



SYDOR™

TECHNOLOGIES

COMPLEX MEASUREMENTS—CRITICAL RESULTS



## Sydor Technologies

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Developments in imaging, via advanced electronics and  
detection methodologies

# Sydor Technologies



- 🎯 Experts at solving diagnostics and imaging problems
  - Personally Committed in partnership with our customers
  - Sensitivity ranging from high energy x-ray to IR to ballistics



U of R LLE OMEGA



Lawrence Livermore Labs



Brookhaven National Lab

# History of Sydor Technologies



- Started in 2004 with Tech Transfer of ROSS Streak Cameras from LLE. Now over 60 streak cameras installed
- Continued SBIR/grants and other developmental and funding channels
- Wide ranging novel applications (cameras/detectors/imaging/ballistic sciences)
- Core R&D with USA/EU labs
- Now over 35 people, <\$10M revenue

# Sydor Technologies DNA



🎯 [Sydor Instruments](#): Rochester, New York USA

- 🎯 Manufacturing of streak cameras and [detectors](#)
- 🎯 System integration, tech-transfers, and application support

🎯 [SABRE Ballistics](#): Caterham, United Kingdom

- 🎯 Ballistic testing systems

🎯 North American partner for:

- 🎯 [Photek](#)
- 🎯 [Kentech Instruments, Ltd.](#)

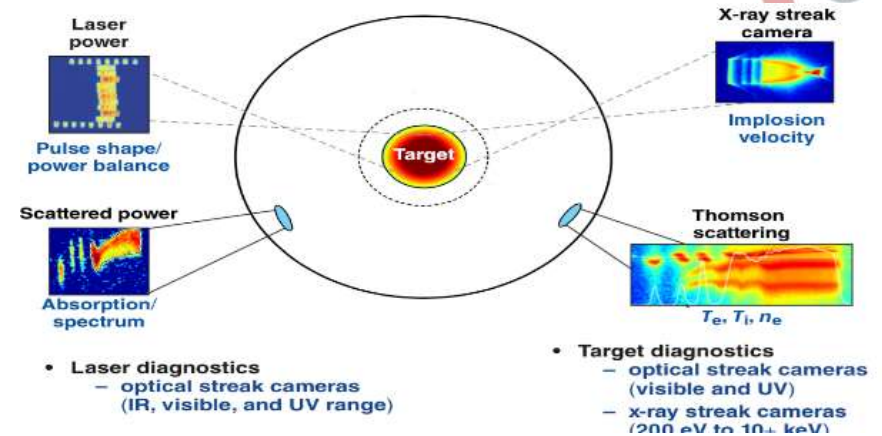
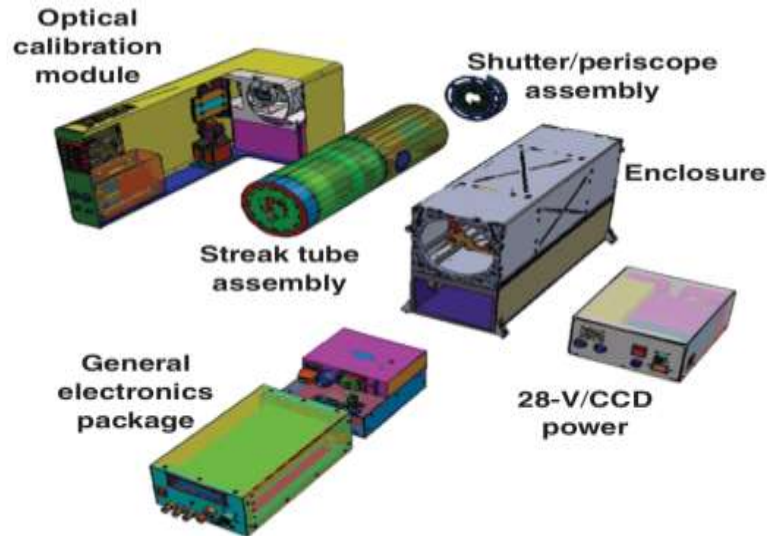




*Experts at solving diagnostics  
and imaging problems*

# Our Core: ROSS Streak Cameras

- Maintains accuracy
- Capable of in-situ, remote pre-shot calibrations



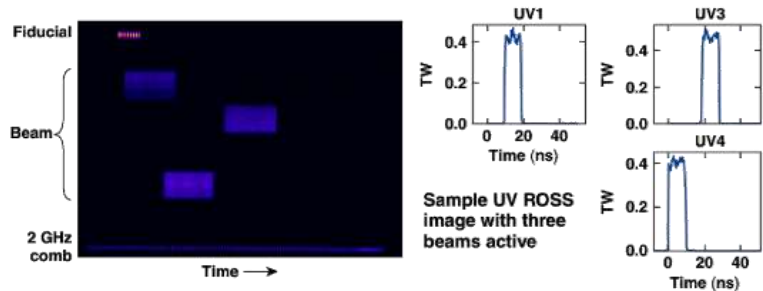
- Several different streak tube options available
  - Exclusive designs
- Modular and upgradable



# Source Diagnostics

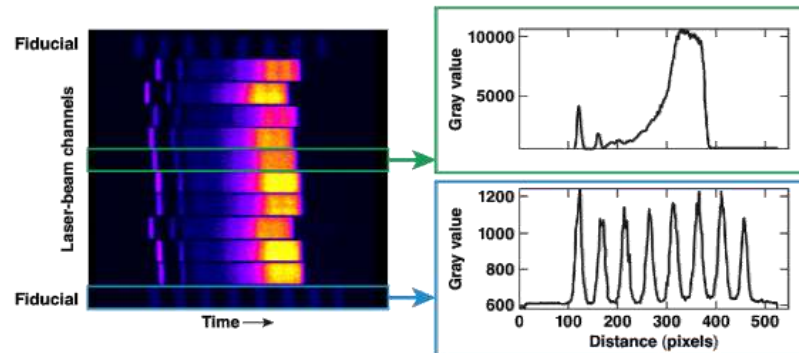


Laser IR & UV performance – ROSS 5100

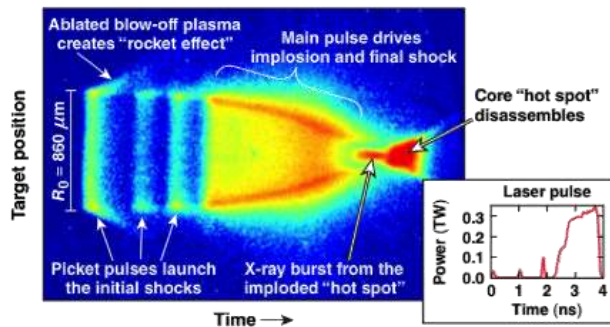


(Acts as 12 channel recorder)

Laser timing and power balance ROSS-8200



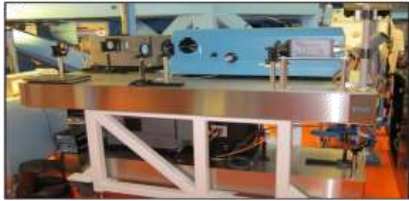
X-Ray timing, spectral, imaging



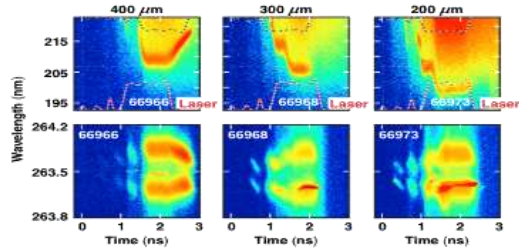
# Target Diagnostics



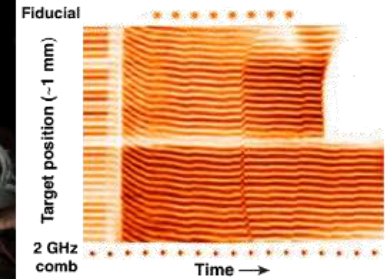
## Optical Thompson Scattering – Dual ROSS 5100's



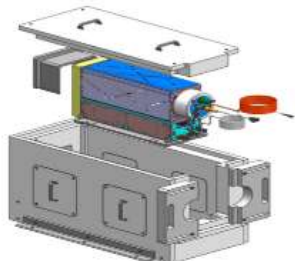
Thomson instrument cart



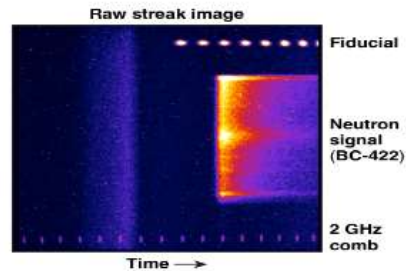
## Line VISAR Results – Dual ROSS 5100's



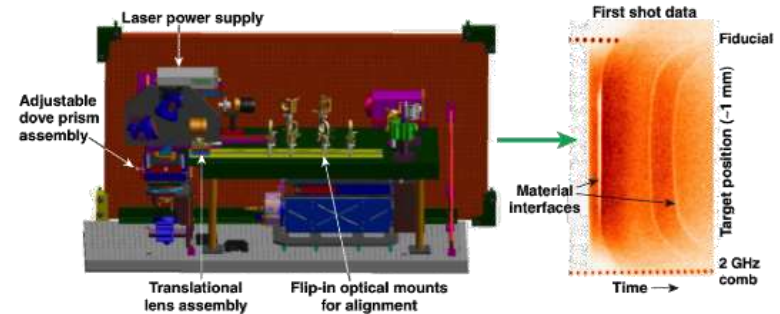
## Neutron Burn History ROSS 5100



Liquid cooled preferred for enclosed application



## Optical Pyrometer – ROSS 5100

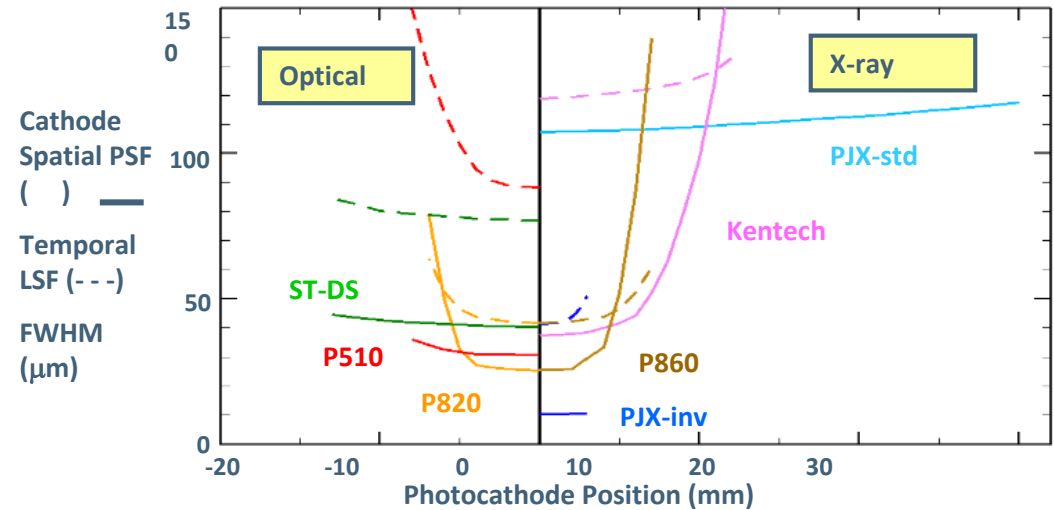




# Streak Tube Resolution



- ❖ Sydor understands the pros & cons of multiple systems & tubes
- ❖ *Sydor is a valuable consultant to solve specific application issues*
- ❖ Sydor welcomes customized configurations



## ROSS Comparison Overview

Camera	ROSS 8600	ROSS 8200	ROSS 6000	ROSS 5800	ROSS 5100	ROSS 2000	ROSS 1000
Streak Tube	P860X	P820	Kentech Low Mag	ST-DS	P510	ST-X	Photochron 5
Tube Manufacturer	Photonis	Photonis	Kentech	Photek	Photonis	Photek	Photek
X-ray or Optical	X-ray	Optical	X-ray	Optical	Optical	Optical	Optical
Photocathode Size	10 mm	10 mm	25 mm	35 mm	35 mm	20 mm	8 mm
MCP	No	No	Optional (40 mm)	No	No	Yes (25 mm)	Yes (25 mm)
Standard Camera	2048 x 2048 chilled scientific grade CCD 16-bit	2048 x 2048 chilled scientific grade CCD 16-bit	4096 x 4096 chilled scientific grade CCD 16-bit	2048 x 2048 chilled scientific grade CCD 16-bit	2048 x 2048 chilled scientific grade CCD 16-bit	1040 x 1392 interline CCD 12-bit	1040 x 1392 interline CCD 12-bit
Cooled Camera	Standard	Standard	Standard	Standard	Standard	Available	Available
Camera Coupling	1:1 Fiber	1:1 Fiber	1:1 Fiber	1:1 Fiber	1:1 Fiber	Lens	Lens
Spatial Resolution	20 lp/mm @ 50% contrast	20 lp/mm @ 60% contrast	10 lp/mm	10 lp/mm @ 70% contrast	10 lp/mm @ 70% contrast	10 lp/mm @ 50% contrast	10 lp/mm @ 50% contrast
Limiting Temporal Resolution	1 ps	1 ps	5 ps	5 ps	5 ps	< 36 ps	< 2 ps
Synchroscan	No	No	No	No	No	No	Yes
Maximum Sweep Speeds	2 speeds	4 Speeds	12 speeds	6 speeds	6 Speeds	12 Speeds	16 Speeds
Gateable Photocathode	No (Blanking Available)	No (Blanking Available)	Yes	Yes	Yes	Yes	No
Mu-metal Shielding	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Integrated Fiber Input	No	2 standard	No	2 Standard	2 standard	1 optional	N/A
Mounting Configurations	TIM/DIM	Bench (Multiple Slit Configurations)	Flange, TIM/DIM	Bench (Multiple Slit Configurations)	Bench (Multiple Slit Configurations)	Bench	Bench
DynaCal OCM Support	No	Yes	No	Yes	Yes	No	No

# What's New?



- ROSS 5800
- ROSS 6000
- ROSS 2000 speed ramps
- psGOI gated optical imager
- PD-PMT Pulse dilation  
Photomultiplier tube
- Direct X Ray detection cameras
  - SBIRs and P2 funding
- Torch PMT (square)
- Multi-anode
- Space rated IPD's

# What's New: ROSS 5800



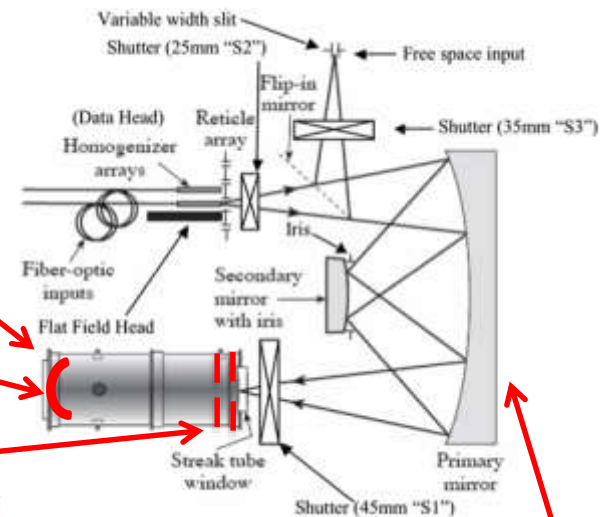
- Optimizes temporal and spatial tradeoff Target accuracy much improved over full photocathode. Best when paired with DynaCal.
- Integrates tube and dual slots with electronics, software, and controls for optimum performance.
- Tube exclusive to Sydor Instruments

Lower magnification  
This provides 3.5mm more usable (optimized) cathode area

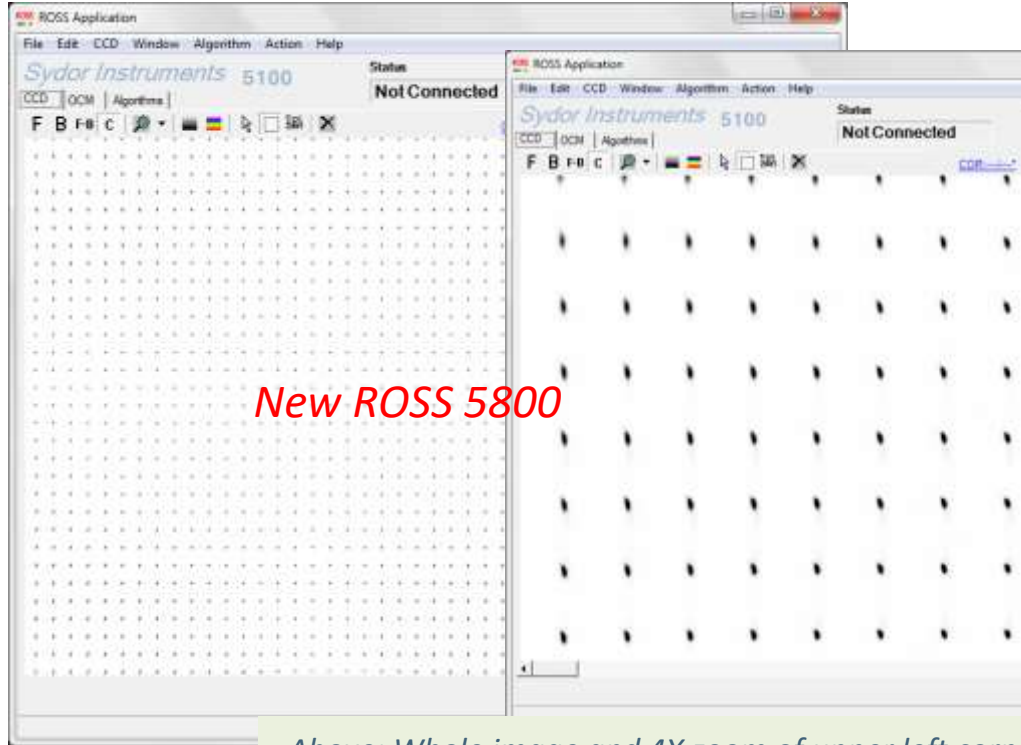
Image plane focused on a curved output screen for uniform focus over the entire field.

Adds dual slots to eliminate Space-Ti focus astigmatism.

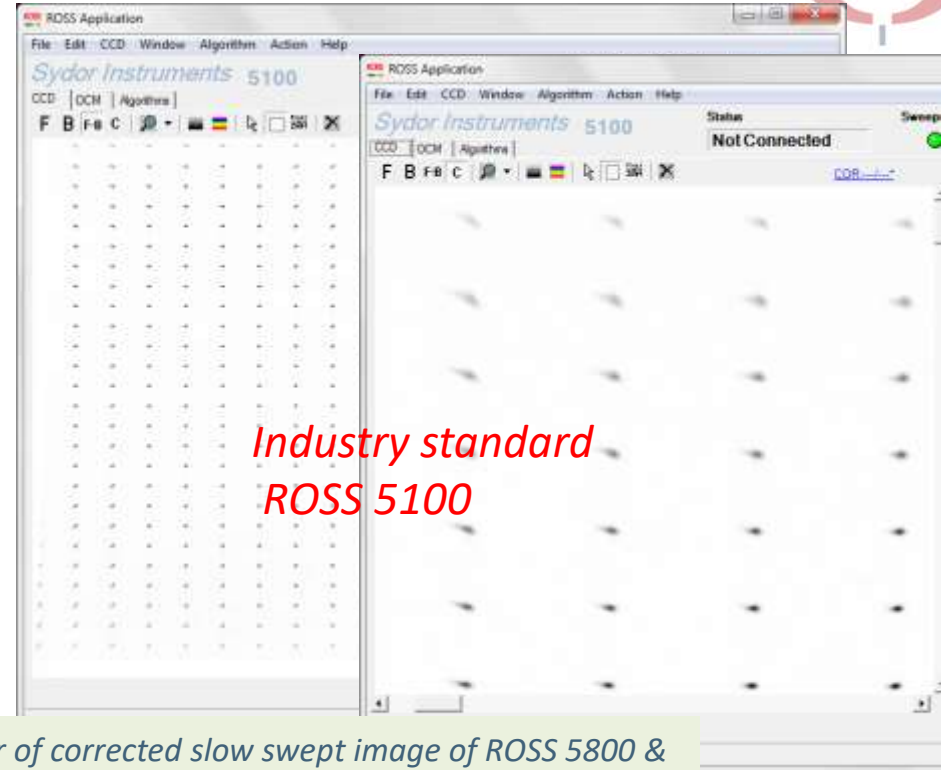
Offner input optics via DynaCal or bench configuration



# ROSS 5800 improvement



*New ROSS 5800*



*Industry standard  
ROSS 5100*

*Above: Whole image and 4X zoom of upper left corner of corrected slow swept image of ROSS 5800 & 5100 Streak Camera System with GeoCal reticle pattern*



# What's New: ROSS 6000



- ⊕ A more comprehensive x-ray streak camera
- ⊕ Re-entrant, TIM or DIM design
- ⊕ High rep-rate system
- ⊕ Integrates ROSS\_App with X-Ray system

## Specifications:

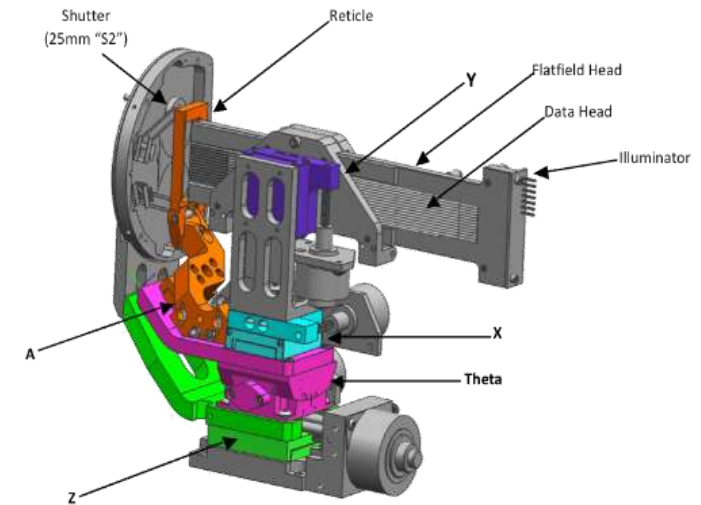
- ✓ 25 mm interchangeable photocathode.
- ✓ <5ps time resolution and a spatial resolution of 10 lp/mm
- ✓ Fiber coupled 1:1 cooled scientific readout system
- ✓ Capable of both single shot and high rep rate applications up to 1kHz.
- ✓ Can be supplied with a 40 mm single stage image intensifier
- ✓ A UV fiber optic timing fiducial system is available for use with the ROSS 6000

# What's New: DynaCal



- ⊕ DynaCal adds calibration during a sweep function, thus providing in-situ testing of static and dynamic verification
- ⊕ Lowers COO via remote calibration and reducing the need to remove a unit from service or have expensive labor spend time calibrating pre shot.

*COMPACT motorized assembly containing Offner input optics, 35mm shutter & variable slit, comb generator, data head, flat-field head, illumination head, reticle, flat field generator, grid pattern reticles. ROSS\_App Wizard software controls actions and geometric distortion calibration and other parameters.*



*Aft Assembly w/ 12 axis motor controller*

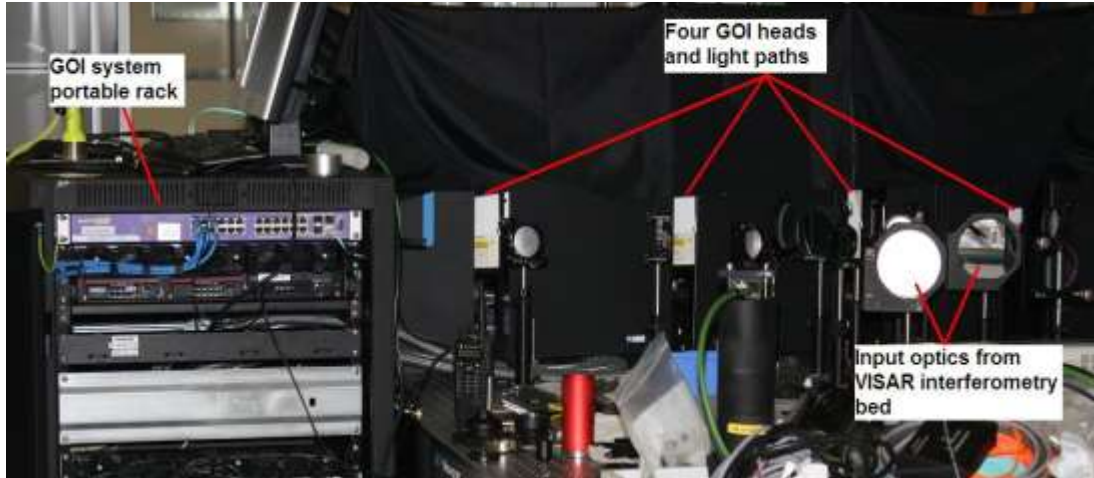
# psGOI (gated optical imager)



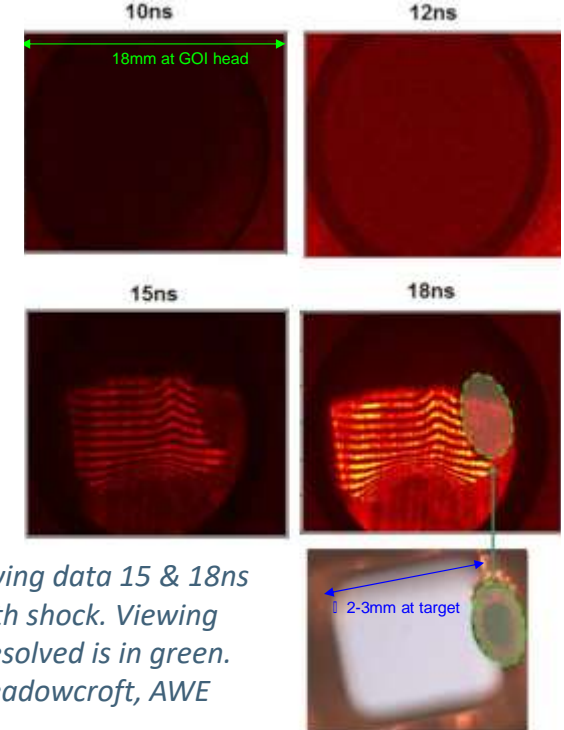
- ❁ 2D 18mm MCP based 80-100ps imaging – clean, in focus images
- ❁ Heads use axial magnetic field linked to high performance MCP and unique pulser driver to achieve performance
- ❁ Flexible multichannel (1,4,8) configurations
- ❁ Excellent trigger configuration for serial or concurrent channel triggering



# psGOI (gated optical imager)

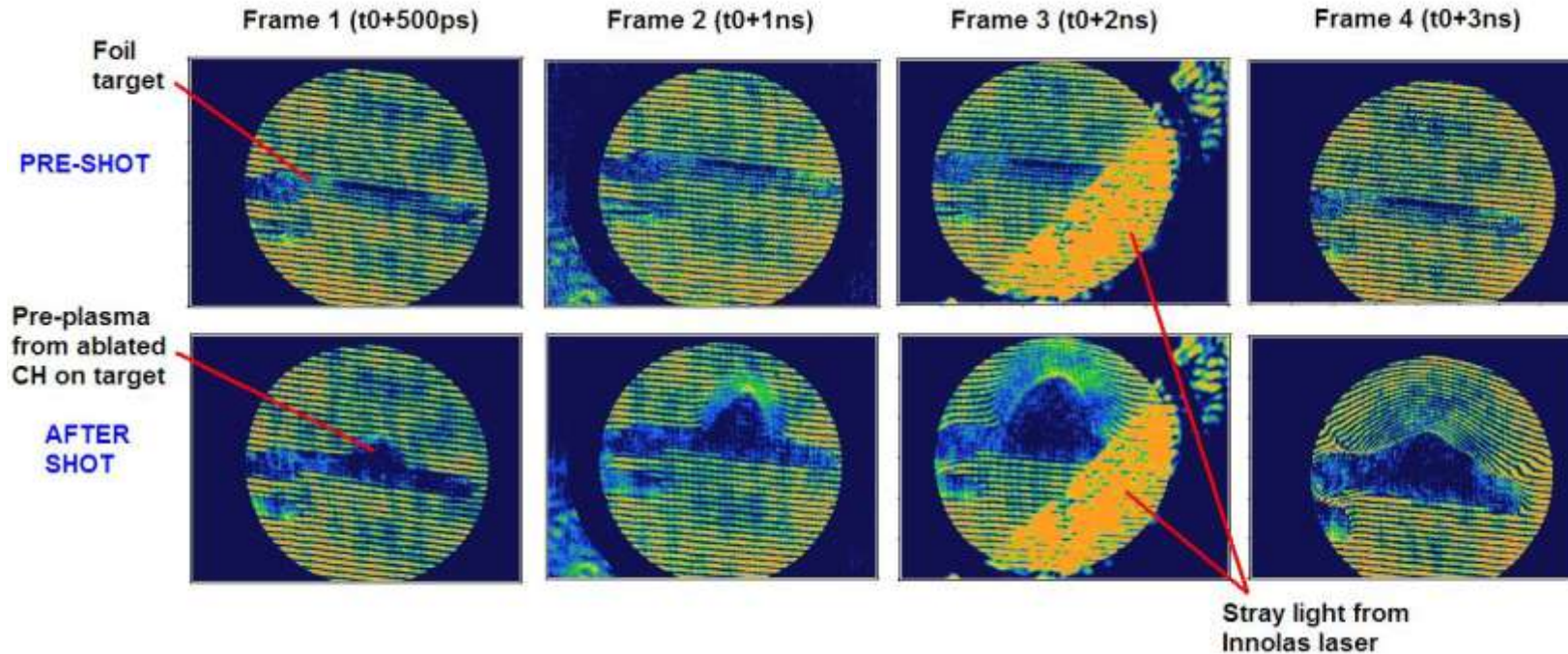


*4 channel bench configuration, courtesy of A. Meadowcroft, AWE*



*4 channel, 80ps showing data 15 & 18ns after laser shot with shock. Viewing window of target resolved is in green. courtesy of A. Meadowcroft, AWE*

# psGOI (gated optical imager)



*Interferometry traces of preplasma captured at 80ps with interframe times of 500ps and 1ns. Preplasma blowoff is still evident 3ns after long pulse laser shot. Courtesy of A. Meadowcroft, AWE*



# PD-PMT development



## Background:

Multi kV sub ns risetime pulsers with very low jitter and proven repeatability have been the enabling technology for several fast diagnostic instruments including:

- GXD (Gated X-ray Detector) (LANL/LLNL)
- DISC DIM cart X-ray streak camera
- Sub 100ps GOI (Gated Optical Imager)
- DIXI ultra-fast X-ray gating

Plus projects in progress such as

- ✓ SLOS (Single Line of Sight) X-ray framing camera
- ✓ PD-PMT (Pulsed Dilation Photo-Multiplier Tube)

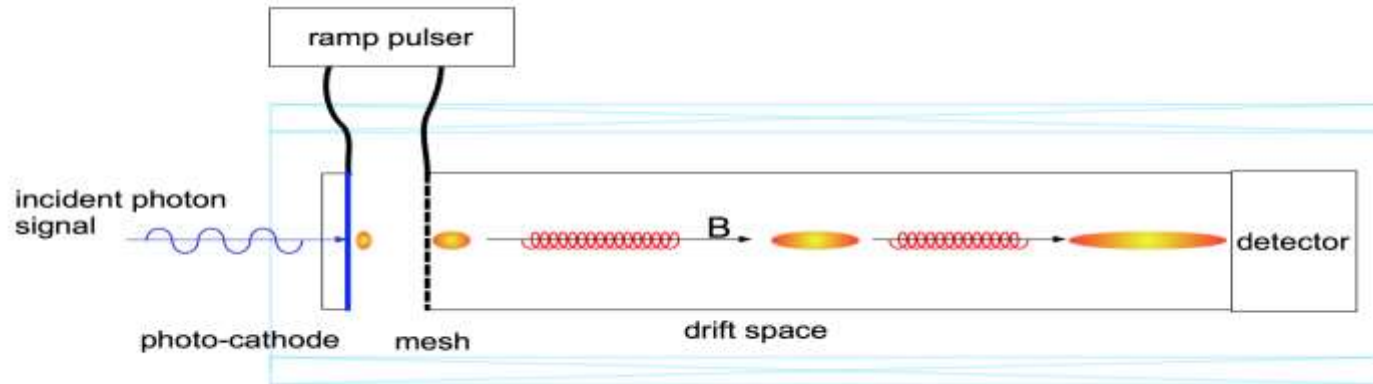
Enabling capability – pulse drive

- ⊗ Linear Ramp: DIXI - Dilation Xray Imager, 10ps X-ray gating
- ⊗ Shaped Ramp: SLOS - Single Line Of Sight Xray imager, 10ps X-ray framing
- ⊗ Shaped Ramp with Blanking: PD-PMT - Pulsed Dilation PhotoMultiplier Tube, 10ps PMT
- ⊗ Photo-cathode drive pulses need to be shaped, need to have multi kV amplitude and have rise times down to 100psecs
- ⊗ Support systems such as MCP bias, local delay control and high current solenoid drive are also required, usually constrained by the need for a limited volume

# Pulse Dilation – what is it?



- ❖ Photo-electrons (pe) are launched and the ramp pulser reduces the drift velocity via  $\Delta v$
- ❖ PE's are guided through the drift section via magnetic field and the electron signal spreads out in time.
- ❖ Net effect is a short exposure at the cathode is diluted into a long exposure at the readout device.

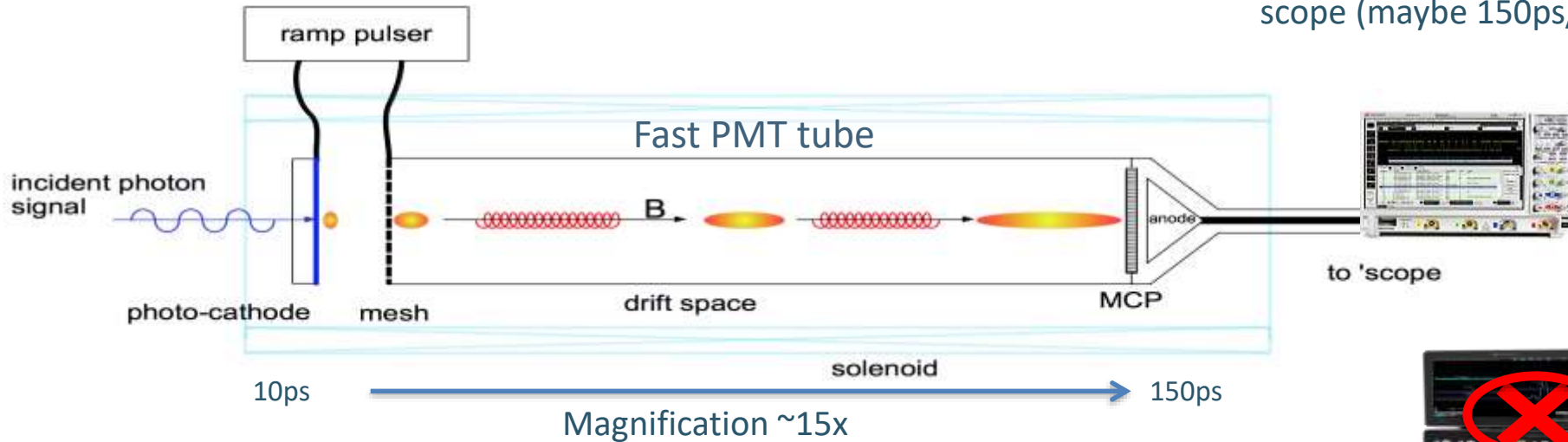


# PD with PMT and Oscilloscope



10ps with 1ns record length (requires about 150ps rise time scope)

Allows use of less expensive scope (maybe 150ps/2GHz)

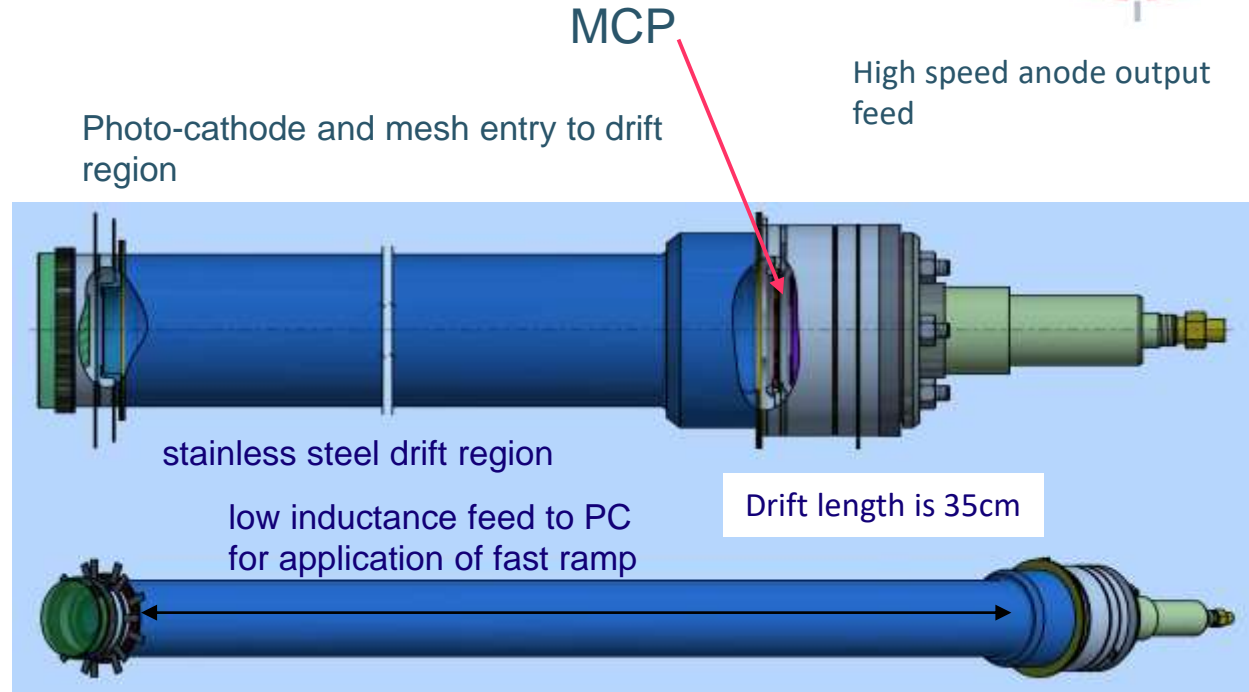


Expensive/fast scope not required<sup>23</sup>

# Tube Basics



- 10mm active area
- High Speed, stainless tube
- Mesh Drift (entry  $\Delta v$ )
- Ramp generator jitter 3ps RMS
- Modest magnetic field
  - Not imaging
  - DC solenoid for repetition
- Environmentally stable and can handle much more severe environment than a streak camera.



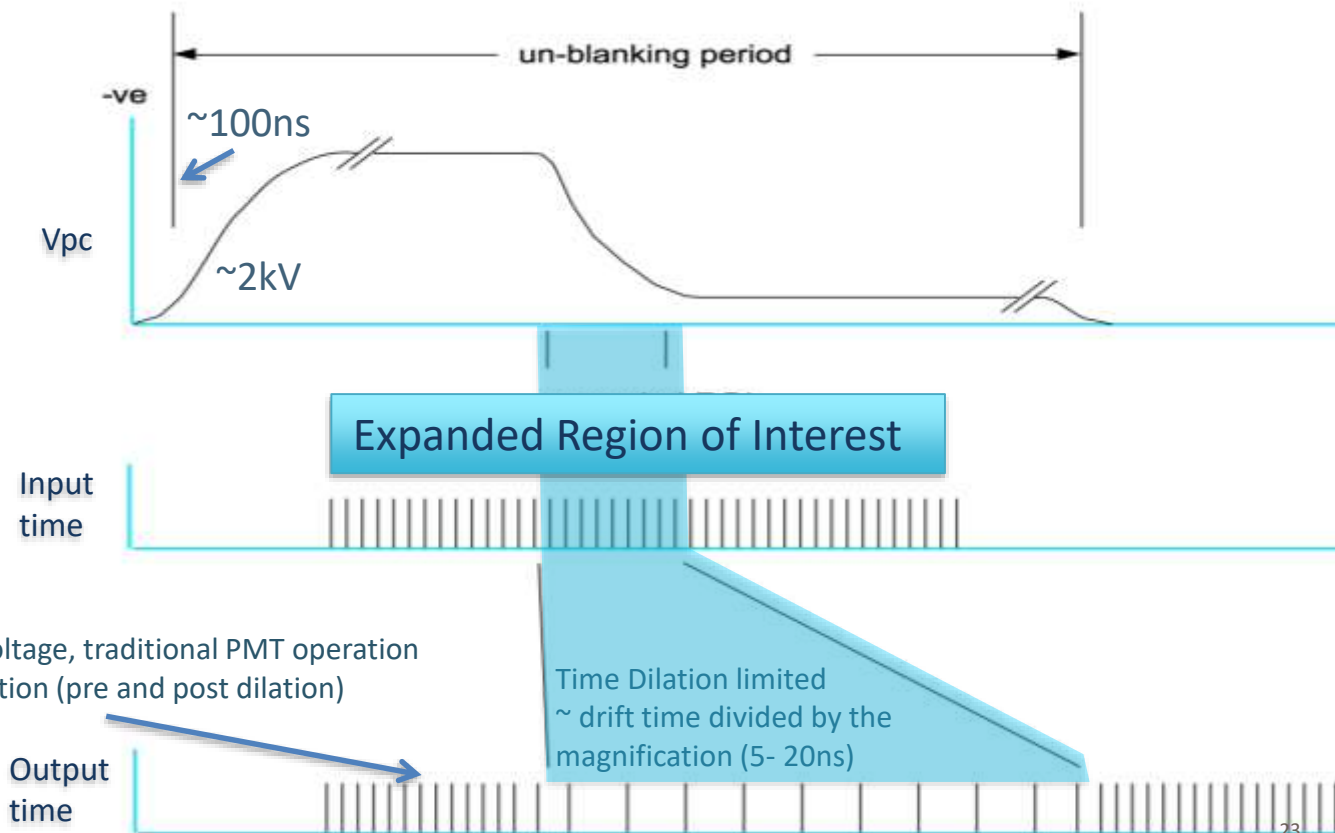
the axial B field will be  $\sim 100$  gauss, enabling a DC field and repetitive operation.

# Blanking and Recording



Blanking uses a slow pulsing of the cathode bias voltage.

Eases timing setup  
Allows recording of a short, fast event together with a slower signal





# Sydor Instruments - Detectors



- ✧ X-Ray Detectors
- ✧ Diamond Beam Monitors
- ✧ Tech Transfers
- ✧ Developing Technology



*Original 1947 GE Synchrotron*

# X-Ray Detector Family and DBPM's



## Direct Detectors

- ⊗ [Fast CCD – soft X-ray](#)
- ⊗ [SpectroCCD – soft, fine pixel](#)
- ⊗ [KeckPAD –tender X-ray,  
irreversible event](#)
- ⊗ [MMPAD – Tender, HDR](#)
- ⊗ [X-Ray Strip – 1D, unique pixel](#)

## Indirect/other:

- ⊗ [X-Ray framing cameras](#)
- ⊗ [psGOI -Gated Optical Imagers](#)
- ⊗ [PD-PMT](#)
- ⊗ [Streak Cameras](#)
- ⊗ [X-Ray Streak Cameras](#)

## DBPM's

- ⊗ [DBPM's – position and flux](#)

# FastCCD X-ray Detector

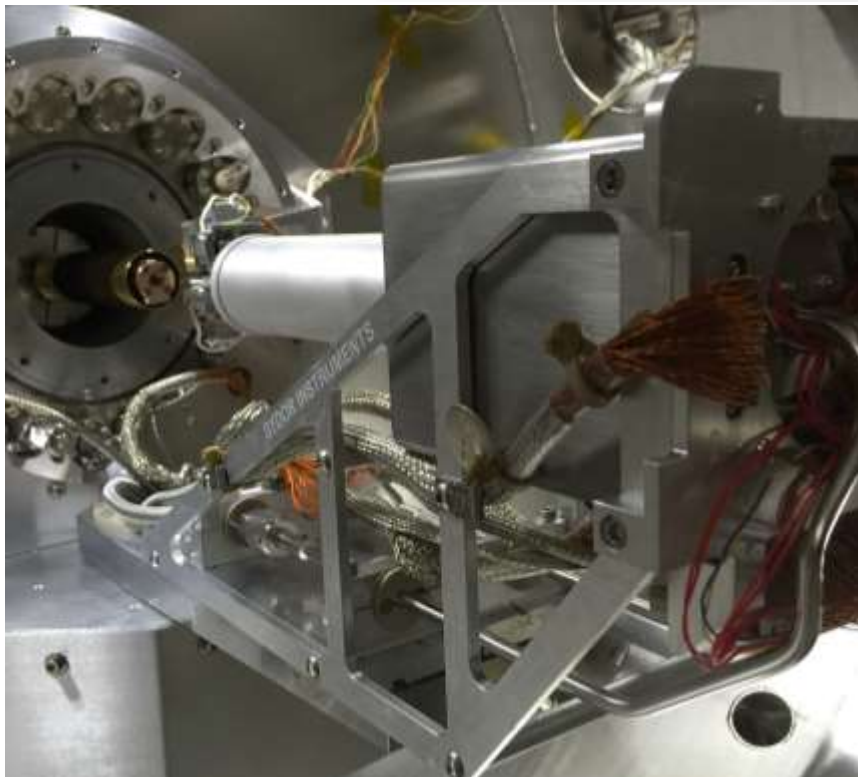


eV Range	0.5 keV-9 keV (100% eff), 100eV to 20keV
Pixel Size	30 $\mu\text{m}$ $\times$ 30 $\mu\text{m}$
Sensor Size	1920 $\times$ 960
Speed	5 ms/frame (120fps)

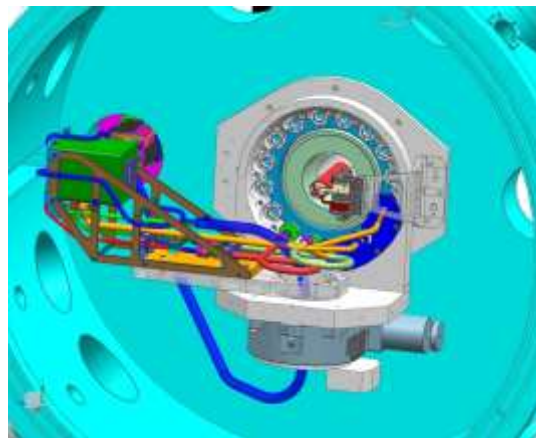
- ❖ Direct detection of EUV to soft x-rays to 20keV
- ❖ Photon counting @ high efficiency
- ❖ Readout speeds up to 120 fps plus burst modes (compared to commercial x-ray CCD options with 1 fps readout)
- ❖ In-vacuum camera head, multiple mounting configurations, incl. mounting on swing arm w/ vacuum ports

*Commercialization partner for LBNL*

# FastCCD X-ray Detector cont'd



- As installed at NSLSII
  - Swing arm



# FastCCD Roadmap



## FastCCD: Soft X-ray Detector — Sydor/LBNL collaboration



120 fps DUV to soft X-ray

**Commercial Supply**  
**Custom Integration**  
**Installation & Support**

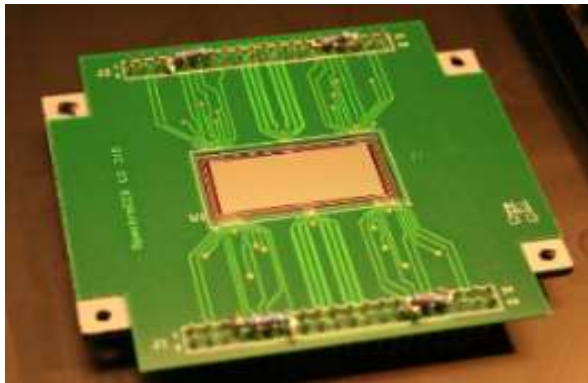


NSLS II CXS beamline

- FastCCD is in production, available commercially from Sydor
- SBIR is submitted for further commercialization, key focus on read out optimization and simplicity in computer operations
- Sensor and components undergo incremental improvements



# SpectroCCD

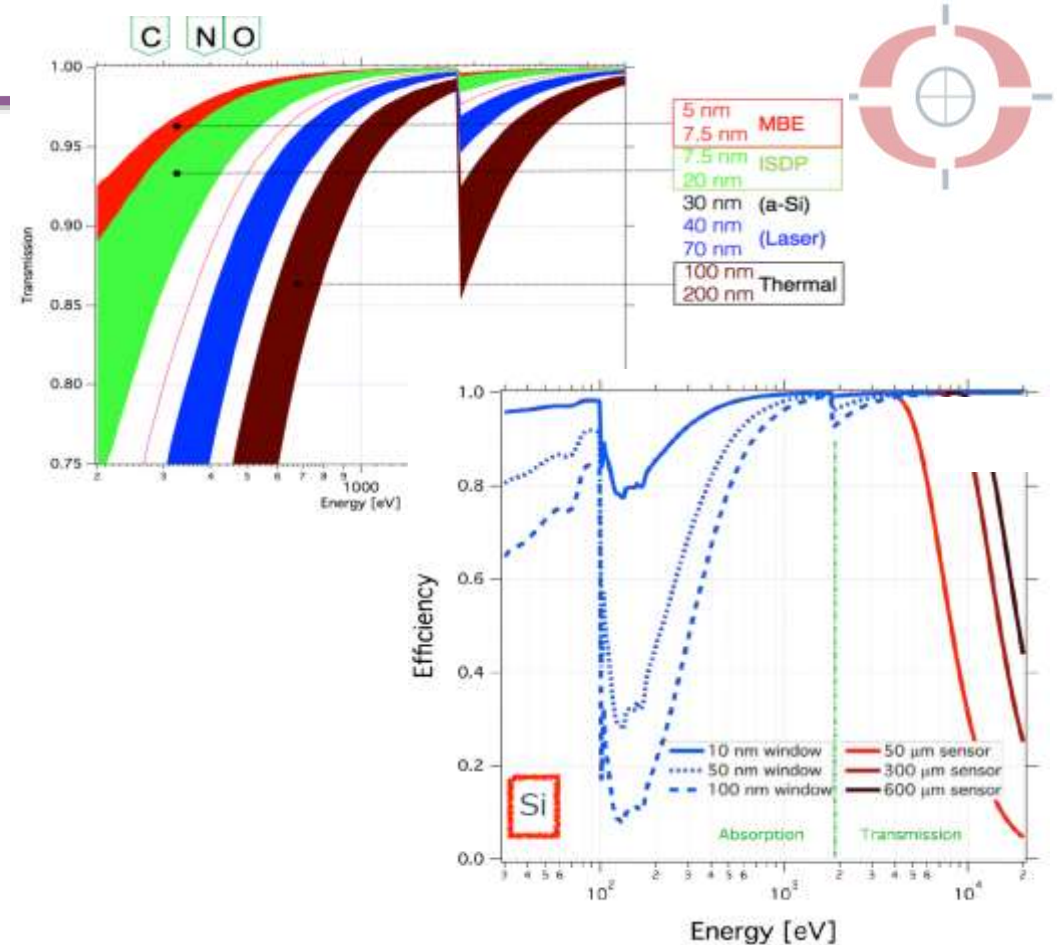


eV Range	0.5 keV-9 keV (100% eff), 100eV to 20keV
Pixel Size	45 $\mu\text{m}$ $\times$ 5 $\mu\text{m}$
Sensor Size	620 $\times$ 2,496
Speed	6 s/ frame

- ❖ Direct detection of EUV to soft x-rays to 20keV
- ❖ Improved detector position resolution and  $\therefore$  improved energy resolution (5-10x better)
- ❖ No need to use centroiding
- ❖ Slow readout and long integration times. Low noise  $4e^-$  capable.
- ❖ Pixel-level resolution
- ❖ Reduces spectrometer length

# SpectroCCD applications

- Current SBIR Phase II furthers development
  - ALS test very good
- Same basic sensor structure as the FastCCD
- Electronics/readout differ and ultra low noise capable



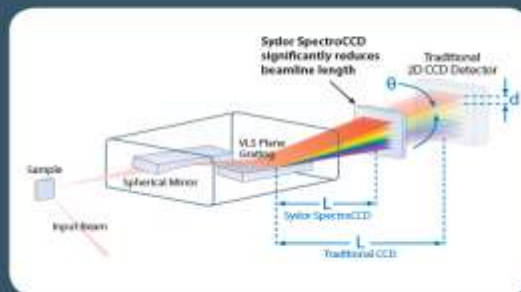
# SpectroCCD Roadmap



## SpectroCCD: X-ray Camera for Energy Dispersive Spectrometers — Sydor/LBNL collaboration



Direct detection 0.5–10 keV



5  $\mu\text{m}$   $\times$  45  $\mu\text{m}$  pixels



Larger arrays

- SpectroCCD is in prototype, commercialization underway by Sydor
- Successful tests at ALS complete
- P2A SBIR submitted for larger array sensor
- Looking for partners for initial installations with some time horizon

# KeckPAD



## Energy Range

8 keV-20+ keV

## Pixel Size

150  $\mu\text{m}$   $\times$  150  $\mu\text{m}$

## Sensor Size

128\*128 n\*n sensors

## Speed

150 ns/ frame, 8 frames  
independently controllable

- Well depth  $\sim$ 5k photons at 8keV, read noise 1.1 photons
- Currently 8 frames, individually controllable, of storage @150 ns
- Can be synchronized to x-ray pulse trains
- Allows measurements of dynamic compressions via very high dynamic range ( $10^3$ x-rays/pixel/frame) capability
- Single photon sensitivity
- Cost effective versus other pending developments

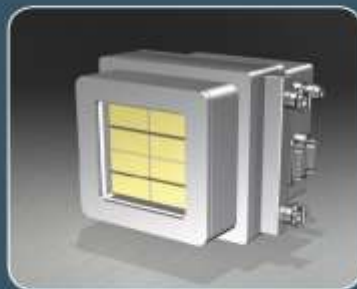
# KeckPAD Roadmap



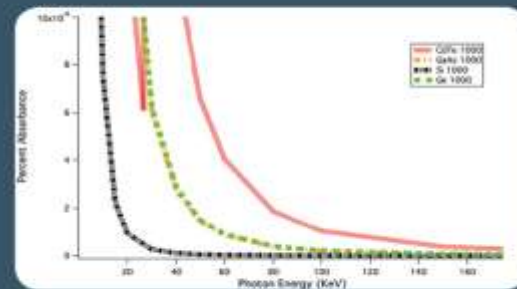
## Keck-PAD: Fast-Framing Hybrid Pixel Array Detector — Sydor/Cornell collaboration



150 ns 8–20 keV



Tileable  $n \times n$  arrays



Sensor development for 8–70 keV

- ❖ KeckPAD initial design is available. Tiled array soon ready for orders or beta installs.
- ❖ SBIR for High Energy (HE Keck) materials for hard X-Ray
- ❖ Looking for partners for initial installations with flexible time horizon

# MM-PAD - HDR

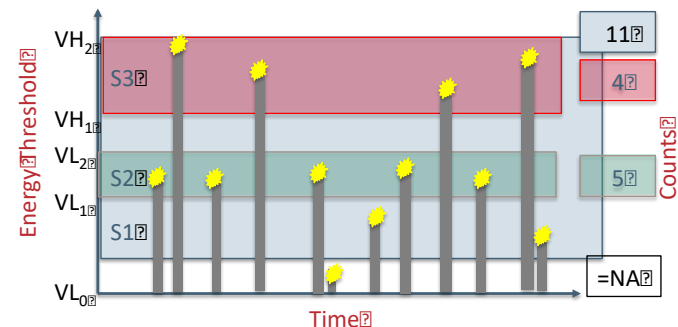


Energy Range	8 keV-20+ keV
Pixel Size	150 $\mu\text{m}$ $\times$ 150 $\mu\text{m}$
Sensor Size	128*128 n*n sensors
Dynamic Range	10e8 @ 8keV at 1kHz.

- ❖ Mixes analog and digital (Mixed Mode):
- ❖ At 8keV HDR of 10e8 photons/sec/pixel with read noise of 0.16 photons. Single photon counting ability remains.
- ❖ Uses PAD technology from KeckPAD
- ❖ Sample application: APS ran entire profile of Bragg peaks, captured at a rate of  $\sim 1$  kHz at each angle of incidence for every field pulse
- ❖ Phase I STTR underway between Cornell and Sydor



# X-ray Strip Detector



eV Range	3 keV-30 keV
Pixel Size	125 $\mu\text{m}$ $\times$ 4 mm
Sensor Size	1 $\times$ 640
Speed	1 ms/ frame

1-D array Si detector

Simultaneous, threshold of 3 acquisition buckets, all with different energy ranges, with resolution down to  $\sim 350$  eV. 24bit and high DR than competitor

Used at BNL-XPD, CHESS-GISAXS, CHESS-XRR APS-MERIX & CHESS-RIXS

# X-Ray Strip Detector Roadmap



## X-Ray Strip Detector: One-Dimensional Linear Array — Sydor/BNL collaboration



Laboratory  
prototype

**Commercial Engineering**

**Reduced Cost of Ownership**

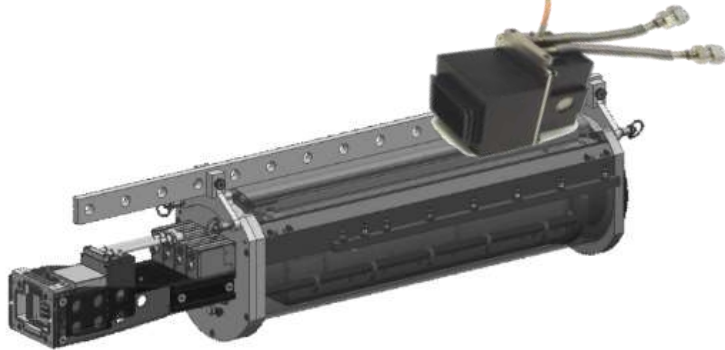
**Installation & Support**



640 pixels, 3–30 keV detection,  
excellent dynamic range

 In production, demo unit available

# X-Ray Framing Camera (XRFC)



- ❖ 2D spatially time-resolved frames or 1D spectrally resolved images of target features
- ❖ Allows 4 independent strips/pulser
- ❖ Can resolve spectral info on strip
- ❖ Nanosecond time regime, ps resolutions
- ❖ Designed for use in vacuum

Energy Range	6 eV-15 keV
Pixel Size	9 $\mu\text{m} \times 9 \mu\text{m}$
Sensor Size	4096 $\times$ 4096
Speed	40-1,000 ps/ frame

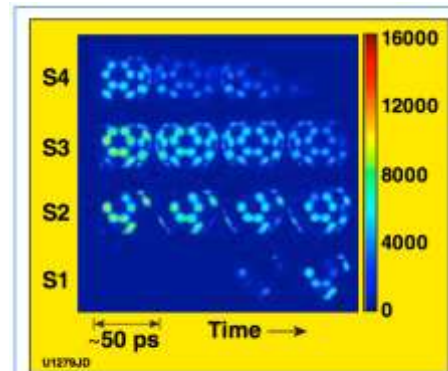
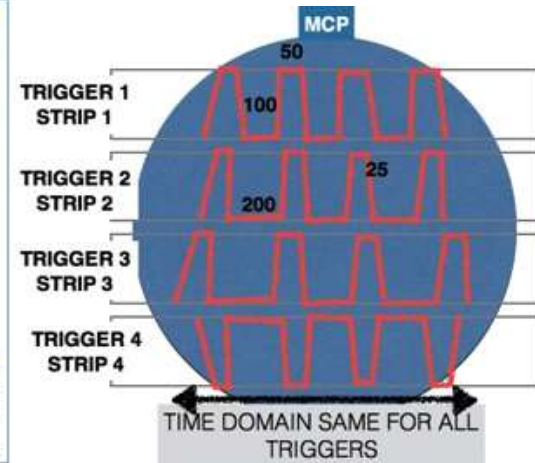
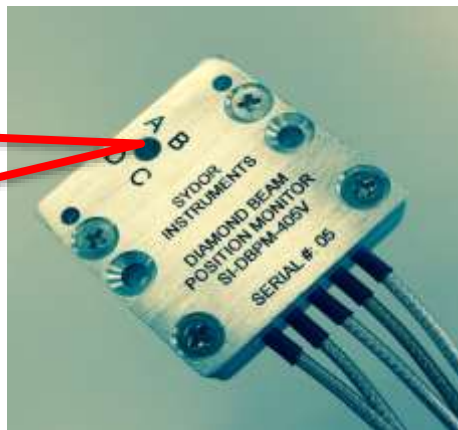
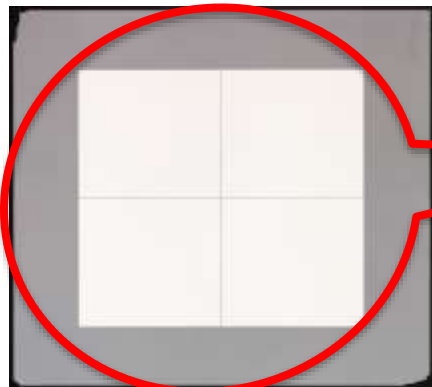


Figure 1. OMEGA gated XRFC output on a pointing shot with a spherical target. Here the individual strip lines (S1-S4) are staggered in increments of 200 ps.



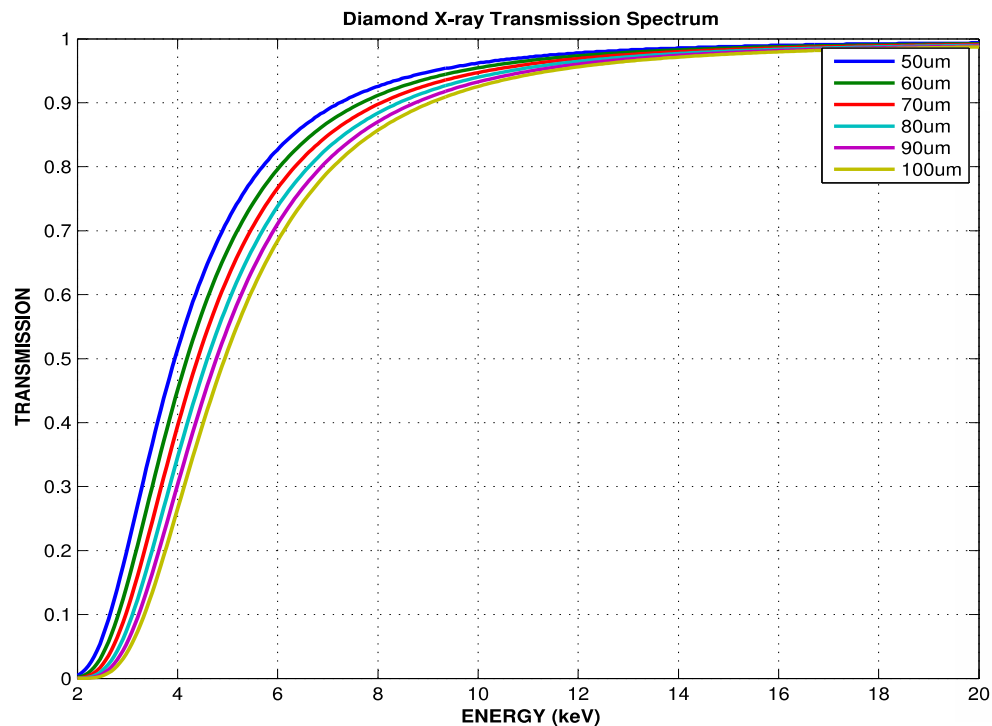
# Diamond based BPM's (DBPM's)



- Position resolution 0.1% of beam diameter
- Flux linearity tested to over to 11 orders of magnitude
- Less dispersion than ion chambers (some testing in progress)
- Thickness selectable. Sydor producing @  $<50 \mu\text{m}$  to  $>100\mu\text{m}$
- Evolving metallization, optimum electronics grade CVD diamond
- Sydor in-house X-Ray source for manufacturing assurance

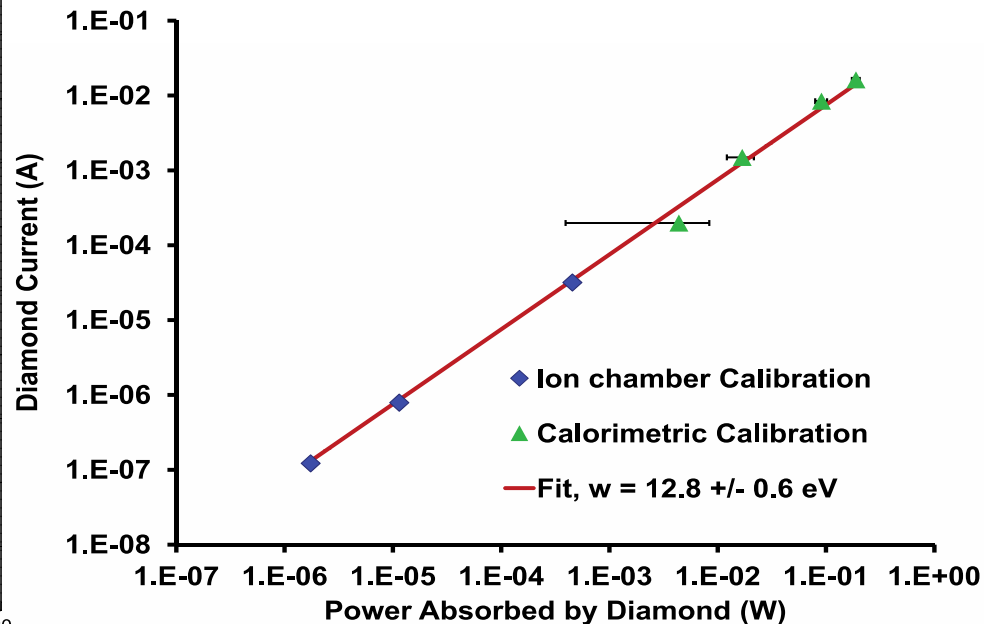
Energy Range	Mono, pink, white
Aperture	3mm circular
Environment	Air (He), HV, UHV
Speed	Compatible with modern synchrotron sources ( $>1\text{Mhz}$ )

# DBPM's



Transmission options

## Single Crystal Diamond Flux Calibration



Linearity

# Matching DBPM smart electrometer



- Smart unit with 4 DAC outputs for feedback, 6 SFP ports and Ethernet based communications
- Software included – Linux and EPICS

Data Rate	378k samples/sec [customizable to 1.1M samples/sec]
Resolution	18 bit
Gain	Five, programmable 20 pA to 35 mA



# DBPM's Roadmap



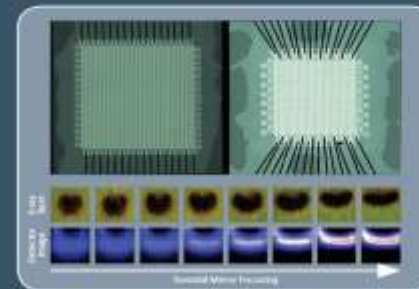
## Diamond X-ray Beam Monitors — Sydor/BNL/Stony Brook collaboration



Position/Flux/Timing



Commercial offerings

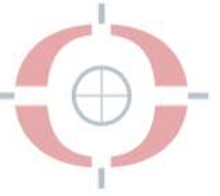


Imaging detector

- Currently shipping, many packaging designs available, optimized thicknesses.
- Matching electrometers, smart A3P ready to integrate detector, calibration, motion control etc.
- SBIR for pixelated imaging detector for future applications that include beam profiling and more

# North American Partners For:

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[Photek Ltd.](#)



[Kentech Instruments Ltd.](#)

# Photek Products

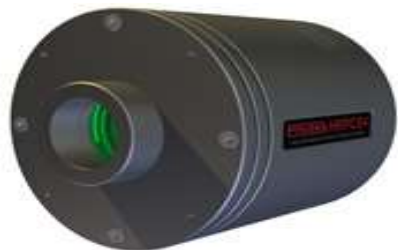


Image Intensifiers

Photomultiplier tubes & Photodiodes

Photon Counting Cameras

Space Detectors and Electronics



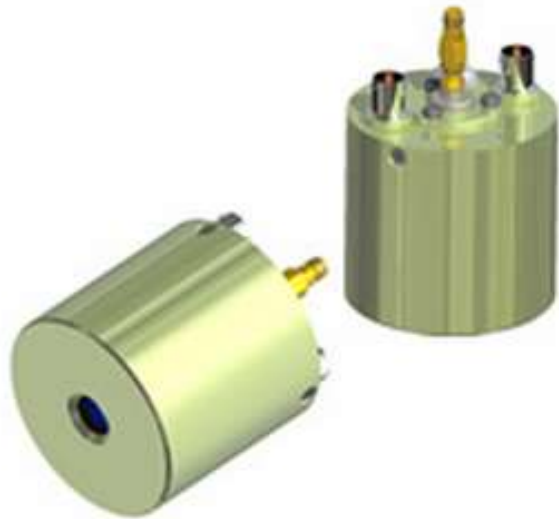
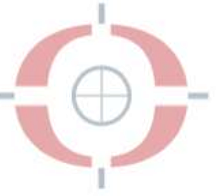
# Image Intensifiers



- ❖ Custom configurations
- ❖ 18 mm, 25 mm, 40 mm, 75 mm, and 150 mm optical
- ❖ Single, chevron, or z-stacked
- ❖ Wide range of spectral responses
- ❖ Photek offers high voltage power supplies and gate
- ❖ Optional environmental stress screening, space qual

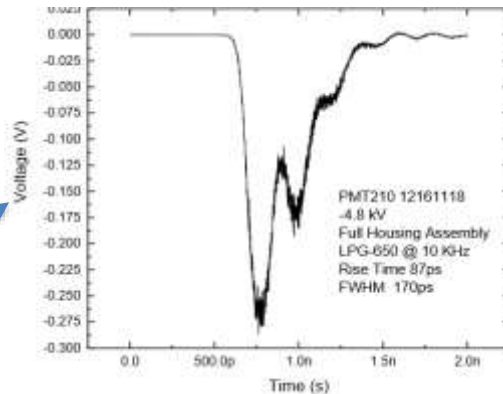
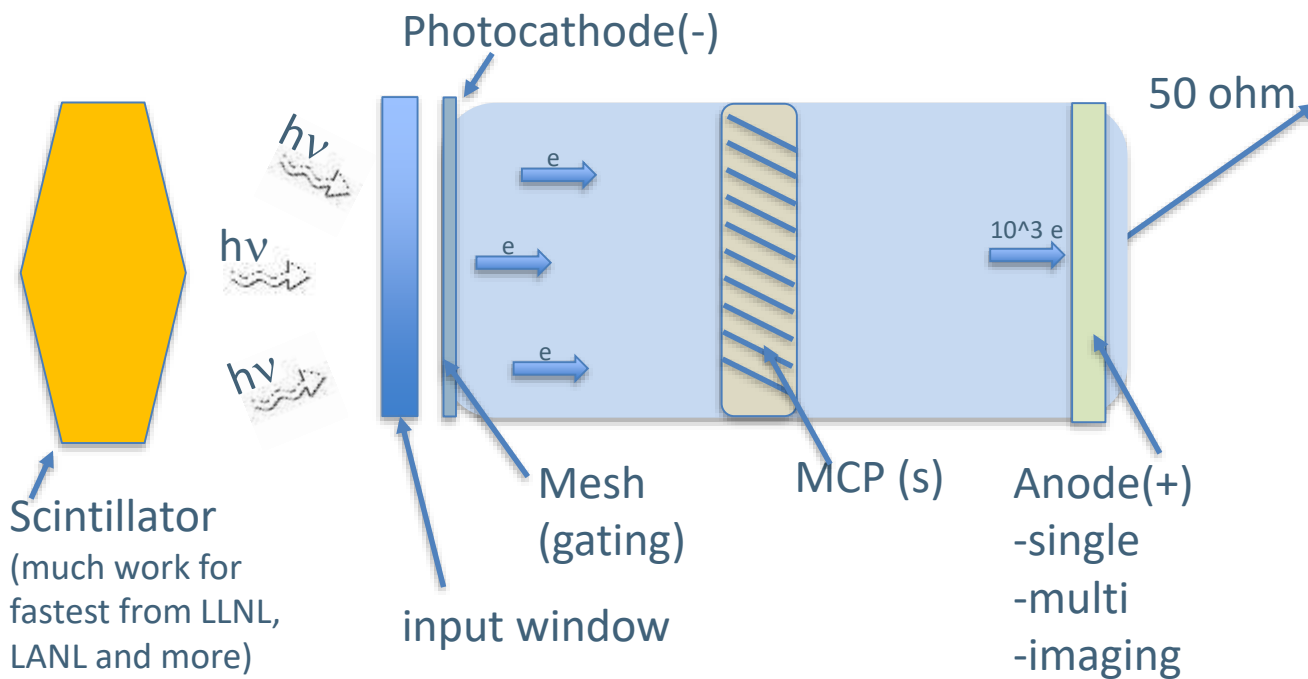


# Photomultiplier Tubes & Photodiodes



- ⊕ Fastest responding PMTs and PDs in the world
- ⊕ Custom configurations
- ⊕ 10 mm, 25 mm, and 40 mm options
- ⊕ Space rated, tube and electronics
- ⊕ Electronics available, custom pulsers available via Photek and Kentech

# Intensifier/PMT review



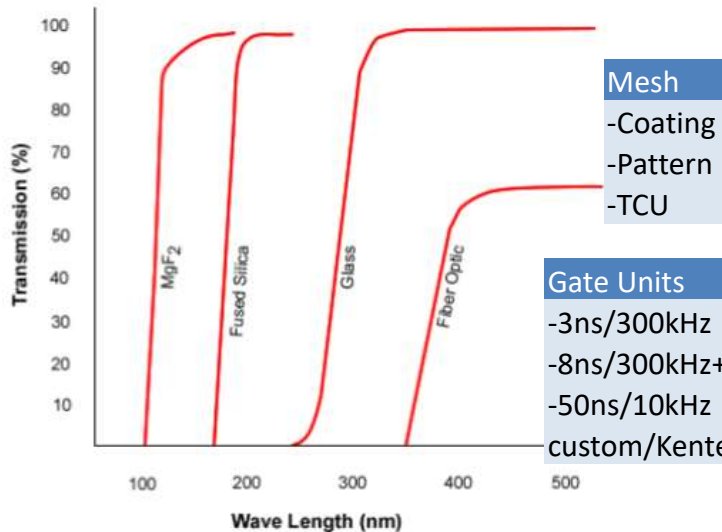
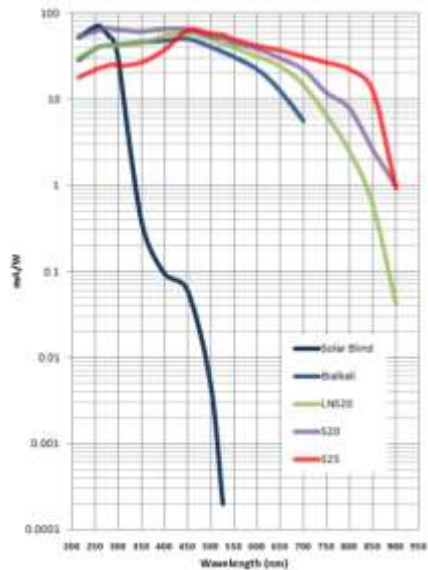
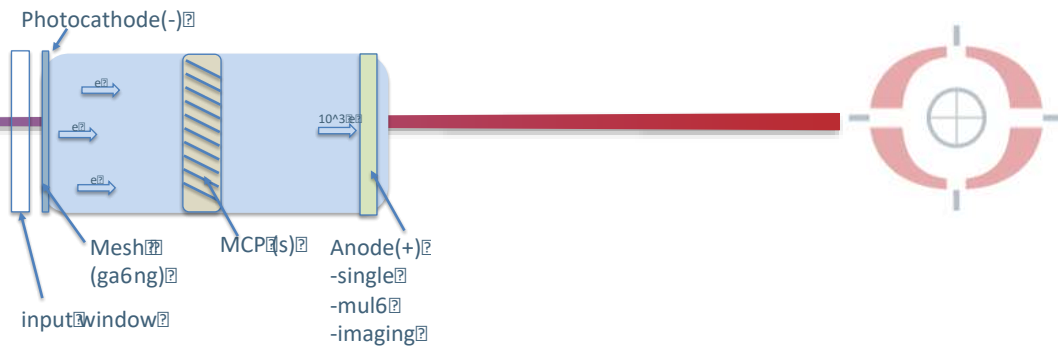
Analog signal

Rise times:

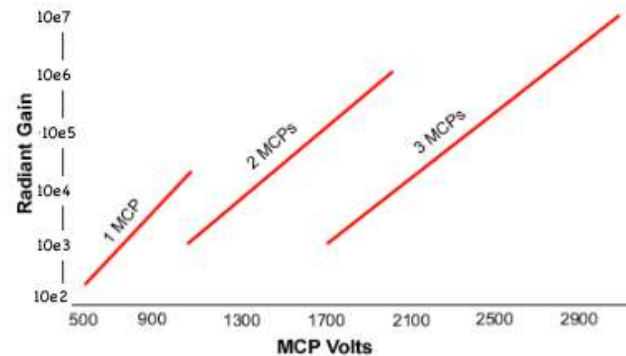
- As fast as 50 ps
- FWHM 80 ps



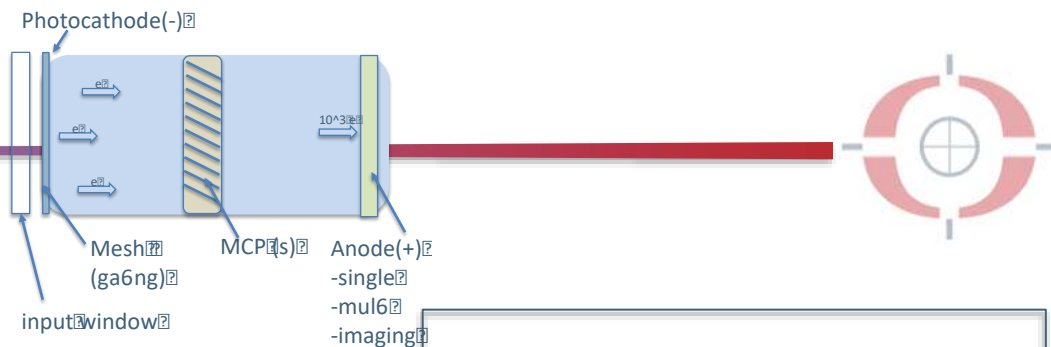
# Intensifier/PMT review



Gate Units  
 -3ns/300kHz  
 -8ns/300kHz+univ  
 -50ns/10kHz  
 custom/Kentech



# Intensifier/PMT review



## II Units

-18, 25, 40, 75, 150mm ++

## PMT Units

-18, 25, 40mm ++

## Multi-Anode "Cameras"

-25mm@ 8\*8

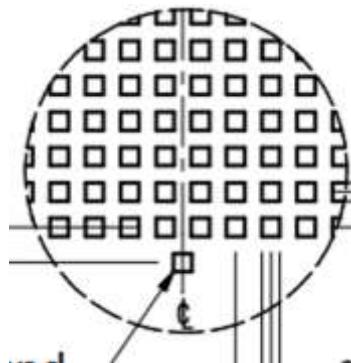
-40mm@ 32\*32

## VID Units

-25, 40, 75mm ++

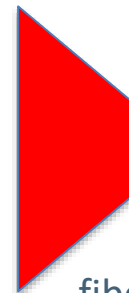
## IPD (Image Photon) Units

-25, CDL40, 75mm ++



Multi anode  
TORCH: square PMT

## output window



CCD sensor

fiber optic taper  
or 1:1 Fiber optics  
or glass

Phosphor  
P43, P46, P47....

# Photon Counting Cameras



## 3<sup>rd</sup> Gen. Image Photon Detector (IPD3)

- Single photon counting system
- Serial readout
- 10 ns time tag resolution



Applications :Bio/chem iluminescence;  
Measurement of Aequorin , Luciferase & ATP  
Multiλ imaging; Missile warning; Astronomy



## 4<sup>th</sup> Gen. High Resolution Photon Counting System (HRPCS4)

- Single photon counting system
- Parallel readout device
- 10 ms time tag resolution
- X-ray input, VID, and cooled housing options

# Sydor Instruments - Photek



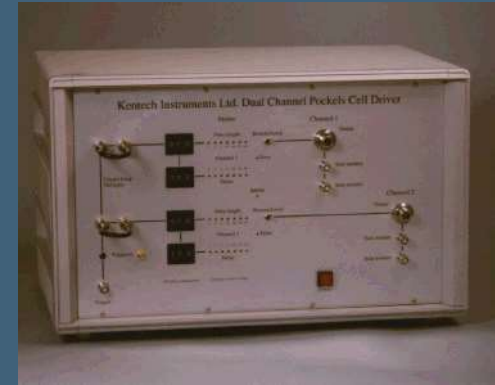
## Vacuum Imaging systems

### VID 225/240/275, cooled housing





Kentech PBG1 and Lasermetrics 1111  
Pockels Cell



Kentech Dual Channel PC  
Driver

Kentech Instruments Ltd.

# Kentech Instruments Ltd.



- ⊕ UK based high-speed electronics company
- ⊕ Pulse generator systems
  - High-voltage (<50 kV)
  - Fast rise-time (~90 ps)
  - High rep-rate (< 500 MHz, single shot)
- ⊕ Custom designs for unique applications
- ⊕ Supplier of x-ray streak camera components



# Kentech Instruments Ltd.

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## Kentech Engineered Products:

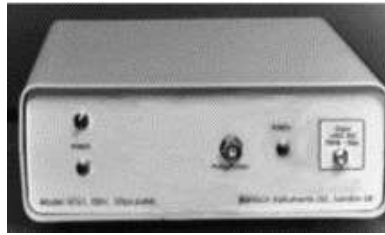
- Pulse generators
- Gated optical imagers
- Gated x-ray imagers
- Delay generators
- Pockels cell drivers
- Arbitrary waveform generators
- Laser electronics

# Kentech Instruments Ltd. Products



## PBG Series

- 5 models:
  - Amplitudes 6.5kV-45kV
  - Rep. rates 10 Hz-100Hz
- <100 ps rise, 3 ns exponential fall time



## CPS Series

- 3 models:
  - Amplitudes 2kV-6kV
  - Rep. rates 10Hz-1000Hz
- <150 ps rise, 2 ns fall time



## SPS/V Pulser

- Amplitudes >1kV-6 kV
- Rep. rates 1K Hz
- 0.7ns rise
- 1,2,4,8,10 and 12ns pulses



## Programmable Sub-ns Pockels Cell (PSP1) Driver

- Single channel
- 2.5kV-3.5kV
- <300ps to 10ns pulse width in 25ps steps
- $\geq 150$ ps rise time
- $\geq 100$ Hz rep rate

## High Voltage Pockels Cell Driver

- Adjustable to  $\sim 9$ kV
- 12ns to 60ns single pulse; 20ns to 60ns double pulse
- Various delay modes up to 400ns
- $\sim 4$ ns rise time
- 20Hz rep rate single pulse, 10Hz rep rate double pulse

# Kentech Instruments Ltd. Products



## Arbitrary Waveform Generator

- Used as a fiber optic modulation driver and for RF testing
- 5V output
- <100ps rise and fall times
- 100ns duration
- 100kHz rep rate



## Reverse Terminated Voltage 30 (RTV30) Sub-ns Pulser

- <30V amplitude, with 25% to 100% adjustment
- Adjustable <300ps to 20ns pulse width
- <300ps rise time
- <100kHz rep rate



## Underminated Voltage 50 (UTV50) Pulse Generator

- 0-50V amplitude, adjustable
- 1-100ns pulse width, adjustable
- <200ps rise time, <500ps fall time
- 200kHz rep rate

# Thank You!

