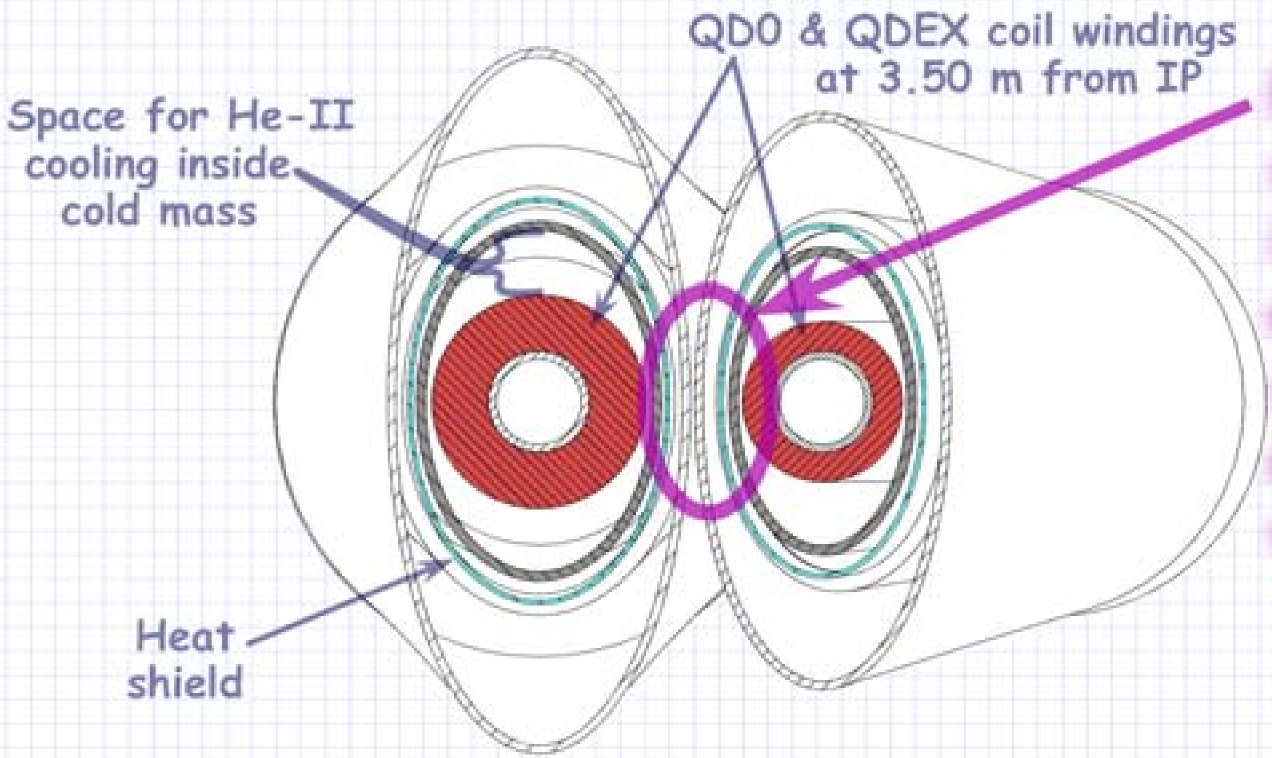
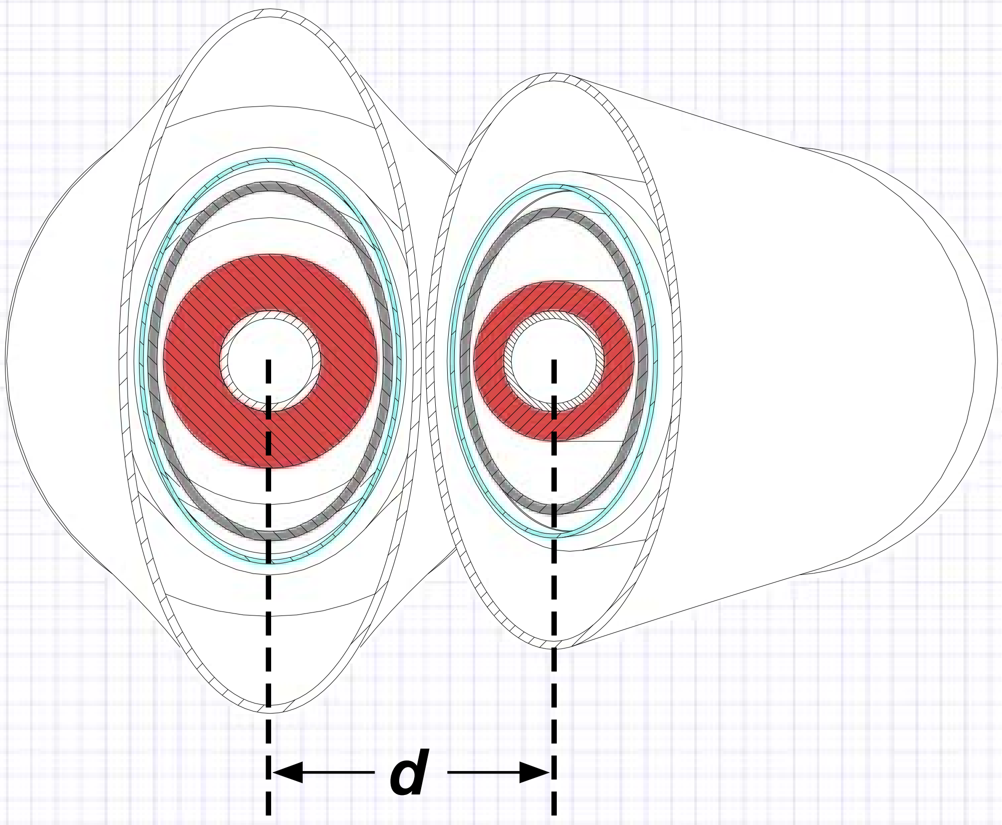
Crossing Angle Lower Limits Using Compact Superconducting Magnets



Eliminating some of the structure between the incoming and extraction apertures would allow smaller crossing angles but does have consequences which must be studied.

Reference 20 mr X-ing Angle Design

Magnet design assumptions give smallest separation: need L* to get X-ing angle.

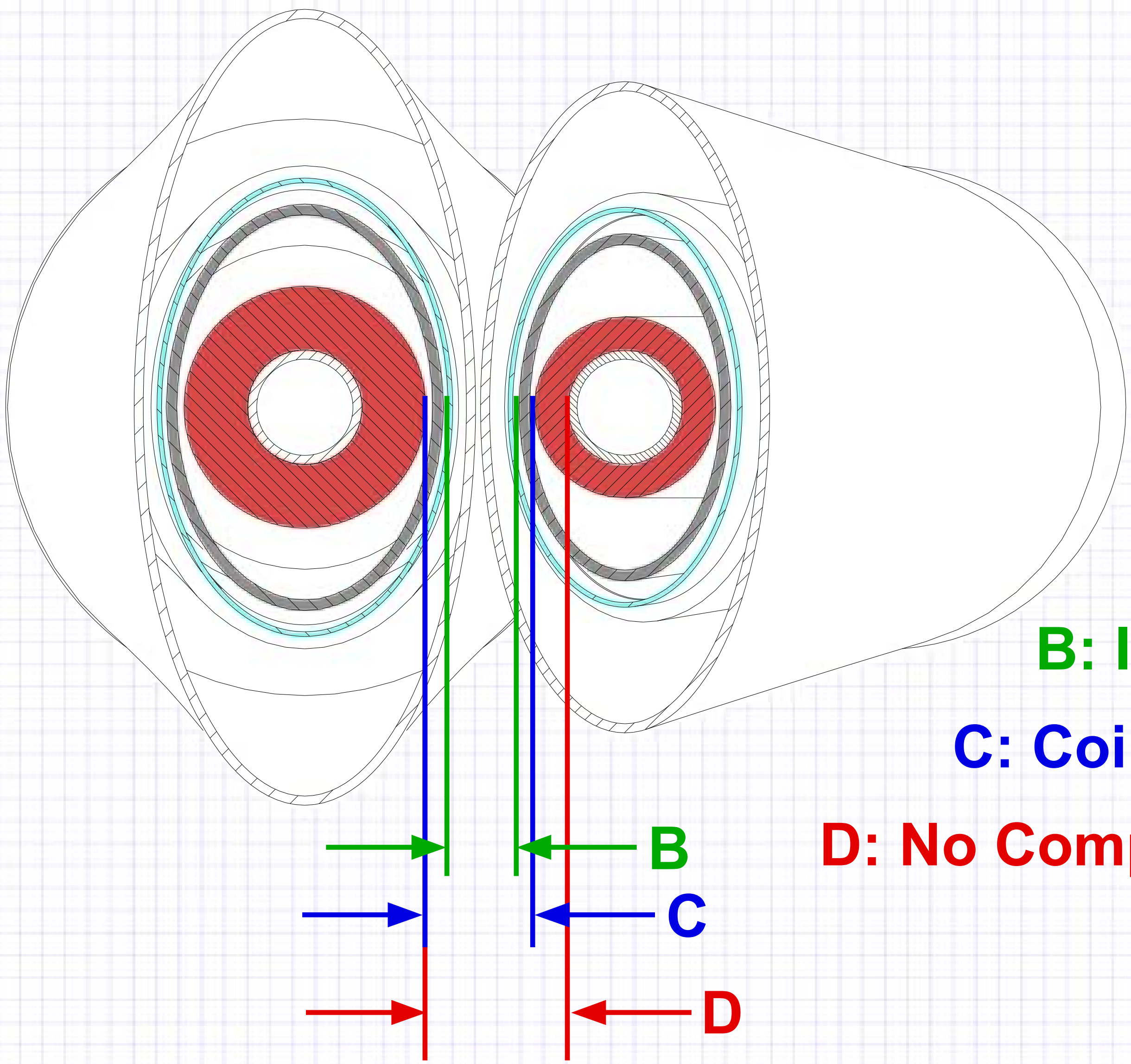


For given minimum center-to-center beam separation, *d*, the minimum crossing angle is:

$$\theta_{min} = d / L^*$$

Here we require 10 & 12 mm beam pipe radius for the incoming and extraction beamlines and provide values for *d* for a series of increasingly aggressive (risky) scenarios.

Some Compact Superconducting Magnet Design Scenarios.



A: Reference Design

B: Independent Cold Mass

C: Coils Touching

D: No Compensation

BROOKHAVEN NATIONAL LABORATORY
Superconducting Magnet Division

The Matrix of Design Options.

Scenario	*d* (mm)	Angle Range* (mr)	Issues	Confidence Level
A	70	20 - 15.5	Standard	Recommended
B	53	15 - 11.8	+ Cold Support	Probably OK
C	44	12.5 - 9.8	+ Stronger Comp’	Needs Study
D	38	10.8 - 8.4	+ Give Up Comp’	Highest Risk

Angle range is for 3.5 m < L < 4.5 m

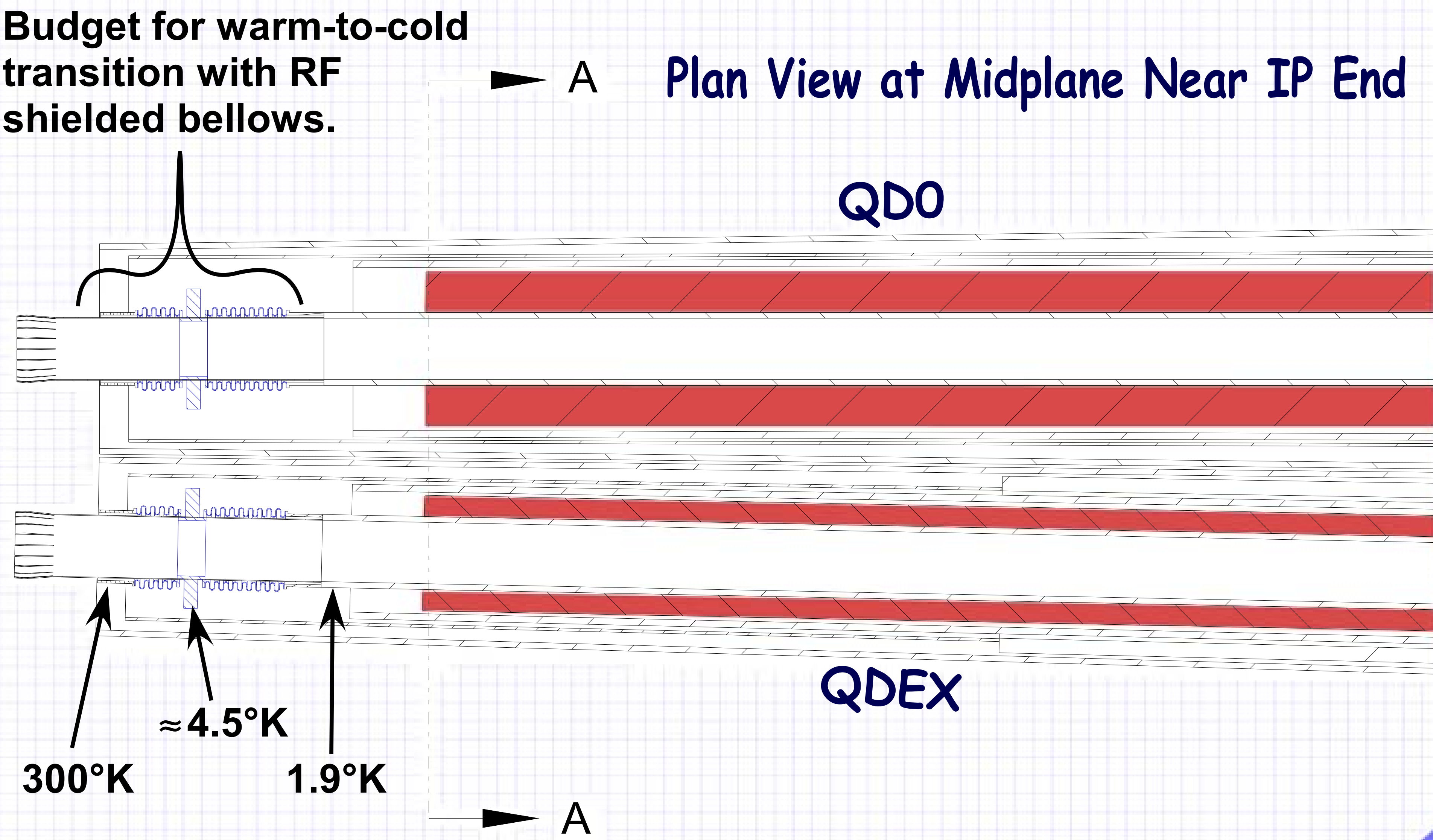
Some Magnet Design Considerations.

Decreasing *d* will mean that the external field that has to be compensated is greater and even after compensation the result is less linear (for exception see final note). If we get rid of the compensation coil completely (Scenario D) we will have to check carefully if the extraction line optics, energy deposition etc. are still ok.

Using the formula of Animesh Jain (too much to include here!) we can estimate the field harmonics due to external fields analytically.

BROOKHAVEN NATIONAL LABORATORY
Superconducting Magnet Division

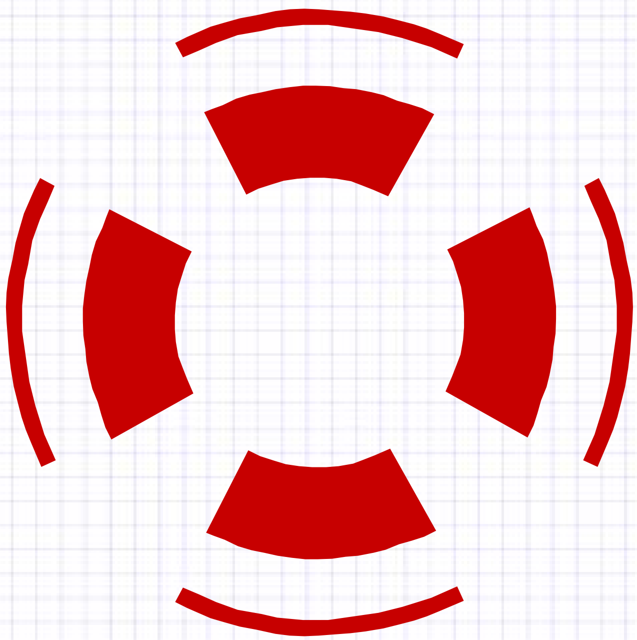
Smaller *d* makes the warm-to-cold transition more challenging?



BROOKHAVEN NATIONAL LABORATORY
Superconducting Magnet Division

Related Work: QD0 external field compensation possibilities for γγ?

QD0 with Active Shield



Note: This solution maintains quadrupole symmetry.

Maybe we should reconsider an early concept, kill the external field with a second active shield coil of opposite polarity to the main quad?

This will do the best job close to the magnet (without messing up the field inside QD0).

Cost is transfer function reduction (magnet efficiency) but maybe we have enough margin to stand this now?

Can work on this during Snowmass.