

# Comments on Central Injector

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ILC Workshop 2006 Valencia

9 November 2006

# Fully Self-Replicating --> Fractionally Self-Replicating

- A “positron path sum” that is an integer number of half ring turns would replicate the e+ fill pattern, but with a half-turn offset.
- If we restrict ourselves so both 3.3 km halves of a 6.6 km ring have the same fill pattern, and we extract from the halves in the same sequence, there is guaranteed to be an empty bucket exactly halfway around the ring, as well as the bucket we extracted from, before the fresh positrons get back.
- So getting the “positron path sum” right to a half ring turn is just as self-replicating as getting it right to a full turn, provided we slightly restrict the initial fill pattern to be symmetric, and extract the halves in the same sequence.
- The fill pattern and extraction sequence are just as unrestricted as they would be for a 3.3 km ring.
- If beam physics and kicker technology allowed a 3.3 km rather than 6.6 km damping ring, we would probably not build the 6.6 km ring just for extra operational flexibility in the ring fill or extraction pattern.
- You could extend this argument to 3-fold symmetric fill patterns and nearest 1/3 ring turn being the same as a 2.2 km ring. But not forever, because at some point the equivalent ring really would be too small for flexibility.

## It's too early to know the CFS cost of e+ timing

- The linac length would change if the target accelerating gradient changed.
- The linac length would probably be changed up or down during construction if the achieved gradient was much higher or much lower than the target gradient.
- The extra positron path length that is “free” in the “circumscribed” layout (Paterson option A) could end up making the total cost higher, because it could push the path length past a self-replicating value, and we could have to add more extra delay tunnel than we would have to add with the shorter “tangent” layout (e.g. Paterson option D).

## What I think the RDR should say

- The cost of the positron timing solution should be excluded from the decision of which layout to cost for the RDR
- The RDR should contain a consistent positron timing solution, and its cost
- The RDR should mention there are a number of possible layouts with advantages and disadvantages, and the final choice can only be made after more gradient R&D and selection of the site. It may not be the choice in the RDR.

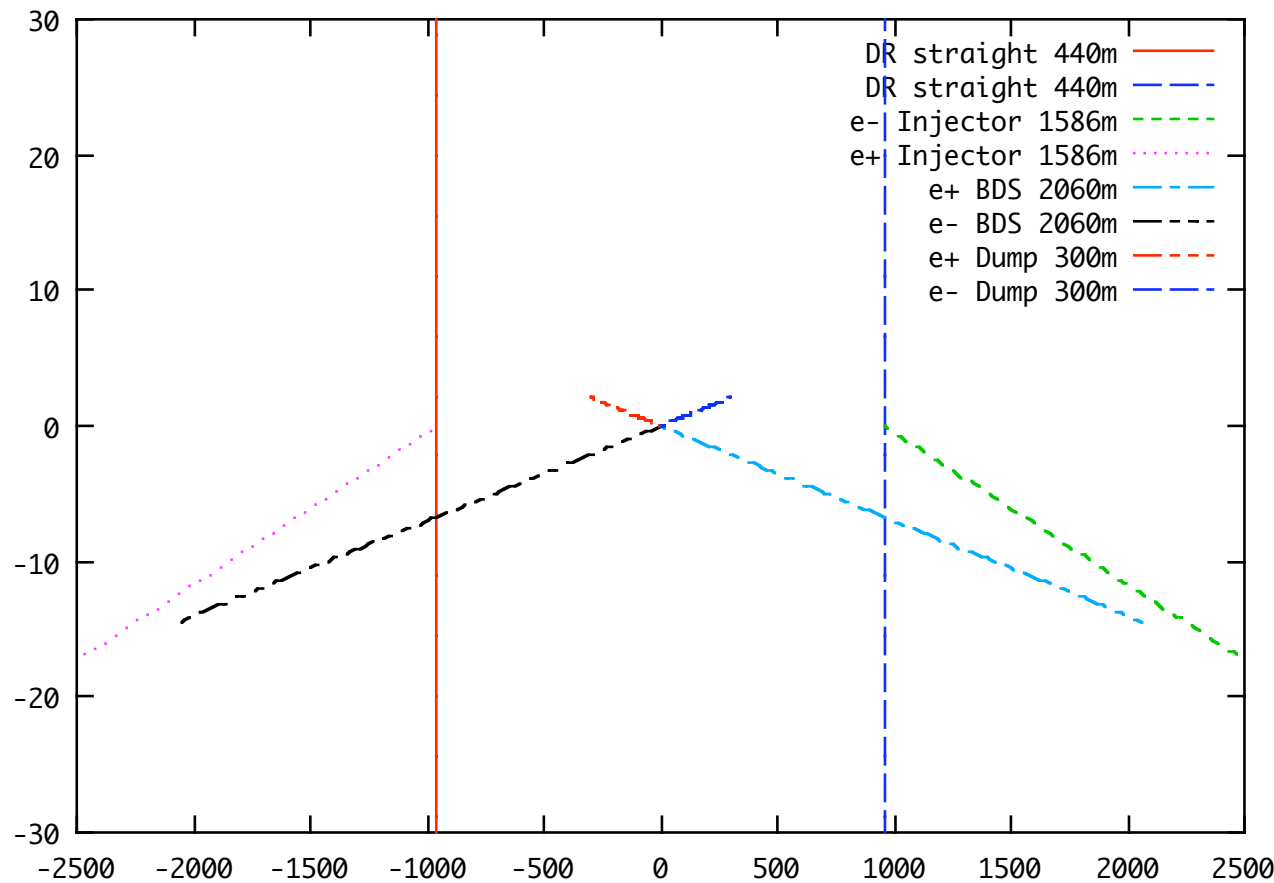
# Advantages of injection & extraction in same straight

- Frees other straight for other functions like abort, tune insertions
  - We need these functions, perhaps more, that aren't in present decks
  - Opposite long straight is last place to put them
- Injection & extraction can share components (several \$M)
  - Septum, large-aperture beta matching quads
  - Can use extractor+injector in closed bump for accumulation of e+ from KAS for early commissioning at high current
- If need RF separator for 3 ns bunch spacing, only need one

# Standard Circumscribed Layout

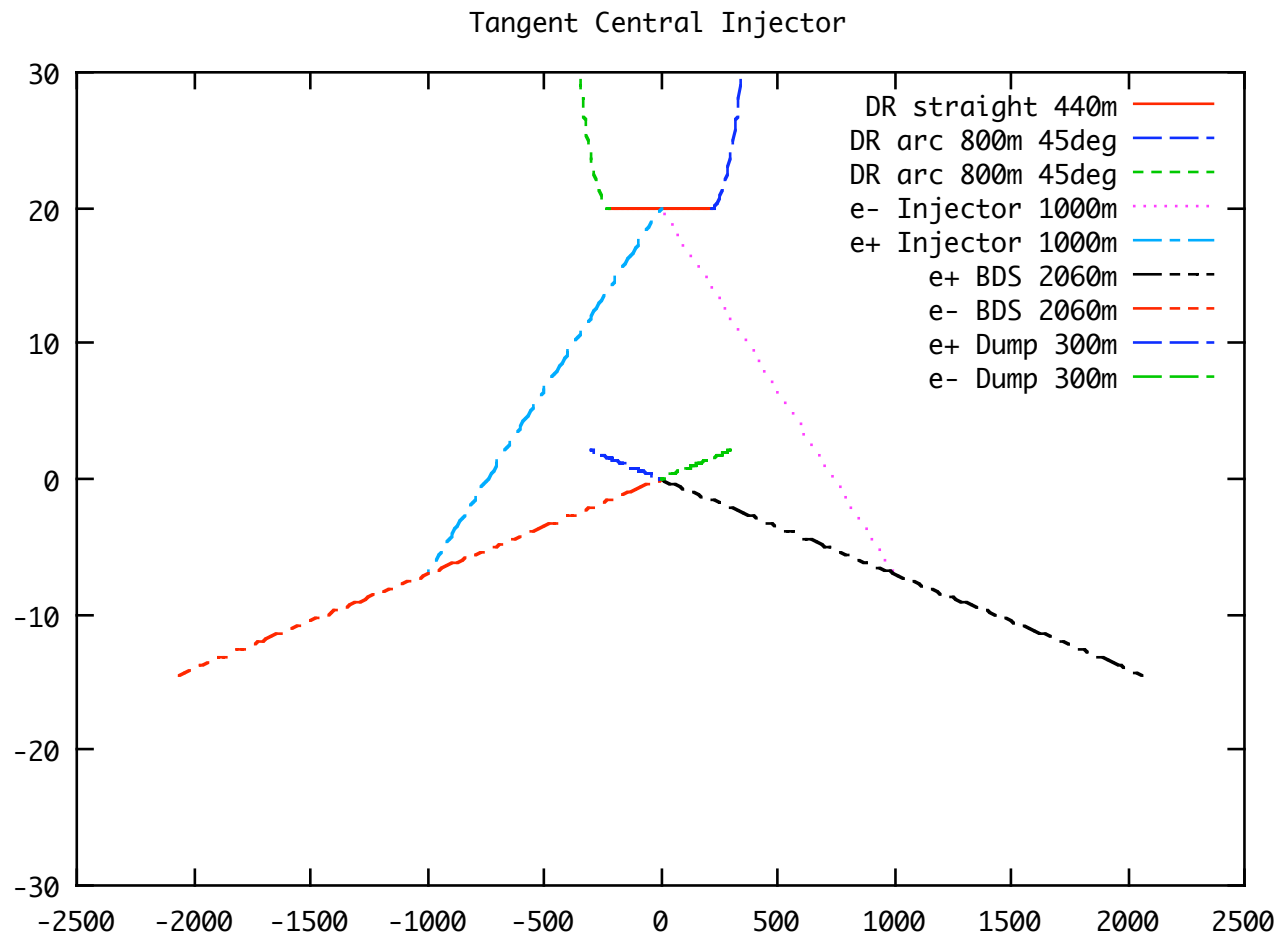
- Damping ring straights cross BDS about 1000m from IP, 10m higher
- Injectors in 1000m tunnels, shared with RTMLs
  - 10m above BDS tunnel, but drawn here with horiz offset and angle for visibility
- About 600m of sloped tunnel (with only RTML, PRL) to match linac elevation

Circumscribed Central Injector



# My Tangent Layout (C? D'? E?)

- Damping ring straight parallel to BDS, offset by 10-100m, can be in same plane
- Injectors in 1000m tunnels shared with RTMLs
- Tunnels join BDS 1000m from IP, or farther if you want/need to
- RTML shares upstream BDS tunnel, as does PRL on one side



# Advantages of Tangent Layout

- Injection, extraction in same straight
- Minimizes risk to vertical emittance from vertical bending
- Less tunnel length (sloped tunnels are not needed)
- Tunnel junctions are in horizontal plane, not vertical
  - Can TBMs do vertical-plane breakthrus?
- No 90 degree bends that require drill&blast construction
- Maximizes opportunity to share service tunnel, shafts, etc.
  - Damping ring straight tunnel is close to both BDS, injector tunnels
  - In circumscribed layout, DR tunnel doesn't stay close for long
- Injectors and DR are 1000m closer to detector hall
  - Short walk from 24/7 occupied hall to DR and injectors



## Further Layout Comments

- Shared service tunnels could be out of beam plane
- A shared shaft etc. appearing in a place where the other system didn't actually need it, doesn't add much value.
- Damping ring has some freedom to relocate services that want shaft-access, how much requires study
- Sum of short straights in DR is more than sum of long straights. Making the ring very race-tracky with more services near IP might give improved access/cost ratio

# Conclusion

- Fractionally self-replicating e+ timing solutions could save significant cost with minimal loss of flexibility
- Cost of timing solution shouldn't determine RDR layout
  - But a timing solution should be in RDR, and costed
  - Other layouts should be mentioned since we won't know until late
- Injection and extraction in same DR straight is preferred
  - Although opposite-straight layout could be made to work
- Tangent layout with DR straight and injectors near IP seems to have quite a few advantages