A Novel Solution for H^- Laser Stripping

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List of Participants

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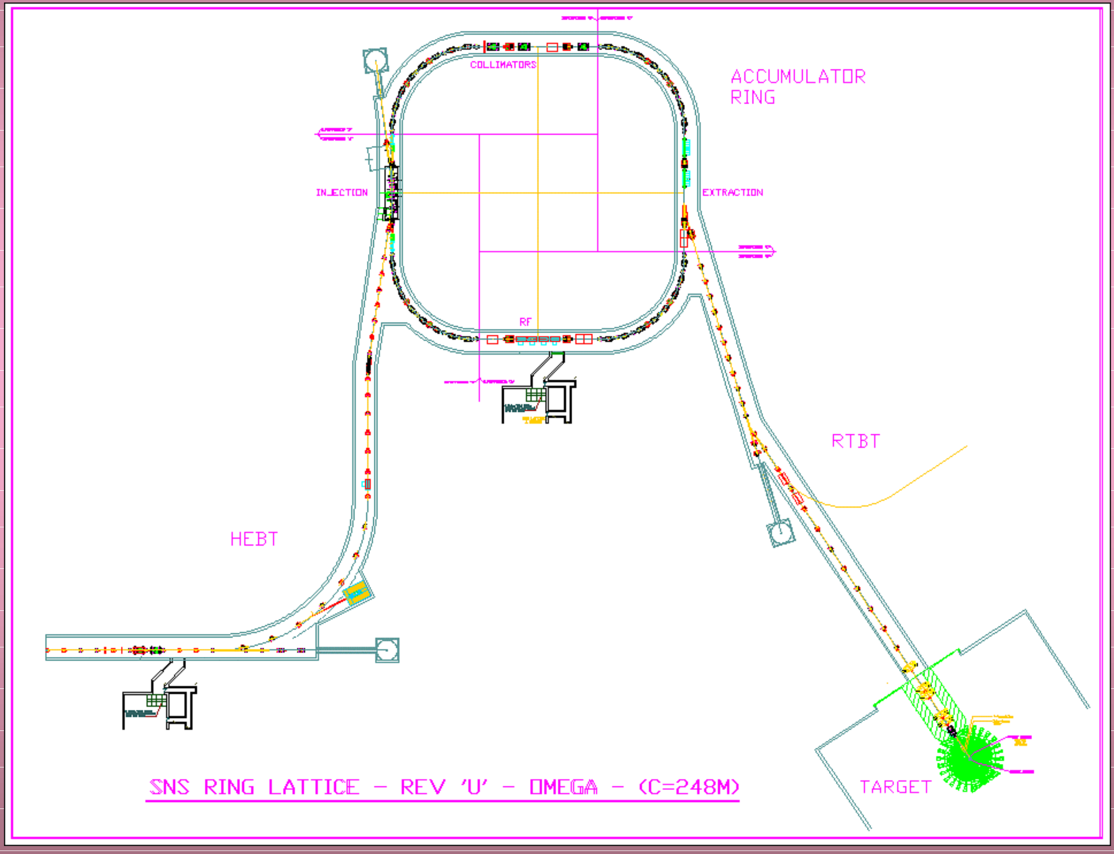
Summary Parameters for the SNS

• Proton beam power on target	1.4 MW
• Pulse repetition rate	60 Hz
• Linac beam duty factor	6.0 %
• Ring orbit rotation time	945 ns
• Number of injected turns	1060
• Ring fill time	1.0 ms
• Ring beam extraction gap	250 ns
• Accumulator ring circumference	248.0 m
• Ring injection energy	~1 GeV (H^-)
• Fraction of lost particles	~ less than 10^{-4}

Ring Lattice

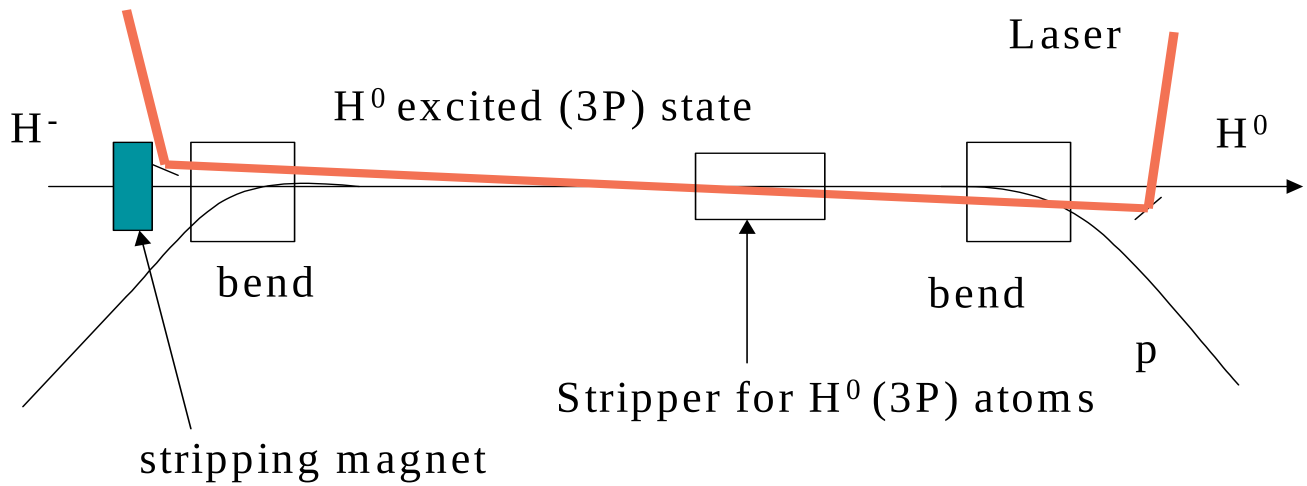


Laser Foil Advantages

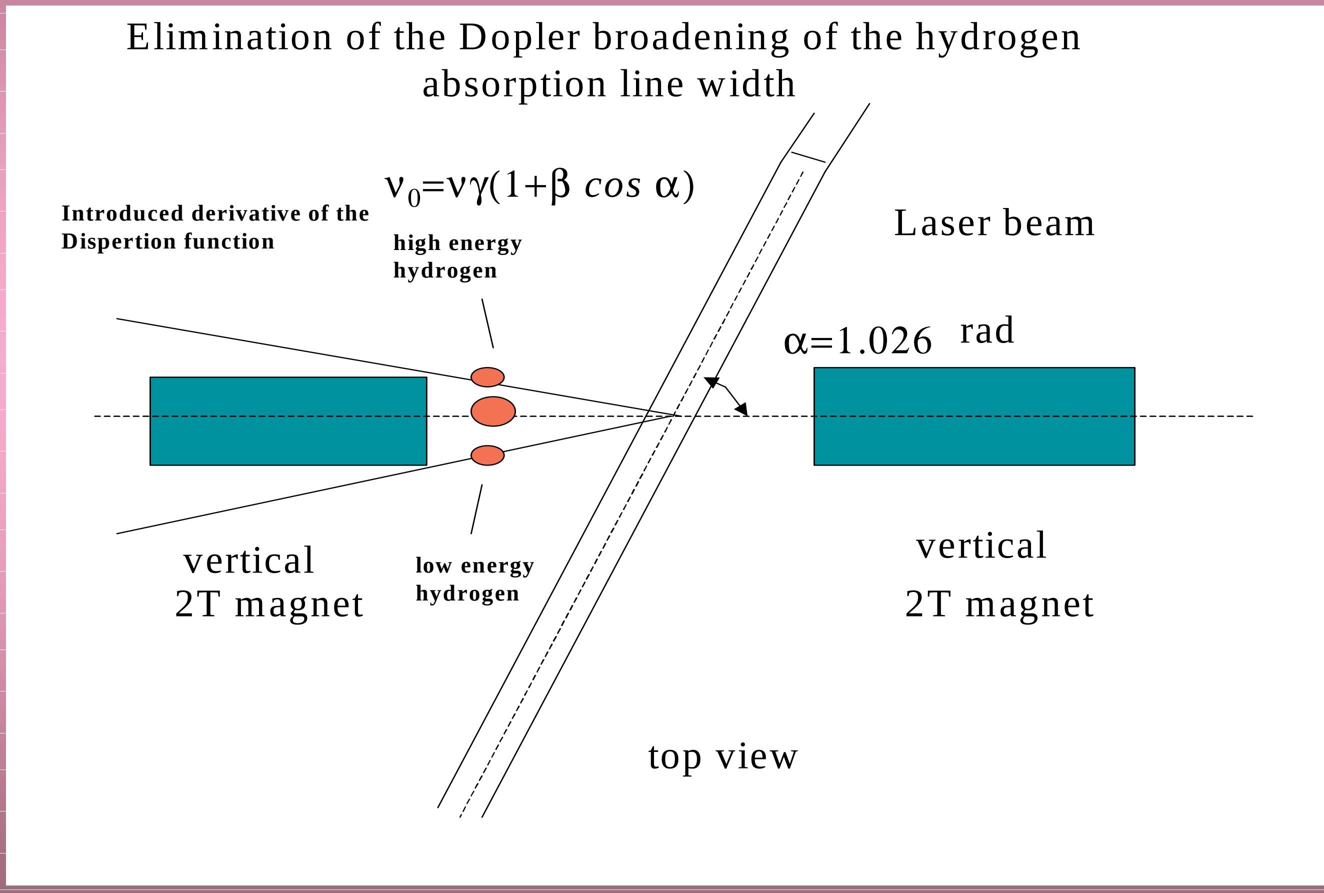
- the light beam is easy to operate with;
- it doesn’t produce radioactive elements;
- the laser stripping could be turned off and on in nanoseconds, leading to a possibility to clean the residual beam in gap (10^{-3} – 10^{-4} of the peak linear density) and to clean the tails left by slower LEBT chopper (if they were not lost in the linac), therefore one can eliminate H^- beam chopper, which will be built to clean the beam gap after the Radio Frequency Quadruple (RFQ);
- uncontrolled losses due to multiple traversals of the stripping foil by stored protons are eliminated;
- foil lifetime issues are eliminated;
- the laser stripping employs the resonant method of the hydrogen excitation, which depends on particles energy. This automatically provides the possibility to measure the beam energy with good accuracy after the acceleration in the SNS linac.

Basic Scheme for Medium Energy Stripping

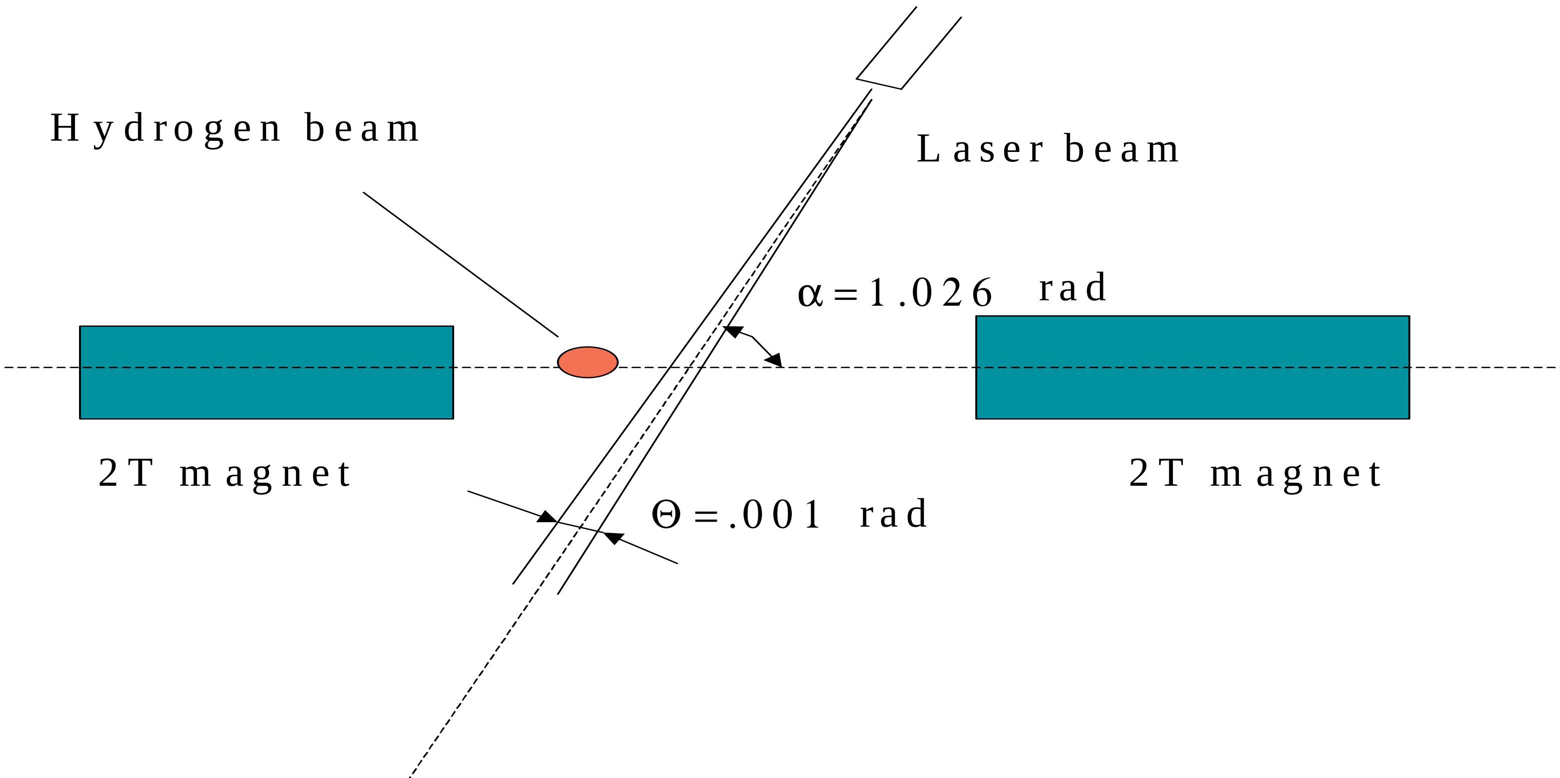
I. Yamane stripping scheme



1st Component of New Scheme – Elimination of the Dopler Broadening of the Absorption Line Width



2^{nd} Component of New Scheme – Light Beam Divergence to Cover All Excitation Frequencies



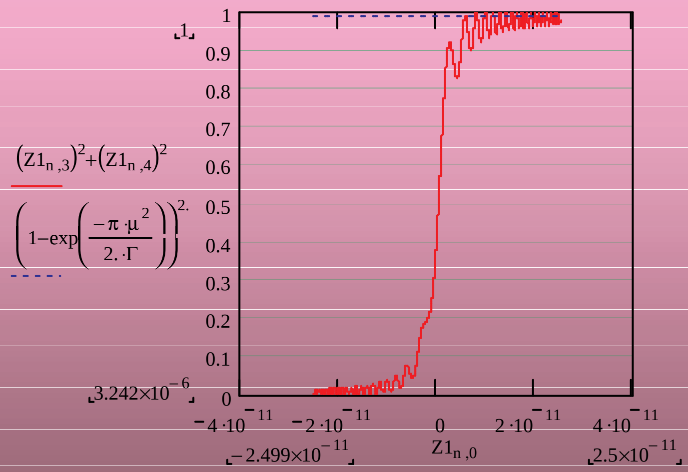
Froissart – Stora Solution

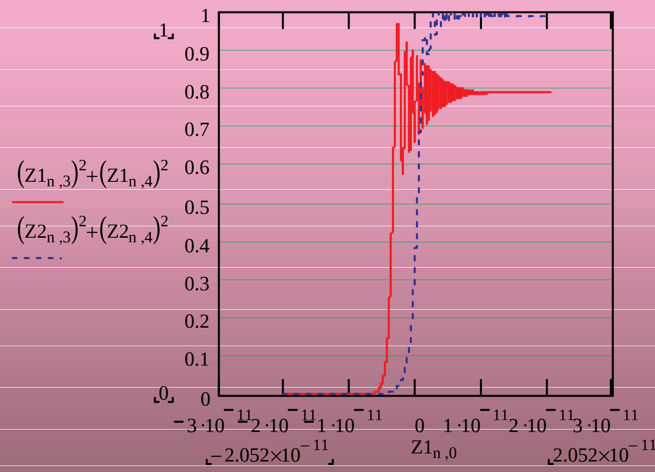
- Linear in Time Frequency Change – Two State Quantum Resonant System. Ideal case from t=- ∝ to t=+ ∝
- Asymptotic probability of excitation C_n^2 is expressed via Rabi frequency Ω and light frequency derivative with respect to time $\Gamma = d\omega/dt$

$$C_n^2 = (1 - \exp(-\frac{\pi\Omega^2}{2\Gamma}))^2$$

First Stage Experiment Estimations

- Linac Dump Transfer Line , 20 MW Excimer laser (308 nm), 20 ns pulse, vertical size of the light beam – 1.5 mm, horizontal size varies from 100 μm to 2cm, maximal angle divergence 0.001 rad – estimated stripping efficiency above 90%.
- Two examples – constant laser power density (20 MW total) with sharp edges (1.0× 0.17 cm²) (left) and Gaussian round beam 1.36 mm (right):

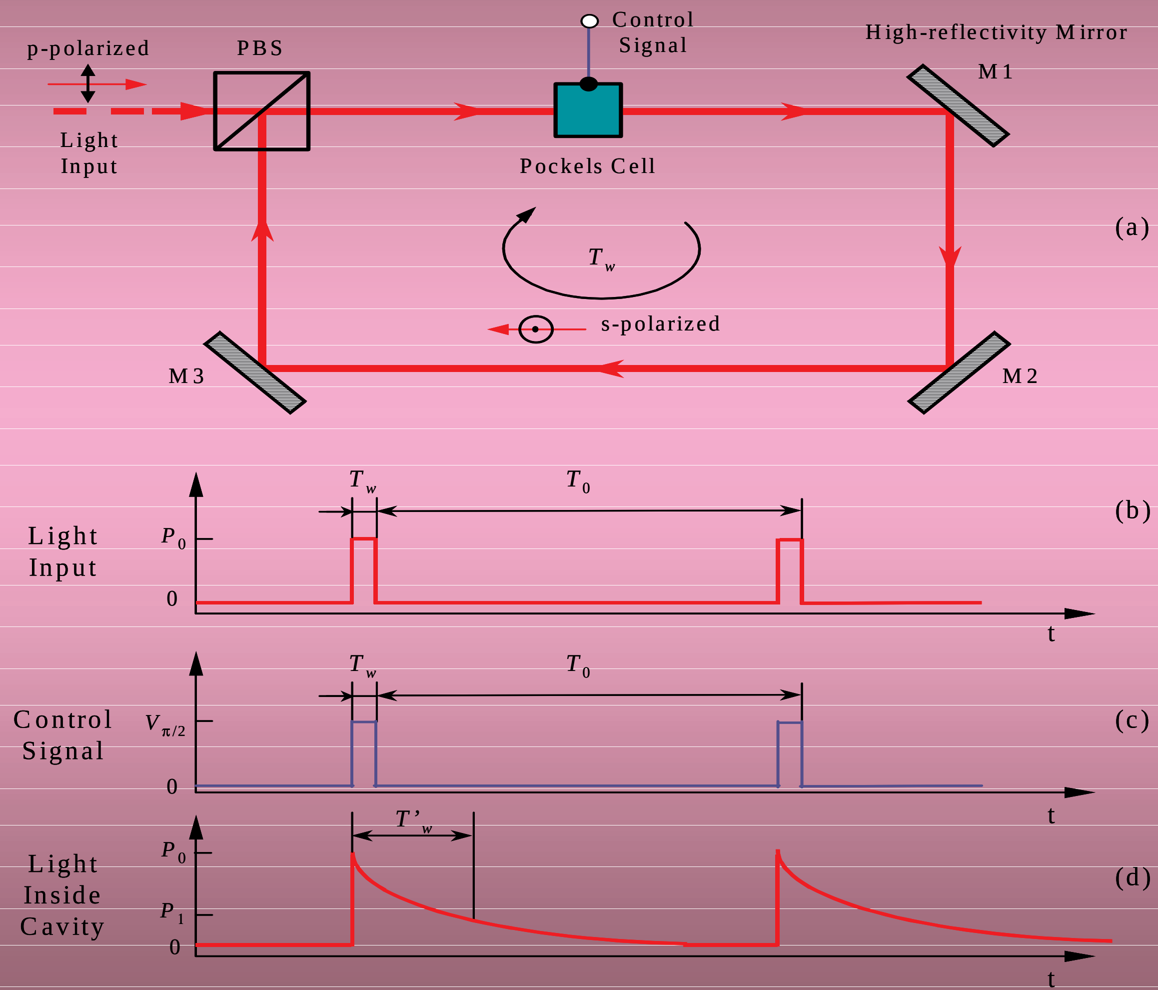




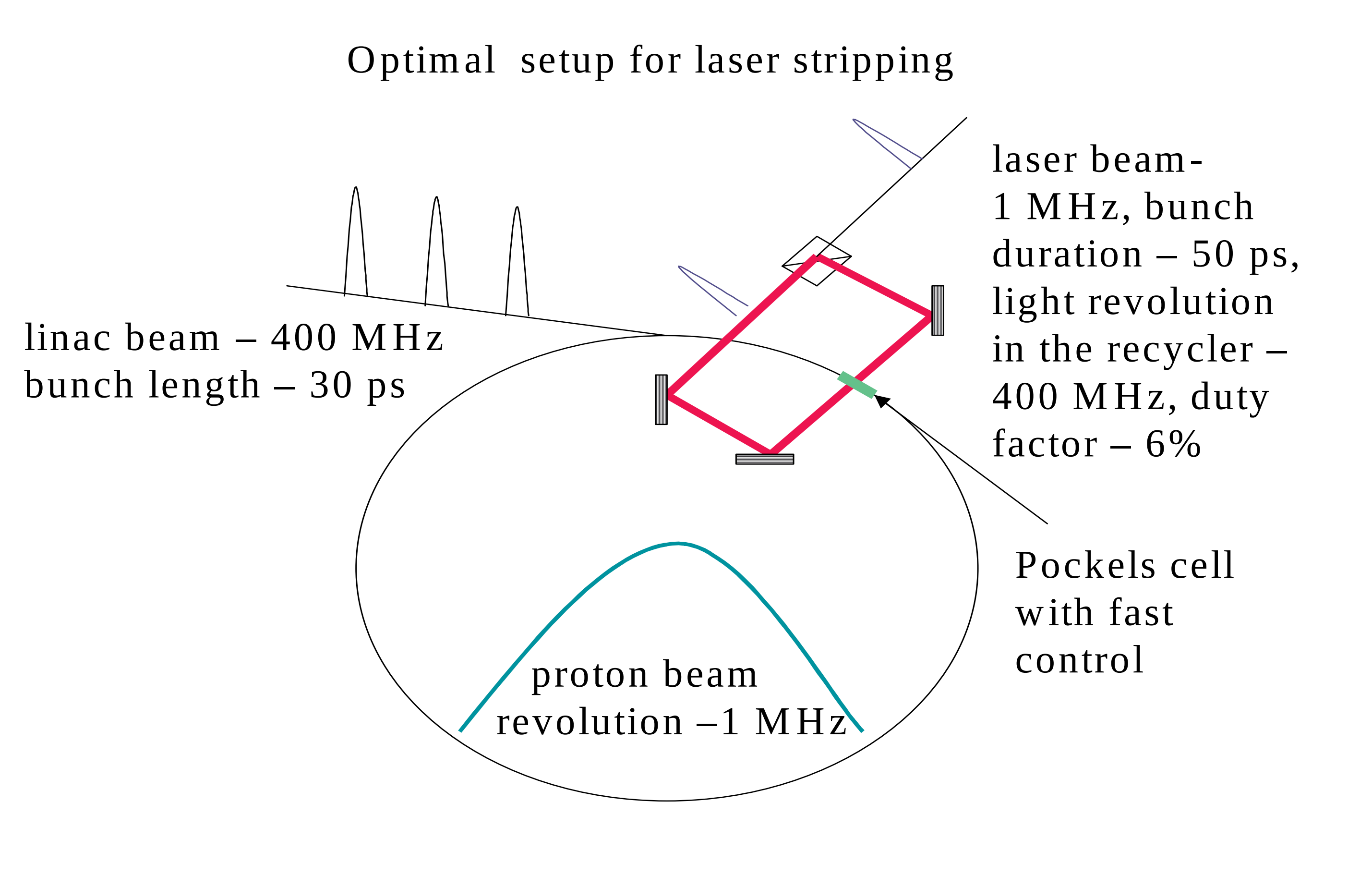
Second stage of proposed experiment – to reduce the required average laser power

- Laser beam recycling (factor 1000 of reduction anticipated)
- Dispersion derivative to eliminate the Dopler broadening of the absorption line (factor 10 of reduction)
- Vertical size reduction (factor 3 available)
- With taking into account linac beam duty factor (6%), the average laser power can be brought down below 100W with all the listed tricks

Laser Beam Recycling Scheme



Ideal Stripping Scheme



Summary

- It is found how to eliminate the Dopler broadening of the absorption line width due to the particle beam energy spread
- Laser beam recycling scheme is presented
- The most optimal scheme for the laser stripping is outlined
- The optimal variant has average power about 100W that is available in nonexpensive lasers – the problem is to have needed frequencies and repetition rates.
- Unresolved theoretical issues – to reduce betatron angle spread and to minimize angular spread from magnetic stripping