Optical inspection of SRF cavities at Fermilab

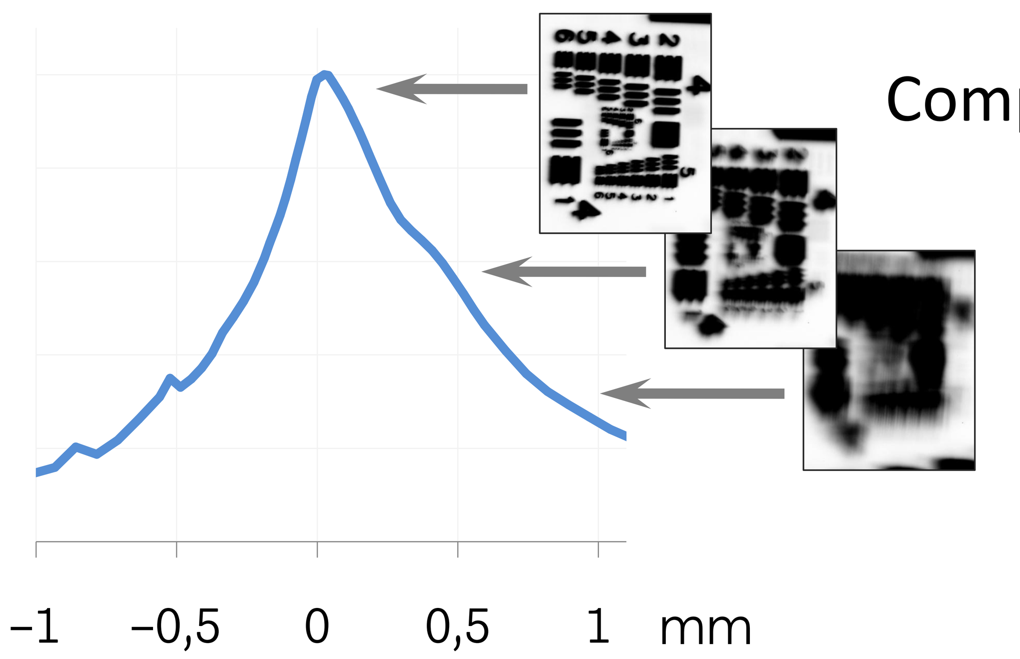
Fermilab

Evgeny Toropov, Dmitri Sergatskov, FNAL

Autofocus

is the central feature in automated inspection

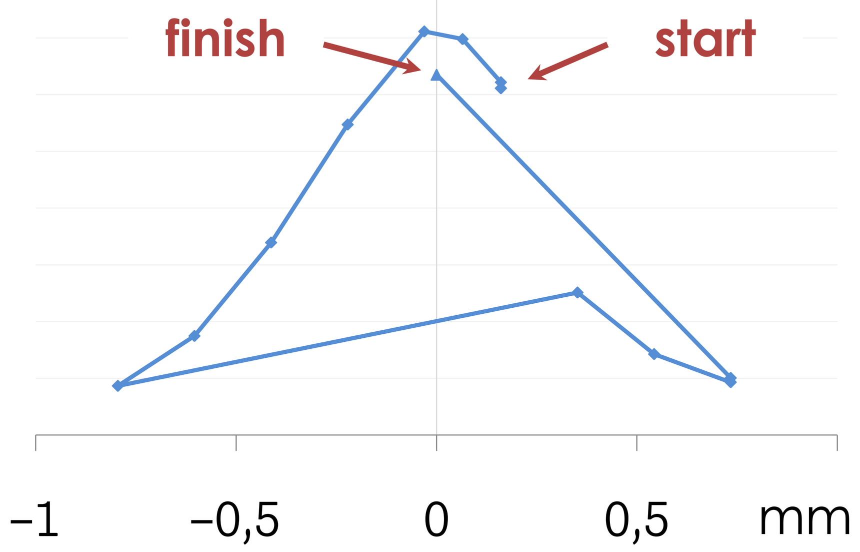
1. Sharpness metrics example



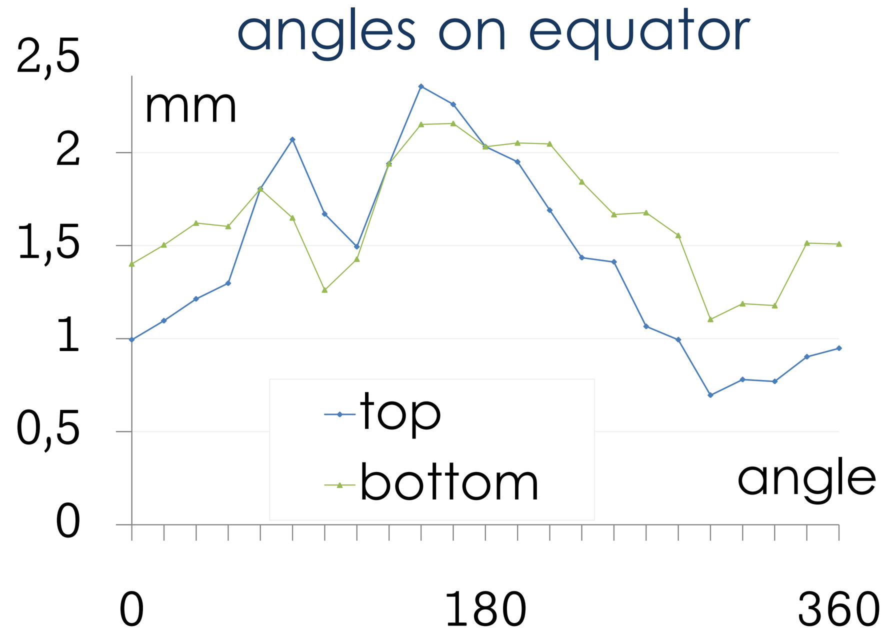
Computer considers focusing as maximizing a sharpness metrics

2. Peak-reaching algorithm

An algorithm changes camera-surface distance until the metrics peak is reached

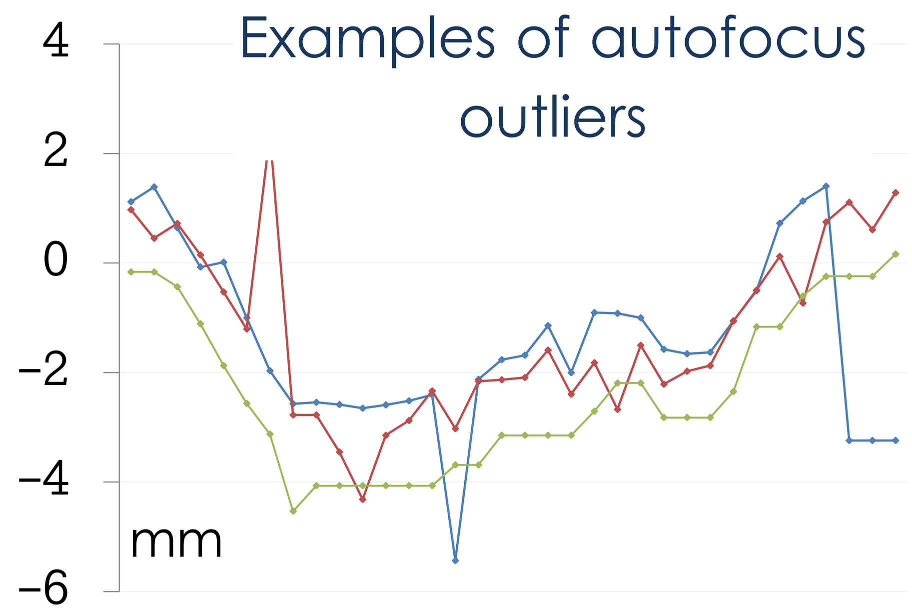


3. Focal distance for different angles on equator



We need to decide how often the program should focus

4. A mechanism to manage outliers is necessary



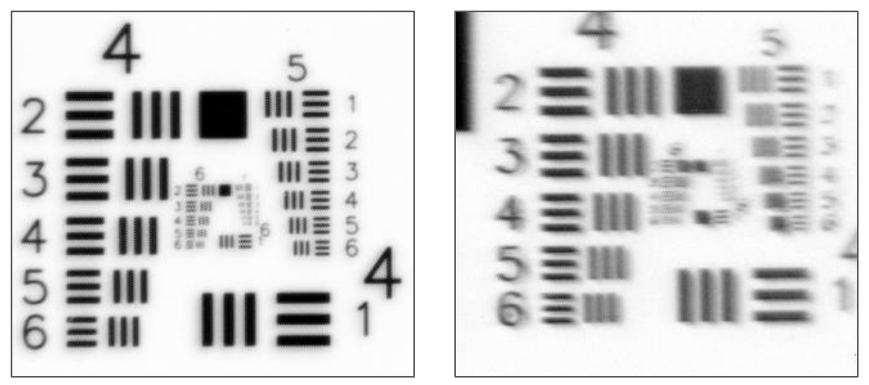
Abstract: Interjection of optical inspections between processing steps of SRF cavity production cycle provides us with an instant feedback on the processes involved as well as gives us new insight on the mechanisms responsible for forming surface abnormalities. The major drawback of inclusion of frequent optical inspections is the increased amount of time and labour in the cavity production cycle. We developed an automated procedure where a computer takes over the most of the routine operations including adjusting the camera focus. We will describe the developed system including the focusing algorithm and discuss ways to further optimize the procedure.

Inspection issues

Image resolution is the only characteristic of optical "power" of an inspection system

In the R&D system resolution is limited by the width of aperture in the camera boom (in original Kyoto design)

aperture effect on R&D system resolution:



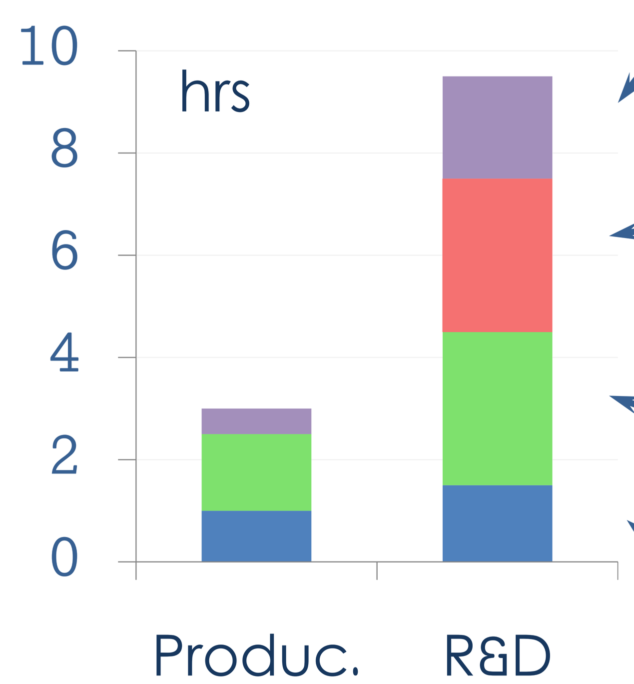
(a) wide aperture: res. = 10 x 10 um

(b) 6 mm aperture: res. = 10 x 35 um

Aperture in the boom must be widened (now 6 mm)

Time consumption is high for the R&D system:

time consumption by system

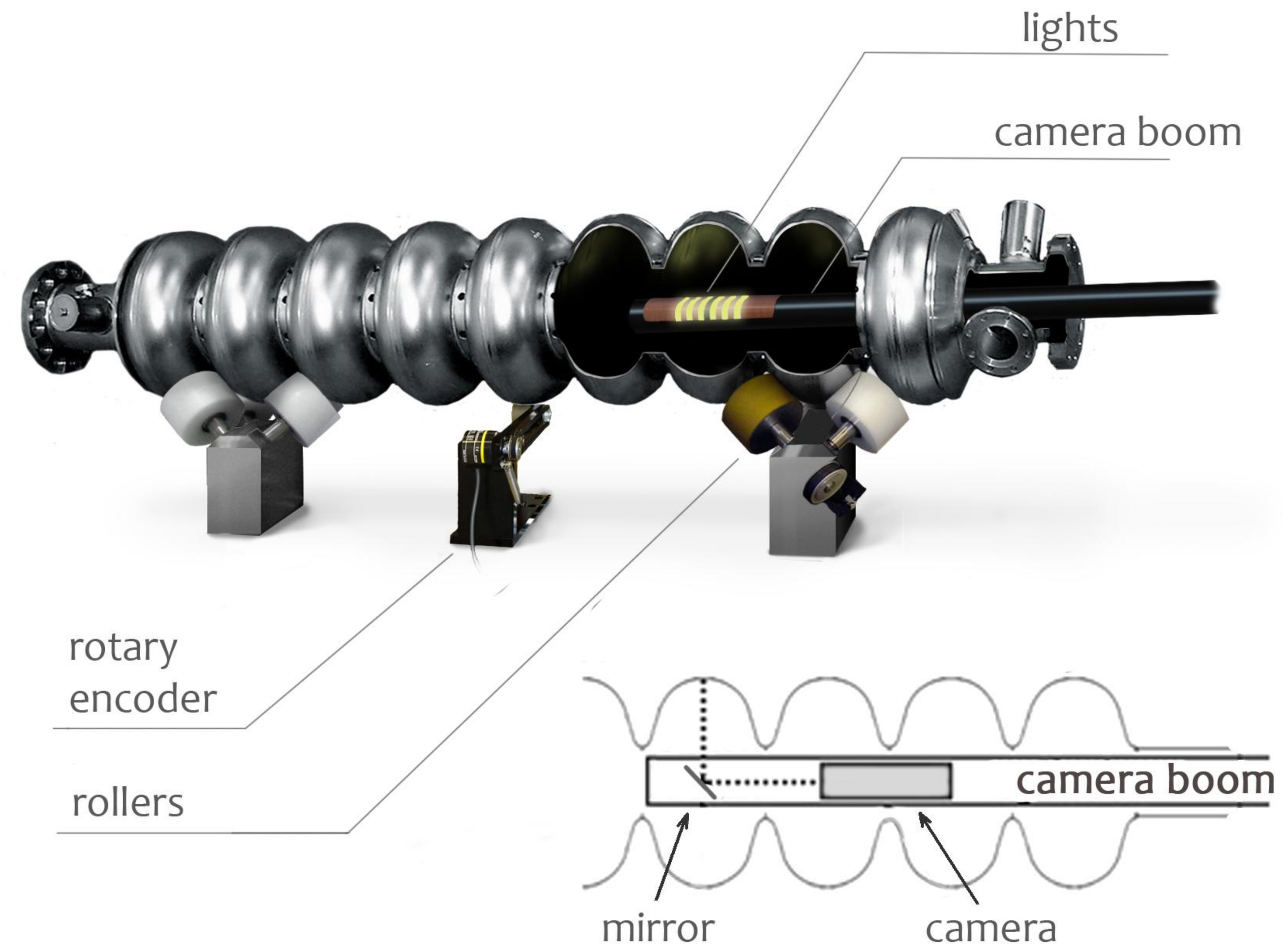


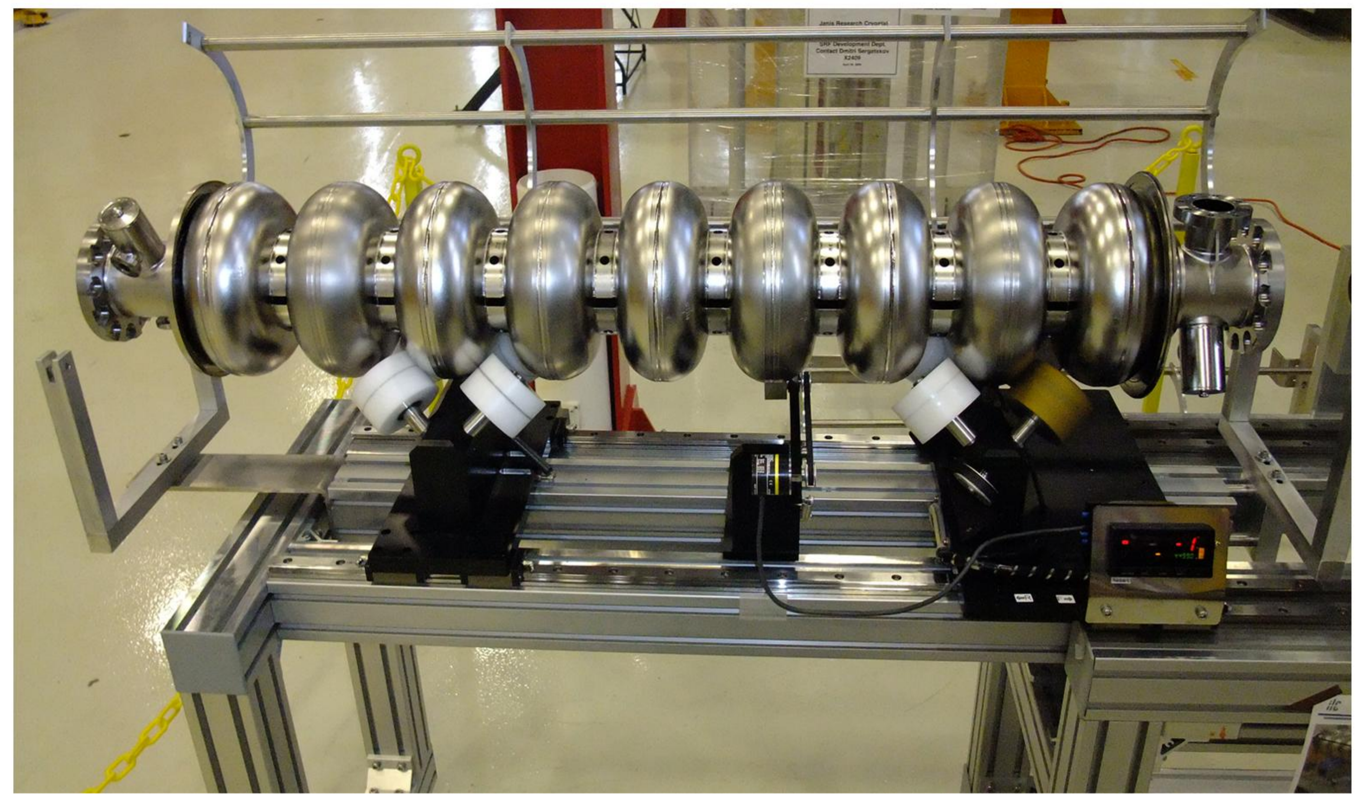
Mechanical relaxation time: higher because the rotating part is the boom, not cavity

Camera communication: higher due to slow camera

Focusing: larger number of images

Motors larger number of images





Automated inspection results for 1.3 GHz cavities:

Optical inspection system	Production	R&D
Rotating element	cavity	camera boom
Image resolution, μm (naked eye – 100 typically)	20	10
Field of view, mm	12.8 x 9.1	7.5 x 5.7
Camera sensor pixels	1400 x 1000	3488 x 2616
# images for 9-cell cavity	2500	5500