Overview
UVIT Calibration

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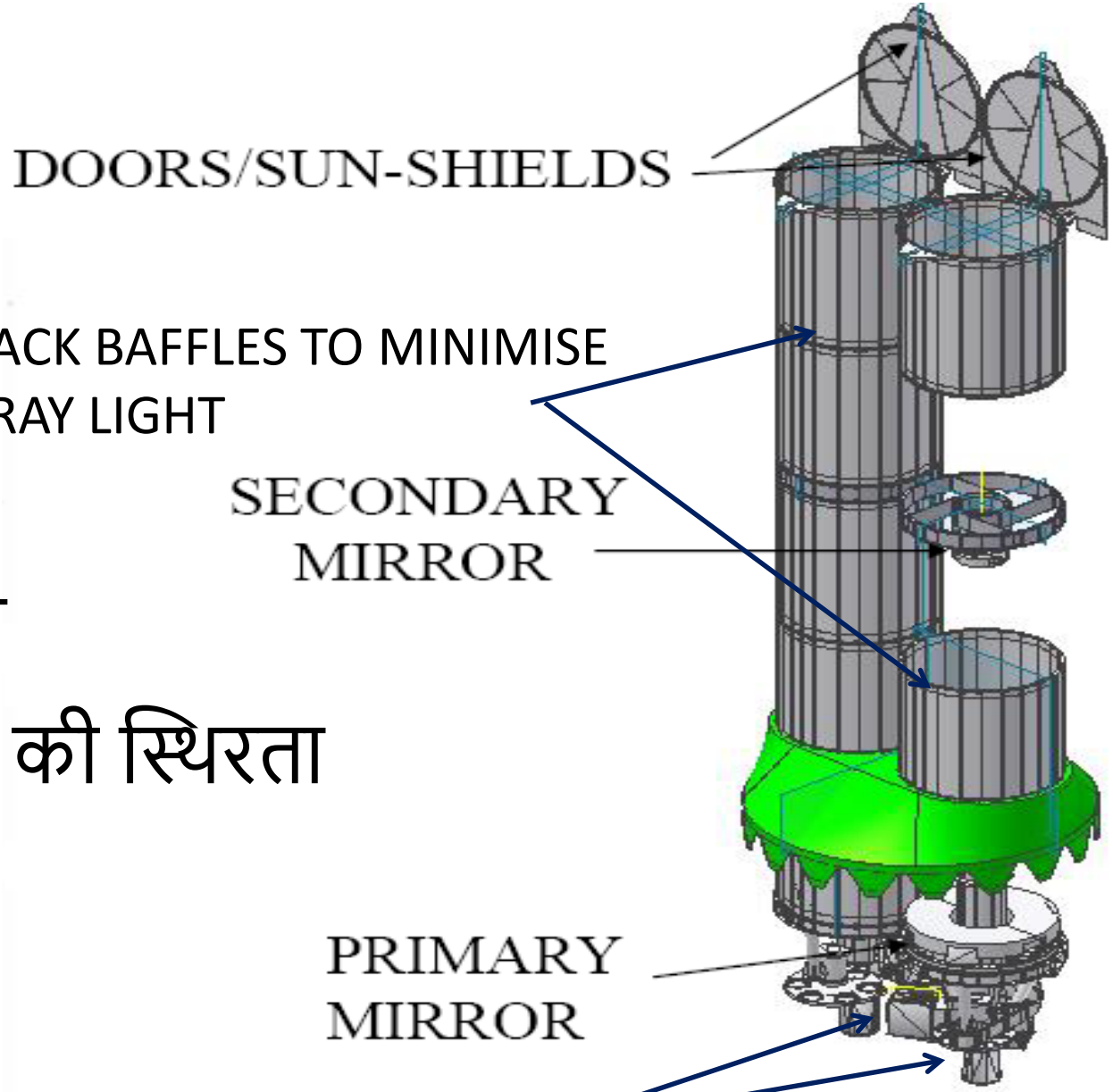
Plan of the Talk

- Configuration of UVIT
- Performance Specifications of UVIT
- Required Tests and Calibration
- Ground Calibration
- In-orbit Calibration
- Current Status of Calibration

Configuration of UVIT



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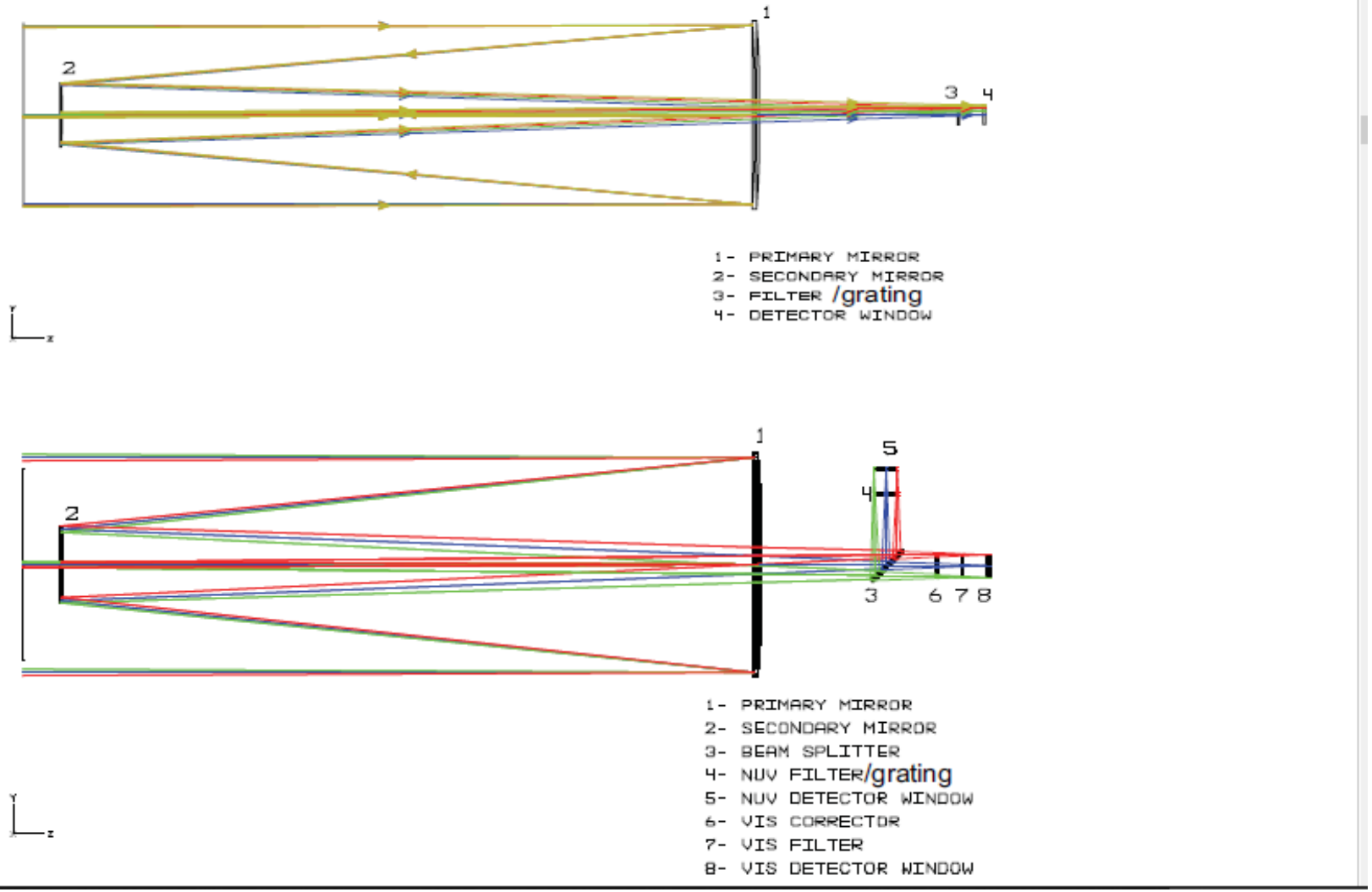
Optics of UVIT



Configuration of UVIT

- Full field of view is ~ 28’
- Photon-count mode is used to get ~ 29 frames/s for FUV and NUV; higher rates of frames possible for partial field
- Visible channel is only for tracking the pointing every ~ 1s and no photometry is possible; multiple filters are used to get high dynamic range of magnitudes
- Launch with doors closed, and open after about 6 weeks of getting in the orbit (~ 600 km high) to minimise cross contamination
- Constraints on pointing: Ram direction, bright earth, sun, moon, planets, BOD and bright sources,
- Pointing and drift <~ 1”/s

Performance Specs of UVIT

- **SPECTRAL CHANNELS : FUV NUV VIS**
  130-180 200-300 320-550 nm
- **FIELD OF VIEW : ~ 28'**
- **Aperture of Telescopes : 375 mm, f/12 Cassegrain**
- **SELECTABLE FILTERS : for Part of the Band**
- **SPECTROSCOPY (Slitless) : ~ 100 res. in FUV/NUV**
- **TEMPORAL RESOLUTION : ~ 5 ms**
- **OBSERVING MODE : STARE**
- **PEAK EFF. AREA IN FUV : 10 sq cm**
- **PHOTOMETRIC ACC. : < 10%**
- **SPATIAL RESOLUTION : FWHM <1.5"**
- **SCATTERING : < 10^-10 for source at > 30 deg (Sun, Moon, …)**

NUV Detector died in 2018

Required Tests and Calibration

- Tests

  Done on ground to ensure that the required performance would be met within a factor < 2 but not used for the calibration

  Scattered light with a 50% size model

  Ghosts due to sources within 2 deg.

  Alignment of the mirrors

  Position and tilt of the detectors for optimising Core of the PSF

  Relative alignment of the optical axes and S/C axes

… Calibration

• Calibration	On Ground	In Orbit
QE vs wavelength of the detectors	Yes	No
Variation with temperature of QE	No	No
Reflectivity of the mirrors	Yes	No
Transmission of the various filters and the gratings	Yes	No
Red/Blue leak of the filters	Partly	No
Full PSF of the optics including the pedestal	No	Yes
Saturation for bright sources	Yes	Yes
Flat field calibration of the detectors	Yes	No
Flat field calibration with assembled telescopes	No	Yes
Effective area with assembled telescopes	Rough	Yes
Backgrounds cosmic Ray showers (only information not a calibration)	Yes	Yes
Distortion in the detectors	Yes	No
Linearity of plate scale (only check)	No	Yes

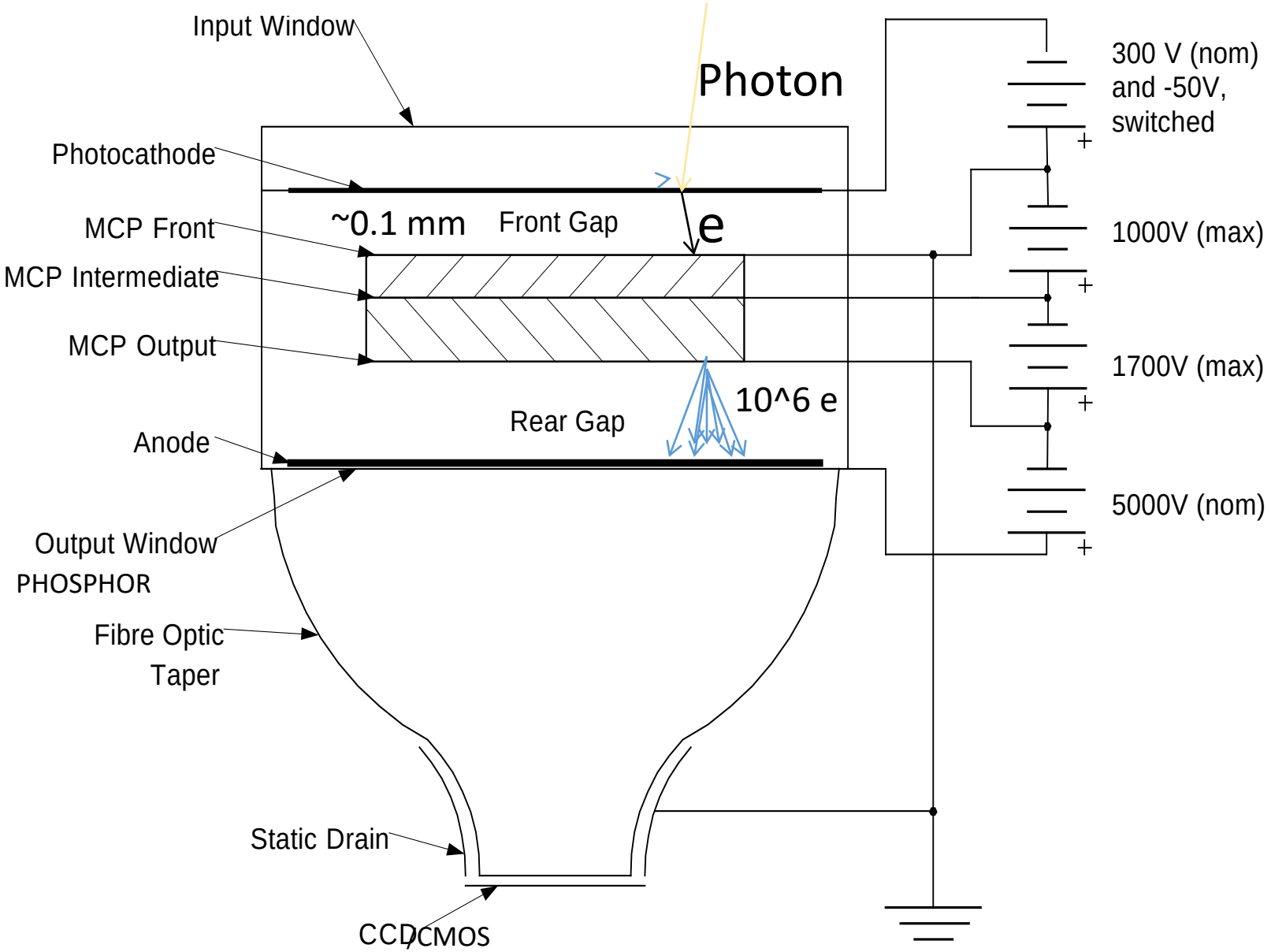
Some Details

- Effective Area vs wavelength from Ground Calibration
- Detector: Saturation and PSF
- Distortion
- Cosmic Ray Showers

Effective Area vs wavelength from Ground Calibration

- Product of area of the primary mirror and all the transmission
  Obstruction of the secondary mirrors and the ribs
  Wavelength vs transmission for the filter
  Wavelength vs QE of the detector
  Reflectivity of the mirrors
  Reflectivity of the beam splitter for NUV
- The photometric calibration in orbit essentially gives a multiplying factor of correction for each filter (for all the wavelengths)

UV PHOTON COUNTING DETECTOR



Detector: Saturation …

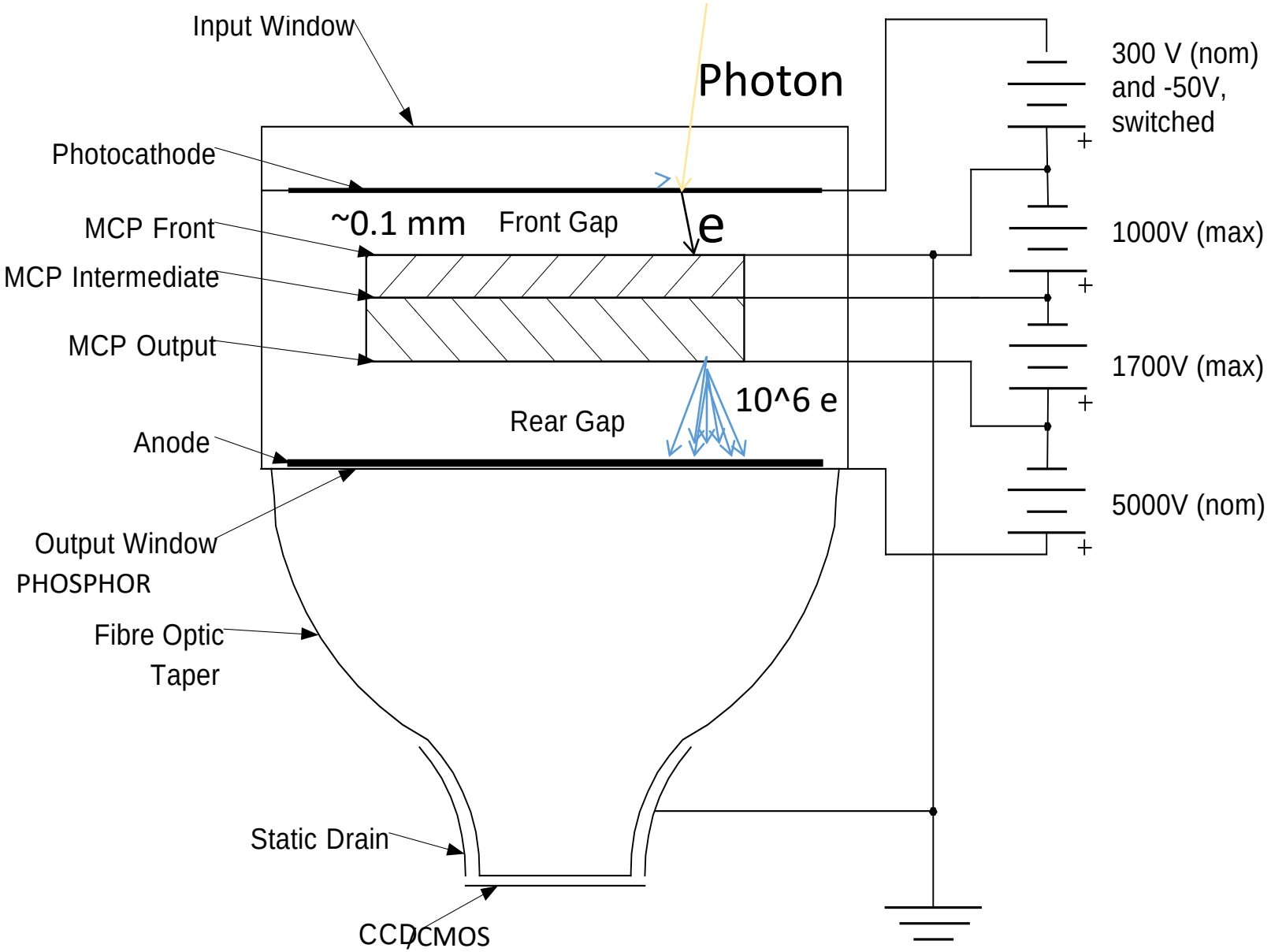
- Each photon event spread over ~ 1.5 pixels (~ 4”) of CMOS
- Most of the photon events, for a point source, on the same pixels
- If >1 event appears in any frame it is counted as 1 event
- Percentage of frames with no events within the full PSF (40” radius)

  gives events/frame for Poisson statistics

  Compare number of events/frame in the full PSF to get saturation
- Another source of saturation is the reduction in the average number of electrons per event due to local reduction of HV in the MCP.

  Not calibrated but neglected. Expected to be < 5% for 150 events/s

UV PHOTON COUNTING DETECTOR



Detector: … PSF

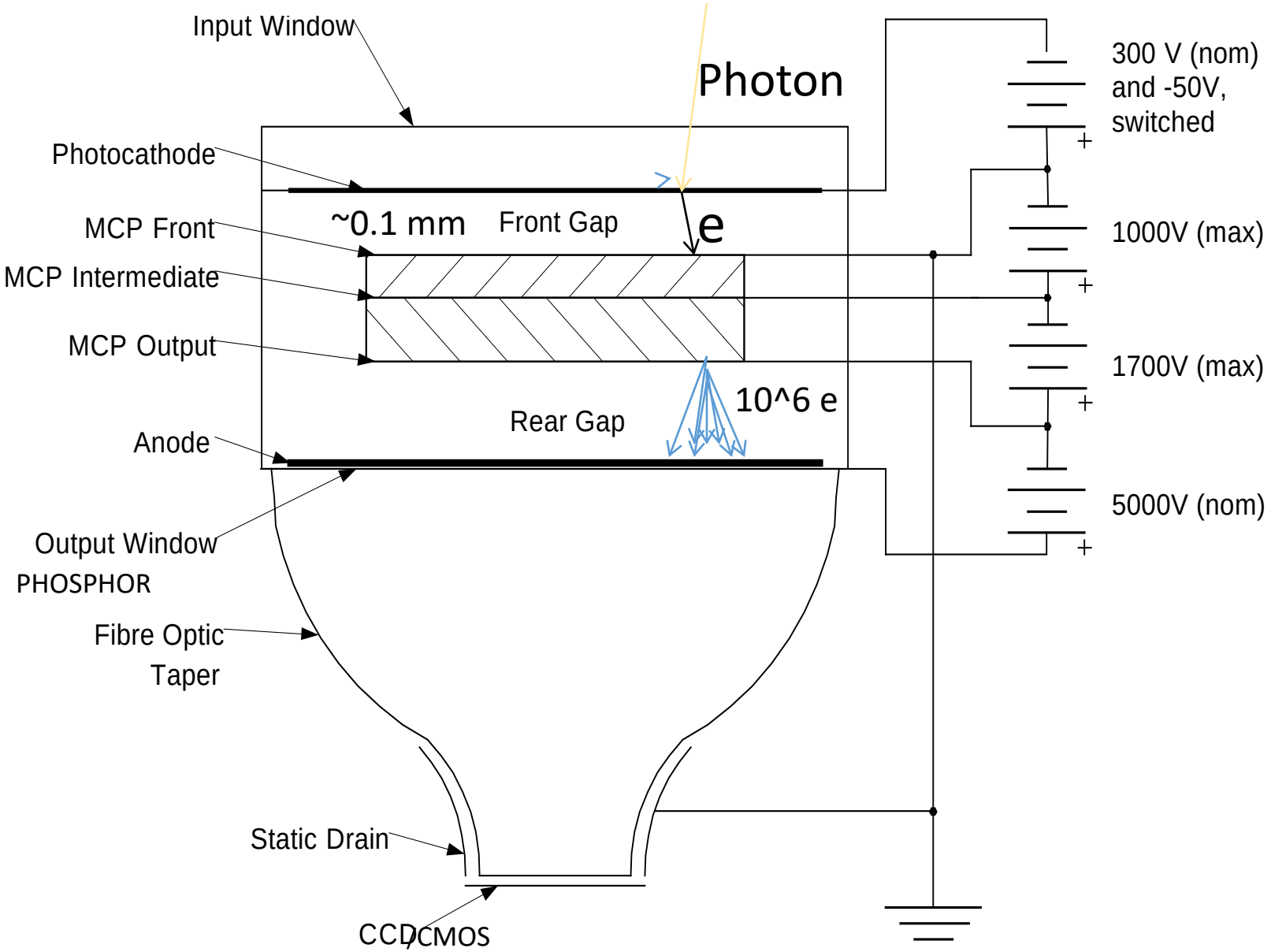
- Small drift of photo-electron --small gap 0.1 mm to MCP
- MCP tubes of 10 micron (< 0.5”)
- Good centroiding of > 10000 electrons spread over ~ 30 micron
- Core of PSF due to the detector < 1” FWHM
- Pedastal of the PSF de to scattering by the ribs,

  and micro-roughness of the optical surfaces (~ 20% energy)

Distortion

- Mainly in the fibre taper
- More near edges of the taper
- Is seen up to ~ 6” near the edges
- Calibrated on ground with an accurate 2D-grid of holes, and
  a set of straight lines drawn by a moving point source

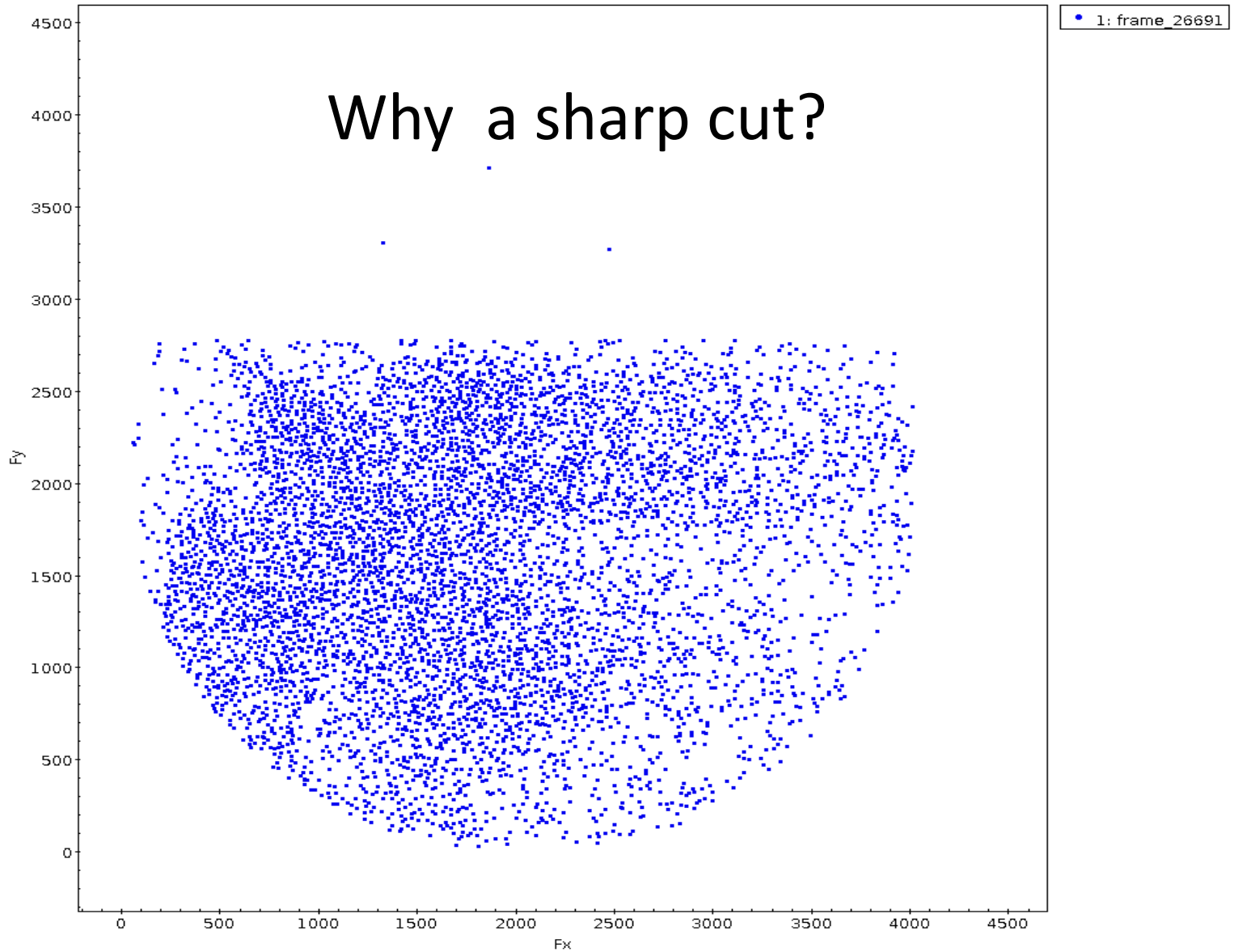
UV PHOTON COUNTING DETECTOR



Cosmic Ray Showers

- In ~ 5 frames/s (for ~ 29 frames /s) shower of events created by cosmic rays are seen
- These seem independent of the filter used
- In the orbit give rise to a background of ~ 150/s in the full frame
- Can be eliminated statistically for a field with < ~ 10 events/frame in the field, as a typical shower gives >> 10 events.
- Best to discard the frames with number of events more than the average number plus a few sigma. in case the background events are <~ 150/s. ***This would also lead to some underestimate of the flux.***

Cosmic Ray Shower



References

For Calibration of sub-systems on ground

J. POSTMA, J. B. HUTCHINGS And D. LEAHY

PASP, 123:833–843 (2011) : **Calibration of the Detectors**

V. Girish, S. N. Tandon, S. Sriram, Amit Kumar, and J. Postma

Experimental Astronomy, 43:59-74 (2017**): Mapping Distortion of the Detectors**

For In-orbit Calibration

S. N. Tandon, Annapurni Subramaniam, V. Girish and others

AJ, 154:128 (2017): **Calibration of UVIT**

S. N. Tandon, J. Postma, P. Joseph and others

AJ, 159:158 (2020): **Additional Calibration of UVIT**