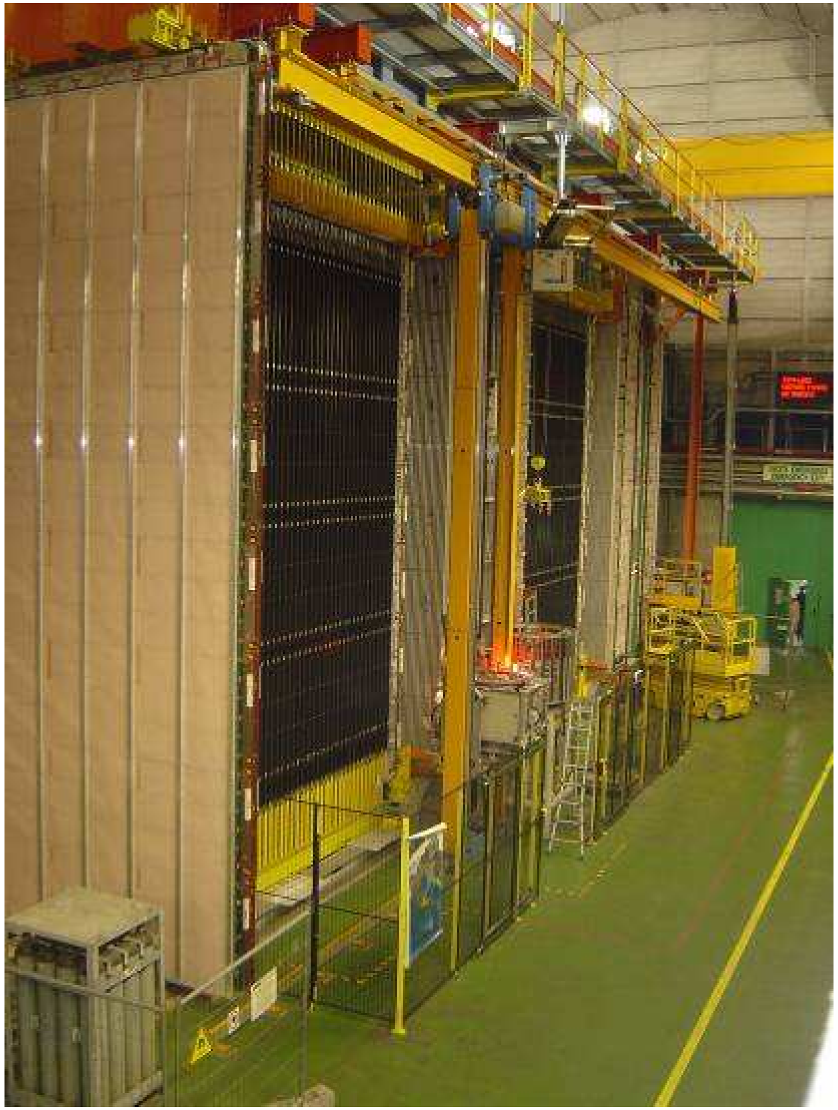
OPERA/CNGS1

Oscillation Project with Emulsion-tRacking Apparatus

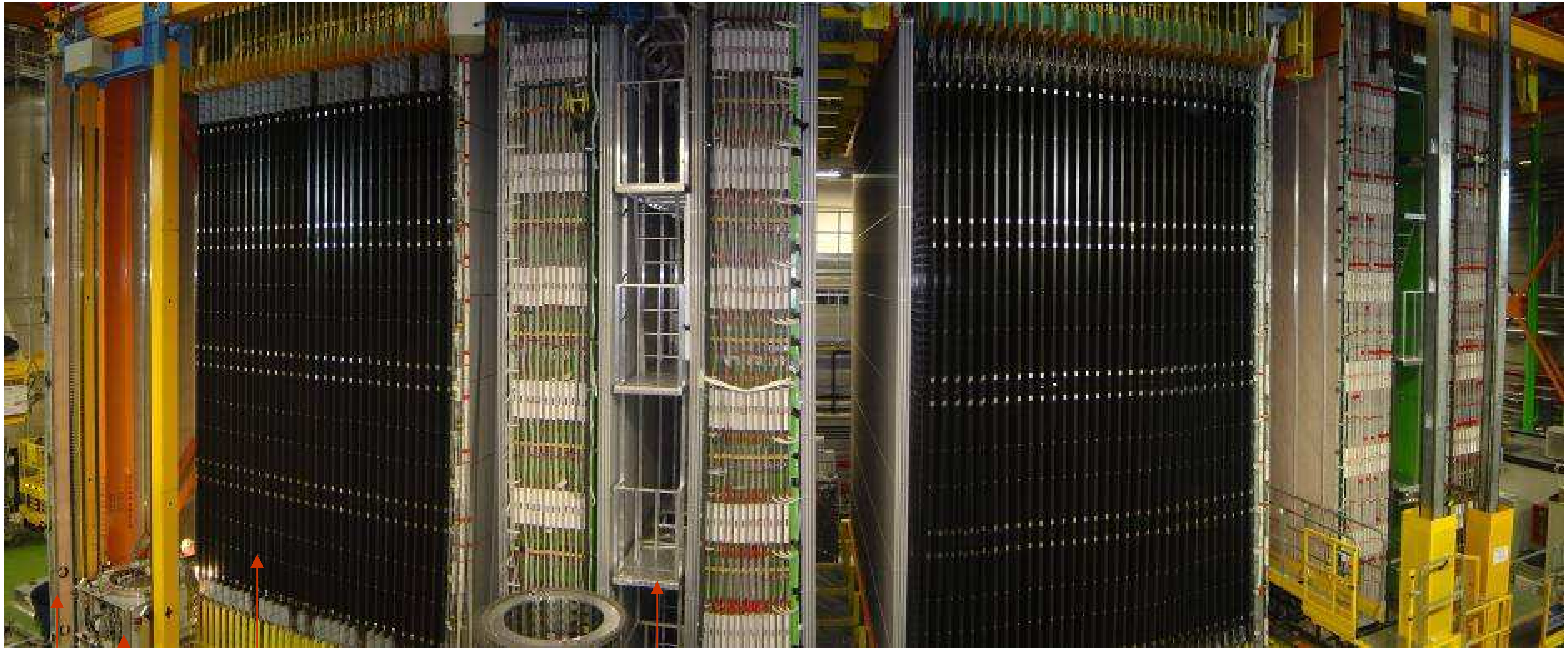
OPERA



1. Electronic detectors
   status of installation
2. DAQ and data analysis software
3. Results from the commissioning of the electronic detectors
   - TT
   - RPC
   - HPT
4. Cosmic and CNGS run results
5. Brick processing & Emulsions analysis
   - Scanning facilities
   - Track matching and analysis
6. Test beam activities
7. Brick production and Detector filling: status
8. OPERA sensitivity updated
9. Conclusions

Electronic detectors installation & commissioning completed

SM1 SM2



Veto

BMS

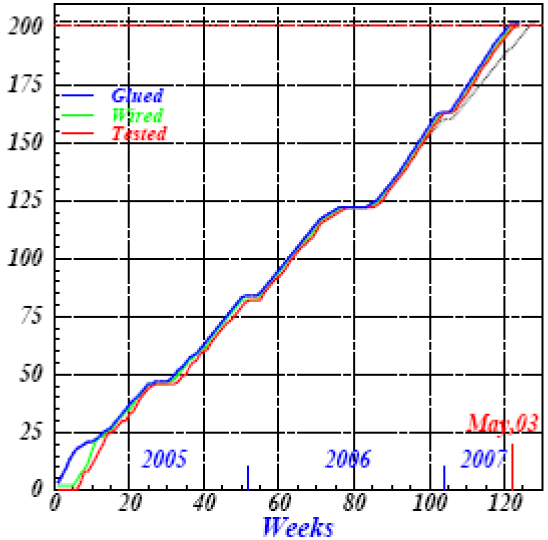
Target tracker

Spectrometer:
XPC, HPT, RPC, magnet

VETO & HPT/SM2
commissioning in progress

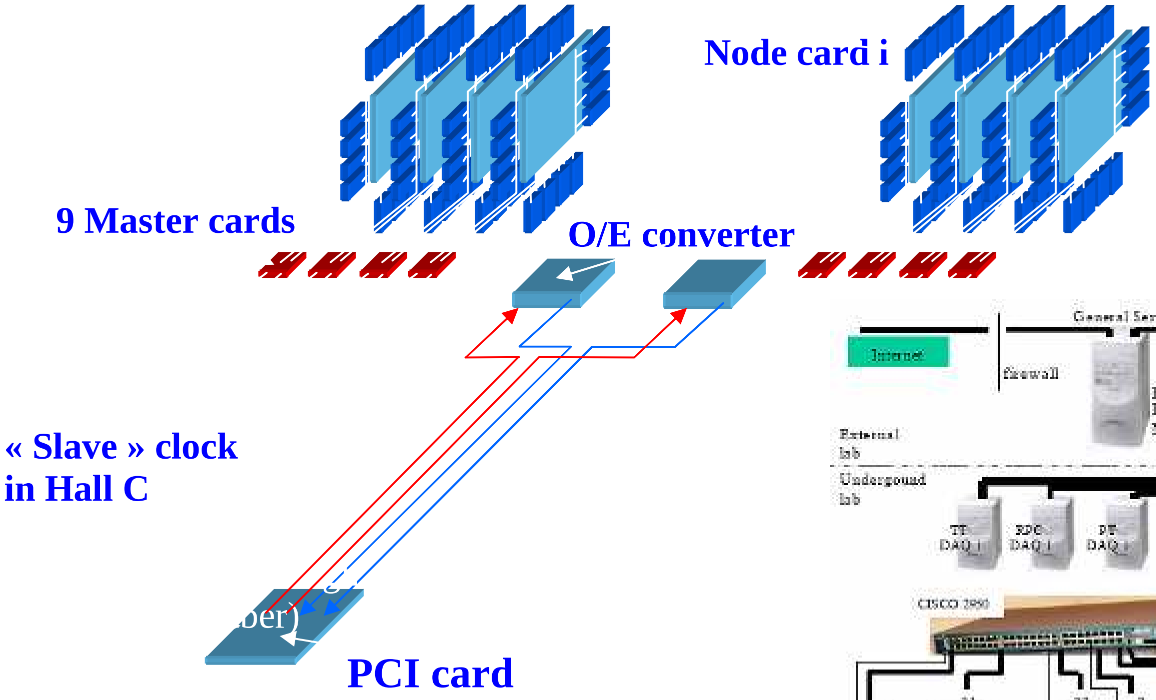
Completion of HPT installation

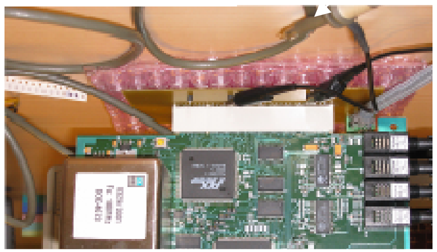
- March 2007: HPT 9&11
- May 2007: end of mass production
- June 2007: HPT 10&12

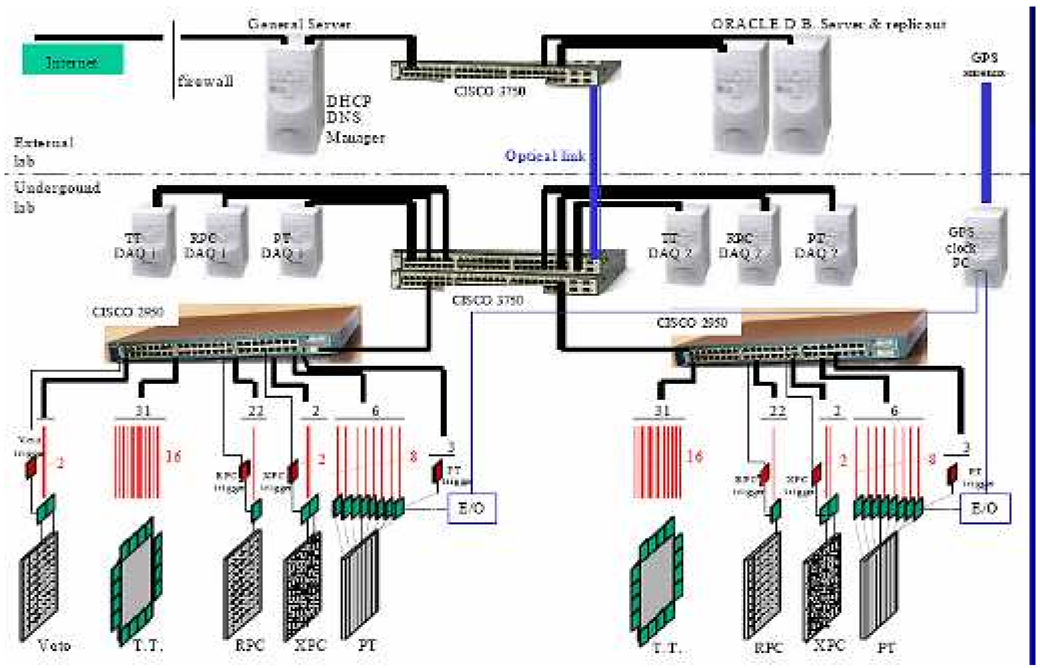


DAQ readout architecture

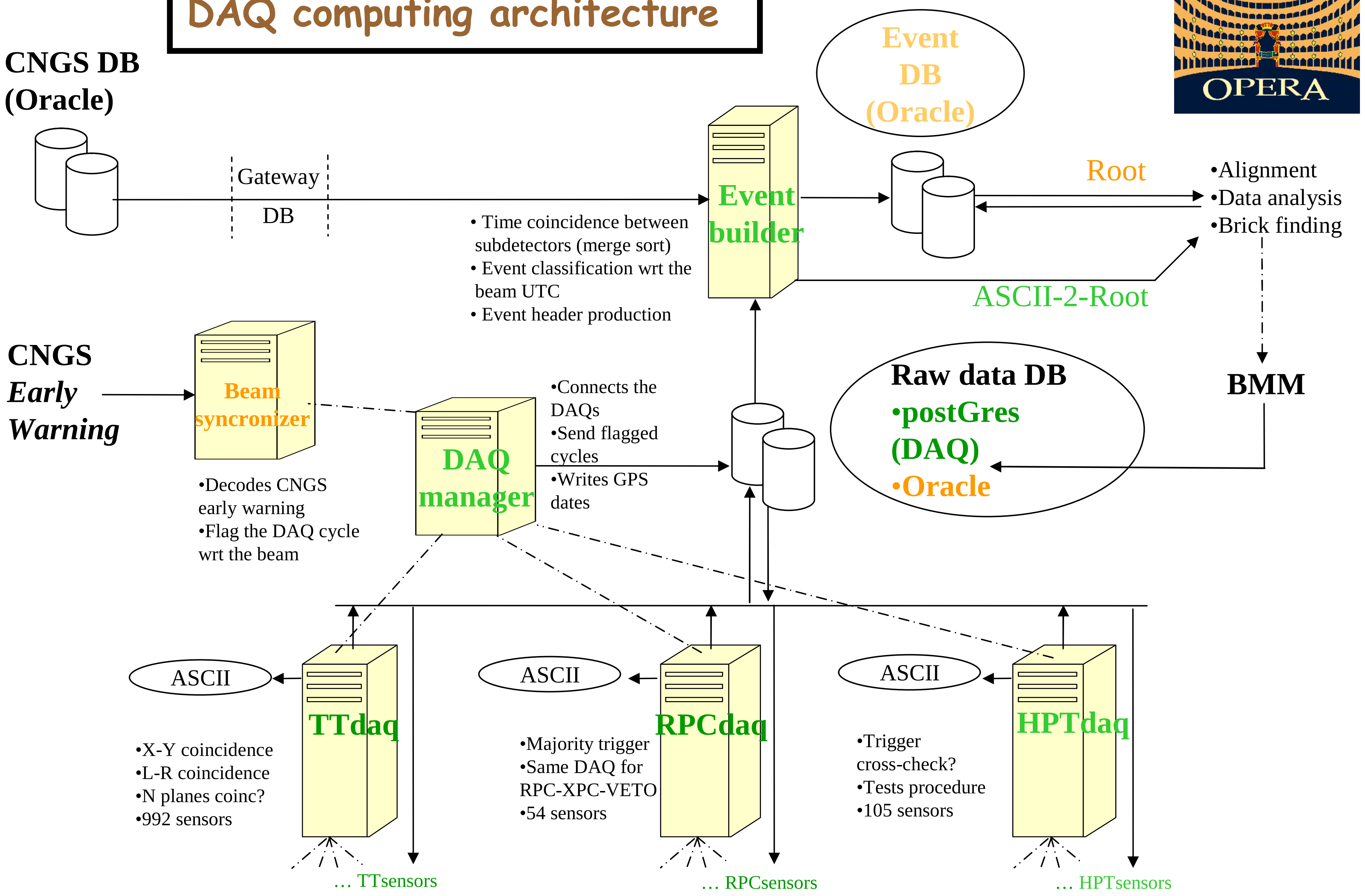
➢ Each individual node runs a local 100MHz clock generated via a common 20MHz clock send from a precise and stable oscillator. The oscillator is plugged onto a dedicated PCI board which locks the clock signal on the GPS and encode specific commands (propagation delay meas., reset, reboot etc).



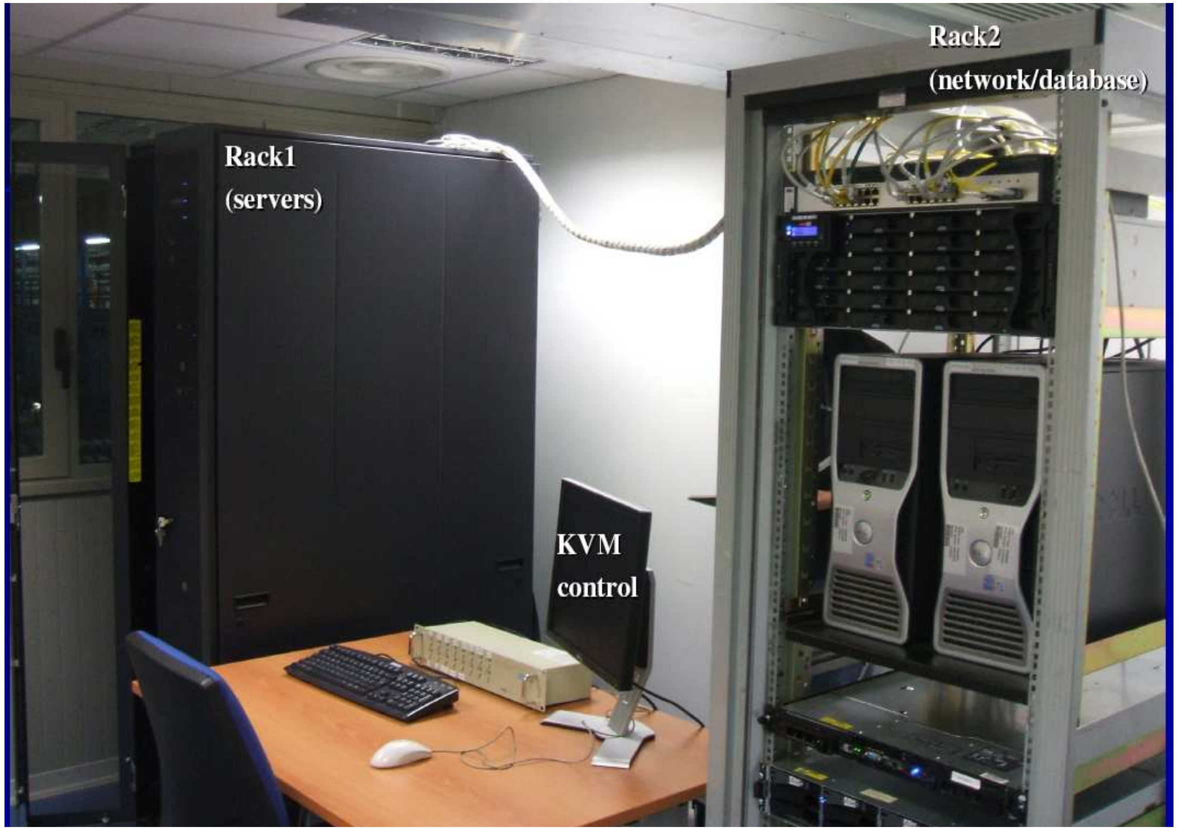




DAQ computing architecture



Control room

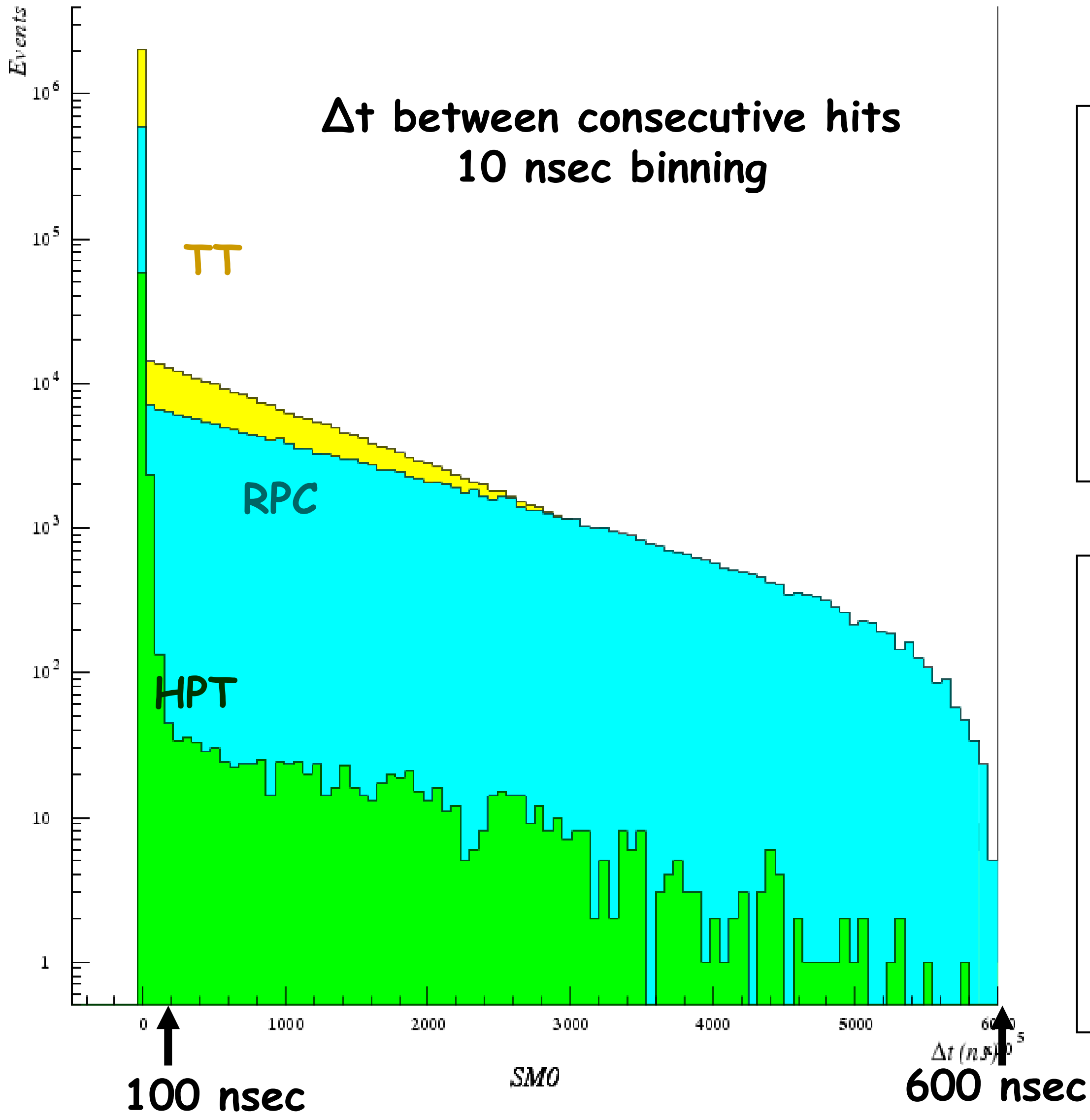


Currently in Hall B:

- DAQ servers
- Gateway server
- DAQ-MMS Database

DAQ DB: migration to Oracle completed

DAQ: event building concept



Trigger for sub-detectors :

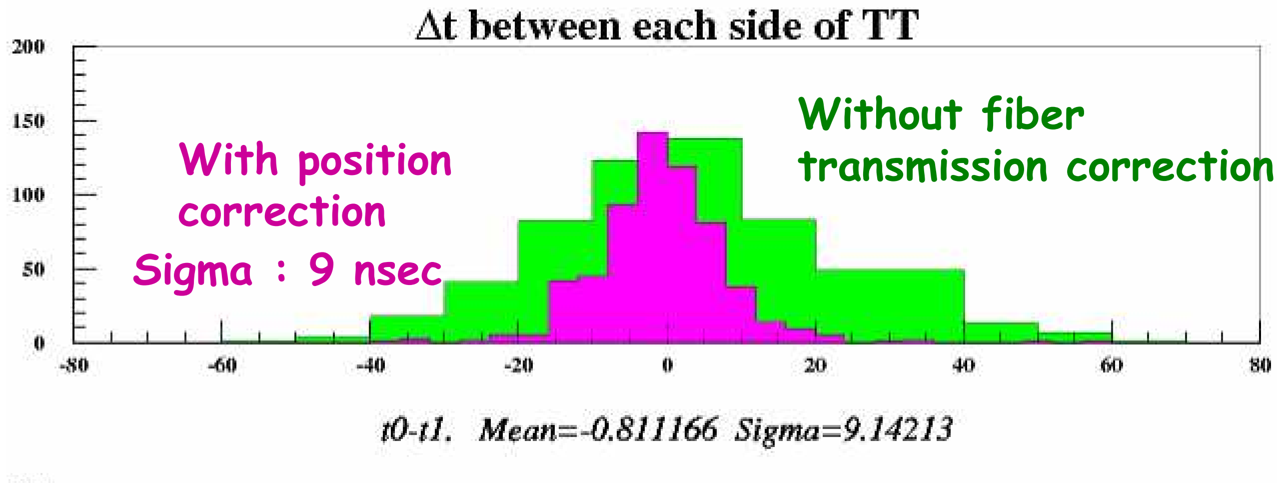
- free running mode at the hardware threshold for TT, RPC & Veto
- Common stop formed by using RPC signals (dedicated electronics) for the HPT

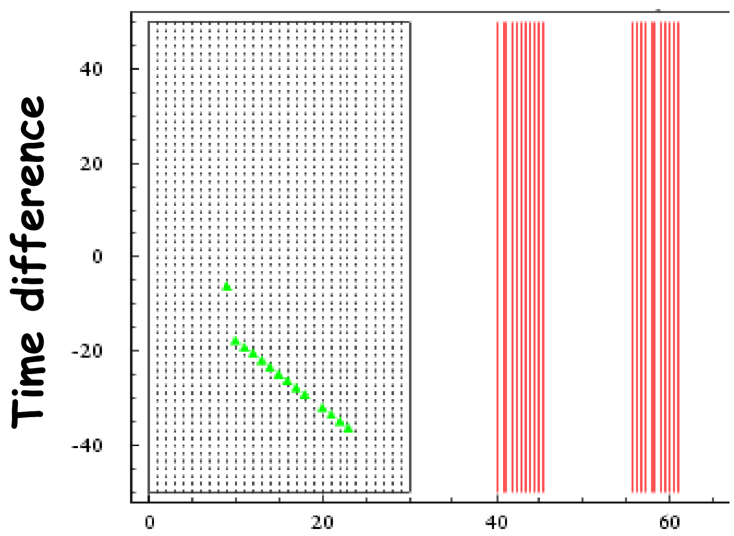
Event building :

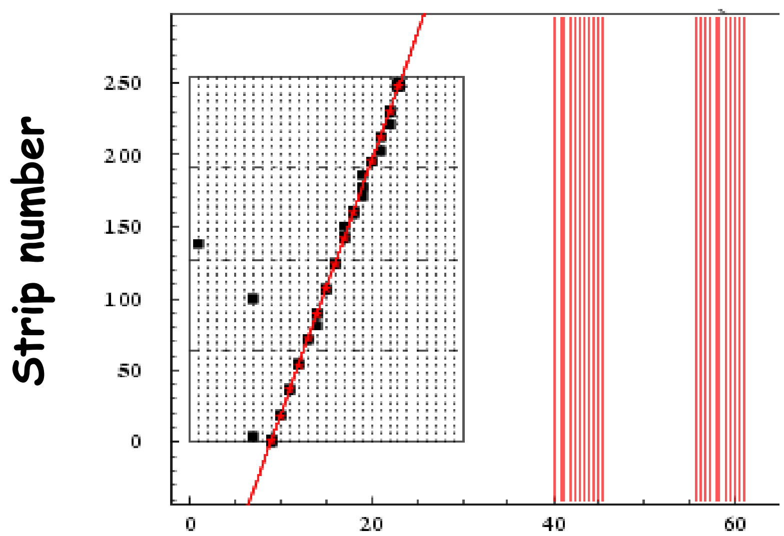
by sorting in time individual hit from sub-detectors:

- for each sub-detector in the dedicated sub-detector DAQ machine + filtering algorithms
- between sub-detectors in the event builder machine + filtering algorithms

Time stamp resolution

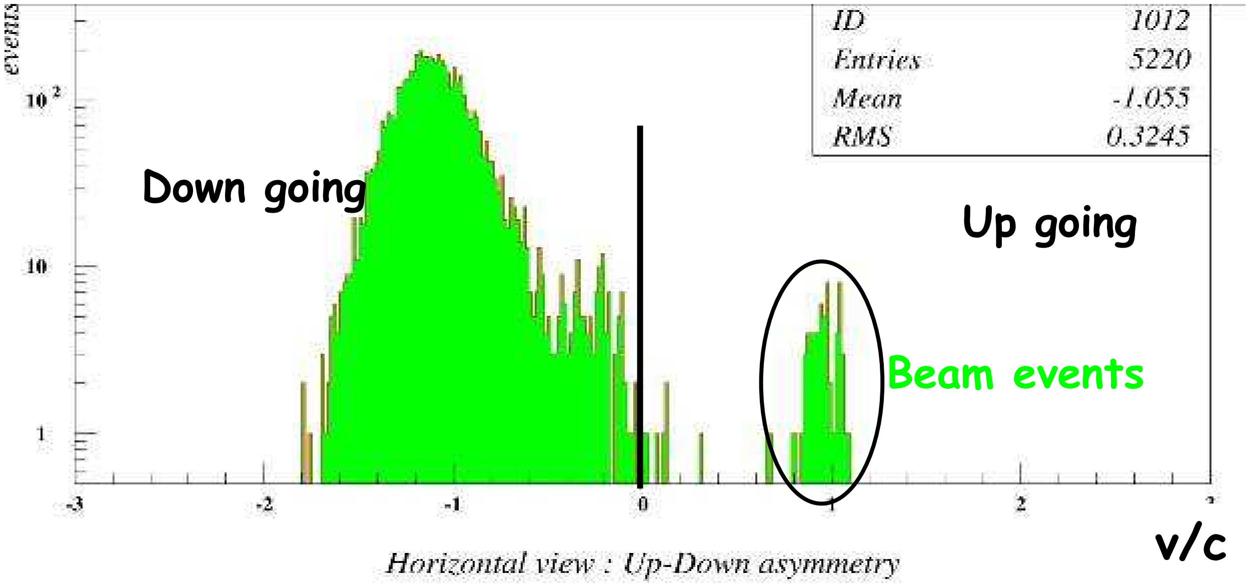




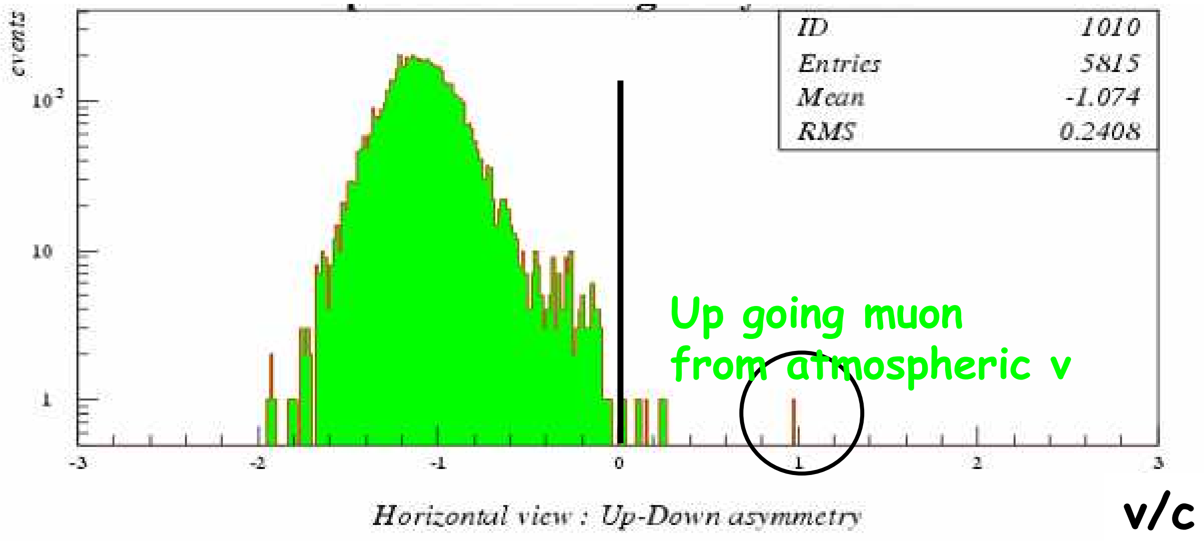


down going muon : side view

Up-going muon selection using the time stamp

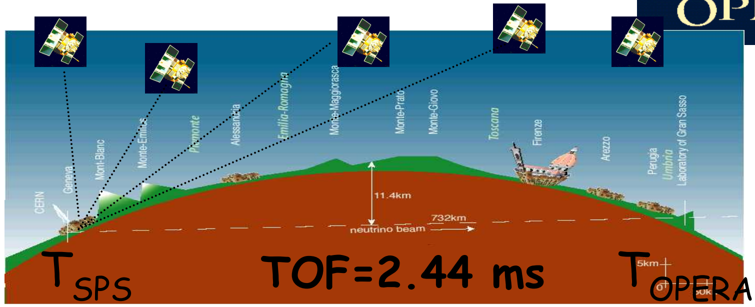


2006 data:
Cosmics and beam data



Only cosmics data:
- 44 days of data
- expected 2
- observed 1

CNGS event selection by using the GPS Timing Information



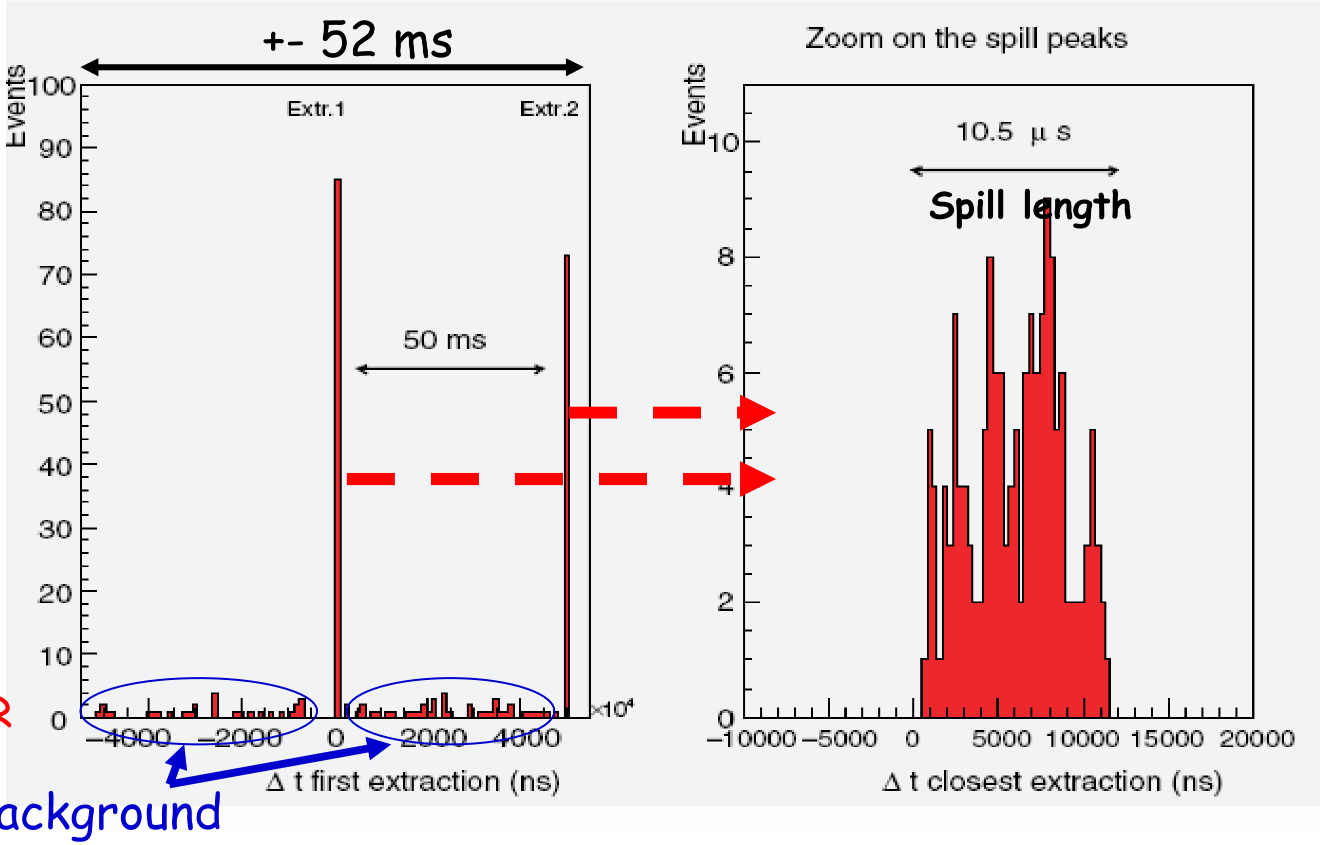
$$T_{OPERA} - (T_{SPS} + TOF) < T_{gate}$$

GPS time stamp intercalibration ~100 ns

T_{gate} slightly larger than the extraction length (10.5 μs)

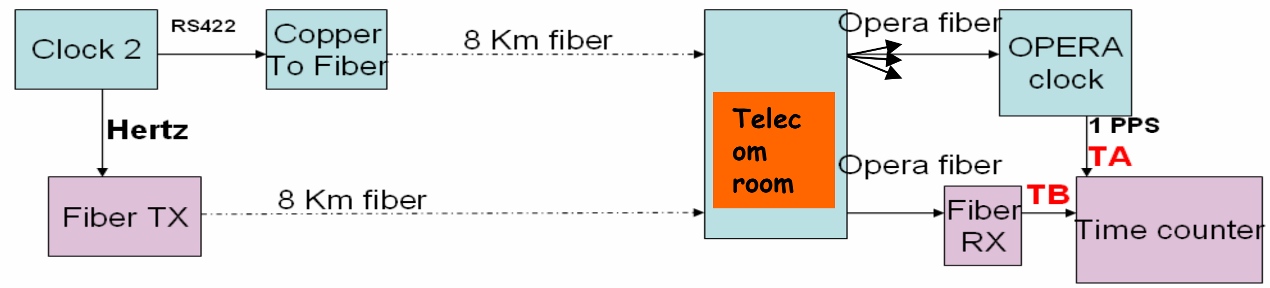
Beam time structure shown with an enlarged windows around the first extraction

Searching events in $\mathcal{O}$(ms) windows just yields a narrow peak of the order of the spill width (10.5 us) with practically no CR background: $\mathcal{O}(10^{-4})$



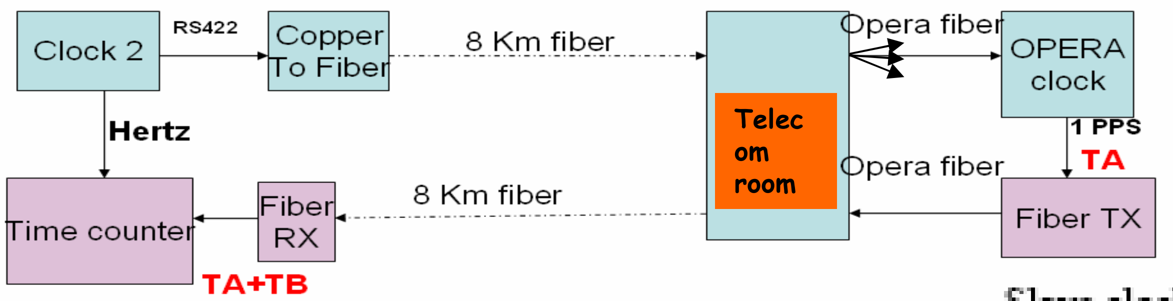
Complete Calibration of the time distribution chain

T0 1) Hertz and RS422 are emitted at T0. Measure the arrival times difference underground TB-TA



2) The components of the B arm are reshuffled to invert the direction the TB+TA is measured

T0



Calibration of the paths for OPERA, BOREXINO, LVD towers 1,2,3 performed on July 06:

Measurement on two paths one of which is the standard one:

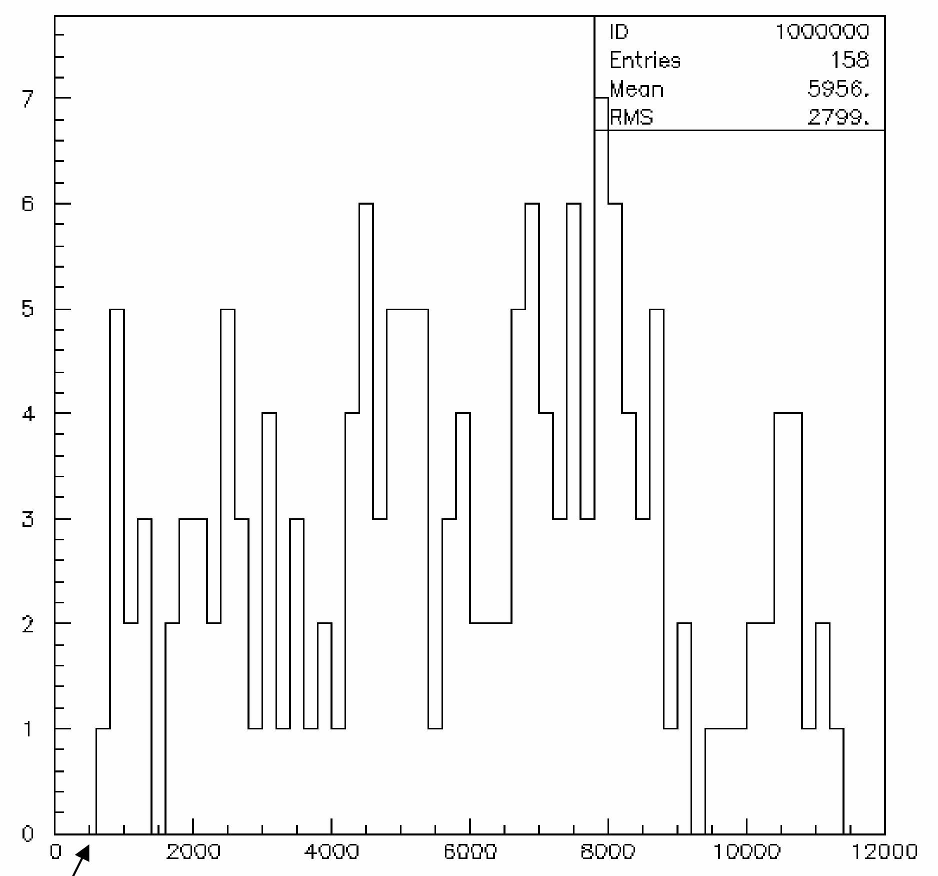
T1=TA+TB
T2=TA-TB

Solve for TA and TB

Slave clock delays:

Slave clock	Delay w.r.t clock 2
OPERA	40975.4 ns
BOREXINO	41729.5 ns
LVD Tower 1	42116.5 ns
LVD Tower 2	42063.8 ns
LVD Tower 3	42040.6 ns

Absolute Time Comparison



600 ns offset, reason for additional 100 ns offset found at CERN

➔ 500 ns offset remaining

New calibration campaign 2007:

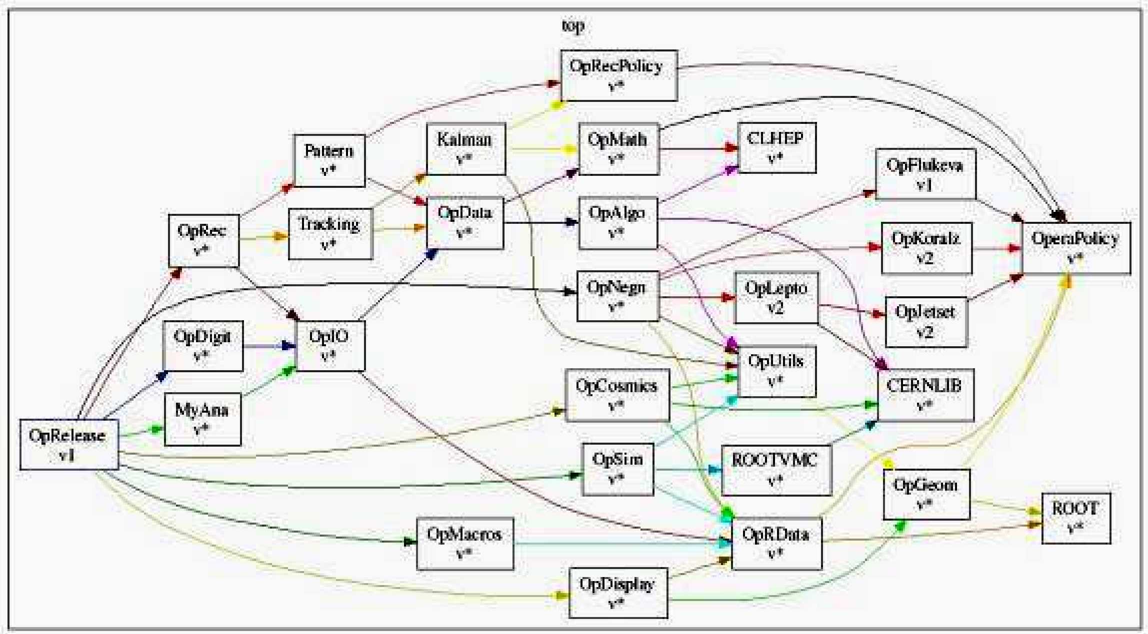
July 2007 with a portable atomic Cs clock capable of providing a 1PPS signal synchronized with UTC and stable at the level of few ns over several days

✓ Measure the timing signals at various points of the chain at CERN and LNGS compared to the 1PPS of the Cs clock
➔ absolute calibration transported in all the single points, check the calibrations performed last year with independent method

✓ Precise timing: implement a fast digitizer recording the proton current at the level of the BCT

Computing framework

- The offline computing framework is a set of software C++ packages:
  - * running on CERN Linux platforms (and partly on Windows)
  - * managed by CMT and stored on a CERN CVS server
  - * with built-in Doxygen documentation

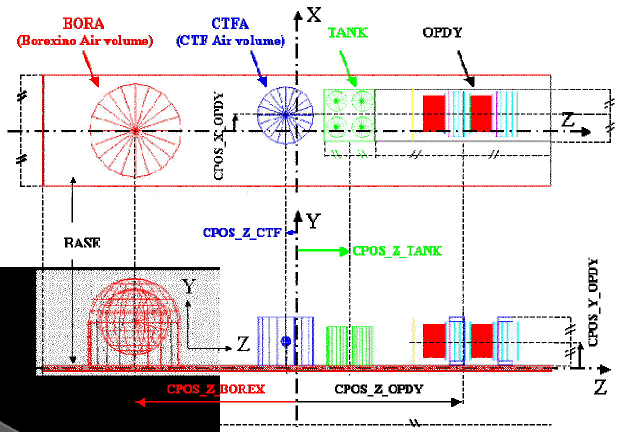


- ROOT is used extensively:
  - * for data persistency with TTrees in files
  - * for detector description with TGeoManager
  - * for data simulation with Virtual Monte Carlo GEANT3-VMC
  - * for data analysis: reconstruction in emulsions, ROOT macros, GUI for display

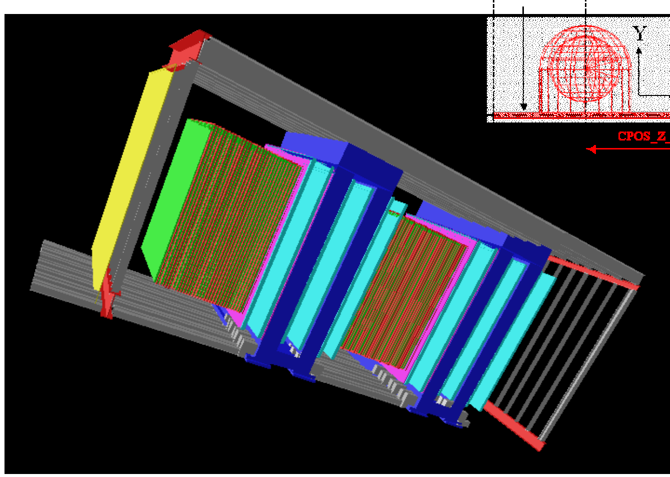
- The software team sticks continuously to the upgrades:
  - * of platforms and compilers (Scientific Linux CERN SLC4, 64 bits)
  - * of softwares (ROOT 5)

Analysis chain

- Data model and detector model are stable and robust with:
  - * standardization of real data / simulated data access
  - * description of the hall, Borexino, OPERA support structure, magnetic field, etc…
  - * insertion of alignment effects



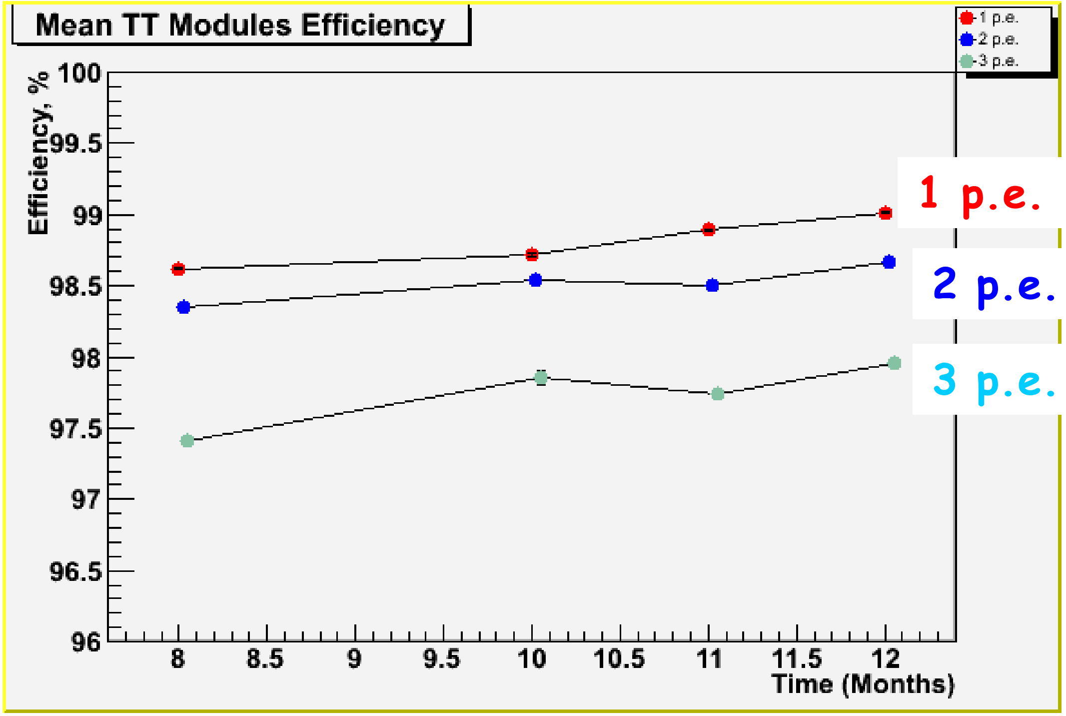
- Simulation chain (generation-simulation-digitization) is under control with a production plan: beam events, rock events, cosmics



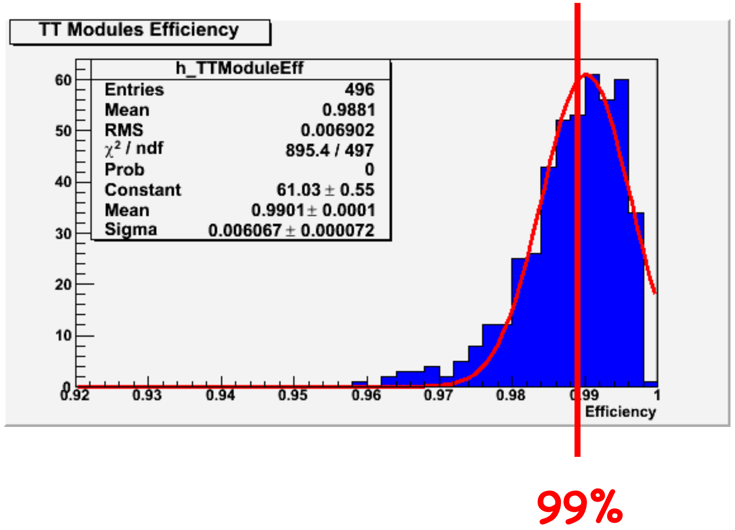
- Reconstruction and analysis algorithms are well advanced with:
  - * electronic detector reconstruction almost « final »
  - * several emulsion data reconstruction algorithms
  - * connection of electronic detectors data and emulsion data under study
  - * offline « heavy » event display and online « light » event display OED
  - * possibilities to perform analyses in the ROOT context (macros) and outside ROOT using the Standard Templated Library STL

3. Results from the commissioning of the electronic detectors

Target Tracker efficiency



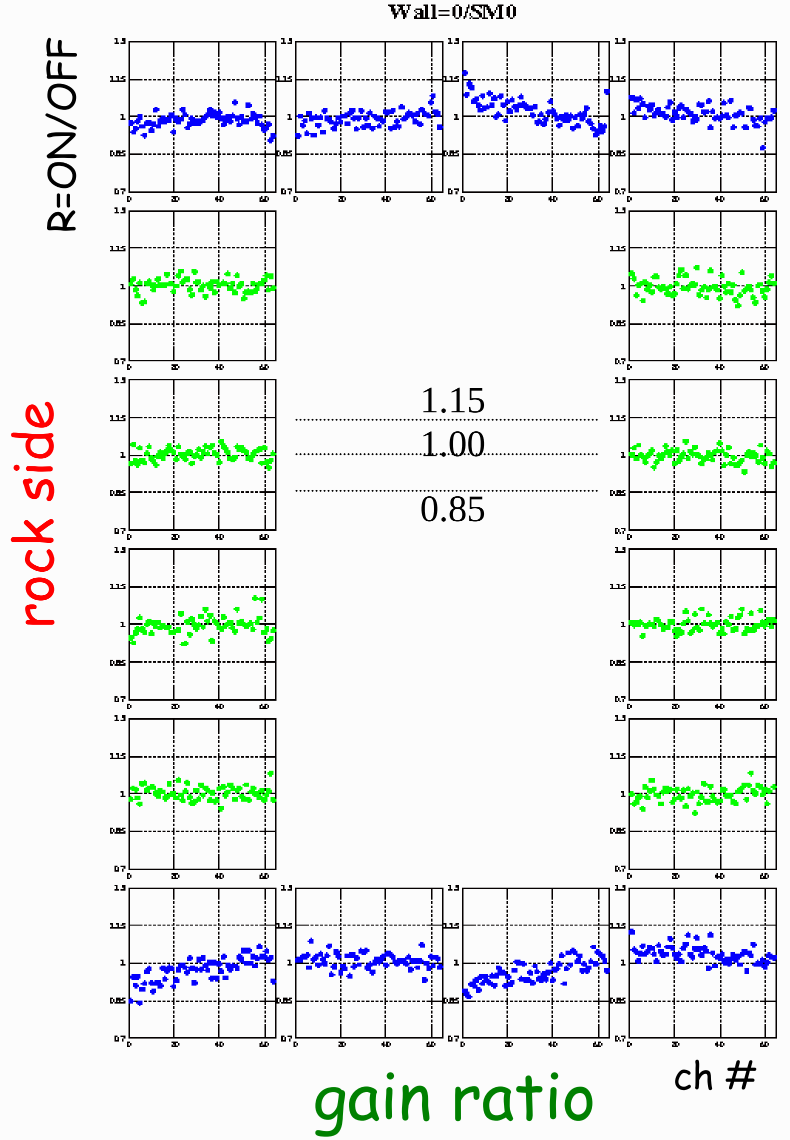
using cosmic ray tracks

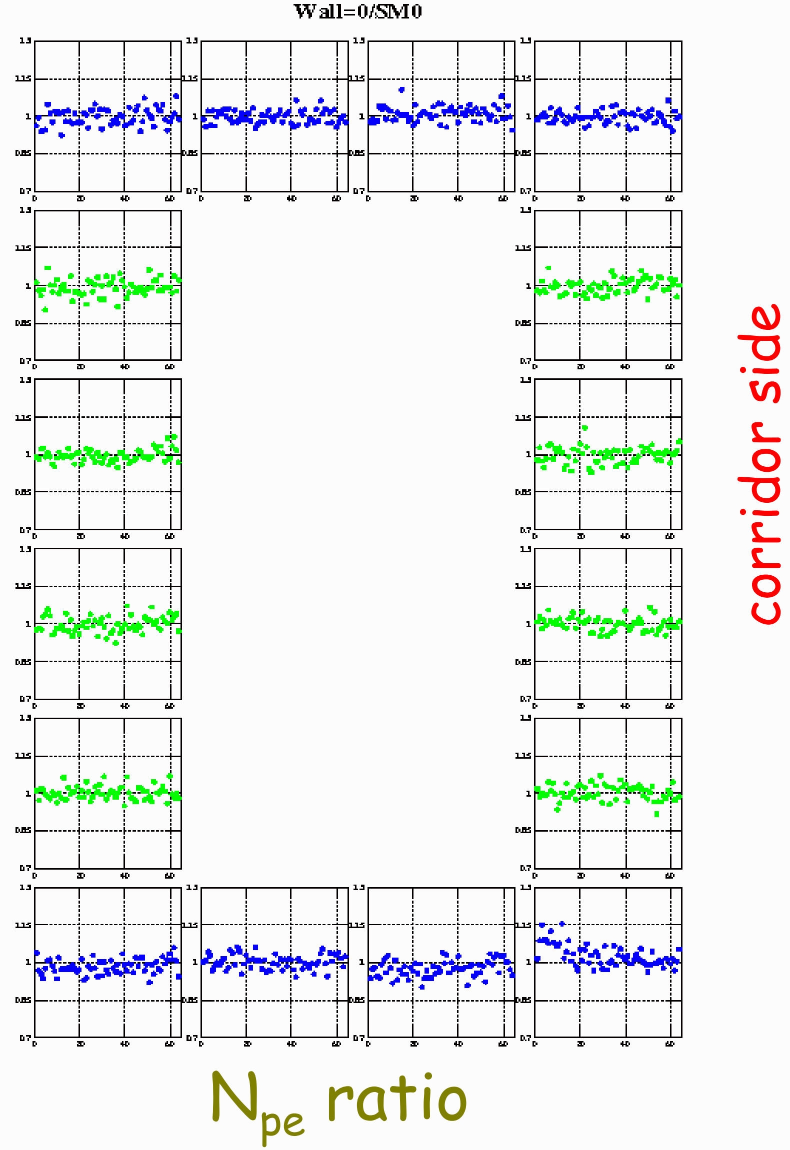


Trigger rate:
- 1 p.e. → 20 cps per pixel
- 2 p.e. → 10 cps per pixel

Mgnetic field influence on TT response

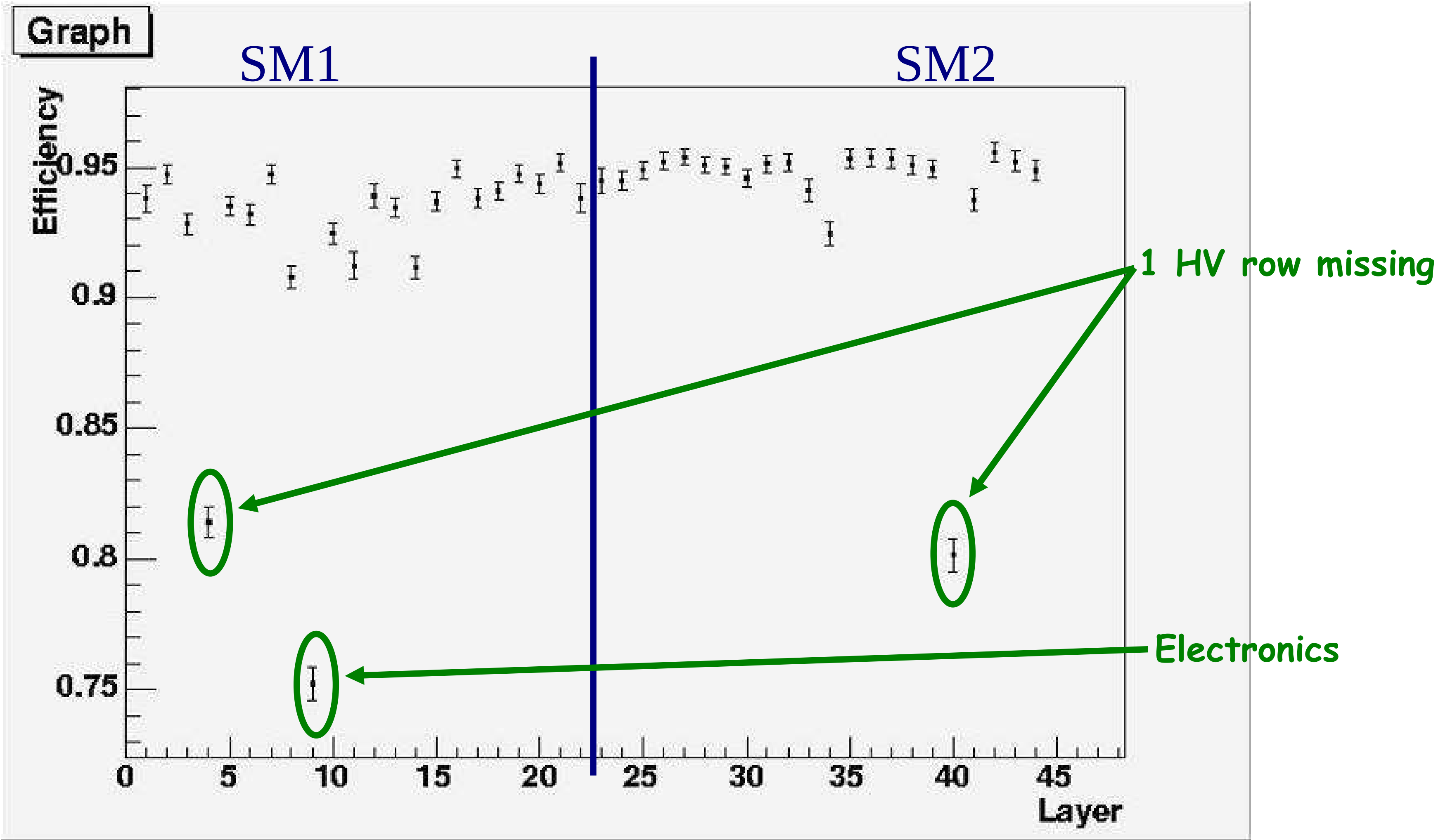
10<B<40<Gauss
inside the TT





RPC efficiencies

using cosmic ray tracks

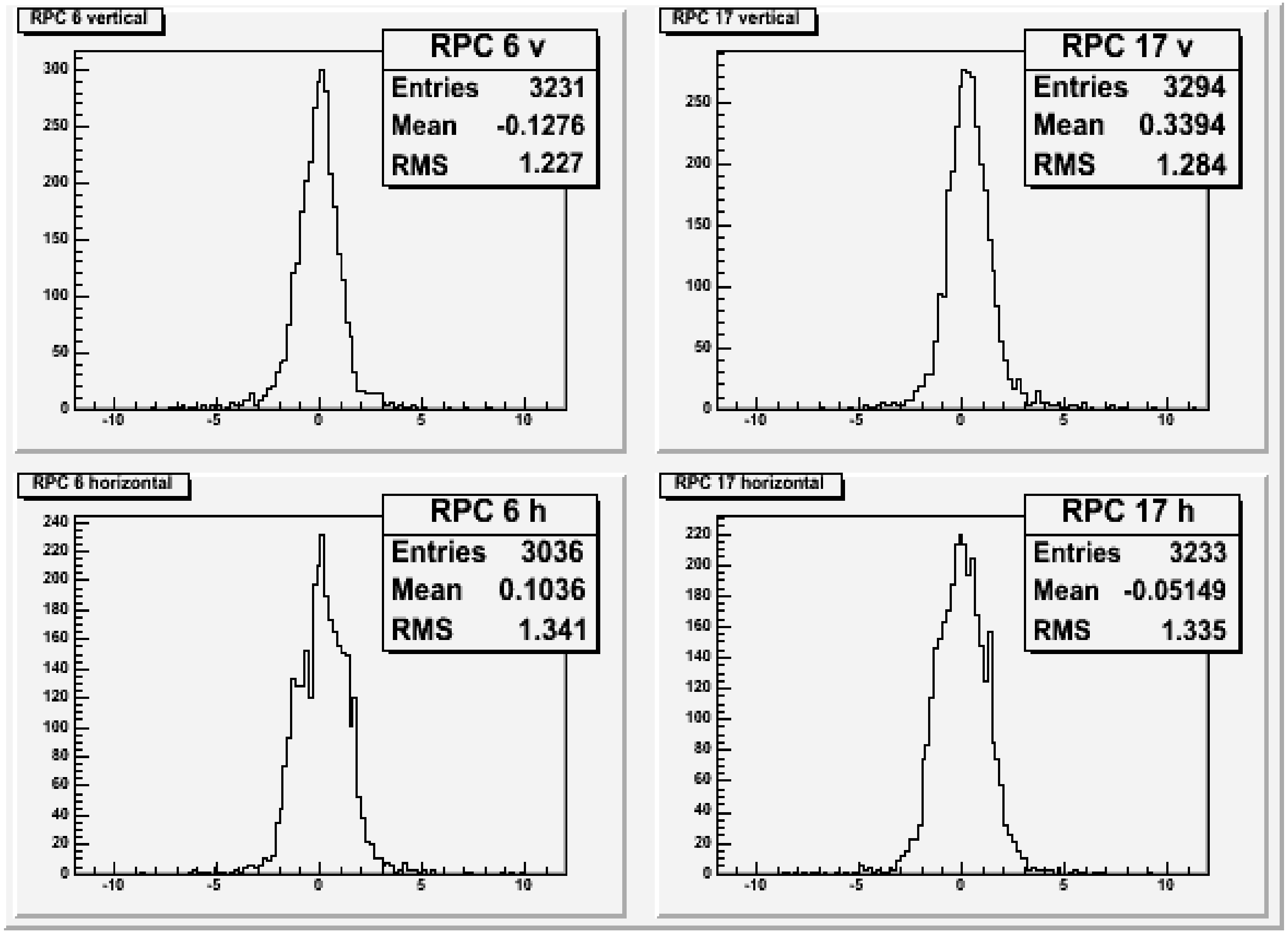


All problems have been cured

RPC spatial resolution

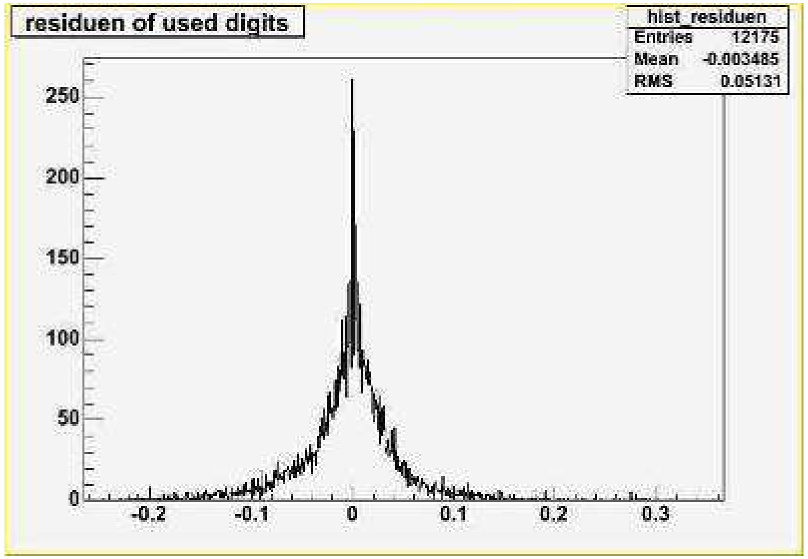
using cosmic ray tracks

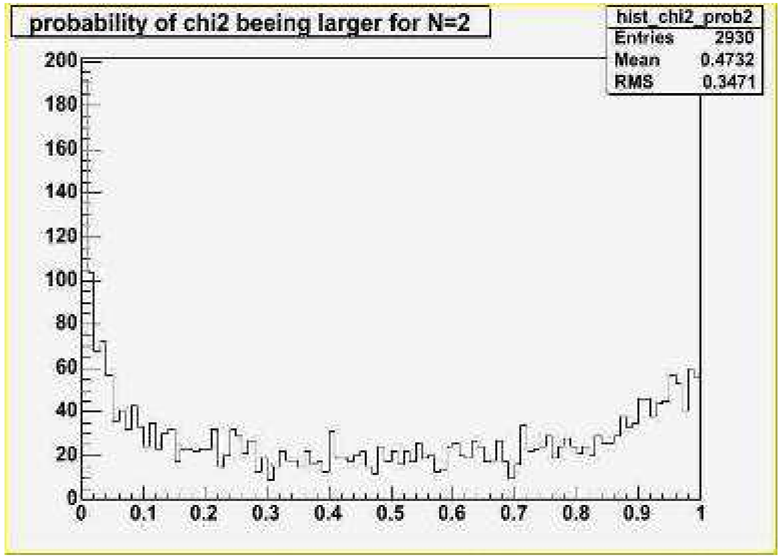
Tracking resolution ~ 1.3 cm, Misalignments < 1 cm



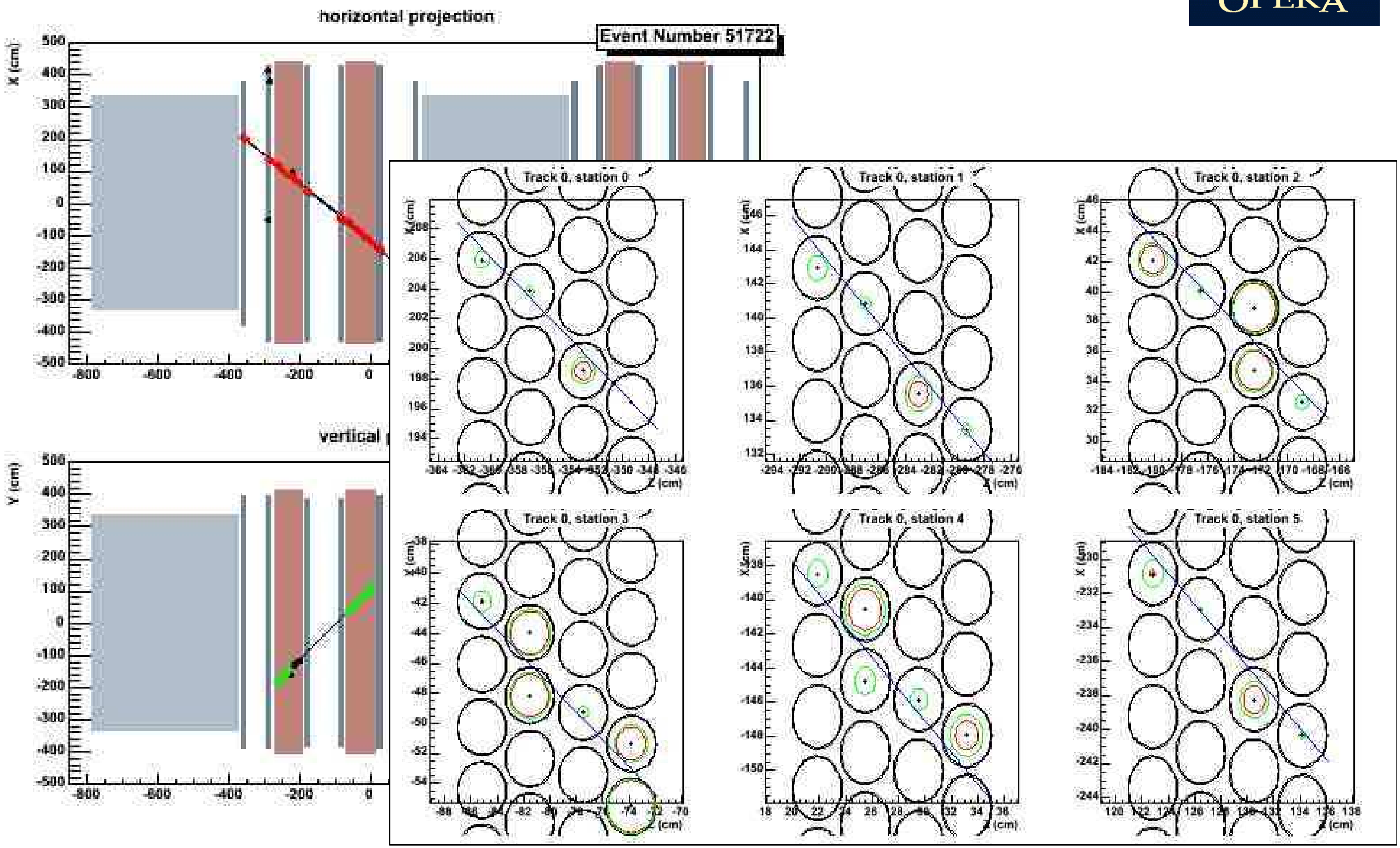
Status of reconstruction for HPT

- Reconstruction running stable for data and MC events
- Timing corrections implemented
- Alignment ongoing, starting from TDA measurements
- Resolution of ~500µm in single planes for cosmic data (see plots below)
- Alignment will bring improvements (300µm prototype measurements)
- 80% track efficiency for cosmic data

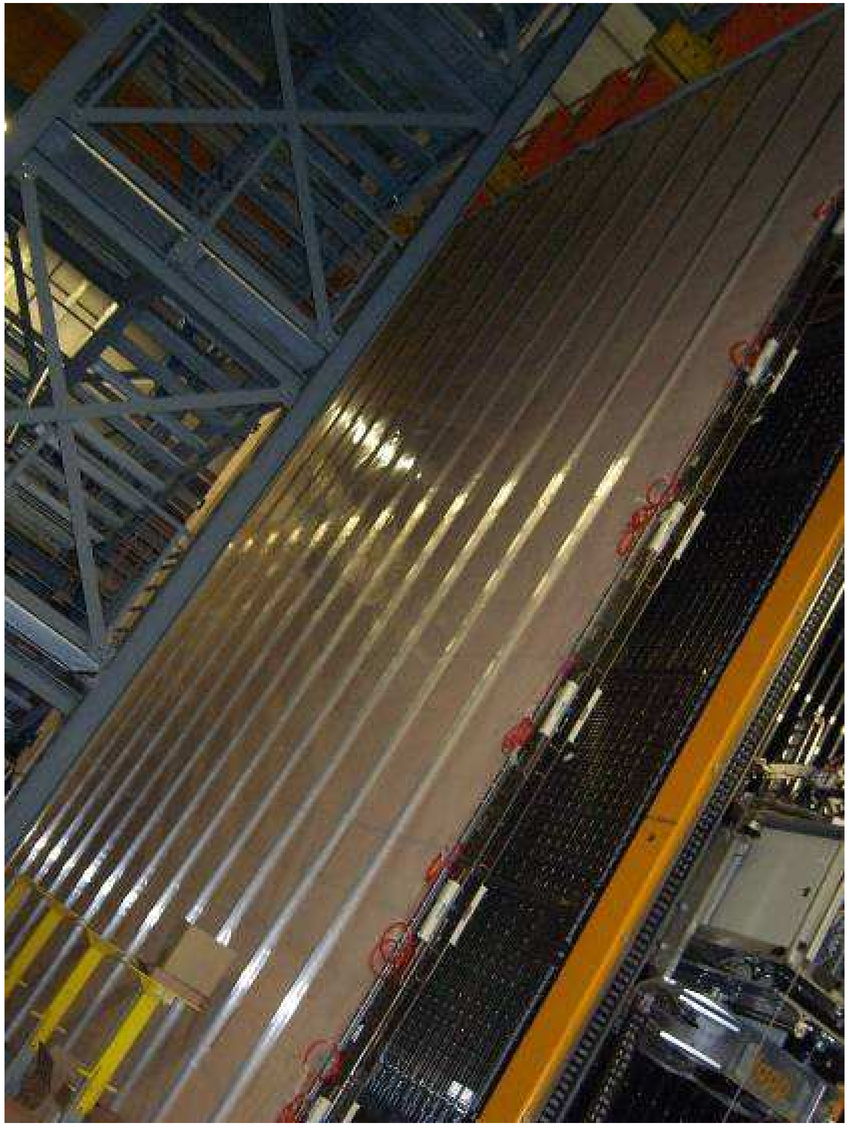


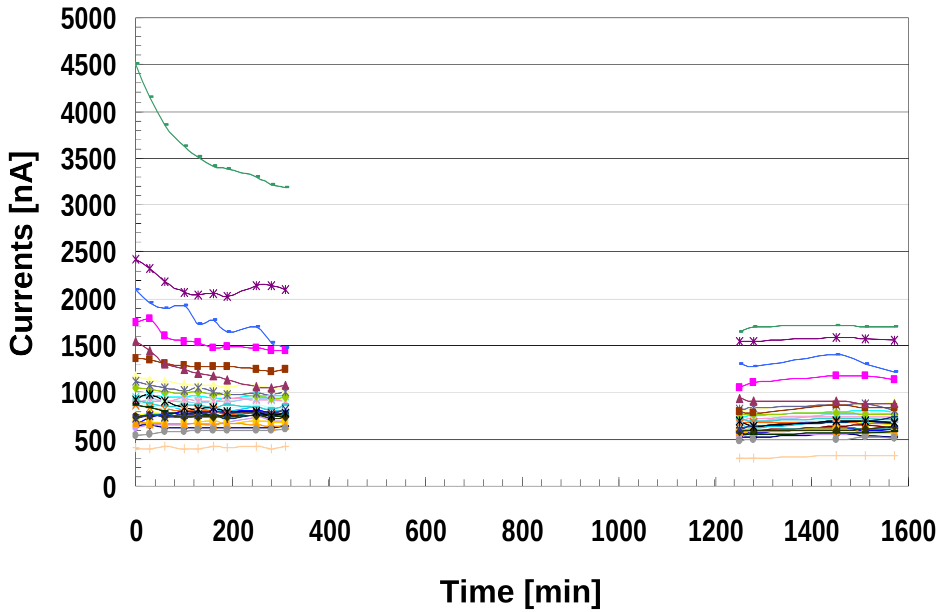


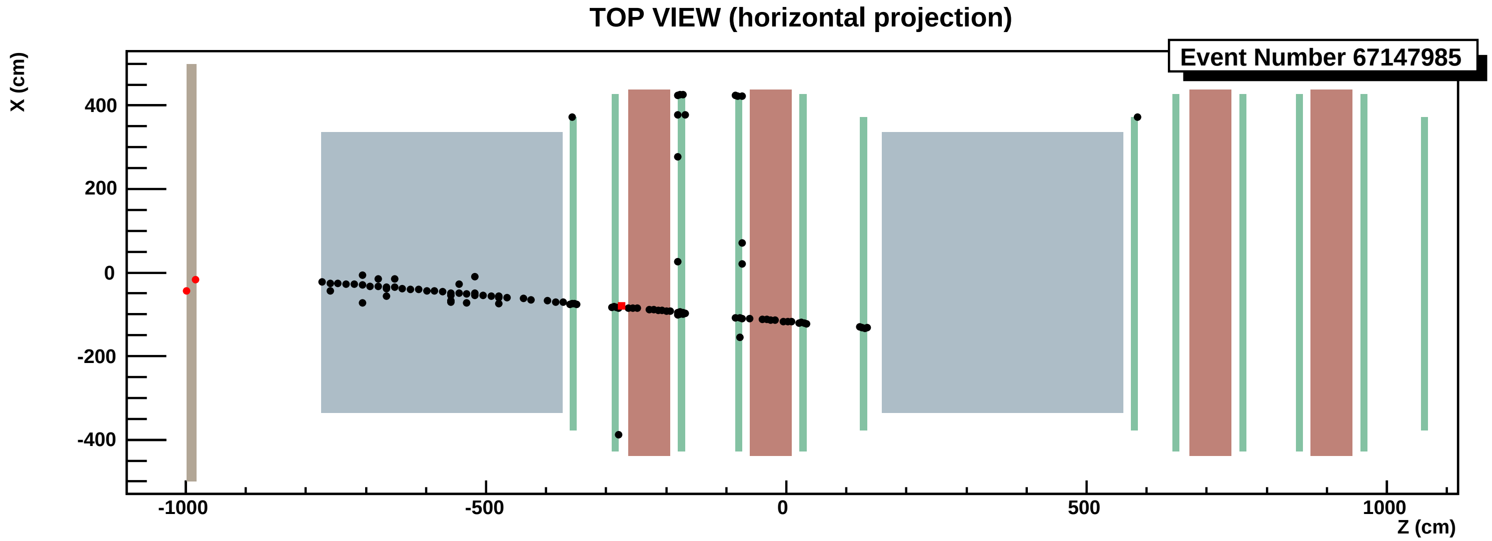
Example of a reconstructed cosmic ray event

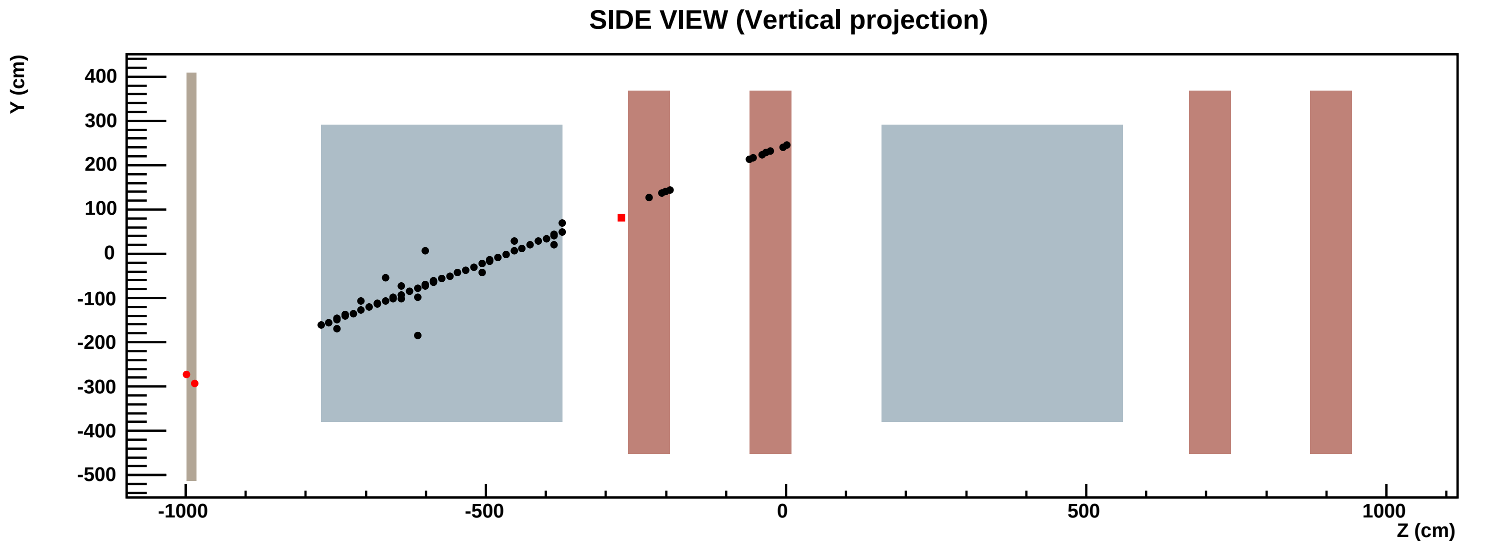


VETO commissioning






TOP VIEW (horizontal projection)
Event Number 67147985
X (cm)
400
200
0
-200
-400
-1000
-500
0
500
1000
Z (cm)


SIDE VIEW (Vertical projection)
Y (cm)
400
300
200
100
0
-100
-200
-300
-400
-500
-1000
-500
0
500
1000
Z (cm)

4. Cosmic and CNGS runs results

CNGS/LNGS Working Group

Involving representatives of the CNGS project and the LNGS experiments which can see the beam: OPERA, ICARUS, LVD, BOREXINO

Meeting regularly on the following topics:

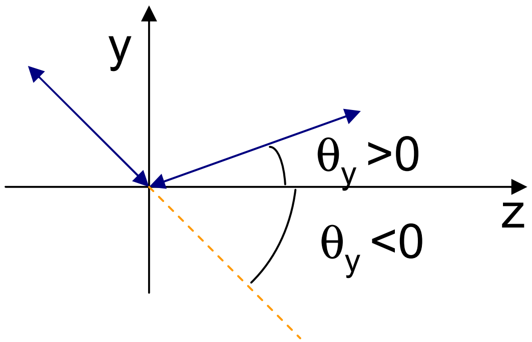
Beam performance and scheduling
Beam timing
Beam geodesy (detector distances and orientations)
Beam analysis and CNGS-LNGS data exchange
Comparison of far detector results on beam monitoring
Comparison of experimental simulation on beam muon fluxes

Beam timing:

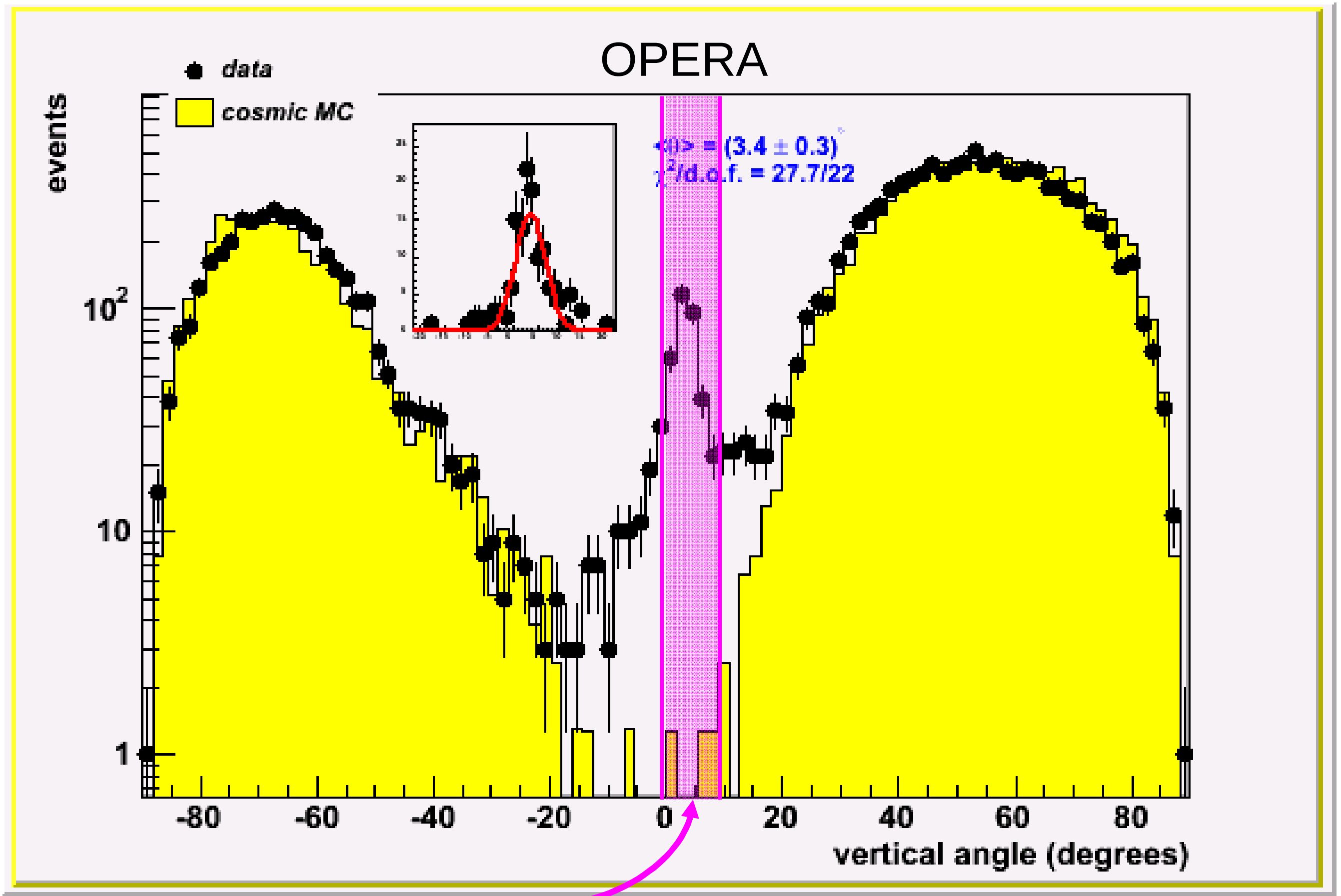
Calibration of timing chain at CERN (kicker pulse tagging)
Inter-calibration of GPS master clocks
Calibration of optical fiber paths
Calibration of OPERA slave clock

Beam Direction: August run

Zenith angle of muon track



August Run result:
<θ>=3.4±0.3



Select events around beam (0 < θ < 0.15 rad) direction and check if there are on time

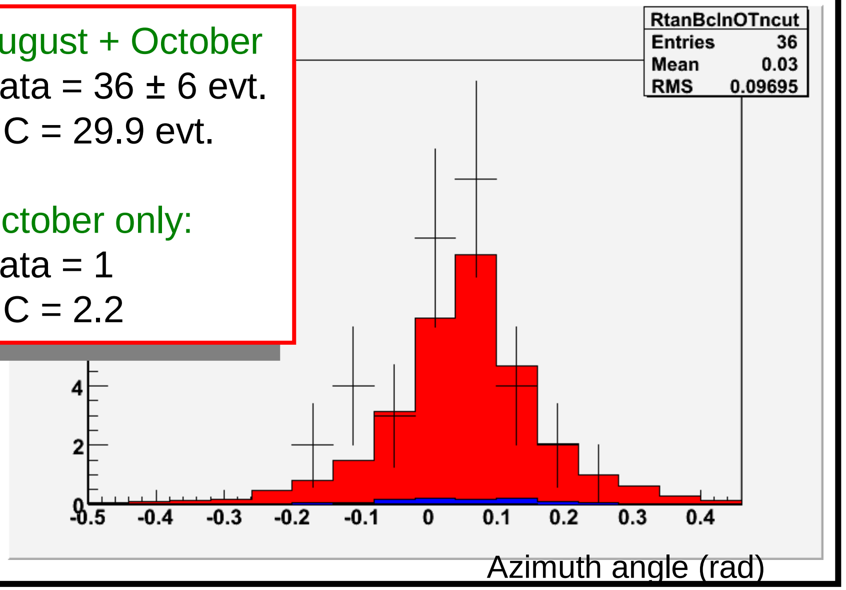
CNGS events

Interaction in the magnet

Event selection:
- **on time beam events**
- **μ id (> 10 Fe slabs)**
- **fiducial volume**

August + October
Data = 36 ± 6 evt.
MC = 29.9 evt.

October only:
Data = 1
MC = 2.2

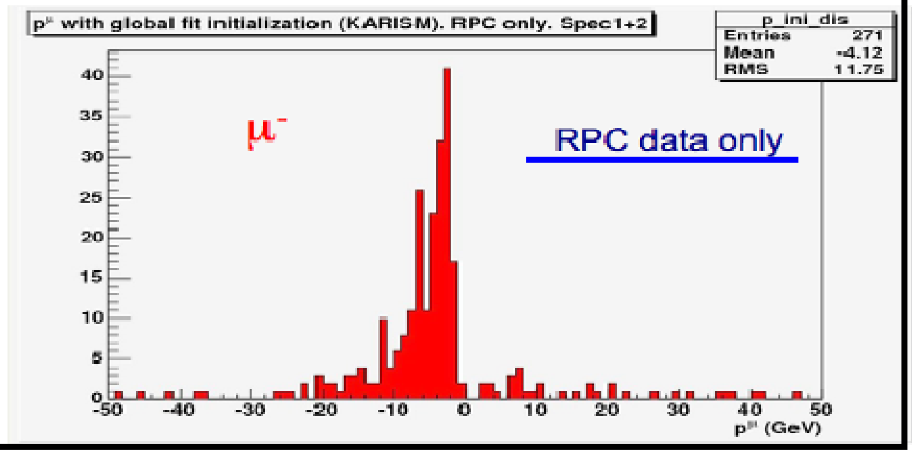


Interaction outside OPERA

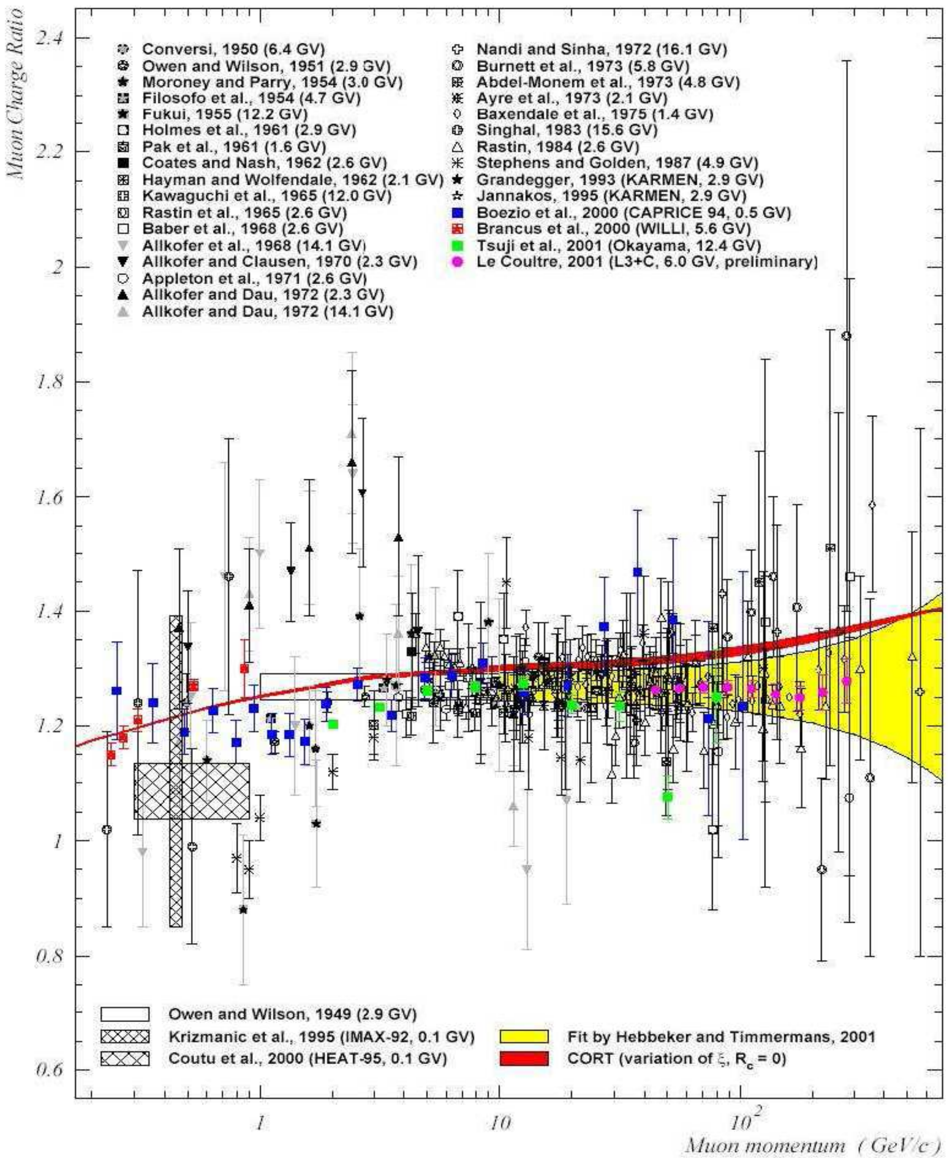
	DIS_CC	CC	NC	Total (previous result)
Borexino (1°Run)	23.2	27.7	2.6	30.3 (25)
Upstream Rock	75.0	89.1	/	89.1 (105)
Lateral Rock	45.1	49.6	/	49.6 (100)
Concrete	48.2	55.1	1.4	56.5
Total	191.5	221.5	4.0	225.5 (230)

Events with vertex outside OPERA with N.hits > 10 integrated for N_{pot} = 7.60E17 pot (August Run)

Momentum and sign analysis



High energy muon charge ratio



Can be measured in using the OPERA spectrometers :

Overburden : ~3000 m.w.e.

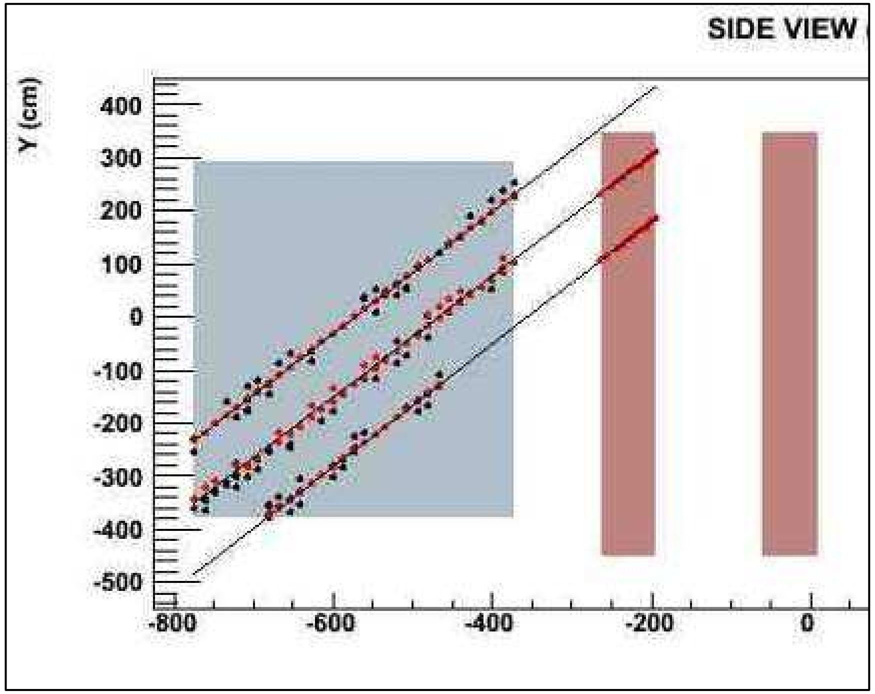
⇓

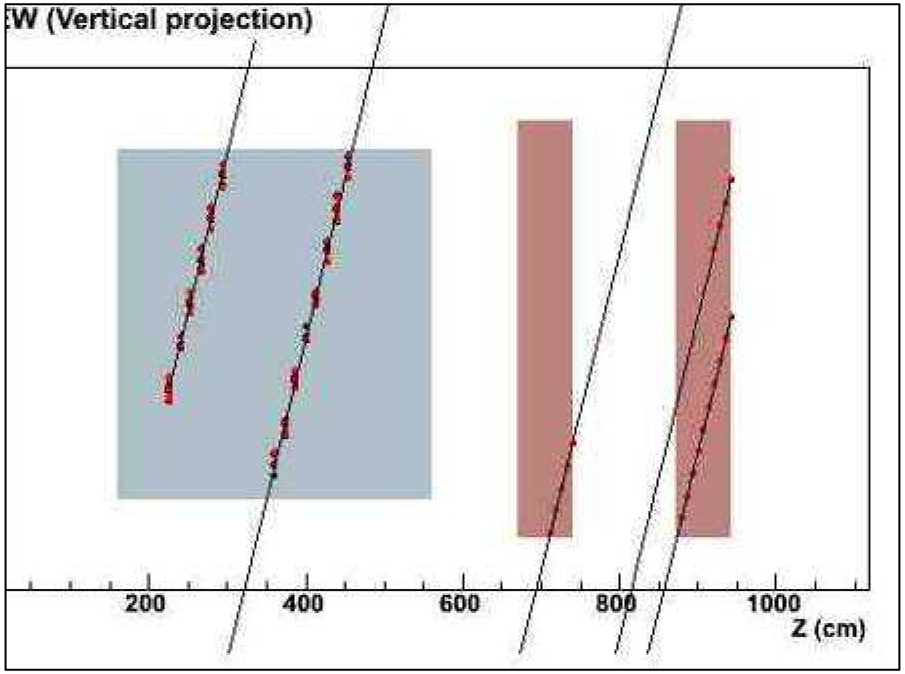
Eμ underground : 300 GeV
Eμ surface cut-off : 1400 GeV

Muon multiplicity study: primary composition

Optimized Pattern Recognition to reconstruct muon bundles:

- Hough transformation to select the event direction
- local Pattern Recognition to select aligned hit in the selected slices





Coincidence among LNGS experiments

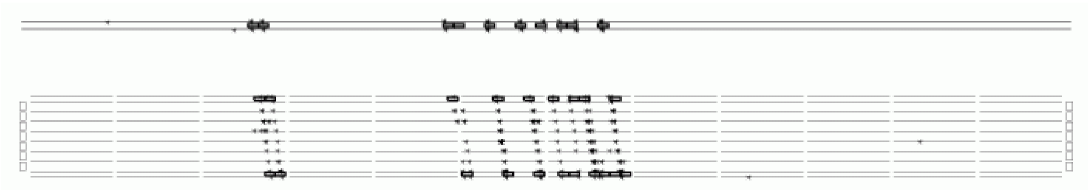
LNGS : largest underground array of detectors:

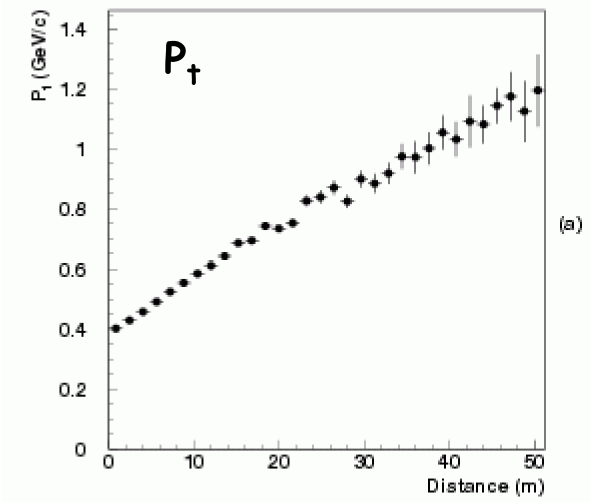
- OPERA → T600 : ~90m
- OPERA → LVD : ~180m
- Eμ surface cut-off : 1400 GeV

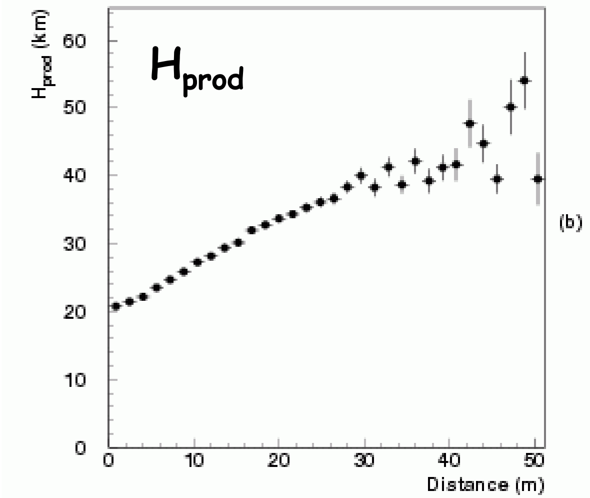
→ Study of high P_t events (Decoherence)

$$r \sim \frac{P_t}{x_F^{\pi,K} E_0} H_{prod} \propto \frac{P_t}{x_F^{\pi,K} E_0} \left(\log \sigma_{n-Air}^{inel} + const. \right)$$

→ Minijet formation (high energy hadronic features)



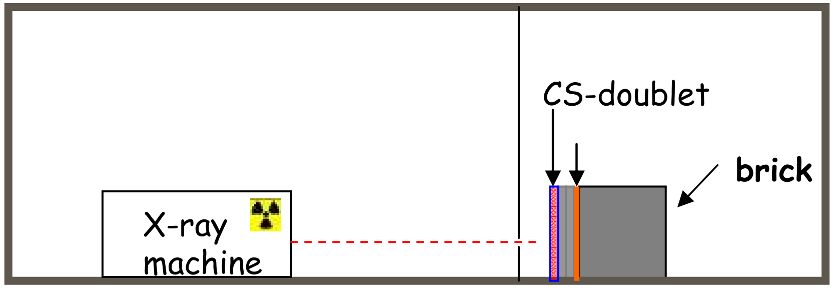




5. Brick processing & Emulsion analysis

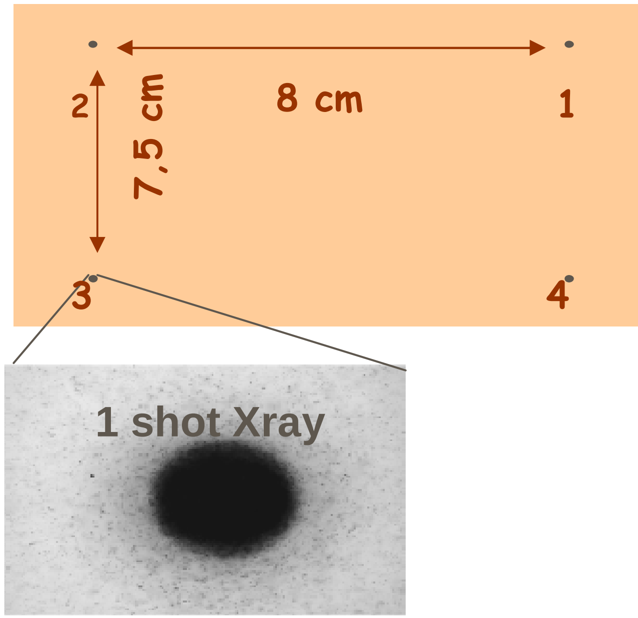
X ray marks

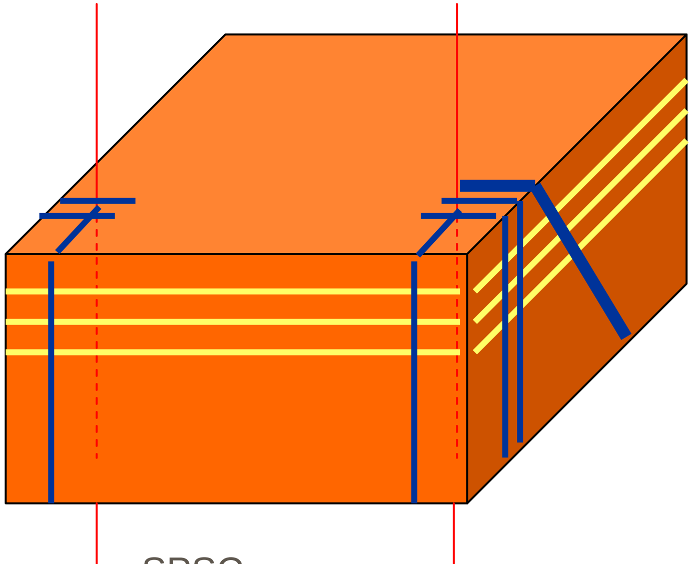
CSd alignment & CSd brick connection

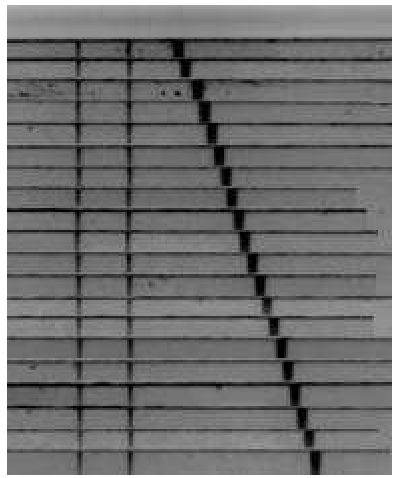


Brick films alignment

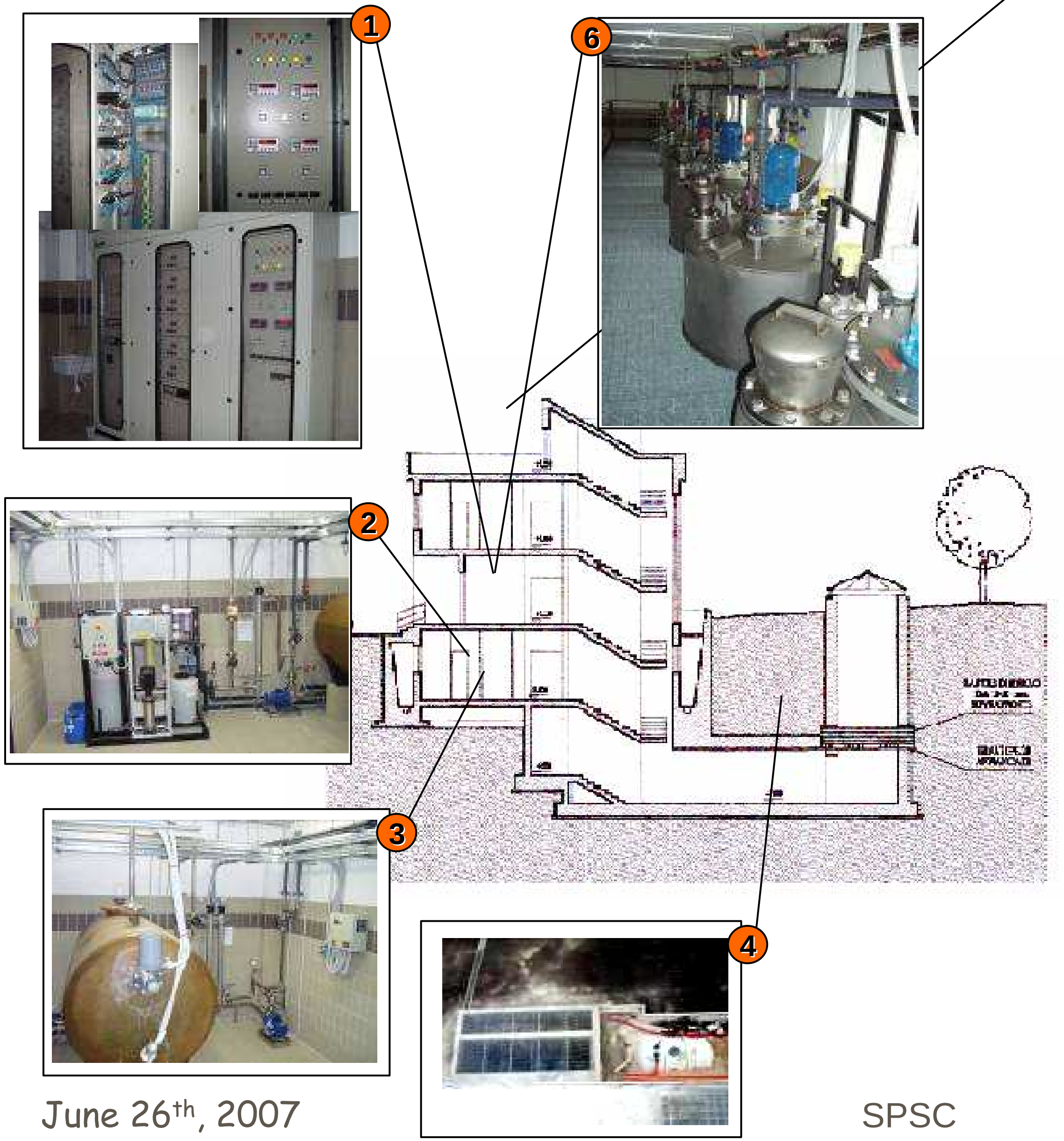
- 6 lines for alignment (crossing point)
- 1 line (inclined) for plate numbering







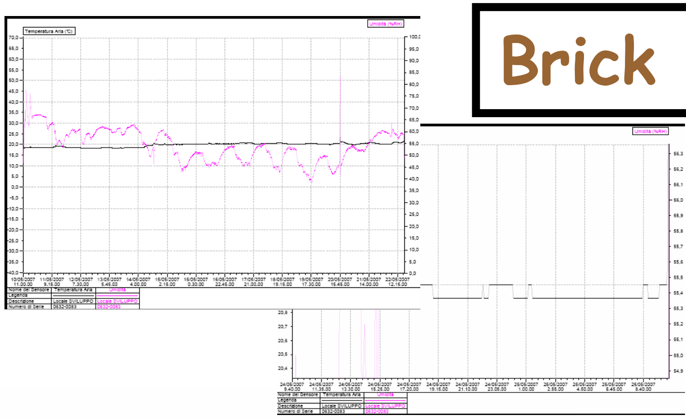
Chemical plant

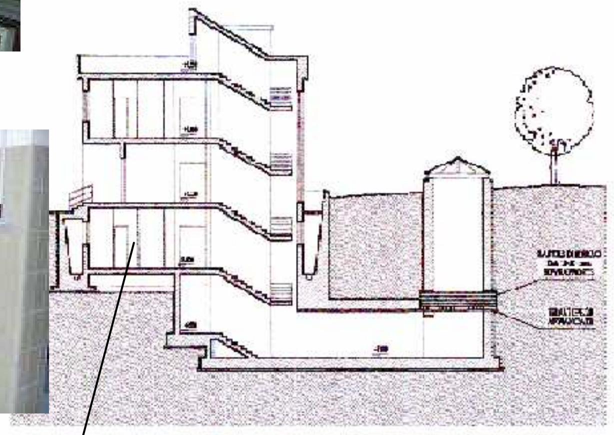


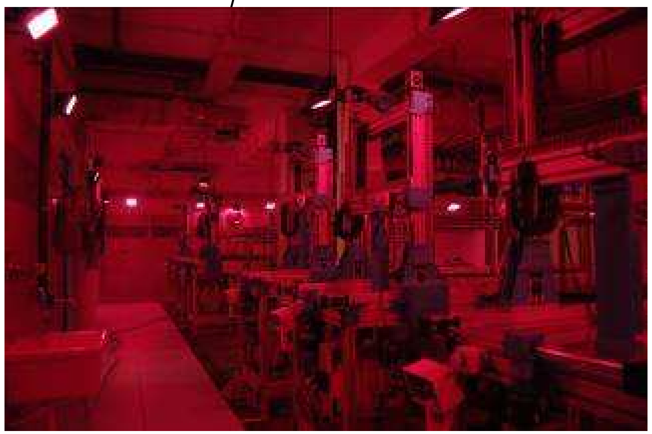
Progress report:

- Main control unit powered, working 1
- Demi water ready, 20°C ok 2
- Filtered water available, 20°C ok 3
- Collection tanks secured 4
- A nice chemical Lab set aside (small operations, & quality check! : thanks to LNGS Chemical Service) 5
- Big preparation tanks fully "dressed", cleaning to be started this week, pilot preparation and commissioning soon after… 6

Brick processing lab







Progress report:

- **Climatization resumed, ok!**
- **Safelight darkroom ok**
- **5 proc. lines cabled to front-end (6th suspended)**
- **Lines # 1 and 2 tested, ready and operational in automated mode**

➔Lines # 3,4,5 to follow soon; some refinement suggested by tests

➔Control box for sliding carpet designed, waiting for delivery

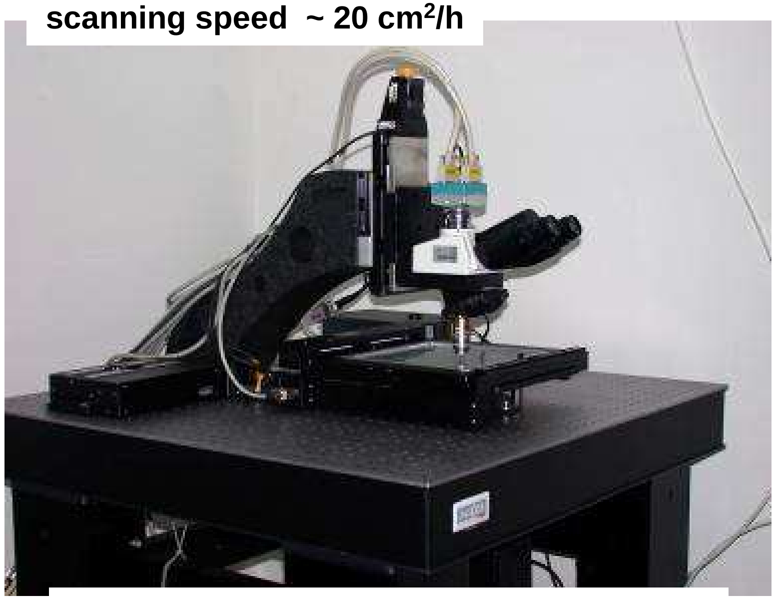
➔Wait for chemical plant ready to do over-all "integrated" large scale tests

Automated Microscopes for Nuclear Emulsions

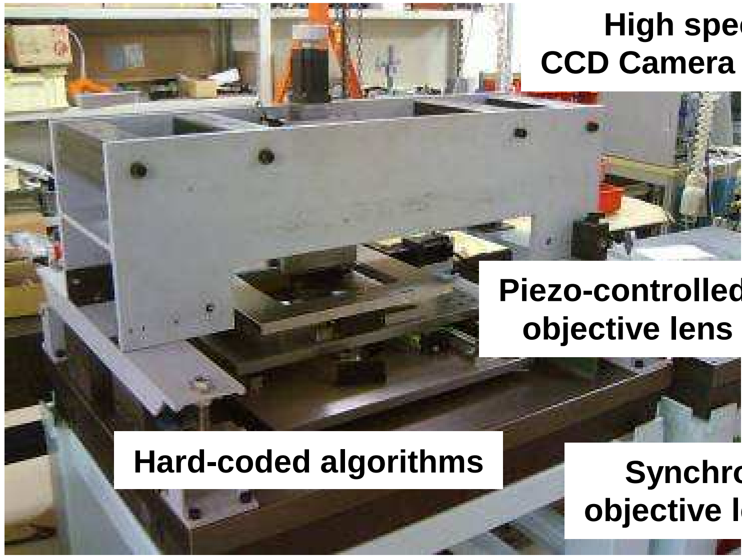
~ 30 bricks will be daily extracted from target and analyzed using high-speed automatic systems

European Scanning System | **S-UTS (Japan)**

scanning speed ~ 20 cm^2/h



Customized commercial optics and mechanics + asynchronous DAQ software



High speed CCD Camera (3 kHz)

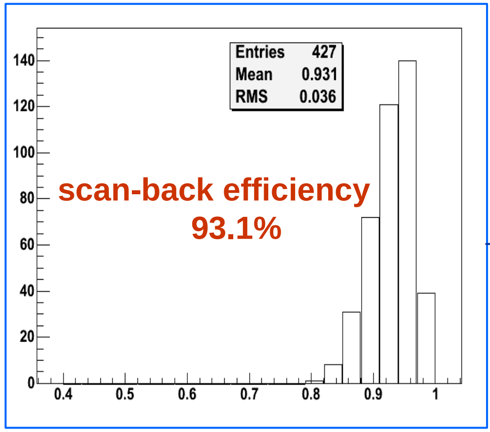
Piezo-controlled objective lens

Hard-coded algorithms

Synchronization of objective lens and stage

Constant speed stage

Automated Track Reconstruction and Vertex Search



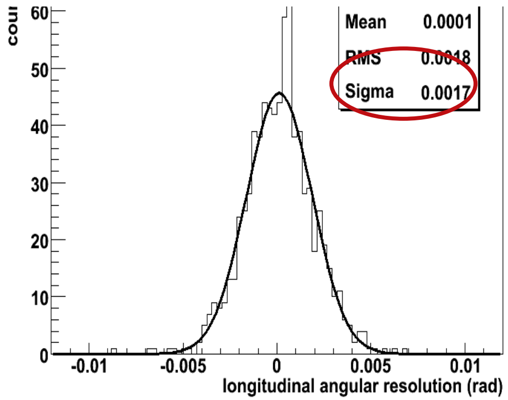
tracks in the CS doublet

scan-back
tracks followed backward film by film

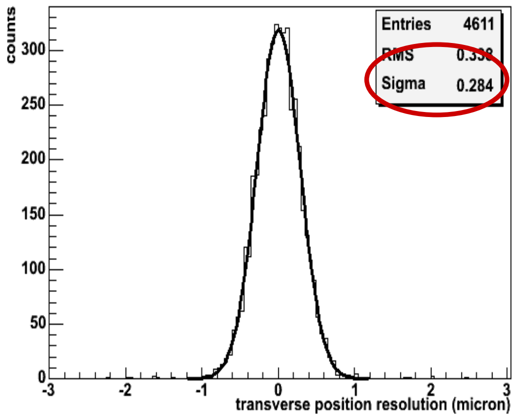
volume scan

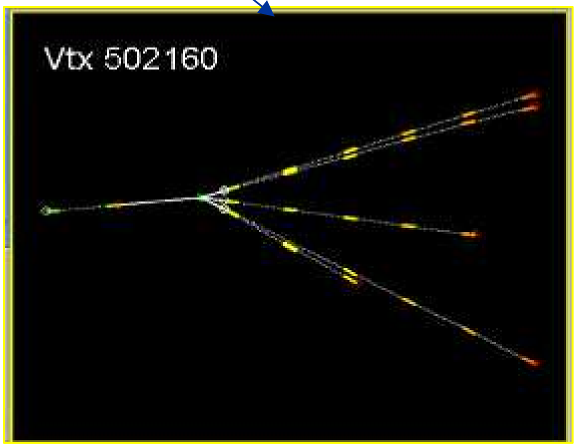
vertex reconstruction

angular residuals between base-tracks and fitted volume tracks (vertical tracks)



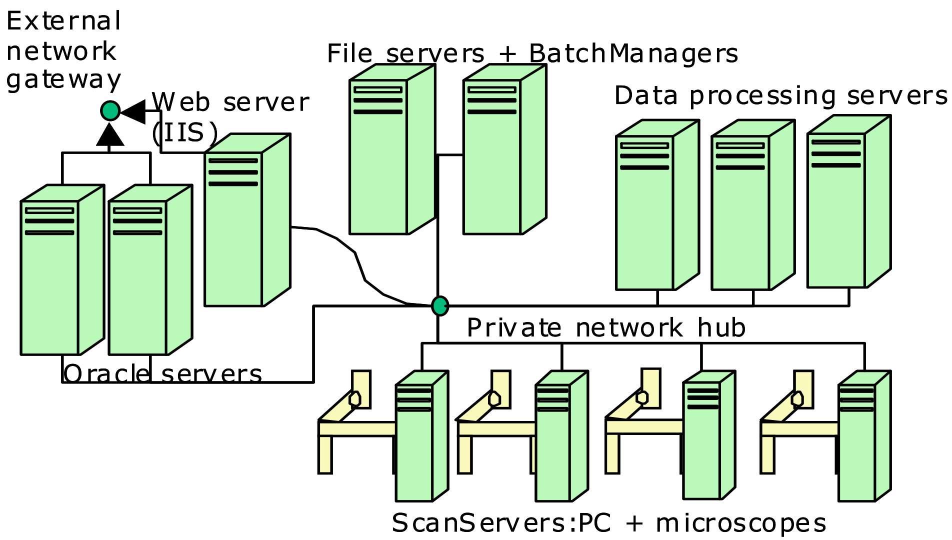
position residuals between base-tracks and fitted volume tracks





European Scanning System

- R&D on 20 cm2/h European Scanning System completed successfully (end 2004)
- 30 ESS distributed among 11 labs (22 ESS in 8 Italian labs):
  Bari, Bern, Bologna, Lngs, Lyon, Napoli, Salerno + Neuchatel, Roma, LNF, Padova
- Integrated in a online computers network :
  including DB, manager , on line computation , plate changer …..



Scanning capabilities in Europe

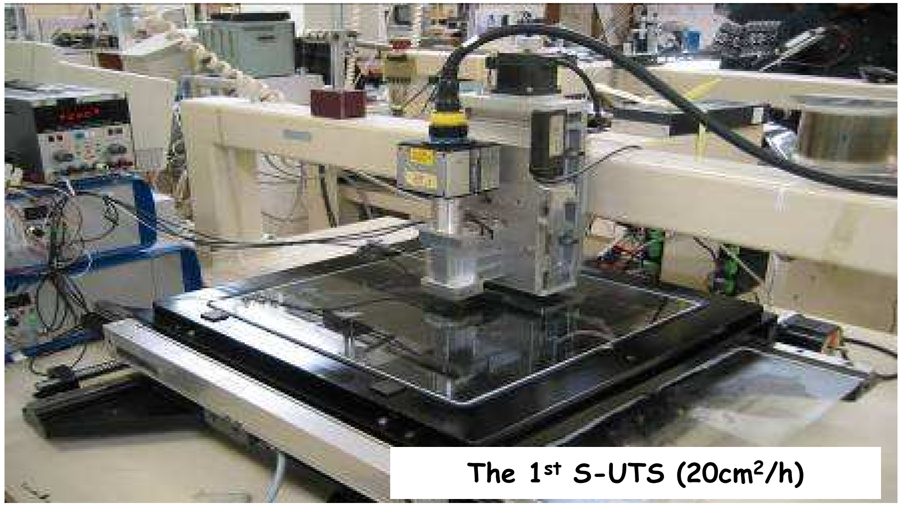
1. **<u>CSD scanning</u>** :
   6 ESS at LNGS -> ~ 8CSdoublet/day (~ 5 microscopes missing)

2. **<u>Brick Vertex location and confirmation</u>** :
   Italy : 12 ➔ 10 bricks/day
   EU : 6 ESS ➔ 5 bricks/day
   plate changer in progress (with dry and oil objectives)

1. **<u>Dedicated to Special events</u>** (min. bias, decays, electrons, …):
   Italy : 4 ESS ➔ ~ 200 events/yr
   EU : 2 ESS ➔ ~ 100 events/yr

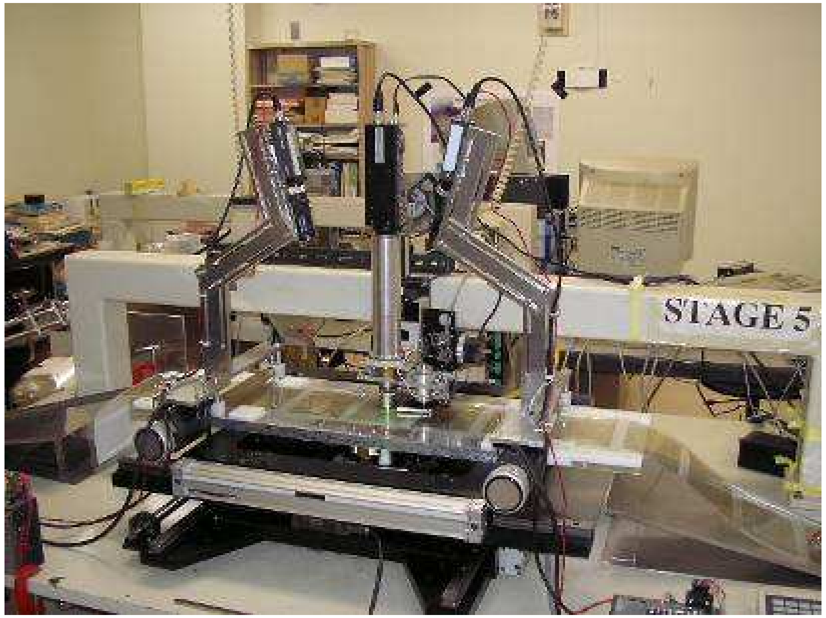
Scanning in Japan

CSD scanning


The 1st S-UTS (20cm²/h)

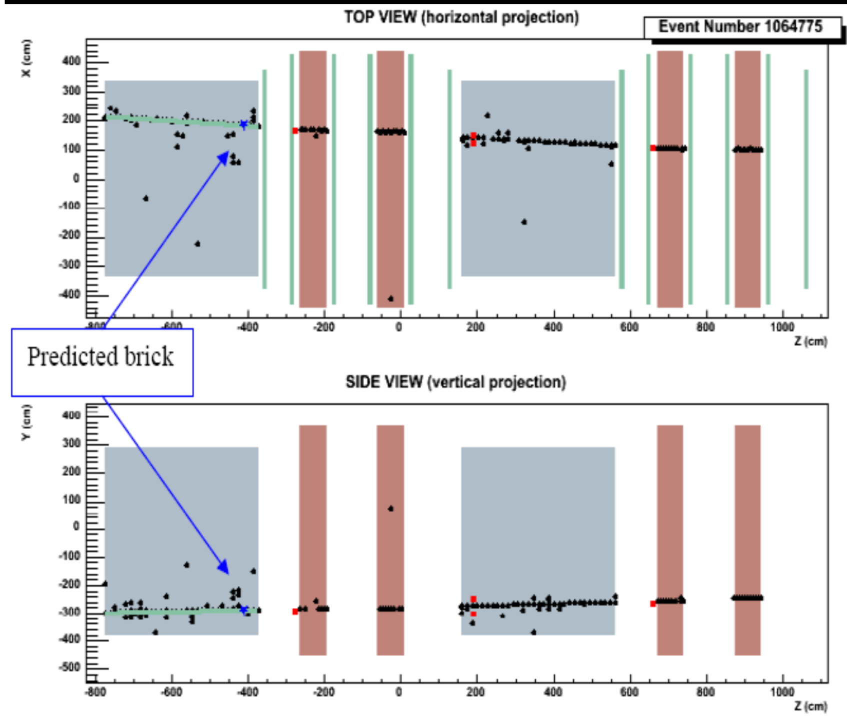
SUTS status:
- first unit ready : 20 cm^2/h
- R&D in progress in order to reach 60 cm^2/h
  - ➢X50 lens
  - ➢Optimized FPGA code
- 5 units in preparation ➔ 300 cm^2/h

Brick scanning



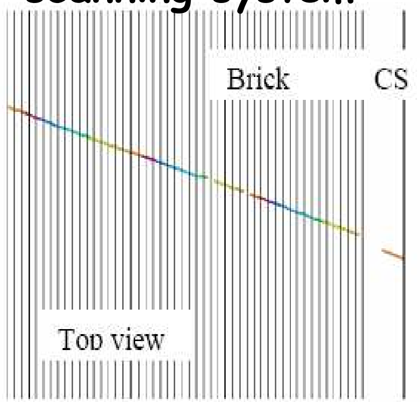
Vertex finding performances:
- Single track scan back :
- Vertex finding:
  - ν_μCC : 15' for vertex finding
    nx10' for vertex studies
  - ν_μNC : 2-3 x CC vertex finding time

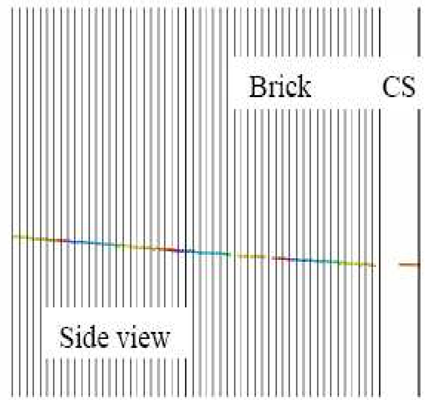
Brick Tagging rehearsal with the OPERA detector

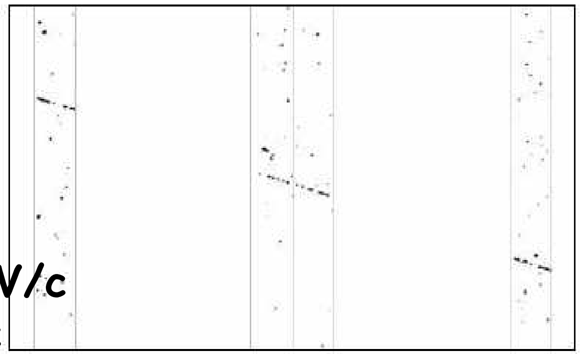


October 2006: (very short) CNGS run:

- CNGS induced rock muon selected by electronic detectors
- brick tagging using the reconstruction software
- CSD and brick analysed using the standard scanning system







Details of the CS scanning showing the reconstructed grains.

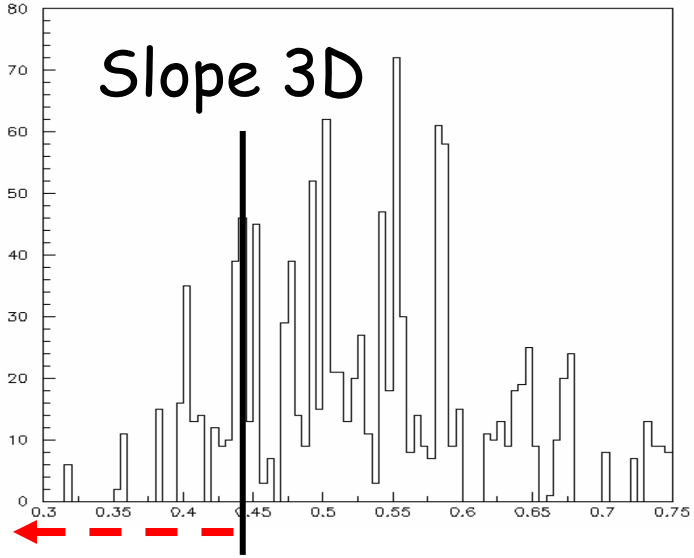
<u>Prediction accuracy</u>
(without final corrections):

- Δx = 5.5 mm (along the tray)
- Δy = 0.4 mm (vertical direction)
- $\Delta\theta x$ = 16.6 mrad
- $\Delta\theta y$ = 24.8 mrad

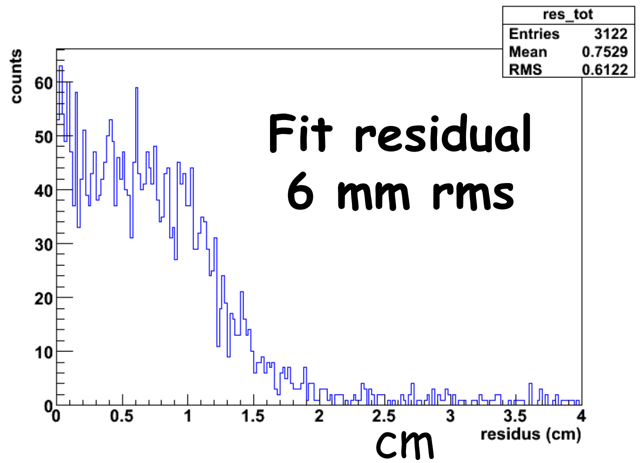
<u>Muon momentum:</u>

- MCS (coordinate method) : 6.4 ± 1. GeV/c
- Spectrometer (RPC) : 7.05 ± 0.4 GeV/c

Brick finding commissioning with cosmic runs

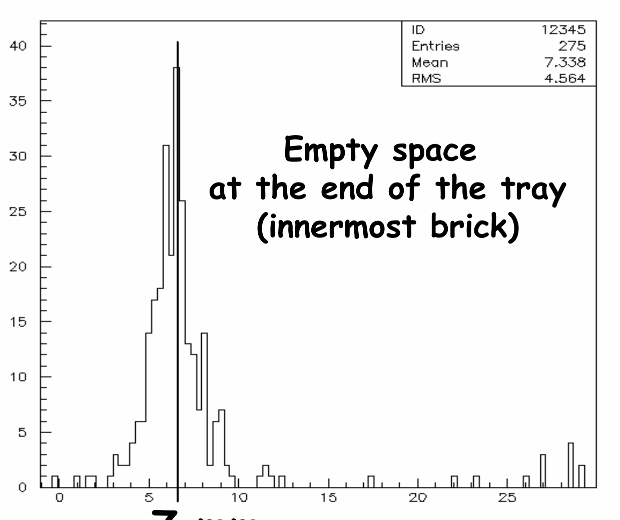


Very low rate of events inside scanning acceptance
< 1 event per day
~20 'good' bricks per month



- the predictions machinery and its automatization during the run were satisfactory
- first data confirm the good accuracy of the ED predictions (3mm) including:
  - Measured detector geometry
  - Dynamic effects (wall elongation under the weight
  - Interface with the BMS DB for the measured brick position train

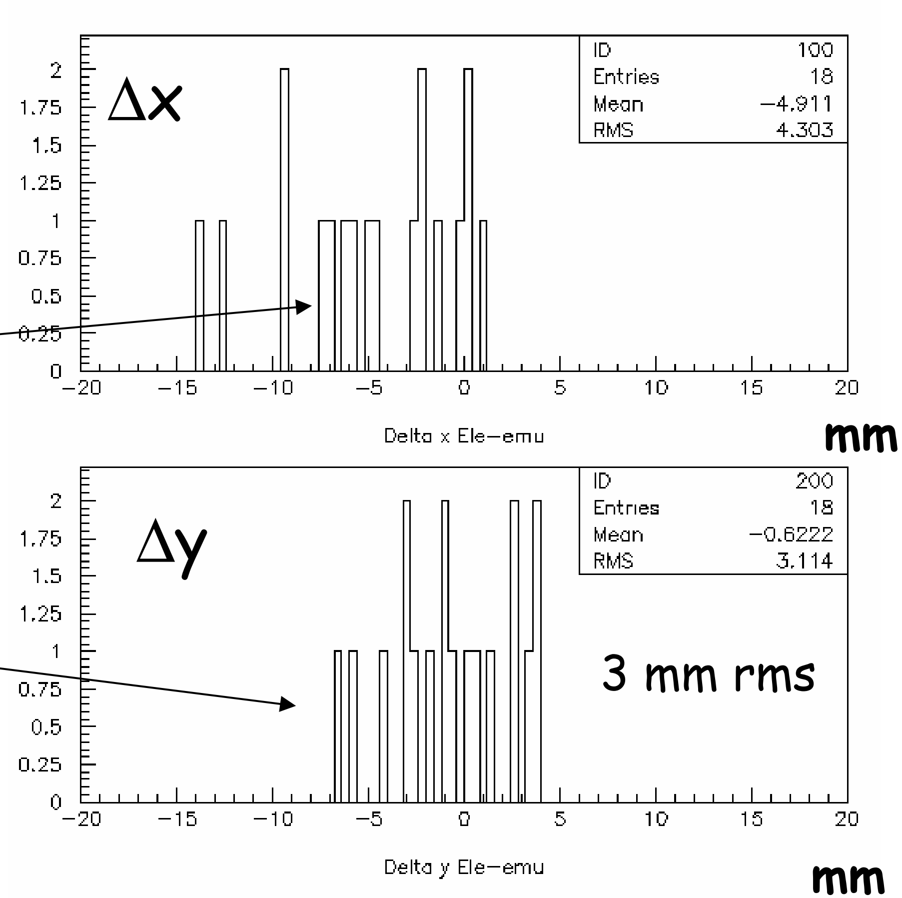
TT → CSd connexion



7 mm

Angular resolution 20 mrad

Position difference prediction-CS track

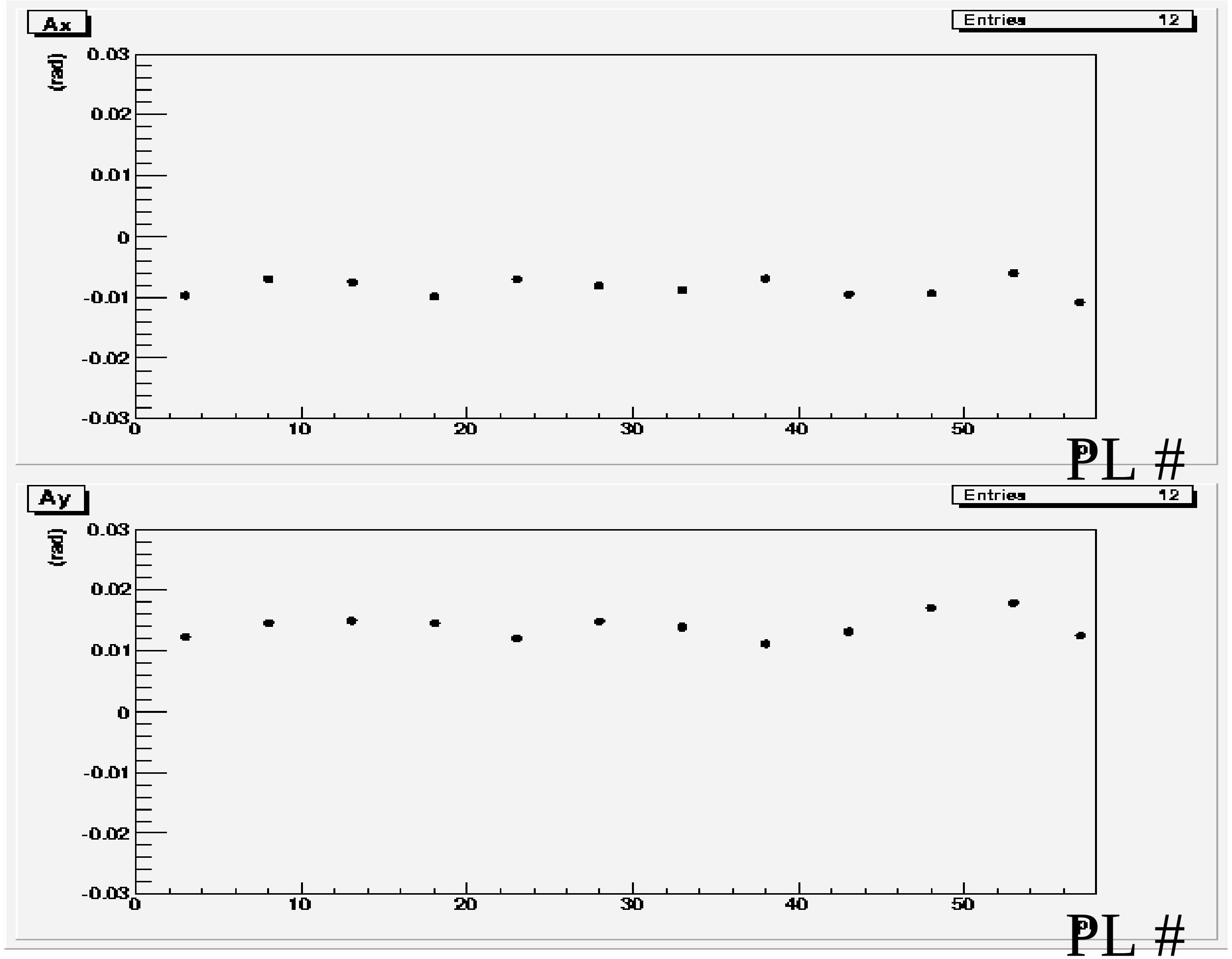


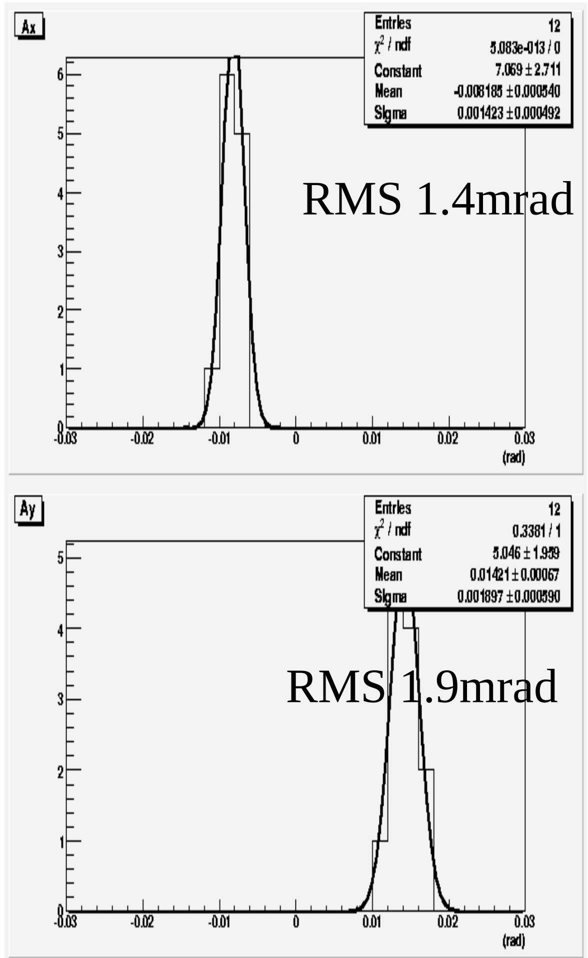
Missing BMS measurements of the bricks position

walls elongation due to bricks weigth not accounted yet

Brick flatness measured with cosmics

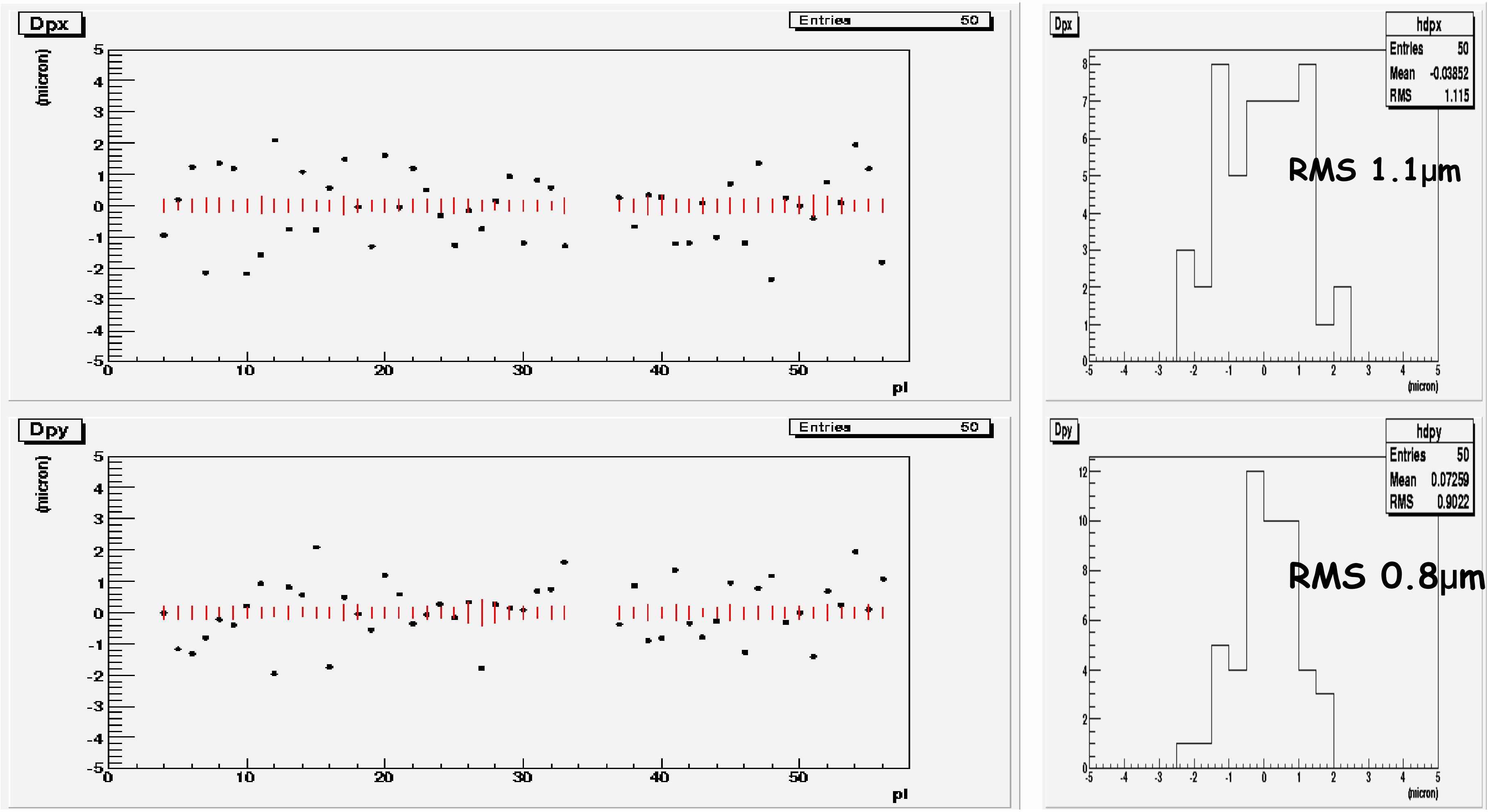
- μ momentum measurement by MCS
- τ kink search : θ > 20 mrad)





Brick emulsion alignment with cosmics

CNGS rock muon analysis



6. Test beam activities

- **CERN exposures:**
  - measurement of the π topological cross-section → direct measurement of the hadronic background (thousand of interactions reconstructed);
  - measurement of the large-angle μ scattering off lead nuclei → direct measurement of the main source of the background in the muonic channel;
  - study of the momentum measurement by using the Multiple Coulomb Scattering;
  - study of the π →e mis-identification
- **DESY exposures:**

  availability of a pure electron beam → electron identification studies and energy measurement
- **PSI exposures:**

  study of the π/μ separation through the dE/dx method (about 60% of the stoping muons are identified, while about 3% of the pions are misidentified as muons)
- **LNGS tests:**

  by using cosmic-rays we studied the electronic detector predictions vs CS scanning. We managed to go from the cm precision scale of the electronic detector to the μm precision scale of the nuclear emulsions
- **PEANUT test experiment:**

  about 50 ECC have been exposed to the NuMI neutrino beam and several hundred of neutrino interactions collected. Very useful for vertex location and vertex reconstruction studies

Electron/Pion separation

JINST

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Electron/pion separation with an Emulsion Cloud Chamber by using a Neural Network

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ABSTRACT: We have studied the performance of a new algorithm for electron/pion separation in an Emulsion Cloud Chamber (ECC) made of lead and nuclear emulsion films. The software for separation consists of two parts: a shower reconstruction algorithm and a Neural Network that assigns to each reconstructed shower the probability to be an electron or a pion. The performance has been studied for the ECC of the OPERA experiment [1].
The e/π separation algorithm has been optimized by using a detailed Monte Carlo simulation of the ECC and tested on real data taken at CERN (pion beams) and at DESY (electron beams). The algorithm allows to achieve a 90% electron identification efficiency with a pion misidentification smaller than 1% for energies higher than 2 GeV.

KEYWORDS: Particle tracking detectors; Particle identification methods.

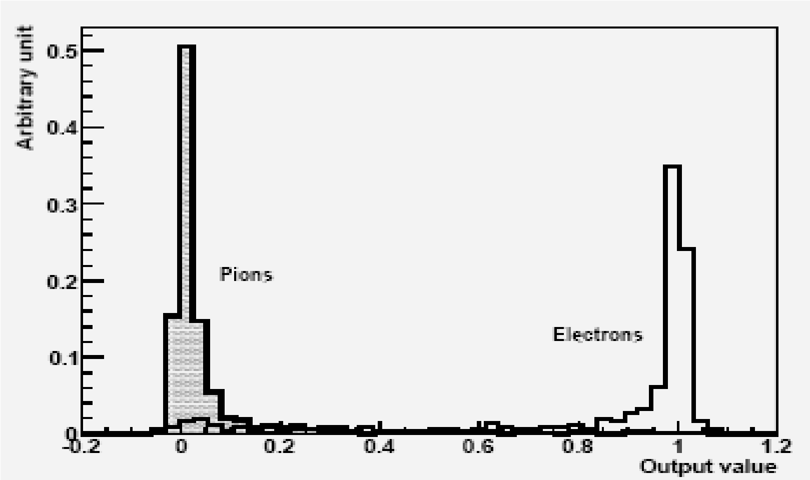
Figure 2. xz projection (left) and yz projection (right) of a reconstructed shower generated by a 6 GeV electron interacting in the ~3.3 X_0 ECC exposed at DESY. Each segment corresponds to a base-track associated with the reconstructed electromagnetic shower.

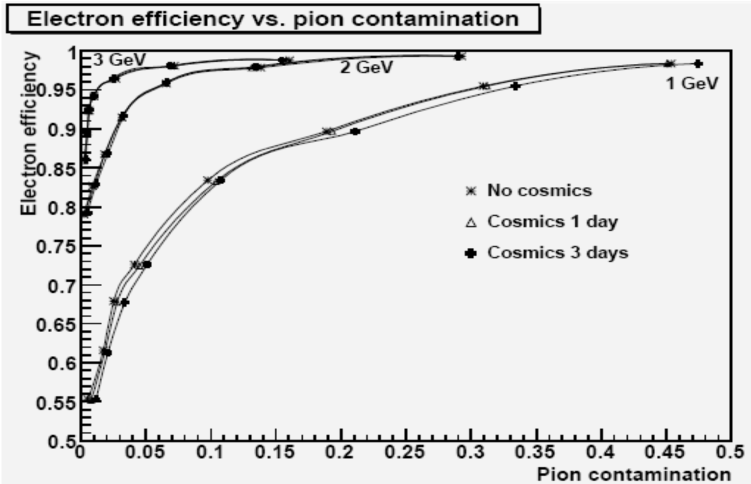
Neural network analysis

Input variables :
- **basetrack and film number**
- **Longitudinal and transversal profile**

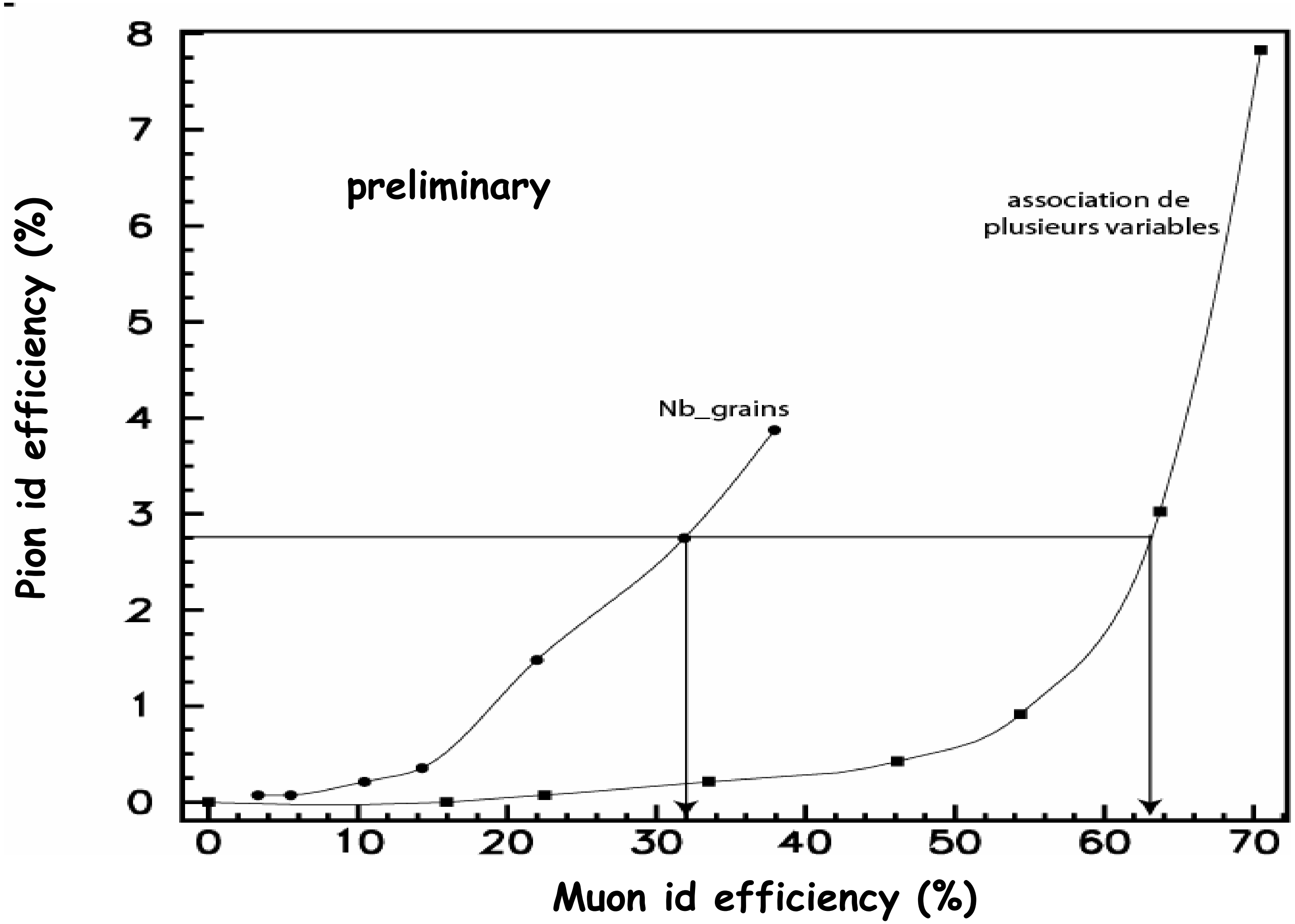
E (GeV)	$\varepsilon_{e\to e}$ %	$\eta_{\pi\to e}$ %	$\varepsilon_{e\to e}$ %	$\eta_{\pi\to e}$ %
	Simulated Events		Data	
0.5	90.5±1.5	81.3±1.6	—	—
1	81.1±1.6	8.4±1.0	—	—
2	82.0±1.4	0.7±0.3	—	2.0±0.3
3	89.2±1.2	0.5±0.3	> 61	—
4	89.9±1.1	0.4±0.2	—	0.4±0.1
5	93.9±0.9	0.4±0.2	—	—
6	93.1±0.9	0.4±0.2	96.3±0.8	0.4±0.2
8	95.3±0.8	0.1±0.1	—	—

E (GeV)	$\varepsilon_{e\to e}$ %	$\eta_{\pi\to e}$ %	$\varepsilon_{e\to e}$ %	$\eta_{\pi\to e}$ %
	Simulated Events		Data	
0.5	53.4±2.6	28.9±1.9	—	—
1	59.4±2.0	0.9±0.4	—	—
2	73.6±1.6	0.1±0.1	—	0.5±0.1
3	82.2±1.4	0.1±0.1	80±18	—
4	86.0±1.3	0.1±0.1	—	0.3±0.1
5	90.3±1.1	0.1±0.1	—	—
6	90.2±1.1	0.2±0.2	94.7±0.9	0.2±0.1
8	94.1±0.8	0.1±0.1	—	—

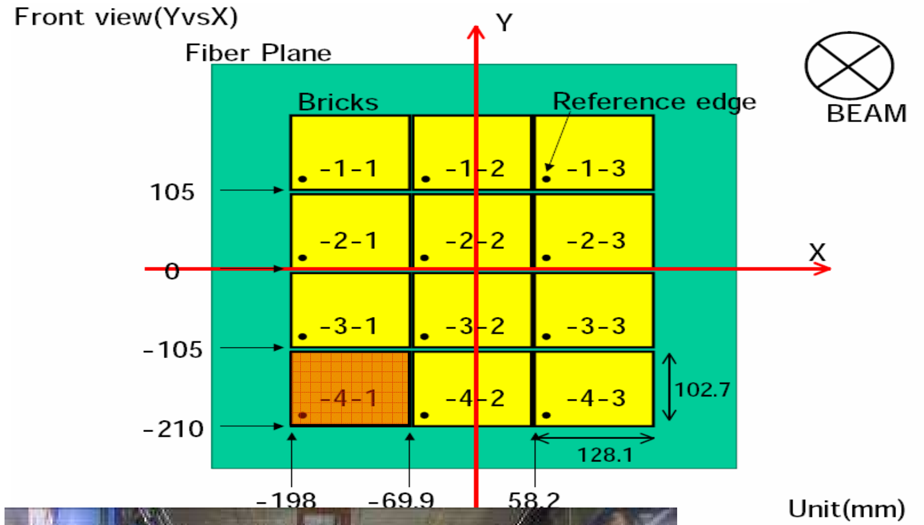


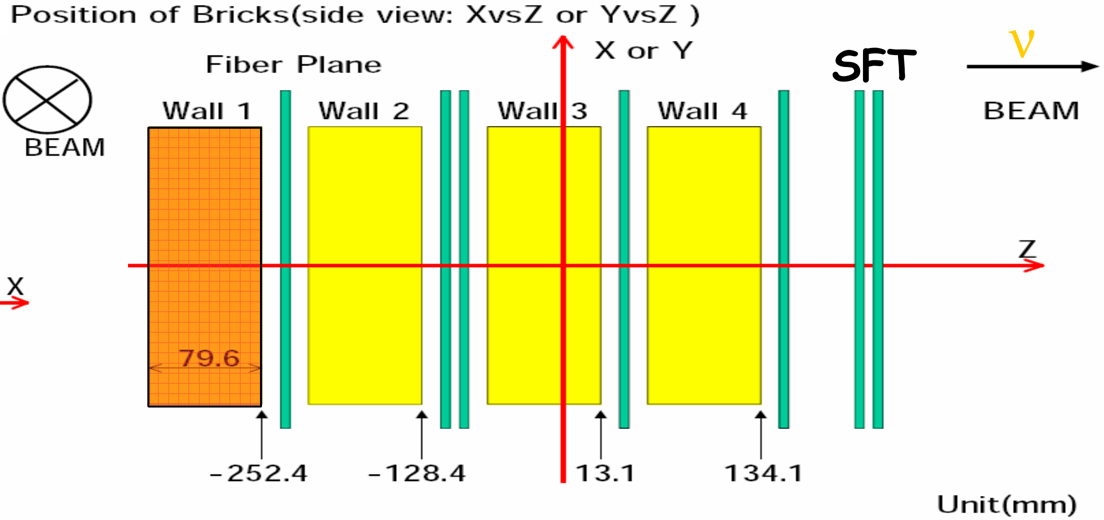


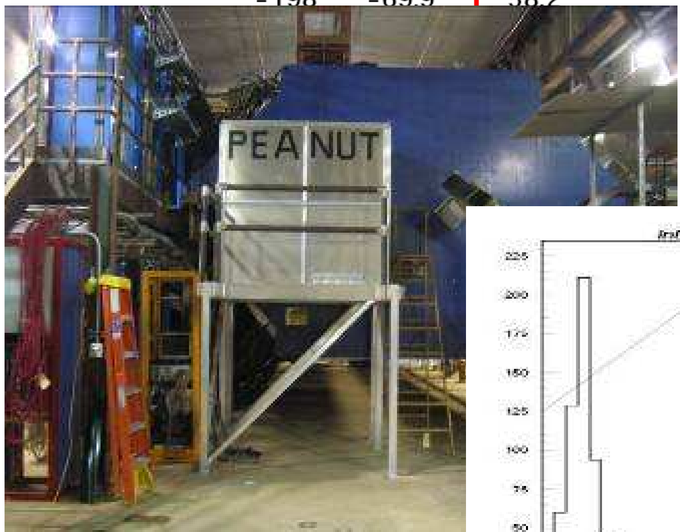
π/μ separation using dE/dx and MCS

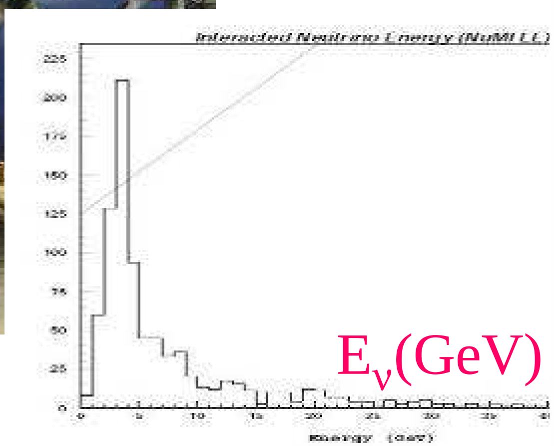


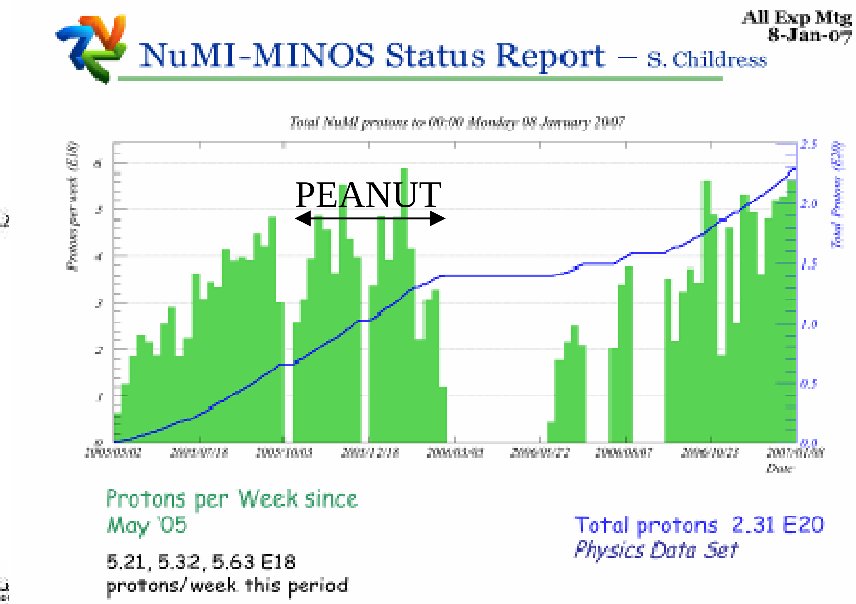
OPERA rehearsal in the NUMI beam : PEANUT











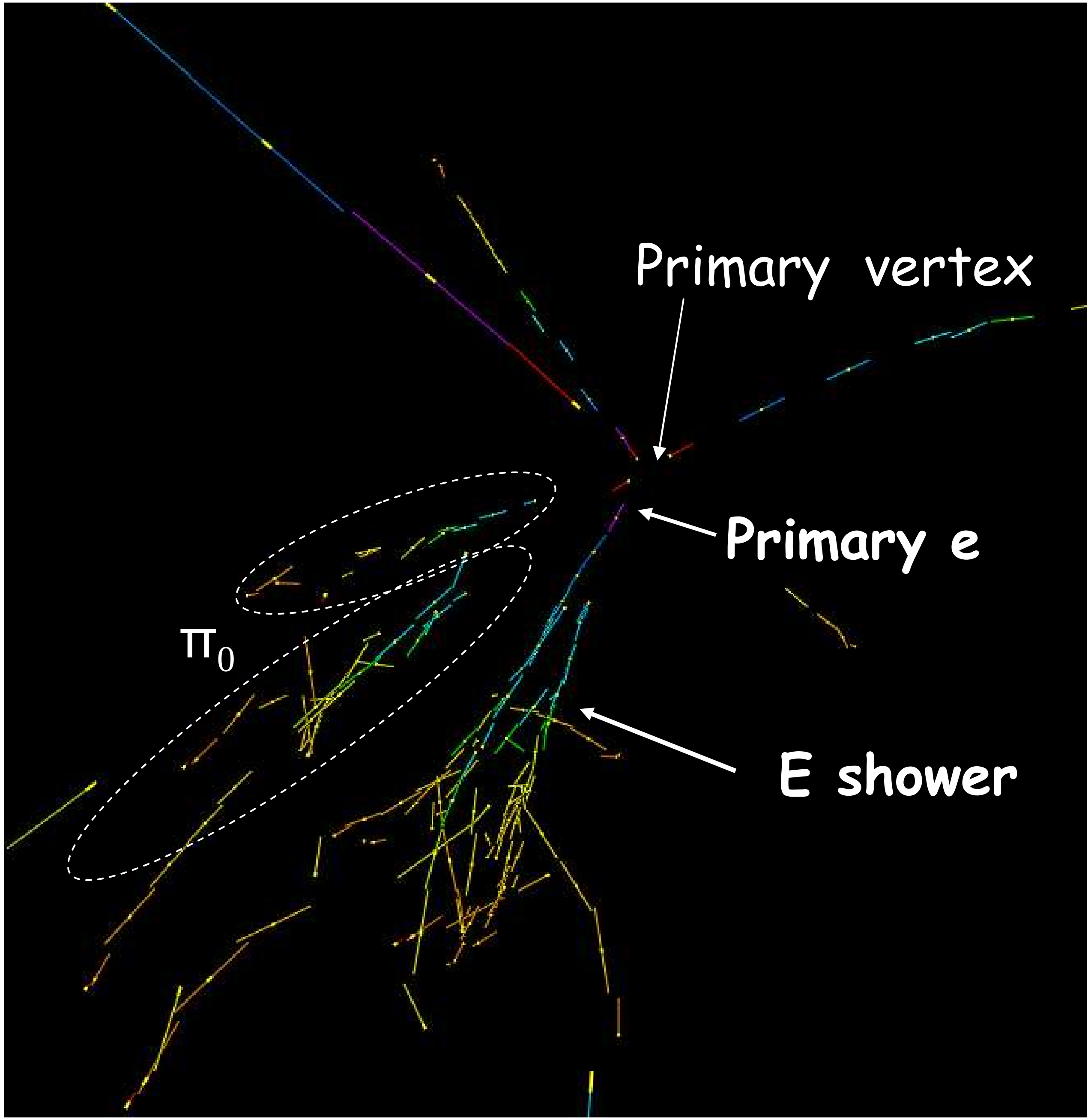
PEANUT status and objectives

Status:

- About 100 bricks exposed and a few thousands interactions expected
- 20 bricks currently under analysis (1000 located ν interactions expected)
- The SFT predictions are stored in the DB (same OPERA schema)
- Emulsion to SFT alignment successfully done with expected performances
- Pilot vertex analysis for 2 bricks in general scanning mode is now completed.
- Full Monte-Carlo simulation developed including SFT hit simulation

Main goals:

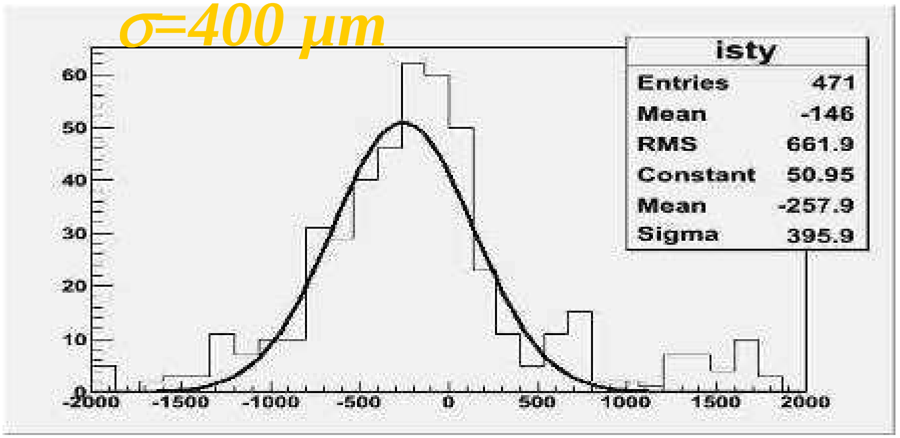
- Multiplicity studies for both biased (SFT-matching events) and unbiased samples
- De-convolution of the 3 cross-section components (QE, RES and DIS)

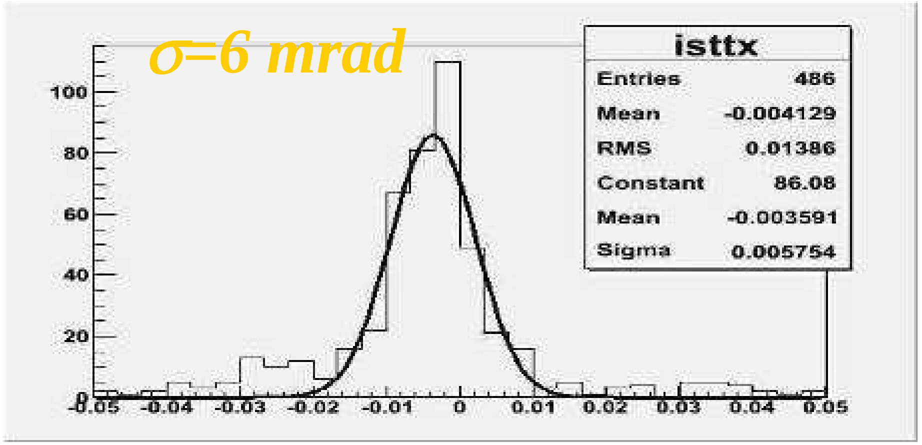


ν_e interaction

SFT – emulsion matching and vertex analysis

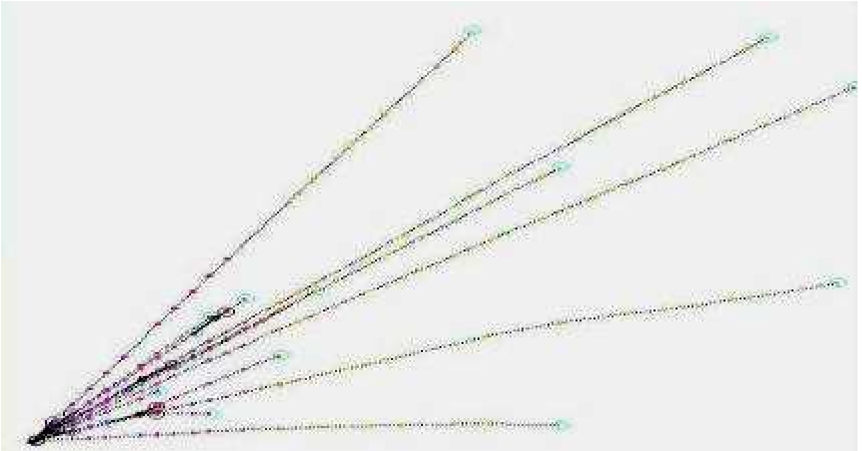
30 neutrino interactions with an SFT matching located in 1 brick





After efficiency correction (estimated through a full MC simulation):
N/ε = 56 ± 10, to be compared with (54±7) from flux and cross-section

1 high multiplicity event observed:
- 4 tracks from 2 e-pairs
- 8 primary tracks



7. Brick production and detector filling: status

Brick components

Emulsions: delivered in GS material for 154000 bricks (including CSd) : **75%**

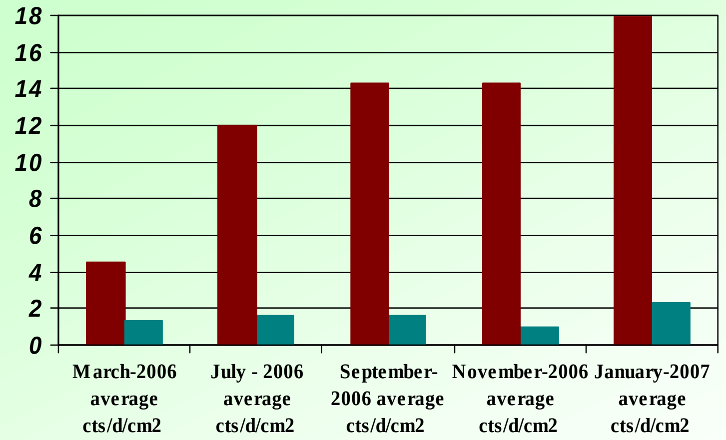
➔ **no room for finding new funds (Funding Agency Meeting, March 23, 2007)**

Lead:

- present production rate is 13000 pcs/day (~ 1 drum/day).
- by end of June production rate will go to 29000 pcs/day (~2.3 drums day).
- the production rate will be increased following the stability of brick production (BAM) and detector filling (BMS) rate.
- Lead mechanical quality is now good and stable. Air flow is still needed to secure single sheet pick up in BAM piling stations.
- Lead radioactivity

+ no surface migration observed

+ family equilibrium restored following the expected $T_{1/2}$ ~4.6 months



	March-2006 average cts/d/cm2	July - 2006 average cts/d/cm2	September-2006 average cts/d/cm2	November-2006 average cts/d/cm2	January-2007 average cts/d/cm2
total	4,5	12	14,3	14,3	17,9
5-5.5 MeV	1,3	1,6	1,6	1	2,3

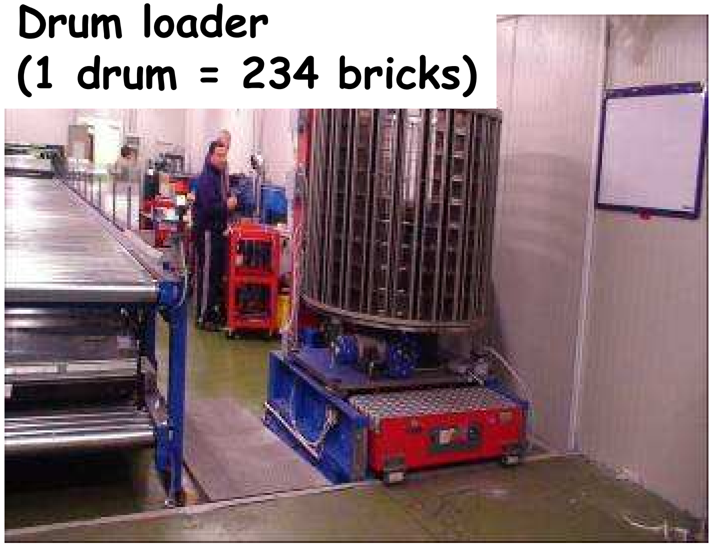
BAM in *Dark*
5 Piling/Pressing stations
1 Wrapping station

BAM

Running with 2 shifts/day

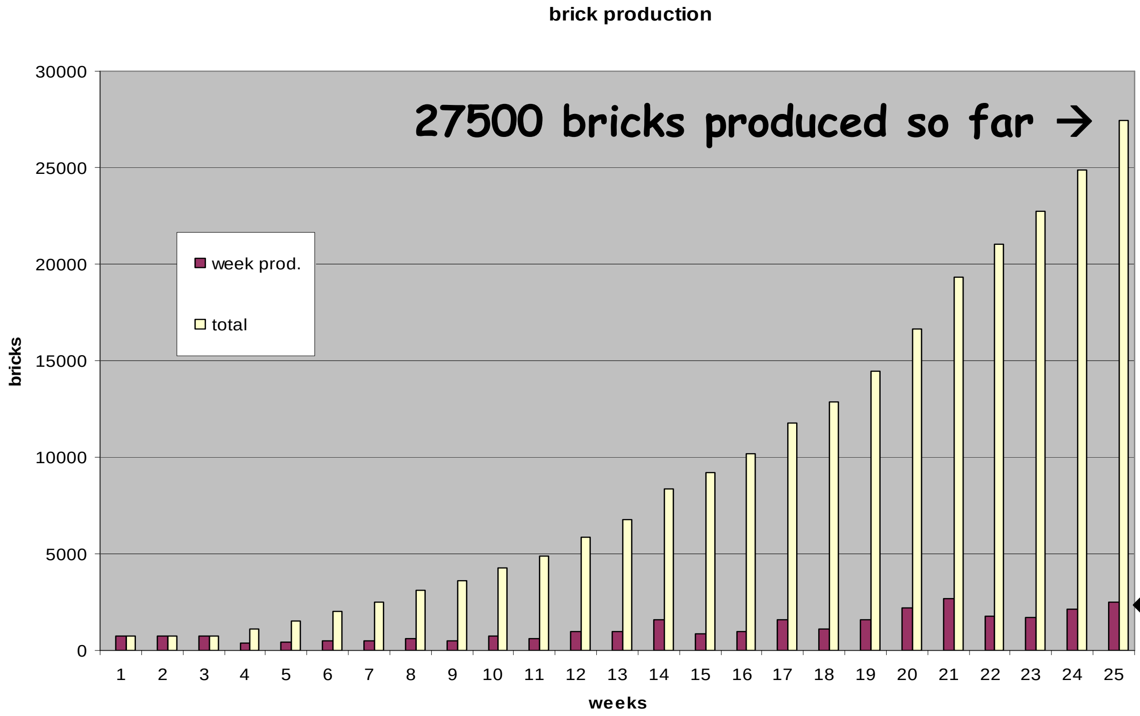
Lead Loading

Drum loader
(1 drum = 234 bricks)



Achieved milestones:
- 10 Kbricks by last SPSC
- 2 drums/day in May → 20 Kbricks by end of may
- 2.5 drums/day in June

Next milestone:
- 3 drums/day from sept 1st
  - **all technical aspects under control**
  - **but resource dependent !**



Brick production summary

Running with 2 shifts per day

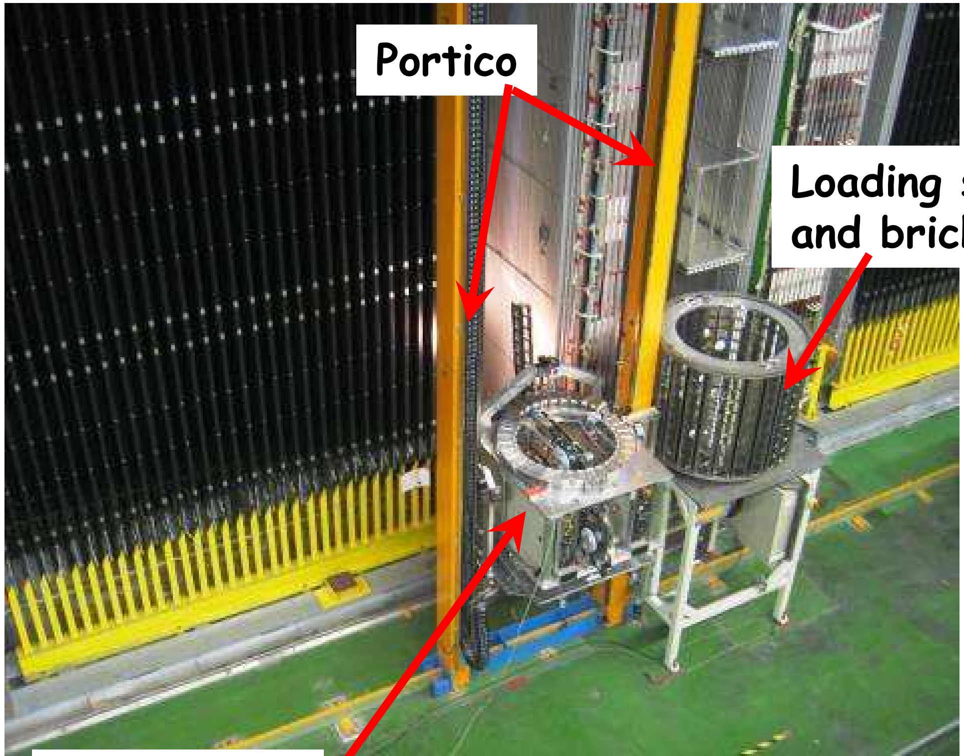
← 2500 bricks per week achieved

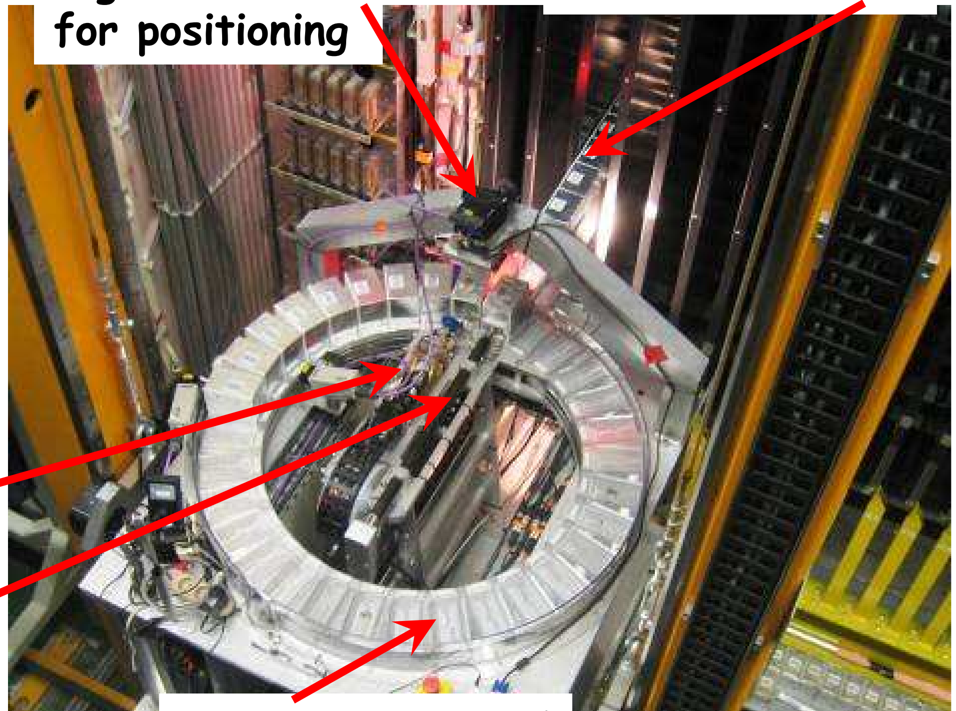
	Mean number of bricks During the October run	Completion of the filling of the detector
2 drums per day ~500 bricks	60 000	Mid September 08
2.5 drums per day ~600 bricks	70 000	End of June 08
3 drums per day ~700 bricks Starting in september	73 000	End of April 08

Our goal !

Brick Manipulator System

Spatial precision o(0.1 mm) on ranges o(10 m) using digital camera vision

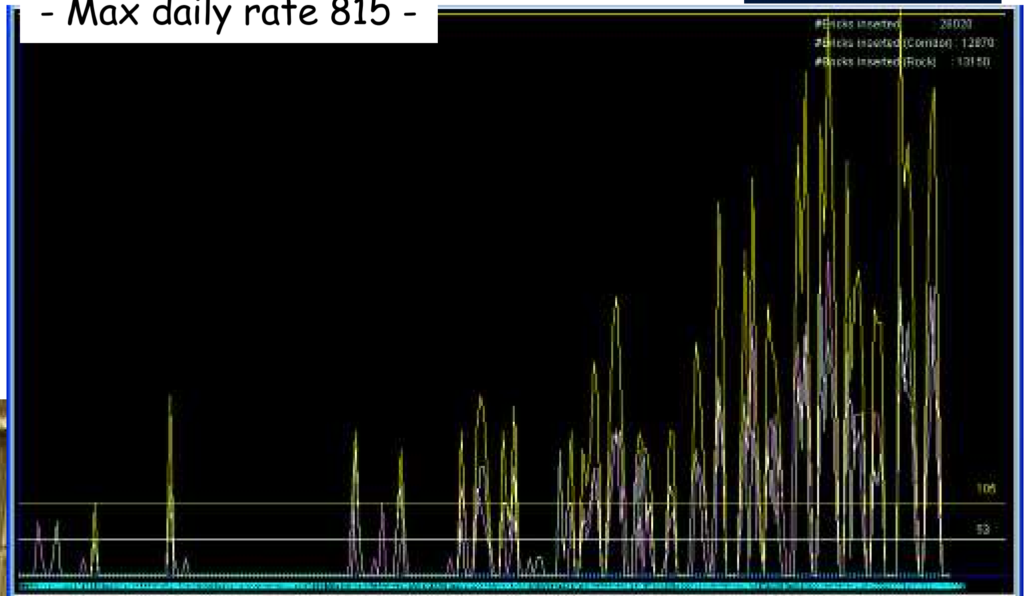




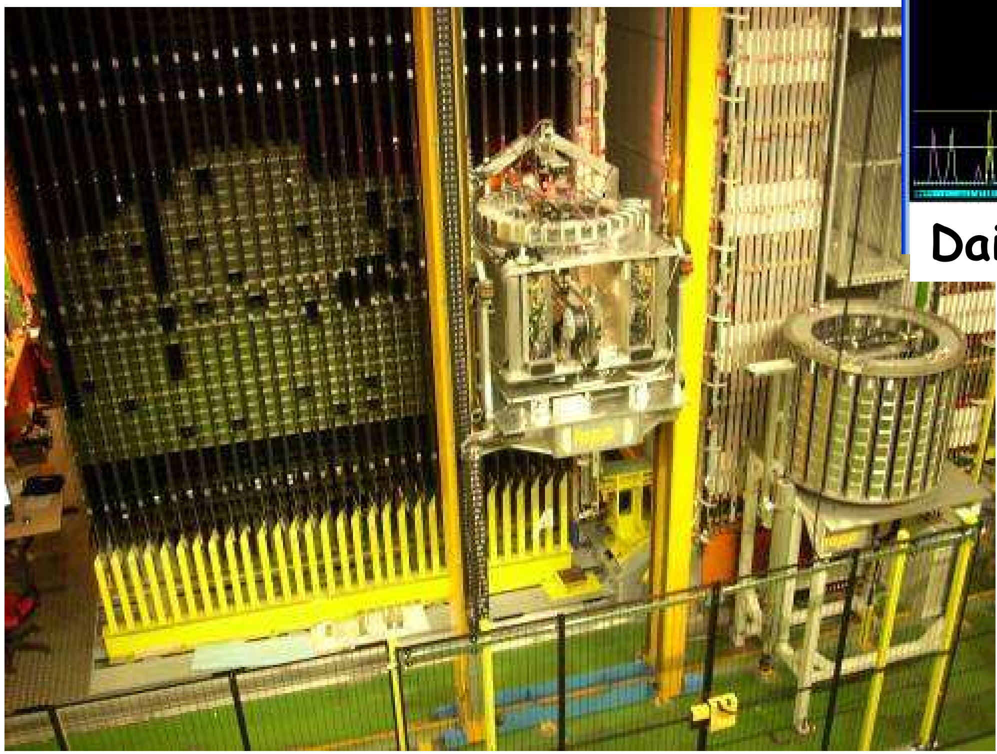
BMS : Insertion performances

Running with 2 shifts per day

26000 bricks inserted
since beginning of 2007
in the OPERA detector



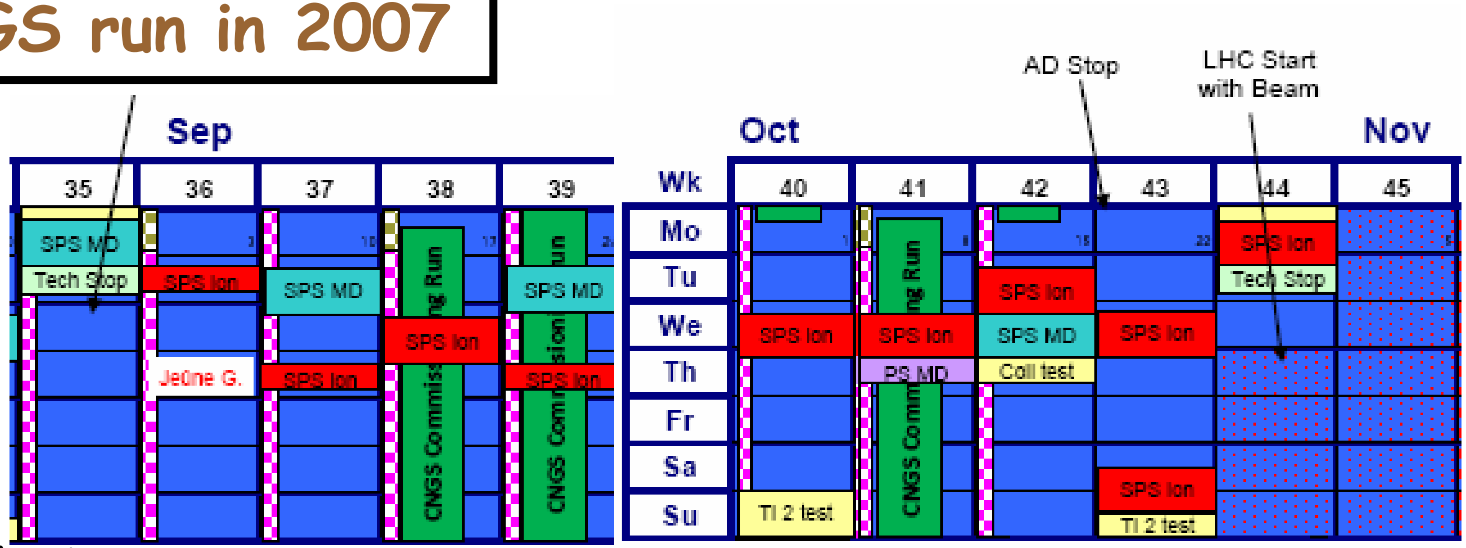
Daily rate from 21/10/06 to 21/06/07



Running staff: 1 expert and 1 operator per shift

<u>Verified performance (without failures or waiting time in drum exchange):</u>
insertion of 500 bricks in one shift

CNGS run in 2007



Hypothesis:

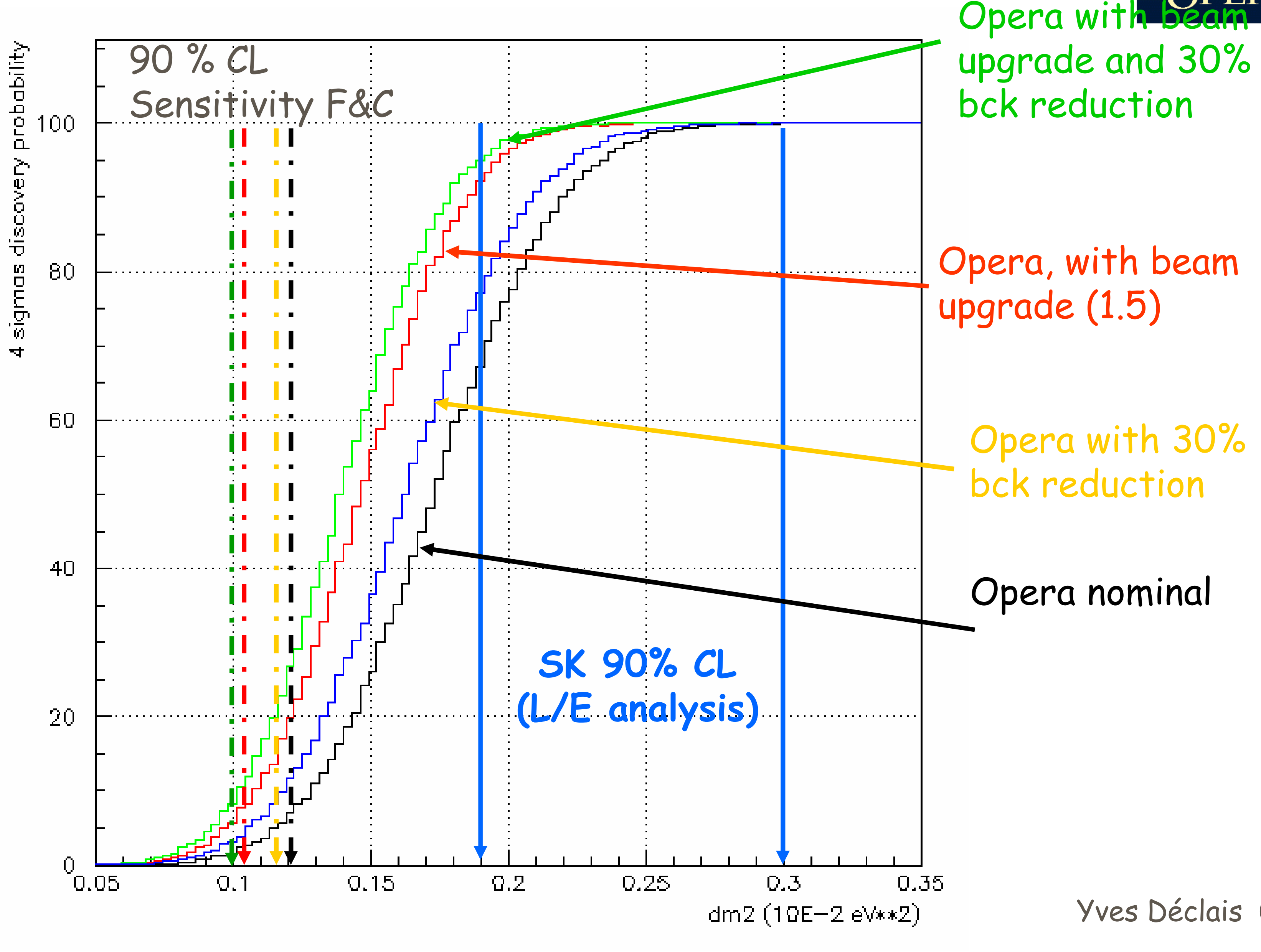
- 3 weeks of CNGS commissioning: 38 (half intensity, 1 CNGS cycle) , 39, 41
- 3 additional weeks of physics run : 40, 42, 43
- super cycle with 3 CNGS : 39.6 sec
- intensity as in the 2006 run : 1.7 10^{13} pot/extraction (70% of nominal high intensity)
- 70% efficiency of the machine complex

Bricks at the start of the run	Bricks at the end of the run	Integrated p.o.t	Bricks with interactions
58749 505 tons	71687 616 tons	0.43 10^{19} pot	180 (~6/day) 10 charm decay

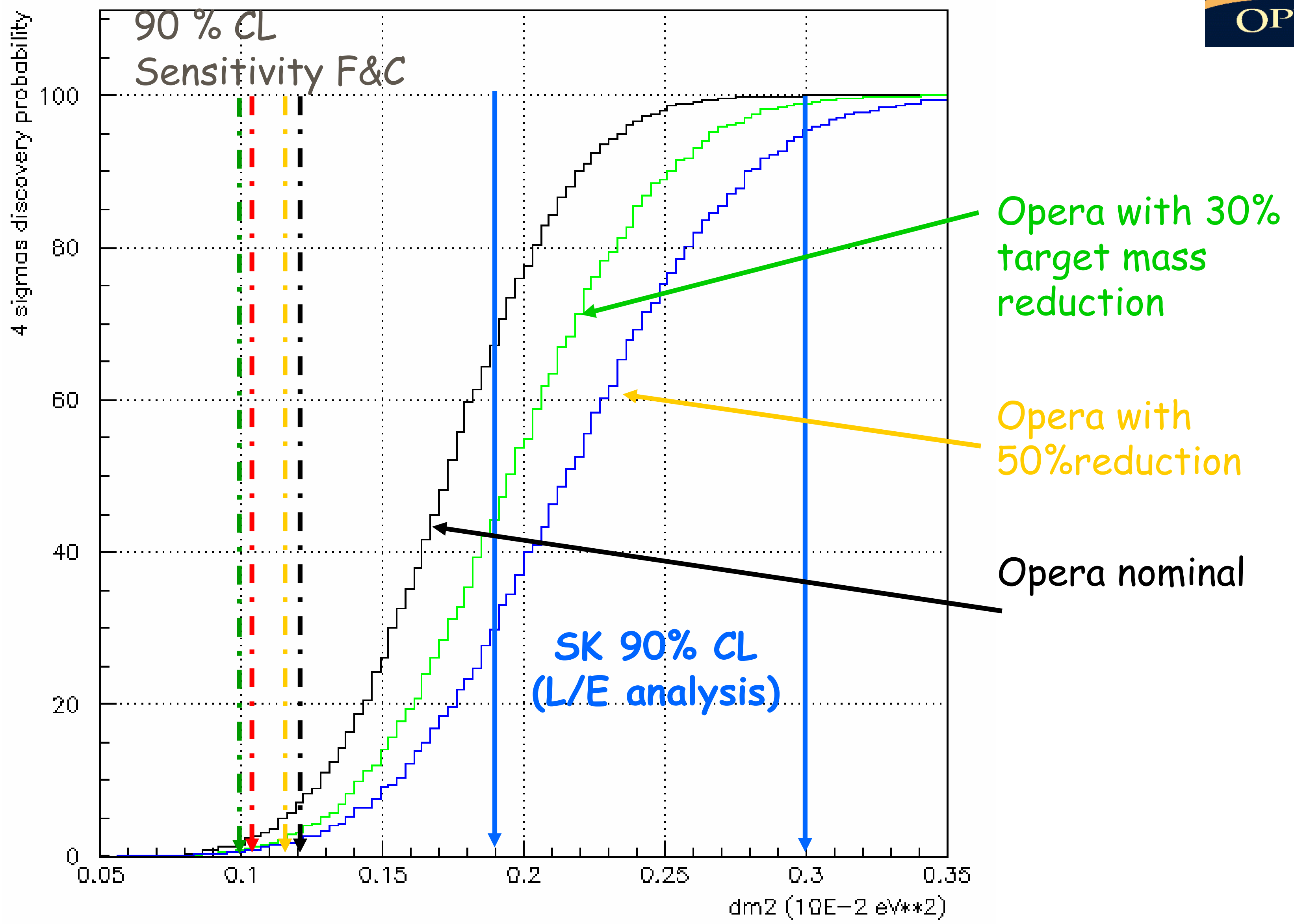
- 2006 CNGS run : ~ .1 10^{19} pot
- nominal CNGS year : 4.5 10^{19} pot

8. OPERA sensitivity revisited

OPERA sensitivity : nominal conditions



OPERA sensitivity with reduced target mass



9. Conclusions

- The electronic detectors of the OPERA experiment are ready for data taking during the fore coming CNGS runs
- The brick production is launched and the detector could be filled before the physics run in 2008
- The data analysis chain has been validated for the :
  - electronic detectors: during the CNGS beam periods in 2006 and also with cosmic rays in 2006 & 2007
  - emulsion detectors: during many test runs, especially with real neutrino event from an exposure in the NUMI beam

Caveat:

✓ the schedule is tight and the resources limited

➔ any problem will now induce delays impossible to recover

✓ OPERA sensitivity is limited by the statistics

➔ missing emulsions will seriously reduce its sensitivity