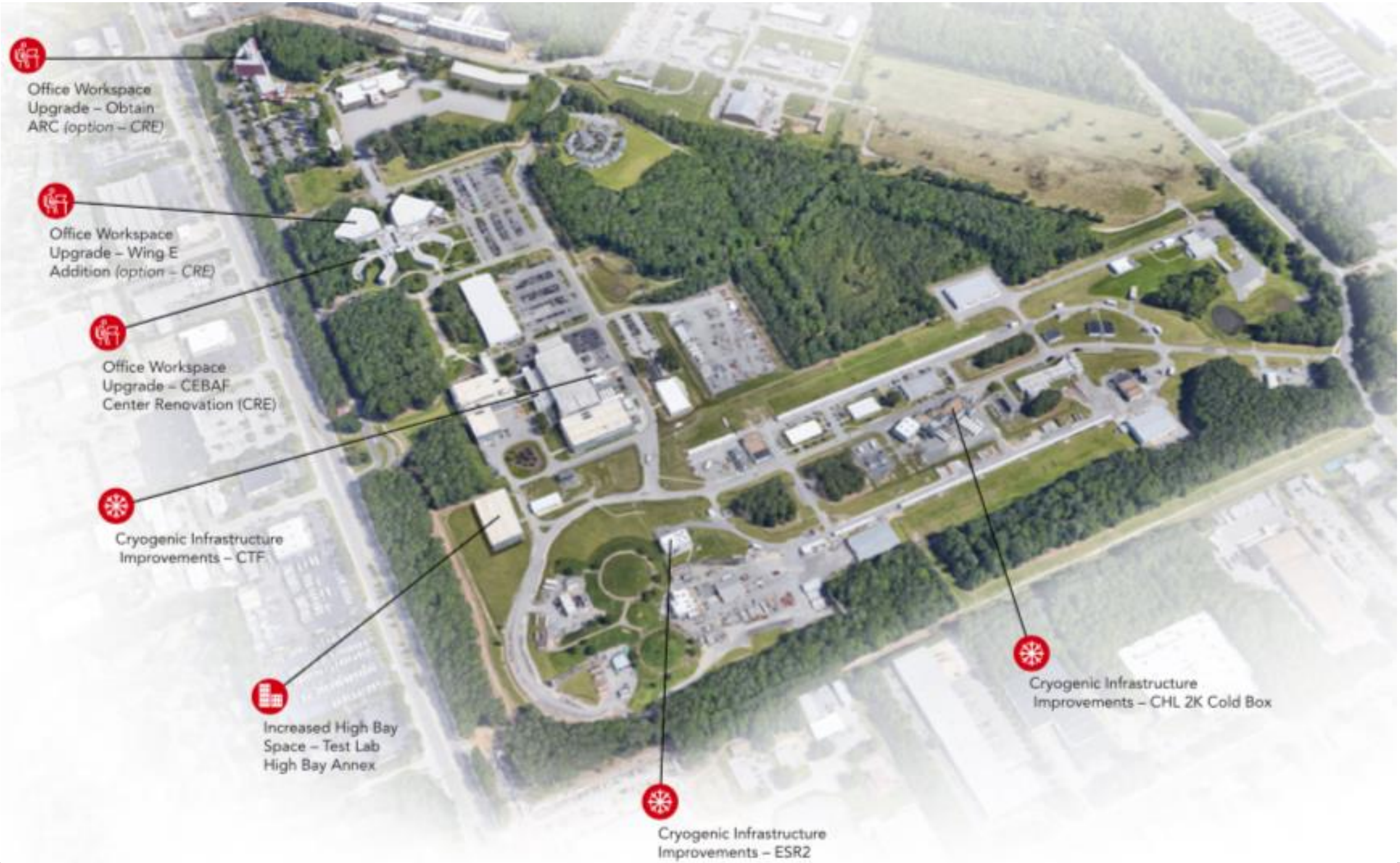
Jefferson Lab Scintillating Screens

Kevin Jordan

Jefferson Lab – Newport News, VA

JLab Campus Layout

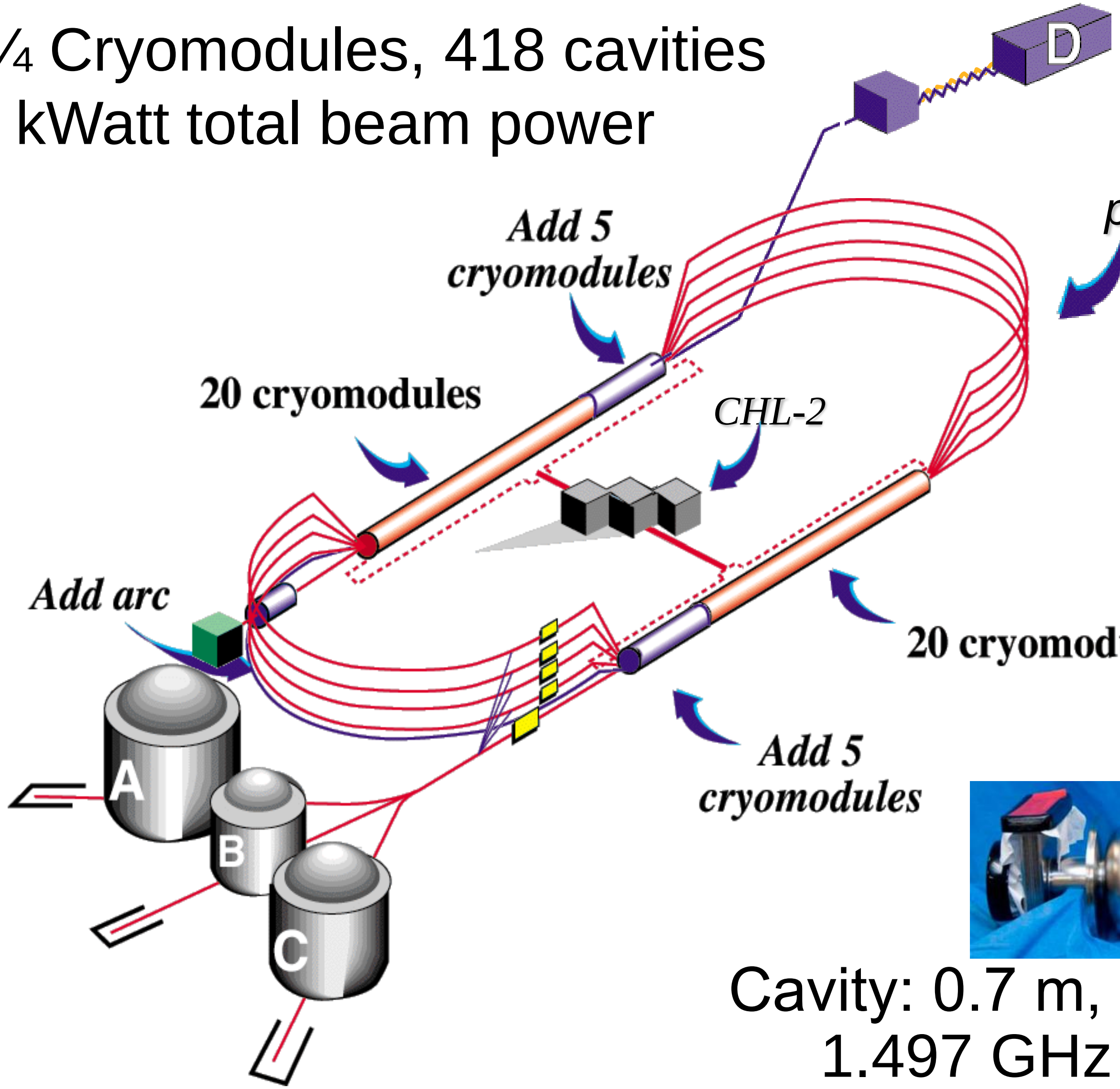


Jlab Accelerators

- CEBAF (Continuous Electron Beam Accelerator Facility)
  - 12 GeV, 4 Hall simultaneous operations
- LERF (Low Energy Recirculation Facility, former FEL)
  - Reworked as medical Isotope Facility
  - Also LCLS-II cryomodule test facility
- UITF (Ultimate Injector Test Facility)
  - 10 MeV polarized electron injector facility
- GTS (Gun Test Stand)
  - 300 keV multi-alkali cathode + magnetized beam

CEBAF 12 GeV Upgrade

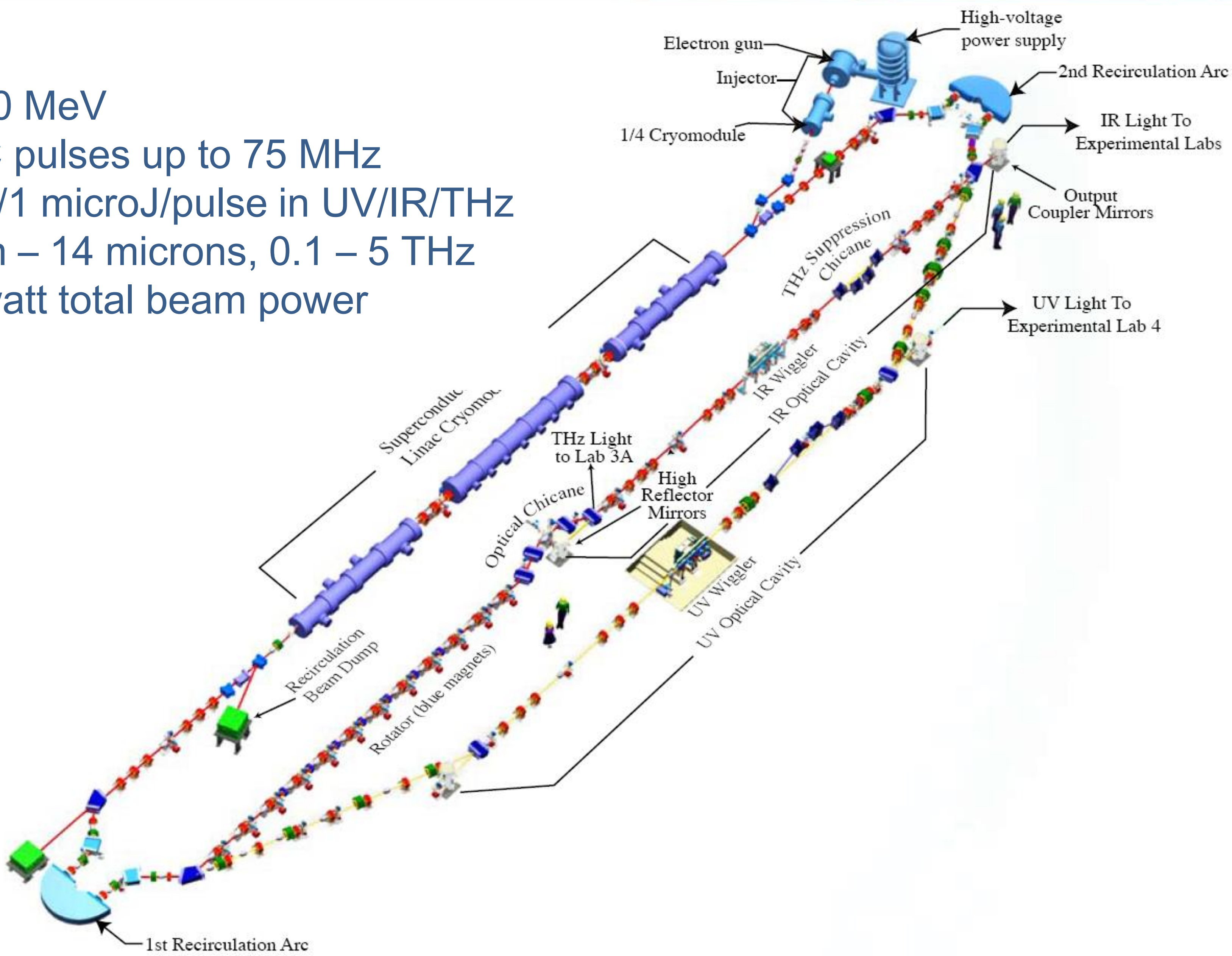
52 ¼ Cryomodules, 418 cavities
800 kWatt total beam power



Cavity: 0.7 m, “Low loss” cell shape, 1.497 GHz

JLab Upgrade FEL/ERL Schematic

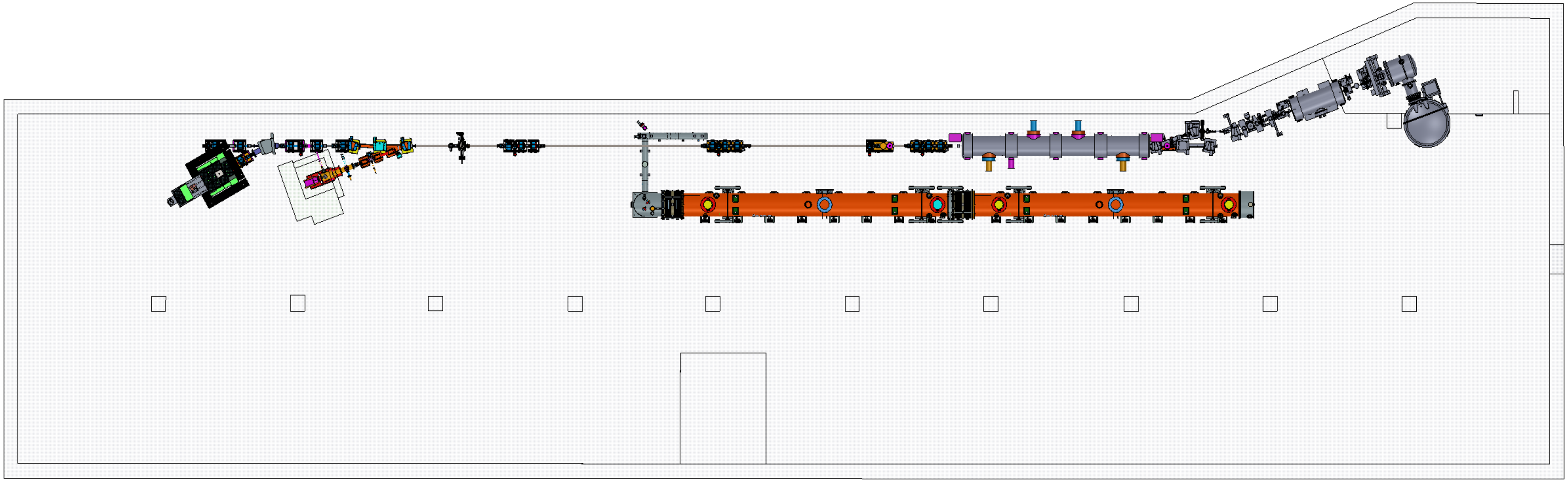
E = 150 MeV
135 pC pulses up to 75 MHz
20/120/1 microJ/pulse in UV/IR/THz
250 nm – 14 microns, 0.1 – 5 THz
1.2 Mwatt total beam power



LCLS-II CM Test Facility / Isotope Schematic

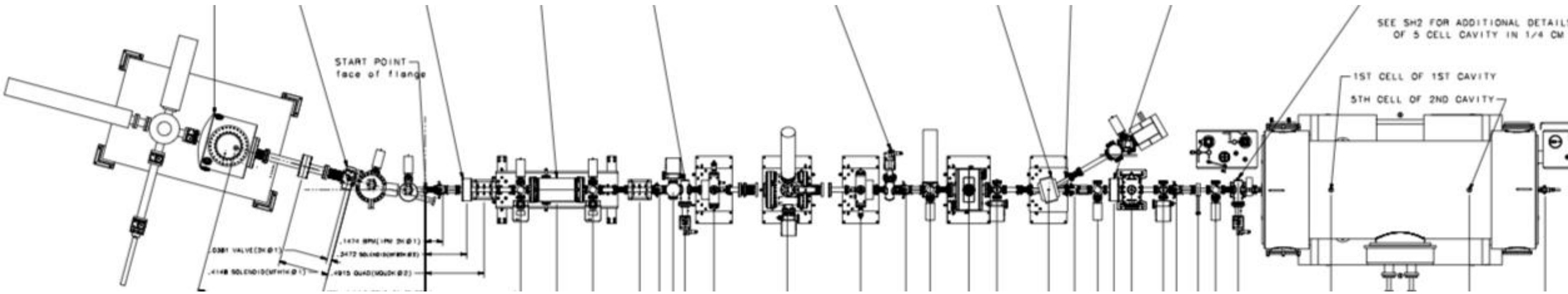
First isotope will be Cu67 from liquid Gallium target
E = 15-40 MeV
60 pC @ 75 MHz/6 pC @ 750 MHz
~50 kWatt beam power

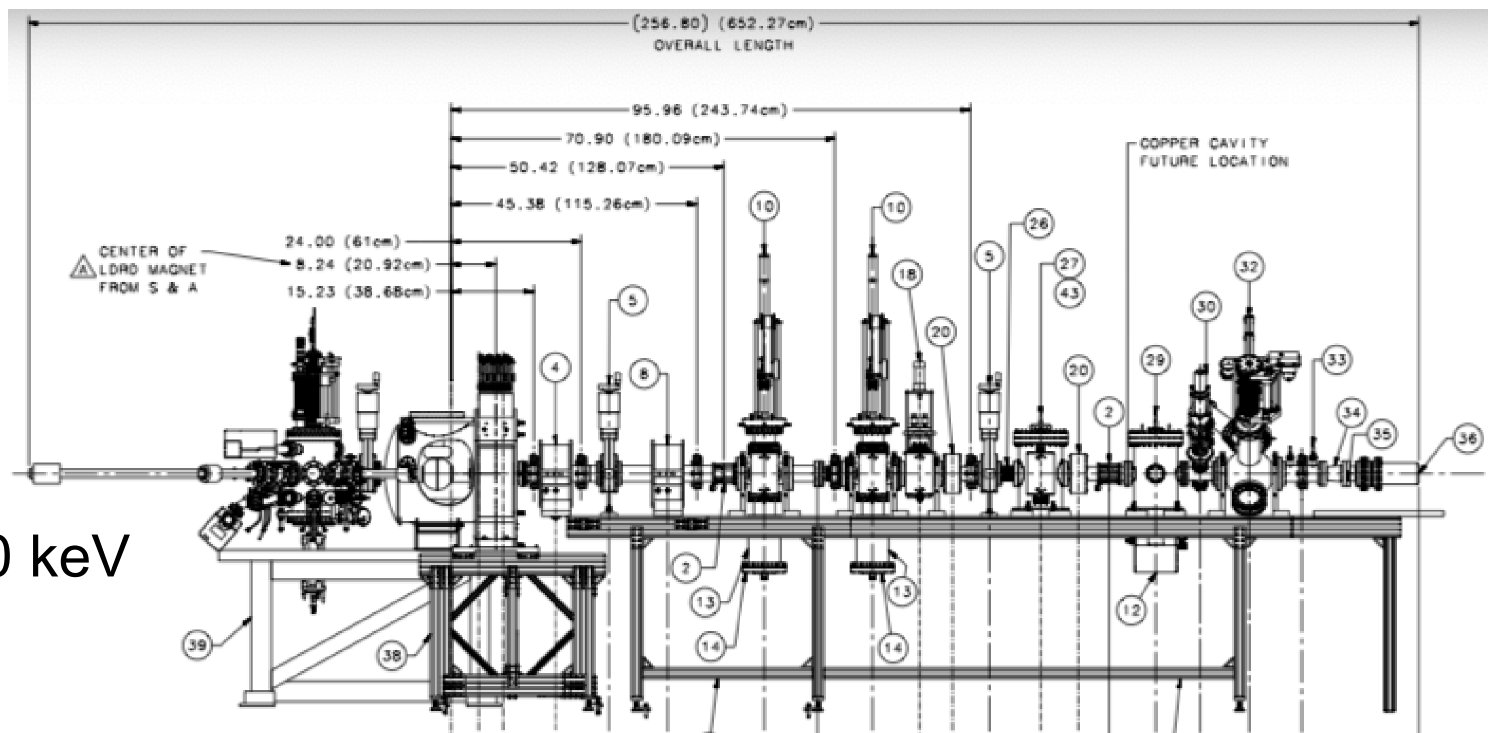
1[ST] integration of all production systems
LCLS-II "L2" full test of 16 cavities



UITF & GTS; YAG Screens

UITF; E = 10 MeV, current limited by radiation shielding





GTS; E = 300 keV

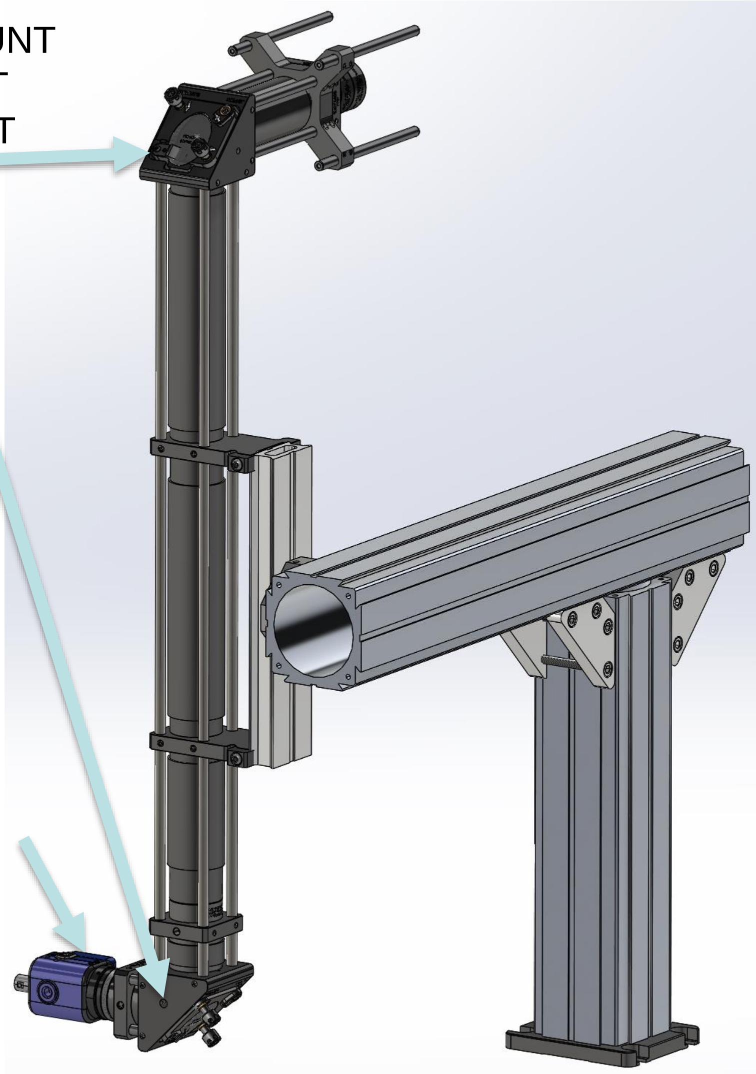
I $\geq$ 5 mAmp

CEBAF Screens

- Machine was built in the early 1990s
  - 139 Chromox screens with Vidicon cameras
- Vidicon cameras were small ‘lipstick’ like, with disk of lead glass for radiation shielding
  - They were mounted next to vacuum window and were dosed each time the viewer was inserted
  - These eventually all failed and were replaced with CCD lipstick cameras – these are also failing depending on location
- 6 YAG Screens
- Select locations are being upgraded with telescopes to move camera away from flag (radiation source)

ITV2C00 Optical Assembly

MIRROR MOUNT
TO ADJUST
ALIGNMENT



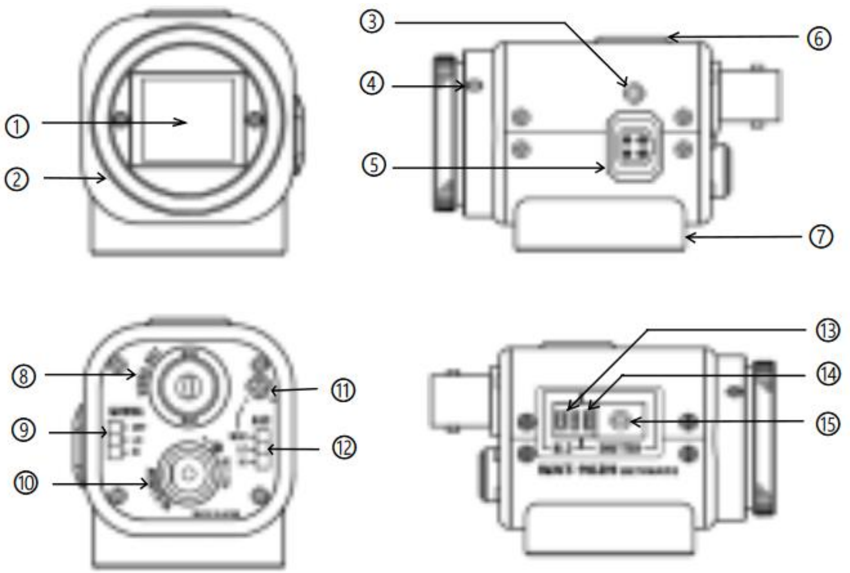
WATEC
WAT-902H2
ULTIMATE
CAMERA

LOOSEN SCREW TO MAKE
FOCUS/ROTATION
ADJUSTMENTS

TO REPLACE CAMERA JUST
UNSCREW IT FROM THE
C-MOUNT THREADS

Design in zemax by Joe Gubeli

WATEC WAT-902H2 ULTIMATE



Key Features:

- Compact design
- ½” CCD
- No OSD (On Screen Display)

Specifications

WAT-902H2 ULTIMATE

Model	WAT-902H2 ULTIMATE	
	EIA	CCIR
Pick-up Element	1/2 inch interline transfer CCD image sensor	
Unit Cell Size	8.4um(H)×9.8um(V)	8.6um(H)×8.3um(V)
Minimum Illumination	0.0001lx. F1.4	

WAT-902H3 ULTIMATE

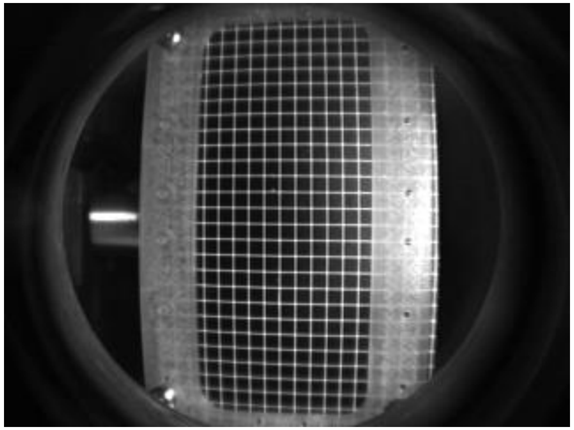
Model	WAT-902H3 ULTIMATE	
	EIA	CCIR
Pick-up Element	1/3 inch interline transfer CCD image sensor	
Unit Cell Size	6.35um(H)×7.4um(V)	6.5um(H)×6.25um(V)
Minimum Illumination	0.0002lx. F1.4	

WAT-902H2 ULTIMATE／WAT-902H3 ULTIMATE

Model		WAT-902H2 ULTIMATE	WAT-902H3 ULTIMATE
		EIA	CCIR
Number of Total Pixels		811(H)×508(V)	795(H)×596(V)
Number of Effective Pixels		768(H)×494(V)	752(H)×582(V)
Scanning System		2:1 interlace	
Sync. System		Internal	
Video Output		Composite video, 1.0V(p-p) 75Ω (Unbalanced)	
AGC	ON	HI: 5〜60dB／LO: 5〜32dB	
	OFF	5〜60dB（MGC）	
Back Light Compensation		①OFF(Default) ②Center ③Lower ④Center+Lower	
Resolution (H)		570TVL	
S/N		More than 50dB (AGC=5dB, γ off)	
Auto-iris		Video／DC (Auto-Select)	
Gamma Characteristics		HI(γ≒0.3)／LO(γ≒0.45)／OFF(γ≒1.0)	
AE Mode	OFF	1/60 sec.	1/50 sec.
	FL	1/100 sec.	1/120 sec.
	ES	1/250、1/500、1/1000、1/2000 1/5000、1/10000、1/100000 sec.	
	EI: OFF	1/60-100000 sec.	1/50-1/100000sec.
	EI: FL	1/100-100000 sec.	1/120-100000sec.
Power Supply		DC12V±10%	
Power Consumption		1.32W	
Operating Temperature		-10〜40℃	
Operating Humidity		Less than 95% RH (Without condensation)	
Storage Temperature		-30〜70℃	
Storage Humidity		Less than 95% RH (Without condensation)	
Size		35.5×40×63 (mm)	
Lens Mount		CS-mount	
Weight		98g	

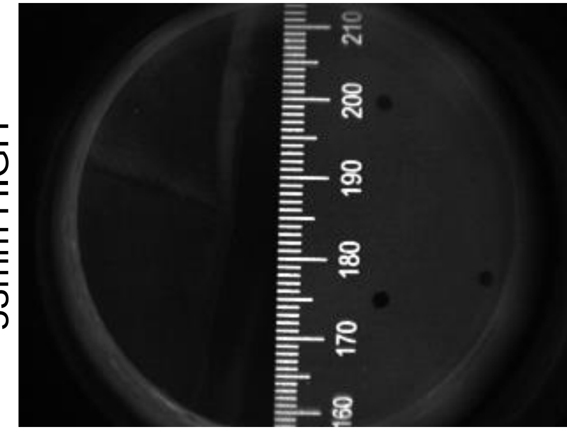
Telecentric Design; 2 Lens + Aperture

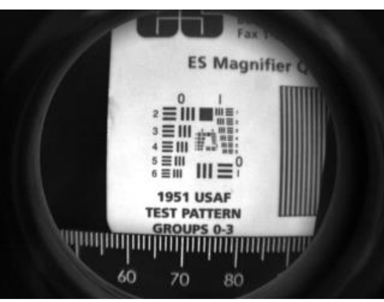
TARGET FRAME



~56mm WIDE

~53mm HIGH



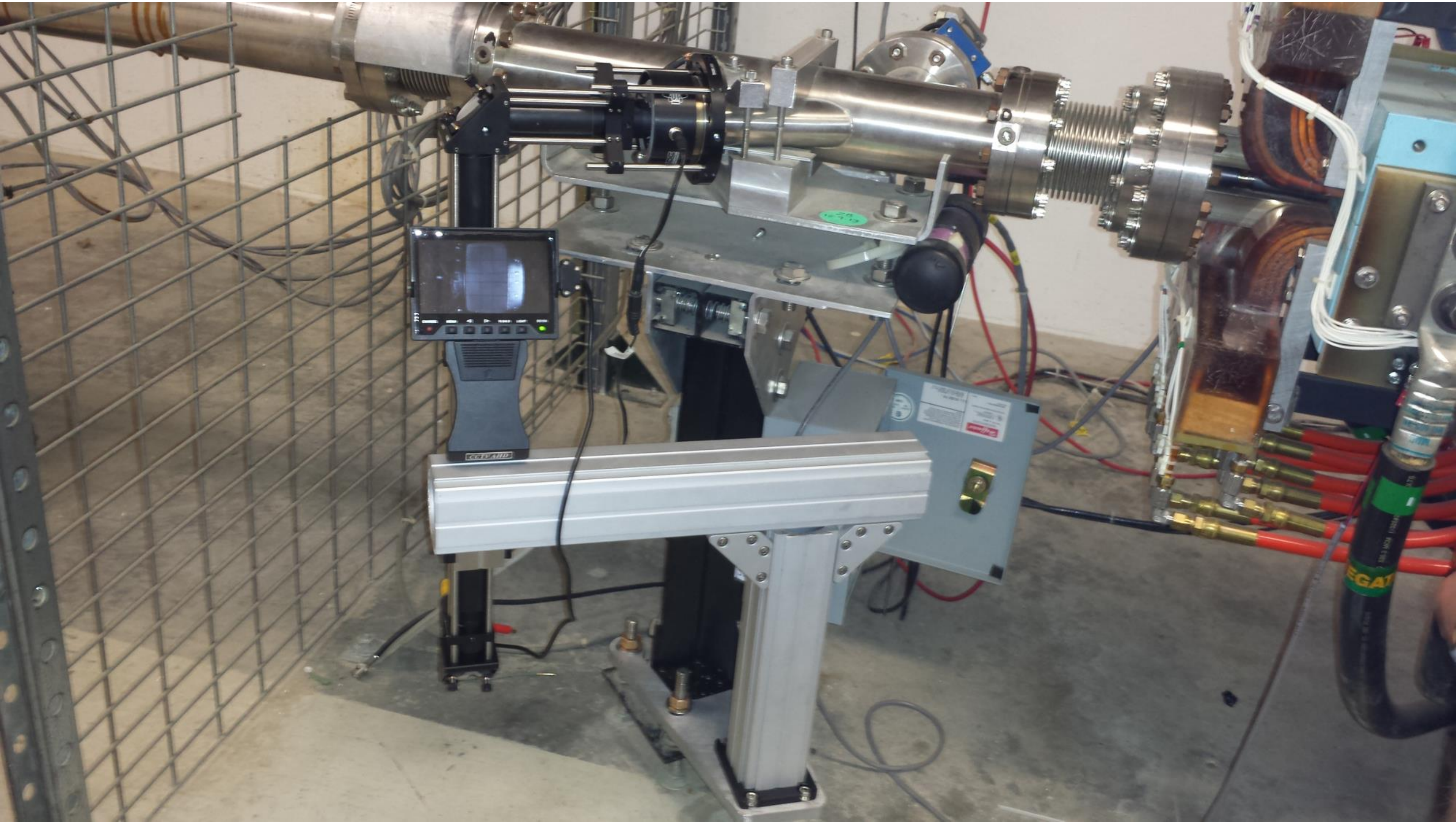


TEST PATTERN

02-06-2018 (OLD OPTICS)

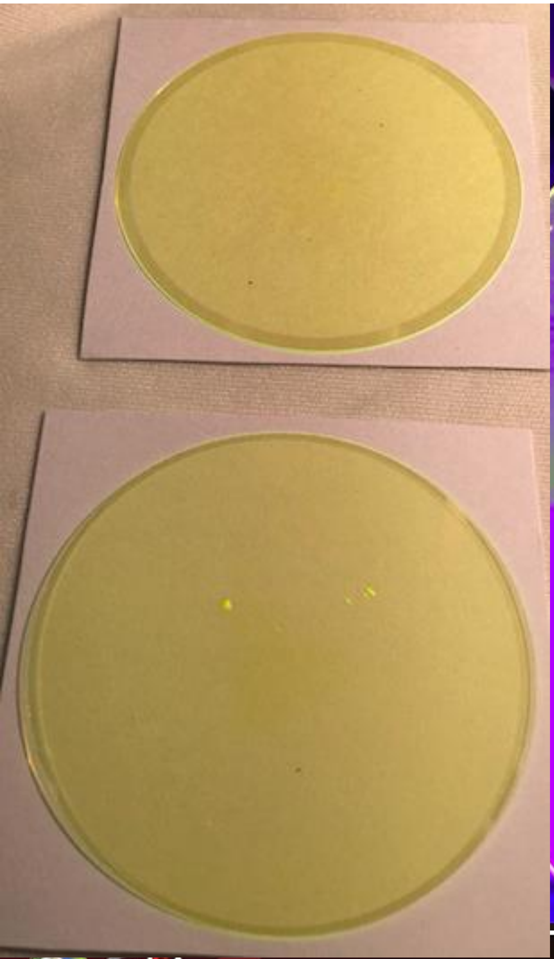
05-24-2018 (NEW OPTICS)

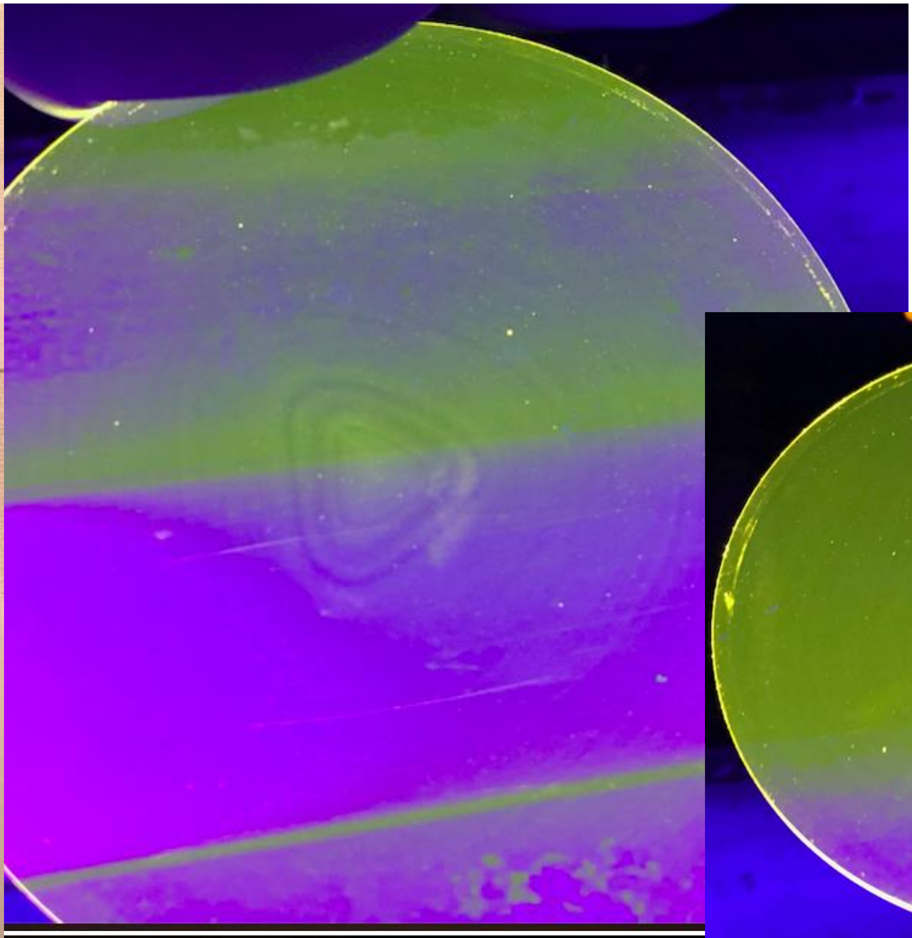
ITV2C00 New Imaging System

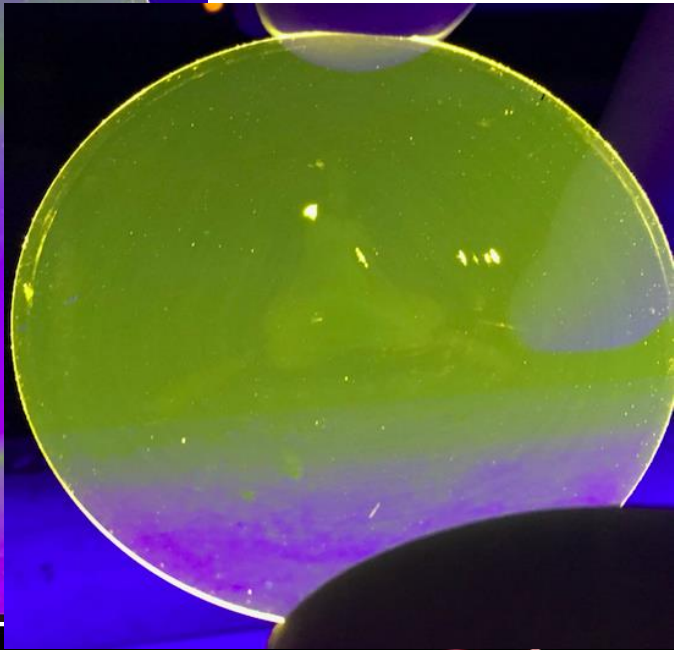


YAG Screen Damage; GTS

- Bleaching damage under UV light
  - Magnetized beam DC; 300kV few mAmps (exposure??)
  - Shadow from frame is also seen on left image







Powder Phosphor Coated Flags

CRT PHOSPHOR - TYPE QMPK58/UF-C1

YTTRIUM ALUMINIUM GALLIUM OXIDE : CERIUM
$Y_3(Al,Ga)_5O_{12}$: Ce

TEPAC-WW TYPE : P46(Ga)

PHYSICAL PROPERTIES

Material Density, g/ml : 5.2

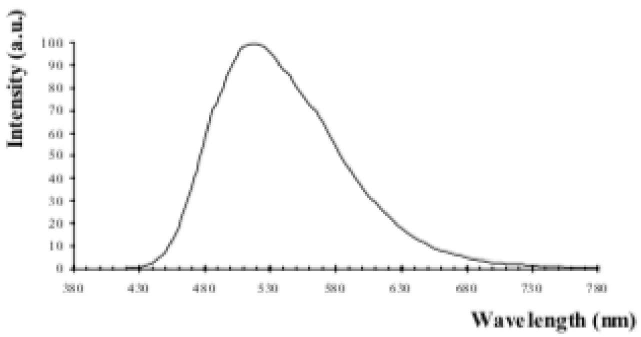
Particle size distribution - by Coulter Counter (50 µm Aperture)
Ultrasonic Dispersion. Sizes at listed Volume %

vol %	5	25	50	75	95
µm	1.1	1.8	2.5	3.3	4.2

Quartile Deviation: 0.29

OPTICAL PROPERTIES

Emission colour : Yellow-Green
Wavelength at peak, nm : 515
CIE Colour Co-ordinates : x=0.306, y=0.521
Decay Classification : Very Short



CRT PHOSPHOR - TYPE GL29/N-C1

ZINC SULPHIDE : COPPER
ZnS : Cu

TEPAC-WW TYPE : P31-GH

PHYSICAL PROPERTIES

Material Density, g/ml : 4.1

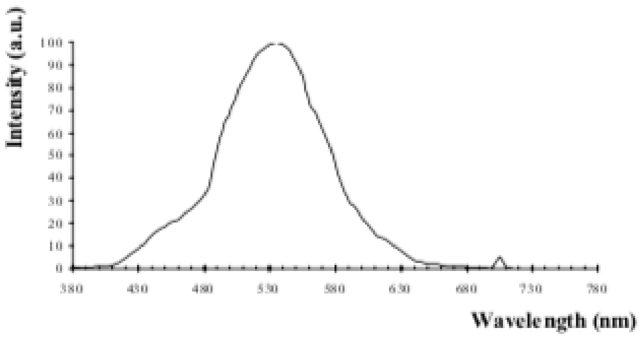
Particle size distribution - by Coulter Counter (100 µm Aperture)
Ultrasonic Dispersion. Sizes at listed Volume %

vol %	5	25	50	75	95
µm	3.1	5.6	8.0	10.0	13.4

Quartile Deviation: 0.28

OPTICAL PROPERTIES

Emission colour : Green
Wavelength at peak, nm : 530
CIE Colour Co-ordinates : x=0.287, y=0.521
Decay Classification : Medium Short



Phosphor Technologies

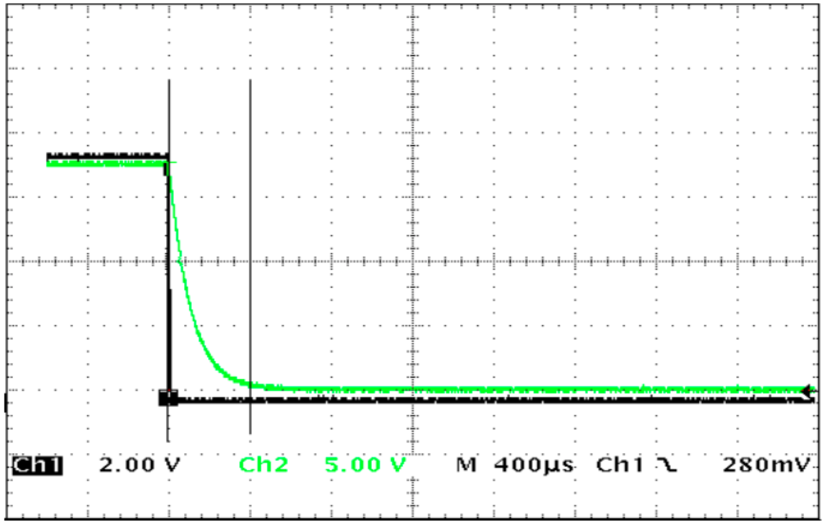
Technique was adopted from DESY, mix powder with ”Vacseal” diluted with Acetone & air brushed on Aluminum https://www.2spi.com/category/vacseal/

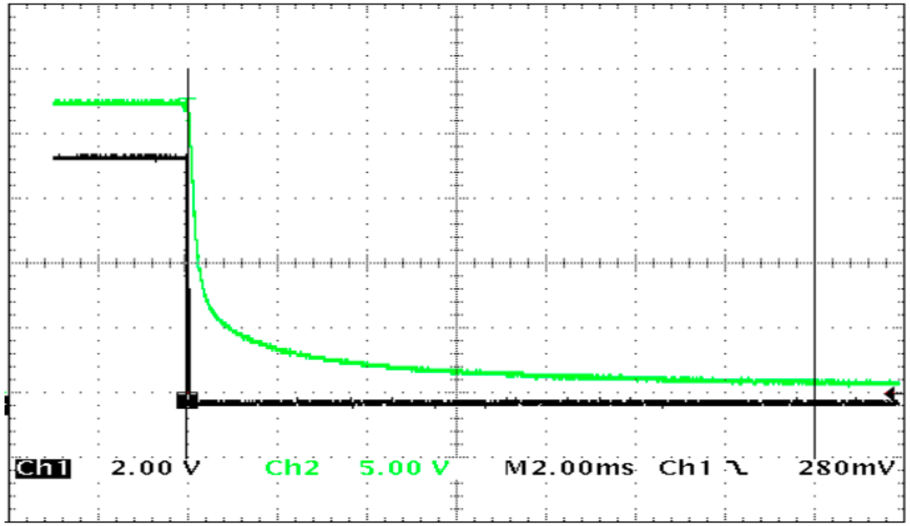
QMPK58/UF-C1

Decay time constant around 400 us. Particle size ranges from 1.1 to 4.2 microns.

GL29/N-C1

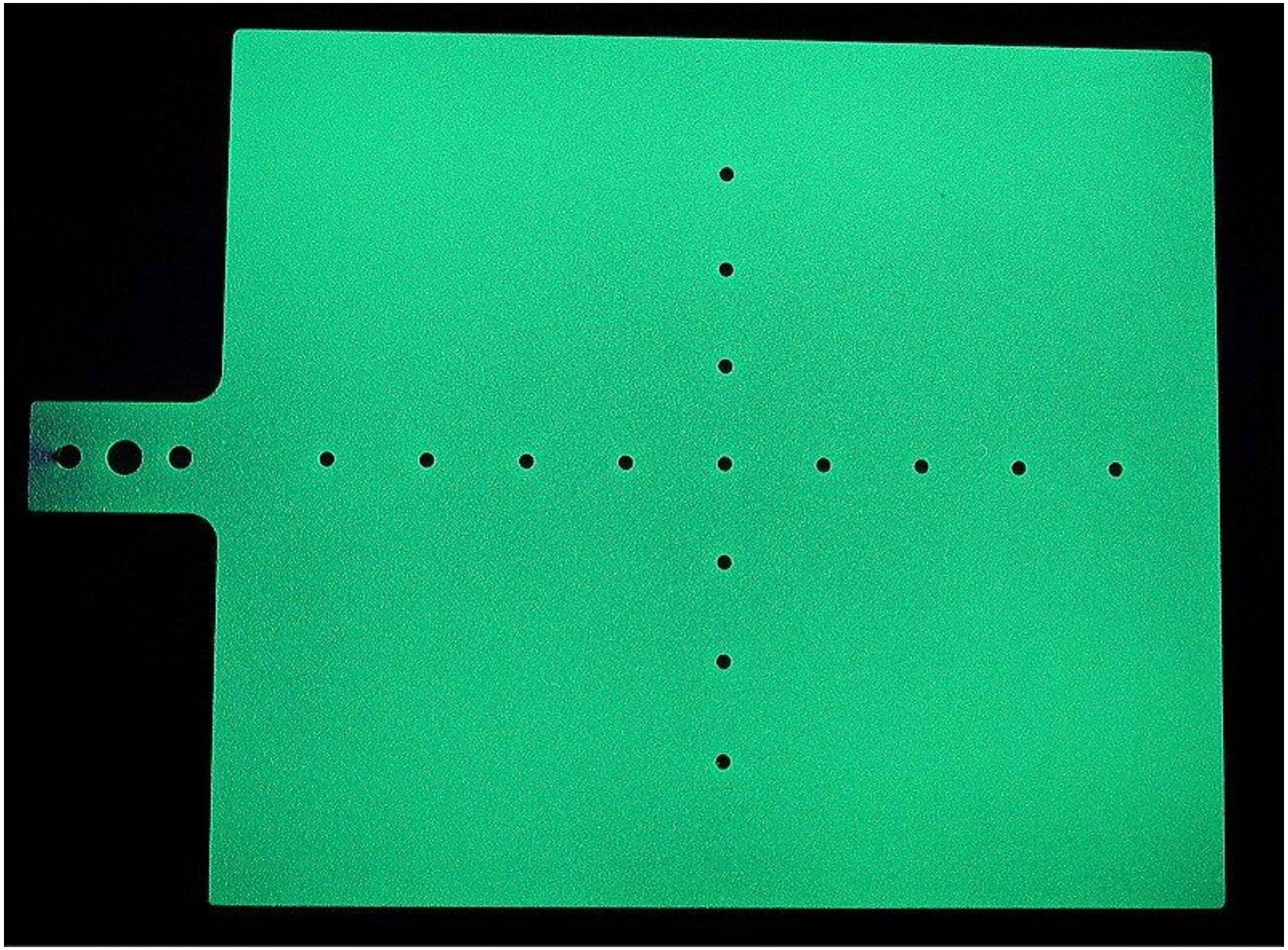
Decay time constant around 14 ms. Particle size ranges from 1.8 to 9 microns.





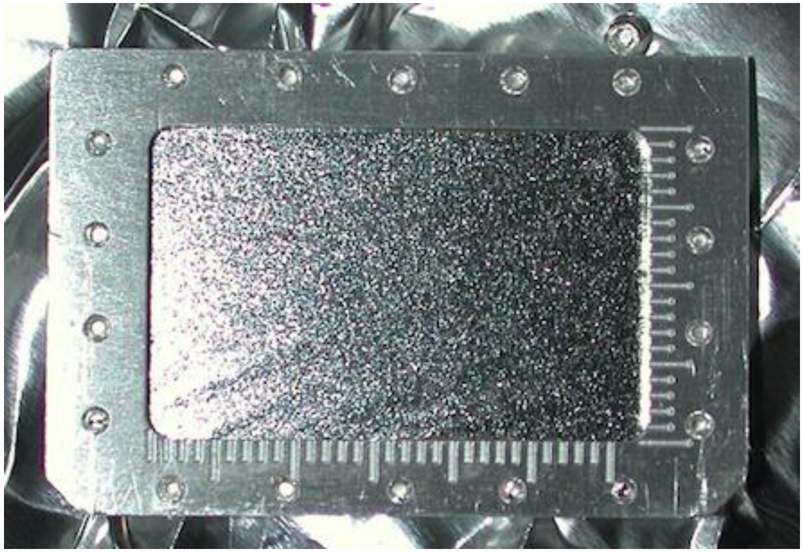
Phosphor Spray on Screens

Any geometry can be spray coated; FEL Beam Dump
~100mm Al square used to set dump raster pattern



OTR Screens

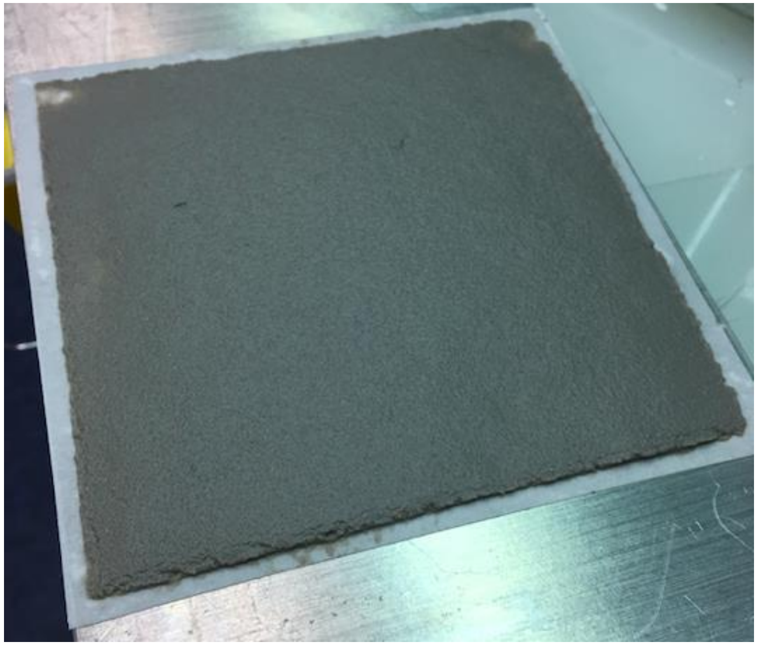
- Initial screens 10µ to 100µ Aluminum foil
  - Very rough texture, scattered 1/gamma cone
- Transitioned to optically flat surfaces
  - Needed to have better alignment!
  - Then needed to add OD 1 & 2 filter, all of light collected
- Beam tube shields used for high charge beams

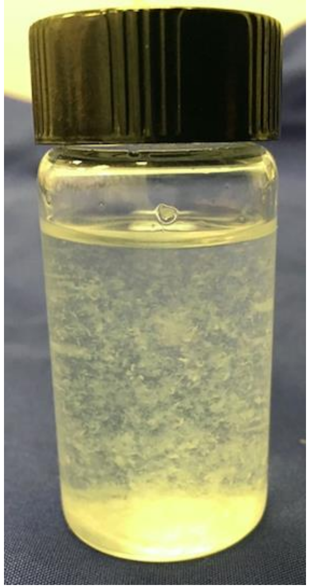


Boron Nitride Nano Tubes

Boron Nitride Nano Tube Bucky Paper

- Stable to 1000˚C in air
- Electrically insulating
- Band Gap 5.7 eV
- Good thermal conductor
- Many properties yet to be know & understood!

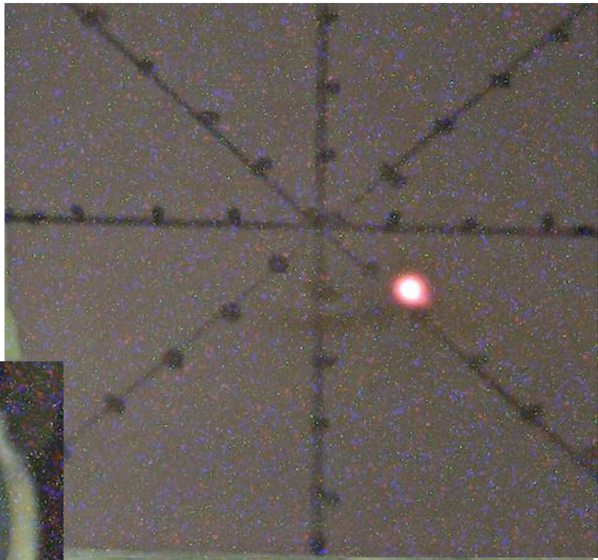


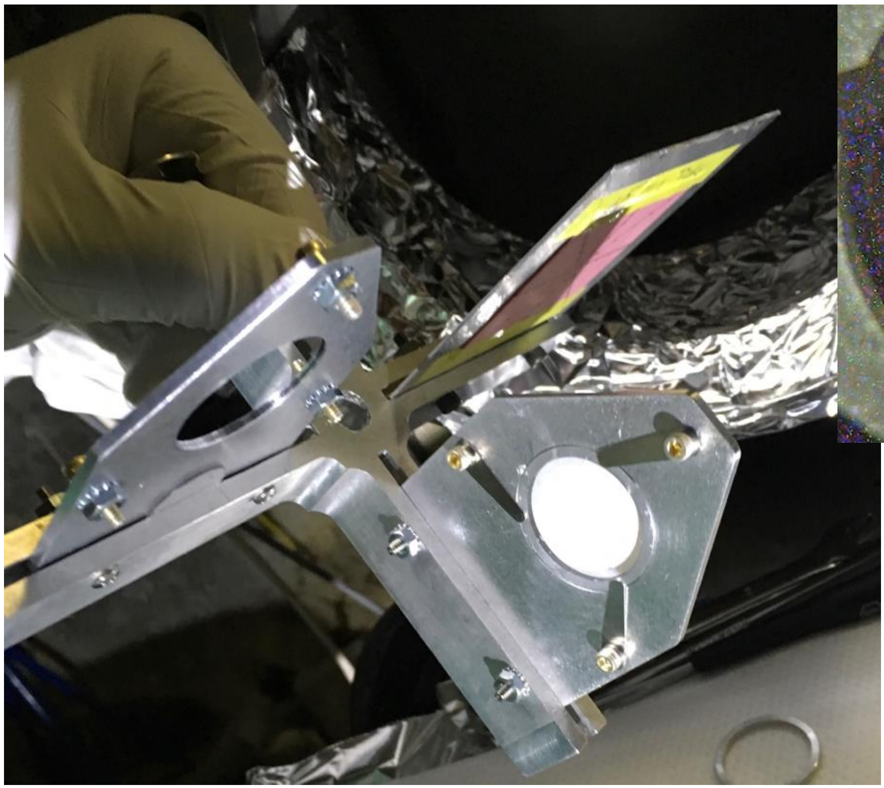


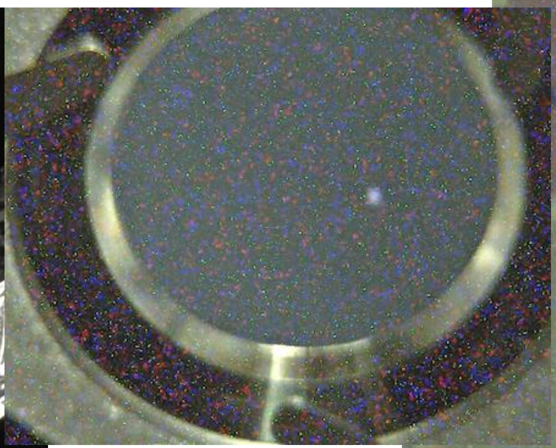
- Disperse BNNT
- Vacuum filtrate to mat
- Press mat; 20µ to 50µ
- Vacuum bake
- Mount in frame

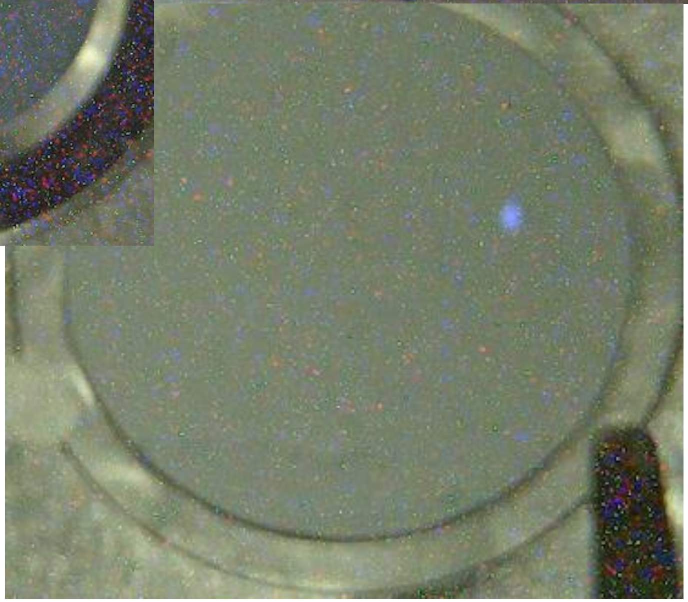
Boron Nitride Nano Tube Screens

- Hall B dump beam; 11 GeV, 40 nAmp
- Comparison of YAG (right), OTR (mid), and BNNT (lower)
  - Caveat OTR may not be well aligned



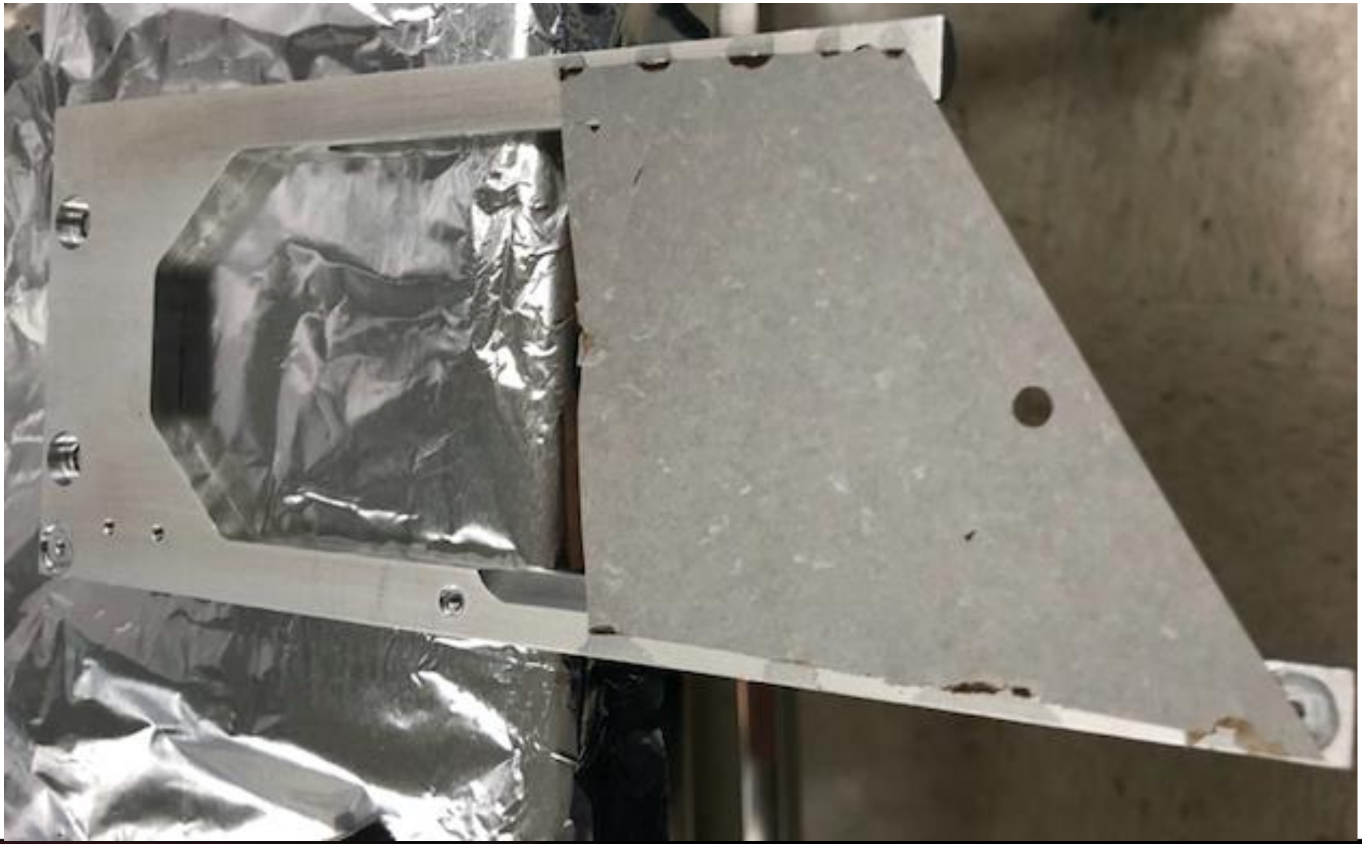






BNNT Halo Monitor Experiment

- One experiment will look for emission slope changes with fast photodiode to distinguish OTR (prompt) vs scintillation (slower decay)
- Also measure emission spectrum



Conclusion / Outlook

- YAG screens work very well for most applications
- Spray on phosphor screens are very convenient
  - Especially for unusual shapes
- BNNT is interesting new material
  - Mechanism (scintillation/OTR) in research stage
  - May be unique solution for radiation resistant & high power applications
  - Experiments done from 300kV to 11 GeV electrons
- A warm thanks to organizing committee and to ARIES for their support in the interesting workshop!!!