

WG1: Overall Design: Including civil construction, instrumentation and controls, and reliability

Charge

- Develop a list of design elements that are
 - non-controversial in concept and may need only some optimization
 - should be considered open for evaluation from scratch.
- Work according to the list above.
- Present the topics the different groups are interested in, and can contribute to the overall design.
- Not focused on technology but on impact of system choices

Approach

- Six focused sessions with $\frac{1}{2}$ hour intro talk followed by ~1 hour group discussion

Primary issues / decisions

- Initial / upgrade gradient
- Beam parameters
- 1 tunnel versus 2 or 3 tunnels
- Positron source: undulator, conventional, Compton

Impact

- Cost optimization
- Schedule impact
 - Commissioning
 - Technology
- Integrated luminosity
 - Peak luminosity
 - Operating flexibility
 - Availability
 - MPS system and tuning capabilities (diagnostics)

Hardcore attendees

BNL, Jlab, FNAL, LLNL, SLAC, ...

Conveners

Mike Harrison, Andrew Hutton, Tor Raubenheimer, Marc Ross

Thursday

RF Gradient - H. Padamsee

Overall Parameters - T. Raubenheimer

Friday

Availability - T. Himel

Commissioning - N. Phinney

Instrumentation and MPS - M. Ross

Summary - conveners

Overall Philosophy for Parameters

- Flexibility in parameter space desirable (essential) to meet luminosity goals
 - Luminosity goals for collider have gotten push very hard
 - One year commissioning after construction, followed by four years of operation averaging ~50% of the design peak luminosity
- Factors of two variation in parameters appear to be significant and feasible and can have a large impact on operations
 - Beam power / bunch charge (reduce backgrounds, rf system, Δv)
 - Bunch length (reduce IP disruption or reduce β_y for more L)
 - Bunch spacing in ML (change effects in DR, ML, and IP)
- Need to consider technology, cost impact, and gain from flexibility

Beam Power (bunch charge)

- Single bunch density is an issue - at some point there is a damage threshold. R&D should be performed on this topic
- Detector backgrounds will be determined by beam power - hard to to quantify. Simulations will help but probably not definitive.
- Average power (factor of 2 reduction is useful & R&D possible).

Potential benefits:

- DR's easier (space charge, collective effects, etc...)
- ML wakefields reduced
- Beam tails reduced (scaling faster than linear in charge)
- Positron production easier
- RF cost reduction & operating margins improved (e.g. couplers)

Shorten bunch length by a factor of 2 more in the bunch compressor

- **Cons**

- HOM's worse *
- Compressor more complex - two stage system probably required
- Linac energy spread increased
- IP Optics more complex - reduced beta-star required to benefit from shorter bunches
- CSR effects need to be re-calculated
- Beamstrahlung increases *
- * Balanced if bunch intensity reduced to hold luminosity constant

- **Pros**

- Luminosity increase (root 2)
- Transverse wakes reduced (scaling for longitudinal and transverse wakes weight towards shorter, lower charge bunches)

Reduced by a factor of 2 with reduced bunch charge and more bunches to keep luminosity constant

- **Cons**
 - DR Kickers harder
 - DR collective effects worse
 - IP beta values ($b_x \cdot b_y$ 4x smaller for constant L)
- **Pros**
 - DR space charge reduced
 - DR emittances could likely be reduced
 - DR lower energy might be possible

Reduce emittance growth in ML

Consensus that it is difficult to reduce the emittance growth in main linac by a factor of 2 and that the present allowances are about right

Suggest sensitivity studies on tolerances as R&D topic

- 1) There are many things that are cheaper if we adopt a higher gradient. Are there any things that get more expensive?
 - AC power higher due to increased cryogenic needs
 - Cryogenic plant
 - Total impact is weak, RF losses increase, static losses decrease
 - Inside cryomodule, may need larger cooling channels
 - RF Power sources and modulator
 - Longer pulse length

- 2) Are there things that get harder if we adopt a higher gradient (outside of the cryomodule itself)?
 - Lorentz detuning
 - Low level RF control
 - Dark current
 - Depends on field emission levels
 - Klystron pulse length
 - Power couplers

- 3) Are there any technology changes that could result (either by necessity or by providing additional options) from adopting a higher gradient?
 - Higher gradient allows ILC to fit on smaller site
 - Lorentz detuning rapidly becomes a limit somewhere above 35 MeV/m

- 4) Things that would be cheaper with a higher gradient.
 - Shorter linac tunnels
 - Installation, fewer elements
 - Schedule
 - Fewer cryomodules (same number of RF stations)

- 5) Things that would be easier with a higher gradient
 - Beam dynamics

Cavity Gradient - Conclusion

- Cost drivers for gradients higher than 35 MV/m seem weak
- Need to update cost curves and sensitivity to input parameters
- Need to perform 2/3-D optimization

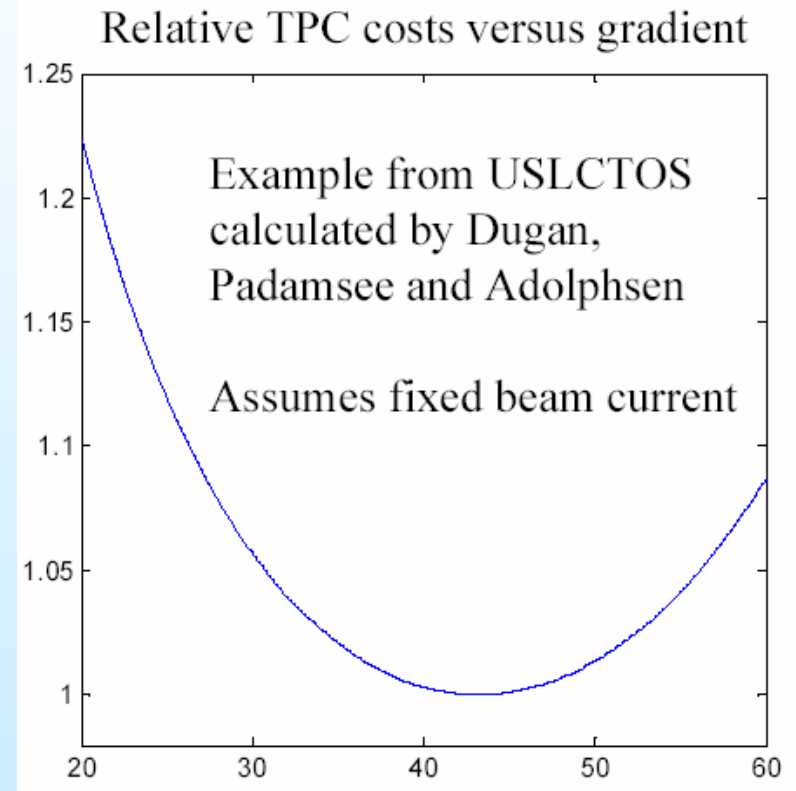
Lorentz detuning (proportional to square of gradient) gets more difficult above ~35 MV/m

Dark current could be a problem

Good reasons to go to higher gradients are reduce costs or to meet specific site requirements

Significant payback for higher Q_0 at given gradient

- Lower cryogenic losses
- Less dark current



Availability - 1 vs 2 tunnels

con - against 1 tunnel

- Higher component availability required to achieve luminosity
- US safety regs permit (desire?) 2nd tunnel for egress
- Surface visibility of support buildings may cause public concern
- Risk associated with commissioning due to limit access
- Remnant fields near the SC cavities - trapped fields

pro for 1

- Possible euro safety regs that prevent entry to 2nd during ops
 - Understand the counter example of the LEP side tunnel
 - How to evaluate the hazard of personnel access
 - Use availability simulation to look at 2 tunnel/1 tunnel with 2nd tunnel personnel exclusion
- Cost!!!

Comments

Issues of availability code application

Need to understand actual delta in cost for the 2nd tunnel and the delta in cost to equalize availability

Does the availability simulation include downtime planning - why doesn't scheduled downtime help

One tunnel with gallery (SLAC)-curved tunnel near surface or with a vertical crossing angle may be the cheapest solution

Beamline design difference

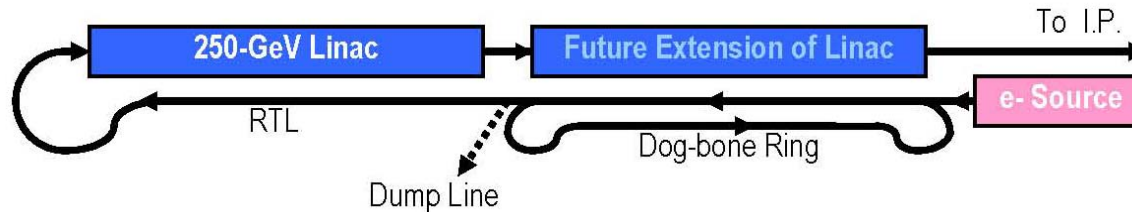
DR in the linac tunnel - impact from 1 vs 2

Difficulties in locating utilities (i.e. PS, elec, etc) in BDS

Zero Defect Zero Downtime approach
Positron source for ops and commissioning
General engineering improvement in MTBFs
Need systematic approach
Compare MTBFs with SRS

- **General agreement that the appropriate method involves sequential commissioning**
 - **Gun -> LEBT -> DR's -> BC -> ML -> BDS**
 - Each machine component will be operated independently of the downstream components.
 - Internal dumps and diagnostic stations will separate each element in the chain at the transition points. The dumps would also be available for the MPS

- $1\frac{1}{2}$ or $2\frac{1}{2}$ Tunnels for use with a dogbone DR?



- $1\frac{1}{2}$ refers to the DR installed in the second half of the (unoccupied) Phase 1 tunnel, ditto $2\frac{1}{2}$ for a 2 tunnel scenario
 - Requires ~ 35 MV/m initial gradient
 - Gun & LEPT close to the IP
- **Pro**
 - Avoid delays in commissioning
 - Helps Ops by separating DR & ML
 - Avoids klystron & DR coupling
 - Added time to dump fault condition beam from DR's & BC
- **Con**
 - Minor increase in phase 1 cost
 - Added length to the transfer lines

Group consensus is that this is a good idea

Positron Source

- Conventional source + civil construction for future undulator
 - Pro
 - Could complete commissioning ~15 month earlier
 - No undulator (or required R&D)
 - No undulator insertion with narrow bandpass
 - Ops friendly due to separation of systems
 - Con
 - Target issues
 - Larger production emittance (~x2)
- Group consensus that this is the preferred design
- Positrons from positron linac ?
 - Long production pulse for convention source ?

- **Low intensity fuzzballs**
 - Diagnostics must be single bunch capable with large dynamic range. Low intensity large emittance (low density) single bunch operation is crucial in both operating (for MPS) and commissioning scenarios
- **Instrumentation stations**
 - Periodic instrumentation down the ML is deemed necessary for commissioning
- **ML 2 tunnel advantages for commissioning**
 - Electronic accessibility
 - Raw signal accessibility
 - Beam on during installation or upgrade in equipment tunnel

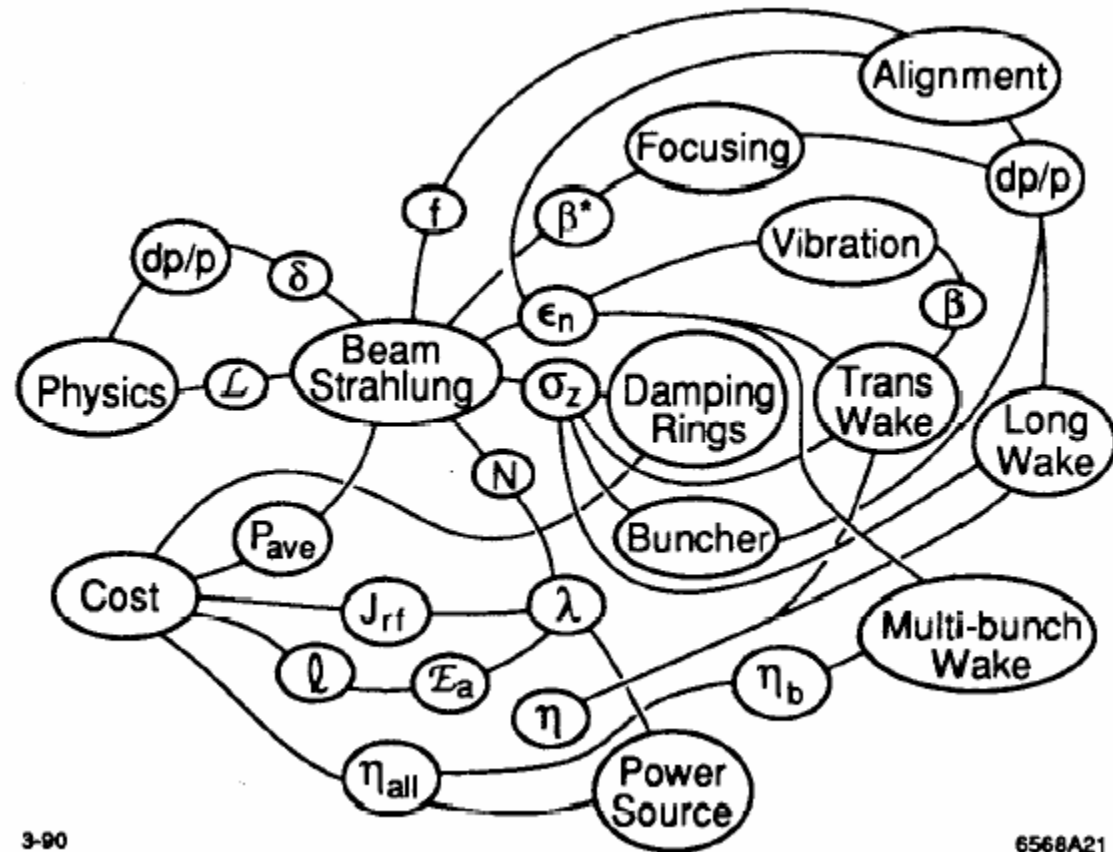
- **Model correction schemes**
 - **Understand requirements for instrumentation**
- **Optimize schemes to simplify instrumentation requirements**
- **Define diagnostics to monitor sub-system performance at transition points**
- **Feedback requirements**
- **Operations requirements**

R&D Topics

- **Laser wires**
- **BPMs**
- **Correlation monitor (slice emittance)**
- **IP specific BPMs**

- List possible causes of beam loss
 - Identify response
 - “sacrificial” collimator
- Perform FMEA analysis on machine
- Limit feedback ability to drive beam into wall
- Self-diagnostics on equipment that are single-point failure
- Need logic for “ready for beam”
- Pilot bunch

- Identified major system-wide issues
- Started developing dependences between issues and decisions
- Excellent participation and discussions during the meeting
- Great to see people united behind the goal of designing the LC!



3-90

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(from R. Palmer 1990)

- Talks → nixx@slac.stanford.edu