Operation of and results from OPERA

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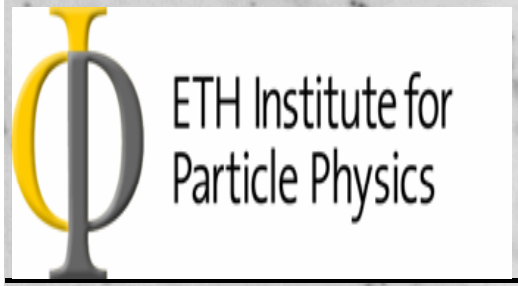
LHEP Bern University



The swiss participation in OPERA

A. Badertscher

C. Lazzaro

A. Rubbia

T. Strauss

A. Ariga

T. Ariga

A. Ereditato

J. Knüsel

F. Juget *

I. Kreslo

G. Lutter *

F. Meisel *

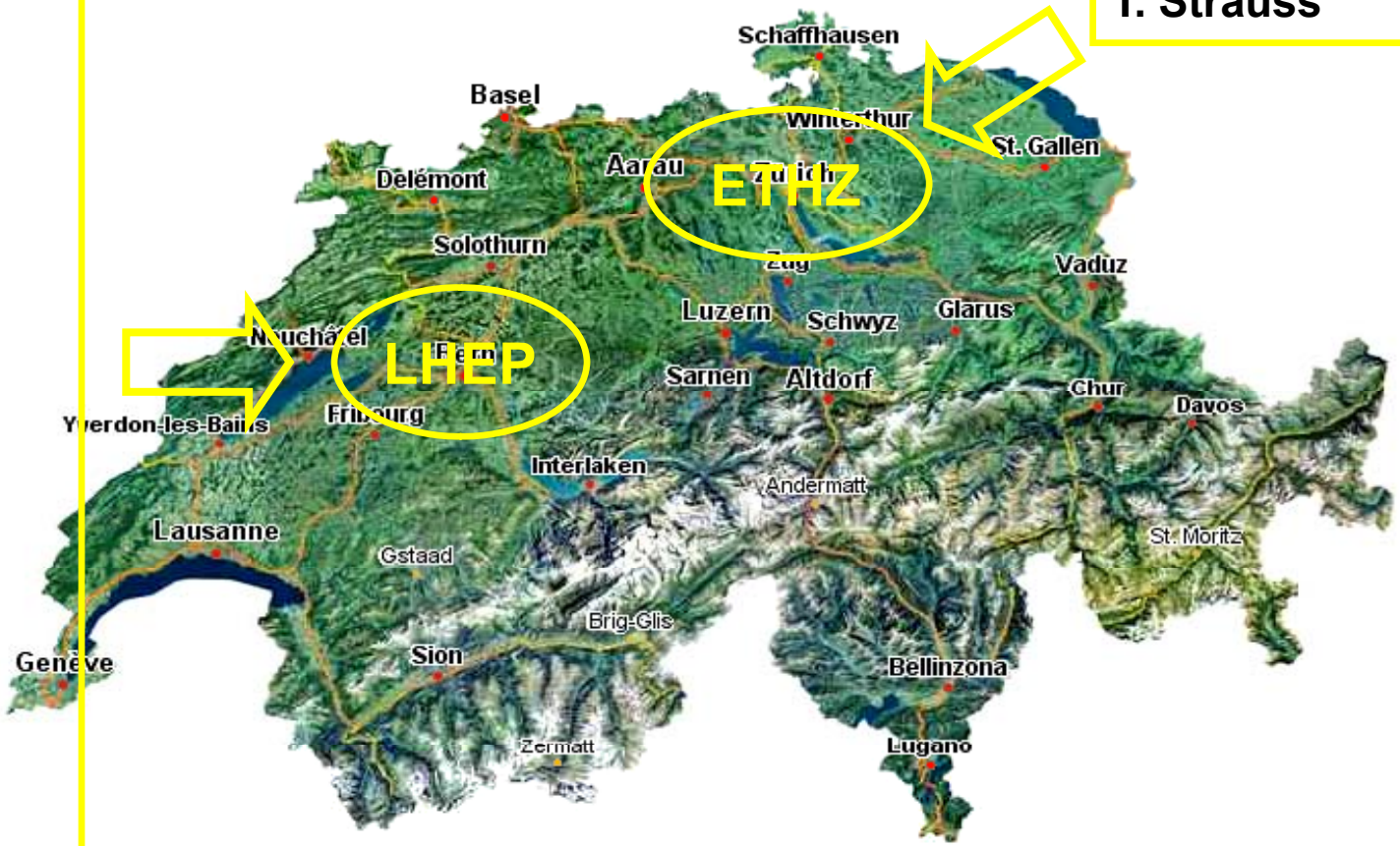
U. Moser

M. Messina

C. Pistillo

K. Pretzl

J.L Vuilleumier *



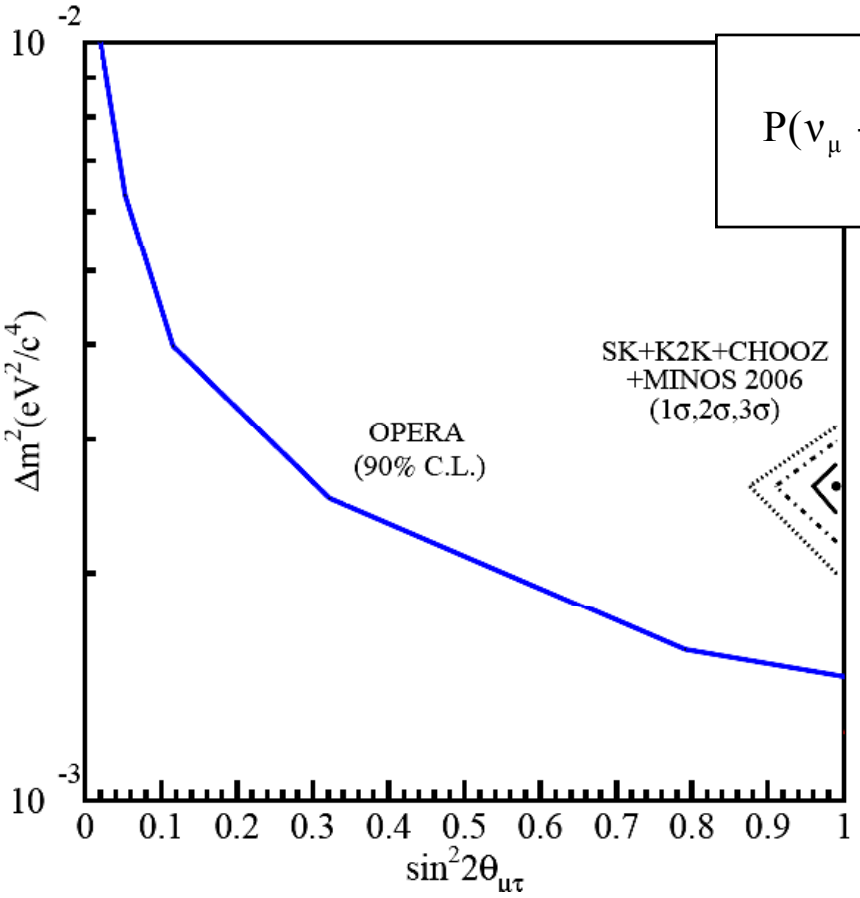
2 INSTITUTIONS, 17 PHYSICISTS

(OPERA: 35 institutions, ~200 physicists)

* previously forming the Neuchatel group, moved to Bern in August

Physics goal

OPERA is designed for the direct observation of ν_τ appearance in a pure ν_μ beam in order to provide a final confirmation of neutrino oscillations in the atmospheric sector



$$P(\nu_\mu \rightarrow \nu_\tau) \cong \sin^2(2\theta_{23})\cos^4(\theta_{13})\sin^2\left(\frac{1.27\Delta m^2_{31}L(\mathrm{Km})}{E(\mathrm{GeV})}\right)$$

best fit:

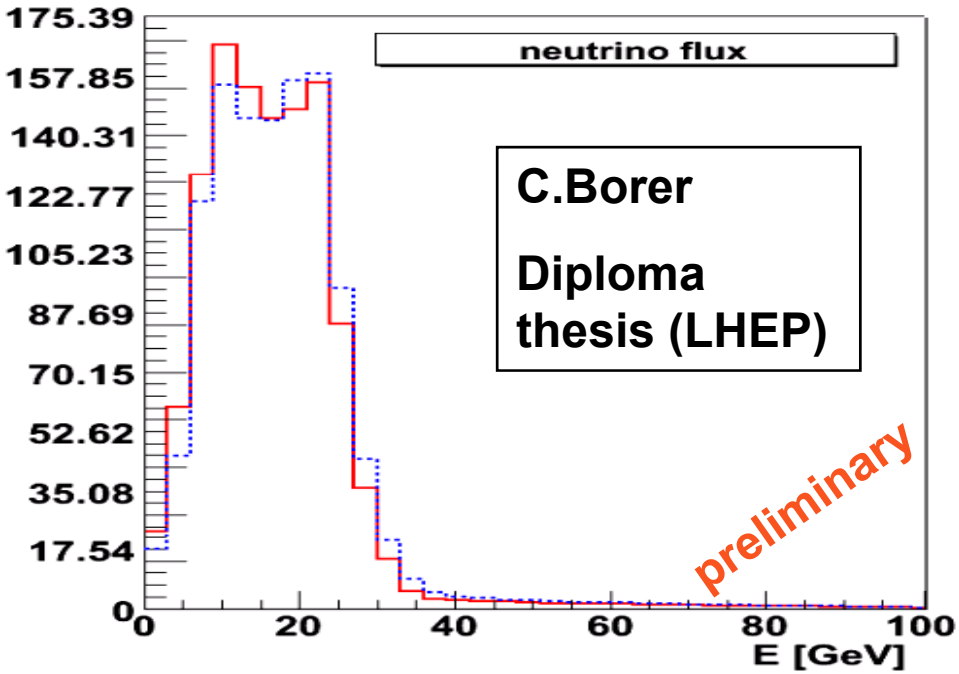
$$\Delta m^2_{31} = \begin{cases} -2.37 \pm 0.15 \times 10^{-3}\ \mathrm{eV}^2 & (\text{inverted hierarchy}) \\ +2.46 \pm 0.15 \times 10^{-3}\ \mathrm{eV}^2 & (\text{normal hierarchy}) \end{cases}$$

$$\theta_{23} = 42.3^{+5.1}_{-3.3}$$

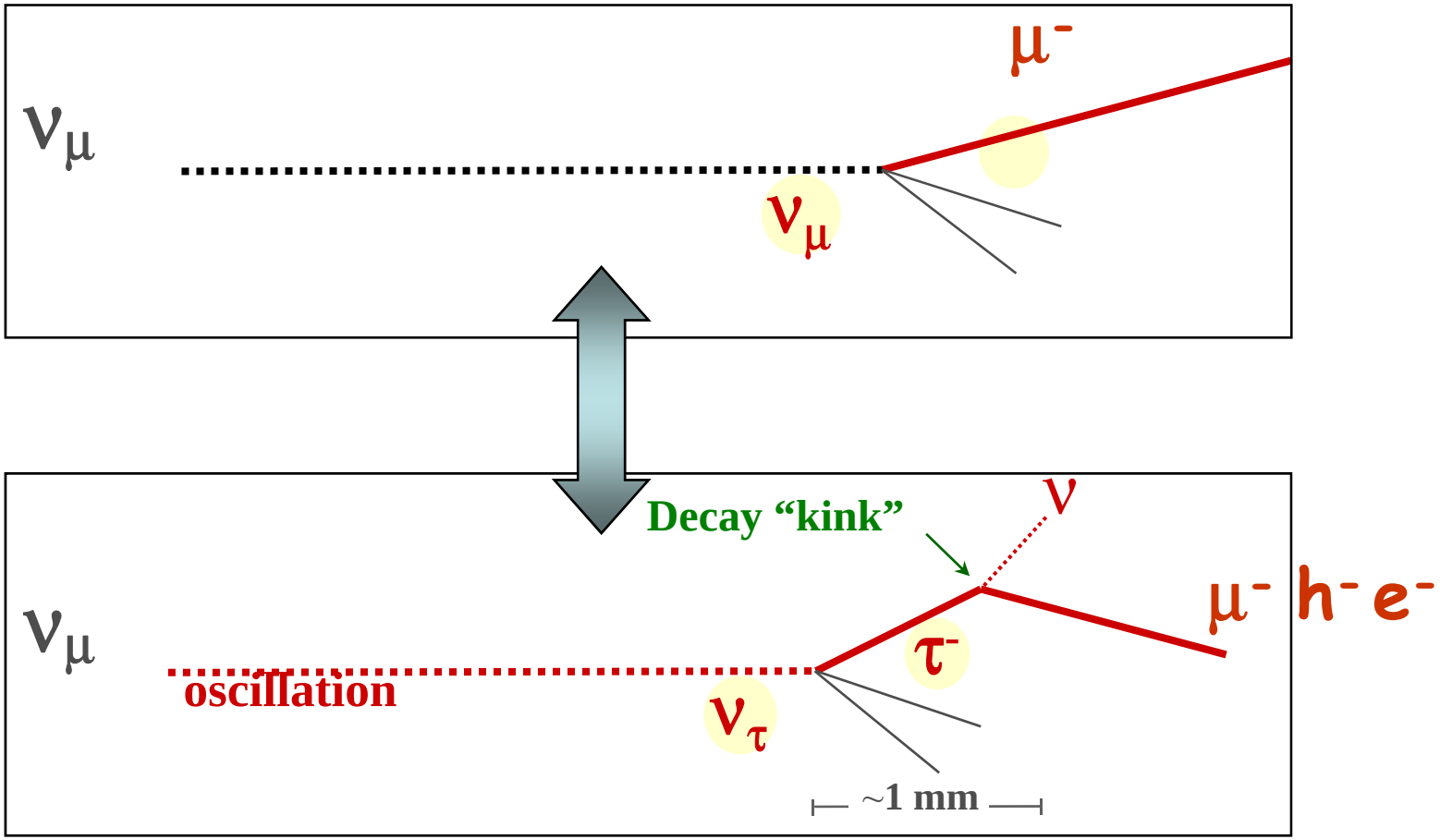
The Cern Neutrino to Gran Sasso (CNGS) beam

L=730 km ;
<Eνμ>=17 GeV

$(\overline{\nu e}+\nu e)/\nu\mu=0.7\%$
$\overline{\nu\mu}/\nu\mu = 2\%$



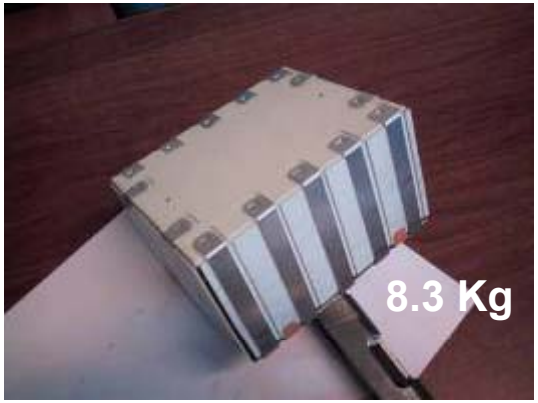
Detection of the ν_τ appearance signal

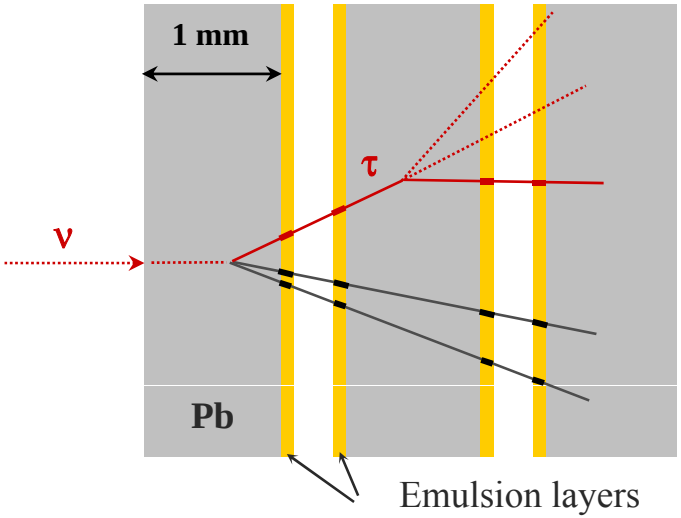


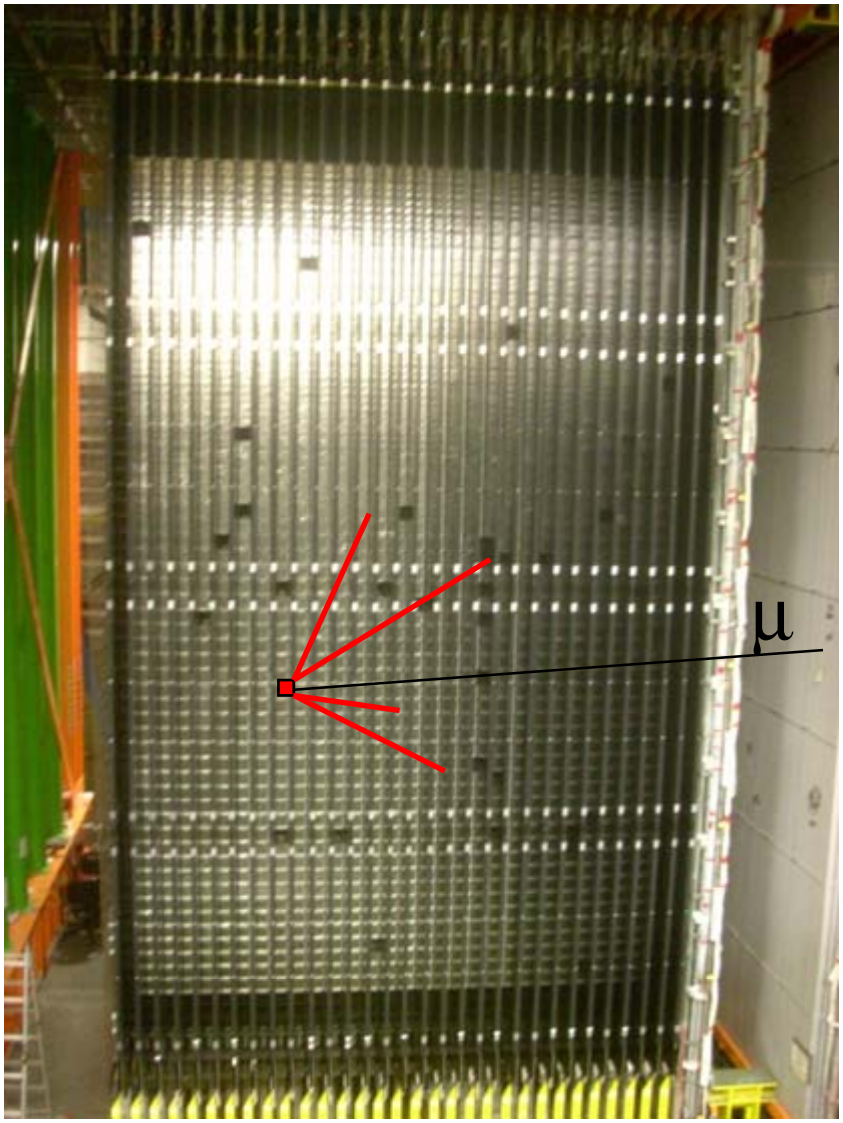
Two conflicting requirements:

- Large mass ➔ low Xsection
- High spatial resolution ➔ signal selection, background rejection

The OPERA target

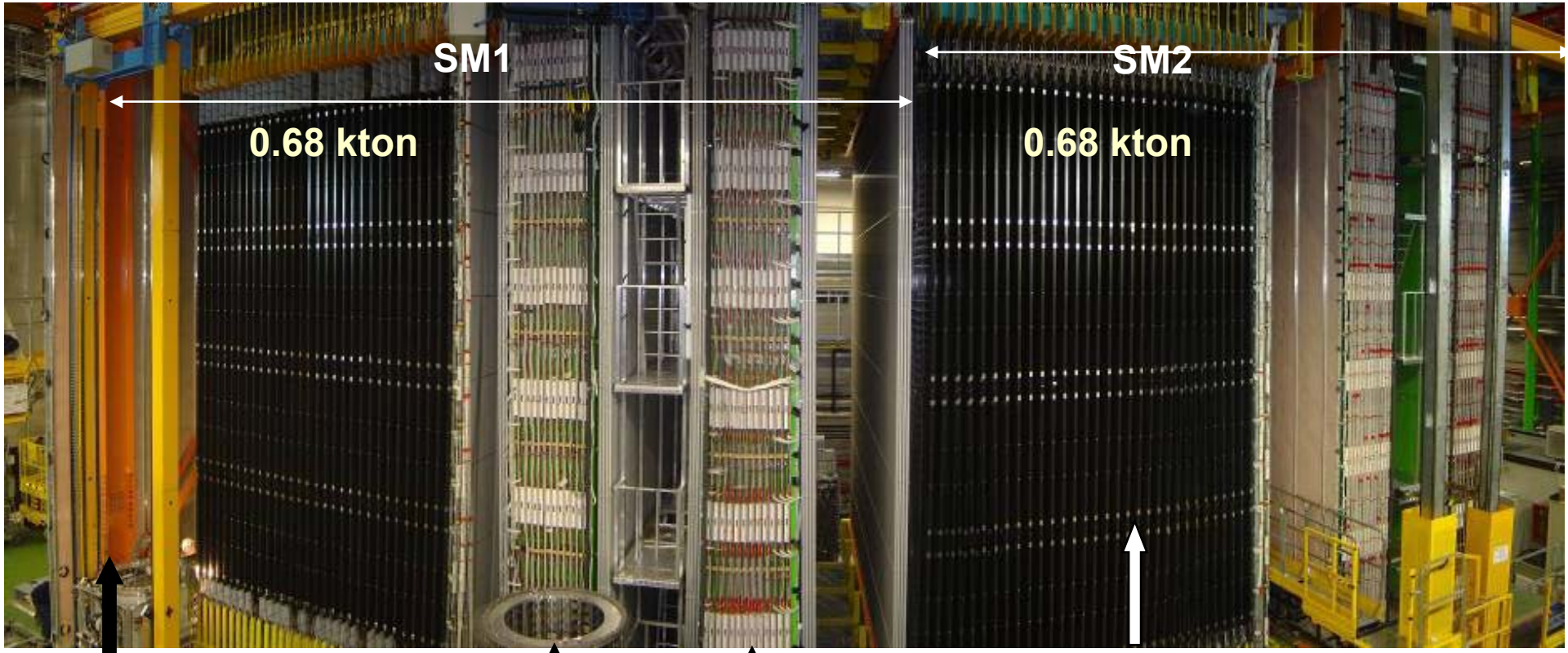






The OPERA target is composed of ~150000 bricks

OPERA : a hybrid detector



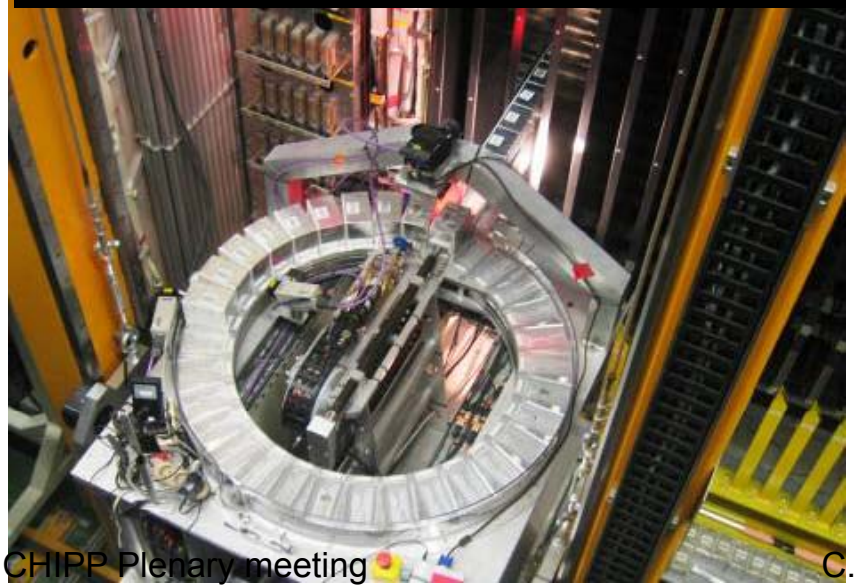
Veto plane
(RPC)

Spectrometer:
XPC, HPT, RPC, magnet

Target and Target Tracker

Brick handling

Brick Manipulator System



Xray machine

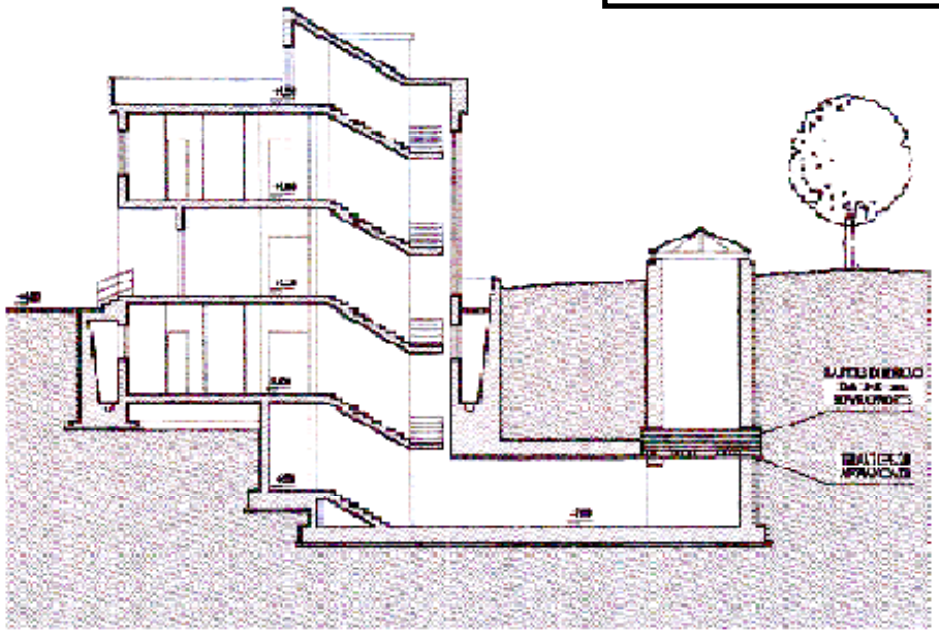
- Brick extraction
- XRay exposure (local reference frame)

Chemical plant for emulsion development





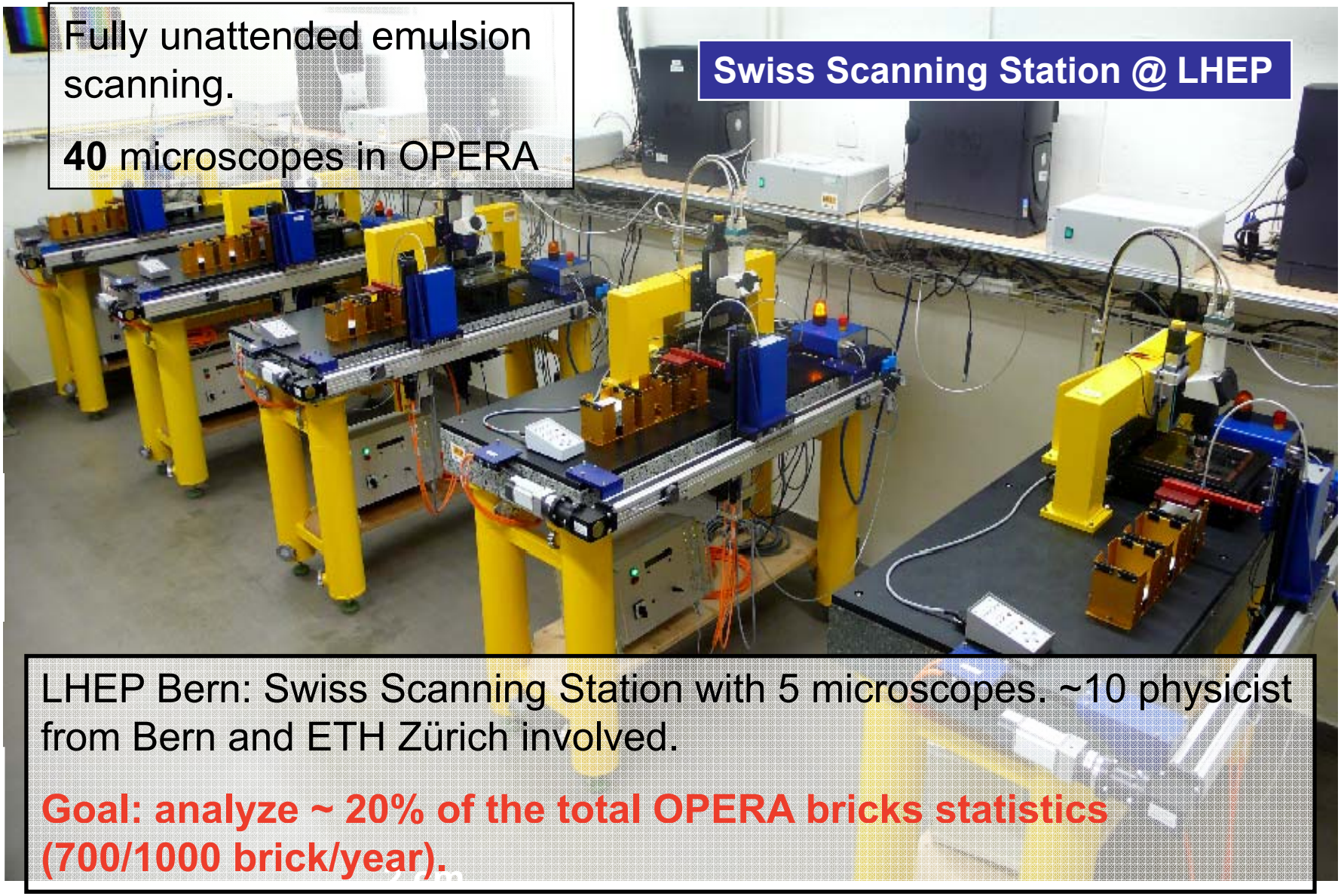

A dedicateted building @ LNGS



Automated emulsion analysis

Fully unattended emulsion scanning.

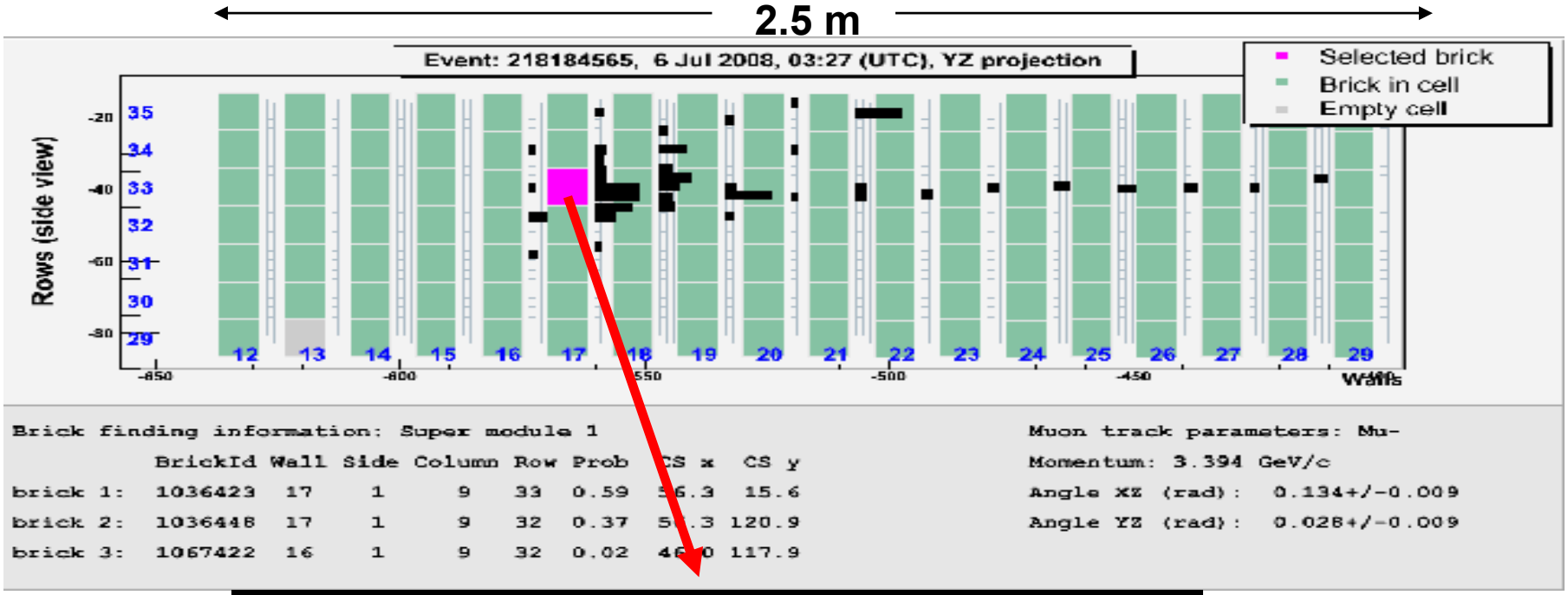
40 microscopes in OPERA

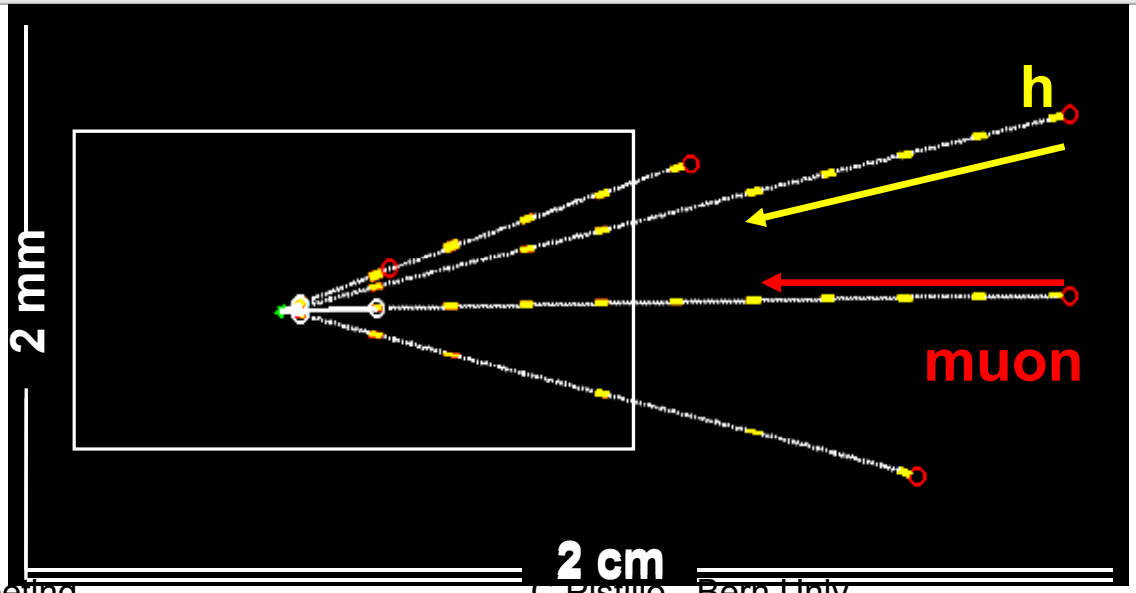


LHEP Bern: Swiss Scanning Station with 5 microscopes. ~10 physicist from Bern and ETH Zürich involved.

Goal: analyze ~ 20% of the total OPERA bricks statistics (700/1000 brick/year).

Strategy for event analysis





Status of the experiment data taking

May 2006: electronic detectors commissioning

Aug 2006: technical run, **0.76*10^{18} pot** collected

1 year CNGS nominal
4.5*10^{19} pot

319 interactions in the rock, mechanical structure and iron of the spectrometer

Oct 2006: start of brick production

Oct 2007: pilot physics run (~40% target) **0.82*10^{18} pot**

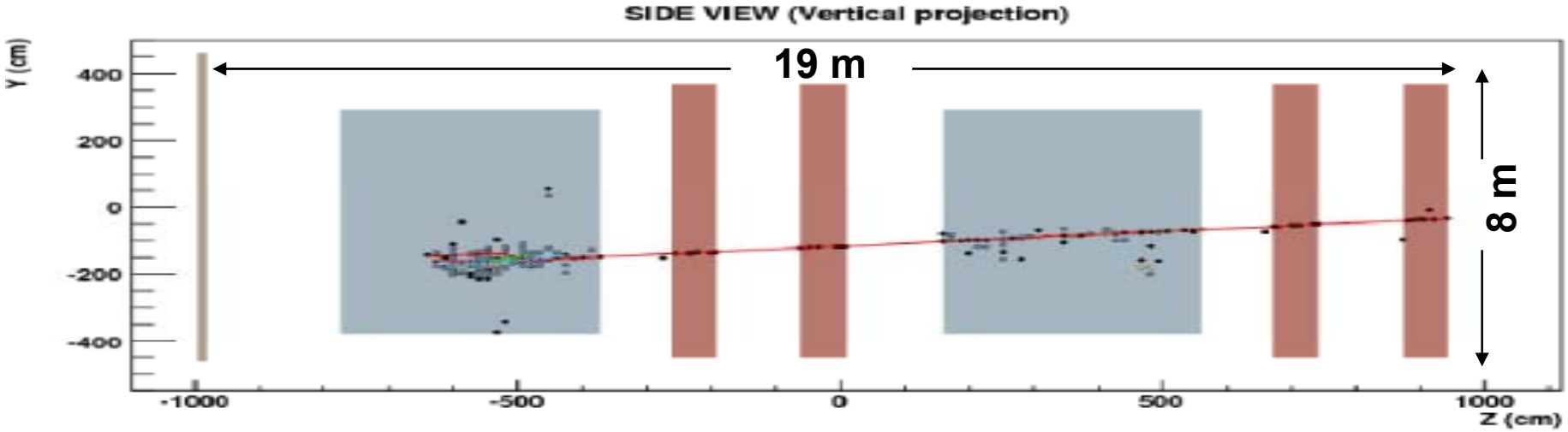
first **38** neutrino events in the target

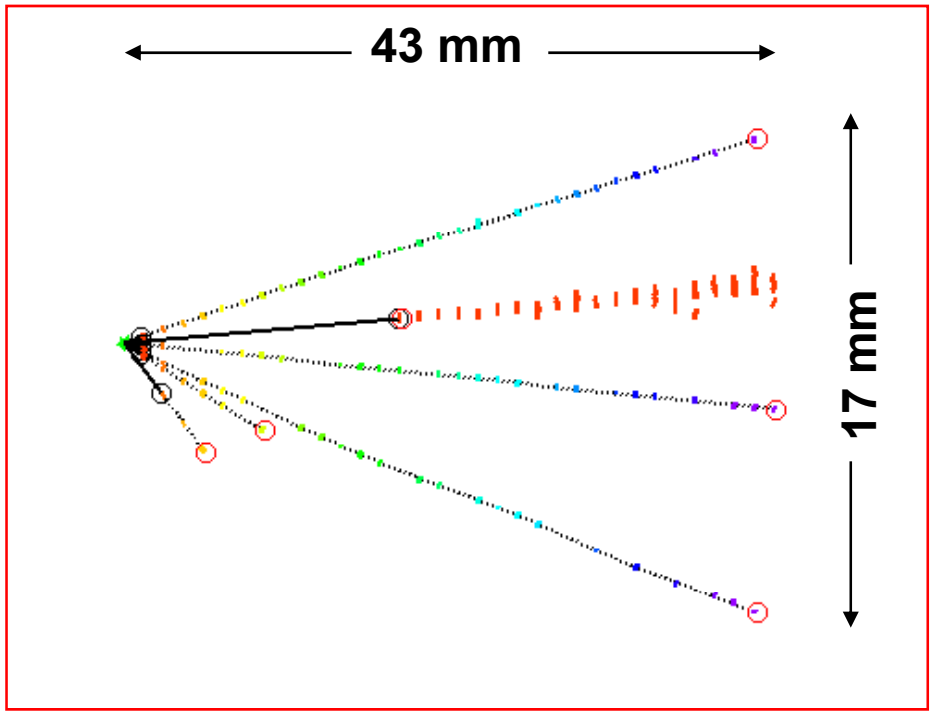
Jun 2008: OPERA detector filled and fully commissioned, 146000 bricks inserted (150000 by end 2008)

Jun 2008: Start first OPERA production run

Sep 2008: **5.6*10^{18} pot** and ~**500** neutrino events in the target

Event 178969961: ν_μCC interaction



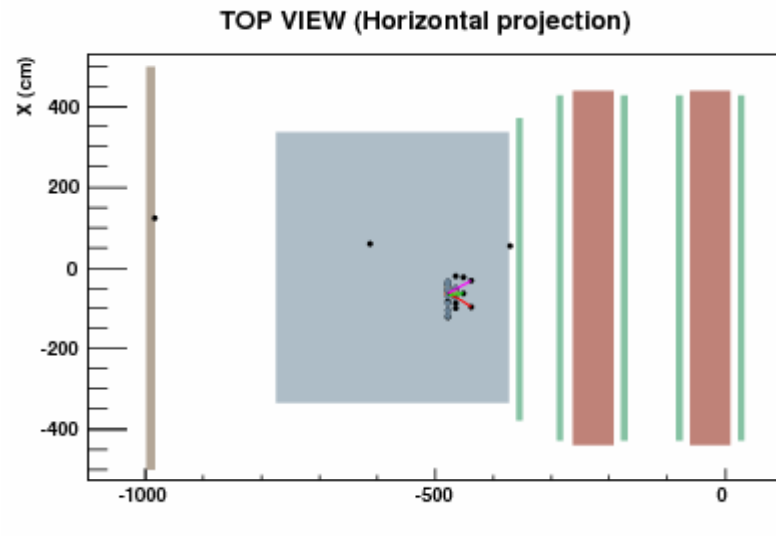


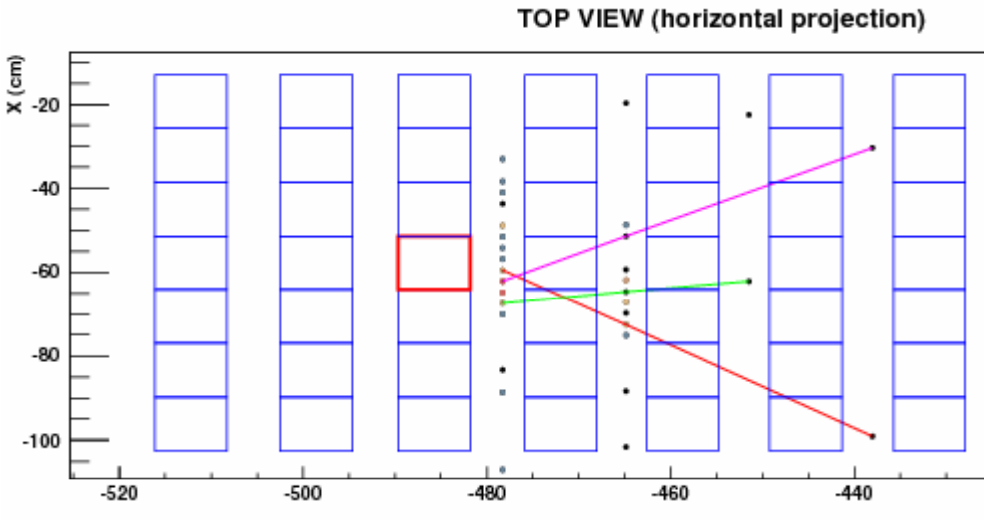
5 prongs

<IP> = 9 μm

Electromagnetic shower pointing to the vertex (γ conversion)

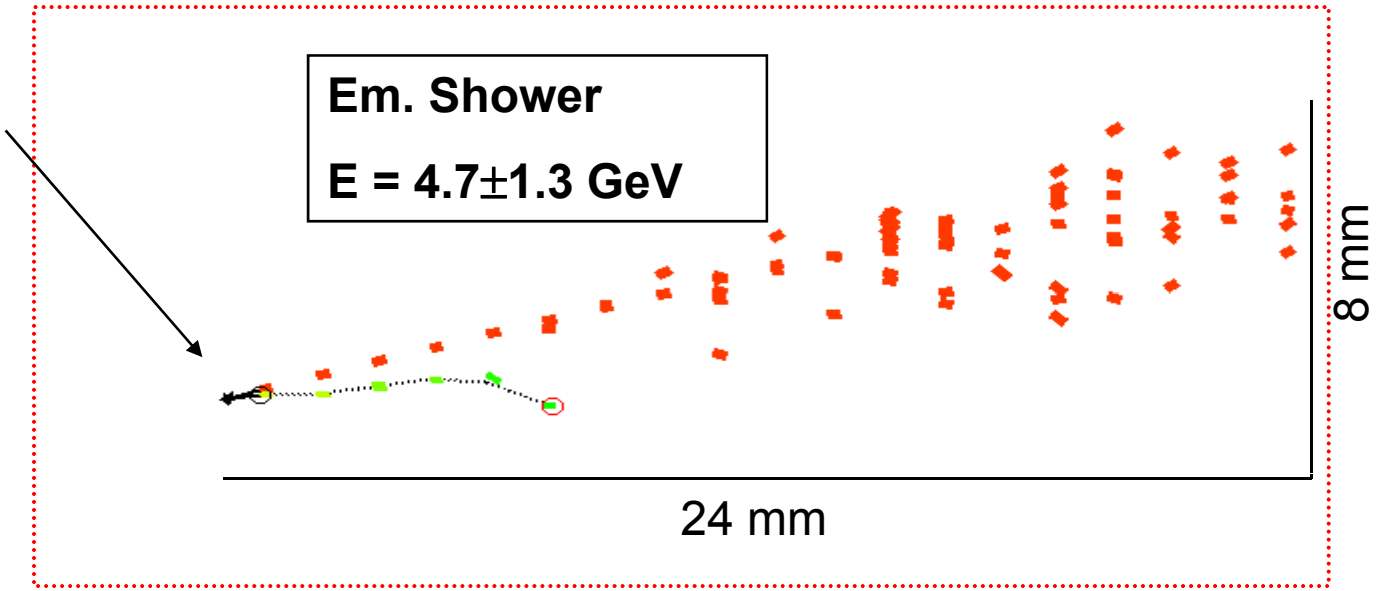
Event 183545620 located in Bern – first (only) ν_e candidate



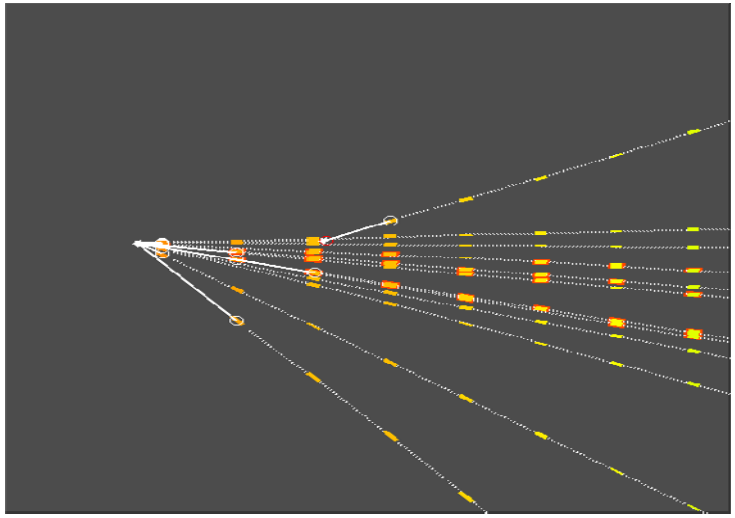


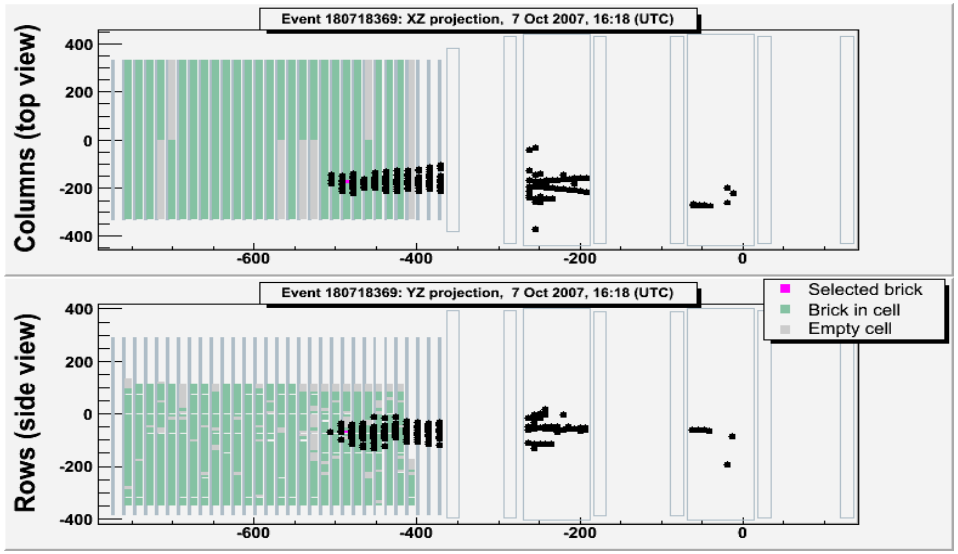
Neutrino vertex

IP = ~3μm



Event 180718369: a charm candidate





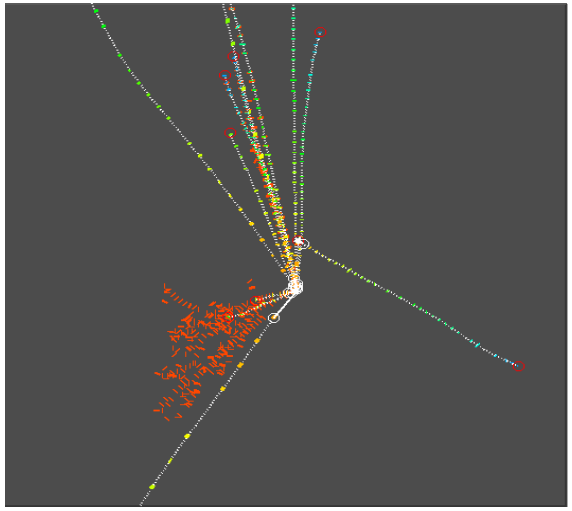
Flight length: 3247.2 μm

θ_{kink}: 0.204 rad

$P_{daughter}$: 3.9 (+1.7 -0.9) GeV

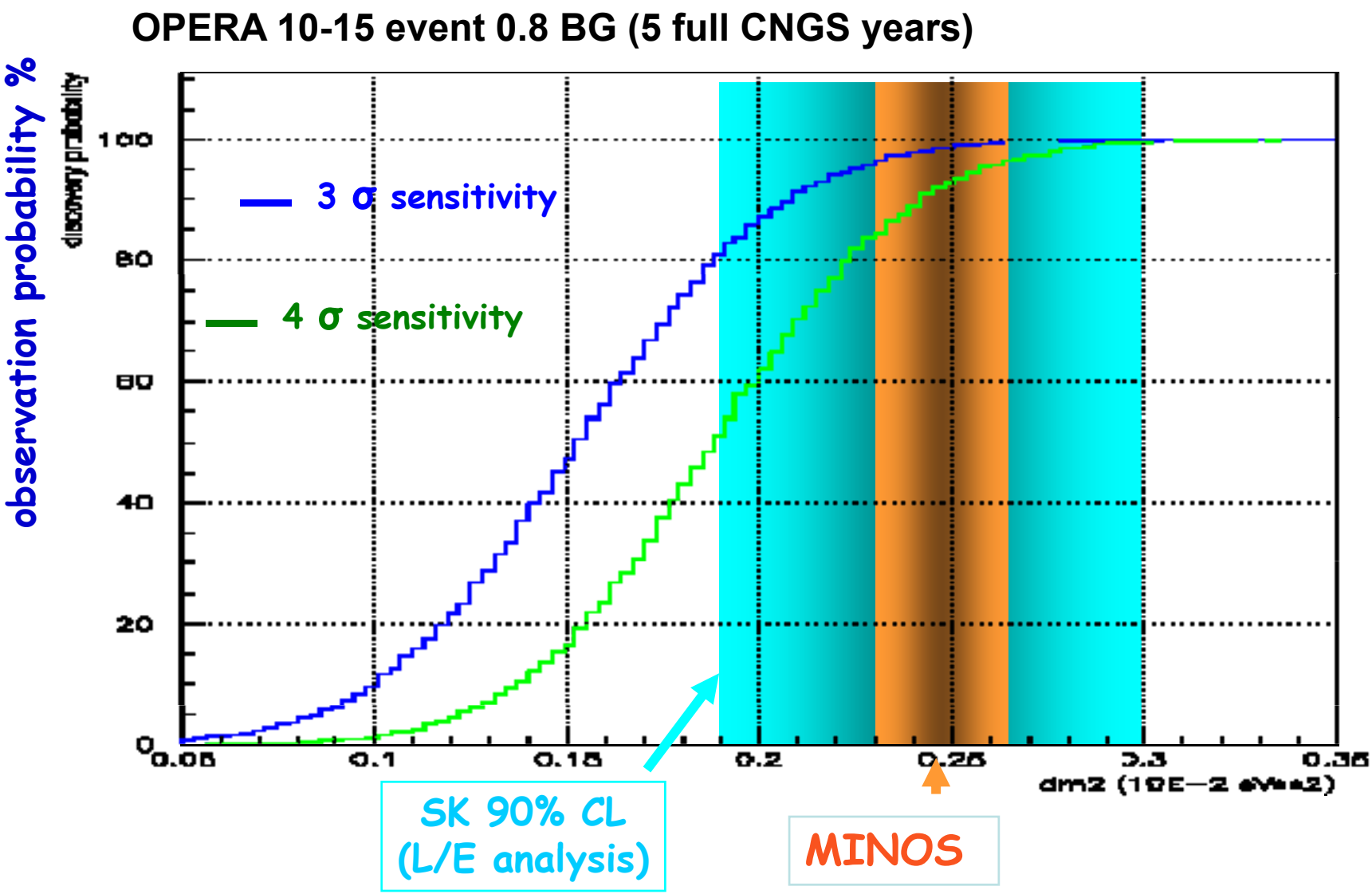
P_T: 796 MeV (> 606 MeV)

Clear kink topology + EM shower



Two e. m. showers pointing to vertex

OPERA ν_τ observation probability



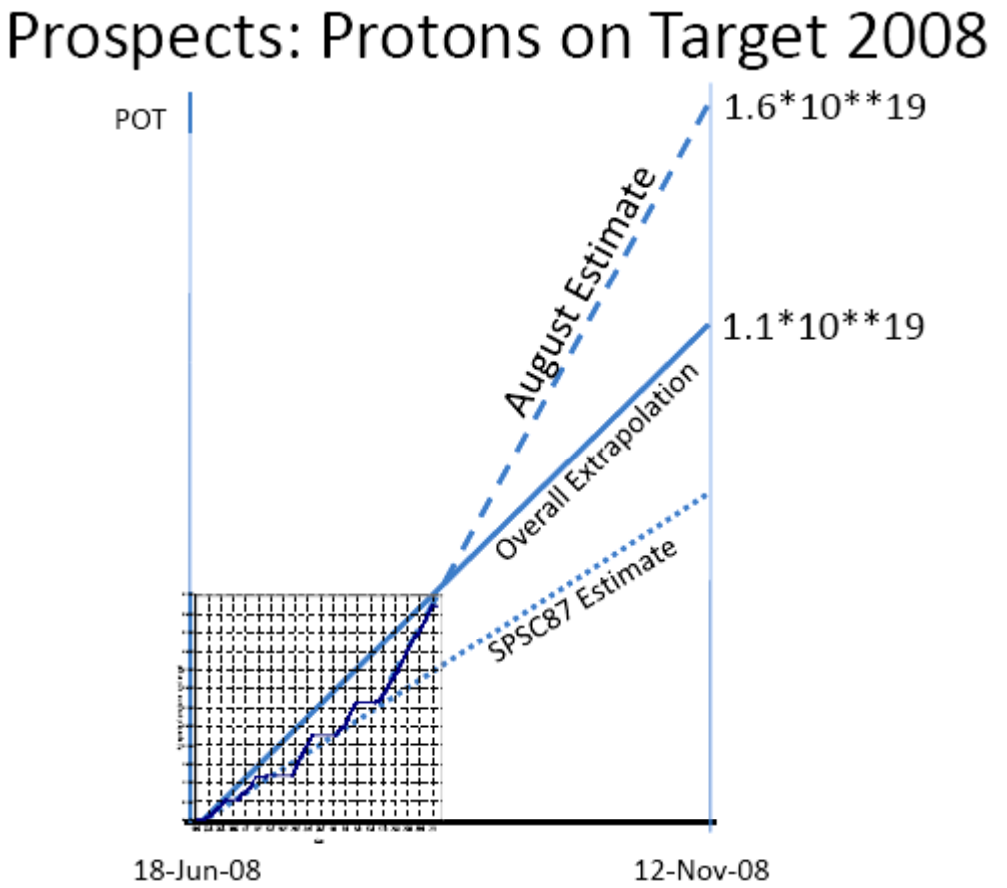
The 2008 OPERA run

Expectations:
127 days for the CNGS
$2.3*10^{19}$ p.o.t

Current situation (Aug 31th)

After 68 days: $5.6*10^{18}$ p.o.t
~45% of what originally expected

Total number of interactions	**2660**
ν_μCC events	**2000**
ν_μNC events	**600**
$\nu_e/\bar{\nu}_e$ events	**17**
Charm decay	**84**
Tau candidate (@2.5 10^{-3} eV^2)	**1.0**



Past activities of the Swiss researchers

- conceptual design
- proposal
- CNGS beam design and optimization
- construction of the Target Tracker
- lead production monitoring
- development of European microscopes
- emulsion film robot
- test beams
- physics analysis
- …

Responsibilities of the Swiss researchers

Management of the experiment:

A.Ereditato (spokesperson), U. Moser (member of publication committee)

Emulsion scanning:

Largest scanning team in Europe (~10 physicist) and ~20% brick scanning at LHEP

Data Analysis responsabilities:

Electron identification, shower reconstruction, π^0 detection and τ search in τ -> e channel

Other Analysis activities:

Strategies for neutrino interaction vertex location for muon-less events

Determination of neutrino energy spectrum

Charm event studies

Education

PhD thesis in progress:

J. Knüsel (LHEP): low momentum muon identification

C. Lazzaro (ETHZ): determination of the CNGS neutrino energy spectrum from CC events reconstructed with the electronic detectors

F. Meisel (LHEP): measurement of the ν_e contamination of the CNGS beam

T. Strauss (ETHZ): neutrino induced charmed particle decays

Conclusions

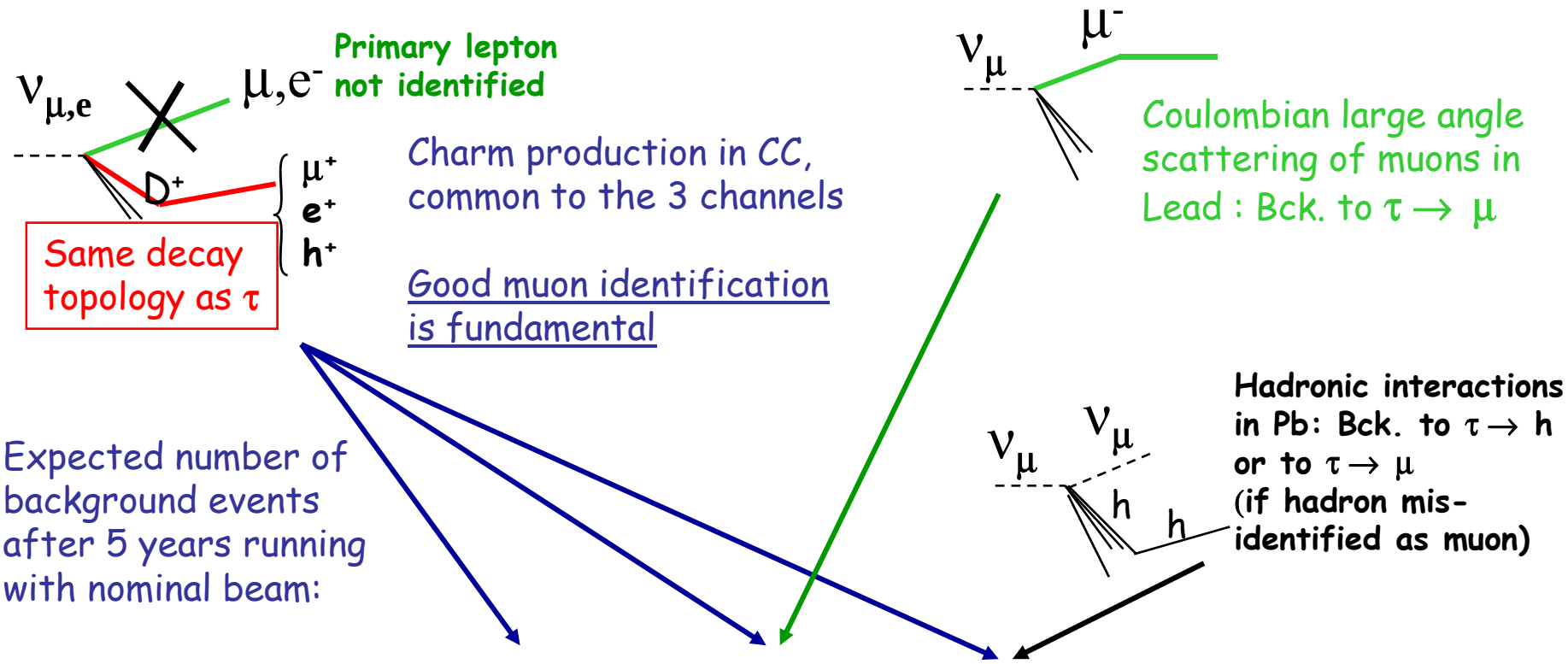
-The whole detector is fully commissioned
-The concept of the OPERA detector is experimentally validated

The first physics run started in June
- After 68 days $5.6*10^{18}$ p.o.t have been collected
~500 neutrino interactions have been triggered by electronic detectors and are being analyzed in the scanning laboratories

Interesting topologies detected (charmed particle decay, prompt ν_e) We just miss the tau! Chance to observe the first ν_τ candidate event with 2008 run?

BACKUP SLIDES

τ search : Backgrounds



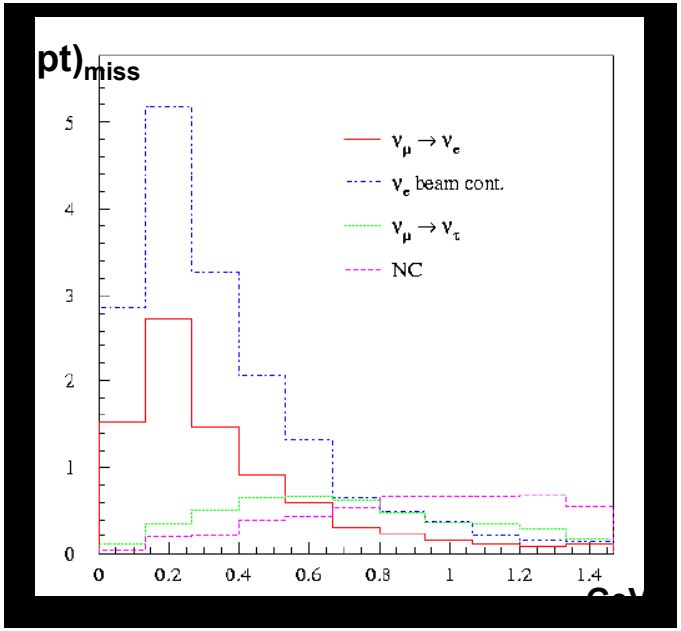
	τ→e	τ→μ	τ→h	τ→3h	Total
Charm background	**.173**	**.008**	**.134**	**.181**	**.496**
Large angle μ scattering		**.096**			**.096**
Hadronic background		**.077**	**.095**	**.**	**.172**
Total per channel	**.173**	**.181**	**.229**	**.181**	**.764**

$\nu_\mu \rightarrow \nu_e$ oscillation search

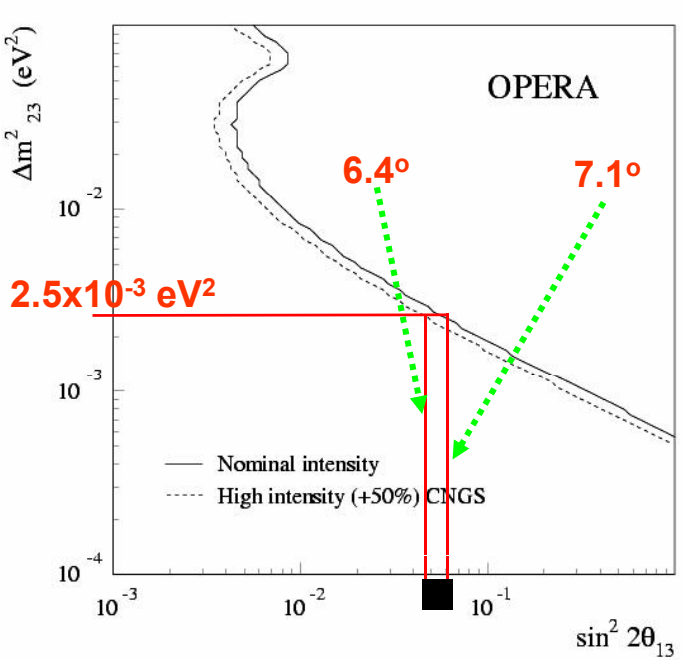
Θ_{13}	SIGNAL	ν_e beam	$\tau \rightarrow e$	ν_μ NC	ν_μ CC
9°	9.3	18	4.5	5.2	1.0
7°	5.8	18	4.5	5.2	1.0
5°	3.0	18	4.6	5.2	1.0

$\Delta m_{23}^2 = 2.5 \times 10^{-3}$ eV^2 $\quad \Theta_{23} = 45°$

nominal CNGS beam $\quad$ 5 years



Combined fit of E_e, E_{vis}, $(pt)_{miss}$ to improve S/B ratio



90% C.L. limits on $\sin^2(2\Theta_{13})$ and Θ_{13} :

$\sin^2(2\Theta_{13}) < 0.05 \quad \Theta_{13} < 7.1°$