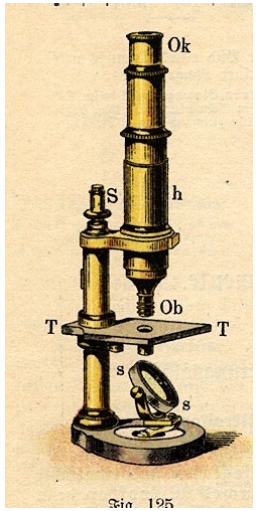

Instrumentation

Probes for Nuclear Processes



To "see" an object, the wavelength λ of the light used must be shorter than the dimensions **d** of the object. (DeBroglie: $p=\hbar k=\hbar 2\pi/\lambda$)

Rutherford's scattering experiments

$\mathbf{d_{Nucleus}} \sim$ few 10^{-15} m

Need light of wave length $\lambda \leq 1$ fm, or an energy

$$E = pc = \hbar kc = 2\pi\frac{\hbar c}{\lambda} \geq 6\cdot\frac{200MeV\cdot fm}{1\,fm} = 1.2GeV$$

Not easily available

Massive (m) particle, e.g., proton:

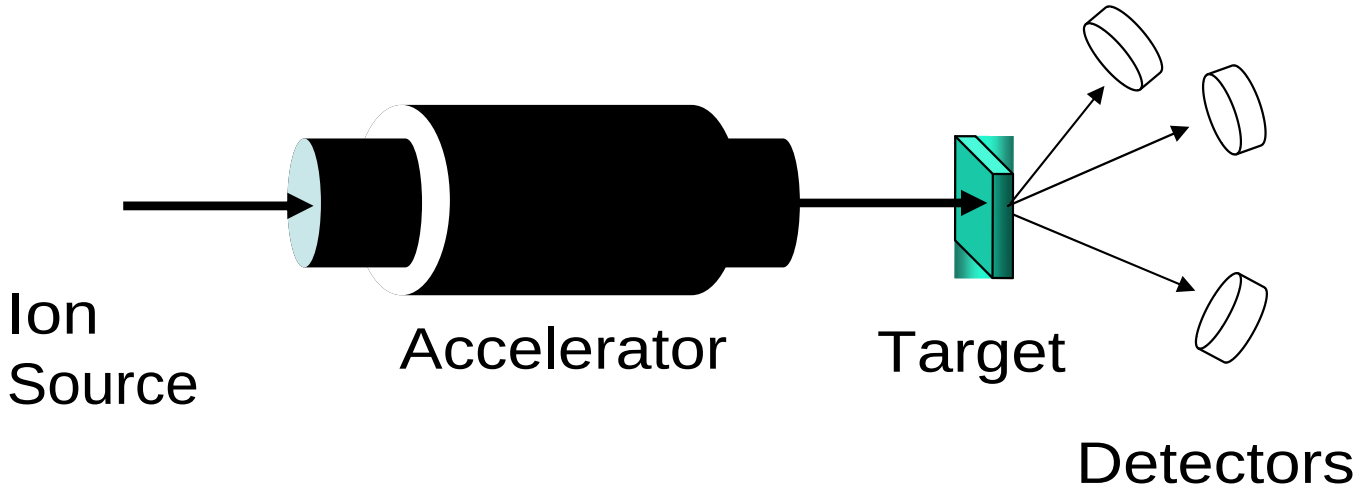
$$E = \frac{p^2}{2m} = \frac{(\hbar k)^2}{2m} = \frac{(\hbar ck)^2}{2mc^2} \geq \frac{(200MeV\cdot fm)^2}{1.8GeV}\cdot\frac{(2\pi)^2}{\lambda^2}$$

$$= \frac{80\cdot 10^4 MeV^2\,fm^2}{GeV}\frac{1}{fm^2} = 800MeV$$

Can be made with charged particle accelerators

Program

- Particle Accelerators
- Interaction of Radiation with Matter
- Radiation Detection
- Applications



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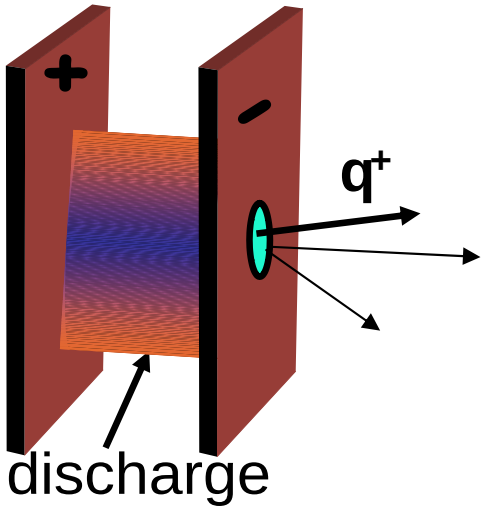
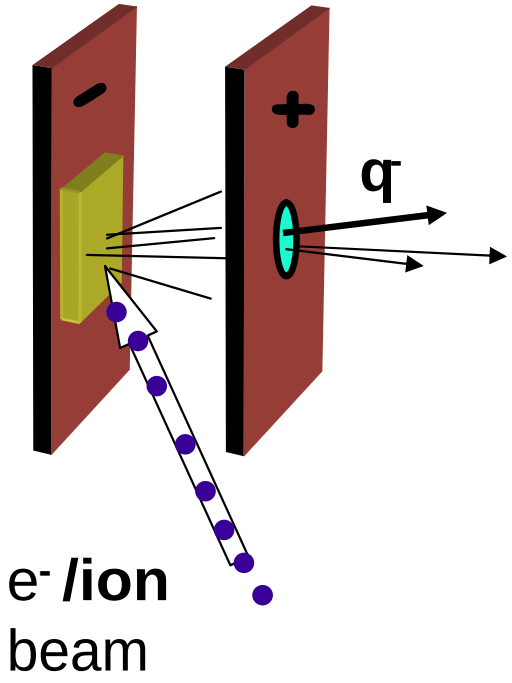
Ionization Process



1. e^- impact (gaseous ionization)
   - hot cathode arc
   - discharge in axial magnetic field (duo-plasmatron)
   - electron oscillation discharge (PIG)
   - radio- frequency electrode- less discharge (ECR)
   - electron beam induced discharge (EBIS)



2. ion impact
   - charge exchange
   - sputtering

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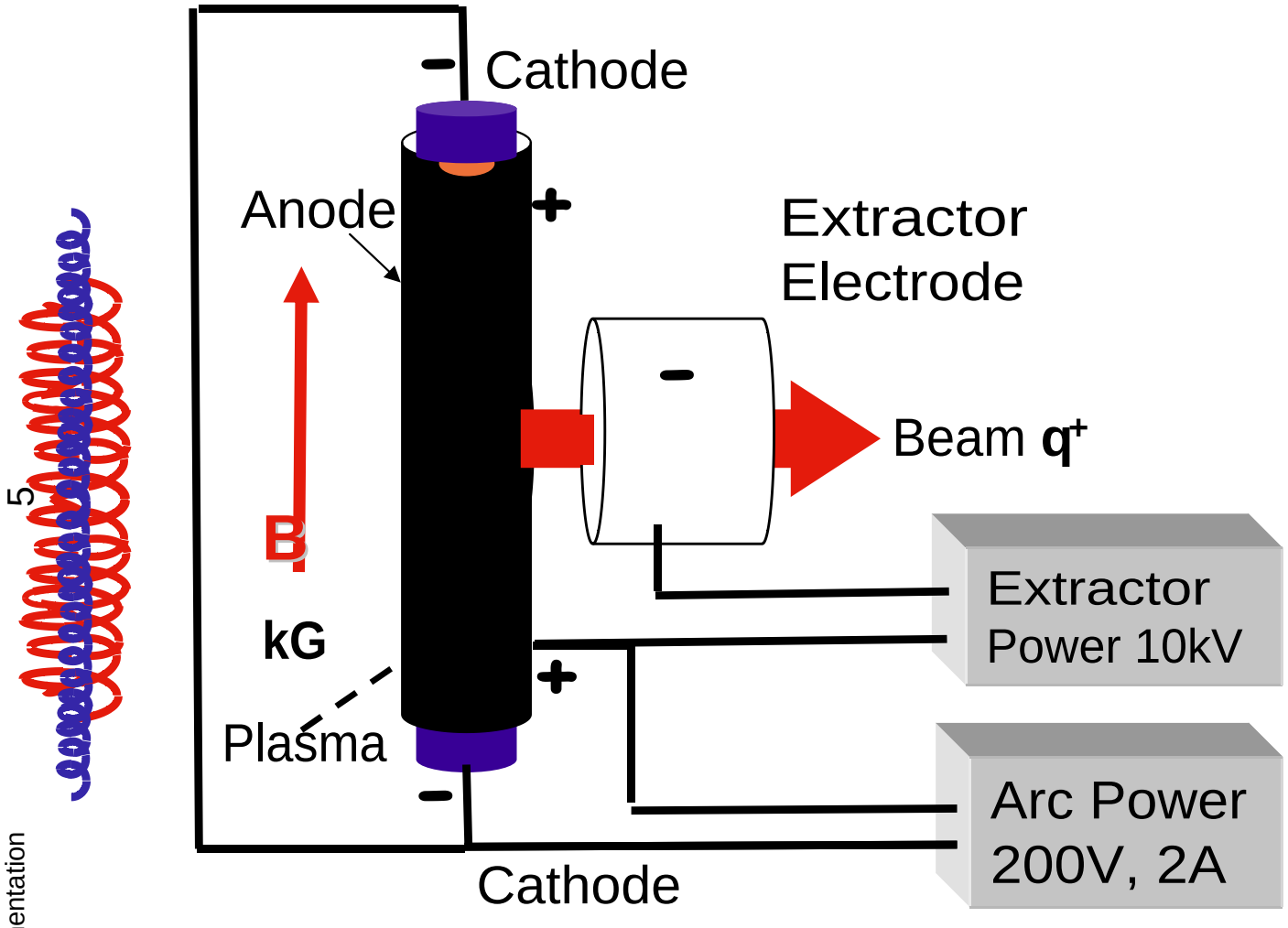
Penning Ion Gauge (PIG) Source



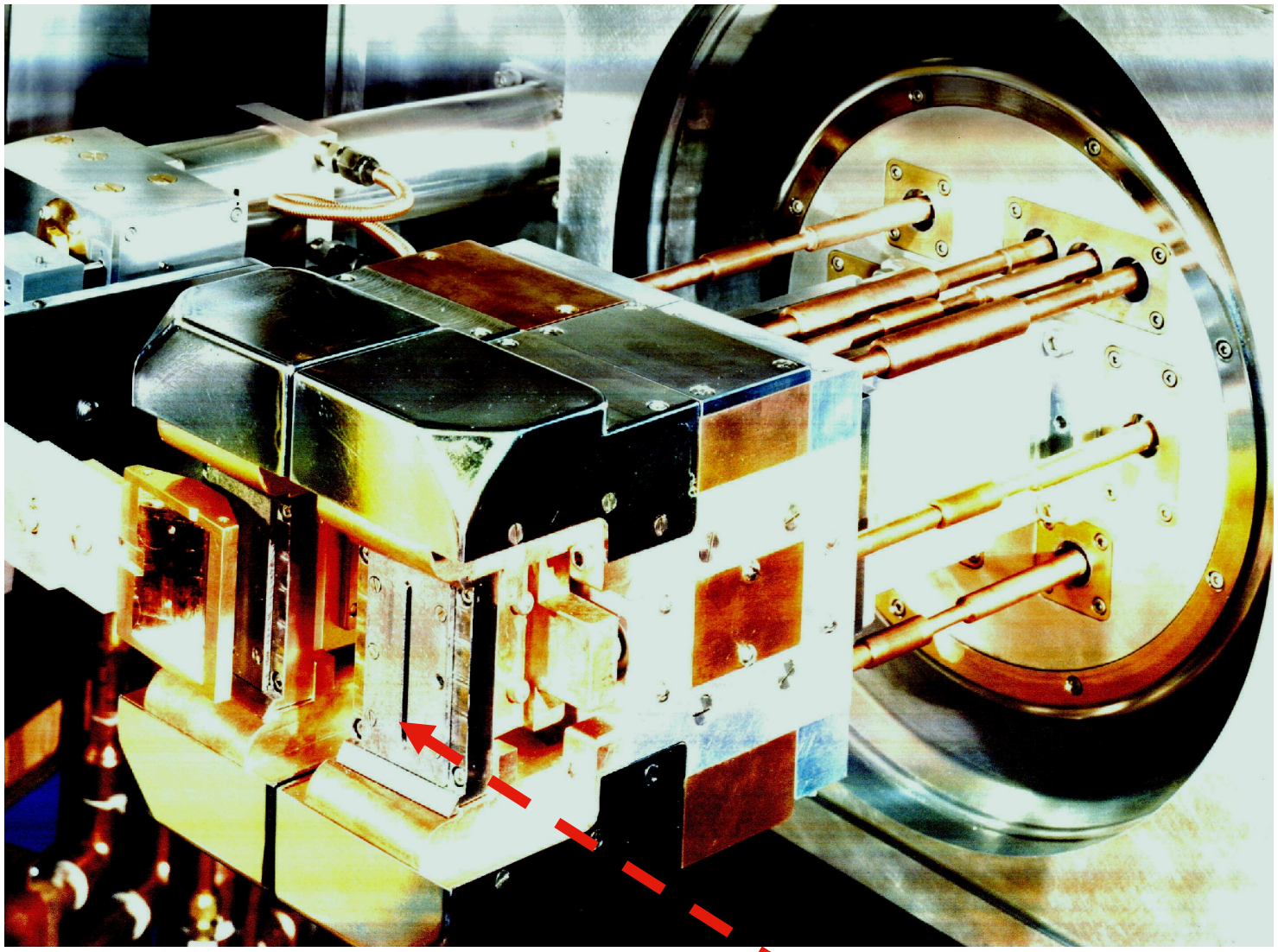
Assembly placed within magnetic field B.

Secondary e^- emission from cathode oxide layers

$j^+ \sim$ 10-50 mA extracted beam

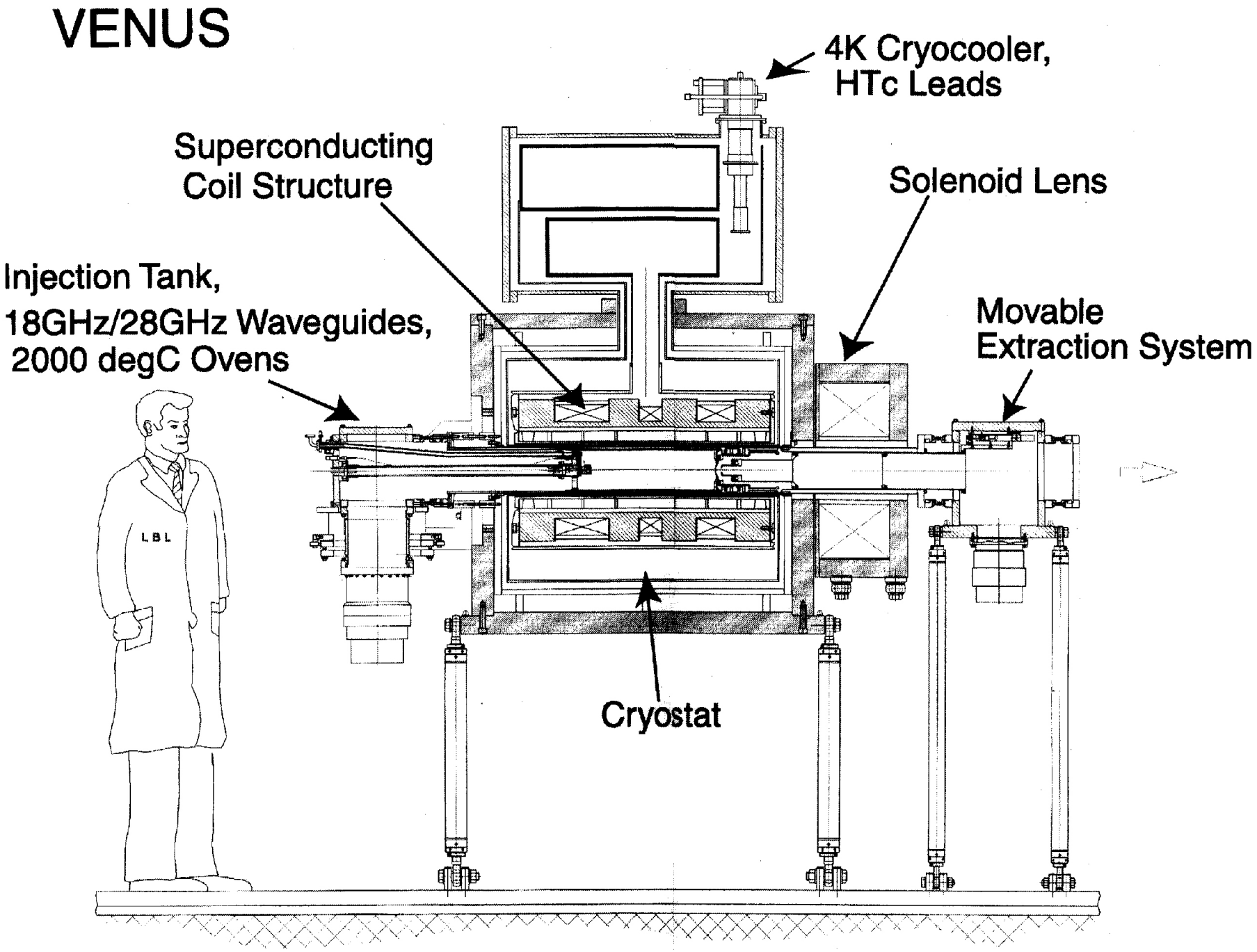
More efficient ion sources use microwave radiation to produce highly ionized plasma → Electron Cyclotron Resonance (ECR)source

LBL- 88" Cyclotron PIG Ion Source

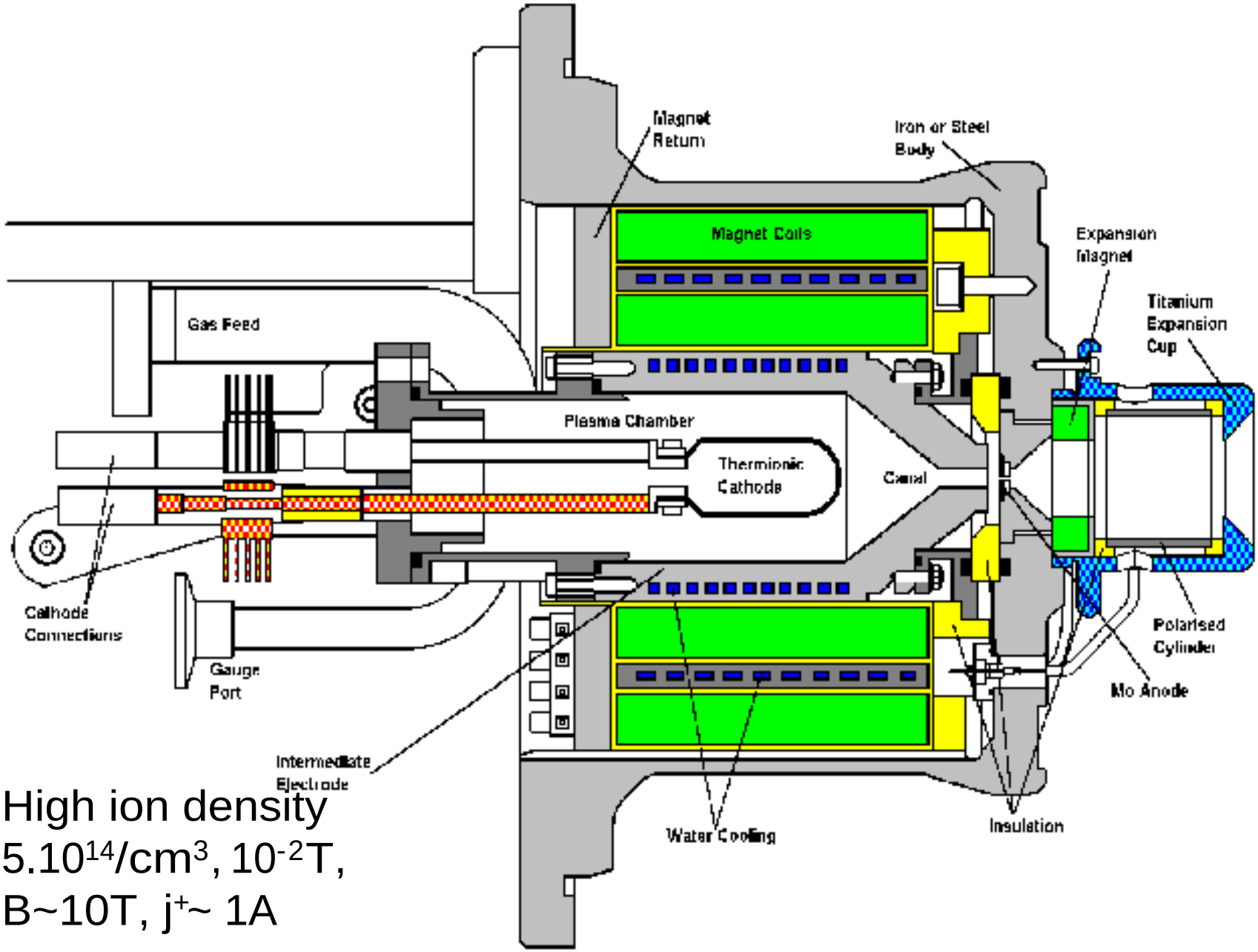


Hinged assembly swings between the poles of the cyclotron magnet.

Electron Cyclotron Resonance Source

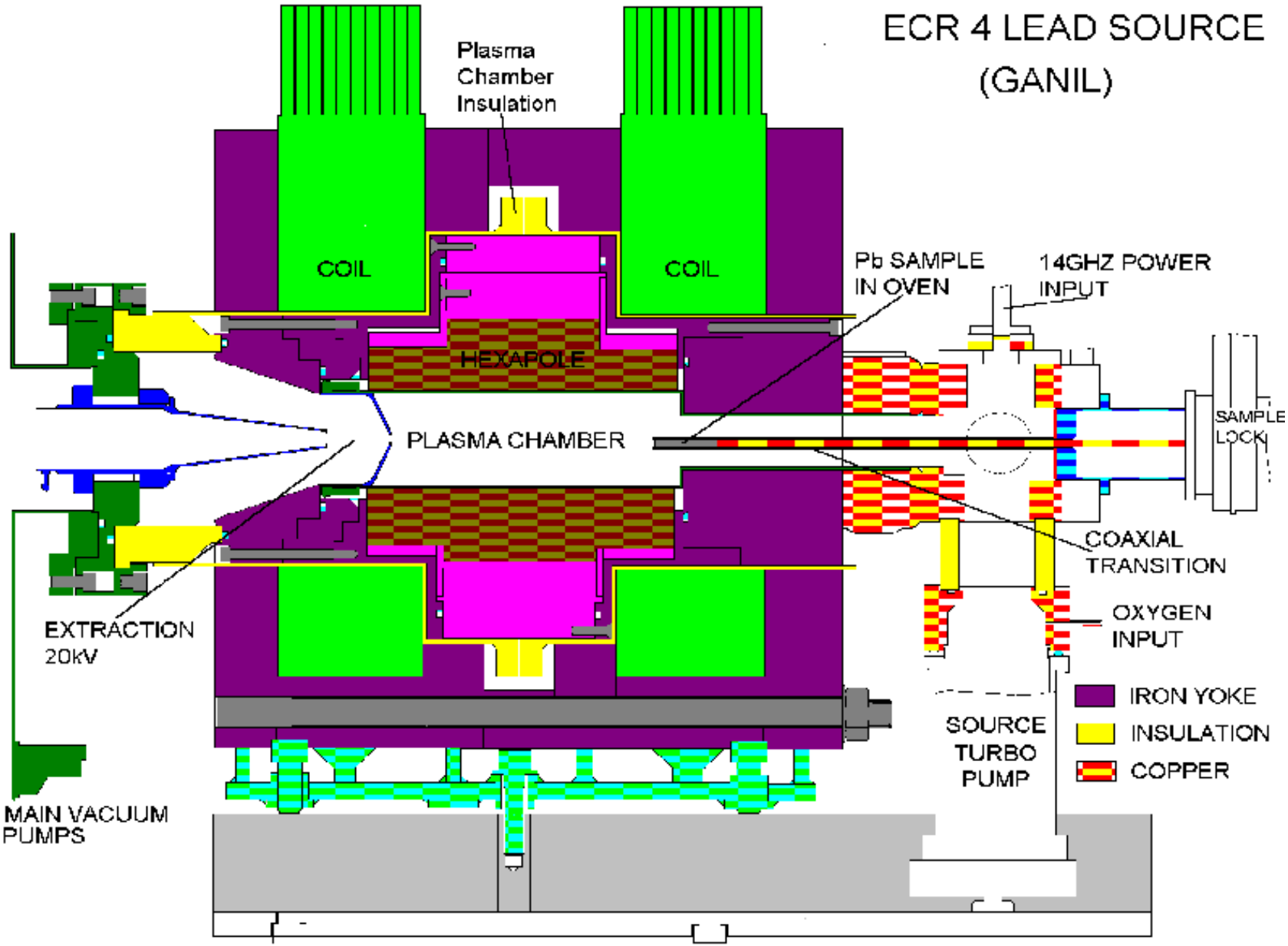


Duoplasmatron Ion Source



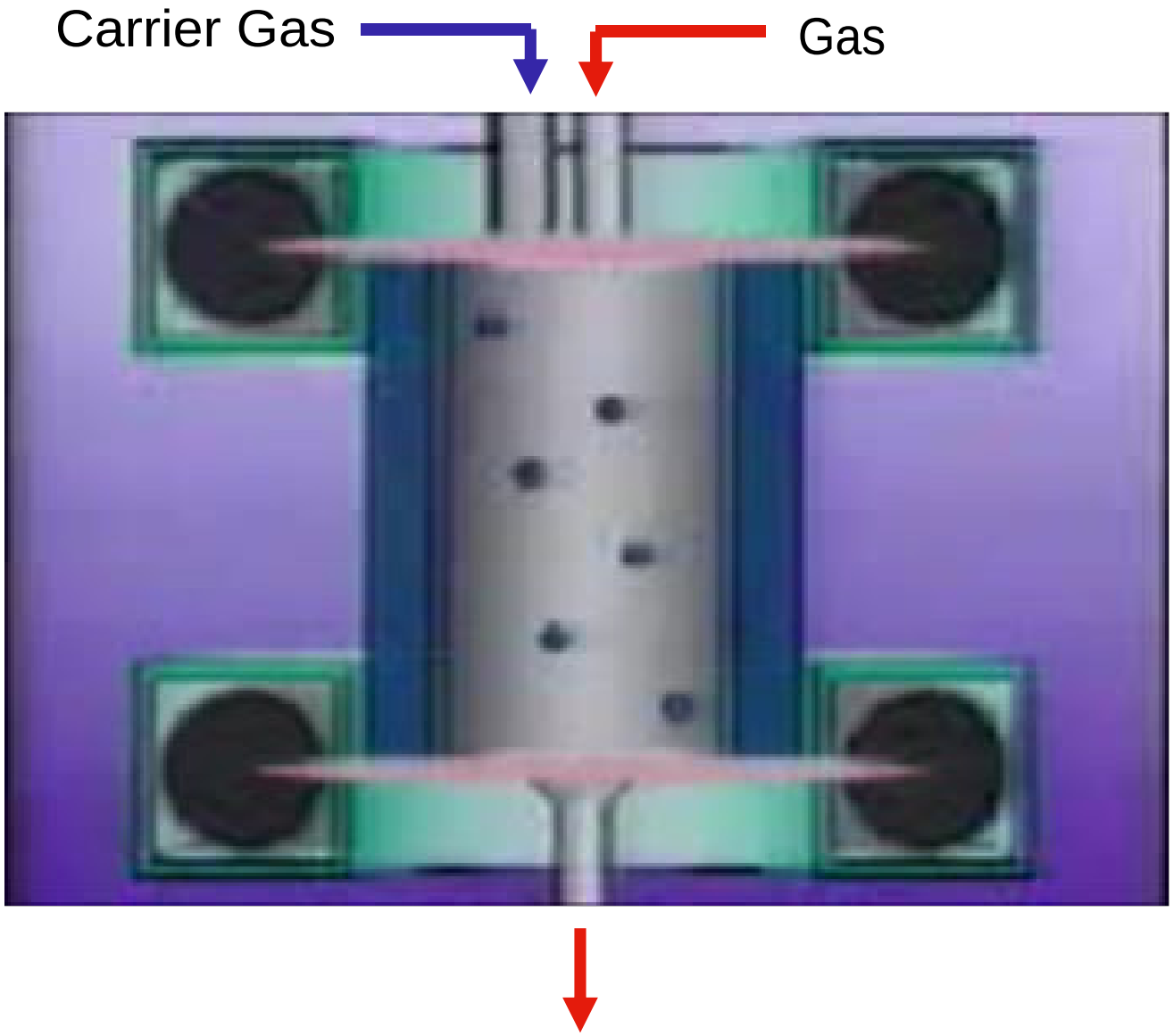
High ion density
$5.10^{14}/cm^3$, $10^{-2}T$,
B~10T, j^+~ 1A

Electron Cyclotron Resonance Source



No electrodes, magnetic bottle, microwave power 10GHz, 1-2kW, high charge states

Generation and Selection of Ions



Ions produced in the source can leave through extraction channel

Desired ion species selected by deflection magnet with adjustable field.

Transfer of slow ions to accelerator

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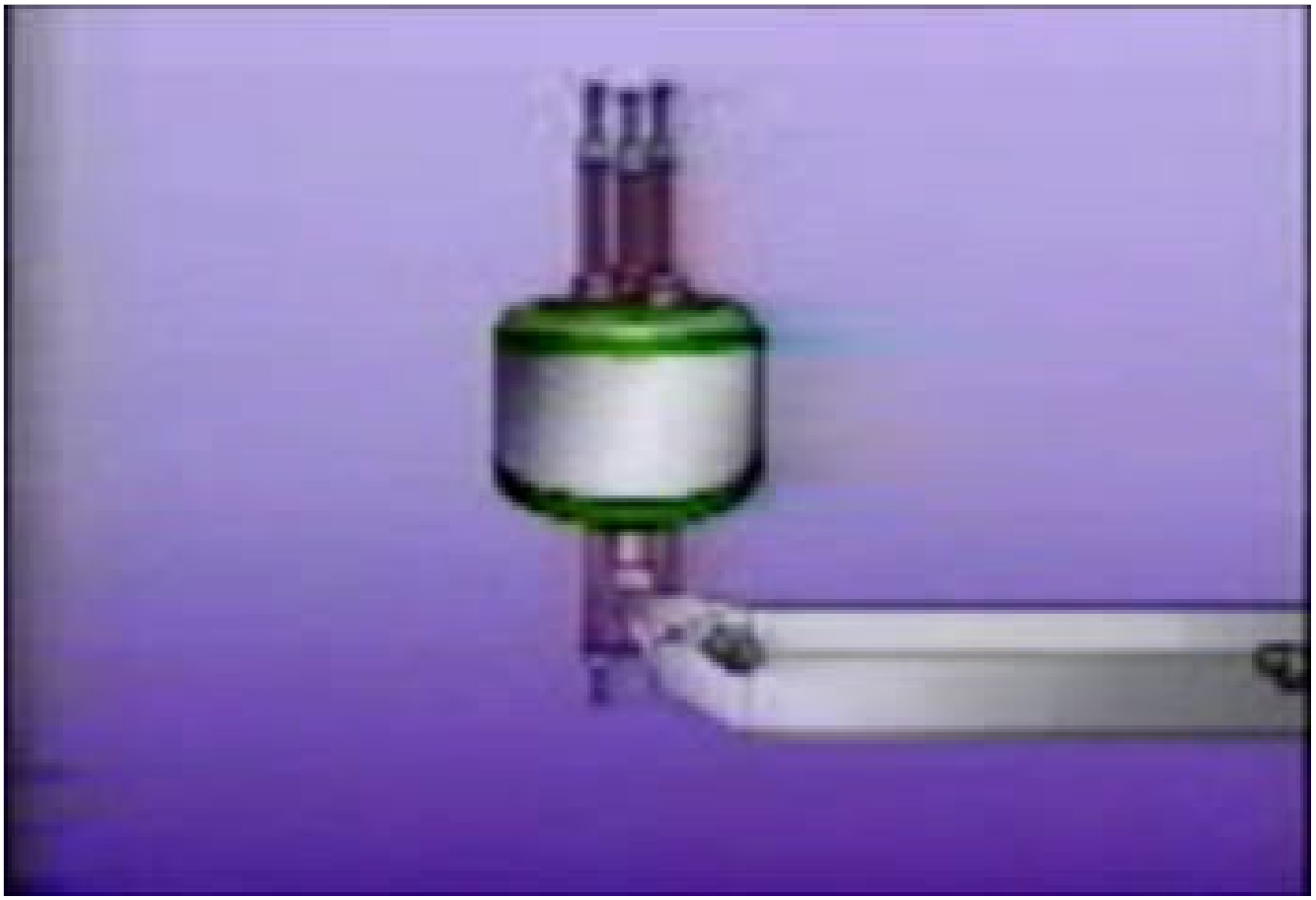
Next:
Acceleration of ionized particles

Injection and Acceleration



Ion trajectory (cyclic)

Acceleration

Injection (axial)

Transfer to accelerator

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