ET Enterprises Ltd

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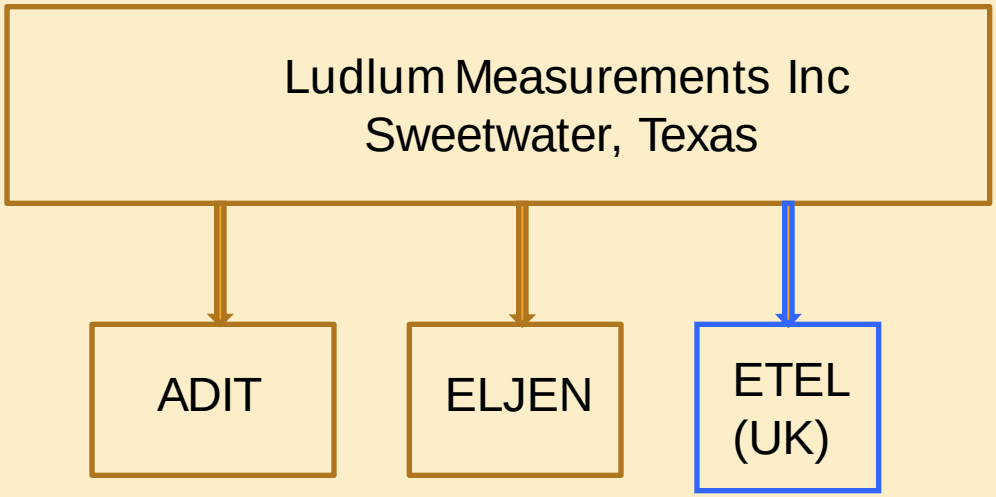
ET Enterprises electron tubes

Background on the Ludlum Group



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Ludlum Company Overview

In Business since 1962

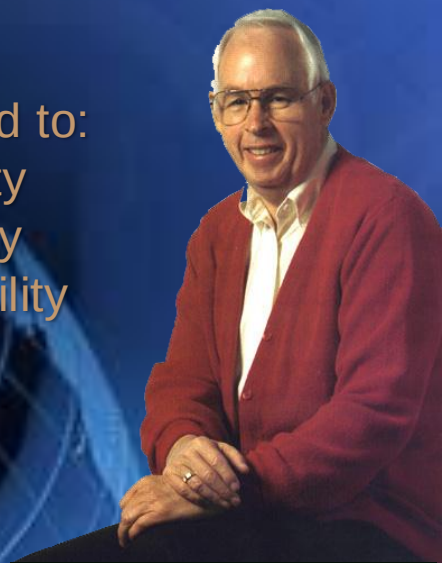
Almost 500 Employees

Engineering Excellence

Vertical Manufacturing

Sweetwater, Texas

Committed to:
- Reliability
- Durability
- Affordability



Don Ludlum – Founder & President

ADIT

Photomultiplier Tubes for Radiation Detection

Sweetwater, Texas

Product Lines

- Photomultiplier Tubes
- Sockets
- Bases
- Voltage Dividers

Markets Served

- Industry
- Scientific Community

www.aditpmt.com

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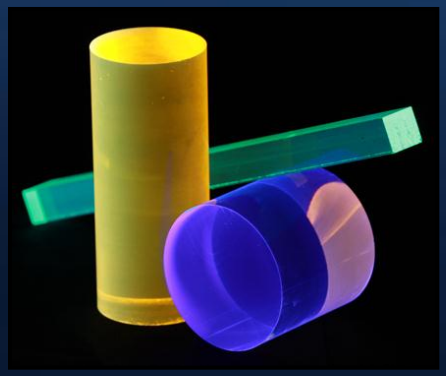
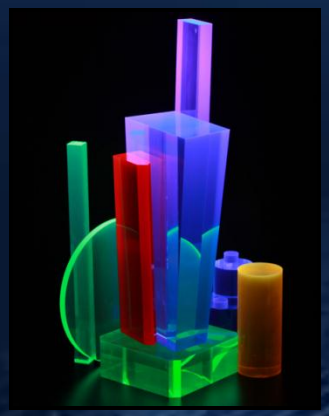
Eljen Technology

Organic Scintillators

Sweetwater, Texas





Product Lines

- Plastic Scintillators
- Liquid Scintillators
- PMMA & UVT Material
- Loaded Scintillators
- Paints
- Neutron Detectors
- Wave Shifting Plastics
- Zinc Sulfide Shifting Plastics
- Optical Cement, Greases, Adhesives etc.

Markets Served

- Industry
- Research

www.eljentechnology.com

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ET Enterprises electron tubes

Photomultiplier manufacturing

ET Enterprises, UK

- Pmts for specialist applications
- 19 mm to 225 mm diameter
- QE to 30%
- Low dark noise for photon counting
- High SER p/v

ADIT, US

- Pmts for industrial applications
- 13 mm to 135 mm diameter
- Plastic, inorganic, and photon counting

Additional manufacturing facility being prepared

Flexible dual site manufacturing for high volumes

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Specific requirements for the PMT design

- 3” (76 mm) diameter
- Very short length of 103.5 mm
- Low transit time jitter ($\sigma < 2$ ns)
- High QE at 470 nm
- High collection efficiency
- Good cathode uniformity
- High gain capability (single photoelectron detection)
- High gain for low operating voltage
- Low dark noise

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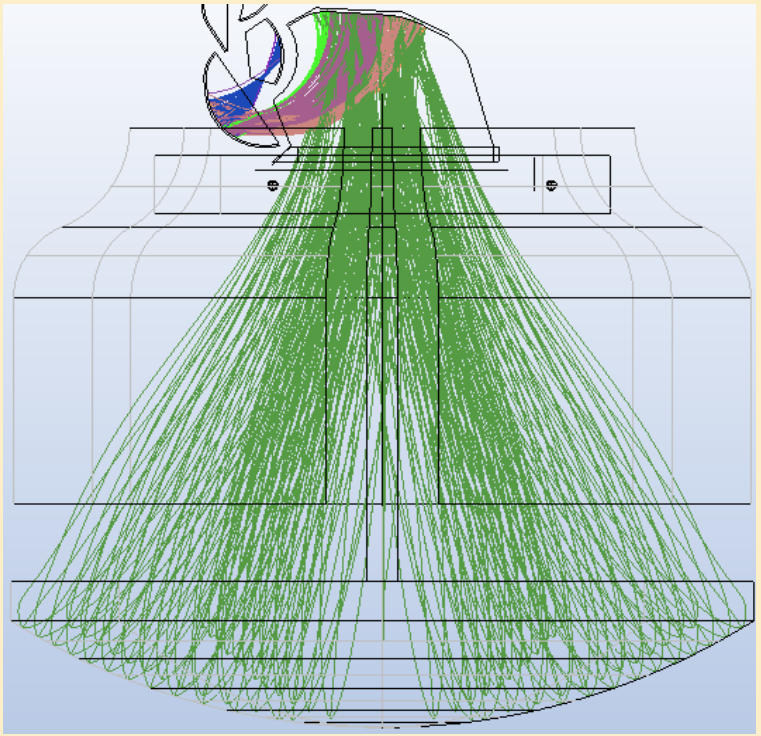
Electron optical simulation

Simulated time response

Full 3D simulation

	Overall	Sigma
k-d1	23.4	0.8
k-d2	29.5	1.6
k-d3	31.6	1.8



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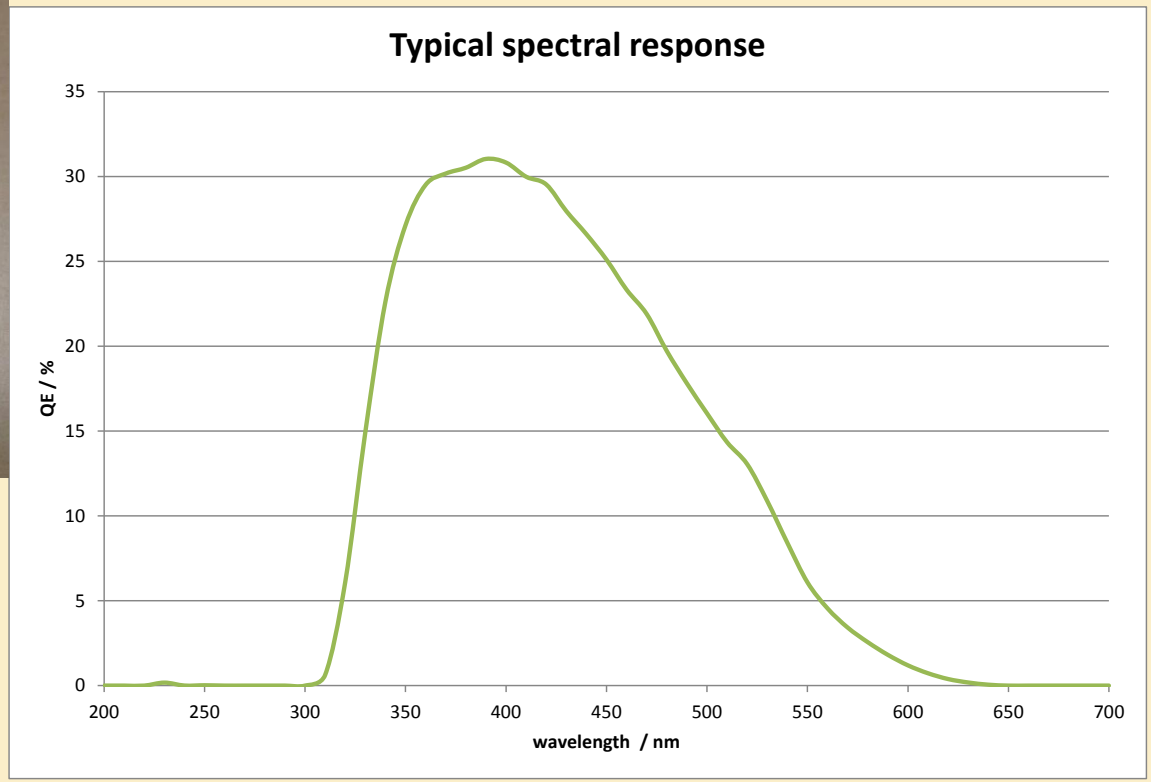
D783FL typical performance



Typical QE at 470 nm 22%

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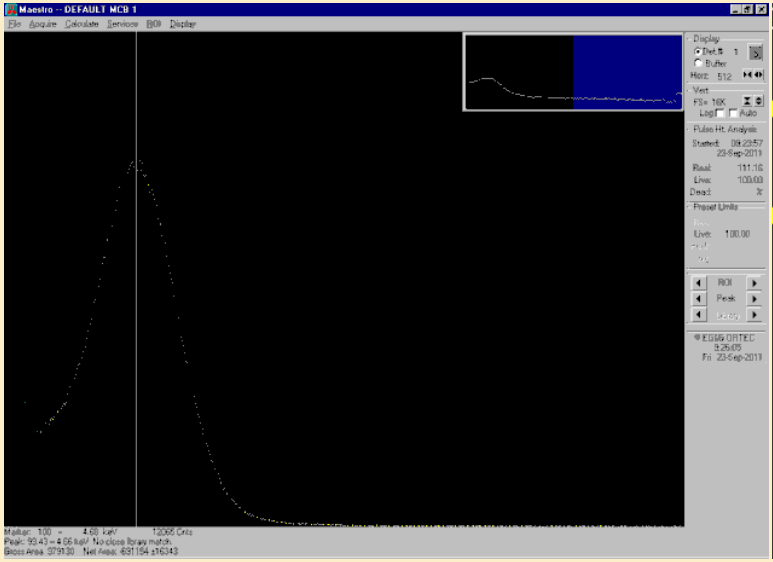
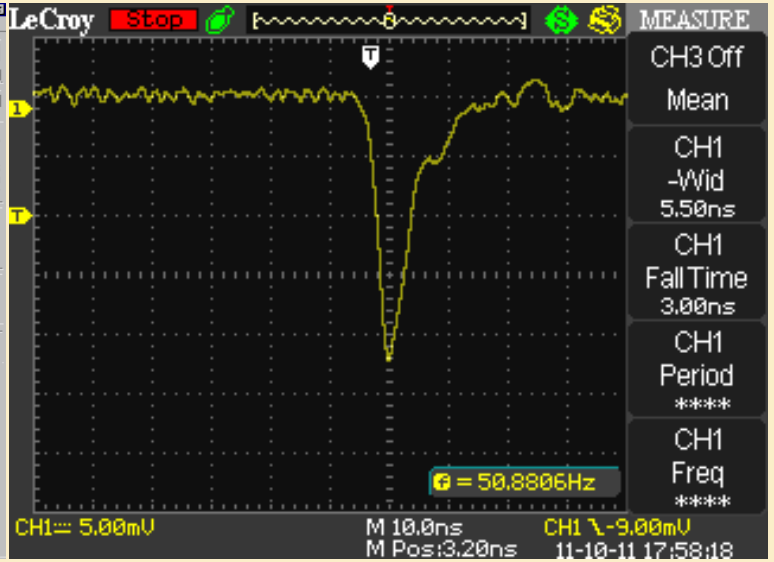
D783FL typical performance



Single photoelectron response



Single photoelectron timing

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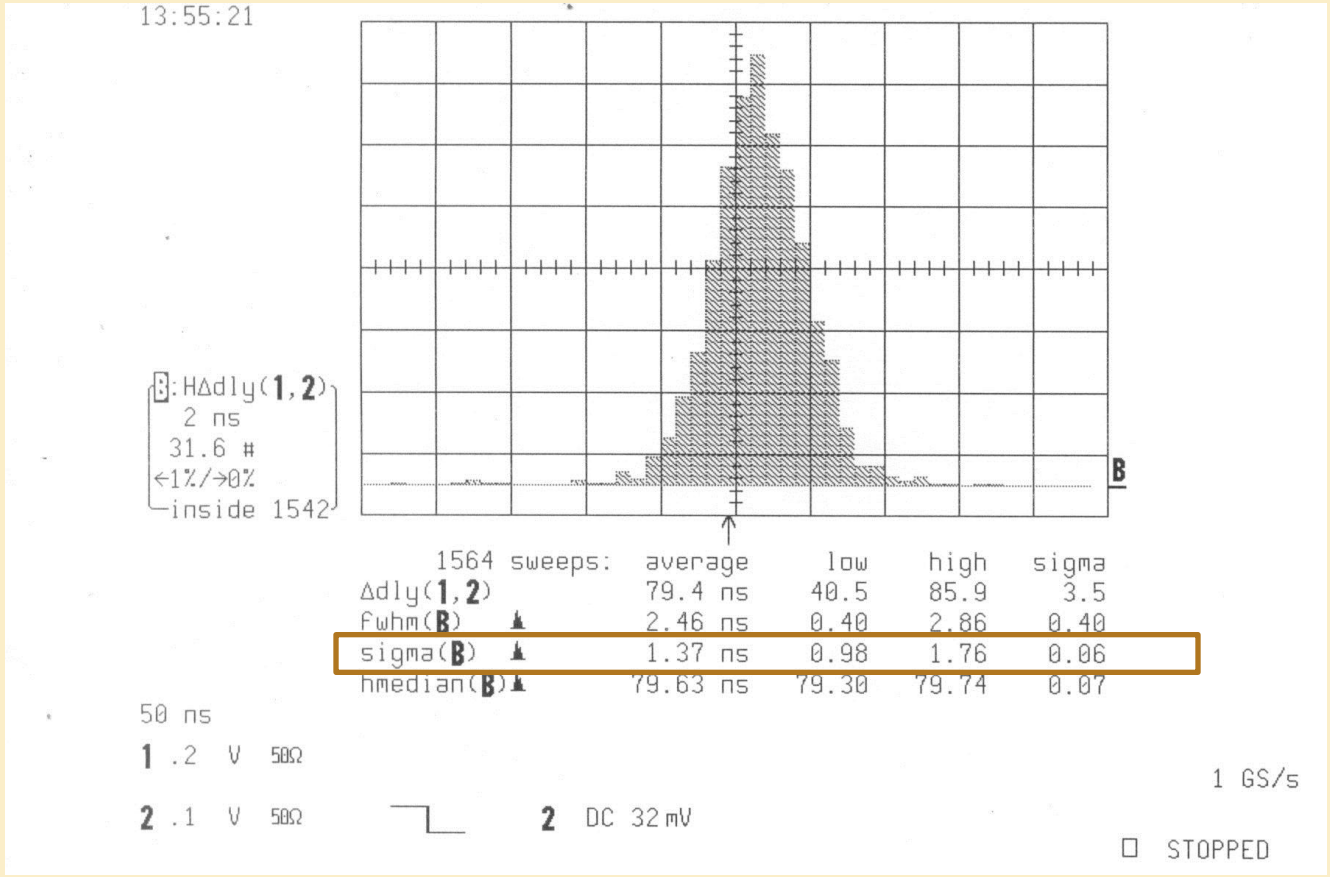
D783FL typical performance



Single photoelectron jitter less than 2 ns sigma

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Large diameter pmt range

Parameter	9372	9350	9352	9354	9357	*D784*
Diameter (in)	5	8	8	8	8	11
No. of stages	6	14	6	12	12	12
Typical operating gain	10^7	10^8	10^4	10^7	10^7	10^7
Typical QE% at peak	28	30	30	30	18	30
Surface area (cm^2)	160	425	425	425	425	*800*
Typical dark cps at 20C	1500	4000	-	4000	4000	*8000*
Typical SER ratio	1.5	1.5	-	2	2	*2*
Typical 1e TTJ fwhm(ns)	2.7	8	-	2.7	2.7	*3*
Minimum Temperature	-30C	-30C	-30C	-30C	-196C	*-30C*
Weight (grams)	380	700	700	700	700	*2000*

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Design specifications:

- External water pressure of 11 bar
- Long life in pure water
- Glass with low content of radioactive isotopes
- Design for good photoelectron collection
- Design for good timing (TTJ)

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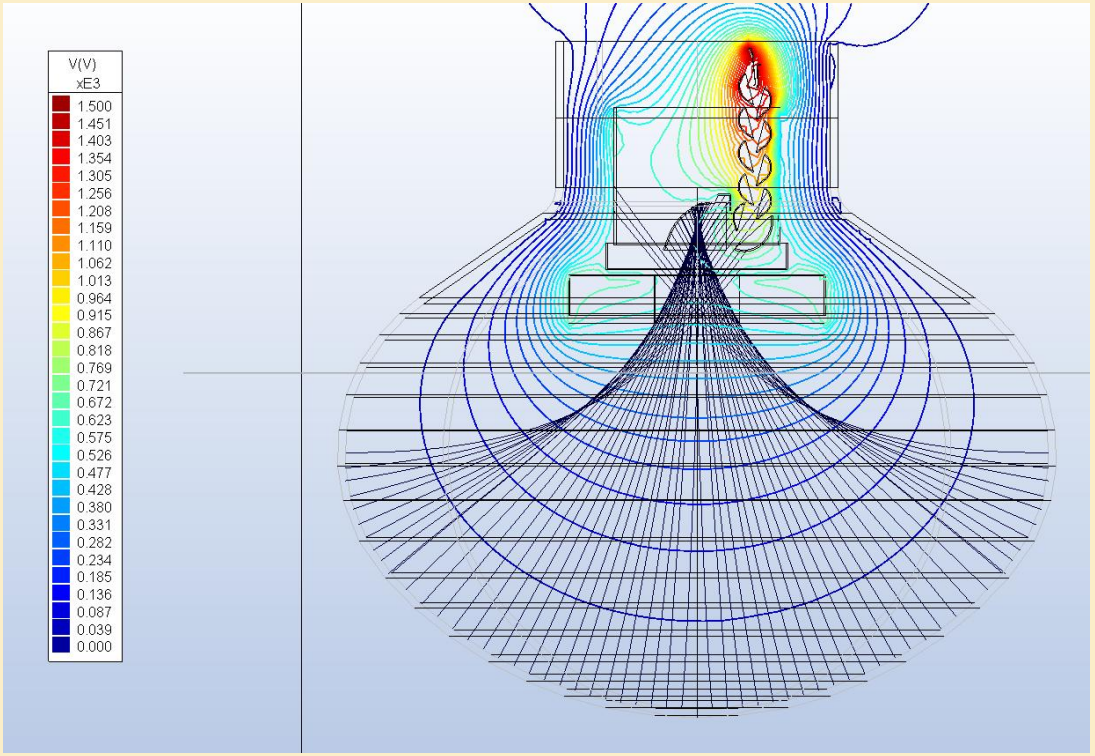
Electron optical modelling



Launch distance ⊥ to tube axis (mm)	k-d1 transit time (ns)
0	36.1
12	36.1
24	36.0
36	36.0
48	35.9
60	35.7
71	35.7
83	35.4
95	35.2
107	35.2
119	35.6
137	34.9

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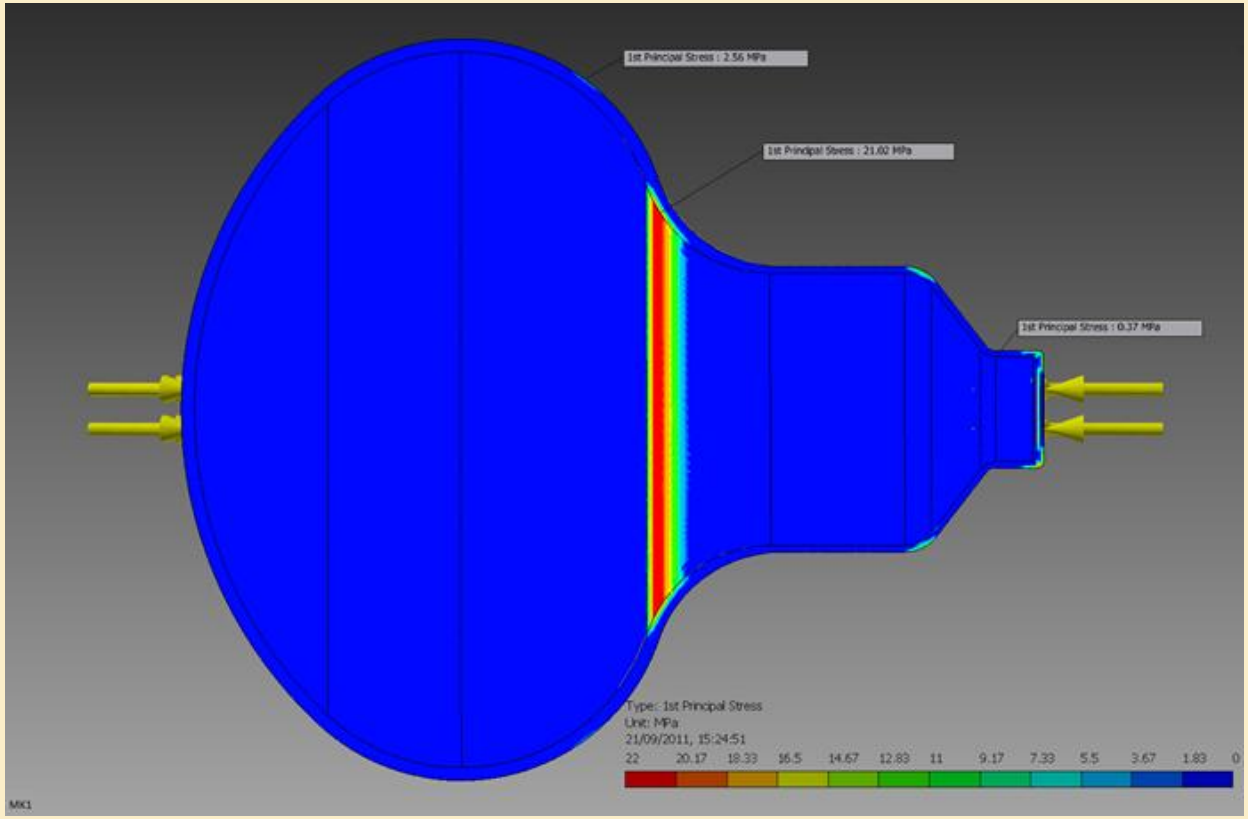
Mechanical stress analysis – Mk1 design



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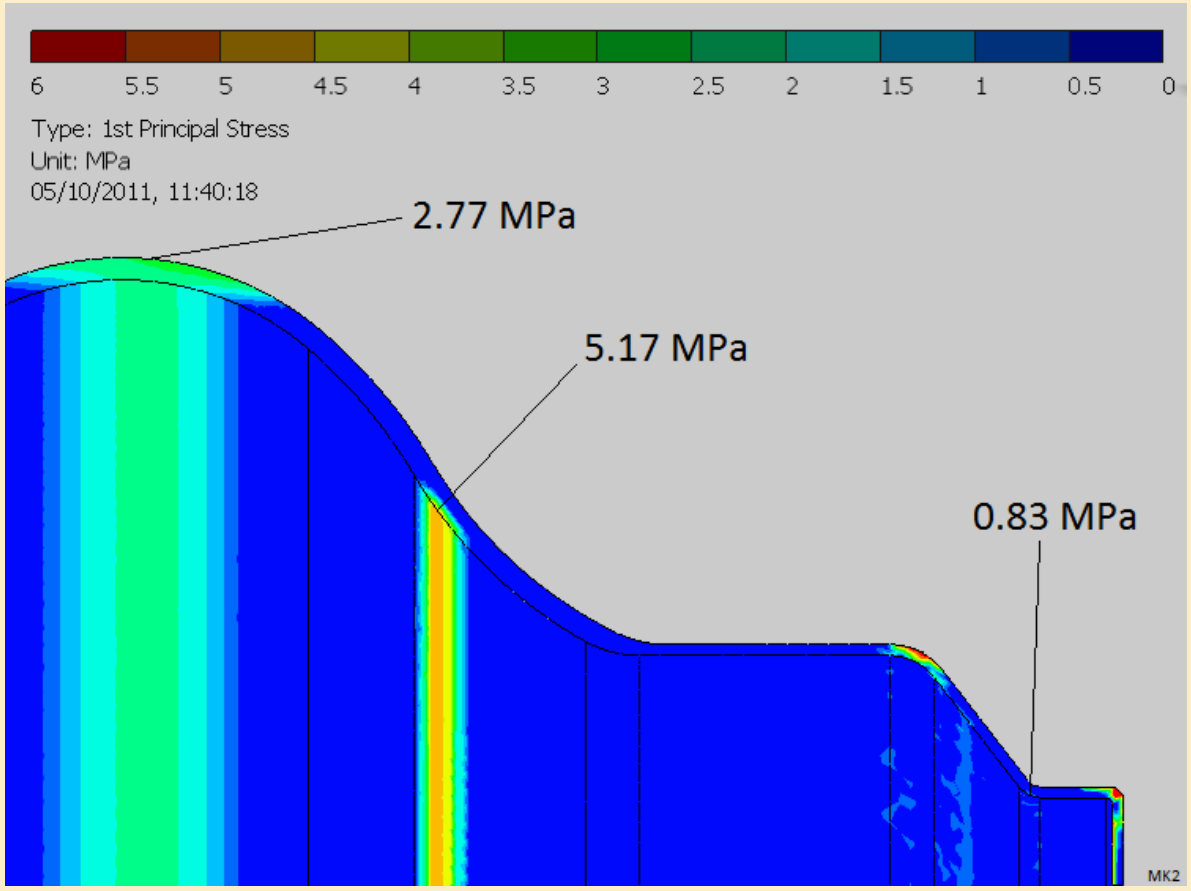
Mechanical stress analysis – Mk2 design



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Expected gamma decay rate – Mk4

UL BGD glass	Concentration
Natural potassium	60 ppm
Thorium	30 ppb
Uranium	30 ppb

Glass Activity

Glass thickness	Expected mass (g)	Gamma rate (Bq)* (60ppm K, 30ppb Th, 30ppb U)
Maximum	2,218	3.2 ± 1.7
Minimum	1,482	2.2 ± 1.1

*Estimated Gamma emission > 0.1 MeV

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Thank you

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