

Munitions effects: a schematic overview of munitions and warheads, trends for the future

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TNO | Knowledge for business



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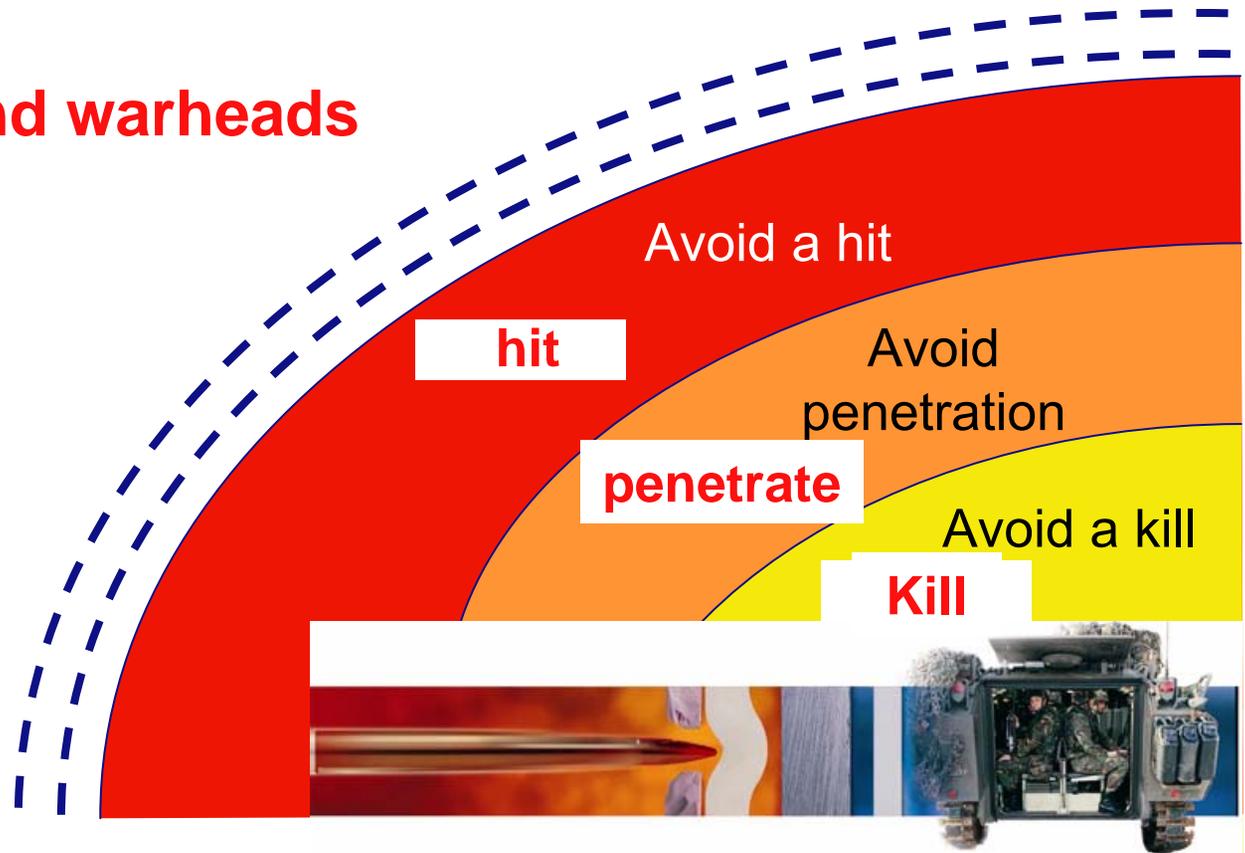
Outline

- Types of energy transfer media
atoms, electrons and photons
- Classification scheme of munitions and weapons effects
examples for kinetic energy, blast and heat, electric current
and electromagnetic radiation
- Trends
 - adaptive effects and enhanced lethality

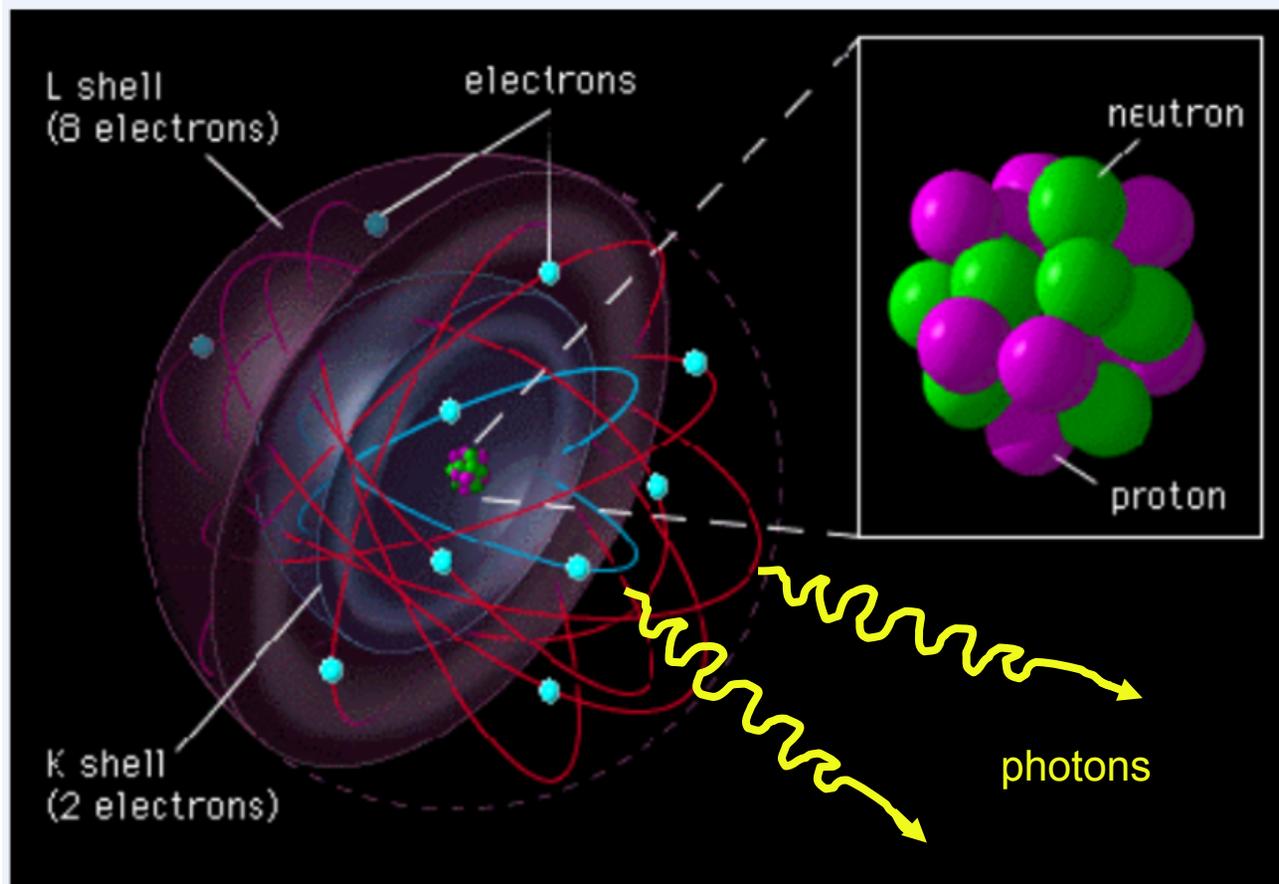
Layers of { protection **attack**

Passive, reactive and hard-kill active armour

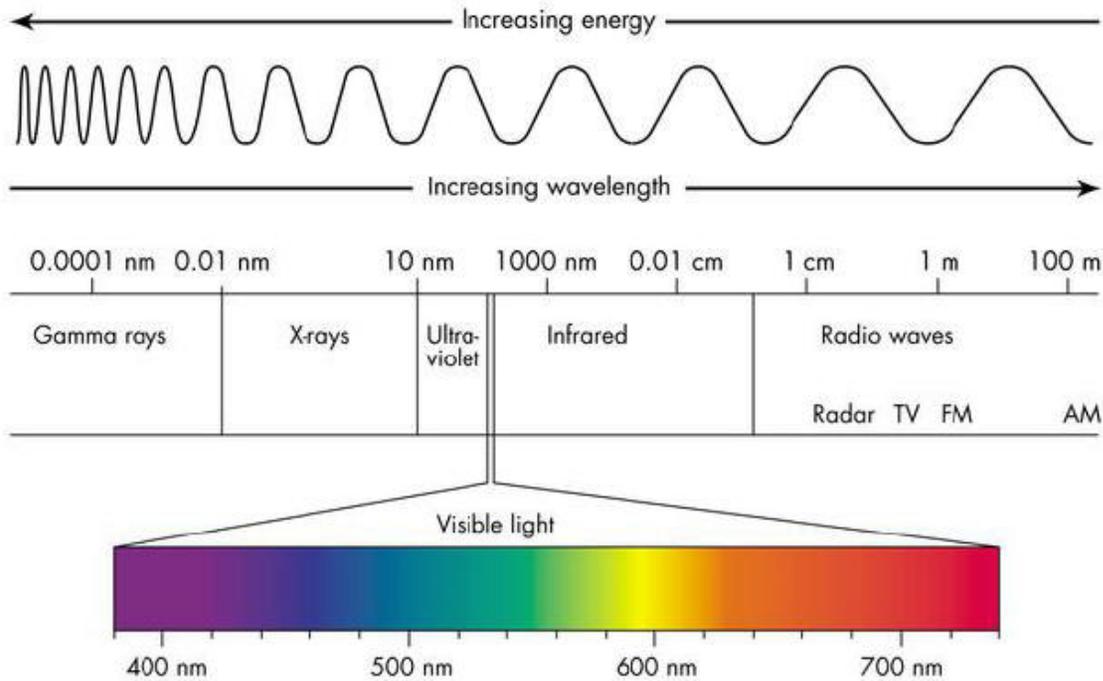
Projectiles and warheads



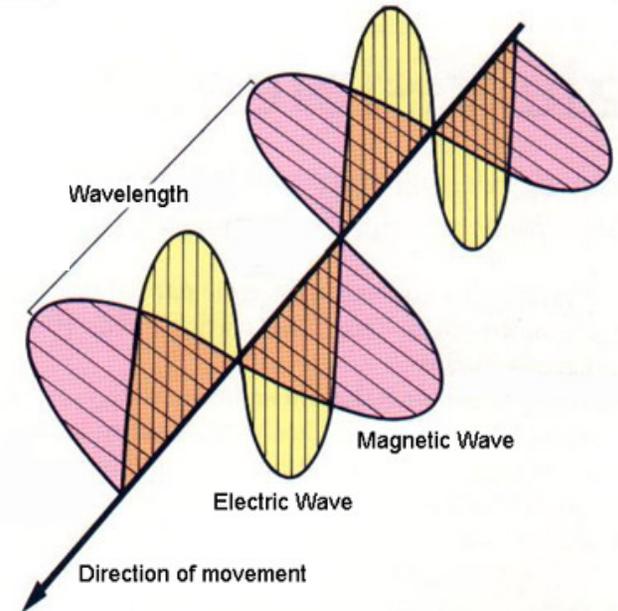
Munitions effects: atoms, electrons and photons as energy transfer medium



Photons as energy transfer medium: wave behaviour

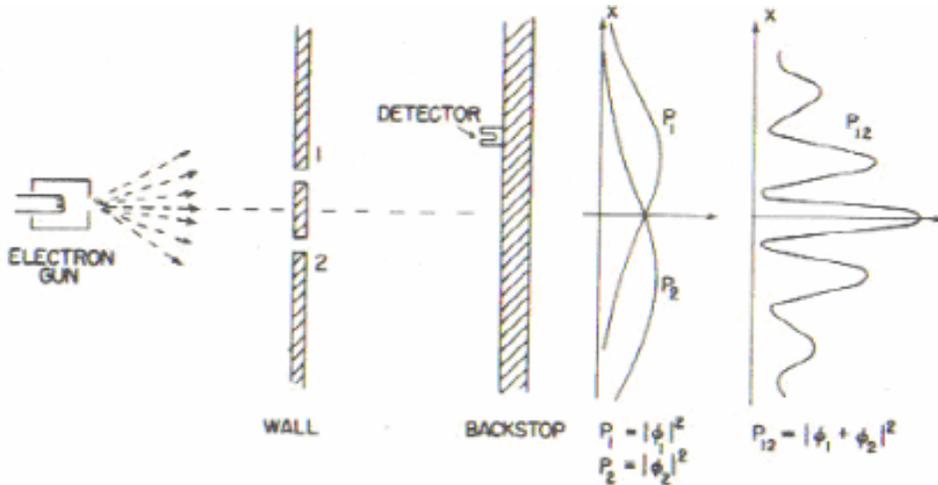


oscillating
electromagnetic
field



energy per photon:
Planck constant x frequency

Wave aspects:
besides photons, also electrons and atoms exhibit
diffraction and interference



particles of matter: pressure waves and
shock waves could be interpreted as
“waves of excess density”

Atoms, electrons and photons: strength in numbers

Example: energy transfer of 100 KJ

- Burning a hole in a metal target:
 10^{24} photons (at typical wavelength)
- Shortcutting a shaped charge jet (electric armour):
 10^{19} electrons (at typical high voltage)
- 200 g steel penetrator at 1000 m/s:
 10^{24} atoms

Classification scheme of munitions and weapons effects

damage maximalisation

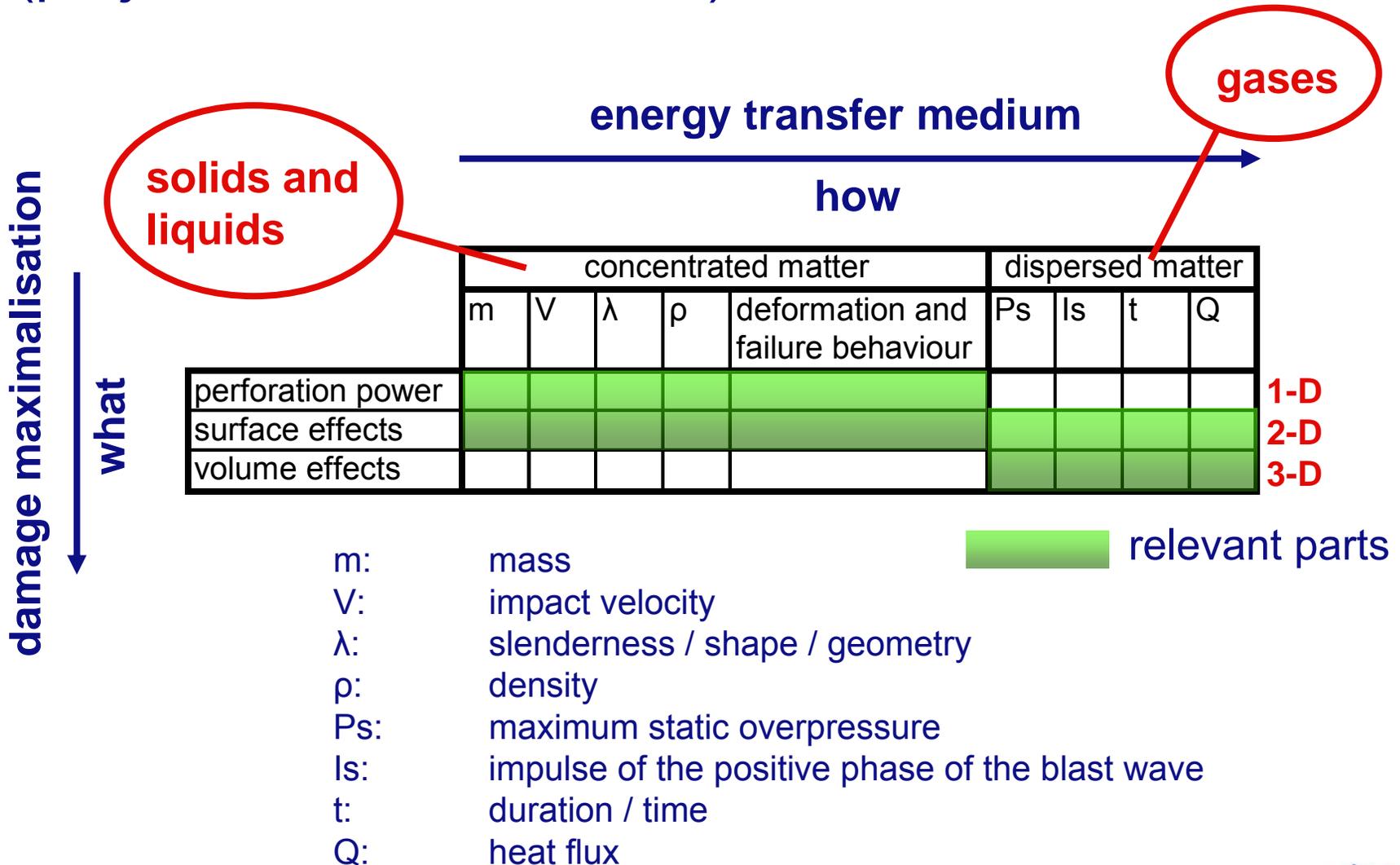
energy transfer medium

	matter									electrons				photons			
	solid/liquid-like					gaseous											
	m	V	λ	ρ	deformation and failure behaviour	Ps	Is	t	Q	I	V	t	spotsize	n	h.v	t	spotsize
perforation power																	
lateral effects																	
volume effects																	

 relevant parts



Classification scheme: particles of matter (projectiles and warheads)

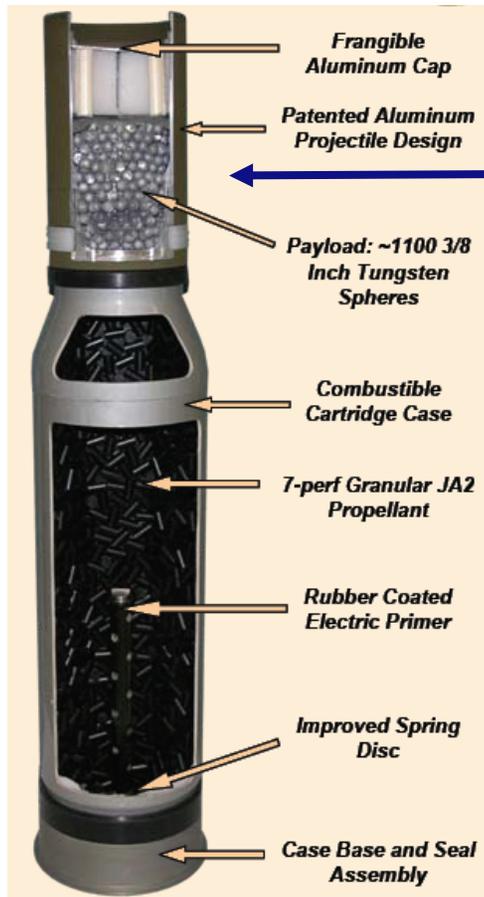


Desired effects determine parameter choices

Example:
highly lethal versus non-lethal

	concentrated matter				dispersed matter				
	m	V	λ	ρ	deformation and failure behaviour	Ps	Is	t	Q
perforation power									
surface effects									
volume effects									

M1028



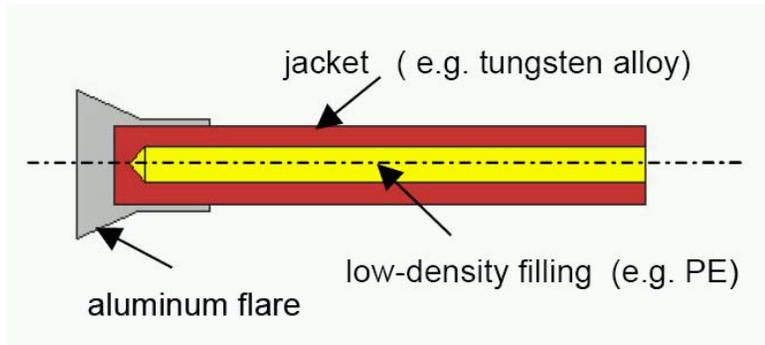
tungsten spheres

rubber projectiles



Example: penetrators with enhanced / advanced lateral efficiency (PELE[®], ALP[®])

longitudinal section of a typical PELE projectile:



	concentrated matter				dispersed matter				
	m	V	λ	ρ	deformation and failure behaviour	Ps	Is	t	Q
perforation power									
surface effects									
volume effects									

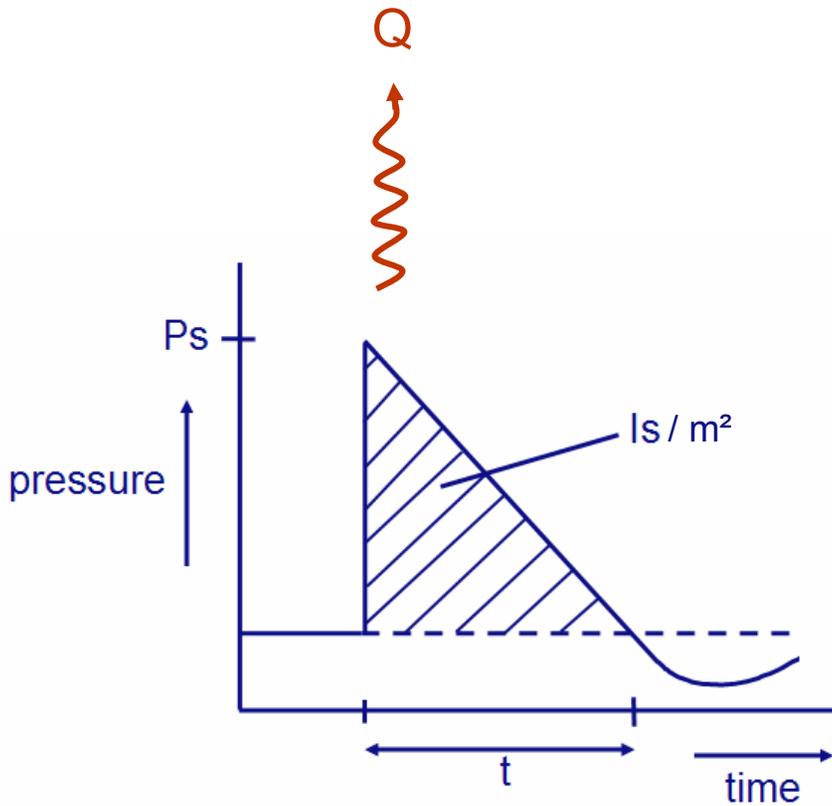
wall breach after 3 hits of large calibre PELE



(source: ISL/ Diehl/ Rheinmetall)

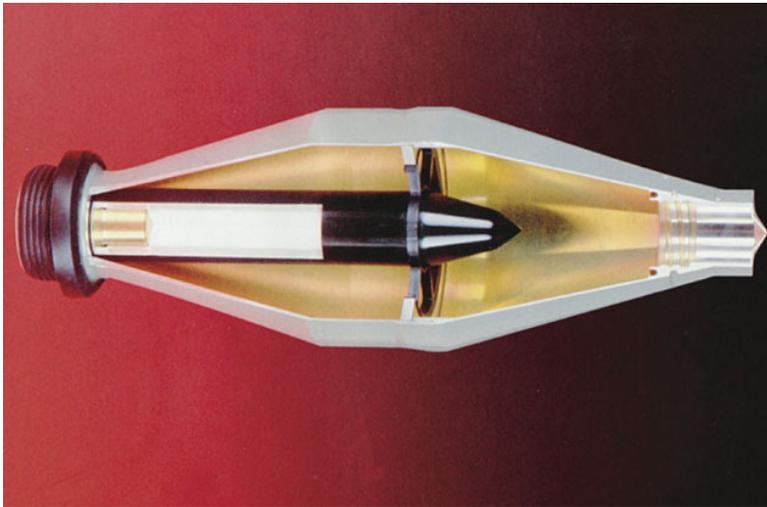
Blast (and heat)

	concentrated matter				dispersed matter				
	m	V	λ	ρ	deformation and failure behaviour	Ps	Is	t	Q
perforation power									
surface effects									
volume effects									



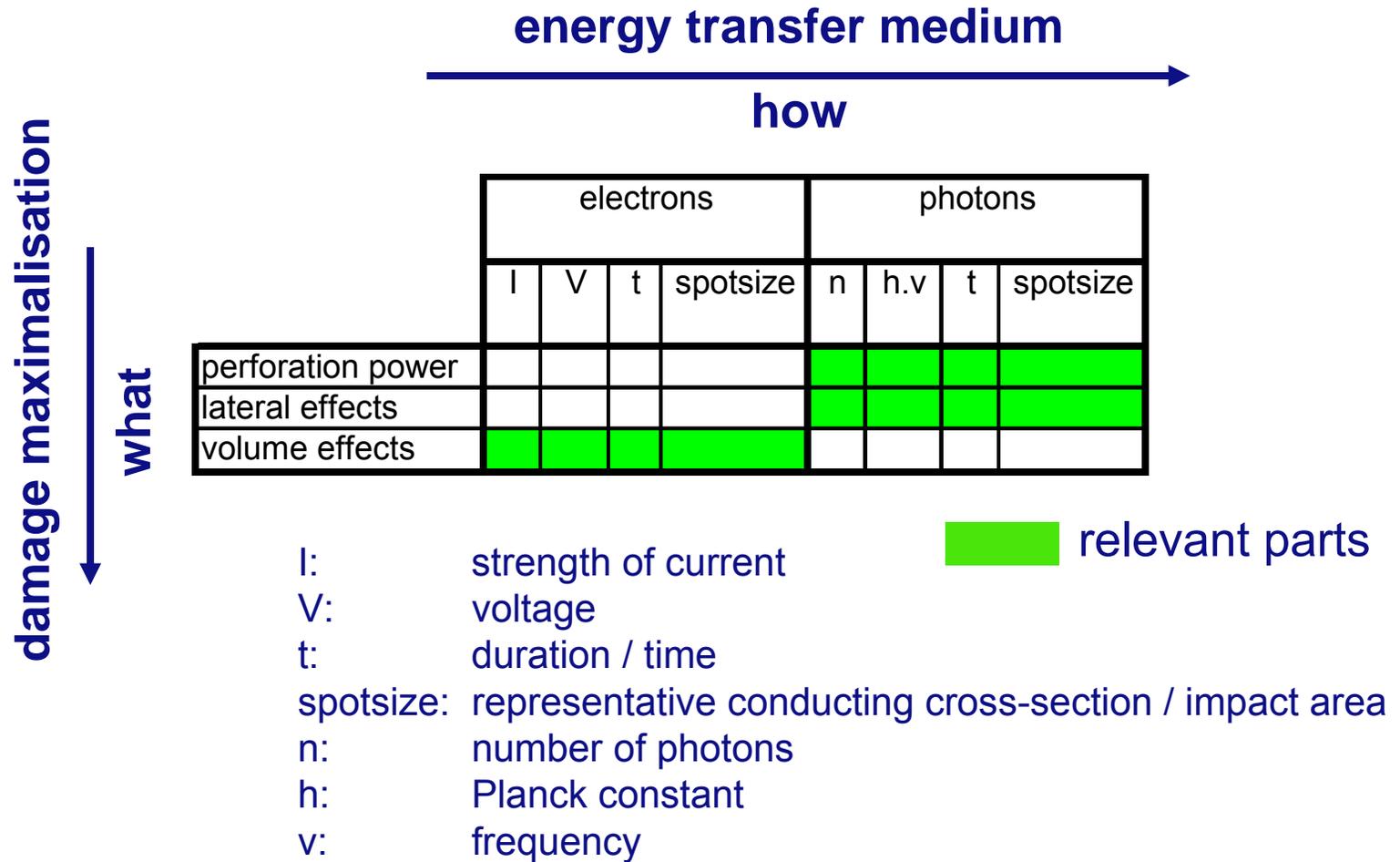
Combination of penetration/ perforation and blast

Example: Modular Explosive Penetrator (RUAG)



	concentrated matter				dispersed matter				
	m	V	λ	ρ	deformation and failure behaviour	Ps	Is	t	Q
perforation power									
surface effects									
volume effects									

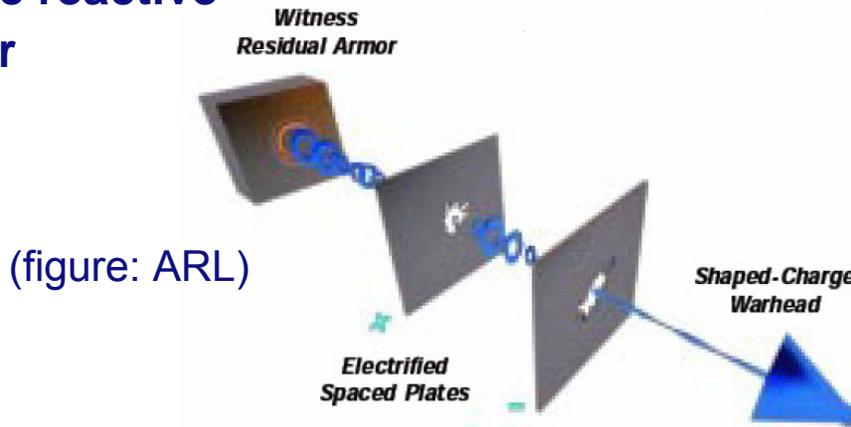
Classification scheme: electrons and photons



Electrons as transfer medium

	electrons				photons			
	l	V	t	spotsizes	n	h.v	t	spotsizes
perforation power								
lateral effects								
volume effects								

- **Electric reactive armour**



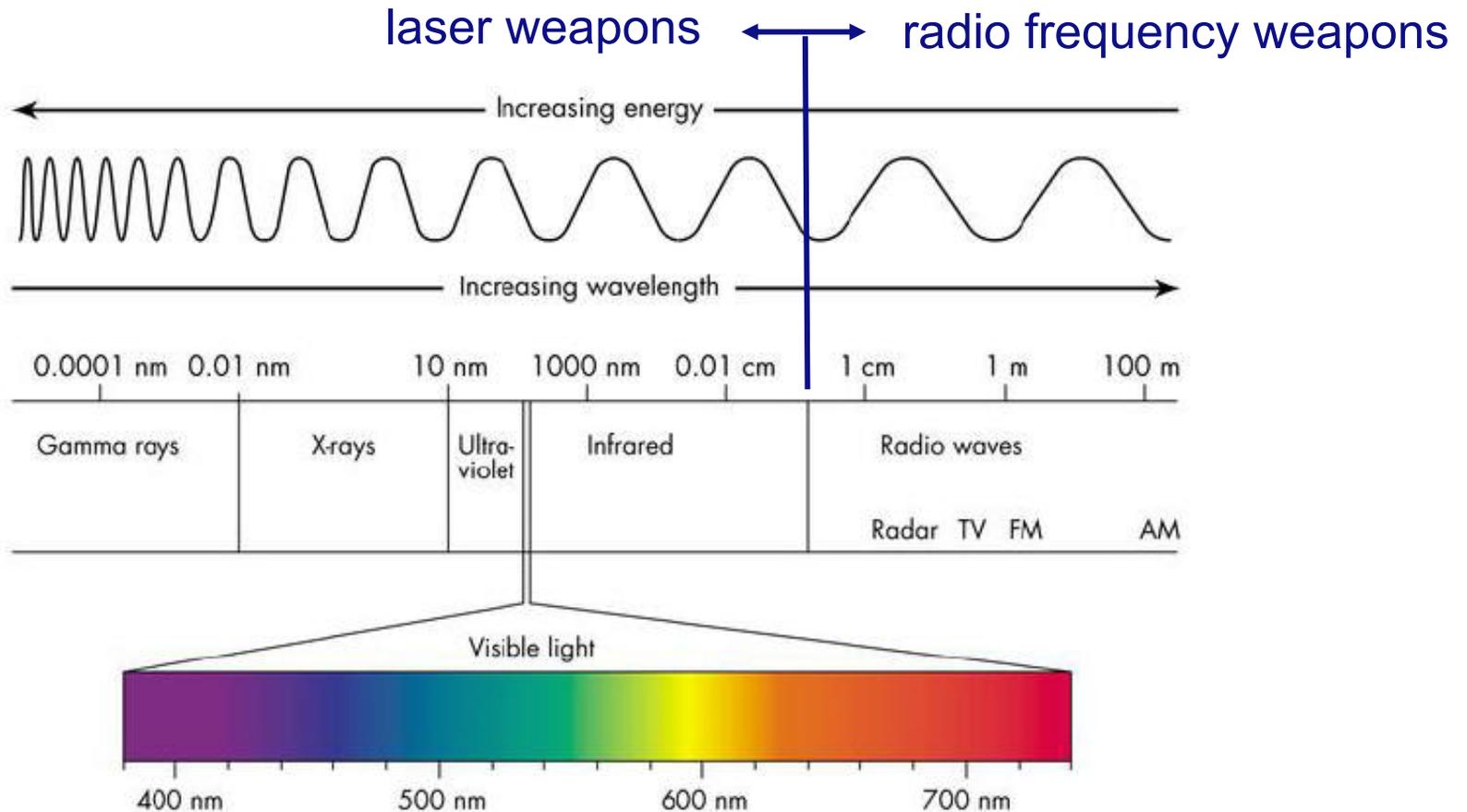
disturbance of the shaped charge jet due to magnetohydrodynamic instabilities

- **Taser**



less lethal:
incapacitation by electric current through body

Photons as energy transfer medium: EM spectrum



Photons as transfer medium

	electrons				photons			
	l	V	t	spotsizes	n	h.v	t	spotsizes
perforation power								
lateral effects								
volume effects								

- Radio frequency weapons



95 GHz

Effective beam volume:
1m x 1m x 250m

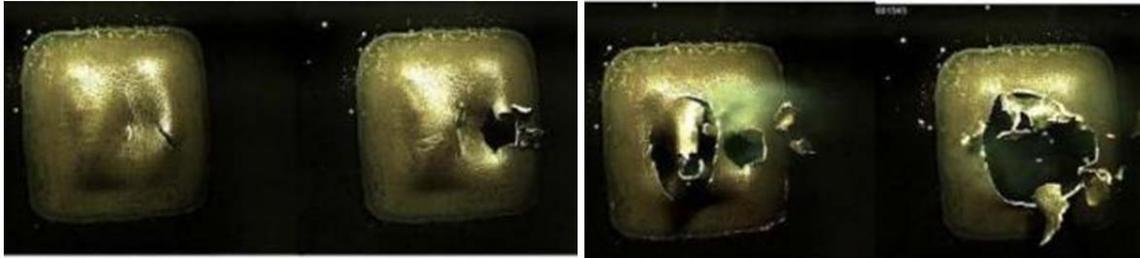
Silent Guardian (30 KW, left),
formerly known as Area Denial System (100 KW, right)

(source: Raytheon)

Photons as transfer medium

	electrons				photons			
	I	V	t	spotsizes	n	h.v	t	spotsizes
perforation power								
lateral effects								
volume effects								

- Laser weapons**



(photo: Lawrence Livermore National Laboratory)



melting, ‘erosive’ heating or ‘explosive’ heating of (armour) material

Laser Area Defence System (50 KW), to be mounted alongside the Phalanx guns (source: Raytheon/ Air Force Research Lab.)



Combining photons and electrons as transfer medium: “directed lightning”

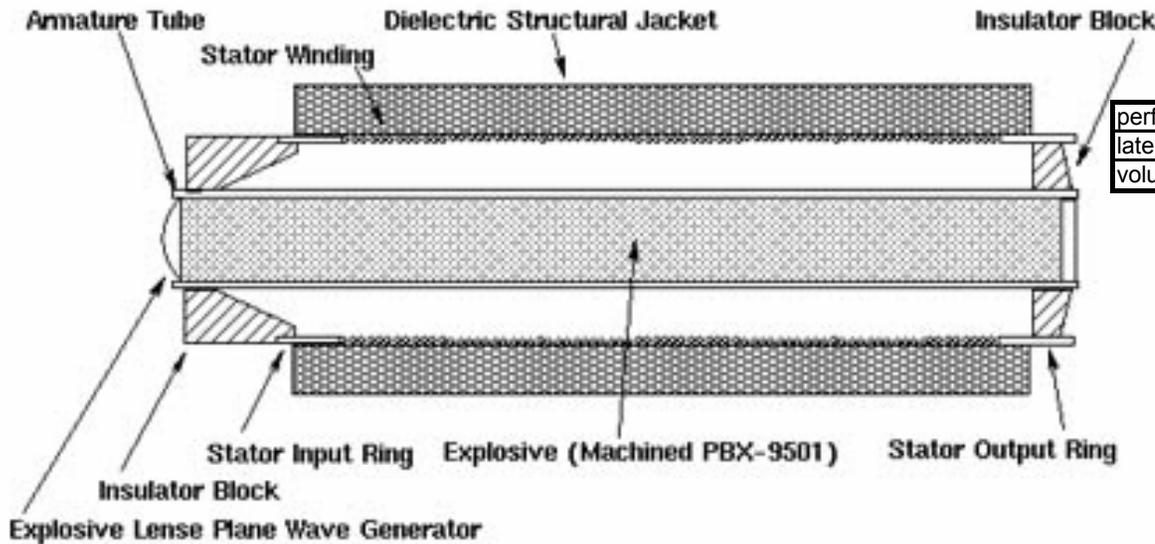


	electrons				photons			
	I	V	t	spotsizes	n	h.v	t	spotsizes
perforation power								
lateral effects								
volume effects								

 facilitating

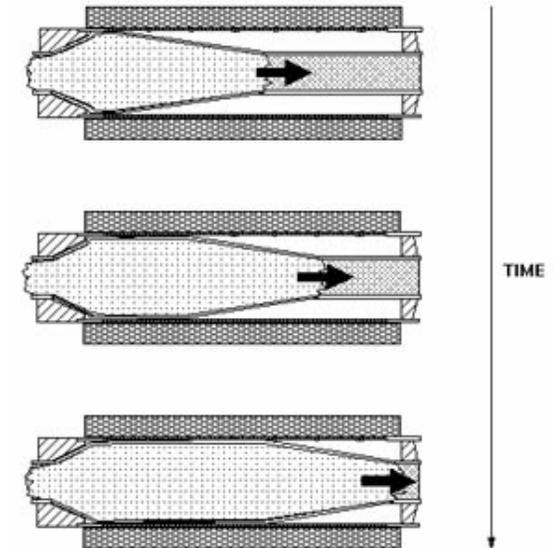
use lasers (or other EM radiation) to ionize the air in the path of the subsequent electric current

Using the high energy density of energetic materials: “E-bomb”, electromagnetic pulse



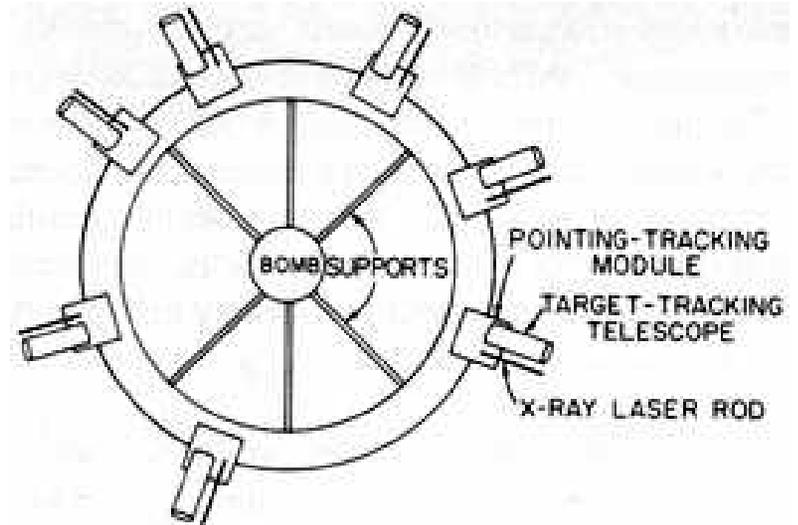
electrons				photons			
I	V	t	spotsizes	n	h.v	t	spotsizes
perforation power							
lateral effects							
volume effects							

future



explosively pumped coaxial flux compression generator

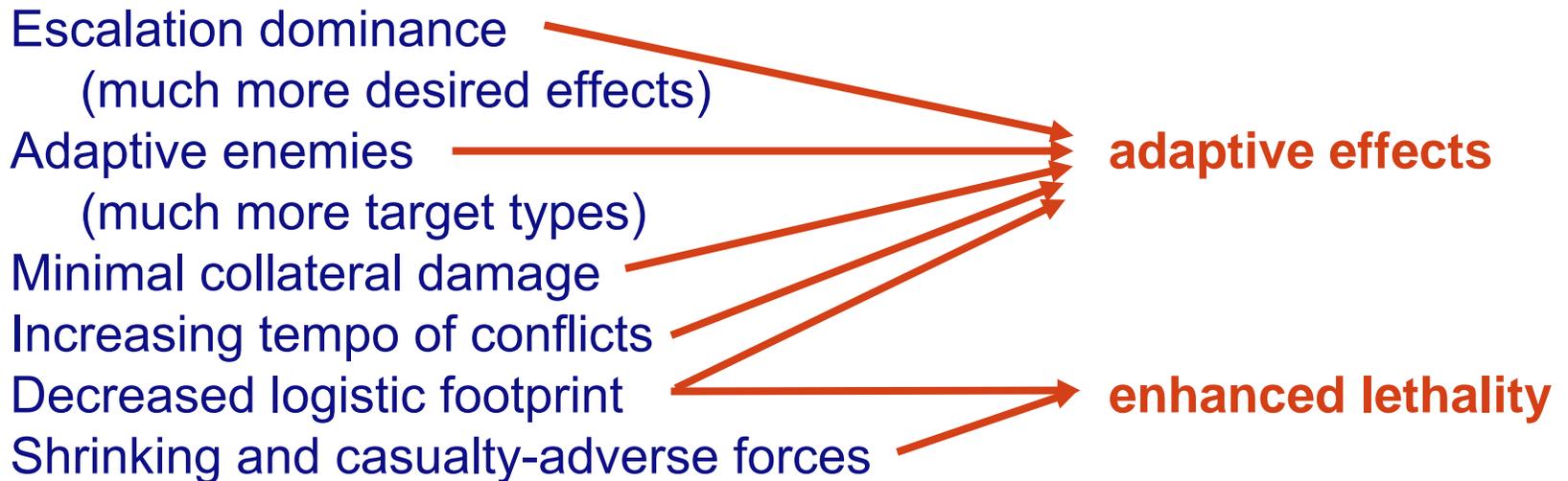
Using the high energy density of energetic materials: detonation-pumped laser?



SDI: nuclear explosion pumped X-ray laser (5MJ per laser)

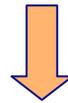
Current and future munitions drivers

Starting conditions: pinpoint accuracy, insensitive energetic materials



Adaptive and enhanced lethal effects: enhanced blast

Chemical energy released by detonation



Kinetic energy of
reaction products, surrounding air and liner or casing material

(near field) blast, heat

(mid/far field) blast

SCJ, FCJ, EFP, (preformed) fragments



Deformation energy
in the target

can be enhanced
by reactions with
metals

anaerobic

aerobic



HE

enhanced blast

thermobaric

FAE

Examples of enhancement by reactions with metals

Dense Inert Metal Explosive / Multi-phase Blast explosive



	concentrated matter				dispersed matter				
	m	V	λ	ρ	deformation and failure behaviour	Ps	Is	t	Q
perforation power									
surface effects									
volume effects									

(Source: US Air Force Research Laboratory)

reactive fragments



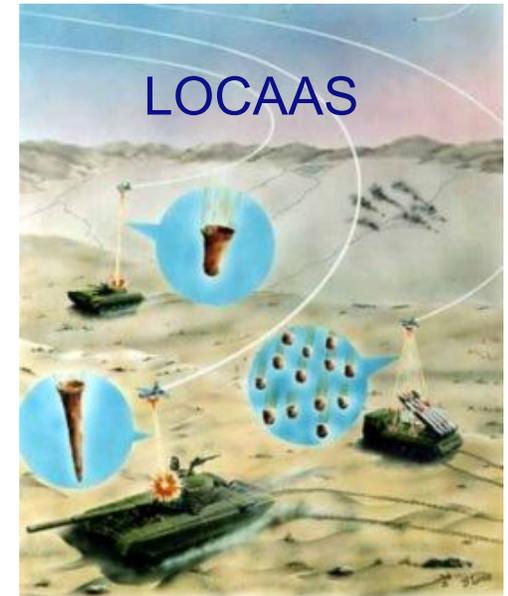
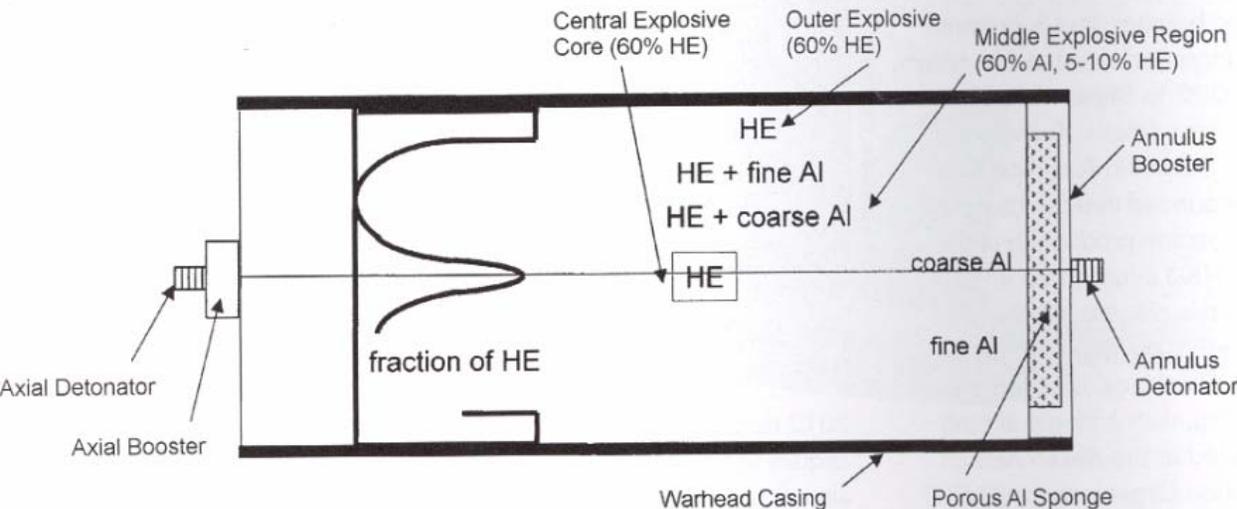
	concentrated matter				dispersed matter				
	m	V	λ	ρ	deformation and failure behaviour	Ps	Is	t	Q
perforation power									
surface effects									
volume effects									

(Source: US Office of Naval Research)

Multimode or adaptive effects

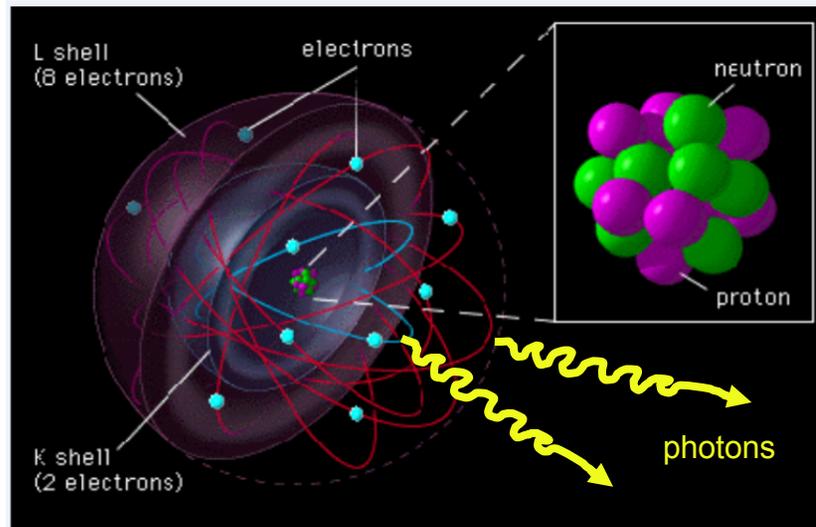
	concentrated matter					dispersed matter			
	m	V	λ	ρ	deformation and failure behaviour	Ps	Is	t	Q
perforation power									
surface effects									
volume effects									

graded explosives (US Navy)



Ultimate multimode or adaptive effects

	matter									electrons				photons			
	solid/liquid-like					gaseous				I	V	t	spotsize	n	h.v	t	spotsize
	m	V	λ	ρ	deformation and failure behaviour	Ps	Is	t	Q								
perforation power																	
lateral effects																	
volume effects																	



Questions?

**“If everyone thinks the same,
someone isn’t thinking”**

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