Development of Exploding Foil Initiators and Micro Chip EFIs

2007 Insensitive Munitions & Energetic Materials Technology Symposium

TNO | Kennis voor zaken

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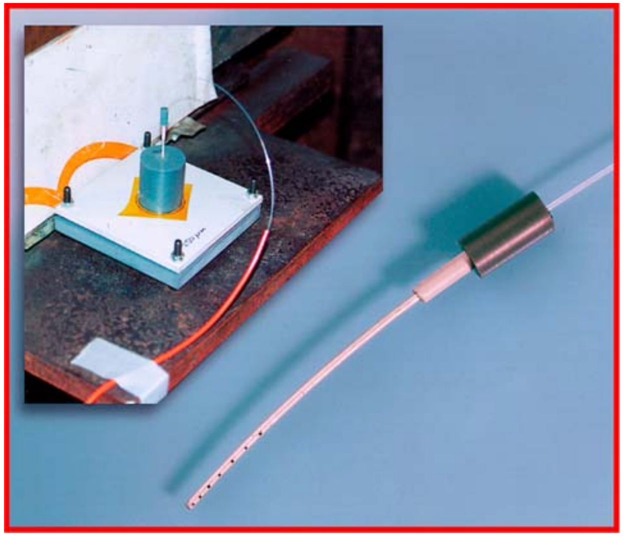
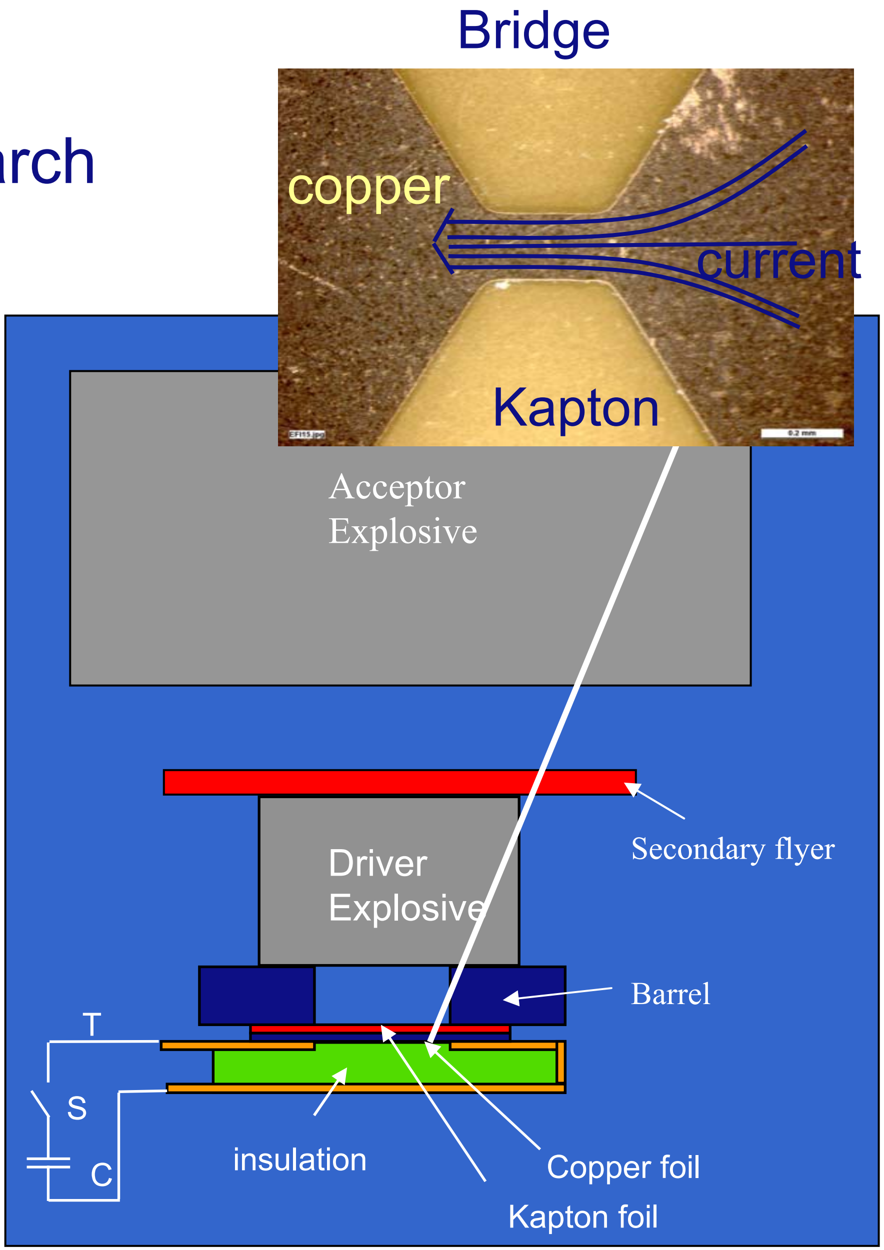
Overview

- Introduction
- Why EFI systems
- Exploding Foil Initiator Research
- Research on Explosives
- Conclusions

Introduction
Exploding Foil Initiator Research

- Exploding foil
- Electrical circuit
- Velocity of the flyer
- Driver Explosive
- Secondary flyer
- Acceptor explosive

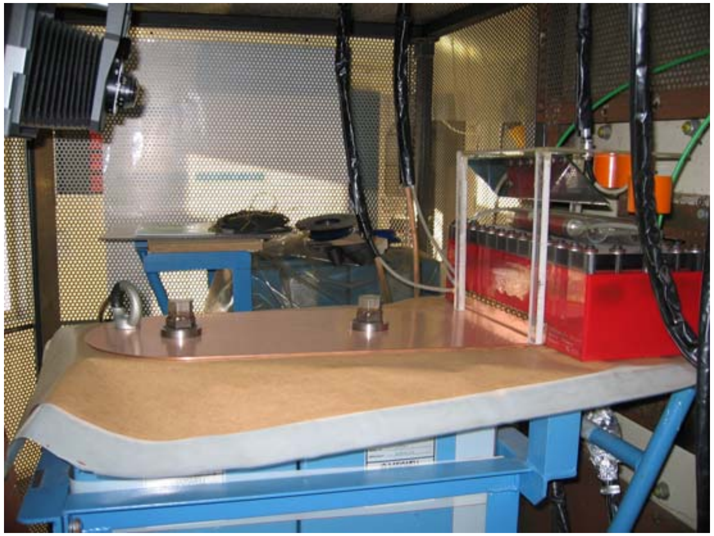




Shock initiation research at TNO: Mega Ampere Pulsar and Flyer Impact

~4 feet

Wim Prinse



Why an EFI system

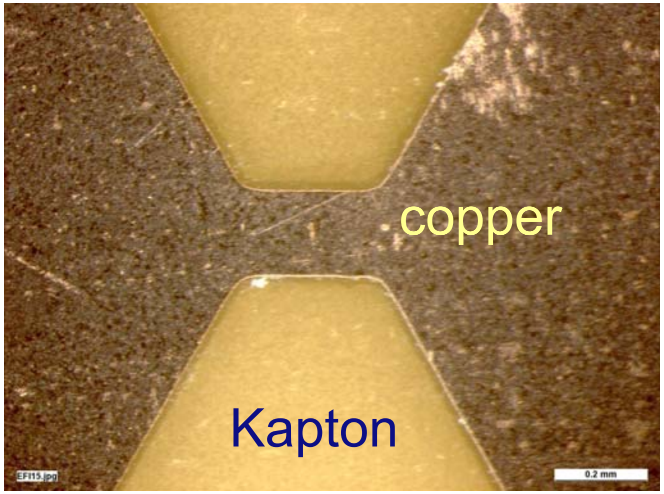
- An EFI is intrinsically safer than standard initiators (no primary explosive)
- More reliable (So, no UXO's)
- Works much faster < microseconds
- Can be smaller (near future)
- Is compliant with new STANAG (4560) regulations
- New opportunities (tandem charges, aim able warheads etc.)

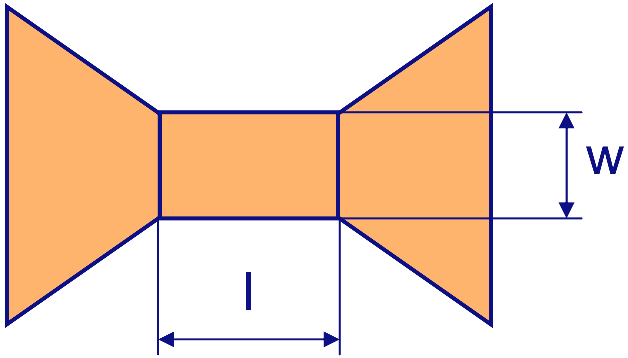
- Disadvantage : More expensive (at the moment)

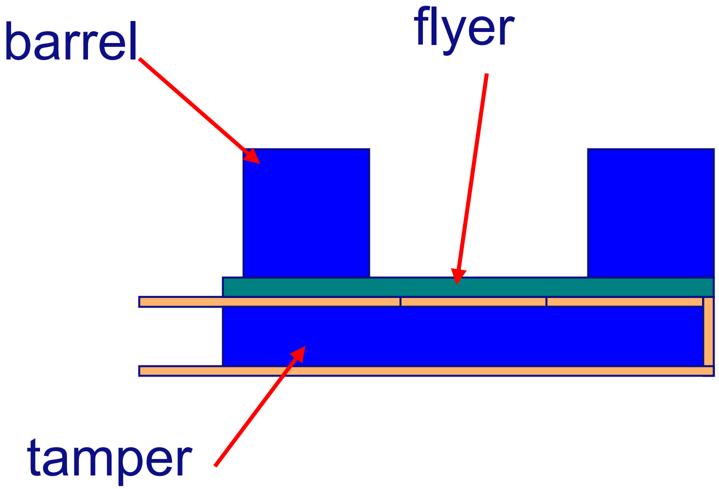
- Future: Micro Chip EFI (McEFI) → inexpensive

Exploding foil

- Dimension of the foil
  (length, width, thickness, shape, material)
- Shockwave impedance of the tamper
- Thickness and material of the flyer
- Length and width of the barrel

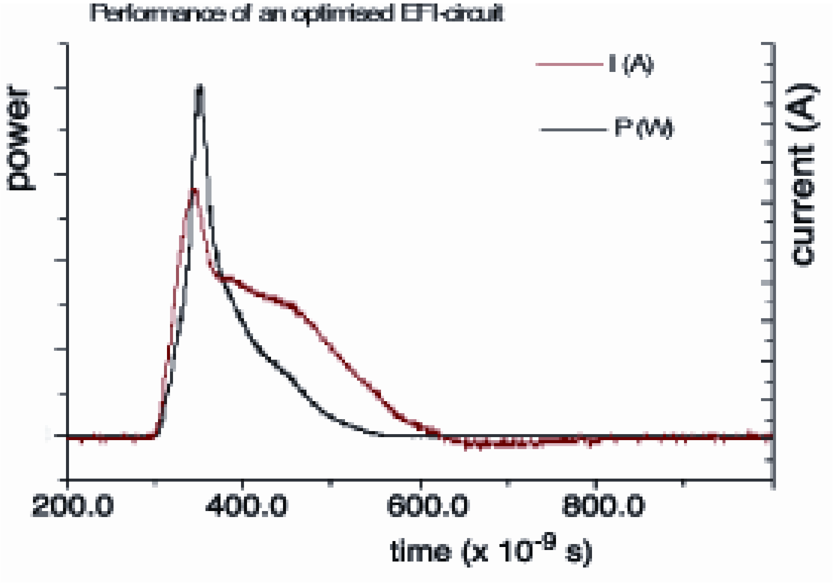




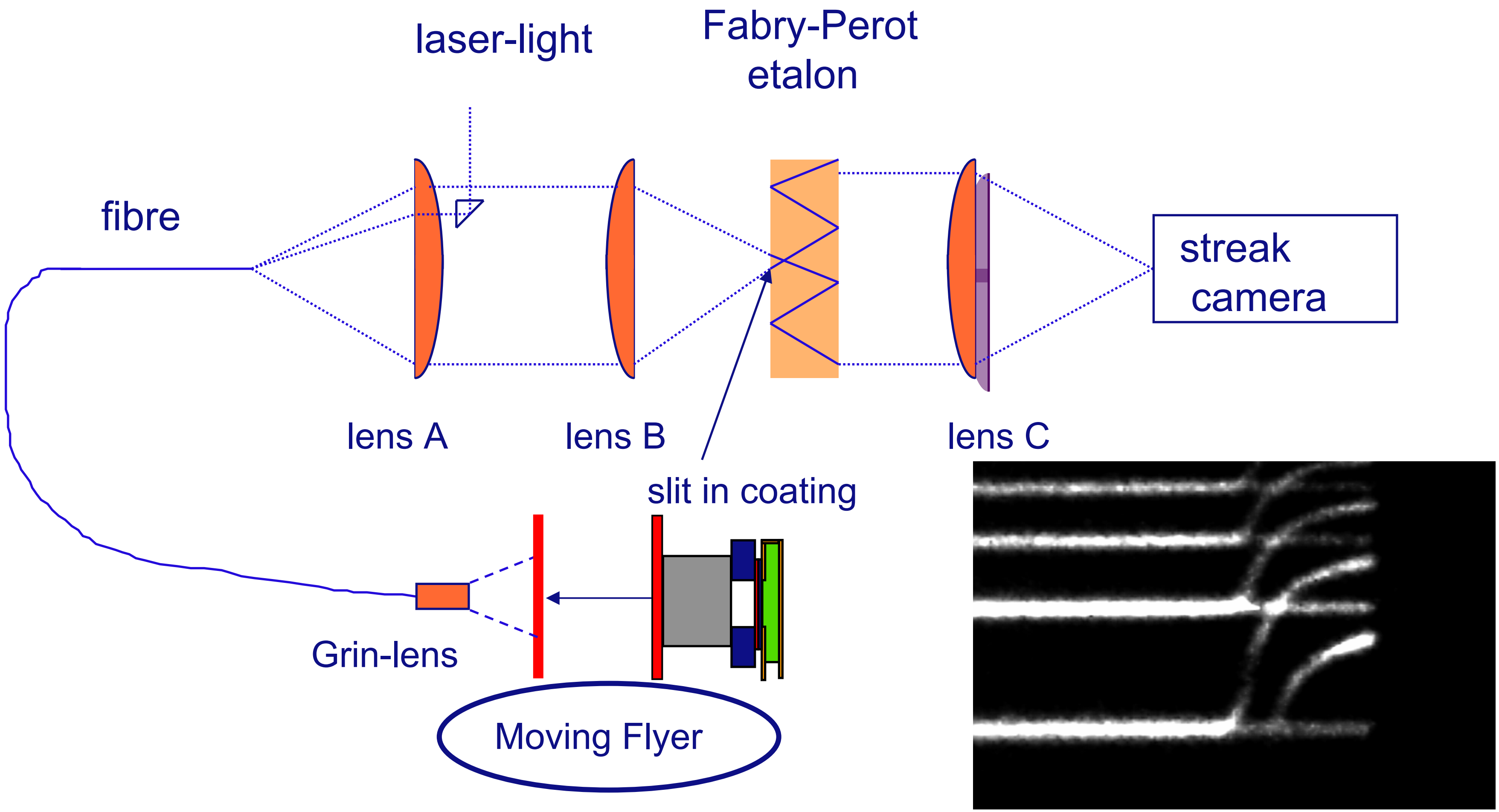


Electrical circuit

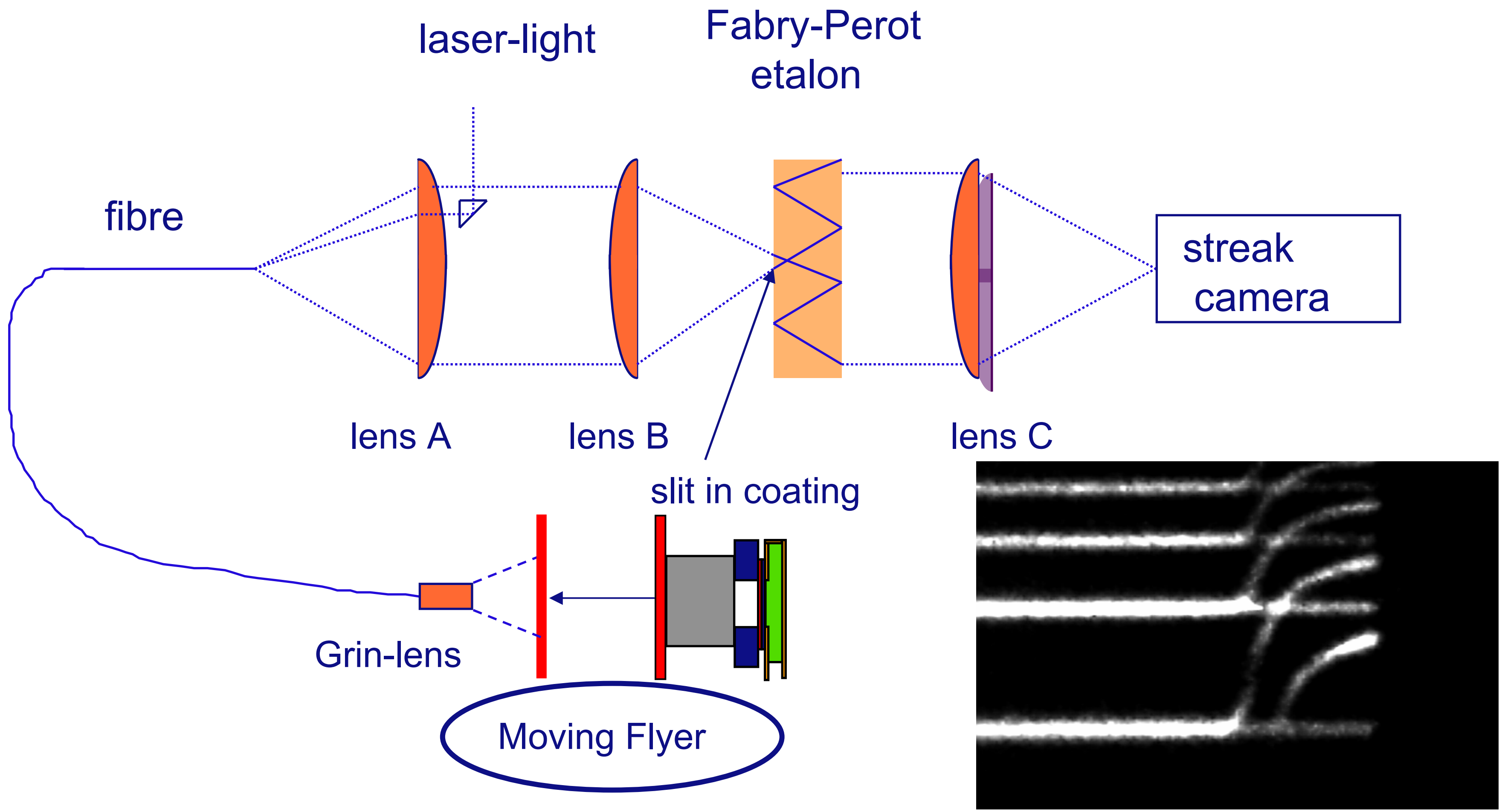
- Optimisation of the circuit
  - low loss capacitor
  - Switch (solid state)
  - transmission line
- Development of measuring techniques (current, voltage, velocity of the flyer)
- 90 % efficiency of energy deposited in the exploding foil (50 % other circuits)



Fabry-Perot system

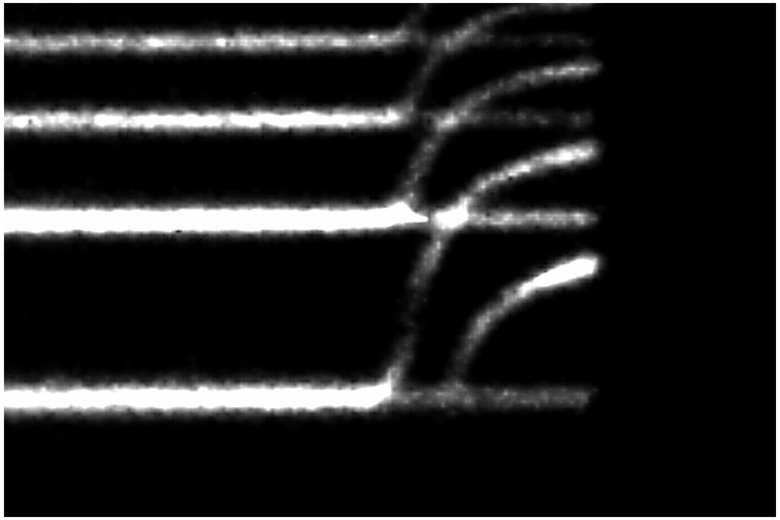


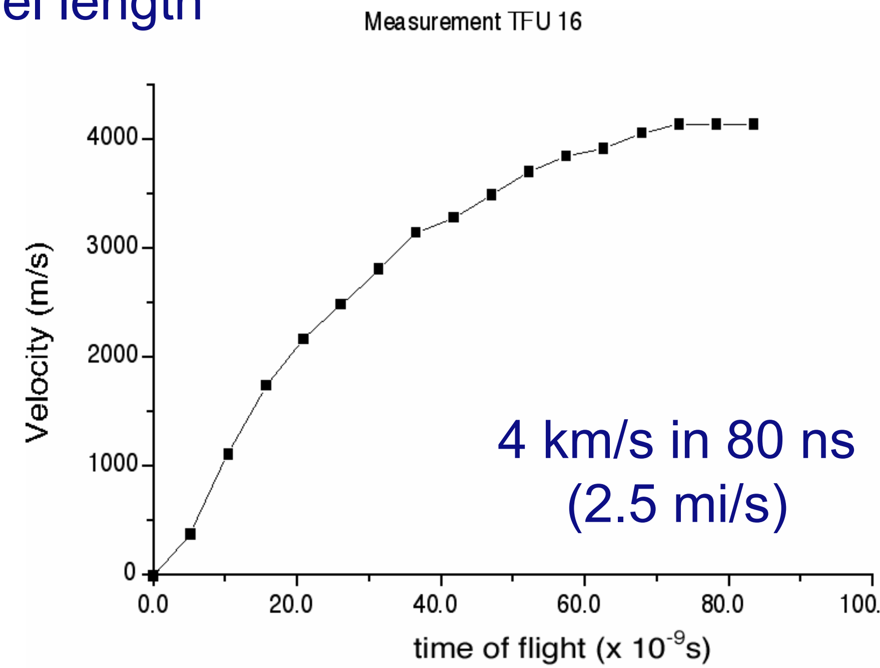
Fabry-Perot system



Flyer velocity measurement by F-P Interferometer

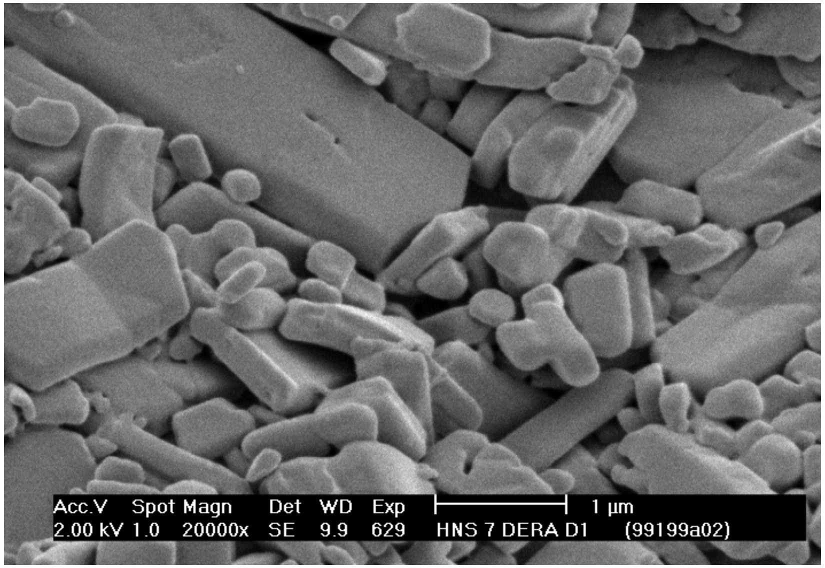
- Acceleration of the flyer influenced by:
  - thickness and material
  - exploding foil dimensions and material
  - shockwave impedance of the tamper
- Integrity of the flyer during acceleration
  - Determination of optimum barrel length





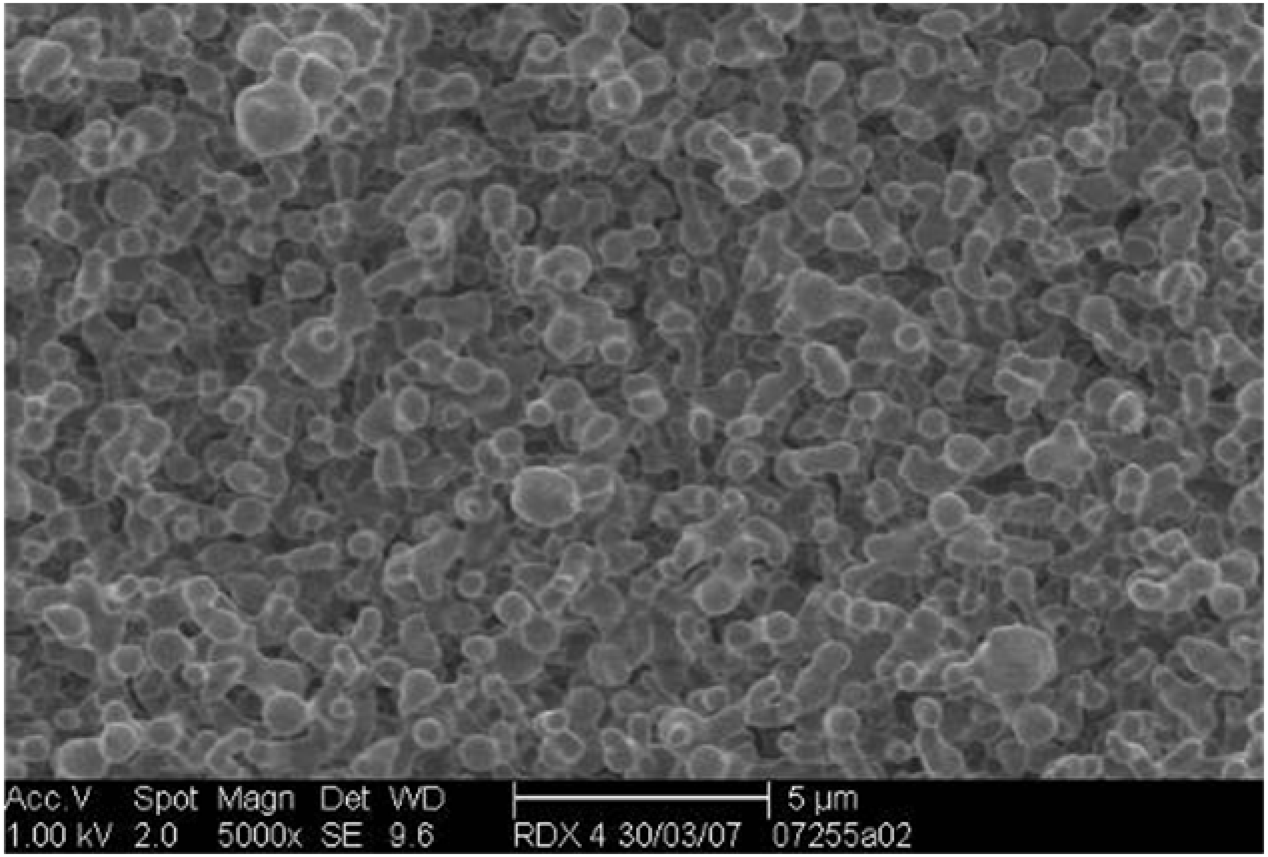
Research on Explosives

- Recrystallisation of HNS II to HNS IV
- The crystals are more uniform (smaller distribution)
- The length to width to thickness is 10:3:2
  a further increase in specific surface area is possible



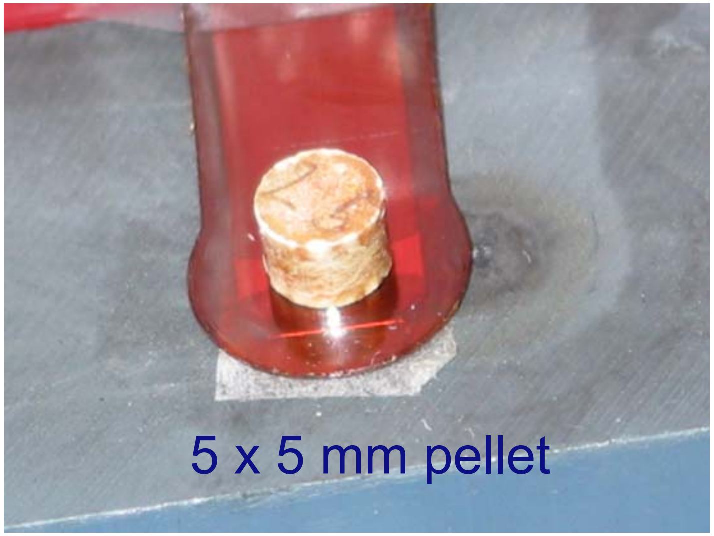
Research on Explosives

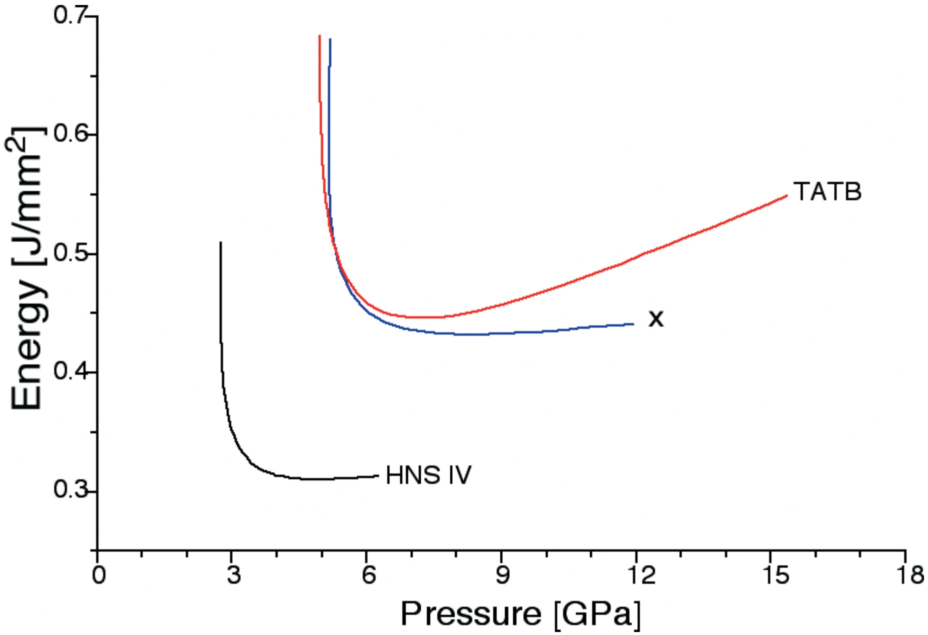
- HNS has a relative low output
- Submicron/nano RDX could be an option



Initiation behaviour of different explosives

- Different types of explosives
  - HNS IV several brands
  - TATB several grades
  - New explosives
- Initiation energy depends on flyer thickness and velocity

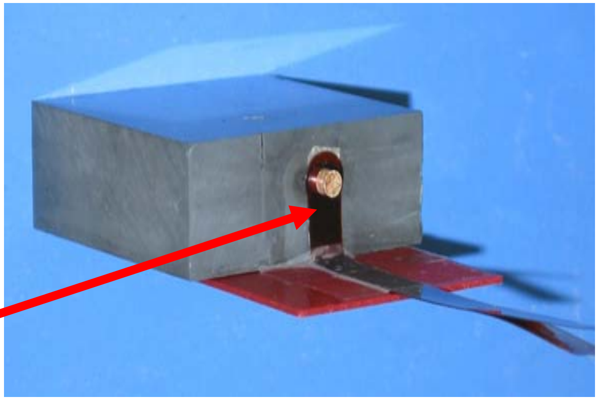


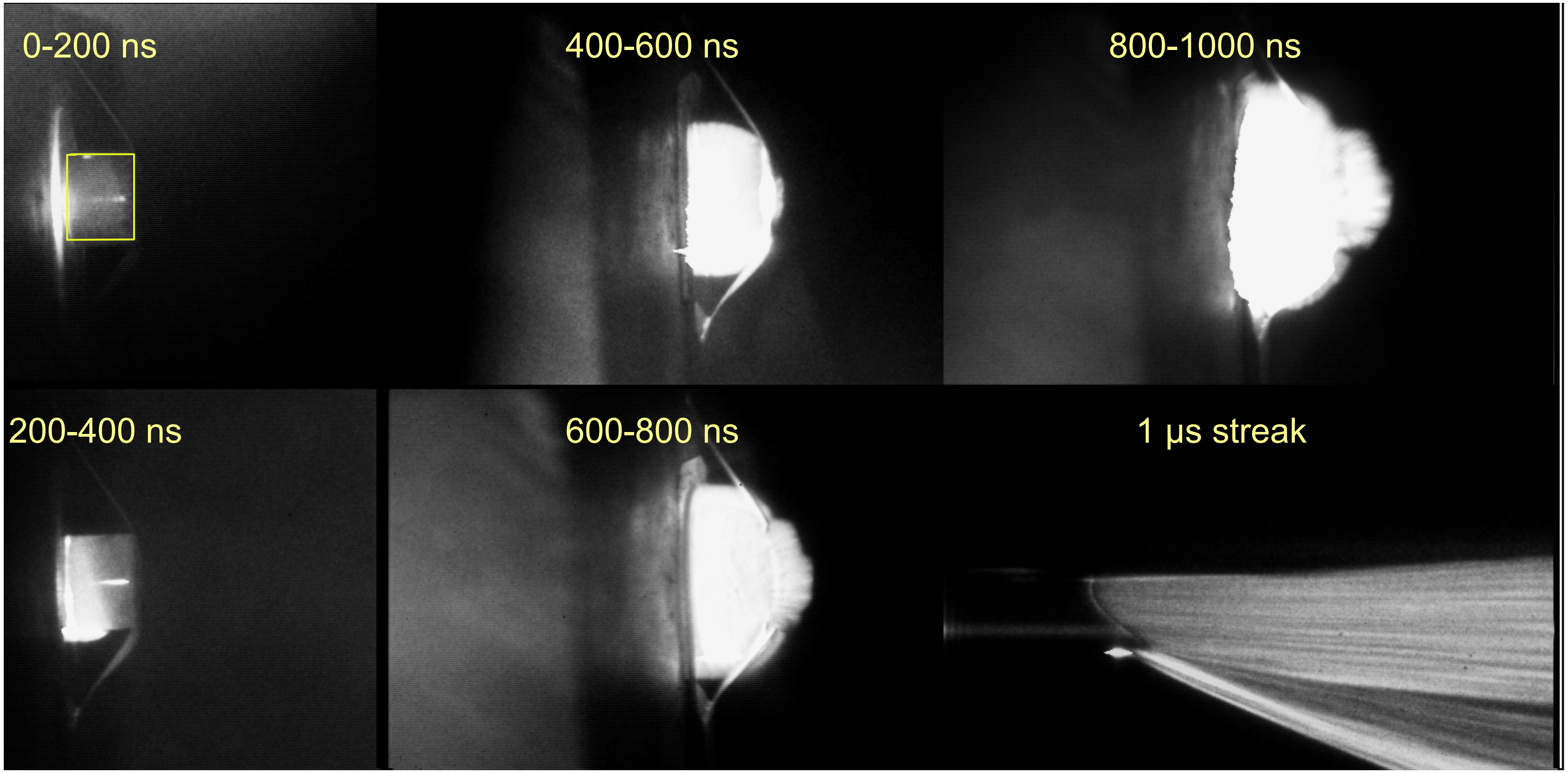


Initiation of 5 x 5 mm HNS IV pellet

Voltage < 1300Volt

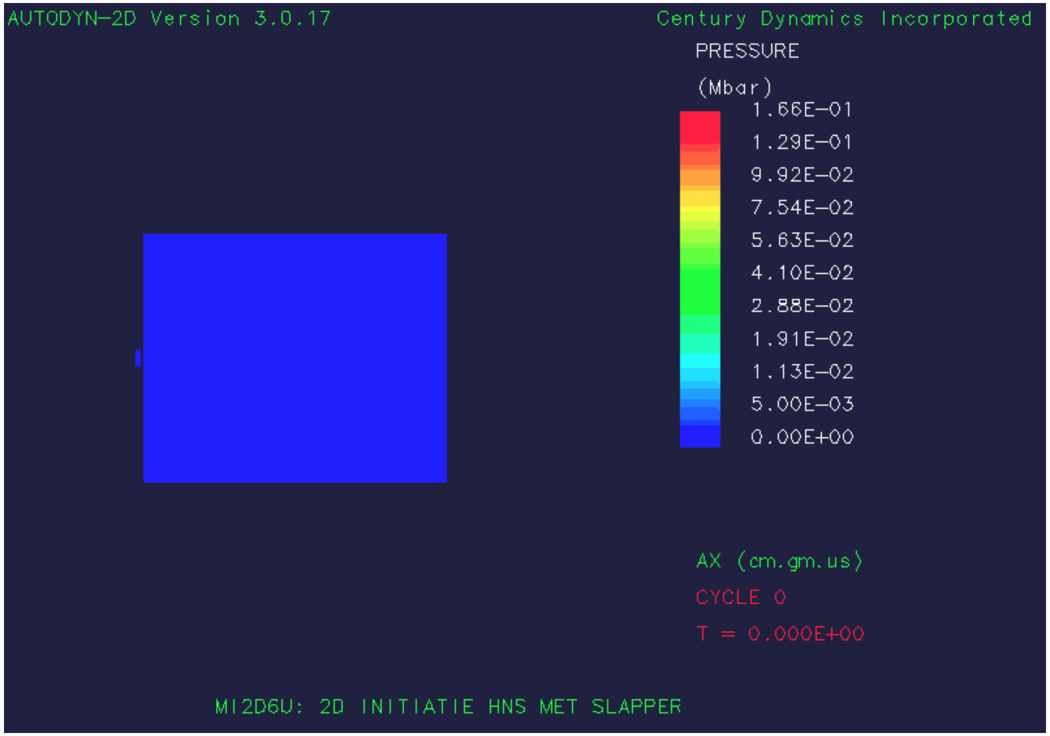
Transmission line





Numerical simulations of flyer impact

- Lee-Tarver model modified with visco-plastic pore collapse model
- Qualitatively the simulations can explain the experiments

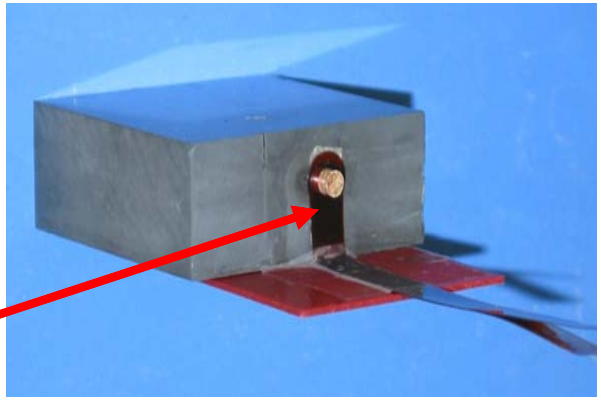


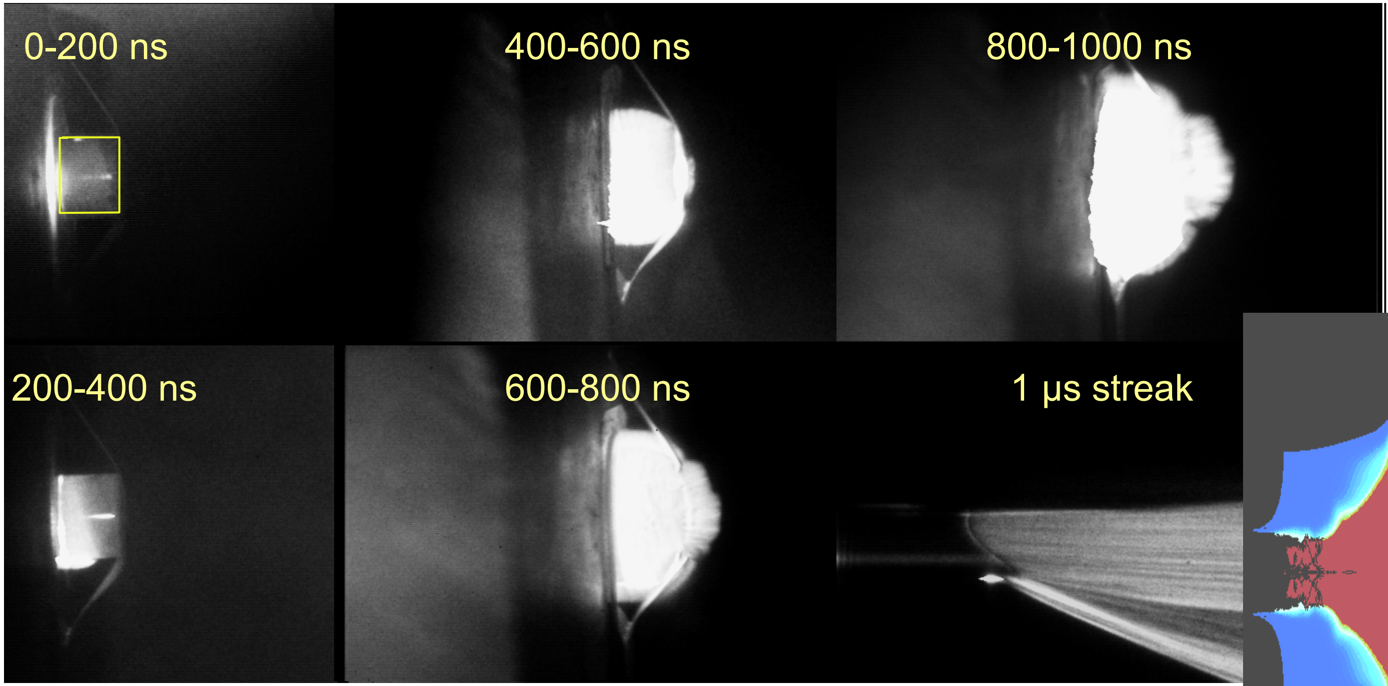
Reacted fraction of HNS IV after initiation by 5.4 mm/μs flyer

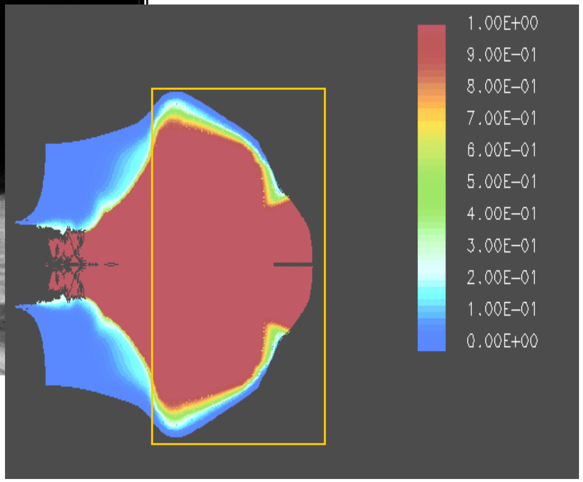
Initiation of 5 x 5 mm HNS IV pellet

Voltage < 1300Volt

Transmission line

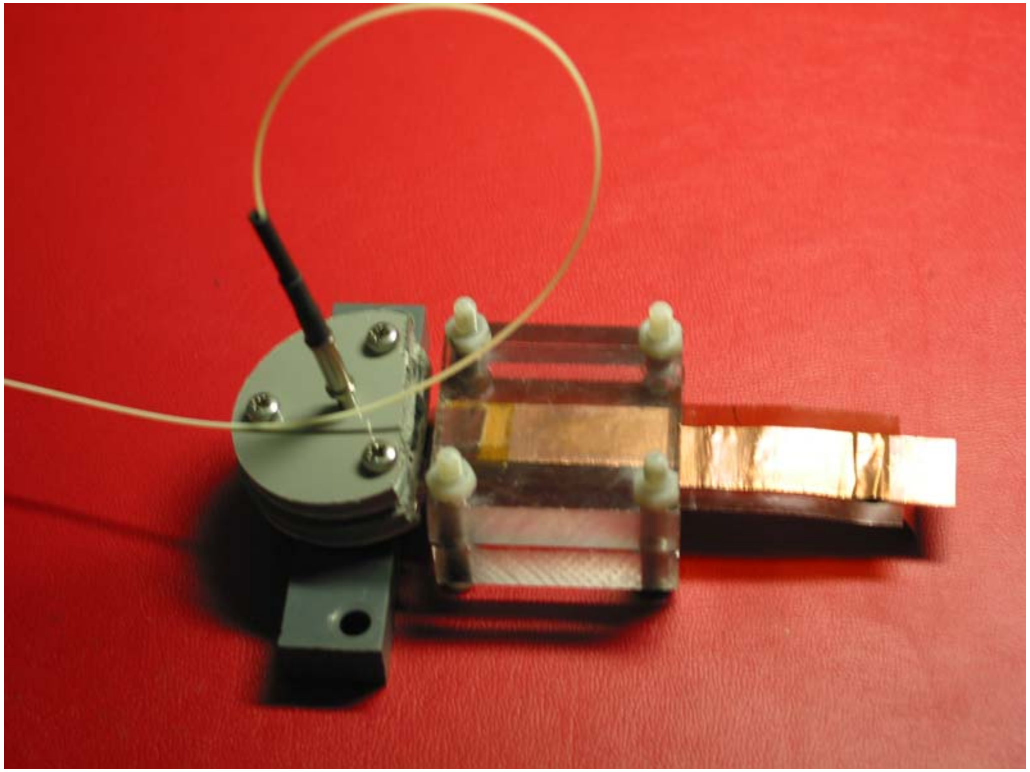






Secondary flyer acceleration

- Driver explosive (HNS IV), confined
- Secondary flyer material:
  - aluminium
  - stainless steel
  - kapton
  - mylar
- Important properties:
  - spall strength (attenuator)
  - shockwave impedance
  - size and thickness
- Velocity of flyer measured with Fabry-Perot Velocity Interferometer System



Secondary flyer acceleration test results

Flyer material	TATB (ρ = 1.688 g / cm3)	TATB (ρ = 1.842 g / cm3)	Hexocire (RDX/wax)
0.15 mm Stainless Steel	+	-	+
0.25 mm Stainless Steel	+	-	+
0.35 mm Mylar	+	-	+
0.3-0.5 mm Aluminium	+	-	+
0.43-0.55 mm Kapton	-	Not tested	+
0.81 mm Kapton	-	Not tested	-

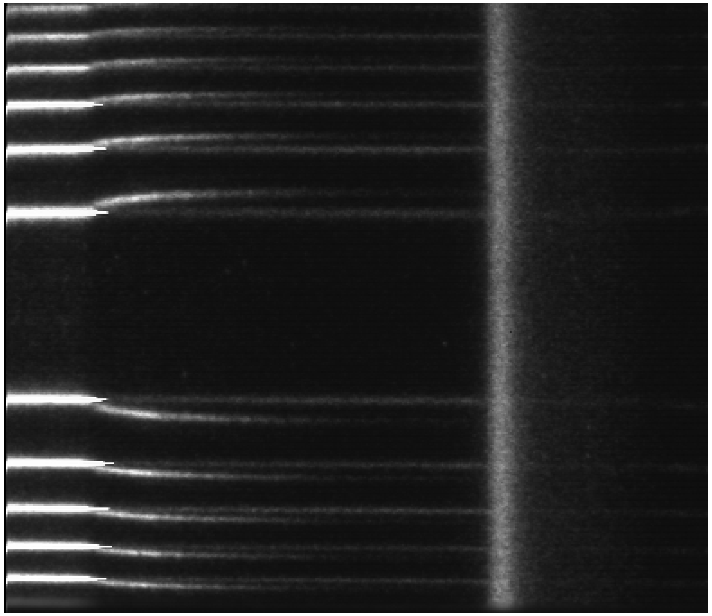
Secondary flyer impact

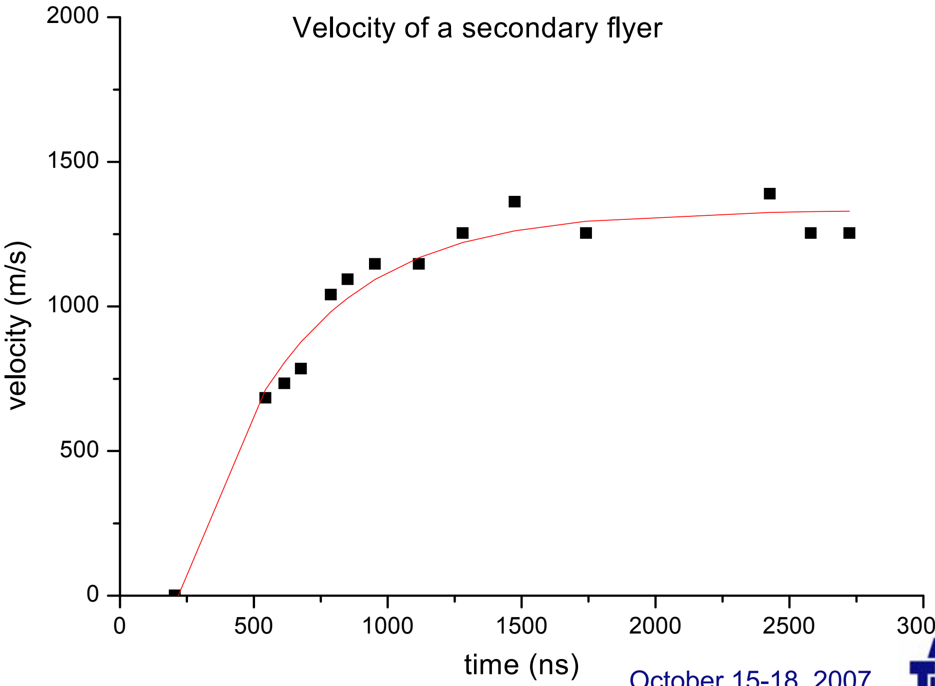
Acceleration of a 0.25 mm stainless steel flyer by HNS IV

Successful initiation of TATB and RDX by

- 0.15 mm SS steel flyer
- 0.35 mm mylar flyer
- 0.3 - 0.5 mm Al flyer

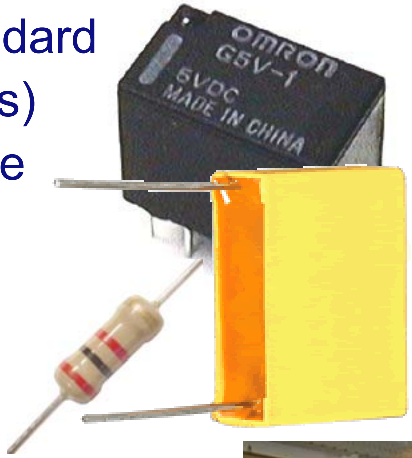
0.25 mm Stainless Steel

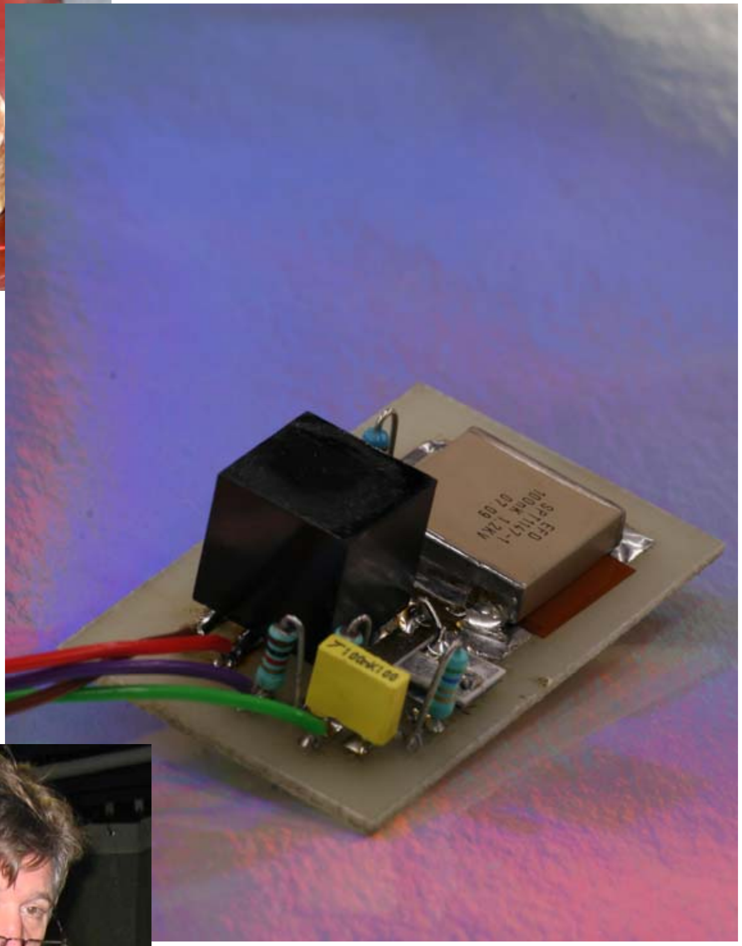




Development of mini EFI and developer platform for Micro Chip EFI (McEFI)

- Efficient Transmission line with exploding bridge
- Pressed HNS IV
- Electronic component of the shelf (capacitor, HV unit, solid state switch and some standard electronic components)
- Knowledge/experience

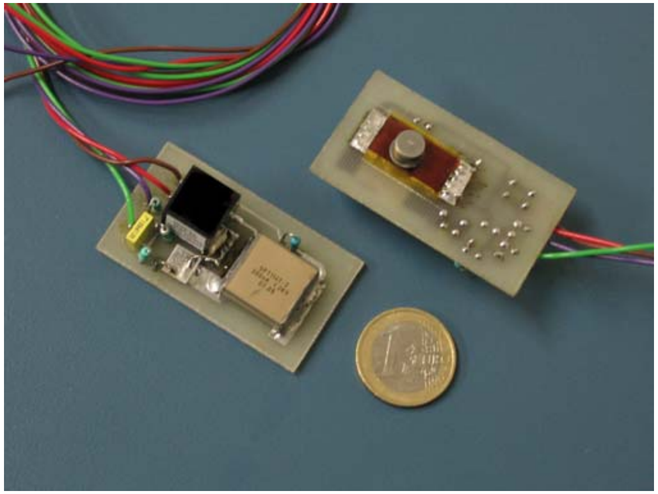


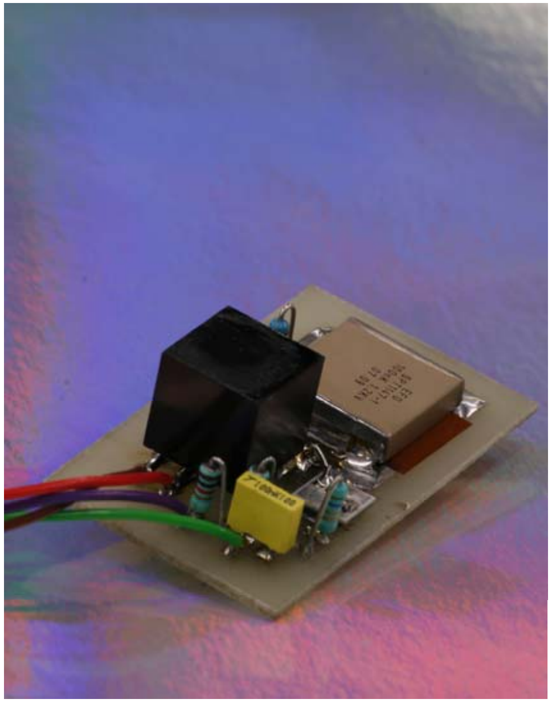


- Mini-EFI and developer platform for McEFI

Conclusions

- A very efficient electrical circuit (η = 90%)
- Mini-EFI Works at Voltage lower than 1300 Volt (Solid state switch)
- With “of the shelf components” small IM compliant EFI-detonators can be built (~8cm^3 including High Voltage-supply)
- The use of secondary flyers makes the detonation train more reliable (in case of set-back)
- Combining the EFI with the ESAD with Micro Chip technology can make a small and <u>cost effective</u> unit





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