IONIZATION COOLING (BUDKER, SKRINSKY) *

- Schematic of basic principle
  (see figure)

- $\frac{dE}{dz}$ in Li, Be, LiH reduces both
  longitudinal and transverse momentum
  a subsequent *rf* cavity restore $p_{\parallel}$

- Combined effect is: beam divergence is reduced. Transverse $\epsilon_n \rightarrow$ decreases.

- MULTIPLE SCATTERING is source of heat
  $\epsilon_n \rightarrow$ increases

†

- Emittance rate of change

$$\frac{d\epsilon_n}{dz} = -\frac{\epsilon_n}{E\beta^2}\left\|\frac{dE}{dz}\right\| + 0.5\beta\gamma\frac{d<\theta^2>}{dz}$$

- MINIMUM EMITTANCE

$$\epsilon_n \approx \frac{0.5E_s^2}{m_\mu c^2}\frac{\beta_\perp}{\beta}\left(L_R\|dE/dz\|\right)^{-1}$$

- Best material for cooling, Li, LiH, Be

Material	ρ	dE/dx	L_R	cof.of $\beta_\perp$
	[g/cm^3]	[MeV/cm]	[cm]	[mm mr/cm]
liq.H_2	0.071	0.286	890.	42
liq.He	0.125	0.242	756.	59
LiH	0.82	1.34	102.	78
Li	0.534	0.875	155.	79
Be	1.848	2.95	35.3	103