

Observation of Atmospheric Neutrinos with Baksan Telescope

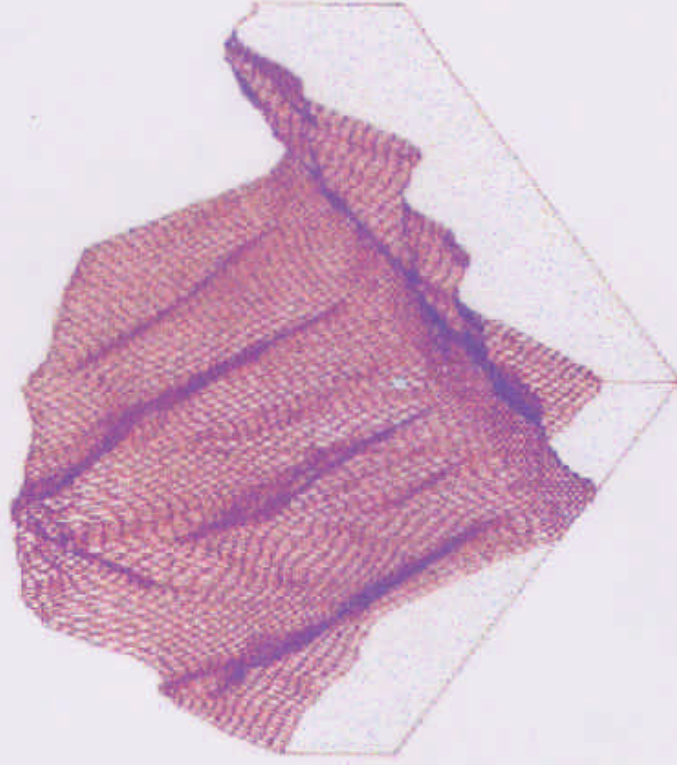
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- ◆ *Baksan Underground* ◆ *Simulation*
- ◆ *Scintillator Telescope* ◆ *Data Vs. Monte Carlo*
- ◆ *Detection of Upward* ◆ *Background*
- ◆ *Going Muons* ◆ *Conclusion*
- ◆ *Data Reduction*

S.P. Mikheyev Atmospheric Neutrinos with Baksan Telescope

Baksan Underground Scintillator Telescope

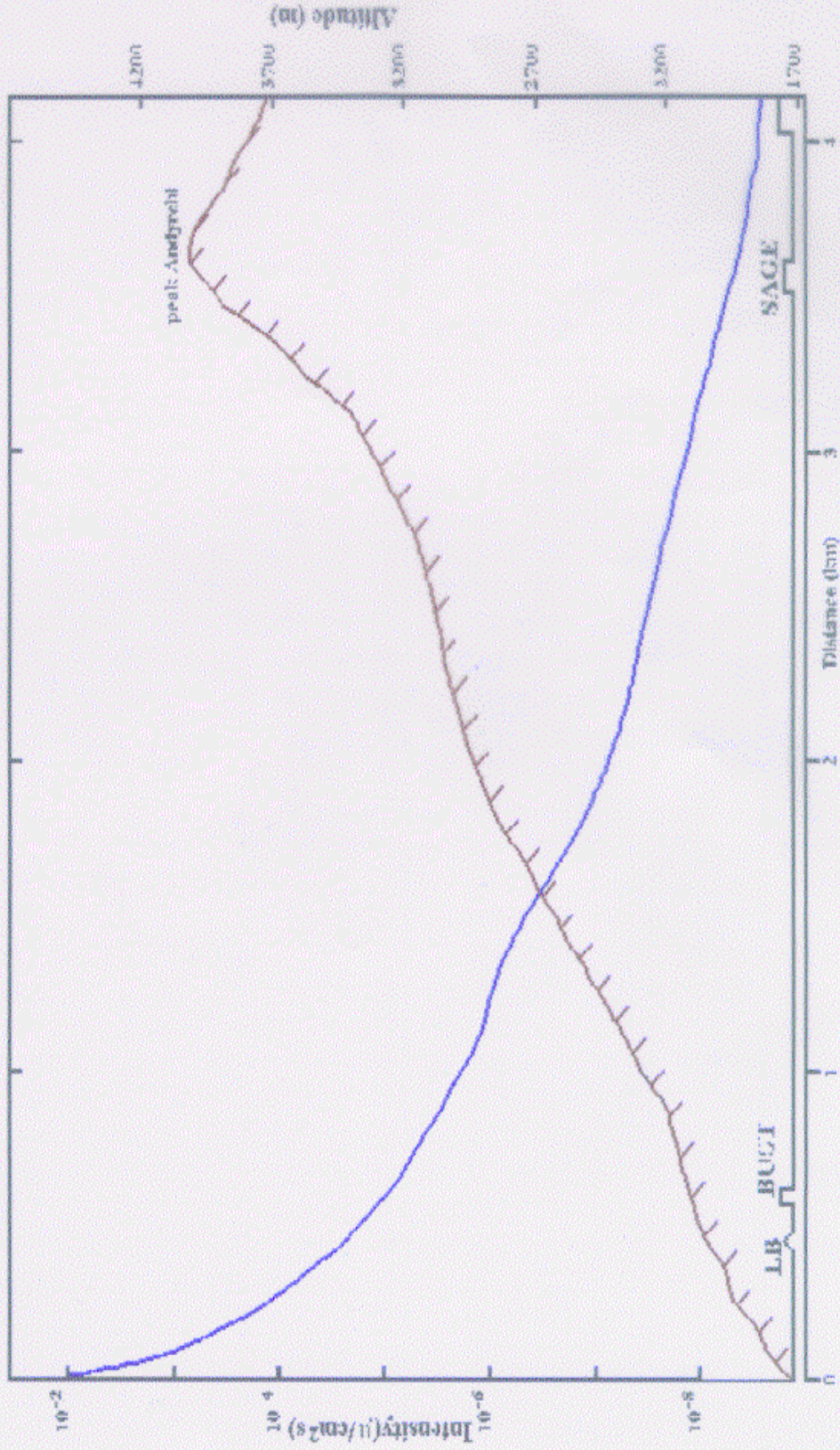


June 17 2000

Neutrino 2000, Sudbury, Canada

S.P. Mikheyev Atmospheric Neutrinos with Baksan Telescope

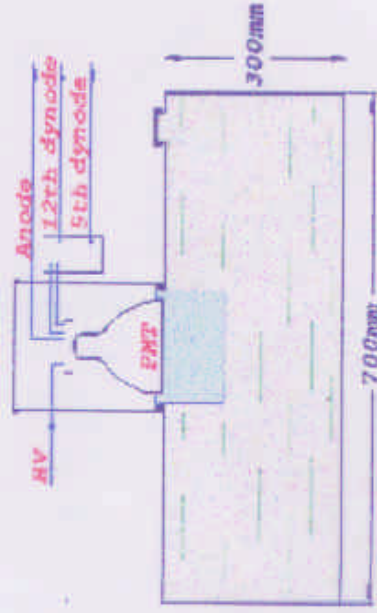
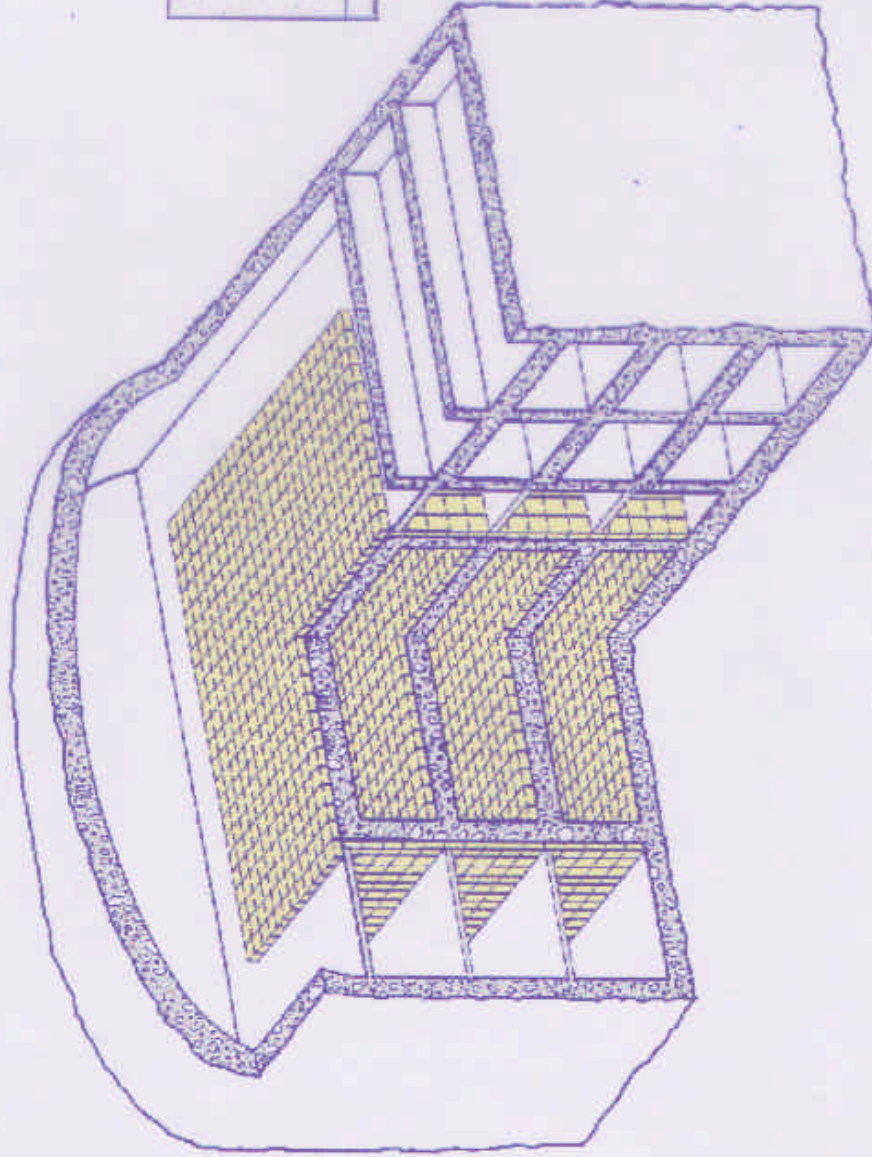
Baksan Underground Scintillator Telescope



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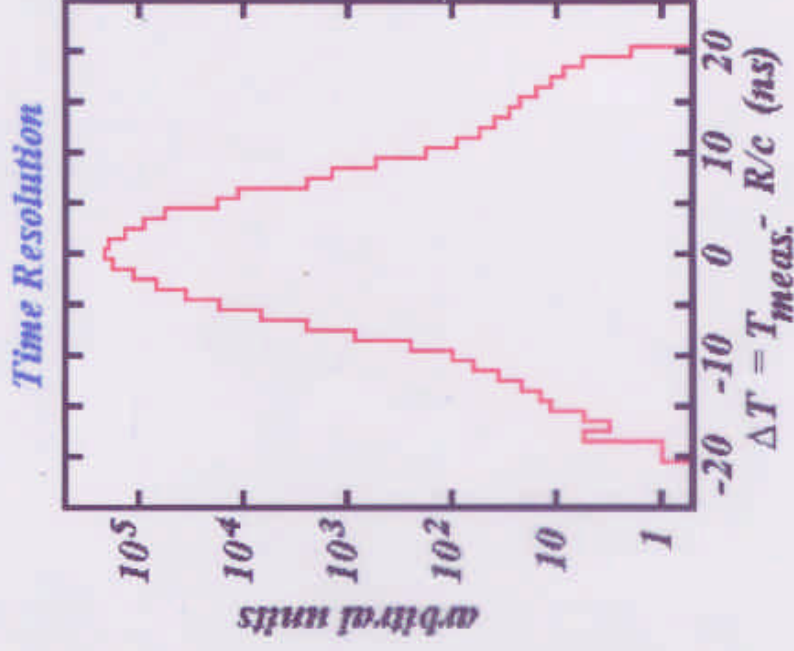


June 17 2000

Neutrino 2000, Sudbury, Canada

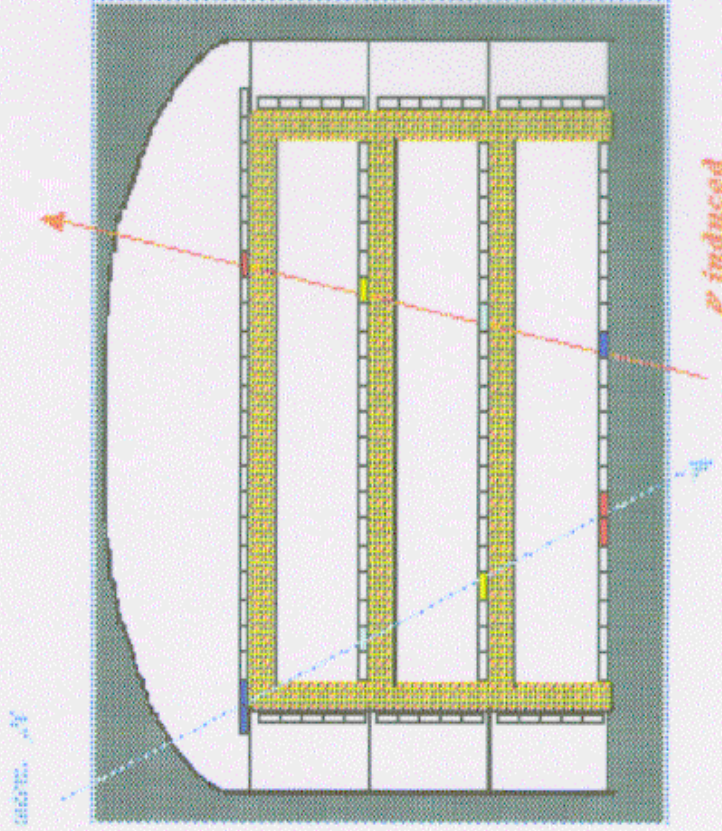
Baksan Underground Scintillator Telescope

- ◆ **Depth: 850 hg/cm²**
- ◆ **Size: 17m×17m×11m**
- ◆ **Tank size: 70cm×70cm×30cm**
- ◆ **Number of tanks: 3150**
- ◆ **Angular resolution: 2°**
- ◆ **Time resolution: 5 ns**
- ◆ **Trigger: ≥ 10MeV in any plane**
- ◆ **Rate: 17 Hz**
- ◆ **upward/downward: 10⁻⁷**

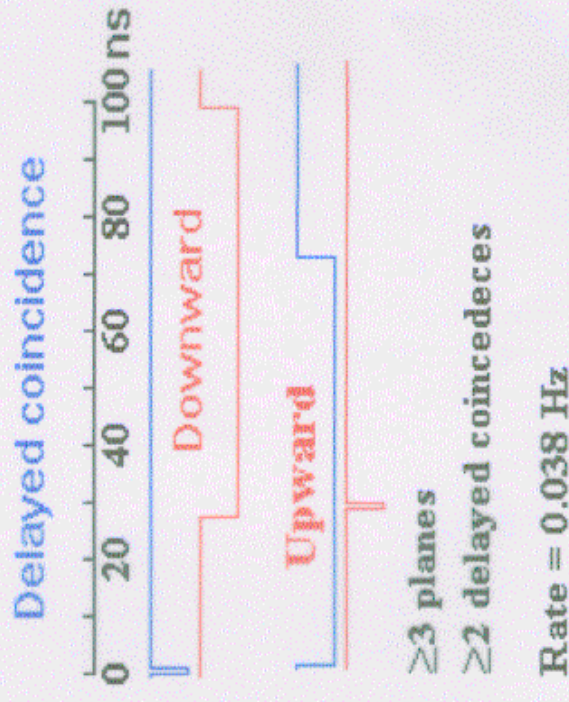


S.P. Mikheyev Atmospheric Neutrinos with Baksan Telescope

Detection of Upward-Going Muons

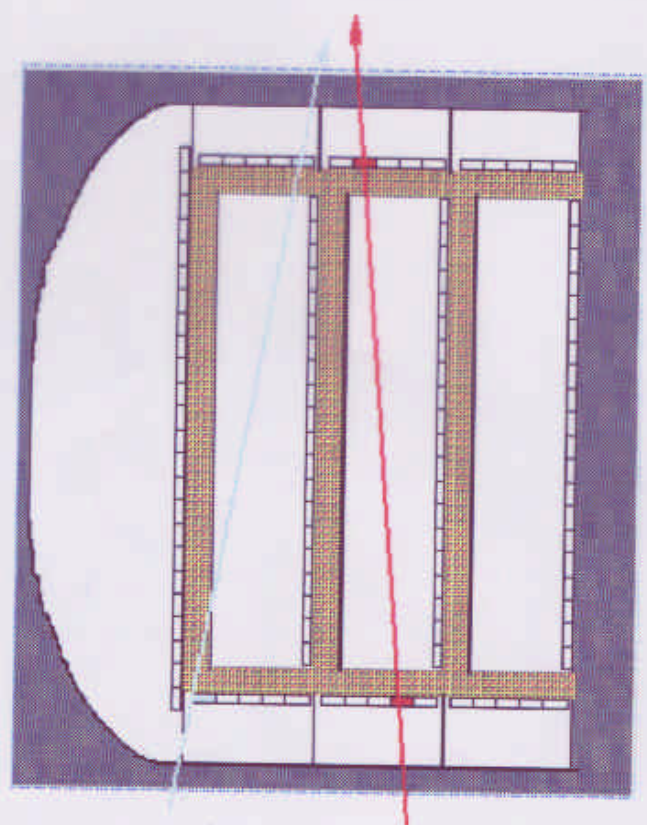


Hard Trigger I



Detection of Upward-Going Muons

Hard Trigger II



Soft Trigger

$$\frac{1}{N} \sum |\Delta T_{ij}| > 20 \text{ ns}$$

$$N = 3, 4$$

$$\Delta T_{ij} = T_i - T_j - \frac{R}{c}$$

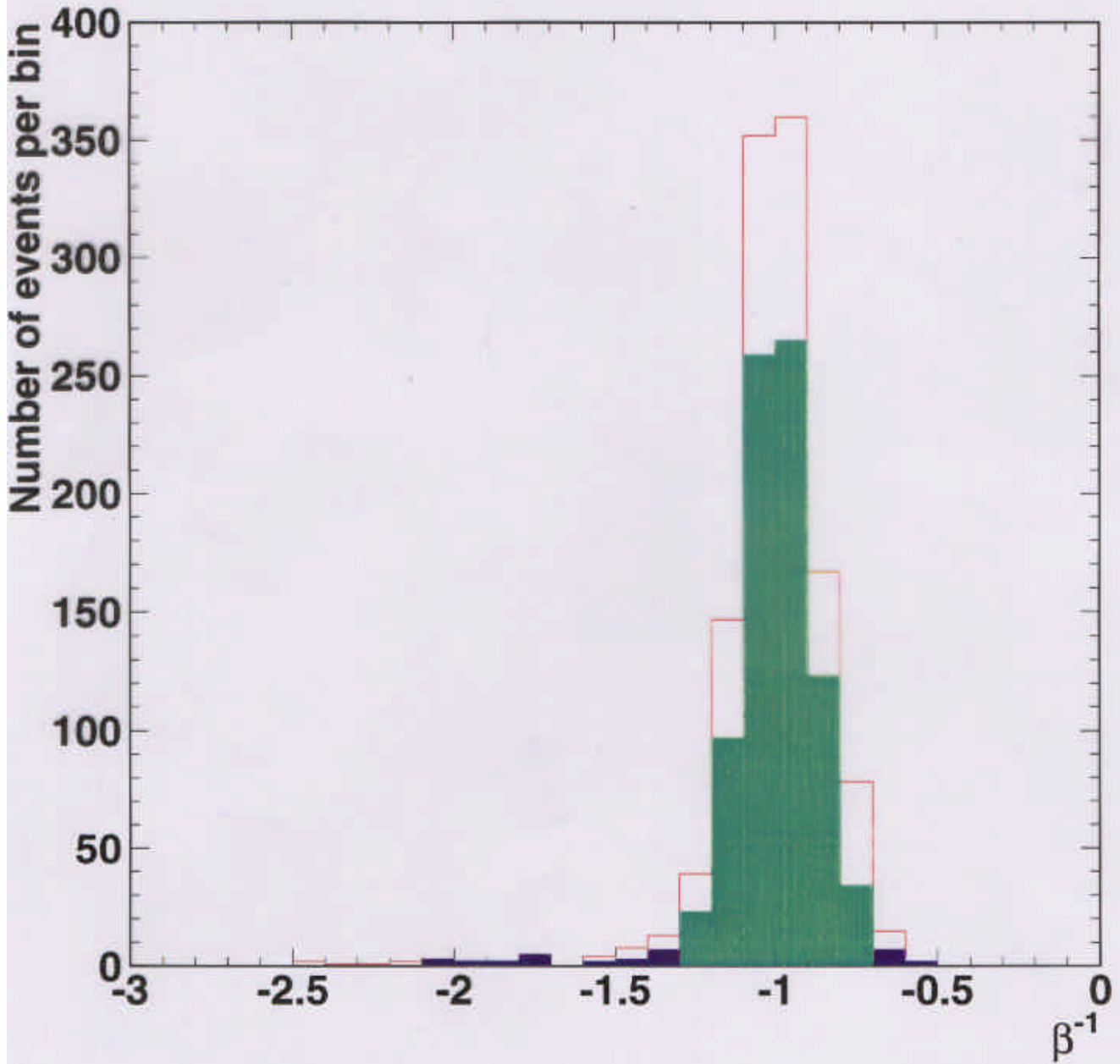
Data

Dec. 1978 ÷ Jan. 2000

Live Time 15.7 y.

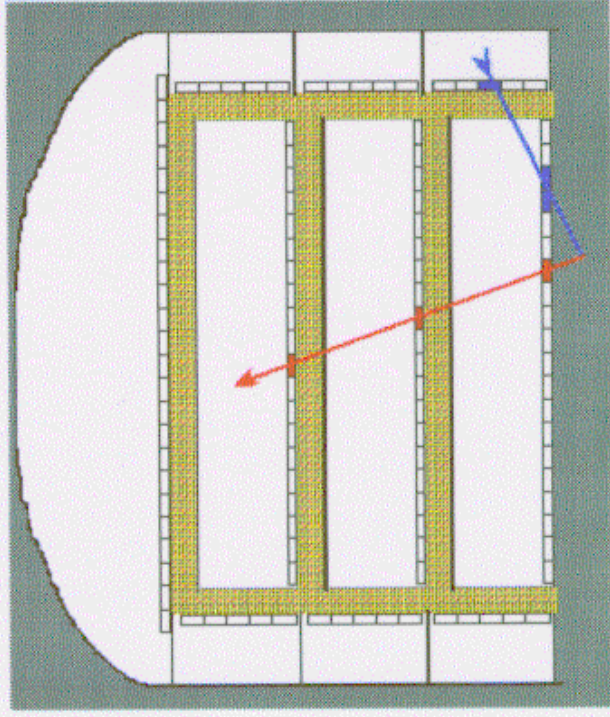
Data Reduction

◆ <i>General Trigger</i>	<i>17 s⁻¹</i>
◆ <i>Special Trigger</i>	<i>0.045 s⁻¹</i>
◆ <i>Reconstructed track $\cos\theta < 0$</i>	<i>1202</i>
◆ <i>Geometrical cuts</i>	<i>1087</i>
◆ <i>≥ 2 external planes</i>	<i>998</i>
◆ <i>Muon range > 500 g/cm²</i>	<i>834</i>
◆ <i>$-1.3 < 1/\beta < -0.7$</i>	<i>801</i>



Background

◆ Backscattering:



12990 hours

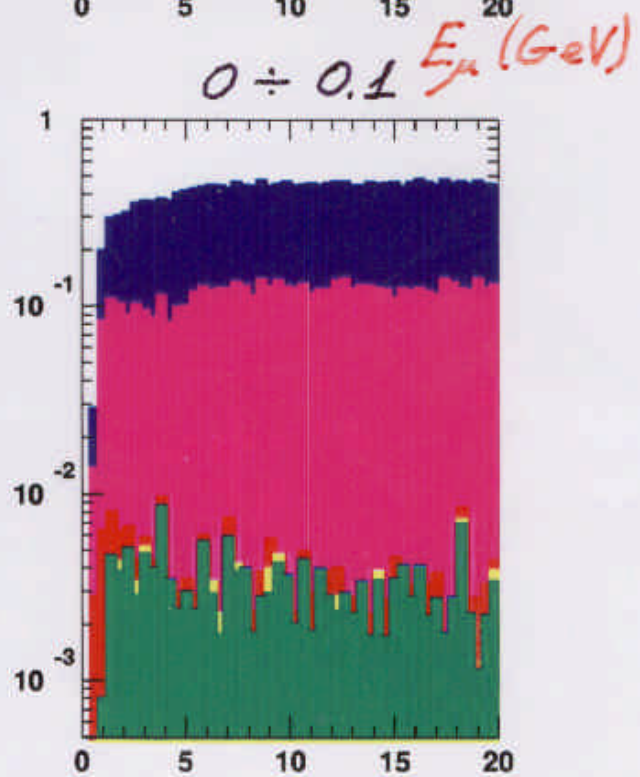
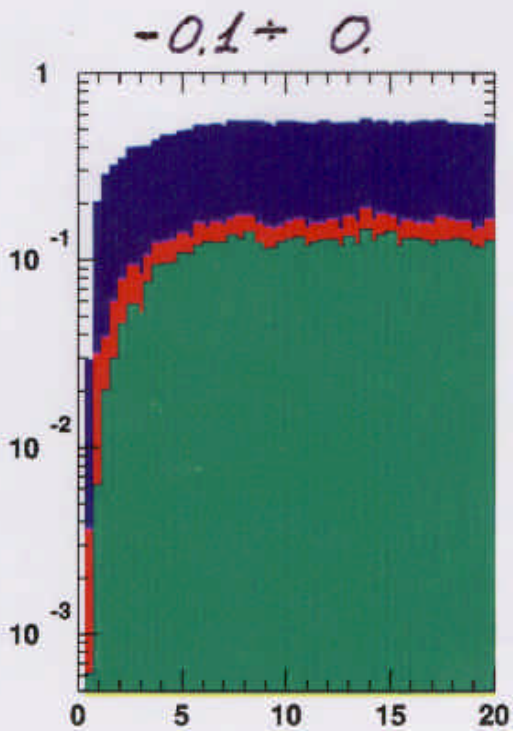
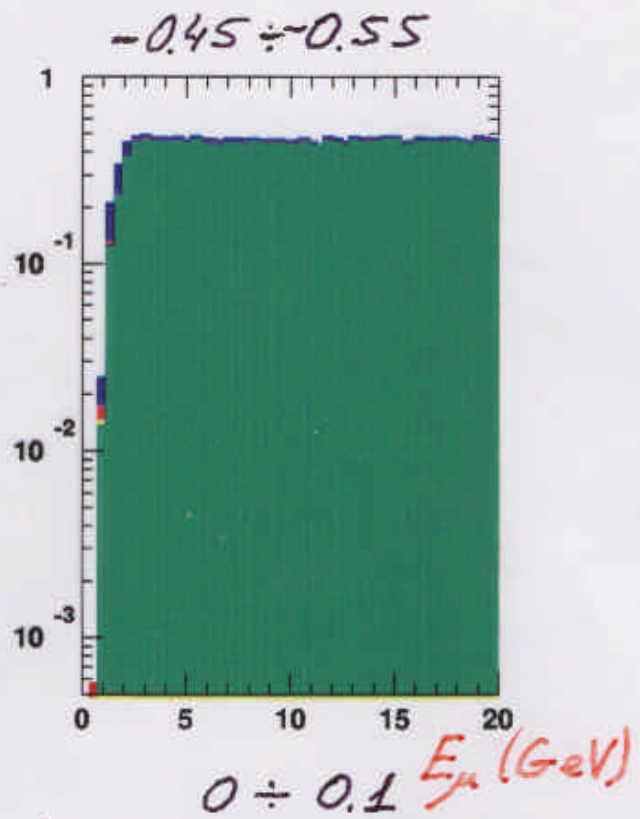
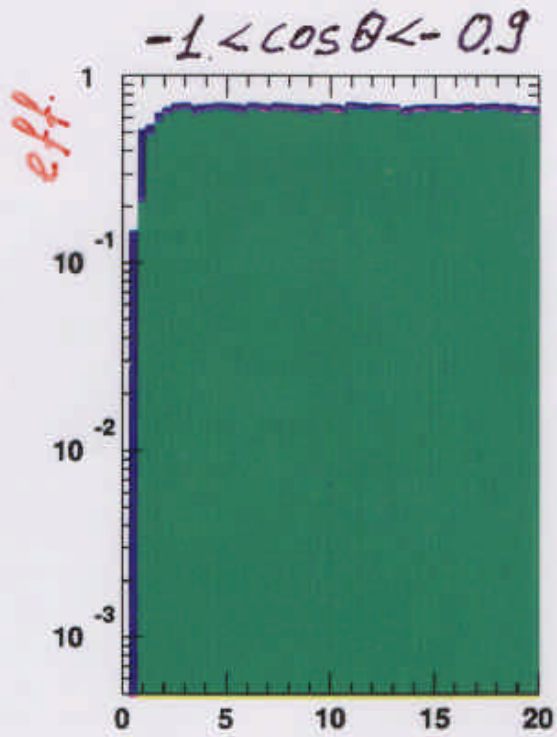
*26 events (good trajectory)
probability $4.7 \cdot 10^{-7}$*

*139 events (questionable
trajectory)*

probability $2.5 \cdot 10^{-6}$

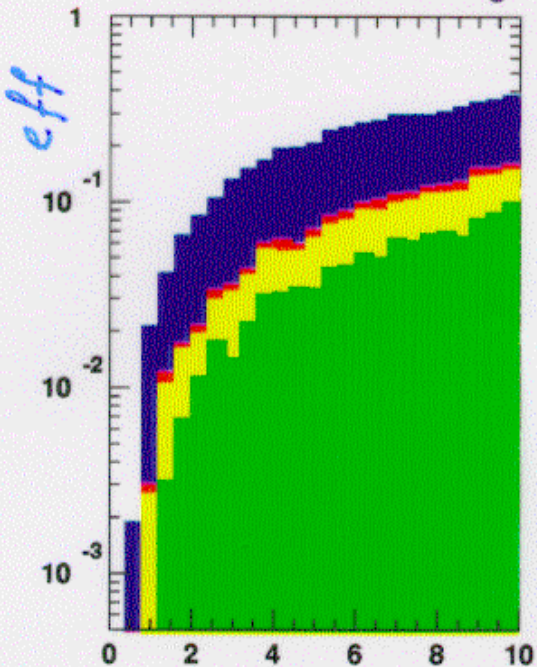
No events with range $> 500\text{g}/\text{cm}^2$

μ

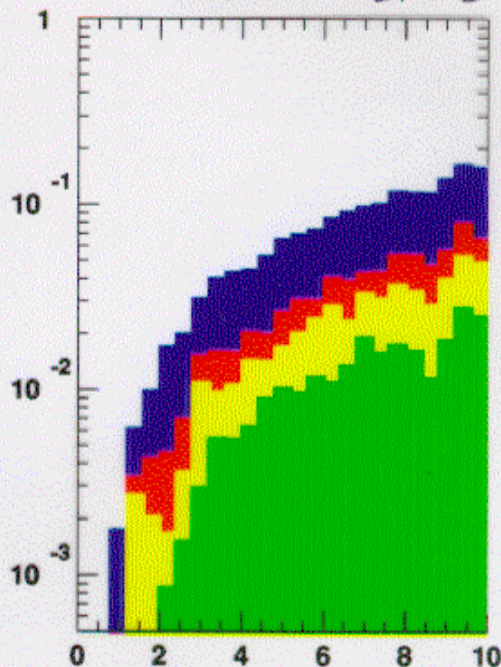


π

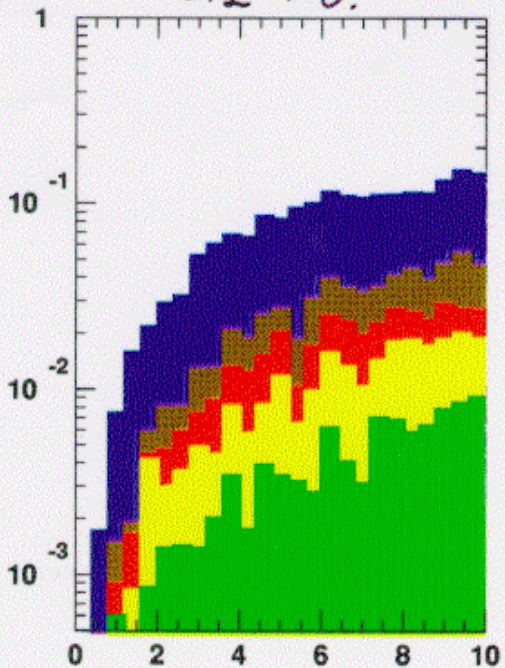
$-1 < \cos\theta < -0.9$



$-0.45 \div -0.55$

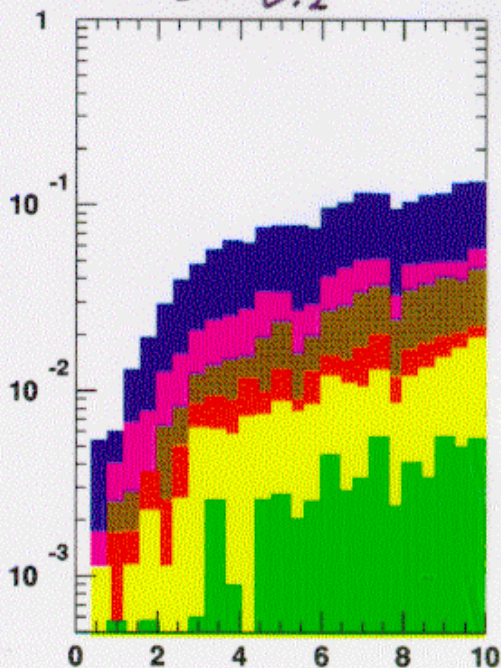


$-0.1 \div 0.$



$0 \div 0.1$

$E_\pi(\text{GeV})$



Background

$1/\beta$ cut: $-1.3 < 1/\beta < -0.7$

MC

μ - 1% rejected

π - 50% rejected

DATA

- 2% rejected

*π contribution to upgoing
muon sample $< 2\%$*

Monte Carlo

Physical Input

- ◆ *Neutrino Cross - Section:*
 - Quasielastic Scattering*
 - Resonance Production*
 - Deep-Inelastic Scattering (GRV PDF)*
- ◆ *Bartol Neutrino Flux*
- ◆ *Muon Propagation in Baksan Rock*

Detector response

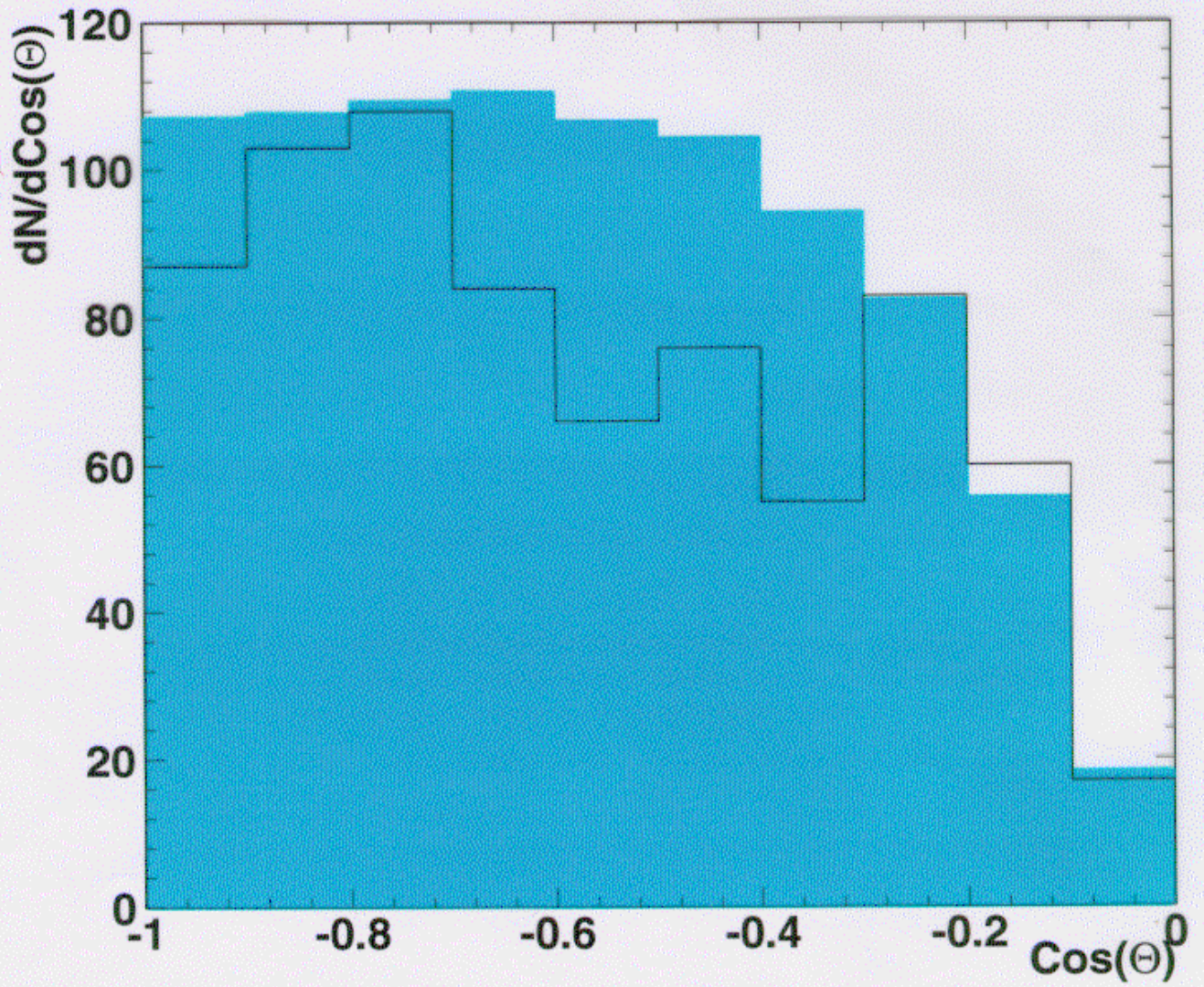
*Measured Time Resolution and Trigger Efficiency
on week by week base.*

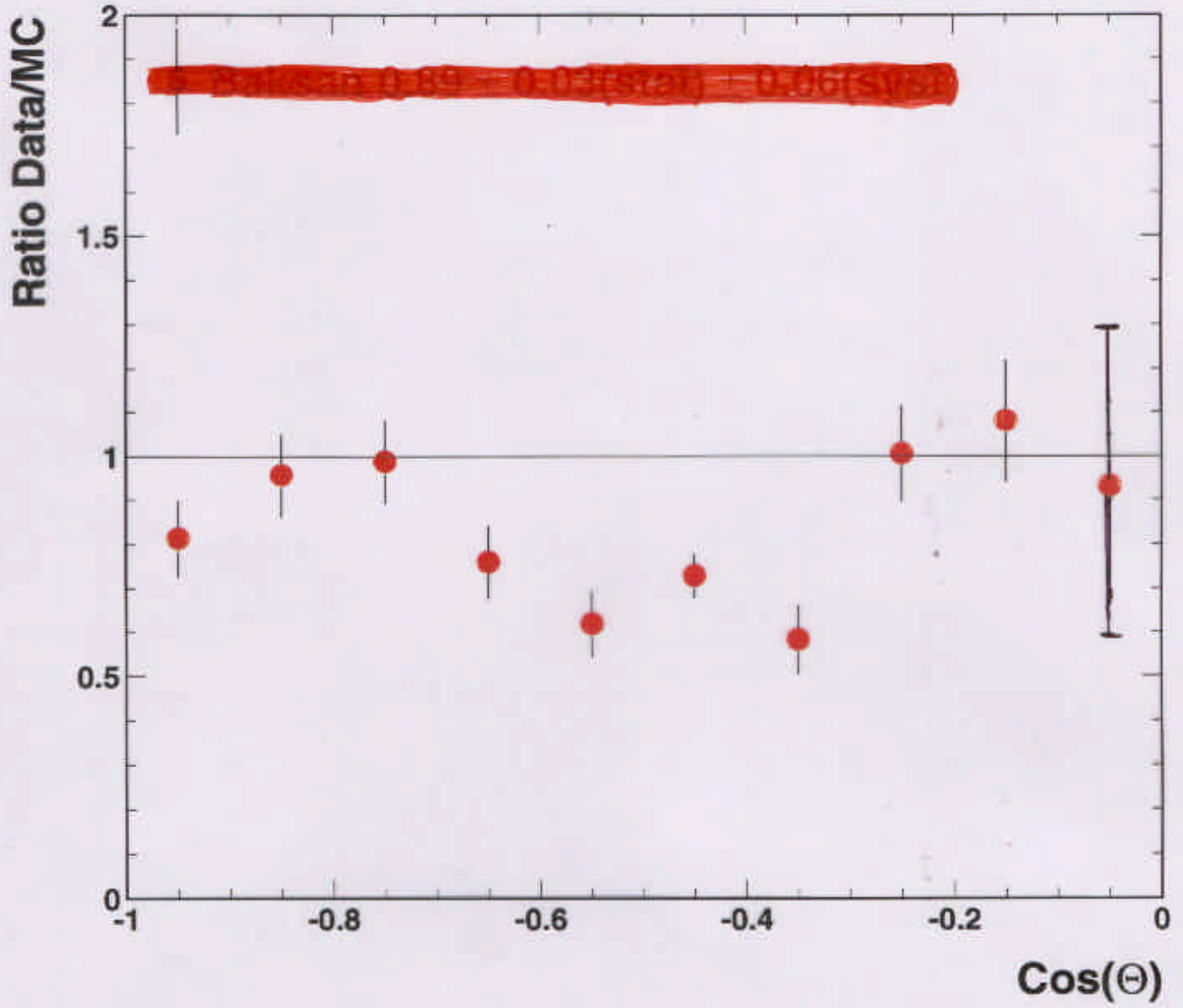
Data Vs. Monte Carlo

	<i>Data (15.7 y.)</i>	<i>MC (30 × 15.7 y.)</i>
◆ <i>General Trigger</i>	<i>17 s⁻¹</i>	<i>3603.2</i>
◆ <i>Special Trigger</i>	<i>0.045 s⁻¹</i>	<i>1266.9</i>
◆ <i>Reconstructed track</i>	<i>0.033 s⁻¹</i>	<i>1266.4</i>
◆ <i>cos θ < 0</i>	<i>1202</i>	<i>1223.9</i>
◆ <i>Geometrical cuts</i>	<i>1087</i>	<i>1145.4</i>
◆ <i>≥ 2 external planes</i>	<i>998</i>	<i>963.6</i>
◆ <i>Muon range > 500 g/cm²</i>	<i>834</i>	<i>953.1</i>
◆ <i>-1.3 < 1/β < -0.7</i>	<i>801</i>	<i>941.6</i>

Ratio Data/MC = 0.85 ± 0.03 stat. ± 0.05 syst.

(Theoretical uncertainties ≈ 15 ÷ 20 %)





Conclusion

- ◆ *> 20 years of stable operation* \Rightarrow 801 upward-going muons.
- ◆ $\text{Data/MC} = 0.85 \pm 0.03_{\text{stat.}} \pm 0.05_{\text{syst.}}$
- ◆ No indications for background from “backscattering” were found.
- ◆ The shape of angular distribution fit with small probability atmospheric neutrino model without neutrino oscillation.