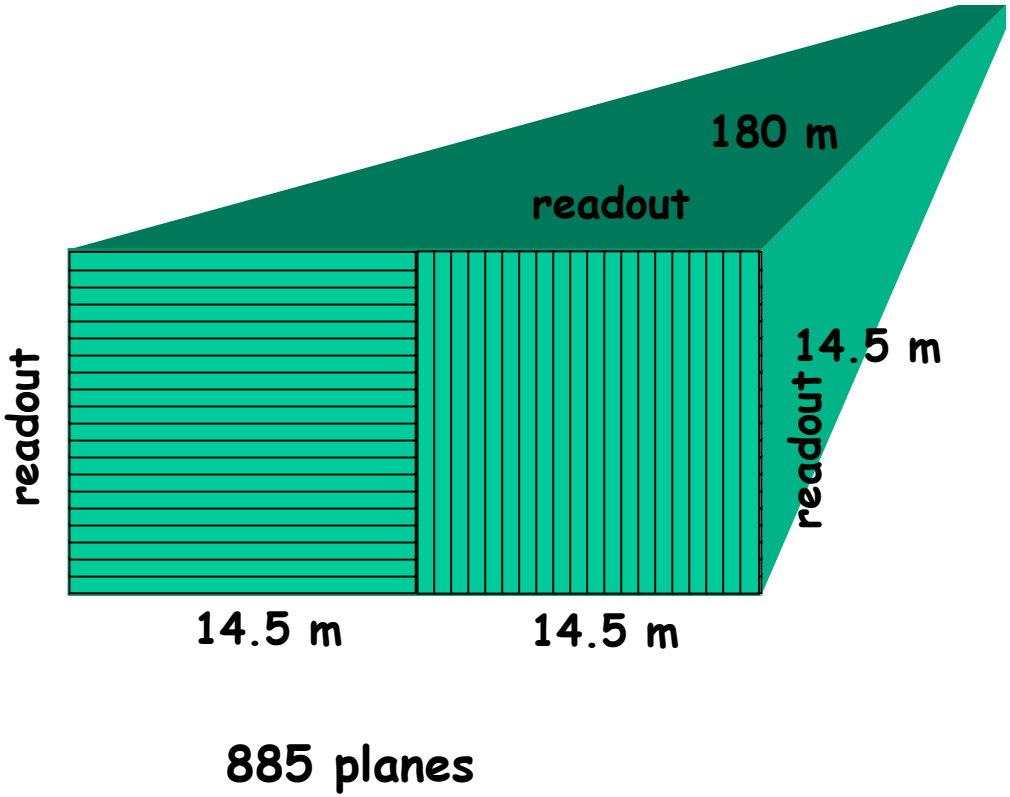
Scintillator
Summary, New Thinking, Future Plans & Cost Update

Jeff Nelson
Fermilab

- Reminder of current scintillator detector concepts and alternatives
  - Revised M64 design (12m x 24m planes)
  - Revised APD design (14.5m x 29m planes)
  - Revised liquid version (14.5m x 29m; APD)
- Value engineering
- Labor for construction
- Cost summaries
- Issues to address

Basic Object

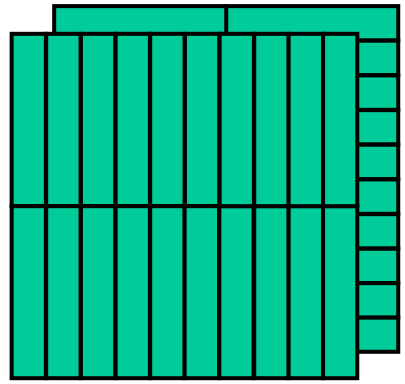
- For Solid scintillator and APDs shown to right
- For M64-based readout we'd use 12m modules and the lateral dimensions shrink accordingly
- Alternating view every 8"



Evolution -> only top half

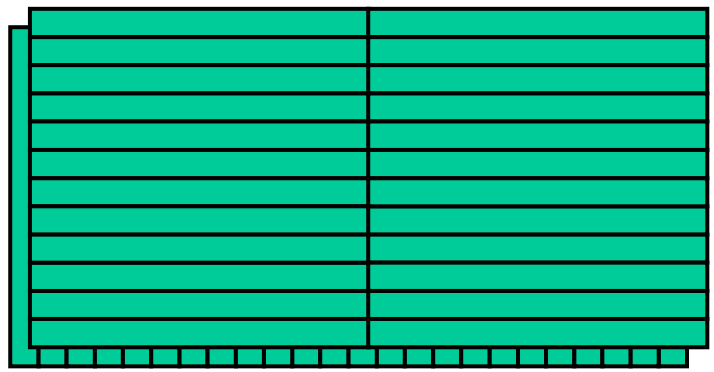
Jan

20m x 20m



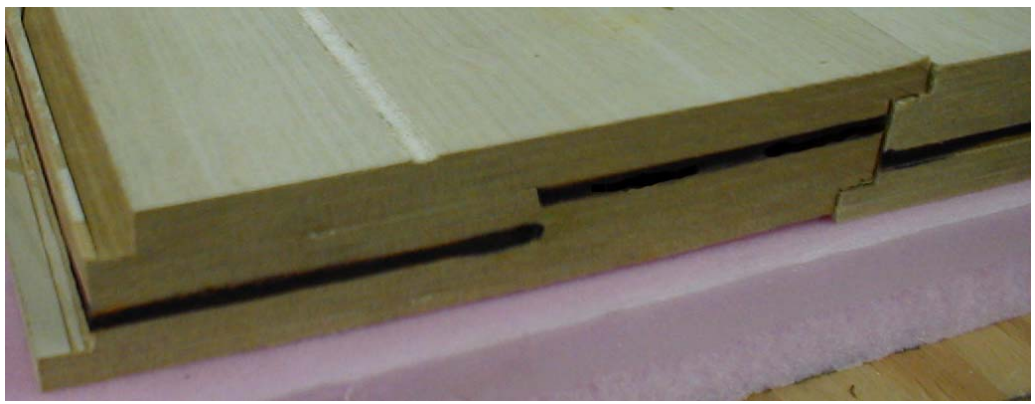
Jul

14.5 m x 29 m



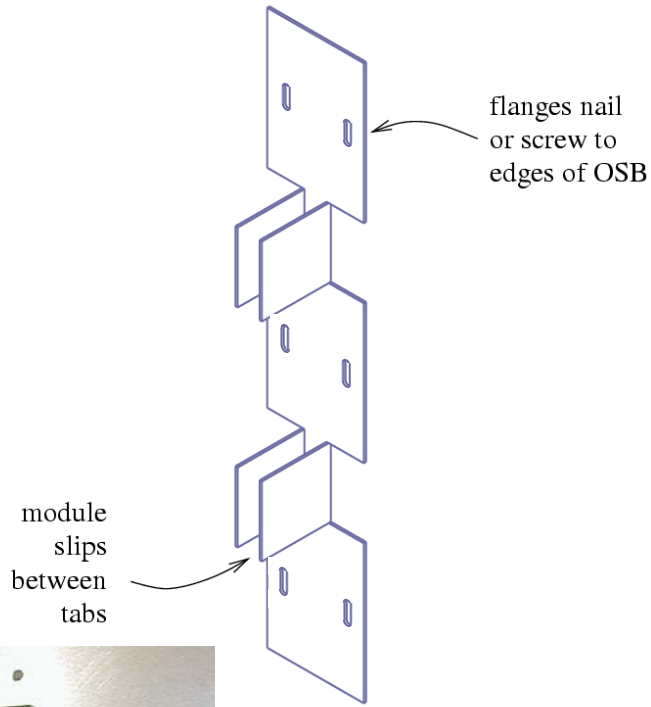
A detector "unit"

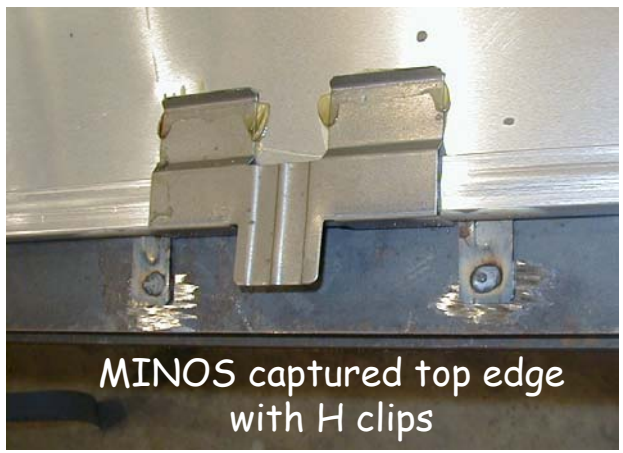
- Units made from natural OSB dimensions
- 8" x 48ft x 8ft
- 2 or 3 pieces of wood in 7 layers (see Tom's explosion drawing)
- Two 32-strip modules which are 4ft x 48ft
- Encased in wood and captured with clips



Module brackets

- This bracket holds the modules and acts as a spacer
- Made from stamped & folded steel - just like the MINOS "H" clips
  - $50/100 units
- A similar bracket captures the internal edge not may not be needed (but in costs)
- Slots allow for differential expansion




MINOS captured top edge with H clips

NUMI

MINOS

Putting up the units

- Rigged two different ways for the two views
  - Either a vacuum fixture or a strongback
- MINOS rigged lots of big heavy loads with 2.5mm position requirements
  - $50m^2$ & 22 ton (planes)
  - $16m^2$ & 6 ton (steel and scintillator loads)
- These objects are $40m^2$ and 5ton (+fixture) with similar tolerances
- Crew of 5 can install a plane per shift
  - 2 on each scissor lift to screw in the unit and survey + 1 operator

Mounting

- Collated Screw Driving Systems
  - They go in faster that you can move your hand
  - These will be used to attach the detector units
  - Assume a standard subfloor mat for expansion compliance (spec is $\frac{1}{4}$" per 8ft) in lateral direction
- Like MINOS you survey & shim every 2 planes
  - Vulcan point-n-shot survey
  - Screw in shims to level to 3/8"

Labor for the unit fabrication

- This is involves moving board on roller beds, running through glue station, placement, adding modules with screws, activating jig clamps, placing compression grid, and moving for 30 min cure
  - 4 person operation on 2 workstations per shift
- Materials come in at rate of 3 OBS trucks and 1 scintillator truck per day for 855 shifts
  - Removes things with fork truck – 1 operator per shift
- Run two shifts and work is just over 2 years
  - Add in for sick/vacation + supervision + support
  - Crew of people – includes all mounting and passive labor

Labor FTE roll up

24	Plane / brick builders
4	QA / cablers
7	Support / supervision
4	Receiving / staging
39	Total (for 2 years)

- Very comparable to MINOS in FTEs and schedule
  - Could be stretched to better match factories an level labor over longer installation (e.g. 24 for 4 years)
- Cost as carpentry trade instead of iron workers for large fraction of construction crew

Other Changes

- Aluminum -> Steel skins (at same thickness)
- Step scintillator
- Simpler / smaller manifolds
- New liquid scintillator extrusion dimensions

NUMI

MINOS

Cost of M64 Solid Scintillator

		unit cost	per	quant	Total ($M)
2.1.1	EDIA	$ 1,000,000		1.00	$ 1.0
2.1.2	OSB	$ 141.10	1000 lbs	103,240	$ 14.6
2.1.3	wood adhesive	$ 15.00	gal	85,245	$ 1.3
2.1.4	fasteners	$ 251.00	bx (6000)	679.68	$ 0.2
2.1.5	brackets	$ 0.50	each	509,760	$ 0.3
2.1.6	bookends	$ 42,000	bookend	12.00	$ 0.5
2.2.1.1	EDIA	$ 700,000		1.00	$ 0.7
2.2.1.2	strips	$ 2.68	m	9,943,990	$ 26.6
2.2.2	wls fiber	$ 0.56	m	21,247,341	$ 12.0
2.2.4.1	skin	$ 136	mod	25,896	$ 3.5
2.2.4.2	manifold	$ 100	mod	25,896	$ 2.6
2.2.4.3	connector	$ 5	mod	25,896	$ 0.1
2.2.4.4	comsumables	$ 200	mod	25,896	$ 5.2
2.2.5	factory set up	$ 500,000	factory	4.00	$ 2.0
2.2.6	factory labor	$ 400	module	25,896	$ 10.4
2.2.7	module shipping	$ 75	module	25,896	$ 1.9
2.3.1	PMTs	$ 11.00	ch	679,680	$ 7.5
2.3.2	Readout boxes	$ 125.00	pmt	25,896	$ 3.2
2.3.3	Frontend chips	$ 5.30	ch	679,680	$ 3.6
2.3.4	HV	$ 100.00	pmt	25,896	$ 2.6
2.3.5	Fab/base	$ 225.00	pmt	25,896	$ 5.8
2.3.6	DAQ	$ 2,000,000		1.00	$ 2.0
2.3.7	Control & monitoring	$ 500,000		1.00	$ 0.5
2.4.1	set up SWF	$ 500,000		1.00	$ 0.5
2.4.2	plane SWF	$ 1,680,000	yr	2.70	$ 4.5
2.4.3	support & supervision SWF	$ 420,000	yr	2.70	$ 1.1
2.4.4	receiving/staging SWF	$ 240,000	yr	2.70	$ 0.6
2.4.5	installation oversight	$ 50,000	yr	2.70	$ 0.1
2.5	building	$ 20,000,000		1.25	$ 25.0
2.6	outfitting	$ 2,000,000		1.00	$ 2.0
total					$ 142.0

M64 Rolled Up

2.1	absorber & structure	$ 17.78
2.2.1	scintillator	$ 27.33
2.2.2	WLS fiber	$ 11.98
2.2.3/.4/.5	modules parts	$ 11.42
2.2.6/.7/.8	modules labor/shipping	$ 14.30
2.3.1	photodetector	$ 7.48
2.3.2	FEE/base/housing/HV	$ 15.26
2.3.x	other elec	$ 2.50
2.4	installation	$ 6.95
2.5	building	$ 25.00
2.6	outfitting	$ 2.00
2.0	total	$ 141.99

APD Version

		$M
2.1	absorber & structure	$ 17.78
2.2.1	scintillator	$ 27.33
2.2.2	WLS fiber	$ 11.98
2.2.3/.4/.5	modules parts	$ 9.37
2.2.6/.7/.8	modules labor/shipping	$ 12.09
2.3.1	photodetector	$ 1.70
2.3.2	FEE/base/housing/HV	$ 8.38
2.3.x	other elec	$ 2.50
2.4	installation	$ 5.79
2.5	building	$ 25.00
2.6	outfitting	$ 2.00
2.0	total	$ 123.91

Liquid Scintillator

		$M
2.1	absorber & structure	$ 17.78
2.2.1	scintillator	$ 14.22
2.2.2	WLS fiber	$ 11.98
2.2.3/.4/.5	modules parts	$ 7.77
2.2.6/.7/.8	modules labor/shipping	$ 5.71
2.3.1	photodetector	$ 1.70
2.3.2	FEE/base/housing/HV	$ 8.38
2.3.x	other elec	$ 2.50
2.4	installation	$ 5.79
2.5	building	$ 25.00
2.6	outfitting	$ 2.00
2.0	total	$ 102.83

Scintillator Issues & Plans

- Continue Cost/Physics Optimization
  - Longitudinal sampling clearly the cost driver
- Results from the APD test stand
- Continue to pursue options for reducing module component and fabrication costs due to 10x more units