

HOM Damping on sc. Cavities

J. Tückmantel

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Why:

- 1) Reduce beam-impedance of cavity HOMs: Instabilities
- 2) Avoid HOM overvoltage in cavity (if HOM on machine line)

In **circular machines** necessity of HOM damping **accepted**

Coupled Bunch Instabilities, longitudinal. & transverse

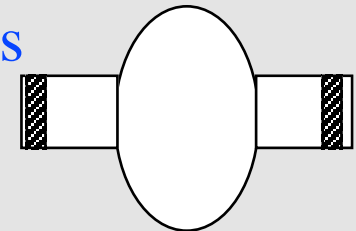
In **high current p linacs under discussion** -> other session

How: (• dump power into LHe (CEBAF): very low beam current (power) only)

- absorb power ‘far away from cavity’ by resistive tiles
works in CESR, -> Ilan (RHIC)

Very elegant but thermal/cut-off separation to cavity:

costs real estate



- couple and transport power out of cryostat, dump there →

Properties of HOM couplers on sc. cavities:

Couplers NOT on cells: Field-enhancement, MP, welding,..
but on cut-off tube close to endcell(s) (CERN 5-cell in PETRA !!)

-RF-wise:

- Good coupling over the whole f-range (no holes, ...)
- Do NOT couple to the acc. mode: notch filter

(geometrical 'tricks (*)' do not work for couplers on cut-off tube !)

-Cryogenic/mechanic/vacuum wise

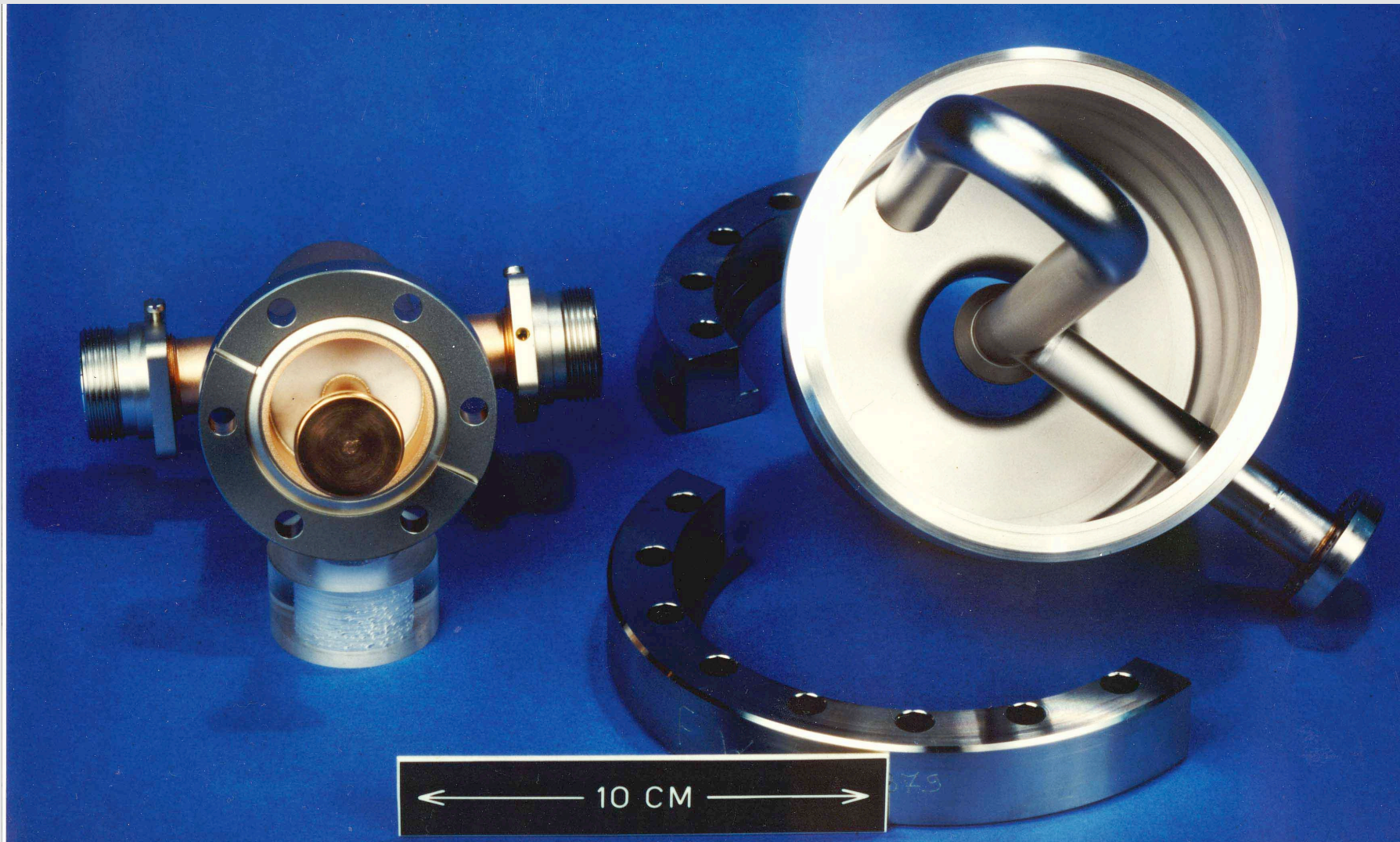
- Coupler is close to cavity: no heat creation -> superconducting
- Keep superconducting state: good cooling ->

He in/out, thermal conduction

heating not only by surface resist.: e-loading, MP, ..

- no (ceramic) RF window to LHe; demountable (?), ...

(*) as electrically well centered pure antenna coupler on cell equator: $E_{\text{main}}=0!$



Example: The hook-type HOM coupler (LEP2 at 352 MHz)

LEP2 'hook type'

Example of an
HOM coupler

rigid line
HOM power
outlet

ceramic
RF window

HOM coupler
'hat' (Nb)

Cavity port
on beam tube

**Notch filter
Capacitor
acc mode 'short'**

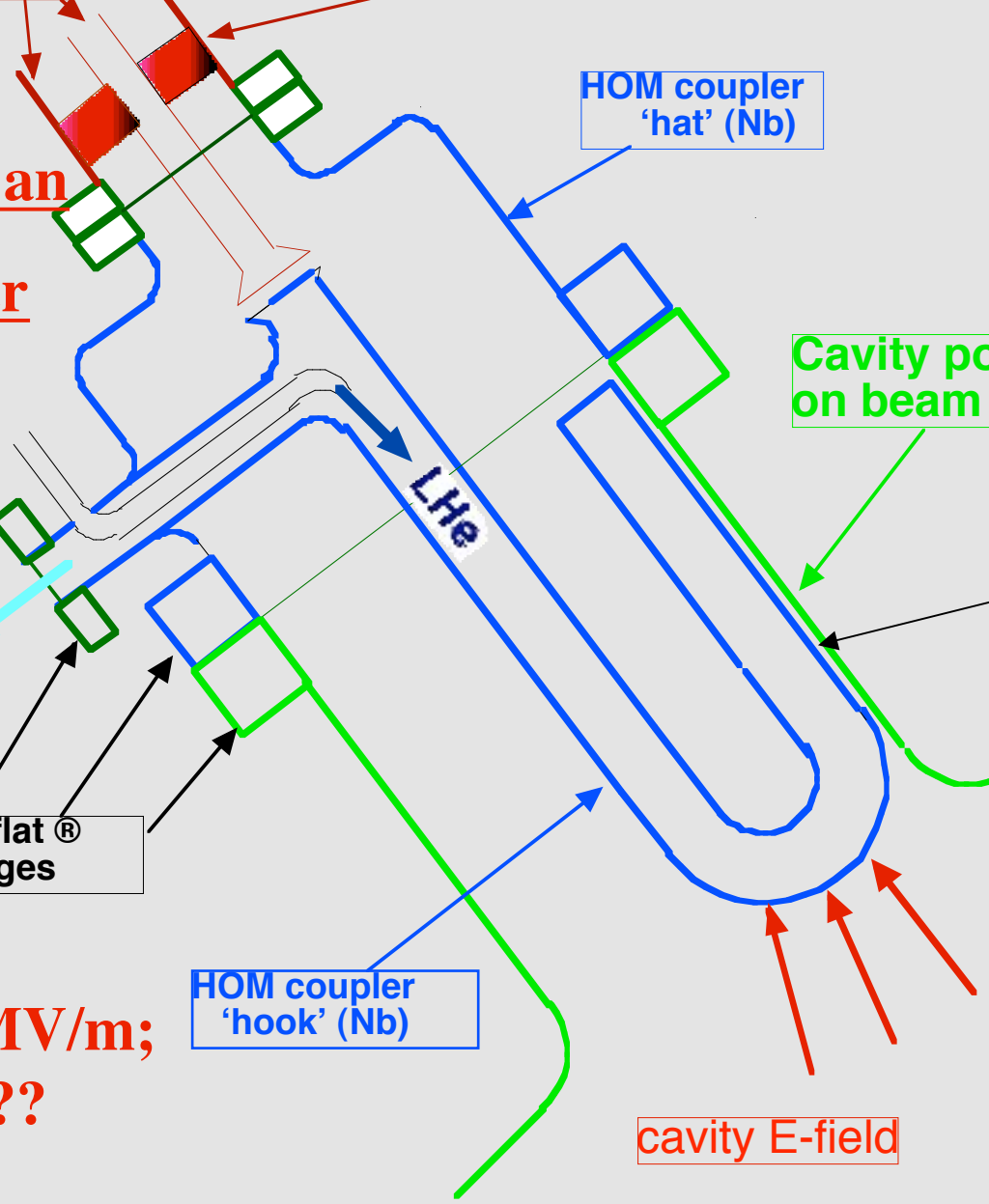
GHe

Conflat[®]
flanges

HOM coupler
'hook' (Nb)

cavity E-field

Used ≤ 8 MV/m;
above ??????



General Strategy for Coupler Design:

- To avoid HOM overvoltage on machine-line:

Cavity designer: should avoid coincidences as far as possible

(example: LHC nc 200 MHz capture cavities avoid 40MHz multiples of 25ns bunch distance.
Now 50ns / 75ns is discussed: machine lines all 20 / 16.7 MHz !!!! See Murphy's laws)

For 'unavoidable' modes: Q_{ext} low enough !! Mode-by-mode analysis for those few
(Secondary machine lines: beam micro structure, bunch-to-bunch intensity scatter)



- Coupler has only very few 'free' design parameters:

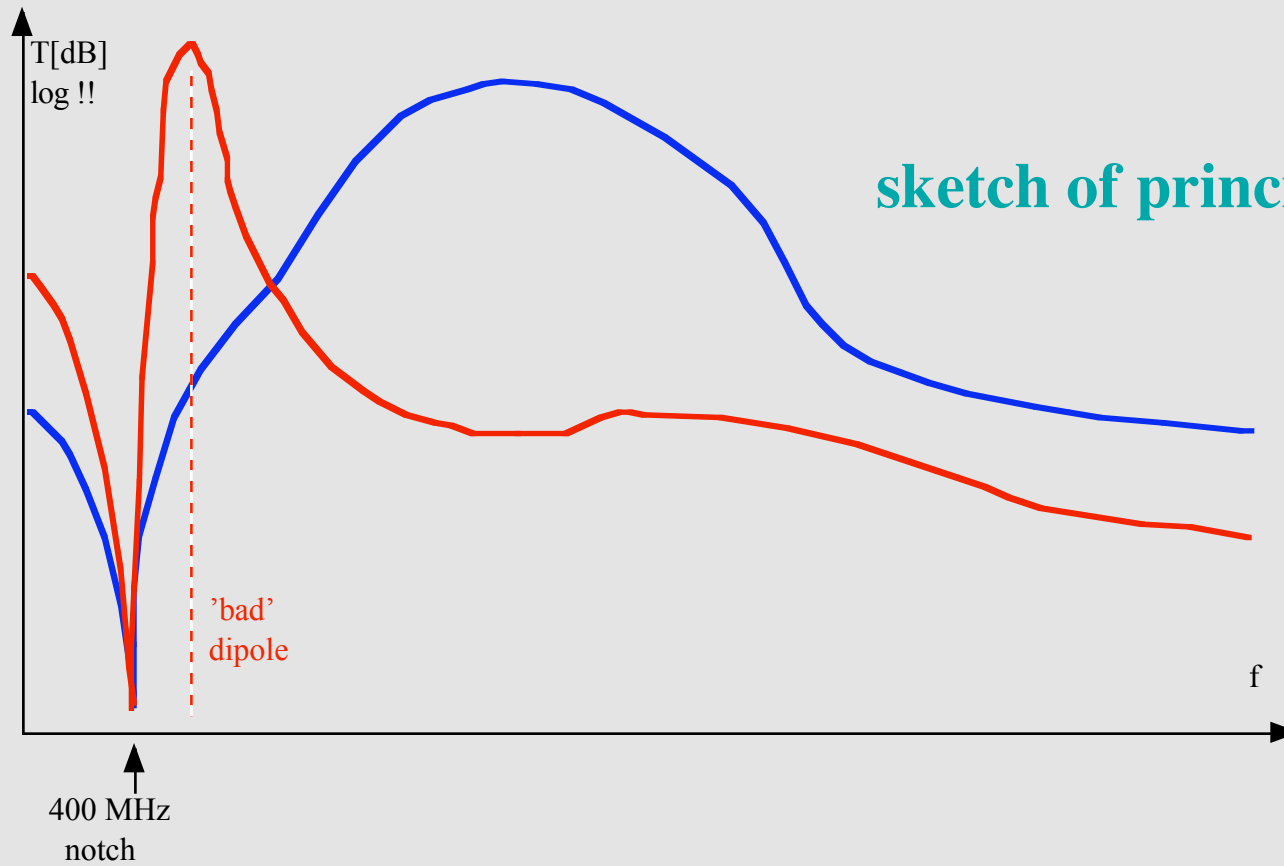
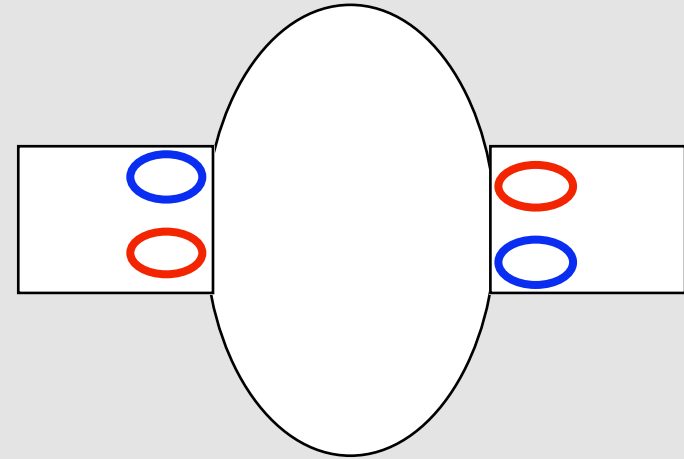
One cannot target mode by mode (with very few exceptions):

optimize smooth transfer-function for a 'global mode profile'

- If there is a 'bad' problem mode: additional 'resonant' coupler
(as done for LHC with a dipole mode close to notch —>)

LHC 400 MHz single cell coupling scheme

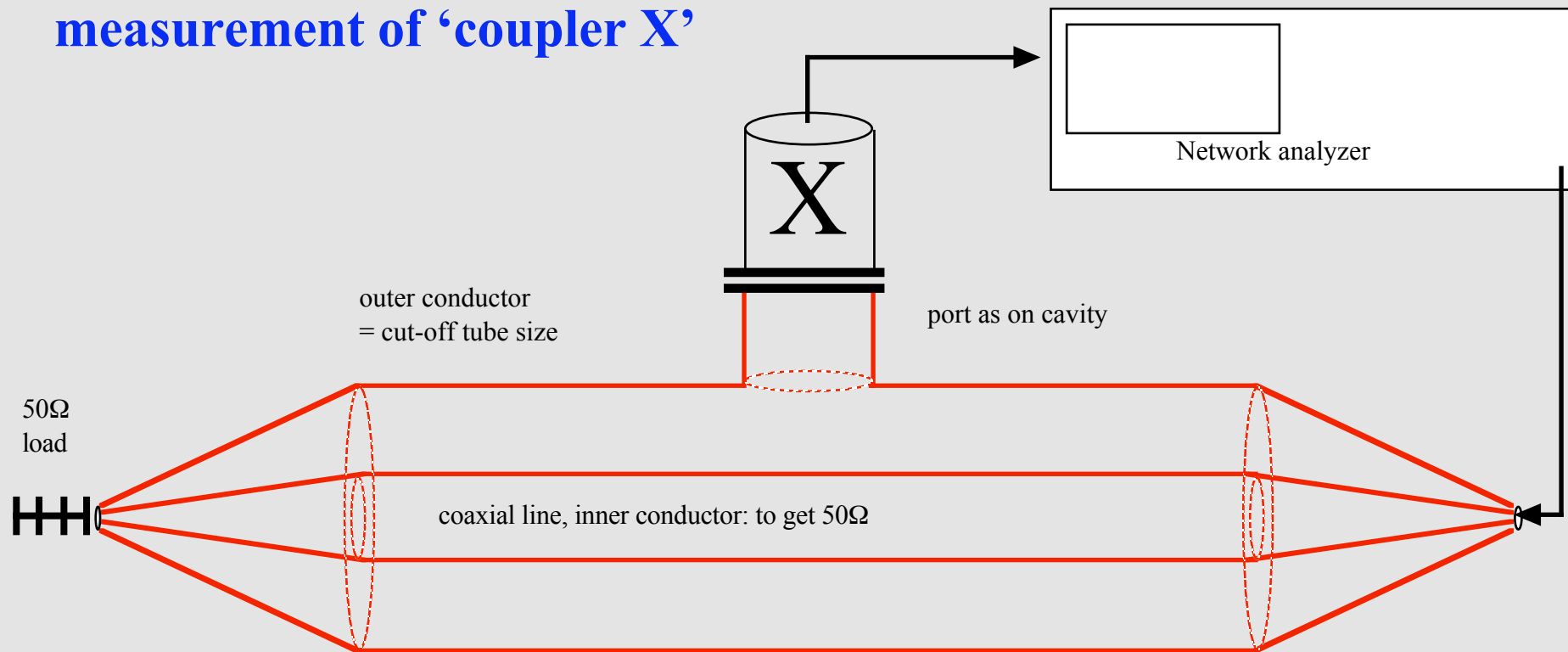
-  **Broadband** coupler for 'all' modes
-  **Resonant** coupler for single 'bad' dipole (close to notch)



Transfer function measurement without being bothered by modes:
smooth sweep (a factor 2 doesn't matter !!?)

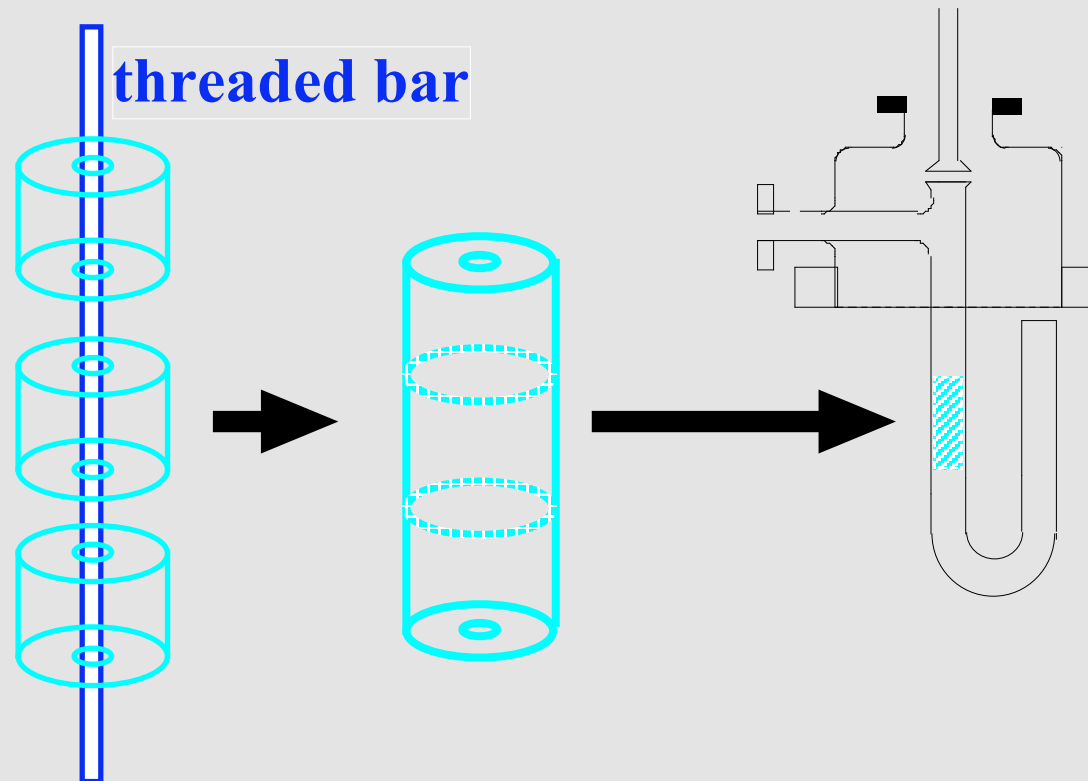
**Setup for smooth transfer function
measurement of 'coupler X'**

© E. Haebel



Field configuration is not exactly as the one of the considered mode but E-field coupling dominates : OK on coaxial line

Ernst Haebel's HOM Coupler 'LEGO set' for cut and try



Today can be done by EM calculation tools
BUT: 'only' another **tool**, it has to be applied:

'need a smart pilot': what to modify to obtain
(keep cryo/mechanic/vacuum constraints in mind !!!!!!!)

Nevertheless, once an RF wise acceptable coupler exists on computer-file (and also cryo/mechanic/vacuum 'seems' OK):

- A full size coupler in Nb (Nb/Cu) has to be tested on a Nb cavity (as foreseen) at cryogenic temperatures and above design field level
- Such tests have to be repeated for a set of couplers and different cavity conditions:
MP, e-loading, cryo-regulation oscill., ...