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Infield ERL Option Integration

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THE UNIVERSITY OF CHICAGO

Office of Science
U.S. DEPARTMENT OF ENERGY

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Outline

- Constraints/Boundary Conditions
- Impact Minimization
- Utilities/General Layout
- Layout Option 1
- Injection/Extraction options
- Bypass transport line in the booster tunnel
- Layout Option 2
- Conclusions

Infield ERL: Constraints/Boundary Conditions

- An infield ERL must supply beam to existing APS beamlines
- No significant interruption of 5000 hour/year operations
- Preserve stored beam operation with top-up
- Smooth transition to ERL operation
- Infield space is at a premium
- Recirculation will be required to reach 7 GeV

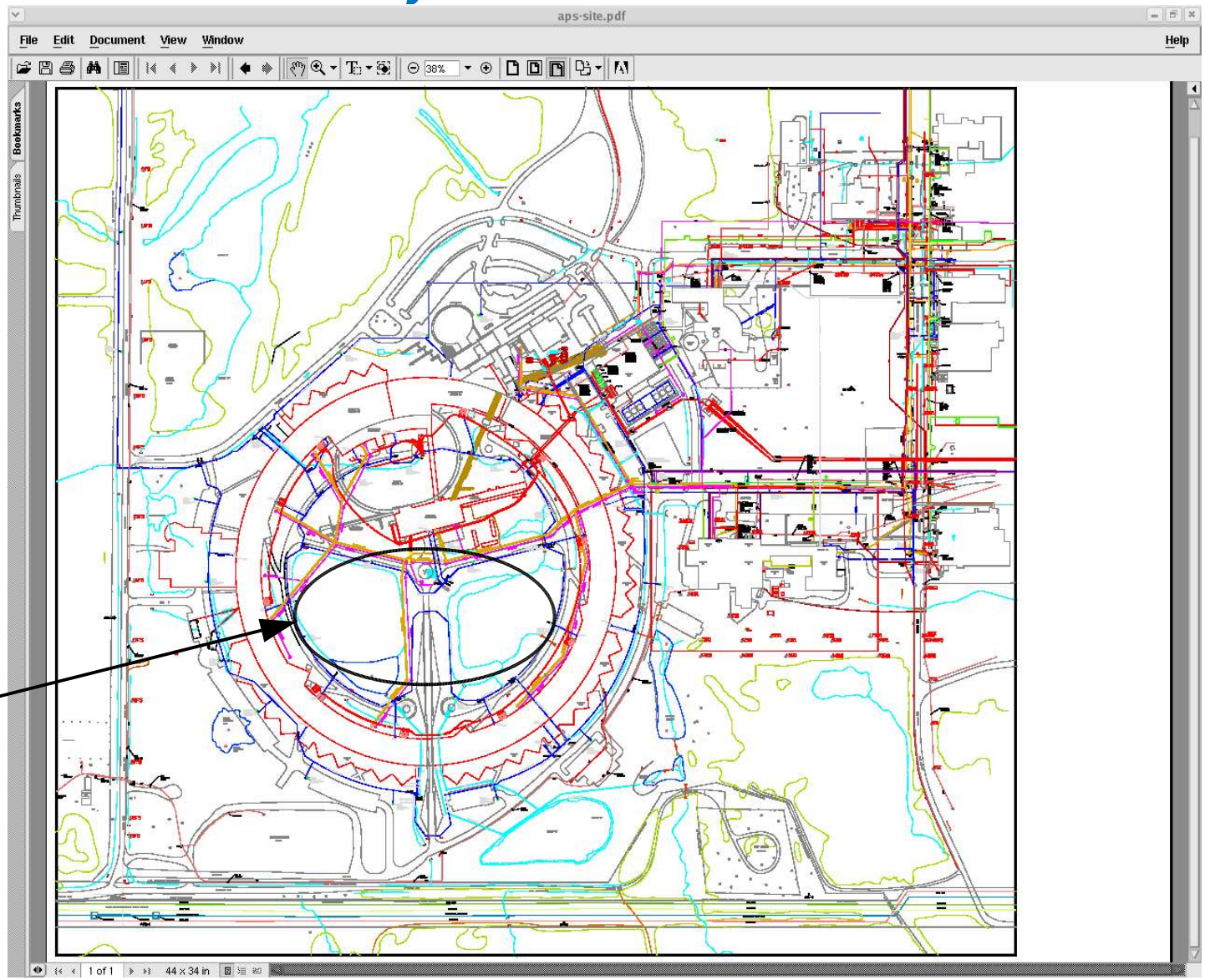
Infield ERL: Impact Minimization

- Infield ERL should minimize environmental concerns
- Minimize interference with existing injector complex
- Minimize interference with other infrastructure/buildings
- Keep transport line bending radii large enough to minimize CSR/ISR.
- Some utilities may have to be relocated as well as some existing building structures

Infield ERL: Utilities/General Layout

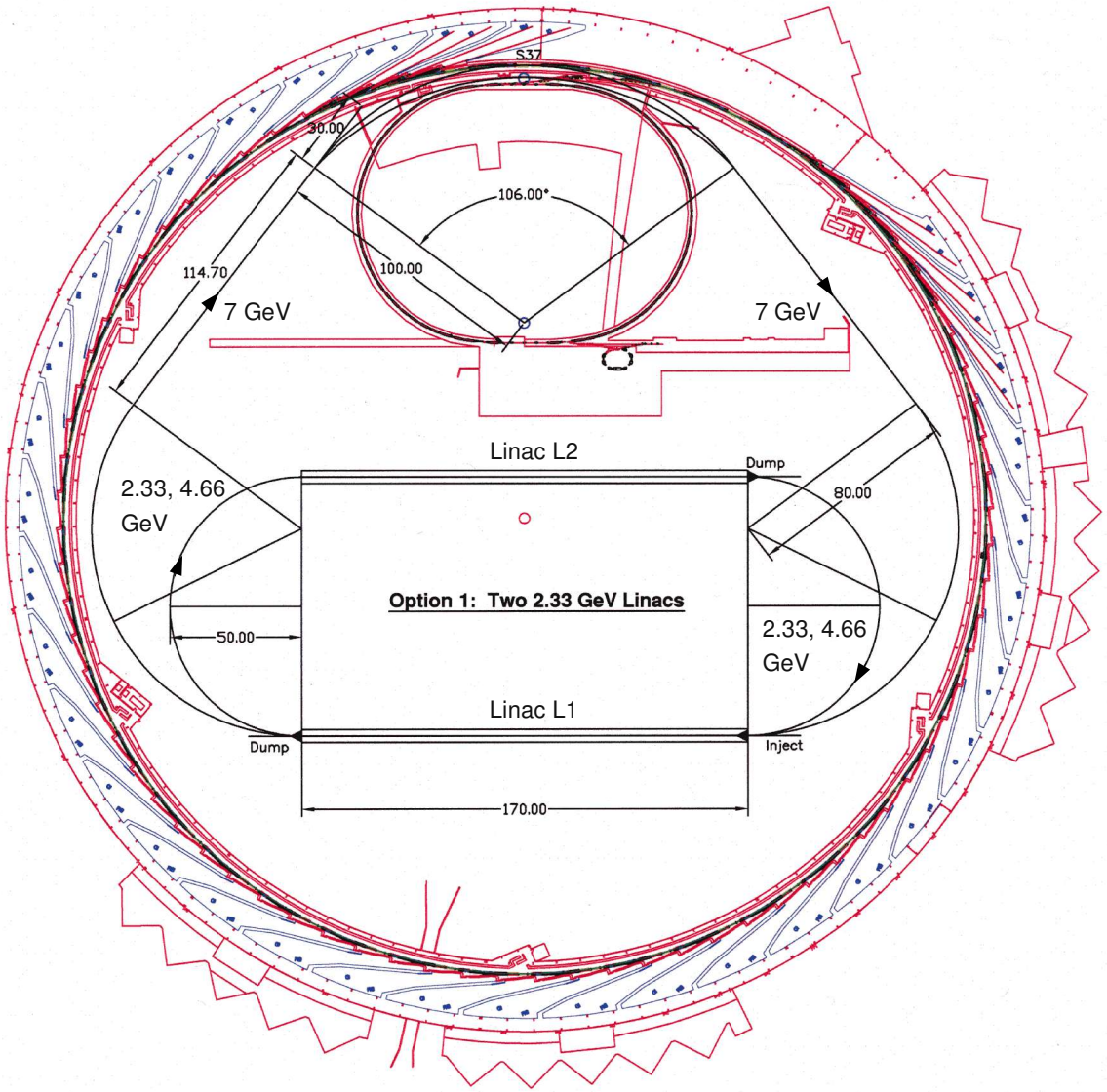
- Dark Gold: DI H20
- Cyan: Storm H20 piping
- Red: Electrical
- Dark Blue: Domestic H20
- Gold/White: Sanitary Sewer
- Magenta: Lab sewer

- Put ERL racetrack in this general area



Infield ERL: Layout Option 1

- Two 2.33 GeV Linacs
- Four low energy recirculation arcs connecting linacs L1 and L2
  - Two at 2.33 GeV
  - Two at 4.66 GeV
- Inject/extract into sector 37
- Use L2 beam dump to commission energy recovery at 4.66 GeV
- Commission energy recovery at 7 GeV using booster bypass line



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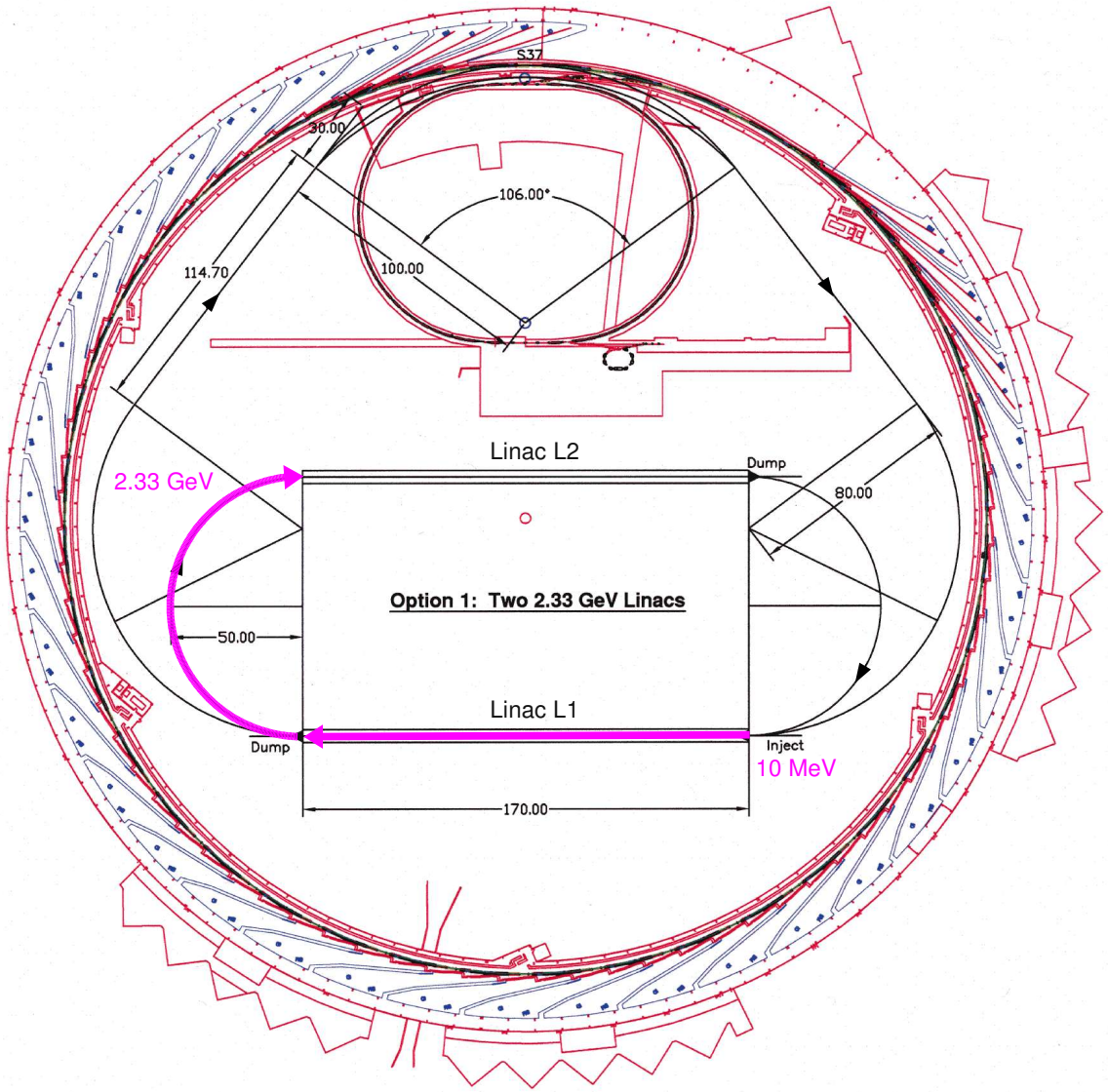

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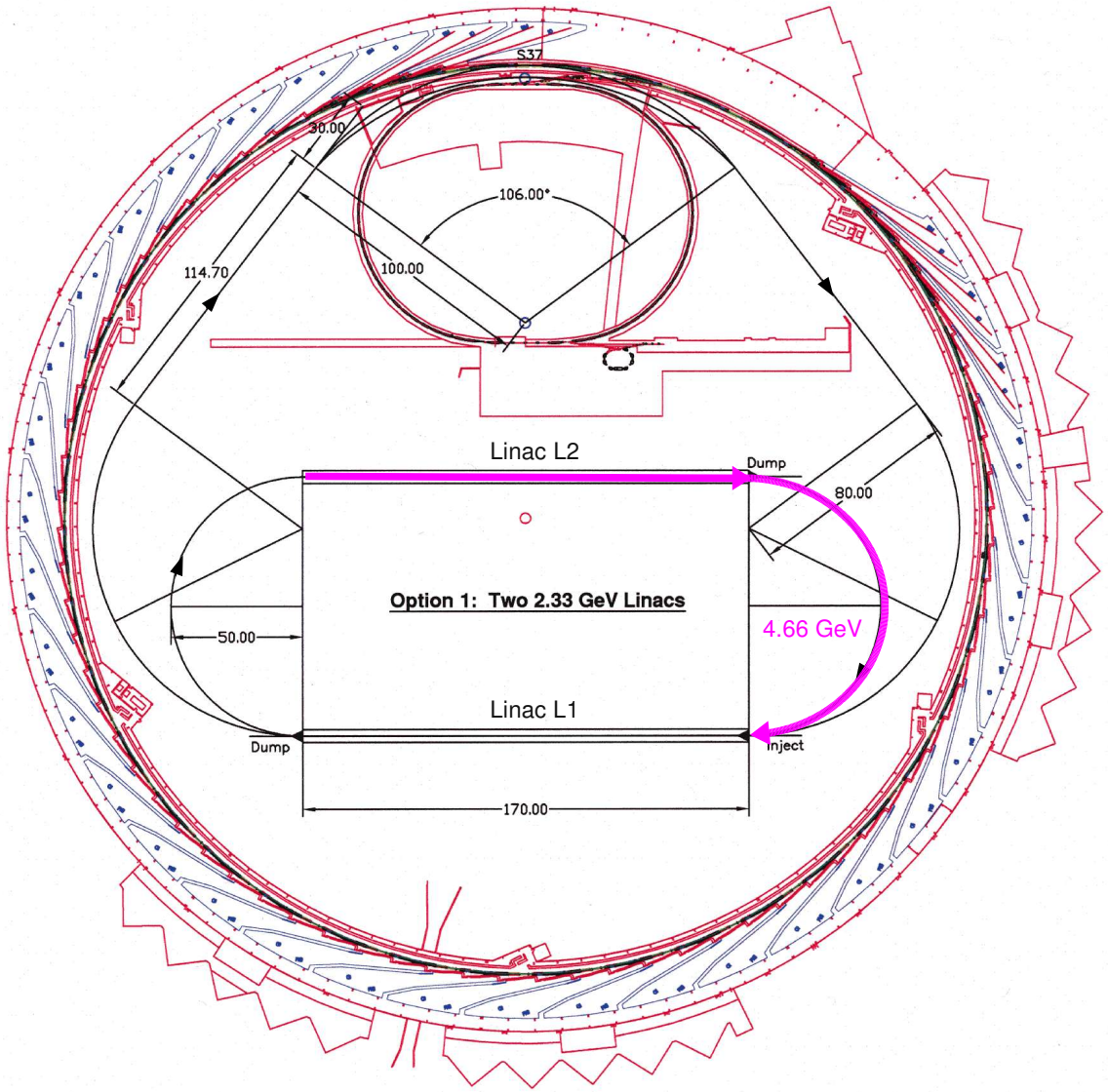

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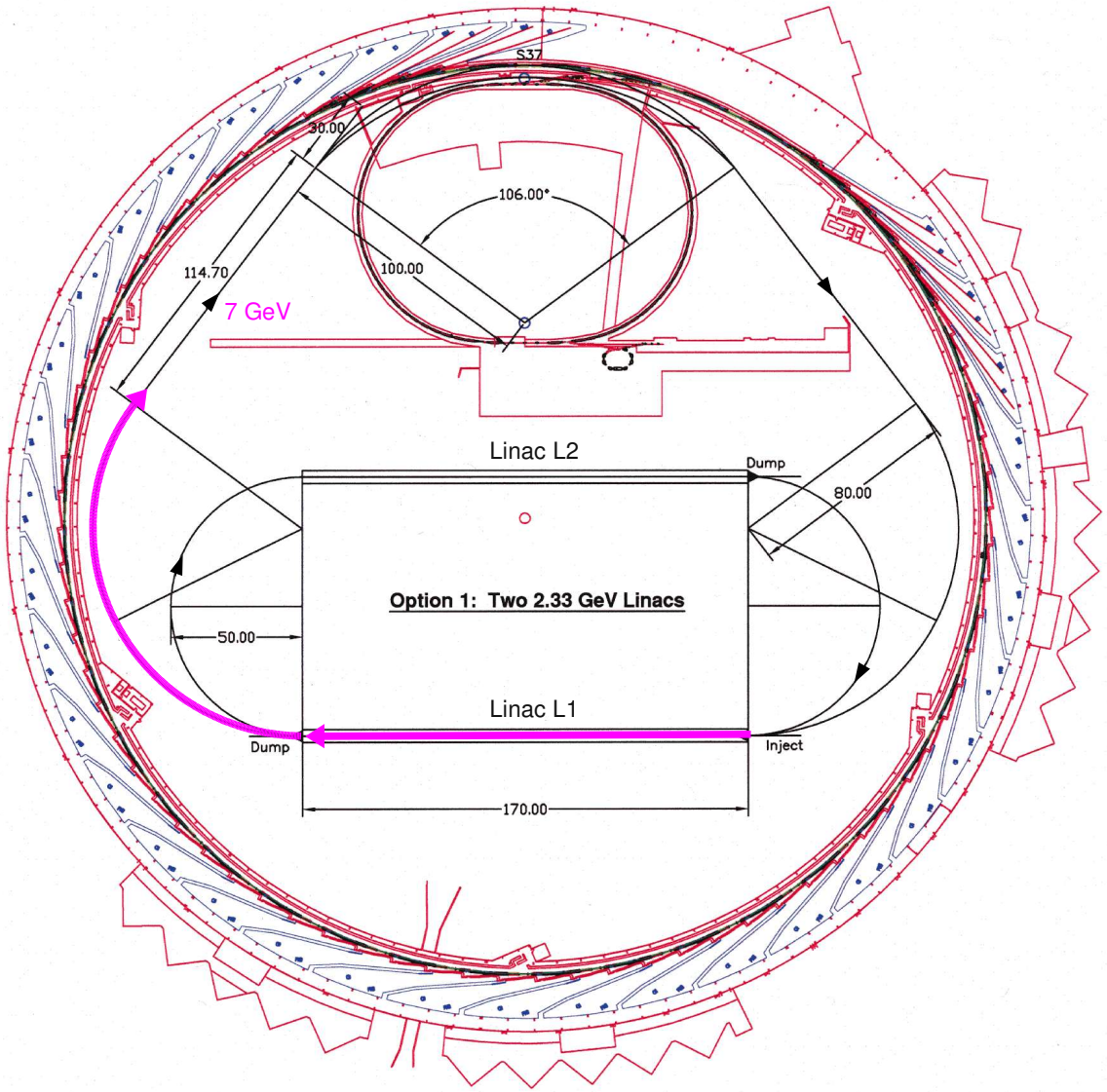

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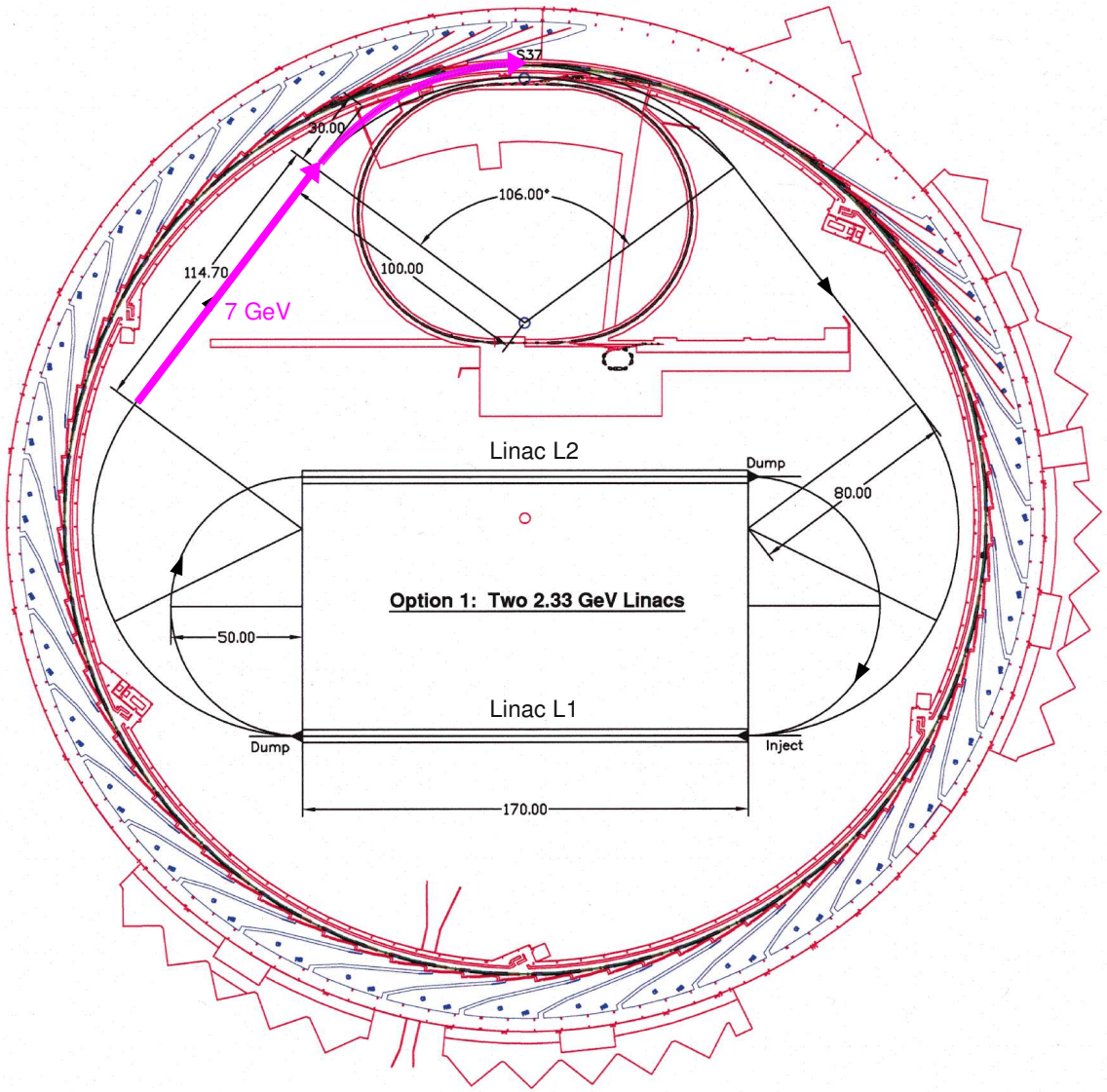

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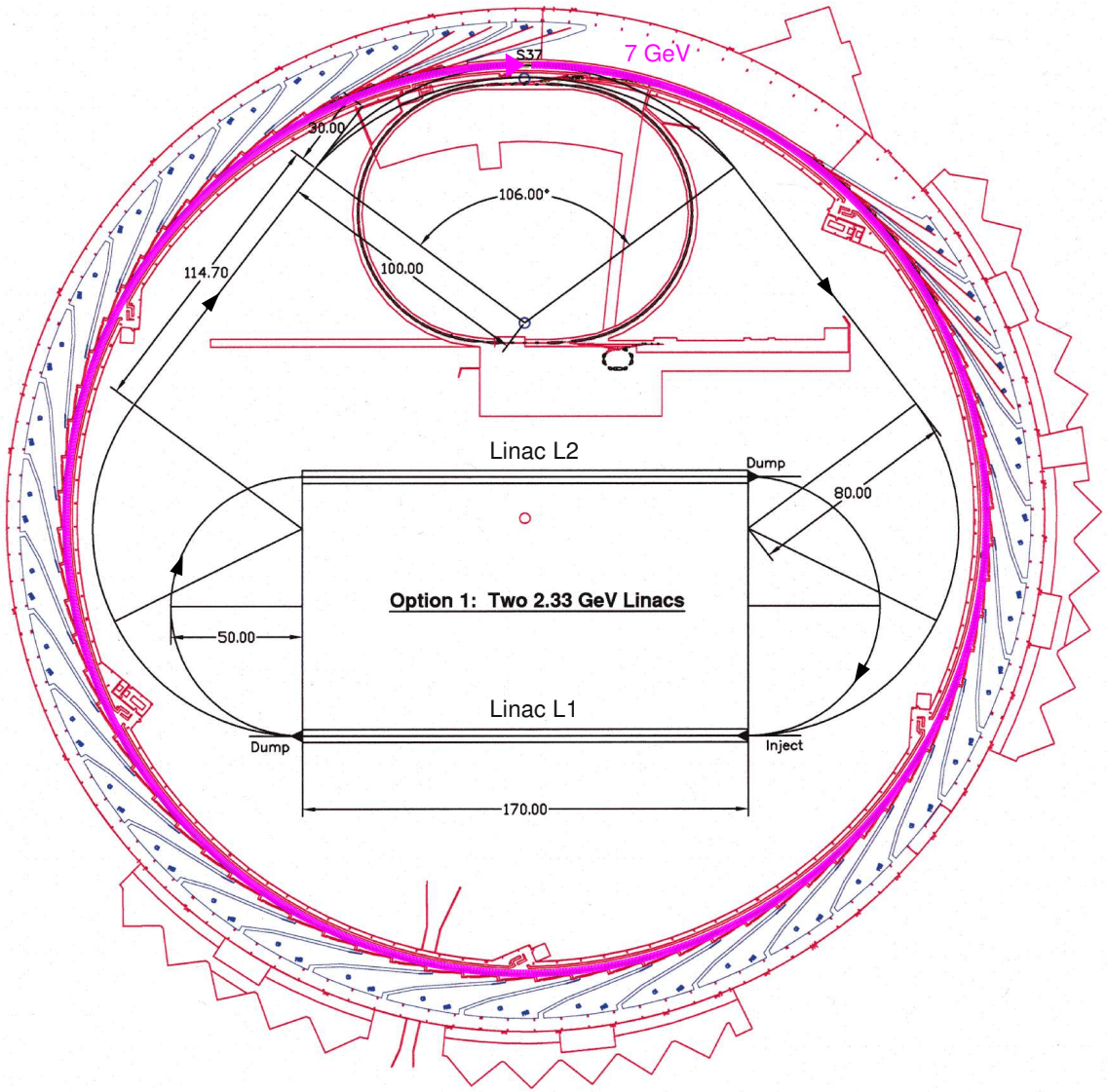

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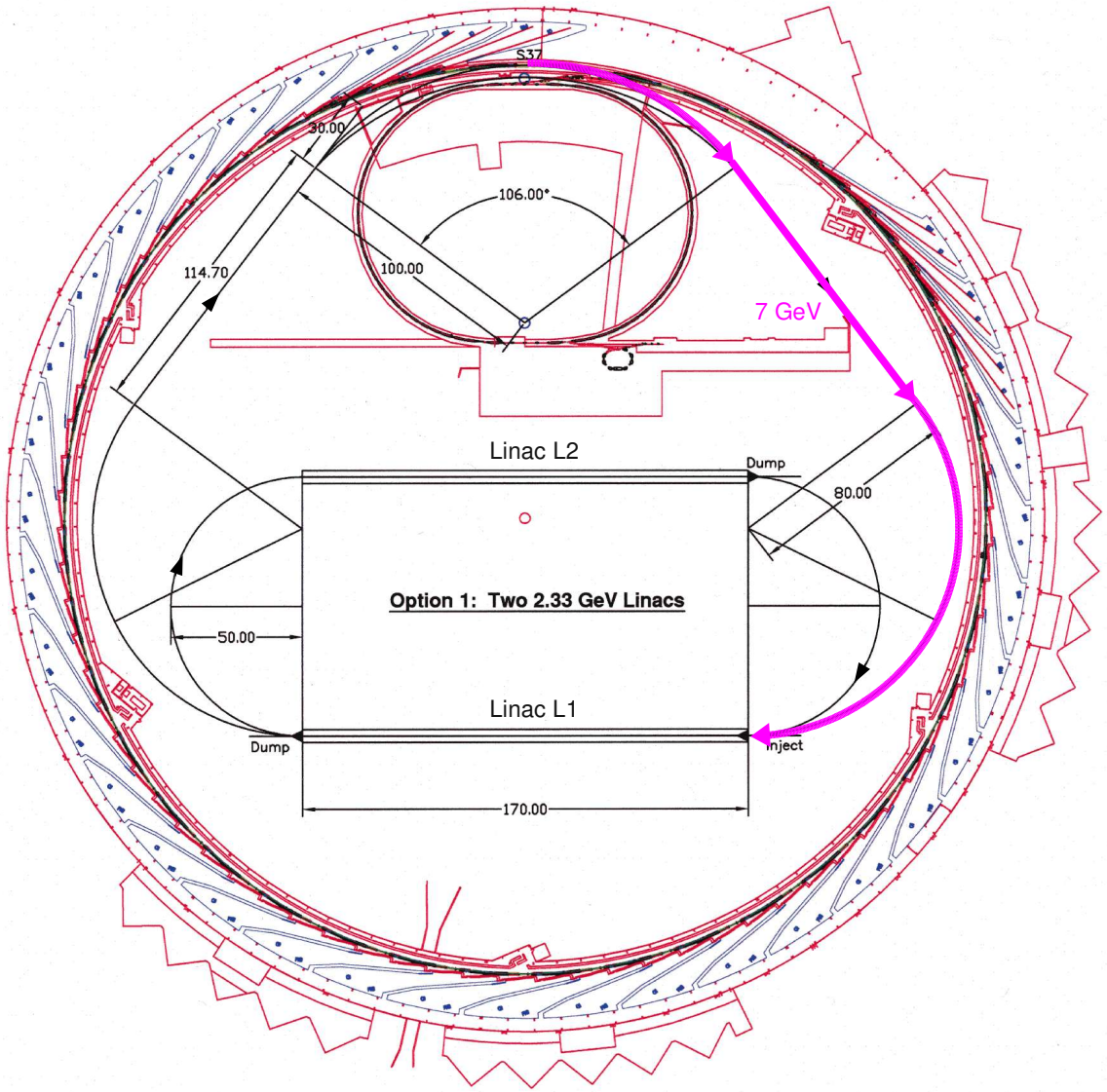

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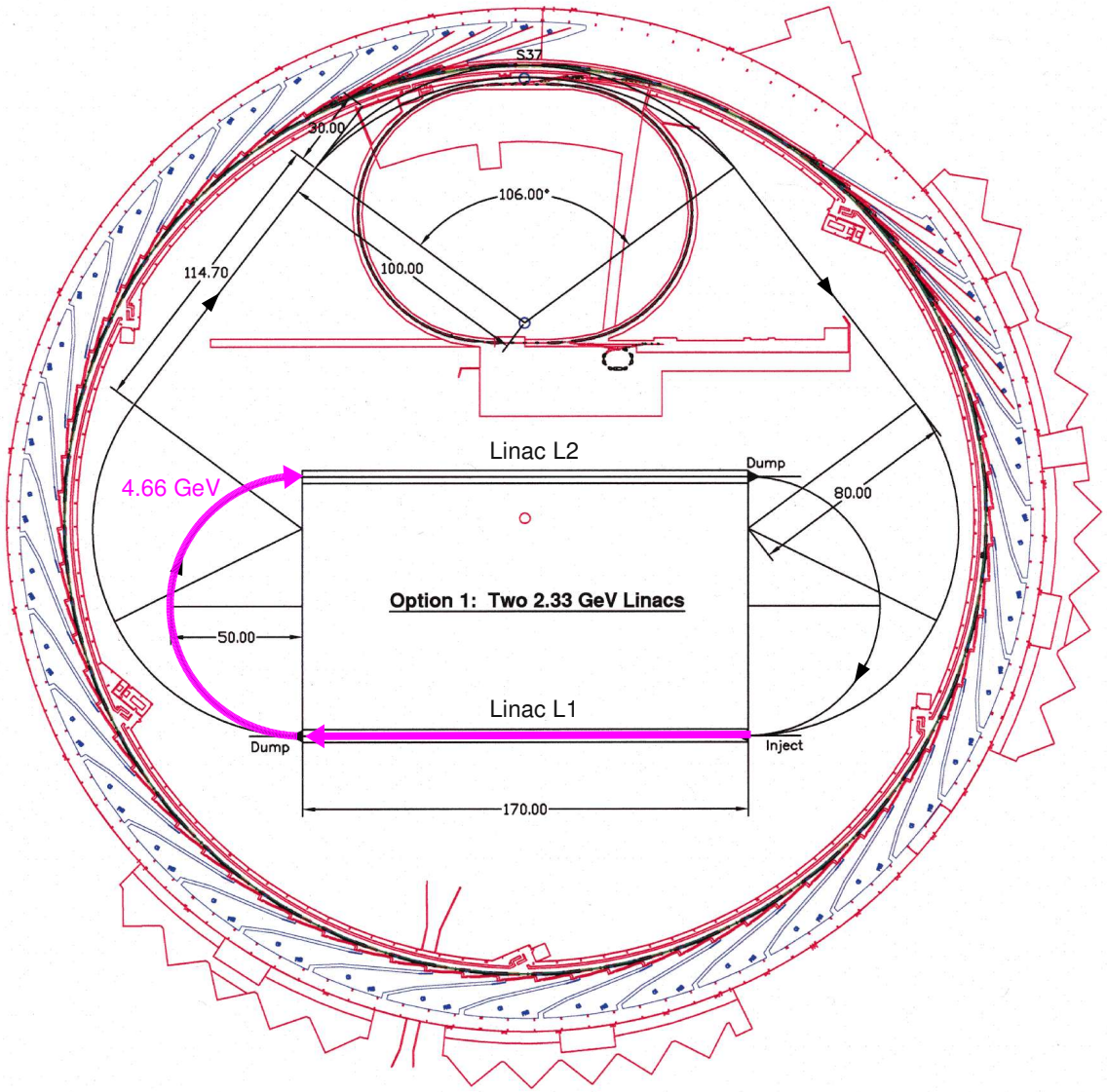

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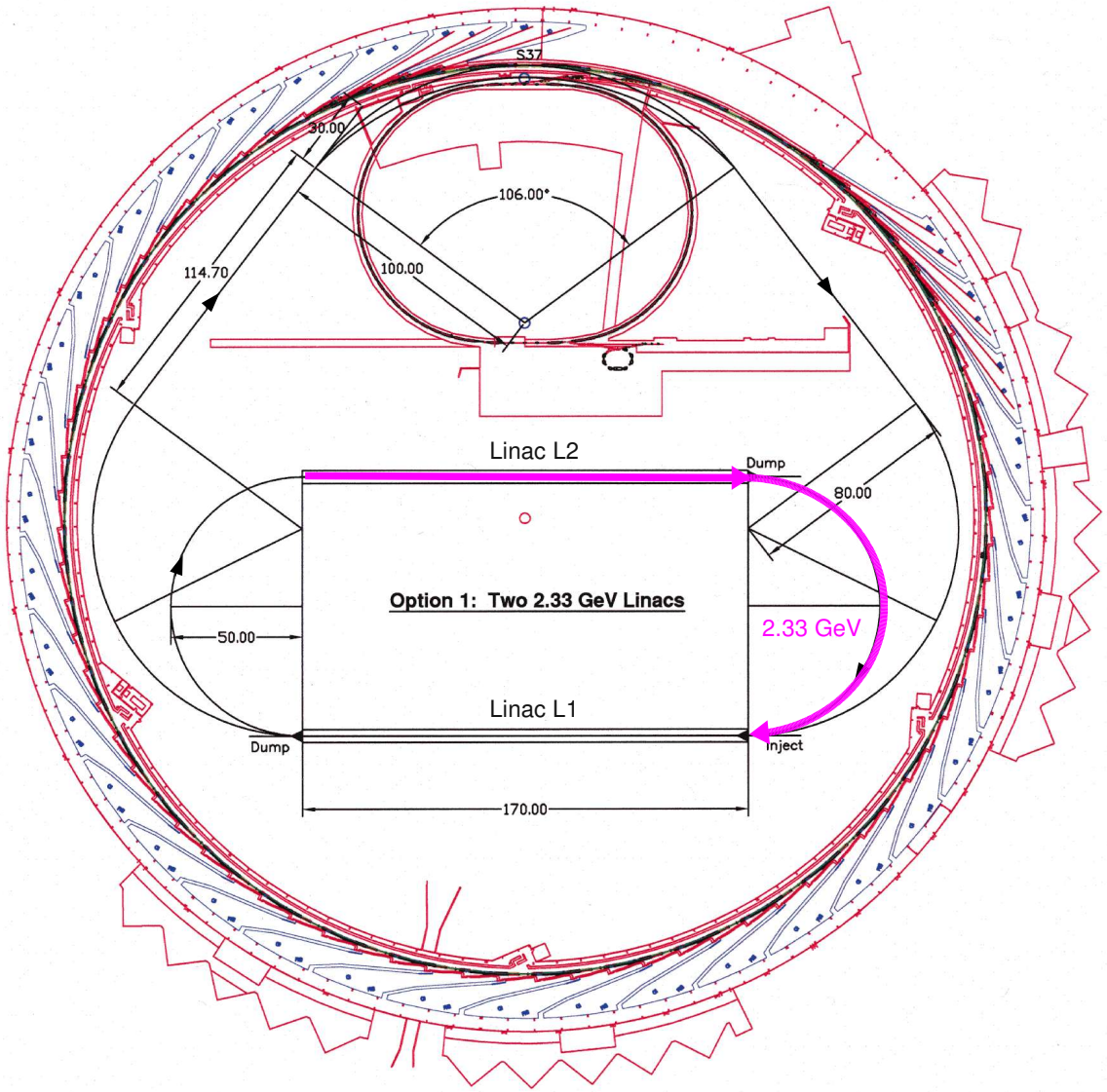

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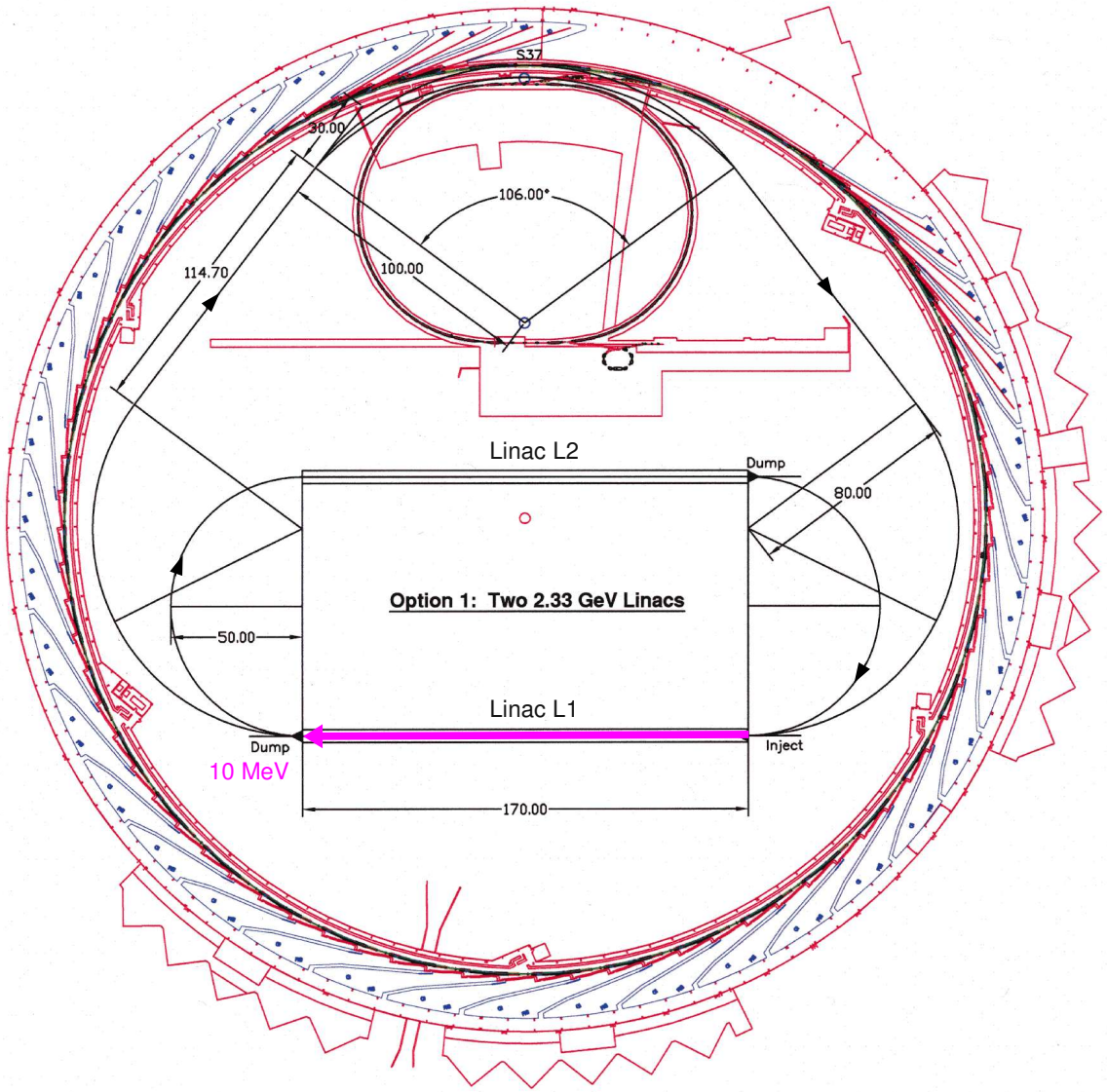
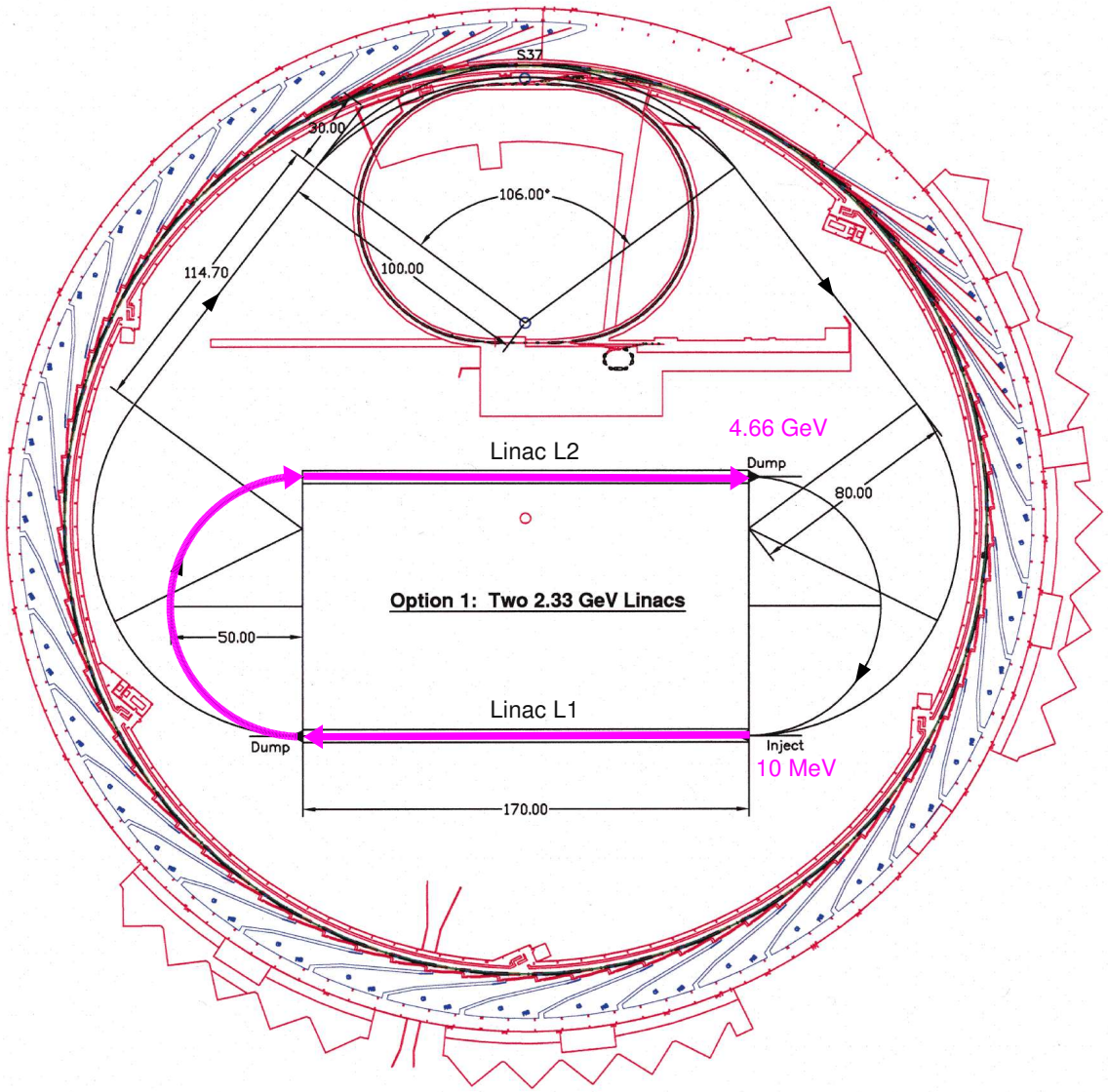


Infield ERL: Layout Option 1, 4.66 GeV Energy Recovery



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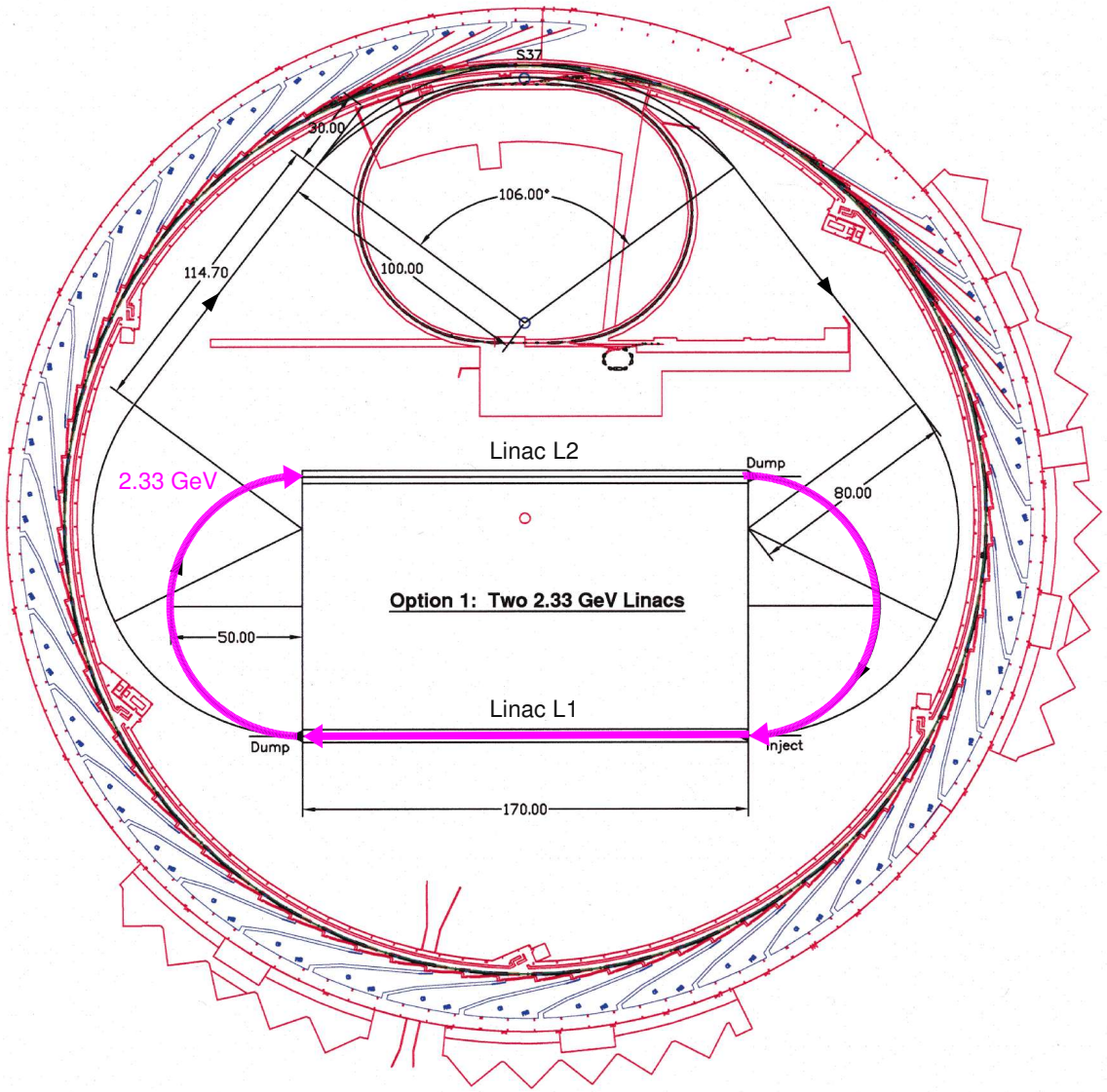

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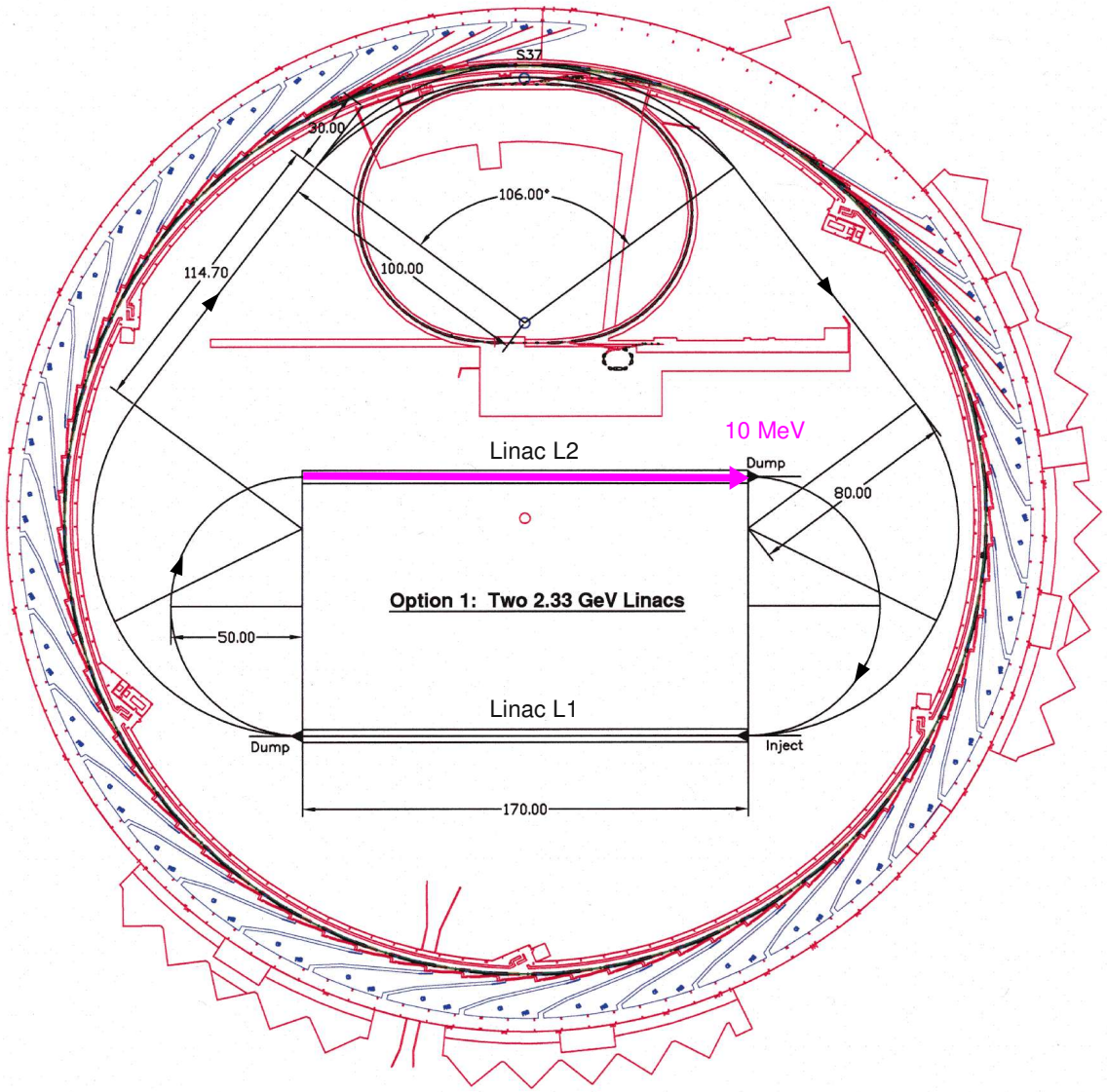
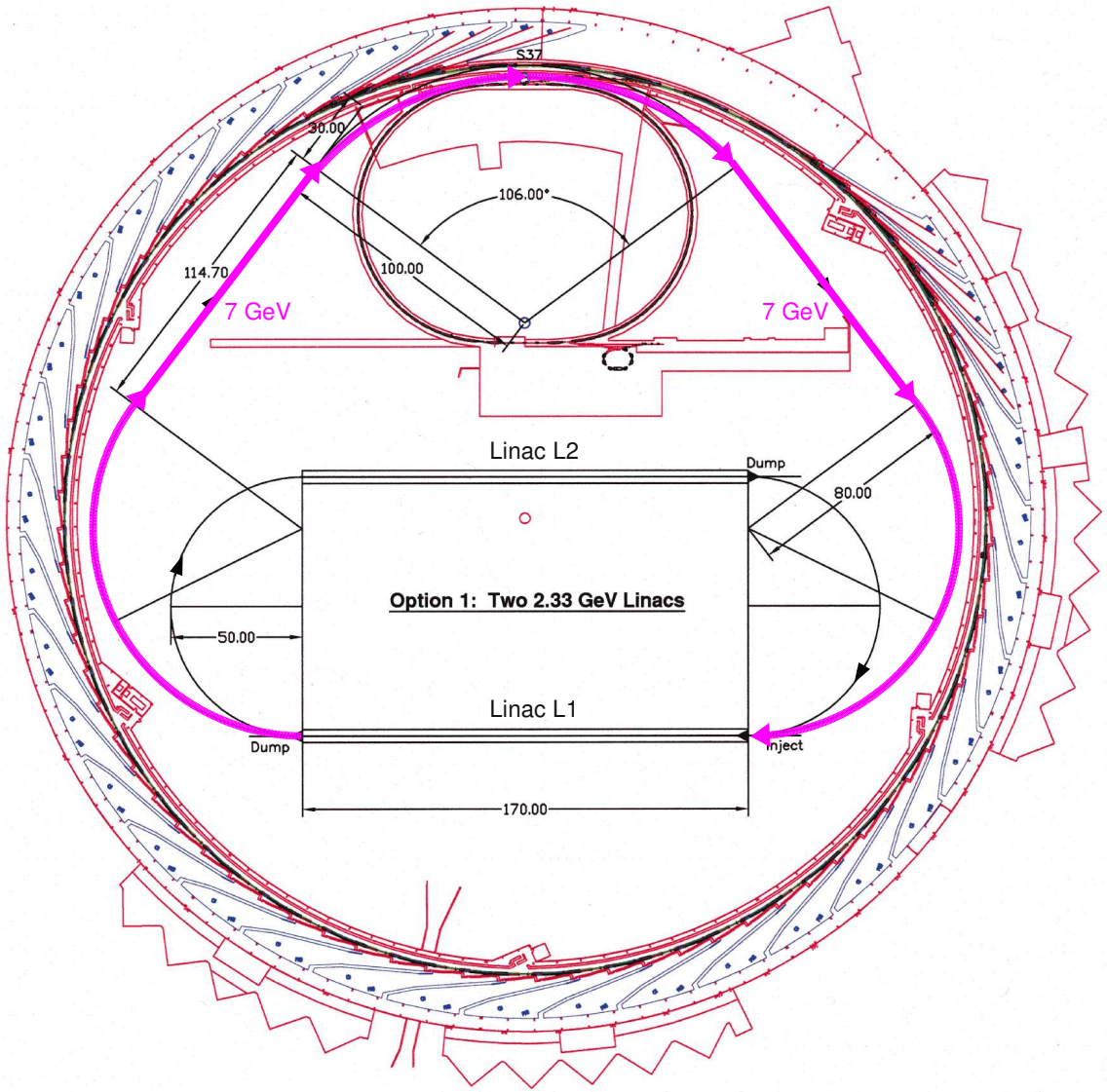


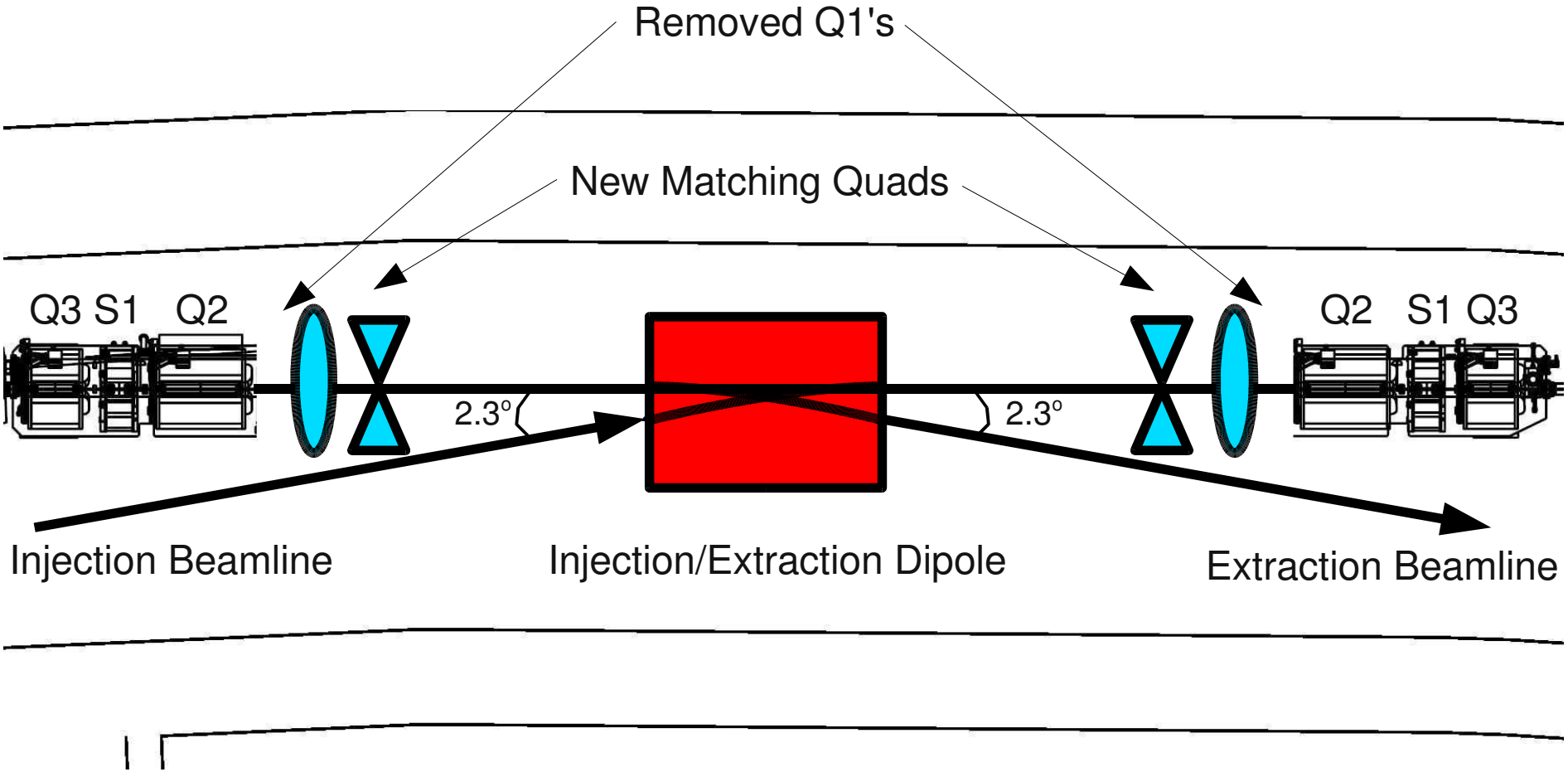
Infield ERL: Layout Option 1, 7 GeV Energy Recovery



Infield ERL: Layout Option 1 Summary

- Use 2 linacs in racetrack configuration with total energy gain of 2.33 GeV / linac, 170 m length each.
- Implies an effective gradient of 13.7 MV/m
- Implies 22.8 MV/m cavities with 60 % fill factor (A. Nassiri's talk)
- Requires 102 (~1 m) cavities per linac
- Linacs are relatively short so linac optics should be less severe than the outfield ERL option
  - Use graded gradient optics in the linac
  - Keep high energy arcs at large radius (~90 m) to minimize ISR/CSR emittance blowup (M. Borland's talk)

Infield ERL: Sector 37 Common Dipole Injection Scheme

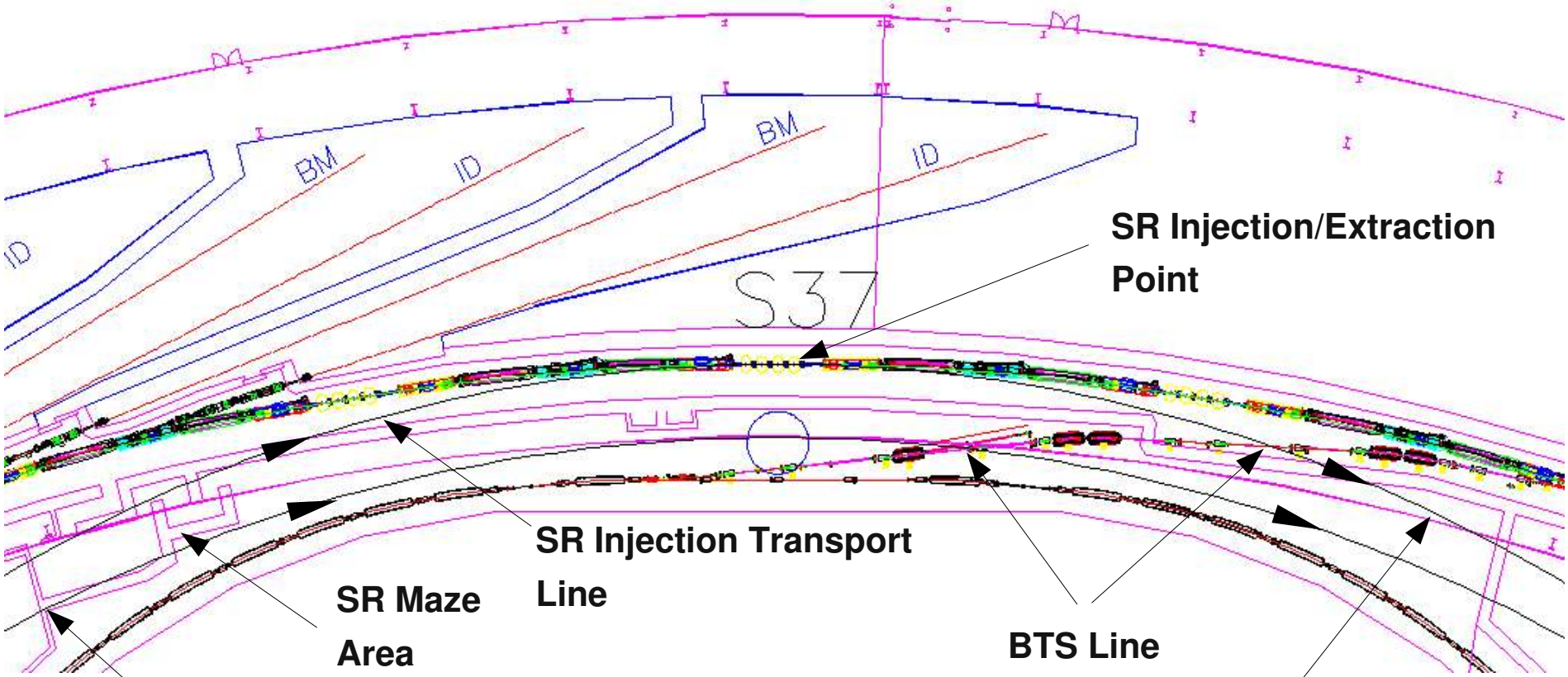


Remove 4 rf cavities and relocate

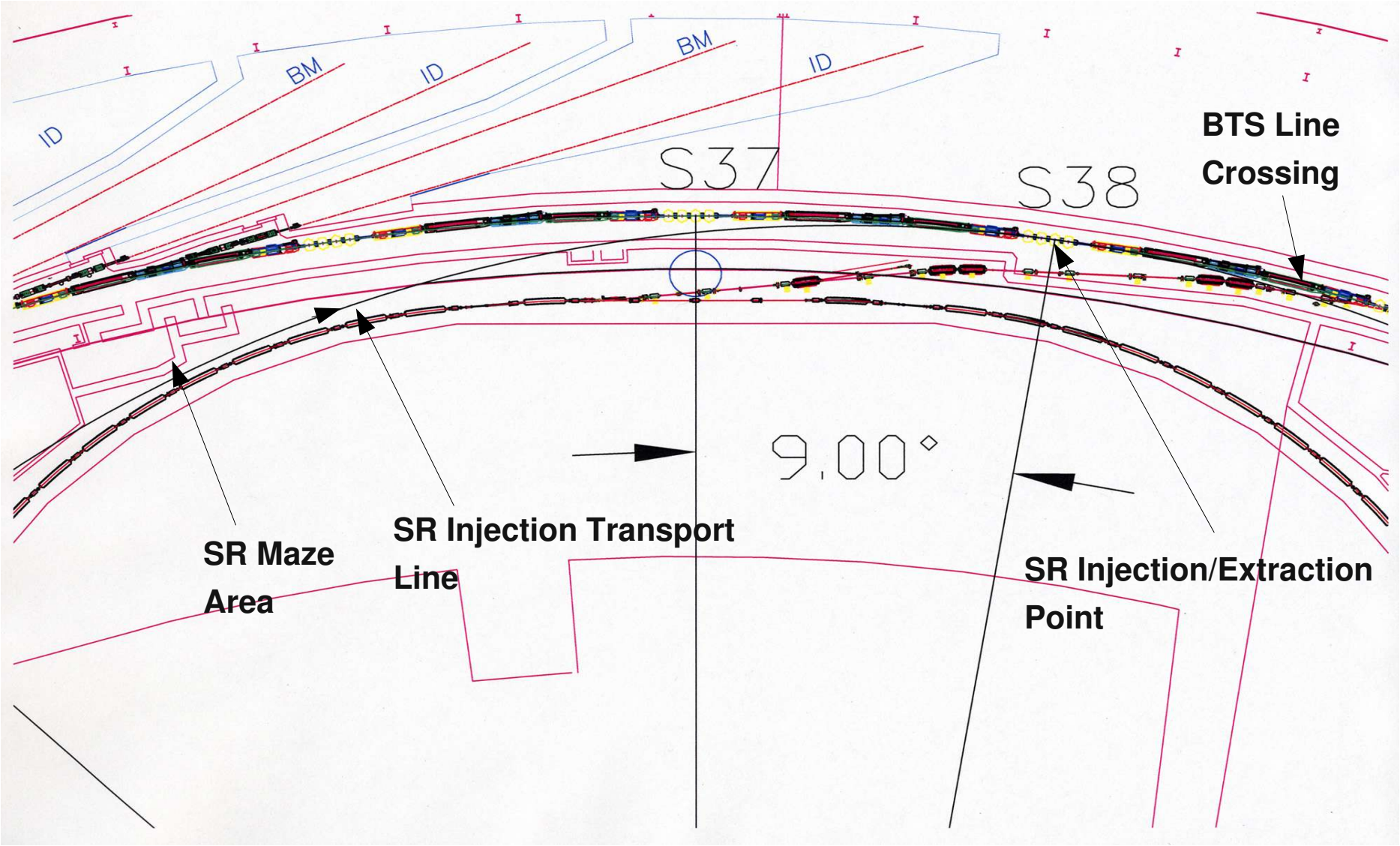
Infield ERL: Injection/Extraction Summary

- Inject/Extract into/out-of APS using a common dipole in sector 37
- Dipole length could be as short as 1.5 m bending at 2.3 degrees
  - Make space for matching doublets
  - Avoid interference of injection/extraction beamlines with ring magnets
- Follow Decker's suggestions to move sector 37 rf cavities
  - Only 4 to relocate (maybe only 2 if rf requirements are met with 14 cavities)
  - Could put up to 3 in sector 38 after relocating IK1, Q1
  - Remaining cavity could go in sector 35, 36 or 40
- ERL beam passes through all rf cavities

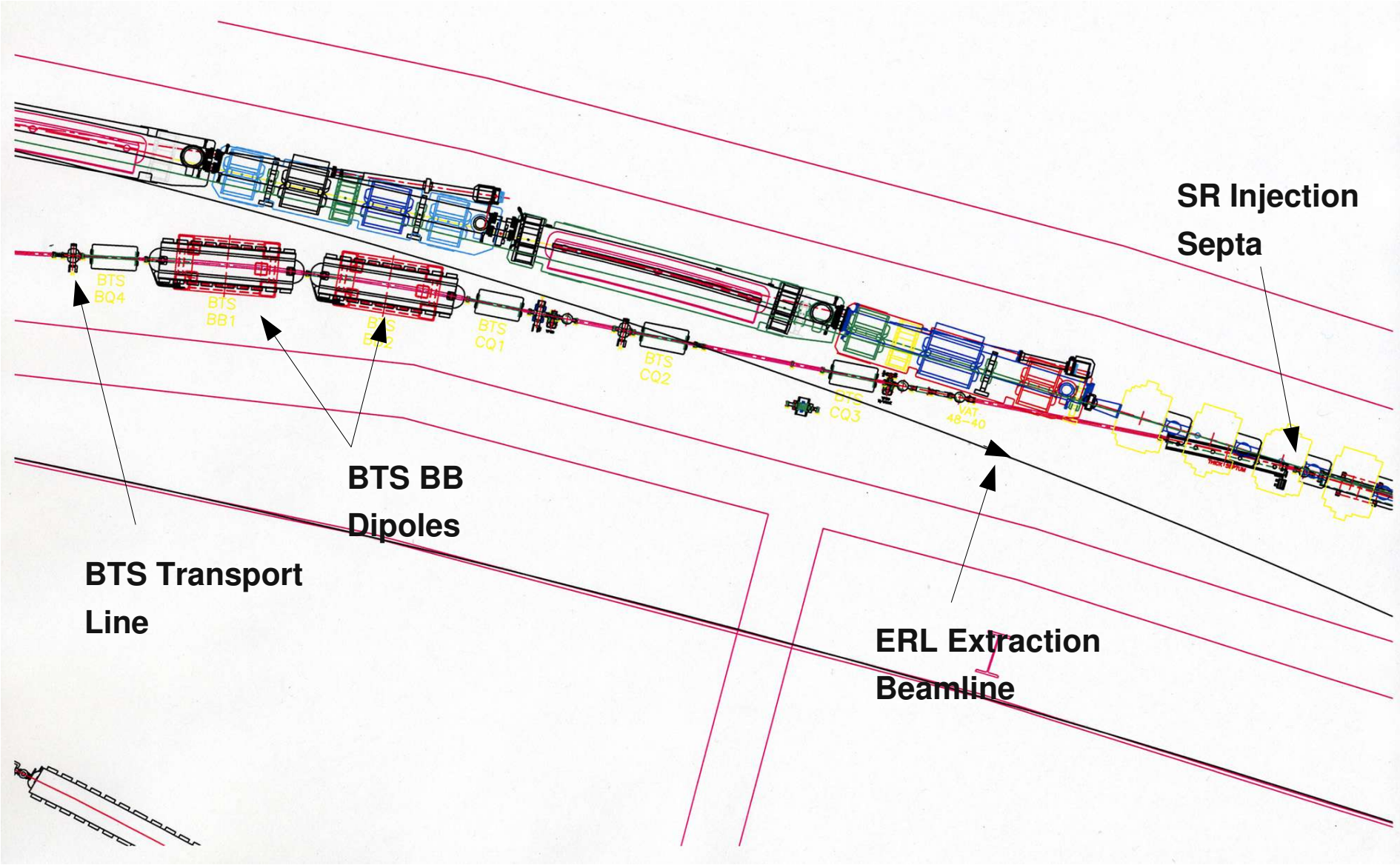
Infield ERL: Booster Bypass Transport Line Summary



Infield ERL: Sector 38 Injection/Extraction Option

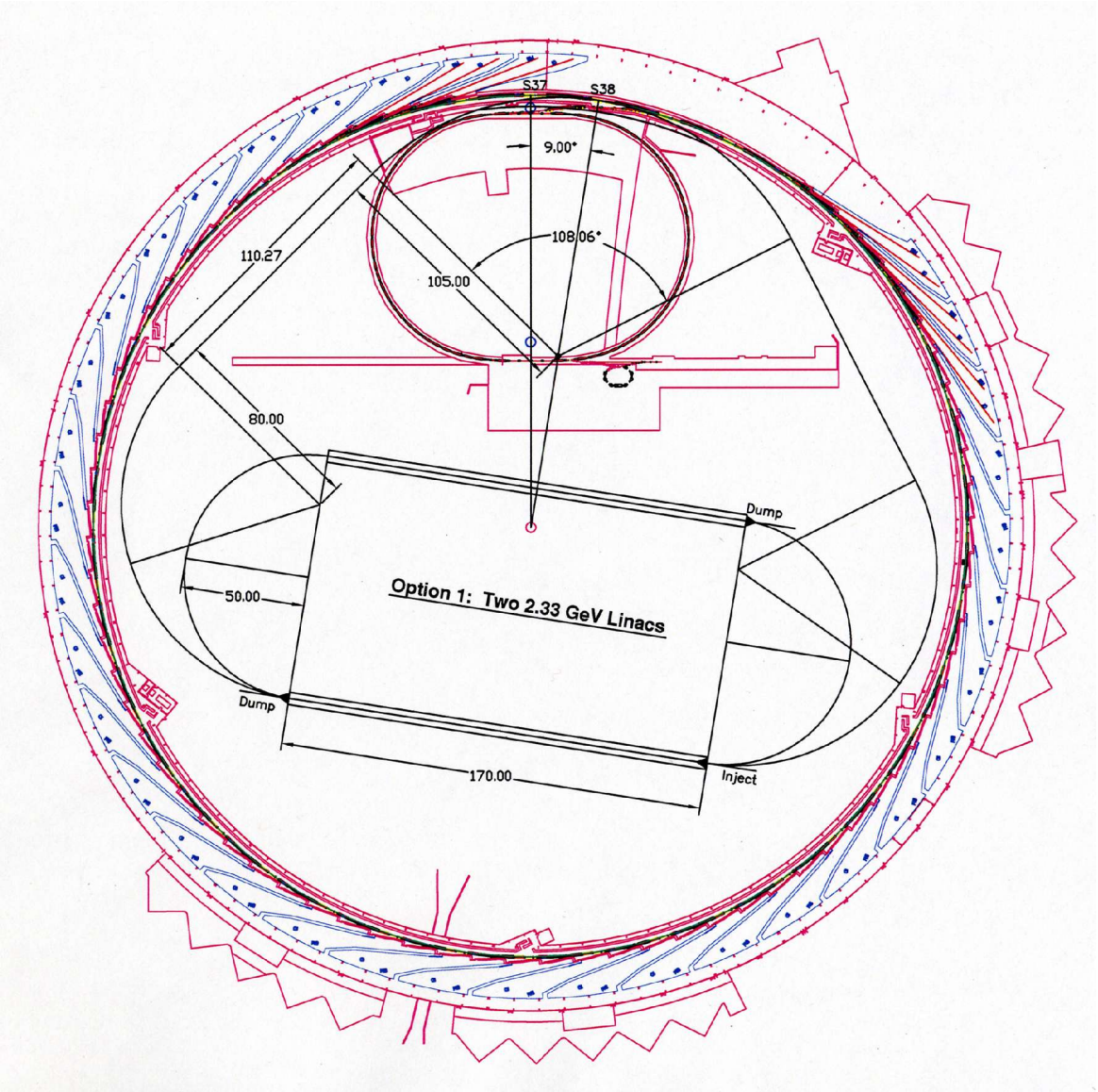


Infield ERL: Sector 38 Injection/Extraction Option BTS Area

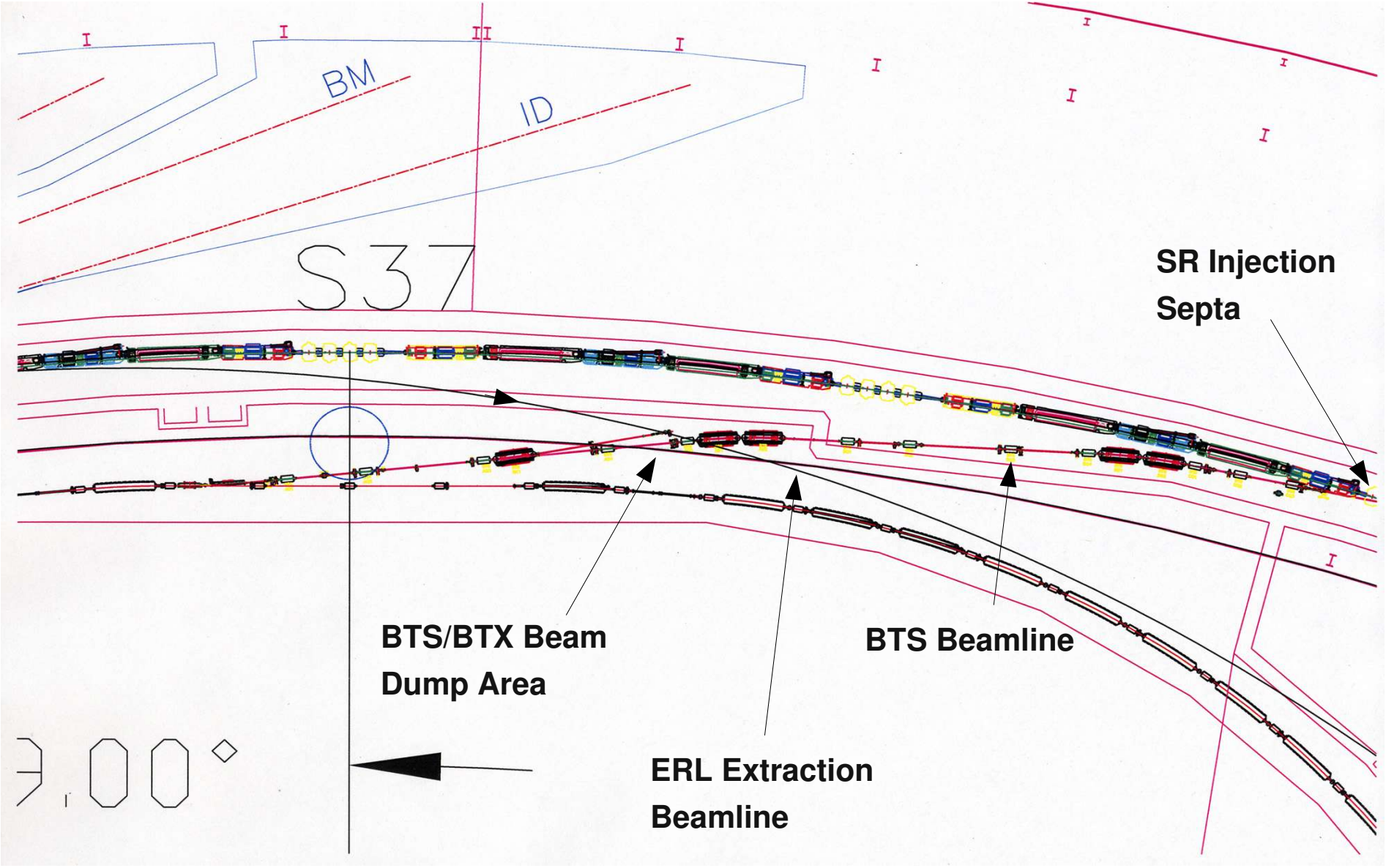


Infield ERL: Sector 38 Injection/Extraction Option

ERL Complex rotated by 9 degrees clockwise



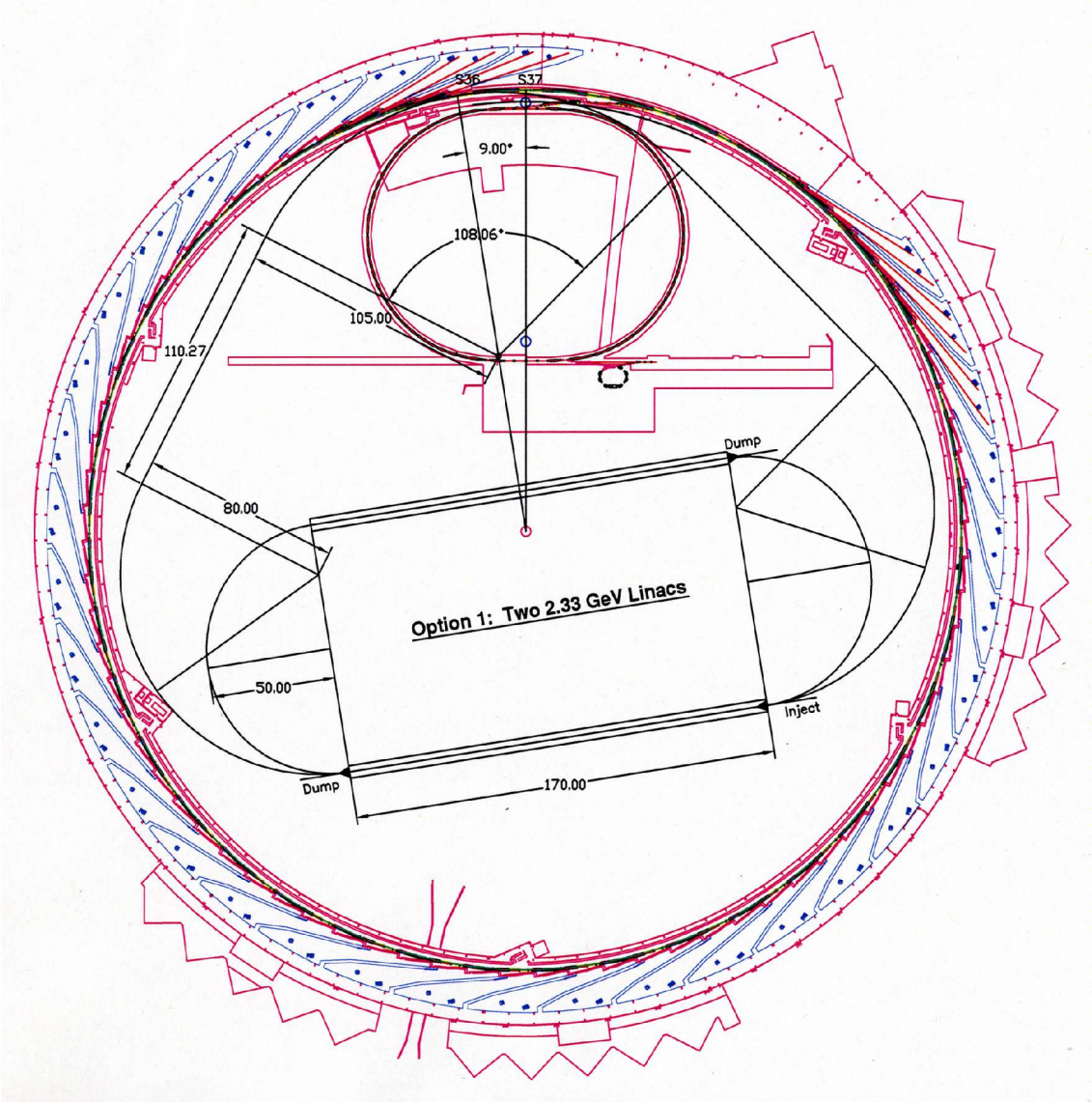
Infield ERL: Sector 36 Injection/Extraction Option



Infield ERL: Sector 36 Injection/Extraction Option

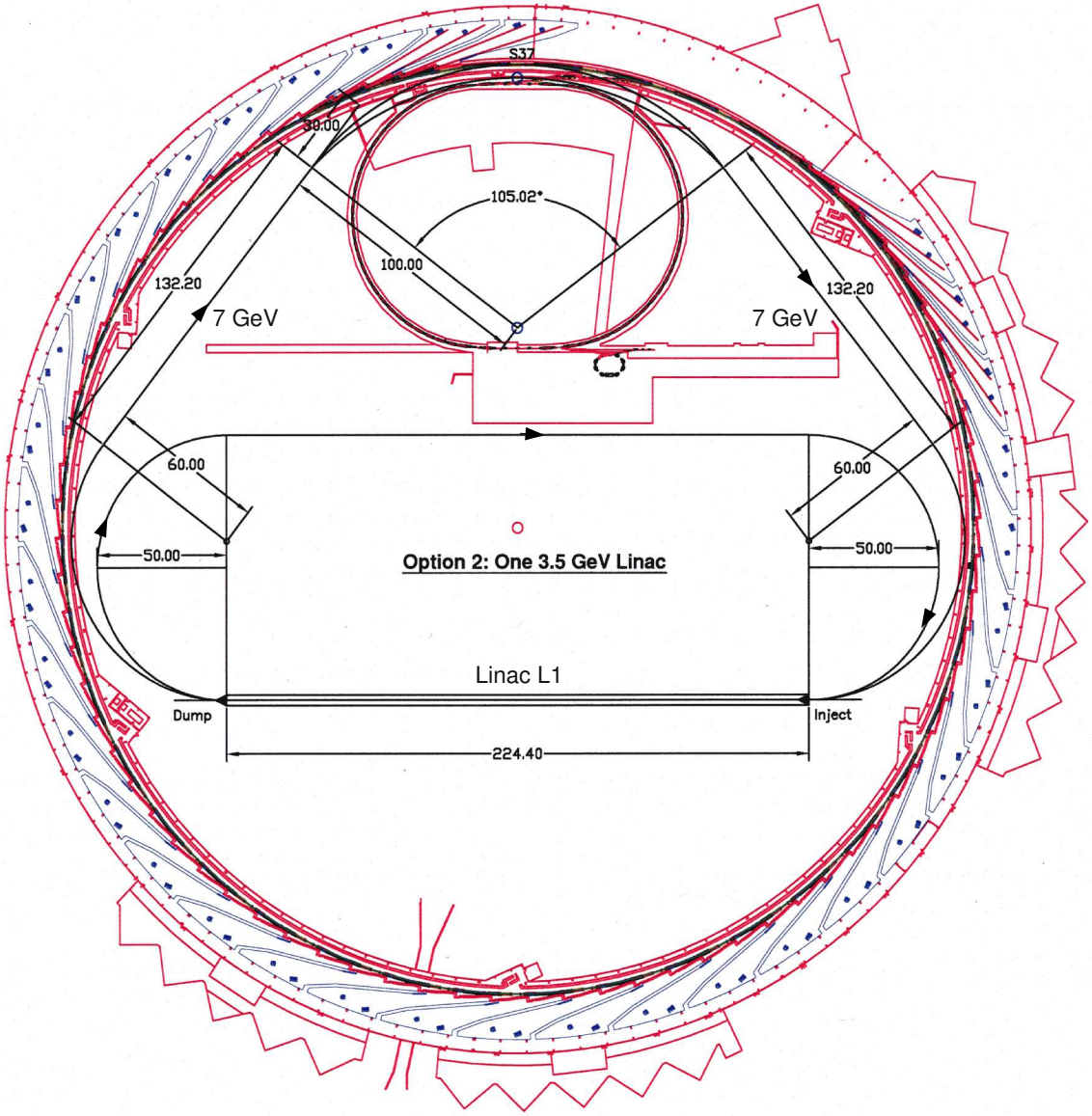
ERL Complex rotated by

9 degrees counterclockwise



Infield ERL: Layout Option 2 Summary

- Single (longer) 3.5 GeV Linac L1
- Two low energy 3.5 recirculation arcs around L1
- Same injection/extraction booster bypass line configuration as option 1
- Longer linac means 7 GeV arcs interfere with SR enclosure
- Only 60 m 7 GeV arcs possible at injection/extraction of L1



Infield ERL: Layout Option 2 Summary

- Use a single linac with total energy gain of 3.5 GeV, 224.4 m length
- Implies an effective gradient of 15.6 MV/m
- Implies 26 MV/m cavities with 60 % fill factor (A. Nassiri's talk)
- Requires 135 (~1m) rf cavities (about 34 % less than option 1)
- Linac is relatively short so recirculation optics should be less severe than the outfield ERL option
  - Use graded gradient optics in the linac
  - Interference with SR building requires 60 m radius 7 GeV arcs
  - Use same injection/extraction scheme as option 1
- **Depends on being able to reliably achieve high gradient/Q required for this option**

Infield ERL: Conclusions

- Options proposed are driven by achievable cavity gradient
- In general, more gradient allows more compact configurations
  - Fewer recirculation and shorter linacs
  - Fewer rf cavities/cryogenics than for outfield option
- Interference with utilities/building structures is unavoidable due to lack of space (more of a problem with option 2)
- Build in path length adjustment to optimize energy recovery
- Interference with the SR maze door for sector 37 injection
  - Can inject into sector 38 and redesign BTS line BB dipole area
  - Can inject into sector 36 with possible sector 35 and BTX beam dump interference

Infield ERL: Conclusions cont.

- Only have to relocate up to four existing storage ring cavities removed from sector 37 (or 38) (maybe only two)
- Need to evaluate multipass BBU impact for each option
- Option 1 has 40 % emittance increase at injection in the APS ring (nearly all) due to 7 GeV arcs (M. Borland's talk)
- Need to evaluate ISR emittance increase for 4.66 GeV arcs used in option 1
- V. Sajaev found a similar emittance increase for a layout similar to option 2
- **Both options allow initial commissioning of energy recovery without disturbing users by using booster bypass transport line**
- Option looks feasible. Details of injection/extraction need further development