Tsinghua University

ACCELERATOR LABORATORY *of* TSINGHUA UNIVERSITY

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
- Problems and Plans

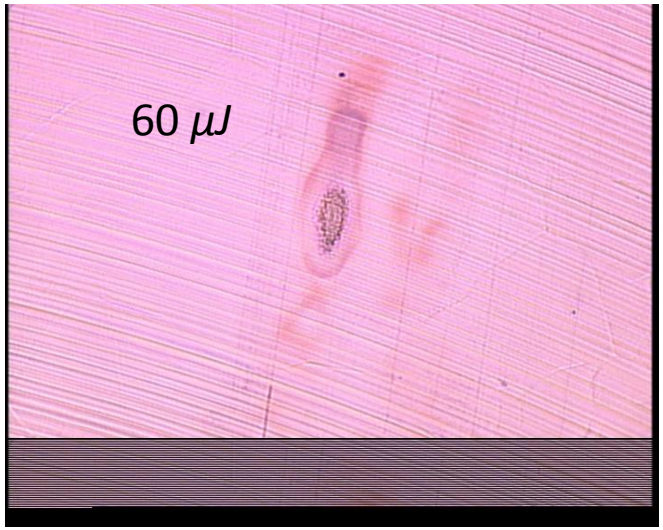
Motivation

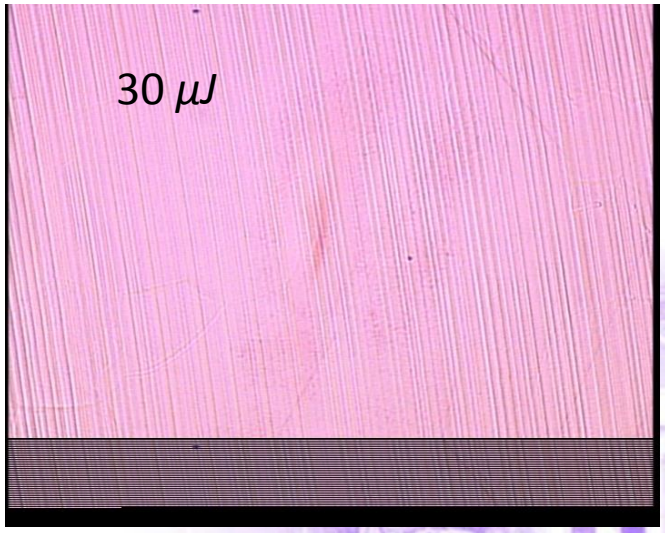
- RF breakdown dependence on *E, B, Sc,* ΔT_p...
  - Laser assistant RF breakdown experiment is trying to isolate some of the contributing effects. Hopefully, a more coherent picture of RF breakdown. [1]
- RF breakdown phenomenon
  - To better understand detailed RF breakdown progress and time scale.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

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

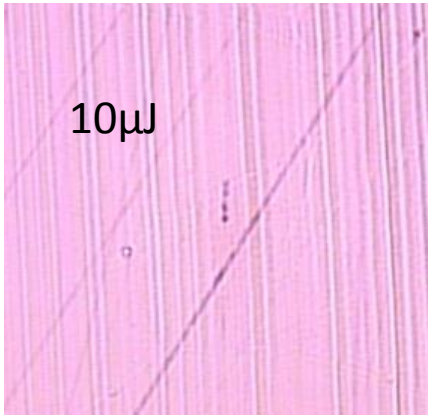
Pre-Experiment: Laser damage on copper surface

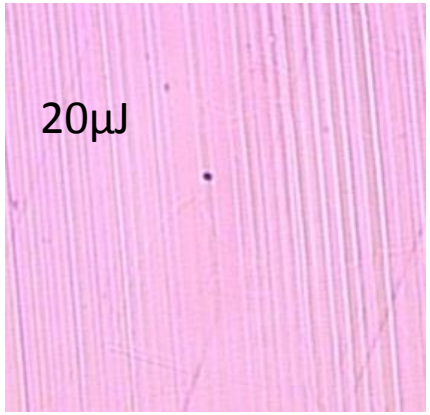
- Shot UV Laser pulse on copper surface.
  - 10μJ, *20, 30…*; 1mm diameter spot size; 1ps pulse length
  - Microscope image: (30sec@10Hz)

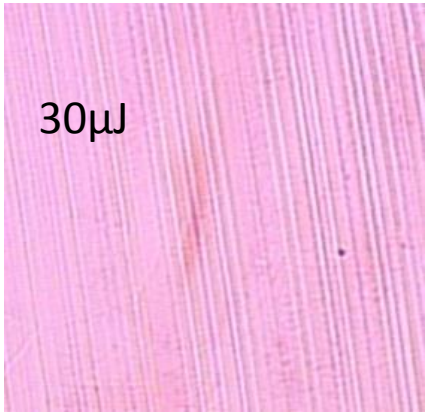




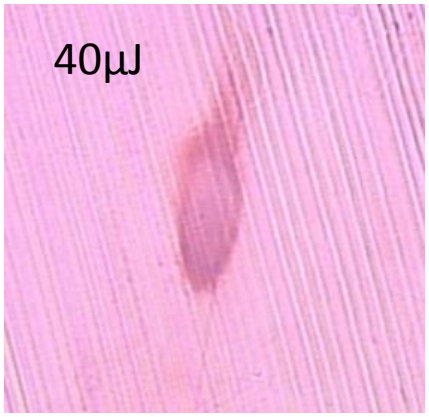
Laser damage

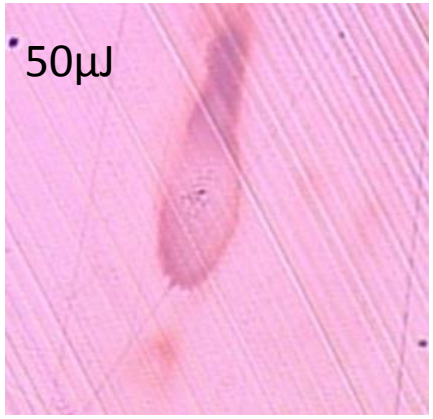


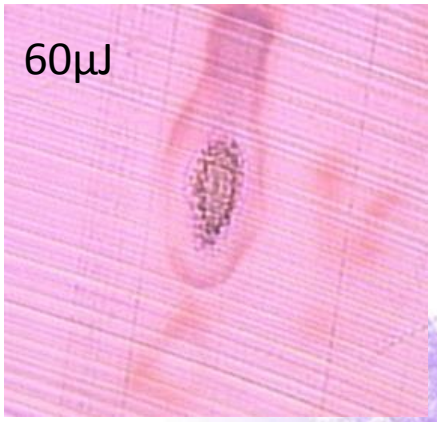




oxidization



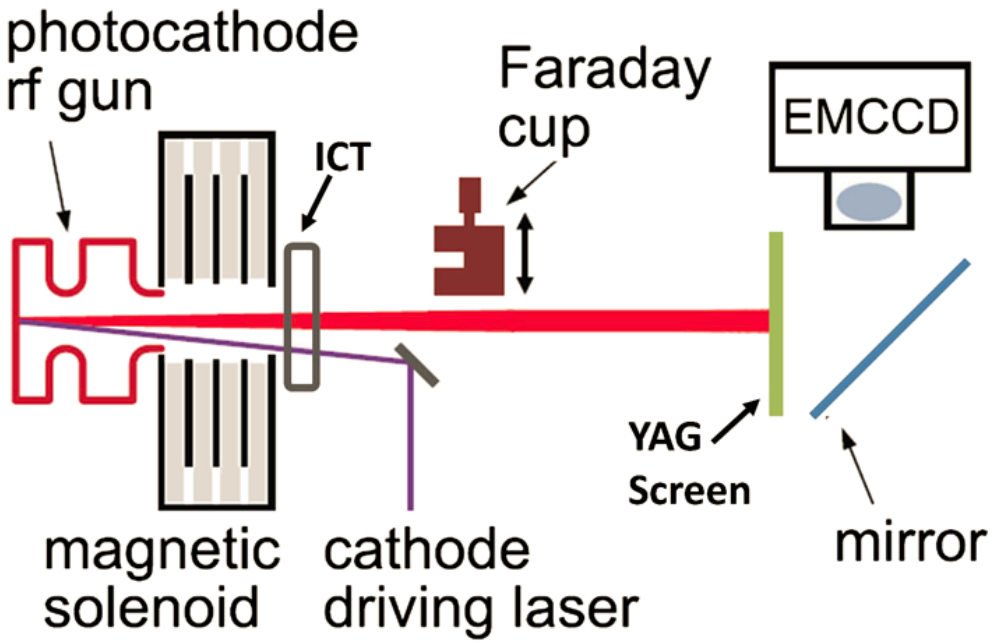




Surface damage

10μJ / 1mm^2 → 0.1 J/cm^2 @1ps →10GW/cm^2

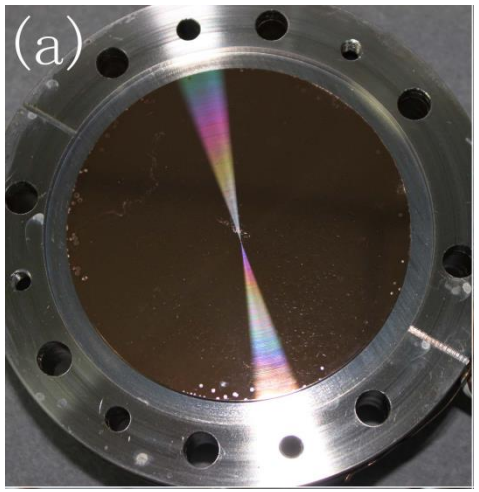
Schematic of the Beamline

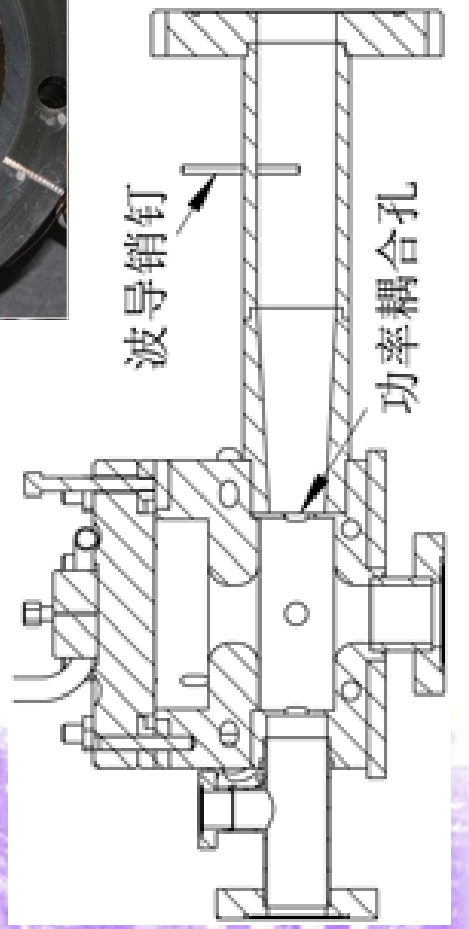


- laser
  - Laser: Ti:Sapphire, 800nm, 400nm and 266nm
  - 90 degree incident
  - Pulse duration: ~1ps
  - Max Energy： ~2mJ
    - 1/3 to cathode from clean room
  - Energy jitter: ~5%

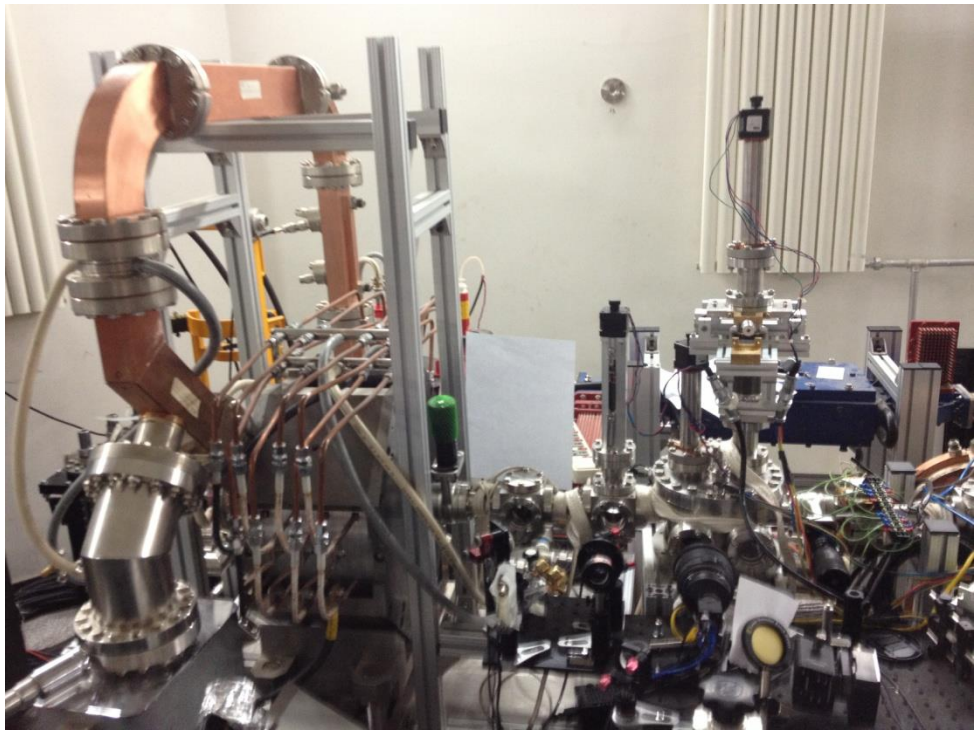
RF gun at Tsinghua

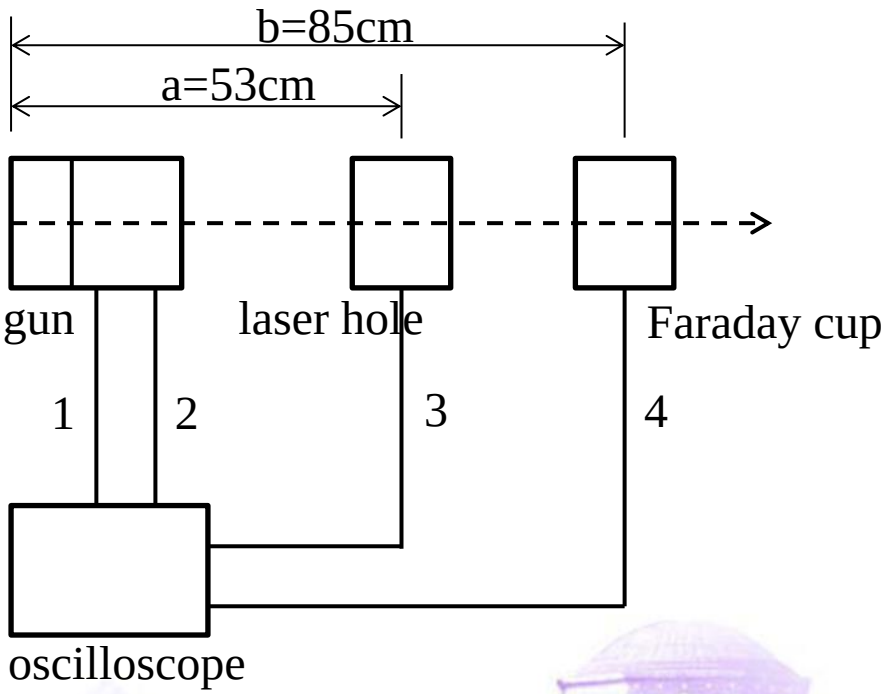
- RF Source
  - 5MW klystron
- RF Gun
  - 1.6-cell S-band 2856MHz
  - Solid, demountable Cu back-plate
  - Q~6000
  - 30~50MV/m





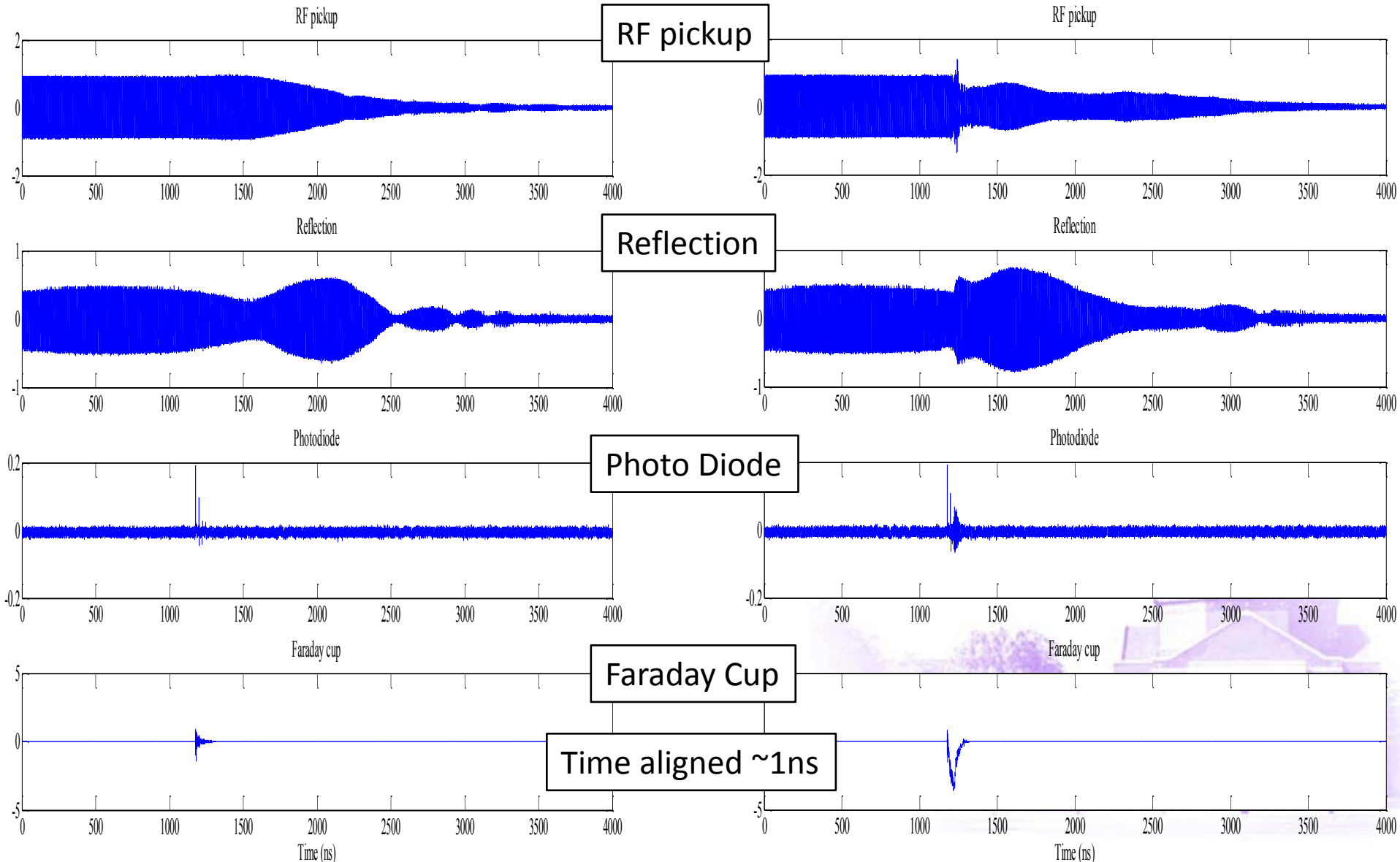
Beamline





Scope: 12GHz Bandwidth / 50GHz sampling rate

Scope signal w/ and w/o breakdown



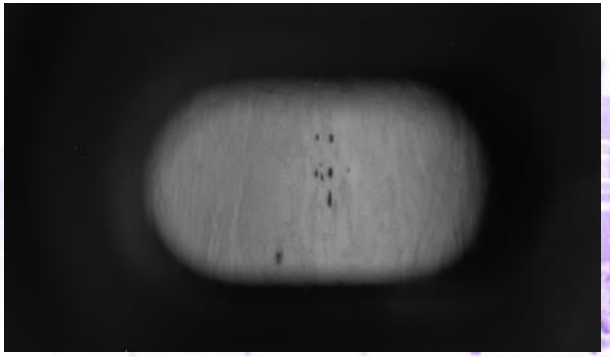
Experiment

	Apr 12		Apr 18		Apr 19		
	p1	p2	p3	p4	p5	p6	p7
Laser Energy @ cathode (μJ)	Scan up to 135μJ		55	150	100	117	128
Input Power (MW)	4.3MW		Scan 2-5MW				
E field (MW/m)	50MV/m		30-50MV/m				

Change location on cathode: (p1, p2, p3)

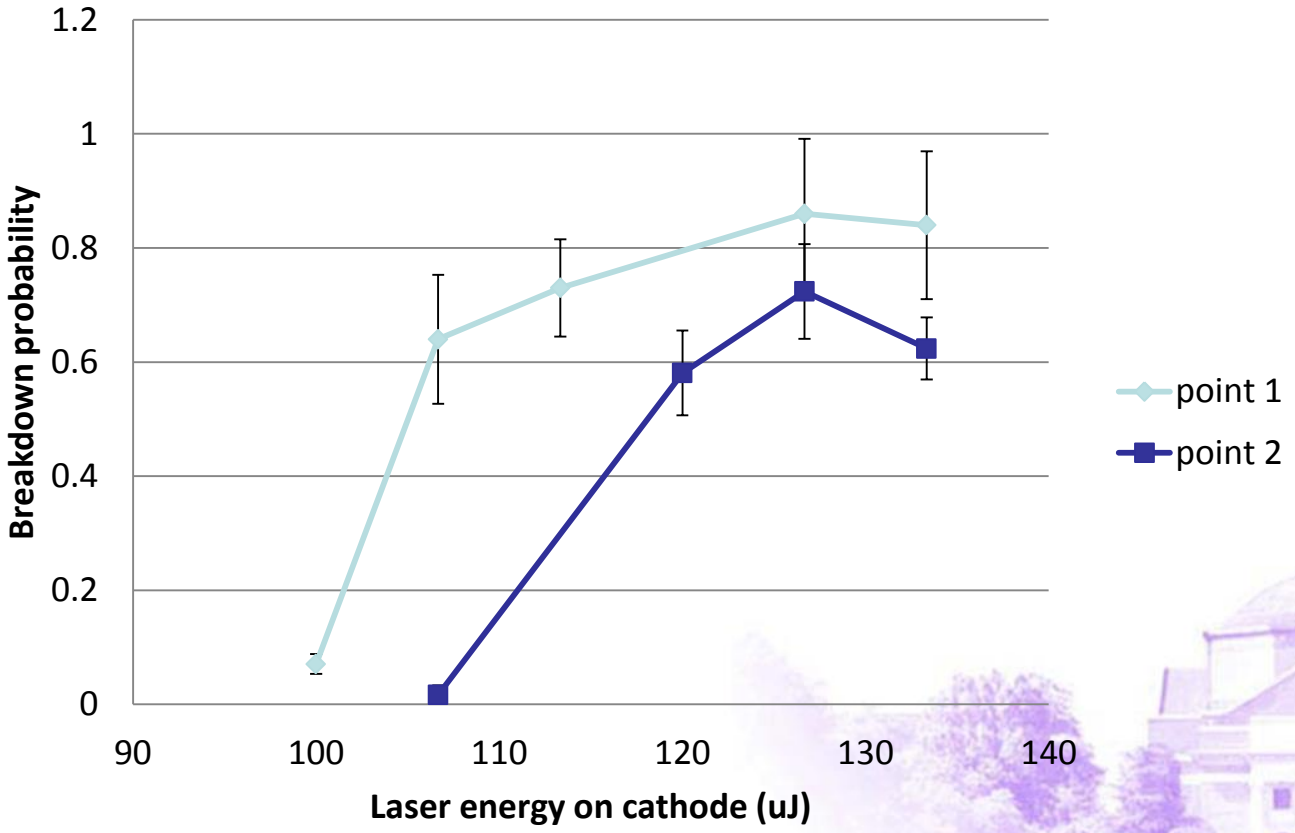
RF phase fixed 30 degree.

Image after experiment
(view from oblique-incident laser window)

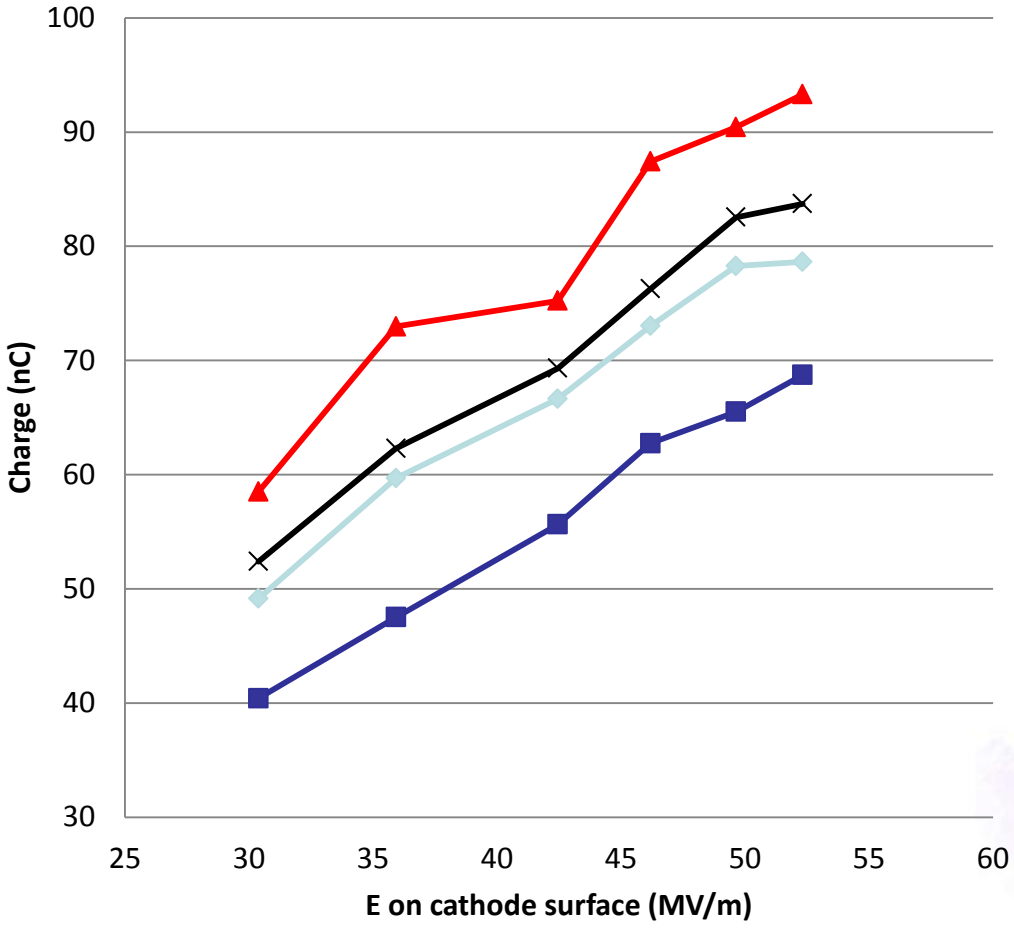


Breakdown rate v.s. Laser Energy

- *E* at center of cathode ~50MV/m, note: small statistics



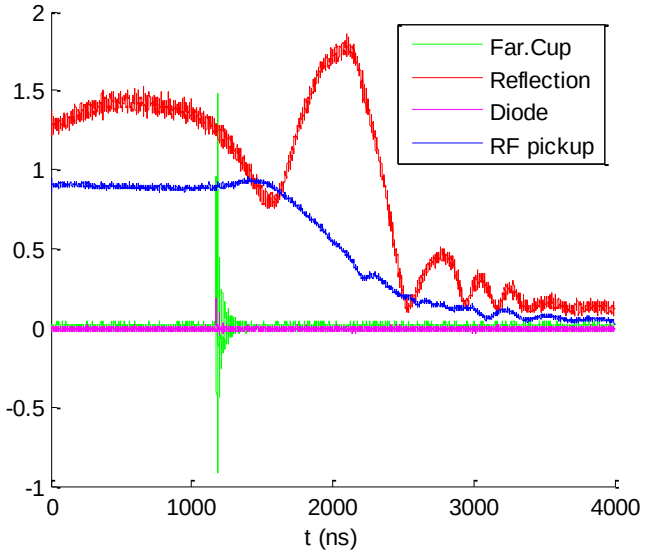
Charge v.s. Laser Energy and *E*-field



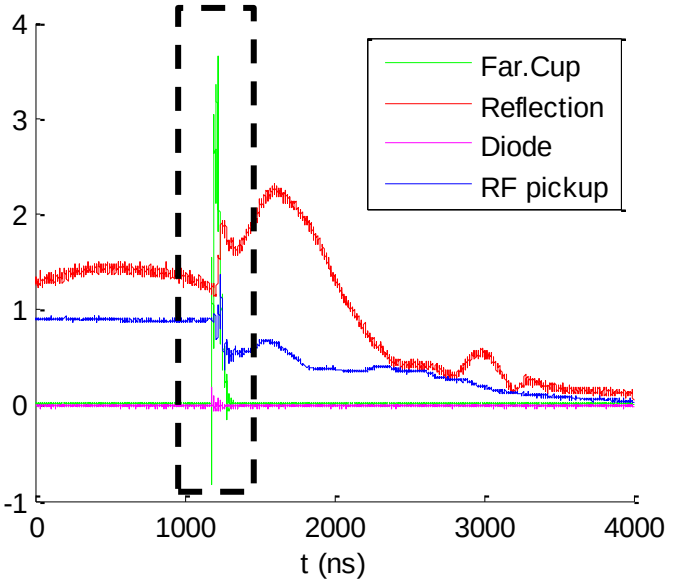
Charge strongly-related to E field

Different Laser energy?
Maybe: from different location

Timing (cables calib.'ed)



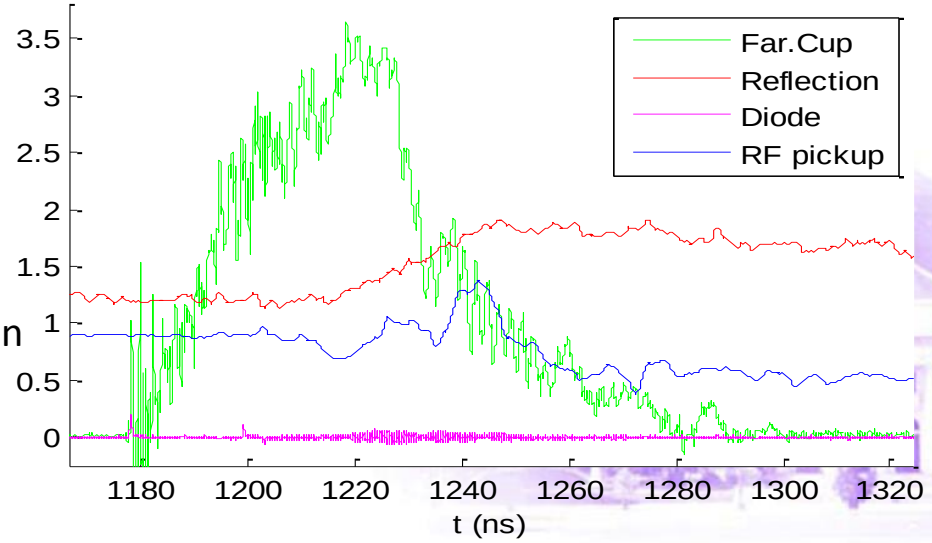
w/o breakdown



w/ breakdown

after photo-electron:

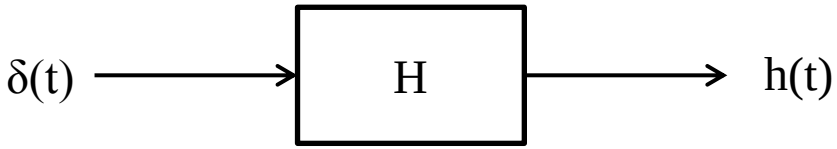
- Breakdown current rises ~ns
- Reflection starts to change ~40ns
- RF pickup increase because of beam excitation

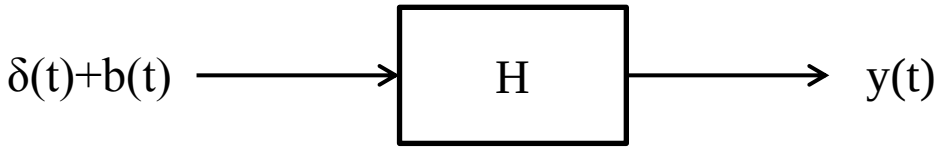


Data Processing

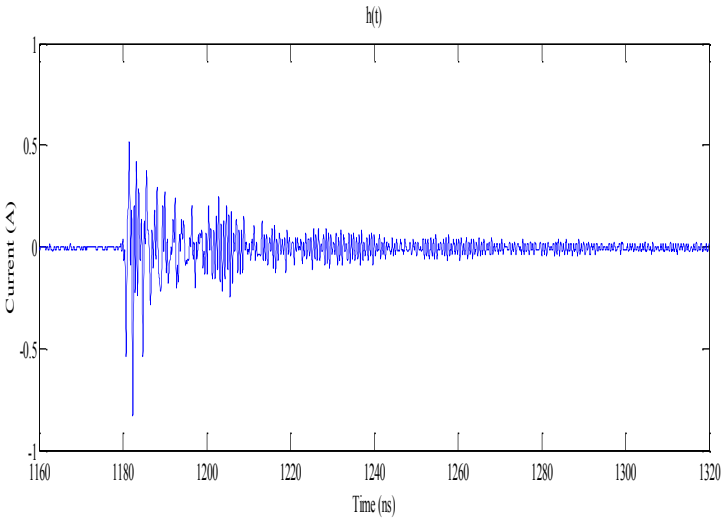
J. Shao

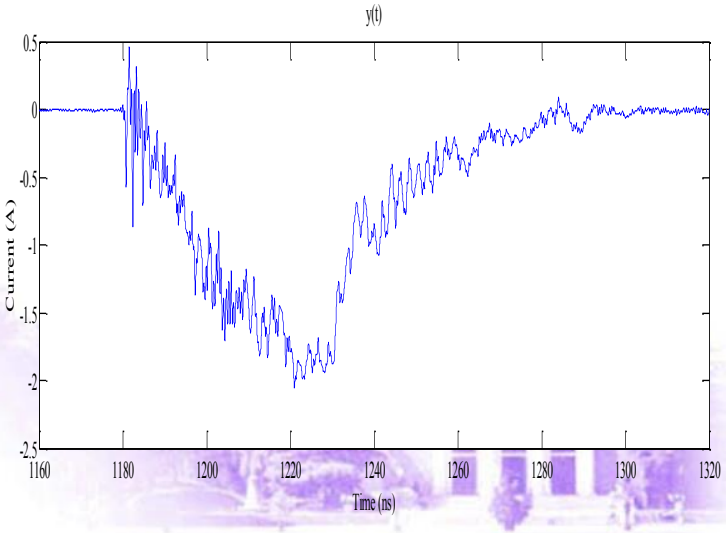
Take Faraday cup as an LTI system.
signal without breakdown can be seen as the impulse response of the system.
Try to solve the 'real' current signal by deconvolution.





δ(t) : impluse function
b(t) : 'real' breakdown current
h(t) : Faraday cup signal without breakdown
y(t) : Faraday cup signal with breakdown

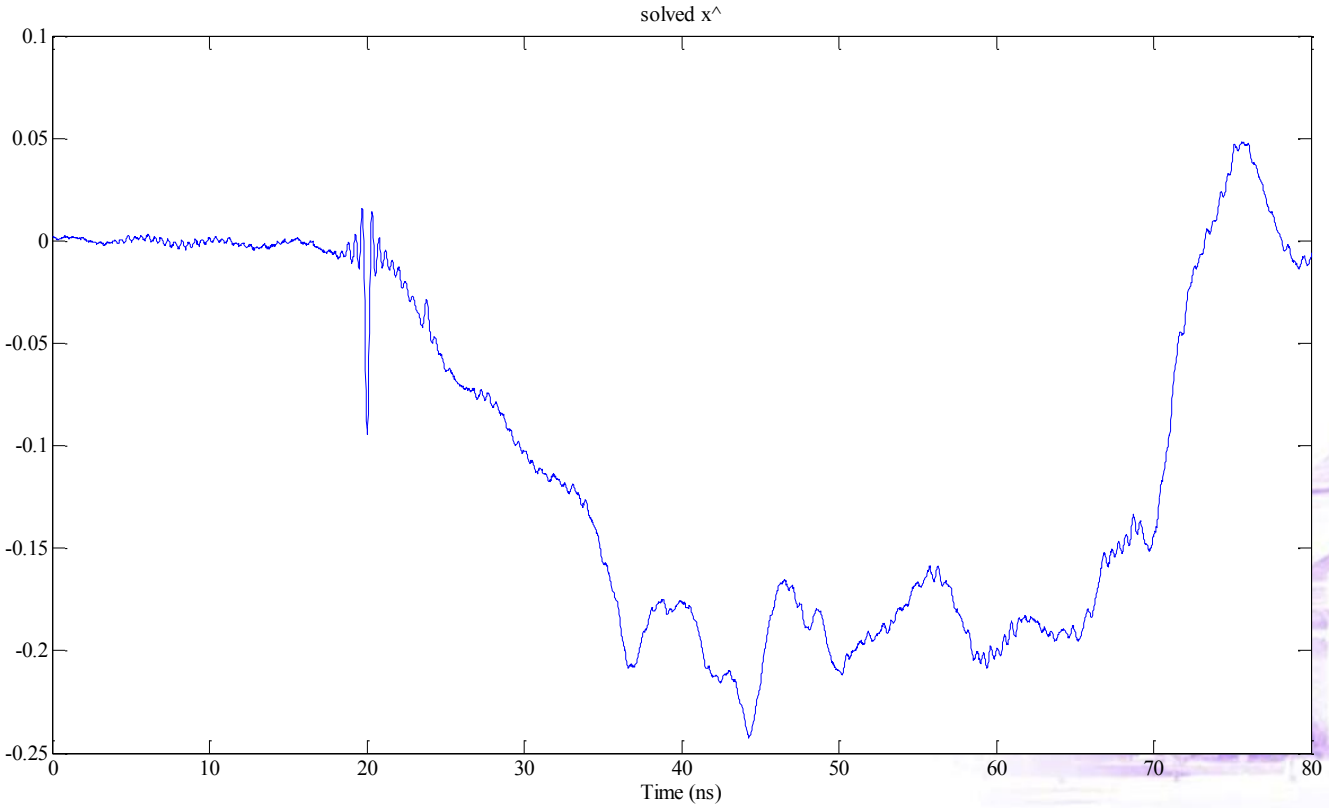




"real" breakdown current (by de-convolution)

J. Shao

- Time: Rise time ~15ns, flattop ~35ns, ~5ns (fast) turn-off
- Charge: Photo-electron ~100pC, breakdown (collected) ~30nC



Plans and discussion

- Different laser wavelength
- Missing Energy?
- Update Faraday Cup → eliminate resonance, better matching, faster time response
- Streak Camera → Diagnostics of the breakdown current, micro structure?

Summary and discussion

- Very preliminary data analysis
  - charge → (? get real breakdown current)
  - (Rough) delay time, turn one time
  - Laser threshold
- Laser-triggered RF breakdown v.s. self-breakdown,
- v.s. DC breakdown?
- Suggestions?