WP5 summary

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IFIC (Valencia)

EURO-ν general meeting

Strasbourg, 4 June 2010

Aims of WP5

P. Soler

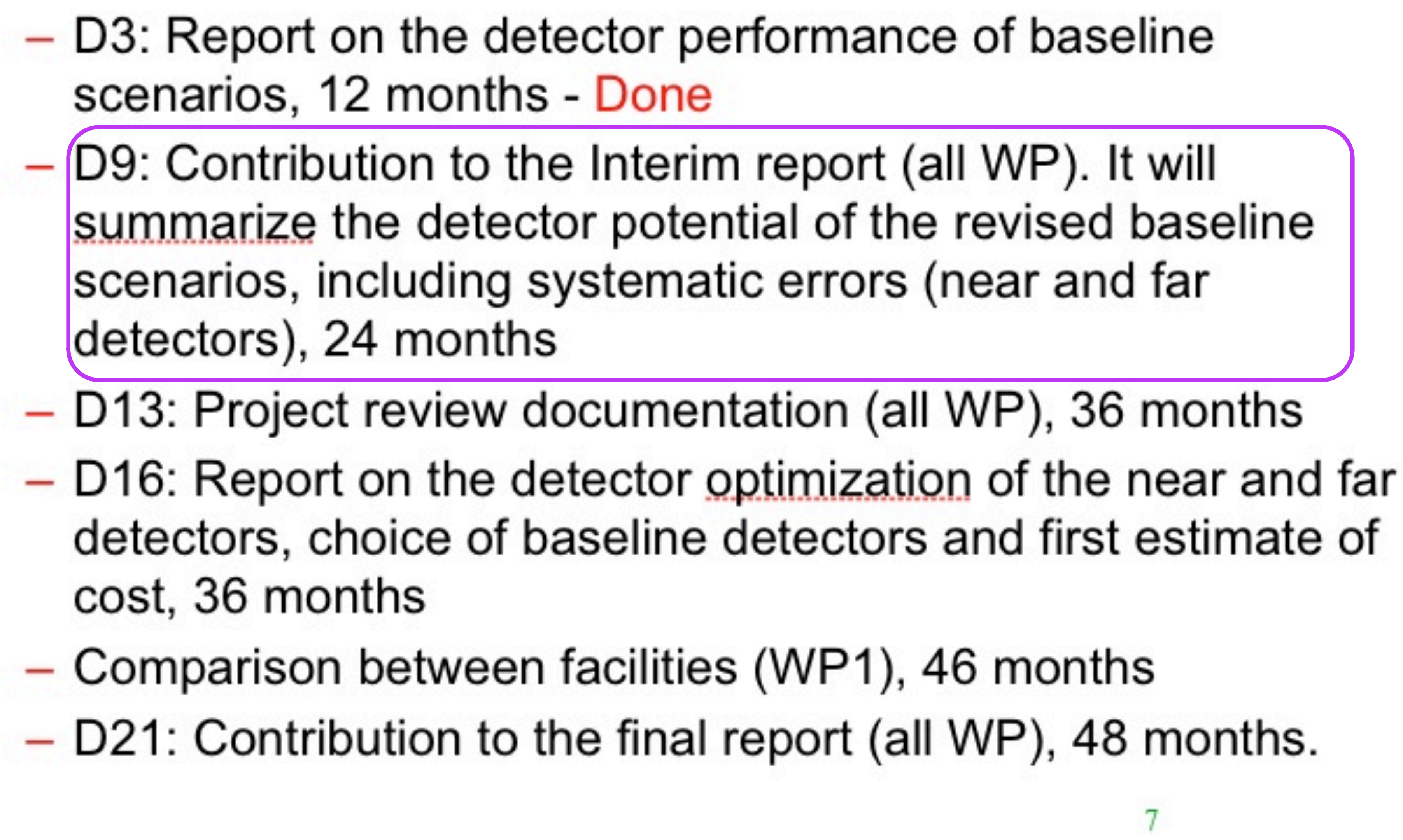
- Define the **baseline detector options** needed to deliver the physics for each of the neutrino facilities and **determine their cost**.
- Priorities include baseline detector options from ISS:
  - **MIND** (Magnetised Iron Neutrino Detector) for the golden channel at a Neutrino Factory,
  - **Water Cherenkov** detector for the Super-Beam and Beta Beam facilities
  - **Near detector:** performance at each of the facilities for absolute flux normalisation, measurement of differential cross sections and detector backgrounds.

- Desirable studies: extensions to the baseline options
  - Totally Active Scintillator Detector (TASD). Emulsion Detectors and Liquid Argon detectors for the platinum and silver channels
  - Define beam instrumentation and shielding requirements for the near detector.

WP5 talks

MIND	A. Laing
Water Cerenkov	N.Vassilopoulos
Near detector	P. Soler
Liquid Argon	A.Rubbia
Systematics	A.Cervera
Milestones and deliverables	P. Soler
Cost	P. Soler

Deliverables



- D3: Report on the detector performance of baseline scenarios, 12 months - Done
- D9: Contribution to the Interim report (all WP). It will summarize the detector potential of the revised baseline scenarios, including systematic errors (near and far detectors), 24 months
- D13: Project review documentation (all WP), 36 months
- D16: Report on the detector optimization of the near and far detectors, choice of baseline detectors and first estimate of cost, 36 months
- Comparison between facilities (WP1), 46 months
- D21: Contribution to the final report (all WP), 48 months.

7

Milestones

- M5.1: Review detector performance for Neutrino Factory, 12 months (WP5) - Done
- M5.2: Review of systematic errors for all detectors, 24 months (WP5)
- M5.3: Choice of optimal baseline scenarios for all facilities, 36 months (WP5)
- M5.4: Comparison of detector performance for all facilities, 40 months (WP5)

Next Milestones and deliverables

- Next Milestone
  - M5.2: Review of systematic errors for all detectors

- Next deliverable
  - D9: Interim report potential of the revised baseline scenarios, including systematic errors

We need to revise the performance of the baseline detectors, including systematic errors, by September

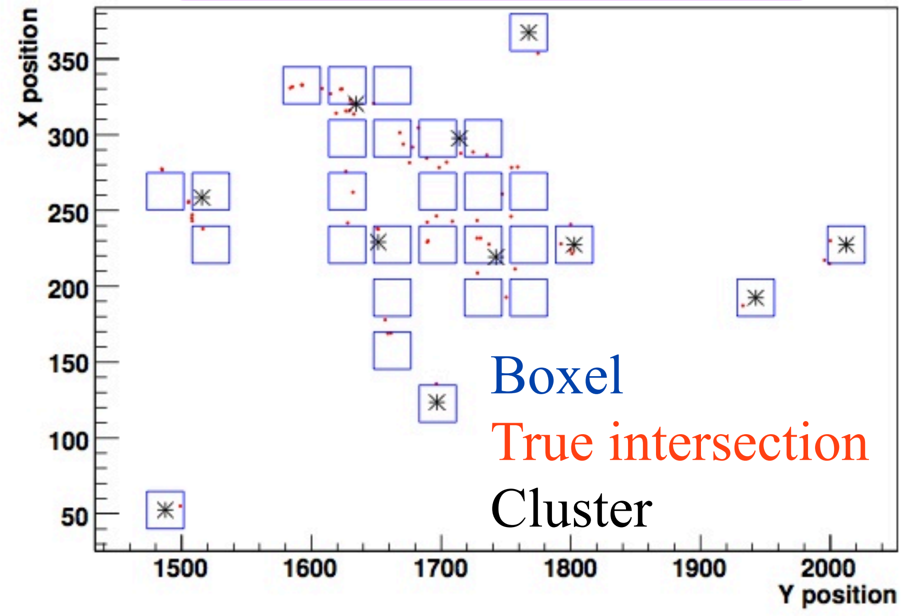
MIND

- MIND analysis has evolved significantly
- Geant4 simulation now exists
  - Full development of the hadron shower
  - Optimised segmentation 3cm (iron) + 2cm (scintillator)
  - Nuance used as event generator (DIS, QEL, RES, coh, ...)
- A proto digitisation is being used, replacing the previous smearing
- Kalman filter is used for muon reconstruction
- Hadron shower reconstruction still based in a parameterisation (this is the next step)
- Full likelihood analysis for NC rejection based on MINOS

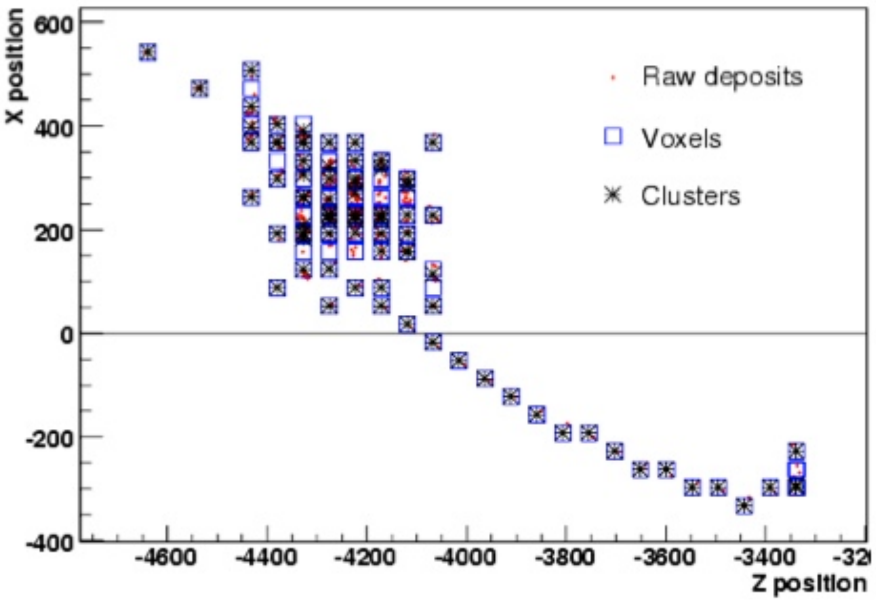
Digitisation

- Two layers of orthogonal scintillator bars (15m x 3.5 cm x 1 cm) between iron plates. Assume perfect view matching for the moment (3.5 x 3.5 x 1cm voxels)
- Parameterisation of scintillator response. Assumes WLS with λ= 5m
- Raw energy in a 'voxel' split in 4 and attenuated to the edges:
    - smeared with sigma = 6%E.
    - Bad voxels/views rejected, 4.7 pe in 30% QE photodetector.
    - Clustering of adjacent voxels with signal

transverse plane

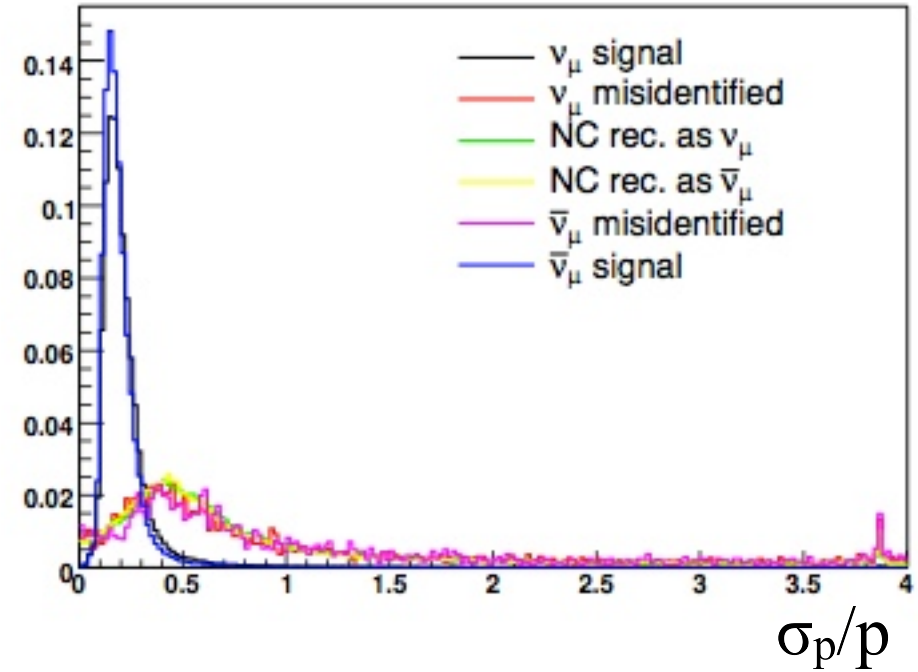


bending plane

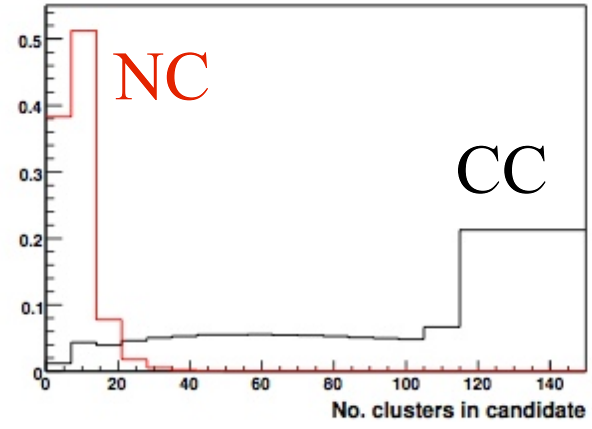


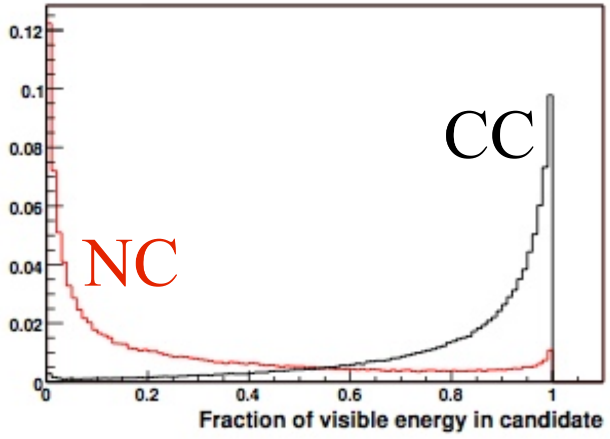
Analysis I: charge ID and CC/NC

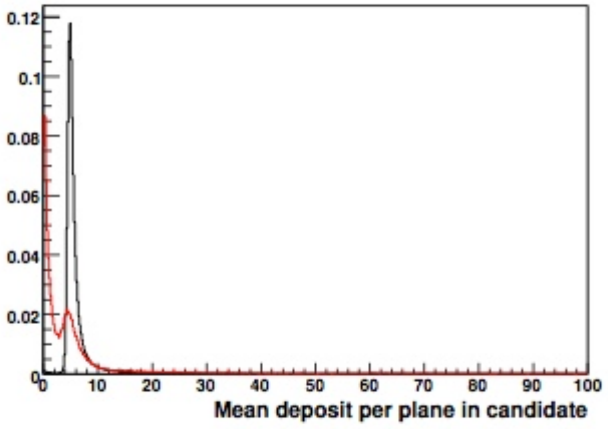
charge identification



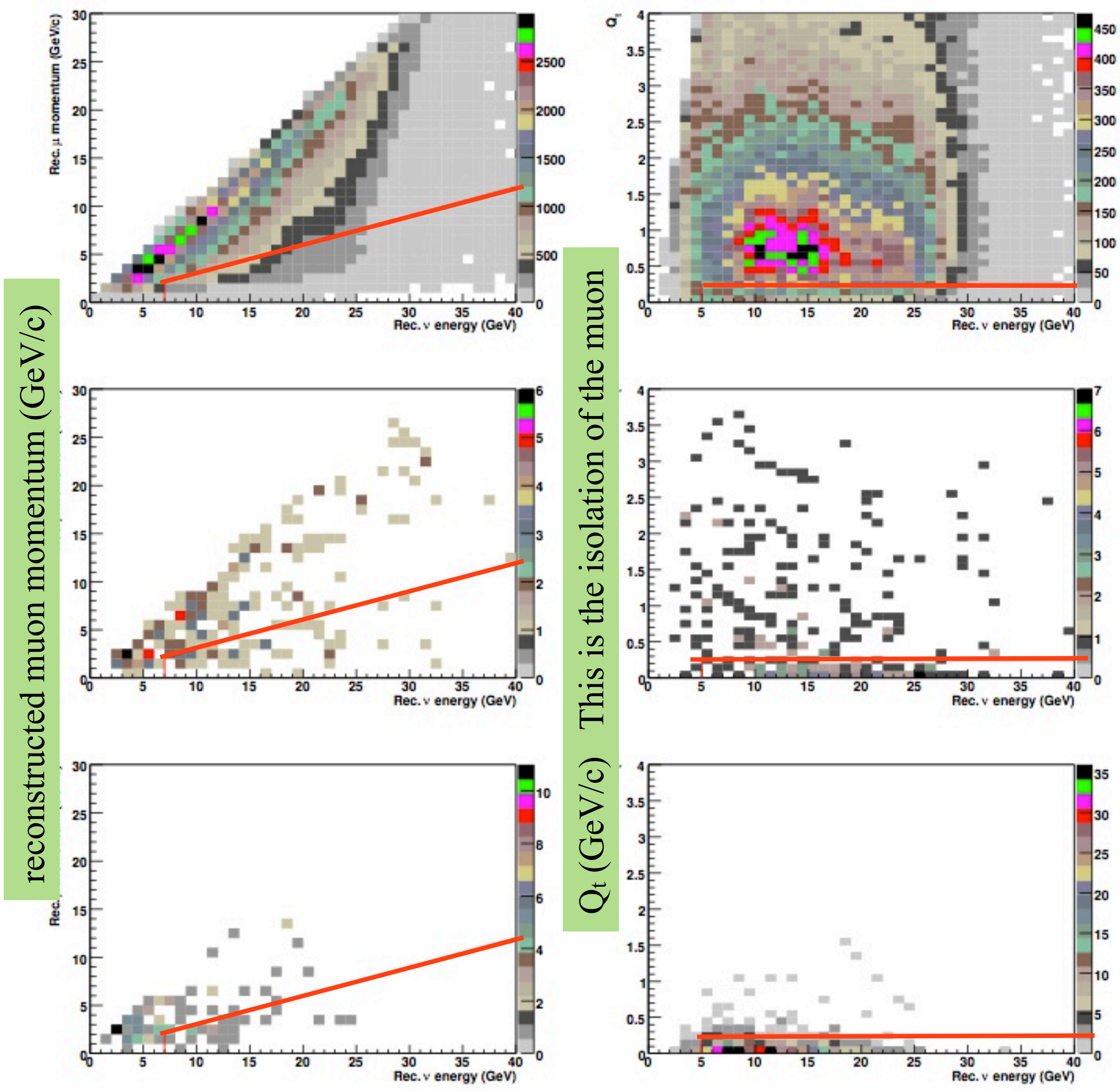
CC/NC separation







Analysis II: Kinematic cuts



reconstructed muon momentum (GeV/c)

Q_t (GeV/c)   This is the isolation of the muon

reconstructed neutrino energy (GeV/)

$\overline{\nu}_\mu$ CC signal

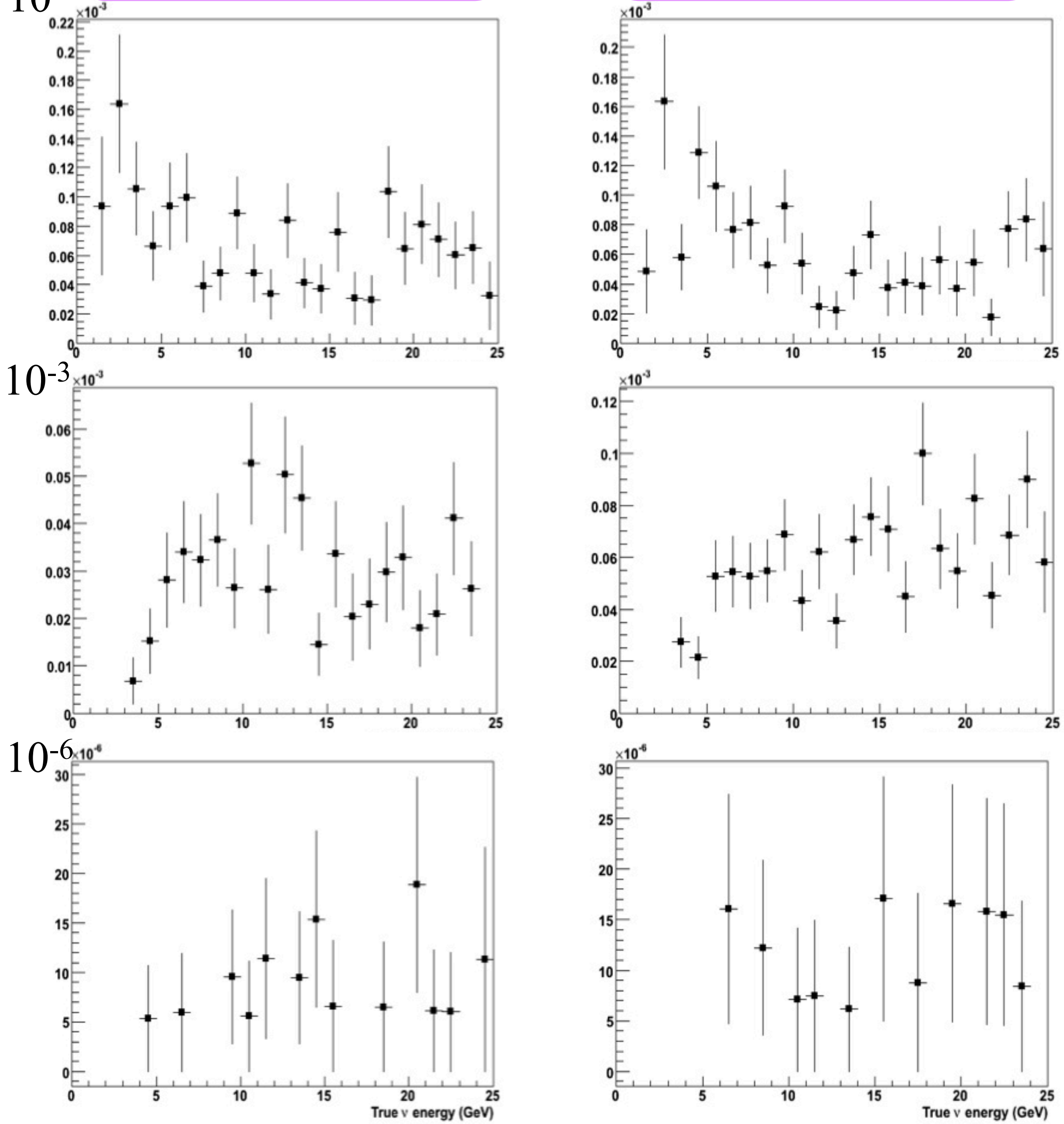
ν_μ CC

NC

Fractional backgrounds

μ^- appearance

μ^+ appearance



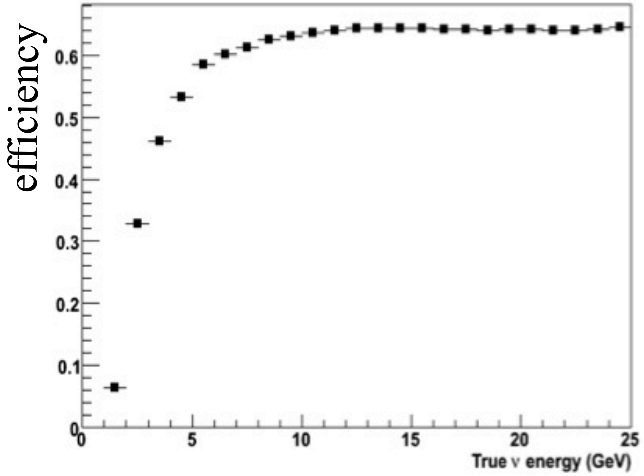
ν_μ CC $\sim 10^{-4}$

NC $< 10^{-4}$

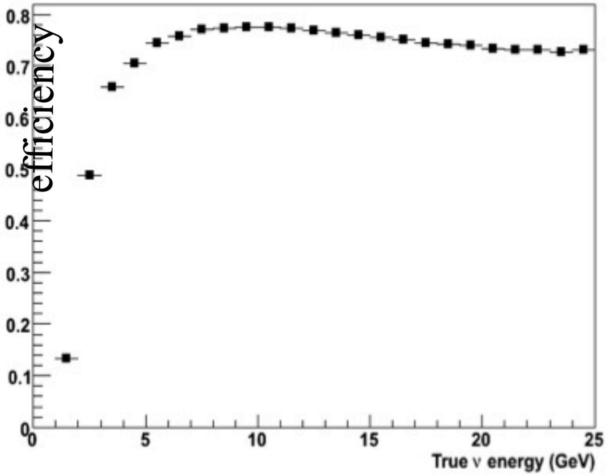
ν_e CC $\sim 10^{-5}$

Signal efficiency

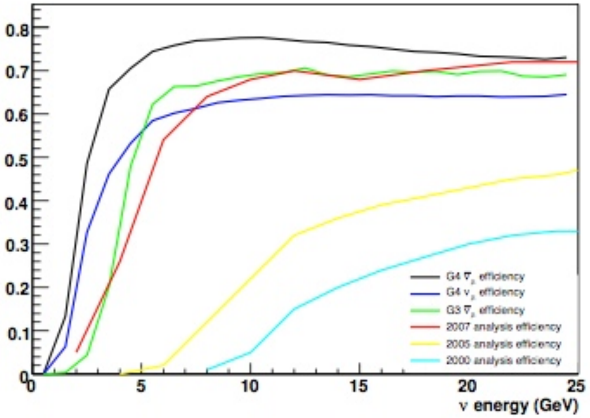
μ^- appearance



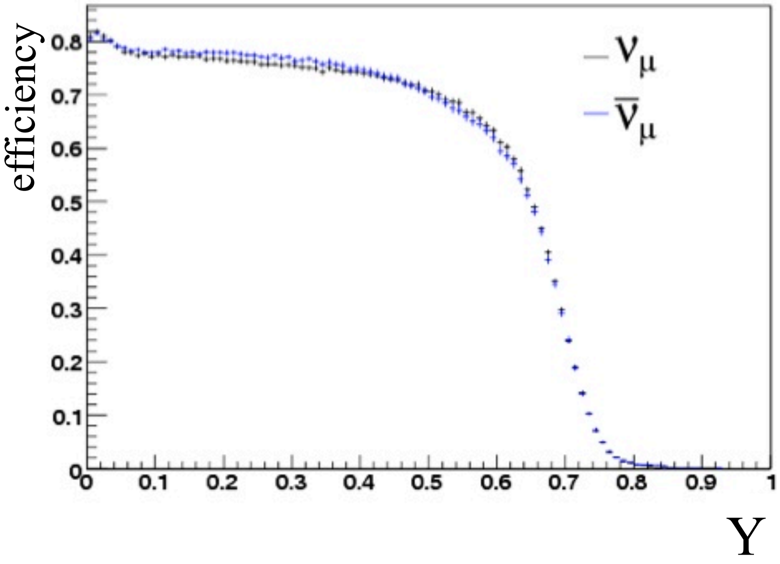
μ^+ appearance

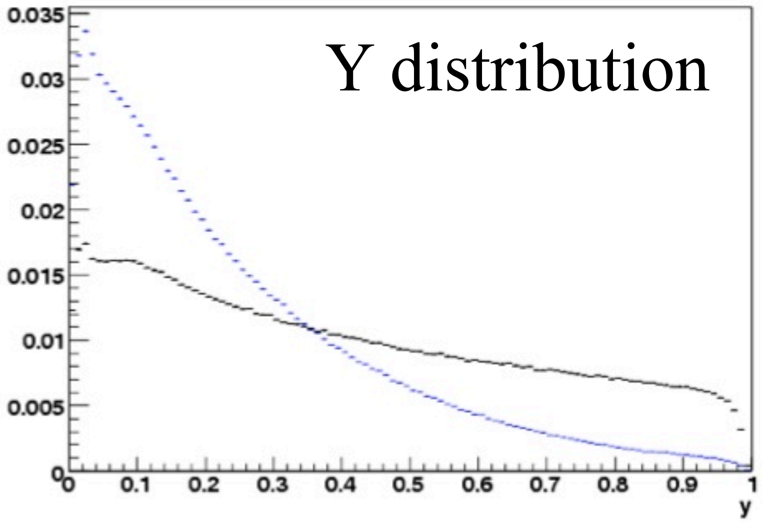


Evolution of eff



- Why efficiency is different for neutrinos and antineutrinos ?

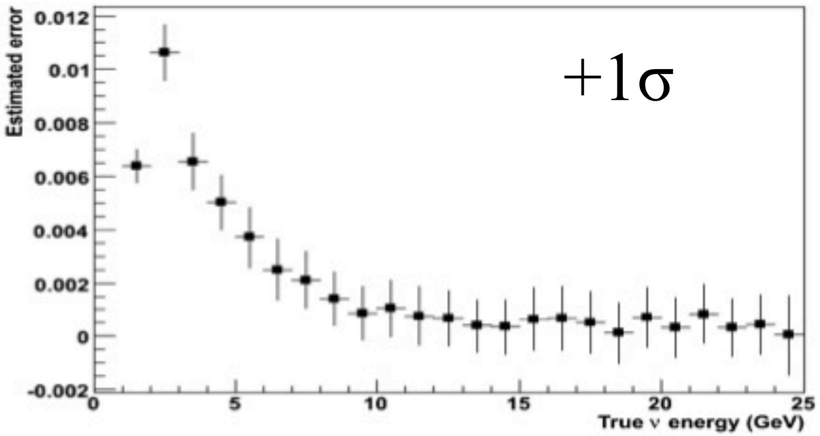


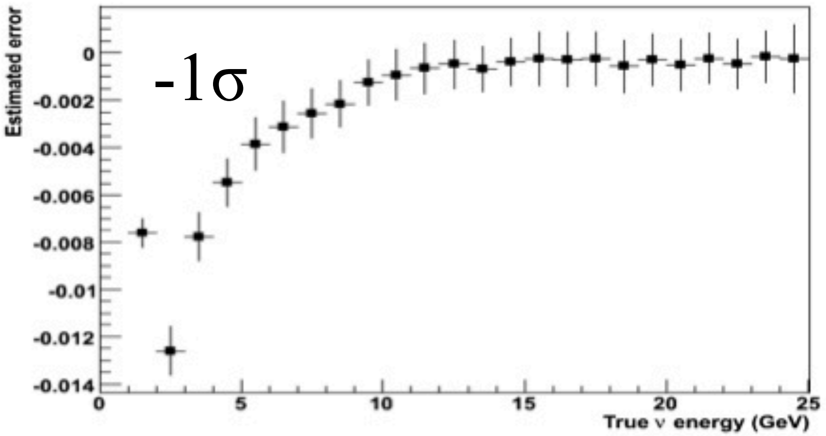


Y distribution

Systematic errors

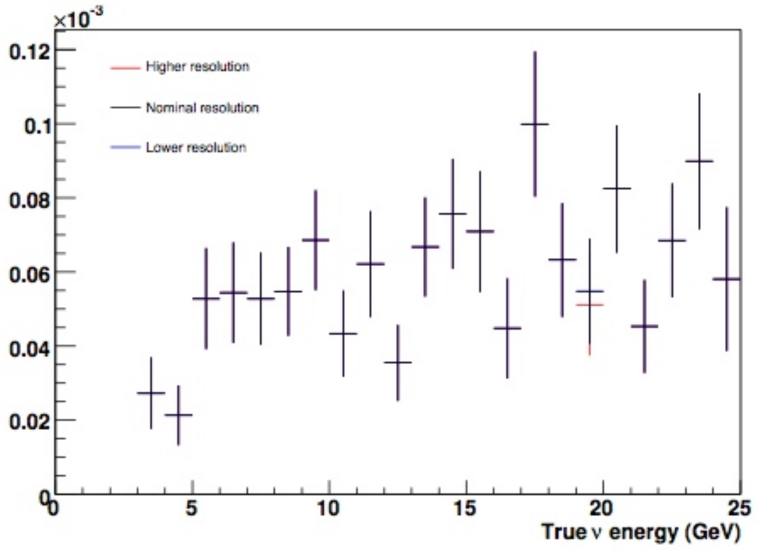
- Variation of efficiency when the QEL relative content is changed 1σ using NOMAD and MiniBooNE x-section errors





1% effect

- 6% variation in hadron shower energy and angular resolution

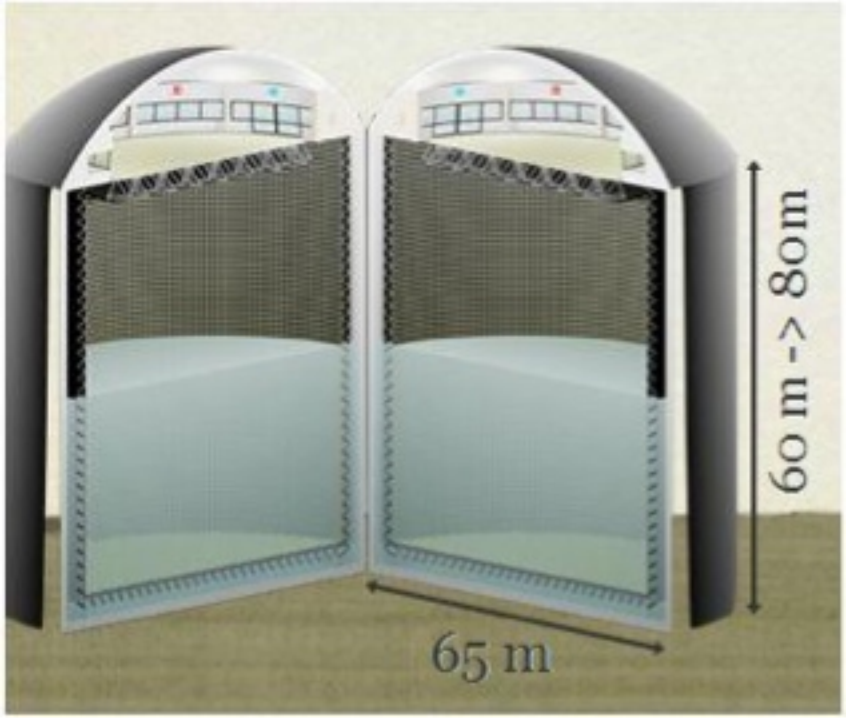


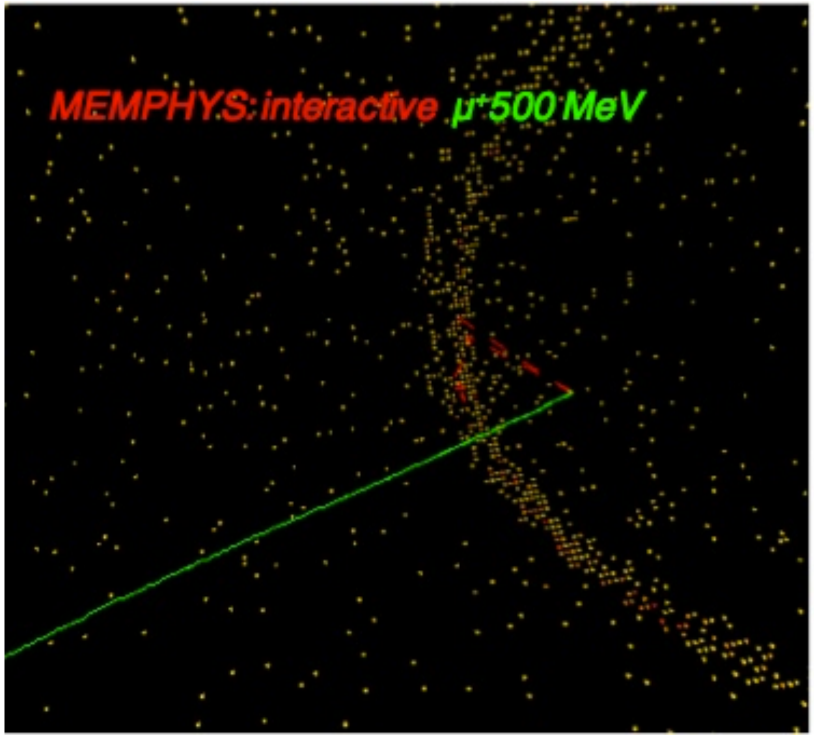
Negligible effect

Under study or pending

- Finalise systematic error study
- Hadron reconstruction under study
- Response matrix for ν_τ to ν_μ misidentification
- How does single sided readout change results ?
- Change the 2cm single plane for 2 1cm planes to be different views. View matching
- Toroidal field map. Integration of field map with simulation important step.

Water Cerenkov: Memphys

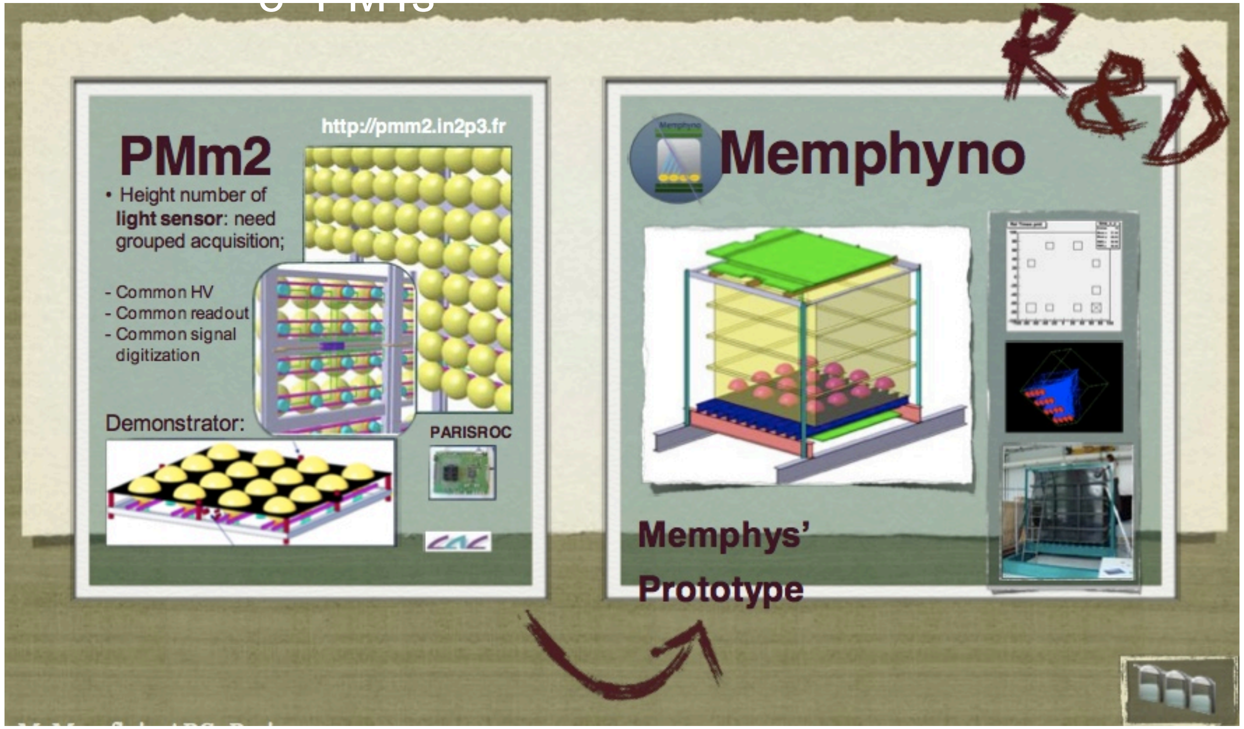




400-572 Kton FV

Memphys R&D

- PMm2 is a macropixel of PMTs connected to an autonomous front- end electronics
- Replace large PMTs (20”) by groups of 16 smaller ones (8”) with central ASIC
- $2x2x2\ m^3$ prototype



PMm2

http://pmm2.in2p3.fr

- Height number of **light sensor**: need grouped acquisition;

- Common HV
- Common readout
- Common signal digitization

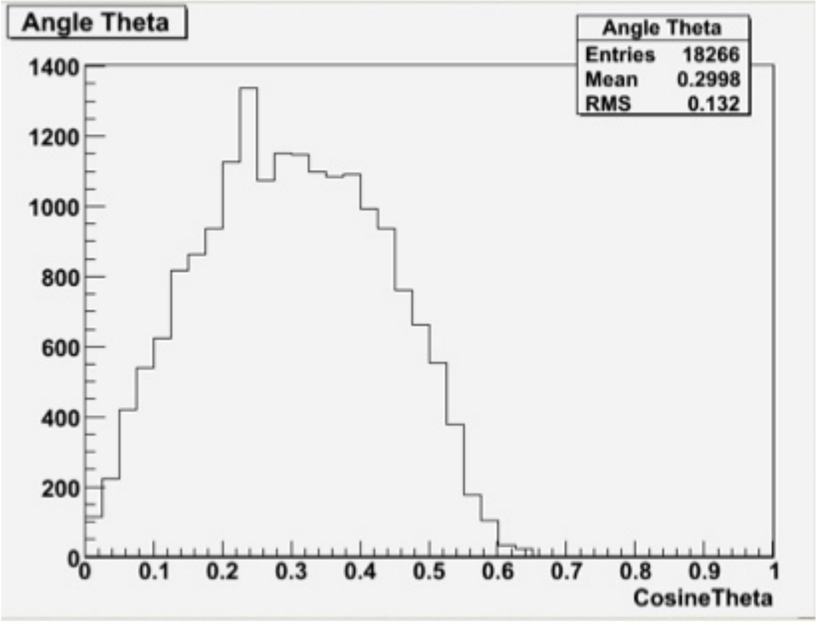
Demonstrator:

PARISROC

Memphyno

Memphys’ Prototype

Memphyno data

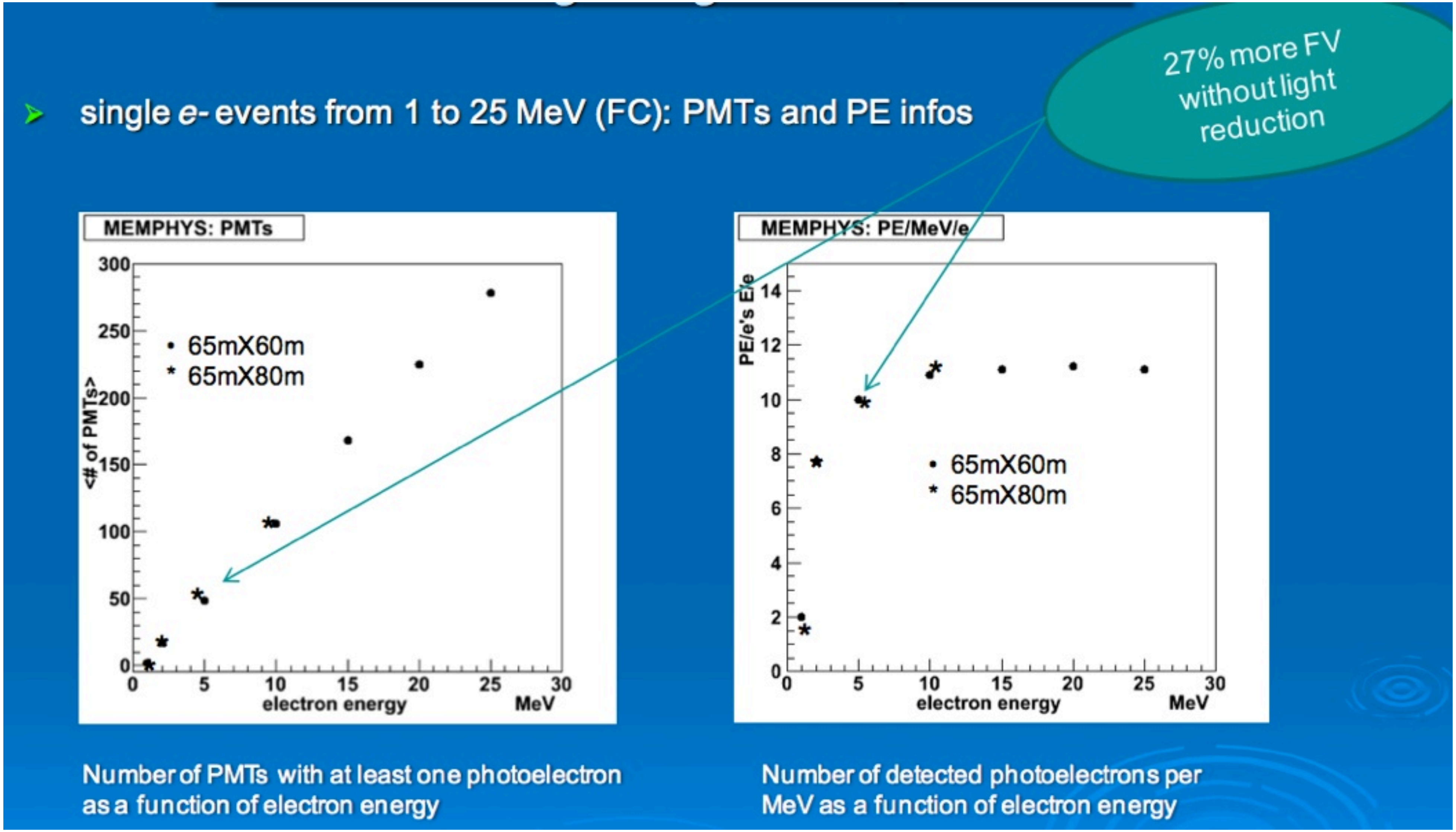


Memphys simulation and analysis

- Event Generator:
  - NUANCE for beam, Atmospheric & Proton Decay
- Simulation:
  - Geant4
  - Event info from MC: primary + secondary + Optical Photon info, track
  - process selection a la Geant4, modular detector geometry
- Reconstruction
  - Ring reconstruction based on SK
  - Studies of vertex and direction reconstruction
  - Particle identification

Light reduction for bigger detector

- No reduction for 17% more FV



- single *e*- events from 1 to 25 MeV (FC): PMTs and PE infos

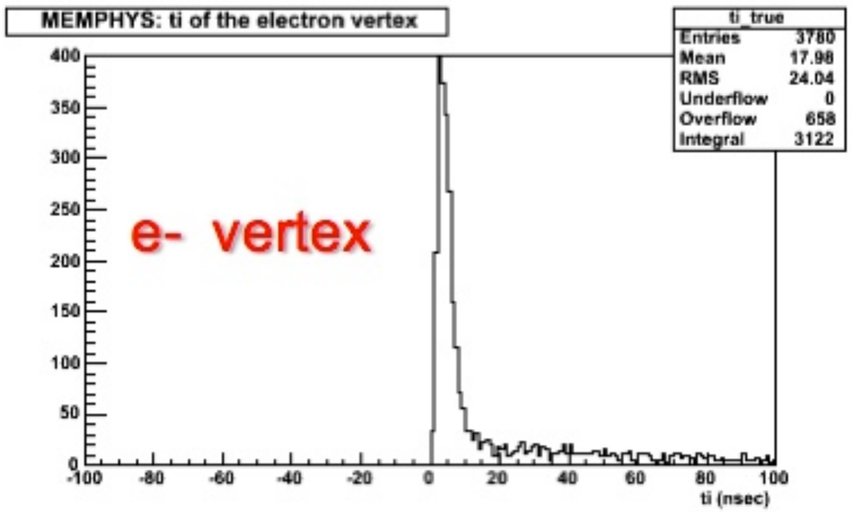
27% more FV without light reduction

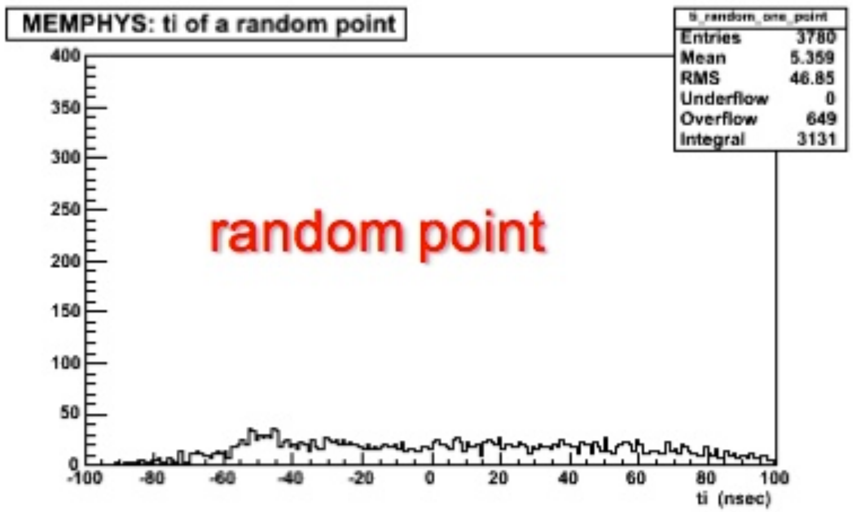
Number of PMTs with at least one photoelectron as a function of electron energy

Number of detected photoelectrons per MeV as a function of electron energy

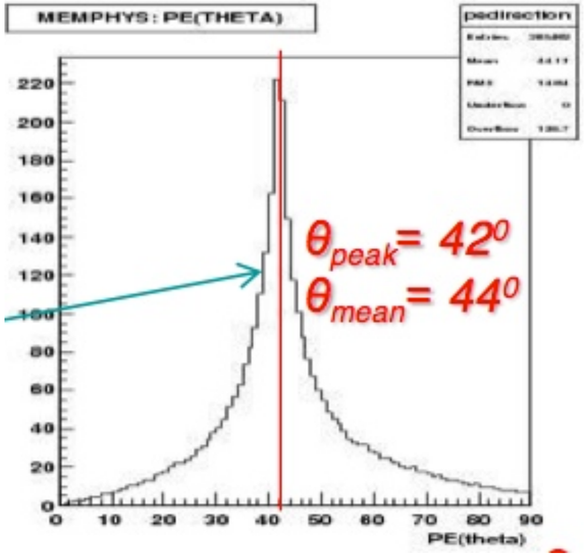
Vertex and direction recon

- Vertex reconstruction based on timing information





- Direction reconstruction

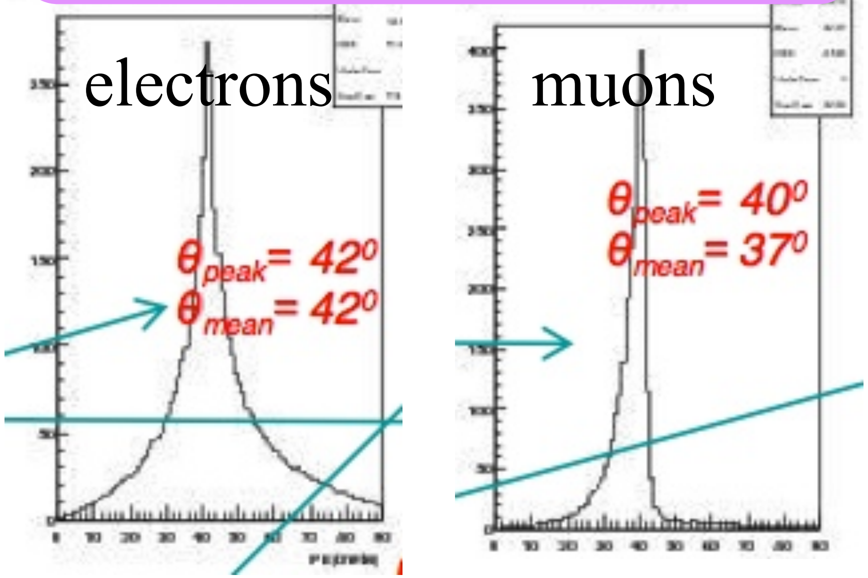


Number of photoelectrons vs angle of line connecting photodetector and vertex

$$Q(\theta_{\rm edge}) = \frac{\int_0^{\theta_{\rm edge}} {\rm PE}(\theta)d\theta}{\sin\theta_{\rm edge}} \times \left(\frac{d{\rm PE}(\theta)}{d\theta}\bigg|_{\theta=\theta_{\rm edge}} \right)^2 \times \exp\left(-\frac{(\theta_{\rm edge}-\theta_{\rm exp})^2}{2\sigma_\theta^2} \right)$$

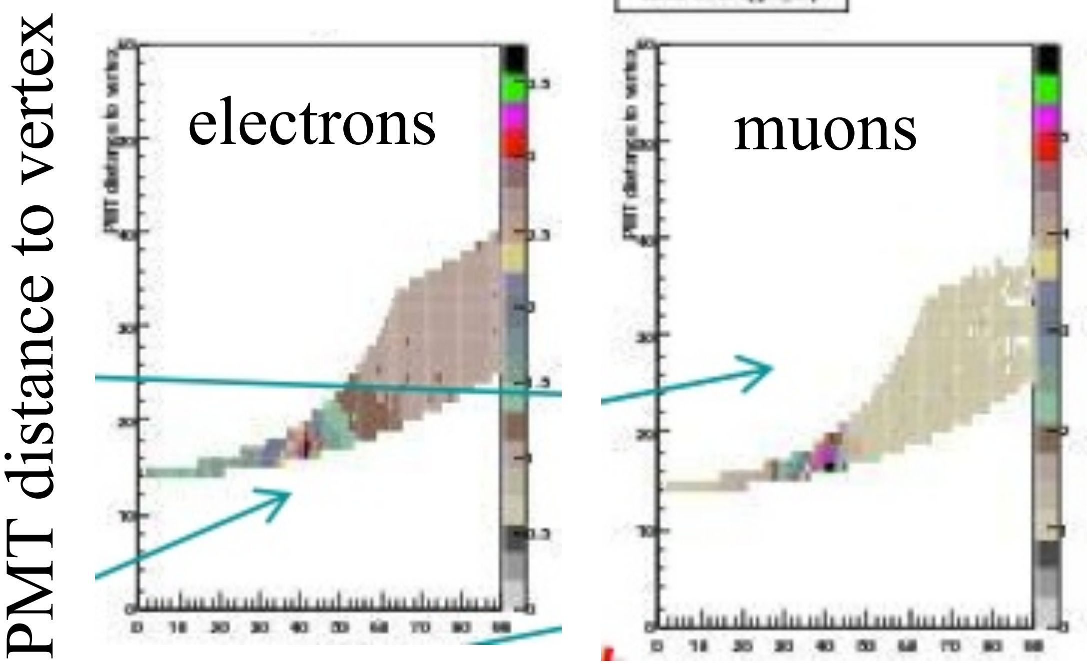
Particle identification

Number of photoelectrons



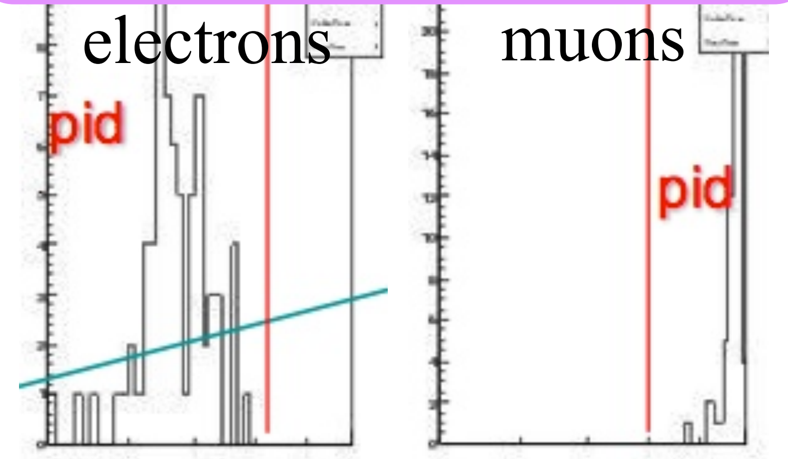
Angle of the PMT with respect to true direction

Number of photoelectrons



Angle the PMT with respect to true direction

final PID discriminator



Next steps

- QE (ve ,vμ) efficiency: ring counting: one-ring events, reconstruct momentum
- NC: π0 reconstruction and discrimination from e. Separation between single charged π from μ
- Volume vs. performance studies: more detailed
- Compare MEMPHYS results with SK
- Migration/Response matrices (input for Globes)
- Systematic errors

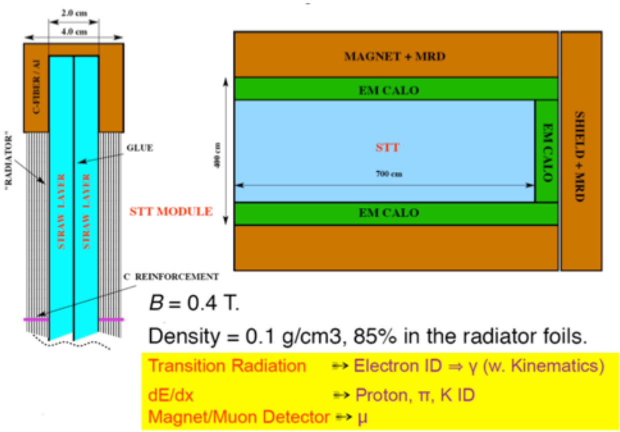
Near detector

- Currently there is no near detector baseline. Several options
- Dedicated studies by Sophia Group
- Essential measurements to reduce the neutrino oscillation systematics:
    - Neutrino flux and extrapolation to Far Detector
    - Charm production (important bkg to golden oscillation signal)
    - Cross-section measurements: DIS, QEL, RES, coh, ...
- Other desirable measurements with Near Detector
    - Fundamental electroweak and QCD physics (ie PDFs)
    - Search for Non Standard Interactions (NSI) from taus
- Have established links with LBNE near detector since many of the issues are similar

Detector design

- A number of options:

HResNu (MOMAD-like)

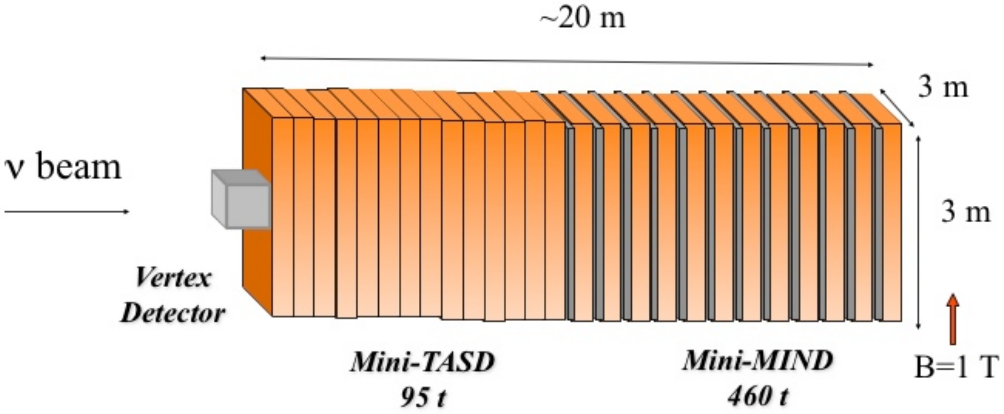


$B = 0.4$ T.

Density = 0.1 g/cm3, 85% in the radiator foils.

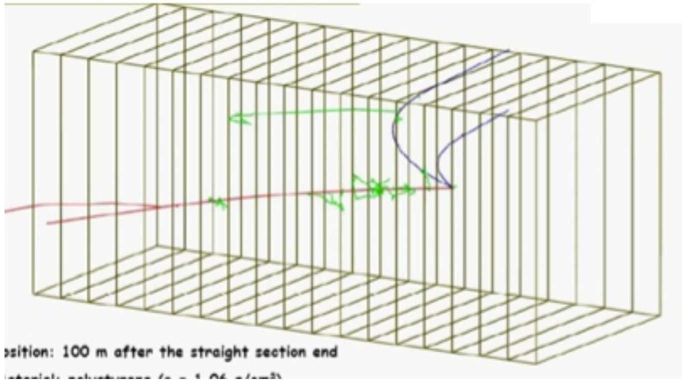
Transition Radiation ⇸ Electron ID ⇒ γ (w. Kinematics)
dE/dx ⇸ Proton, π, K ID
Magnet/Muon Detector ⇸ μ

mini-TASD / mini-MIND

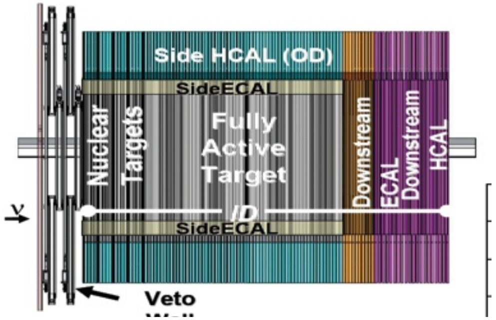


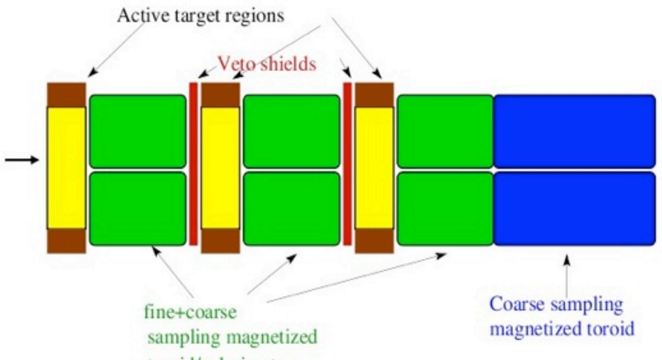
Current Euro-ν dedicated study

scintillating fibres



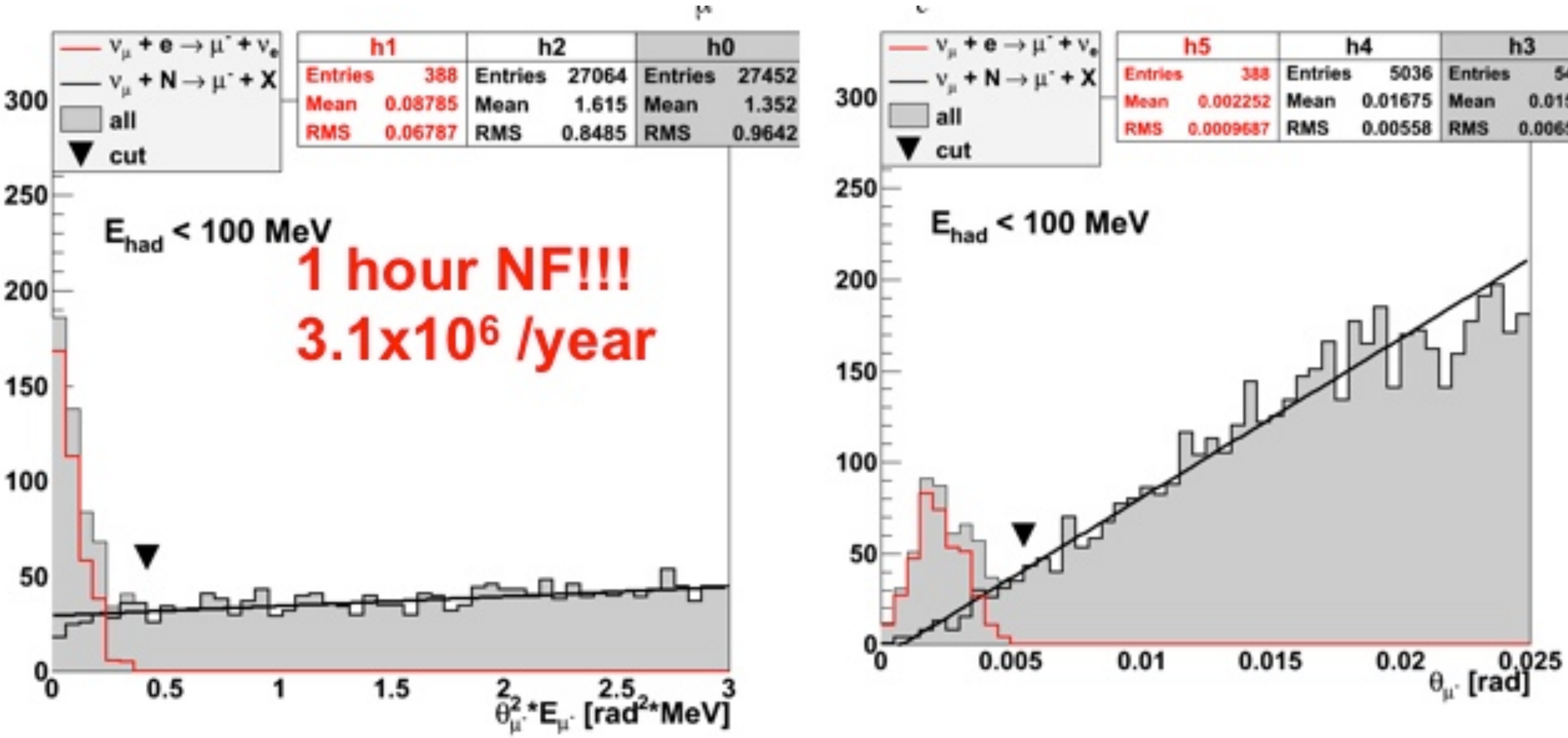
Minerva-type detectors





Flux measurement

- Dedicated study by Sophia group (Tsenov/Kharadzhov)
- Use inverse muon decay which has a very well known x-section



1 hour NF!!!

3.1×10^6 /year

- Smearing analysis done
- Ongoing realistic reconstruction (results soon)

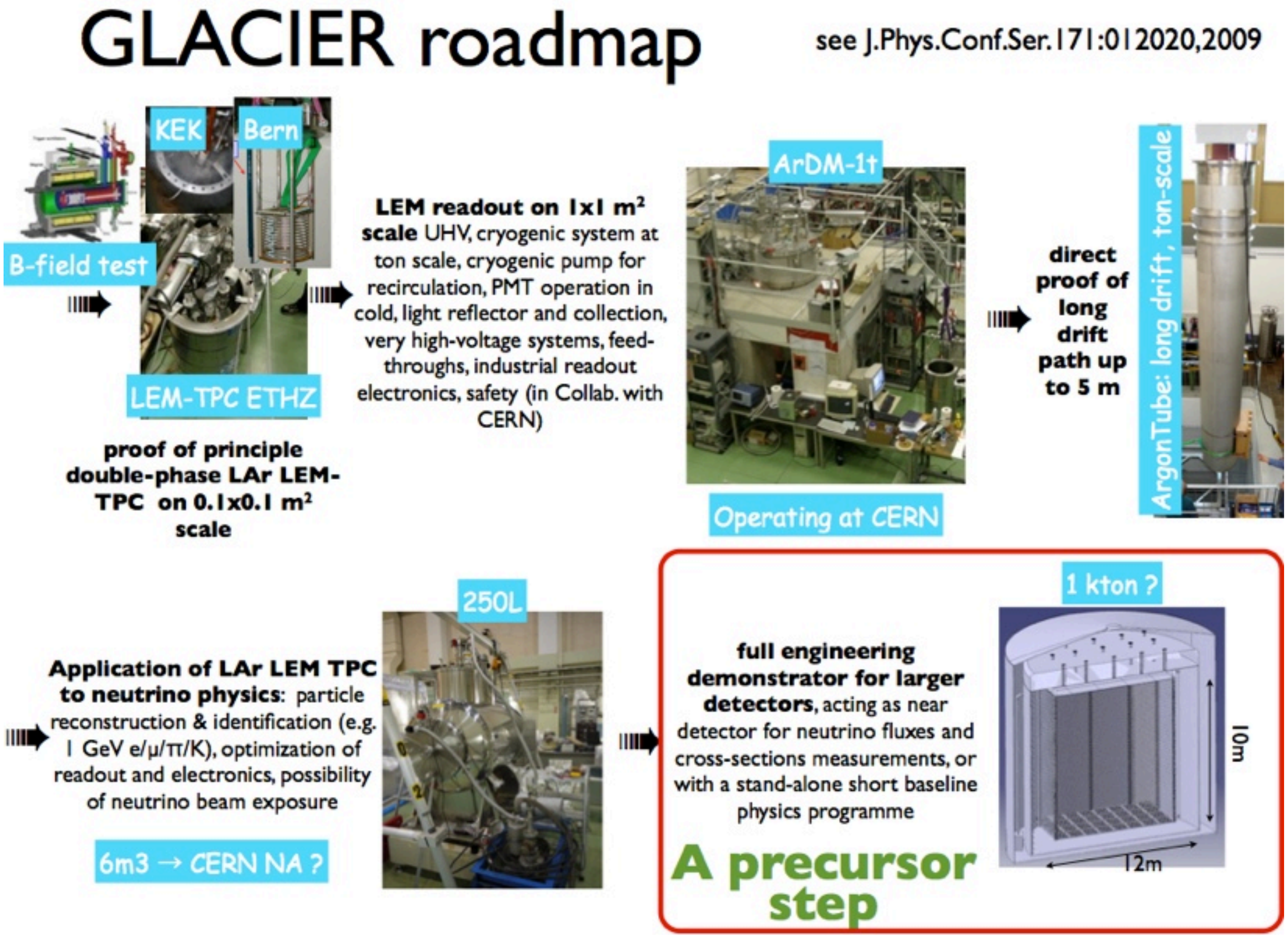
Tasks

- Simulation of near detector and optimisation of layout: benefit from common software framework for Far Detector
- Flux determination with inverse muon decays, etc.
- Analysis of charm using near detector
- Determination of systematic error from near/far extrapolation
- Expectation of cross-section measurements

- Test beam activities to validate technology (eg. vertex detectors, tracking detectors)
- Construction of beam diagnostic prototypes
- Other physics studies: PDFs, etc. (engage with theory community for interesting measurements)

Liquid Argon

A. Rubbia



GLACIER roadmap

see J.Phys.Conf.Ser.171:012020,2009

B-field test

KEK

Bern

LEM-TPC ETHZ

proof of principle double-phase LAr LEM-TPC on 0.1x0.1 m^2 scale

LEM readout on 1x1 m^2 scale UHV, cryogenic system at ton scale, cryogenic pump for recirculation, PMT operation in cold, light reflector and collection, very high-voltage systems, feed-throughs, industrial readout electronics, safety (in Collab. with CERN)

ArDM-1t

Operating at CERN

direct proof of long drift path up to 5 m

ArgonTube: long drift, ton-scale

Application of LAr LEM TPC to neutrino physics: particle reconstruction & identification (e.g. 1 GeV e/μ/π/K), optimization of readout and electronics, possibility of neutrino beam exposure

6m3 → CERN NA ?

250L

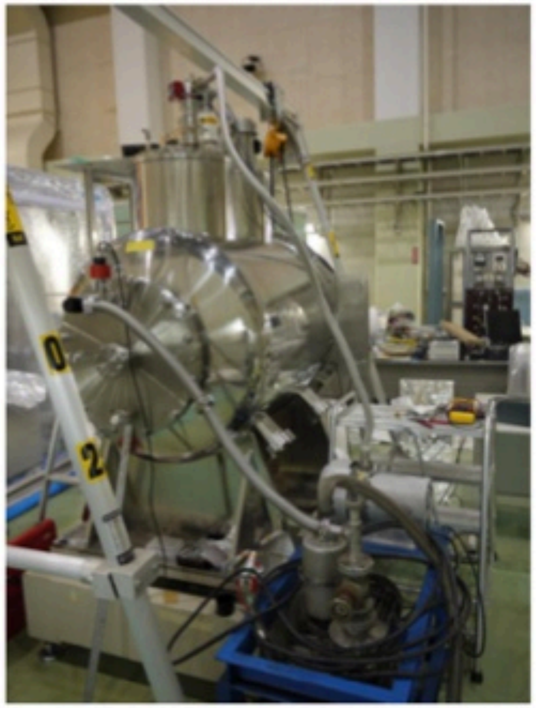
full engineering demonstrator for larger detectors, acting as near detector for neutrino fluxes and cross-sections measurements, or with a stand-alone short baseline physics programme

A precursor step

1 kton ?

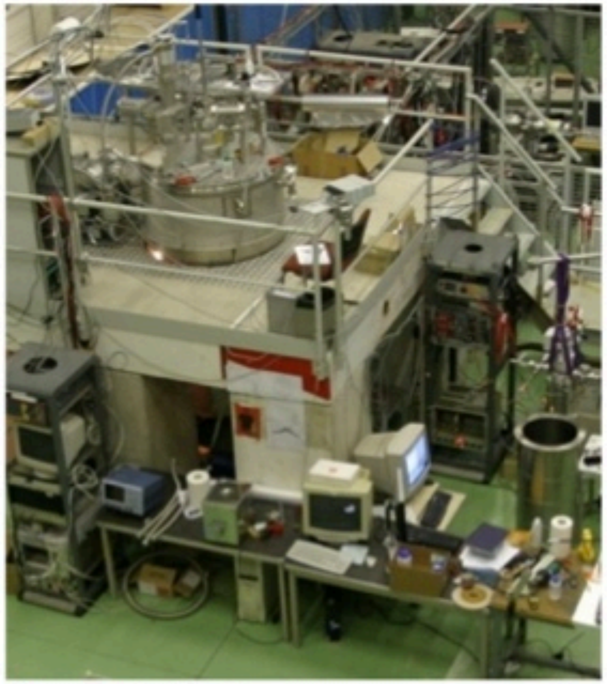
Ongoing tests at Ton scale

250 lt @ KEK



0.4 ton LAr, vacuum, cryogenic system, gas purging, argon liquefaction, optimized for test beam pion / kaon response

ArDM (RE18) @ CERN

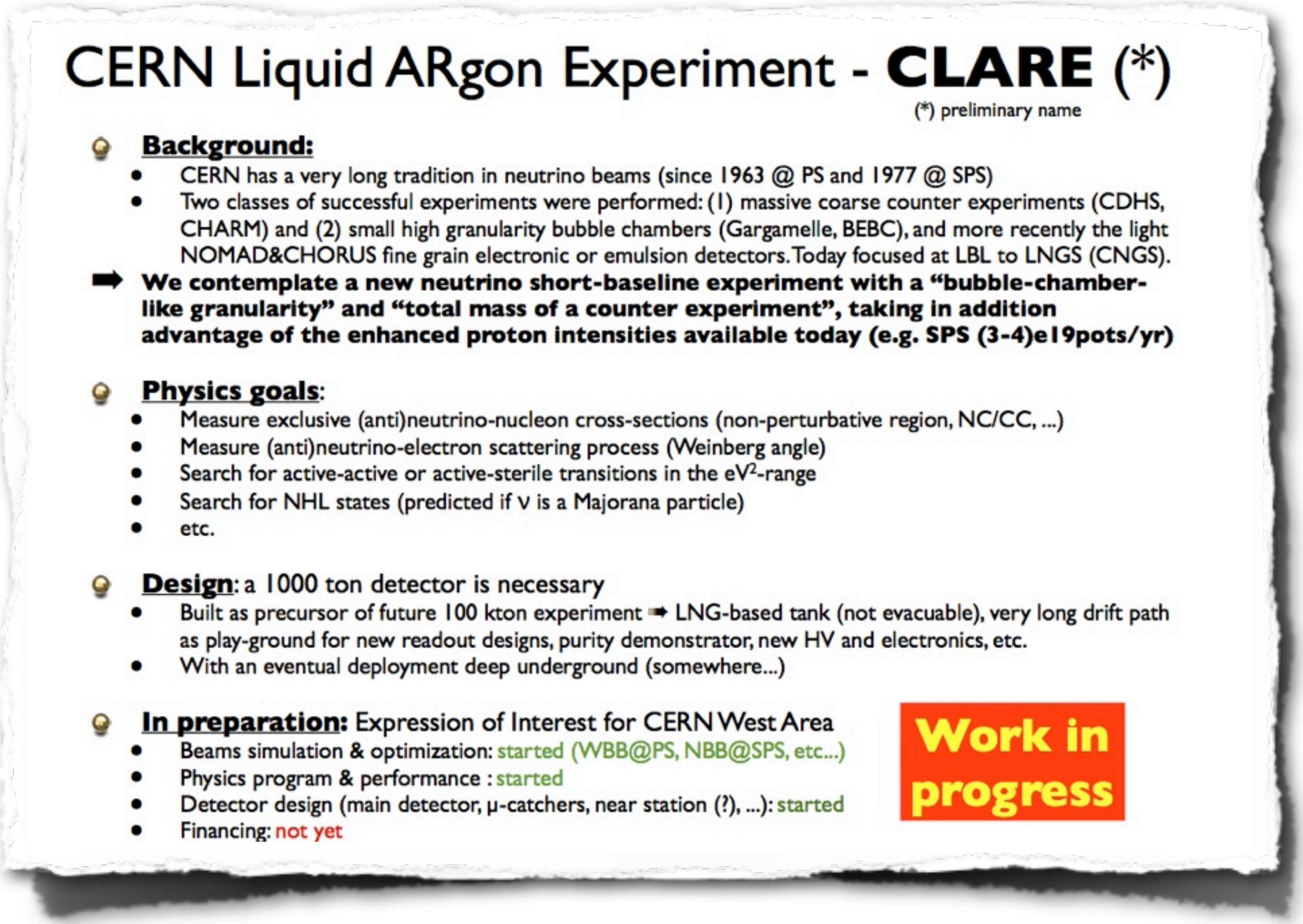


1 ton LAr, large area readout, 1m drift with Cockroft-Walton, LAr recirculation and purification, electronics, safety, optimized for dark matter searches, underground location foreseen for 2011

6m3 @ CERN

R&D towards non evacuated vessels, warm Ar purging starting from air, high capacity closed gas recirculation

The 1 Kton detector



CERN Liquid ARgon Experiment - **CLARE** (*)

(*) preliminary name

- **Background:**
  - CERN has a very long tradition in neutrino beams (since 1963 @ PS and 1977 @ SPS)
  - Two classes of successful experiments were performed: (1) massive coarse counter experiments (CDHS, CHARM) and (2) small high granularity bubble chambers (Gargamelle, BEBC), and more recently the light NOMAD&CHORUS fine grain electronic or emulsion detectors. Today focused at LBL to LNGS (CNGS).

➡ **We contemplate a new neutrino short-baseline experiment with a "bubble-chamber-like granularity" and "total mass of a counter experiment", taking in addition advantage of the enhanced proton intensities available today (e.g. SPS (3-4)e19pots/yr)**

- **Physics goals**:
  - Measure exclusive (anti)neutrino-nucleon cross-sections (non-perturbative region, NC/CC, ...)
  - Measure (anti)neutrino-electron scattering process (Weinberg angle)
  - Search for active-active or active-sterile transitions in the eV^2-range
  - Search for NHL states (predicted if ν is a Majorana particle)
  - etc.

- **Design**: a 1000 ton detector is necessary
  - Built as precursor of future 100 kton experiment ➡ LNG-based tank (not evacuable), very long drift path as play-ground for new readout designs, purity demonstrator, new HV and electronics, etc.
  - With an eventual deployment deep underground (somewhere...)

- **In preparation:** Expression of Interest for CERN West Area
  - Beams simulation & optimization: started (WBB@PS, NBB@SPS, etc...)
  - Physics program & performance : started
  - Detector design (main detector, μ-catchers, near station (?), ...): started
  - Financing: not yet

Work in progress

Source of systematics

- Neutrino flux:
  - Super-beam: p.o.t, hadron production, horn simulation, near detector ...
  - Beta-beam: # stored ions, energy of ions
  - Nufact: # stored muons, polarisation and beam divergence
- Propagation:
  - Matter density
- Total cross section:
  - Difference between neutrinos and antineutrinos
  - Difference between ν_e, ν_μ and ν_τ
- Detector
  - Assumptions in simulation: Attenuation, PD threshold, electronics ...
  - Relative x-section for specific processes: QEL, RES, DIS, charm, ...
  - Fiducial volume definition (vertex resolution)
  - ...

Input for fits

- Cross section
  - Parameterisation of total x-section for each of the 6 species result of a fit to data
- Detector response
  - Response (migration) matrices

$$M[\nu_e - \nu_\mu]\,(E',E)$$

Fraction of ν_e's with true energy E
reconstructed as a ν_μ with energy E'

Example for MIND

- For $\overline{\nu}_\mu$, ν_e beam, searching for $\nu_e \sim \nu_\mu$ oscillation

M[ν_μ-ν_μ] (E’,E) signal efficiency

~~M[ν_e -ν_μ] (E’,E) from beam~~ → ~ negligible

M[ν_τ -ν_μ] (E’,E) from $\nu_e \sim \nu_\tau$ subdominant oscillation (A. Donini’s talk)

M[$\overline{\nu}_\mu$-ν_μ] (E’,E) from beam (charge mis-id, hadron decay, ...)

~~M[$\overline{\nu}_e$ -ν_μ] (E’,E) from $\overline{\nu}_\mu \sim \overline{\nu}_e$ subdominant oscillation~~ → negligible

~~M[$\overline{\nu}_\tau$ -ν_μ] (E’,E) from $\overline{\nu}_\mu \sim \overline{\nu}_\tau$ dominant oscillation~~ → negligible ?

osc prob
x
tau-mu BR

Example for MIND

- arXiv:1004.2798. Separate CC and NC
  - So far only signal and non-oscillated beam related backgrounds

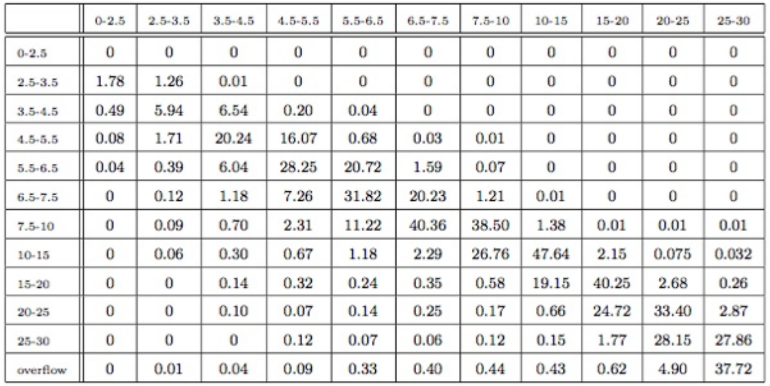
signal efficiency

(10^{-2})

$M[\nu_\mu\text{-}\nu_\mu]$ (E’,E)

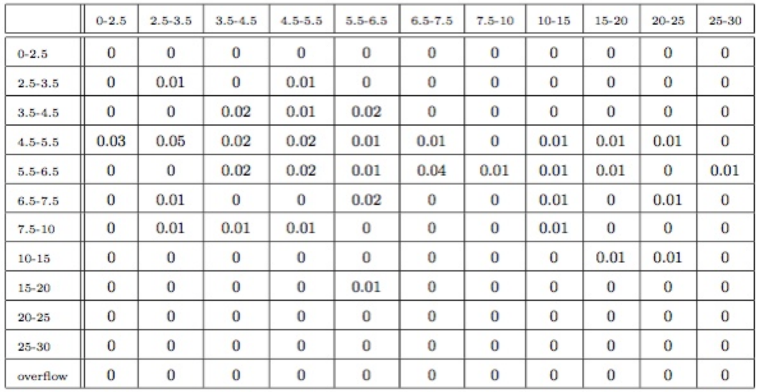
true energy

rec energy



	0-2.5	2.5-3.5	3.5-4.5	4.5-5.5	5.5-6.5	6.5-7.5	7.5-10	10-15	15-20	20-25	25-30
0-2.5	0	0	0	0	0	0	0	0	0	0	0
2.5-3.5	1.78	1.26	0.01	0	0	0	0	0	0	0	0
3.5-4.5	0.49	5.94	6.54	0.20	0.04	0	0	0	0	0	0
4.5-5.5	0.08	1.71	20.24	16.07	0.68	0.03	0.01	0	0	0	0
5.5-6.5	0.04	0.39	6.04	28.25	20.72	1.59	0.07	0	0	0	0
6.5-7.5	0	0.12	1.18	7.26	31.82	20.23	1.21	0.01	0	0	0
7.5-10	0	0.09	0.70	2.31	11.22	40.36	38.50	1.38	0.01	0.01	0.01
10-15	0	0.06	0.30	0.67	1.18	2.29	26.76	47.64	2.15	0.075	0.032
15-20	0	0	0.14	0.32	0.24	0.35	0.58	19.15	40.25	2.68	0.26
20-25	0	0	0.10	0.07	0.14	0.25	0.17	0.66	24.72	33.40	2.87
25-30	0	0	0	0.12	0.07	0.06	0.12	0.15	1.77	28.15	27.86
overflow	0	0.01	0.04	0.09	0.33	0.40	0.44	0.43	0.62	4.90	37.72

$M[\nu_x^{NC}\text{-}\nu_\mu]$ (E’,E) x=e, μ, τ (and $\overline{\nu}$)

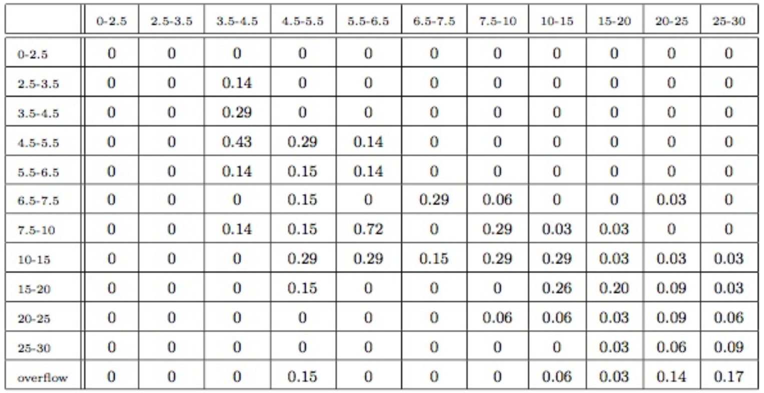


	0-2.5	2.5-3.5	3.5-4.5	4.5-5.5	5.5-6.5	6.5-7.5	7.5-10	10-15	15-20	20-25	25-30
0-2.5	0	0	0	0	0	0	0	0	0	0	0
2.5-3.5	0	0.01	0	0.01	0	0	0	0	0	0	0
3.5-4.5	0	0	0.02	0.01	0.02	0	0	0	0	0	0
4.5-5.5	0.03	0.05	0.02	0.02	0.01	0.01	0	0.01	0.01	0.01	0
5.5-6.5	0	0	0.02	0.02	0.01	0.04	0.01	0.01	0.01	0	0.01
6.5-7.5	0	0.01	0	0	0.02	0	0	0.01	0	0.01	0
7.5-10	0	0.01	0.01	0.01	0	0	0	0.01	0	0	0
10-15	0	0	0	0	0	0	0	0	0.01	0.01	0
15-20	0	0	0	0	0.01	0	0	0	0	0	0
20-25	0	0	0	0	0	0	0	0	0	0	0
25-30	0	0	0	0	0	0	0	0	0	0	0
overflow	0	0	0	0	0	0	0	0	0	0	0

(10^{-3})

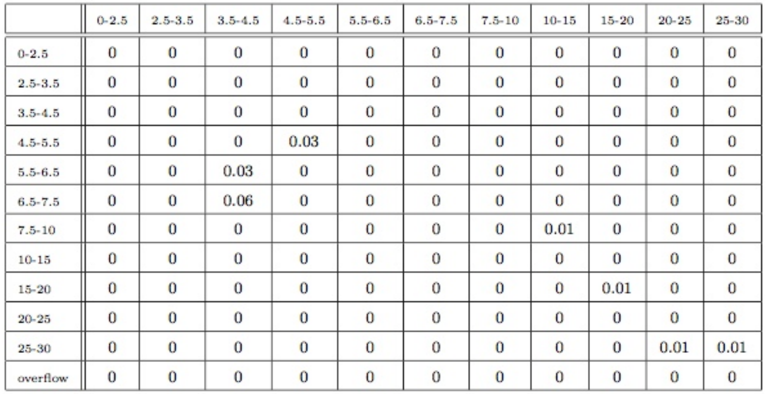
$M[\overline{\nu_\mu}^{CC}\text{-}\nu_\mu]$ (E’,E)

(10^{-3})



	0-2.5	2.5-3.5	3.5-4.5	4.5-5.5	5.5-6.5	6.5-7.5	7.5-10	10-15	15-20	20-25	25-30
0-2.5	0	0	0	0	0	0	0	0	0	0	0
2.5-3.5	0	0	0.14	0	0	0	0	0	0	0	0
3.5-4.5	0	0	0.29	0	0	0	0	0	0	0	0
4.5-5.5	0	0	0.43	0.29	0.14	0	0	0	0	0	0
5.5-6.5	0	0	0.14	0.15	0.14	0	0	0	0	0	0
6.5-7.5	0	0	0	0.15	0	0.29	0.06	0	0	0.03	0
7.5-10	0	0	0.14	0.15	0.72	0	0.29	0.03	0.03	0	0
10-15	0	0	0	0.29	0.29	0.15	0.29	0.29	0.03	0.03	0.03
15-20	0	0	0	0.15	0	0	0	0.26	0.20	0.09	0.03
20-25	0	0	0	0	0	0	0.06	0.06	0.03	0.09	0.06
25-30	0	0	0	0	0	0	0	0	0.03	0.06	0.09
overflow	0	0	0	0.15	0	0	0	0.06	0.03	0.14	0.17

$M[\nu_e^{CC}\text{-}\nu_\mu]$ (E’,E)



	0-2.5	2.5-3.5	3.5-4.5	4.5-5.5	5.5-6.5	6.5-7.5	7.5-10	10-15	15-20	20-25	25-30
0-2.5	0	0	0	0	0	0	0	0	0	0	0
2.5-3.5	0	0	0	0	0	0	0	0	0	0	0
3.5-4.5	0	0	0	0	0	0	0	0	0	0	0
4.5-5.5	0	0	0	0.03	0	0	0	0	0	0	0
5.5-6.5	0	0	0.03	0	0	0	0	0	0	0	0
6.5-7.5	0	0	0.06	0	0	0	0	0	0	0	0
7.5-10	0	0	0	0	0	0	0	0.01	0	0	0
10-15	0	0	0	0	0	0	0	0	0	0	0
15-20	0	0	0	0	0	0	0	0	0.01	0	0
20-25	0	0	0	0	0	0	0	0	0	0	0
25-30	0	0	0	0	0	0	0	0	0	0.01	0.01
overflow	0	0	0	0	0	0	0	0	0	0	0

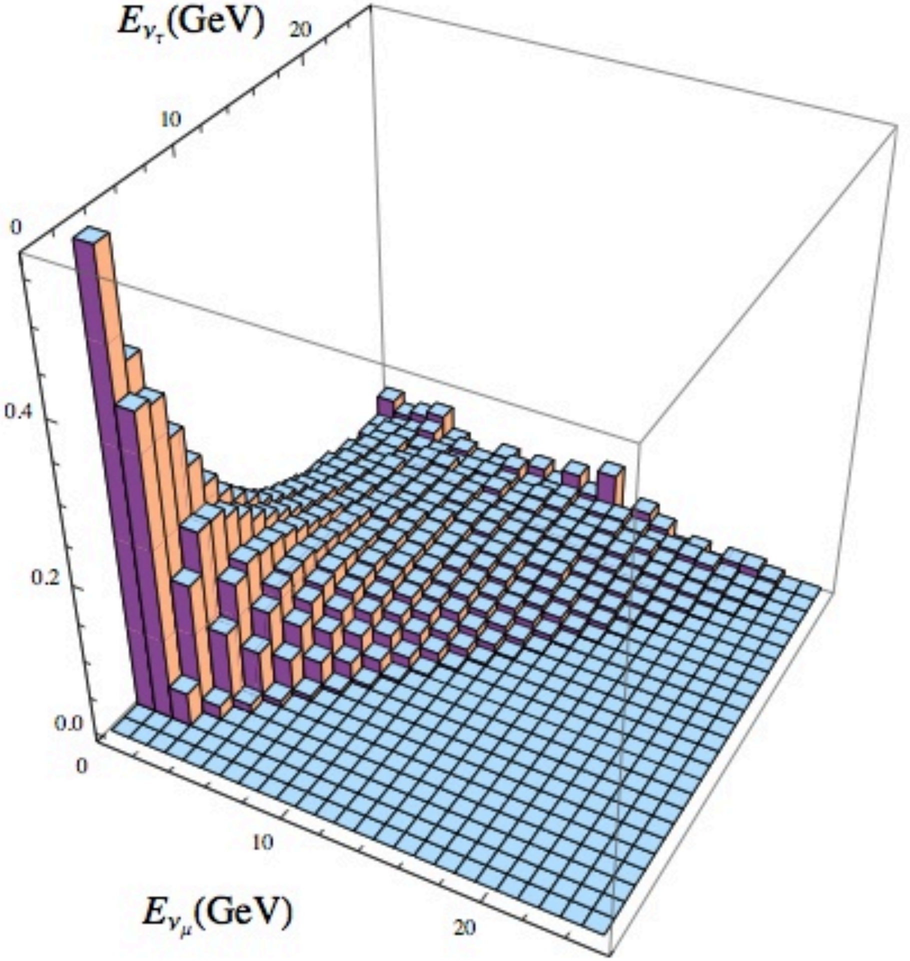
(10^{-3})

$M[\nu_\tau^{CC}\text{-}\nu_\mu]$(E’,E) missing

ν_τ to ν_μ background (or signal)

A. Donini

- This migration has been studied for the first time (A. Donini et al.)
- And included into the oscillation fits
- For the moment only true migration (from missing energy carried by neutrinos) has been considered
- Detector effects need to be included (to be done within MIND framework)



Status Milestones/deliverables

P. Soler

- D9: Interim report potential of the revised baseline scenarios, including systematic errors
  - **MIND**:
    - Good progress in delivering full performance and systematic errors
  - **Near detector:**
    - Concept far from being finalised. Design needs to be frozen asap (i.e. Sophia, event if not optimal) and performance evaluated.
    - could concentrate on flux error (near/far), cross-section error and charm identification error
  - **Water Cherenkov**:
    - detector design for MEMPHYS now frozen
    - reconstruction and performance evaluation (efficiency and background migration matrices) not finalised.
    - Systematic errors similar to Super-K, but need to highlight differences due to bigger volume and granularity

MIND Work Breaking Structure

P. Soler

- Initial rough estimate (no absolute costs yet)

Num	Item	Cost (k$)	%
1	**Magnets: steel and coils**		**36.8**
1.1	Steel plane fabrication		31.1
1.2	Steel handling fixtures		1.9
1.3	Support structures		0.7
1.4	Magnet coil		0.1
1.5	Detector plane prototypes		2.5
1.6	Steel management		0.6
2	**Scintillator detector fabrication**		**32.9**
2.1	Scintillator strips		7.2
2.2	Fibre		5.6
2.3	Scintillator modules		7.2
2.4	Photodetectors		7.2
2.5	Multiplex boxes and connectors		3.2
2.6	Calibration systems		1.1
2.7	Assay and test equipment		0.3
2.8	Factories		0.6
2.9	Scintillator management		0.5

Num	Item	Cost MIND (k$)	%
3	**Electronics and DAQ**		**7.9**
3.1	Front ends		4.8
3.2	Hubs and interface crate		1.8
3.3	Central system and trigger farm		0.3
3.4	Data acquisition		0.6
3.5	Database		0.5
3.6	Auxiliary systems		0.2
3.7	Electronics management		0.1
4	**Installation**		**21.6**
4.1	Infrastructure		18.6
4.2	Materials receiving and handling		0.8
4.3	Detector assembly		2.1
4.4	Alignment and survey		0.1
5	**Project management**		**0.8**
5.1	Salary support		0.7
5.2	Travel support		0.1
	Total		**100**

MIND Work Breaking Structure

P. Soler

- Initial rough estimate (no absolute costs yet)

Num	Item	Cost (k$)	%
1	**Magnets: steel and coils**		**36.8**
1.1	Steel plane fabrication		31.1
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2.4	Photodetectors		7.2
2.5	Multiplex boxes and connectors		3.2
2.6	Calibration systems		1.1
2.7	Assay and test equipment		0.3
2.8	Factories		0.6
2.9	Scintillator management		0.5

Num	Item	Cost MIND (k$)	%
3	**Electronics and DAQ**		**7.9**
3.1	Front ends		4.8
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3.3	Central system and trigger farm		0.3
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3.5	Database		0.5
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3.7	Electronics management		0.1
4	**Installation**		**21.6**
4.1	Infrastructure		18.6
4.2	Materials receiving and handling		0.8
4.3	Detector assembly		2.1
4.4	Alignment and survey		0.1
5	**Project management**		**0.8**
5.1	Salary support		0.7
5.2	Travel support		0.1
	Total		**100**

MEMPHYS

Num	Item	Cost (k$)	%
1	**Photomultiplier tubes**		48.5
1.1	Photomultiplier tubes		45.1
1.2	PMT Housing		1.1
1.3	PMT support		0.4
1.4	Cables		1.1
1.5	Calibration systems		0.4
1.6	Assay and test equipment		0.4
2	**Electronics and DAQ**		1.4
2.1	Front ends		0.1
2.1	High Voltage		0.1
2.1	Online computing		0.3
2.4	Data acquisition		0.2
2.5	Database		0.4
2.6	Auxiliary systems		0.2
2.7	Electronics management		0.1

3	**Civil Engineering**		49.4
3.1	Cavern excavation		49.0
3.2	Water and services		0.4
4	**Assembly**		2.0
3.3	Detector assembly		1.8
3.4	Alignment and survey		0.1
5	**Project management**		0.7
5.1	Salary support		0.6
5.2	Travel support		0.1
	Total		100.0

MEMPHYS

Num	Item	Cost (k$)	%
1	**Photomultiplier tubes**		48.5
1.1	Photomultiplier tubes		45.1
1.2	PMT Housing		1.1
1.3	PMT support		0.4
1.4	Cables		1.1
1.5	Calibration systems		0.4
1.6	Assay and test equipment		0.4
2	**Electronics and DAQ**		1.4
2.1	Front ends		0.1
2.1	High Voltage		0.1
2.1	Online computing		0.3
2.4	Data acquisition		0.2
2.5	Database		0.4
2.6	Auxiliary systems		0.2
2.7	Electronics management		0.1
3	**Civil Engineering**		49.4
3.1	Cavern excavation		49.0
3.2	Water and services		0.4
4	**Assembly**		2.0
3.3	Detector assembly		1.8
3.4	Alignment and survey		0.1
5	**Project management**		0.7
5.1	Salary support		0.6
5.2	Travel support		0.1
	Total		100.0