Low / High Energy IR Option

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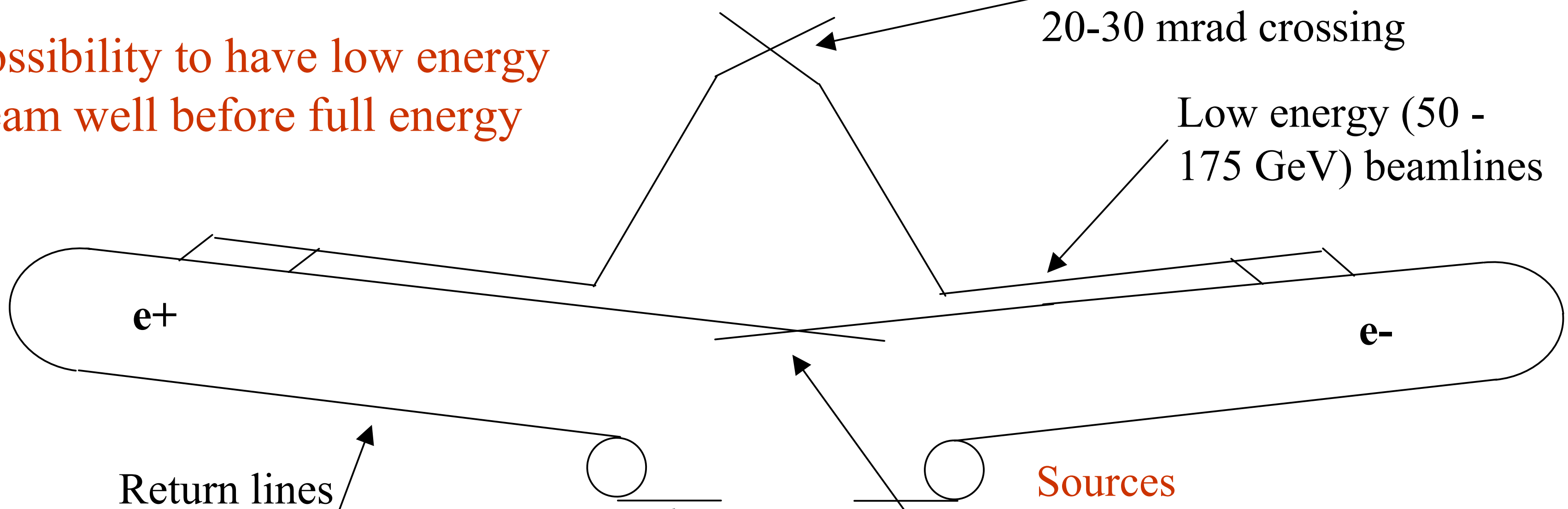
Qualifier: Real work has yet to be done!

Low/High Energy IP Option

Poorly drawn schematic of high/low energy IP option!

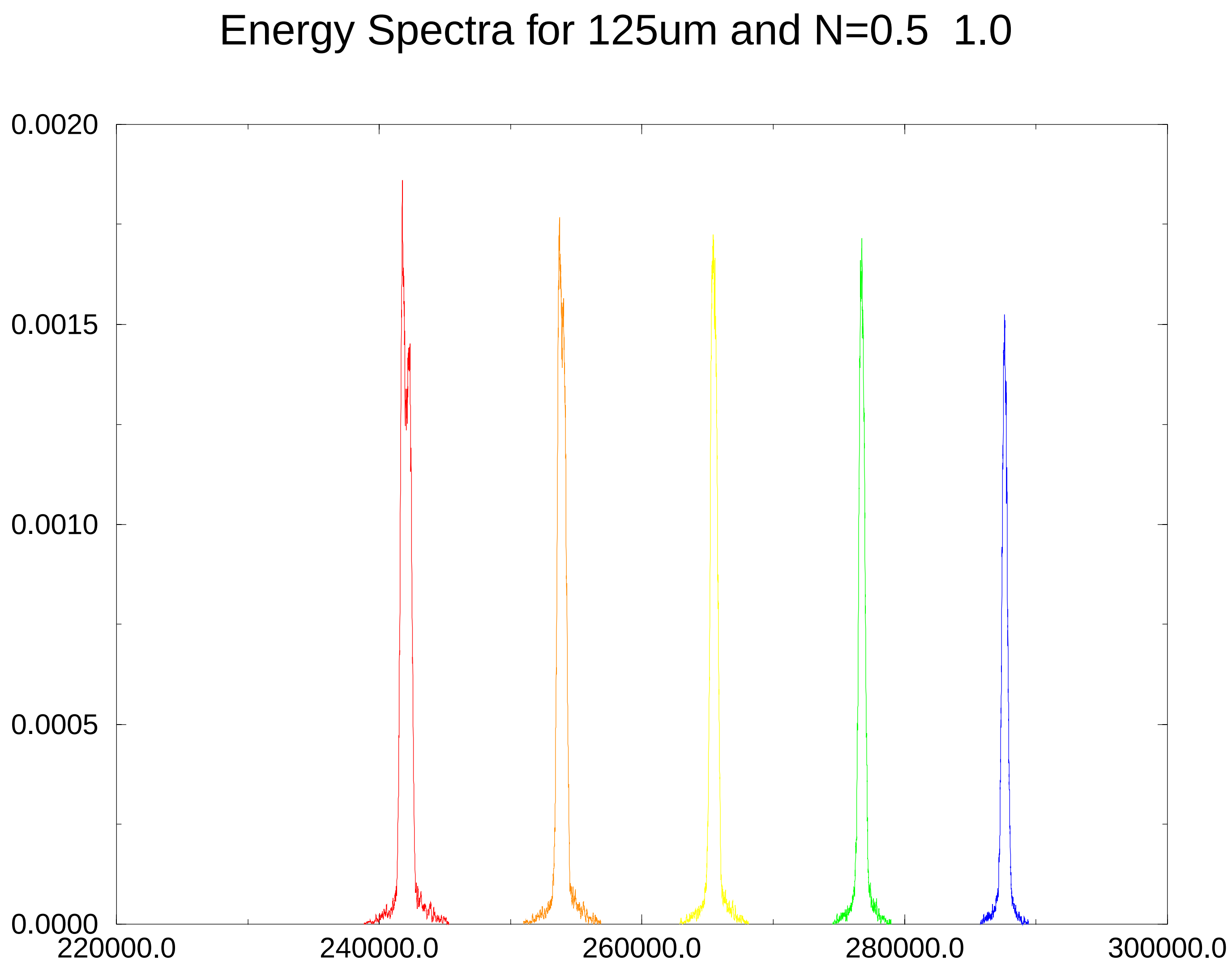
Possibility to have low energy beam well before full energy



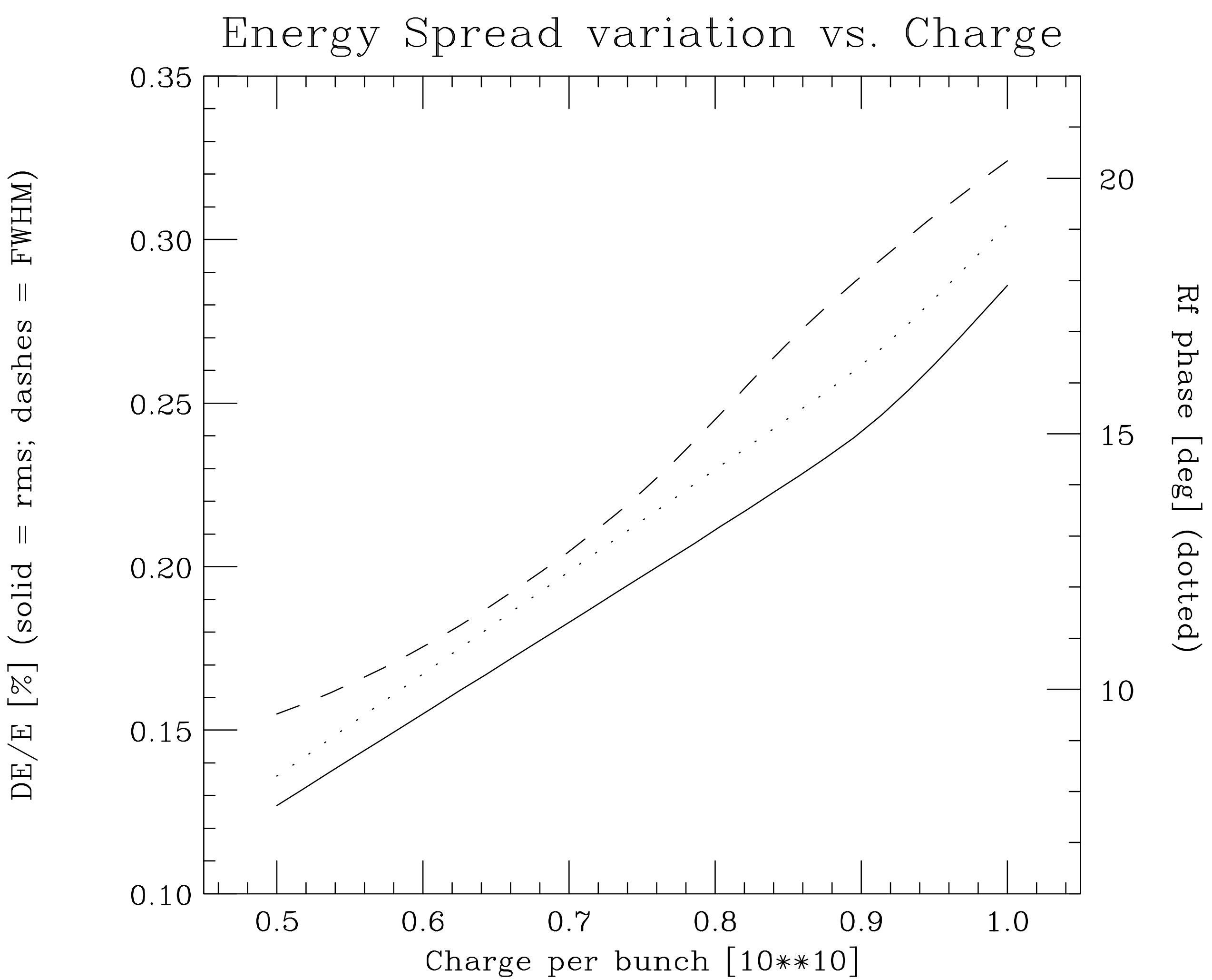
Luminosity Estimates

	Preliminary! IP Parameters for low energy IR					
	90 GeV		250 GeV		350 GeV	
	1.4 ns	Low δB	1.4 ns	Low δB	1.4 ns	Low δB
Luminosity (10^{33})	**4.1**	**2**	**10.4**	**5.1**	**14.1**	**7**
Pinch Enhancement	1.4	1.3	1.4	1.3	1.4	1.3
Repetition Rate (Hz)	**180**	**180**	**180**	**180**	**180**	**180**
Bunch Charge (10^{10})	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**
Bunches/RF Pulse	190	190	190	190	190	190
Bunch Separation (ns)	1.4	1.4	1.4	1.4	1.4	1.4
Injected $\gamma\varepsilon_x$ / $\gamma\varepsilon_y$ (10^{-8})	300 / 3	300 / 3	300 / 3	300 / 3	300 / 3	300 / 3
$\gamma\varepsilon_x$ at IP (10^{-8} m-rad)	400	400	400	400	400	400
$\gamma\varepsilon_y$ at IP (10^{-8} m-rad)	**4.6**	**4.6**	**5.2**	**5.2**	**5.5**	**5.2**
Tolerances	**10**	**10**	**10**	**10**	**10**	**10**
β_x / β_y at IP (mm)	10 / 0.12	35 / 0.12	10 / 0.12	35 / 0.12	10 / 0.12	35 / 0.12
σ_x / σ_y at IP (nm)	**670 / 7.8**	**1250 / 7.8**	**404 / 5.1**	**760 / 5.1**	**340 / 4.4**	**640 / 4.4**
σ_z at IP (um)	125	125	125	125	125	125
L0 / Ltotal (%)	62	78	49	67	44	63
Υ_{ave}	0.007	0.004	0.033	0.017	0.081	0.043
Beamstrahlung δB (%)	0.16	0.05	1	0.31	1.8	0.57
Photons per e+/e-	0.47	0.25	0.75	0.41	0.88	0.48
Polarization loss (%) ??	0.07	0.02	0.2	0.06	0.31	0.09

Beam Energy Spread Issues



Beam Energy Spread Issues



Scaling δ_B and δ_E with Luminosity

- Can reduce beamstrahlung and beam energy spread at the expense of the luminosity
  - Assuming flat beams:

$$L \propto \frac{N^2}{\sigma_x \sigma_y} \qquad \delta_B \propto \frac{N^2}{\sigma_z \sigma_x^2} \qquad \delta_E \propto \frac{N}{\sqrt{\sigma_z}}$$

$$y_{align} \propto \frac{1}{N\sigma_z}$$

- Decrease beamstrahlung by increasing horizontal beam size
- Decrease energy spread and beamstrahlung by increasing bunch length (tightens alignment tolerances)
- Decrease energy spread and beamstrahlung by decreasing bunch charge

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?
- Staging construction

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 1-10um 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

Specific Issues

Compton-based Source

- Possible layout and cost
- e^- beam – few Gev
- Laser - difficult
  high power, high rate
- Polarization easy
- Provides for random helicity flips

- Low intensity expt done at KEK
- Being pursued at LLNL

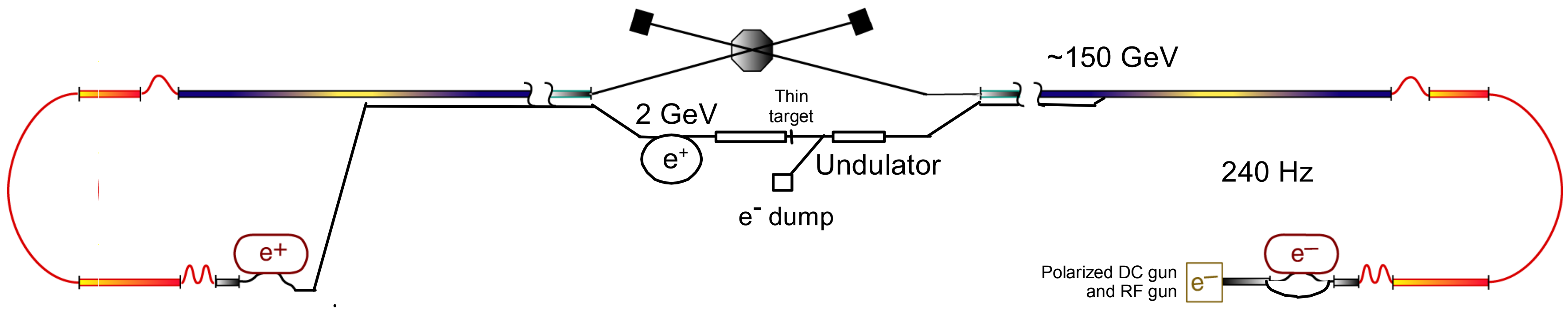
Undulator-based Source

- Possible layout and cost
- e^- beam – 150Gev?, intensity?
- Undulator - wavelength?
  Can undulator be in main e^- beam?
- Polarization challenging
- Changing helicity is difficult

- 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.

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
  - 2-9 kicker has an integrated field of 3 kG-m and would cause a 1 mrad deflection of a 100 GeV beam
  - Stability must be << 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 - also have to move magnets to optimize beam size due to dispersion versus emittance
- 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