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Single Photon Workshop 2005:

Summary report from the 2nd International workshop on single photon sources, detectors, applications and measurement methods, 24-26 October 2005, NPL

Jessica Y. Cheung

ORM Club meeting, 29 June 2006

Overview of talk

- Photon counting applications
- Single photon sources
- Single photon detectors
- Workshop motivation
- The event
  - Structure
  - Networking and lab visits
  - Outcomes
- Outlook

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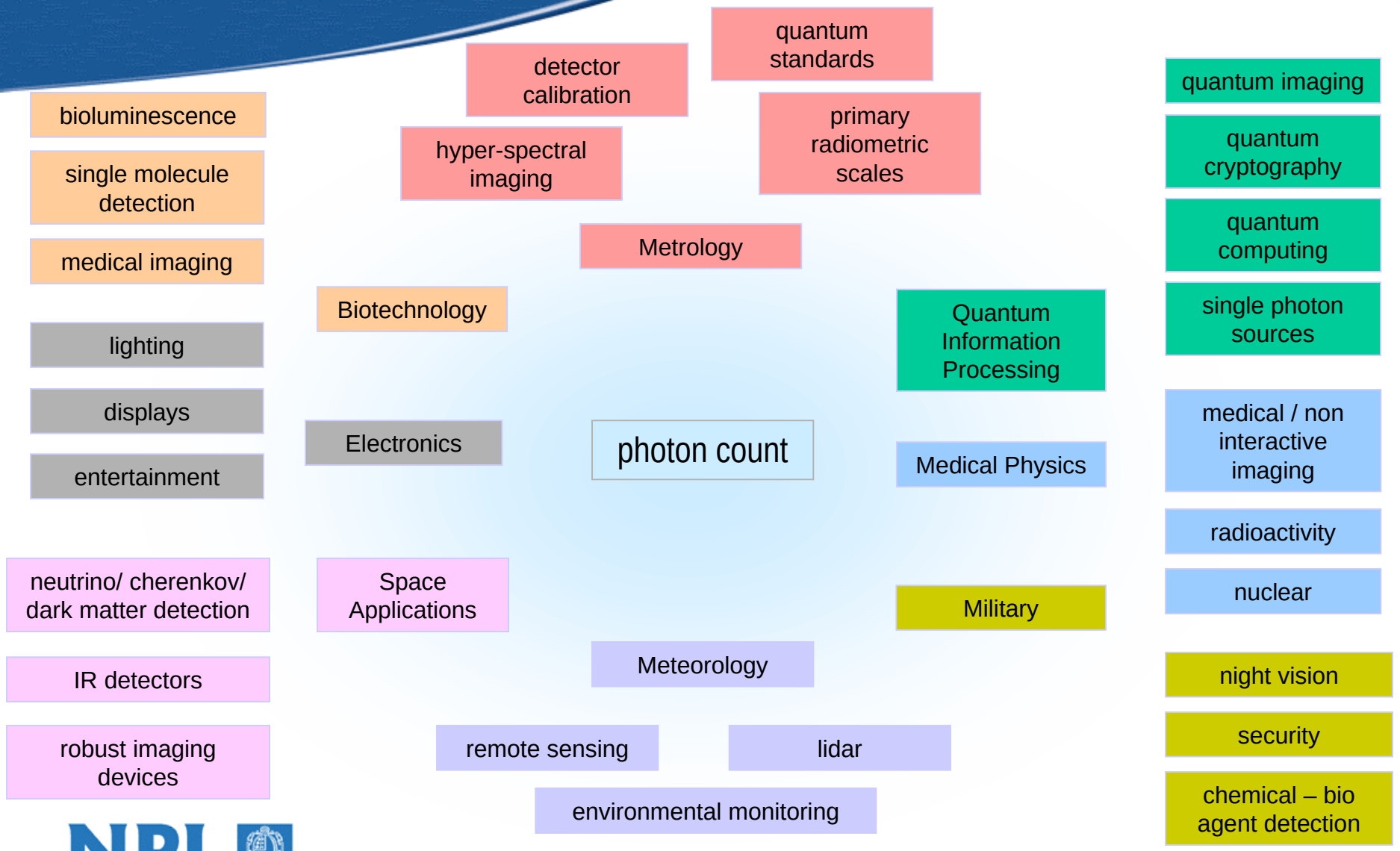
Photon counting applications



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Single photon sources and detection Quantum information processing community

single photon source

ideal case: a source which produces one photon at a time and on demand

what do we need them for?

quantum cryptography

quantum computing

tests of quantum mechanics

what are the challenges?

Producing the single photons

Detecting the single photons

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Single photon detectors: requirements

- High quantum efficiency
- Low jitter, low dead-time, low dark counts,
- Low after pulsing, breakdown flashes
- Faster response
- Spatial uniformity
- Wavelength range of detectors
- Range of detector active areas

Also requirements of photon counting detectors

- **Photon number resolving capability**
- **Very high quantum efficiency (>99%)**

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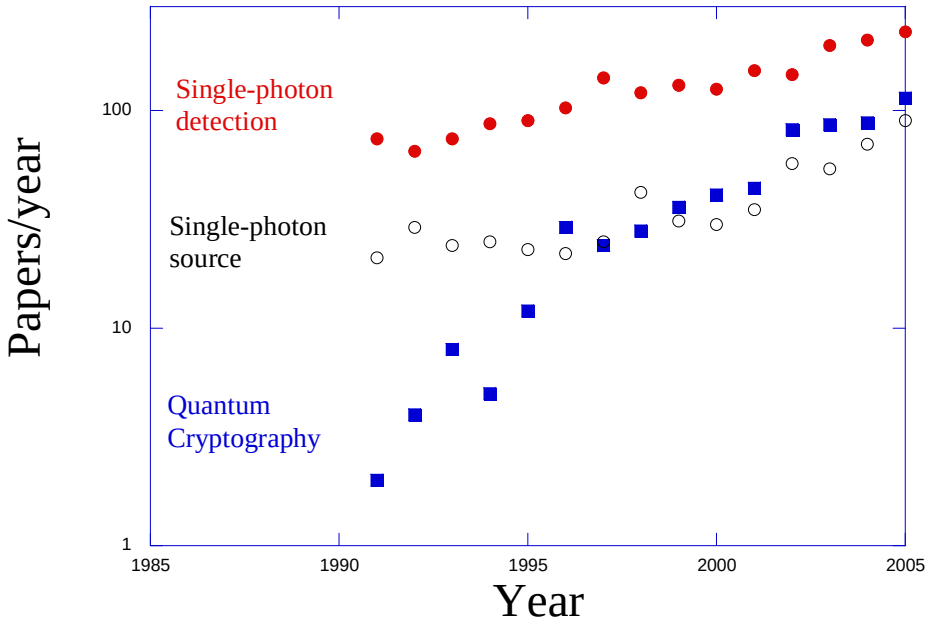
Single photon research development

- April 2003: NIST Single photon detector workshop
  - 85 delegates: focus detector issues
- October 2005: NPL host Single photon sources and detector workshop with efforts to involve researchers from other relevant scientific communities
- Many conferences on quantum information processing



A search on *Web of Science* reveals that the number of papers per year in quantum cryptography starts to overtake the number of papers published on single photon detectors

Migdall '06

Workshop motivation

- Bring together researchers working with single photon sources and detectors
- Find out what the measurement issues are
- Introduce QIP community to photon detection community
- Report on progress since 2003 workshop
- Discuss problems, solutions and road blocks
- Discuss new ideas
- Networking
- Launch of photon counting webpage

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Single photon workshop 2005
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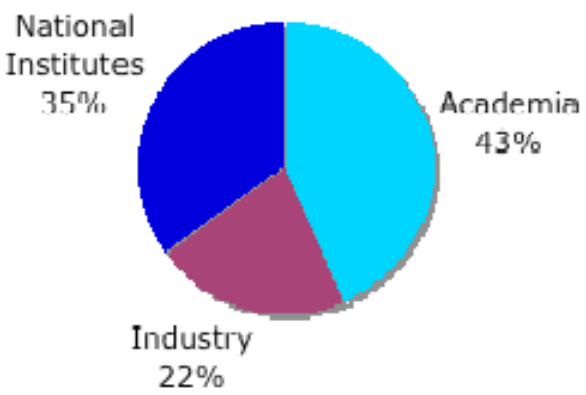

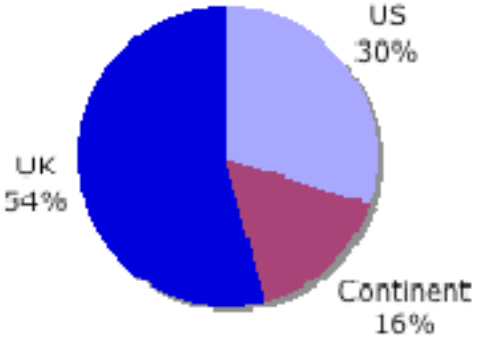

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Workshop Structure

- 82 international delegates
- 33 talks, 5 review talks
  - Day 1: Sources
  - Day 2: Detectors
  - Day 3: Applications
- 7 posters
- Dti and ORM club
- US Army international research
- 5 industrial sponsors

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Single photon sources - highlights

- **Methods of producing single photons**
- Heralded single photon sources using correlated photons
  - non-linear crystals (PPLN)
  - photonic crystal fibres
- Quantum dots
  - semiconductors, e.g. InAs in GaAs films
  - Nitrogen vacancies in diamond
- Atoms in micro-cavities
- Surface Acoustic Wave - driven single photon source (NPL poster)
- **Methods of characterization**
- Hanbury - Brown Twiss Interferometer (NPL poster)
- Two photon interferometer (NPL poster)

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Single photon detectors - highlights

- Development of single photon and photon counting detectors for a variety of applications
  - Telecoms (InGaAs/InP photodiodes/upconversion), q.e. 30%
  - Space (Single photon avalanche diode arrays)
  - Remote sensing
- Commercial detectors now come with USB interfacing, low jitter, low after-pulsing
- Superconducting photon detectors : photon number resolving detectors required for quantum computer
- Characterisation and metrology techniques for testing detector performance – better uncertainties

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Applications - highlights

- Quantum cryptography using heralded source
  - Commercial devices now available
- Commercial applications of photon counting devices
  - medical imaging
- Quantum computing
- Single molecule fluorescence spectroscopy
- Metrology techniques - radiometry: NIST, NPL, INRIM, BU

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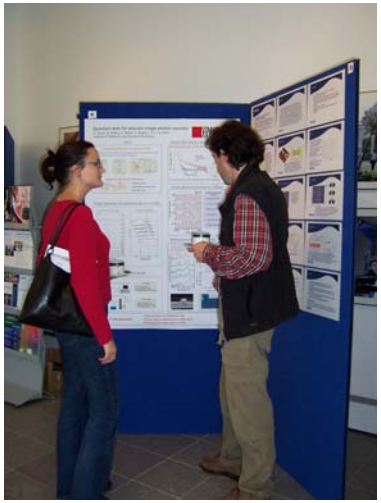
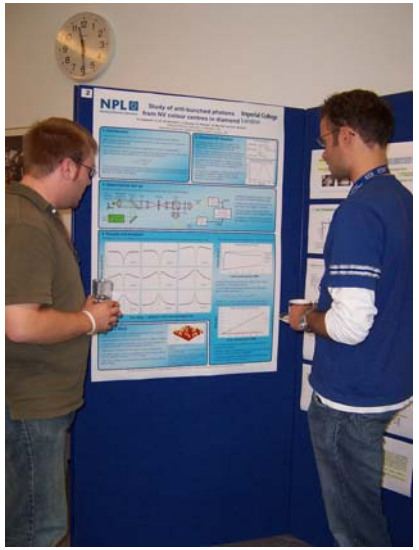
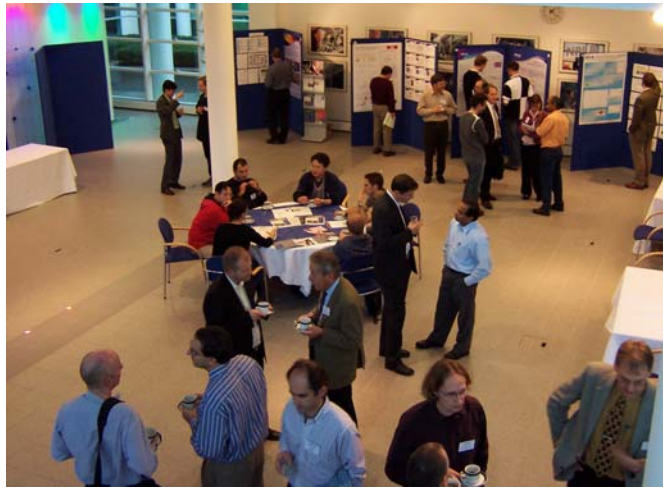
www.photoncount.com

- NPL KT team
- Over 100 members
- International – UK, USA, mainland Europe, India, China Canada, Australia…
- Events, research news and products
- Promote Knowledge transfer between different scientific communities

Poster sessions and coffee breaks!







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Evening event: Bushy House

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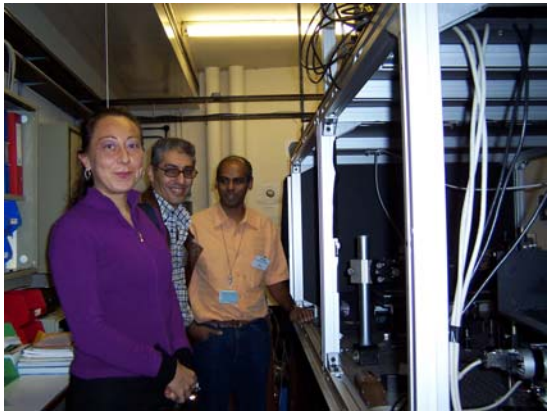
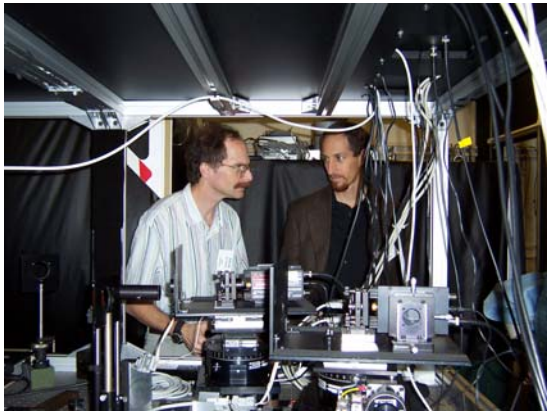
Lab visits: correlated photons facility, cryogenic radiometer, ARD, NLRF





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Outlook

- Proceedings to appear in a Special Edition of Journal of Modern Optics (Summer 2006)
- Photoncount webpage, continuing to grow
- Look out for research and business in the Asia Pacific region
- Positive feedback regarding workshop - consultancy
- New collaboration opportunities, EU funding, NPL - INRIM
- Preparations are being made for Single Photon Workshop 2007, likely to be at INRIM, Turin 2007

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Acknowledgements

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  - –Dave Taylor

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