Appendix A - Coincidence.vi

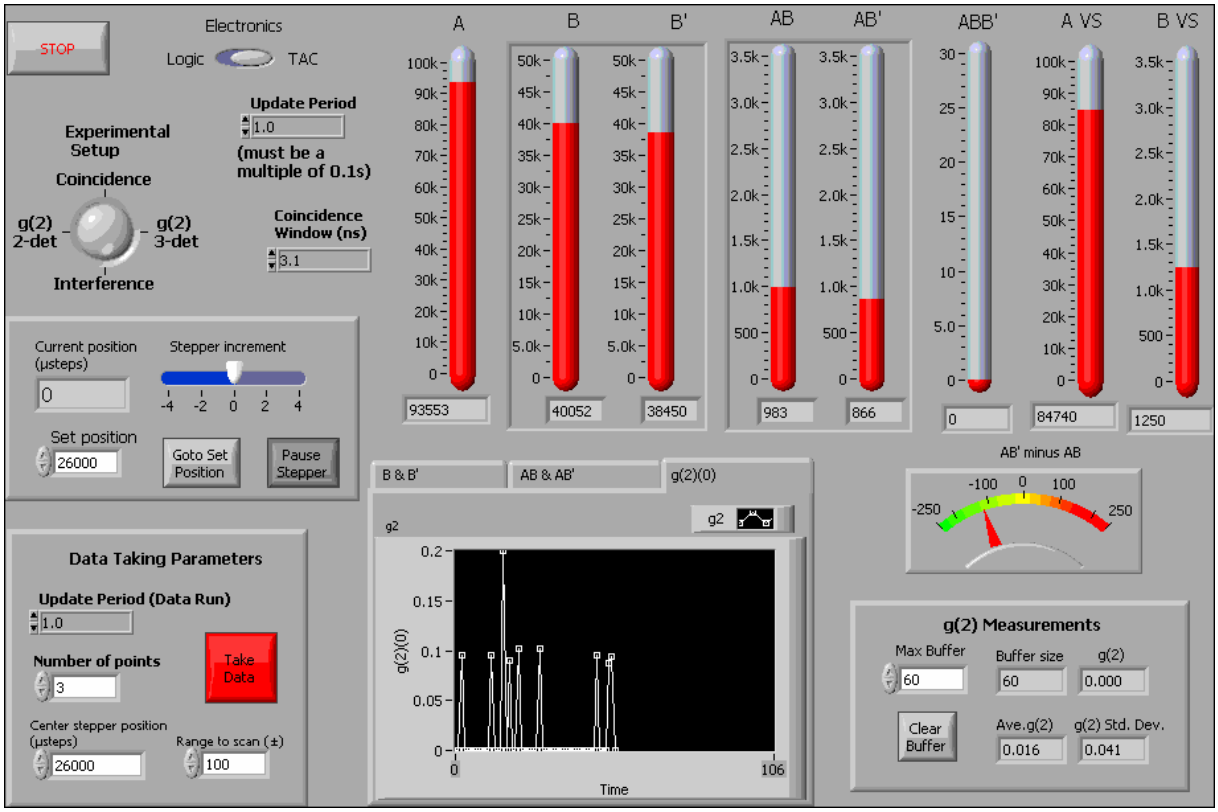
This appendix describes the LabView vi used to acquire data for several experiments: coincidence measurements, proving the existence of photons, and single photon interference.

I. Starting Out

The appearance of this vi will change depending on the experiment you are doing (as determined by the **Experimental Setup** knob on the vi.) The experiment with the most controls and indicators is the interference experiment, and the front panel for this experiment is shown below. If you are doing a different experiment, some of the objects may not be visible.

Coincidence.vi

Front Panel



Description

This is the program you use to run one of 4 different experiments:

1) Simply measuring coincidences between two beams.
2) Measuring g(2)(0) for 2-beams using 3-detectors.
3) Measuring single photon interference patterns.

4) Measuring g(2)(0) for 1-beam using 2-detectors.

Note that g(2) is calculated differently depending on whether you're making 3-detector or 2-detector measurements. The calculation also depends on whether you're using TAC's or Logic to do the coincidence detection. See details in the description of the "g(2) Measurements" parameter.

The program does not record data to a file right away, but displays the counters in real time so that you can align things.

Once everything is aligned and the parameters are set, you press the "Take Data" button. This transfers control to another program which records a data set and saves it to a file.

Uses a National Instruments PCI-6602 and reads counters 0 thru 7. The device number for this board is should be set to 2. Input to this board is via a BNC-2121 connector block.

Note that there are two controls: "Func Gen?" and "NewStep?" that tell the computer what hardware you have present in your experiment. These are useful so that the computer won't try to communicate with an instrument you don't have, causing a hang-up. These controls are not visible normally. They are located below the "Data Taking Parameters", so you'll need to scroll the window down to access them. By default they've been set to "Yes"-if you don't have these instruments, you'll want to change the defaults to "No". These parameters are only read once at the beginning--so they must be properly set BEFORE you run the program. For more info on these, see the descriptions of the individual controls.

Counters are gated by an HP (Agilent) 33120A using the SYNC (TTL) output. This unit is at GPIB address 9--program calls it on initialization to set the gate period if "Func. Gen?" is set to "Yes". Note that if you do not have a GPIB controlled function generator, you will need to set this parameter to "No". You will still need to have a 0-5V, 10Hz square wave in order to gate the counter. Connect it to the Gate 0 (PFI 38) connector.

For interference measurements, a Newport NewStep actuator (inexpensive stepper motor) is used to tilt a beam displacing polarizer to adjust the phase of a polarization interferometer. This actuator is controlled by a NewStep controller, connected to the serial port of the computer with an RS-485 to RS-232 converter. If you do not have this controller, set the "NewStep?" parameter to "No".

The inputs connect to the sources (SRCn) for the individual counters.

Electrical connections for counters:

When using TACs:

A (Counter 0): PFI 39

B (Counter 1): PFI 35

B' (Counter 3): PFI 27

AB (Counter 4): PFI 23

AB' (Counter 6): PFI 15

ABB' (or just BB' for 2-det measurement) (Counter 5): PFI 19

A Valid Start (from back of AB TAC) (Counter 2): PFI 31

B Valid Start (from back of ABB' TAC) (Counter 7): PFI 11s

When using Logic:

A (Counter 0): PFI 39

B (Counter 1): PFI 35

B' (Counter 3): PFI 27

AB (Counter 4): PFI 23

AB' (Counter 6): PFI 15

ABB' (Counter 5): PFI 19

BB' (Counter 7): PFI 11

Unused (Counter 2): PFI 31

Note that for the coincidence experiment, only 3 counters are needed: A, B, and AB. For the other 2 experiments, 7 counters are needed. Counter 7 is unused. The A Valid Start measurement is used to determine the normalization for g(2), not the raw A counts.

Note further that the A, B, and B' outputs are terminated on the BNC-2121 connector block into 50 ohms. The coincidence and Valid Start outputs are terminated straight into the BNC-2121.

The gate pulse from the 10Hz, 0-5V (TTL) clock goes to the Gate 0 (PFI 38) connector.

On startup, the program initializes the counters.

After initialization the program simply loops and displays the counts in a given time window (determined by the "Update Period" control in the upper left.) This is useful for tweaking the alignment and adjusting parameters.

Nothing is written to disk until the parameters are chosen and the "Take Data" button is pressed. This loads a second VI that records and saves data to disk. Parameters for this data acquisition phase are set in the "Data Taking Parameters" box.

When performing an interference experiment, the stepper motor will automatically adjust the tilt of the beam displacing prism, changing the phase.

Help for each of the controls and indicators can be obtained from the Contextual Help window <cntrl - H> by mousing over each control or indicator. Full documentation for each control and indicator can be obtained by printing using: File>Print>Custom, and then checking "All controls" and "Descriptions".

Controls and Indicators

Coincidence Measurements

Experimental Setup

Which measurement to perform.

Coincidence: Measures A, B, and AB counts.

g(2) 3-det: Make g(2) measurements on 2 correlated beams using 3-detectors. This is the single photon measurement.

Interference: interference measurement [with simultaneous g(2) 3-detector measurement]

g(2) 2-det: Make g(2) measurements on a single beam using 2-detectors. This is the classical field measurement.

Stop

Use this to stop. If you stop some other way you'll probably need to quit LabView and restart; you may even need to reboot the computer.

Electronics

Which coincidence electronics are being used.

This is important because different electronics have different signals connected to the various counters. It also influences the formulas that are used to calculate g(2).

Update Period

[Must be a multiple of 0.1s]

Time window (in s) for the counters during setup phase (i.e., before the "Take Data" button is pressed.) Readings update once each time window if "Status" reads "Reading Counters".

Counts A, B

Singles counts in the time window specified by “Update Period” (upper left)

Counts AB

Coincidence counts in the time window specified by “Update Period” (upper left)

AB Plot

Chart displaying history of AB coincidence counts

Update Period (Data Run) [Data Taking Parameter]

[Must be a multiple of 0.1s]

Time window (in s) for counters during data acquisition.

This applies after the "Take Data" button has been pressed.

Number of points [Data Taking Parameter]

Number of measurements that are made during data acquisition.

Error measurements are essentially useless if this is less than 5. 10 is a better minimum number. For interference measurements, you will want to use many more than this so you can better see the pattern.

Take Data [Data Taking Parameter]

Leave the setup "tweaking" mode and switch to data acquisition mode.

Func Gen?

Control function generator w/ GPIB?

If No, no GPIB commands are sent. Useful so that the program won't hang if you don't have a GPIB controlled function generator. However, in this case you still need to have a 0-5V, 10Hz square wave input to PFI38 (Gate 0) to use as a clock.

If Yes, the vi uses GPIB to sets the function generator to output a 0-5 V, 10Hz square wave to use as the clock. I still recommend using the SYNC output from the generator--then only the frequency matters.

This parameter is only read once, when the vi first starts to run. Therefore, it needs to be set BEFORE you run the program.

NewStep?

Is the NewStep controller present?

If No, there is no attempt to communicate with the NewStep controller. Useful if you don't have a NewStep controller. In this case, the "Interference" experiment is unavailable. If you set "Experimental Setup" to "Interference", the program will act as though it's set to "g(2) 3-det".

If Yes, the NewStep functions normally.

This parameter is only read once, when the vi first starts to run. Therefore, it needs to be set BEFORE you run the program.

3-Detector g(2) Measurements

All of the above parameters apply, plus the following:

Coincidence window Coincidence window for ABB' or BB' measurements.

Used to determine expected g(2) for 2-beam (single-photon) measurements. Basically, this parameter determines the number of expected accidental ABB' counts.

Needed to determine g(2) for single-beam (classical) measurements.

Counts A, B, B'

Singles counts in the time window specified by "Update Period" (upper left)

Counts AB, AB'

Coincidence counts in the time window specified by "Update Period" (upper left)

Counts ABB'

Three-fold coincidence counts in the time window specified by "Update Period" (upper left)

Counts A VS

A Valid starts.

Only used for TAC measurements. Comes from valid start output of AB TAC, and is connected to Counter 2.

This is useful for measuring how many starts get triggered from the A detector. For A rates of about 100k/S or less, the Avs will be slightly less than A (within about 10%). For larger A rates, this can be significantly less than A. Really should keep this rate so that Avs is within 10% of A.