FERMILAB IEEE NUCLEAR & PLASMA SCIENCES SOCIETY ROME 2004 nicadd

FNAL-NICADD extruded scintillator

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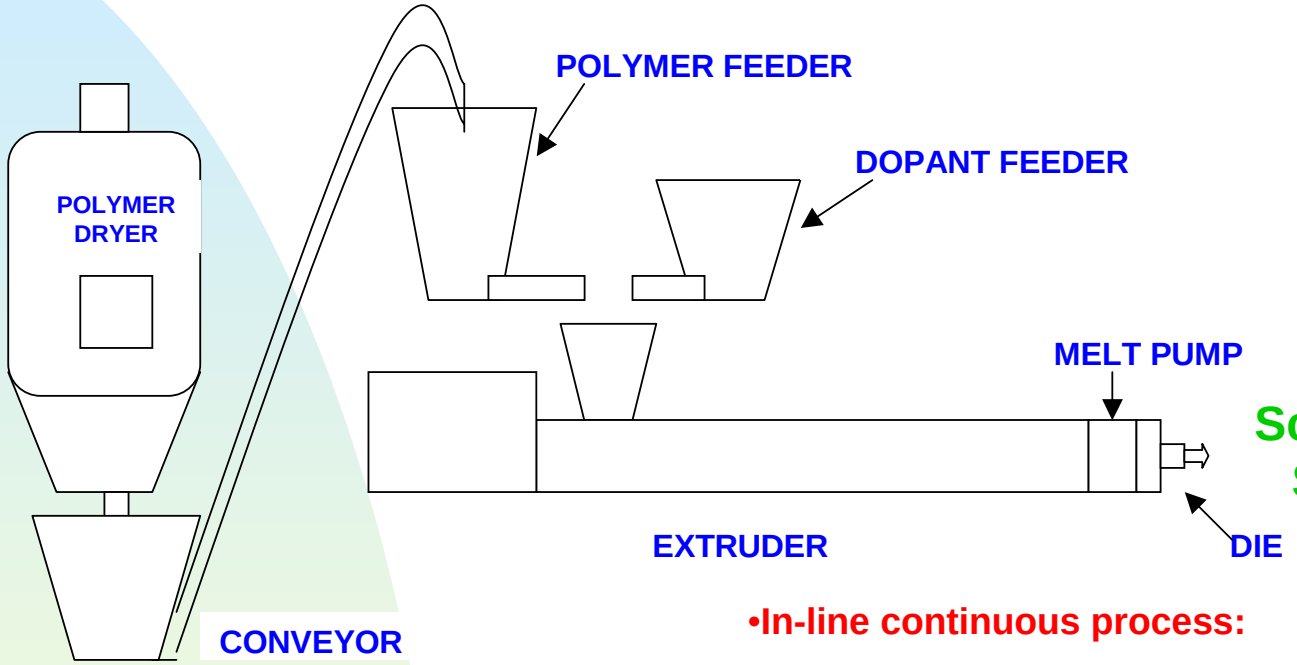
FERMILAB [1]

NICADD NIU[2]

FNAL-NICADD EXTRUSION FACILITY



OUTPUT:

Scintillating pellets
Scintillator bars

- **In-line continuous process:**
  - **Less handling of raw materials**
  - **Precise metering of feeders**
  - **Twin-screw extruder (better mixing)**
  - **Melt pump offers steady output**
  - **Control instrumentation**
- **Line under nitrogen atmosphere:**
  - **Drying under nitrogen**
  - **Each piece of equipment is purged**

ZE 40A UTS Technical Data

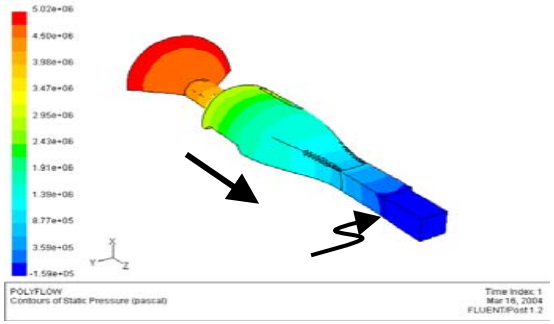
- Screw diameter — 44 mm
- Screw speed — 1200 RPM
- Drive power — 200 HP

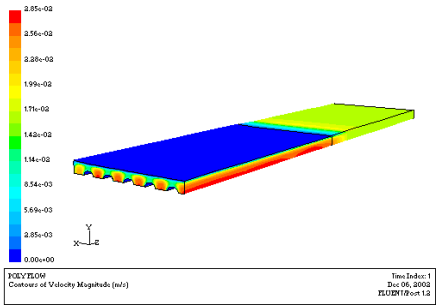
- Height — ~1100 mm
- Weight — ~3500 kg
- Theoretical life — ~40000 hours

Output range

30-200kg/h

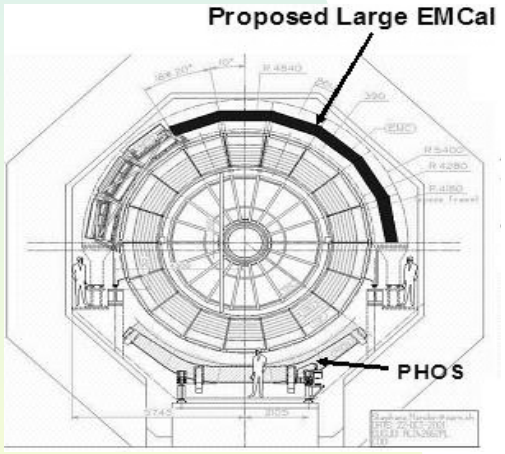
Simulation of the extrusion profiles



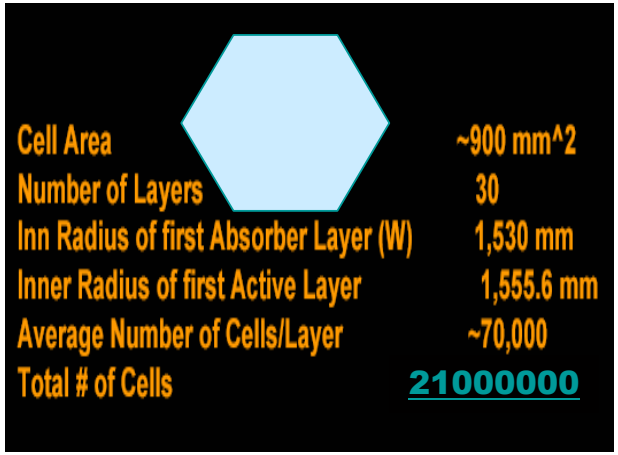


The projects on which we collaborate

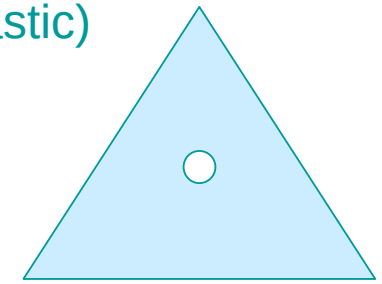
- ALICE ECAL upgrade (~15 T of extruded plastic)

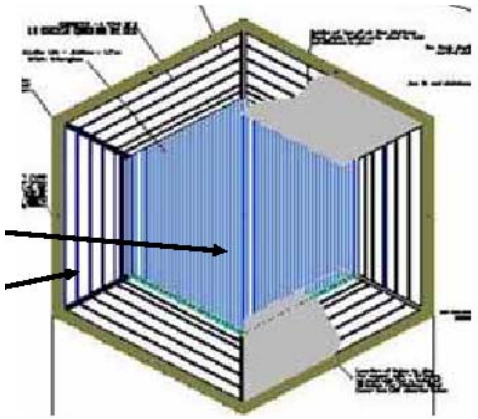


- DHCAL (~20 T)



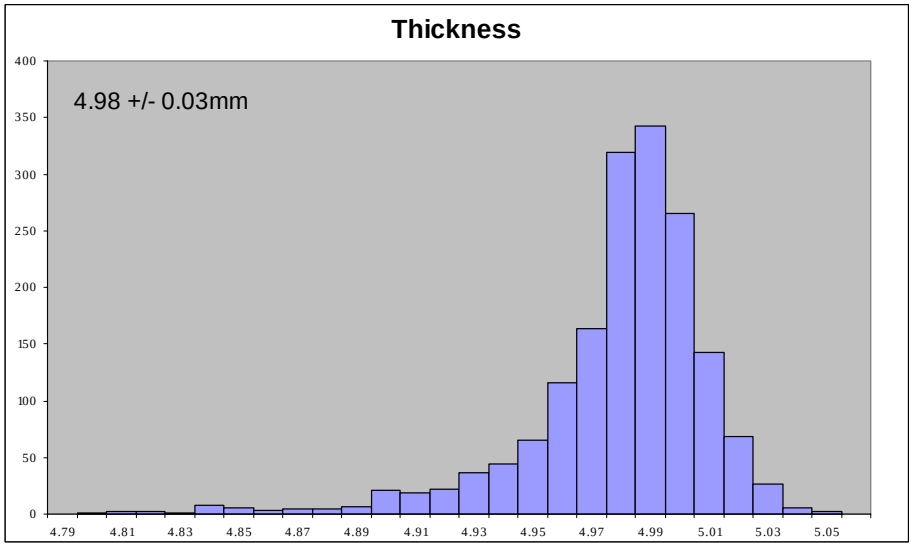
- MINERVA (~10 T of extruded plastic)

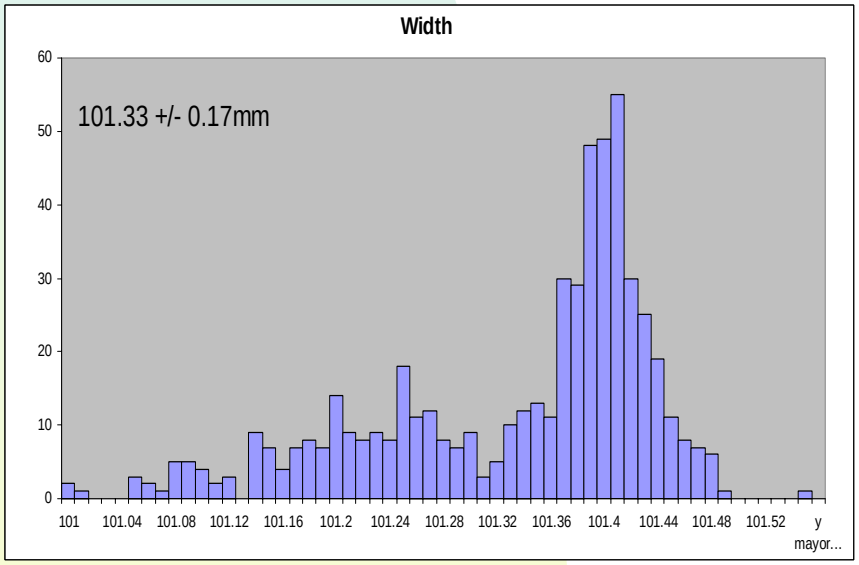




Mechanical tolerances, 300 m of extrusion profile.

Thickness 4.98±0.03 mm



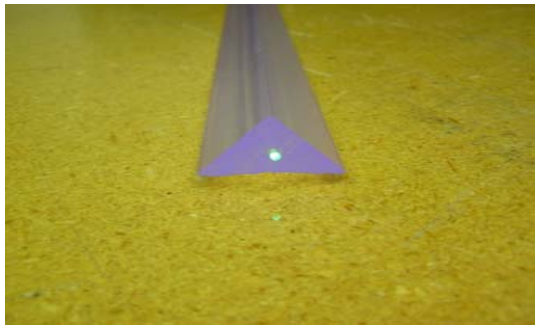


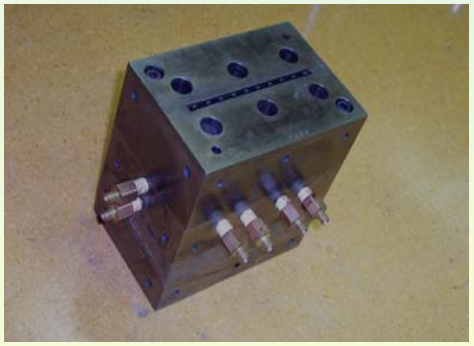
Width101.33±0.17 mm

Die impact on the scintillator profile

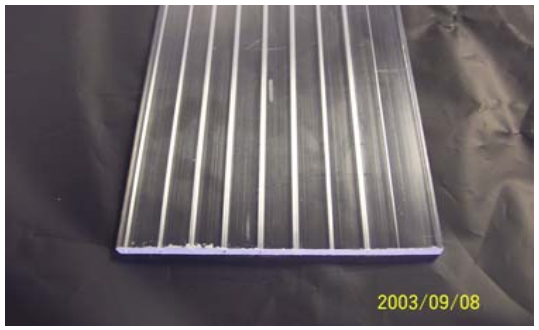
Rectangle, with or without hole to host 1.2 mm WLS fiber

Triangle, with or without hole to host 1.2 or 1.5 mm WLS fiber

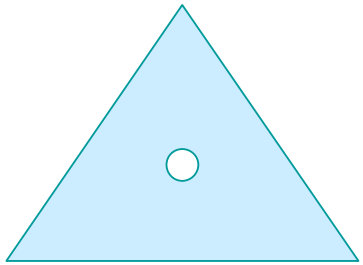




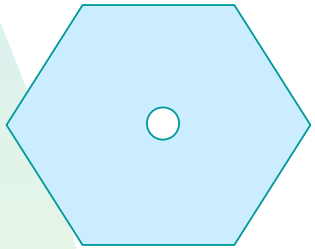
Rectangle, with 10 holes, or without them, to host 1.2 mm WLS fibers



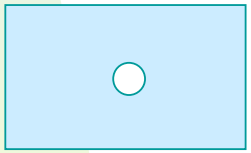
Possible shapes of the extrusion process



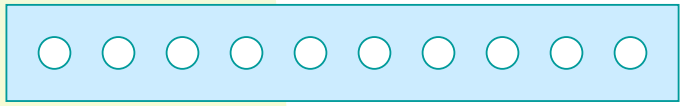
MINERVA, D0 approach, gives very good coordinate resolution, die is at our disposal(base 3.3 cm, height 1.7cm)



Calorimeter applications, die is not available.

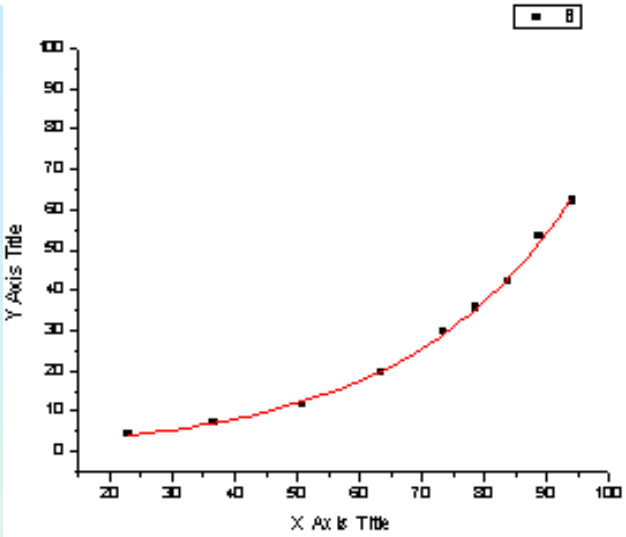


K2K solution, the die is available(2cm*1cm)



Imagination is limited by the fiber cost, the die is in our disposal(10cm*0.5cm)

Light attenuation length(short component)

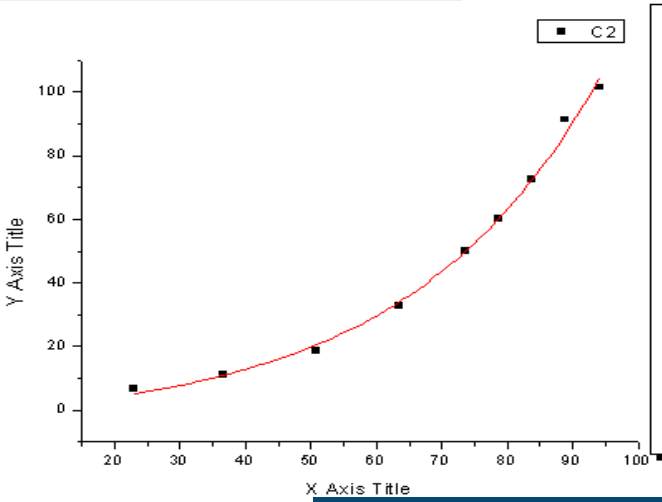


Data: Data1_B
Model: ExpDec2
Equation: y = A1*exp(-x/t1) + A2*exp(-x/t2) + y0
Weighting:
y No weighting

Chi^2/DoF = 1.20041
R^2 = 0.99858

y0	-0.58879	±--
A1	0.9824	±--
t1	-27.06481	±--
A2	0.9824	±--
t2	-27.06482	±--

Attenuation Length
L=27.1 cm (No-Tyvek)



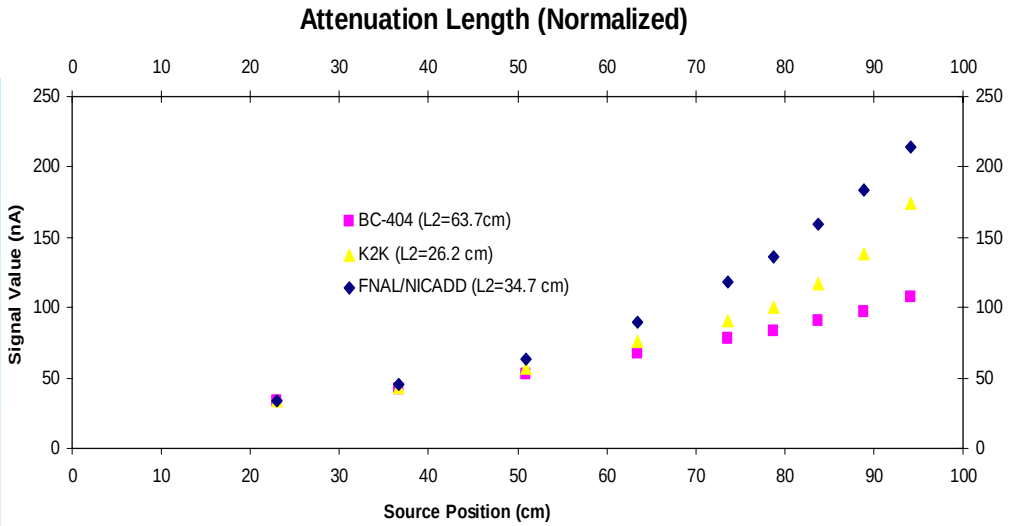
Data: Data1_C2
Model: ExpDec2
Equation: y = A1*exp(-x/t1) + A2*exp(-x/t2) + y0
Weighting:
y No weighting

Chi^2/DoF = 9.35515
R^2 = 0.99612

y0	-4.58359	±4.63456
A1	2.22998	±--
t1	-29.4206	±--
A2	2.22998	±--
t2	-29.4206	±--

Attenuation Length
L=29.4 cm (with Tyvek)

Light attenuation length



1. **Samples are cut to the same size(2*0.5*100 cm)**
2. **All edges are polished to the same level**
3. **Far end is painted black**
4. **The samples are wrapped in the same Tyvek.**

Different sizes and wrappings

Type:	Wrapping:	End:	Polished:	L1 (Long):	L2 (Short):
FNAL (2x1 cm)	Tyvek	Black (Taped)	No	46.3 cm	36.5 cm
K2K (2x1 cm)	Co-extrusion	Black (Taped)	No	16.3	7.9 cm
K2K (2x0.5cm)	Tyvek	Black (Painted)	Yes (All edges)	53.8 cm	26.2
FNAL (2x0.5cm)	Tyvek	Black (Painted)	Yes (All Edges)	44.6 cm	34.7
BC404 (2x0.5cm)	Tyvek	Black (Painted)	Yes (All Edges)	64.5cm	63.7

Light output

BC408	**2.70 ± 0.25**
F-NICADD	**2.01 ± 0.30**
Kuraray SCSN-81	**2.03 ± 0.21**

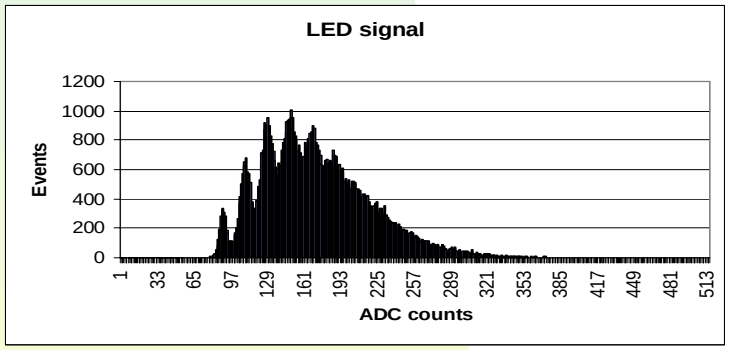
⟺

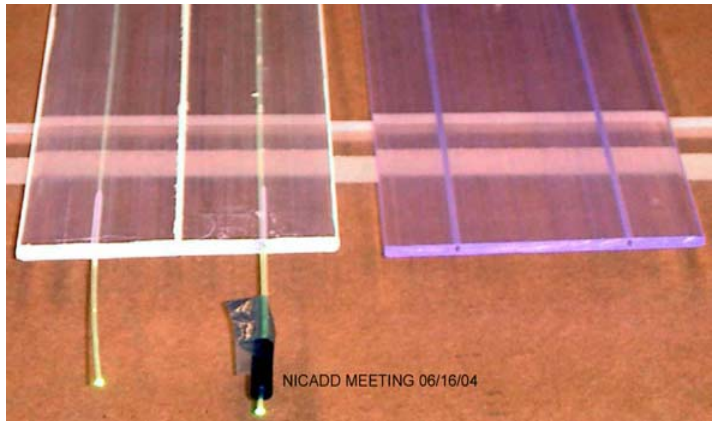
Samples 2*2 cm²

^{106}Ru

Normalized to the thickness of 1 mm

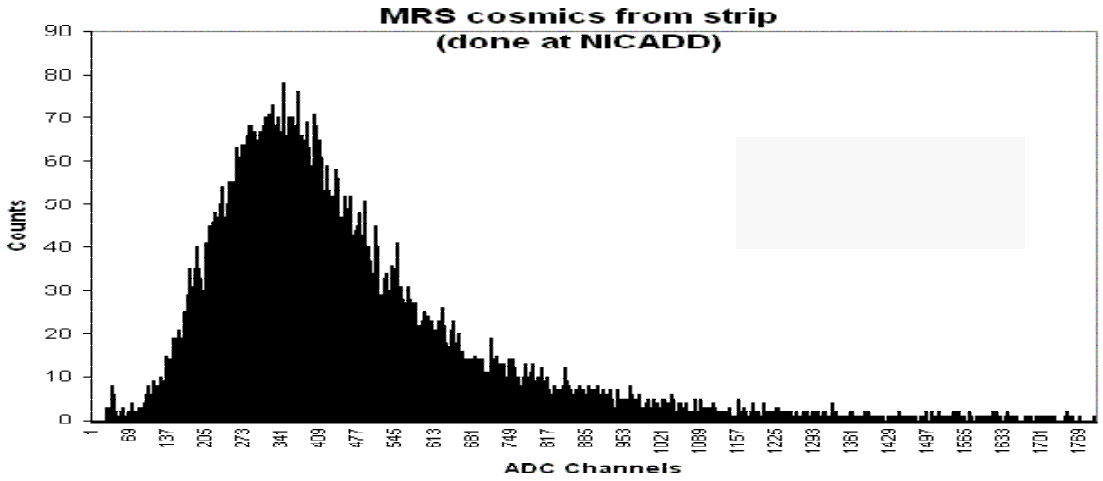
5 mm extruded scintillator thickness, extruded hole,1.2 mm Y11 fiber, 10 cm out of scintillator, MRS readout ~ **17 PE**



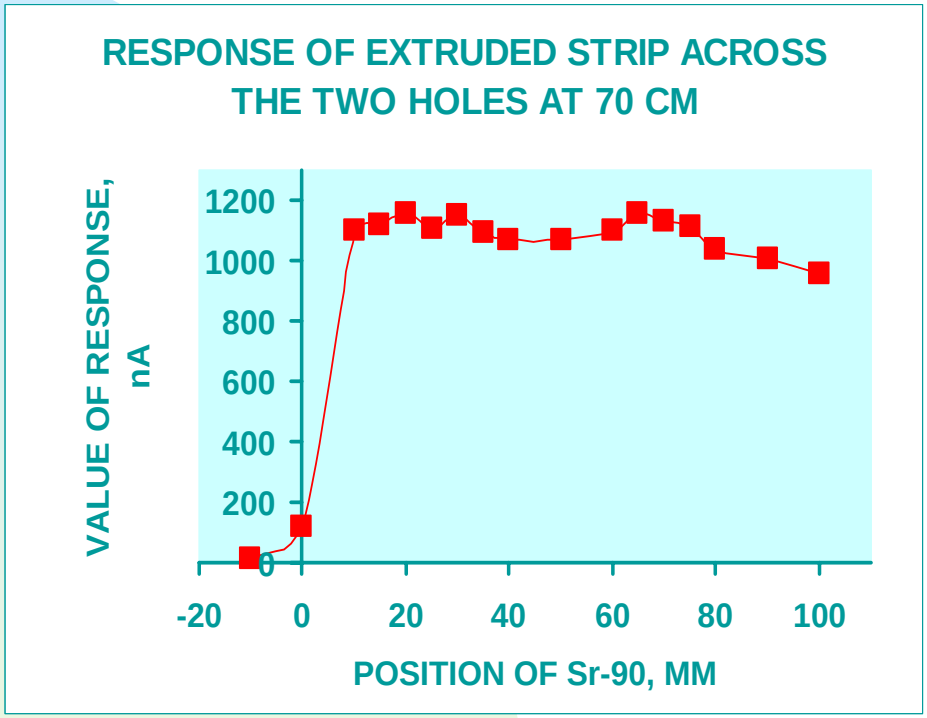


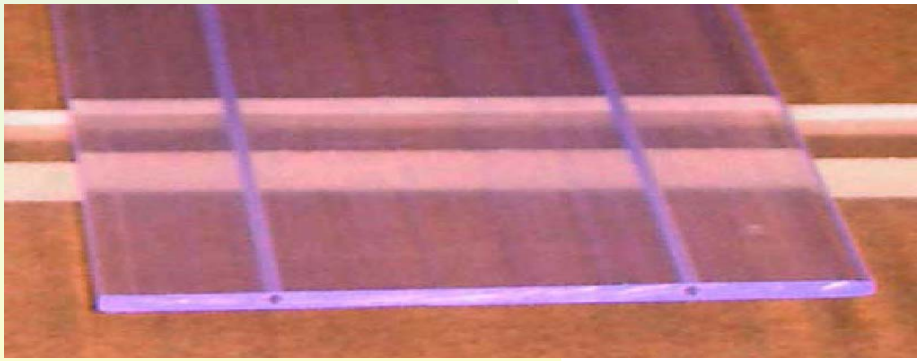
Light output (MRS Readout, 1*1 mm)

WLS FIBER DIAMETER [MM]	SCINTILLATOR THICKNESS [MM]	RESPONSE [PE]
1.00(hole+glue)	5	14.5
1.20(hole+glue)	5	17.0
1.50(hole+glue)	5	20.5
1.20(groove+glue)	10	22.1

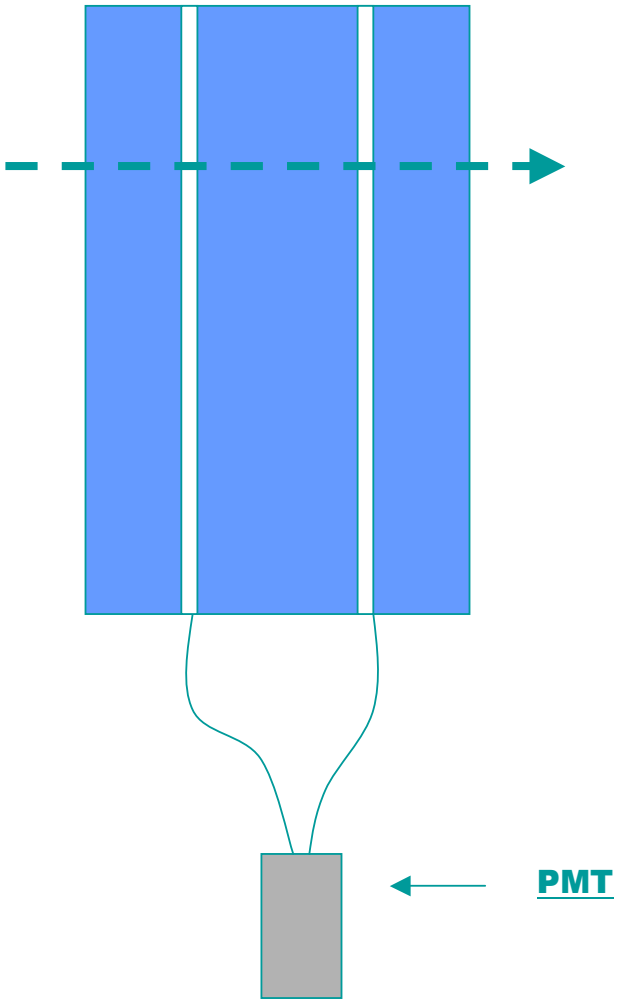


Light yield uniformity response

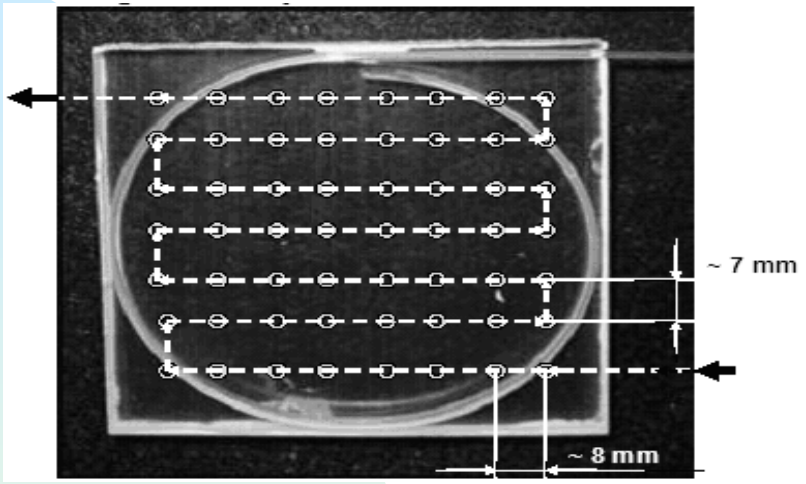




Uniformity LY σ ~ 4 % NICADD (10 cm)

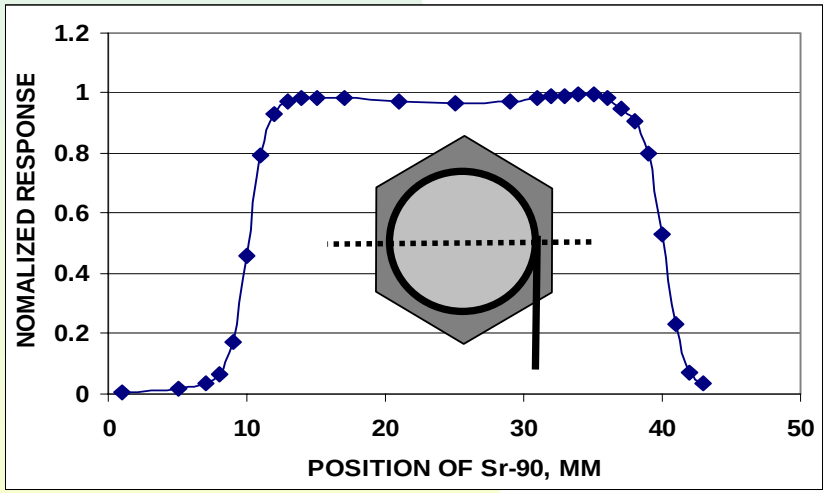


Light yield uniformity response



Uniformity LY σ ~ 2.2 % F-NICADD (10*10 cm²)

σ ~ 2.3 % (10*10 cm² SCSN-81)



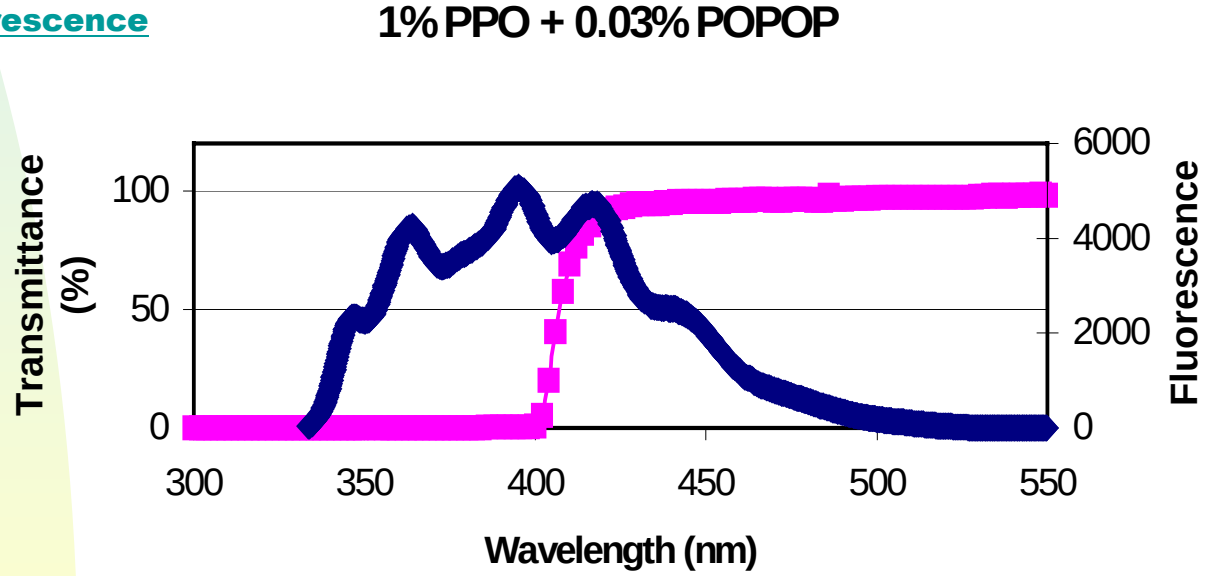
Uniformity LY < 3 % 9 cm² HEX. Cell for DHCAL

Radiation hardness

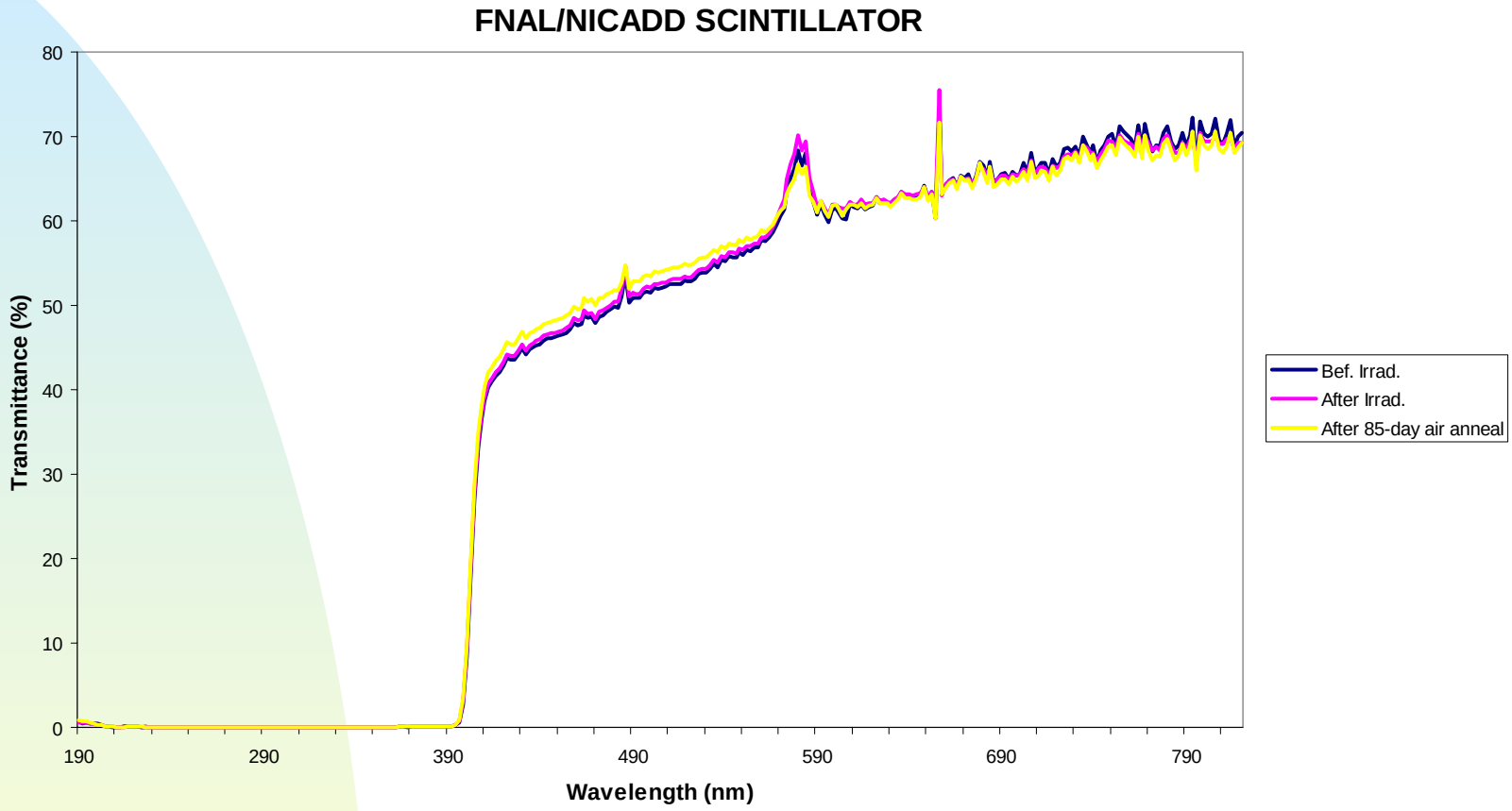
FNAL-NICADD extruded scintillator, 18 samples of 2*2 cm², Irradiation in air and annealing in air during 85 days, 9KGy/h).

Dose absorbed γ, ^{60}Co	Before Irradiation (ADC counts)	After irradiation and anneal (ADC counts)	Light yield loss
0.5 Mrad (5KGy)	264±8.6	266±7.7	
1 Mrad (10KGy)	273±5.8	261±7.1	5 %

FNAL-NICADD extruded scintillator, Transmittance and Fluorescence



Transmittance



Brief summary of the FNAL-NICADD extruded scintillator characteristics.

Thickness σ ~ 0.6 % (Over 300 m)
Width σ ~ 0.2 % (Over 300 m)

Uniformity LY σ ~ 4 % (across 10 cm)

Uniformity LY σ ~ 2.2 % ($10*10\ cm^2$)

Uniformity LY ~ 3 % (Hexagonal cell 9 cm^2)

Light Yield 66 % of BC408

~100% of Kuraray SCSN-81

Rad. Hardness < 5 % LY degradation after 1 Mrad (gamma)