A High-Resolution Transverse Diagnostic Based on Fiber Optics, and Other Devices

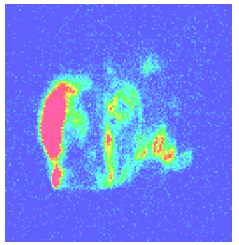
Marcos Ruelas

RadiaBeam Technologies

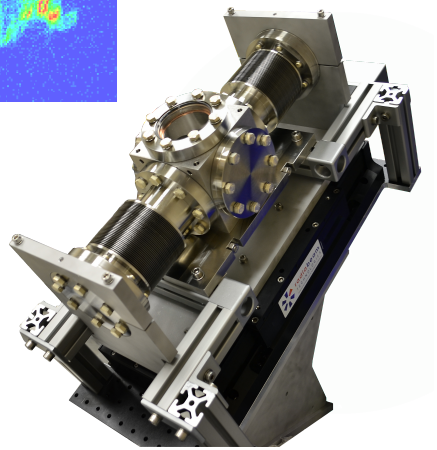
Motivation – Small Profiles

- *Scintillating Screens*
  - Excellent sensitivity
  - Simplicity
  - Resolution to ~5 microns

- *Optical transition radiation*
  - excellent resolution but low response
  - Collective effects (e.g. COTR)



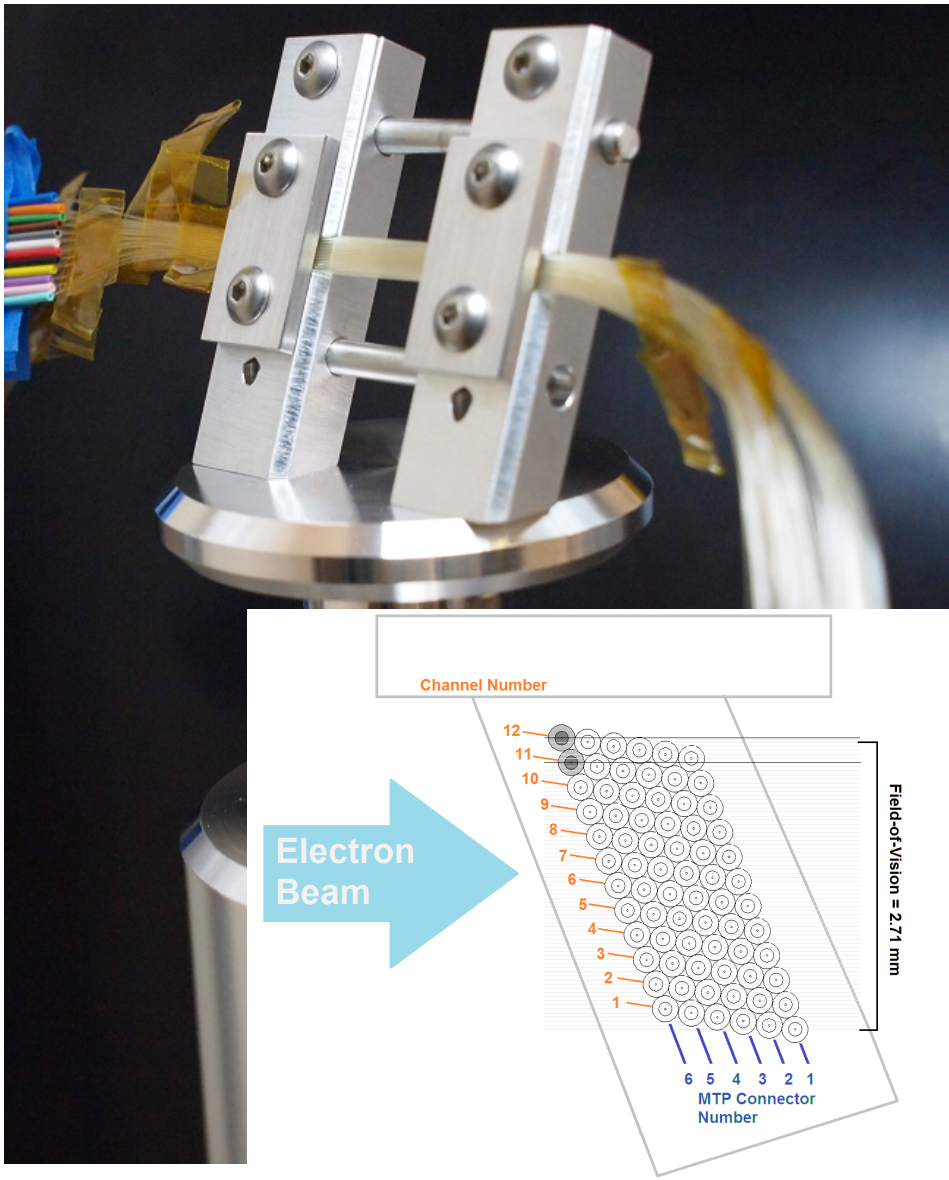
- *Wirescanners*
  - Slow
  - multishot



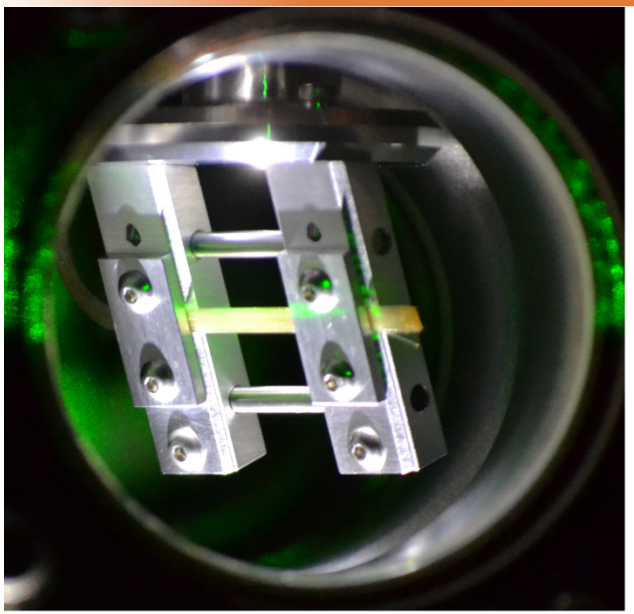
- Everyone has a wish list
  - single- shot – FMD
  - high sensitivity and immune to collective effects – FMD
  - <1 micron resolution – DUVTR
- 9-day run in September 2013 on beamline 2

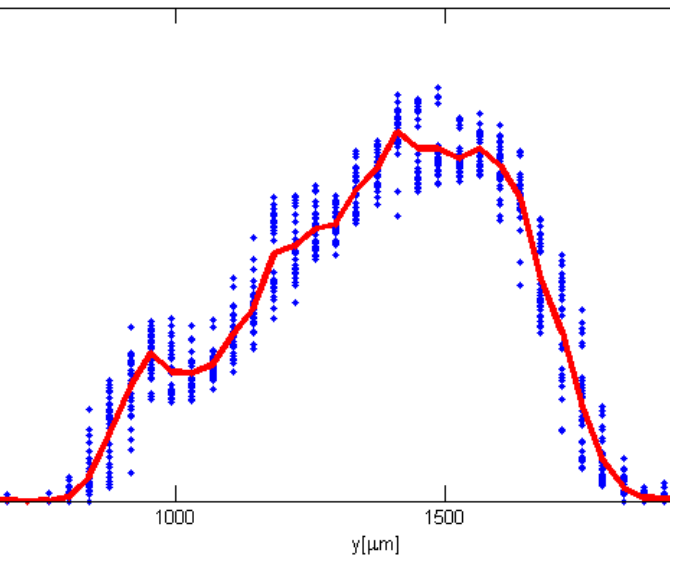
Fiber Mesh Diagnostic – FMD

- Cherenkov light will be emitted when electrons travel through the silica core of an optical fiber
- Align the fiber to the cherenkov angle (~ 45˚) and couple out the light
- 6-layer hexagonal packing at an angle yields 18.4 micron resolution
- Field of View is set by width of layers, set to 2.71 mm
- Measured intensity with fiber-coupled CCD

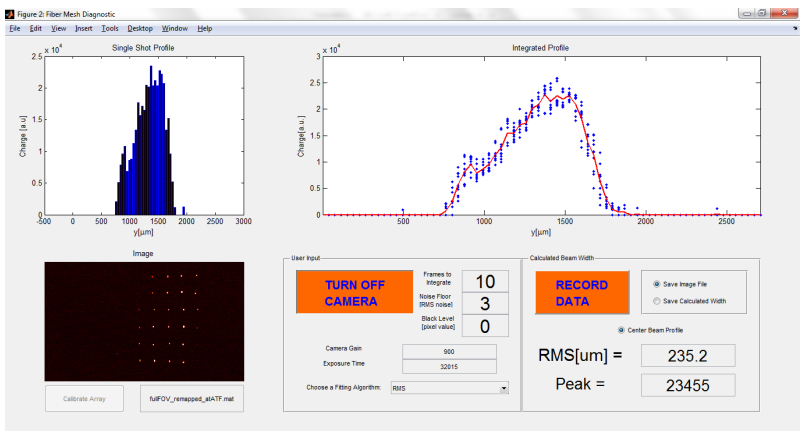


FMD Quad scan results

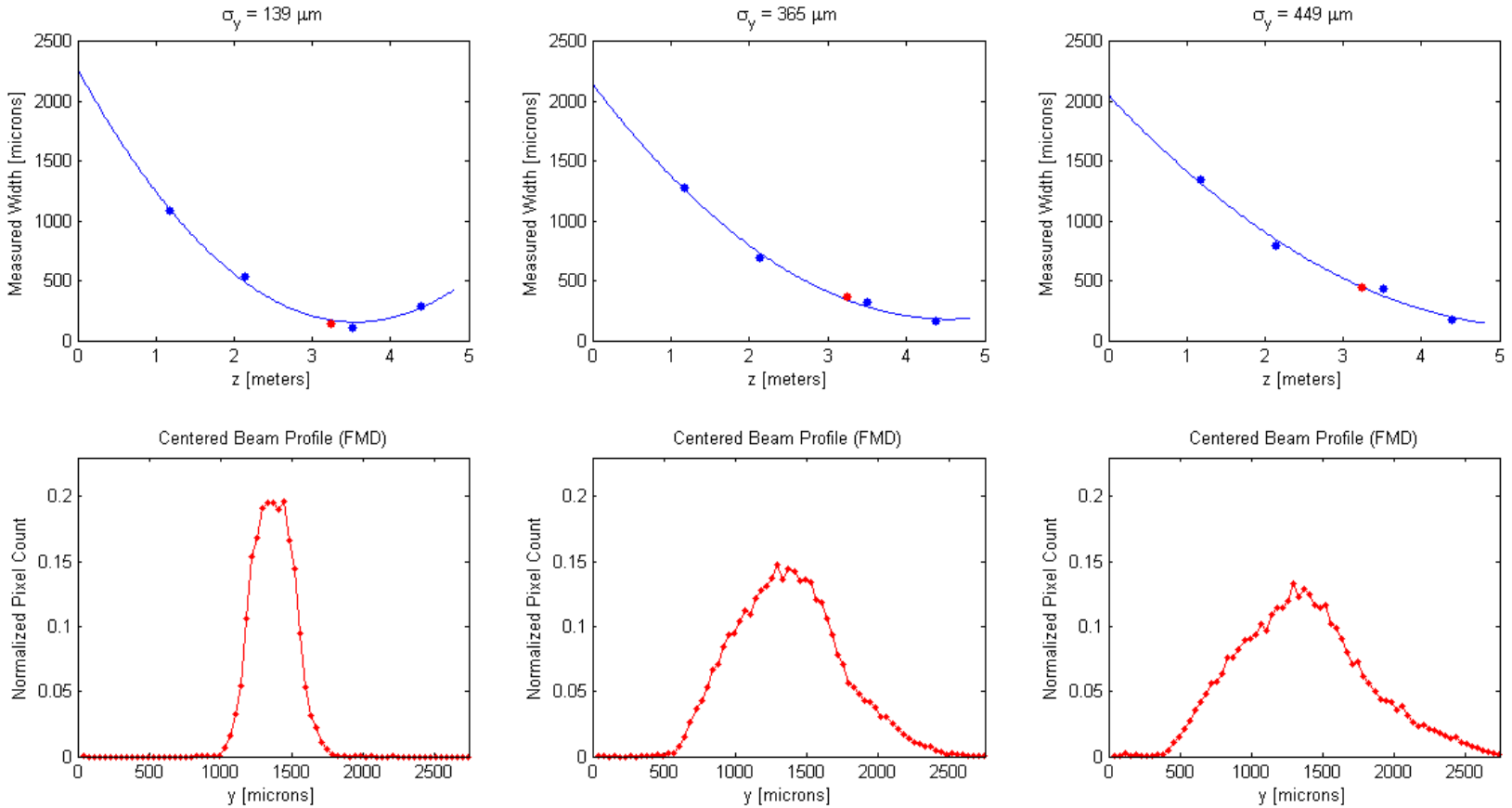




- Two week run on beamline 2 in September 2013
- Beam widths agree with YAG:Ce
- In good agreement with 100 μm thick YAG screen during quad scan of 500 pC, 55 MeV, 80 pC beam
  - $\epsilon_{N,YAG}$ = 3.9 μm
  - $\epsilon_{N,FMD}$ = 4.2 μm



FMD beam widths vs. YAGs

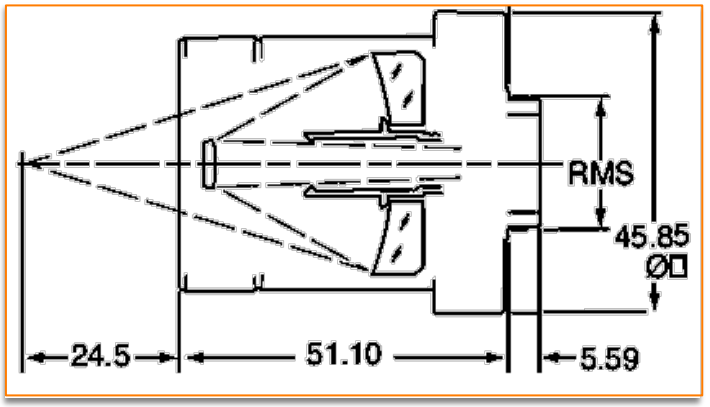


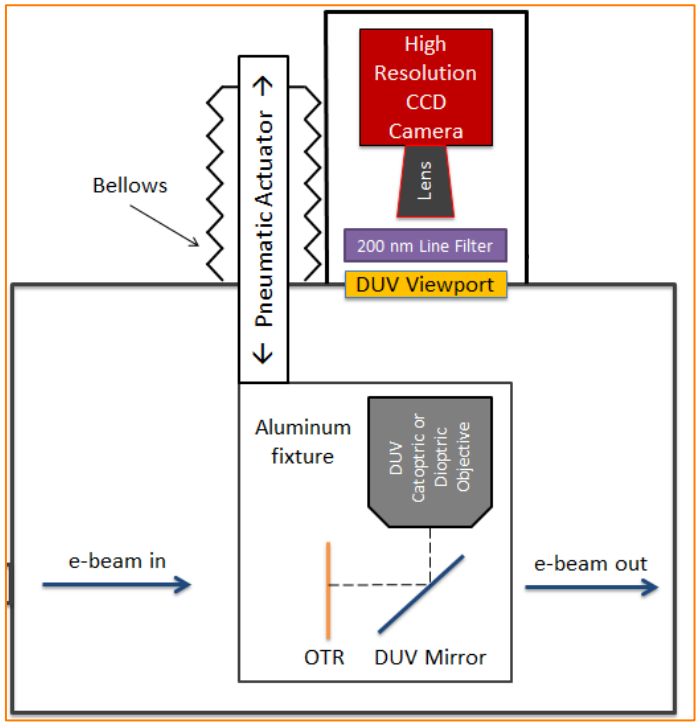
Top Row –Beam widths measured with YAG screens along the beamline (blue). Beam width measured with FMD plotted at the measured z- distance (red).
Bottom Row – The averaged beam profile as measured with FMD.
E =57.6 MeV, 500 pC

Deep UV Transition Radiation

“New” optical design - microscope

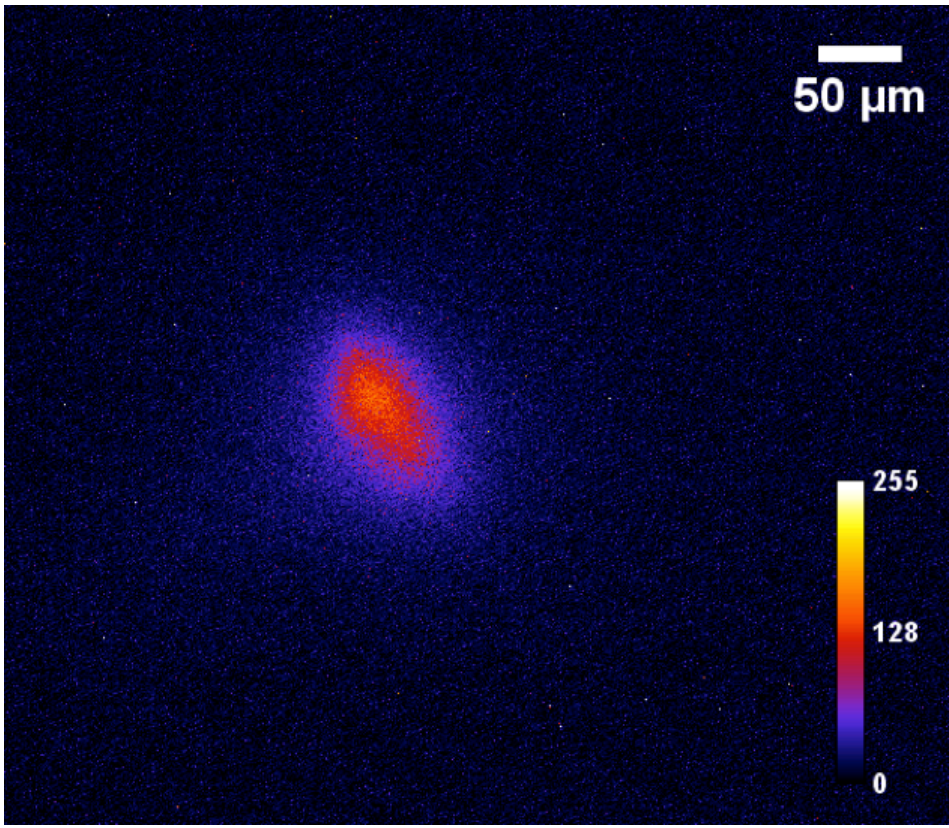
- Motivated by small 0.5-10 μm beams:
  - Current optics are diffraction limited and slow
  - These beams are necessary for DWA, PWA, and other 5th generation light sources
  - Optical TR is limited by the Point Spread Function to ~ 1 μm
- Improve resolution by limiting the PSF – move to Deep-UV
- High NA in-vacuum microscope objective to minimize aberrations





Deep UV TR

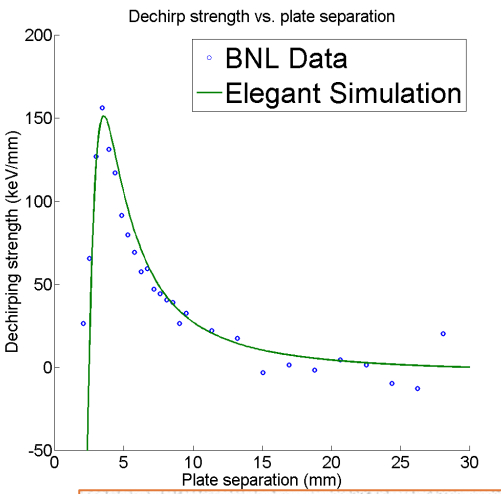
- Installed ‘commercial’ prototype design in UCLA plasma box
- One day set-up, one day run
- PMQ triplet for 50 μm beam
- Refractive objective and tube lens – minimal spherical aberrations remain
- TR is line filtered at 275 nm – minimal chromatic effects
- Beam images showed ~ 1.0 μm digitally-limited resolution

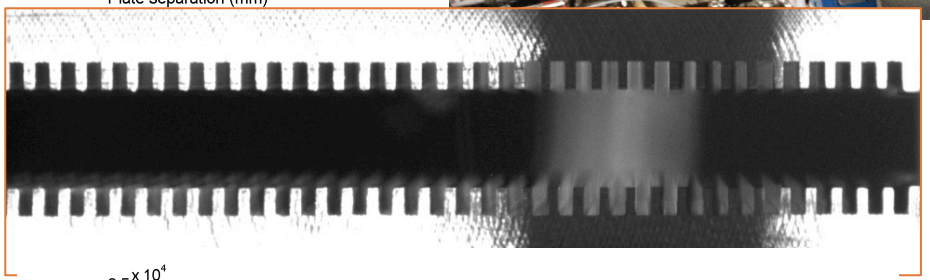


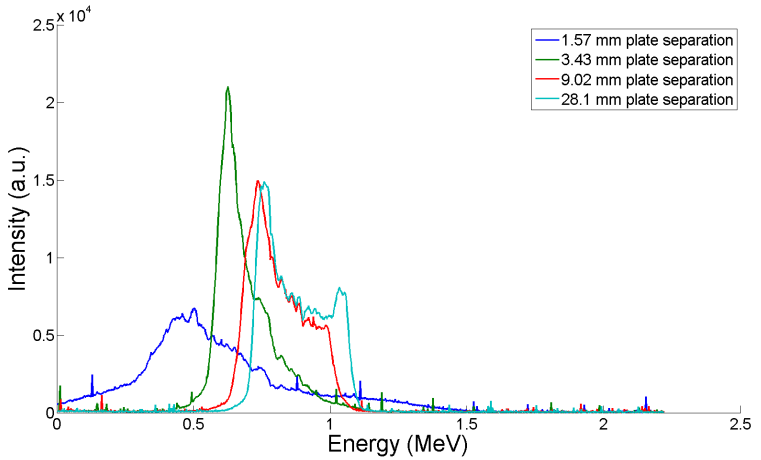
Corrugated Plate Dechirper

Corrugated Dechirper

- Corrugated structures were proposed as an efficient self-induced wakefield dechirper (K. Bane and G. Stupakov, SLAC-PUB-14925, 2012) for NGLS and PAL-XFEL
- RadiaBeam received funding in 2013
- Results matched simulation well, presented at NA-PAC'13 and FEL'14
- We are now in final engineering of a four meter dechirper for LCLS







Beam Energy	57.6 MeV
Bunch Charge	340 pC
Initial Chirp	400 keV/mm
Transverse Beam Size	100 μm
Pulse Length (full width)	3.4 ps
Longitudinal Profile	Flat

Future Plans and papers

- FMD – now a commercial product
  - S. Wu et al, NA-PAC'13, THPAC32
- Deep UV Transition Radiation – now extending to Extreme UV for improved COTR mitigation
  - B. Jacobson et al, NA-PAC'13, TUOBB4
  - B. Jacobson et al, IBIC'13, TUPF12
- Dechirper – now installing 4 meters at LCLS
  - M. Harrison et al, NA-PAC'13, MOPH025
  - M. Ruelas et al, FEL'14, THP034