Summary of detector design and costing

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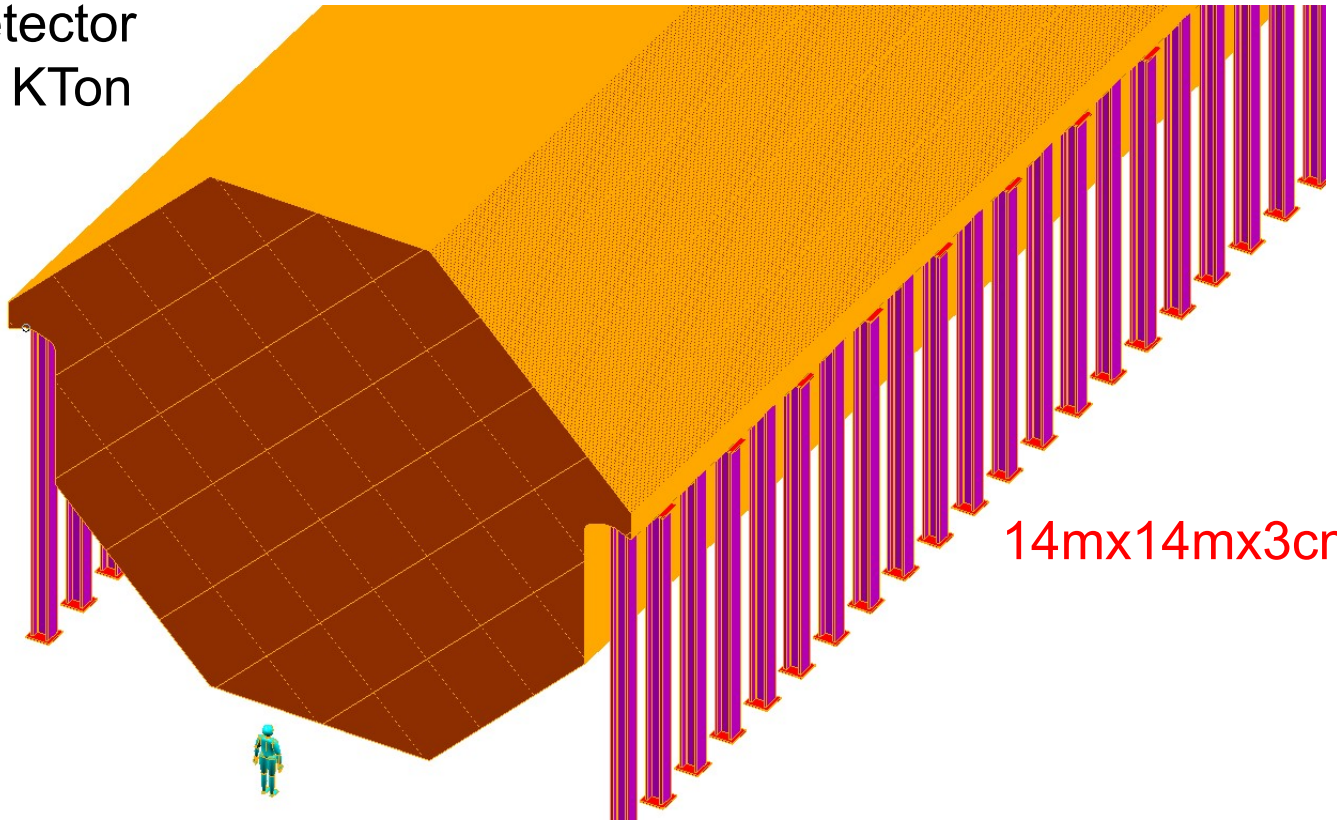
MIND engineering concept

- MIND steel plates: 14 m octagonal plates (3 cm thick)
- Two planes of scintillator (1 cm each) between steel plates
- Toroidal field by having100 kA through STL in centre
  - Engineering and magnetic field maps being developed at Fermilab

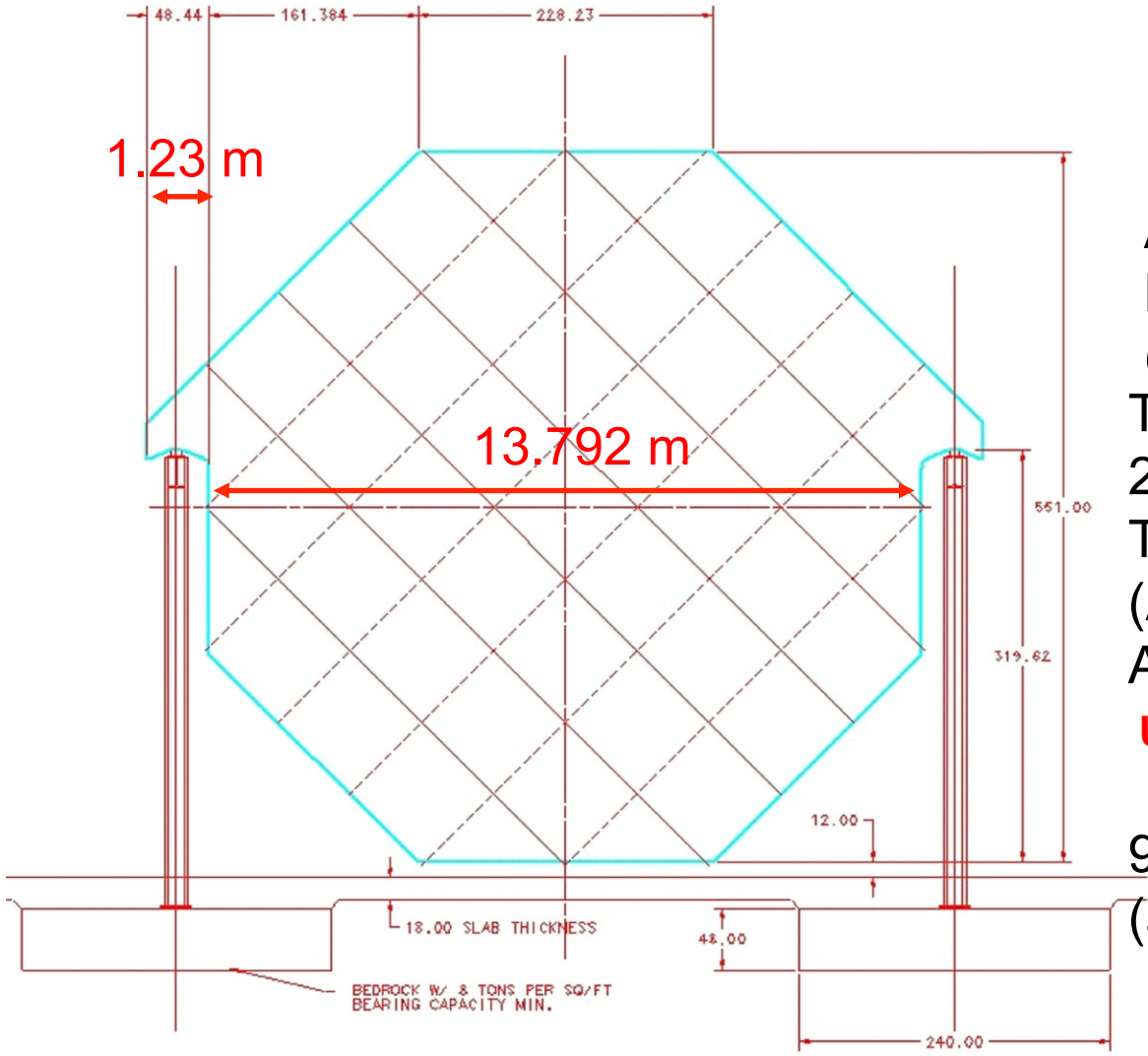
One detector
M~100 KTon



MIND engineering concept

- Dimensions of each plane and support structures

Bross, Wands (FNAL)



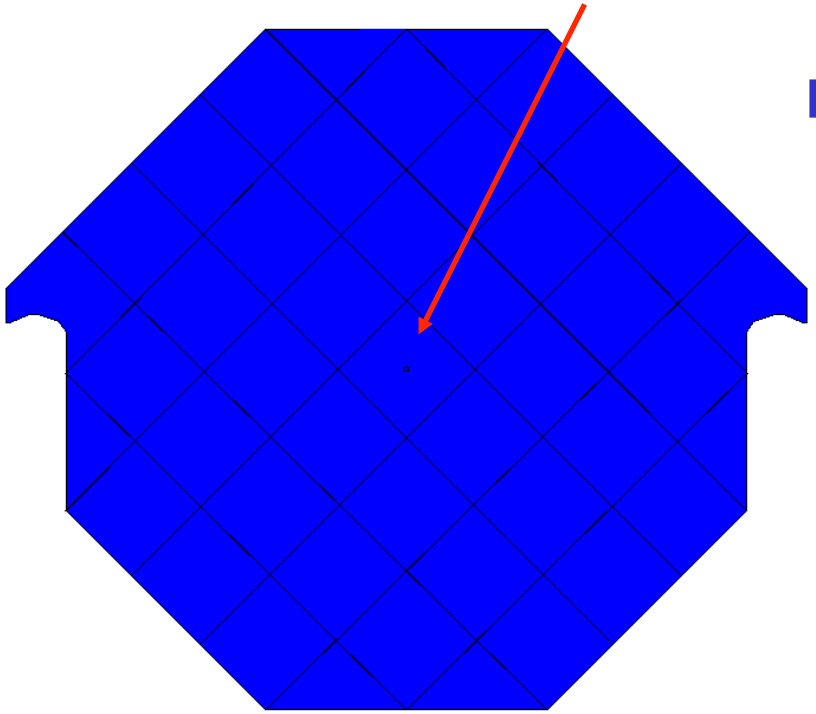
Area plate=156.6 m^2
Mass plate=37.6 t
(159.6 t with the ears)
Total length = 140 m
2800 modules (5 cm)
Total 105 kton steel
(AISI1010 €1150/ton **MINOS Steel**
ARMCO €1800/ton)

Use €1150/ton instead of €1000/ton

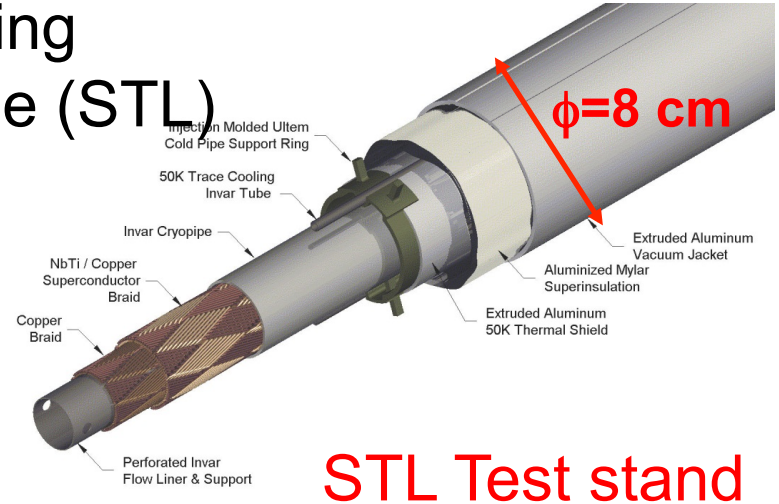
9.2 kton scintillator
(assume €6000/ton)

MIND magnetisation

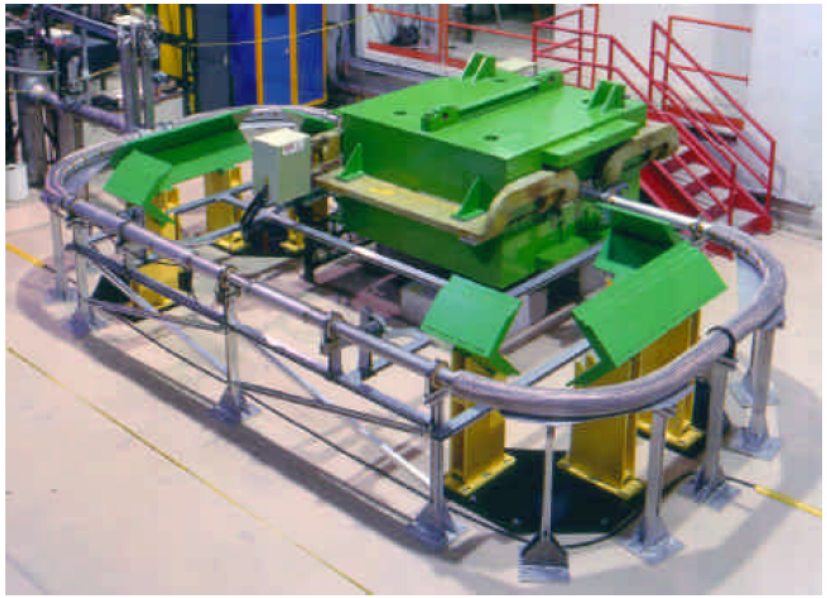
- Magnetisation can be achieved using Superconducting Transmission Line (STL) developed for VLHC: $500/m
  - Can carry 100 kA turn
  - Only need 10 cm diameter hole



Bross



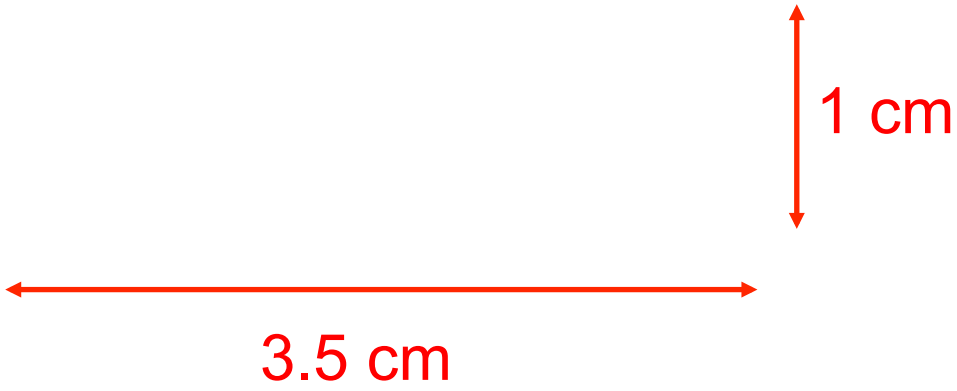
STL Test stand



The test apparatus used at MW-9 for developing the transmission line.

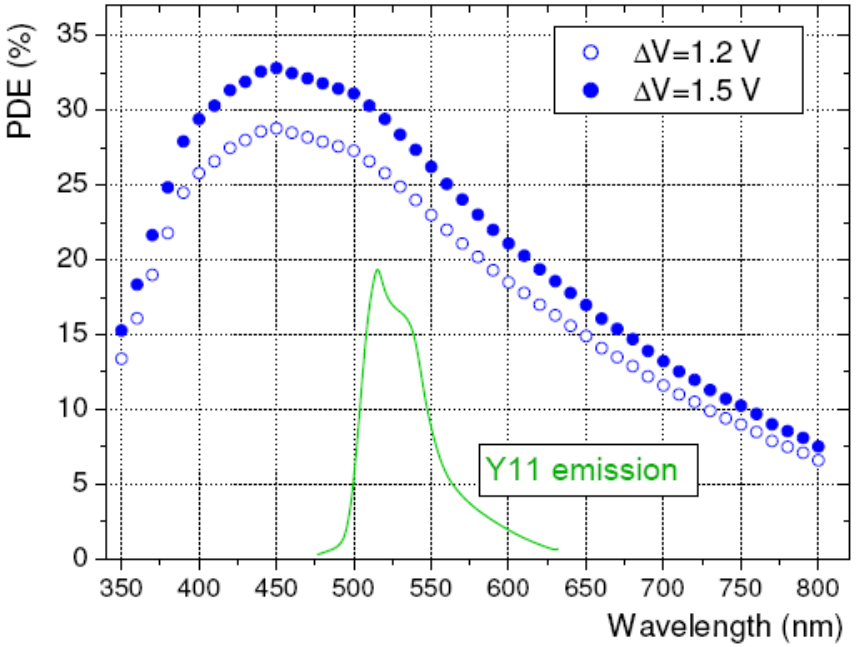
MIND scintillator

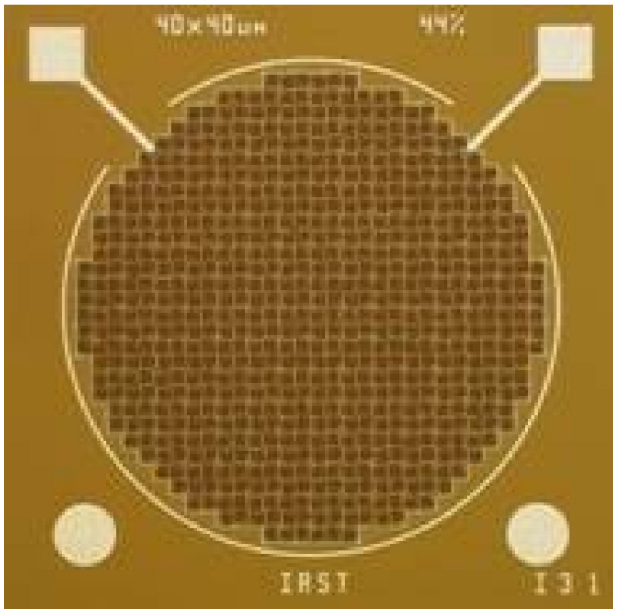
- Scintillator: x-view and y-view planes 1 cm thick each plane
  - Baseline: rectangular scintillator strips (3.5 cm wide, $\sigma \sim 1$ cm)
  - Co-extrusion fibre-scintillator
- Wavelength shifting fibres
  - Kuraray WLS fibres shown to give consistently good performance
- Numbers: 788 scint./module x 2800 modules = 2.2 M bars
  - 25,000 km of WLS fibre (~€1/m)



Photon detectors

- Photodetectors: SiPMT (also known as MPPC, MRS, etc.)
  - SiPMTs improving and cost is lowering (assume €10/channel) – total estimated number of channels = 4.4 M
  - Silicon avalanche photodiode operating in Geiger mode
  - Multi-pixels: number of pixels that fire is prop. number of photoelectrons
  - Hamamatsu are already producing quads (ie 4 channel devices)
  - Further encapsulation might be possible





MIND WBS

- Work Breakdown Structure
  - MINOS and NOvA provide useful examples of WBS for MIND

Assume 7 years for project: 2+5 years

Only management and engineering manpower included

		Cost (M€)	FTE (mths)
2.2.1.	**Detector R&D**	**0.7**	**96**
2.2.1.1.	Scintillator R&D	0.3	48
2.2.1.2.	STL R&D	0.3	24
2.2.1.3.	Photon detector and electronics R&D	0.2	24
2.2.2.	**Underground cavern**	**107.1**	**36**
2.2.2.1.	Geomechanical studies	0	36
2.2.2.2.	Cavern construction	71.1	0
2.2.2.3.	Cavern outfitting	36.0	0

60,000 m3 of cavern compared to MINOS 13200 m3

Agrees with number from MEMPHYS cavern

MIND WBS

- Work Breakdown Structure

		Cost (M€)	FTE (mths)
2.2.3.	**Steel plate fabrication**	**215.8**	**252**
2.2.3.1.	Engineering, design	0	72
2.2.3.2.	Steel management	0	180
2.2.3.3.	Detector plane prototypes	0.3	0
2.2.3.4.	Steel procurement	121.1	0
2.2.3.5.	Steel plate assembly 60% of raw material	72.6	0
2.2.3.6.	Steel transport 3% of raw material	3.6	0
2.2.3.7.	Steel support structures and handling fixtures 15% of raw material	18.2	0
2.2.4.	**Magnet coil**	**0.9**	**12**
2.2.4.1.	Engineering, design	0	12
2.2.4.2.	STL fabrication	0.2	0
2.2.4.3.	STL cryo plant	0.5	0
2.2.4.4.	Power supplies	0.2	0

MIND WBS

- Work Breakdown Structure

		Cost (M€)	FTE (mths)
2.2.5.	**Scintillator detector fabrication**	**148.6**	**372**
2.2.5.1.	Engineering, design	0	72
2.2.5.2.	Scintillator strips	55.3	0
2.2.5.3.	WLS fibre	25.1	0
2.2.5.4.	Scintillator modules	5.5	0
2.2.5.5.	Photon detectors (SiPMTs)	44.1	0
2.2.5.6.	Multiplexing boxes and connectors	3.4	0
2.2.5.7.	Calibration systems	4.4	0
2.2.5.8.	Assembly and test equipment	4.8	0
2.2.5.9.	Factories	6.0	0
2.2.5.10.	Scintillator management	0	300

MIND WBS

- Work Breakdown Structure

		Cost (M€)	FTE (mths)
2.2.6.	**Electronics, DAQ and database**	**28.6**	**216**
2.2.6.1.	Front end electronics	22.1	0
2.2.6.2.	Data routing and trigger farm	4.4	0
2.2.6.3.	Data acquisition and triggering	0.3	72
2.2.6.4.	Database	0	24
2.2.6.5.	Auxiliary systems	0.6	0
2.2.6.6.	Slow controls and monitoring	1.1	0
2.2.6.7.	High Voltage systems	0.2	0
2.2.6.8.	Electronics management	0	120

MIND WBS

- Work Breakdown Structure

		Cost (M€)	FTE (mths)
2.2.7.	**Detector installation**	**6.8**	**120**
2.2.7.1.	Management	0	120
2.2.7.2.	Lab infrastructure	1.4	0
2.2.7.3.	Plane assembly area	0.8	0
2.2.7.4.	Installation	4.4	0
2.2.7.5.	Alignment and survey	0.3	0
2.2.8.	**Project management**	**0**	**252**

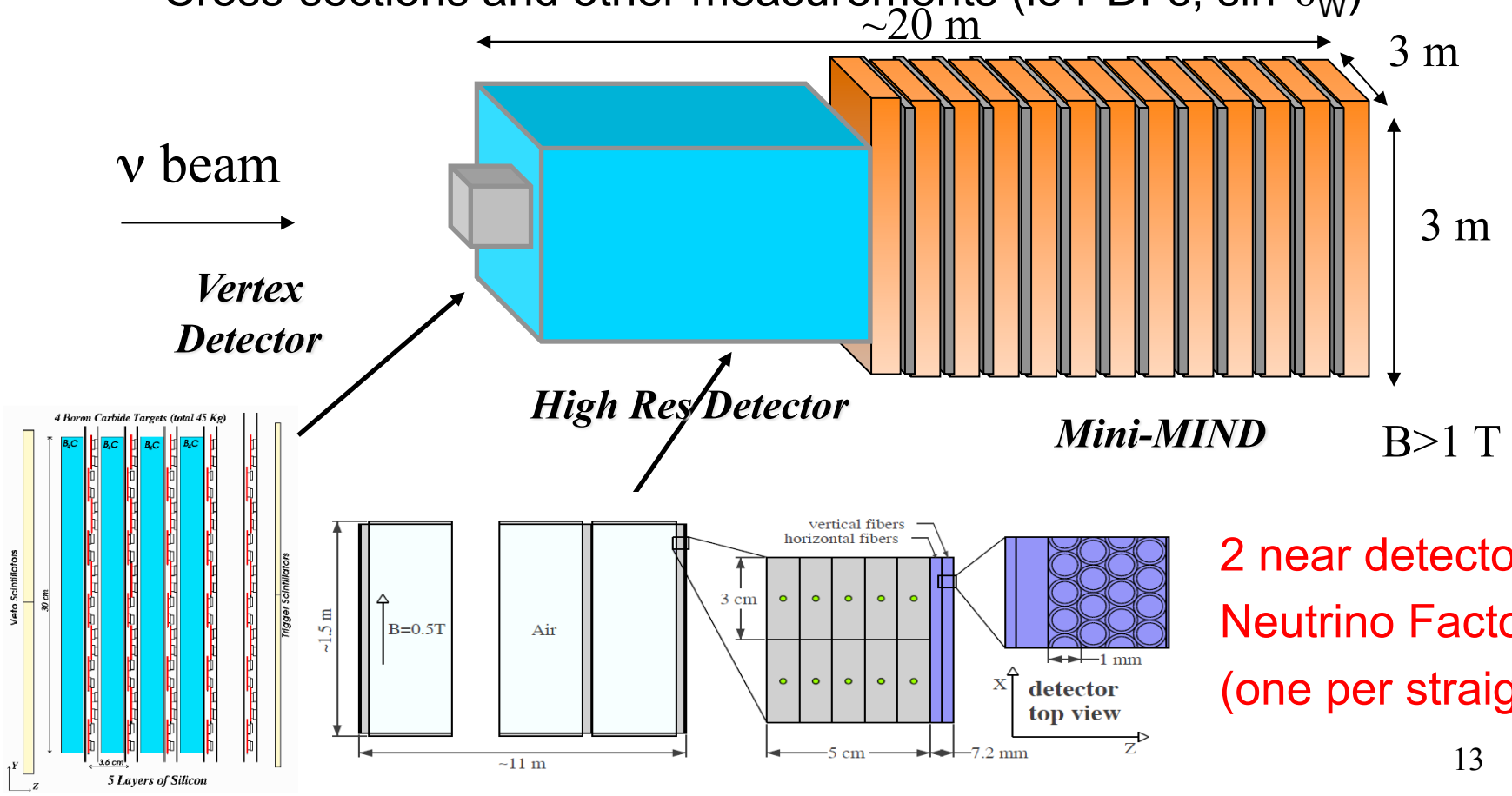
MIND WBS

- Work Breakdown Structure

2.2.	Intermediate baseline detector (MIND 100 kton)	Cost (M€)	FTE (mths)
2.2.1.	Detector R&D	0.7	96
2.2.2.	Underground cavern	107.1	36
2.2.3.	Steel plate fabrication	215.8	352
2.2.4.	Magnet coil	0.9	12
2.2.5.	Scintillator detector fabrication	148.6	372
2.2.6.	Electronics, DAQ and database	28.6	216
2.2.7.	Detector installation	6.8	120
2.2.8.	Project management	0.3	252
	Manpower (management & engineering)	8.1	1356
	Total	**508.5**	

Near Detectors

- Near detector for a Neutrino Factory:
  - Neutrino flux (<1% precision) and extrapolation to far detector
  - Charm production (main background) and taus for Non Standard Interactions (NSI) searches
  - Cross-sections and other measurements (ie PDFs, $\sin^2\theta_W$)



2 near detectors at Neutrino Factory (one per straight)

Near Detector WBS

- Work Breakdown Structure

2.1.1.	**Mini-MIND**	**3.1**
2.1.1.1.	Steel plane fabrication MIND	0.9
2.1.1.2.	Scintillator MIND	0.3
2.1.1.3.	Fibre MIND	0.2
2.1.1.3.	SiPM MIND	1.2
2.1.2.1.	Electronics MIND	0.6
2.1.2.2.	Coil Mind	0.01

Near Detector WBS

- Work Breakdown Structure

2.1.2.	**High resolution tracker**	**11.8**
2.1.2.1.	Scintillator HighRes	0.6
2.1.2.2.	Fibre for scintillator HighRes	0.9
2.1.2.3.	SiPM for scintillator HighRes	6.0
2.1.2.4.	Electronics for scintillator HighRes	3.0
2.1.2.5.	Coil	1.2

Near Detector WBS

2.1.3.	**Silicon vertex**	**8.0**
2.1.3.1.	Silicon	6.7
2.1.3.2.	Silicon electronics	1.3
2.1.4.	**Computing**	**1.4**
2.1.4.1.	Central system and trigger farm	1.0
2.1.4.2.	Data acquisition	0.2
2.1.4.3.	Database	0.2
2.1.5.	**Installation**	**2.9**
2.1.5.1.	Infrastructure	2.0
2.1.5.2.	Materials receiving and handling	0.4
2.1.5.3.	Detector assembly	0.4
2.1.5.4.	Alignment and survey	0.1
2.1.6.	**Project management**	**1.2**

- Total estimated manpower for Near Detector construction:
  - 1236 person months over about 4 years (at €6000/month): 6.3 M€

Near Detector WBS

- Work Breakdown Structure:

2.1.	Near Detector	Cost (M€)
2.1.1.	Mini-MIND	3.1
2.1.2.	High resolution tracker	11.8
2.1.3.	Silicon vertex	8.0
2.1.4.	Computing	1.4
2.1.5.	Installation	2.9
2.1.6.	Project management	1.2
	Manpower	6.3
	Total (one detector)	34.7
	Total (two detectors)	69.4

Conclusions

- WBS is the same as presented at previous meetings
- This is the first public showing of costs
- The main issues are keeping up with current costs of raw materials that can be very large (ie. Iron, scintillator, electronics channels)
- Hard to quantify manpower included in manufacture and manpower that is accounted separately for management – manpower numbers are softest numbers in tables
- MIND bottom line – 509 M€
- Near detectors bottom line – 69.4 M€
- I haven't shown uncertainties – can estimate per-item and add

Currently in the process of writing the costing report for the EUROnu final report, which should be first basis for RDR costing report