Polarized Ion Sources

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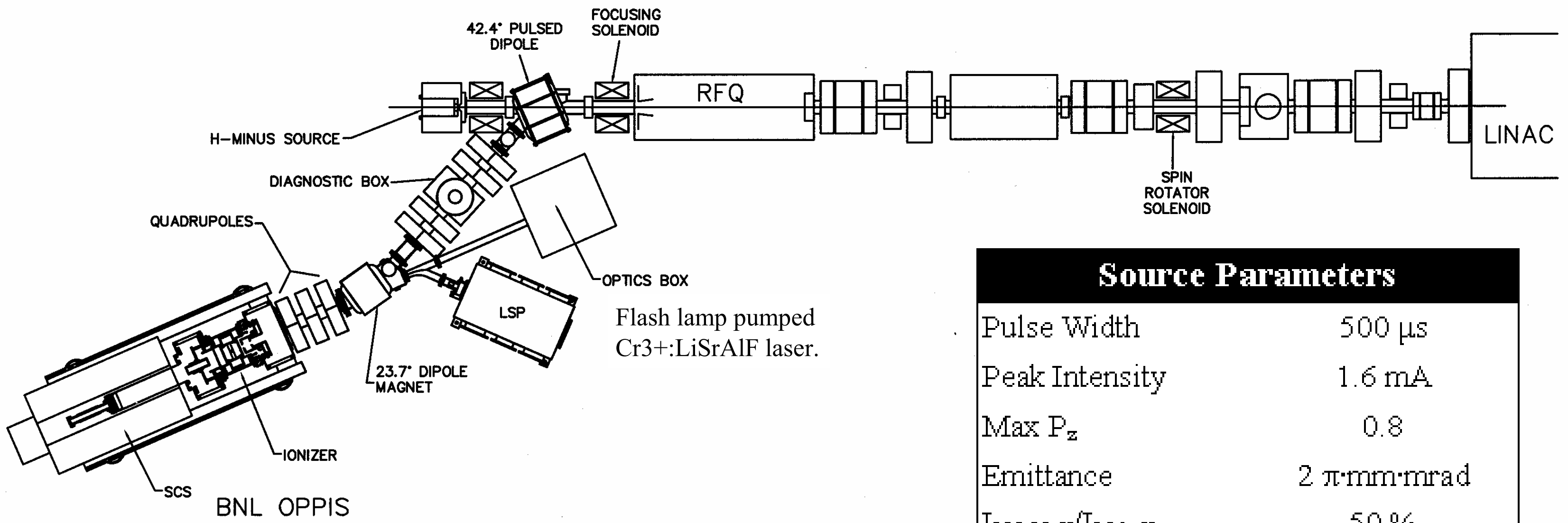
The OPPIS

POLARIZED SOURCE LAYOUT AT THE LINAC INJECTOR



Source Parameters	
Pulse Width	500 µs
Peak Intensity	1.6 mA
Max P_z	0.8
Emittance	2 π·mm·mrad
$I_{200\ MeV}/I_{35\ keV}$	50 %

Allows interleaving of 1 mA polarized H– beam and 100 mA unpolarized beam on pulse-to-pulse basis.

Longitudinal polarization out of the source converted to vertical polarization at the linac entrance.

A. Zelenski, SPIN 2002 Symposium, BNL, September 2002.

Potential H^+/H^- Source Parameters

Techniques:

- Atomic Beam Source with Resonant Charge Exchange Ionizer, eg., IUCF/INR CIPIOS with improvements.
- Optically Pumped Polarized Ion Source, eg., BNL OPPIS

Claimed Future Potential*:

ABS/RX Source:

H^- ~10 mA, 1.2 π·mm·mrad (90%), Pz = 85%
H^+ >20 mA, 1.2 π·mm·mrad (90%), Pz = 85%

OPPIS

H^- ~40 mA, 2.0 π·mm·mrad (90%), Pz = 85%
H^+ ~40 mA, 2.0 π·mm·mrad (90%), Pz = 85%

* Estimates are based on projections of existing source parameters. These characteristics seem feasible but must be proven.

Potential D^+/D^- Source Parameters

Techniques:

- Atomic Beam Source with Resonant Charge Exchange Ionizer, eg., IUCF/INR CIPIOS with improvements.
- Optically Pumped Polarized Ion Source, eg., KEK OPPIS

Claimed Future Potential*:

ABS/RX Source:

D^- ~10 mA, 1.3 π·mm·mrad (90%), Pz = 90%, Pzz=90%

D^+ >20 mA, 1.3 π·mm·mrad (90%), Pz = 90%, Pzz=90%

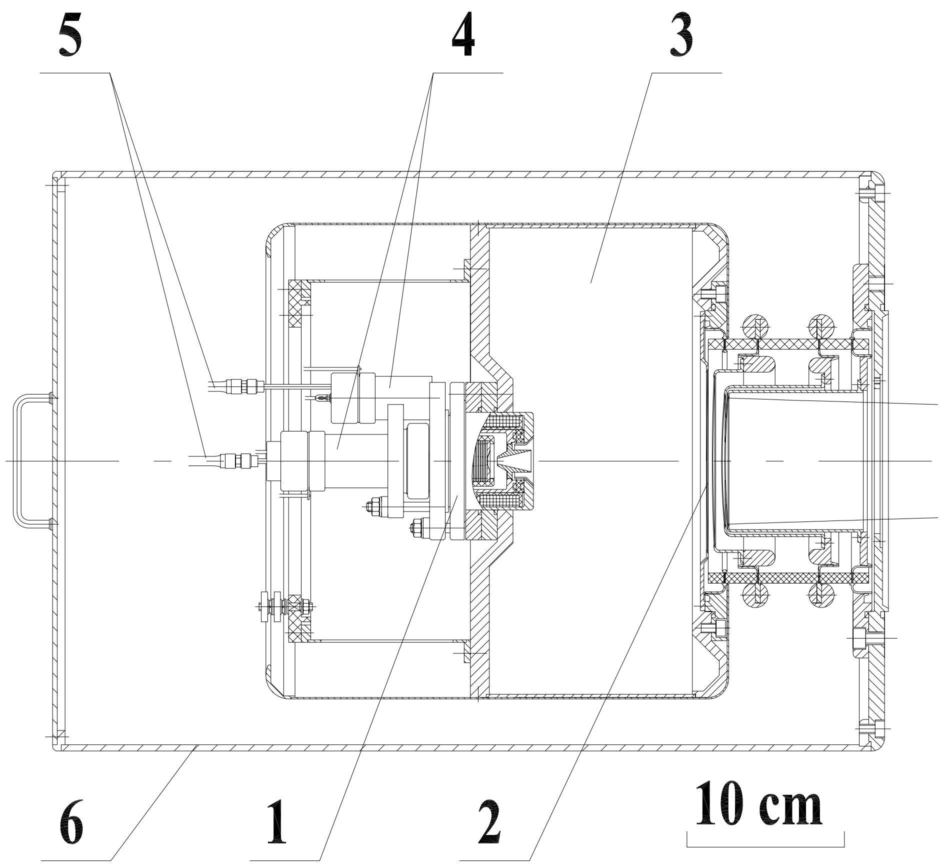
OPPIS

D^- ~40 mA, 2.0 π·mm·mrad (90%), Pz = 55%, Pzz=?

D^+ ~40 mA, 2.0 π·mm·mrad (90%), Pz = 55% , Pzz=?

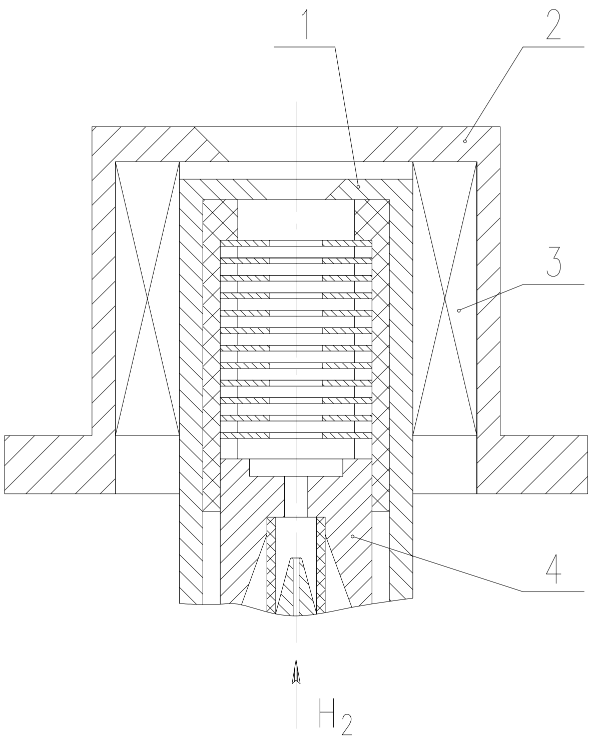
* Estimates are based on projections of existing source parameters. These characteristics seem feasible but must be proven.

Short pulse ion source



1- plasma generator, 2- electrodes of the ion optical system, 3- plasma expansion volume, 4- gas puffing valves, 5- HV feedthrough, 6- magnetic screen.

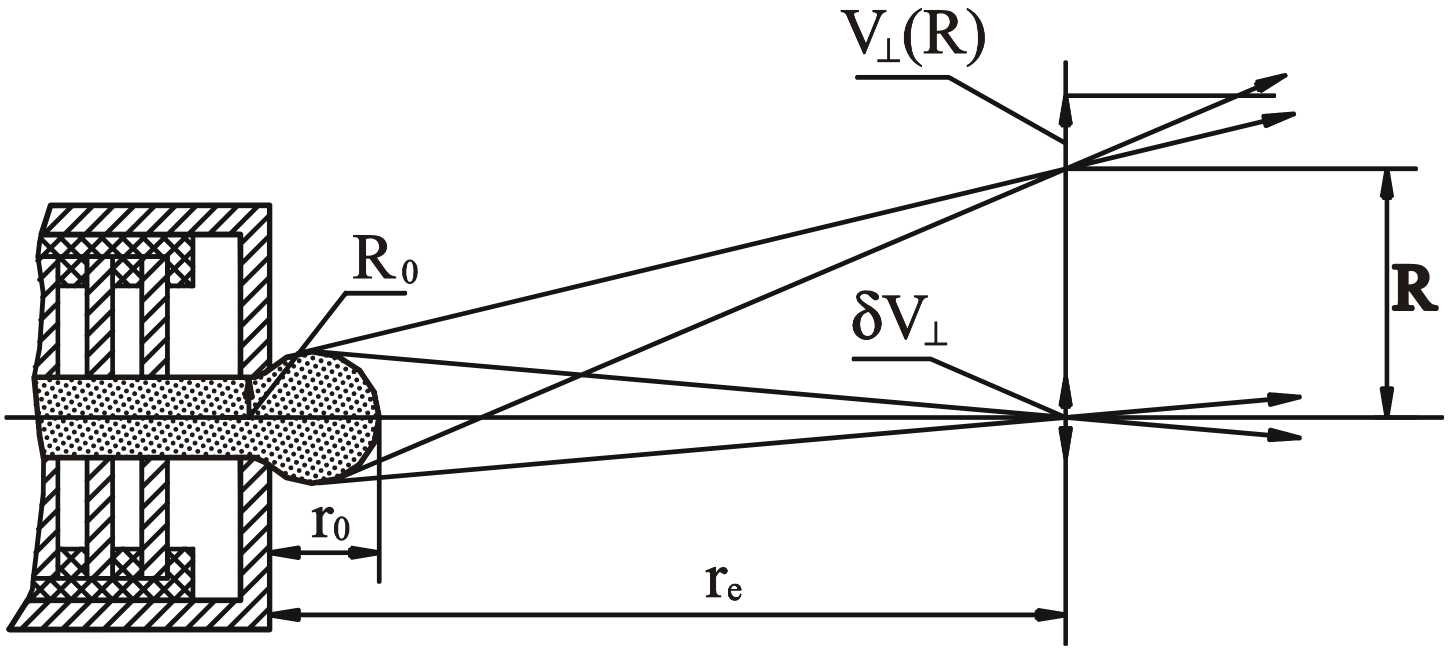
Arc plasma generator



1- anode, 2-magnetic shield, 3- coil, 4-anode

$I_d \approx 200\text{-}800$A, $U_d \approx 60\text{-}80$V, $\tau_d \leq 0.5$ s, $J_i \leq 180$ A

Low ion temperature in the plasma stream



$R_0 \sim 0.3$ cm $\quad n_0 \sim 10^{14}$ cm^{-3} $\quad T_{i0} \sim 3\text{-}5$ eV

$r_0 \sim 1$ cm $\quad T_{ie} \approx T_{i0}\, r_0^2/r_e^2$

Experimental value of $T_{ie} \approx 0.2$ eV

Existing Source Parameters

OPPIS/BNL, H^- only:	Pulse Width	500 μs (up to DC?)
(In operation)	Peak Intensity	>1.6 mA
	Max Pz	85% of nominal
	Emittance (90%)	2.0 π·mm·mrad
IUCF/INR CIPIOS:	Pulse Width	Up to 500 μs
(Shutdown 8/02)	Peak Intensity H-/D-	2.0 mA/2.2 mA
	Max Pz/Pzz	85% to > 90%
	Emittance (90%)	1.2 π·mm·mrad
INR Moscow:	Pulse Width	> 100 μs
(Test Bed Only)	Peak Intensity H+/H-	11 mA/2.5 mA
	Max Pz	80%/85%
	Emittance (90)%	1.0 π·mm·mrad/ 1.8 π·mm·mrad

Polarized $^3He^{++}$ Options

Spin Exchange in Optically Pumped Rb

with EBIS Ionizer (Zelenski)

- Polarization of 50% - 70% expected.
- ~ 2 x 10^{11} particles/pulse, small emittance.

Resonant Charge Exchange

of Polarized Atoms with $^4He^{++}$ (Belov)

- Polarization of ~ 70% - 80%.
- > 1mA beam current with 1 π·mm·mrad.

Note: No existing high current polarized $^3He^{++}$ source using these techniques exists.

Polarized $^{6}Li^{+++}$ Options

Existing Technology:

- Create a beam of polarized atoms using ABS.
- Ionize atoms using surface ionization on an 1800 K Tungsten foil – singly charged Li of a few 10's of μA
- Accelerate to 5 keV and transport through a Cs cell to produce negative ions. Results in a few hundred nA's of negative ions.

Investigate alternate processes such as EBIS ionizer proposal or ECR ionizer. Should be possible to get 1 mA? fully stripped beam with high polarization.

Properties of ^{6}Li: B_c = 8.2 mT, $m/m_N = 0.82205$, $I = 1$

B_c = critical field m/m_N = *magnetic moment*, I = *Nuclear spin*

Polarized $^{6}Li^{+++}$ Options

Existing Technology:

- Create a beam of polarized atoms using ABS.
- Ionize atoms using resonant charge exchange with Li ions from Arc discharge source, as for H^{+},and He^{+}.
- Accelerate to 5 keV and transport through a Cs cell to produce negative ions. Results in a few hundred mcA's of negative ions.

Investigate alternate processes such as EBIS ionizer proposal or ECR ionizer. Should be possible to get 1 mA? fully stripped beam with high polarization.

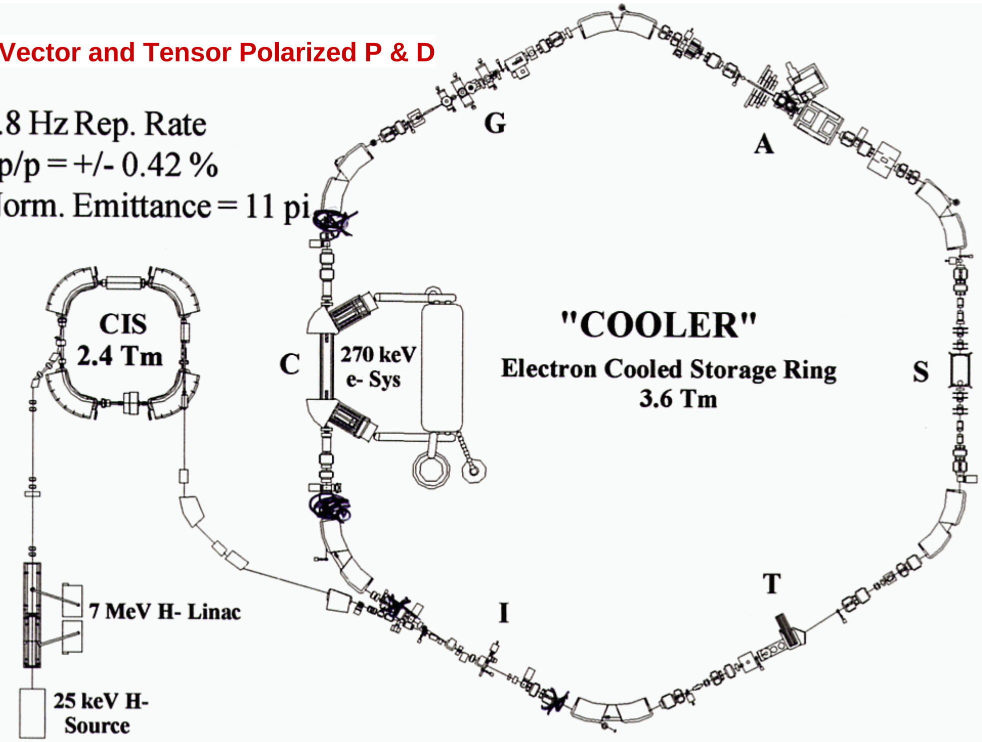
Properties of ^{6}Li: B_c = 8.2 mT, $m/m_N = 0.82205$, $I = 1$

B_c = critical field m/m_N = *magnetic moment*, I = *Nuclear spin*

IUCF Kick Injection with e-Cooling

~85%-90% Vector and Tensor Polarized P & D

0.8 Hz Rep. Rate
dp/p = +/- 0.42 %
Norm. Emittance = 11 pi



II. COOLER INJECT PERFORMANCE:

4 x 10^9 unpol p/pulse Injected at 202 MeV } 50% Injection Efficiency
1 x 10^9 pol p/pulse Injected at 202 MeV }
3.5 x 10^{10} p Accumulated in 120 seconds at 202 MeV (cooled accum)
0.99 x 10^{10} pol p Accumulated in 120 sec at 202 MeV "
0.7 x 10^{10} unpol d Accumulated in 60 sec & ramped to 240 MeV "
0.7 x 10^{10} pol d accumulated and ramped to 230 MeV

~85%-90% Vector and Tensor Polarized P & D

Goal: 2.5 x 10^{10} p/p Injected, 1-5 Hz, 80 % Vector Polarized