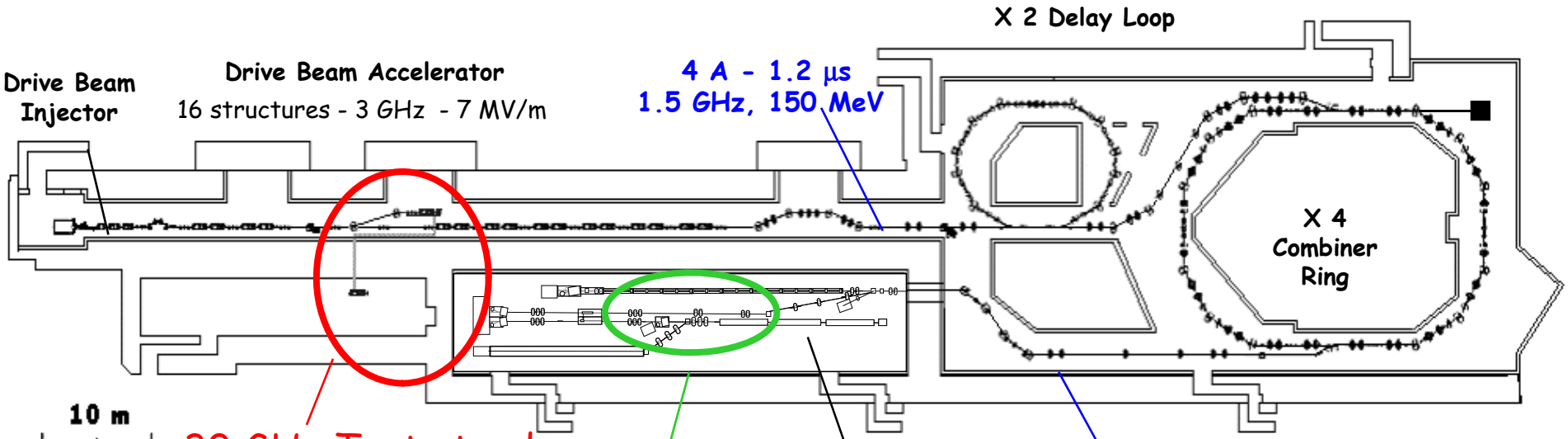
Recent 30 GHz high-gradient results

- 30 GHz test stand in CTF3
- Recent 30 GHz tests
  HDS4_vg2.6_thick
  NDS4_vg2.5_thick
  C40vg7.5_pi/2
  C30vg4.7_speed bump
- Conclusions and Outlook

Rf power production with CTF3



Two Beam Test stand 12 GHz

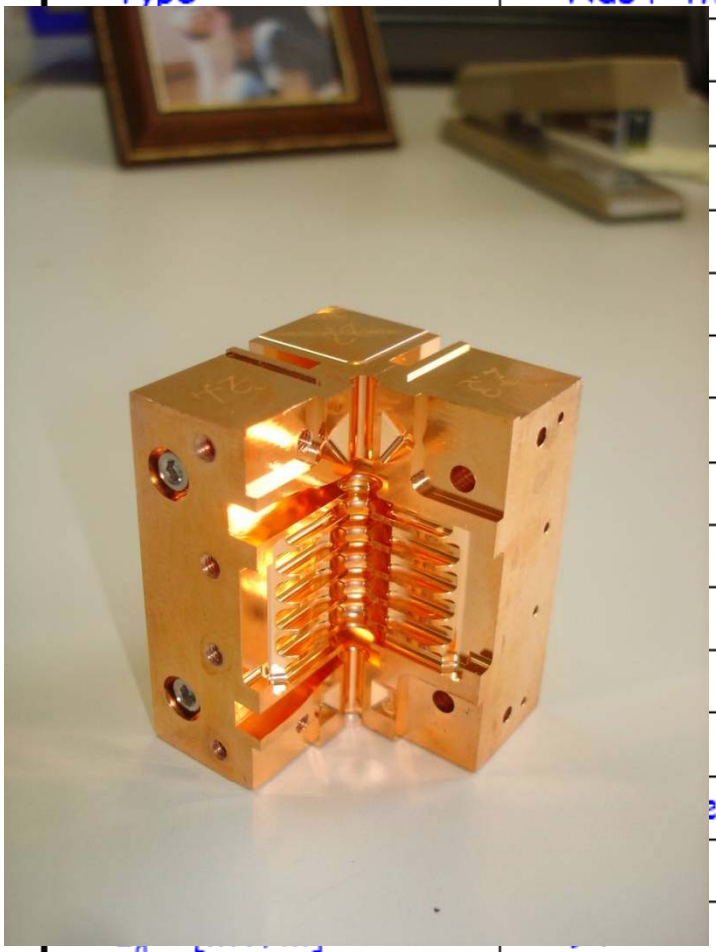
200 MW, 140 ns

TBL, 16*160 MW, 140 ns

Relevance of 30 GHz tests for x-band

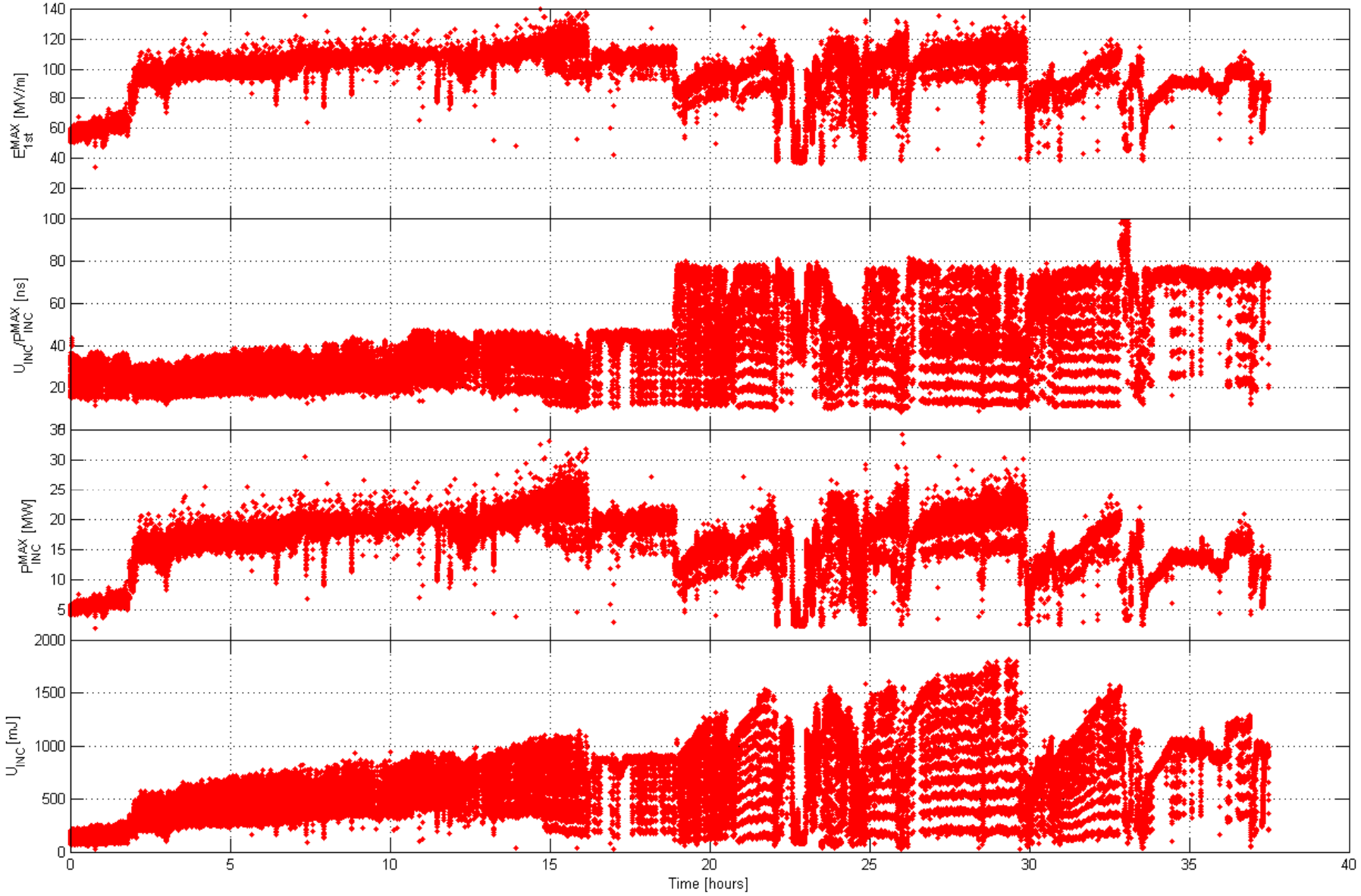
- Get data on frequency scaling
- Scaled structures show very similar performance
- Economical high power testing
  (exotic ideas, materials)
- Additional testing slots
- Breakdown physics studies

Parameters for 30 GHz test structures

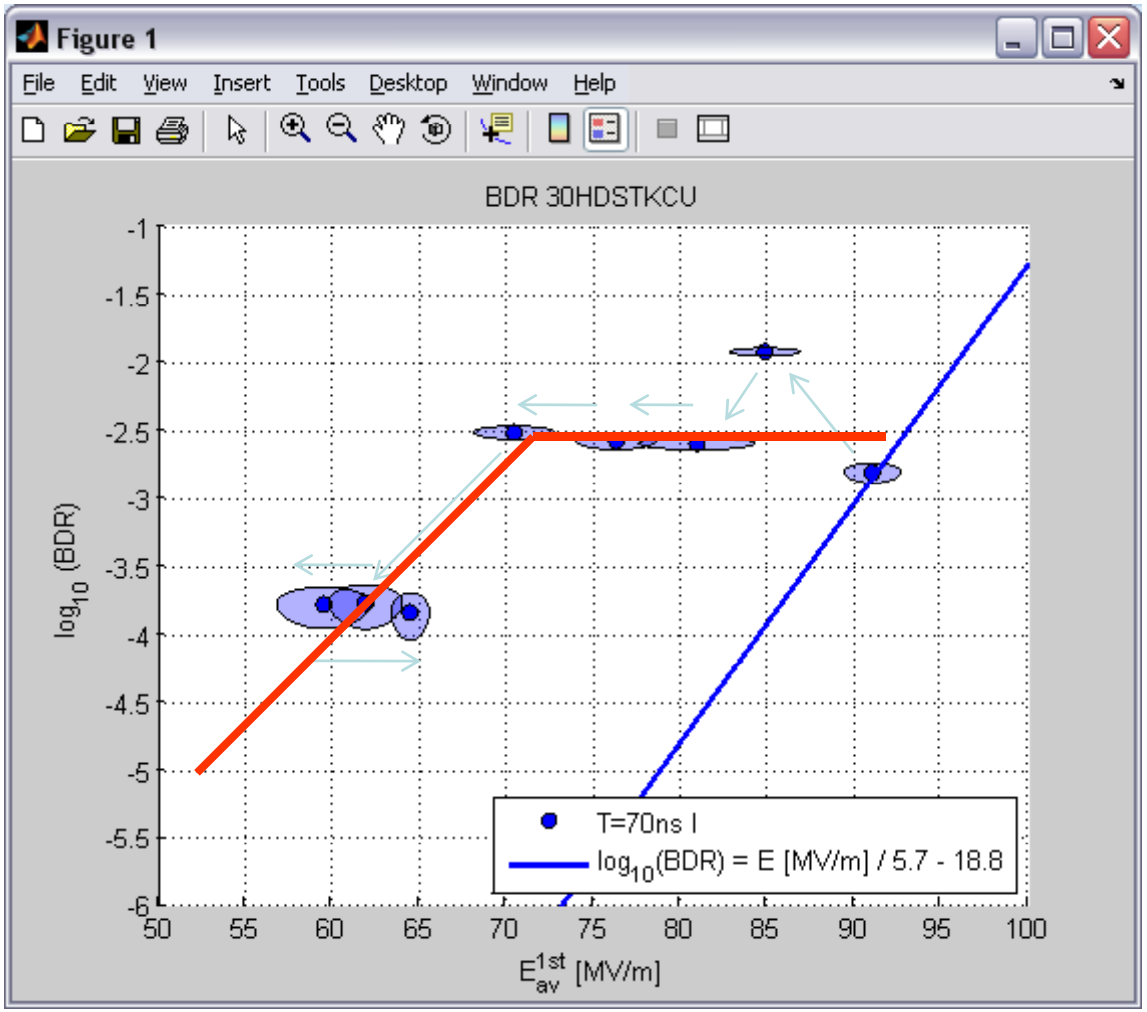


Type	Nds4_thin	Nds4_thick	Hds4_thick	Hds11_r1.2
		150	150	60
		1	1	0.55
		1	1	2
		1.75	1.75	1.2
		1.75	2.1	1.8
		1.1	1.1	0.55
		5250	4610	2350
		2.46	2.57	2.0
		25600	24500	41900
		2.2	2.4	1.7
		3.2	4.4	3.1
		15.3	16.7	7.6
		e @ 70ns, BDR=10^{-3} for circular and hds (75% of circ)		
		19.7	14.8	10.1
		113	94	115
E_{surf}^{max}[MV/m]	244	250	226	196

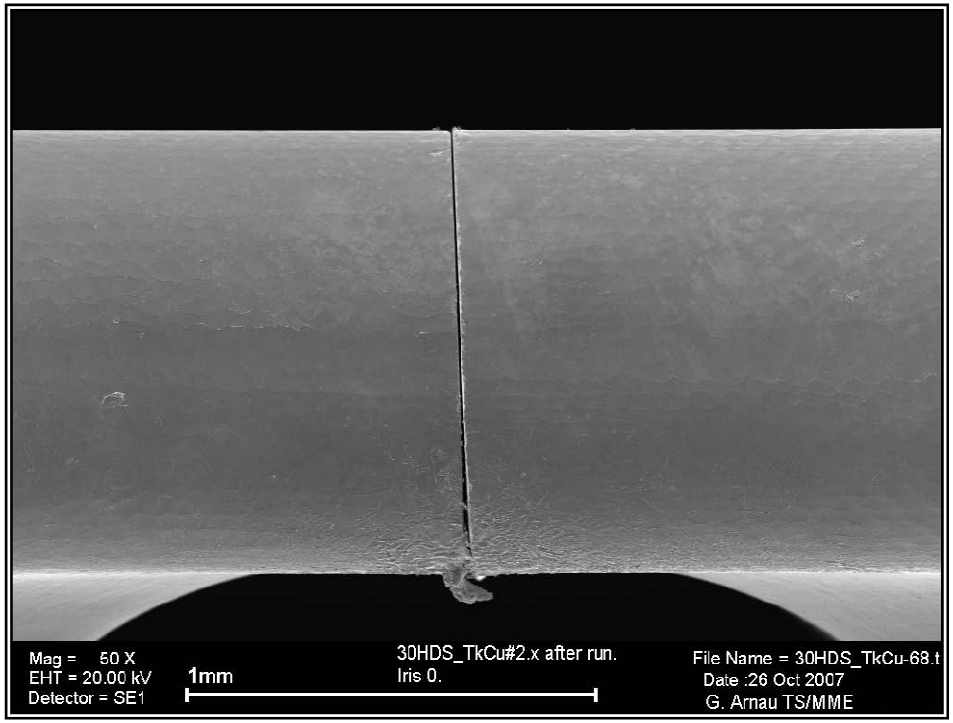
Conditioning history HDS4_vg2.6_thick

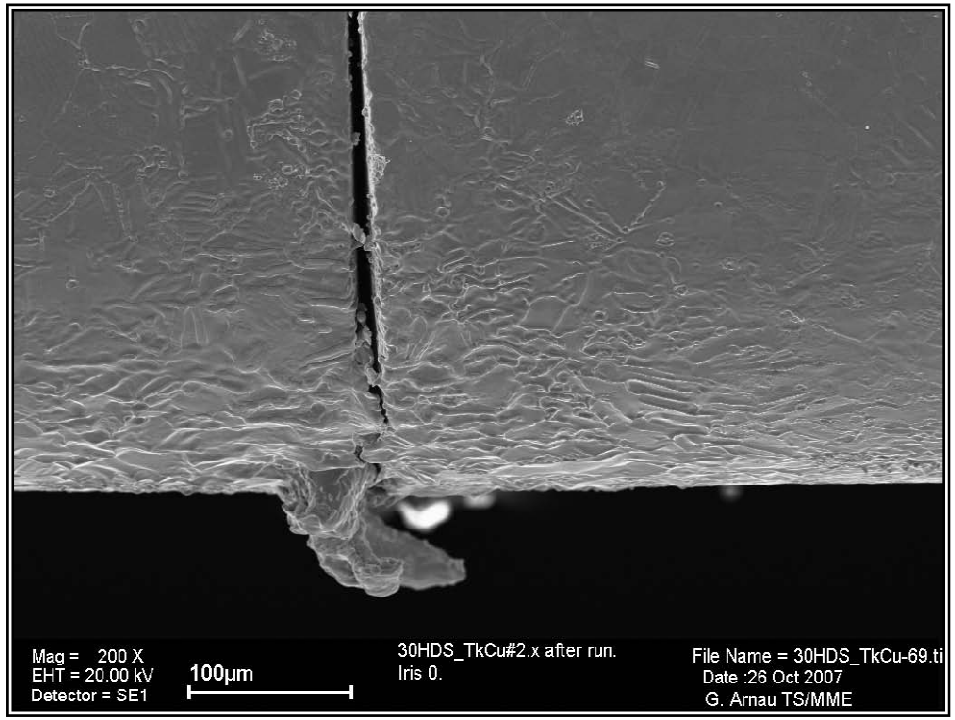


HDS4_thick results, 70 ns



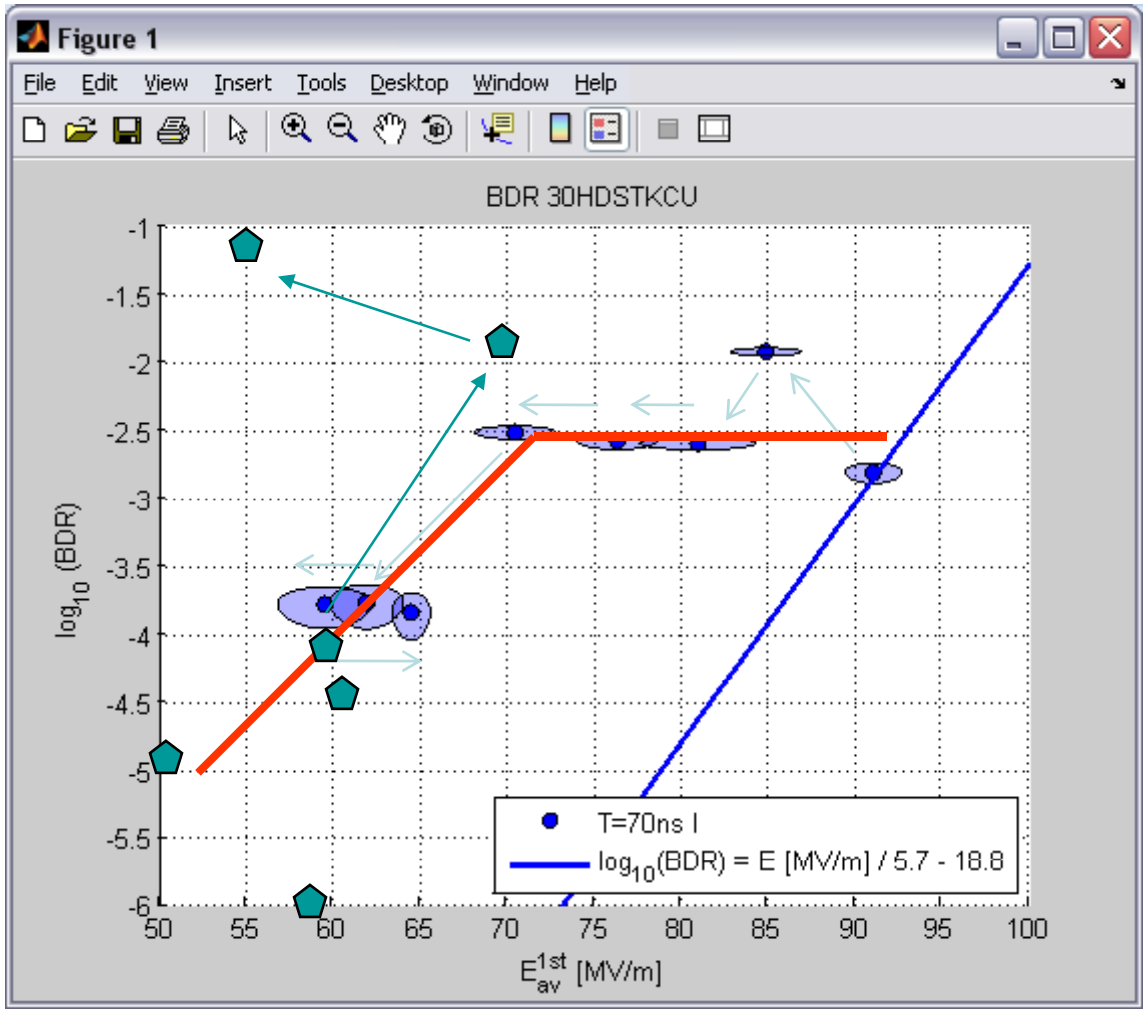
HDS4_thick post mortem





Burrs found in the slot areas and on the matching cell iris

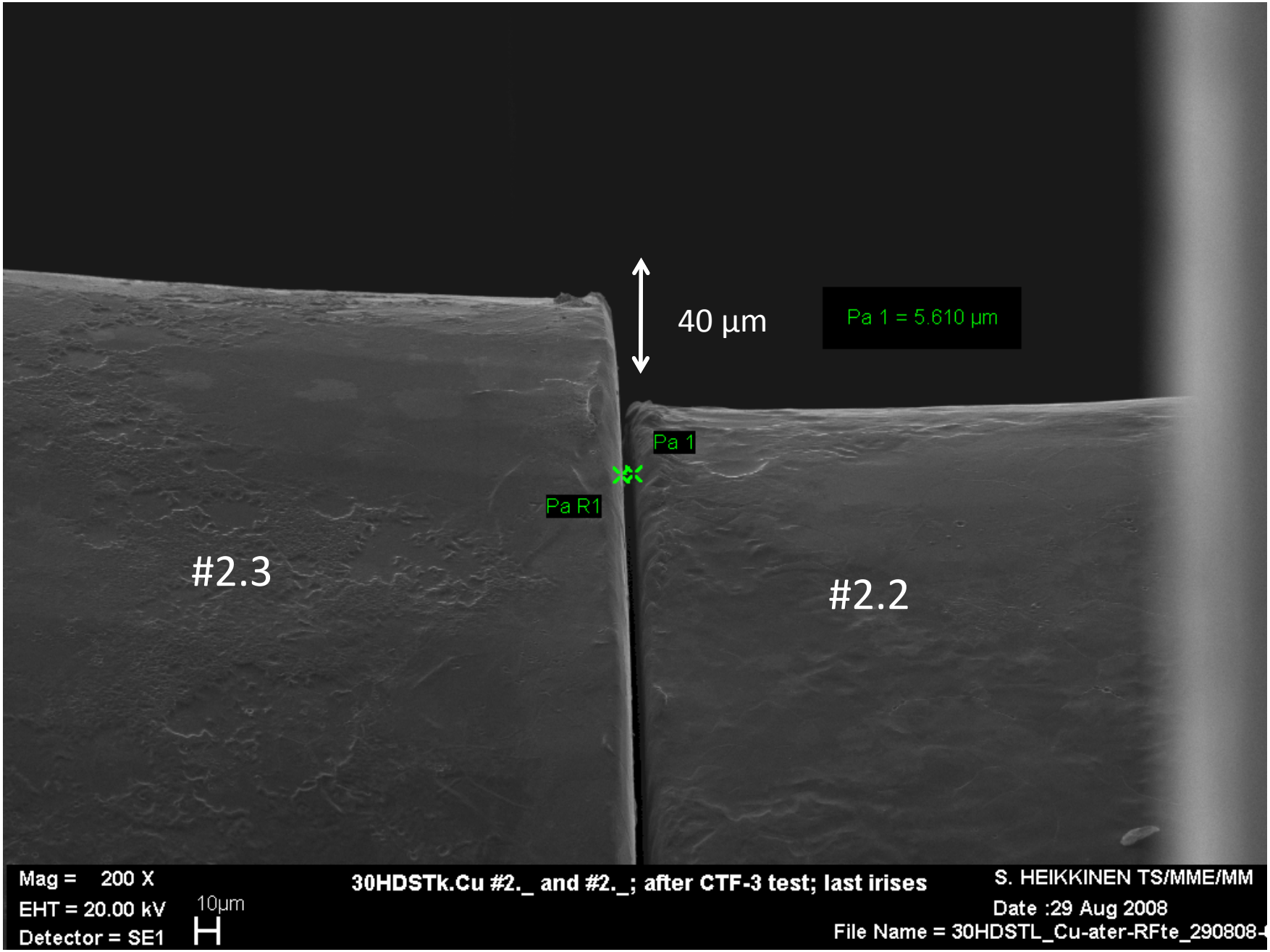
HDS4_thick retested after burr removal, subu and 800 deg heat treatment



New data, ~60 ns

Result: no improvement, typical HDS damage pattern

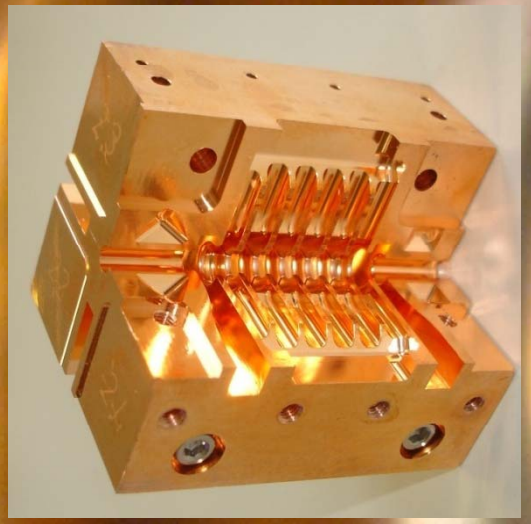
Post mortem SEM inspection (S. Heikkinen)



First iris aperture
Original CTF-3 assembly

Quadrant #2.3

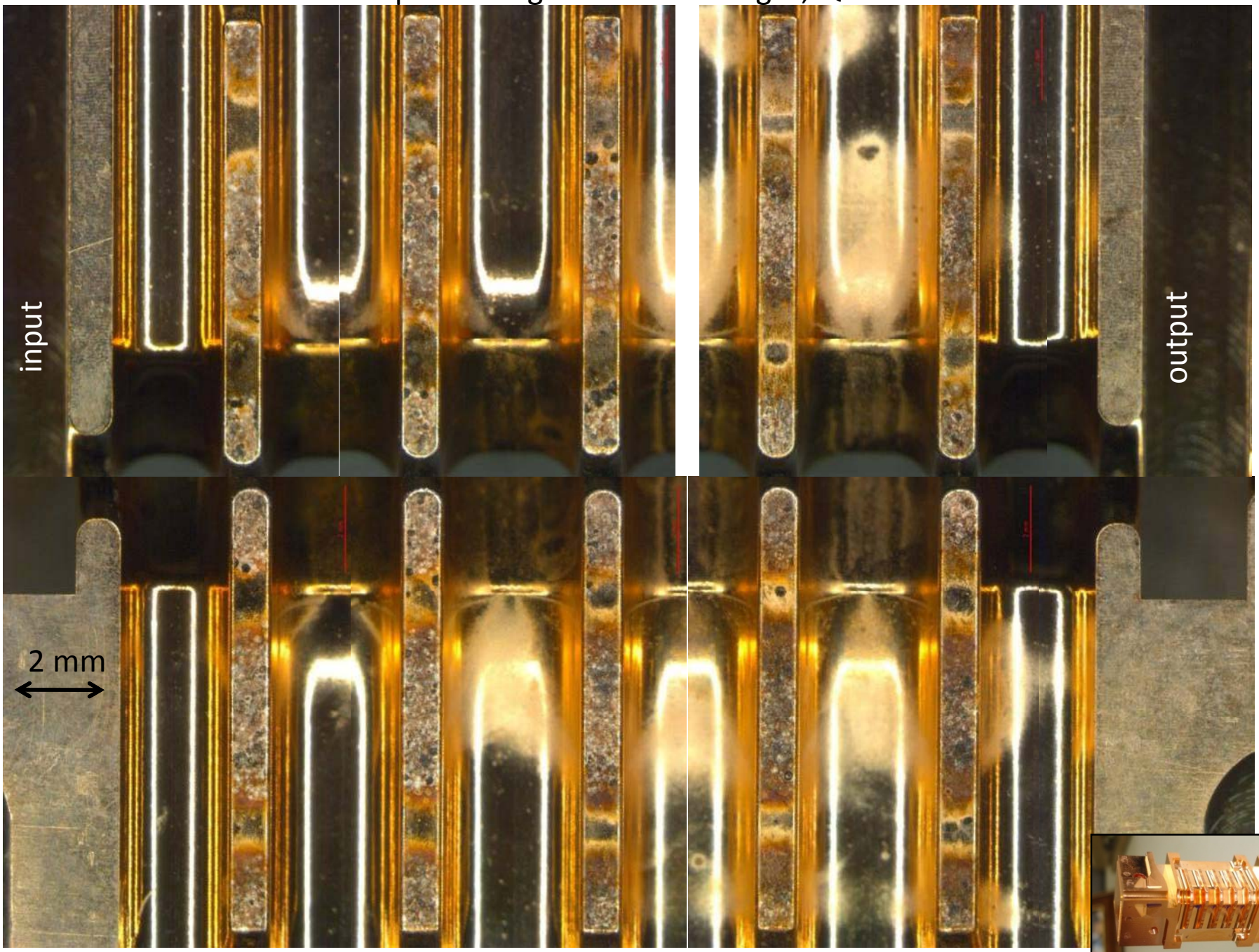
Quadrant #2.2



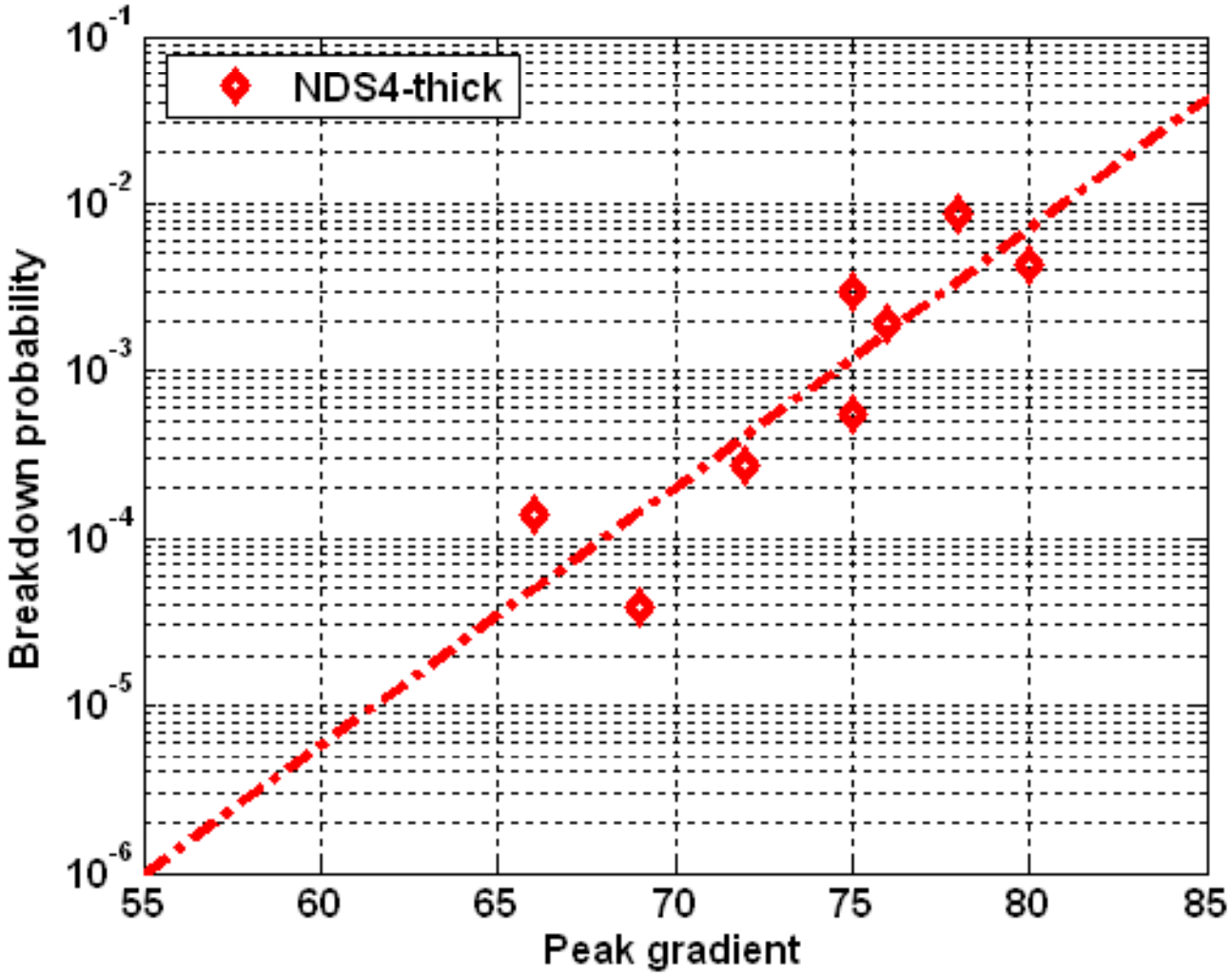
Quadrant #2.4

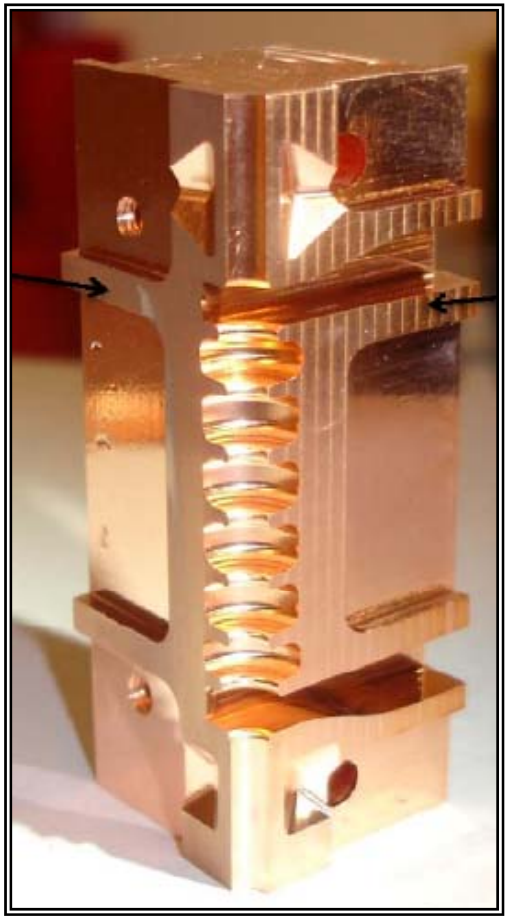
1 mm

Optical images of the Iris ridges, Quadrant #2.1

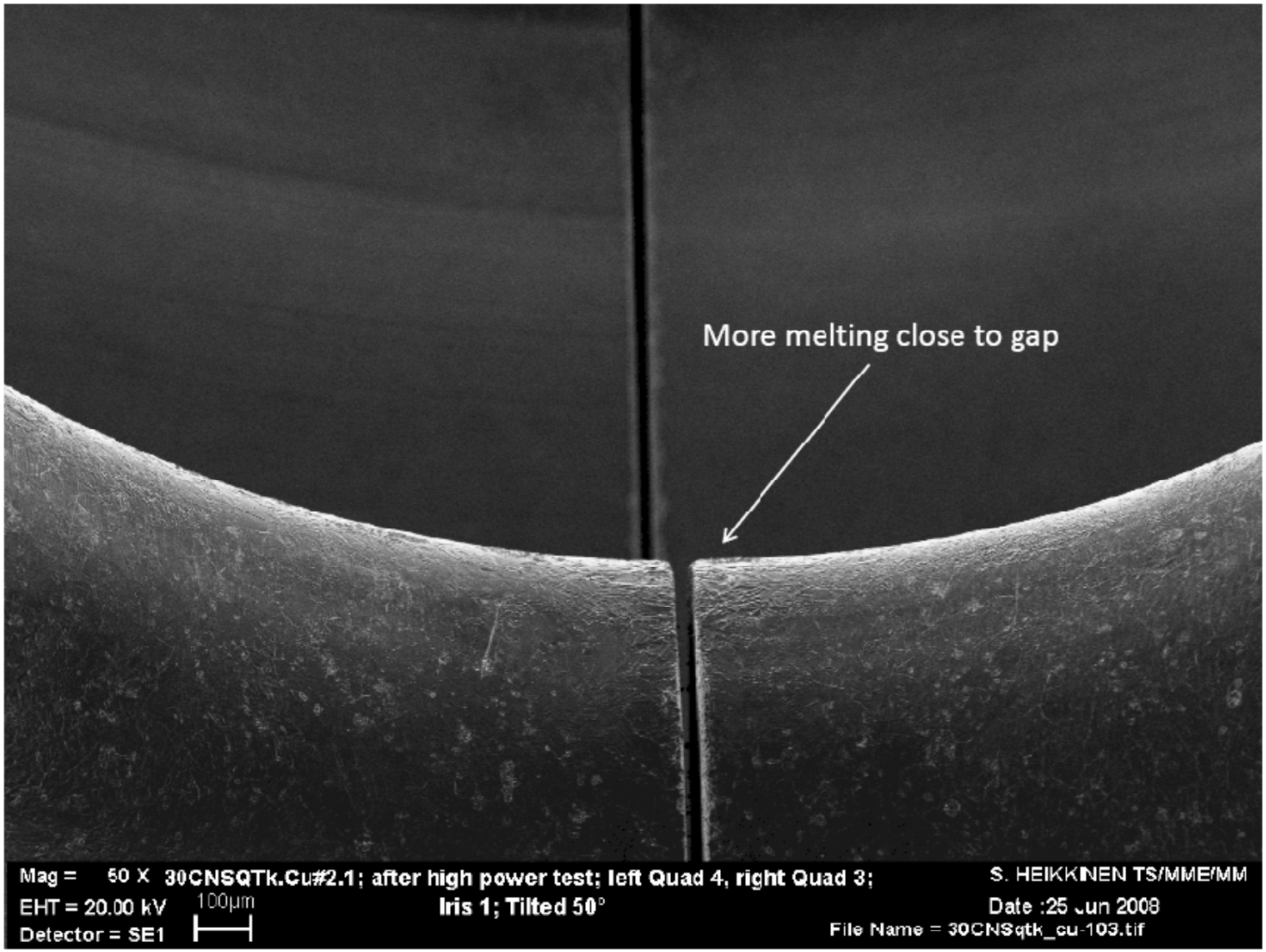


NDS4_vg2.5_thick result

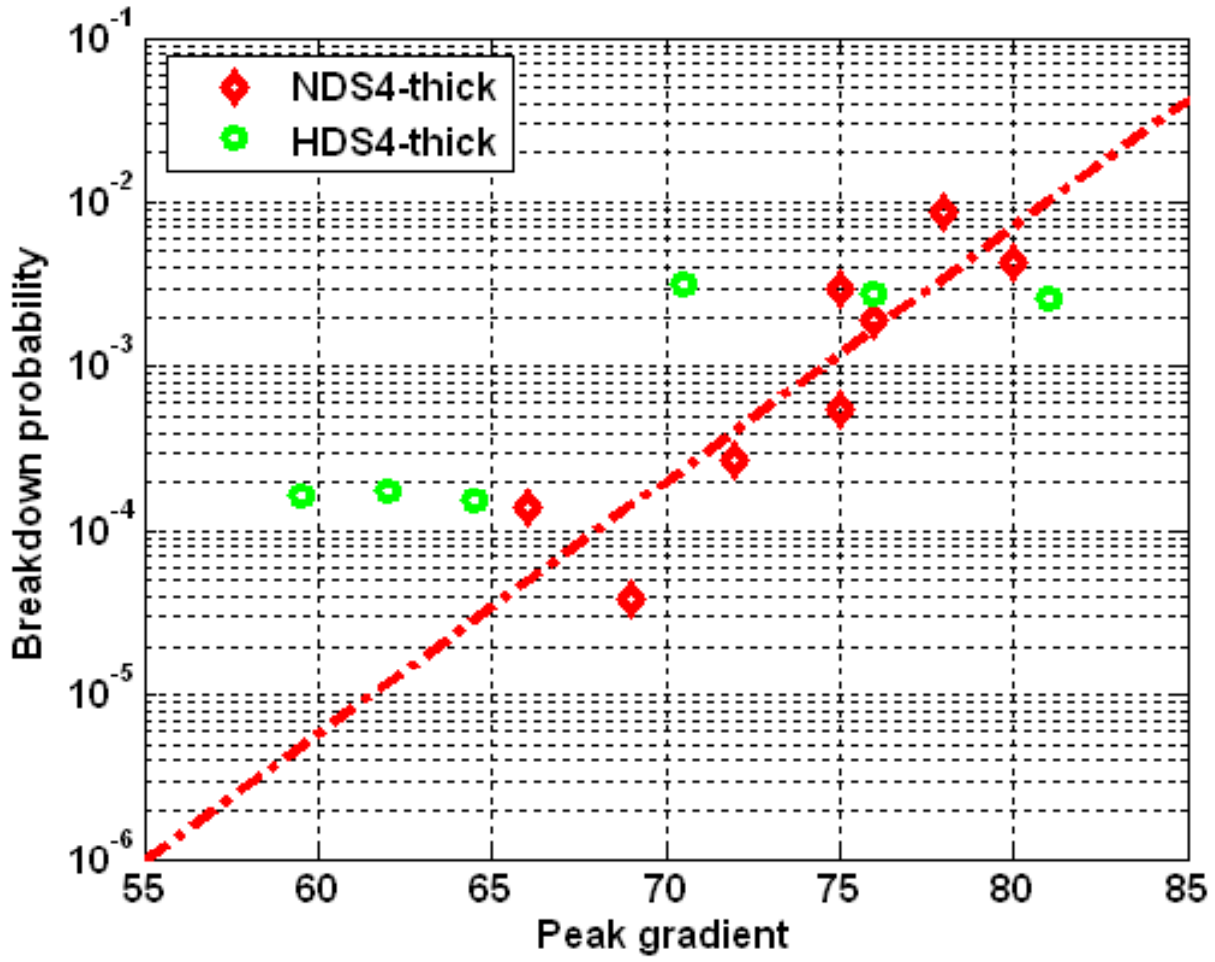




NDS4_vg2.5_thick SEM inspection



NDS4_thick vs HDS4_thick



Comparable performance with and without slots

C40vg7.5_pi/2

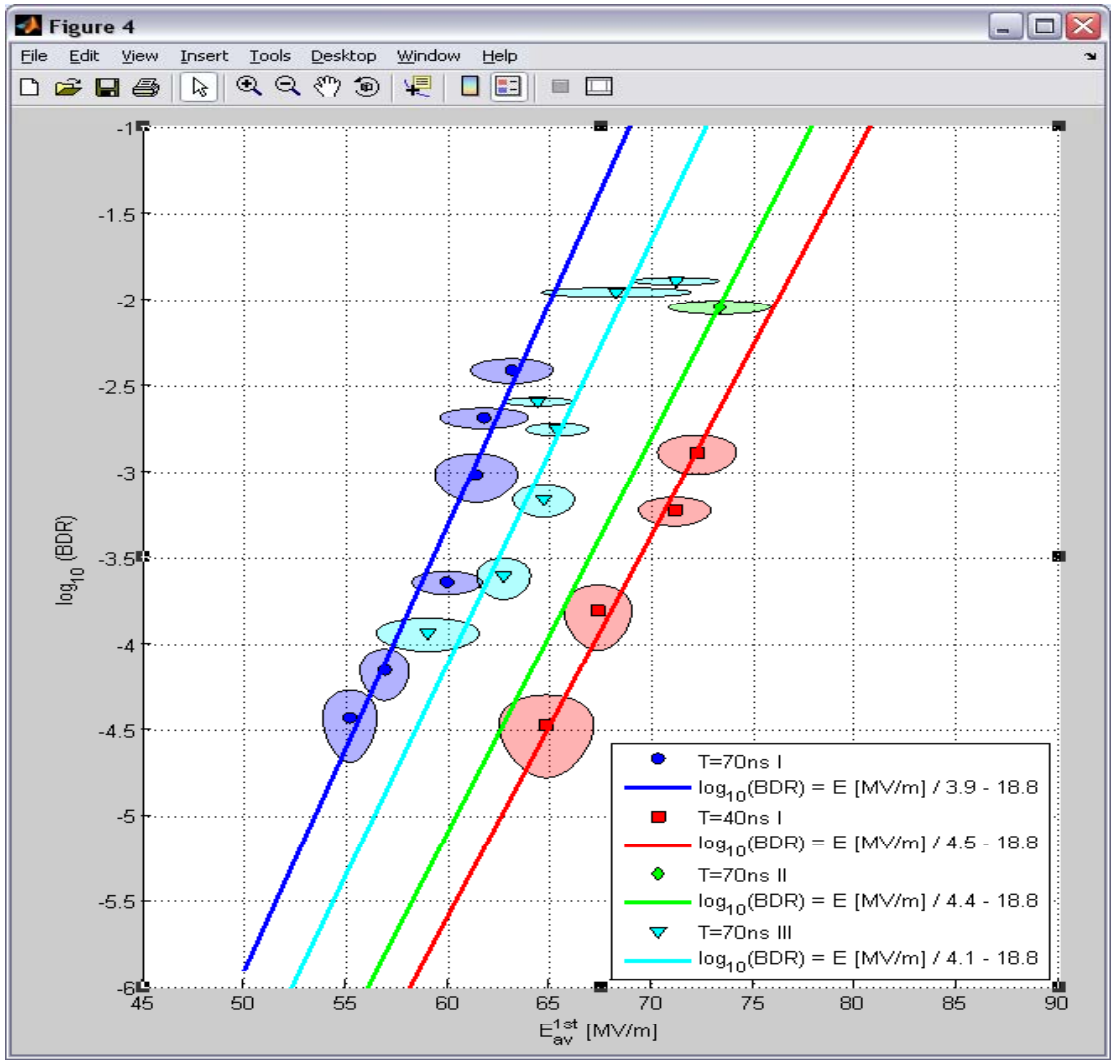
Original motivation: shorter phase advance, lower surface field
→ gain back in aperture

similar surface field to accelerating field ratio by bigger aperture, higher vg and higher power

Old structure from 2002, cleaned after being exposed to air since fabrication.

New motivation: Bad results with short phase advance structures
HDS series, test of phase advance and P/C

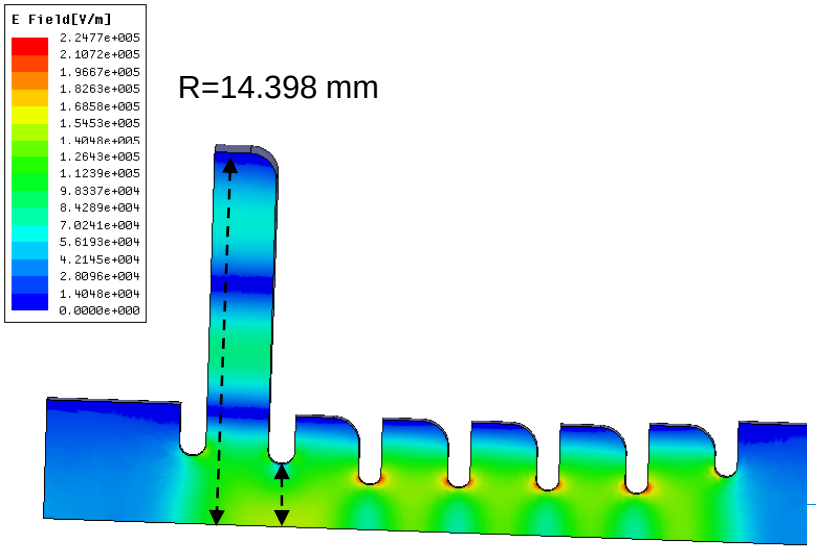
Short phase advance: C40vg8_pi/2



30 % less gradient than 2pi/3 structure, but comparable power

Speed bump motivation

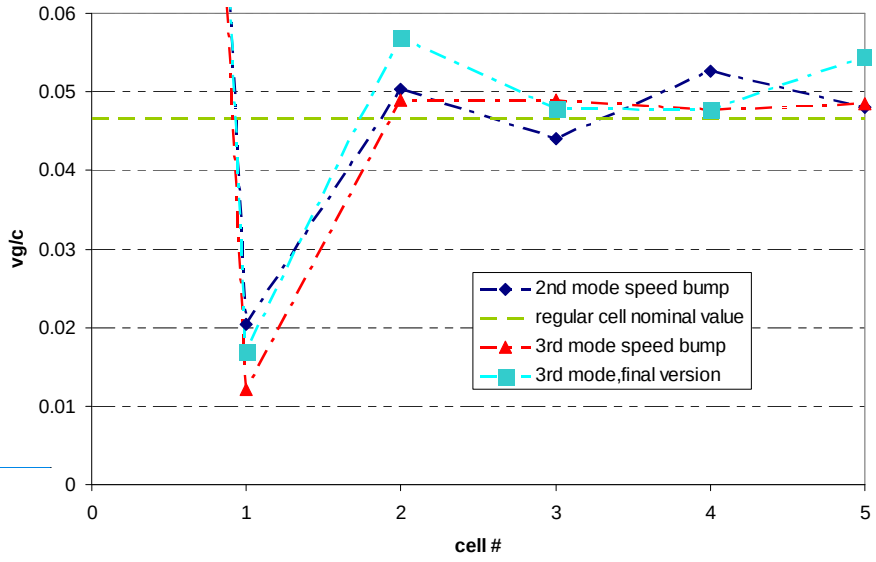
- Speed bump structure was designed to protect structure with a low group velocity cell and possibly boost performance because surface could sustain higher fields without damage



R=14.398 mm

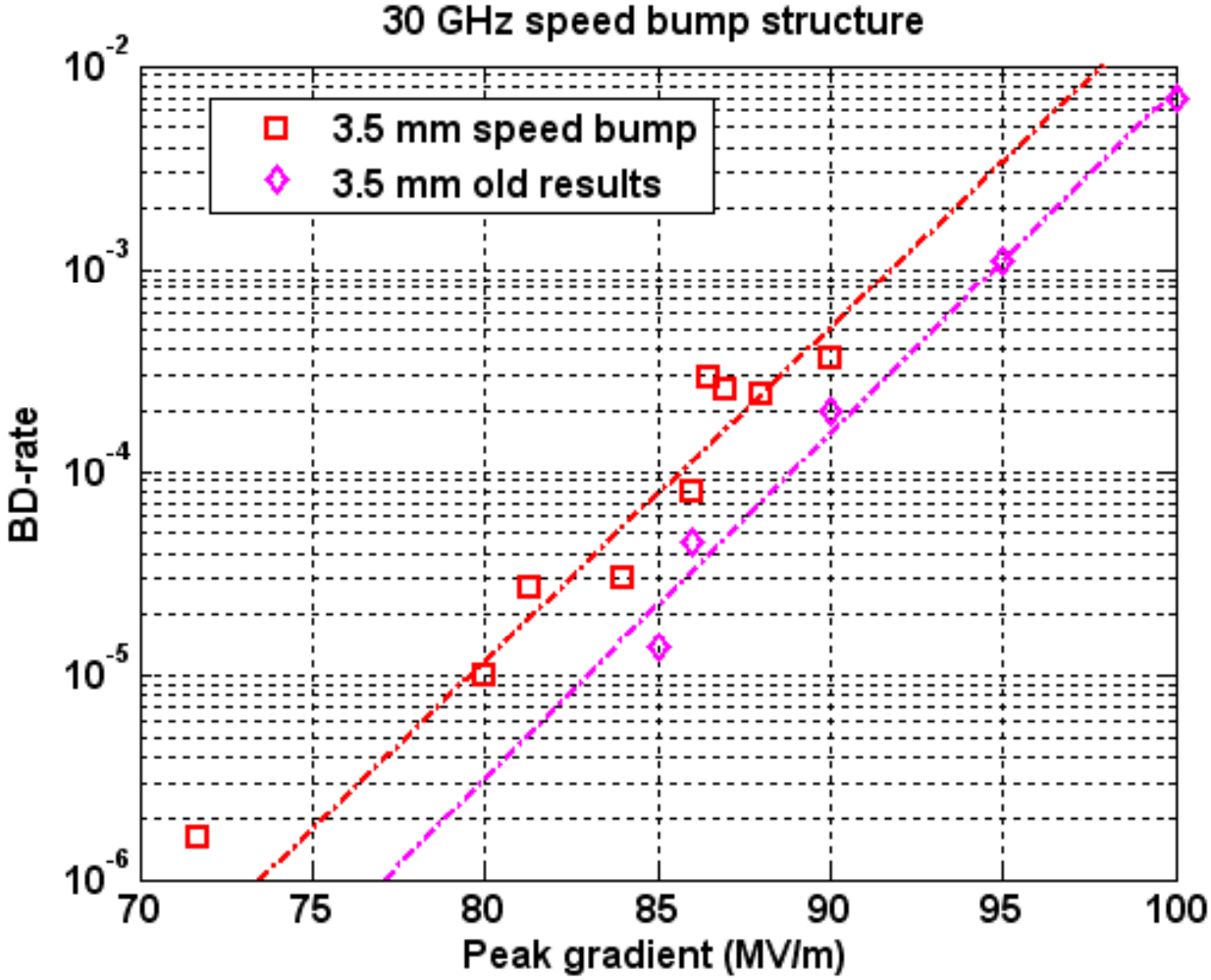
R_iris= 2.428 mm

Iris_thickness= 1mm



Riccardo Zennaro

Speed bump results at 70 ns



Structure reached very similar performance as the old 3.5 mm structure (about 2 % difference lower in gradient for fixed breakdown rate)

Summary of 30 GHz results

All measured data at 70 ns pulse length and 10^{-3} breakdown rate
(Sc- value scaled to 100 ns and 10^{-6} breakdown rate)

Structure	2a (mm)	P (MW)	E (MV/m)	Sc (MW/mm^2)	$PT^{1/3}/C$ (wue)
C30vg4.7	3.5	21.0	94	3.3	7.7
HDS60vg8.0	3.8	16.1	61	2.7	5.6
HDS60vg5.1	3.2	13.3	75	3.0	5.5
C40vg7.4_pi/2	4.0	19.2	65	2.3	6.2
HDS4vg2.6_thick	3.5	7.5	67	1.6	2.8
NDS4vg2.5_thick	3.5	8.6	75	2.0	3.2
C30vg4.7_sb	3.5	20	92	3.2	7.5

Round brazed structures show better performance

Conclusions

- **30 GHz results are relevant for CLIC at X-band**
- **Some doubts on P/C theory**
  (prediction of tested structures including those optimized with this assumptions, new developments on theories)
- **Quadrant technology appears not mature**
  (alignment, surface quality, performance)
- **Short phase advance seems not beneficial**
- **Speed bump seems not able to protect the structure**

- **Most likely we will stop 30 GHz testing at the end of this year**

What's wrong with the quadrants ?

an experimental point of view

- **What's different:**

damping slots	HDS-type vs NDS-type (no slots)
surface finish	milling vs turning
alignment	field quality, small gaps (10-20 μm)
phase advance	60, 120 and 150 deg tested
rf design	identical structures made in disks and quadrants
clamping/brazing	no high temperature brazing needed

- **What did we learn in testing:**

damping slots seems not to be the main problem, but…
phase advance changed but no improvement
heat treatment at 800 and 1000 deg tried with no significant effect
electro polishing/subu applied with no significant effect
strange degradation of the performance observed
suspicious activity in slot areas

- **Waiting for the results of TD18_quad**

30 GHz break down R&D program in CTF3

Possible list of 30 GHz experiments

- C30_vg4.7_sb (speed bump)
- C30_vg2_TM02 (vg)
- C30_vg2.6
- T28 at 30 GHz ?

The End

Spare slides

30 GHz flow chart