

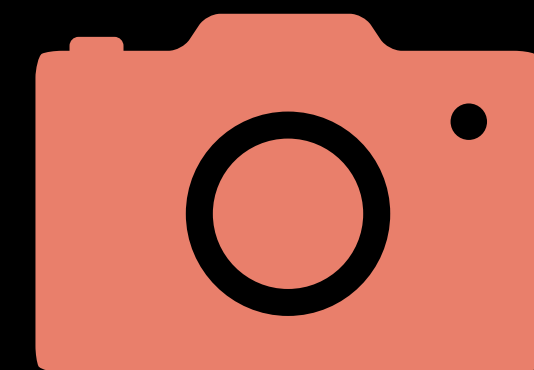
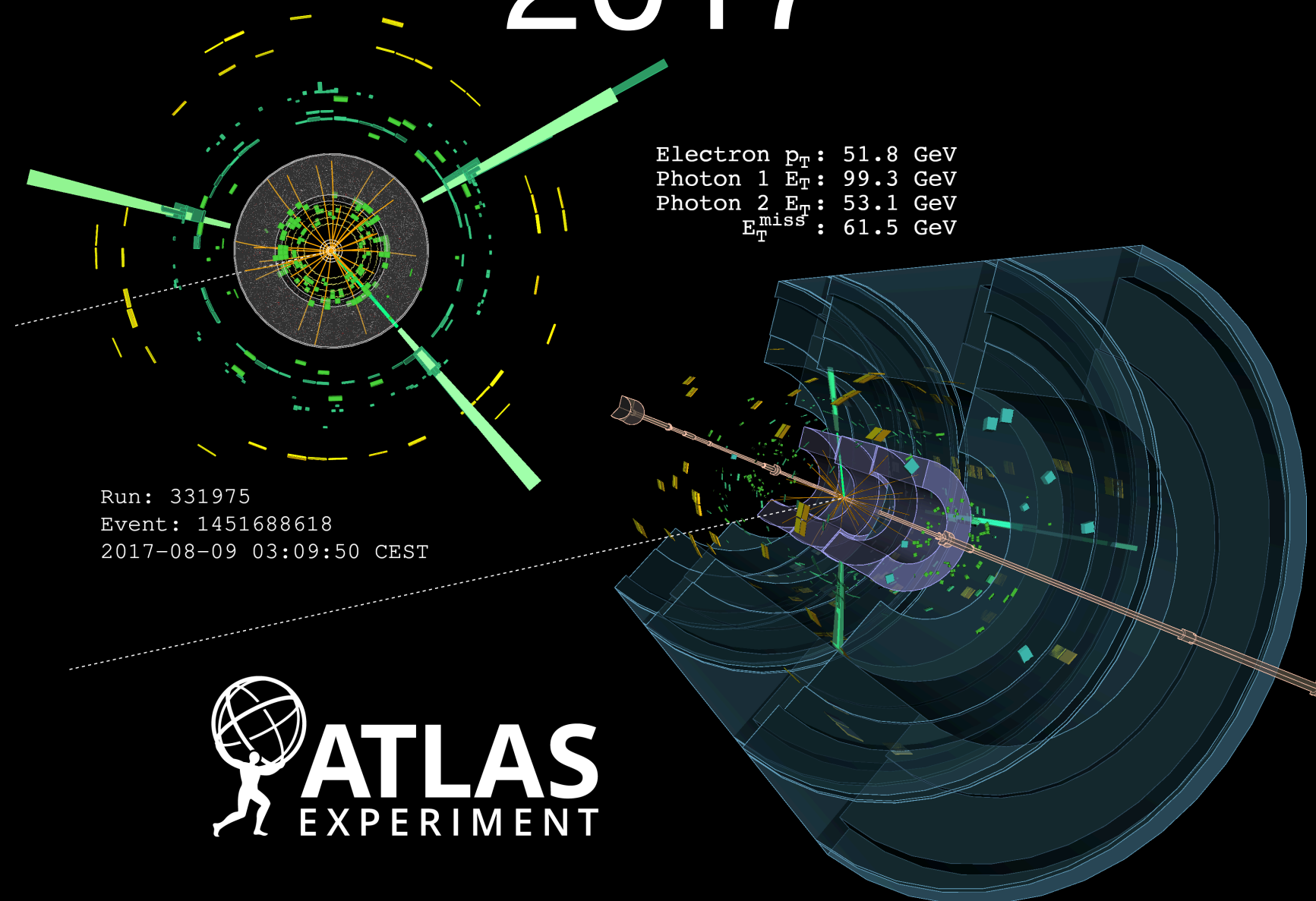
# PHYS 7363 - Experimental Particle Detection and Detectors I



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Particle detectors are the workhorses of experimental physics. In this course, we'll dive deep into their physics, exploring the incredible evolution of our experimental techniques over the past nine decades. You'll gain a solid understanding of *particle detection and identification*, examine the intricate designs of modern detectors, and learn how machine learning is being harnessed to push the boundaries of detector design. If you're intrigued by how we “see” subatomic particles, this course is for you!

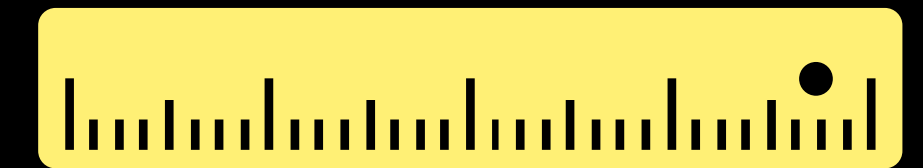
2017



Detect



Identify



Measure

To discuss prerequisites (and any questions on the content of the course), please contact me: [saptaparnab@smu.edu](mailto:saptaparnab@smu.edu)

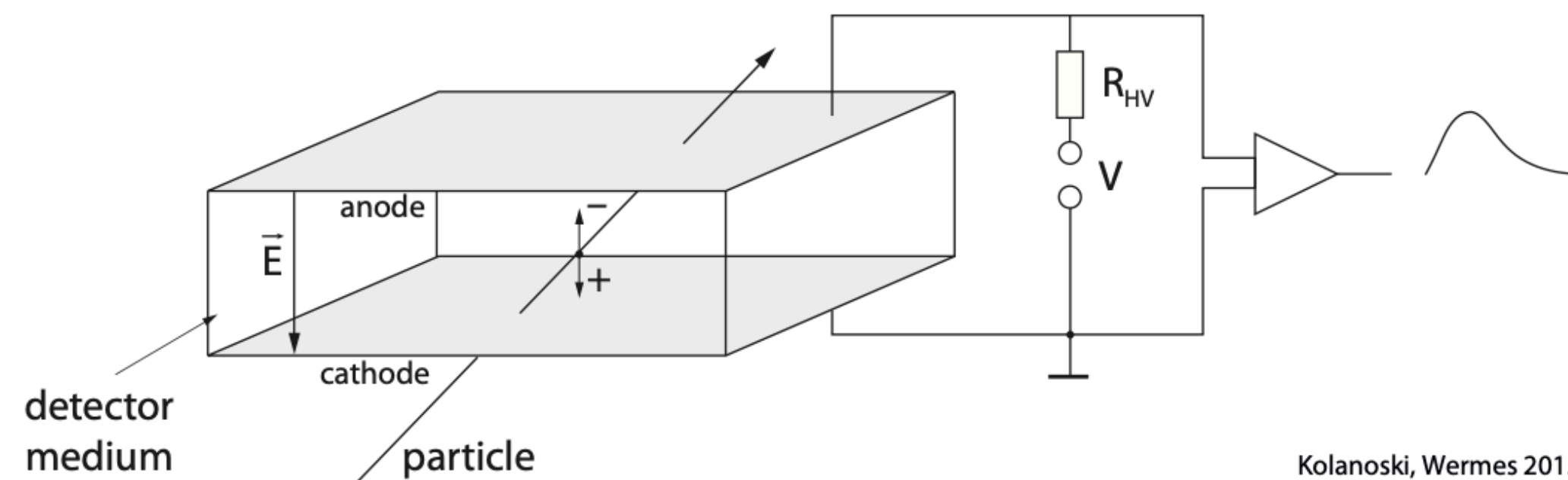


# Schedule

Month	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
October	6 <input checked="" type="checkbox"/> 1.5 hours	7	8 <input checked="" type="checkbox"/> 1.5 hours	9	10	11	12
	13 <input checked="" type="checkbox"/> 1.5 hours	14	15 <input checked="" type="checkbox"/> 1.5 hours	16	17 <input checked="" type="checkbox"/>	18	19
	20	21	22	23 <input checked="" type="checkbox"/> 1.5 hours	24 <input checked="" type="checkbox"/> 1.5 hours	25	26
	27: Midterm	28	29 <input checked="" type="checkbox"/> 1.5 hours	30	31 <input checked="" type="checkbox"/> 1.5 hours	1	2
November	3 <input checked="" type="checkbox"/> 1.5 hours	4	5 <input checked="" type="checkbox"/> 1.5 hours	6	7 <input checked="" type="checkbox"/> 1.5 hours	8	9
	10 <input checked="" type="checkbox"/> 1.5 hours	11	12 <input checked="" type="checkbox"/> 1.5 hours	13	14 <input checked="" type="checkbox"/> 1.5 hours	15	16
	17	18	19	20	21	22	23
	24	25	26	27	28	29	30
December	1	2	3	4	5	6	7
	8	9	10	11	12	13	14

# Gas-filled detectors

- In many particle physics experiments detectors are employed which measure charged particles through their ionization of gases
- Gas-filled detectors allow for the determination of particle trajectories in large volumes, often in a magnetic field
- Compared to semiconductor detectors gaseous detectors are in most cases cheaper, in particular for large volumes, and tend to present less material for the passing particles
- Ionization detectors: best for radiation fluxes containing large number of particles

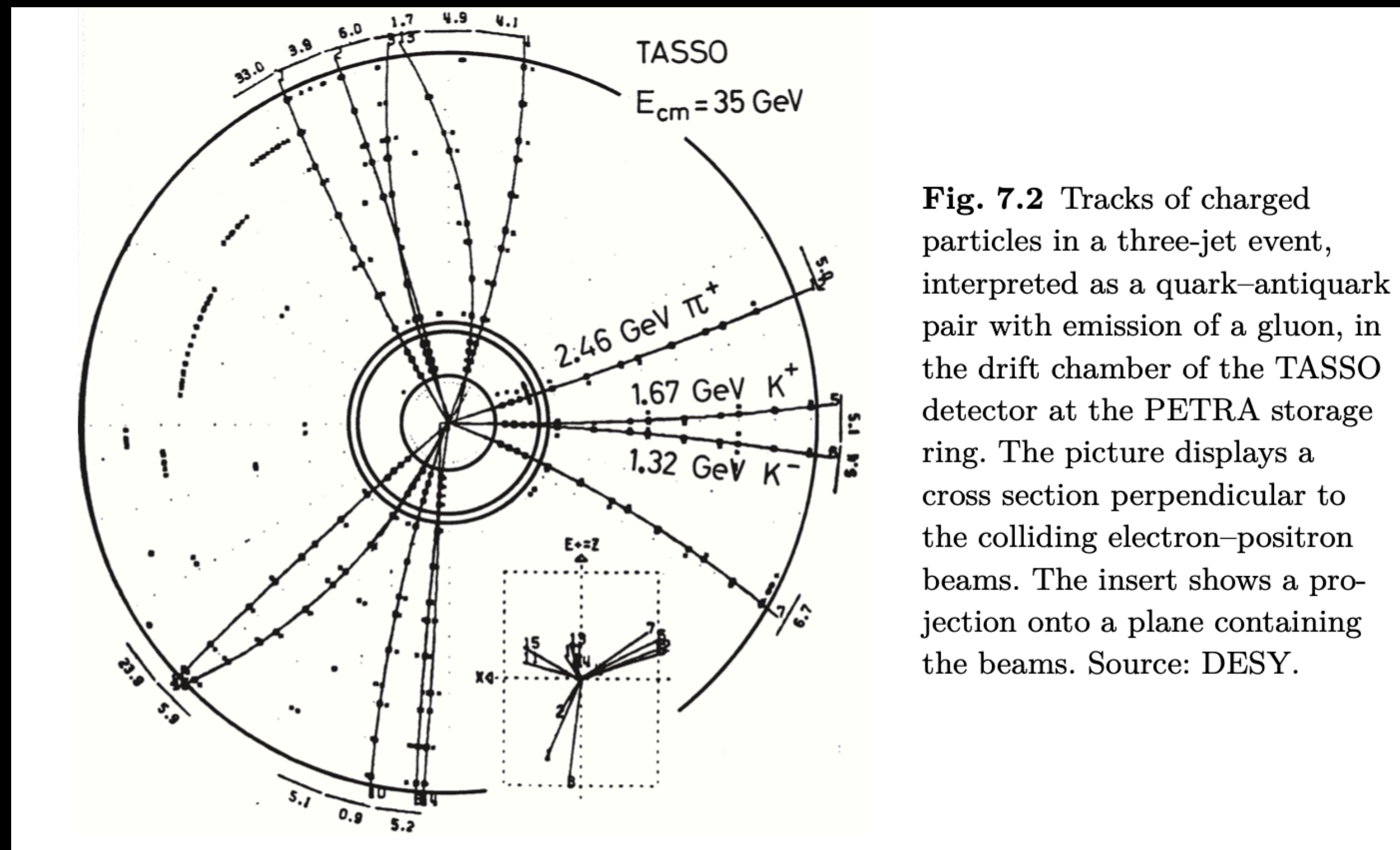


Kolanoski, Wermes 2015

**Fig. 7.1** Principle of an ionisation detector. The sensitive detector medium, in this case gas, resides between two electrodes with a voltage applied across. During the passage of a charged particle through the gas charges are liberated which move in the electric field towards the electrodes. The moving charges induce a current signal at the electrodes (see chapter 5). In principle, the detector is a capacitor which discharges upon ionisation of the medium. Electrically it acts as a current source.

# Gas-filled detectors

- Figure below shows as an example the tracks of a three-jet event in the central drift chamber of the TASSO experiment at the PETRA storage ring
- This chamber was put into operation in 1978 and was one of the first large drift chambers comprising a sensitive volume of about  $16 \text{ m}^3$  and 2340 readout channels
- Today such detectors for charged particles may have  $10^5$  or more readout channels

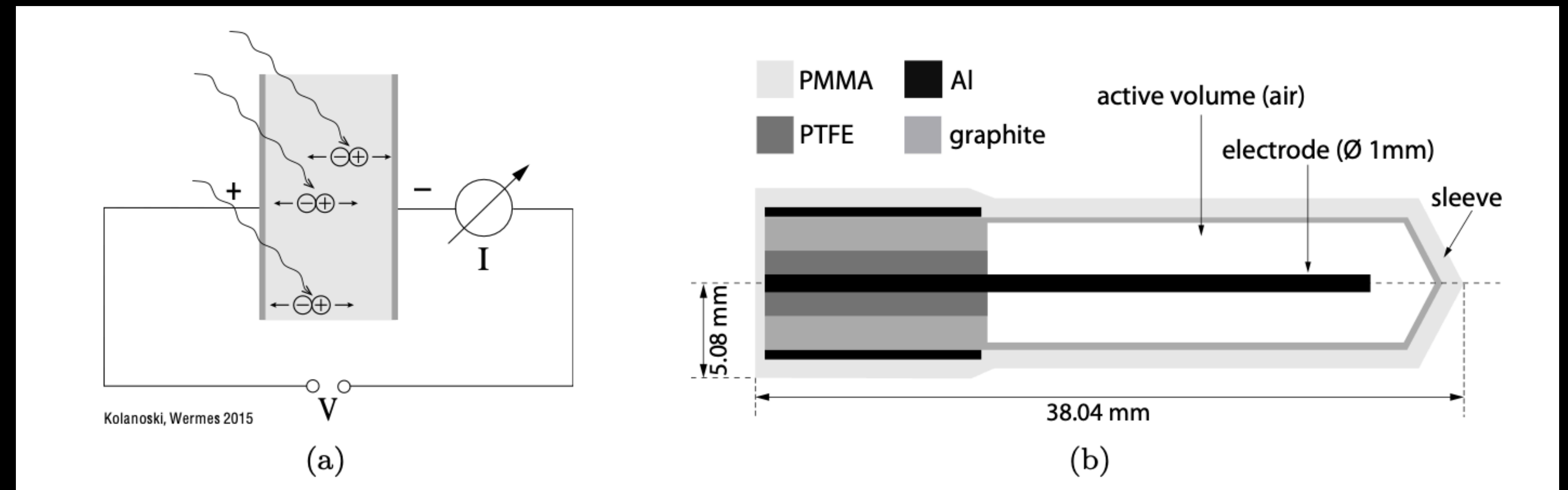


**Fig. 7.2** Tracks of charged particles in a three-jet event, interpreted as a quark–antiquark pair with emission of a gluon, in the drift chamber of the TASSO detector at the PETRA storage ring. The picture displays a cross section perpendicular to the colliding electron–positron beams. The insert shows a projection onto a plane containing the beams. Source: DESY.

# Detector types

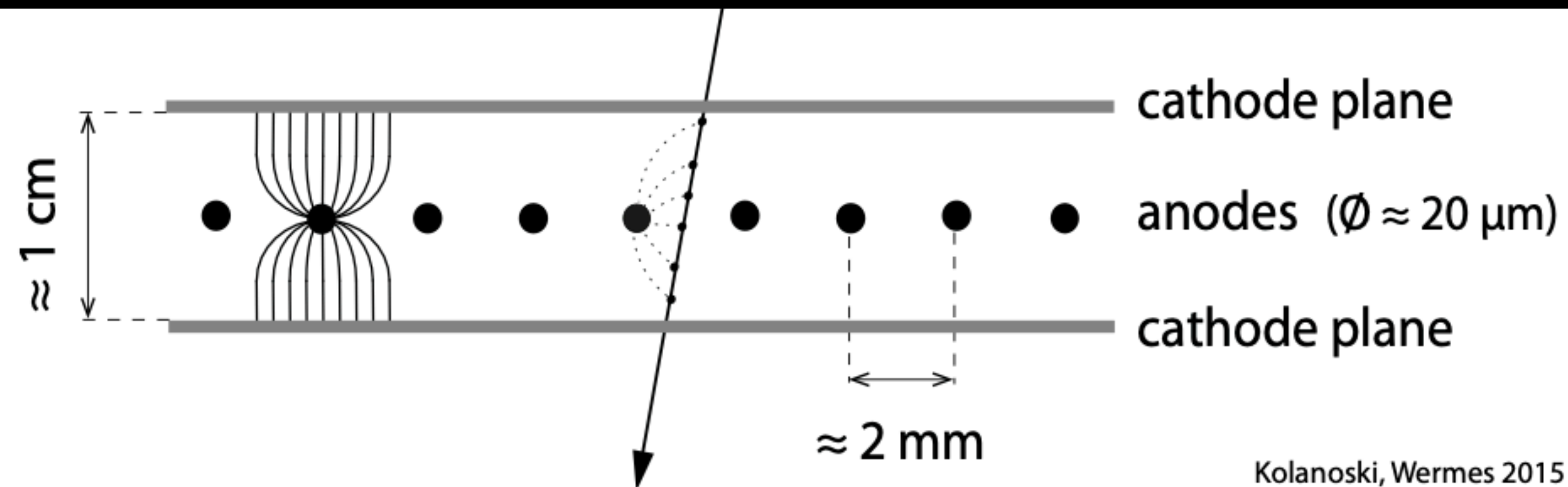
- For different application areas a variety of different detector types exist using gas as the sensitive medium
- Detectors which measure radiation fluxes (radiation monitors such as ionization chambers and proportional counters)
- Those which provide information about the locations where the particle passed the detector (position-sensitive detectors such as multi-wire proportional chambers, drift chambers and gaseous micro-structure detectors)

Ionization chamber is essentially a capacitor, charged up by a voltage  $V$ , which discharges due to the ionization in the capacitor volume. The current is a measure of the radiation flux.



# Position sensitive detectors

- Basic idea: gas-filled chamber with which the coordinate of a traversing particle can be detected



**Fig. 7.5** Principle of a position-sensitive multiwire proportional chamber (MWPC). The continuous lines represent the field lines around an anode and the dashed lines the drift paths of electrons generated by ionisation.

# Gas amplification

- If the electric field is strong enough (near the anode of a wire chamber), the drifting electrons can be accelerated such that they can initiate secondary ionizations
  - An avalanche developed and the ionization charge is amplified with typical amplification factors of  $10^4 - 10^6$
  - The number  $\alpha$  of ions generated per path length, the so-called first Townsend coefficient is given by:
    - $\alpha = \alpha_{ion} n = \frac{1}{\lambda_{ion}}$  where  $\sigma_{ion}$  and  $\lambda_{ion}$  are the cross section for ionization and mean free path between ionizations, respectively