Pyro-MEMS ®
Technological breakthrough in fuze domain

Fuze Conference 2011

Renaud Lafont

Salt Lake City, UT

24th of May 2011

Content

1. NEXTER Munitions Fuze activities
2. Design & Demonstration of 25mm Airburst ammunition Mk I
3. Design & Demonstration of 40mm Airburst Fuze Mk I
4. Pyro-MEMS ® for ammunition Mk II

1. NEXTER Munitions Fuze activities

NMu: Fuzing System manufacturer

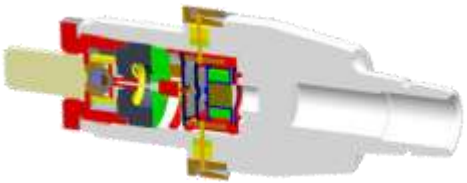
Products: Fuzing system & SAU for missile, tank ammunition (120, 100, 90 mm caliber), naval artillery (100mm caliber) and medium caliber (40, 30 and 25 mm caliber).



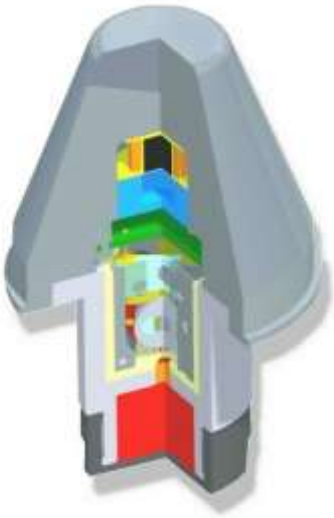


Strengthes:

- Pyrotechnical components manufacturer (primary & secondary explosive)
- Own proving ground, recovery system and data recorder
- Designer of the complete munition




NMu: Fuzing System designer



Applications:

- Airbursting ammunition
- Opto-Pyro
- Low Energy EFI
- Pyro-MEMS
- Course Correction fuze **(cooperation with JUNGHANS Microtec)**

Strengthes:

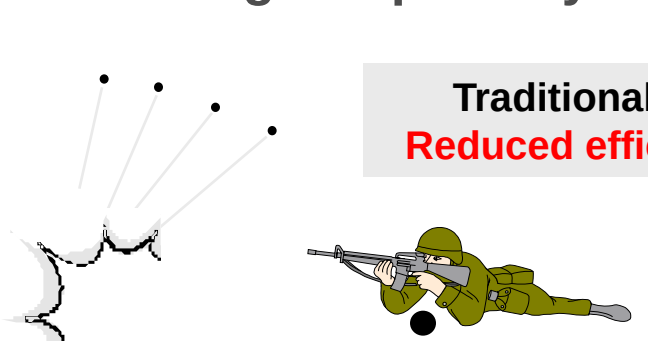
- Modelisation
- Data recorder
- Own proving ground (static, pyrotechnics, dynamic)
- Same group than weapon system designer (NEXTER Systems)

1. Design & Demonstration of 25mm Airburst ammunition-Mk I

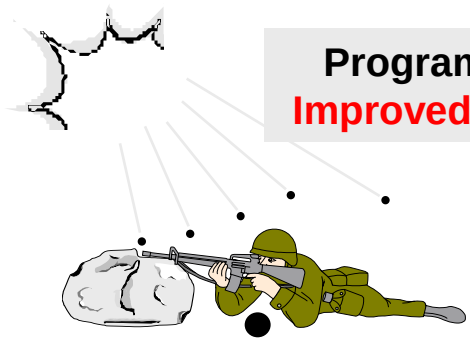
Contract n°05.50.208 – Improvements of medium calibre ammunition

Aims of the study

- Airburst has to be initiated above the target with an accuracy of 1 m at 1000 m
- Airburst mode shall be compliant with the maximal range of the 25, 30 and 40 mm weapons
- Impact mode available
- Compliance with STANAG 4187
- Airburst Fuze Programming Unit shall be able to equip existing weapons systems (upgrading)

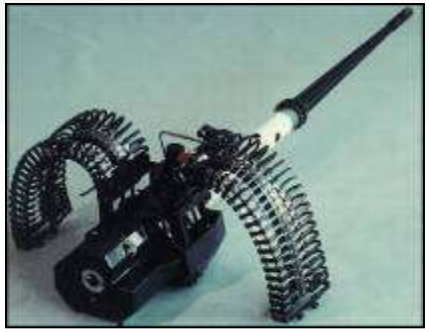


Traditional PD
Reduced efficiency

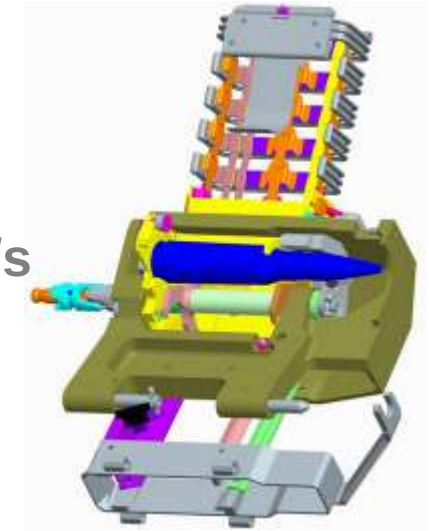


Programmed AB
Improved efficiency

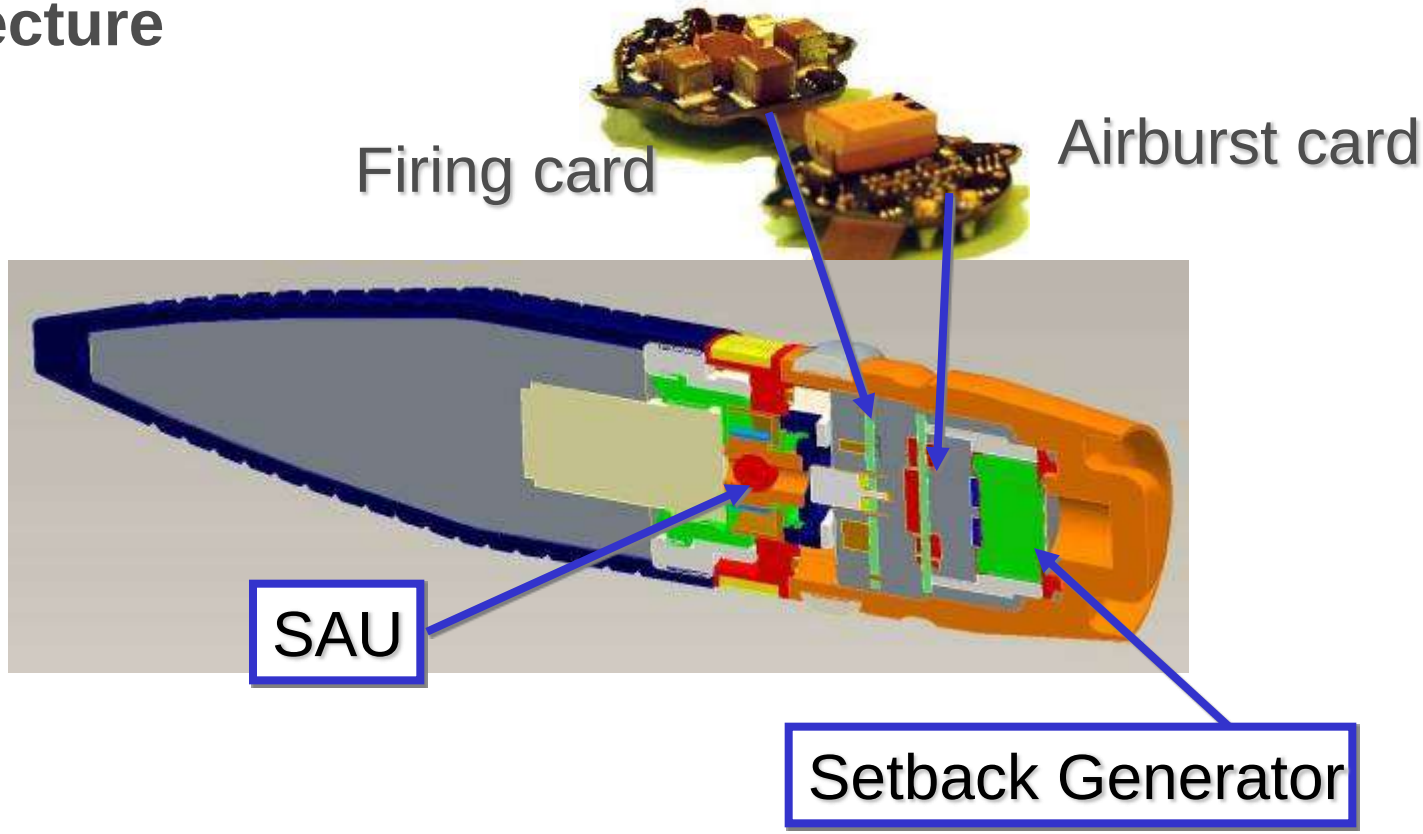
25 HEI AB Mk I



- **Programming Unit**
  - Inductive coil (Mode + Chronometry)
  - Impact mode remains available without programming unit
- **Operational modes**
  - Airburst +PD +Self-destruct
- **Airburst performances**
  - Chronometry : **+/- 0.5ms**
- **Environment conditions :**
  - Medium calibre 25x137 : 100 000 g 1000rd/s



Architecture

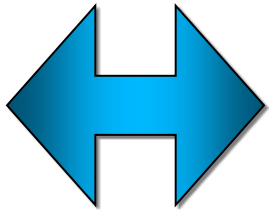


Electronics and SAU designs are deeply fitted into each other during engineering process.

25 HEI AB Mk I

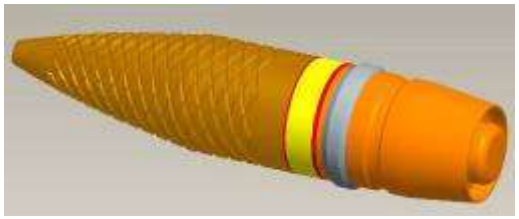
Architecture

HEIT



HEI-AB

Same shape + Same mass
=Equivalent ballistics



Programming coil

- **Induction programming**
- **The ammunition are programmed before entering in gun chamber**
- **Programming time about 65ms**
- **Weapon cycle: 150ms (firing rate 400 rds/mn)**

Programming Head

25 HEI AB Mk I

Firing evaluation

Airburst mode

-single shot

-Burst

Functioning @ 100m

Impact mode (spotting charge)

Functioning @ 100m

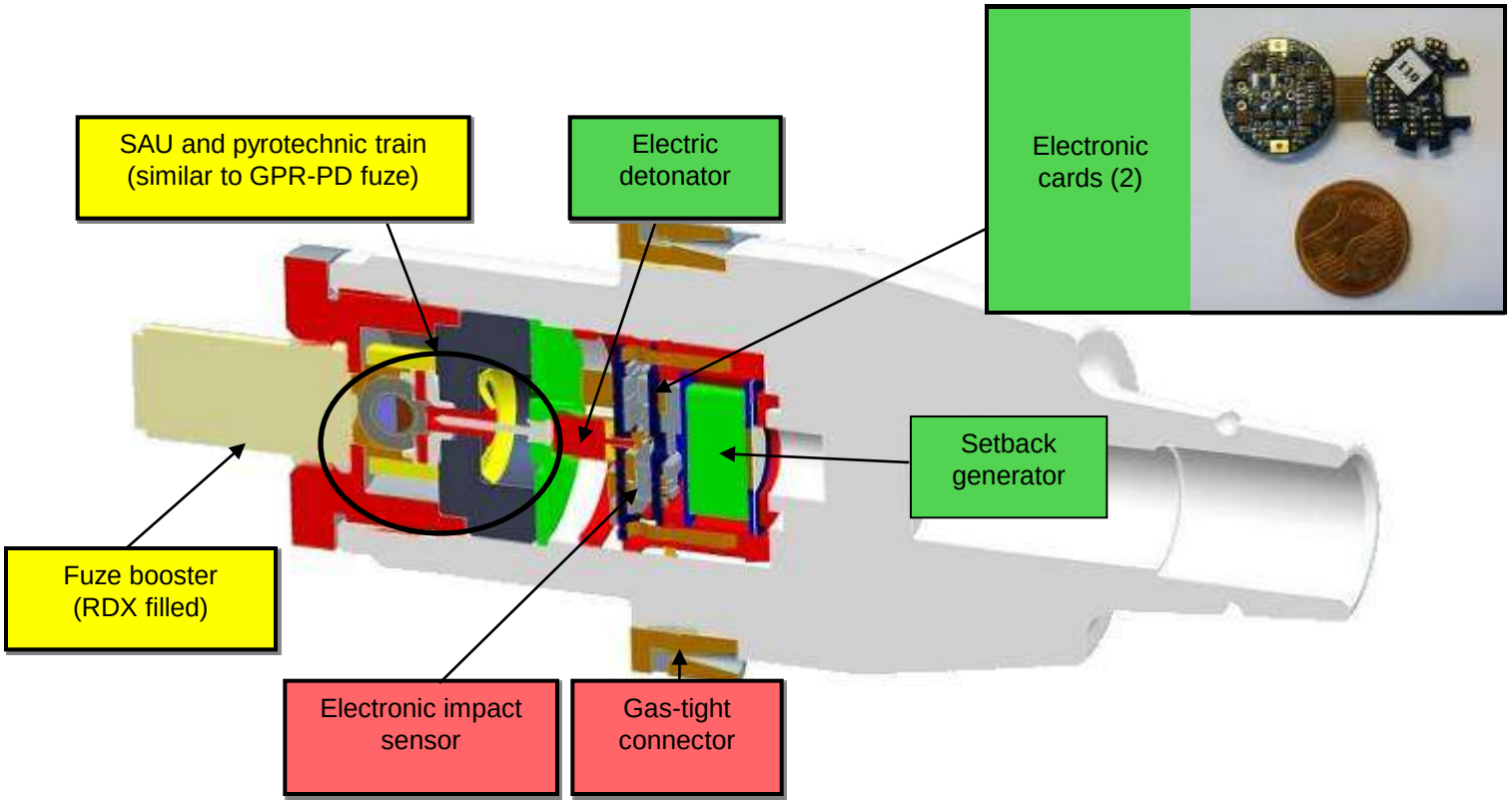
1. Demonstration and development of Nexter 40CTA Airburst sub-system -Mk I

Nexter 40CTA Airburst sub-system

- **Nexter Munitions proposal**

  - **A two stages fuze :**
    - **Mechanical SAU : low risk design validated with 30x150 Rafale and GPR-PD ammunition fuze for safety and STANAG 4187 compliance,**
    - **Electronic unit with :**
      - **Two electronic boards including Airburst, Point Detonating, Self Destruction functions,**
      - **A setback generator integrated in the fuze : electrical energy on-board generation for the pyrotechnic train electric initiator**
  - **A fuze setter :**
    - **Compact and tunable design compliant with the weapon mechanical interfaces and current cartridge programming coil**

Nexter Munitions 40CTA Airburst Fuze



Nexter 40CTA Airburst Fuze (1)

Main features :

- **Three modes fuze, electronically driven**
  - **Impact mode delay,**
  - **Impact mode quick**
  - **Airburst mode**
- **Safety (mechanically driven, compliant with Stanag)**
  - **Storage**
  - **Handling**
  - **Firing phase**
  - **Muzzle safety**
- **Self-destruction time, two options**

Nexter 40CTA Airburst Fuze (2)

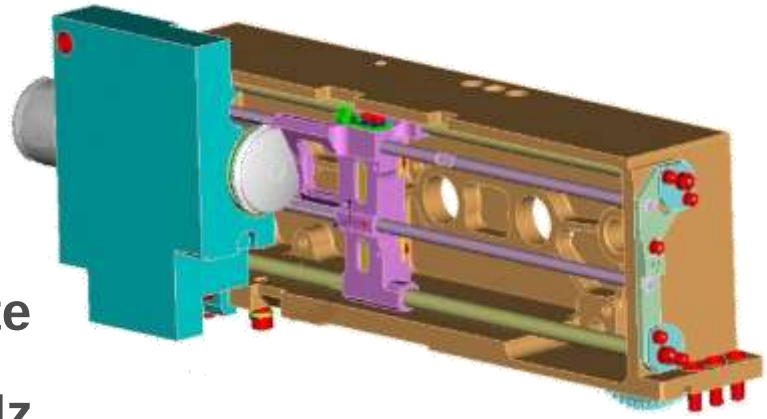
Main features :

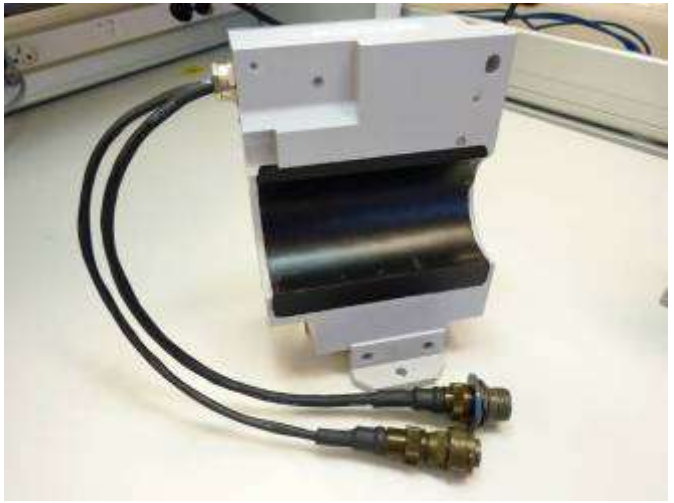
- **Safety**
  - **If fizzle occurs, there is no on-board energy after 10 s : ammunition is then totally safe for handling ,**
  - **Self-destruction is independent of programmation,**
  - **The energy for pyrotechnic train is given by setback generator : the low level of energy transmitted by Fuze Setter is not compliant with electric detonator initiation,**
  - **Default mode : point detonating (if no signal transferred or false programming message),**
  - **No functioning of the fuze against thin aluminium plate**

Nexter 40CTA Airburst Fuze setter

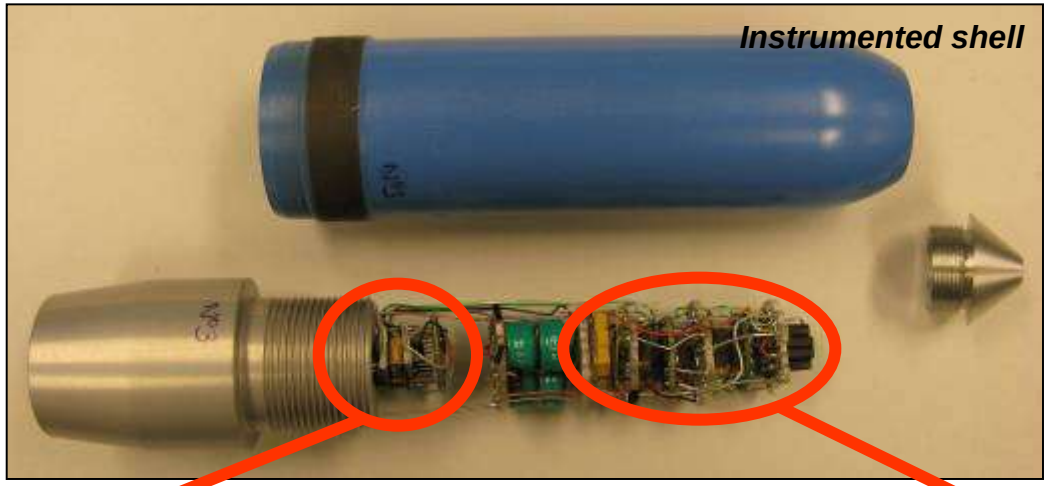
Main features :

- **Magnetic head**
- **Programming phase duration compliant with maximal firing rate**
- **Programming frequency : 100 kHz**
- **Firing in CTA Weapon with FS : more than 400 firings**





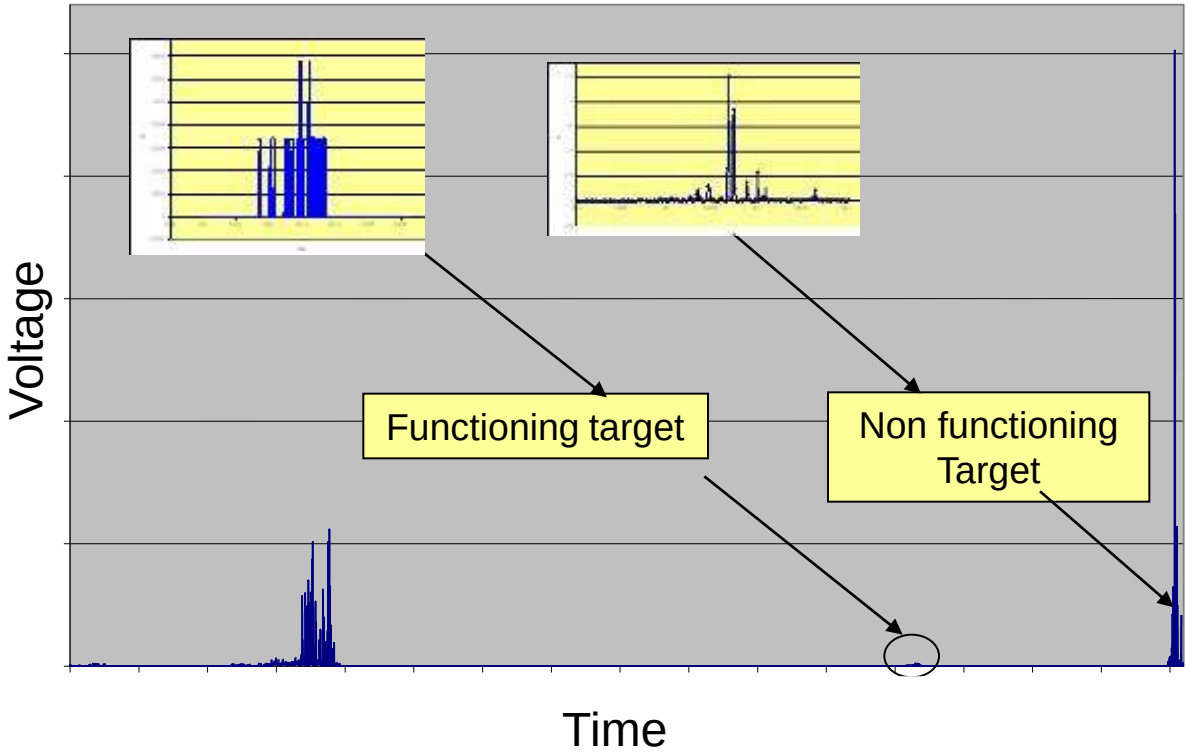
Embedded Instrumentation



Instrumented functions
(Impact detection + setback generator)

Instrumentation
(Battery / recorder / Interfaces)

Impact Detection



Analysis :

- Very high sensibility of the detector
- Detection of a target with thin aluminium plate
- Detection of the specified target
- Tested successfully on others targets types

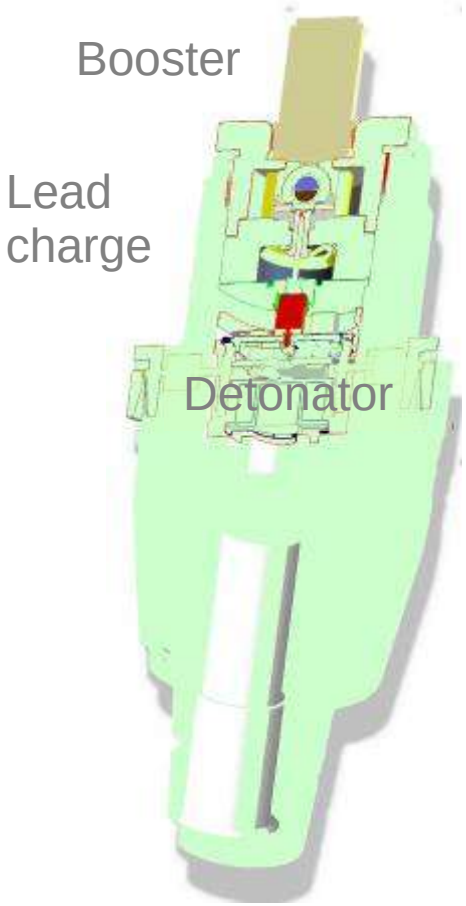
Pyrotechnic fire train

Normal functionning :

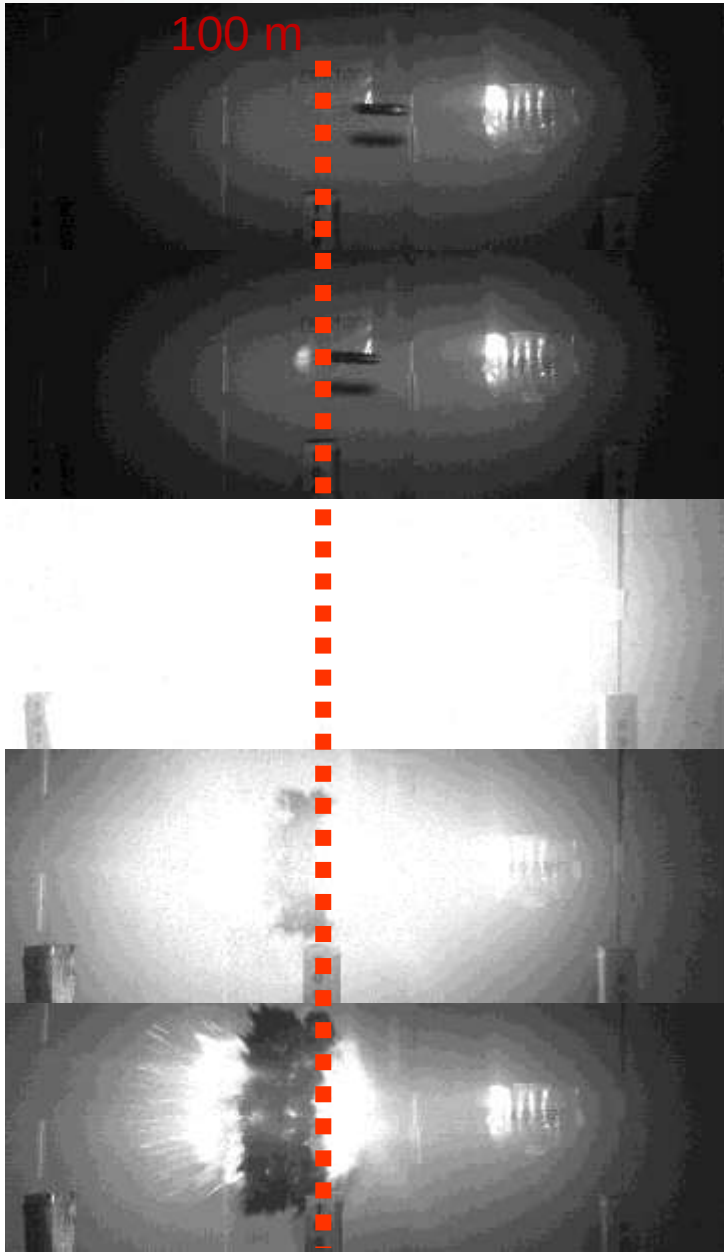
- **Transmission : 16 functioning on 16 trials**

Hardened tests:

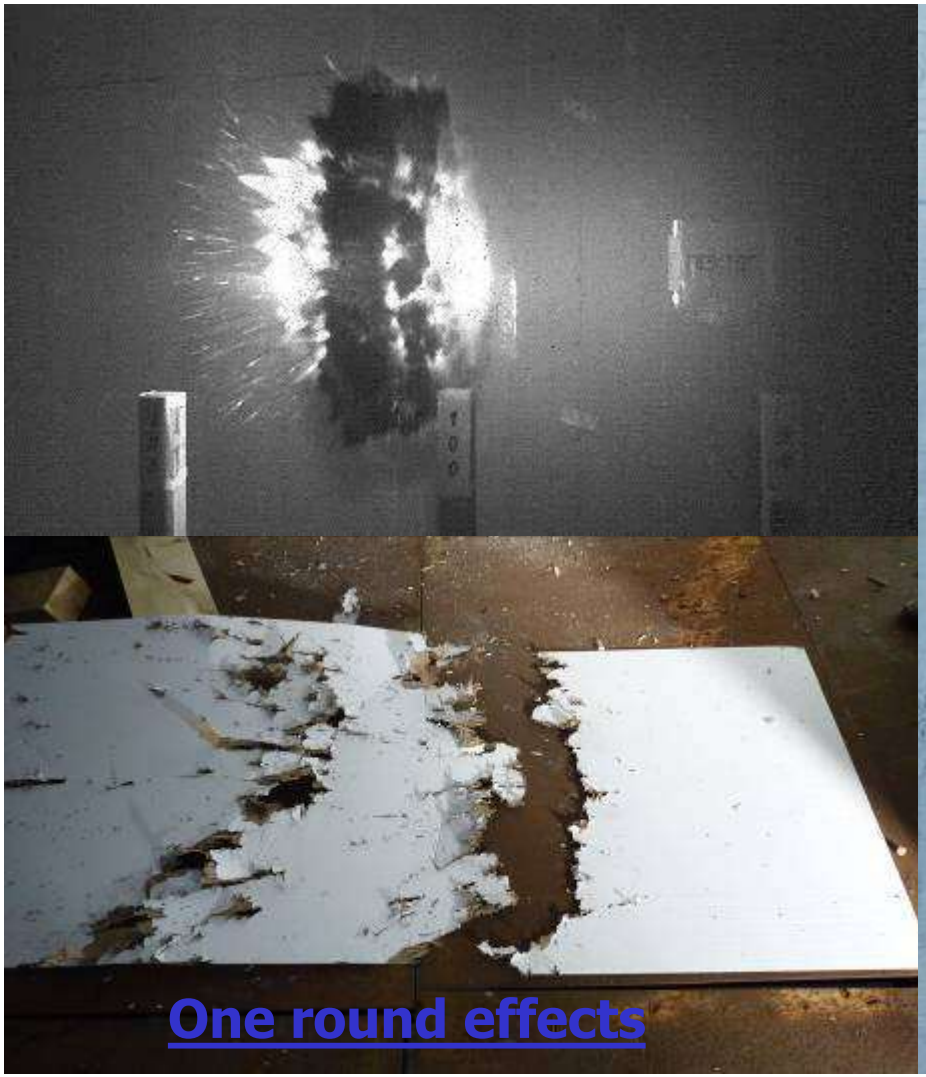
- **Transmission :**
  - Temperature tests (-46°C et +63°C)
  - Hardened factor : filling of the detonator.
- **No-transmission:**
  - Temperature tests(-46°C et +71°C),
  - Hardened factor : increase of booster sensibility**.**

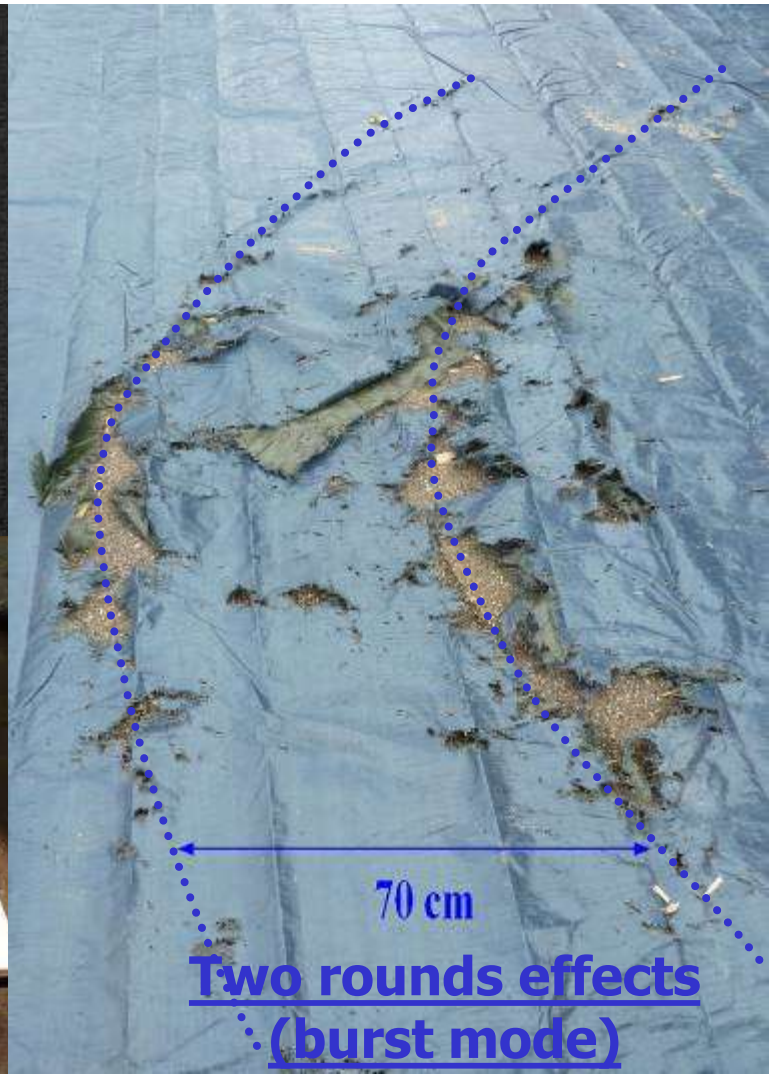


Airburst accuracy



Airburst accuracy





Warhead effects

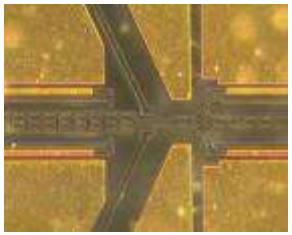
AIRBURST

Impact double brick-wall impact

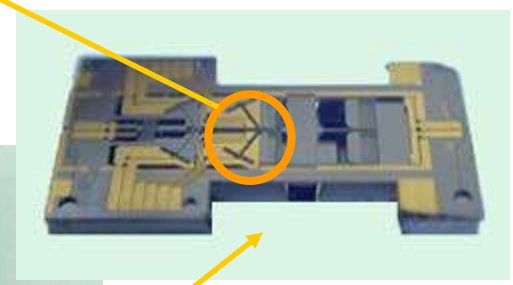
1. Pyro-MEMS®

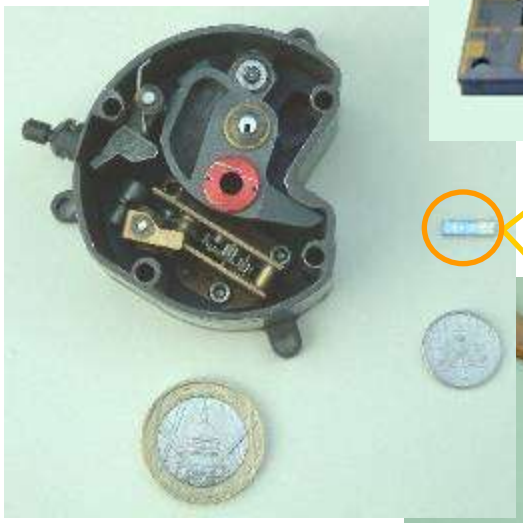
- **Preliminary study of µSAU**
- System level test: Warhead functioning demonstration
- Preliminary study of medium caliber MEMS based SAU

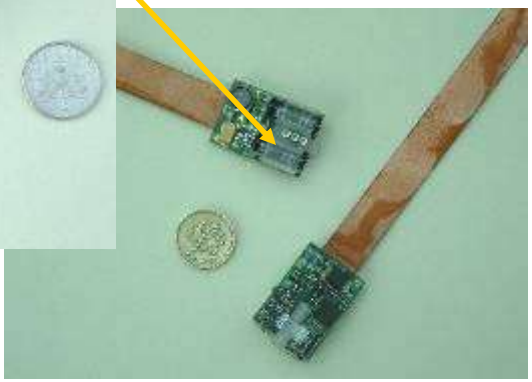
Contract 03.04.078 – Demonstration of miniaturized SAU



Pyro-MEMS: Merging of mechanics, electronics & pyrotechnics







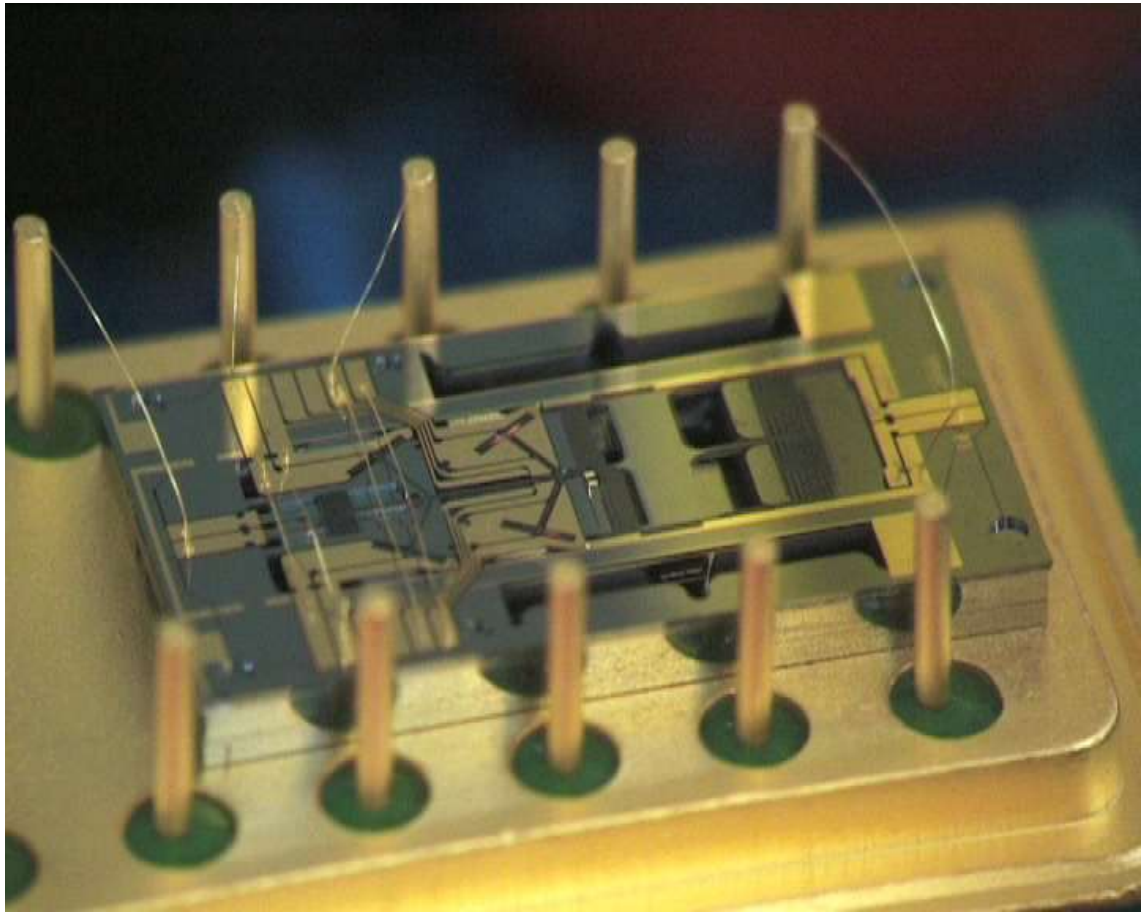
The Step Forward

03/2007 – delivery of 10 µ-SAU

Requirement

- **Pyrotechnical safety managed by electronically controlled MEMS**
- **Volume less than 2 cm^3**
- **In accordance with STANAG 4187 (last edition)**
- **Ignition of EIDS**
- **Low cost**
- **Generic SAU**

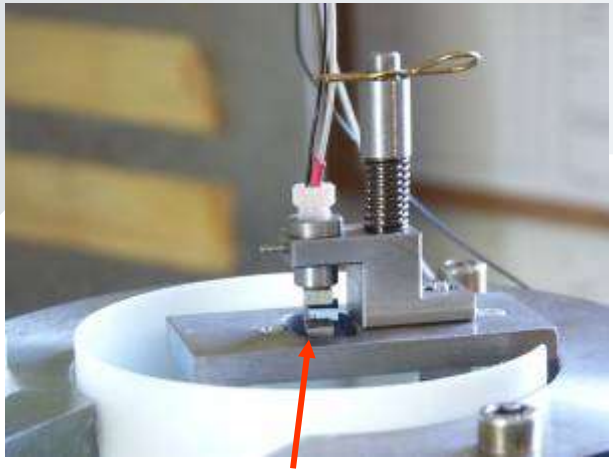
Arming ability and reversibility



1. Pyro-MEMS®

- Preliminary study of µSAU
- **System level test: Warhead functioning demonstration**
- Preliminary study of medium caliber MEMS based SAU

Demonstration
µSAU PyroMEMS® and in service missile warhead



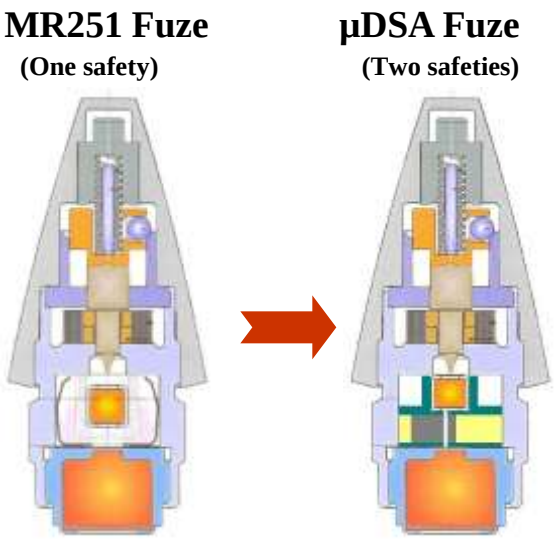
MEMS

Missile warhead

Two succesful firings of warhead (transmission and interruption)

Firing train for missile warhead OK

1. Pyro-MEMS®



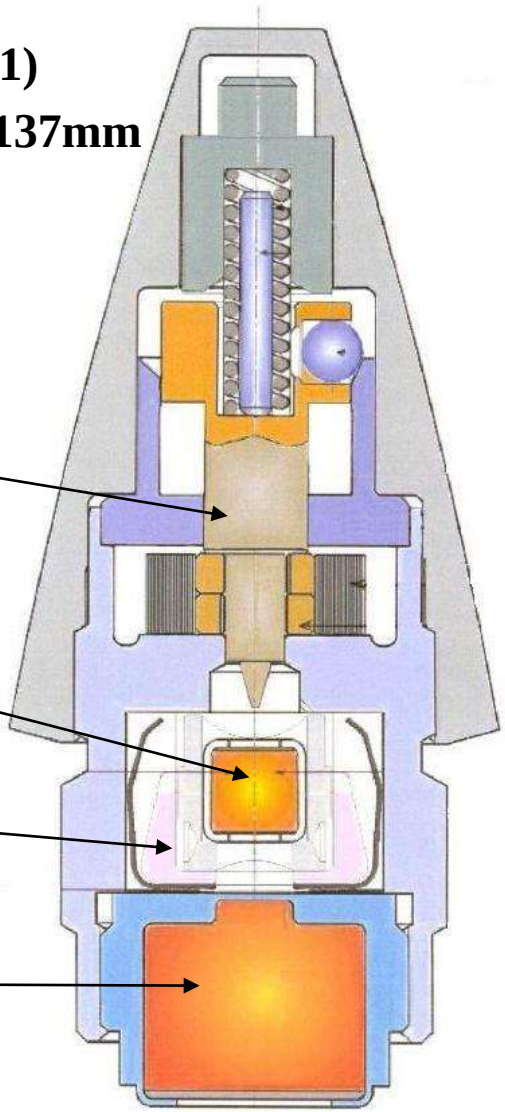
- Preliminary study of µSAU
- System level test: Warhead functioning demonstration
- **Preliminary study of medium caliber MEMS based SAU**

Two safeties fuzing system

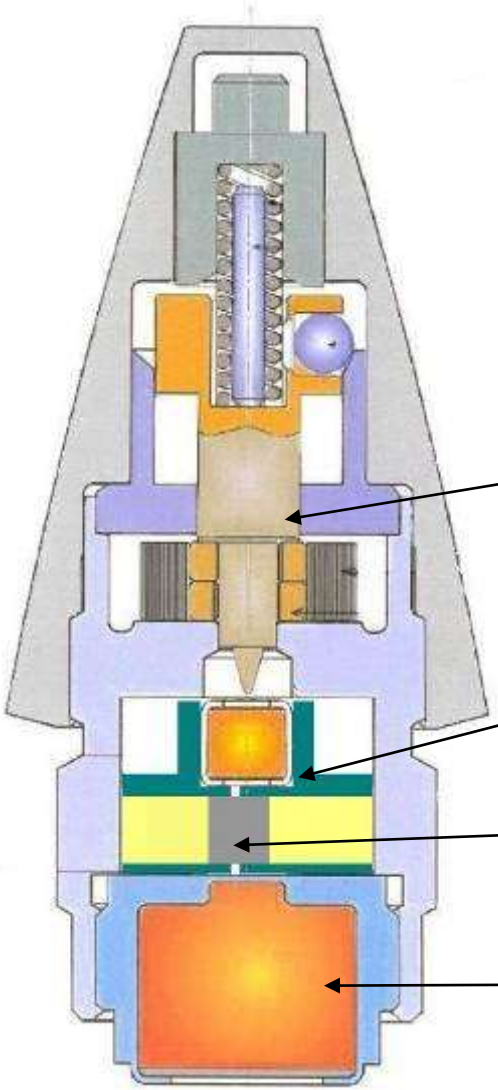
VBCI (25M811)

Munition 25x137mm

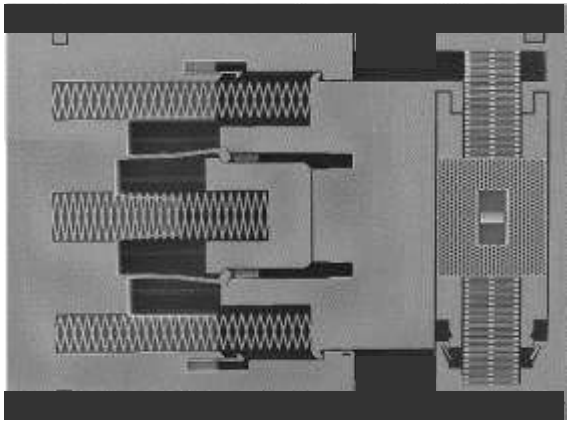
MR251 Fuze
(one safety)



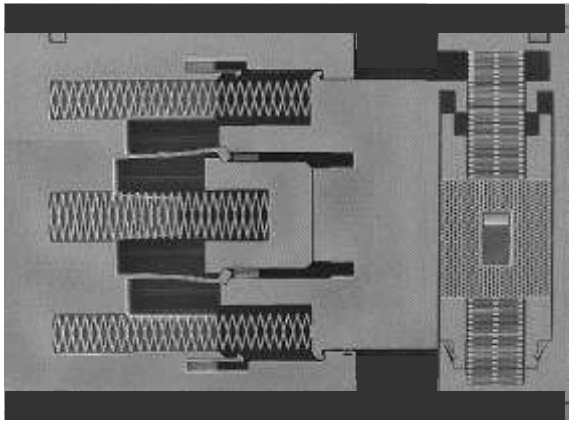
µSAU Fuze
(two safeties)



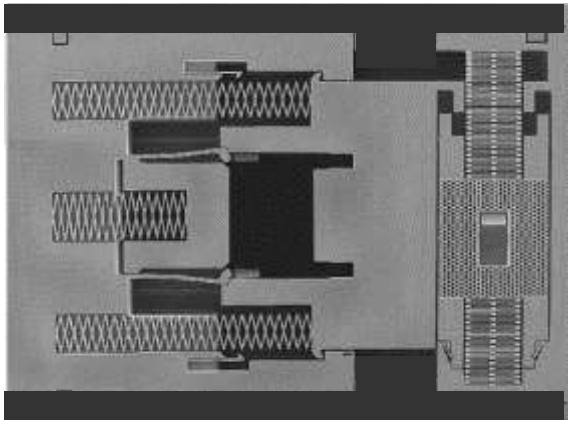
Focus on MEMS elements



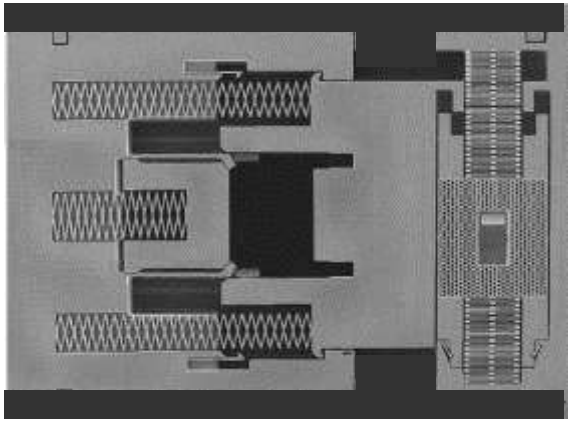
MEMS in safe position



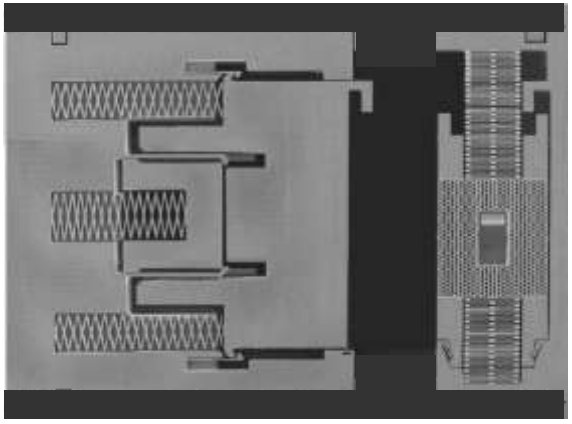
Axial satety unlocked



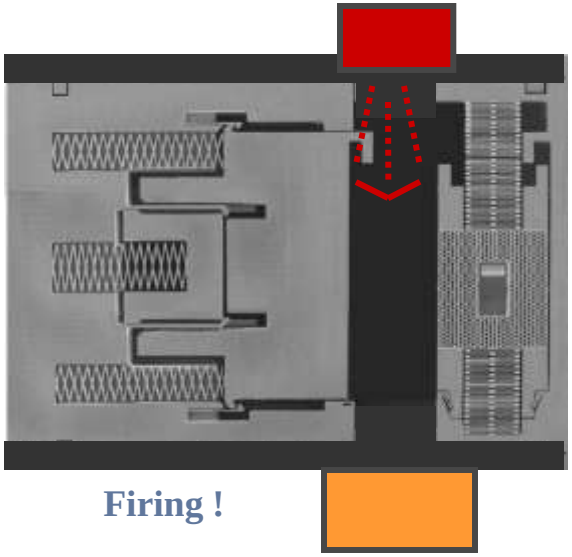
Progressive motion of the centrifugal safety



Unlocking of the shutter



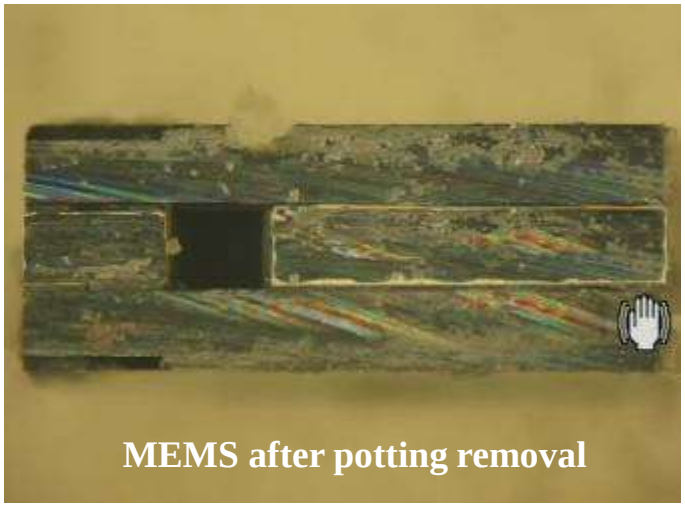
MEMS in in-line position



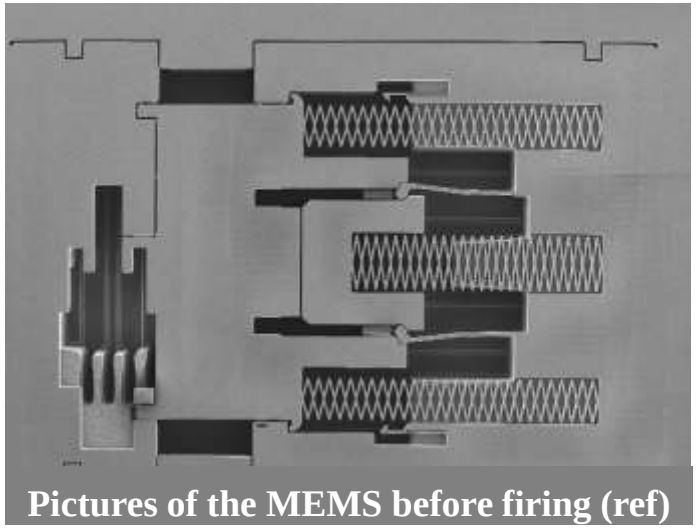
Firing !

High-G levels assessment

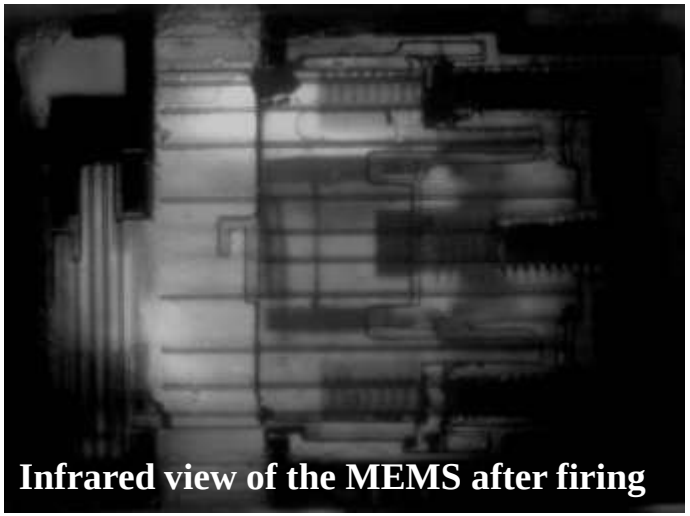
Carrier shell after firing



MEMS after potting removal



Pictures of the MEMS before firing (ref)



Infrared view of the MEMS after firing

PyroMEMS® advantages for MK II

- Replacement of obsolete mechanical timer
- Innovation able to reduce the product price
- New step in the SAU miniaturization
- Better ammunition performances: 2nd safety
- Better safety performances
- MEMS technology is now mature and largely diffused (products and processes)
- A lot of application in ammunition domain (medium and large caliber, missiles, adjustable warheads) and in spatial domain (pyromechanisms) based on a generic component.

Thank you for your attention