

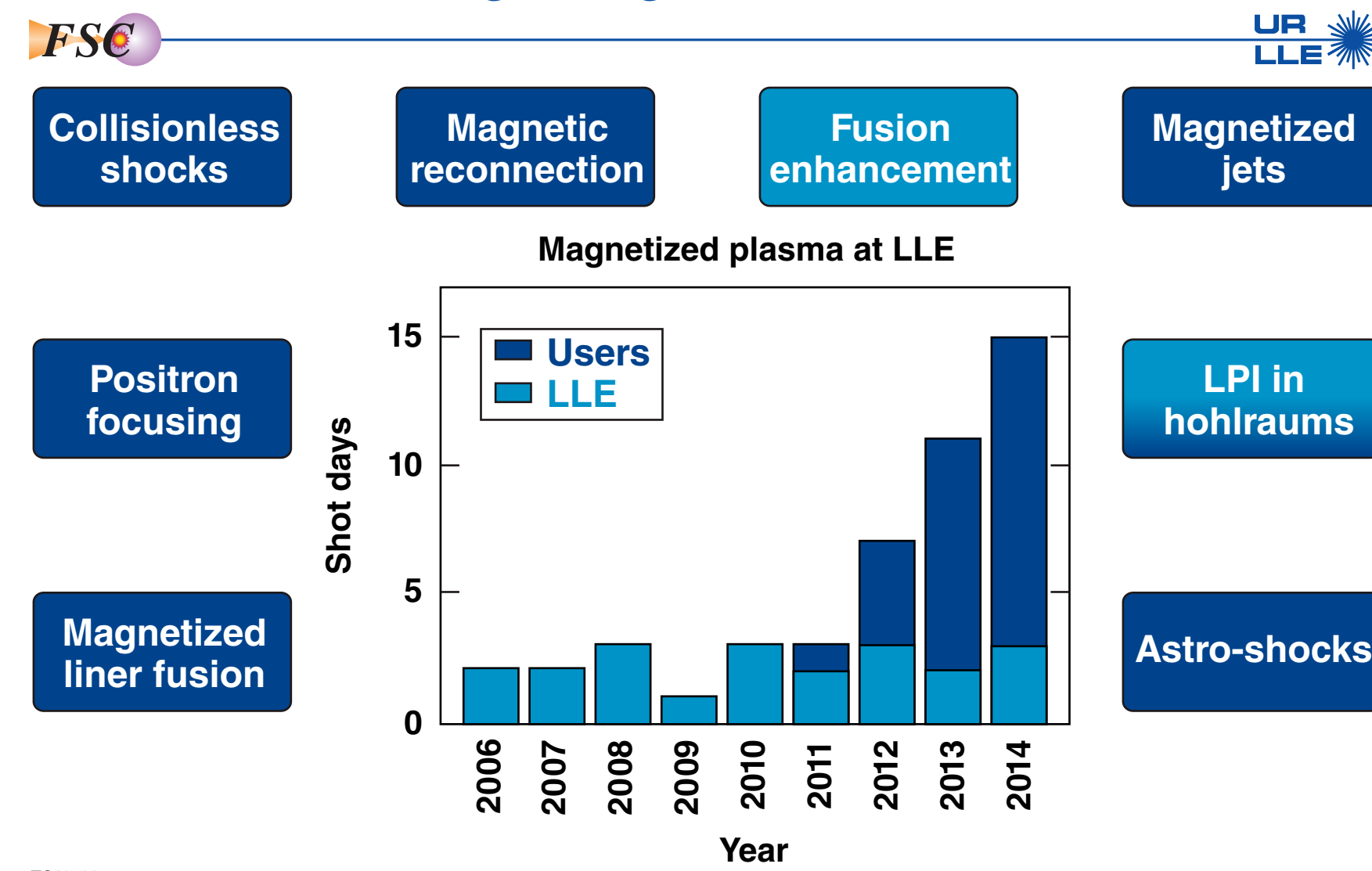
Fielding MIFEDS on OMEGA



D. MASTROSIMONE, G. FIKSEL, J. MAGOON, A. AGLIATA, P.-Y. CHANG, and D. BARNAK

University of Rochester, Laboratory for Laser Energetics

The Fusion Science Center platform for magnetized high-energy-density-physics (HEDP) experiments (MIFEDS)* has attracted a fast growing number of external users

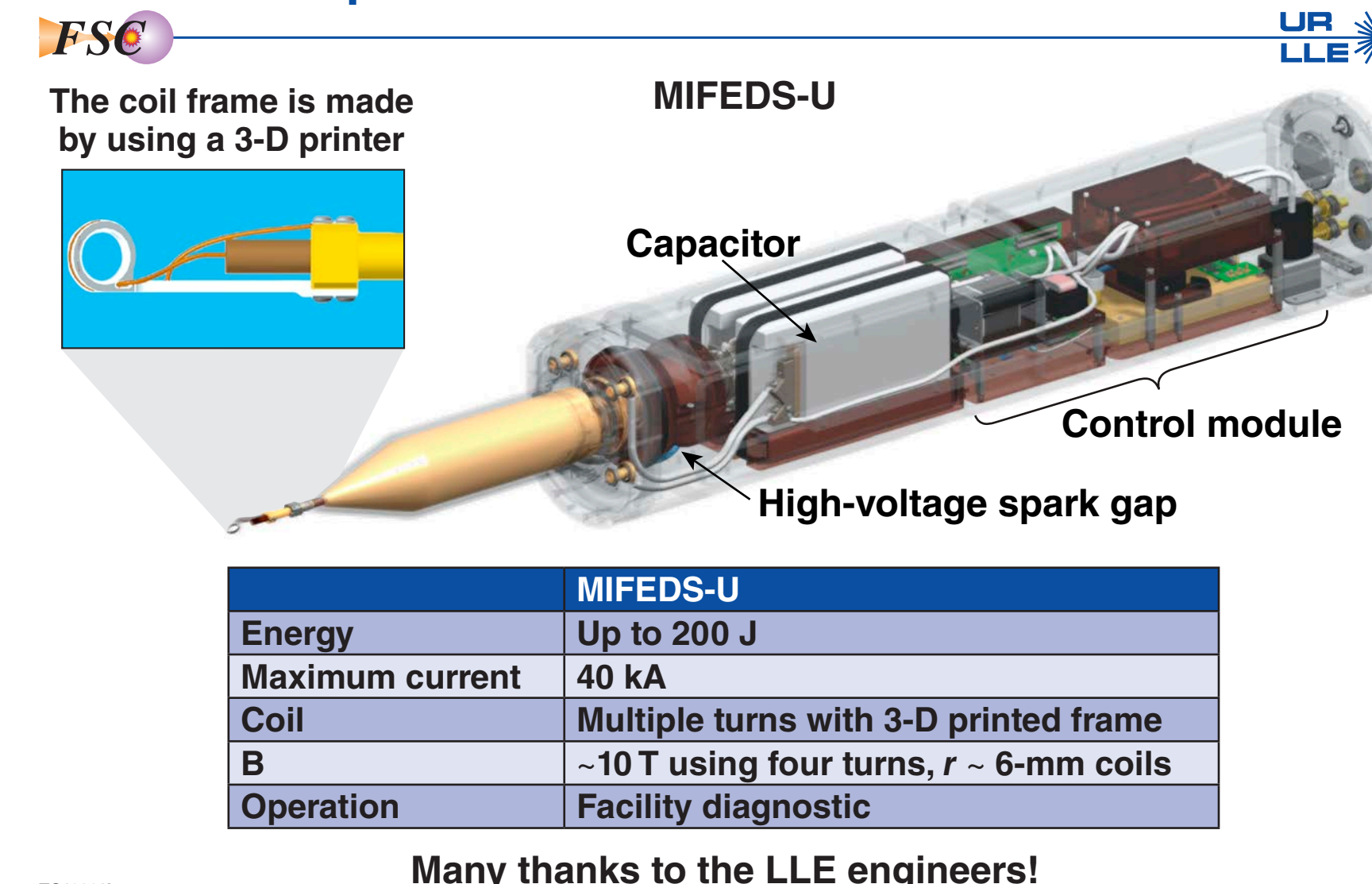


Methods of increasing the magnetic field delivered by MIFEDS

	Pros	Cons
• Decrease coil size	Easy to design and make	Limited by wire size; possible blocked beams
• Increase stored energy in MIFEDS	Does not change coil design; works for all applications	High voltages inside MIFEDS cause many issues; limited storage
• Increase number of turns in the coil	Easy to design and make; not limited by wire size	Coil too bulky and blocks laser beams; large inductance
• Decrease internal impedance of MIFEDS	Does not change coil design; works for all applications	Very hard to accomplish; requires redesign of all MIFEDS circuitry

* A high current in a small volume is needed; this can be accomplished by using a small coil with low inductance

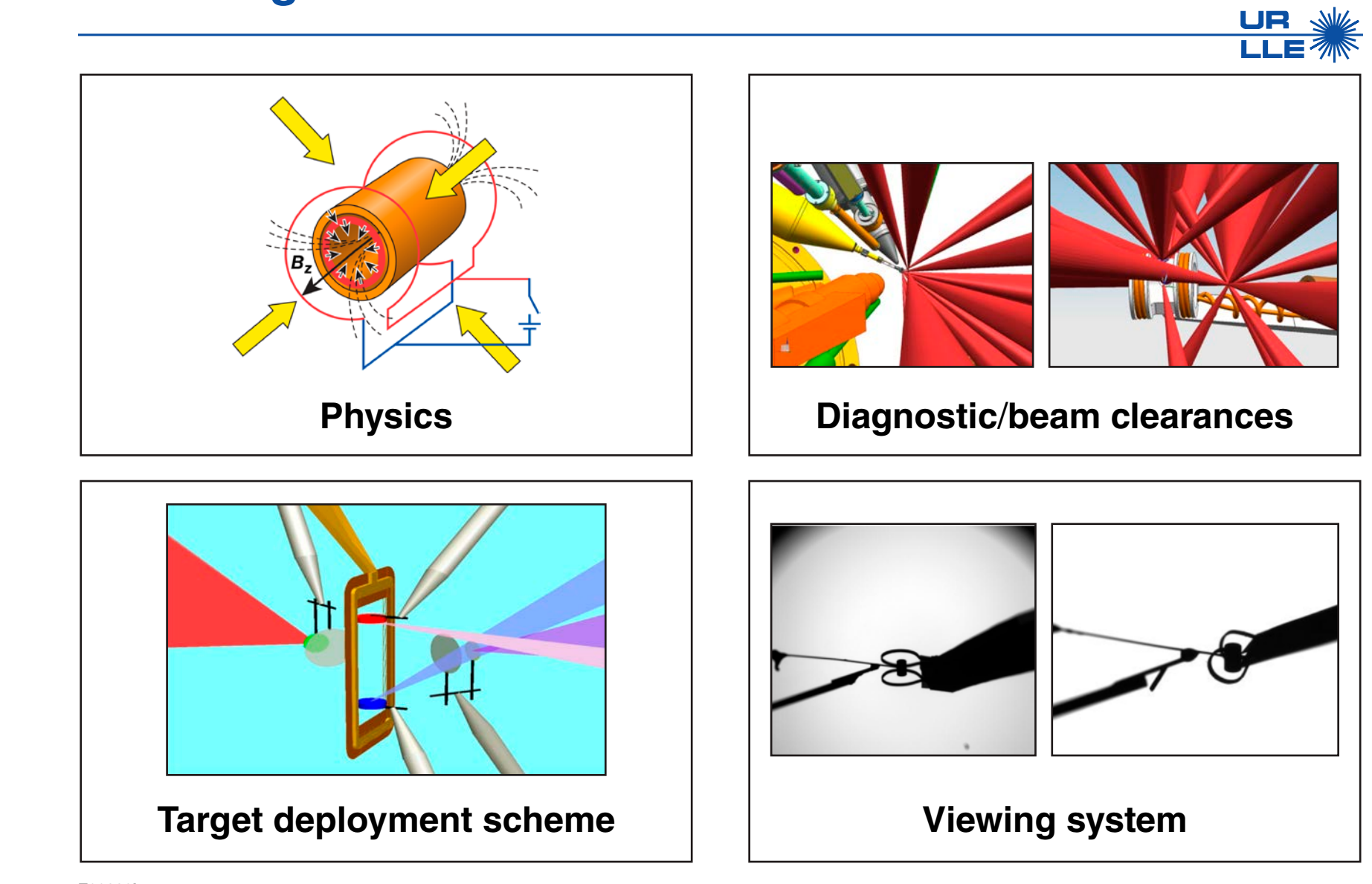
The upgraded MIFEDS (MIFEDS-U) device provides for higher B fields, flexible field topologies, and robust operations



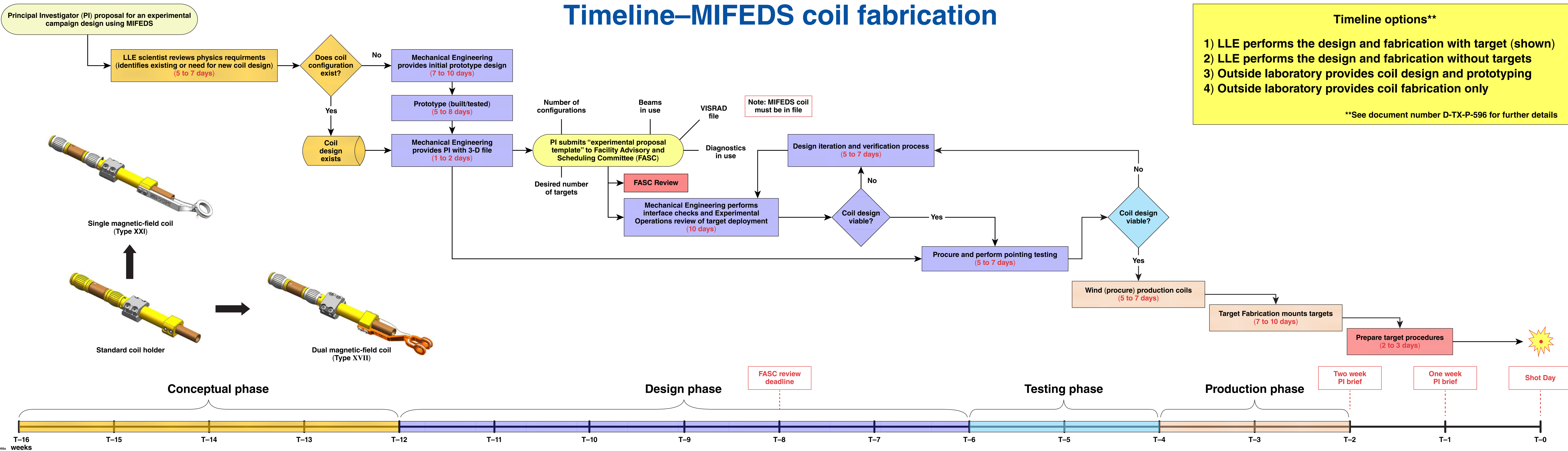
Existing coil library (LLE designed)

Part	Description	Principal	Beam	Assembly	Material	Size	Comments
010018	COMMON COIL ASSEMBLY - MIFEDS	010018	A	OMEGA	304 SS		
010020	MIFEDS TEST COIL	010020	A	OMEGA	304 SS		
010021	MIFEDS COIL TYPE I	010021	A	OMEGA	304 SS		
010022	MIFEDS COIL TYPE II	010022	A	OMEGA	304 SS		
010023	MIFEDS COIL TYPE III	010023	A	OMEGA	304 SS		
010024	MIFEDS COIL TYPE IV	010024	A	OMEGA	304 SS		
010025	MIFEDS COIL TYPE V	010025	A	OMEGA	304 SS		
010026	MIFEDS COIL TYPE VI	010026	A	OMEGA	304 SS		
010027	MIFEDS COIL TYPE VII	010027	A	OMEGA	304 SS		
010028	MIFEDS COIL TYPE VIII	010028	A	OMEGA	304 SS		
010029	MIFEDS COIL TYPE IX	010029	A	OMEGA	304 SS		
010030	MIFEDS COIL TYPE X	010030	A	OMEGA	304 SS		
010031	MIFEDS COIL TYPE XI	010031	A	OMEGA	304 SS		
010032	MIFEDS COIL TYPE XII	010032	A	OMEGA	304 SS		
010033	MIFEDS COIL TYPE XIII	010033	A	OMEGA	304 SS		
010034	MIFEDS COIL TYPE XIV	010034	A	OMEGA	304 SS		
010035	MIFEDS COIL TYPE XV	010035	A	OMEGA	304 SS		
010036	MIFEDS COIL TYPE XVI	010036	A	OMEGA	304 SS		
010037	MIFEDS COIL TYPE XVII	010037	A	OMEGA	304 SS		
010038	MIFEDS COIL TYPE XVIII	010038	A	OMEGA	304 SS		
010039	MIFEDS COIL TYPE XIX	010039	A	OMEGA	304 SS		
010040	MIFEDS COIL TYPE XX	010040	A	OMEGA	304 SS		
010041	MIFEDS COIL TYPE XXI	010041	A	OMEGA	304 SS		
010042	MIFEDS COIL TYPE XXII	010042	A	OMEGA	304 SS		
010043	MIFEDS COIL TYPE XXIII	010043	A	OMEGA	304 SS		
010044	MIFEDS COIL TYPE XXIV	010044	A	OMEGA	304 SS		
010045	MIFEDS COIL TYPE XXV	010045	A	OMEGA	304 SS		
010046	MIFEDS COIL TYPE XXVI	010046	A	OMEGA	304 SS		
010047	MIFEDS COIL TYPE XXVII	010047	A	OMEGA	304 SS		
010048	MIFEDS COIL TYPE XXVIII	010048	A	OMEGA	304 SS		
010049	MIFEDS COIL TYPE XXIX	010049	A	OMEGA	304 SS		
010050	MIFEDS COIL TYPE XXX	010050	A	OMEGA	304 SS		
010051	MIFEDS COIL TYPE XXXI	010051	A	OMEGA	304 SS		
010052	MIFEDS COIL TYPE XXXII	010052	A	OMEGA	304 SS		
010053	MIFEDS COIL TYPE XXXIII	010053	A	OMEGA	304 SS		
010054	MIFEDS COIL TYPE XXXIV	010054	A	OMEGA	304 SS		
010055	MIFEDS COIL TYPE XXXV	010055	A	OMEGA	304 SS		
010056	MIFEDS COIL TYPE XXXVI	010056	A	OMEGA	304 SS		
010057	MIFEDS COIL TYPE XXXVII	010057	A	OMEGA	304 SS		
010058	MIFEDS COIL TYPE XXXVIII	010058	A	OMEGA	304 SS		
010059	MIFEDS COIL TYPE XXXIX	010059	A	OMEGA	304 SS		
010060	MIFEDS COIL TYPE XXXX	010060	A	OMEGA	304 SS		
010061	MIFEDS COIL TYPE XXXXI	010061	A	OMEGA	304 SS		
010062	MIFEDS COIL TYPE XXXXII	010062	A	OMEGA	304 SS		
010063	MIFEDS COIL TYPE XXXXIII	010063	A	OMEGA	304 SS		
010064	MIFEDS COIL TYPE XXXXIV	010064	A	OMEGA	304 SS		
010065	MIFEDS COIL TYPE XXXXV	010065	A	OMEGA	304 SS		
010066	MIFEDS COIL TYPE XXXXVI	010066	A	OMEGA	304 SS		
010067	MIFEDS COIL TYPE XXXXVII	010067	A	OMEGA	304 SS		
010068	MIFEDS COIL TYPE XXXXVIII	010068	A	OMEGA	304 SS		
010069	MIFEDS COIL TYPE XXXXIX	010069	A	OMEGA	304 SS		
010070	MIFEDS COIL TYPE XXXXX	010070	A	OMEGA	304 SS		

Four major requirements for MIFEDS coil design considerations



Timeline—MIFEDS coil fabrication



The Fusion Science Center platform for magnetized high-energy-density-physics (HEDP) experiments (MIFEDS)* has attracted a fast growing number of external users



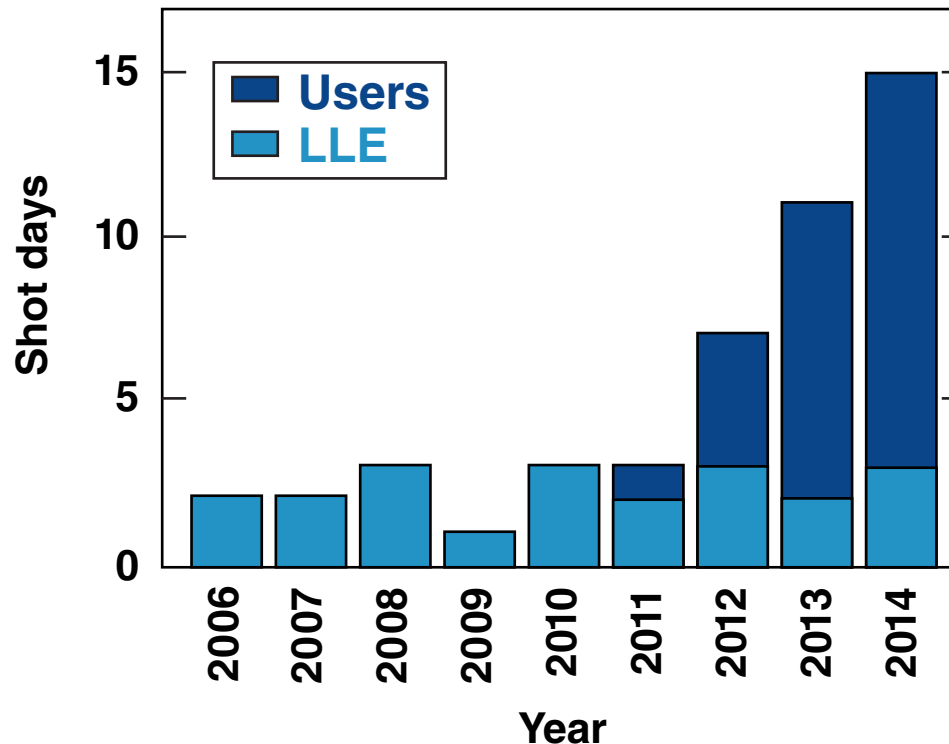
Collisionless shocks

Magnetic reconnection

Fusion enhancement

Magnetized jets

Magnetized plasma at LLE



Positron focusing

LPI in hohlraums

Magnetized liner fusion

Astro-shocks

Methods of increasing the magnetic field delivered by MIFEDS



- **Decrease coil size**
- **Increase stored energy in MIFEDS**
- **Increase number of turns in the coil**
- **Decrease internal impedance of MIFEDS**

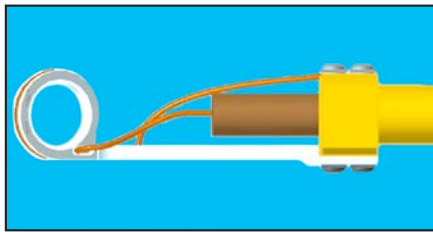
Pros	Cons
Easy to design and make	Limited by wire size; possible blocked beams
Does not change coil design; works for all applications	High voltages inside MIFEDS cause many issues; limited storage
Easy to design and make; not limited by wire size	Coil too bulky and blocks laser beams; large inductance
Does not change coil design; works for all applications	Very hard to accomplish; requires redesign of all MIFEDS circuitry

- **A high current in a small volume is needed; this can be accomplished by using a small coil with low inductance**

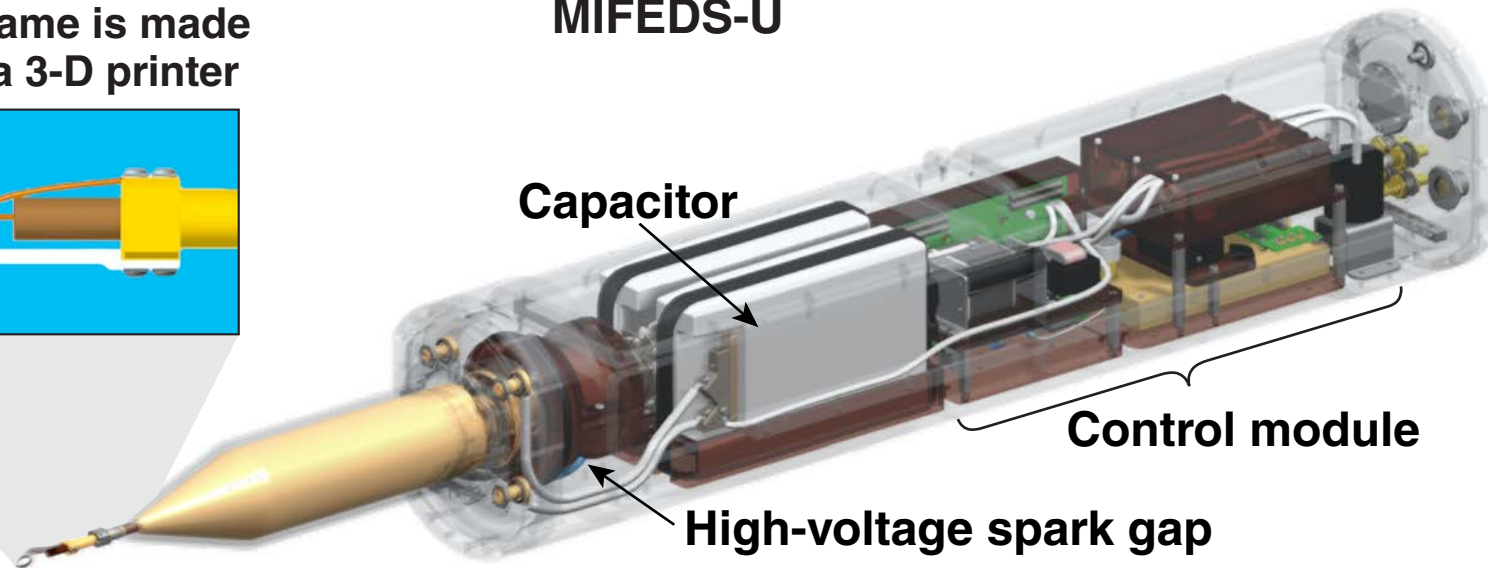
The upgraded MIFEDS (MIFEDS-U) device provides for higher B fields, flexible field topologies, and robust operations



The coil frame is made by using a 3-D printer



MIFEDS-U



	MIFEDS-U
Energy	Up to 200 J
Maximum current	40 kA
Coil	Multiple turns with 3-D printed frame
B	~10 T using four turns, $r \sim 6$ -mm coils
Operation	Facility diagnostic

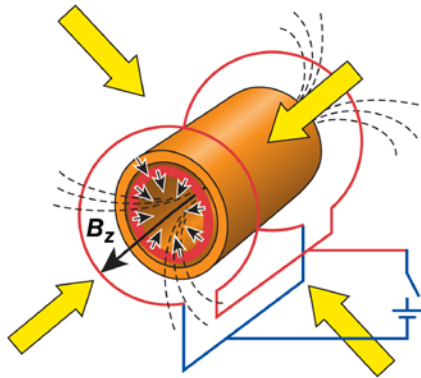
Many thanks to the LLE engineers!

Existing coil library (LLE designed)

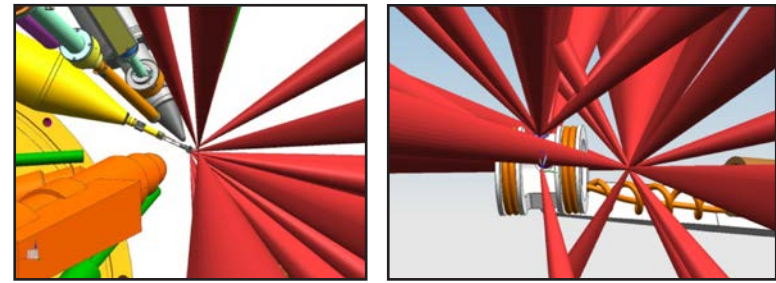


Part #	Description	First Use	TIM	System	Assembly #	Interference Check	RID's	Campaign's
D-ES-B-936	COMMON COIL ASSEMBLY - MIFEDS	-	-		-			
D-ES-C-950	MIFEDS TEST COIL	02/13/13	4	OMEGA/Joint	D-ES-B-950			
D-ES-C-941	MIFEDS COIL - TYPE II	02/13/13	4	OMEGA	D-ES-B-941			MagICF-J-13A
D-ES-C-718	HELMHOLTZ FOIL_TYPE I	02/21/13	10	EP	D-ES-B-717			DynMagRecon-13A
D-ES-C-942	MIFEDS COIL - TYPE III	02/28/13	10	EP	D-ES-B-942			EP-MagShock-13A
D-ES-C-944	MIFEDS COIL FORM - TYPE IV	04/17/13	4	OMEGA	D-ES-B-944			MagICF-O-13B
D-ES-C-945	MIFEDS COIL FORM - TYPE V - 0 DEG	05/21/13	4	OMEGA	D-ES-B-945	D-ZA-X-012	43594	MagShock-J-13A
D-ES-C-946	MIFEDS COIL FORM - TYPE V - 35 DEG	05/21/13	4	OMEGA	D-ES-B-946	D-ZA-X-011	42966	MagShock-J-13A
D-ES-C-947	MIFEDS COIL FORM - TYPE V - 45 DEG	05/21/13	4	OMEGA/Joint	D-ES-B-947	D-ZA-X-013	42623	MagShock-J-13A
D-ES-C-948	MIFEDS COIL FORM - TYPE VI	05/29/13	10	OMEGA EP	D-ES-B-948	D-ZB-X-008 D-ZB-X-009	41593 41594	PairPlasma-13C (Positron-13C, 08/06/13) PairPlasma-13B (Positron-13B, 05/29/13)
D-ES-C-949	MIFEDS COIL FORM - TYPE VII	08/15/13	1	OMEGA	D-ES-B-949	D-ZA-X-026	44444	ExpAstro-13B
D-ES-C-1011	MIFEDS COIL FORM - TYPE VIII	08/20/13	1	OMEGA	D-ES-B-1011	D-ZA-X-025	44259	MagLPI-13A
D-ES-C-1012	MIFEDS COIL FORM - TYPE IX	09/05/13	10	OMEGA EP	D-ES-B-1012	D-ZB-X-013	44135	DynMagRecon13B
D-ES-C-1013	MIFEDS COIL FORM - TYPE X	09/11/13	4	OMEGA	D-ES-B-1013	D-ZA-X-027	44564	AstroShock-13B
D-ES-C-1015	MIFEDS COIL FORM - TYPE XII	11/19/13	10	OMEGA EP	D-ES-B-1015	D-ZB-X-014	44818	MagShockEP-14A
D-ES-C-1015	MIFEDS COIL FORM - TYPE XII	12/04/13	10	OMEGA EP	D-ES-B-1015	D-ZB-X-014		MagShockEP-14A
D-ES-C-1075	MIFEDS COIL FORM - TYPE XIV - 0 DEG	02/04/14	4	OMEGA/Joint	D-ES-B-1075	D-ZA-X-043		MagShock-J-14A
D-ES-C-1076	MIFEDS COIL FORM - TYPE XIV - 35 DEG	02/04/14	4	OMEGA/Joint	D-ES-B-1076	D-ZA-X-043		MagShock-J-14A
D-ES-C-1078	MIFEDS COIL FORM - TYPE XVI	02/06/14	4	OMEGA/Joint	D-ES-B-1078	D-ZA-X-042		MagICF-J-14A
D-ES-C-1084	MIFEDS COIL FORM - TYPE XVIII	02/19/14	10	OMEGA EP	D-ES-B-1084	D-ZB-X-019		PairPlasma-14A
D-ES-C-1079	MIFEDS COIL FORM - TYPE XVII	02/26/14	4	OMEGA	D-ES-B-1079	D-ZA-X-044		AstroShock-14A
D-ES-C-1091	MIFEDS COIL FORM - TYPE XIX - 3 mm	04/08/14	10	OMEGA EP	D-ES-B-1091	D-ZB-X-020	46567	MagLiFEP-14A
D-ES-C-1092	MIFEDS TARGET HOLDER - TYPE XIX - 3 mm	04/08/14	10	OMEGA EP	D-ES-B-1092	D-ZB-X-021	46567	MagLiFEP-14A
D-ES-C-1093	MIFEDS COIL FORM - TYPE XIX - 4.5 mm	04/08/14	10	OMEGA EP	D-ES-B-1093	D-ZB-X-022	46567	MagLiFEP-14A
D-ES-C-1094	MIFEDS TARGET HOLDER - TYPE XIX - 4.5 mm	04/08/14	10	OMEGA EP	D-ES-B-1094	D-ZB-X-023	46567	MagLiFEP-14A
D-ES-C-1095	MIFEDS COIL FORM - TYPE XX	04/17/14	4	OMEGA	D-ES-B-1095	D-ZA-X-052		MagICF-14A
D-ES-C-1096	MIFEDS COIL FORM - TYPE XXI	04/23/14	10	OMEGA EP	D-ES-B-1096	D-ZB-X-024	47096	JETEP-14A
D-ES-C-1104	MIFEDS COIL FORM - TYPE XXI - NORMAL	04/23/14	10	OMEGA EP	D-ES-B-1104	D-ZB-X-025	48015	JETEP-14A
D-ES-C-1109	MIFEDS COIL FORM - TYPE XXII	05/06/14	5	OMEGA	D-ES-B-1109	D-ZA-X-054	47844	ICF MagLPI-14B
D-ES-C-1106	MIFEDS COIL FORM - TYPE XXIII	05/08/14	1	OMEGA	D-ES-B-1106	D-ZA-X-053	47376	Magnetized jets
	MIFEDS COIL FORM - TYPE	07/29/14		OMEGA				LBS MagICF-LBS-14B
	MIFEDS COIL FORM - TYPE	07/30/14		OMEGA EP				ICF MagLiF-14B
	MIFEDS COIL FORM - TYPE	07/31/14		OMEGA				NLUF AstroShock-14B
	MIFEDS COIL FORM - TYPE	08/06/14		OMEGA EP				NLUF DynMagRecon-14B
	MIFEDS COIL FORM - TYPE	09/04/14		OMEGA EP				LBS PairPlasma-14B
	MIFEDS COIL FORM - TYPE	TBD		Joint				NLUF MagShock-J-14A

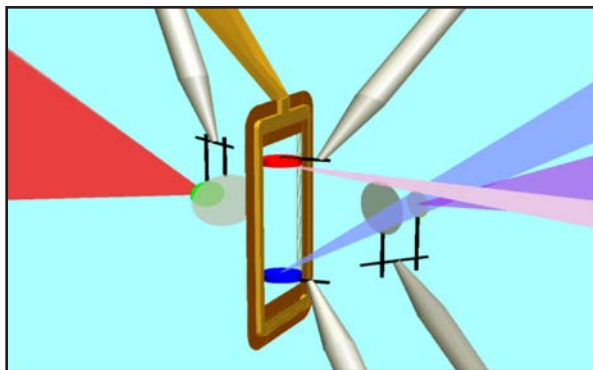
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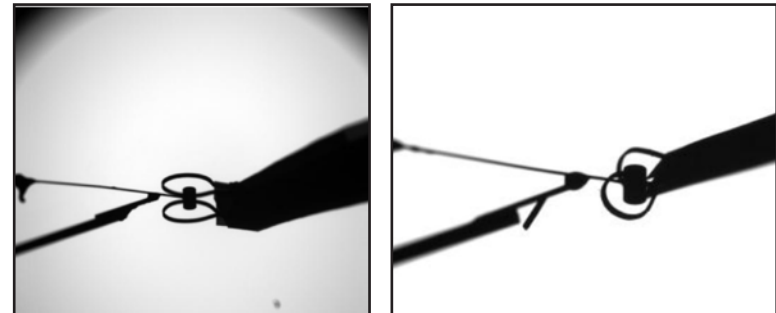
Physics



Diagnostic/beam clearances

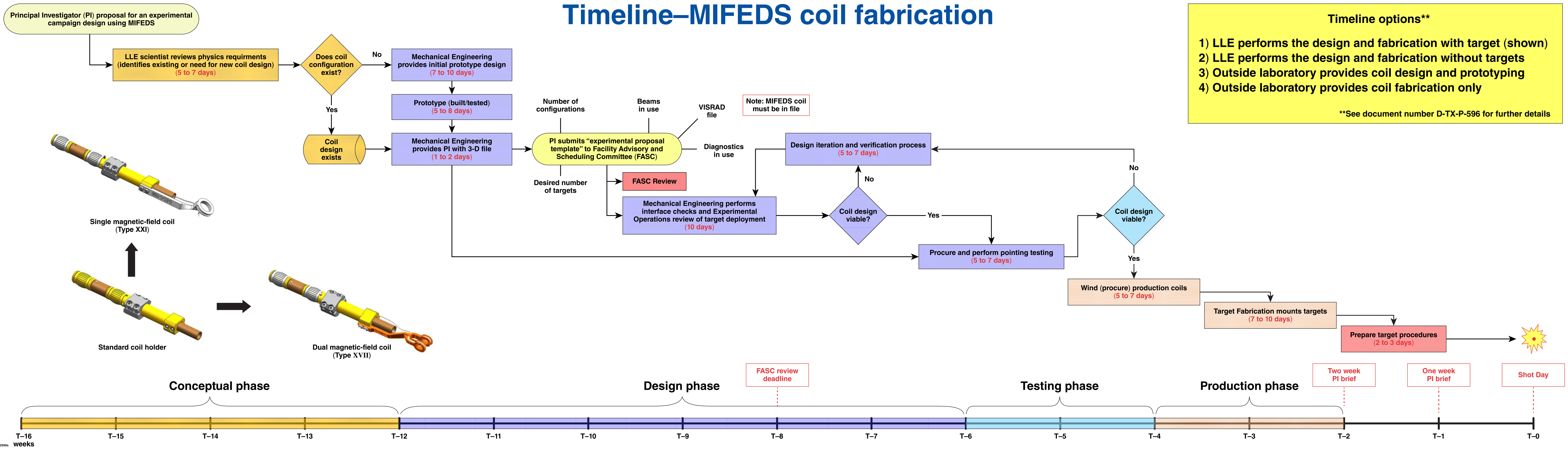


Target deployment scheme



Viewing system

Timeline–MIFEDS coil fabrication



Timeline options**

- 1) LLC performs the design and fabrication with target (shown)
- 2) LLC performs the design and fabrication without targets
- 3) Outside laboratory provides coil design and prototyping
- 4) Outside laboratory provides coil fabrication only

**See document number D-TX-P-596 for further details

