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Laser-triggered RF breakdown experiment with a photo-cathode RF gun at Tsinghua University

Presented on behalf of the collaboration by

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- ANL
  - Wei Gai, Chunguang Jing
- SLAC
  - Faya Wang

Content

- Pre-experiment
- Experiment setup
- Data Analysis
- Summary and Plans

Motivation

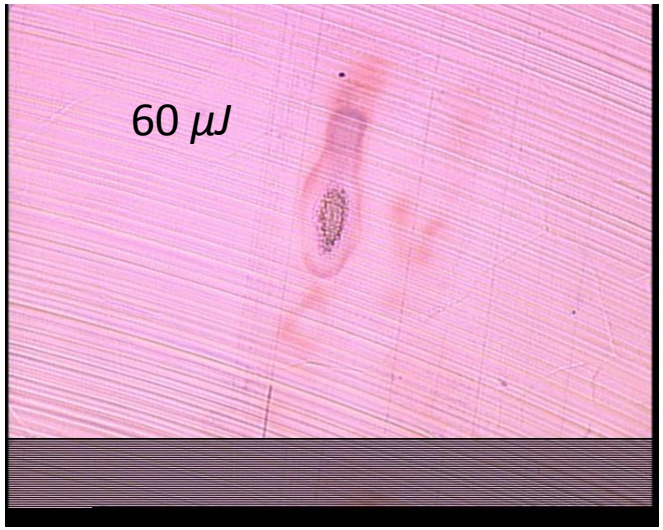
- RF breakdown dependence on *E, B, Sc,* ΔT_p...
  - Laser assistant RF breakdown experiment is trying to isolate some of the contributing effects. Hopefully, a more coherent picture of RF breakdown. [1]
- RF breakdown phenomenon
  - To better understand detailed RF breakdown progress and time scale. Quantities like turn on time, breakdown current, explosive emission… [2]

[1] Faya Wang
[2] Wei Gai, Chunguang Jing

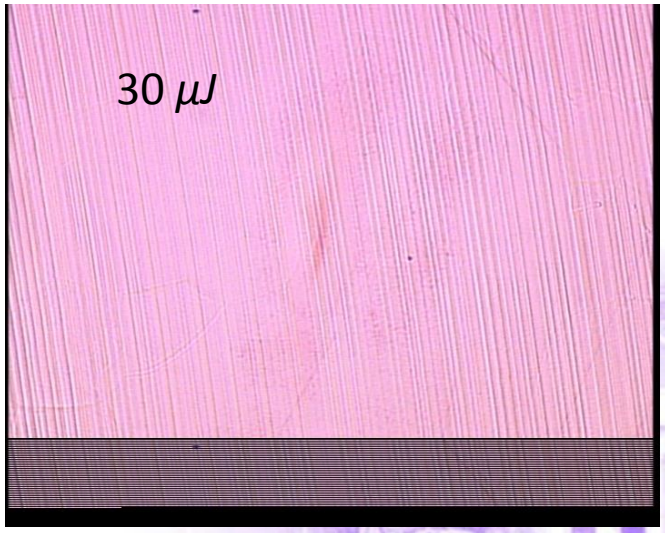
Pre-Experiment: Laser damage on copper surface

- Shot UV Laser pulse on copper surface.
  - 10μJ, *20, 30…*; 1mm diameter spot size; 1ps pulse length
  - Microscope image: (30sec@10Hz)

oxidization

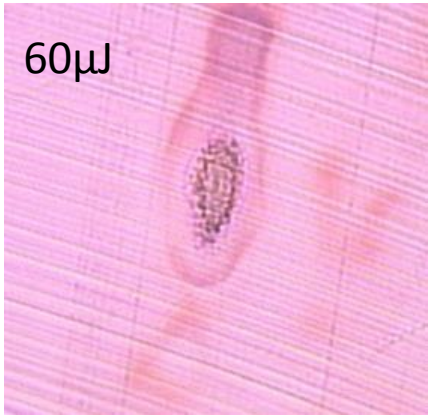


surface damage



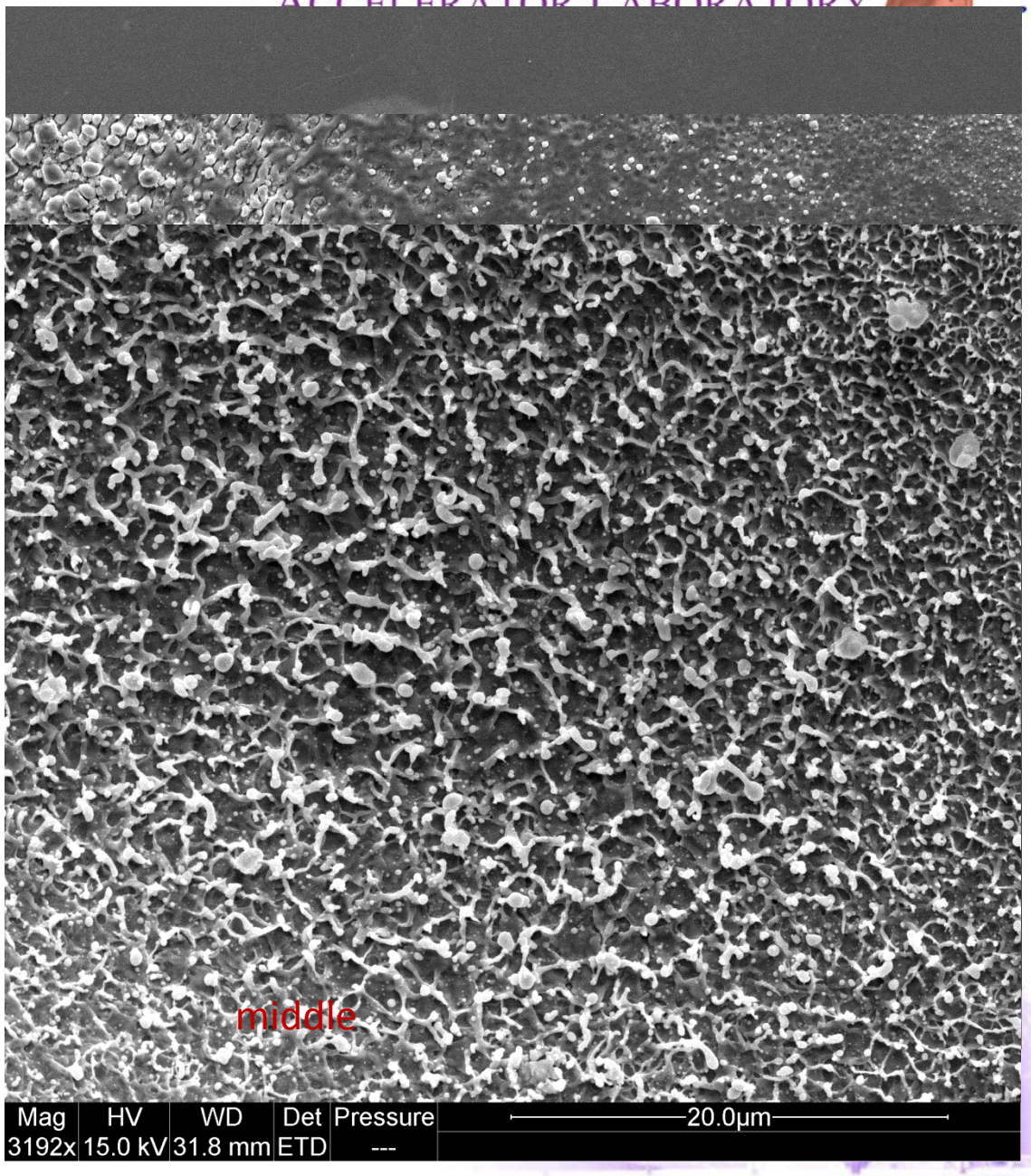
10μJ / 1mm^2 → 1m J/cm^2 @1ps →1GW/cm^2

SEM image



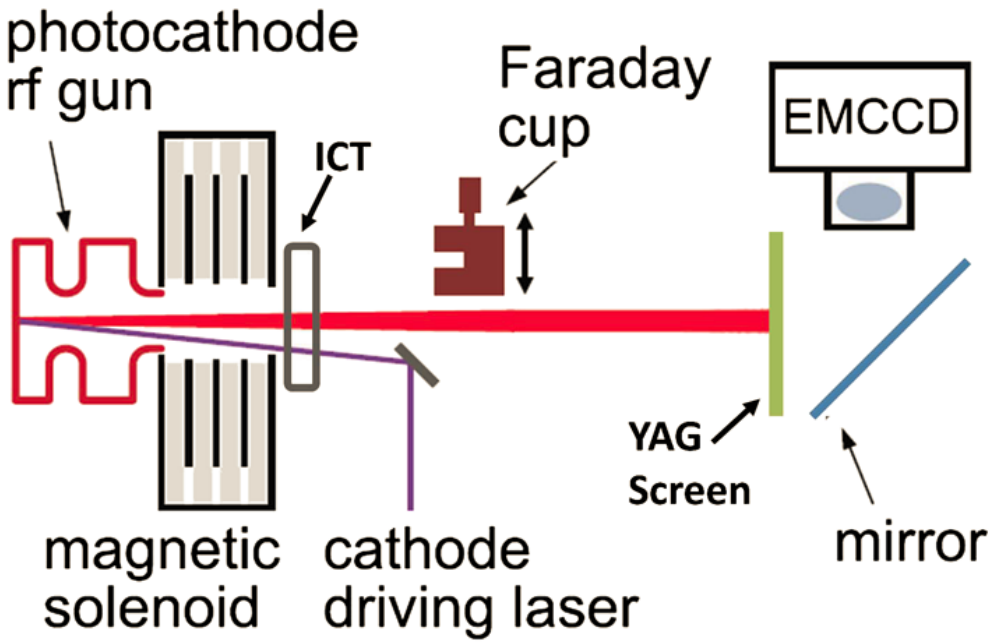
Laser energy < ablation threshold 150mJ/cm^2 (248nm UV, 1ps [3])

evidence of melting



[3] S. Preuss, et al, Appl. Phys. A 61, 33-37 (1995)

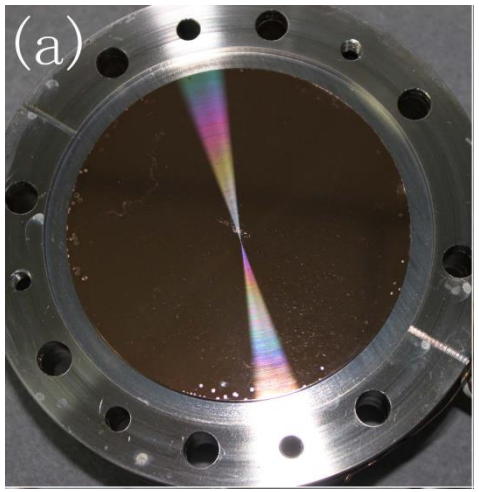
Schematic of the Beamline

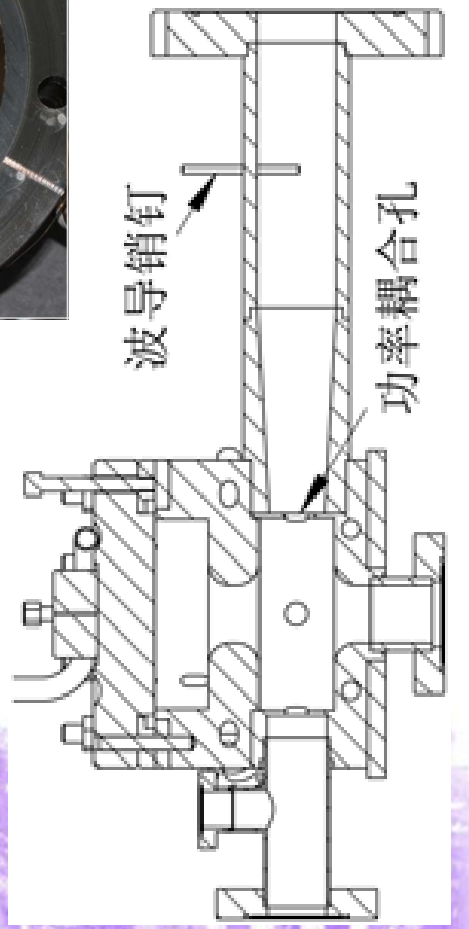


- laser
  - Laser: Ti:Sapphire, 800nm, 400nm and 266nm
  - 90 degree incident
  - Pulse duration: ~1ps
  - Max Energy：~500uJ
    - 1/3 to cathode from clean room
  - Energy jitter: ~5%

RF gun at Tsinghua

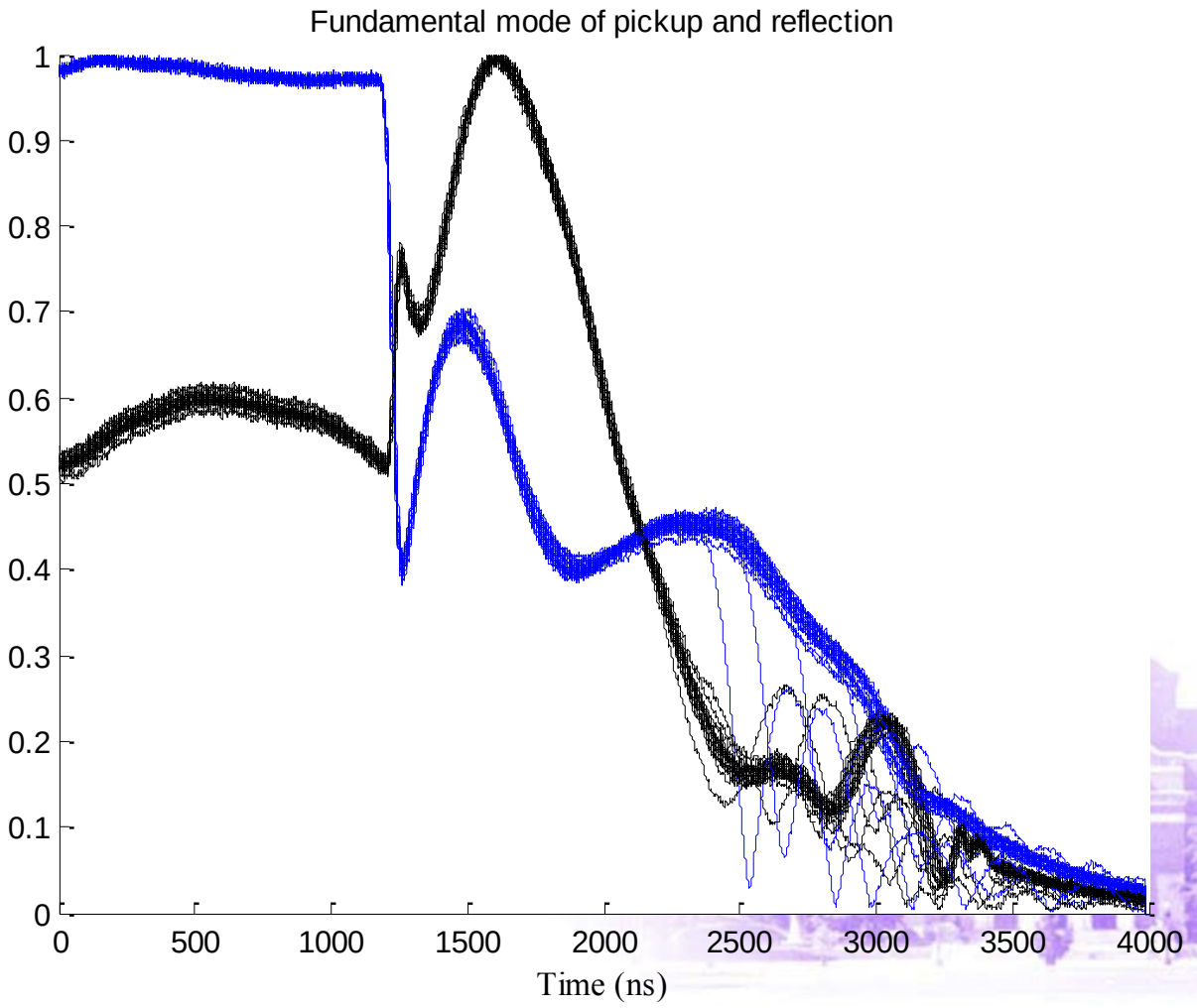
- RF Source
  - 5MW klystron
- RF Gun
  - 1.6-cell S-band 2856MHz
  - Solid, demountable Cu back-plate
  - Q~6000
  - 30~50MV/m



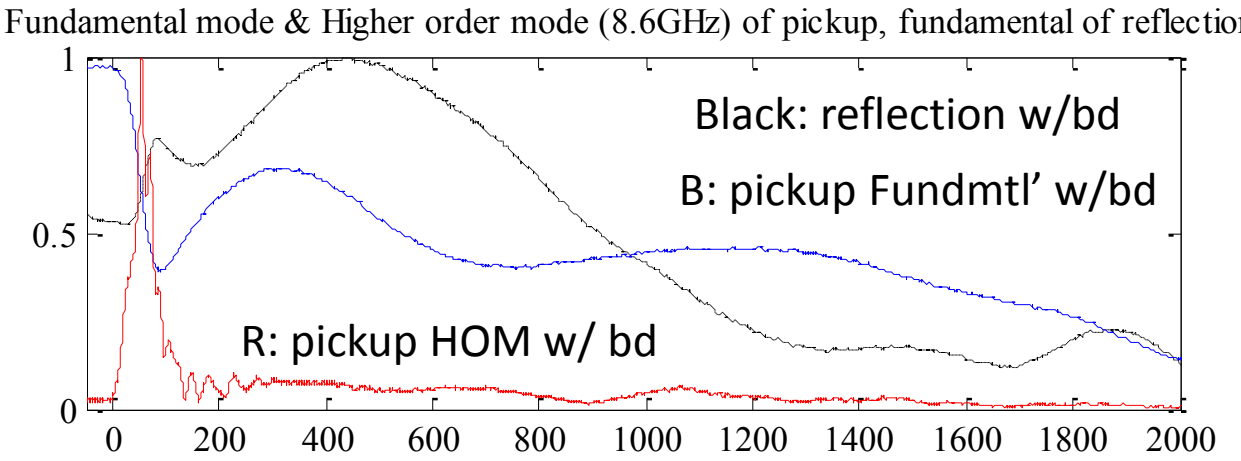


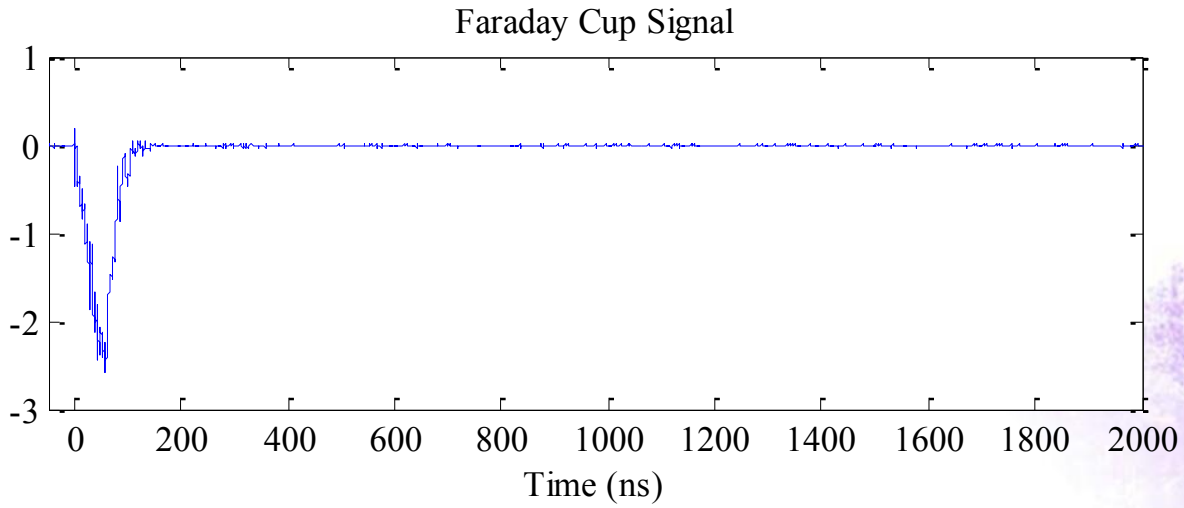
Breakdown events with laser-trigger

- @ cathode center
  - ~55uJ
  - 52MV/m
- 23 events



Breakdown events with laser-trigger

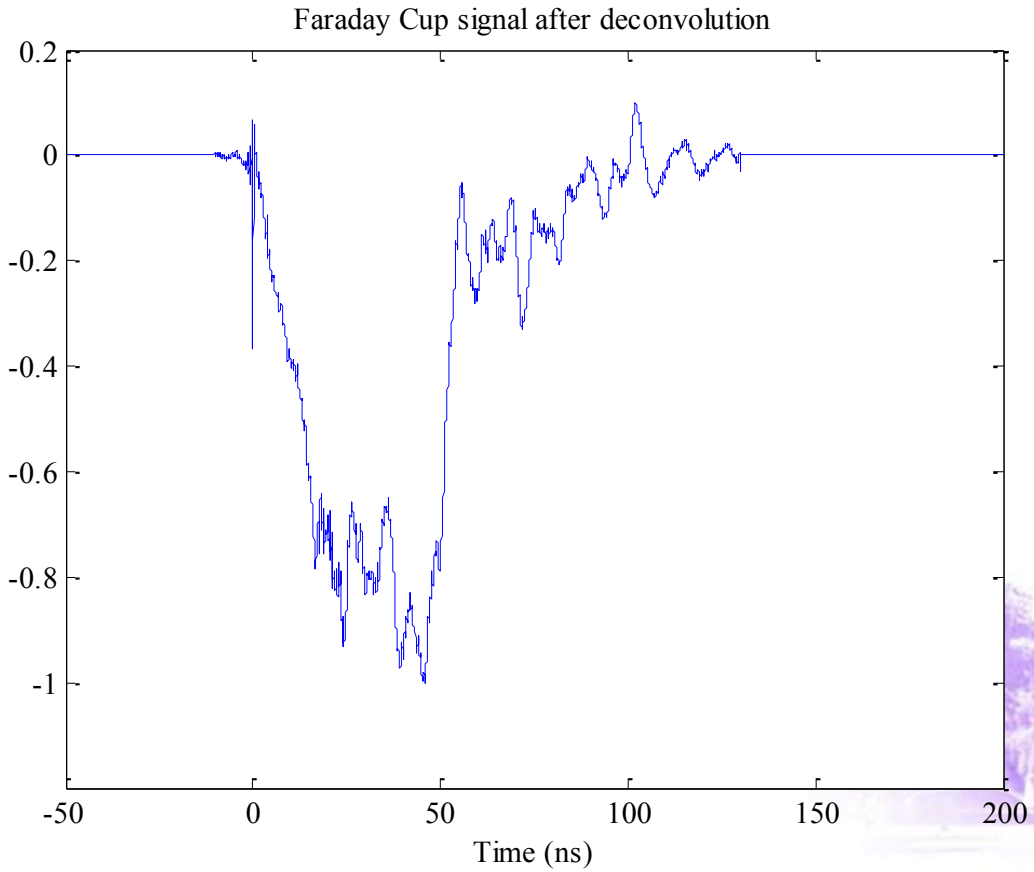




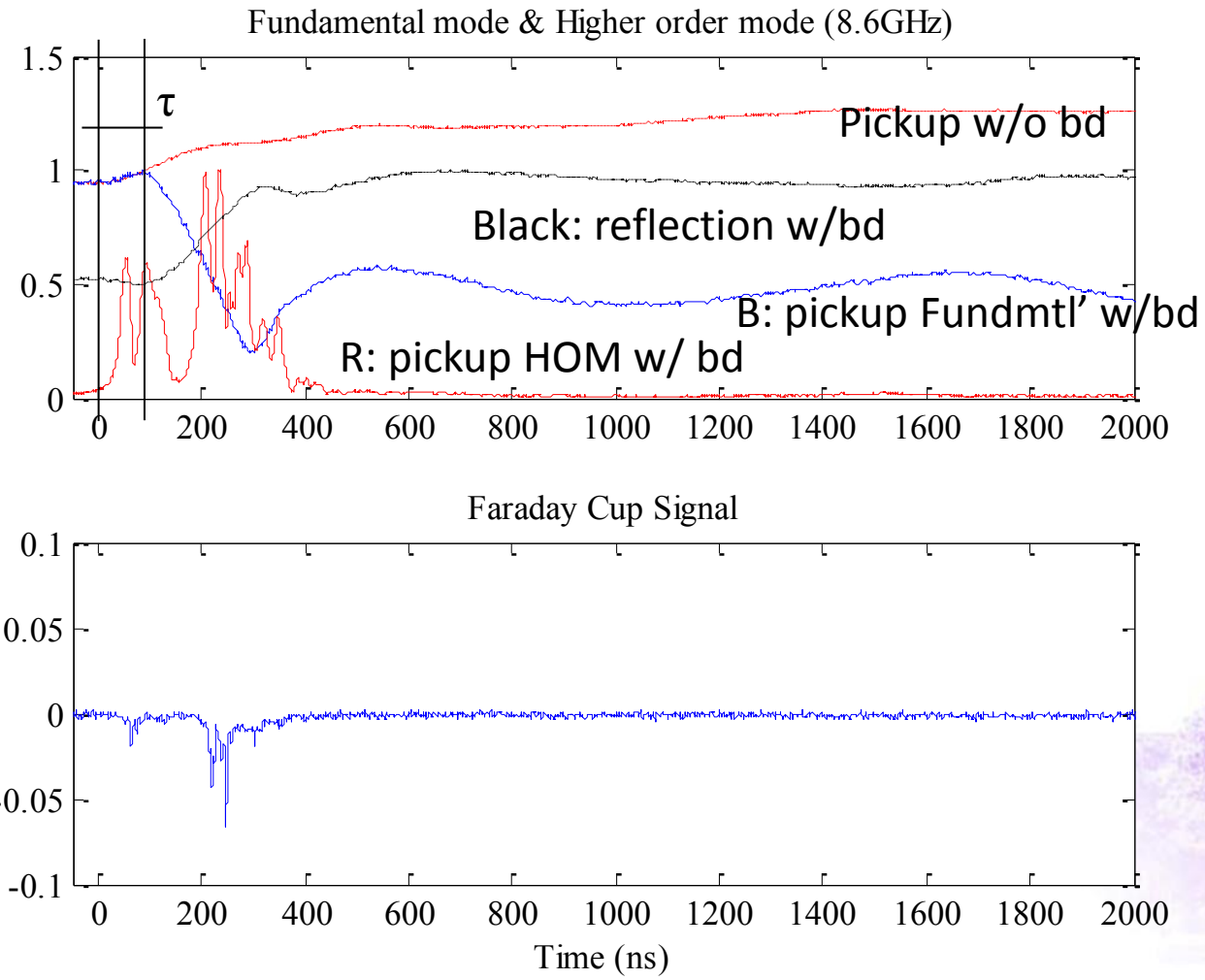
- Fall time
  - ~ 90 ns
- Energy loss
  - ~ 1.2 J

"real" breakdown current (by de-convolution)

- Time: Rise time ~15ns, flattop ~35ns, ~5ns (fast) turn-off
- Charge: Photo-electron ~100pC, breakdown (collected) ~10nC

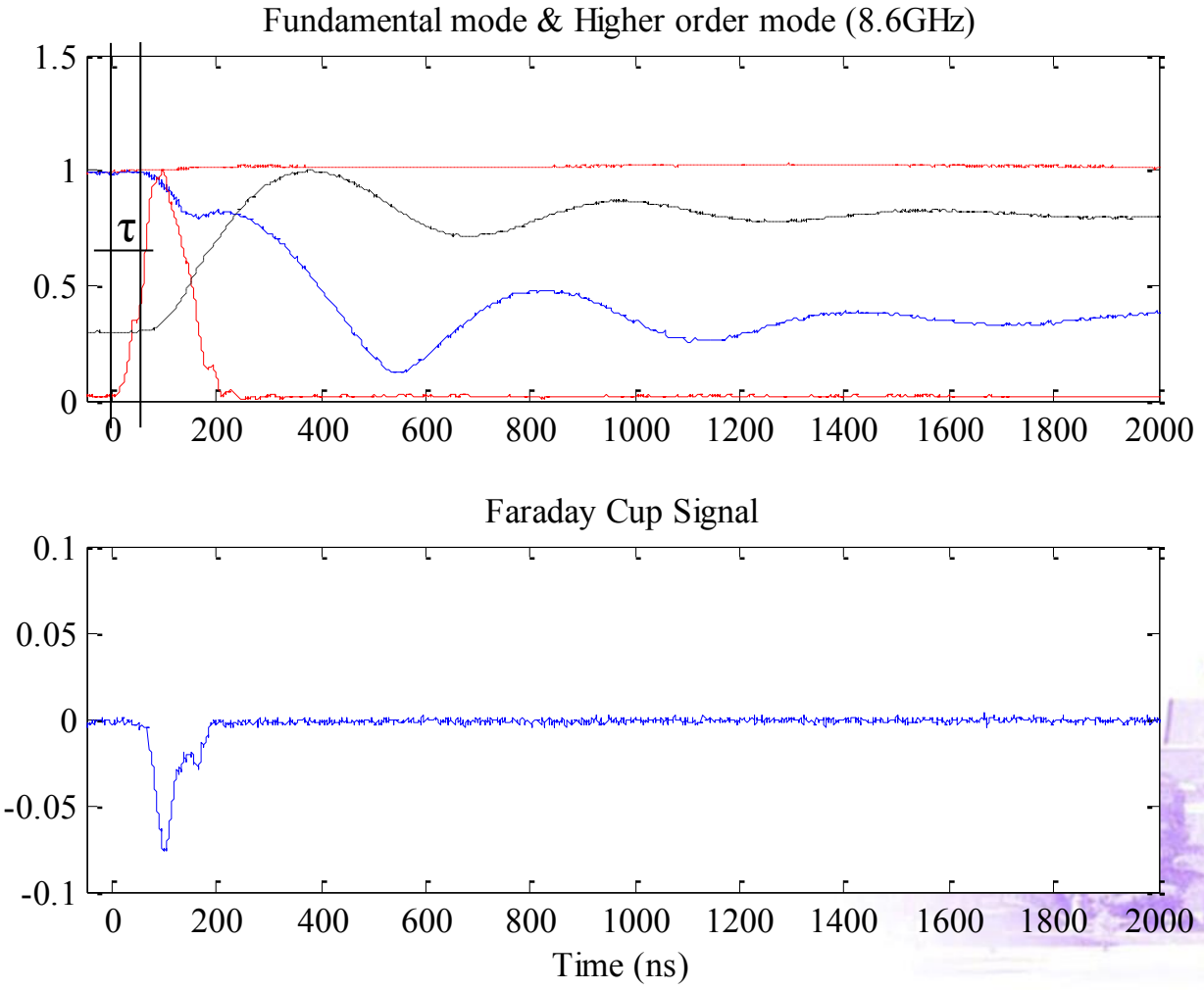


Breakdown events without laser trigger
Multi pulses (85%)



- τ: time difference between fall of fundamental mode and raise of HOM (evidence for field emission)
- Random location
- Longer fall time
  - > 200 ns

Breakdown events without laser trigger
Single pulse (15%)



Summary and plan

- Field emission ~100ns prior to the main breakdown event

  -> short pulse (<50ns), reduce BDR for given gradient

- Laser triggered breakdown: controllable; meaningful to study temporal evolution during breakdown event
- Other controllable breakdown experiment

L-band gun breakdown experiment in ANL

- 0.5 cell high gradient photogun with flat/pin cathode
- Study field enhancement, and breakdown dependences
- Study the surface treatment techniques -> reducing conditioning time for high gradient structures