

# TECHNICAL EXPERIENCE FROM PRINCETON

Stellarators - I plead ignorance

ST-Tokamak - See Joel in back of room

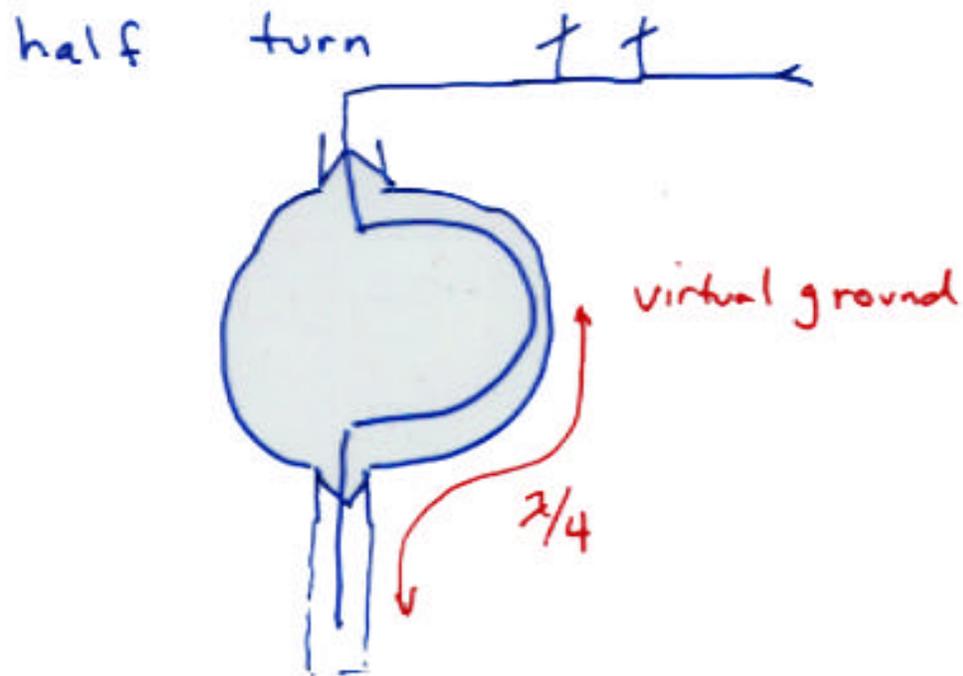
however I do remember him

mentioning many times :) the problems with alumina insulators which suffered from "punch-thru" and "worm-holes"

PLT - lengthen rf pulses to 1 s  
at high (multi-MW) power levels

# PLT

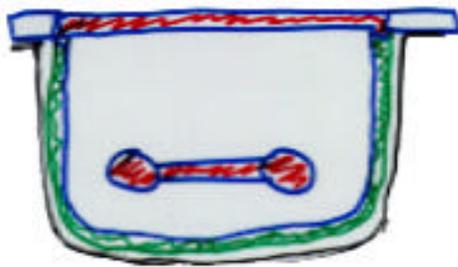
Utilized up to 6 single strap antennas



tried low and high field side launching

length adjusted by extending the lower end to place a virtual ground in the midplane

## Composition of single antenna



X-section

- - Cu center cord and back plate
- - MACOR™ cover
- - Faraday Shield

Faraday Shield - double layer

Many materials utilized

- thin stainless steel
- thick stainless steel
- thick Ti
- Carbon on thin stainless

insulated on one end with MACOR™ washers

Some later antennas had no MACOR™ shield

Experience with these materials

Stainless was easily damaged  
and added high  $Z$  material to plasma

Ti and C were lower  $Z$  and  
showed less damage but absorbed  
and released gas.

MACOR<sup>™</sup> absorbed and released gas  
was demonstrated on test stand  
that  $H_2O$  was readily taken up  
and required Hi-temperature to release

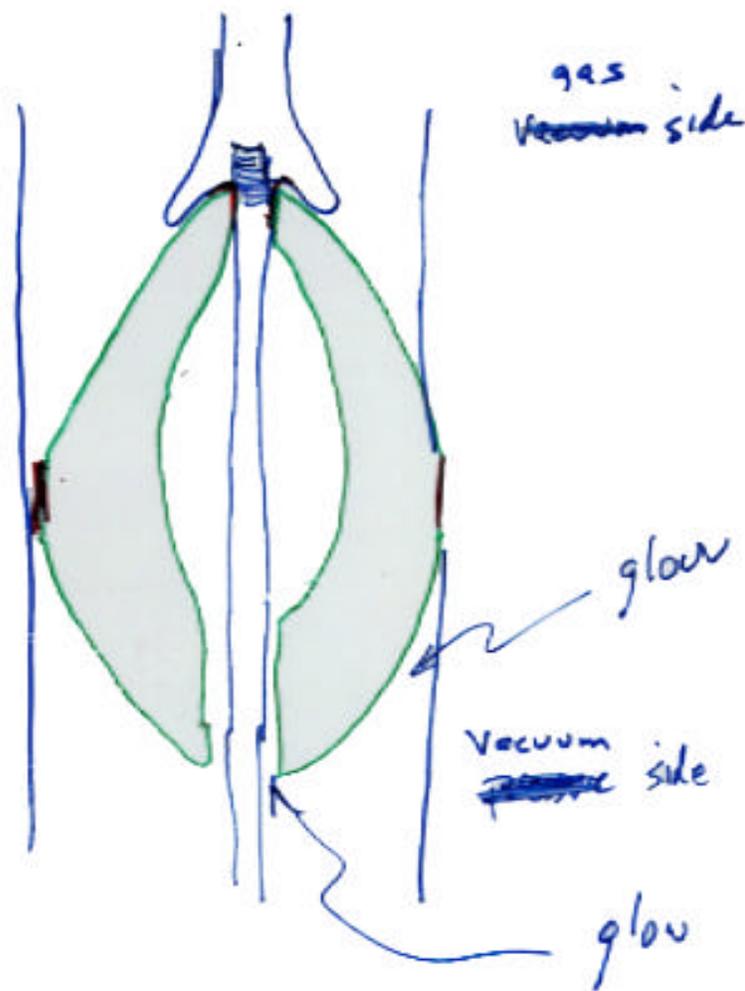
In-situ Ti gettering onto antenna  
improved performance but was addictive

Antennas without MACOR<sup>™</sup> covers performed  
well but were more sensitive to plasma  
conditions [gas/plasma inside Faraday shield??]

Feed-through development very important  
on PLT

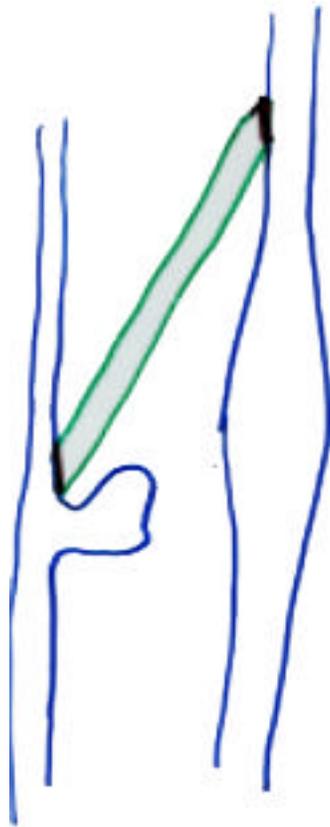
Original feedthrough was adopted  
from DC design

“football” design



corona rings helped  
but not sufficient

# Cone Design





Other details

Carbon "fingers" used to protect top, bottom and midplane of antenna

center fed - end shorted  $\frac{1}{4}$  turn antennas also used.

IBW antennas - similar details.

Antennas were considered as constantly under development, changes were made every operating, some damage was considered "normal"

## Transition to TFTR

### Change in philosophy

"The first antenna would be the last antenna" D. Grove

"Must be installed purely from outside" (D-T)

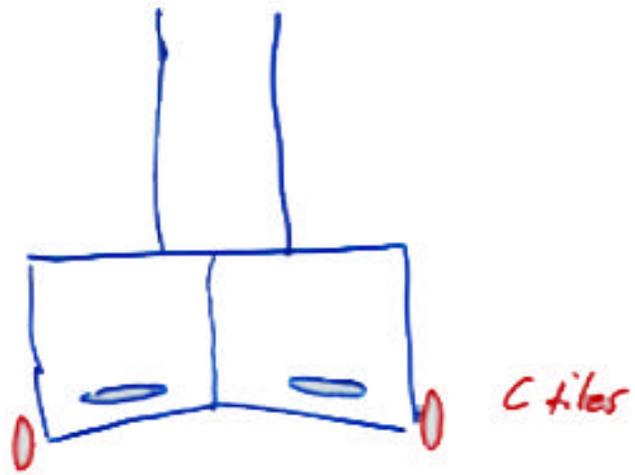
Long pulses

high heat loads

large disruption forces

Lead to

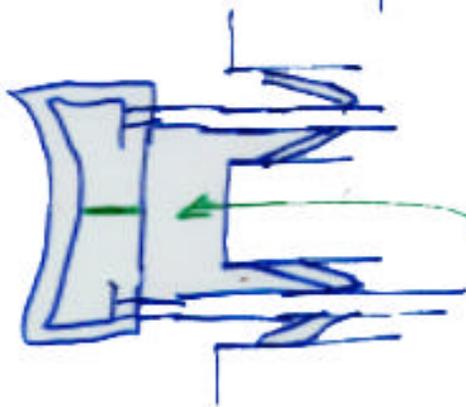
Antenna in box



At first  
double layer FS

round rods  $3/8$ " and  $1/2$ " Inconel rods  
Cu plated  
TiCN Coated

All parts Stainless Steel or Inconel  
plated



Center ground  
added to allow  
water cooling of  
center strap and to  
resist disruption forces

Original design had  
virtual ground

The original bay M antenna operated up  
to 5MW and 50 kV. It was on the  
machine for all but the last year of  
TFTR operation

The only change to the antenna during this time (~10 yrs) was to move the protective tube forward by a few mm

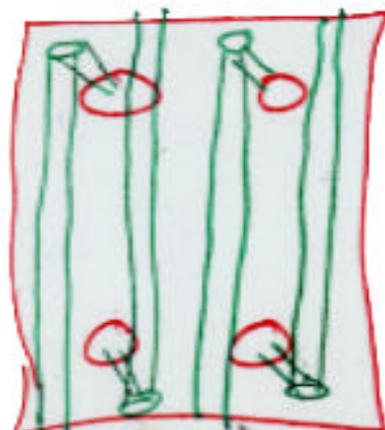
⇒ New Issue alignment of antenna with plasma (rippte)

Very careful alignment of the antenna with the plasma head loss was required to avoid hot spots on various antennas.

later TFTR antennas were similar

single layer shields - tilted/not tilted  
no obvious difference.

For last campaign used 4 straps  
single ended antennas in same boxes



Were not quite as successful at high power

## ~~Damage~~ Damage on TFTR Antenna

Arc damage was observed in  
3 locations

between shield and radiating element  
(caveat)

between sharp corners on radiating  
element and box

at mouth of feed thru

Some damage on surface of FS  
(poorly adhered coating)

# NSTX Antenna

~~Try~~ Try to avoid pushing technology at all.

disruptions much less heat

12 individual modules

single ended straps (Solid Cu)

single layer shield (Moly)

low power density

low voltage requirement (25-30 kV)

⇒ must be able to handle wide range of phase relationships

Sheaths? (low  $|B|$ )

Use BN insulators to minimize

field line connections

So far antenna performance has  
continued to improve

Phase 1	2MW for 10ms max
Phase 2	4MW for 10ms 2.5MW for 300ms

however  
Individual parts of the antenna  
(elements used in pairs) have performed to  
full spec. with relative ease but  
full antenna seems harder to get to  
full performance

System problem?  
interactions between sov.