



# Indian Institute of Technology Kanpur

Department of Mechanical Engineering

<b>Subject:</b>	Enquiry for supplying <b>Time resolved PLIF system</b> (with provision to simultaneous high speed PIV facility upgrade) for combustion applications.
<b>Tender Reference No:</b>	IITK/ME/SDE/2017/PLIF/1
<b>Tender Type:</b>	Open
<b>Date of Opening:</b>	December 8, 2017
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Sealed bids are invited for the procurement of **Time resolved (high speed) Planer Laser Induced Fluorescence (PLIF) system** with simultaneous high speed PIV upgrade facility to analyze and measure temperature of the combustion zone as well as species concentrations of OH, CH, HCHO and others along with **Time resolved Tracer PLIF measurement facility (Acetone, Toluene)** to measure scalar mixing characteristics and temperature of the combustion zone.

### **Scope of the Work:**

- 1) A prototype gas turbine combustor (with optical access) will be designed and various experiments will be performed. High speed PLIF facility will be used to investigate the species concentration and temperature of the combustion zone.
- 2) High speed PIV facility will be used to investigate the velocity field and turbulent fluctuations simultaneously/separately with PLIF facility.
- 3) Tracer PLIF facility will be utilized to investigate the scalar mixing characteristics of various fuels as fuel flexibility study will also be done.
- 4) High-speed chemiluminescence imaging will be performed by using the same camera and intensifier.
- 5) The above-mentioned characteristics for open and high pressure burner will also be investigated.
- 6) In the near future, the facility will be used to get volumetric/tomographic flame imaging and tomographic velocity imaging by using in-house and/or commercial software.
- 7) In future, some other optical diagnostics methods may be developed by using same components with some upgrade (like Rayleigh Thermometry and others).

## Technical Specifications of Time Resolved PLIF/PIV System

The desirable hardware and software capabilities and specifications are given below:

Sl. No.	Item Description	Quantity
<b>Module A</b>	<b>Lasers for PLIF</b>	
A.1.	<p><b>High Speed Pump Laser for PLIF:</b>            The vendor should provide 532 nm diode pumped Laser with Nd:YAG crystal, consisting of Laser head, <b>power supply</b> and <b>chiller</b> (including extension of laser base plate and the SHG unit). The laser must be prepared for 355 nm and 266 nm output also with proper modifications through harmonic generator (<b>including optics module for 355 nm and 266 nm</b>). <b>The point to be noted that these three frequencies can be triggered independently according to the experimental requirement.</b> The laser should satisfy the following specifications:</p> <ul style="list-style-type: none"> <li>• Diode Pumped, frequency double, q-switched Nd:YAG laser source.</li> <li>• Include chiller unit and power supply</li> <li>• <b>Wavelength:</b> 532 nm, 355 nm and 266 nm (include proper external pump optics module like SHG, THG and FHG)</li> <li>• The pump optics modules for all three wavelengths should be <b>flexible</b> and <b>each wavelengths should be generated independently and separately</b>, so that all three wavelengths can be <b>accessed</b> according to experimental need (that means these modules should be removable and can be realigned)</li> <li>• Include all necessary and best suitable <b>desiccant</b> and other <b>cartridges, filters</b> etc.</li> <li>• <b>Repetition Rate:</b> single shot to 15 KHz or better</li> <li>• <b>Maximum Average Power (W):</b> <ul style="list-style-type: none"> <li>➤ ≥ 140 W @ 10 kHz (at green region and SHG module)</li> <li>➤ ≥ 65 W @ 10 kHz with THG module</li> <li>➤ best available with FHG module</li> </ul> </li> <li>• <b>Pulse energy: @ 10 KHz</b> the pulse energy should be -               <ul style="list-style-type: none"> <li>➤ ≥ 14 mJ at wavelength 532 nm with SHG module</li> <li>➤ ≥ 6.5 mJ at wavelength 355 nm with THG module</li> <li>➤ best available at 266 nm wavelength with FHG module</li> </ul> </li> <li>• <b>Pulse - Pulse Energy Stability:</b> ≤ 4 % rms</li> <li>• <b>Beam Size:</b> 3 mm x 8 mm or better</li> <li>• <b>Beam Profile:</b> Gaussian/Top Hat</li> <li>• <b>Pulse Width:</b> ≤ 9 ns</li> <li>• <b>Beam Divergence:</b> ≤ 4 mrad</li> <li>• <b>Beam Quality:</b> <math>M^2 \leq 2</math> or better (for all harmonic generation and all region)</li> <li>• <b>Polarisation:</b> &gt; 100:1</li> <li>• Include all necessary and suitable cables, mounts, optics for <b>alignment</b> and total system integration</li> <li>• Onsite installation by qualified engineer</li> <li>• 10 days onsite training should be provided for installation, operating and maintenance</li> </ul>	1 No.

A.2.	<p><b>Tunable Dye Laser:</b>  The vendor should provide a tunable dye laser with high repetition rate (up to 15 kHz or better) having external frequency doubling unit (<b>must be flexible and the dye laser can be used with or without FCU as per the experimental requirement</b>), oscillator and resonator in <b>separate dye cells</b>.  The laser should satisfy the following specifications:</p> <ul style="list-style-type: none"> <li>• <b>Repetition Rate:</b> up to 15 KHz or better</li> <li>• <b>Grating:</b> 1800 l/mm primary <b>long</b> (90 mm) grating</li> <li>• <b>Grating Lift:</b> long grating lift with 1800 l/mm second grating</li> <li>• <b>Pump Wavelength:</b> Different wavelength <b>pumping option</b> (532 nm, 355 nm and 266 nm) and should be flexible in using with any of the mentioned wavelength according to experimental requirement.</li> <li>• <b>Linewidth:</b> <math>\leq 0.05 \text{ cm}^{-1}</math> @ 625 nm</li> <li>• <b>Tuning Range:</b> Gap free tuning of 400 (or less)-900 nm or better without frequency doubling and 200 to 450 or better with frequency doubling (Please include suitable <b>BBO crystals</b>)</li> <li>• <b>Polarization:</b> <math>\geq 98\%</math></li> <li>• <b>Output Energy:</b> <math>\geq 0.5 \text{ mJ}</math> @ 283 nm, 10 KHz (<b>after FCU</b>)  <math>&gt;0.6 \text{ mJ}</math> @ 431 nm, 10 KHz</li> <li>• <b>Frequency Doubling Unit:</b> <ul style="list-style-type: none"> <li>➤ <b>Multi crystal</b> (to achieve <b>gap free</b> tuning 200 nm to 450 nm or better) Frequency conversion unit must be <b>flexibly</b> operated <b>according to experimental requirements</b> (some experiments need frequency doubling and some are not)</li> <li>➤ Therefore this FCU must be <b>controllable</b> and <b>flexible</b> (can be used whenever it needs to double the frequency)</li> <li>➤ The FCU should be equipped with stepper motor <b>drive and driver</b></li> <li>➤ The FCU must come with standalone <b>auto-tracking</b></li> </ul> </li> <li>• <b>Oscillator/Resonator</b> (gap free) and <b>amplifier</b> unit with <b>separate dye cells</b> (suitable for high repetition rate)</li> <li>• <b>Two</b> high repetition rate and high flow rate <b>dye Circulator</b> for oscillator/resonator and amplifier. Each dye circulator (temperature stabilized) should consists of reservoir (4 liter minimum), suitable pump and <b>filter cartridges</b></li> <li>• <b>Additional large reservoir (<math>\geq 8</math> liter volume)</b> for short lifting dyes</li> <li>• Set of <b>Pellin-Broca</b> prism for <b>wavelength separation</b></li> <li>• <b>Compensator</b> for temperature stabilized BBO crystals</li> <li>• <b>Pump Beam Alignment</b> (including mounts pedestals and optics)</li> <li>• Include all necessary and suitable cables, mounts, optics for total system integration Onsite installation by qualified engineer</li> <li>• 10 days onsite training should be provided for installation, operating and maintenance</li> </ul>	1 No.
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Module B	Light Sheet Optics	
B.1.	<p><b><u>Divergent and Parallel Light Sheet Optics for PLIF (UV Version):</u></b>  The vendor should provide series of spherical and cylindrical UV lens by which the proper laser sheet can be generated for experiment and should be used in combination with beam waist adjustor. The light sheet optics should satisfy the following specifications:</p> <ul style="list-style-type: none"> <li>• Combination of spherical and cylindrical lens should generate parallel and divergent light sheet</li> <li>• <b>Adjustable focus:</b> minimum 0.2 m to 3.5 m (or better)</li> <li>• <b>Parallel light sheet optics:</b> Collimated Sheet optics to generate a parallel laser light sheet of approximately 50 mm/100 mm height</li> <li>• <b>Collimator Upgrade:</b> Best suitable</li> <li>• Beam waist adjuster should expand or compress the beam diameter</li> <li>• Adjustable light sheet thickness and light sheet angle (best suitable)</li> <li>• 360 degree adjustable light sheet orientation (<b><i>including all angle modules</i></b>)</li> <li>• Mountable on articulated mirror arm or can be used as separate unit</li> <li>• The optics should be suitable for laser wavelength in the range of 220-800 nm</li> <li>• Adapter piece for mirror arm</li> <li>• Output lens units for fixing multiple light sheet angles</li> <li>• Suitable for high speed PLIF measurement with coatings for loss less than 5%</li> </ul>	1 No.
B.2.	<p><b><u>Divergent and Parallel Light Sheet Optics for PIV:</u></b>  The vendor should provide series of spherical and cylindrical UV lens by which the proper laser sheet can be generated for high speed PIV measurement. The light sheet optics should satisfy the following specifications:</p> <ul style="list-style-type: none"> <li>• Combination of spherical (should allow continuously vary or adjust focal length) and cylindrical lens (having best suitable divergence angles) should generate parallel and divergent light sheet</li> <li>• <b>Adjustable focus:</b> minimum 0.2 m to 3.5 m (or better)</li> <li>• <b>Parallel Light sheet optics:</b> Collimated Sheet optics to generate a parallel laser light sheet of best suitable height with best suitable collimator upgrade</li> <li>• Beam waist adjuster should expands or compresses the beam diameter</li> <li>• Adjustable light sheet thickness and light sheet angle (best suitable)</li> <li>• 360 degree adjustable light sheet orientation (<b><i>including all angle modules</i></b>)</li> <li>• Mountable on articulated mirror arm or can be used as separate unit</li> <li>• Adapter piece for mirror arm</li> <li>• Output lens units for fixing multiple light sheet angles</li> </ul>	1 No

Module C	Imaging Instruments	
C.1.	<p><b>High speed camera for PLIF and Chemiluminescence:</b>  The vendor should provide a high speed monochrome camera with 1400 fps at a maximum resolution of 4 MP or better. The system <b><i>should be supplied with a 50 mm camera lens.</i></b> The camera should satisfy the following specifications:</p> <ul style="list-style-type: none"> <li>• <b>Sensor Type:</b> CMOS</li> <li>• <b>Minimum resolution:</b> 2560 x 1600 pixels (4MP) or better</li> <li>• <b>Capture Rate at 4MP Resolution:</b> 1400 Frames/Sec or better</li> <li>• <b>Quantum Efficiency:</b> ≥ 50%</li> <li>• <b>Trigger:</b> External</li> <li>• <b>Global electronic shutter</b> ≤ 1 μs independent of frame rate</li> <li>• <b>Inter-frame transfer time</b> &lt; 2 μs</li> <li>• <b>Camera Memory:</b> Minimum 36 GB or better</li> <li>• Capable of working in low light conditions with ISO ≥6400 (daylight)</li> <li>• <b>Pixel Size:</b> 10 μm or better</li> <li>• <b>Pixel Depth:</b> 12 bit or better</li> <li>• <b>Operational Temperature:</b> 10°-50°C or better</li> <li>• <b>Sensor Size:</b> 25.6 mm x 16.0 mm</li> <li>• <b>Throughput:</b> 6 Gpx/sec or better</li> <li>• <b>Camera Lens:</b> 50mm/F1.4</li> <li>• <b>Image and video Formats:</b> JPEG, AVI, TIFF, BMP, RAW (both compressed or uncompressed), PNG and FTIF.</li> <li>• <b>Video monitoring</b></li> <li>• <b>Power requirements:</b> 100 V - 240 V AC ~ 1.5 A, 50-60 Hz</li> <li>• Gigabit Ethernet Interface (10 Gb Ethernet will be preferred)</li> <li>• All suitable Interface, power cables and connection sets including BNC cables</li> <li>• Rugged camera case</li> </ul> <p><b># Please quote unit price of each camera unit</b>  <b># Please also quote for similar camera with 72 GB or better memory separately under optional</b></p>	2 Nos.
C.2.	<p><b>External Intensifier:</b>  The vendor should provide a <b><i>latest generation</i></b> high speed hybrid intensifier unit having dedicated gate controller and delay generator/controller. <b><i>Additional mechanical shutter</i></b> will be preferred as it increases the lifespan of the intensifier. The light sheet optics should satisfy the following specifications:</p> <ul style="list-style-type: none"> <li>• Two-stage, <b><i>latest generation</i></b>, hybrid intensifier</li> <li>• Suitable for use along with the above-mentioned High Speed Camera for combustion experiments</li> <li>• Standard C-mount and F-mount input and output</li> <li>• S20 Photocathode</li> <li>• <b>Phosphor material:</b> P46</li> <li>• <b>Gating Time:</b> 10 ns or better</li> <li>• <b>Repetition Rate:</b> single shot to 300 KHz or better</li> <li>• 1:1 Lens coupling (Relay Lens)</li> <li>• <b>Quantum Efficiency:</b> ≥ 30%</li> <li>• 25 mm diameter</li> <li>• Dedicated intensifier gate control</li> <li>• delay controller/generator</li> <li>• <b>Mounting kit</b> for use with high speed camera</li> </ul>	1 No.

C.3.	<p><b>Image Doubler:</b> Dichroic Image Splitter/Doubler that allows simultaneous acquisition of two spatially identical but spectrally separated images simultaneously with the use of only one single camera. This item should provide:</p> <ul style="list-style-type: none"> <li>• Combined PIV/LIF measurements</li> <li>• Multi species LIF measurements during combustion</li> <li>• Combined Mie/LIF measurements for droplet sizing</li> <li>• Tomographic imaging using one camera and many more</li> </ul>	1 No.
<b>Module D Lens, Filters and Mirror Optics</b>		
D.1.	<p><b>UV Lens:</b></p> <ul style="list-style-type: none"> <li>• UV Camera Lens</li> <li>• Focal Length around 100 mm with best suitable free aperture</li> <li>• Focal depth f/2.8 or better</li> <li>• Suitable for laser wavelength in the range 200-550 nm or better.</li> </ul>	1 No.
D.2.	<p><b>Camera Filters for PLIF and Chemiluminescence:</b> Suitable high transmission (up to 90% or better) filters (with thread suitable with the lens to be supplied) for:</p> <ul style="list-style-type: none"> <li>• OH LIF (310 nm)</li> <li>• CH LIF</li> <li>• HCHO/CH<sub>2</sub>O LIF</li> <li>• HCO LIF</li> <li>• Acetone Tracer LIF (peaks at 445 nm and 480 nm)</li> <li>• Toluene Tracer LIF</li> </ul> <p><i>The vendor should also suggest filters of varied wavelength range that serve the purpose of our requirement</i></p>	1 No. (each filter)
D.3.	<p><b>Band pass Filters:</b></p> <ul style="list-style-type: none"> <li>• Narrow band interference filter</li> <li>• <b>Wavelengths:</b> 527 nm and 532 nm</li> <li>• Best suitable angle of incidence at 527 nm/532 nm.</li> <li>• <b>FWHM:</b> ± 5 to 10 nm</li> <li>• <b>Transmissivity</b> ≥ 90%</li> <li>• <b>Lens diameter:</b> 52 mm and 62 mm or better (best suitable)</li> </ul> <p><i>The vendor should also suggest and quote suitable band pass filters for 355 nm and 266 nm.</i></p>	1 No. (each filter)
D.4.	<p><b>Mirror Optics: Laser Beam Steering Unit:</b> The vendor should supply set of combined, adjustable, high reflection mirror for the following wavelengths including housing to avoid stray light:</p> <ul style="list-style-type: none"> <li>• <b>Pump optics (Beam Steering):</b> Beam steering to dye Laser for 532 nm, 355 nm and 266 nm.</li> <li>• <b>LIF optics (Beam Steering):</b> OH (283 nm), CH (387 nm, 314 nm, 431 nm), HCHO (355 nm), HCO LIF (259 nm), Acetone (peak between 270 nm to 280 nm) and toluene (266 nm).</li> </ul> <p><i>The vendor should exclude beam steering unit for HCHO, Acetone and Toluene if these are parts of pump optics/ laser beam steering unit.</i></p>	<b>Suitable Nos.</b> (To cover all wavelengths mentioned here)
D.5.	<p><b>Beam combining optics for simultaneous PIV-PLIF</b> The vendor should supply set of suitable dichroic mirrors to combine laser sheets of the two systems (PLIF of above-mentioned species and PIV simultaneously) including necessary mounts</p>	<b>Suitable Nos.</b> (To cover all wavelengths mentioned here)

Module E	Workstation and Synchronizer	
E.1.	<p><b>Workstation:</b> The vendor should provide a high performance workstation which would serve the purpose of both PIV and PLIF facility and also simultaneously. The work station should match the following specification following specifications:</p> <ul style="list-style-type: none"> <li>• Intel Xeon processor with 64 bit architecture</li> <li>• Base frequency 3.2 GHz or higher</li> <li>• <b>Core count:</b> 8 core</li> <li>• Intel Server Motherboard</li> <li>• <b>RAM:</b> 128GB DDR4 2400 MHz for server or better</li> <li>• DVD RW</li> <li>• Hard Disk 4 TB (SATA) or better</li> <li>• Additional slots should be available for future expansion of HDD and RAM</li> <li>• Best available 256 GB SSD for OS</li> <li>• Best available 4 GB or better Graphics Card (NVIDIA or better)</li> <li>• The graphics card must be compatible with DDR4/DDR5 RAM</li> <li>• <b>Ultra HD (4K)</b> Display (<math>\geq 27''</math> LED) with <b>3840 x 2160 resolution</b>, optical drive, mouse and keyboard.</li> <li>• Power supply</li> <li>• Proper and <b>best suitable cooling feature</b> (Total DELL system with <b>DELL cooling system</b> will be preferred)</li> <li>• Original Windows 10 Professional 64 bit OS package</li> </ul>	1 No.
E.2.	<p><b>Synchronization Unit:</b> The vendor should provide a synchronization unit which would work for simultaneous TR PLIF-PIV facility and also for individual TR-PLIF (including tracer PLIF), TR PIV facility. The unit should be <b>best suitable</b> for the facility and must match the specifications mentioned below:</p> <ul style="list-style-type: none"> <li>• Should be able to work in high speed mode</li> <li>• Front panel control with digital display</li> <li>• 8 or more independent output channels, 2 or more input channels</li> <li>• Multiple BNC cables</li> <li>• Time Resolution: <math>\leq 10</math> ns (picosecond range will be preferred)</li> <li>• Trigger: Internal or external and delay between triggers (minimum 30 MHz or better)</li> <li>• Communication ports: USB/ RS-232</li> <li>• Ethernet (TCP/IP) control with the suitable software</li> <li>• Jitter <math>\leq \pm 0.2</math> ns or much better</li> <li>• TTL compatible pulse</li> <li>• Repetition rates from 0.1 Hz up to 10 MHz or better</li> <li>• <b>Laser power control</b> by Q-Switch delay</li> <li>• Positive or inverted TTL signal for all outputs configurable</li> <li>• Software for standard and high speed PLIF/PIV timing</li> </ul>	1 No.



Module F	Software	
F.1.	<p><b>Base Software with LIF module:</b></p> <ul style="list-style-type: none"> <li>• User licenses allowing usage of user interface</li> <li>• Parallel processing capability on 8 processors (or better)</li> <li>• Automated recording and mapping of images for background and sheet correction, (considering non-uniform light sheet illumination) and calibration image</li> <li>• Image acquisition, processing/filtering and analysis software for <b>PLIF</b> and <b>Chemiluminescence</b> measurements.</li> <li>• <b>Image processing methods:</b> FFT, DFT, POD and others.</li> <li>• Supports TIFF, BMP, JPEG, PNG,AVI and other image and movie formats</li> <li>• Suitable for OH, CH, HCHO, HCO PLIF.</li> <li>• Suitable for Acetone and Toluene <b>tracer</b> PLIF.</li> <li>• Suitable for liquid and gas LIF also.</li> <li>• Suitable for <b>Temperature</b> and <b>Concentration</b> measurements.</li> <li>• Suitable for Scalar mixing studying by tracer PLIF.</li> <li>• Integrated Tecplot and/or Enight link for data presentation.</li> <li>• All hardware components of the PLIF system would be controlled using this software. This should include the software control of tuning range of Dye laser.</li> <li>• The user should be able to use individual image.</li> <li>• These individual images and all data (with suitable formats) should be accessed, plotted and processed by third party software (<b>Matlab</b> and others).</li> <li>• Easy upgrade to volumetric/tomographic flame imaging</li> </ul>	1 No.
F.2.	<p><b>PIV Software module:</b></p> <ul style="list-style-type: none"> <li>• User licenses allowing usage of user interface</li> <li>• Parallel processing capability on 8 processors (or better)</li> <li>• Image acquisition, processing (pre and post processing) and analysis software for 2D PIV and Shape-Size in Multiphase Flows.</li> <li>• Cross or auto-correlation technique for high accuracy velocity and velocity gradient calculations.</li> <li>• Velocity, vorticity and derivative analysis modules</li> <li>• Analysis of uncertainty of PIV Processing</li> <li>• Dynamic masking of object in the image field captured by PIV</li> <li>• Integrated <b>Tecplot</b> and/or <b>Enight</b> link for data presentation.</li> <li>• <b>Image processing methods:</b> FFT, DFT, POD and others.</li> <li>• Supports TIFF, BMP, JPEG, PNG,AVI and other image and movie formats</li> <li>• All hardware components of the PIV system would be controlled using this software.</li> <li>• Time averaged statistics of velocity fluctuations for turbulent flows and turbulent flow field movie generator.</li> <li>• Output data should be individually accessible and compatible with the plotter like <b>Matlab, Tecplot and others.</b></li> <li>• Compatible <b>plotter software</b> at least <b>2 licenses.</b></li> <li>• Easy upgrade to Stereo and Volumetric/tomographic PIV</li> </ul>	1 No.

Module G	Support Accessories	
G.1 (O).	<p><b>Light Guide Arm (optional):</b> The vendor should provide a <b>long laser guide arm</b> with accessories (excluding light sheet optics) to connect it with the laser source unit at one end and light sheet optics at the other end. The light guide should be flexible and the laser arm should allow 360o of light sheet rotation. This item should match the following specifications:</p> <ul style="list-style-type: none"> <li>• Suitable for: 532 nm, 527 nm, 355 nm and 266 nm</li> <li>• Suitable for lasers with length up to 2 m or better</li> <li>• Aperture: minimum of 15 mm</li> <li>• Length: ≥1.8 m</li> <li>• Optimum mirror combination with antireflection coating</li> <li>• Mirrors capable of withstanding energy produced from a high speed laser head</li> <li>• Mount for light sheet optics</li> <li>• Suitable <b>holders</b> and <b>mounting kit</b> to fix it with laser (of larger dimension)</li> <li>• All necessary <b>alignment tools</b> and <b>optics</b></li> <li>• High mechanical stability</li> <li>• Safe laser beam guidance between laser and experiment</li> <li>• 360° orientation and positioning of light sheet</li> <li>• Rugged case for transport and storage</li> </ul>	1 No.
G.2 (O*).	<p><b>Optical Table:</b> The vendor should provide a suitable <b>pneumatic type</b> vibration isolation table with <b>necessary rails</b> (for movement) to house lasers and light guide arm. Include all necessary accessories to secure beam pass between the lasers up to the test section</p> <p><b>*The vendor should provide either G.2 (O*). Item (Optical Table) or G.3 (O*). Item (Laser cradle)</b></p>	1 No.
G.3 (O*).	<p><b>Laser Cradle/Bench with flow box:</b></p> <ul style="list-style-type: none"> <li>• Rigid optical rail construction for the laser bench to house lasers and other accessories</li> <li>• Mounts for all the lasers</li> <li>• Retractable wheels to facilitate movement of the entire system</li> <li>• Include <b>flow box</b> for standard laser cradle (must include fan filter unit for efficient dust protection of lasers)</li> </ul> <p><b>*The vendor should provide either G.2 (O*). Item (Optical Table) or G.3 (O*). Item (Laser cradle)</b></p>	1 No.
G.4.	<p><b>Laser Safety Eyewear</b> High quality laser protection eyewear/goggles suitable for UV and visible range (220 nm – 550 nm). The vendors should provide goggles for:</p> <ul style="list-style-type: none"> <li>• PIV lasers</li> <li>• PLIF lasers</li> </ul>	4 Nos.
G.5 (O).	<p><b>Camera Mounting Device (optional):</b></p> <ul style="list-style-type: none"> <li>• Solid tripod for camera</li> <li>• Should be vibration free and rigid and include all necessary mounts</li> <li>• Heavy duty 3 axis/way swiveling head with height adjust</li> <li>• Suitable for cameras up to 12 kg or more</li> </ul>	2 Nos.
<p style="text-align: center;"><b>Comments on Module G items</b></p> <ul style="list-style-type: none"> <li>➤ Items G.1 (O). and G.5 (O). should be quoted as optional items also. The institute will buy these components as per the budget available.</li> <li>➤ *The vendor should provide either G.2 (O*). Item or G.3 (O*). Item to house/mount lasers and guide arm.</li> </ul>		

<b>Module H</b>	<b>Seeders, Dyes and Tracers</b>	
H.1.	<b>Dyes:</b> <ul style="list-style-type: none"> <li>• Rhodamine B (in Ethanol), 1 g</li> <li>• Rhodamine 6G (in Ethanol), 1 g</li> <li>• Rodamine 101 (in Ethanol), 1g</li> <li>• DCM (in Ethanol), 1g</li> <li>• Coumarin 120 (in Ethanol), 1g</li> <li>• Stilbene 3 (in Ethanol + H<sub>2</sub>O) , 1g</li> <li>• Exalite 389 (in p-Dioxane), 1g</li> <li>• Exalite 428 (in p-Dioxane), 1g</li> <li>• Mix. Exalite 389/398 (in p-Dioxane), 1g</li> <li>• Styryl 8 (in DMSO) , 1g</li> <li>• Styryl 9 (in DMSO) , 1g</li> <li>• LDS 867 (in Ethanol), 1g</li> </ul>	1 No. (Each)
H.2.	<b>Seed generator for Tracer PLIF with tracer material:</b> <ul style="list-style-type: none"> <li>• The vendor should provide a suitable tracer generator (seeder) for acetone and toluene PLIF.</li> <li>• This item should come along with acetone and toluene samples</li> </ul>	1 No.
H.3 (O).	<b>Seed generator for PIV with tracer particles (Optional):</b> <ul style="list-style-type: none"> <li>• Solid particle seed generator including the powder cartridge</li> <li>• Maximum outlet pressure: 5 bar or better (preferable)</li> <li>• Particle size/diameter: 0.2 to 2 microns</li> </ul>	1 No.
<p style="text-align: center;"><b><u>Comments on Module H items</u></b></p> <p>➤ The vendor may quote this H.3 (O). component as an optional item also. The institute will buy this item according to available budget.</p>		

Module I	Dual Head Laser for PIV (Optional**)	
I.1 (O**).	<p><b>Double cavity high speed laser (Optional**):</b>  The vendor should provide Dual Head (DH) laser (Nd: YAG or Nd: YLF) that combines the output from two identical lasers in an external beam combination box, short temporal pulse separation, and/or alignment independence. In addition, the two laser beams can be triggered independently or simultaneously. The laser should satisfy the following specifications:</p> <ul style="list-style-type: none"> <li>• Dual Head DPSS, Q switched PIV laser</li> <li>• Include <i>chiller unit</i> and <i>power supply</i></li> <li>• <b>Wavelength:</b> 527 nm (for Nd: YLF) or 532 nm (for Nd: YAG)</li> <li>• <b>Pulse Energy @ 1kHz :</b>2x20 mJ (each head) or better</li> <li>• <b>Average Power @ 3 kHz</b> ≥ 60 W</li> <li>• <b>Pulse Width @ 1kHz</b> &lt; 200 ns</li> <li>• <b>Repetition Rate:</b> up to 10 kHz or better</li> <li>• <b>Pulse to Pulse Stability:</b> ≤ 1.5% rms or better</li> <li>• <b>Nominal beam Diameter</b> :≤ 5.0 mm</li> <li>• <b>Beam Divergence:</b> ≤ 8 mrad</li> <li>• <b>Beam Circularity:</b>&gt;85%</li> <li>• <b>Beam pointing stability:</b> &lt; 25 μrad</li> <li>• <b>Long Term Stability:</b> 1% rms or better</li> <li>• <b>Interface:</b> RS 232, External TTL Triggering, GUI software included</li> <li>• <b>Operating Voltage:</b>100 - 240 V</li> <li>• <b>Line Frequency:</b>50-60 Hz</li> <li>• Operating Temperature: 15 to 30°C or better</li> <li>• Include all necessary and suitable cables, chord b/w power supply to head unit, mounts, optics for <i>alignment</i> and system integration</li> <li>• Onsite installation by qualified engineer</li> <li>• Include all filters and cartridges</li> <li>• 10 days onsite training should be provided for installation, operating and maintenance</li> <li>• Internal and external trigger option</li> <li>• Flexibility in time delay between pulse pairs</li> </ul>	1 No
<p style="text-align: center;"><b><u>Comments on Module I items</u></b></p> <ul style="list-style-type: none"> <li>➤ ** The cost of the item I.1 (O**) should be provided on a separate document in the financial bid. This item should be treated as an optional one but if the cost fits our budget, firm will be given <b>preference</b> in the financial bidding.</li> <li>➤ This item is <b>conditionally optional</b> (but <b>desirable</b>) and will be purchased only if budget is available</li> </ul>		

<b>Module O</b>	<b>Optional Items</b>	
O.1.	<p><b><u>Laser Energy and Power Meter with Sensor (Optional):</u></b></p> <ul style="list-style-type: none"> <li>• The Laser Energy ( up to 100 kHz) and Power monitor (up to 450 W or better) should be from a reputed manufacturer</li> <li>• Should capable of working in UV and visible range</li> <li>• Please include necessary and suitable commercial software interface with sensor</li> </ul>	1 No.
O.2.	<p><b><u>Rayleigh Thermometry (Optional):</u></b></p> <ul style="list-style-type: none"> <li>• By using same system components further upgrade to Rayleigh Thermometry system for temperature measurement</li> <li>• Include necessary software add on, thermal sensor and other components</li> </ul>	1 No.
O.2.	<p><b><u>Flat Flame Calibration (Optional)</u></b></p> <ul style="list-style-type: none"> <li>• Calibration flame with known gas species concentrations and temperature distribution</li> <li>• Burner head with chiller</li> <li>• Include all suitable mounts and controllers</li> <li>• Include calibration literature</li> </ul>	1 No.
O.3.	<p><b><u>Absorption correction and sheet correction kit (Optional)</u></b></p> <ul style="list-style-type: none"> <li>• Should account for inhomogeneous laser intensity and light sheet divergence</li> <li>• Corrects for strong absorption and signal gradient in camera image</li> <li>• Optical gas cell suitable calibration for LIF and sheet correction</li> </ul>	1 No.
O.4.	<p><b><u>Lens: 135 mm, F/2 (Optional)</u></b></p> <ul style="list-style-type: none"> <li>• Suitable for visible and/or UV region</li> </ul>	1 No.
O.5.	<p><b><u>Laser volume illumination optics (Optional)</u></b></p> <ul style="list-style-type: none"> <li>• Light bundle for volume illumination</li> <li>• Adjustable output aperture</li> <li>• Set of light optics to control illuminated area</li> <li>• Include all necessary mounts, cables</li> </ul>	1 No.
O.6.	<p><b><u>Volumetric/Tomographic Software Platform (Optional)</u></b></p> <ul style="list-style-type: none"> <li>• Volumetric/Tomographic Flame imaging by using minimum no. of cameras</li> <li>• Volumetric/tomographic LIF software module</li> <li>• Tomographic image reconstruction techniques and algorithms</li> <li>• Volumetric/tomographic and/or stereo PIV software module for 2D-3C and 3D-3C velocity field measurement</li> </ul>	1 No.
<p><b><u>Comments on Module O items</u></b></p> <ul style="list-style-type: none"> <li>➤ All the items listed in Module O are fully optional</li> <li>➤ The vendor has the freedom to quote other optional items</li> </ul>		

## **Terms and Conditions:**

### **1. Preparation of bids:**

- Please submit your quote in **two parts**, i.e. **Technical Bid** and **Financial Bid**.
- The technical bid should **consist of all technical details** along with commercial terms and conditions.
- Please indicate **item-wise price** in the Financial Bid. Vendors should mention the cost of each component and include those in total cost.
- Please indicate **cost per unit for each system component** in the financial bid.
- The prices (in quotation) should be in **Indian currency**
- In case any of the items listed above require **Export License Compliance**, please **mention** the same and **quote separately**.
- Bidder should organize the quotation in such a way that it should match the original technical specification mentioned above (*i.e., please indicate each module mentioned above and components of each module as it has been organized in the above chart*).
- Bidders should **provide contact details (including contact no.) of technical service person/s** with the quotation document for communication during the tender process and in future to discuss technical and financial issues

### **2. Dates and time period:**

- The date of opening the tender is **8<sup>th</sup> Dec, 2017**.
- The last date for sending the quotation in **sealed envelope** is **1<sup>st</sup> January, 2018**
- The validity of quotation should be **at least 90 days**.
- Delivery period should not be more than **20 weeks** from the date of purchase order and letter of credit (LC) and delivery should be at the institute. The installation should be done **within 21 days after delivery**.
- The institute purchase committee may ask the vendor for a **technical presentation before financial bid**

### **3. Warranty:**

- The vendor should provide a minimum **three years standard warranty** for the total system **from the date of installation** of the system. The warranty should include each and every components (e.g. lasers, cameras, intensifier and others) of the total experimental setup. The warranty includes replacements of the damaged parts and onsite visiting charge, service charge, etc.
- The vendor should **quote additional two years** (after first 3 years) **warranty separately (as an option)** for the total system. The institute may/may not **purchase** the extended warranty depending on available budget. This extended warranty also includes damaged parts replacements, visiting and service charge.
- The warranty should include onsite **visit and service** by the technical service team of the vendor for **at least twice a year within the warranty period**.
- The purchaser shall promptly notify the supplier/vendor if any problem arises in any of the system component and the supplier has to **reply and send their technical support team promptly and fix the problem/repair the item within 7 days or replace the faulty item/component within 30 days**.
- The vendor has to ensure **satisfactory after sales support and supply of spare parts for the system**
- Defective part in equipment, if found before installation and/or during warranty period, shall be replaced within 30 days (from reporting date by the institute). Early delivery will be preferred.

#### 4. Supplier's Capability:

- Availability of after sales service and support in India. Supplier should **compulsorily** indicate details of facilities / expertise/ qualification of support staff in India. Factory trained engineer/s should be available in India for complete product support.
- The firm should supply authorization certificate by the original equipment manufacturer, for dealership/distributorship along with the quotation, if applicable. Parent company should be an established and reputed company with good number of installations.
- The firm should give a declaration that they have not been blacklisted/debarred for dealing by Government of India in the past.

#### 5. Technical Details:

- The vendor **must fulfill** the above mentioned specification in the **technical specifications section**. These specifications are minimum criteria for participating in the tender process.
- The vendor should **mention all the technical specifications of each system component in detail** and that should **at least match the above mentioned technical specifications**.
- The firm should submit and **enclose complete technical brochure/catalogue** with all technical details
- Please note that the technical **specifications of the above mentioned system components** are only **indicative and minimum requirement**. If there are **specific system components (related to particular vendor)** required for total system integration and successful performance of the facility, then those **should be mentioned and provided. It is the responsibility of the bidder to include all the required accessories and components** for successful integration and operation of the facility.
- Please **clearly mention** (in the quotation) **the OEM's name and model number** for each system component of the total facility. This is a **mandatory criteria**.
- The vendor should also supply all necessary **operation and maintenance manuals (written in English), drawings, driver CD/Software support CD (supplied by the OEM)** of each system component.
- Non-compliance of tender terms, lack of clarity of all specifications, non-submission of required document or any contradiction may lead to rejection of the bid.
- Inspection and **end test** prior to shipment of each and every items are **desirable** for the verification of the system performance.

#### 6. Payment terms and offers:

- Normal payment terms for the institute will be applicable (**90% on delivery of the items and remaining 10% after satisfactory installation/inspection at the institute site**).
- The **total cost** (proposed in financial bid by the vendor) should **include delivery of all components and installation** of the total system along with successful operation of the facility.
- Suppliers shall be **entirely responsible for all taxes, duties, license fees, bank charges, packing and forwarding charges**, roads permits, etc., **incurred until delivery of the contracted system components to the institute**.
- For Imports, LC will be opened for 100% FOB/CIF value after final purchase order.
- The vendor should provide maximum educational and other discounts and the price of the items should be quoted after applying all discounts.
- Institute is partially exempted from custom duty.

#### 7. Institute's rights:

- The institute reserves the right to **add or delete any item** from the item list. This means that the institute has the **right to choose** the **final item/component's** list to be purchased during the tendering process.
- The intender reserves the **right to withhold placement of final order**.
- The **right to reject** all or any of the quotations (at any time of the procurement process) and **to split up the requirements** or relax any or all of the above conditions without assigning any reason is reserved.
- The institute reserves the **rights to charge penalty or take any legal action** on **delayed delivery** of components, supplying **defected/used/refurbished/substandard equipment**.

#### 8. Selection of Bid:

- The final selection will be made based on **weights given to technical merit (including fulfillment of technical specifications, terms and conditions) and pricing as 70% and 30%, respectively**
- Technical merit will be judged according to the fulfillment of the technical specification (which the vendor must clearly mention)
- The pricing merit will be judged based on the best quotation price of the final items to be purchased.
- Please note that the final items/components list will be decided by the institute (as the **institute reserves the right to add or delete any component during the total procurement/tendering process**) and the **pricing merit will be based on this final components list**.

#### 9. Packing and delivery:

- All the items are very delicate. The packaging should be such that **none of the components get damaged**. The supplier has to ensure this and they should take care of all these issues during the shipment process. **Damaged/partly damaged product will not be accepted**.
- **In case of any defect/damage to equipment** during the carriage of supplies from the origin of equipment to the installation site, the supplier has to **replace it with a new one immediately** at his own risk and responsibility. The supplier may deal this with their respective insurance company as per their convenience. **IIT Kanpur will not be liable/responsible to any type of losses in any form**.
- Each Package should be marked (in three sides) with **item nomenclature, OEM and model no., order/contract no., country of origin of goods, supplier's name and address, packing list reference no.** and the marking should be done by **proper paint/ink**.
- Documents to be supplied with delivery are **4 copies of supplier/OEM invoice** showing contract no., item description, quantity, unit price, total amount and **2 copies of the packing list identifying the contents of each packing**.

#### 10. Installation, Commissioning and Training:

- Installation and commissioning should be done by the vendor within **21 days** from the date of delivery
- Vendor should assemble the system and make the system operational. The vendor should also be responsible for suitable demonstration and smooth working of the entire system.
- This should **include testing with a prototype burner (provided by the institute) and collect data to prove the total functionality of the facility**
- The vendor should provide **10 days training for operation, maintenance, and system integration**.



- **Training for each component** of the facility should also be provided by the vendor
- The purchaser would try to utilize the facility in conducting multiple experiments and would try different combinations (e.g., generating multiple wavelength from pump and dye laser, using different dyes, changing the camera resolution and fps, controlling the repetition rate of laser, changing tracer for tracer PLIF application and others). **The vendor has to train the purchaser in such a way, so that the purchaser can reintegrate (each and every items), realign, and again fit the system in different position with different experimental setup and perform experiment successfully.**
- If the purchaser face some difficulties in realigning and reintegrating the total system for a specific set of experiment/acquiring result then the vendor must come to the institute promptly (after informing) and should sort out the issue. **Therefore true aftersales support is required.**

In case of any queries, you may please write to [sarmasaikat@gmail.com](mailto:sarmasaikat@gmail.com) and [sarmasai@iitk.ac.in](mailto:sarmasai@iitk.ac.in).

Kindly send the quotation in **sealed envelope** latest by **1<sup>st</sup> January, 2018** to the following address:

**Dr. Santanu De**  
**Assistant professor**  
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