Detection of biological threats

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Open Air Trials

Point and Stand-Off Detection Trials

200 meter

Fokus areas:

- Threat assessment
- CBR(NE): from detection to forensic analysis
- Medical countermeasures (CB)
- EIHH – toxicology and risk assessment
- Incident response/decontamination

Winter trials

9th International Symposium on Protection against Chemical and Biological Warfare Agents

22-25 May, 2007
Göteborg, Sweden

together with

The Exhibition of CBW Defence Equipment

www.cbwsymp.foi.se

The scientific program includes plenary lectures, presentations on various aspects on protection, workshops and round table discussions. The following topics will be covered:

- Detection
- Medical countermeasures CB
- Diagnostics and triage CB
- International operations standards & equipment
- Body protection
- Crisis management CBRN
- Developing technologies
- CBRN terrorism
- Forensic analysis
- Filters & respirators
- Decontamination
- Modelling & risk assessment
- Emerging diseases
- Industrial strategies & development

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CBR Defence and Security

1. Defence against weapons of mass destruction (WMD).
2. Protection against deliberate release (terrorist release)
   - Chemical warfare agents
   - Biological threats, toxins
   - Radioactive substances
3. Protection against accidental release, or cause of earlier accidents, or naturally high levels of CBR related compounds that can be hazardeous for humans.
   - *Environmental and Industrial health hazards (EIHH)*

CBR – *Chemical, Biological, Radioactive (also EIHH)*

CBR Defence and Security

The CBR Defence and Security (traditional) function within the Swedish Armed Forces strives to minimize impact from CBR incidents and maintain operation capability to fulfill missions at CBR-threats and incidents.

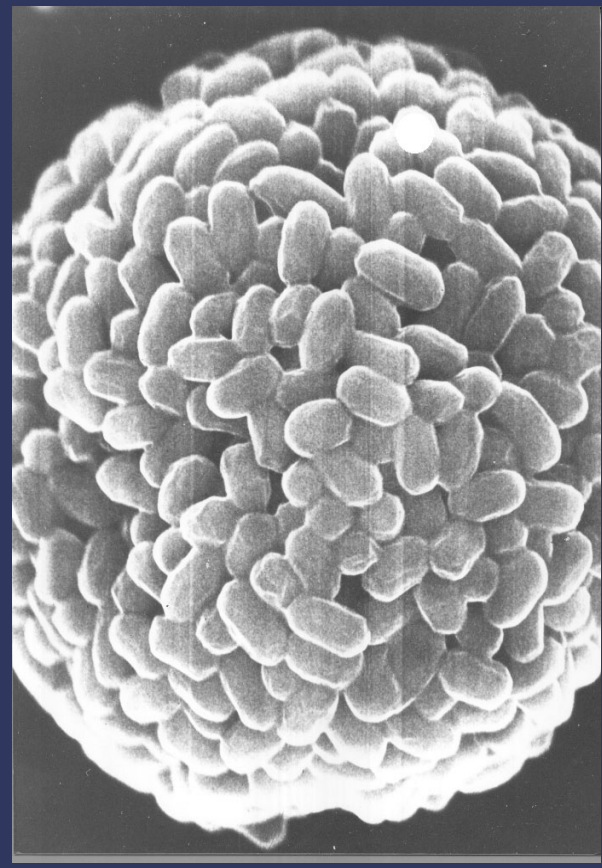
The biological threat

B-aerosols

- Many bacteria/spores/virus/toxins aggregate as aerosol particles at dissemination.
- The most dangerous particles are **1-10 µm in diameter**.
- Very small amounts of spores or organisms can cause infection.

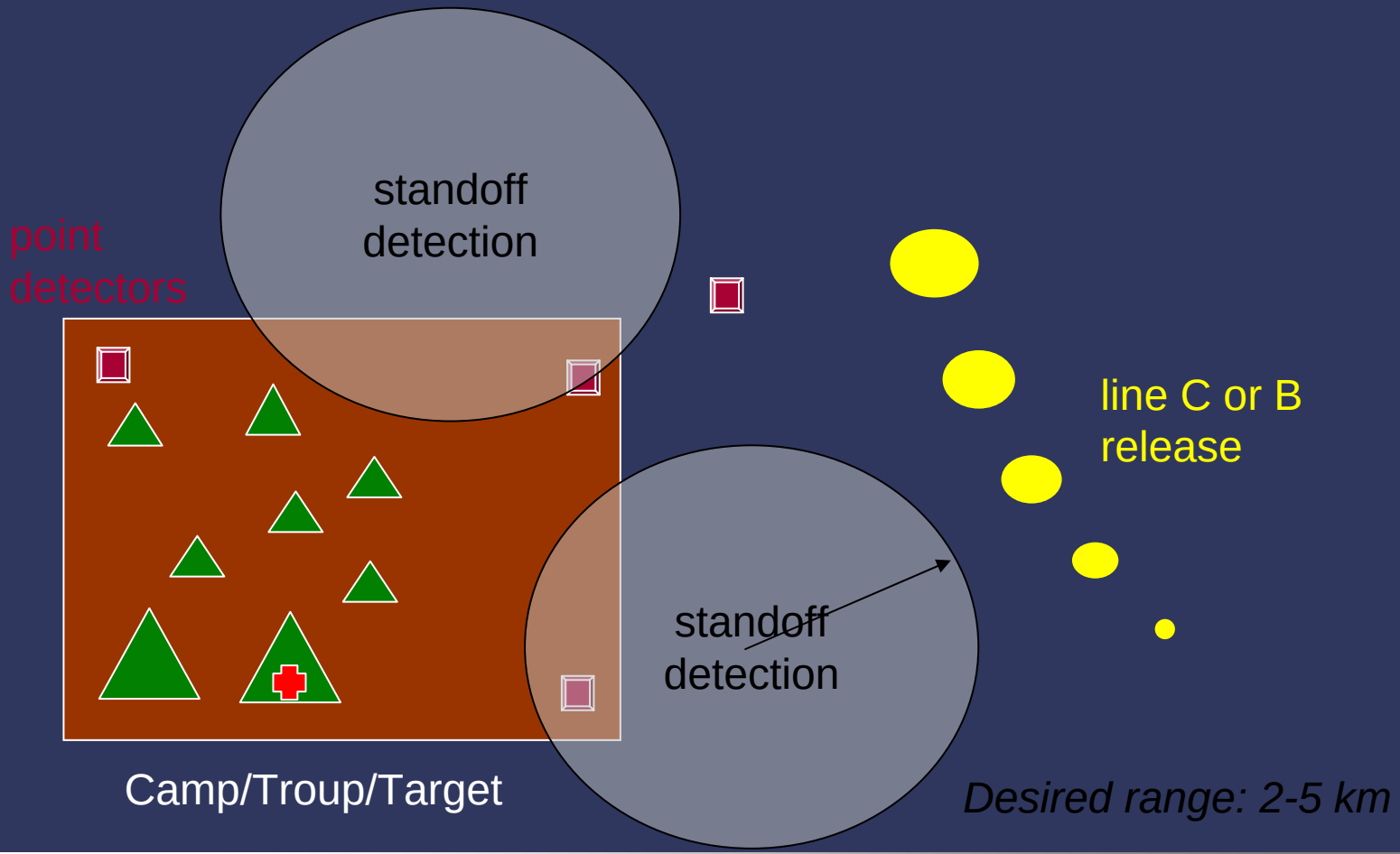
Threat	***infective dose***
Anthrax	*8000-10000 spores*
Plague	*3000 organisms*
Smallpox	*10-100 organisms*
Q-fever	*1-10 organisms*
Viral hemorrhagic fevers	*1-10 organisms*
Botulinum toxin	*0.07 µg/kg*

Walt; Franz; Anal. Chem., 738A-746A (2000)



Aggregates of B. subtilis (BG) approx. 13 µm diameter.

CBR-incident (military perspective) classical release/ defence scenario



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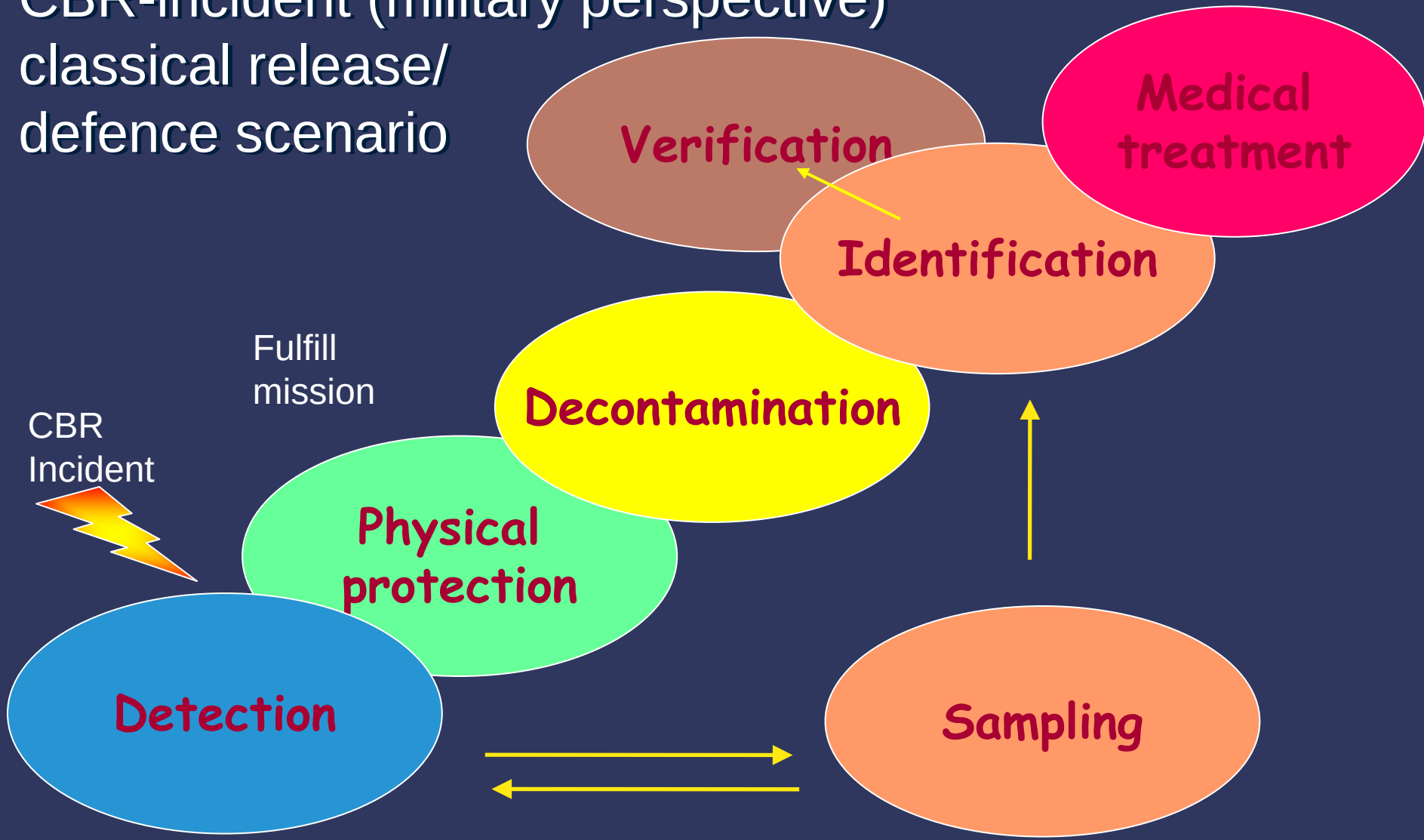
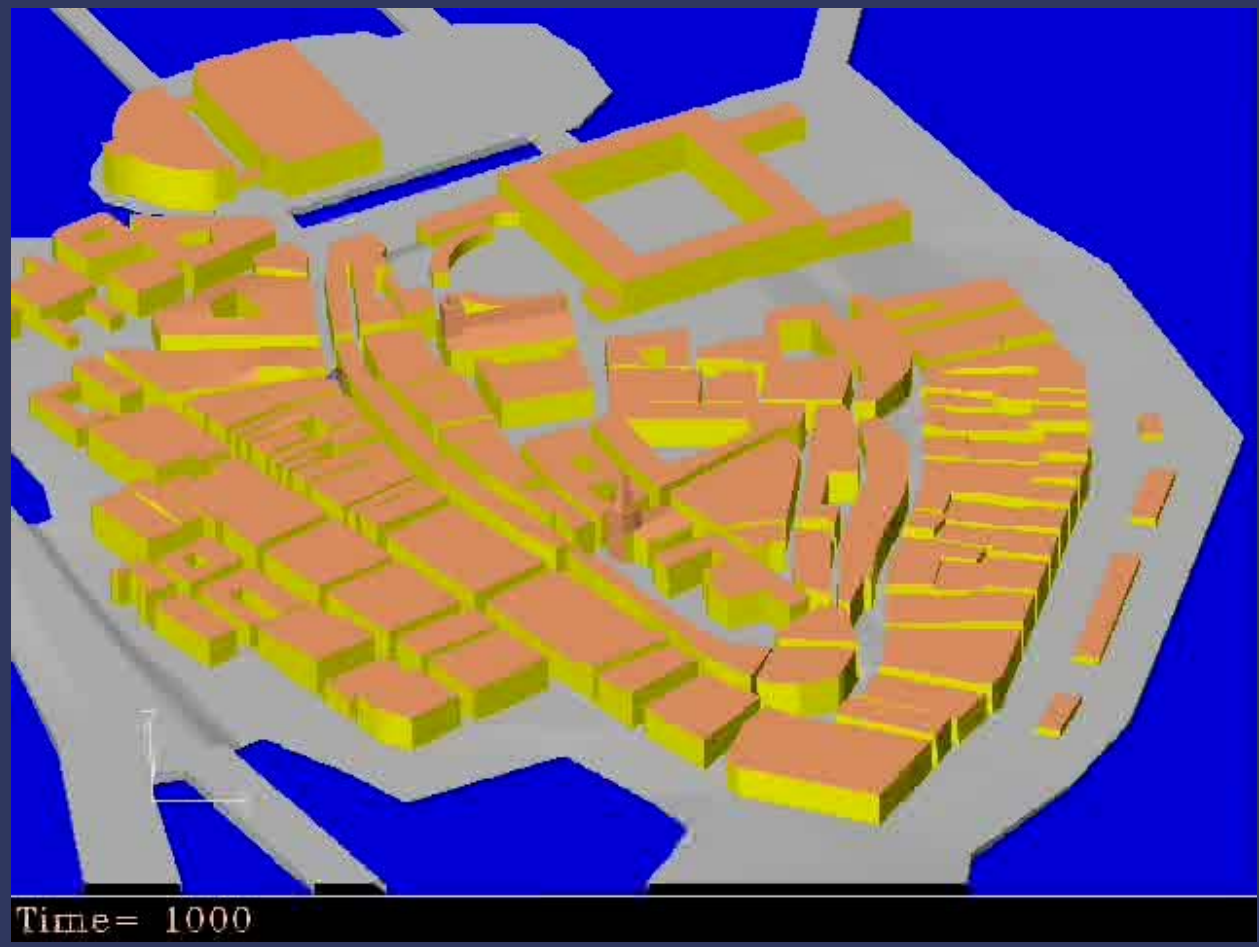


CBR-incident (civilian perspective) terror attack

Gamla Stan Stockholm



Time (seconds)
Release at 10 m hight
Wind 3 m/s
Monitor at 3 m height

Simulated release of Sarin

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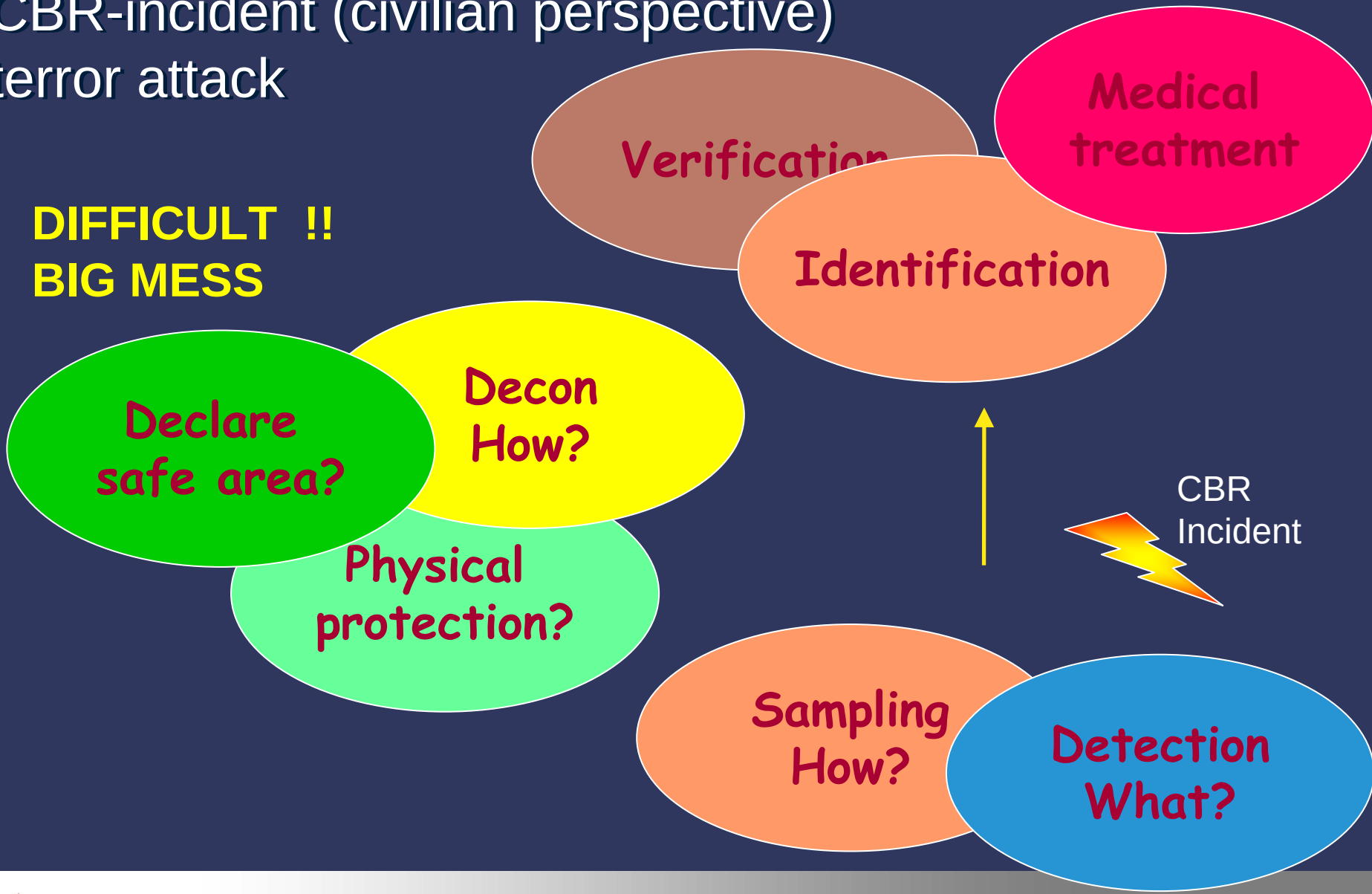
CBR-incident (civilian perspective) terror attack



There are conciderable differences between how armed forces and civil society can handle CBR incidents.

Experiences have shown that CB incidents (Tokyo subway; Anthrax letters) can cause high death rates and in addition tremendous economic and psycological impact on society.

What do we want ?

The ultimate detector
CBR; EIHH; everything
→sensitive; instant response;
tell where; cheap;
no false alarm …..

Point-detection B-sensors

- Fluorescense
- Elemental analysis
- Particle analys
- Content of ATP or other specific biomarkers
- Antibody reactions on surfaces + various detection schemes (optical, mass, etc)
- Biologal mass-spectroscopy
- DNA detection – requires steps of wet chemistry…

Canadian Integrated Biochemical Agent Detection System (CIBADS) innehåller detektions- och identifikations--system för både B- och C-agens i realtid, eller nära realtid.

Swedish defence forces today…

Biological standoff detection

Much research, development and studies of technical systems

USA
Canada
Frankrike
England
Norway
Sweden

BSDS:
Biological Standoff Detection Systems

Emerging Technology
-
Two Ongoing Detection Projects

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System for early warning

Fluorescence - basic principles

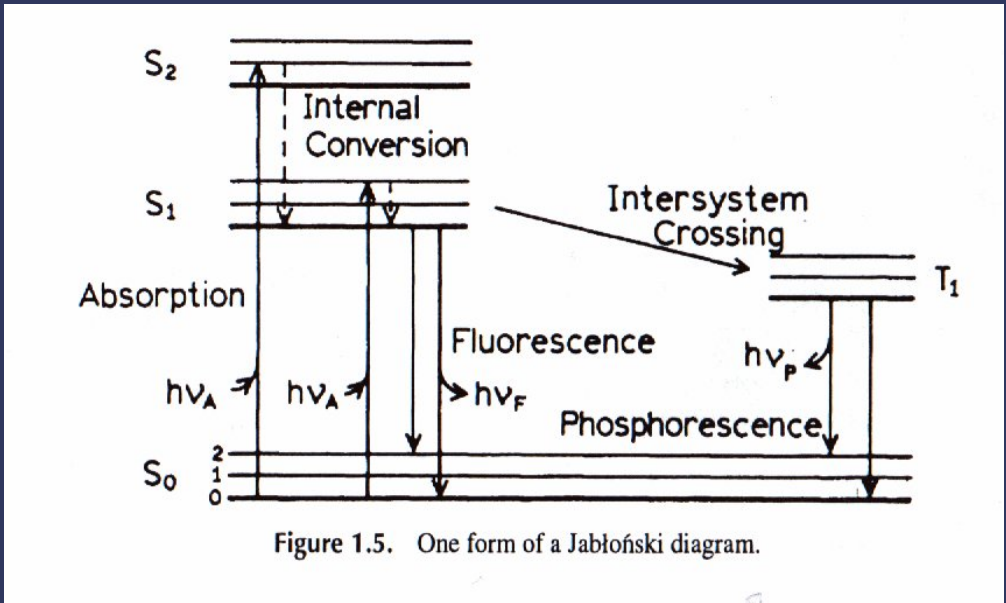
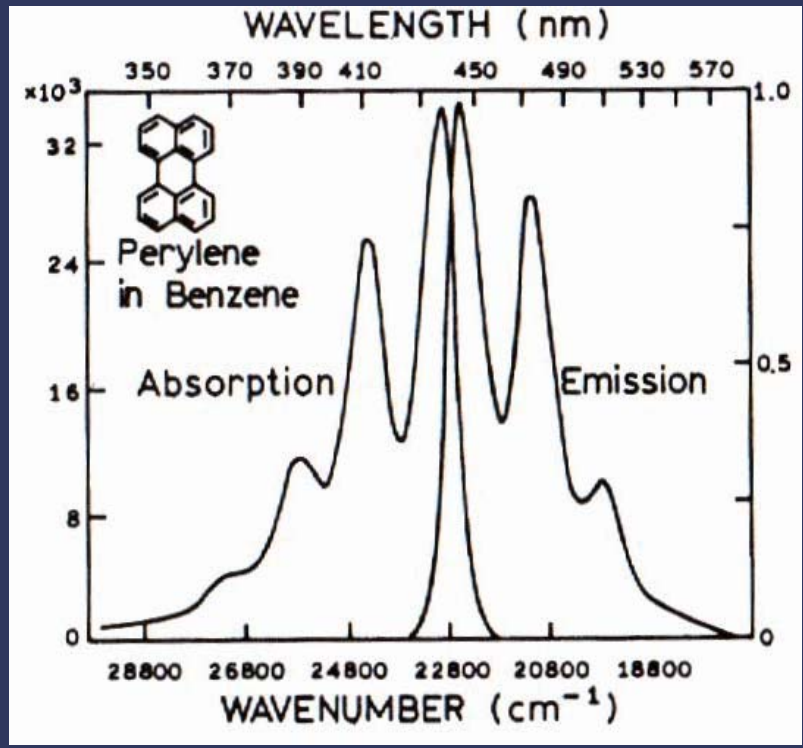
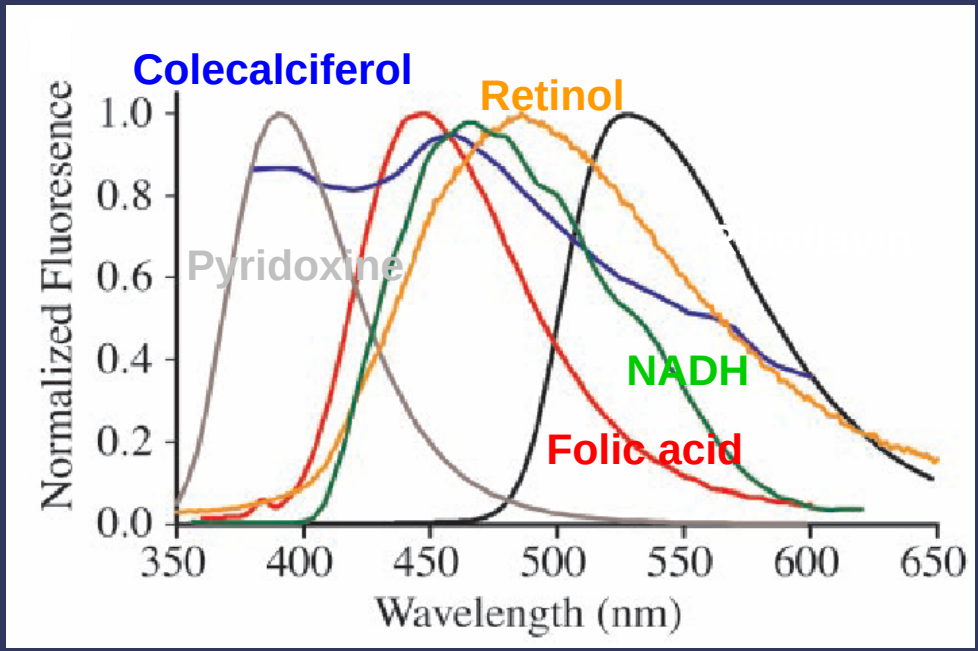


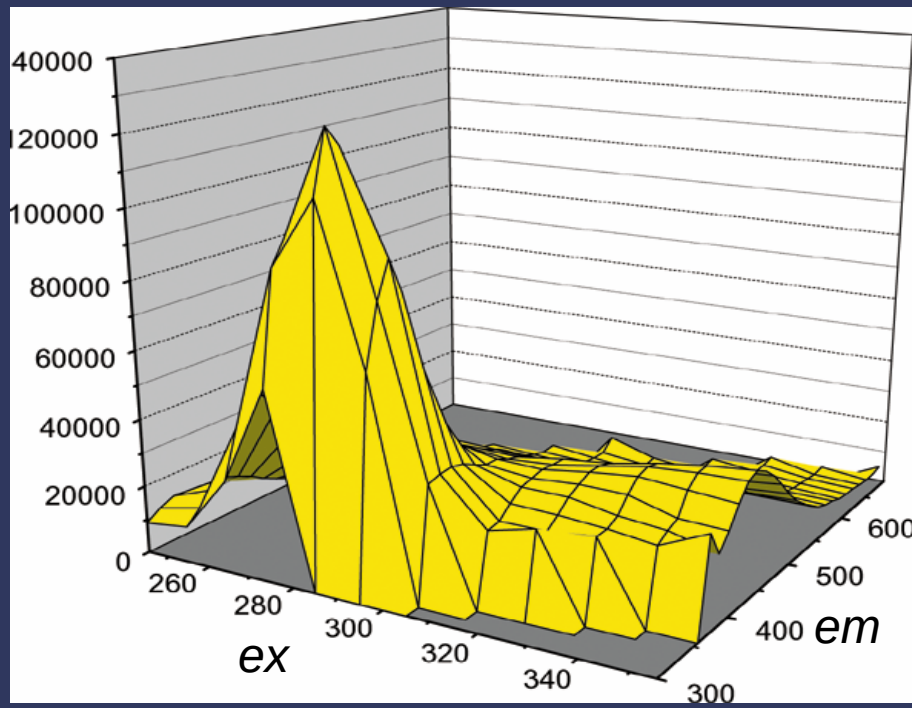
Figure 1.5. One form of a Jabłoński diagram.



System for early warning

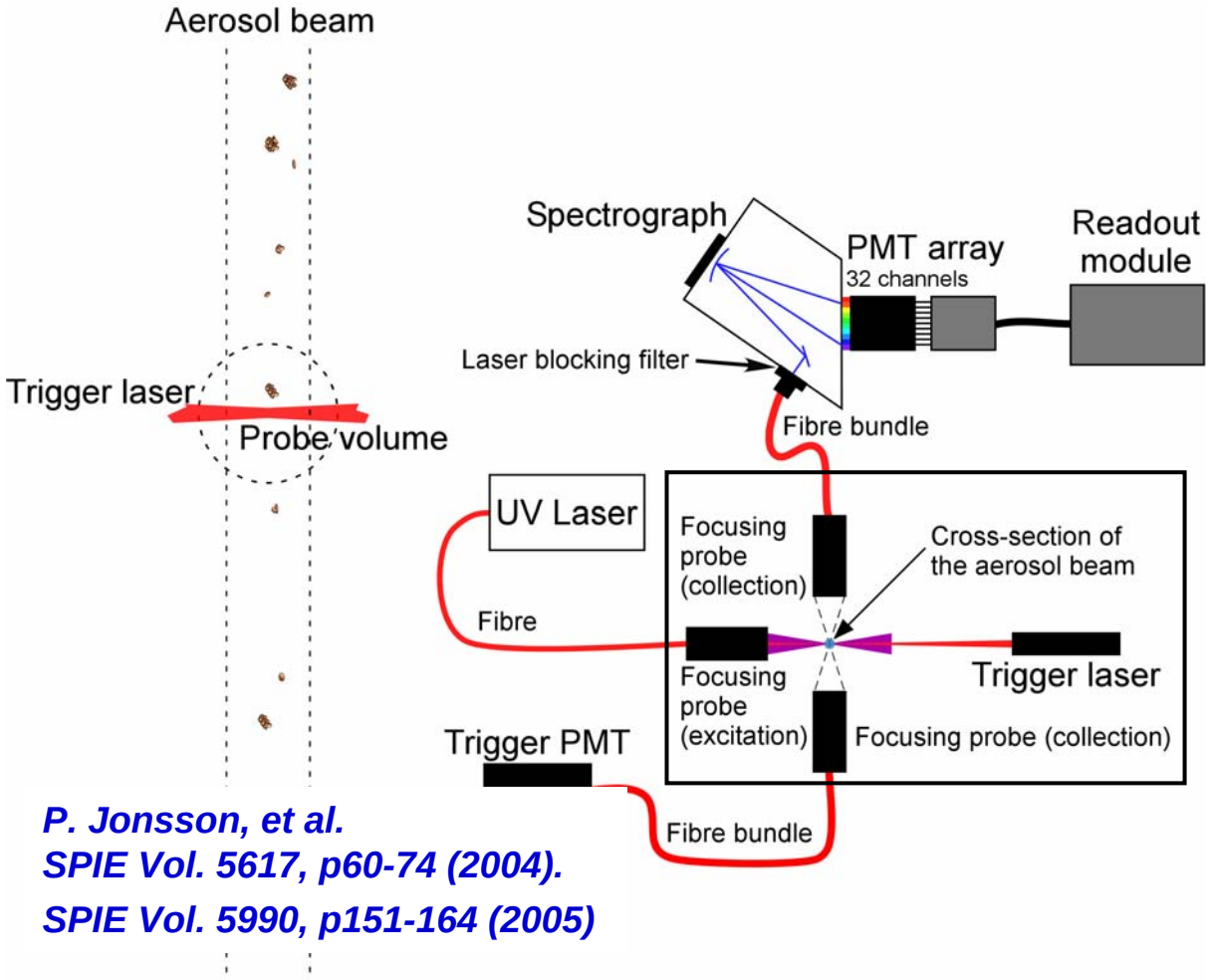
Bacillus atrophaeus (BG)





Optimal excitation wavelengths
280 nm; 340 nm

System for early warning

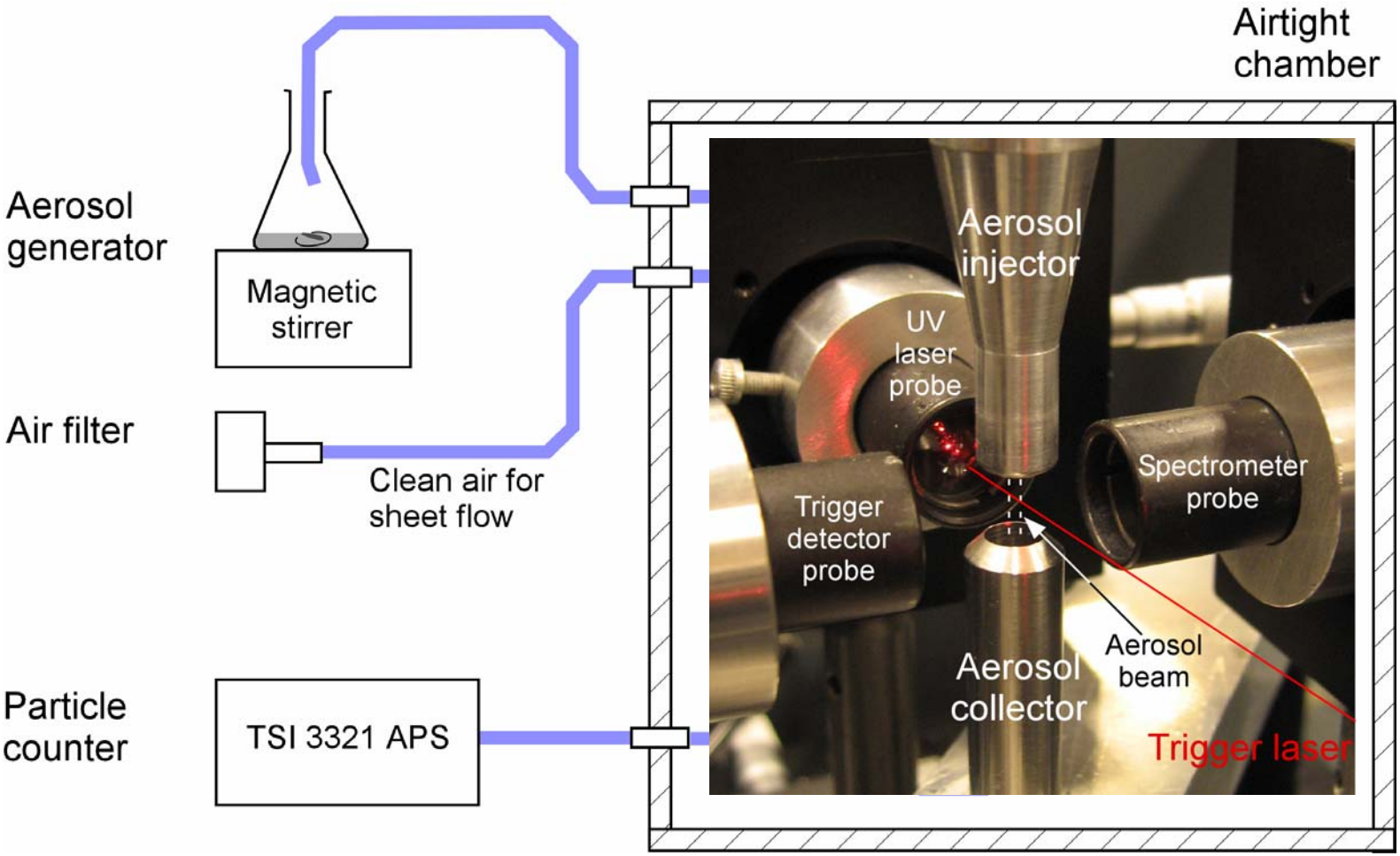


P. Jonsson, et al.
SPIE Vol. 5617, p60-74 (2004).
SPIE Vol. 5990, p151-164 (2005)

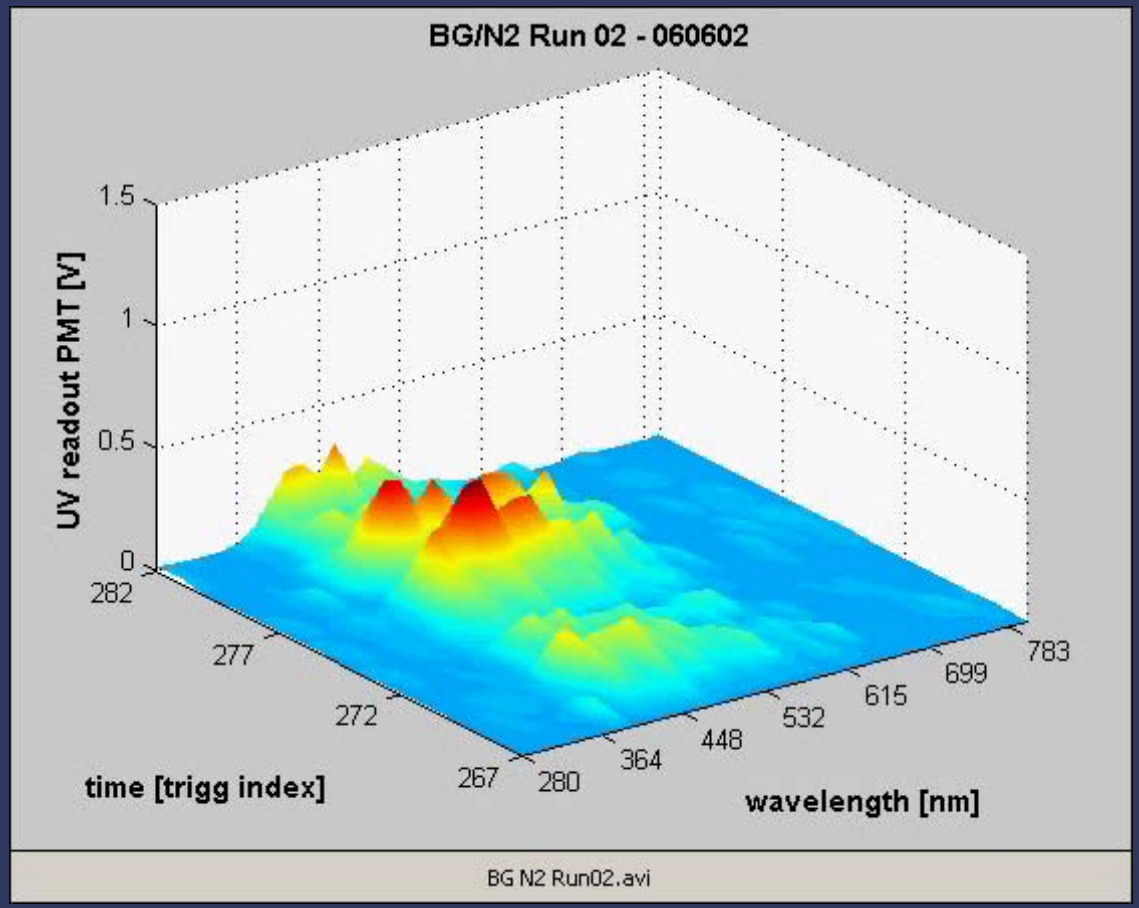
Detection sequence

1. Presence of an aerosol particle in the probe volume is detected when trigger laser light scattered on the particle is sensed by the trigger PMT.
2. A UV laser pulse (290 nm or 337 nm) is triggered.
3. The fluorescence spectra is detected with a spectrograph and a PMT array.

Aerosol beam generation

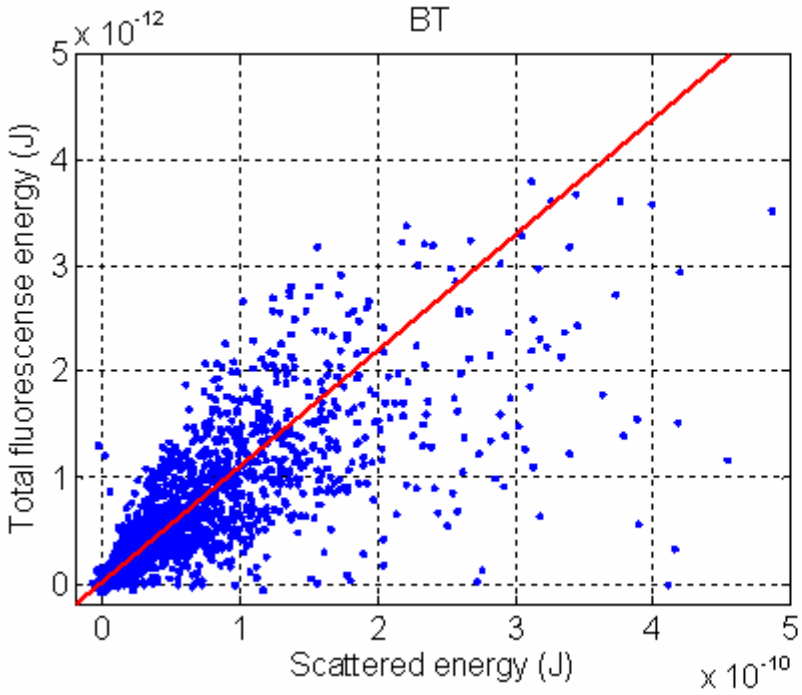


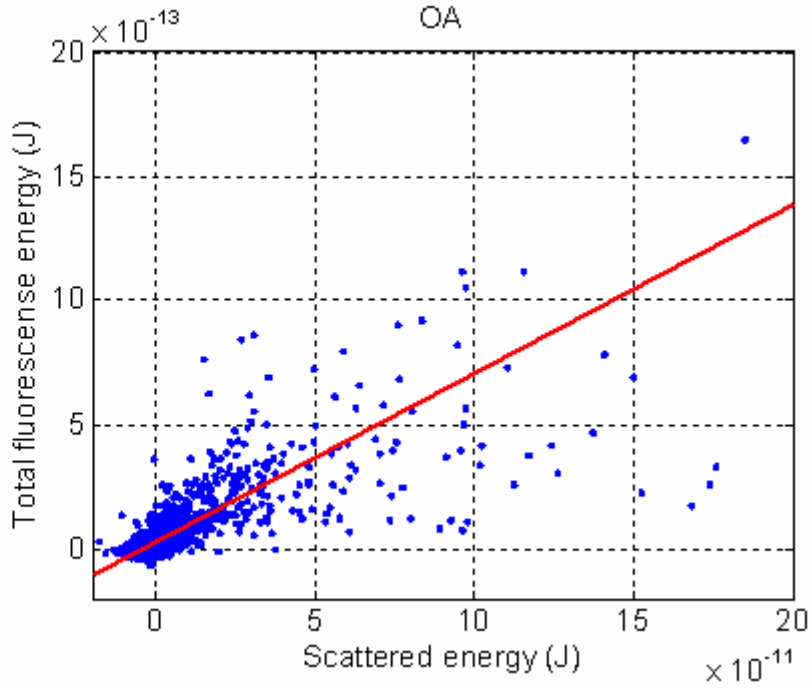
Single bioparticle fluorescence spectra



BG spores
excited with 337 nm
30-40 μJ per pulse

Fluorescence vs. Scattering





Absolute slope:

BG = 0.0099

BT = 0.011

OA = 0.068

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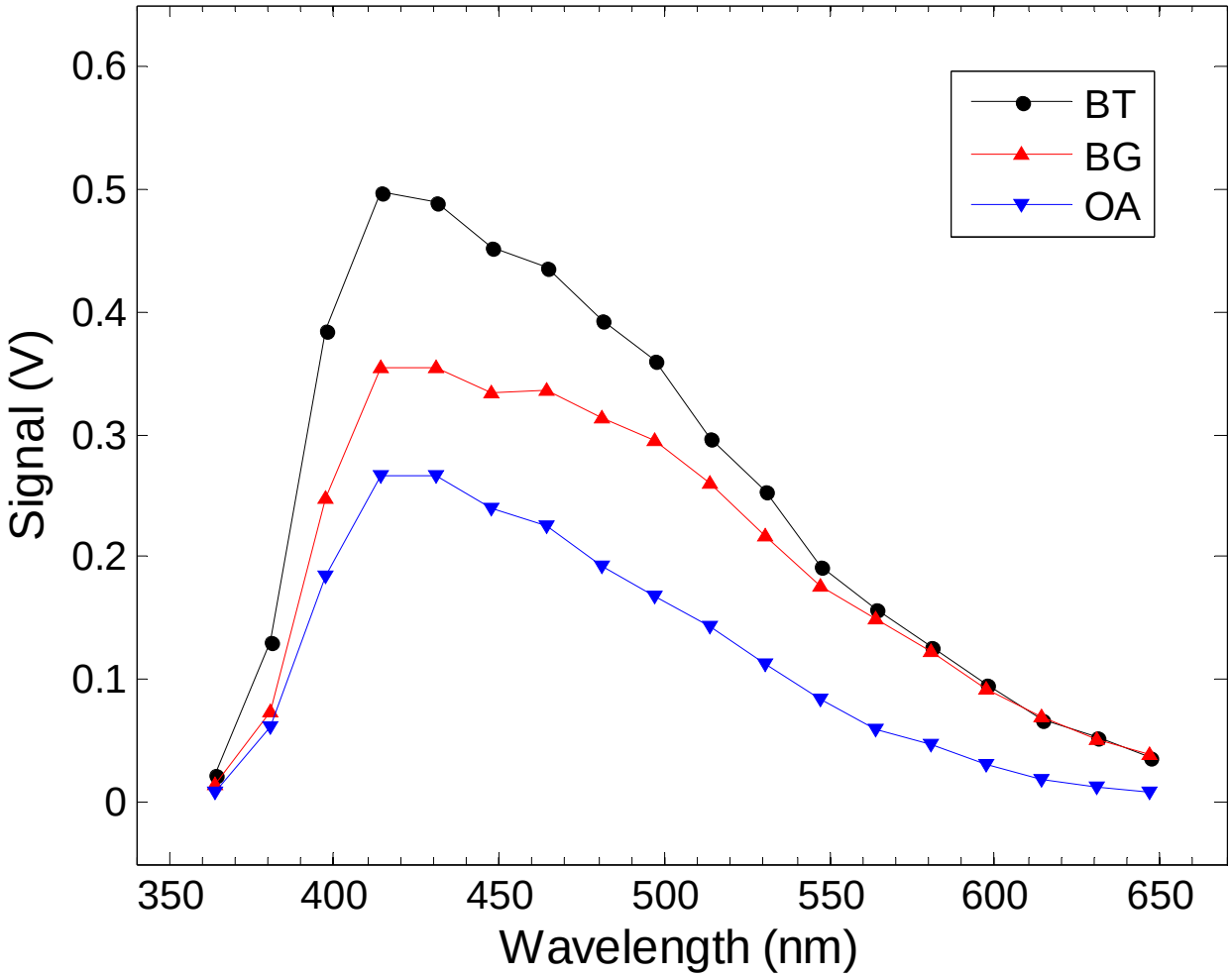
Spectra for particles excited with 337 nm



Mean spectra for UV scattered energies between 1 and 3 V

Corresponds to particle sizes approx. between 4 and 5 μm

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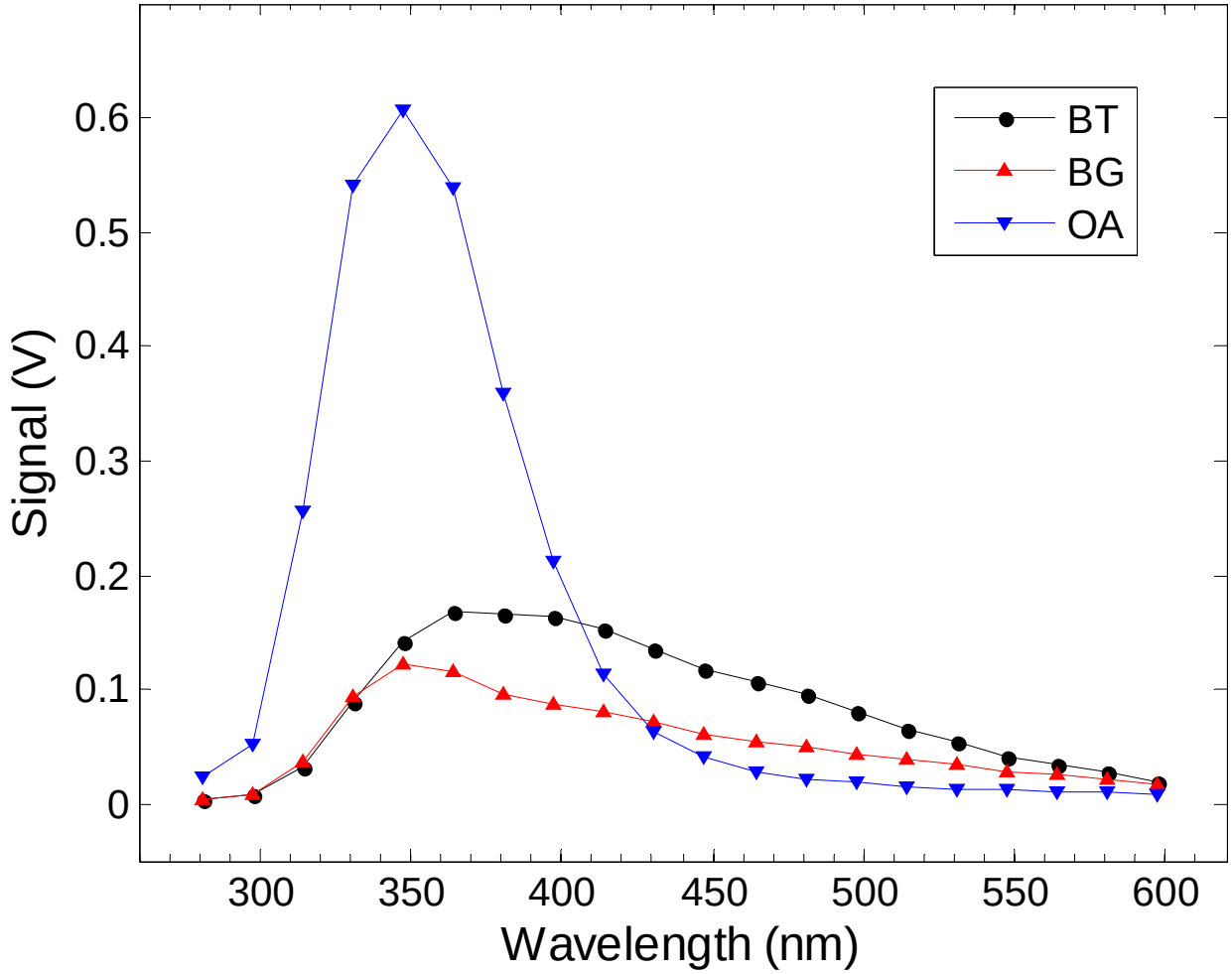
Spectra for particles excited with 290 nm



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System for identification

New DNA analysis

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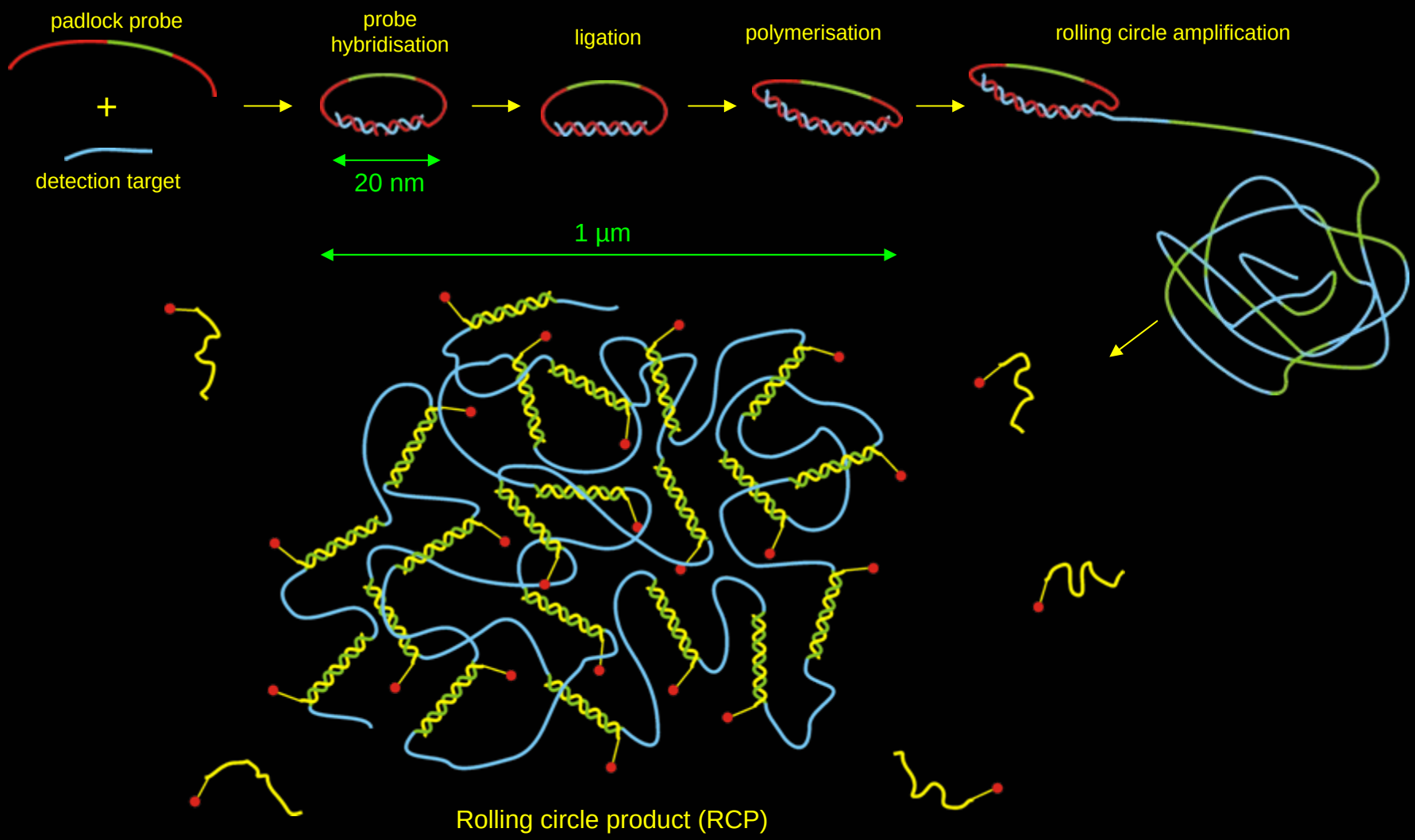
System för identifiering



Jarvius *et al*. Nature Methods 725-727 (2006)

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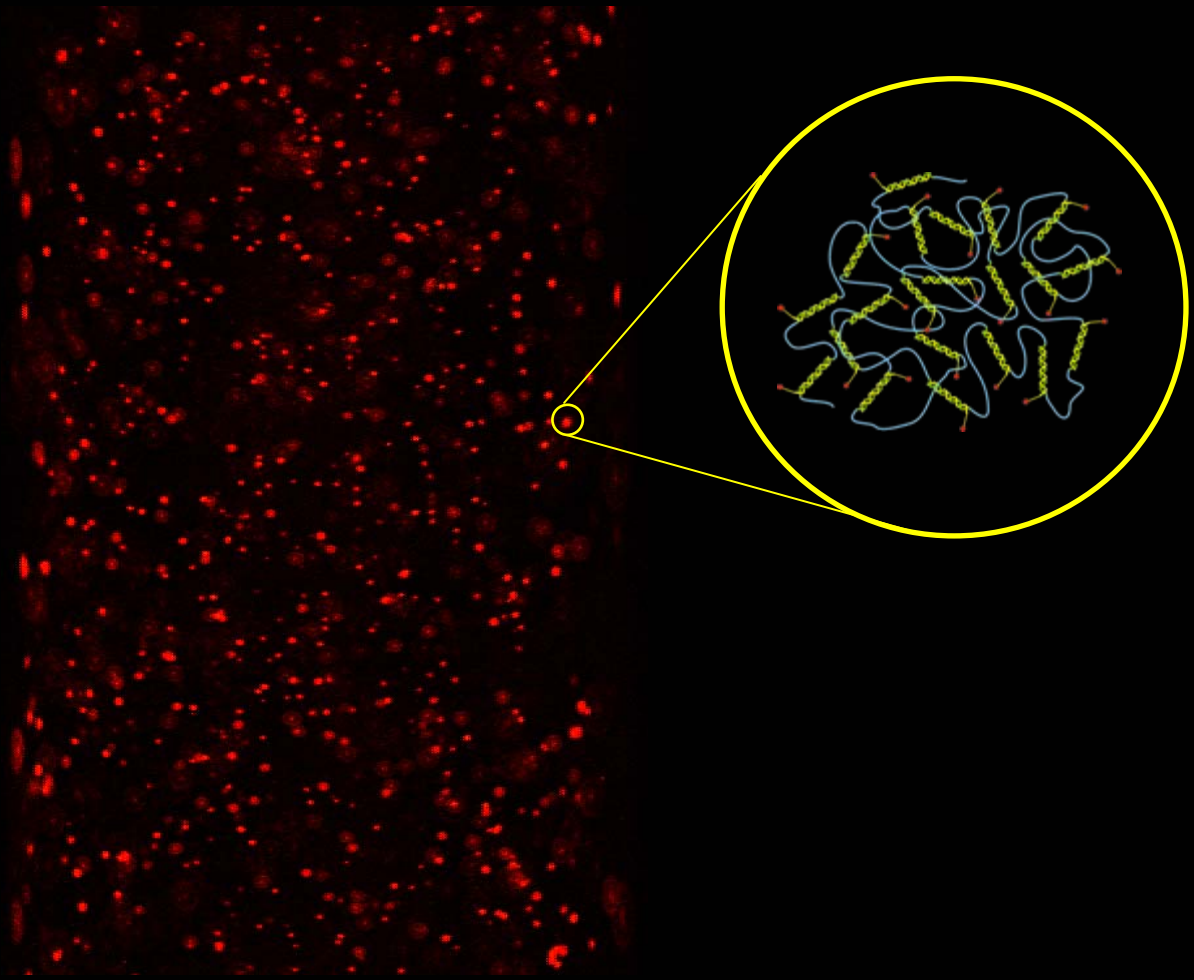
Amplified Single Molecule Detection



- The RCPs are visible as bright objects in fluorescence microscopy
- Each RCP contains about 1000 fluorophores

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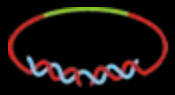
Advantages relative state-of-the-art

- High specificity, high sensitivity and short analysis time (ca min).
- One single platform for rapid detection of fundamentally disparate bio-agents such as bacteria, DNA viruses, RNA viruses, toxins etc.
- Great potential for high degree of multiplexing, i.e. simultaneous sample processing of numerous agents.
- Insensitive to contamination from sampling (water, soil, blood, faeces etc).
- ”Digital” read-out, i.e. the system will offer single-molecule detection – the ultimate analysis method



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Conclusions

Early warning and indentification systems by optical means can be made sensitive down to ”spore”, ”organism” or ”molecular” level.

These have the potential to become relatively compact and affordable systems in the near future.

System for early warning

System for identification

Questions?