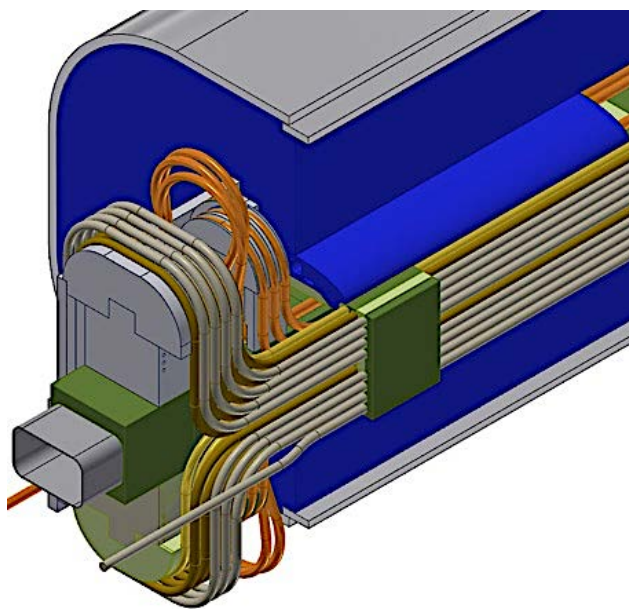


6 Tesla CIC Dipole to Double the Ion Energy for JLEIC

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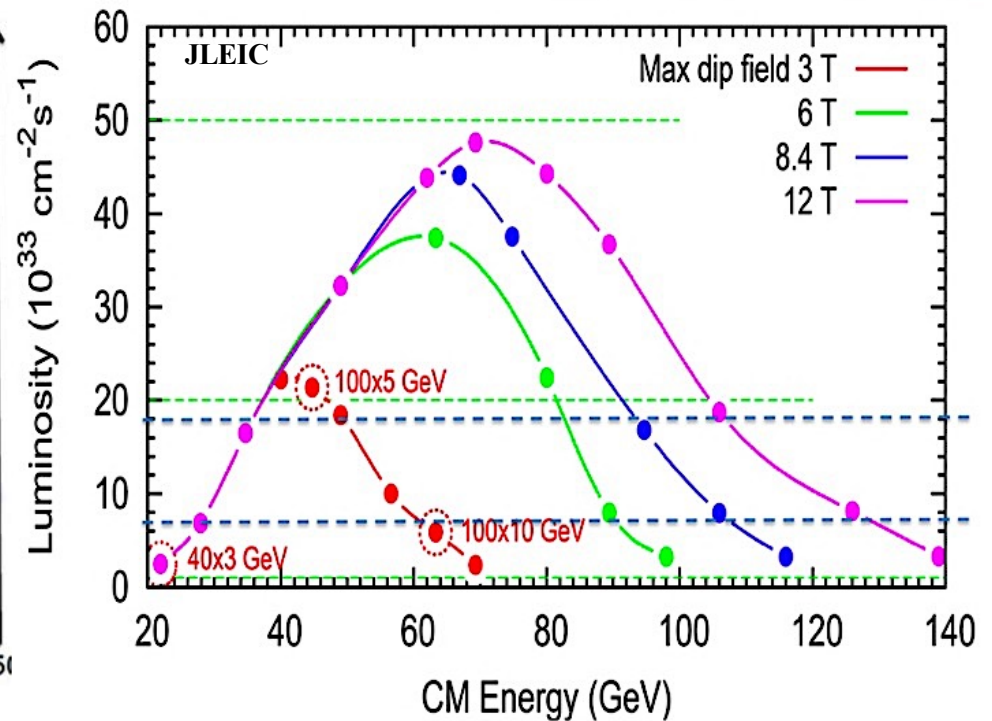
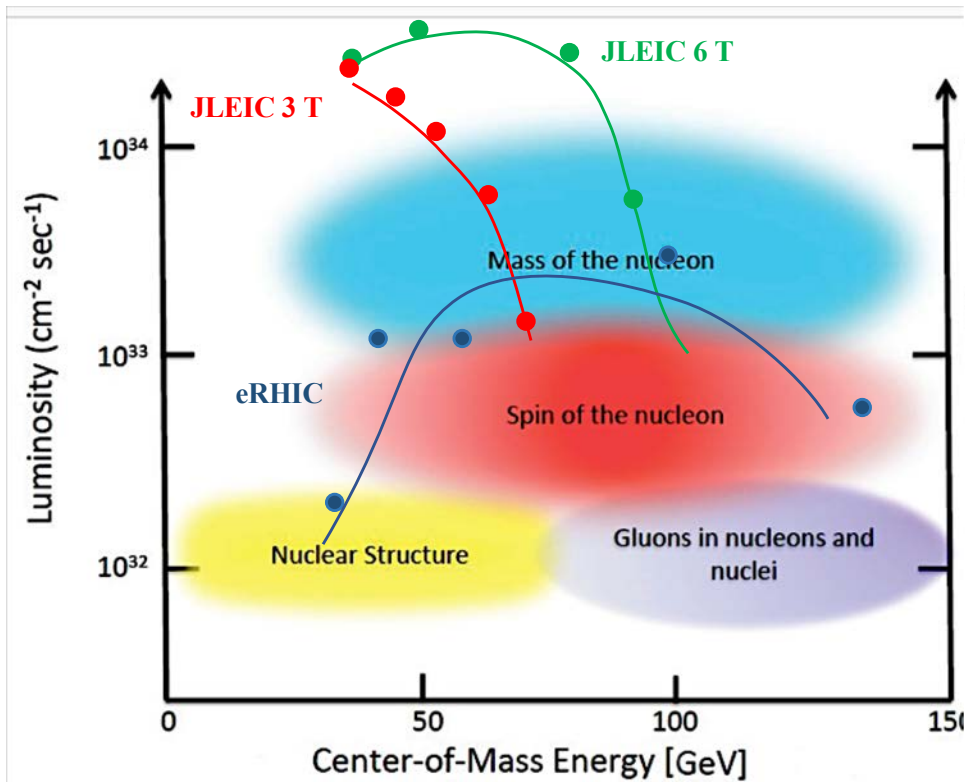
²Accelerator Technology Corp.



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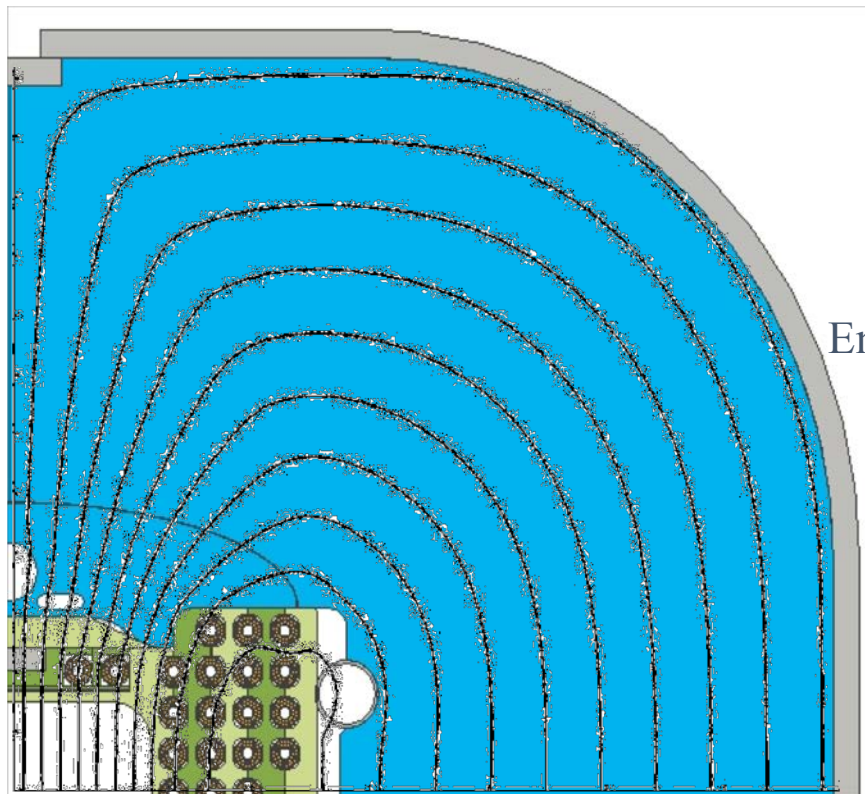
Motivation: JLEIC's collision energy limits its coverage of EIC physics

The NRC report compared the luminosity vs collision energy for the physics objectives of EIC in the two competing designs.

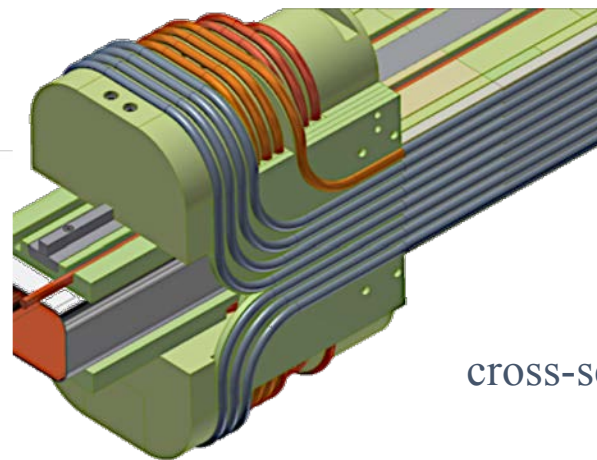


Yuhong calculated the luminosity vs c.m. energy for several choices of dipole field in the Ion Ring. ***A 6 T Ion Ring would provide excellent coverage for all of the EIC physics objectives.***

TAMU has developed the 3 T JLEIC dipole based upon NbTi cable-in-conduit.



Quadrant cross-section of 3 T CIC dipole for JLEIC



End region of the 3 T CIC dipole;



cross-section of 15-strand NbTi CIC



FRP structural beam;



motorized bend fixture used to form the flared ends.

TAMU transferred the cable technology to ATC and HyperTech

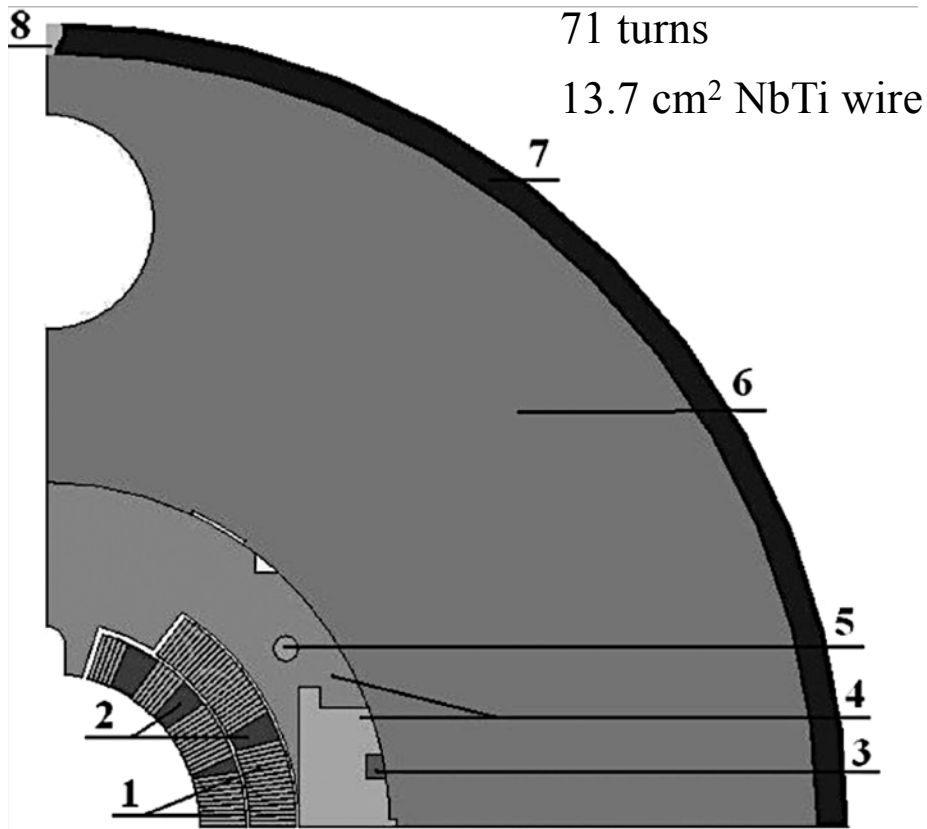


CIC manufacturing process at ATC: a) 24-spool stranding machine; b) SS foil over-wrap Drawing of sheath onto cable Completed 125 m length of CIC.

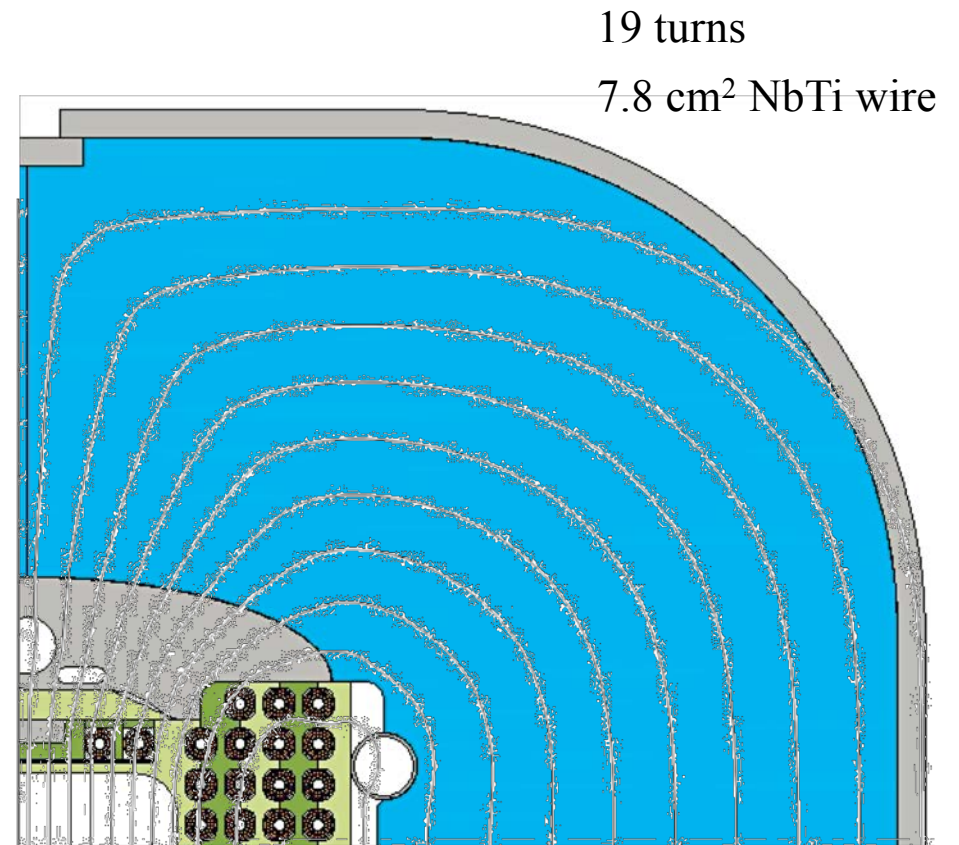
ATC now manufactures 140 m CIC cables suitable for a complete 4 m 3 T JLEIC dipole.

The cabling facility has 24-spool capacity, and can accommodate the 2-layer CIC for the 6 T dipole presented below.

Motivated by the NRC challenge, we have designed a 6 T dipole using 2-layer CIC.

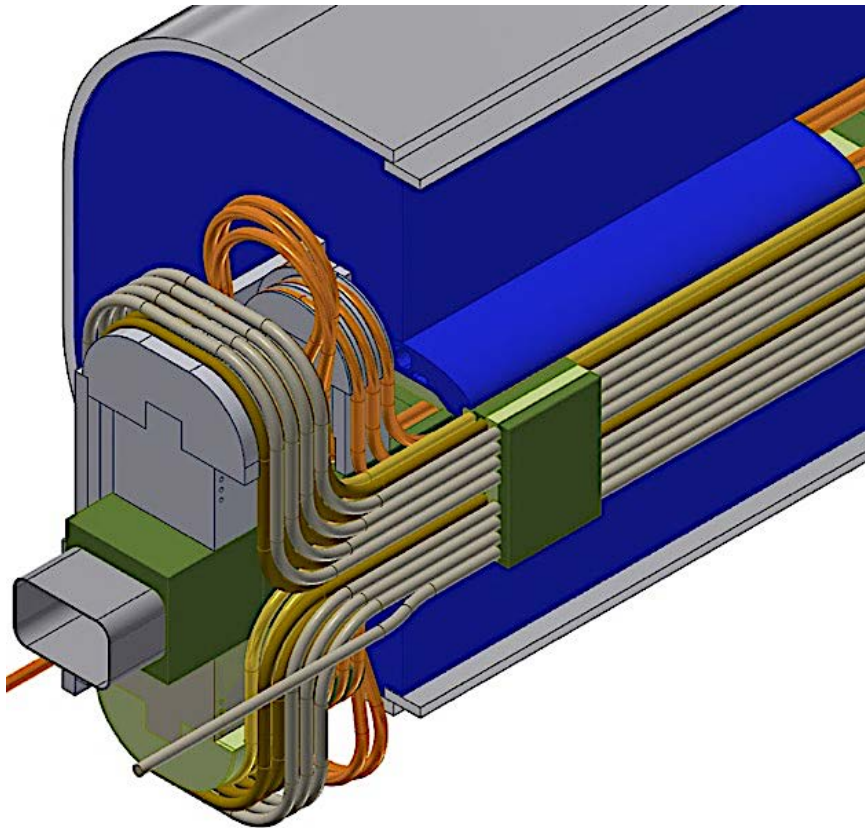


Quadrant cross-section of the 6 T cos θ dipole developed for SIS300 by IHEP and GSI: 1-coil, 2-spacer wedges, 3-key, 4-collars, 5-pin, 6-yoke, 7-outer cylinder, 8-weld.



Quadrant cross-section of a CIC-based 6 T dipole with the same aperture and performance as the SIS300 cos θ dipole green – G-11 structure elements, blue – steel flux return.

Flared end geometry, 2-layer CIC



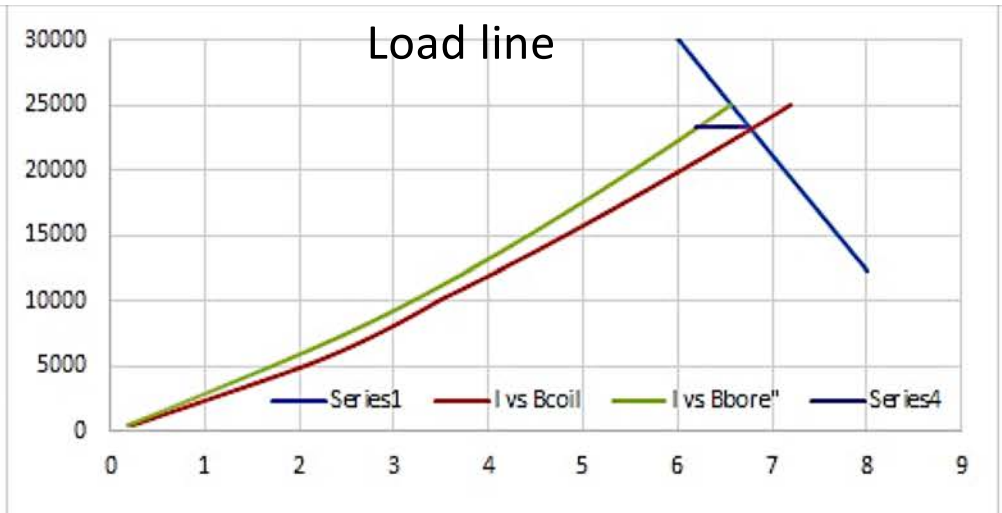
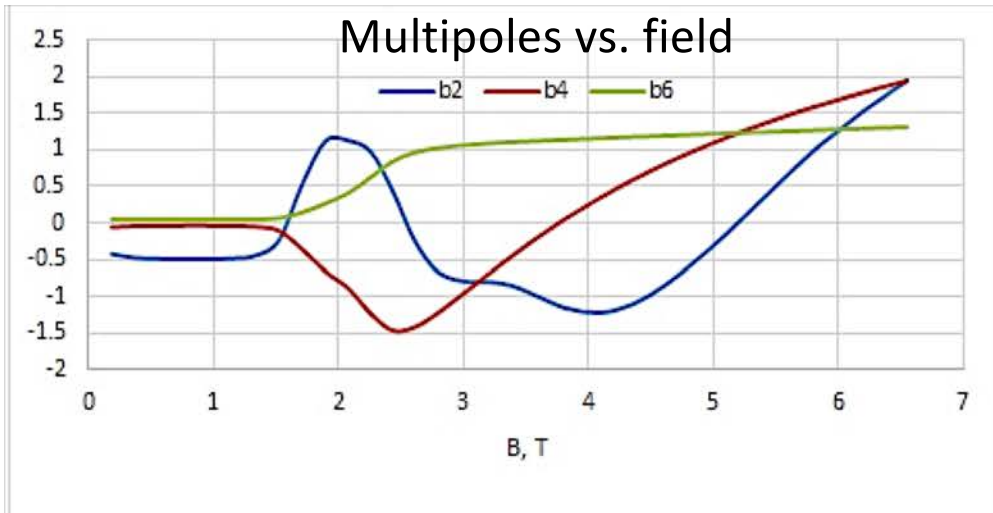
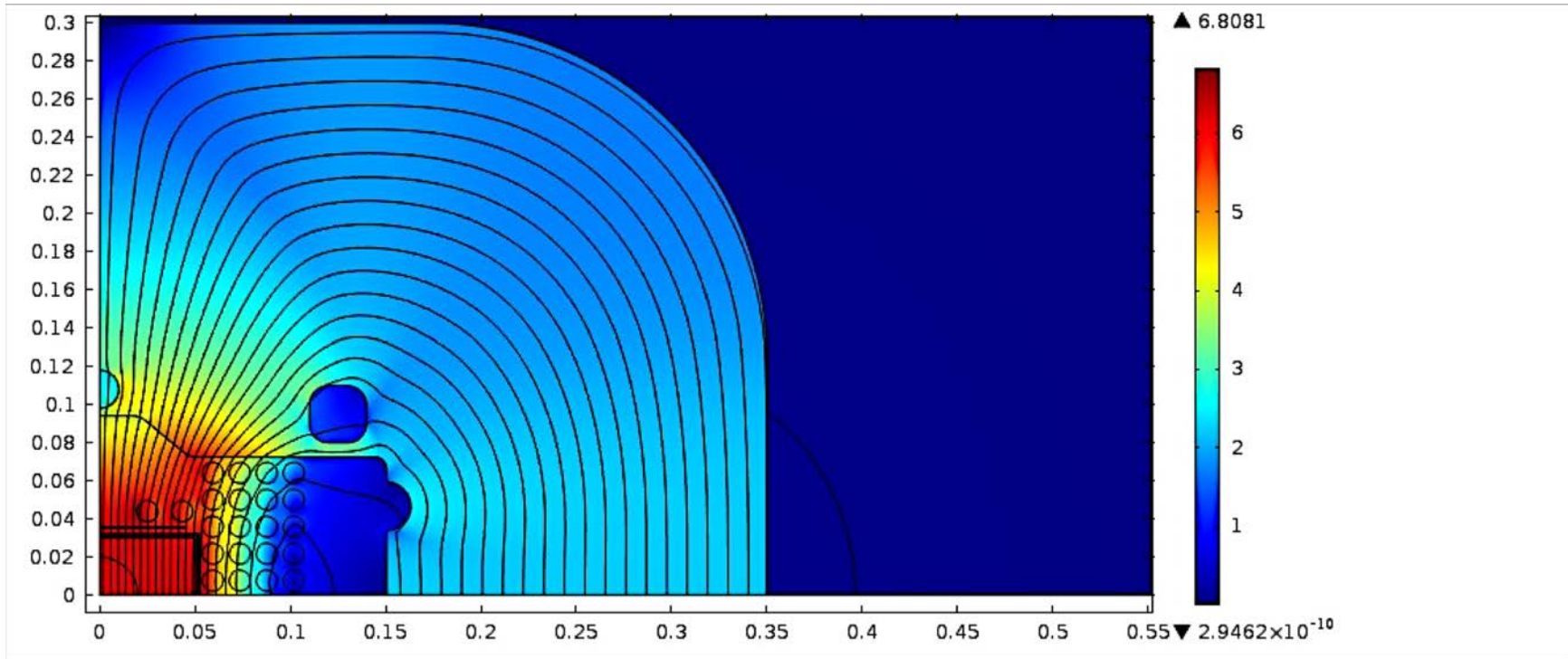
Cutaway of the end region of the 6 T CIC dipole, showing the end windings and the FRP structure.



Sample of 2-layer CIC, bent on 61 mm bend radius.

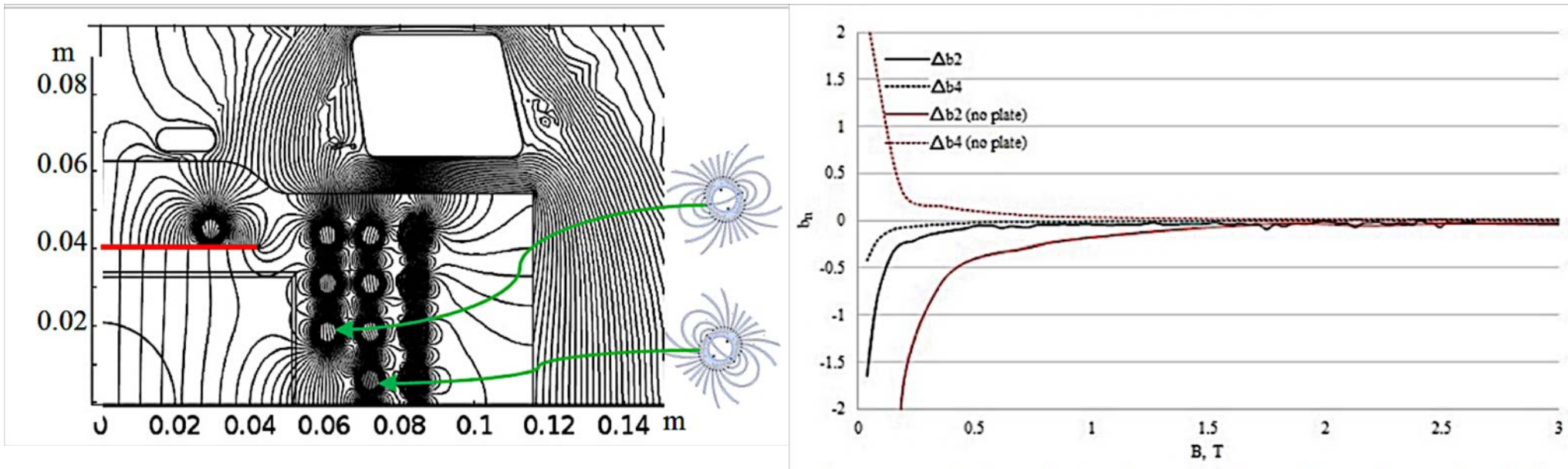


Magnetic design of the 6 T dipole



Flux plate suppresses persistent-current multipoles, snap-back

At low-field excitation of superconducting dipoles (injection), the ramp-down induces current loops in the superconducting filaments of all the wires in the windings. Those current loops drive multipole fields that de-stabilize the beam at injection.



We locate horizontal steel flux plates over/under the beam tube. The flux plates create a dipole boundary condition that suppresses such multipoles.

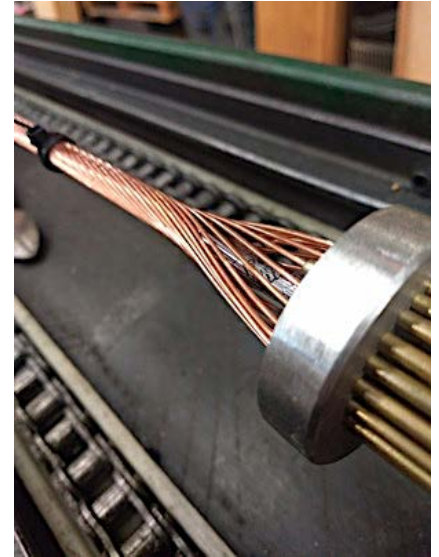
Quantitative simulation for the 3 T JLEIC dipole shows x5 suppression of snap-back.

The flux plate preserves the low-field performance for the 6 T dipole – protons can still be injected at 8 GeV then accelerated to 200 GeV.

Systematic development of 2-layer cable

- We develop a new cable by fabricating short lengths by hand in the lab:

- Layer 1 wires wound with CW twist pitch



- First CCW over-wrap



- Second CW over-wrap



- Layer 2 wires wound

- Draw sheath to optimum compactness, Bend on 60 mm radius, dissect



Splice joint to connect CIC to Rutherford cable leads and splice CIC



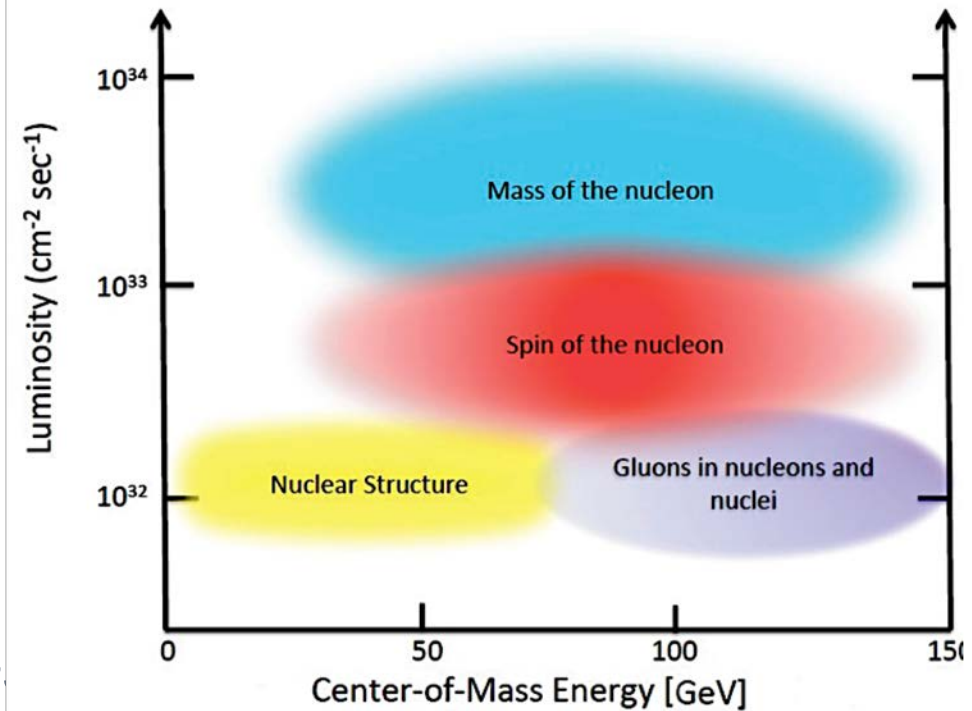
First in CAD,



Then using 3D printing to work out details,

Next with Cu, SS, and CIC

The 6 T dipole provides a major competitive benefit for JLEIC



But what does it cost?

Main cost-driver parameters of 5 dipole design

	cos θ dipoles		CIC dipoles		
Dipole	BNL RHIC 1-shell	IHEP SIS300 2-shell	TAMU/ATC CIC 3T	ATC CIC 6T	
Operating field	4	4	6	3	6 T
Aperture	8 dia.	10 dia.	10 dia.	10 x 6	10 x 6 cm
# turns/pole	32	40	71	12	19
Wire cross-section/pole	3.2	4.0	13.7	2.0	7.8 cm ²

From Willen's cost model, the 6 T dipole should cost ~twice as much as the 3 T CIC dipole.

Conclusions

- TAMU and ATC are developing a 2-layer NbTi CIC and a 6 T dipole suitable for JLEIC requirements.
- The CIC development is going well – we expect to qualify it for performance requirements in Phase 1.
- The CIC bend tools are being upgraded to handle the much stiffer 2-layer CIC.
- A Phase 2 effort will be proposed in which we build a short-model 6 T dipole and test it at BNL test facility.
- ***We will need JLab's support in the competition for Phase 2 funding.***