Fermilab

U.S. DEPARTMENT OF ENERGY | Office of Science

Multipacting simulations and experience at FNAL

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TTC, DESY

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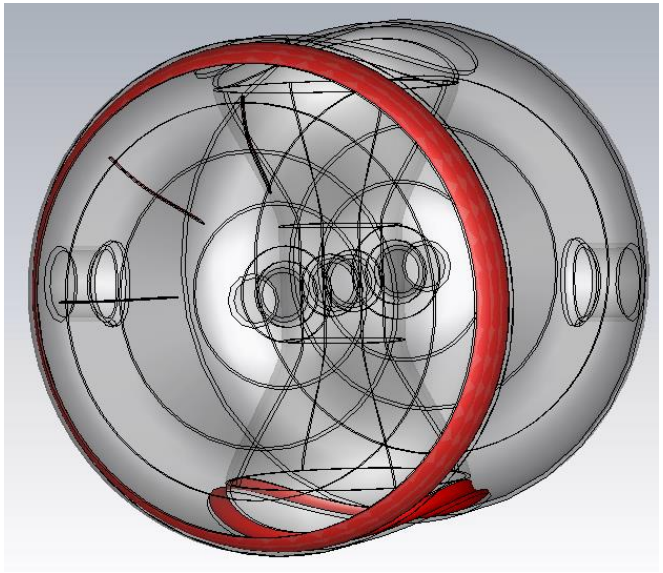
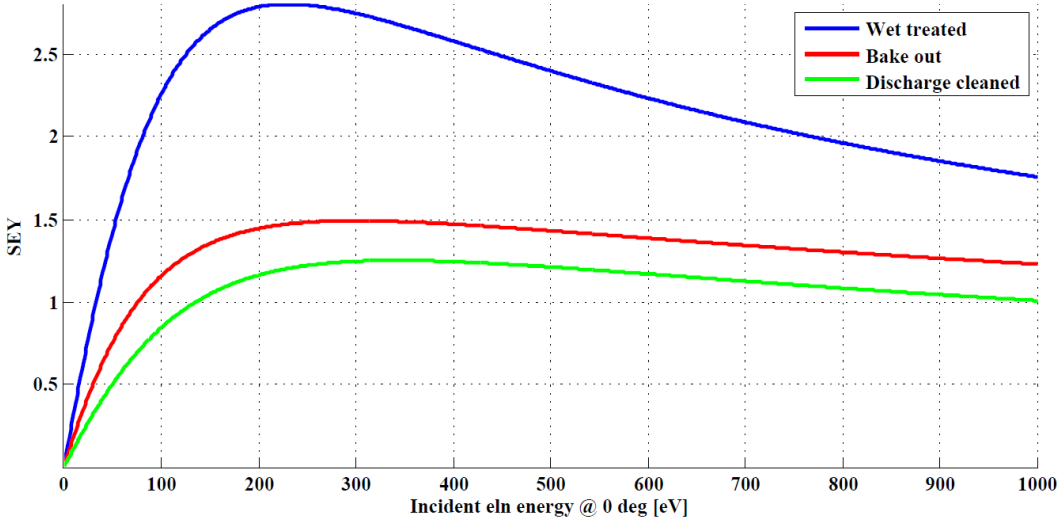
MP simulations

- For latest SSR1 and SSR2 multipacting simulations a CST particle studio is used. It requires creation a shell all around the cavity volume to have a layer of emitting material.
- Initial particle energy usually ranges from 2 to 6 eV, the emission angle can be set to random.
- Different Secondary Emission Yields (SEY) have been applied to the cavity walls, which depends on preparation and material properties.

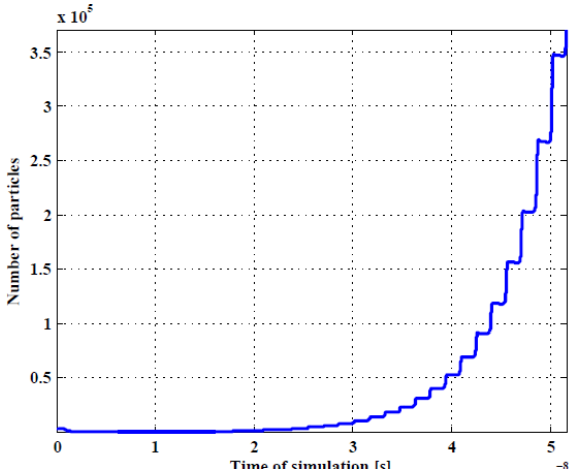


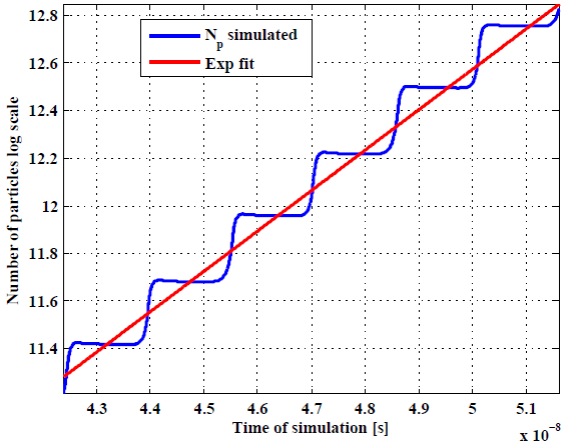
An example of particle source areas for a single spoke cavity are highlighted in red.



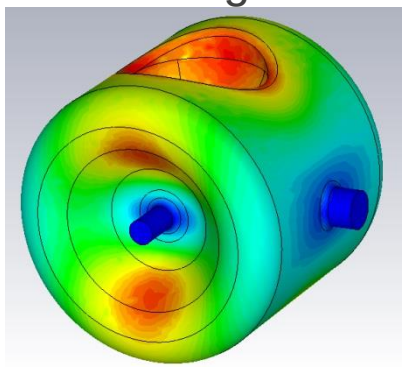
Growth rate and MP locations

- If MP resonant condition is satisfied, the number of electrons in the cavity increases exponentially with time
- The growth rate is the exponential coefficient of the best fit of number of particles vs. time (ns).
- The number of particles increases every half RF period.

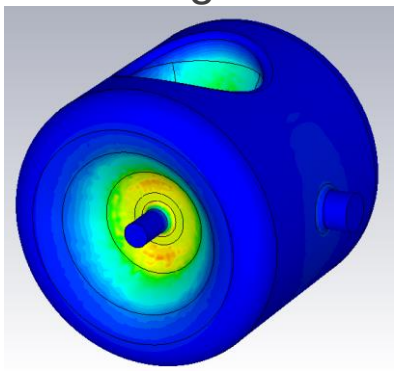




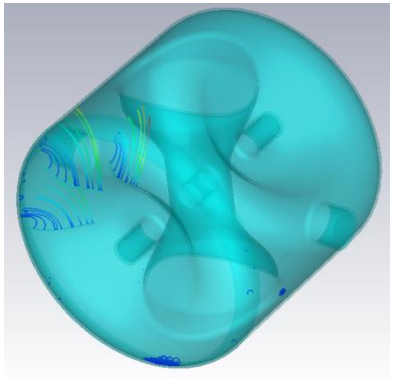
- MP locations depends on gradient: the resonant condition needs a certain field amplitude to be sustained, increasing the gradient the MP moves from higher field regions to lower field regions.



SSR2 H field

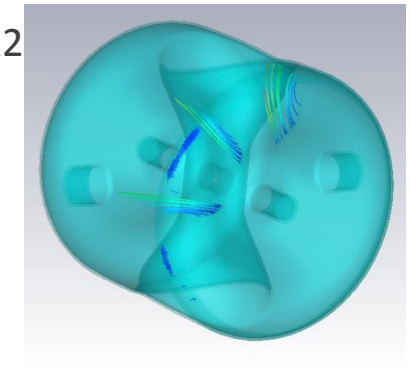


SSR2 E field



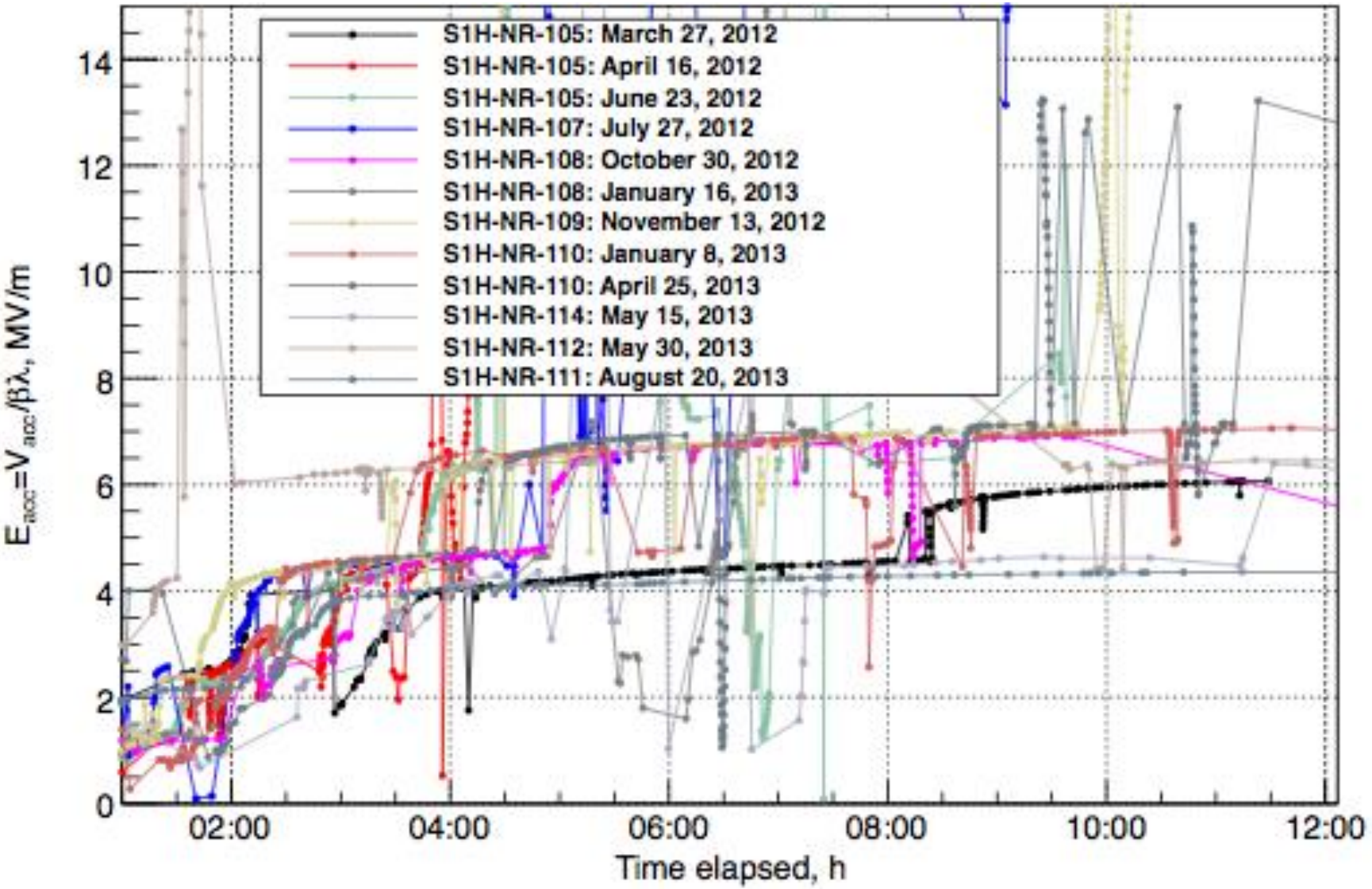
MP @ Eacc=4.4 MV/m

SSR2



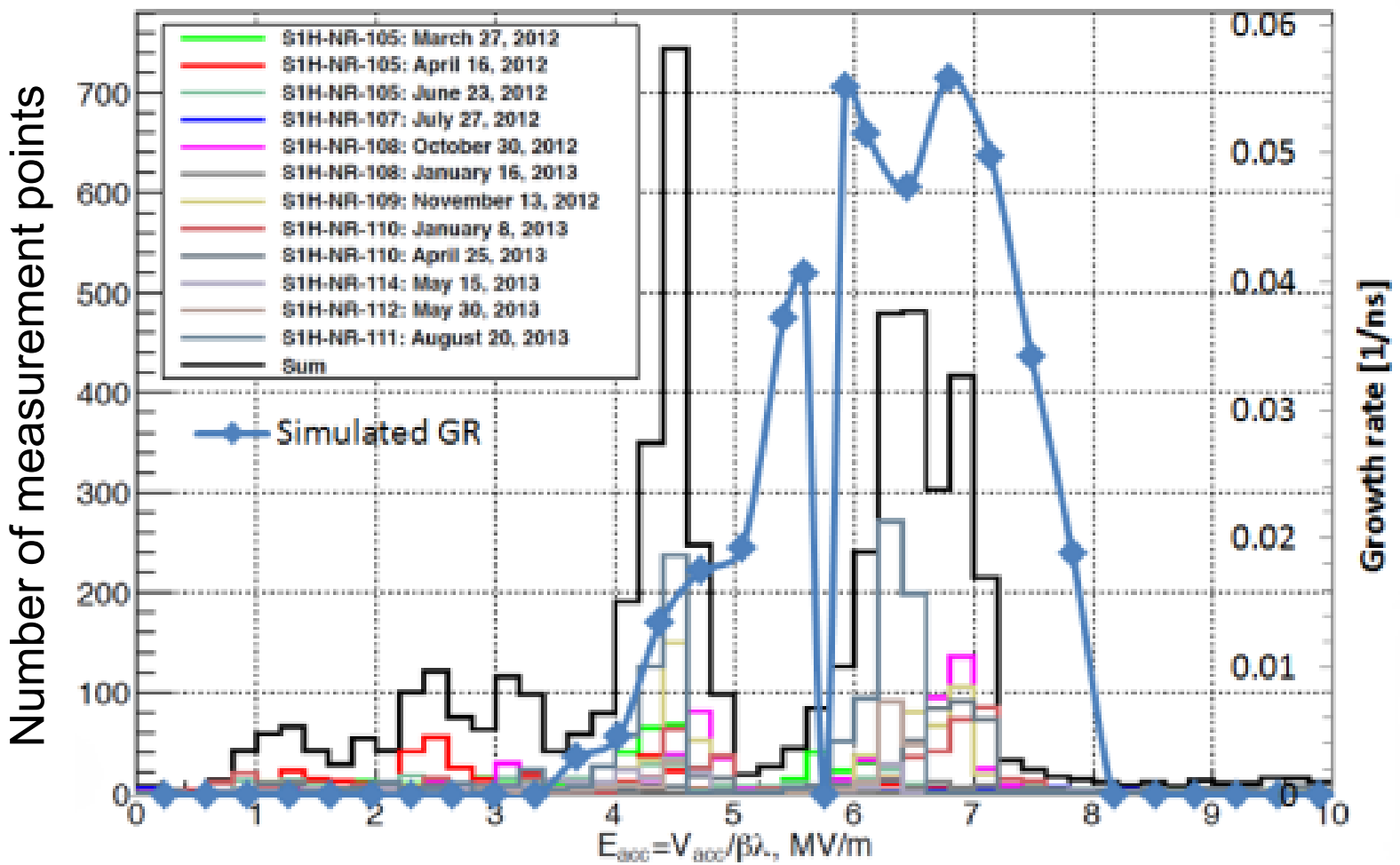
MP @ Eacc=10.4 MV/m

Summary of MP conditioning: 8 SSR1 cavities, 12 tests



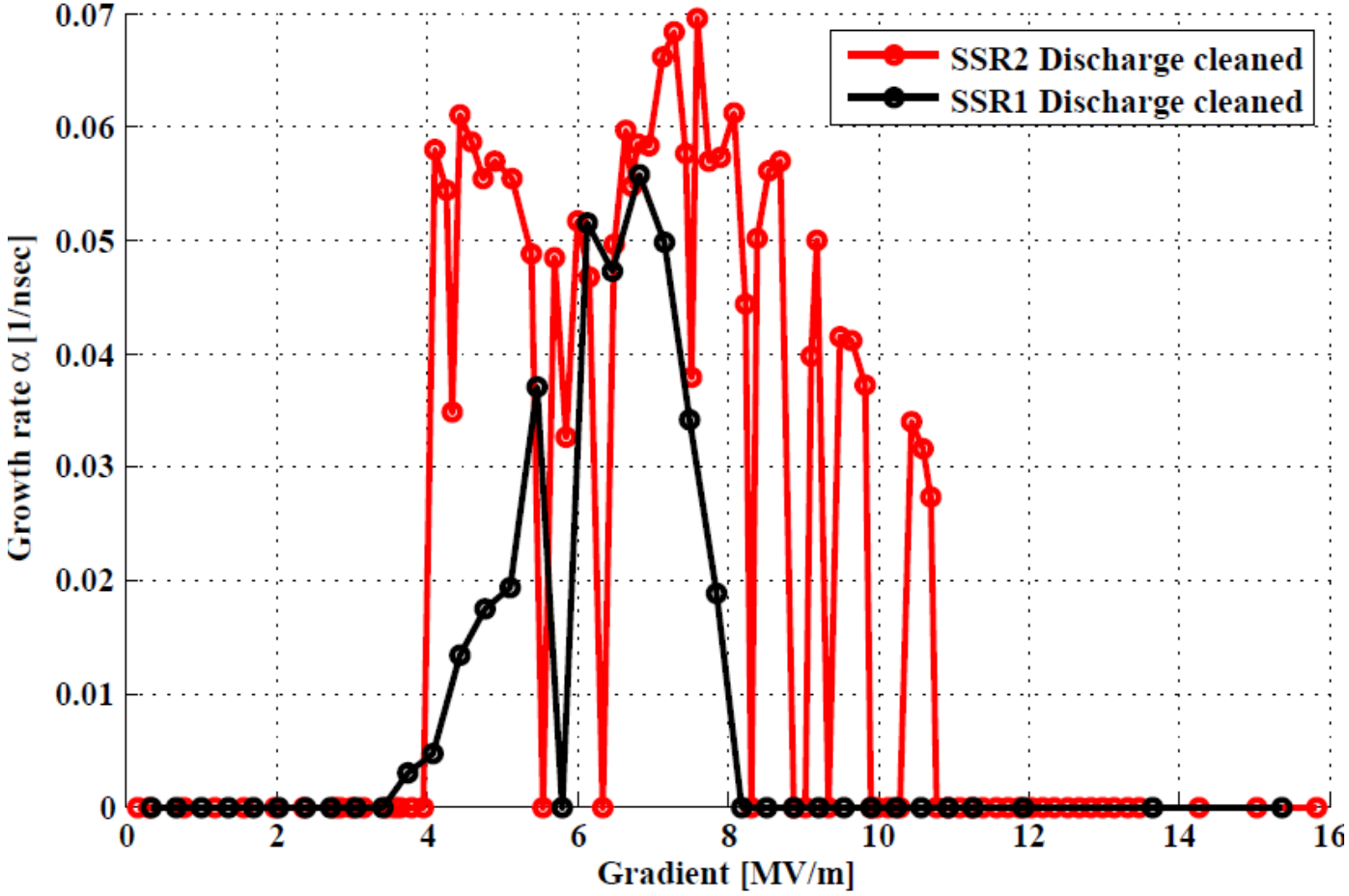
MP simulations

Results of multipacting simulations of SSR1 have been compared with the data collected during the vertical tests of the cavities. Operating gradient 12 MV/m.



MP simulations of SSR2

- SSR2 seems to have harder barriers compared to SSR1
- New cavity design will be re-optimized in order to reduce MP.
- Modification will involve mostly rearrangements of the outer wall corner.

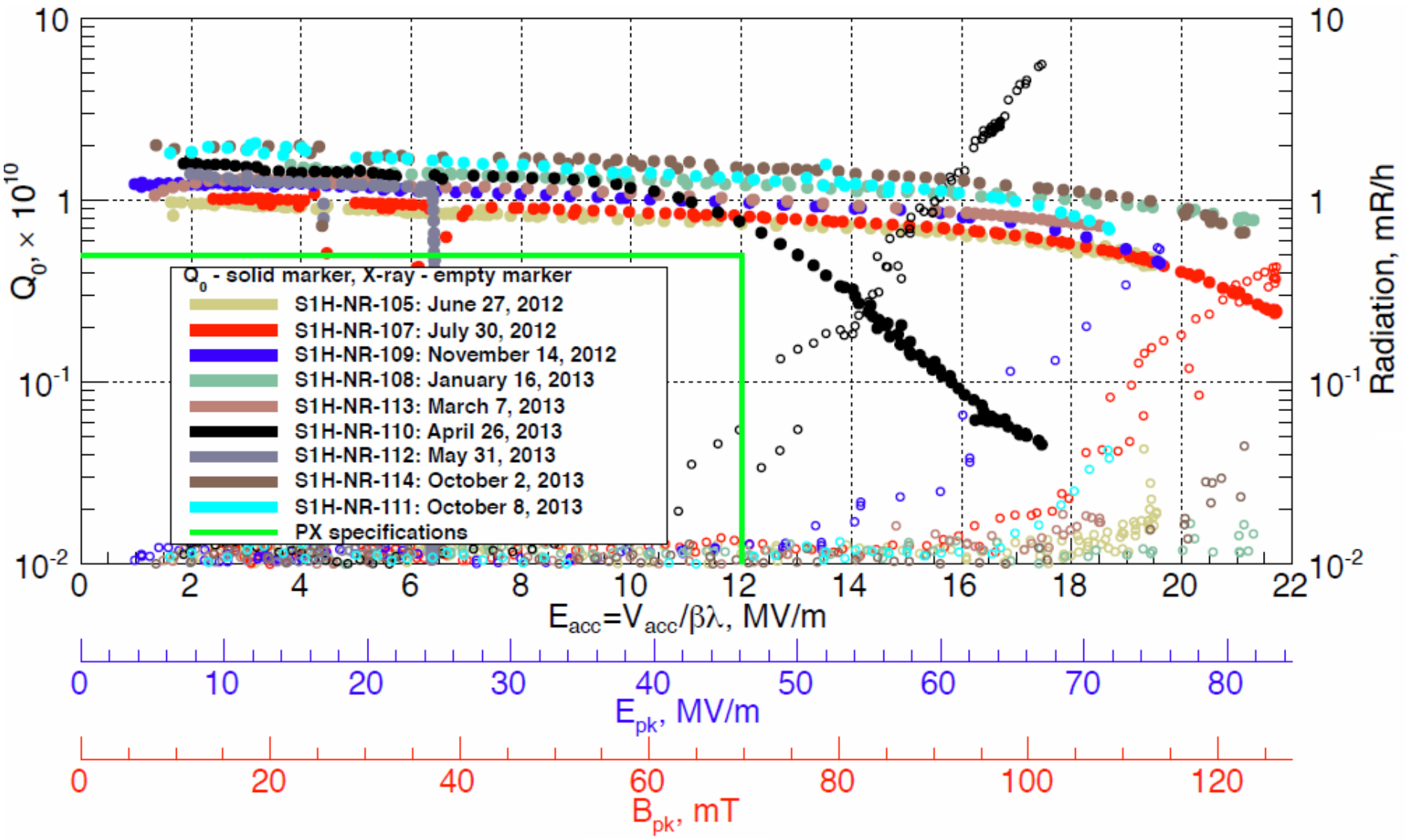


Summary

- Severe multipacting in FNAL SSR1 cavity can be processed away
  - More than 3 hours of MP processing per cavity was necessary
- Cavity preparation is very important to reduce MP
  - HPR in horizontal and vertical positions necessary
  - 2nd HPR needed for some cavities with severe field emission
  - 120C baking with active pumping significantly reduces MP processing time
- MP returns after storing the cavity at room temperature
  - MP reprocessing time is much shorter if cavity kept in dry conditions
- No MP at operating gradient after processing away of MP at lower gradients

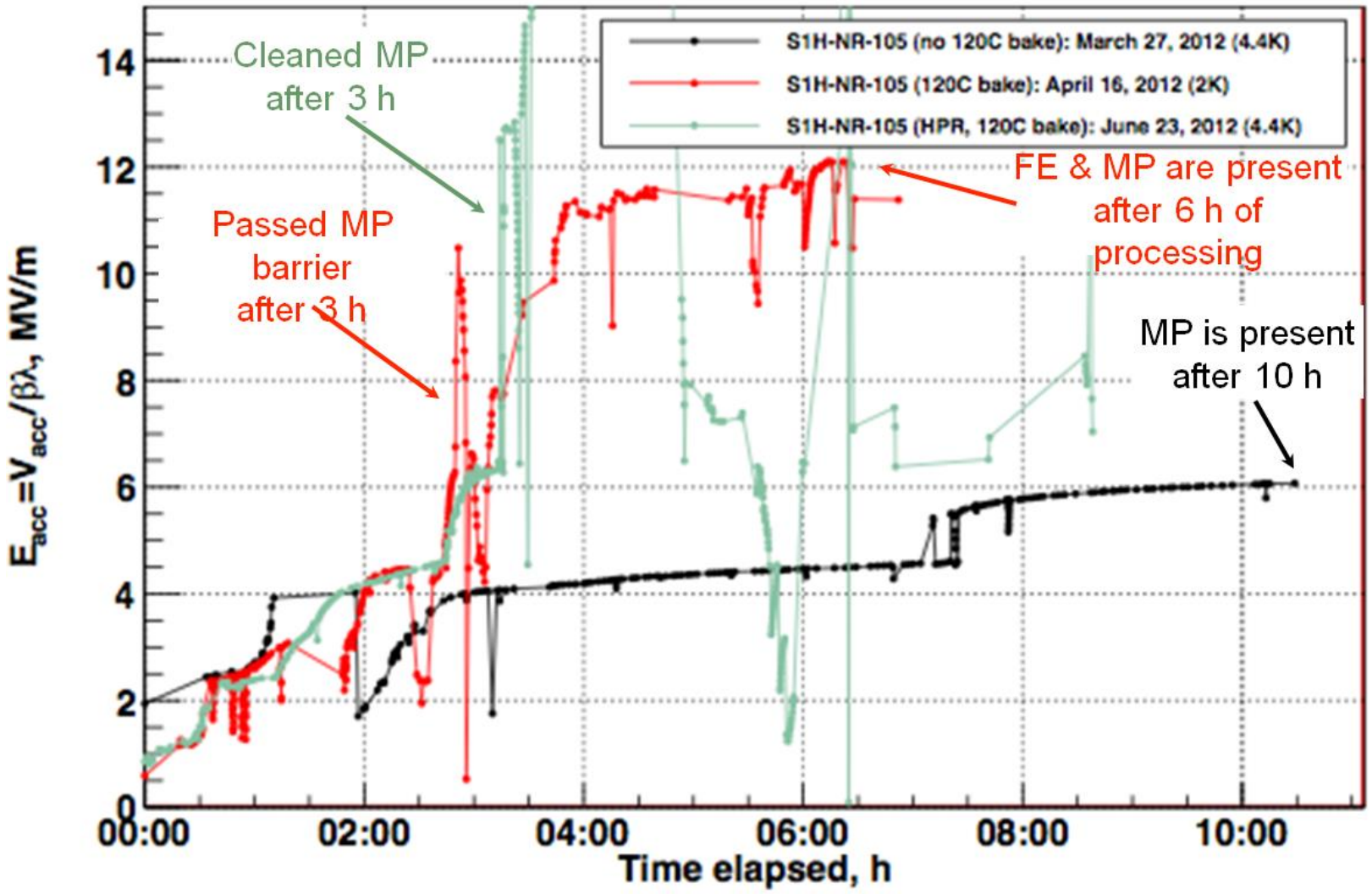
- MP simulations of current design of FNAL SSR2 results are pessimistic
  - Harder and more barriers compared to SSR1
  - MP exist at operating gradient
  - Processing away could be not possible
  - SSR2 cavity design will be re-optimized in order to reduce MP

Additional


Q_0, × 10^{10}
Radiation, mR/h
Q_0 - solid marker, X-ray - empty marker
S1H-NR-105: June 27, 2012
S1H-NR-107: July 30, 2012
S1H-NR-109: November 14, 2012
S1H-NR-108: January 16, 2013
S1H-NR-113: March 7, 2013
S1H-NR-110: April 26, 2013
S1H-NR-112: May 31, 2013
S1H-NR-114: October 2, 2013
S1H-NR-111: October 8, 2013
PX specifications
$E_{acc}=V_{acc}/\beta\lambda$, MV/m
E_{pk}, MV/m
B_{pk}, mT

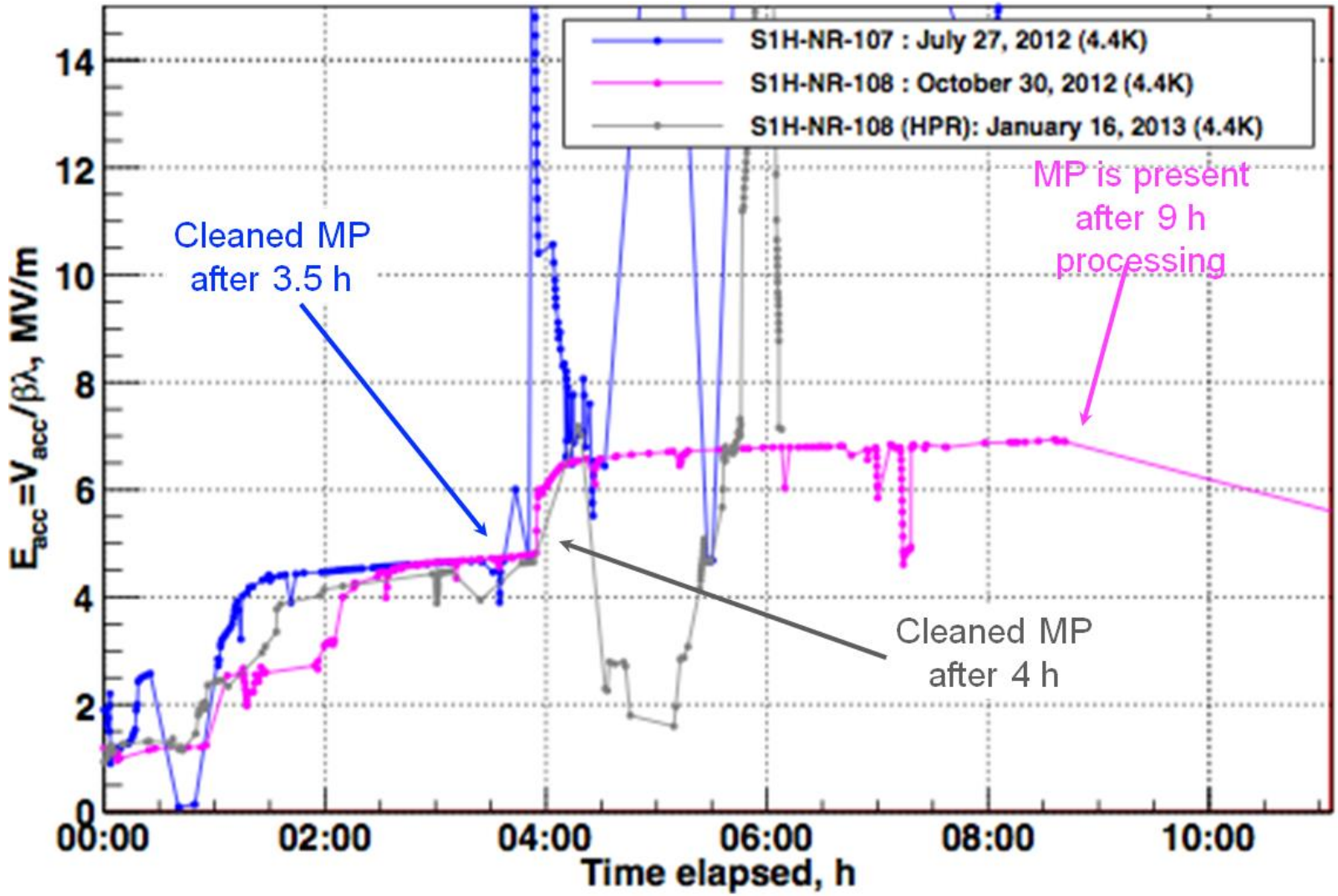
Additional

S1H-NR-105



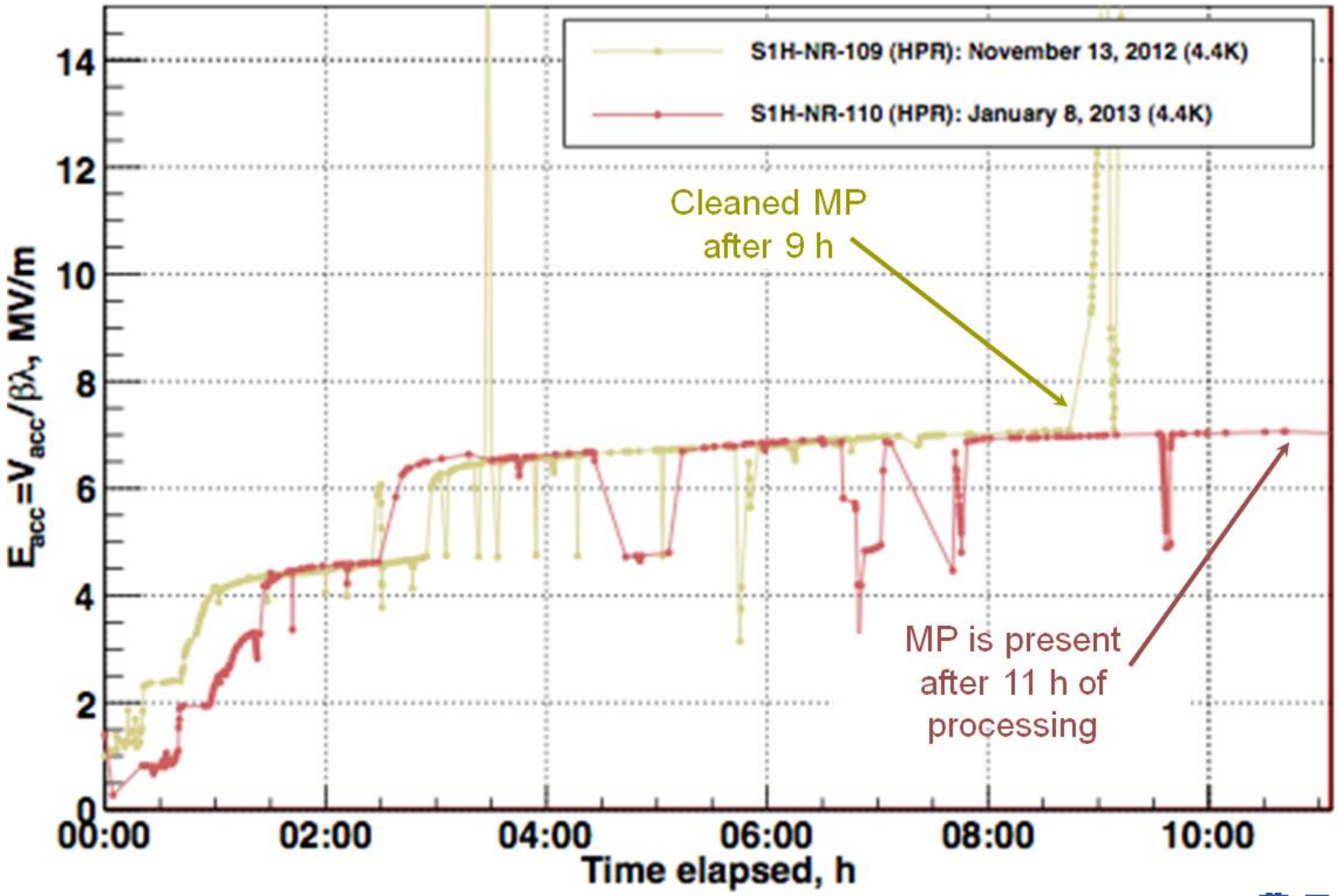
Additional

S1H-NR-107 & S1H-NR-108



Additional

S1H-NR-109 & S1H-NR-110



Additional

Results of field-emitter processing in S1H-NR-010 cavity