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COMPACT DT FUSION SPHERICAL TORI AT MODEST FIELD

Preliminary Assessments Suggest That Ignition Spherical Torus(IST) Has High Potential but Requires New Physics Data Base

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SPHERICAL TORUS

A spherical torus is obtained by retaining only the indispensable components on the inboard side of a tokamak plasma. It features an exceptionally small aspect ratio (around 1.5), a naturally elongated, D-shaped plasma cross section (2 to 1 elongation), and ramp-up and maintenance of the plasma current primarily by advanced methods. It takes on the spherical shape with a modest hole through the center, suggesting the name.

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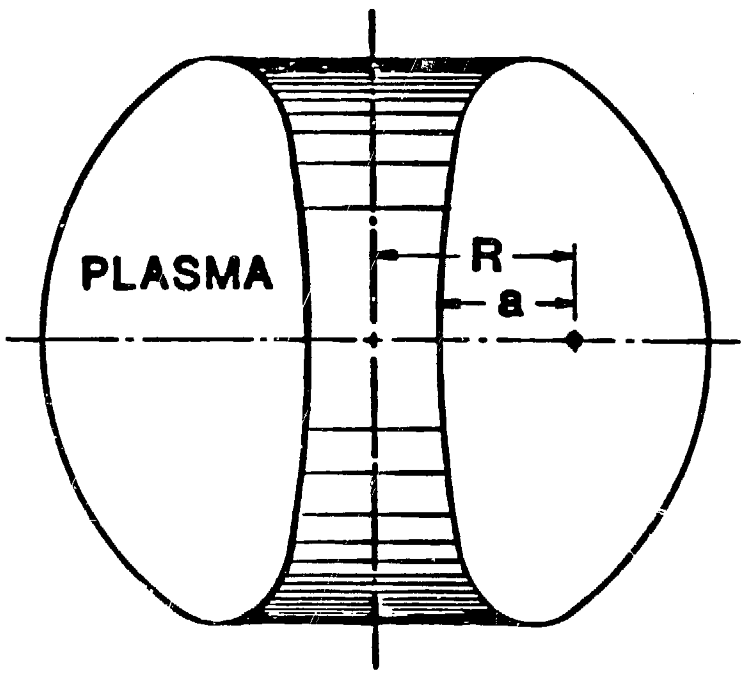


PURPOSE OF THE ASSESSMENT

- *Quantify its potentials and challenges*
- *Characterize its critical issues*
- *Highlight its data base needs*

MISSION OF AN IST

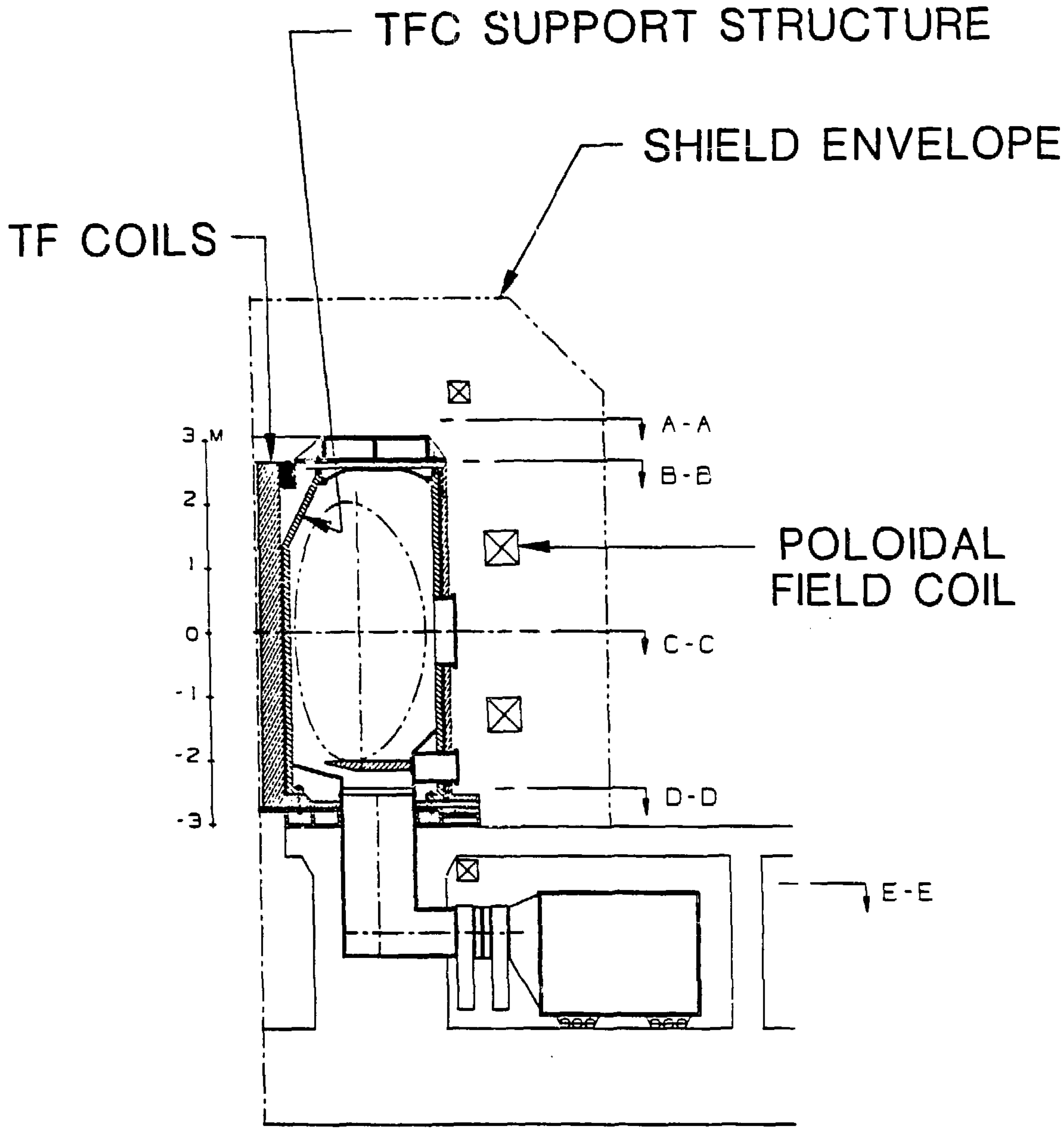
- *Achieve ignition*
- *Pulse length for 10's of seconds*
- *Enough cycles for repeatability*
- *Achieve lowest overall cost*

MAJOR ASSUMPTIONS OF A FUSION IGNITION SPHERICAL TORUS

- ***Plasma Assumptions And Features***
  - *Troyon beta scaling, coef = .035, 77 DT*
  - *neo-Alc. or Mirnov confinement scaling*
  - *naturally large plasma elongation, b/a=2*
  - *strong paramagnetism, B/Bo = 1.7*
  - *Murakami density limit*
  - *RF wave current rampup, 50-sec burn*

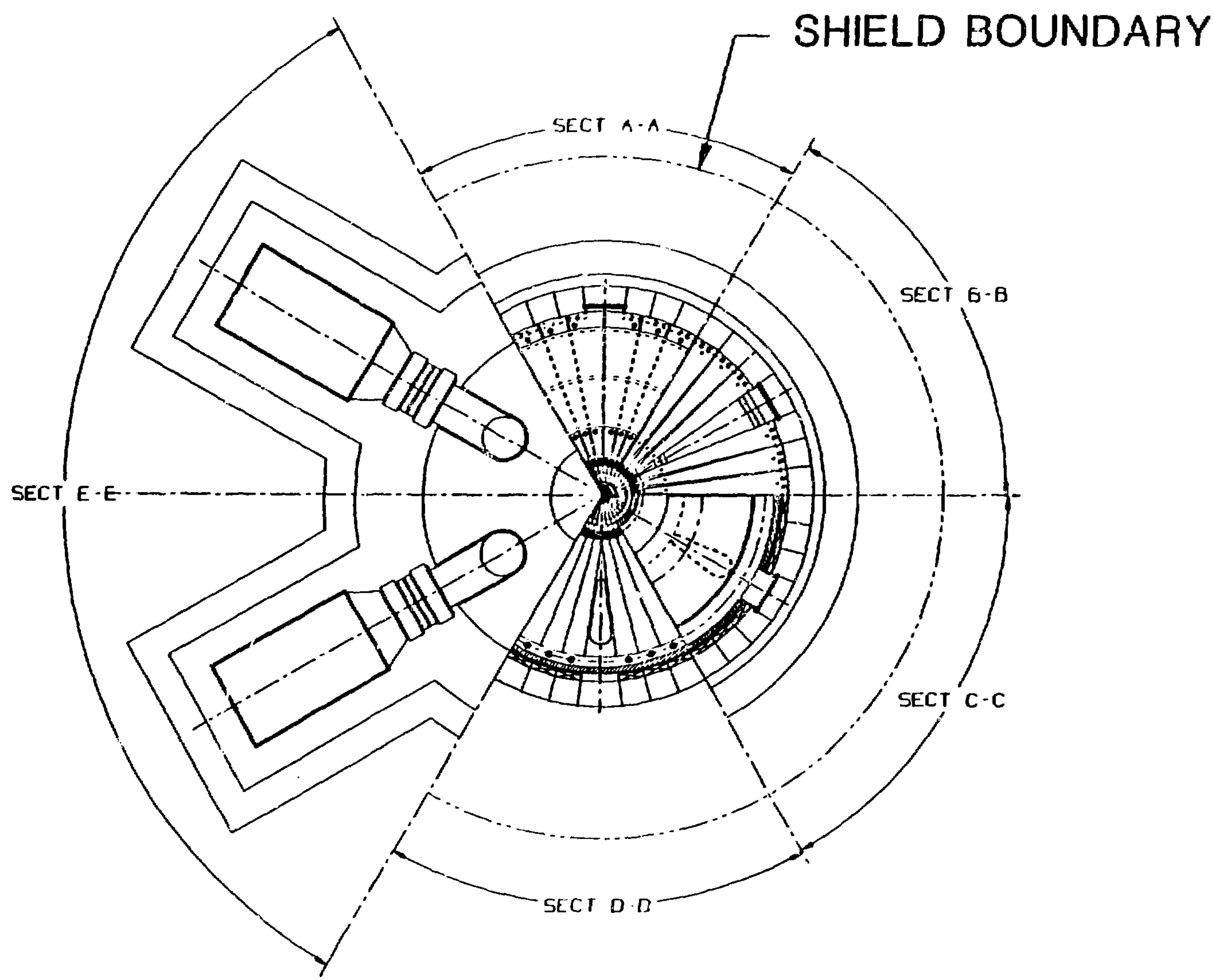
- ***Engineering Assumptions***
  - *conventional engineering*
  - *C-17510 alloy option for center conductor (hi-vel pressurized water at 300 deg. C)*

NOMINAL IGNITION SPHERICAL TORUS



SPHERICAL TORUS ELEVATION

PLAN VIEW

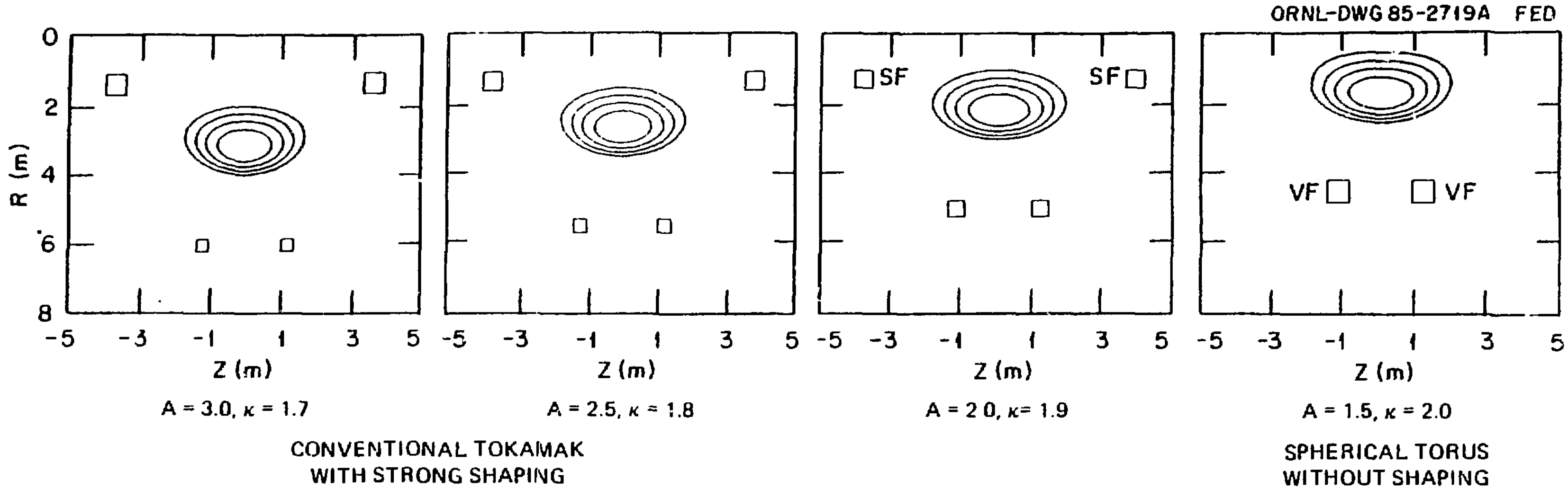


THE SIZE AND PERFORMANCE OF IST DEPEND STRONGLY ON PLASMA PHYSICS EXTRAPOLATIONS AND TOROIDAL FIELD COIL TECHNOLOGY

	Nominal TF Coils	*High-Tech TF Coils*
Vacuum field(T)	2.0	3.0
Plasma field(T)	3.4	5.1
Coil J(kA/cm)	3.3	10
Elongation, b/a	2	2
Major radius(m)	1.6	1.0
Minor radius(m)	1.0	0.61
Plasma current(MA)	14	12
TF Amp-turn(MA)	16	15
Beta	0.24	0.23
RF rampup power(MW)	8	5
Fusion power(MW)	55(160)	56(160)
Wall load(MW/m)	0.26(0.76)	0.69(2.0)
IM(Mirnov)	1.0(2.0)	1.0(1.9)
IM(neo-Alc)	0.27(1.3)	0.22(1.2)

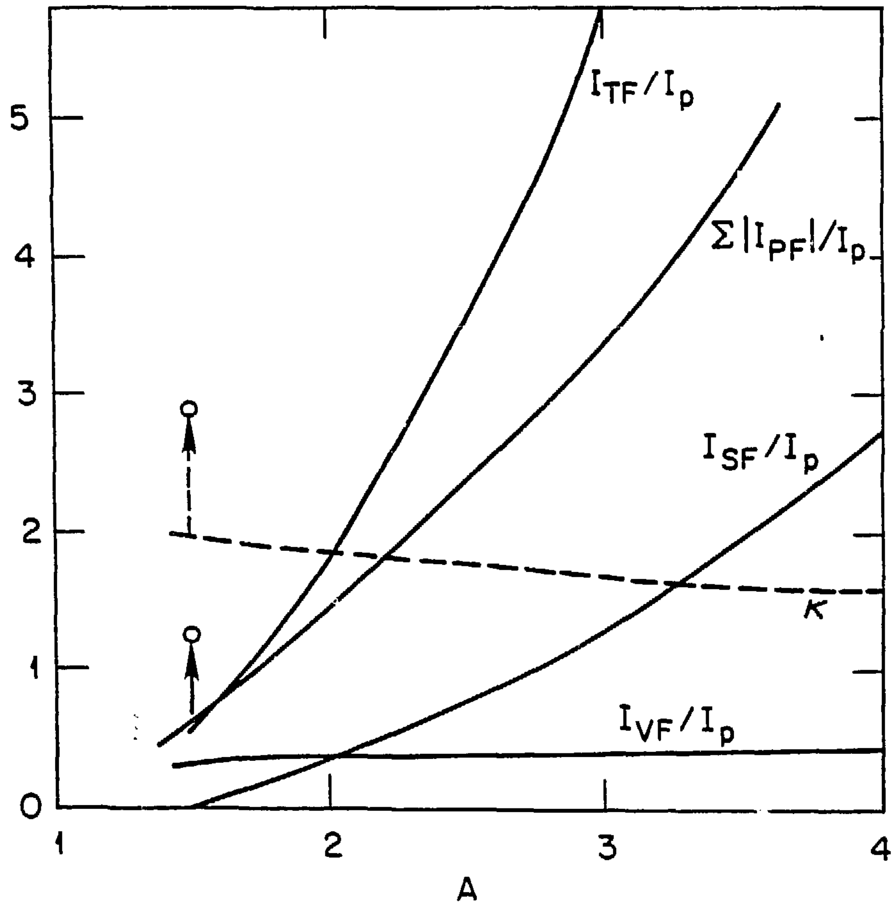
The values in parentheses assume favorable effects of the enhanced plasma field, plasma paramagnetism of the spherical torus

SPHERICAL TORUS HAS A NATURAL ELONGATION OF ABOUT 2



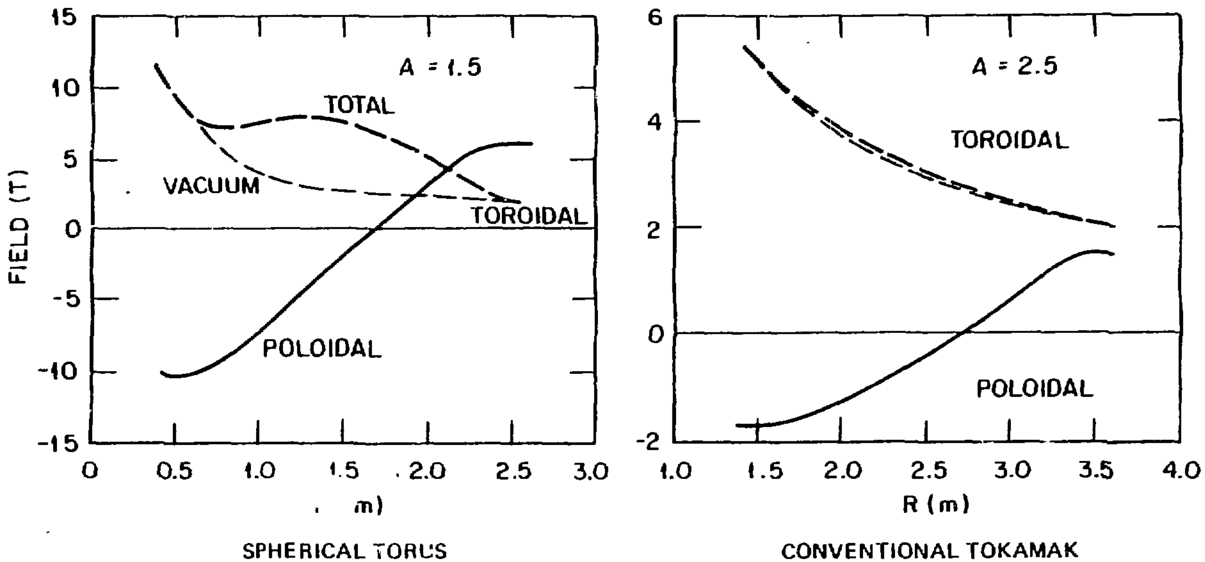
(a = 1 m, B_{to} = CONST. q_ψ = 2.4, $I_p \propto \frac{\epsilon(1.22-0.68\,\epsilon)}{(1-\epsilon^2)^2}(1+\kappa^2)$,
AND COIL CROSS SECTION PROPORTIONAL TO COIL CURRENT)

SPHERICAL TORUS REQUIRES ONLY MODEST COIL CURRENTS IN COMPARISON WITH CONVENTIONAL TOKAMAKS



Spherical Torus is a NATURAL Plasma Configuration

SPHERICAL TORUS DISTINGUISHES ITSELF WITH STRONG PLASMA GENERATED MAGNETIC FIELD -- PLASMA PARAMAGNETISM



SIGNIFICANT PARAMAGNETISM SETS IN WHEN A BECOMES LESS THAN 2

COMPARED WITH HIGH-FIELD COMPACT IGNITION TOKAMAK CONCEPTS, IST HAS SIMILAR SIZE, LOWER ENGINEERING RISK BUT HIGHER PHYSICS RISK

	IST	ISP(PPPL)
Major radius(m)	1.6	1.6
Aspect ratio, R/a	1.6	3.1
Elongation, b/a	2.0	1.6
Vacuum field(T)	2.0	9.0
Plasma field(T)	3.4	9.0
Plasma current(MA)	14	8
Safety factor	2.4	2.6
Beta	0.24	0.05
Current rampup	rfw	induction
Fusion power(MW)	160	300
Ignition margin	1.3	1.3
Coil $J(kA/cm^2)$	3.3	5.5
TF Amp-turn(MA)	16	73
PF Amp-turn(MA)	9	23
Pulse length(s)	50	5
Coil cooling	s.s.	inertial

FOR COMPACT FUSION AT LOW FIELD, SPHERICAL TORUS HAS HIGH POTENTIAL BUT REQUIRES NEW PHYSICS DATA BASE

ATTRACTIVE FEATURES

- *Compact, Low Field and Conventional Engineering*
- *Can Benefit From High Technology Toroidal Field Coils*
- *Has Free-Standing TFC Configuration*

PHYSICS DATA BASE NEEDS

- *New Physics Regime in spherical torus*
- *Uncertainties in Plasma Physics Have Strong Effects on IST Size and Performance*
- *ORNL Will Propose a Small (R = 0.45 m) and Low Field (0.5 T) Spherical Torus Experiment - STX*