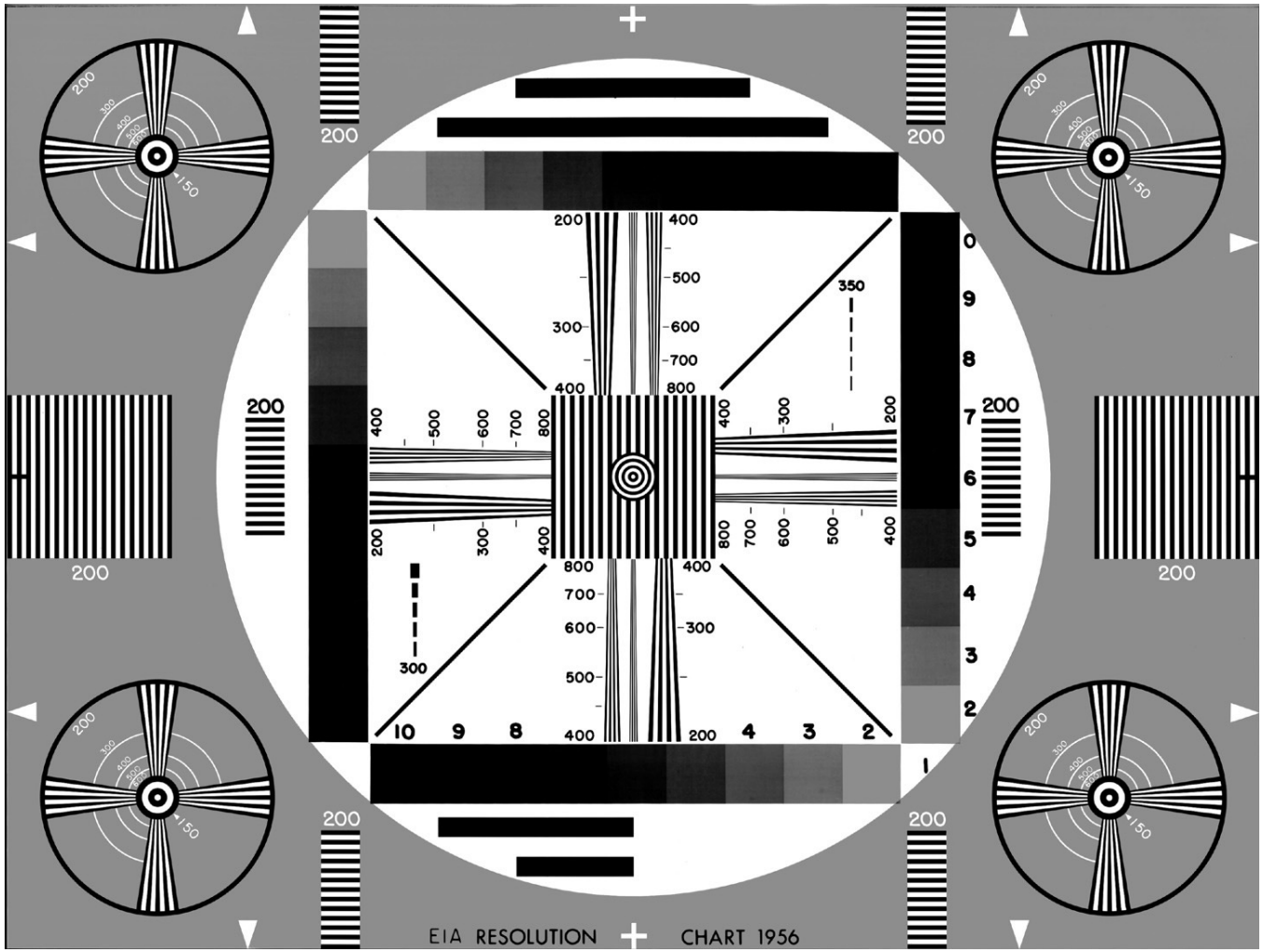


Diffraction



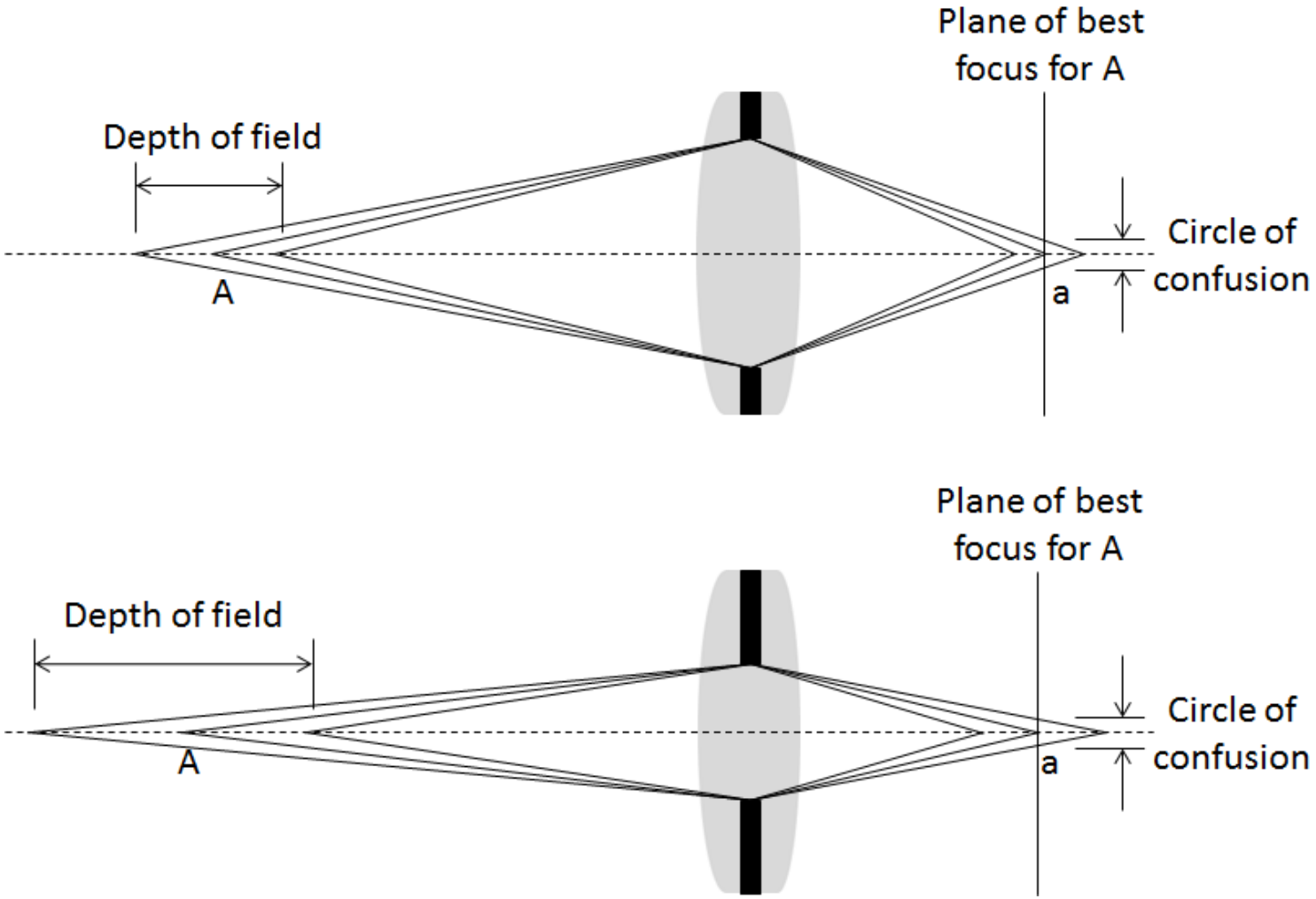


Resolution Test Chart



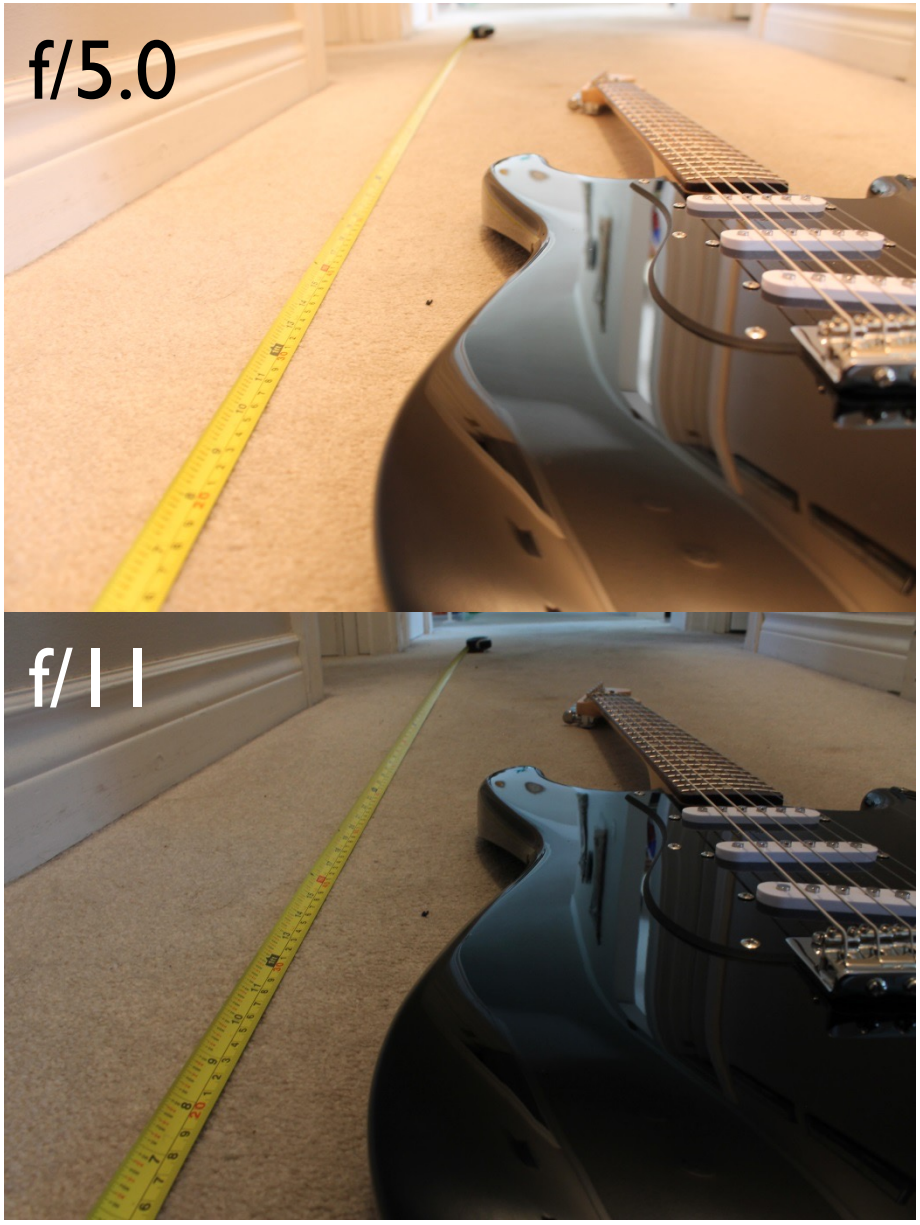
http://www.bealecorner.com/trv900/respat/

Depth of Field



Depth of Field (cont'd)

- Example
  - Camera EOS Rebel T3
  - Image size 4272 x 2848
  - Lens: EFS 18-55 mm
  - f=18 mm
  - Exposure time Δt=0.25 s
  - Variable aperture
- What are the effects of varying the aperture?

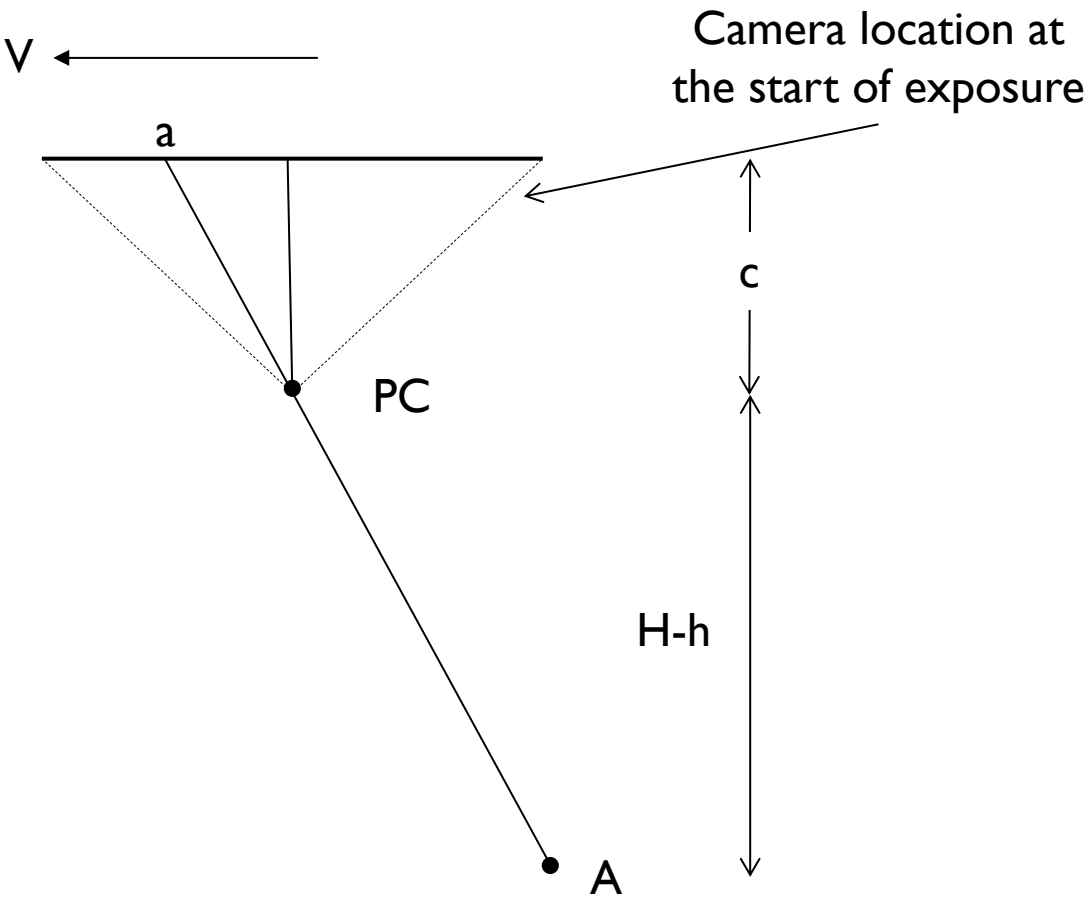

f/5.0


f/7.1

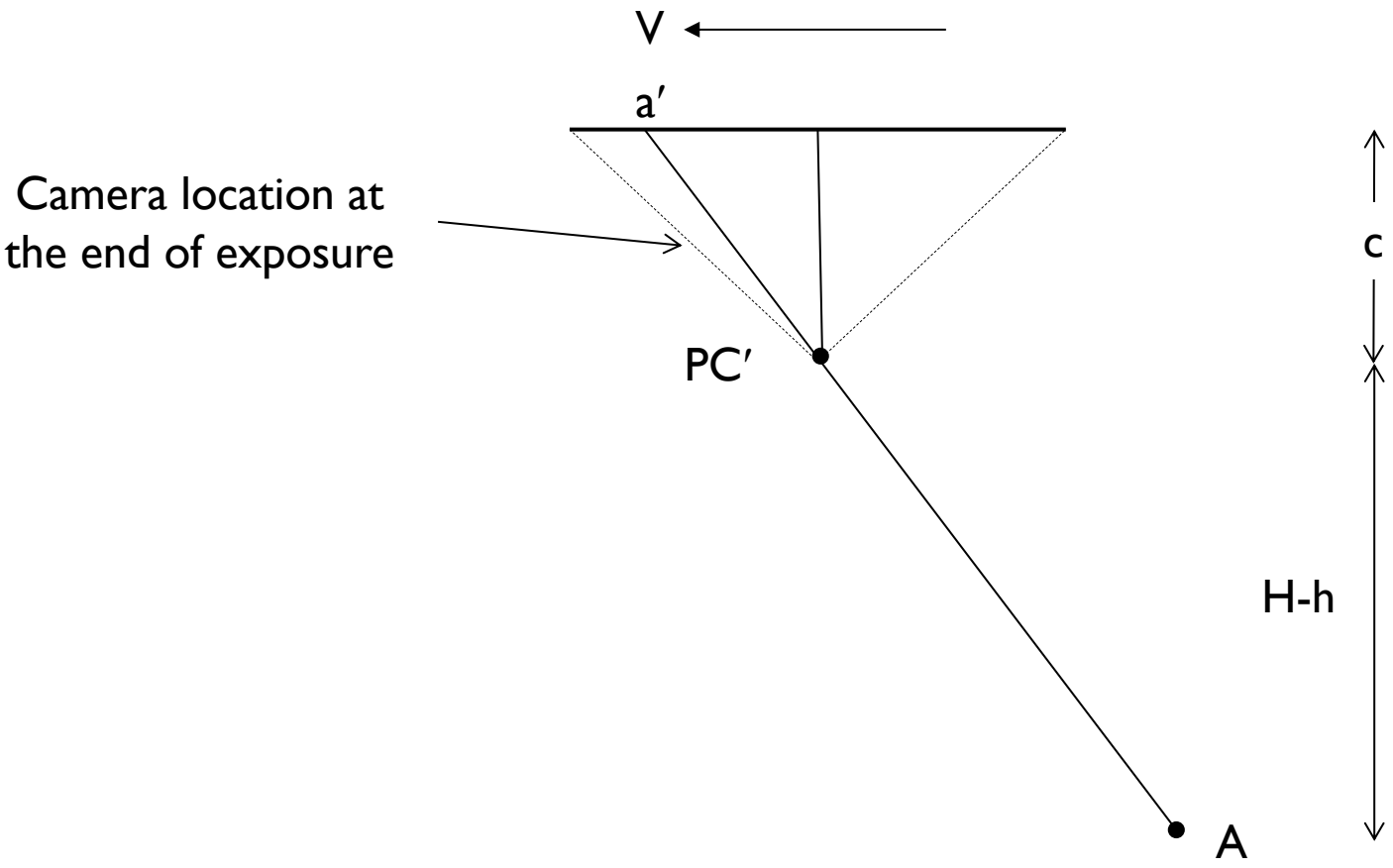
f/11

f/18

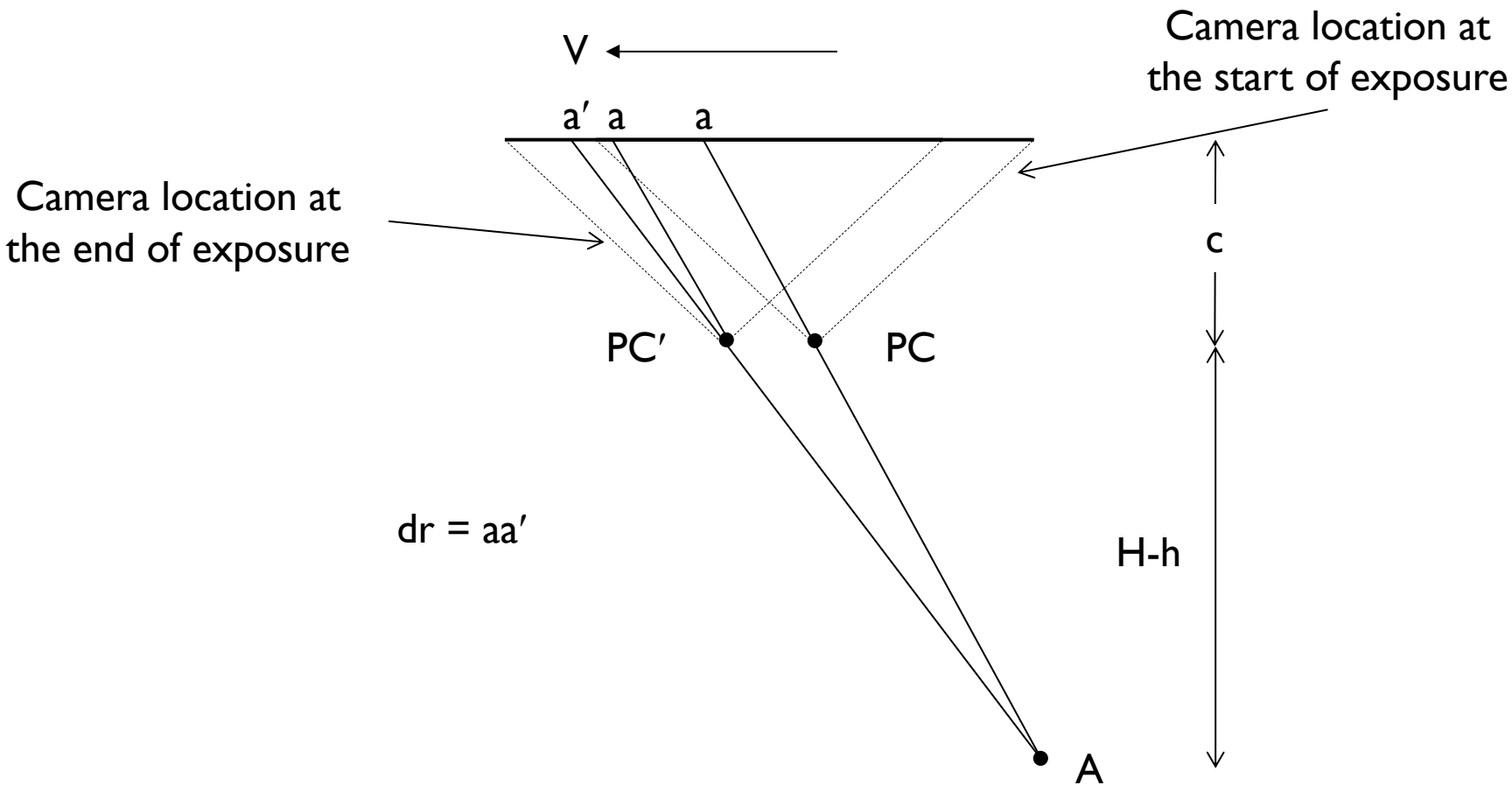
Motion Blur



Motion Blur (cont'd)



Motion Blur (cont'd)



Motion Blur (cont'd)

- An aerial camera fitted with a 6″ lens makes an exposure at a shutter speed of 1/1000 s
- If an aircraft is flying 800 m above the ground at 300 km/h, how far must the image motion compensation mechanism move to prevent blurring?
- Would the amount of blurring be significant?
- How far does the aircraft travel (ground distance) during the exposure time?