# Shielding of the Final Focusing System in the HIF Point Design*

by

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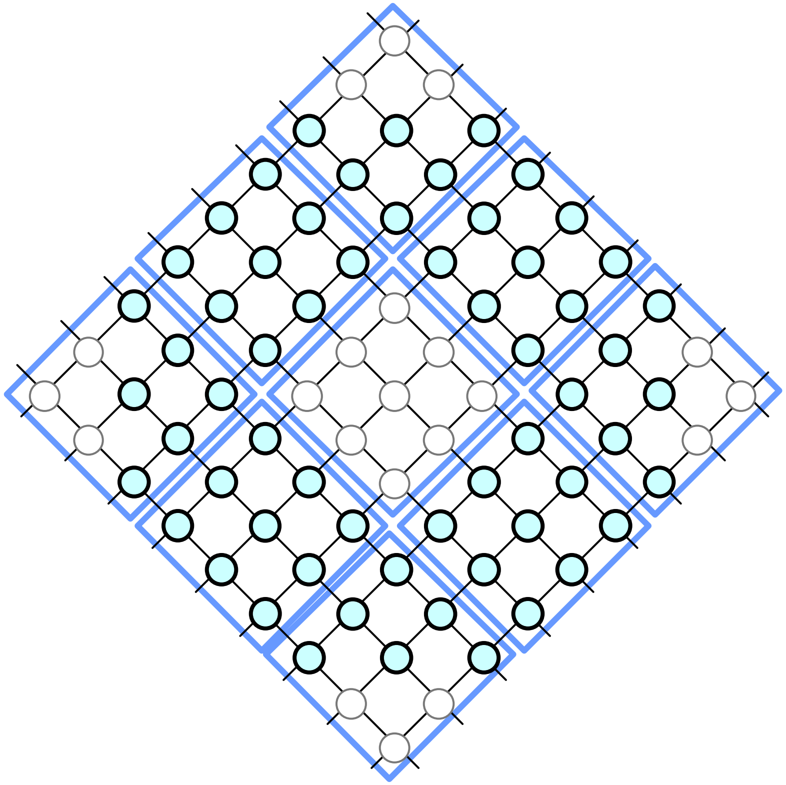
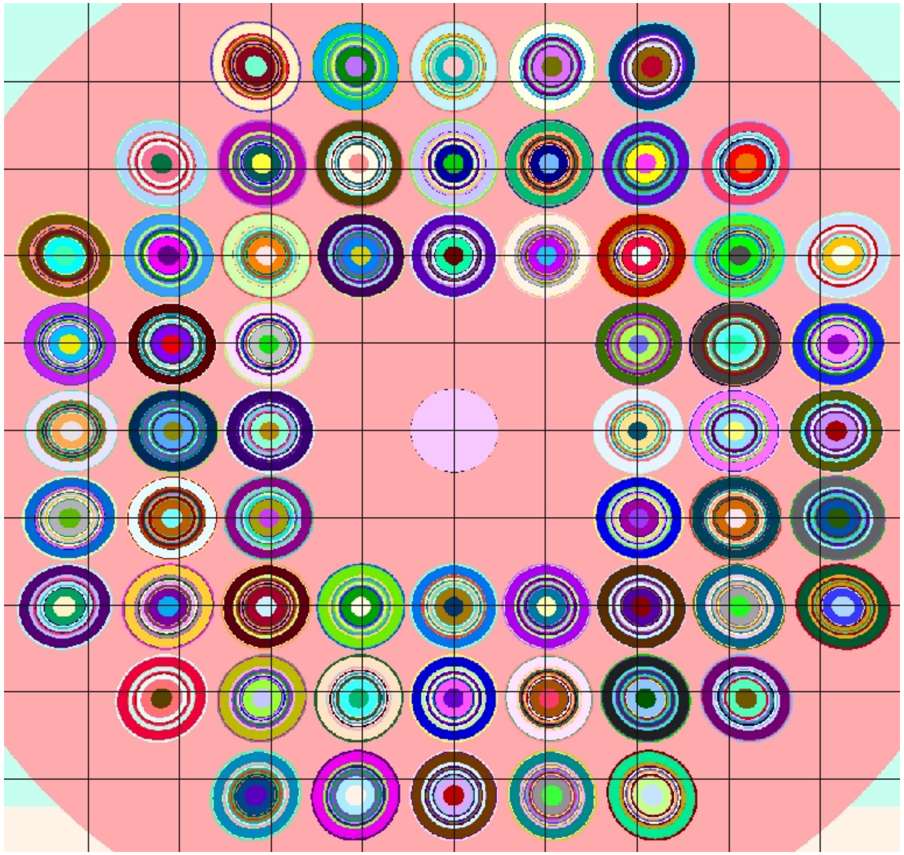
# General requirements for the final focusing magnet shielding design

- Shielding design consistent with target beam requirements (e.g., half-angle of array <30º)
- Magnets don't quench on a per-shot basis (limits energy deposition in superconductor regions to ~100 mJ/cc/shot)
- Recirculating power for magnet cooling doesn't cause unacceptably large economic hit
- Magnets have reasonable radiation damage lifetime:
  - 100 MGy for insulators (dominated by gamma-rays)
  - Fast neutron fluence of $10^{19}$ n/cm$^2$ for NbTi superconductor (room temp anneal at $3 \times 10^{18}$ with 70% recovery)
- Avoid generation of above Class C waste, if possible

# The new HIF point design was modeled

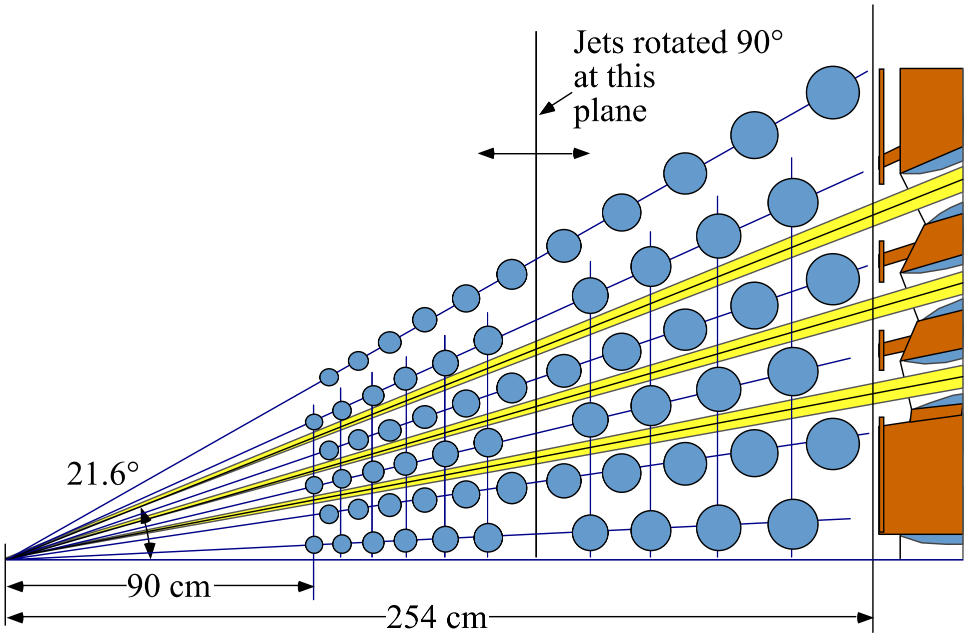


Chamber Beam Map
24 foot / 36 main
(Same both sides)



Neutronics Model
Shown is slice through last set of magnets
(Note: model rotates actual by 45º)

# HIF point design, (Cont'd.)

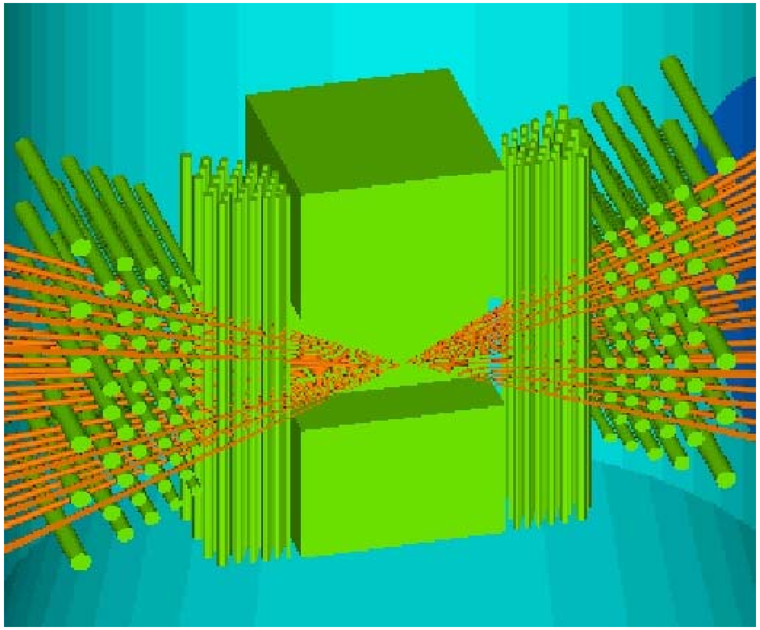



<u>HIF RPD-2002 Cross Jets</u>

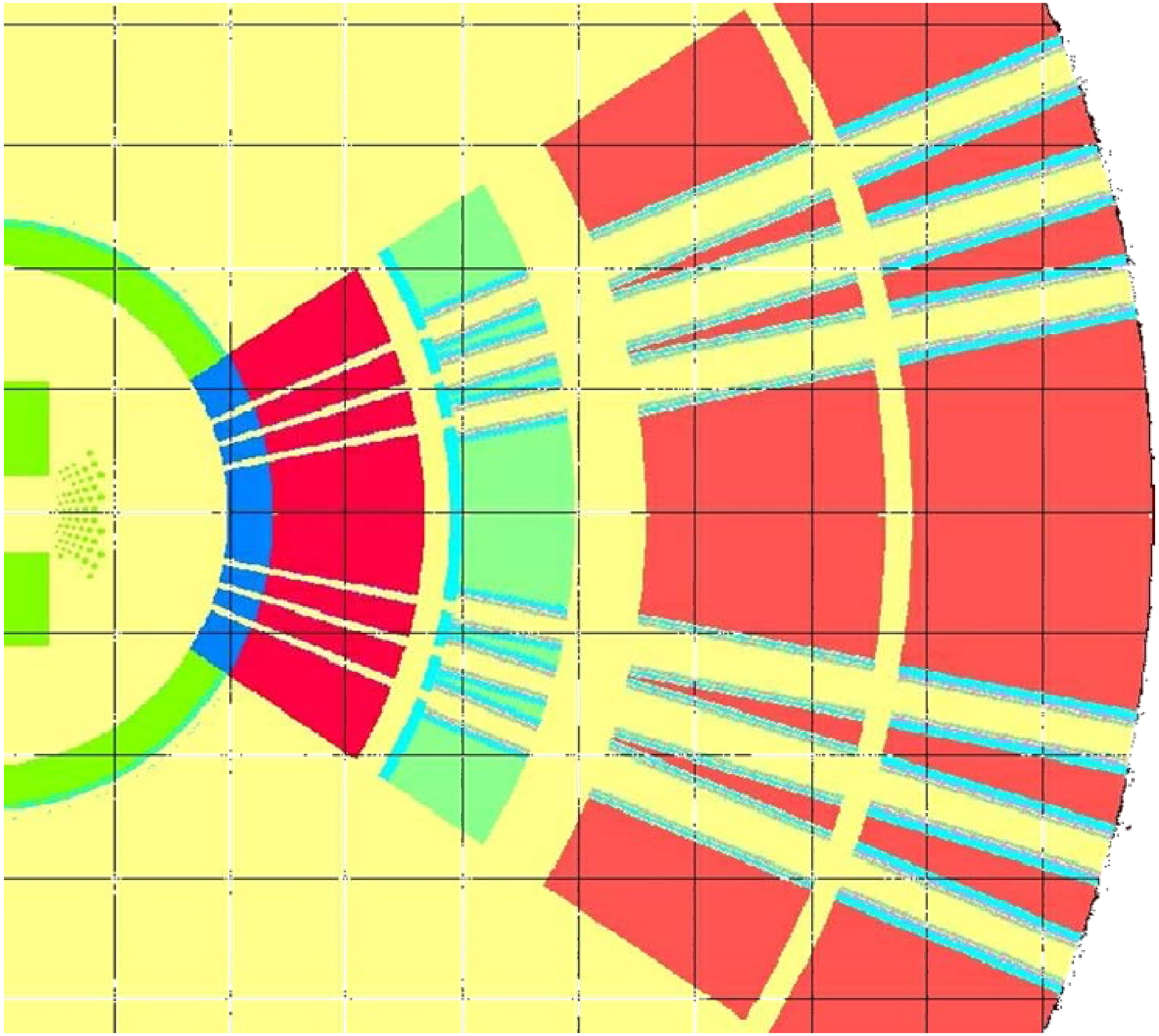
Jets are positioned in rows at specified distances from the target, on vectors spaced 5.4° apart.

<u>Neutronics Model</u>

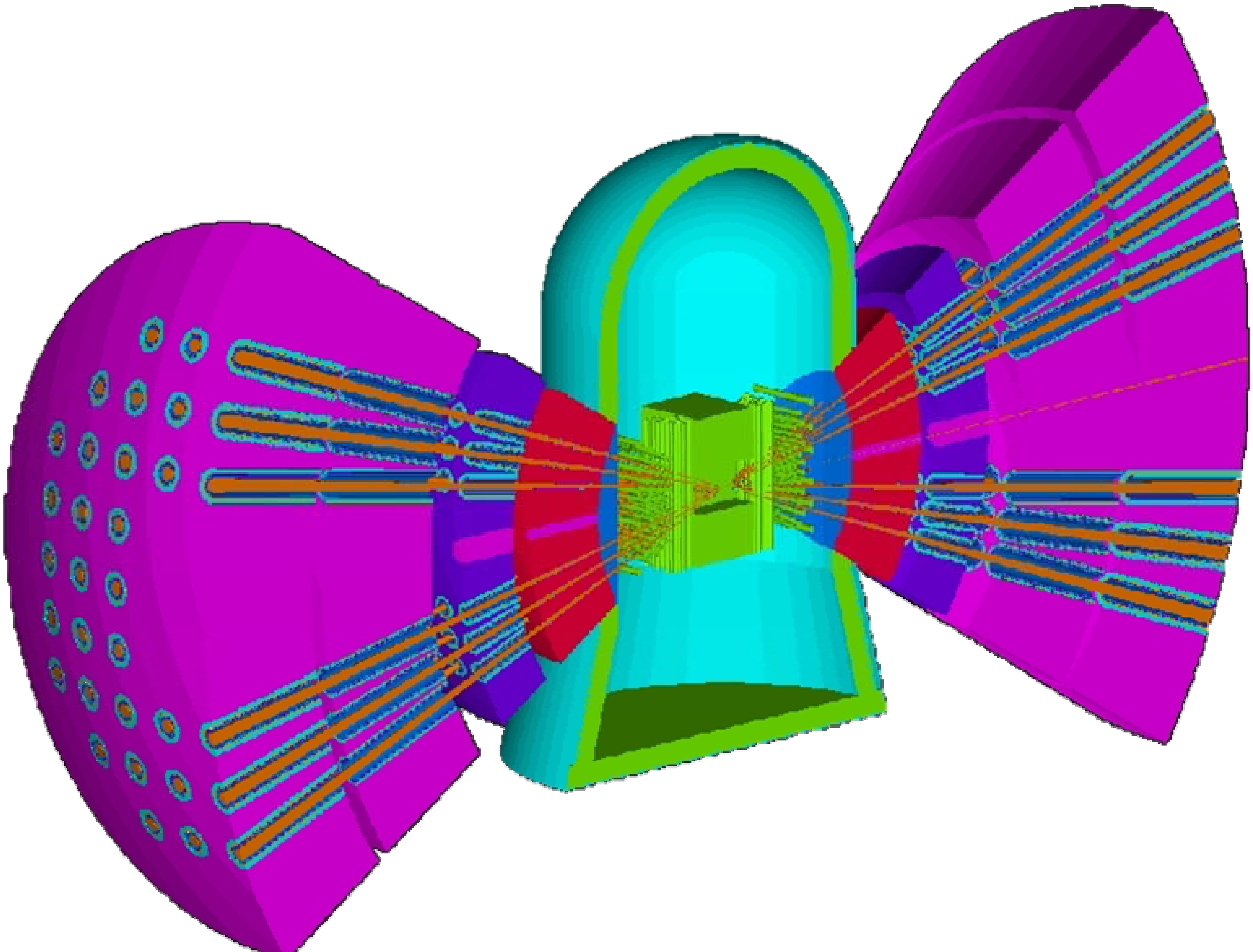
Details of the cross jets are included



# The flibe jets, vortex tubes, and final three focusing magnets are modeled



# Neutronics modeling for the new HIF point design is quite detailed



# Results: Magnet heating & cooling

- Prompt heating of superconductor, stabilizer, and insulation is very low (~17 μJ/cc/shot) → little risk of quench from nuclear heating

- Even if all magnets had to be cooled to liquid helium temperatures, the recirculating power would be only ~3 $MW_e$

- Cooling of the larger shielding blocks, however, would be expensive. If these must be cooled to LHe temperatures, an additional 40 $MW_e$ is required

# Results: Magnet lifetimes and waste disposal rating (WDR)

- Last magnet:
  - Insulator lifetime = 230 full-power-years (FPY)
  - Superconductor lifetime = 260 FPY WDR = 1.68

- $2^{nd}$-to-last magnet:
  - Insulator lifetime = 410 FPY
  - Superconductor lifetime = 1580 FPY WDR = 0.42

- $3^{rd}$-to-last magnet:
  - Insulator lifetime = 100 FPY
  - Superconductor lifetime = 610 FPY WDR = 0.48

# Synthesis & additional work

- Significant performance increases result from: (1) a reduction in vortex liquid stand-off distance, and (2) a reduction in the beam focusing angle (10 mrad)
- Aggressive liquid stand-off distance of only 1 mm assumed in vortices; Past work suggests that increasing this to 5 mm reduces lifetimes by ~2x → Need to confirm for this specific layout
- Trade-off insulator lifetime (gammas) vs. superconductor WDR for last magnet → with large margin, should be able to achieve both WDR<1 *and* lifetime magnets
- Add beam neutralization hardware, liquid jet nozzles
- Look at life-cycle waste volume vs. shielding design (long life magnets may actually increase overall waste volume)