DSP Project

- Oral presentation, web presentation, and user manual are combined into a single web-based document (i.e. html, pdf, etc …).
- Web-based document should include the following:

    1. Device objectives.
    2. Explanation of design.
    3. Final budget.
    4. Device performance and highlights.
    5. Conclusion including possible future improvements.
    6. Brief user manual.

- Explain what you have done, explain why your device is the best, and explain how it works.

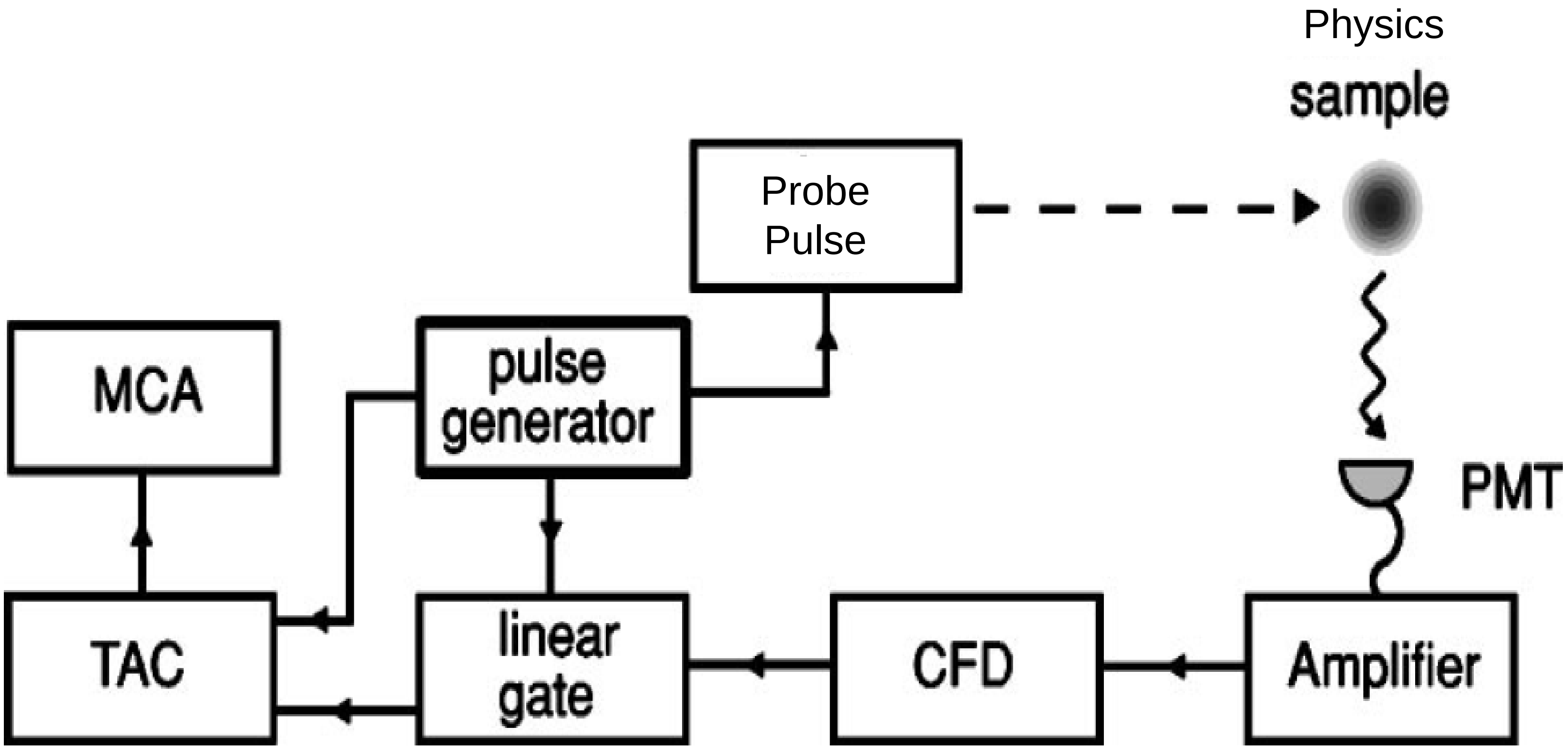
- Due date: Wednesday, December 3, 2008.

Pulse Electronics & Physics

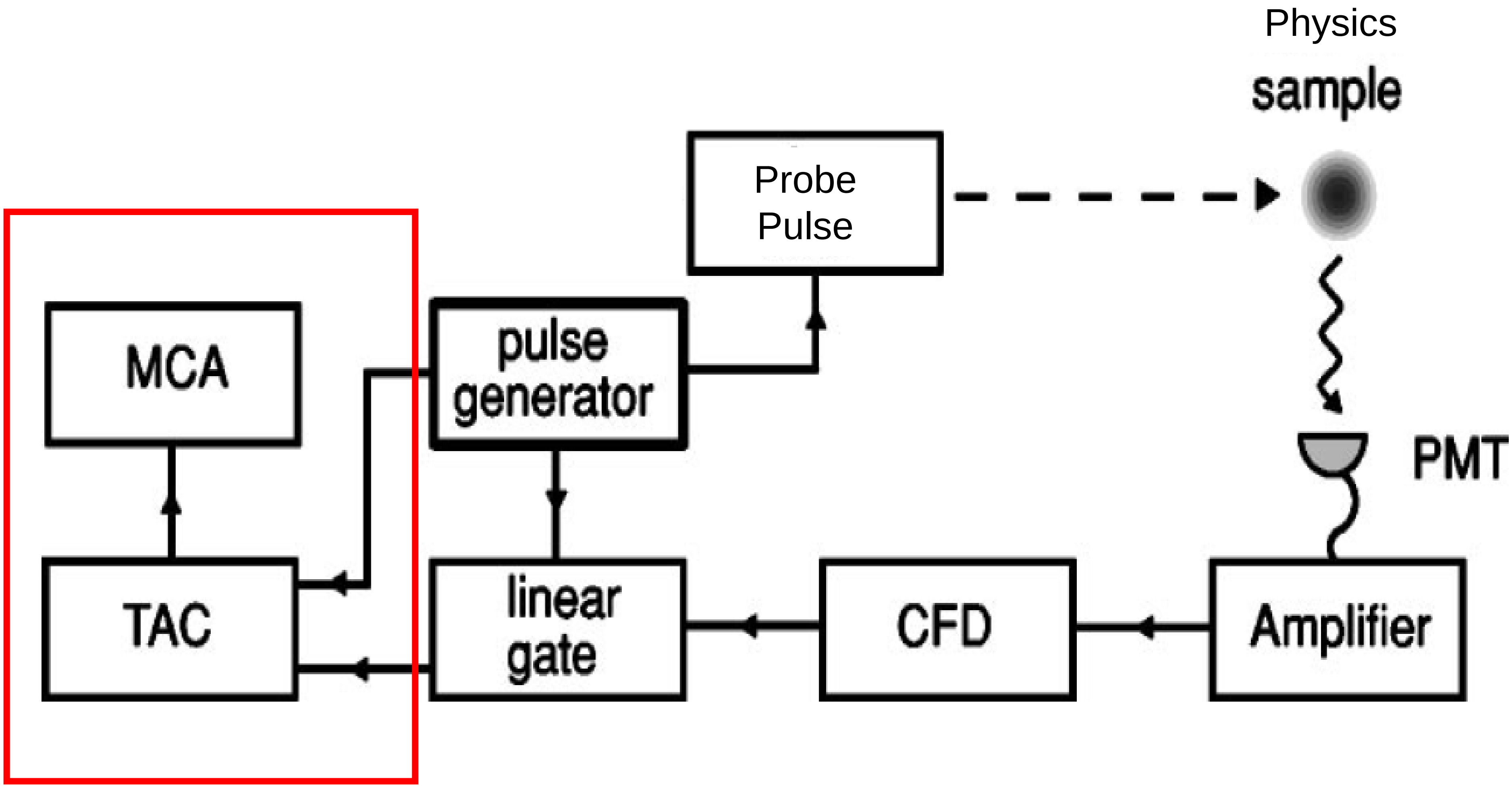
Outline

1. Pulse Electronics Architecture.
2. Time-correlated Measurements.
3. Constant Fraction Discriminator.
4. Pulse Physics Examples.
    - → Lifetime measurements.
    - → Correlation functions.

Pulse Electronics Architecture



Pulse Electronics Architecture



Histogram electronics … easily replaced by an FPGA .

[Figure adapted from Phys. Rev. A 70, 042504 (2004)]

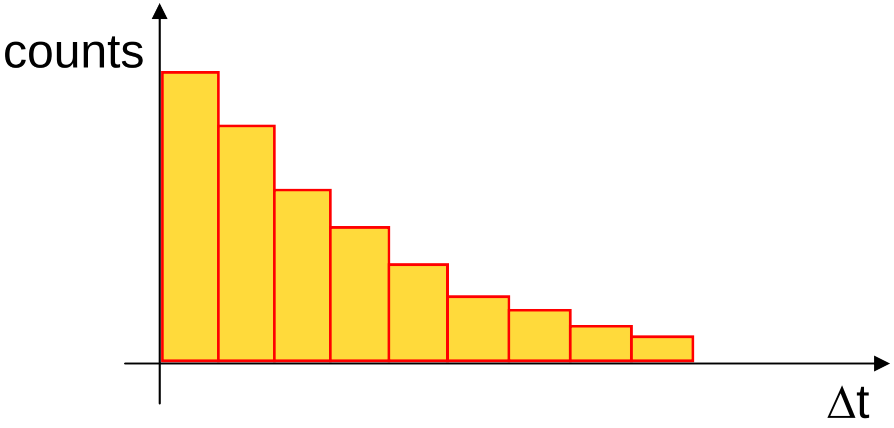
Time-correlated Measurements

IDEA

STEP 1: Measure the time, Δt, between probing a physical system and the reception of a physics pulse (photon, particle, complex event, etc …).

→ Can also be the time between two physics events.

STEP 2: Repeat experiment many, many, many times … and bin all the measured Δt's to make a histogram (i.e. 10-20 ns bin = 3 counts, 21-30 ns bin = 25 counts, etc…).



Use FPGA to make the histogram

Pulse Discrimination

Problem 1: Pulses generally come with a range of sizes, but a common duration.

→ The small ones are generally noise and only the bigger ones are important.

Solution → keep only the pulses above a certain threshold.

Problem 2: Big pulses still come in a range of sizes, so triggering on a threshold will generate a trigger whose timing is dependent on the pulse height.

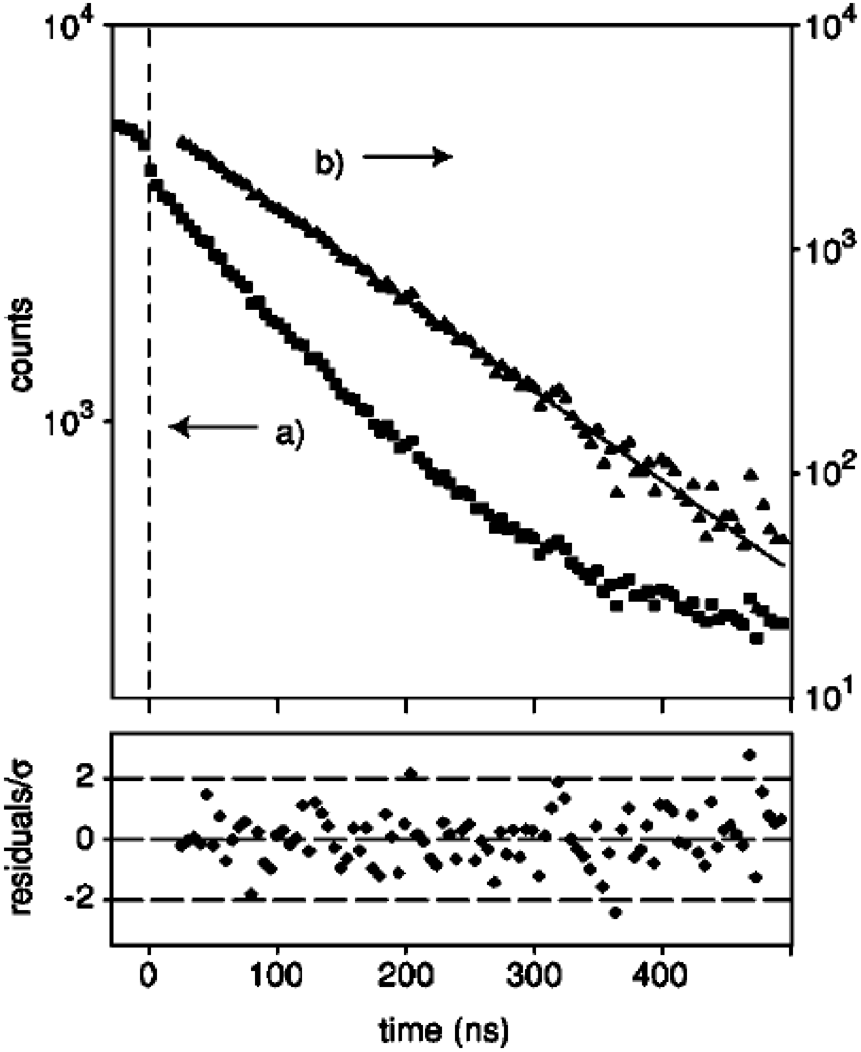
Solution → Use a constant fraction trigger (discriminator).

Lifetime Measurement

Experiment:

1. Excite atom with a laser pulse.
2. Measure time Δt to detect a radiative decay photon.
3. Repeat many times.
4. Histogram of decay times, Δt, is shown on right.

Statistical error on an average of N counts in a bin is $\sqrt{N}$



[Figure adapted from Phys. Rev. A 70, 042504 (2004)]

Correlation Functions

In quantum optics, the correlation between light intensities at different times can tell you about the quantum statistics of the particles.

Intensity-intensity correlation functions:

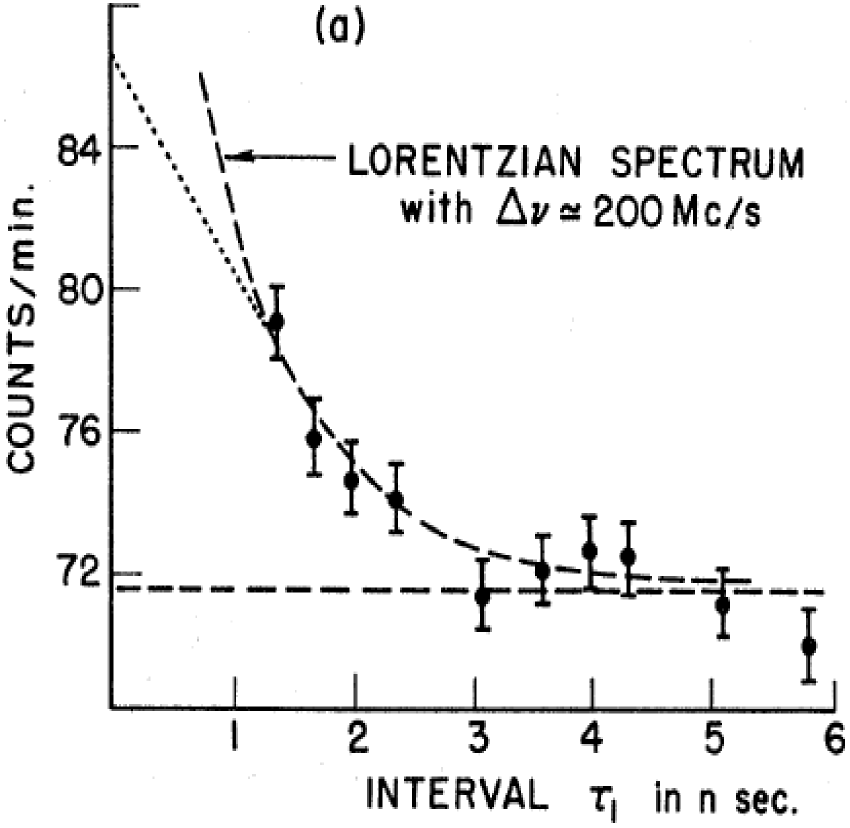
$$G^2(\tau) = \langle I(t) I(t+\tau) \rangle$$

$$g^2(\tau) = \frac{\langle I(t) I(t+\tau) \rangle}{\langle I(t) \rangle^2}$$

→ Measure the statistics of photon arrival times

Thermal Photons

G^2(τ)



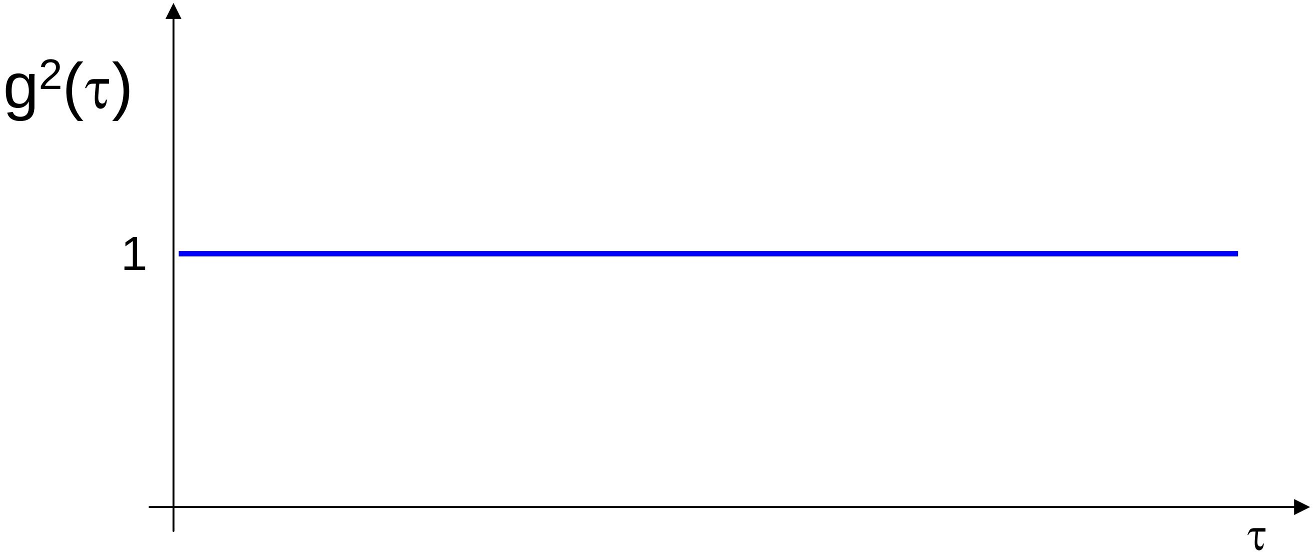
bosonic particles

random classic

Thermal photons exhibit “bunching” at short correlation times

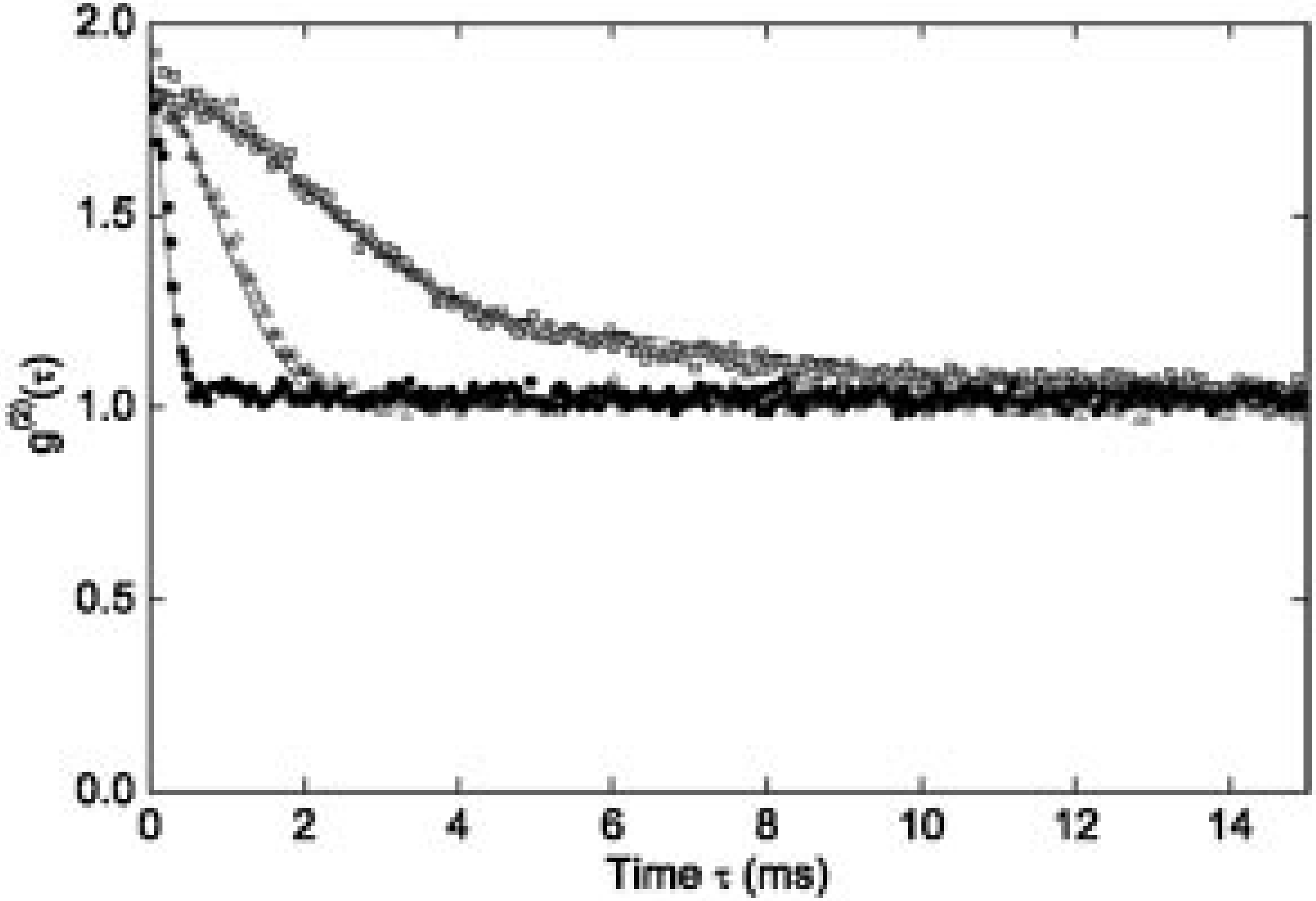
[Figure from Morgan & Mandel, Phys. Rev. 16, 1012 (1966).]

Laser Photons



Laser photons exhibit NO “bunching”.

Thermal Bosonic Atoms

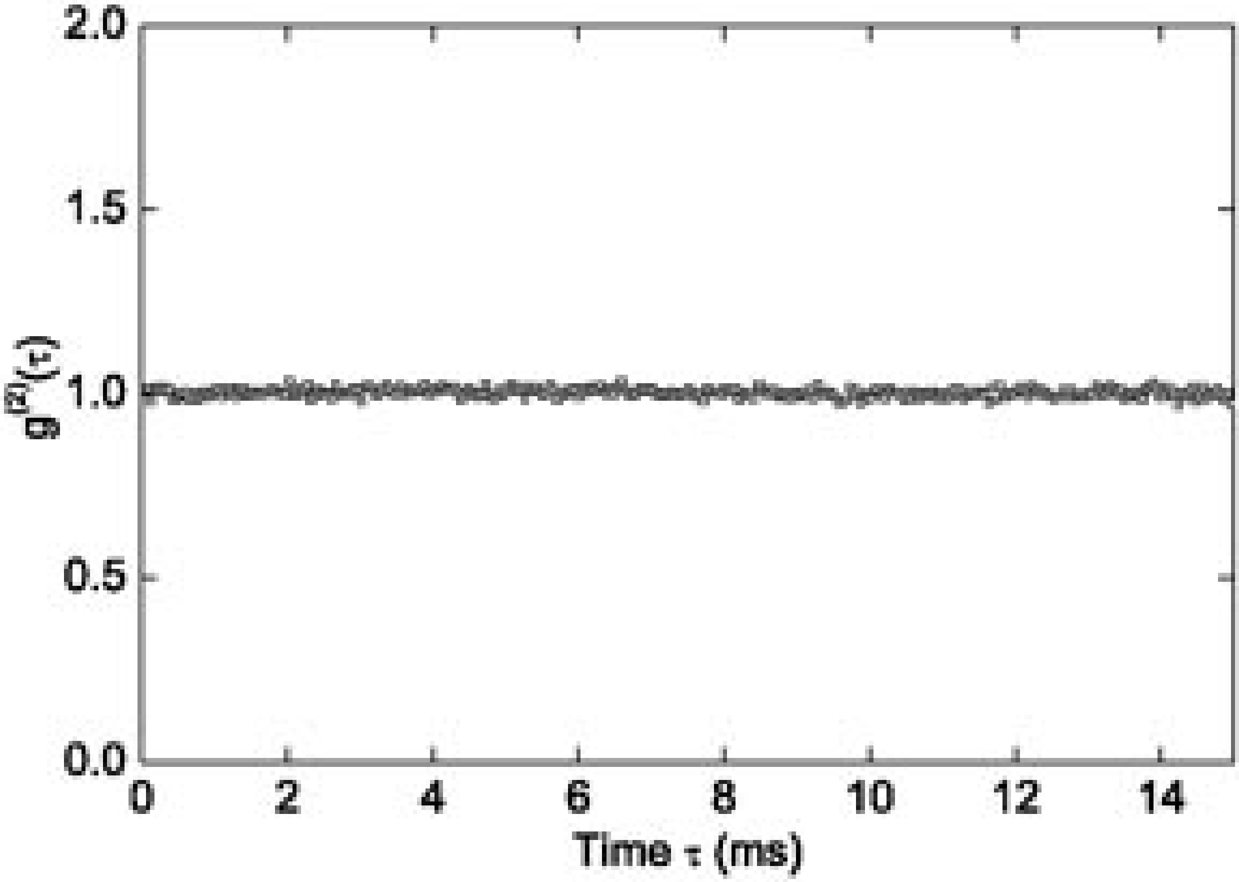


Thermal bosonic atoms are statistically identical to thermal photons !!!

[figure from A. Öttl, S. Ritter, M. Köhl, T. Esslinger, Phys. Rev. Lett. 95, 090404 (2005)]

Coherent Bosonic Atoms (BEC)

In a **Bose-Einstein Condensate (BEC)** all the atoms are in the same state. It is the analog of a laser but with atoms (coherent matter waves).



Atoms in a BEC are statistically identical to laser photons !!!

[figure from A. Öttl, S. Ritter, M. Köhl, T. Esslinger, Phys. Rev. Lett. 95, 090404 (2005)]