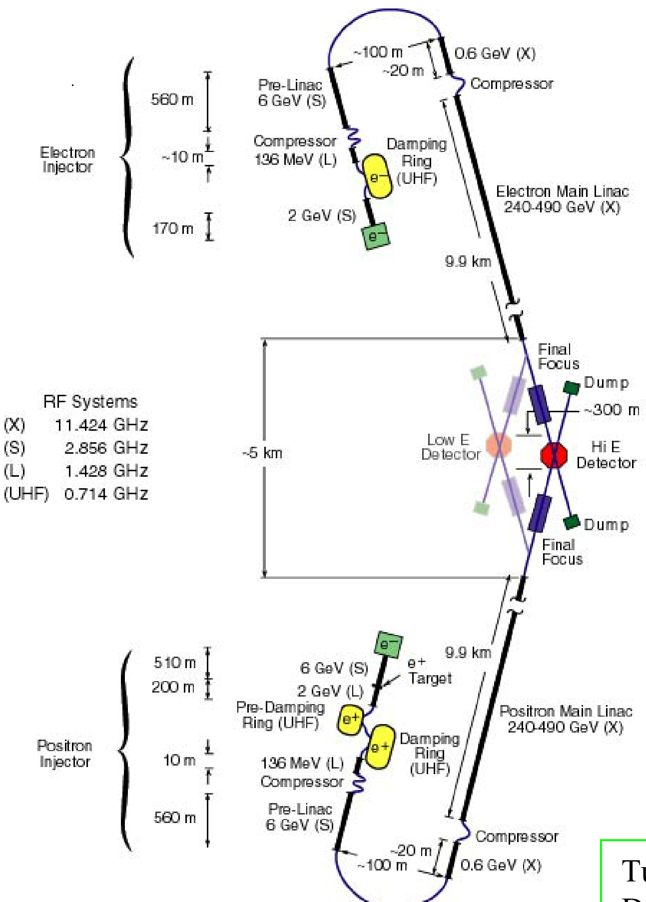
NLC structure electrodynamics design and test results.

July 11, 2003

G.Romanov

JLC - NLC Accelerator Physics

NLC Next Linear Collider



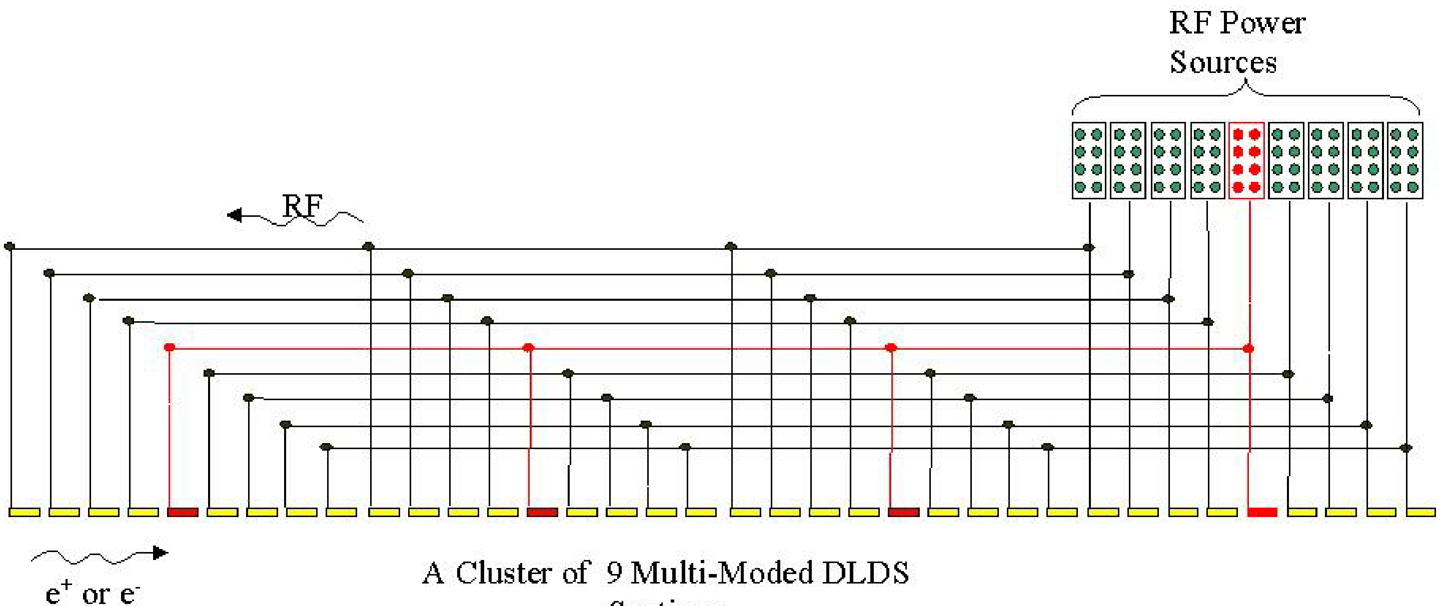
Two Purposes in support of LC R&D:

- build and demonstrate the technical feasibility of multiple structures (same as converge on a "final"design)
- develop the route to mass-produced structures along with determining their final cost.

- Seven Elements of the RF Factory
  - RF Design *
  - Produce Copper / Machine Copper *
  - RF Measurements & Development / Low Power *
  - Structure and Vacuum *
  - Mechanical Measurements of Straightness *
  - Brazing / Bonding Facility *
  - High Power Processing

From David Finley's Presentation at the May 31, 2000 NLC Collaboration Meeting at Fermilab

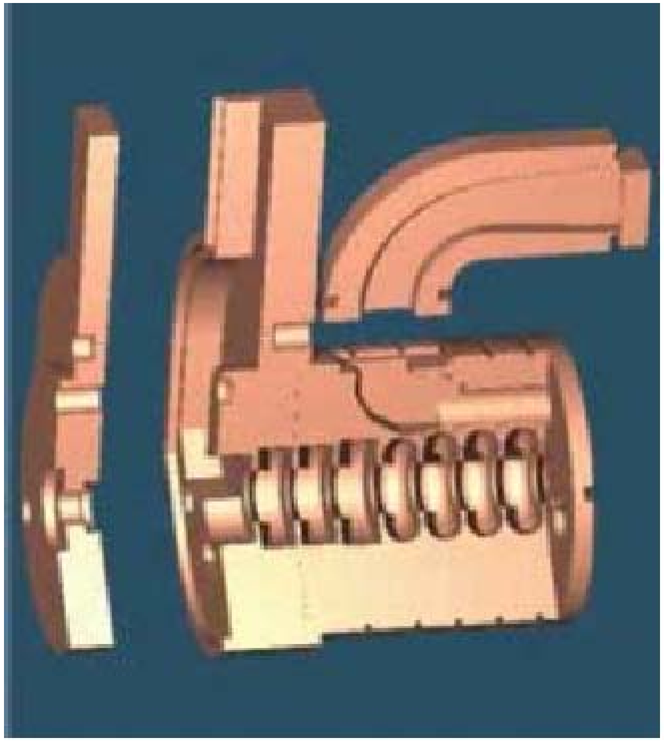
Tug Arkan, Marco Battistony, Cristian Boffo, Evgeny Borissov, Harry Carter, David Finley, Ivan Gonin, Timergali Khabiboulline, Gennady Romanov, Nikolay Solyak



A Cluster of 9 Multi-Moded DLDS
Sections

A Single Multi-Moded Delay Line RF
Distribution System

Traveling wave constant gradient detuned damped accelerating structure

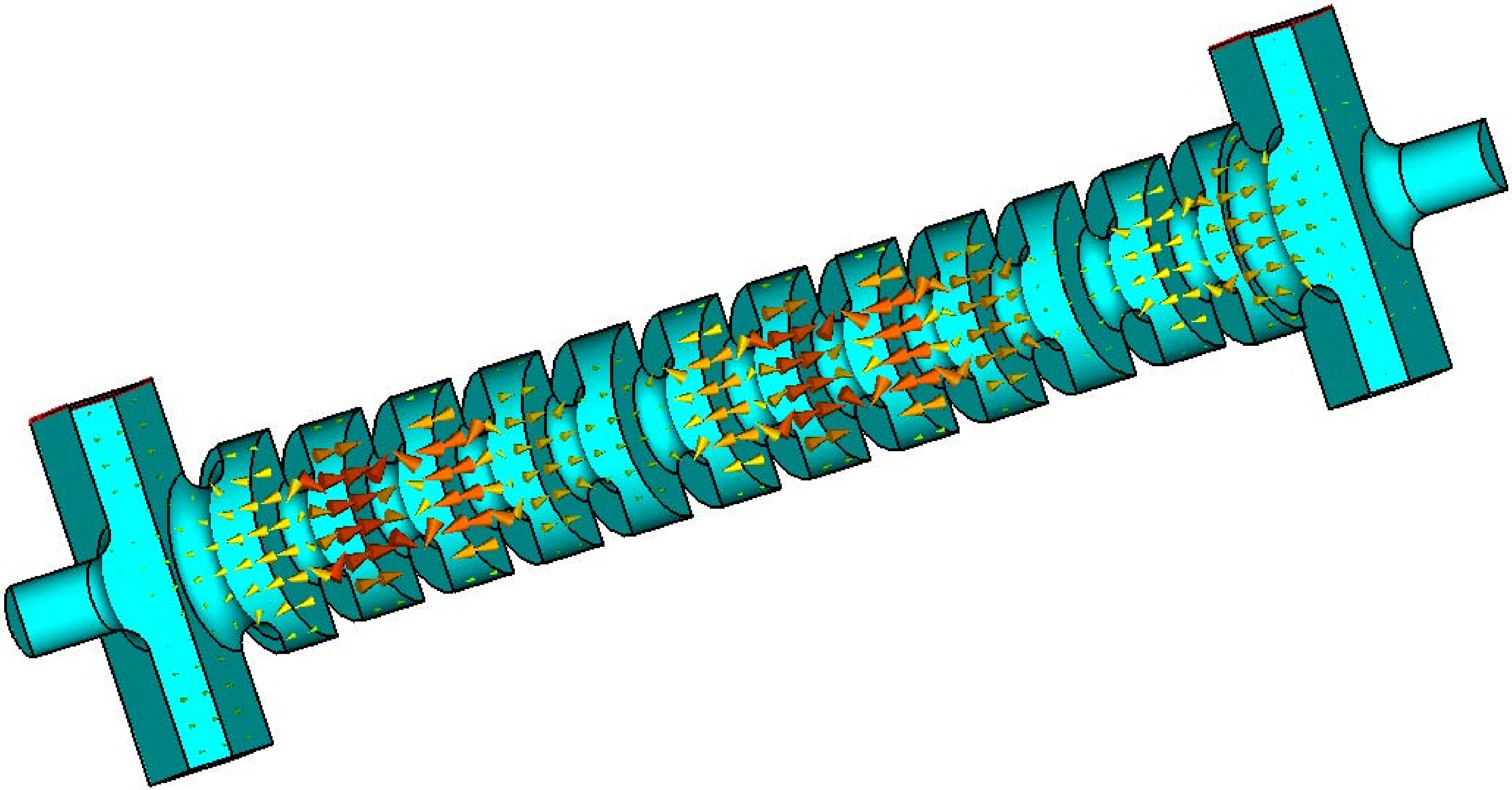


RDDS1

Description: 1.8 m long Rounded, Damped-detuned Structure (RDDS) used in the NLC X-band linacs. "Y" style input rf coupler; double horizontally symmetric output couplers each terminating in water cooled high power rf loads. Internal and external HOM loads. **Average unloaded gradient of 72.3 MV/m,** effective loaded gradient of 55 MV/m. A diffusion brazed assembly of 206, longitudinally coupled copper cells 60 mm OD and 8.75 mm thick which are precision machined to micron tolerances. Integral to the assembly are rf bpm feedthrus brazed to the HOM manifolds. Vacuum pumping is symmetric to both sides of the structure to stabilize vacuum loads.

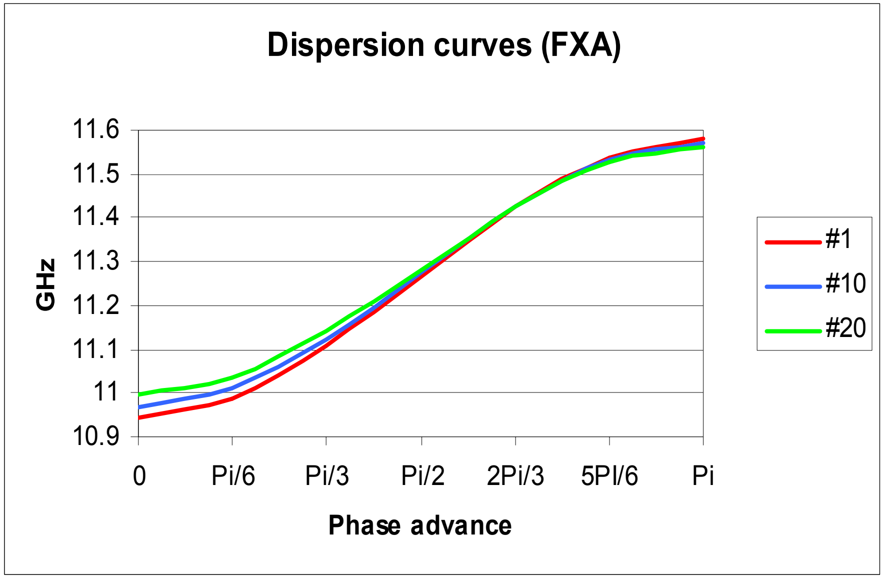
note(1): <3 breakdowns/hr at operating gradients

In spite of all parameter variations, it's still
…traveling wave…



FXB type, 150° phase advance, FNAL waveguide couplers,

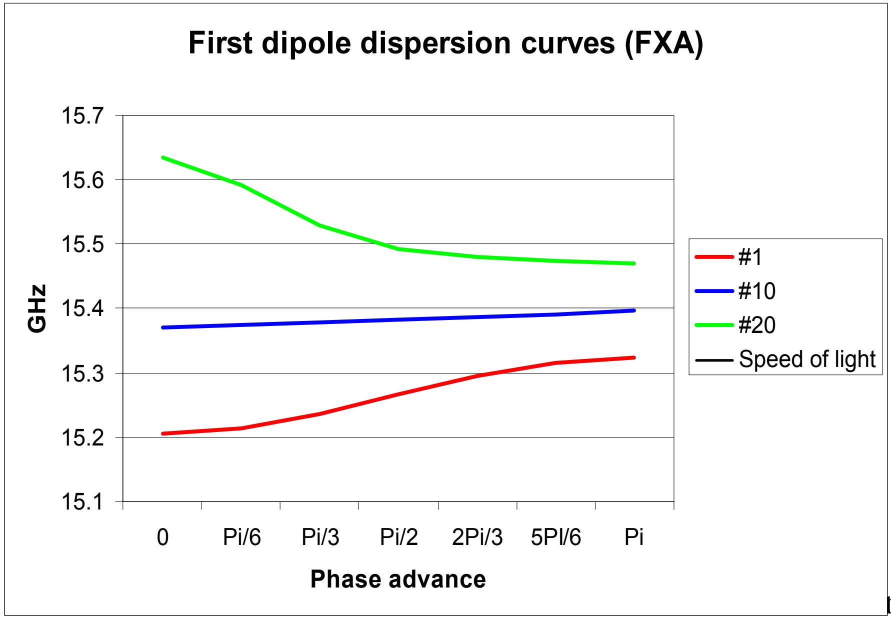
…constant gradient detuned…



R.H.Helm, G.A.Loew. 1969.

"By suitable variation of the transverse modular dimensions, it is feasible to design an accelerator in which the axial electric field are essentially constant along the length of the structure."

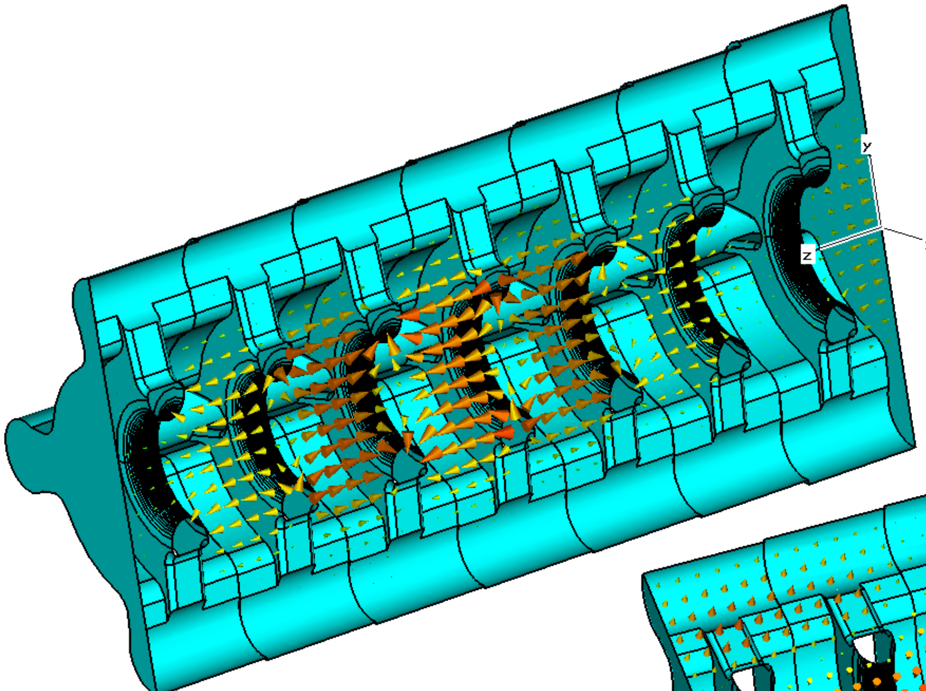
+



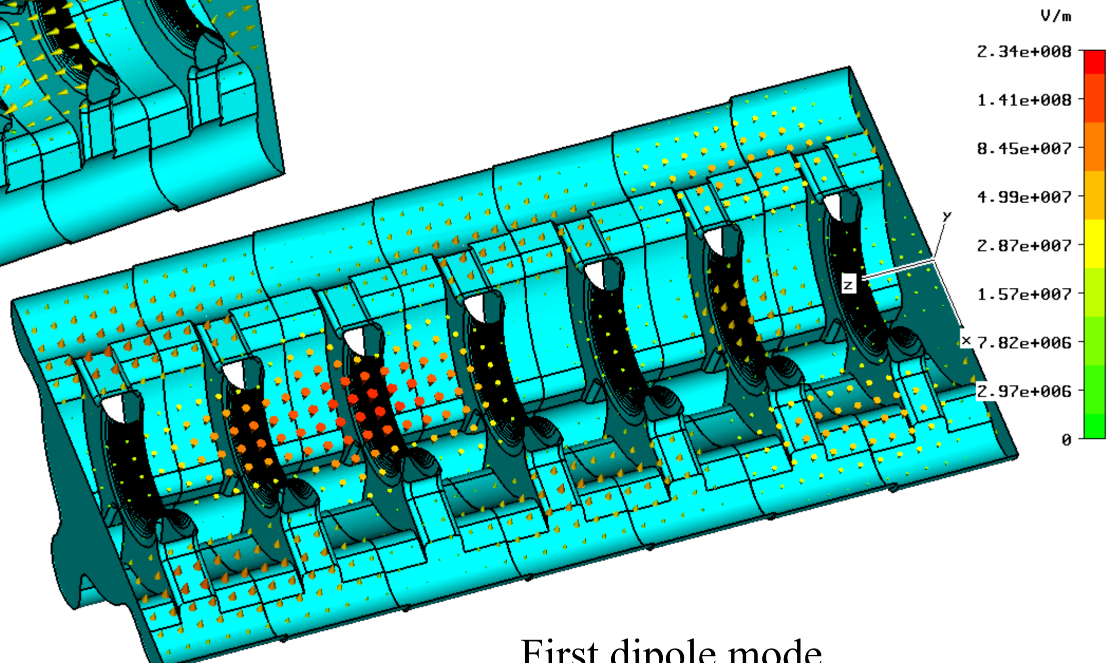
"Another remedy is to displace the ◆-δ of the HEM mode by modifying the modular dimensions of the cavities or perturbing their symmetries …"

= All disks are different.

…damped accelerating structure.

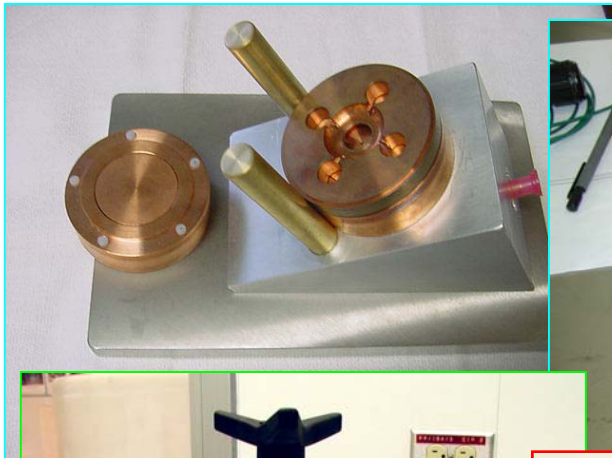


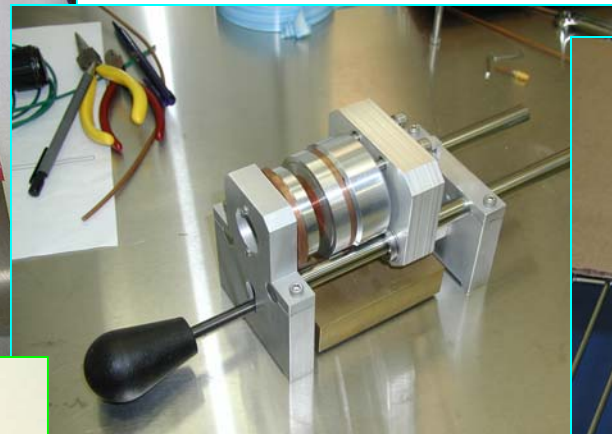
Fundamental mode

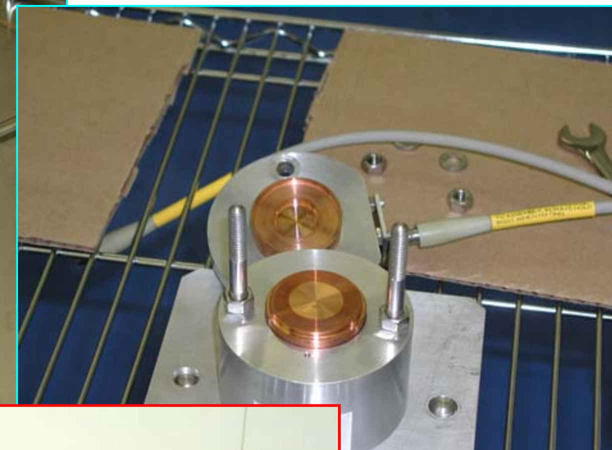


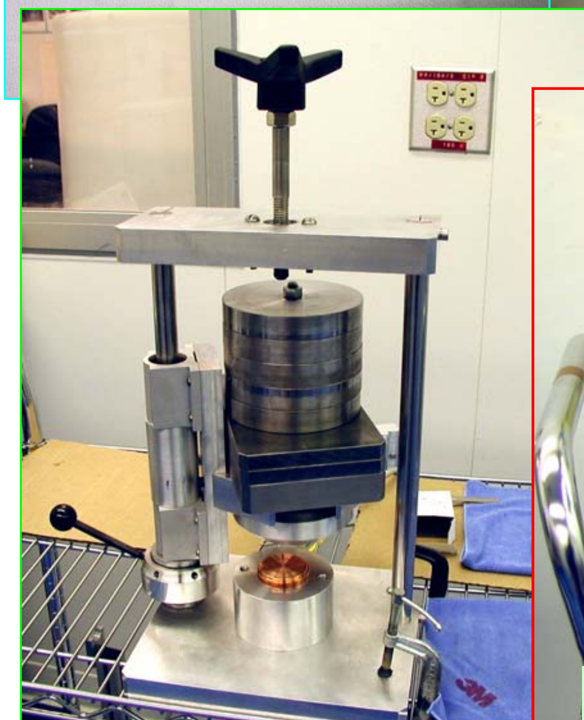
First dipole mode

Single disk QC Set-Up

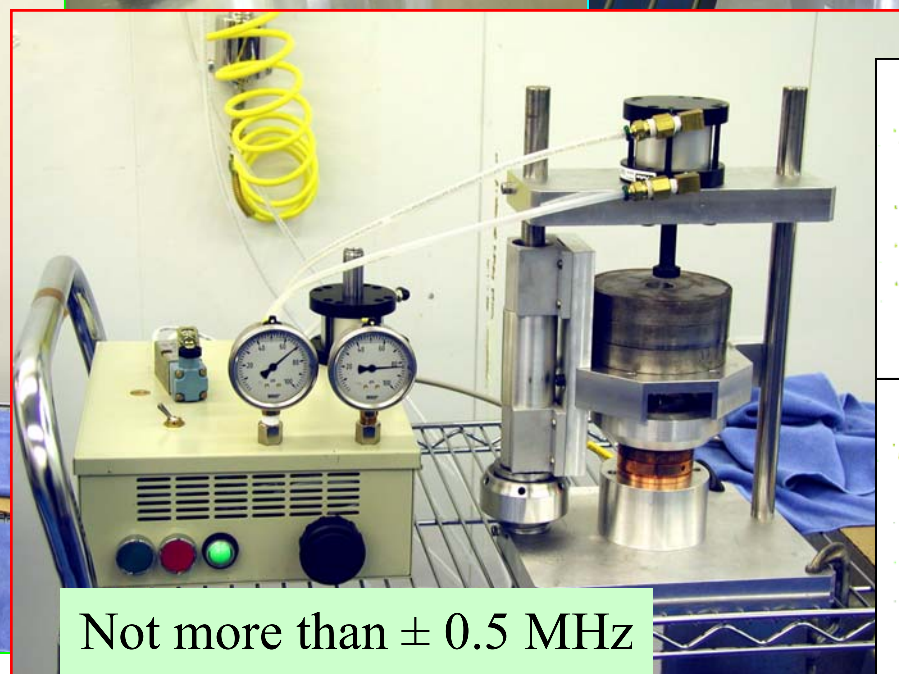




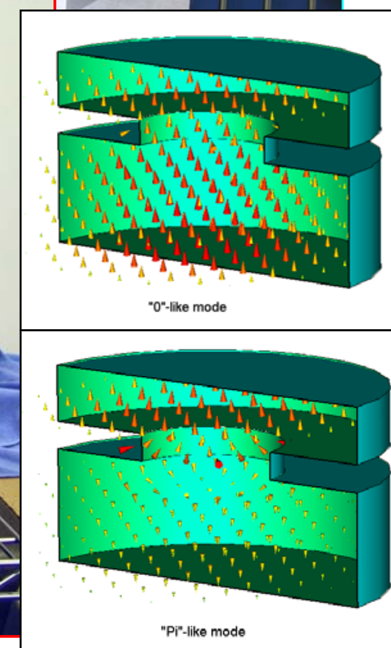




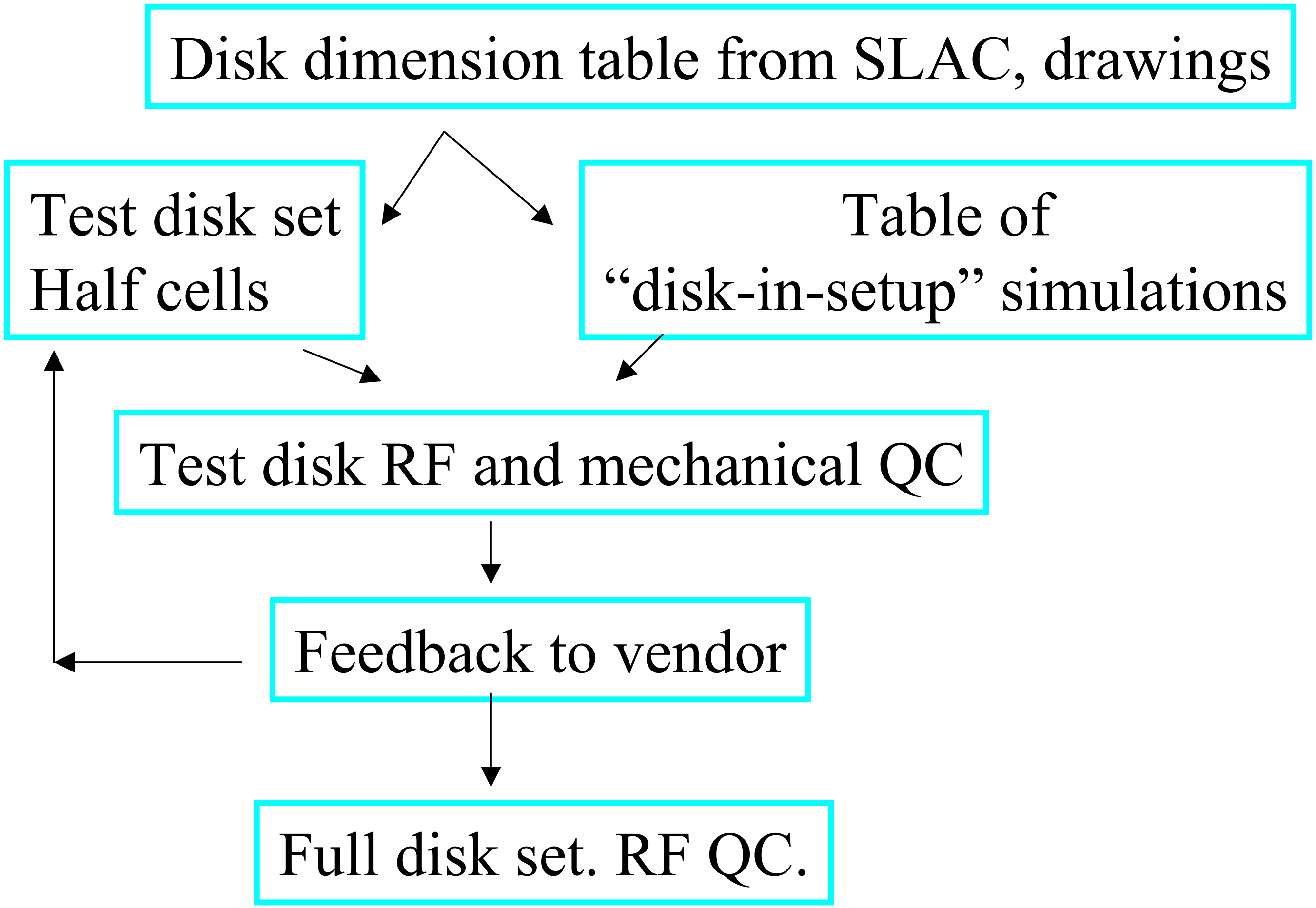
± 0.2 MHz



Not more than ± 0.5 MHz (goal)



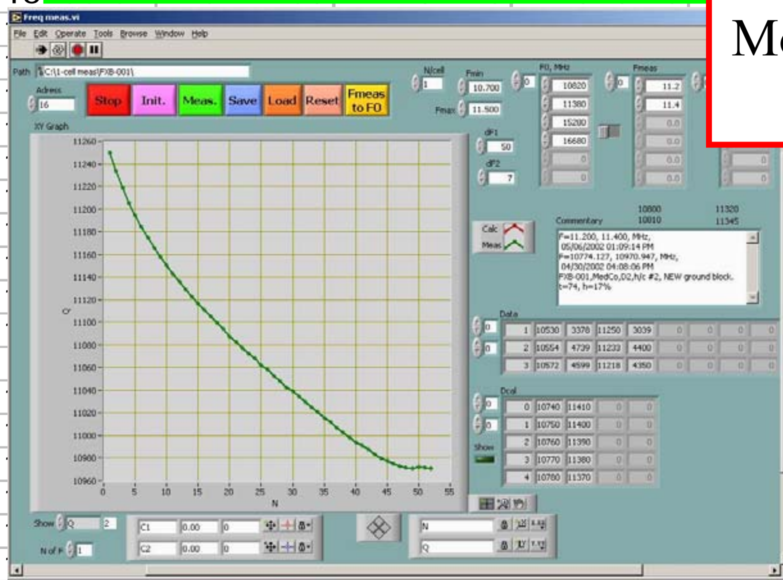
Single disk QC Set-Up

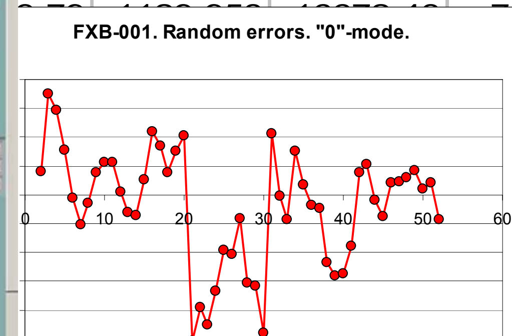


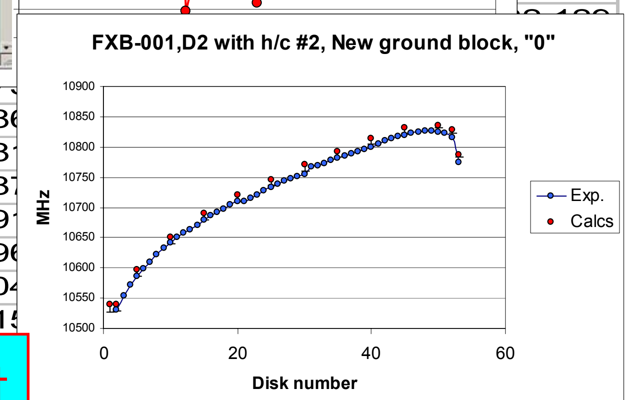
Structure testing

Single disk QC. Automation.

More than 600 measurements of frequency per set







1	10				5375.93	4066.513	16721.56	4770.846
2	10				5286.43	4092.262	16675.09	4955.865
3	10							
4								
5								
6								
7								
8					9.95	1516.353	16686.55	1271.711
9								6.659
10								2.851
11								9.417
12								5.589
13								2.921
14								5.343
15								254.1
16								2.476
17								28.65
18								9.895
19								
20								
21	10826.68	2053.331	11332.09	1354.798				
			6.13	1376.345	1538			
			6.36	790.105	1538			
			4.32	640.284	1538			
		1663.798	11321.69	893.568	1539			
		1636.642	11320.67	1367.396	1539			
		1567.718	11316.18	961.363	1540			
28	10838.18	1559.081	11314.85	1585.231	1541			
				3				
				3	.53	3783.204	16733.97	4658.971
32	10830.38	4065.423	11332.12	2483.74	15376.22	3487.199	16721.48	4325.541

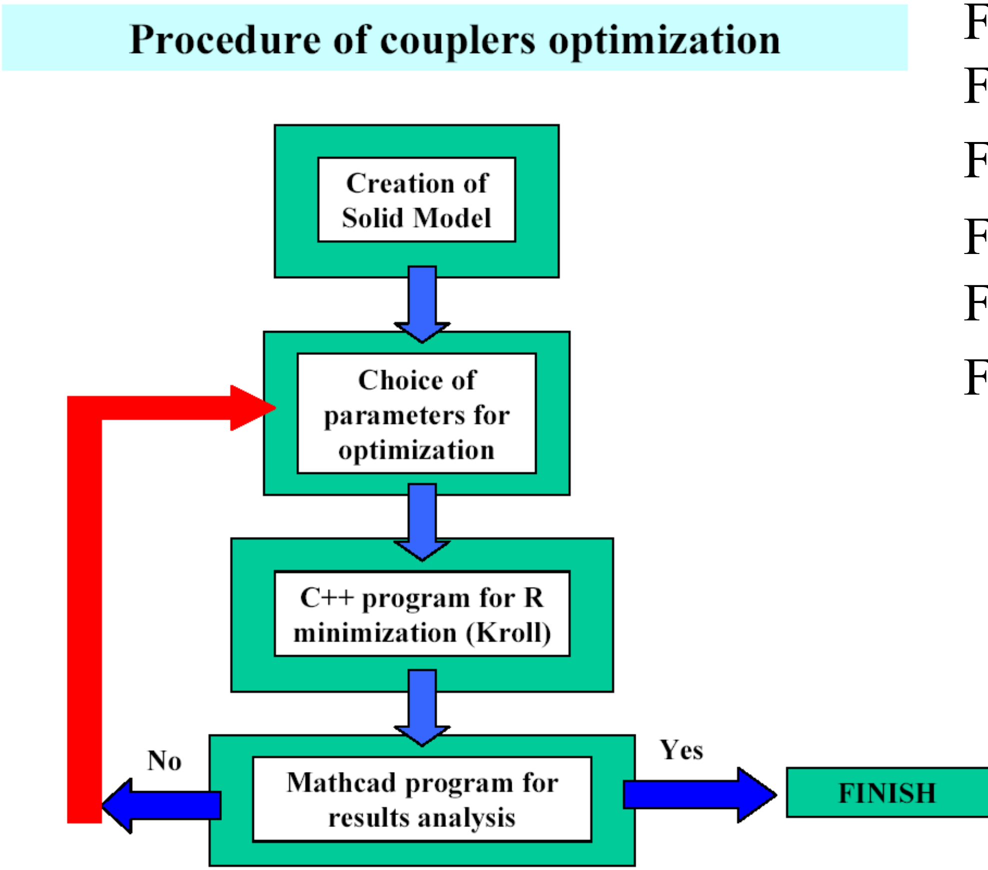
Arbitrary number of modes

On-line control

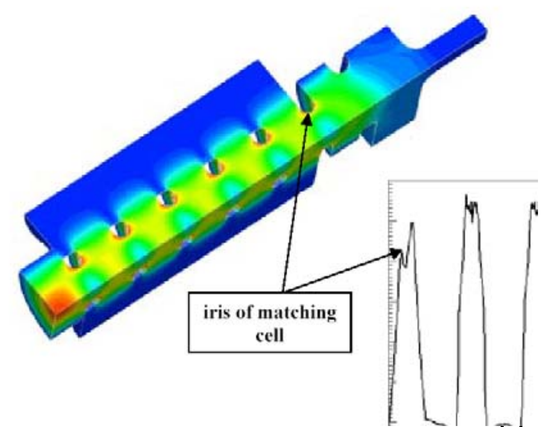
Record is 35 seconds per disk

It's fast

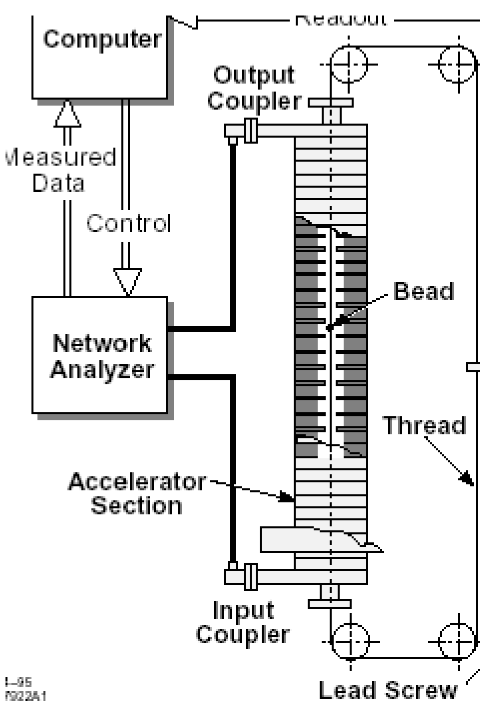
Fundamental mode coupler design



FXA – correction
FXB(2,3) – "fat lip"
FXB(4-6) – "waveguide"
FXC (75 cm, 3D) – "waveguide"
FXC (60 cm) – "waveguide"
FXD(?) – "waveguide"



Structure tuning. Bead-pull.



The traveling wave field distribution measurement is based on a non-resonant perturbation theory [3]. In this technique the measurements of the reflection coefficient **S11** are measured at the same frequency with and without a perturbing object placed at the point at which the field parameters have to be determined. On the axes of the section the magnetic component of the field is zero and the dependence of the reflection coefficient from the electric component of the field is expressed by the following formula:

$$2\mathbf{P}_i\,(\mathbf{S11}_p-\mathbf{S11}_a)=-j\omega k\mathbf{E}_a^2 \qquad 2.1$$

with $\mathbf{P}_i$ - the input power, $\mathbf{S11}_p$ - the reflection coefficient in the presence of a perturbing object, $\mathbf{S11}_a$ - the reflection coefficient in the absence of the perturbing object, k depends on the electric parameters and the geometry of the object and $\mathbf{E}_a=A\mathbf{e}^{j\varphi}$ - the electric component of the field. The perturbing

A NEW TUNING METHOD FOR TRAVELING WAVE STRUCTURES

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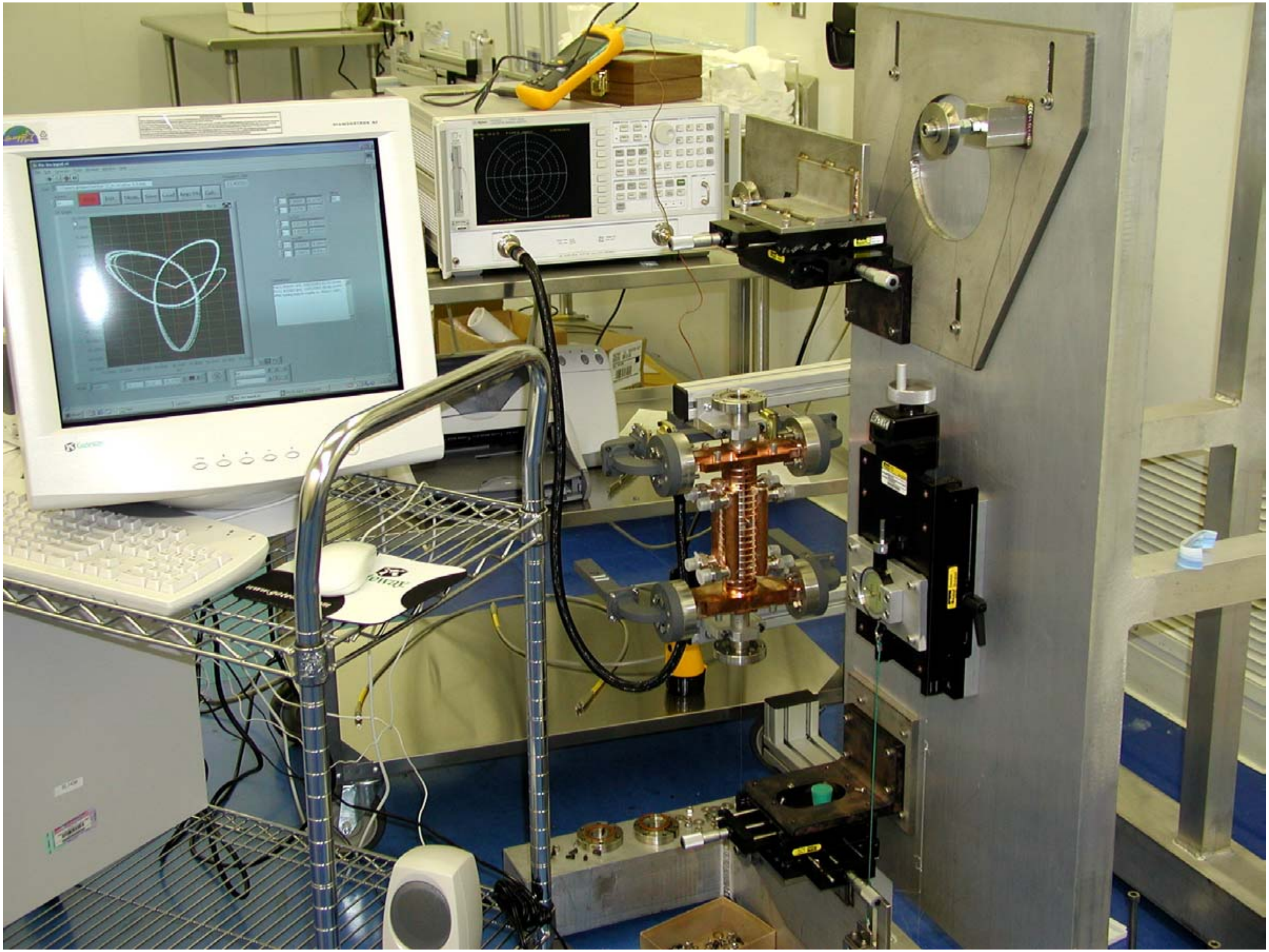
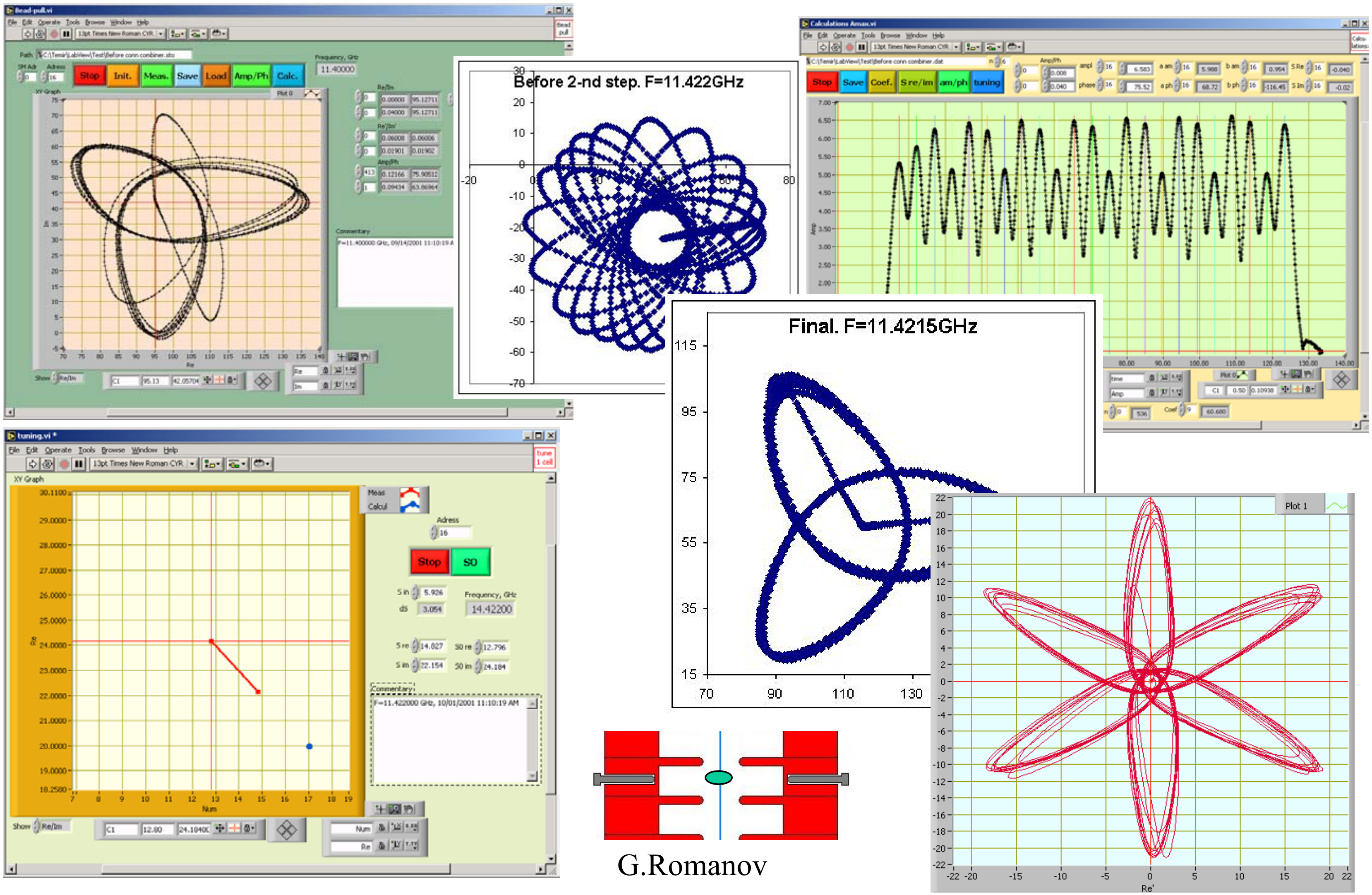
[3] C.W.Steele, 1966

Structure tuning. Bead-pull



Structure tuning

Bead-pull measurements



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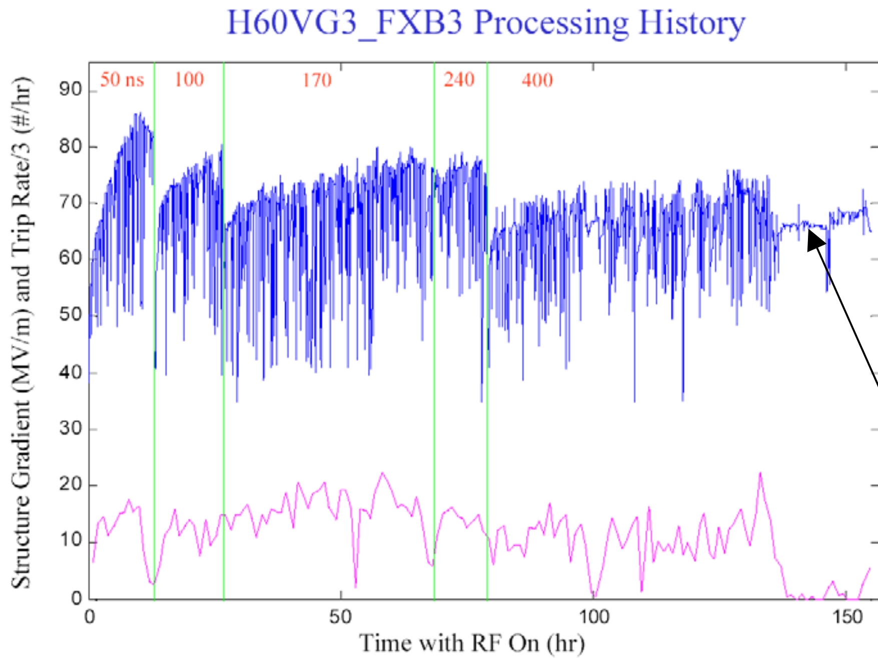


Short 50nsec pulse processing,12 hours

100nsec pulse processing, 12 hours

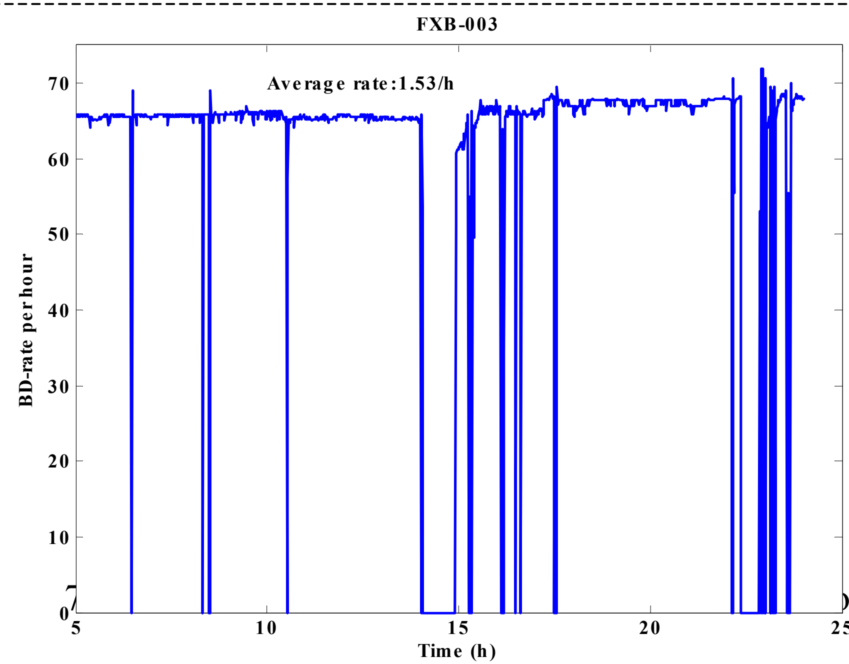
170nsec pulse processing, 40 hours

240nsec pulse processing, 10 hours

400nsec pulse processing, 60 hours

400nsec pulse at design accelerating field 65 MV/m, 12 hours

400 ns , first 65 MV/m run. About 1 Breakdowns/h



Later:

400nsec pulse at design accelerating field 65 MV/m, 8 hours. About 0.6 Breakdowns/h.

400nsec pulse at accelerating field 67 MV/m, 9 hours. About 2.5 Breakdowns/h.

NLC project:

400nsec pulse at design accelerating field 65 MV/m. 0.1 Breakdowns/h.

Rumor: Breakdown level 0.25-0.3 per hour for RF pulse 400 nsec and 65 MV/m unloaded accelerating gradient.