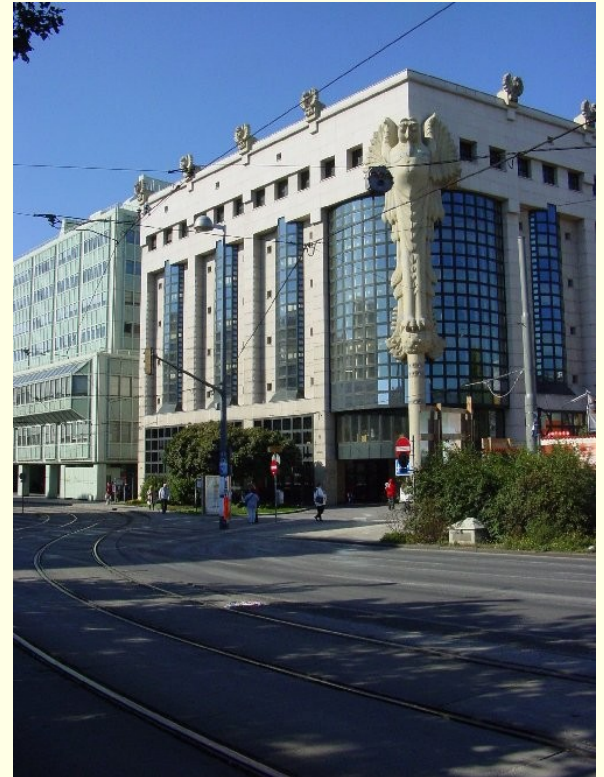


Drift Chambers: The Science behind the Art

- 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

Two-dimensional Readout Concepts

Amplifying structure and read-out structure can be optimized independently of each other.
The electron charge is collected on strips, pixels or pads on the read-out board. A fast signal can be detected on the top GEM electrode for triggering or energy discrimination.

The diagram illustrates a detector structure with three main layers: a top grey plate, a middle yellow plate with circular holes, and a bottom green plate with a grid of strips. Labels indicate the 'Fast trigger' signal from the top plate, the 'Y-coordinate' from the green strips, and the 'X-coordinate' from the bottom strips. To the right, three square images show different readout patterns: 'Cartesian' (a grid of squares), 'Small angle' (vertical wavy lines), and 'Pixels' (a hexagonal grid).

Cartesian

Small angle

Y-coordinate

X-coordinate

Pixels

PIXIE
BIFI - PI

The Xth Vienna Conference on Instrumentation - February 16-21 2004

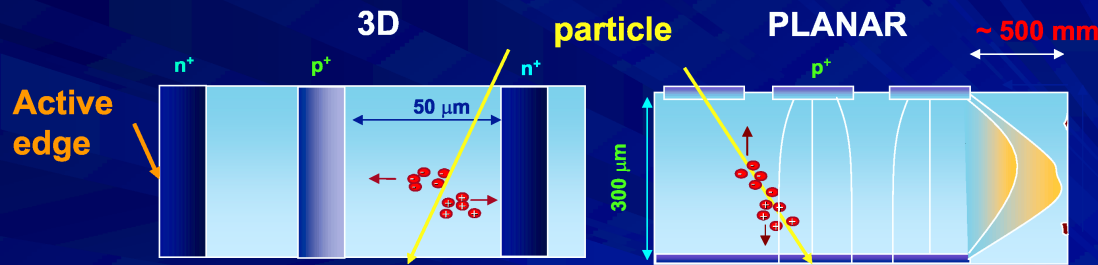
R. Bellezzini - INFN Pisa

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	50 μm	300 μm
V _{depletion}	<10V	70 V
Edge sensitivity	10 μm	500 μm
Q Collection time	1-2 ns	10-20 ns

Proposed by Parker, Kenney 1995

- ❖ 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

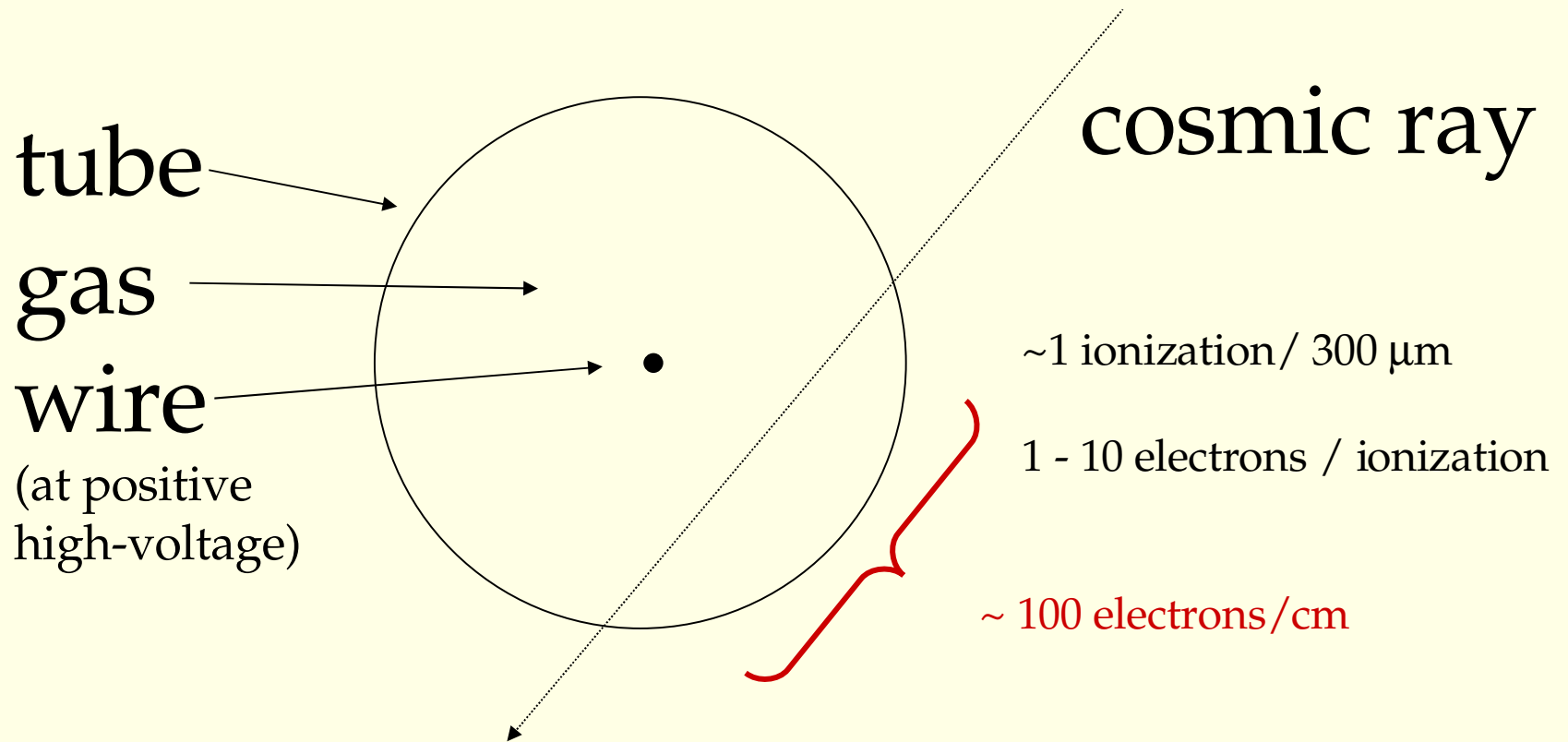
36

so why drift chambers ?



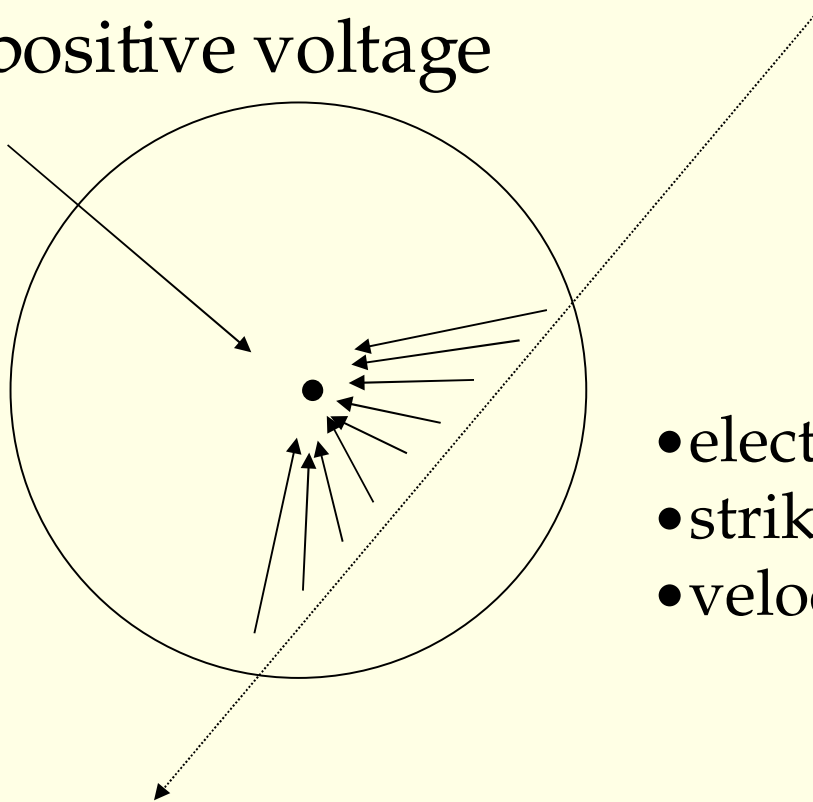
- economical way to cover a large volume with tracking chambers

gas ionization by particles



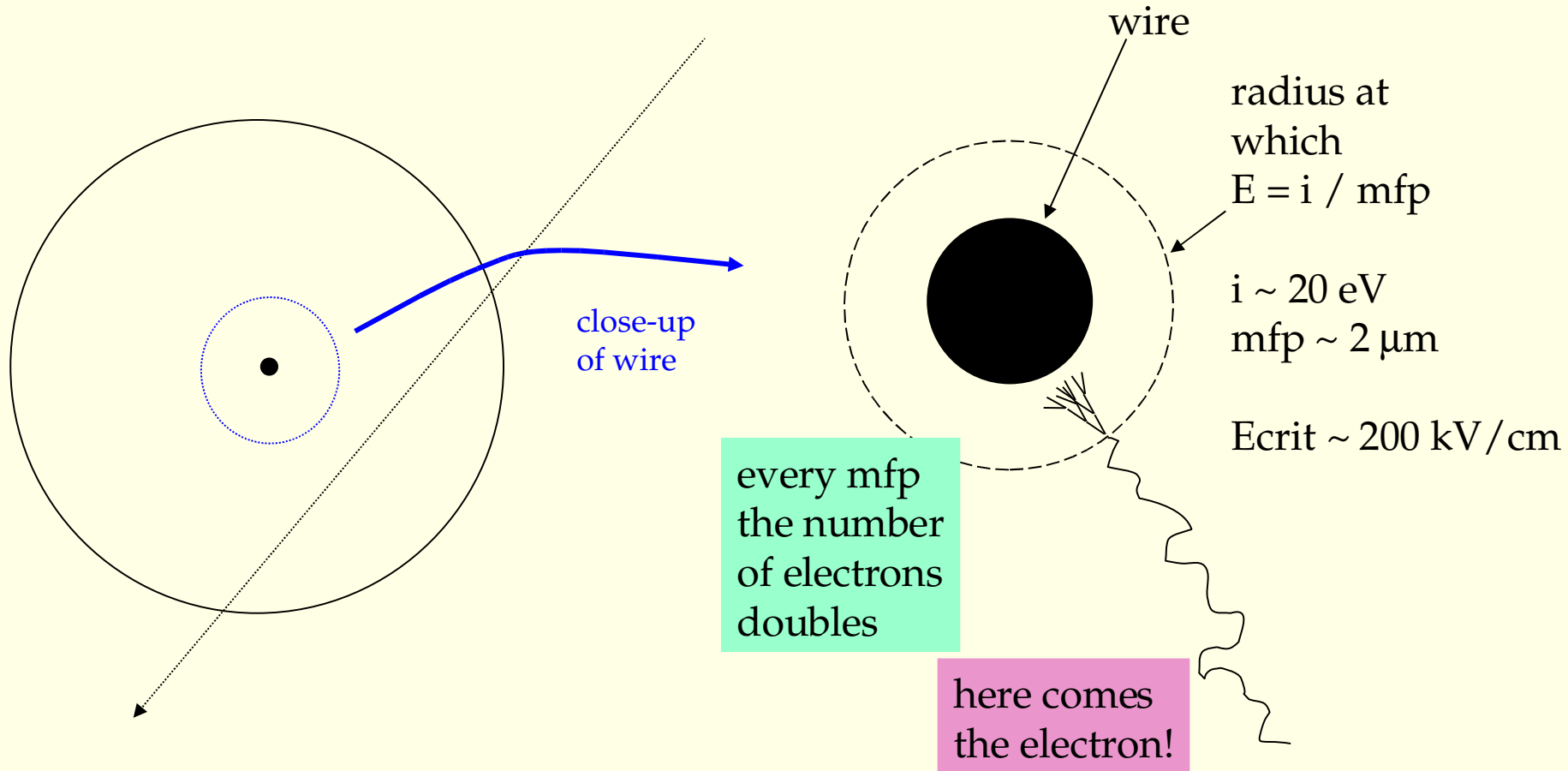
“drifting” of the electrons

wire at positive voltage



- electrons drift to the wire
- strike a molecule every $2\text{ }\mu\text{m}$
- velocity $\sim 50\text{ }\mu\text{m/ns}$ (max)

the “avalanche”



the “avalanche” (cont.)

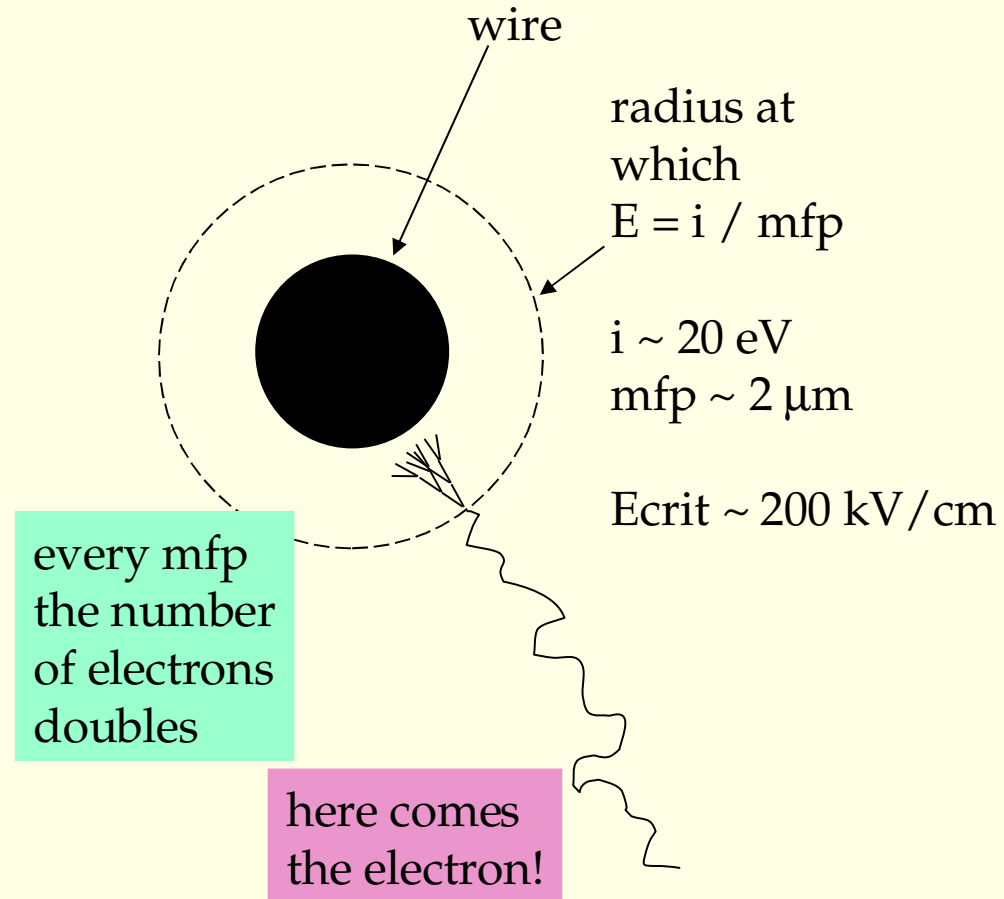
$$\text{gain} \sim 2^{\text{ndbl}}$$

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

$$E_{\text{crit}} = k * V / r_{\text{crit}}$$

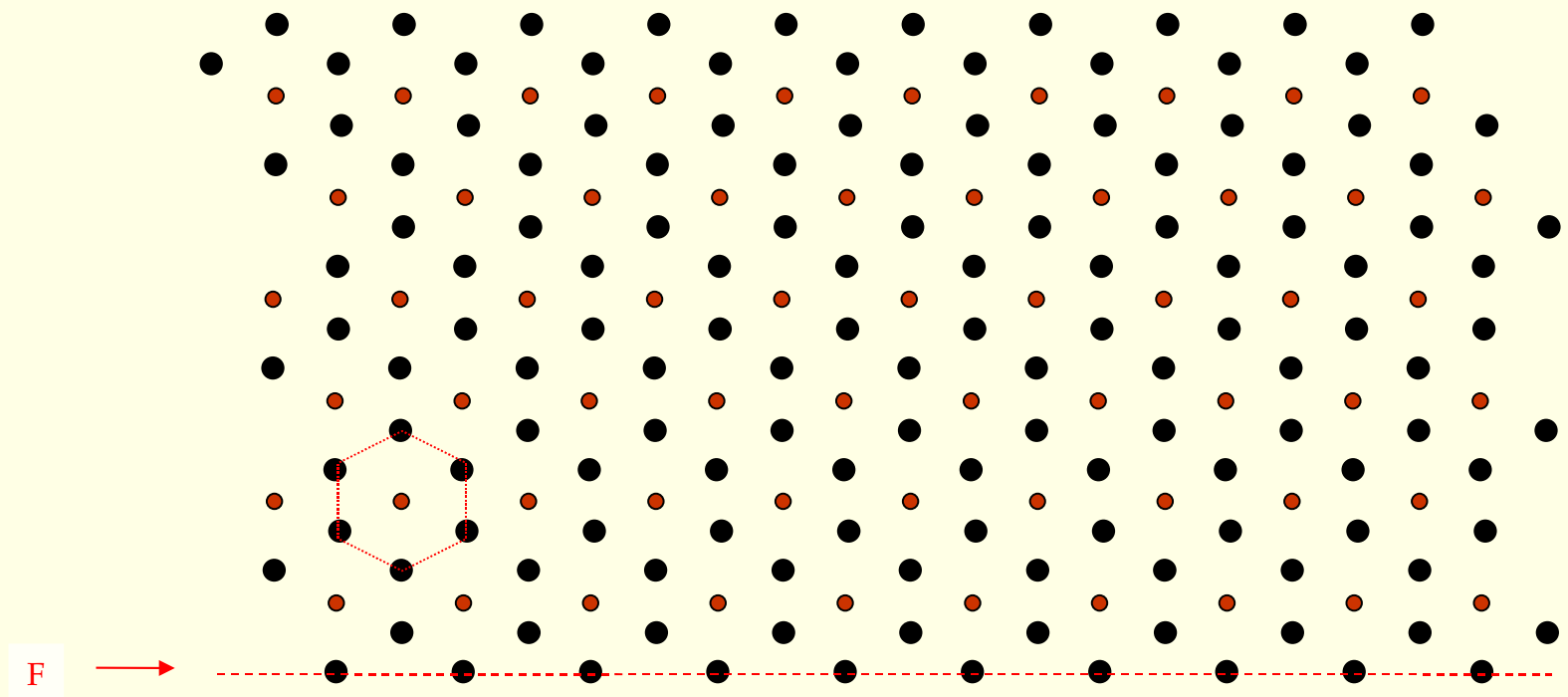
$$\text{gain} \sim 2^{k*V}$$

rule of thumb:
gain doubles every
75 or 100 Volts

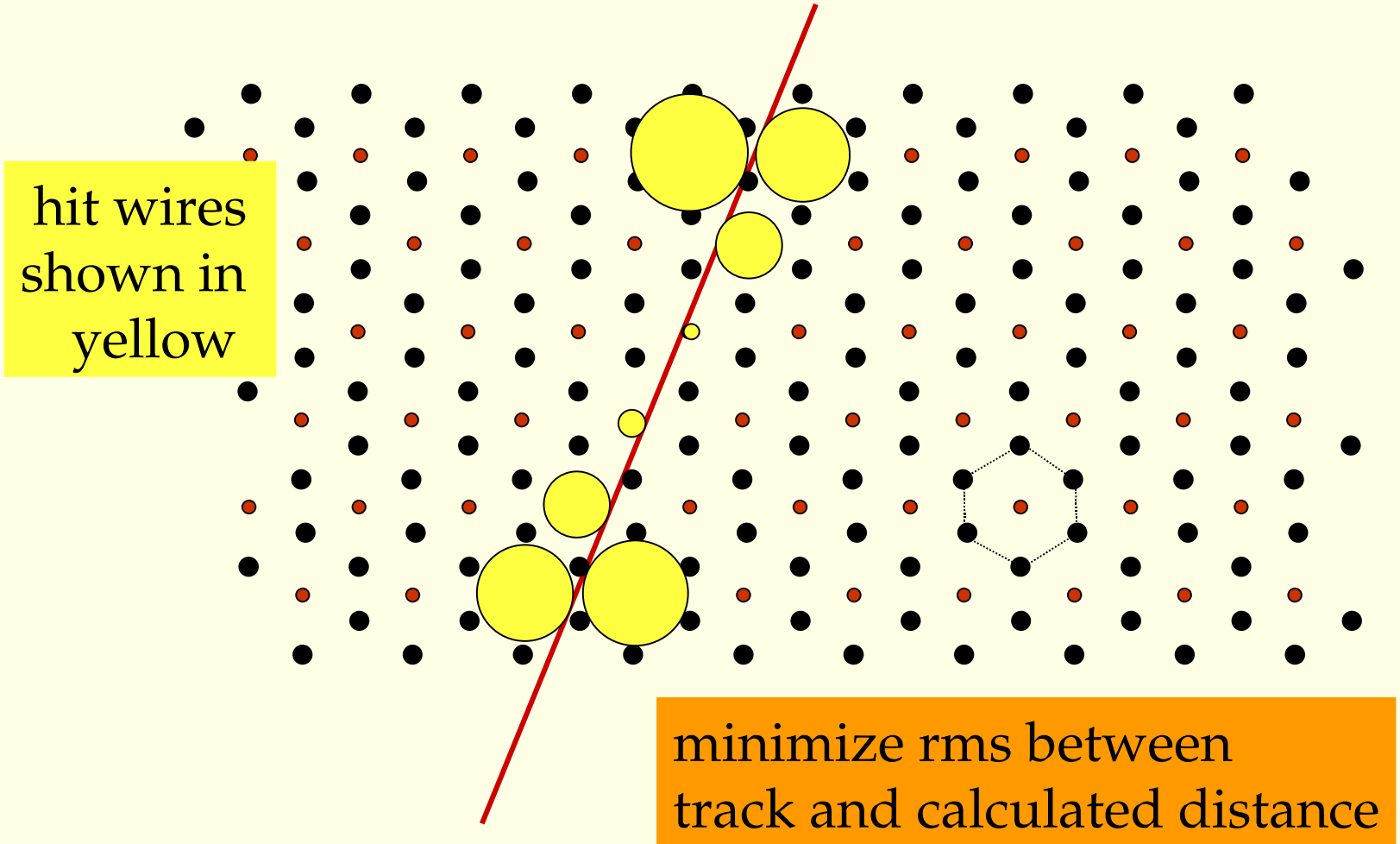


“all-wire” drift chamber

wires in layers
“brick-wall” fashion



how tracking works



Drift Velocity Calculation

20 μm wire
2325 V
88:12 AR:CO₂

30 μm wire
2475 V
92:08 AR:CO₂

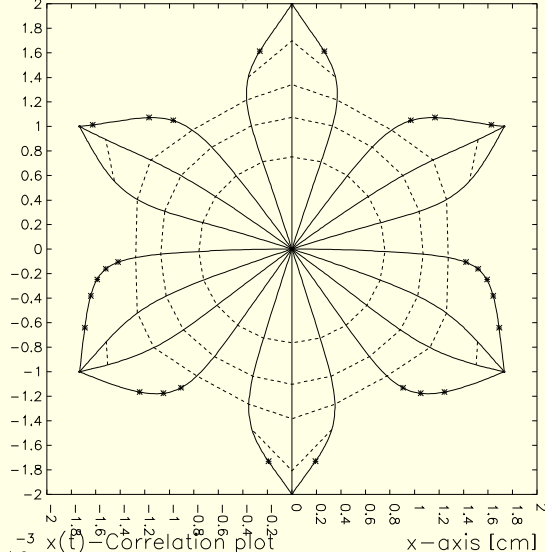
same gain

58% faster

- and more linear !

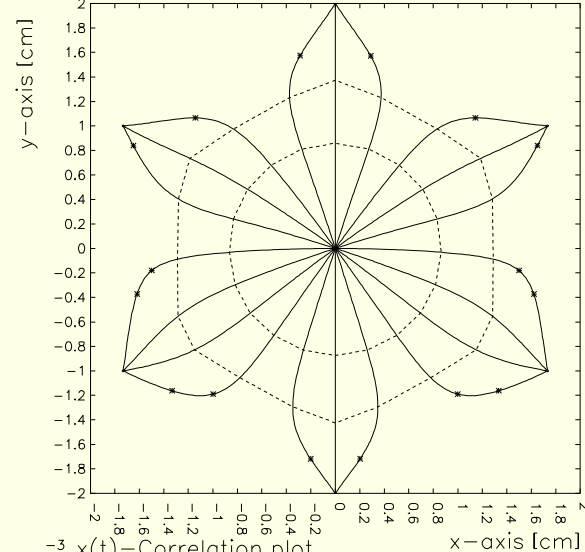
WIRE DRIFT LINE PLOT

Particle ID= Electron
Gas: Ar 88%, CO2 12%, T=300 K, p=1 atm Delta T= 0.2000 (Micro sec)

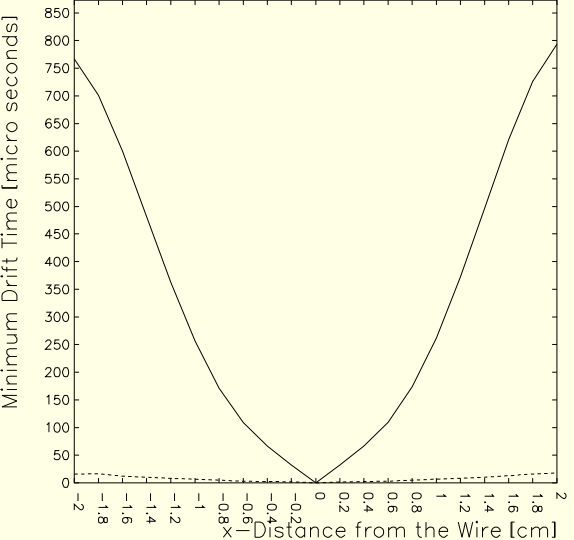


WIRE DRIFT LINE PLOT

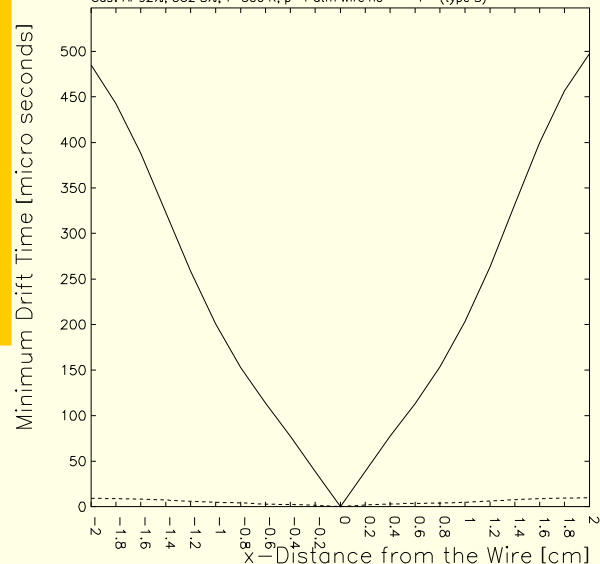
Particle ID= Electron
Gas: Ar 92%, CO2 8%, T=300 K, p=1 atm Delta T= 0.2000 (Micro sec)



x(t)-Correlation plot
Angle to y = 29.00 degrees
Gas: Ar 88%, CO2 12%, T=300 K, p=1 atm Wire no = 1 (type S)



x(t)-Correlation plot
Angle to y = 29.00 degrees
Gas: Ar 92%, CO2 8%, T=300 K, p=1 atm Wire no = 1 (type S)



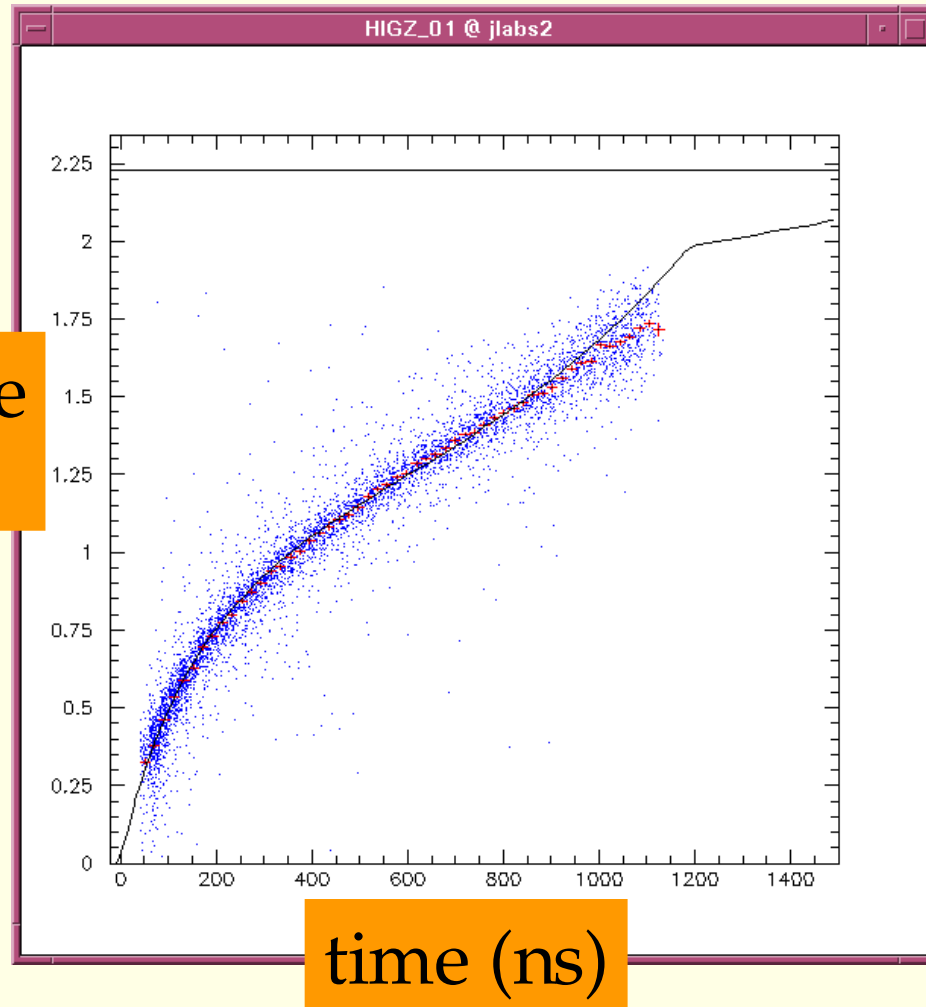
June 9, 2008

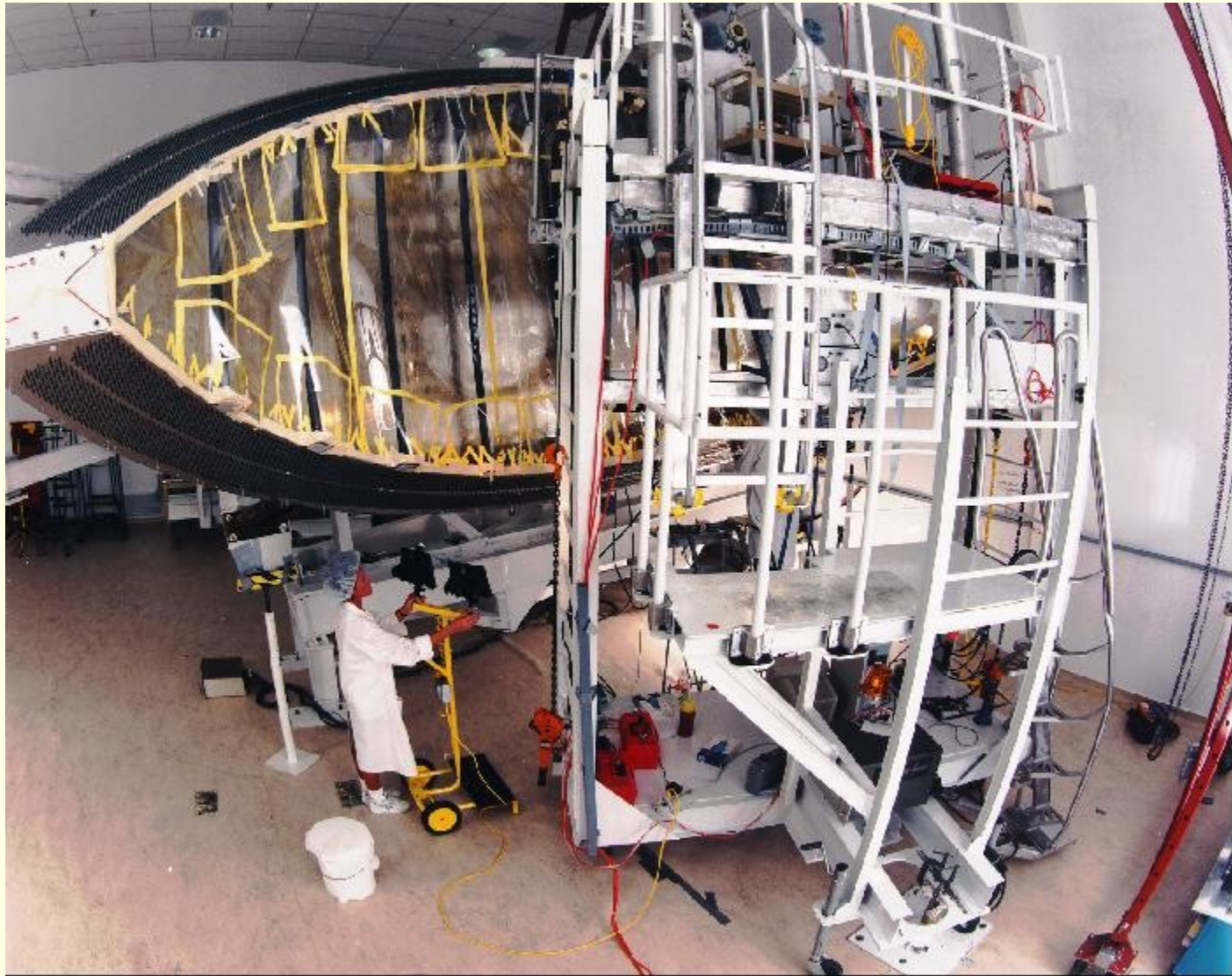
What's a Drift Chamber?

Mac Mestayer

drift velocity calibration

distance
(cm)





June 9, 2008

What's a Drift Chamber?

Mac Mestayer

Installing Pre-tensioning Wires

Pre-tensioning

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



- Operating successfully for ~10 years

....



June 9, 2008

What's a Drift Chamber?

Mac Mestayer

FAQ's (your turn!)

drift time calibration

efficiency vs. noise trade-off

magnetic field effects

Malter effect

fast gas

cathode emission

material choices: wires, endplates

quenching gas

reference books

HV plateau