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MINISTÈRE DE LA DÉFENSE

Intelligent fuzing for penetrating munitions: experiments and analysis of representative configurations

53nd Annual Fuze Conference

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DGA

DÉLÉGATION GÉNÉRALE POUR L'ARMEMENT

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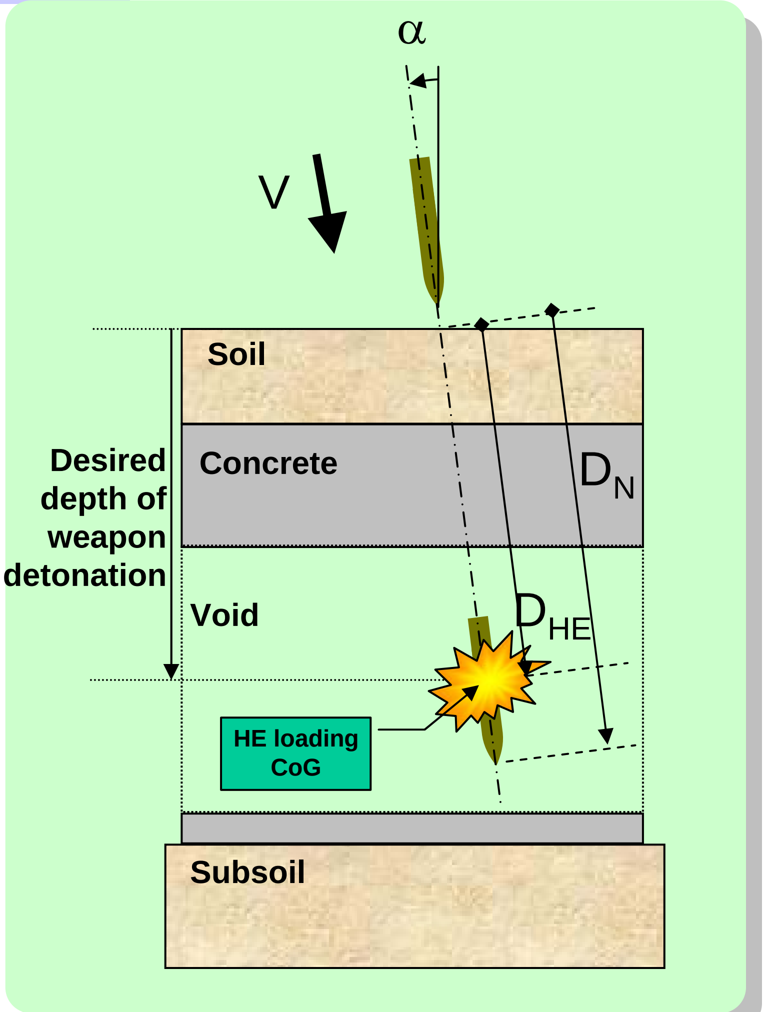
Area of activity

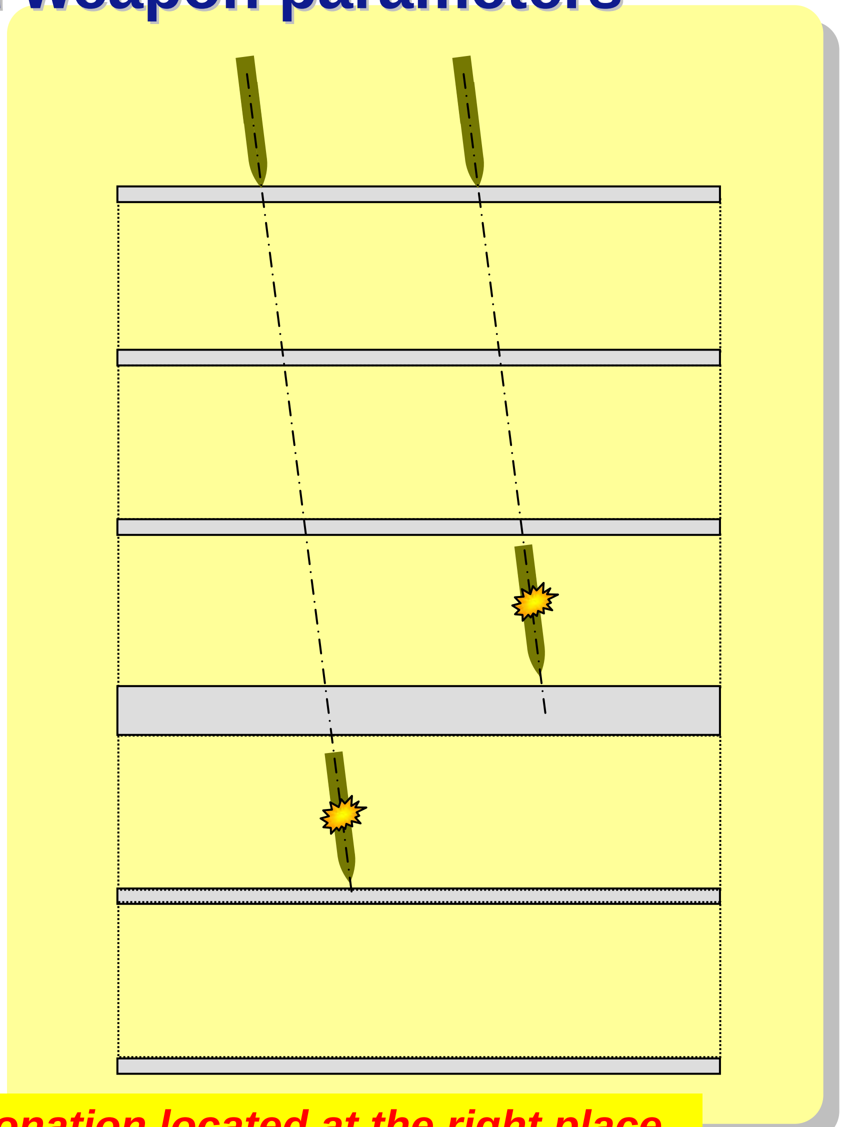
- CEG is Technical Center of the French MoD procurement Agency (DGA)
- Expert center for **Terminal effectiveness** of Conventional Air-to-Ground weapons and missiles
- Gives support to program managers for weapons or components development (SCALP/EG missile, AASM PGM, MdCN Navy cruise missile, FBM 21 fuze for air delivered munitions)
- Provide *Armée de l'air* and *Aéronavale* (French Air Force and Navy Air Force) with means for determining effectiveness of strikes and perform mission planning
- Anticipate on threat evolution

Next generation fuzing will make use of embedded intelligence

- Hardened targets (Hard target defeat) and soft targets
- Objective: Improve warhead lethality while minimizing collateral damage
- Capability to control weapon’s depth of burst and eventually full trajectory

Hard and soft targets defeat: optimal fuze delay depends on target and weapon parameters

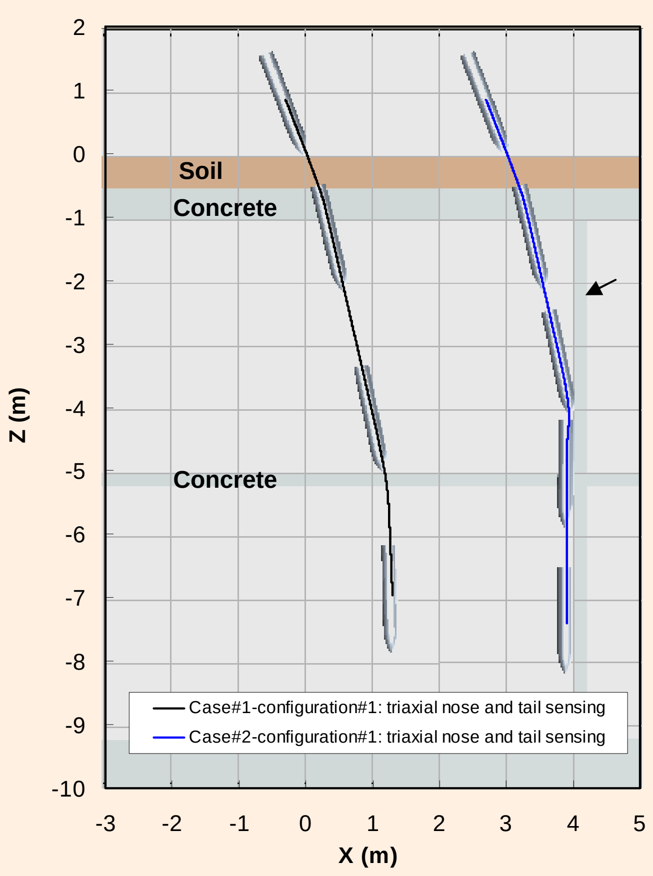




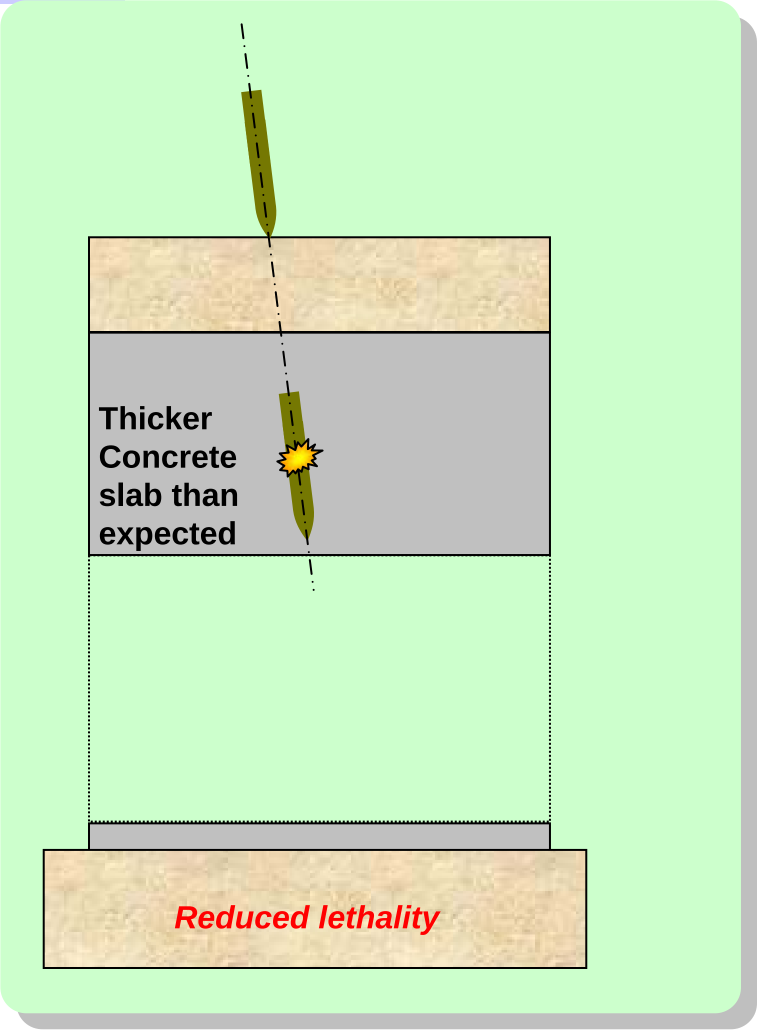
maximum lethality if point of detonation located at the right place

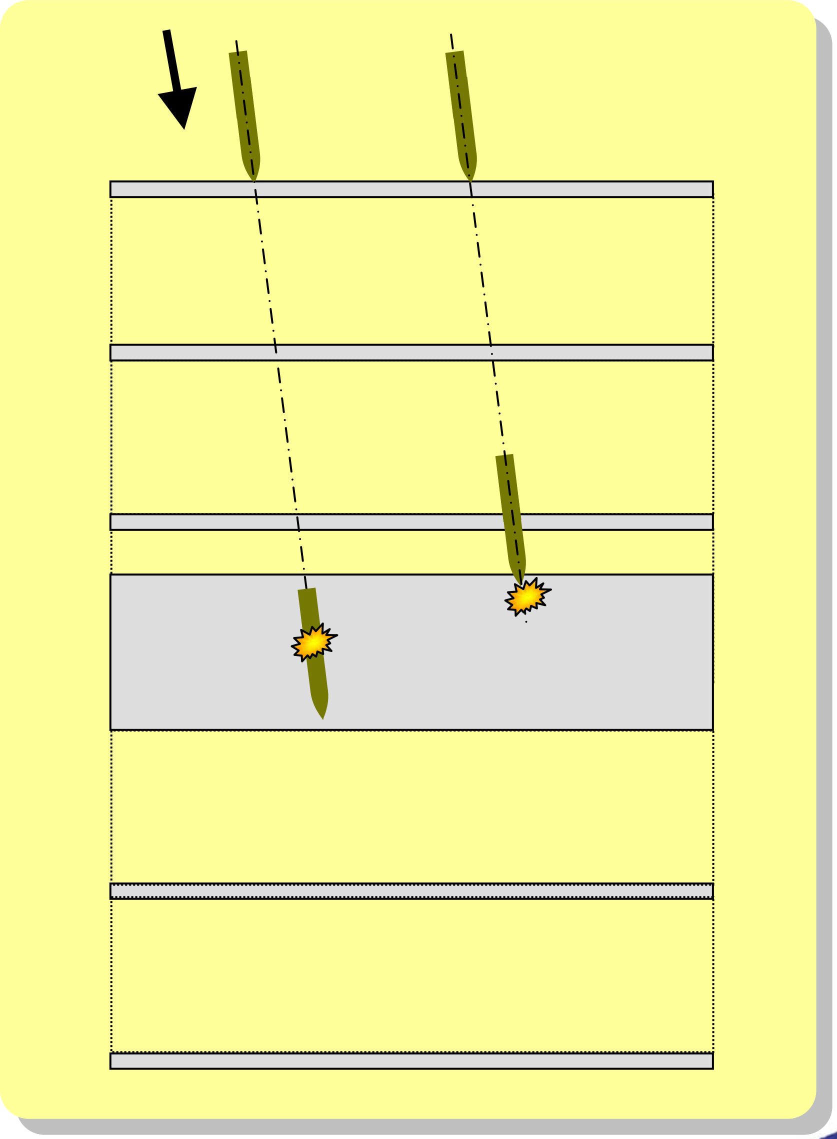
Validated analytical and computational tools exist to help predict the fuze delay for a given mission

- CEG and the French targetting Center operate the CalPen3D analytical program that computes the curvilinear trajectory of the weapon within the target
- The fuze delay is therefore accessible to the mission planner



Hard target defeat: unexpected situations using a constant fuze delay



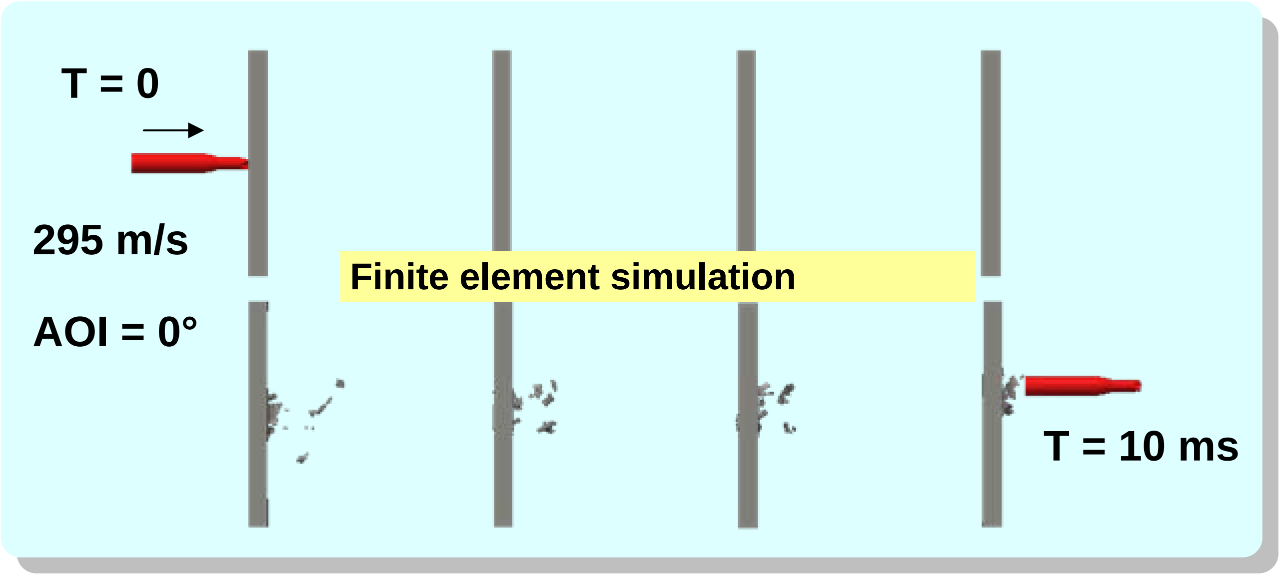


Smart fuzing

- The munition analyses its environnement and triggers the HE charge when conditions are met
  - Void sensing
  - Layer counting
  - Trajectory calculation
- In this latter option, the warfighter specifies the point of detonation instead of a fuze delay

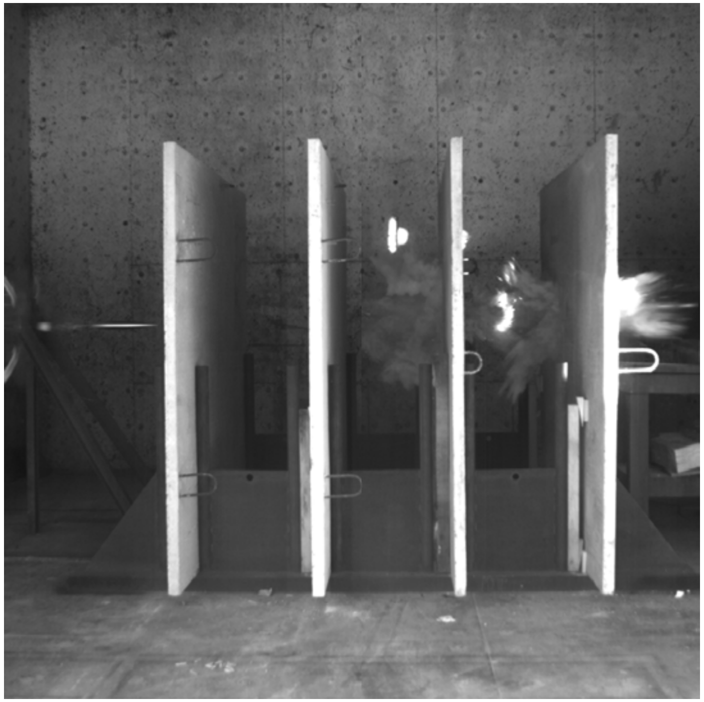
⇨ High-G sensors, rugged electronics and complex algorithms must be developped and integrated

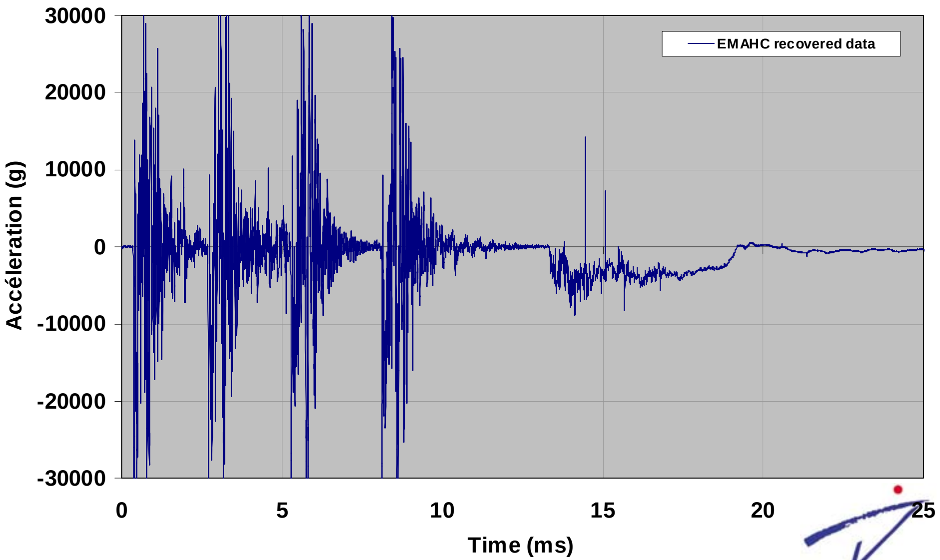
An illustration of the possibilities and challenges: perforating of spaced concrete plates with a model scale projectile



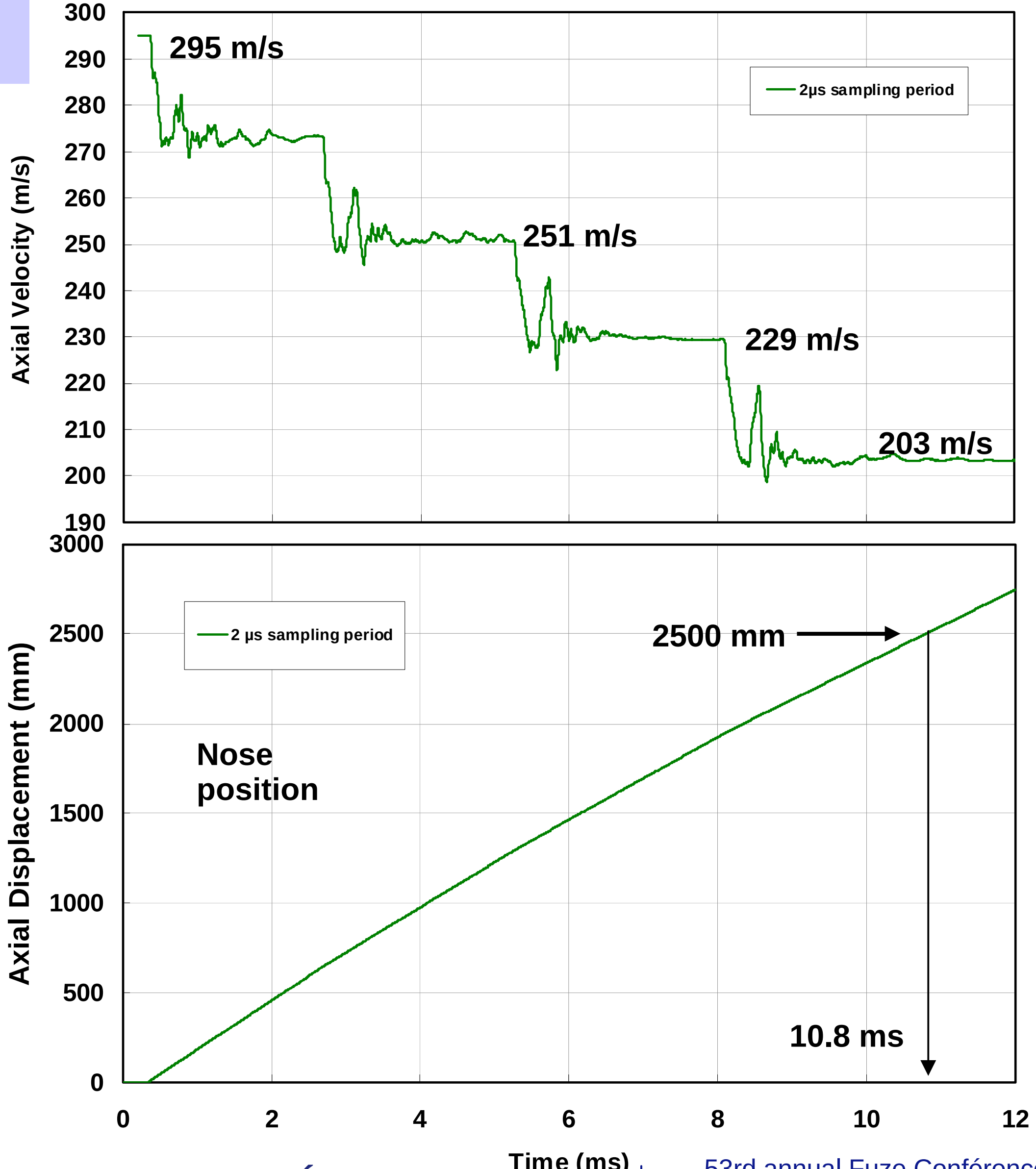
Presentation of the EMHAC High-G recorder and Experimental result

- Triaxial T2M-Junghans Shock datta recorder
- Range of data acquisition ± 20 kGs (Channel X1) ; ± 60 kGs (channels X2, Y, Z)
- Storage duration : unlimited (FLASH memory)
- Sensors : Endevco Accelerometers
- Sampling rate : up to 500kHz (4-channel) or 1MHz (2-channels)
- Memory size : 256 M samples
- Reusable





Double integration of signal



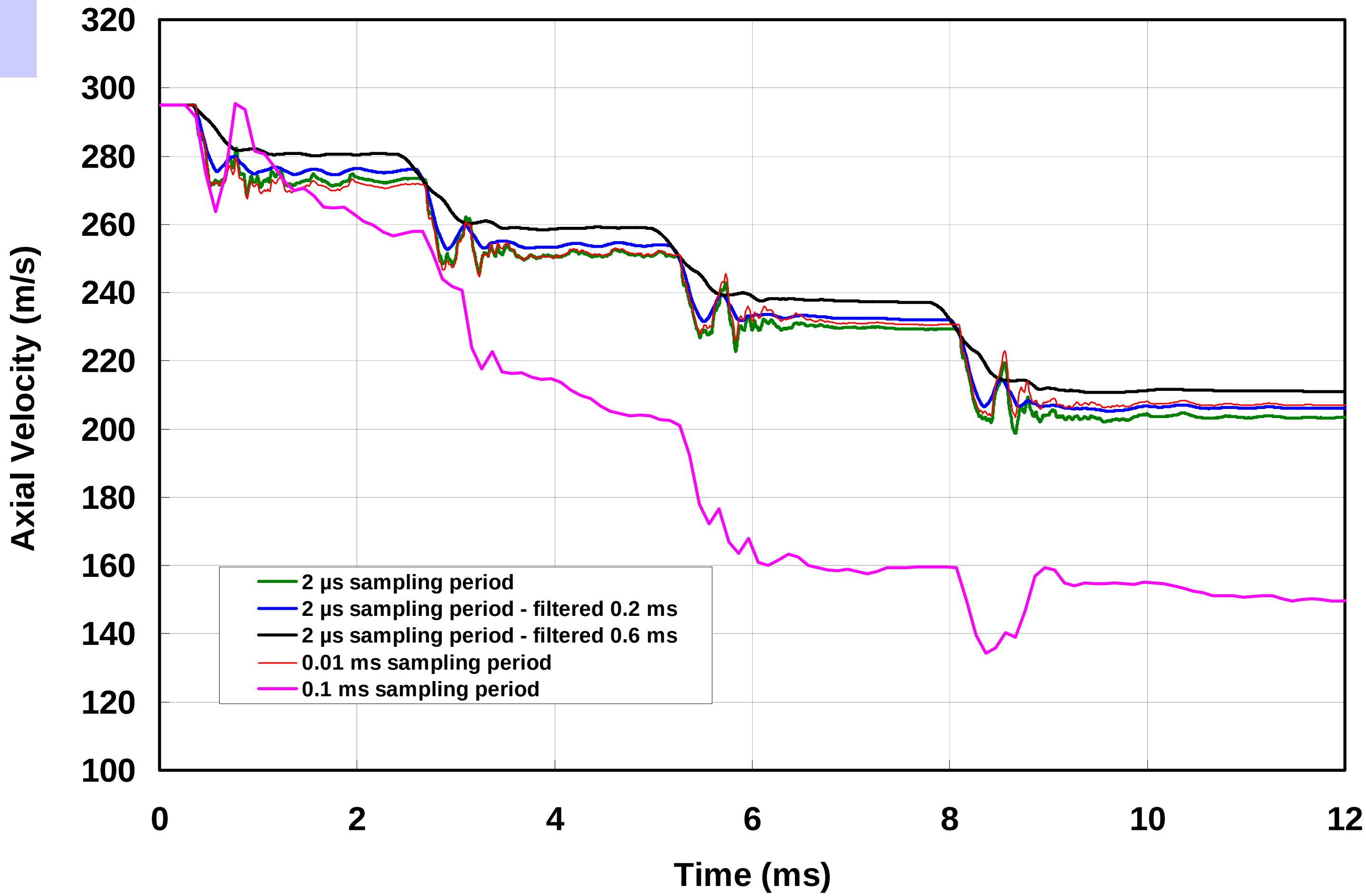
... provides continuous velocity and displacement time histories

prior knowledge of initial conditions (velocity) is required

⇨Smart fuze development would require knowledge of initial conditions (velocity)

⇨Must be transferred from weapon guidance system

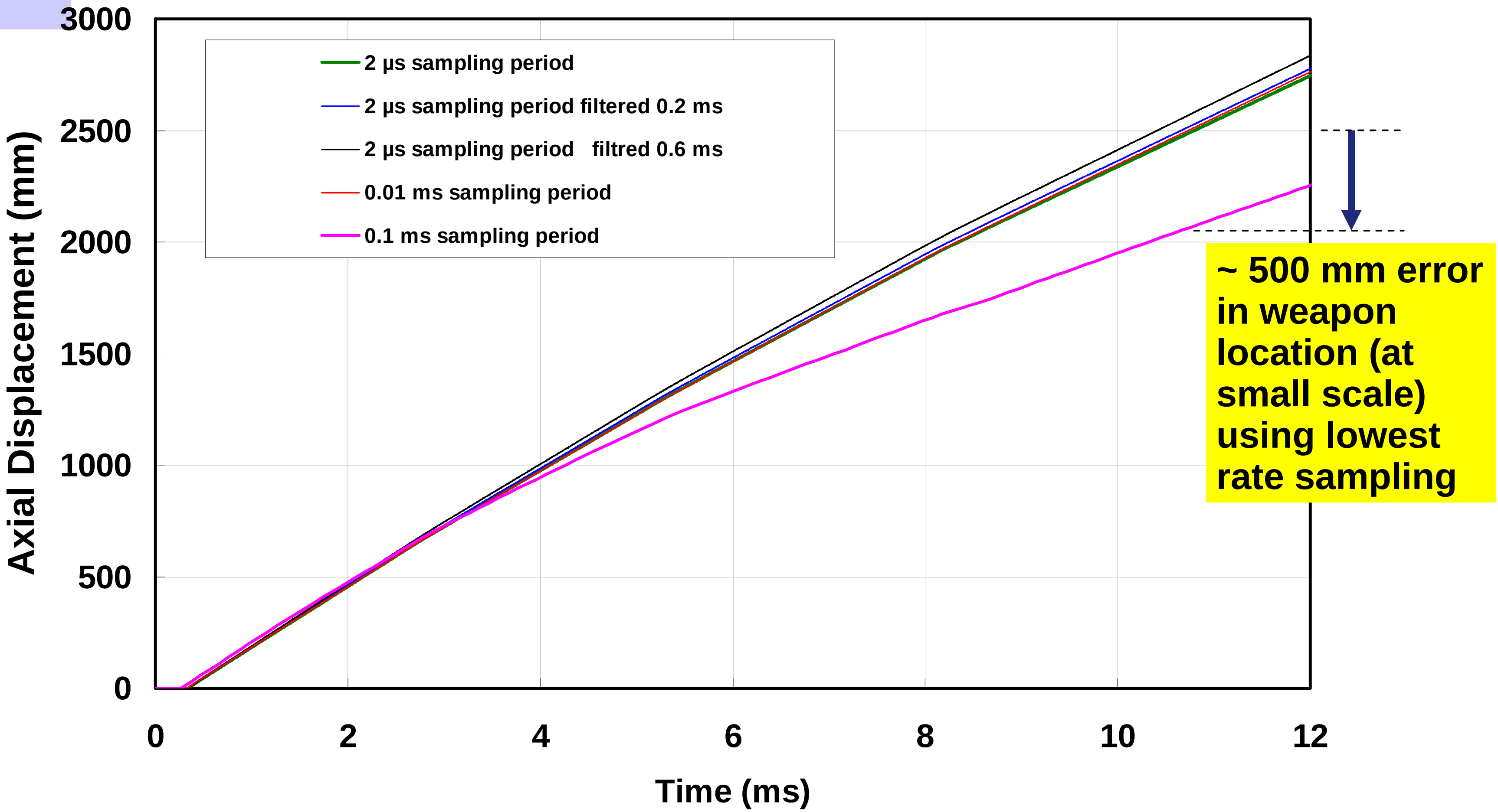
Influence of sampling rate and filtering on velocity



⇨**Consistent velocity prediction requires minimum sampling rate (at least 100 kHz or one sample every 0.01 ms)**

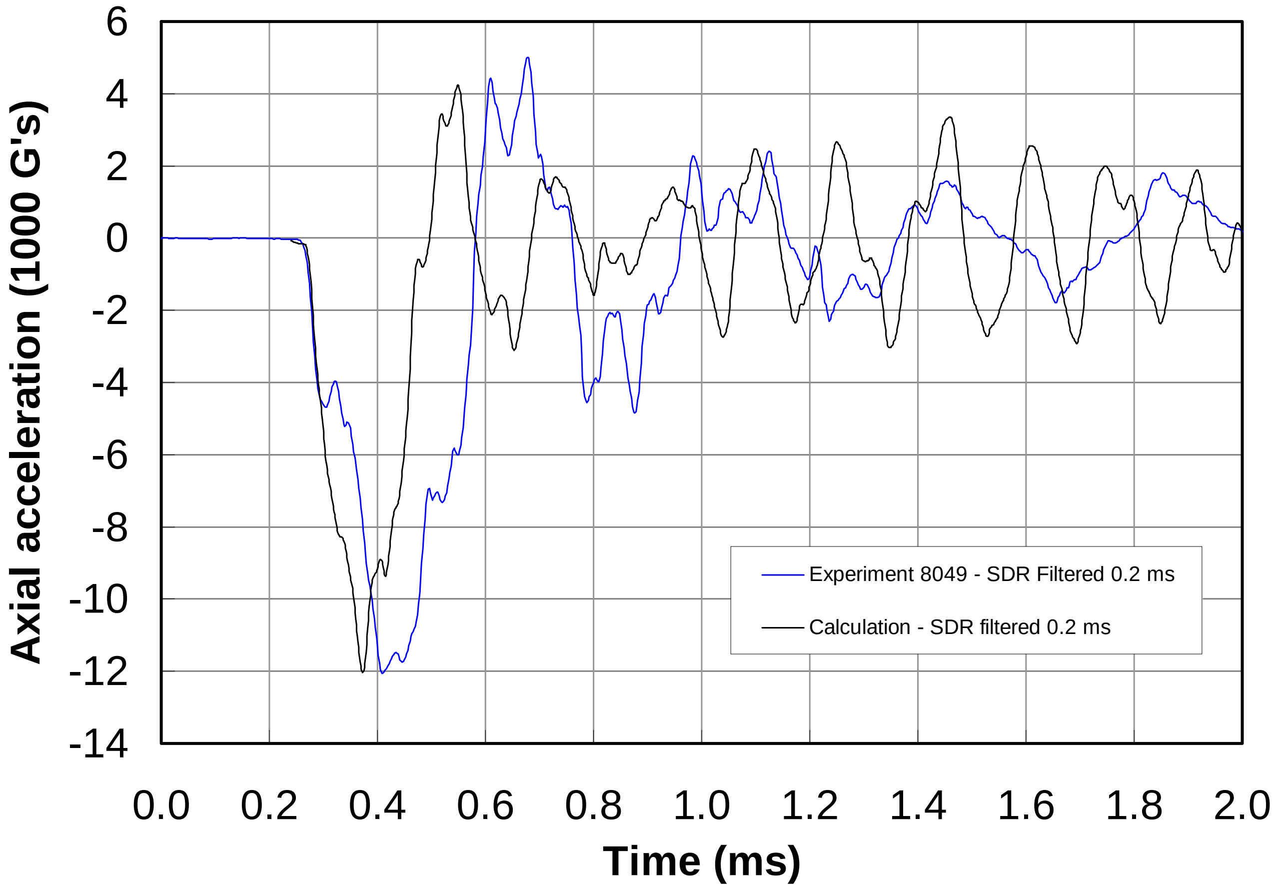
⇨**Filtering of acceleration signal has marginal effect on velocity determination**

Influence of sampling rate and filtering on location



⇨ **Prediction of displacement highly affected by sampling rate**

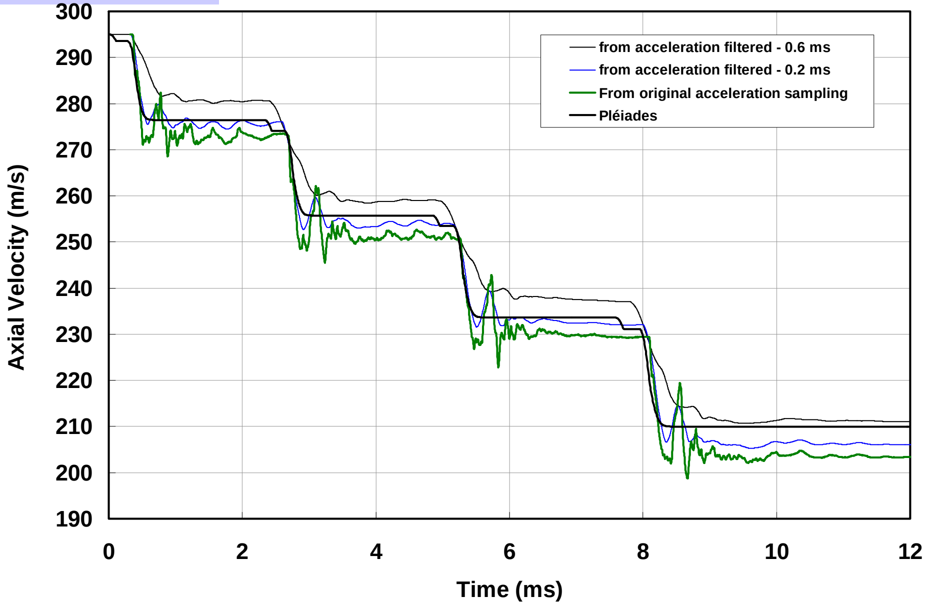
Numerical simulation capabilities in order to better understand process

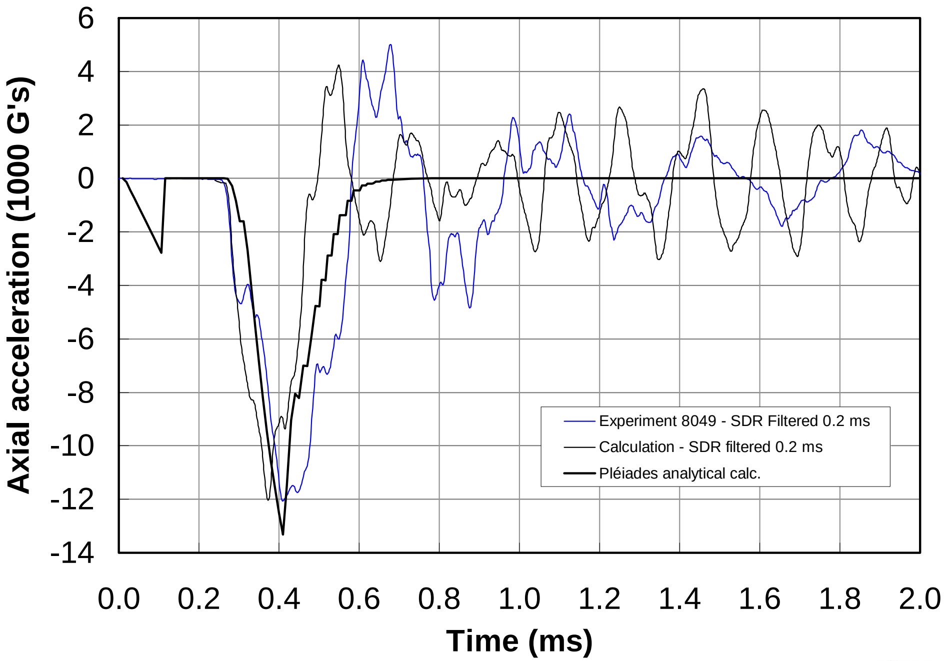


⇨ FE calculation result match reasonnably well data (both filtered similarly)

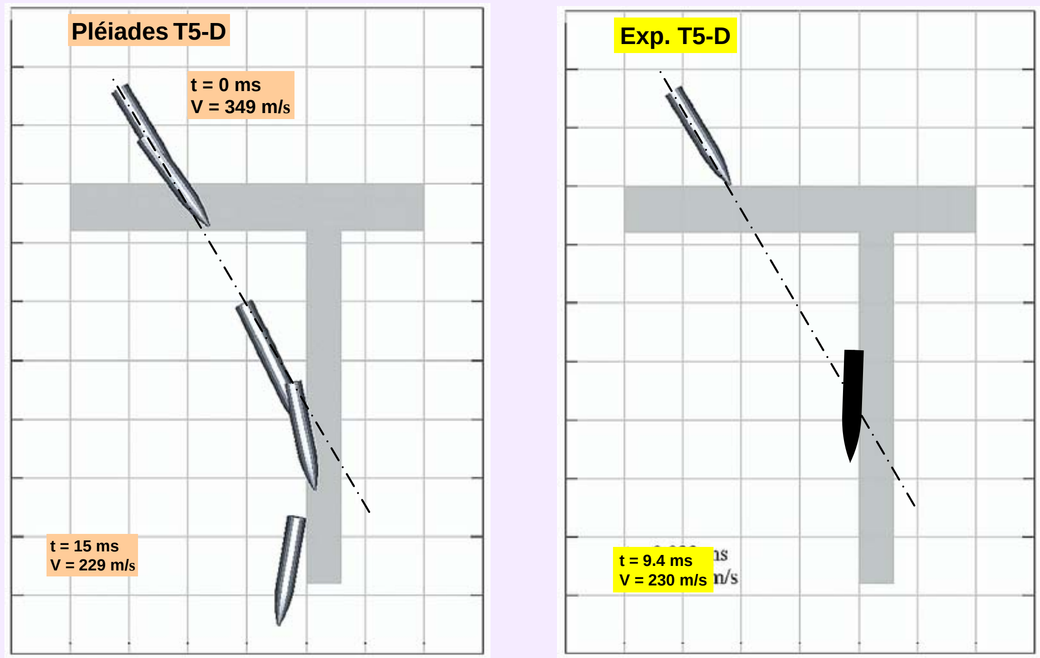
FE prediction need to be improved in order to reduce frequency mismatch (eigen modes of model must be monitored)

Analytical modeling (CalPen curvilinear calculation of projectile trajectory within the target)



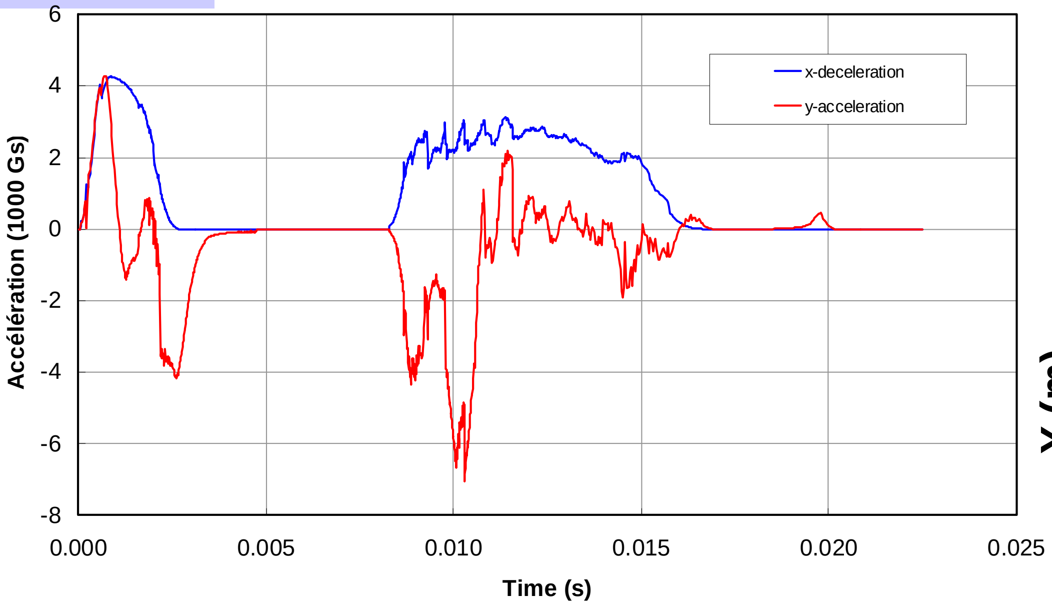


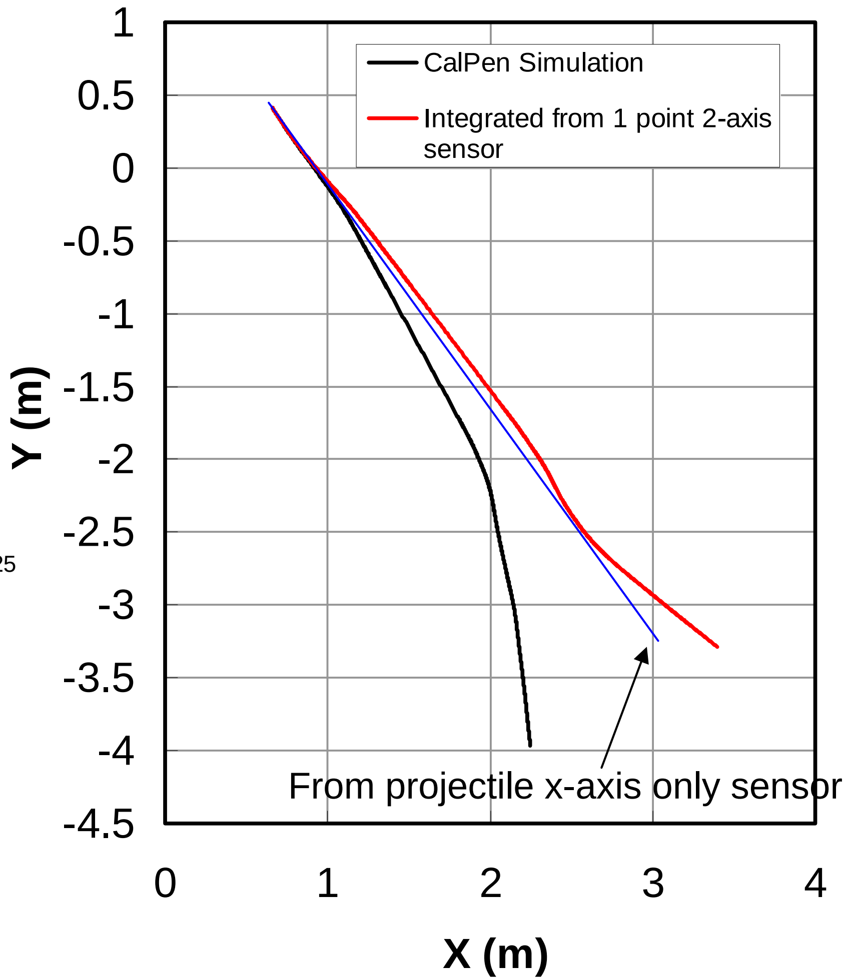
Next step : analysis of a plane trajectory using experiments at scale 2/3 (see Fuze 52 paper)



- Assumption : plane trajectory
  - 1 sensor – 1 axis
  - 1 sensor 2 axis (longitudinal (x) and transverse (y) of projectile)
  - 2 sensors 2-axis per sensor

T5-D configuration - 2 sensors –2-axis

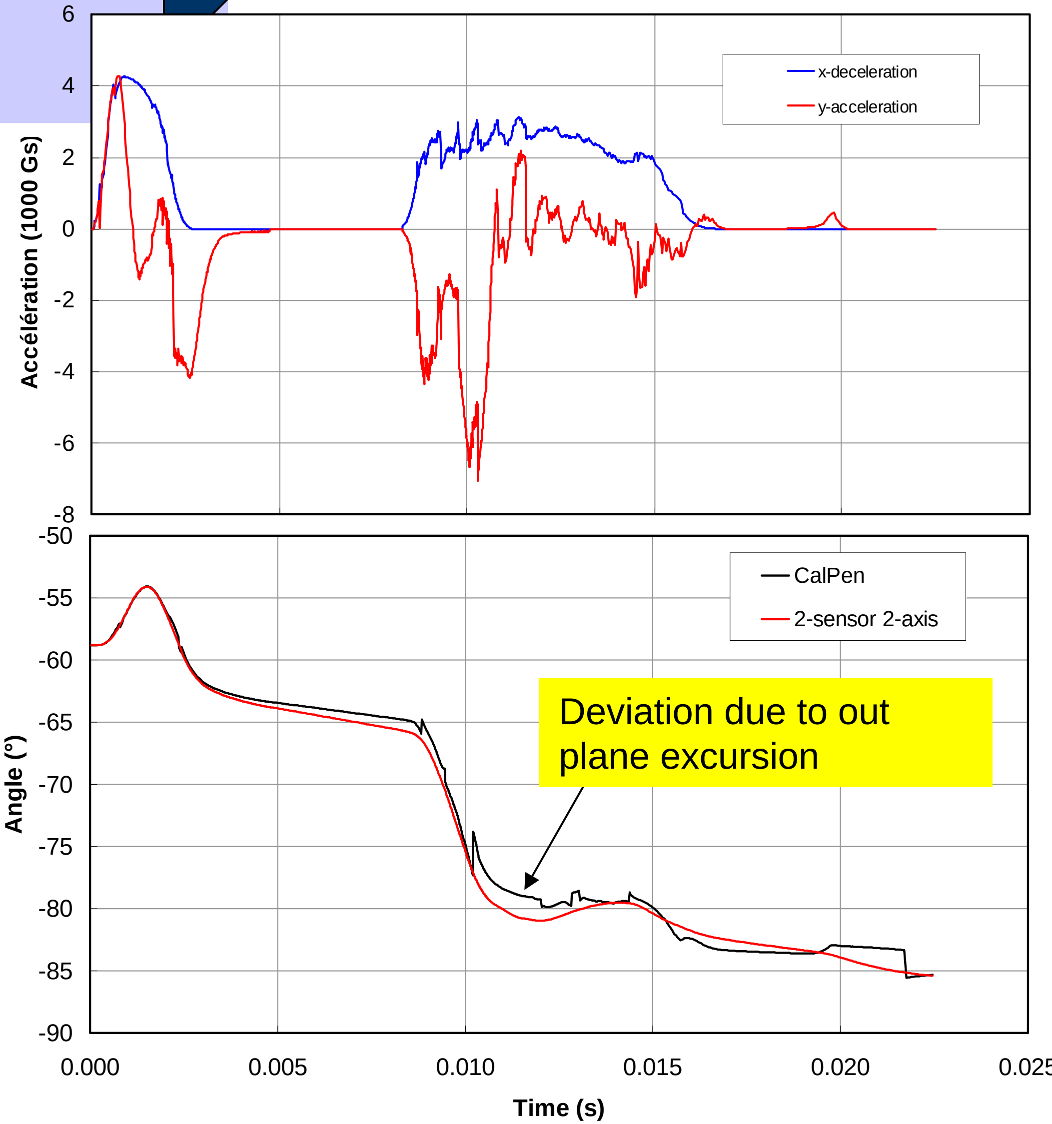


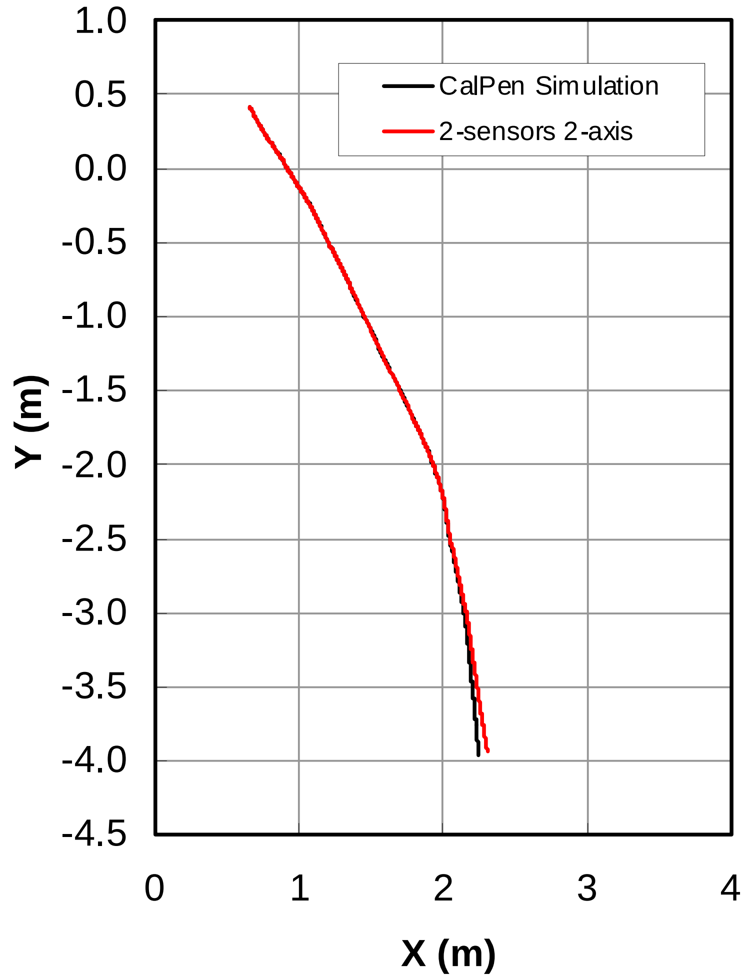


Single axis sensing performs well provided that initial direction of munition is given

If this data is not available integration of x and y strapdown signals provide the expected trajectory and depth. Error appears important because of ricochet of munition on vertical wall cannot be interpreted by a single point sensor

T5-D configuration - 1 sensor – 1 and 2-axis





Angle between projectile and inertial coordinate axis can be calculated and therefore inertial accelerations from which velocity and position are derived

Accurate if trajectory is plane

General case : curvilinear trajectory

- To be developed and hopefuly presented at the 54th annual Fuze Conference

Conclusion

- Shock data recorder provides invaluable information for penetrator trajectory analysis and identification of challenges posed by smart fuzing for Hard target Penetration applications

- Three channel Shock data recorder currently investigated

- Use of multiple miniature G-hardened sensors may allow inertial measurement to be done and therefore a precise determination of the detonation point in the target core