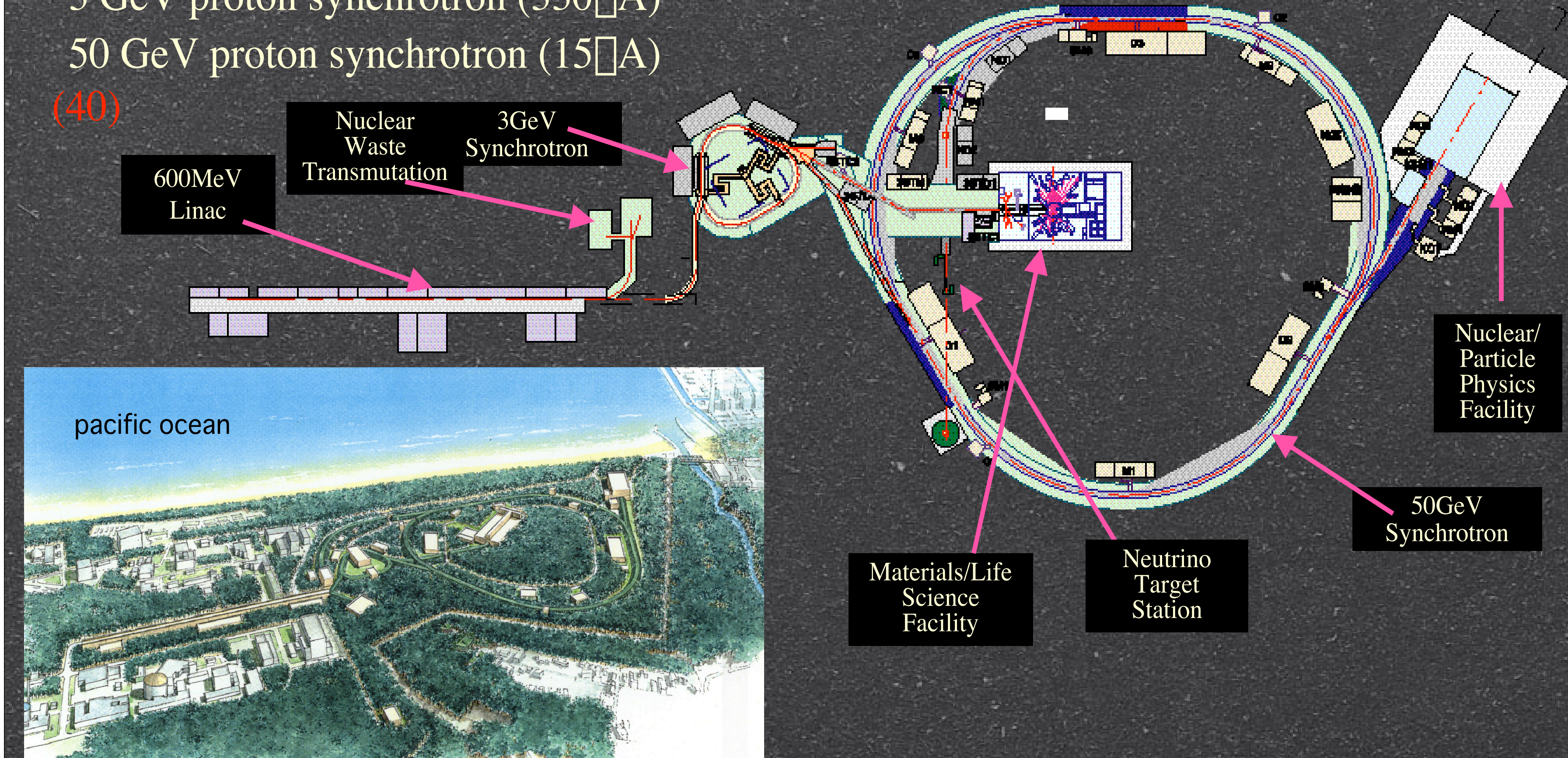
Proton Driver

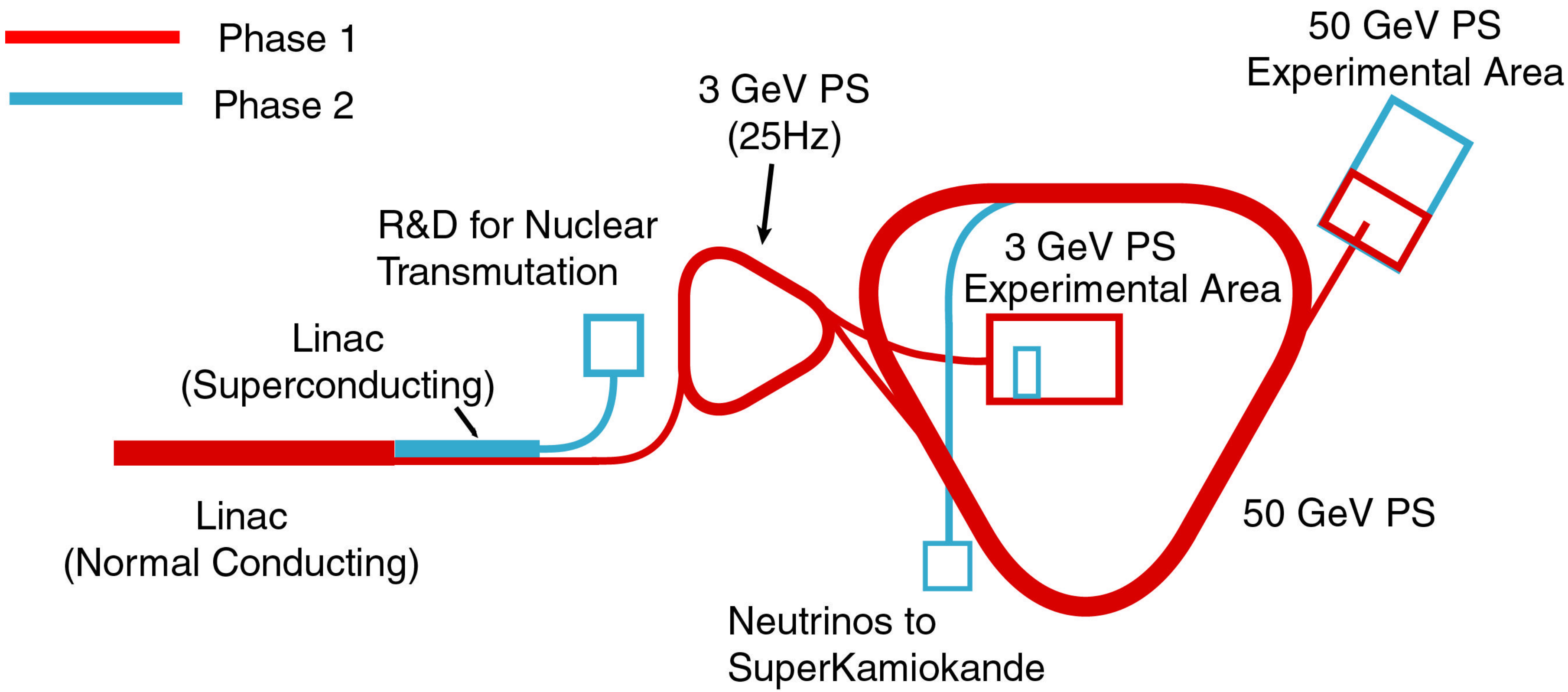
J-PARC = Japan Proton Accelerator Research Complex

400 (200) MeV proton linac
3 GeV proton synchrotron (330μA)
50 GeV proton synchrotron (15μA)
(40)

At Tokai

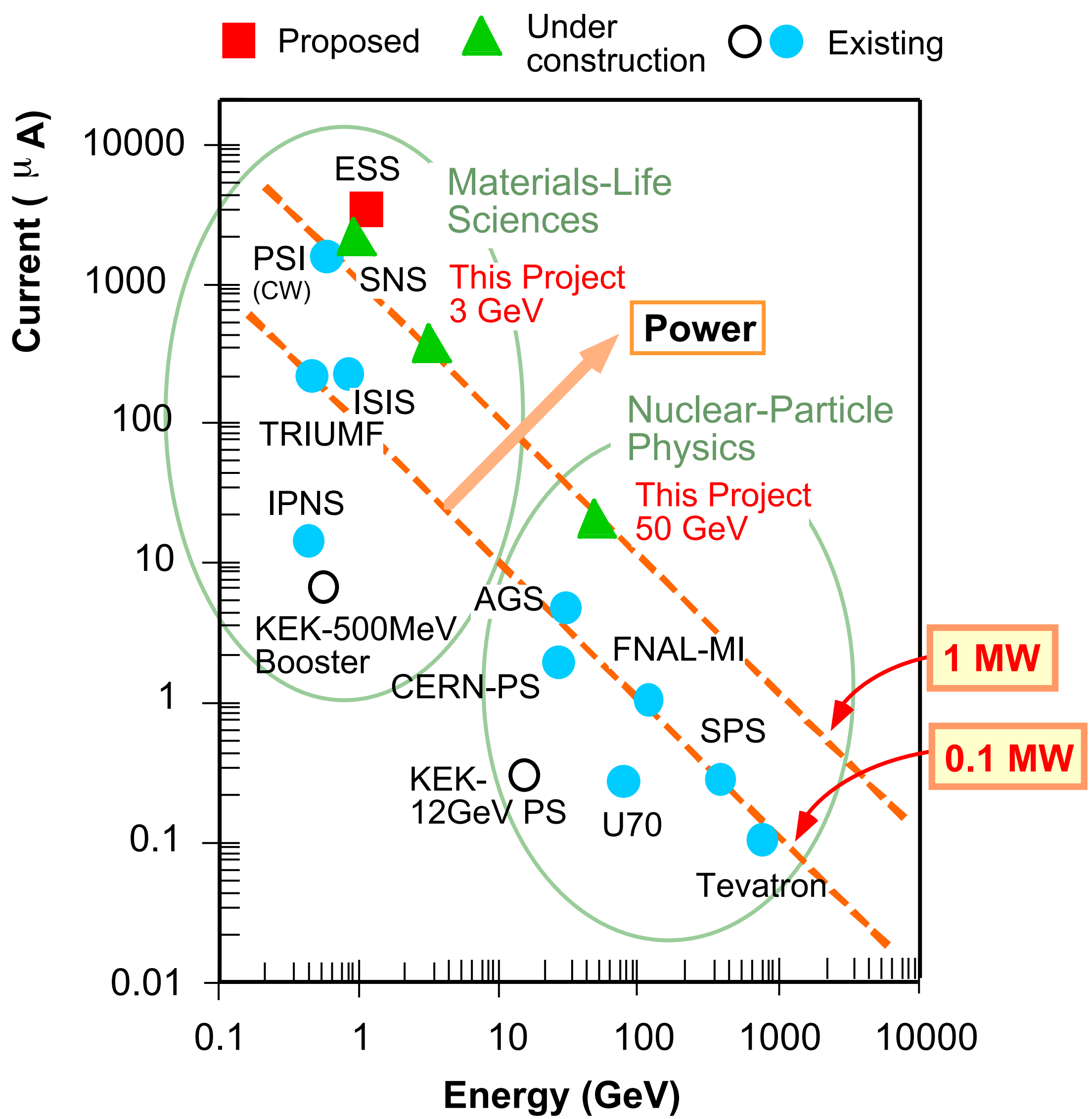


Phase 1 and Phase 2

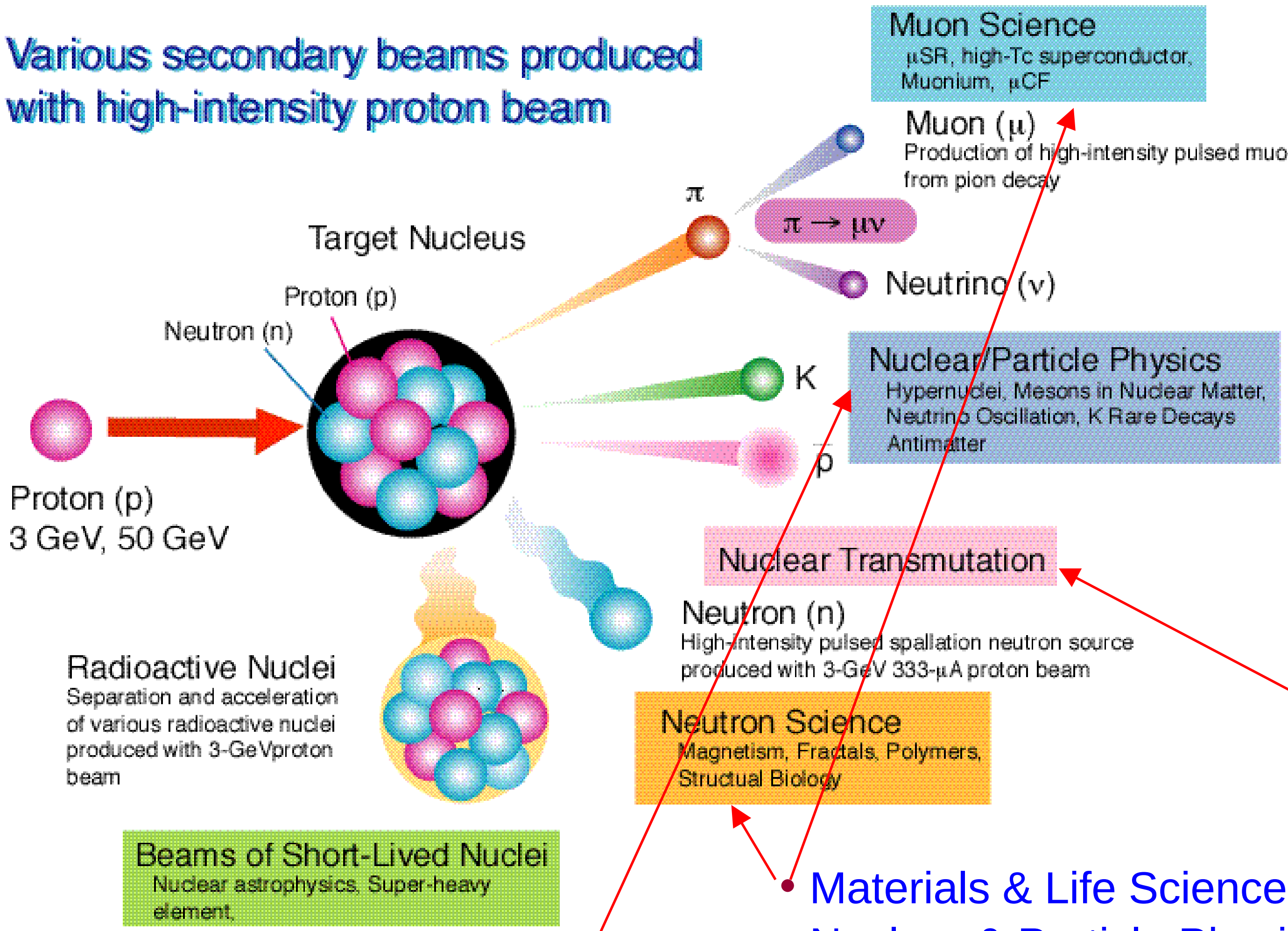


- Phase 1 + Phase 2 = 189 billion Yen (= $1.89 billion if $1 = 100 Yen).
- Phase 1 = 133.5 billion Yen for 6 years (= 2/3 of 189 billion Yen).
- Construction budget does not include salaries.

World's Proton Accelerators

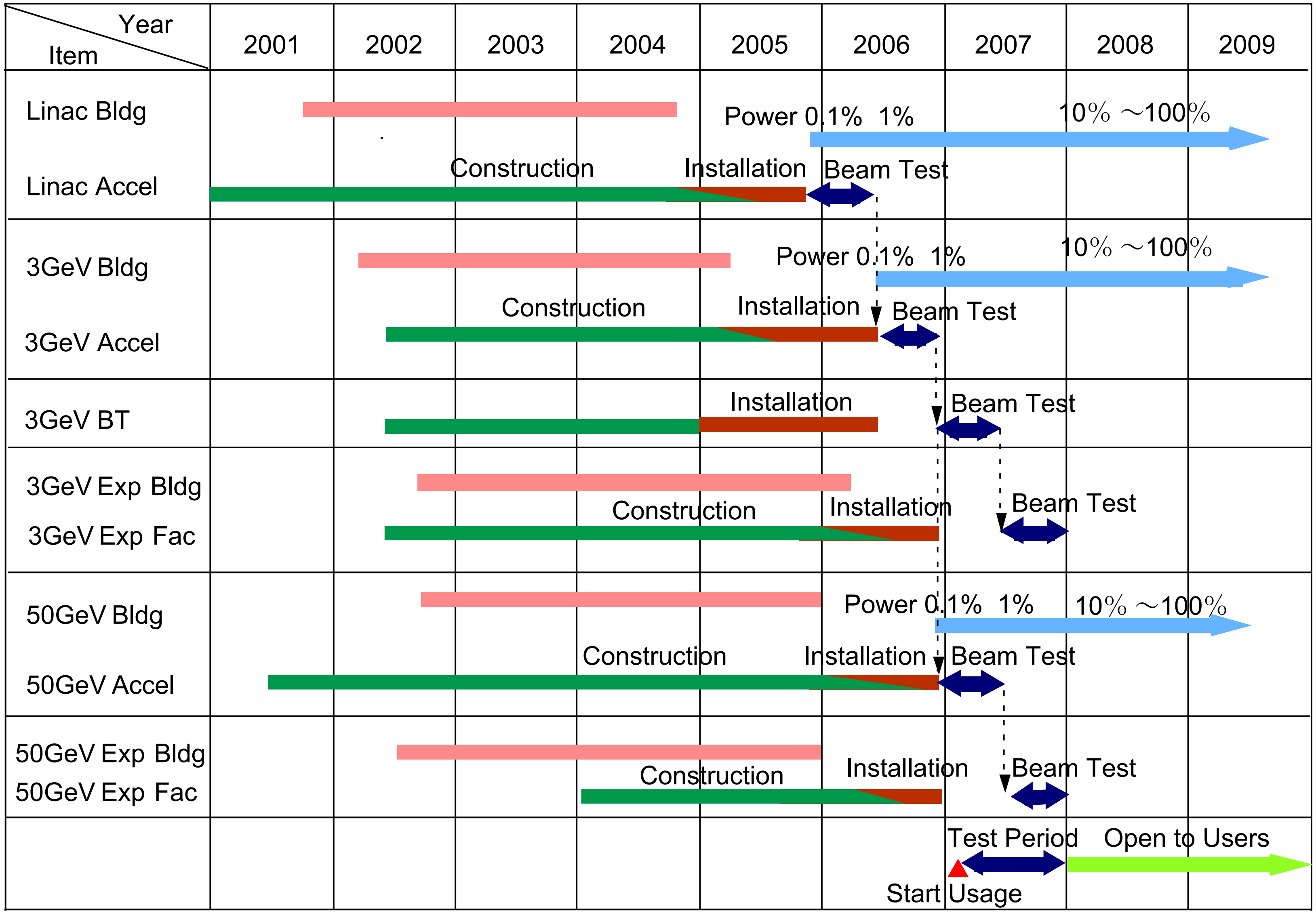


Why Do We Need High Intensity Protons?



- Materials & Life Sciences at 3 GeV
- Nuclear & Particle Physics at 50 GeV
- R&D toward Transmutation at 0.6 GeV

Beam Commissioning




ν

Maury’s Long Baseline News

Long-Baseline news, October 2003

***** JPARC neutrinos setback**

Japanese Council for Science and Technology Policy, Cabinet Office (CSTP) recently evaluated the J-PARC neutrino project as a rank C project (the lowest priority in the four steps of evaluation, S, A, B, and C). C means "needs re-consideration." 3 reasons given: 1. A question remains whether suitable prior evaluation was made about the advance of the J-PARC second phase plan. (J-PARCnu had been classified as one of the J-PARC second phase projects.) 2. In view of the present severe financial situation of Japan, a question remains about whether a large amount of investment is justified only from a viewpoint as basic research. 3. Concerns if there exists a domestic similar plan or domestic facility where similar research can be conducted. - There was better news from a subsequent meeting of Koshiba & the panel. The chair of the panel stated that if a concrete plan for overcoming these difficulties is formulated, they'll reconsider.

Long-Baseline news, December 2003

***** JPARCnu approved again**

Reversing an earlier setback, the Japanese cabinet agreed in December to approve the neutrino program (JPARCnu) starting next fiscal year. The decision is based on the recommendation from the November review on J-PARC. The input from the International Advisory committee, which labeled the neutrino program the #1 priority, was very important. The final official decision will be made at the end of March at the House level. The total cost for the neutrino program is 16 billion Yen. Thus, the total budget for J-PARC is now increased from 135 billion Yen to 151 billion Yen. The first-year budget (JFY04) for neutrino is 0.6 billion Yen, and the total construction period is 5 years.

A bit of history…

- 2000: Initial review of J-PARC (at that time, JHF). JHF Phase-I recommended. Neutrino project classified into JHF Phase-II.
- Dec. 2000: JHF Phase-I funded as a 6-year project.
- June 2002: KEK submitted T2K funding request to MEXT.
- Aug. 2002: It did not go from MEXT to MOF.
- June 2003: KEK submitted T2K funding request to MEXT again.
- Aug. 2003: T2K funding request submitted from MEXT to MOF. At the same time, however, MEXT decided to extend the construction of J-PARC Phase I by 1 year.
- Oct. 17, 2003: CSTP announced the rating of T2K as a rank-C.
- Oct. 21, 2003: Professor Koshiba visited CSTP and protested against its eveluation of T2K. CSTP suggested him possible reevaluation of T2K if MEXT would properly review the progress of J-PARC project and inclusion of T2K into its Phase-I.
- Nov. 2003: MEXT set up a review committee for J-PARC Phase-I and T2K. The committee met 4 times and a report was submitted to CSTP on Nov. 27.
- Dec. 4, 2003: CSTP did not revise its rating on T2K, but decided to endorse funding to T2K.
- Dec. 20, 2003: MOF announced funding to T2K (6 Oku-Yen for JFY 2004).

Condition

- The budget will be finalized in March 2004 in the congress, but it is already certain that we will get 600M¥ as a first year budget of five-year construction project.

- The total budget will be 15,800M¥, which covers beam line and 280m detectors

‘Rough Cost Estimate’

Total	**159.6**
Civil construction	**83.5**
Instrumentation	**76.1**
Normal conducting magnets	6.9
Power supply	3.5
Superconducting magnets	12.8
Cryostats	8.9
Power supply	1.9
Cryogenics	9.7
Proton beam monitors	1.9
Vaccum system	0.5
Target system	0.7
Horn	1.5
Power supply	2.7
TS/Dump Fe shield	4.7
Decay pipe	3.0
Cooling water system	15.2
280m detector	0.5
Online/control	0.6
Etc	0.9

Unit:
Oku ¥
$=10^8$¥
~M$

Rough cost

	Real Estimate	Requested	Diff
Civil construction	83.5	83.5	
Beam line instrumentation	84	75.6	~8
280m detector	7.5	0.5	~7
Total	175	159.6	~15

1. **We need both contributions in beam line and 280m detector to start the run amount ~800M¥(beam line)~700M¥(min. detector)**

2. **We have to concentrate on <u>beam line and 280m detectors (see letter from KEK DG) for now</u>**

   - Otherwise no beam or down grated beam

   - No endorsement as the collaboration for proposal for other components at this time

   - 2 km need more studies, need consensus with whole collaboration and KEK, J-PARC directors to publicize any document about it

Budget Request Profile for 5 Years

2004	8.04 Oku-Yen	(6 Oku-Yen approved)
2005	27.40	
2006	27.50	
2007	56.16	
2008	40.50	

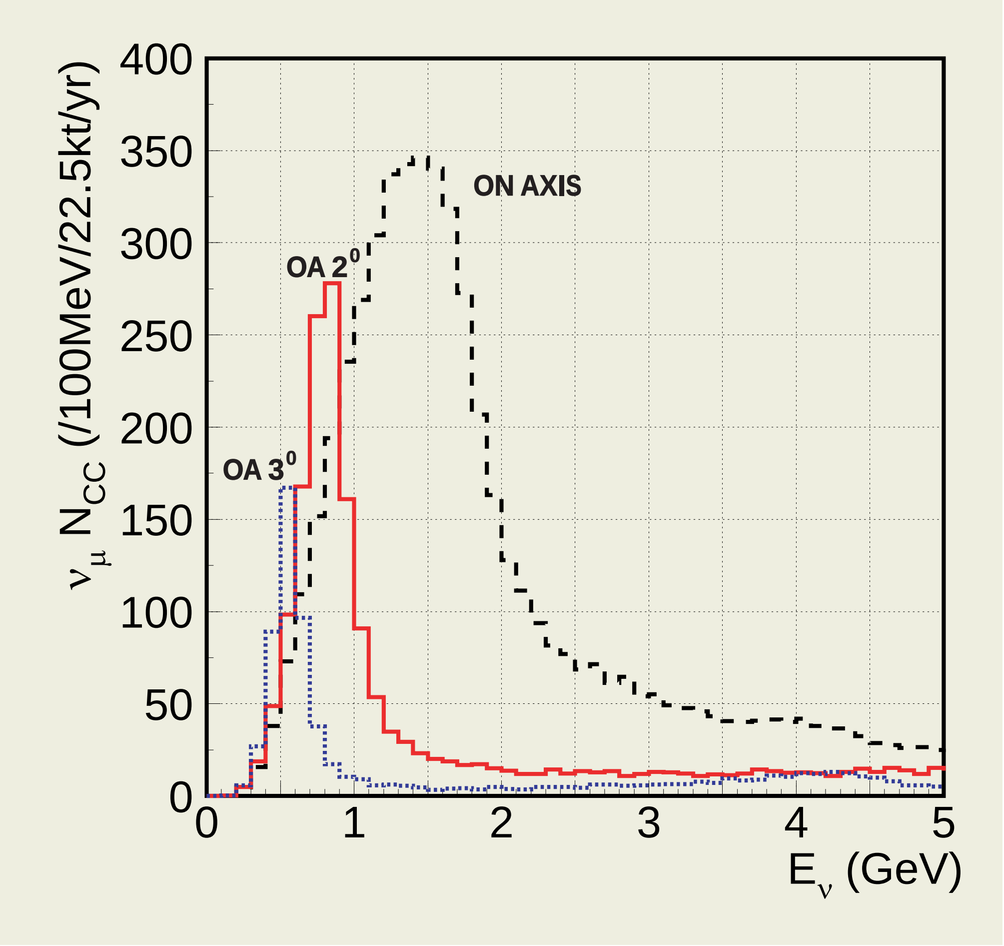
total 159.6*

*does not include the 2km detector and its hall. Funding source for the 2km detector hall (～14 Oku-Yen) should be found later. No guarantee now.

JPARC-Japan Proton Accelerator Complex

Neutrino beam from the 50 GeV - 0.75 MW proton beam at the Hadron Facility at Jaeri, Japan.

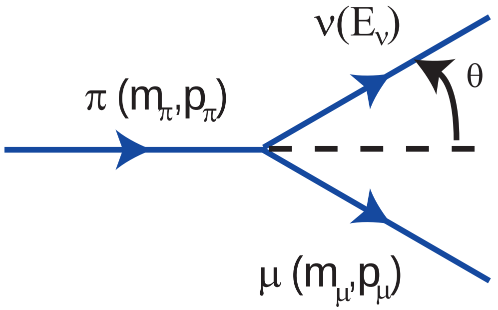
Taken off-axis to better match the oscillation maximum at the SuperKamiokande location (295 km).



K2K		JPARCnu
$6 \cdot 10^{12}$	Protons per pulse	$3 \cdot 10^{14}$
2.2 s	Cycle	3.4 s
12 GeV	Proton energy	50 GeV
40	Events in SK per year (no osc.)	2200
1.5	Mean neutrino energy	0.8

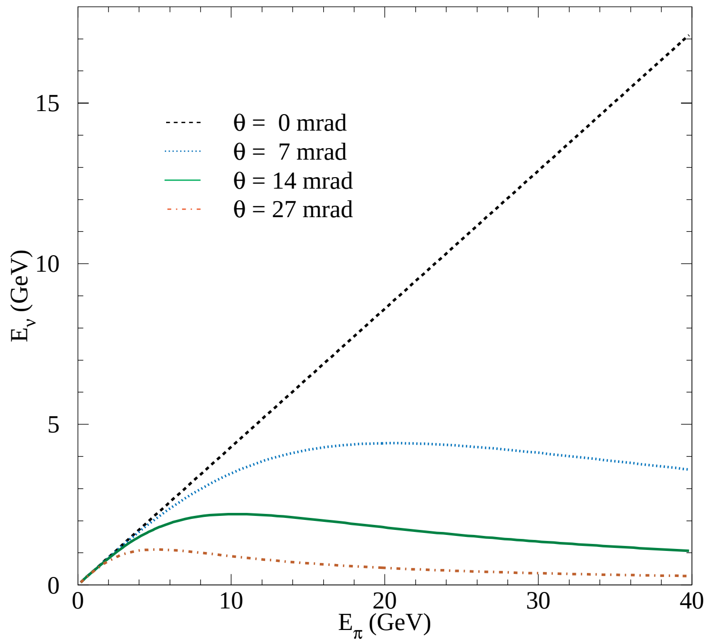
Off Axis Neutrino Beams. BNL-E889 proposal: http://minos.phy.bnl.gov/nwg/papers/E889

Decay Kinematics

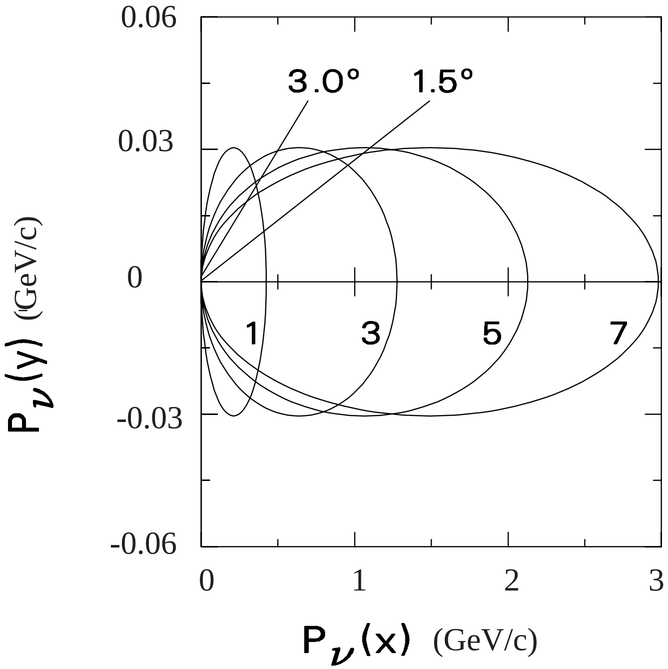


From momentum energy conservation:

$$E_\nu = \frac{m_\pi^2 - m_\mu^2}{2(E_\pi - p_\pi cos\theta)}$$



A qualitative argument:

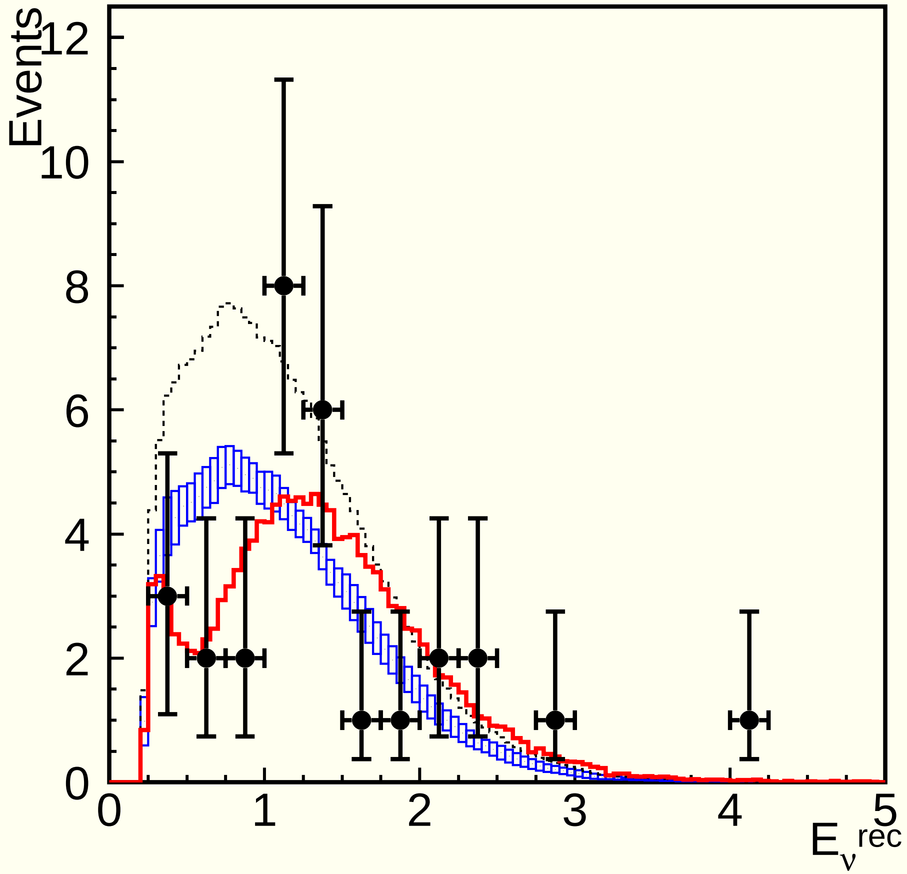


- Transverse momentum, Lorentz invariant: $m_\pi - m_\mu$.
- Longitudinal momentum is Lorentz boosted.
- At an angle θ there is an accumulation of lower energies neutrinos

- **Maximum neutrino flux at 0°.**
- **Off axis is the most efficient way to have a narrow band beam.**
- ν_e **come from 3 body decays (kaons or muons) while off-axis is optimized on the pion 2 body decay$\Rightarrow$ the** ν_e **contamination below the peak is reduced.**

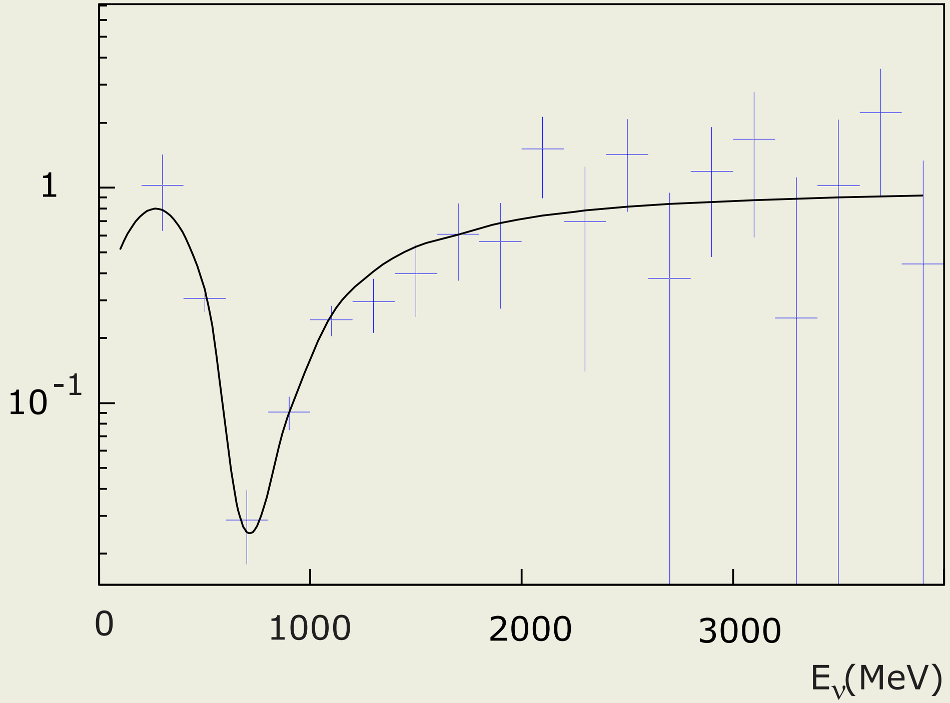
JHF: ν_μ disappearance

K2K at half of its statistics:



JHF in 5 years

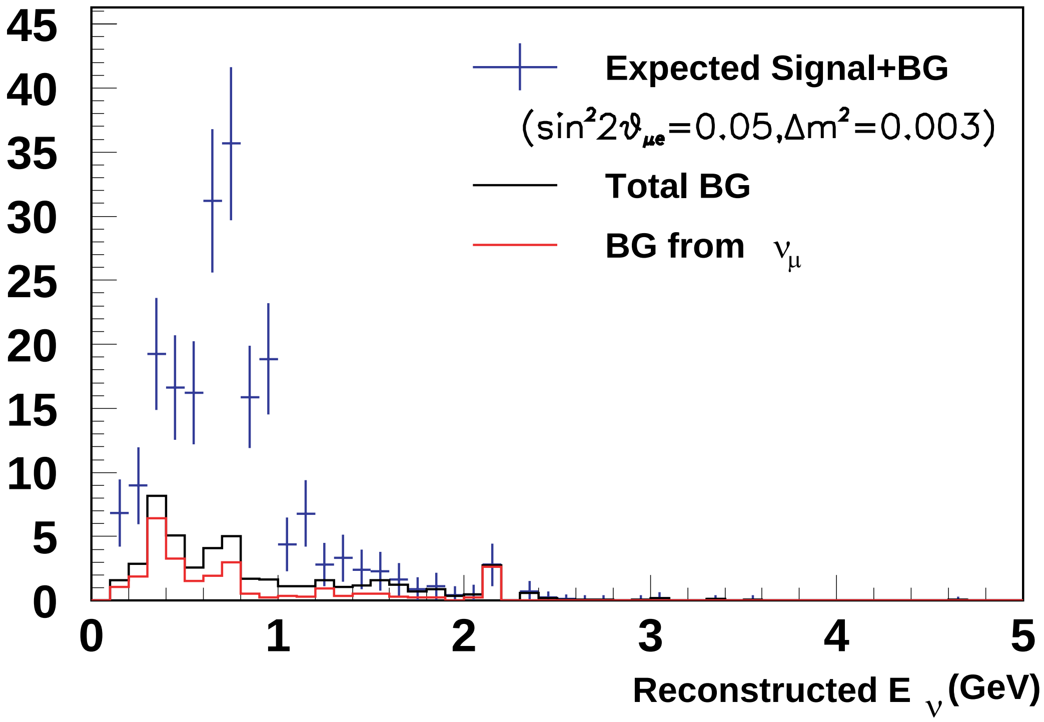
- δm^2_{23} with a resolution of 10^{-4} eV^2.
- $\sin^2 2\theta_{23}$ at $1 \div 2$ %.



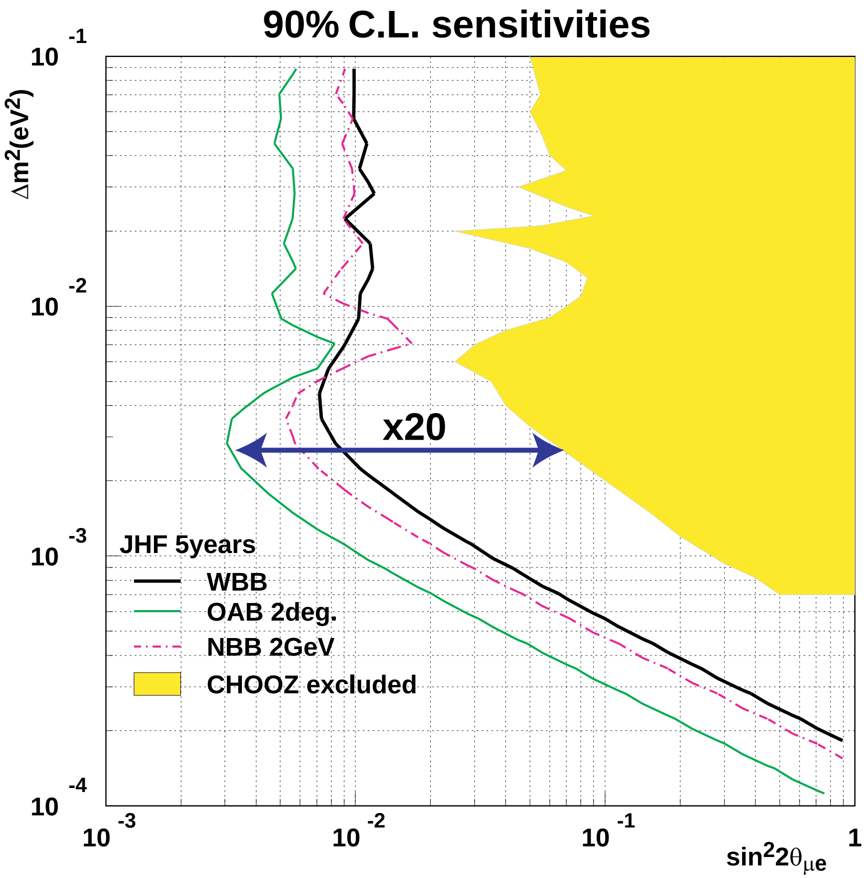
Ratio of the measured ν_μ spectrum with respect to the non-oscillation prediction in case of oscillation.

JHF ν_e appearance

OAB 2°	ν_μ CC	ν_μ NC	ν_e CC	Osc. ν_e
Generated in F.V.	10713.6	4080.3	292.1	301.6
1R e-like	14.3	247.1	68.4	203.7
e/π^0 separation	3.5	23.0	21.9	152.2
0.4 GeV$< E_{rec} < 1.2$ GeV	1.8	9.3	11.1	123.2



Sensitivity to θ_{13}



Time is an important issue

Sensitivity to to θ_{13} as a function of the year

	2004	2005	2006	2007	2008	2009
CHOOZ	**<0.14**	**<0.14**	**<0.14**	**<0.14**	**<0.14**	**<0.14**
MINOS		→	<0.085	<0.06	<0.049	<0.042
CNGS*			→	<0.067	<0.047	<0.039
CNGSx1.5*			→	<0.056	<0.039	<0.033
Low energy CNGS				→	<0.040	<0.028
JHF					→	<0.013

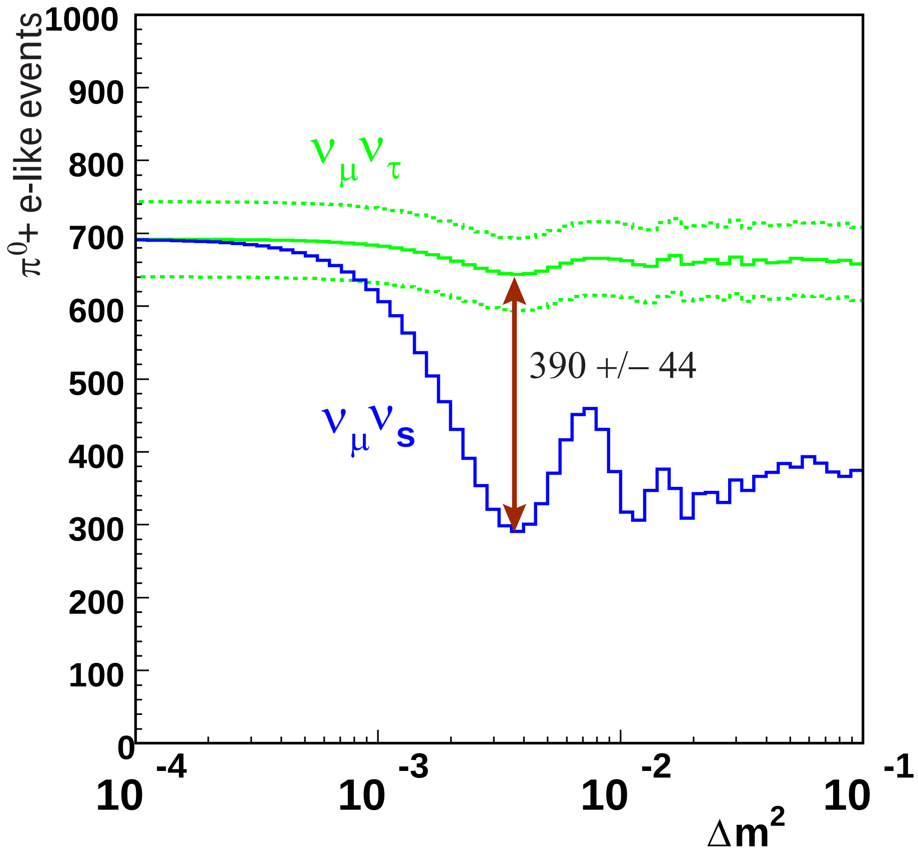
* Designed for ν_τ appearance

Separazione $\nu_\tau - \nu_{\text{sterili}}$

Tag delle correnti neutre con i π° (metodo Vissani-Smirnov), usato anche in SK ($\nu + N \rightarrow \nu + N + \pi^\circ$)

Le sistematiche sulla sezione d'urto di produzione risonante di π° in eventi di NC verranno fortemente ridotte dal close detector di K2K e dai close detectors di JHF.

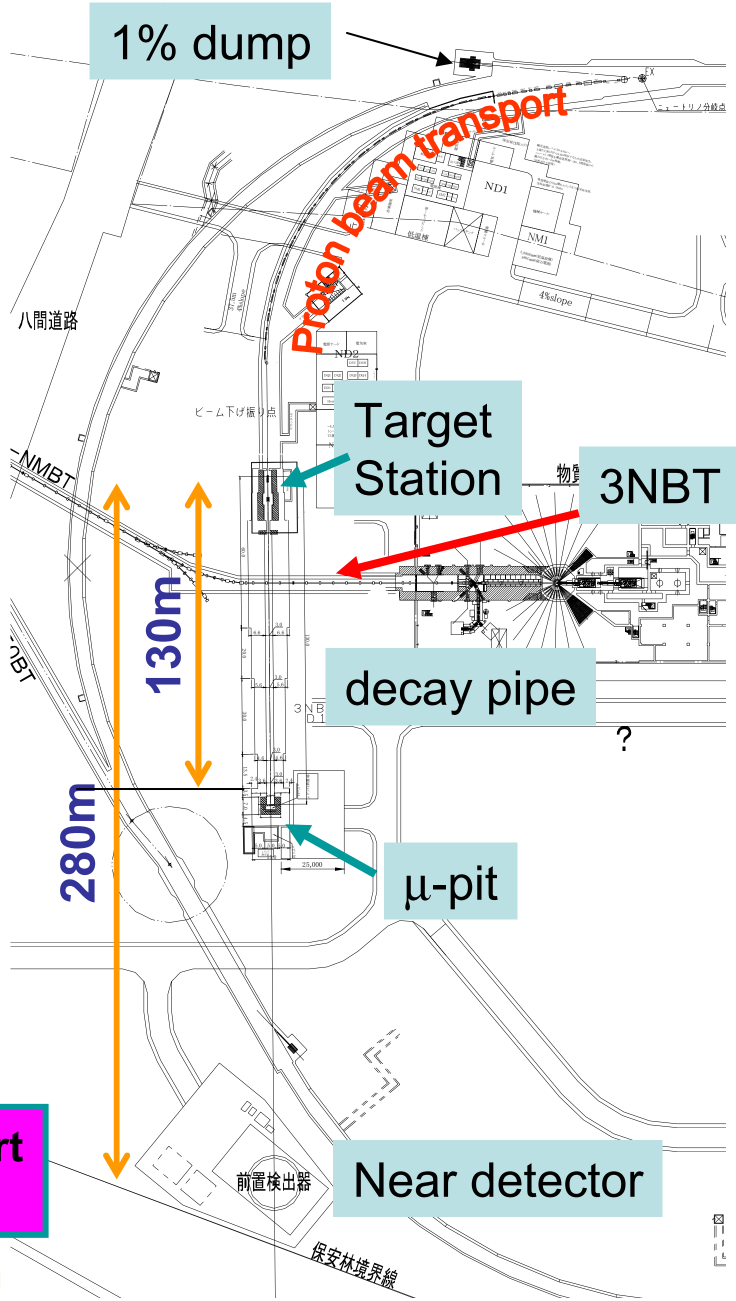
Limite alla frazione di ν_s a circa 0.1 (90% CL).



Neutrino beam facility Overview

Components
- Primary proton beam line
  - Normal conducting magnets
  - Superconducting magnets (Ogitsu)
  - Proton beam monitors (Iwasaki)
  - Vacuum system
  - Collimators/beam plug
- Target station (Yamada)
  - Target (Hayato)
  - Horn (Ichikawa)
  - Remote handling system
- Decay pipe
- Beam dump
- muon monitors (Kameda)

Technical Design&Development (Status) Report
http://jnusrv01.kek.jp/jnu/nu-TAC/



The role of close detectors

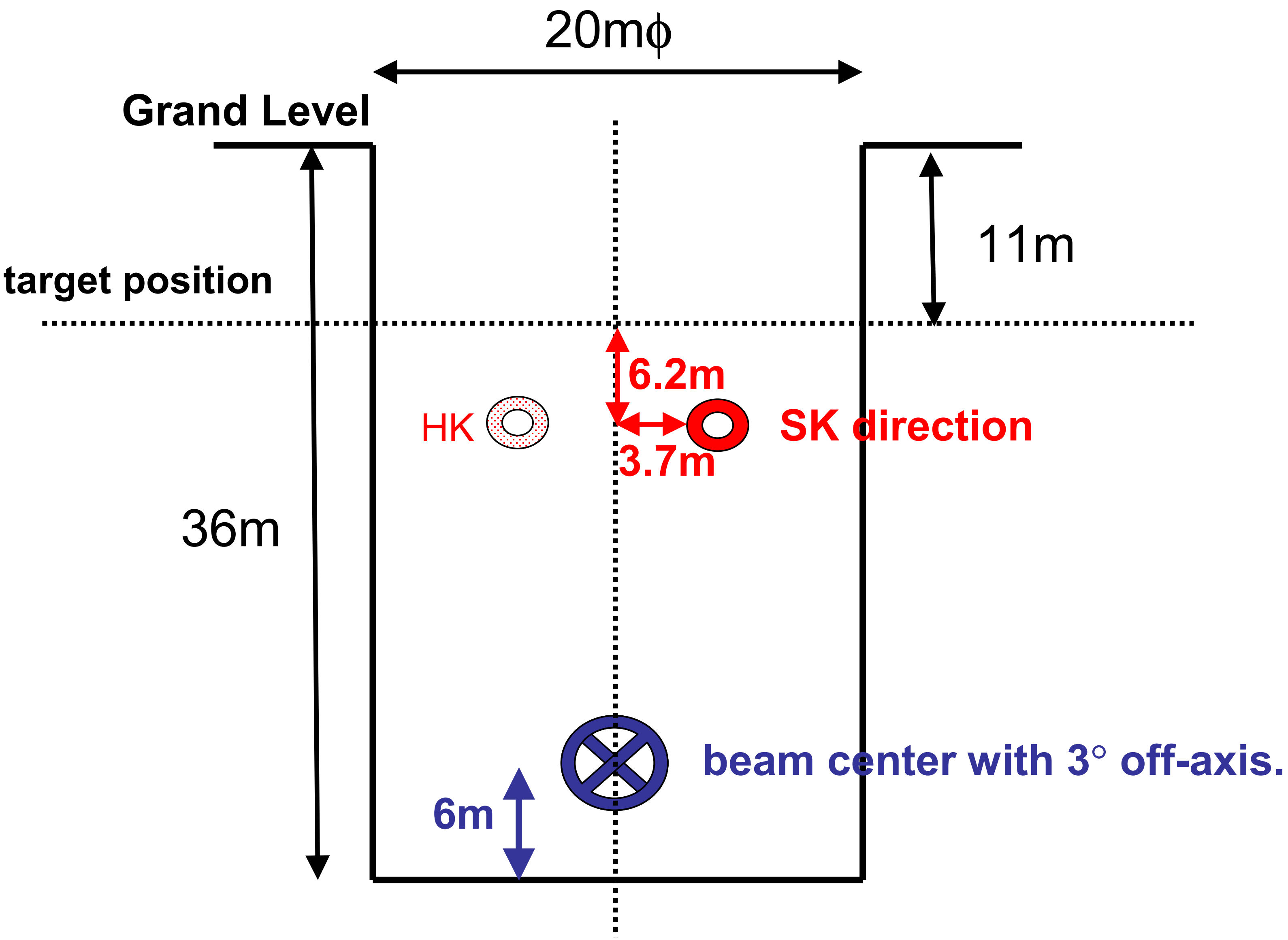
The need is not (only) to subtract backgrounds with 2%, 5% or 10% systematic error.

The need is to ground to solid rock the discovery of the elusive subleading ν_e appearance.

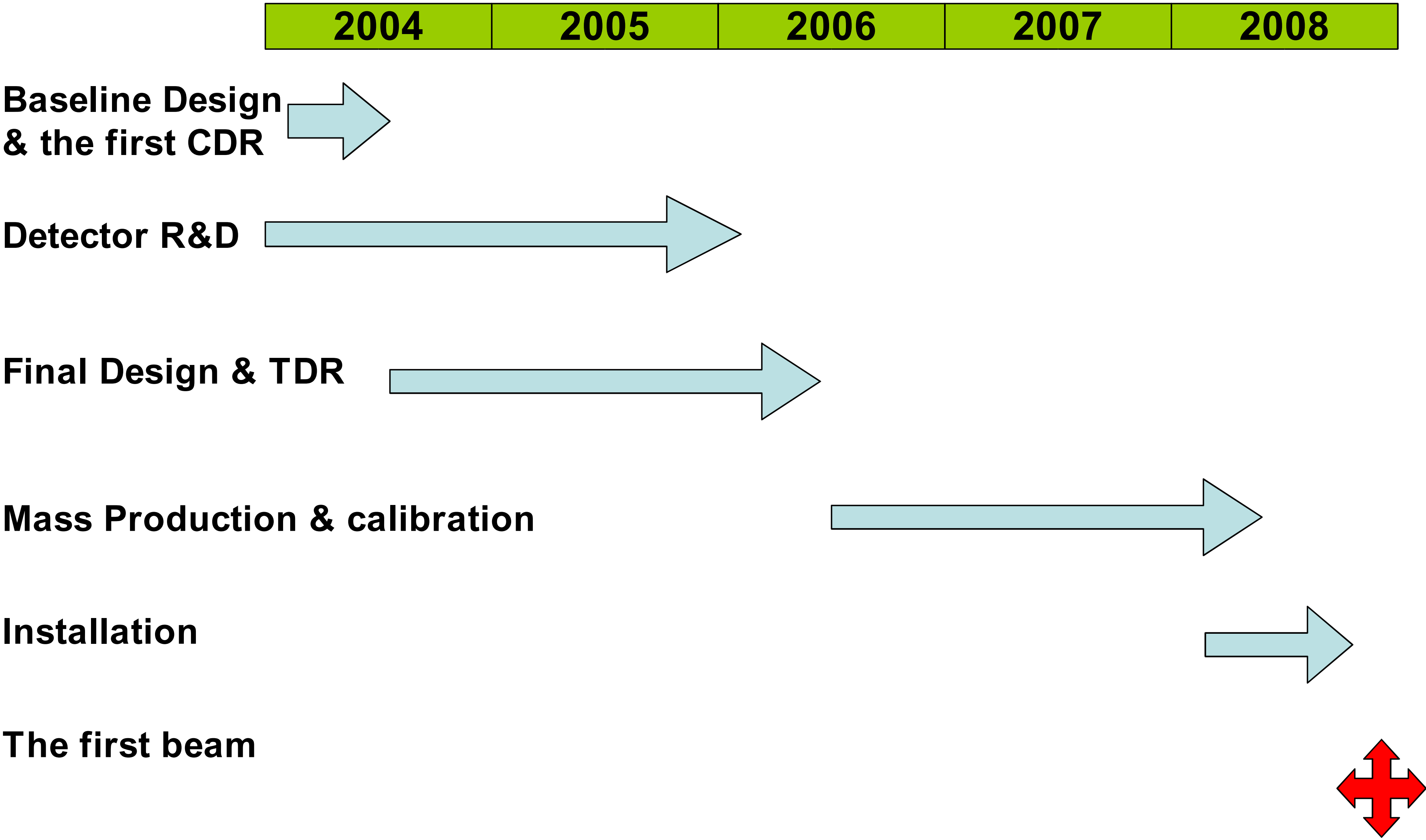
Fluxes , particle identification and background subtractions should be computed with redundant experimental informations and the minimum need of MonteCarlos.

- ν_μ (10%) and ν_e (3%) flux predictions with the minimum far/near bias.
- Measure of the single π° resonant cross sections. Possibly as function of the energy. They are the main backtround for the ν_e appearance (CC) and the experimental sample for the sterile neutrino appearance (NC).
- Evaluation of the quasi-elastic/resonance ratio, the major uncertitude of the reconstruction of the energy of the events.
- Measure of the particle identification algorithms in a close-detector similar to SuperKamiokande.
- Direction of the horn focused pions:
  - $\delta < E_\nu > \simeq 25\, MeV/\mathrm{mrad} \rightarrow \delta(\Delta m^2) = 10^{-4}\, eV^2/\mathrm{mrad}$
  - $\delta\Phi_\nu/\Phi = 4\%/\mathrm{mrad} \rightarrow \delta(\sin^2 2\theta) = 0.001 - 0.005$

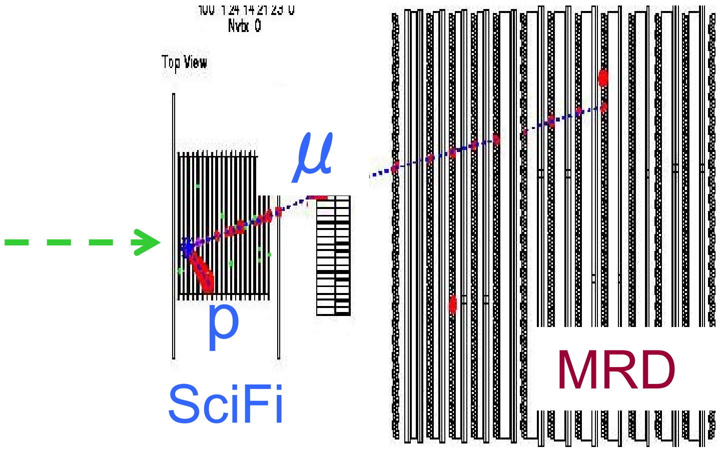
2. The detector hall at 280m from the target

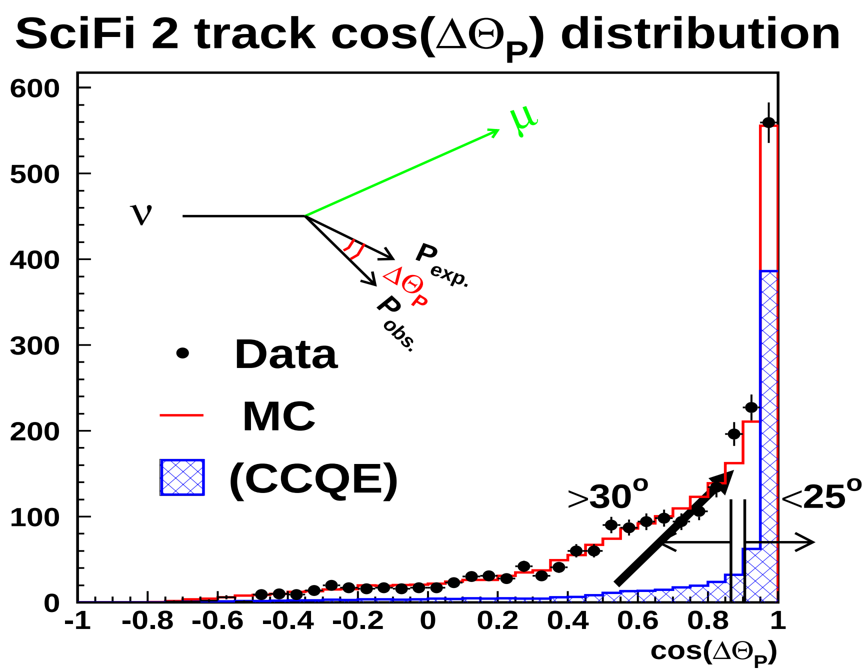


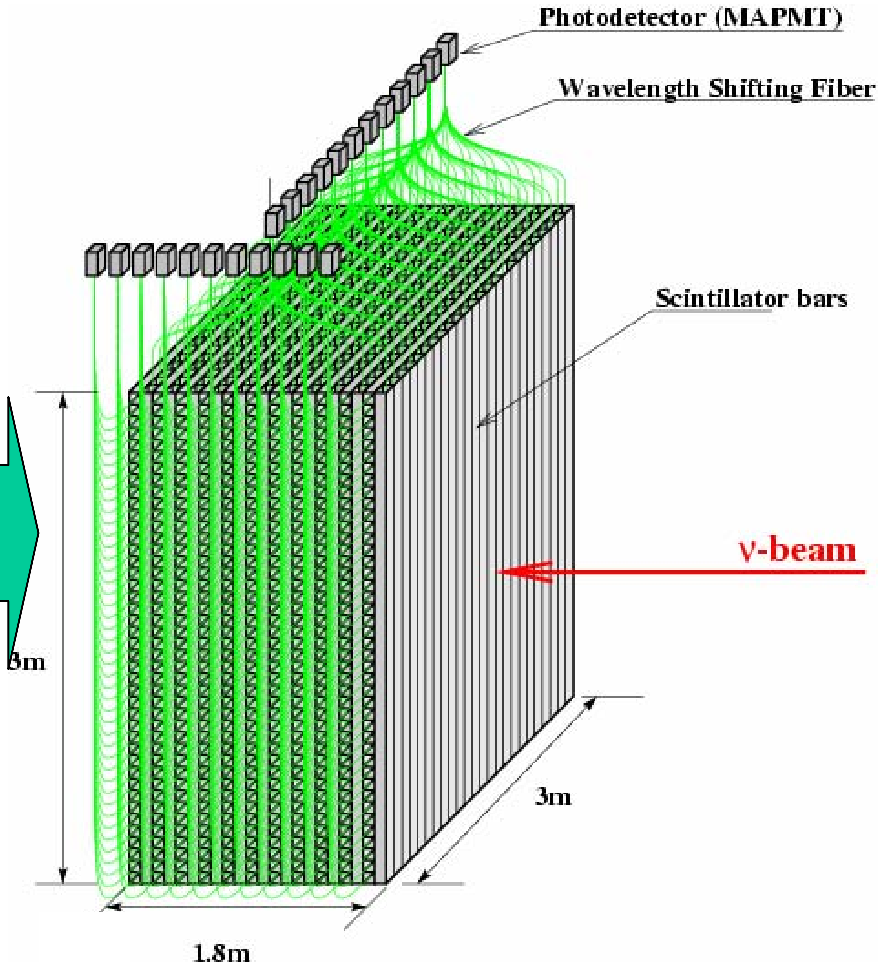
280 m Schedule



Fine grained detector (fully active scintillator ?)

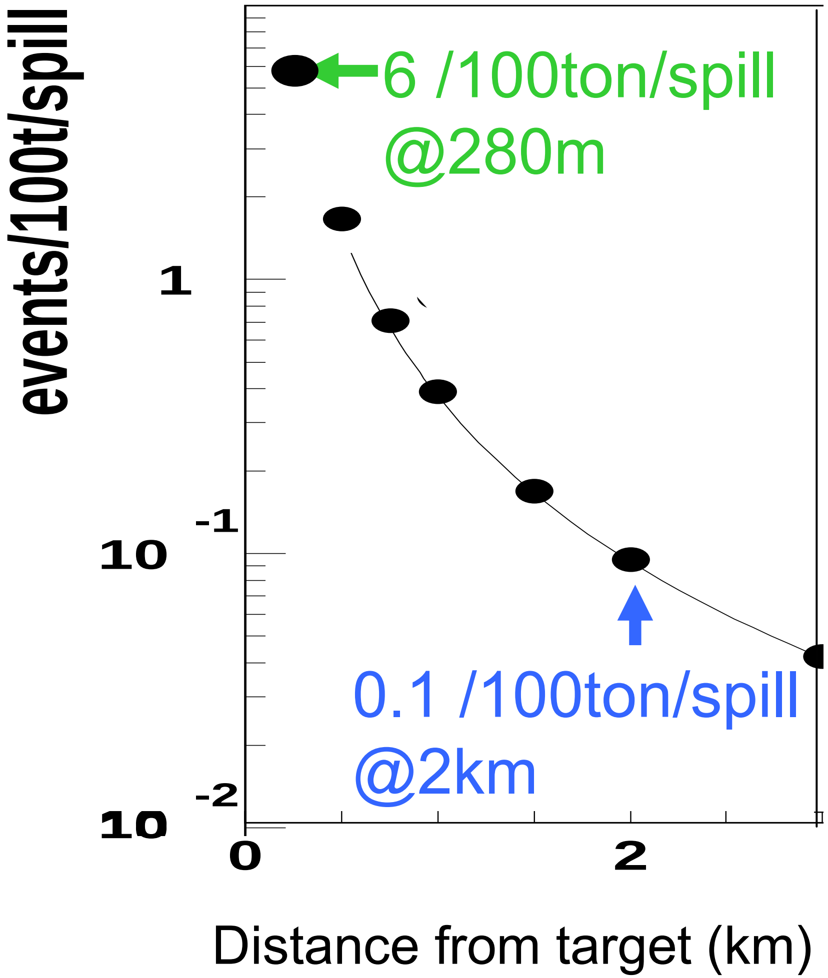


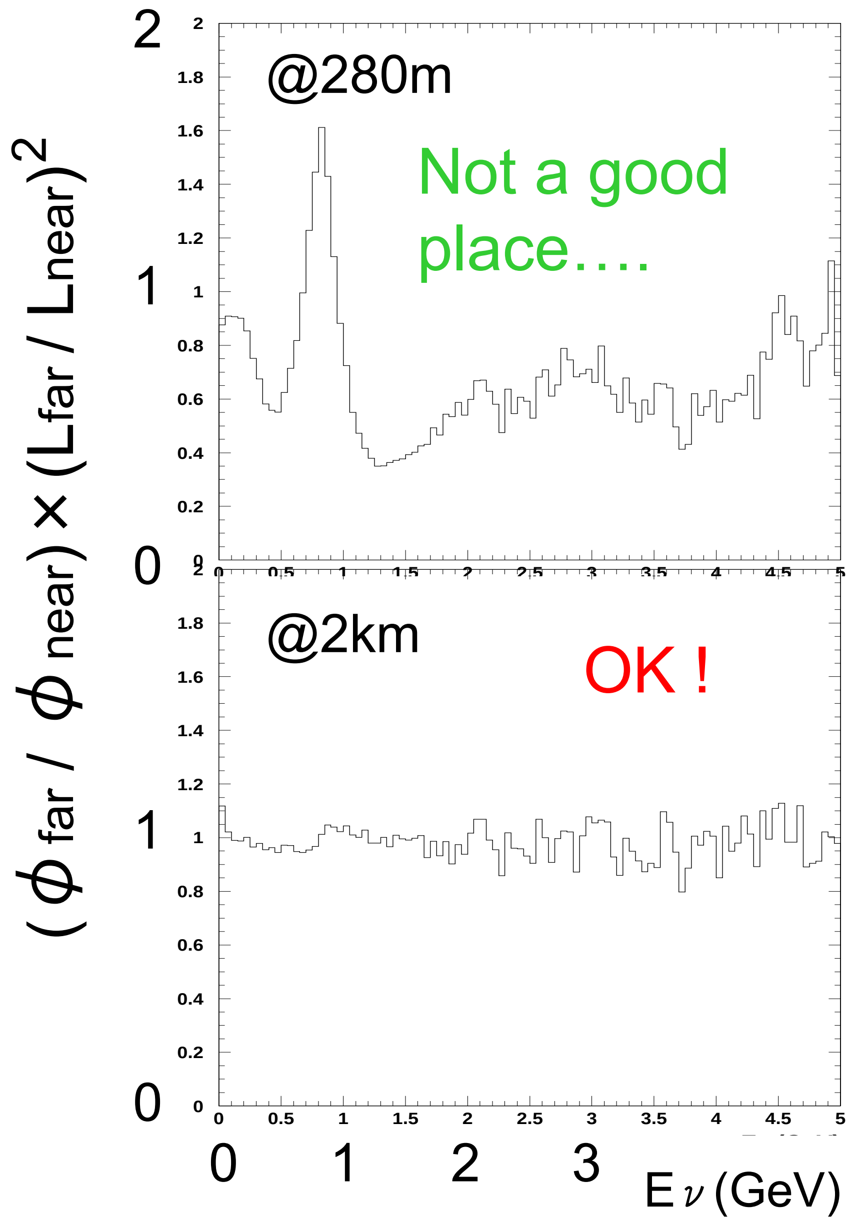




Very important to understand the details of ν interactions.

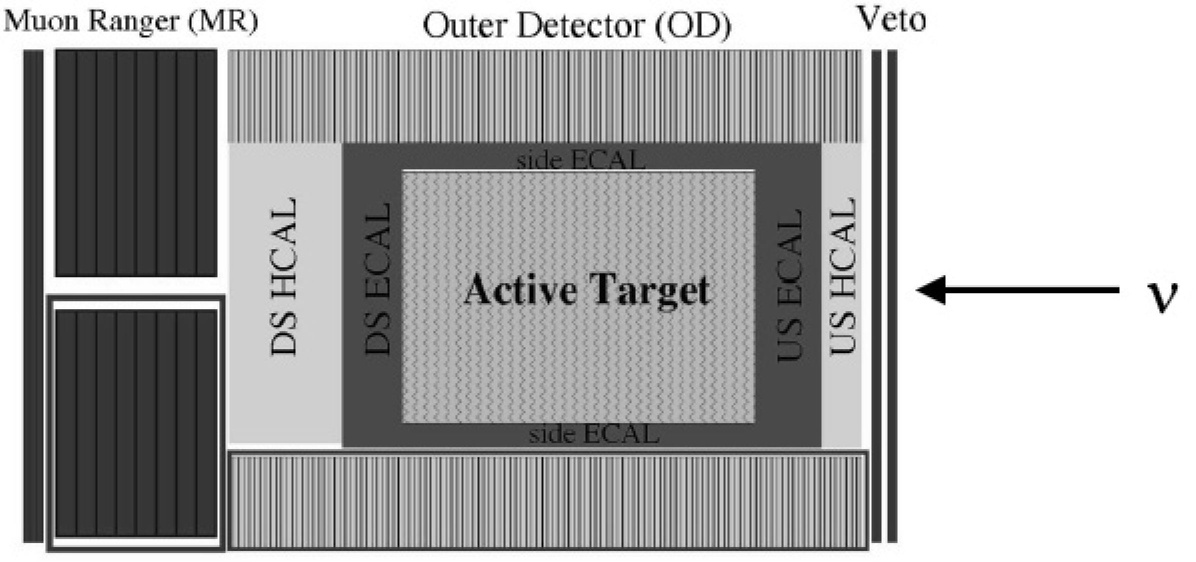
Event rate & Far/near ratio





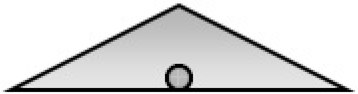
Water Cherenkov :
Impossible @280m
(Total mass > 100 tons)

MINERvA Detector Overview



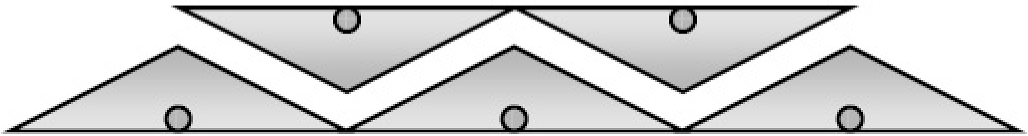
- Active target, surrounded by calorimeters
  - upstream calorimeters are Pb, Fe targets
- Magnetized side and downstream tracker/calorimeter

Fully-Active Target: Extruded Scintillator

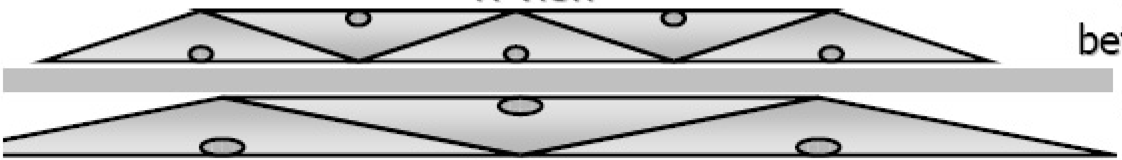


Basic element: 1.7x3.3cm triangular strips.
1.2mm WLS fiber readout in grove at bottom

Assemble into planes



X-View

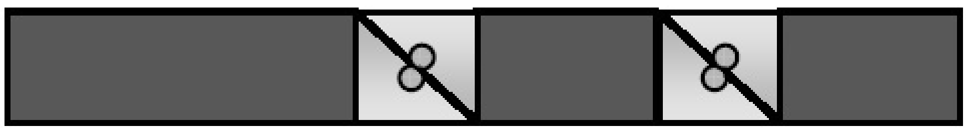


U/V-View

Absorbers between planes

e.g., E- or H-CAL, nuclear targets

Or replace strips with absorber (outer detector)



Motivations for the 280m off-axis

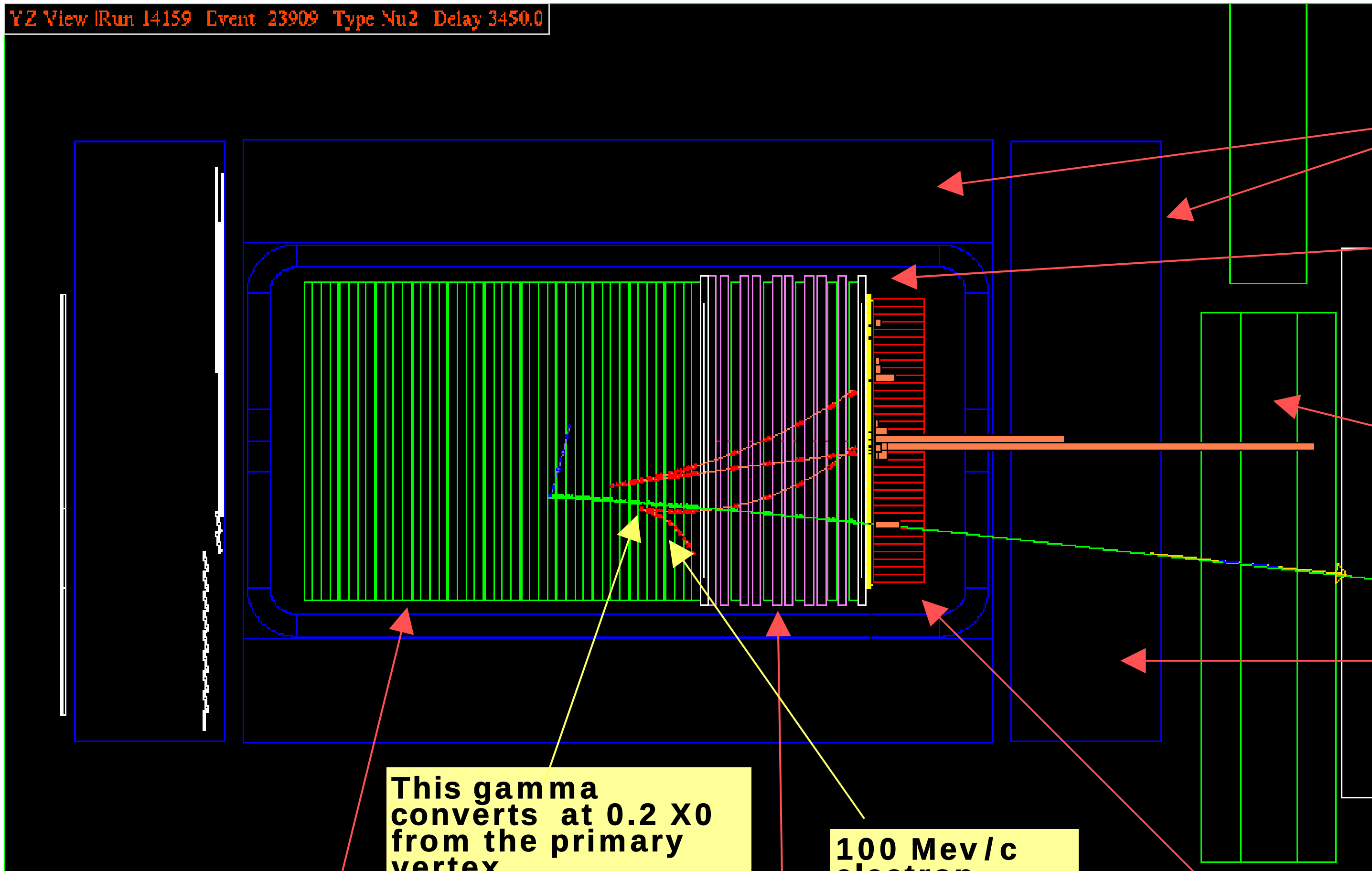
- understanding the beam: energy spectrum + composition
- study π_0 production
- study q.e.: pμ vs Eν, q.e. vs n.q.e.
- less crucial: study all exclusive reactions

Magnetic field could help to

- improve study of beam composition by sign measurement e+e-μ+μ-
- improve photon id (e+e- opening)
- improve classification of exclusive reactions because of measurement (charge and momentum) of all secondary particles

DETECTOR

Full data sample (1995-98) 1.35 10^6 ν_μ CC



MAGNET: 0.4 T. Recycled from the UA1 experiment

PRESHOWER: 1.6 X0 of lead antimony followed by proportional tubes.

MUON CHAMBERS: recycled from UA1. Identify muons with p>3.5 GeV/c

HCAL: magnet iron instrumented with scintillators.

Electrons are identified by TRD, preshower and ECAL

This gamma converts at 0.2 X0 from the primary vertex

100 Mev/c electron

2.7 ton TARGET: 11 planes of Drift Chambers (DC). Density: 0.1 g/cm3 Resolution: 3% (p< 10 GeV/c)

9 planes of TRD interspersed with 5 planes of DC

ECAL: 875 lead glass towers. Resolution: 3% /E $^{1/2}$.

UA1/Nomad magnet

Outer dimensions: 7.5 x 6.2 x 5.8 m3

Inner dimensions (available for FGD): 7.0 x 3.5 x 3.5 m3

B (uniform) : up to 0.7 T (Nomad ran at 0.4 T)

EXAMPLE - FGD and B = 0.7T

"SCIBAR" like = target, coarse tracker, dE/dx, γ conversion
+ "frame" to absorb gammas
+ few planes of drift chambers (measure only in bending plane)

- Scint bars - could measure low energy part with many points (Δx = 7 mm)

- Drift chambers could measure q.e. up to 4 GeV (forward, few points with Δx = 1mm (Nomad – Δx = 0.15 mm))

- $\Delta p/p$ (multiple scattering) = 12% for L = 1m
- $\Delta p/p$ (measurement)

p = 500 MeV, L = 1 m , n = 20, Δx = 7 mm

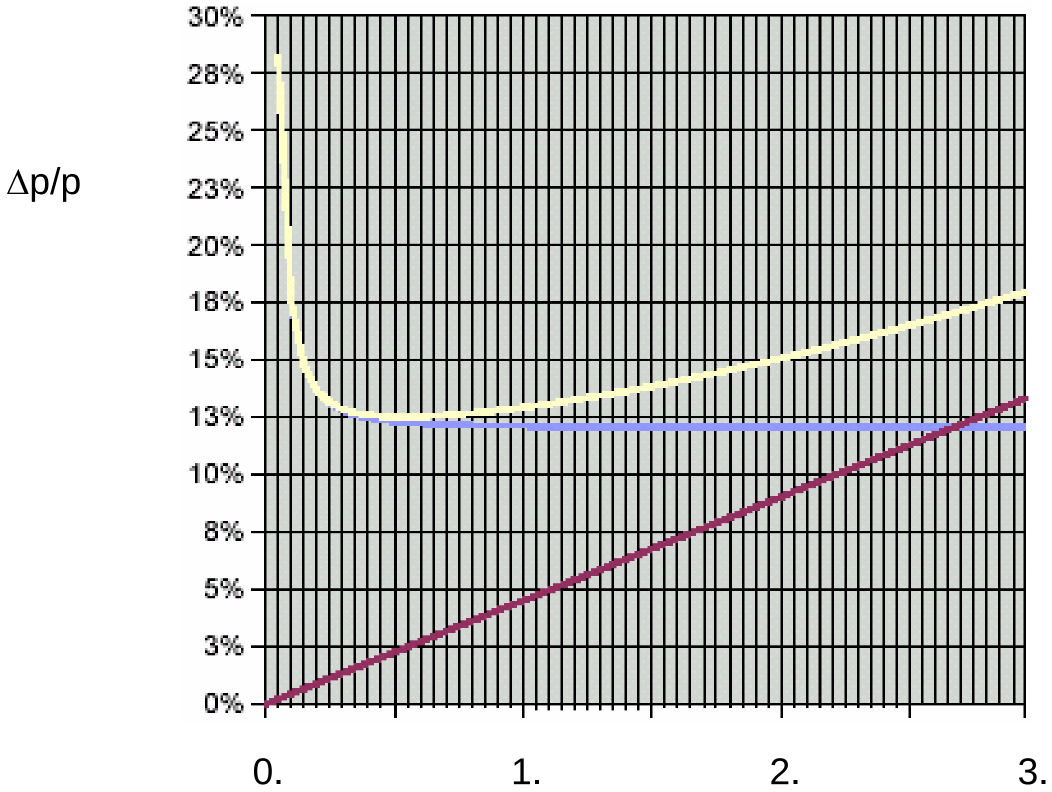
$\Delta p/p$ = 9%

p = 3 GeV, L = 1 m , n = 5, Δx = 1 mm

$\Delta p/p$ = 12%

B = 0.7 T   L = 1 m Δx = 1 mm

N(points) = 4 X_0 = 0.4 m



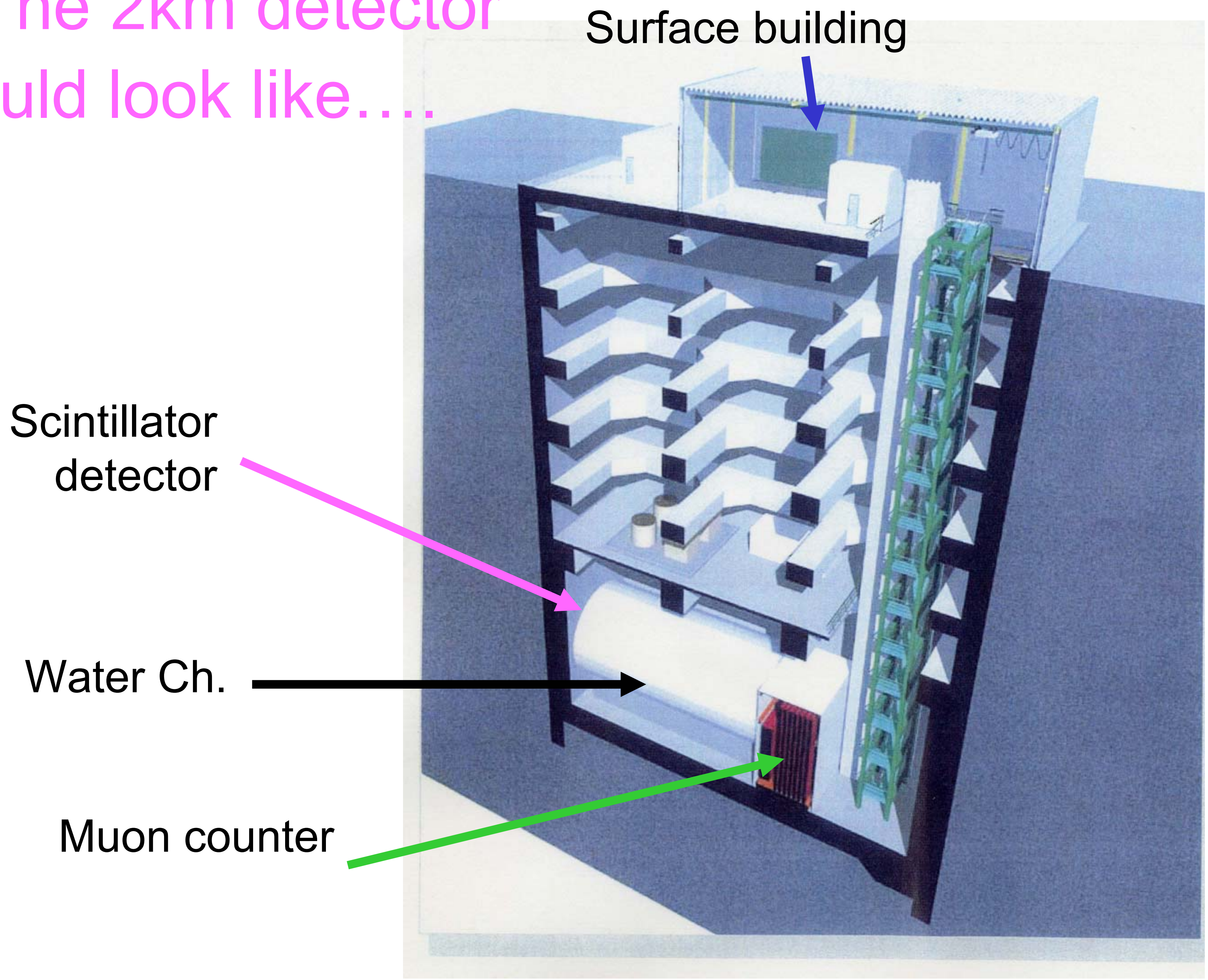
Can we use the UA1 magnet?

- Iron – 16 C shaped pieces (40 tons each) – available
- Coils – available
- Power supply – not available (6000 A – 500 V for 0.4 T – 3 MW)
- Wheels,rails,motors – not available

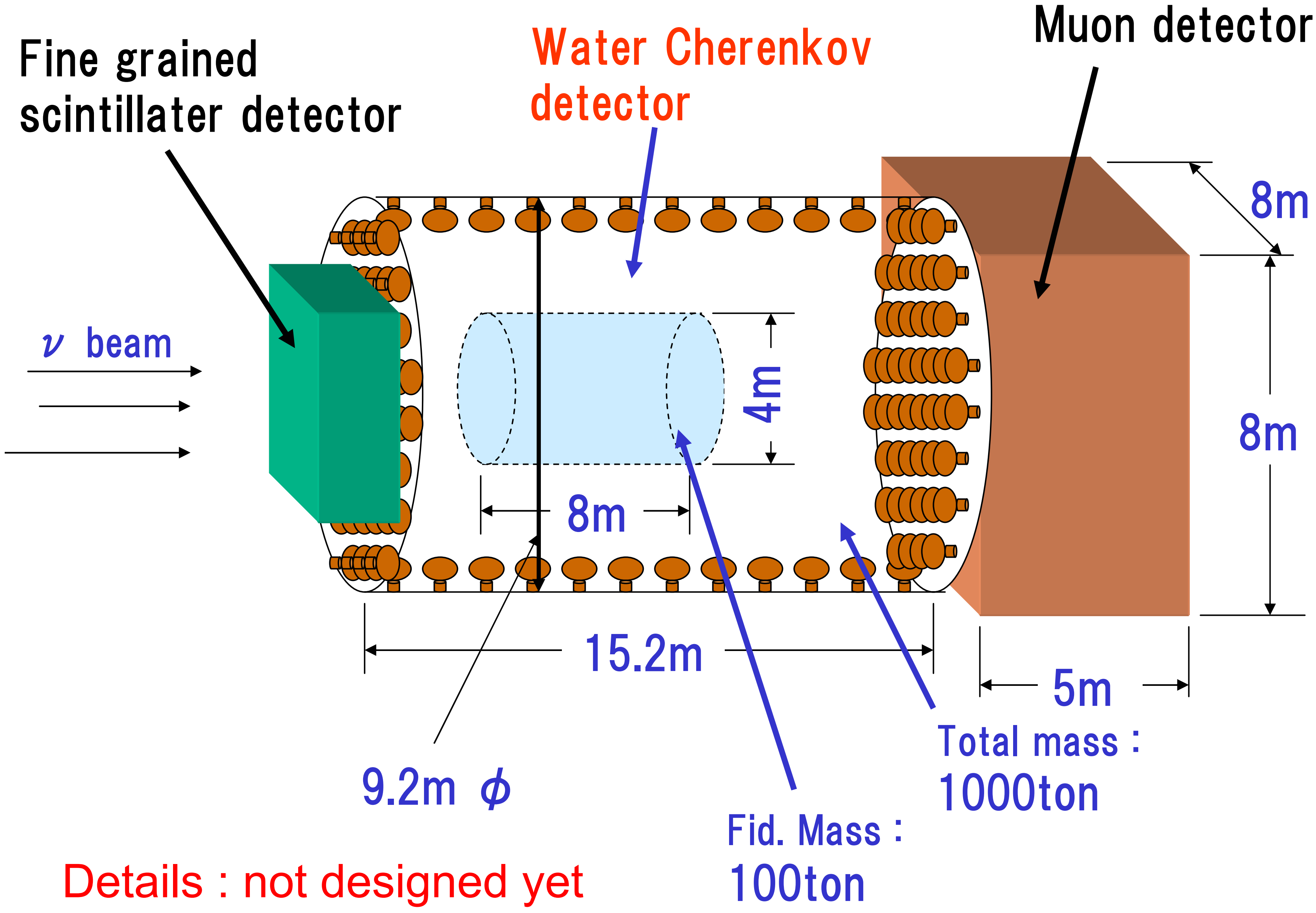
Cost

- shipping (order of 1 Kton) – (0.2 MEURO ?)
- power supply – (0.5 MEURO ?)
- engineering (size is OK, weight is huge (1 Kton))
- running 3MW 130 days/year (0.2 MEURO ?)

The 2km detector should look like….



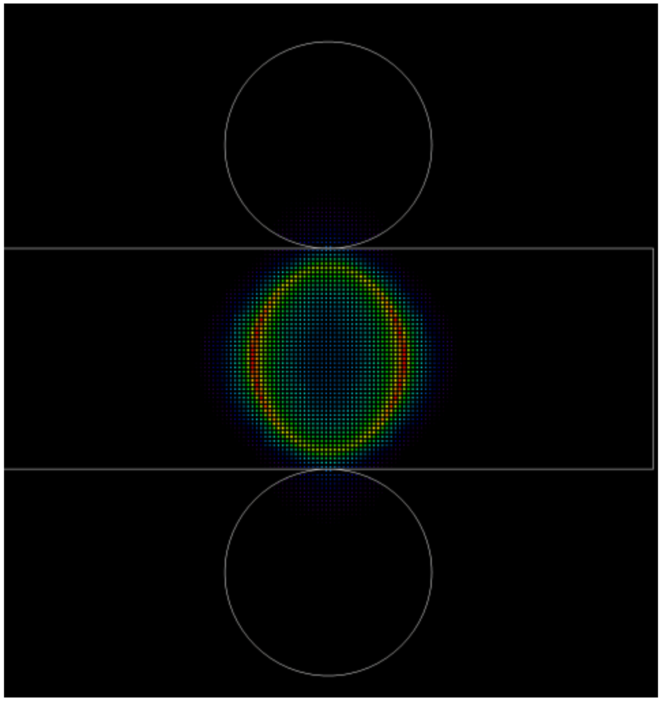
Near detector @2km



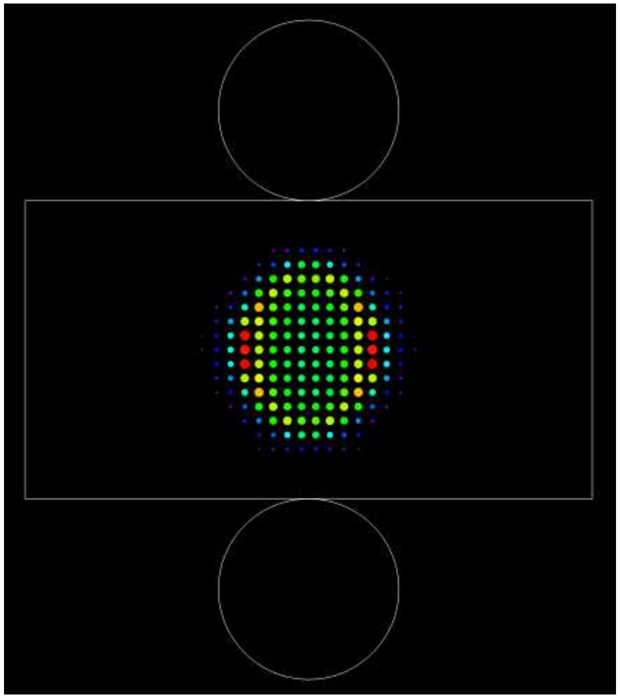
Details : not designed yet

2km Intermediate Detector

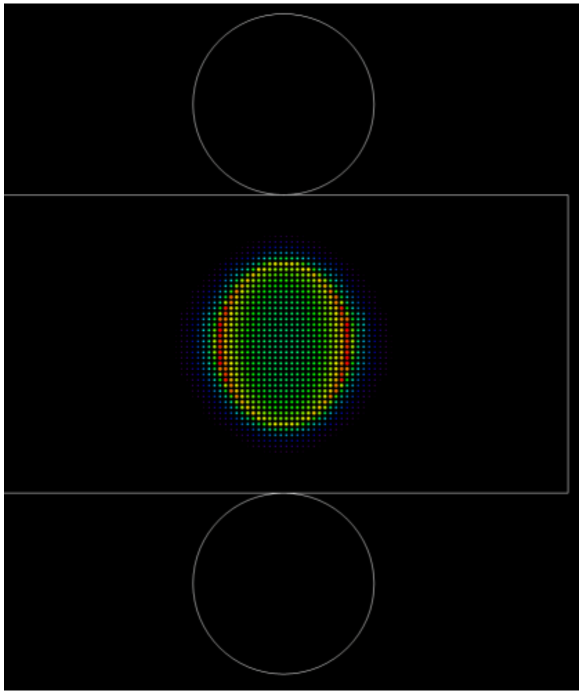
Electron simulation



Super-Kamiokande



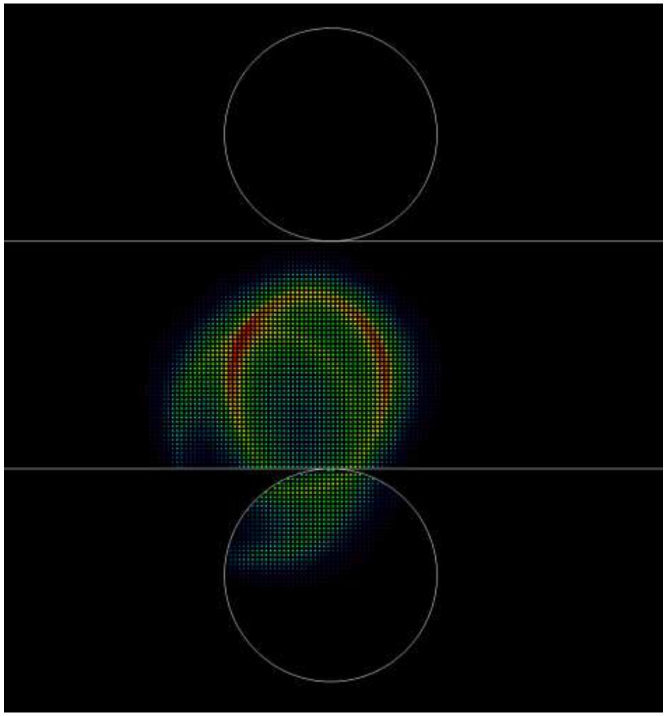
Intermediate detector
20 inches



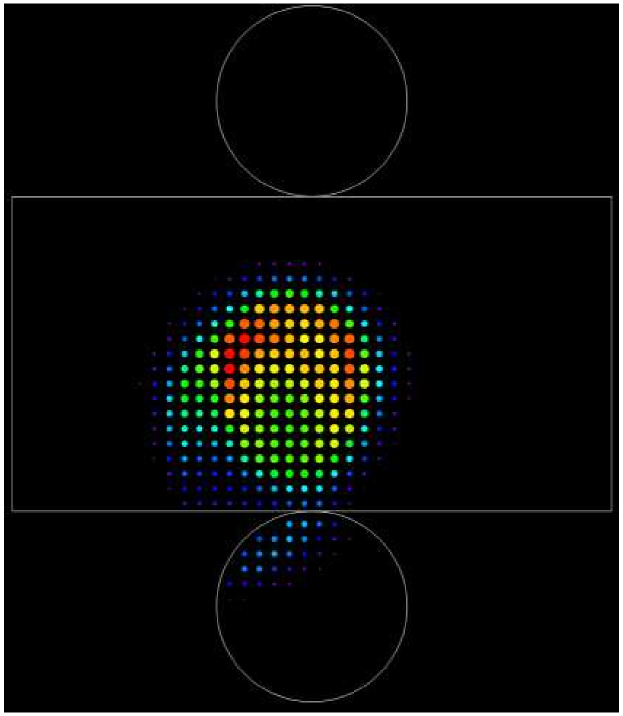
Intermediate Detector
8 inches

2km Intermediate Detector

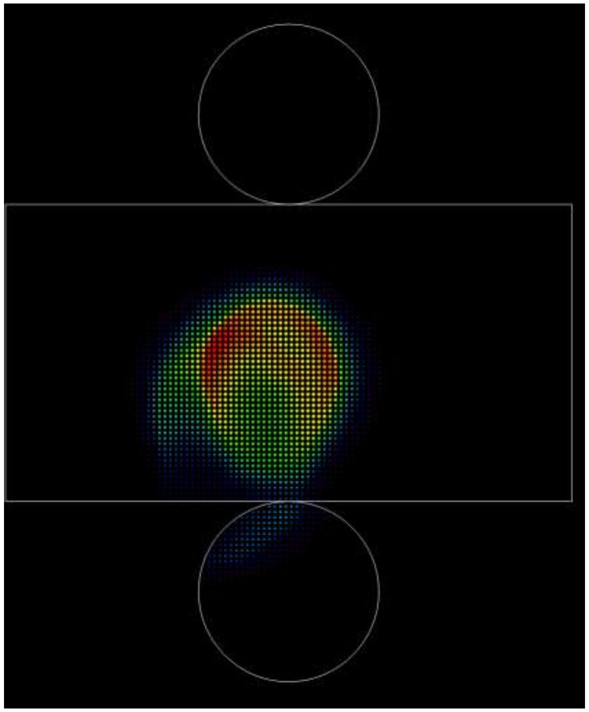
π^0 simulation



Super-Kamiokande



Intermediate detector
20 inches



Intermediate Detector
8 inches

Upgrade degli algoritmi di ricostruzione degli eventi in SK

1) Ricostruzione di E_ν con una precisione di 80 MeV

2) Miglioramento di un fattore 30 della reiezione e/π°

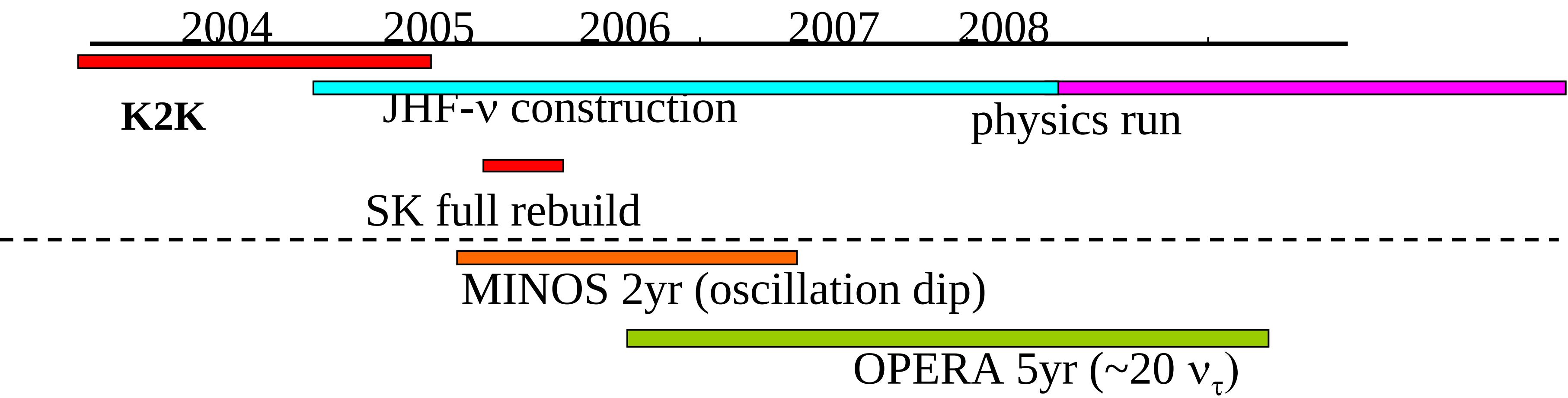
Gli algoritmi di SK ad oggi porterebbero il fondo dei π° al 2.5% delle ν_μ^{CC} con una efficienza sugli elettroni dell'80%.

D'altra parte ad oggi SK non ha bisogno di reiezioni spinte dei π° negli eventi atmosferici o per la ν_μ disappearance di K2K.

Gli algoritmi sono provati sul MC di SK tunato sui dati di K2K

3) Separazione e/μ a 10^{-4}.

Schedule & Summary



- **Beyond the ‘confirmation’ of neutrino oscillation**
- **Best possible measurements of neutrino oscillation with present technology**
- **World-wide interests to join the experiment**

- **Possible upgrade in future**
  - **4MW Super-JHF + Hyper-K (1Mt water Cherenkov)**
  - **CP violation in lepton sector**

Possibile Schedula per il gruppo italiano

- 9 marzo: open meeting a Roma
- 22 marzo: presentazione in commissione II
- Giugno: richiesta di apertura di sigla (T2K R&D)
- Fine agosto: meeting in Giappone, possibile inizio di definizione dei rivelatori e degli impegni
- Fine anno: T2K proposal
- Giugno 2005: proposta completa di esperimento alla Commissione II

Letter of Intent
Neutrino Oscillation Experiment at JHF

Summary

The first stage of a next-generation long baseline neutrino oscillation experiment is proposed to explore the physics beyond the Standard Model. The experiment will use the high intensity proton beam from the JHF 50 GeV proton synchrotron (JHF PS), and Super-Kamiokande as a far detector. The baseline length will be 295 km. The beam power of JHF PS is capable of delivering 3.3×10^{14} 50 GeV protons every 3.5 seconds (0.75 MW). The experiment assumes 130 days of operation at full intensity for five years. The high intensity neutrino beam is produced in an off-axis configuration. The peak neutrino energy is tuned to the oscillation maximum of ∼0.8 GeV to maximize the sensitivity to neutrino oscillations.

The merits of this experiment can be summarized as follows:

- The off-axis beam can produce the highest possible intensity with a narrow energy spread. The oscillation maximum will be ∼0.8 GeV for the distance of 295 km and $\Delta m^2 \sim 3 \times 10^{-3} eV^2$. The corresponding angle of the beam line axis relative to the direction of far detector is about 2 degrees.
- The far detector, Super-Kamiokande (SK), already exists. Experience in operating SK, including analysis tools, already exists. SK has excellent performance in detecting low-energy neutrinos.
- The neutrino events at sub-GeV are dominated by charged current quasi-elastic interactions, hence the neutrino energy E_ν can be reconstructed by two body kinematics.

The expected sensitivities in the first stage, assuming 0.75 MW and 130 days operation for five years are:

- Discovery of $\nu_\mu \to \nu_e$ at $\Delta m^2 \sim 3 \times 10^{-3} eV^2$ down to $sin^2 2\theta_{13} \sim 0.006$. This is a factor of twenty improvement in sensitivity over past experiments.
- Precision measurements of oscillation parameters in ν_μ disappearance down to $\delta(\Delta m^2_{23}) = 10^{-4}$ eV^2 and $\delta(\sin^2 2\theta_{23}) = 0.01$.
- Search for a sterile component in ν_μ disappearance by detecting neutral current events.

With successful completion of the first stage, a second stage of the experiment can be envisaged. In the second stage with the 1 Mt Hyper-Kamiokande detector and upgraded 4 MW PS, CP violation in the lepton sector can be probed, if $\sin^2 2\theta_{13}$ is in the discovery range of the first stage of the experiment. Sensitivity to proton decay is significantly extended up to 10^{35} ($(2 \sim 3) \times 10^{34}$) years lifetime for the $p \to e^+\pi^0$ ($p \to \bar{\nu}K^+$) mode.

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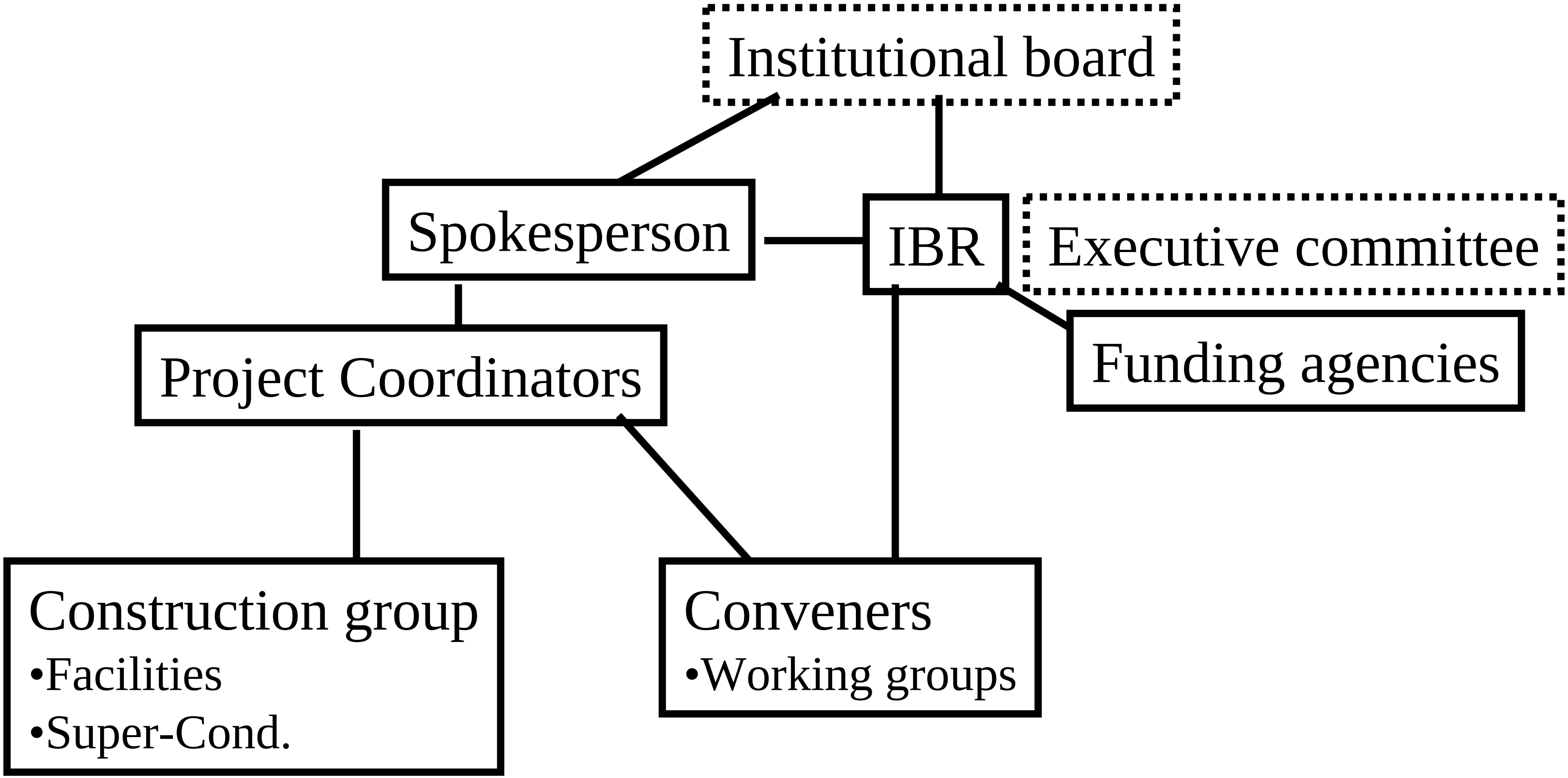
Minimum organization



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