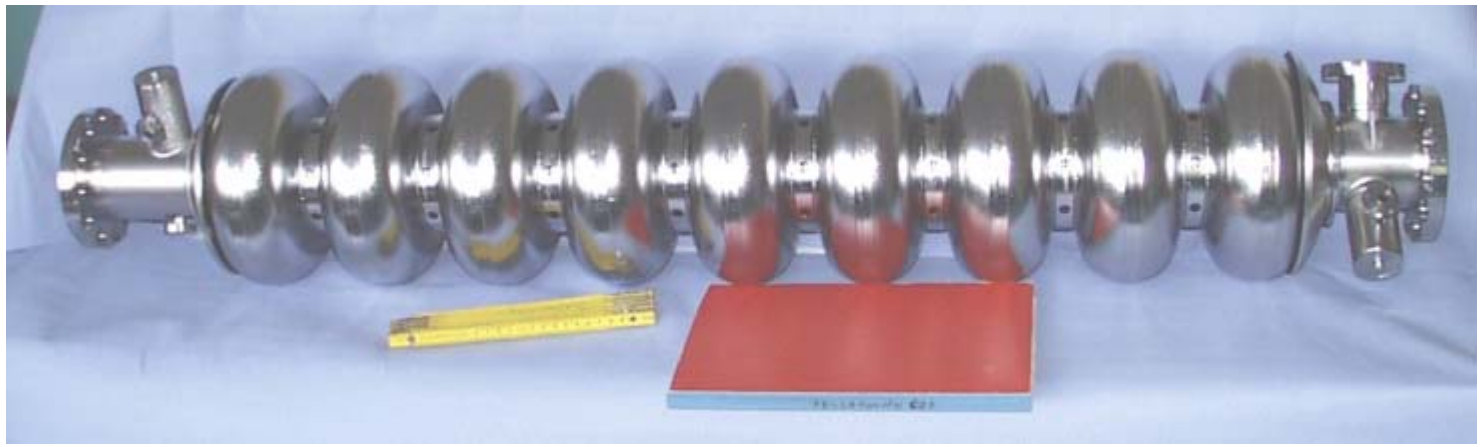
SRF Surface Preparation Technique

for High Gradient Superconducting Cavities

A.Matheisen
Deutsches Elektronen Synchrotron DESY
Hamburg Germany
For TTF/TESLA/XFEI community

Experiences for this preparation techniques gained on TTF / Tesla cavities



Cavity data

Standing wave structure
No of cells **9**
fo=1,3 Ghz
Active length 1.038 m
HOM Couples 2
Power coupler 1
R/Q= 1036 ohm
E_p / E_{acc} = 2.0
B_{peak}/E_{acc} =4.26 (mT/MV/m)
Accelerator mode TM 010 Pi mode
Power transfer KW pulsed (10 Hz) 400-500KW@35 MV/m

Toolboxes for cavity preparation

Inputs coming form TTF collaborations
CEA-Saclay/ CERN/ INFN / KEK

Cleanroom

Clean water supply

Degreasing and Rinsing

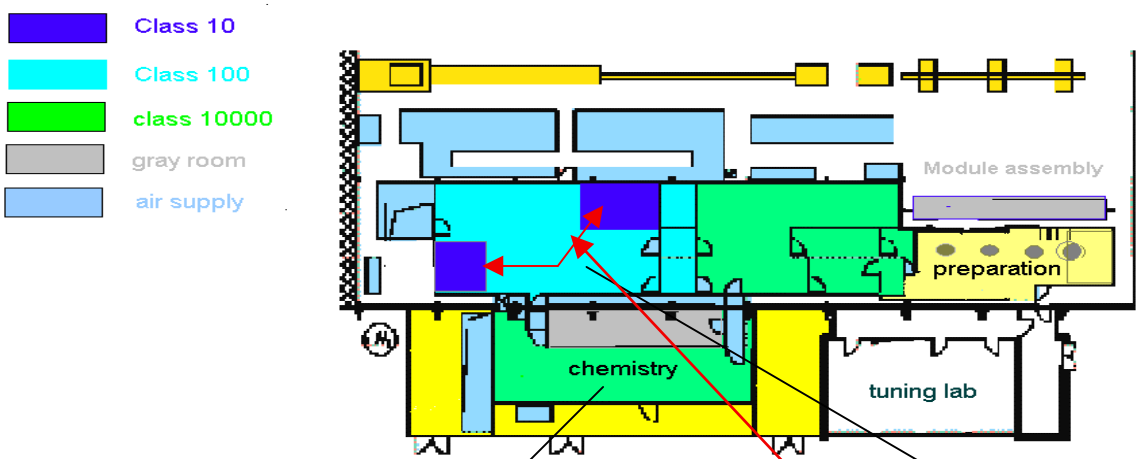
Chemistry

Assembly / Personal

Procedures

High pressure rinsing

TTF Cleanroom



Ground space assembly area

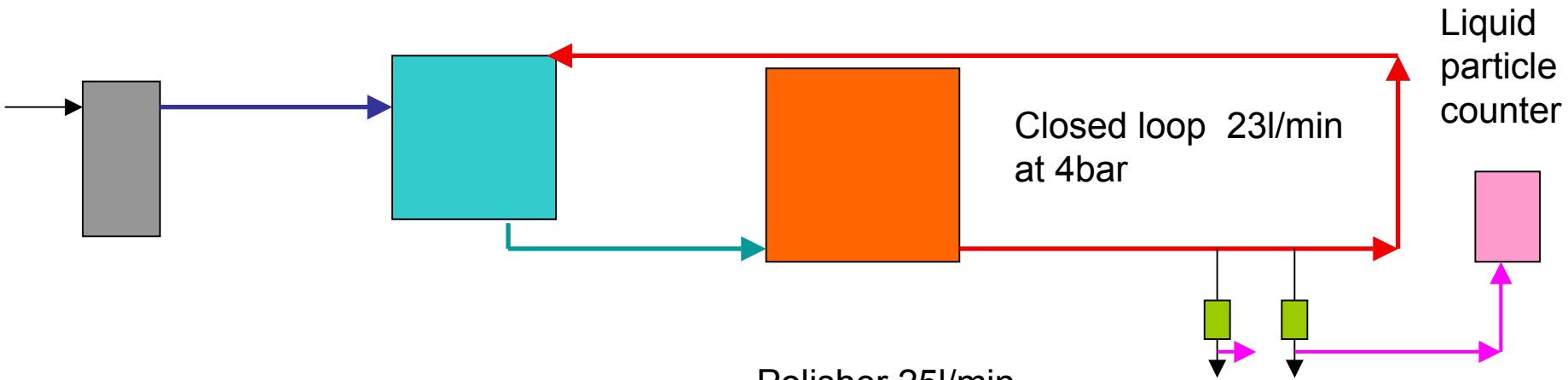
Class 10 23 m2
Class 100 96 m2
Class 10000 108 m2

View on chemistry area

View on cl 10 assembly area No 1

View on cl 100 area (storage of cavities)

Clean water supply



Ro 1400l/h
L 0,5-1 µS

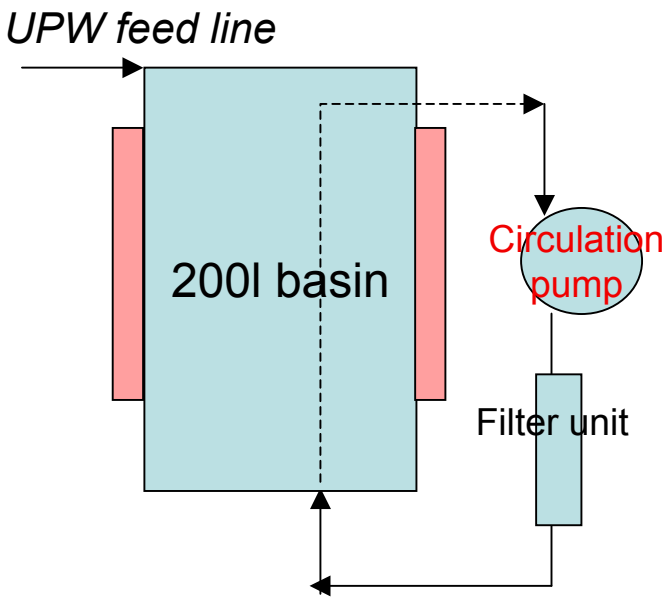
Reservoir
4000l

Polisher 25l/min
L>=18 Mohm cm
0,4 µm filter
UV light bacteria

Point of use
L>=18 Mohm cm
0.2-0.04 µm filter
20l/min

Degreasing and Rinsing

Removal of Grease , particulates , residues from former treatments



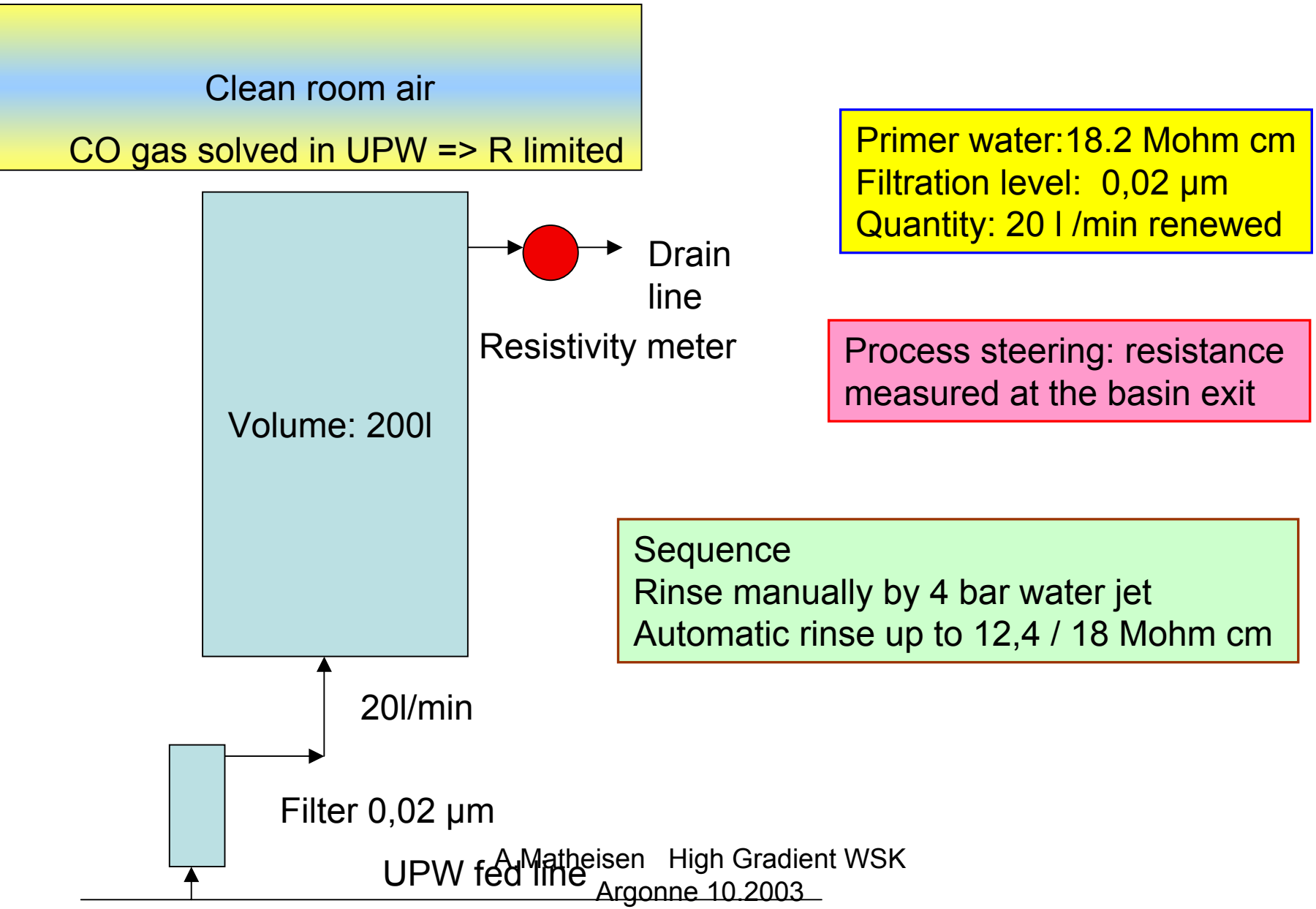
Ultra Clean water (>= 18 Mohm cm)
+detergent (Ticopur)
concentration 3%@Temperature 45 C

Specifics:
Ultrasound power: 10W/liter
Circulation: system with 2 µm inline filter
Volume: 200l
Circulation: 40 l/min

US cycle

5 Min circulation and warm up of item
5 Min US sound + circulation
5 Min US sound NO circulation
5 Min circulation

rinsing



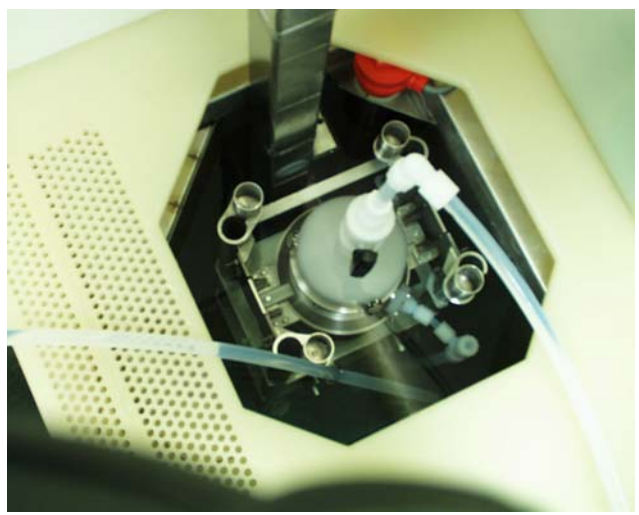
Primer water:18.2 Mohm cm
Filtration level: 0,02 µm
Quantity: 20 l /min renewed

Process steering: resistance measured at the basin exit

Sequence
Rinse manually by 4 bar water jet
Automatic rinse up to 12,4 / 18 Mohm cm


VORBEHANDLUNG


SPÜLLF



Test on cleaning procedure

Nb sample polluted with grease and oil

Not efficient cleaning

After U Sound cleaning procedure

Chemistry

BCP (buffered chemical polishing)
Mixture by volume 1/1/2 HF/HNO3/H3PO4

$$2\,Nb + 5\,NO_3^- \Rightarrow Nb_2O_5 + 5\,NO_2 + 5\,e^-$$

$$Nb_2O_5 + 6\,HF \Rightarrow H_2NbOF_5\,(l\ddot{o}sl.) + NbO_2F \bullet 0.5\,H_2O\,(unl\ddot{o}sl.) + 1.5\,H_2O$$

$$NbO_2F \bullet 0.5\,H_2O + 4\,HF \Rightarrow H_2NbOF_5 + 1.5\,H_2O$$

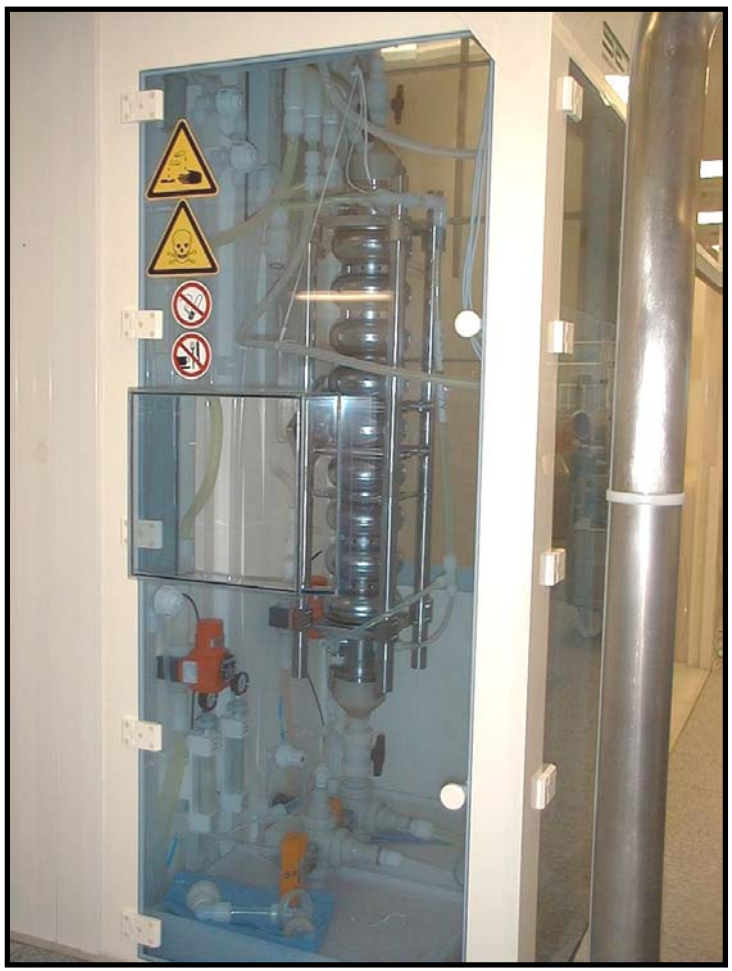
EP (electro chemical polishing)
Mixture by volume 1/9 HF/H2SO4

$$2\,Nb + 5\,SO_4^{2-} + 5\,H_2O \Rightarrow Nb_2O_5 + 10\,H^+ + 5\,SO_4^{2-} + 10\,e^-$$

$$Nb_2O_5 + 6\,HF \Rightarrow H_2NbOF_5\,(l\ddot{o}sl.) + NbO_2F \bullet 0.5\,H_2O\,(unl\ddot{o}sl.) + 1.5\,H_2O$$

$$NbO_2F \bullet 0.5\,H_2O + 4\,HF \Rightarrow H_2NbOF_5 + 1.5\,H_2O$$

BCP facility

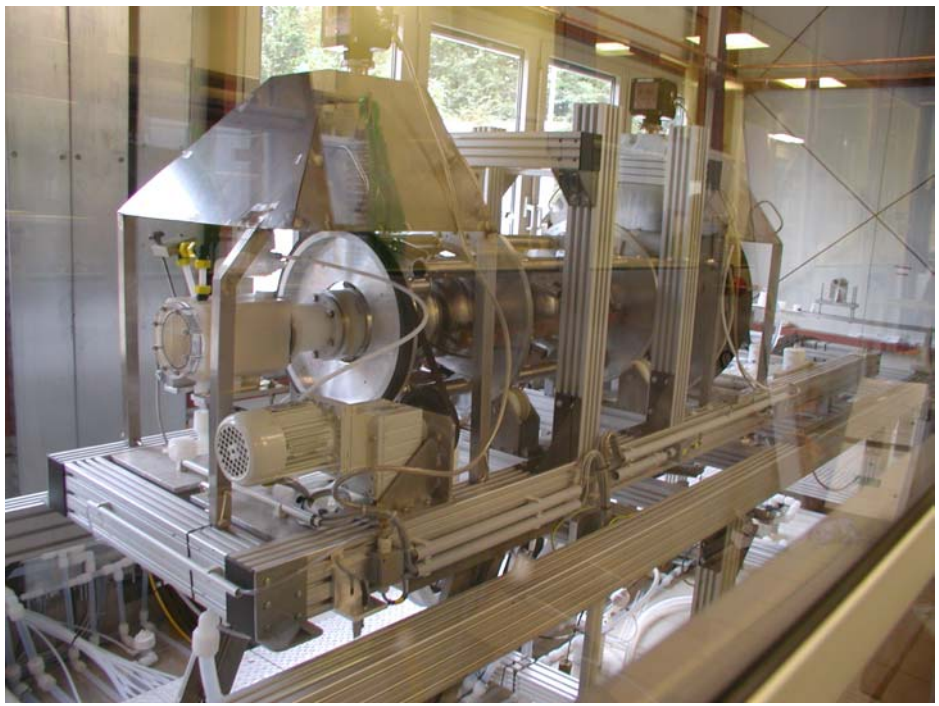


2 independent circuits
“Nb” clean and fresh Acid for final treatment
“Ti” used acid for Ti removal /pre cleaning
Inline filter 0,2 µm
T <=15 C in average during process
Start T 5 C

EP facility

First experiences gained

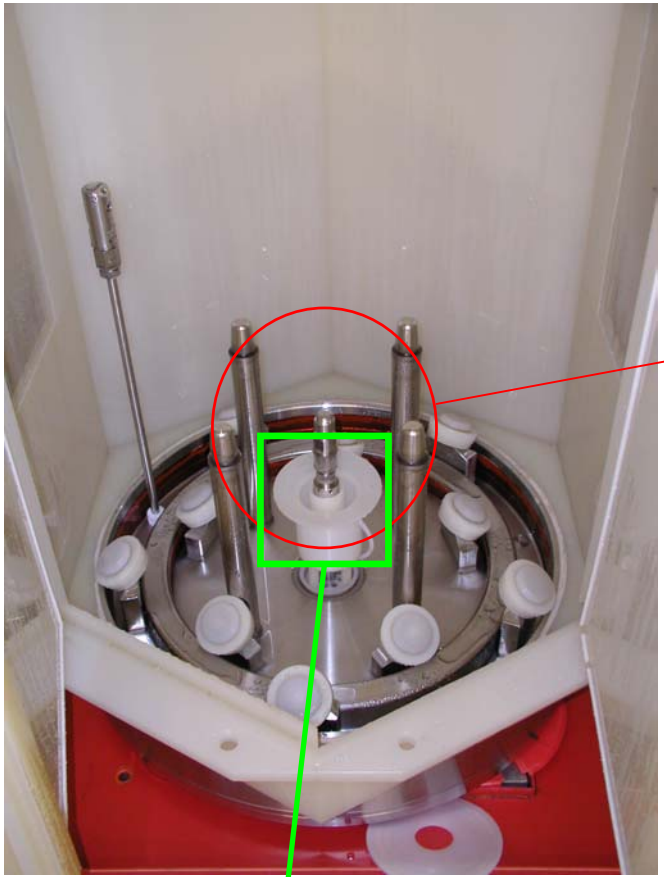
1 circuits
Inline filter ??µm 8 first experiences bad filter blocked
T 30-35 C in average during process
Start T 30 C Current 360A @ 18 V (9cell)
First experiences since commissioning June 2003



High pressure rinsing

System Parameters
Pressure :4,2-200 bar
Quantity: 20 l/min @ 200 bar
Particle filter @200 bar line: 0,02 µm
Ultra pure water: R spec 18.2 Mohm cm
Special: N2 gas overlay

Standard setting: 100 bar
Process duration: >2h
Volume: 2000 l total per rinse
Spray head 2*4 jets (8 nozzles)
Nozzle : sapphire 0,4 mm ID



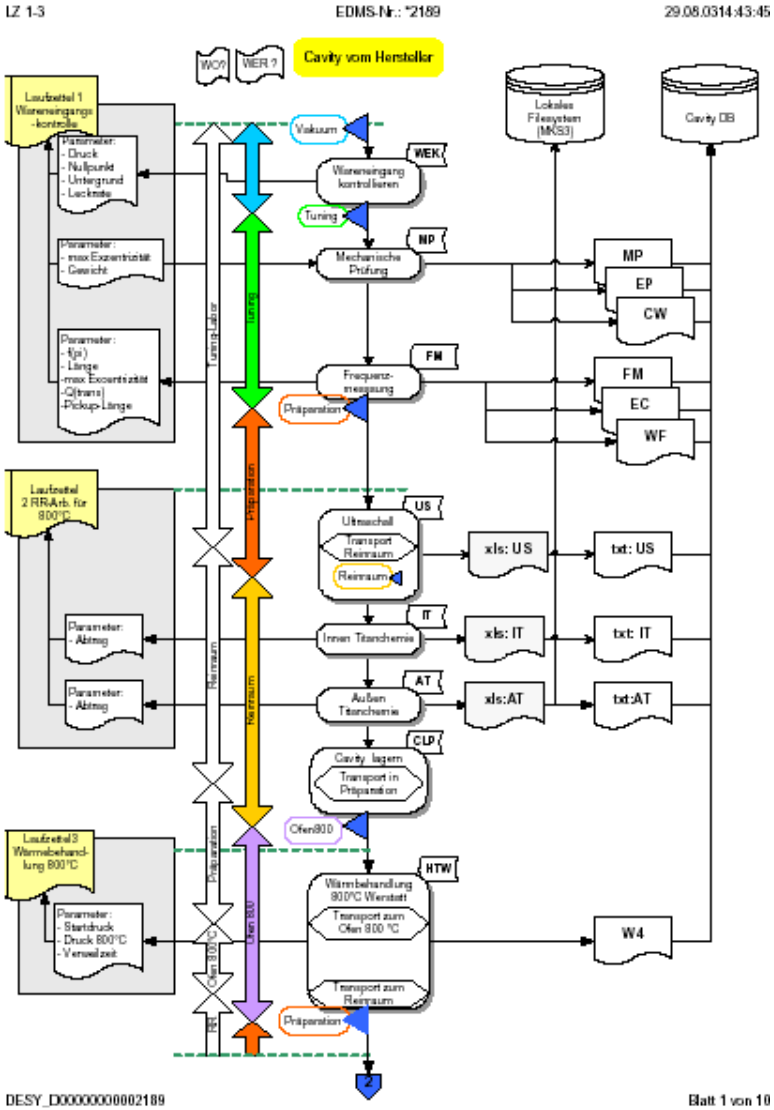
A.Matheisen High Gradient WSK
Argonne 10.2003

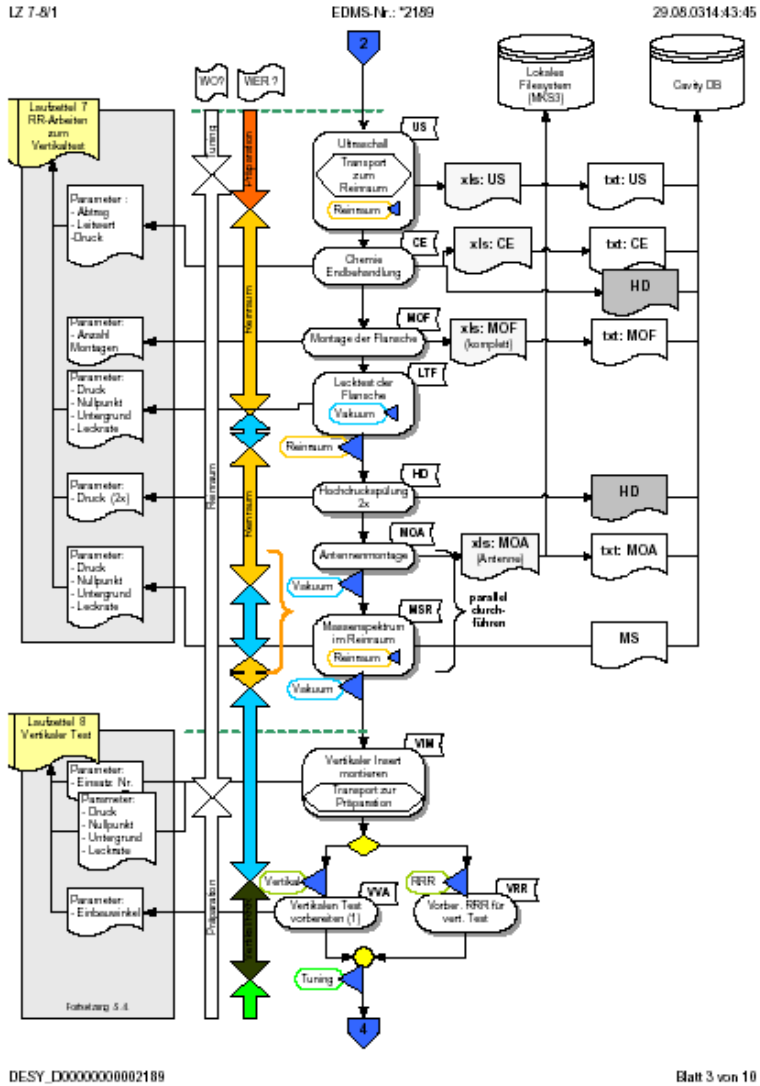
Procedures

delivery	annealing and titanisation	tank welding	system component test	module assembly
acceptance inspection	degreasing and rinsing	cleaning +degreasing	adjustment of HOM antennas	cleaning +degreasing
	titanium BCP inside 80µm outside 20µm	ventilation of cavity with innert gas	cleaning +degreasing	alignment of cavity n for module
	insertion to oven 1+ 800°C annealing	electron beam welding of titanium rings	BCP niobium circuit inside 20µm	ventilation of cavity
		frequency control and adjustment	1st high pressure rinse	assembly of connecting bellow
	insertion to oven 2 + 1400°C titanisation	TIG welding of Nb to Ti connection	assembly of flanges +leak test	assembly of cavity n+1
	titanium BCP inside 80 µm outside 40µm	frequency control and field profile	2nd and 3rd high pressure rinse	alignment of coupler port distance
	tuning of field profile	welding of helium vessel	insertion of power-coupler	general leack check
	niobium BCP inside 20µm	leak test of tank	assembly of tuner	alignment and frequency control
	1st high pressure rinse		acceptance test for module assembly	assembly of mech.tuners, insulation, magnetic shielding
	assembly of flanges +leak test			assembly of vacuum vessel
	2nd and 3rd high pressure rinse			assembly of power-coupler warm part
	RF acceptance test for tank welding			module test / module installation

A.M WSK

EDMS Processing cycles





Total 46 work packages

Cavity Nr.	ac73	Datum	16.07.02
Behandlung Nr.			
Operateur	Saegebarth/Habermann		
Zweck	Antennenmontage für Vertikaltest		

Zubehör

Daten	Vorgabe/ Einheit	Istwert	Bemerkung
Reinigung Antenne	Datum TT.MM.JJ	15.07.02	
Anschlußflansch Strahlrohrsatz kurz	TYP		Antennen-Nr.
Reinigung Schrauben	Datum TT.MM.JJ	15.07.02	
Einkoppelantenne	TYP/No	0	Blind = 0 / High Q saitlich =1/HPP=2/ variabel =3

Trocknung Cavity	Vorgabe/ Einheit	Istwert	Bemerkung
Art der Trocknung	Lam / Vac	lam	
Beginn	Datum TT.MM.JJ	15.07.02	
Beginn	Uhrzeit HH:MM	15:00	
Ende	Datum TT.MM.JJ	16.07.02	
Ende	Uhrzeit HH:MM	08:00	

Reinraumdaten vor Beginn

Daten	Vorgabe/ Einheit	Istwert	Bemerkung
Montageplatz	Nummer	2,00	K10 hinten = 1 vorne =2
Datum	TT.MM.JJ	16.07.02	
Uhrzeit	HH:MM	08:10	
Zähler No	Nummer	2,00	neuer Zähler = 2

Montage

Daten	Vorgabe	Istwert	Bemerkung
Beginn	Uhrzeit HH:MM	09:20	
Strahlrohr kurz	Ja/Nein	ja	
orientierung gataliter Flansch	Ja/Nein	ja	NEIN = nein
Montagedauer	Minuten	20	
Hilfsmittel	TYp	0,00	keine =0 / Matschband = 1
Flansche festgezogen	JA / Nein	ja	
Ende der Montage	Uhrzeit HH:MM	09:40	Bei mehrmaliger Montage die letzte Endzeit eintrag

Lecktest 1

Daten	Vorgabe	Istwert	Bemerkung
Beginn Lecktest	Uhrzeit HH:MM	10:30	
Vakuum	mbar	4,00E-10	Eingabe xxE-yy
Untergrund	mbar l/ sec	8,00E-10	Eingabe xxE-yy
Ende Lecktest	Uhrzeit HH:MM	10:40	

Nachprüfung	Soll	Anzahl	Bemerkung
Montagen Strahlrohr lang	0	0,00	
Montagen Pic Up	0	0,00	
Montagen HOM Koppler Strahlrohr lang	0	0,00	
Montagen HOM Koppler Strahlrohr kurz	0	0,00	
Montagen Einkoppler Strahlrohr kurz	0	0,00	
Montagen Strahlrohr kurz	0	0,00	
Montagen Kopplerstrahlrohr kurz	0	0,00	
Montagen am Koppler Kaltteil (pic up)	0	0,00	

Gesamtmontage Zeit	HH:MM		
Ende der Montage	Datum TT.MM.JJ	16.07.02	
Gesamt Zahl der Dichtversuche		1,00	
Gesamtpartikel Zahl/ Filename		23000	

Kommentar (max. 80 Zeichen!):

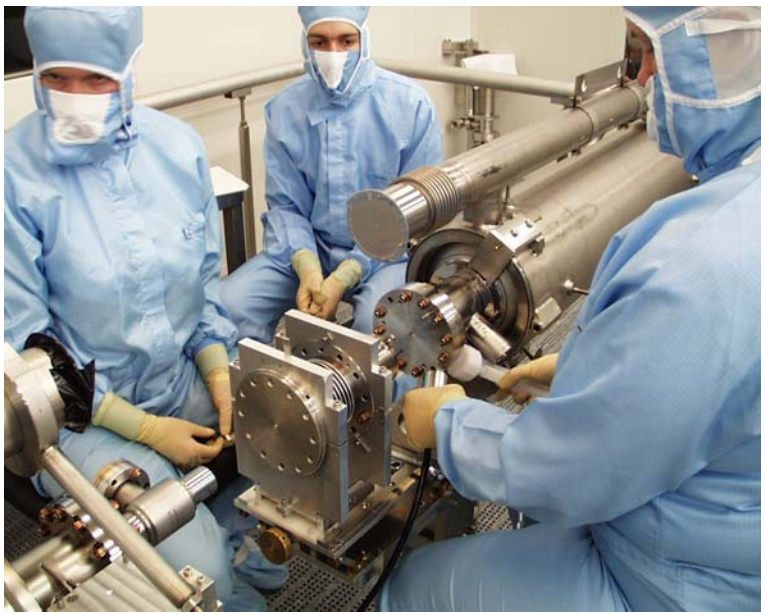
Legende:	
Allg. Daten	Eingabe allgemeiner Daten
CP-Daten	Eingabe Daten Cavity-Prozess

Processes

adient WSK

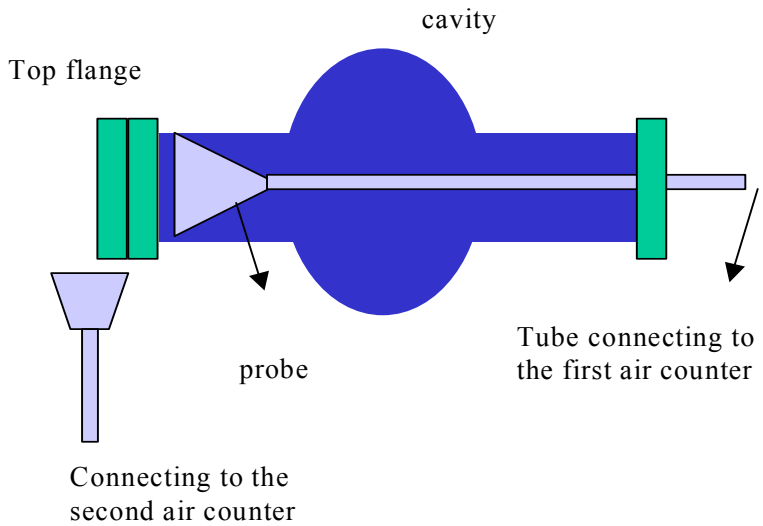
003

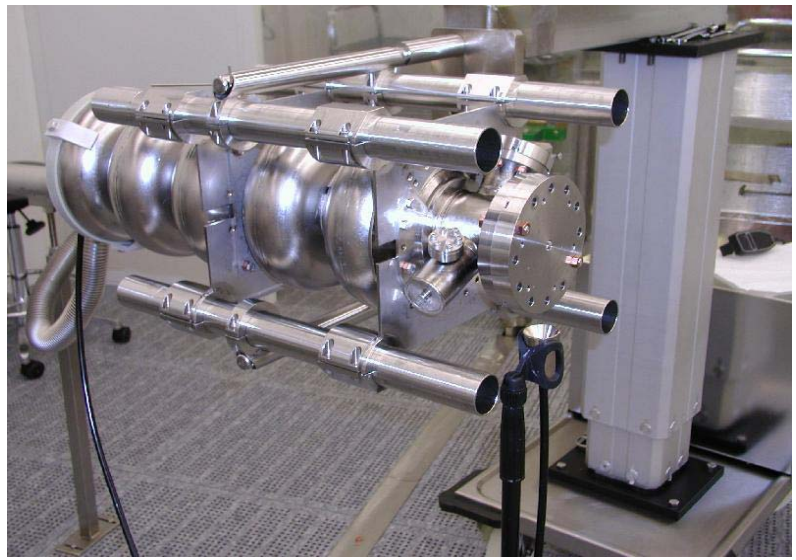
Assembly / Personal

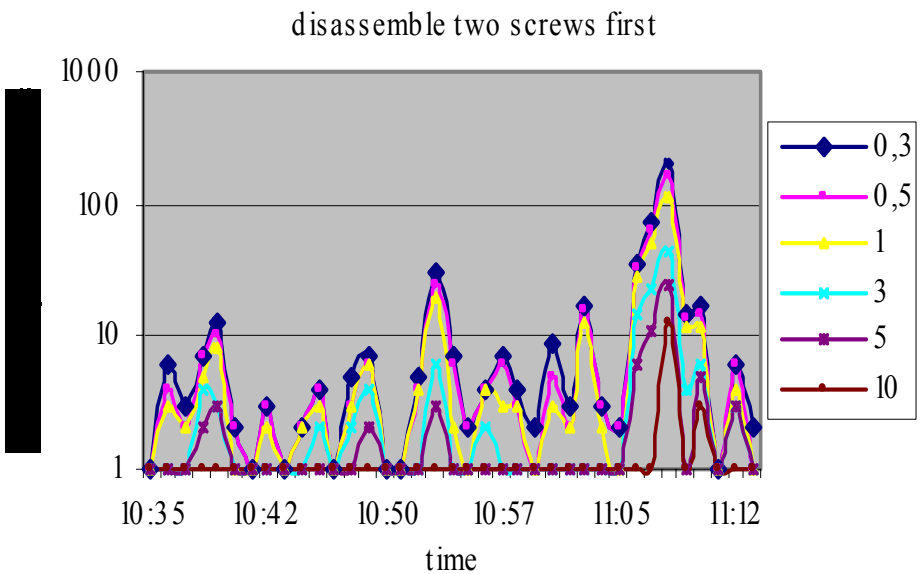


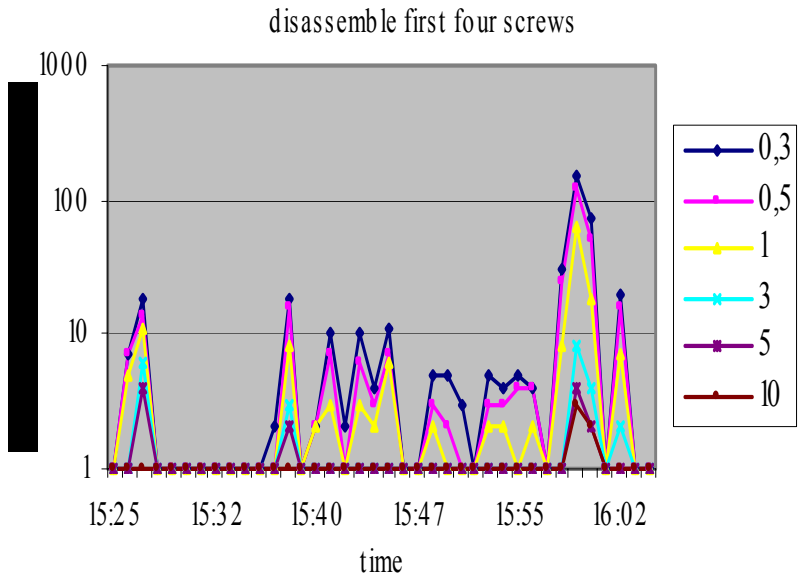
Personal: Defined procedures for handling /assembly

Test of procedures by air particle counters









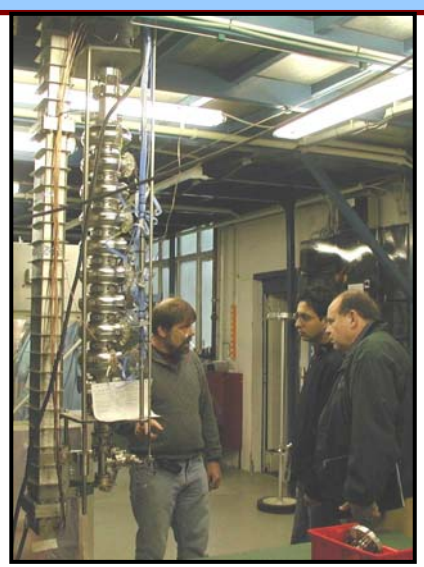
Some results

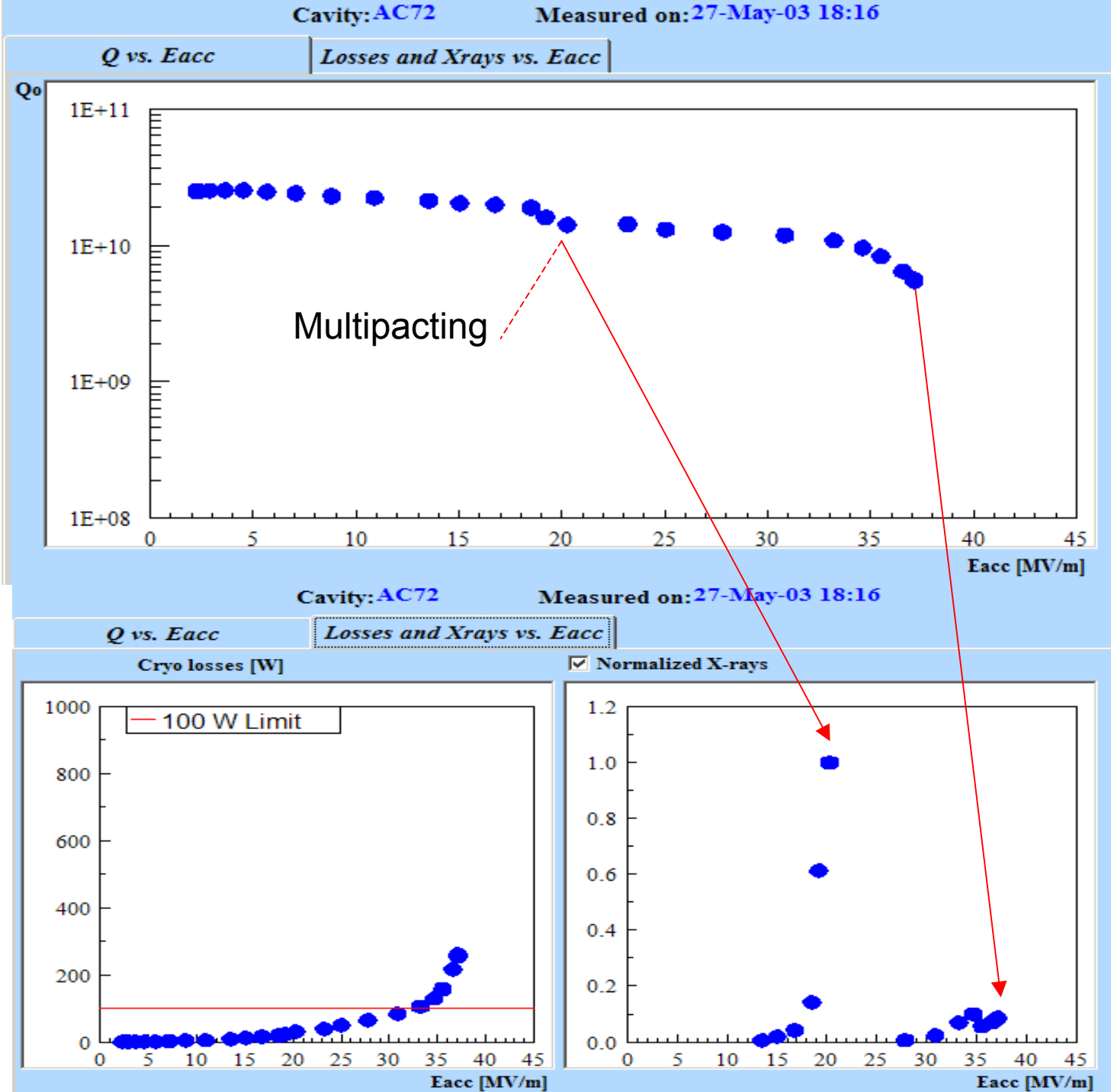
Vertical measurements

- Undressed resonator
- Vertical bath cryostat
- Power coupler
  variable high Q antenna $3*10^9$=> $2*10^{10}$
- HOM feed not installed
- Rf measurements
  Test mode CW operation
- Eacc
•calculated from power measurement
• power from calibrated pick up signal
- Qo calculated from decay signal RF off

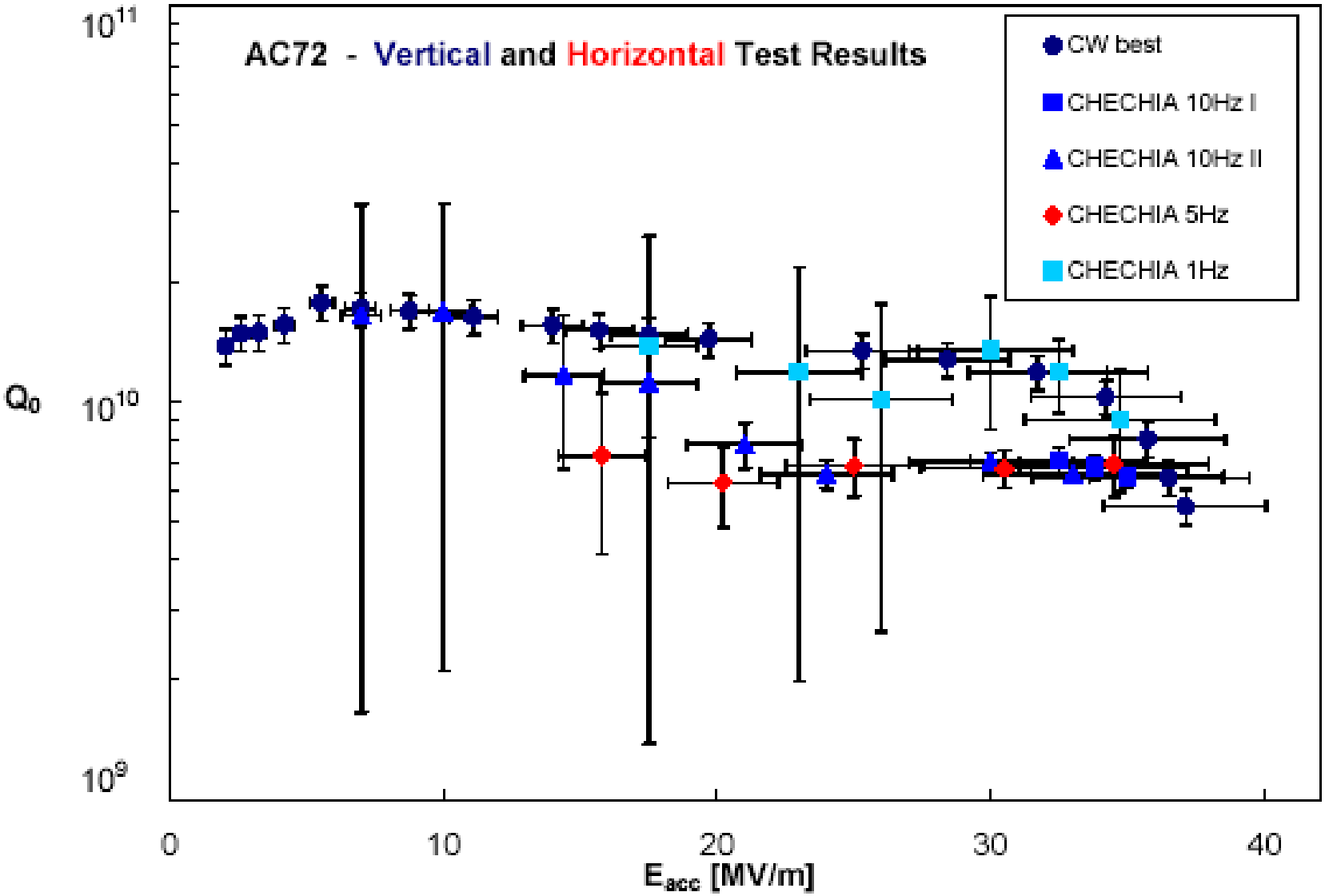
Horizontal measurements

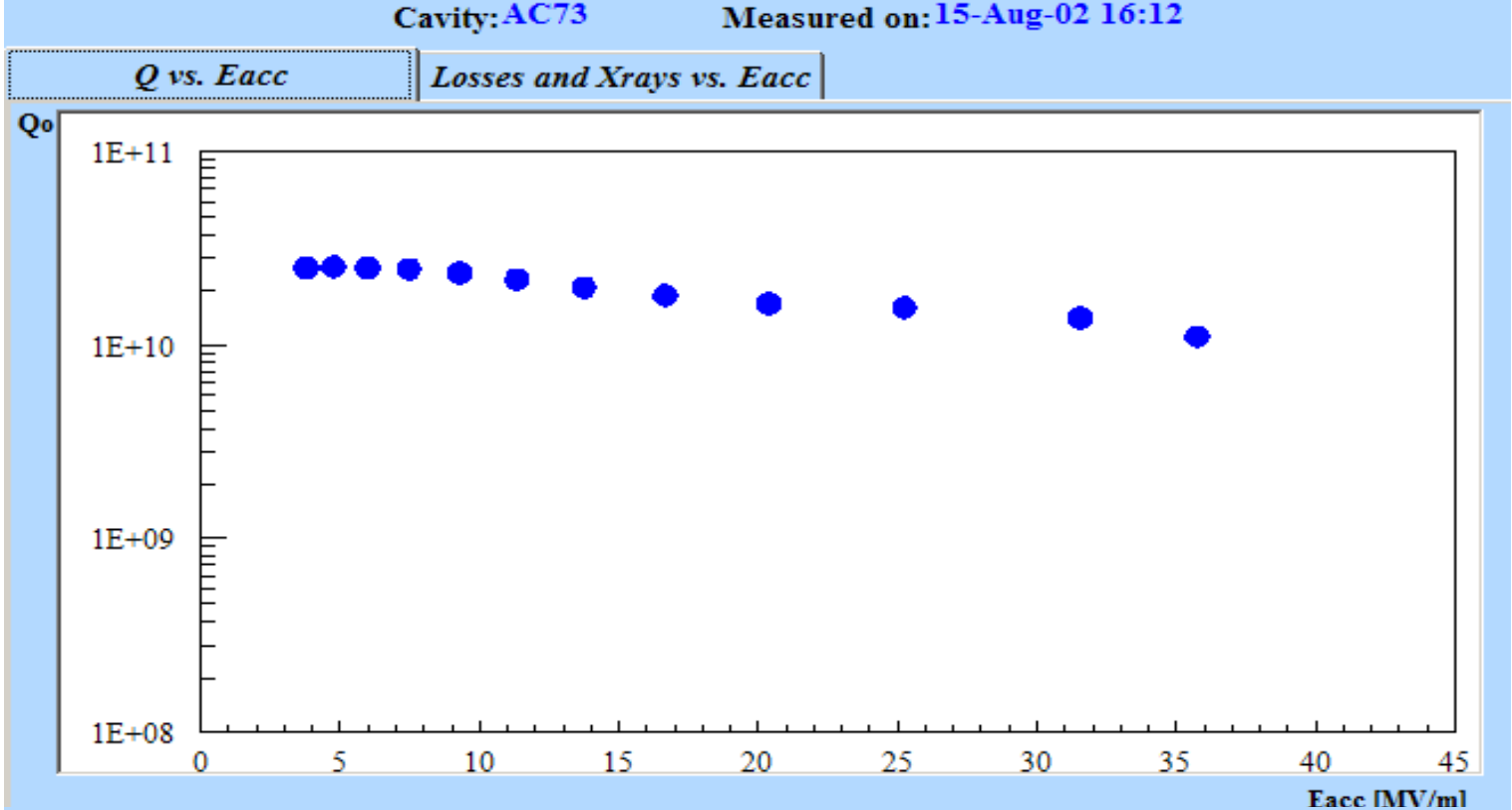
- Undressed resonator
- Horizontal cavity vessel= bath cryostat
- Power coupler
- variable antenna $3*10^6$=> $8*10^6$
- HOM feed and antenna installed
- Rf measurements
  Test mode pulsed 1-10 Hz operation
- Eacc
•calculated from power measurement
•power from calibrated pick up signal
- Qo calculated He losses

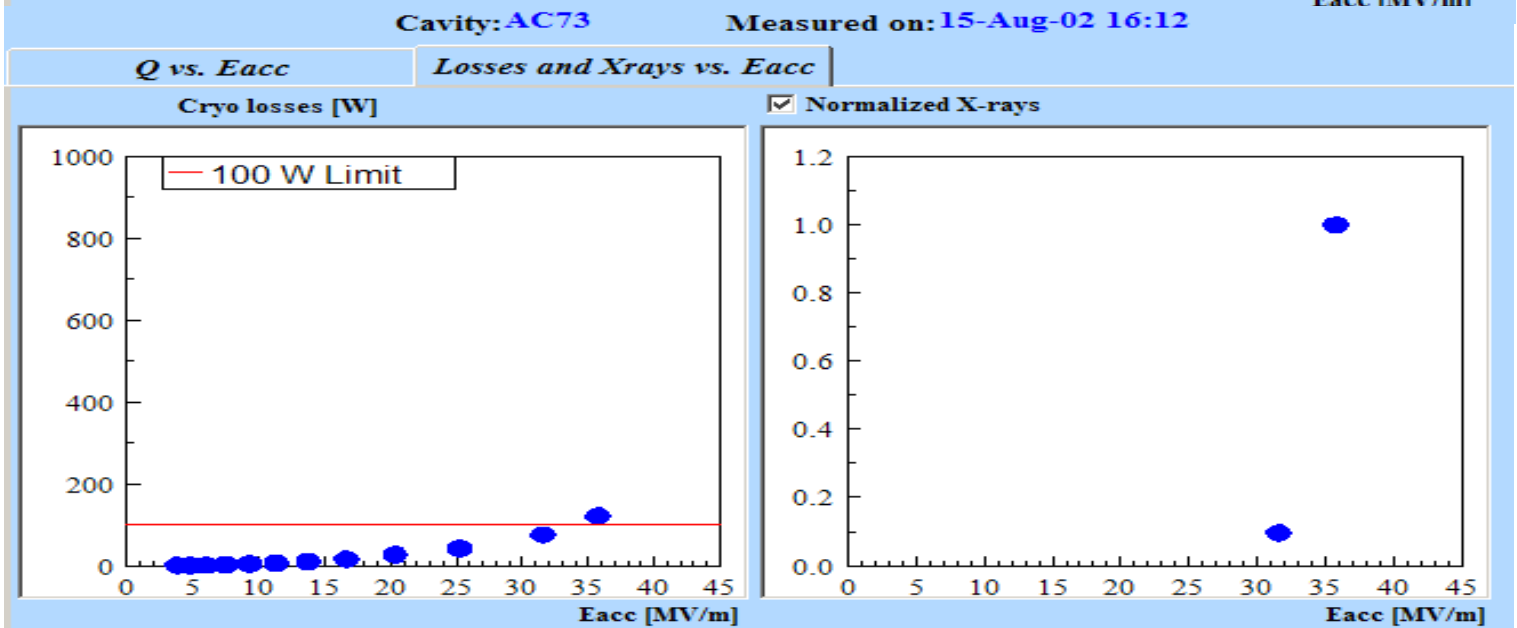




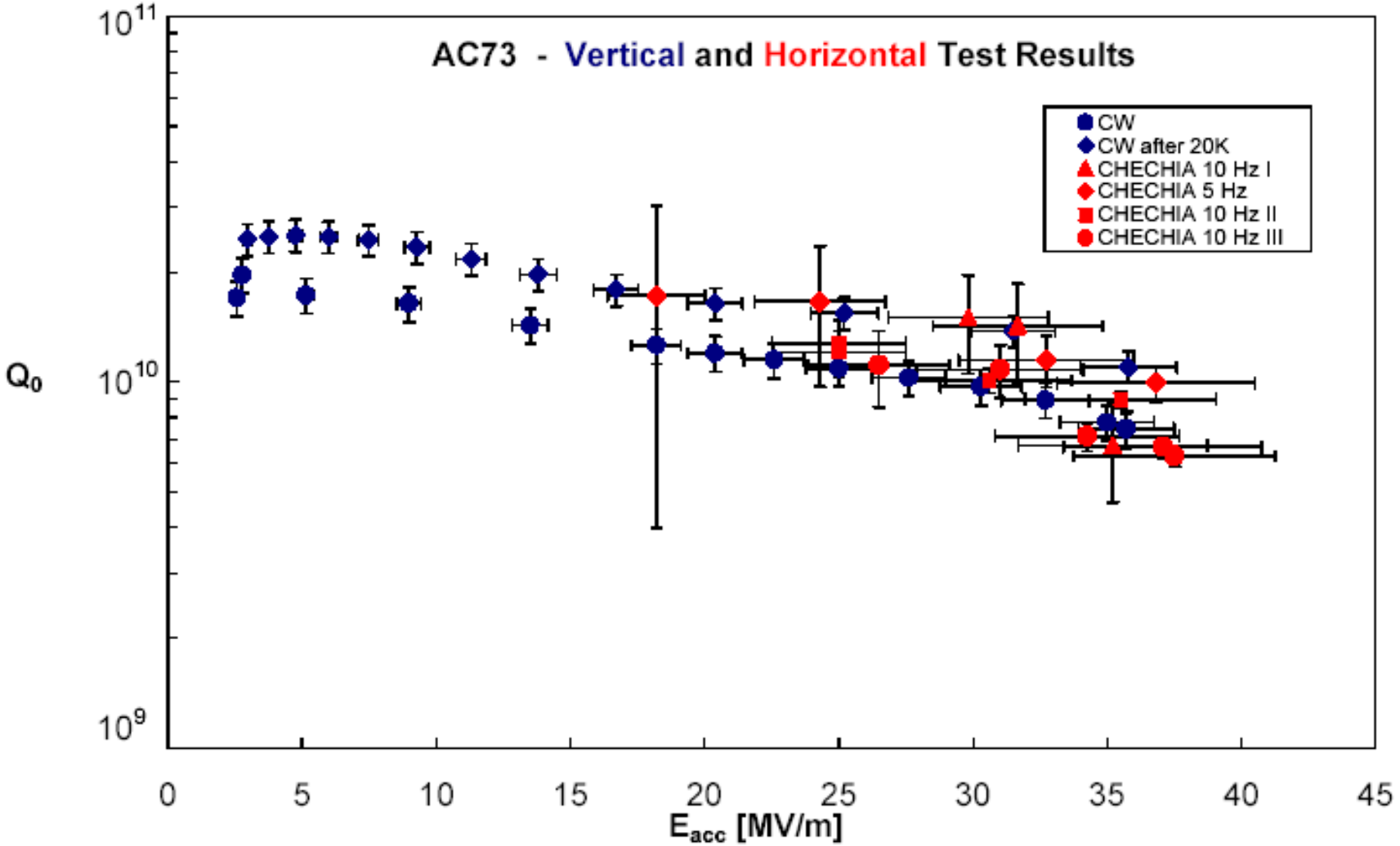
Results of vertical test´s


AC72 - Vertical and Horizontal Test Results
CW best
CHECHIA 10Hz I
CHECHIA 10Hz II
CHECHIA 5Hz
CHECHIA 1Hz
Q_0
10^{11}
10^{10}
10^{9}
0
10
20
30
40
E_{acc} [MV/m]

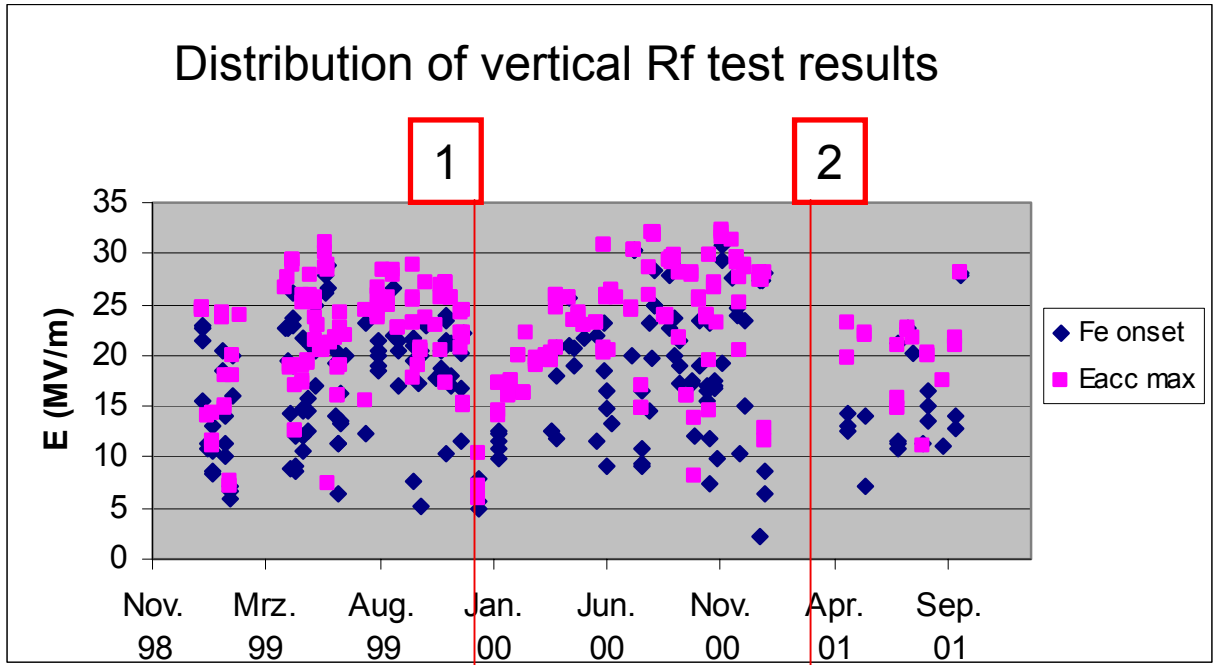


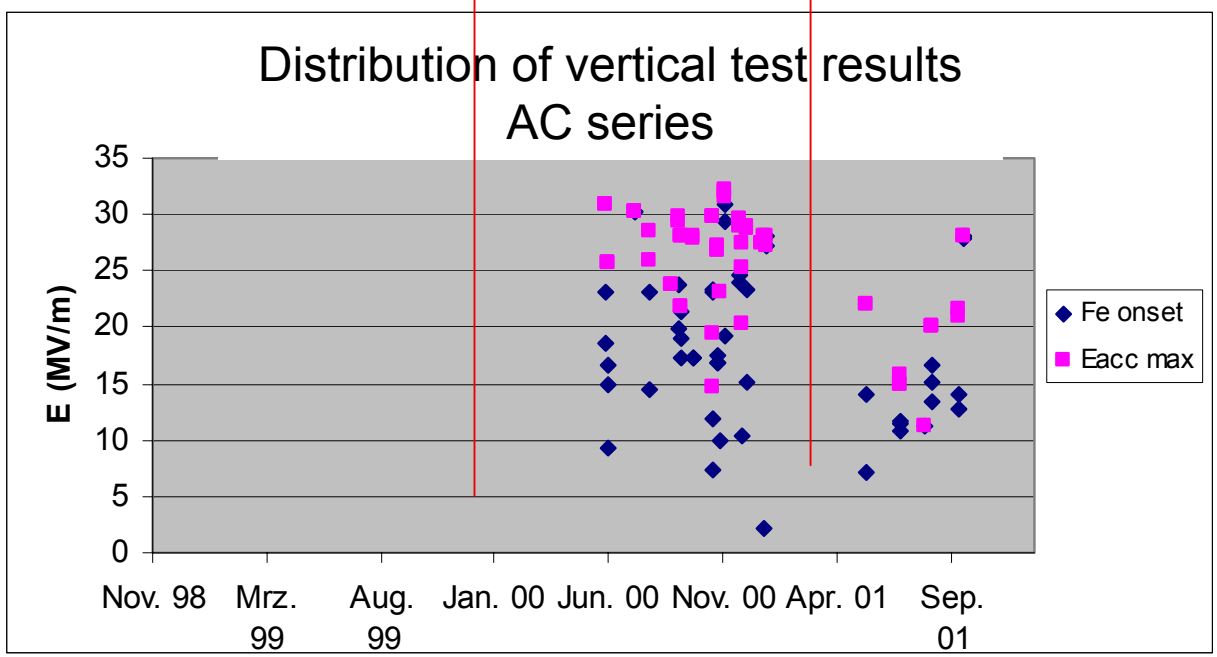


Results of vertical test´s

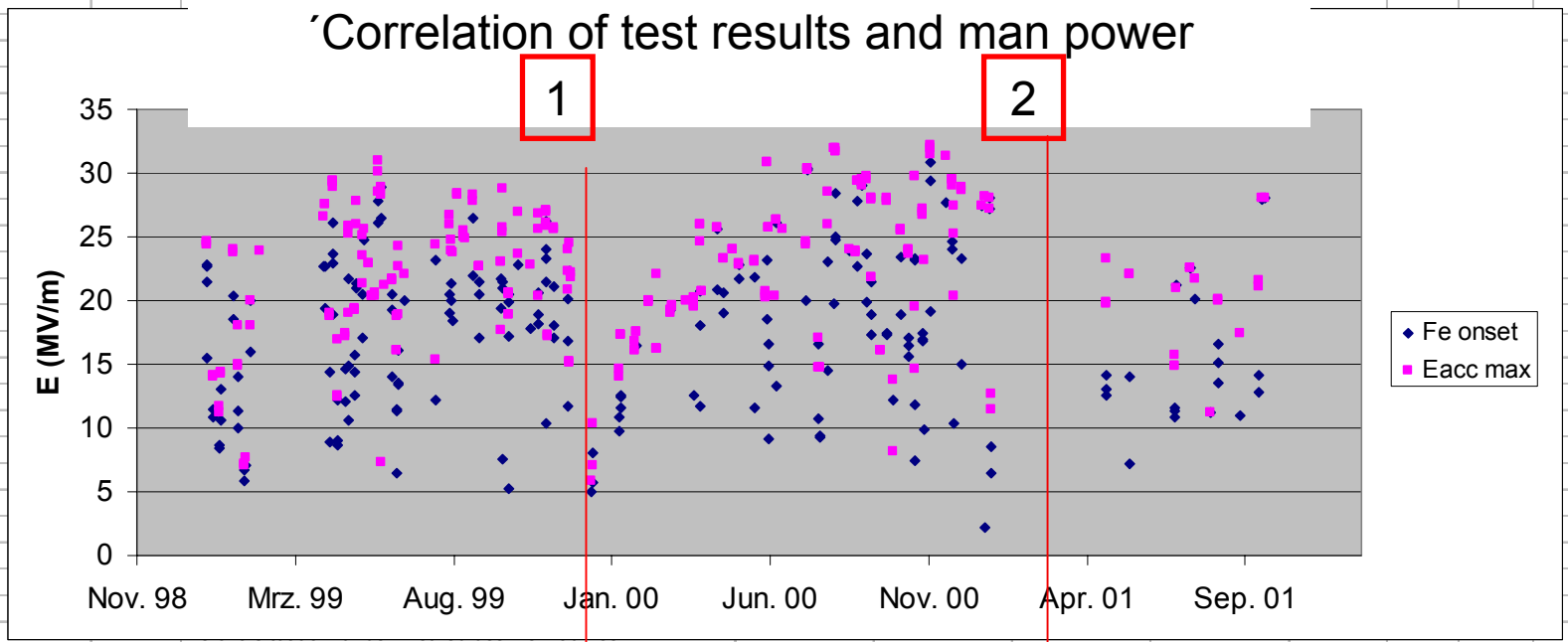

AC73 - Vertical and Horizontal Test Results
CW
CW after 20K
CHECHIA 10 Hz I
CHECHIA 5 Hz
CHECHIA 10 Hz II
CHECHIA 10 Hz III
Q_0
10^{11}
10^{10}
10^{9}
0
5
10
15
20
25
30
35
40
45
E_{acc} [MV/m]
Lutz Lilje
DESY -MPY-
01.10.2003

Cavity Performance versus time and events / reproducibility





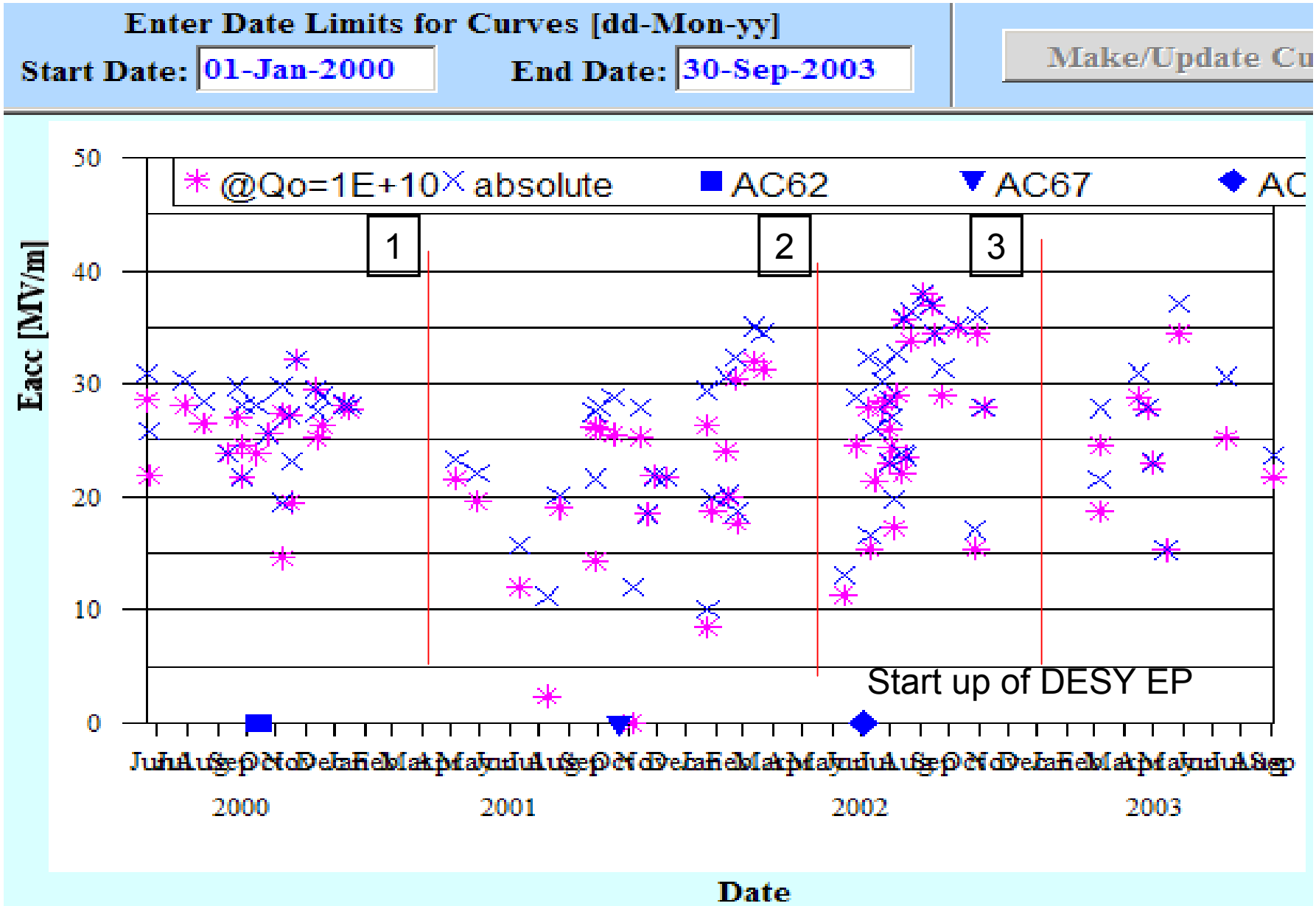
´Correlation of test results and man power



	98	99=<1	99=>2	99=>3	00=>1	00=>2	00=>3	01=>1	01=>2	01=>3	02=>1	02 =>2
1 Reinraum	z	z	z	z	z	D	D	D	D	D	D	D
3 Reinraum	z	z	z	z	z	z	z	z	z	z	z	z
2 Reinraum	z	z	z	z	z				Z (1-3 Jahre)		z	z
4 Reinraum	z	z	z	z	z	z	z		Z (1-3 Jahre)		z	z
5 Reinraum	z	z	z	z	z	z	z		Z (1-3 Jahre)		z	z
6 Reinraum	D	D	D	D	D	D					z	z
7 Chemie	D	D	D	D	D	D	D	D	D	D	D	D

Eingearbeites Personal
Einarbeitungszeit
nicht besetzte Stelle
Z= Zeitvertrag
D= Dauervertrag

Results of vertical test on AC cavity series



Some comments on reproducible high gradients / low field emission levels on srf cavities

Material and fabrication

High quality Nb available

Improved and high standard cavity fabrication available

Tools are available

•BCP for Eacc~ 30 MV/m Epeak 60 MV/m

•Electropolishing for Eacc 35-40 MV/m Epeak 70-80 MV/m

Gives improvement on surface /cleaning quality

•High pressure rinsing to fight field emission

BUT ! Facility has to be under control /intensive QC necessary

Sequences and personal structure

Preparation sequences are tested

Test set up for assembly build up and applied

Well trained personal !!!

Experiences on other than Nb surfaces

CU => Gun cavity for TTF / Power coupler / connecting bellows

In first order bad results
- CU surface oxidized strongly during treatments
- Chemical treatments more complicated
- Different results on different CU qualities

Most critical: Impact on UP water / CO from air start strong oxidations on Cu

Changes :
Chemistry => citric acid in use for final chemistry
Drying => Ultra pure alcohol for fast drying
Oxidation=> N2 inert gas overlay on UP water rinsing basin
HPR => strong N2 gas overlay on tank and rinsing cane

But we still do not have lots of experiences and need more investigations

Results on Gun cavity : Improvement compared to standard treatment
low dark current was seen