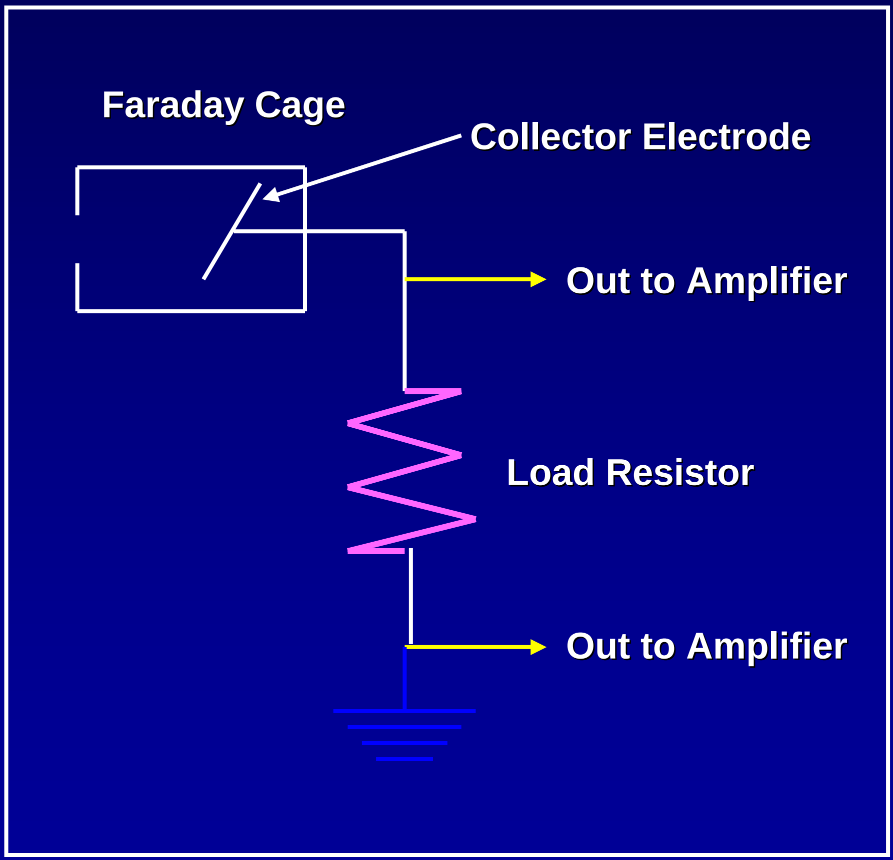
Denton Research Group's Advanced Detector Technology

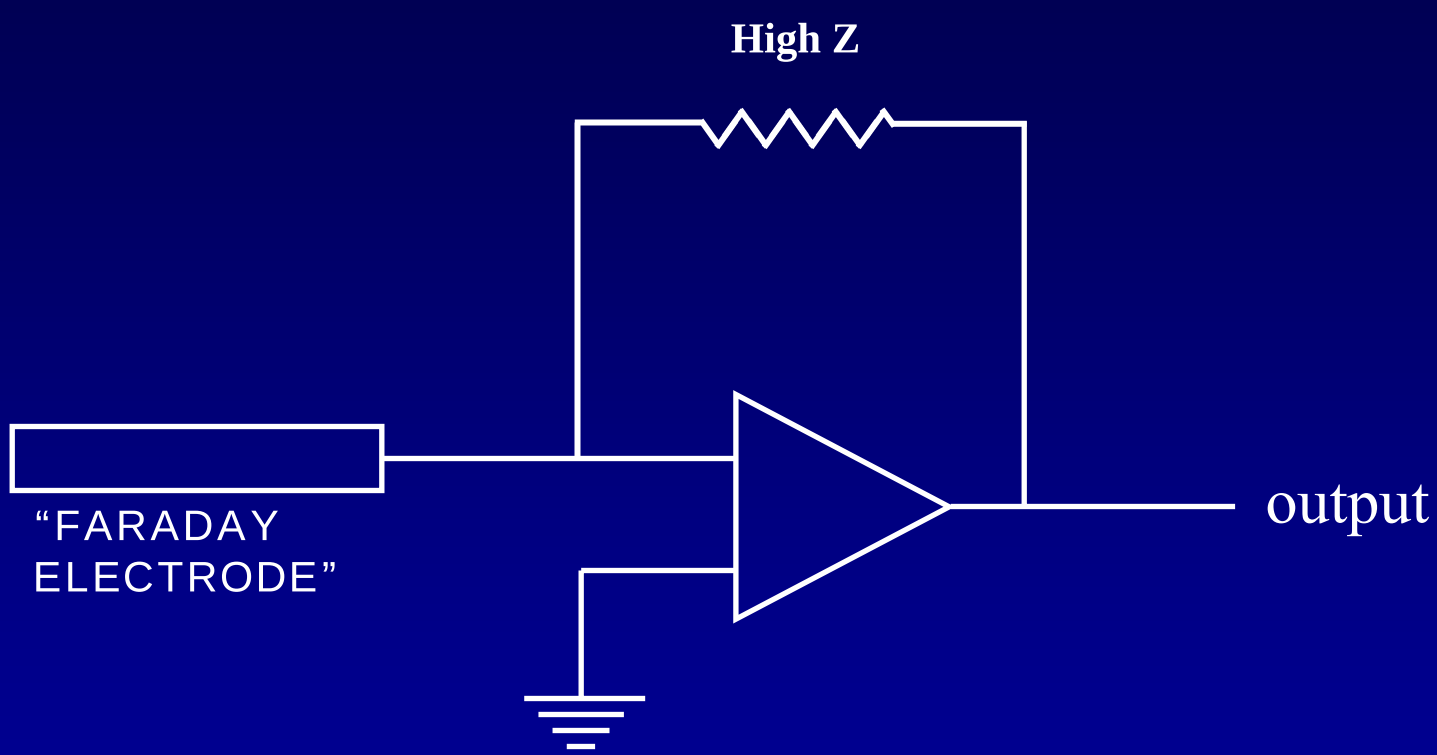
- Optical Spectroscopy
  - **Raman Spectroscopy**
  - Atomic Emission Spectroscopy
  - Molecular Fluorescence Spectroscopy
  - Array Infrared Spectroscopy
  - Imaging Spectroscopy
- Mass Spectrometry
  - **Magnetic Sector**
  - **Ion Mobility**
  - Secondary Ion Mass Spectrometry
  - Quadrupole
  - Time of Flight
- X-Ray Techniques
  - Diffraction
  - Fluorescence
  - X-Ray Photoelectron Spectroscopy

Present Ion Detector Technology – Faraday Cups

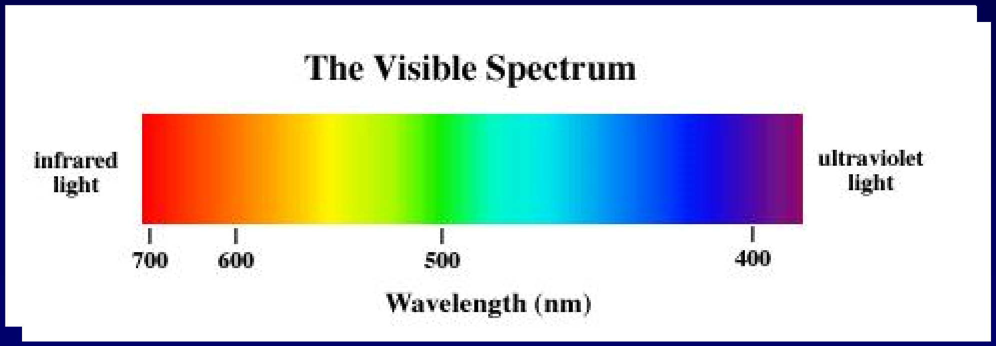


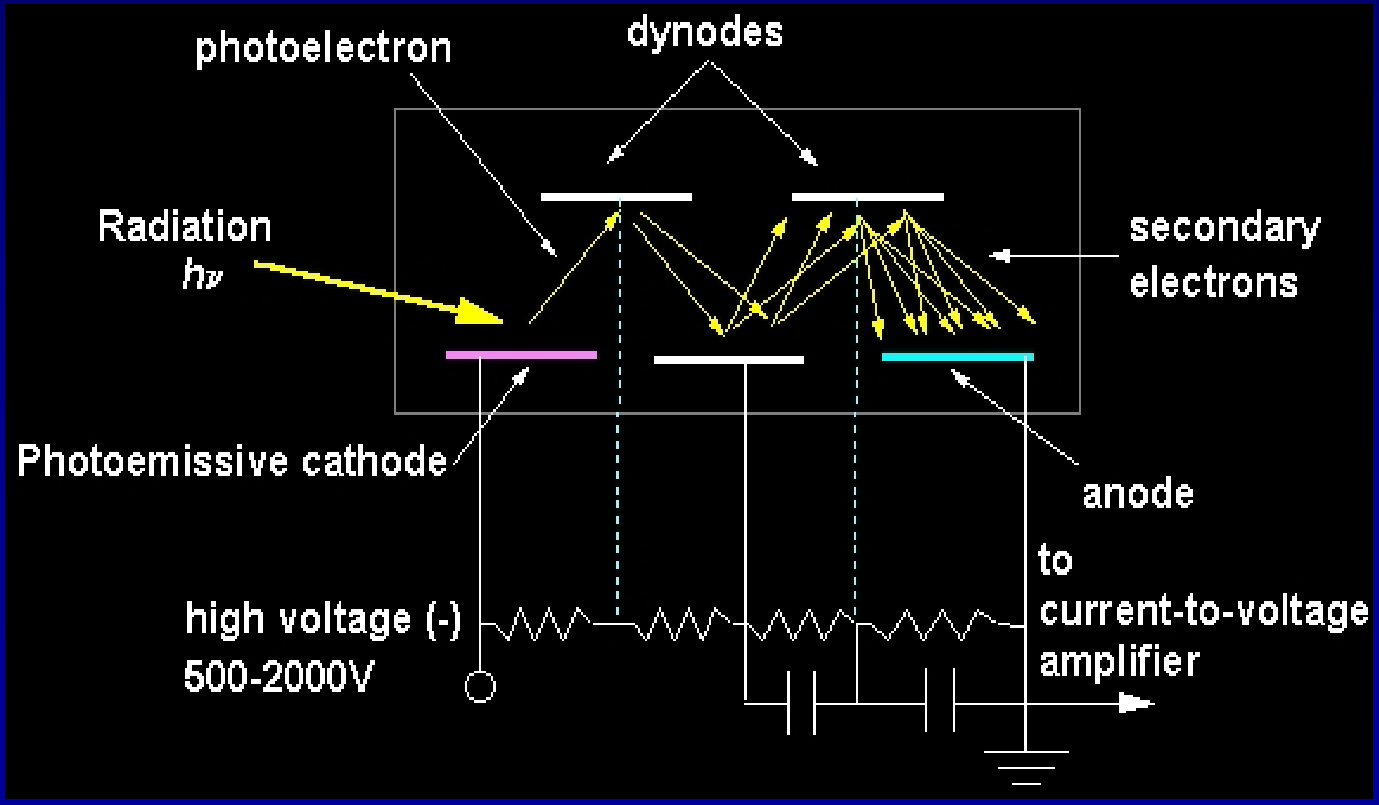
- Gain is stable and precisely known (gain=1)
- Bandwidth is consistent with use in sector-based mass spectrometry
- Useful for $I_{ion} \geq 10^{-15}$ amp (1 ion/sec $= 1.6 \times 10^{-19}$ amps)
- Implies that one needs about 6250 ions/sec for detection by Faraday cup

Operates at any pressure !

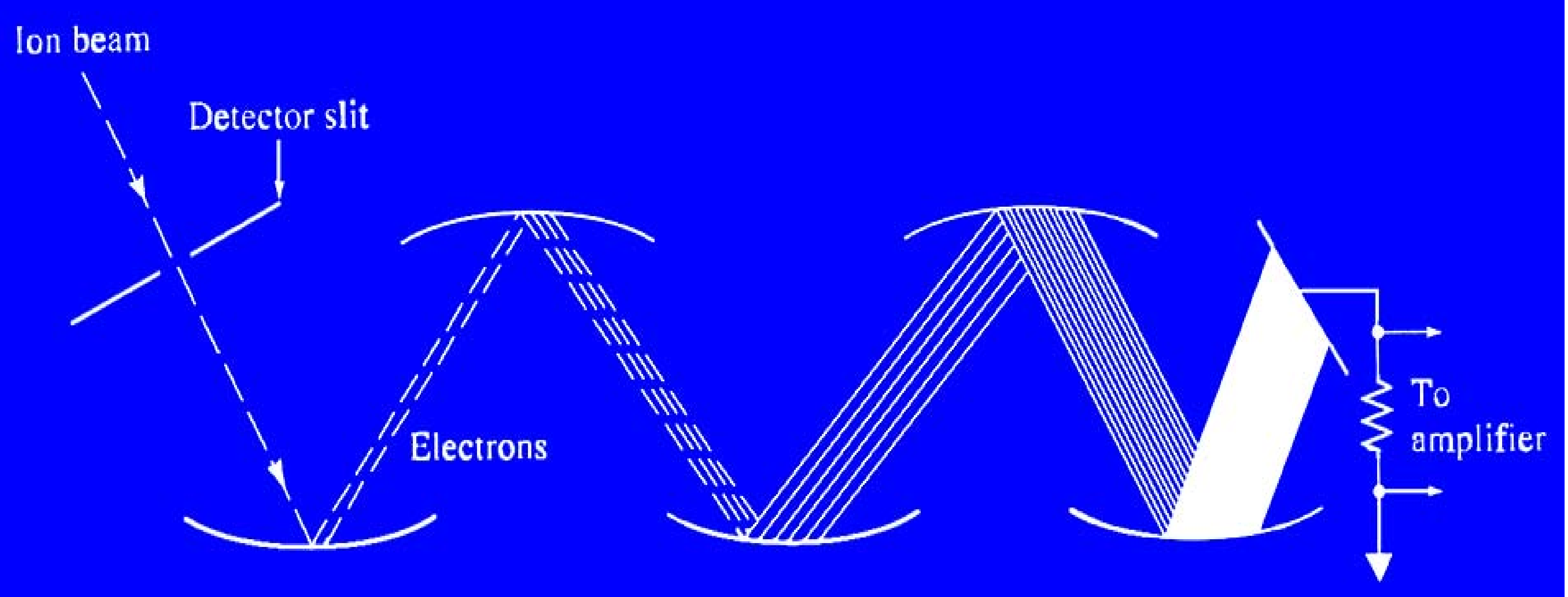

High Z
output
"FARADAY ELECTRODE"

Photomultiplier Tube





Ion Detection with "Multiplication"

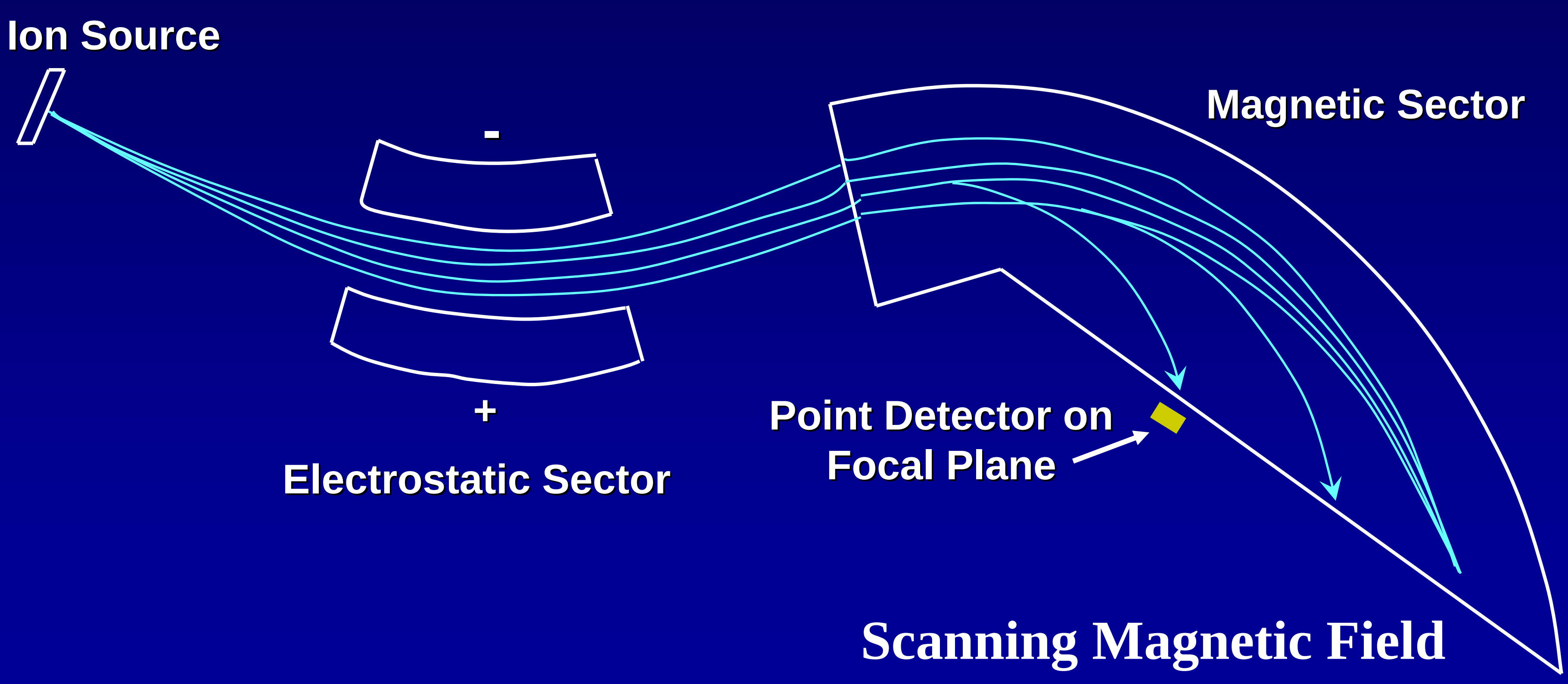


Operates only when free mean path of the electrons is large

ie. a high vacuum **Not stable enough for isotope ratio analysis**

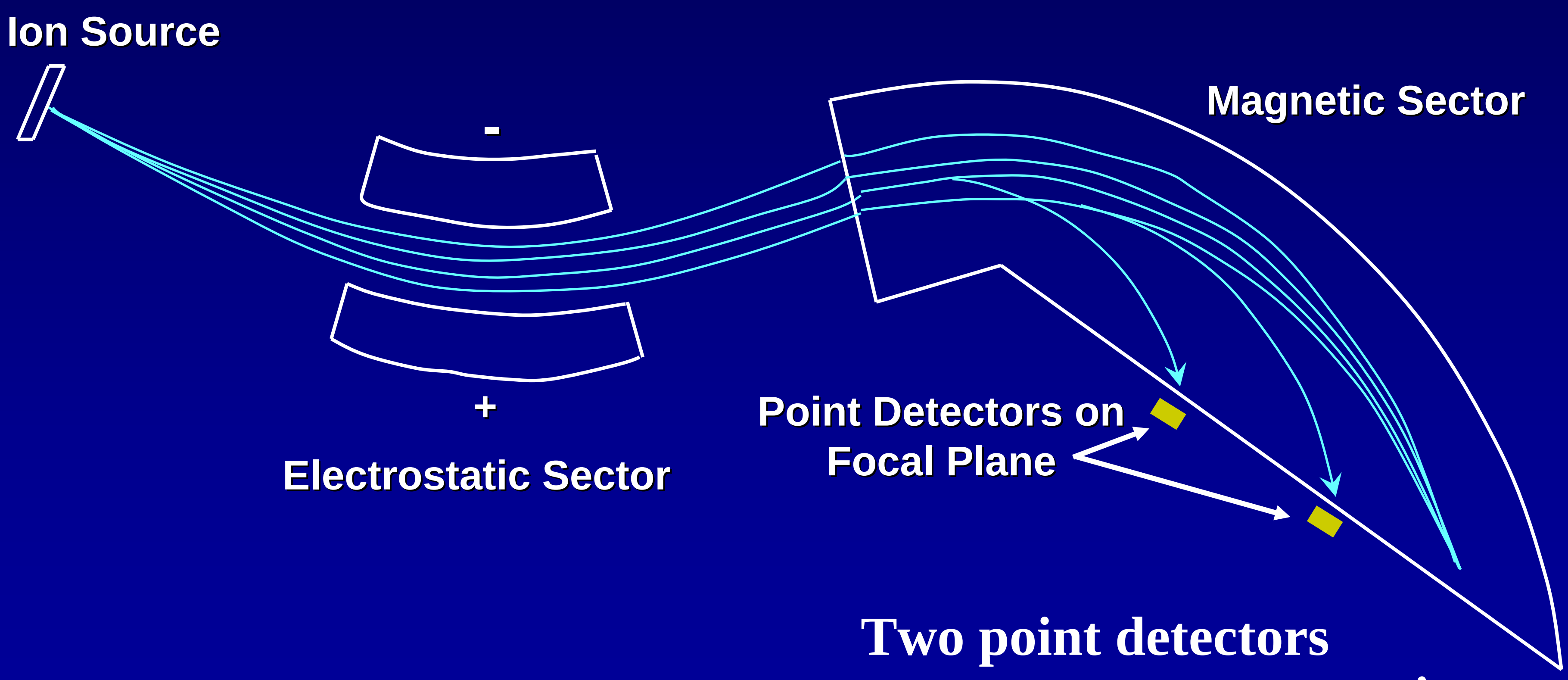
Today in Mass Spectrometry Array Detectors are not Utilized!!!

Mattauch-Herzog Mass Spectrometer Geometry



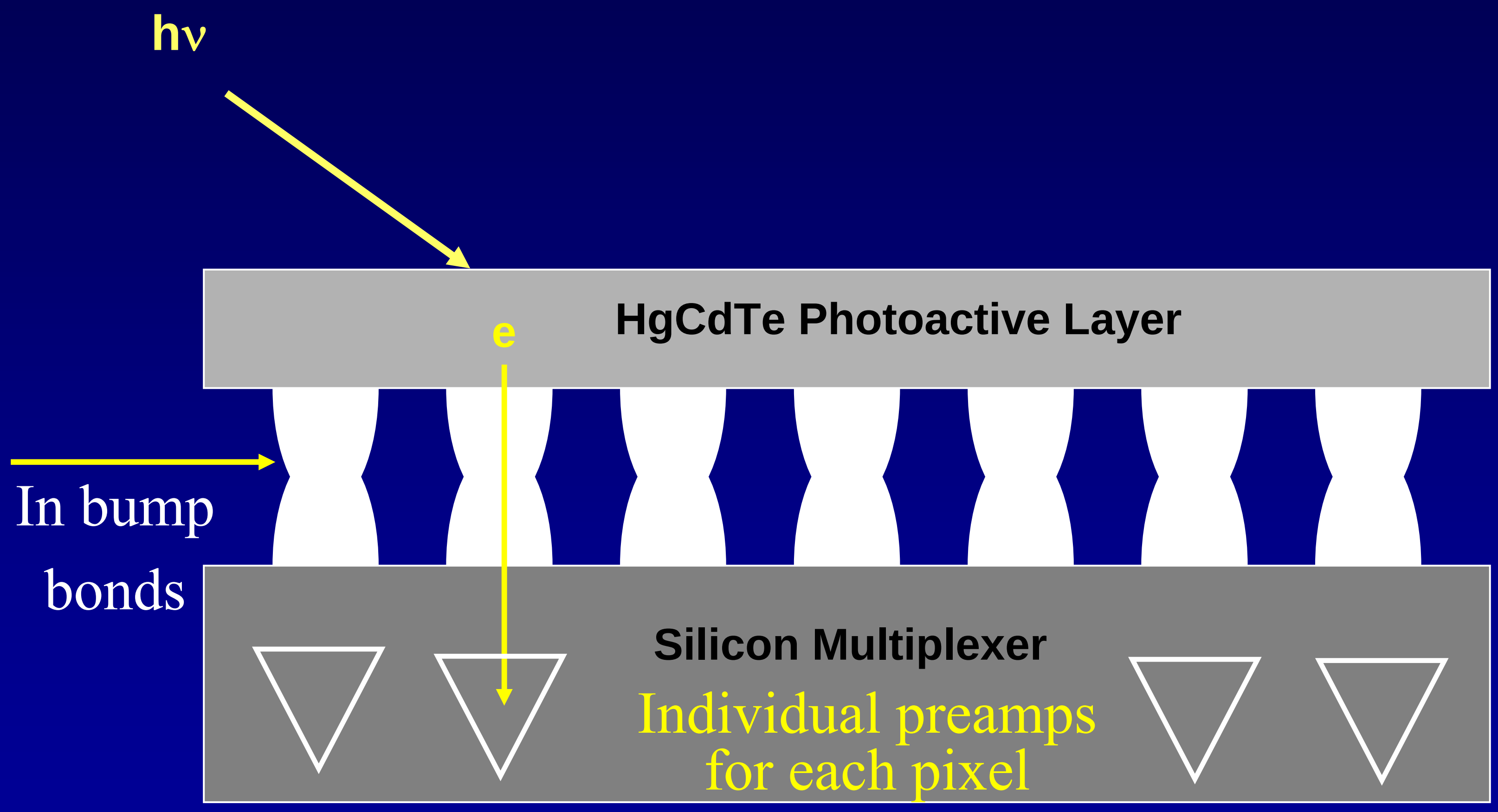
Scanning Magnetic Field Brings Different Mass Ions Onto Detector

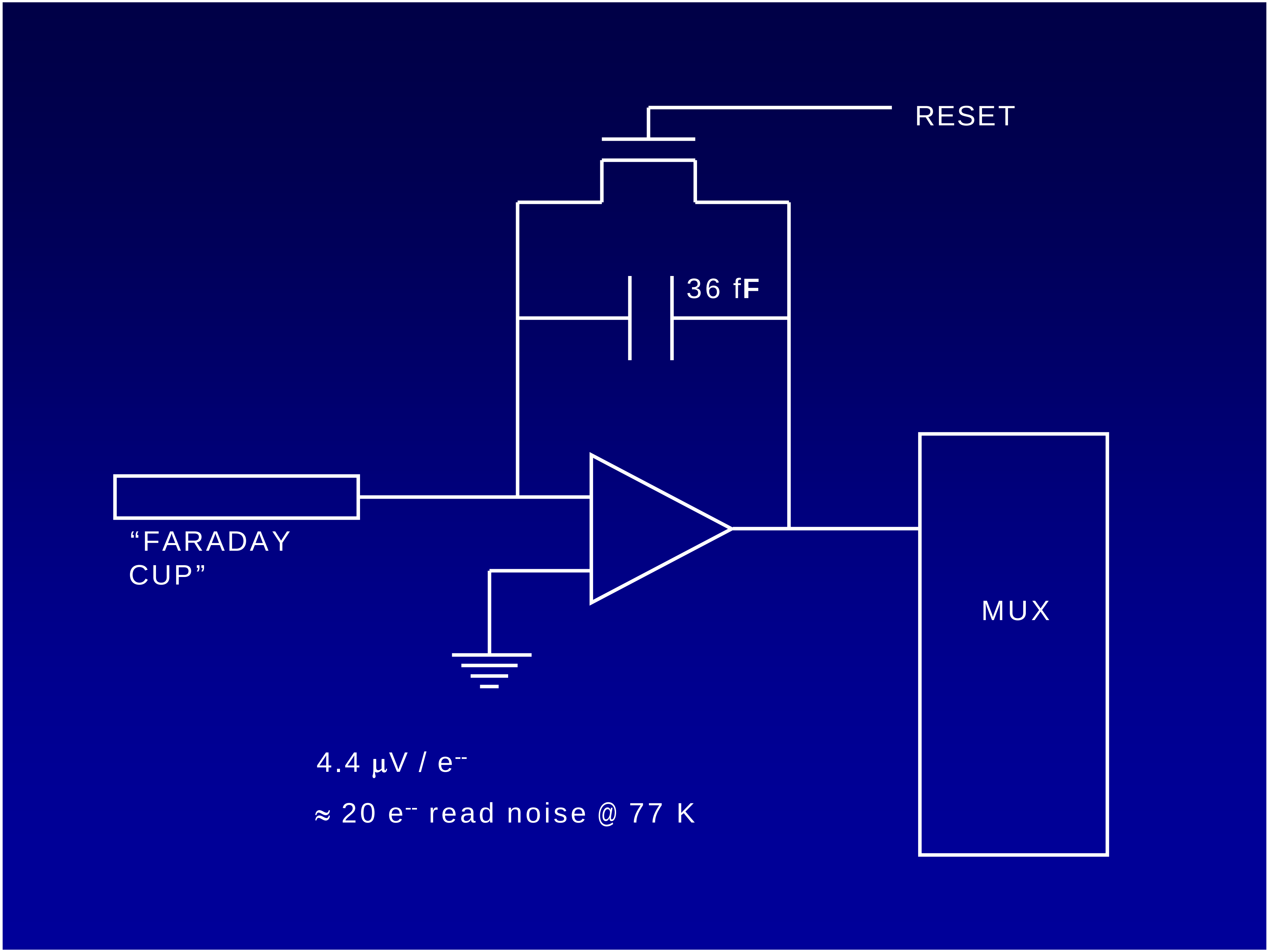
Mattauch-Herzog Mass Spectrometer Geometry

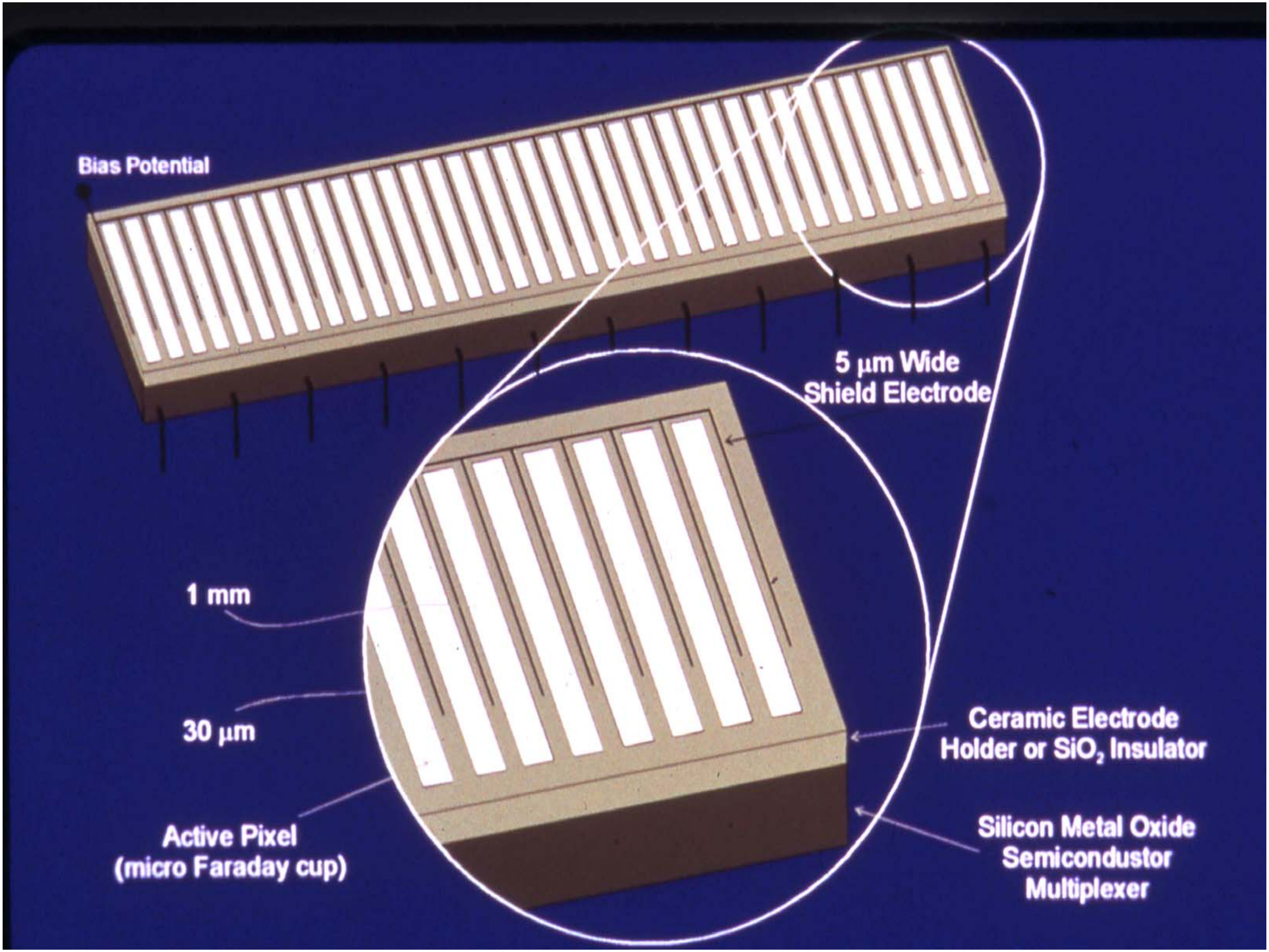


Two point detectors
Are used for isotope ratio

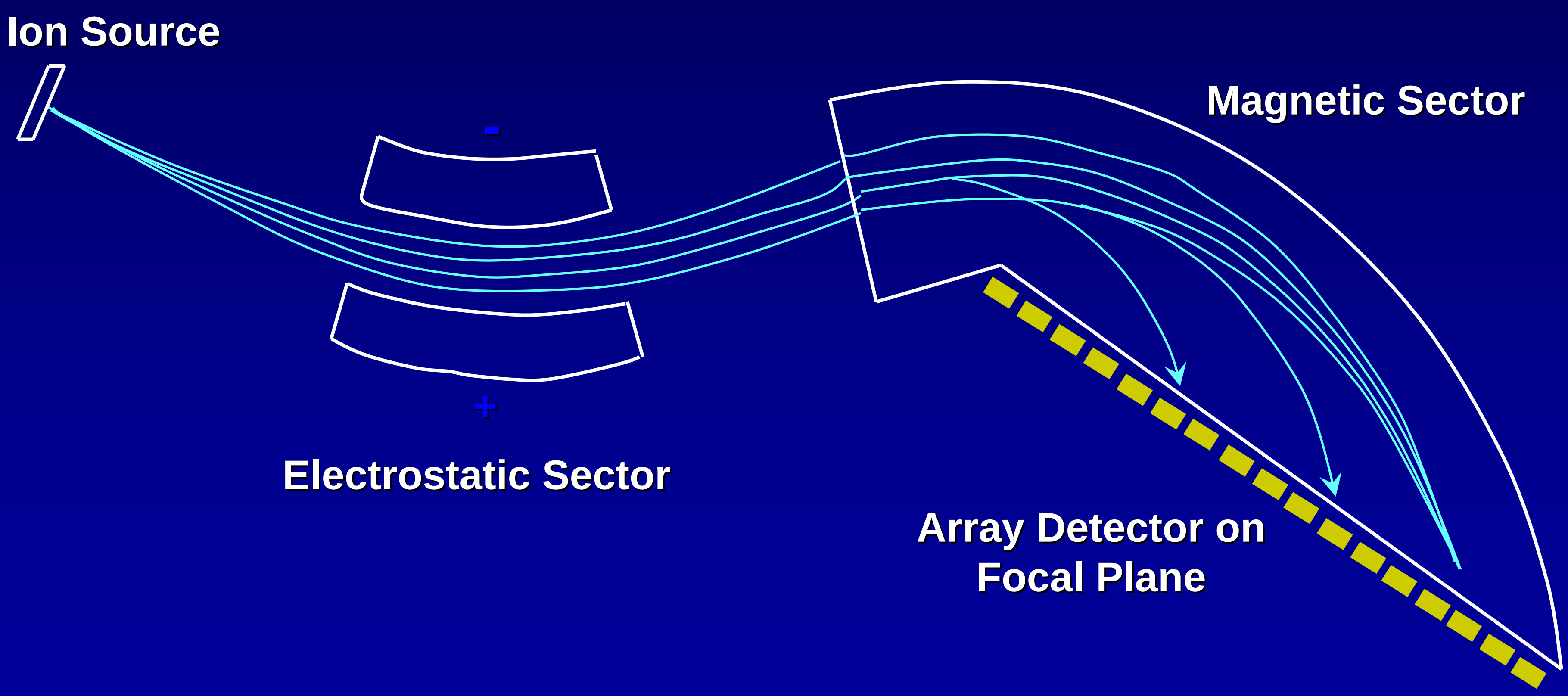
Focal Plane Array



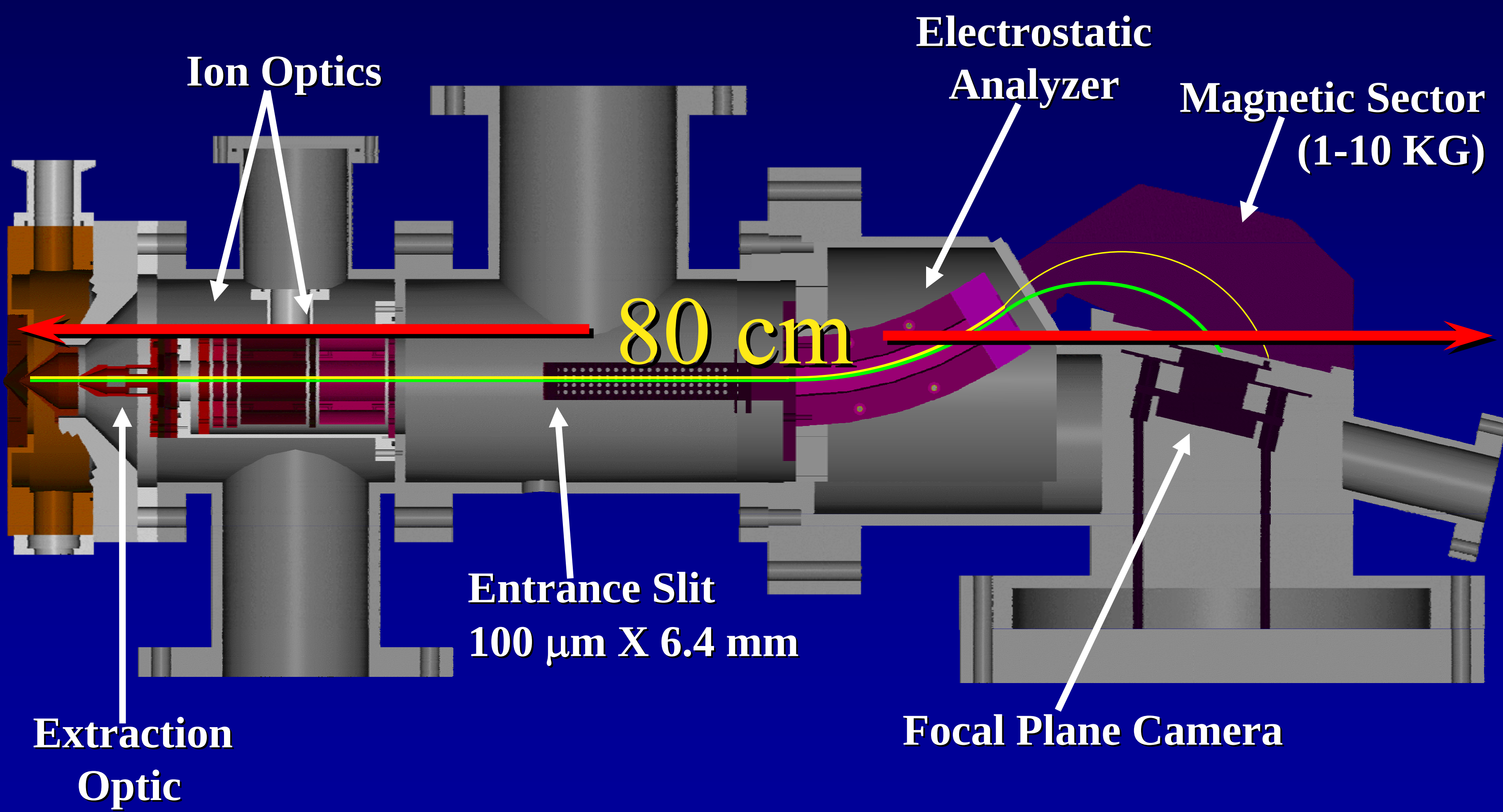

RESET
36 fF
"FARADAY CUP"
MUX
4.4 µV / e⁻
≈ 20 e⁻ read noise @ 77 K


Bias Potential
5 µm Wide
Shield Electrode
1 mm
30 µm
Ceramic Electrode
Holder or SiO2 Insulator
Active Pixel
(micro Faraday cup)
Silicon Metal Oxide
Semicondustor
Multiplexer

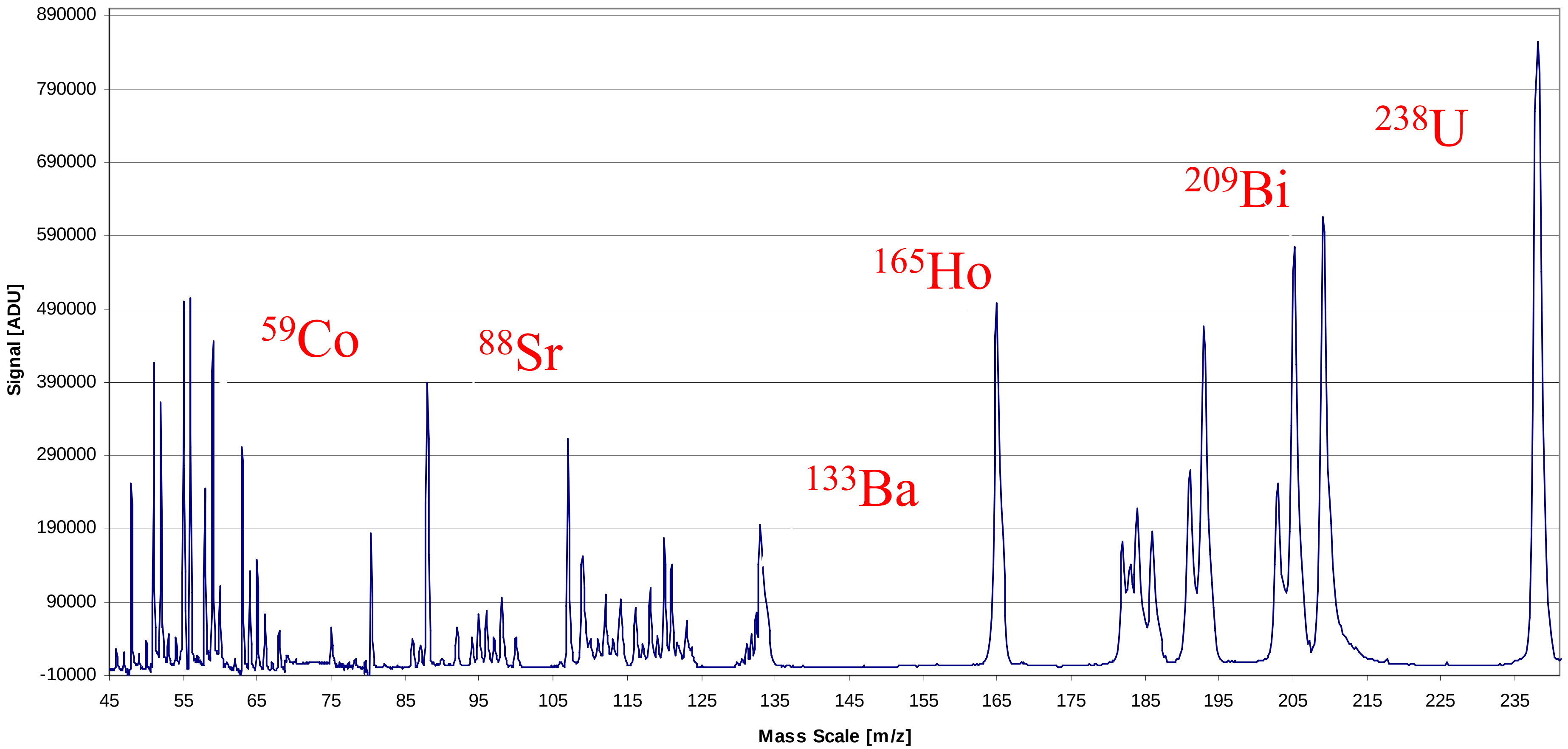
Mattauch-Herzog Mass Spectrometer Geometry



Mattauch-Herzog Mass Spectrograph

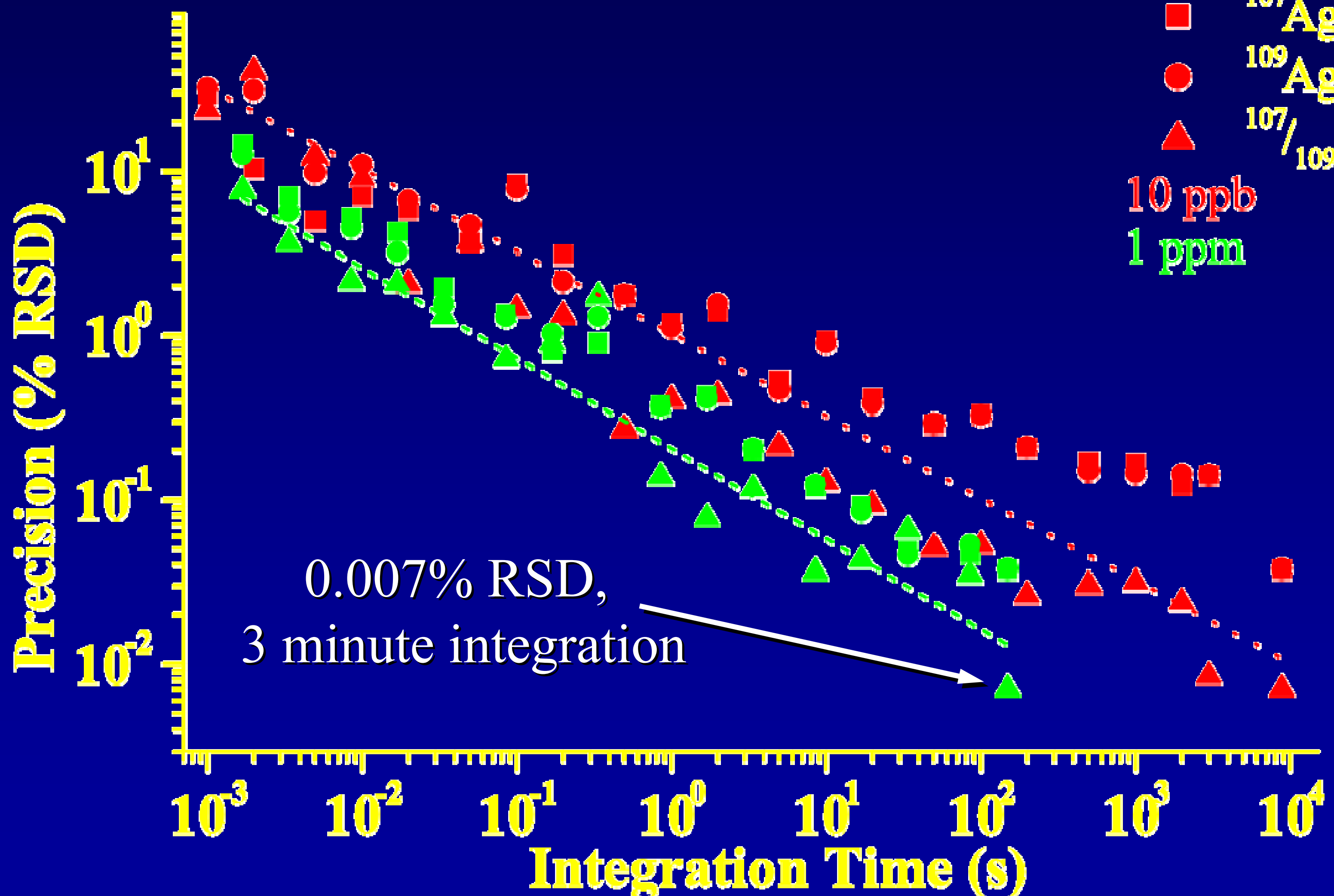


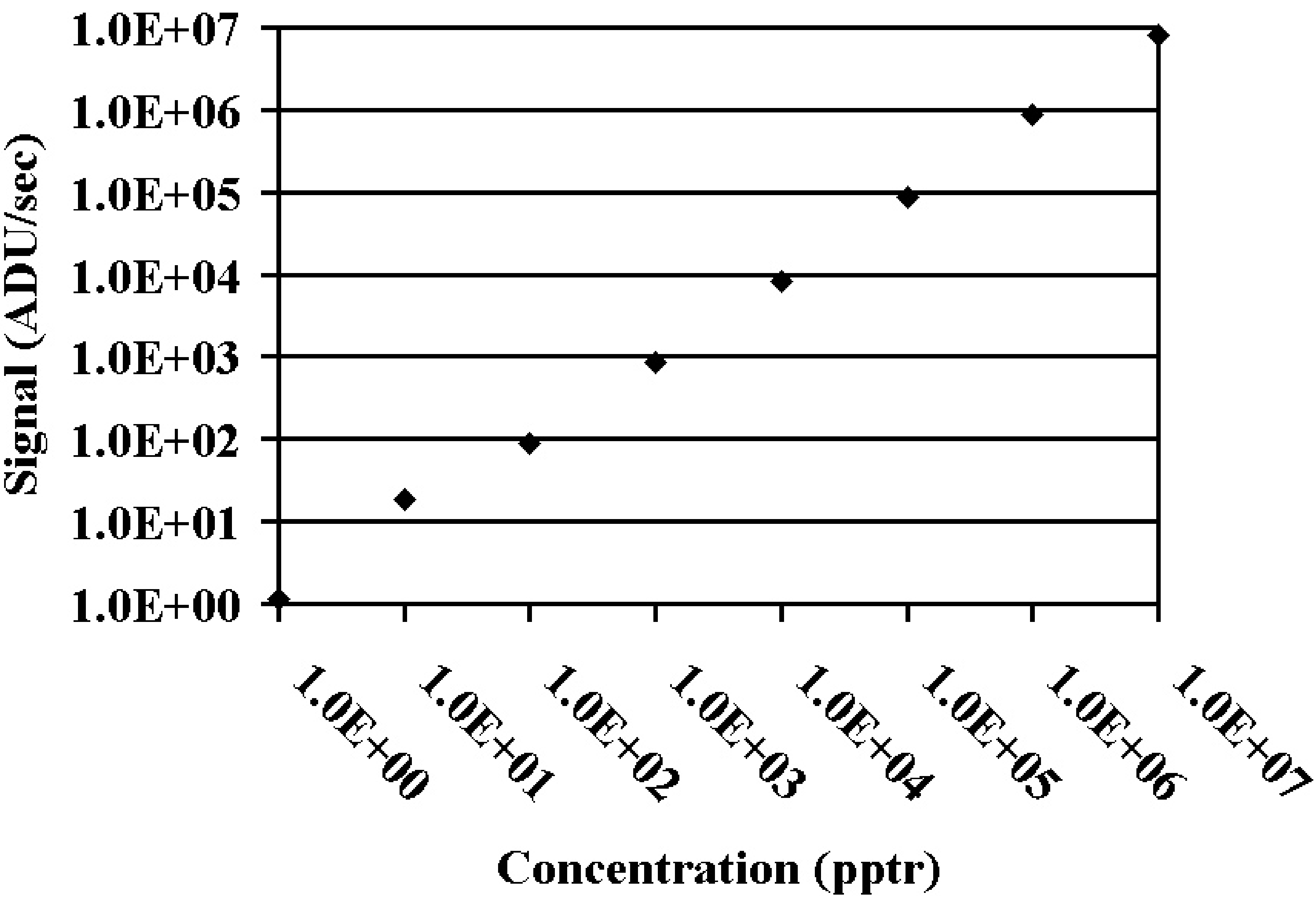
Mass Spectrum made from several Mass Windows

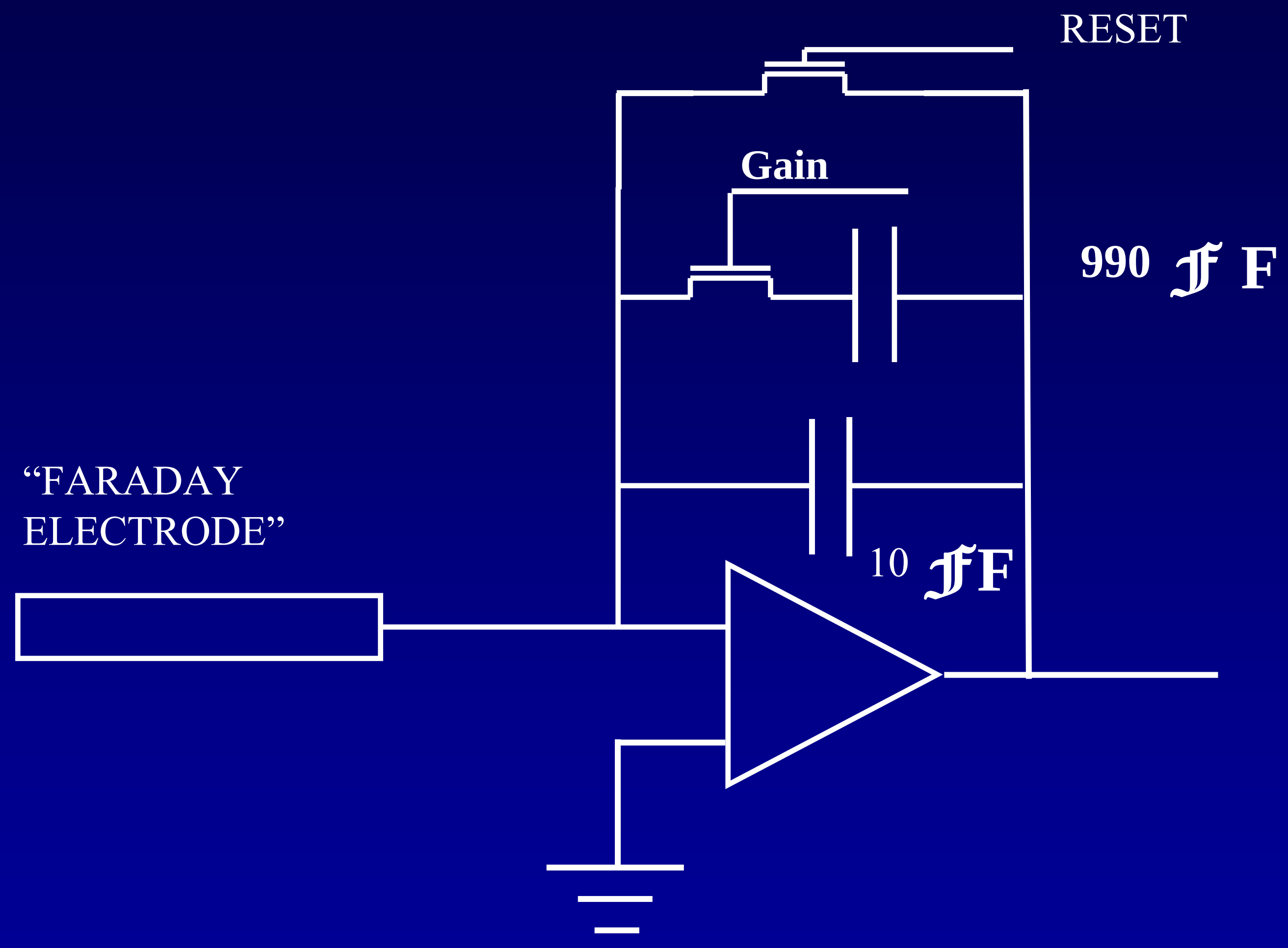


Conditions: 10 ppb multi elemental solutions, 5.011 ms Integration, 100 Reads, 20 replicates, 10.022 s total integration time, 1 ADU = ~2.4 counts

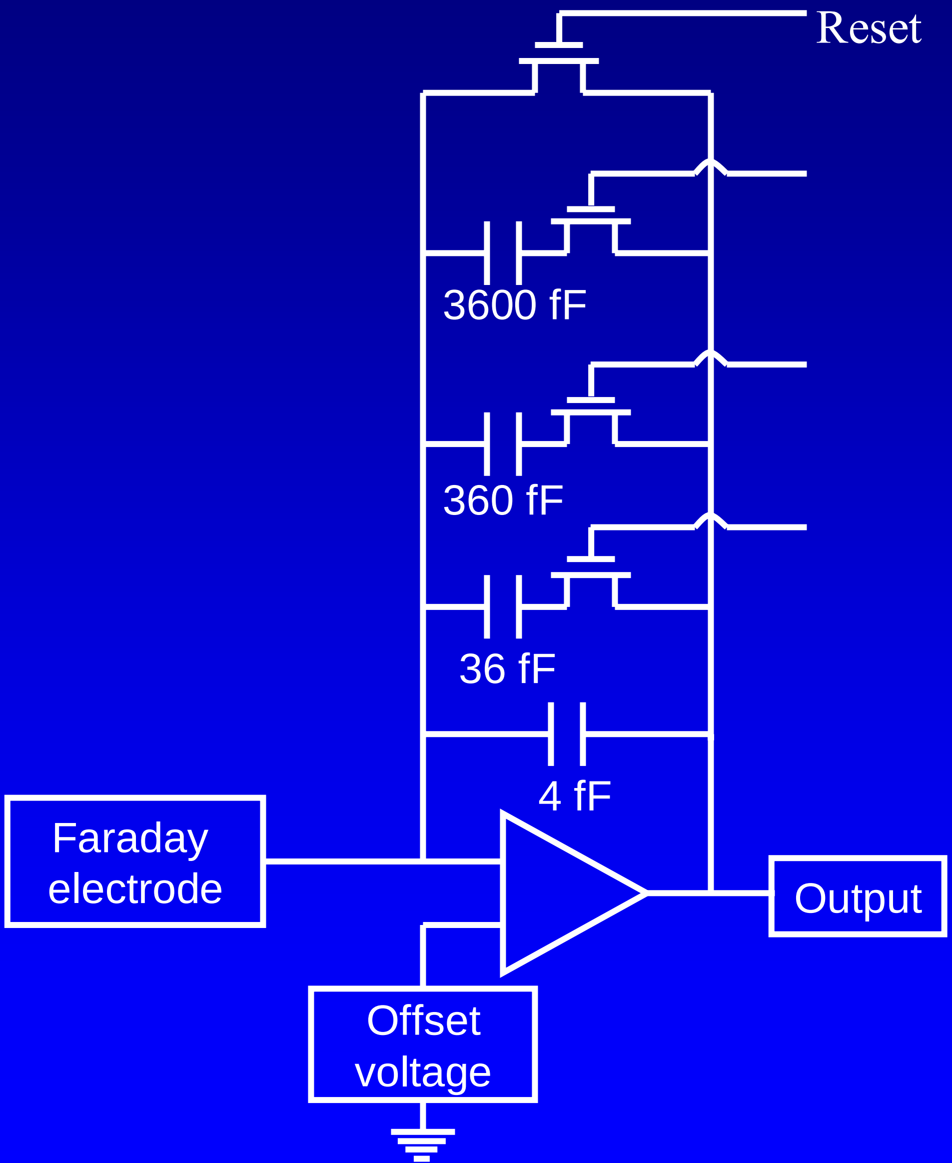
Isotope Ratio Precision




Signal (ADU/sec)
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
1.0E+00
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
1.0E+05
1.0E+06
1.0E+07
Concentration (pptr)


RESET
Gain
990 F F
"FARADAY
ELECTRODE"
10 FF

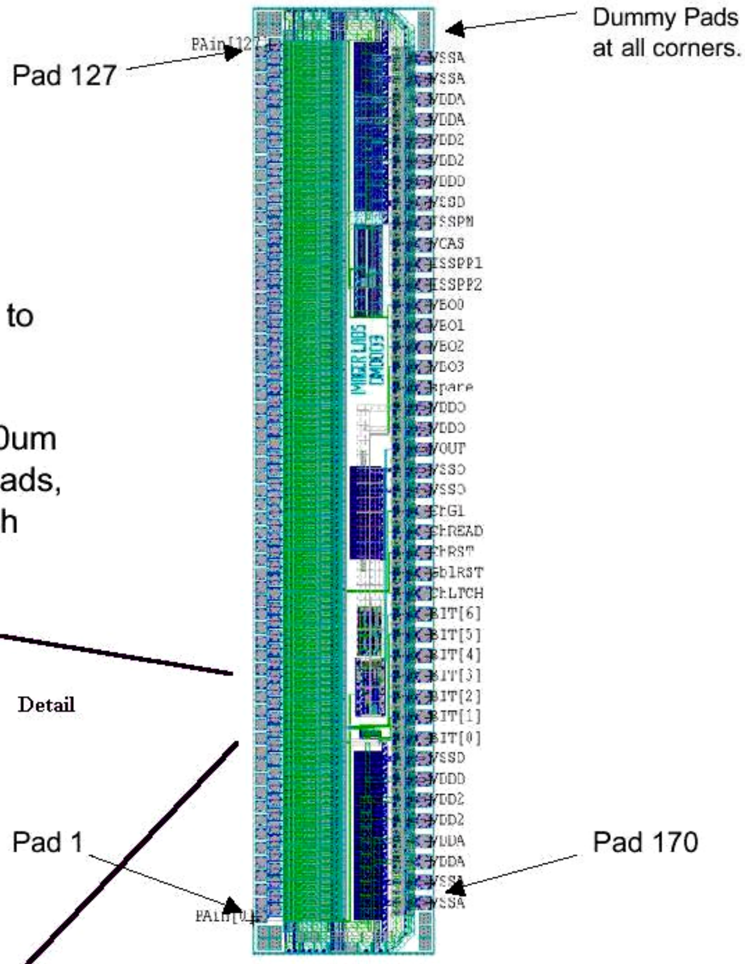
Variable gain CTIA electronics

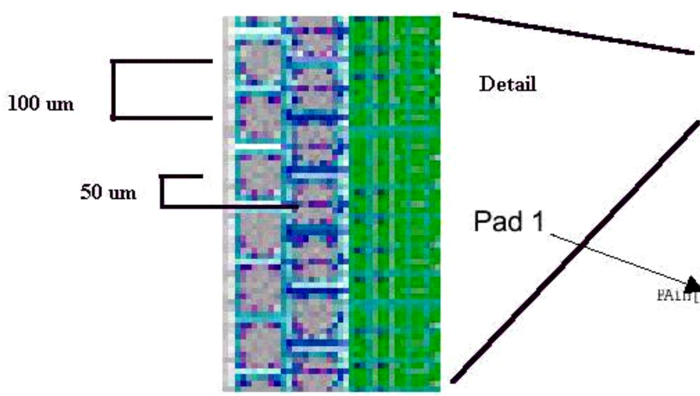


DM0003 Layout

iMAGERLABS

- Chip layout measures 1320um x 6900um.
- Cut die size can be up to 1500um x 7100um.
- Bonding pads have 150um pitch except for input pads, which have 100um pitch with 50um stagger.





Detection Limit

2 electrons of read noise
with NDRO

6 IONS !

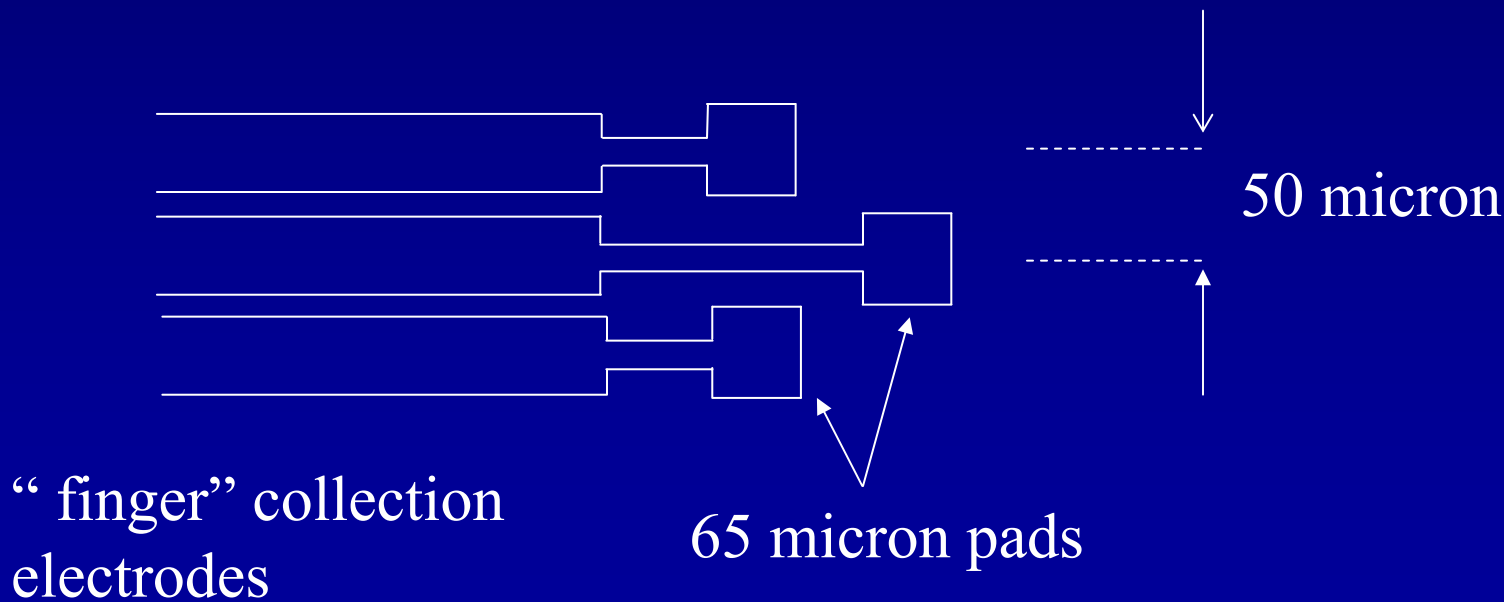
& we are still optimizing it !!

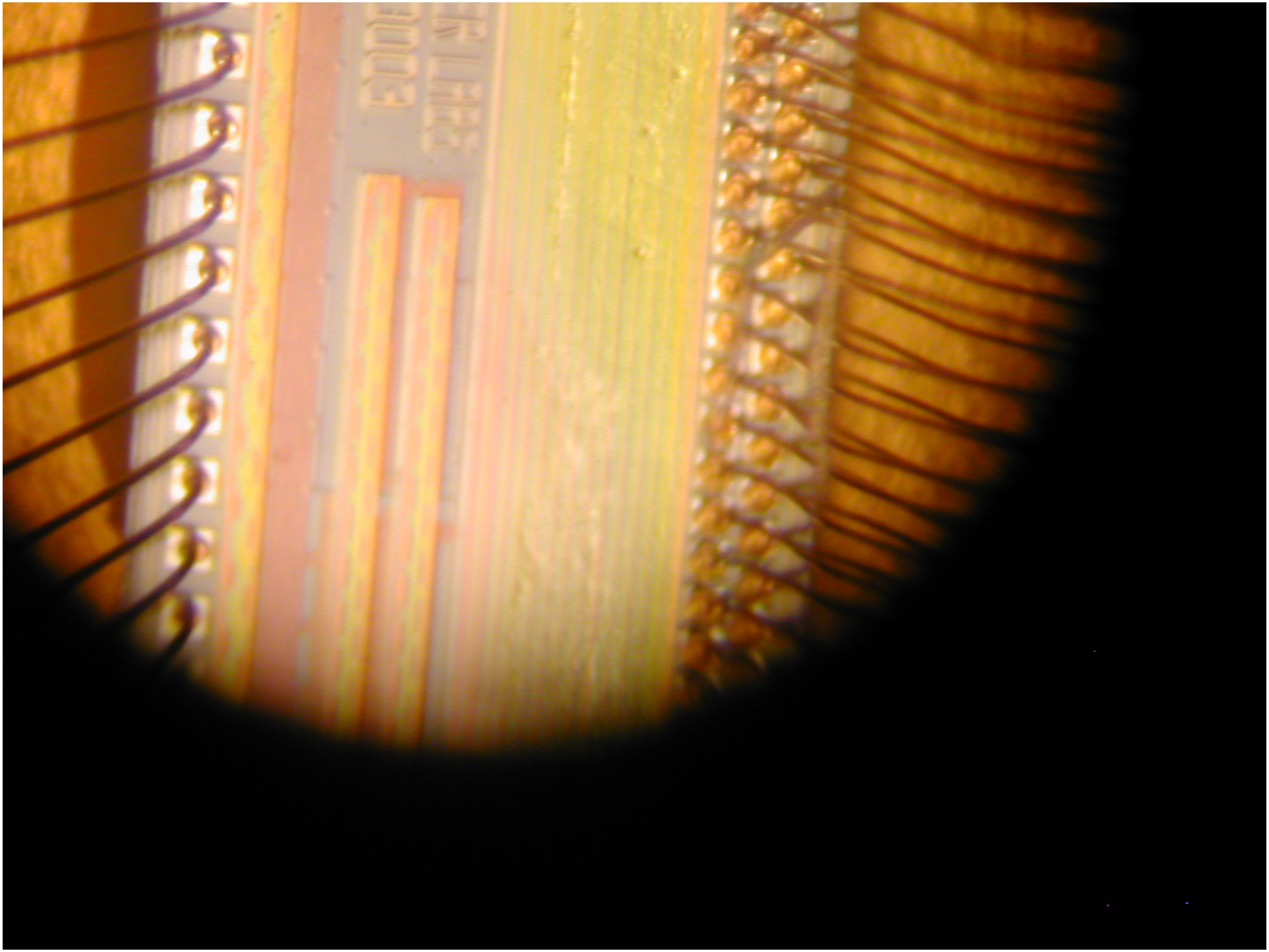
Keep tuned

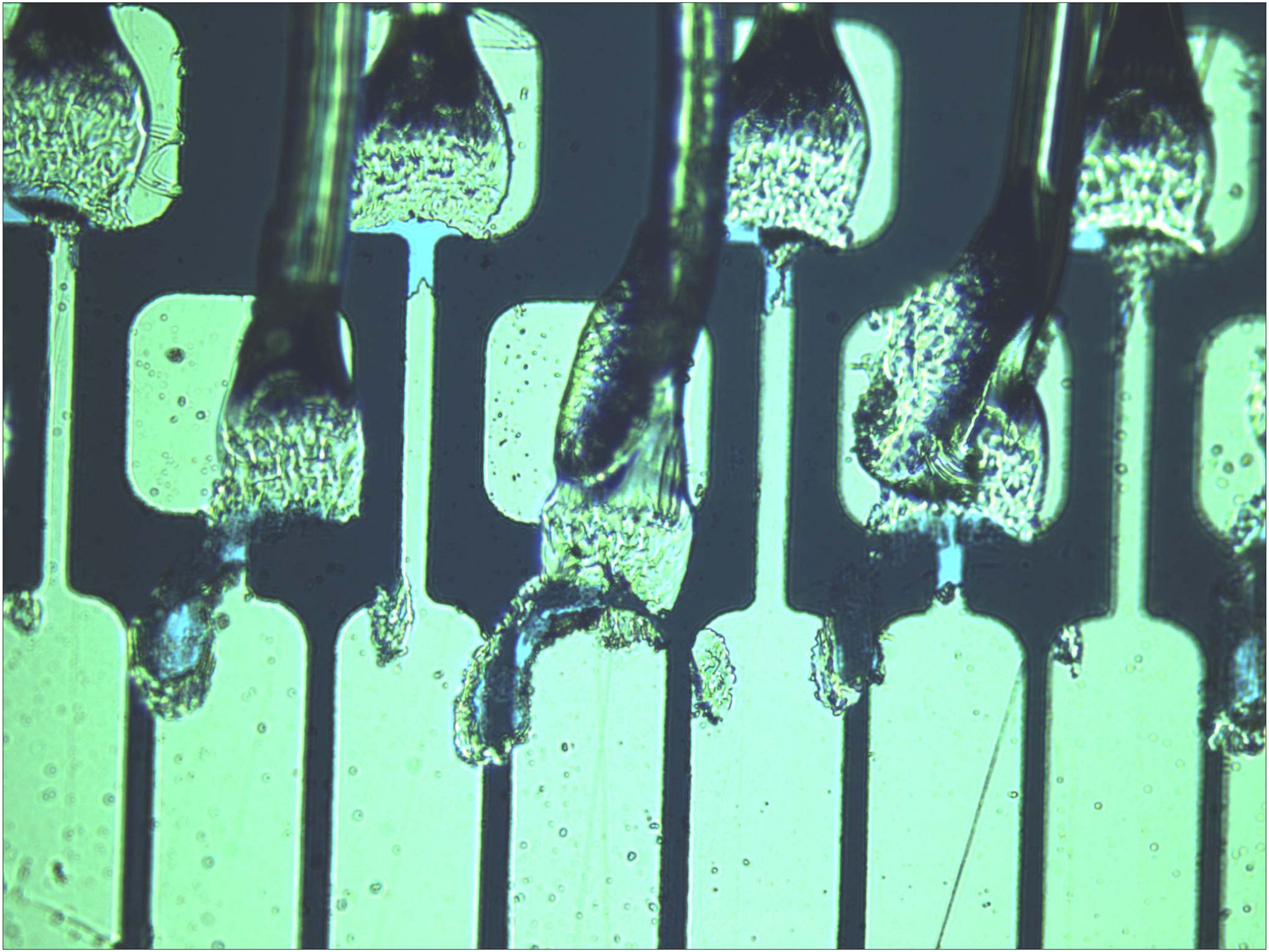
Issues to be Addressed

(1) Pixel Spacing

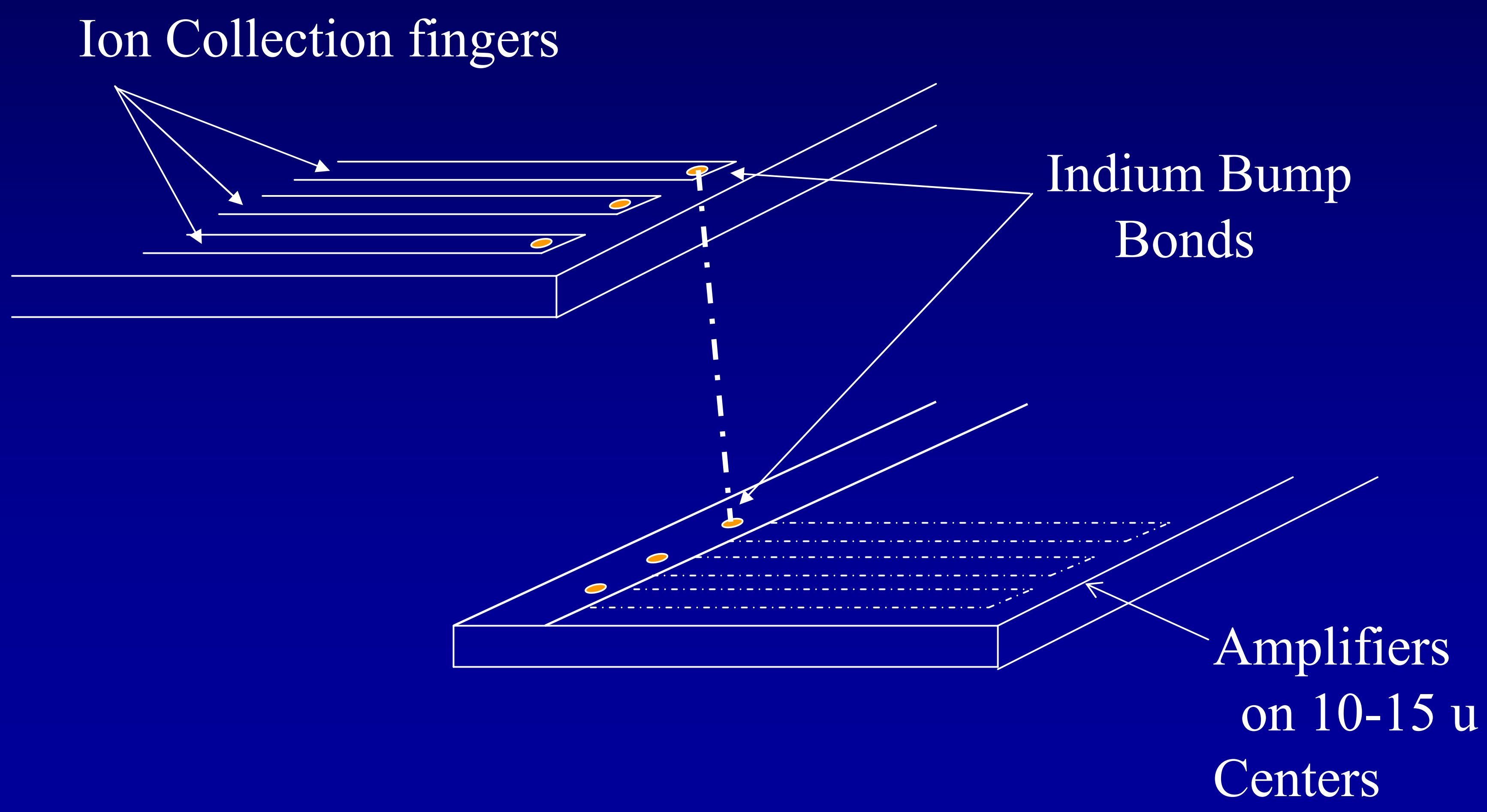
Smallest practical using Wire Bonding Connections is ≈ 50 microns





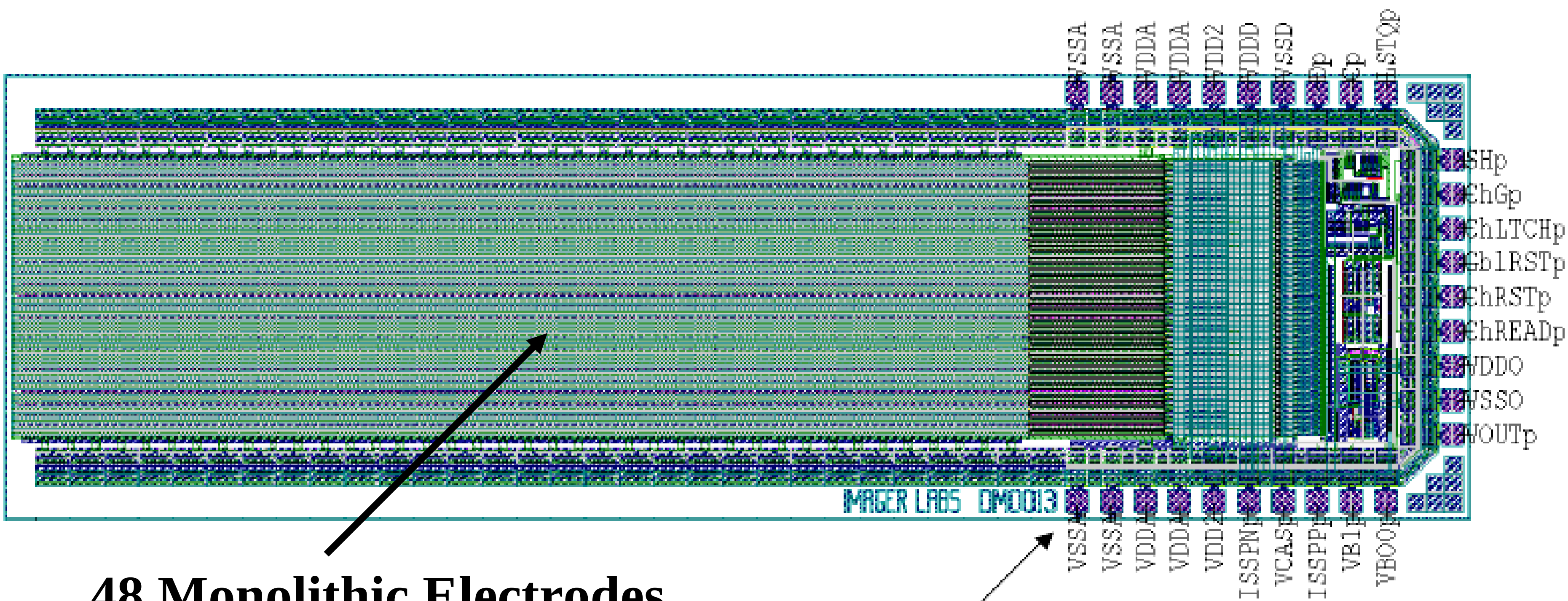


Bump Bonding Allows Connections to as Small as a Few Microns



Monolithic Collection Electrodes

- Chip layout measures 6410um x 1950um.
- There are 29 bonding pads on 150um pitch.
- 48 Detector array is 5mm x 25um.

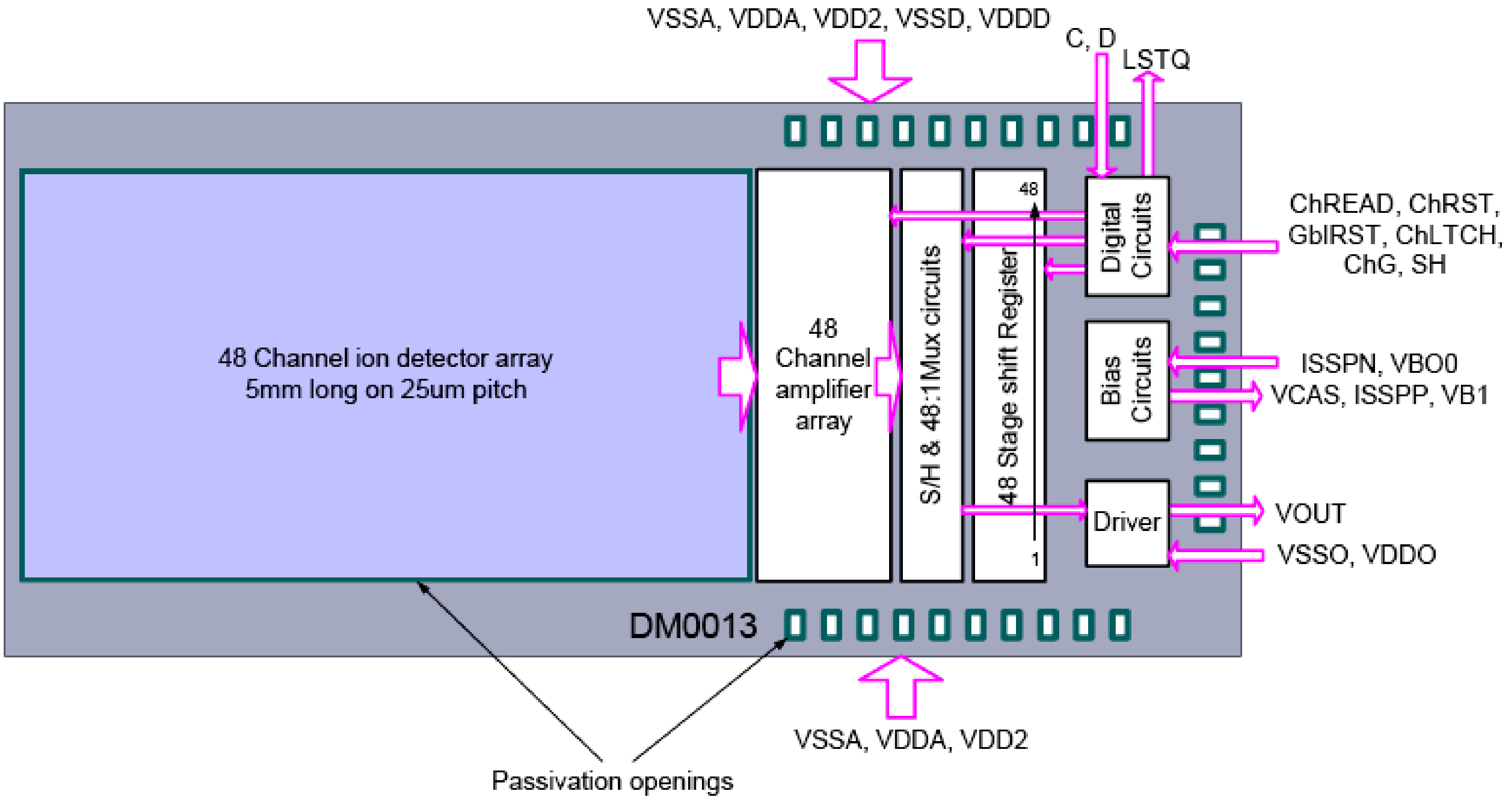


48 Monolithic Electrodes

Pad 1

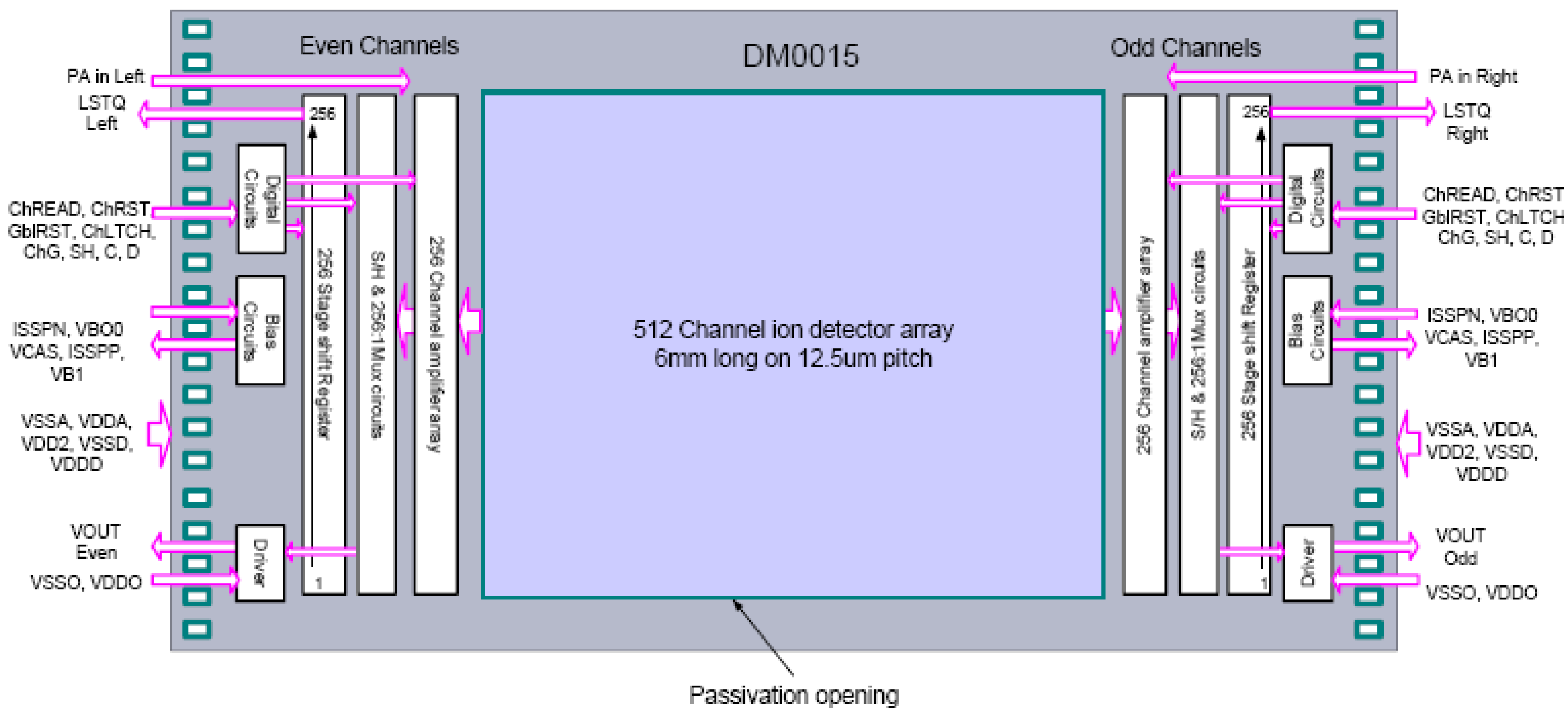
DM0013 Block Diagram / Floor Plan

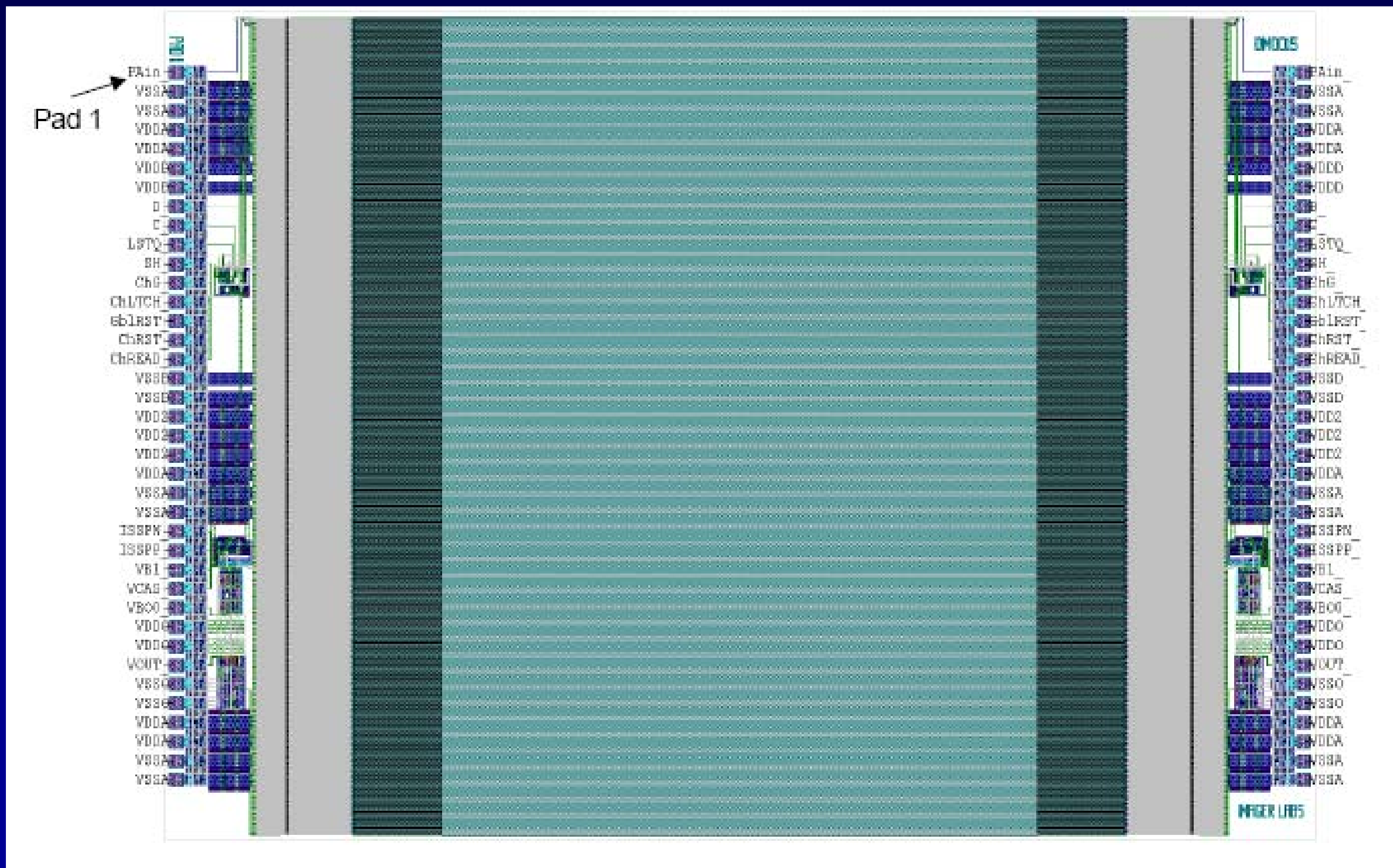
iMAGERLABS

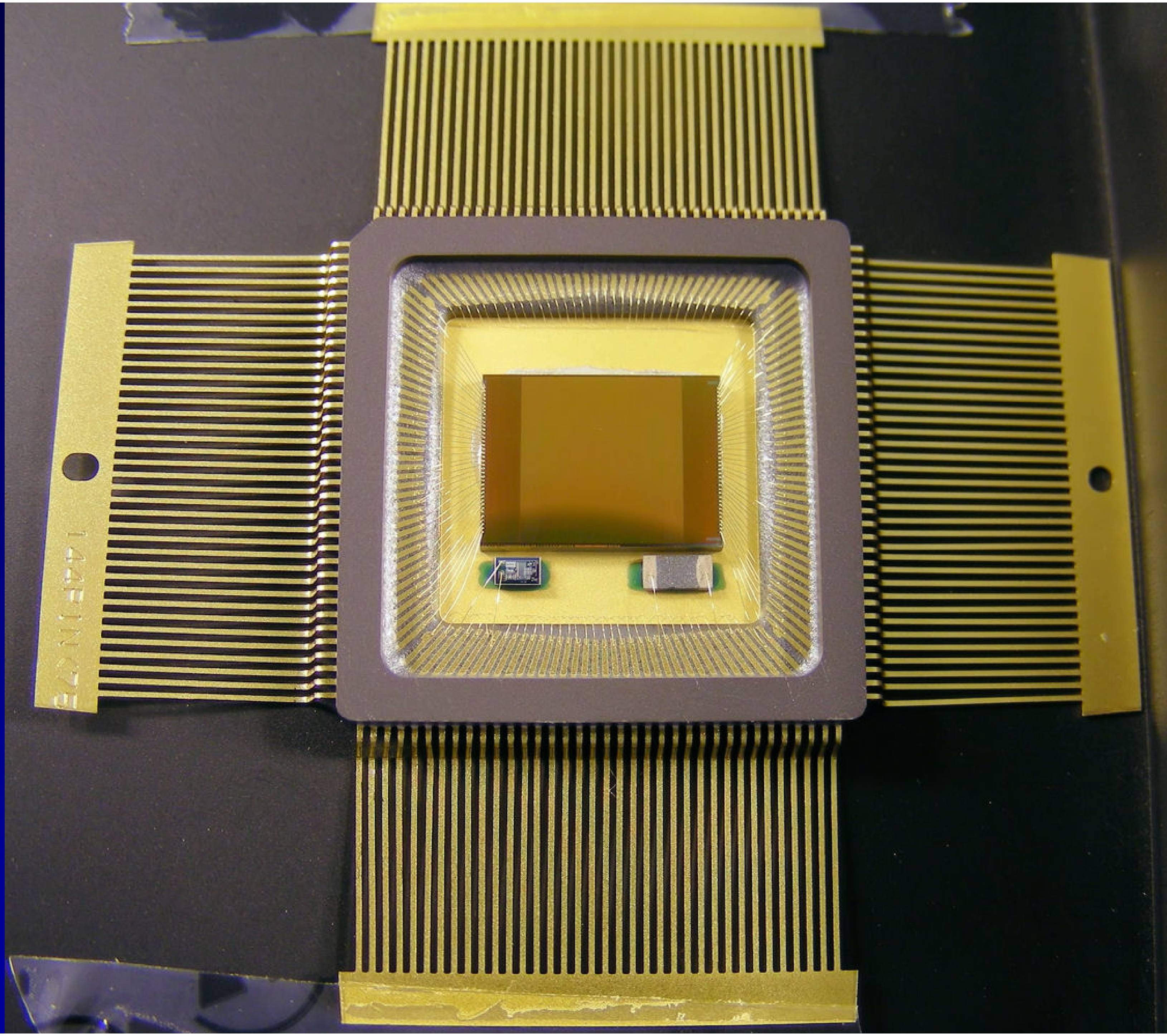


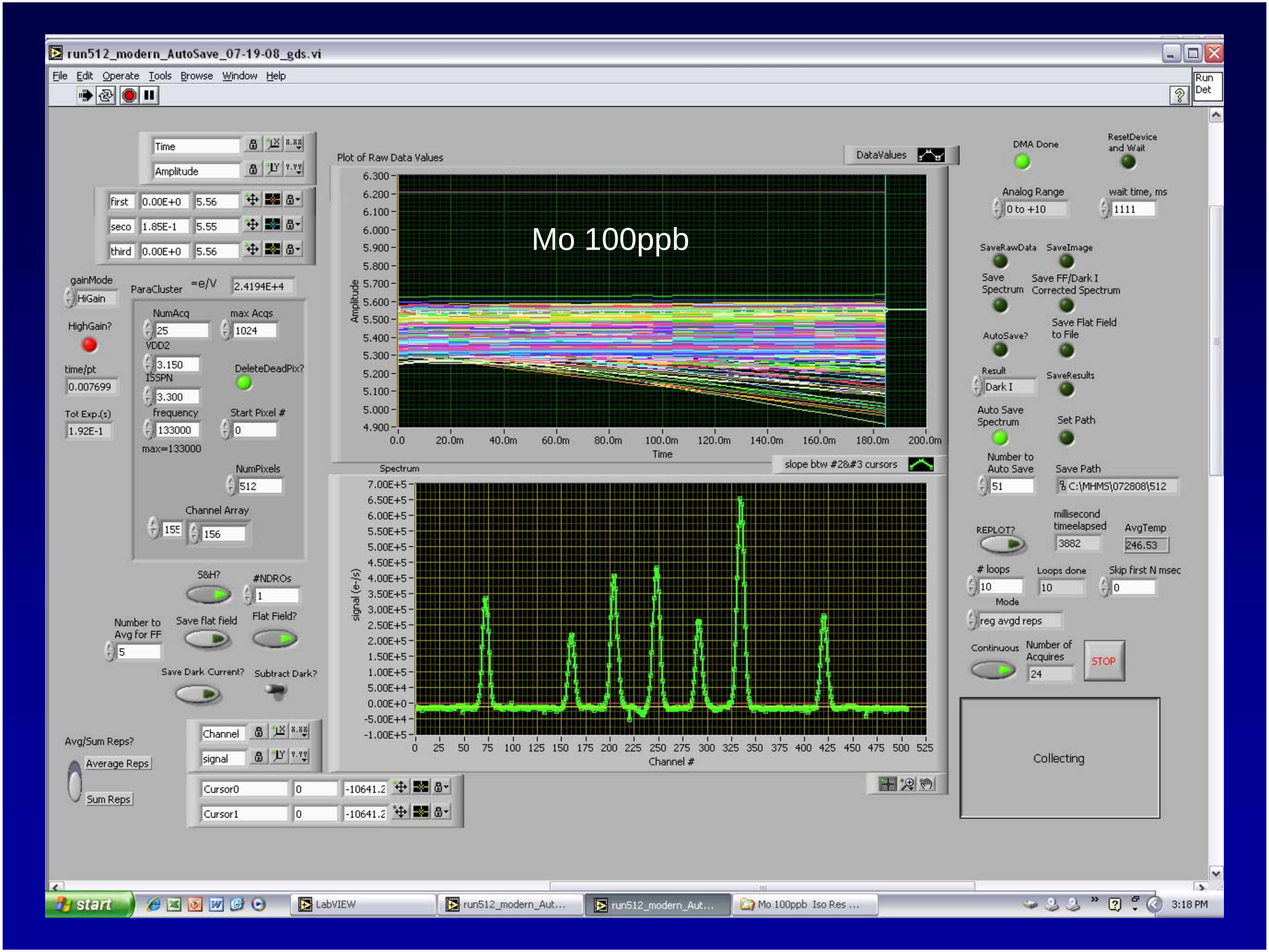
K. Johnson
5-16-06

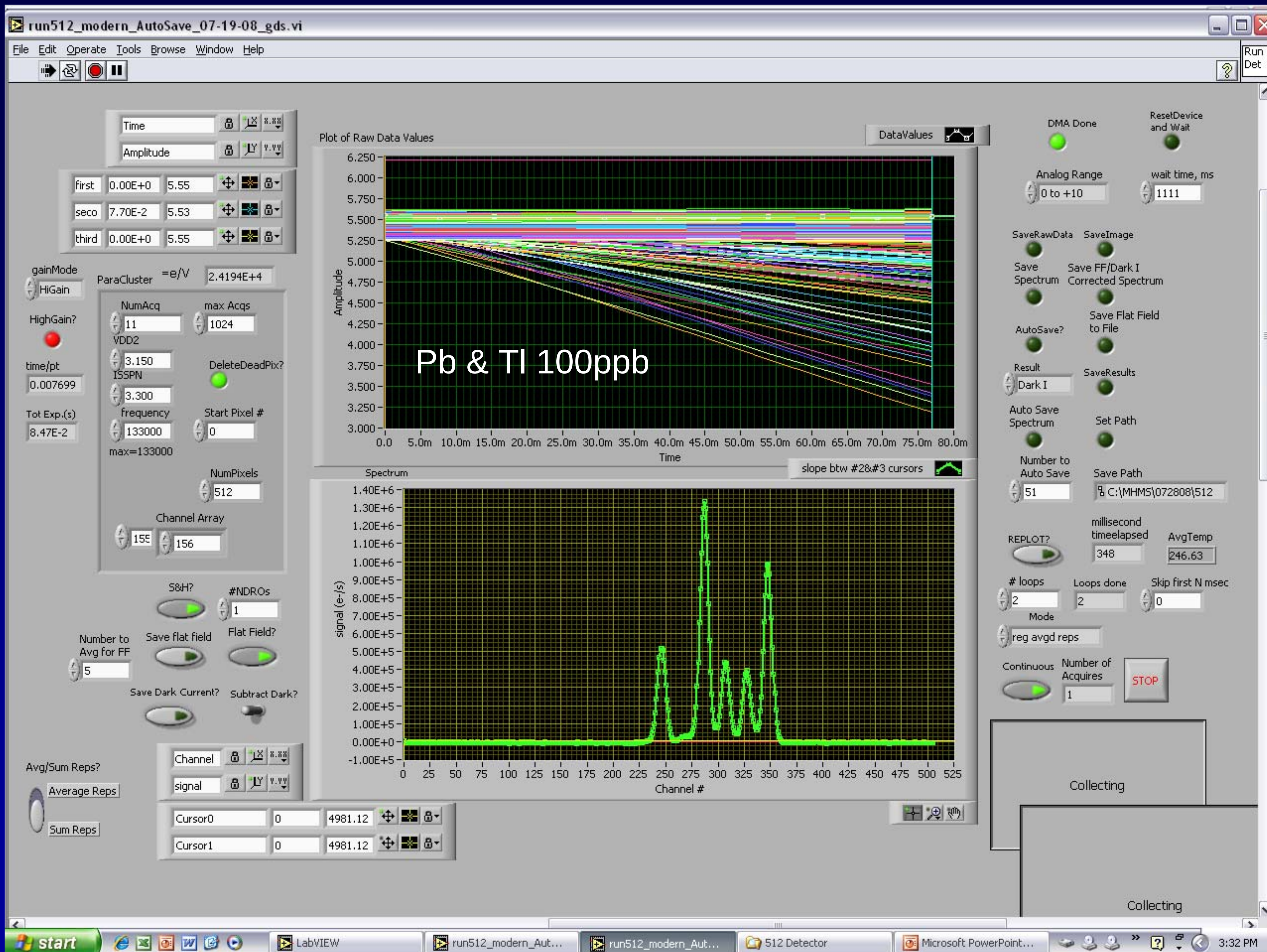
DM0015 Block Diagram / Floor Plan

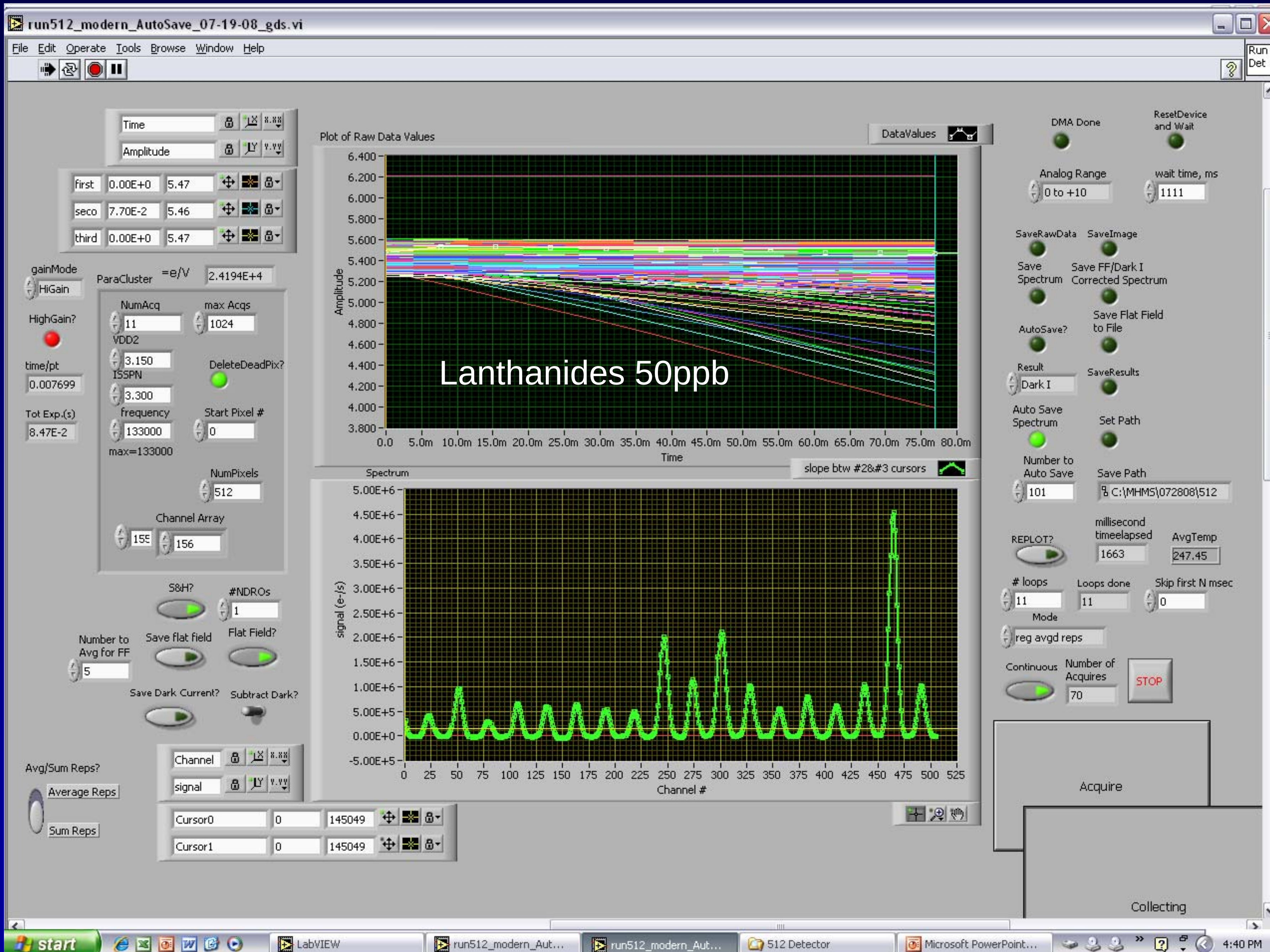



Pad 1
PAin
VSSA
VSSA
VDDA
VDDA
VDDD
VDDD
D
C
LSTQ
SH
ChG
ChLTCH
SblRST
ChRST
ChREAD
VSSD
VSSD
VDD2
VDD2
VDD2
VDDA
VSSA
VSSA
ISSPN
ISSPP
VB1
VCAS
VBOO
VDDO
VDDO
VOUT
VSSO
VSSO
VDDA
VDDA
VSSA
VSSA
IMAGER LABS



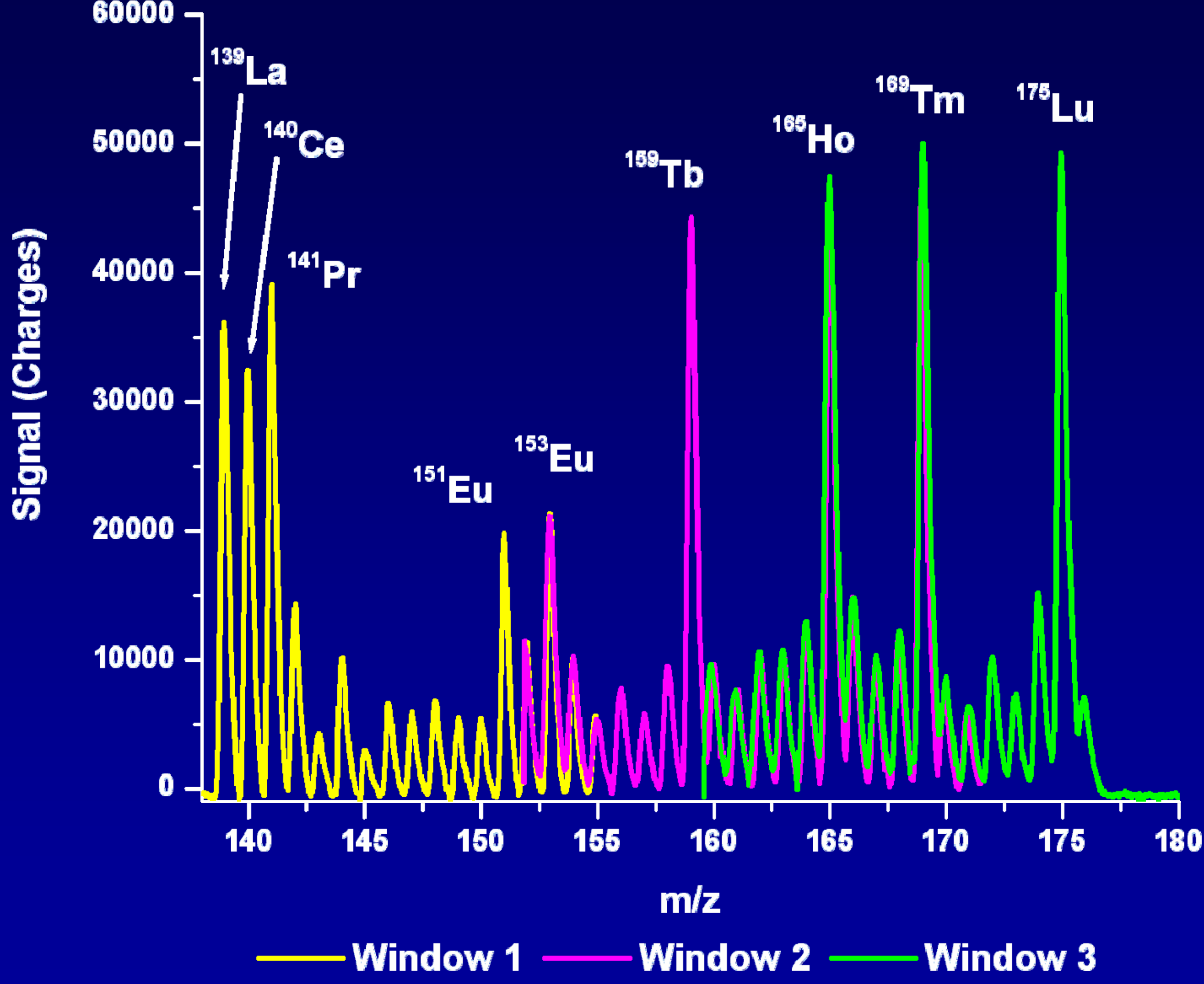

Mo 100ppb
run512_modern_AutoSave_07-19-08_gds.vi
File Edit Operate Tools Browse Window Help
Run Det
Plot of Raw Data Values
DataValues
Amplitude
Time
Spectrum
slope btw #2&#3 cursors
signal (e-/s)
Channel #
Time
Amplitude
first 0.00E+0 5.56
seco 1.85E-1 5.55
third 0.00E+0 5.56
gainMode
HiGain
HighGain?
time/pt
0.007699
Tot Exp.(s)
1.92E-1
ParaCluster =e/V 2.4194E+4
NumAcq 25
max Acqs 1024
VDD2 3.150
ISSPN 3.300
DeleteDeadPix?
frequency 133000
max=133000
Start Pixel # 0
NumPixels 512
Channel Array 155 156
S&H?
#NDROs 1
Number to Avg for FF 5
Save flat field
Flat Field?
Save Dark Current?
Subtract Dark?
Avg/Sum Reps?
Average Reps
Sum Reps
Channel
signal
Cursor0 0 -10641.2
Cursor1 0 -10641.2
DMA Done
ResetDevice and Wait
Analog Range 0 to +10
wait time, ms 1111
SaveRawData
SaveImage
Save Spectrum
Save FF/Dark I Corrected Spectrum
AutoSave?
Save Flat Field to File
Result Dark I
SaveResults
Auto Save Spectrum
Set Path
Number to Auto Save 51
Save Path C:\MHMS\072808\512
REPLOT?
millisecond timeelapsed 3882
AvgTemp 246.53
loops 10
Loops done 10
Skip first N msec 0
Mode reg avgd reps
Continuous
Number of Acquires 24
STOP
Collecting
start
LabVIEW
run512_modern_Aut...
run512_modern_Aut...
Mo 100ppb Iso Res ...
3:18 PM


run512_modern_AutoSave_07-19-08_gds.vi
File Edit Operate Tools Browse Window Help
Plot of Raw Data Values
DataValues
Amplitude
Time
Pb & Tl 100ppb
Spectrum
slope btw #2&#3 cursors
signal (e-/s)
Channel #
Time
Amplitude
first 0.00E+0 5.55
seco 7.70E-2 5.53
third 0.00E+0 5.55
gainMode
HiGain
HighGain?
time/pt
0.007699
Tot Exp.(s)
8.47E-2
ParaCluster
=e/V
2.4194E+4
NumAcq
11
max Acqs
1024
VDD2
3.150
ISSPN
3.300
DeleteDeadPix?
frequency
133000
max=133000
Start Pixel #
0
NumPixels
512
Channel Array
156
S&H?
#NDROs
1
Number to Avg for FF
5
Save flat field
Flat Field?
Save Dark Current?
Subtract Dark?
Avg/Sum Reps?
Average Reps
Sum Reps
Channel
signal
Cursor0 0 4981.12
Cursor1 0 4981.12
DMA Done
ResetDevice and Wait
Analog Range
0 to +10
wait time, ms
1111
SaveRawData
SaveImage
Save Spectrum
Save FF/Dark I Corrected Spectrum
AutoSave?
Save Flat Field to File
Result
Dark I
SaveResults
Auto Save Spectrum
Set Path
Number to Auto Save
51
Save Path
C:\MHMS\072808\512
REPLOT?
millisecond timeelapsed
348
AvgTemp
246.63
loops
2
Loops done
2
Skip first N msec
0
Mode
reg avgd reps
Continuous
Number of Acquires
1
STOP
Collecting
Collecting
start
LabVIEW
run512_modern_Aut...
run512_modern_Aut...
512 Detector
Microsoft PowerPoint...
3:32 PM



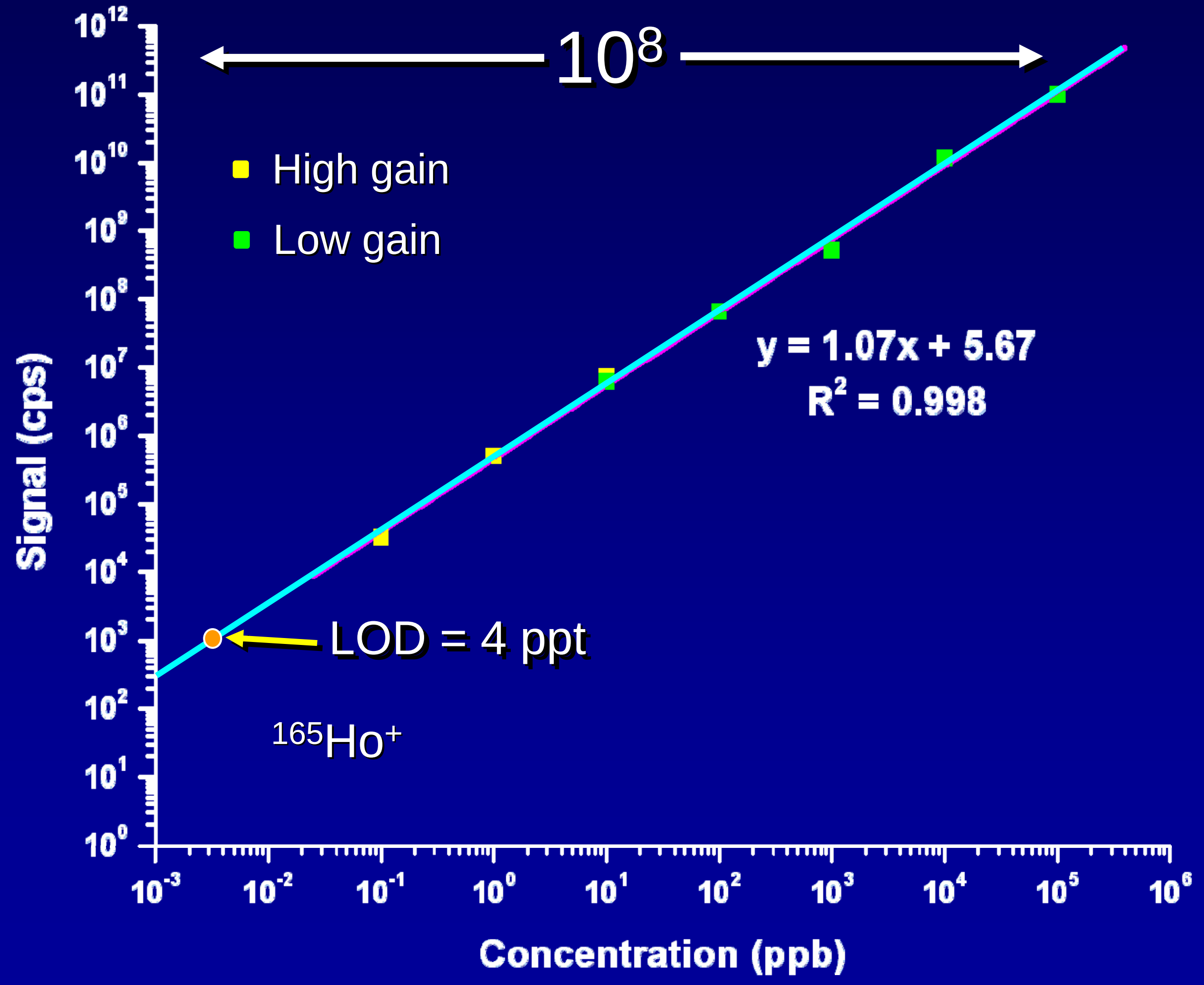
run512_modern_AutoSave_07-19-08_gds.vi
File Edit Operate Tools Browse Window Help
Plot of Raw Data Values
DataValues
Amplitude
Time
Lanthanides 50ppb
Spectrum
slope btw #2&#3 cursors
signal (e-/s)
Channel #
gainMode
HiGain
HighGain?
time/pt
0.007699
Tot Exp.(s)
8.47E-2
ParaCluster
=e/V
2.4194E+4
NumAcq
11
max Acqs
1024
VDD2
3.150
ISSPN
3.300
frequency
133000
max=133000
DeleteDeadPix?
Start Pixel #
0
NumPixels
512
Channel Array
156
S&H?
#NDROs
1
Number to Avg for FF
5
Save flat field
Flat Field?
Save Dark Current?
Subtract Dark?
Avg/Sum Reps?
Average Reps
Sum Reps
Cursor0
Cursor1
145049
DMA Done
ResetDevice and Wait
Analog Range
0 to +10
wait time, ms
1111
SaveRawData
SaveImage
Save Spectrum
Save FF/Dark I Corrected Spectrum
AutoSave?
Save Flat Field to File
Result
Dark I
SaveResults
Auto Save Spectrum
Set Path
Number to Auto Save
101
Save Path
C:\MHMS\072808\512
REPLOT?
millisecond timeelapsed
1663
AvgTemp
247.45
loops
11
Loops done
11
Skip first N msec
0
Mode
reg avgd reps
Continuous
Number of Acquires
70
STOP
Acquire
Collecting
start
LabVIEW
512 Detector
Microsoft PowerPoint...
4:40 PM

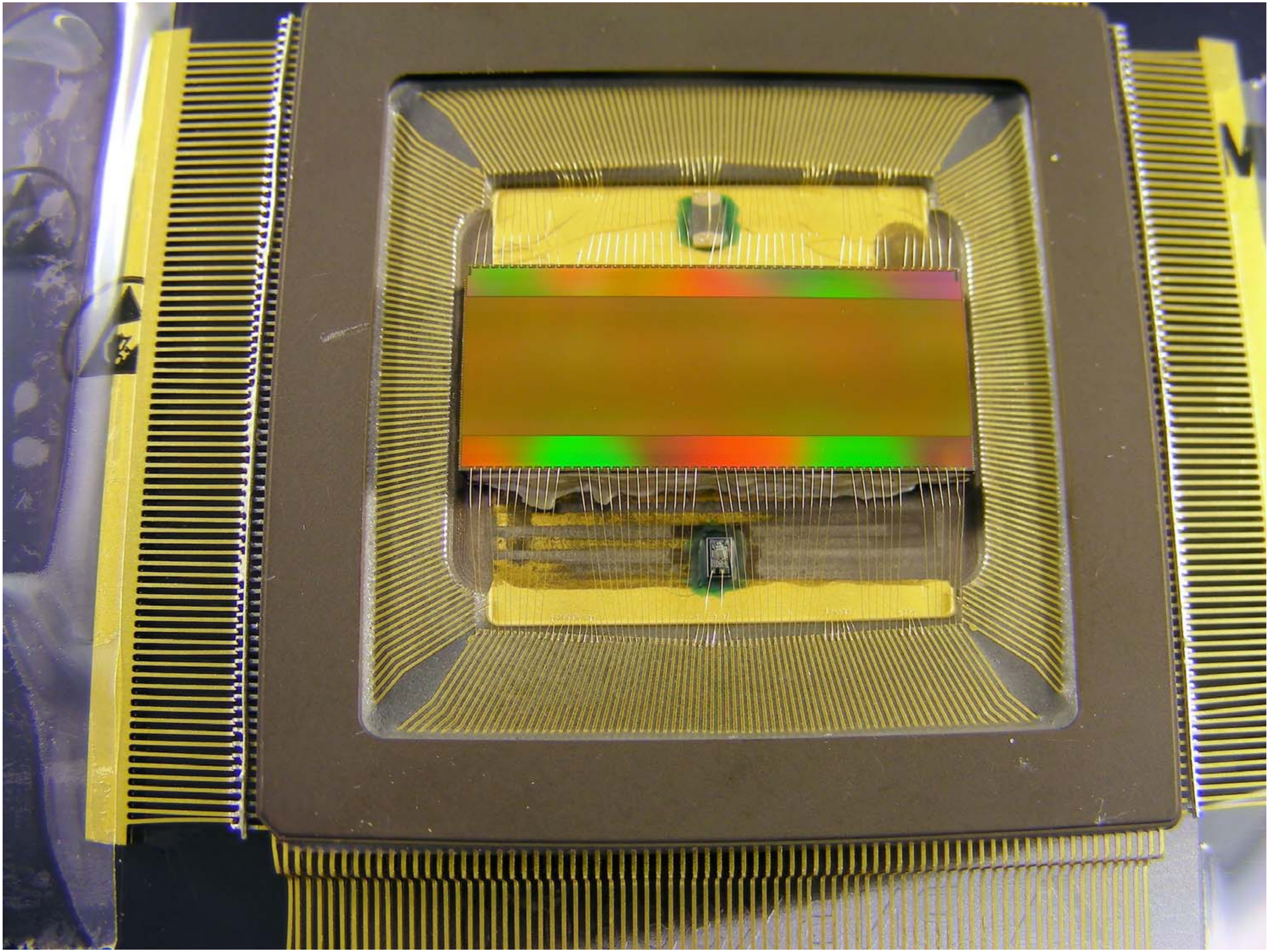
Rare Earth Elements

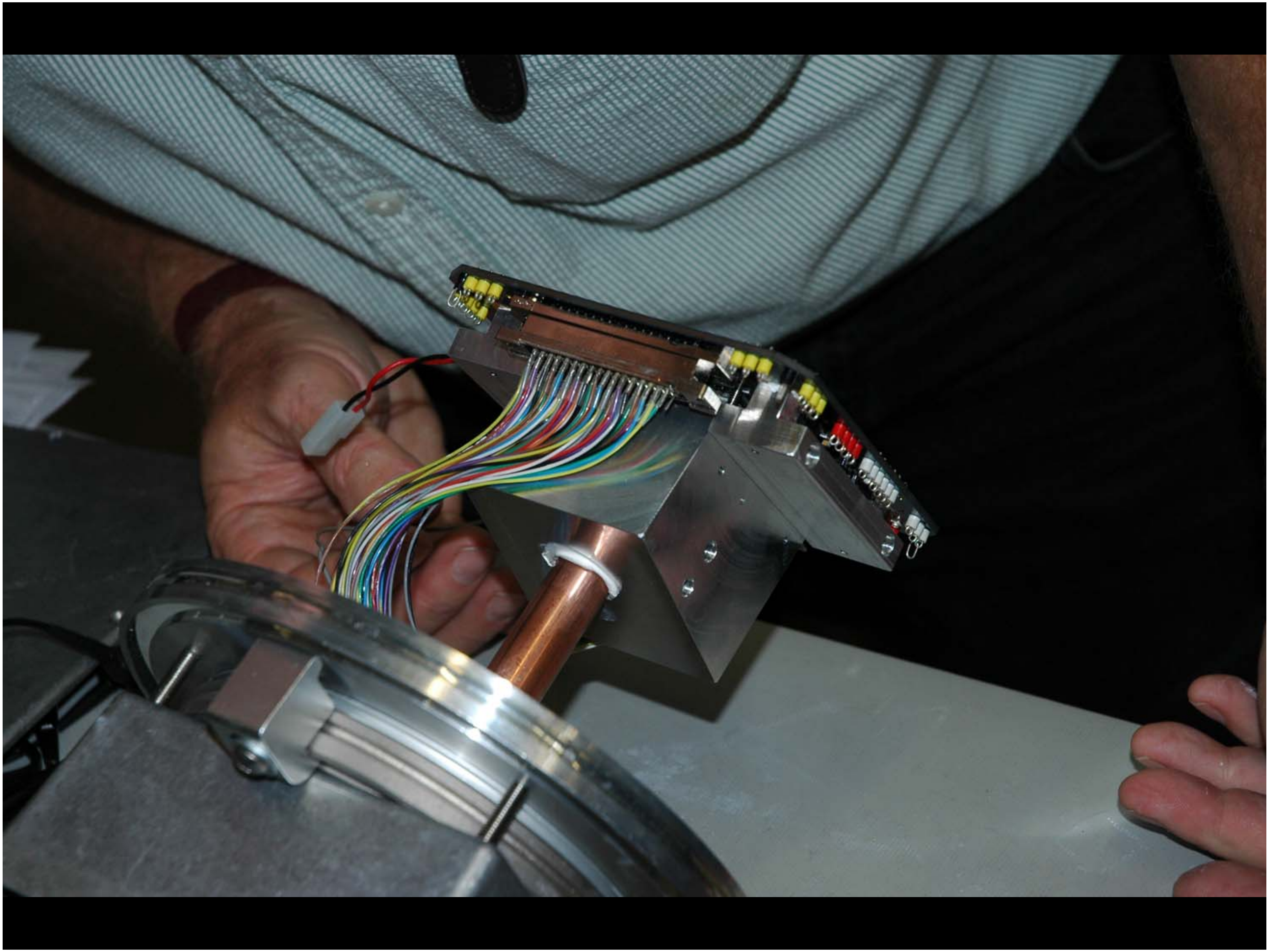


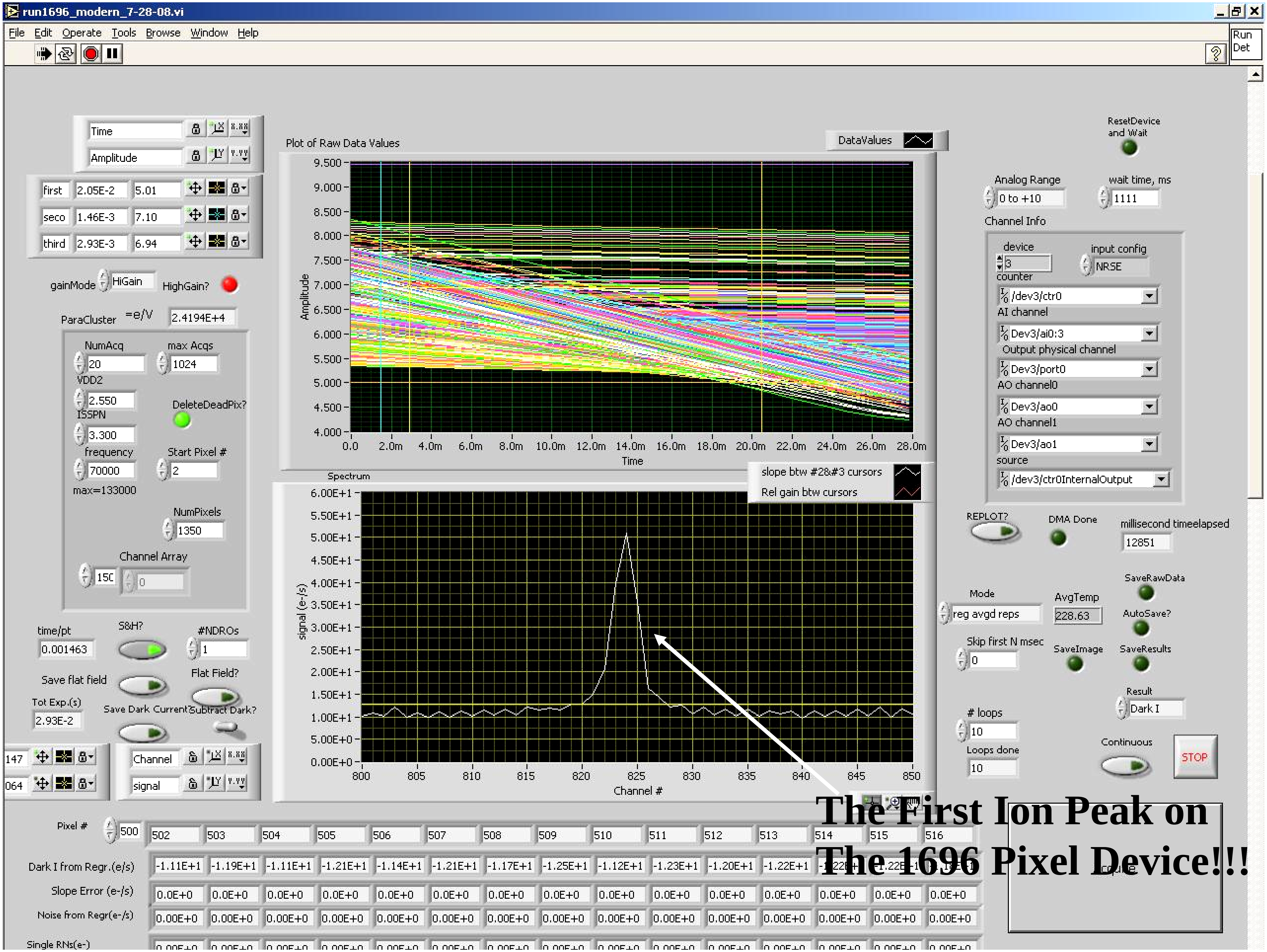
10 ppb multi-elemental solution, 0.5 s Integration Time

Linear Dynamic Range



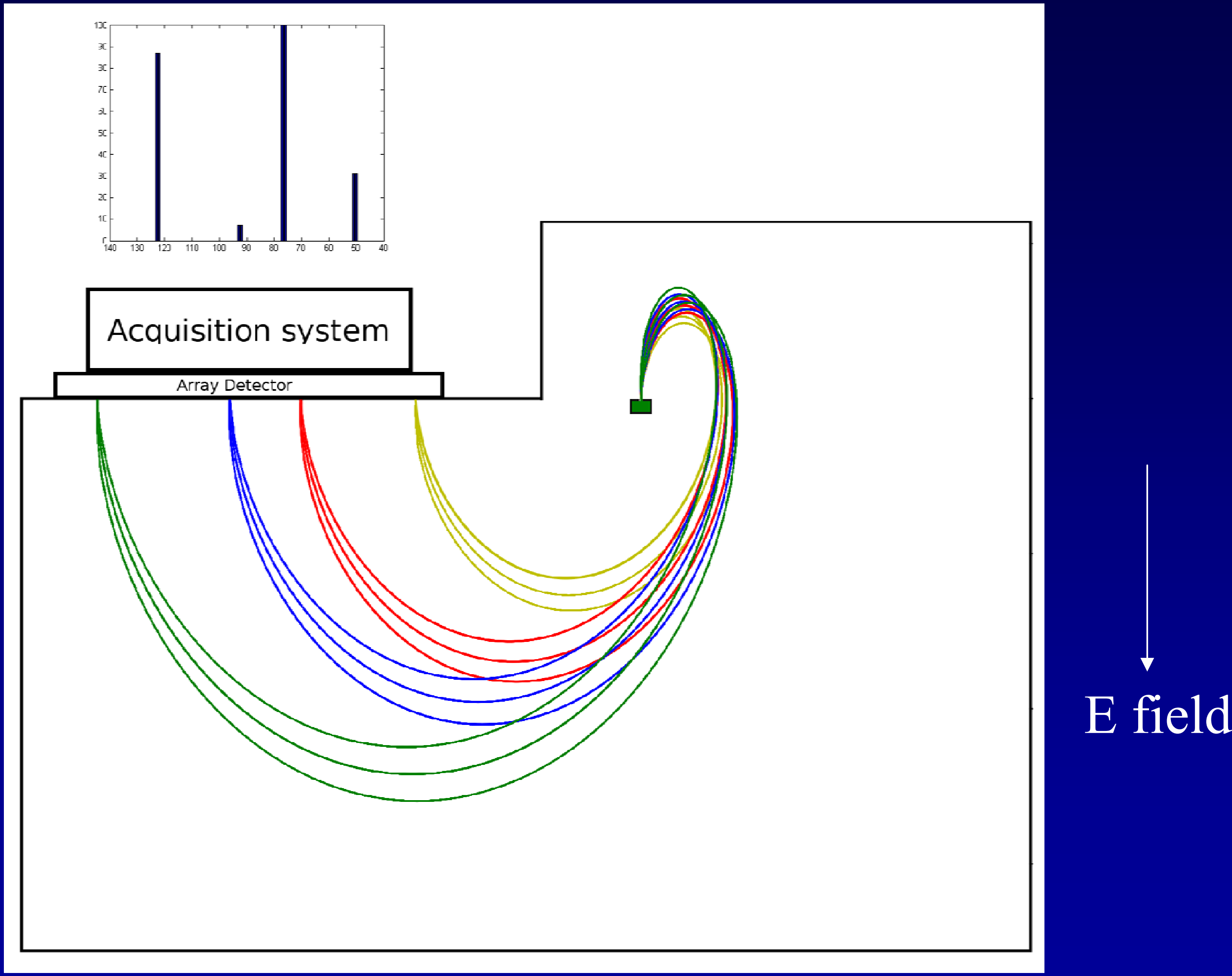




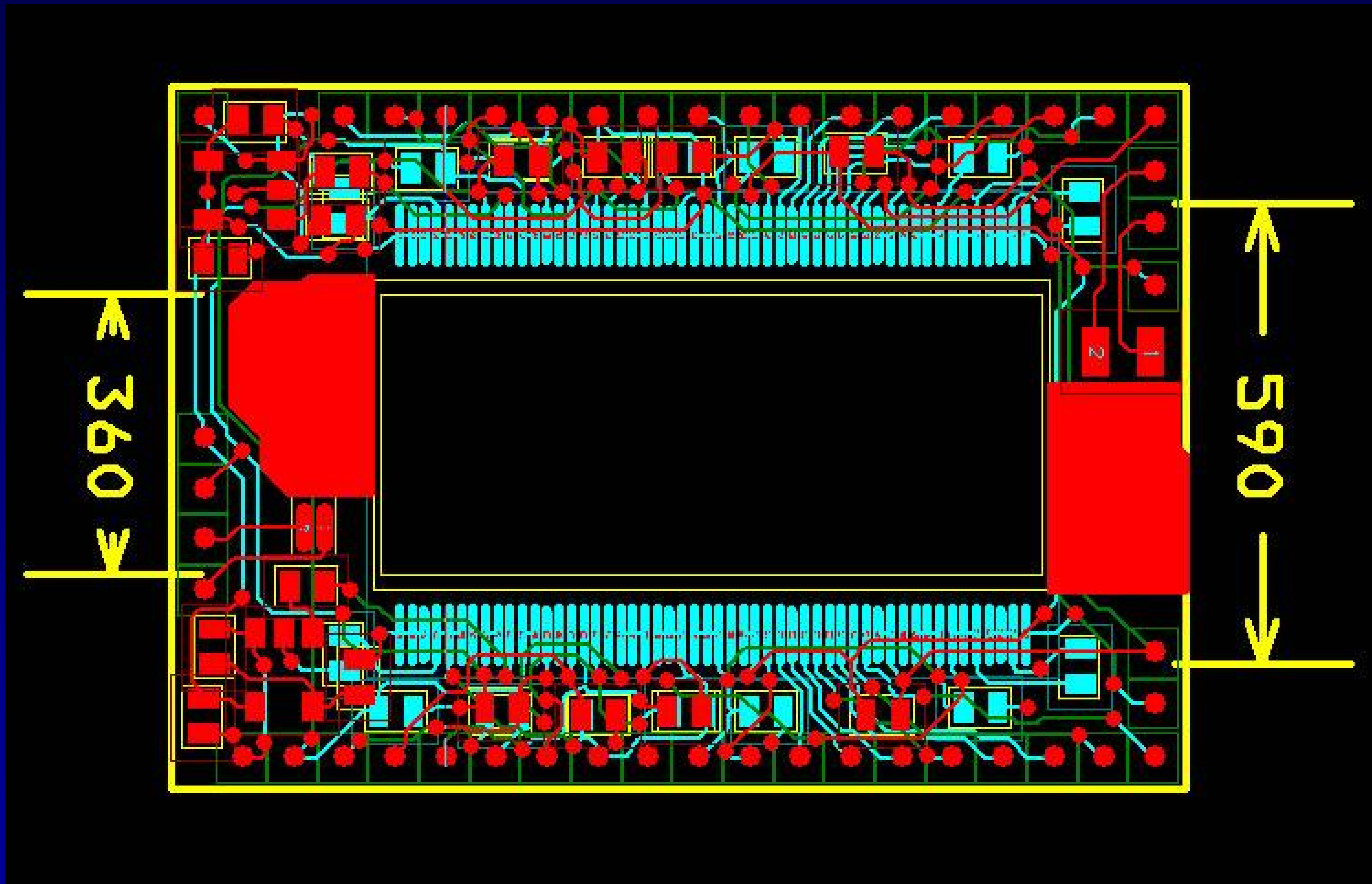


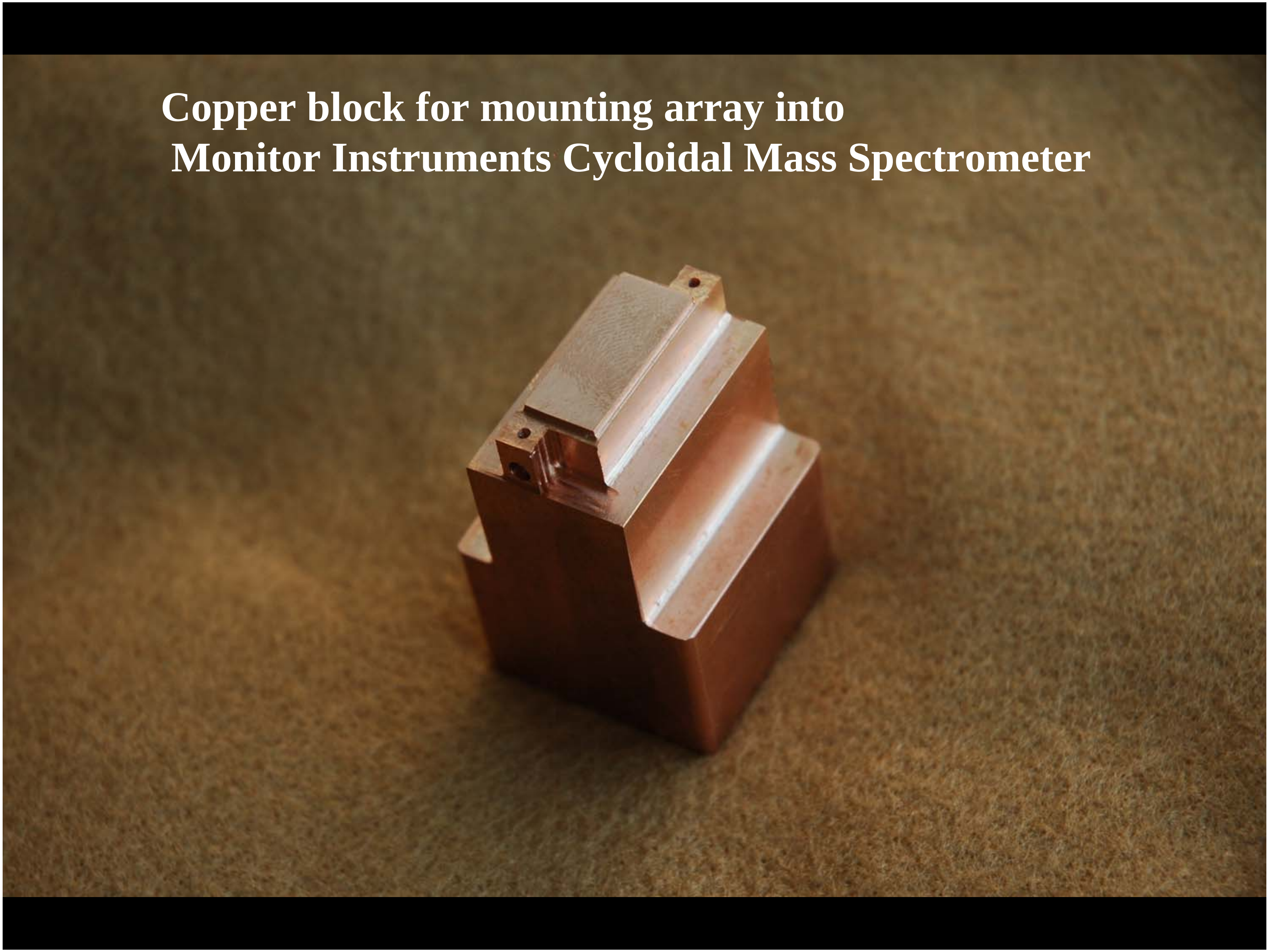
The First Ion Peak on The 1696 Pixel Device!!!

Cycloid MS Equipped with an Array



B field up out of plane


360
590


Copper block for mounting array into
Monitor Instruments Cycloidal Mass Spectrometer

Technology Currently Deployed for Explosives (IED)

Ion Mobility Spectrometers (IMS)

Require particles ~ micrograms

Swipe Tests

" Puffers" blow particles loose

These can NOT "smell" explosives !!!

Major suppliers

Smith's Detection

General Electric Security

Many , many others

New Ion Detectors

Capable of Very High Sensitivity

Operate at High Pressure (no upper pressure limit)

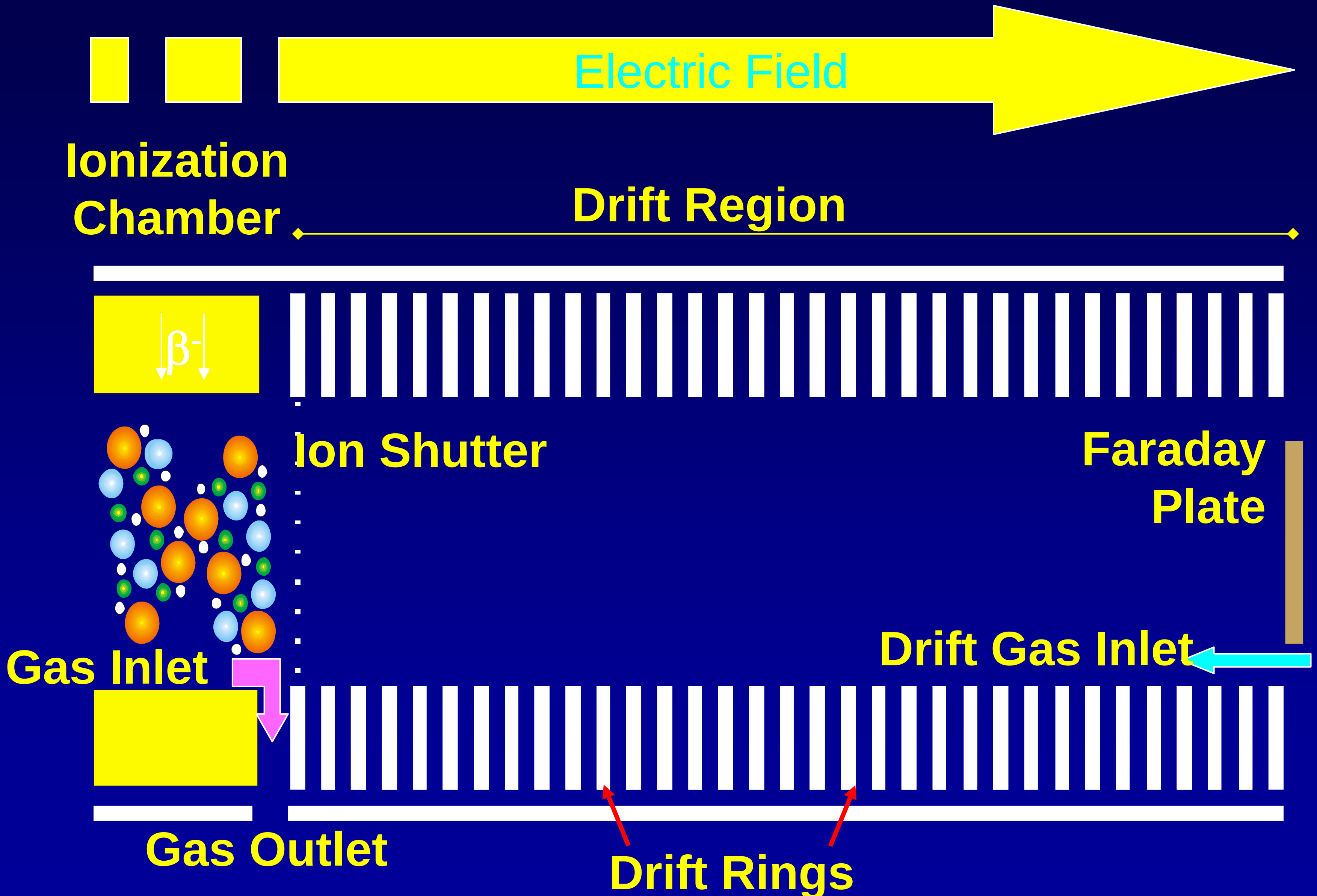
Sufficient Frequency Response (currently to 1 MHz)

Ability To Operate in High Background
Noise Environments

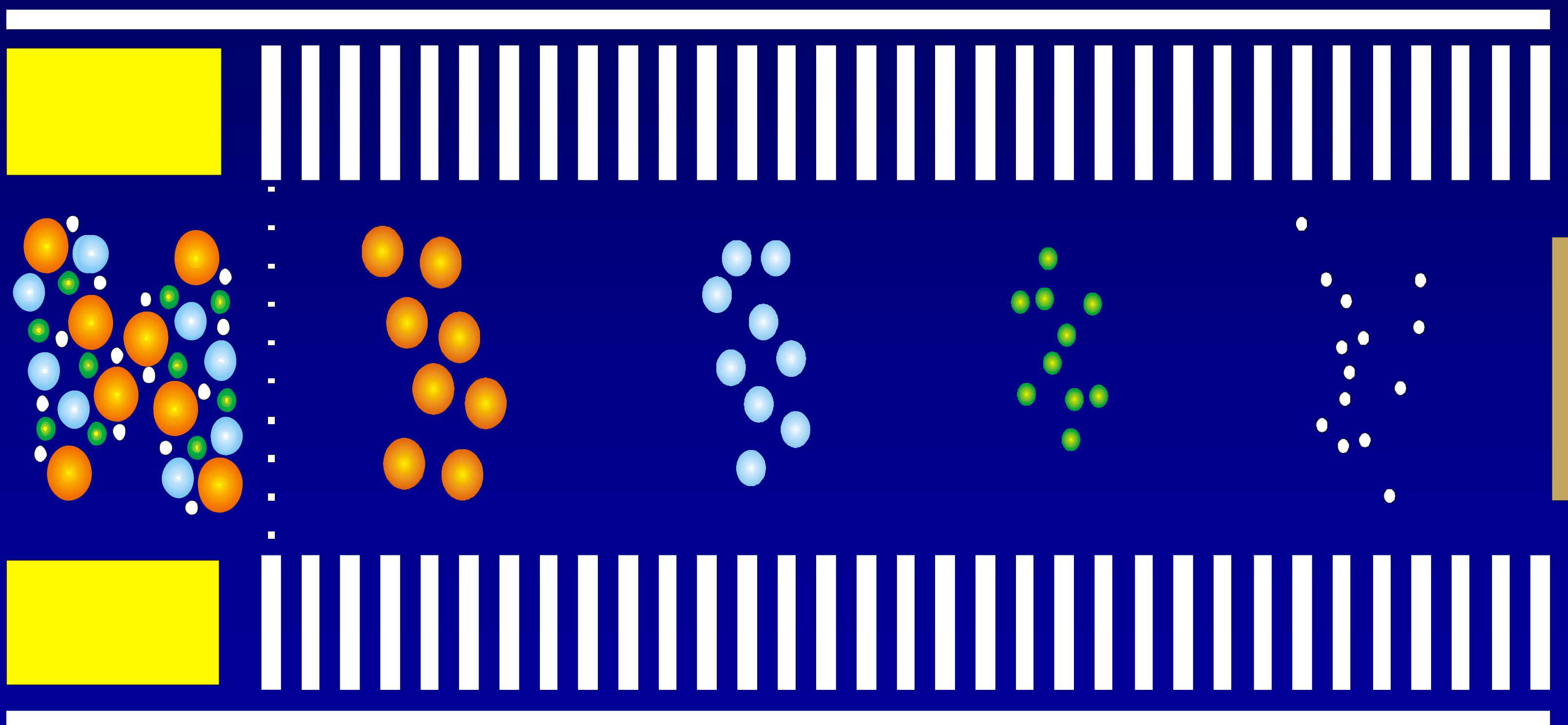
Inexpensive (in production)

Multi Gain Levels – Allows implementation of
Automatic Gain Control – Important when
Deployed in High Background Environments

Ion Mobility Spectrometer



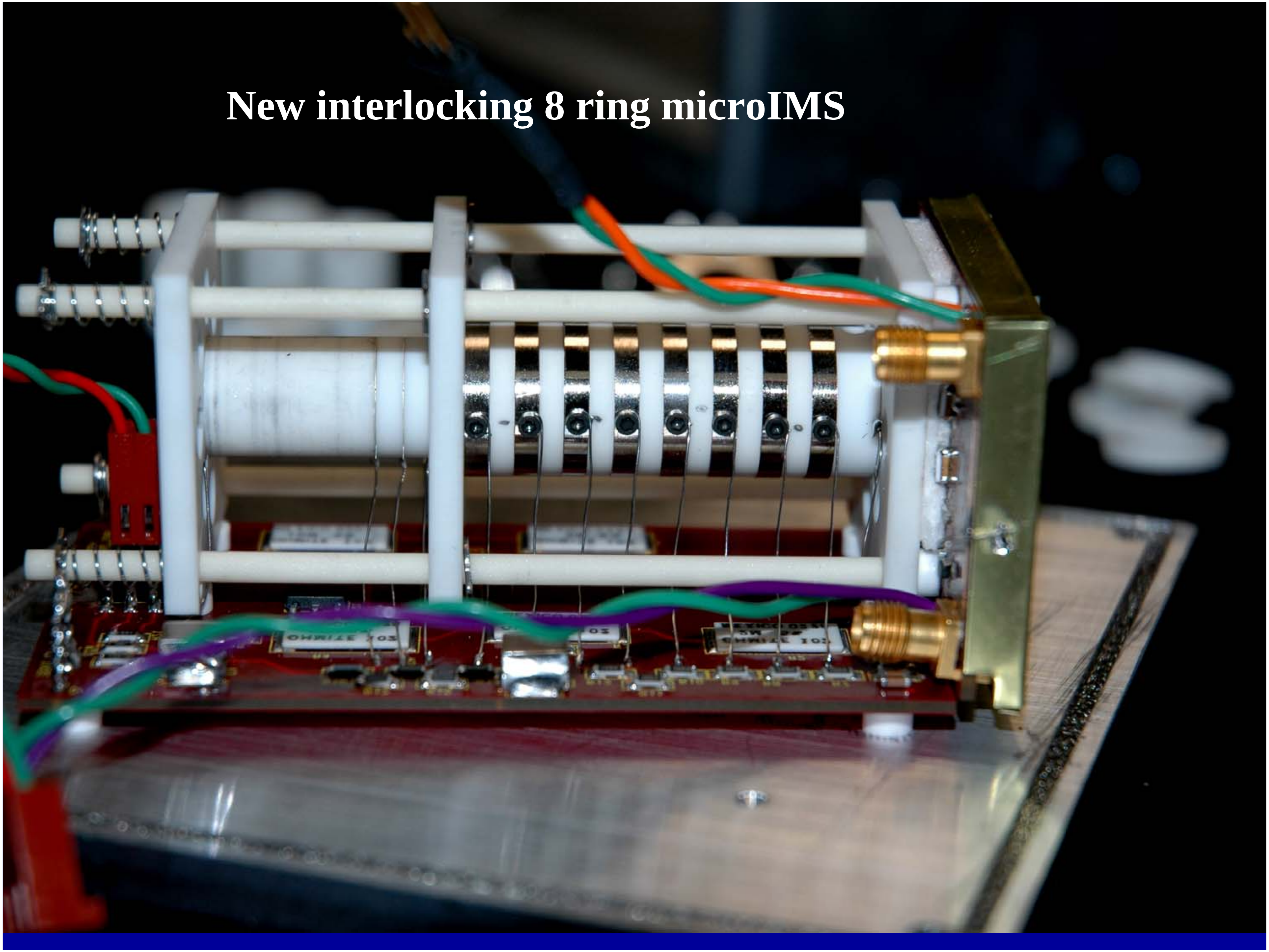
Chemical Identification Based Upon Ion Mobility

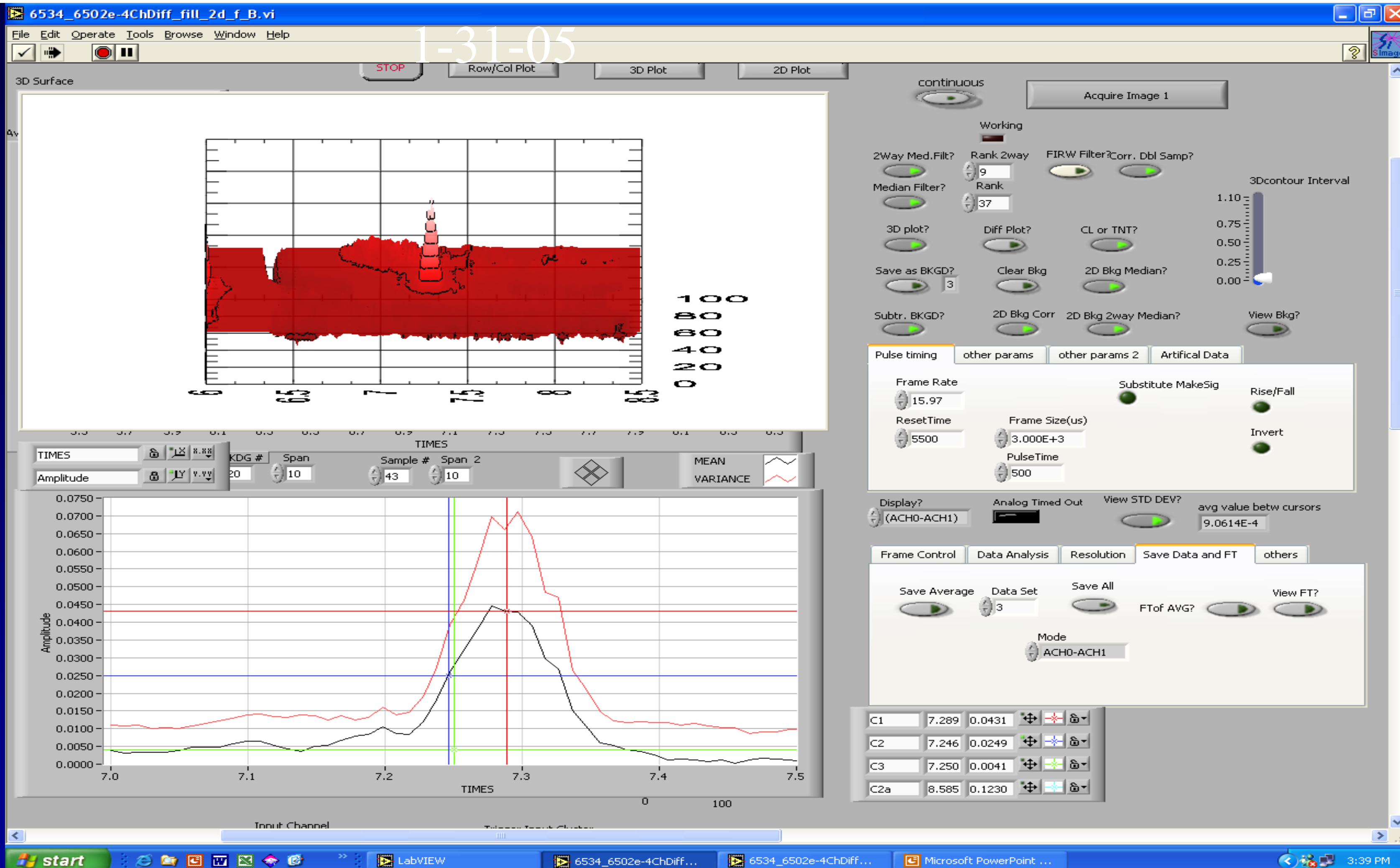


Note: The analyzer is operated at or near atmospheric pressure

Development of A Handheld IMS for Explosive Detection

New interlocking 8 ring microIMS

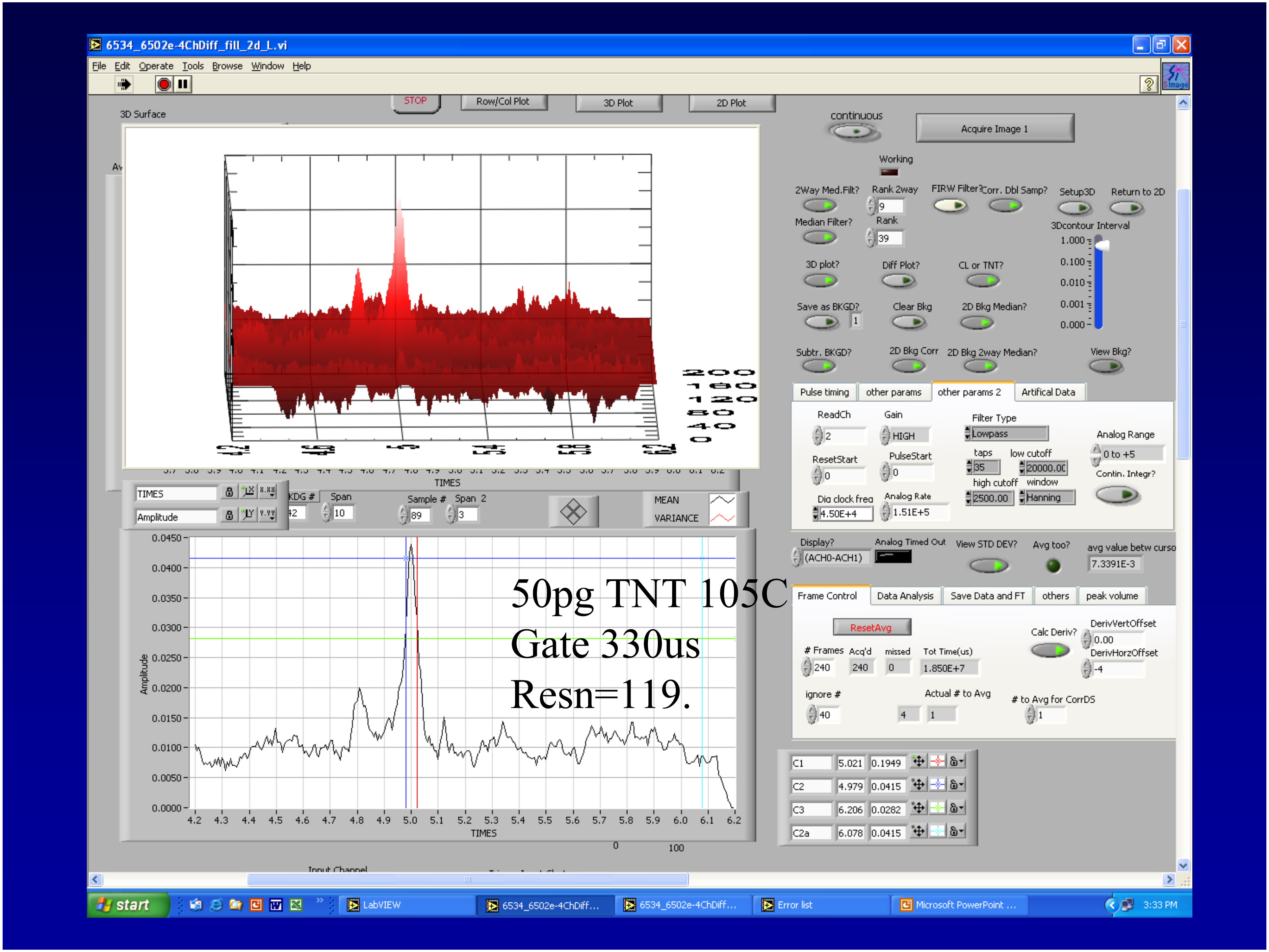


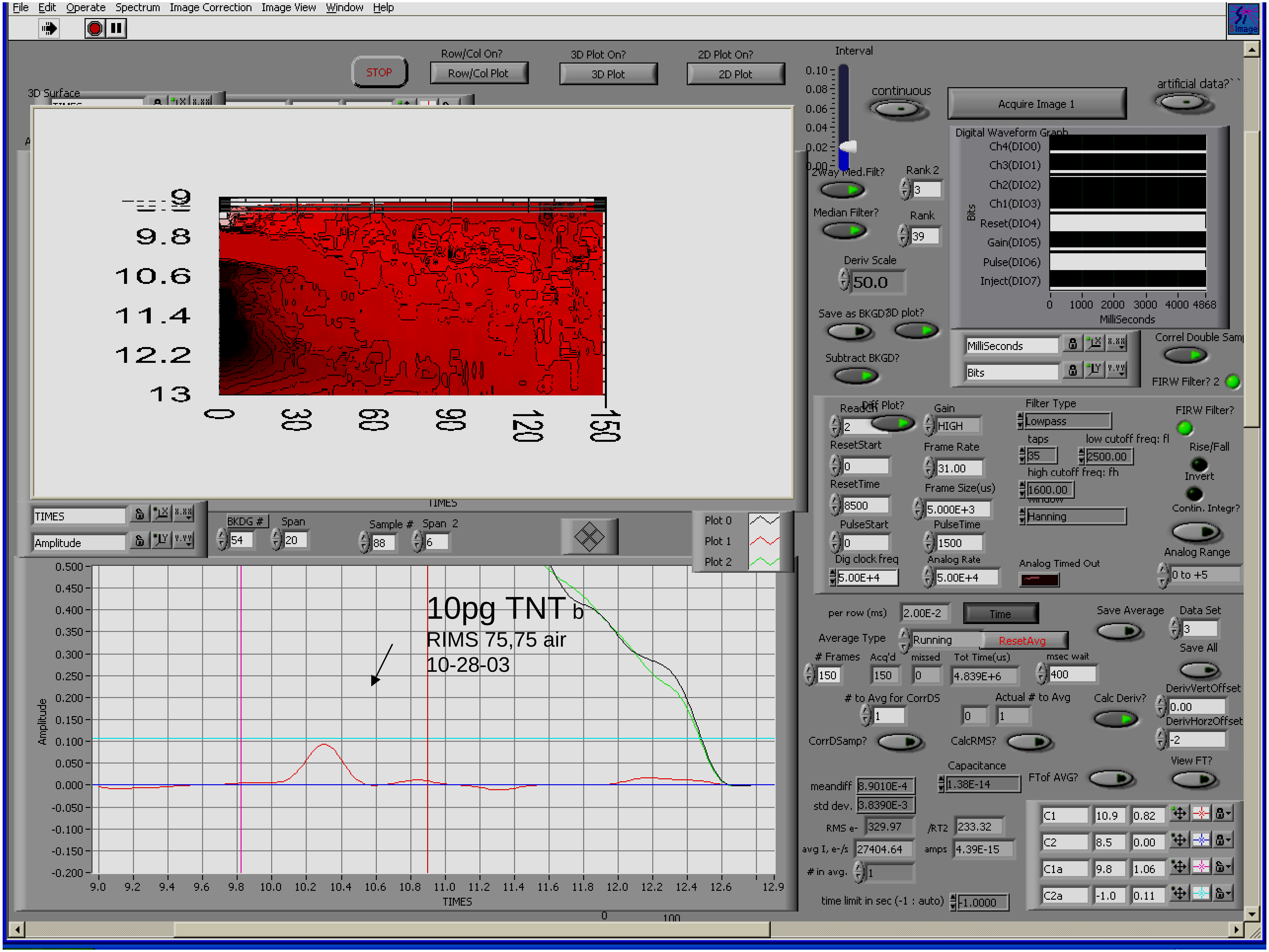


25pg TNT -1825VDC Emco PS, 90C 100/50 ml/min Cl-/Air Filament, inj 125C. Filters OFF

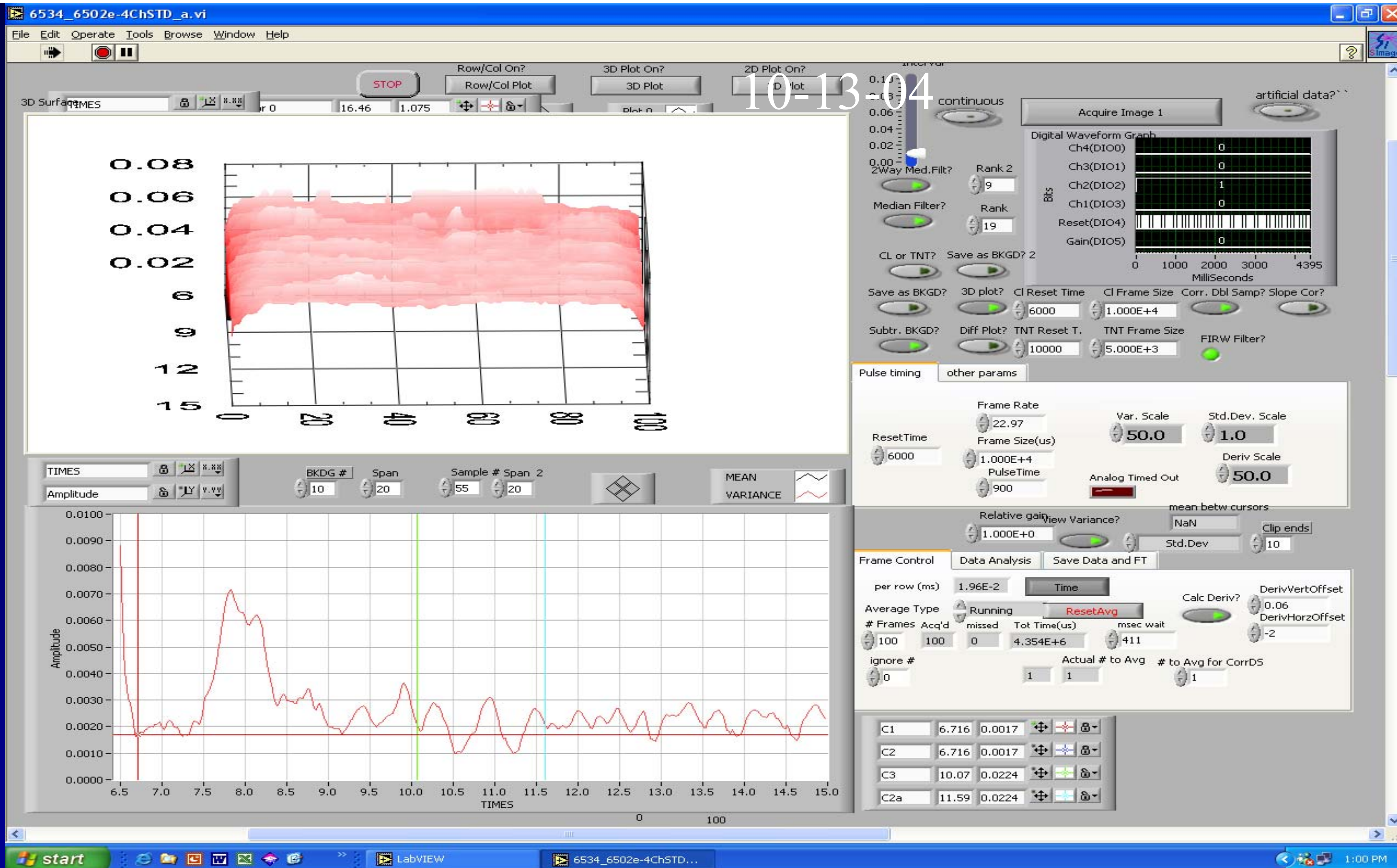
Resolution 84. Run a baseline noise 0.005 S/N=30

Detection Limit = 2.5 pg


50pg TNT 105C
Gate 330us
Resn=119.

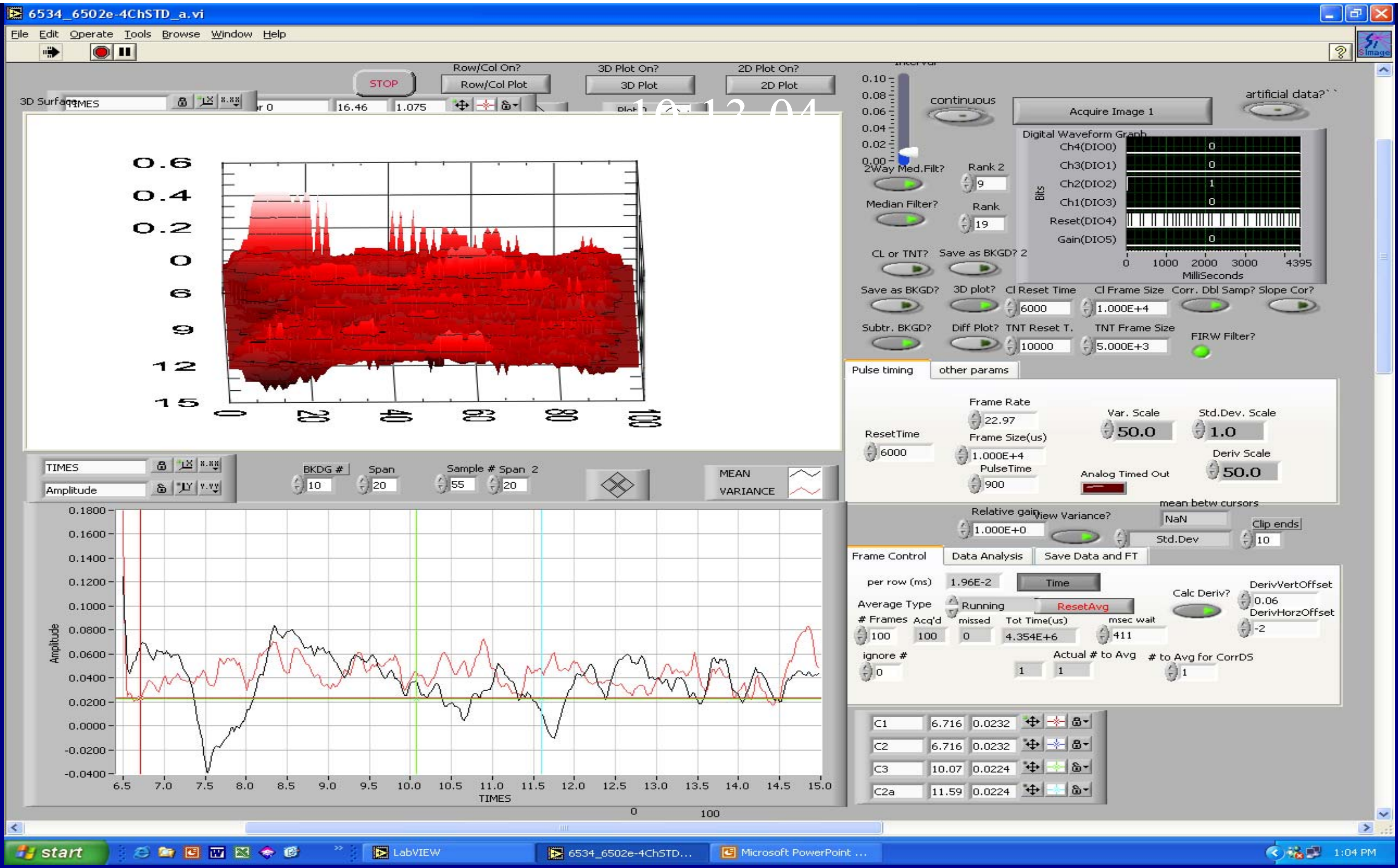


File Edit Operate Spectrum Image Correction Image View Window Help
STOP
Row/Col On?
Row/Col Plot
3D Plot On?
3D Plot
2D Plot On?
2D Plot
Interval
continuous
Acquire Image 1
artificial data?
3D Surface
9
9.8
10.6
11.4
12.2
13
0
30
60
90
120
150
TIMES
Amplitude
BKDG #
54
Span
20
Sample #
88
Span 2
6
Plot 0
Plot 1
Plot 2
10pg TNT b
RIMS 75,75 air
10-28-03
TIMES
Digital Waveform Graph
Ch4(DIO0)
Ch3(DIO1)
Ch2(DIO2)
Ch1(DIO3)
Reset(DIO4)
Gain(DIO5)
Pulse(DIO6)
Inject(DIO7)
Bits
MilliSeconds
2way Med.Filt?
Rank 2
3
Median Filter?
Rank
39
Deriv Scale
50.0
Save as BKGD?
3D plot?
Subtract BKGD?
Correl Double Samp
FIRW Filter? 2
Diff Plot?
Gain
HIGH
Filter Type
Lowpass
FIRW Filter?
ResetStart
0
Frame Rate
31.00
taps
35
low cutoff freq: fl
2500.00
Rise/Fall
high cutoff freq: fh
1600.00
Invert
ResetTime
8500
Frame Size(us)
5.000E+3
Hanning
Contin. Integr?
PulseStart
0
PulseTime
1500
Dig clock freq
5.00E+4
Analog Rate
5.00E+4
Analog Timed Out
Analog Range
0 to +5
per row (ms)
2.00E-2
Time
Save Average
Data Set
3
Average Type
Running
ResetAvg
Save All
Frames
150
Acq'd
150
missed
0
Tot Time(us)
4.839E+6
msec wait
400
to Avg for CorrDS
1
Actual # to Avg
0
1
Calc Deriv?
DerivVertOffset
0.00
DerivHorzOffset
-2
CorrDSamp?
CalcRMS?
View FT?
Capacitance
1.38E-14
FTof AVG?
meandiff
8.9010E-4
std dev.
3.8390E-3
RMS e-
329.97
/RT2
233.32
avg I, e-/s
27404.64
amps
4.39E-15
in avg.
1
time limit in sec (-1 : auto)
-1.0000
C1 10.9 0.82
C2 8.5 0.00
C1a 9.8 1.06
C2a -1.0 0.11



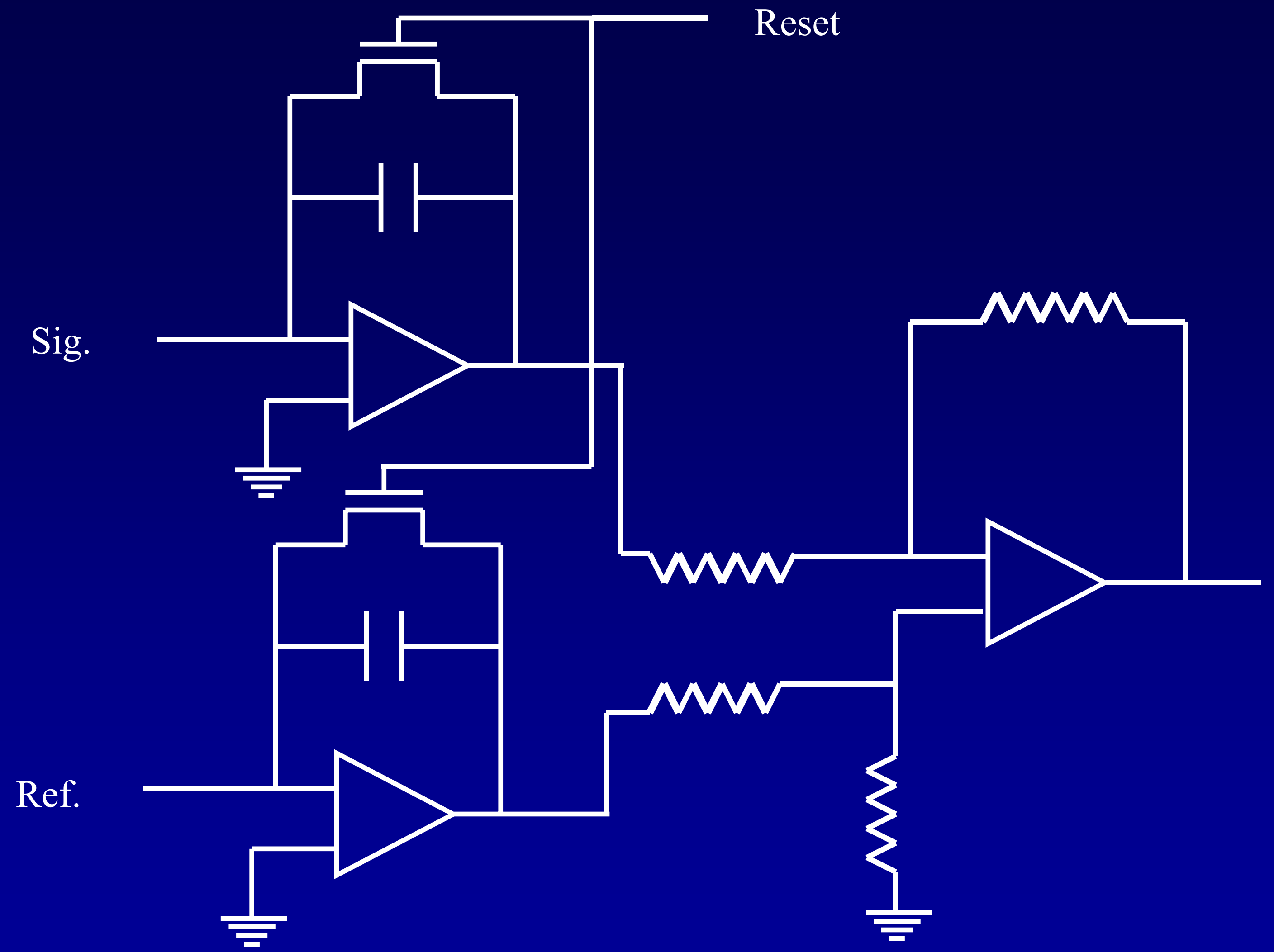
Blank, Cl-/air 110C, Lid ON - same STD Det, fan on

Base noise level 0.002-0.0025



Blank, Cl-/air 110C, Lid OFF - same STD Det, fan ON

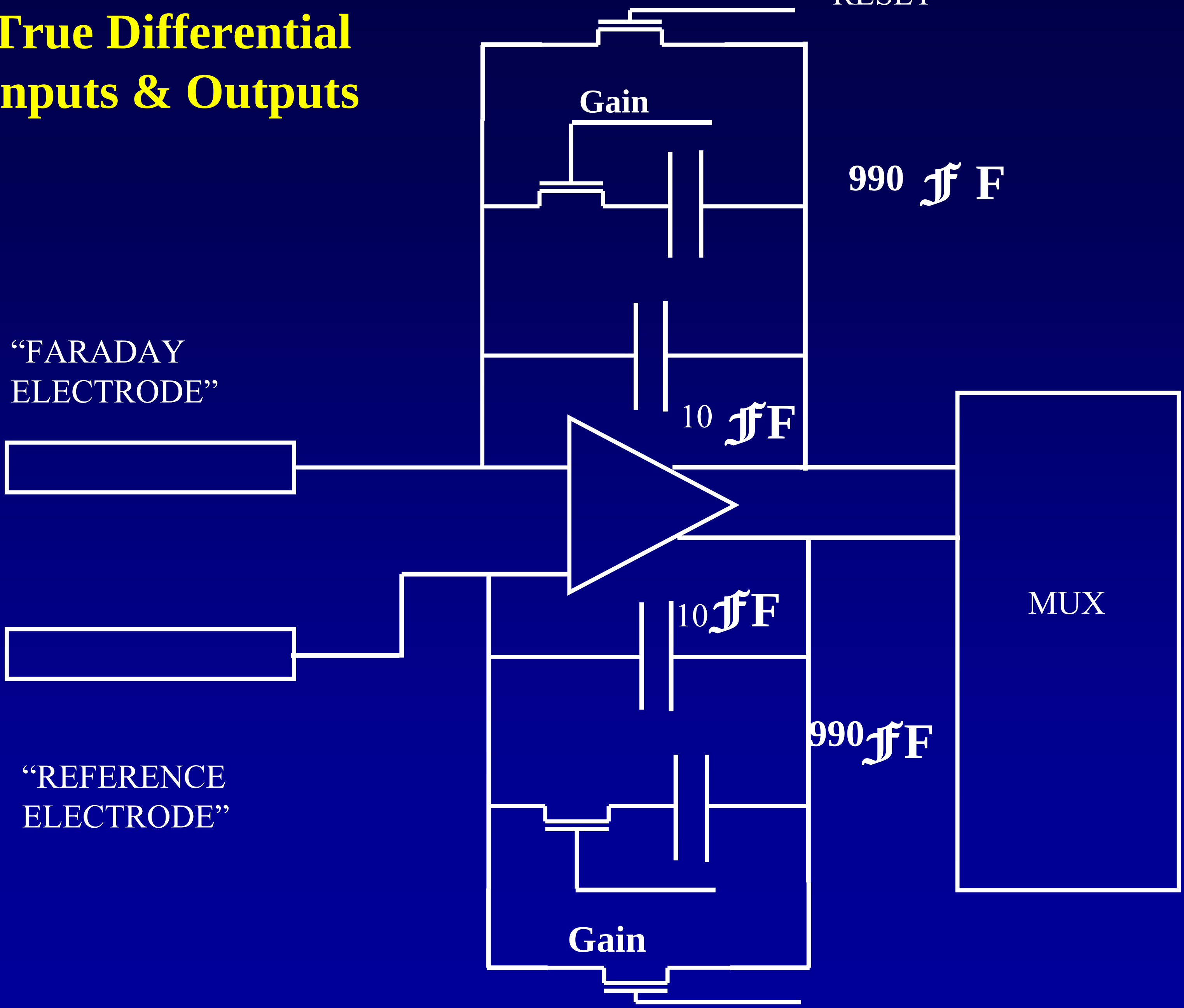
Base noise level 0.040-0.050 **(ie 20X worse)**


Reset
Sig.
Ref.

Subtracting Environmental Noise with Independent Amplifiers

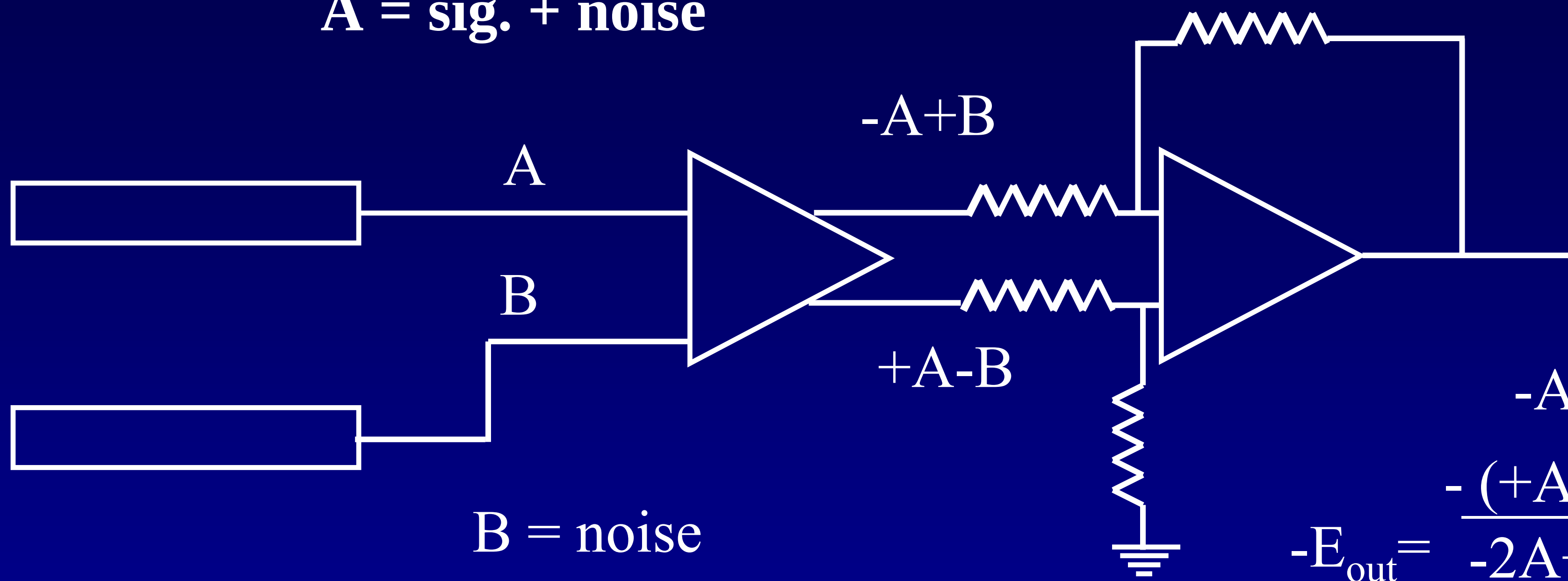
- Internal amplifier noise is uncorrelated
- Amplifier noise from both preamps adds
- Clipping can occur

True Differential Inputs & Outputs



Differential Ion Detector

A = sig. + noise



$$
\begin{array}{r} -A+B \\ \underline{-\ (+A-B)} \\ -E_{out} = -2A+2B \end{array}
$$

E_{out}=2A-2B

= 2 signal without noise

True Differential Inputs & Outputs

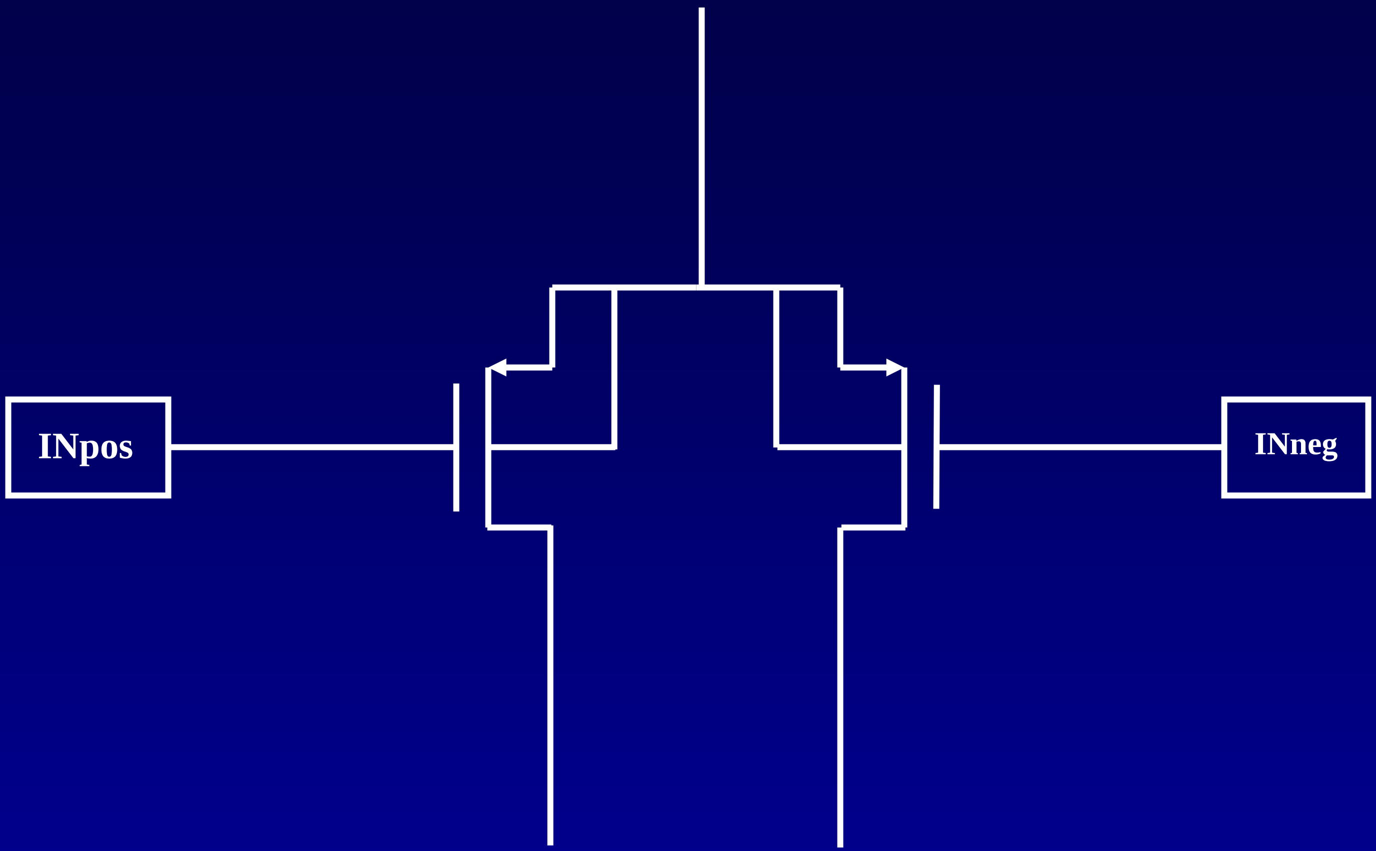
True Differential Input Amplifier

(1) Noise is canceled in input stage (before high gain amplification)

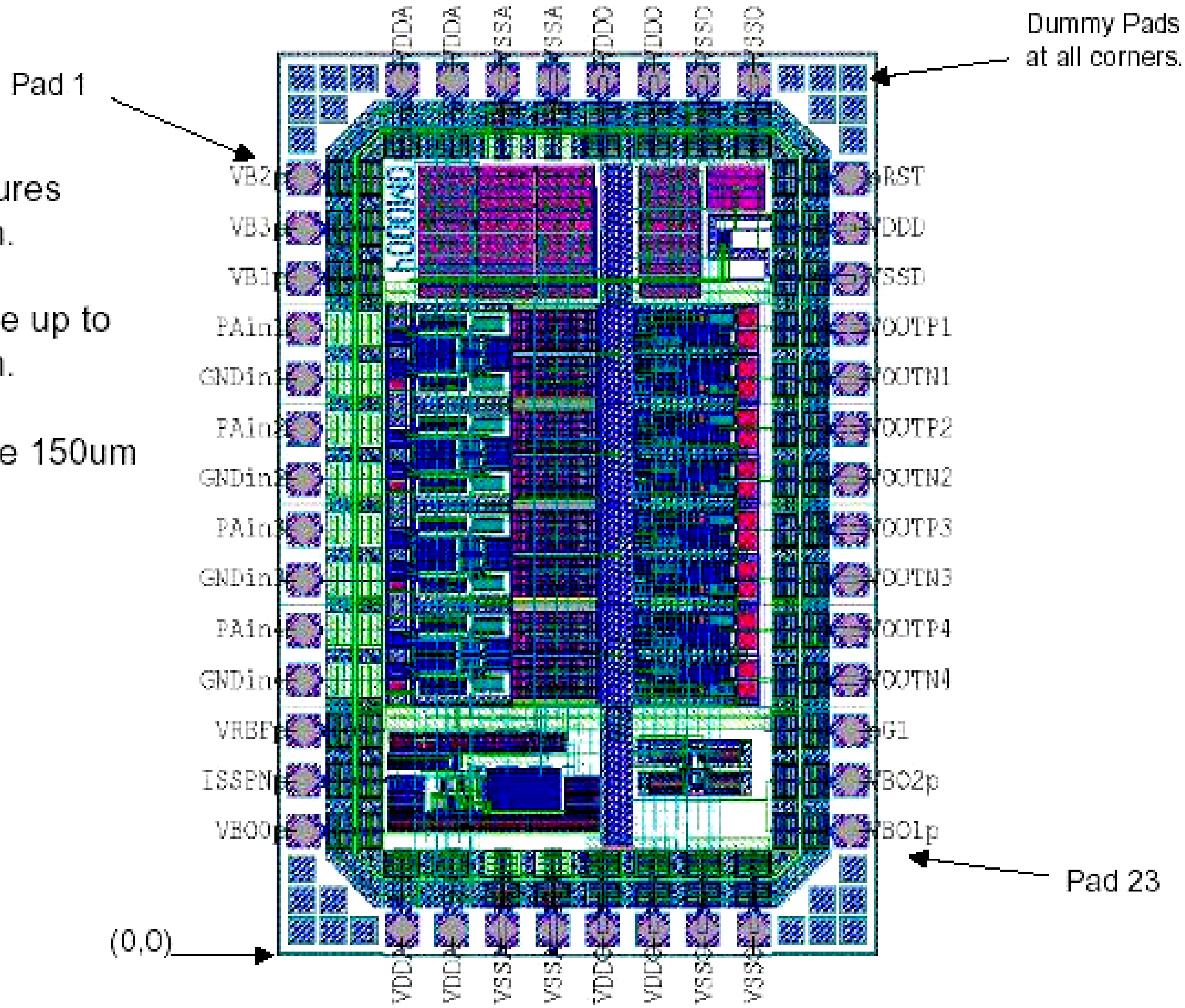
(2) True correlated subtraction

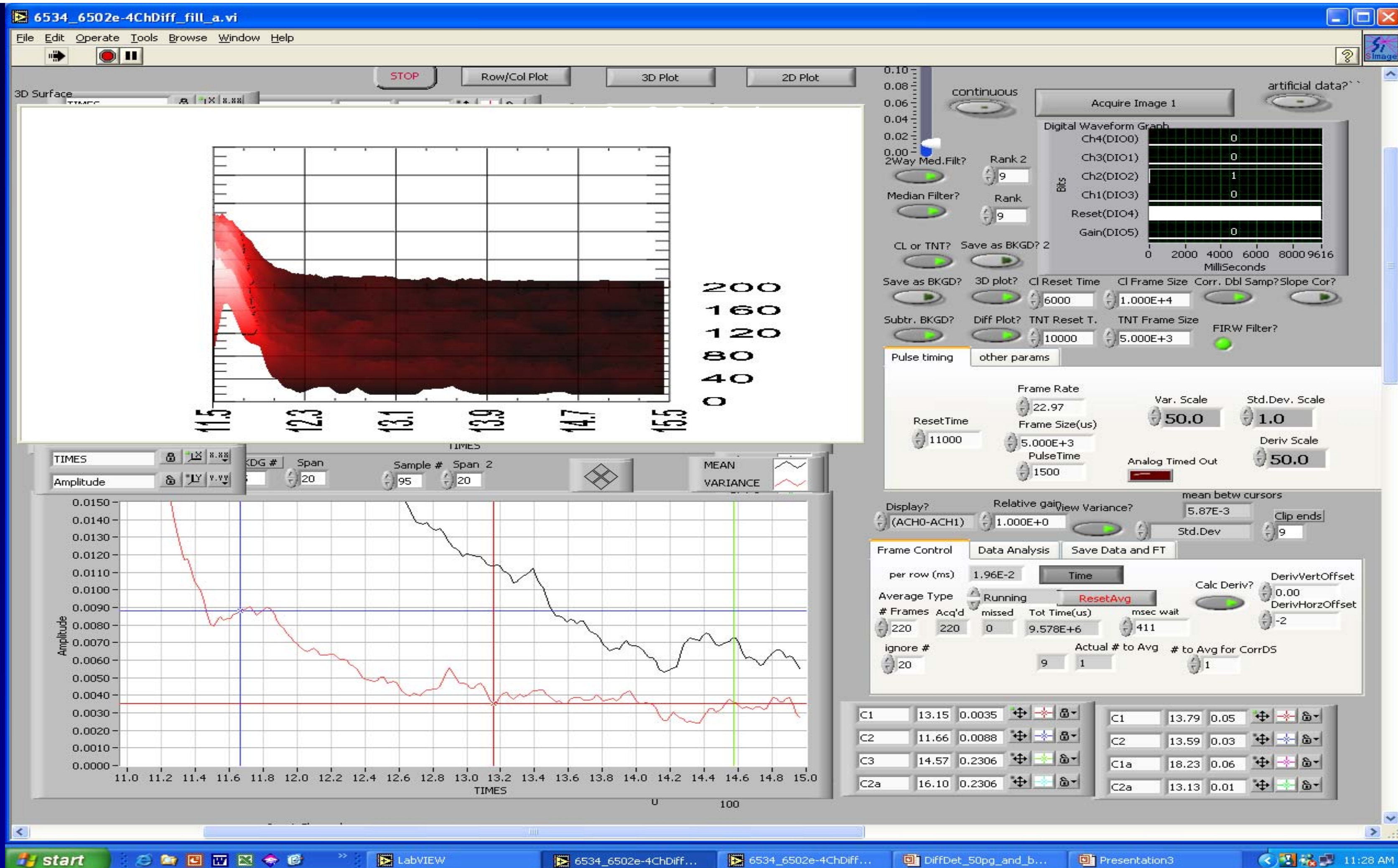
(3) Balanced FETs help ensure equal subtraction

(4) Noise cannot limit amplifier


INpos
INneg

- Chip layout measures 1795um x 2695um.
- Cut die size can be up to 2000um x 2900um.
- Bonding pads have 150um pitch.

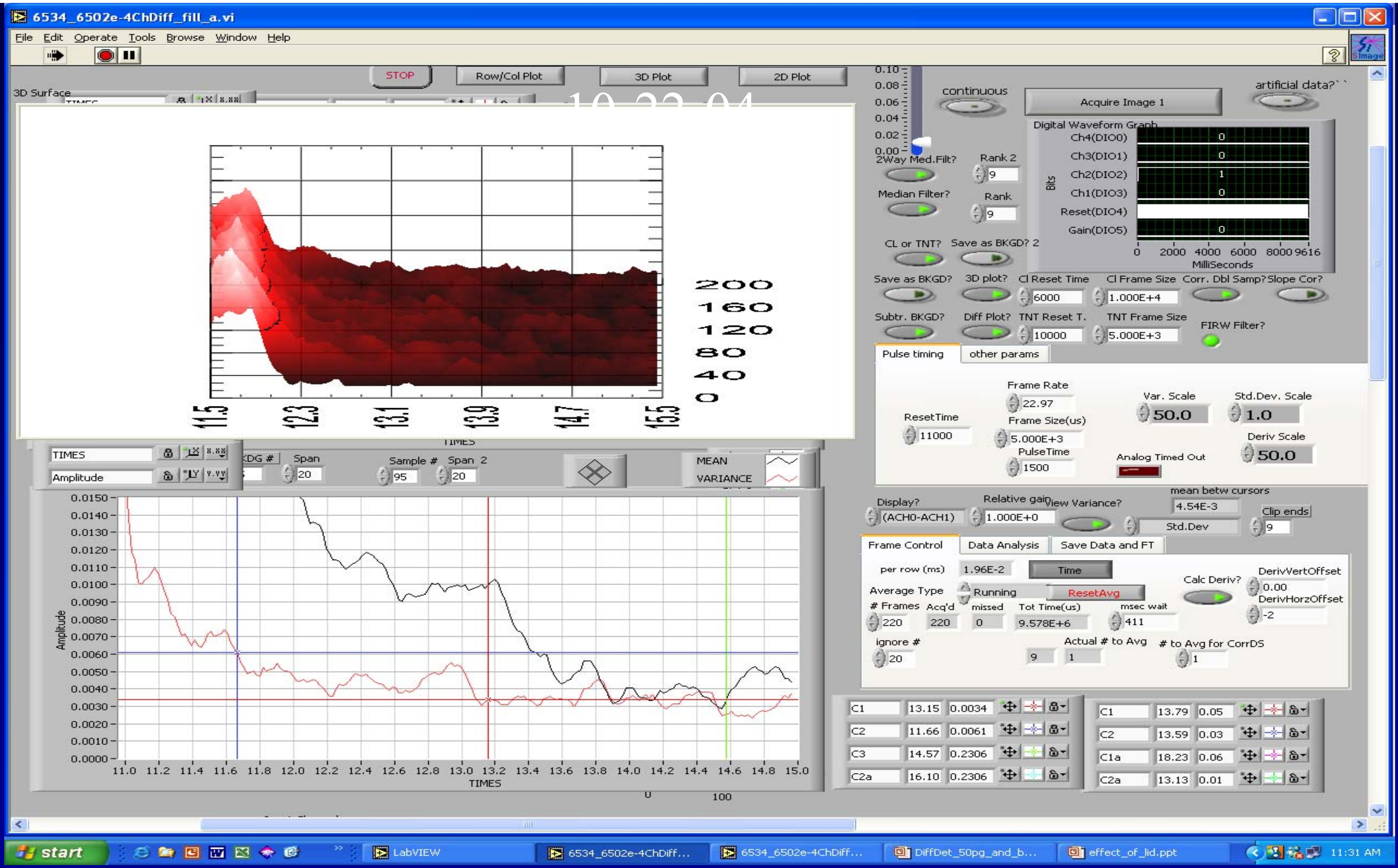




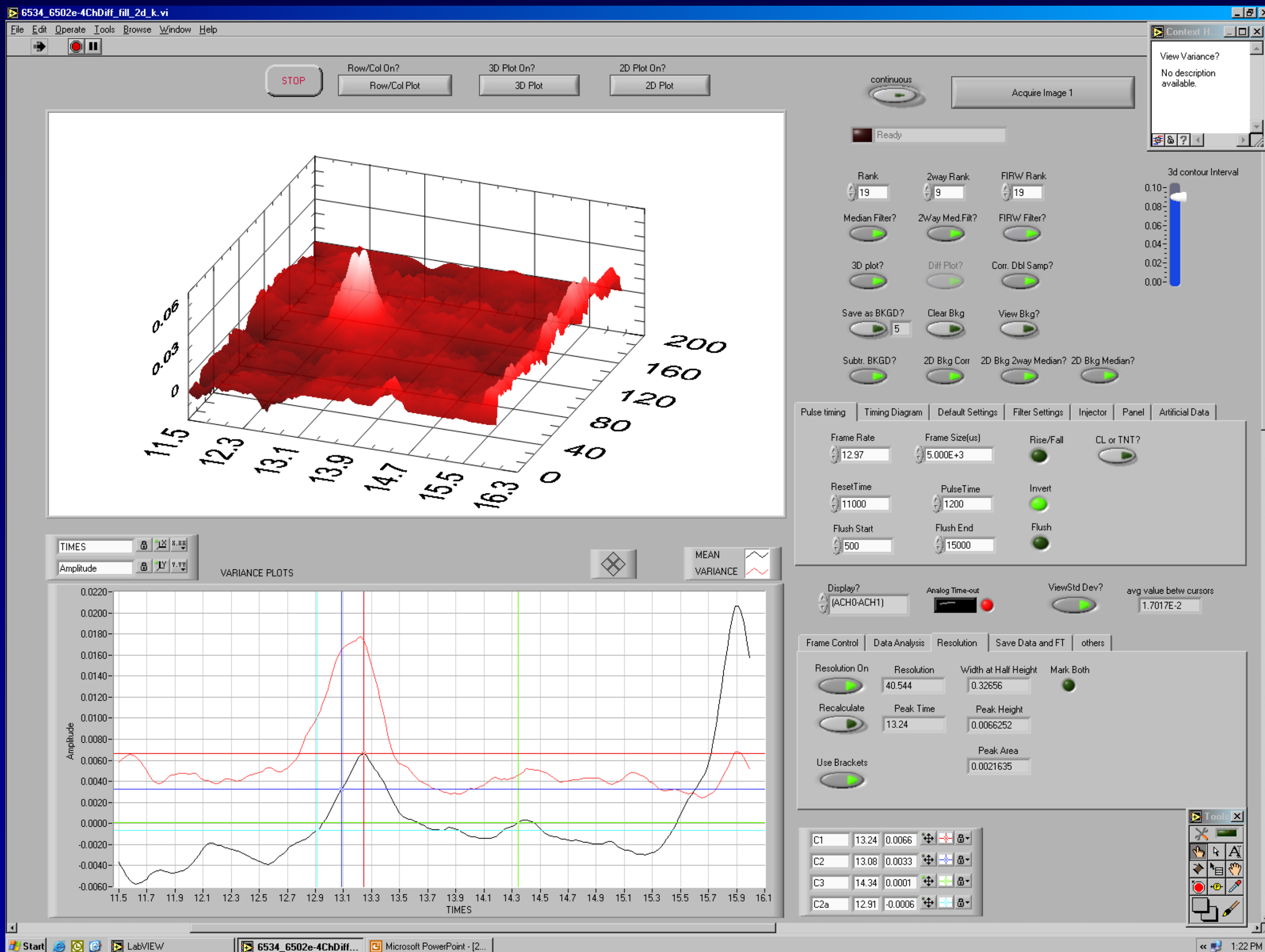
Blank, Hot, Lid ON – same

Differential Det, Cl-/Air, 90C

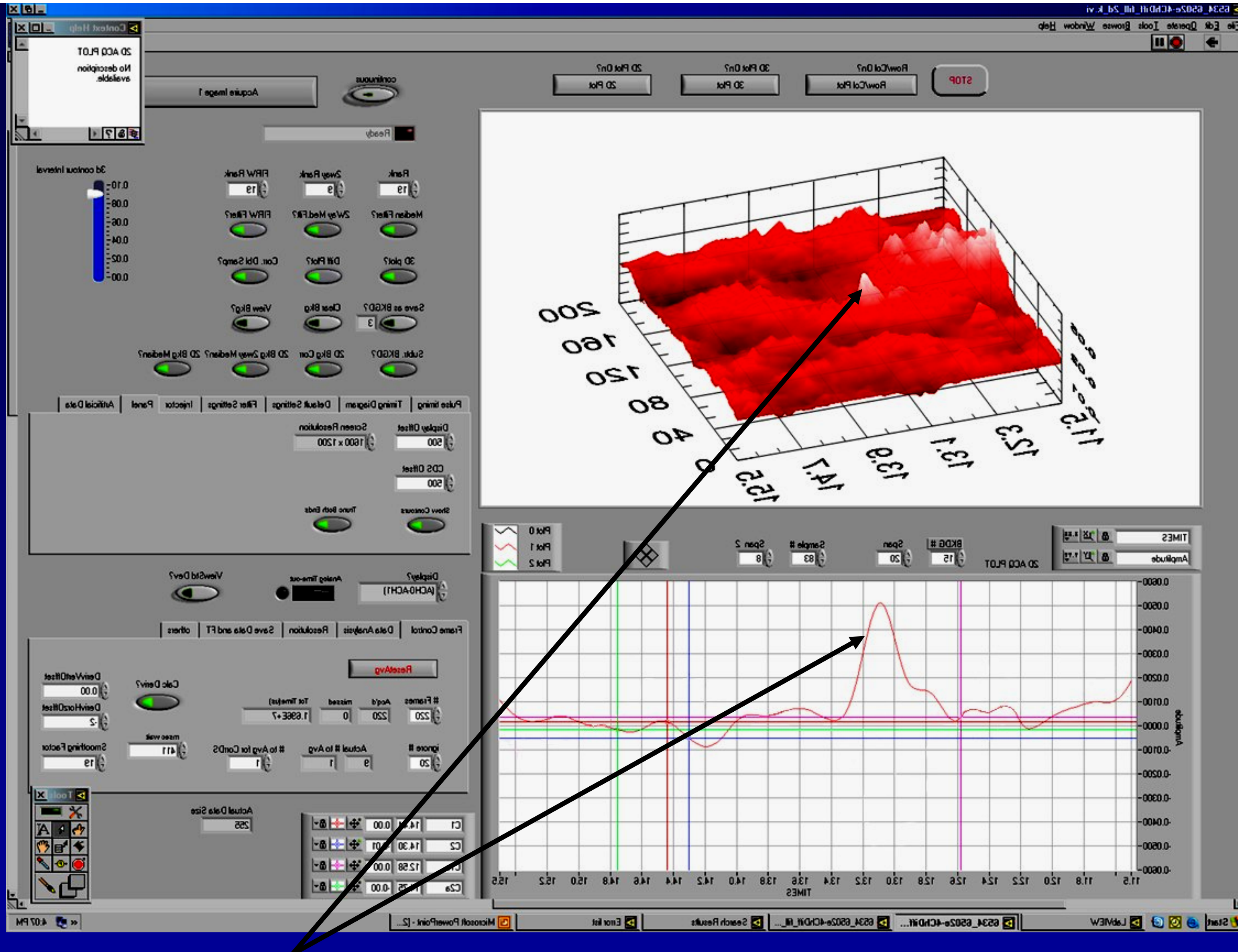
Base noise level 0.003-0.004



Blank, Hot, Lid OFF – same
Differential Det, Cl-/Air, 90C
Base noise level 0.0035-0.004 (**no noise degradation**)



12.5pg TNT 96C, 25V Injector Block, 0.85A Filament, 1200us Pulse, B.C. FIRW On



5pg TNT 95 ºC 25V Injector Block 0.85A Filament, 1200 us Pulse B.C. FIRW on

Detection limit 400 fgm

4 hours @ 0.5 w
Rechargeable
Wireless capable
Vapor sampling

Version 3.0 2x4x8”

First field prototype for Fall 2006 Version 2.0 3x3x9”

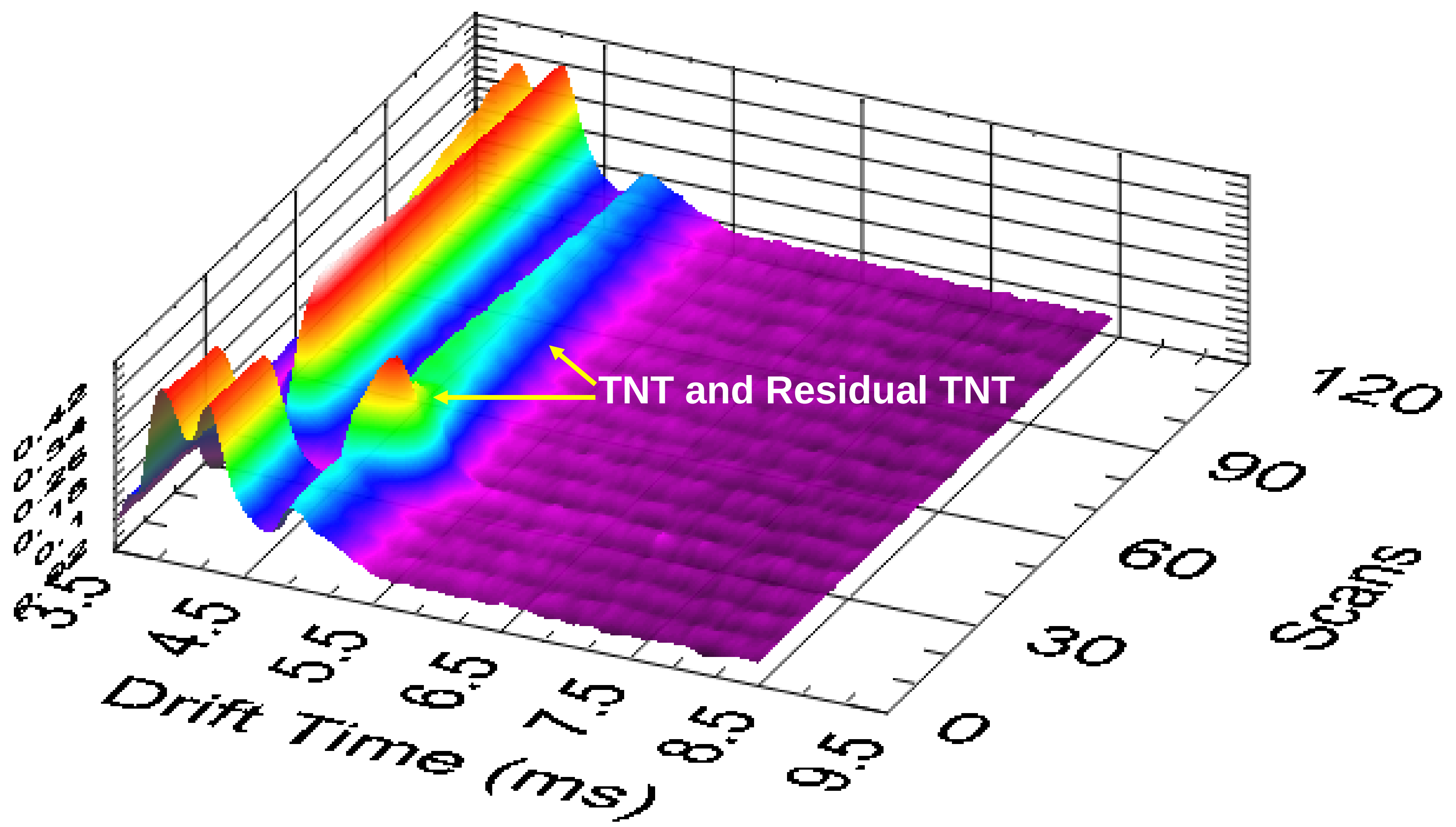
Version 4.0 future

1.5 X 2 X 4 in.
4 to 6 hours

Version4.0 is where we want to go for our customer – 2 years out.

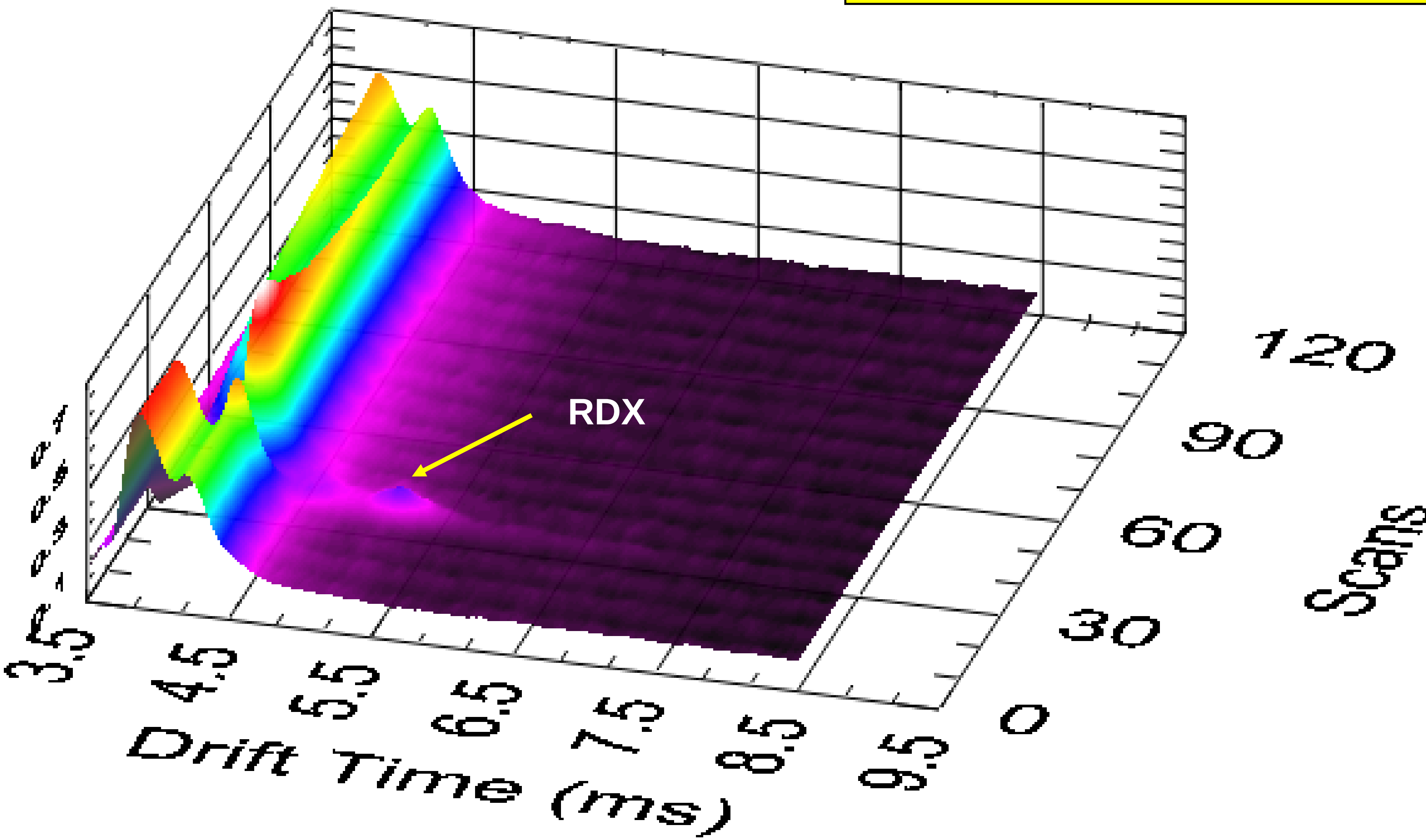
TNT Vapor Analysis

- No background correction
- Vapor emanating from glass surface exposed to 9 ppb TNT vapor
- Non-optimized system



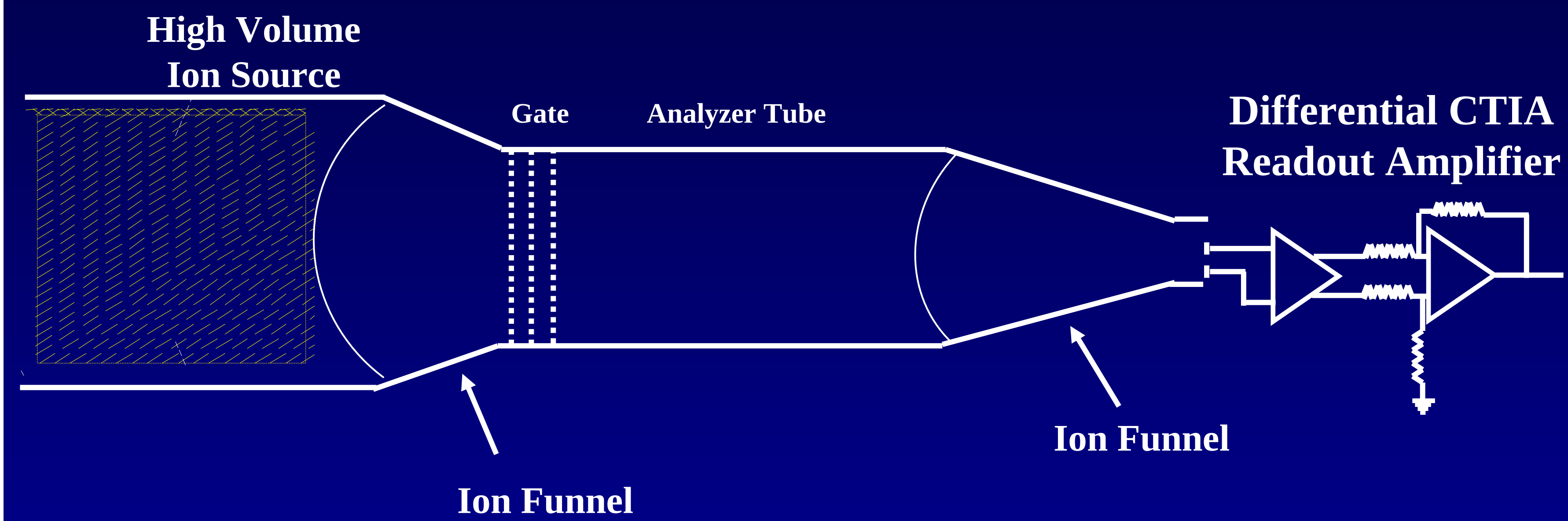
RDX Vapor Analysis

- No background correction
- Vapor emanating from glass surface exposed to 4 ppt RDX vapor
- Non-optimized system



Development of a Ultra High Sensitive Explosive Detection System

New System for Achieving parts per Quadtrillion Detection Limits

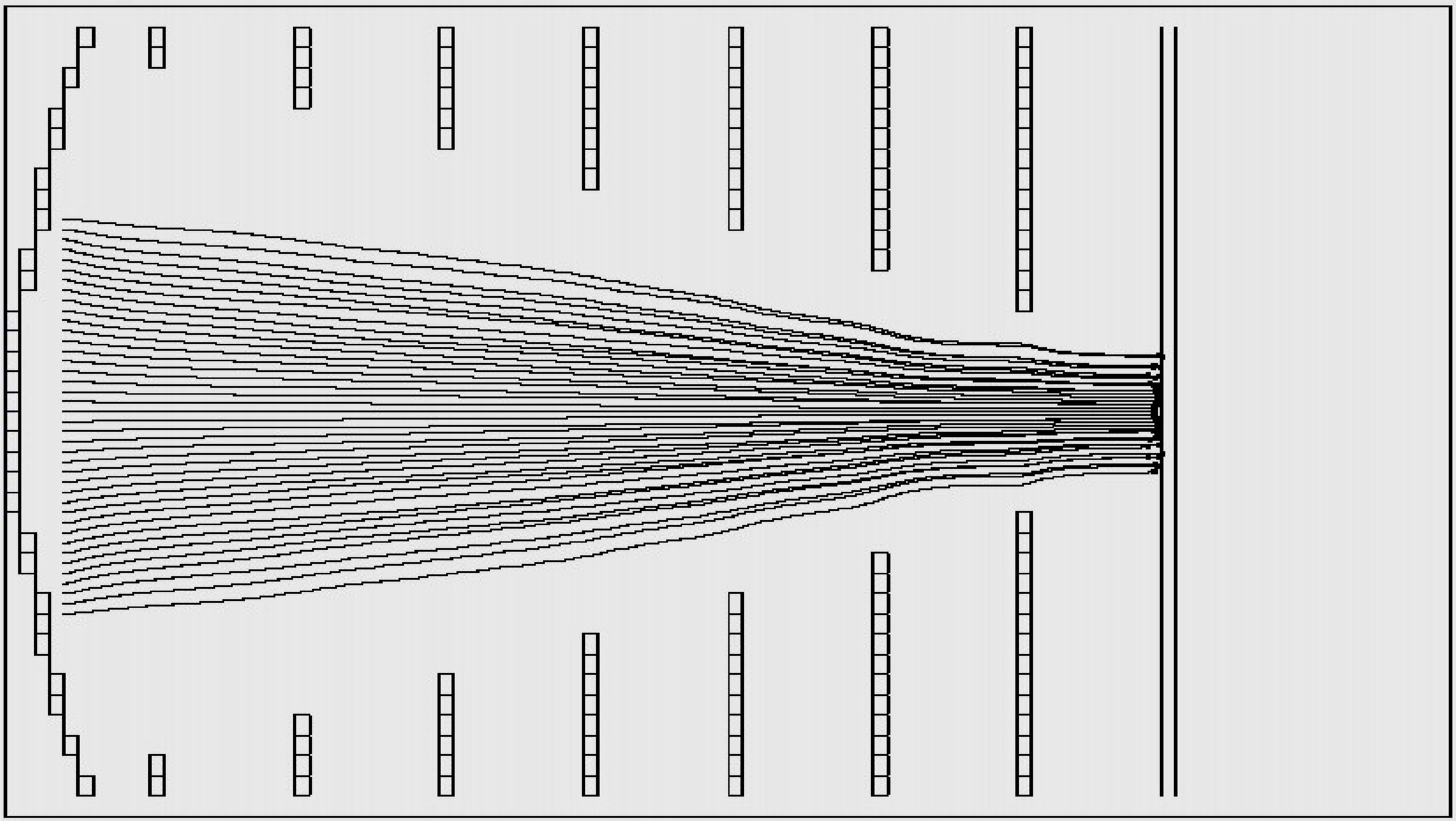


High Volume Ion Source - high ion flux from low concentration vapor pressure explosives

Relative Large Diameter Analyzer Tube - minimize spacecharge effects ie. higher resolution

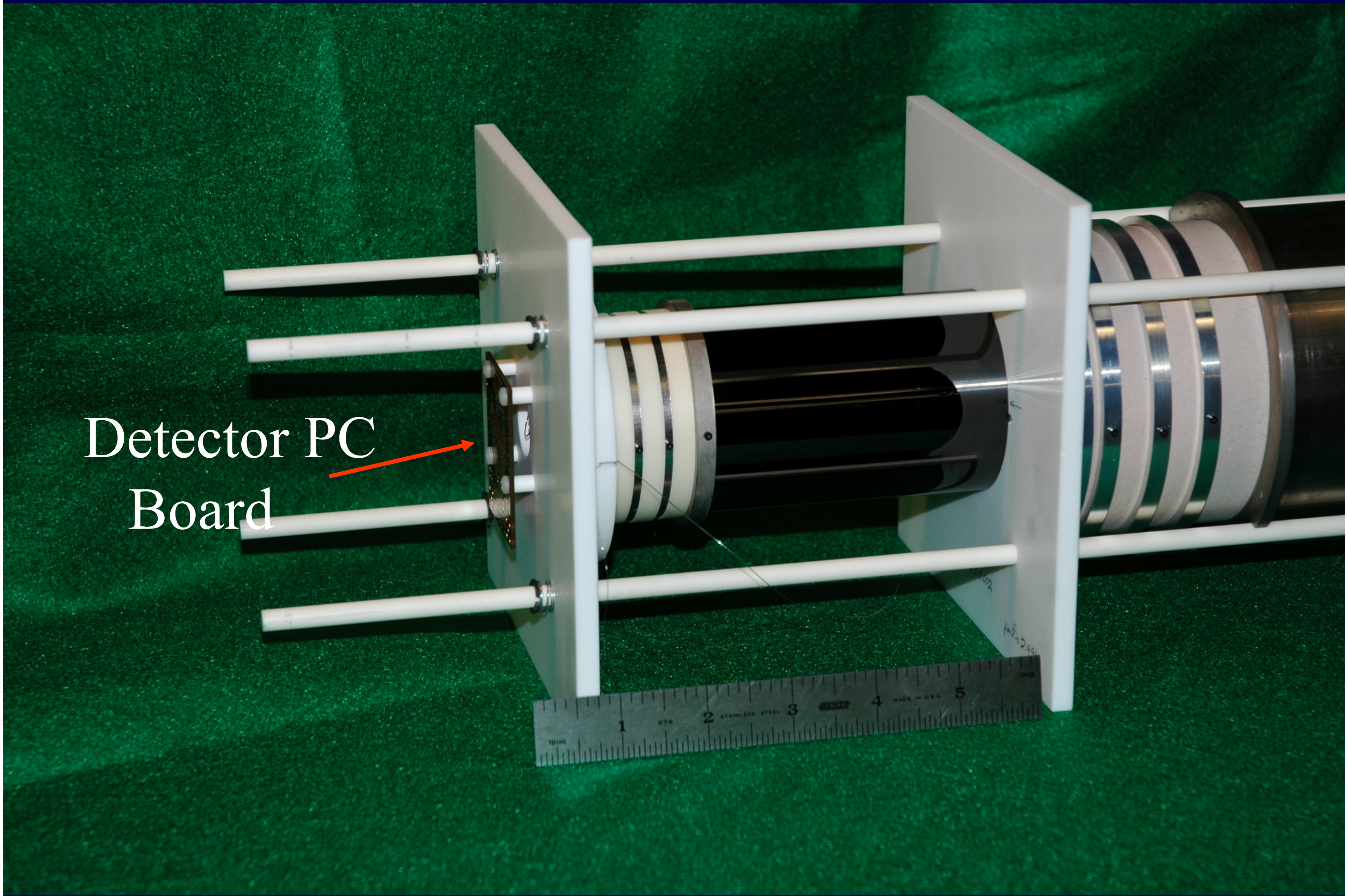
Ion funnels - provide ion compression between stages

Atmospheric pressure
DC Ion Funnel

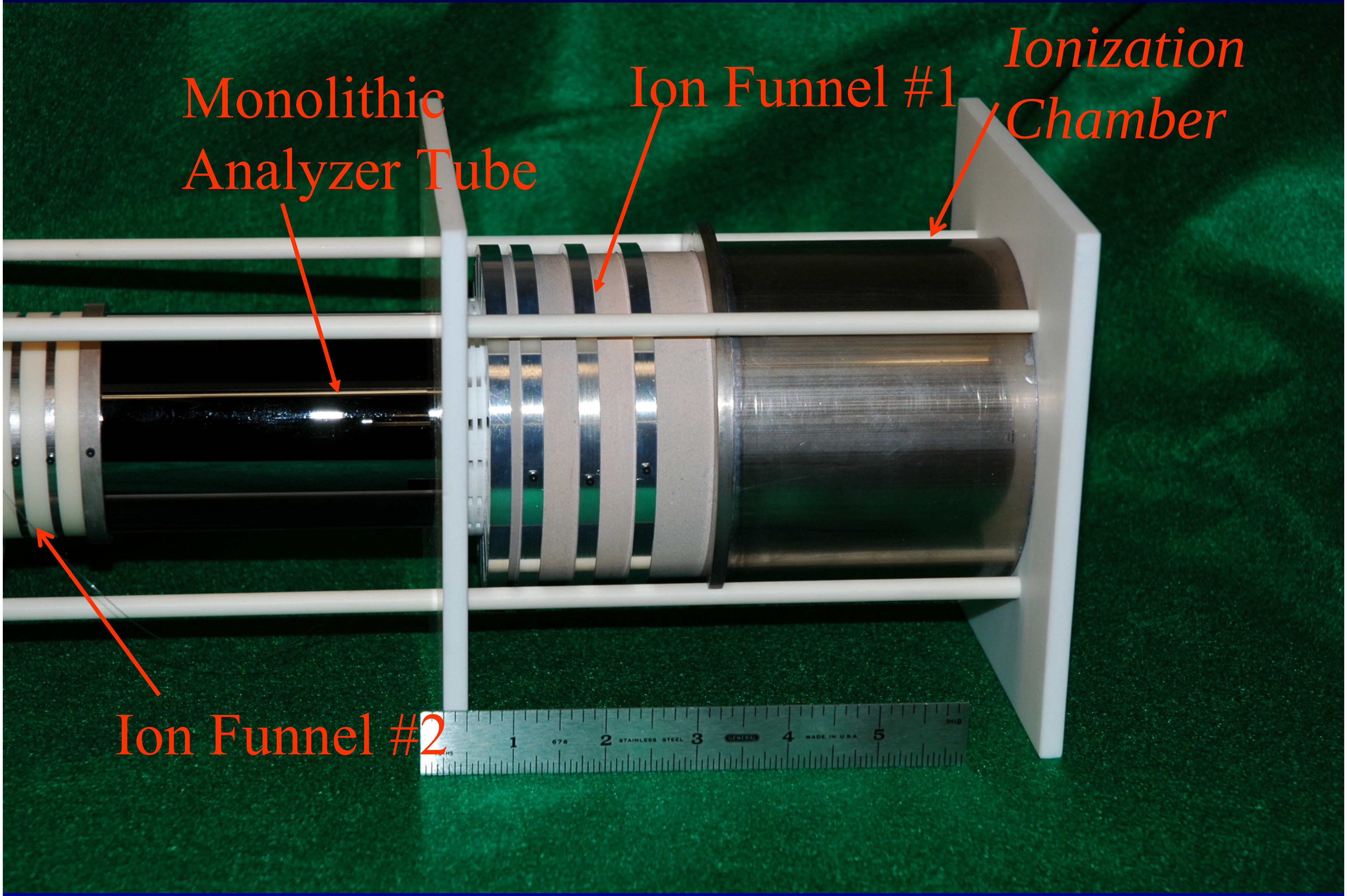


Vehicle & Checkpoint Based Explosive Detection System

Progress

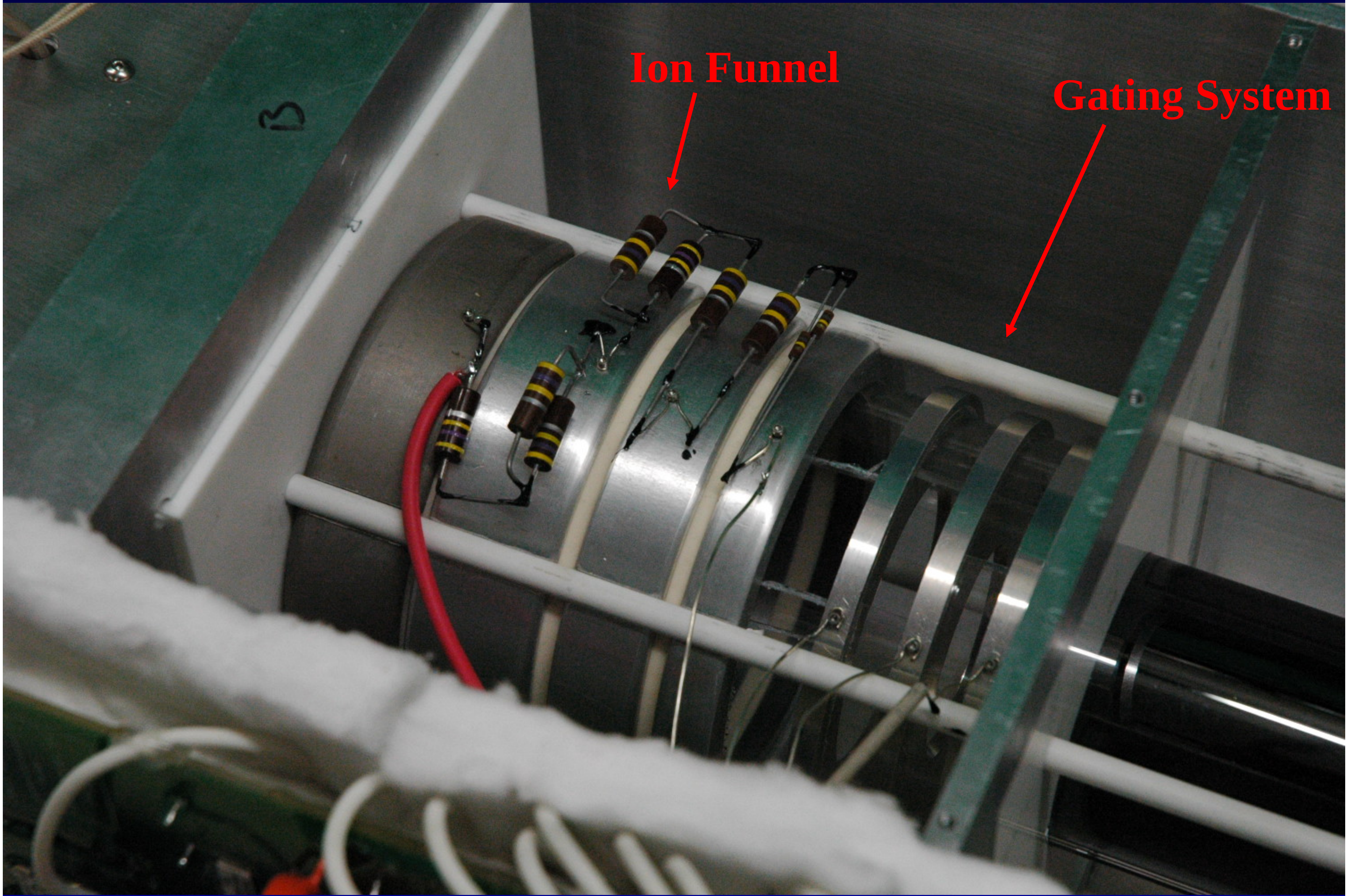

Detector PC
Board


Sample Inlet
to Ionization
Chamber


Ionization Chamber
Ion Funnel #1
Monolithic Analyzer Tube
Ion Funnel #2
1
2
STAINLESS STEEL
3
GENERAL
4
MADE IN U.S.A.
5


Signal
Detector
Pin Location
Reference
Detector
Pin Location


Aperture Grid
& Detector But


Ion Funnel
Gating System

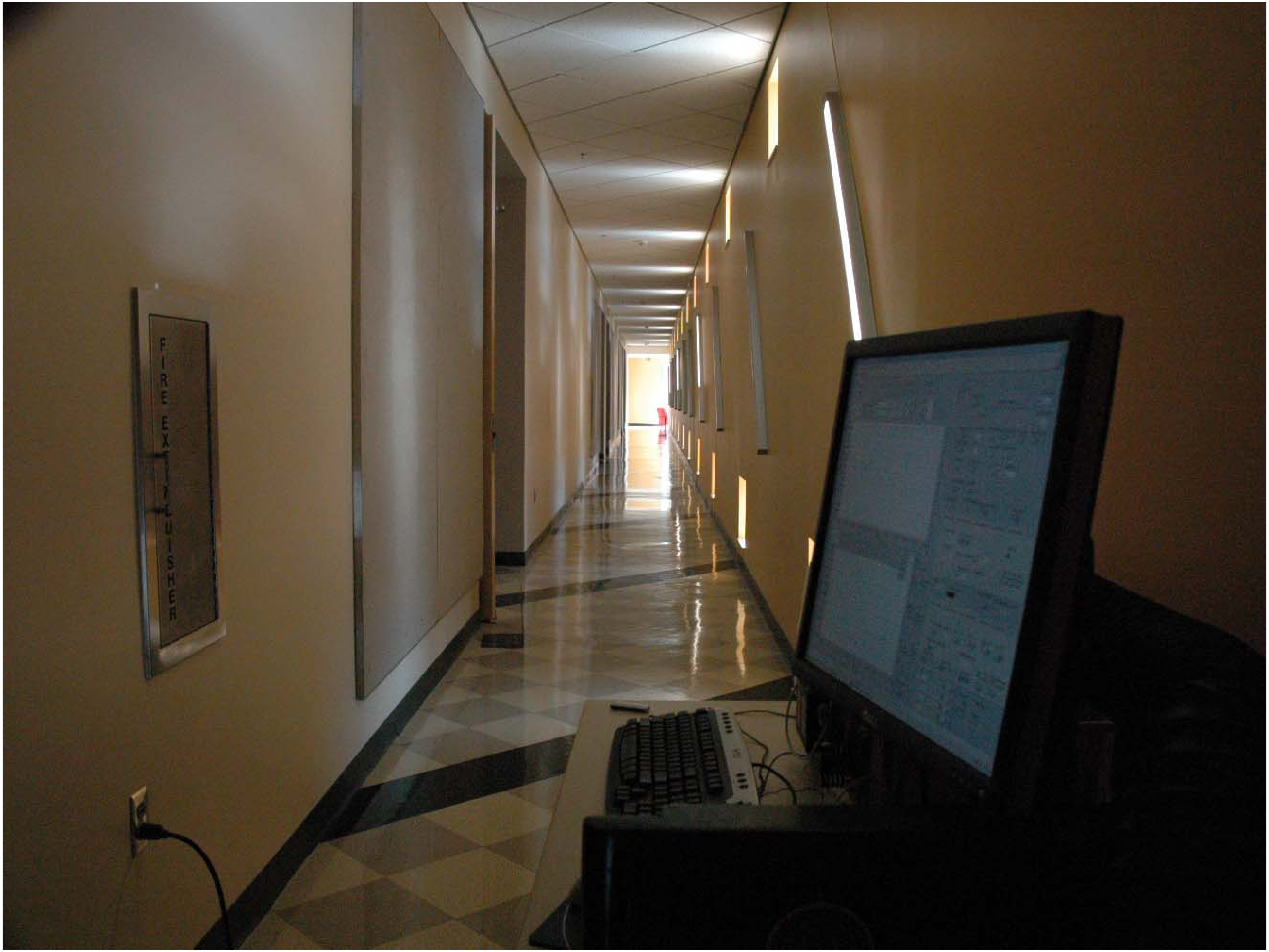

Version I - For laboratory
evaluation

Standoff Testing

Note - Currently funding is for other applications

NOT Explosives or Improvised Explosive Devices !!

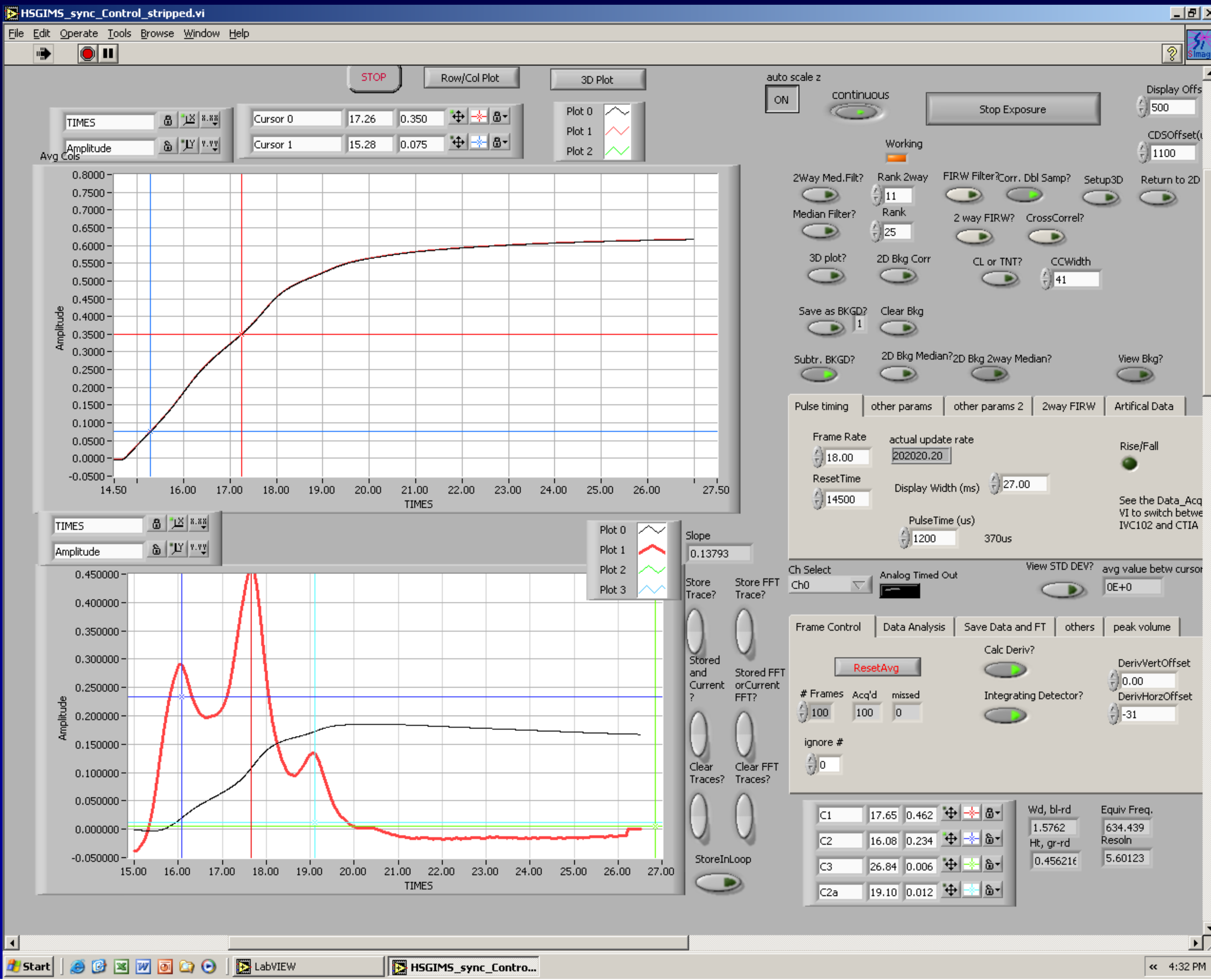
(The System must be modified for optimal Explosive Detection)


FIRE EXTINGUISHER

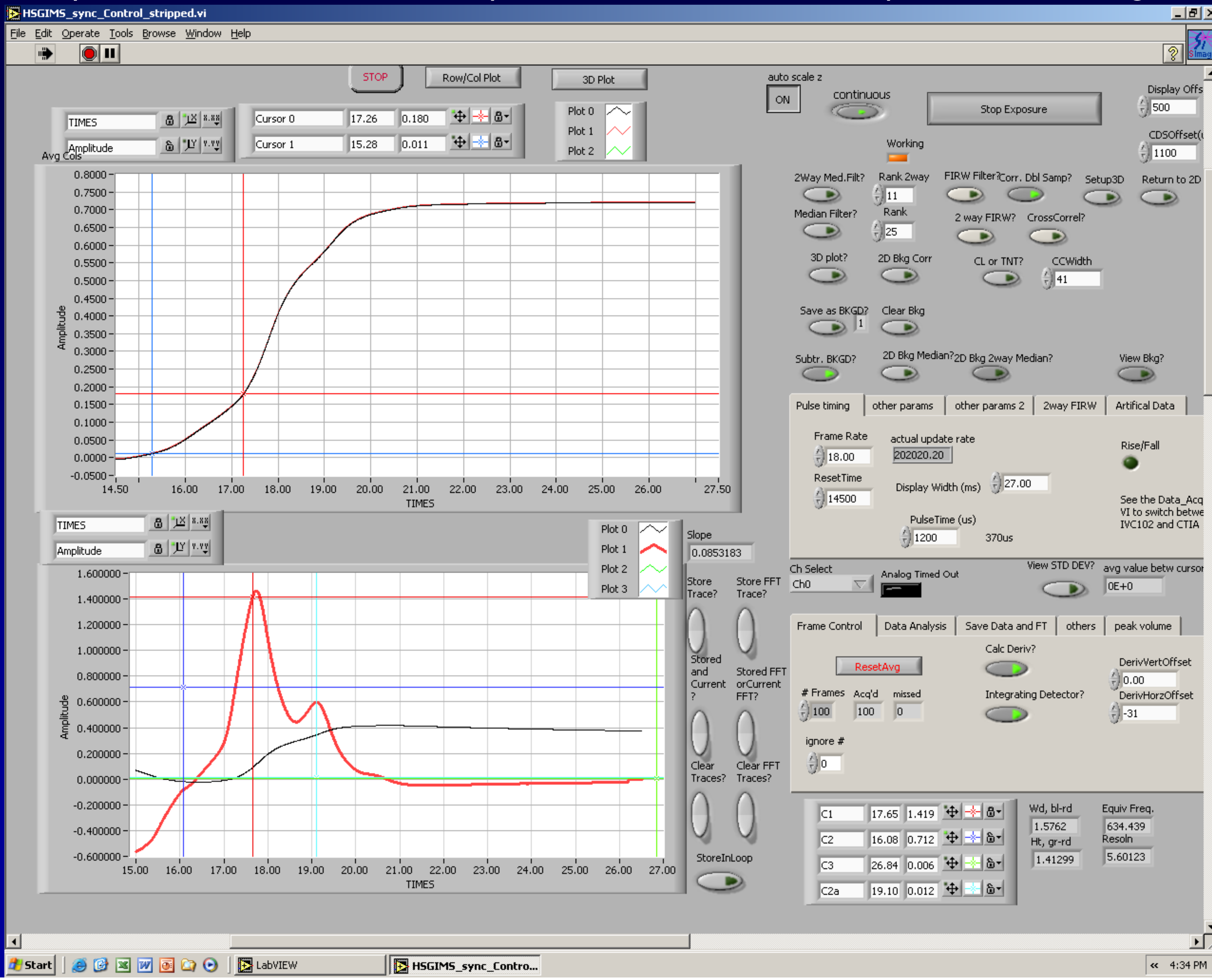
Super Sensitive Instrument

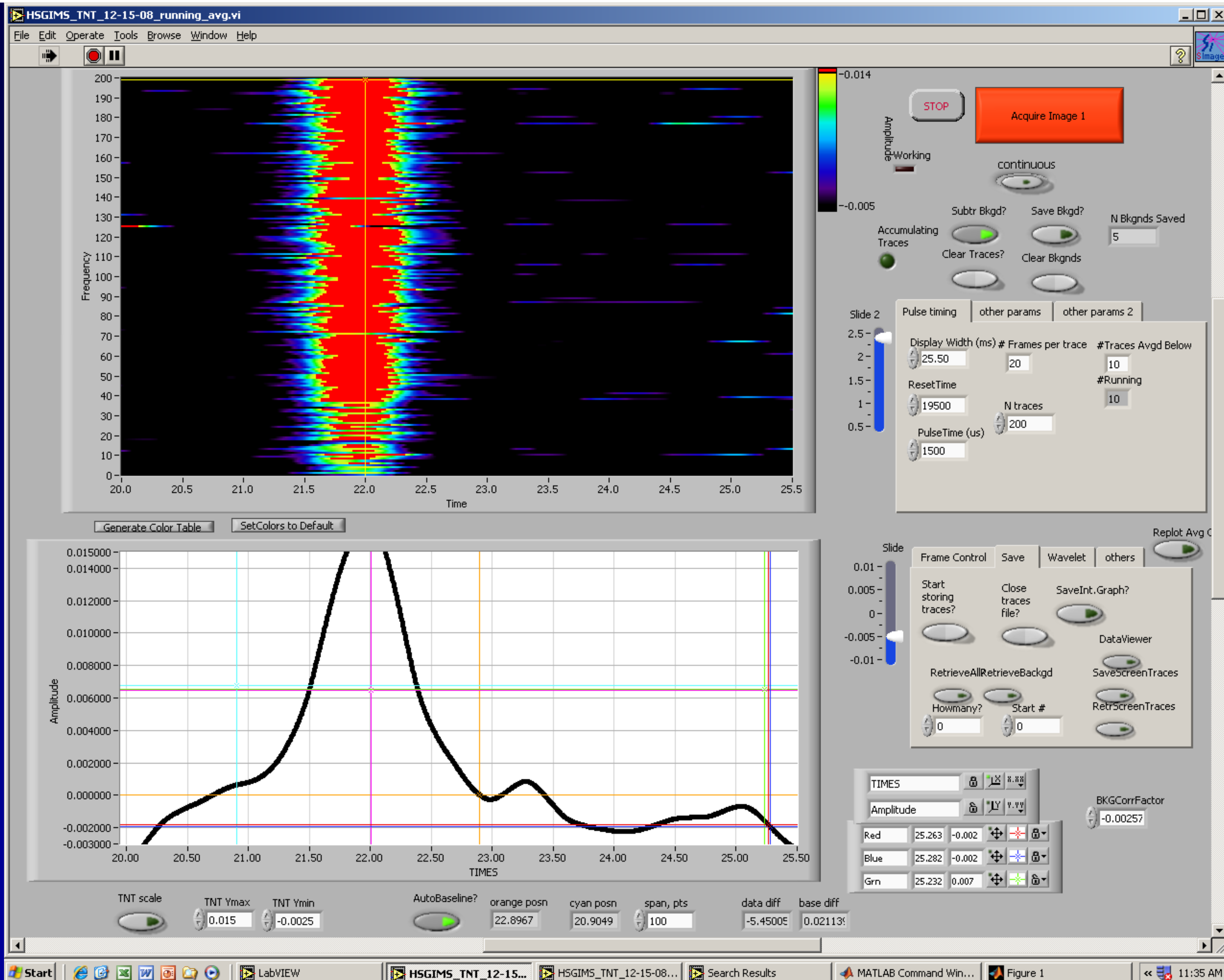
Vial Containing 20 milligrams of sample

Cmpd.A 90 feet down the hall (open vial) 11-30-06, low gain= ÷ 100

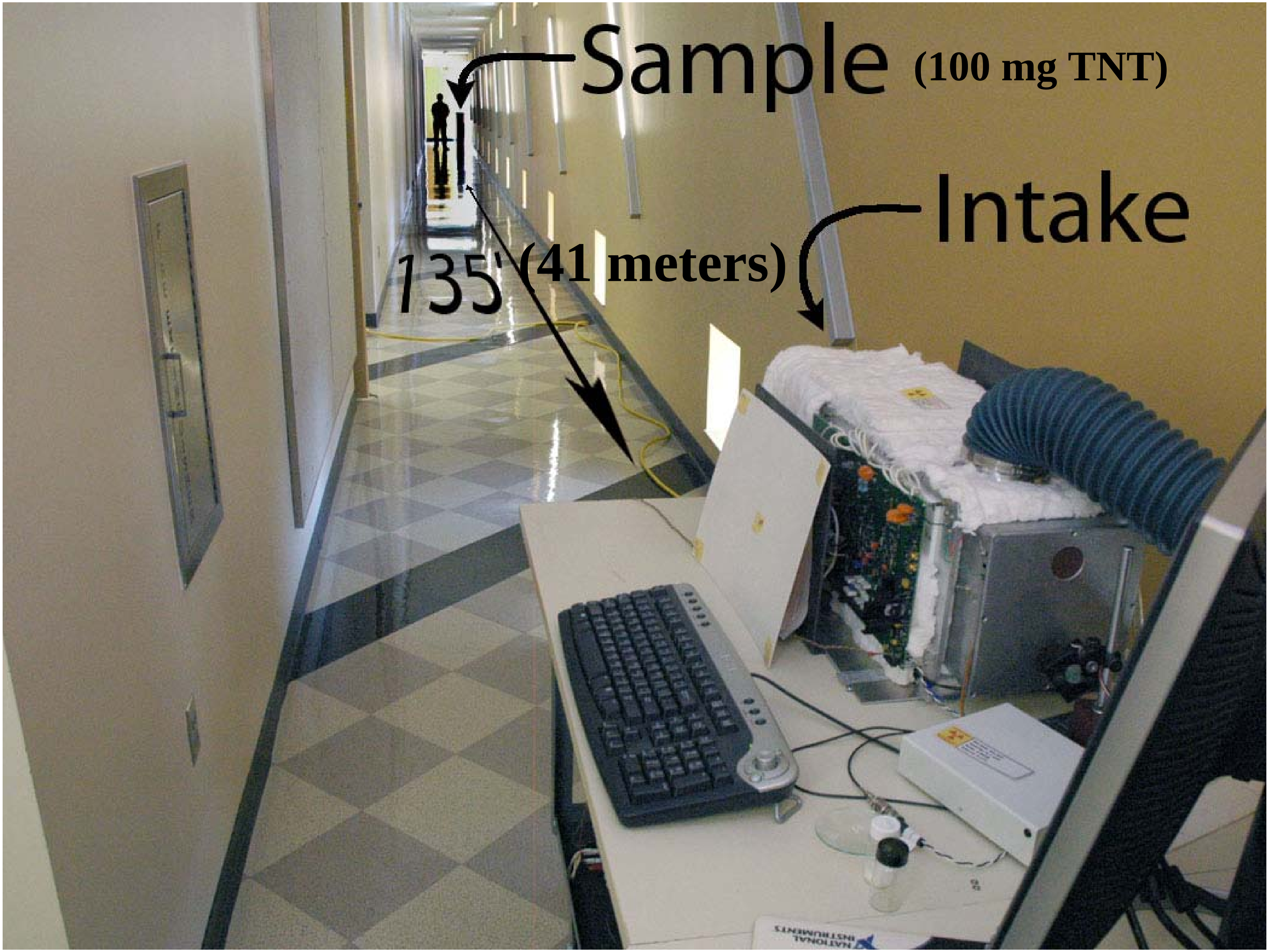


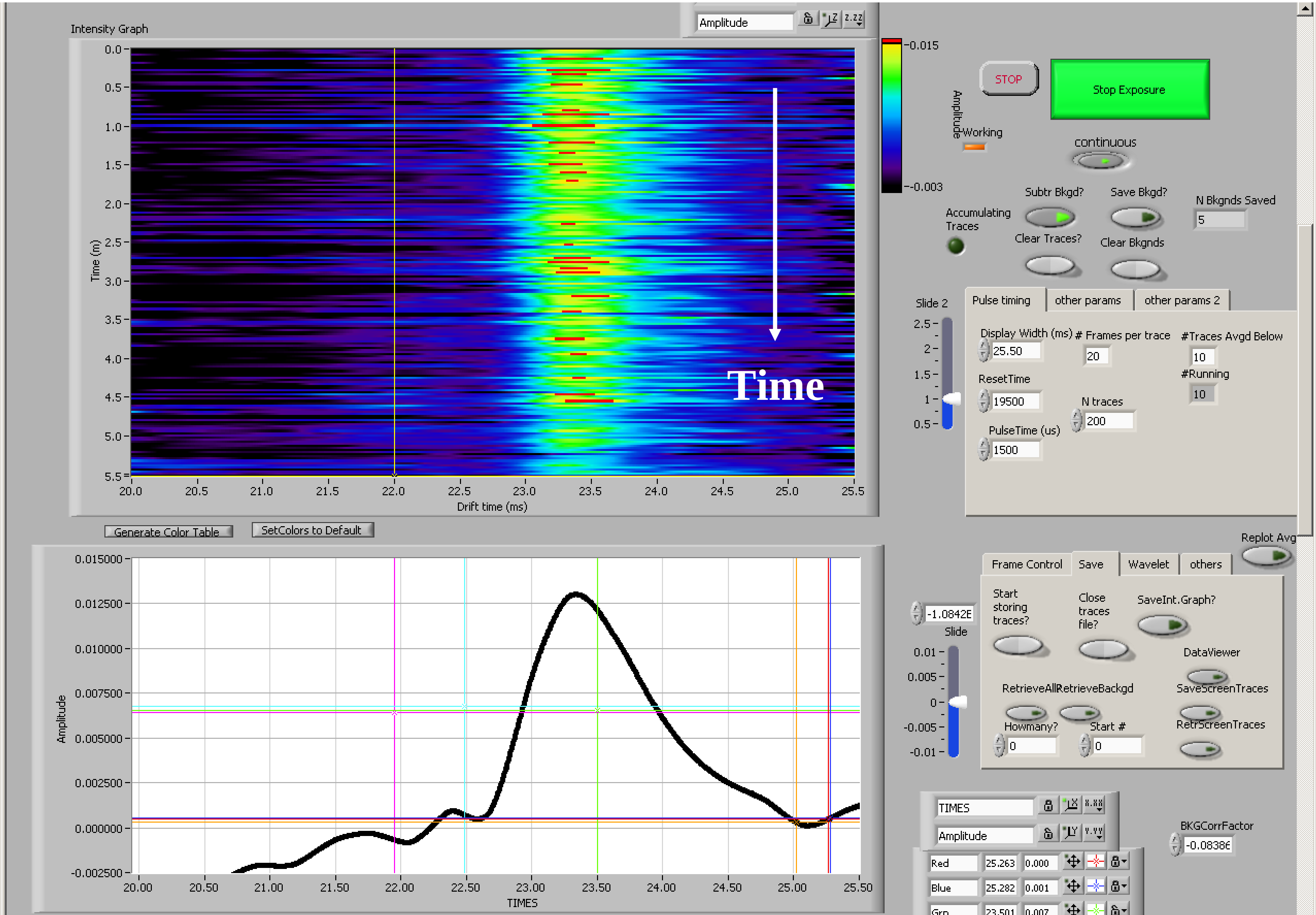
Cmpd.A 90 feet down the hall (vial closed for 20 minutes) 11-30-06, low gain = ÷ 100



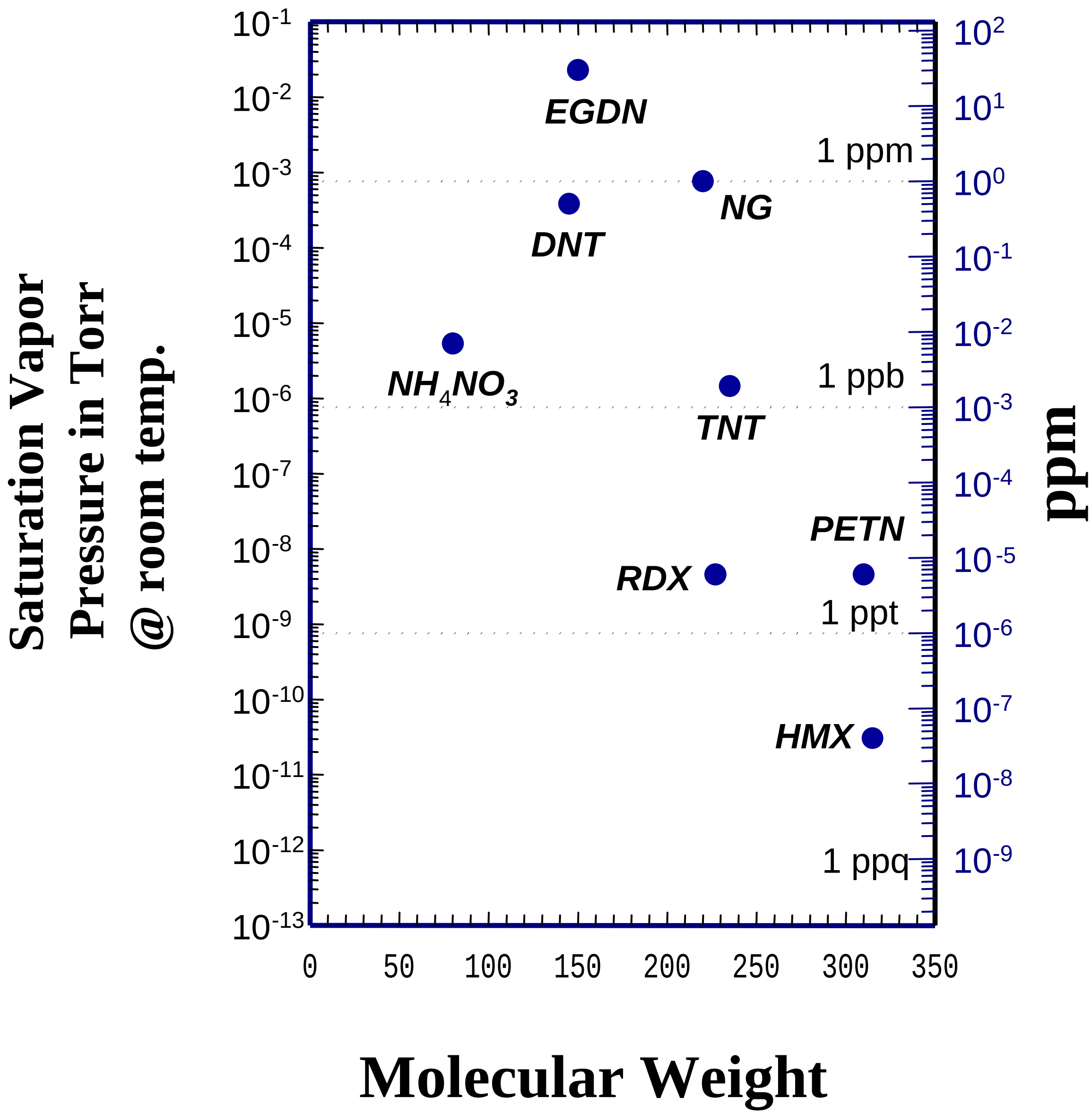


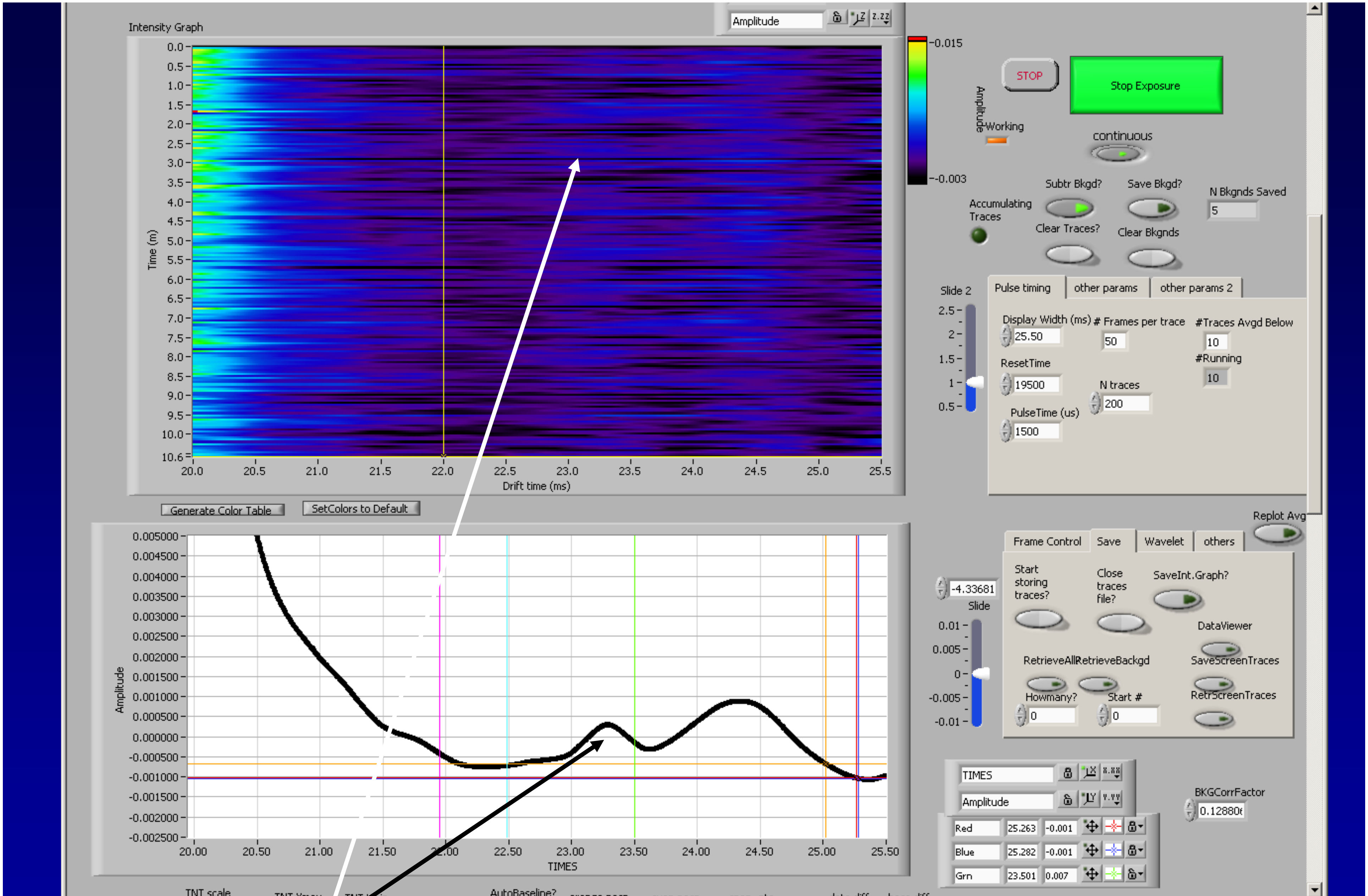
100 mg TNT @ 135 ft, 12-16-08


Sample (100 mg TNT)
Intake
135' (41 meters)
NATIONAL INSTRUMENTS

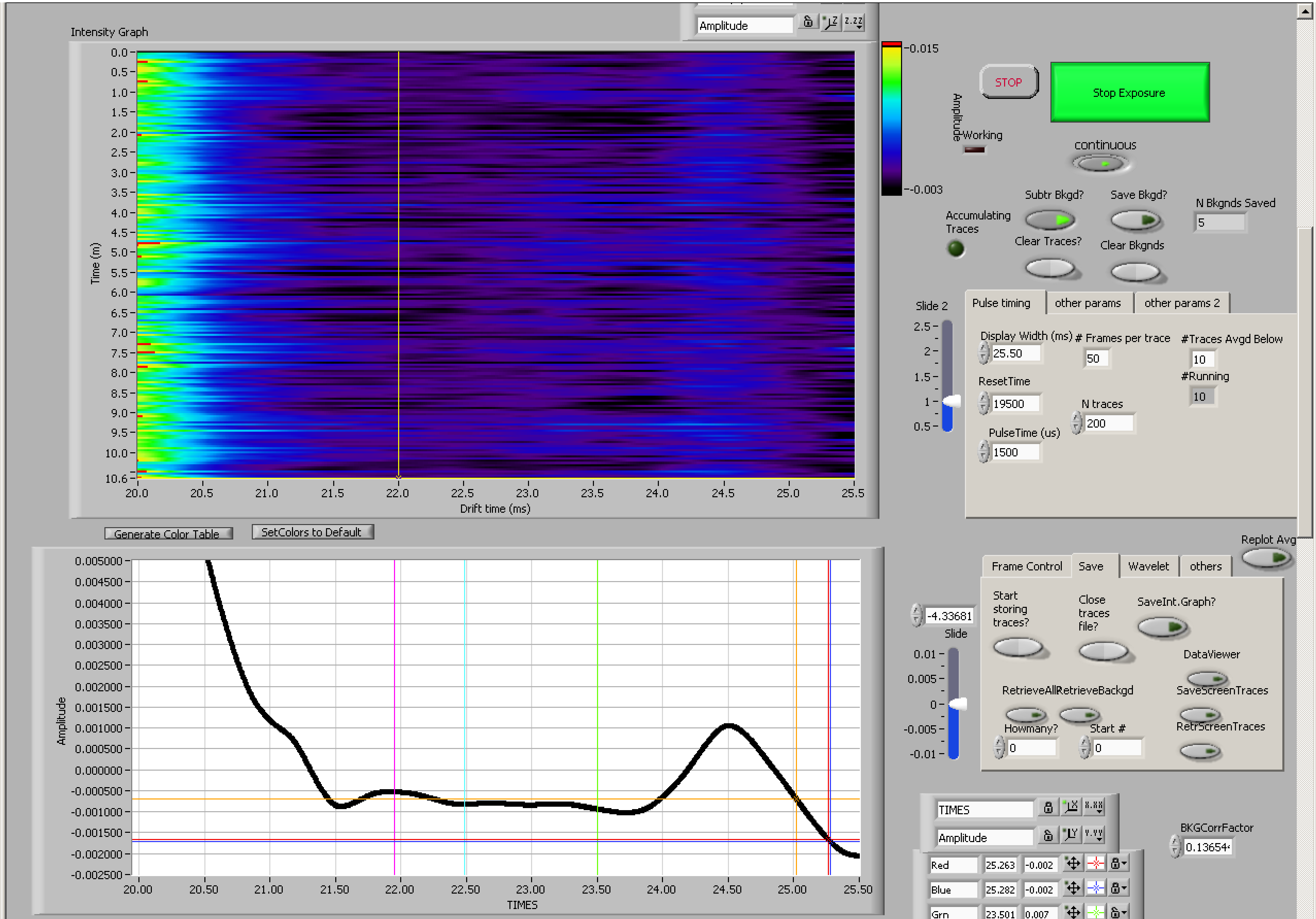


100 mg RDX 50 ^{0}C @ 70feet


Saturation Vapor Pressure in Torr @ room temp.
ppm
Molecular Weight
EGDN
DNT
NG
NH4NO3
TNT
RDX
PETN
HMX
1 ppm
1 ppb
1 ppt
1 ppq
10-1
10-2
10-3
10-4
10-5
10-6
10-7
10-8
10-9
10-10
10-11
10-12
10-13
102
101
100
10-1
10-2
10-3
10-4
10-5
10-6
10-7
10-8
10-9
0
50
100
150
200
250
300
350



100 mg RDX 24 deg C w/ ring fan on at top; distance 5’



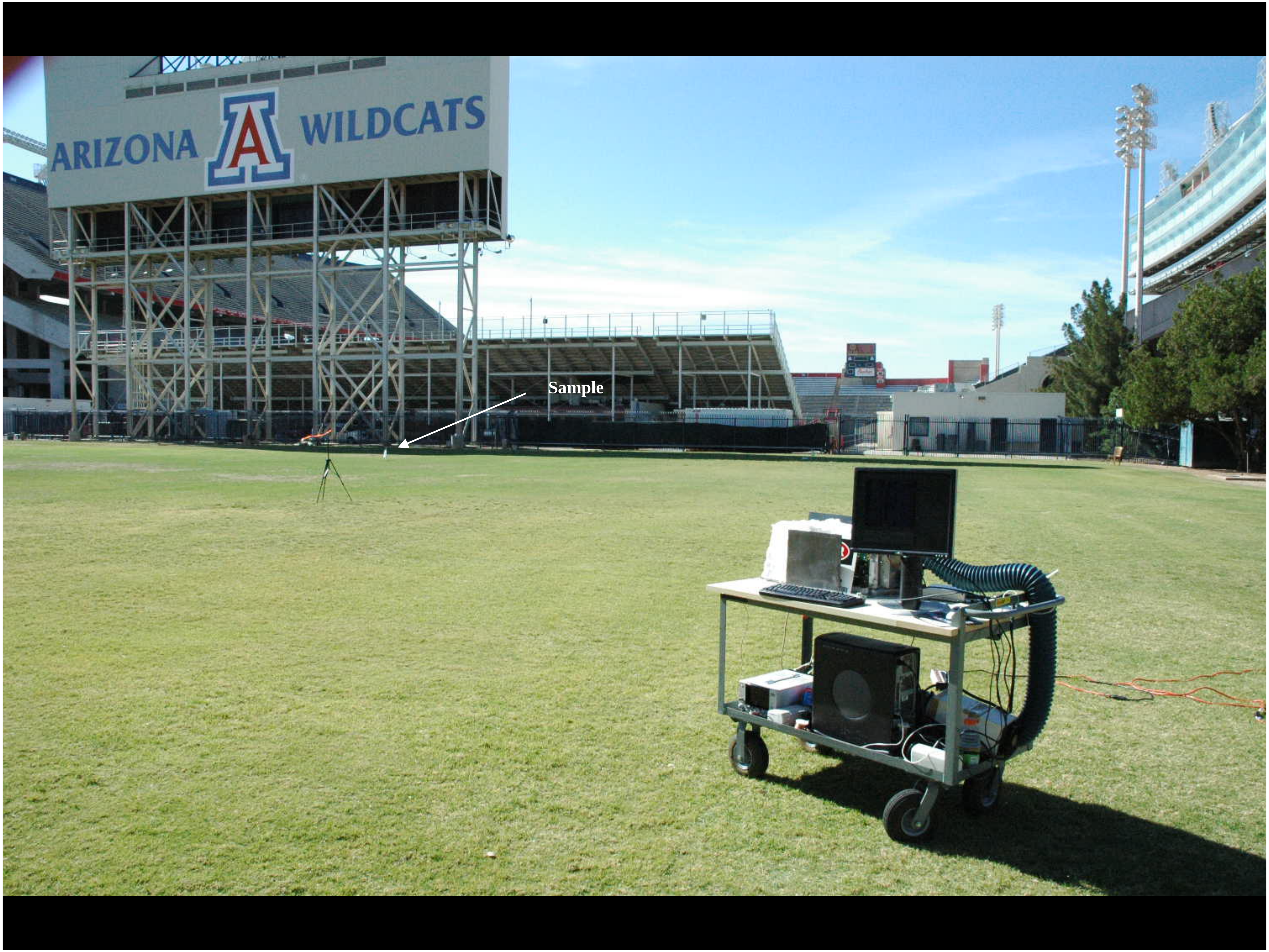
Sample Capped

Remember

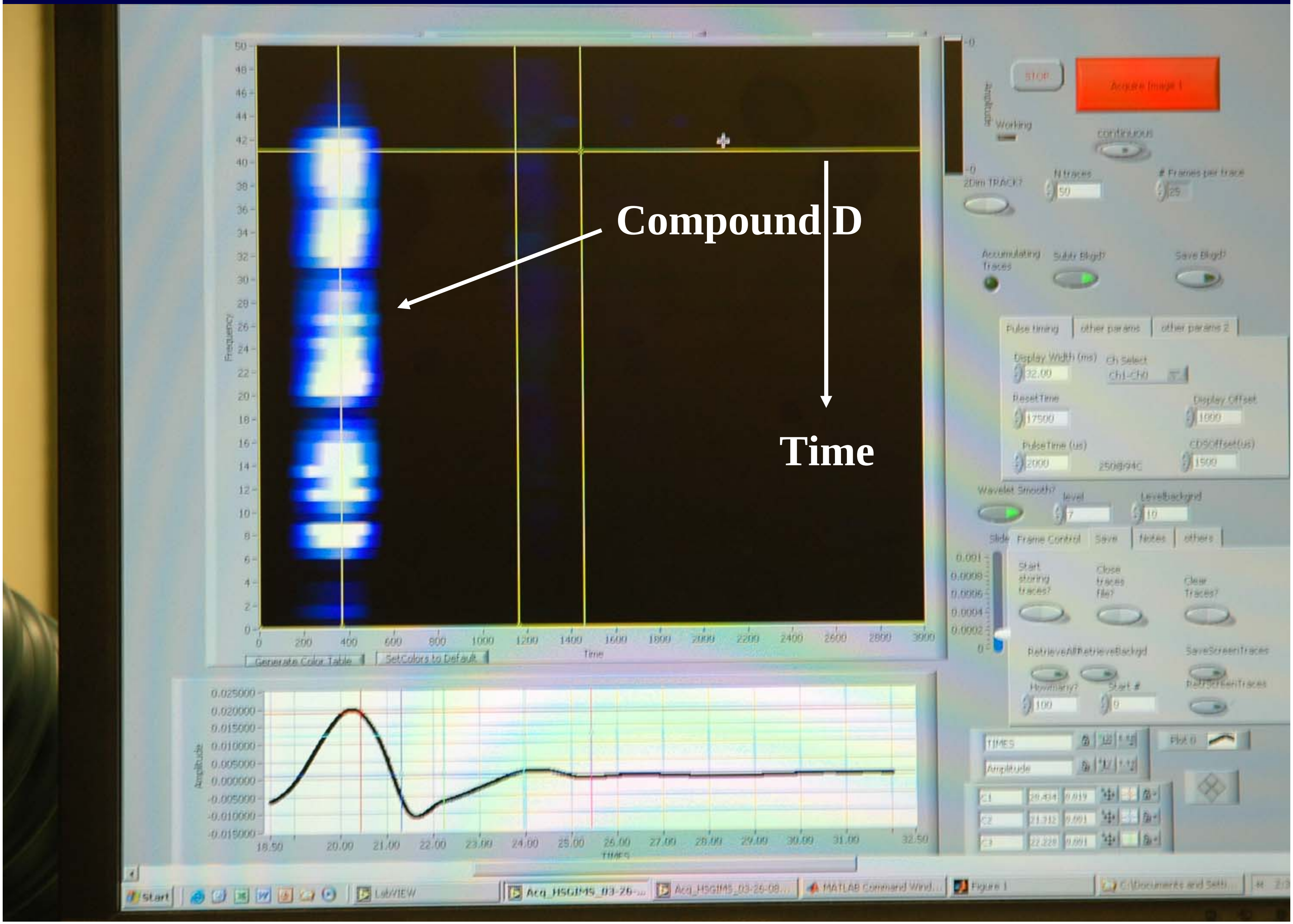
Until three months ago there was NO funding for explosive detection with the super sensitive Instrument.

Field Tests

- Initial field tests using compounds selected for customer applications (Not Explosives) conducted 12-15- 2007
- Outside tests reported conducted on 4-1-2008 & 4-3-2008
- Inside tests reported conducted 4-4-2008
- Proposed modifications for additional sensitivity have not yet been incorporated !!

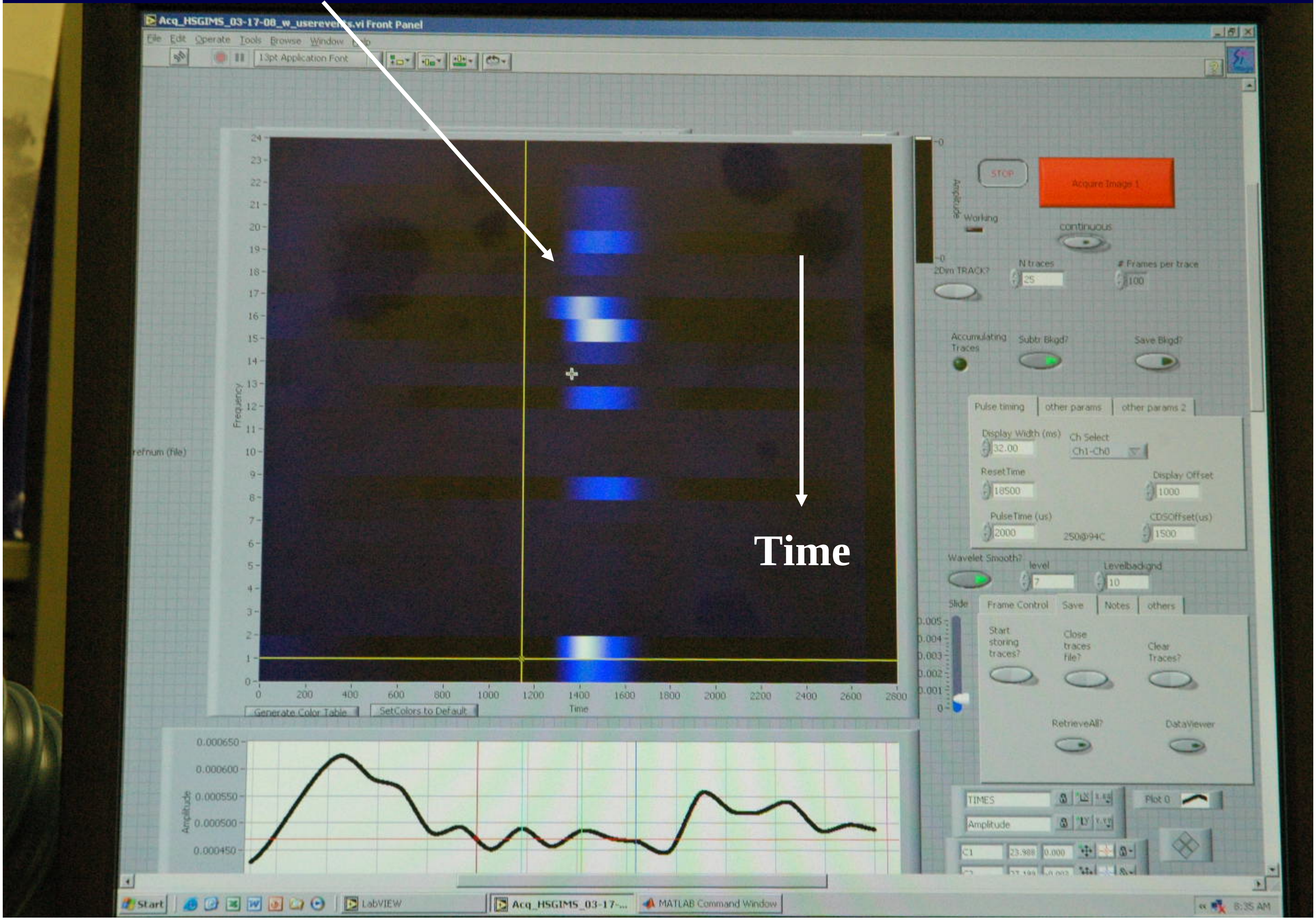


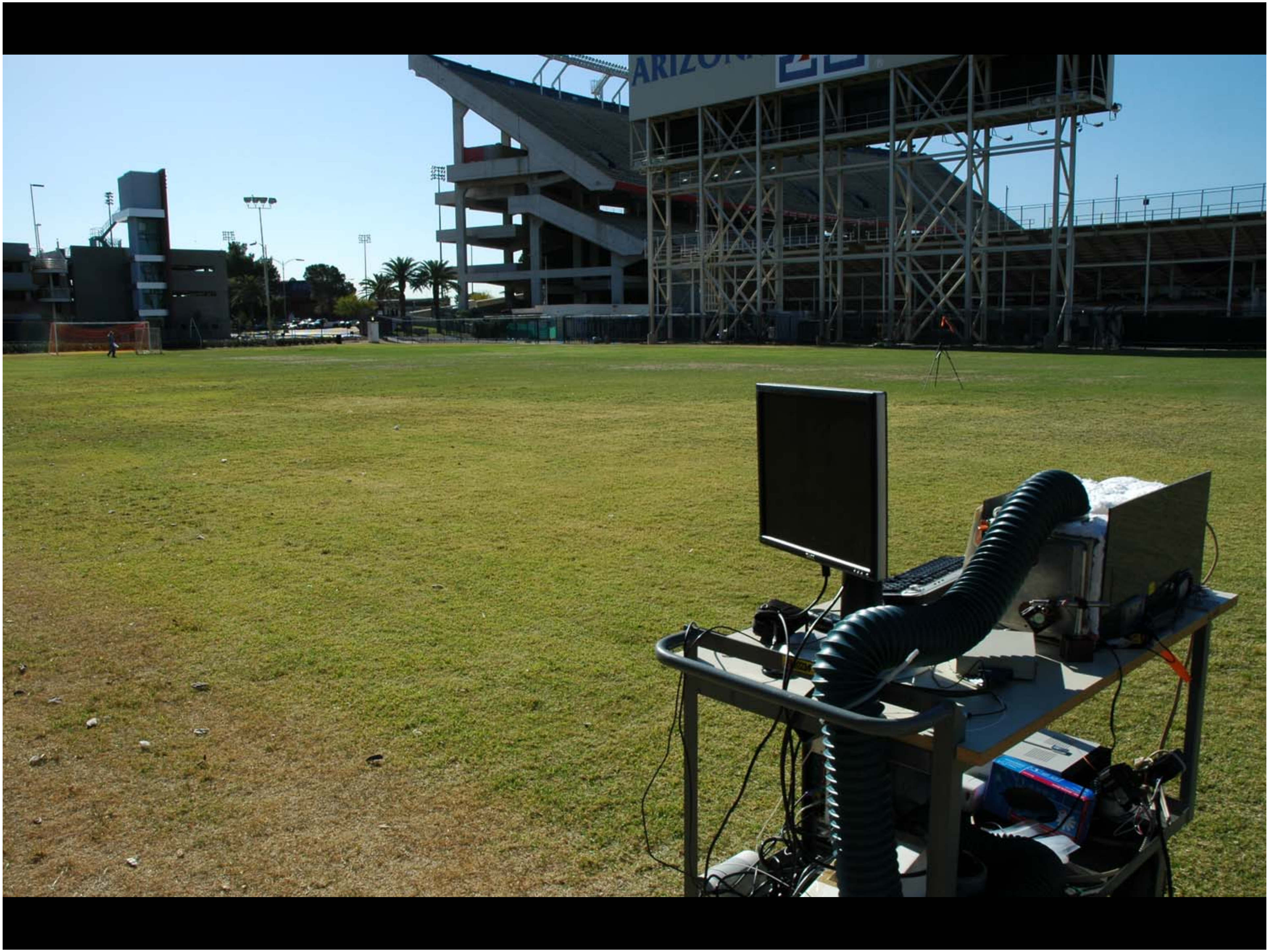
ARIZONA
A
WILDCATS
Sample


Compound D
Time

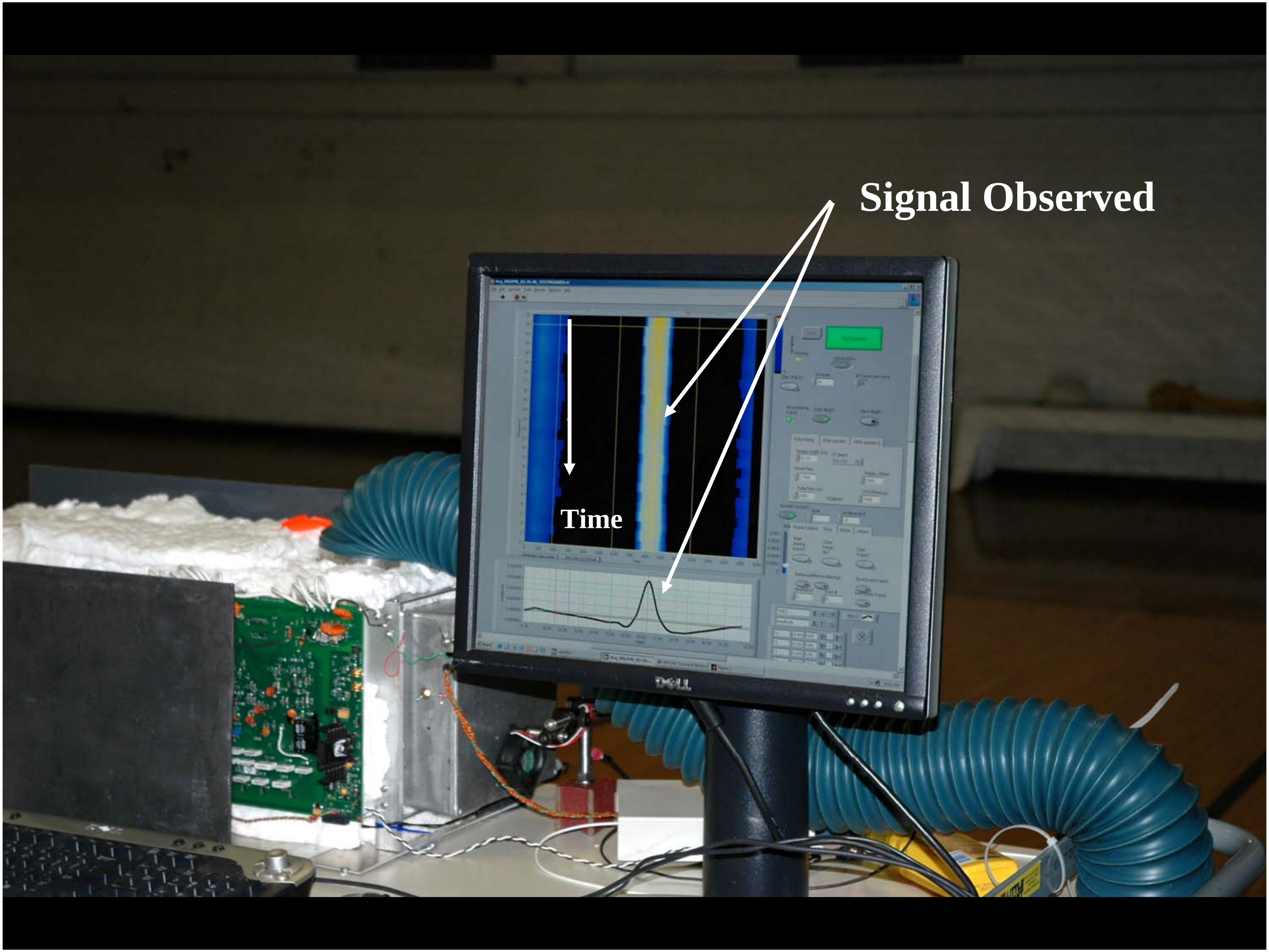

ARIZONA
A
Sample

Vapor from small area blows around a bit, but is still detected!!

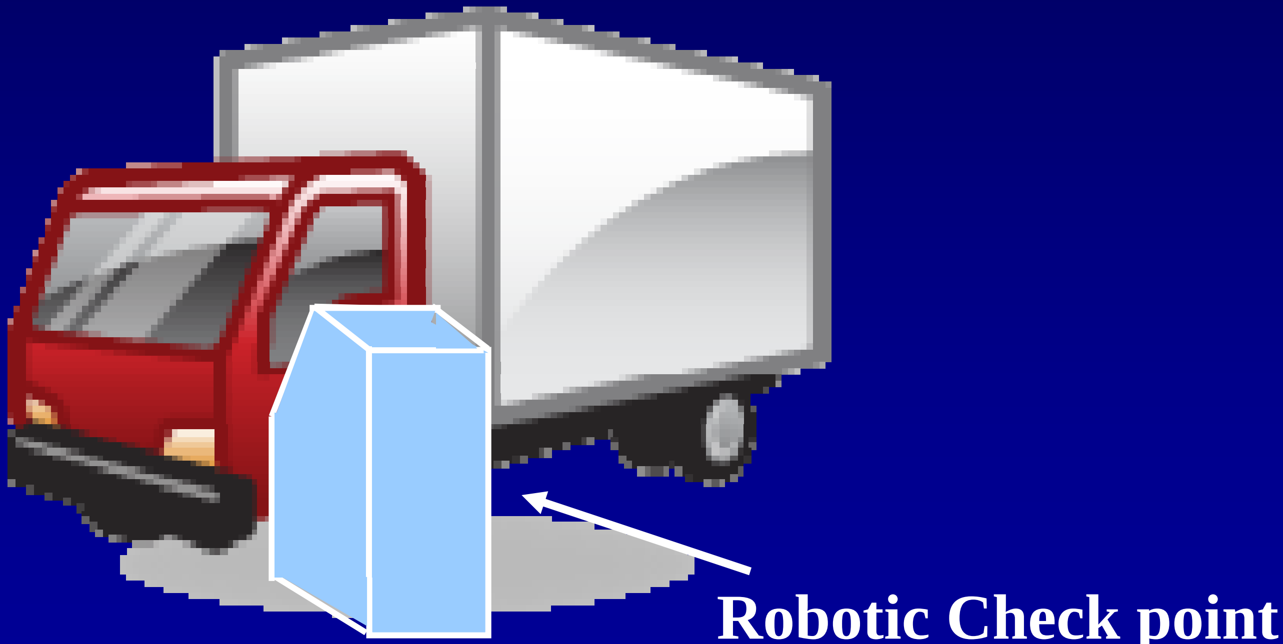


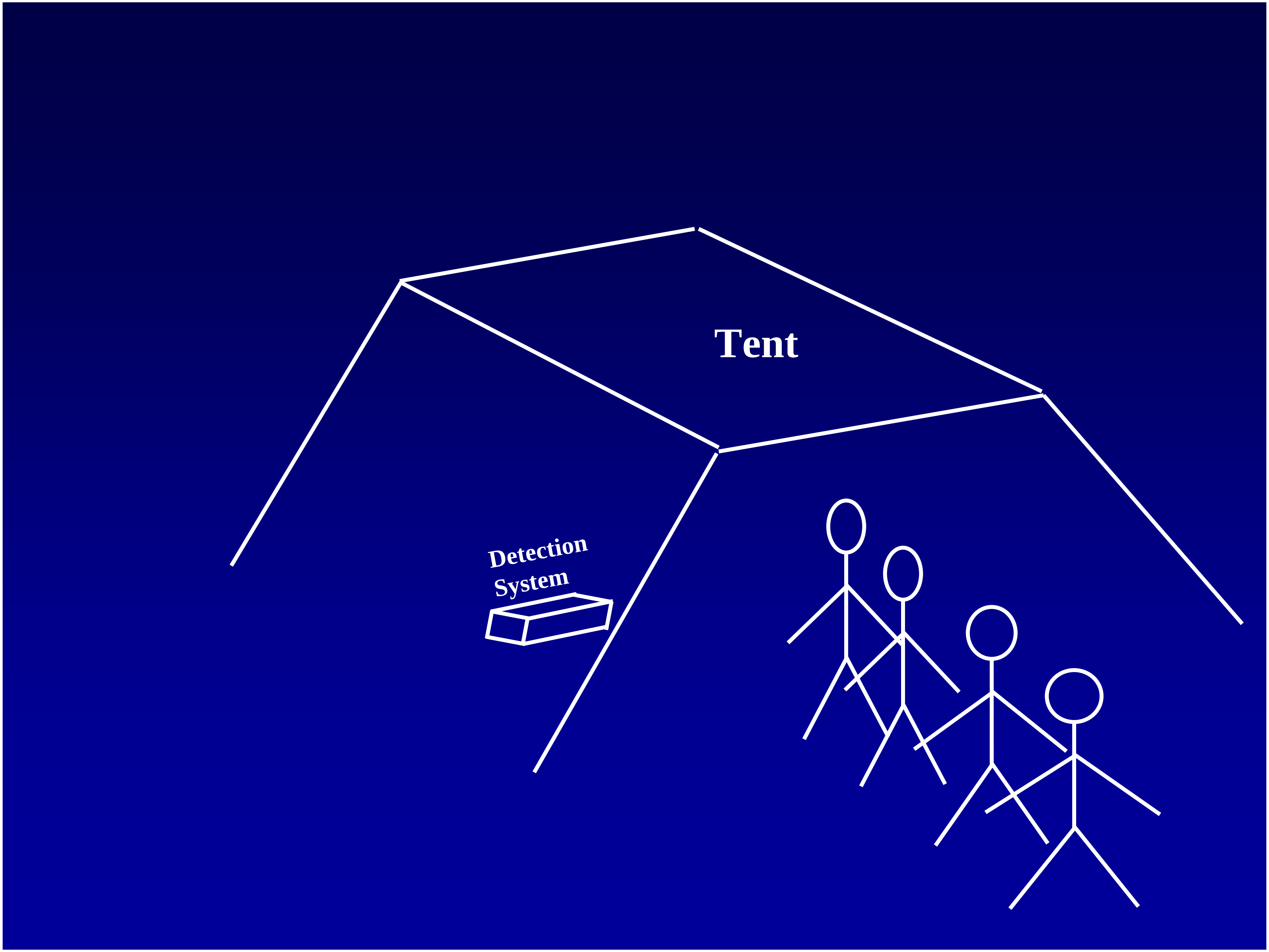


Inside Gym Tests

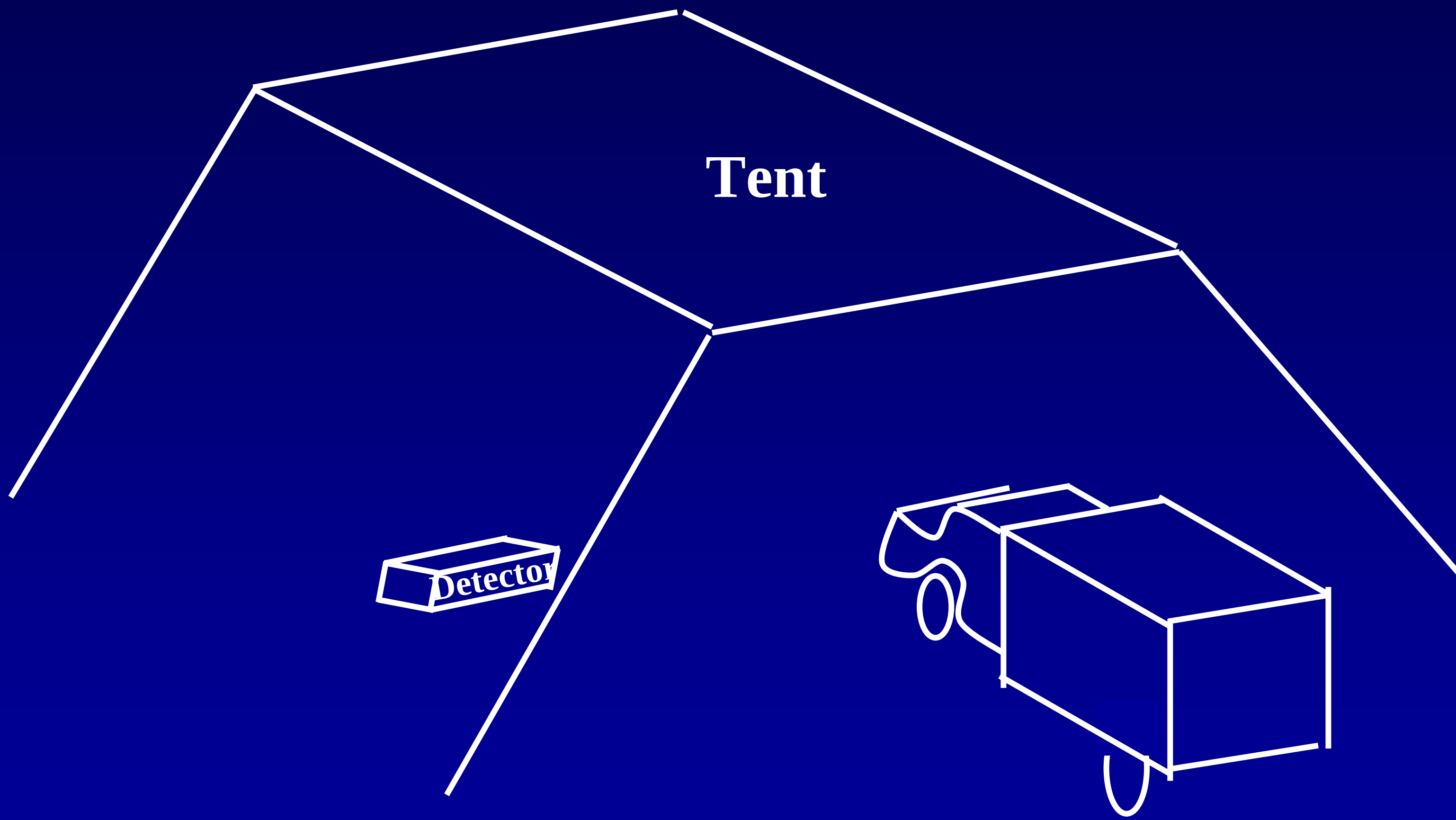

Signal Observed
Time

One of many other scenarios suitable for the Super Sensitive Explosive Detection Instrument's Deployment

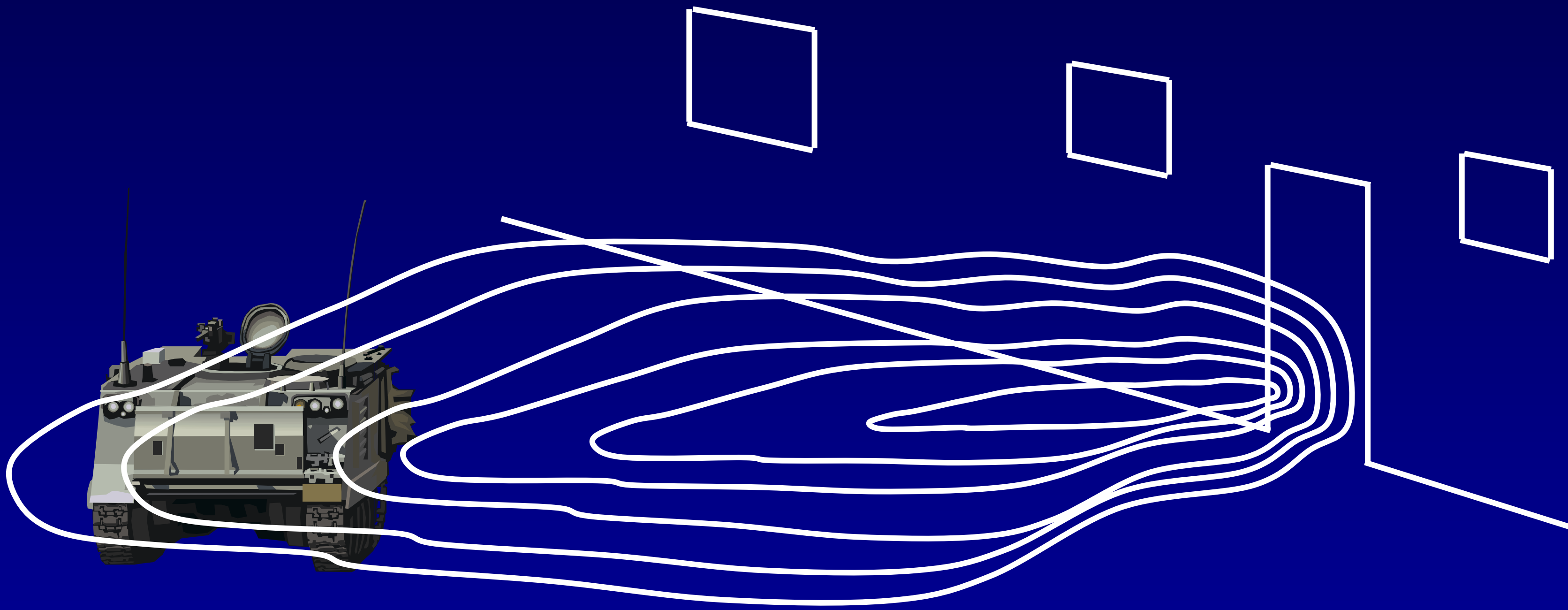



Tent
Detection
System

On a larger scale highly portable check points can be implemented using tents etc. etc.



Vehicle based Instrument hunts IED’s



Escalators , elevators or even corridors provide excellent opportunities for real time vapor phase screening

Raman Spectroscopy

The “Awakened Giant” of Molecular Spectroscopy

Modern Raman Instrumentation

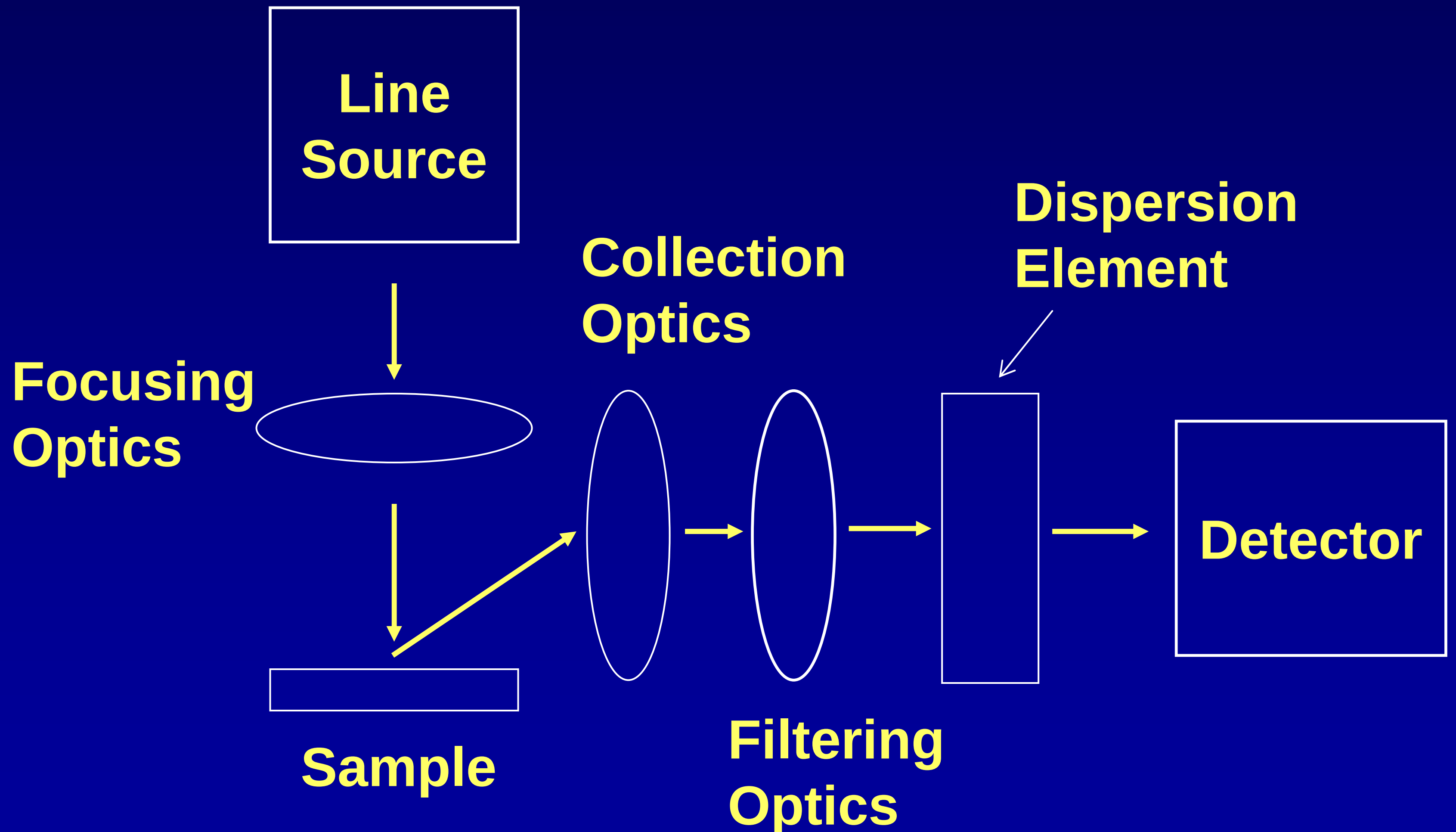
Stable

Rugged

Compact

Inexpensive ?

Basic Raman Spectrometer Block Diagram



Raman Scattering Intensity

$$\Phi_R \propto \sigma(\nu_{ex})\nu_{ex}^4 E_0 n_i e^{-E_i/kT}$$

Φ_R ≡ **Raman scattering intensity**

$\sigma(\nu_{ex})$ ≡ **Raman cross section (analyte dependent)**

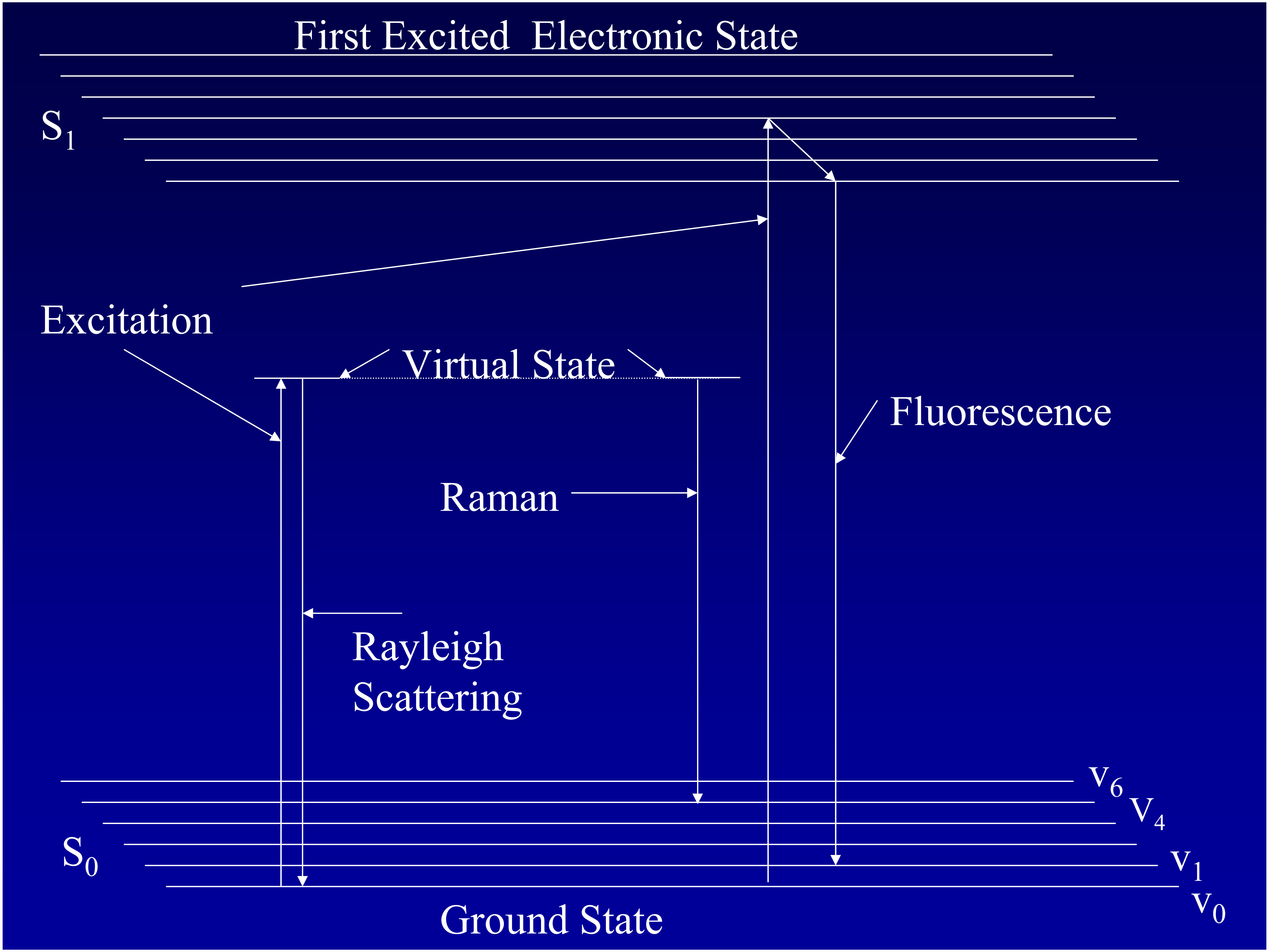
ν^4_{ex} ≡ **Frequency of excitation energy (4th POWER)**

E_0 ≡ **Energy of source irradiance**

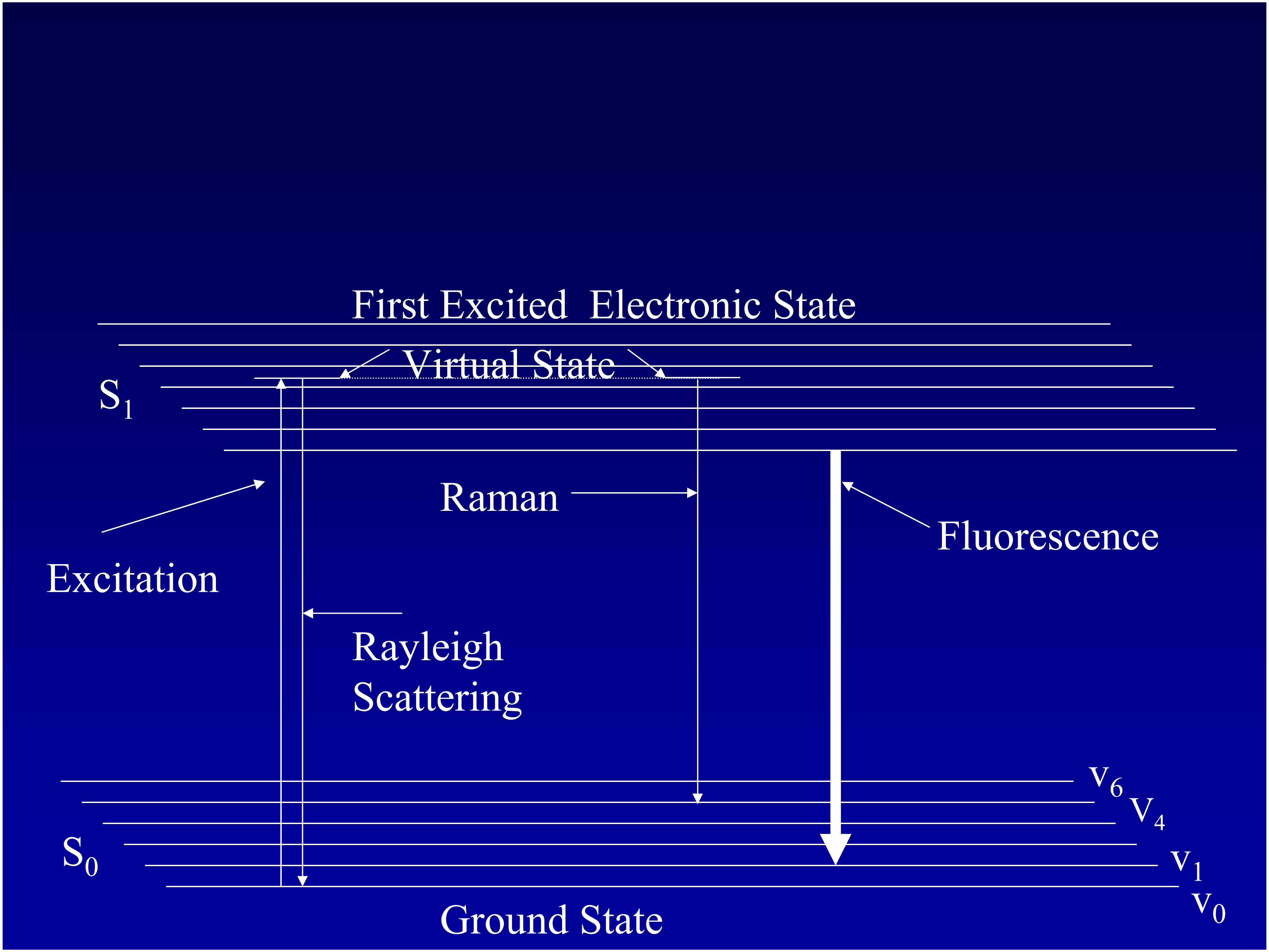
n_i ≡ **Number density of state i**

$e^{-E_i/kT}$ ≡ **Boltzmann factor for state i**

Number of available scattering centers



First Excited Electronic State
S1
Excitation
Virtual State
Fluorescence
Raman
Rayleigh
Scattering
v6
V4
S0
v1
v0
Ground State



First Excited Electronic State
Virtual State
S1
Raman
Fluorescence
Excitation
Rayleigh
Scattering
v6
V4
S0
v1
v0
Ground State

What Wavelength Should be Used?

Problems Associated with Laser Wavelength

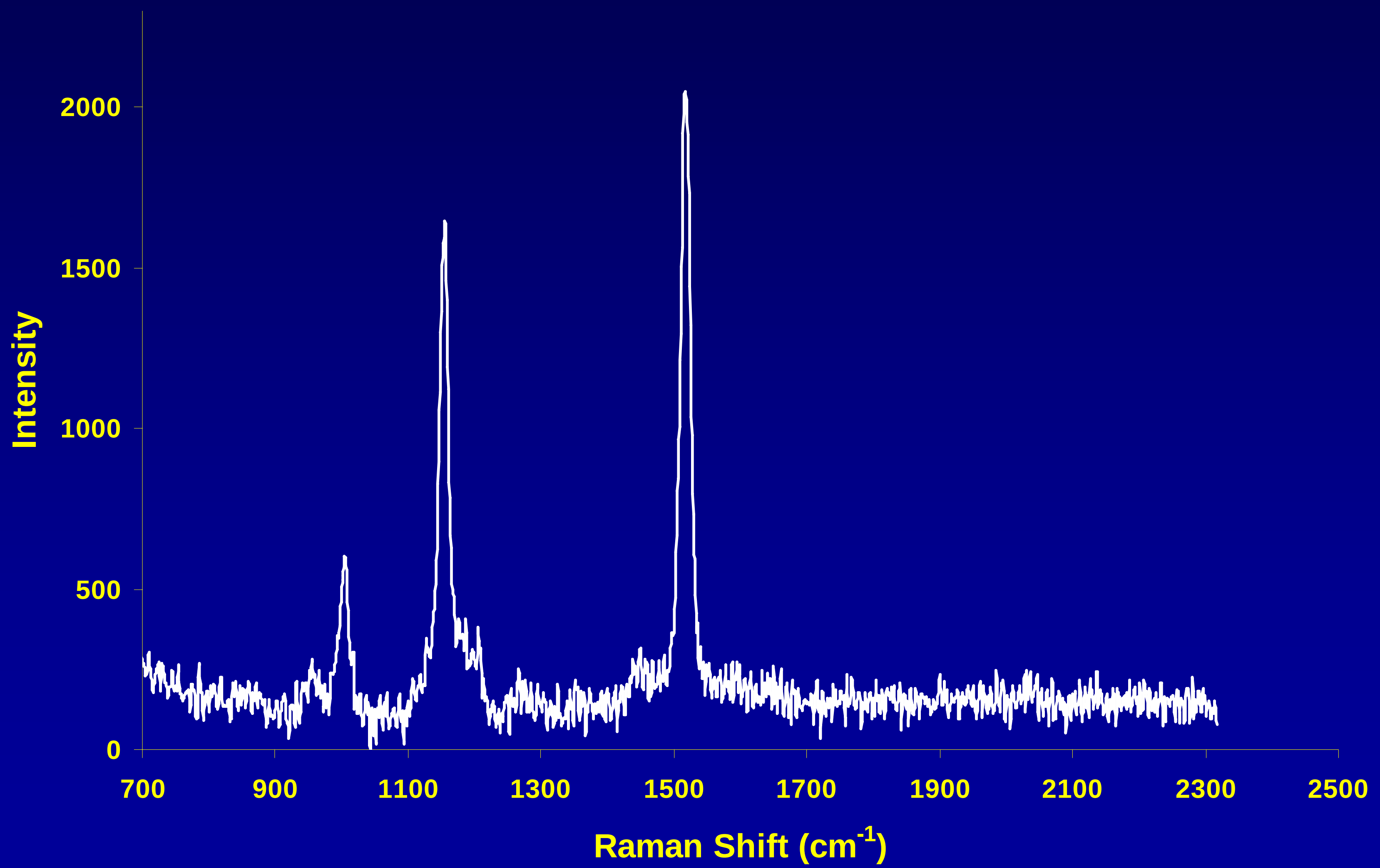
- Fluorescence
- ν^4
- Self absorption
- Laser availability
- Detector availability

Raman Spectral Range Dependence on Excitation λ

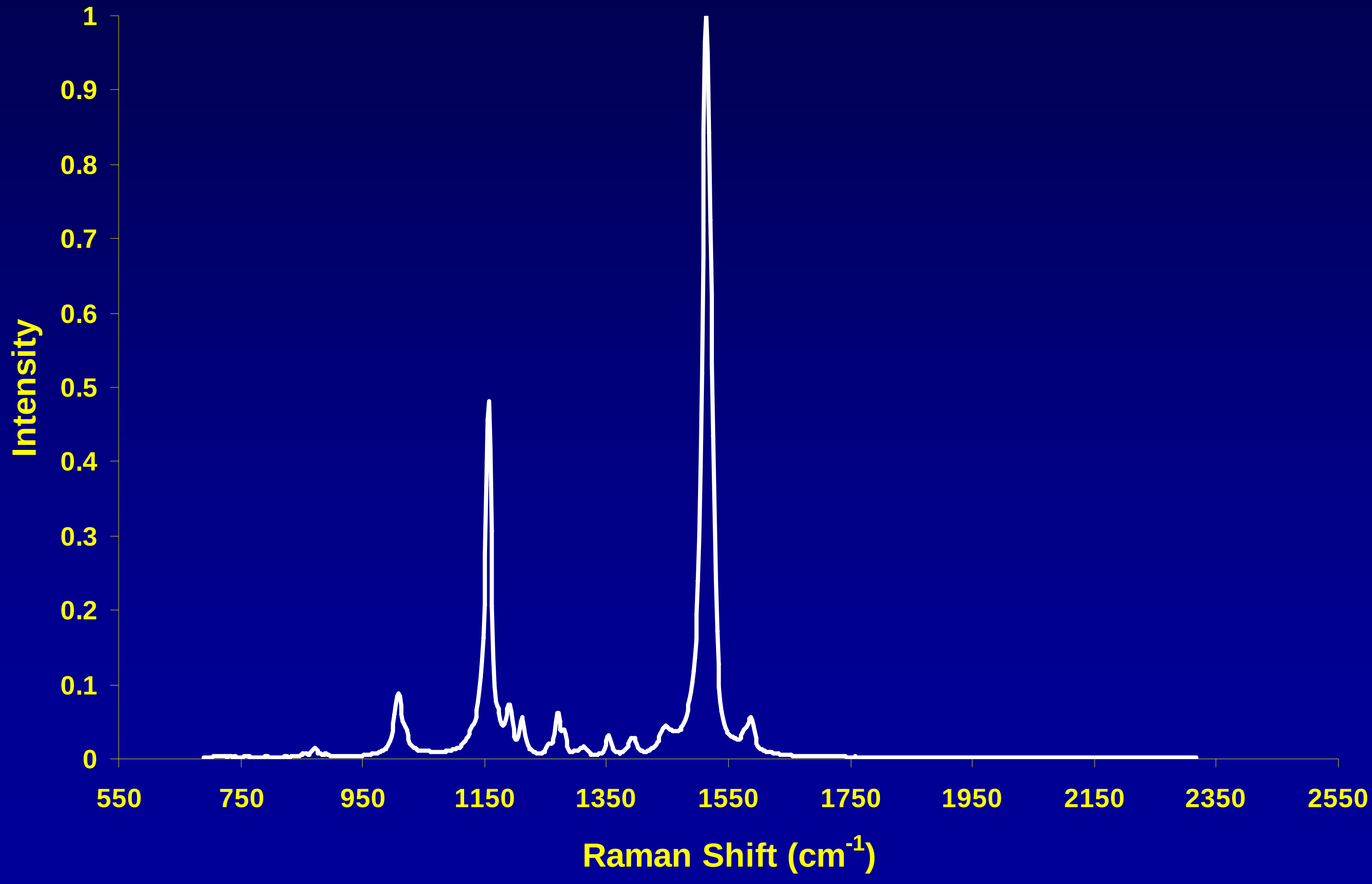
785 nm

- 0 - 3500 cm^{-1} = 785 - 1100 nm
- Shot noise limited detection with a CCD
- Few electronic absorption bands at or below 785 nm
- No significant NIR bands above 1100 nm
- Inexpensive, durable diode lasers
- ν^4

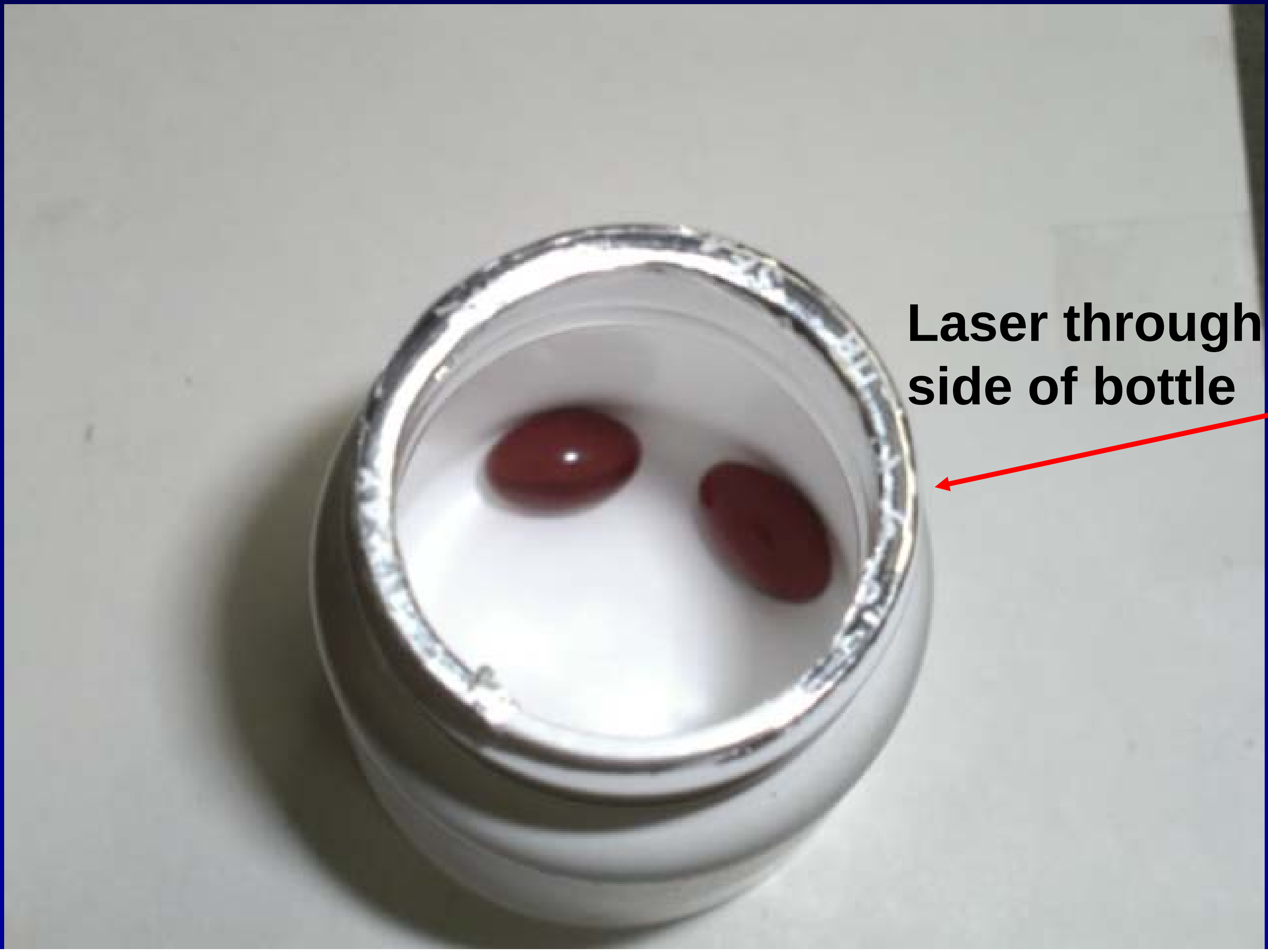
Raman Spectrum of a Carrot



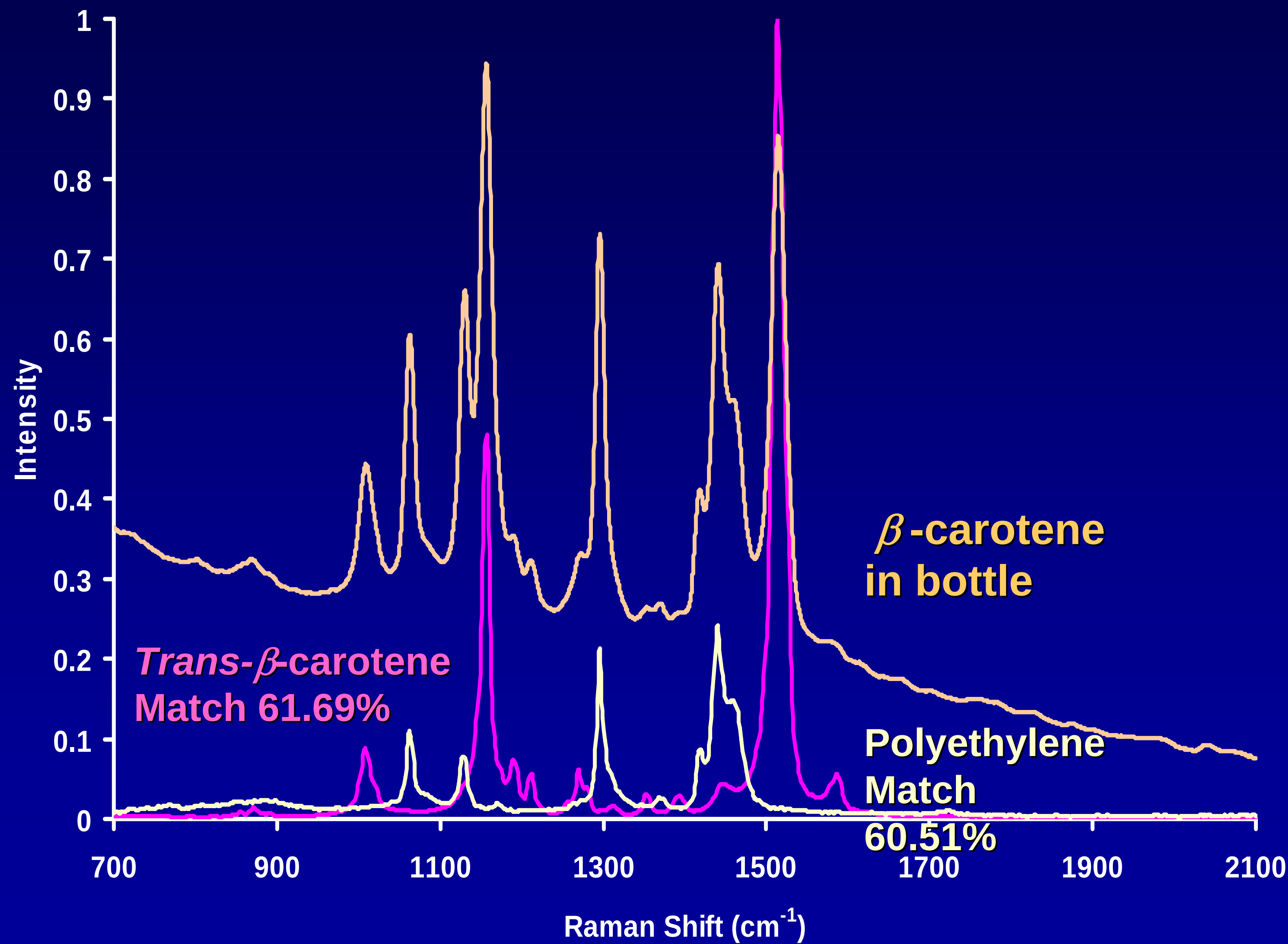
Beta -Carotene



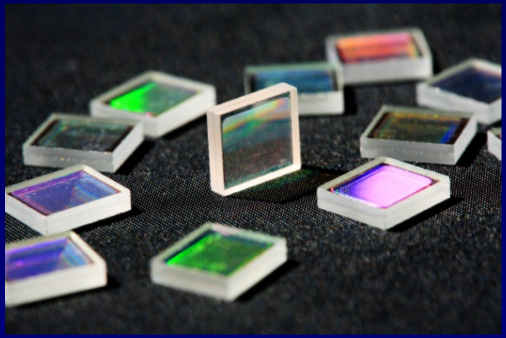
Beta-Carotene in Plastic Bottle

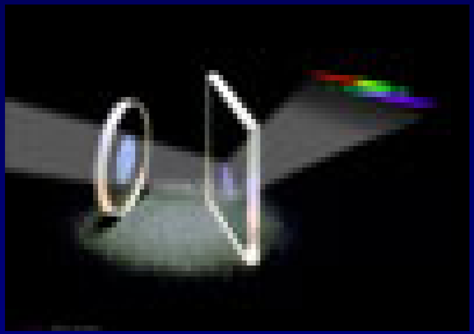


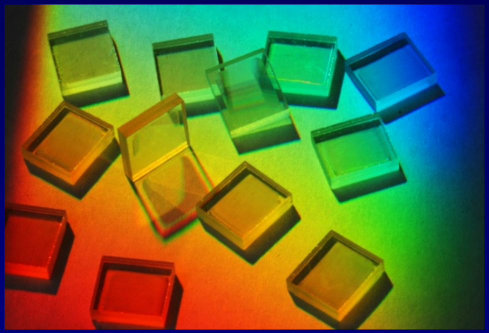
Omnic Library Match Results



Partnering with BaySpec's which is a successful manufacturer of Telecom Optics including H*olographic Optical & Dispersive Elements*

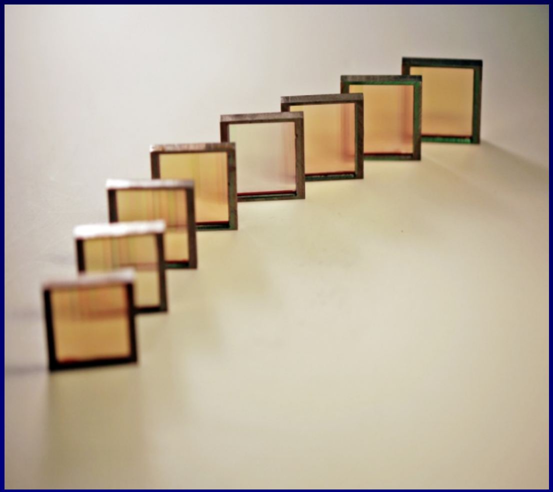


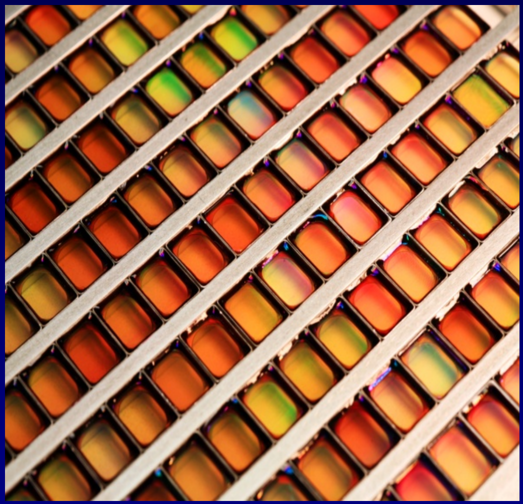


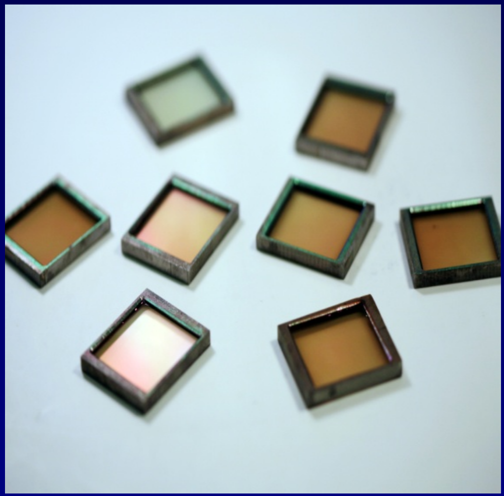


- **Holographic optics enable large volume production of *high efficient, rugged, low noise, low cost gratings***
- **High efficiency, compact spectrographs**
- **Transmission gratings enable *Spectral Imaging* capabilities**

BaySpec's VPG based H*olographic*
Optical & Dispersive Elements



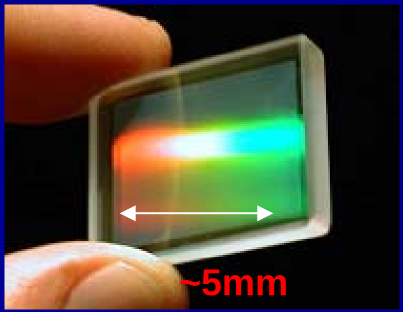


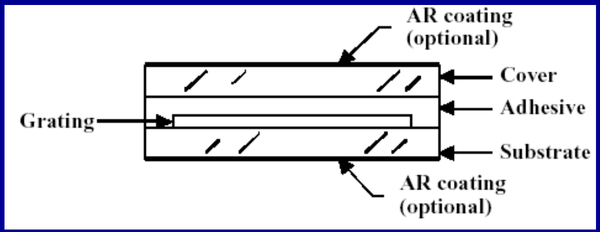


- **Holographic optics enable large volume production of *high efficient, rugged, low noise, low cost gratings***
- **High efficiency, compact spectrographs and Notch filters**
- **Transmission gratings enable *Spectral Imaging* capabilities**

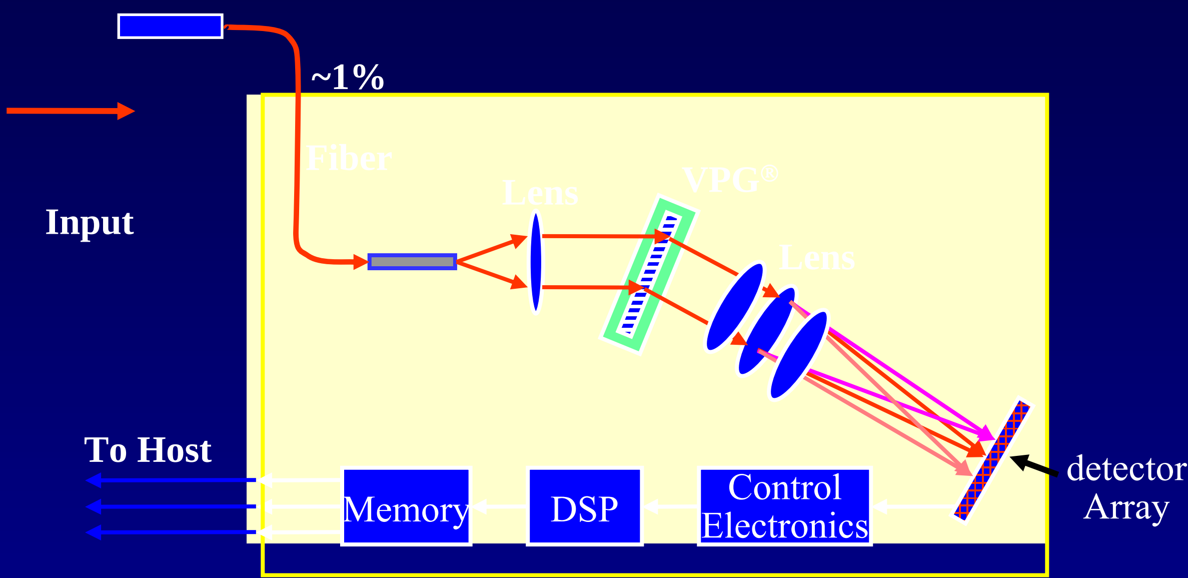
VPG™ – Volume Phase Gratings

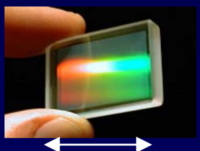
- Class 100 manufacturing facility at BaySpec
- Widely used in spectroscopic instrumentation, military/defense head-up display, telecom, medical diagnostics, and other demanding applications
- Works in Transmission mode
- Wide wavelength range, 300-3000nm
- High and equal P&S diffraction, Peak diffraction efficiency >98%
- Polarization effects minimal, PDL <0.1dB
- Ruggedized, no affected by shock or vibration
- Fast production cycle of 1-2 days allows for easy customization
- Athermal design feasibility
- Low cost, large qty production capability

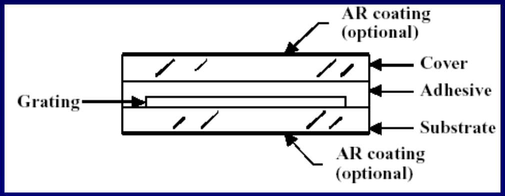




Miniature Spectral Engine-
Design and Design Diagram







Major Reliability Benefits:

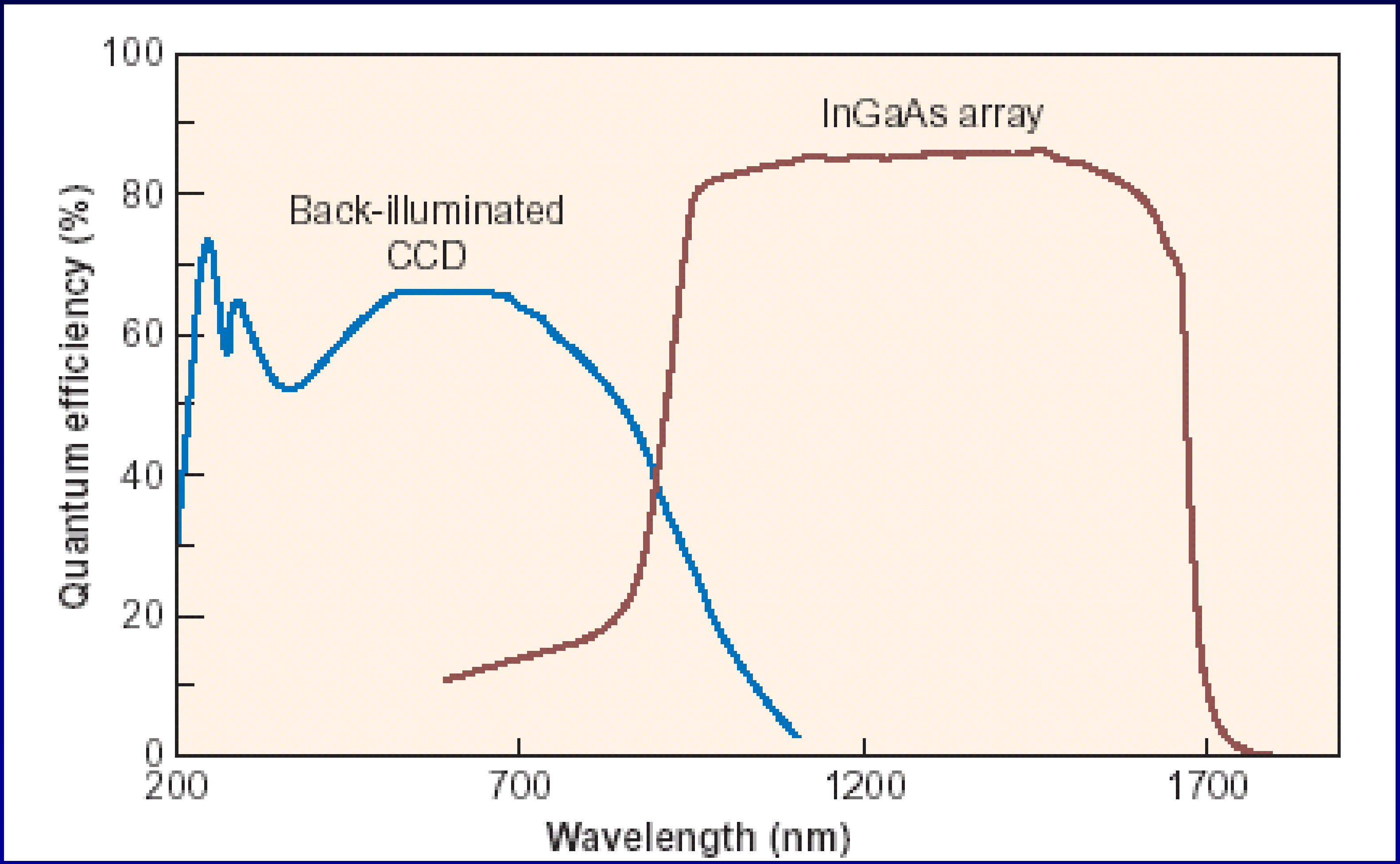
- ***No moving parts***
- ***Rugged Volume phase gratings***
- ***Solid state electronics***
- ***Hermetic seal of individual units***

Smaller than a Blackberry

Handheld 1064 nm Raman For Substance Identification

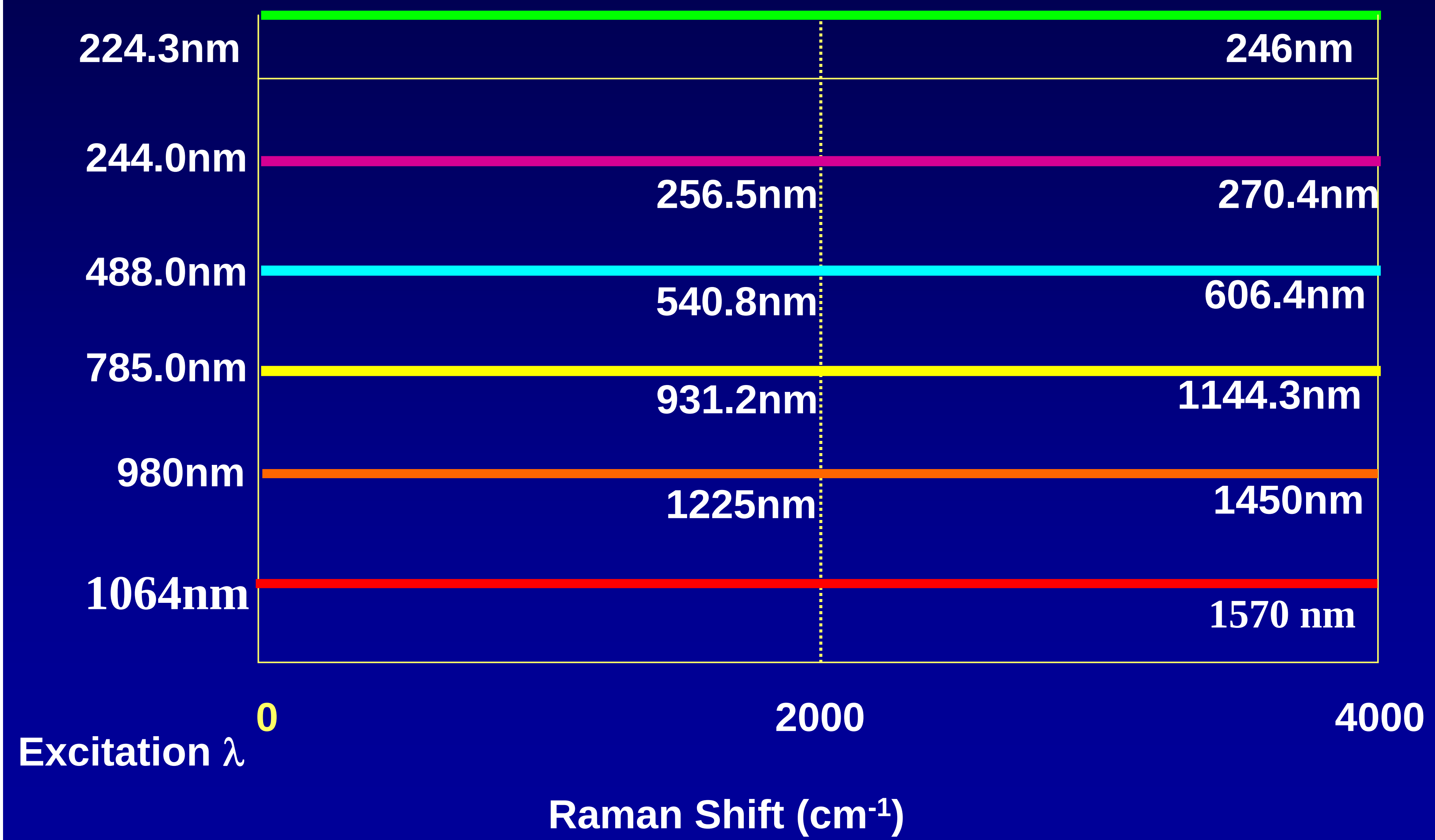
- Specifications
  - Range: 200 to 3000 cm^{-1}
  - Resolution: 5-7 cm^{-1}
  - Acquisition Time: 10 sec
  - Size: Handheld
  - Weight: ~1 lb
  - Power Consumption: 10 W peak

NIR Spectroscopy/Imaging With Focal Plane Arrays



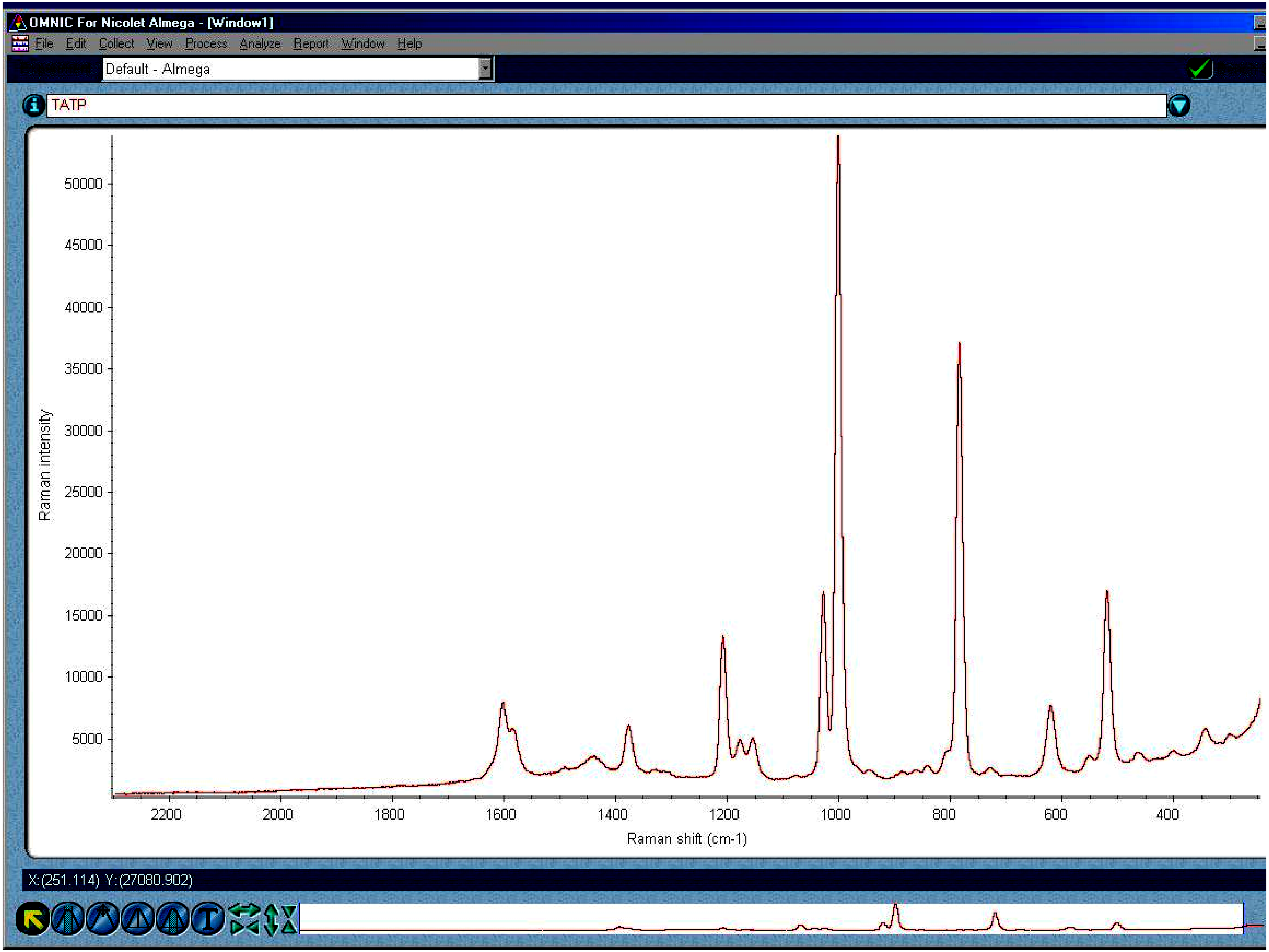
•Ideal NIR sensor will have high QE between 900-1700 nm, high sensitivity, high dynamic range.

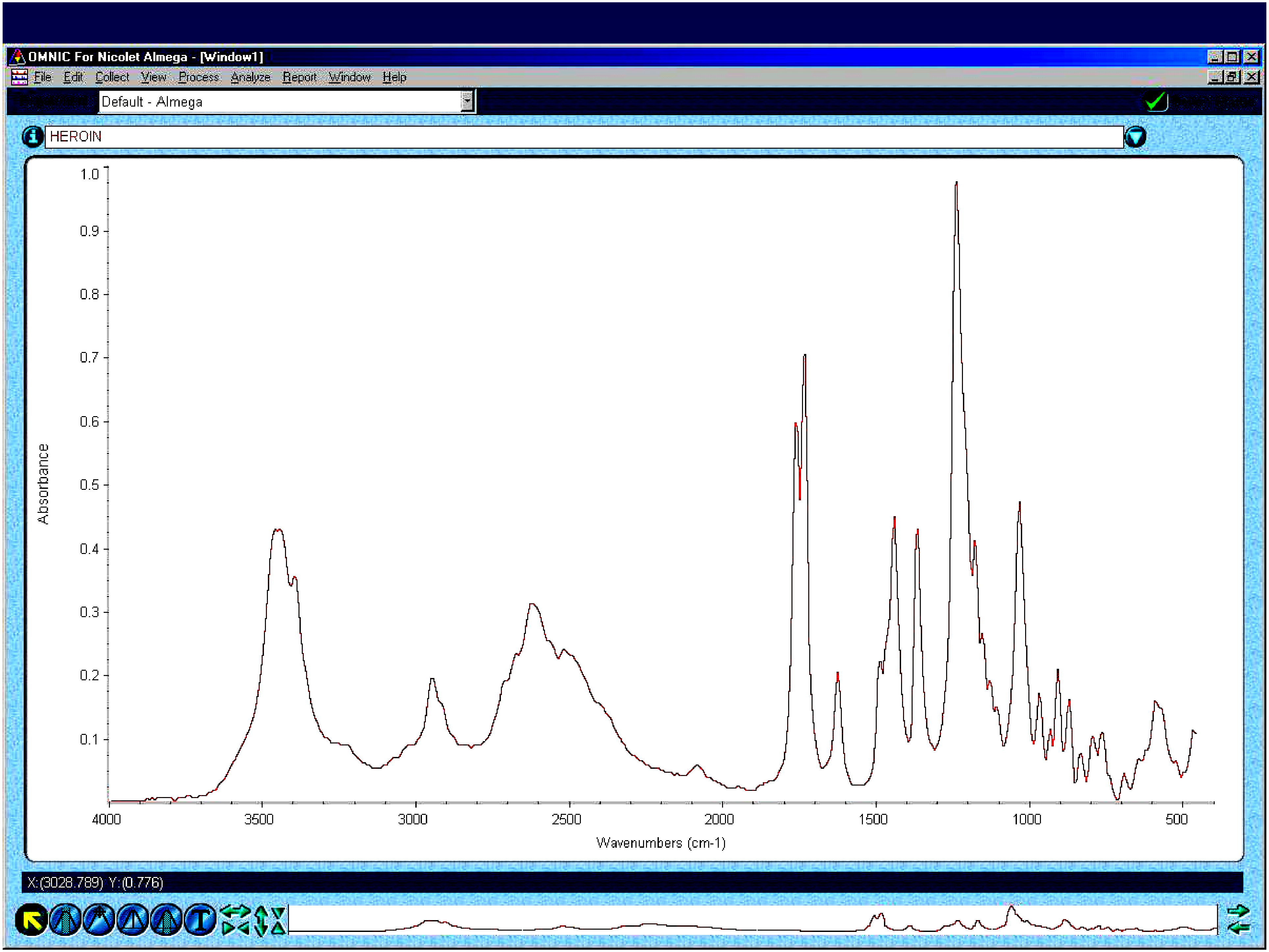
Raman Spectral Range Dependence on Excitation λ



Richard Reid

22nd December 2001
“Shoebomber”


OMNIC For Nicolet Almega - [Window1]
File Edit Collect View Process Analyze Report Window Help
Default - Almega
TATP
Raman intensity
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
2200
2000
1800
1600
1400
1200
1000
800
600
400
Raman shift (cm-1)
X:(251.114) Y:(27080.902)


OMNIC For Nicolet Almega - [Window1]
File Edit Collect View Process Analyze Report Window Help
Default - Almega
HEROIN
Absorbance
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
4000
3500
3000
2500
2000
1500
1000
500
Wavenumbers (cm-1)
X:(3028.789) Y:(0.776)

"New directions in science are launched by new tools much more often then by new concepts. The effect of a concept-driven revolution is to explain old things in new ways. The effect of a tool-driven revolution is to discover new things that have to be explained."

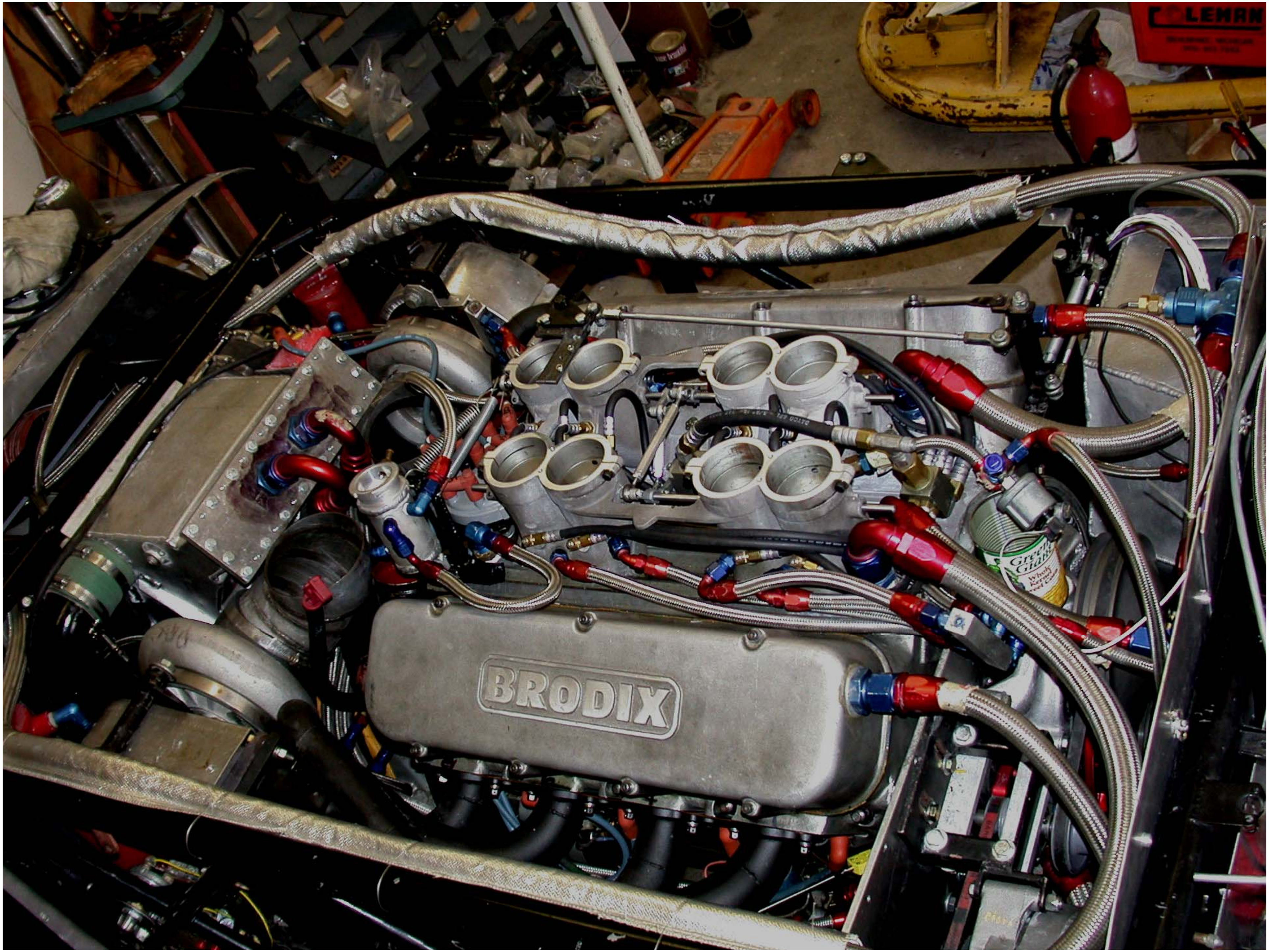
Freeman Dyson, Imagined Worlds
as quoted by Dudley Herschbach, Nobel Laureate in Chemistry


3000

Previous Record A/BMS

- Qualifying 267.555 (430.496 KPH)
- Return 260.459 MPH (on 5 cylinders)
- (419.079 KPH)
- --------------------
- Average 264.007 (424.787KPH)

Also hold AA/BMS Record @ 254.135 MPH (408.903KPH)


BRODIX


BRODIX

Down Run

283.908 MPH

(456.808 KPH)

Blew motor

Caught on Fire

could not make return run!

Are we having fun yet?

We were Just WAITING until this August !

I had regeared the car for

316 MPH (508KPH)

(assuming no slippage)

(for this Aug. 18-24)


3000
AA/BMS
GAS

Bonneville 2008

- Down Run
- QUALIFIED @ 292.241 MPH (470.261 kPH)
- Exit speed 301.138 MPH (484.531 kPH)

- Record Run 305.726 MPH (491.913 kPH)
- Exit speed 310.398 MPH (499.430 kPH)

- Record 298.983 MPH (481.064 kPH)


3000