EXTRUDED PLASTIC SCINTILLATOR
FOR THE MINOS CALORIMETERS

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MINOS: MAIN INJECTOR NEUTRINO OSCILLATION SEARCH

[Map showing the locations of Minos, Soudan, Fermilab, and their connections]
• 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
Far Detector

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

Magnetized Fe Plates
- 486 Layers x 2.54 cm Fe
- 5.4 kT Total Mass

Fermilab

31 m
(2 sections 15 m long)

Magnet coil

\[<B>=1.5 \text{ T}\]
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

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

- 1.2 mm WLS fiber
- 0.25 mm TiO₂ reflective cap
- Optical epoxy
- Aluminized Mylar tape

Dimensions:
- 10 mm height
- 41 mm length
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

PS pellets and dopant mixture

EXTRUDER (64-mm single screw)

titanium dioxide mixture

CO-EXTRUDER (32-mm single screw)

DIE

Scintillator strip with white reflector coating
Polystyrene Handling

Dry PS purged with nitrogen

Hopper purged with nitrogen

PS mixture purged with nitrogen

PS mixed with PPO+POPOP

DRYER

170°F
4 hours minimum

100 pounds

Dopant
15 minutes

Nitrogen
EXTRUSION AT ITASCA PLASTICS
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## QC: PROFILE DIMENSIONS

![Diagram of profile dimensions](image)

<table>
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<tr>
<th>Week</th>
<th>W</th>
<th>H</th>
<th>Groove Width</th>
<th>Groove Depth</th>
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<tr>
<td>Average</td>
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<td>Average</td>
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<td>0.14</td>
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All units in millimeters
QC: LIGHT YIELD

QC SETUP AT THE FACTORY

Xenon Lamp

Monochromator

Fiber optics

Sample to be measured

Photomultiplier

450 nm

COMPARISON OF MEASUREMENTS

LIGHT YIELD

SAMPLE NUMBER

FNAL (Cs-source)
Itasca (UV)
Baseline
AVERAGE SUMMED LIGHT OUTPUT > 7.0 pe
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