EUROnu Costing Detectors

EUROnu WBS
Safety Meeting, 29 September 2011

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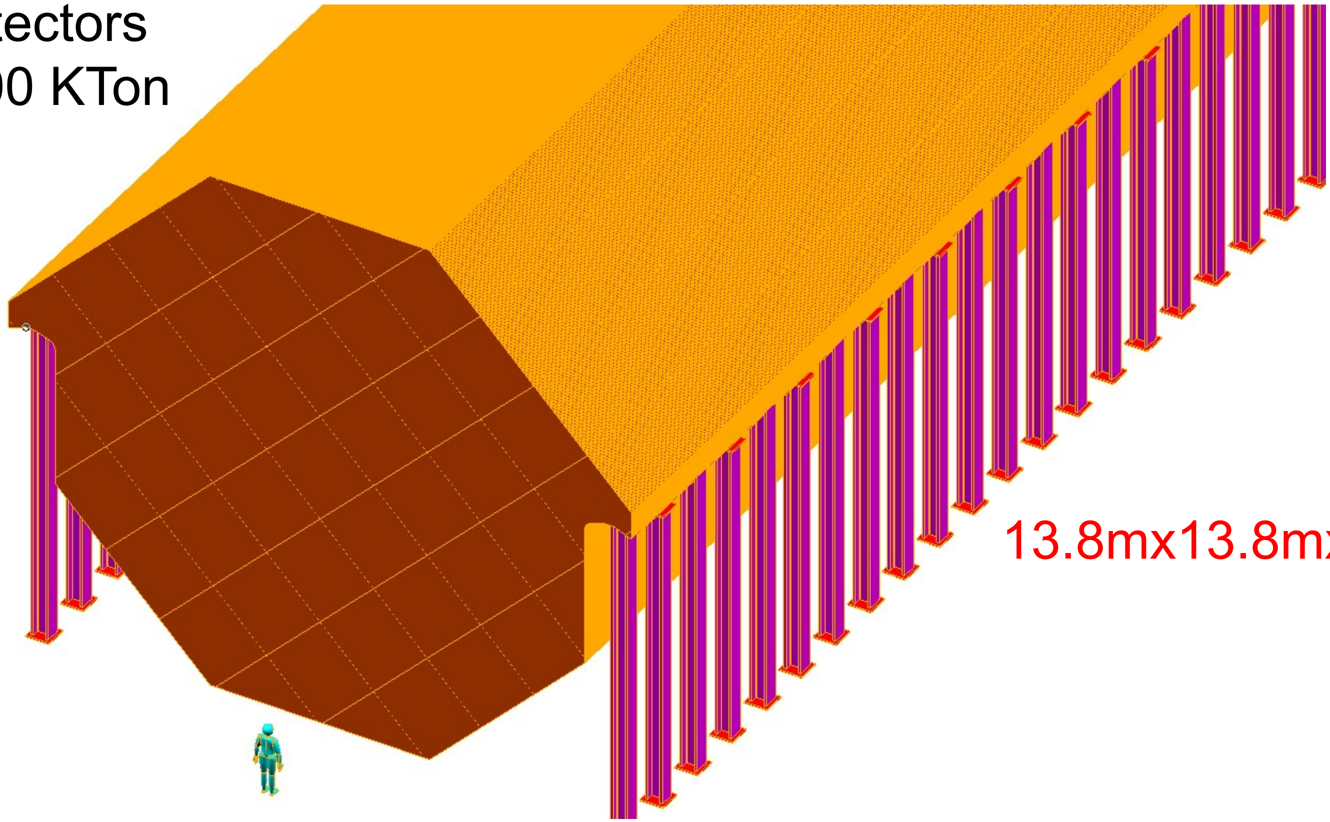
MIND engineering concept

- 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

Two detectors
M~50-100 KTon

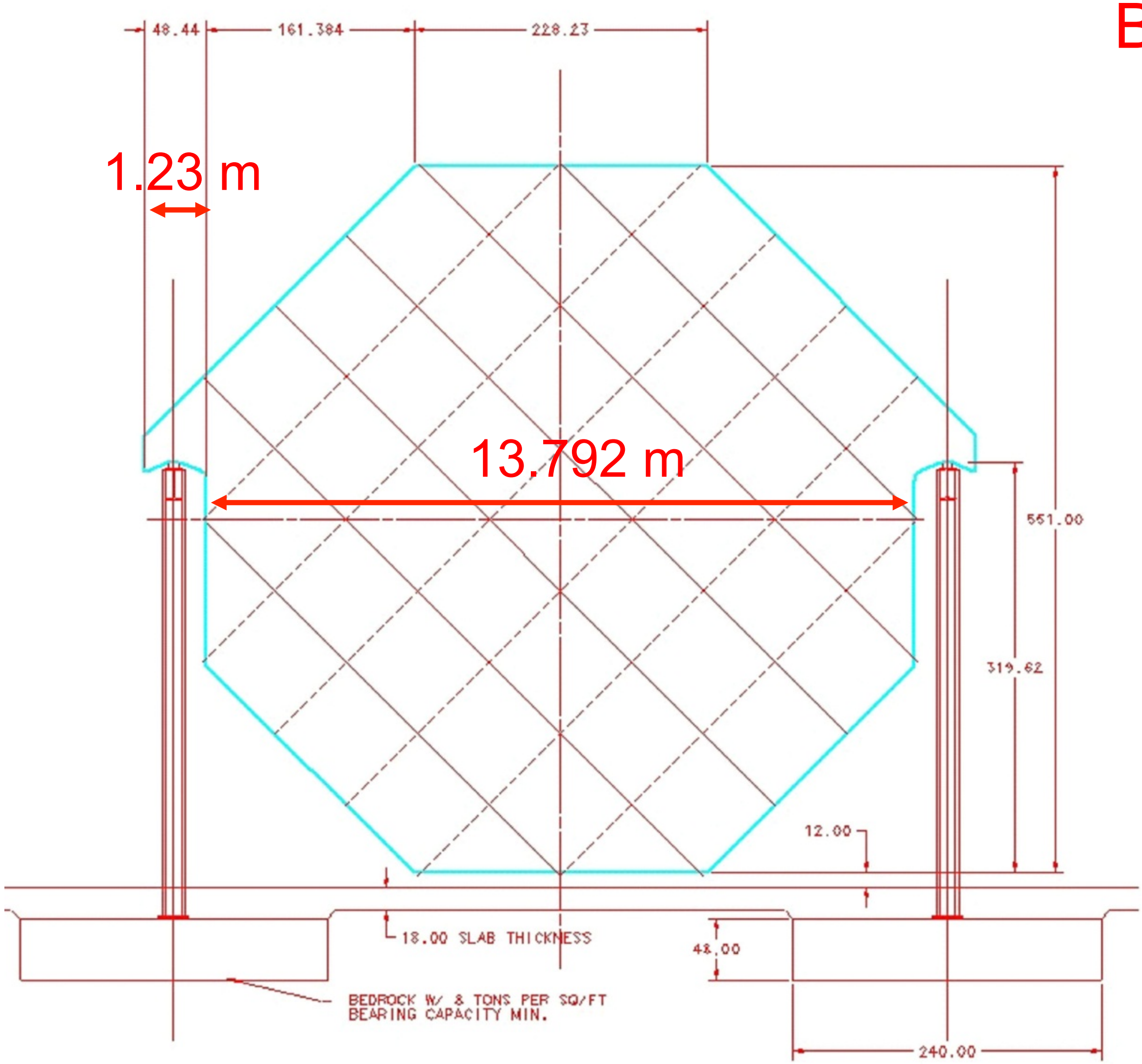


13.8mx13.8mx3cm plates

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)

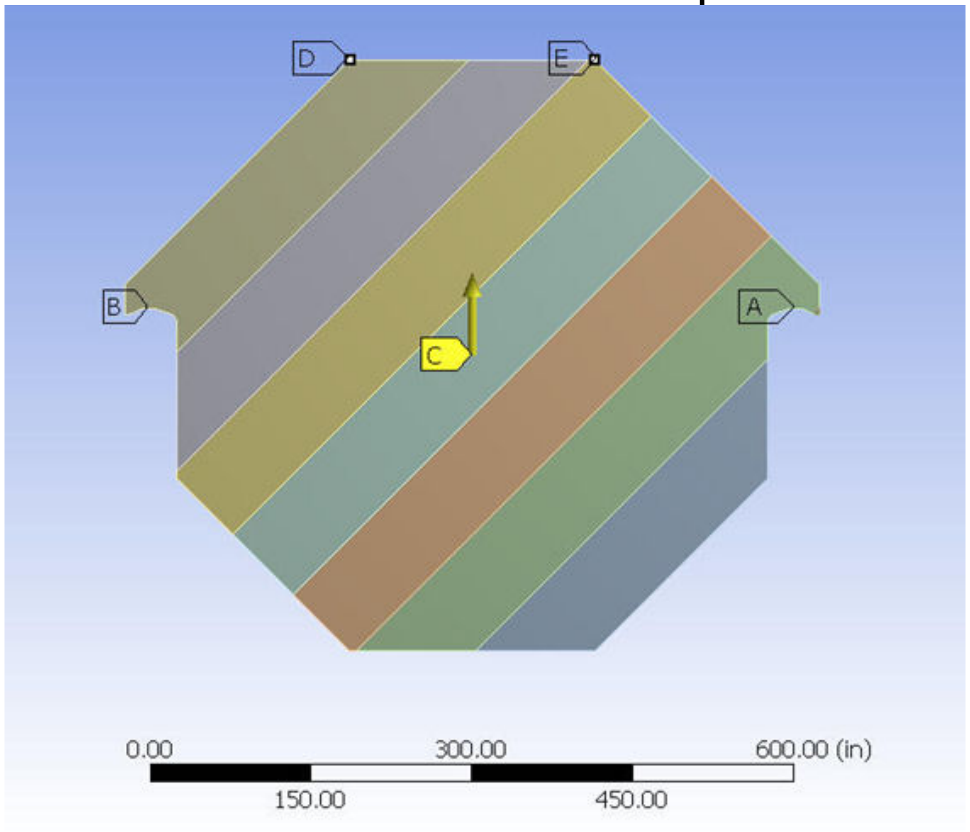
Total length = 140 m
2800 modules (5 cm)
Total 105 kton steel
(assume €1000/ton)

9.2 kton scintillator
(assume €6000/ton)

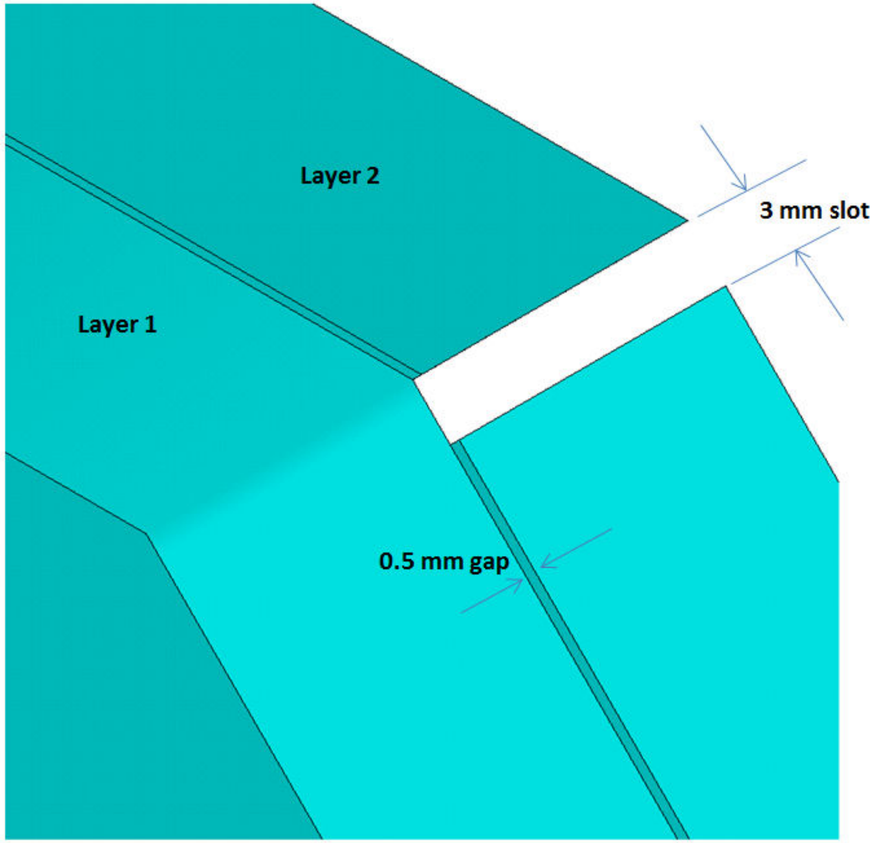
MIND engineering concept

- Manufacture of metal plates:
  - 2 m strips or mixture 2 m & 3 m
  - 3 mm slots between plates

Bross, Wands (FNAL)



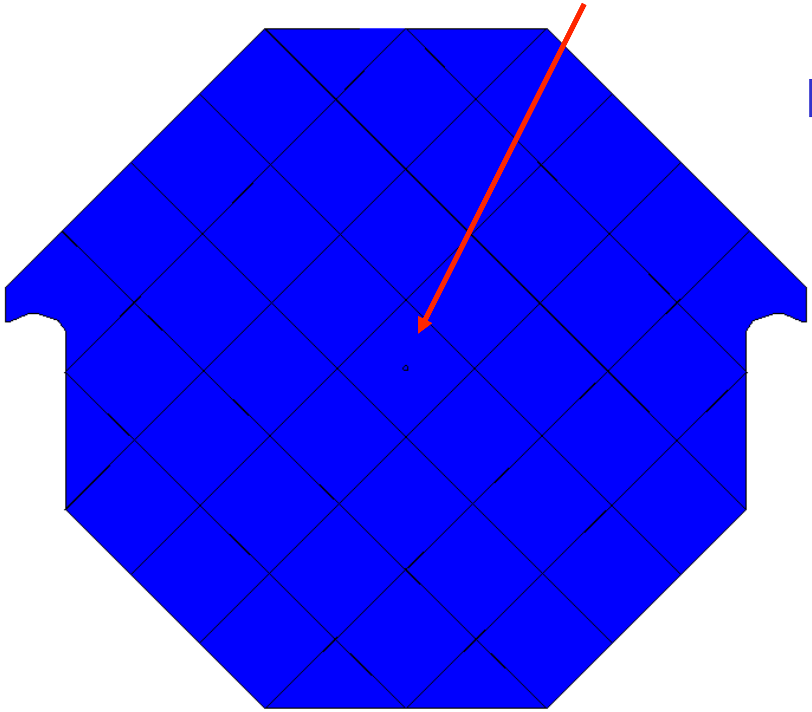
2m strip

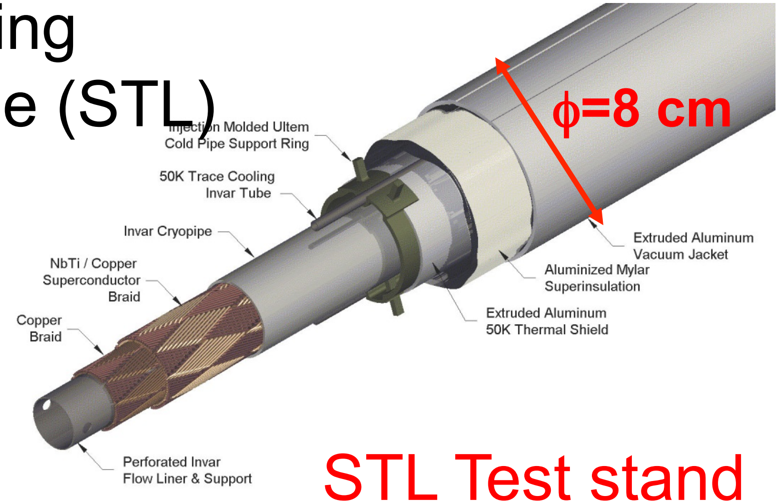


2m & 3m strip

MIND magnetisation

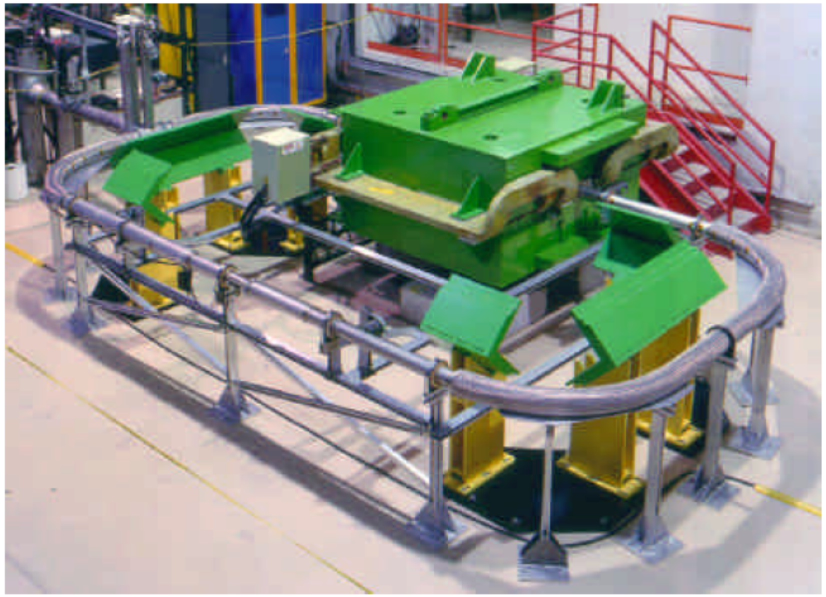
- Magnetisation can be achieved using Superconducting Transmission Line (STL) developed for VLHC: $500/m
  - Can carry 100 kA turn
  - Only need 10 cm diameter hole





Bross

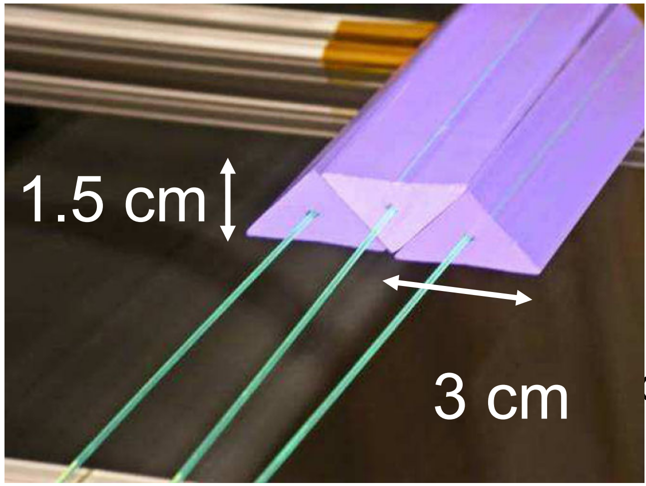
STL Test stand



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

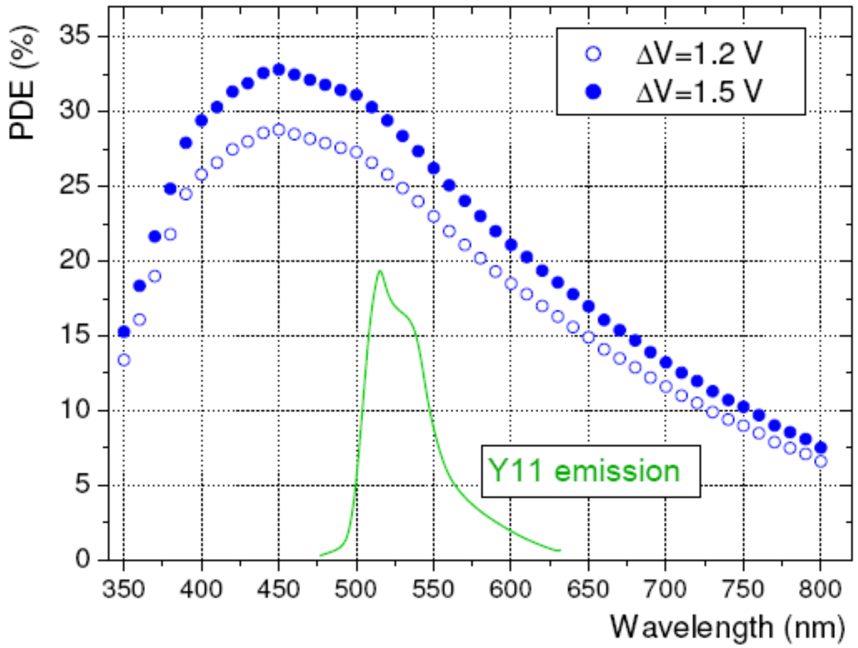
MIND scintillator

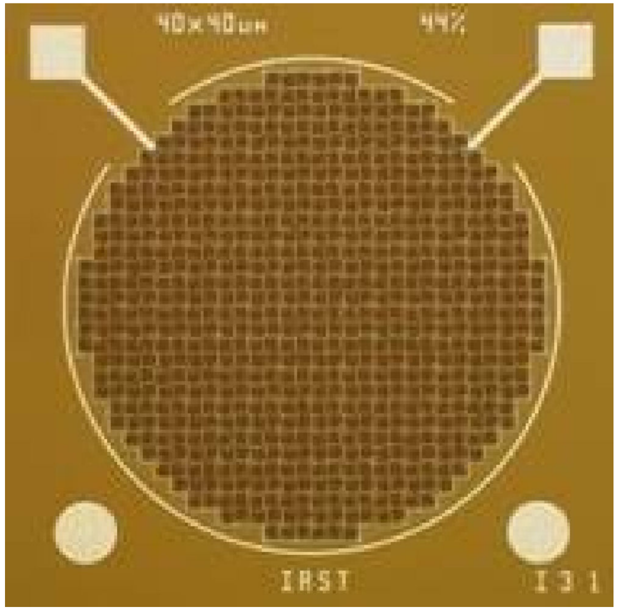
- Scintillator: x-view and y-view planes 1 cm thick each plane
  - Baseline: rectangular scintillator strips (3.5 cm wide, $\sigma \sim 1$ cm)
  - Alternative: triangular strips ($\sigma \sim 5$ mm) - 2.3 times more channels (makes project ~20% more expensive)
  - Co-extrusion fibre-scintillator
- Wavelength shifting fibres
  - Kuraray currently is the only manufacturer in the world that can deliver WLS fibres of 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
  - Started to populate spreadsheet used as interface for costing tool (but there are still many things I don't understand about how to fill it in)
  - Note: 2.3 Magic baseline detector (the same as 2.2 but cost ~50%)

2.2.	Intermediate baseline detector (MIND 100 kton)	Cost (%)
2.2.1.	Detector R&D	0.3
2.2.2.	Underground cavern	22.0
2.2.3.	Steel plate fabrication	38.7
2.2.4.	Magnet coil	0.2
2.2.5.	Scintillator detector fabrication	30.9
2.2.6.	Electronics, DAQ and database	6.1
2.2.7.	Detector installation	1.5
2.2.8.	Project management	0.3

MIND WBS

- Work Breakdown Structure

2.2.1.	**Detector R&D**
2.2.1.1.	Scintillator R&D
2.2.1.2.	STL R&D
2.2.1.3.	Photon detector and electronics R&D
2.2.2.	**Underground cavern**
2.2.2.1.	Geomechanical studies
2.2.2.2.	Cavern construction
2.2.2.3.	Cavern outfitting

MIND WBS

- Work Breakdown Structure

2.2.3.	**Steel plate fabrication**
2.2.3.1.	Engineering, design
2.2.3.2.	Steel management
2.2.3.3.	Detector plane prototypes
2.2.3.4.	Steel procurement
2.2.3.5.	Steel plate assembly
2.2.3.6.	Steel transport
2.2.3.7.	Steel support structures and handling fixtures
2.2.4.	**Magnet coil**
2.2.4.1.	Engineering, design
2.2.4.2.	STL fabrication
2.2.4.3.	STL cryo plant
2.2.4.4.	Power supplies

MIND WBS

- Work Breakdown Structure

2.2.5.	**Scintillator detector fabrication**
2.2.5.1.	Engineering, design
2.2.5.2.	Scintillator strips
2.2.5.3.	WLS fibre
2.2.5.4.	Scintillator modules
2.2.5.5.	Photon detectors (SiPMTs)
2.2.5.6.	Multiplexing boxes and connectors
2.2.5.7.	Calibration systems
2.2.5.8.	Assembly and test equipment
2.2.5.9.	Factories
2.2.5.10.	Scintillator management

MIND WBS

- Work Breakdown Structure

2.2.6.	**Electronics, DAQ and database**
2.2.6.1.	Front end electronics
2.2.6.2.	Data routing and trigger farm
2.2.6.3.	Data acquisition and triggering
2.2.6.4.	Database
2.2.6.5.	Auxiliary systems
2.2.6.6.	Slow controls and monitoring
2.2.6.7.	High Voltage systems
2.2.6.8.	Electronics management

MIND WBS

- Work Breakdown Structure

2.2.7.	**Detector installation**
2.2.7.1.	Management
2.2.7.2.	Lab infrastructure
2.2.7.3.	Plane assembly area
2.2.7.4.	Installation
2.2.7.5.	Alignment and survey
2.2.8.	**Project management**

MIND WBS

- Safety MIND:
  - 2.2.2: Construction of cavern in underground facility

    Usual underground safety considerations: ventilation, rock bolting, structural stability of cavern and construction infrastructure
  - 2.2.3: Steel plate fabrication

    Safety in welding and assembly of plates underground, engineering solution for mounting 14x14 m^2 plates vertically
  - 2.2.4: Magnet coil

    Operation of small cryogenic plant underground
  - 2.2.5: Scintillator fabrication

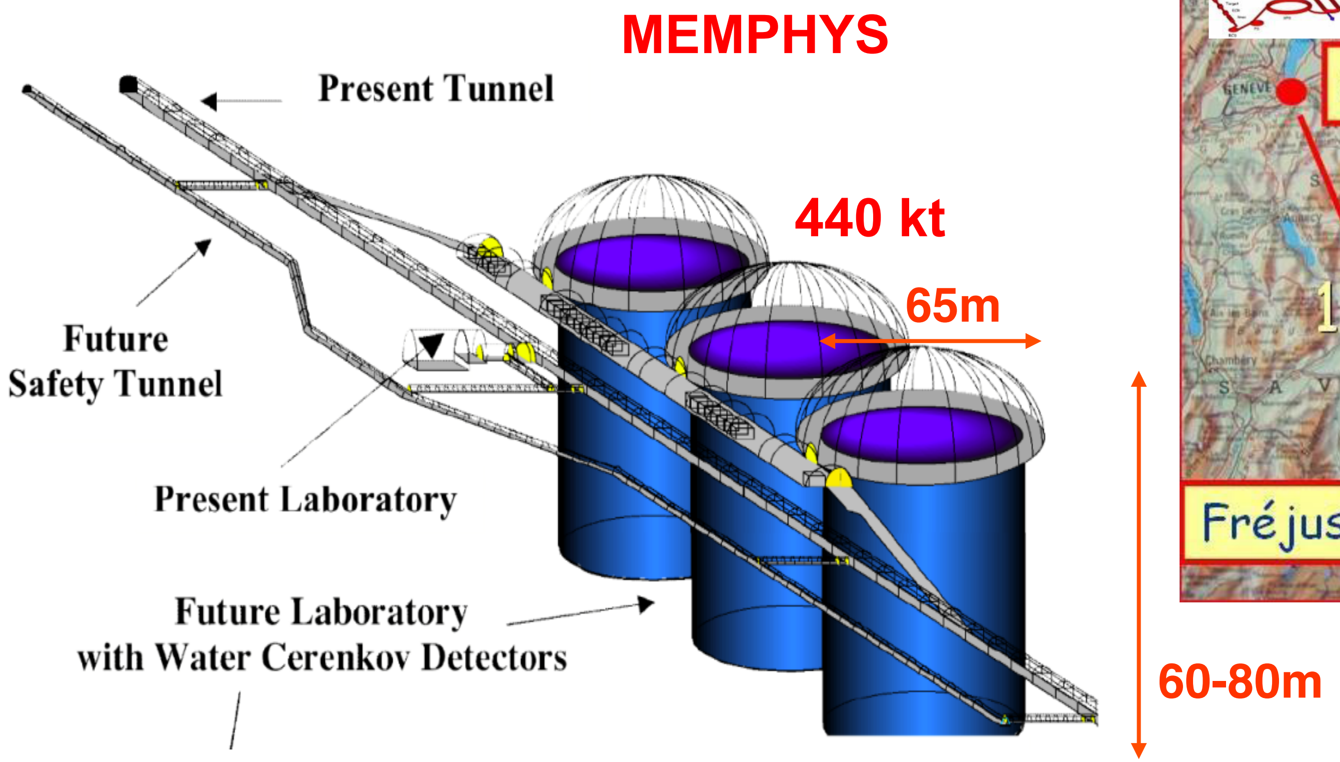
    Module fabrication in laboratories and final assembly udnerground
  - 2.2.6: Electronics, DAQ, database

    Electronics assembly in labs and installation underground
  - 2.2.7: Detector installation

    Final installation of all components underground, personnel safety and integrity of detector components

Water Cherenkov

- MEMPHYS: 3x65mx60m water Cherenkov modules (440 kton fiducial) but could be expanded to 3x65mx80m (572 kton)
- Either SPL Super Beam or CERN Beta Beam to Frejus tunnel in Modane, France, 130 km from CERN.



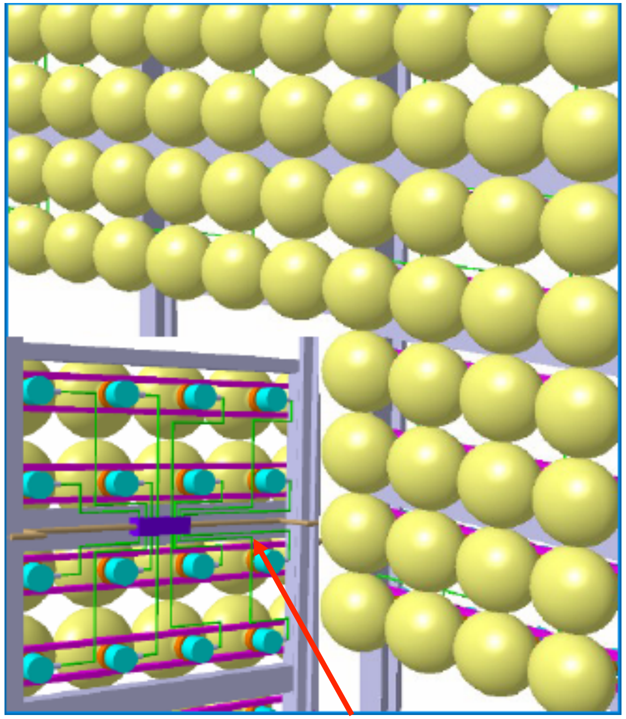
Water Cherenkov design

- **MEMPHYS concept: engineering of cavern from LAGUNA**
  - Laboratoire Souterrain de Modane Fréjus at 4800 m.w.e.
  - Fiducial: 440 kton (3 x 65mX60 modules), or 572kton (3 x 65mX80m)
  - Readout : ~3 x 81,000 12″ PMTs (alternatively 8″, 10″) for 30% cover

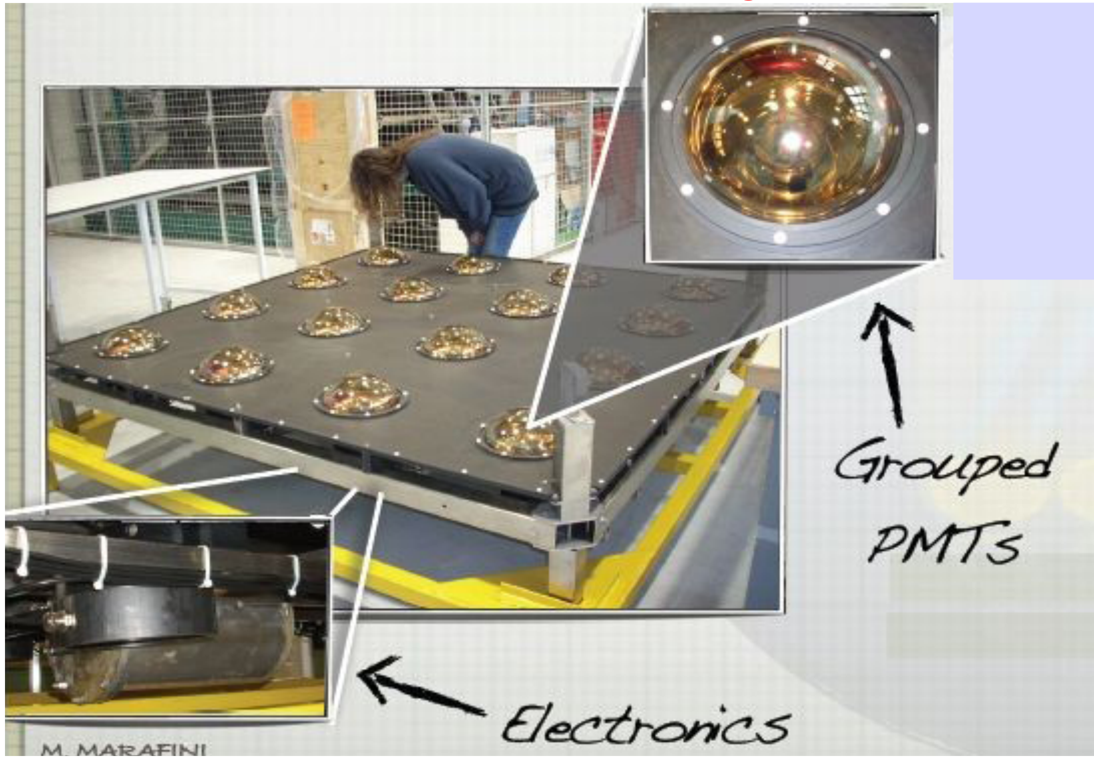


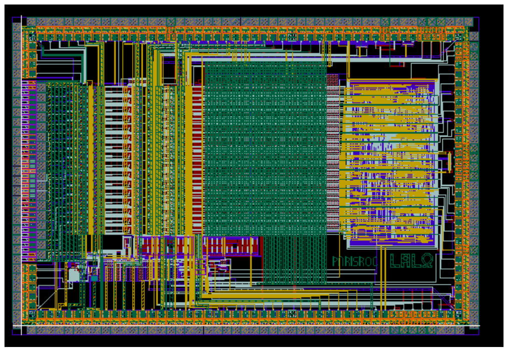
MEMPHYS R&D

- R&D on photon detector readout: 12” and 8” PMT design
  - Groups of 16 PMTS read out by one ASIC: PArISROC



MEMPHYNO Prototype





16 channel front end chip testboard

MEMPHYS WBS

- Work Breakdown Structure: to be included in each project
  - Cern2Frejus WBS: 5. Far Detector (x=5)
  - Beta Beams WBS: 4. Main Detectors (x=4)

x.2.	**Water Cherenkov detector (MEMPHYS)**	**Cost (%)**
x.2.1.	**Detector R&D**	0.1
x.2.2.	**Underground cavern**	31.4
x.2.3	**Tank**	27.0
x.2.3.	**Photomultiplier tubes**	36.4
x.2.4.	**Electronics, DAQ and database**	0.9
x.2.5.	**Detector installation**	3.3
x.2.6.	**Project management**	0.9

MEMPHYS WBS

- Work Breakdown Structure

x.2.	**Water Cherenkov detector (MEMPHYS)**
x.2.1.	**Detector R&D**
x.2.1.1.	PMT R&D
x.2.1.2.	Electronics R&D
x.2.2.	**Underground cavern**
x.2.2.1.	Geomechanical studies
x.2.2.2.	Cavern excavation
x.2.3.	**Tank**
x.2.3.1	Materials
x.2.3.2	Manpower

MEMPHYS WBS

- Work Breakdown Structure

x.2.3.	**Photomultiplier tubes**
x.2.3.1.	Photomultiplier tubes
x.2.3.2.	PMT Housing
x.2.3.3.	PMT support
x.2.3.4.	Cables
x.2.3.5.	Calibration systems
x.2.3.6.	Assay and test equipment

MEMPHYS WBS

- Work Breakdown Structure

x.2.4.	**Electronics, DAQ and database**
x.2.4.1.	Front end electronics
x.2.4.2.	High Voltage
x.2.4.3.	Online computing
x.2.4.4.	Data acquisition
x.2.4.5.	Database
x.2.4.6.	Auxiliary systems
x.2.4.7.	Electronics management
x.2.5.	**Detector installation**
x.2.5.1.	Management
x.2.5.2.	Detector assembly
x.2.5.3.	Water/purification
x.2.6.	**Project management**

MEMPHYS WBS

- Safety MEMPHYS:
  - x.2.2: Underground cavern

    Usual underground safety considerations: excavation, ventilation, rock bolting, structural stability of cavern and construction infrastructure
  - x.2.3: Construction tank

    Sealing cavern for leaks, detector supports, ventilation during construction, operation at heights (80 m x 65 m diameter)
  - x.2.3: Photomultiplier tubes

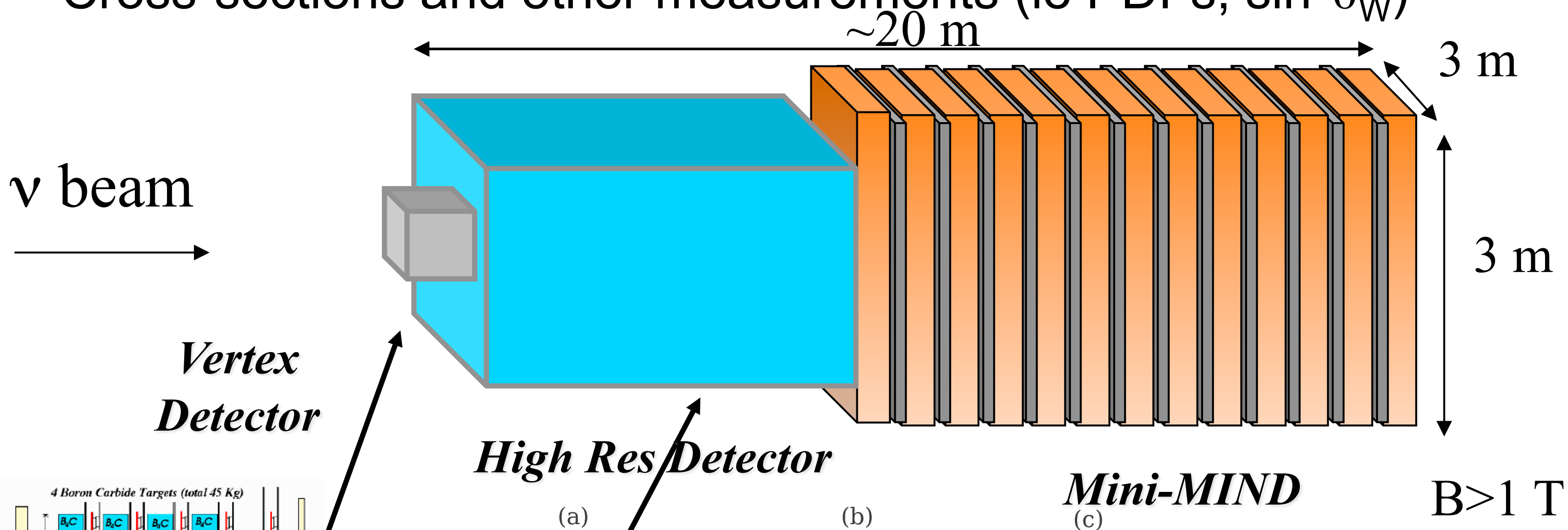
    Assembly tube modules in labs, installation underground by gradual filling (as in Super-K)
  - x.2.4: Electronics, DAQ, database

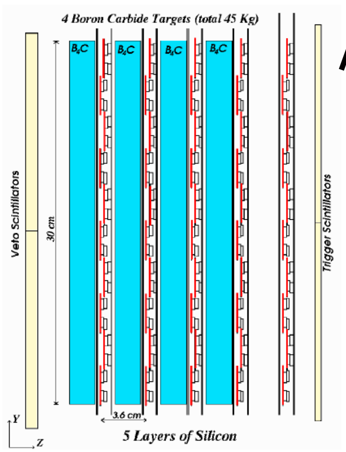
    Electronics assembly in labs and installation underground
  - x.2.5: Detector installation

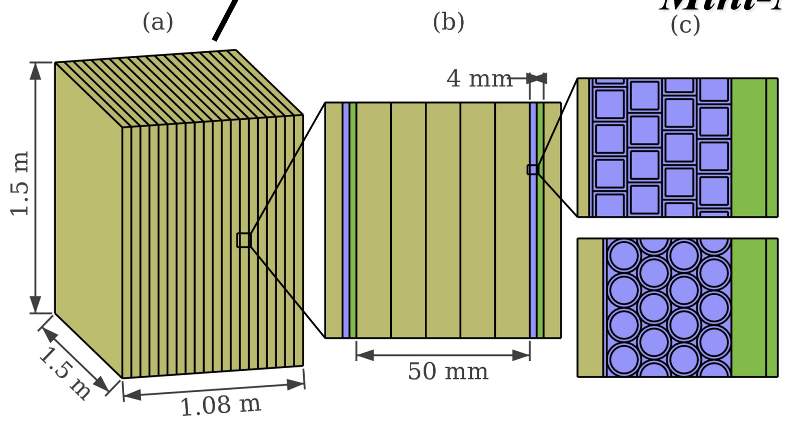
    Final installation of all components underground, personnel safety and integrity of detector components

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, $\sin^2\theta_W$)







4 near detectors at Neutrino Factory (one per straight)

Near Detector WBS

- Work Breakdown Structure: start off with Neutrino Factory

2.1.	Near Detector	Cost (%)
2.1.1.	Mini-MIND	10.1
2.1.2.	High resolution tracker	41.9
2.1.3.	Silicon vertex	28.5
2.1.4.	Computing	5.0
2.1.5.	Installation	10.3
2.1.6.	Project management	4.3

Near Detector WBS

- Work Breakdown Structure

2.1.1.	**Mini-MIND**
2.1.1.1.	Steel plane fabrication MIND
2.1.1.2.	Scintillator MIND
2.1.1.3.	Fibre MIND
2.1.1.3.	SIPM MIND
2.1.2.1.	Electronics MIND
2.1.2.2.	Coil Mind
2.1.2.	**High resolution tracker**
2.1.2.1.	Scintillator HighRes
2.1.2.2.	Fibre HighRes
2.1.2.3.	SiPM HighRes
2.1.2.4.	Electronics HighRes
2.1.2.5.	Coil

Near Detector WBS

- Work Breakdown Structure

2.1.3.	**Silicon vertex**
2.1.3.1.	Silicon
2.1.3.2.	Silicon electronics
2.1.4.	**Computing**
2.1.4.1.	Central system and trigger farm
2.1.4.2.	Data acquisition
2.1.4.3.	Database
2.1.5.	**Installation**
2.1.5.1.	Infrastructure
2.1.5.2.	Materials receiving and handling
2.1.5.3.	Detector assembly
2.1.5.4.	Alignment and survey
2.1.6.	**Project management**

Near Detector WBS

- Safety Near Detector:
  - 2.1.1: MiniMIND

    Same safety issues associated to the assembly of the iron pates and scintillator planes underground
  - 2.1.2: High resolution tracker

    Mechanics of scintillator support structure needs to be engineered. No safety issues associated with making of scintillator modules
  - 2.1.3: Silicon vertex

    No major issues in the assembly of a silicon detector, mechanics needs to be well engineered for precision alignment but does not affect safety
  - 2.1.5: Detector installation

    Final installation of all components underground, personnel safety and integrity of detector components

Conclusions

- WBS is the same as presented at the last costing meeting
- I have added comments on the safety of each of the detector components.
- The main issues arise in the construction and operation of detectors underground
- There is already experience from MINOS, SuperK and other underground detectors on these issues.