State-of-the-art gaseous detectors

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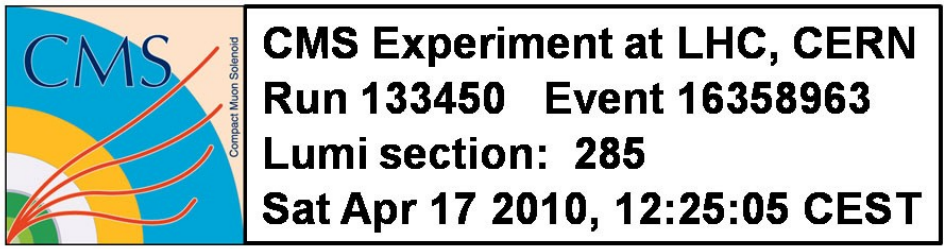
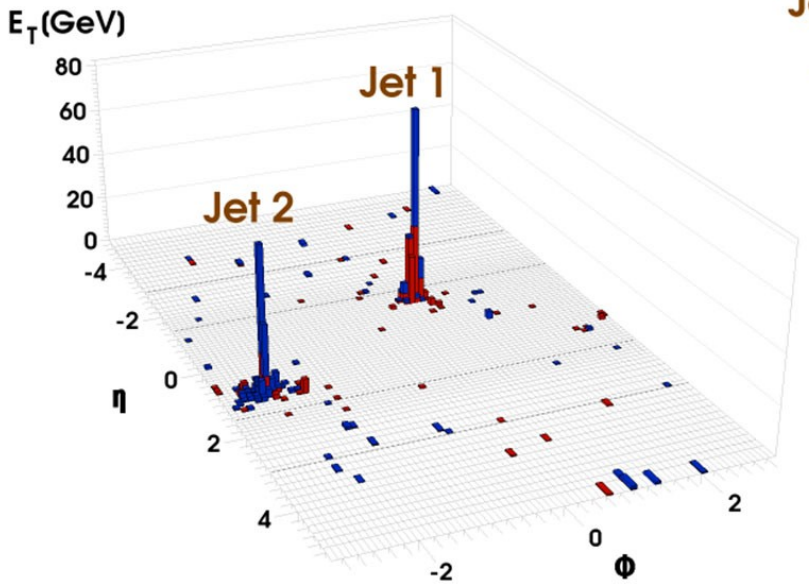
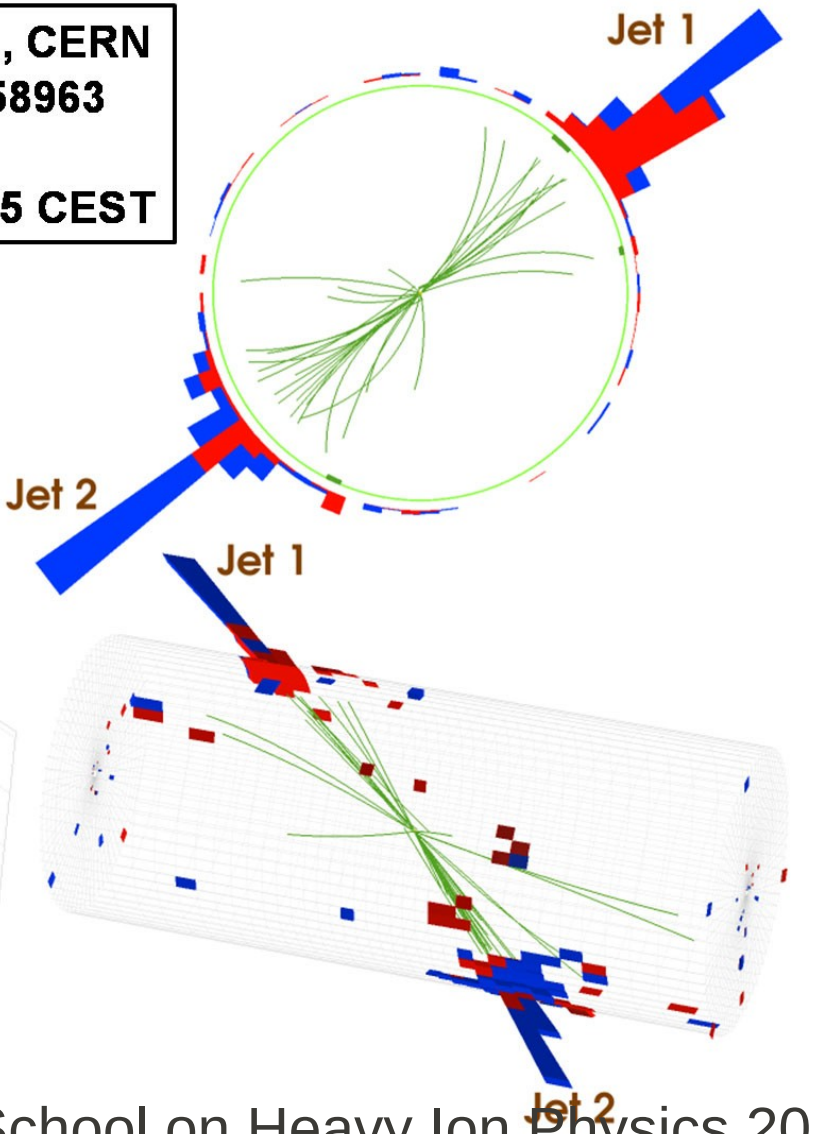
- Overview of tracking detector properties: resolution, cost and material budget
- MWPC-s: revolution in detector systems
- MPGD-s: possibilities of contemporary technology
- REGaRD group at RMKI and ELTE: physics motivations

Zimányi Winter School on Heavy Ion Physics 2010 dec.

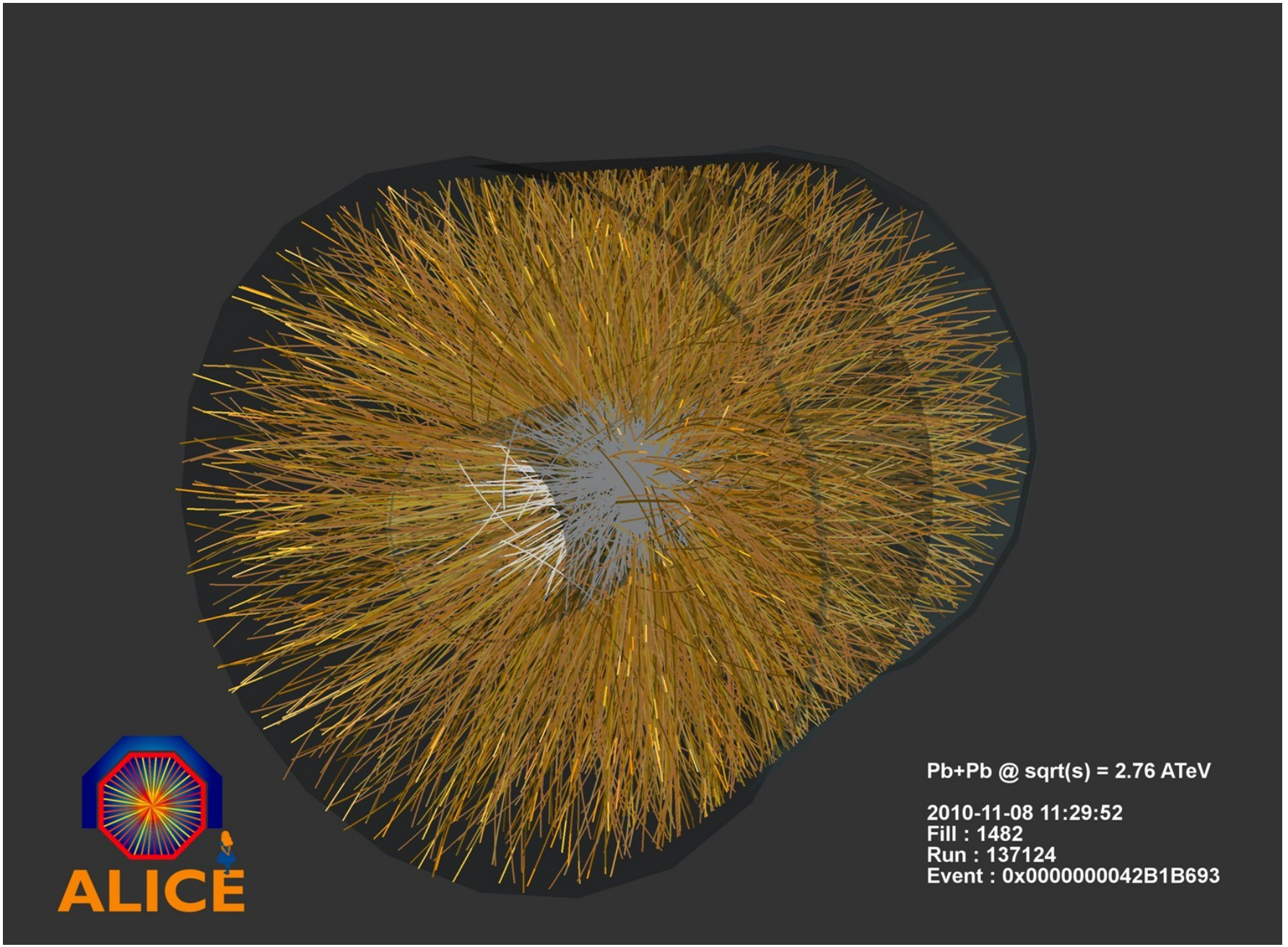
Tracking detectors: essential component of HEP instrumentation







… none the less in R-HI physics...



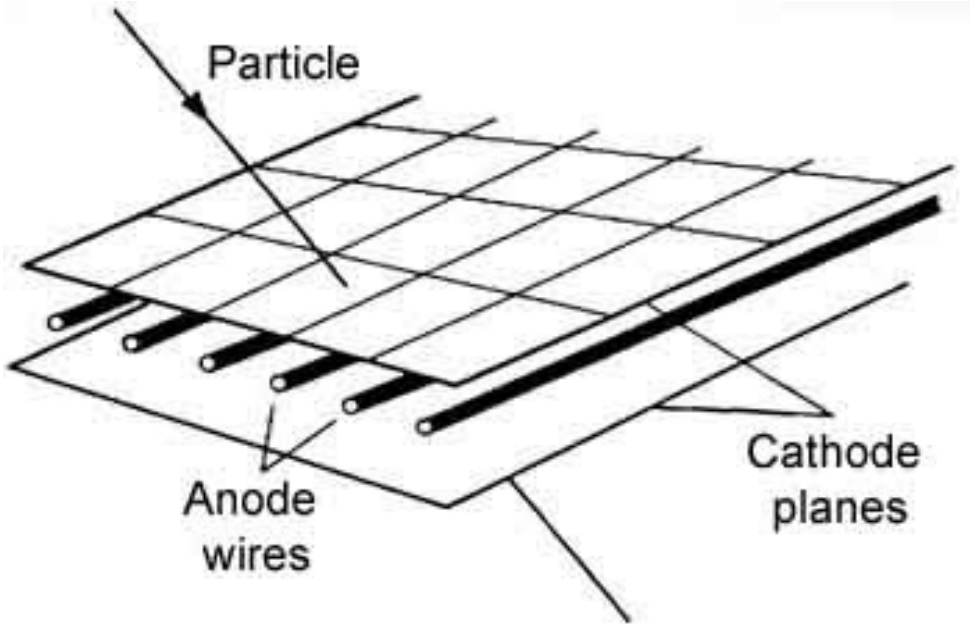
Most essential parameters

- Position resolution
- Time resolution
- Material budget
- Construction cost: practical coverable volume

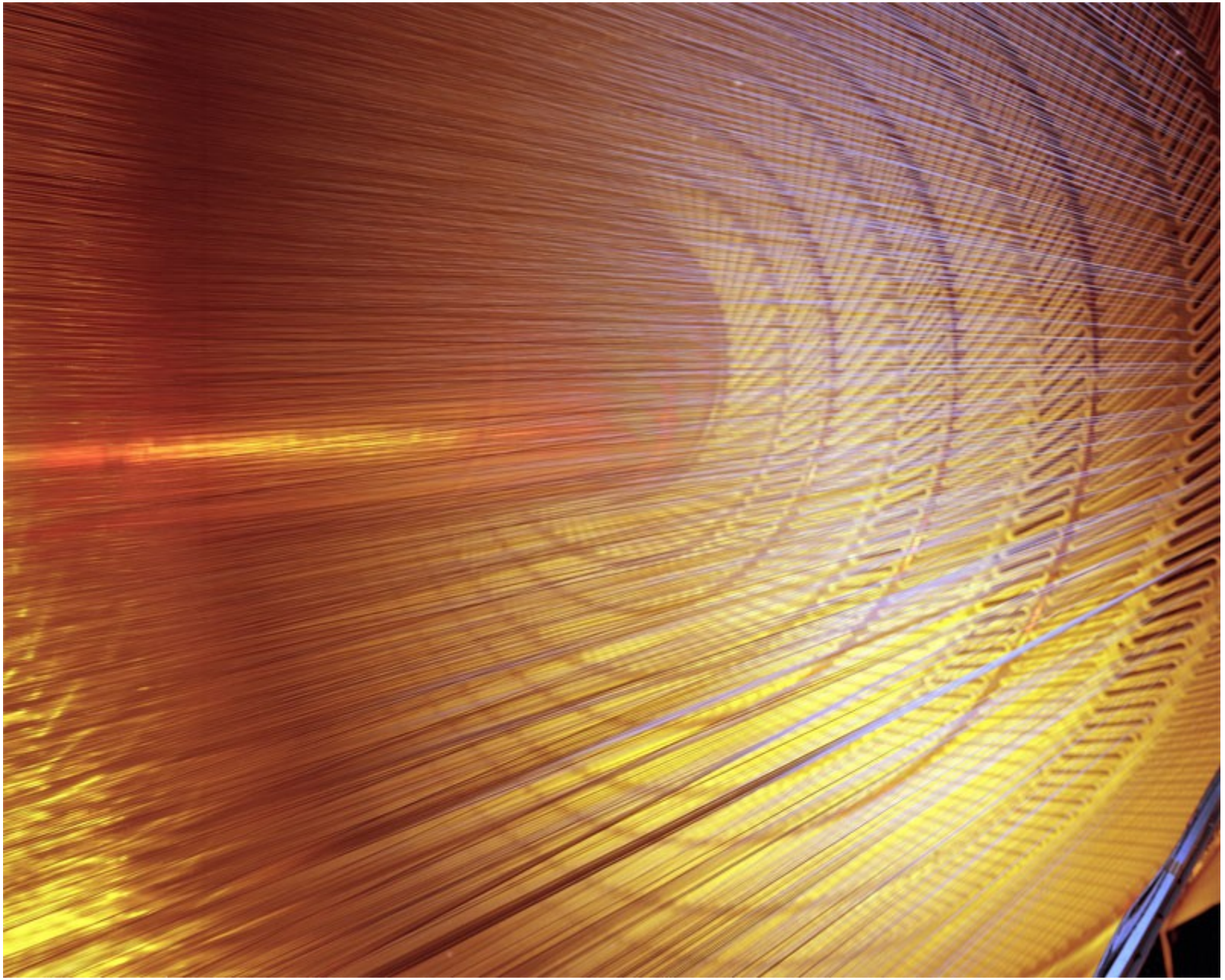
Comparing the most relevant types

Type	Position resolution (um)	Time resolution (ns)	Material budget (full track) (X0)	Cost (Euro/cm^3)
Silicon (pixel or strips)	5 - 10	10 - 100	0.03 (for 10 points)	10 - 50
Scintillators	1000 - infty	0.2 - 2	0.02 - 0.05 (for 2 points)	0.01 - 0.05
Gaseous detectors	100 - 300	30 - 100	0.01 – 0.1 (10 to 100 pts)	0.05 - 0.1

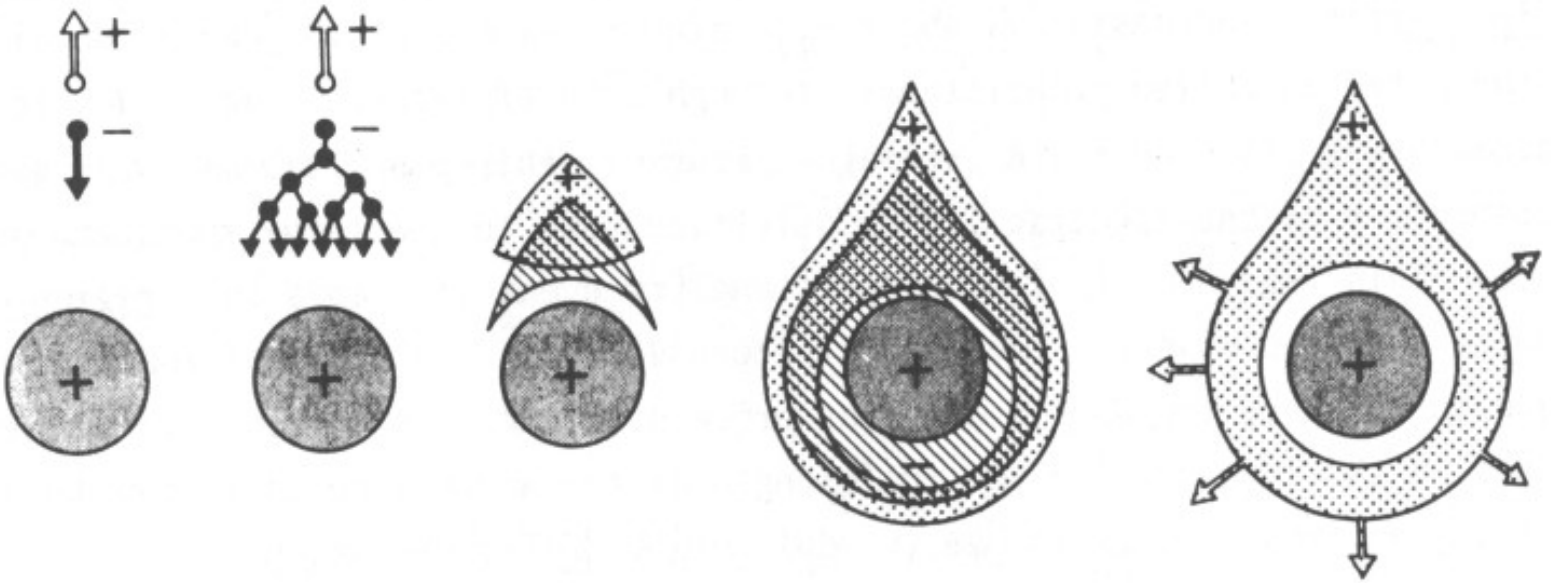
Multi-Wire Proportional Chambers: the revolution of electronic detectors



- Nobel-prize winning concept, which superseded Bubble Chambers
- Low material budget
- Limited position resolution (by 21st century standards)
- Limited timing resolution

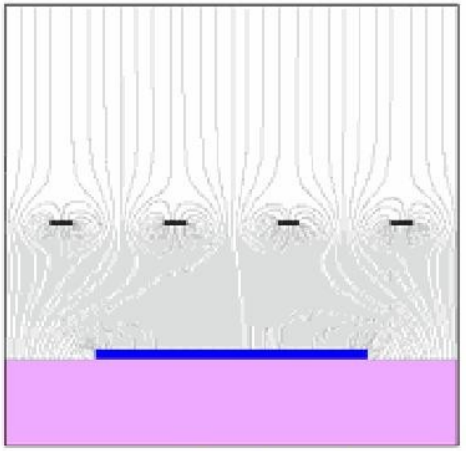


Gaseous detector operation principle: avalanche of ionization

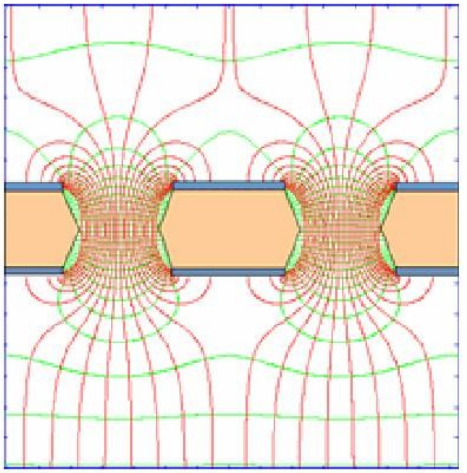


- Few hundred primary electrons per cm
- Few thousand times amplification by avalanche

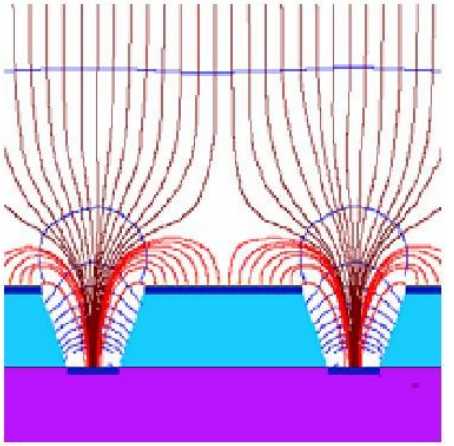
Micro-Pattern Gaseous Detectors: posssibility of advanced technology



parallel plate



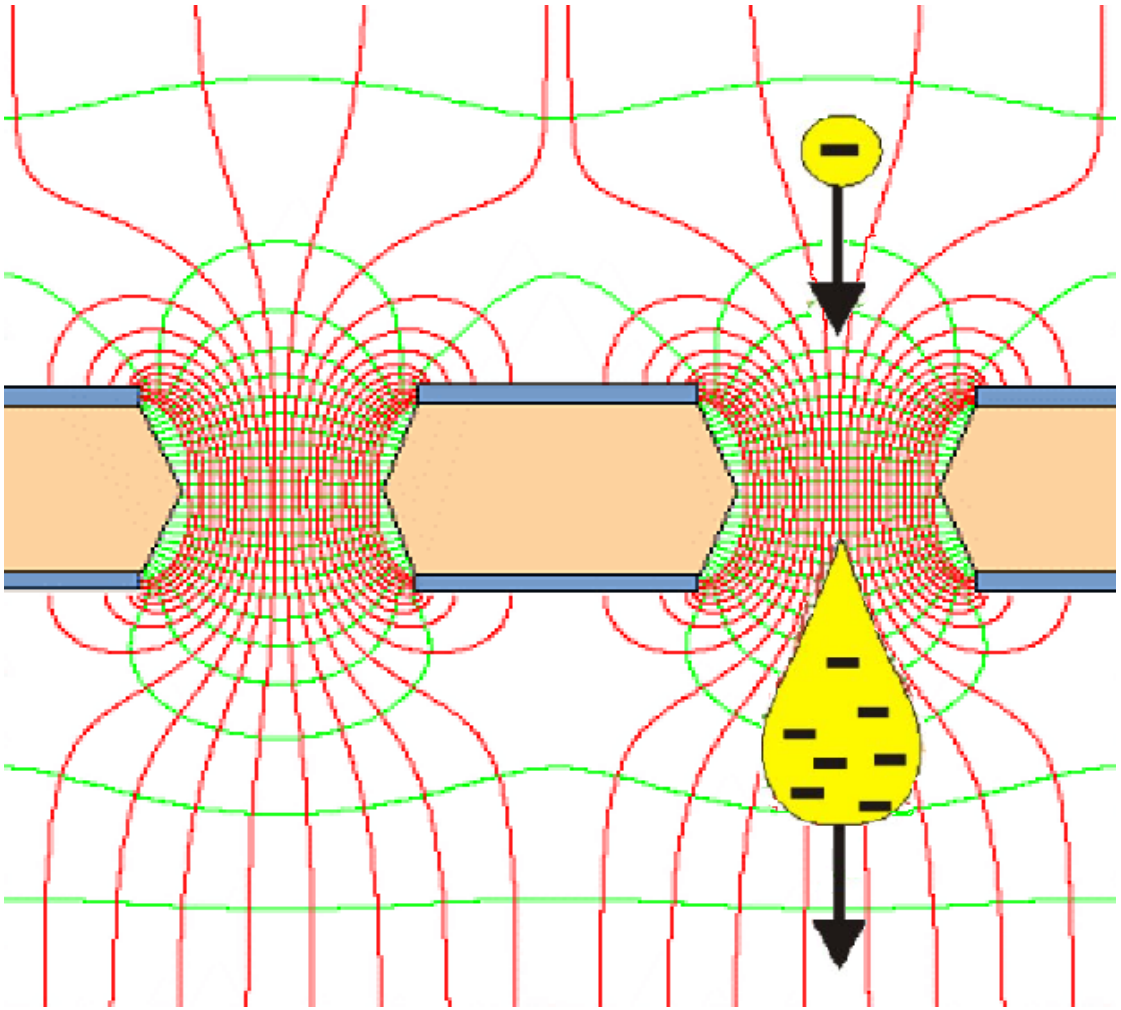
hole



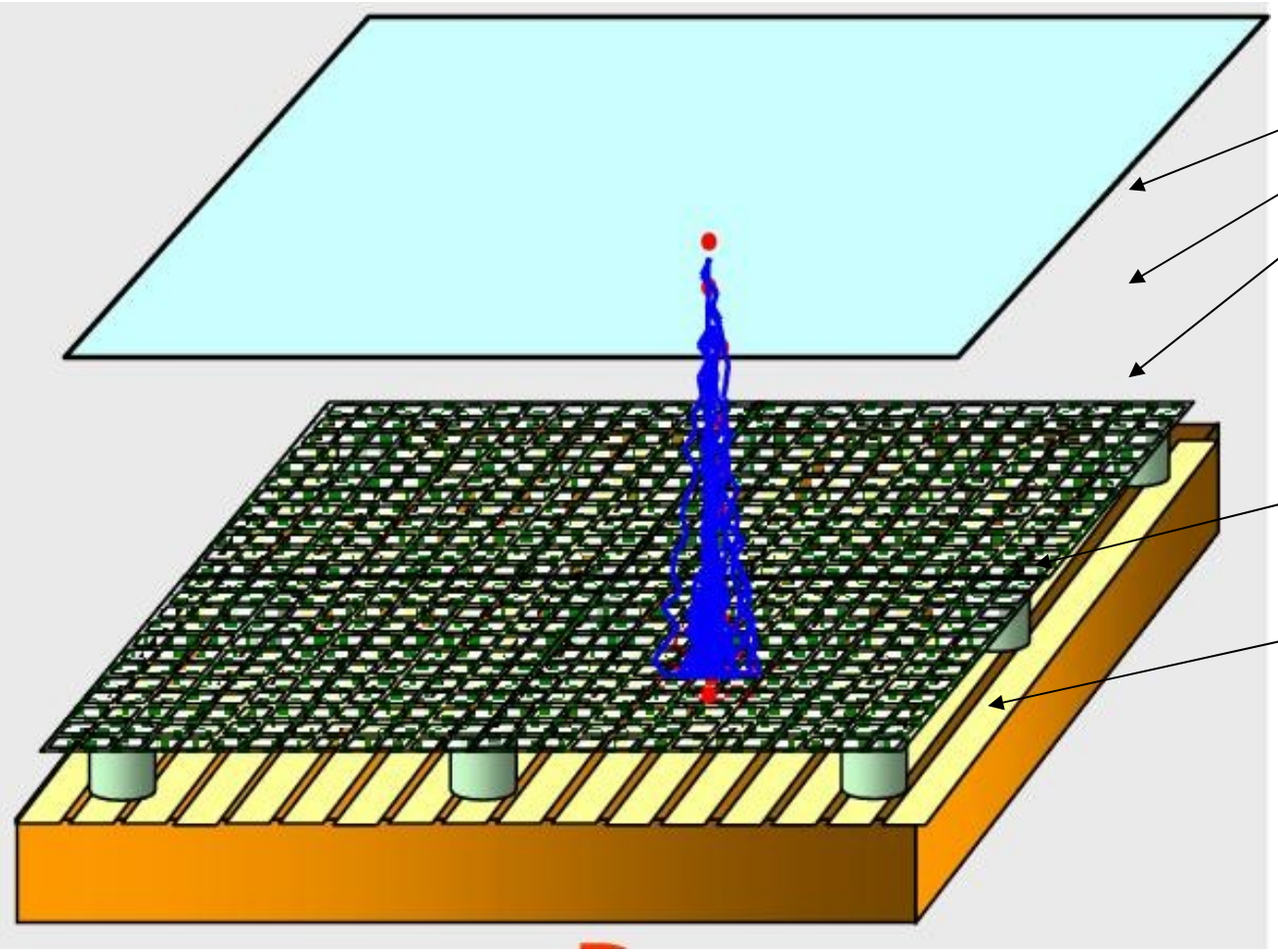
groove

CERN RD51 Collaboration initiative for coordination

Gas Electron Multiplier (GEM): focusing geometry



Micro-MEsh-GAS detector



Primary ionization

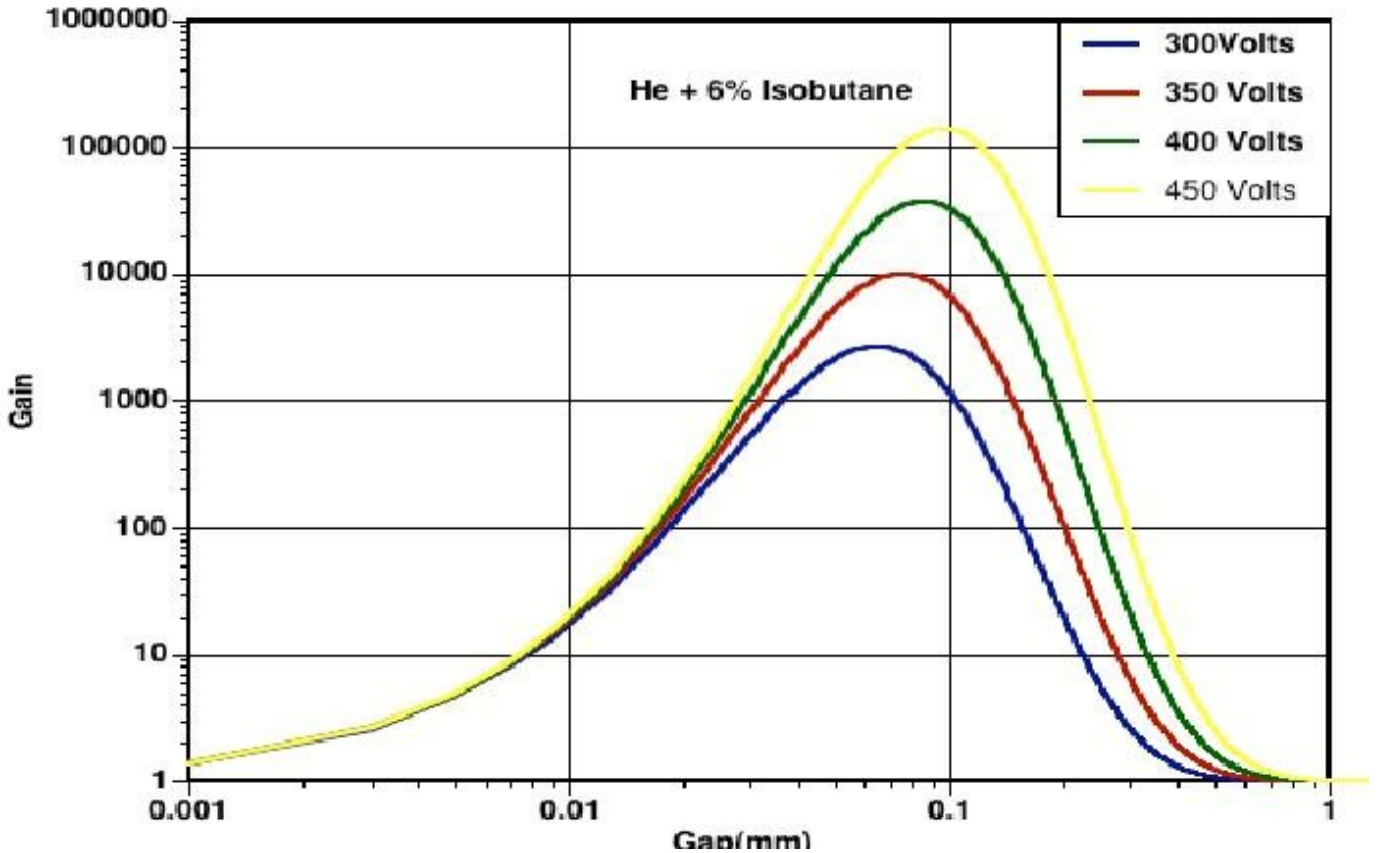
Mesh

Readout structure

Avalanche: between mesh and ground

The avalanche gain turns out to be independent of the gap size

Micromegas concept: amplification independent of mesh gap

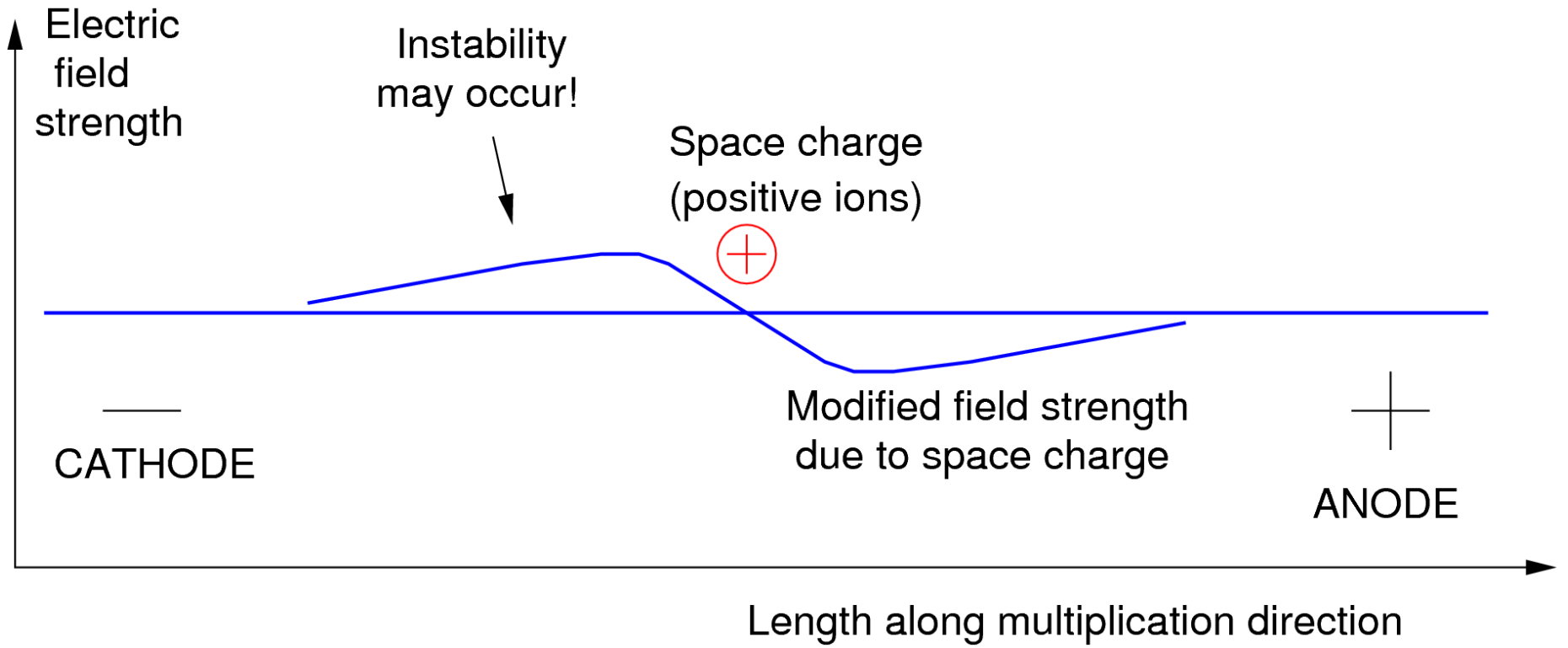


Increasing gap: reduced field strength reduces gain

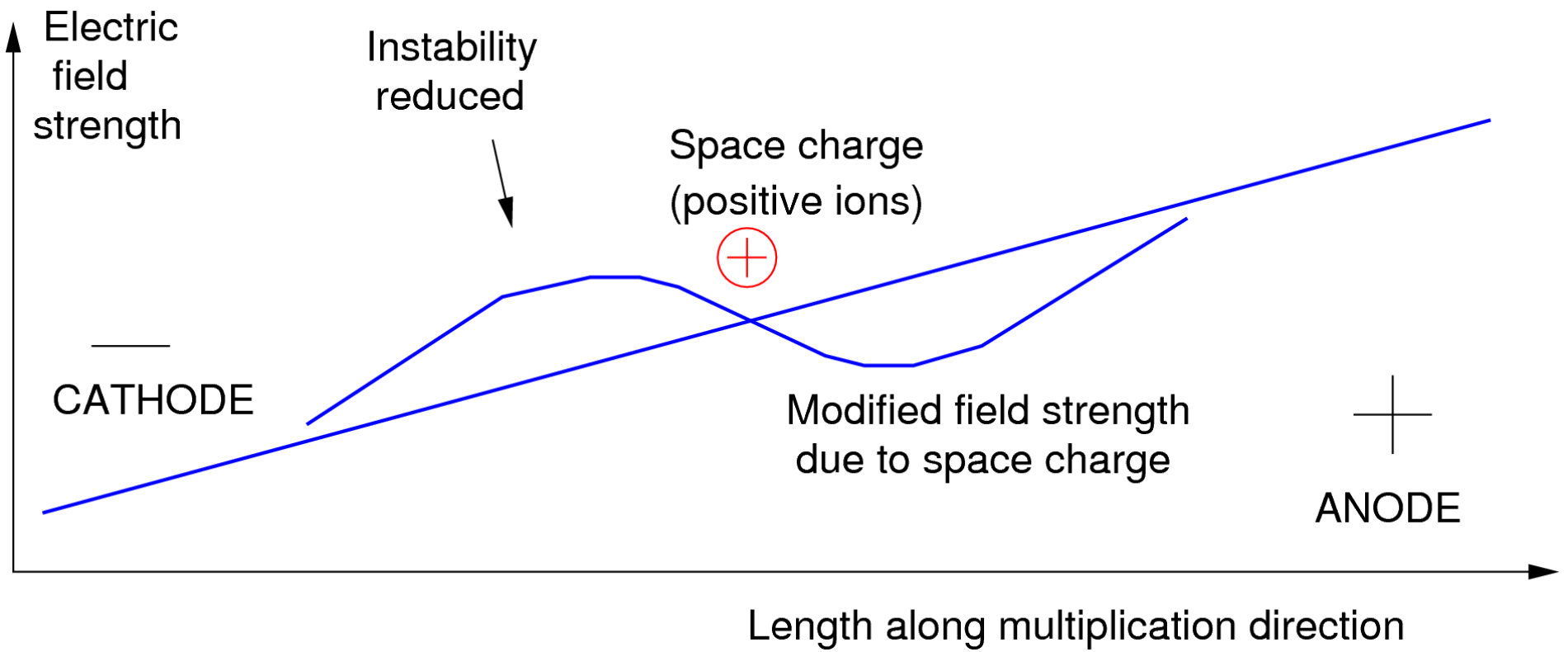
Decreasing gap: shorter length of avalanche reduces gain as well

Stability issues of MPGD-s

- Local space-charge in avalanche non negligible
- If the field is increased by space-charge, runaway multiplication can occur: sparking!



MWPC-s: reduced effect!



- In MPGD-s, sparking is part of normal operation. Either the detector is spark protected, or the electronics, or both

Raether-limit for MWPC and MPGD

- MWPC: limited amplification

A_{max} order of 10^7

- MPGD: limited total charge per hit

Q_{max} order of $10^7 e$

RMKI/ELTE initiative for detector development: REGaRD

- All projects are physics-driven! **RD51** framework
- Trigger for CERN ALICE VHMPID (G. Hamar, G. Kiss); MWPC development
- NA61: Low Momentum Particle Detector (see K. Márton's talk from Monday)
- Muon tomography (L. Oláh, G.G. Barnaföldi) for underground structure mapping
- PET: revision of an old idea with new approach
- Other applications such as radon detection