High Precision Thermal Neutron Detector Development at BNL

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BNL's Thermal Neutron Detectors Performance Summary*

Position Resolution (FWHM)	< 0.4 - 2 mm
Number of Resolution Elements	from 128×128 to 4096×512
Active Area	from 5cm×5cm to 150cm×20cm
Wavelength Range	1 - 20 Å
Detection Efficiency	50 - 90 %
Counting Rate (total)	10^5 - 10^6 sec^{-1}
Counting Rate (single peak)	5×10^4 sec^{-1}
Integral Non-linearity	2×10^{-4} to 10^{-3}
Absolute Position Accuracy	30-100 μm
Stability of Origin	< 50 μm
Stability of Response (efficiency)	< 1%
Differential Non-linearity	±3%
Dynamic Range	Single Neutron Detection
Timing Resolution	~1 μs

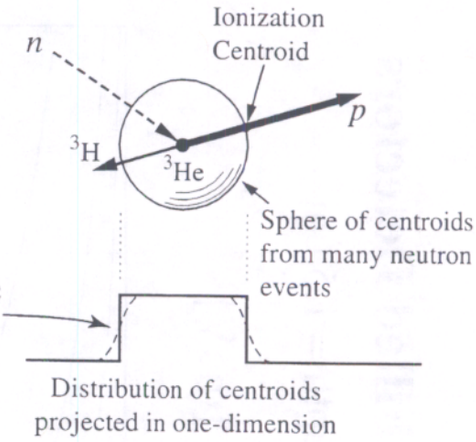
* Not all properties listed can necessarily be achieved in one detector.

Proton/Triton Range and Position Resolution

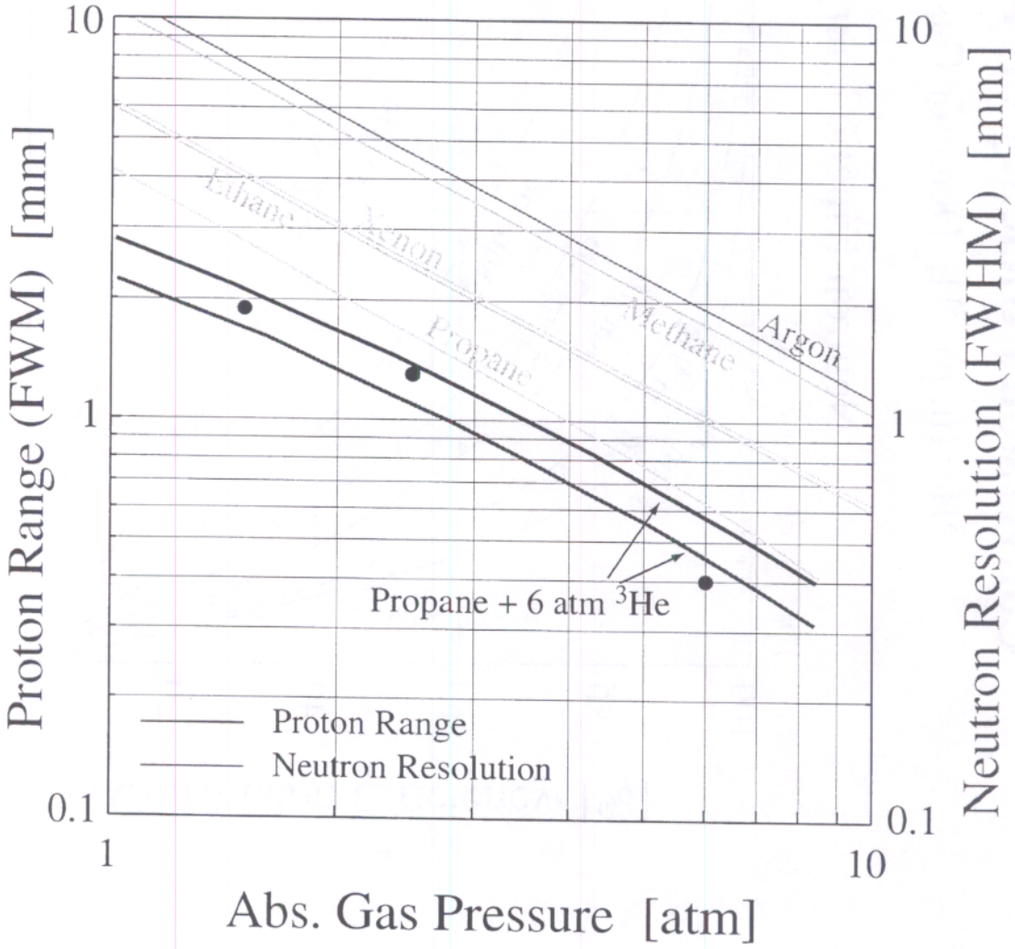
$n + {}^3He \rightarrow p + {}^3H + 764\ keV$

$\downarrow$

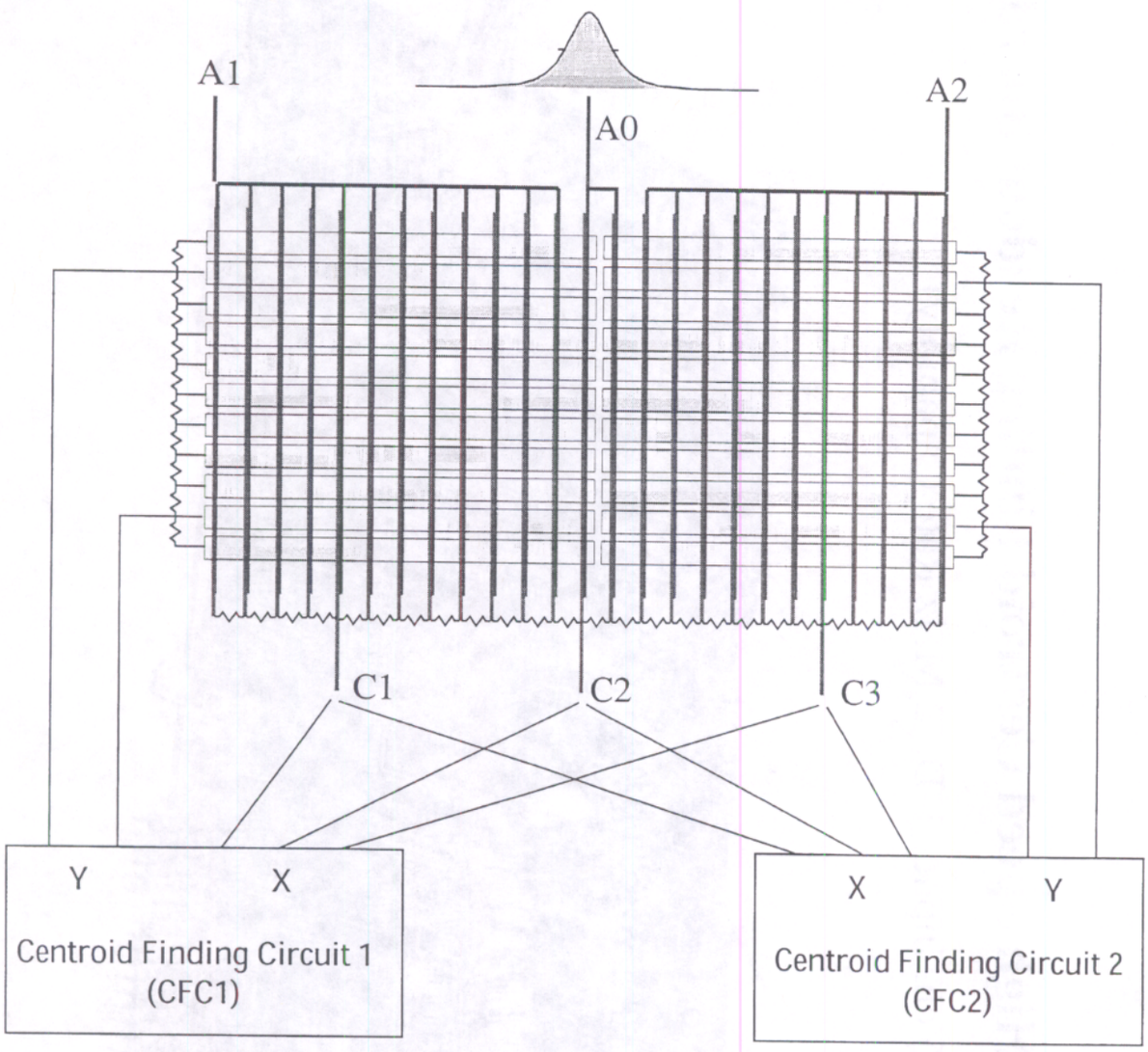
$\sim 3\times10^4$ ion pairs



FWHM ~ 0.8 × Proton Range
(~4.2mm in atm. Propane)



Position Encoding Across Module Boundaries



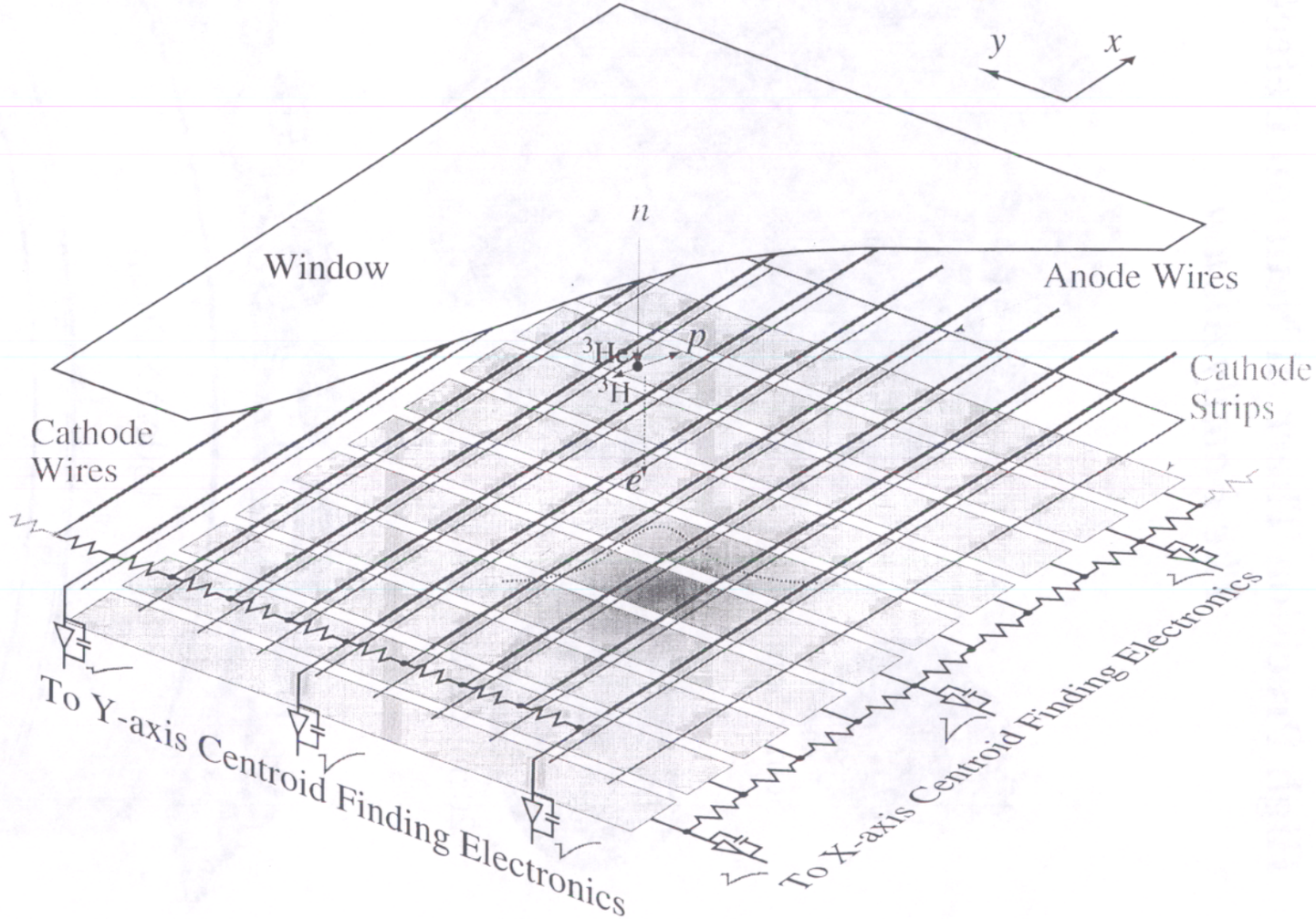
If (A0 > Threshold0) then
Both CFC1 and CFC2 start
Whoever finds the X within its boundary, generates an X-Y output.

OR

If (A1 > Threshold1) then
CFC1 starts
If (A2 > Threshold2) then
CFC2 starts
Else
Both CFC1 and CFC2 start

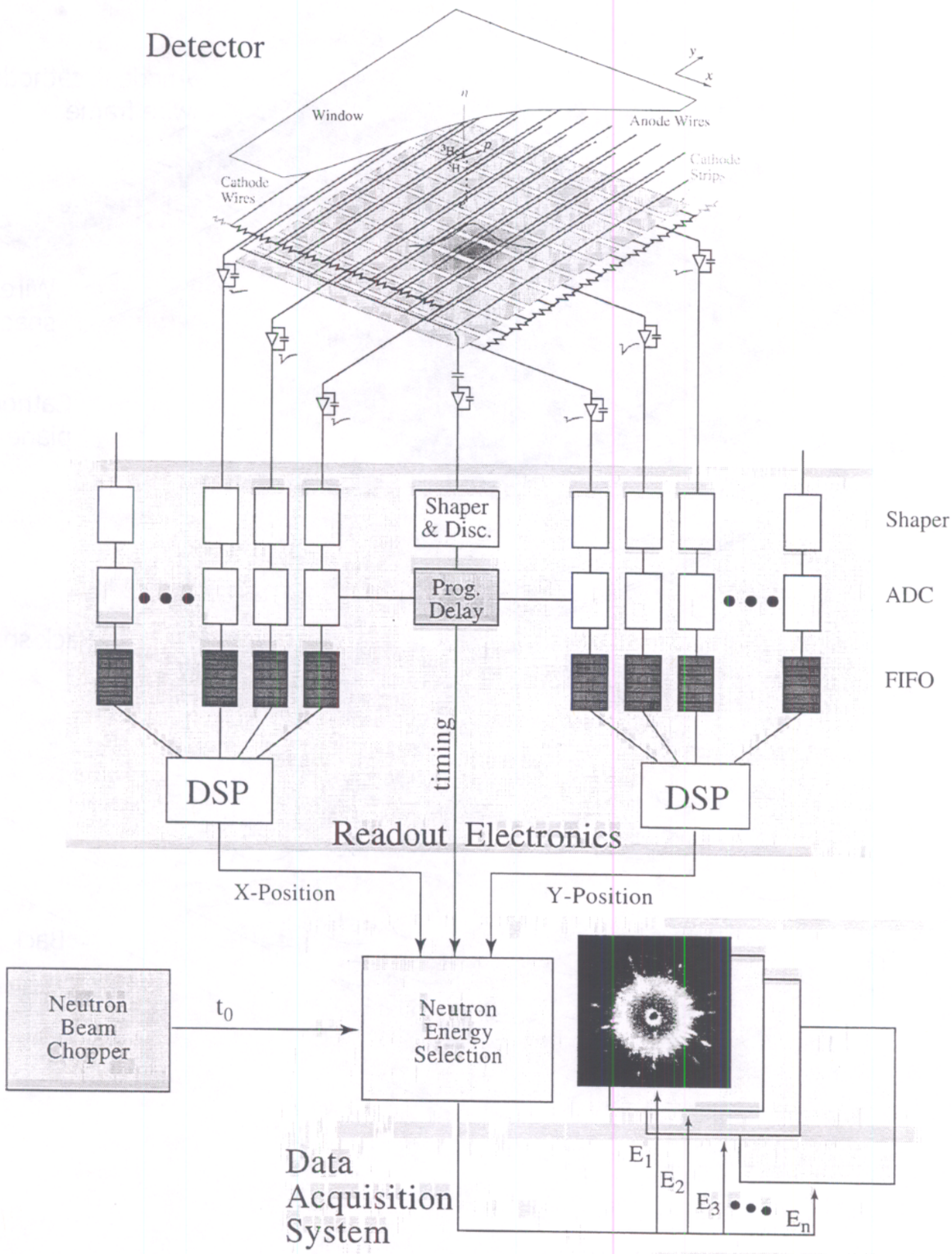
Else
If (A1 > Threshold1) then
CFC1 starts, generates an X-Y output.
If (A2 > Threshold2) then
CFC2 starts, generates an X-Y output.

High Performance Position Sensitive Thermal Neutron Detector
Principles of Operation



Detector for a Spallation Source

Electronic Block Diagram

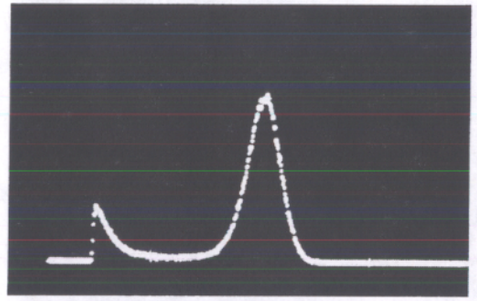


Anode Charge Resolution

Identification of Neutrons from γ-rays

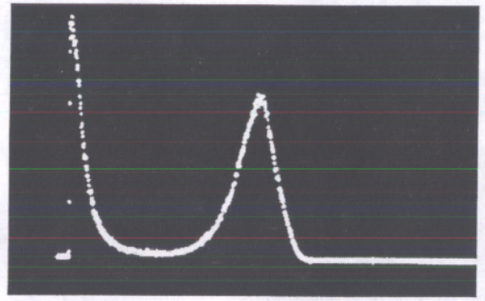
^3He / C_3H_8 (3 atm. / 2.5 atm.)

$Q_{sa} = 2\times10^5\ e$
$V_a - V_c = 4.2$ kV



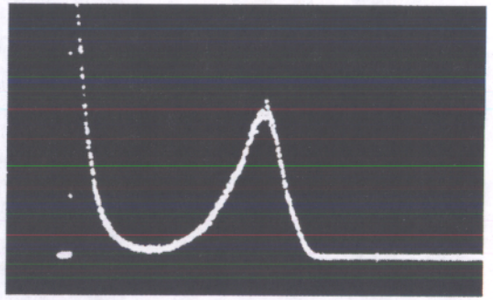
Gas Gain ~ 13

$Q_{sa} = 6\times10^5\ e$
$V_a - V_c = 4.66$ kV



Gas Gain ~ 40

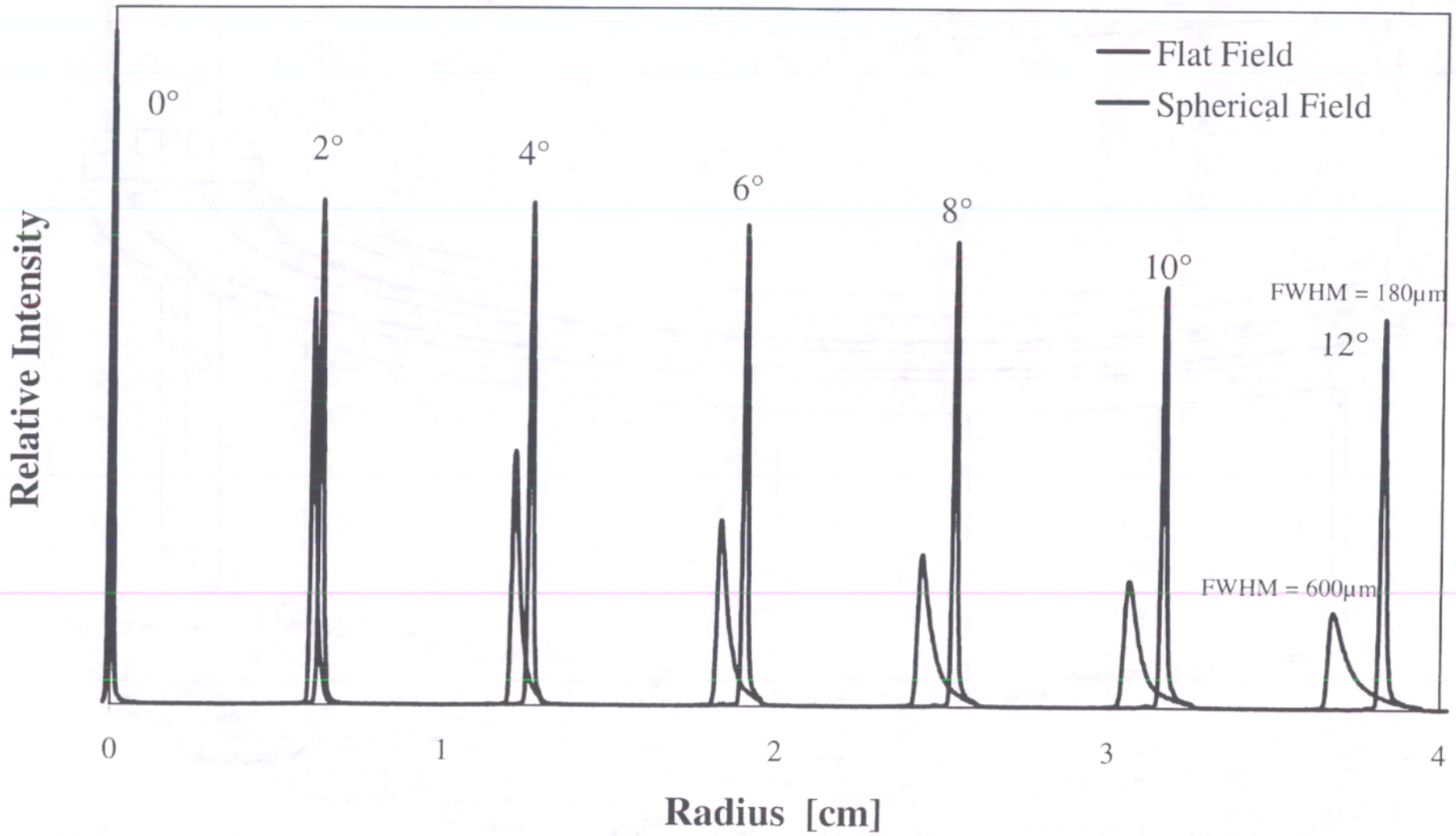
$Q_{sa} = 1\times10^6\ e$
$V_a - V_c = 4.88$ kV



Gas Gain ~ 70

Detector Responses to Collimated Beam at Various Incident Angles

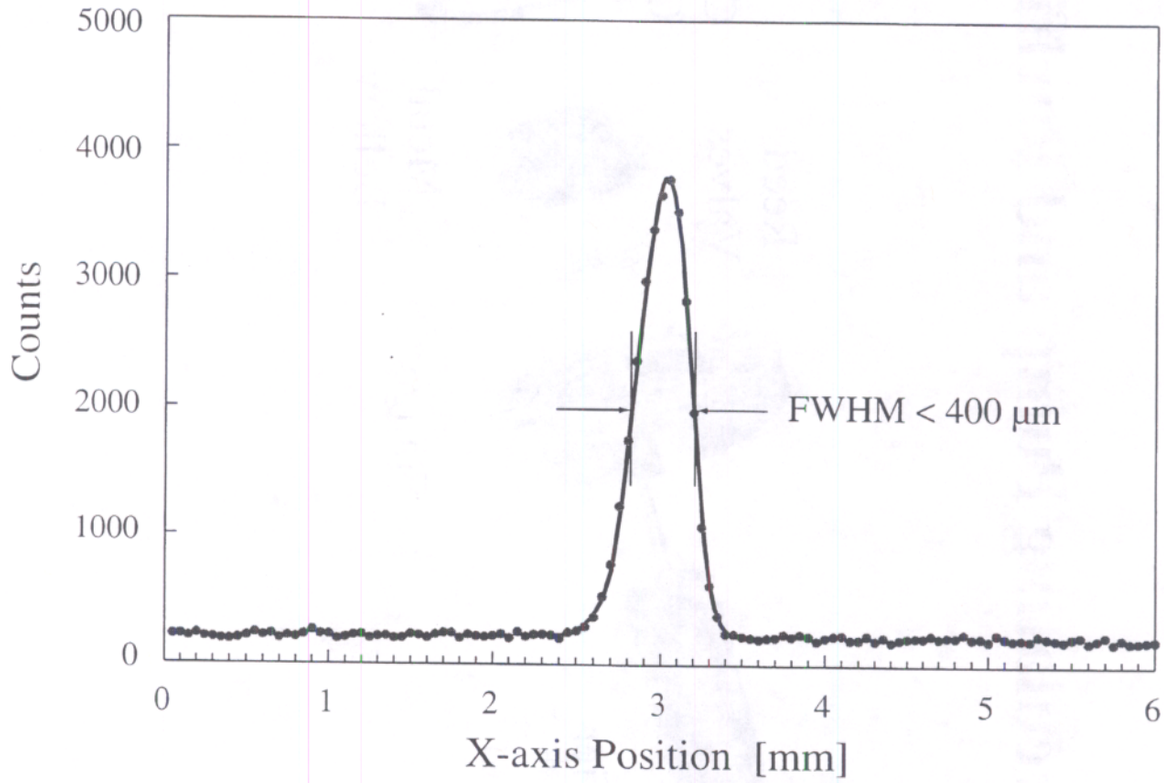
(5.4keV x-rays, Xenon+10%CO_2, 1.27cm Gas Depth, 18cm focal length)



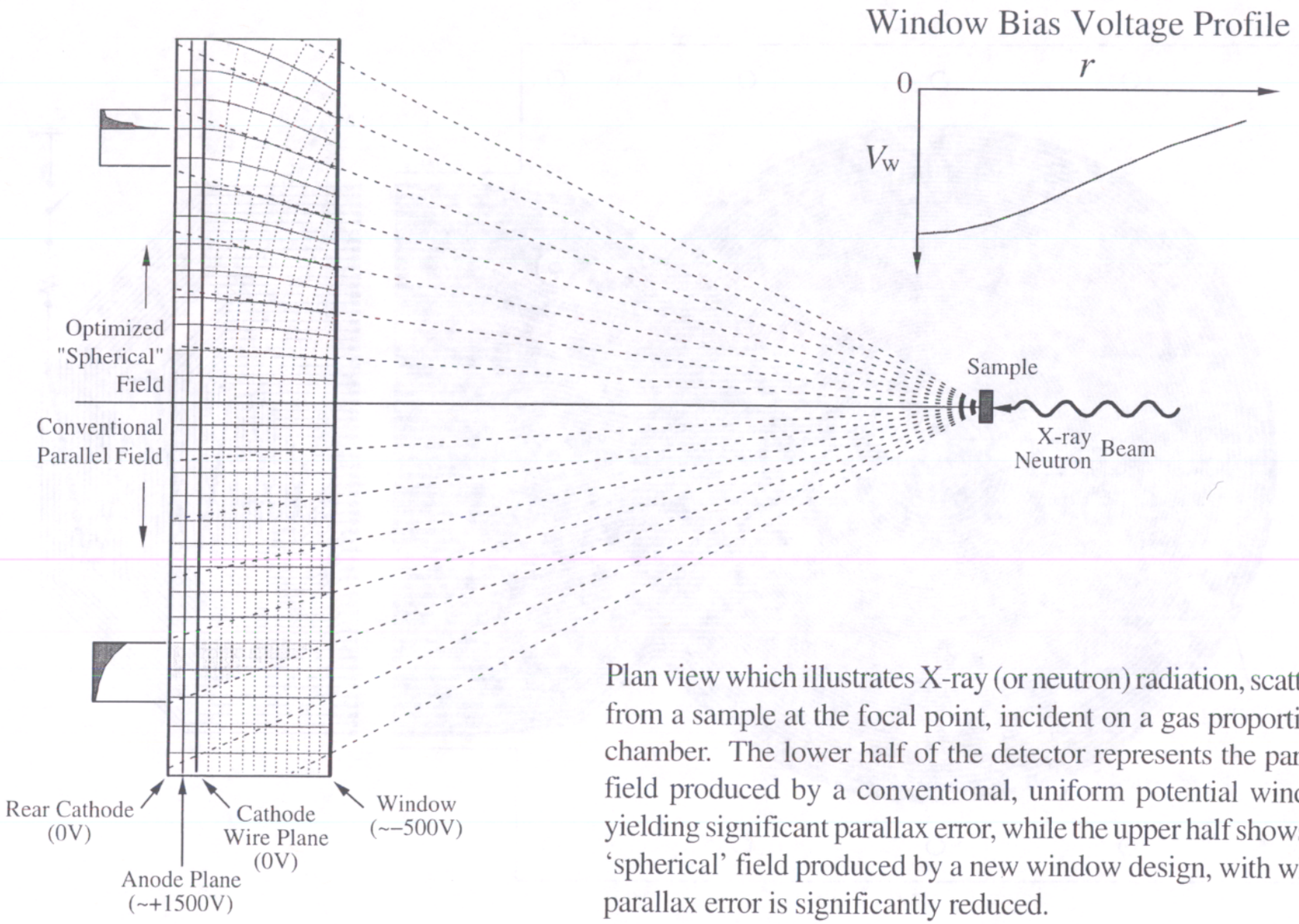
Position response of detector to 25μm wide X-ray beams, incident on the entrance window over the range of 0° (normal incidence at center) to 12° (near edge of detector). Thick lines represent parallel field in the drift region, and thin lines represent the new 'spherical' field. All peaks are normalized to the same number of counts.

5cm×5cm Thermal Neutron Detector Position Resolution Measurement

Position response to a neutron beam, 0.3mm×10mm
Gas filling: 8 atm. ^3He, 6 atm. C_3H_8



Parallax Reduction in a MWPC

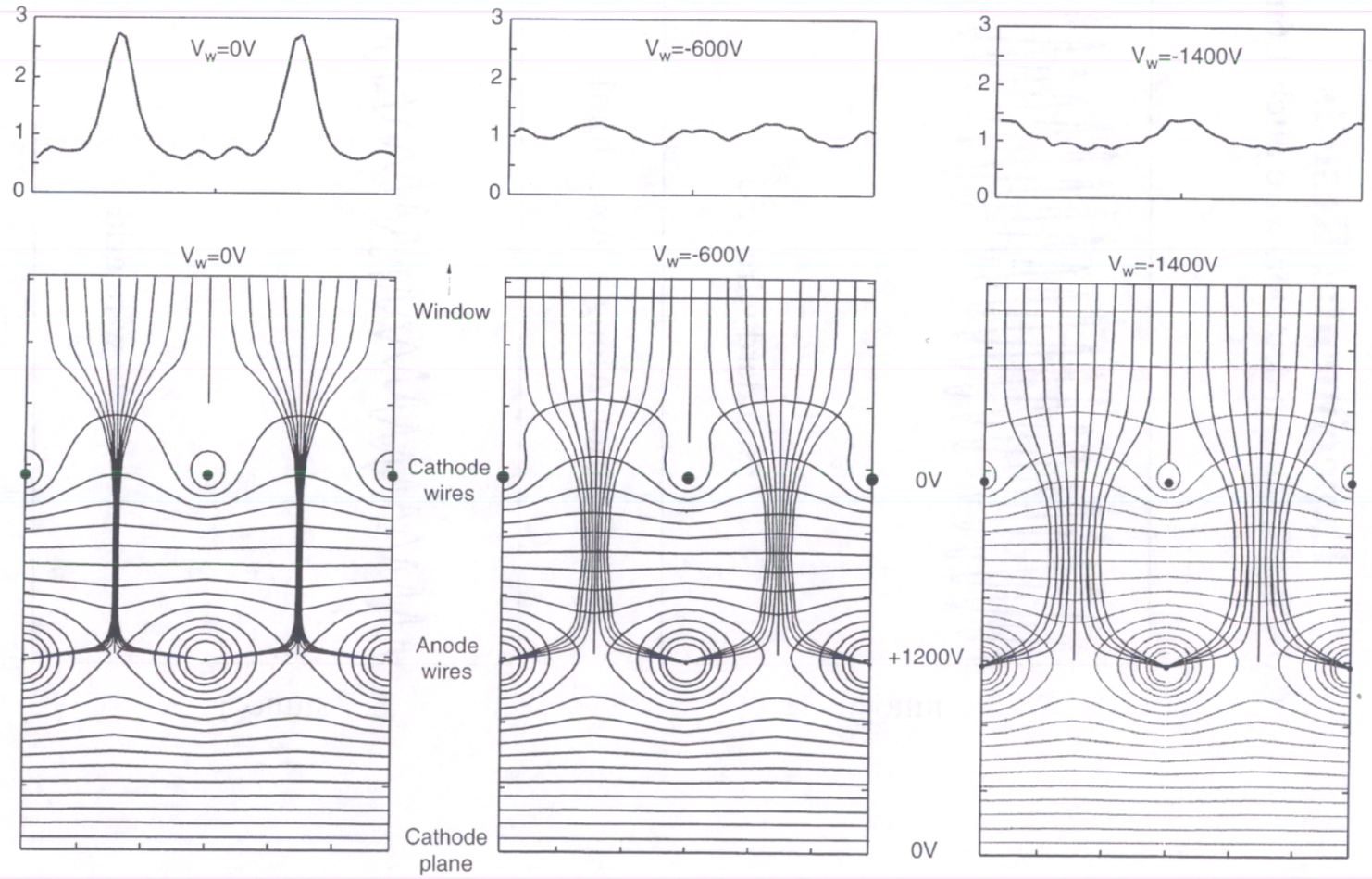


Plan view which illustrates X-ray (or neutron) radiation, scattered from a sample at the focal point, incident on a gas proportional chamber. The lower half of the detector represents the parallel field produced by a conventional, uniform potential window, yielding significant parallax error, while the upper half shows the 'spherical' field produced by a new window design, with which parallax error is significantly reduced.

Anode Wire Modulation Reduction

Plots of Uniform Irradiation Responses and Electron Drift Lines

(5.4 keV X-rays, Argon/20% CO_2 Gas Mixture)



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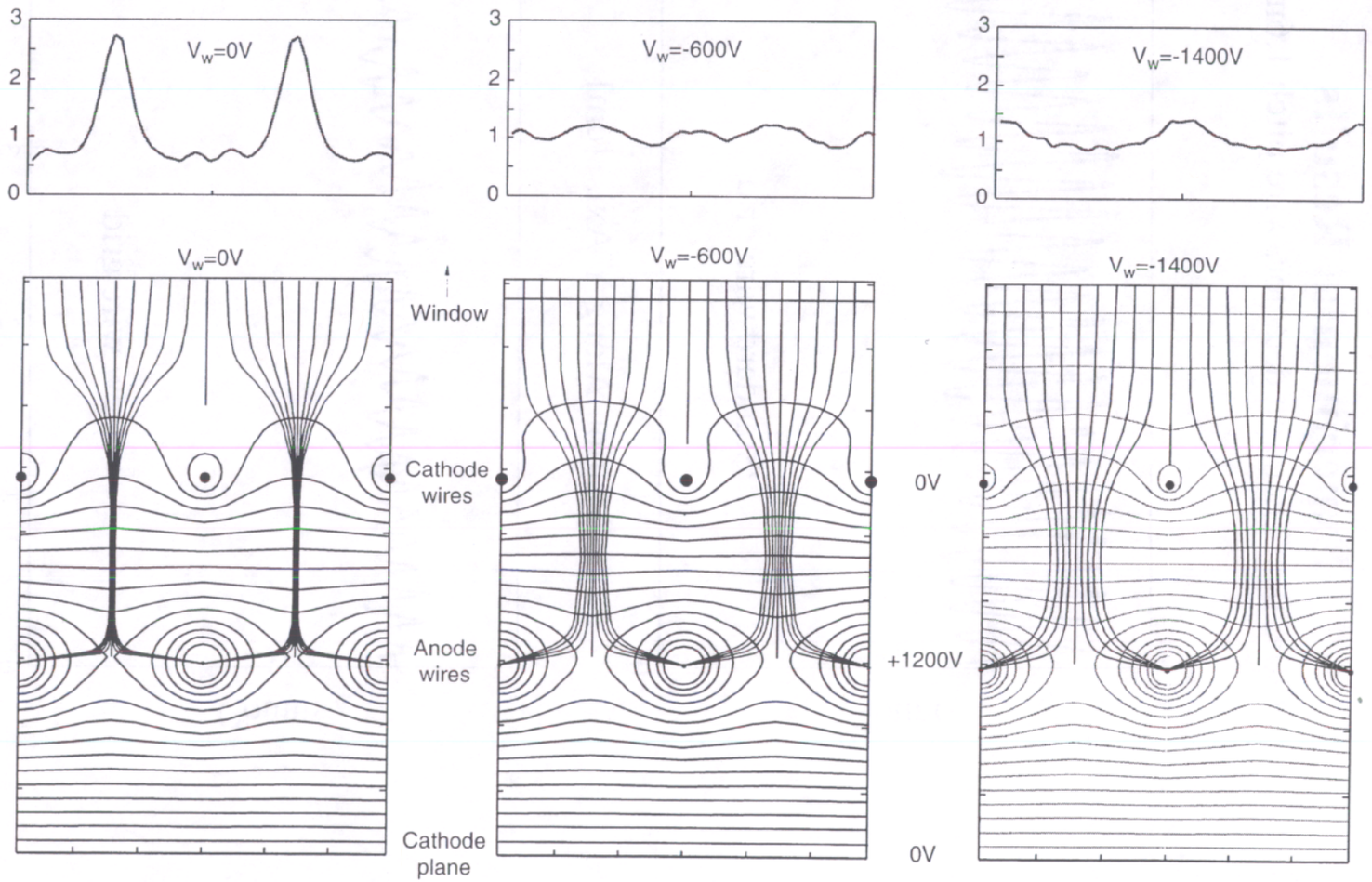

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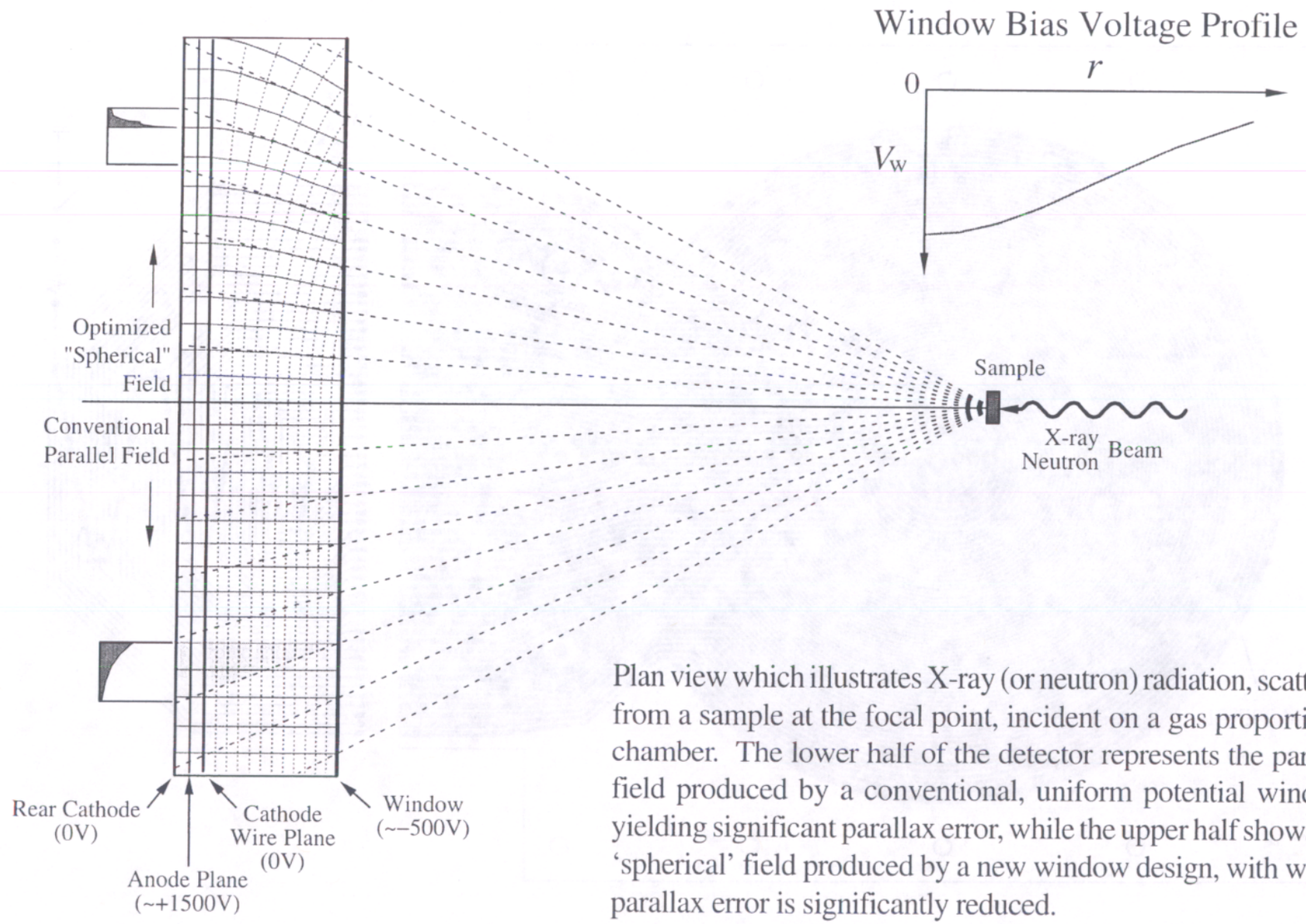

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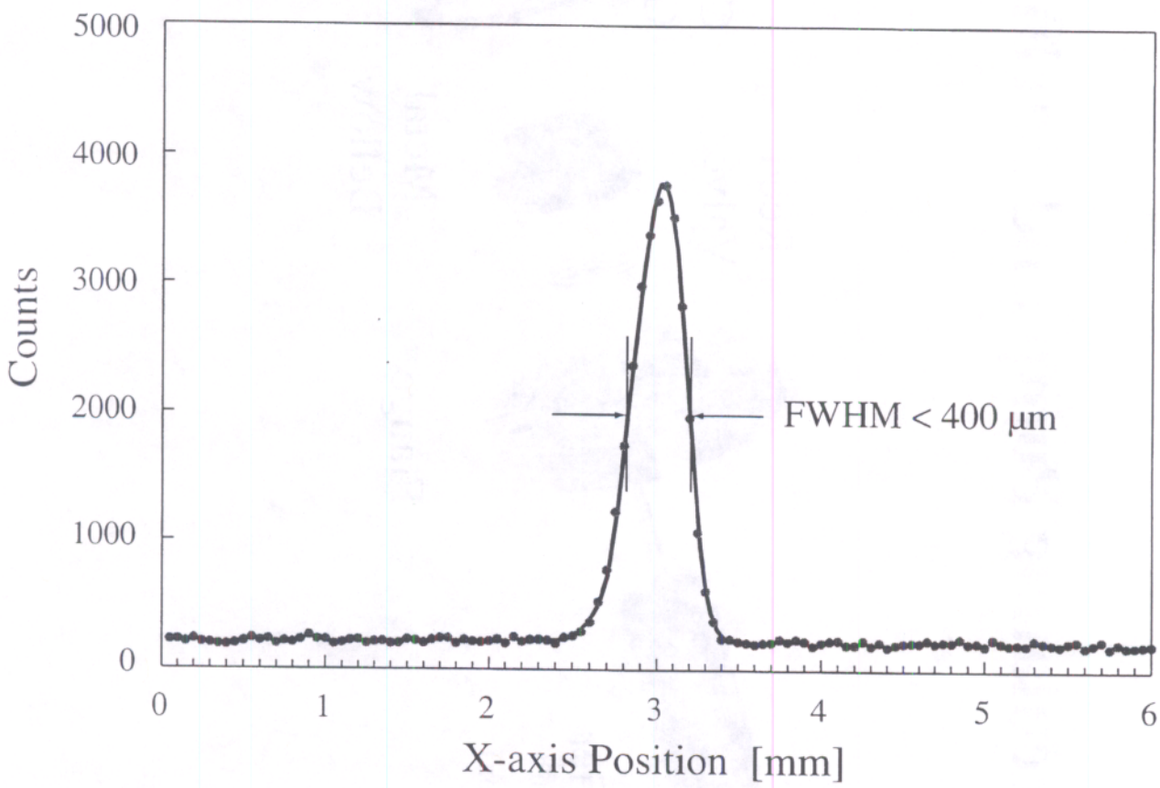

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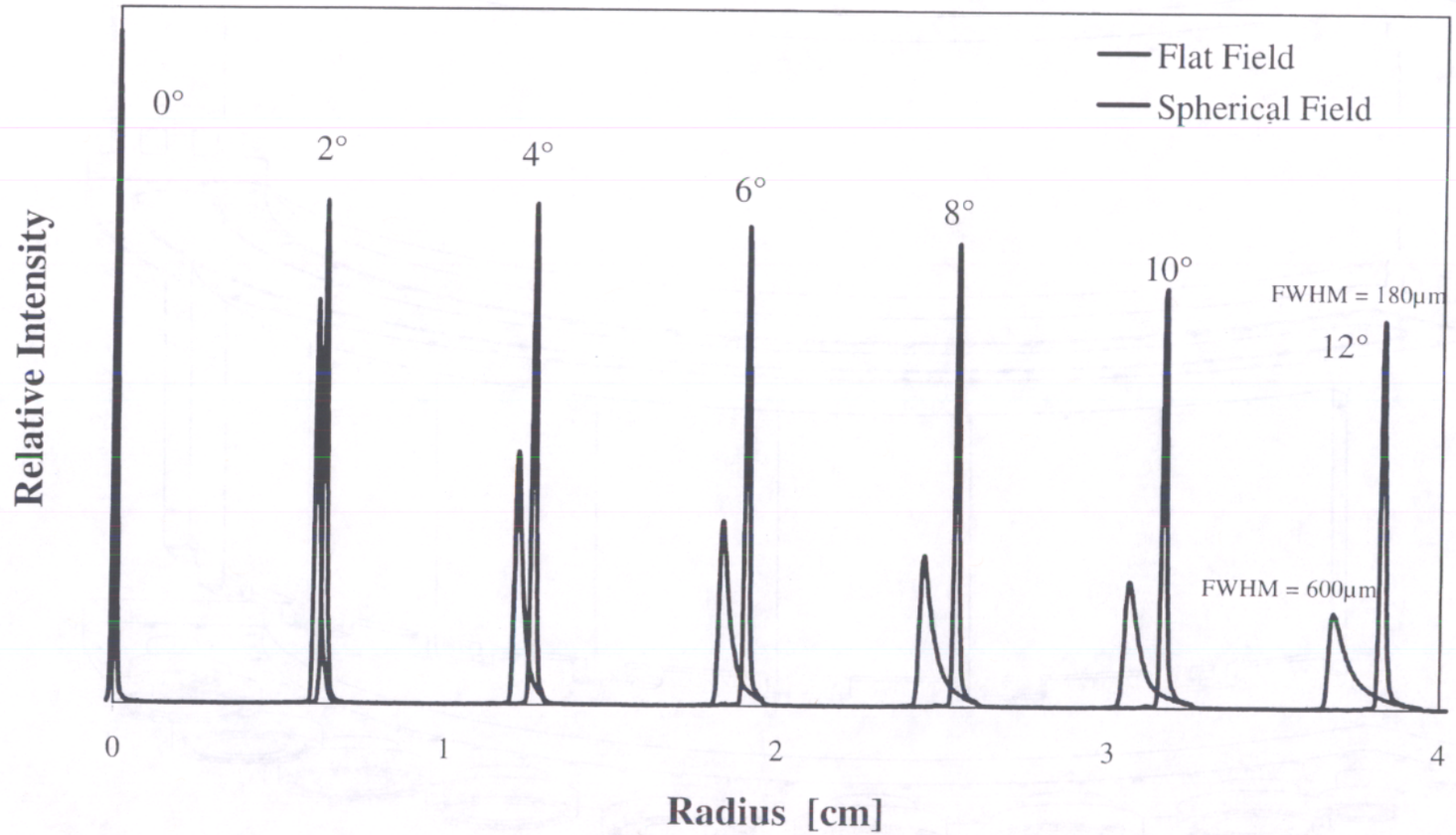

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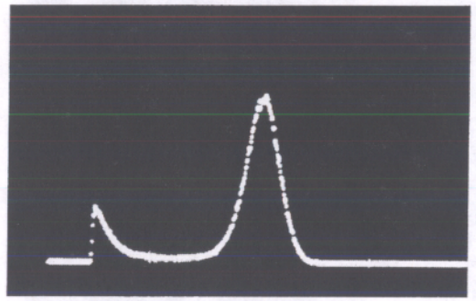

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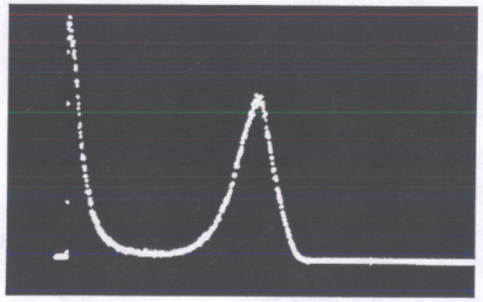

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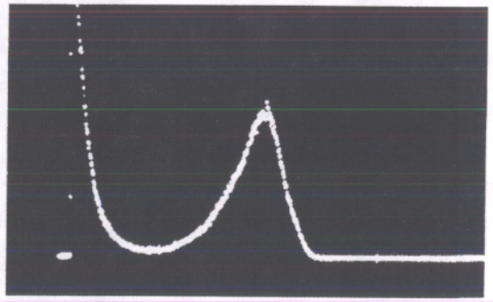

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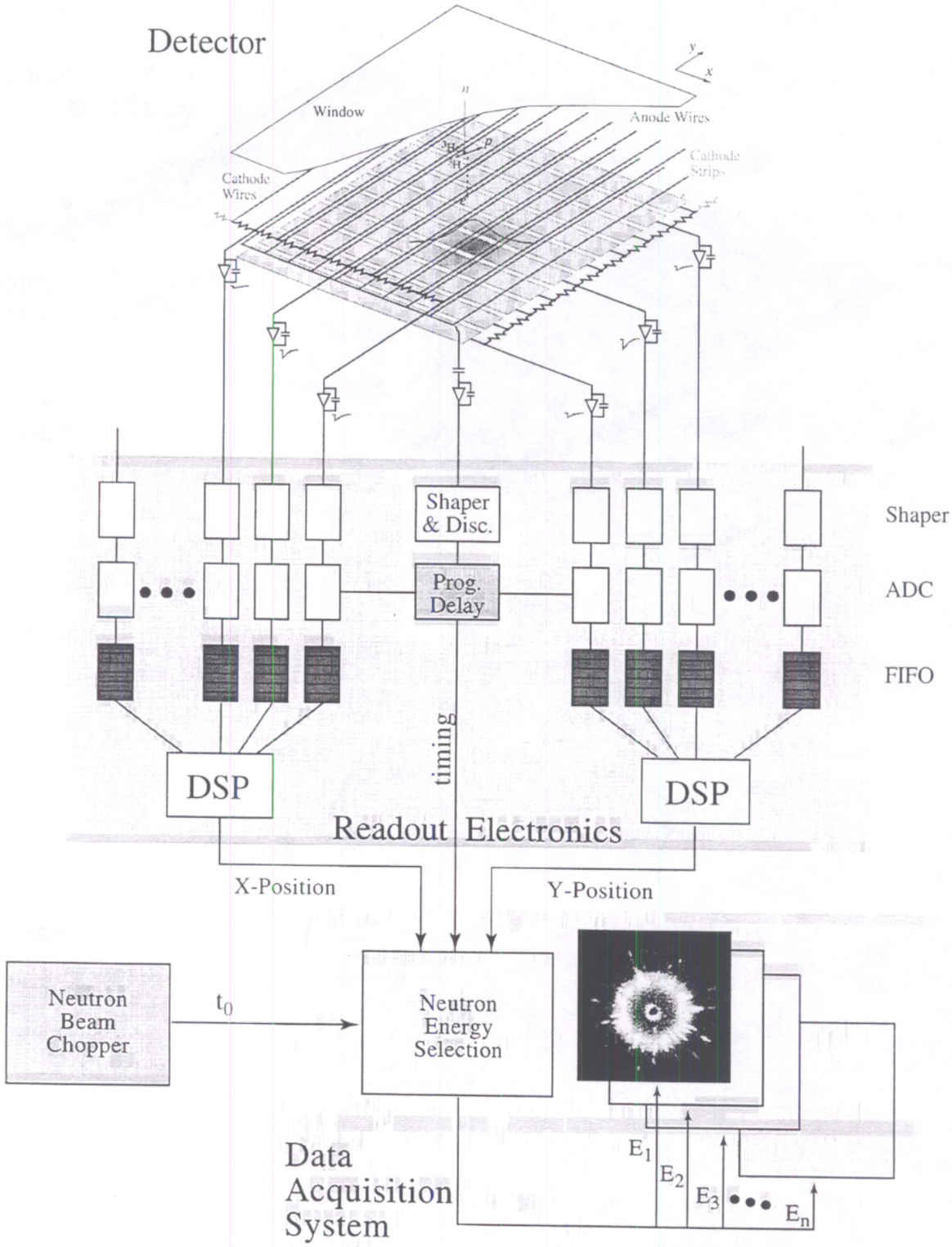

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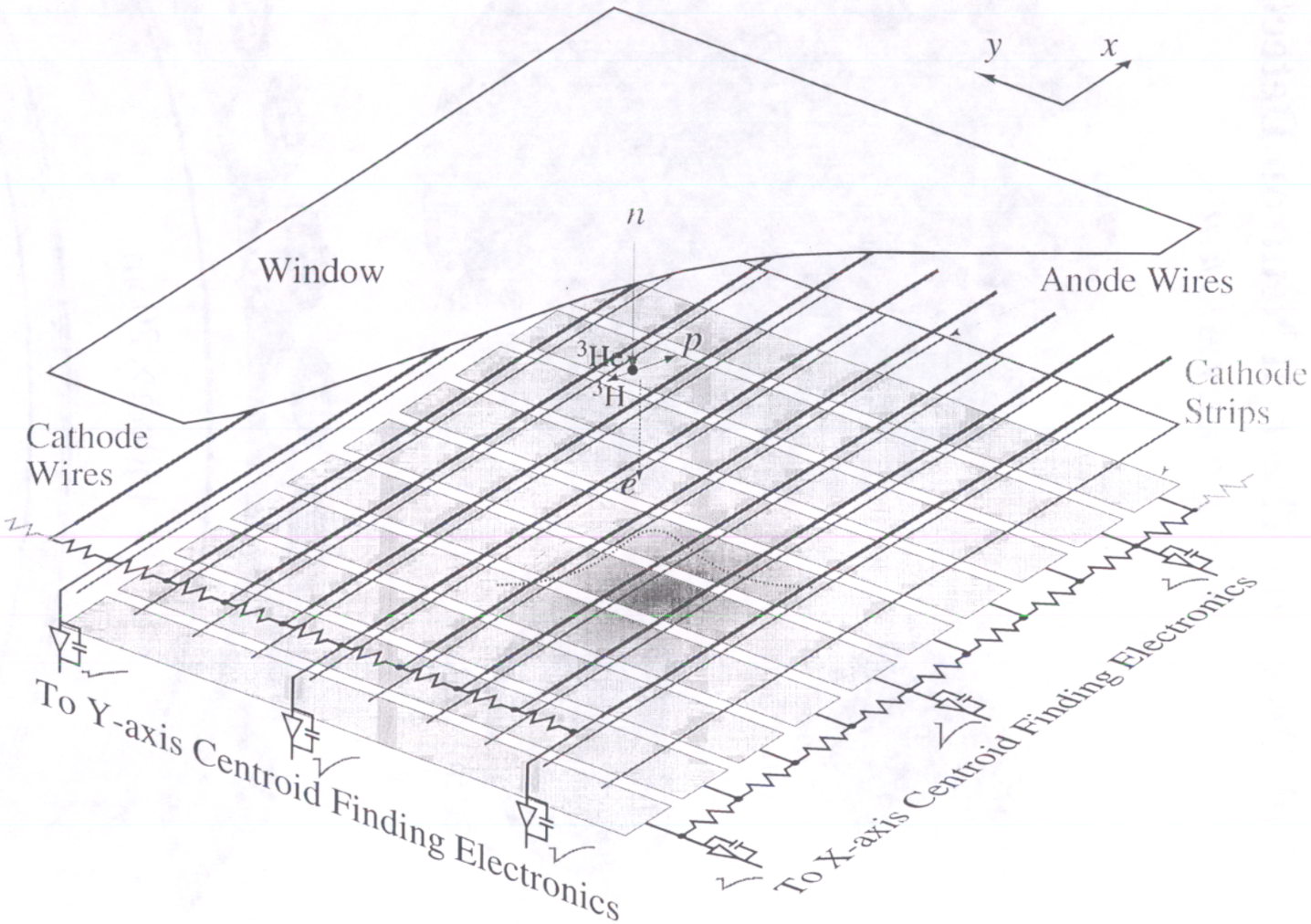

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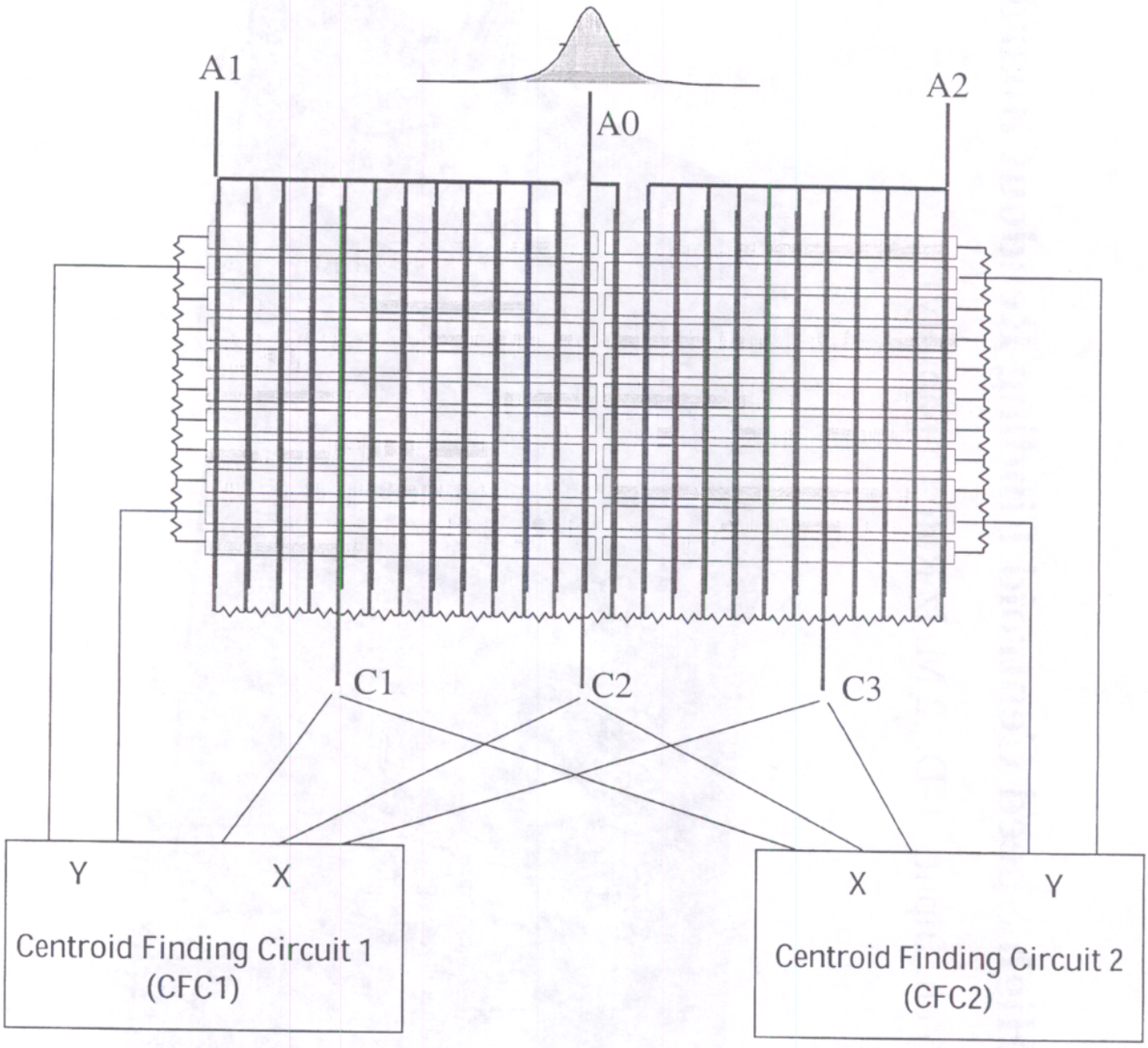

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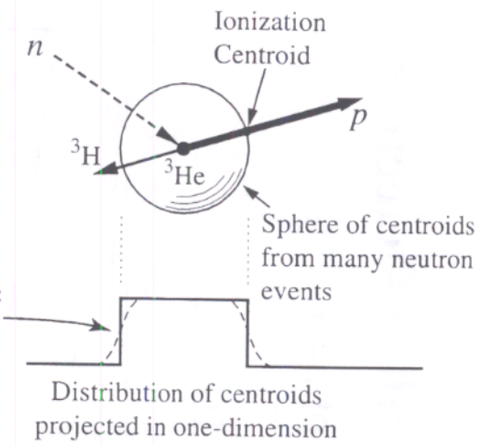

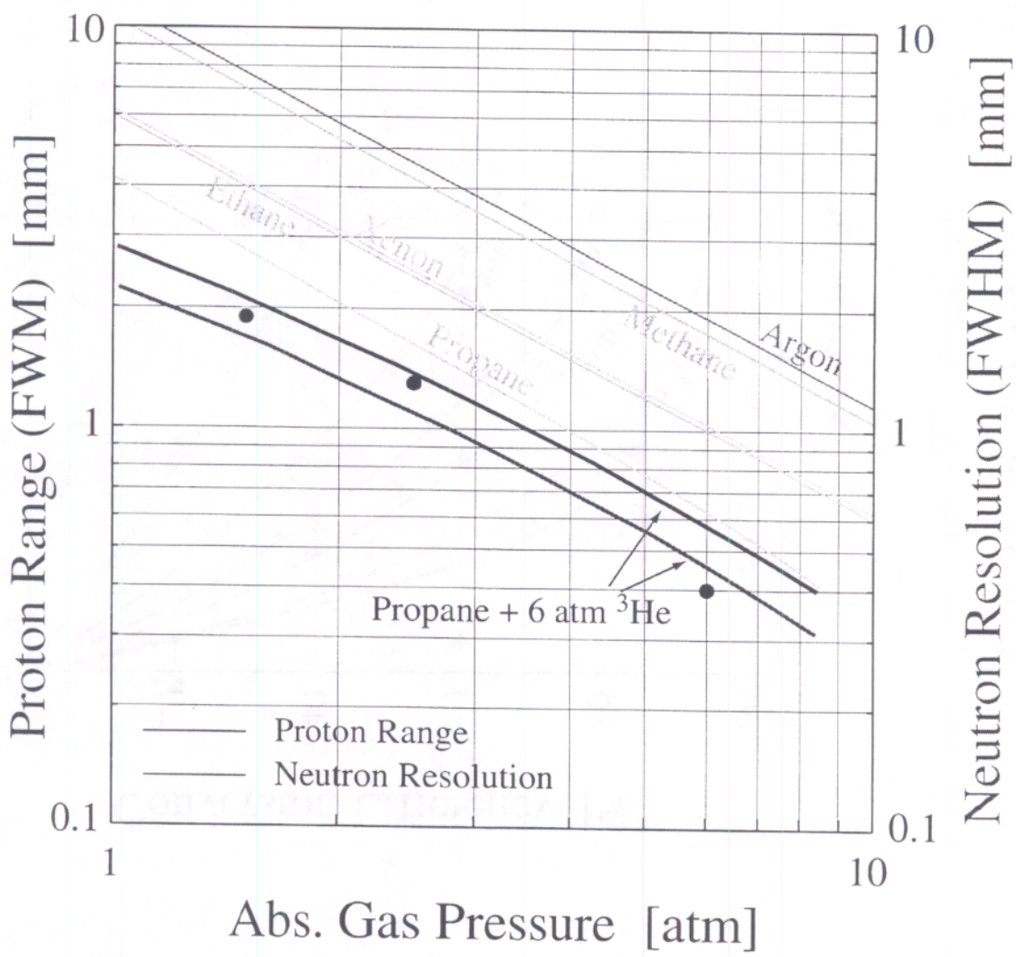

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