Why the US Should Build the ITER Ion Cyclotron System*

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Introduction

The US should build all (or part) of the ITER ion cyclotron (IC) system because:

- IC is a major heating (and current drive) system on all major US experiments
  - Presently operating: C-Mod, DIII-D, NSTX
  - Proposed with design funding: NCSX, QPS
  - Future: FIRE

- Results from design and R&D for the ITER antenna would provide results directly applicable to present-day US experiments

- It will enable US researchers to
  - have a major role in ITER physics experiments
  - increase involvement in near-term experiments on JET, Tore Supra, et al.

- The US has unexcelled capability to do the job
  - Lots of experience in real-world machine operation
  - Dedicated rf technology program
  - Good modeling capabilities for scenarios, rf-plasma interaction, engineering

What is the ITER IC system and what does it do?

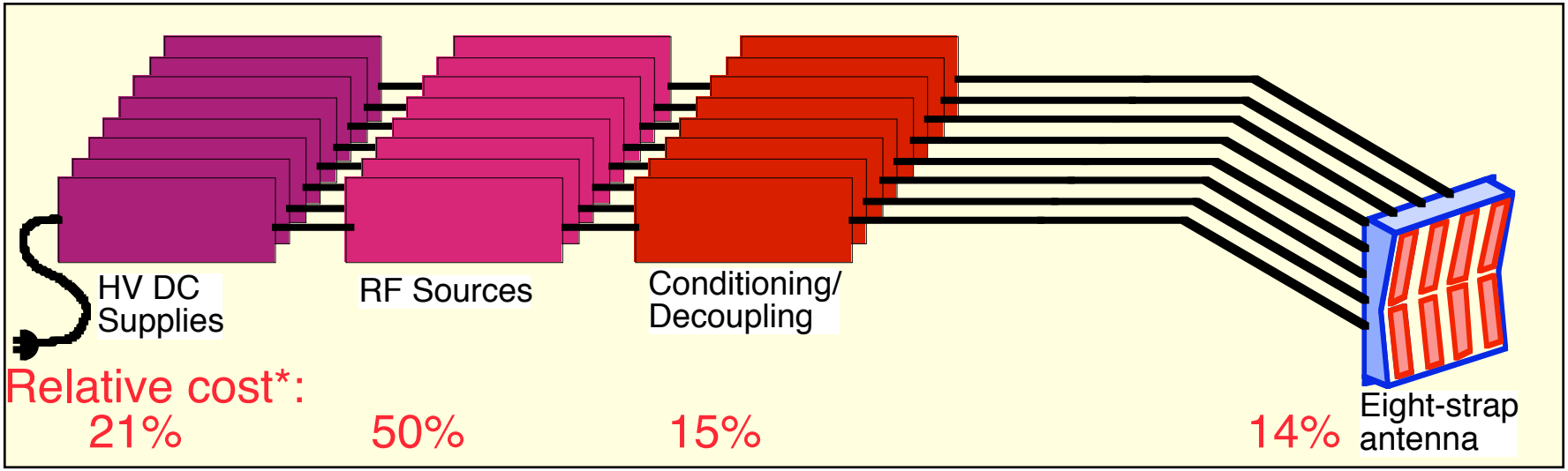
What it is:

- One antenna, eight current straps
- Eight rf sources, each feeding one strap in the antenna
- 35-55 MHz, 30-60 MHz at reduced power
- 20 MW total power to the plasma
- Variable phasing between straps

What it can be used for:

- Tritium ion heating during DT ops.
- Minority ion heating during initial ops.
- Current drive near center for AT operation
- Minority ion current drive at sawtooth inversion radius

ITER ion cyclotron system block diagram



*Basis: JCT cost est.

What can the US contribute to the ITER IC system?

The US has the research and industrial capacity to design and build *all* the ITER IC system.

Antenna –

- Of particularly high interest to US
- Critical component, both for ITER and present-day experiments
  - high-power antenna must deliver power to plasma in presence of ELMs
  - will require R&D to validate present antenna conceptual design
  - results could be *directly applicable* to present-day or proposed US experiments

Transmission lines, conditioning/decoupling –

- Medium interest to US
- Components could be specified and ordered from US industry

RF sources and power supplies –

- Medium interest to US
- Industrial contract to build prototype unit, tested in collaboration with labs.
- Build eight more units (one spare) when prototype demonstrated successful
- US has highest-power tube in the world for this purpose (EIMAC tetrode)

Antenna concept is very interesting to the US

Basic concept is a “resonant double loop” –has operated on TFTR, Tore Supra.

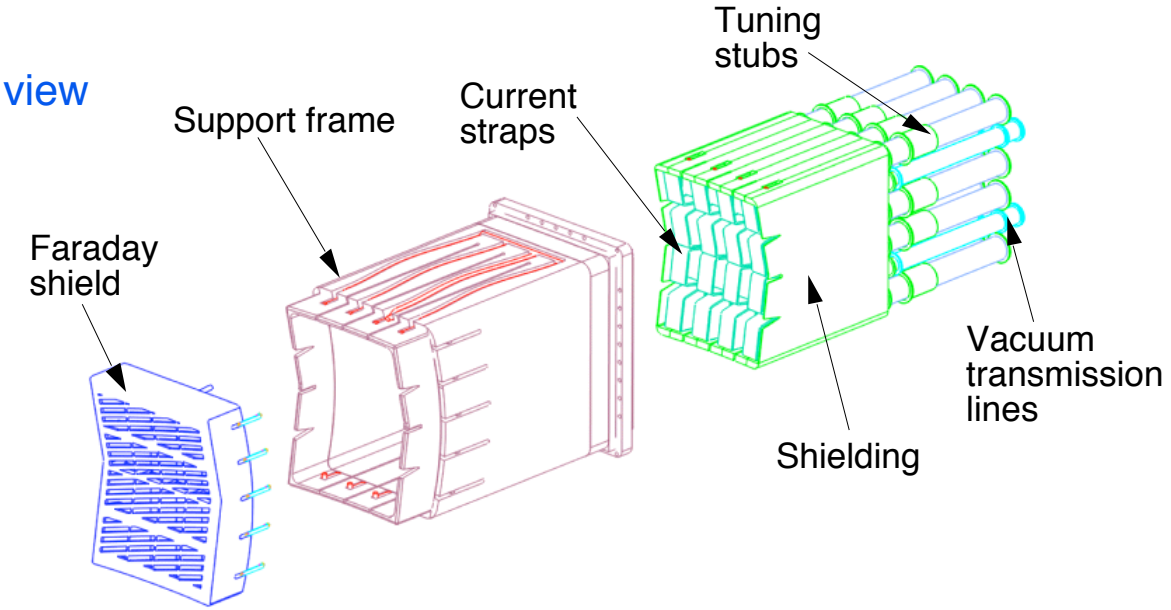
As usual, the devil is in the details –

- Strap is grounded, capacitor is hot (opposite from earlier antennas)
- To be tested on JET-EP antenna using vacuum variable capacitors for tuning
- Present ITER design uses new tuning stub design for tuning elements – needs to be demonstrated as part of R&D program

If successful, concept could have significant advantages

- Capable of high-voltage, high-power operation
- Tolerant of load variations (e.g., during ELMs), could maintain full power to plasma
- Mechanically good design – all-metal, strong
- Could be applied to present experiments for better power-handling and flexibility

Antenna exploded view



Why should the US do this?

It is important that the US be responsible for high-tech components that:

- Position the US for significant Physics responsibilities during ITER operation
- Provide near-term benefits to the US fusion program

The ion cyclotron system, and the antenna in particular, fills this role.

Showing up at an experiment with a piece of equipment that
- is important to successful operation of the experiment
- you know more about than anyone else

makes you a key member of the experimental team and provides access to experimental time
  – (also true of diagnostics, pellet injection, and other heating systems)

Its not just hardware, it is a long-term experimental program

Transmission lines, rf sources

US can build the transmission line and decoupling components

US can build the rf sources

- Continental is the only US vendor for the integrated package
- EIMAC can build the final output tubes, and has the best tubes in the world

Good tasks for industry.

Summary

It is in the interest of the US fusion program to provide the ion cyclotron system (*in particular the antenna*) to ITER because:

- The results of ITER-relevant R&D will
  - have direct applicability to the US fusion program
  - will improve the ion cyclotron systems on present or planned US experiments
- It will position the US to have a major role in ITER physics and operation
- Antenna is the most interesting part. R&D can be leveraged from base program.
- The US has unexcelled capability to do the job.
  - EU requested collaboration on new JET antenna. US has built and now starting tests of a high-power prototype of a load-tolerant, ITER-like antenna for JET.