



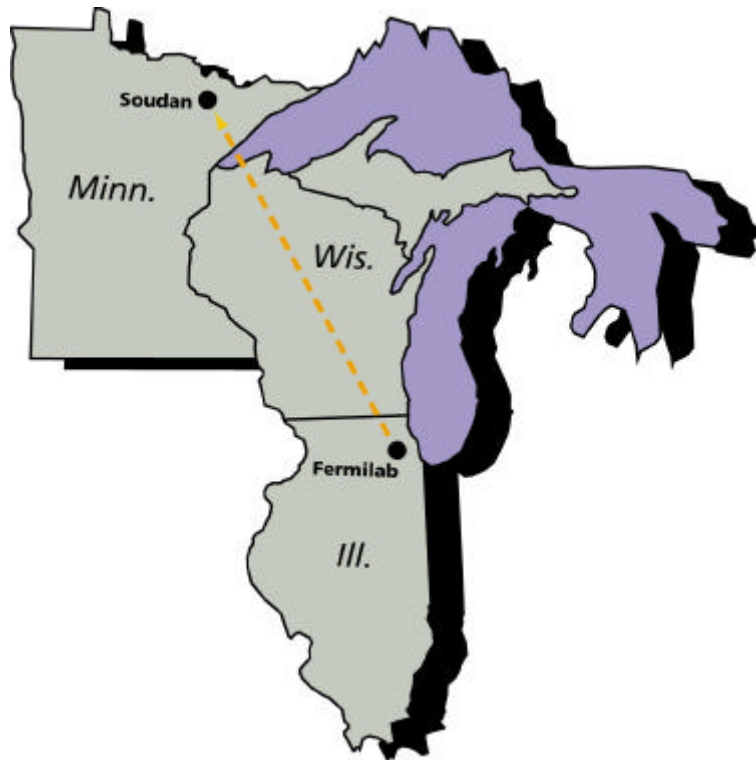
EXTRUDED PLASTIC SCINTILLATOR FOR THE MINOS CALORIMETERS

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MINOS Scintillator Group
Fermilab

Calorimetry 2000 Workshop
LAPP - Annecy
October 12, 2000



MINOS: MAIN INJECTOR NEUTRINO OSCILLATION SEARCH

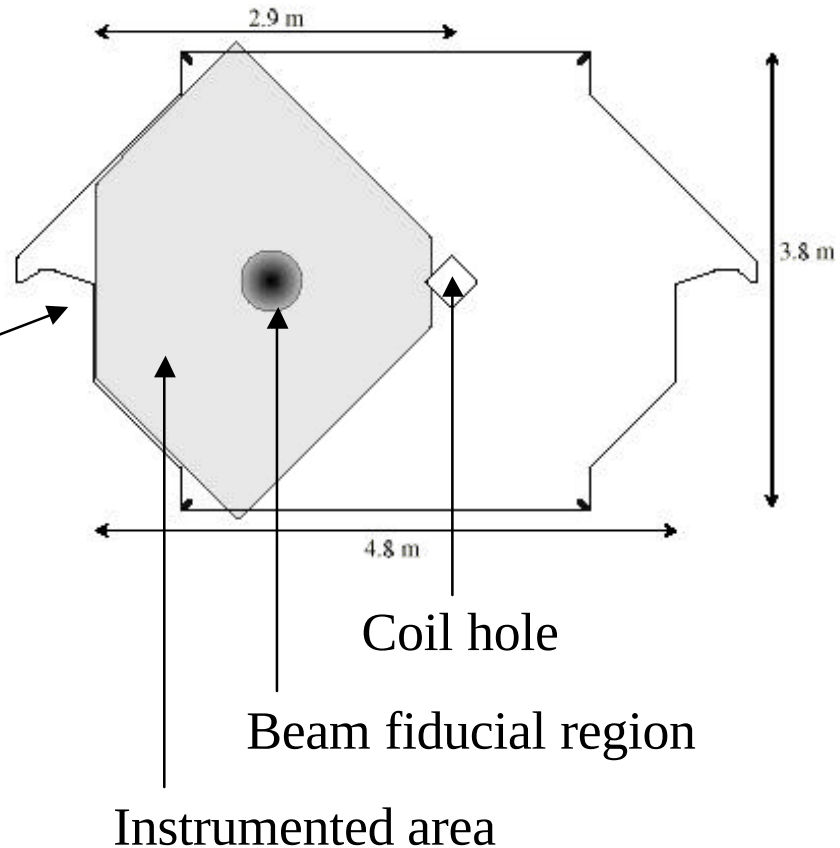




MINOS NEAR DETECTOR



- 16.6 m long, 980 tons
- 280 “squashed octagon” planes
- **Forward section:** 120 planes
 - 4/5 partially instrumented
 - 1/5 planes: full area coverage
- **Spectrometer section:** 160 planes
 - 3/4 planes not instrumented
 - 1/4 planes: full area coverage





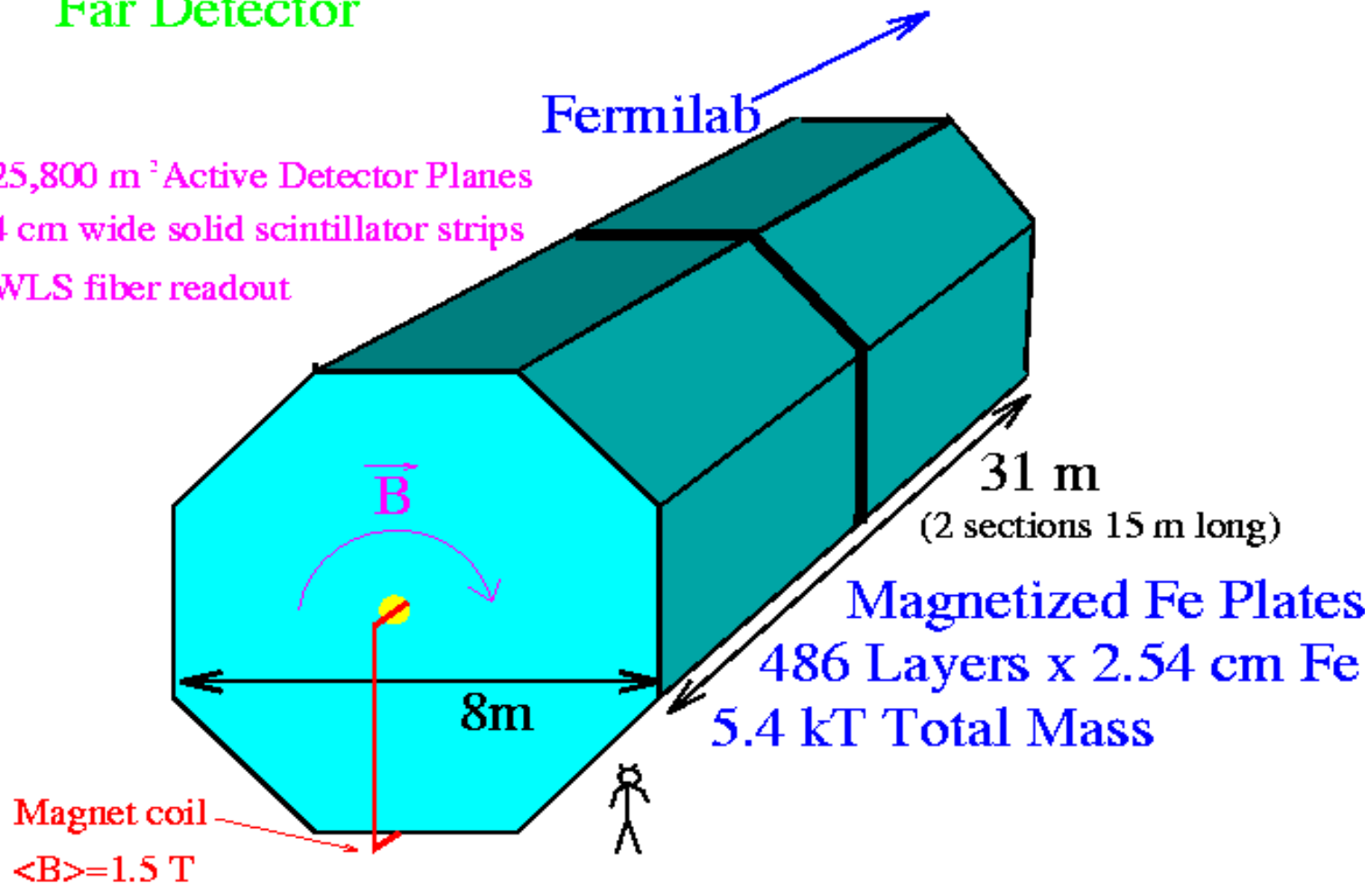
MINOS FAR DETECTOR



Far Detector

25,800 m² Active Detector Planes
4 cm wide solid scintillator strips
WLS fiber readout

Fermilab





MINOS: 4 PLANE PROTOTYPE





CAST SCINTILLATORS



ADVANTAGES

- Fast response
- Ease of manufacture
- Versatile: plates, fibers, tiles

DISADVANTAGE FOR LARGE DETECTORS

- Expensive: price of cast scintillator ~ \$40/kg
✂ MINOS needs 300,000 kg of scintillator!

➔ OBJECTIVE:

USE LOW COST SCINTILLATOR



EXTRUDED SCINTILLATOR



TO LOWER COSTS: EXTRUDED SCINTILLATOR

ADVANTAGES:

- Use commercial polystyrene (PS) pellets
 - ✗ Many grades, many prices
- Processing flexibility
 - ✗ Manufacture of essentially any shape

DISADVANTAGES

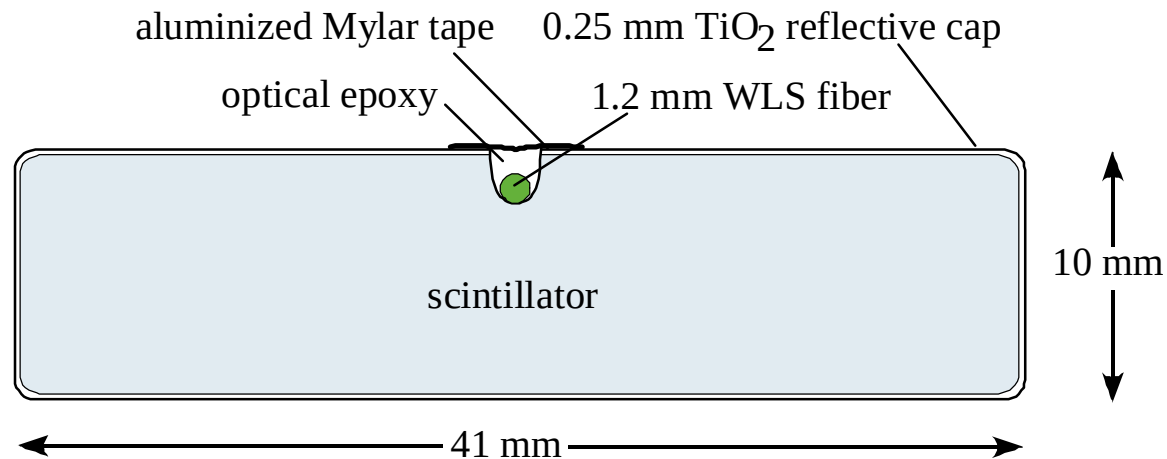
- Poorer optical quality
 - ✗ Particulate matter in PS pellets
 - ✗ Additives in PS pellets



EXTRUDED SCINTILLATORS



- ✎ Extrude a scintillator shape and use wavelength shifting (WLS) fibers as readout.





SELECTION OF RAW MATERIALS



BLUE SCINTILLATOR CORE

- Polystyrene: Dow Styron 663 W
- Dopants: 1% PPO + 0.03% POPOP

WHITE CAPSTOCKING

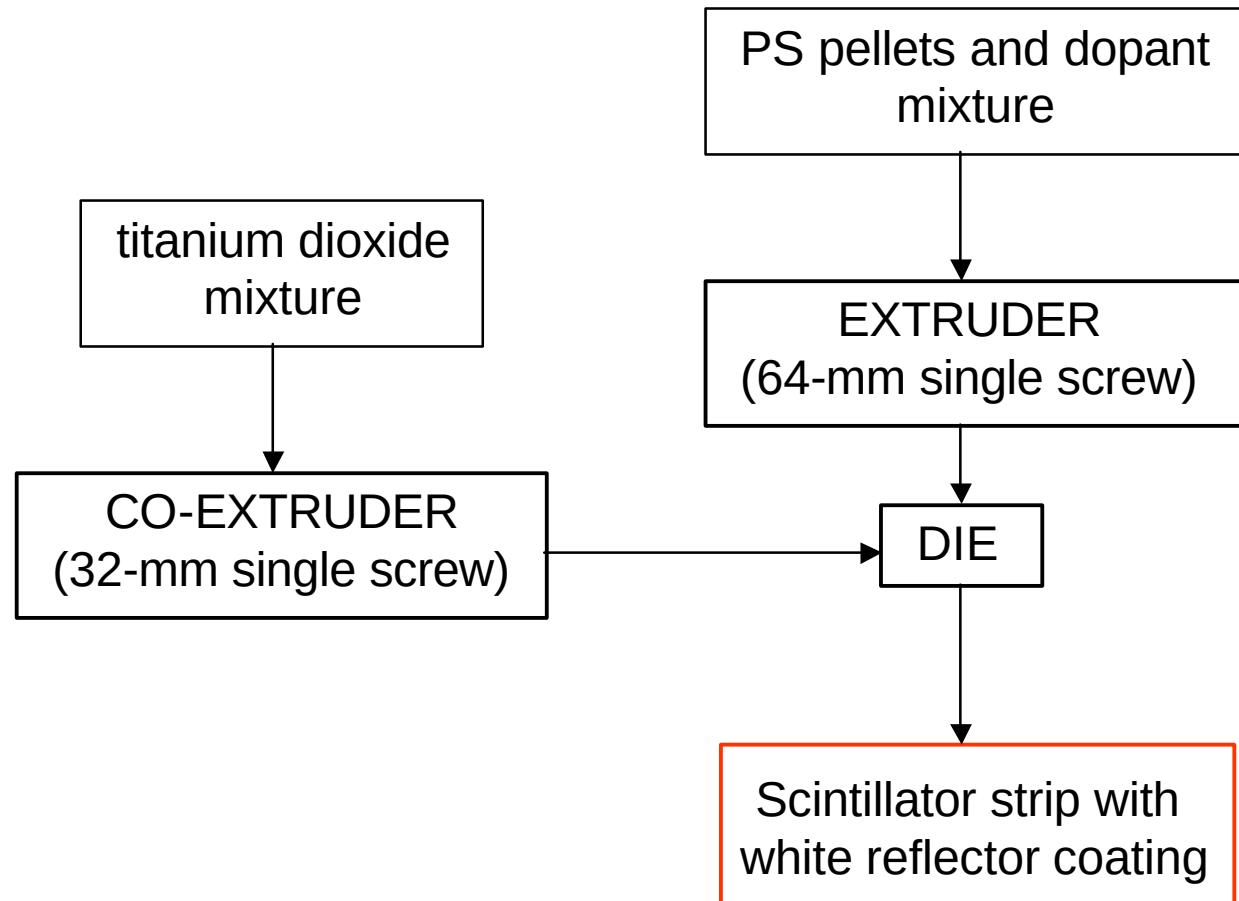
- Polystyrene with 12% TiO_2 – 0.25 mm thick

GREEN FIBER

- K-27 fiber – 1.2 mm diameter



MANUFACTURING TECHNIQUE

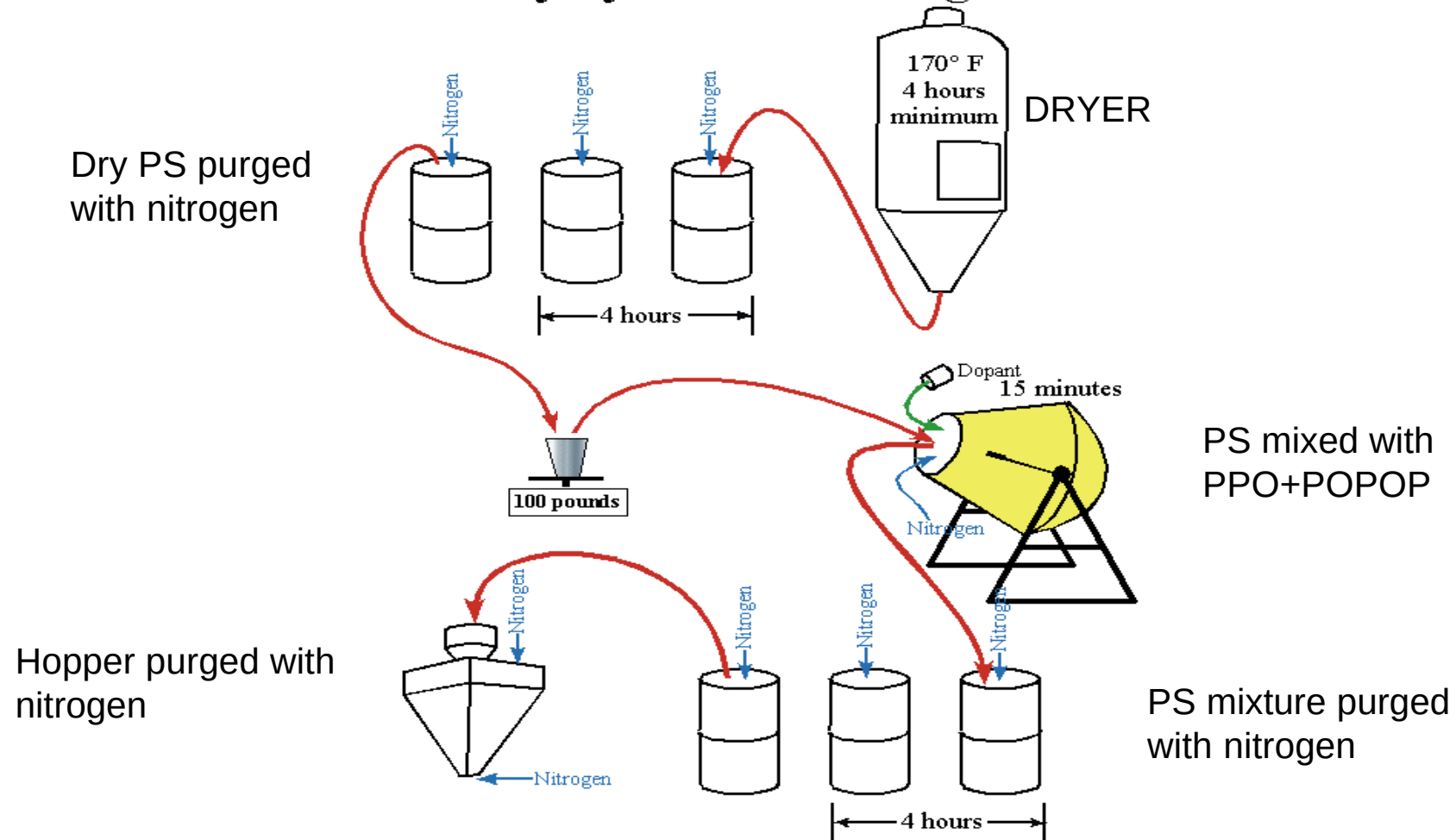




MANUFACTURING TECHNIQUE



Polystyrene Handling





EXTRUSION AT ITASCA PLASTICS





EXTRUSION AT ITASCA PLASTICS



MINOS

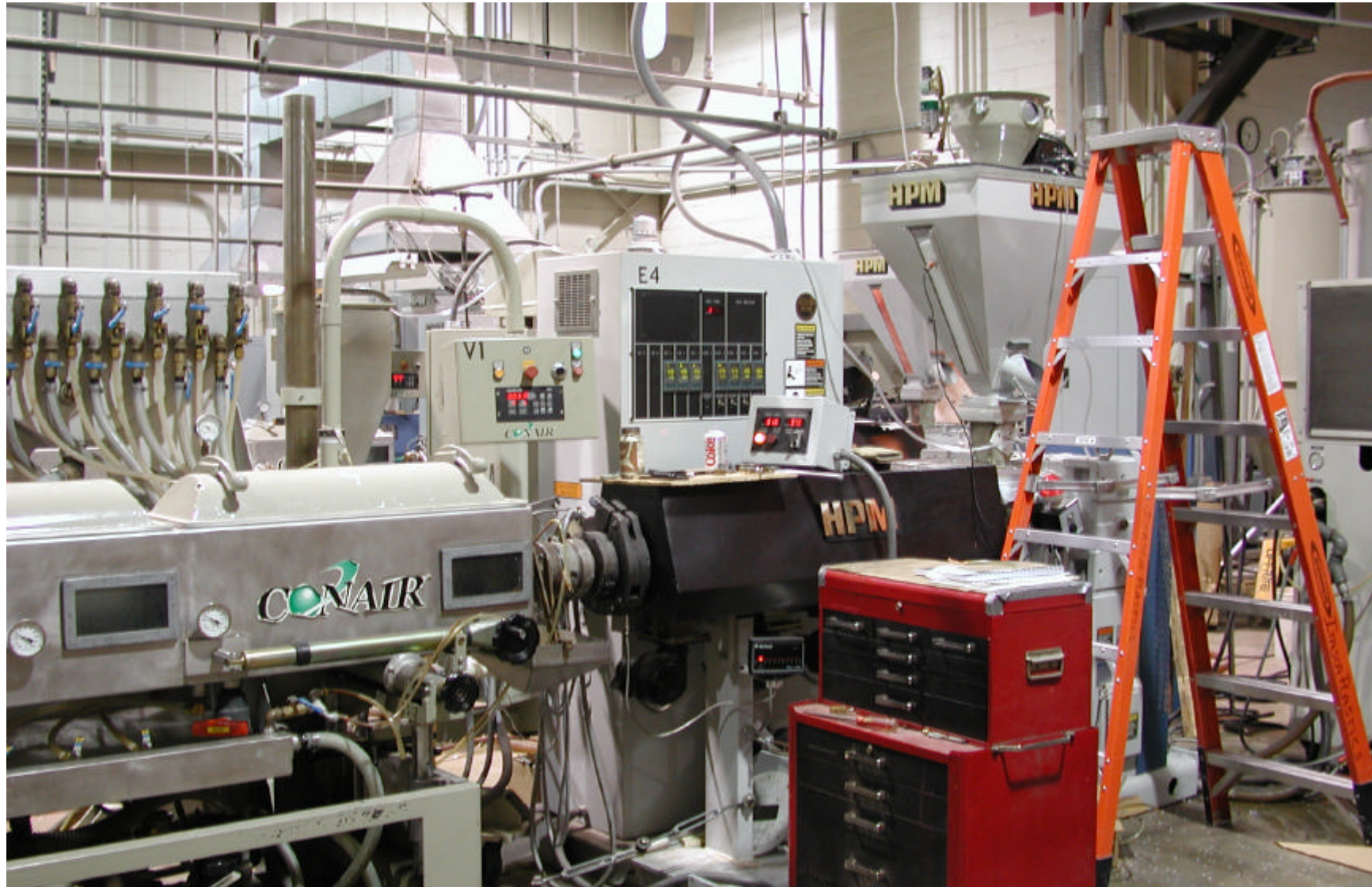




EXTRUSION AT ITASCA PLASTICS



MINOS

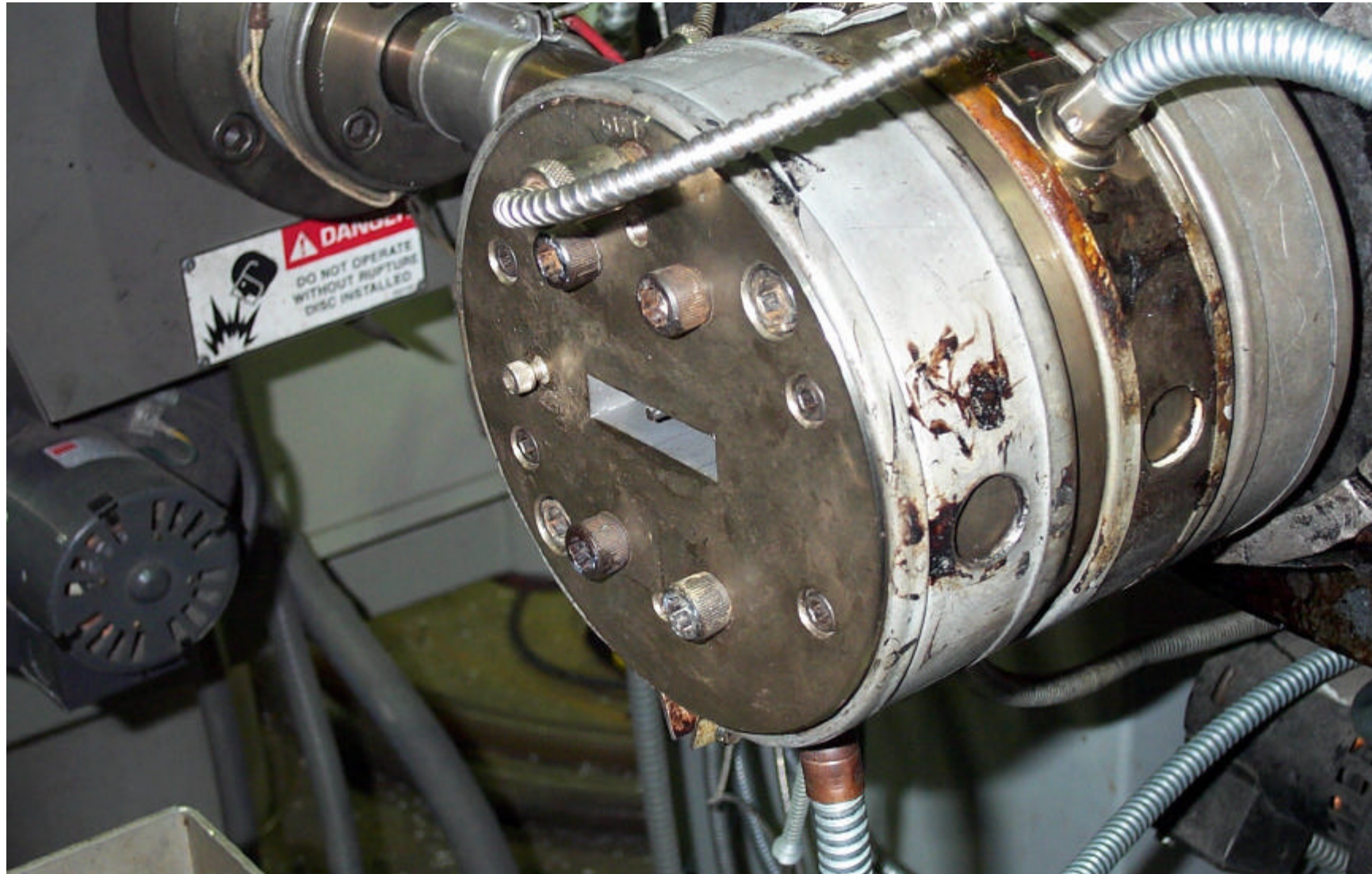




EXTRUSION AT ITASCA PLASTICS



MINOS

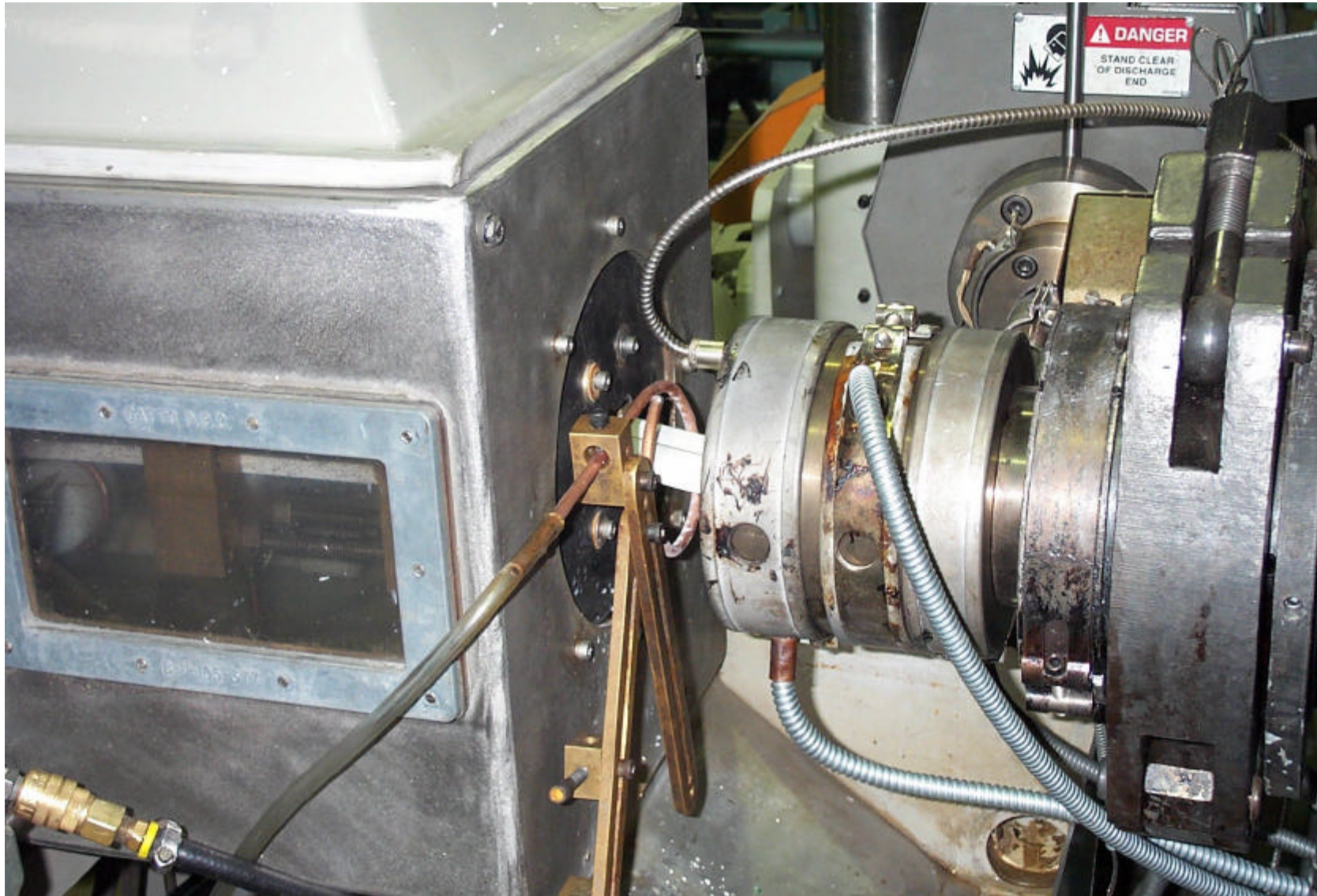




EXTRUSION AT ITASCA PLASTICS



MINOS





EXTRUSION AT ITASCA PLASTICS



MINOS



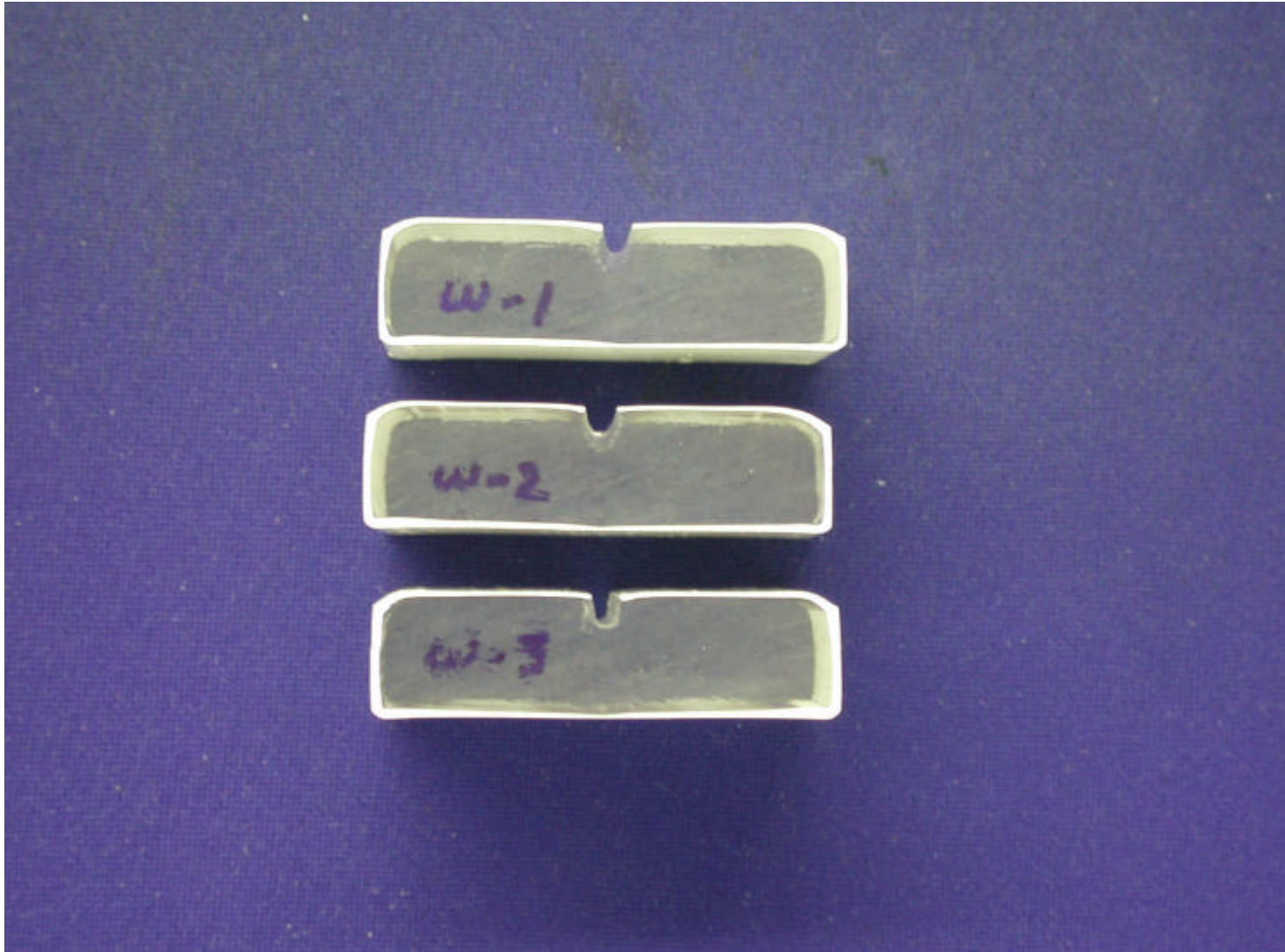


EXTRUDED SCINTILLATOR STRIPS



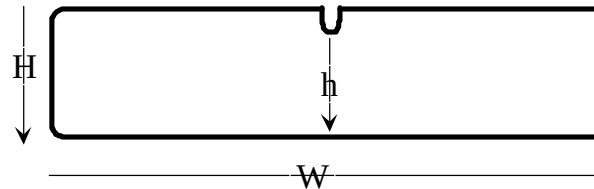


PRODUCTION SAMPLES





QC: PROFILE DIMENSIONS



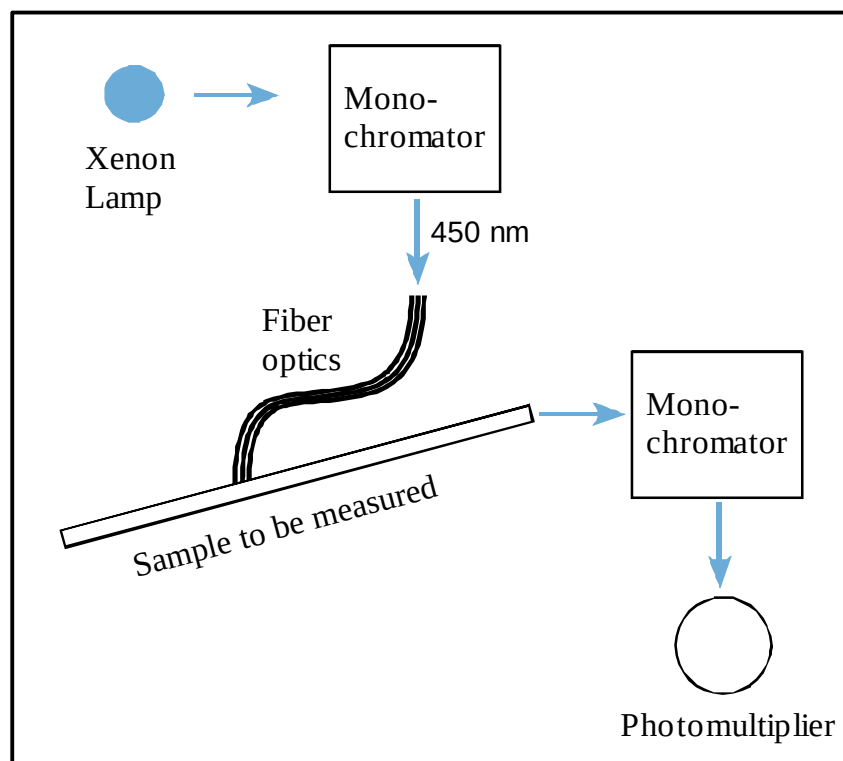
	W	H	Groove Width	Groove Depth	h
Week 1					
Average	40.92	9.94	2.52	2.36	7.37
Std Deviation	0.02	0.07	0.16	0.09	0.07
Week 2					
Average	40.94	9.92	2.92	2.31	7.52
Std Deviation	0.02	0.06	0.17	0.05	0.08
Week 3					
Average	40.96	10.01	2.73	2.66	7.13
Std Deviation	0.02	0.07	0.14	0.14	0.09
All units in millimeters					



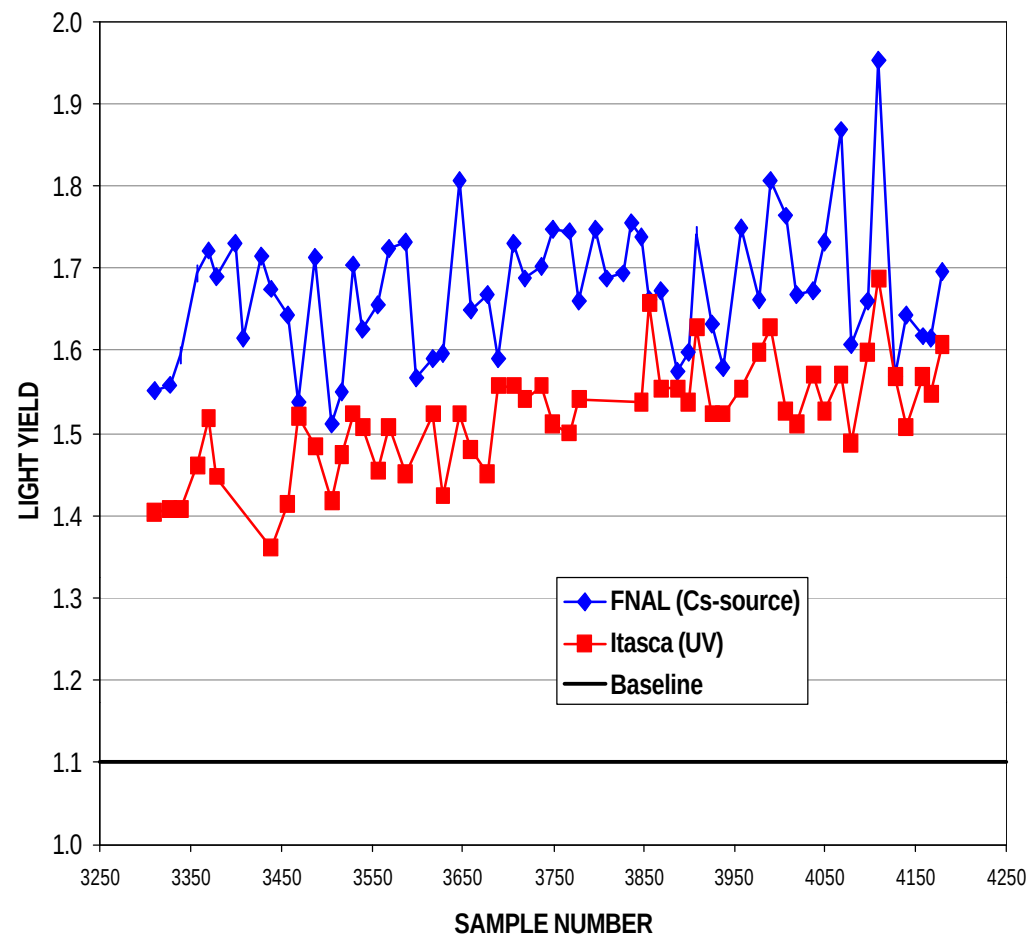
QC: LIGHT YIELD



QC SETUP AT THE FACTORY



COMPARISON OF MEASUREMENTS

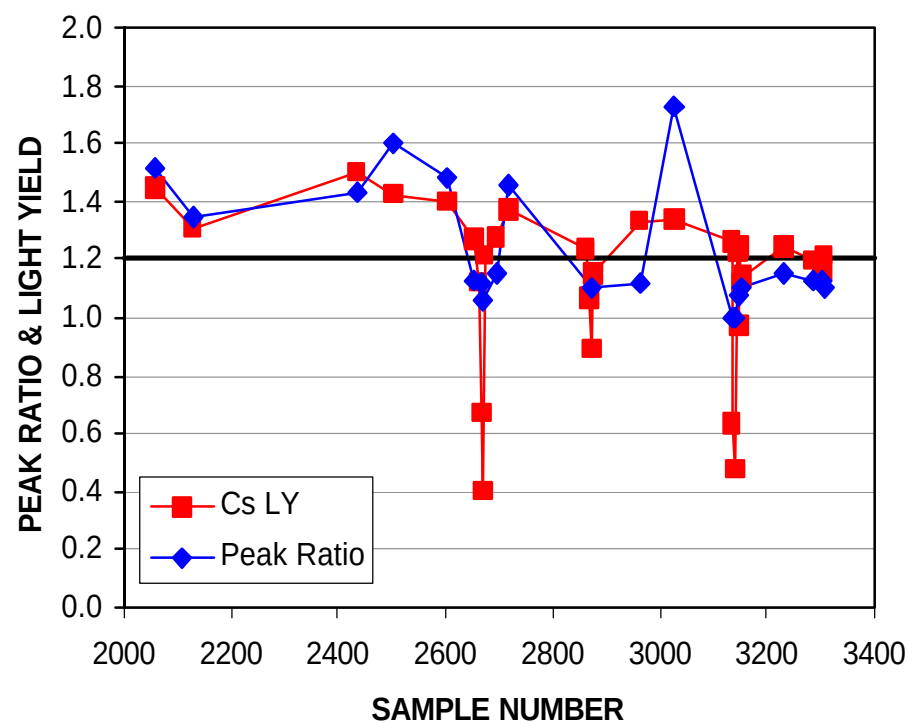
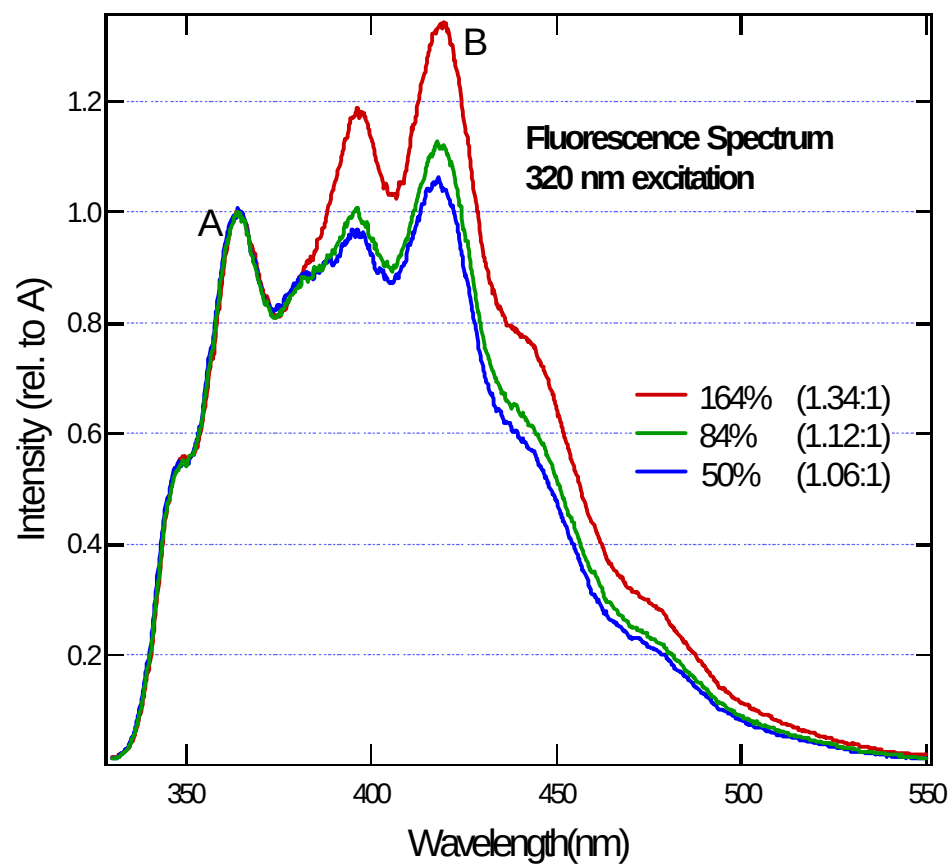




QC: DOPANT CONCENTRATION



MINOS





LIGHT OUTPUT

MAY 2000 MODULE PRODUCTION



MINOS

AVERAGE SUMMED LIGHT OUTPUT > 7.0 pe

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PostScript printer, but not to
other types of printers.

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CONCLUSIONS



-
- **Extruded scintillator is being produced:**
 - **Industrial environment**
 - **Low cost**
 - **High quality material**
 - **MINOS uses extruded scintillator:**
 - **Total of 300 tons**
 - **Cost: \$6 per kg (vs. cast \$40 per kg)**
 - **Average summed light output > 7 pe**