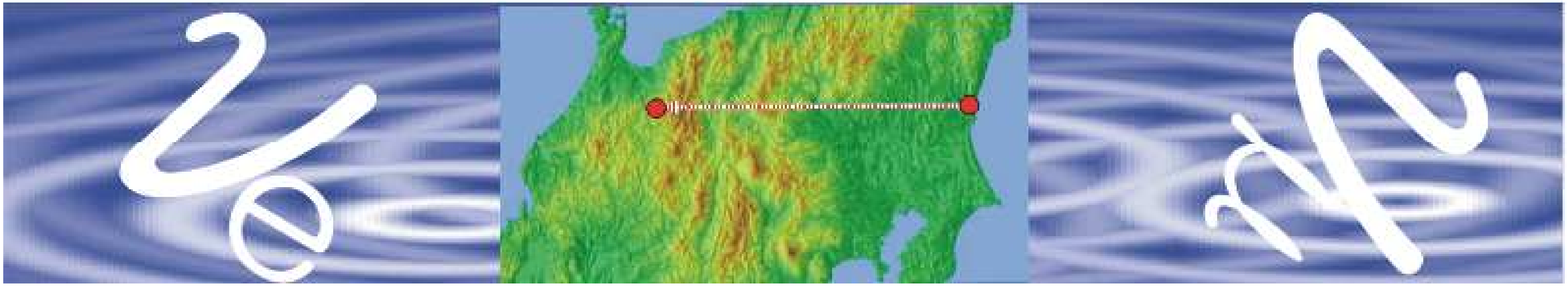
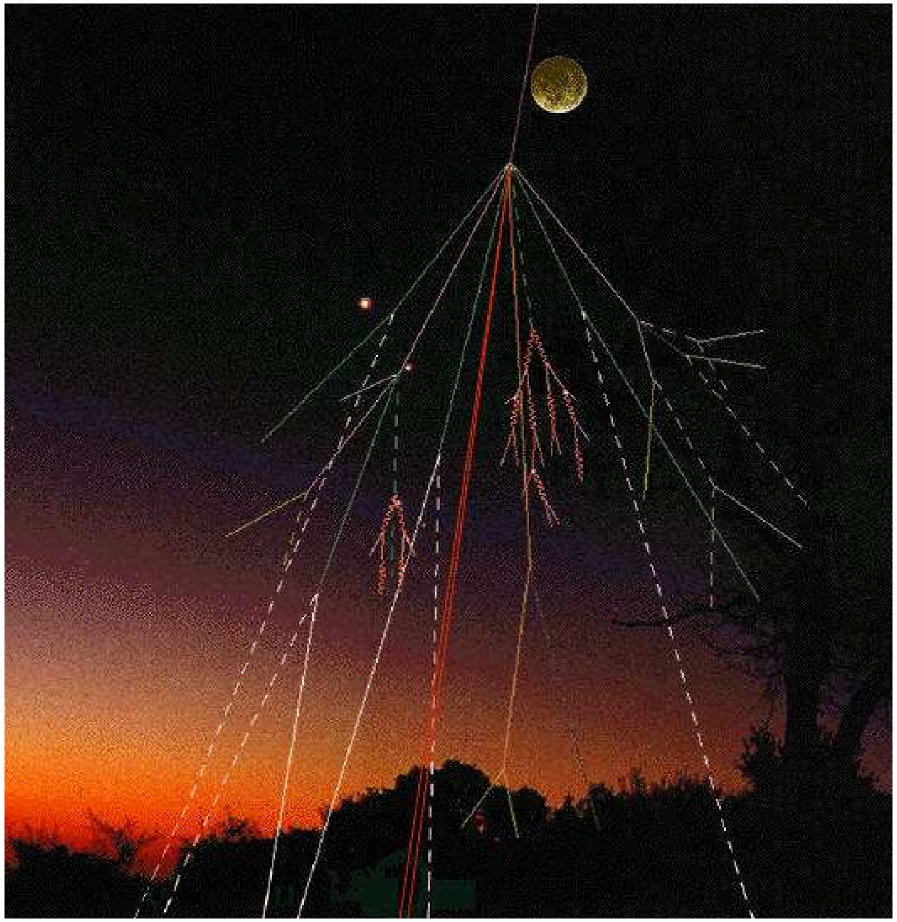


T2K

the Tokai to Kamioka
Neutrino Oscillation Experiment

Gary Barker

Neutrino Beam Experiments

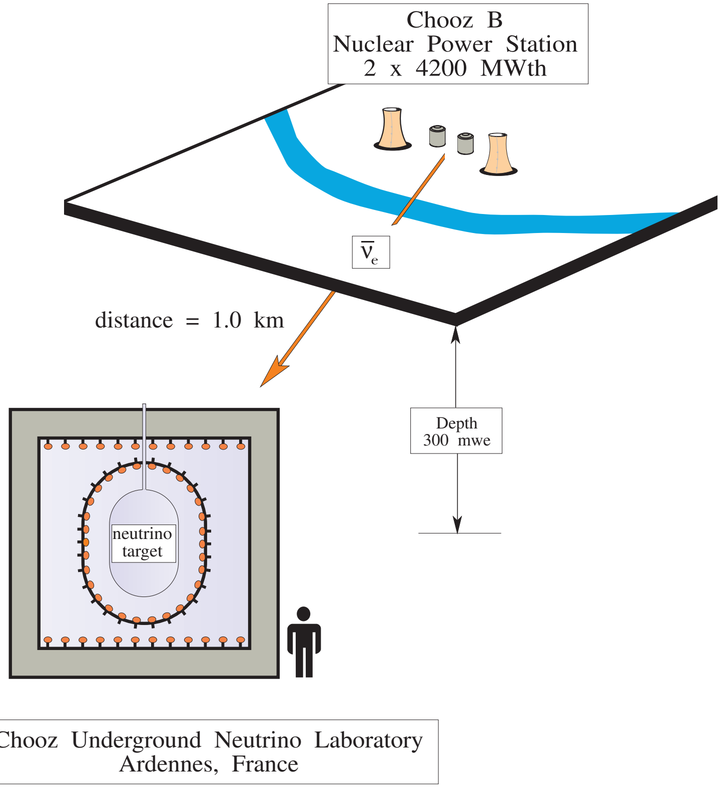


- The problem with using atmospheric or solar neutrinos as sources is that you don't know exactly what is coming in
- To conclude that $\nu_1 \longrightarrow \nu_2$ requires a measurement that some of ν_1 have disappeared or that additional ν_2 have appeared
- You need to know the number of incoming neutrinos (and composition)
- Cosmic-ray neutrino fluxes not known to better than 20%

Neutrino flux entering in your detector is at the mercy of the God's and is typically low (~ 100's events/year) and with a fixed energy spectrum

To go further requires a more controlled source $\Rightarrow$ man-made

Using Man-Made Neutrino Beams



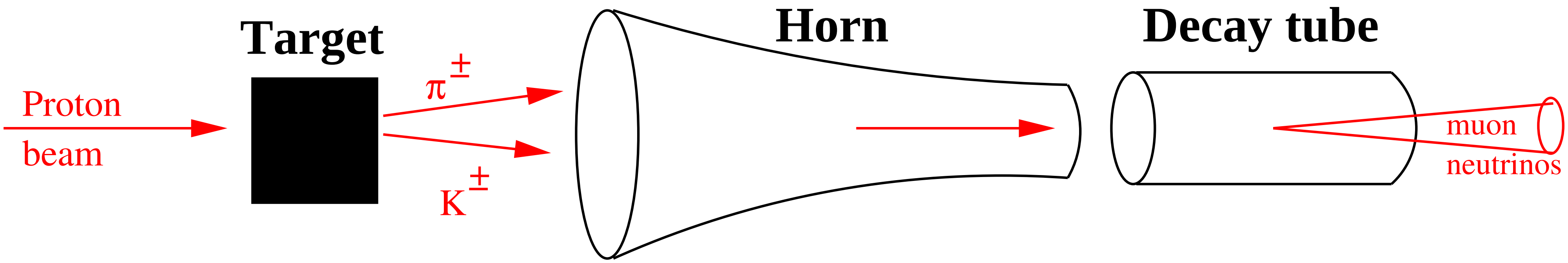
- **Nuclear reactors** emit $\sim 8 \times 10^{20}$ neutrinos/sec

$$\boxed{\bar{\nu}_e + p \rightarrow n + e^+}$$

$\Rightarrow 1T$ mass, 100m away will see *a few* events/hour

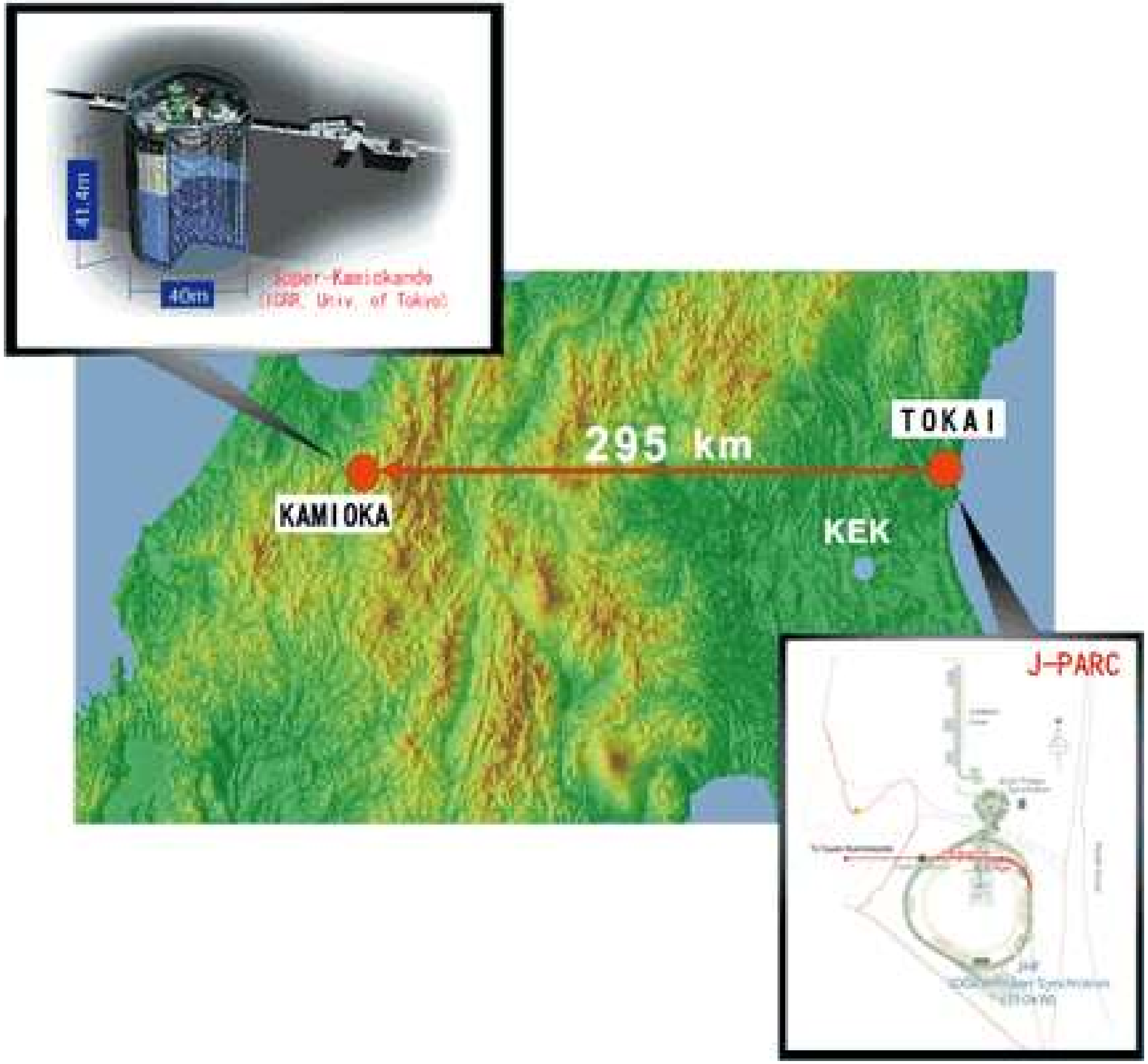
e.g. CHOOZ (France), Palo Verde (USA), KAMLAND (Japan)

- **Accelerator beams** are preferred method because of control over L/E and precise knowledge of ν-beam flux/composition

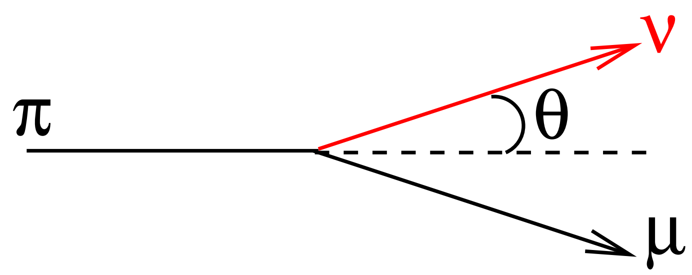


T2K: A Long-Baseline Oscillation Experiment

The current evidence for oscillations suggests Δm^2 is rather small $\Rightarrow$ probability to see oscillations is highest for large L/E_ν $\Rightarrow$ LONG baseline LOW energy



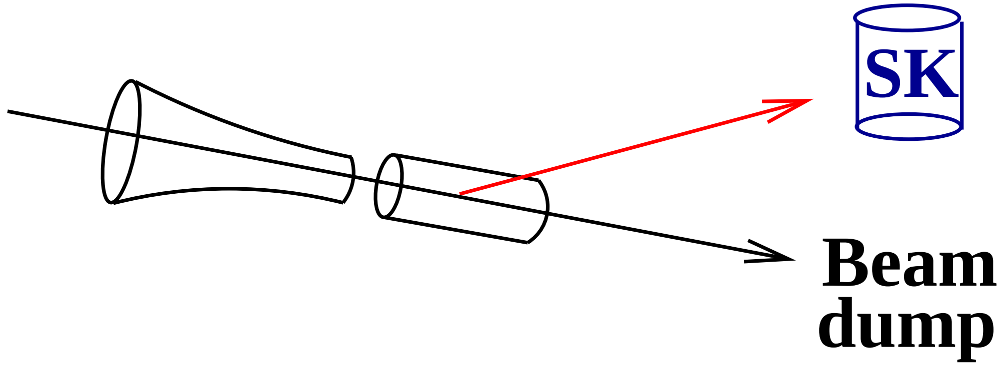
Beam Energy



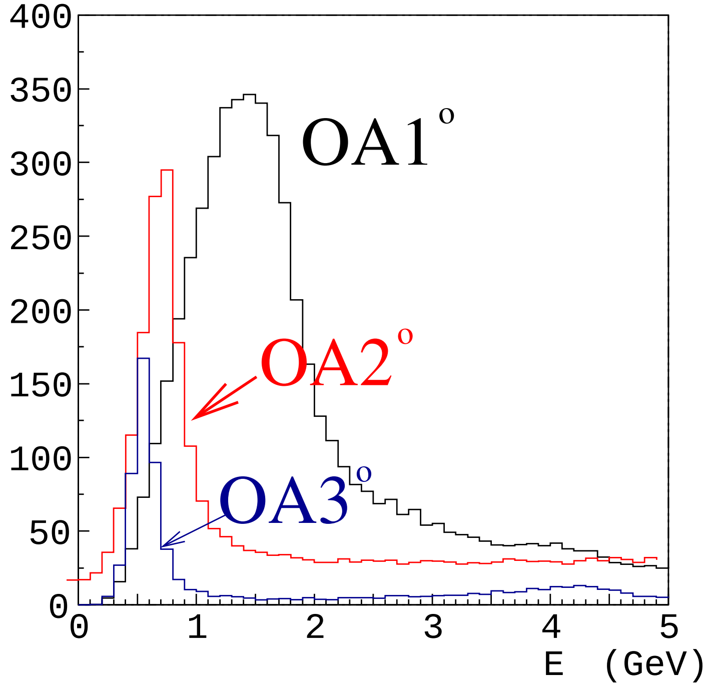
Peak of oscillation probability ($E_\nu =\sim 800$MeV) coincides with peak of ν_μ interaction cross section!

For the first time a (quasi)mono-energetic ν_μ beam will be made by looking 'off-axis'

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

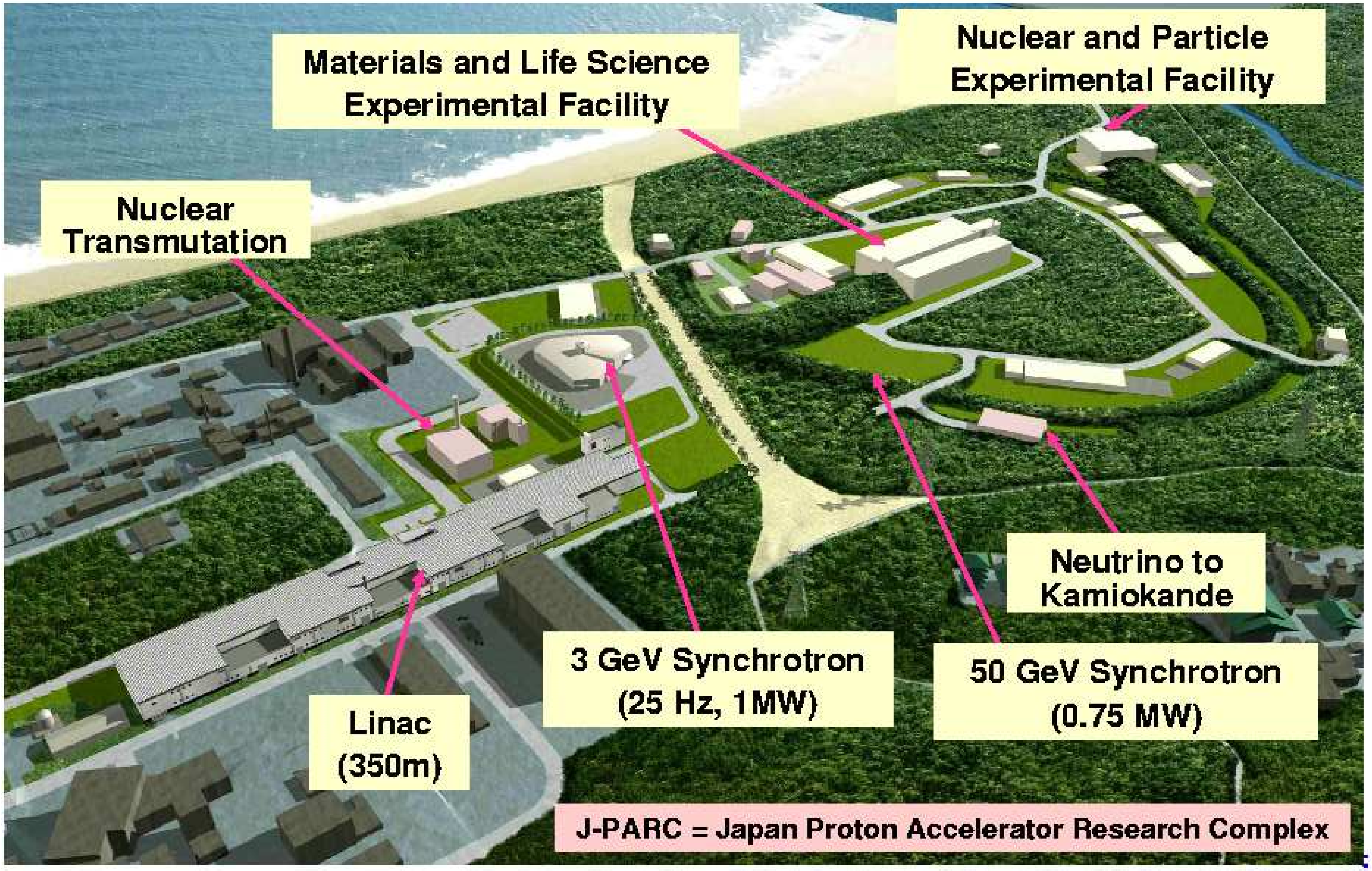


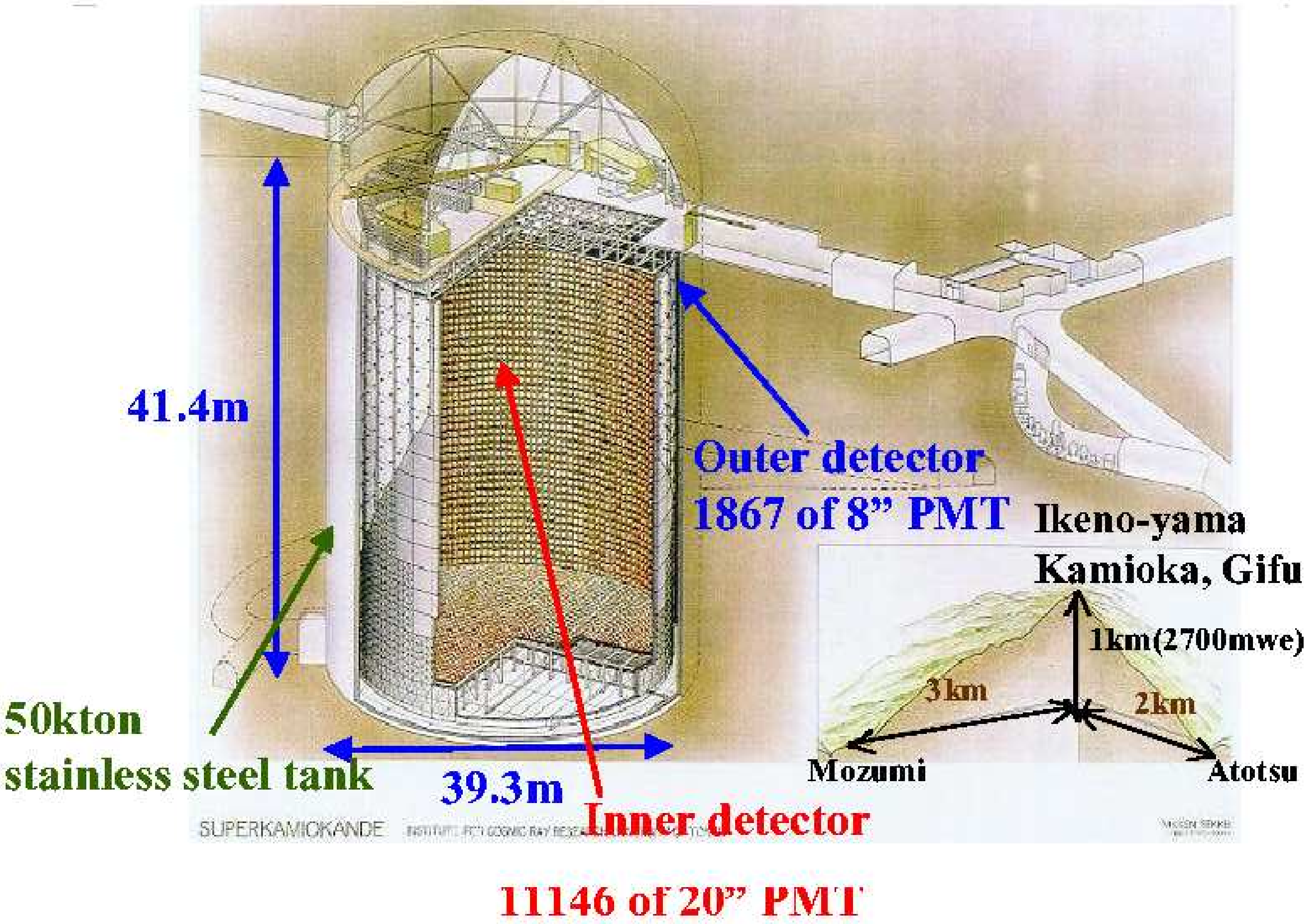
Big Advantage: Backgrounds to $\nu_\mu \rightarrow \nu_e$ observation from high $E(\nu_\mu)$ 'tail' are greatly reduced

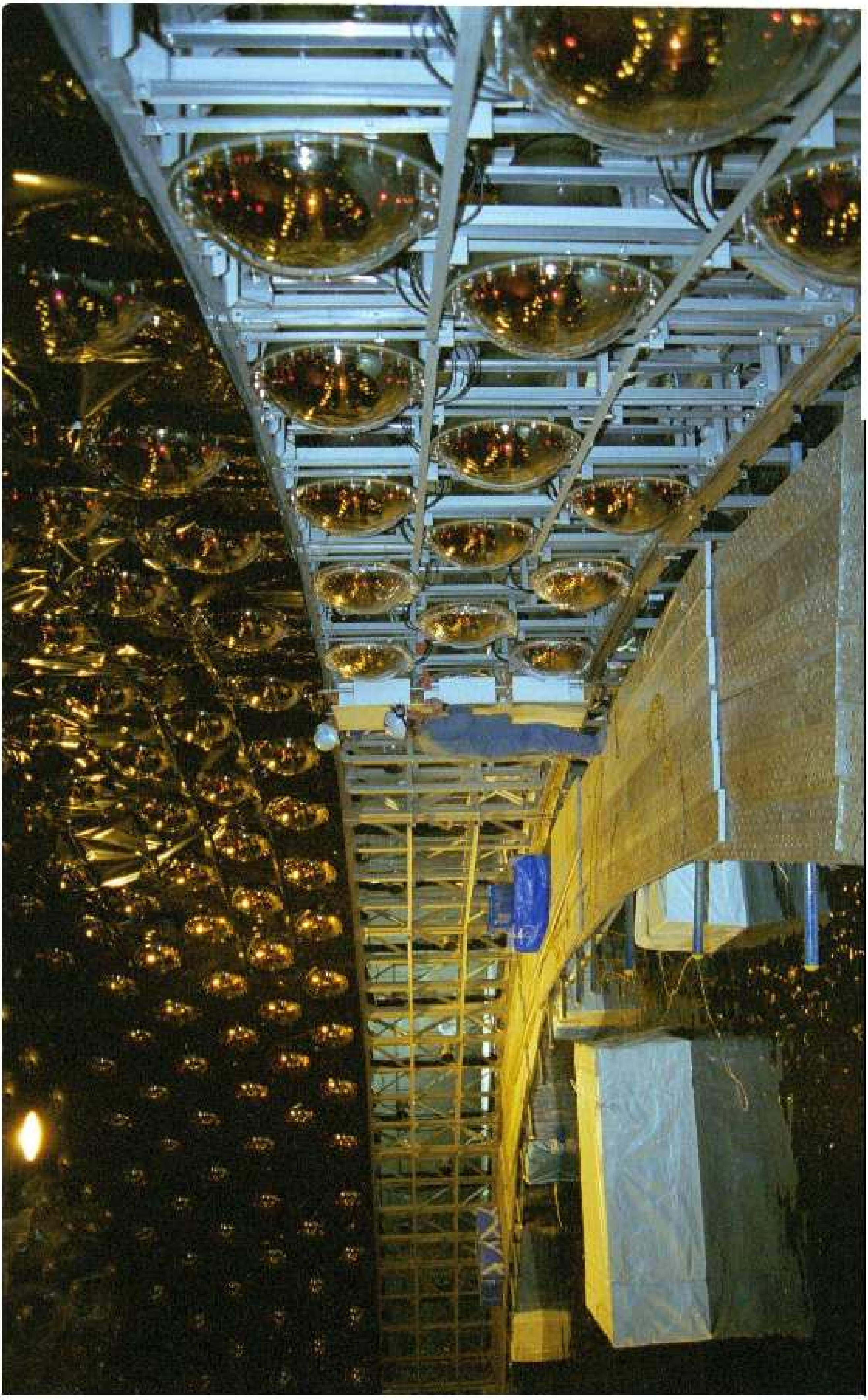


The JPARC Facility

To maximise statistical sensitivity requires the highest possible neutrino flux - the JPARC beam will be the highest power pulsed-proton beam ever built (0.75 MW)




41.4m
Outer detector
1867 of 8” PMT
Ikeno-yama
Kamioka, Gifu
1km(2700mwe)
3km
2km
Mozumi
Atotsu
50kton
stainless steel tank
39.3m
Inner detector
11146 of 20” PMT
SUPERKAMIOKANDE



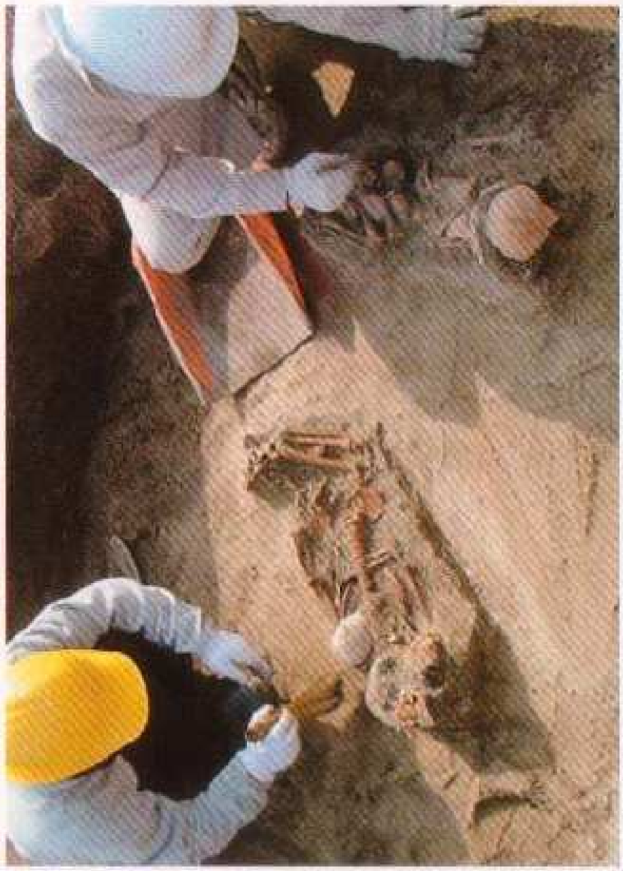
The Competition?

- MINOS (Fermilab $\longrightarrow$ Soudan mine, Minnesota): On-axis beam built at the wrong energy. Can improve CHOOZ θ_{13} sensitivity by factor ~ 2 in next 5 years. (c.f. T2K $\sim$ factor 20)
- CERN to Gran Sasso experiments, OPERA (2006?) and ICARUS (2008?): Baseline too short and no near detector. Could bring factor ~ 2(OPERA) and ~ 5(ICARUS) improvement on CHOOZ limit after five years running.
- NOvA experiment would be an off-axis version of MINOS with a similar sensitivity to T2K. No funding at present.
- Next generation nuclear reactor experiments: claim to have similar sensitivity to θ_{13} as T2K but no chance of seeing CP-violation.

At best, other experiments have a similar experimental sensitivity to T2K and will be complete on time-scales much longer than T2K, if at all. T2K is being constructed .....

Construction: Linac

Construction: 3GeV PS



Construction: 50GeV PS

2) Construction Status

Project Status

- Total project cost: $\sim$$180 million
- $\sim$$160 million already secured by Japanese for civil engineering and accelerator infrastructure
- International Collaboration has formed around supplying the important Near Detectors.
- 184 physicists from 11 countries already signed up, only 30% Japanese.

Warwick/UK Involvement

- The Near Detector at 280m,

  to measure:

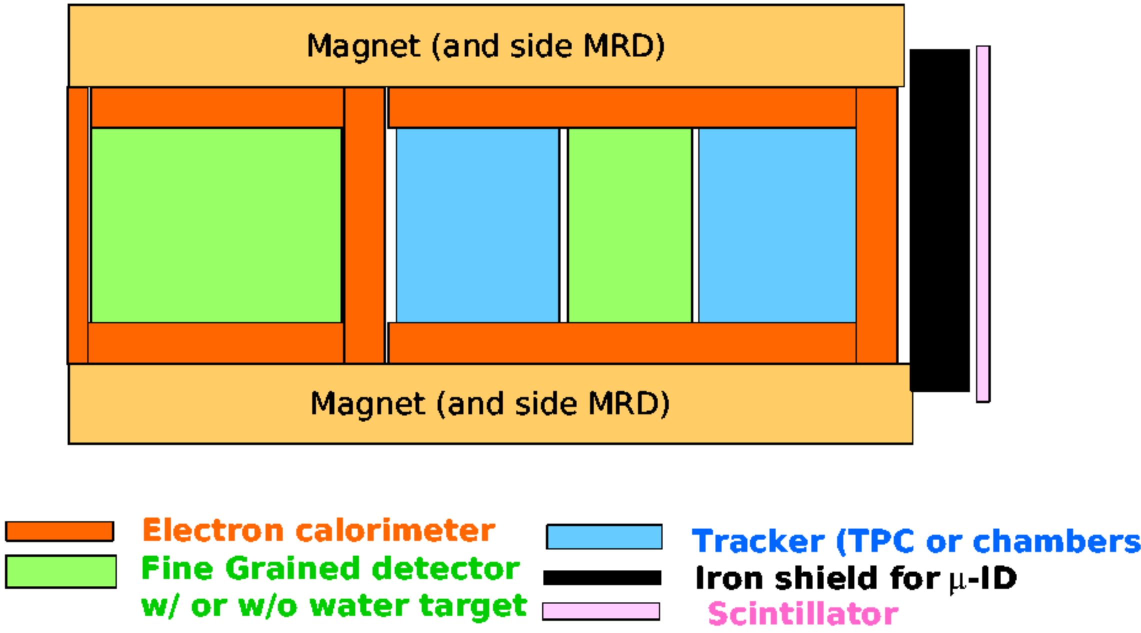
  – flux and energy spectrum of the ν_μ beam

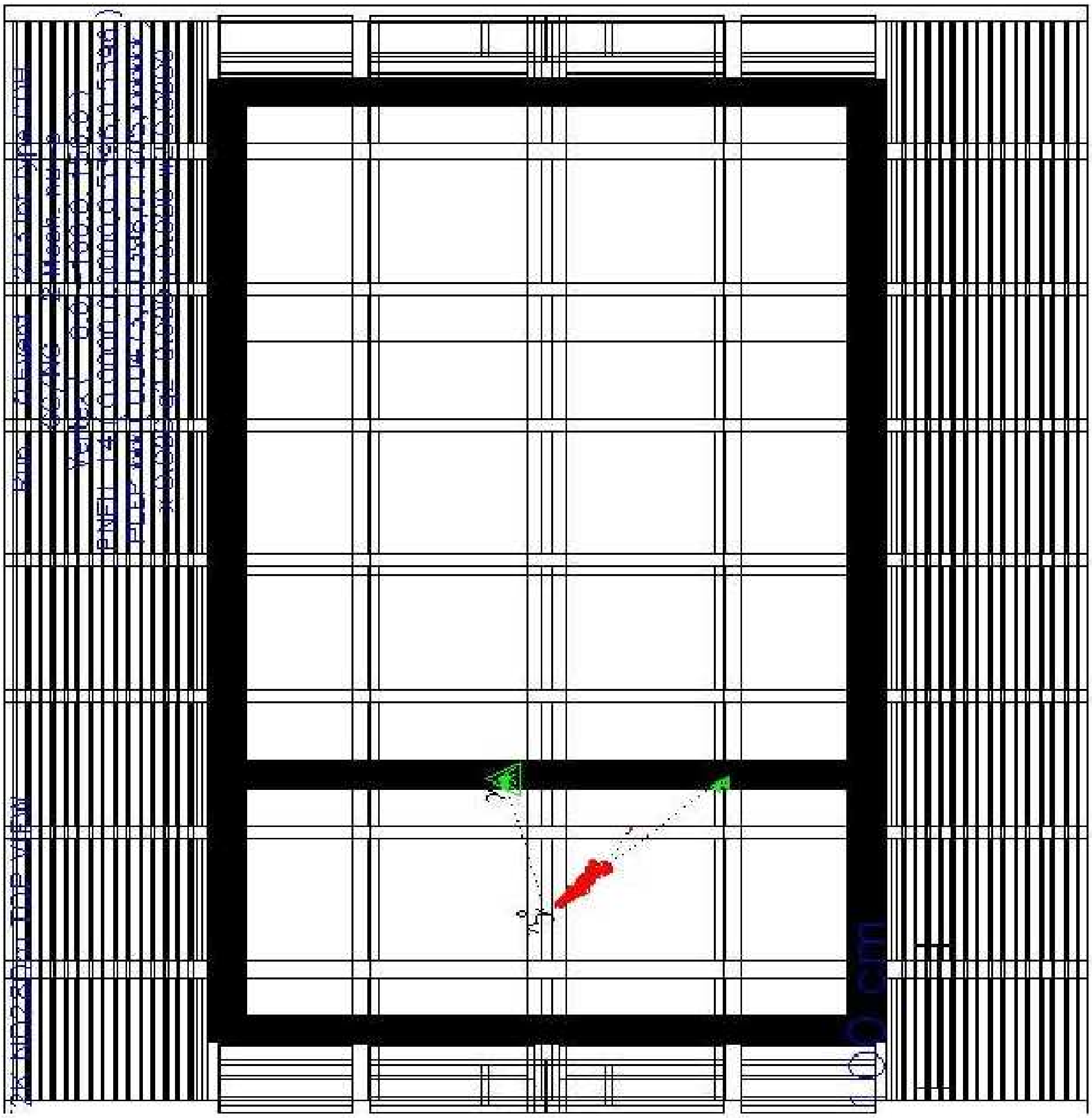
  – ν_e contamination of the beam (from kaon and muon decays)

- The UK focus is on supplying an Electromagnetic Calorimeter:

  – essential to determine the production rate of π^0's

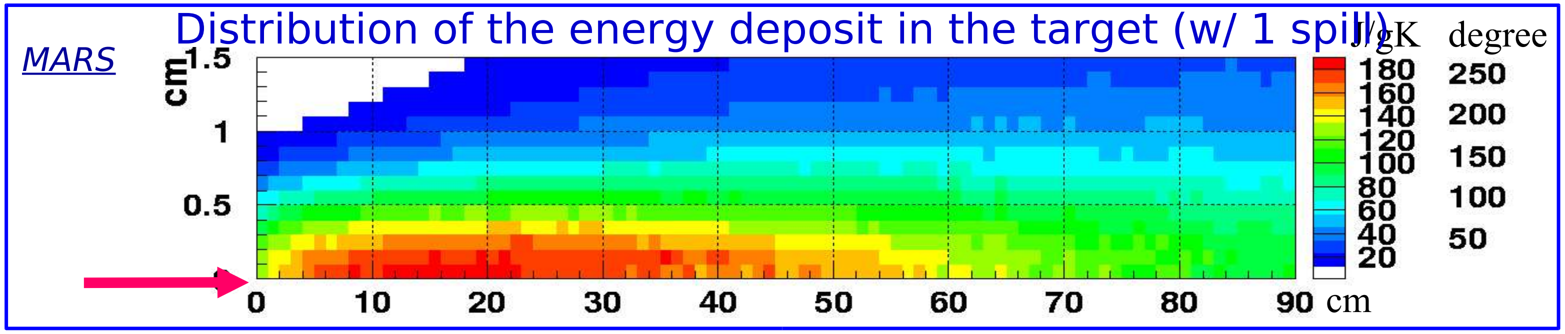
- RAL contributing to target and beam-dump



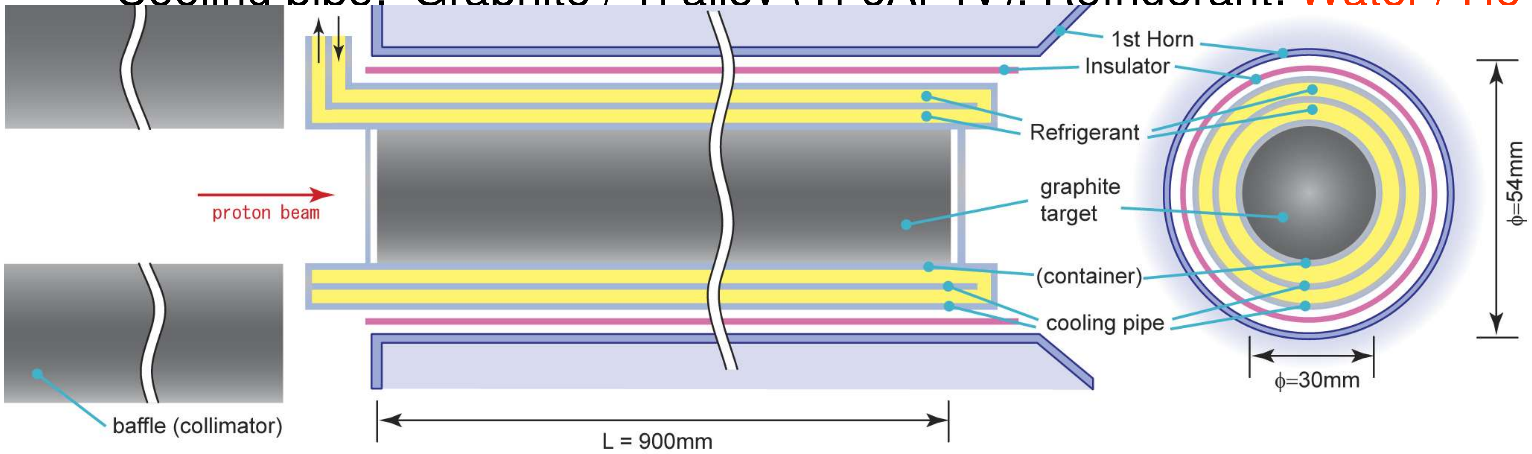


Introduction: Conceptual design

- Graphite Bar Target : r=15mm, L=900mm (2 interaction length)
  - Energy deposit … Total: 58kJ/spill, Max:186J/g → $\Delta T \approx$ 200K



- Co-axial 2 layer cooling pipe.
  - Cooling pipe: Graphite / Ti alloy (Ti-6Al-4V), Refrigerant: Water / He



UK Status

- UK ECAL and beam-line work for T2K approved (last week!) by PPARC and awarded $\sim \pounds 300$K 'seedcorn' funding
- Proposal for full funding late next year ($\pounds 6 - \pounds 8$ million)
- Schedule:
  - 2005: simulation work
  - 2006: detailed design and prototyping
  - 2007-2008: construction
  - April 2009: first beam