Neutrino Physics in Switzerland

Neutrino physics is one of the three pillars of particle physics in Switzerland. 60-70 Physicists & Engineers

High Energy Frontier
Neutrino Physics
Astroparticle Physics

neutrino oscillations
OPERA, T2K (+ NA61), Future (Detector R&D, MICE)
Bern, Geneva, ETHZurich

$\beta\beta0\nu$
EXO, GERDA
Bern, UniZurich

(part of Astro)
ICECube
EPLausanne

Swiss Institute of Particle Physics

Instutitional structure

-- professors are independent.

-- One coordinating body: CHIPP

Board: Straumann, Ereditato, Nakada, Pohl

-- funding by home institutions

Ecole Polytechnique Zurich

Ecole Polytechnique Lausanne

Universités/cantons

--Swiss National Foundation

Typically one grant per professor

Recently project oriented grants (sinergia for T2K: 2M for 3 years)

-- one national lab PSI *(great beams for $\mu \to e\gamma$, $\mu \to eee$)*

-- the other host state of CERN

Very strong incentive to work at CERN

Very interested in the future of CERN

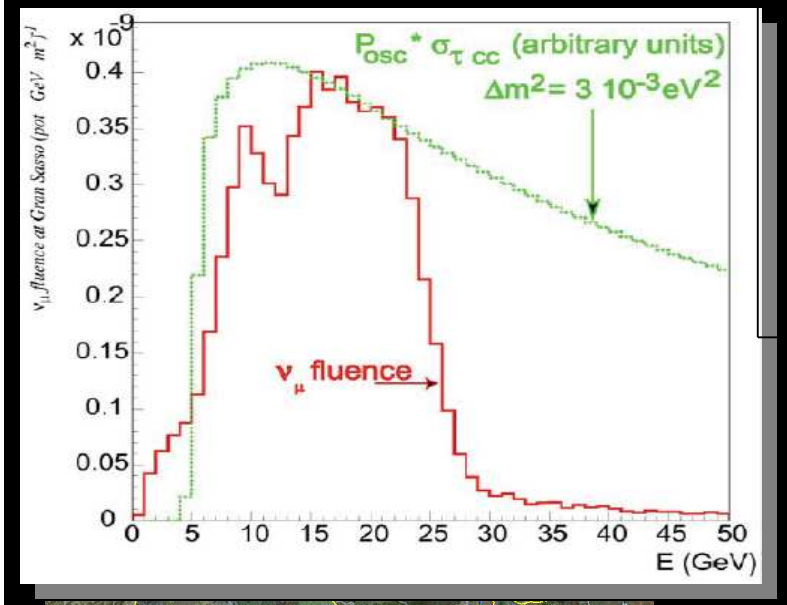
also in neutrino physics!

Swiss Institute of Particle Physics

OPERA experiment at CNGS

$\nu_\mu \rightarrow \nu_\tau$ search

Emulsion Cloud Chamber
+ spectrometer
charm candidate



Full mixing,
5 years run,
4.5×10^{19} pot / year
target mass = 1.3 kton

τ decay channels	ε(%)	BR (%)	Signal ($\alpha\ (\Delta m^2)^2$) $\Delta m^2 = 2.5 \times 10^{-3}$ eV^2	Background:
$\tau \rightarrow \mu^-$	17.5	17.7	2.9	0.17
$\tau \rightarrow e^-$	20.8	17.8	3.5	0.17
$\tau \rightarrow h^-$	5.8	49.5	3.1	0.24
$\tau \rightarrow 3h$	6.3	15	0.9	0.17
ALL	$\varepsilon \times BR = 10.6\%$		10.4	0.75

(730 km => osc. max~1.5 GeV)
450 GeV protons, 20 GeV $\pi \rightarrow \mu\nu_\mu$ peak
*** No near detector
(OK for low background appearance search)

Swiss researchers in OPERA

OPERA: 35 institutions, 200 people

LHEP Bern (including the former Neuchatel group):

A. Ariga, T. Ariga, A. Ereditato, F. Juget , J. Knüsel, I. Kreslo, G. Lutter, F. Meisel, M. Messina, U. Moser, C. Pistillo, K. Pretzl, J.L. Vuilleumier

ETHZ:

A. Badertscher, C. Lazzaro, A. Rubbia, T. Strauss

Past and current activities:

conceptual design (A.E.,Niwa, Strolin, 1997), proposal, CNGS design;
Target Tracker, lead production monitoring, microscopes and emulsion film robot, test beams; emulsion scanning and physics analysis;
management duties: A. E. (Spokesperson)

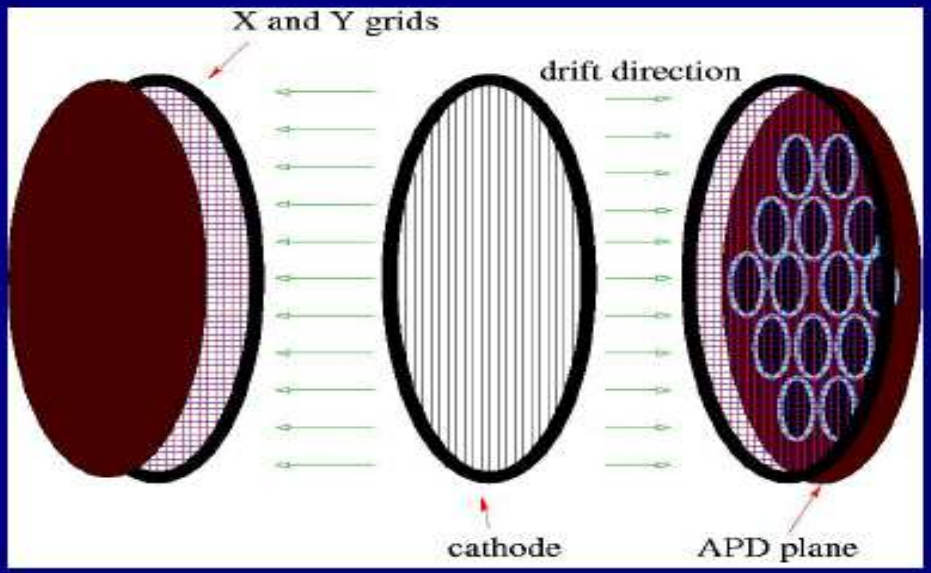
EXO: search for 0νββ decay of ^{136}Xe

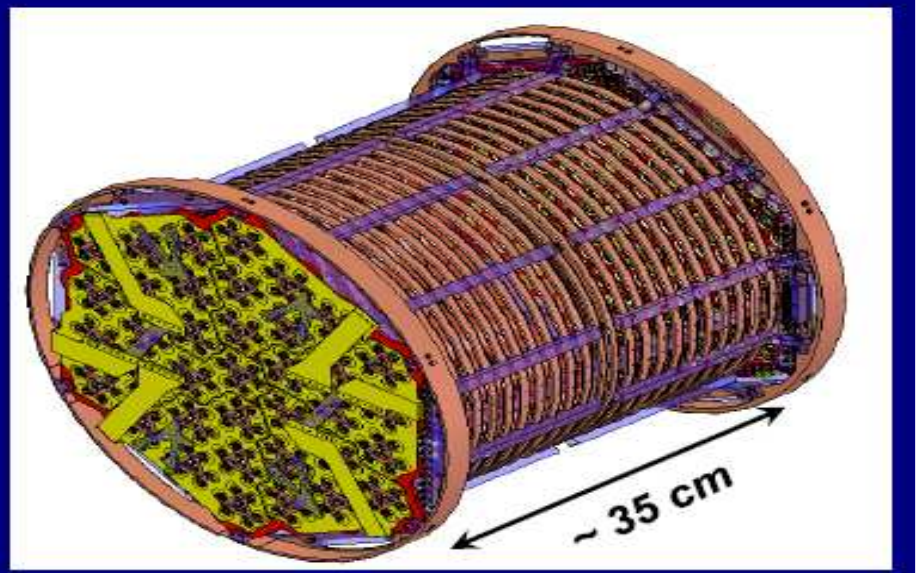
Swiss EXO members

Bern: M.Auger, R.Gornea, F. Juget, G. Giroux, G. Lutter, J-L.Vuilleumier, J-M.Vuilleumier

EXO-200 liquid Xenon TPC

Charge & scintillation light readout





Expected performance of EXO-200

- Very low radioactive background
  - Careful selection of materials, optimized custom design
  - Manufacturing, handling and installation in clean rooms
- Very good energy resolution
  - charge+light readout, 1.6 % @ 2.5 MeV

Physics runs starting in 2009. Projected run time: ~ 2 years

Case	Mass (ton)	Eff. (%)	Run Time (yr)	σ_E/E @ 2.5 MeV (%)	Radioactive background (events)	$T_{1/2}^{0\nu}$ (yr 90%CL)	Majorana mass (eV)	
EXO-200	0.2	70	2	1.6	40	6.4×10^{25}	0.133	0.186

Note: $2\nu\beta\beta$ not yet observed in ^{136}Xe, limit at $T_{1/2} > 1.2*10^{24}$ years (90% CL)

Swiss GERDA members

Zurich: L. Baudis, A. Ferella, F. Froborg, R. Santorelli, M. Tarka

- Phase I: 18 kg ^{76}Ge detectors; 30 kg years
- Sensitivity reach:

$$T_{1/2}^{0\nu} > 3.0 \times 10^{25}\, yr$$

$$\langle m_{\nu e} \rangle < 0.27 eV$$

- Phase II: 40 kg enriched ^{76}Ge detectors
- Sensitivity reach after 150 kg years:

$$T_{1/2}^{0\nu} > 15 \times 10^{25}\, yr$$

$$\langle m_{\nu e} \rangle < 0.11 eV$$

detector array

GERDA LAr cryostat

Swiss responsibility: calibration system

Start commissioning: mid 2009

- type and source configuration
- source collimators; screening of collimator materials with HPGe detector
- gamma and neutron backgrounds in source parking position
- source strength for pulse shape discrimination of single vs multiple-site events
- dynamic data base with calibration parameters

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Swiss T2K members

within a ~300 people international collaboration

Bern:	A. Ariga, F. Bay, A. Ereditato, E. Frank, M. Hess, F. Juget, I. Kreslo, M. Messina, U. Moser, C. Pistillo, H.U. Schuetz
ETHZ:	A. Badertscher, A. Gendotti, S. Horikawa, L. Knecht, A. Marchionni, G. Natterer, V. Pettinacci, A. Rubbia, C. Strabel, T. Viant
Geneva:	N. Abgrall, J. Argyriades, P. Bene, A. Blondel, A. Bravar, F. Cadoux, A. Ferrero, D. Ferrere, F. Masciocchi, S. Murphy, E. Perrin, M. Ravonel

Participation started with K2K (HARP data) and first observation of accelerator based muon neutrino disappearance. *(UNIGE)*

TPC readout development, mechanics, testing and assembly; *(Geneva)*

muon beam monitoring (emulsion detectors); *(Bern)*

ND 280 magnet refurbishment transport installation; *(ETHZ)*

analysis activities; management: Executive Committee (A. Rubbia), Global Analysis Conv. (A. Blondel)

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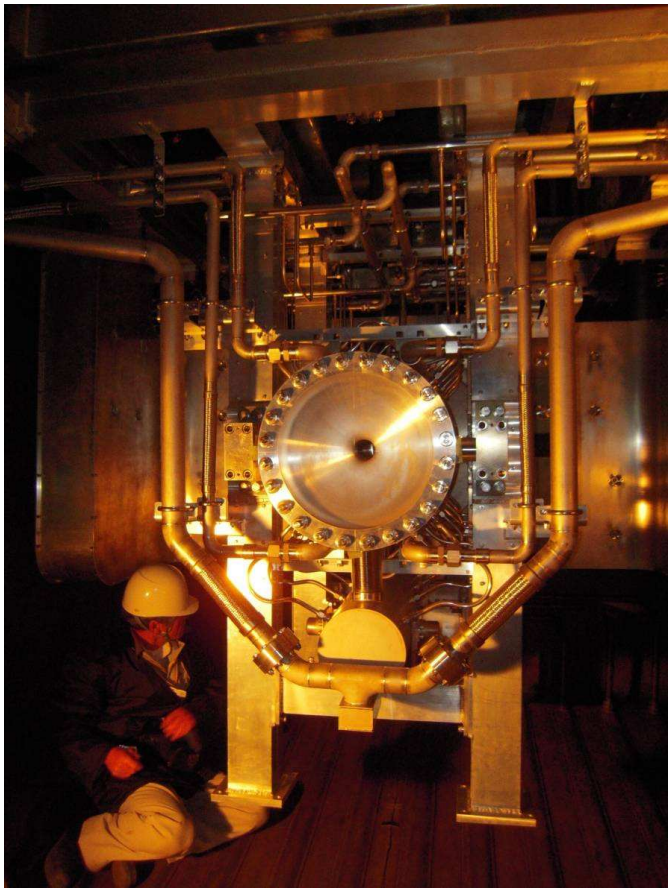
Status of T2K

30 GeV proton beam accelerated 23Dec09!

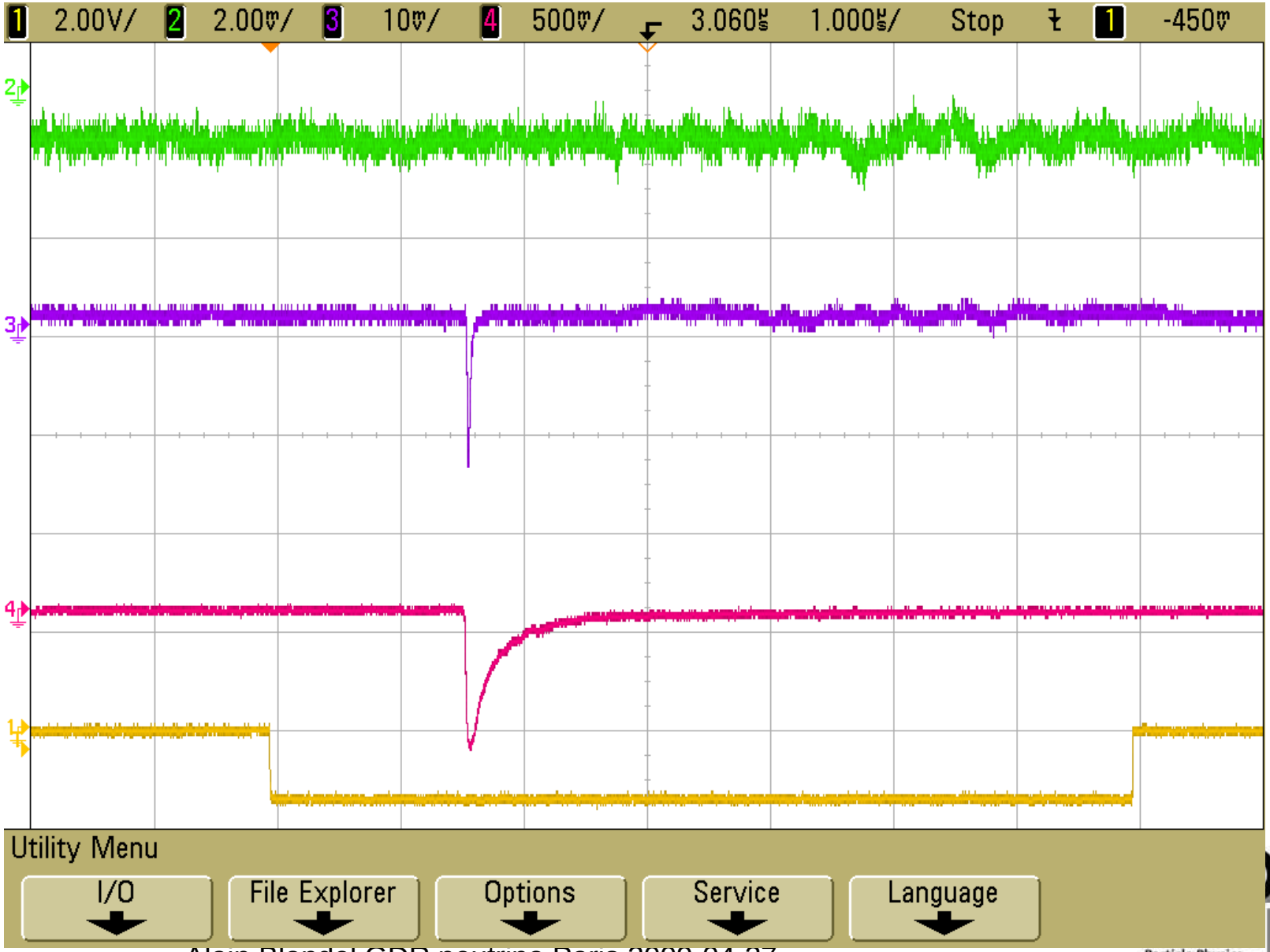
neutrino beam line SC magnets
installed and tested at 30 GeV



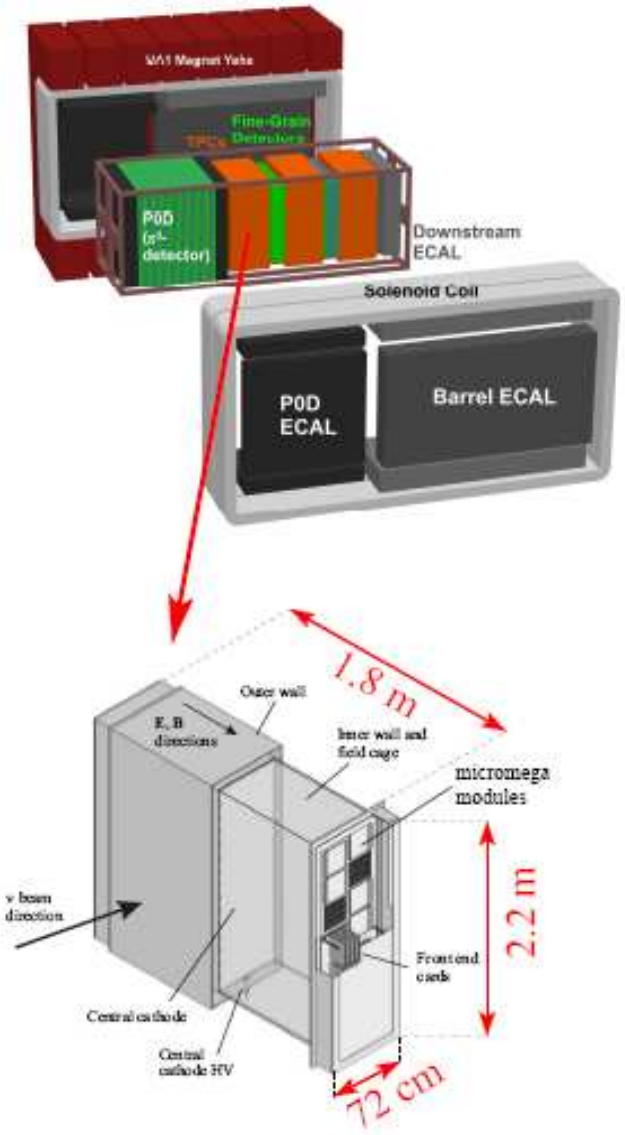
1st horn and target installed

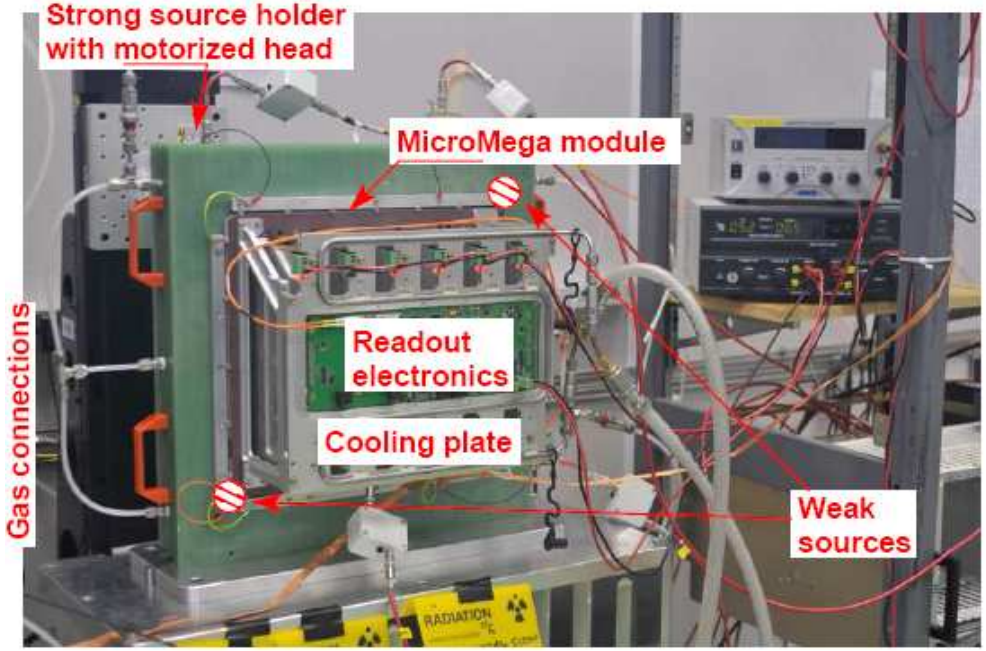
1st beam on target (low power) 23April 2009 19:09 JST
Far detector (Super KamiokaNDE) ready now (new electronics)
Near detector ND280 under completion. Operational end 2009
1st physics run: Dec09 - 2010 ==> $\sin^2 2\theta_{13}$ sensitivity ~ 0.06
5 years (10^7s@ 0.75MW) ==> $\sin^2 2\theta_{13}$ sensitivity ~ 0.006

FIRST BEAM ON T2K TARGET
CONGRATULATIONS!



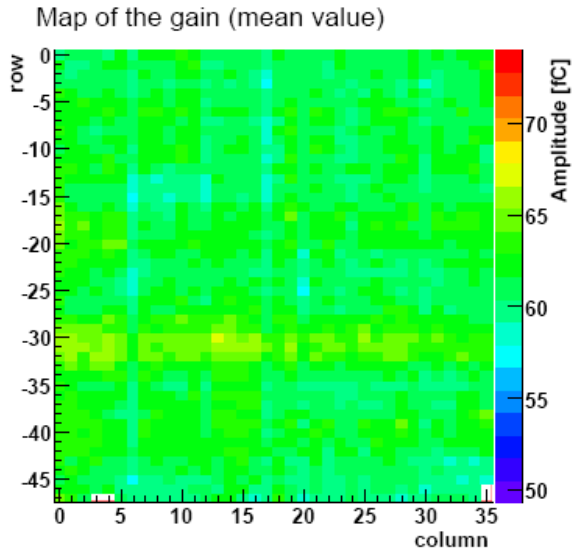
Particle Physics



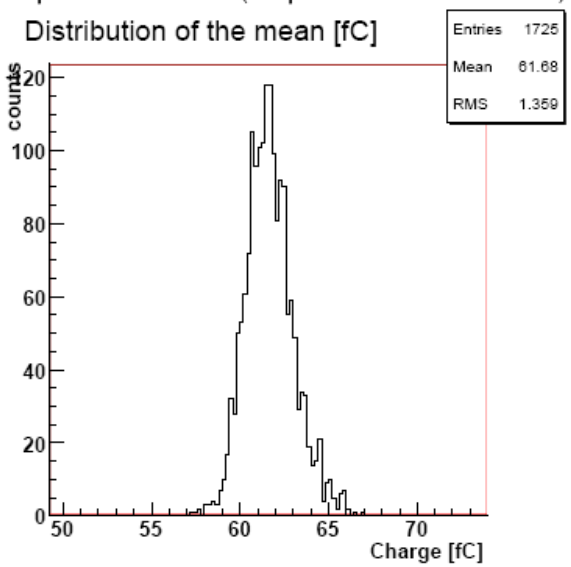


Main detector contribution to T2K: ND280 Magnet and TPC calibration

Amplitude map



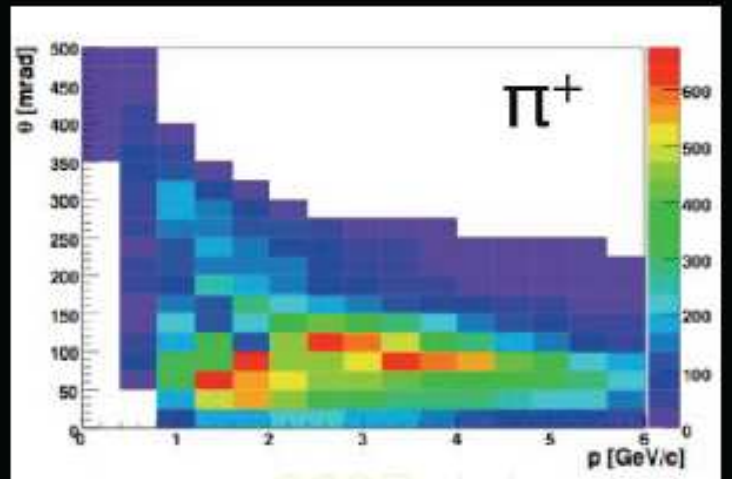
Ampl. distribution (dispersion: 2-3% RMS)

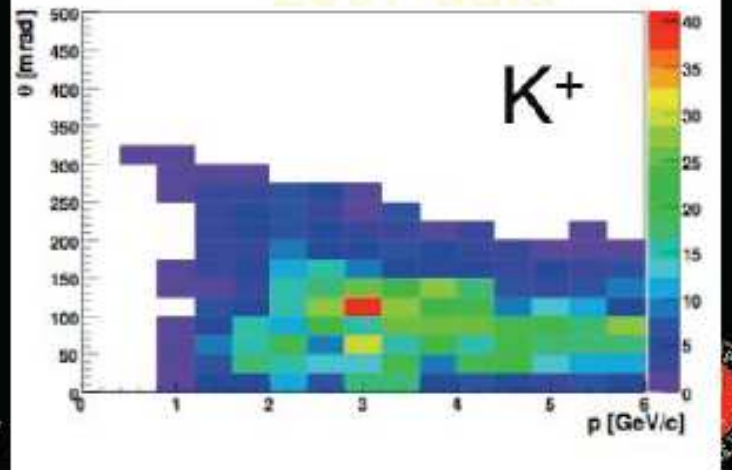


SHINE
NA61

NA61/SHINE expt at CERN

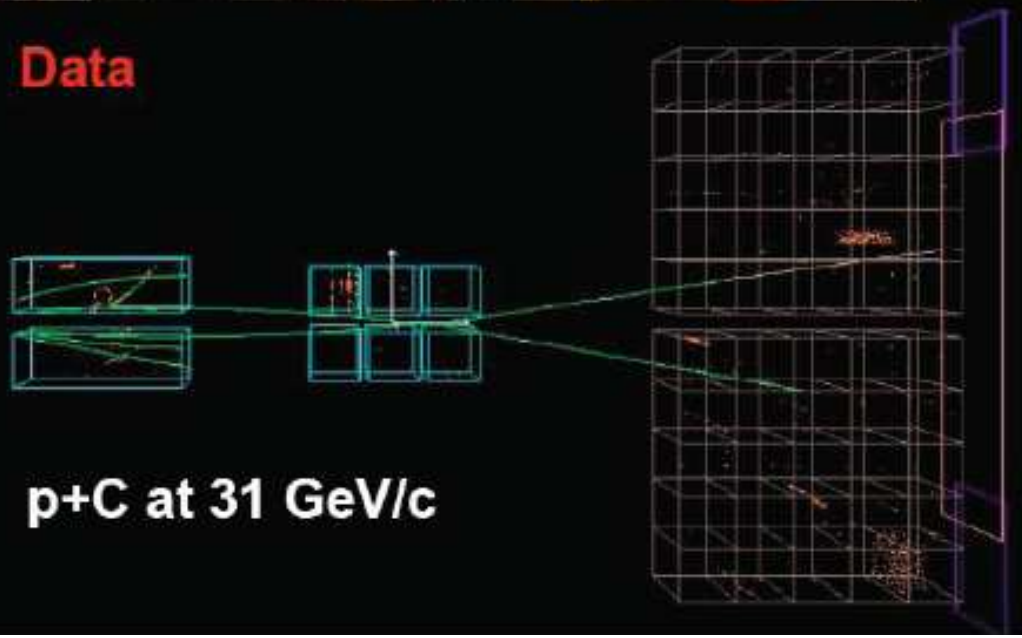
π and K prod. in p+C collisions at 30 GeV
==> predict T2K ν_μ & ν_e fluxes
Acceptance covers T2K beam line
data in 2007 + 30Xmore in 2009





2007 data

Data



p+C at 31 GeV/c

PC 17

Swiss groups certainly follow the future possibilities at T2K!
-- e.g. far detector LArg possibilities (ETHZ)
-- near detector issues (UNIGE)

Three Possible Scenario Studied at NP08 Workshop

Neutrino Intensity Upgrade

Quest for the Origin of Matter Dominated Universe

One of the Main Subject of ***KEK Roadmap***

T2K (2009~)

Discover ν_e app.

Neutrino Anti-Neutrino meas.

Intensity Upgrade

Detector R&D

Tech. Choice

Huge det. Construction

CPV search Proton decay

Possible Timeline

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
	4	4	4	4	4	4	4	4	4	4
Linac(400MeV)		?			?	→ 400MeV				
T2K										
MR Intensity Upgrade					?		?	→ 1.66MW		
Detector R&D										

Presented by KEK DG at KEK Roadmap Review Committee 9,10-March 2008

Long term future of neutrino physics

CP violation in quarks was discovered in 1964. Followed a long program to understand its nature and measure it precisely, test universality etc… Still ongoing after 45 years!

Three-neutrino oscillations predict leptonic CP violation. This is a key ingredient for the leading explanation of the baryon-antibaryon asymmetry of the Universe by Leptogenesis.

We have not discovered leptonic CP yet…

==> it seems that there is a long future for the required accelerator neutrino oscillation experiments !

CH groups are actively involved in the study of future options for neutrino physics

-- 1998 ECFA neutrino factory study groups

==> BENE network in CARE (2004-2008) (UNIGE+UNINE,UNIBE)

==> EUROnu design study + NEU2012 network in EUCARD (UNIGE)

+ Laguna (ETHZ, UNIBE) design study for underground detector sites

Longer term future of neutrino physics & Switzerland

CH groups are actively involved in the study of future worldwide options for neutrino physics. As far as European initiatives are concerned:

Potential future neutrino projects in Europe beyond the CNGS

- **ECFA,** for what concerns the accelerator based programs, and
- **ApPEC,** for large underground (astroparticle physics) detectors,

synergy through searches for rare processes such as proton decay and detection of neutrinos from supernovae.

Two design studies supported by the European FP7 program:
- the **EuroNU** design study (+NEU2012 network in EUCARD) is dedicated to the assessment and technical development of next generation high-intensity superbeams, beta-beams and neutrino factories ***(Geneva)***

- the **LAGUNA** design study dedicated to the feasibility of very large underground infrastructure able to host next generation neutrino physics and astroparticle physics and proton decay experiment ***(Bern, ETHZ)***

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CERN Strategy Group

"…..studies of the scientific case for future neutrino facilities and the R&D into associated technologies are required to be in a position to define the optimal neutrino programme based on the information available in around 2012; Council will play an active role in promoting a coordinated European participation in a global neutrino programme"

- **Crucial R&D for 2nd generation facilities (post T2K)**
- **Include 3 main European candidates:**
  - **CERN to Frejus Super-Beam**
  - **Neutrino Factory**
  - **Beta-Beam**
- **Performance and "cost" comparison**
- **Present outcome to SG**
- **Done in collaboration, not competition**

- **Created end 2006**
- **15 partners, coordinator STFC**
- **Submitted proposal: May 07; total cost 14.5M€, EC 4.8M€**
- **Outcome: August 07 – ranked first, negotiate for 4.0M€**
- **Negotiations slow, but complete!**
- **Project started: 1st September**
- **Duration: 4 years – completion in 2012, as required**
- **GA signed**

CH: University of Geneva, Associated Partner (A. Blondel)

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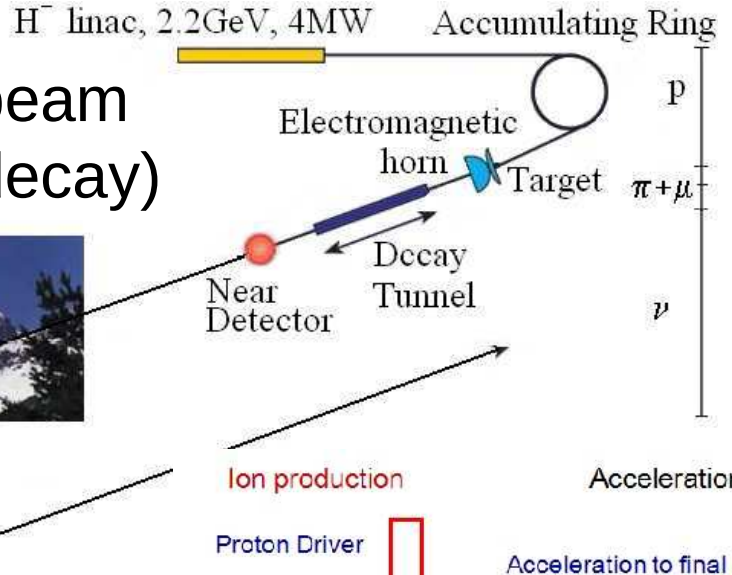
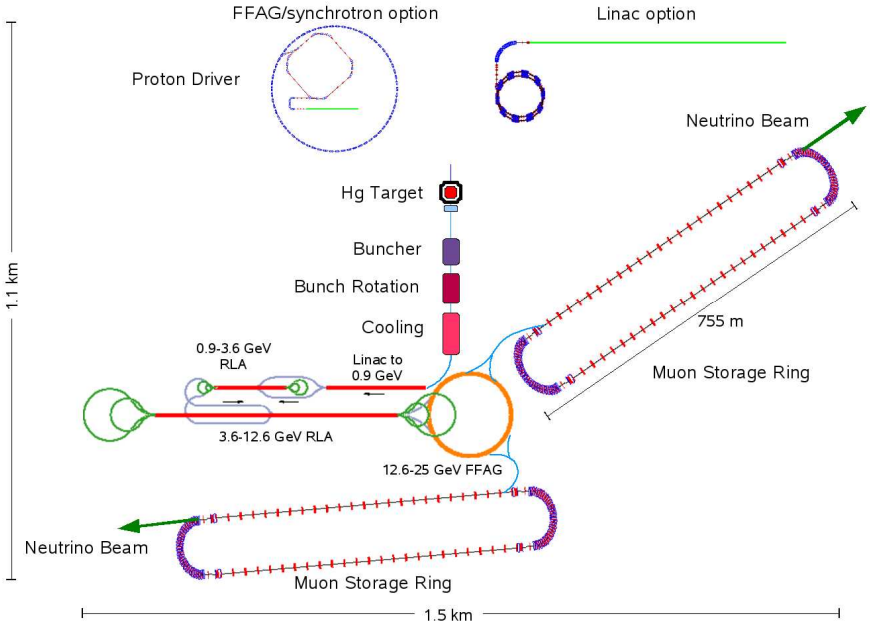
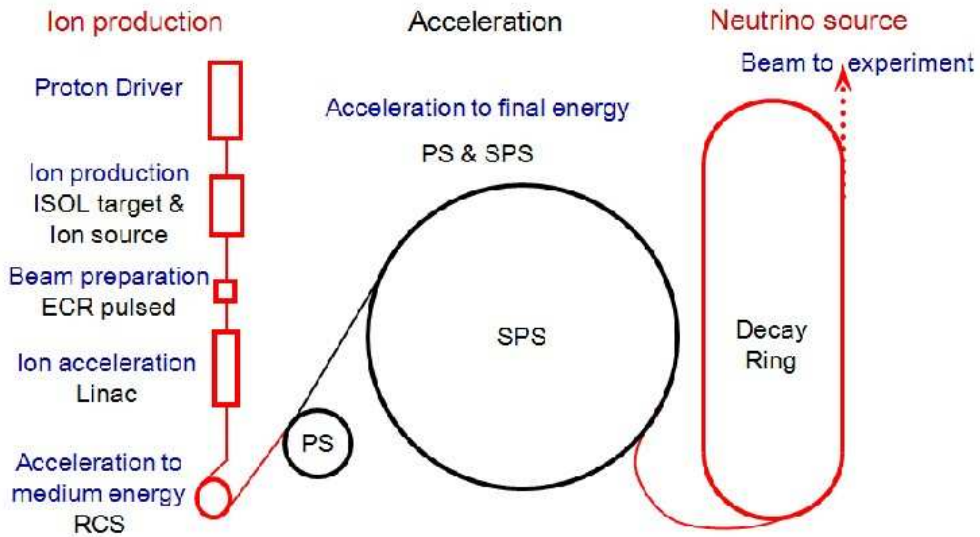
EUROν

superbeam
(pion decay)





Neutrino Factory
(muon decay)



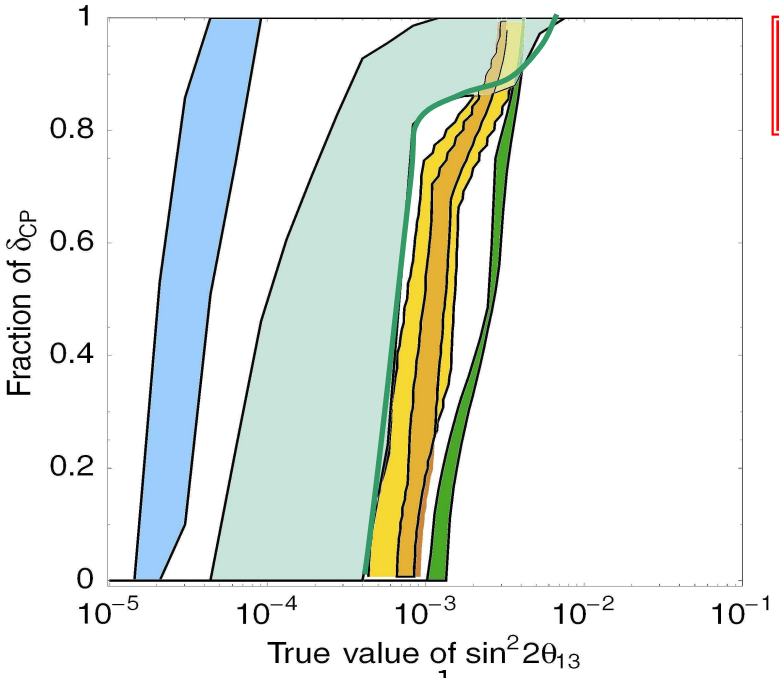
Beta-beam
rad-ion decay

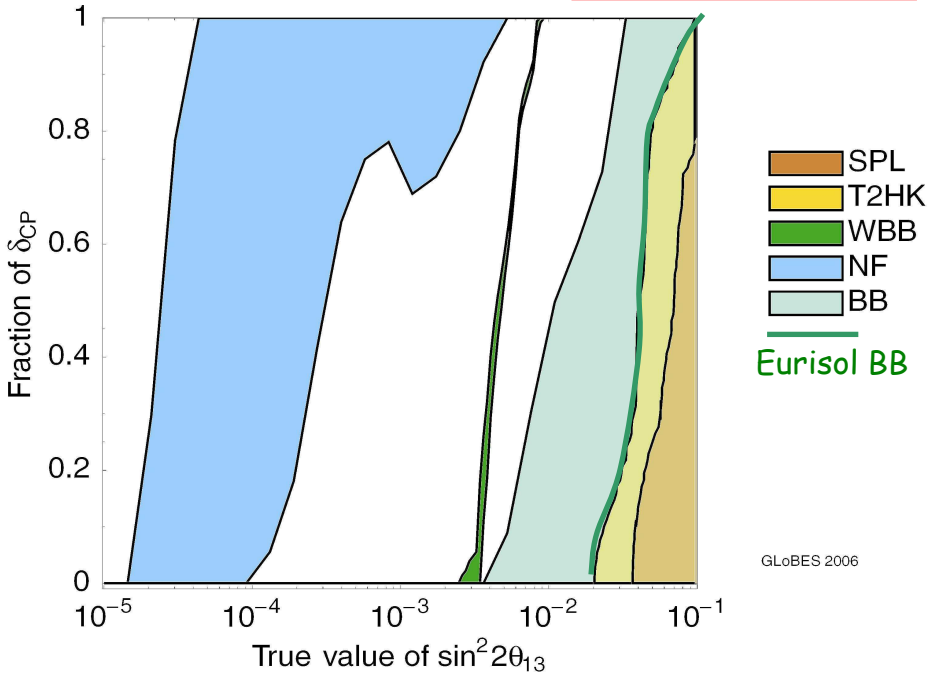
key question for CH groups:
can any of this be at CERN?

Overall comparisons from ISS (2007)

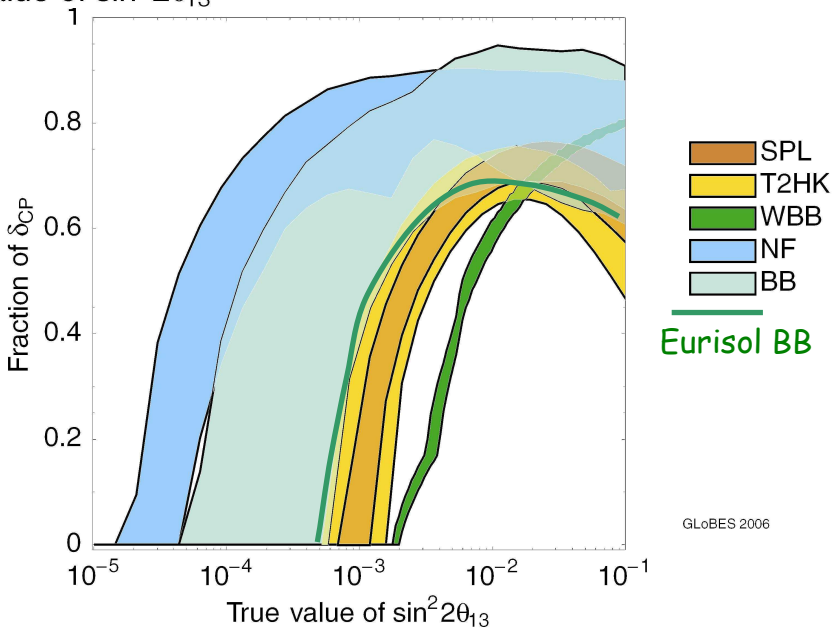
sign Δm^2_{13}

θ_{13}





CP phase δ



NuFACT does it all…
(+ univ. test etc…)
but <u>when</u> can it do it
and <u>at what cost</u>?

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LAGUNA: approved EU FP7, RI design study for site localization of the future European Large Underground Neutrino and Astroparticle Observatory.

Detector options: LENA (liquid scint.), GLACIER (LAr), MEMPHYS (water Cerenkov)

SITE STUDY

Candidate Sites

- Boulby, UK
- Canfranc, Spain
- Fréjus, France
- Pyhäsalmi, Finland
- Sieroszowice, Poland
- Slanic, Romania
- Caso, Italy

LAGUNA Collaboration

100 scientists
more than 20 institutes
10 European countries

- Swiss groups: **Bern** and **ETHZ** (~15 CH researchers)
- Scientific interest in promoting the GLACIER option
- Following the current Swiss initiatives in the field of LAr TPC detectors
- **A. Rubbia Project Coordinator**

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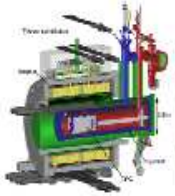
ETH Institute for Particle Physics

Steps towards GLACIER

Small prototypes ➡ ton-scale detectors ➡ 1 kton ➡ ?



B-field test

proof of principle double-phase LAr LEM-TPC on 0.1x0.1 m² scale

LEM readout on 1x1 m² 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 ton-scale

we are here

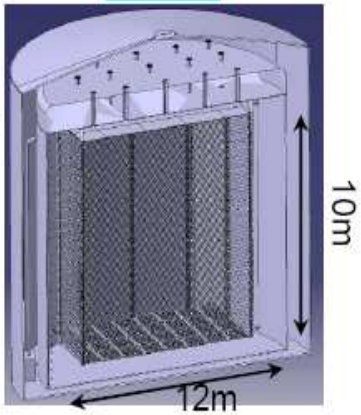
direct proof of long drift path up to 5 m

Test beam 1 to 10 ton-scale

Application of LAr LEM TPC to neutrino physics: particle identification (200-1000 MeV electrons), optimization of readout and electronics, cold ASIC electronics, possibility of neutrino beam exposure

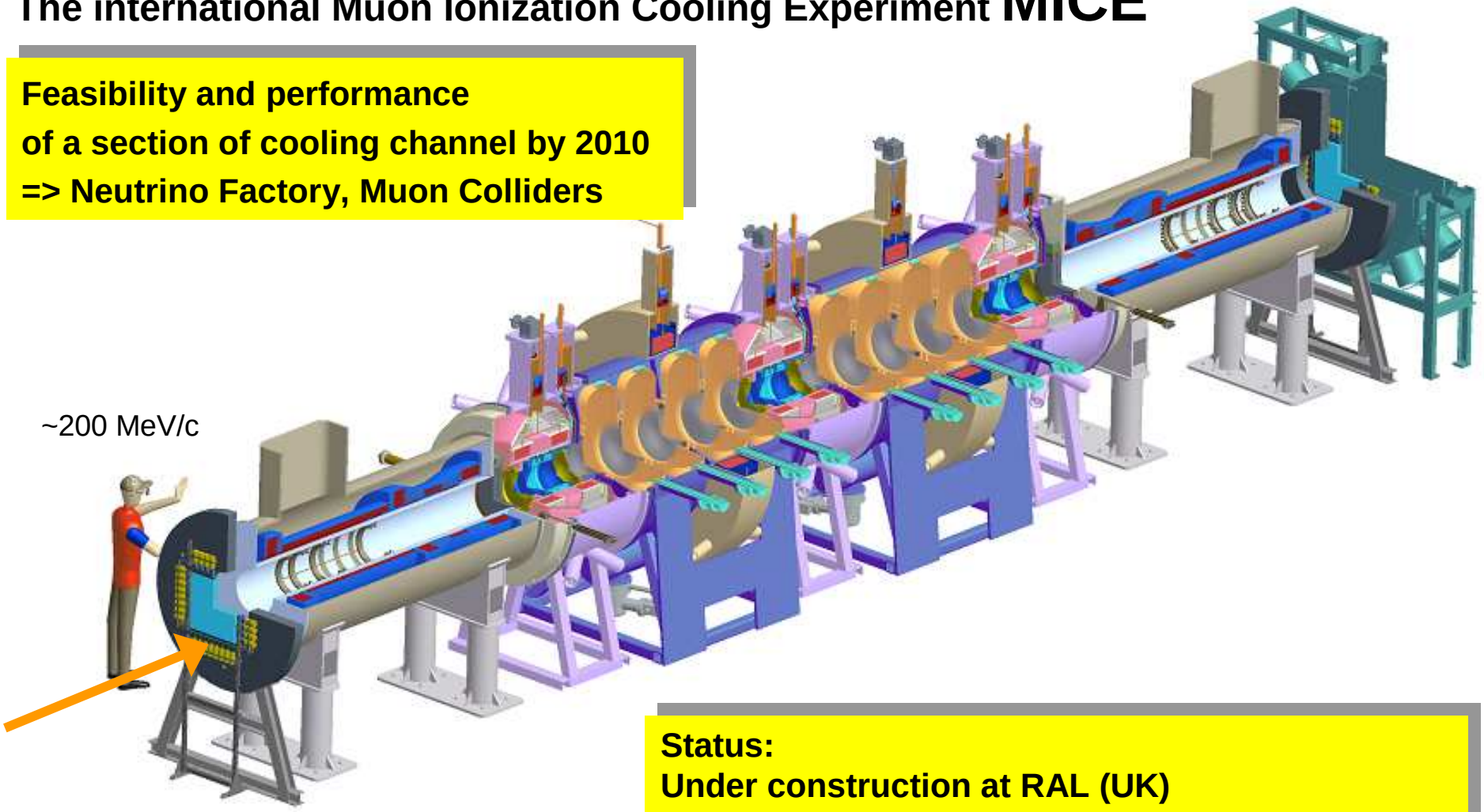
full engineering demonstrator for larger detectors, acting as near detector for neutrino fluxes and cross-sections measurements, ...

1 kton



The international Muon Ionization Cooling Experiment MICE

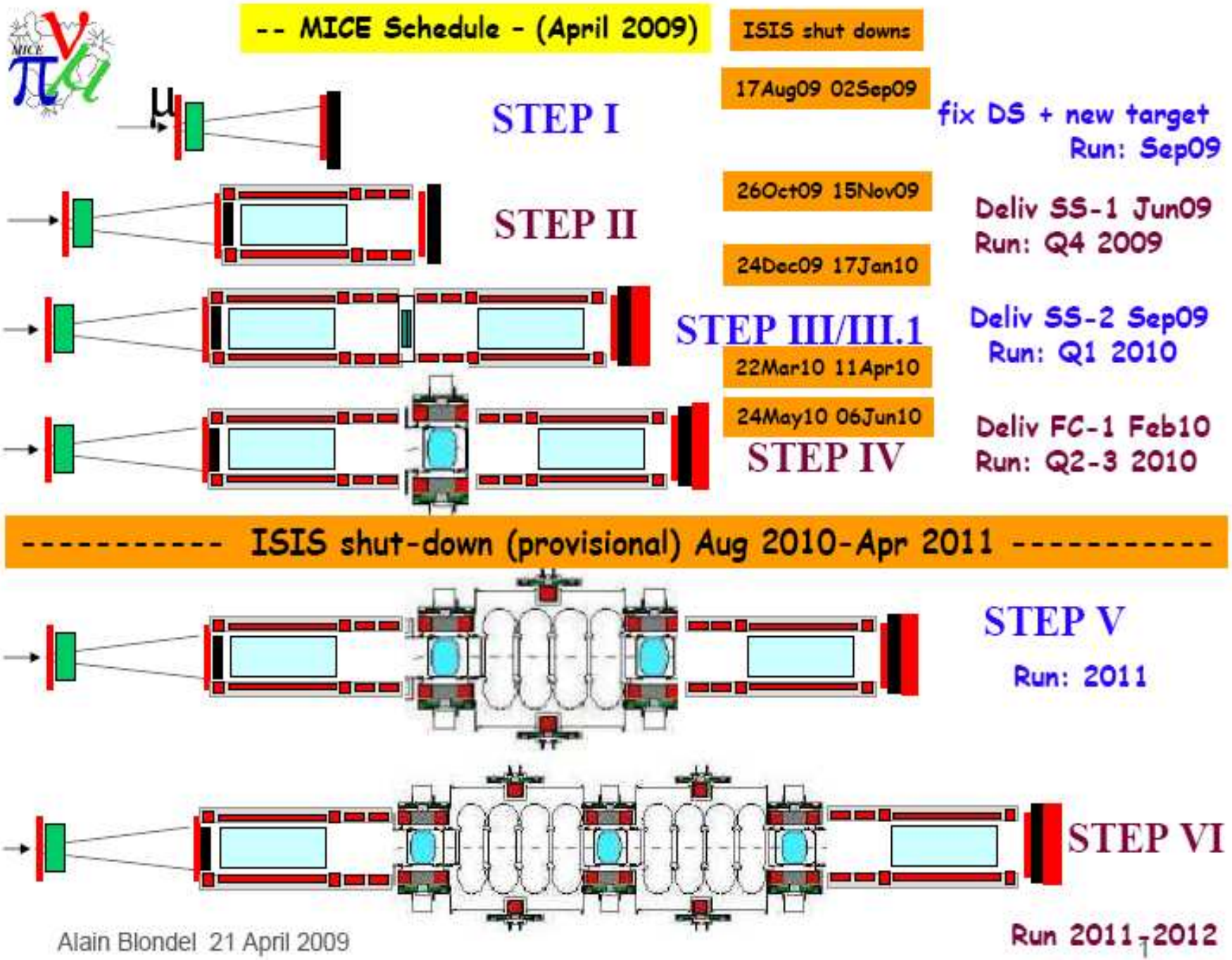
Feasibility and performance
of a section of cooling channel by 2010
=> Neutrino Factory, Muon Colliders



Status:
Under construction at RAL (UK)
First beam: March 2008

CH contributions: TOF, DAQ, Calorimeter
Simulations of RF in magnetic field

Management duties: A. Blondel Spokesmouse


-- MICE Schedule - (April 2009)
ISIS shut downs
17Aug09 02Sep09
fix DS + new target
Run: Sep09
STEP I
26Oct09 15Nov09
Deliv SS-1 Jun09
Run: Q4 2009
STEP II
24Dec09 17Jan10
Deliv SS-2 Sep09
Run: Q1 2010
STEP III/III.1
22Mar10 11Apr10
24May10 06Jun10
Deliv FC-1 Feb10
Run: Q2-3 2010
STEP IV
---------- ISIS shut-down (provisional) Aug 2010-Apr 2011 ----------
STEP V
Run: 2011
STEP VI
Run 2011-2012
Alain Blondel 21 April 2009

Swiss conclusions for oscillation physics

Main lines of interest:

-- present and future of T2K

-- longer term future at CERN
but starting with accelerator and detector R&D at/with CERN

-- Leading effort in Laguna, MICE, Liquid Argon R&D

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Structuring the European Neutrino community

EUCARD NEU2012

Palladino/ Efthymiopoulos / Blondel

Follow up from ECFA WG/BENE
Past successes
-MICE
-NNN02 → T2K-EU
-EUROnu

Aims fro the next 4 years:
-- European Neutrino Roadmap
-- coordinated detector R&D

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Writing the European Neutrino Oscillation Roadmap

Have agreed to contribute:

Theory
Manfred Lindner
John Ellis (POFPA) or Michelangelo Mangano
José Bernabeu
Experiments
André Rubbia (LAGUNA)
Antonio Ereditato (CHIPP-OPERA)
C.Rubbia et al (ICARUS)
Francesco Terranova (INFN-OPERA deputy)
David Wark (T2K International spokesperson)
Jenny Thomas (MINOS deputy spokesperson)
Hervé de Kerret (DCHOOZ)
Agnieszka Zalewska (SPC panel chair)
Marcos Dracos (IN2P3)
Marco Zito (DAPNIA-EUROnu SB)
Alessandro Baldini (MEG spokesperson/Marco Grassi)
will also include EUROnu (NF) (Long),
EUROnu (BB) (Lindroos or other) EUROnu (Rob Edgecock)
Ilias Efthymiopoulos (MERIT)

+ Alain Blondel, Silvia Pascoli and Fanny Dufour

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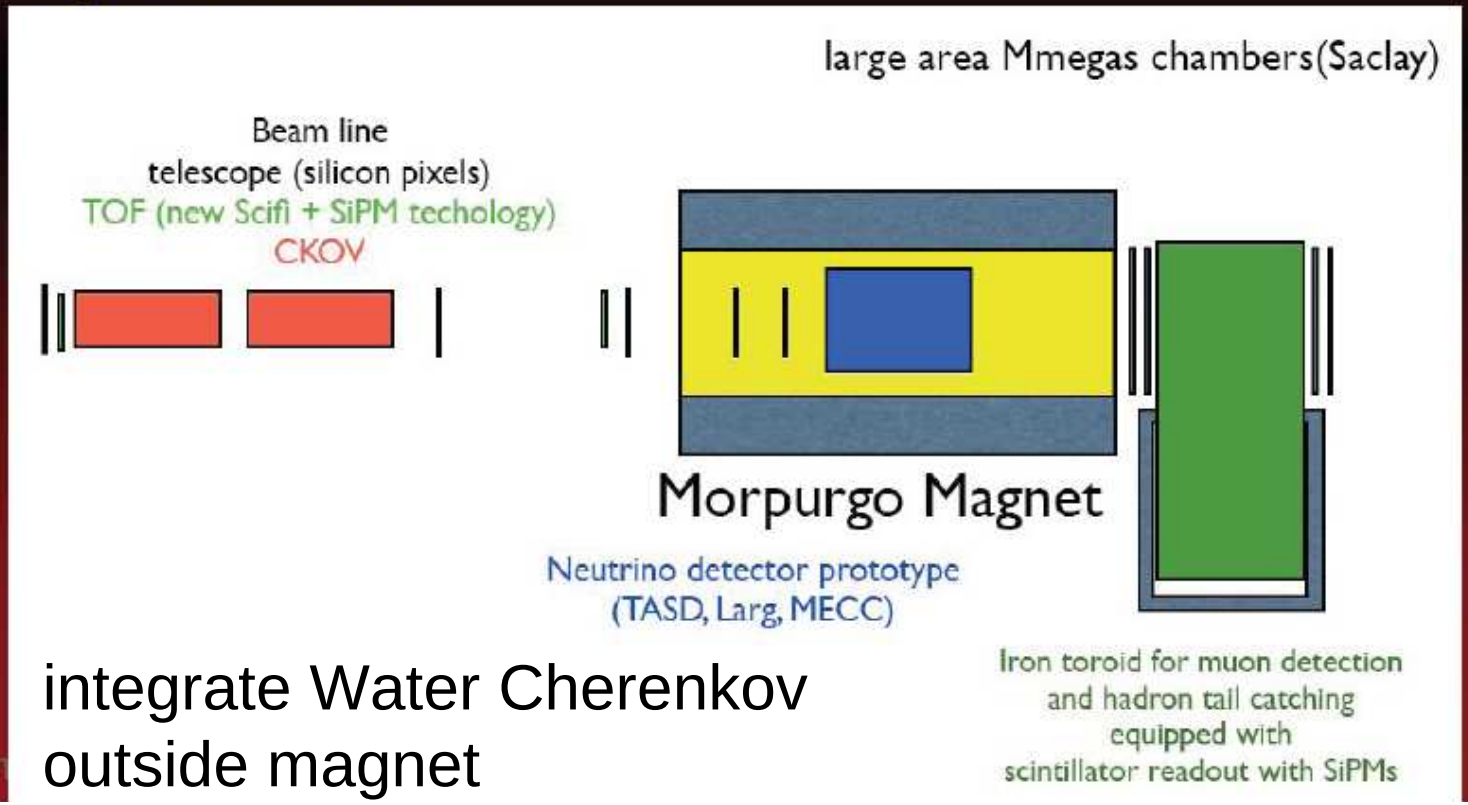
NEUTRINO DETECTOR TEST BEAM

Originally proposed for 'Devdet' detector development in synergy with LHC upgrade and linear collider.

Answer key experimental questions on detectors for future neutrino beams
ex: . charge confusion for low energy muons in iron-scintillator sandwich.
. properties of stopping pions and muons in Liquid Argon and Water
. Integration of emulsions/Larg/TASD with magnetized iron spectrometer (Hybrid detector)



integrate Water Cherenkov outside magnet

Next steps:

Cern workshop in May:
-- make the point that ALL neutrino facilities studied in EUROnu require a high power proton machine

-- make the point that a lot needs to be learned about neutrino detectors e.g. properties of stopping low energy particles

CERN workshop in October
-- organization starting; « roadmap committee » will be informed and consulted.

CERN-SPC working group (Zalewska, Aleksan, Blondel, Dornan, Meyer, Zwirner)
report in december

Decision on SPL will be made in 2011!