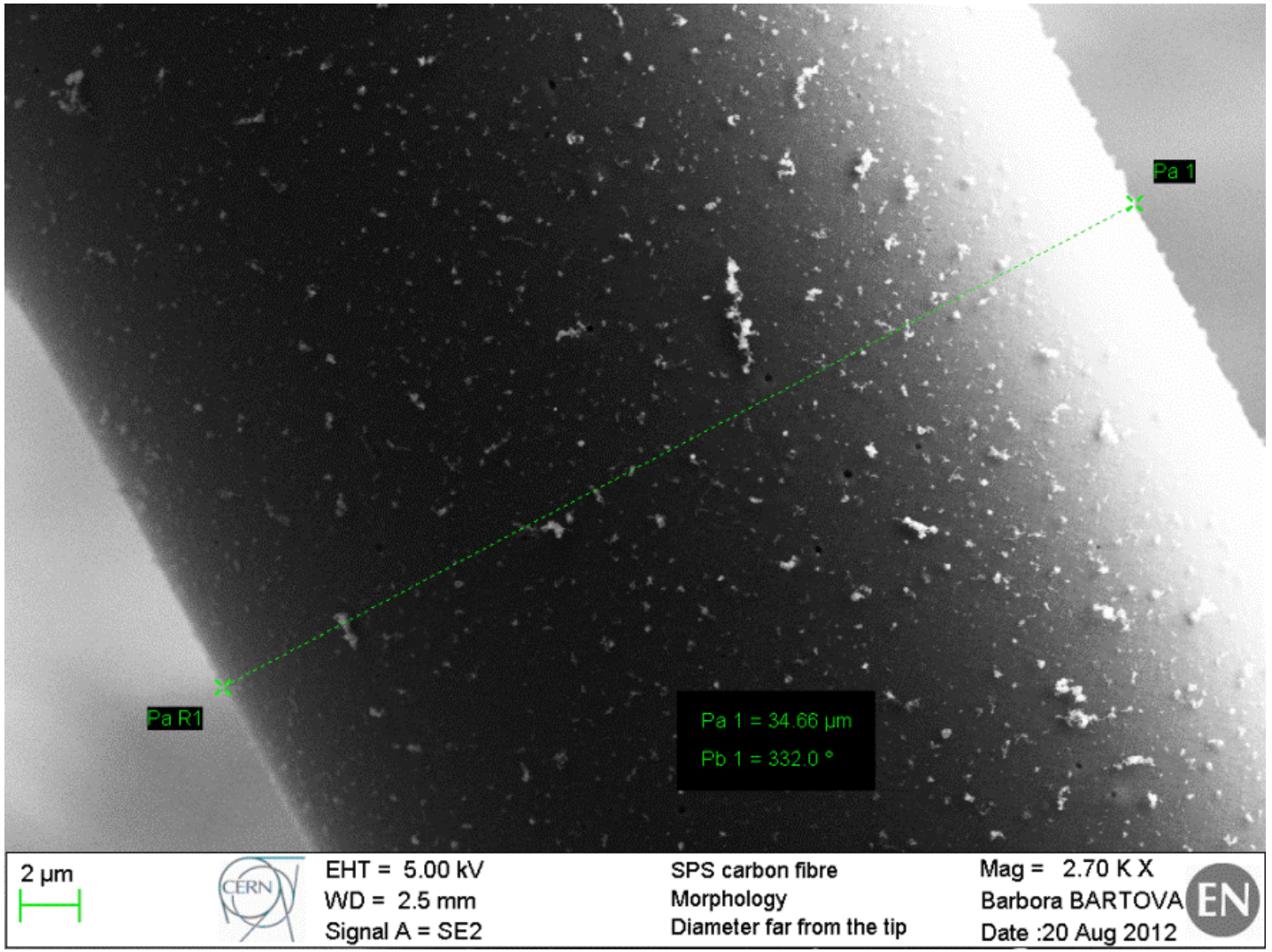
Post Mortem analysis of carbon fibers from Wire Scanners

M. Sapinski

Emittance meeting, CERN

2012.11.21

Healthy wire (not affected by the beam)

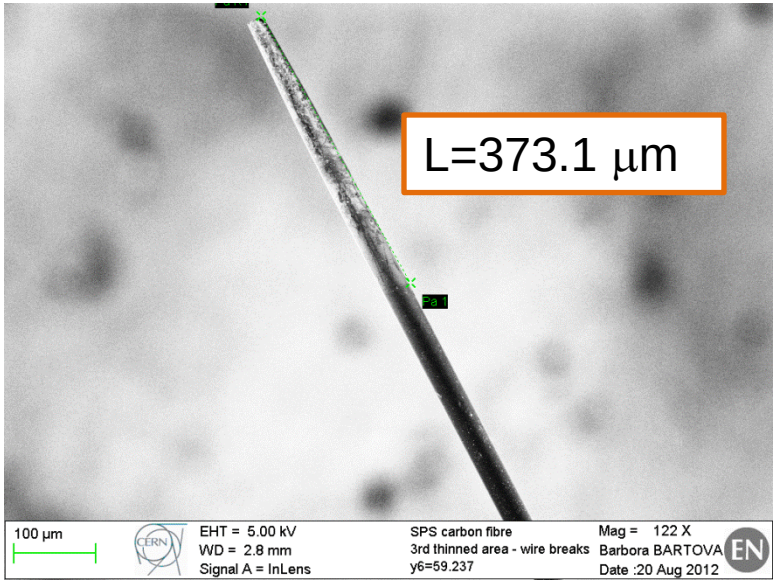


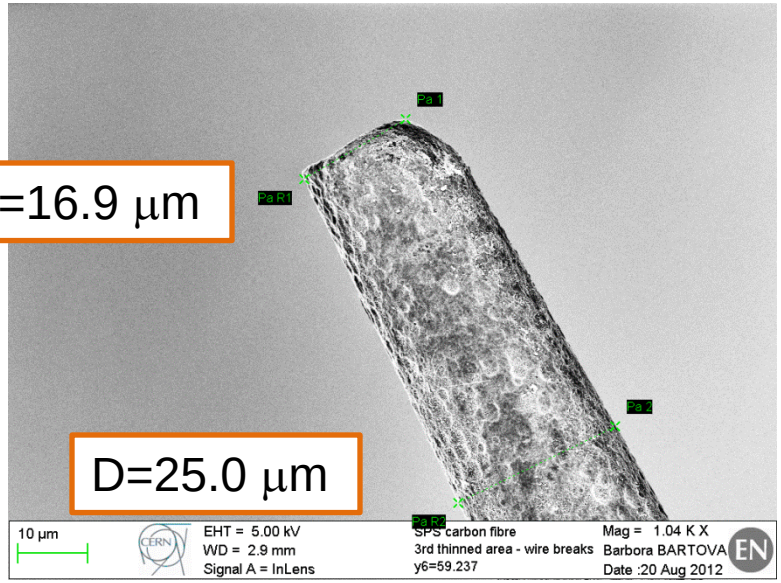
Broken wire from SPS (416V), area not touched by beam

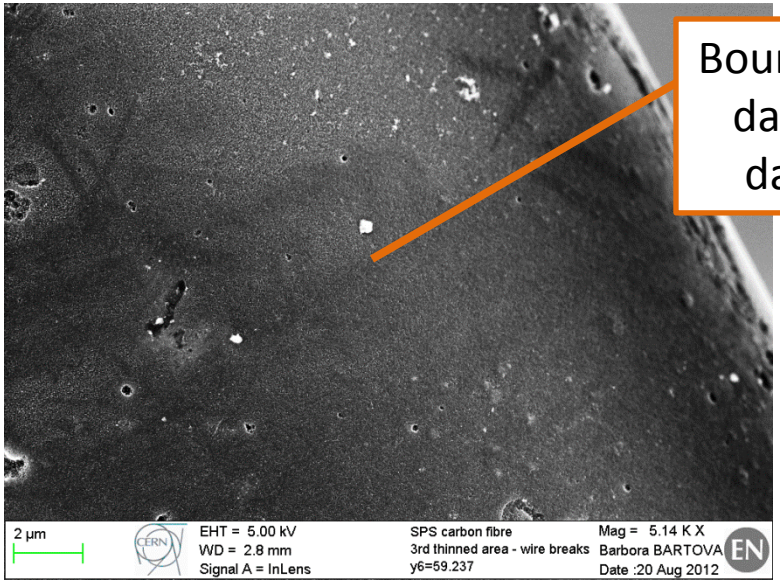
SPS 416V: 20.07.2012 09:22
LHC2 beam

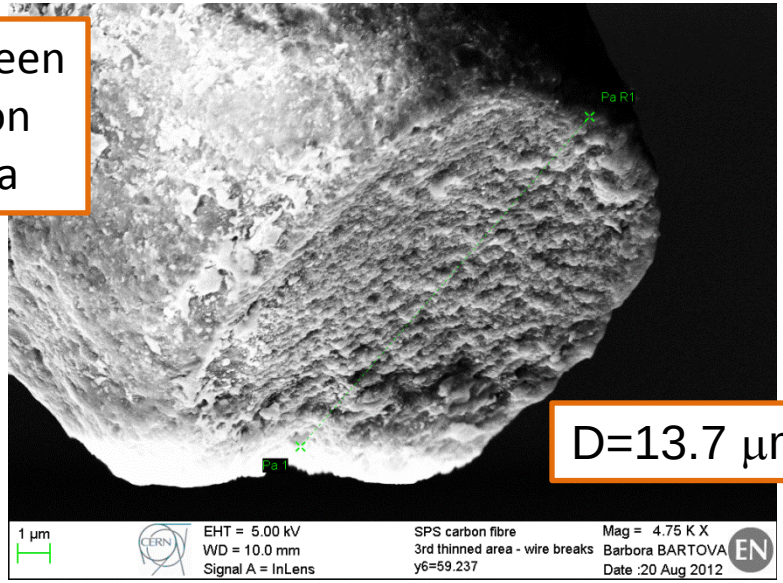
- Details in: EDMS 1239761 (B. Bartova)
- Wire clearly sublimated because of too important beam brightness
- Except of the breakage area two other locations have obviously seen the high-brightness beam
- This suggests operation at the slow sublimation limit, in which single scan sublimates submicrometer amount of material.

Morphology of the 3rd area affected with the beam – wire breaks

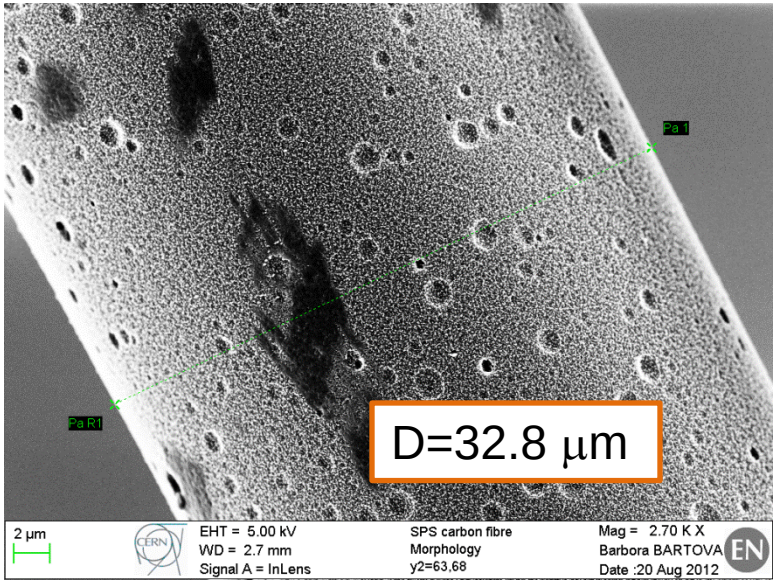


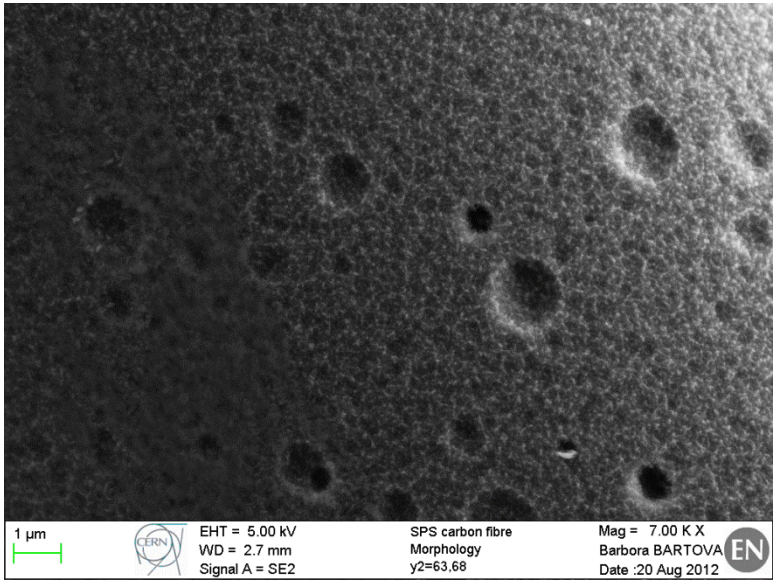


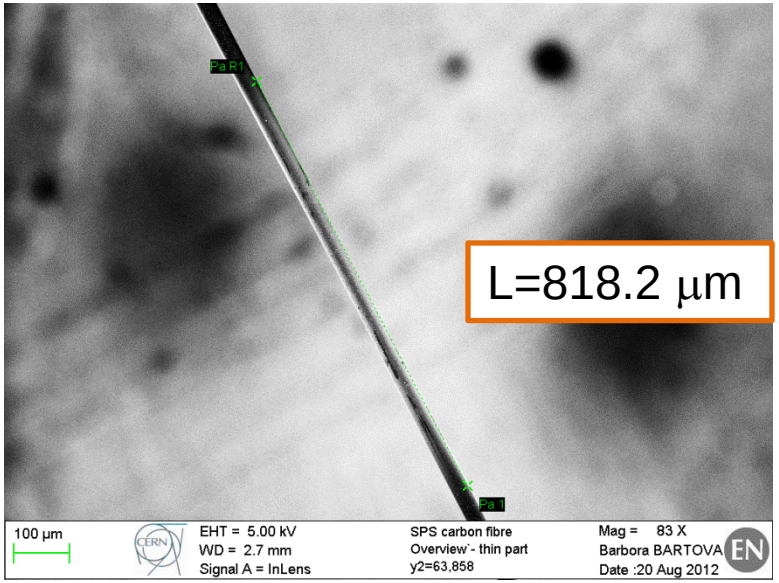




Morphology of the 1st area affected with the beam

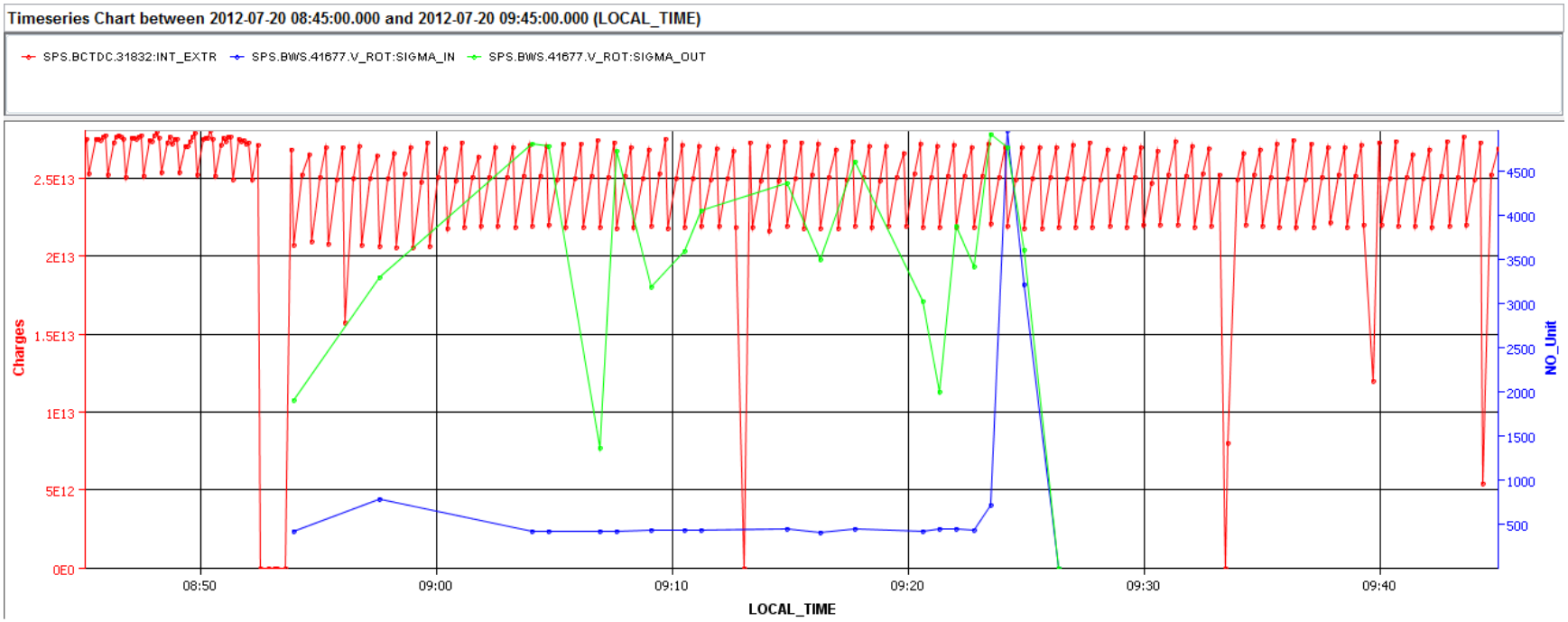






The diameter of 1st area of the wire affected with the beam from reference point is about 32.8 microns. The length is about 820 microns.
Small round hole were found on the surface of damaged area.

Conditions before 416 breakage

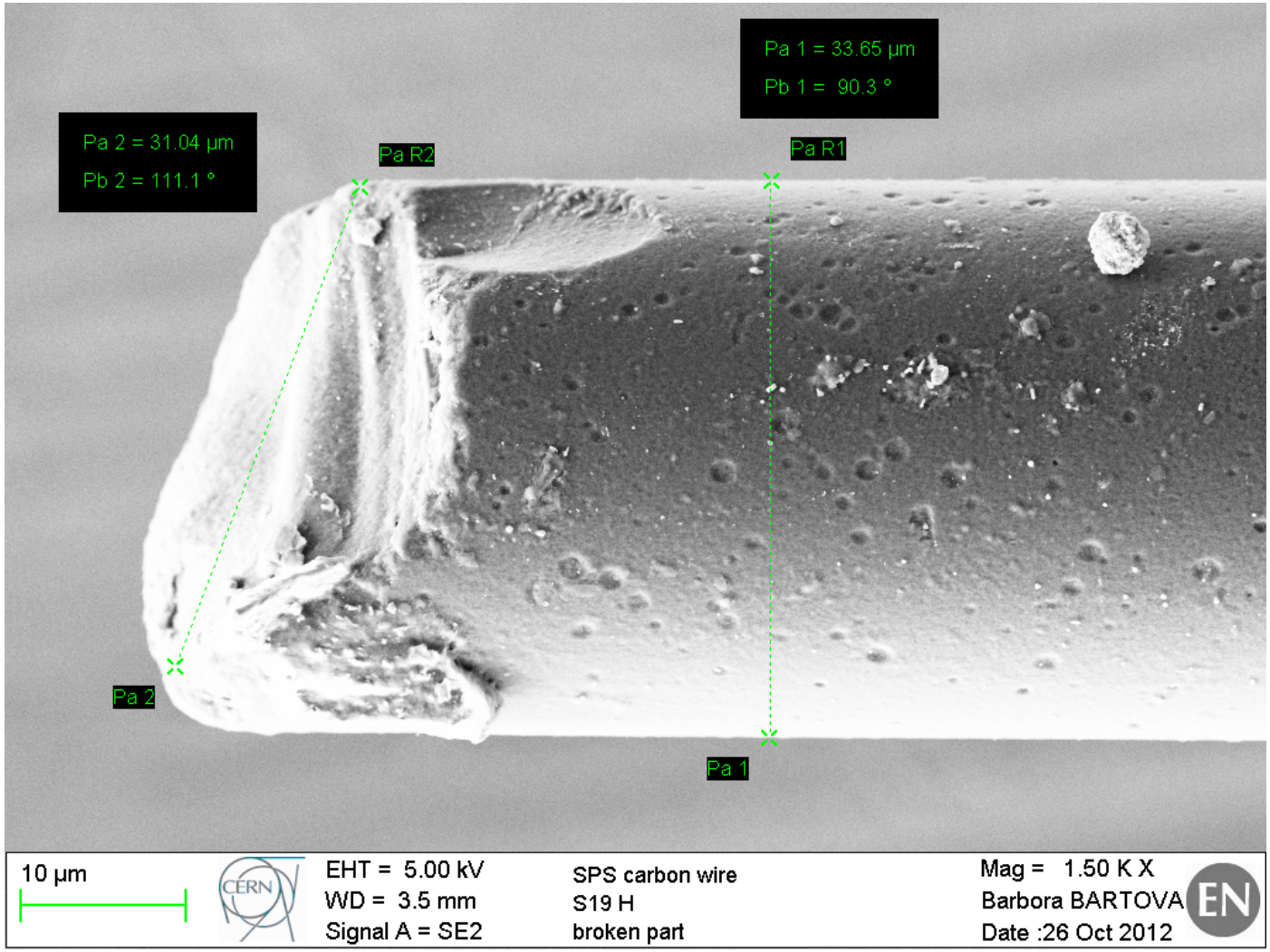


2.6e13, multiple scans, nch=3.8e12 p/mm, maybe more, some scans day before were done with 3 m/s.

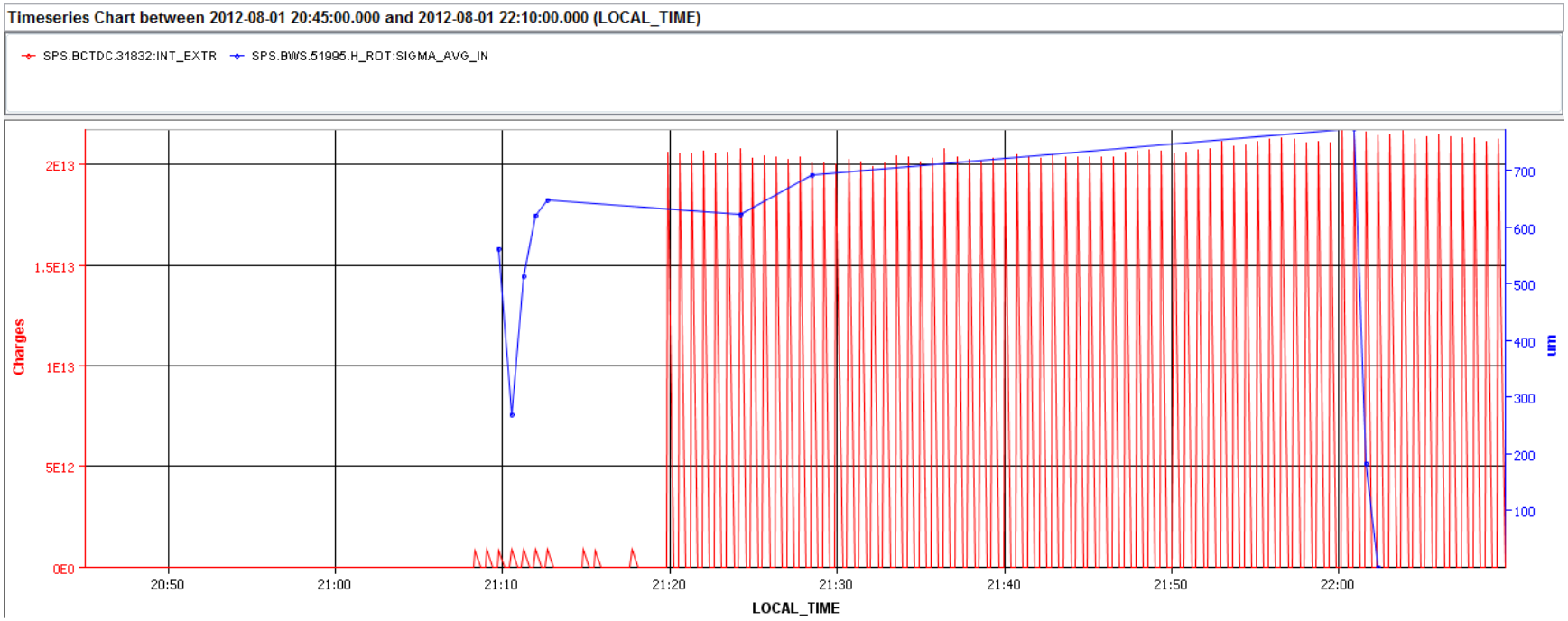
SPS 519H: 01.08.2012 / 22:01
LHC1 beam

- Report not yet ready, but:
- Wire was very hot because of direct beam impact (local surface damage)
- The amount of sublimated material is very small, damage is more mechanical

SEM images

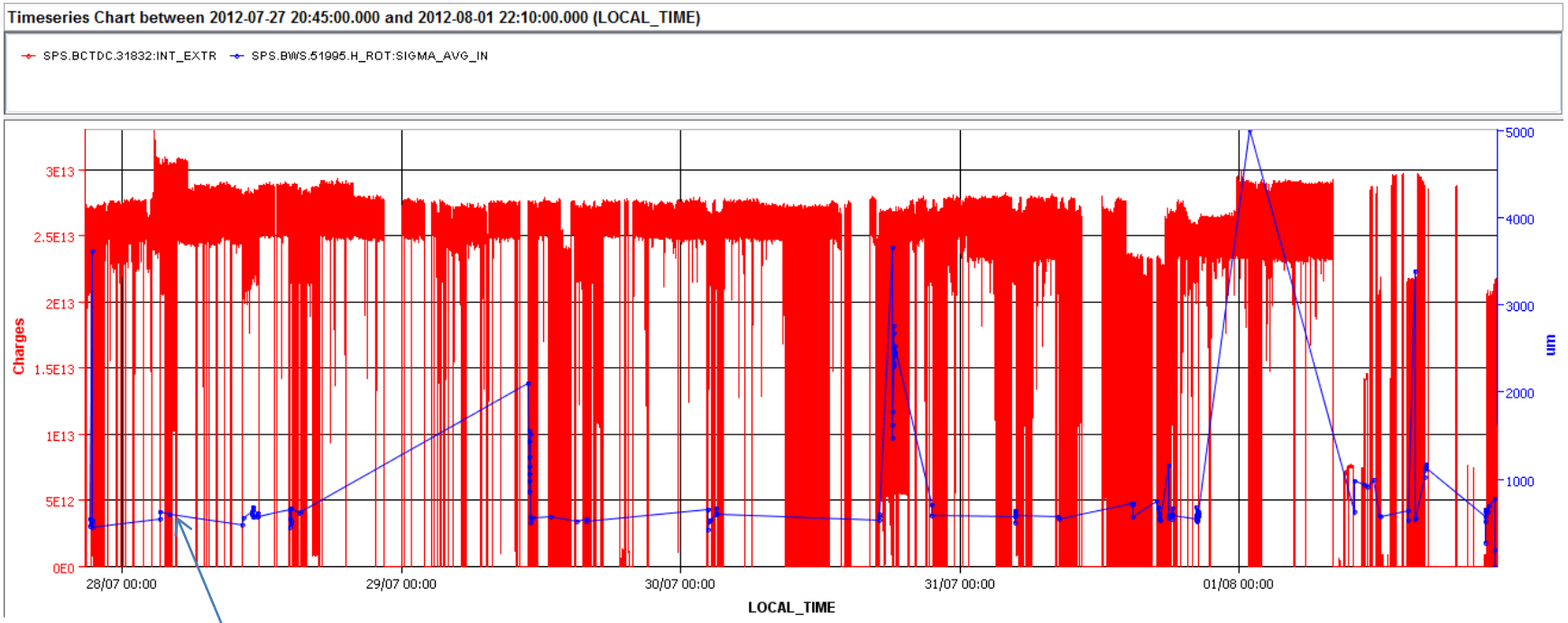

Pa 1 = 33.65 µm
Pb 1 = 90.3 °
Pa 2 = 31.04 µm
Pb 2 = 111.1 °
Pa R2
Pa R1
Pa 2
Pa 1
10 µm
CERN
EHT = 5.00 kV
WD = 3.5 mm
Signal A = SE2
SPS carbon wire
S19 H
broken part
Mag = 1.50 K X
Barbora BARTOVA
Date :26 Oct 2012
EN

Conditions before 519 breakage



2.1e13, multiple scans, nch=3.5e12 p/mm

Conditions before 519 breakage



Scanning higher intensity beam

Summary

- More analyses to come (it is busy time for electron microscope section).
- Beam brightness is clearly a problem for SPS scanners.
- Scans should not be allowed if brightness more than...

Brightness (1D) limit

From wire breaking experiments described in http://cdsweb.cern.ch/record/1461301/files/CERN-ATS-2012-155.pdf (CERN-ATS-2012-155) it could be concluded that at about 2-3*10^{13} charges/mm the carbon fiber used as a moving target in the Wire Scanners starts to sublimate. Including a safety factor and results of other wire breakages on SPS the safe beam density limit is found to be about 5*10^{12} charges/mm. It is calculated in a following way (see Equation 8 of above link):

$$n_{ch} = N_{ch}\, d_W / v_w t_{rev} \sigma_{tr}$$

where:

- N_{ch} - number of charges circulating in the beam
- d_W - wire diameter (30 microns) [m]
- v_w - speed of the wire [m/s]
- t_{rev} - revolution period [s]
- σ_{tr} - physical beam size [mm]

n_{ch}limit=5e12 charges/mm (?)

Excel file prepared for Q26 optics, 416 and 519 scanners

scanner:	416H	416V	519H	519V
betaH [m] =		38.03		81.49
betaV [m] =	62.96		28.15	
dispH [m] =	-0.252		-0.0151	
V [m/s] =	6	6	6	6
emittance [um] =	1.00	1.00	1.00	1.00
Ebeam [GeV] =	26.00	26.00	26.00	26.00
gamma:	2.67E+01	2.67E+01	2.67E+01	2.67E+01
beam size [mm]:	1.535062	1.193045	1.026438	1.746408
intensity limit:	3.53E+13	2.74E+13	2.36E+13	4.02E+13

Part of the file, for very small emittance.

File will be completed, but likely we need to put it in FE.