



Towards a Polarized Positron Source

based on talk by Dave Schultz
FNAL 6/1/00



Introduction

- Why do it?
 - Physics potential with polarized positrons.
 - If the conventional approach fails, reduces energy loss in target to ~20%.
 - Lower emittance e^+ beam simplifies capture, damping rings.
- Scheme:
 - Generate circularly polarized high energy gammas
 - Convert in a thin target, high energy e^+ retain polarization
- Two approaches being pursued
 - Gammas from Compton backscattering (LLNL)
 - Gammas from an undulator (SLAC)
- Incremental cost; \$\$\$
 - Little work done to date.
 - Savings from lower emittance, but need laser/undulator, transport lines.



Specific Issues (an incomplete list)

Compton-based Source

- Possible layout and cost
 - e^- beam – few GeV
 - Laser - difficult
 high power, high rate
 - Polarization easy
 - Provides for random helicity flips
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- Low intensity expt done at KEK
 - Being pursued at LLNL

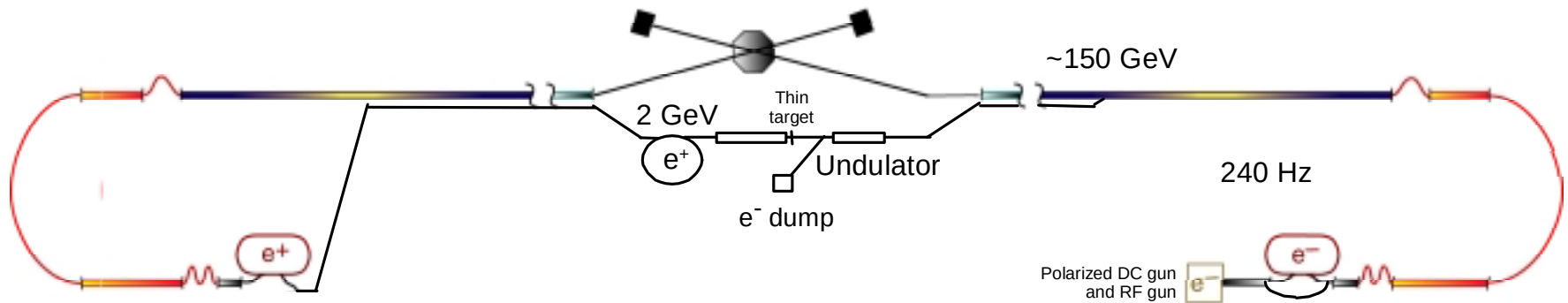
Undulator-based Source

- Possible layout and cost
 - e^- beam – 150 GeV?, intensity?
 - Undulator - wavelength?
 Can undulator be in main e^- beam?
 - Polarization challenging
 - Changing helicity is difficult
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- TESLA design uses undulator
 - Being pursued at SLAC



Undulator-based Example Layout

Based on work of Artem Kulikov at SLAC, also Mikhailichenko and Bessanov.



Scenario 1

e^- Source runs at 240 Hz , 120 into + 120 bypassing DR, Polarized RF Gun?
First 150 GeV of e^- Main Linac also runs at 240 Hz (\$\$\$).

Scenario 2

Primary e^- beam passes through undulator. Emittance preservation needs study.



Polarized Positron Timetable

- by Fall, 2000
 - Finish with SLC positron target damage analysis
 - Finish shock/stress simulations at LLNL
 - Determine if the conventional target should be dropped
 - Finish calculations / simulations of e^+ yield and net Polarization
 - Finish parameter table for the photon beam
- by Snowmass
 - Specify and cost scheme(s) as possible options

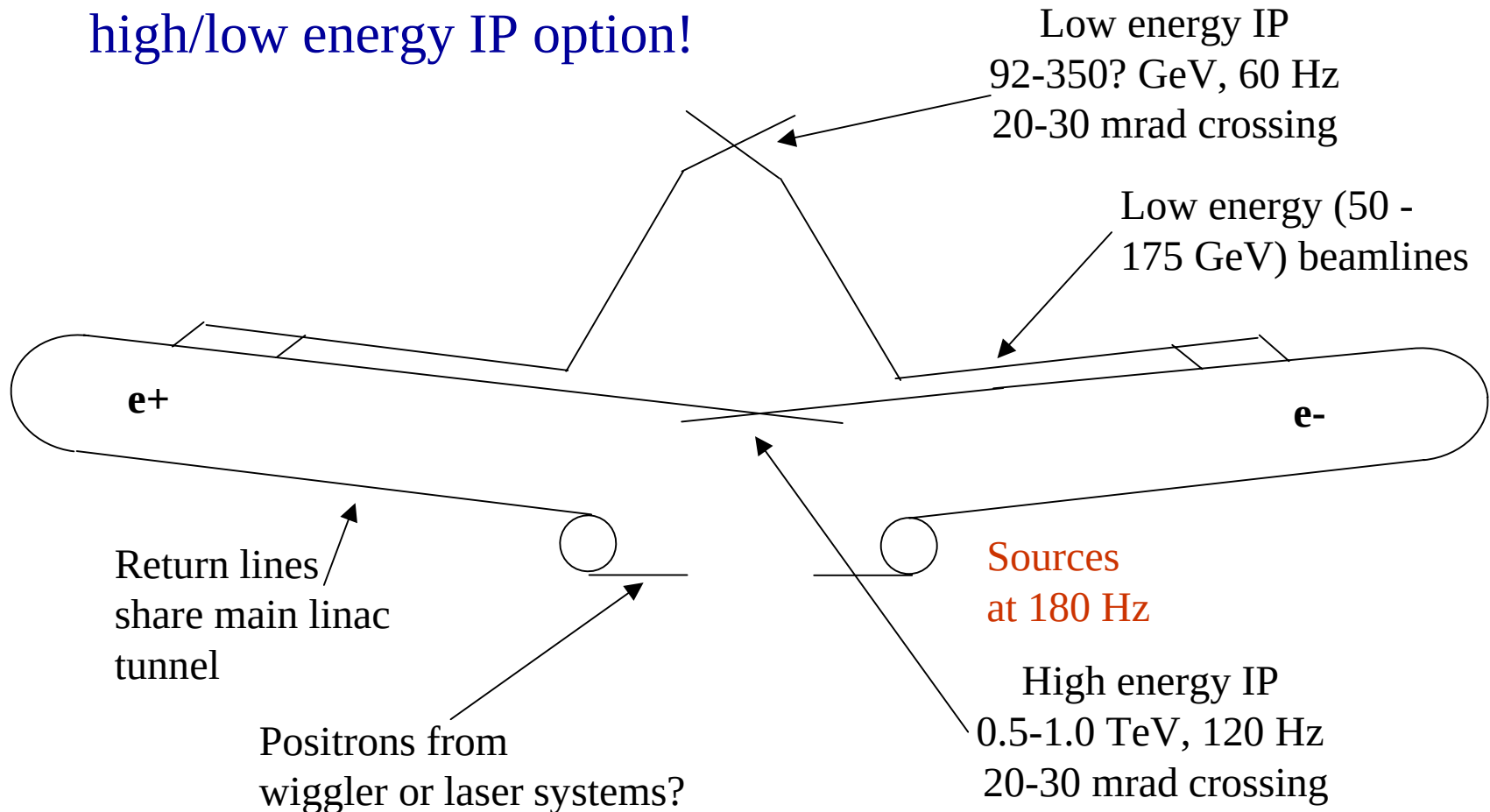


Low / High Energy IR Option

Qualifier: No work has been done!

Low/High Energy IP Option

Poorly drawn schematic of
high/low energy IP option!





IR Layouts

- **CD1**
 - 10 mrad “Big Bend”
Studied IP layout, energy scaling, muon backgrounds, magnet technologies
 - 2 IRs separated by $(\Delta x, \Delta z) = (44\text{m}, 280\text{m})$
only one detector gets luminosity at a time
- **Present layout**
 - 10 mrad “Big Bend” but shorter FF, now $(\Delta x, \Delta z) = (16\text{m}, 280\text{m})$
actually increased FF length to provide sufficient separation
 - studying issues with this IR now
- **Future layout?**
 - Single high-energy IR without big bend (and push-pull detectors?)
 - Low-energy IR optimized for maximum beam energy of 360 GeV?
 - Both regions receive luminosity with injector operating at 180 Hz

Luminosity Estimates

Preliminary! IP Parameters for low energy IR						
	90 GeV			250 GeV		
	Nominal	Semi-High	Round	Nominal	Semi-High	Round
Luminosity (10^{33})	1.3	1.7	4.1	2.7	4.4	7.7
Pinch Enhancement	1.3	1.4	4.4	1.4	1.4	3.9
Repetition Rate (Hz)	60	60	60	60	60	60
Bunch Charge (10^{10})	1	0.75	0.7	1	0.75	0.7
Bunches/RF Pulse	95	190	190	95	190	190
Bunch Separation (ns)	2.8	1.4	1.4	2.8	1.4	1.4
Injected $\gamma\epsilon_x / \gamma\epsilon_y$ (10^{-8})	300 / 3	300 / 2	300 / 3	300 / 3	300 / 2	300 / 3
$\gamma\epsilon_x$ at IP (10^{-8} m-rad)	400	360	360	400	360	360
$\gamma\epsilon_y$ at IP (10^{-8} m-rad)	6	3.5	5	7	4	5
Tolerances	10	10	13	9	9	10
β_x / β_y at IP (mm)	10 / 0.10	10 / 0.10	1 / 1	10 / 0.12	10 / 0.10	1.3 / 1.3
σ_x / σ_y at IP (nm)	670 / 8	632 / 6	200 / 24	400 / 6	384 / 4	140 / 16
σ_z at IP (um)	125	100	125	125	100	125
L0 / Ltotal (%)	55	62	13	40	48	9
Yave	0.01	0.01	0.03	0.06	0.06	0.12
Beamstrahlung δB (%)	0.28	0.22	4.2	1.7	1.3	13.9
Photons per e+/e-	0.6	0.5	2.5	1	0.8	3.1
Polarization loss (%) ??	0.1	0.1	0.6	0.3	0.2	1.7



Low / High Energy IR Issues

- 180 Hz beam rate
 - Positron target
 - Damping rings
 - Klystrons / modulators average power limitations - probably OK
 - Injector beam dumps
 - Site power and cooling
- Main linac extraction sections
- Beam Delivery
 - Smaller energy range allows for better FF magnet optimization
 - Muon backgrounds increase for high-energy IR
 - Push/pull detector arrangement for high-energy IR?
 - Required IR separation?
 - Required luminosity performance?



Positron Generation

- NLC ‘conventional’ e^+ source is difficult
 - 6 GeV e^- beam incident on a ‘thick’ 4 r.l. target
- Two other options: undulator or laser based systems
 - 100+ GeV beam through an undulator to generate 20+ MeV photons which are directed on a ‘thin’ 0.5 r.l. target
 - Backscatter 1-10 μ m laser on few GeV beam to generate photons - very high power laser system
- Both can generate polarized positrons by using polarized undulator or polarized laser beam although yields are lower and system is more difficult
- TESLA must rely on undulator-based technique because of power into target
- Undulator scheme is more difficult when running at the Z



180 Hz Damping Rings

- High rate beam for simultaneous operation of both IRs

$$\varepsilon_{ext} = \varepsilon_{inj} e^{-2t/\tau} + \varepsilon_0 (1 - e^{-2t/\tau})$$

- Higher beam rate $\Rightarrow$ faster damping or smaller injected emittances
- Improve e- damping ring -- probably need 2 rings but less wiggler which makes each ring simpler
- Similar problem on e+ side -- improved e+ emittance using undulator or laser based system will help although will likely need to replace MDR with 2 rings anyway
- Other components are not a limitation except for ac power



Main Linac Beam Extraction

- Have extractions at 55 GeV, 100 GeV, and 180 GeV??
 - This should cover close to full range
 - What is needed?
- Pulsed kicker might be considered although dangerous for MPS and beam stability
 - Existing SLAC kicker (S2) has an integrated field of 3 kG-m and would cause a 1 mrad deflection of a 100 GeV beam
 - Stability must be $\ll 1/1000$
- Alternately use beam energy in a dispersive region but this requires a larger insertion in the linacs (100 meter)
- Need to add bypass line along length of linac



Beam Delivery Issues

- Final focus aperture is set by low energy beams but magnet strength is limited by highest energy operation
 - Final focus has limited energy range without rebuilding magnets and vacuum system
- Simplify design by dedicating one IR to ‘low’ energy operation and one to high energy operation
 - ‘Low’ energy range of 90–350? GeV
 - ‘High’ energy range of 250–1000 GeV
- High energy beamline would have minimal bending to allow for upgrades to very high collision energies
 - ‘High’ energy BDS could be upgraded to multi-TeV operation
- Separate collimation for low and high energy beams



Interaction Region Issues

- Need transverse and longitudinal separation to isolate one IP from vibration inducing activity at the other
 - how much?
- Need a crossing angle to minimize parasitic collisions from closely spaced bunches
- Need crossing angle of 20 mrad or more to provide space for injection and extraction line magnets
 - Difficulties with low energy beam in solenoid
- Big bend provides order of magnitude reduction in muons generated in collimation section
 - however Big Bend limits the maximum energy of the BDS since emittance dilution in arc scales as E^6 and sets limit on IR separation



Questions

- Is the low/high-energy IR option interesting?
- Is the high-energy IR with a push-pull detector arrangement acceptable by itself?
- Not free!
 - Upgraded DRs, klystrons, modulators, ac distribution, bypass line
 - 2nd collimation system, EOL diagnostics, big bend, FF, and IR
- Luminosity and beam requirements are needed!
 - how much, what beamstrahlung, what polarization loss?
 - Energy and polarization: stability, measurement accuracy, and measurement precision?
- Lots of work on e^+ sources and damping rings