# Plasma Ignition of a 30-mm Cannon

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# Goal of This Study

- Apply the knowledge learned in our earlier **Plasma-Propellant Interaction** research to the Ignition of a 30-mm cannon
- Start to Develop "Design Rules" for plasma ignition

Ultimately: Make plasma ignition in large-caliber guns more efficient

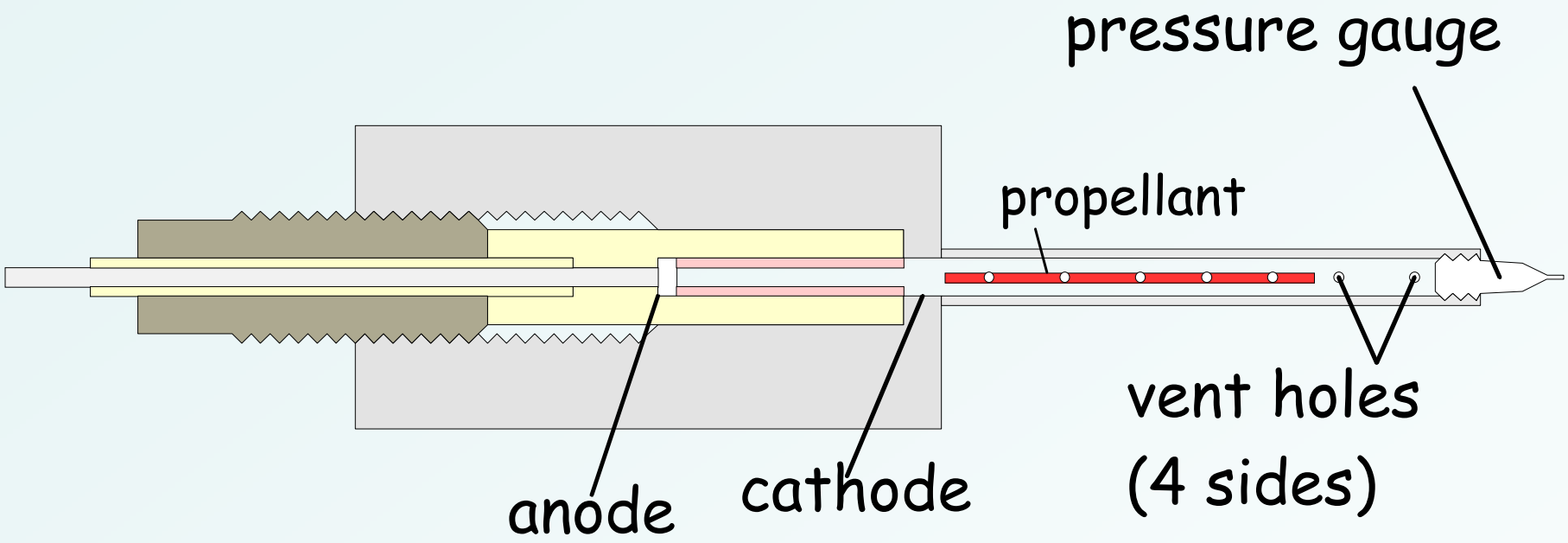
# Hardware

- Power Supply
  - Standard PFN 600 mF, 3 kv, 3 kj
  - Short (300 ms) or Long (900 ms) Pulse
- Propellants
  - JA2, M30, Graphite-Free JA2
- Standard Ignition for 30-mm cannon
  - M52 primer w/1.5 grams Benite in bayonet

# Small-Scale Experiments

Plasma into bayonet igniter tube

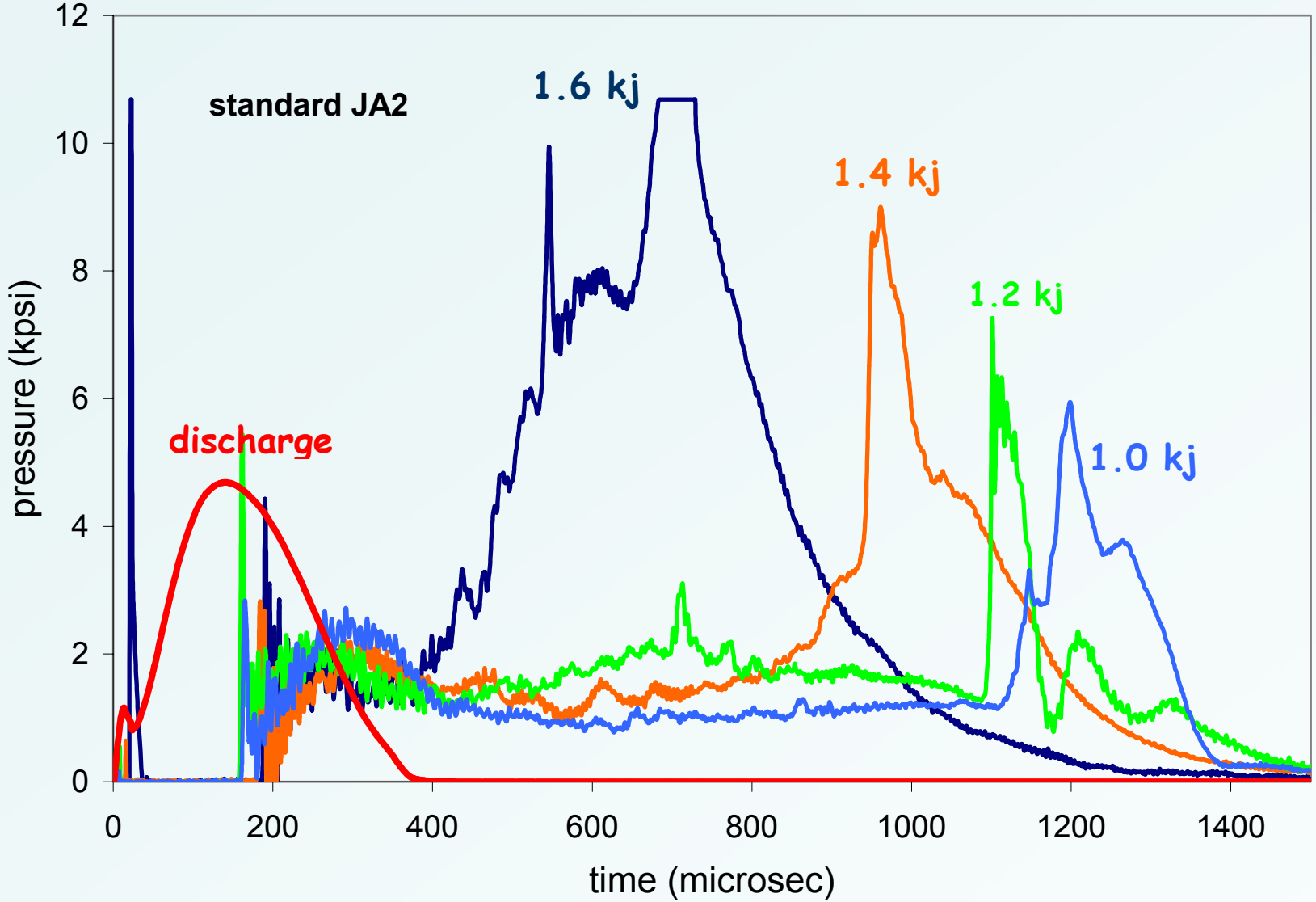
# Schematic of Test "Igniter"




Designed to look like an igniter we can put into 30-mm cannon.
32 total 1/16-inch vent holes (8 per side)

# Response with 1.5 grams Standard JA2 in tube

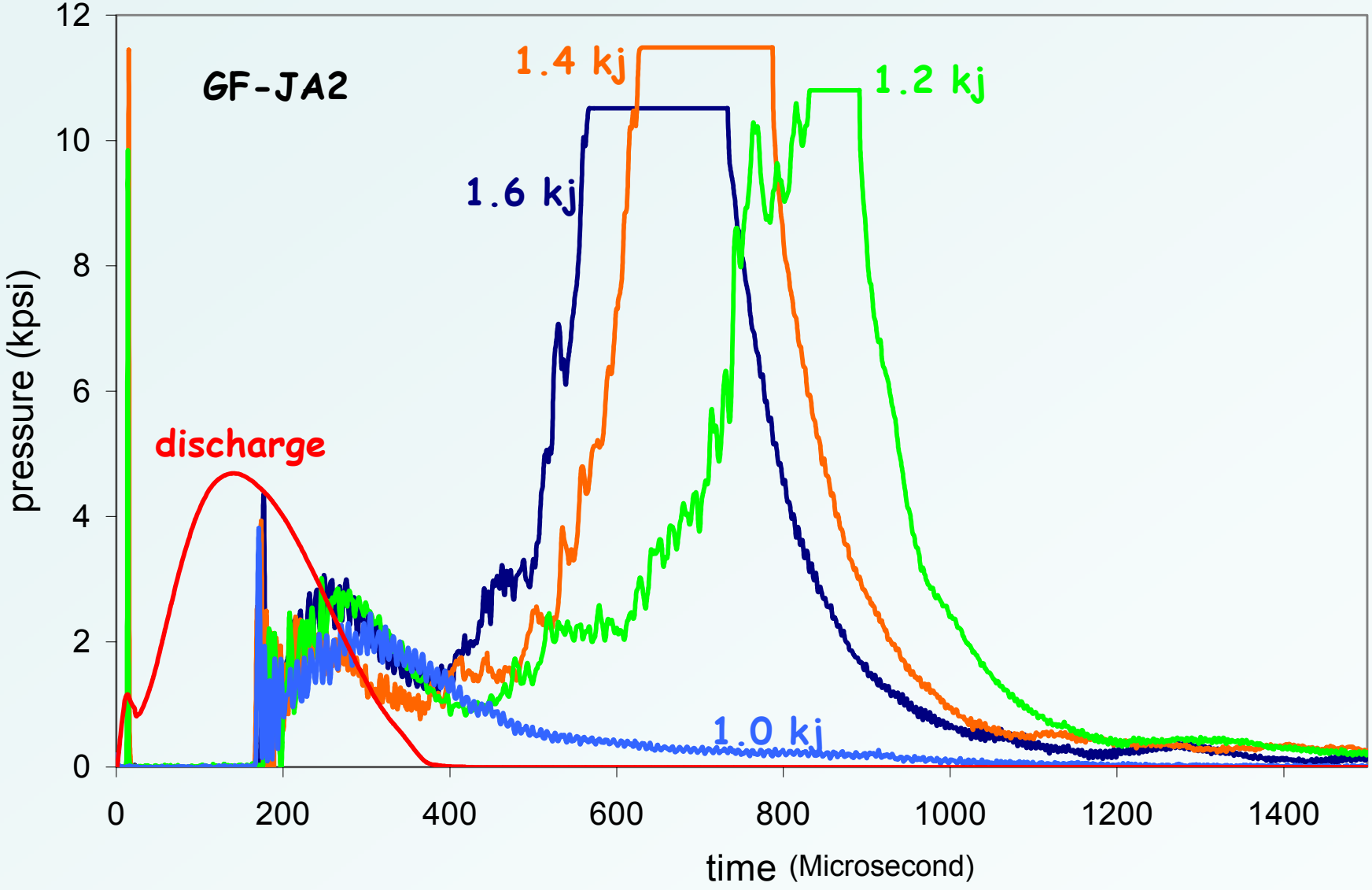
## Parameter = discharge energy




**(1.5 g JA2 ≈ 8.5 kj chemical energy)**

# Response with 1.5 grams Graphite-Free JA2 in tube

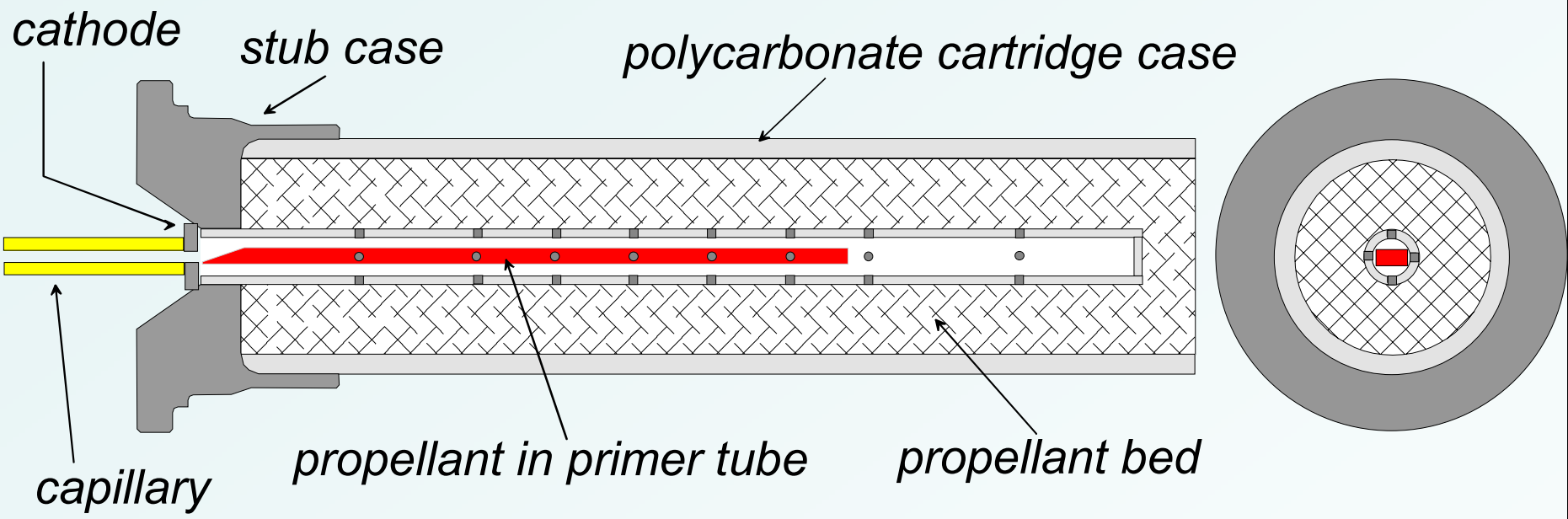
## Parameter = discharge energy




**(1.5 g JA2 ≈ 8.5 kj chemical energy)**

# 30-mm Cannon

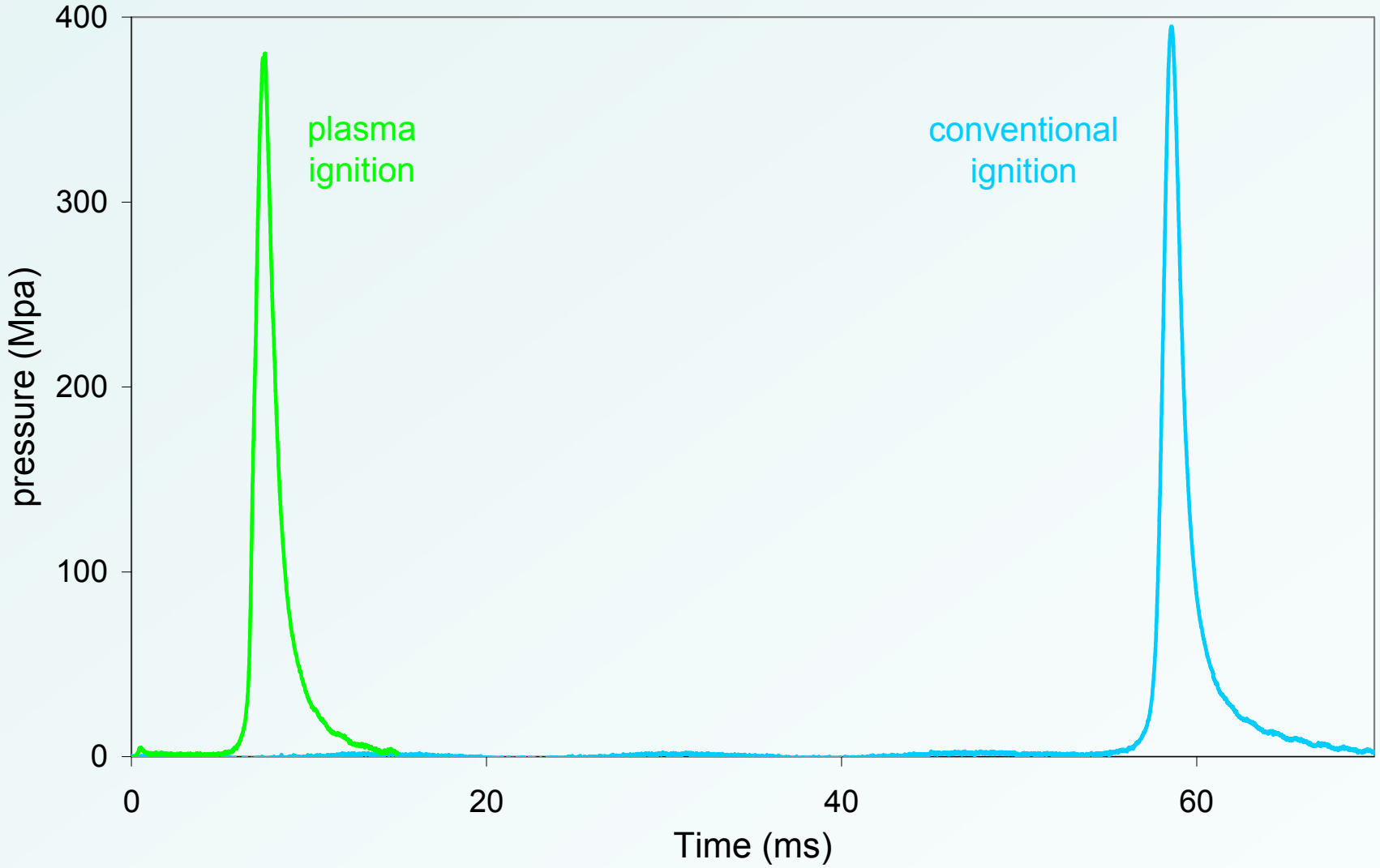
# 30-mm Stub-Case Cartridge for Plasma Injection




**Plasma Discharge Energy:** 2.1 to 2.3 kj
**Propellant in primer tube:** 1.6 to 1.9 grams (8.1 to 9.6 kj chem energy)
**Chamber volume:** 135 cc
**Projectile mass:** 550 g
**Shot-Start Pressure:** very low
**Conventional ignition baseline**: M52 primer and 1.5 grams Benite in bayonet

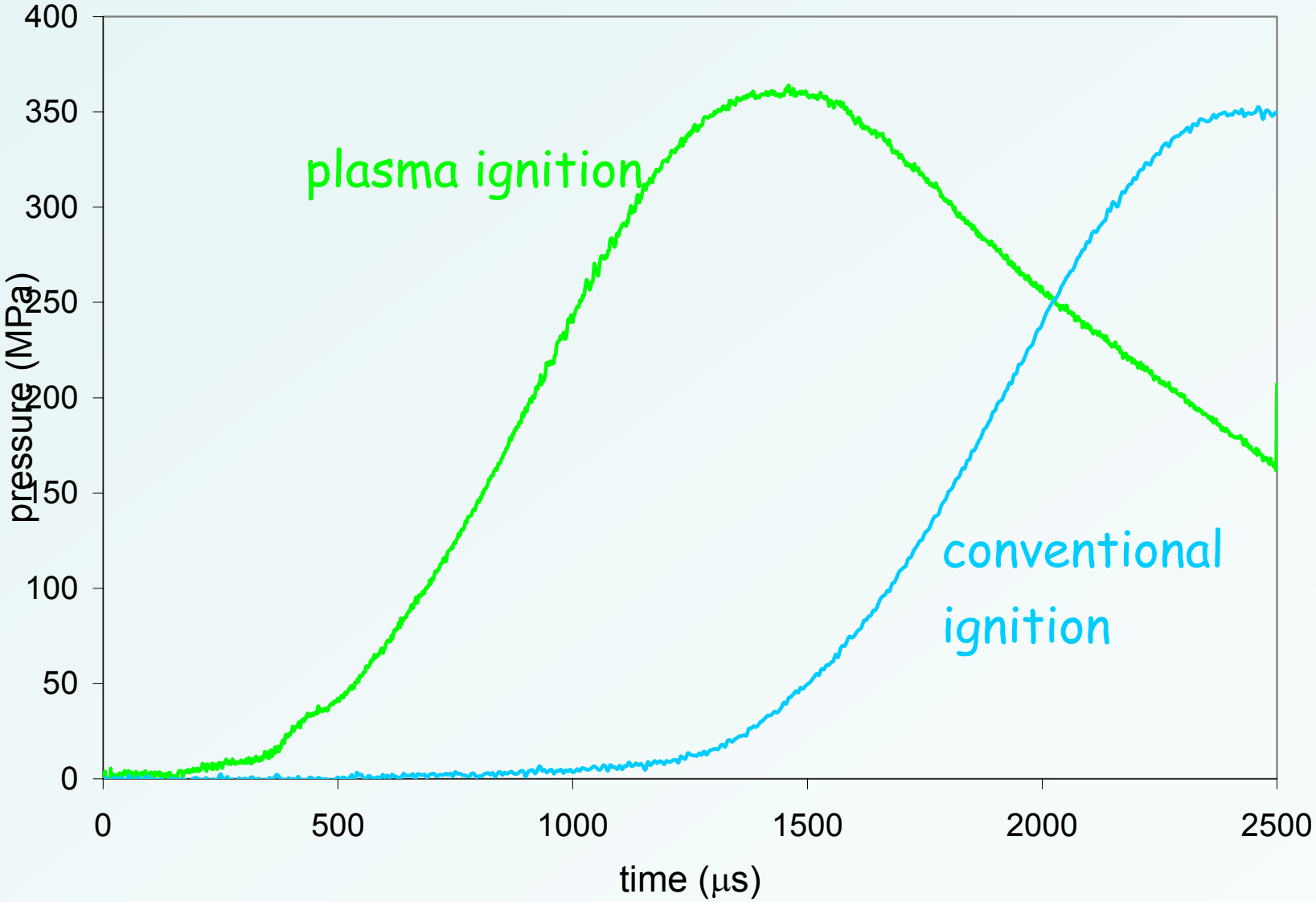
# M30 Propellant Charge

(GF-JA2 in plasma igniter tube)



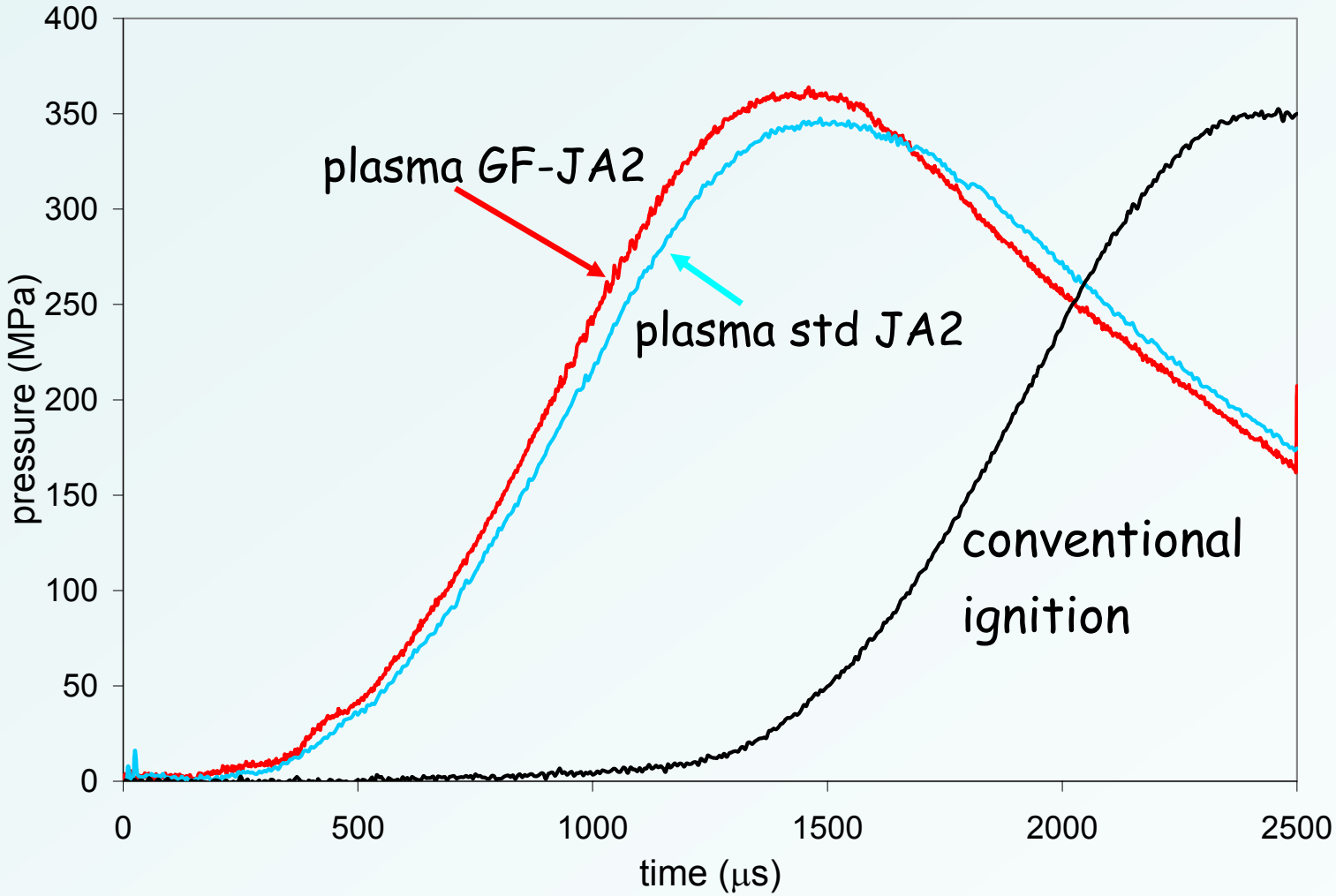
# JA2 Propellant Charge

## Plasma: GF-JA2 in igniter tube



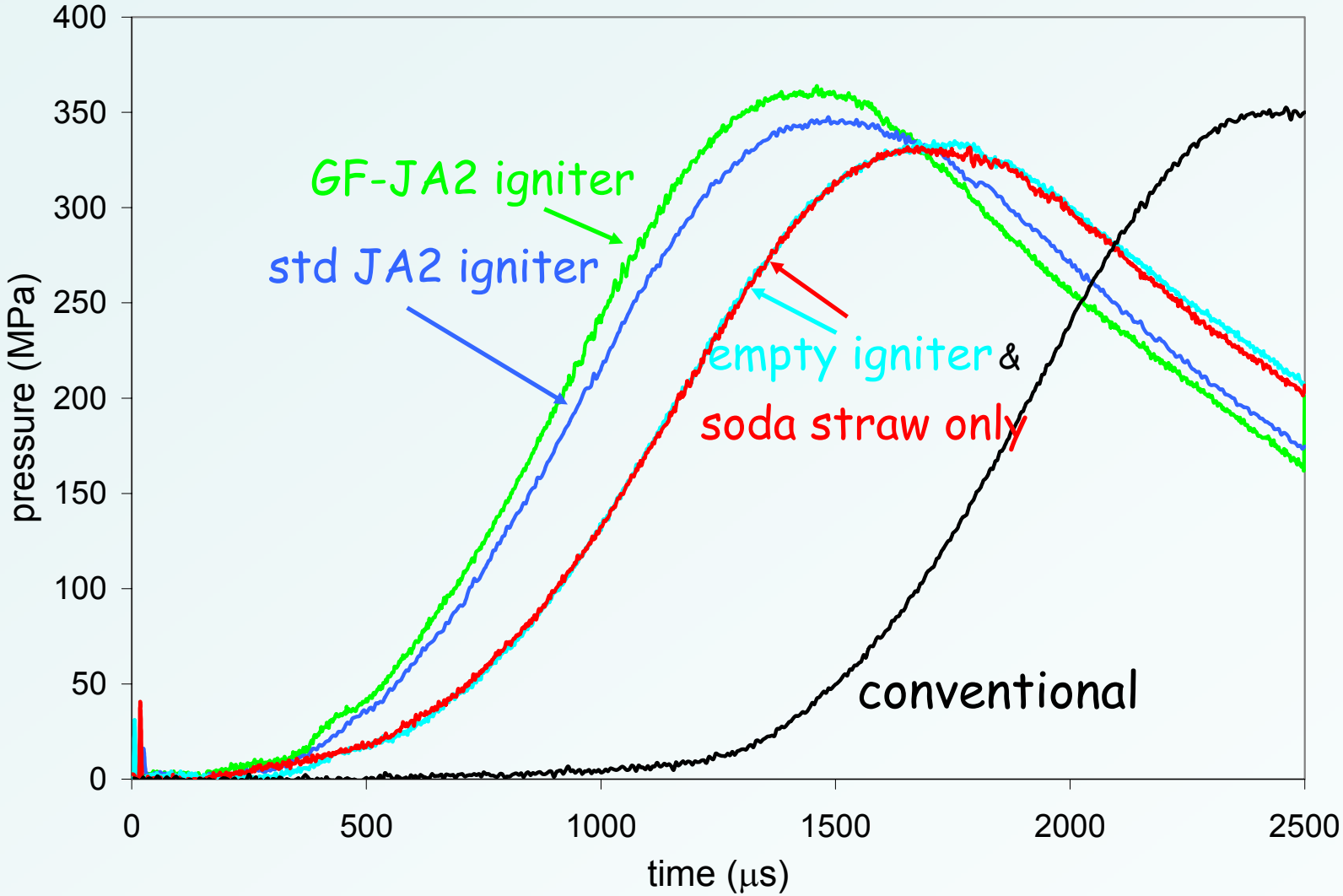
# JA2 Propellant Charge

## GF-JA2 vs. Standard JA2 in igniter tube



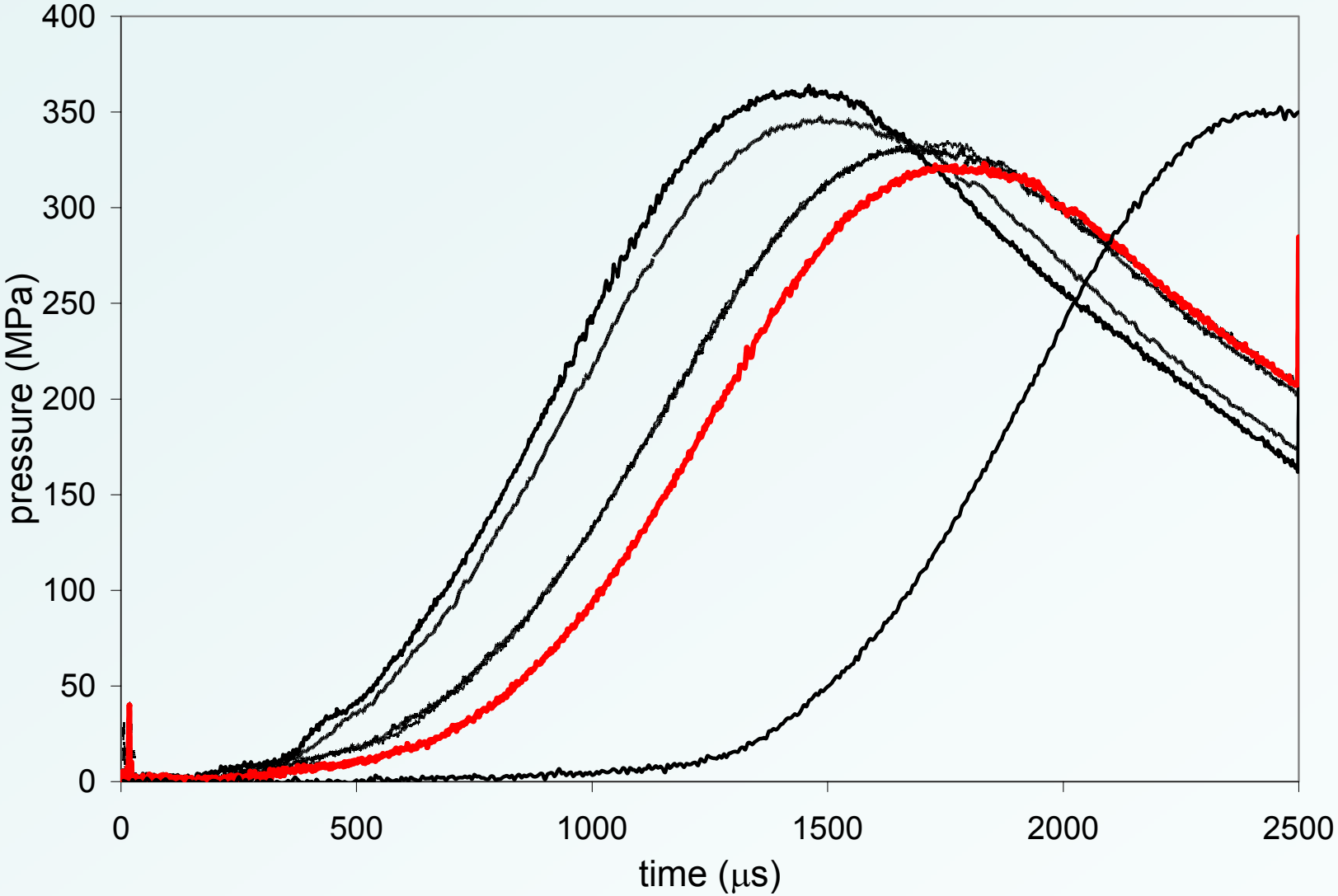
# JA2 Propellant Charge

## Soda straw vs. empty igniter tube



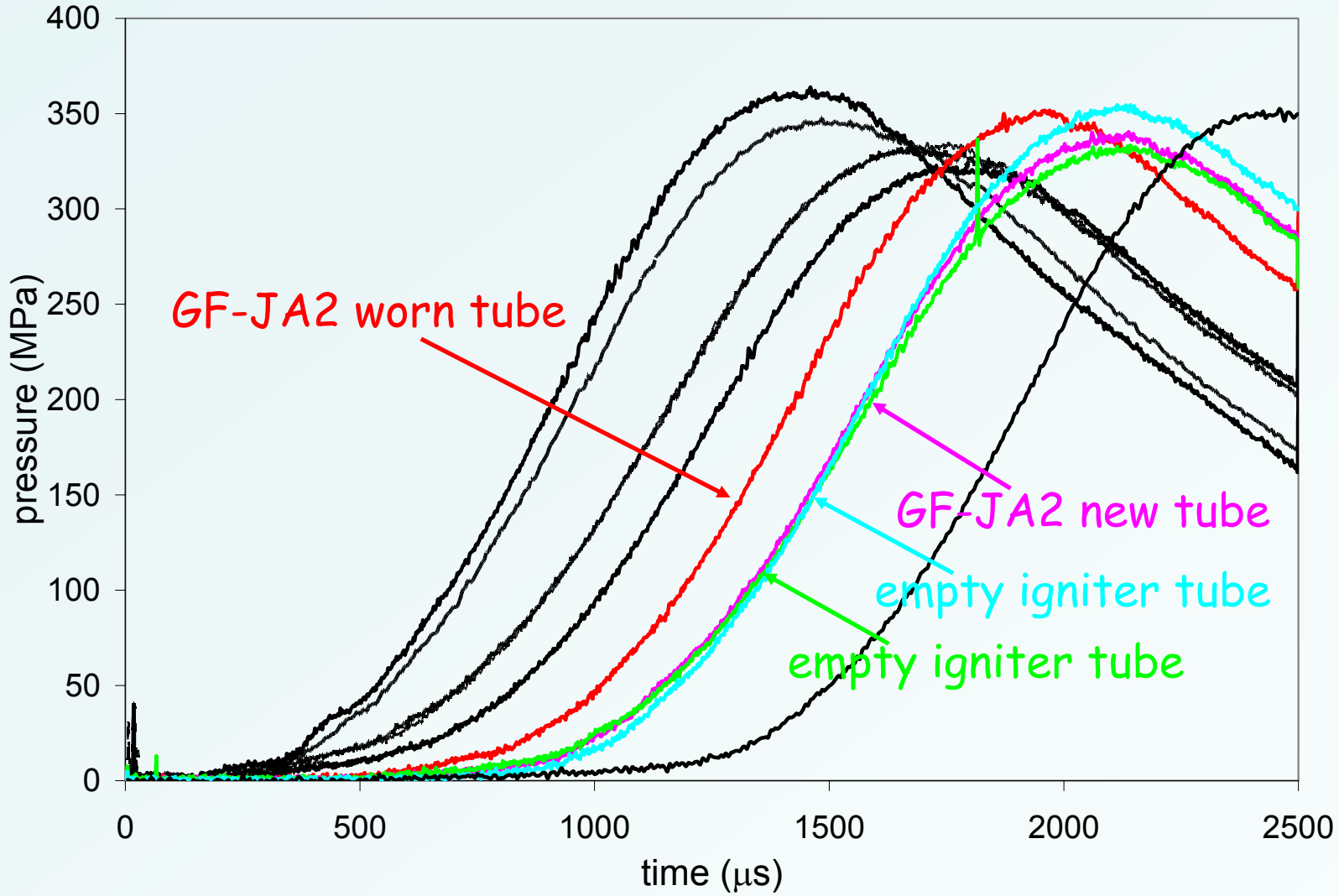
# JA2 Propellant Charge

## Soda straw w/ GF-JA2 "box"



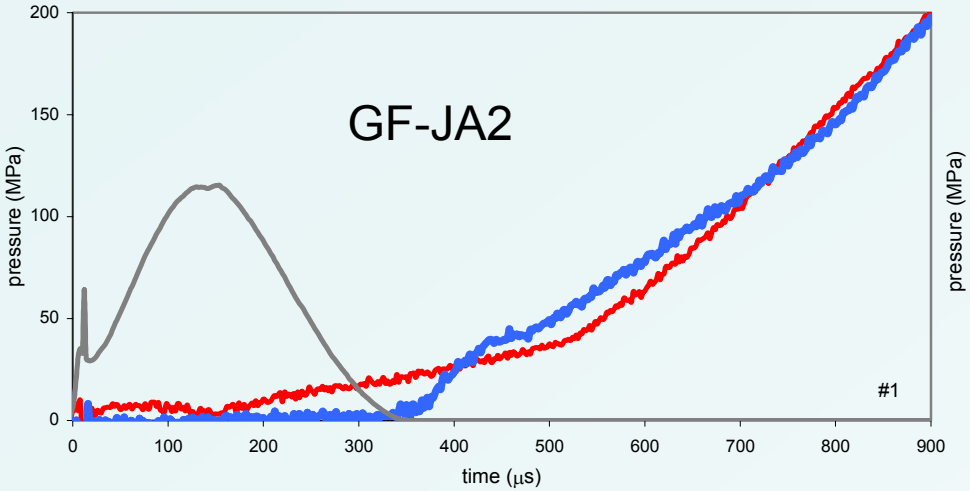
# JA2 Propellant Charge

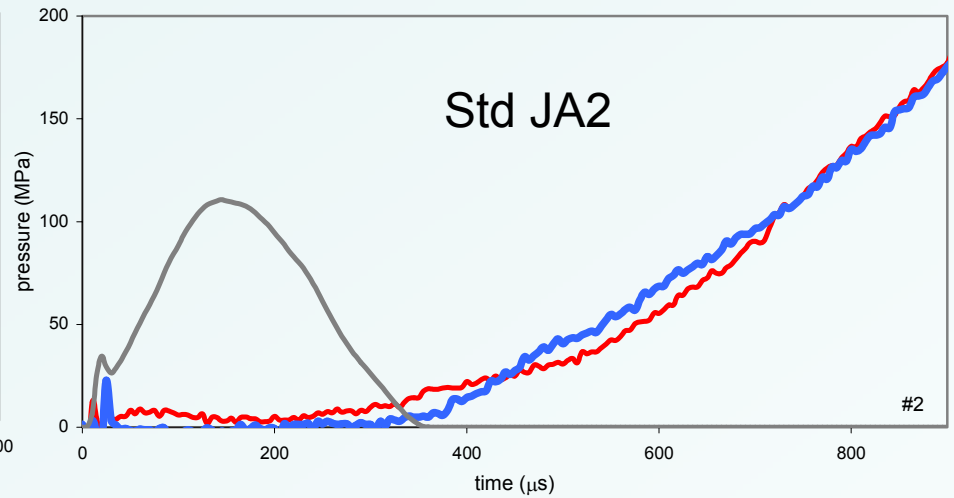
## Long plasma pulse

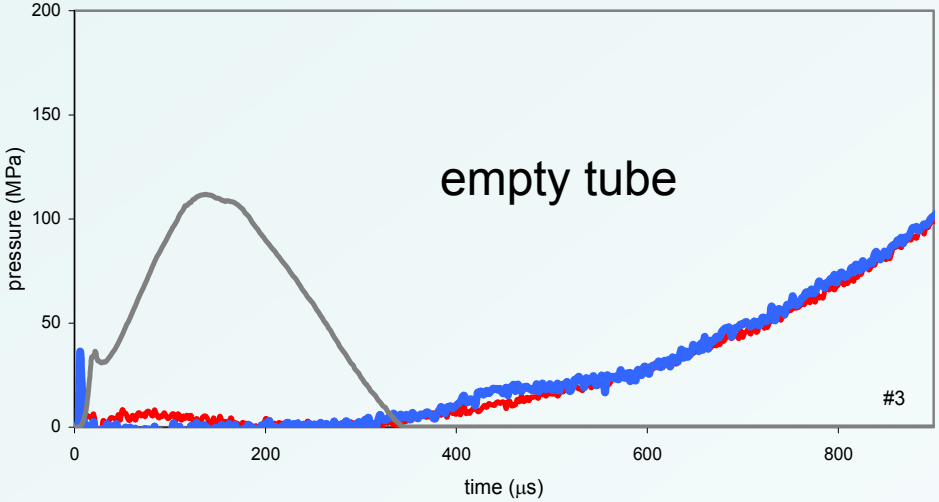


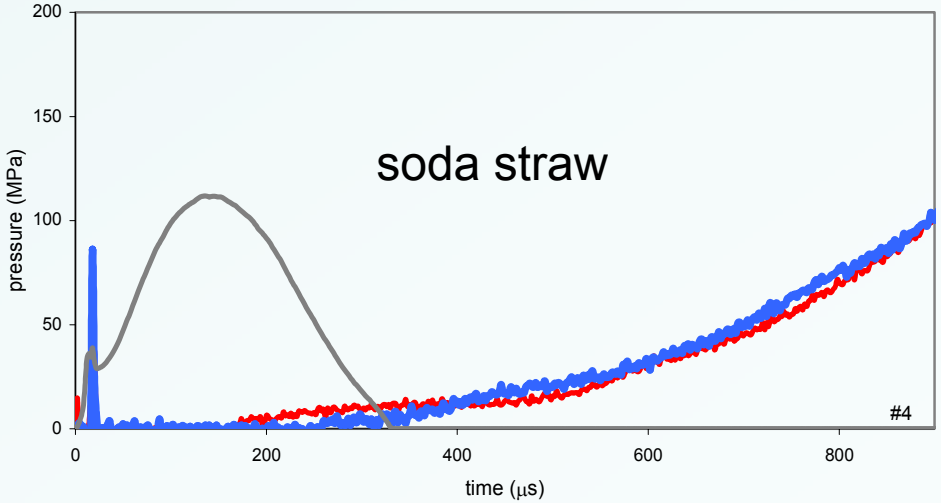
# Early Time Behavior

## with short-pulse plasma ignition



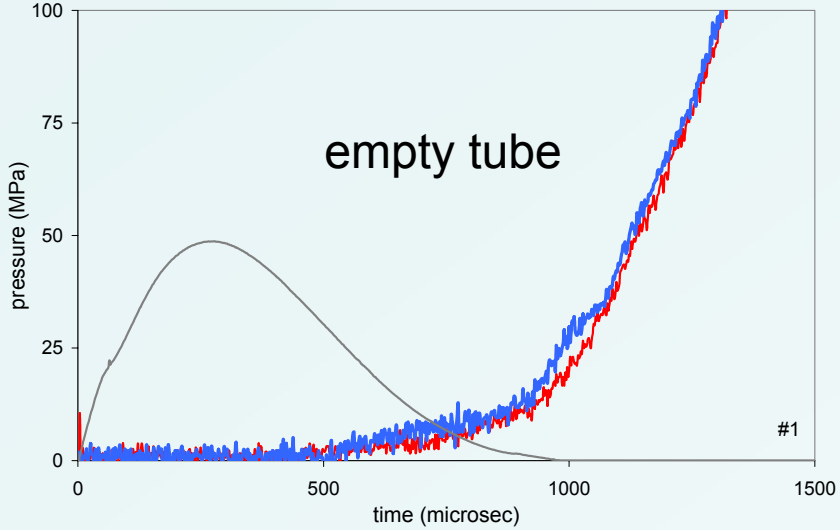



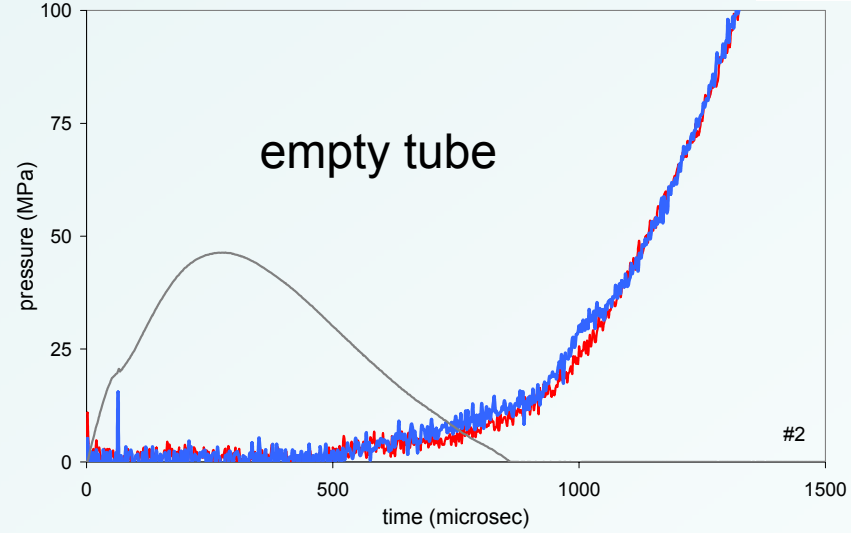



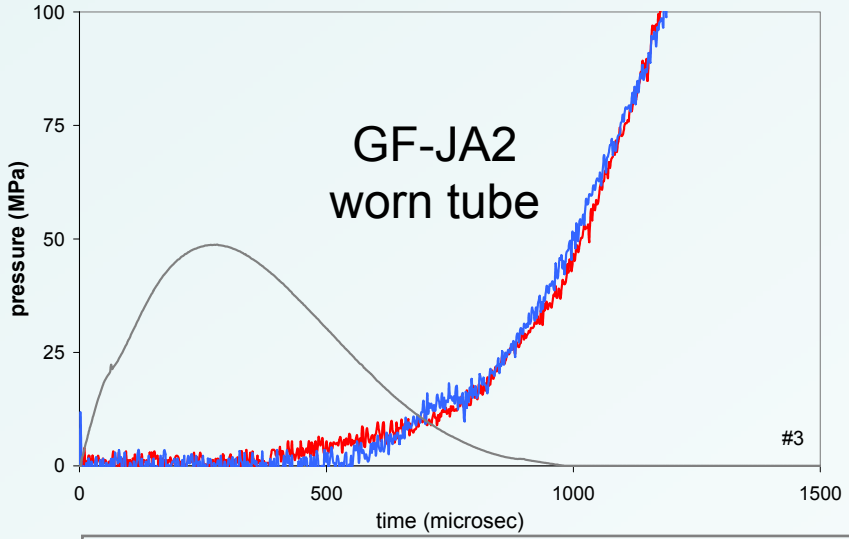

**KEY**: **red line: breech** **blue line: projectile** **gray line: discharge**

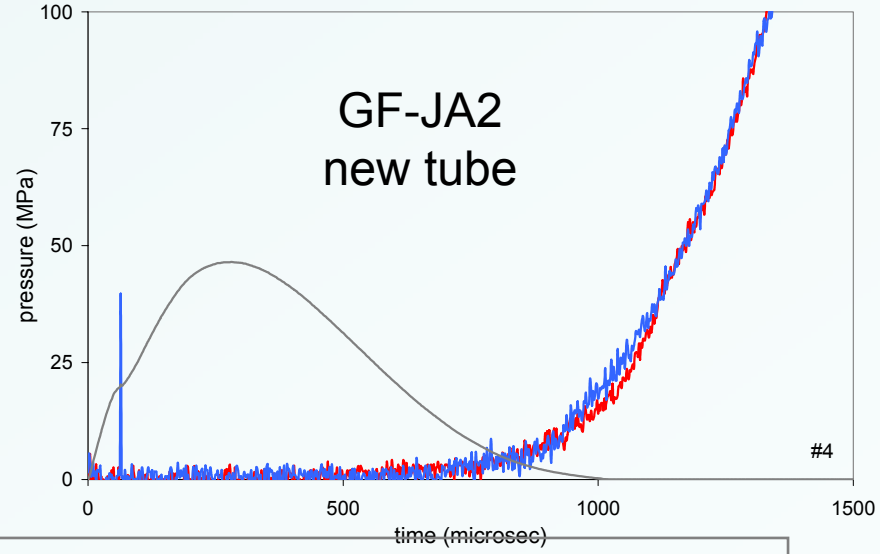
# Early Time Behavior

## with long-pulse plasma ignition




**KEY**: **red line: breech** **blue line: projectile** **gray line: discharge**

# Summary

- Graphite Free JA2 provides higher/faster pressurization inside igniter tube
  - But … The differences not as dramatic in gun firings
- Plasma ignition more prompt than conventional ignition
  - At low (2 kj) plasma energy
  - With M30 “boosted” with JA2 igniter
- Relative quickness of ignition follows our intuition regarding strength of plasma-propellant interactions
  - GF faster than STD JA2
  - Filled igniter tube faster than empty
  - Short pulse faster than long pulse
- Is faster better?
  - Short pulse: Fast and more PPI
  - Long pulse: Only slightly slower; smoother in our cannon

- **Key to Plasma Ignition: Rapid Pressurization of Charge**