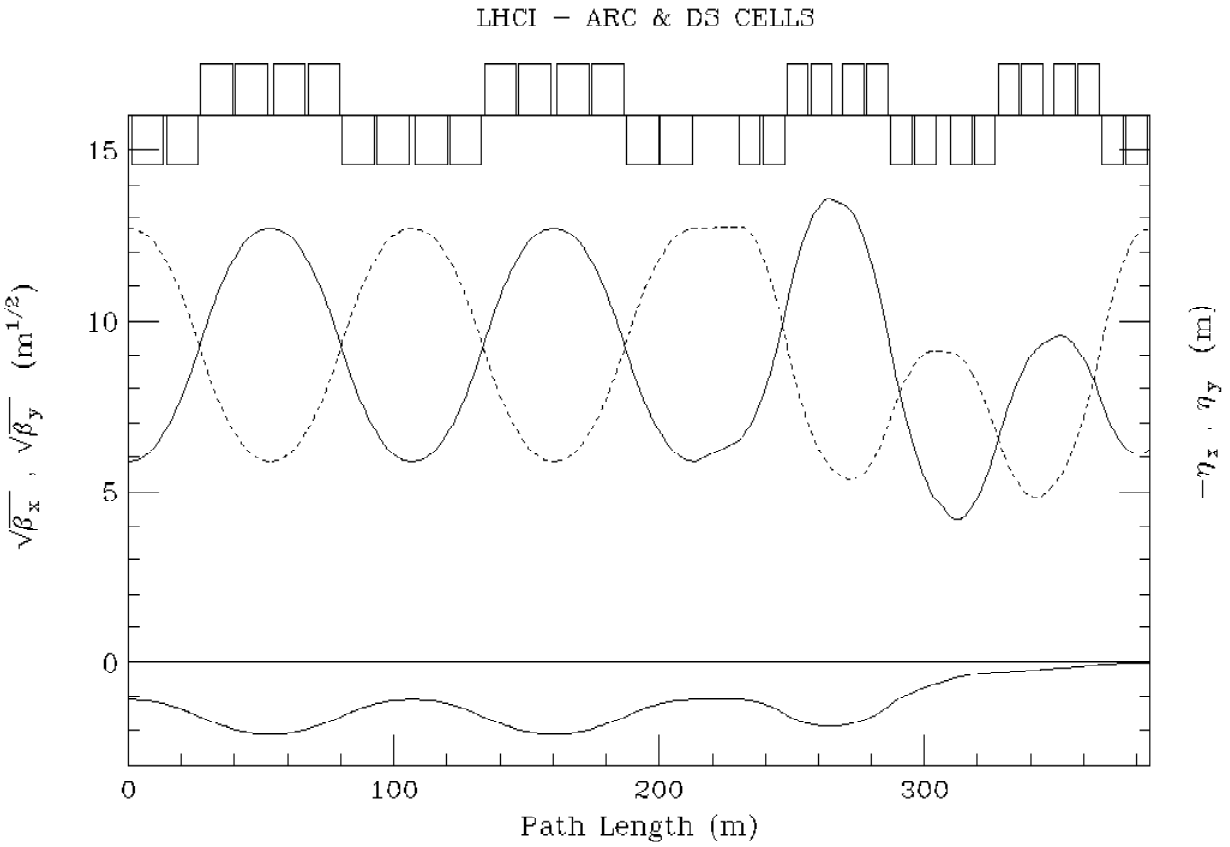
Optics Issues for the LHC-I

Arc & Dispersion Suppressor Cells:

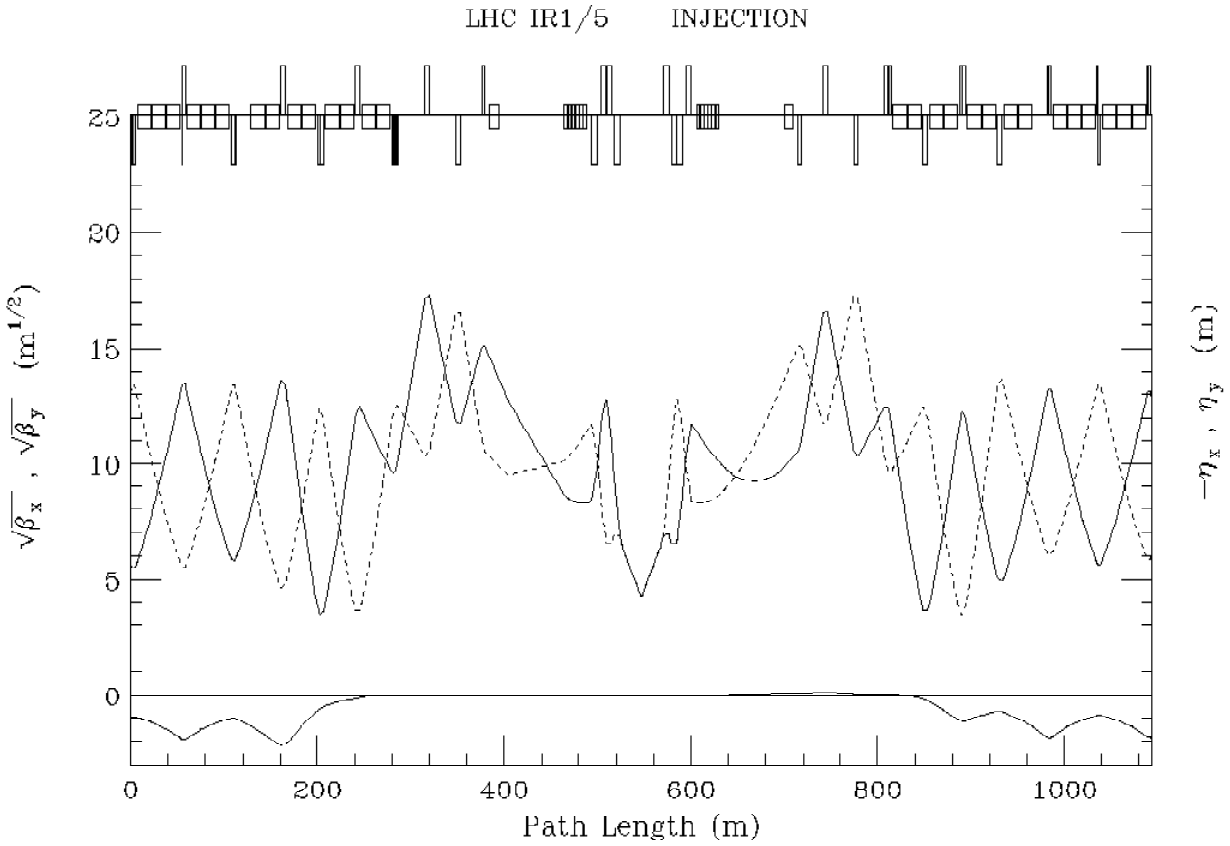
- Constructed from combined function 'transmission line' magnets to replicate LHC optics & match the LHC footprint.
- Magnets originally proposed for VLHC, with B = 1.966 T @ 100 kA.
- Dispersion suppressors are similar (sort of) to the Main Injector -- $^{2}/_{3}$ the bend & $^{3}/_{4}$ the length of arc cells.

Cell Type	Cell Length (m)	Magnet Types	L_{mag} (m)	# / Cell	B (T)	B' (T/m)
Arc	107	GF / GD	12	8	1.595	4.858
Suppressor	80	GSF / GSD	8	8	1.595	10.112

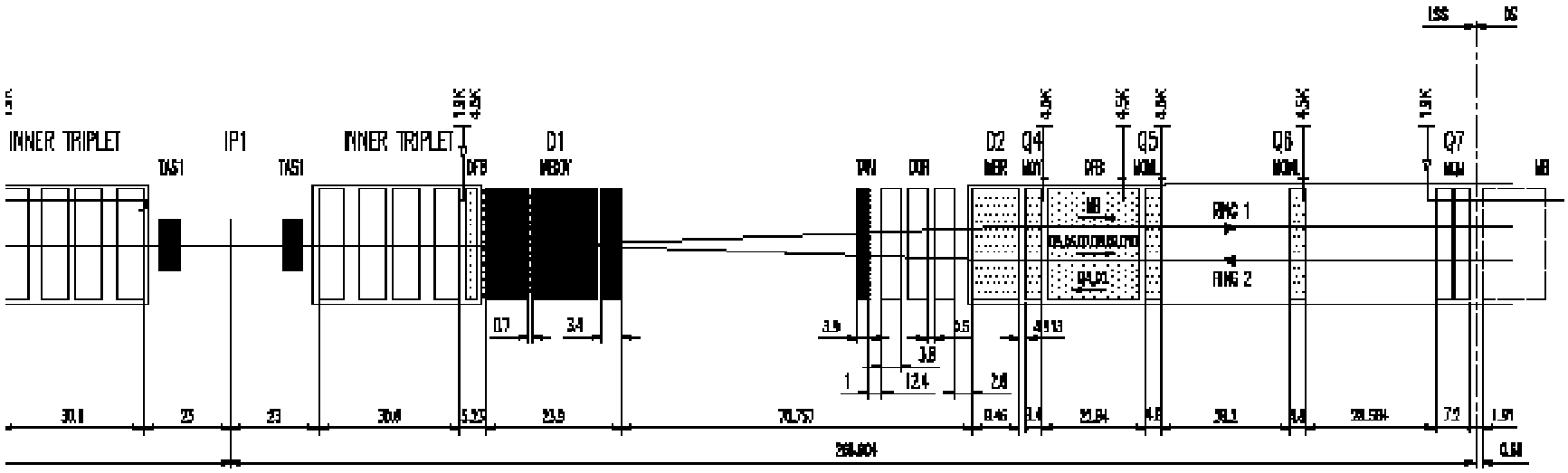


- β (max) = 162 m
- η (max) = 2.10 m
- Phase advance / cell = 90^{o}

(end of the easy stuff)



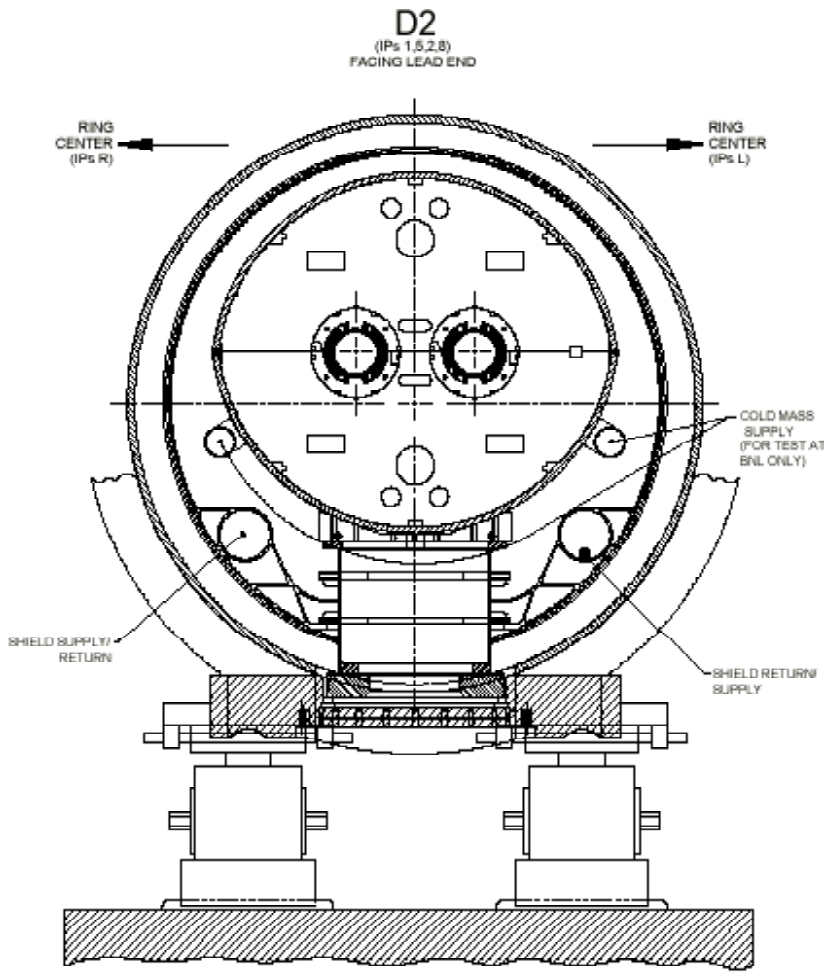
- LHCI must drop to LHC altitude, match the $\beta^* = 18$ m injection optics as beams travel through the detectors, then climb the 1.1 m back to the LHCI altitude by the end of the straight.



- The 1.1 m altitude changes must be accomplished in **very** short distances!

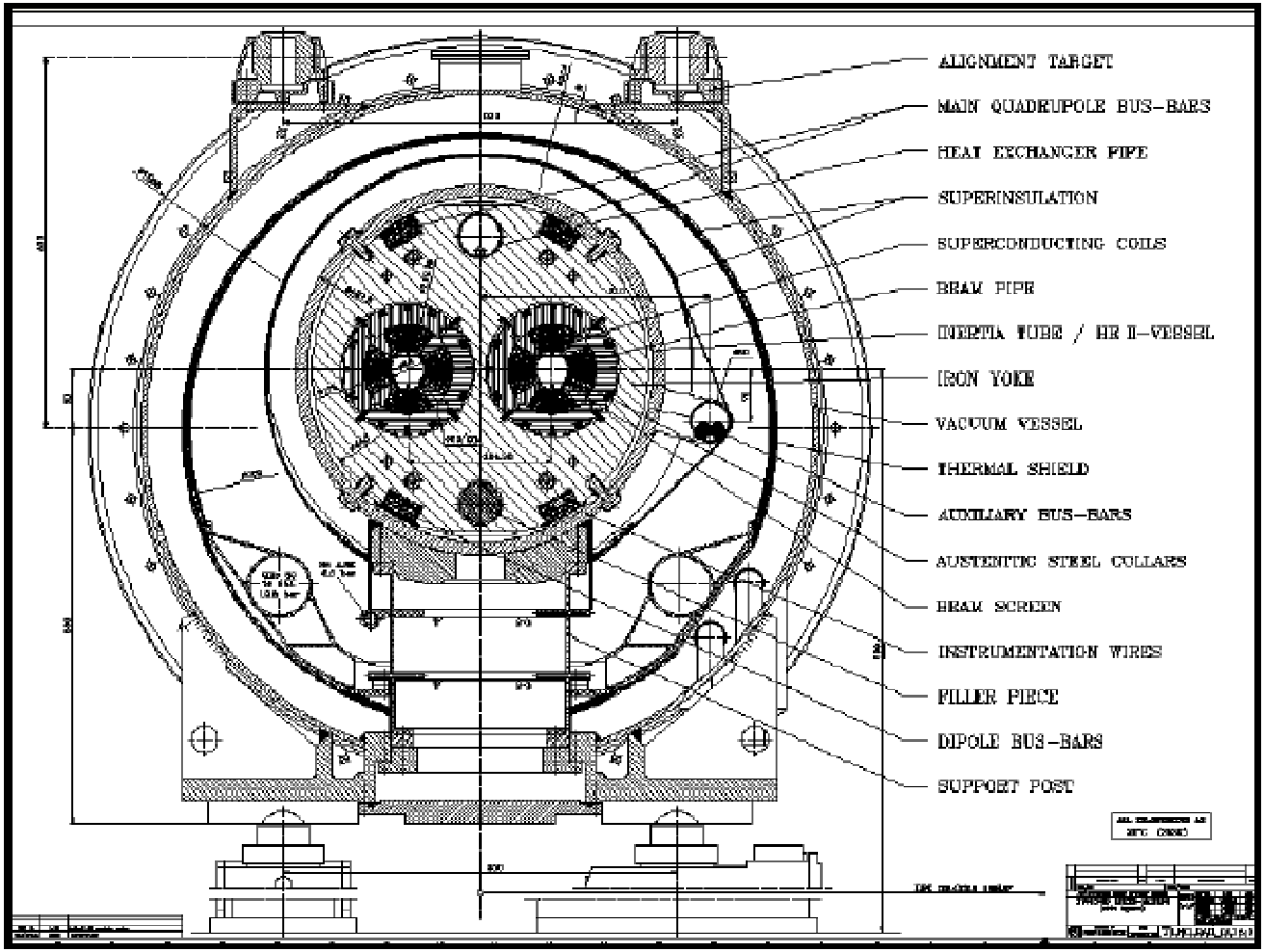
  D1 - D2 ~ 71 m
  Q5 - Q6 ~ 28 m
  Q6 - Q7 ~ 28 m

- The only hope is to use the 'long' 71 m region between separation dipoles, **but** the beams aren't separated enough to insert magnets until *at least* 20 m distance from the face of D1.



D2 Separation Dipole

- LHC magnets are massive -- the beams must rise a minimum of ~480 mm before the LHCI beampipe will clear the D2 (& downstream quadrupoles) cryostat.
- To install quadrupoles in the transfer line above LHC magnets the vertical change needs to be much more -- something ~0.75 m.
- So, vertical bending must be very hard & start as close as possible to D1.
- And, flattening the beam out again has to start soon after the up bends to level off at 1.1 m by the end of the straight.


ALIGNMENT TARGET
MAIN QUADRUPOLE BUS-BARS
HEAT EXCHANGER PIPE
SUPERINSULATION
SUPERCONDUCTING COILS
BEAM PIPE
INERTIA TUBE / HE I-VESSEL
IRON YOKE
VACUUM VESSEL
THERMAL SHIELD
AUXILIARY BUS-BARS
AUSTENITIC STEEL COLLARS
BEAM SCREEN
INSTRUMENTATION WIRES
FILLER PIECE
DIPOLE BUS-BARS
SUPPORT POST

Vertical Bending Magnets:

- 3 flavors are offered by Henryk -- each 1 m long operating near 100 kA:

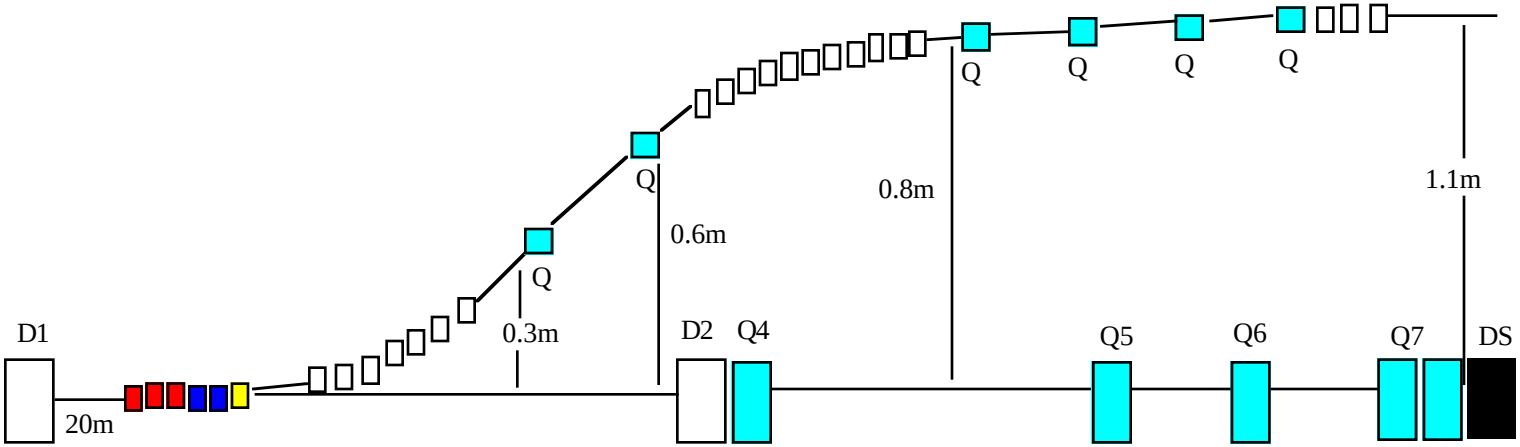
V1	:	4 cm gap	6.1 T
V2	:	5 cm gap	4.8 T
V3	:	6 cm gap	4.0 T

- One sequence to create enough clearance to install a quadrupole above D2 is:

  3*V1, 2*V2, 1*V3,....., 7*V1

- Flattening the beam out at 1.1 m takes 13 V1 magnets at ~5.74 T each.

An Example:



- Because all the bending -- both up & down -- must happen in a very short distance I have so far been unable to find a configuration where the beams can be transferred achromatically!
- Dumping a half meter or so of vertical dispersion into the LHC might cancel any benefits gained by the higher quality LHCI magnets.

the journey continues....

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