OAK RIDGE National Laboratory

POSSIBLE CONTRIBUTION TO ILC - ORNL PLASMA PROCESSING

Marc Doleans for ORNL

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ORNL is managed by UT-Battelle, LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

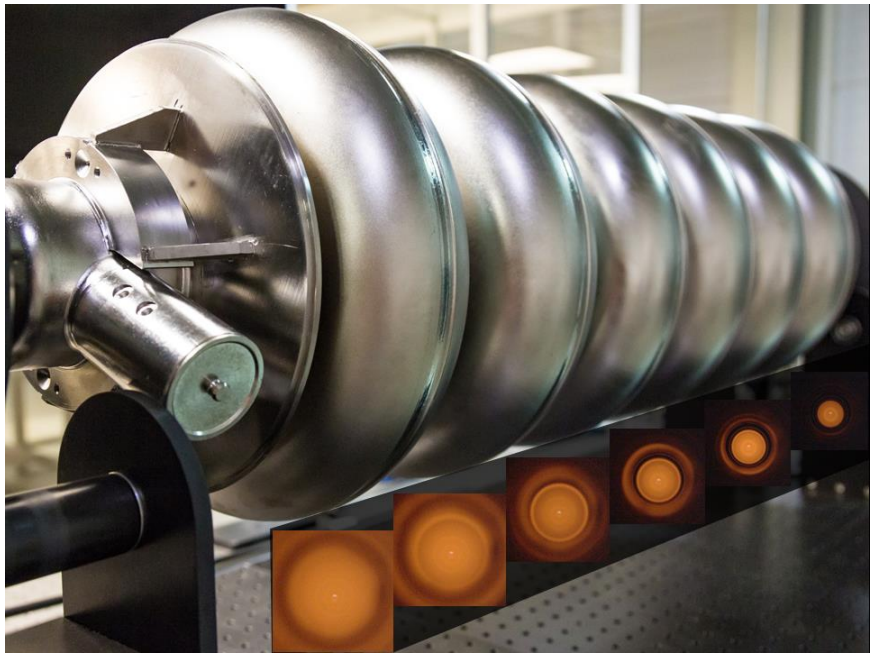
Possible contribution to ILC from ORNL

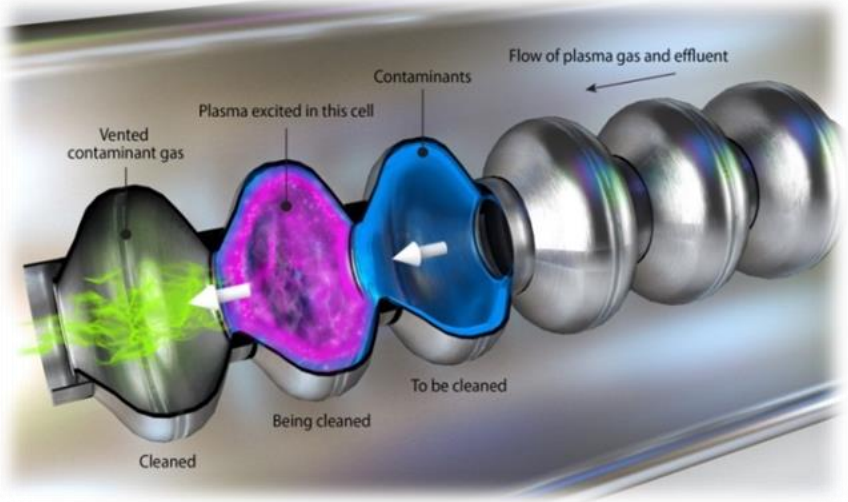
- In-situ plasma processing for ILC
  - Cleaning technique for SRF Nb cavities
    - Help recover and/or improve accelerating gradients
    - Can be done directly in the linac tunnel
  - Pioneered at ORNL
    - Developed and deployed successfully at the SNS (805 MHz)
  - On-going collaboration ORNL-FNAL-SLAC-JLab
    - To adapt technique to 1.3 GHz and 1.5 GHz cryomodules
    - FNAL successfully demonstrated ignition and control of plasma discharge in 9-cell 1.3 GHz cavities using HOM couplers
    - First plasma processing of 1.3 GHz cryomodule using SLAC LCLS-II HE vCM planned for 2021
    - Jlab demonstrated ignition and control of plasma discharge in 7-cell 1.5 GHz cavities also using HOM couplers

More information about in-situ plasma processing developments :
M. Doleans,"Plasma Processing Programmes Overview", **Invited talk at LINAC20**

In-situ plasma processing at SNS

- Cleaning technique uses a neon gas discharge with reactive oxygen for SRF cavities at room-temperature
- Plasma ignited in each cell of a cavity sequentially
- Oxidation of hydrocarbon surface contaminants creates volatile by-products pumped out continuously
- Cleaned surface has increased work function helping mitigating field emission and multipacting





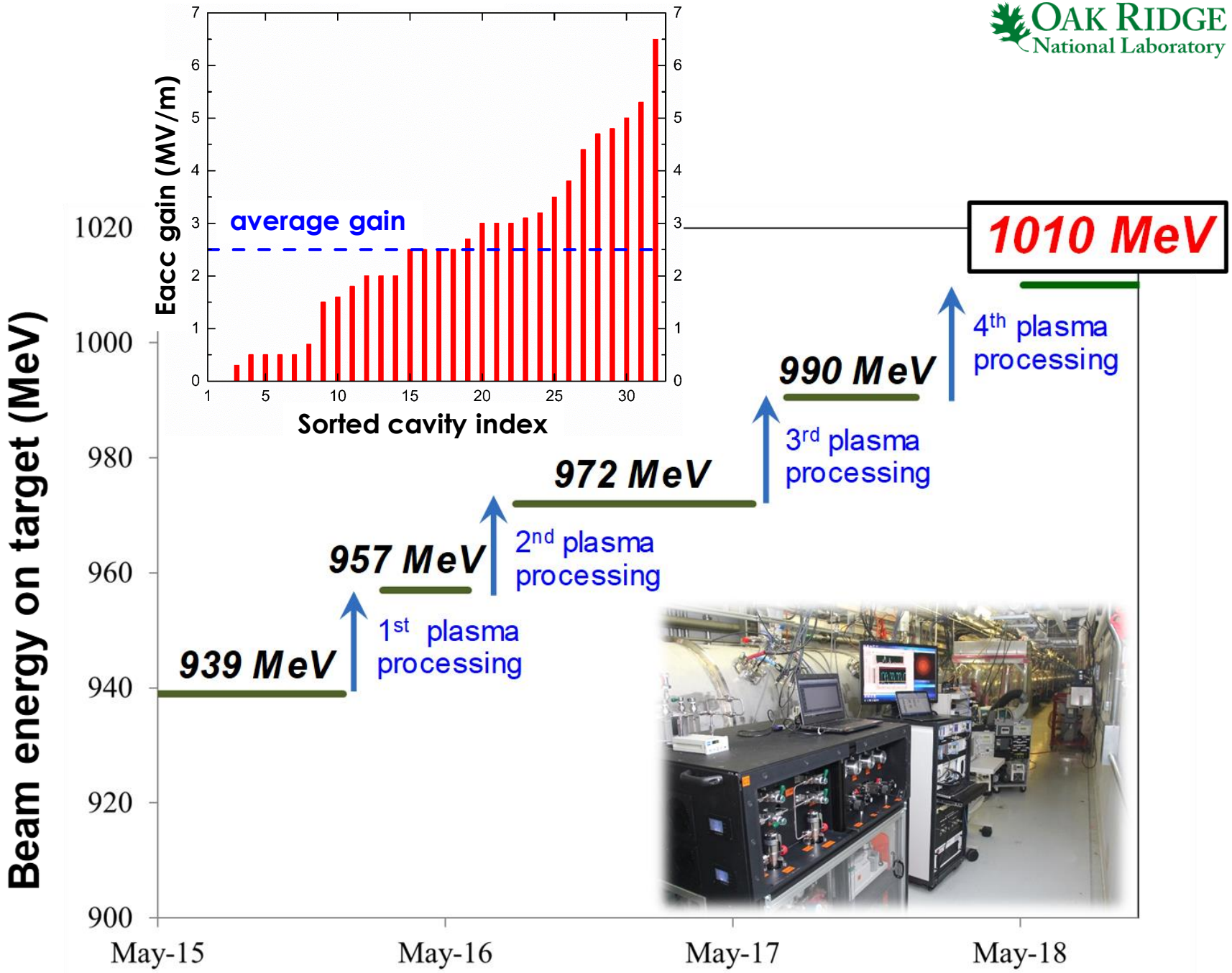
M. Doleans et al., NIMA **812** (2016)
M. Doleans J. Appl. Phys., **120**, 243301 (2016)
P.V. Tyagi et al., Applied Surface Science **369** (2016)

In-situ plasma processing at SNS

- Hardware comprises gas injection, RF and pumping systems
- Packaged in carts and rolled adjacent to the CM for plasma processing
- ~2 weeks to warm-up, plasma process and cool back down a CM

Boost to 1 GeV

- In-situ plasma processing in linac tunnel done during SNS planned down periods on HB CMs
- 32 cavities plasma processed at SNS with an average Eacc increase of 2.5 MV/m
- Beam energy at SNS has been sustained at 1 GeV since summer 2018



Conclusion

- In-situ plasma processing for superconducting RF resonators was developed at ORNL and successfully applied to increase the beam energy at the SNS
- Collaboration in North America is actively adapting plasma processing to other facilities

- In-situ plasma processing could help achieving and sustaining beam energy for the ILC