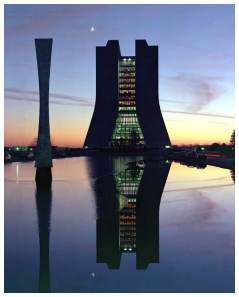
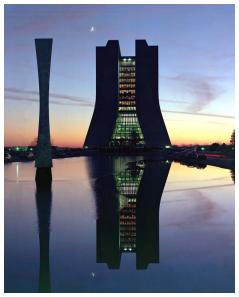


Overview of HPRF project

K. Yonehara

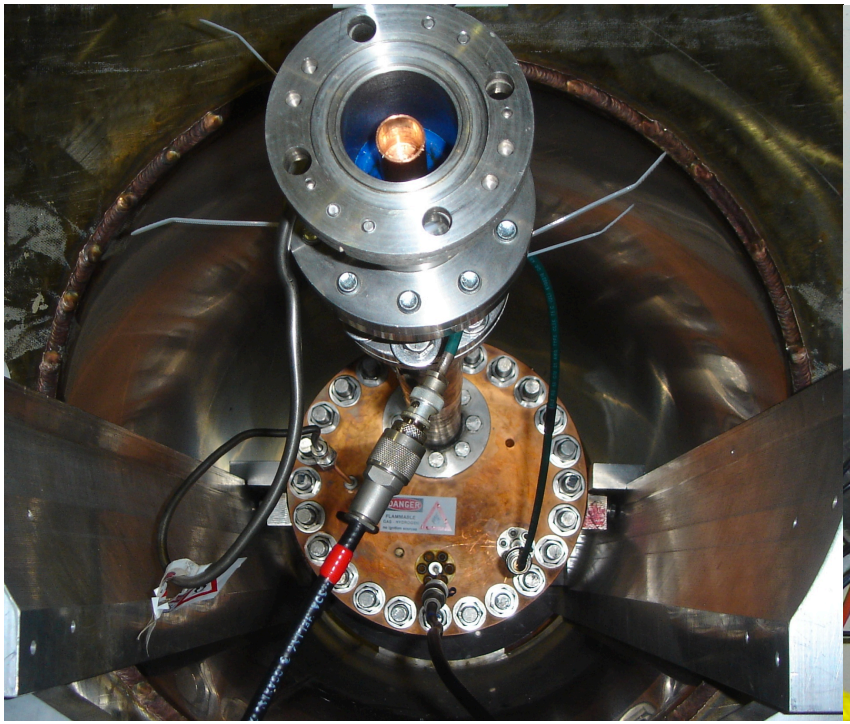
APC, Fermilab

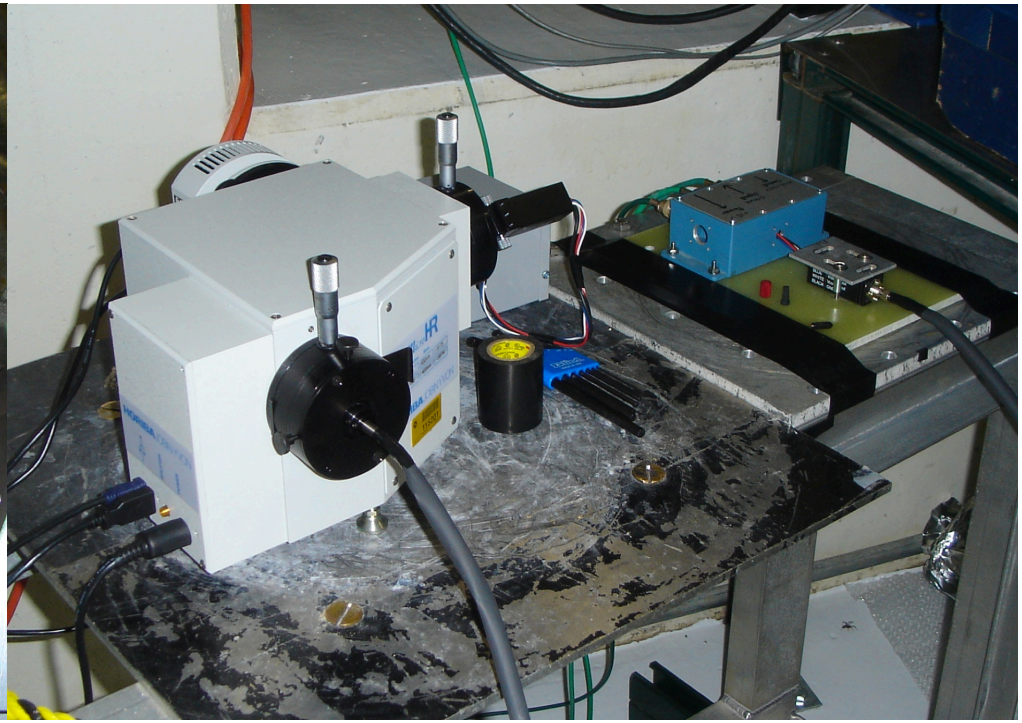
On Behalf of HCC/HPRF simulation group



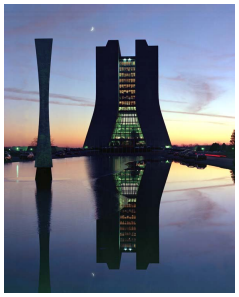
Gas-filled RF program

- 2003-2013: Demonstrate concept of a gas-filled RF cavity in ionizing beams and strong magnetic fields
- 2013-2015: Demonstrate concept of a dielectric loaded gas-filled RF cavity
- 2013-2015: Investigate gas plasma dynamics in simulations
- 2015: Awarded DOE STTR ph-I for a gas-filled RF hadron monitor with Muons Inc

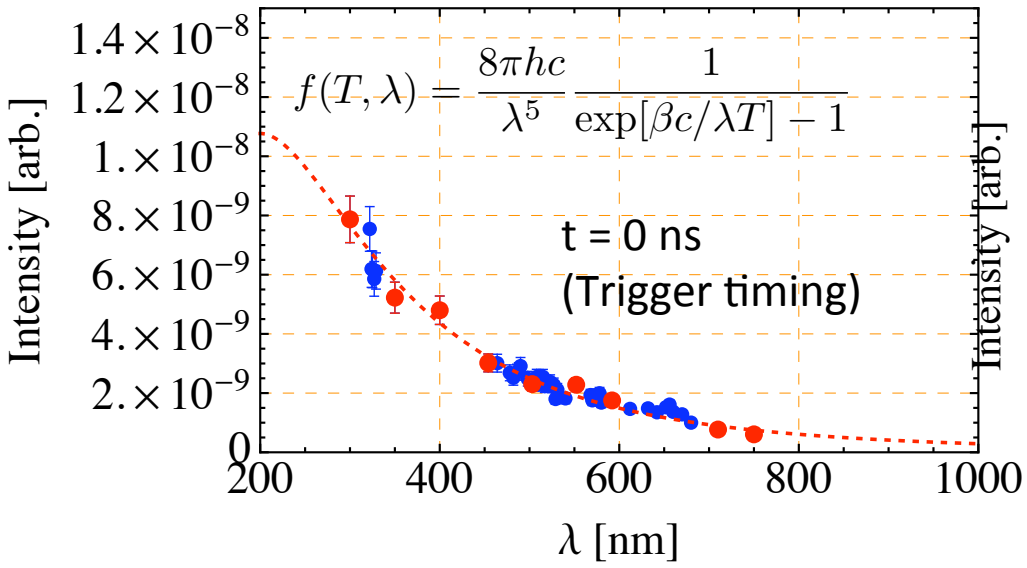


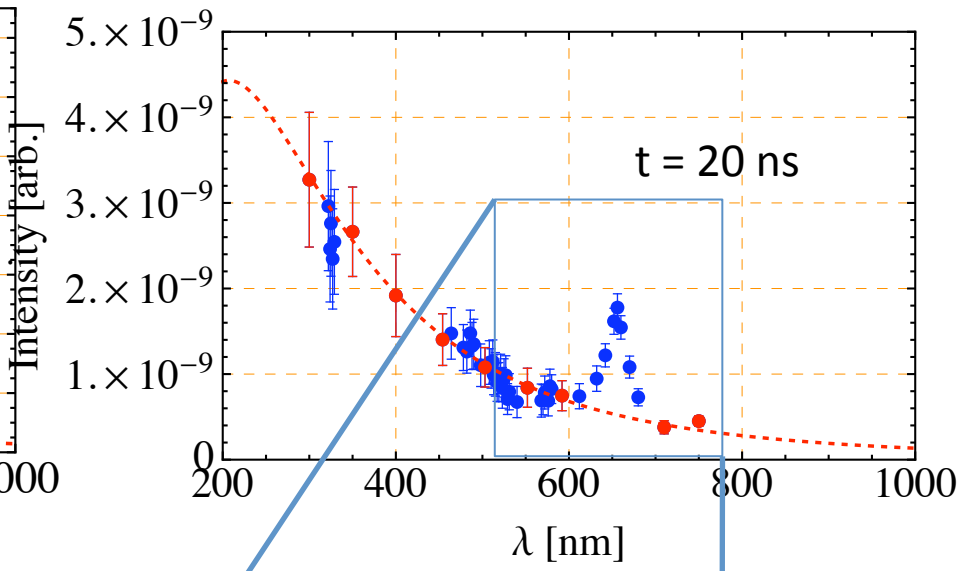


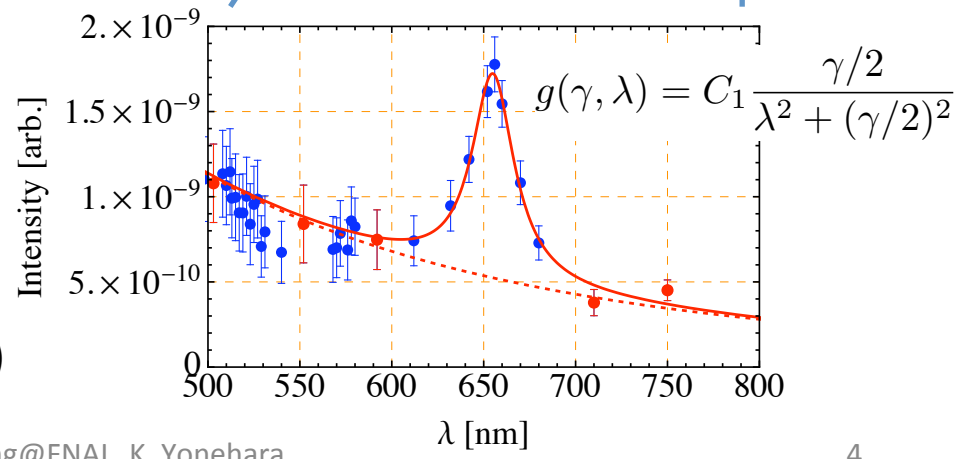
Gas Breakdown Study



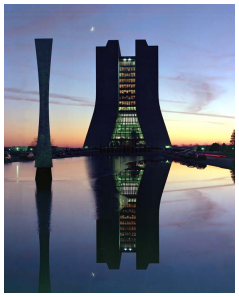
Spectrum in hydrogen gas breakdown



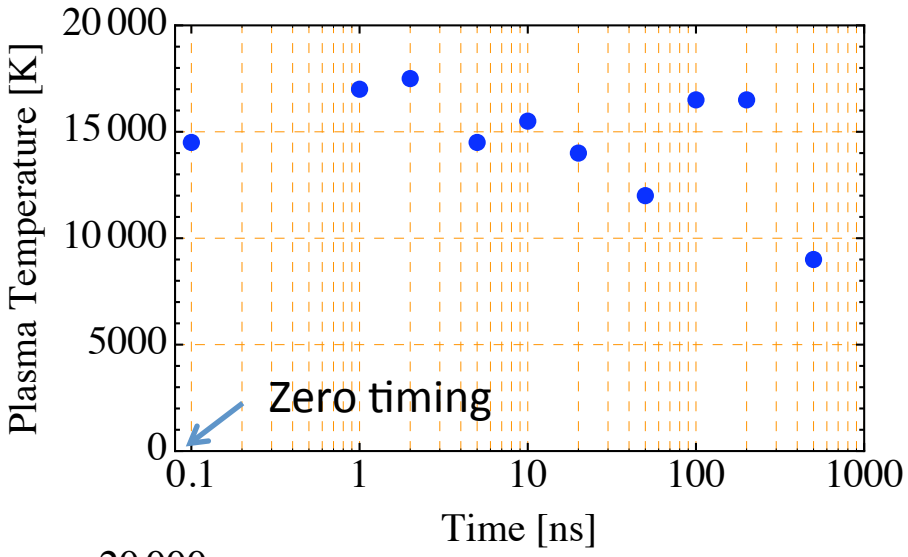


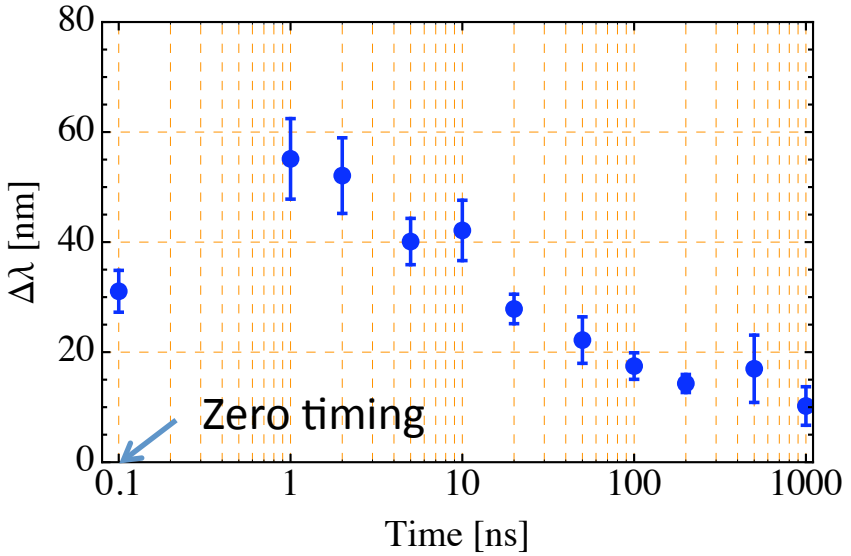


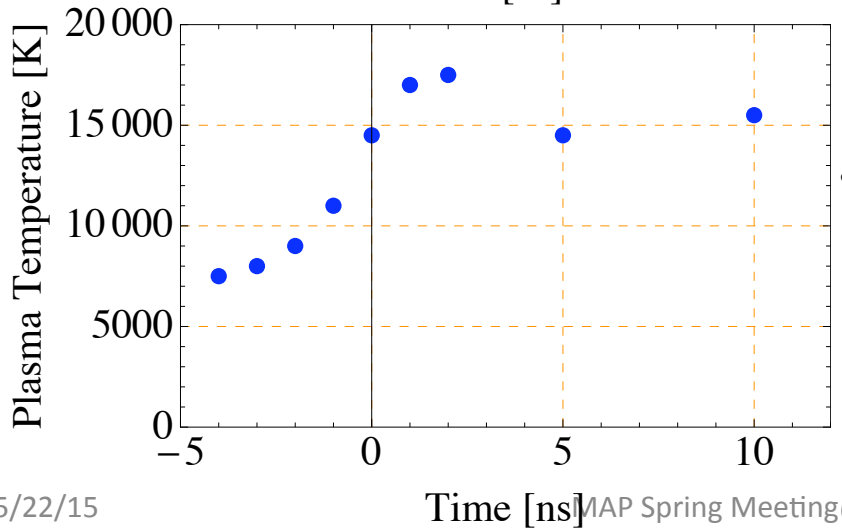
- A continuous curve corresponds to a blackbody radiation emitted by H_2
- Sharp spectrum corresponds to the atomic hydrogen
- Broaden of resonant line is due to the Stark effect by a local plasma electric field (probe for a plasma density)

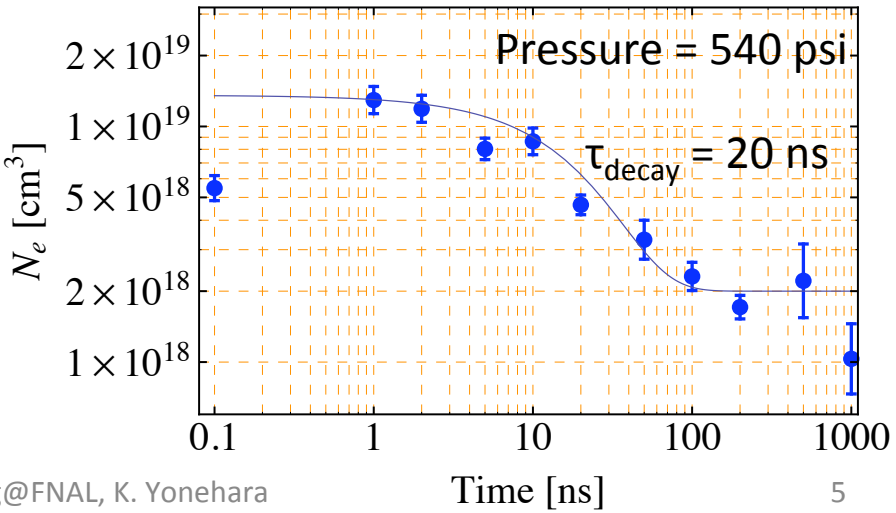


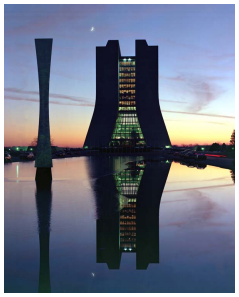
Time dependent plasma density





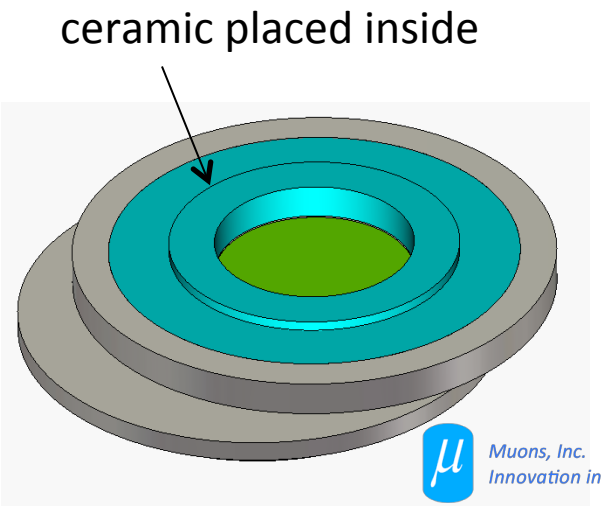


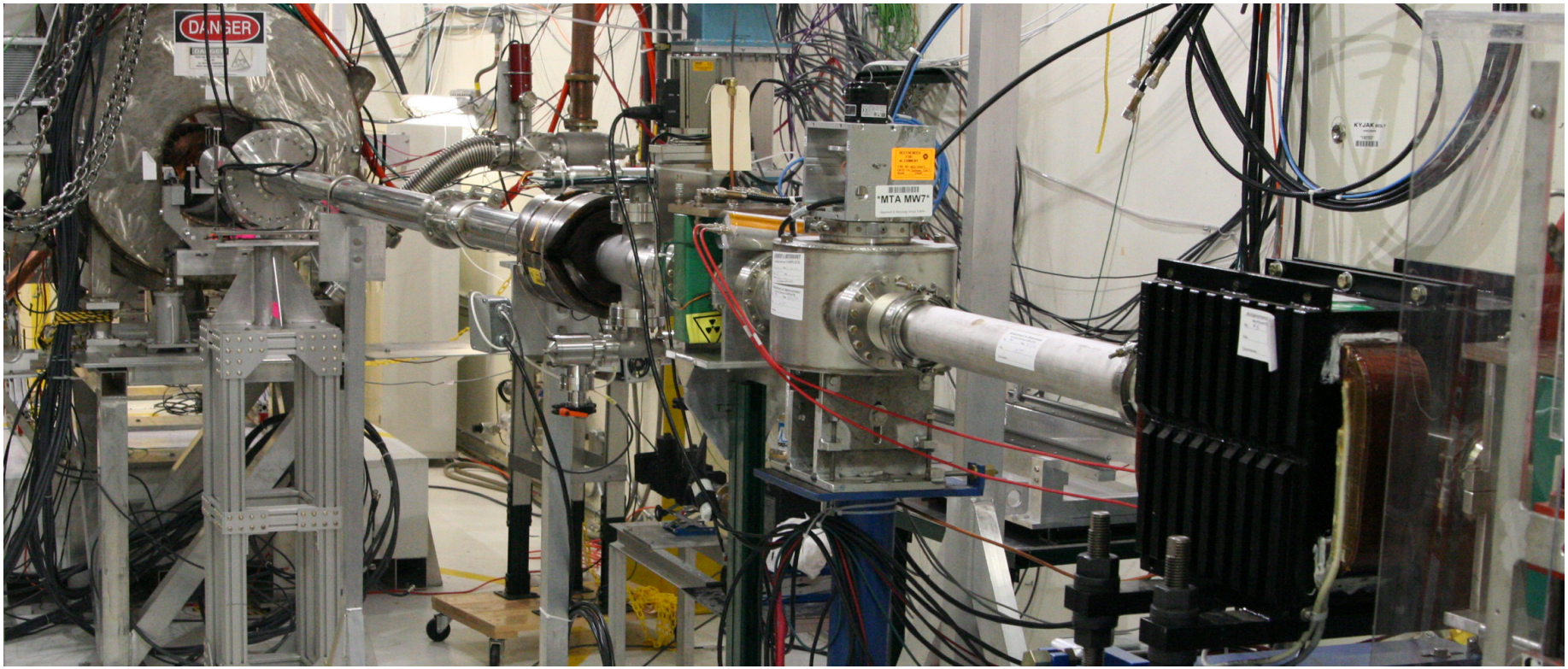




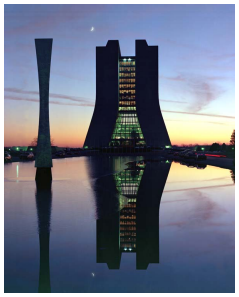
Present project: Dielectric Loaded RF

- Scientific goal
  - Low loss tangent
    - $\tan\delta < 10^{-4}$
  - High dielectric strength
    - E > 20 MV/m
  - Low/No interaction with beam-induced gas plasma
- Plan
  - High power sample test
  - Beam test

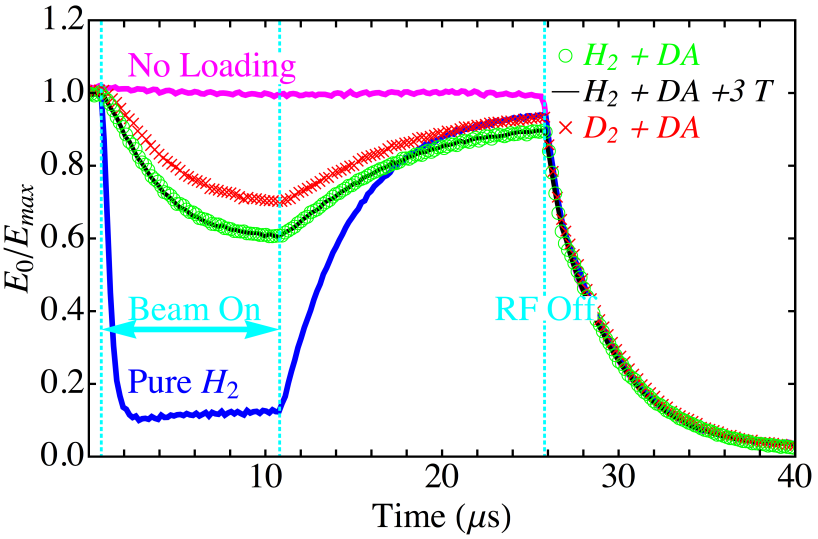


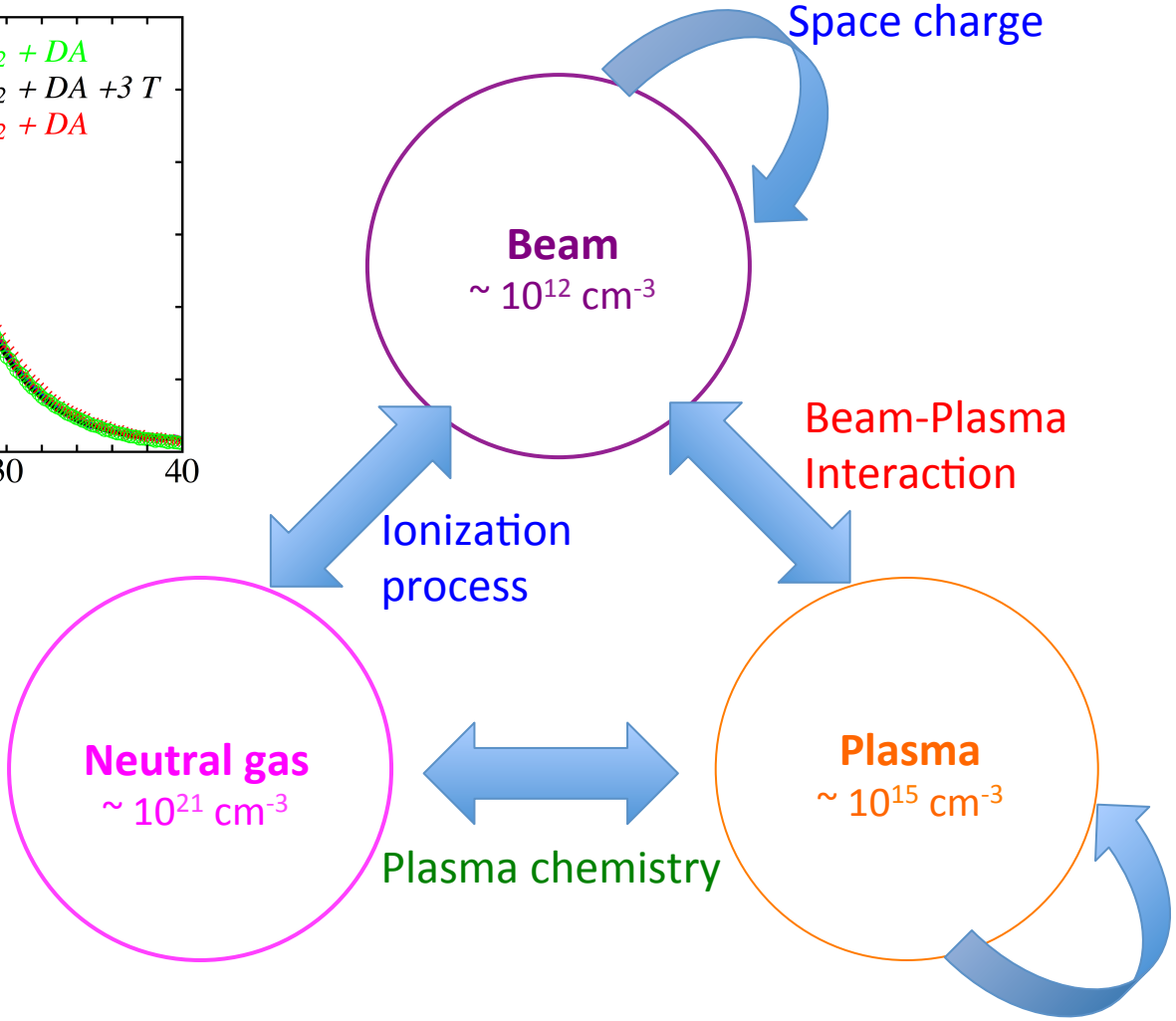


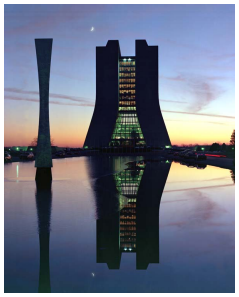
Beam Program



Physics in HPRF in ionizing beam



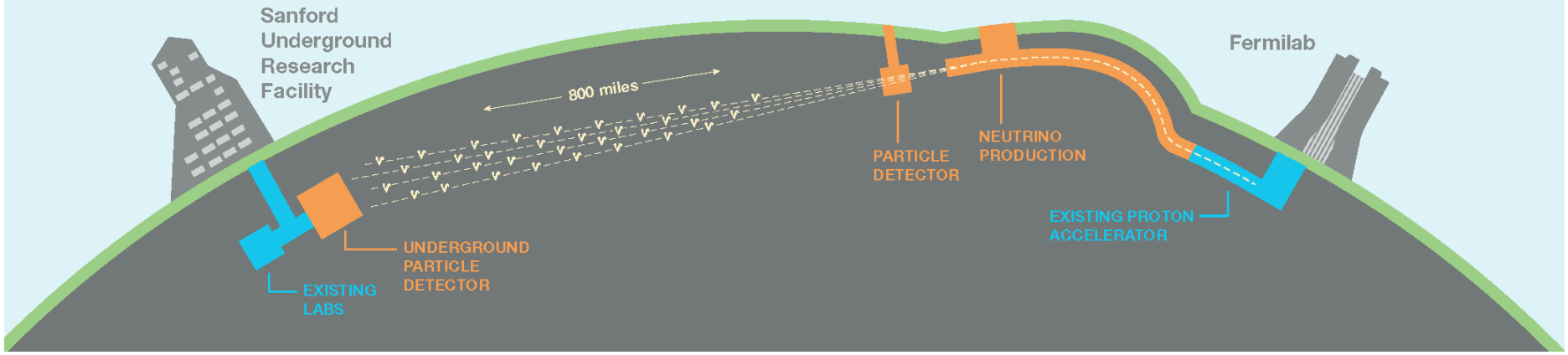




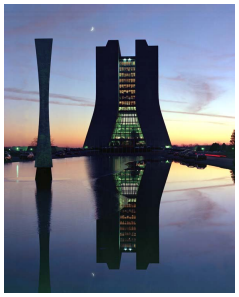
Simulation effort

- Plasma chemistry
  - How to control plasma density?
    - Find quantity of hydrogen recombination rate, electron capture rate by electronegative gas, neutralization of ions
  - How to control plasma dynamics?
    - Find quantity of electron and ion mobility
- Beam-Plasma interaction
  - Study collective effect
    - Space charge: No effect on transverse. Some interest in longitudinal since the longitudinal space charge acts longitudinal focusing in HCC
    - Strong interest in charge neutralization and plasma lens

Long Baseline Neutrino Facility (LBNF)

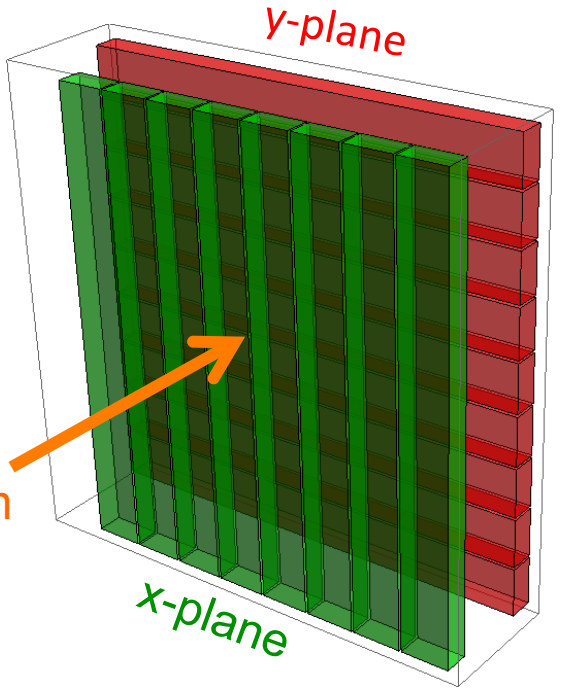


Beyond MAP

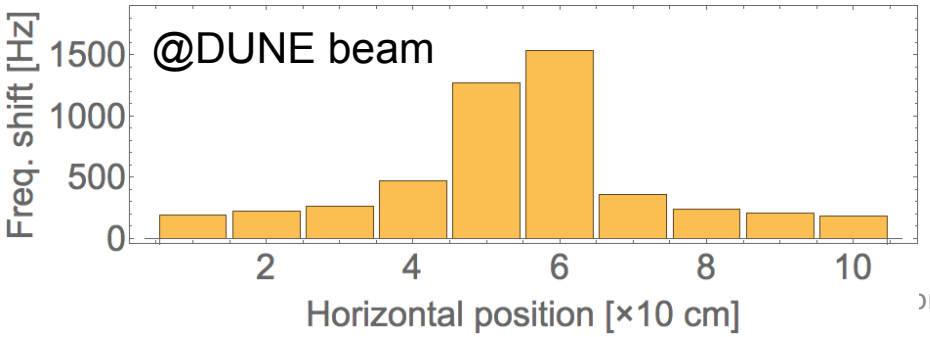


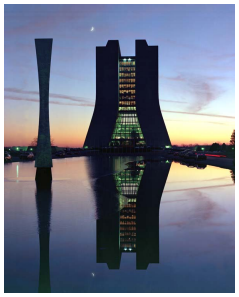
Hadron RF monitor system

- MW-Beam facilities: Require beam monitors with improved radiation resistance
  - Neutrino Sources: DUNE, T2K, LBNO
  - Spallation Neutron Sources: SNS, ESS, CSNS
- Gas-filled RF Resonator Hodoscope
  - Offers radiation robust technology
  - Relative permittivity shift in resonator is proportional to plasma density produced by a hadron beam



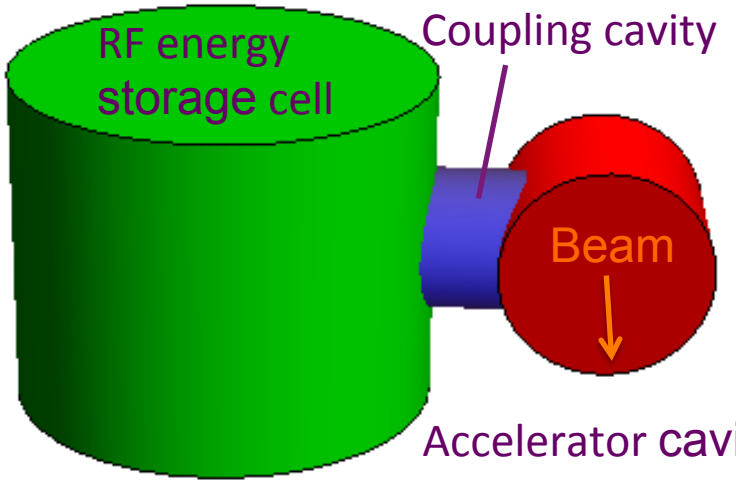
Gas-filled RF resonator strip

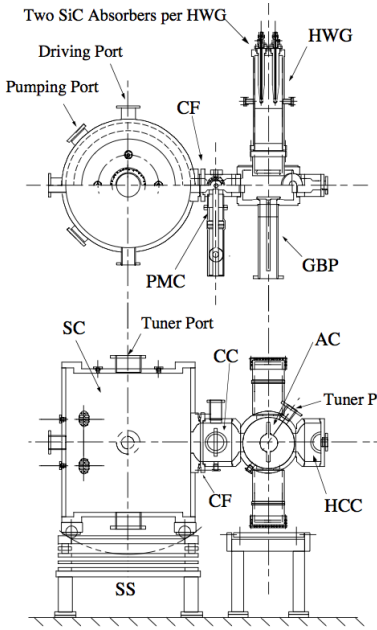




Compact energy storage cell

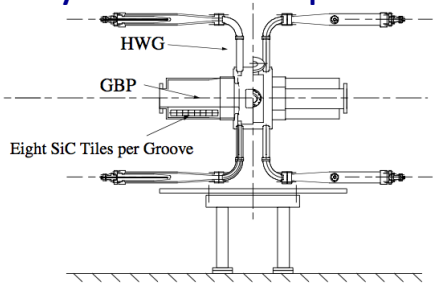
- Beam loading compensation for intense beams
- Dielectric-loaded ⇨ high-density energy storage
- High pressure gas stabilizes against breakdown





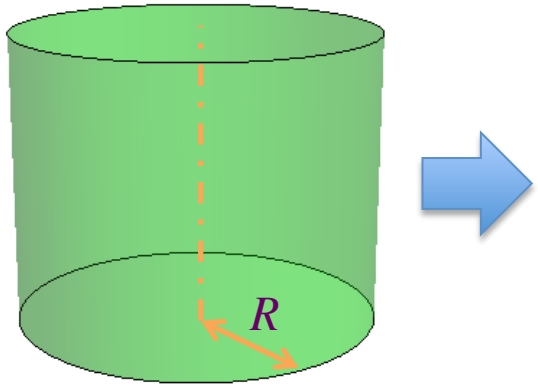
AC: Accelerating Cavity
CC: Coupling Cavity
CF: Connecting Flange
GBP: Grooved Beam Pipe
HCC: Half-Cell Coupling Cavity
HWG: HOM Waveguide
PMC: Parasitic Mode Coupler
SC: Storage Cavity
SS: Supporting Structure

ARES Cavity System Concept



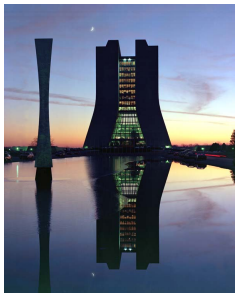
Empty (vacuum) storage cell

Gas and ceramic filled storage cell



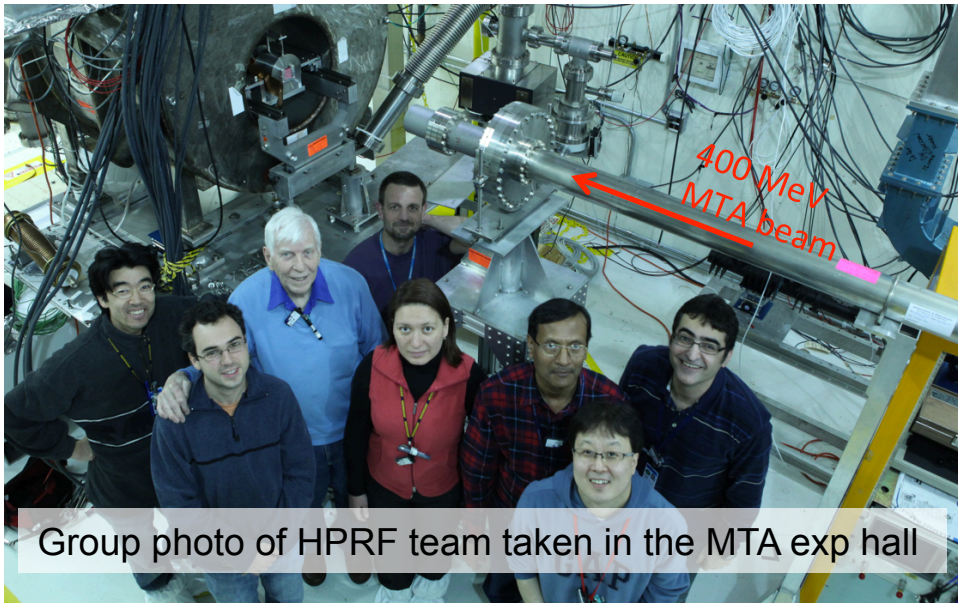
$$r = R/\sqrt{\varepsilon}$$

RF Energy Storage Cell Concept



Summary

- Very successful program!
  - Unique physics aspect
  - Many interesting physics
  - Found new extension
- Preparing a full paper to PRSTAB about the plasma chemistry



Group photo of HPRF team taken in the MTA exp hall