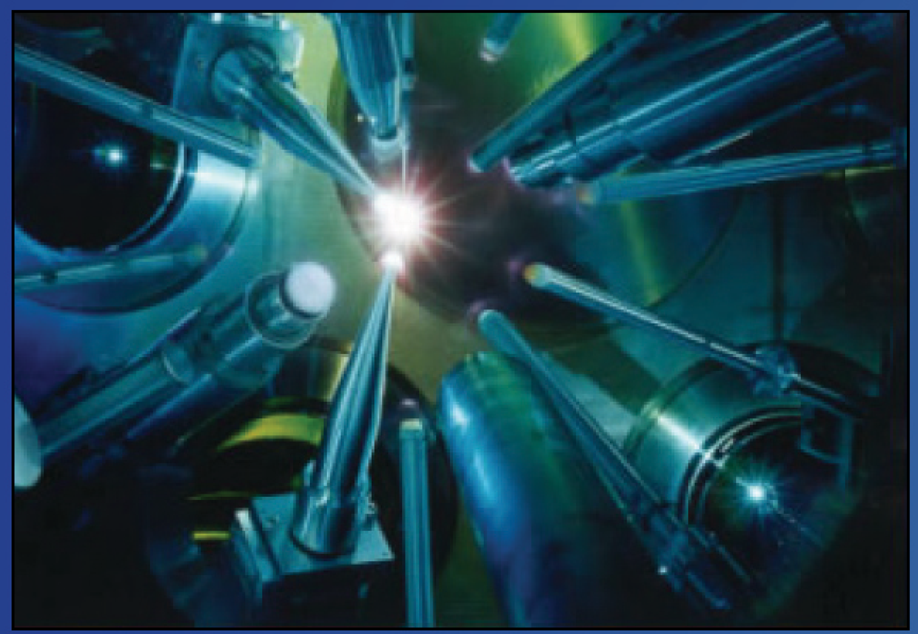
Detecting Charged Particles Using Charge Injection Devices

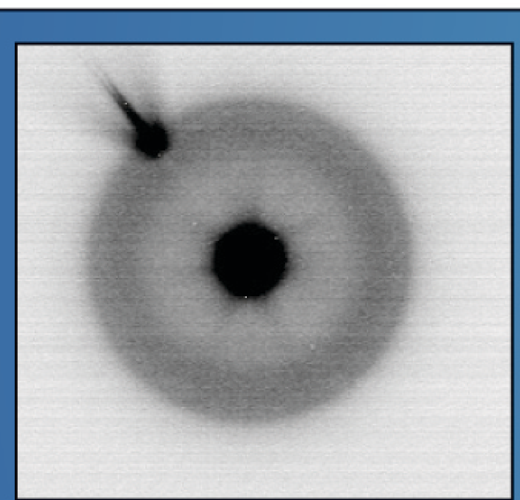
Dr. Kurt Fletcher, Ben Apker, Samantha Hammond, John Punaro, Gary Surman (SUNY Geneseo)
Dr. Frederic J. Marshall, Bob Forties, Ben Schmitt, Jonathan Laine (University of Rochester)

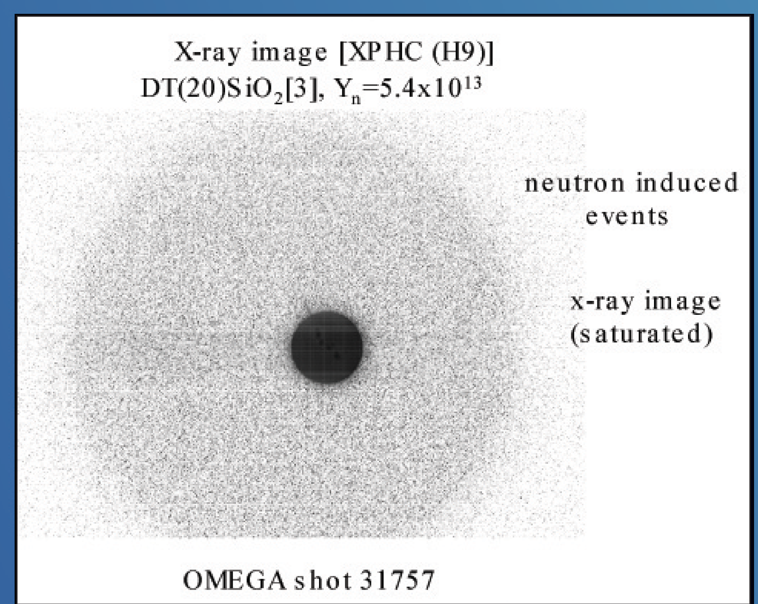
Motivation



To electronically detect charged particles from inertial confinement fusion experiments.

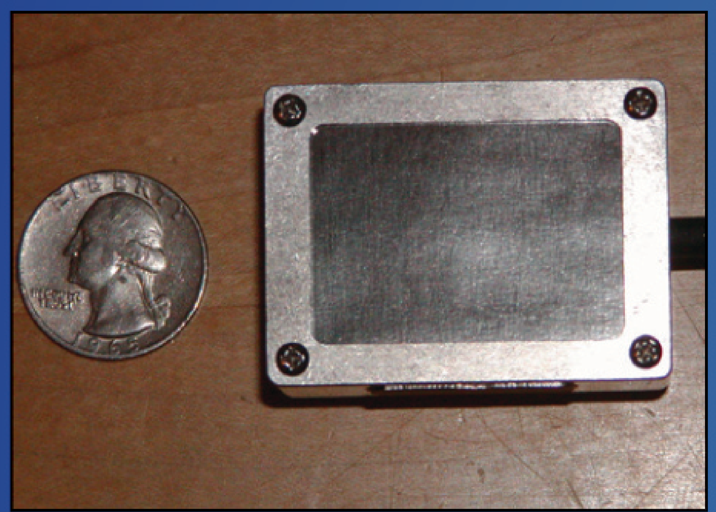
Reaction type	Reactions
Primary fusion reactions	D + D ⟶ T (1.01 MeV) + p (3.02 MeV)
	⟶ n (2.45 MeV) + ^{3}He (0.8 MeV)
	D + T ⟶ α (3.5 MeV) + n (14.1 MeV)
	D + ^{3}He ⟶ α (3.6 MeV) + p (14.7 MeV)
Secondary fusion reactions	^{3}He (0.82 MeV) + D ⟶ α (6.6-1.7 MeV) + p (12.5-17.4 MeV)
	T (1.01 MeV) + D ⟶ α (6.7-1.4 MeV) + n (11.9-17.2 MeV)
14.1-MeV neutron knockons	n (14.1 MeV) + p ⟶ n' + p (≤14.1 MeV)
	n (14.1 MeV) + D ⟶ n' + D (≤12.5 MeV)
	n (14.1 MeV) + T ⟶ n' + T (≤10.6 MeV)
30.8-Mev tertiary reaction chain	D + T → α (3.5 MeV) + n (14.1 MeV) (step 1)
	n (14.1 MeV) + D ⟶ n' + D (≤12.5 MeV) (step 2)
	D (12.5 MeV) + ^{3}He⟶ α + p (≤ 30.8 MeV) (step 3)



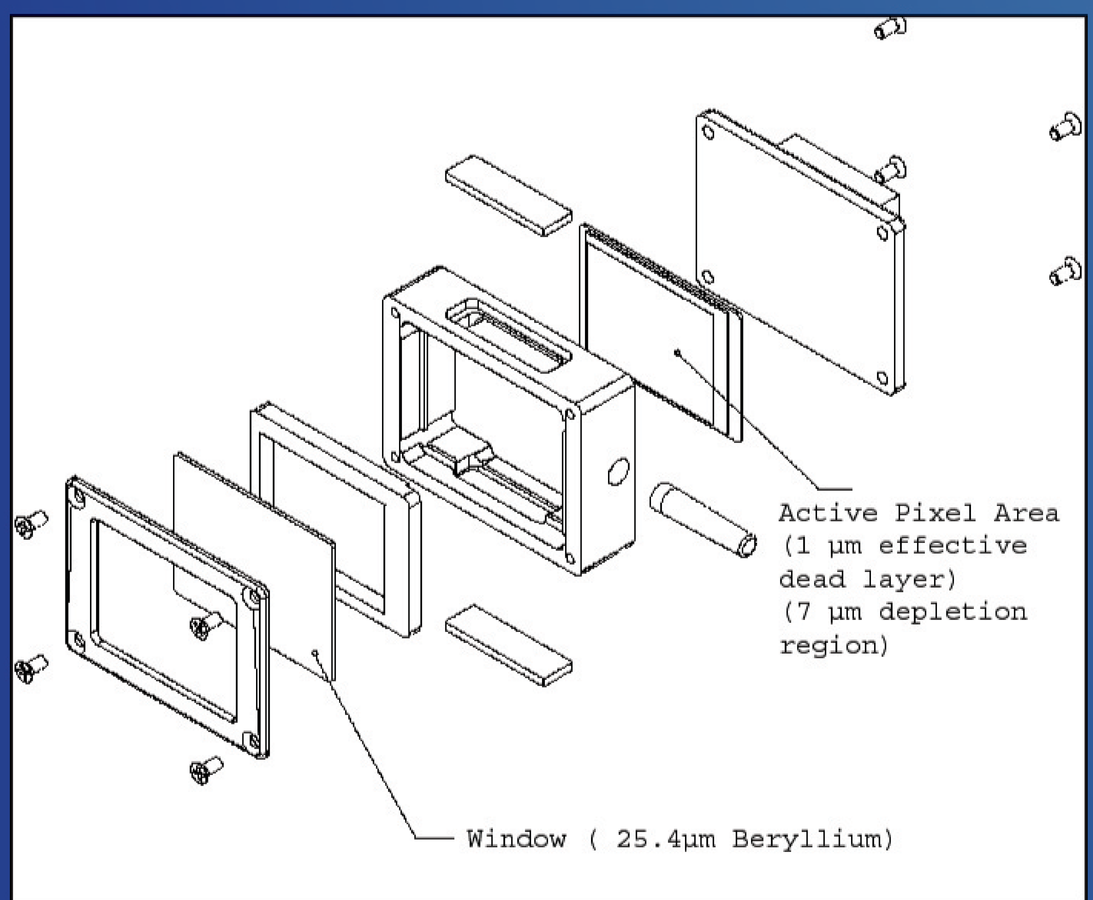


F. J. Marshall et al., Rev. of Sci. Instrum., Vol. 72, p. 713 (2001)
F. J. Marshall et.al., Phys. Plasmas, Vol. 11, p. 251, (2004)

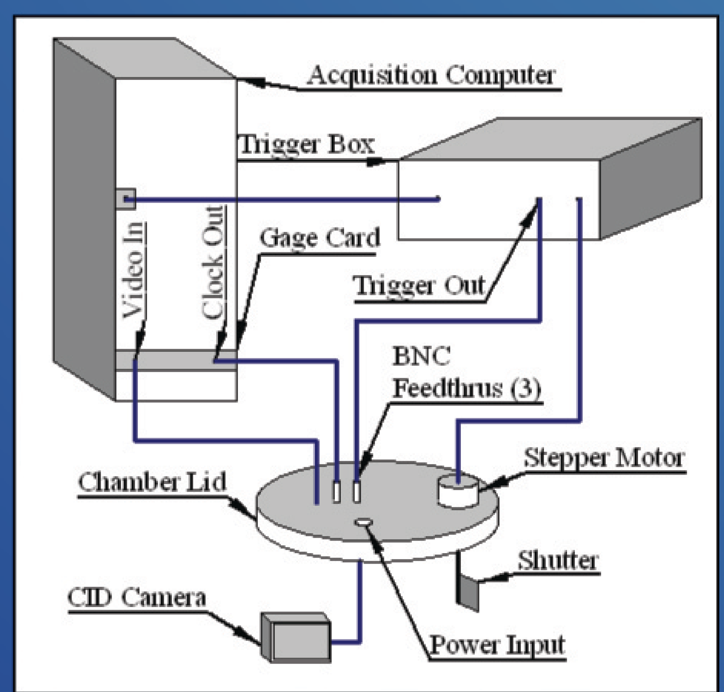
Charge Injection Device



Charge injection devices were chosen for this application because they are compact, provide excellent spatial resolution, and have been used for ICF x-ray detection for many years at the Laboratory for Laser Energetics.

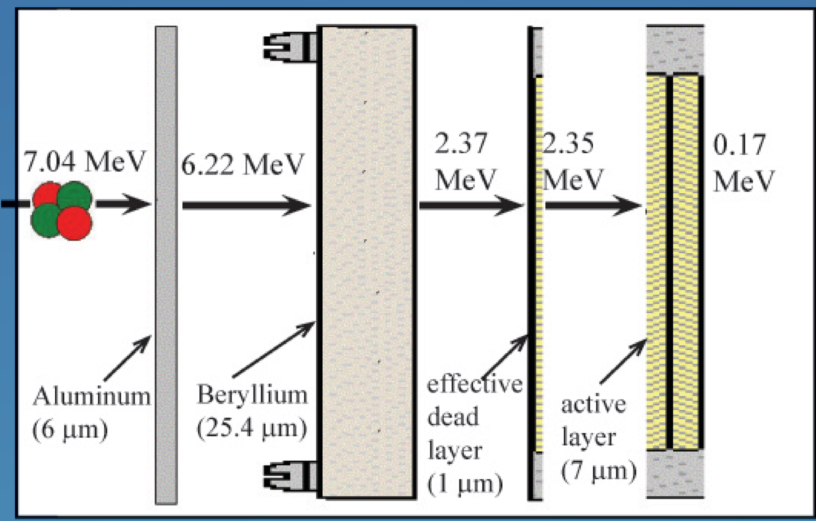


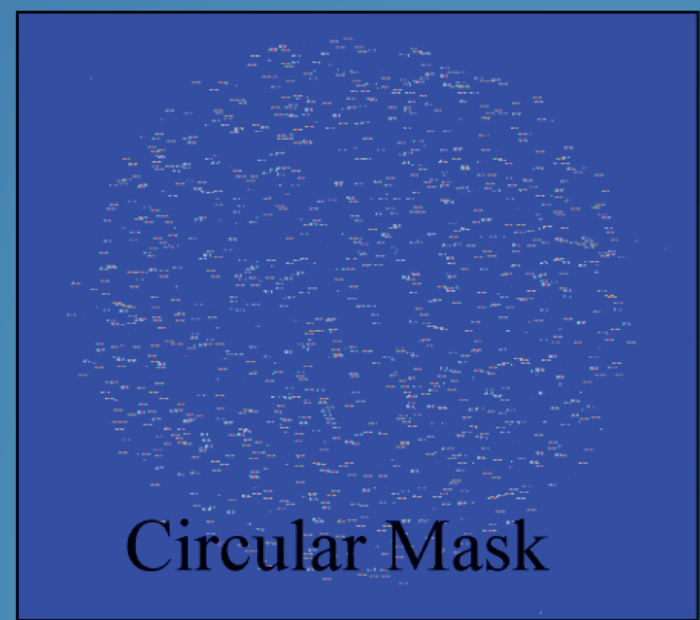
812 x 604 square pixels with 38.5 µm center-to-center spacing



Alpha Source Tests

CID detectors were exposed to 7.20-MeV alpha particles from a Radium-226 source.





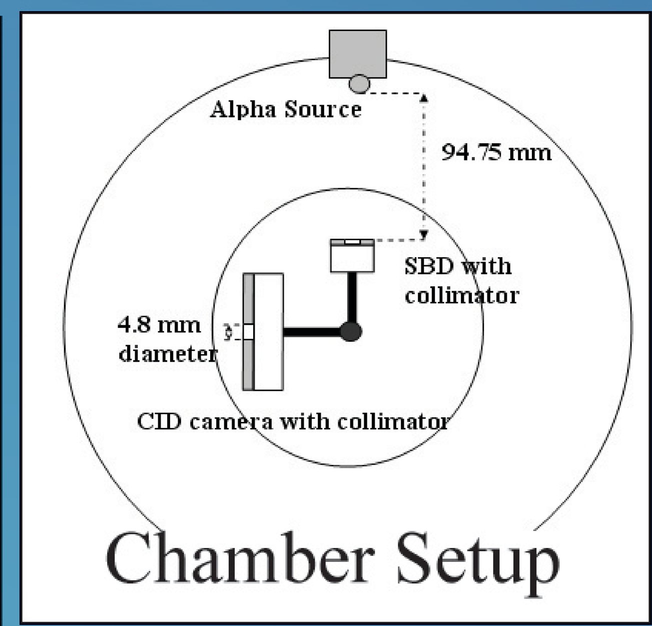
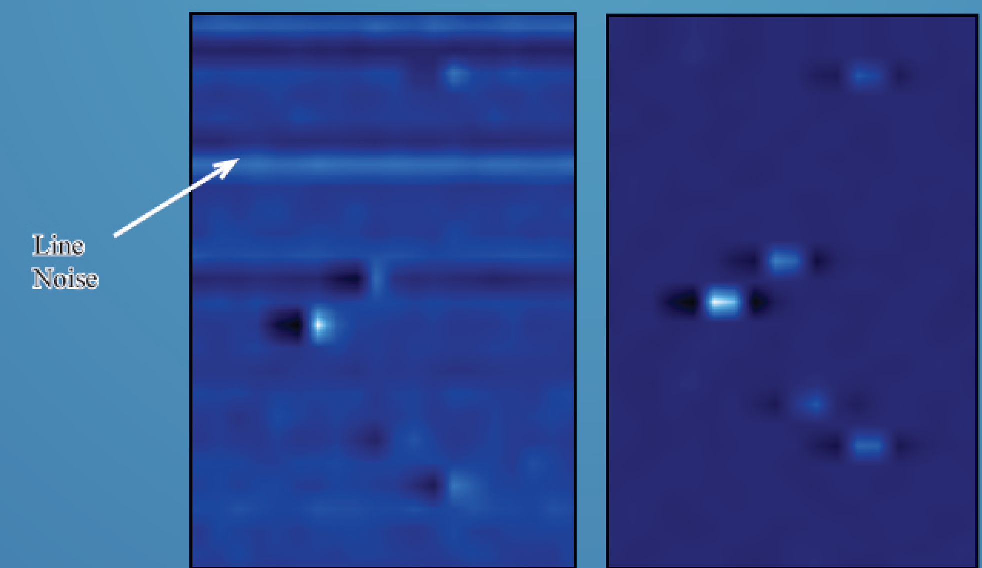
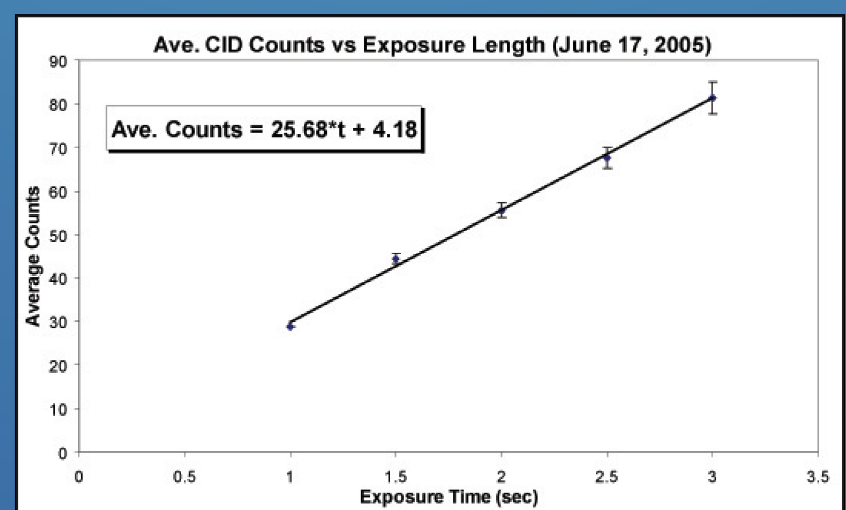


Image Processing - PV Wave



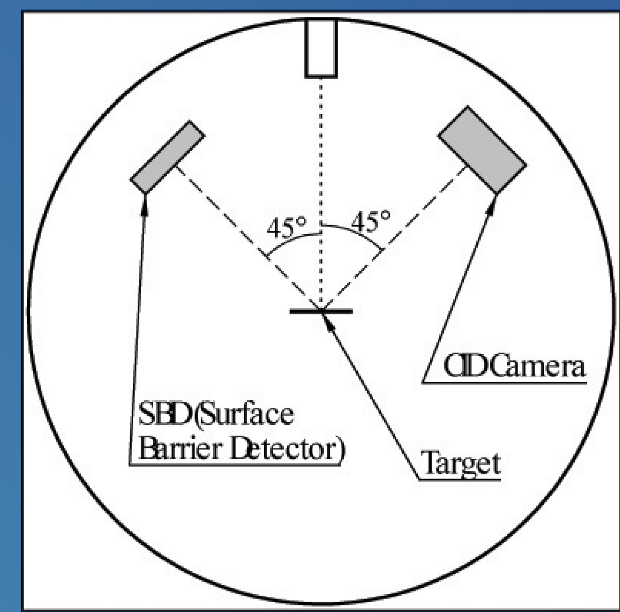
Raw Image X-Derivative (Background Subtraction)

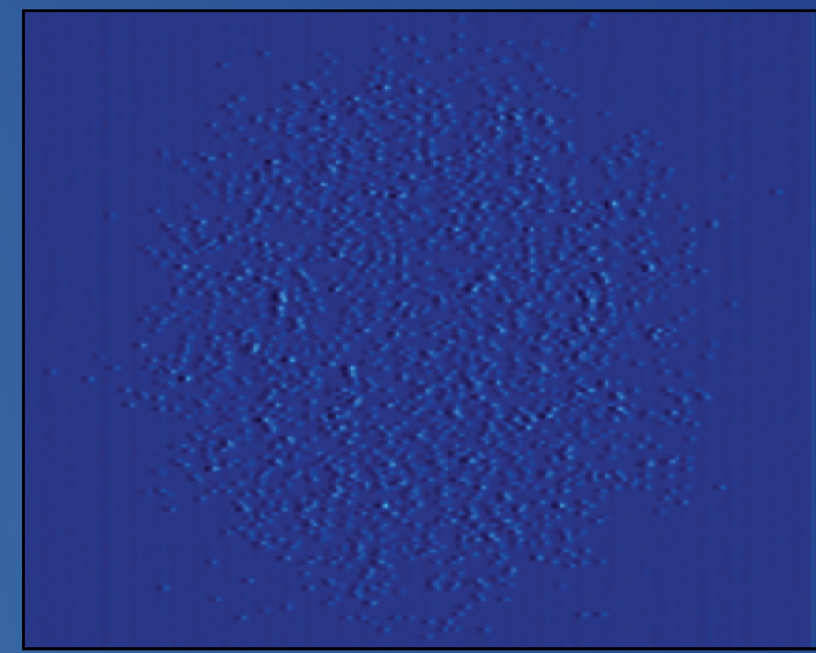


We observed (27.1 ± 0.3) alphas/sec for the SBD and (26 ± 4) alphas/sec for the CID images. The two detectors agree with one another within uncertainties. The results from varying the exposure time suggest that the shutter time may affect the CID results.

Accelerator Tests

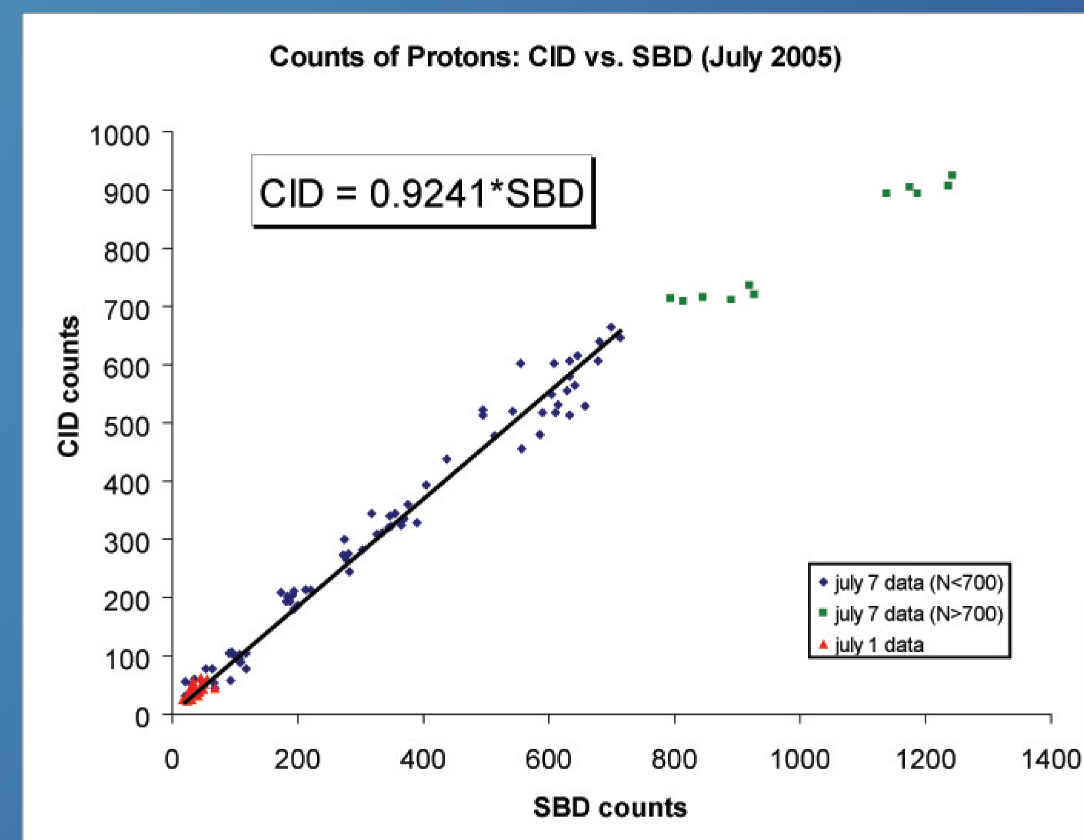
Using the Geneseo Van de Graaff accelerator, 450 keV deuterons were directed to either a ^{3}He-implanted foil or a deuterated polyethylene target to produce high energy protons.

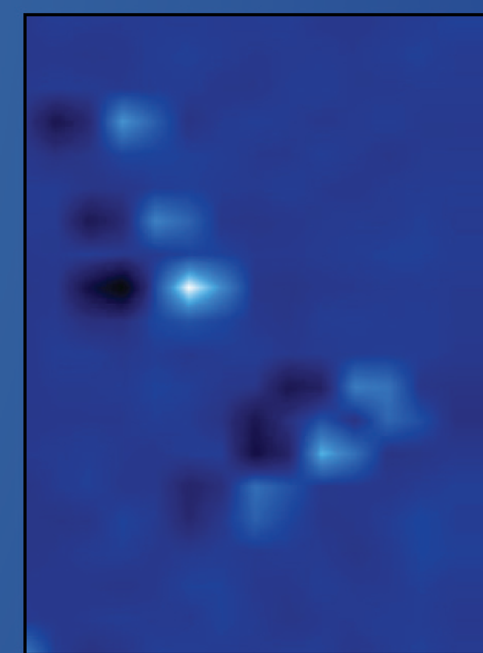




Foils in front of the CID were chosen to maximize the energy deposited in the camera. For ^{3}He(d,p)^{4}He and D(d,p)^{3}H, 1075µm and 34µm Al foils were used respectively.

D(d,p)^{3}H Results





We have demonstrated that CID's can be used to detect D(d,p)^{3}H protons after reducing the energy to ~ 1 MeV. CID's can be used for position-sensitive detection of protons in pulsed experiments if the x-ray and gamma ray flux is low enough.. Alternatively, magnetic dispersion can be used.

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