There are different ways to add Fixed Target Options to a Linear Collider with minimal or reduced impact on Colliding Physics Running.

The specific ways proposed seem to have much to do with the physics background of the proponents. That is to say, the sociology of potential Fixed Target proponents has to be paid attention to.
Genealogy of Lepton Fixed Target Physics: SLAC

SLAC (past and present): 6 × 10^{13}/\text{sec}
of polarized $e^-$ (85%)
Dedicated, high luminosity

Polarized Targets:
$^3$He, $\text{NH}_3$, $\text{ND}_3$, $^6\text{LiD}$

Topics: spin content of the Nucleon

Experiments:
E-142, E-143
E-154, E-155
E-155X
(transverse)

Unpolarized Target: $^1\text{H}$

Topic: Weinberg Angle off the Z

E-158
5 × 10^{11} e on 1.5 m
of $\text{H}_2$ Target to
$\mathcal{L} \approx 5 \times 10^{38} \text{cm}^2 \text{sec}^{-1}$

SLAC (future = Real Photon Collaborations):
produce polarized $10^9 \gamma$'s/second from
4 × 10^{12} polarized e/second
Dedicated, high luminosity

Polarized and Unpolarized Targets

Experiments:
E-159 GDH Sum Rule $\text{NH}_3$, $\text{ND}_3$
$\Delta \sigma^{\gamma/N}(k)$
E-160 $\psi$ Photoproduction various A
E-161 Gluon Spin $\Delta G$ $^6\text{LiD}$
E-154/E-155/E-155X

E-154 $^3$He Target and Spectrometers

E-155 NH$_3$, ND$_3$, $^6$LiD  5 Tesla
Superconducting Microwave Target

Rainer Pitthan
CERN: $5 \times 10^7$ of polarized $\mu$ per SPS cycle (10+ sec) (80% polarization from decay of $\pi$)

Dedicated Low luminosity

Polarized Targets

$\text{NH}_3$ (80%) $\text{ND}_3$ (50%)

Topic: Spin content of the Nucleon (spin crisis)

Experiment: SMC (Spin Muon Collaboration)
DESY: from HERA 10^{17}/s
polarized electrons/positrons
Low luminosity, parasitic operation
quasi-CW beam (100% duty cycle)
Polarized Gas Targets \(^1\)H, \(^2\)D, \(^3\)He
Density: \(\approx 10^{14}\) atoms/cm\(^2\)

Topic: spin content of the Nucleon
Beam Polarization \(<p> = 55\%\)
Target Polarization
\(<^3\text{He} p> = 46\%\)
\(<^1\text{He} p> = 88\%\)

Luminosity: with 20 mA \(\Rightarrow \mathcal{L} \approx 10^{31}\) cm\(^2\) s\(^{-1}\)
The $Q^2$-dependence of the Generalised Gerasimov-Drell-Hearn Integral for the Proton

August 17, 2000

HERMES Collaboration

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Abstract

The dependence on $Q^2$ (the negative square of the 4-momentum of the exchanged virtual photon) of the Generalised Gerasimov-Drell-Hearn integral for the proton has been measured in the range 1.2 GeV$^2 < Q^2 < 12$ GeV$^2$ by scattering longitudinally polarised positrons on a longitudinally polarised hydrogen gas target. The contributions of the nuclear-resonance and deep-inelastic regions to this integral have been evaluated separately. The latter has been found to dominate for $Q^2 > 3$ GeV$^2$, while both contributions are important at low $Q^2$. The total integral shows no significant deviation from a $1/Q^2$ behaviour in the measured $Q^2$ range, and thus no sign of large effects due to nuclear-resonance excitations or non-leading twist.
### $L$ and $E_{\text{CM}}$ for Typical Experiments at Polarized Lepton Facilities $> 5\text{GeV}$

<table>
<thead>
<tr>
<th>Facility/Experiment</th>
<th>$E_{\text{CM}} [\text{ GeV}]$</th>
<th>$L [\text{ cm}^2 \text{ sec}^{-1}]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLAC</td>
<td>5-10</td>
<td>$&lt;5 \times 10^{38}$</td>
</tr>
<tr>
<td>HERMES</td>
<td>7</td>
<td>$2 \times 10^{31}$</td>
</tr>
<tr>
<td>COMPASS</td>
<td>20</td>
<td>$5 \times 10^{32}$</td>
</tr>
<tr>
<td>ELFE@CERN</td>
<td>7</td>
<td>$5 \times 10^{35}$</td>
</tr>
<tr>
<td>TESLA\n</td>
<td>22</td>
<td>$8 \times 10^{34}$</td>
</tr>
<tr>
<td>NLCN</td>
<td>22 – 31</td>
<td>$&lt;5 \times 10^{38}$</td>
</tr>
</tbody>
</table>
Recall: Schematic of Proposed NLC Fixed Target...
... with Disrupted beams, to do one SLAC Style Experiment...
Energy Collimation Possible but needs design effort.

Long energy tails of particles.

At 250 GeV per beam for $\Delta E/E = 1\%$ 1.6 MW have to be collimated.

At higher energy, the beams at collision get smaller, and the beamstrahlung and coherent pair production effects get even more severe.

Disruptive Beam 500 GeV cms

% of Particles, in 1% Bins

Power in MW, in 1% Bins [%]

Energy [GeV]

need to collimate 1.6 MWatt
Yuri Nosochkov's First Design...

Design has three separate beam dumps (red lines in plot) at progressively higher dispersion. The first dump is the conventional dump needed in any case.

Each beam dump has a through pipe which collimates the fixed target beam in energy.

The final energy definition is \( \pm 0.5\% \) (HWHM).
...with Progressively Staged Dumps...
Refinements leading to an engineering design being worked on. In particular, orbit changes due to synchrotron radiation losses have not been taken into account yet.
The beam is progressively more collimated.

Efficiency of collimation (width of through pipe and dispersion) has to be weighed against the impact on the entrance material to the collimator.

<table>
<thead>
<tr>
<th>Stage</th>
<th>D/mm</th>
<th>kW/%</th>
<th>kW/mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.3</td>
<td>100</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>200</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>400</td>
<td>20</td>
</tr>
</tbody>
</table>

Seems to be within the range of past dumps.
But There are Other Styles of Physics

• The Møller Experiment is the extreme case of needing large charges on a non-polarized target. It is an incentive to look for ways to use the disrupted beams.

• But there is other physics, driven by polarized target technology and/or coincidence background to lower currents.

• Then there is the whole world of gluon physics with real photons. Underway at SLAC with 50 GeV are E-159, E-160, and E-161 (look at http://www.slac.stanford.edu/detailed.html). Producing real photons with back scattered lasers requires a pristine quality beam. Coherent Bremsstrahlung production by scattering of diamond crystal planes is a possibility.

• Looking for other alternative ways might be well worth. One alternative, brilliant idea, has been used to develop TESLA-N (arXiv:hep-ph/0011299).
Example TESLA: Using the Positron Arm...
HERMES has specialized in precision measurements of spin structure functions, extending SLAC's work to understand the spin structure of QCD.

TESLA-N is focusing on the measurements of transversity distributions, important to understand missing chirally odd operators, which can only be measured with transversely polarized targets. Hence the importance of SLAC E-155X, http://www.slac.stanford.edu/exp/e155/e155extension/e155x.html, the only dedicated experiment with a transversely polarized target.
What are the Advantages of using the e+ Arm?

Concurrent Operation and Duty Cycle!

- One advantage is the ease of interleaving Collider Bunches with Fixed Target Bunches. The "opposite charge option" allows separation between the main beam and eN-experiment beams by a simple splitter magnet.
Filling the Empty Buckets

- Another advantage by filling the empty 440 buckets between the 2830 e+e- bunches with a very low charge (~2 \(10^4\) e are proposed), a 0.5 % duty cycle beam for coincidence experiments is being created. This increases the beam loading by only 0.04%.

- The physics proposed is an extension of the HERMES physics, and therefore is geared toward needing a good duty cycle.
What About an NLC-N?

- In principle one could use the positron side also with NLC: there are 15 empty buckets between the colliding physics buckets.

- This could enable the production of $\gamma$-beams with back scattered lasers, or with coherent beamstrahlung production.

- Let's assume 1% relative beam loading is acceptable (or lowering the colliding physics charge by 1% is acceptable), then the empty buckets will carry $<1\,\text{pCoul}$ each, making for a very high quality beam, with a charge of up to $10^{11}\,\text{e}^{-}\text{sec}^{-1}$. This will be enough for most experiments, in particular production and scattering of real photons* (http://www.slac.stanford.edu/exp/e159/photonbeam/index.html).

- Details of possible wake field problems in the first few buckets produced by the high charge $e^+$ bucket need to be evaluated.

*remember, the figure of merit for $\gamma$-scattering goes up with energy
from back scattered lasers
(D. Asner)

\[ E_{\gamma}(\text{GeV}) \]

\[ \text{Electron, velocity}=b. \]
Lag by one photon wavelength over distance \(a/\lambda\)

Coherent Bremsstrahlung Production from crystal (diamond) scattering with \(4 \times 10^{10}\) electrons incident, from a 0.0004 radiation length diamond

Calculations by P. Bosted
Conclusions

• There are still ideas out there we have not thought of.

• Using the NLC disrupted beams for Fixed Target experiments has the advantage of having high currents completely parasitically. The price to pay is the cost of the system of clumps, the emittance and energy spread of the beam. While this is not essential for many fixed target experiments, it (probably) precludes to produce $\gamma$'s with Laser Compton Scattering.

• Using an Opposite Charge Scheme has the advantage of producing low emittance quality beams with low energy spread, which could be used to produce backscattered polarized $\gamma$'s. Going this route will have a moderate impact (1%) on the total $e^+$ charge being accelerated for colliding beams.

• Maybe we can come up with an even better idea how to increase at moderate cost the total physics potential of the 250 – 500 GeV Linear Electron/Positron Accelerator we want to build.