Status of

OPERA/CNGS

NAKAMURA M.

Nagoya Univ.

OPERA Collaboration

2003 Feb. 11 for NOON2003,Kanazawa

OLLABORATION

35 groups
~ 160 physicists
rom 11 countries

Belgium
IIHE(ULB-VUB) Brussels

China
IHEP Beijing, Shandong

Croatia
Zagreb

France
LAPP Annecy, IPNL Lyon, LAL Orsay, IRES Strasbourg

Germany
Berlin, Hagen, Hamburg, Münster, Rostock

Israel
Technion Haifa

Italy
Bari, Bologna, LNF Frascati, L’Aquila, LNGS, Naples, Padova, Rome, Salerno

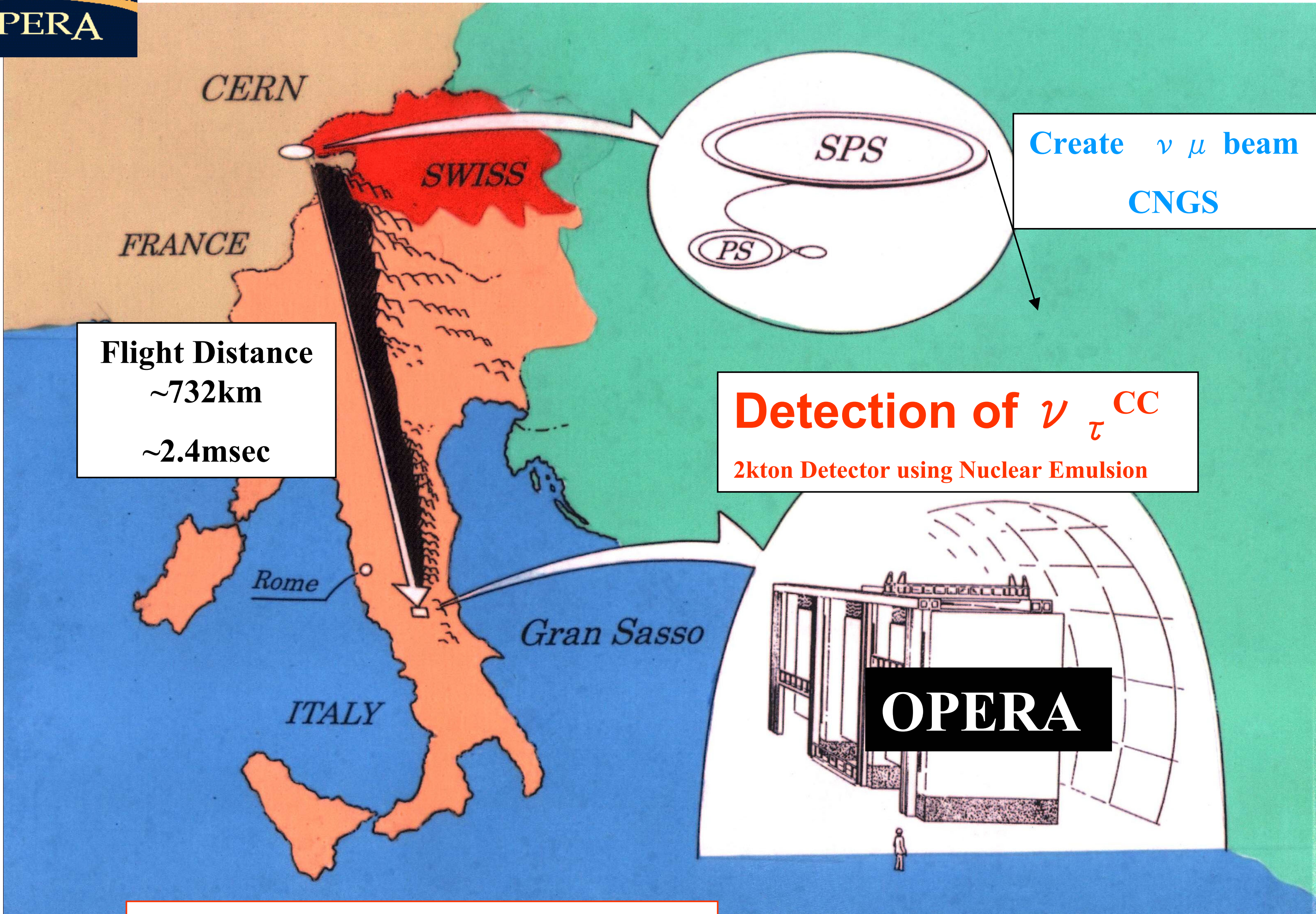
Japan
Aichi, Toho, Kobe, Nagoya, Utsunomiya

Russia
INR Moscow, ITEP Moscow, JINR Dubna, Obninsk

Switzerland
Bern, Neuchâtel

Turkey
METU Ankara

Direct detection of ντ Appearance



2006/June Start beam exposure

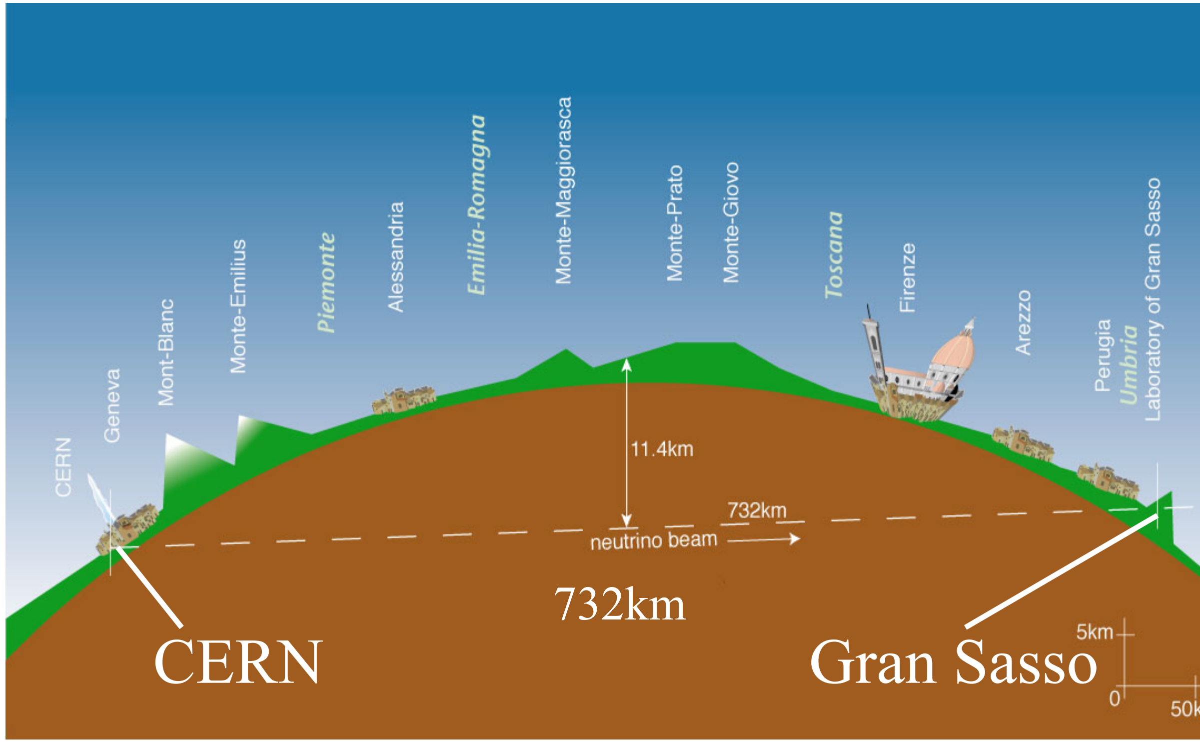
CNGS beam

Optimized to study ν_τ appearance

Nominal ν beam

ν_μ (m^{-2} / pot)	7.45×10^{-9}
ν_μ CC / pot / kton	5.44×10^{-17}
$< E >_\nu$ (GeV)	17
$(\nu_e + \bar{\nu}_e) / \nu_\mu$	0.85 %
$\bar{\nu}_\mu / \nu_\mu$	2.0 %
ν_τ prompt	negligible

400GeV protons from SPS



$\Rightarrow$Interactions at Gran Sasso

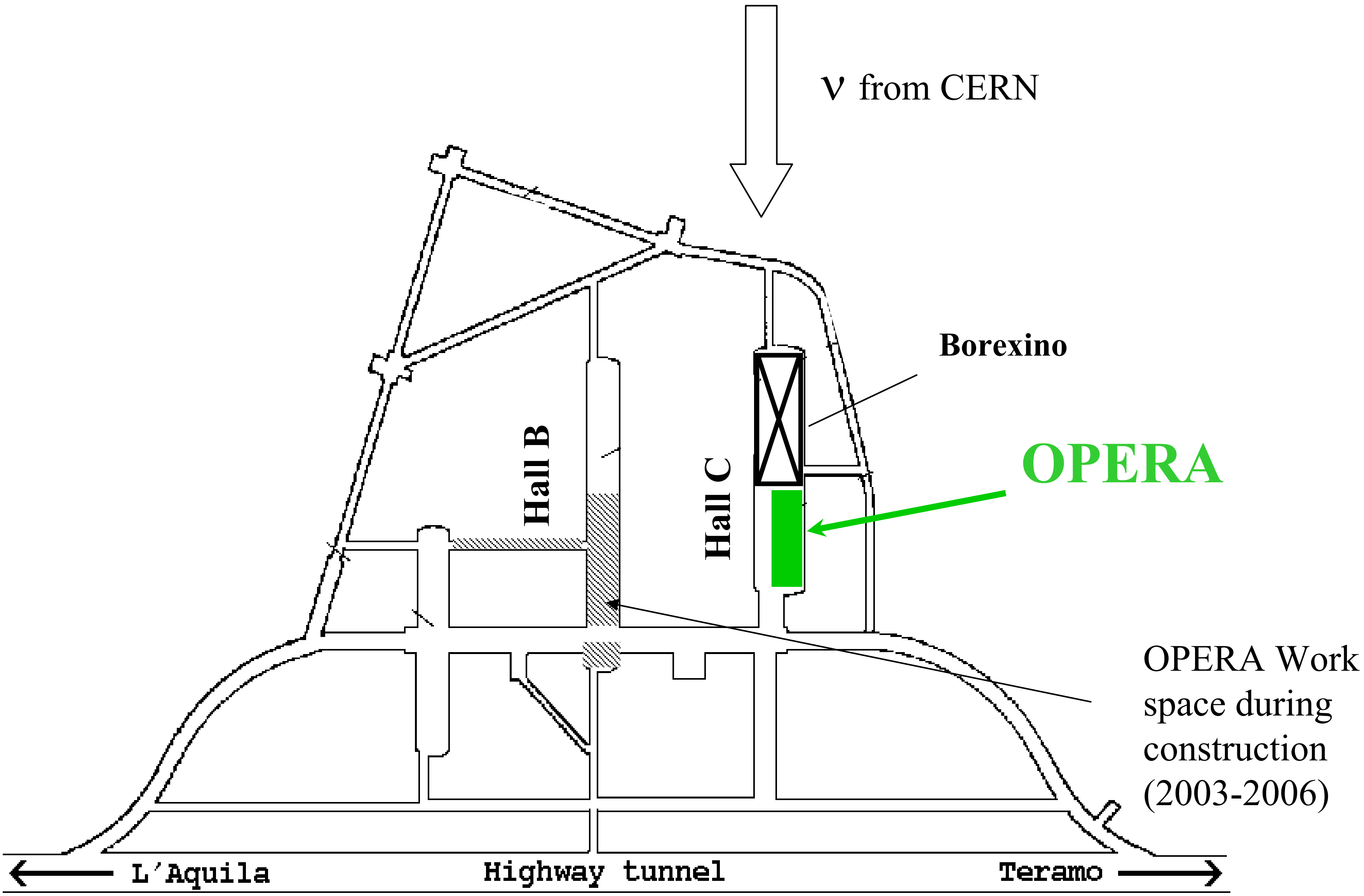
~ 3600 ν NC+CC /kton/year

~ 16 ν_τ CC /kton/year

for $\sin^2 2\theta = 1$, $\Delta m^2 = 2.5\times10^{-3}$ eV^2

Construction started on Oct. 2000
Due to CERN financial situation we have one year delay.
The beam will start on spring 2006.

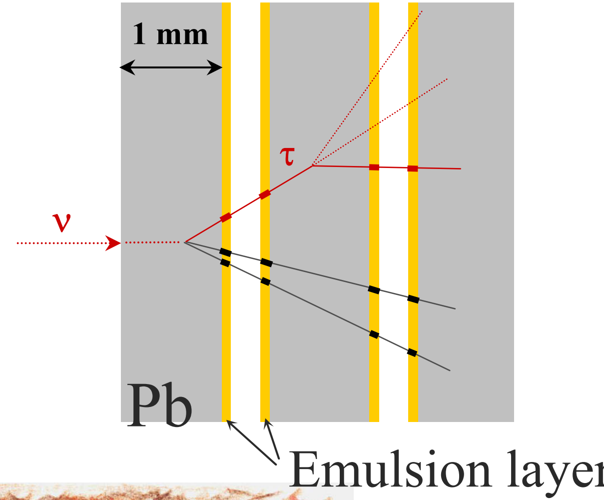
OPERA Detector in Gran Sasso Hall C

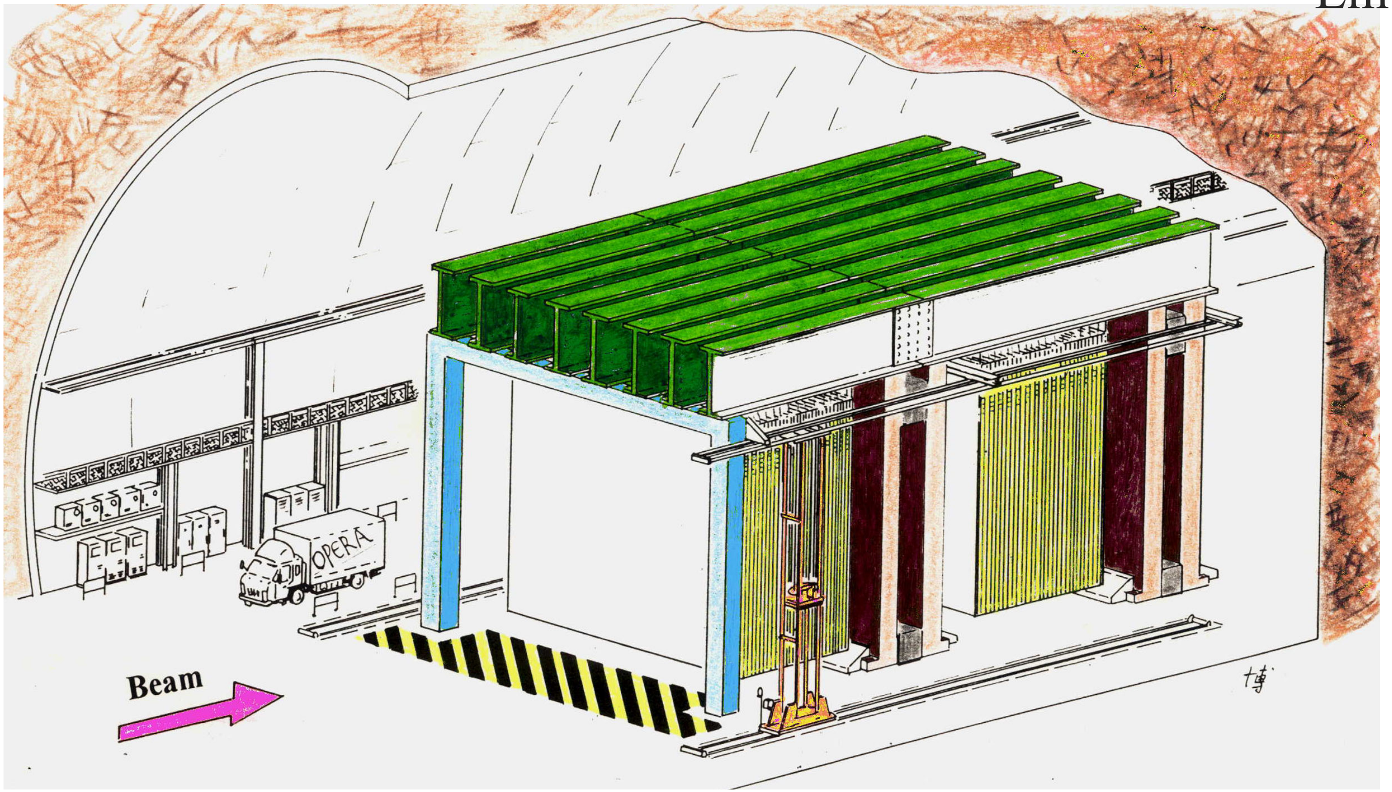


Detector

ECC(Emulsion Cloud Chamber)
to detect decay topology of τ

proven by DONUT

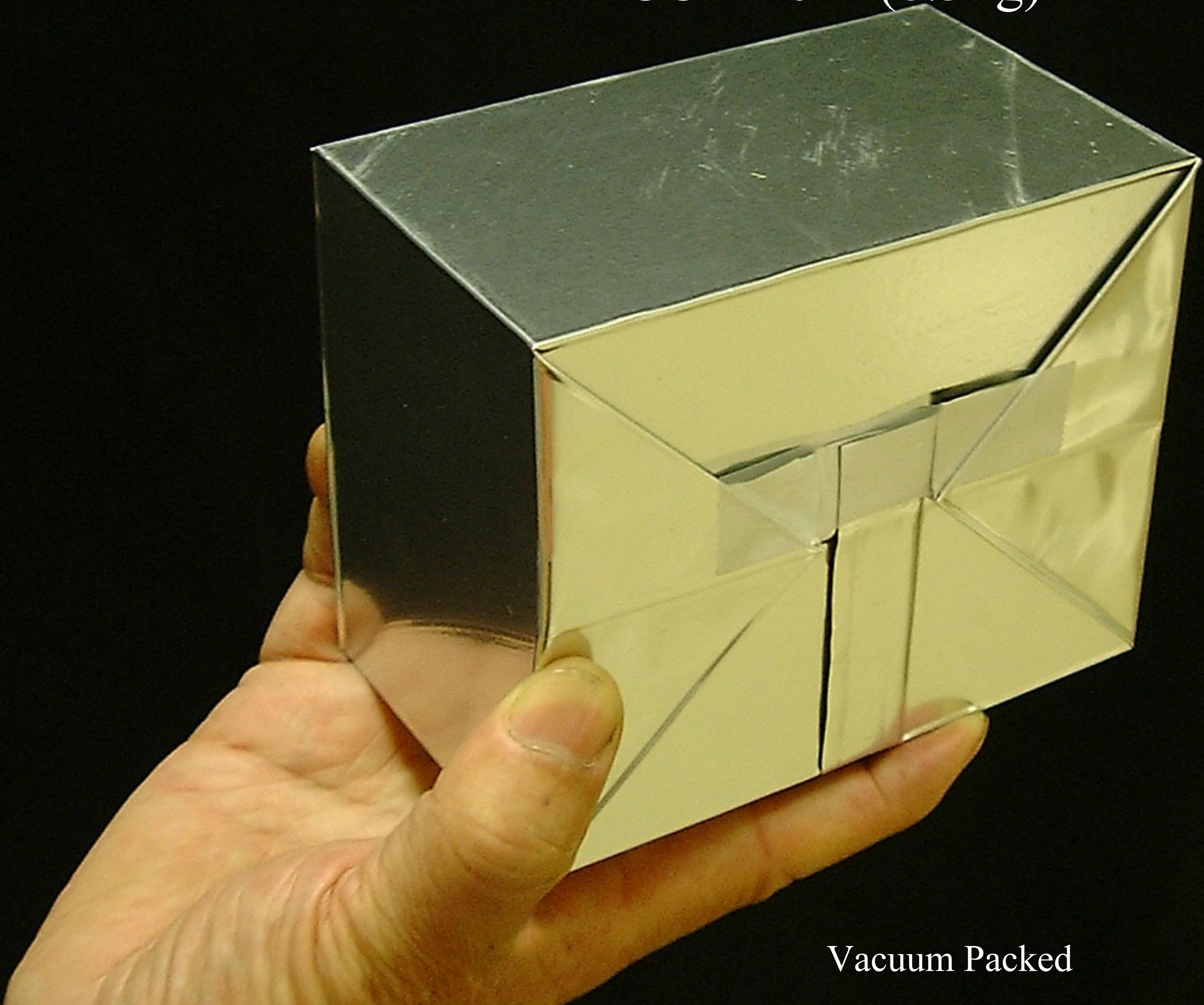




1. 7kton ECC detector

Element of the OPERA detector

ECC Brick (8.3kg)

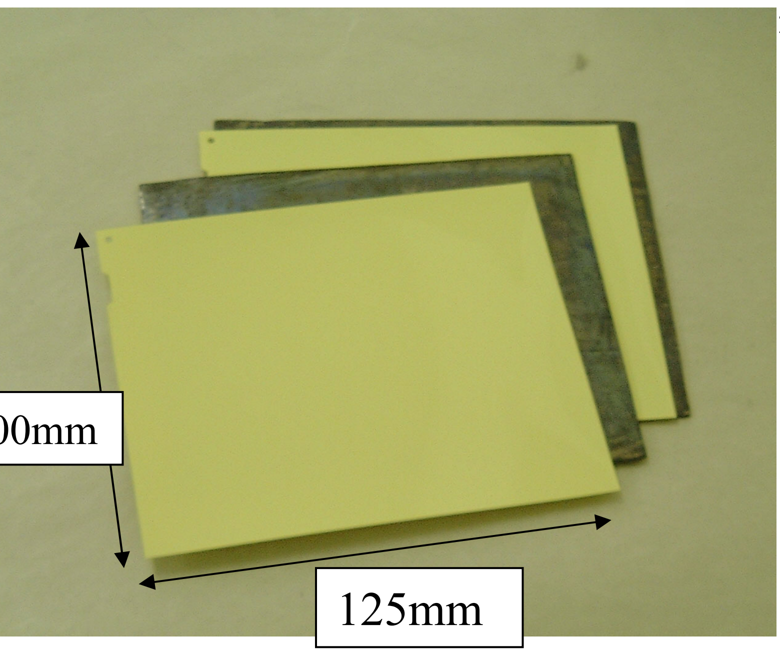


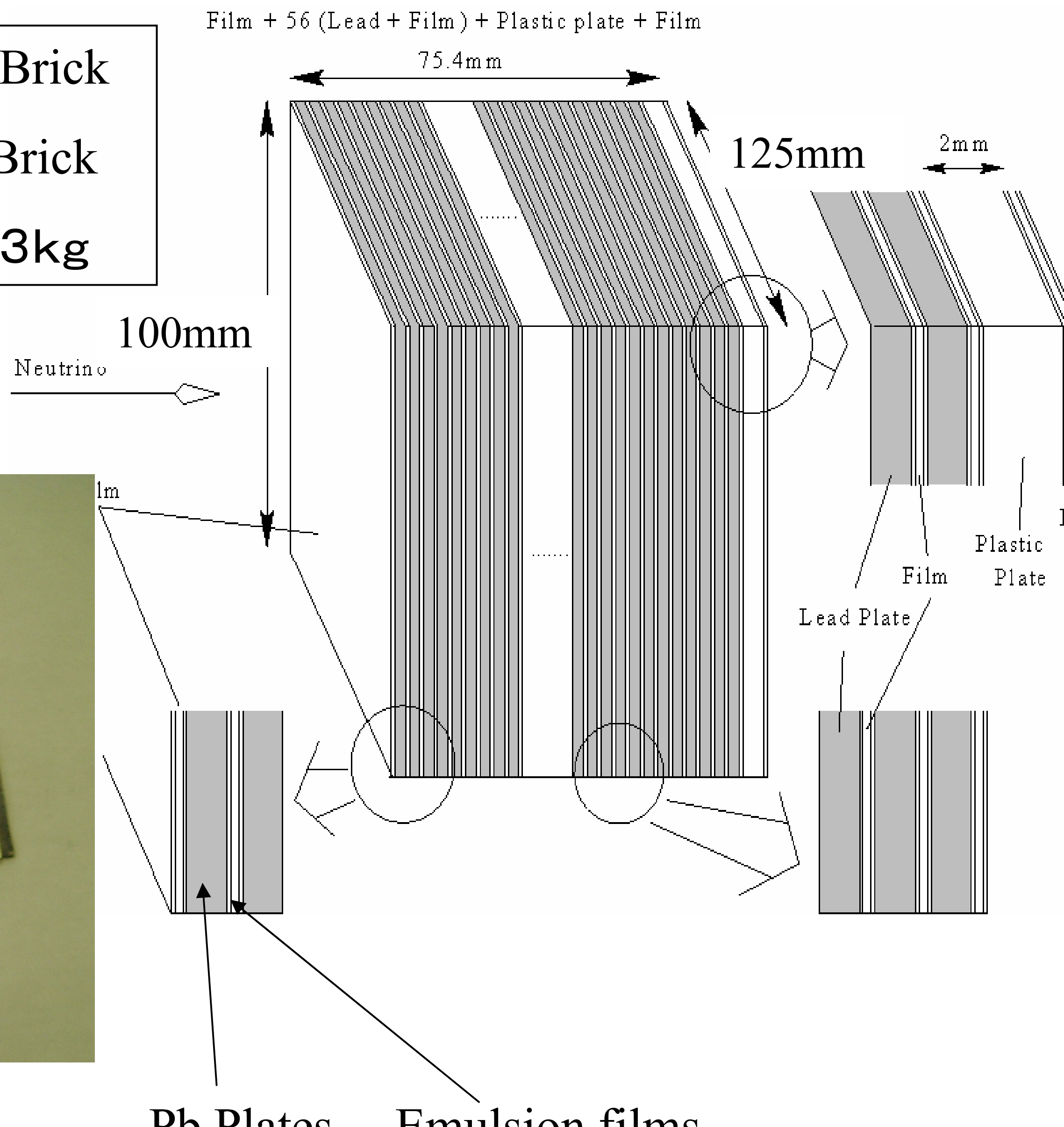
Vacuum Packed

ECC Brick

Sandwich of Emulsion Films and Lead Plates

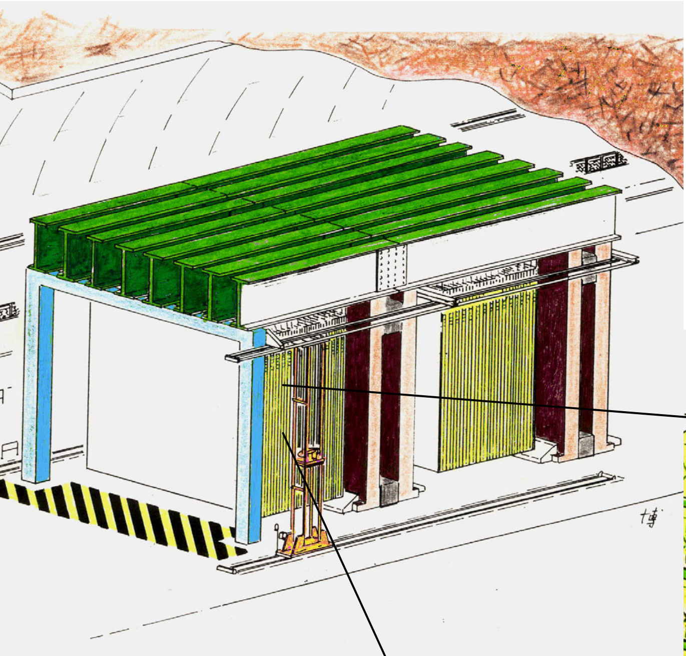
Lead Plates（1mm thick）	56/Brick
Emulsion films	58/Brick
Weight	8. 3kg



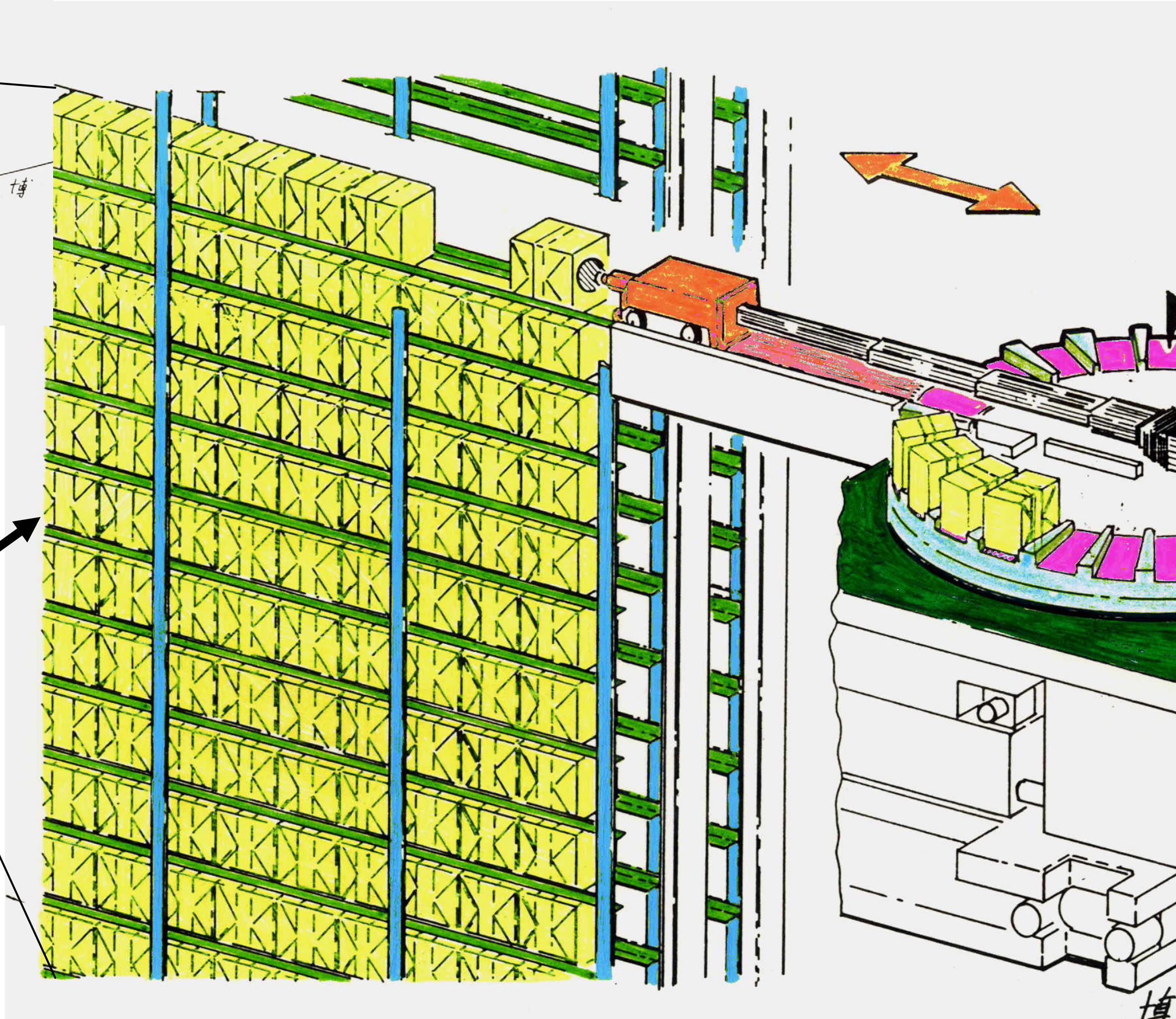


Total Number of ECC bricks :

206,336 Bricks～約20万個
Weight
=8.3kg × 206,336=1,715ton

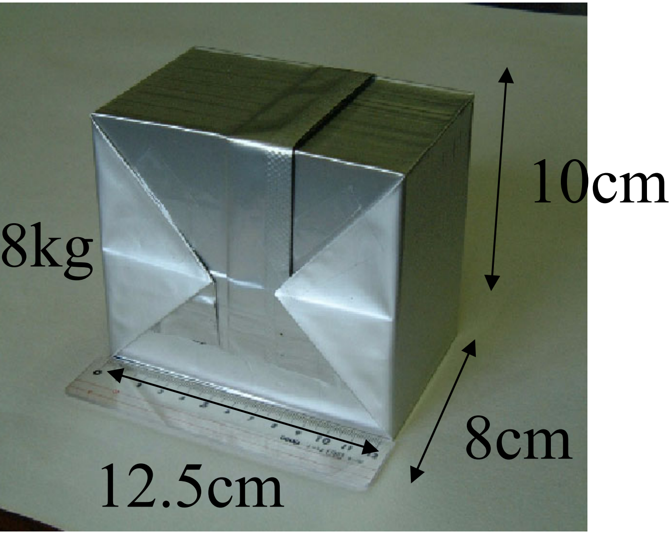


62Walls

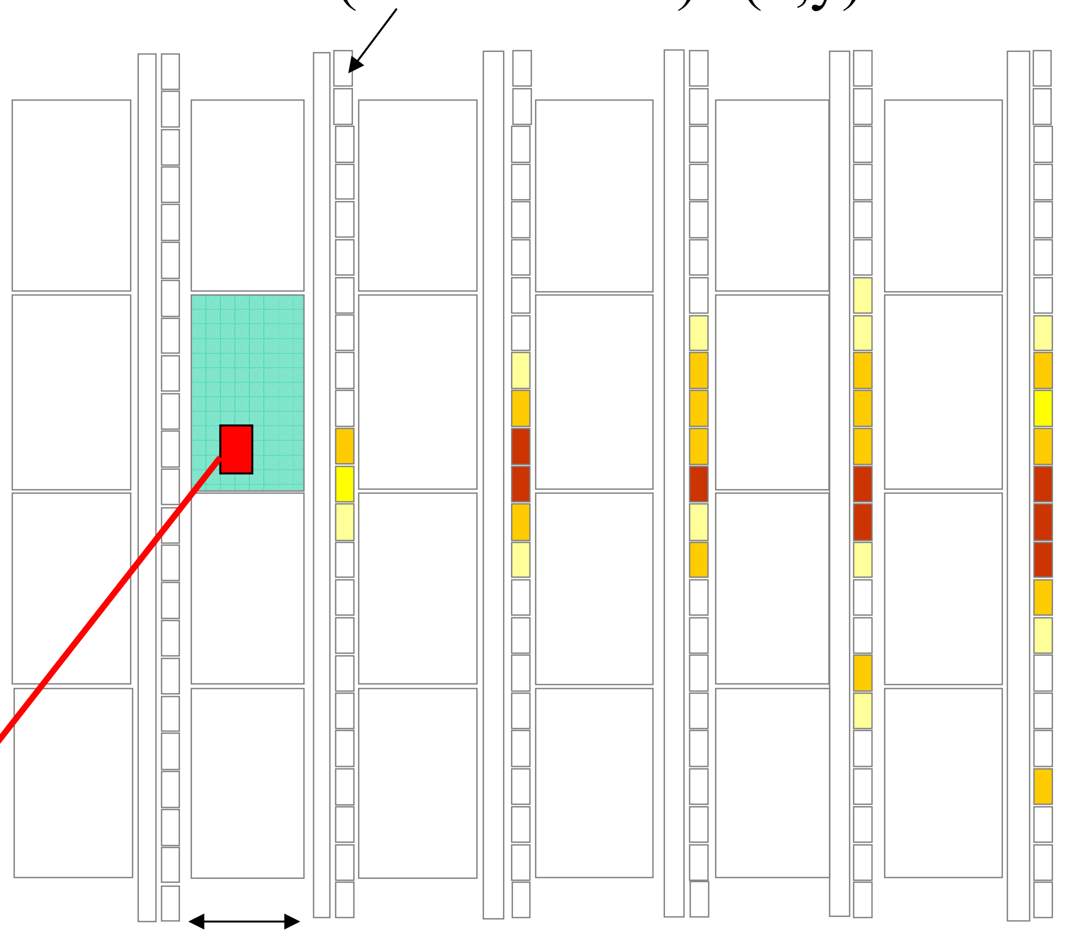


1Wall=64 × 52
bricks :

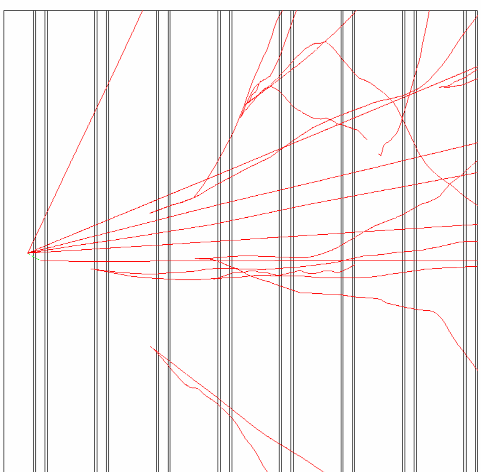
Brick assignment



Plastic scintillator strips
(2.6cm width)   (x,y)



8cm $10X_0$
58 films+56 Pb plates



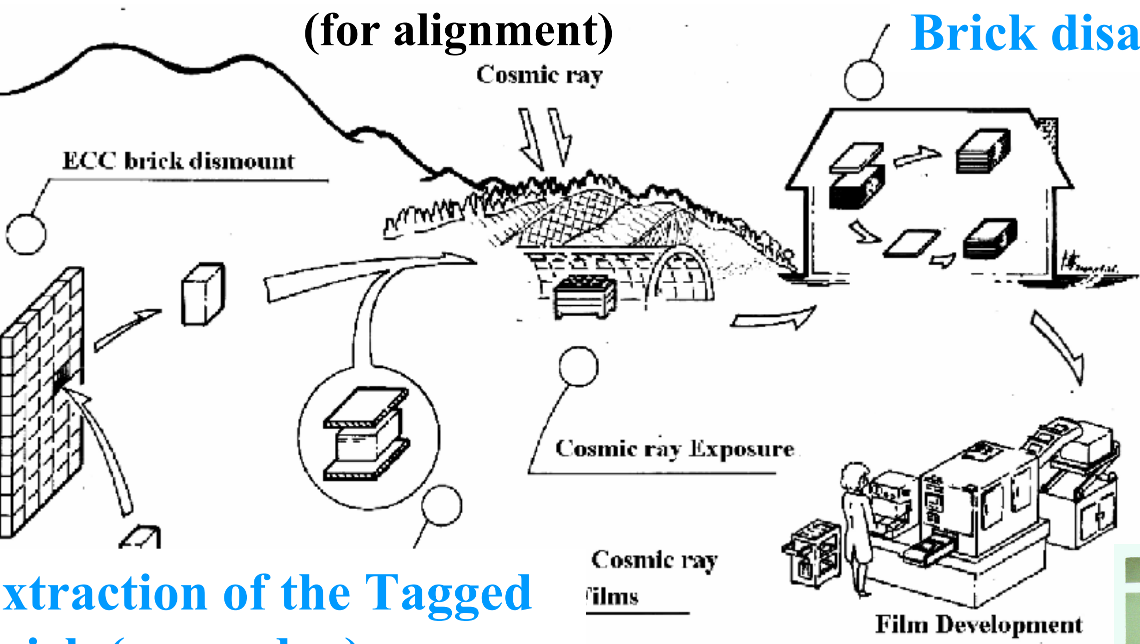
Pulse height

Quasi on-line ECC analysis

Cosmic ray exposure

(for alignment)

Brick disassembling



emulsion development

emulsion read-out

xtraction of the Tagged rick (every day)

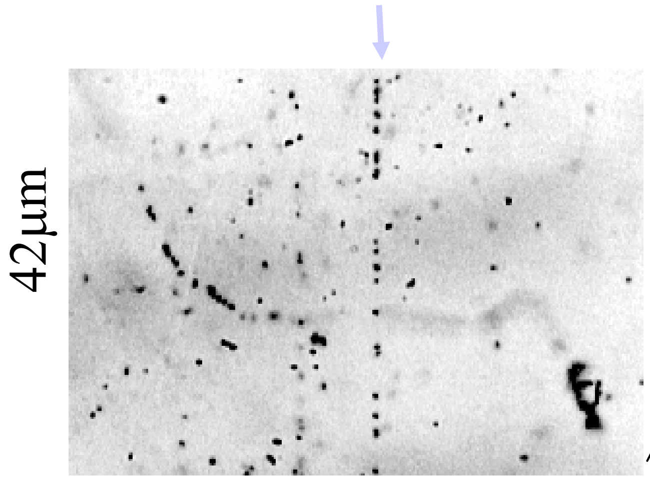
~30 Events./day = 30 Bricks

scanning station @ Nagoya Univ.

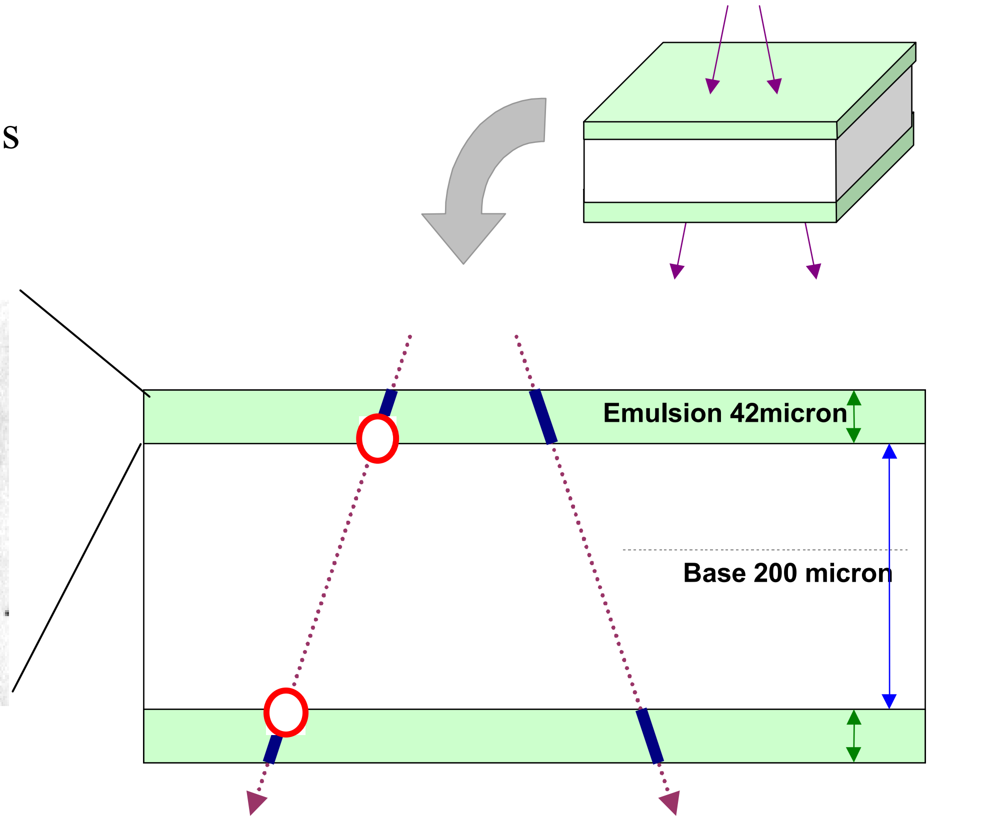
Emulsion Film

3D tracker with sub-micron accuracy

minimum ionizing particles
~ 15 silver grains / 42 μm



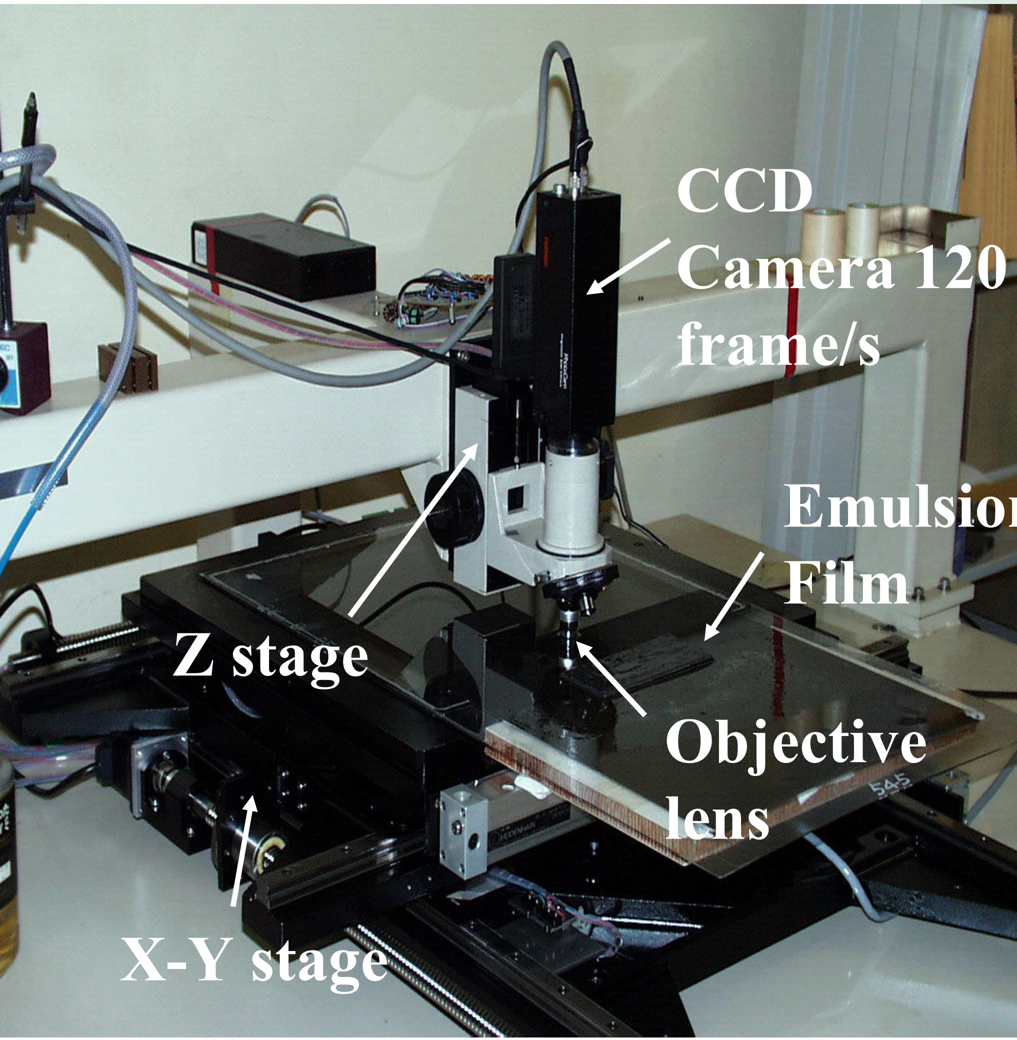
Cross-sectional view of
an Emulsion layer

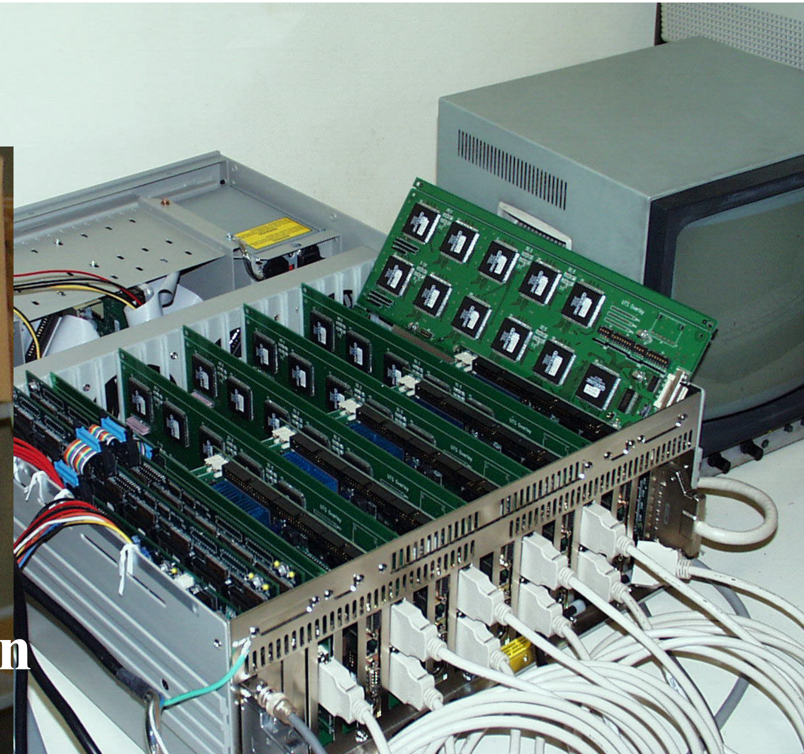


T.Nakano(Nagoya Univ.
R&D @ Nagoya

Film Read-out **Current version -UTS**

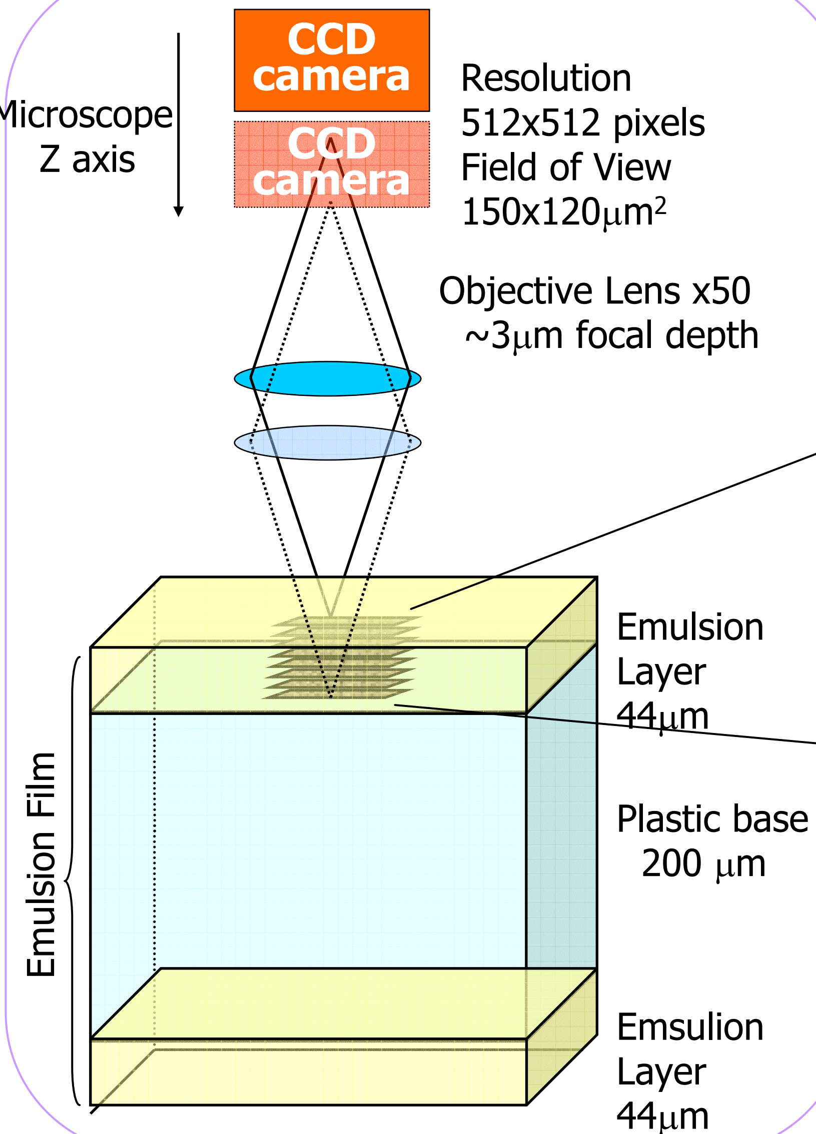
Read-out head





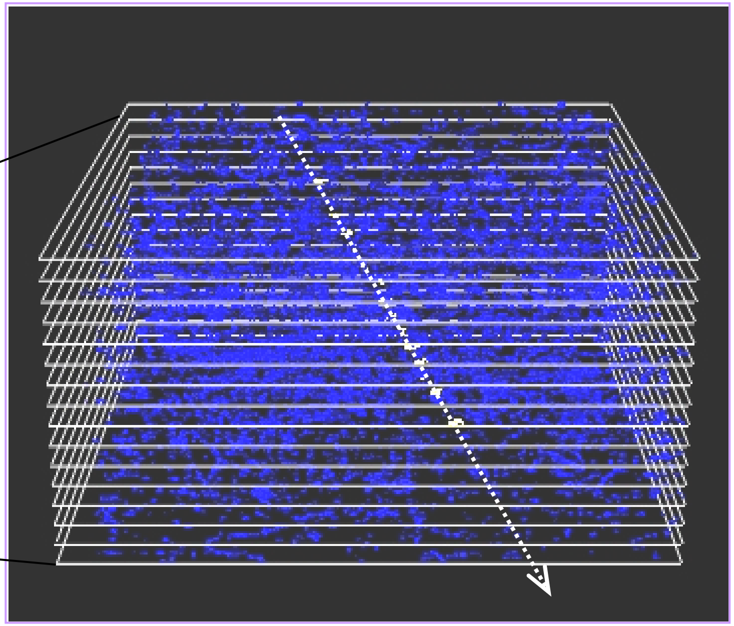
Track recognition hardware

Film Read-out **Principle**



3D digitised Emulsion layer image

(16 two-dimensional images of different focal positions.)



Search for aligned grains

(straight-lines) .

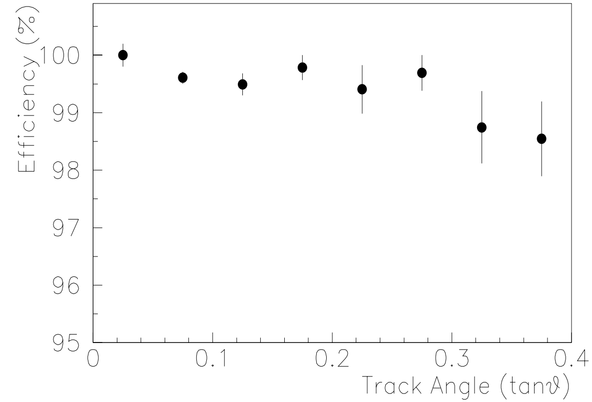
output

Track info: Position and Angle

T.Nakano(Nagoya Univ.
R&D @ Nagoya

Film Read-out **Performance**

- Scanning speed :**$1cm^2/h$**
- Track detection efficiency :**~99%**

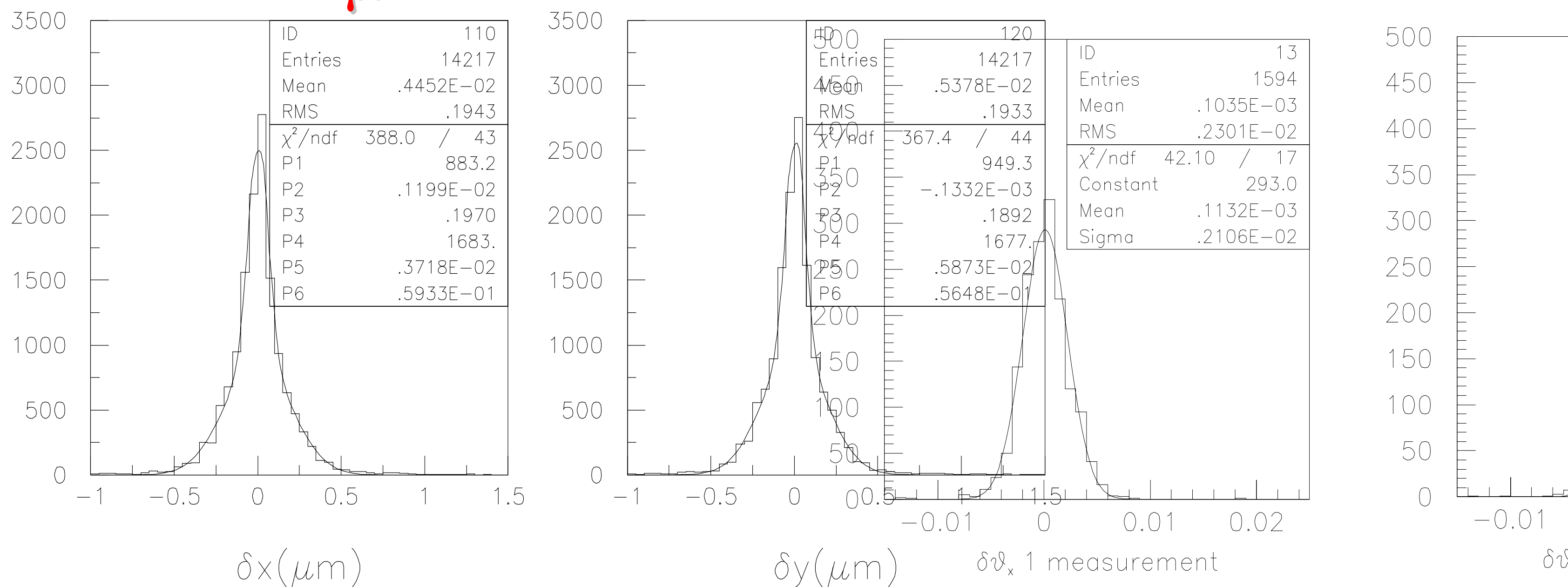


Position resolution

σ~ 0.2 μm

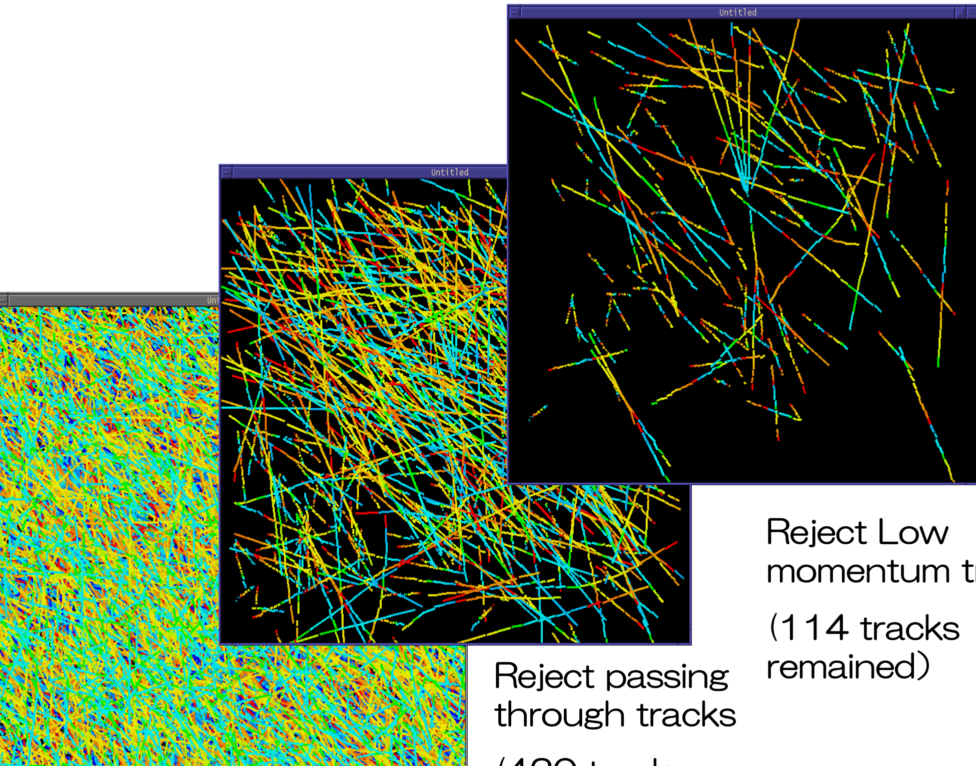
Angular resolution

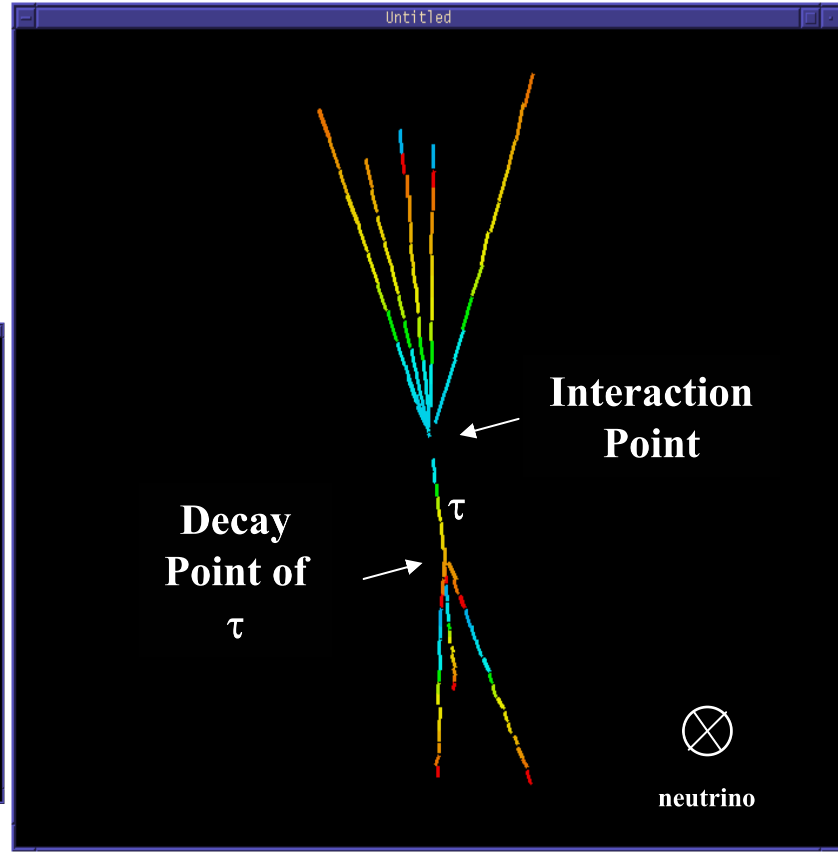
σ~ 2.1 mrad



N.Nonaka, M.Komatsu(Nagoya Univ.)
K.Kodama (Aichi Univ of Edu.)
R&D @ Nagoya for DONUT Analysis.

Event Reconstruction





Reject Low momentum tracks

(114 tracks remained)

Reject passing through tracks

(420 tracks remained)

All tracks in the Scanning region (4179 tracks)

Vertex detection :

Neutrino interaction and decay of short lived particles

Detection of ν_{τ}^{CC} in DONUT

Expected number of events

full mixing; 5 years run @ 4.5 10^{19} pot / year

τ decay mode	ν_τ events Δm^2 (10^{-3} eV^2) 1.6	2.5	4.0	b.g.
e	1.6	3.9	9.7	0.16
μ	1.3	3.2	8.3	0.29
h	1.4	3.2	8.3	0.20
Total	4.3	10.3	26.3	0.65

Aim at evidence of ν_τ appearance after a few years of data taking

Room for improvements:
- **low energy muon tag by dE/dx : background 0.65 $\rightarrow$ 0.41**
- **Changeable Sheet : increase efficiency by 10-15 %**
- **Beam intensity increase by 30-50 %**

Emulsion Film

Taku Nakamura(Nagoya Univ.
R&D @ Nagoya & Fujifilm

OPERA

Film area required 150,000 m^2

Number of Films 1.2 ×10^7
(100mm ×125mm)

Mass production using commercial film production line

R&D Fujifilm & Nagoya （’98－’02）

Mass production start April 2003

8,000 m^2/month ～ 2 years

Emulsion Film **Refreshing**

Taku Nakamura(Nagoya Univ.
R&D @ Nagoya & Fujifilm

Erasing unwanted cosmic ray tracks recorded randomly during the film production process, before installation

Refreshing condition

- Humidity :**>95%R.H**
- Temperature :**30℃**
- Time :**~3days**

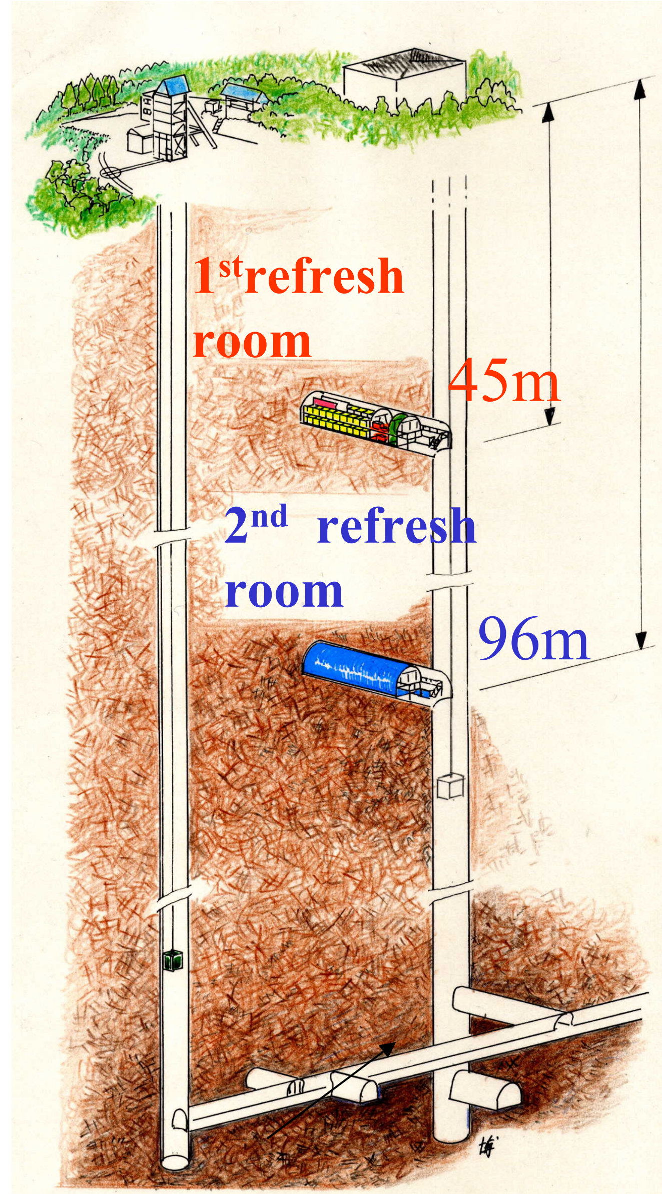
Confirmed erasing rate :

98% of the recorded tracks were erased

Production at FUJI
↓
Refreshing
↓
Transportation form JAPAN to CERN
↓
Experiment

Refresh Facility

TONO Mine underground



Cosmic ray flux

1st room 1/50(115m.w.e.)

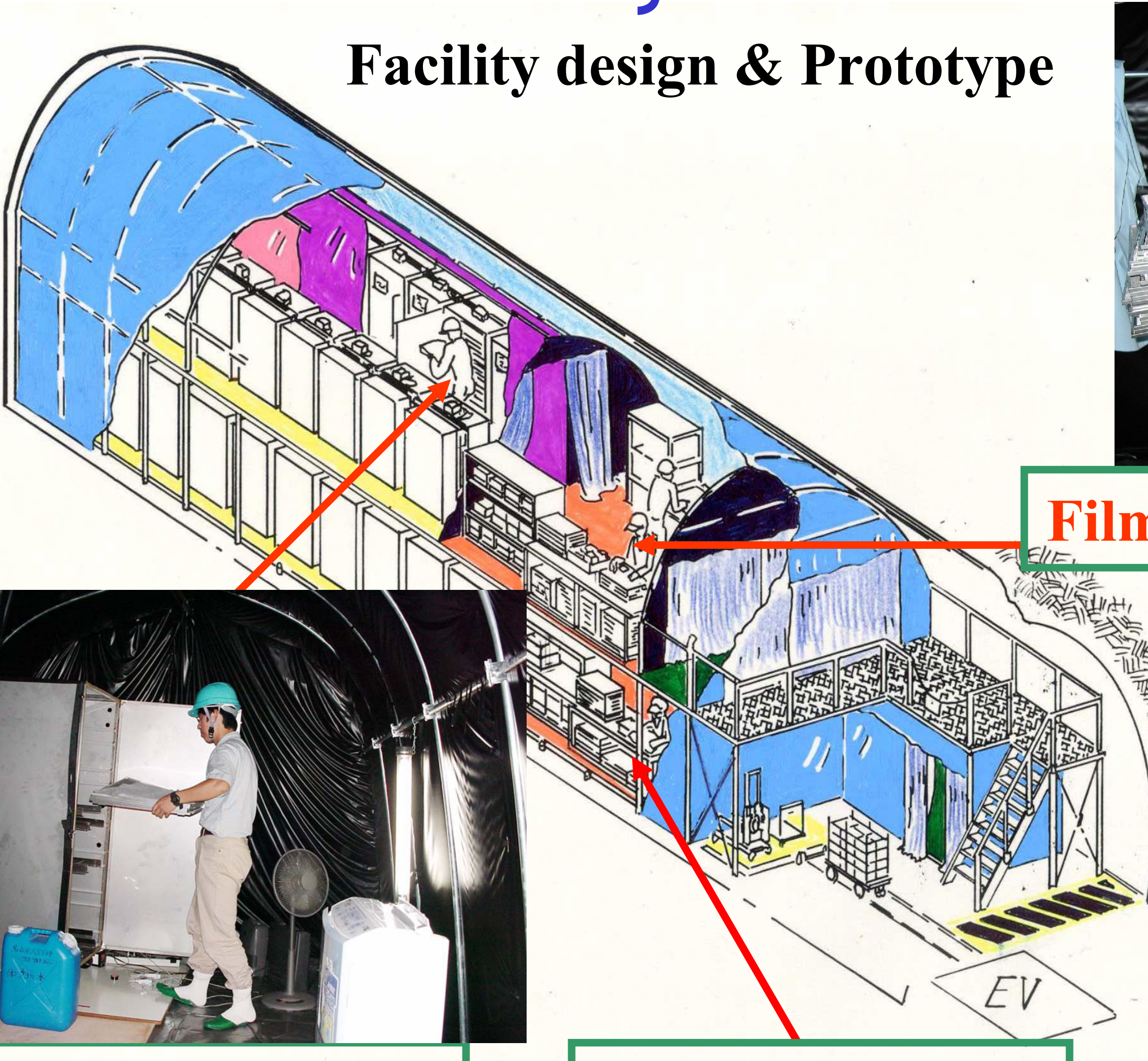
2nd room 1/400(220m.w.e.)

Under construction

Refresh Facility

Taku Nakamura(Nagoya Univ.
R&D @ Nagoya & Fujifilm

Facility design & Prototype



Film lay out on the plates

Film installation

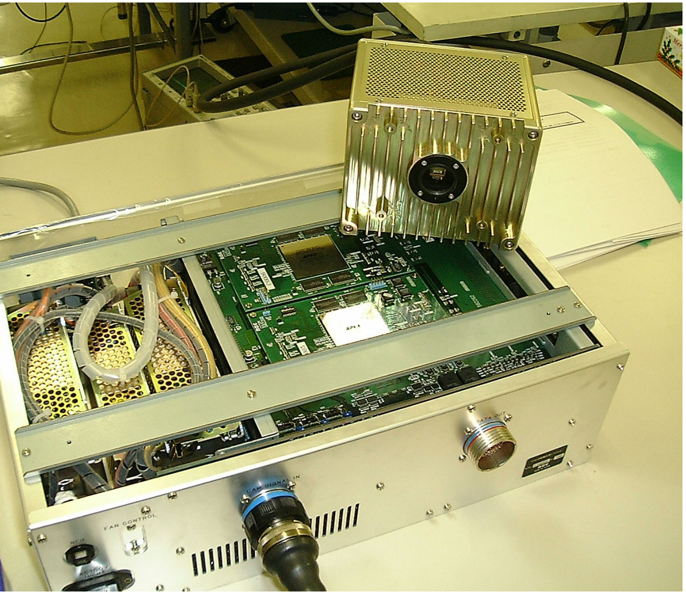
Vacuum packing

Room Size

4.5m × 4.5m × 20m

Film read-out **Next generation**

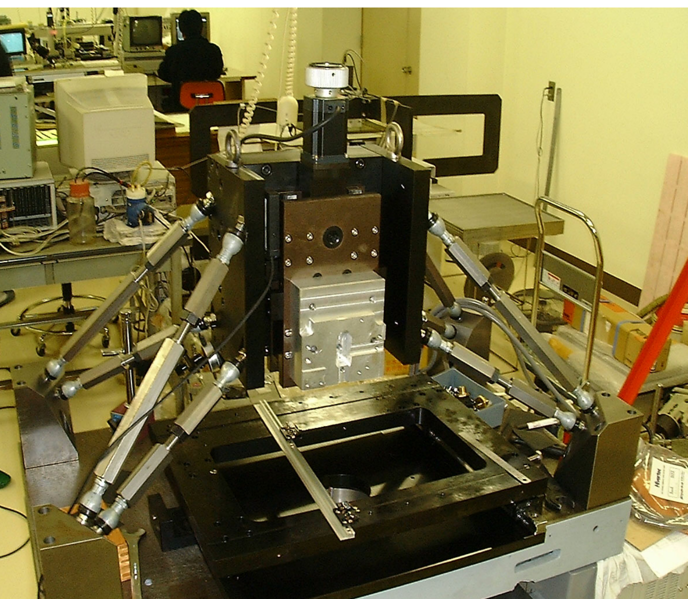
T.Nakano(Nagoya Univ.
R&D @ Nagoya

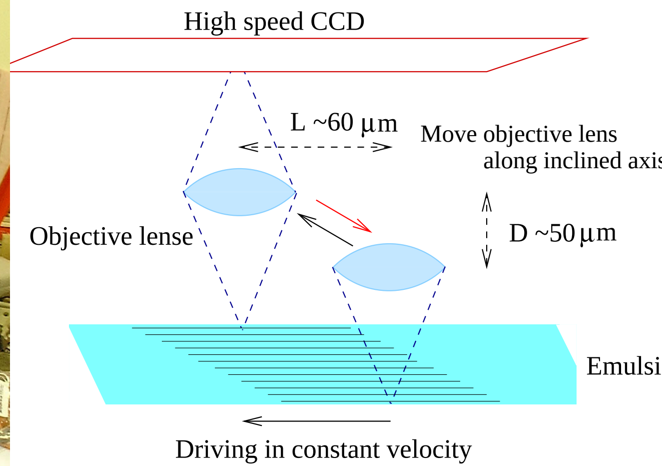


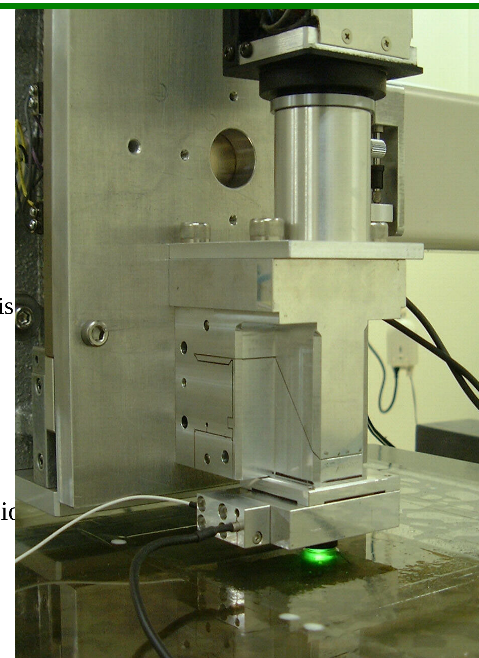
S-UTS Scanning speed: 40cm^2/h

×40 faster than current system (UTS)

- **fast CCD (3k frame/sec) : tested**
- **FPGA preprocessor and track recognition board : in progress**
- **actuator/stage (piezo) synchronisation: tested**
- **mechanics : tested**
- **S-UTS ready by Spring 2003**





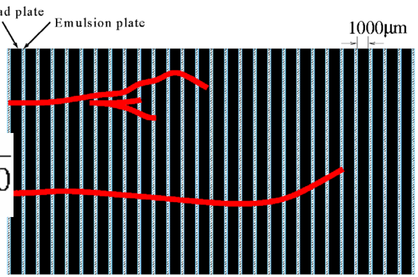


Electron identification

T.Toshito(Nagoya Univ.)
Test exp. @ CERN (May200

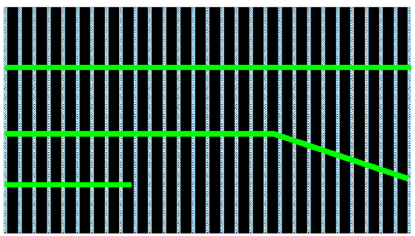
Shower detection & χ^2 analysis

e

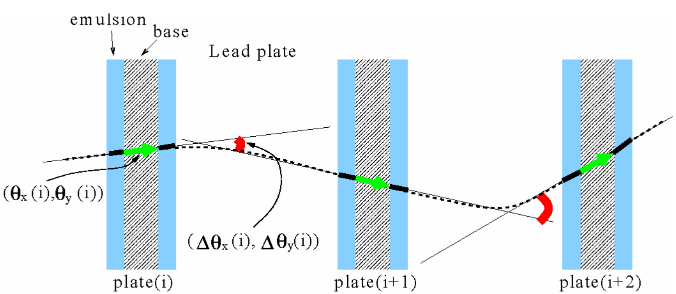


$$E_e(z) = E_0 e^{-\frac{z}{X_0}}$$

π

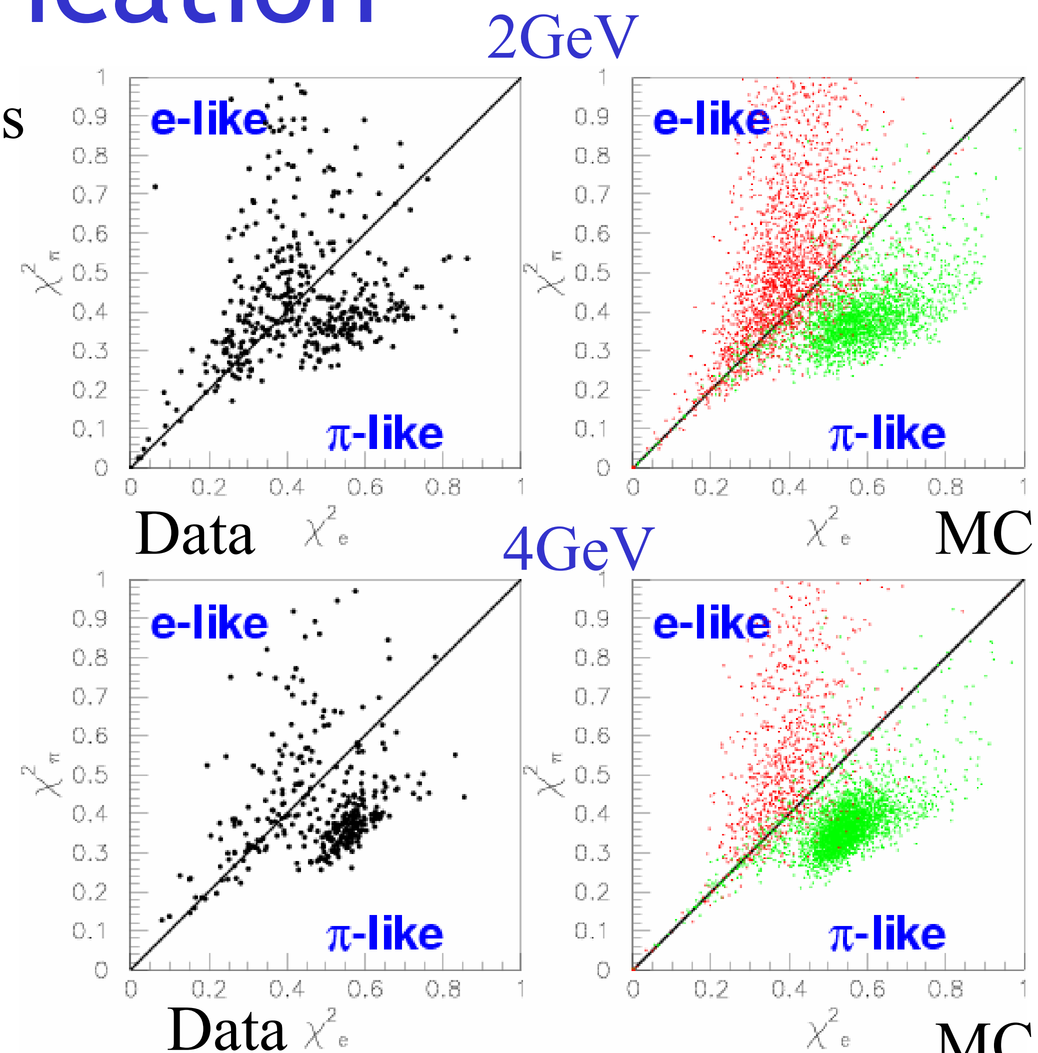


$$E_\pi(z) = E_0$$



$$\Theta_{e,\pi}(i) \equiv \sqrt{\left(\frac{13.6(MeV/c)}{p_{e,\pi}(z)}\sqrt{d/X_0}\right)^2 + (\sqrt{2}\delta\theta)^2}$$

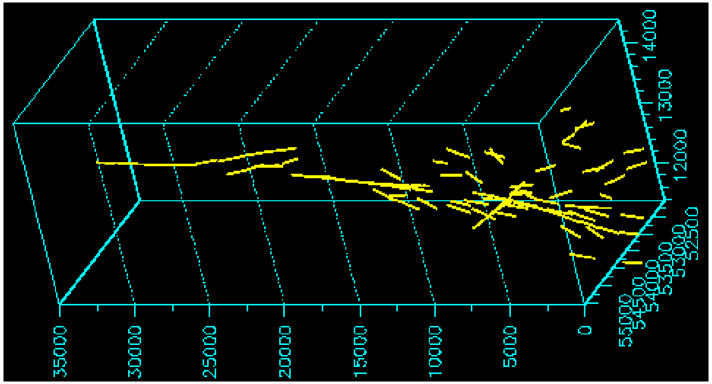
$$\chi^2_{e,\pi} \equiv \sum_{i=1}^{N-1} \frac{\{(\Delta\theta_x(i) - \Delta\Theta_{e,\pi}(i))/\Delta\Theta_{e,\pi}(i)\}^2 + \{(\Delta\theta_y(i) - \Delta\Theta_{e,\pi}(i))/\Delta\Theta_{e,\pi}(i)\}^2}{2(N-1)}$$

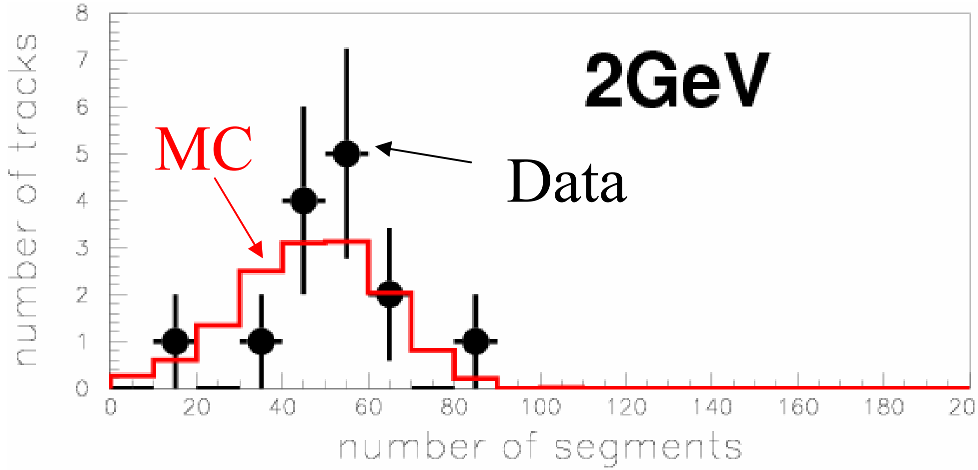


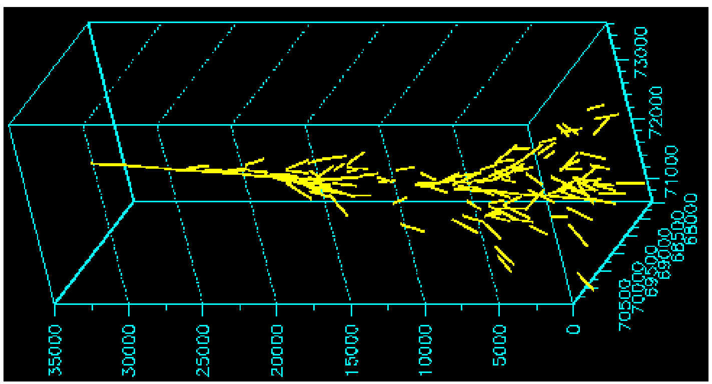
eff~90%,
mis-id prob~5%

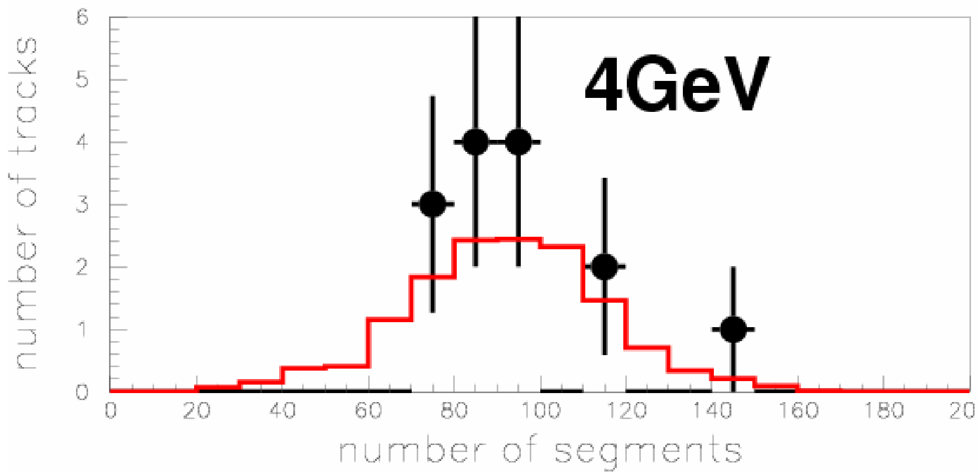
Electromagnetic shower

T.Toshito(Nagoya Univ.)
Test exp. @ CERN (May200
In analysis







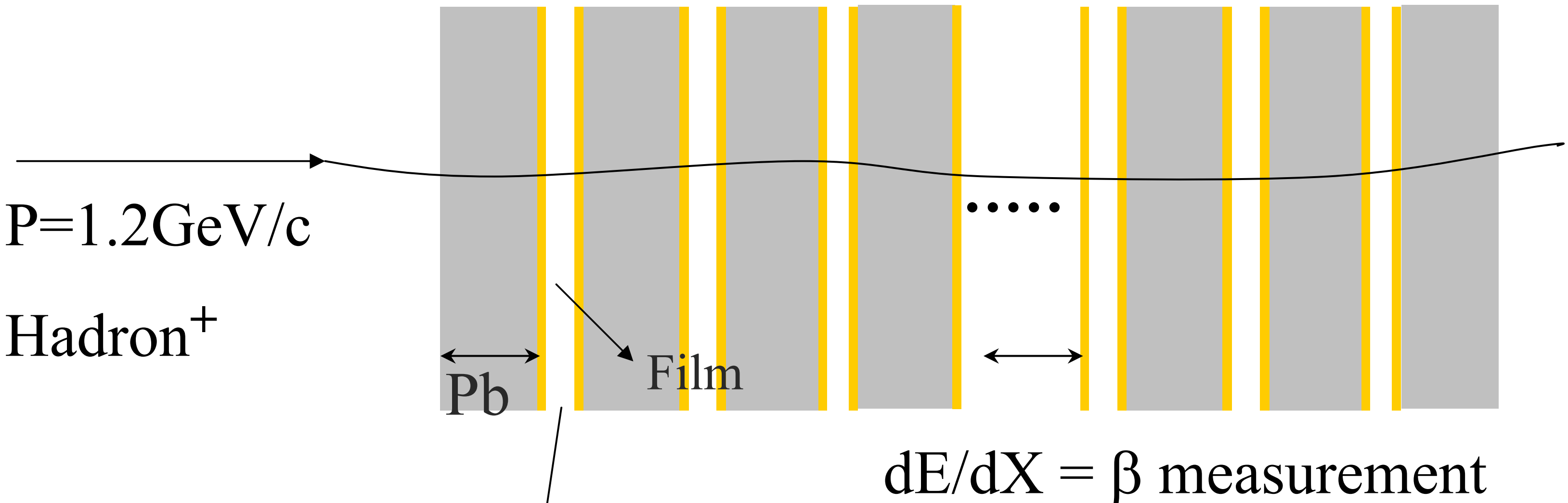


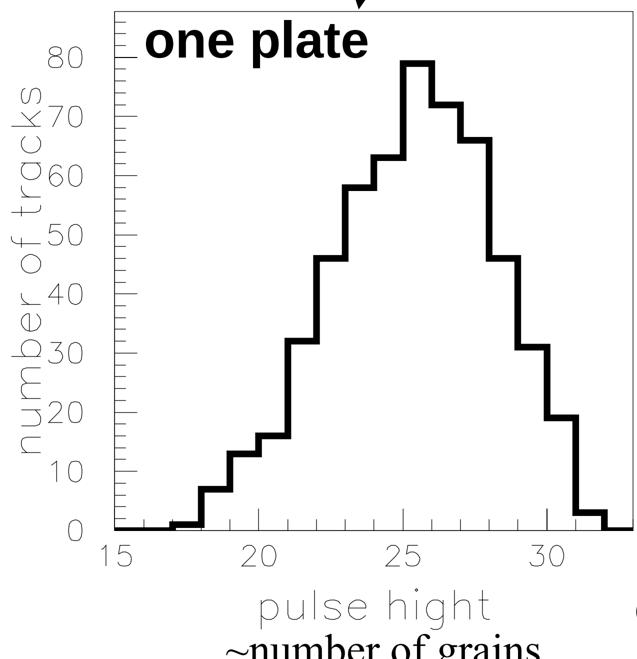
Energy determination
by calorimetric method
(in study)

$$\frac{\Delta E}{E} \sim \frac{0.4}{\sqrt{E(GeV)}}$$ @ a few GeV

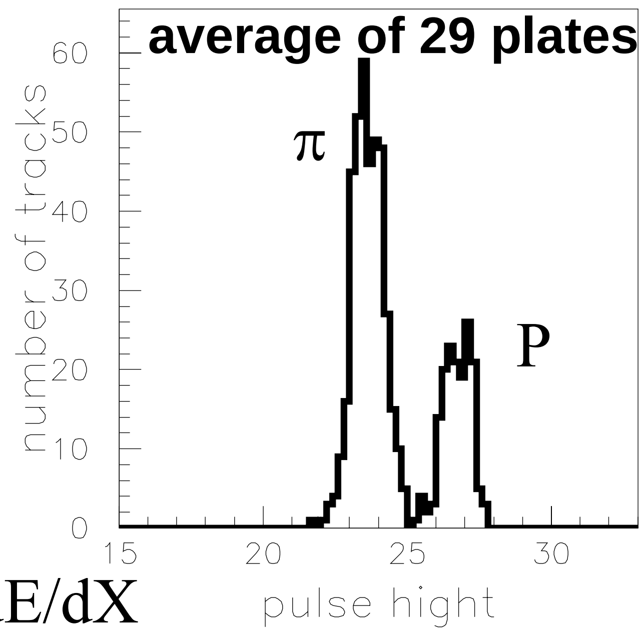
T.Toshito(Nagoya Univ.)
Test exp. @ KEK(Nov.200

dE/dX measurement





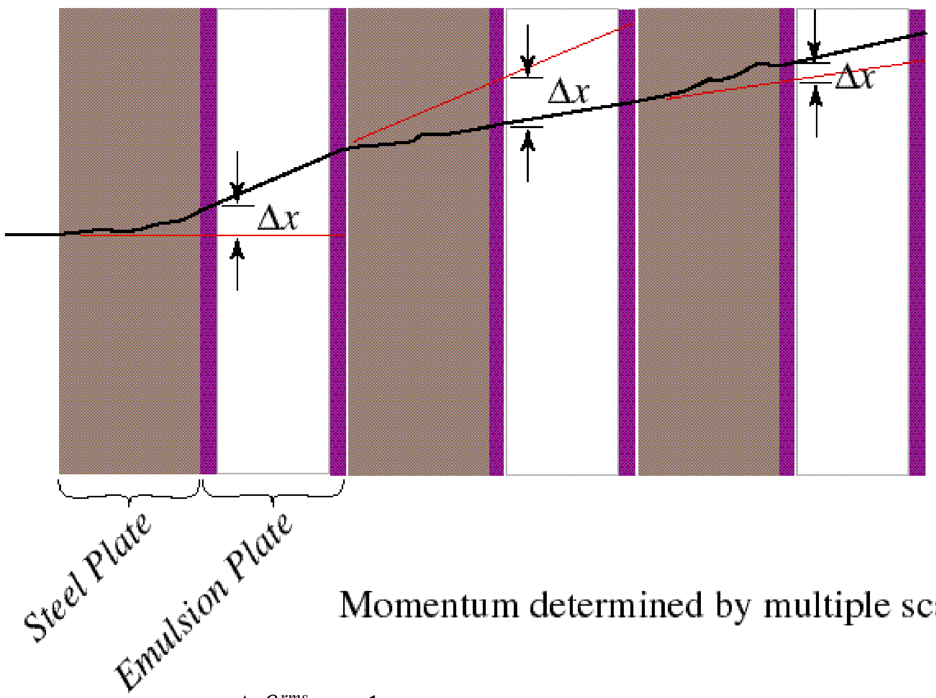
dE/dX



Momentum measurement

M.Komatsu(Nagoya Univ.)
R&D @ Nagoya
for DONUT Analysis.

Pβ measurement using Multiple Scattering



Momentum determined by multiple scattering:

$$\frac{\Delta \vartheta^{rms}}{\vartheta^{rms}} \propto \frac{1}{\sqrt{n}}$$ n : number of measurements

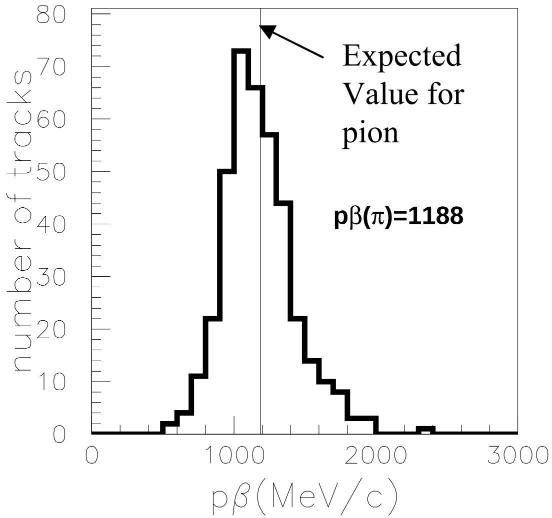
For example: 10 GeV/c has *rms* deflection of 0.3μm

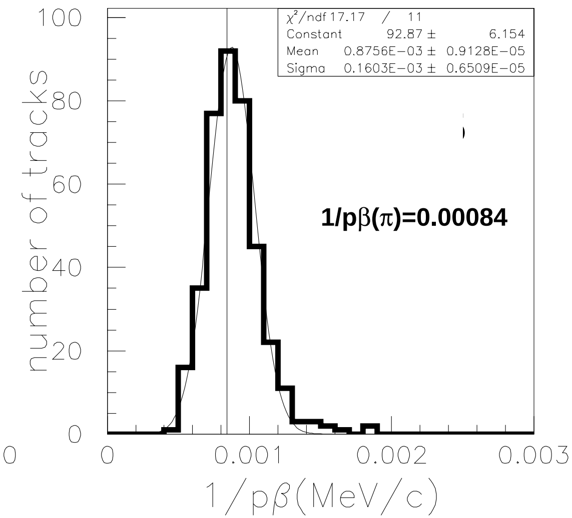
T.Toshito(Nagoya Univ.)
Test exp. @ KEK(Nov.200

Momentum measurement

Pβ measurement using Multiple Scattering

Low dE/dX

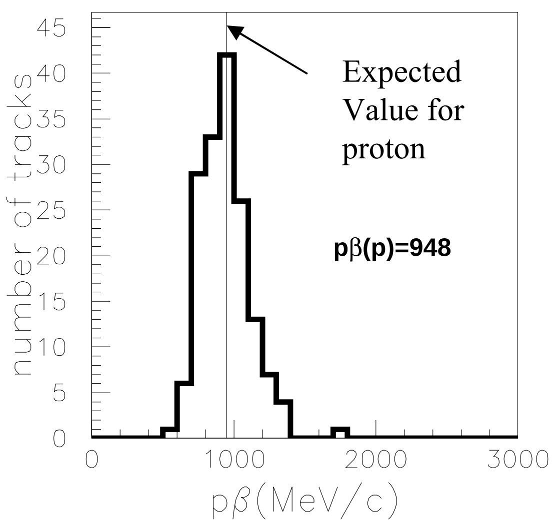


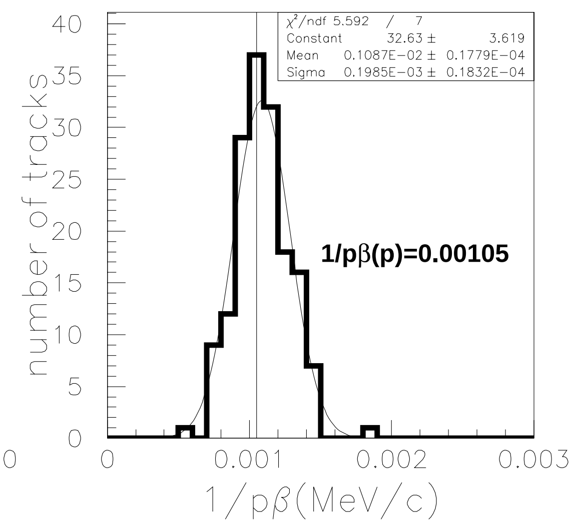


Consistent with Pion

Resolution $\sigma_{p\beta}$ ~16%

Higher dE/dX





Consistent with Proton

Münster (Germany) group

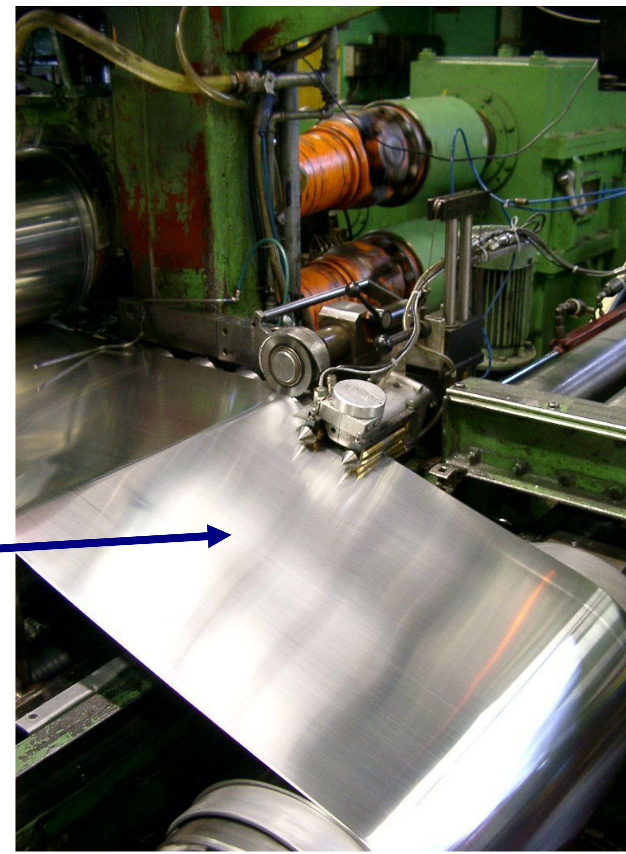
Lead plate production

Lead Production :

- Low radio activity lead (Boliden)
  Pb+0.7%Ca
- Detailed specifications in progress
- Lead production of 8 t /day possible
- Thickness control : 1030 ± 10 μ m
- Transportation : 111 truck load (16.2 t) for 1800 t

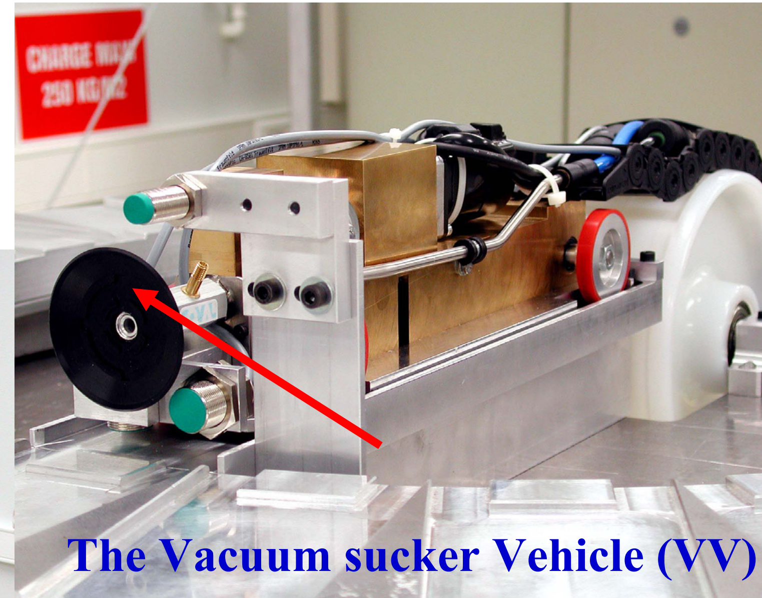
Goslar (Germany)

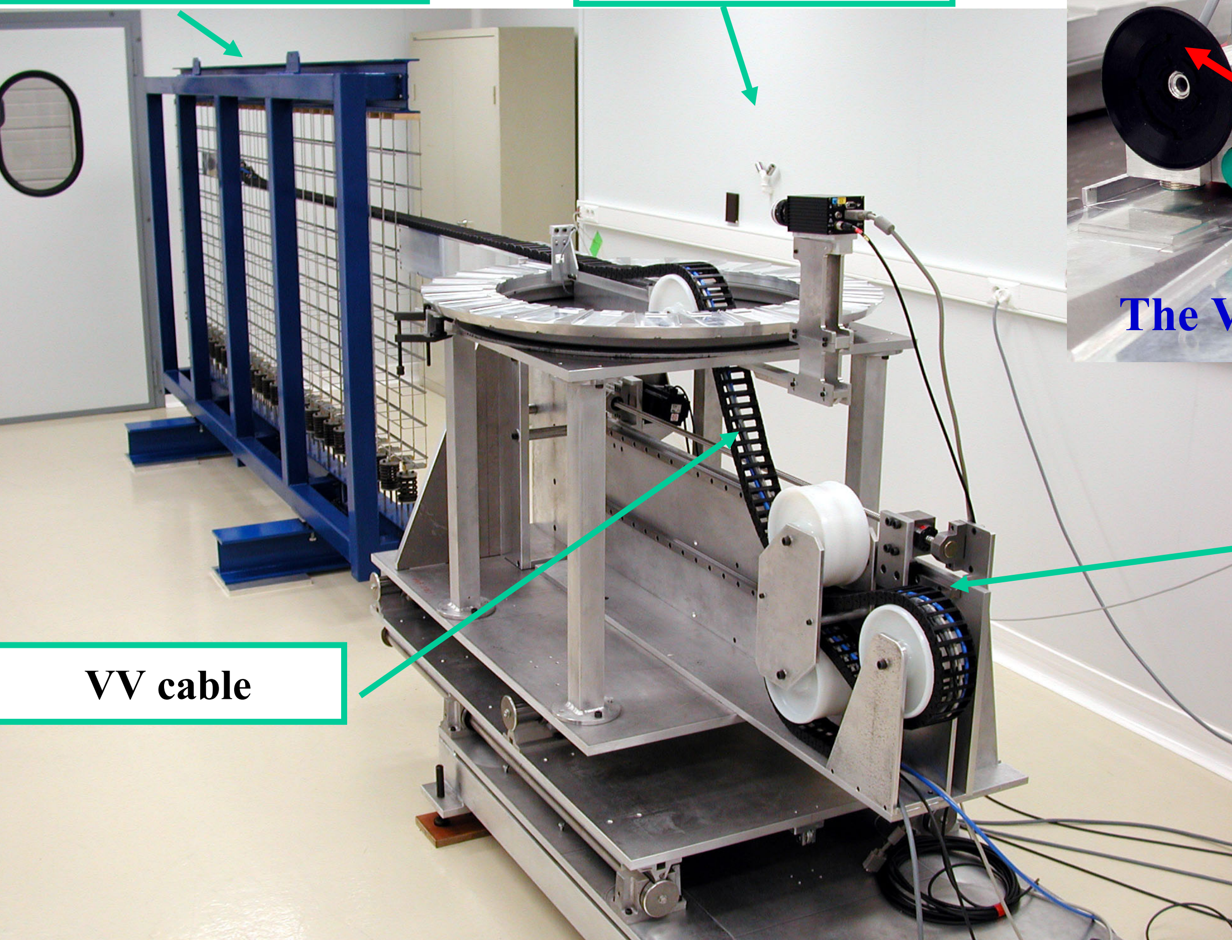
Rolling and thickness control



N.Naganawa (Nagoya Univ.)
Chemical compatibility test @ NAGOYA

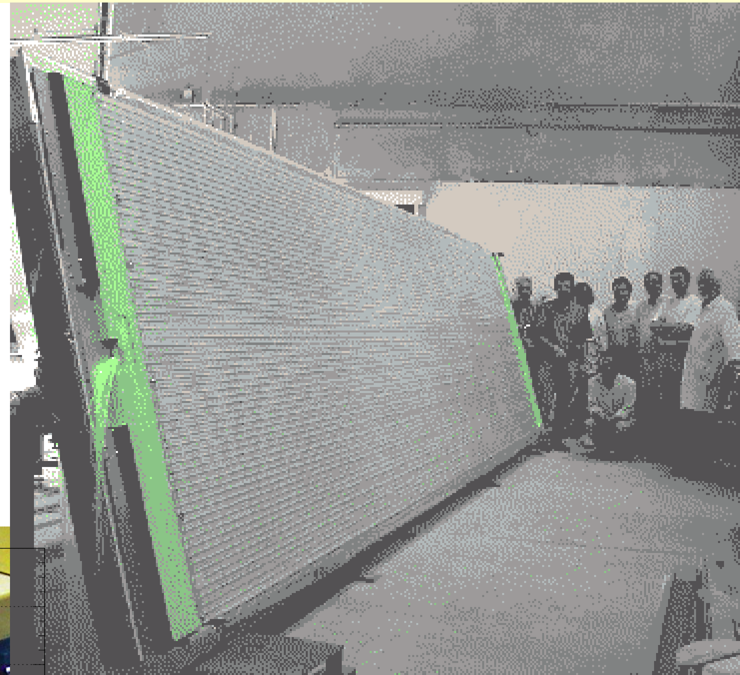
Brick Manupulator System prototype tests



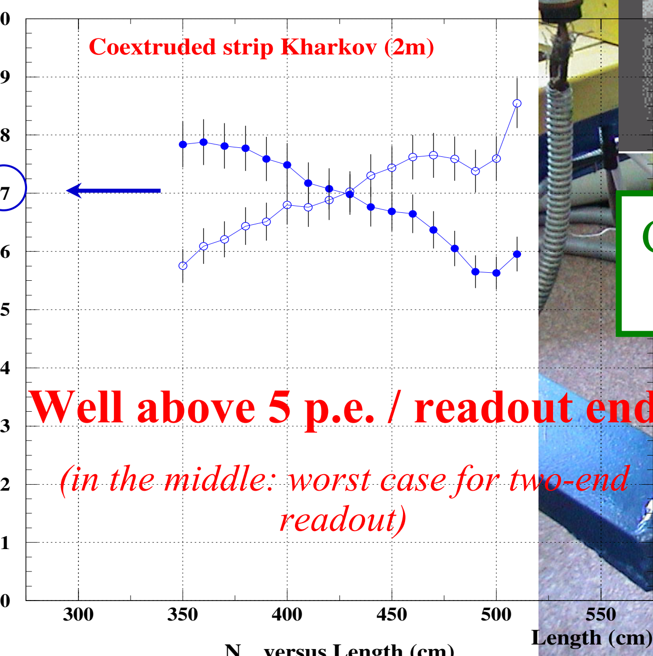


Target Tracker

Tooling and assembly process ready



Handling mechanical tests



Well above 5 p.e. / readout end

(in the middle: worst case for two-end readout)

Co-extruded TiO_2 results

Kharkov coextrusion head

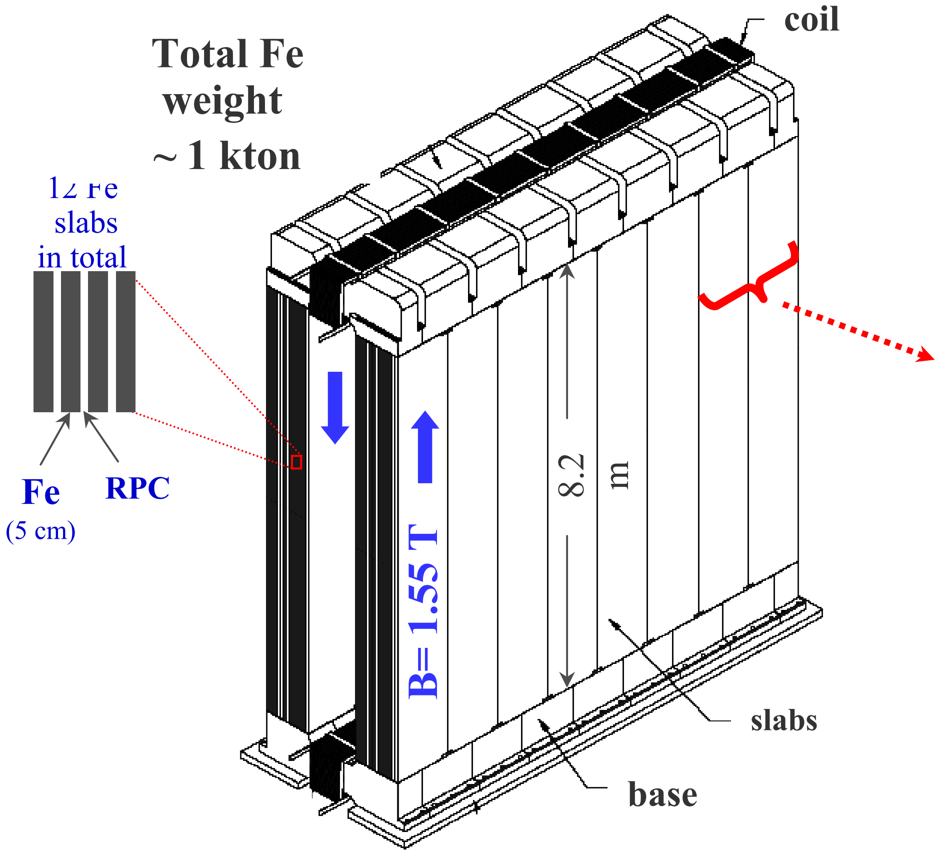
Dipolar magnet

LNF Frascati (Italy) group

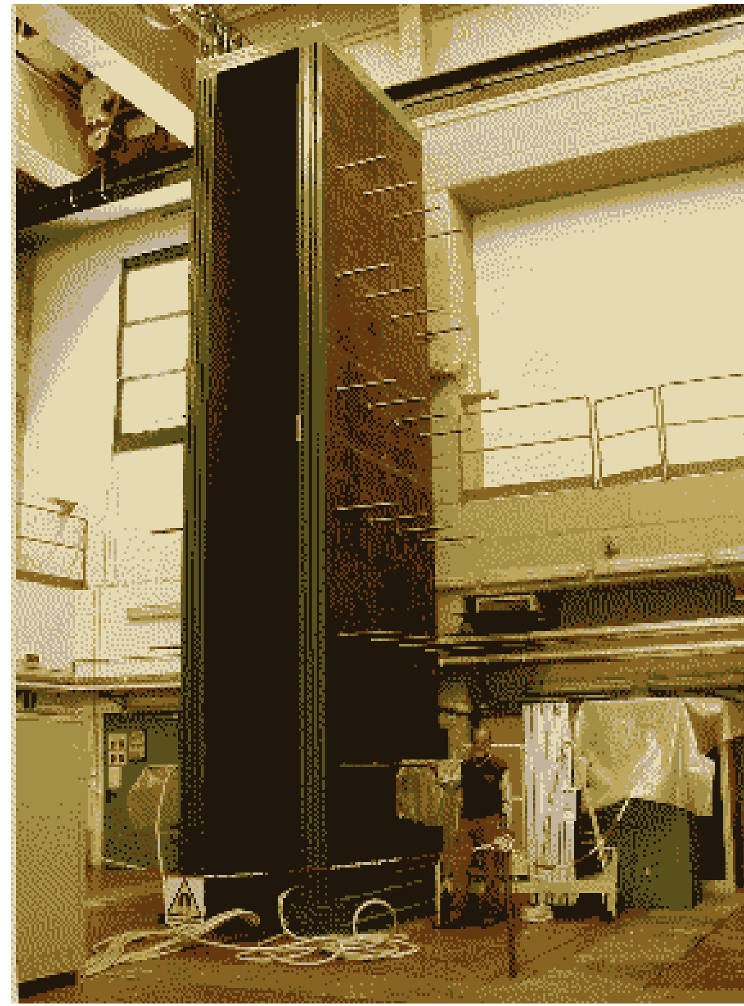
RPCs inside gaps: muon identification , shower ener

Drift Tubes: muon momentum

Hamburg (Germany) group



Full scale prototype magnet
Constructed and tested at Frascati



- Iron slabs ordered, resuming ordering machining
- Yokes, coils, supplies being ordered
- starts installation : march 2003 ← critical path
- magnetic field in good agreement with simulation
- some fringing field in the area of MAPMT (10 Gauss)

Schedule

	starting	ending
Spectrometer	March 2003	September 2004
Drift tubes, XPC	January 2004	April 2005
Target walls & tracker	December2003	September 2005
BAM	October 2004	April 2005
BMS	April 2005	December 2005
ECC Brick filling	July 2005	June 2006

Status of CNGS

K. Elsener (CERN/CNGS)
Status at Feb. 2003

1) **Civil Engineering:**

- **All excavations are now completed (see http://cern.ch/cngs)**
- **Concreting work is ongoing, expected to be completed by end May 2003.**

2) **Next steps:**

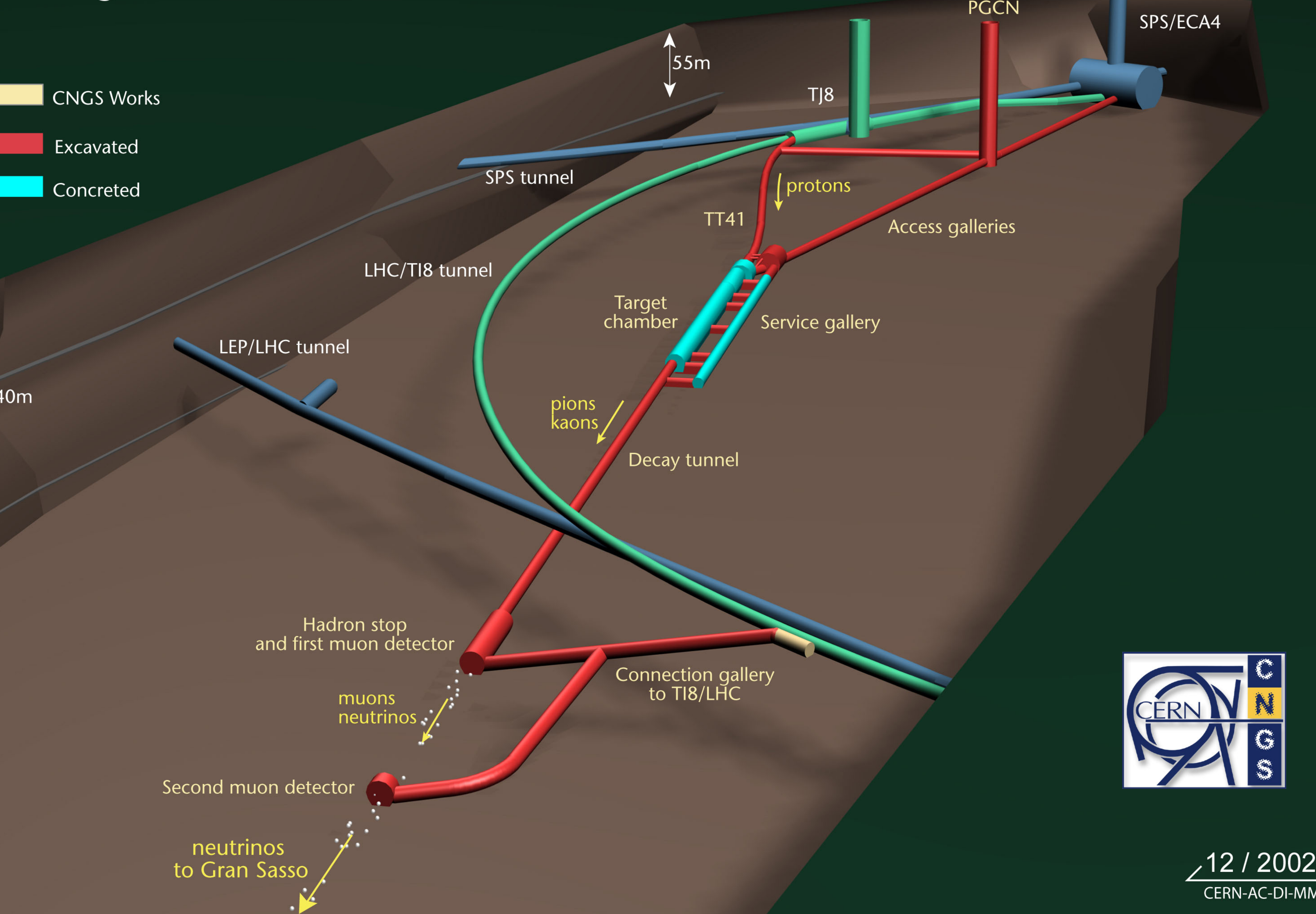
- **Installation of beam dump ("hadron stopper"): Summer 2003**
- **Decay tube installation (1 km long steel tube, 2.45 m diameter): Sept 2003-April 2004**

in parallel:

- **delivery of all magnets and quadrupoles for the proton beam during 2003**
- **delivery of first final horn and final reflector in 2003**
- **start extensive series of horn tests in final configuration**

3) **Planned start-up of CNGS beam: - unchanged, spring 2006**

CERN NEUTRINOS TO GRAN SASSO
Underground structures at CERN



12 / 2002
CERN-AC-DI-MM

Summary

OPERA on CNGS : ν_τ Appearance experiment

sensitive to the SK atm. parameter region

OPERA detector and CNGS beam can be ready in 2006.

(One year delay from the proposal due to CERN financial problem)

First evidence in few years data taking