Electronics Imaging System for the Synchrotron Light Source

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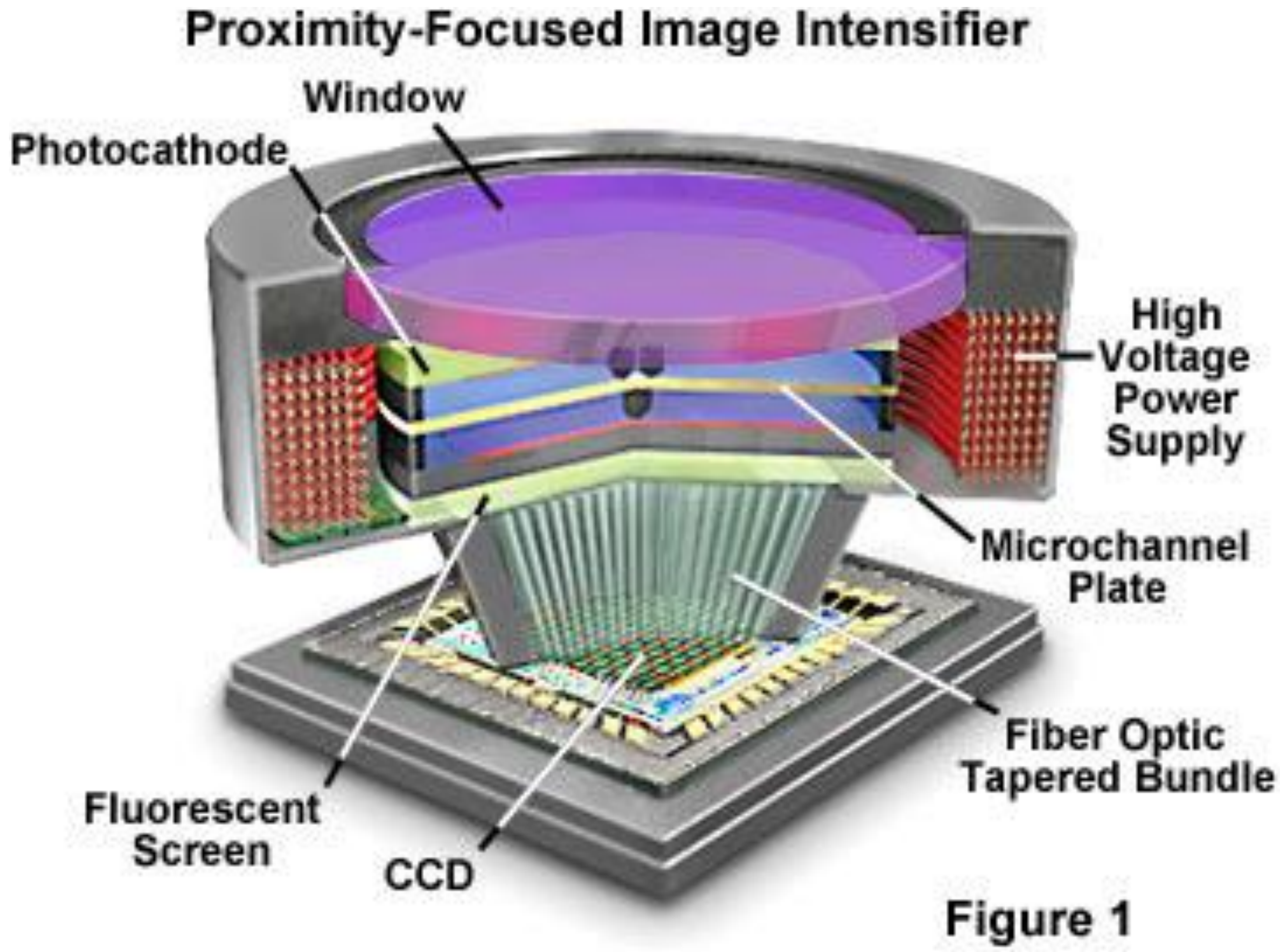
PI-MAX Data Acquisition

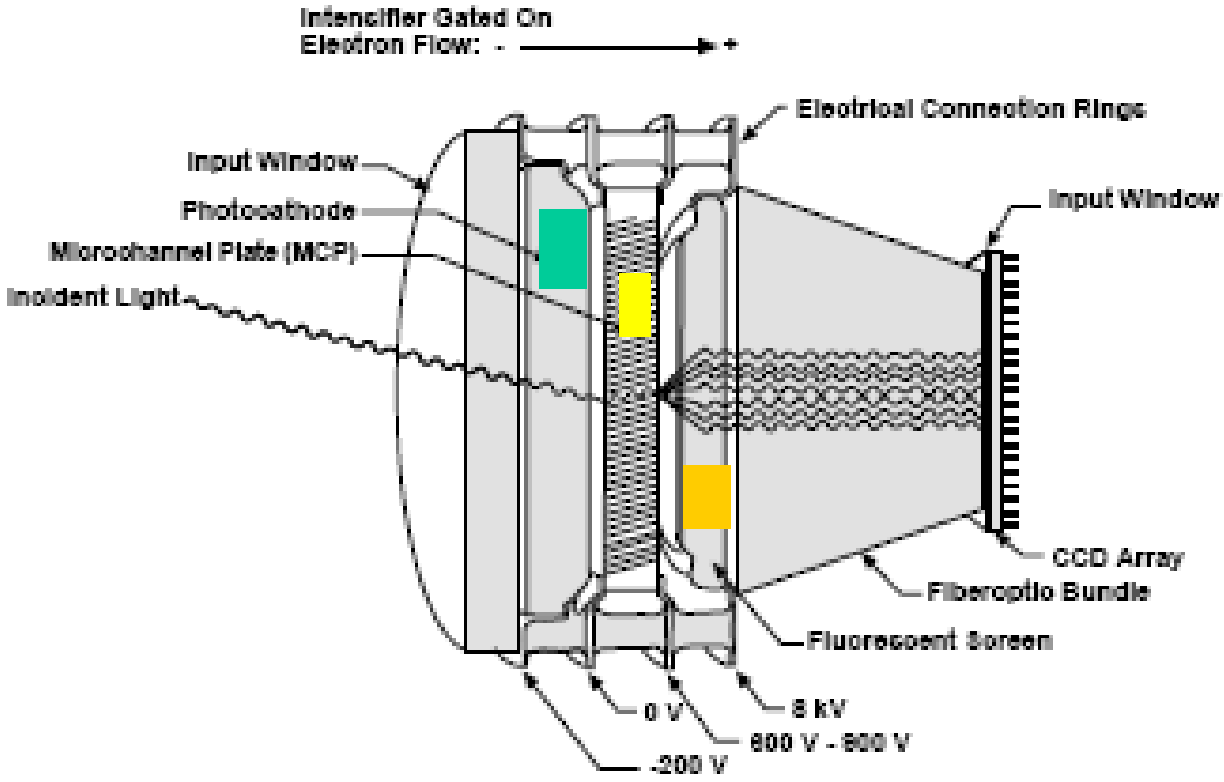
- Major components of the Intensified-CCD
- PI-Max Data Acquisition system
- Operation of PI-Max Data Acquisition system
- Application in synchrotron light imaging.

The PI-MAX imaging system

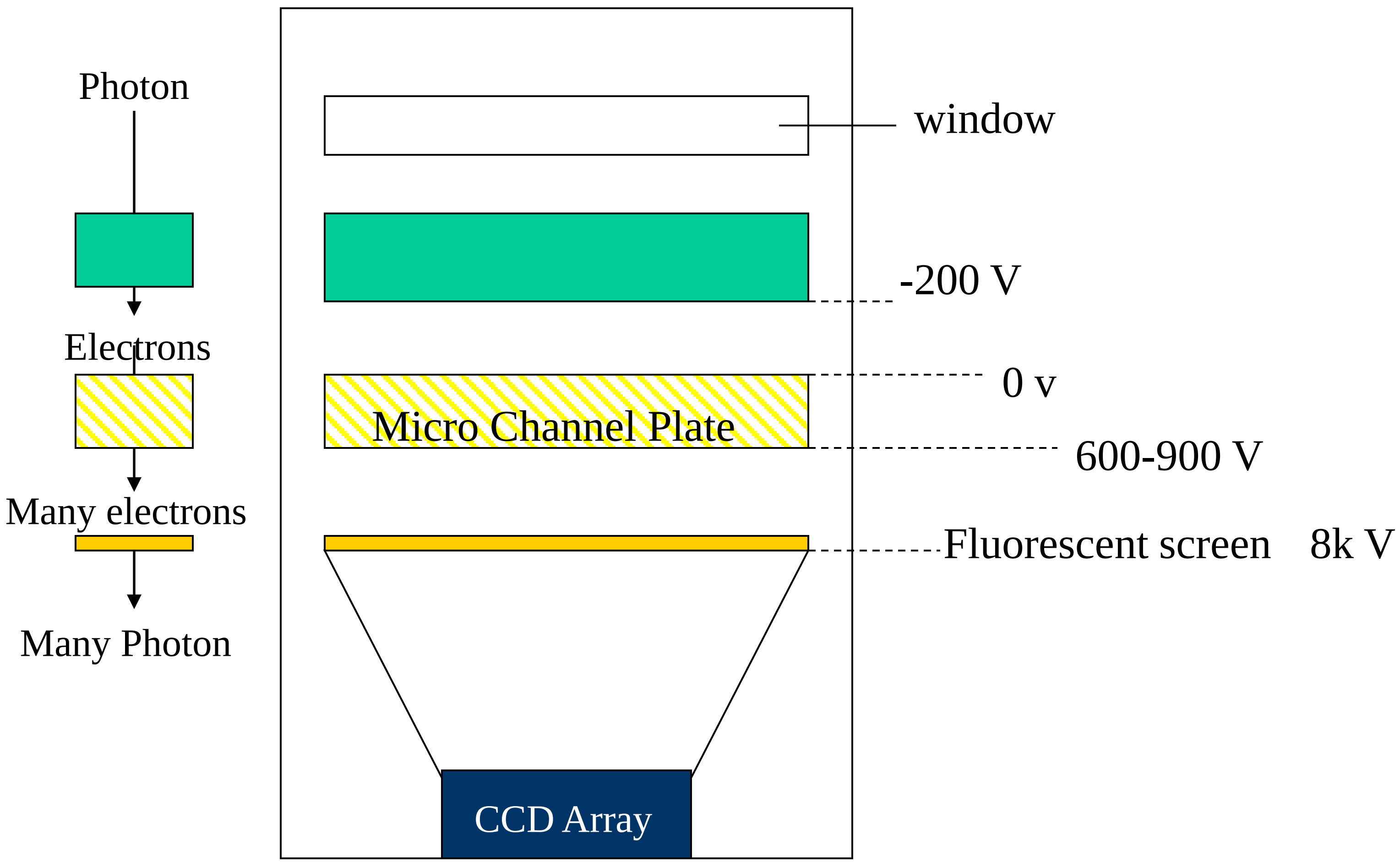
ICCD camera


Proximity-Focused Image Intensifier
Window
Photocathode
High Voltage Power Supply
Microchannel Plate
Fiber Optic Tapered Bundle
Fluorescent Screen
CCD
Figure 1

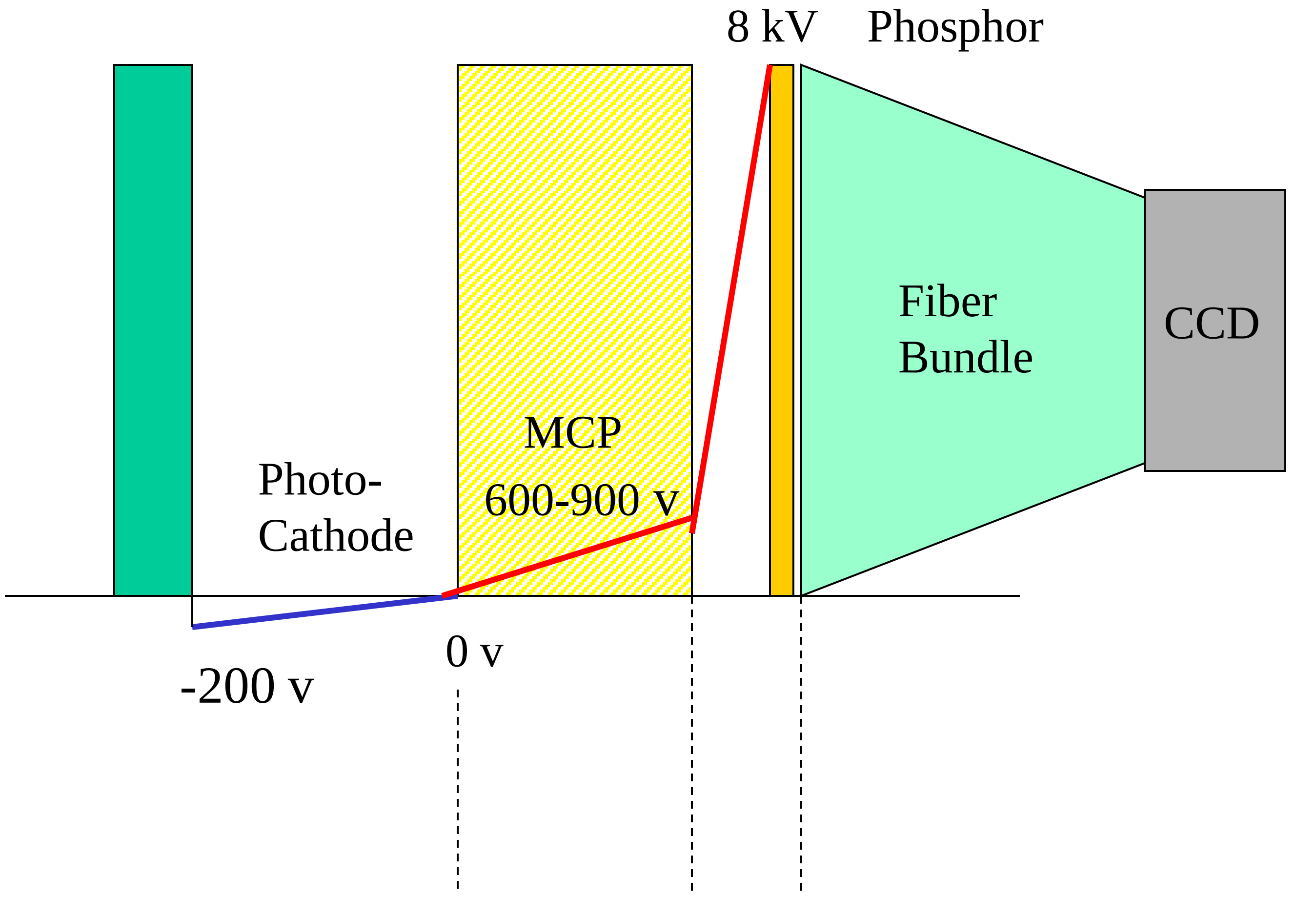
The image intensifier



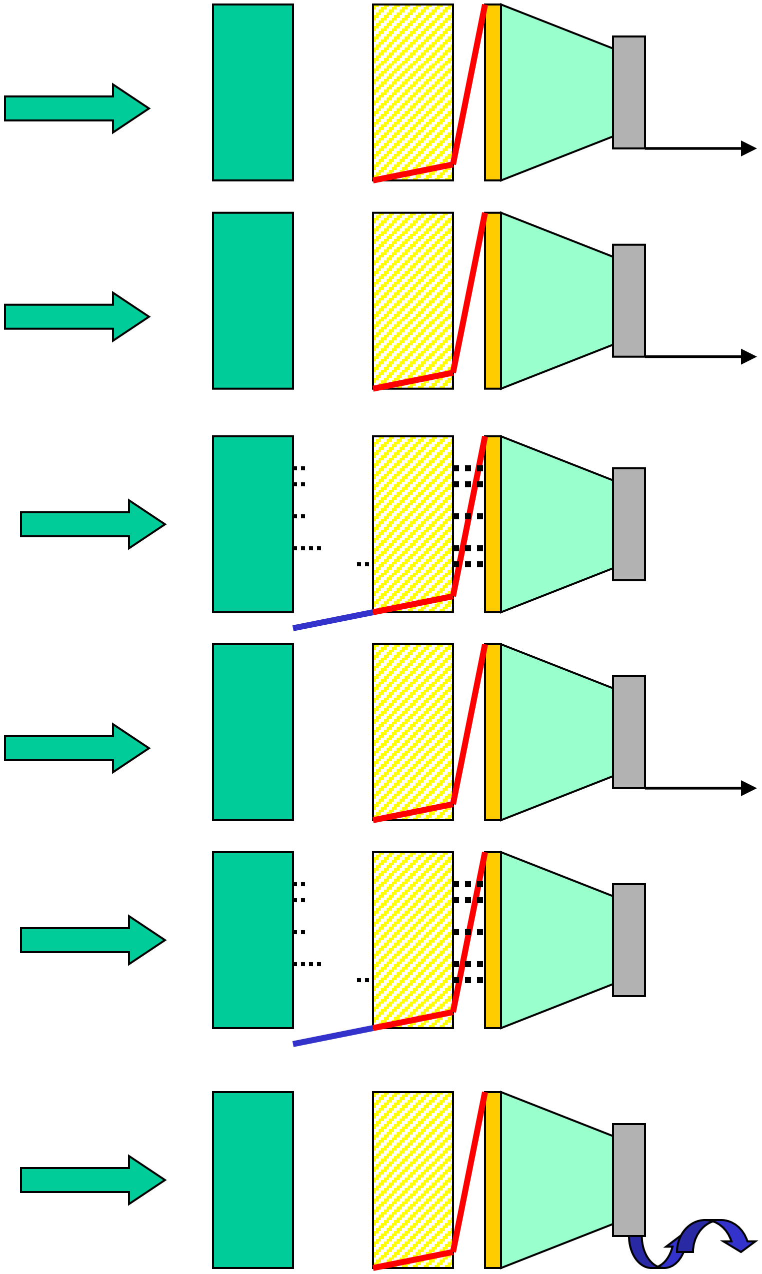
Major components of an Intensified-CCD



Voltage Bias of An Intensifier-CCD



Camera Operating Sequence



Dark charges cleaning cycle starts when the camera is turned on.

After receiving the STARTACQ command, complete the last cleaning cycle in the CCD

With cathode bias voltage on, electrons are accelerated from the cathode to the MCP

With cathode bias voltage on, electrons are accelerated from the cathode to the MCP

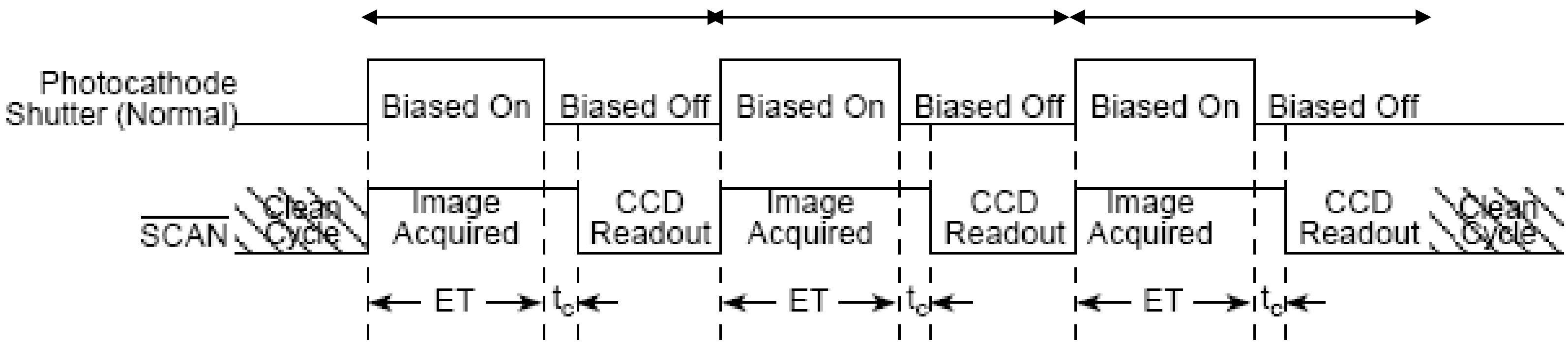
At the end of the exposure time, the cathode bias voltage is off

CCD scan starts. Electric charges are transferred to the output amplifier.

Different mode of operation of the camera by controlling the cathode and MCP bias

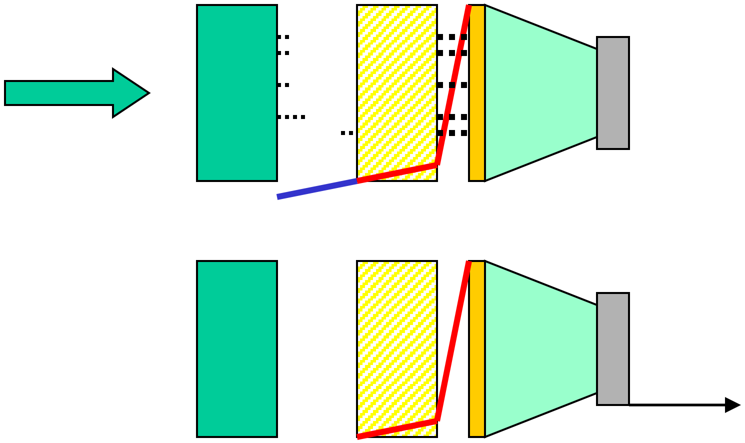
Mode of operation	Cathode bias	MCP	Read out
Safe	off	on	Continuously free running
Shutter	On/off	on	At the end of the exposure time
Gate	On/off	on	After the last gate pulse
Pre-pulse	On/off	On/off	

Shutter Mode

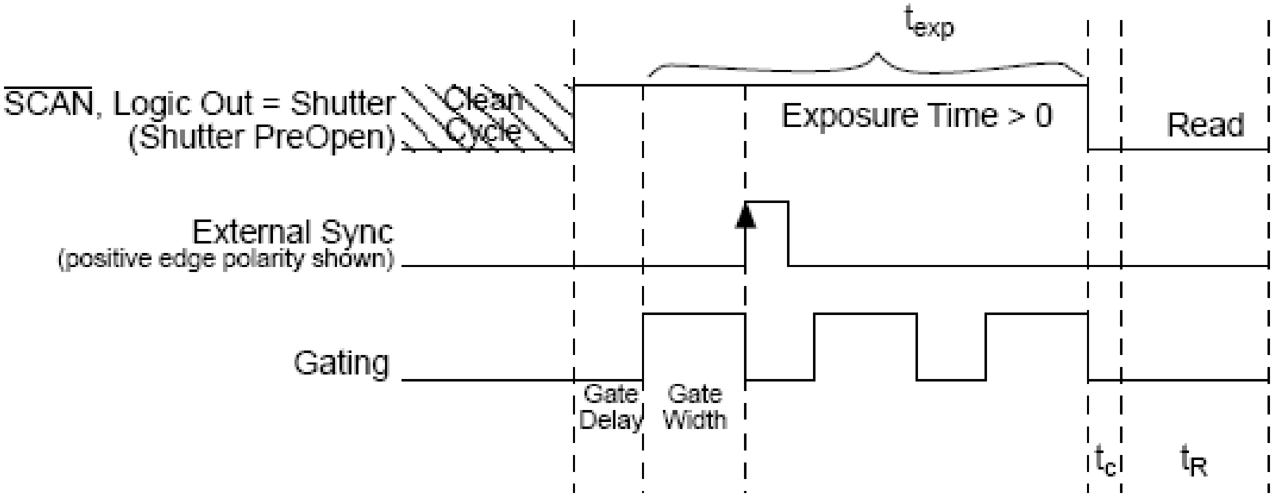


ET = exposure time set in Experiment Setup

t_c = 6 msec shutter compensation for Electronic shutter

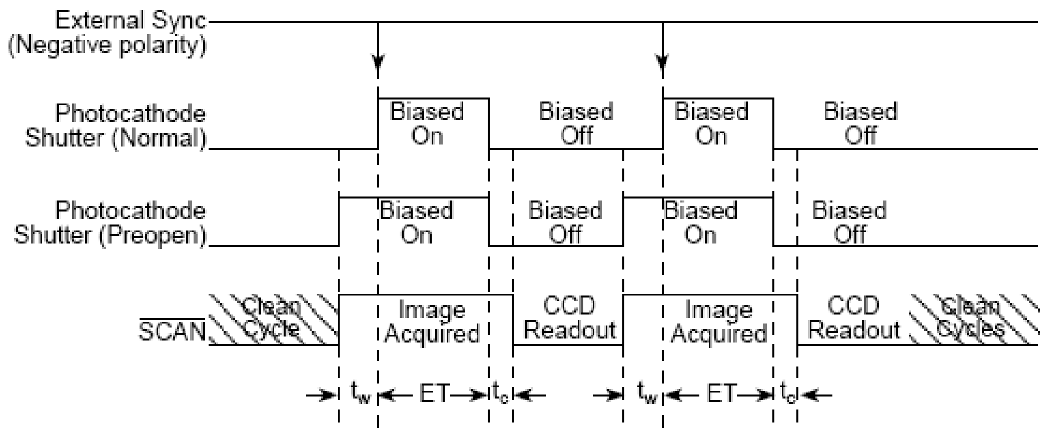


GATE mode



t_{exp} = time array is exposed to incoming signal
t_c = shutter compensation time
t_R = time required to readout the array

Figure 53. DG535: External Sync, PreOpen, Exposure Time > 0 sec.



Shutter Mode

Number of Images = 2

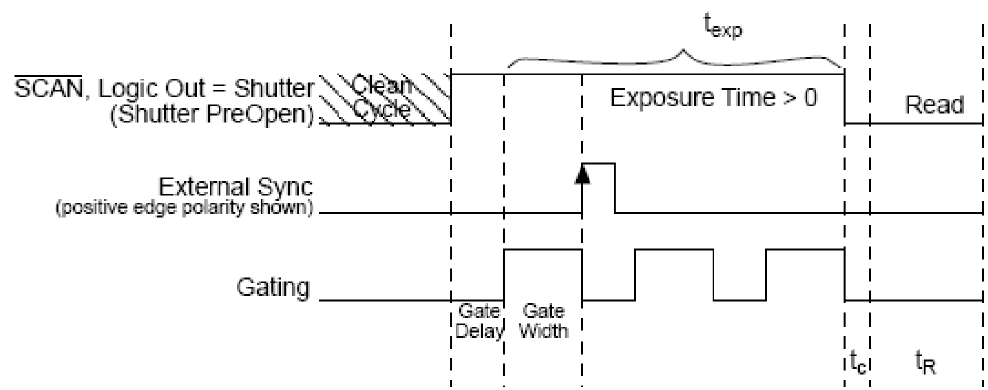
t_w = time between STARTACQ command and Photocathode bias on in Shutter (Normal)

ET = exposure time set in Experiment Setup

t_c = 6 msec shutter compensation for Electronic shutter

Figure 23. Timing Diagram: External Sync

Gate Mode



t_{exp} = time array is exposed to incoming signal

t_c = shutter compensation time

t_R = time required to readout the array

Figure 53. DG535: External Sync, PreOpen, Exposure Time > 0 sec.

Bracket pulsing of MCP

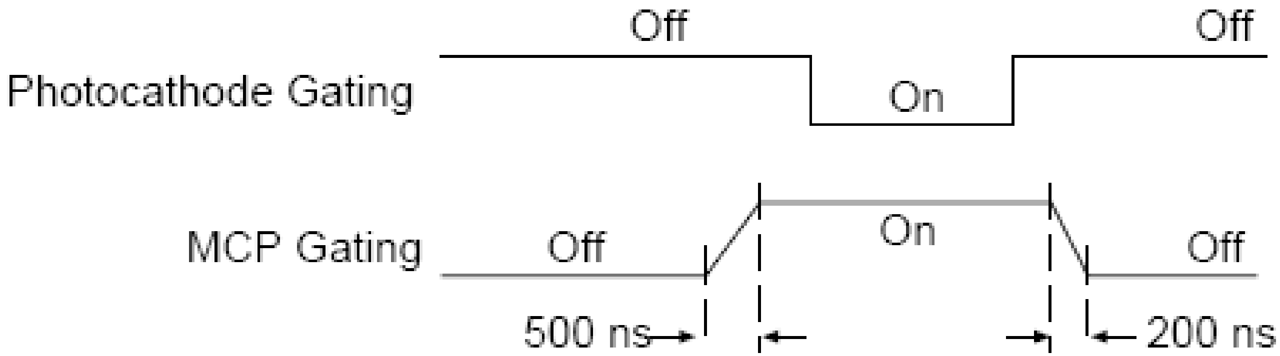


Figure 29. Timing: Bracket Pulsing

Interface the camera controller with the outside world

- Input to the PI-MAX camera –

  External events initiate the PI-MAX operation

- Output from the PI-MAX camera to synchronize external events –

  PI-MAX initiates the external event

- Connecting the PI-MAX

Input to the PI-MAX camera

- Start the PI-MAX camera operation
- The cathode bias voltage…..[Ext. trigger in]
- The charges read out…   [Ext. Syn. In]
- The bias of MCP with a bracket pulse.. [Pre Trigger in]

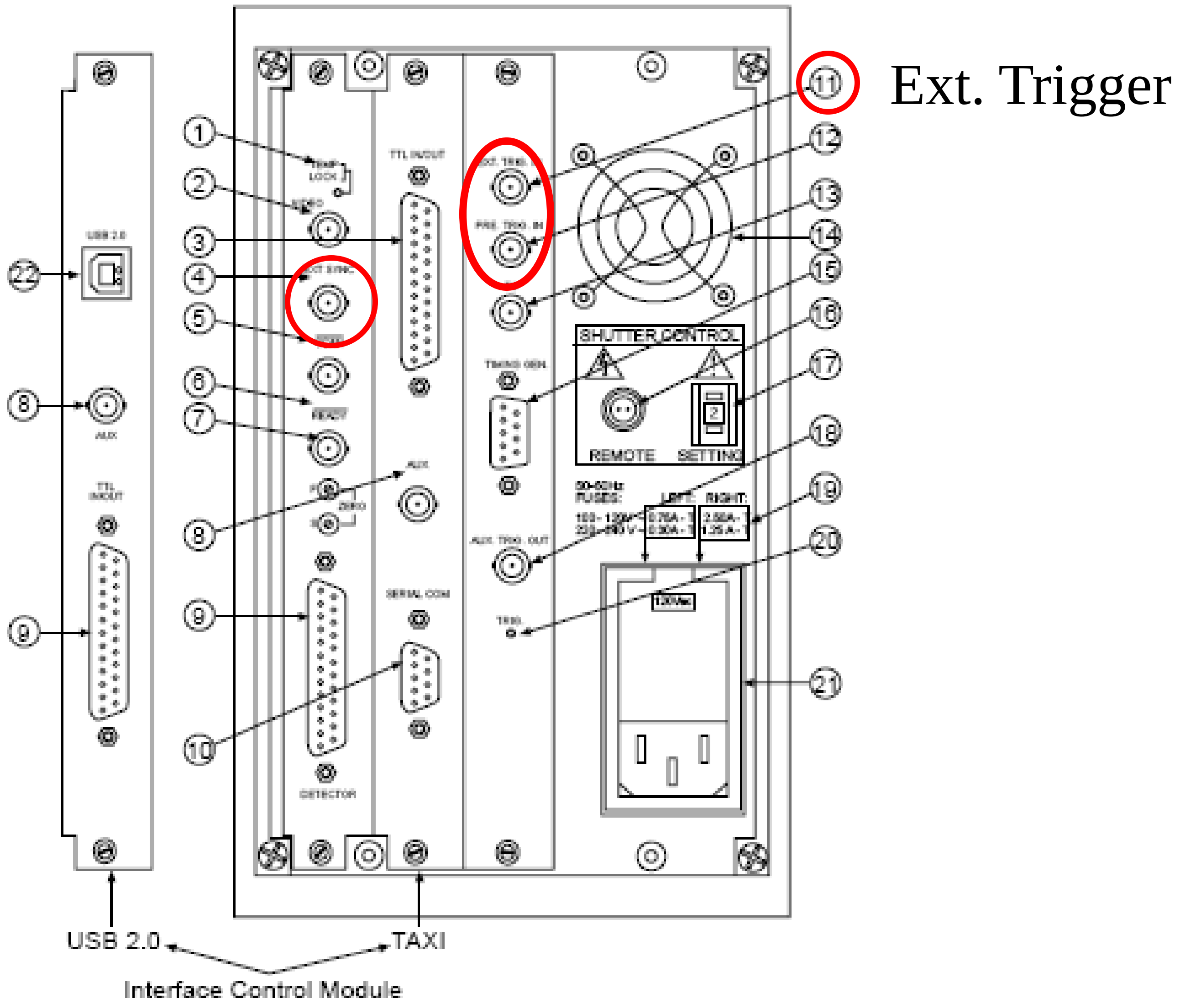


Figure 77. ST-133A Rear Panel Callouts

Out put from the PI-MAX camera

- To synchronize external events
- Variable delay trigger output with reference to the **PTG** **[AUX]**
- Coincident trigger pulse output with the input **GATE** PULSE. [To]

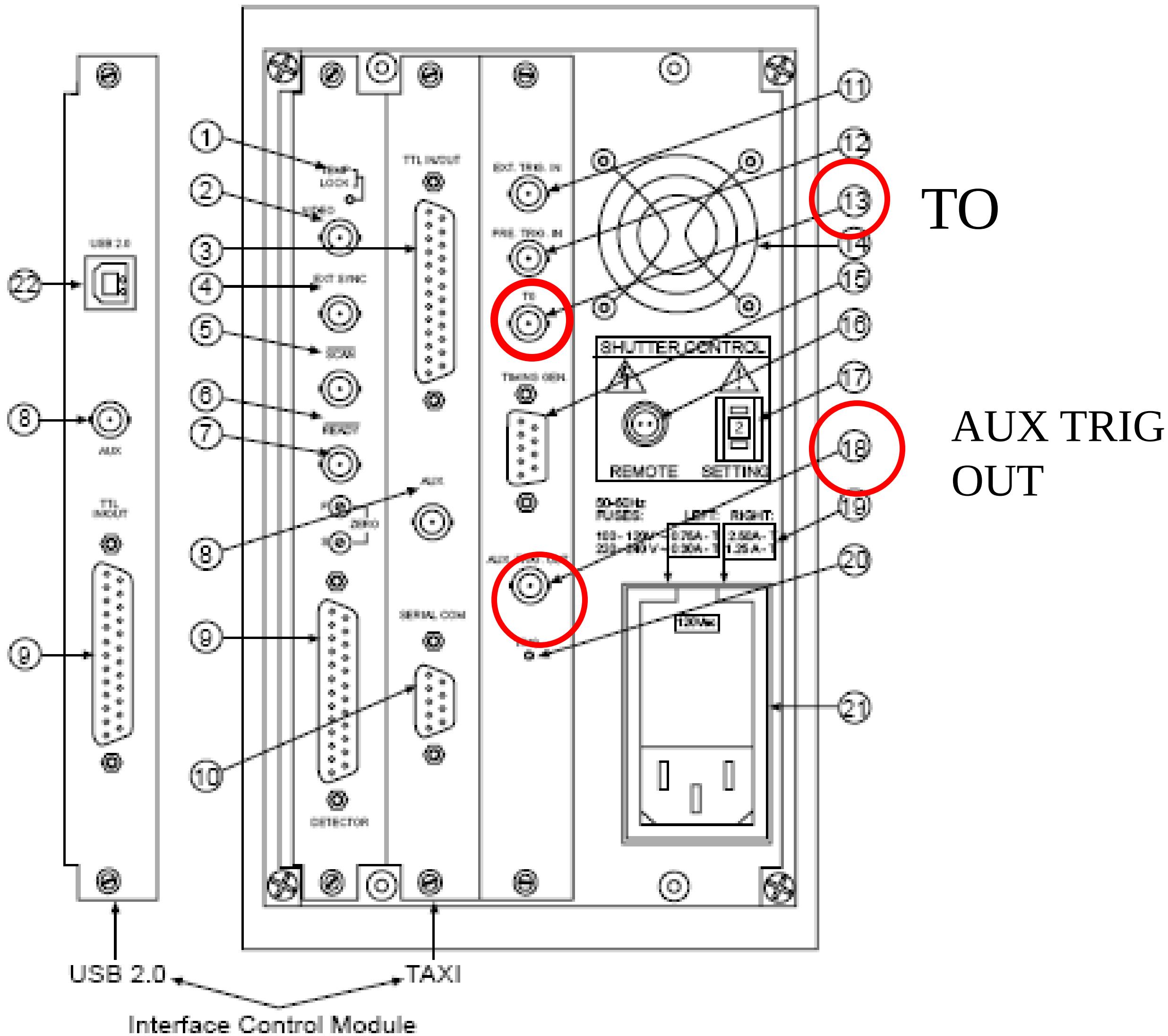


Figure 77. ST-133A Rear Panel Callouts

Connecting the PI-MAX

- Timing Cable [9 pin connector]
- Communicating with the computer [serial com, 9 pin connector]
- Data transfer + bias +control [32 pin connector]

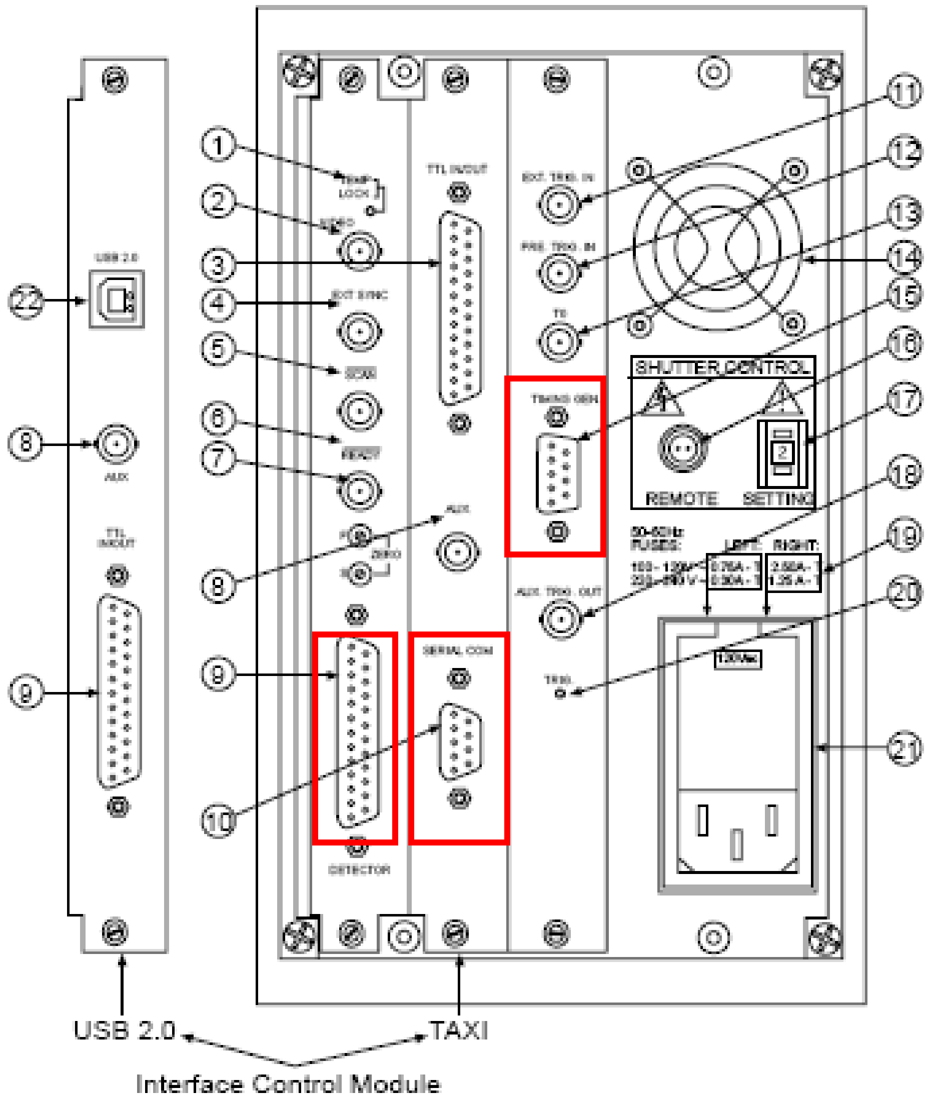
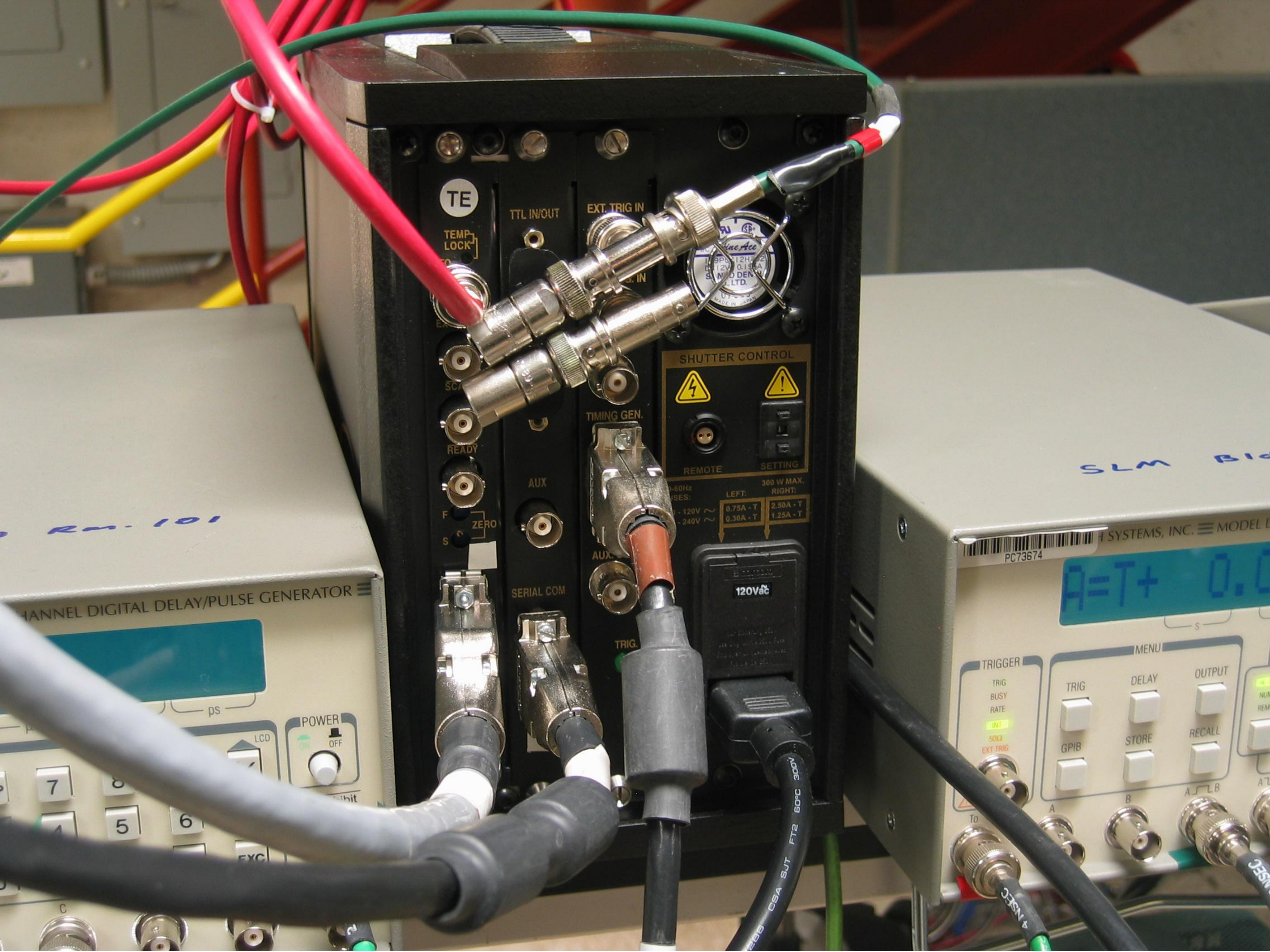


Figure 77. ST-133A Rear Panel Callouts

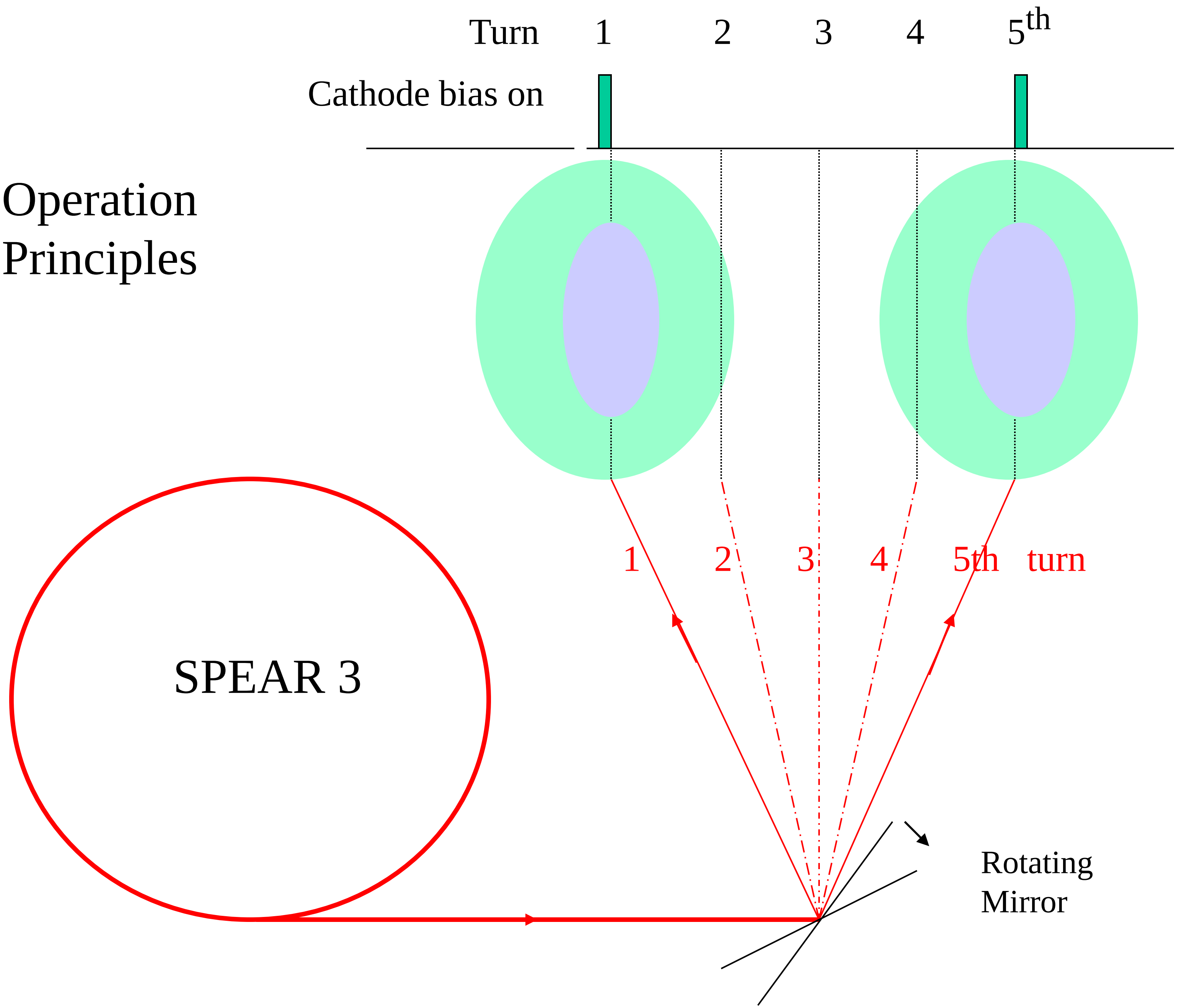

TE
TEMP LOCK
TTL IN/OUT
EXT. TRIG IN
READY
ZERO
AUX
TIMING GEN.
SHUTTER CONTROL
REMOTE
SETTING
300 W MAX.
LEFT:
RIGHT:
0.75A - T
0.30A - T
2.50A - T
1.25A - T
120Vac
SERIAL COM
TRIG.
HANNEL DIGITAL DELAY/PULSE GENERATOR
Rm. 101
POWER
ON
OFF
LCD
ps
EXC
SLM
PC73674
SYSTEMS, INC.
A=T+
TRIGGER
TRIG
BUSY
RATE
INT
50Ω
EXT TRIG
MENU
DELAY
OUTPUT
GPIB
STORE
RECALL
B

Simulating the synchrotron light imaging experiment

Objective: Imaging light pulse from the same bucket after a number of turns

- It takes about 1 micro-second for the bunch to circulate the orbit once. We see the light pulses separated by an interval of 1 microsecond.
- We want to look at the light from the bucket after a number of turns.

Operation Principles



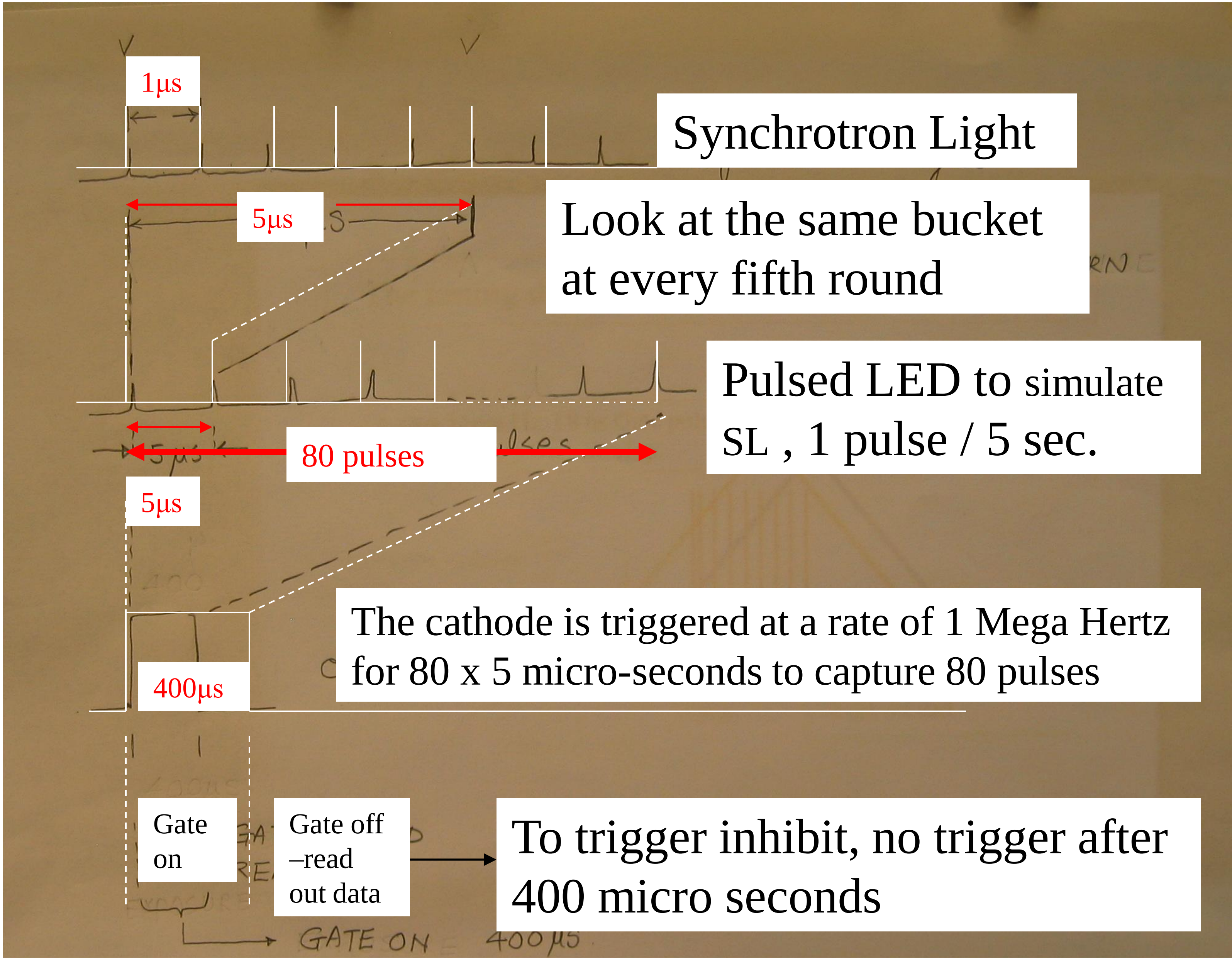
Some design considerations on imaging synchrotron light

Synchrotron Light Characteristics

- Pulse width = 5- 30 pico second.
- Pulse to pulse separation = approx. 2-3 nano-sec.
- Cycle time = 1 micro-sec.

Design consideration of the scanning system

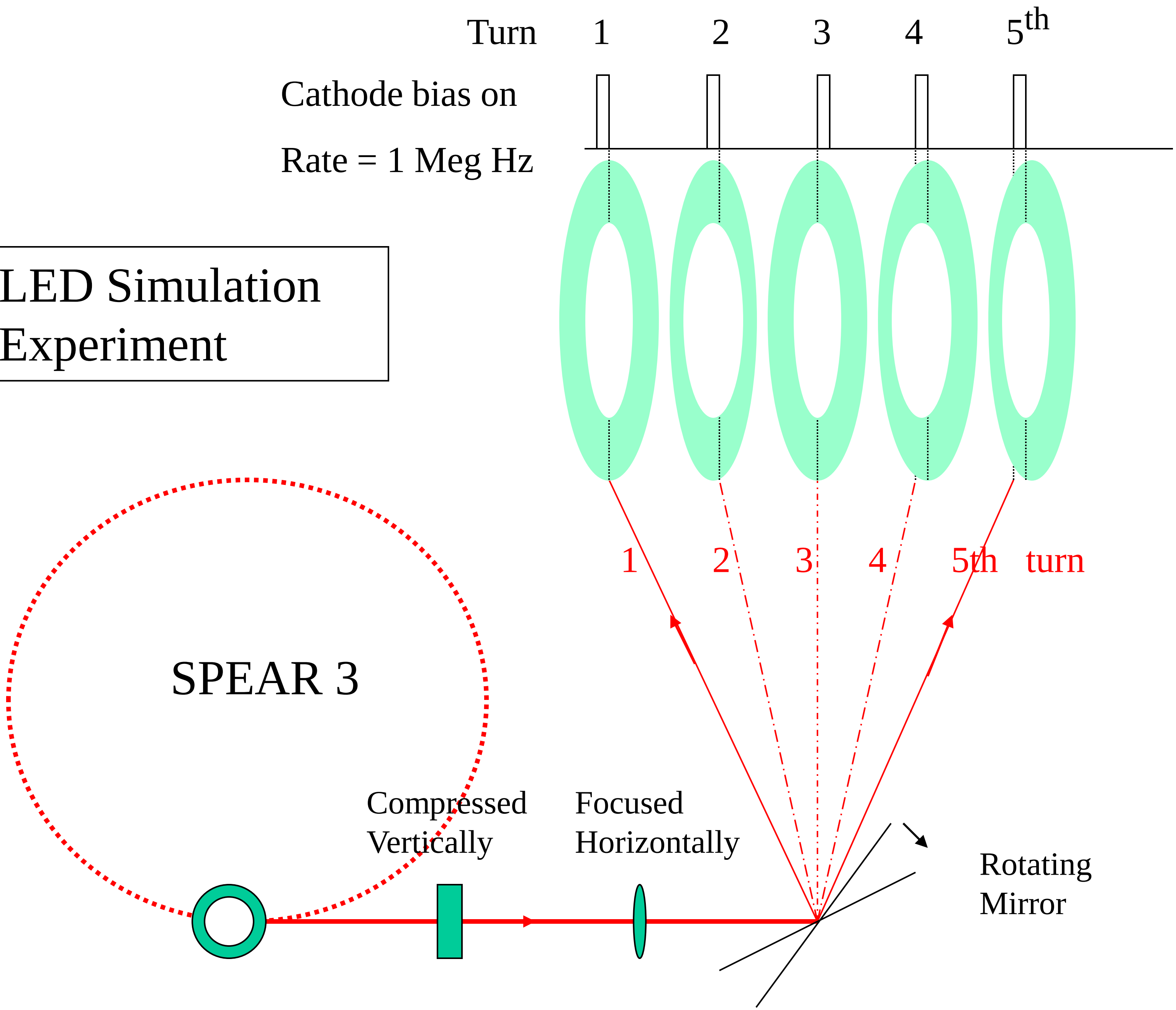
- In order to capture a single shot of the light with minimum smear, the gate width << pulse separation.
- The temporal separation between gate pulses is long enough so that the images on the sensor do not overlap.


1μs
Synchrotron Light
5μs
Look at the same bucket at every fifth round
Pulsed LED to simulate SL , 1 pulse / 5 sec.
80 pulses
5μs
The cathode is triggered at a rate of 1 Mega Hertz for 80 x 5 micro-seconds to capture 80 pulses
400μs
Gate on
Gate off –read out data
To trigger inhibit, no trigger after 400 micro seconds
GATE ON
400μs

Design considerations for simulating the synchrotron light imaging with a scanning mirror and ICCD

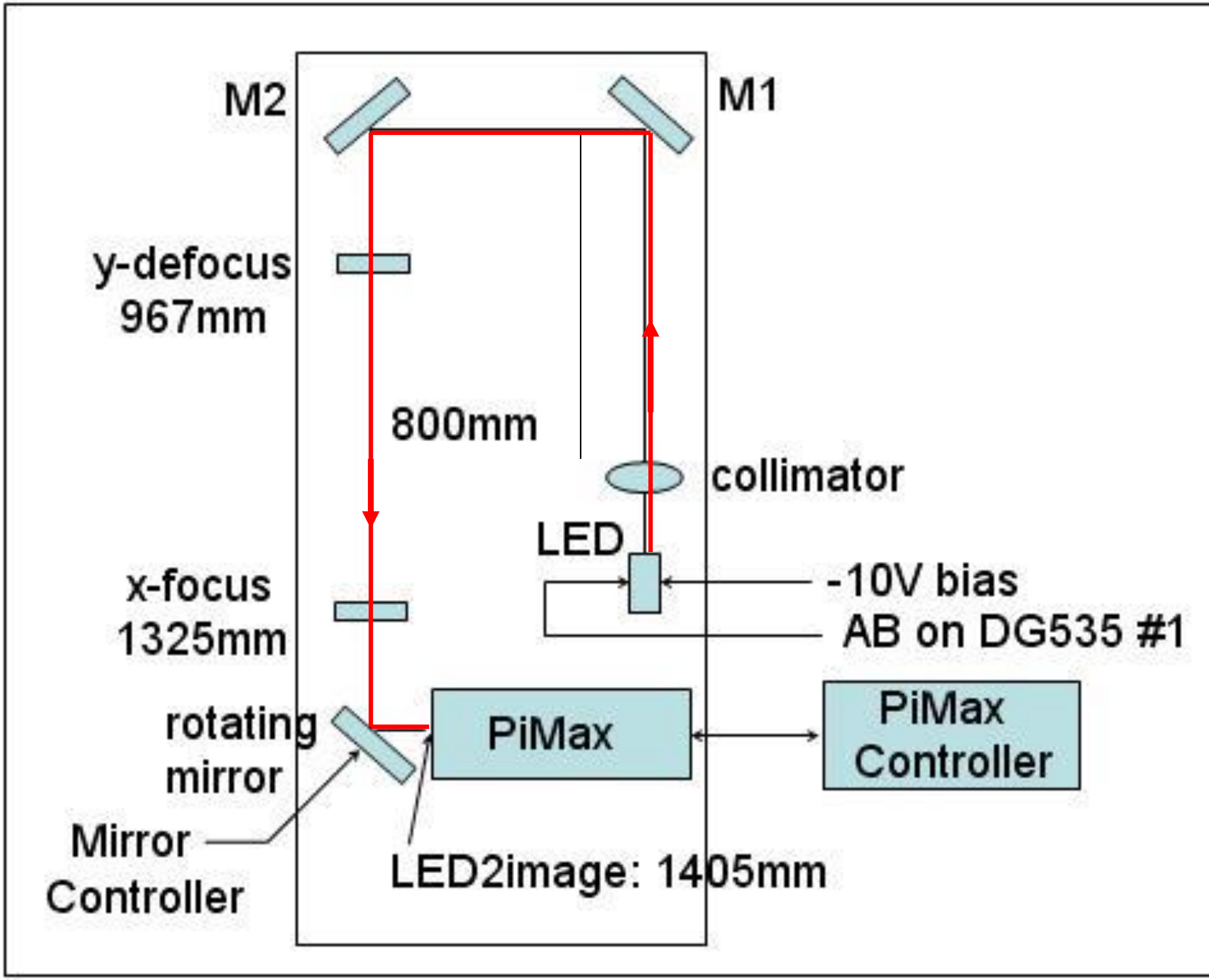
- Synchrotron light – LED
  - Rep rate = 1 mega hertz,
  - Pulse width = approx. 15 ns.
- Imaging Sensor gating requirements
  - Images of the SL from the same bunch are recorded at a designated number of turns.
  - The images of the SL shots separate from each other
  - Ability to take multiple images in each frame
  - Read out the data only after each frame is completed
  - Ability to accumulate many frames

LED Simulation Experiment



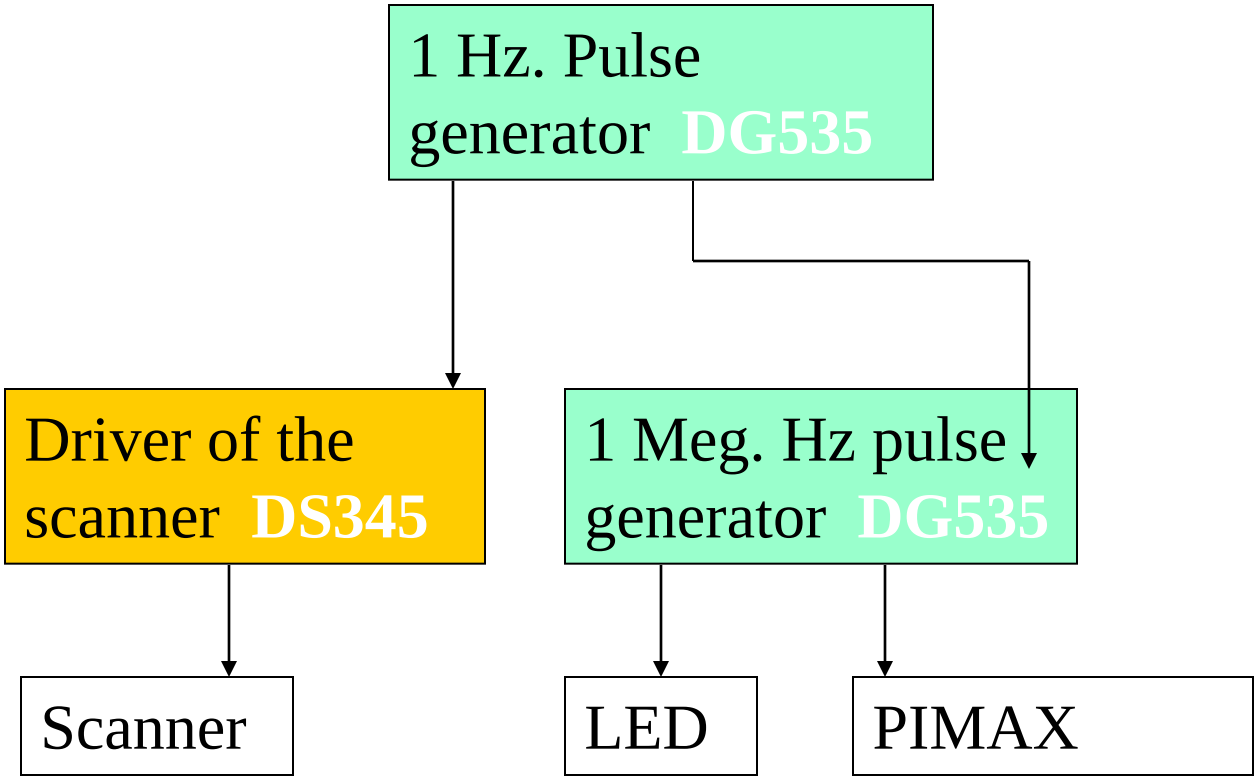
Would the scanning mirror cause image smear?

- Question for the class



M2
M1
y-defocus
967mm
800mm
collimator
LED
-10V bias
AB on DG535 #1
x-focus
1325mm
rotating
mirror
PiMax
PiMax
Controller
Mirror
Controller
LED2image: 1405mm

Driver requirements




PC73674
H SYSTEMS, INC. MODEL DG535 FOUR CHANNEL DIGITAL DELAY/PULSE GENERATOR
A=T+ 0.000220000000
s
ms
µs
ns
ps
TRIGGER
TRIG
BUSY
RATE
INT
50Ω
EXT TRIG
<10V
MENU
TRIG
DELAY
OUTPUT
GPIB
STORE
RECALL
NUM
REM
BSP
7
8
9
+/−
·
4
5
6
EXP
0
1
2
3
EXC
LCD
POWER
ON
OFF
Trig Inhibit
To
A
B
A B
A B
C
D
C D
C D

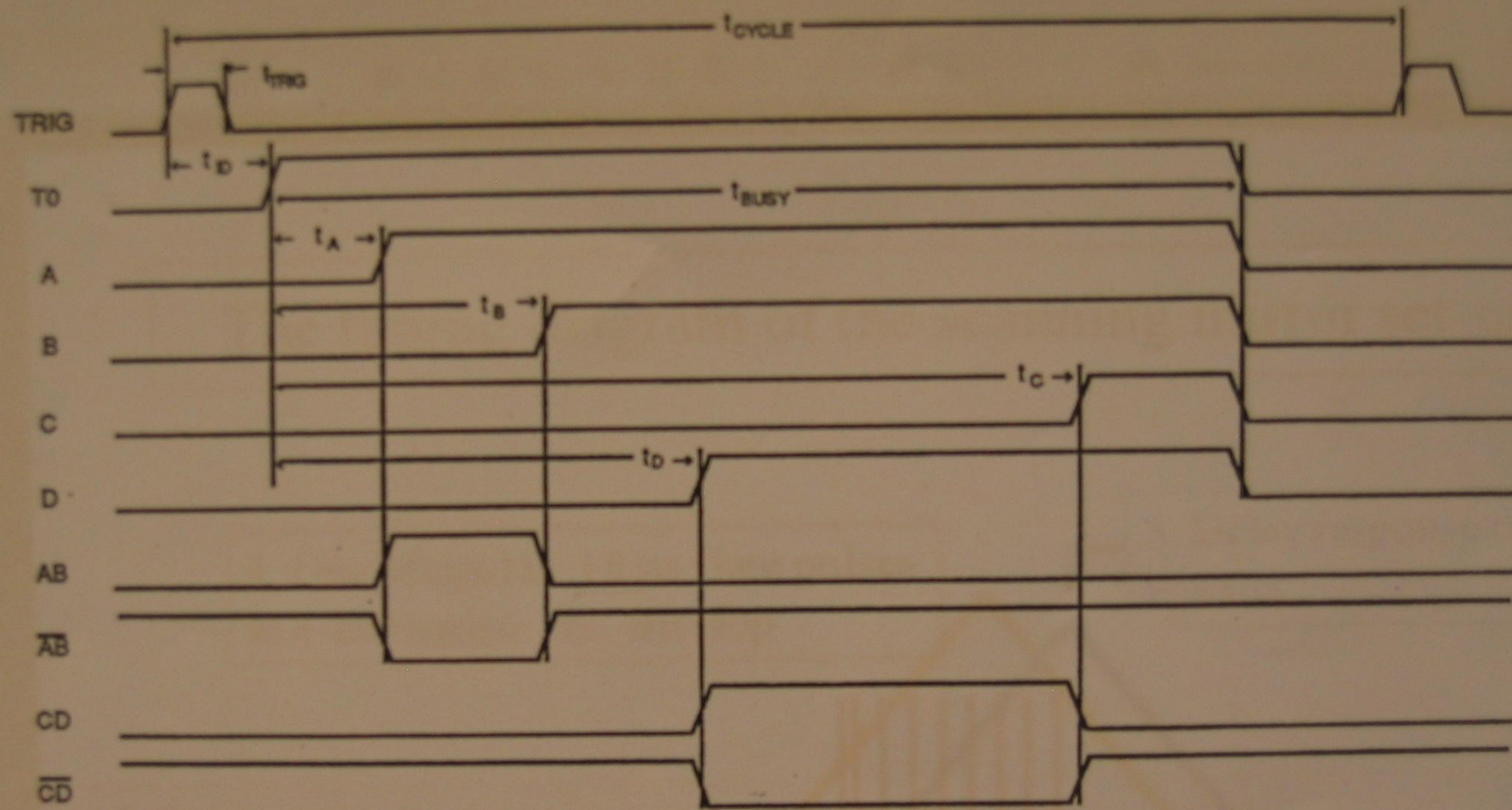
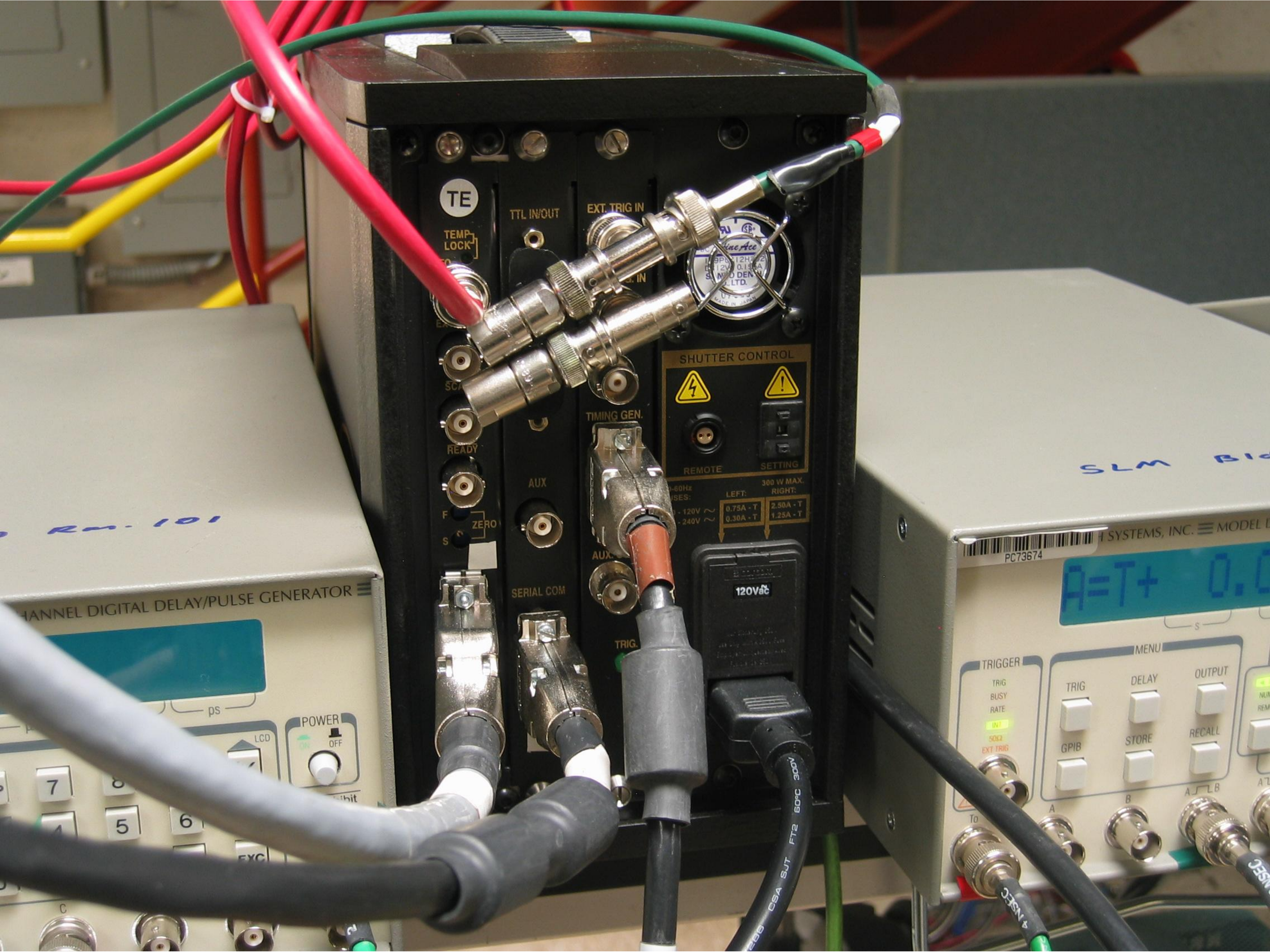
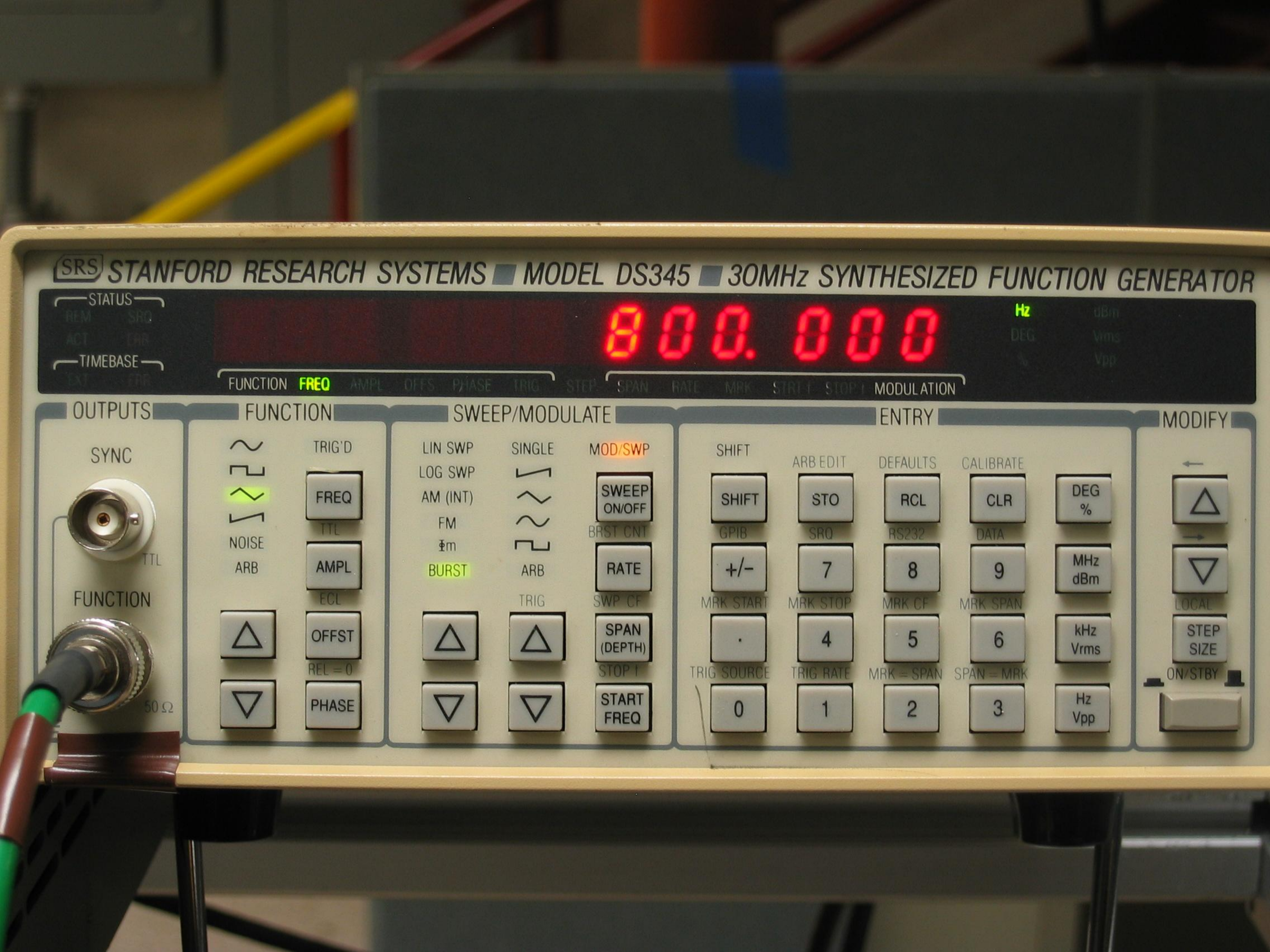


Figure - 7 DG535 Timing Diagram



TE
TEMP LOCK
TTL IN/OUT
EXT. TRIG IN
READY
AUX
ZERO
TIMING GEN.
SERIAL COM
TRIG.
SHUTTER CONTROL
REMOTE
SETTING
300 W MAX.
LEFT:
RIGHT:
0.75A - T
0.30A - T
2.50A - T
1.25A - T
120Vac
HANNEL DIGITAL DELAY/PULSE GENERATOR
POWER
Rm. 101
SLM
PC73674
A=T+
TRIGGER
MENU
TRIG
DELAY
OUTPUT
GPIB
STORE
RECALL


SRS STANFORD RESEARCH SYSTEMS MODEL DS345 30MHz SYNTHESIZED FUNCTION GENERATOR
STATUS
TIMEBASE
800.000
Hz
FUNCTION FREQ AMPL OFFS PHASE TRIG
STEP
SPAN RATE MRK MODULATION
OUTPUTS
SYNC
TTL
FUNCTION
50 Ω
FUNCTION
TRIG'D
FREQ
TTL
AMPL
ECL
OFFST
REL = 0
PHASE
NOISE
ARB
SWEEP/MODULATE
LIN SWP
LOG SWP
AM (INT)
FM
Φm
BURST
SINGLE
ARB
TRIG
MOD/SWP
SWEEP ON/OFF
BRST CNT
RATE
SWP CF
SPAN (DEPTH)
START FREQ
ENTRY
SHIFT
ARB EDIT
DEFAULTS
CALIBRATE
SHIFT
STO
RCL
CLR
DEG %
GPIB
SRQ
RS232
DATA
+/-
7
8
9
MHz dBm
MRK START
MRK STOP
MRK CF
MRK SPAN
.
4
5
6
kHz Vrms
TRIG SOURCE
TRIG RATE
MRK = SPAN
SPAN = MRK
0
1
2
3
Hz Vpp
MODIFY
LOCAL
STEP SIZE
ON/STBY


PC73674
H SYSTEMS, INC. ≡ MODEL DG535 ≡ FOUR CHANNEL DIGITAL DELAY/PULSE GENERATOR
A=T+ 0.000220000000
s
ms
µs
ns
ps
TRIGGER
TRIG
BUSY
RATE
INT
50Ω
EXT TRIG
<10V
MENU
TRIG
DELAY
OUTPUT
GPIB
STORE
RECALL
NUM
REM
BSP
7
8
9
+/−
LCD
.
4
5
6
EXP
0
1
2
3
EXC
POWER
ON
OFF
Trig Inhibit
To
A
B
A B
A B
C
D
C D
C D

Timing sequence of DS 535

- Repetition rate = 1 Hz.
- A=T + 220 micro-sec
- B=A + 410 micro-sec.
- C=A + 70 ns
- D=c + 7.6 ns
- TO terminates at the slowest of A,B,C or D.
- The new cycle starts at 800 ns. later

- Rep. Rate = 1 Mega Hz.
- A=T + 100 ns
- B=A + 18 ns
- C=A- 50ns
- D=T + 3.5 micro sec.
- TO terminates at the slowest of A,B,C or D.
- The new cycle starts at 800 ns. later

Class activity:
Do the timing diagram of
DSG 535
Triggering at1 Meg. Hz operation

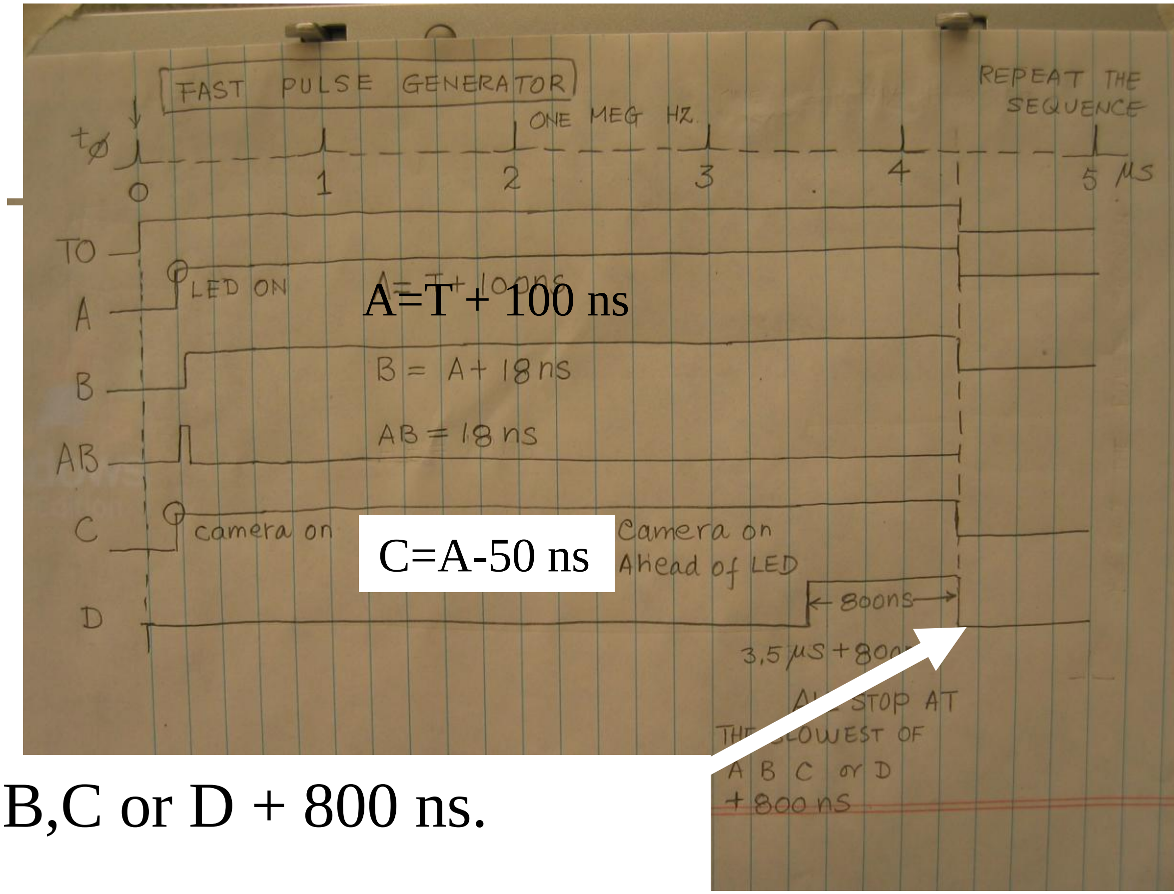
1 Mega-Hertz trigger pulse

A= T + 100 ns

B= A + 18 ns

C= A – 50 ns

D= T + 3.5 micro-sec



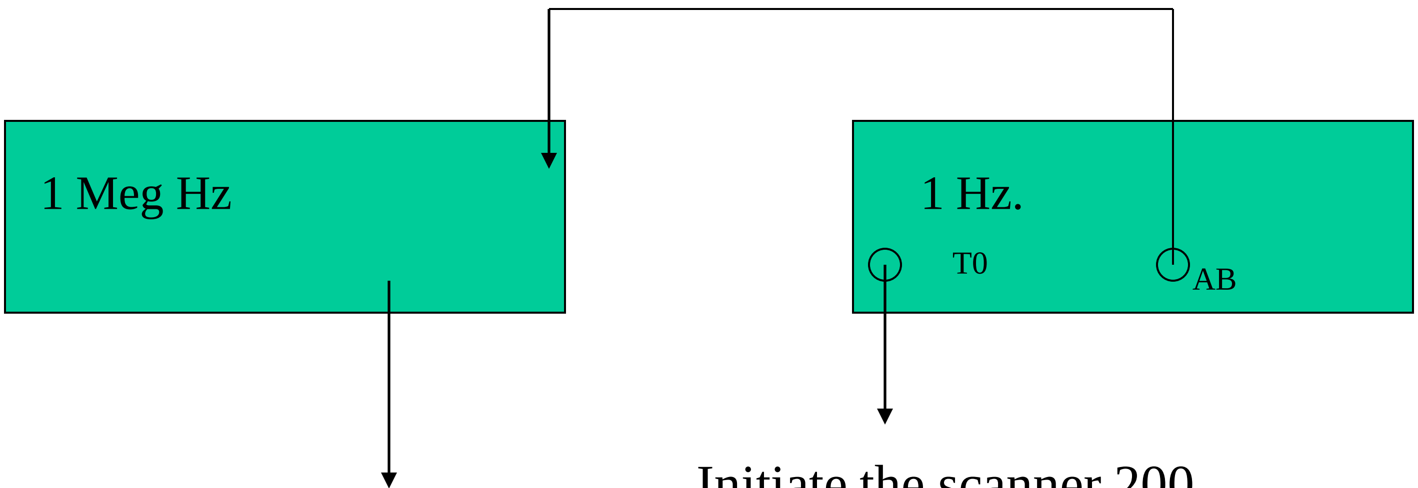
All stop at the slowest of A,B,C or D + 800 ns.

Next cycle starts again at the next trigger pulse

What does the trigger inhibit do?

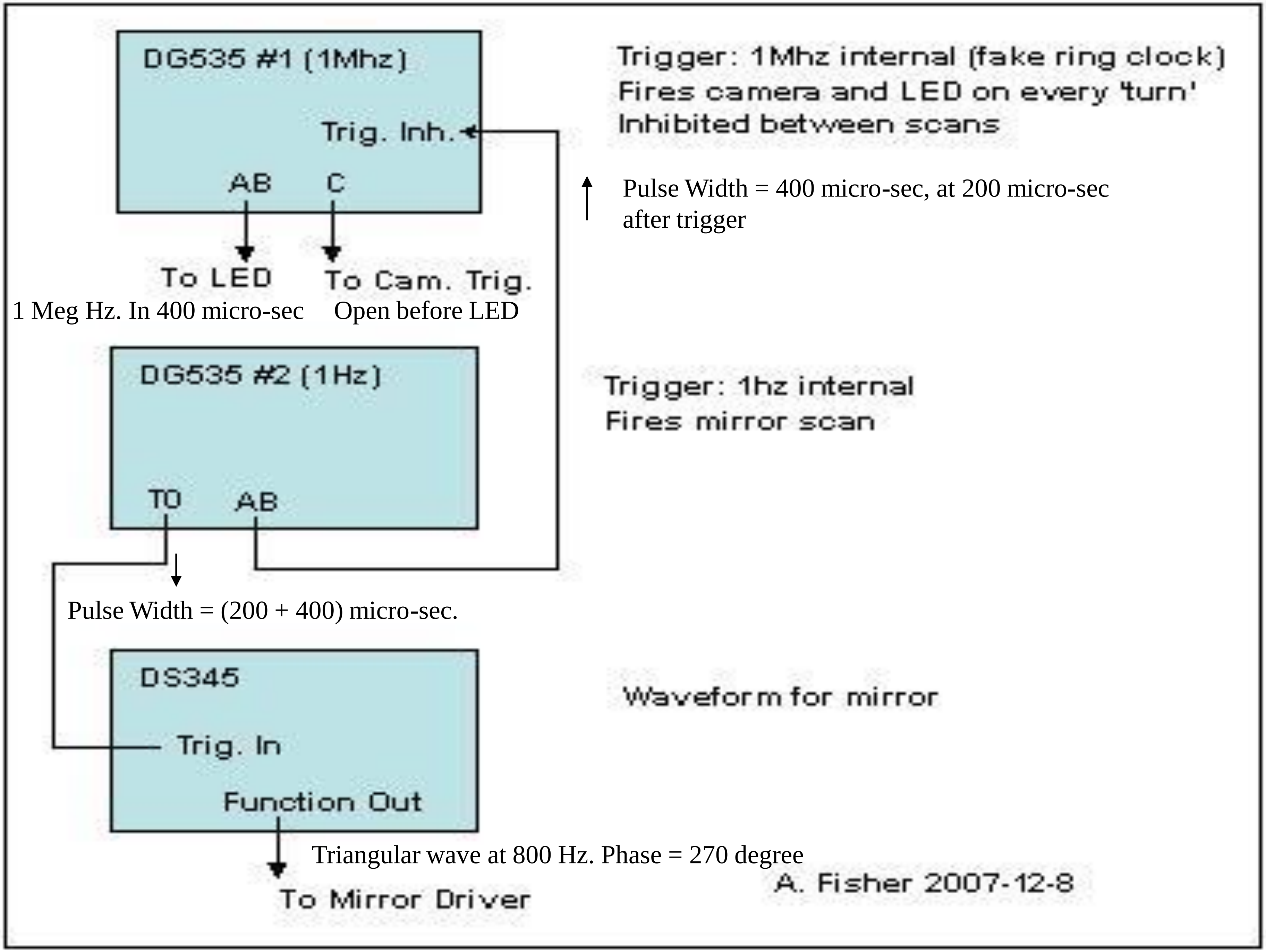
1. Trigger the PIMAX camera with reference to the scanner time line

2. Suppress the triggering outside the 400 micro second envelop



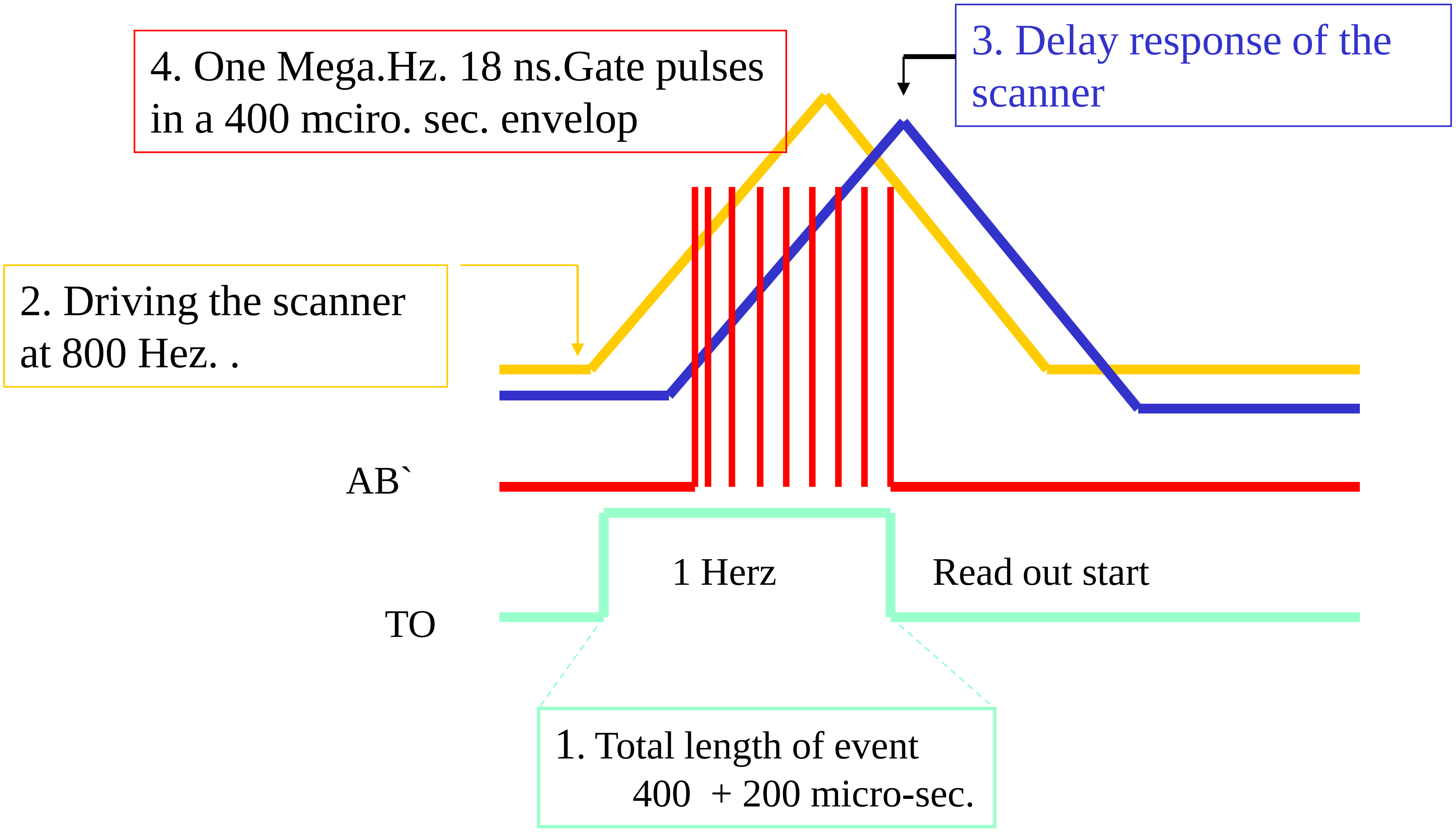
400

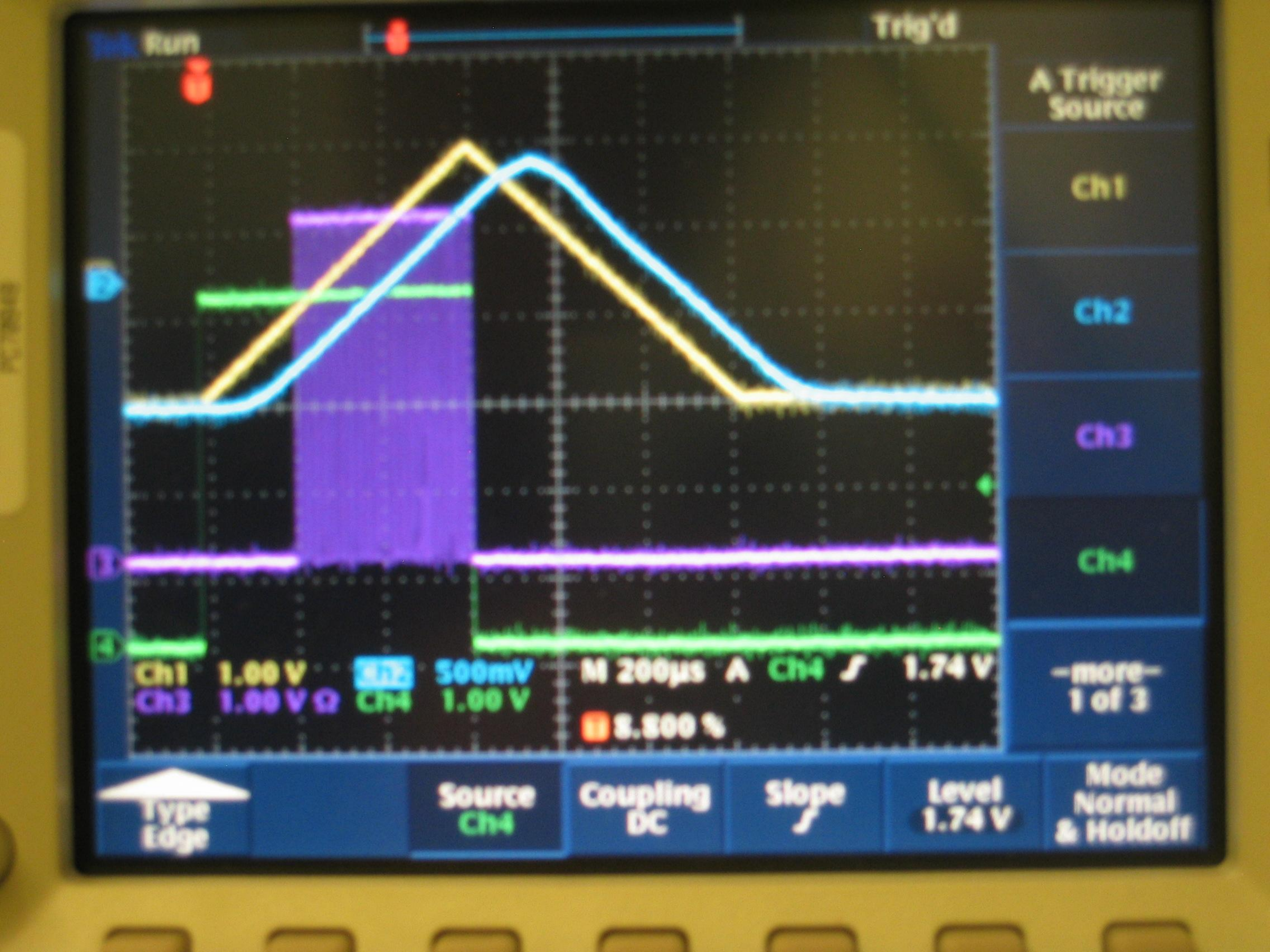
Initiate the scanner 200 micro second ahead of the gate pulse



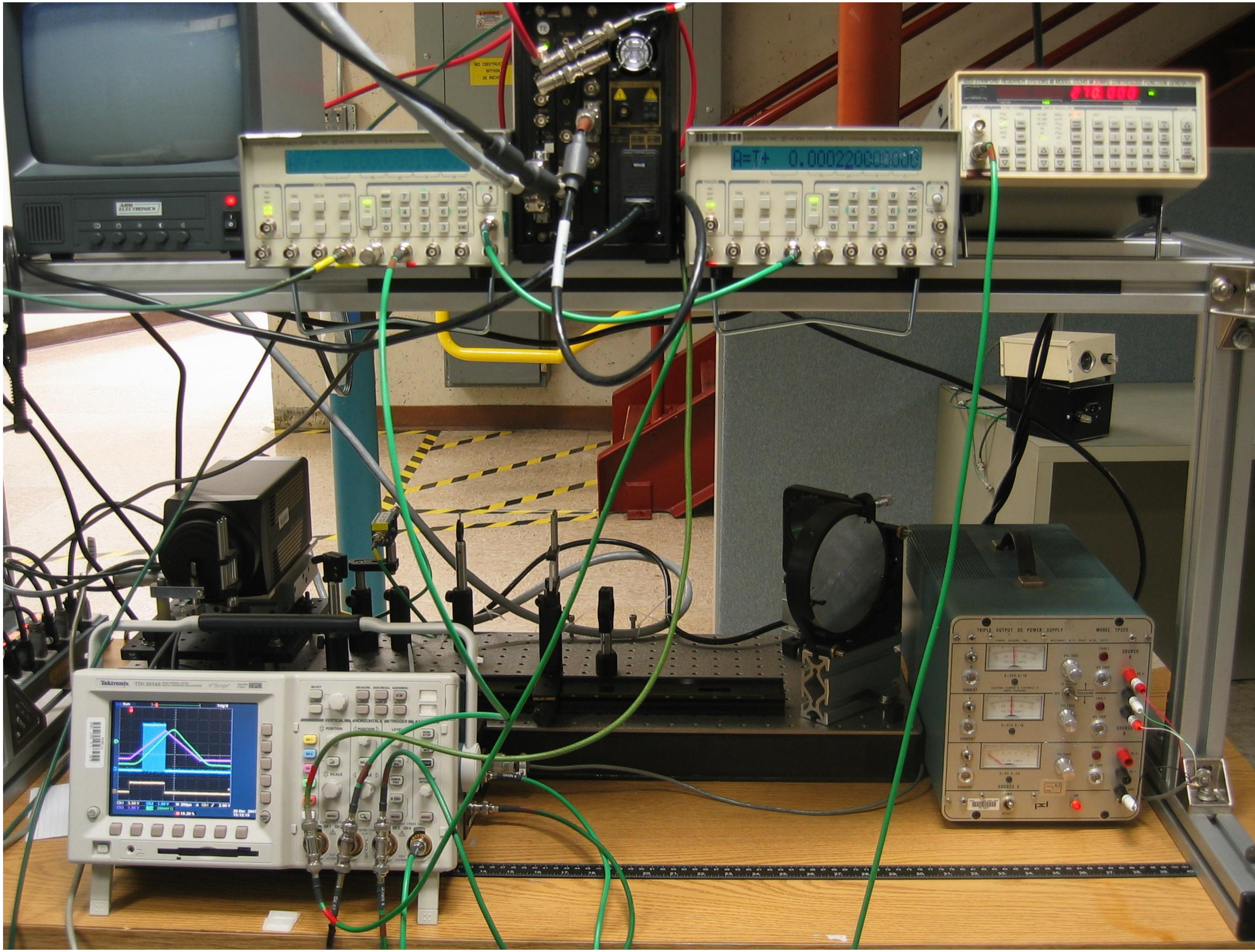
DG535 #1 (1Mhz)
Trig. Inh.
AB
C
To LED
To Cam. Trig.
1 Meg Hz. In 400 micro-sec
Open before LED
Trigger: 1Mhz internal (fake ring clock)
Fires camera and LED on every 'turn'
Inhibited between scans
Pulse Width = 400 micro-sec, at 200 micro-sec after trigger
DG535 #2 (1Hz)
T0
AB
Trigger: 1hz internal
Fires mirror scan
Pulse Width = (200 + 400) micro-sec.
DS345
Trig. In
Function Out
Waveform for mirror
Triangular wave at 800 Hz. Phase = 270 degree
To Mirror Driver
A. Fisher 2007-12-8

The timing diagram of the scanning mirror set-up





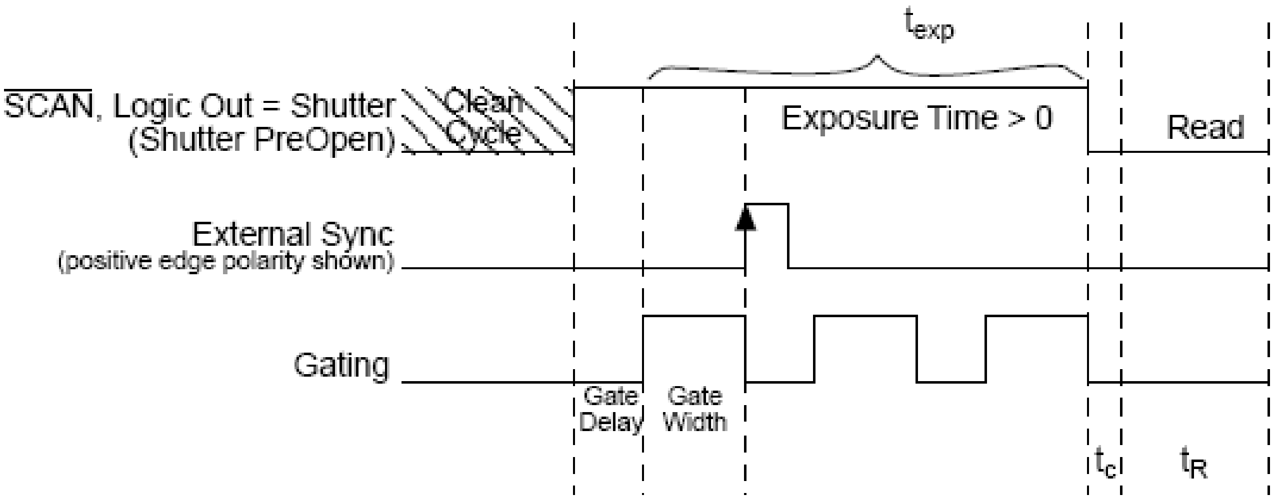
Tek Run
Trig'd
A Trigger Source
Ch1
Ch2
Ch3
Ch4
Ch1 1.00 V
Ch2 500mV
M 200µs A Ch4 1.74 V
Ch3 1.00 V Ω
Ch4 1.00 V
5.800 %
-more- 1 of 3
Type Edge
Source Ch4
Coupling DC
Slope
Level 1.74 V
Mode Normal & Holdoff



A=T+ 0.000220000000
Tektronix
TRIPLE OUTPUT DC POWER SUPPLY

Data acquisition control by PRIMAX

GATE mode



t_{exp} = time array is exposed to incoming signal
t_c = shutter compensation time
t_R = time required to readout the array

Figure 53. DG535: External Sync, PreOpen, Exposure Time > 0 sec.

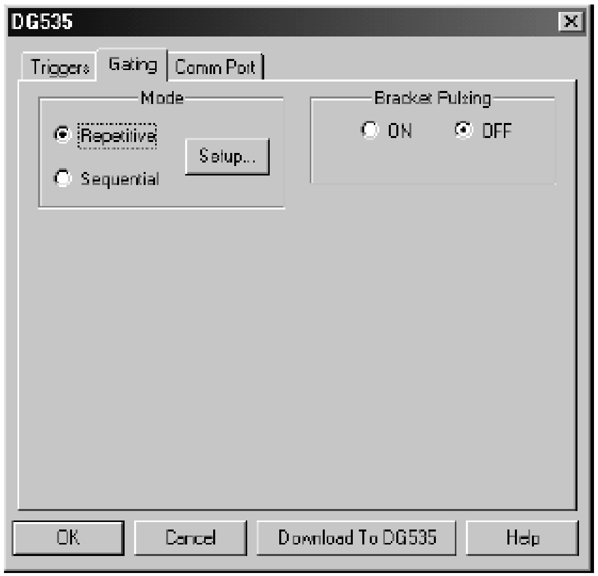


Figure 56. DG535 Gating tab

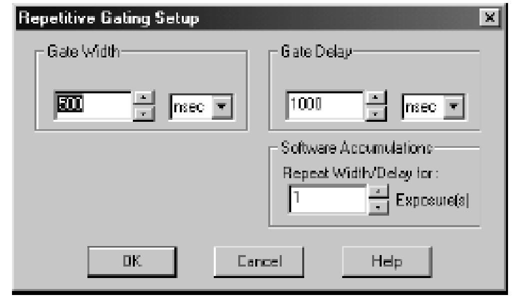


Figure 57. DG535 Repetitive Gating Setup dialog

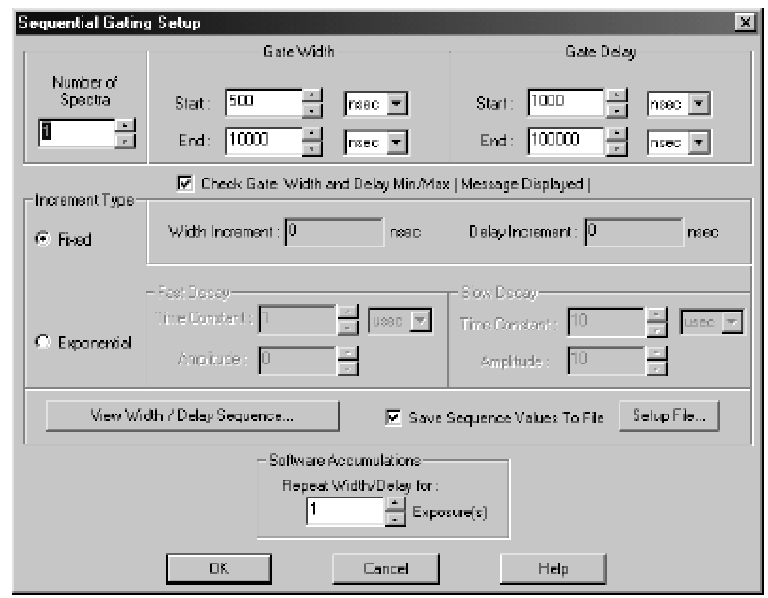
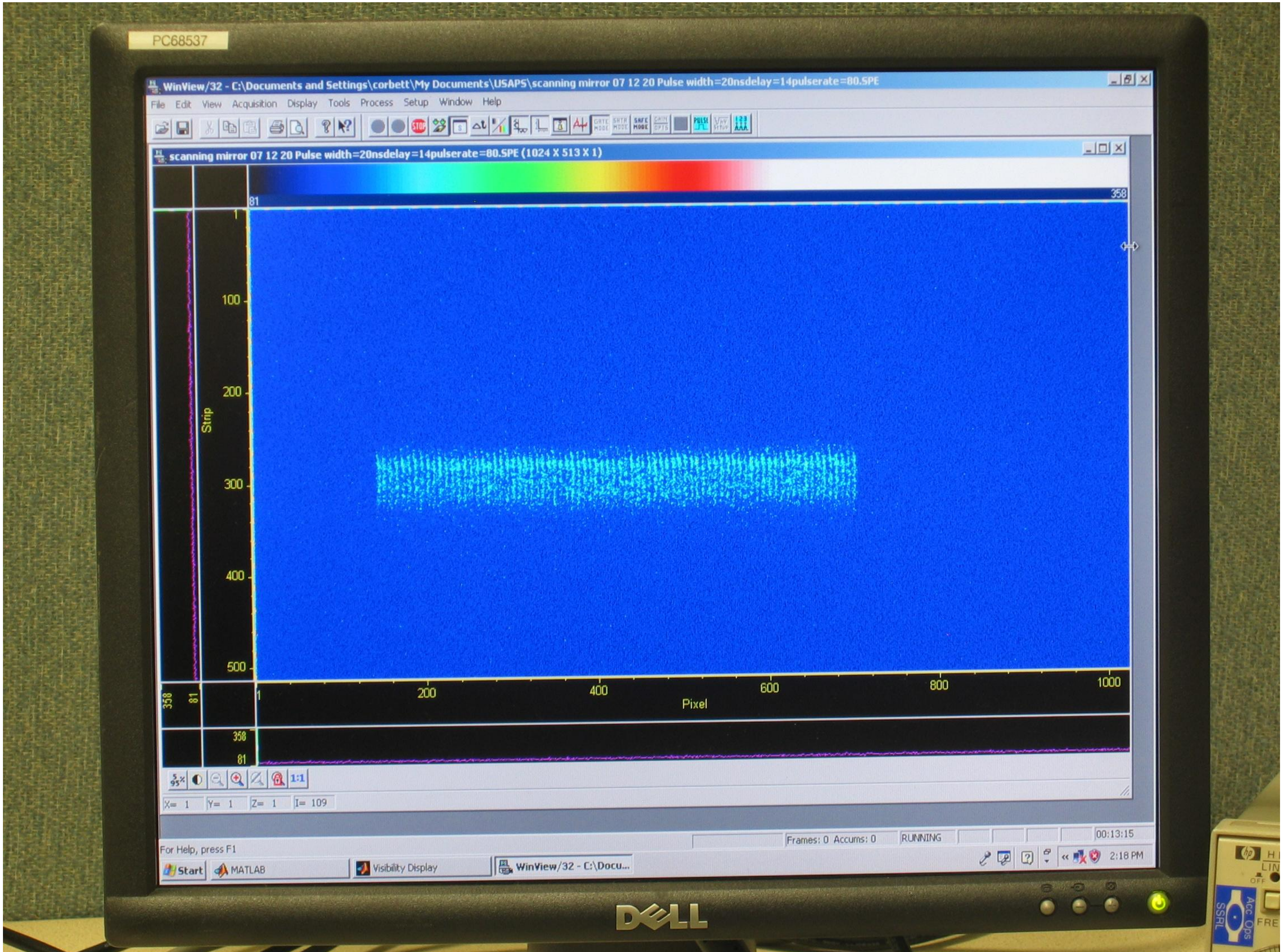
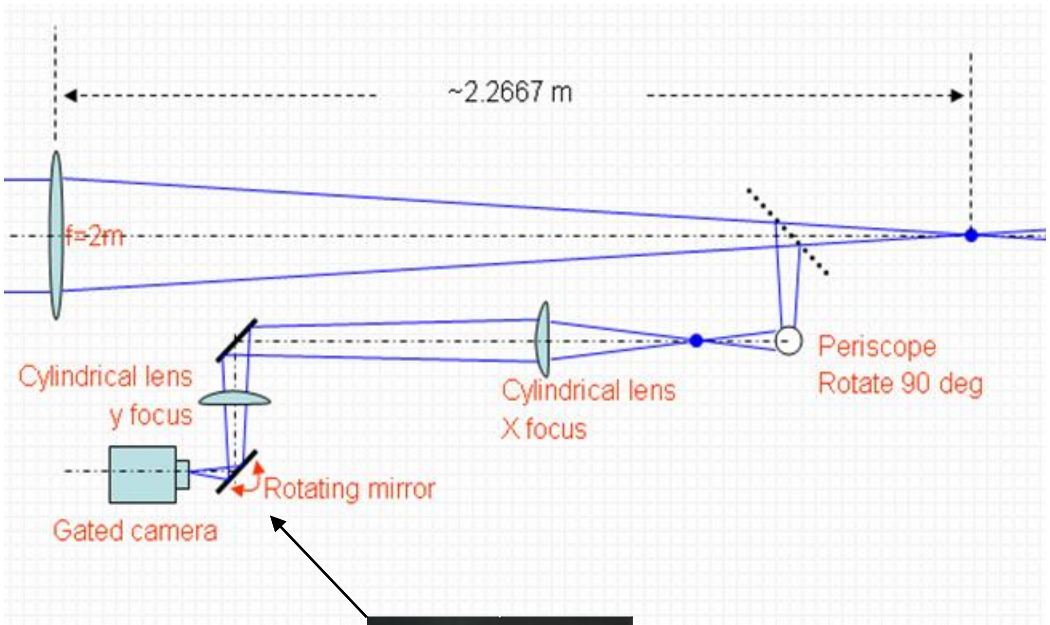
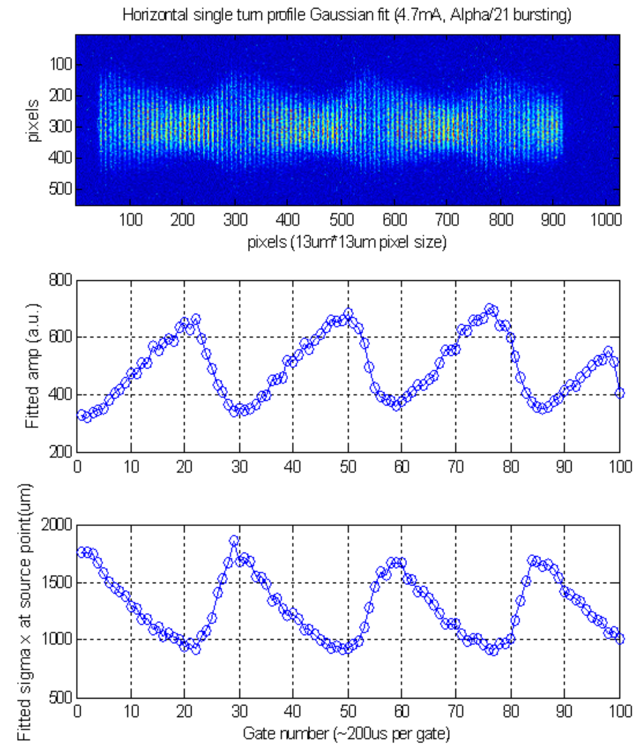


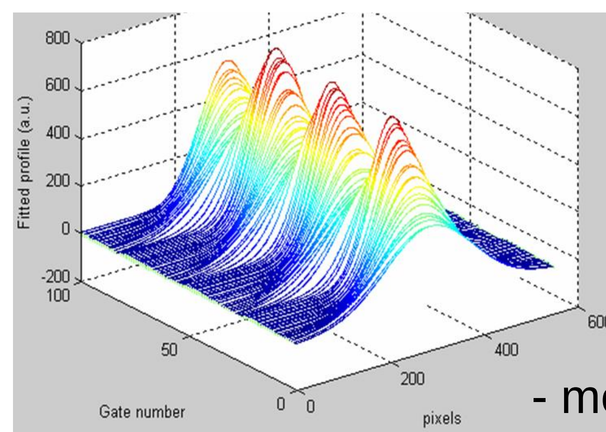
Figure 58. DG535 Sequential Gating Setup dialog


PC68537
WinView/32 - C:\Documents and Settings\corbett\My Documents\USAPS\scanning mirror 07 12 20 Pulse width=20nsdelay=14pulserate=80.SPE
File Edit View Acquisition Display Tools Process Setup Window Help
scanning mirror 07 12 20 Pulse width=20nsdelay=14pulserate=80.SPE (1024 X 513 X 1)
Strip
Pixel
X= 1 Y= 1 Z= 1 I= 109
For Help, press F1
Frames: 0 Accums: 0
RUNNING
00:13:15
Start
MATLAB
Visibility Display
WinView/32 - C:\Docu...
2:18 PM
DELL

THz Bursting Regime and Gated Camera

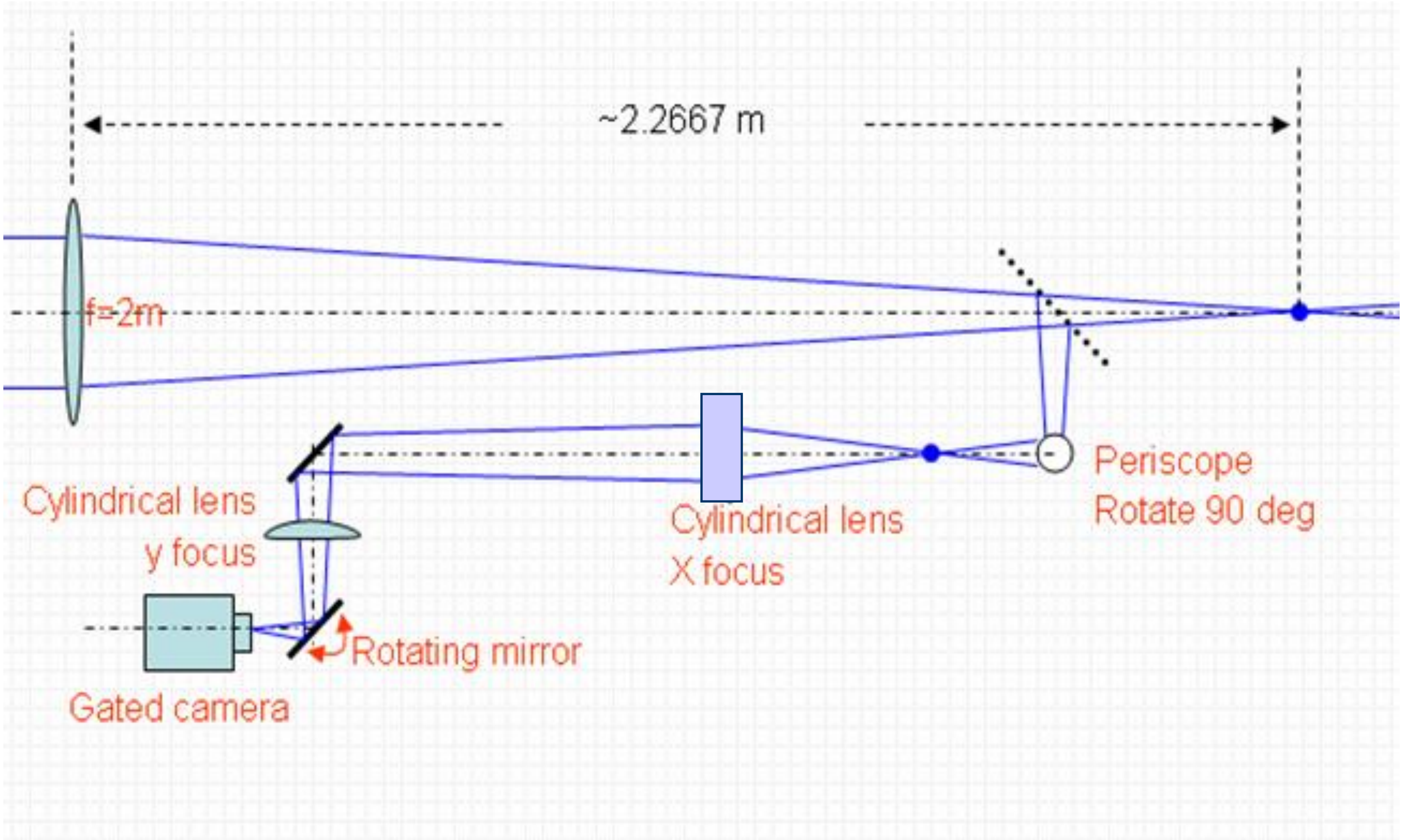




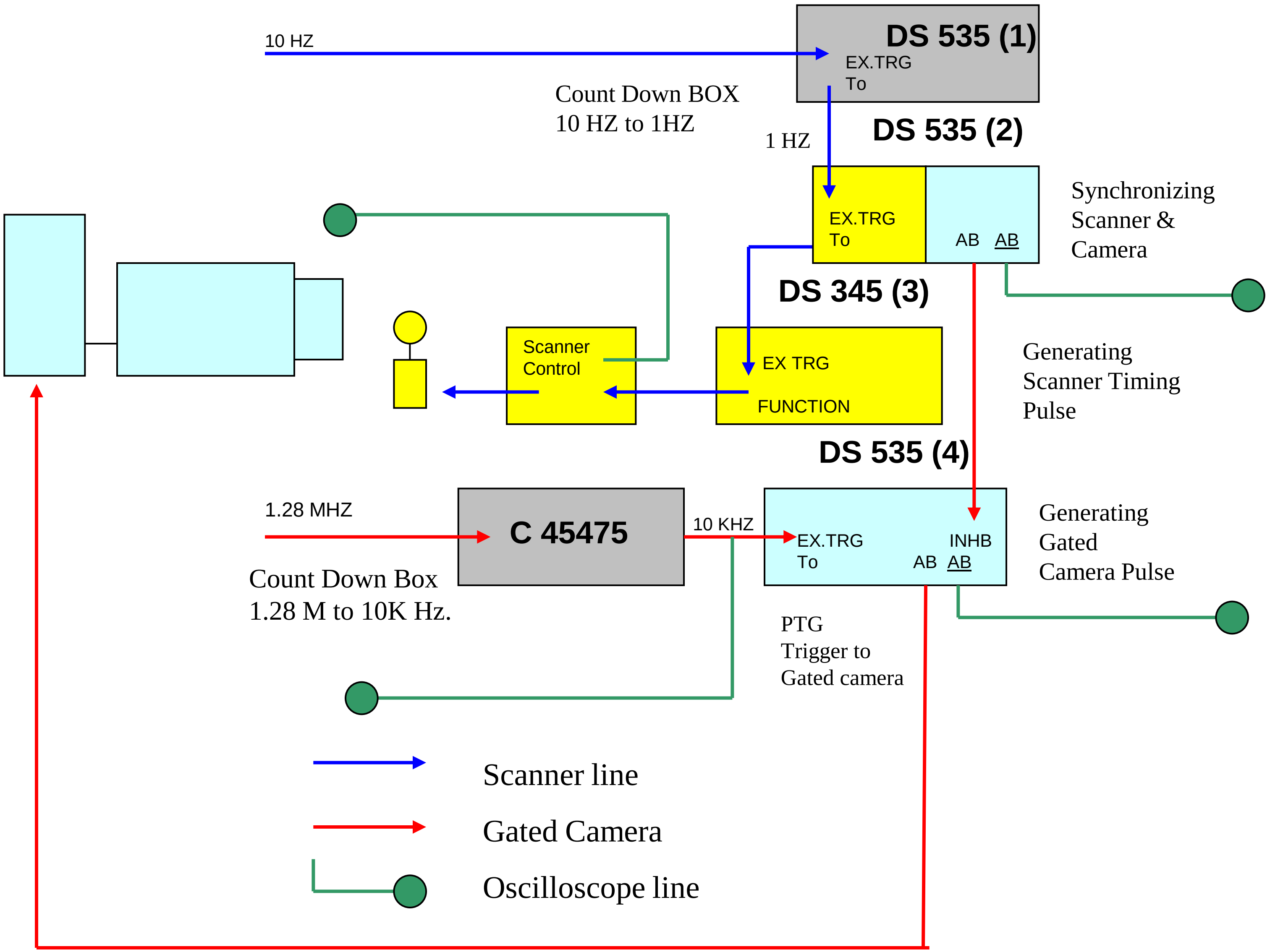


- movie -

Scanning Mirror Experiment Optical Lay out

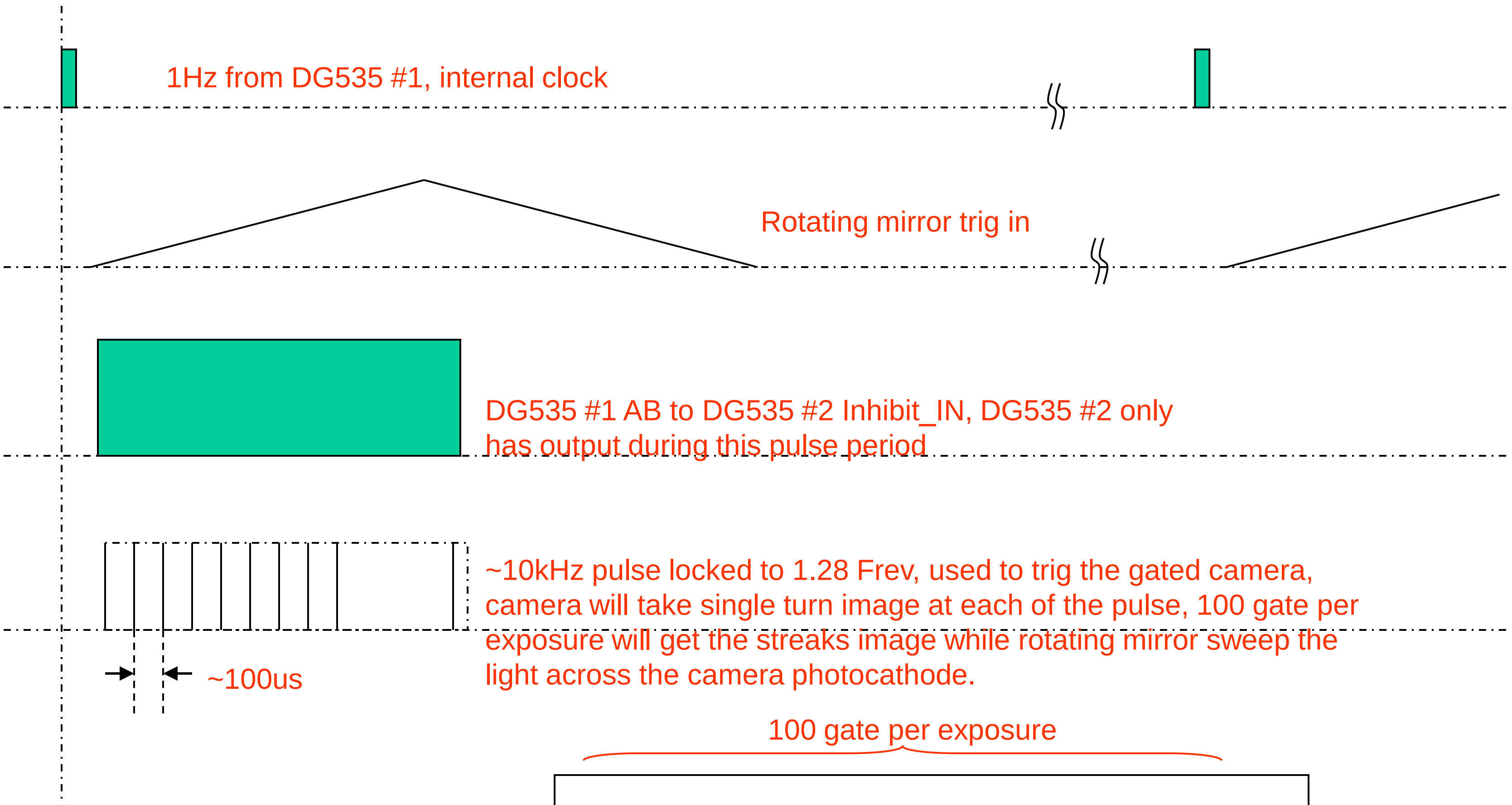


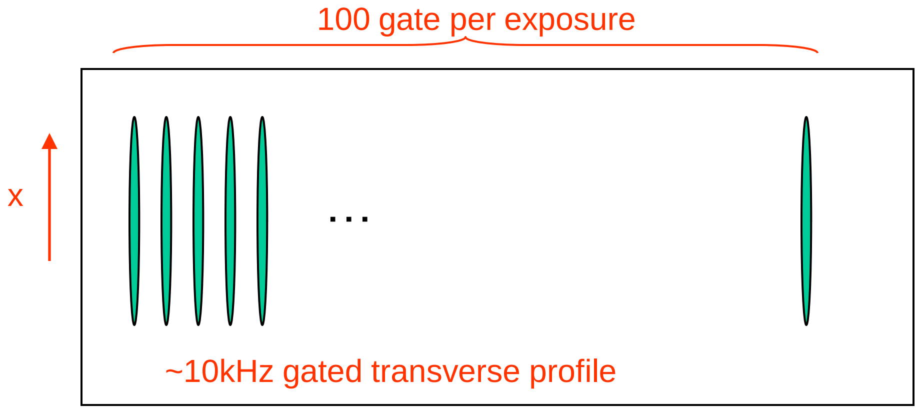
- movie -



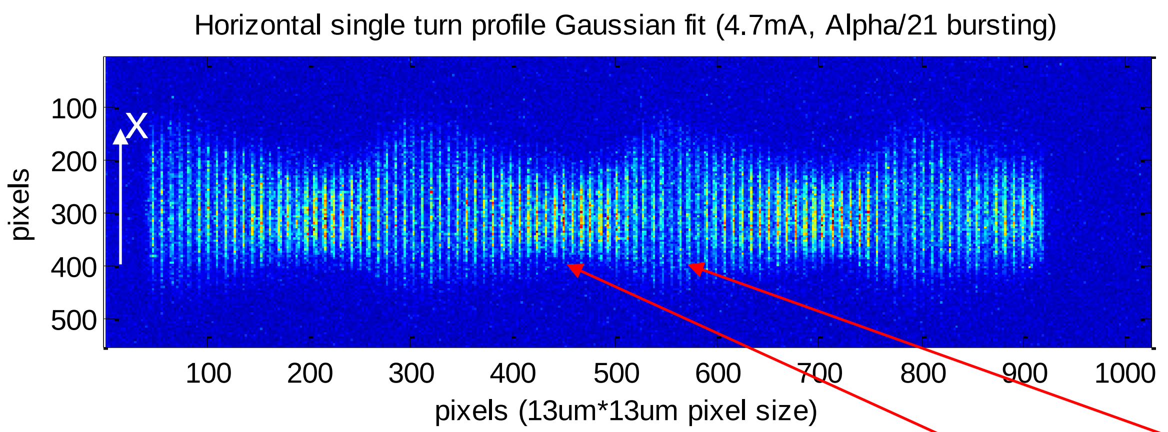
10 HZ
DS 535 (1)
EX.TRG
To
Count Down BOX
10 HZ to 1HZ
1 HZ
DS 535 (2)
EX.TRG
To
AB AB
Synchronizing
Scanner &
Camera
DS 345 (3)
Scanner
Control
EX TRG
FUNCTION
Generating
Scanner Timing
Pulse
DS 535 (4)
1.28 MHZ
C 45475
10 KHZ
EX.TRG
To
INHB
AB AB
Generating
Gated
Camera Pulse
Count Down Box
1.28 M to 10K Hz.
PTG
Trigger to
Gated camera
Scanner line
Gated Camera
Oscilloscope line

20080616 Gated Camera Timing – to measure the low alpha bursting





Since the bursting period is about 6ms, 100us * 100 gives 10ms period, which is enough to see the bursting.



4.7mA, Alpha/21

Gate trig freq: ~5kHz

100 gates per exposure

Sigma_x blow up, loss intensity at streak camera

Damping down to smaller sigma_x, higher intensity at streak camera