Central solenoid-free current startup with electron cyclotron wave preionization in SUNIST

(will be conducted)

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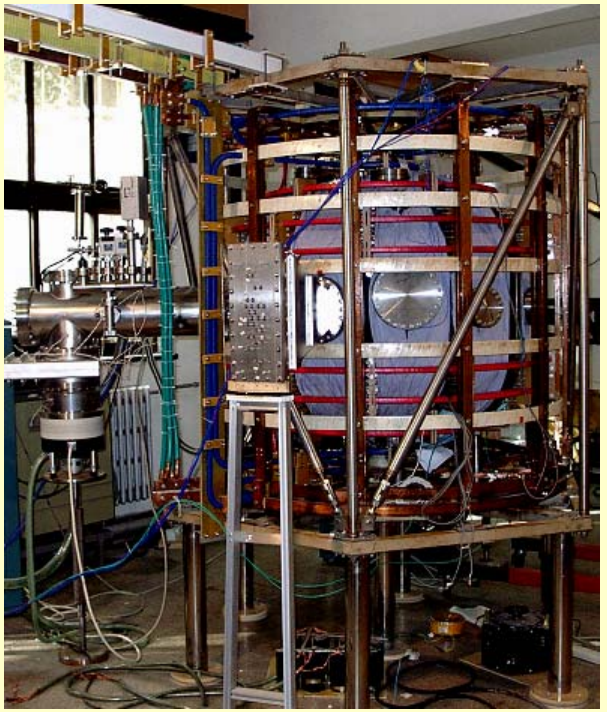
Outline

- Introduction
- Current startup with a toroidal field and a weak vertical field
- An alternative method: with electrode discharges
- Current induced with vertical field.

SUNIST
(Sino-UNIted Spherical Tokamak)

- Main radius: R = 0.3 m
- Aspect ratio: A = 1.3
- Toroidal field: 0.15 Tesla
- Plasma current: Ip = 50 kA



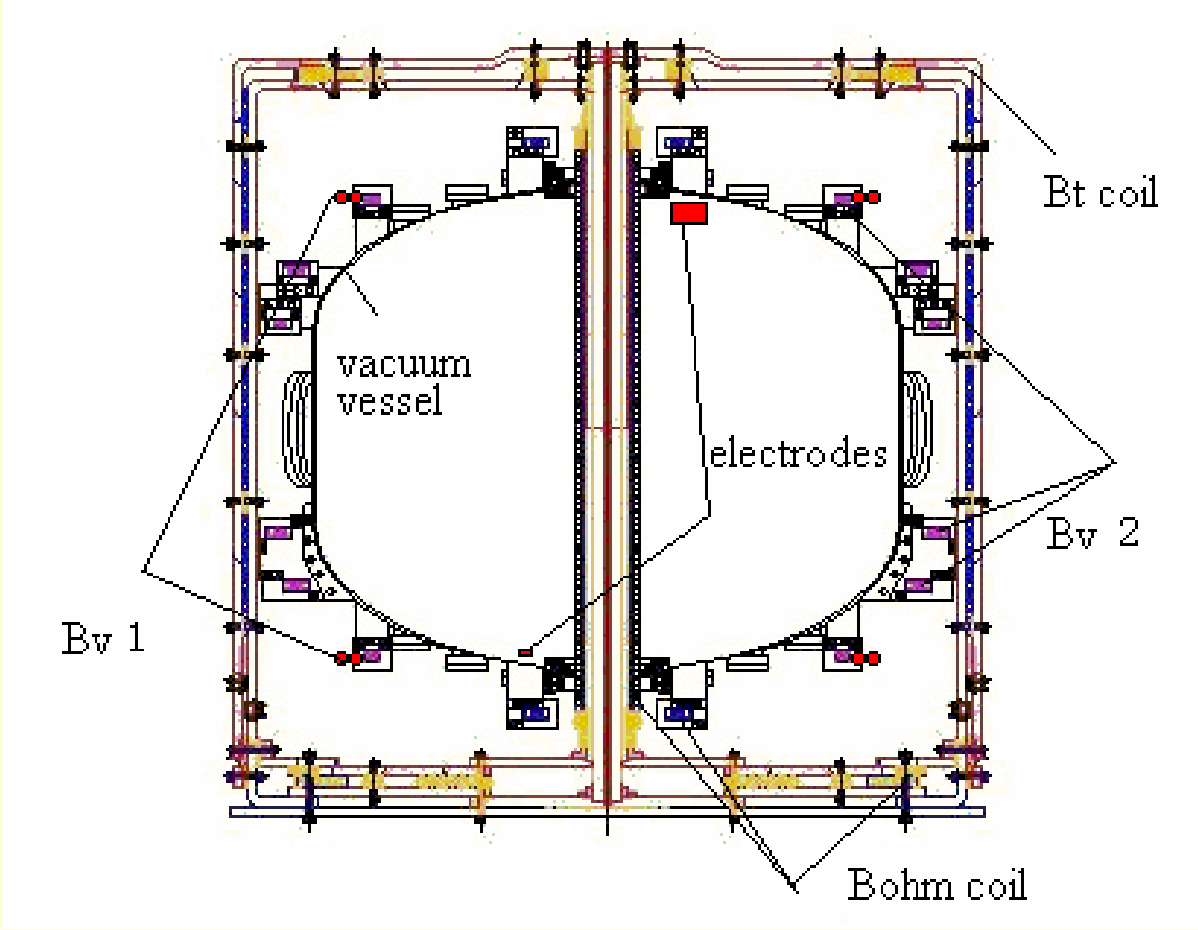
Solenoid free current startup

- A 100 kW, 2.45 GHz microwave system for preionization
- First phase: toroidal field + weak vertical field 1 to generate plasma current
- Second phase: toroidal field + weak vertical field 2 to ramp up plasma current
- No central solenoid action

Microwave system

100 kW, 2,45 GHz, 30 ms, TE_{01}, O mode

Cross section of the coil system and electrodes



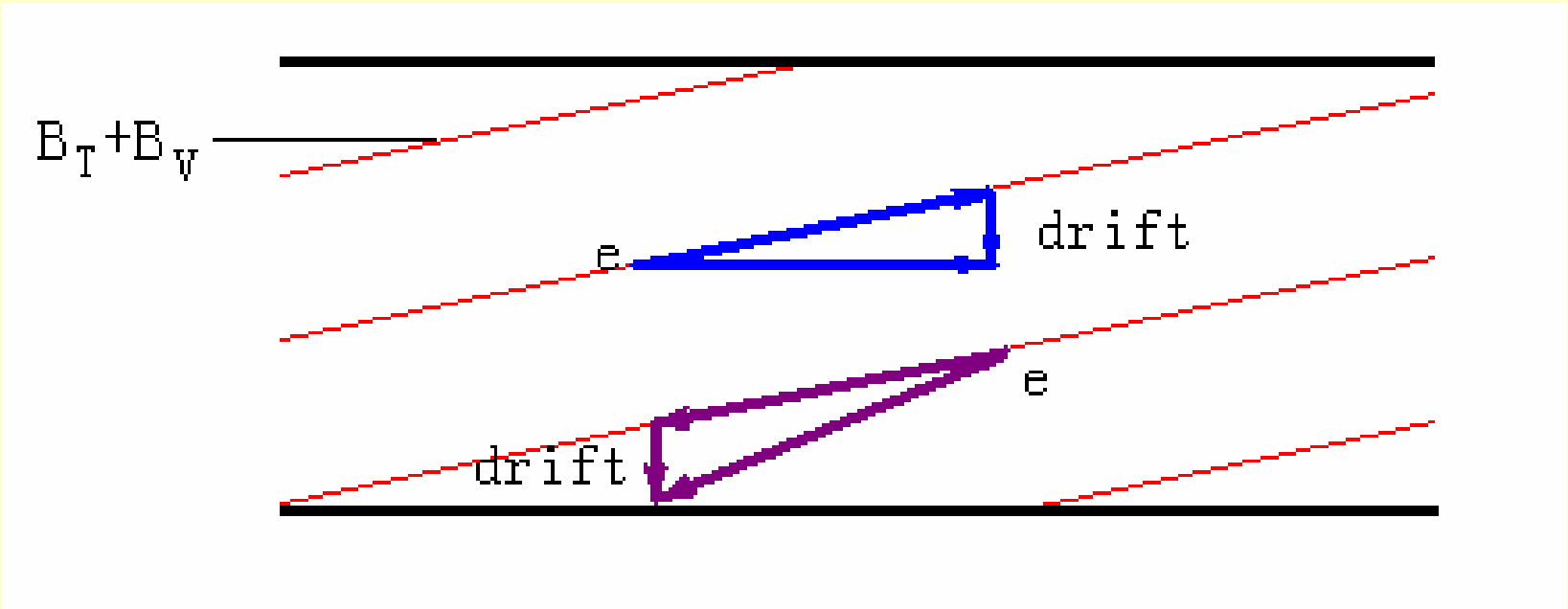
Magnetic flux provided with OH and vertical field coils

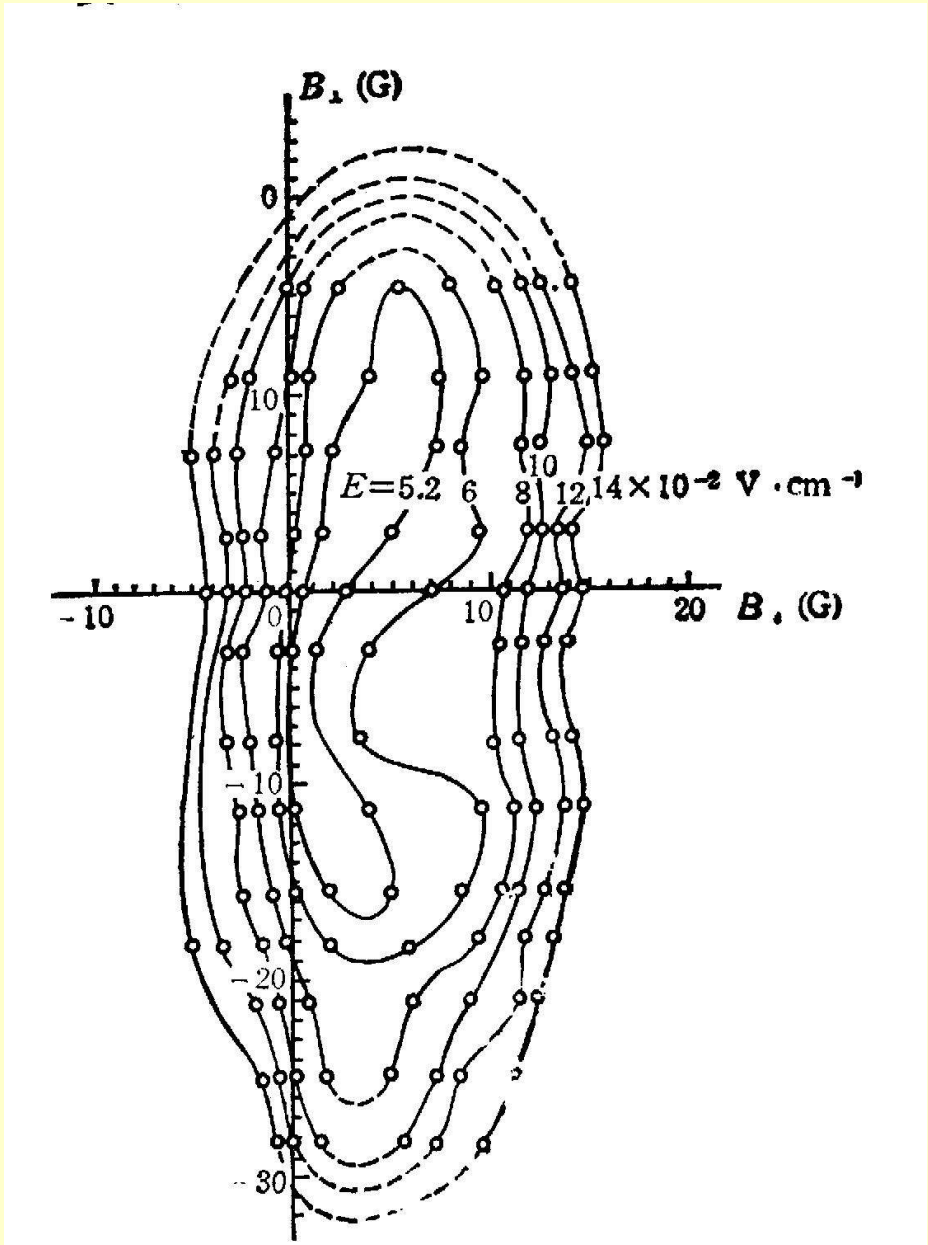
coils	OH	Bv1	Bv2
flux	67 mVs	0.3 mVs	6.2 mVs

Current startup and ramp up in two phases

phase	1	2
Force lines	open	closed
Vertical field	Constant or increasing	increasing
Coils of vertical field	#1	#2
duration	2-3 ms	>10 ms
mechanism	Non-inductive	inductive

The mechanism of current startup with toroidal and vertical fields





Breakdown voltage contours in horizontal field and vertical field plane in CT-6B tokamak

(Acta Physica Sinica 36(1987) 1385)

The current startup mechanism has been experimentally demonstrated on WT-3 (Kyoto Univ.) and CT-6B (IoP)

On CT-6B, 20 GHz gyrotron system produce $8X10^{12}$ cm^{-3}, higher than the cut off density $5X10^{12}$ cm^{-3}, and produce 300 A plasma current

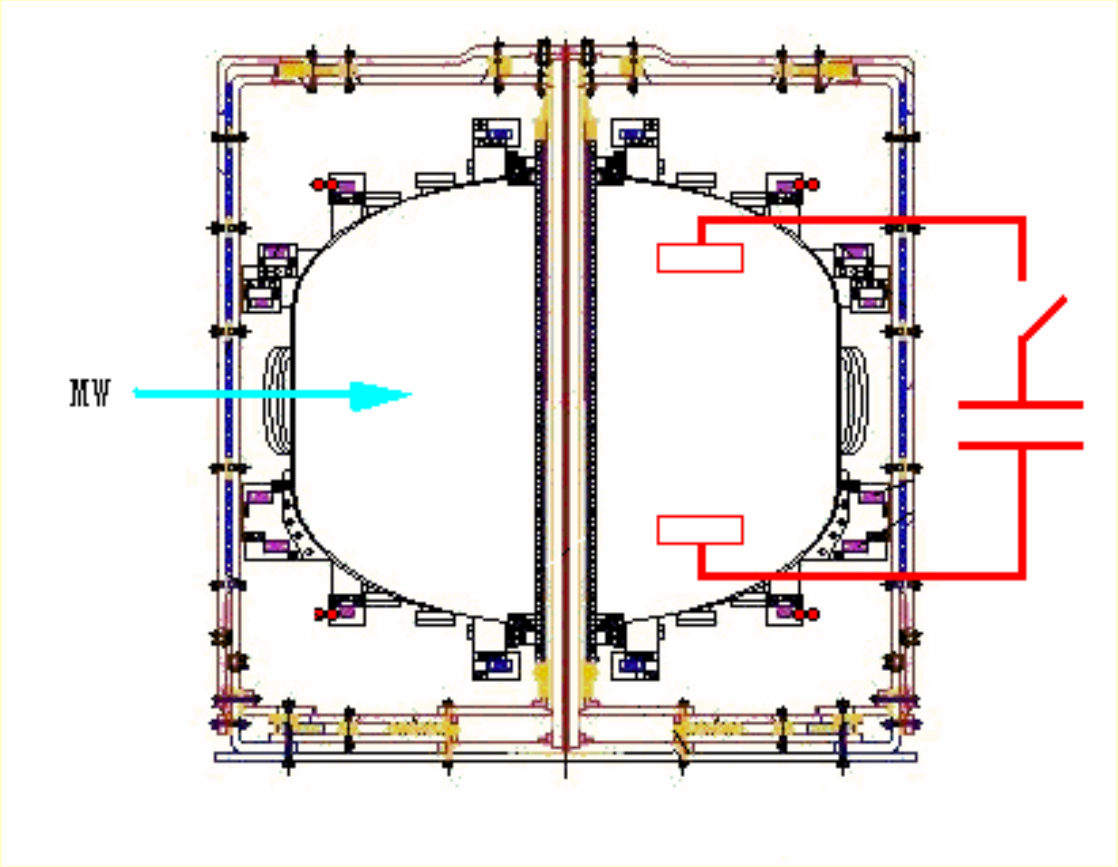
The experiment will be conducted with the 2.45GHz microwave system and the vertical field coil #1 on SUNIST

The ratio of the toroidal field with the vertical field

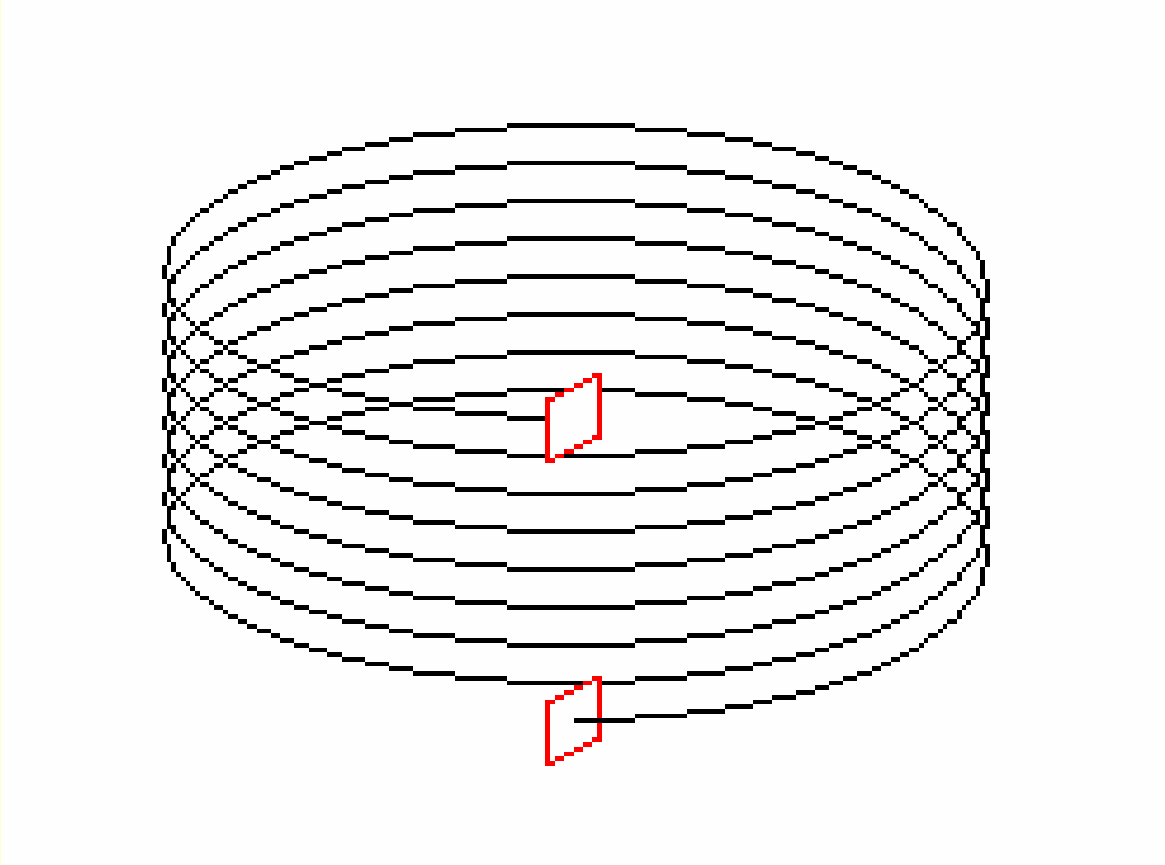
B_T/B_v=20:1—50:1

0.5-1 kA plasma current is expected

Electrode discharge assisted current startup



Toroidal current formed from electrode discharge



The optimal vertical field and the corresponding plasma current

$$B_v = \sqrt{\frac{\mu_0 \kappa a B_T I_d}{\pi k R}}$$

$$I_p = \sqrt{\frac{k \kappa a B_T I_d}{\pi \mu_0 R}} \propto \sqrt{\frac{\kappa B_T}{A}}$$

More plasma current can be generated in ST

The electrode discharge assisted current startup mechanism has been experimentally demonstrated on CT-6B, a small conventional tokamak, and got near 1 kA plasma current.

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A pair of discharge electrodes has been installed,

The experiment will be conducted on SUNIST

1-2 kA plasma current is expected

In the second phase, an increasing vertical field will be applied with the coils #2 to ramp up the plasma current.

2-5 kA plasma current is expected.

Discussions

- How much electron density can be achieved with the MW system (cut off density $7X10^{10}cm^{-3}$)?
- Can the vertical field match the requirement of plasma equilibrium?

Thank you