Achievement of 41 MV/m Gradient by AES8

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Second Production Batch at AES

- FNAL ordered 6 fine-grain 9-cell cavities.
- AES#5, #6, #7, #8, #9 and #10.
- JLab received AES#5, #6, #8, #9 for EP processing and RF testing.
- AES#5 and #6 were processed using standard procedure at JLab.
- AES#5 max. Eacc 21 MV/m; AES#6 14 MV/m. Both limited by quench.
- Pass-band and T-mapping measurements to show quench caused by one defect in one cell, with other cells reaching already 32-44 MV/m.

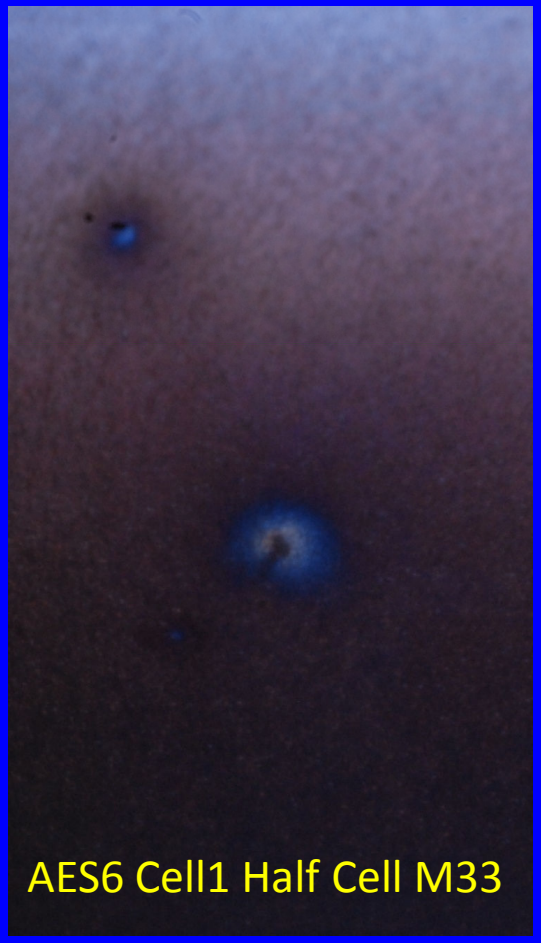
Change for AES#9 Treatment

- It was noticed that AES cavities are stiffer somehow as compared to cavities from other vendors.
  - At one point our tuning machine was broken during AES cavity tuning operation.
- We decided to change vacuum furnace heat treatment recipe for alleviation.
  - 800 C X 2 hr replaces 600 C X 10 hr.
  - The change is considered no risk as it is identical to DESY HT recipe.
- First trial with AES#9
  - tuning condition improved by a factor of 2.
  - AES#9 first RF test reached max. Eacc 34 MV/m at Q0 1E10.
- Optical inspection of AES5, 6, 8, 9 as received did not show much difference
  - We then raised the possibility of change in HT being beneficial.

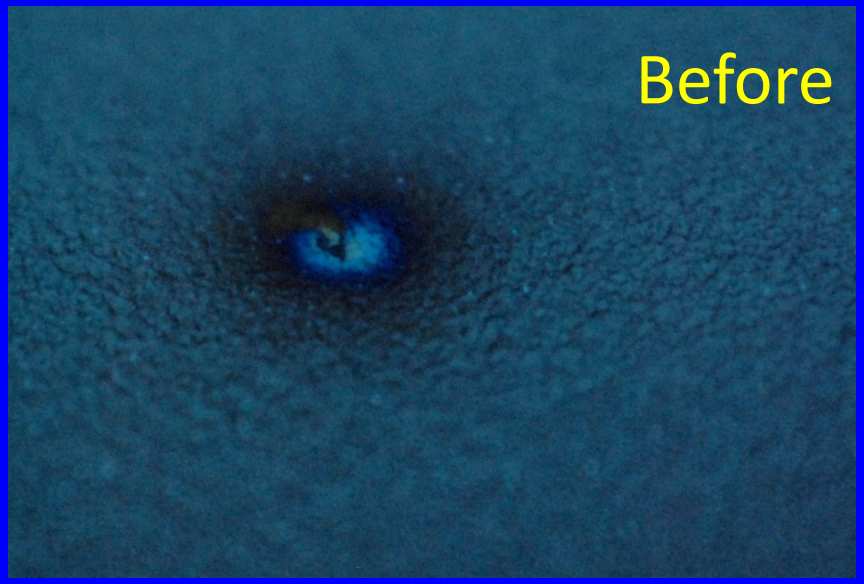
Further Change in AES#8 Treatment

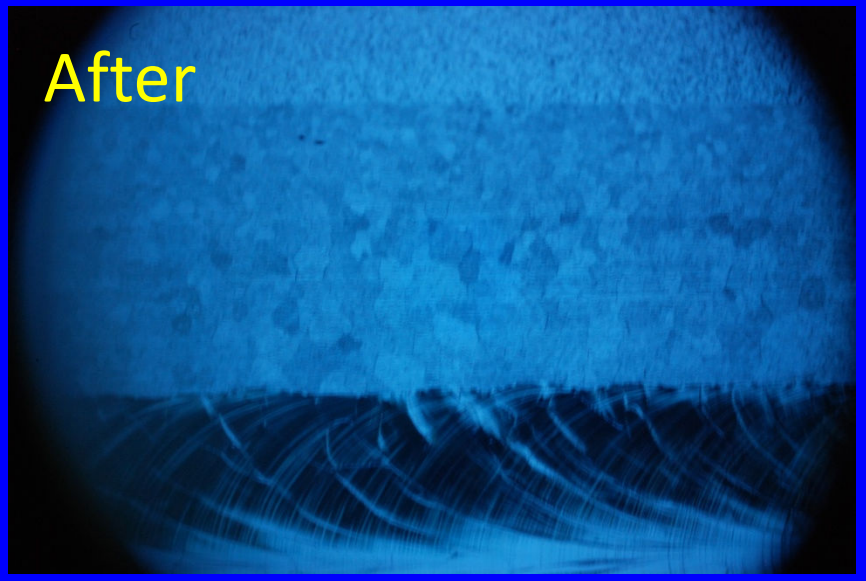
- Encouraged by AES#9 result, we decided to apply the same HT for AES#8.
- In addition, AES#8 was given a 10 μm BCP etching using JLab close-loop BCP machine before heavy EP processing.
  - This decision was driven by the observation of complex weld spatters, regional oxidization on the as-built surfaces of AES cavities.
  - The BCP treatment produces excellent starting surface before main EP!

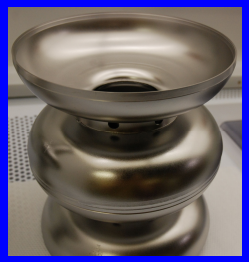
Weld Spatter Examples on As-built Surface



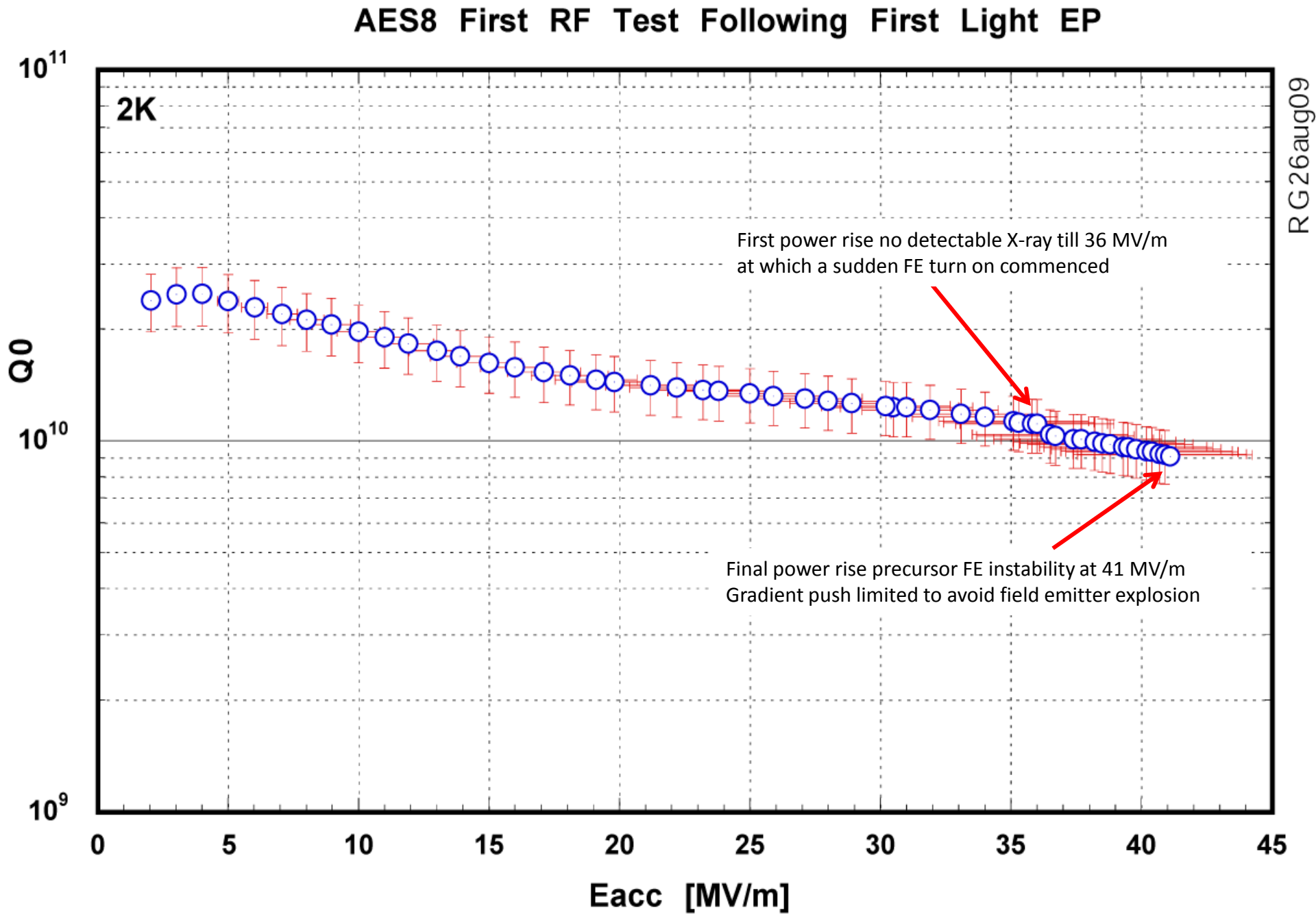
A Pilot Joint JLab/AES Study Confirms Effectiveness of BCP Removal







A rejected double dumbbell welded by AES was studied by JLab
A natural weld spatter was identified and a 5 μm BCP efficiently removes the spatter resulting a uniform surface finish


AES8 First RF Test Following First Light EP
2K
RG26aug09
First power rise no detectable X-ray till 36 MV/m
at which a sudden FE turn on commenced
Final power rise precursor FE instability at 41 MV/m
Gradient push limited to avoid field emitter explosion
Q0
10^{11}
10^{10}
10^{9}
0
5
10
15
20
25
30
35
40
45
Eacc [MV/m]

A Note on Field Emission Behaviors

- Both AES#8 and AES#9 exhibited sudden field emission turn on at very high gradient.
- AES#9 was inspected following RF test – revealing surface damage in high electric field region which appears to be associated with mechanical defect on as-built surface.
- AES has taken actions to eliminate this defect after this information was provided to them.

Summary

- First US industry built 9-cell cavity passed and exceeded ILC spec.
- A story of success due to the close cooperation between national lab and industry.
- Thanks optical inspection which allowed us to introduce changes/improvements.

Tony Favale, CEO and a director of AES, said that conducting vigorous scientific testing and incorporating improvements that boost cavity performance will help his and other companies reliably produce accelerator cavities that meet specifications.

"It's always the partnership between labs and industry that makes benefits for both," Favale said.