# BDS/MDI

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# BDS WA

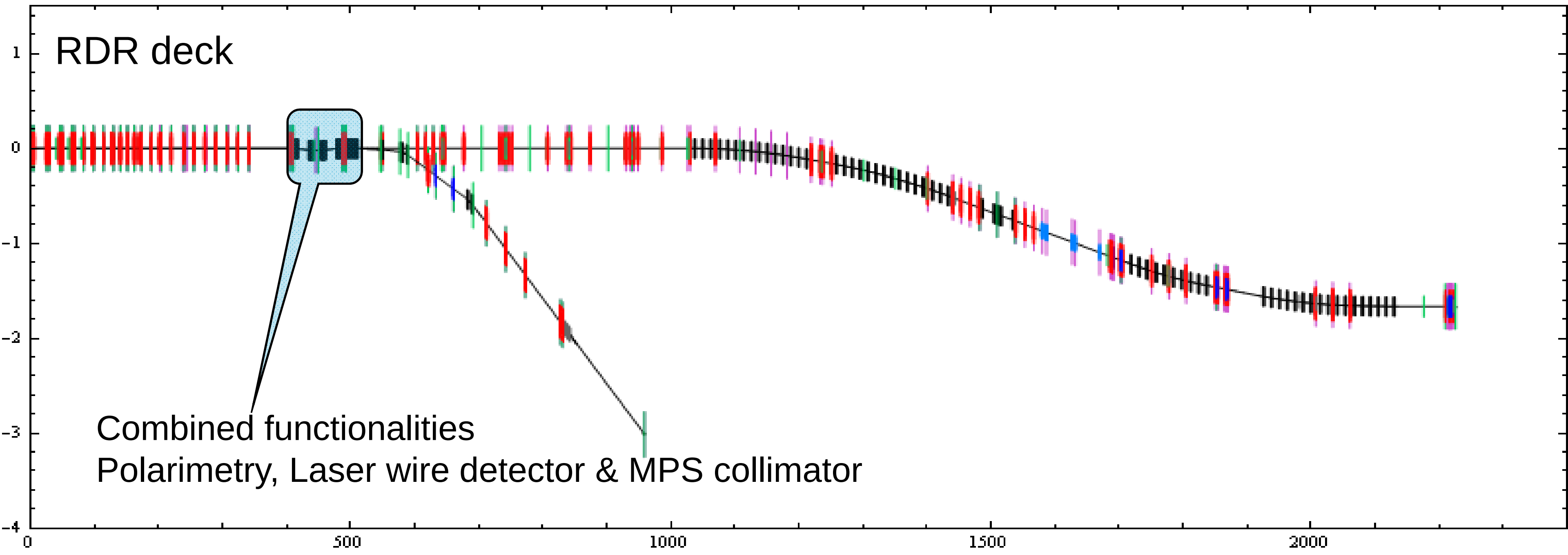
- Maintain support for the 1 TeV geometry (missing magnet or some other suitable scheme)
- Assuming 10-15% (TBD – including e+ target dogleg) synchrotron radiation emittance growth at 1 TeV CM.
- Support for travelling focus IP parameter set (L~2 x $10^{34}$ with $n_b$= 1312)

Questions :

1. What is the status of a compact lattice design with the above WA
2. Location of non-beamline components (klystrons, P/S etc)

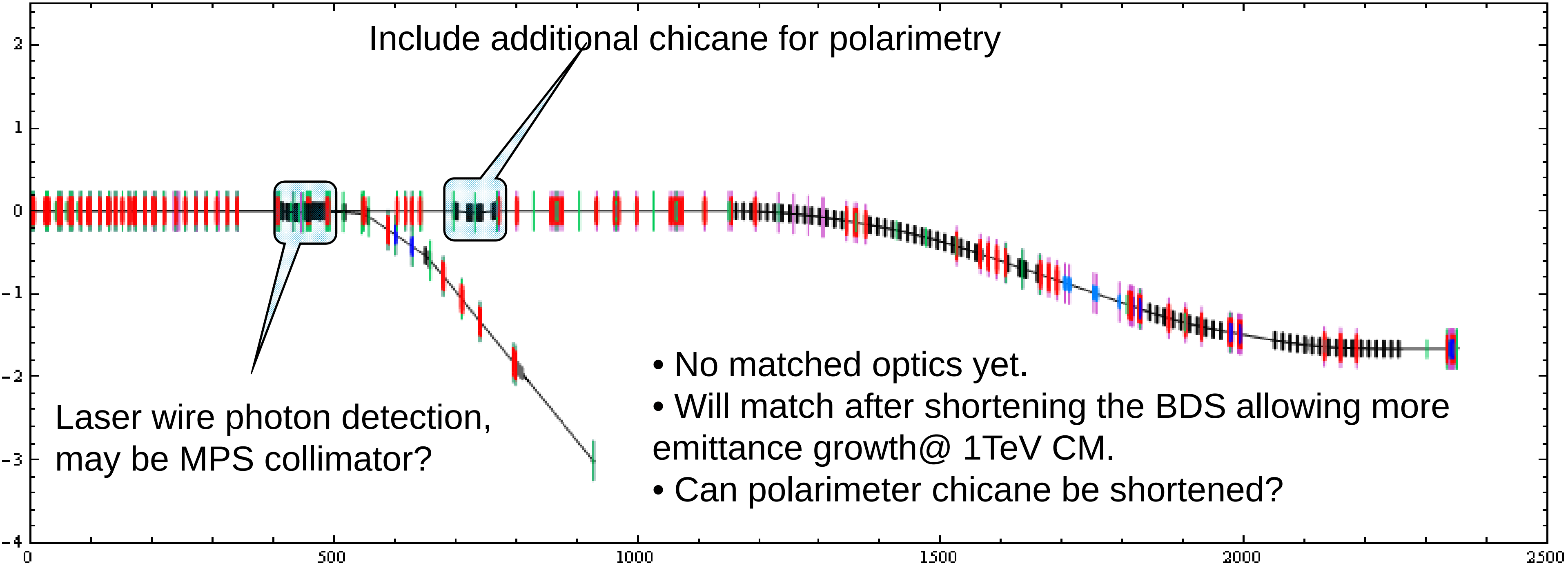
# Status of compact lattice design

- RDR lattice : three changes
  - Separate functionality of upstream polarimeter, MPS and laser wire photon detection
  - Design of dogleg : with transverse off-set (~2.5-1.5m)
  - Shortening of BDS : allowing more emittance growth
- Support for travelling focus



RDR deck

Combined functionalities
Polarimetry, Laser wire detector & MPS collimator

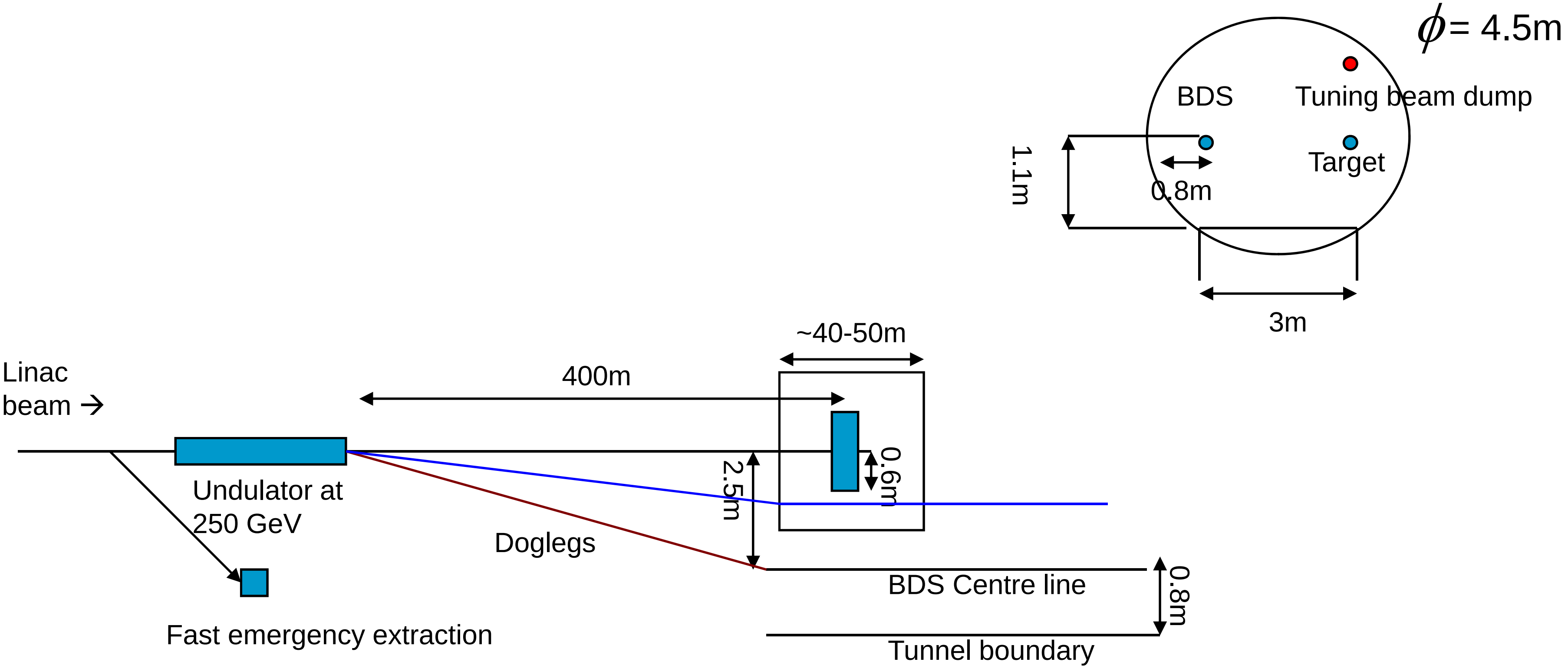


Include additional chicane for polarimetry

Laser wire photon detection,
may be MPS collimator?

- No matched optics yet.
- Will match after shortening the BDS allowing more emittance growth@ 1TeV CM.
- Can polarimeter chicane be shortened?

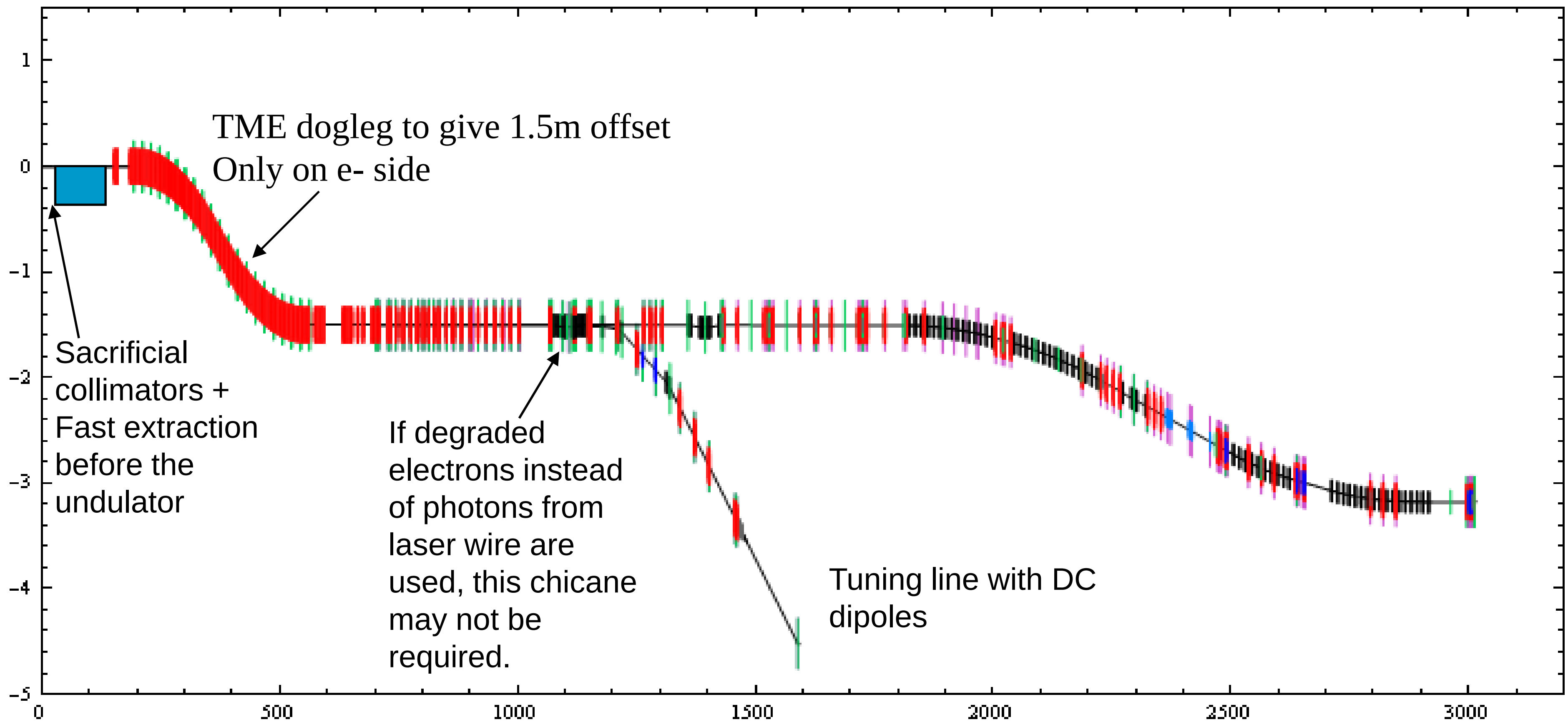
# Central region integration : Minimum Machine, BDS



- 2.5m can be reduced to up to 1.5m if beam passes through a drift space for ~40-50m without any components through the remote shielding block of the target.
- If 2.5 m, not enough space for tuning beam line. Take the beam vertically to beam dump?

Based on discussions with positron source team

# Minimum Machine



TME dogleg to give 1.5m offset
Only on e- side

Sacrificial collimators + Fast extraction before the undulator

If degraded electrons instead of photons from laser wire are used, this chicane may not be required.

Tuning line with DC dipoles

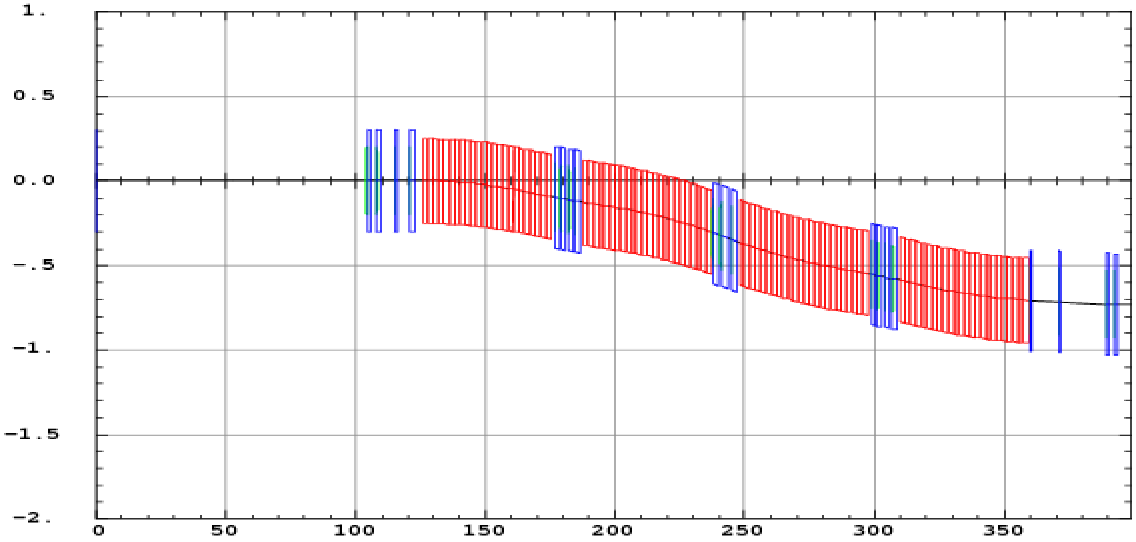
Space for tuning line and dump?

Positron side will be similar to the RDR (modified as necessary). Layout implications.

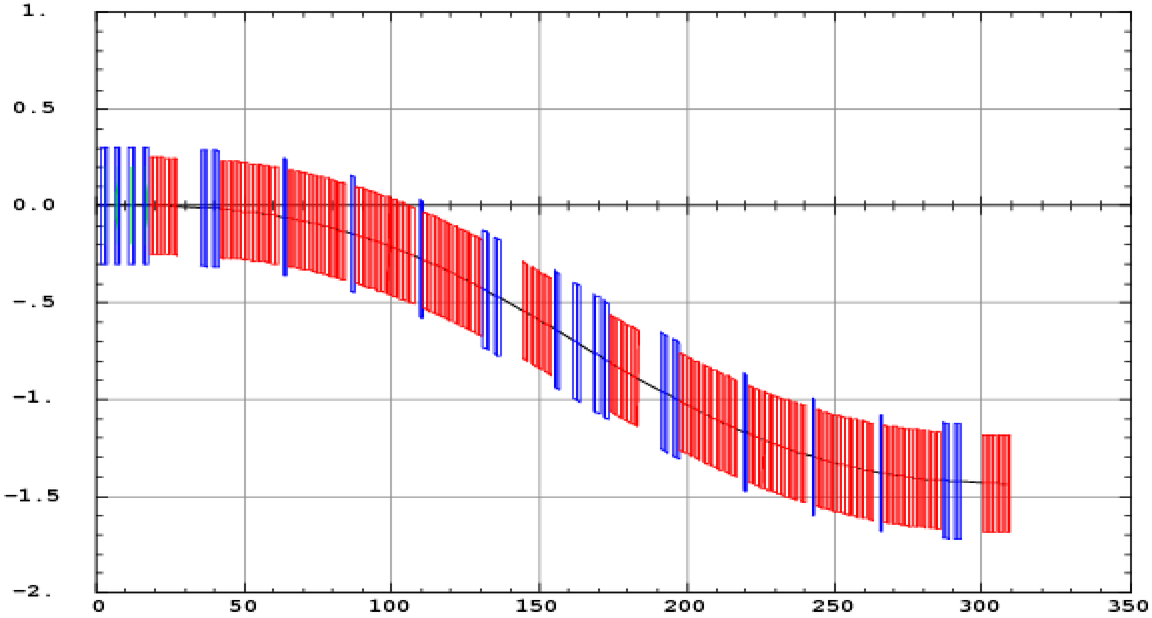
# Dogleg Chicane Designs

- Comparison of three designs
  - TESLA TDR dogleg
  - Big bend of 2mrad (with 2 IR configuration : 2 and 20 mrad)
    - Modified to get an off-set of 1.5m
    - Combined function dipoles
  - Theoretical Minimum Emittance lattice

# TESLA TDR and 2mrad big bend lattices

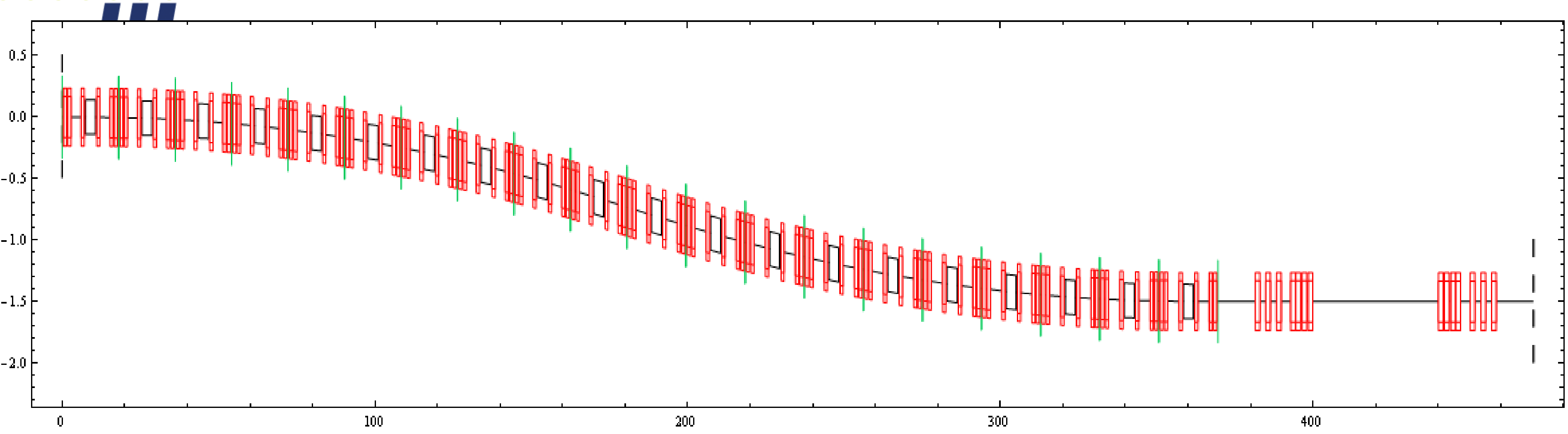


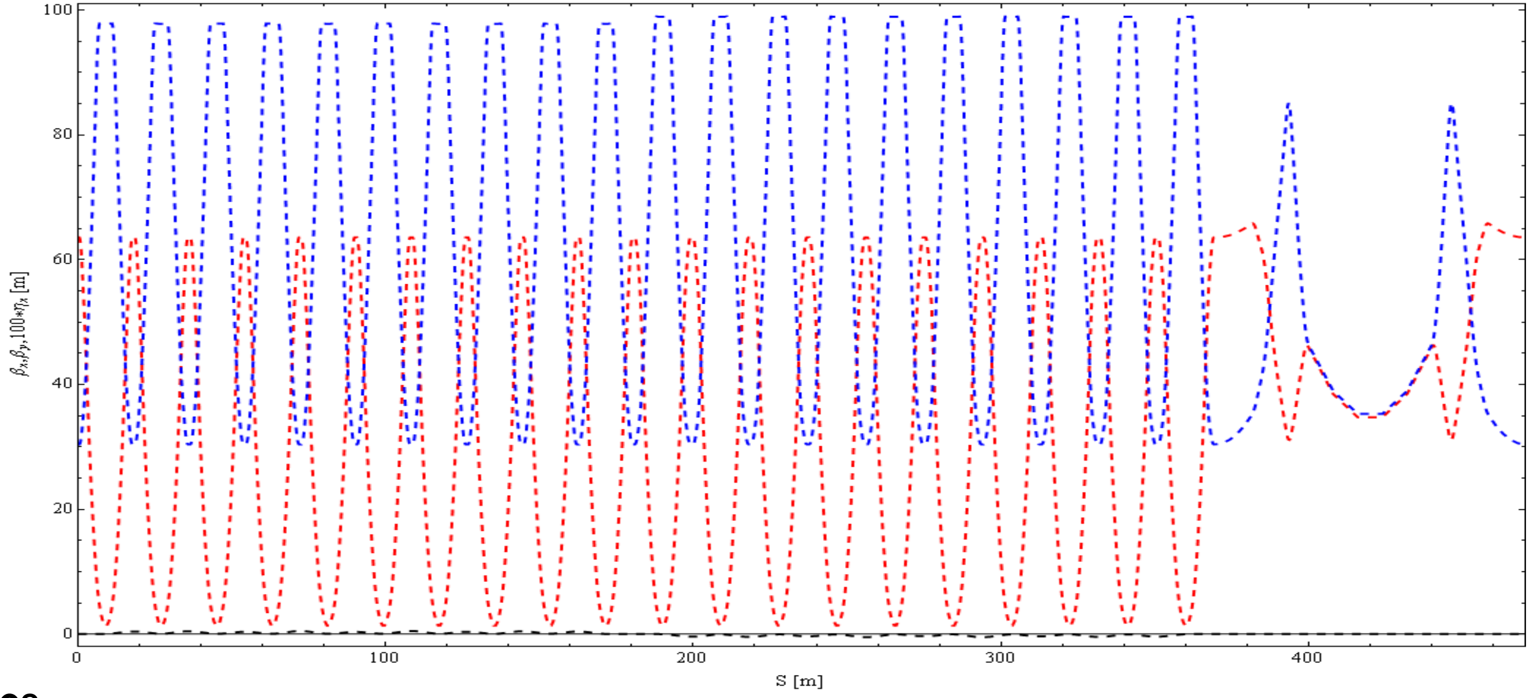
TESLA TDR – includes undulator



2mrad big bend like – without undulator

# Theoretical Minimum Emittance Lattice





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# Comparison of emittance growth and number of magnets

| Lattice | Transverse off-set | Normalised Emittance growth due to dogleg | Number of magnets |
|---|---|---|---|
| TESLA TDR | 0.7 m | 681nm@400GeV<br>~8.5%<br>2544nm@500 GeV<br>~25% | Dipoles 96<br>Quads 16 |
| Big Bend like (20 mrad and 2 mrad configuration) | 1.5 m | 493nm@400 GeV<br>1927nm@500 GeV<br>(~19%) | Dipoles 160<br>Quads 34 |
| TME | 1.5 m | 49nm@400 GeV<br>154nm@500 GeV<br>~1.6% | Dipoles 20<br>Quads 134 |

# Theoretical Minimum Emittance Lattice

- TME lattice presently have integrated strength of quadrupole =1.5T, pole tip will be 1.5T for 10mm radius (will be 0.9T for 6mm radius – probably okay to have this radius after undulator?)
- Number of magnets are too large. But this is extreme case for minimum emittance growth.
- Looking at the possibilities of using weaker quadrupoles, stronger dipoles (possibly with field gradients) which can give reasonable emittance growth.

# Reduction in RDR FFS length

- Emittance growth <1% @1TeV for RDR, Final focus length Total=1582m (betatron coll=388m, energy coll=407m, beta match=245m, FT=540m)
- To allow more increase by shortening the length, use analytical dependence on the length

$$\frac{\Delta\sigma_y^2}{\sigma_y^2} \propto \frac{\gamma^5}{L^2}\eta_B'^3 \propto (\gamma\varepsilon_y)^{3/2} L^{*3}\left(\frac{\eta_{\mathrm{IP}}'^2}{\varepsilon_x}\right)^{3/2}\left(\frac{\varepsilon_x}{\varepsilon_y}\right)^{3/2}\frac{\gamma^{7/2}}{L^5}$$

$$\frac{\Delta\sigma^2}{\sigma^2} \propto \left(\frac{\Delta\sigma^2}{\sigma^2}\right)_0 /(1-dL/L_0)^5$$

dL is shortening of length (Lo is initial length of FF) is what we can allow for shorter FF, let say it is 0.4, which if added in quadratures give 8% of beam size growth.

For = 0.1, $L_0$=540m, dL~145m in FFS,

For = 0.2, $L_0$=540m, dL~70m in FFS (need to check exact numbers)

\+ may be similar reduction from E-collimation (but there will be some increase in the length due to additional chicane for the polarimeter chicane!).

- Complete re-fitting of the FFS will be required, beam sizes on the E-collimator and phases advances of betatron collimators w.r.t. FD.

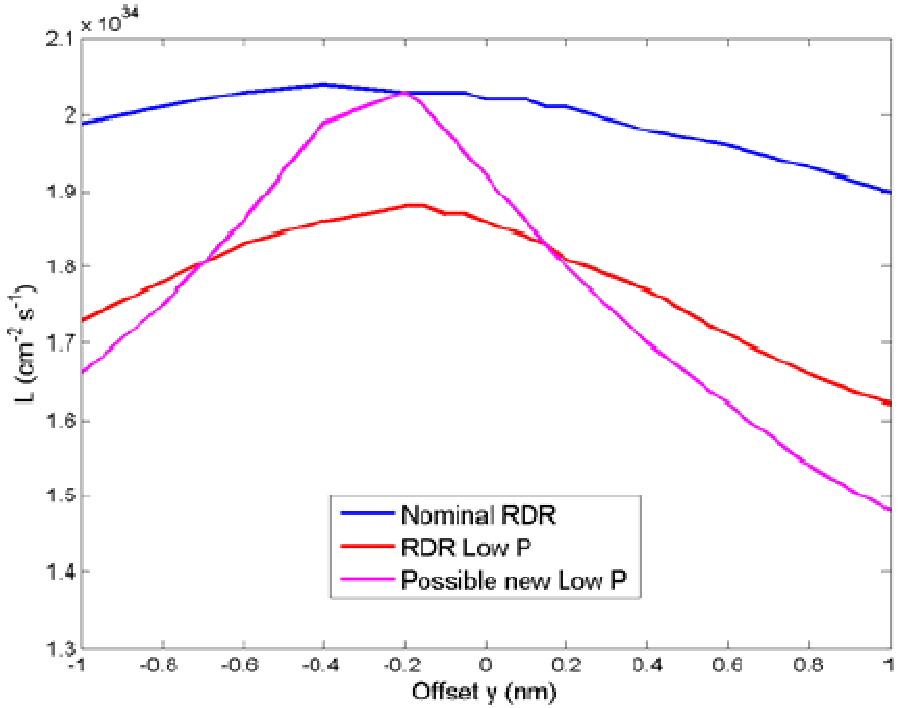
# Support for travelling focus

PAC09 Paper
WE6PFP082

- Travelling focus can be created in two different ways:
  - small uncompensated chromaticity and coherent E-z energy shift dE/dz along the bunch.
    - $\delta E \; k \; L^{*}_{eff} = \sigma_z$ ; k=relative uncompensated chromaticity. $\delta$E needs to be 2-3 times the incoherent spread in the bunch.

    Possible set : $\delta$E=0.3%, k=1.5%, L*eff=6m
  - Use a transverse deflecting cavity giving a z-x correlation in one of the FF sextupoles and thus provide z-correlated focusing.
    - The cavity will be located about 100m upstream of the final doublet, at the $\pi$/2 betatron phase from the FD.
    - The strength required will be ~20% of the nominal crab cavity.
- Tracking studies and possibly mitigation of higher order aberrations are needed for both the schemes.
- Evaluation by detector concepts?

# New Low P parameter option



Luminosity vs beam offset

High sensitivity to any beam offset => operation of the intra-train feedback and intra-train luminosity optimization will be more challenging.

# Pros & Cons

- Pros:
  - Sacrificial collimators in the e- side before undulator, BDS aperture can be reduced in the initial section
  - MPS before undulator
  - Low power – design of extraction line
  - Reduced length of BDS
- Cons :
  - Dogleg ; emittance dilution
  - Asymmetry in the layout (on e-,e+ side)
  - Implications to commissioning due to integration, less flexibility

# Risk Register : RDR

| | Concern | RISK | COST | | RISK | |
|---|---|---|---|---|---|---|
| BDS | (1) Final Doublet Jitter | High | 30 | S4 | Med | Continuing engineering studies and prototypes |
| BDS | (2) Beam Halo too large | Med | 50 | S4 | Med | Install longer muon or magnetized walls |
| BDS | (3) Prompt Push Pull Operation | High | 50 | E/P | Med | Detail engineering |
| BDS | (4) Adequacy of Beam Dumps windows, shielding etc | Med | 50 | E/P | Med | Longer tunnels, more shielding etc |
| BDS | (5) Laser wire Diagnostics | High | 30 | E/P | Med | Engineering and prototypes. Tunnel length |
| BDS | (6) Collimation Performance | Med | 50 | E/P | Low | Measurements and studies |
| BDS | (7) Crab Cavity Performance | High | 20 | S4 | Med | Engineering and prototype tests |
| BDS | (8) Fast Feedback Performance | Med | 20 | E/P | Low | Expts and studies at ATF2 etc |
| BDS | (9) Energy & Polarization Diagnostics | High | 20 | E/P | Med | Design and prototyping |
| BDS | (10) Performance of FF Optics | Med | 200 | S4 | Low | Continuing studies at ATF2 |
| BDS | (11) FD size and 14mrad | Med | 20 | E/P | Low | Detail engineering and prototyping |

*Need to update the risk register : separation of combined functionalities of first chicane will reduce the risk for LW and polarisation measurements.*

*Crab cavity RF phase tests @CI have reached the ILC goal (April'09) for single cell cavities.*

# Plans

- Change the RDR layout to separate functionalities of first chicane and include separate polarimeter chicane
- Finalise the dogleg design with optimum number of magnets and reasonable emittance growth
- Check the required final focus/E-coll emittance growth by re-scaling using analytical formulae, re-scale accordingly
- Implementation of travelling focus and changes to lattice design
- Discuss with MDI group for evaluation of these changes