Detecting low energy protons (& other ions?)

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“Thomson spectromter” – Parallel E & B

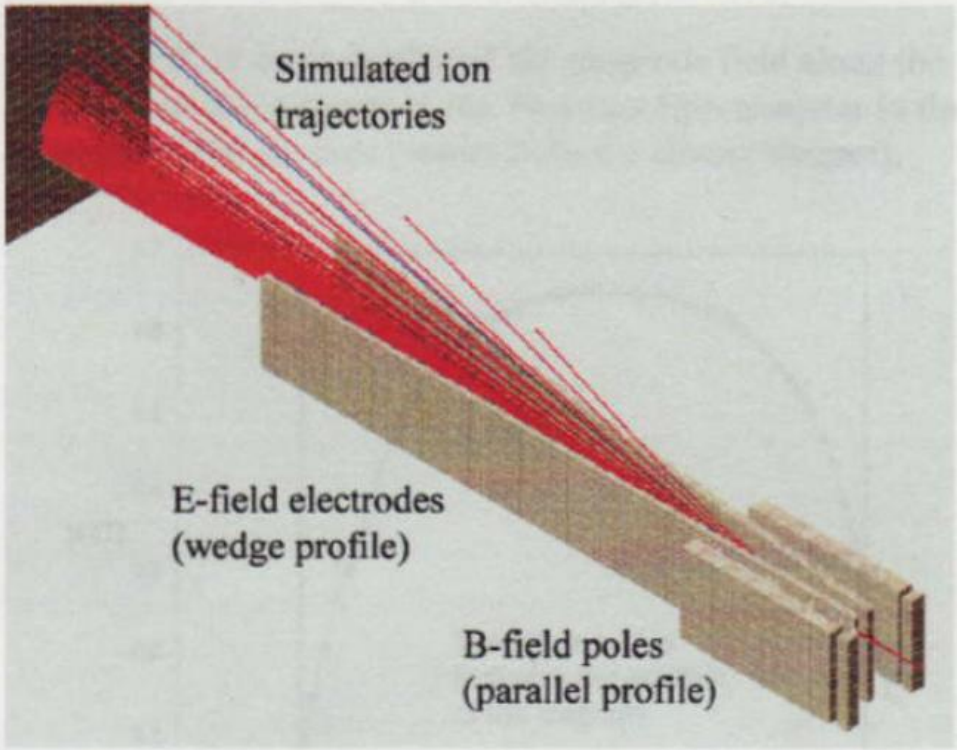


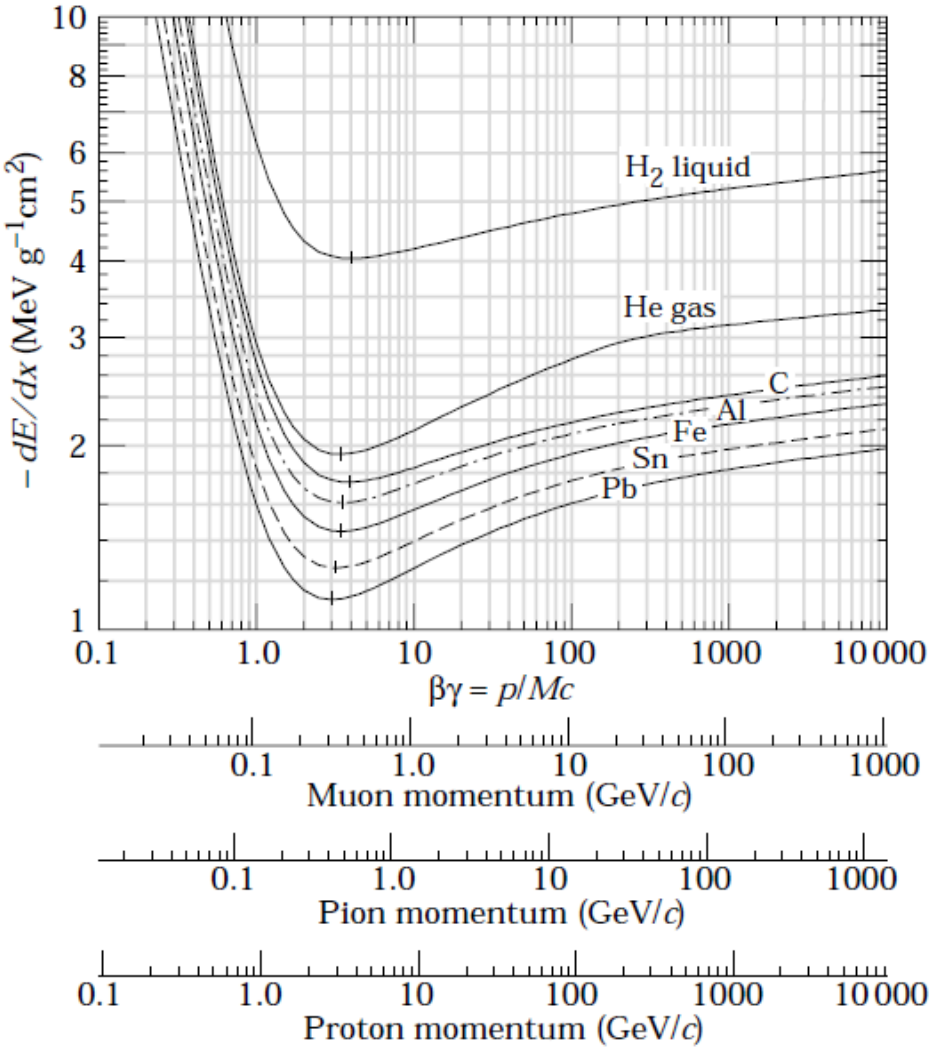
Figure 1. SIMION-3D simulation image of ion trajectories through the electric and magnetic fields of the new Thomson spectrometer design.

- B field separates by (signed) momentum
- E field separates by Q/M (v_y=at)
- Detector = CR-39 (nuclear emulsion?)
- “Another big step is developing other ways of detecting the ions rather than using CR-39 as currently the scanning is time consuming and the Thomson spectrometers are restricted to low rep rate experiments.”

Conceptual design

- Use parallel E&B fields to separate ions by p and Q/M; each species is imaged to an approximately parabolic shape at the (planar) sensor.
  - Not clear on the flux of ions to be measured, but presumably we can’t count; need to integrate.
  - Ideally one would use a sensor with 2-d segmentation, but could also shield all but desired sensitive area (selecting one ion species).

Protons below 100 MeV KE are VERY highly ionizing



Proton kenematics

ion mass	ion KE (MeV)	ion momentum (MeV/c)	ion velocity (p/E)	sqrt(2KE /m)	3 ft TOF (ns)	6in TOF (ns)	6in deflection (10kV/cm) (mm)	Vy due to 6" E (mm/ns)	y deflection at 3 ft (mm)	Range in Si (microns)	Range in Kapton (mils)	Range in Argon (mm)	Range in dry air (mm)
938	1	43	0.046	0.046	65.0	10.84	5.87	1.08	64.59	16	0.8	26.1	23.8
938	2	61	0.065	0.065	46.0	7.67	2.94	0.77	32.35	48	2.3	76.8	73.0
938	3	75	0.080	0.080	37.6	6.27	1.96	0.63	21.60	93	4.6	148.3	144.1
938	5	97	0.103	0.103	29.2	4.86	1.18	0.49	13.00	218	11.0		
938	10	137	0.145	0.146	20.7	3.45	0.60	0.35	6.55	715			
938	20	195	0.203	0.207	14.8	2.46	0.30	0.25	3.33	2408			
938	30	239	0.247	0.253	12.1	2.02	0.20	0.20	2.25				
938	40	277	0.283	0.292	10.6	1.77	0.16	0.18	1.72				
938	50	310	0.314	0.327	9.6	1.59	0.13	0.16	1.39				
938	100	445	0.428	0.462	7.0	1.17	0.07	0.12	0.75				
938	150	551	0.507	0.566	5.9	0.99	0.05	0.10	0.54				
938	200	644	0.566	0.653	5.3	0.88	0.04	0.09	0.43				
938	250	729	0.614	0.730	4.9	0.81	0.03	0.08	0.37				
938	300	808	0.653	0.800	4.6	0.77	0.03	0.08	0.32				

Stopping power & range tables for e, p, & α:
http://physics.nist.gov/PhysRefData/Star/Text/contents.html

Proton detection w/electronic detectors

- KE < 100 keV is HARD (range in Si = 0.99μ!).
- KE > 300 keV is not so bad (range in Si = 3.2μ).
- KE > ~10 MeV no longer stops in a reasonable thickness silicon detector (range = 715μ); can't scale simply by KE.
- KE < 1 MeV is essentially impossible with a wire chamber (range in Kapton = 0.8 mils).
- KE > 2 MeV is "easy" with a wire chamber, but need to use dE/dx to scale (range in Ar = 77mm).