Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Justice and Police FDJP

Federal Office of Metrology METAS

Pin diameter specifications and challenges

European Metrology workshop (Sweden)

Juerg Ruefenacht

13.-15. April 2009

Pin diameter aspects in metrological practice

- **Air line calibration services provided at METAS**
- **Dimensional connector interface measurements**
- **IEEE Standard P287: 2.92 mm specifications**
- **Pin diameter effects in electrical quantities**

Air line calibration services provided at METAS

- **Outer Conductor diameter profile** (OC)
- **Centre Conductor diameter profile** (CC)
- **Calculation of the electrical quantities**
- **OC length measurements** (direct or compressed)
- **Pin-depth measurements** (direct or compressed)
- **Pin diameter and slotted section measurements**
- **In the future: connector modelling** (CoMo70)

Example: OC cross section f(longitudinal position)

Table 2: Measurement of the outer conductor diameter at 10 different angular positions

Position (mm)	0 deg ∅ (mm)	18 deg ∅ (mm)	36 deg ∅ (mm)	54 deg ∅ (mm)	72 deg ∅ (mm)	90 deg ∅ (mm)	108 deg ∅ (mm)	126 deg ∅ (mm)	144 deg ∅ (mm)	162 deg ∅ (mm)	Mean diameter (mm)
0	2.9252	2.9254	2.9255	2.9260	2.9258	2.9254	2.9251	2.9250	2.9250	2.9253	2.9254
145	2.9234	2.9234	2.9233	2.9232	2.9234	2.9235	2.9235	2.9235	2.9235	2.9235	2.9234
146	2.9228	2.9230	2.9225	2.9230	2.9230	2.9229	2.9229	2.9228	2.9230	2.9229	2.9229
147	2.9224	2.9226	2.9224	2.9227	2.9228	2.9227	2.9226	2.9226	2.9227	2.9226	2.9226
148	2.9225	2.9227	2.9229	2.9229	2.9228	2.9227	2.9227	2.9225	2.9226	2.9226	2.9227
149	2.9225	2.9227	2.9229	2.9229	2.9228	2.9227	2.9227	2.9225	2.9226	2.9226	2.9227
150	2.9225	2.9227	2.9229	2.9229	2.9228	2.9227	2.9227	2.9225	2.9226	2.9226	2.9227

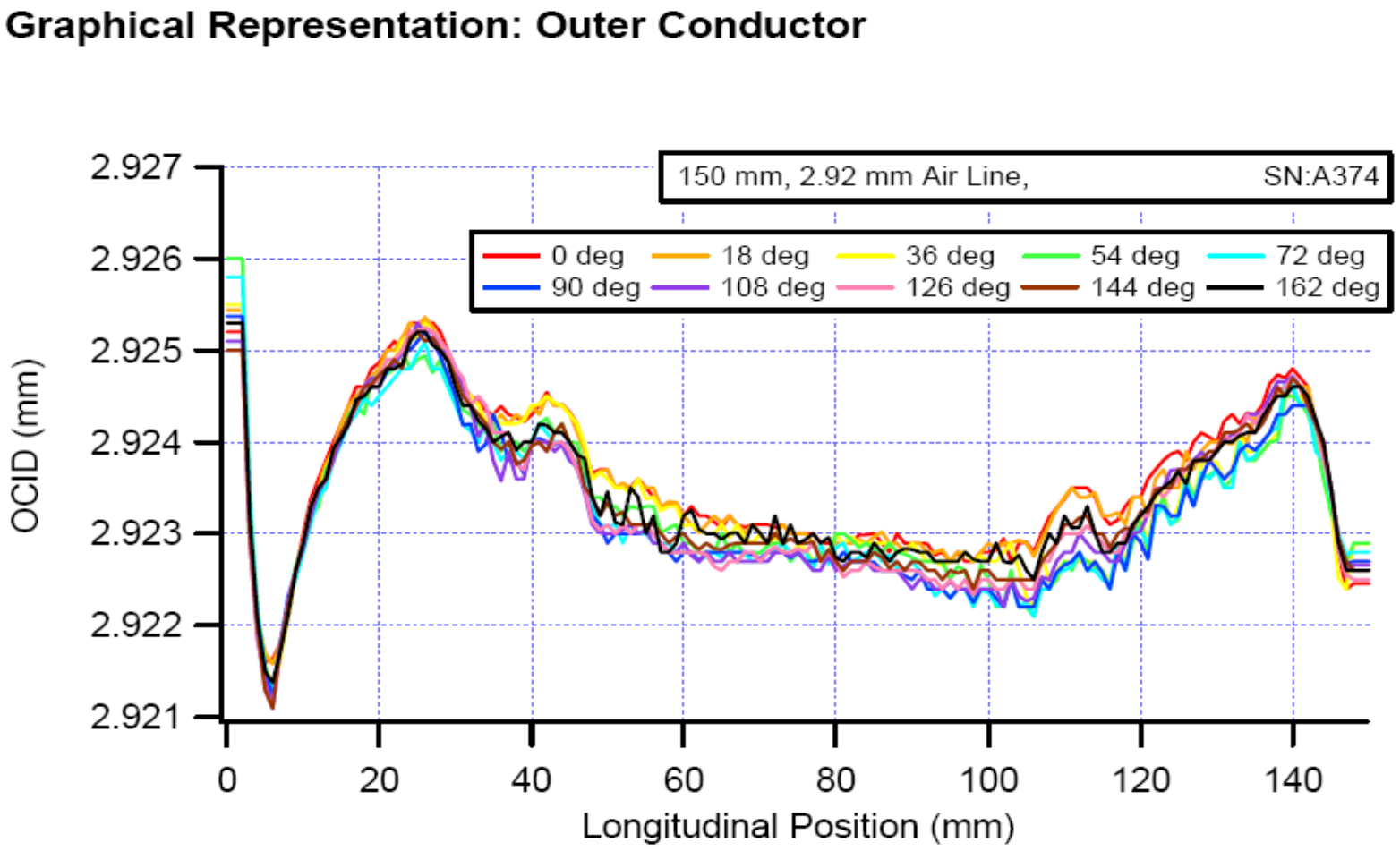
"Outer conductor inner diameter" (OCID), measured with 0.0015 mm uncertainty:

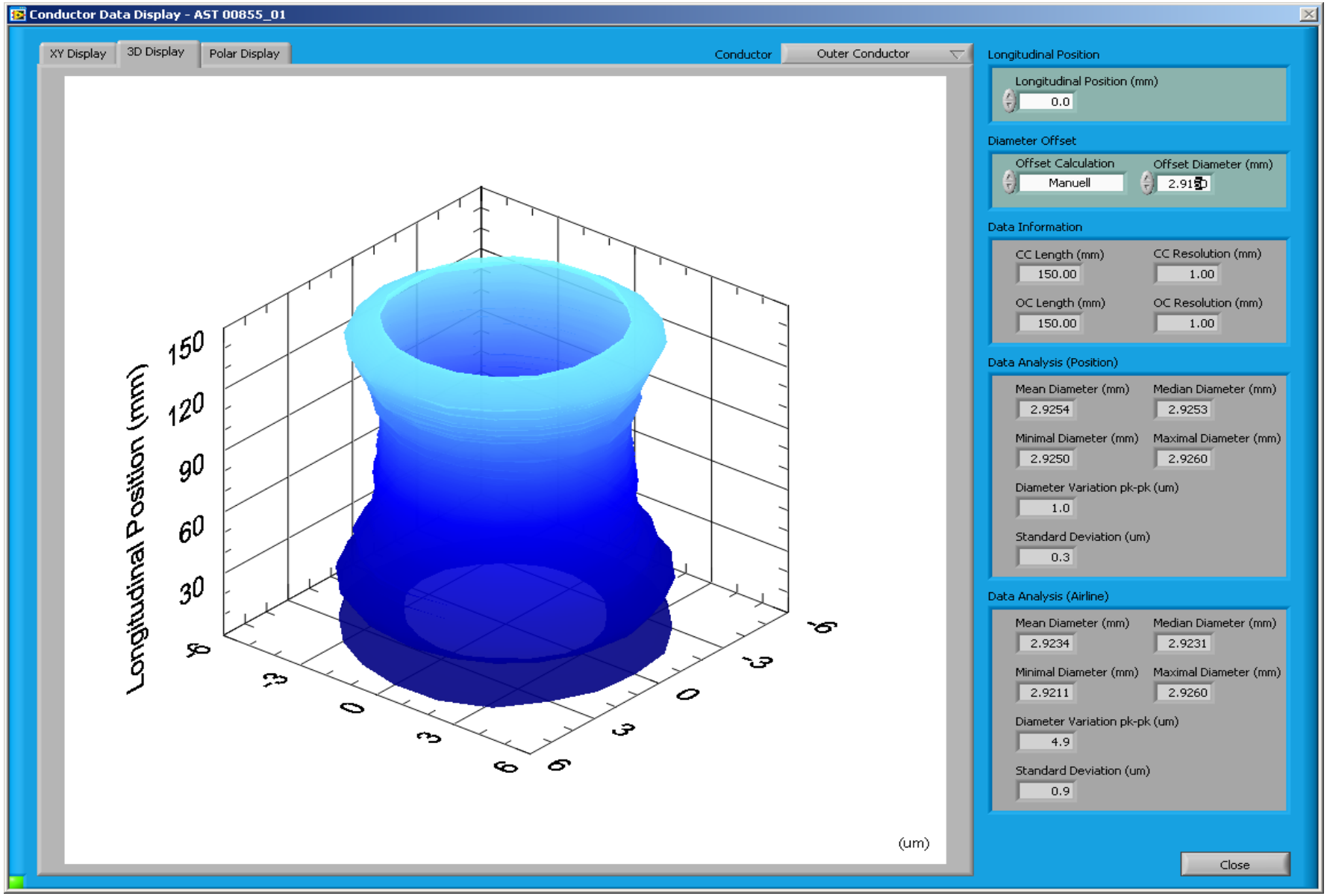
Minimum mean diameter = 2.9213 mm

Average diameter = 2.9234 mm (Arithmetic mean of all mean diameters)

Maximum mean diameter = 2.9254 mm

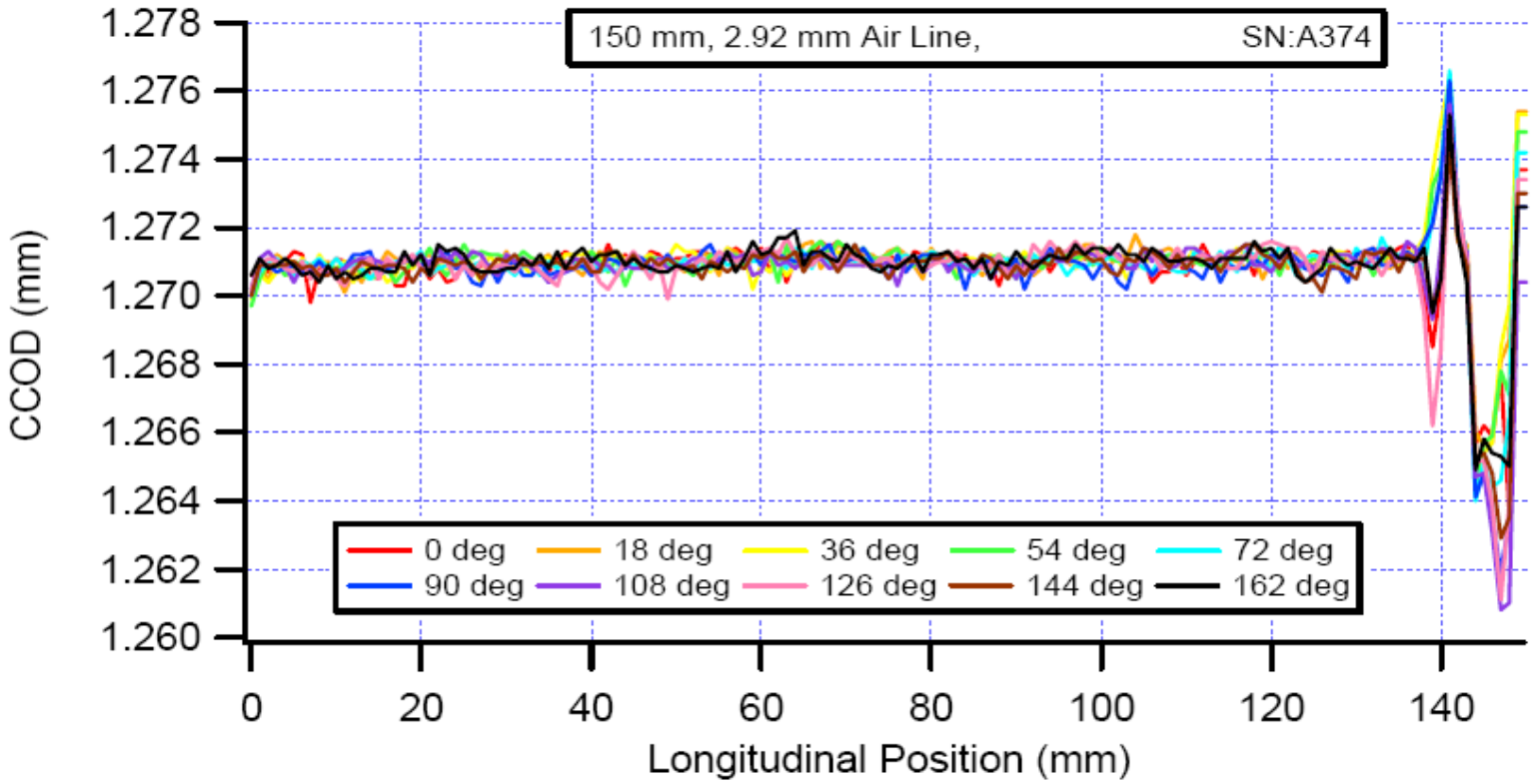
Example: OC cross section f(longitudinal position)




Conductor Data Display - AST 00855_01
XY Display
3D Display
Polar Display
Conductor
Outer Conductor
Longitudinal Position (mm)
150
120
90
60
30
0
(um)
Longitudinal Position
Longitudinal Position (mm)
0.0
Diameter Offset
Offset Calculation
Manuell
Offset Diameter (mm)
Data Information
CC Length (mm)
150.00
CC Resolution (mm)
1.00
OC Length (mm)
150.00
OC Resolution (mm)
1.00
Data Analysis (Position)
Mean Diameter (mm)
2.9254
Median Diameter (mm)
2.9253
Minimal Diameter (mm)
2.9250
Maximal Diameter (mm)
2.9260
Diameter Variation pk-pk (um)
1.0
Standard Deviation (um)
0.3
Data Analysis (Airline)
Mean Diameter (mm)
2.9234
Median Diameter (mm)
2.9231
Minimal Diameter (mm)
2.9211
Maximal Diameter (mm)
2.9260
Diameter Variation pk-pk (um)
4.9
Standard Deviation (um)
0.9
Close

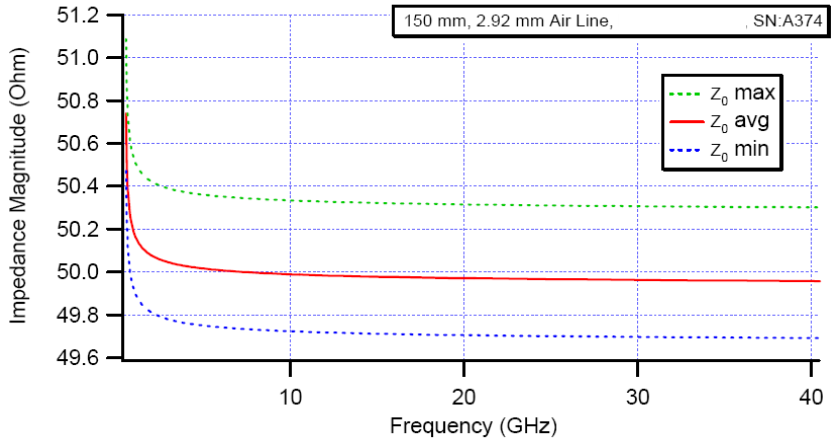
Example: CC cross section f(longitudinal position)

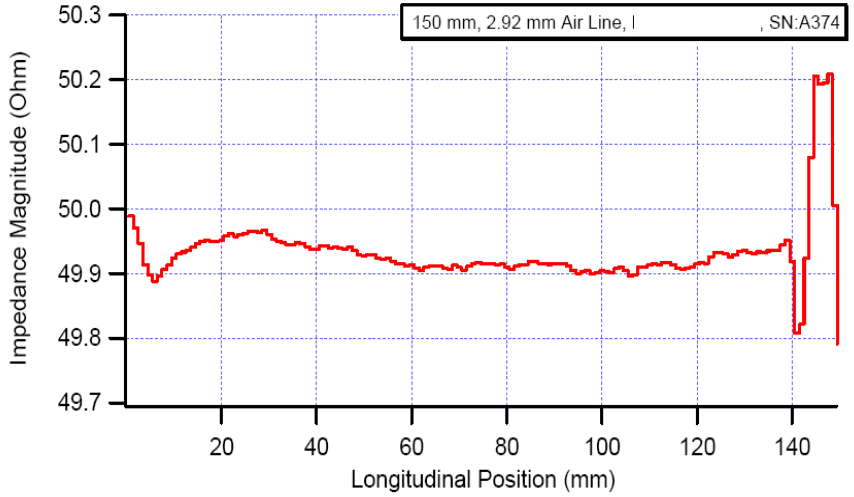
Graphical Representation: Center Conductor



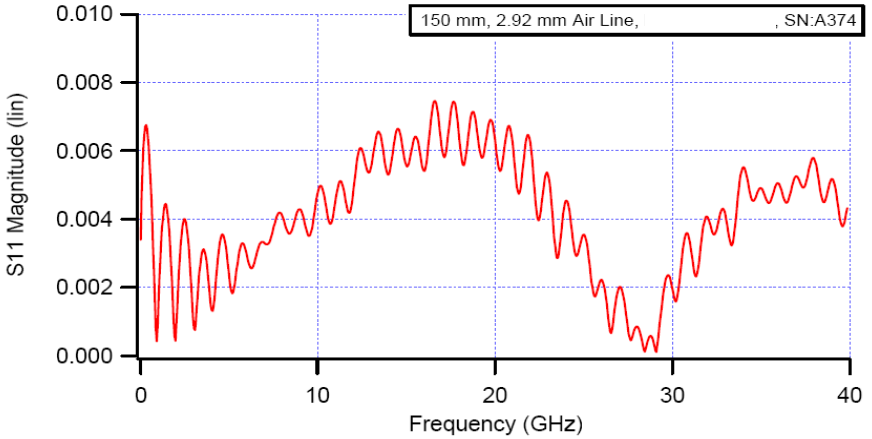
Example: derived electrical quantities

Graphical Representation: Impedance

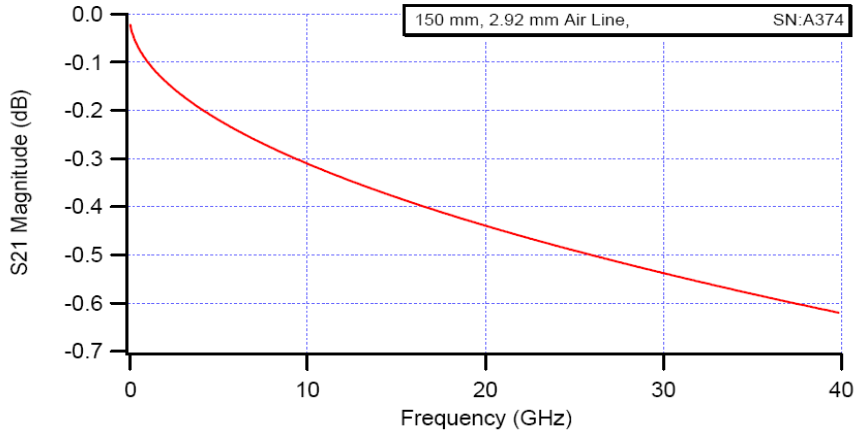


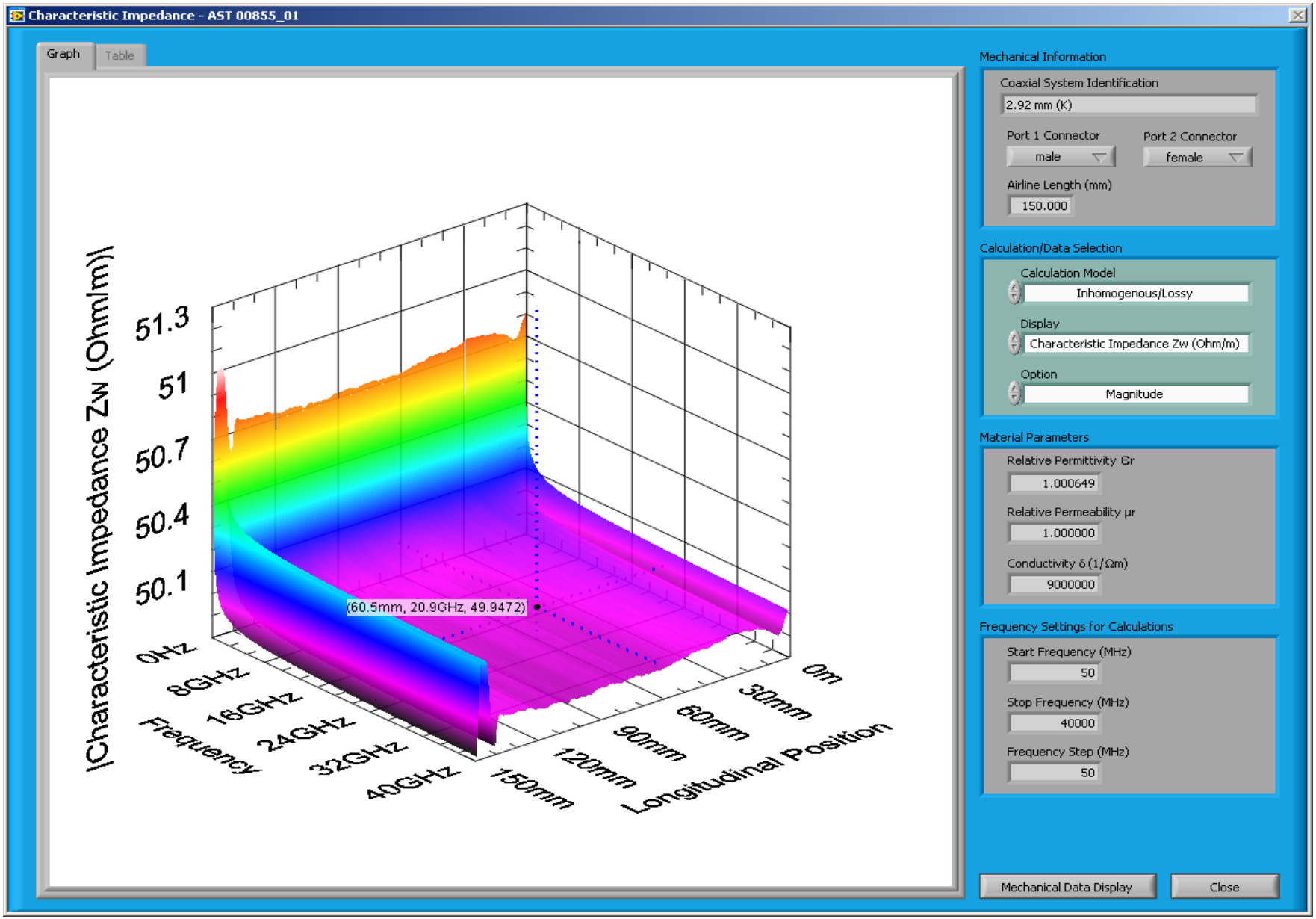


Graphical Representation: Scattering Parameter

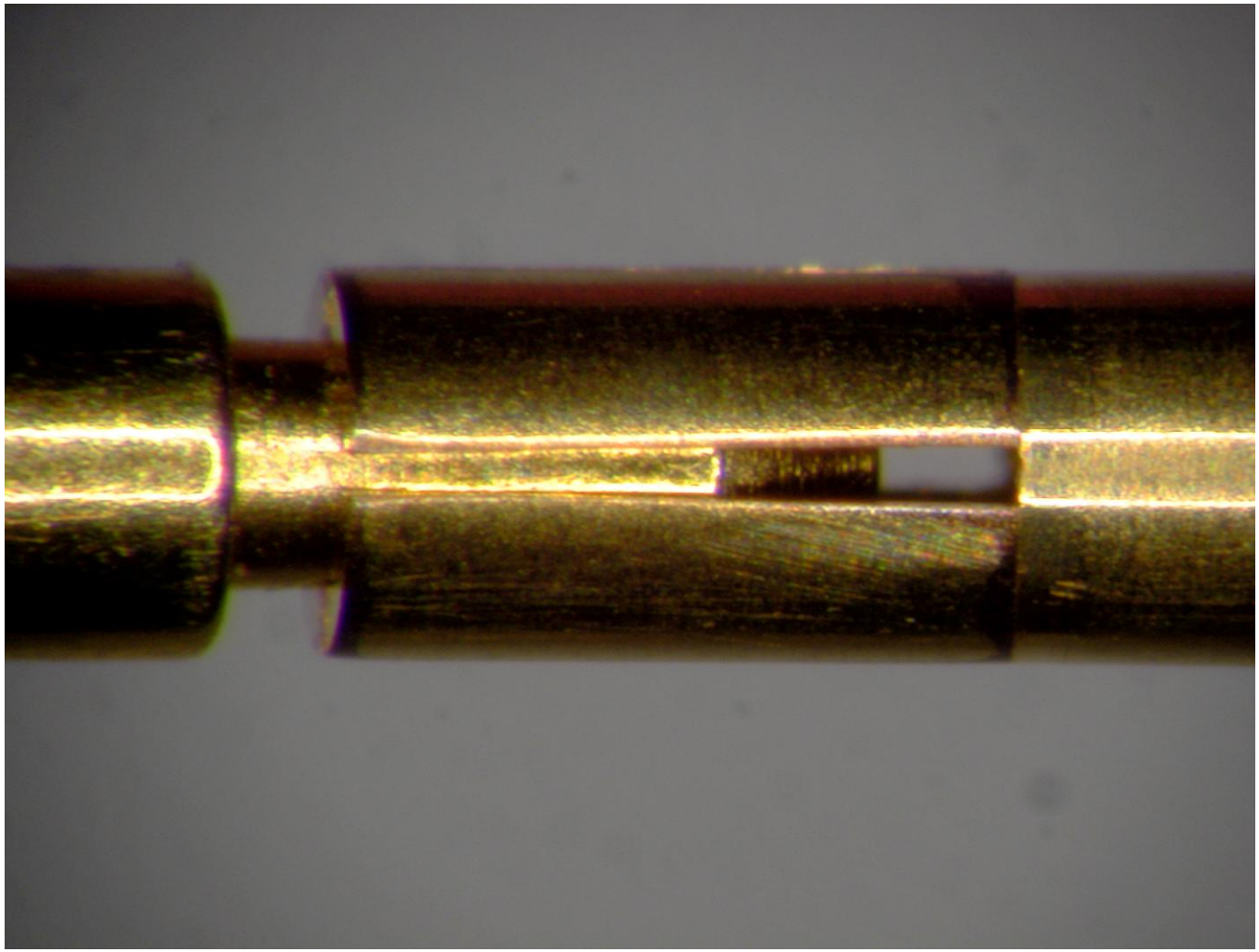


inhomogeneous and lossy case

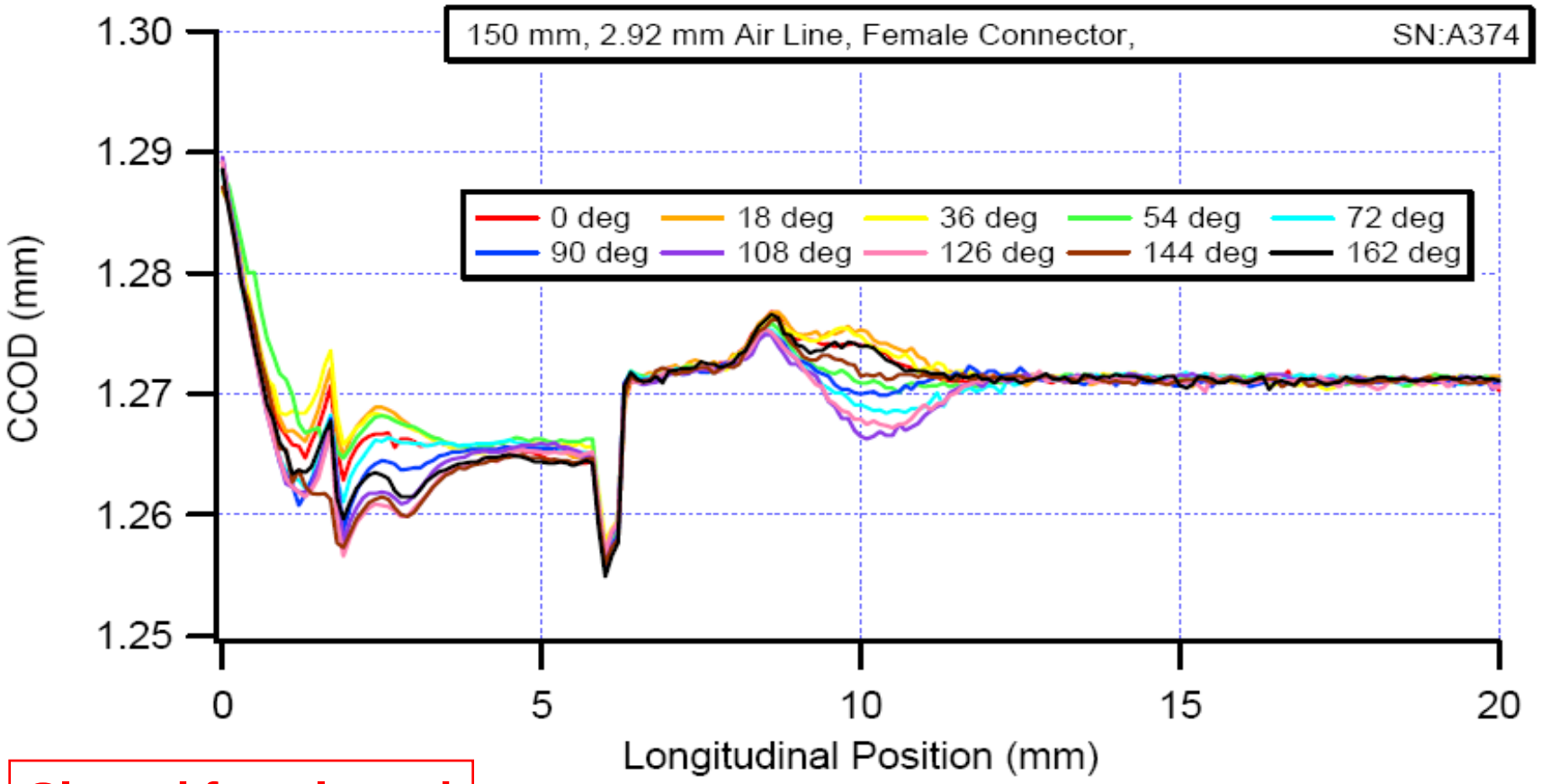



Characteristic Impedance - AST 00855_01
Graph
Table
|Characteristic Impedance Zw (Ohm/m)|
51.3
51
50.7
50.4
50.1
(60.5mm, 20.9GHz, 49.9472)
0Hz
8GHz
16GHz
24GHz
32GHz
40GHz
Frequency
150mm
120mm
90mm
60mm
30mm
0m
Longitudinal Position
Mechanical Information
Coaxial System Identification
2.92 mm (K)
Port 1 Connector
male
Port 2 Connector
female
Airline Length (mm)
150.000
Calculation/Data Selection
Calculation Model
Inhomogenous/Lossy
Display
Characteristic Impedance Zw (Ohm/m)
Option
Magnitude
Material Parameters
Relative Permittivity εr
1.000649
Relative Permeability μr
1.000000
Conductivity δ (1/Ωm)
9000000
Frequency Settings for Calculations
Start Frequency (MHz)
50
Stop Frequency (MHz)
40000
Frequency Step (MHz)
50
Mechanical Data Display
Close

Example: connector cross section

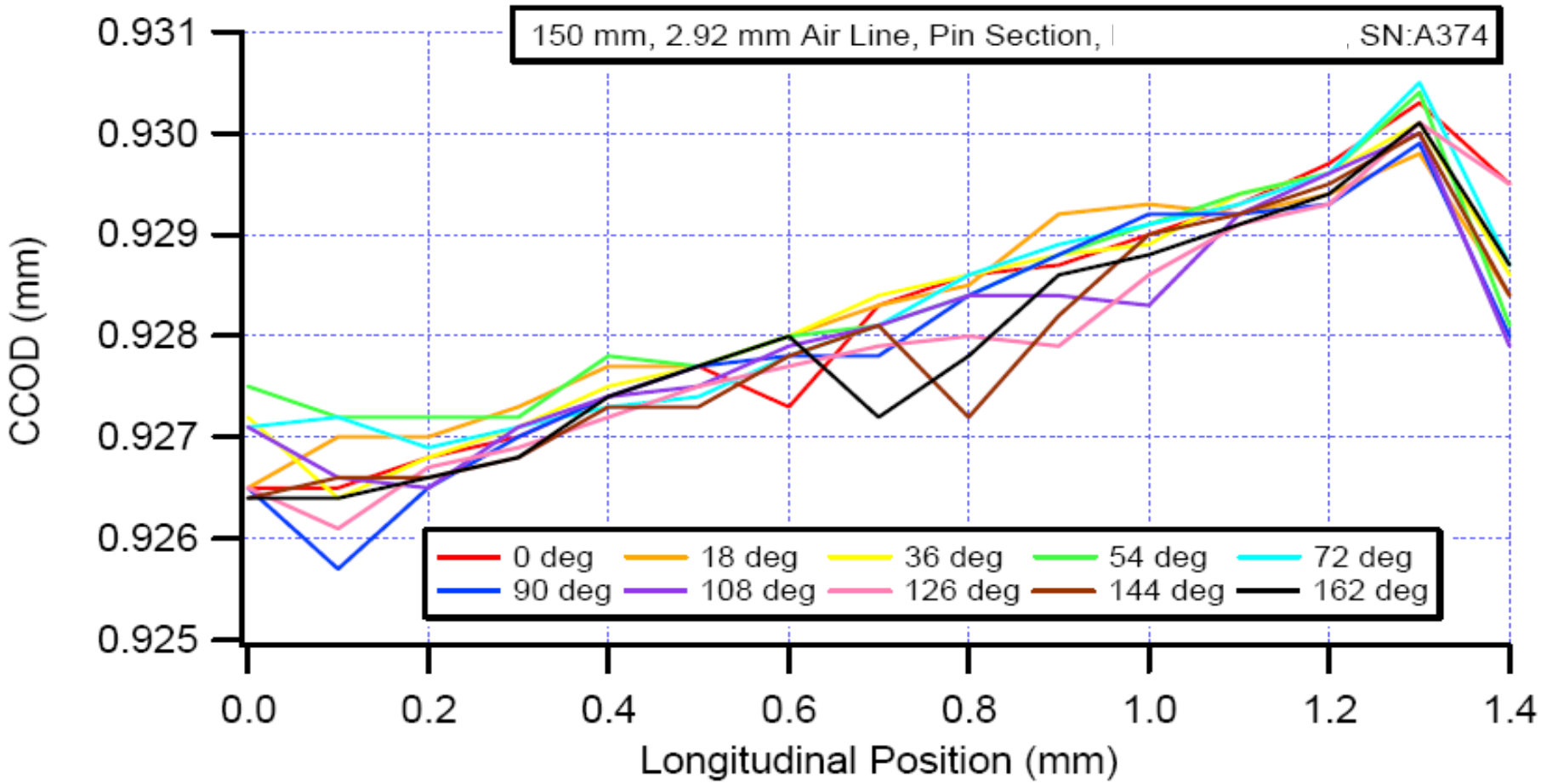


Graphical Representation: Center Conductor Female Connector Cross Section

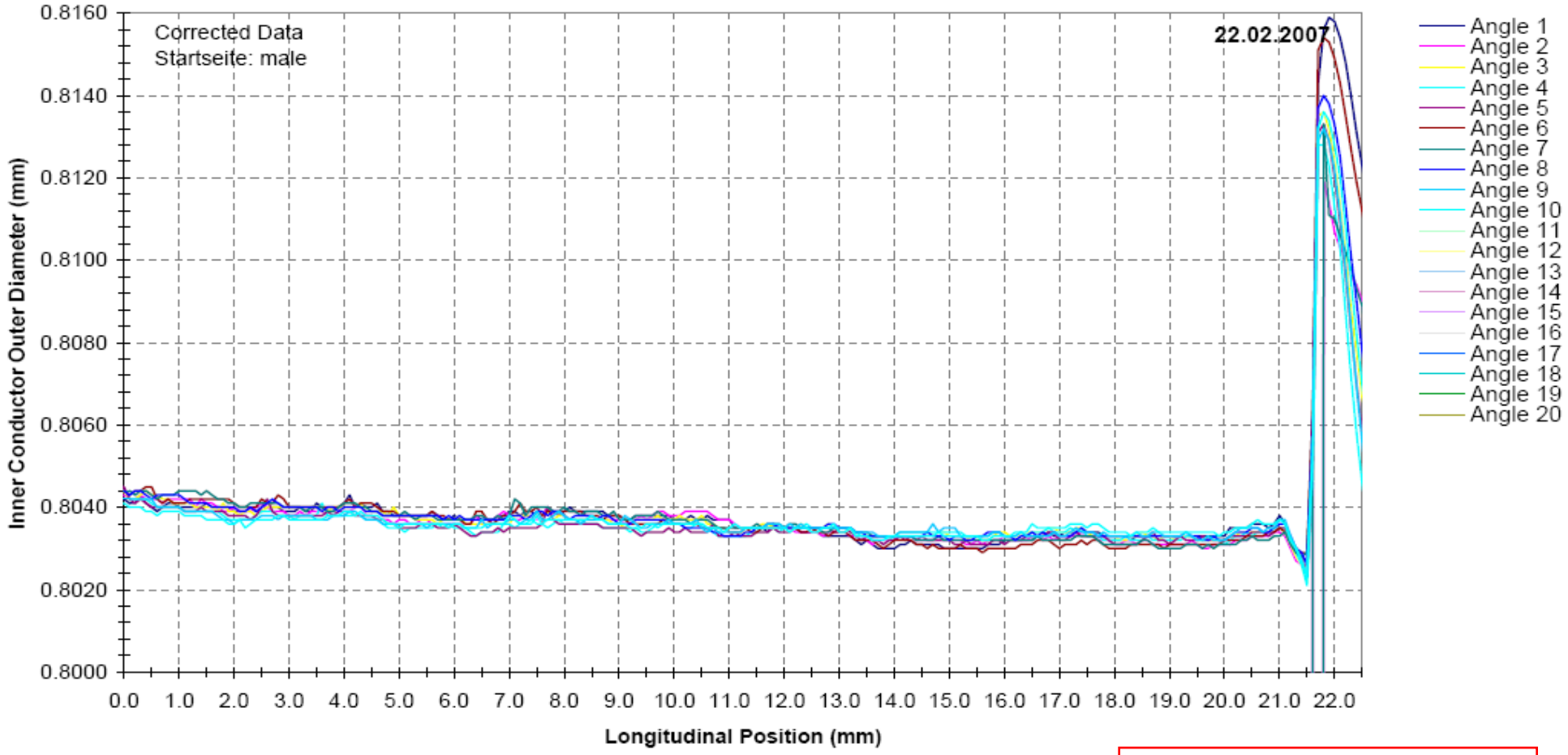


Slotted female end

Graphical Representation: Center Conductor Male Pin Cross Section

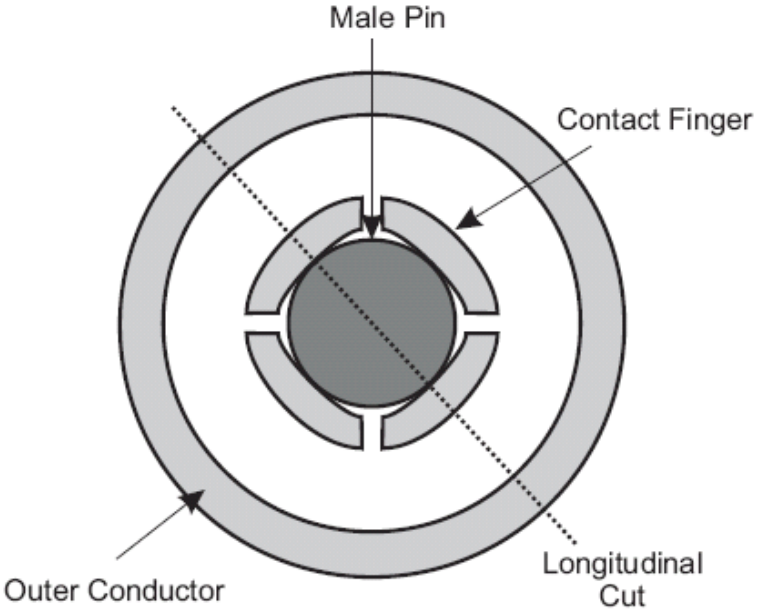


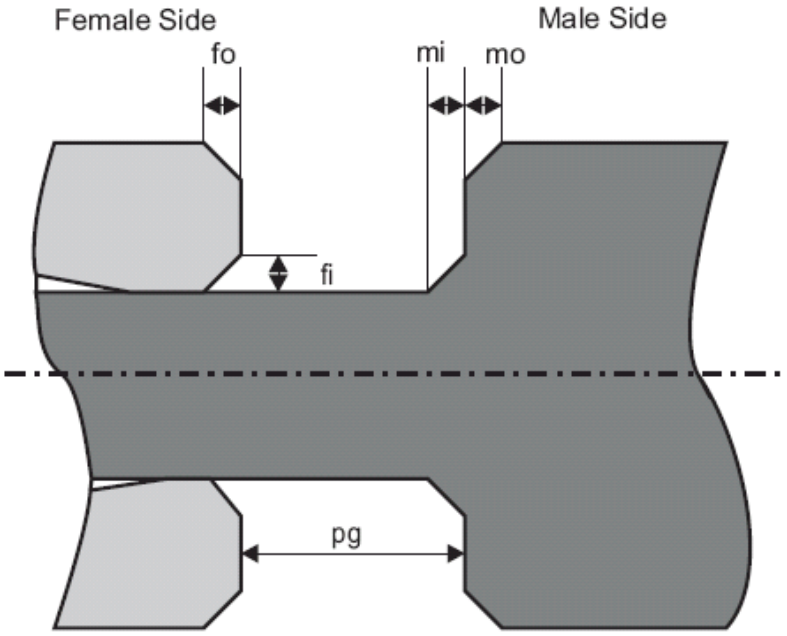
Example: 1.85 mm CC with connector cross section

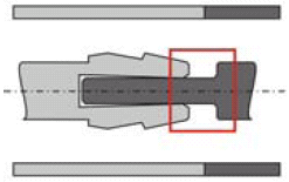


Slotted female end

Future calibration services: connector characterisation and modelling







Johannes Hoffmann, ETHZ, CoMo70 project (Paper published at the EuMW 2007)

Customer request

Calibration of a 2.92 mm(female) cross section when mated with a nominal male pin having a diameter of 0.914 mm
(according the new IEEE Standard P287-2007)

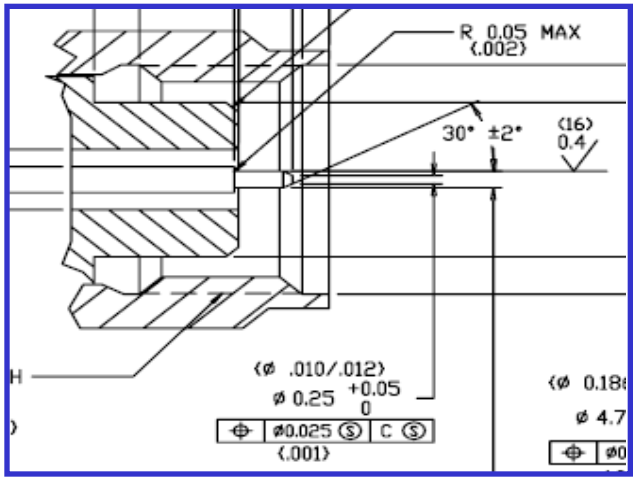
Problem: the reference 2.92 mm (female) pins used at METAS have a nominal diameter of 0.927 mm +/-0.001 mm
(same reference pin used as for the 3.5 mm system)

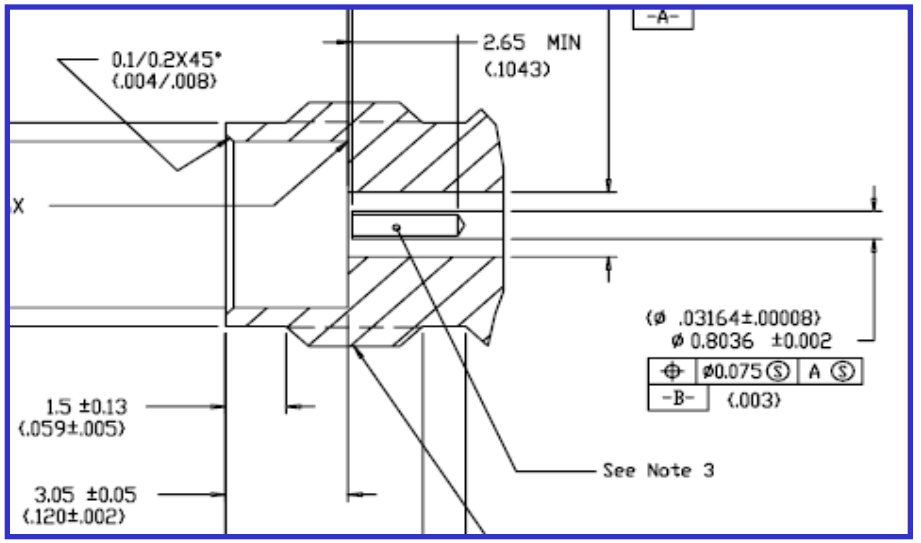
Resulting pin diameter difference = -0.013 mm

IEEE Standard for Precision Coaxial Connectors (DC to 110 GHz)

IEEE Std 287™-2007
(Revision of
IEEE Std 287-1968)

Detail specifications for the precision coaxial 1.85 mm connector (LPC)



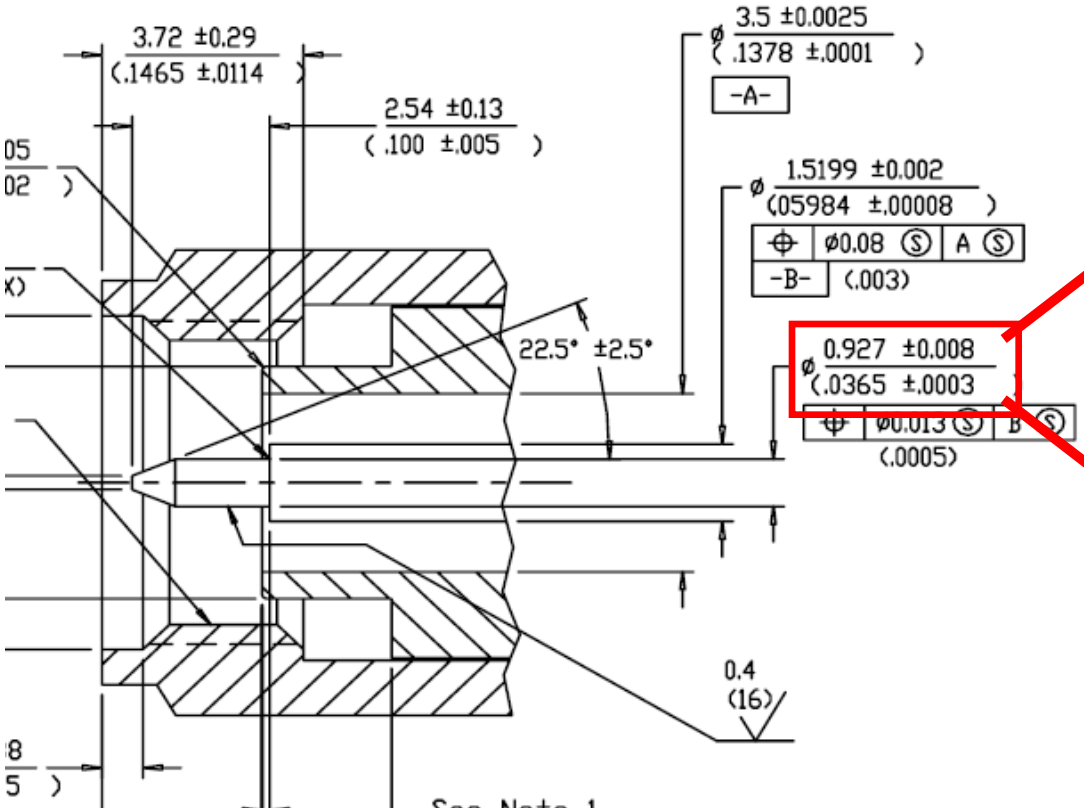


Critical mechanical specifications are missing!

IEEE Standard for Precision Coaxial Connectors (DC to 110 GHz)

IEEE Std 287™-2007
(Revision of
IEEE Std 287-1968)

Detail specifications for the precision coaxial 3.5 mm male connector (LPC)



Ø 0.927 mm +/- 0.008 mm

Ø 0.919 mm - Ø 0.935 mm

Conversion factor: 25.4

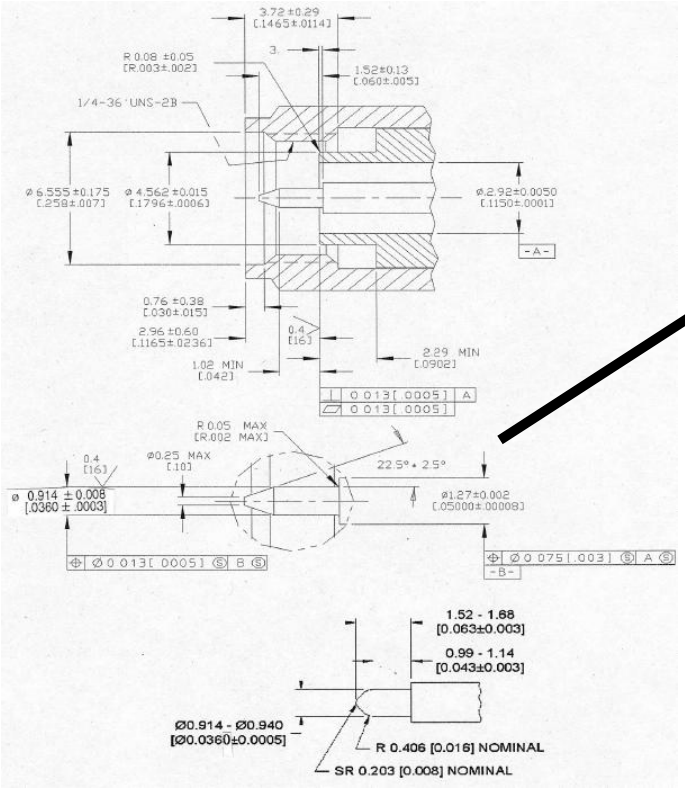
Ø 0.0365 in +/- 0.0003 in

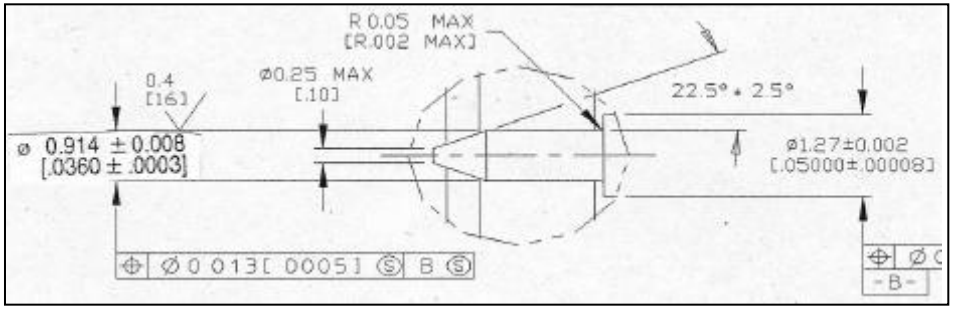
Ø 0.0362 in - Ø 0.0368 in

IEEE Standard for Precision Coaxial Connectors (DC to 110 GHz)

IEEE Std 287™-2007
(Revision of
IEEE Std 287-1968)

Detail specifications for the precision coaxial 2.92 mm male connector (LPC)





→ **Ø 0.914 mm +/- 0.008 mm**

Ø 0.906 mm - Ø 0.922 mm

Conversion factor: 25.4

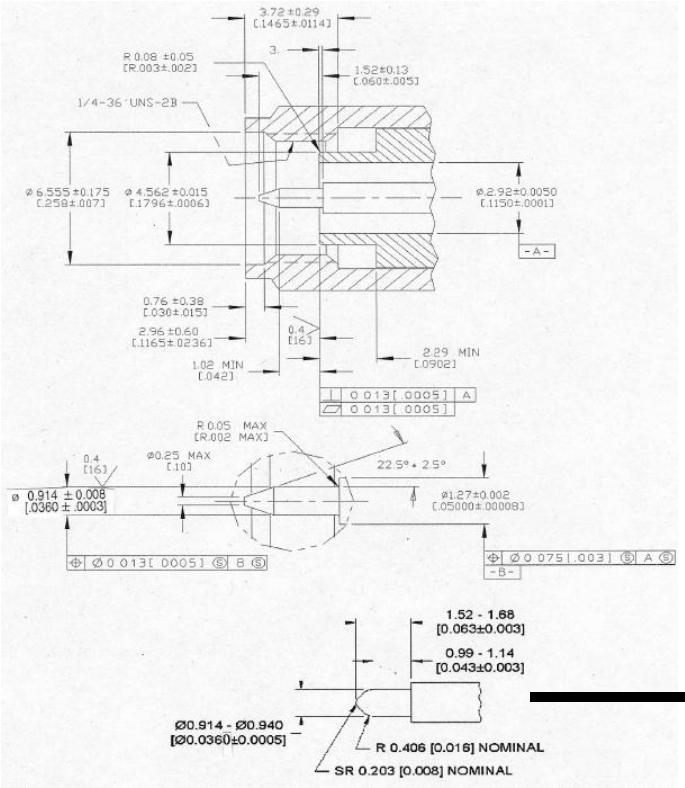
→ **Ø 0.0360 in +/- 0.0003 in**

Ø 0.0359 in - Ø 0.0363 in

IEEE Standard for Precision Coaxial Connectors (DC to 110 GHz)

IEEE Std 287™-2007
(Revision of
IEEE Std 287-1968)

Detail specifications for the precision coaxial 2.92 mm male connector (LPC)



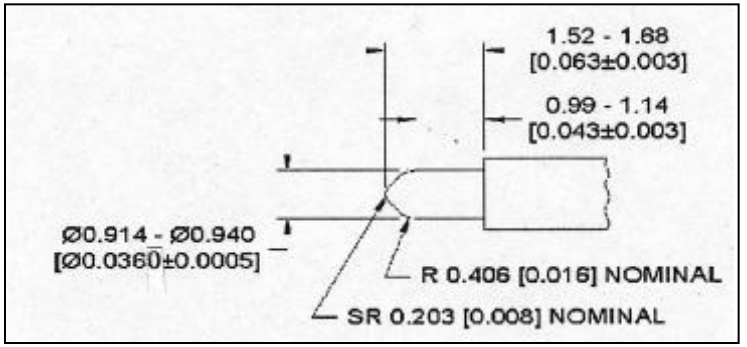
Ø 0.927 mm +/- 0.013 mm

→ **Ø 0.914 mm - Ø 0.940 mm**

Conversion factor: 25.75

→ **Ø 0.0360 in +/- 0.0005 in**

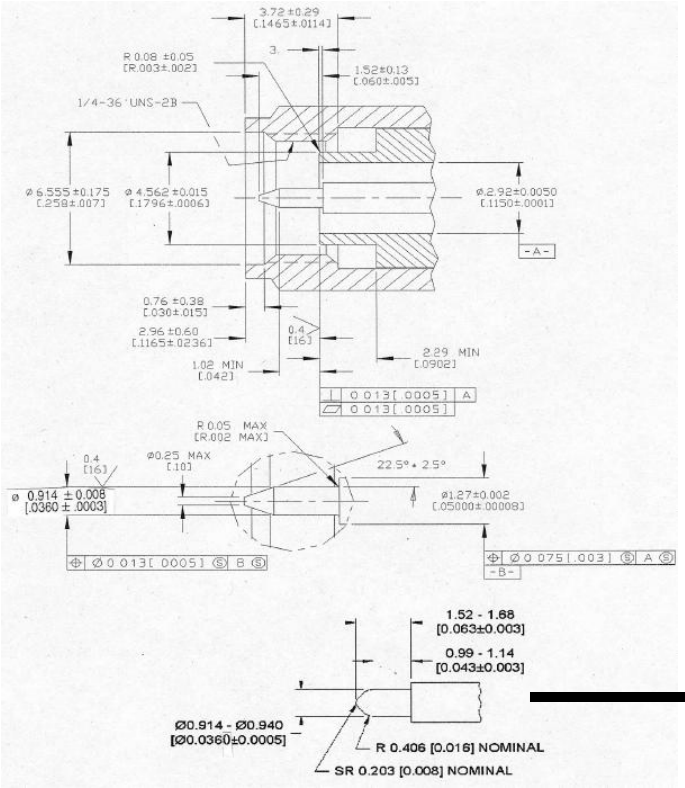
Ø 0.0355 in - Ø 0.0365 in



IEEE Standard for Precision Coaxial Connectors (DC to 110 GHz)

IEEE Std 287™-2007
(Revision of
IEEE Std 287-1968)

Detail specifications for the precision coaxial 2.92 mm male connector (LPC)



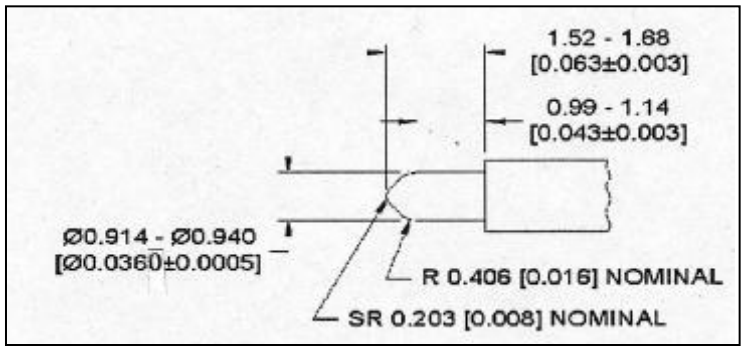
Ø 0.927 mm +/- 0.013 mm

→ **Ø 0.914 mm - Ø 0.940 mm**

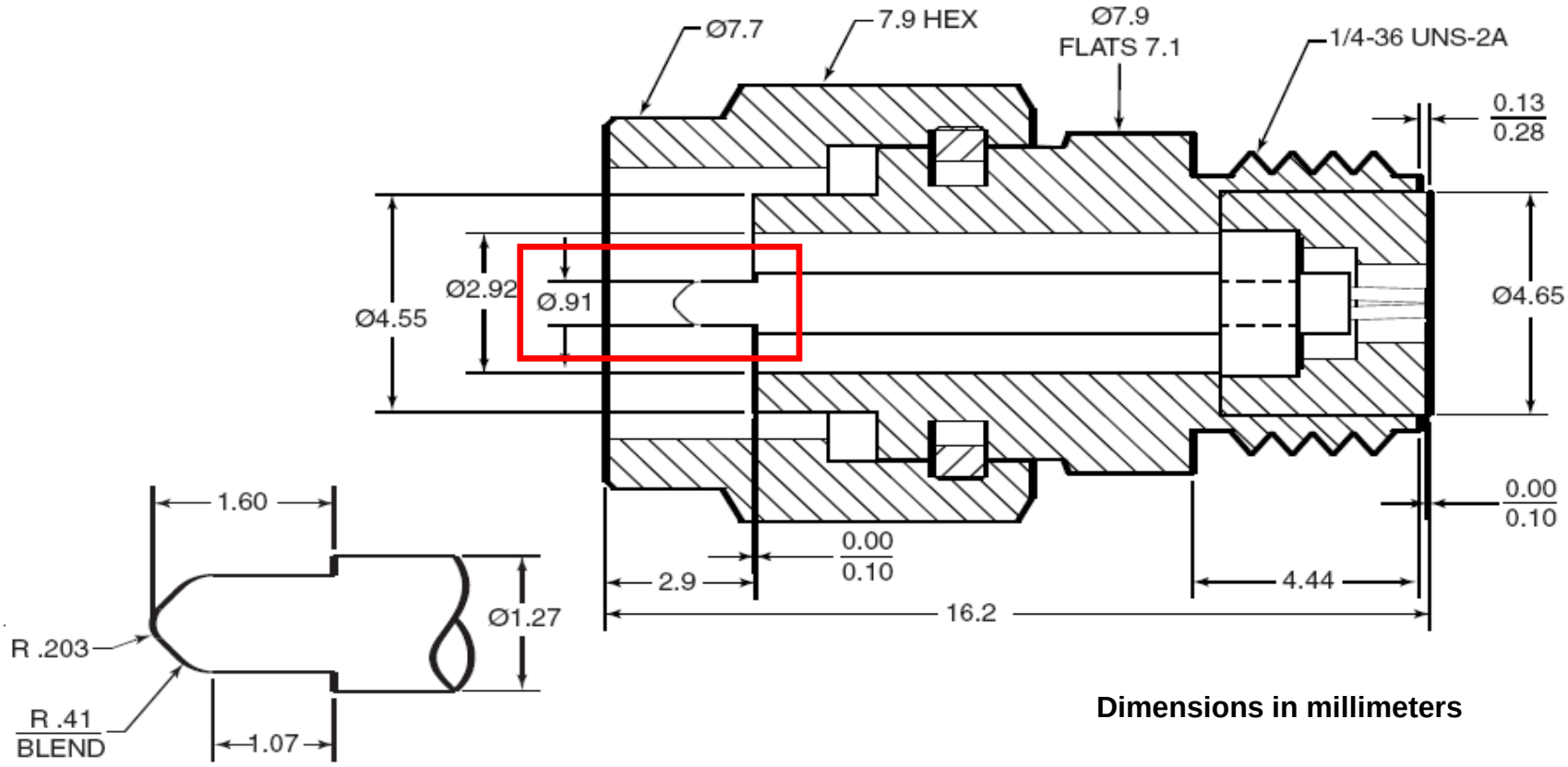
Mean comply with 3.5 mm pin spec !

→ **Ø 0.0360 in +/- 0.0005 in**

Comply with other 2.92 mm pin spec



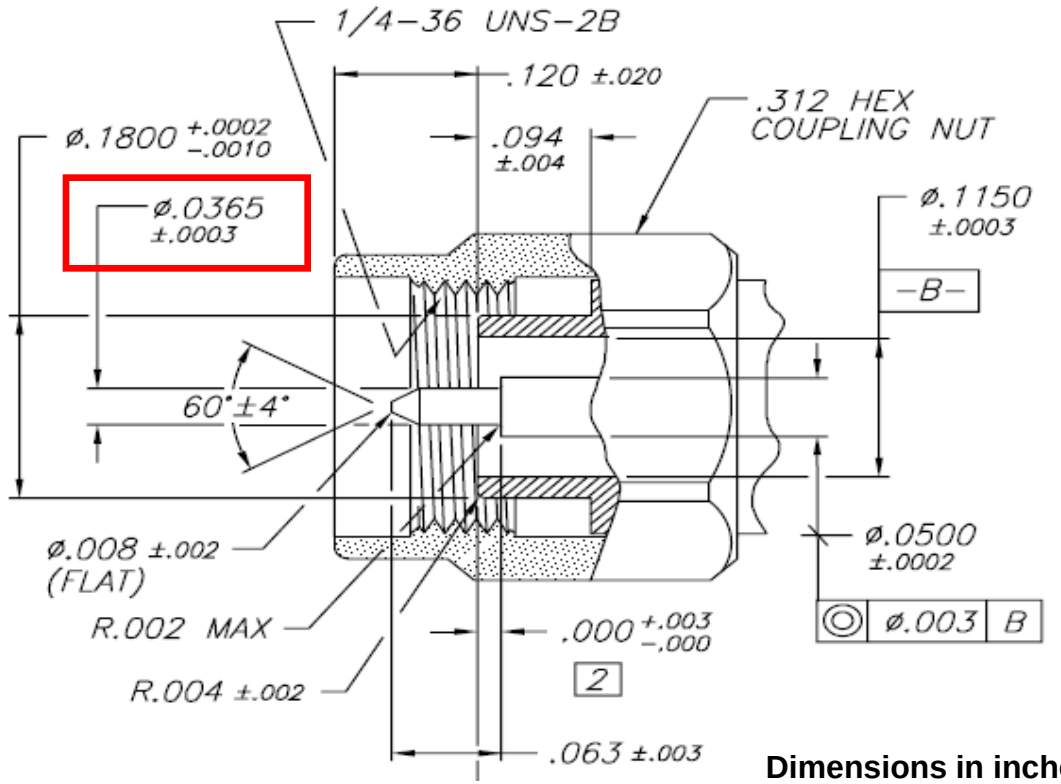
Anritsu: Precision RF & Microwave Components product catalog (2.92 mm or K connector specifications)



Dimensions in millimeters

3.5 mm$_{IEEE}$ – 2.92 mm$_{Anritsu}$ pin diameter difference = - 0.017 mm

Maury: Precision 2.92 mm (K) specifications (drawing 5E-063)



Dimensions in inches

Ø 0.927 mm +/- 0.008 mm

Same nominal pin diameter specification used from:

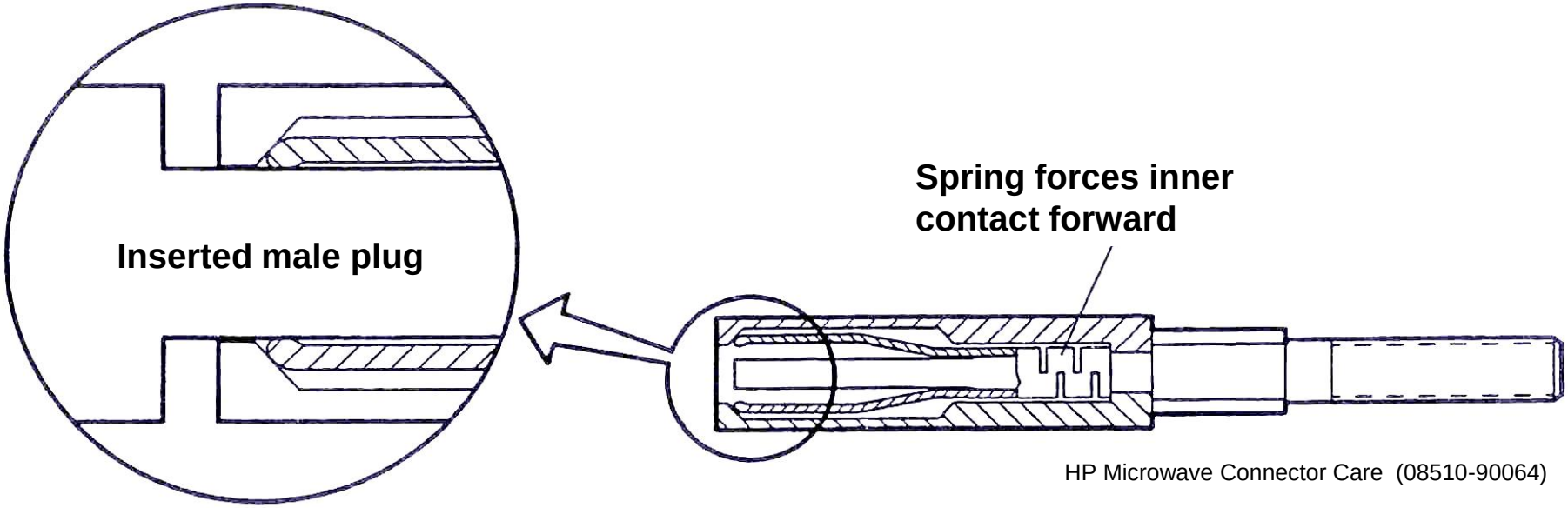
- **Rosenberger**
- **Rohde&Schwarz**
- **Agilent**
- **Huber+Suhner**
- **…**

3.5 mm$_{IEEE}$ – 2.92 mm$_{Maury}$ pin diameter difference = - 0.000 mm

Pin effects and traceability issues

- Slotted versus slotless connectors
- Spreading of the contact fingers
- Length and profile of the male pin
- Contact point
- Contact resistance: plating, material properties

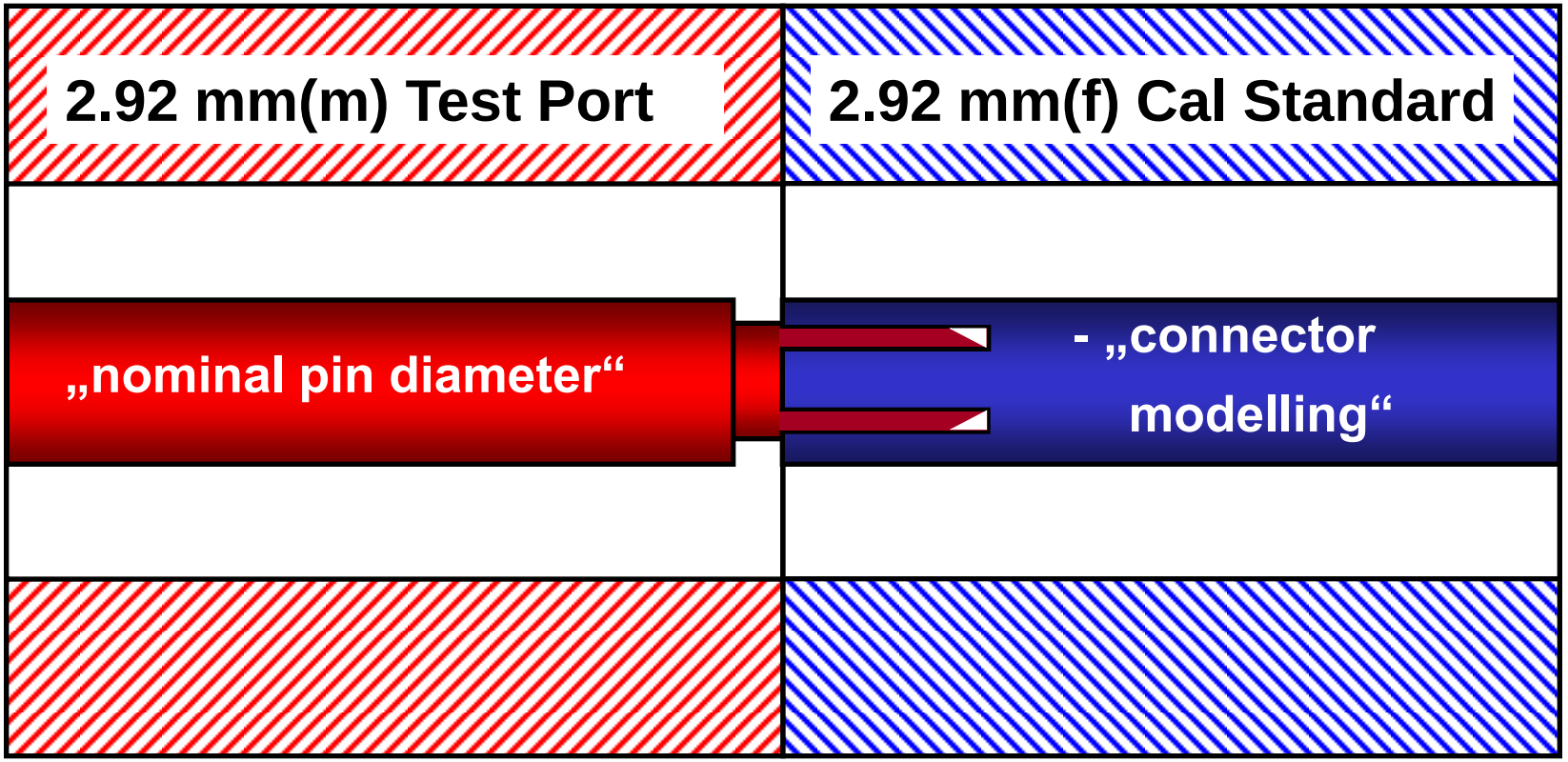
Slotted versus slotless female connector design



Detail of precision slotless female centre conductor developed by Agilent

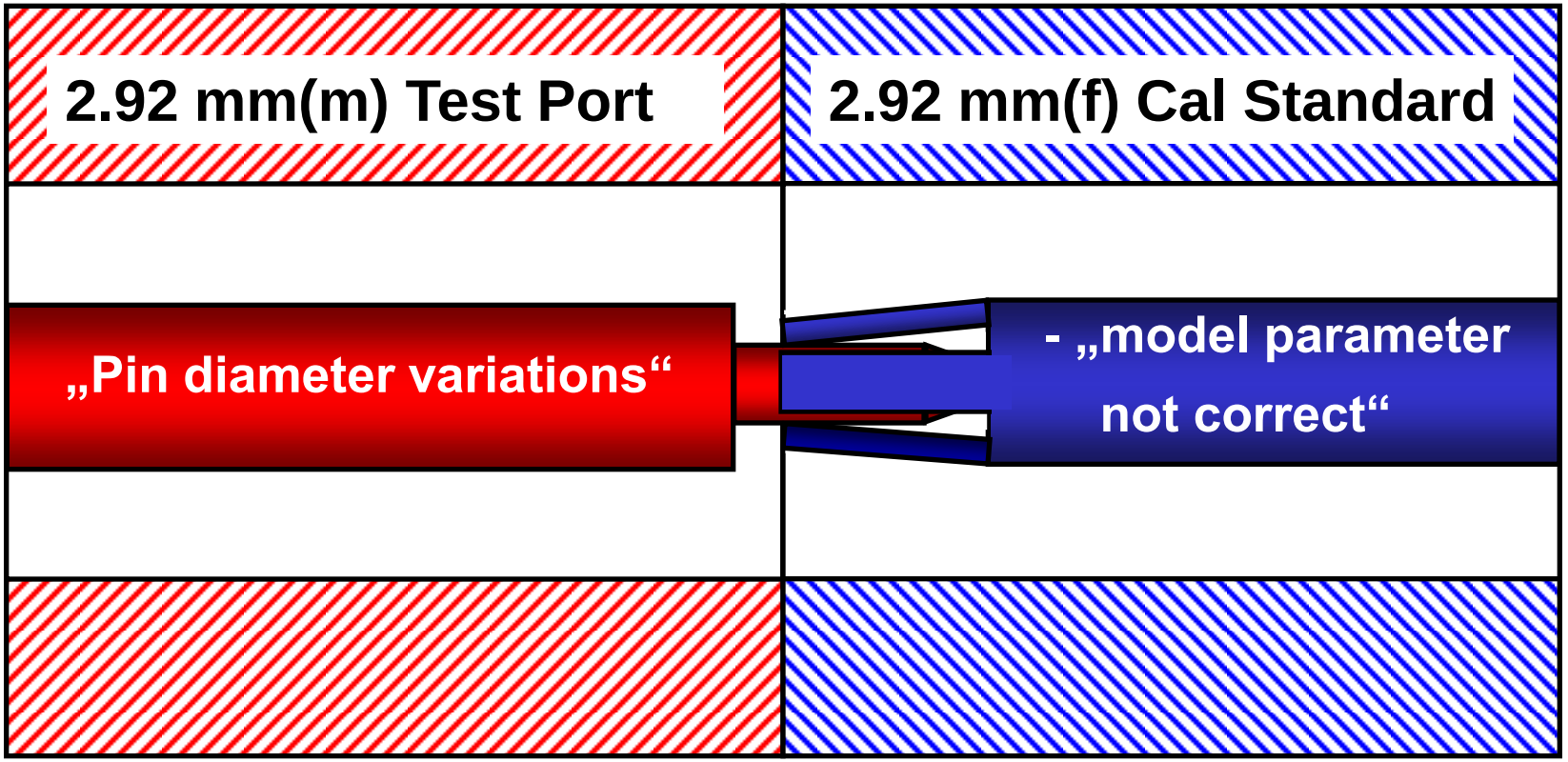
(Slotless female conductors are available for Type-N, 3.5 mm and 2.4 mm connectors)

- Slotted female CC
- Cal Standard „corrected“



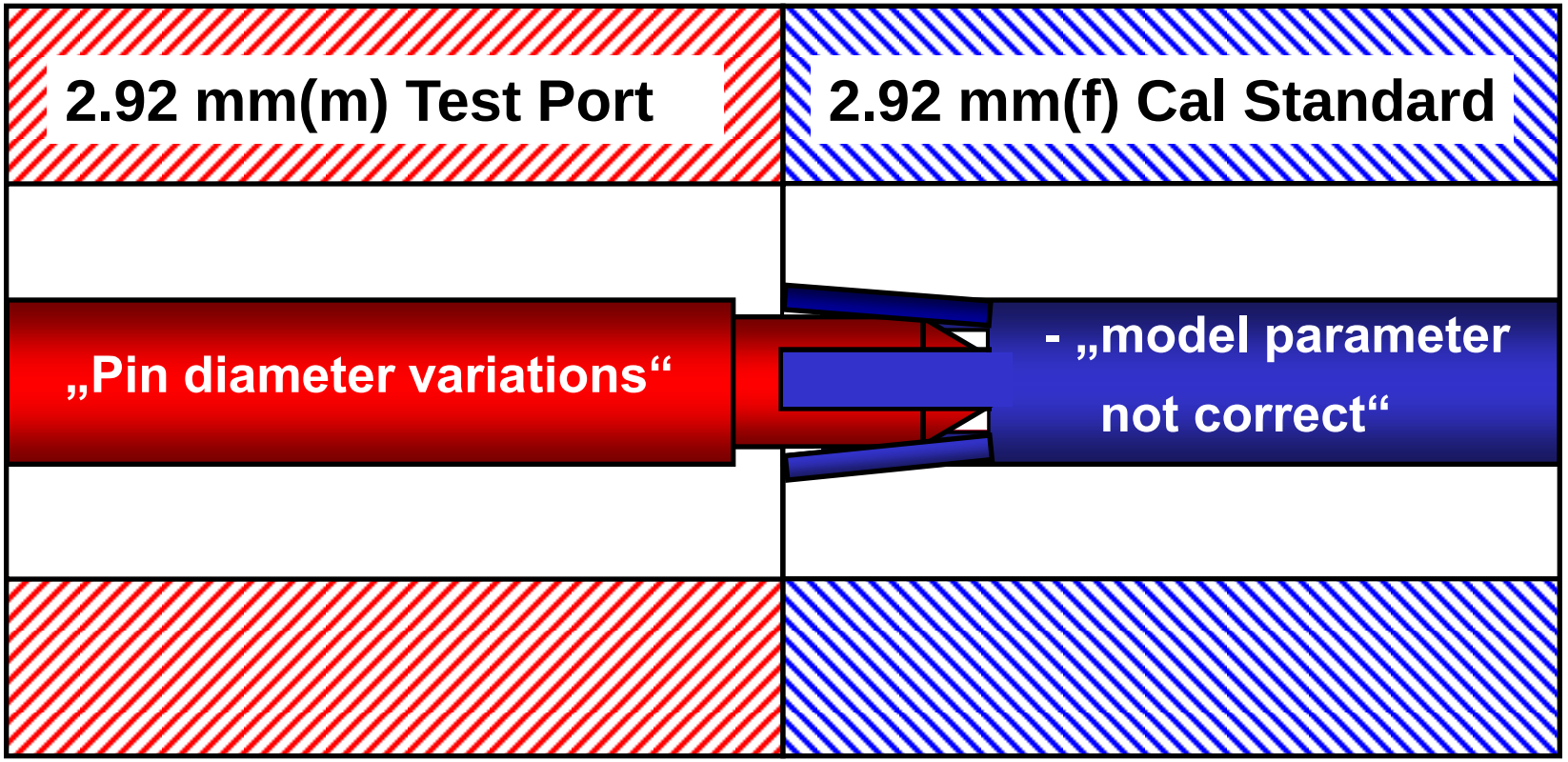
The error introduced by the TP will become „absorbed“ into the error box of the calibration model of the VNA

- Slotted female CC
- **Problem:** pin diameter



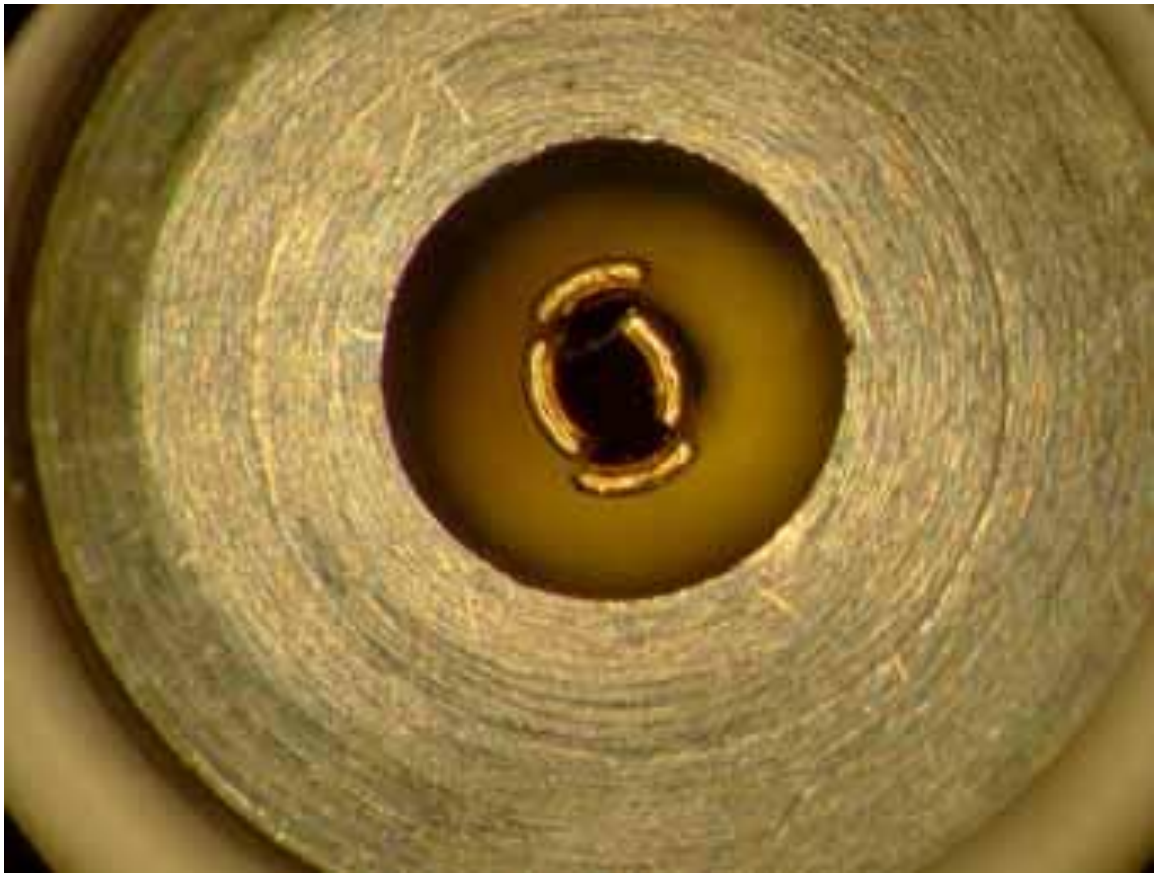
The error introduced by the TP pin will change the impedance characteristics of the connected calibration standard

- Slotted female CC
- **Problem:** pin diameter

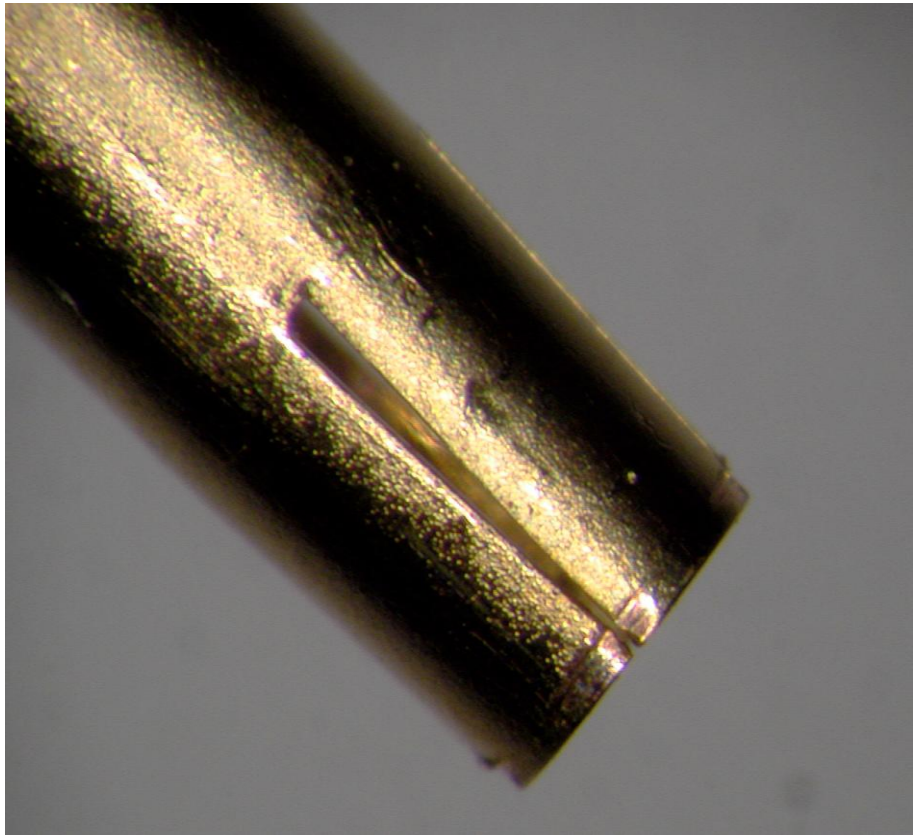


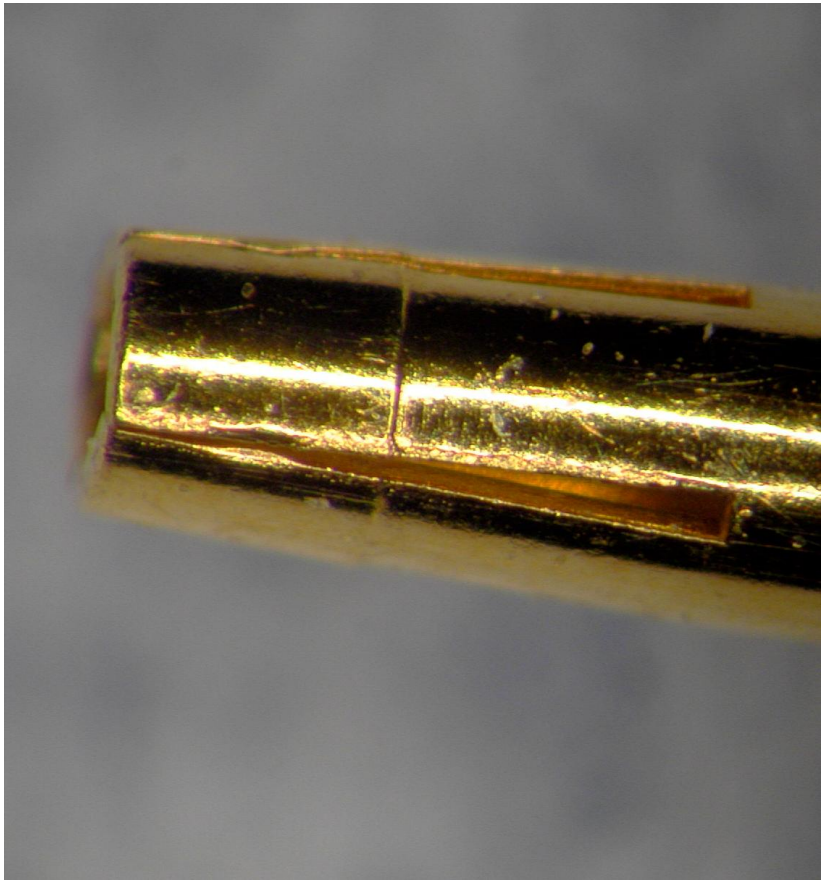
The error introduced by the TP pin will change the impedance characteristics of the connected calibration standard

Manufacturing issues



Manufacturing issues



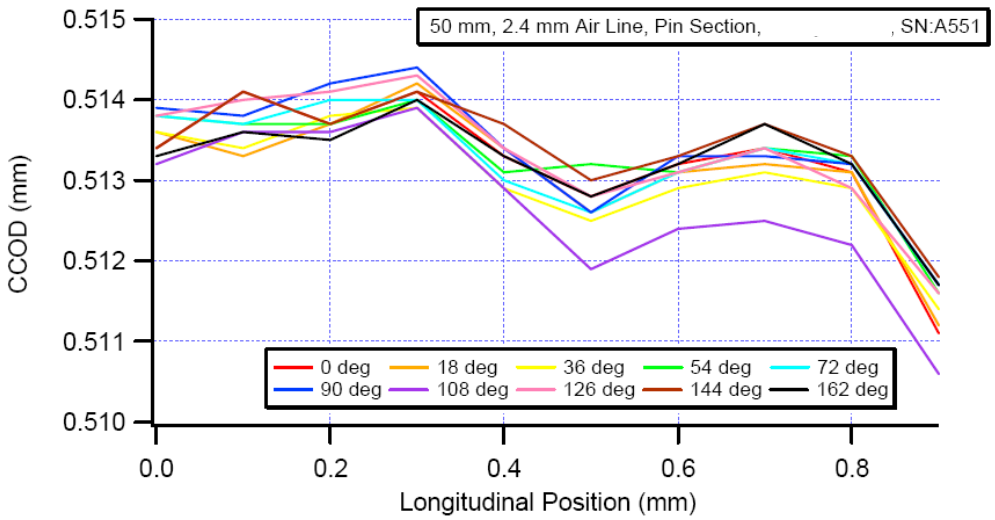


Stamping marks, bone effects or bubbles on fingers (in and outside)

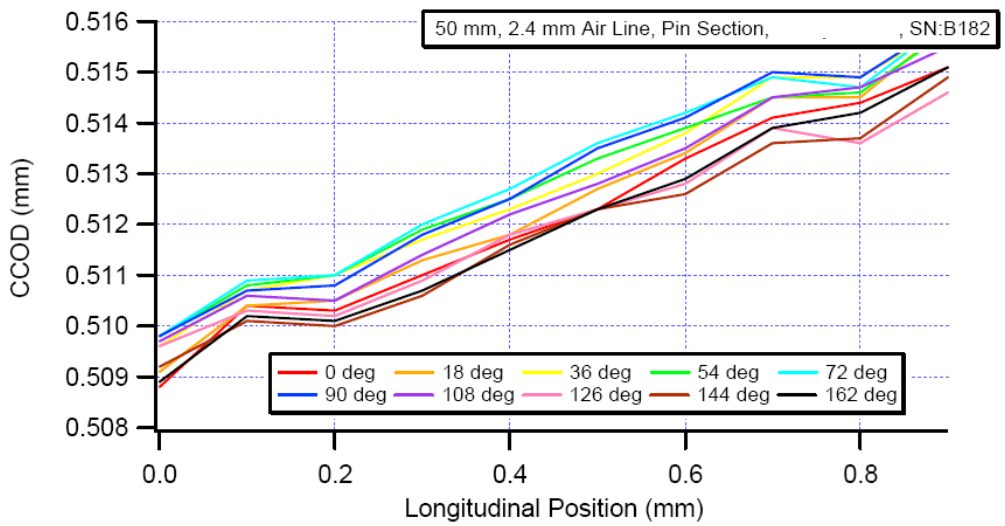
Manufacturing issues

Profile of two 2.4 mm precision air line male pins

Graphical Representation: Center Conductor



Graphical Representation: Center Conductor

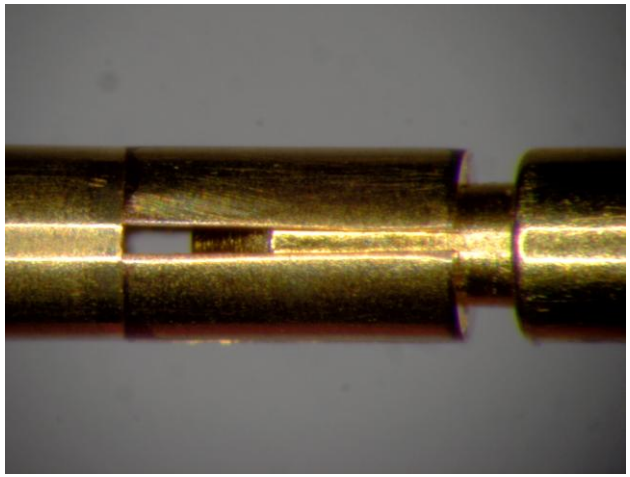


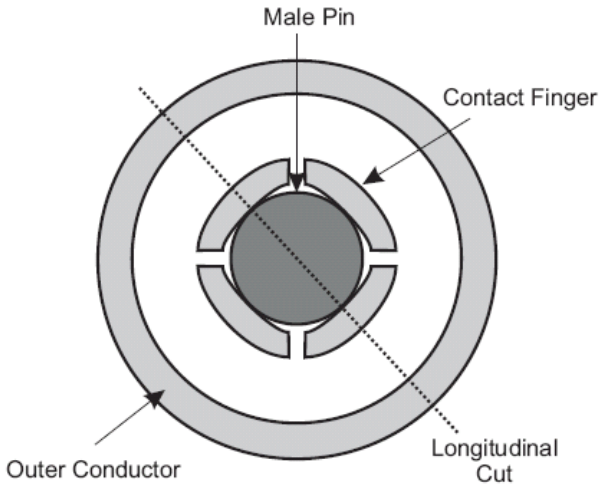
Pin diameter effects in electrical quantities

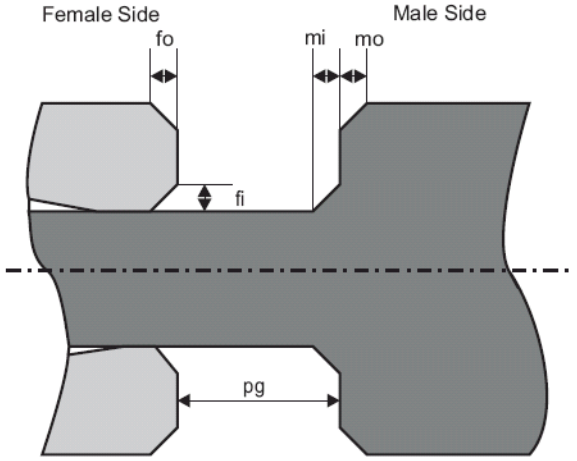
CoMo70 modelling:

1.85 mm male pin diameter reduction of **10 µm**

1.85 mm nominal male pin Ø = 0.511 mm





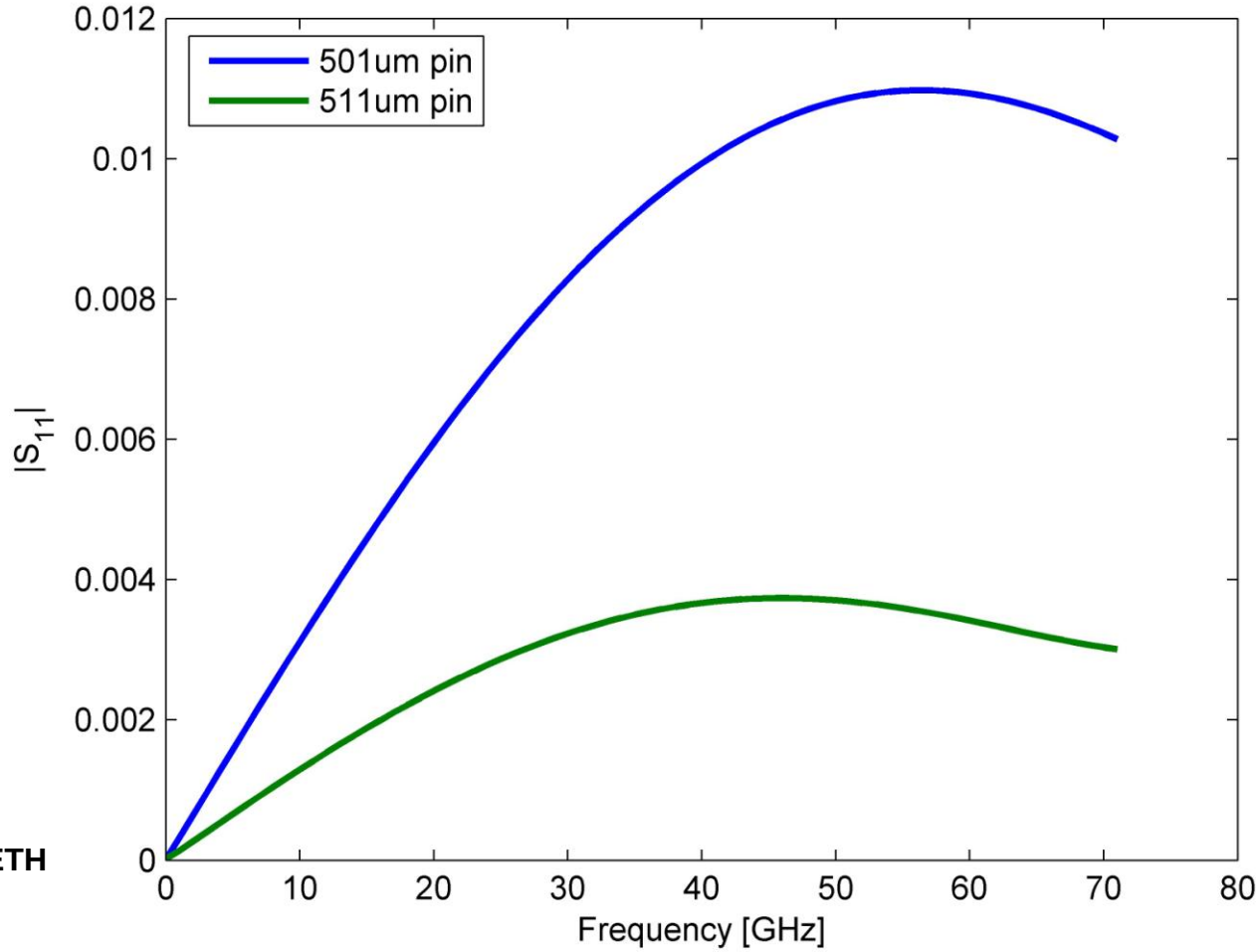


Johannes Hoffmann, ETHZ, CoMo70 project (Paper published at the EuMW 2007)

Pin diameter effects in electrical quantities

CoMo70 modelling:

1.85 mm male pin diameter reduction of **10 µm**



Johannes Hoffmann, ETH

Conclusions : "Standard versus market"

- **IEEE Std P287-2007: be careful with the specifications**
- **Modelling: a must for millimetre-wave coaxial connectors**
- **Traceable pin-diameter and slotted area measurements – a must for modelling**
- **NMIs: need the detailed connector specifications**
- **Impact of pin diameters in measurement comparisons?**
- **Other critical effects not discussed** (near field effects, …)

31st ANAMET meeting news

IEEE Std 287

It is planned to issue a new edition of this standard

- Sponsored by the Connectors in Measurement Technical Committee (TC-5)
- TC-5 is Chaired by Brian Lee, Anritsu, USA
- TC-5 has asked Nick Ridler to initiate the revision of the IEEE 287 standard

NPL

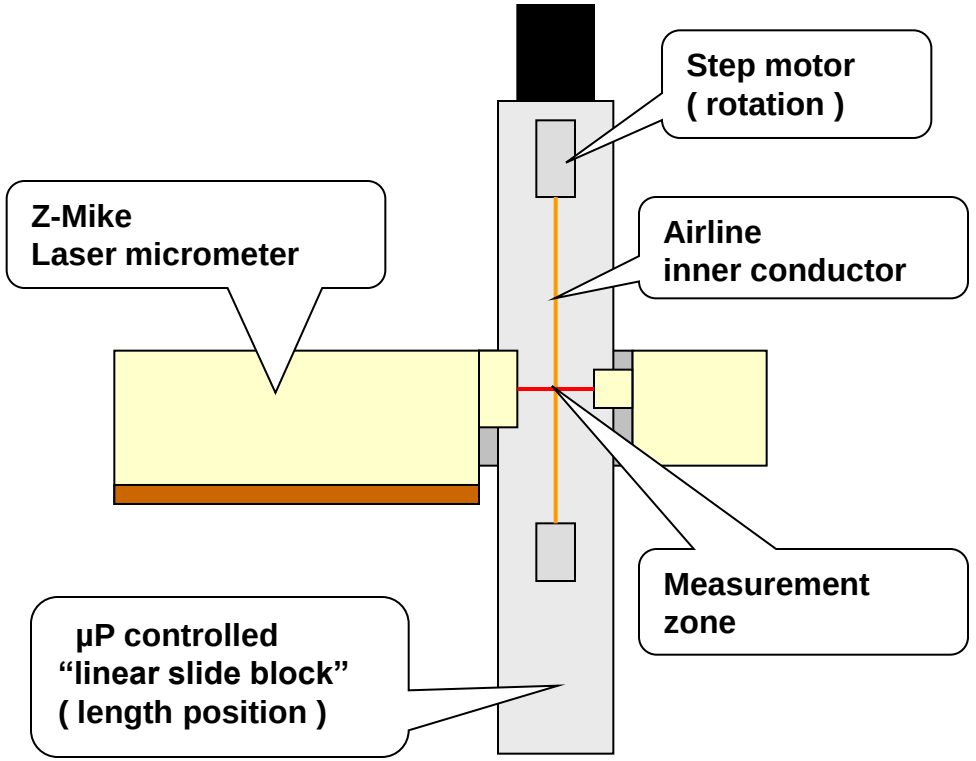
Federal Department of Justice and Police FDJP

Federal Office of Metrology METAS

Thank you very much for your attention !

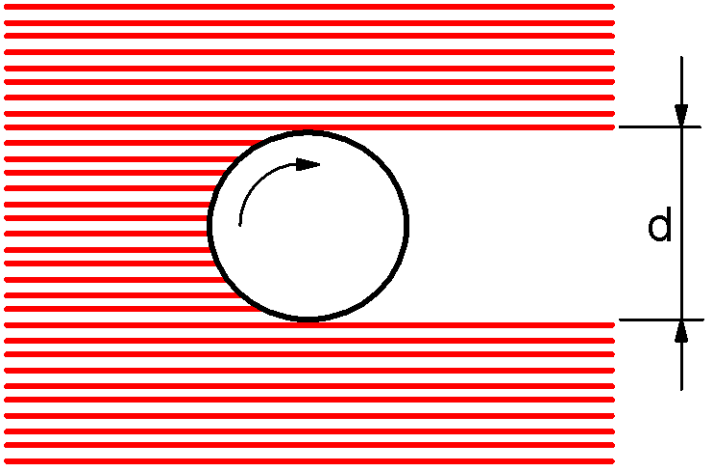
Automated Laser Scanner Measurement System

(-> For the outer diameter of the inner conductor)



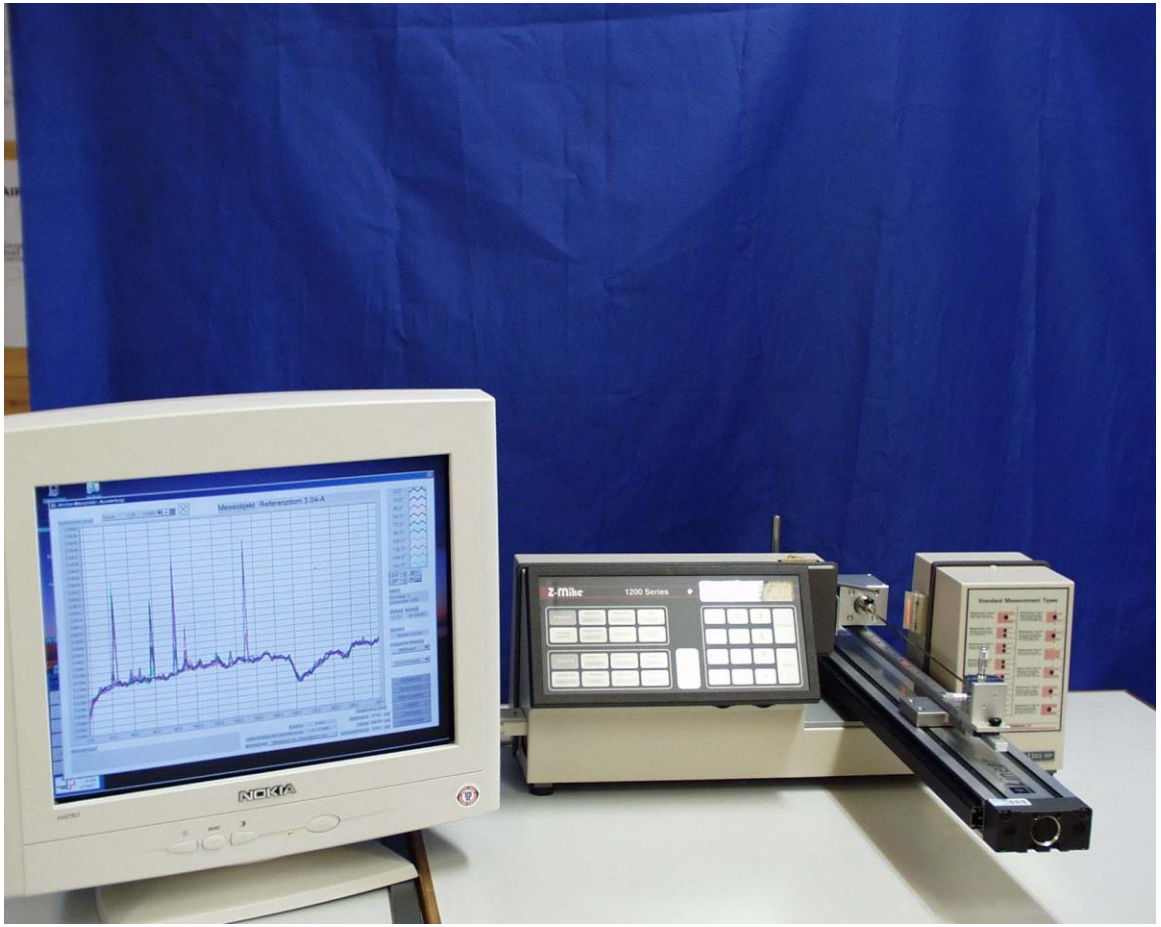
View into the measurement zone

Measurement of the **diameter profile** :



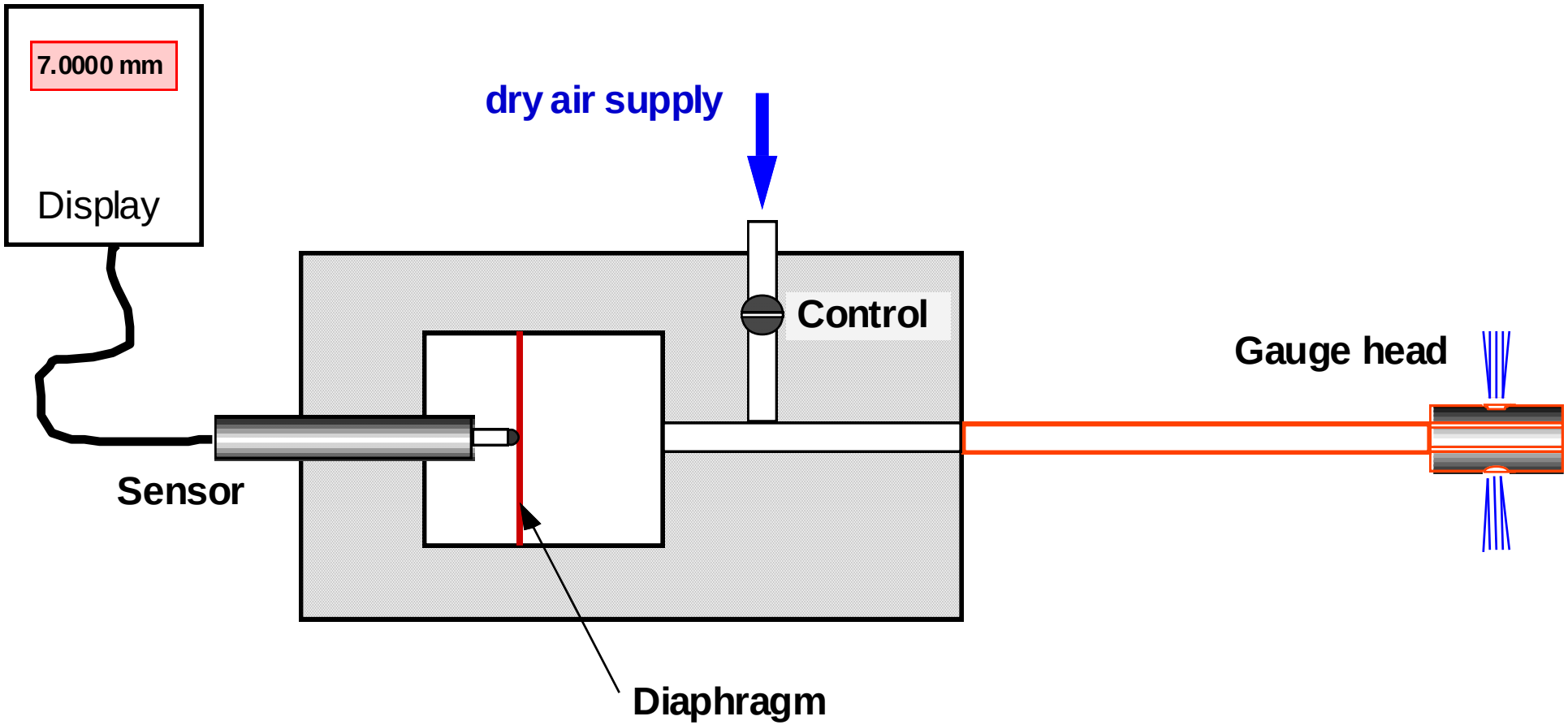
Automated Laser Scanner Measurement System

(-> For the outer diameter of the inner conductor)



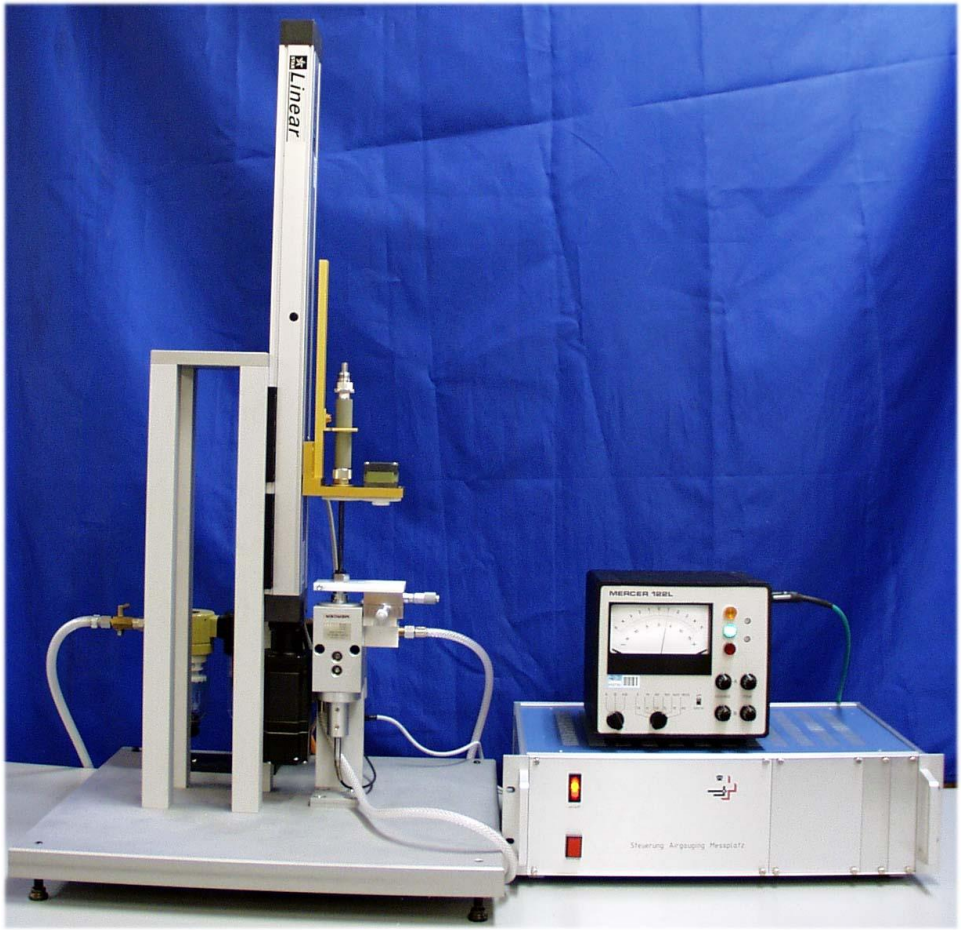
Automated air gauging measurement system

(-> For the inner diameter of the outer conductor)



Automated Air Gauging Measurement System

(-> For the inner diameter of the outer conductor)



S-parameter traceability chain used at METAS