Development of a Plasma Panel, High Resolution Particle & Radiation Detector for Super LHC & Next Generation Colliders

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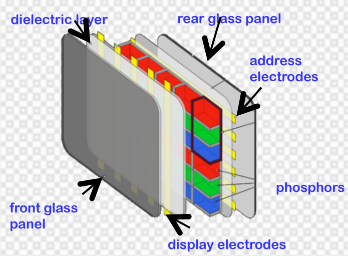
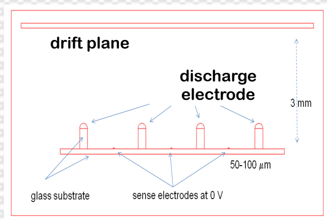
A Gas-system-free Micropattern Detector based on Plasma Display Television Technology

Plasma Panel detectors will have many key attributes of Plasma TVs

- Arrays of electrodes forming gas discharge regions
- Electrode deposition: photolithography on glass
- Small electrode gaps
  - ➔high electric fields @ low voltage
- Possible electrode dimensions: 15-30 μm, ≤ 2μm
- Gas: Non-reactive, inert Penning mixtures.
- Large panels (60") produced. Scalable detector sizes.
- Glass < 1 mm, low Multiple Coulomb Scattering
- Hermetically sealed panels at 500-700 Torr
  - ➔No gas supply system!
- No film polymers, no hydrocarbons, no plastics, no reactive gasses, no ageing components:
  - ➔intrinsically radiation-hard
  - ➔ proven lifetimes > 100,000 hours
- Established industrial infrastructure
- Low fabrication costs: ~ $0.30 inch^{-2} (current market sale price, including electronics)
- Low power consumption
- Effective gains (pixel geometry dependent) ~ 10^5-10^6

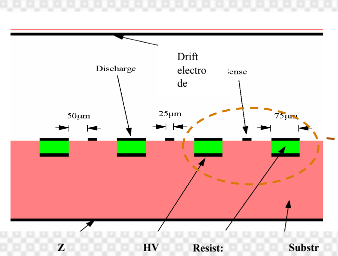




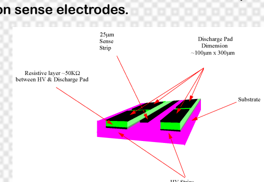
Conceptual 2D view of electrode geometry showing drift regions, avalanche gap. In this view the geometry evokes a Microstrip Gas Counter. However the electrodes here have lengths limited to the pixel dimensions.

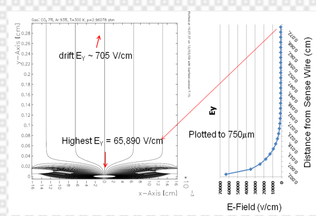
Plasma Detector Design Considerations

- Drift region of ~3 mm
- Generation of ~20-30 ion-pairs for high MIP efficiency
- Avalanche initiated by free drift electrons
- Avalanche across a transverse gap on substrate
- Field lines converge on *sense* electrodes
- High fields (MV/m) to initiate discharge at few hundred volts
- Cells defined by localized capacitance & discharge resistor in the HV line
- Discharge resistor formed by embedded resistance or resistive layer
- Resistance limits and localizes the discharge
- Surface charge buildup to be mitigated by resistive layer and/or conductive gas dopant (e.g. Hg)

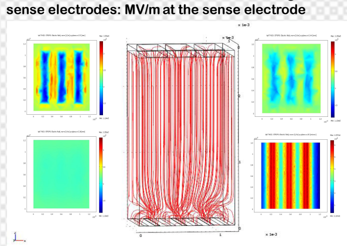


Above: 2D view of conceptual representation for test device substrate: Pixels formed by HV (discharge) and sense lines gaps. Quench resistances from resistive deposition. Signals form on sense electrodes.





2D electrostatics: Electric field lines converge to sense electrodes: MV/m at the sense electrode

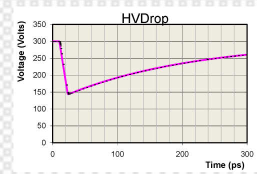


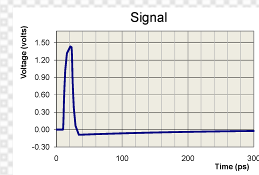
3D electrostatic simulation: convergence of the electric field lines near the electrodes (bottom right) uniformity of the field beneath the drift electrode (40 μm-top left, 100μm-top right, 300μm- bottom left).

Development Effort

Simulations and Laboratory Test Bench

- Electrostatics modeled with Maxwell-2D, COMSOL-3D
- Drift & Avalanche properties simulated with GARFIELD
- Signal and voltage distributions computed with SPICE





50KΩ discharge resistance; 100 μm cell
Cell capacitances = 3 fF

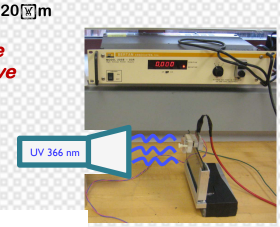
SPICE simulation : a single pixel discharge is represented by a near δ-function current source. (Left) High Voltage drops by ½ & terminates the discharge in < 10 ps. (Right) Signal on sense line.

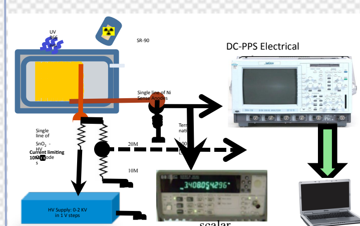
Experimental Proof-of-concept

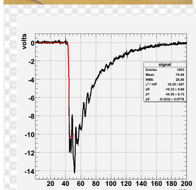
- DC PDP Panel, Xenon filled at 650 Torr in 2003 !
- Column cathodes, 190μm wide
- Row anodes, 810μm wide
- Columnar Gas discharge gap 220μm

Signals are visible on scope under UV light and radioactive radiation (Sr90)

- High Voltage applied ~700V
- Signal rise time ~ 2 ns
- Large Signal Amplitude (Volts)



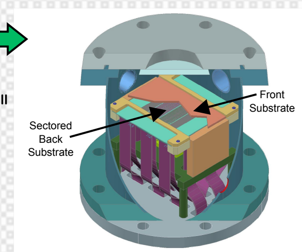




Test chamber

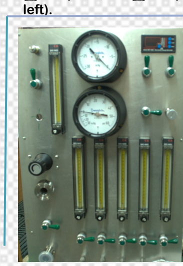
(under construction)

- Ports for rapid gas removal and refill
- Stepper motor stage for test substrate (adjust drift gap)
- Signal/HV vacuum feed-throughs
- Drift electrode: metalized glass (photocathode) or metal window
- Working pressure range 0.1 - 5 bar

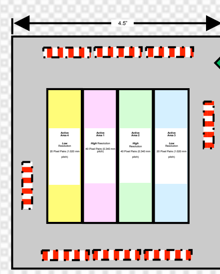


Gas mixing system

(working)



- Mixtures of five different gases
- Working Pressure of up to 5 Bar
- Mass flow controller allows high precision in gas composition.



Glass substrate with various micro-strip pitches.

Basic attributes to be evaluated:

- Rise/Fall discharge time vs pixel capacitance
- Effective gain- integrated pulse width
- Discharge termination and propagation as function of gas quenching, embedded resistance.
- Spontaneous discharge from charge buildup
- MIP detection efficiency vs drift gap
- MIP detection efficiency vs gas composition