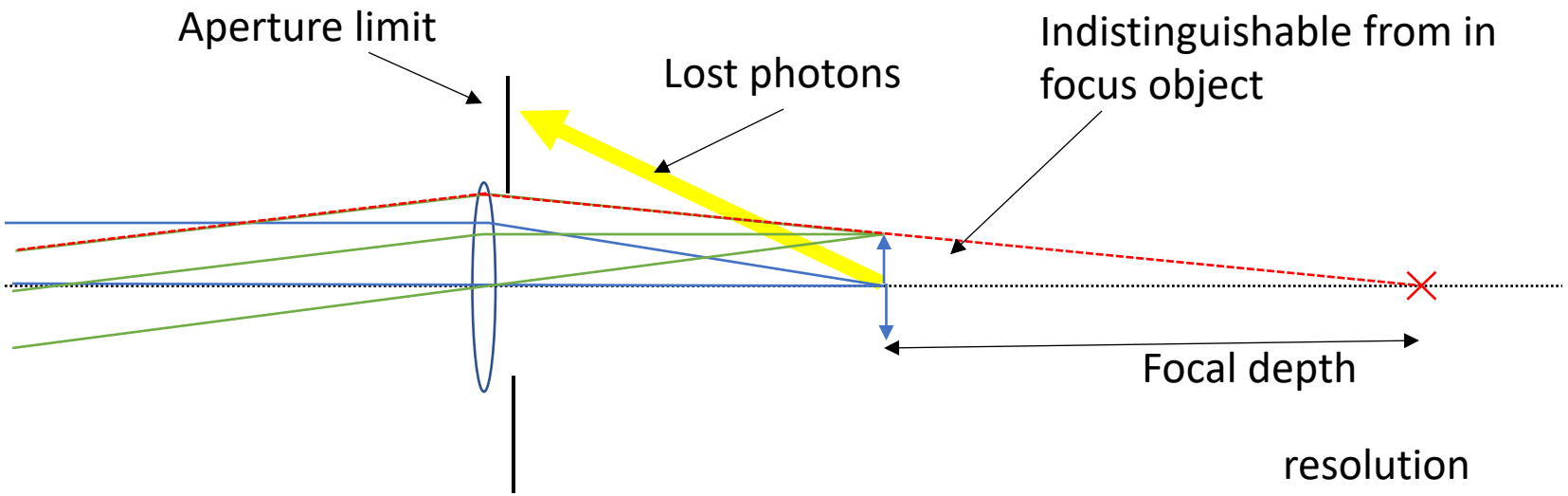
Multi-camera concept

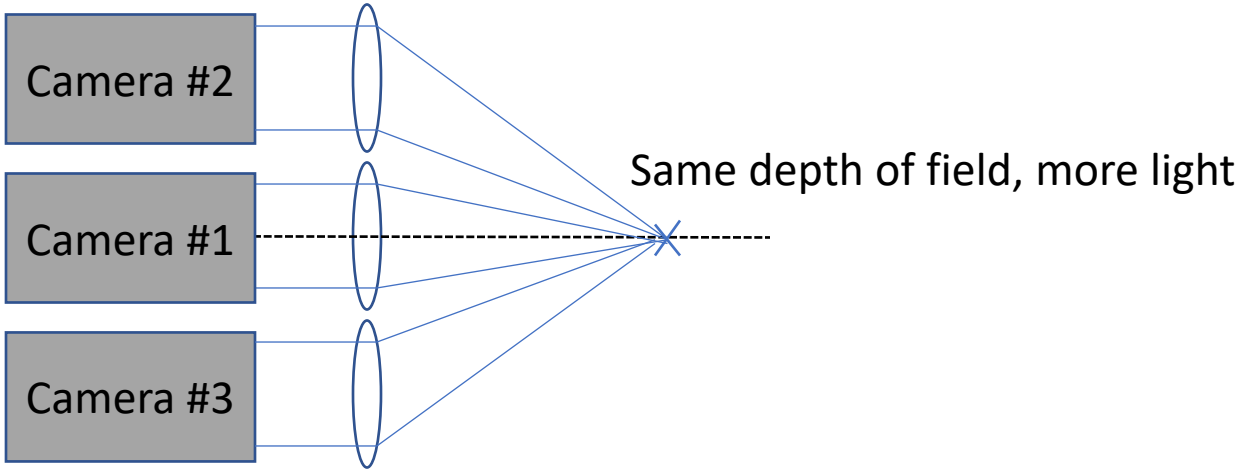
- Depth of field limits F/# of cameras



Numerical Aperture:
NA = blur_diameter / focal_depth
Light collection ~NA^2

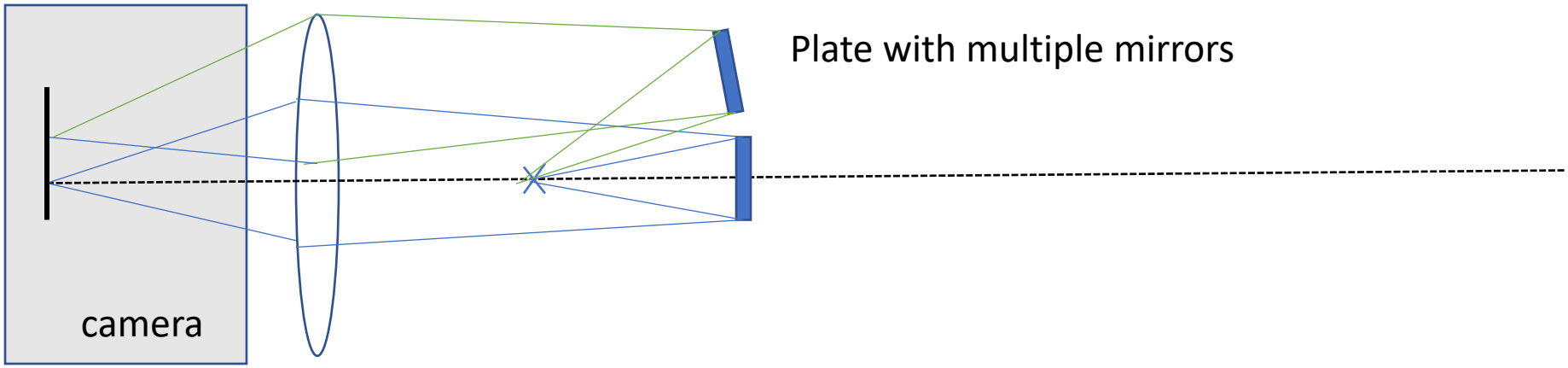
No way around this limit:
With a single lens

Multiple Lenses (Light field / plenoptic camera)



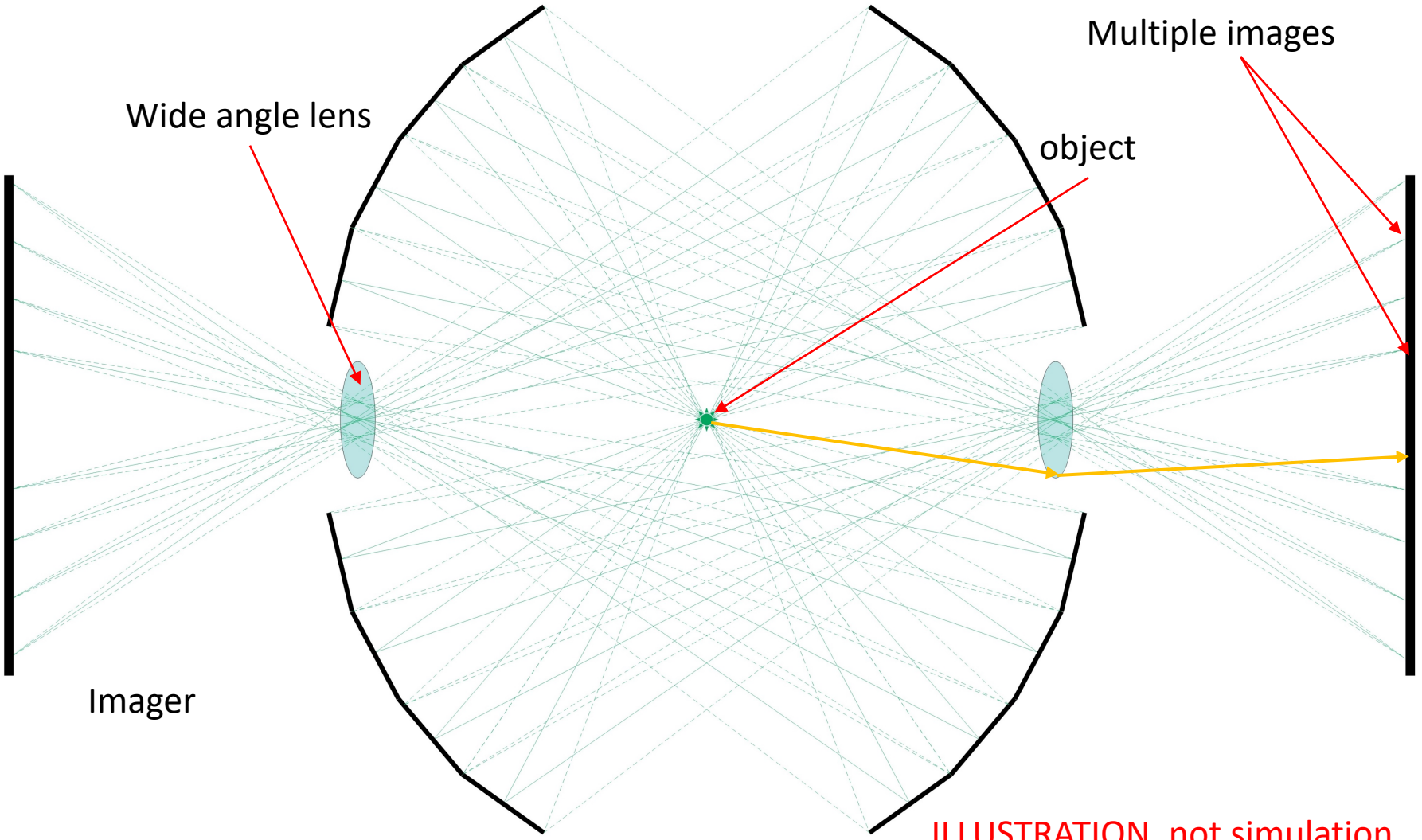
- Works, but cameras and lenses are expensive
- Imaging chips have far more pixels than needed
  - Usually >1Mpix for modern cameras ($30 webcam is 2MP)
- Imaging chips have small pixel sizes ~5um.
- Imaging lenses often have much higher numerical aperture than needed
  - 8mm lens provides 1/10 magnification at 80mm working distance
  - Resolution ~50um (OK)
  - Lens F/1.8
  - But probably can't use more than ~F/10 (1mm depth of focus)
  - Throwing away 96% of light

Multi mirror



- Lens focused on object reflected in mirror
- Multiple mirrors positioned to have same focal length but angle to produce different images on camera sensor
- Increase light collection without sacrificing depth of field
- Get multiple views aiding 3D reconstruction.

Wide Angle Light Collection



Design

- Conventional lenses get to about F/1. Potential for >10X-100X light collection for high depth of field object (atom beam in this case)
- Wide angle measurement – may allow full 3D reconstruction.
- Conventional flat mirrors mounted to a support framework
- Tolerances not very critical, not relying on interference between mirrors

Work / challenges

- Optics design:
  - Low F/# system with mirrors placed to get flat image plane
  - Needs Zeemax or similar
  - Want to use standard lenses, to avoid very complex large aperture lens design (but many choices available)
  - Large optimization problem, but tools exist
- Image reconstruction
  - Multi angle, but may be photon statistics limited
    - (if we had enough light we wouldn’t be doing this)
    - Need to understand reconstruction tools

Test plan

- Develop design in zeemax
  - Can start with modest acceptance angle
- 3-d print mirror holder for test in air
- Demonstrate image reconstruction in high light situation
- Demonstrate image reconstruction in photon limited situation
- Build UHV compatible mount
- Demonstrate on alignment imagers for atom interferometer
- Design for primary camera system