Outlook to a new Residual Gas Beam Profile Monitor at the Swiss Light Source

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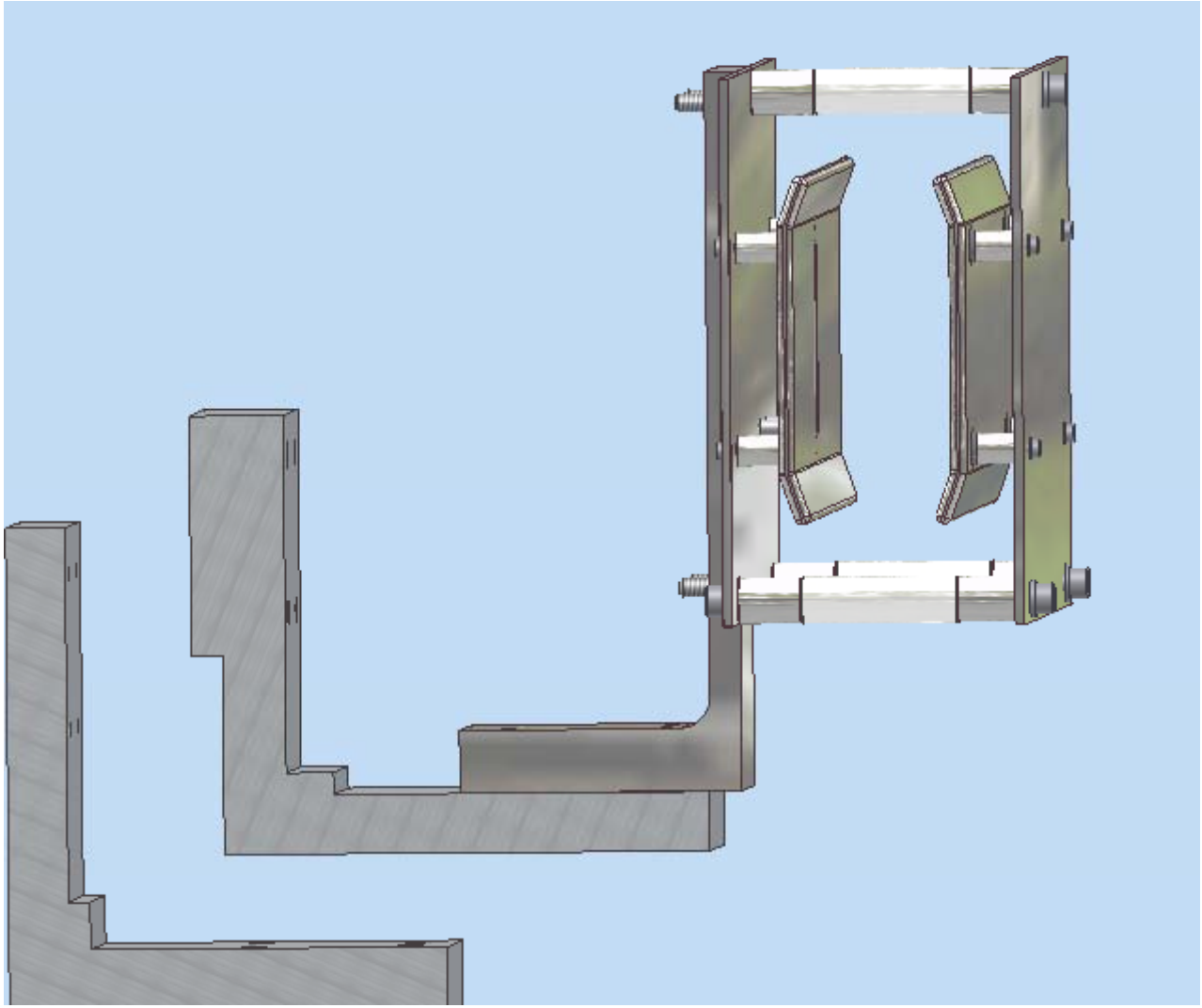
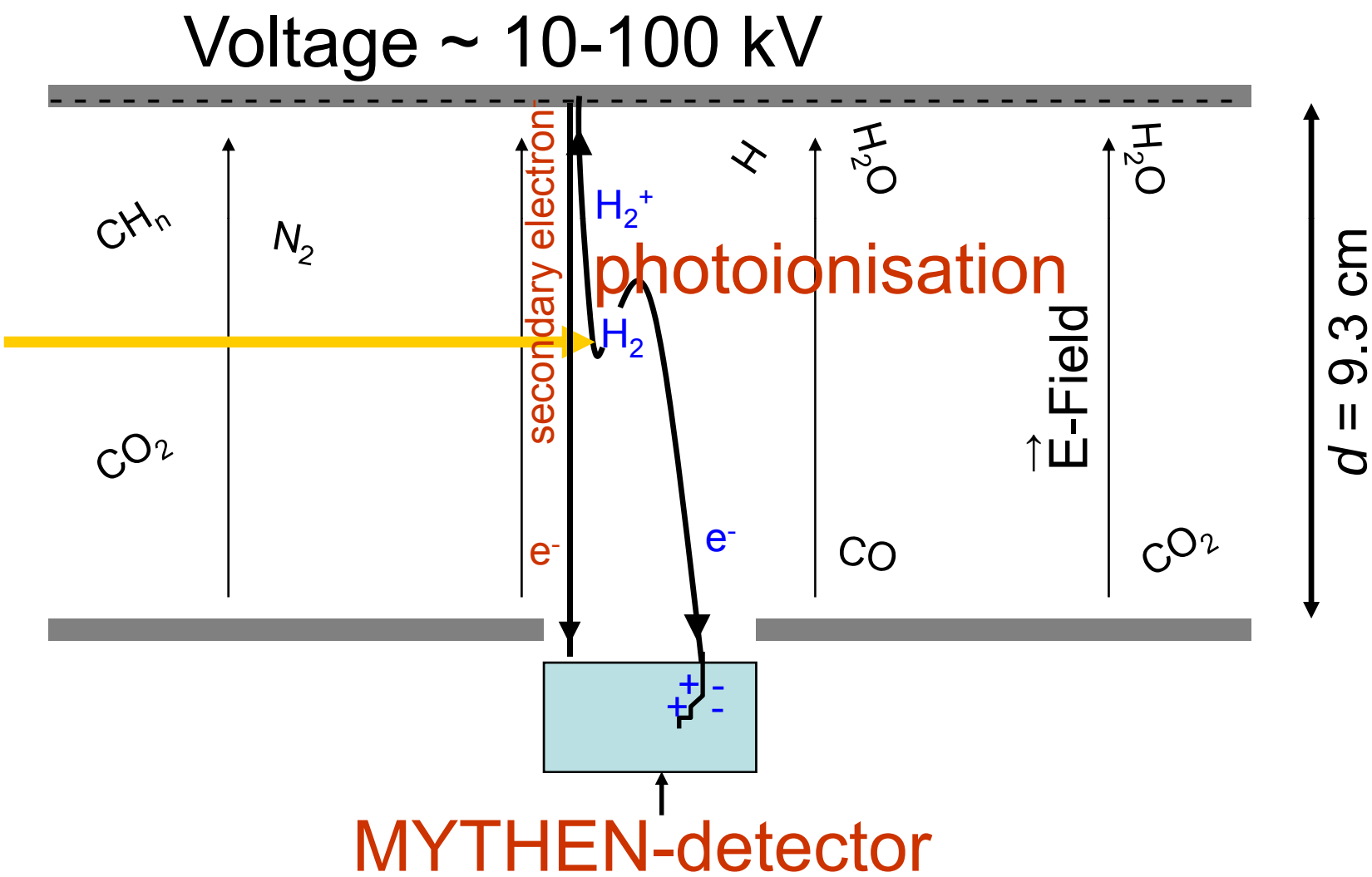
Contents of the presentation

- Overview of the assembly
  - MYTHEN detector
    - detection of photons, electrons/ions(?)
- Expected beam profile for a bending magnet.
- Use of profile information in data analysis

Drawing of the assembly

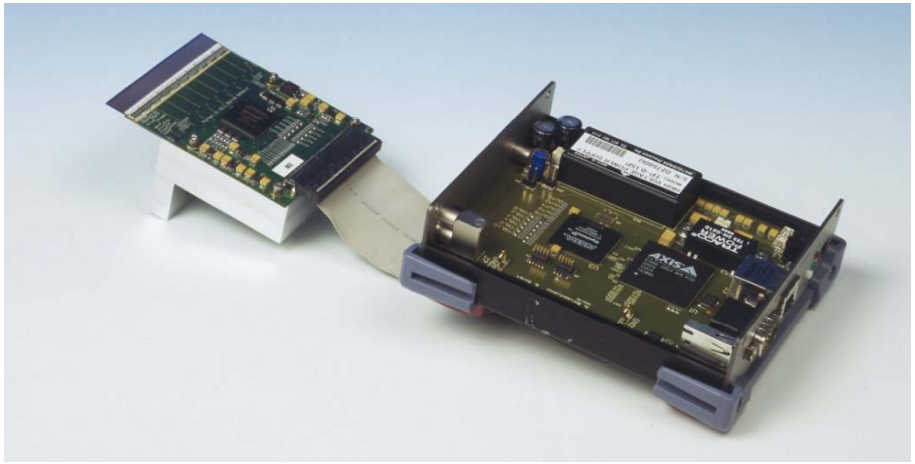


Schematic principle



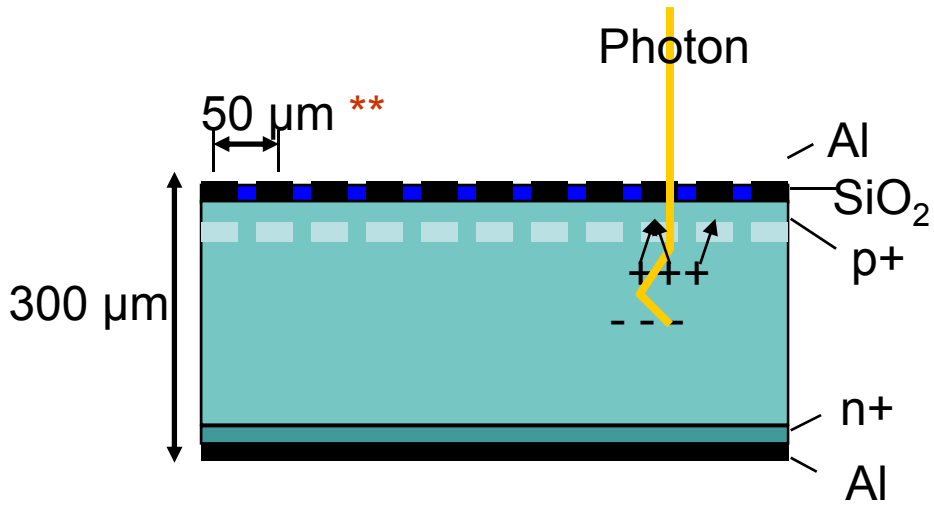
MYTHEN: Microstrip sYstem for Time rEsolved experimeNts

- Silicon microstrip sensor
  - 50 μm pitch
  - 1280 channels
- Read out chip:
  - noise preamp ≈ 230 e^- corresponding to 840 eV

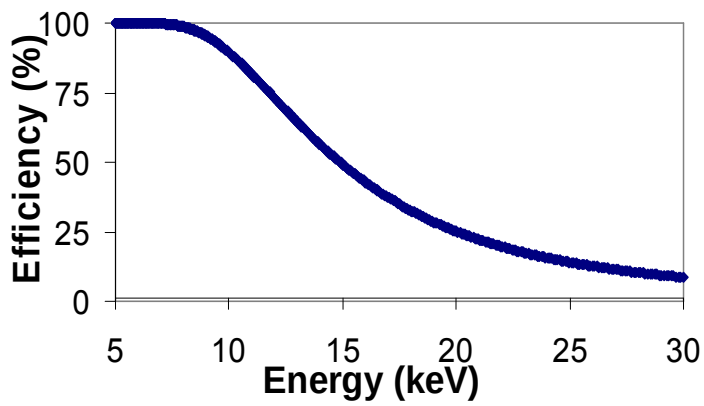


X-ray detection with the MYTHEN

- Used yet for X-ray detection at the SLS (powder diffraction)
  - Direct conversion of X-rays into electric charge through the generation of electron-hole pairs



** 25 µm pitch coming soon



So far: MYTHEN with photons

- Powerful XBPM for photons of ~15 keV.
  - Complete setup available
    - Contact: anna.bergamaschi@psi.ch or bernd.schmitt@psi.ch
- Could be used at undulator beamlines to produce feed forward tables based on the beam profile.
  - Dedicated beam time necessary since the monitor is destructive.

MYTHEN with electrons or ions

- Electrons and ions are absorbed to 100% within few tens of microns (electrons) and few microns (ions).
  - →Partial energy loss in the microstrip cover, which is not sensitive. → Partial signal loss in the “dead” zone, which might be some micron (no precise declaration by producer).
  - →Need for lower comparator threshold?

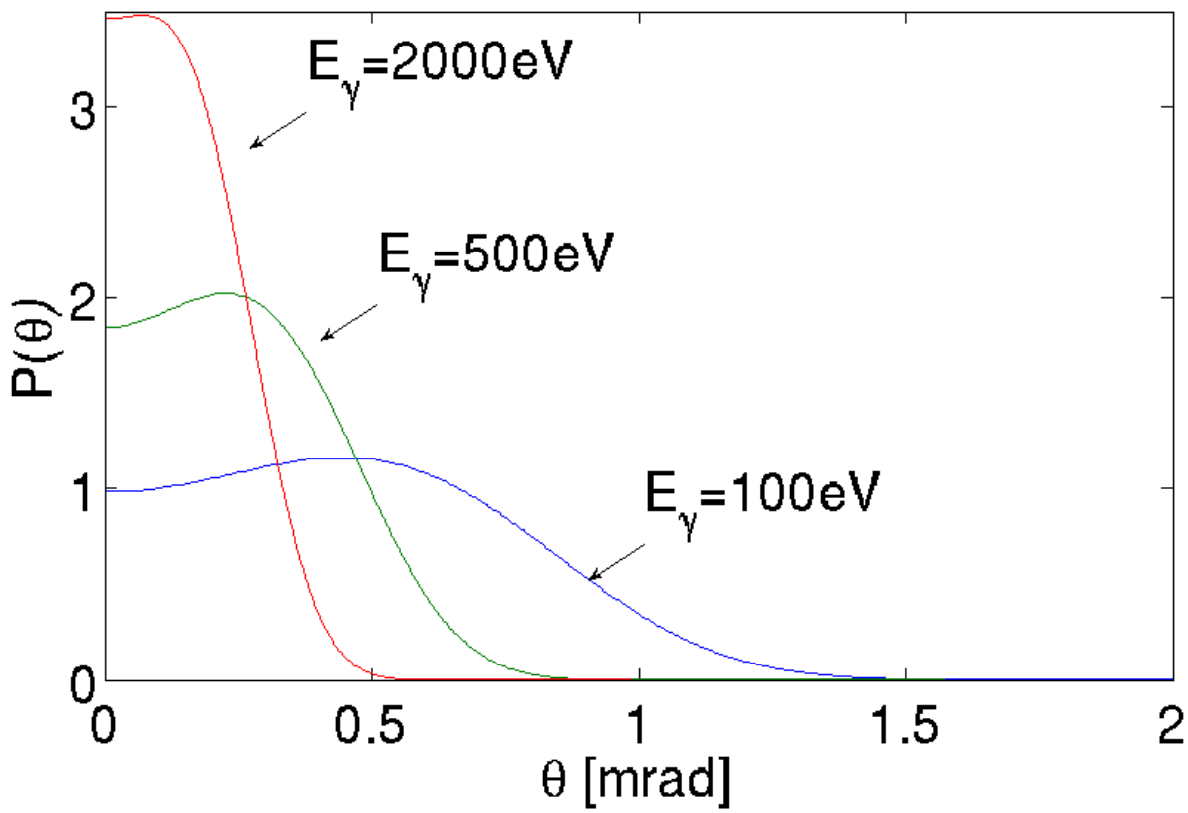
Detect ions or electrons?

- Ions are heavier → Particle momentum has a smaller profile broadening effect.
- Depth of penetration higher for electrons.
- For inner shell ionization one gets Auger electrons → 2+ charged ions with double energy at a given high voltage.
- Secondary ions from electron-molecule interaction, secondary electrons from plate.

Influences to the profile based on electron detection

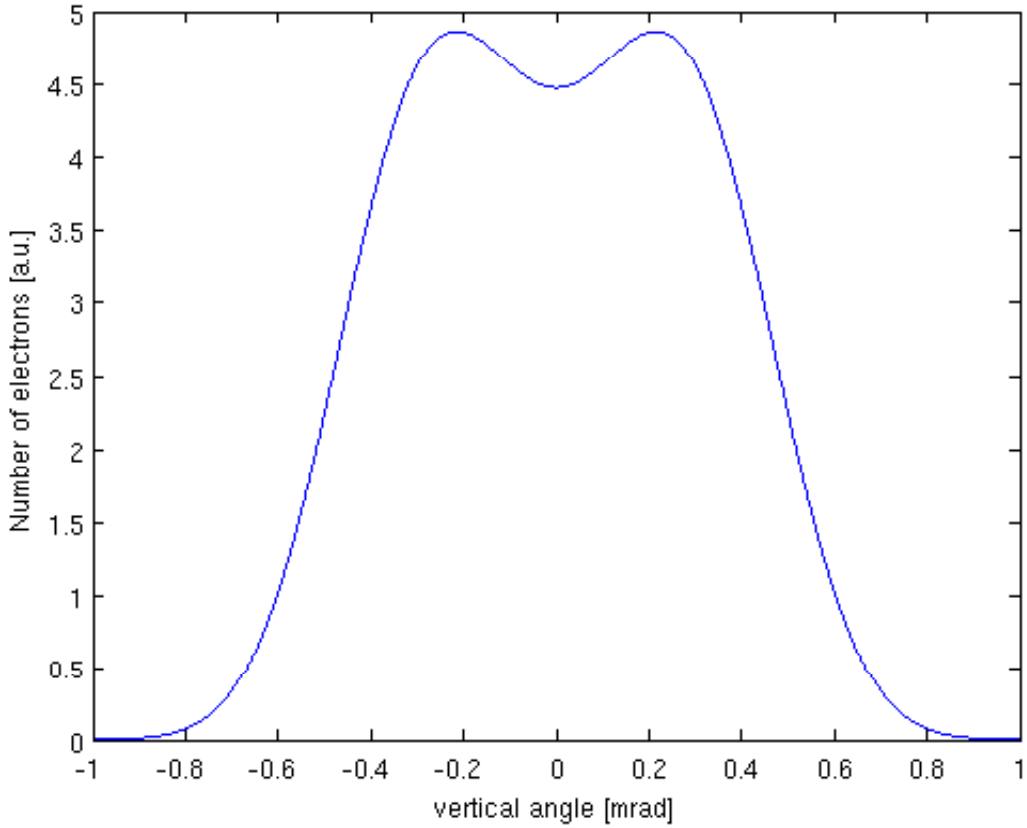
- Photoionisation process.
  - Trajectory of emitted electrons to the detector.
- Secondary electrons
  - SE from ions hitting the upper plate.
  - Auger electrons due to inner shell ionization.
  - SE from electron-gas interaction.
- Apertures may cut out a part of the beam.
- And obviously: The photon beam profile.

Photon distribution



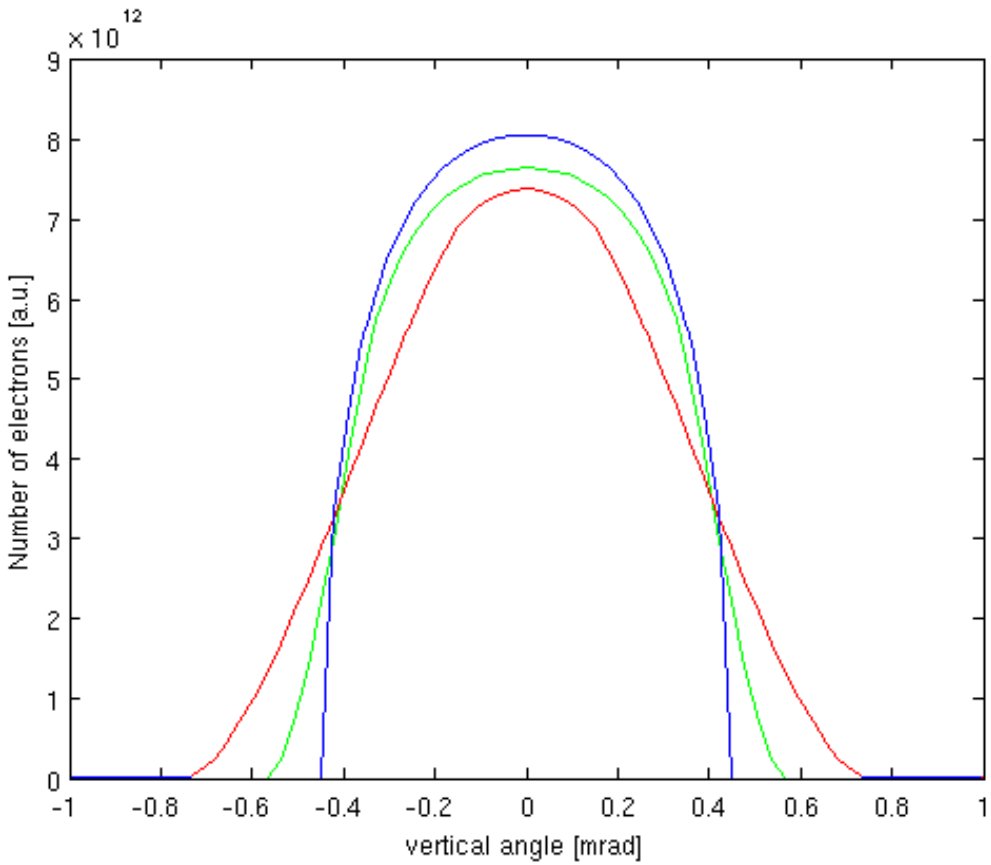
→Local minimum of the distribution for low energy photons.

Cross section corrected beam profile for a Nitrogen 1s electron



→Such beam profiles have to be calculated for each contributing electron shell in order to compose the whole beam profile.

Influence of electron trajectory

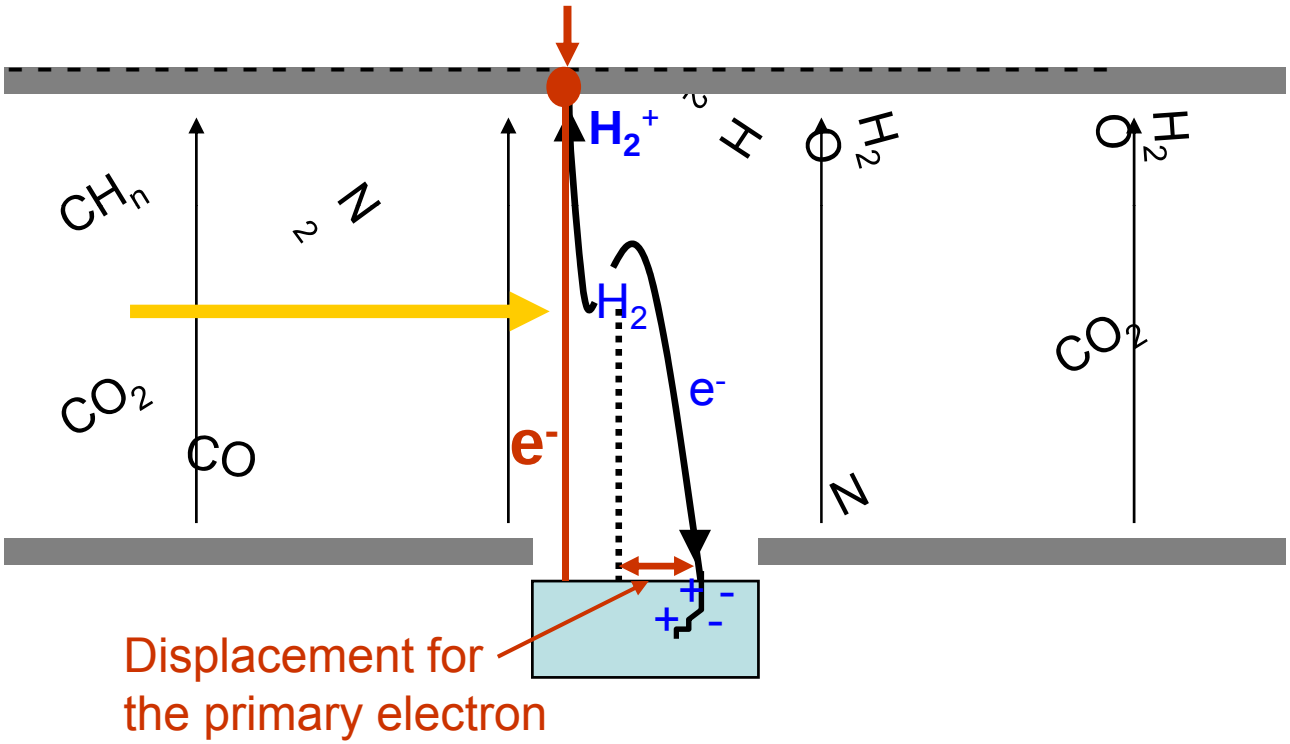


- Bending beam profile is truncated with a round aperture.
- Photon beam is in the center.
- Secondary electrons neglected.

blue: high voltage ∞ green: high voltage 100 kV
red: high voltage 10 kV

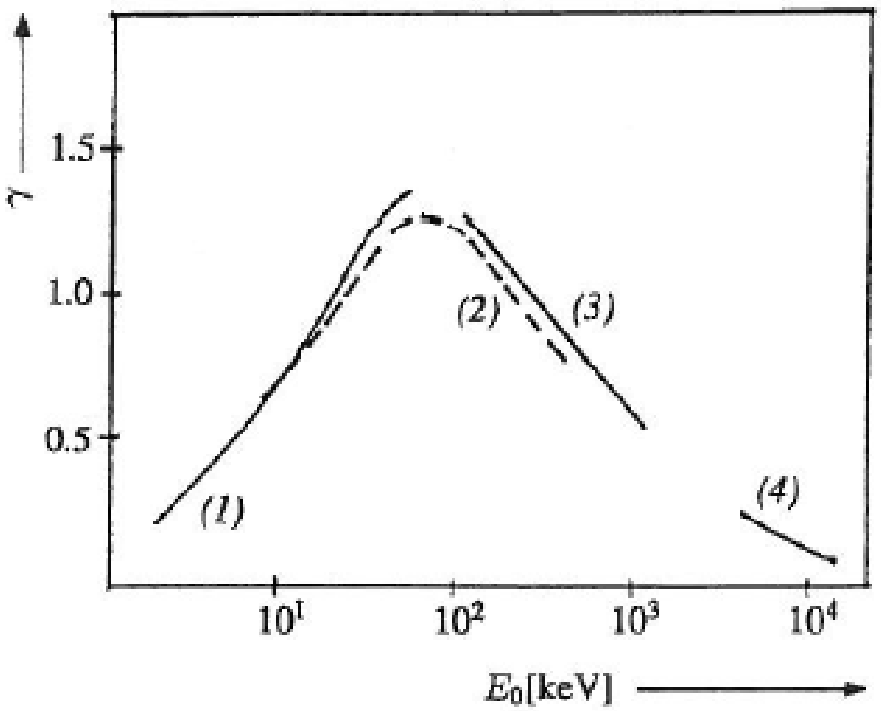
Secondary electrons

Ion Induced Electron Emission



→Trajectory effect on electrons from particle induced emission is opposite to the effect on photoelectrons.

secondary electrons



- Electron yield as a function of proton impact on aluminium

From M. Rösler et al., *"Particle Induced Electron emission"*, Springer (1991)

→If we detect electrons, ions are detected via their production of secondary electrons.

Summary (I)

- The theoretically expected beam profile consists of several aspects:
  - Contribution from all included electron shells (e. g. N 1s, C 2p, H 1s, ...)
  - Contribution from secondary particles.
  - Convolution of these contributions with electron trajectory effects.
  - Convolution with detector properties.

Summary (II)

- Projection of the beam profile to the detector direction.

- Quantitative calculation of the beam profile is not straightforward due to the different influences.

- Influence of apertures (profile cuts).

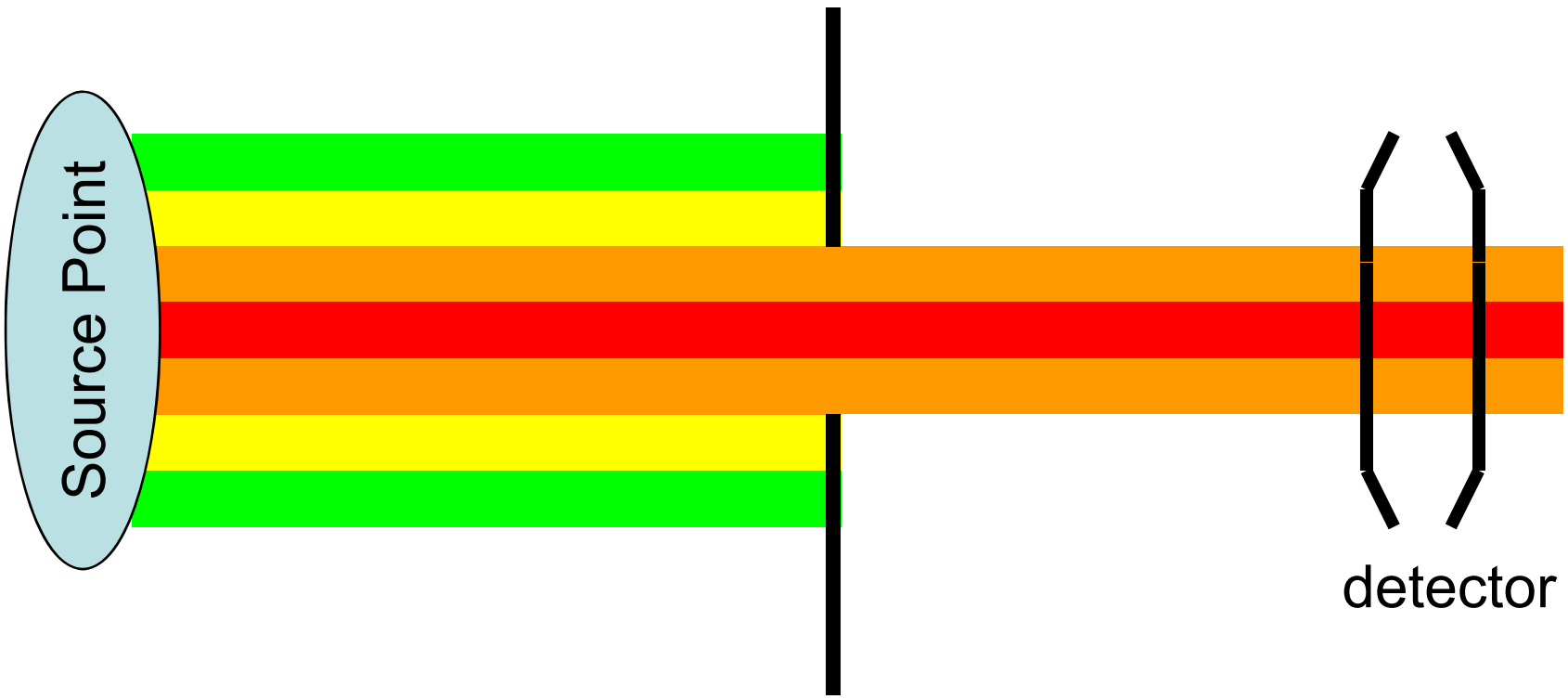
Scheduled tests

- Test setup uses a 5 mm aperture to get a well defined beam shape.

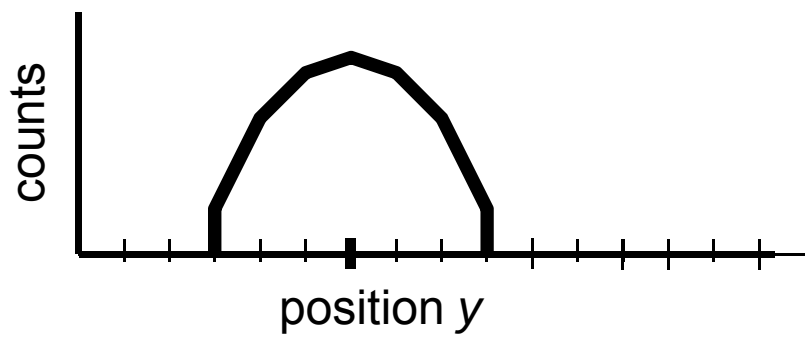
  <u>Measurements:</u>

- Reaction of the photon beam position (arithmetic mean) and the beam profile to
  - a shift of the monitor.
  - a shift of the beam position with orbit bumps.
  - a shift of the aperture.

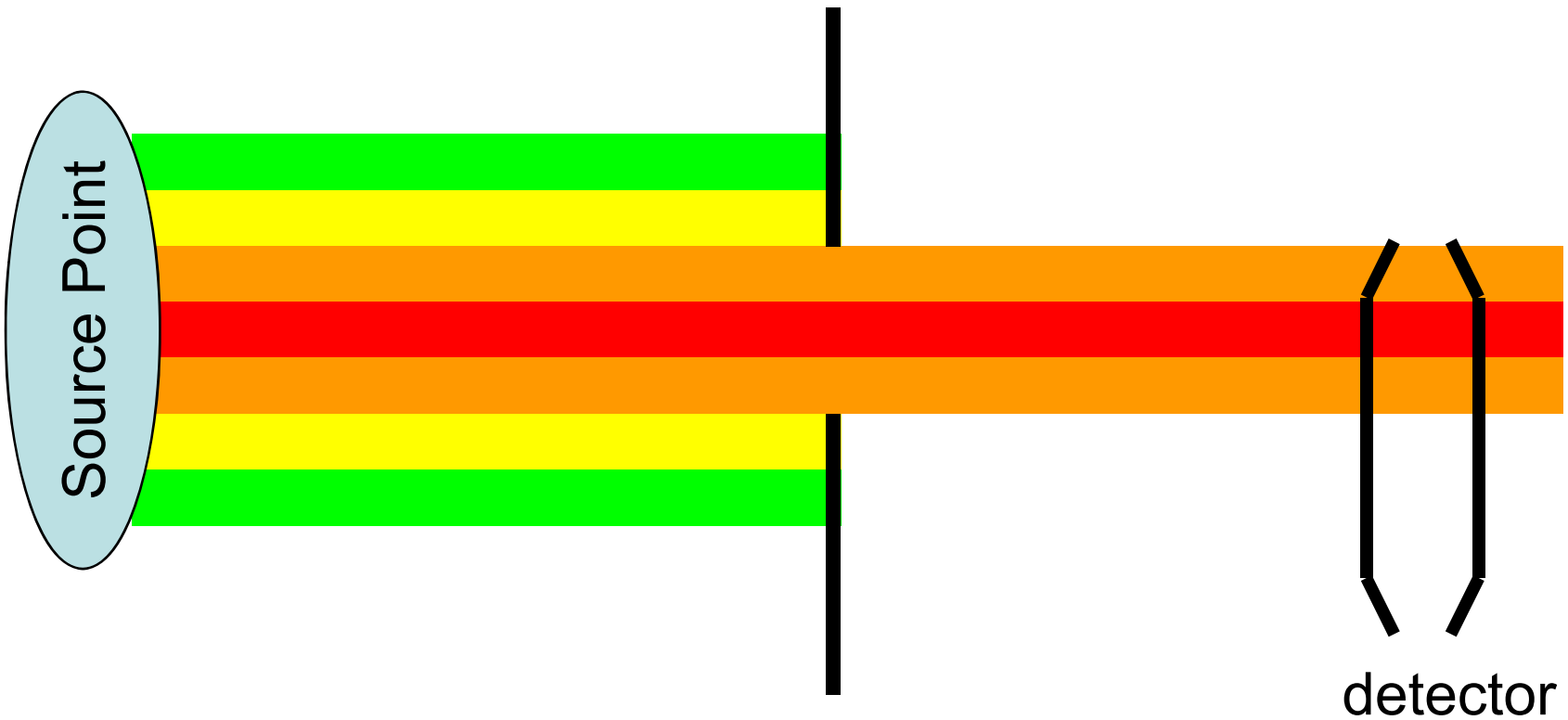
Reference state

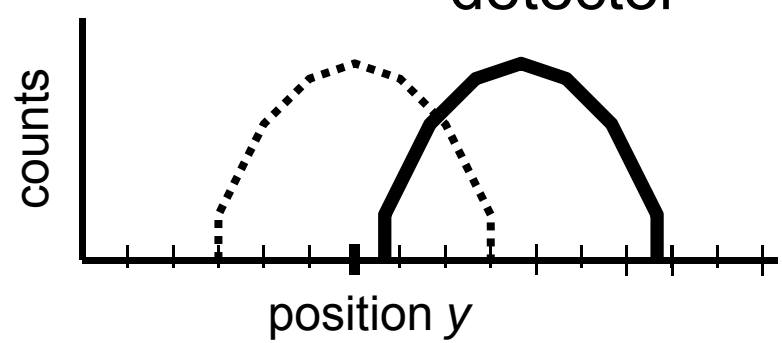


Reference state:
Symmetrical beam
profile around zero.



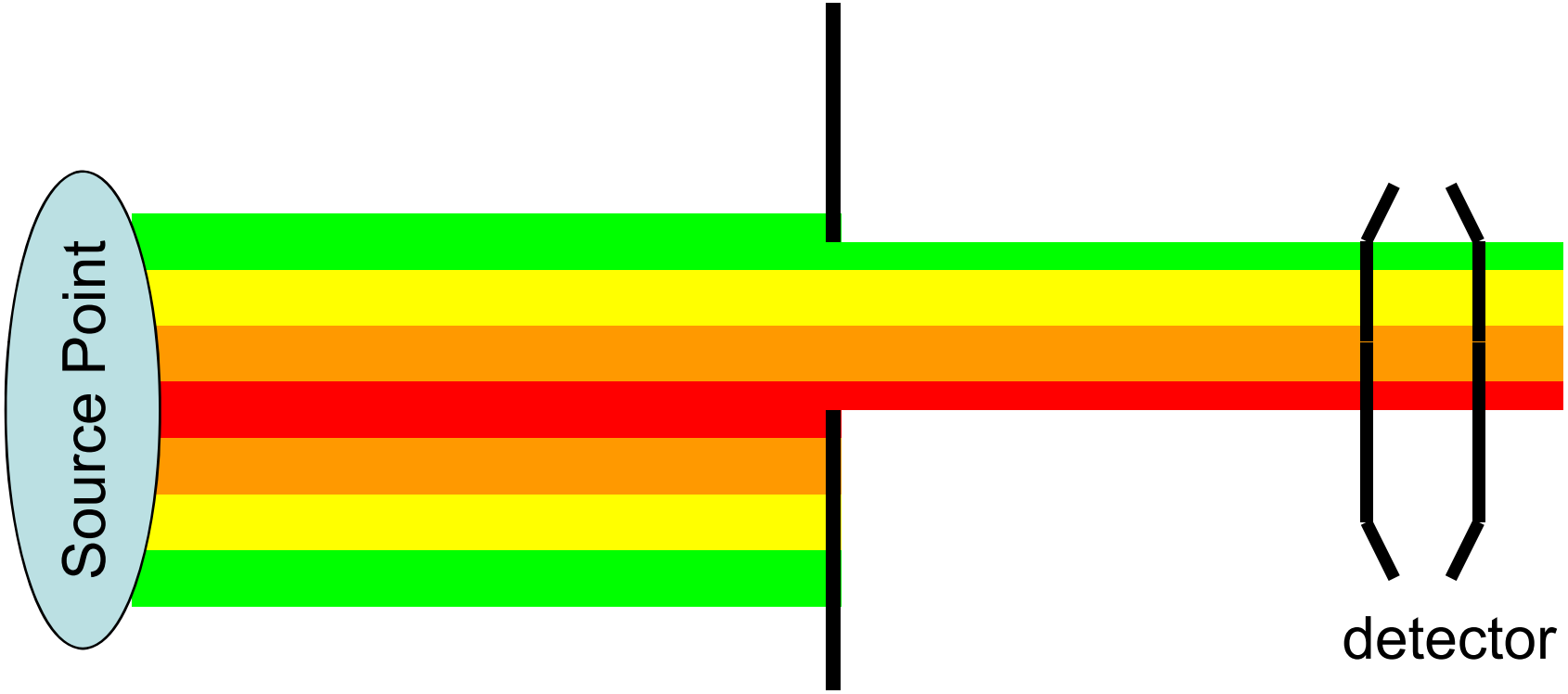
Shift of the detector



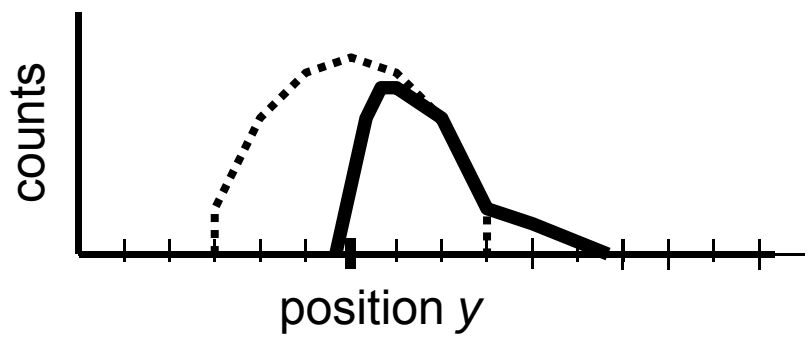


→Beam profile doesn't change.
It only shifts to other strips.

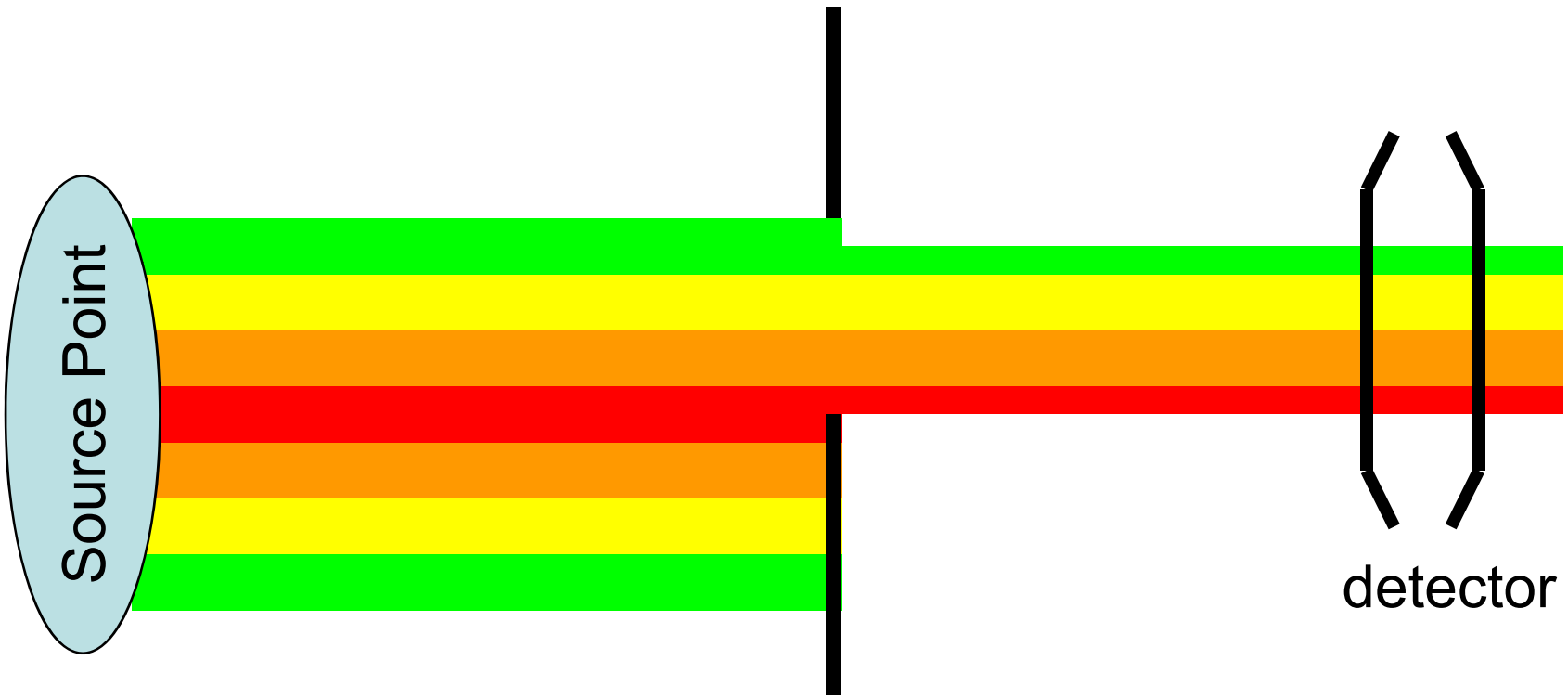
Shift of the aperture

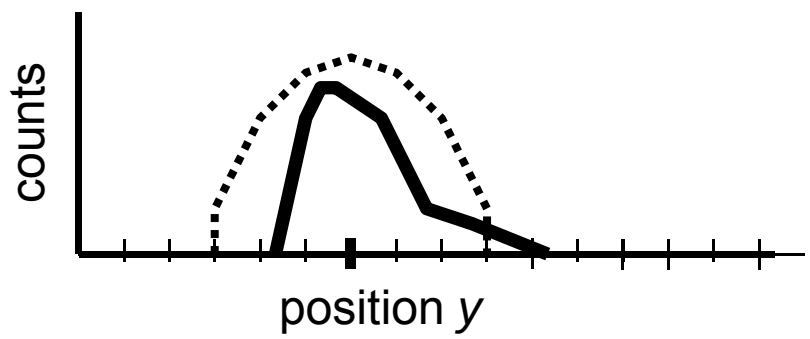


→Detected beam profile is asymmetrical.



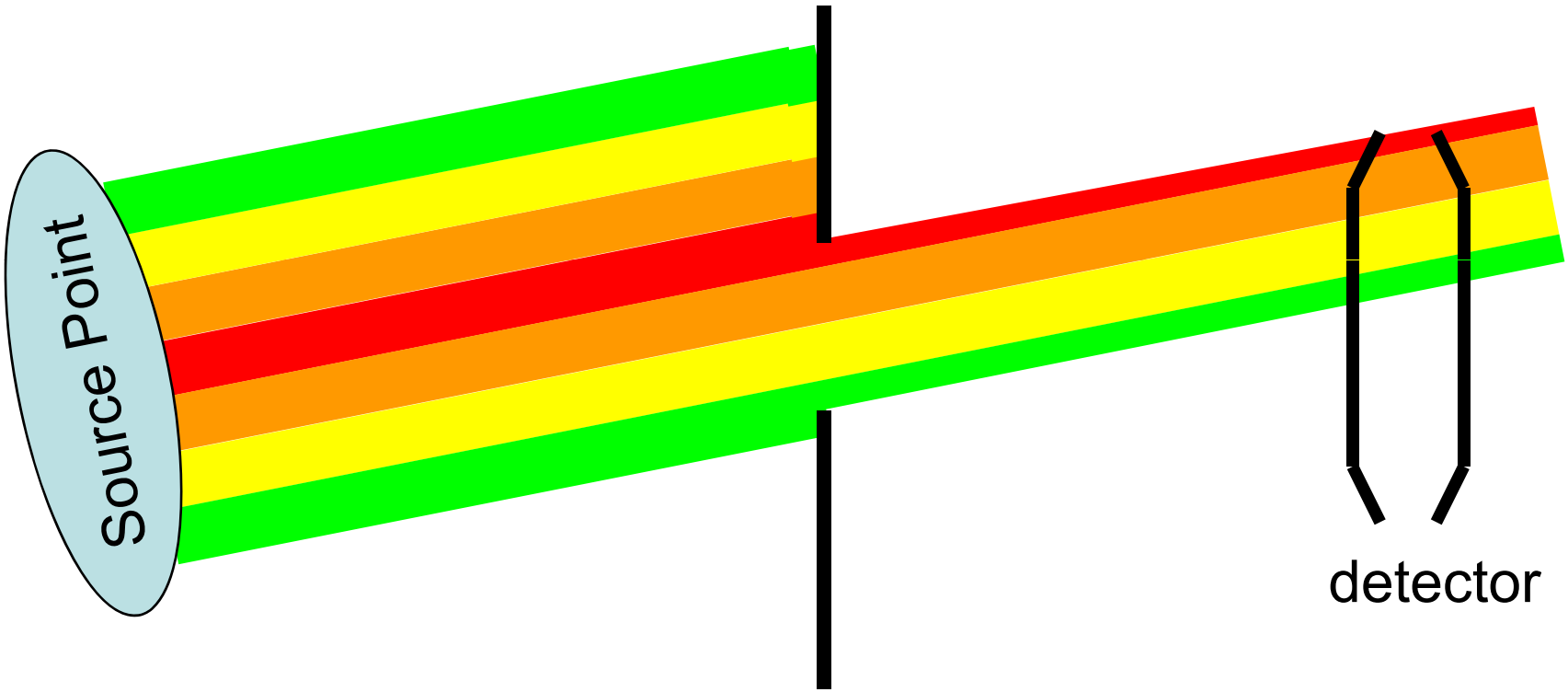
Symmetrical orbit bump



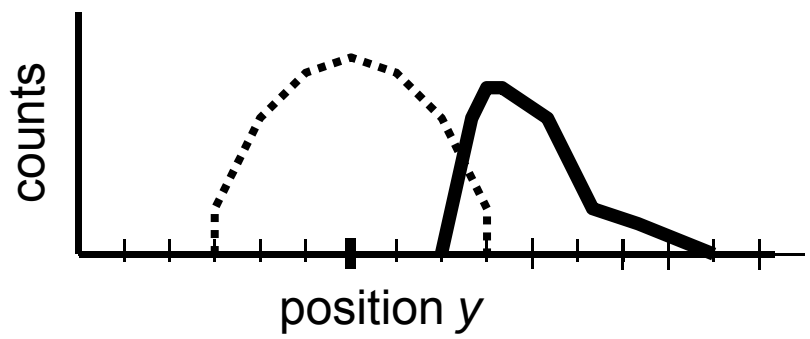


→Similar to a shift of aperture + detector.

Angular orbit bump



→Up to the aperture:
~ symmetrical orbit bump.
→From aperture to detector:
~ shift of the detector



Profile information in data analysis

- A residual gas monitor doesn't only provide a mean value of the beam position:
  - Profile shape changes.
    - In the centre: Symmetrical profile.
    - Out of the centre: Profile positively or negatively skewed →3rd moment of the beam profile not zero.

Outlook to the first tests

- The tests shall show whether we are able to get an understandable profile or not. However, other things could play a key role, too:
  - Outgassing of the assembly (plastic print)
    - Unclear if vacuum will be sufficiently constant
    - Possible cure: Additional gas
  - Temperature of the detector
    - No water cooling...
  - Unexpected things...

Conclusion

- To be given in two years...
- So far, assembly is complete, first measurements are hopefully coming soon.