H- Laser Stripping

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Why Consider the Laser?

May be obvious for some, but to review:

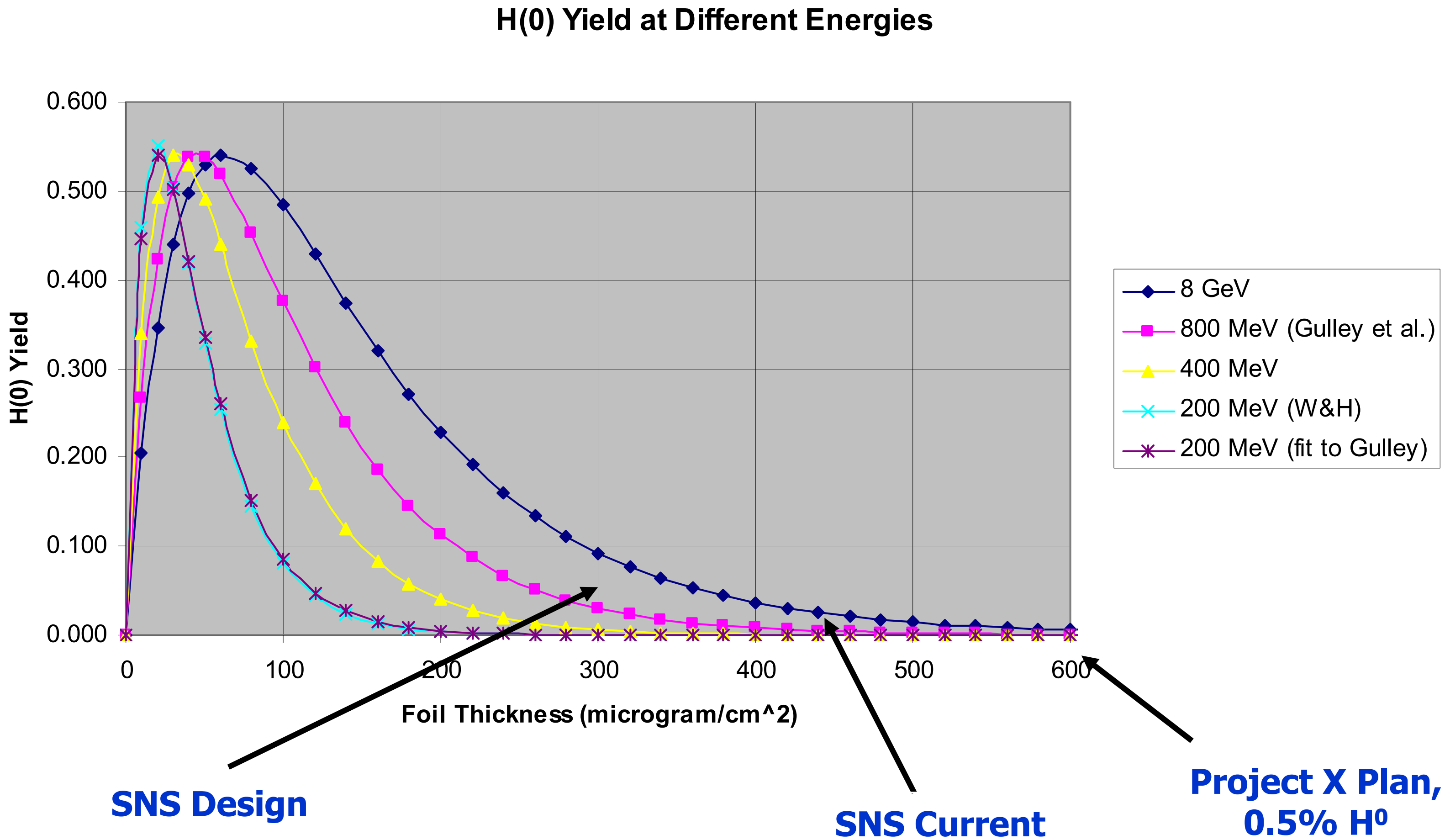
- Foil Survivability
- Losses from nuclear interactions
- Scattering from foil crossings
- More flexible painting schemes (e.g. CW injection)

Also, a foil may not be that conservative

- Machines have tended to need thicker foils
- Machines have tended to involve more foil crossings than planned
  - SNS has ~20 instead of 7 planned
- Longer injections become even more difficult

Stripping Efficiency

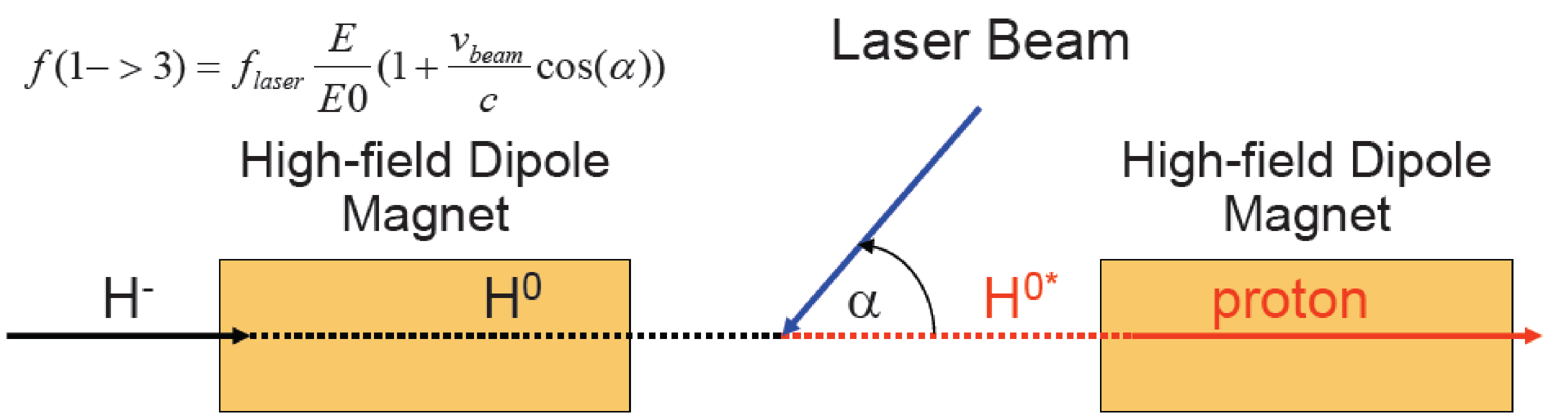
- Will 600 ug be enough?
  - SNS went to thicker foils
  - Booster already uses > 400 ug – PrX should be almost 3 times thicker



SNS Approach to Laser Stripping

- 3 step method:
  - Lorentz strip the outer electron
  - Excite atom with laser photons
  - Lorentz strip the excited electron

$$f(1->3) = f_{laser}\frac{E}{E0}(1+\frac{v_{beam}}{c}\cos(\alpha))$$



Step 1: Lorentz Stripping

$H^- \rightarrow H^0 + e^-$

Step 2: Laser Excitation

$H^0\ (n=1) + \gamma \rightarrow H^{0*}\ (n=3)$

Step 3: Lorentz Stripping

$H^{0*} \rightarrow p + e^-$

SNS Provides the Experience

- SNS has already shown >90% stripping efficiency
  - But, only for a very short segment of the pulse
  - Used a frequency tripled Nd:YAG laser
  - Diverging laser beam avoids problem of doppler broadening

- They are upgrading their experiments and are considering a true stripping system
  - Need to reuse the laser energy to approach a full pulse
    - Mode-locking the laser
    - Fabry-Perot cavity / optical resonator

Project X Application

- 8 GeV laser stripping should be simpler than 1 GeV
  - Less magnet required for stripping
  - Lower laser photon energy required
  - Able to use transition to n=2, instead of n=3
  - Less need for the dispersion function to be tailored
  - Smaller H- beam cross section

- However, still very challenging
  - High average and instantaneous powers
  - Laser/vacuum interface
  - Stripping efficiency of > 99%
  - Reliability, longevity, and cost

Thoughts on an Appropriate Laser

- Nd:YAG is usually the default
  - High-powered, and available
  - Requires 95º interaction angle

- Ho:YAG (Holmium) may be a better choice
  - 2100 nm instead of 1040
  - 35º instead of 95º interaction
  - High powers still available
    - Used in medicine
  - Infrared light has fewer safety concerns, and is less harsh on its optics.

VersaPulse PowerSuite 100 Watt, 60 Watt, and 80/100 Watt Lasers

VersaPulse PowerSuite 20 Watt Laser

Models	Single Wavelength: Holmium		
	20 Watt	60 Watt	100 Watt
Wavelengths	2.1 microns	2.1 microns	2.1 microns
Repetition Rate	5-20 Hz	5-40 Hz	5-50 Hz
Energy per Pulse	0.5 - 2.5J	0.2–3.5J	0.2–3.5J
Max. Tissue Effect Setting	2J/10 Hz	1.5J/40 Hz	2J/50 Hz
Electrical	110V/15A & 220V/10A 50/60 Hz Single Phase	230V, 50/60 Hz 20/30A Single Phase	230V, 50/60 Hz 20/30A Single Phase
Dimensions	19" x 24" x 45" (48 cm x 61 cm x 114 cm)	18" x 36" x 39" (46 cm x 91 cm x 99 cm)	18" x 36" x 39" (46 cm x 91 cm x 99 cm)
Aiming Beam	0.8 mW at 650 nm, 3 intensity settings, constant and blinking modes	2.5 mW at 650 nm, 3 intensity settings, constant mode	2.5 mW at 650 nm, 3 intensity settings, constant mode
Treatment Data Output	Printer Output	None	None
Weight	185 lbs/84 kg	340 lbs/155 kg	340 lbs/155 kg
Pulse Duration	Up to 500 microseconds		
Cooling	Self-contained water-to-air exchanger		
Delivery Systems	More than 20 reusable and single-use, flexible and rigid, with standard SMA connector		
Warranty	One year parts and labor.		

R&D Plans for 2009

- Our best progress will be made by experiments at SNS
  - Opportunity for collaboration

- We need to understand the details of the magnets, laser, and optics involved for 8 GeV stripping
  - Generate a conceptual design
  - Start engineering it to show that it is feasible
  - Start injection/painting simulations
    - Momentum collimation via stripping

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