Normal Conducting RF Cavities for ionization cooling in a Muon Collider

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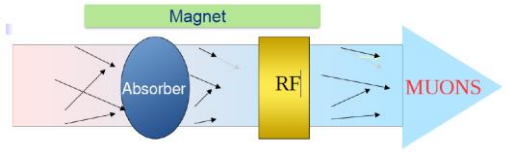
Ionization cooling: the only cooling scheme that can reduce the emittance fast enough to overcome the 2.2 μs muon decay time and achieve the targe luminosity for a TeV MuC.

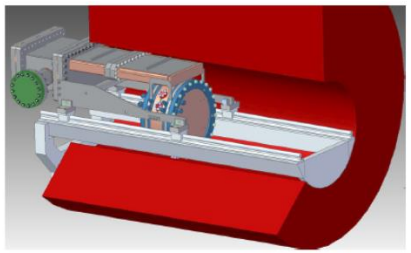


$$\epsilon_0 \approx \frac{\beta_\perp}{\beta_v}\frac{1}{2}\left(\frac{14.1}{m_\mu}\right)^2 \frac{1}{L_R d\gamma/ds},$$

The RF cavity gradient directly affect the cooling efficiency. The higher the gradient the better. Major challenge: the surrounding multi-tesla B field from the focusing solenoids makes the cavities more susceptible to RF breakdown.

Two possible mechanisms: 1) affecting the local plasma environment for the field emission 2) focusing the emitted electrons hitting on the cavity wall.

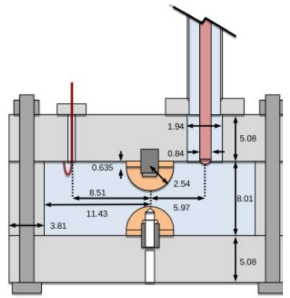
A modest RF gradient (~25 MV/m) for a cooling demonstrator is highly achievable based on current R&D progress within next 10 years. More studies are required to further increase the cavity operation gradient.



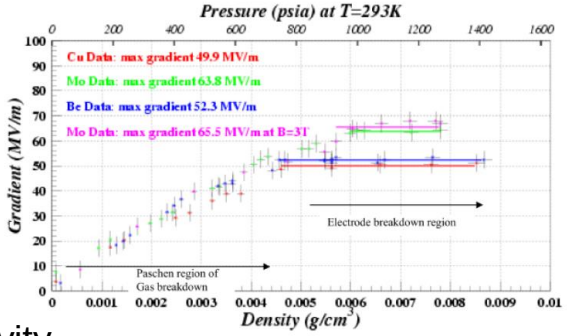
A 805 MHz vacuum cavity with Be end walls

Material	B-field (T)	SOG (MV/m)	BDP ($\times 10^{-5}$)
Cu	0	24.4 ± 0.7	1.8 ± 0.4
Cu	3	12.9 ± 0.4	0.8 ± 0.2
Be	0	41.1 ± 2.1	1.1 ± 0.3
Be	3	$> 49.8 \pm 2.5$	0.2 ± 0.07
Be/Cu	0	43.9 ± 0.5	1.18 ± 1.18
Be/Cu	3	10.1 ± 0.1	0.48 ± 0.14

D. Bowring et al.



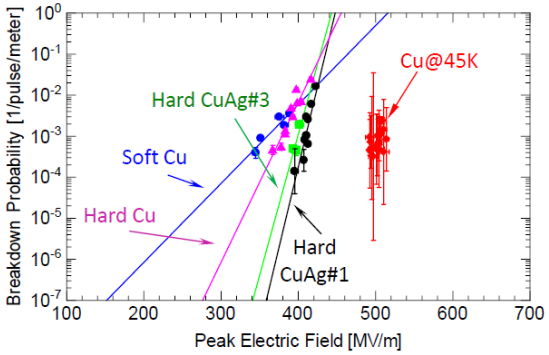
A 805 MHz gas-filled cavity



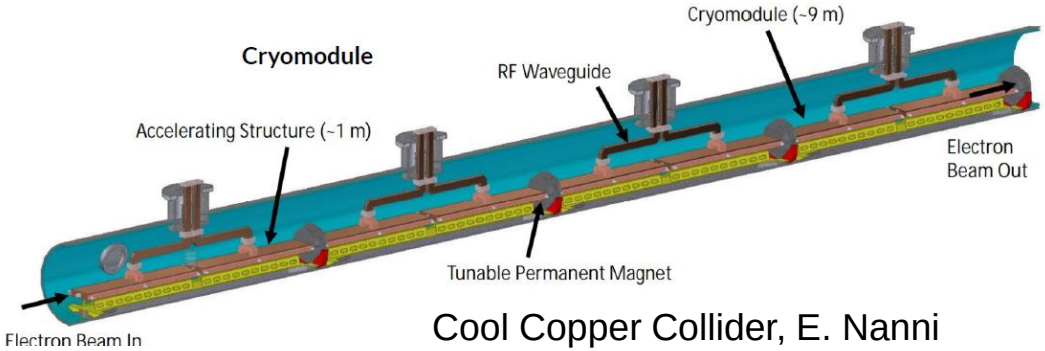
B. Freemire et al.

New possible approaches utilizing recent R&D advancements

- Besides continuing the pathway of current directions, the recent accelerator R&D advancements offer new possible approaches to develop high gradient RF cavities operated in strong B field.
- Cool copper RF cavity
  - Copper cavity operated at LN2 temperature shows significantly stronger resilience to RF breakdown than at room temperature.
  - Discovered in the campaign for high gradient NCRF for future linear colliders.
  - This technology is being applied to the proposed linear collider C3 (with a demo planned for ~2029), high-brightness electron gun, etc.



A.Cahill

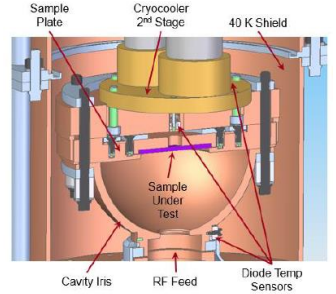


Cool Copper Collider, E. Nanni

- HTS Superconducting RF cavity
  - HTS coating developed for FCC-hh beam screen, RF cavity for dark matter axion search and high power RF for beam acceleration.
  - High critical B field in HTS material.
  - Low power RF tests show promising results.
  - High power RF tests are underway.

REBCO coated conductor cavity for Axion, T. Puig

1st Axion cavity	CC coated cavity	Cu cavity
Q(0T, 4.2K)	80000	40000
Q(11T, 4.2K)	60000	40000



High power test set-up at SLAC

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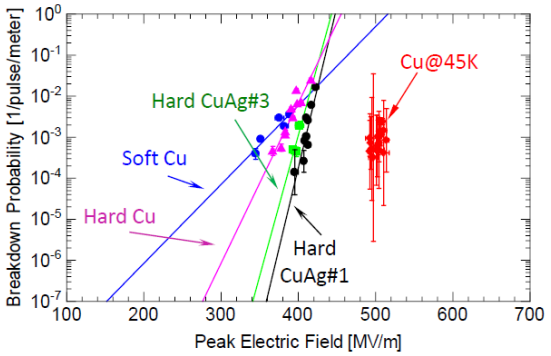

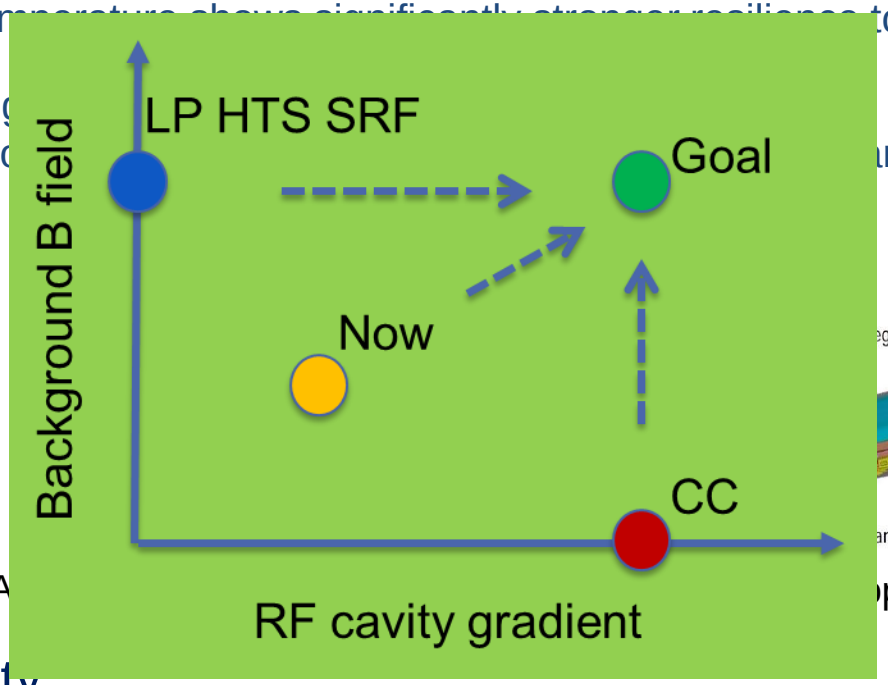

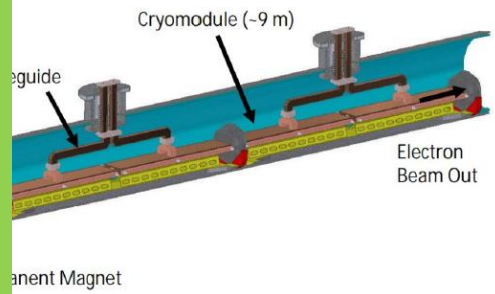

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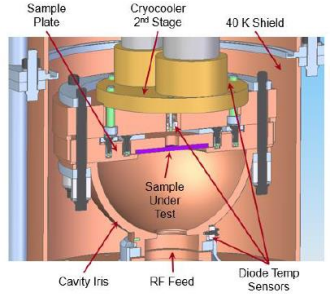

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