Study of alignment procedure for OPERA emulsion brick

Sheshukov Andrey, Zemskova Svetlana

JINR, Dubna, Russia

January 25, 2008

Outline

1 Introduction

- OPERA Brick
- Geometrical defects
- CR exposition

2 Analysis

- Alignment procedure
- Offset distributions
- Exposing conditions

3 Conclusions

OPERA Brick Geometrical defects CR exposition

OPERA Brick

Emulsion Cloud Chamber

- $(DX) \times (DY) = 128 \times 103 \text{ mm}^2$
- Length (DZ) = 81 mm
- 56 Pb plates d = 1 mm
- 57 Emulsion plates
 d = (44 + 205 + 44)μm

OPERA Brick Geometrical defects CR exposition

Geometrical defects



• Plates misalignment

OPERA Brick Geometrical defects CR exposition

Geometrical defects



• Plates misalignment

OPERA Brick Geometrical defects CR exposition

Geometrical defects



• Plates misalignment — 2D affine tranforms:

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} b1 \\ b2 \end{pmatrix}$$

OPERA Brick Geometrical defects CR exposition

Geometrical defects



• Plates misalignment — 2D affine tranforms:

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} b1 \\ b2 \end{pmatrix}$$

Emulsion distorsion

OPERA Brick Geometrical defects CR exposition

Geometrical defects



• Plates misalignment — 2D affine tranforms:

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} b1 \\ b2 \end{pmatrix}$$

 Emulsion distorsion — Shifts for each point f(·)

OPERA Brick Geometrical defects CR exposition

Geometrical defects



• Plates misalignment — 2D affine tranforms:

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} b1 \\ b2 \end{pmatrix}$$

 Emulsion distorsion — Shifts for each point f(·)

Solutions:

• X-ray marks (for example, Japan)

OPERA Brick Geometrical defects CR exposition

Geometrical defects



• Plates misalignment — 2D affine tranforms:

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} b1 \\ b2 \end{pmatrix}$$

 Emulsion distorsion — Shifts for each point f(·)

Solutions:

- X-ray marks (for example, Japan)
- CR exposure (Gran Sasso)

OPERA Brick Geometrical defects CR exposition

Cosmic Rays at Gran Sasso



CR exposure

- flux is about $2 tracks/mm^2/400 mrad$ per day of exposure
- about 70% with E > 1 GeV
- ullet about <10% are ${\rm e^-}$ (the rest are all $\mu^-)$

Alignment procedure Offset distributions Exposing conditions

- Simulation of CR μ^- tracks in <u>unshifted</u> ECC brick FedraVMC
- Alignment procedure (shifts only) FEDRA
- Results of alignment $\{X_{off}, Y_{off}\} \Rightarrow \{\sigma_x, \sigma_y\}$
- Obtain dependences: $\sigma = \sigma(N_{tracks}, E_{\mu}, \theta_{max})$

Alignment procedure Offset distributions Exposing conditions

X_{off} and Y_{off} distributions



oduction Alignment procedur Analysis Offset distributions nclusions Exposing conditions

X_{off} and Y_{off} distributions



Sheshukov A., Zemskova S. Emulsion alignment in OPERA

oduction Alignment procedur Analysis Offset distributions nclusions Exposing conditions

X_{off} and Y_{off} distributions

250 tracks 1 - Z dependence of X offset, 250 tracks plates 0-9 plates 10-19 200 plates 20-29 180 plates 30-39 160 140 plates 40-49 120 plates 50-55 100 --- All plates 80 60 40 20 0.2 0.4 0.6 -0.6 -0.4 -0.2 1 - Z dependence of Y offset, 250 tracks plates 0-9 plates 10-19 220 200 180 160 140 120 100 80 60 40 20 plates 20-29 plates 30-39 plates 40-49 plates 50-55 --- All plates -0.6 -0.4 0.2 0.4 0.6 -0.2

Sheshukov A., Zemskova S. Emulsion alignment in OPERA

 oduction
 Alignment procedure

 Analysis
 Offset distributions

 nclusions
 Exposing conditions

X_{off} and Y_{off} distributions



Atroduction Alignment procedure Analysis Offset distributions Conclusions Exposing conditions

Exposure duration

N _{tracks}	20	30	50	100	500
$\delta heta$	31%	19%	11%	6%	2%
$\sigma, \mu { m m}$	0.7	0.61	0.46	0.33	0.15

- Alignment accuracy improves tracking quality
 - need more exposure!

 Introduction
 Alignment procedur

 Analysis
 Offset distributions

 Conclusions
 Exposing conditions

Exposure duration

N _{tracks}	20	30	50	100	500
$\delta heta$	31%	19%	11%	6%	2%
$\sigma, \mu { m m}$	0.7	0.61	0.46	0.33	0.15

- Alignment accuracy improves tracking quality
 - need more exposure!
- Cosmic background makes reconstruction more difficult — need less exposure!

 Introduction
 Alignment procedur

 Analysis
 Offset distributions

 Conclusions
 Exposing conditions

Exposure duration

N_{tracks}	20	30	50	100	500
$\delta heta$	31%	19%	11%	6%	2%
$\sigma, \mu { m m}$	0.7	0.61	0.46	0.33	0.15

- Alignment accuracy improves tracking quality
 - need more exposure!
- Cosmic background makes reconstruction more difficult — need less exposure!

Need analysis of $\varepsilon_{tr}(N_{tracks})$

∜

ntroduction Alignment procedure Analysis Offset distributions Conclusions Exposing conditions

Exposing conditions



Sheshukov A., Zemskova S. Emulsion alignment in OPERA

Analysis Alignment procedure Offset distributions Exposing conditions

Exposing conditions



Conclusions

- MC analisys of full brick alignment shows to be useful.
- Resolution of alignment procedure had been calculated.
- There is room for alignment procedure improvements
- Full spectrum of CR μ^- to be simulated
- Tracking quality dependence on N_{μ} needs to be analised to determine optimal T_{exp}