Drift Chambers: The Science behind the Art

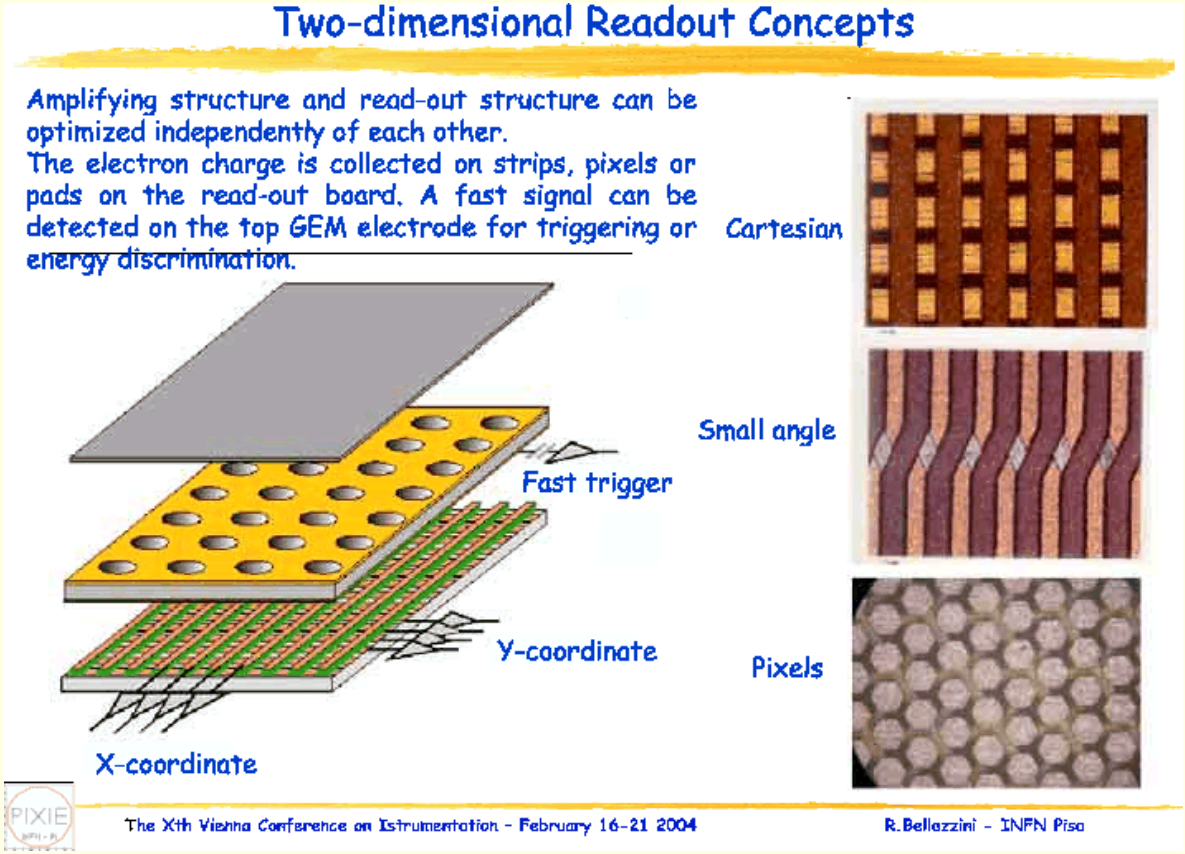
- What are they? how do they work?
  - ionization of the gas by particles
  - “drifting” of the electrons
  - the “avalanche” at the wire
  - how tracking works
- frequently asked questions (your part!)

the motivation (you get to go to Vienna !)

there are alternatives!

- Micro-pattern gas detectors
  - No wires to break, accurate patterns, fast ion clearing, anode at ground
  - Ideal for TPC's; not as uniform as wires
  - Less multiple scattering than Silicon
  - Multi-GEM's -> less ion feedback
    - more stable at same gain
  - shape of dielectric important
  - Micro-megas w/ resistive anodes
    -> competitive with GEM's
  - Flexible readout schemes !

- Monolithic pixel detectors

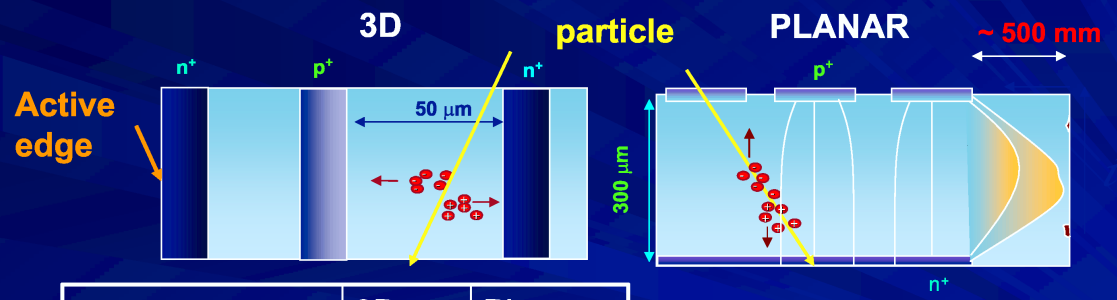


from Bellazini's talk

New Types of Silicon Trackers

3-D sensors

- Combine **VLSI** and **MEMS** (Micro Electro Mechanical Systems) technology.
- **Electrodes** processed inside the bulk instead then implanted on surface.
- **The edge** could become electrode! Dead volume at the Edge < 10 microns!



	3D	Planar
Q collection path	50μm	300 μm
$V_{depletion}$	<10V	70 V
Edge sensitivity	10μm	500 μm
Q Collection time	1-2 ns	10-20 ns

Proposed by Parker, Kenney1995

- NIMA 395 (1997) 328
- IEEE TNS 46 4 (1999) 1224
- IEEE TNS 48 2 (2001) 189
- IEEE TNS 48 6 (2001) 2405
- IEEE TNS 48 5 (2001) 1629
- CERN Courier, Vol 43, Number 1, Jan 2003

Daniela Bortoletto VIC 2004 36

so why drift chambers ?

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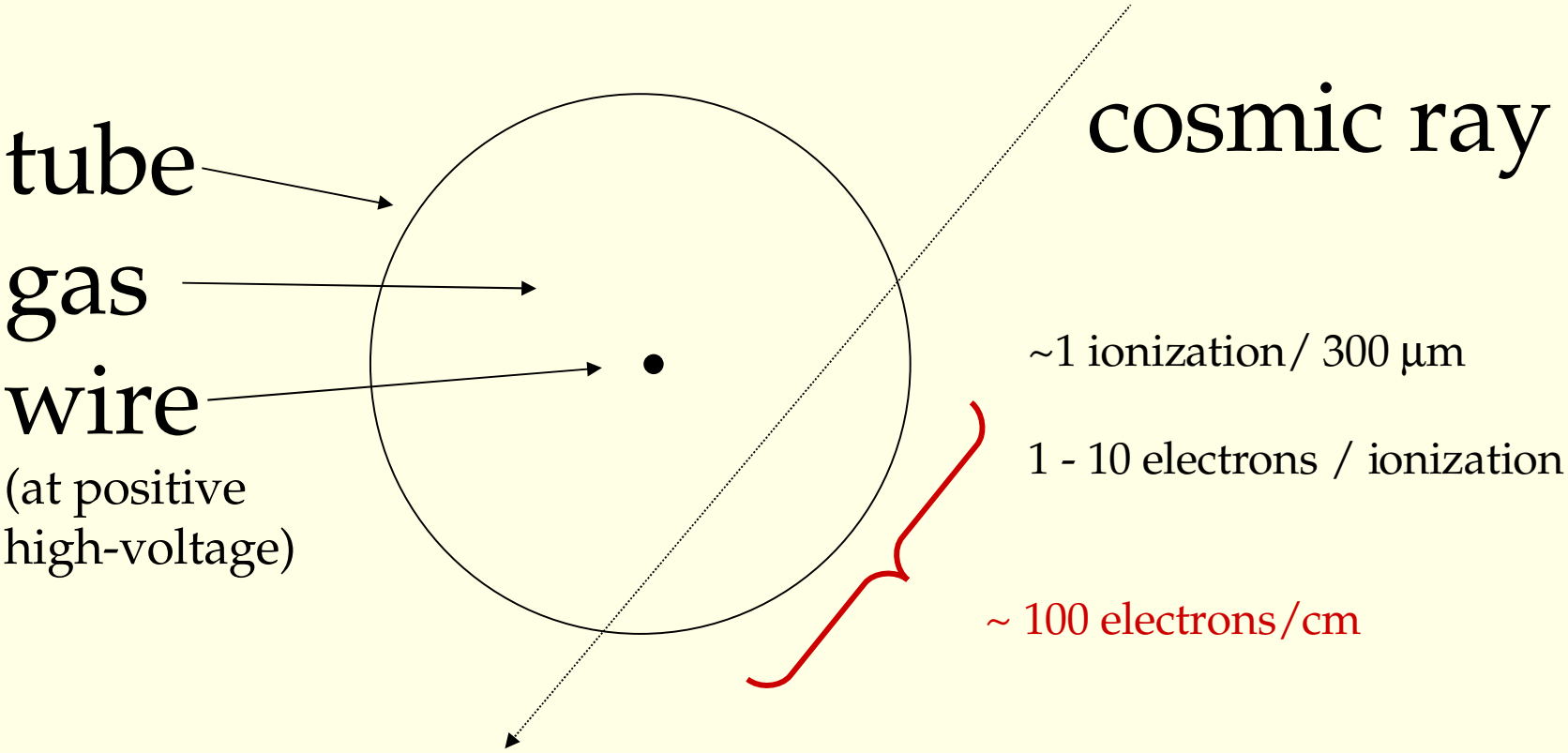
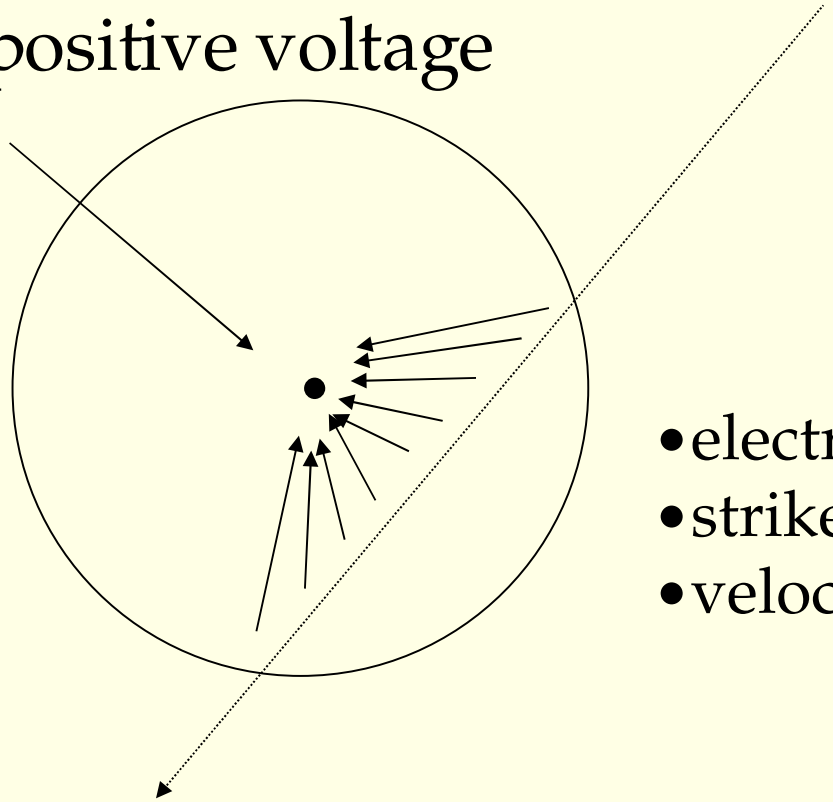
- economical way to cover a large volume with tracking chambers

gas ionization by particles



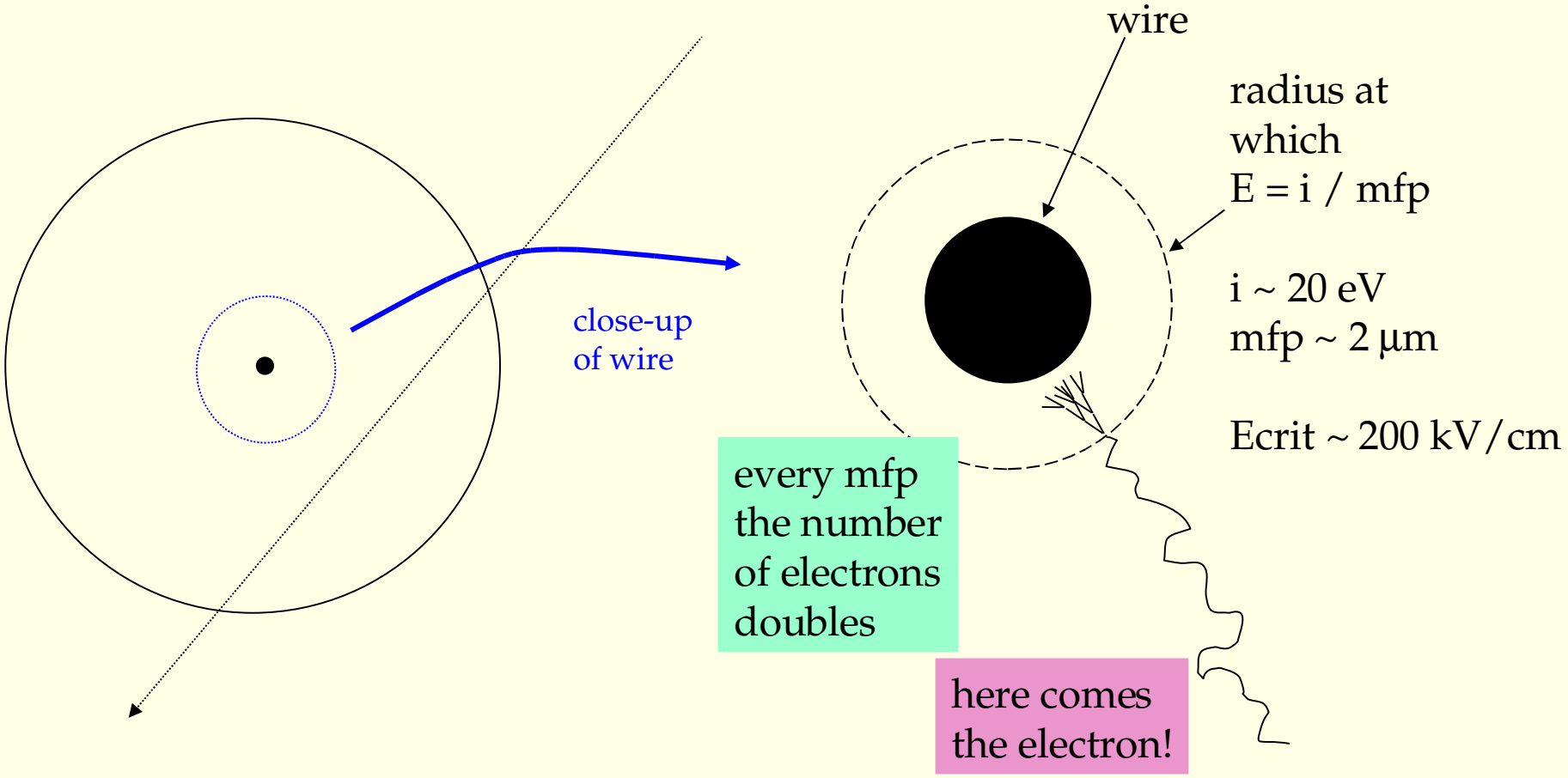
“drifting” of the electrons

wire at positive voltage



- electrons drift to the wire
- strike a molecule every 2 μm
- velocity ~ 50 μm/ns (max)

the “avalanche”



the “avalanche” (cont.)

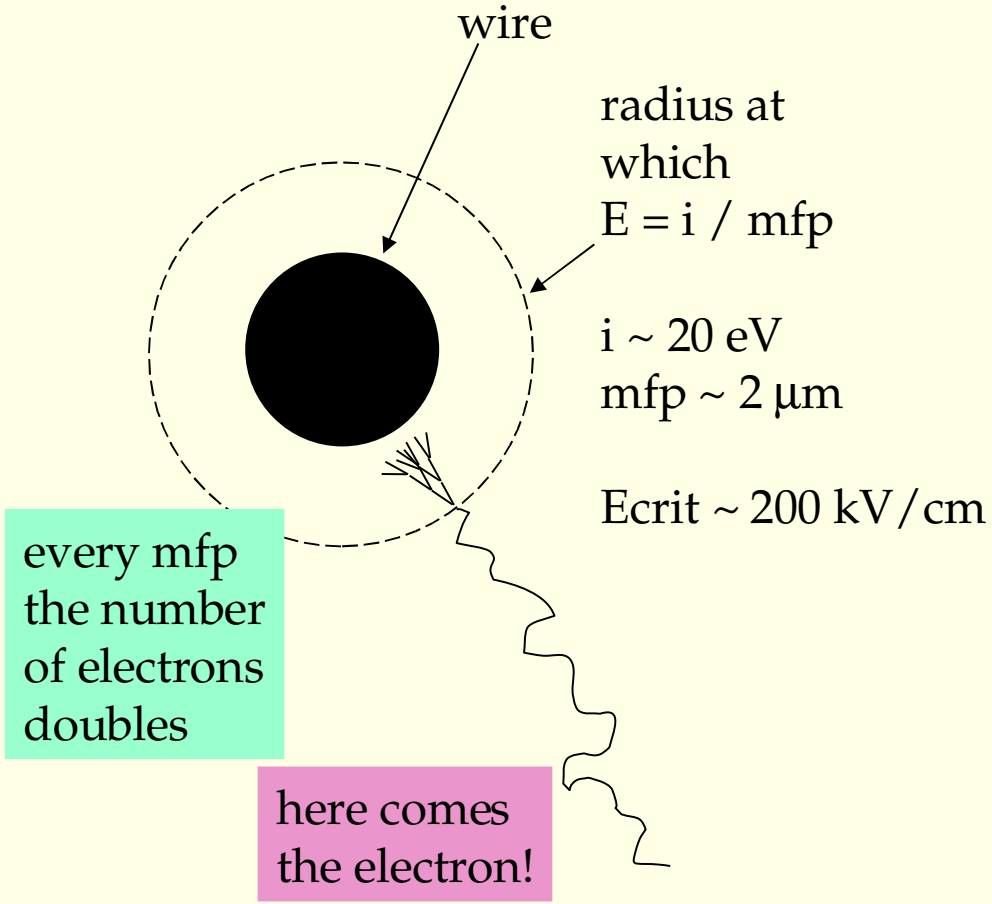
gain ~ 2^{ndbl}

ndbl = $(r_{crit}-r_{wire})/mfp$

Ecrit = $k * V / r_{crit}$

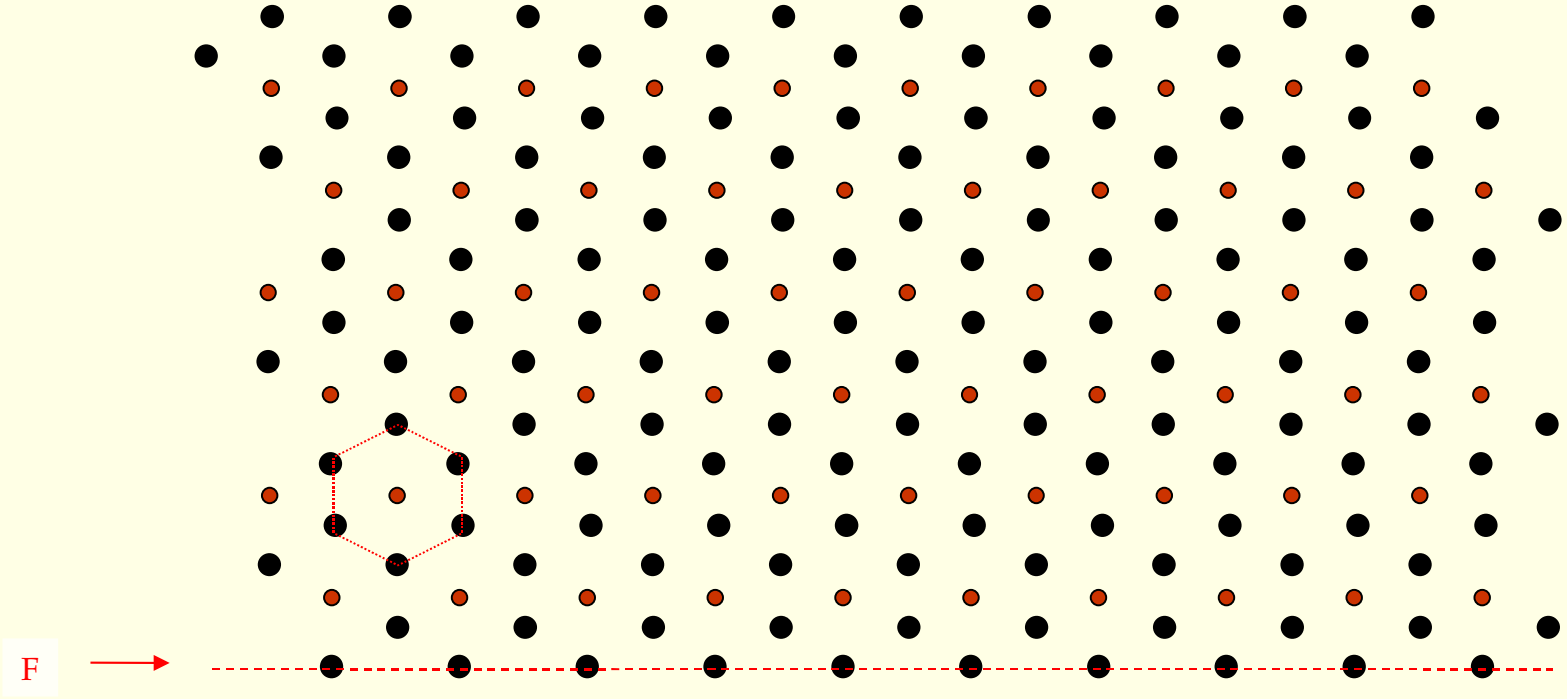
gain ~ 2^{k*V}

rule of thumb:
gain doubles every
75 or 100 Volts

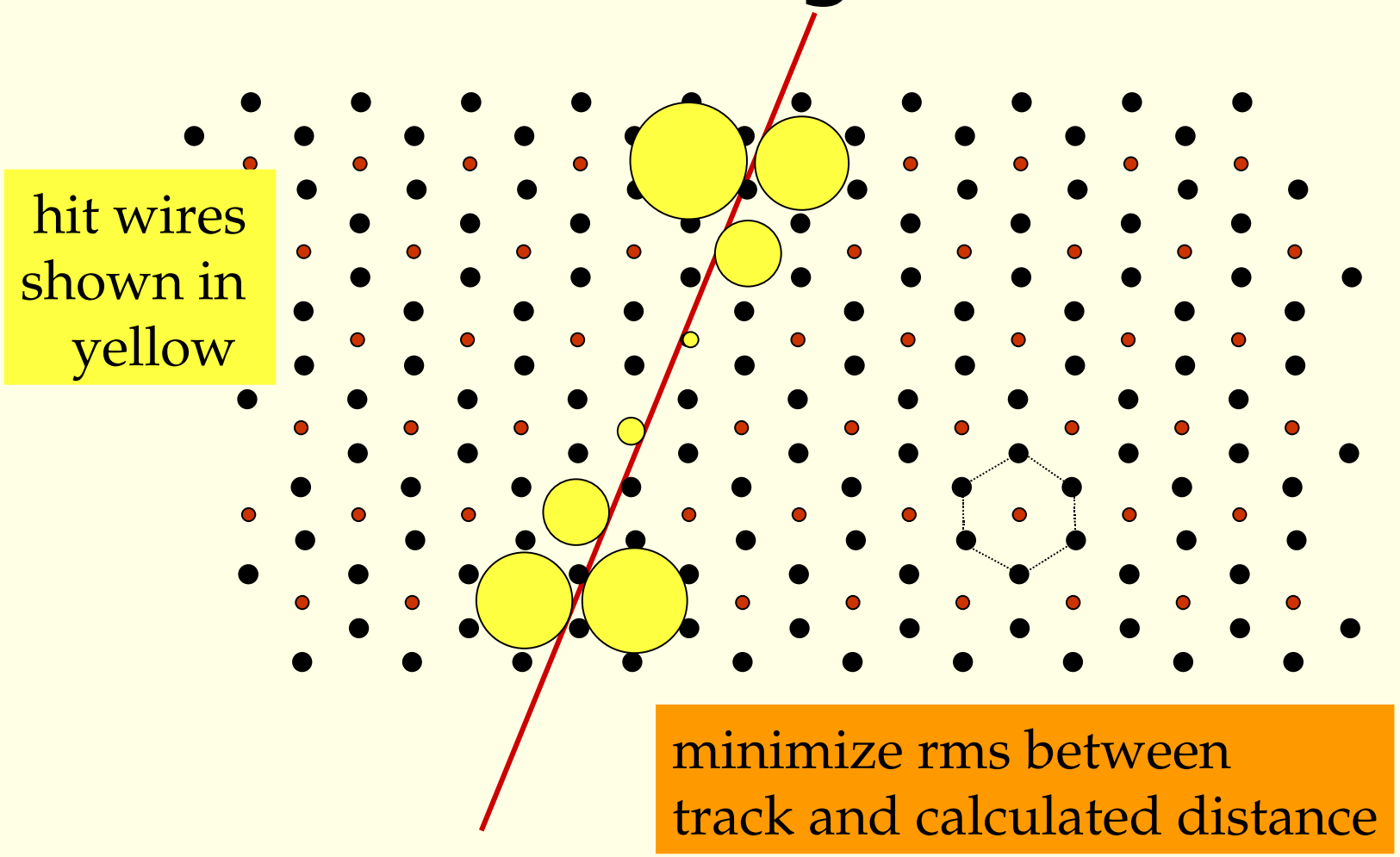


“all-wire” drift chamber

wires in layers
“brick-wall” fashion



how tracking works



Drift Velocity Calculation

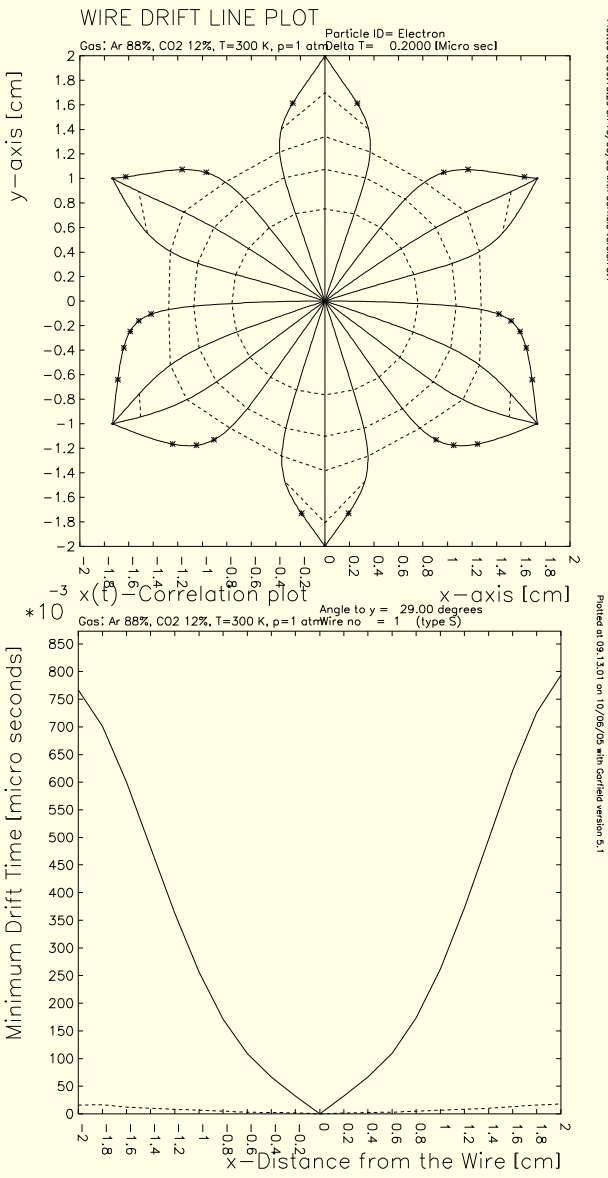
20 μm wire
2325 V
88:12 AR:CO_2

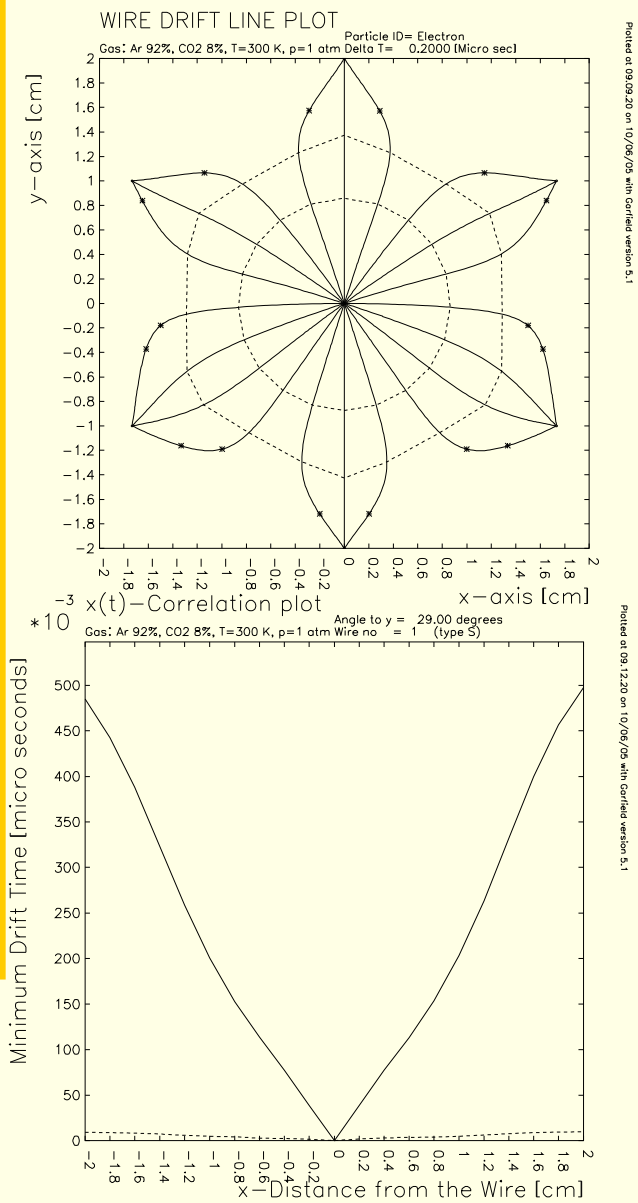
30 μm wire
2475 V
92:08 AR:CO_2

same gain

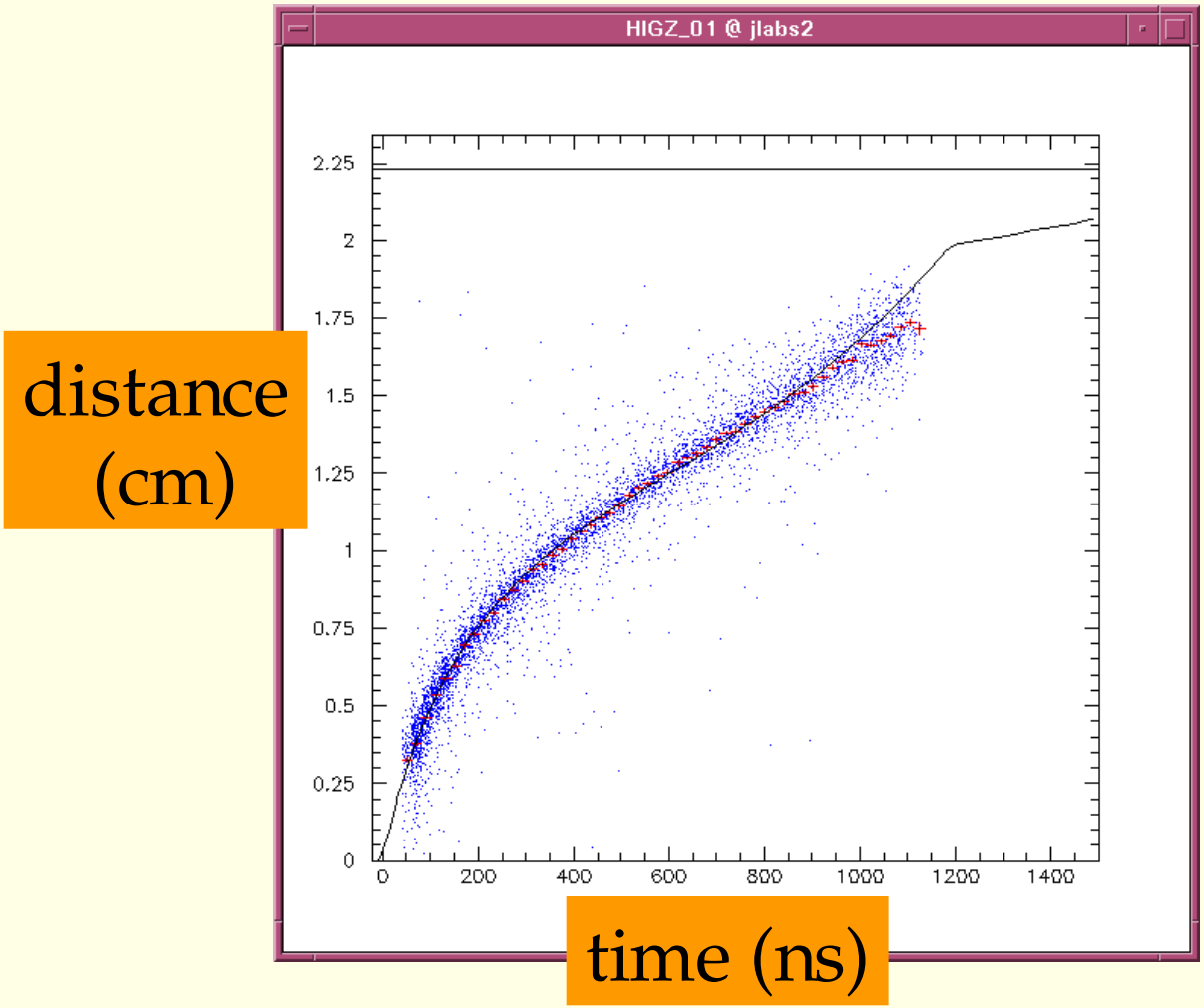
58% faster

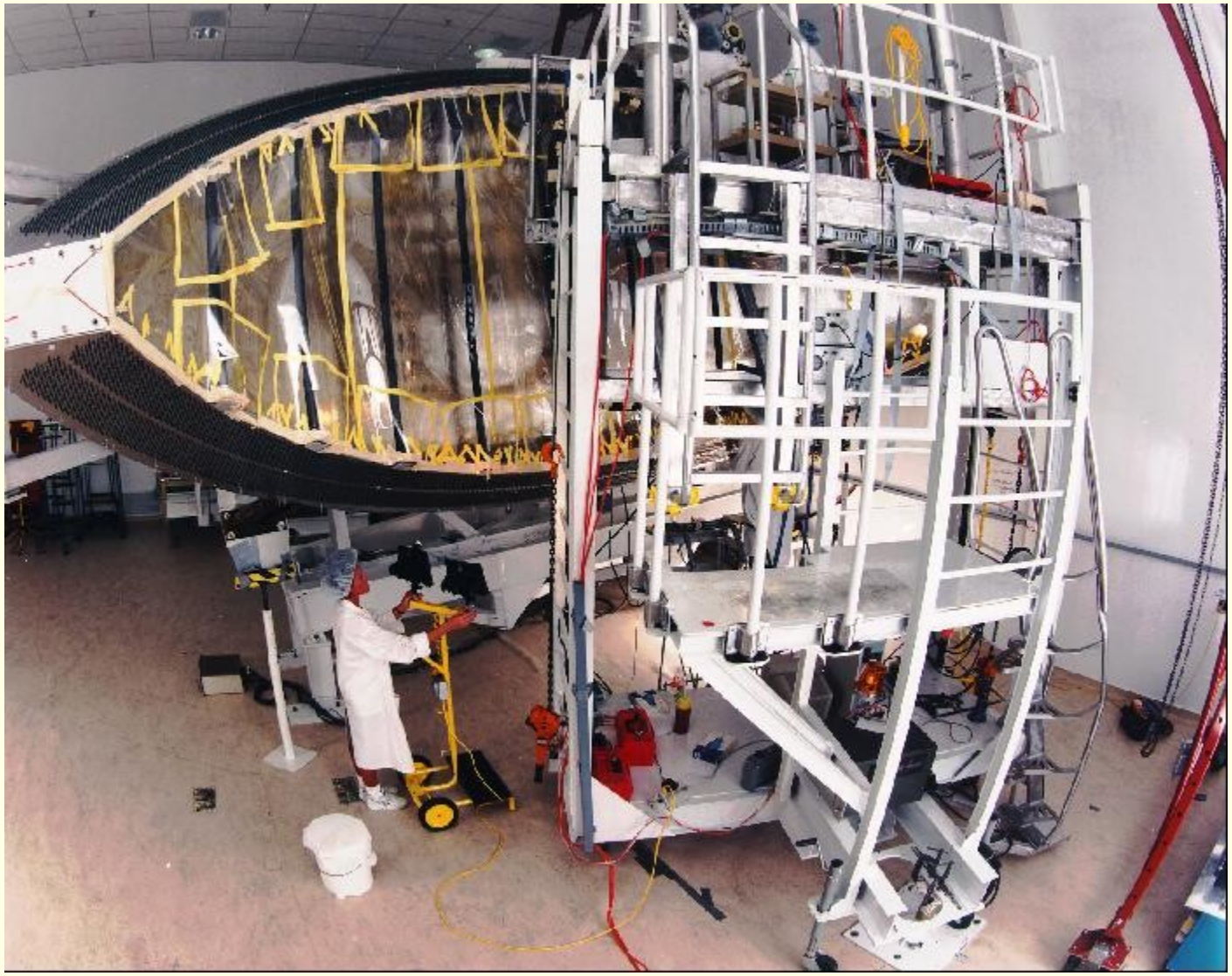
- and more linear !





drift velocity calibration





Installing Pre-tensioning Wires

Pre-tensioning
- before we start stringing
- use springs on guard wires
- gradual release of tension

- Operating successfully for ~10 years ….

FAQ's (your turn!)

efficiency vs. noise trade-off

drift time calibration

magnetic field effects

Malter effect

fast gas

cathode emission

material choices: wires, endplates

quenching gas

reference books

HV plateau