

CNGS Beam profile monitoring at LNGS

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(去年博士とってなかったらD5)

The CNGS beam

CERN SPS

ν_{μ}

conventional ν beam

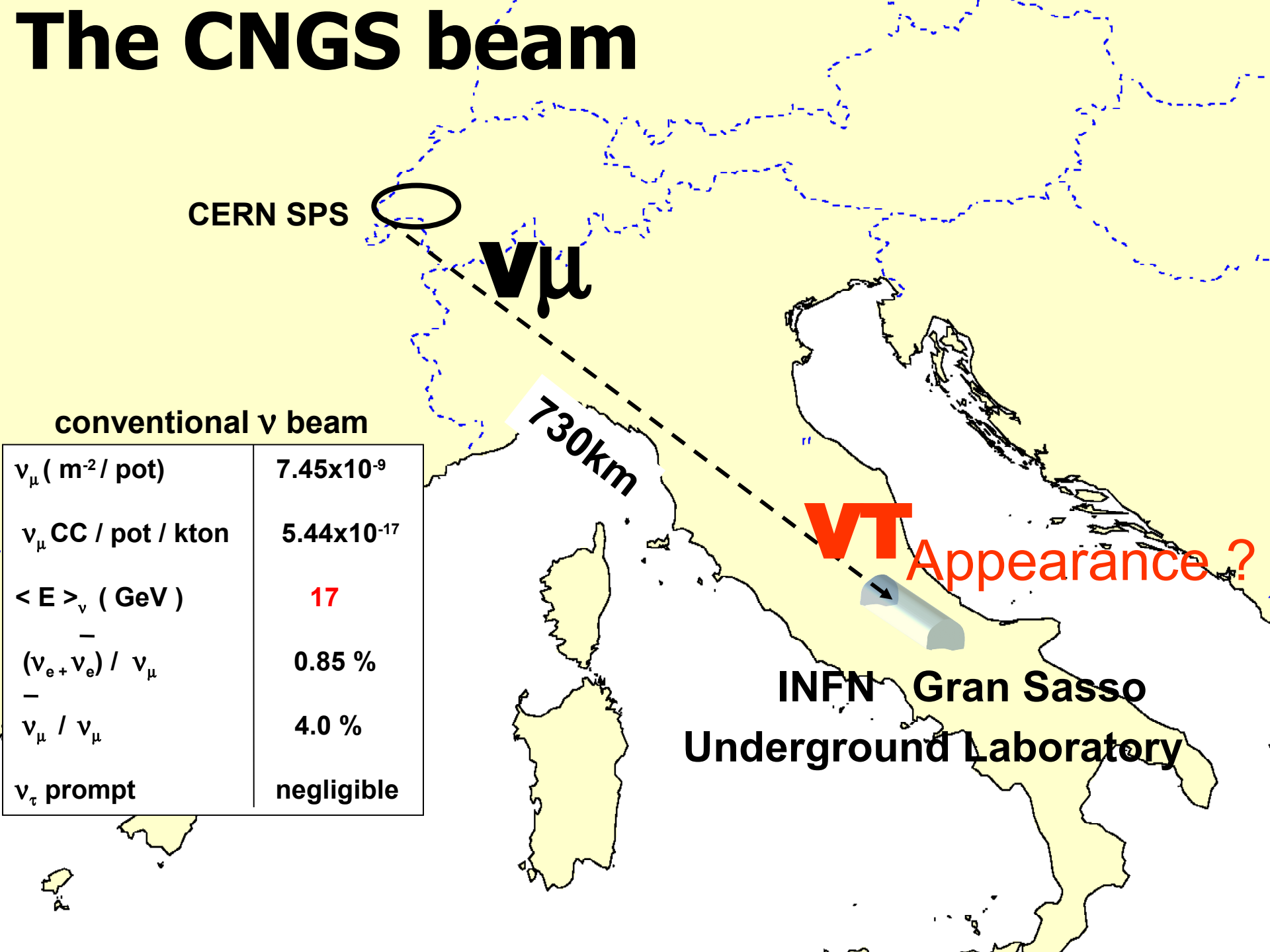
ν_{μ} (m ⁻² / pot)	7.45x10 ⁻⁹
ν_{μ} CC / pot / kton	5.44x10 ⁻¹⁷
$\langle E \rangle_{\nu}$ (GeV)	17
$(\nu_{e+} + \nu_{e-}) / \nu_{\mu}$	0.85 %
ν_{τ} / ν_{μ}	4.0 %
ν_{τ} prompt	negligible

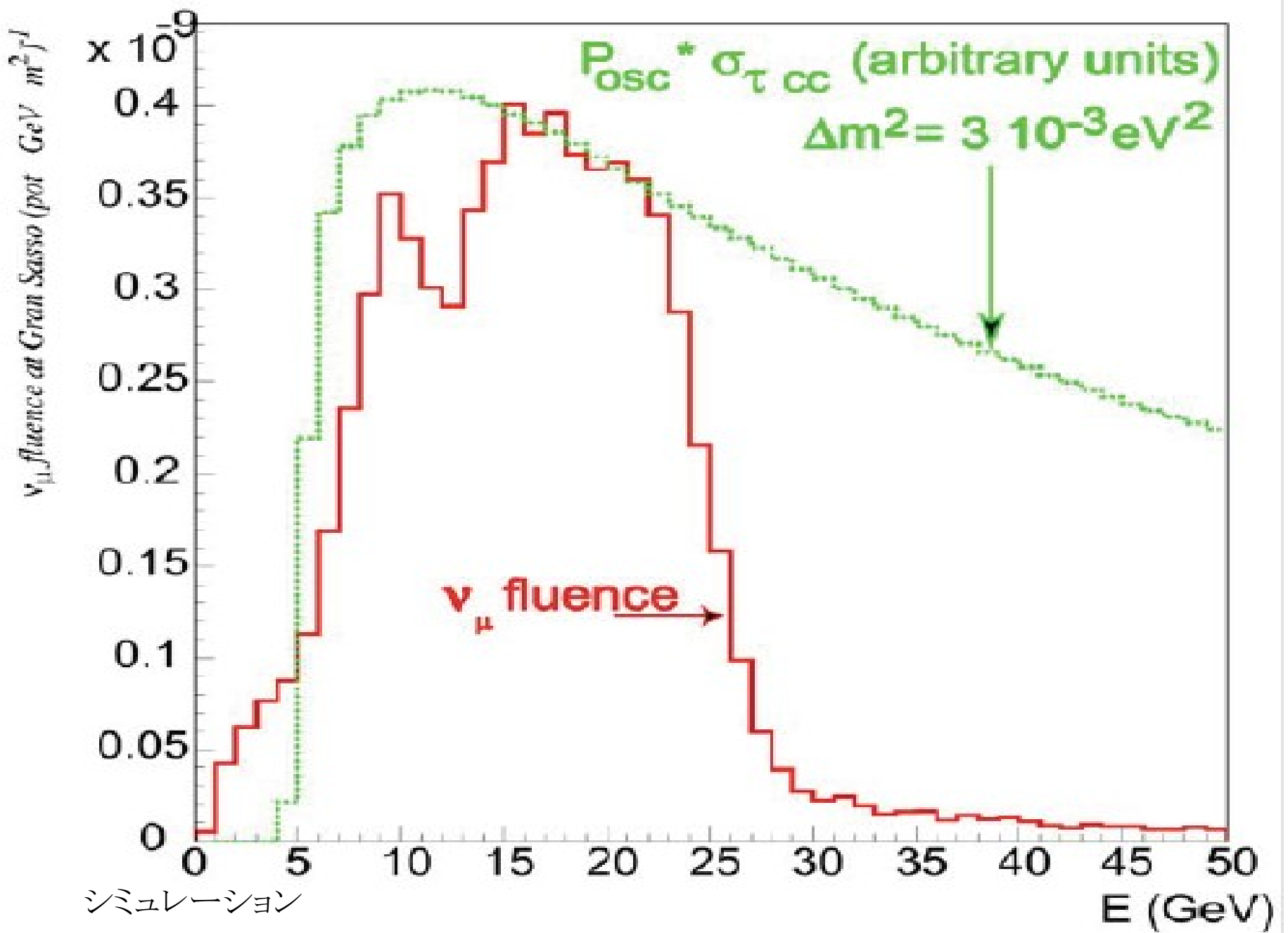
730km

ν_{τ}

Appearance ?

INFN Gran Sasso
Underground Laboratory





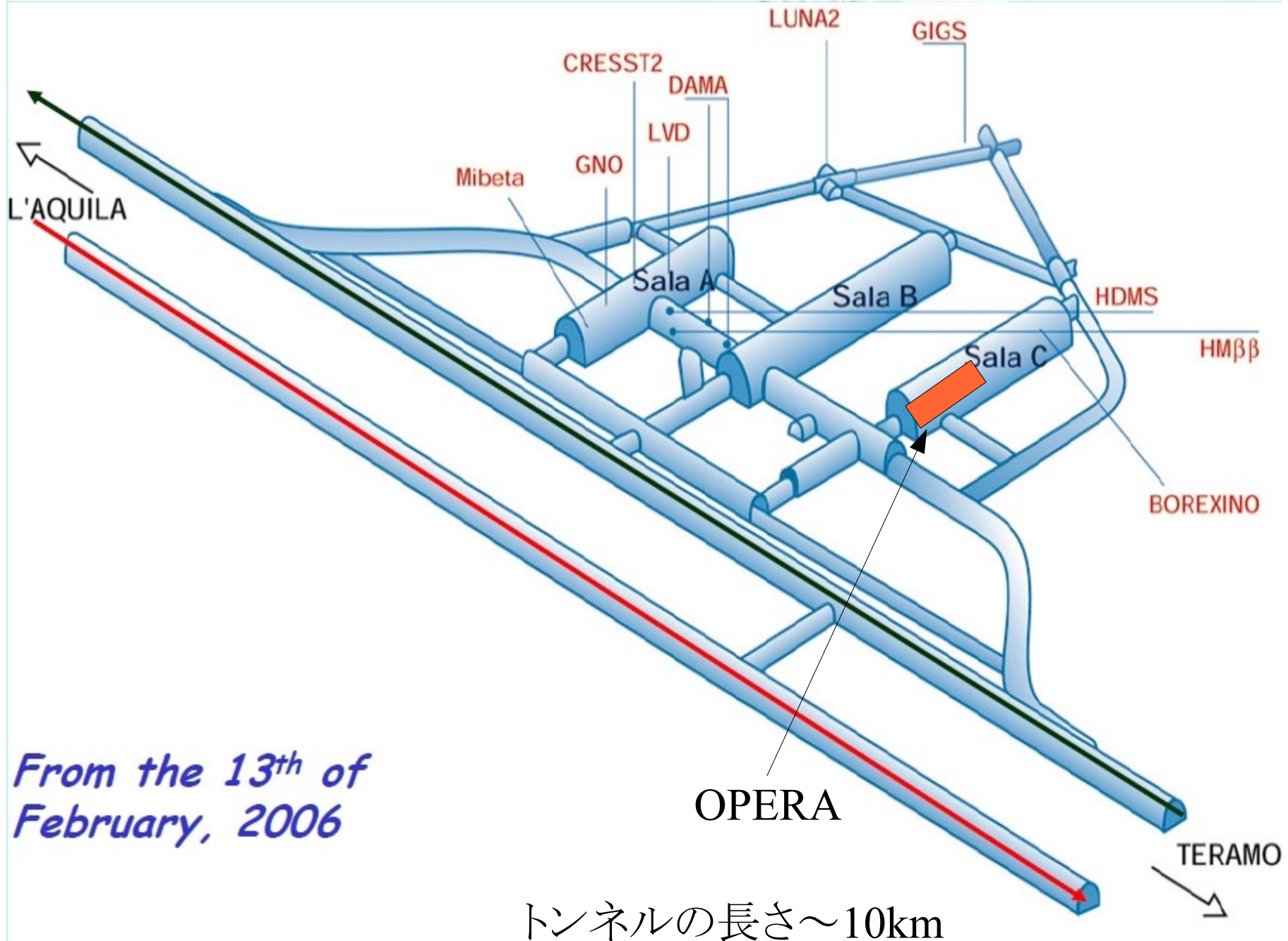


物理

CERNから730km離れたGran Sasso
での、ビームプロファイルを知りたい

測定方法

Rock muonの位置分布、
フラックスを測定する



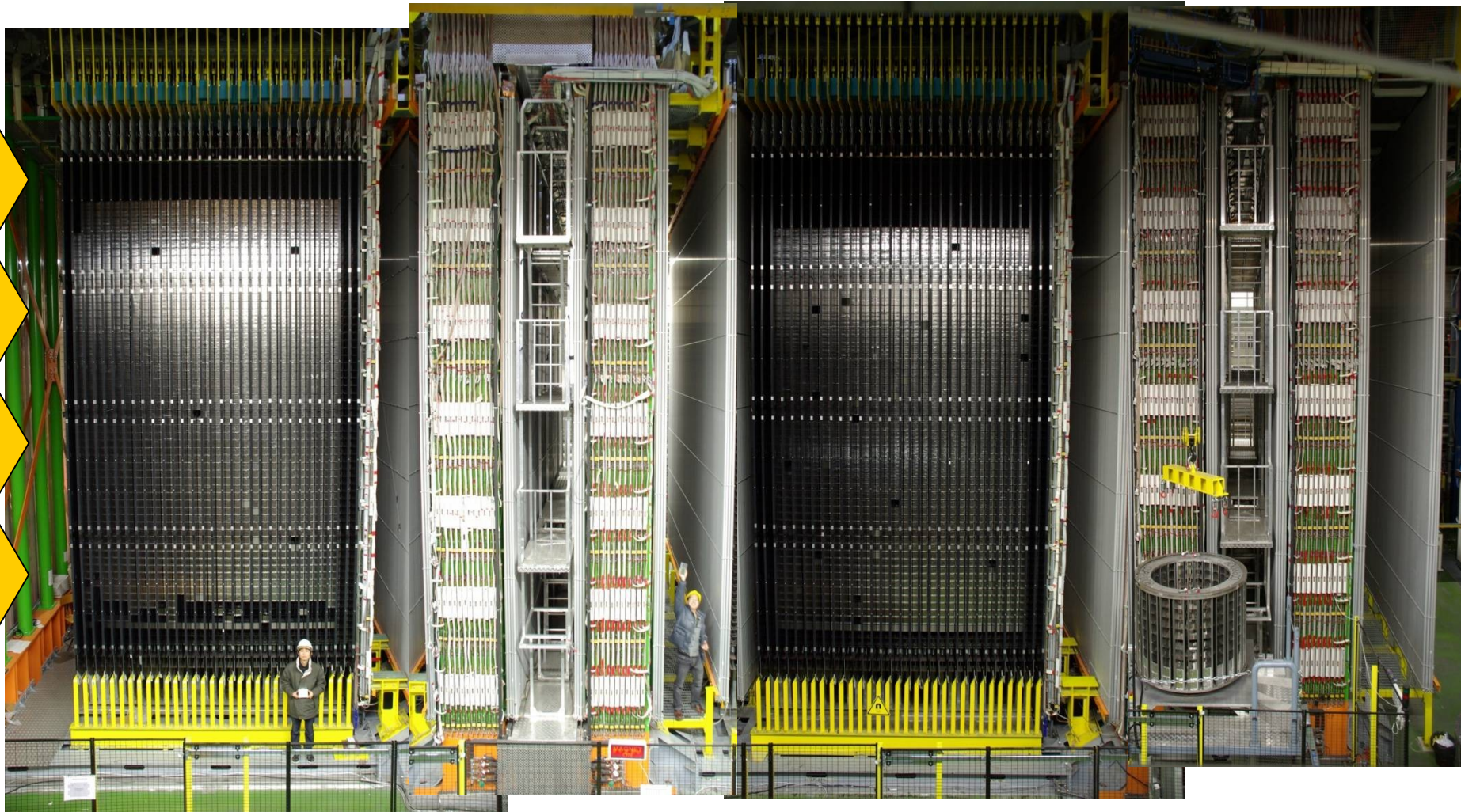
From the 13th of February, 2006

OPERA

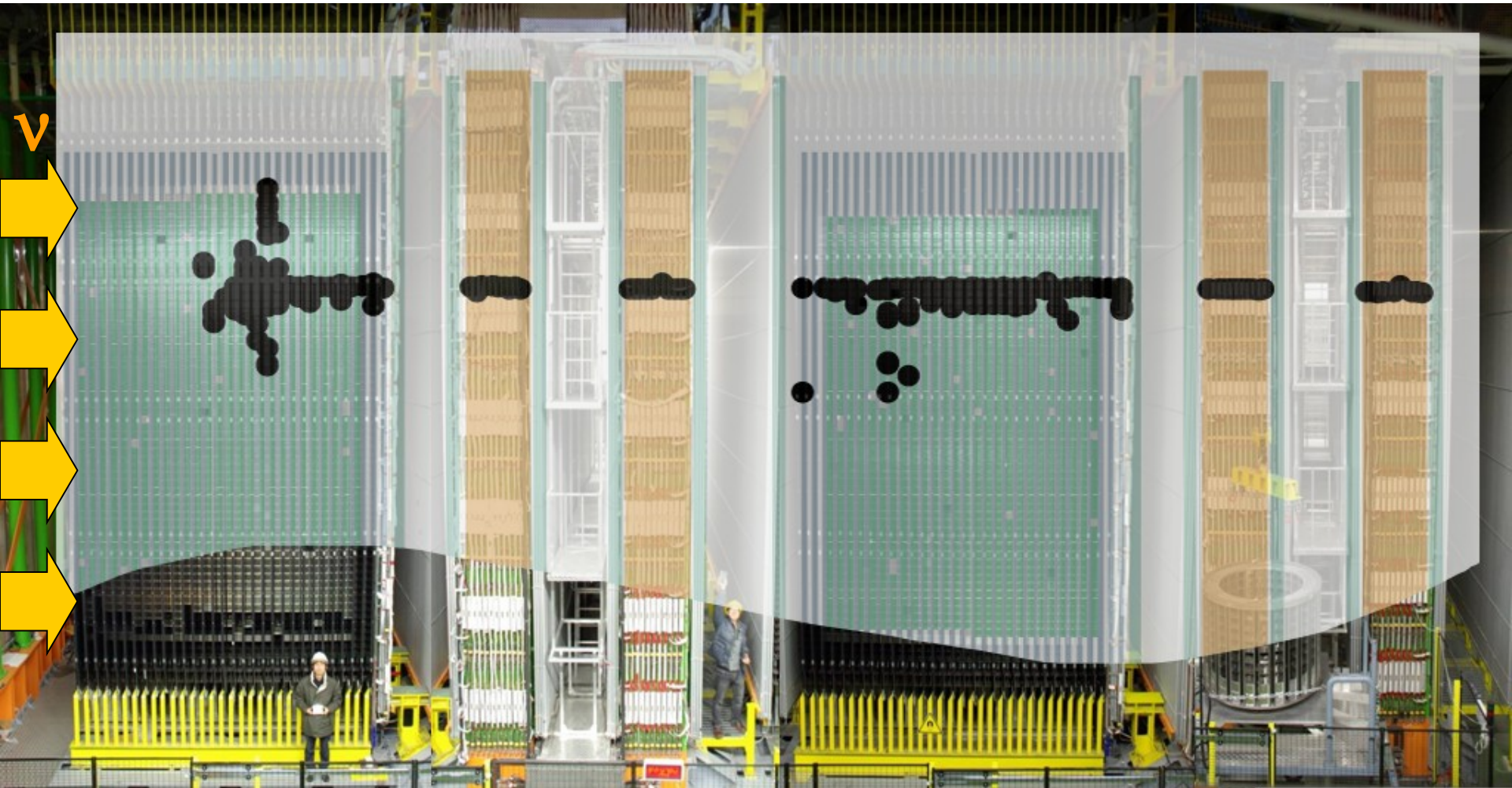
トンネルの長さ~10km

OPERA Detector ^{1400m underground} @ Gran sasso

1.25 kton = 150,000 ECC bricks

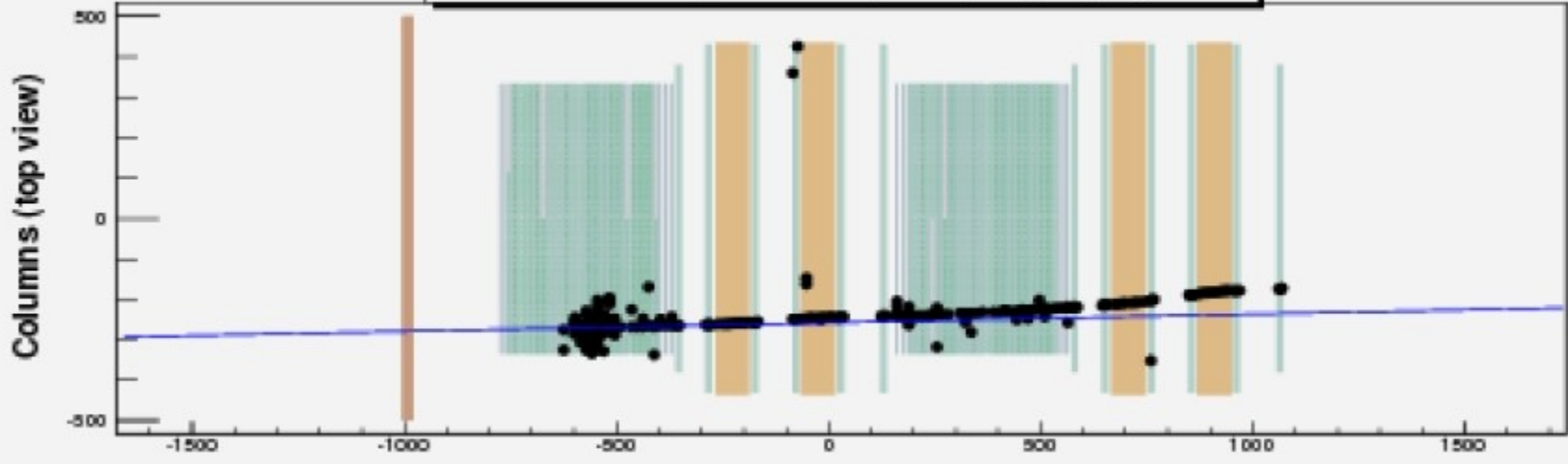


A triggered event in OPERA Detector (one - μ event)



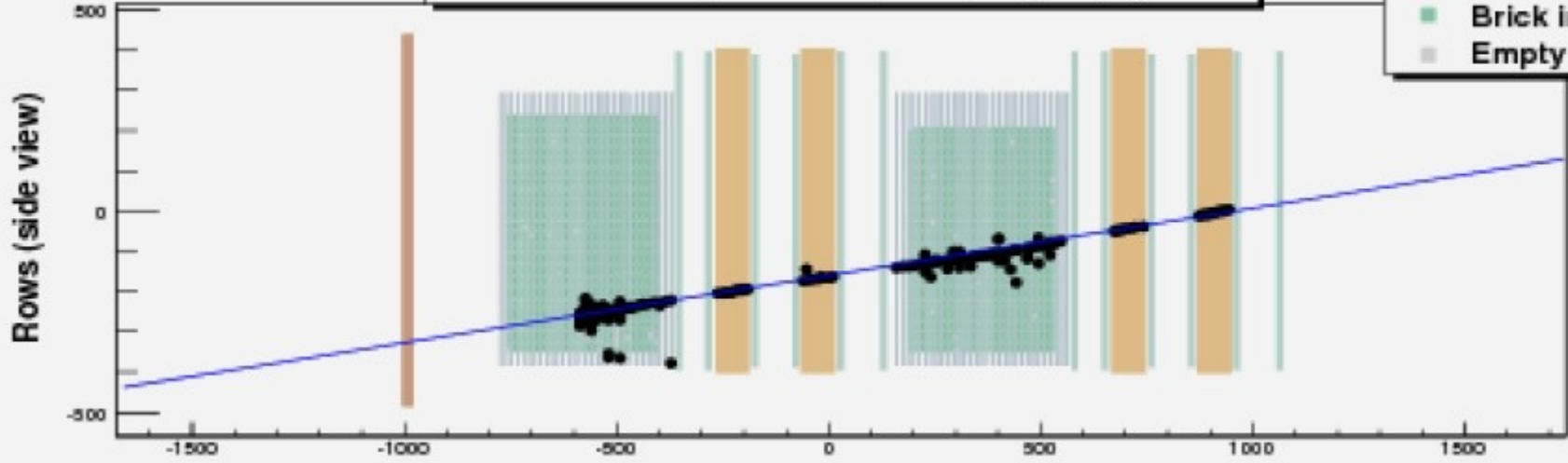
EnergyHist

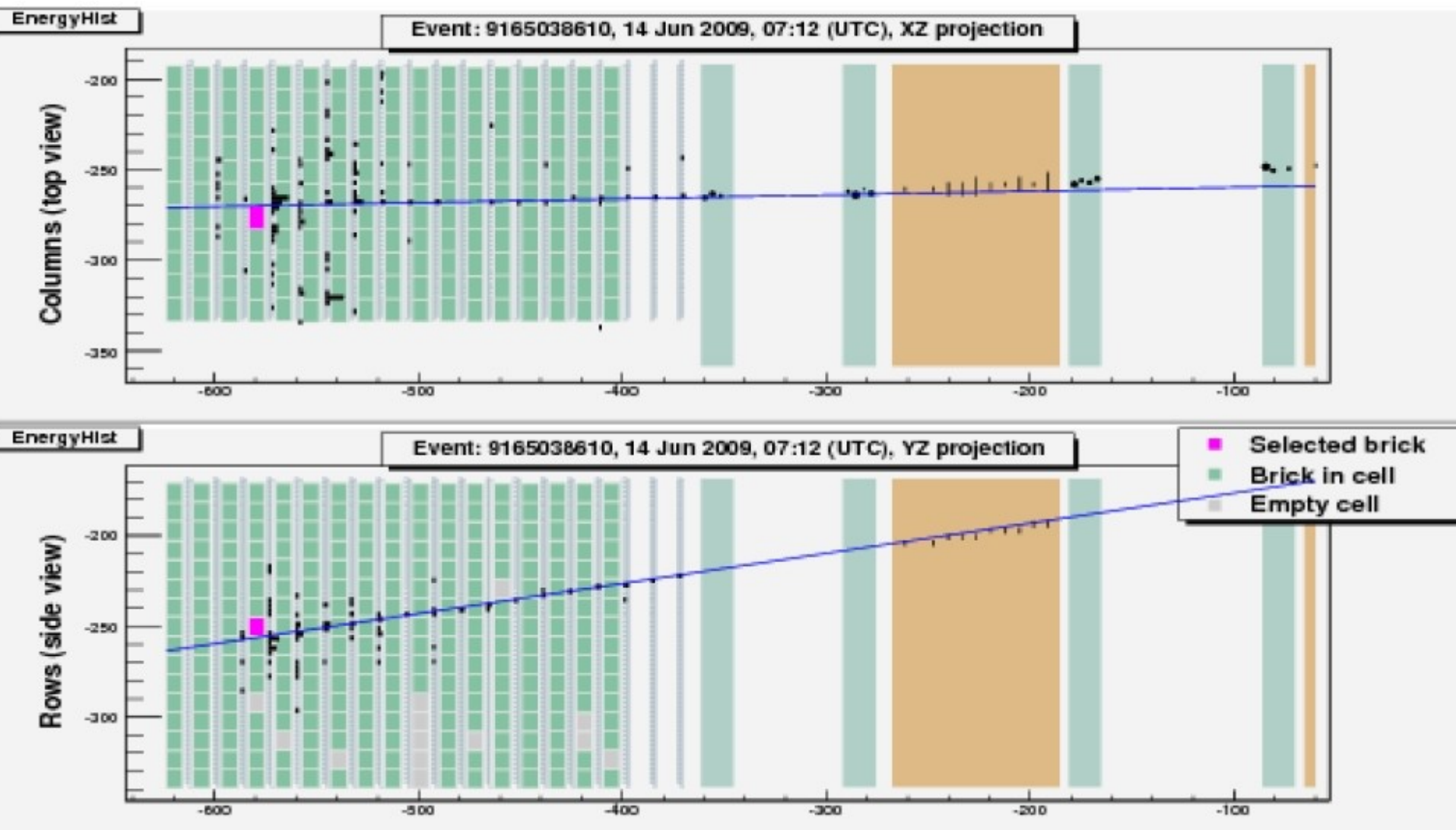
Event: 9165038610, 14 Jun 2009, 07:12 (UTC), XZ projection



EnergyHist

Event: 9165038610, 14 Jun 2009, 07:12 (UTC), YZ projection





Distributed CNGS Beam monitoring at Gran Sasso by CST or CSQ

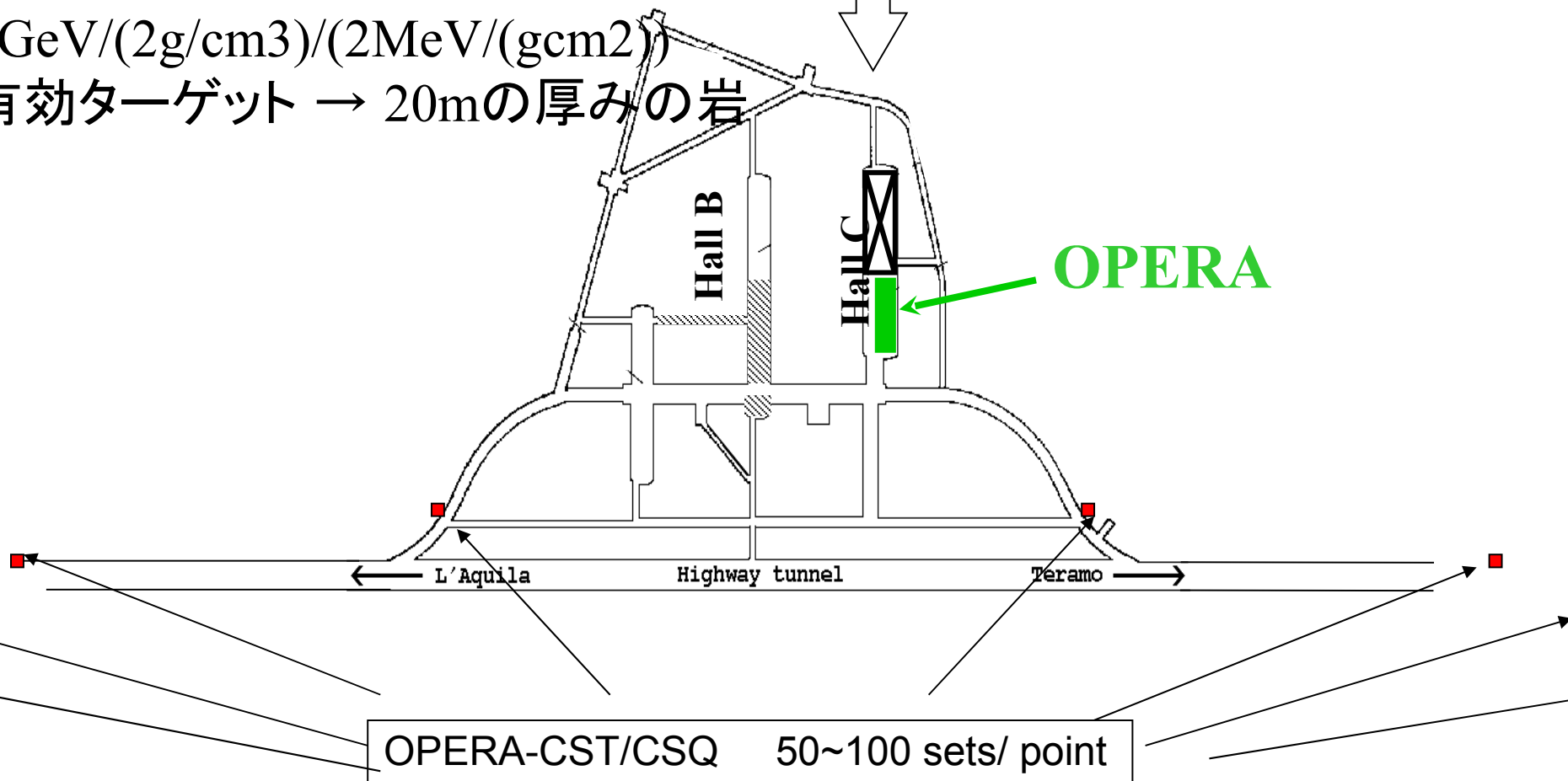
平均17GeV neutrino

ミューオンのエネルギー ~ 8GeV

$8\text{GeV}/(2\text{g/cm}^3)/(2\text{MeV}/(\text{gcm}^2))$

有効ターゲット → 20mの厚みの岩

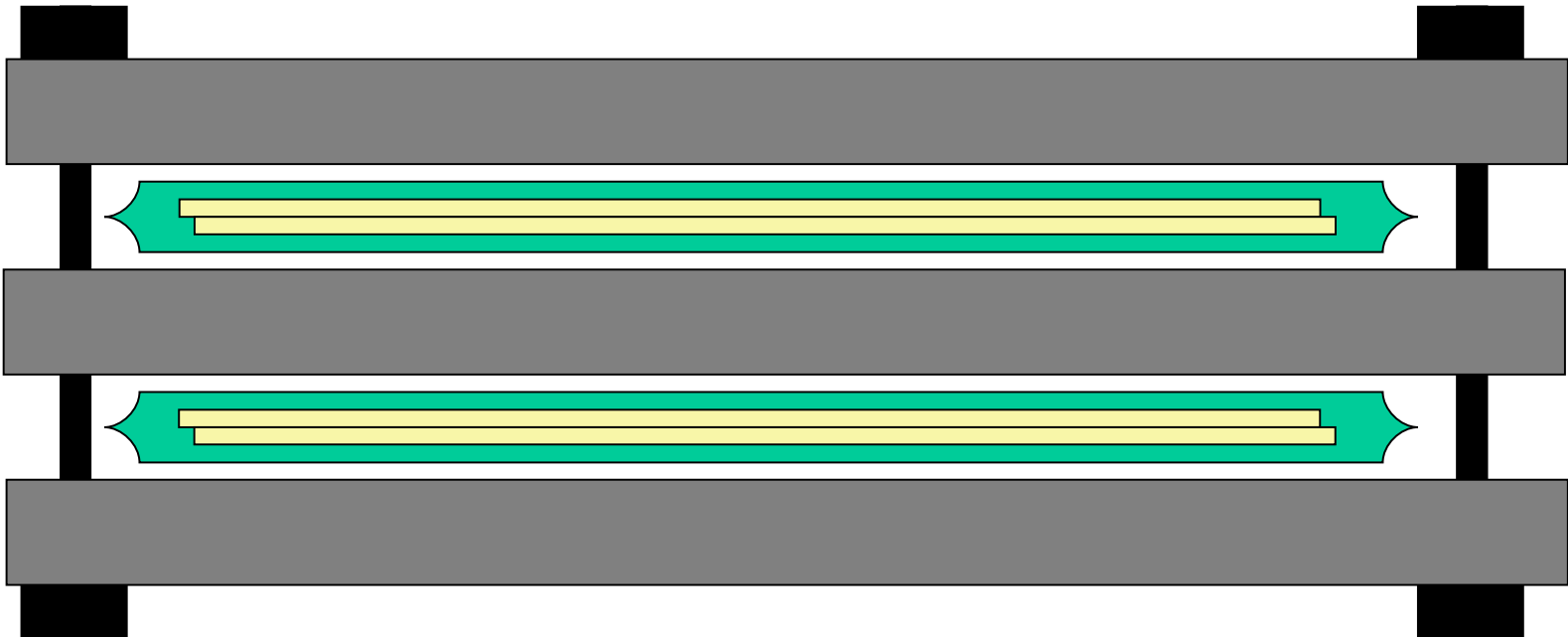
ν from CERN



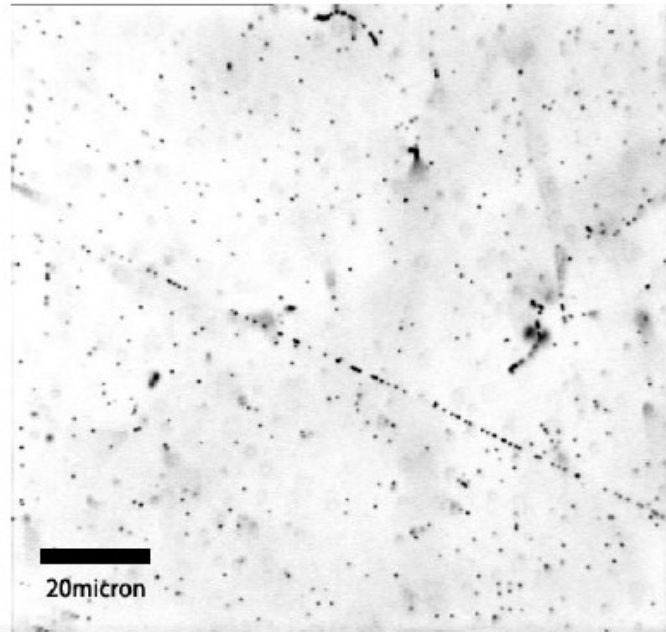
Distributing CST or CSQ detectors at the points apart each ~500m along the highway

detector design

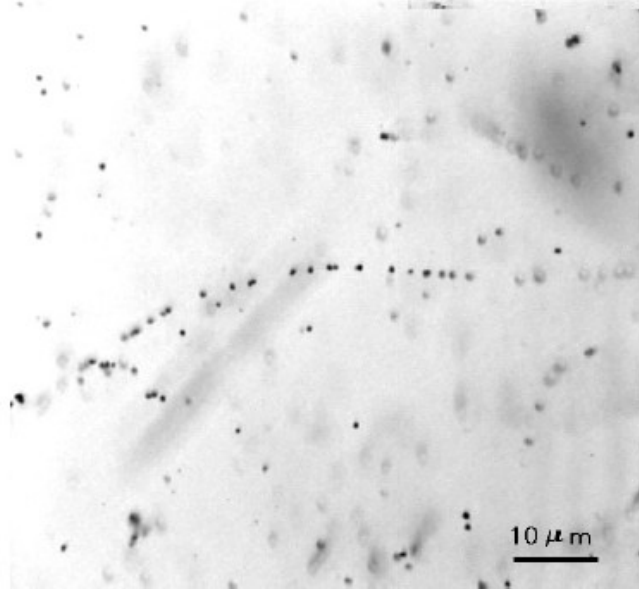
- 4 OPERA Films per 1 detector set.
 - Same ECC structure as used in Mt. Asama investigation
- Compact : 12cm x 14cm x 2cm
- 2 CS Interleaved by Metal plates (shielding Sub-MeV~MeV electron)
- Alignment of Films in the CSd: Compton alignment $\sim 1\mu\text{m}$
 - CS to CS : Mechanical accuracy $\sim 1\text{mm}$ or side X-rays like ECC($\sim 20\mu\text{m}$).
- Muon detection efficiency $> 90\%$ with $S/N > 10$.



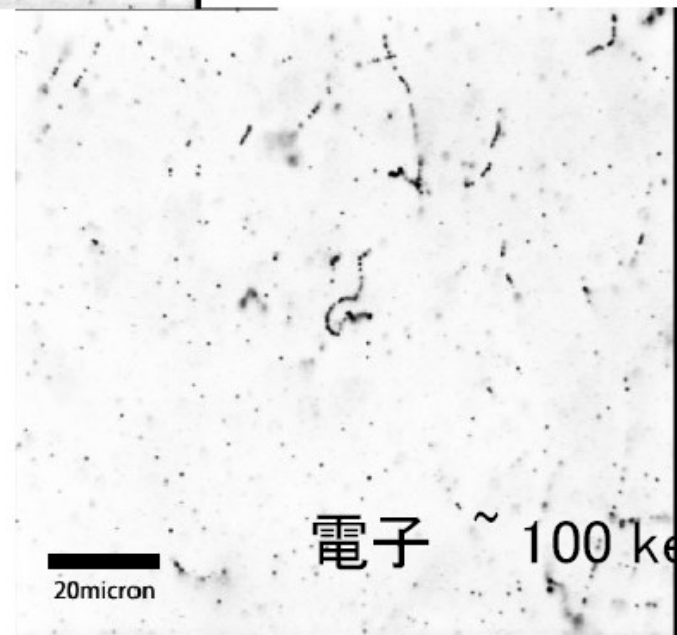




最小電離粒子

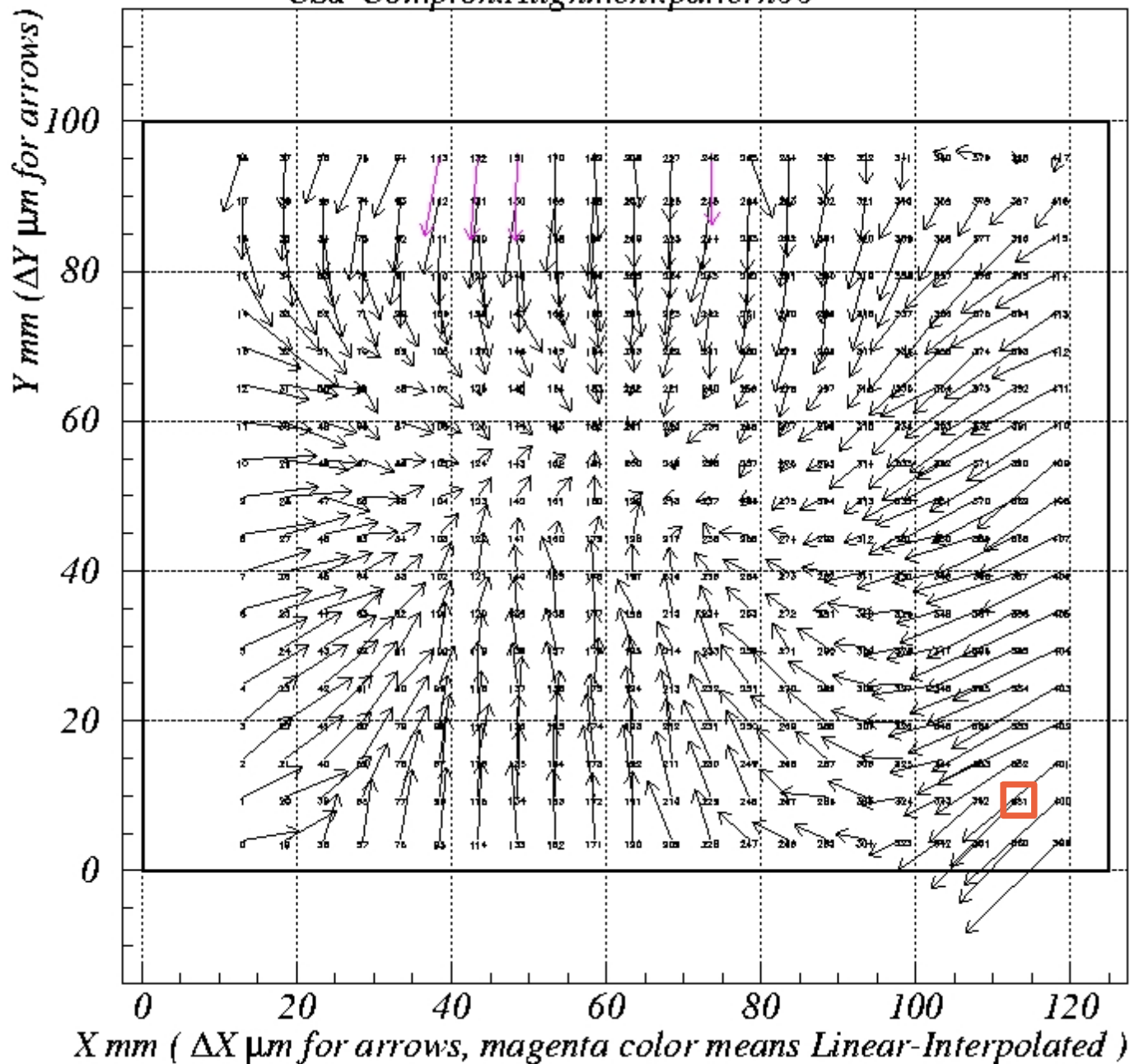


電子 ~ 1 MeV

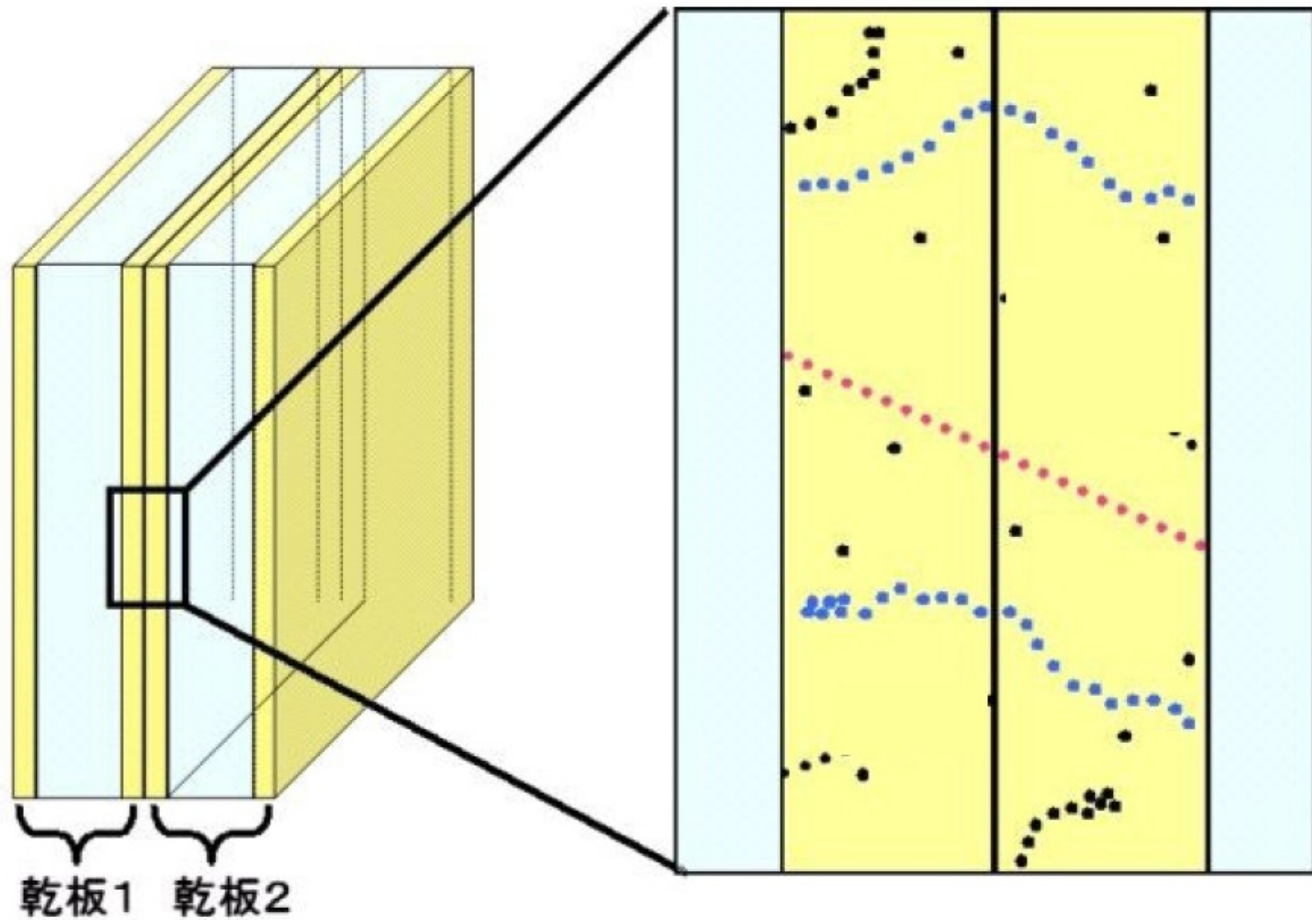


電子 ~ 100 keV

CSd-Compton.Alignment.pattern00



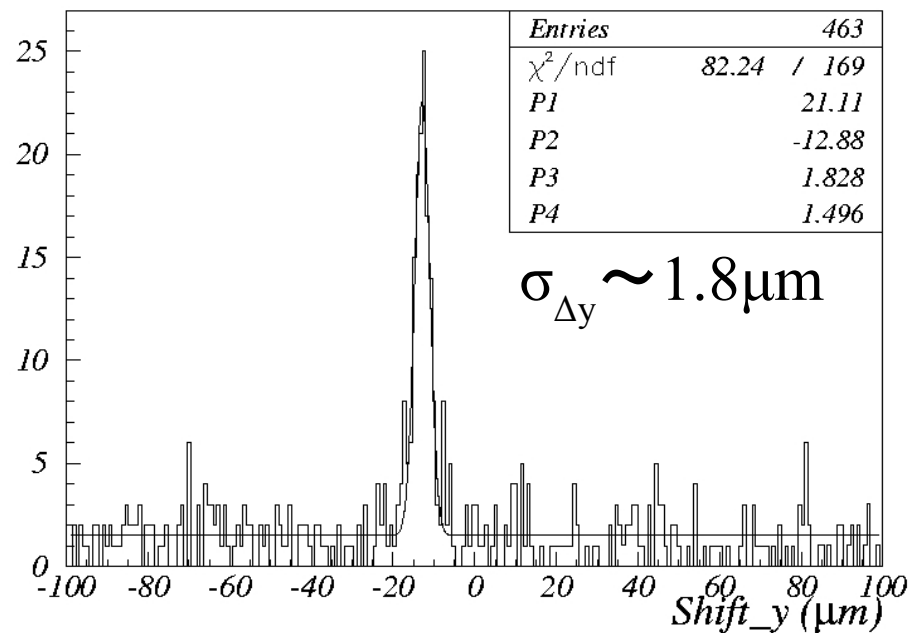
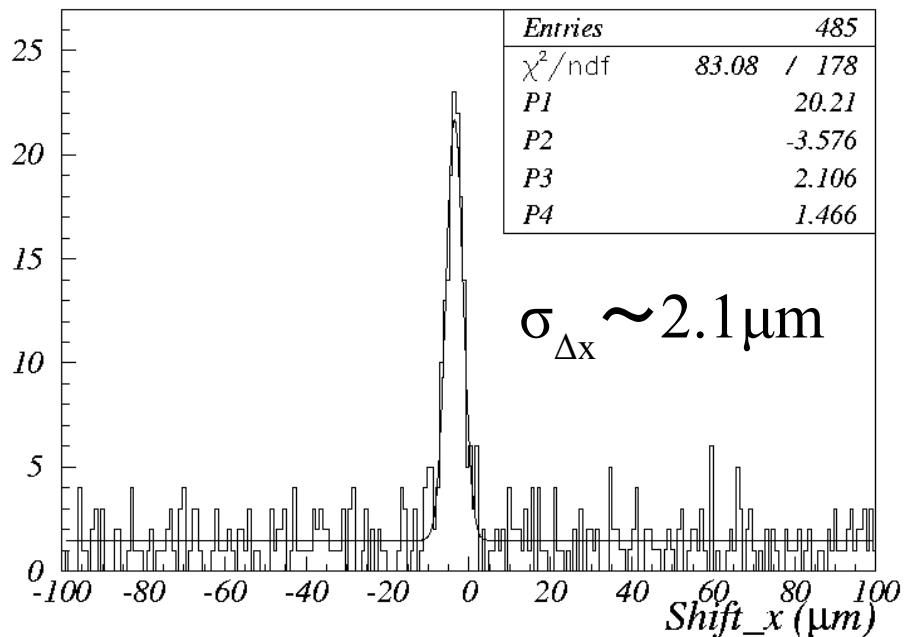
2枚の乾板間の位置合わせ



高エネルギー荷電粒子の代わりに、環境放射線からの低エネルギーを利用する。

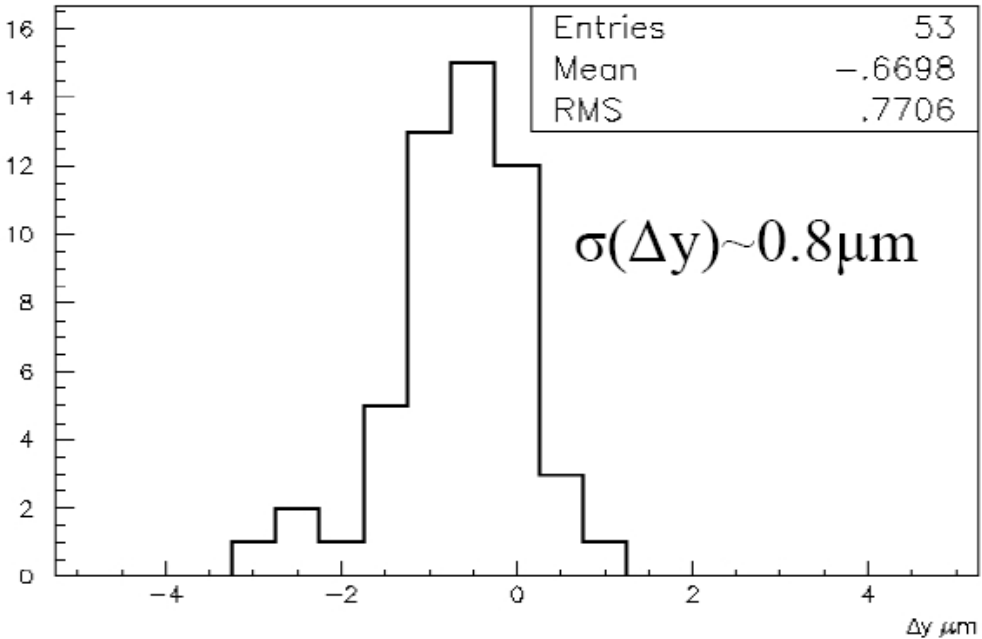
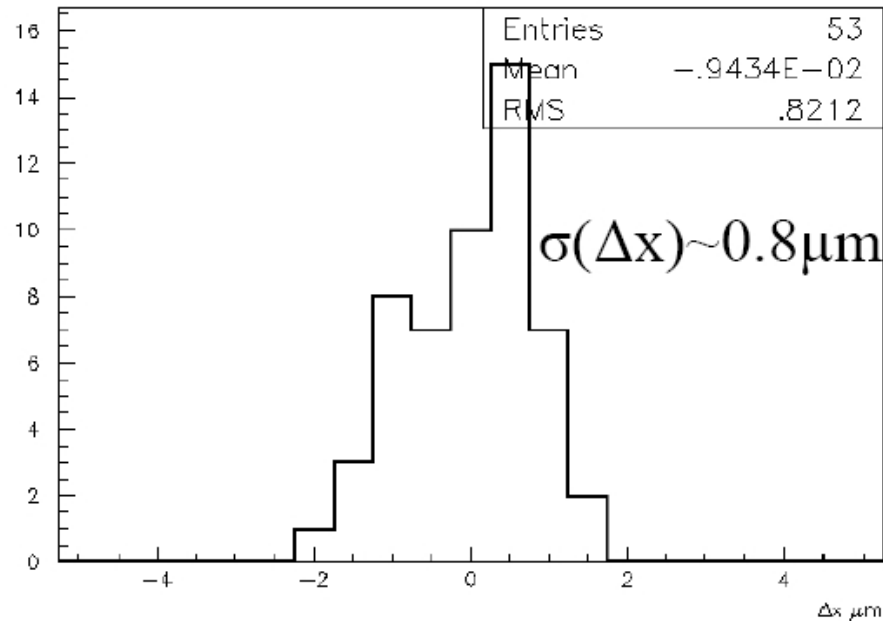
2枚の乾板間の位置合わせ

低エネルギー電子による位置合わせ Alignment Peak



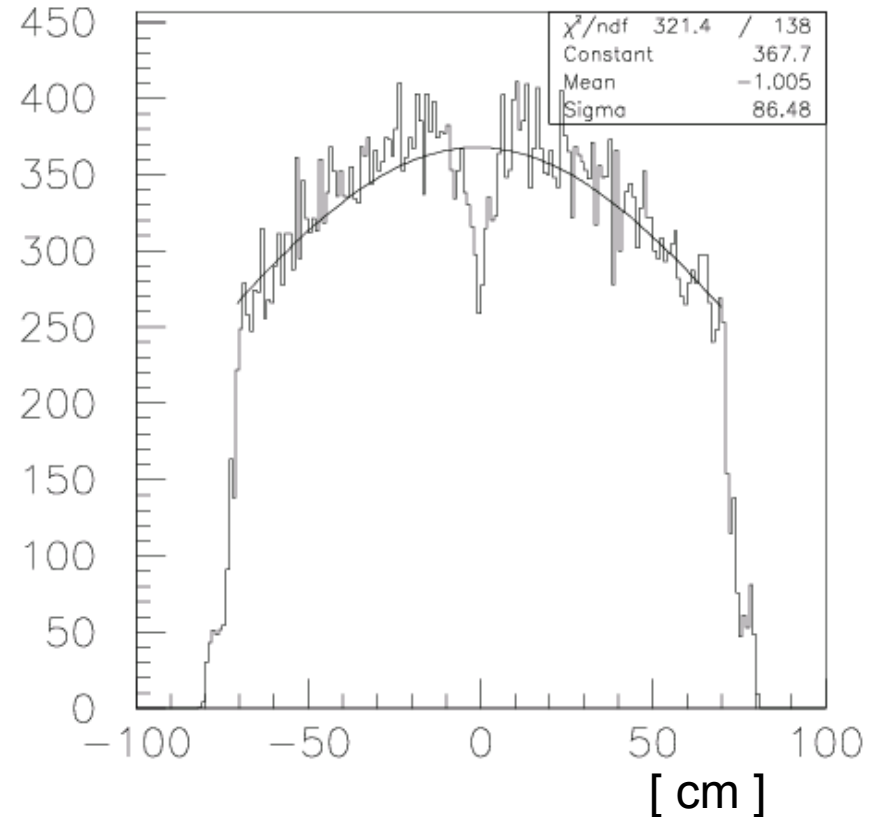
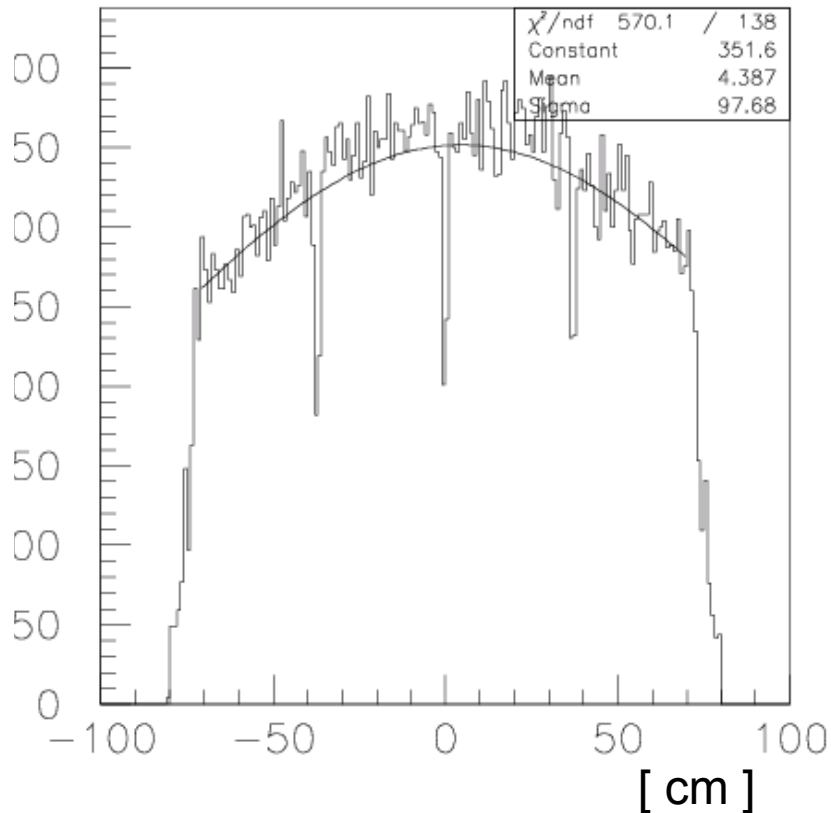
S. Miyamoto et al., N. I. M. A 575 (2007) 466–469.

2枚の乾板間の位置合わせ



Expectation from CHORUS

CHORUS Data (ビームラインのデザイン、エネルギーはOPERAとほとんど同じ)



One sigma^x~0.9m @ 600m

→One sigma~0.9m×730000/600=1100 m @ LNGS

→FWHM~2.5km @ LNGS

Candidate Positions

- Statistical Error < 10% : 100 Rock muons per position.
- Symmetric detector positions to investigate the beam profile symmetry.
- Off axis → flux: drop, Neutrino energy: down → Decrease of the effective target (Rock) → Larger Area is needed

Precise designing of the position → Wait for Dario and Stefano's simulation.

A case: Assumption Required Area = $k \times (\text{Flux})^2$
@ 2.5 muons/CS/ 4.5×10^{19} POT: (0.56 muons / CS / $1E19$ pot by Dario)

Position	Flux	Rock muons	Sets
~ 0 m	1	1	40 sets
± 350 m	1	1	40 sets
± 800 m	0.87	0.75	54 sets
±1100 m	0.71	0.50	80 sets

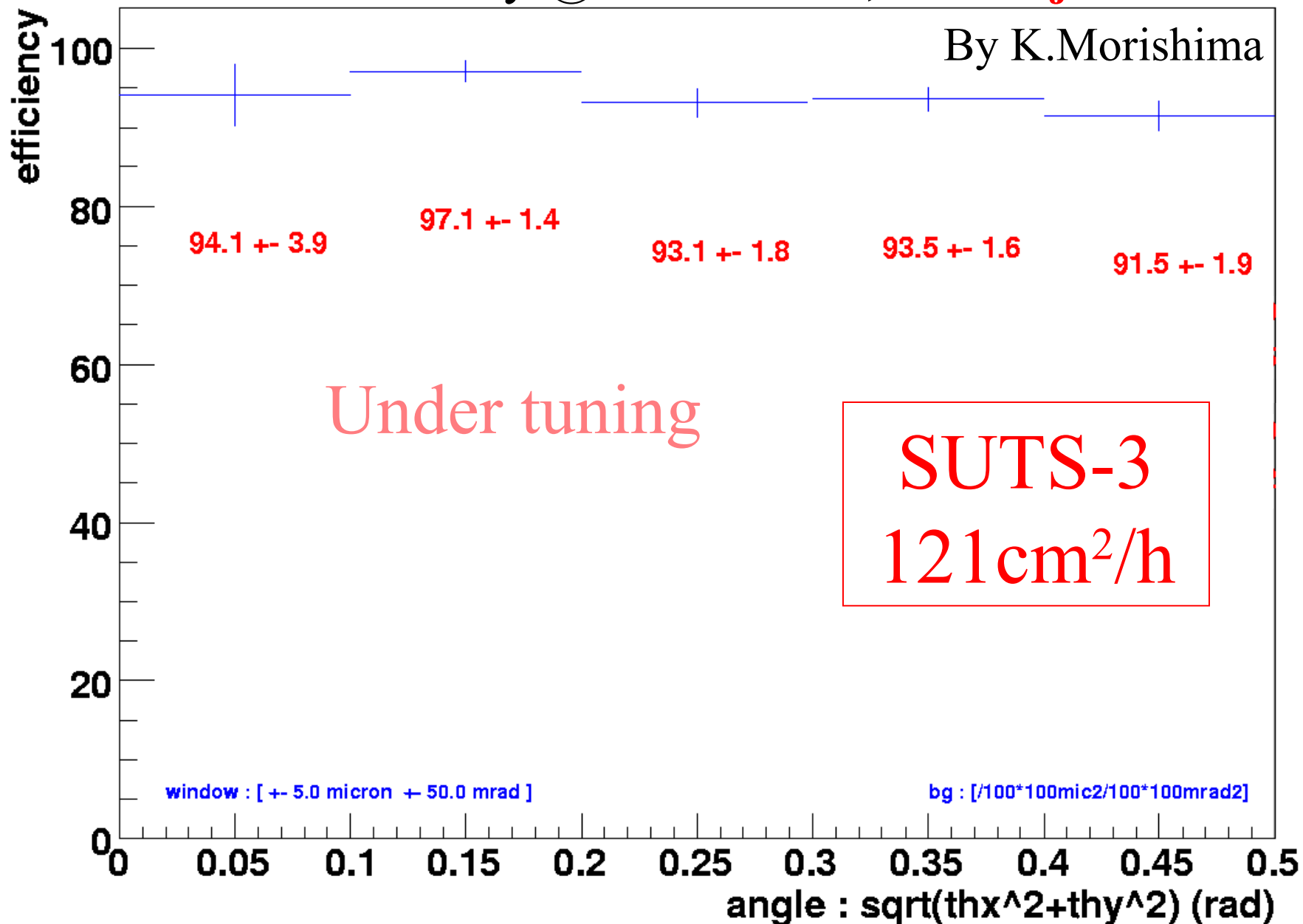
Total $40 + (40 + 54 + 80) \times 2 = 388$ sets -> 1552 films

Scanning time : システム稼働率・・・約70% , 4system → 4ヶ月

efficiency

Efficiency @50views/sec, **×28 objective lens**

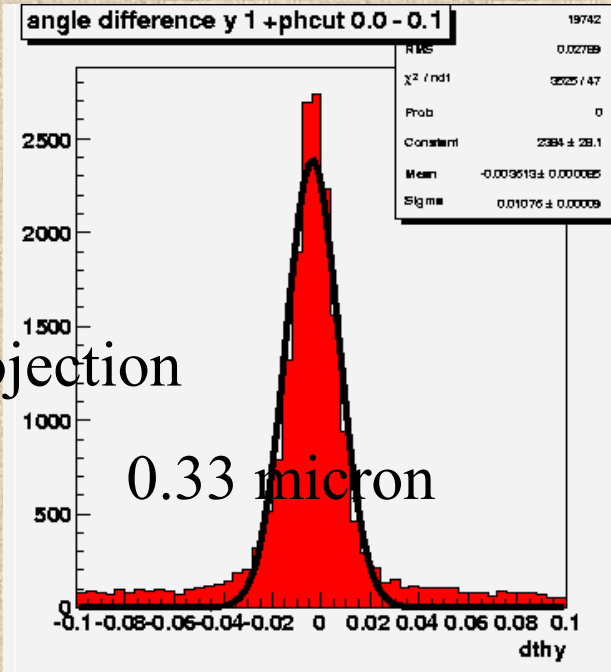
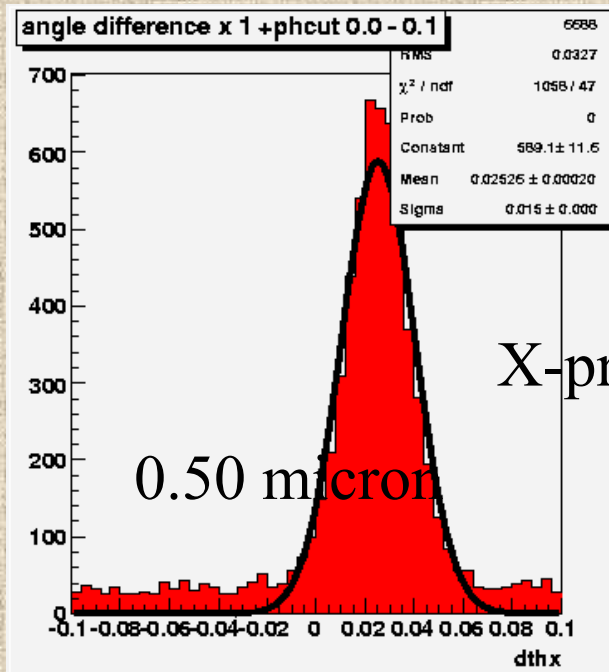
By K.Morishima



Micro track Position resolution

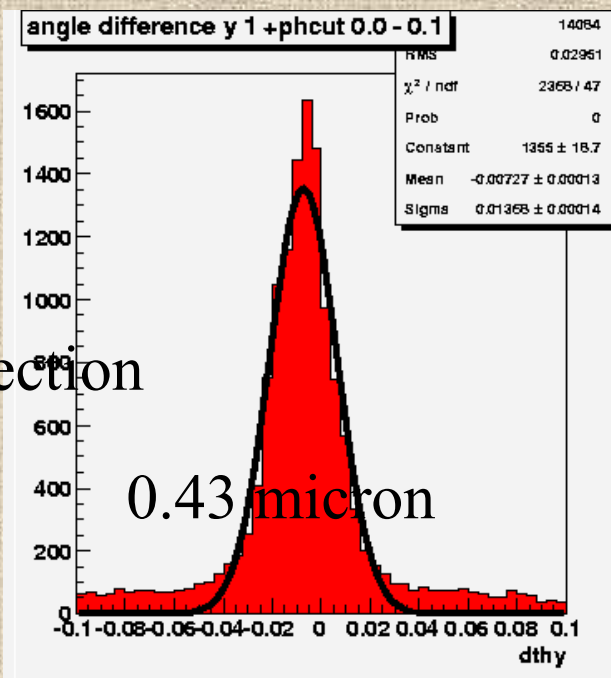
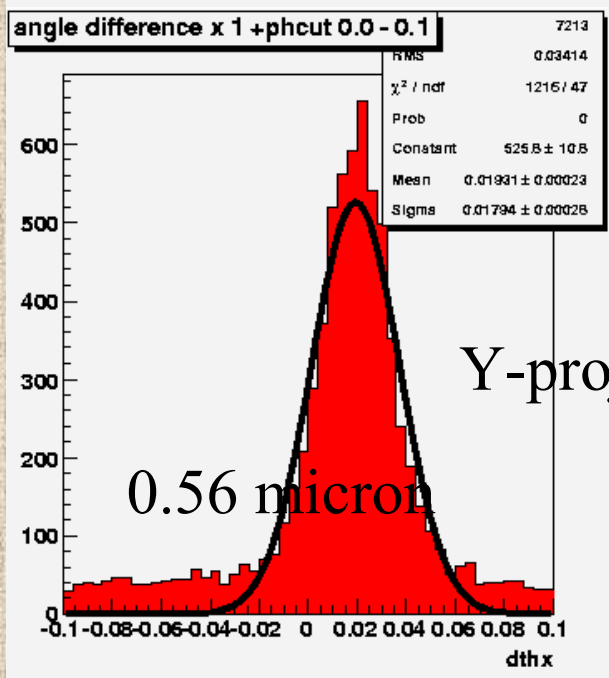
SUTS3号機

35×



Preliminary
Under tuning ...

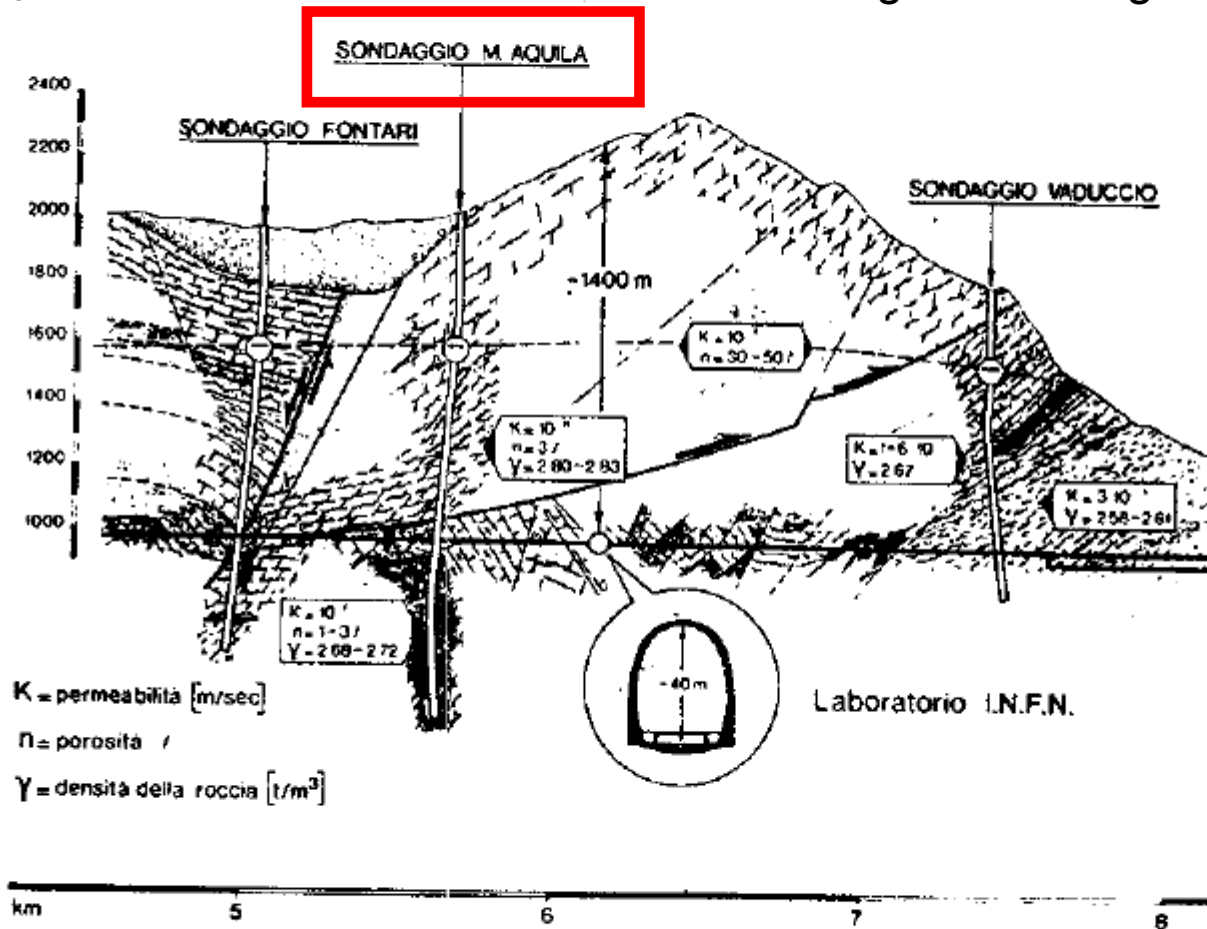
28×



By K.Morishima

Possibility of the Vertical Monitoring

Geological Investigation hole.



This measurement is possible Only by Emulsion detector

Application

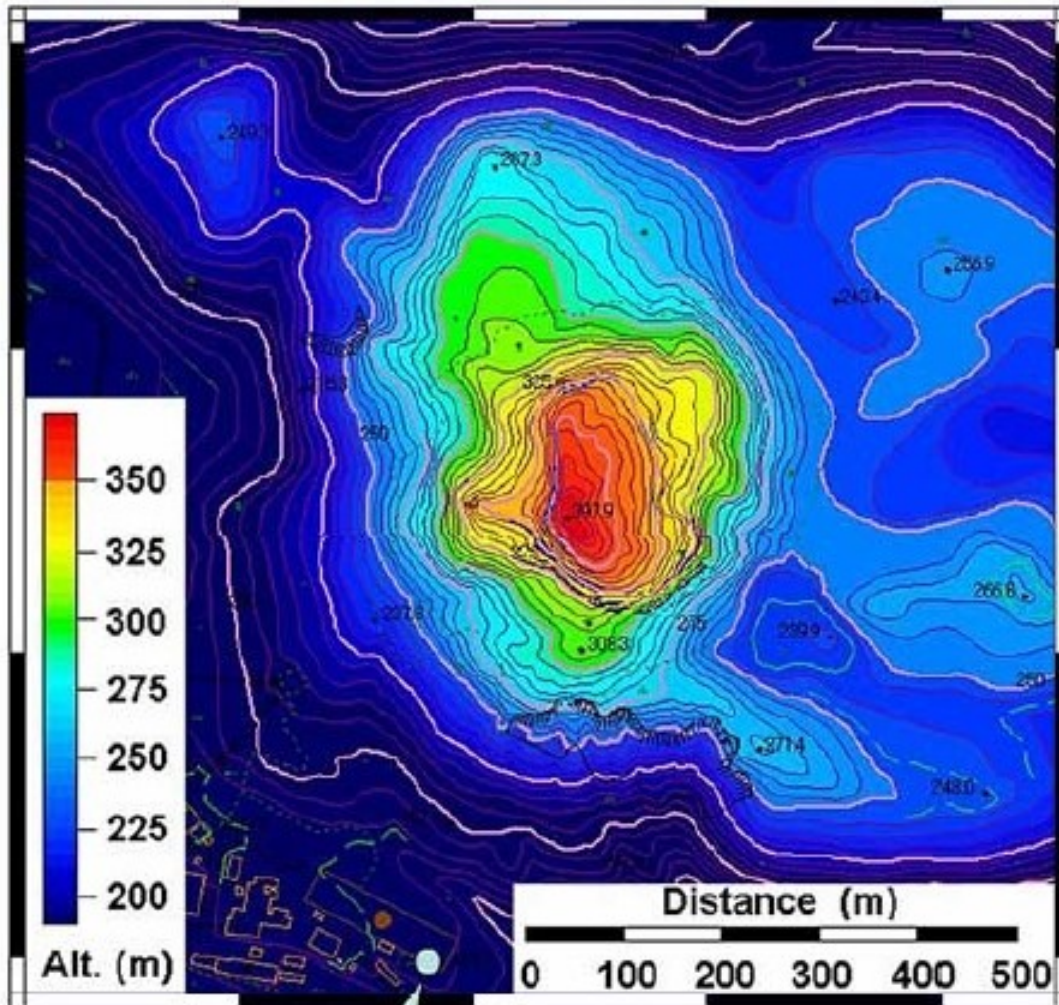
CNGS : easiest because of its High energy. We should show the possibility in CNGS at first.

- **Beam profile monitoring at Far detector cite in any neutrino beam line, NuMI. T2K.** But few statistics (cross section , target region down)

→ **Need More Scanning Speed.**

Back Up

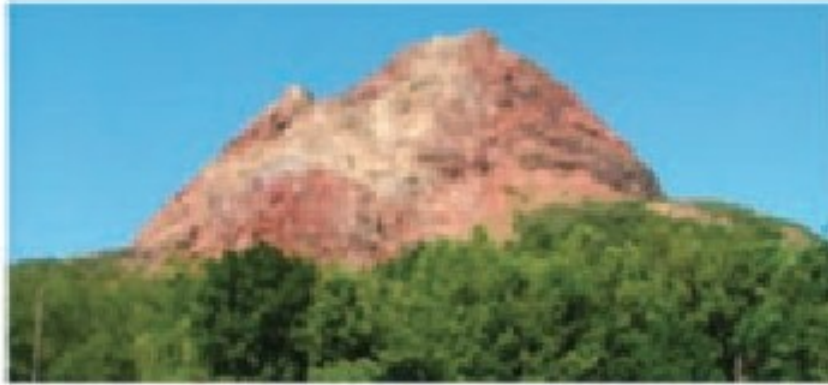
写真乾板技術の応用例



H.K.M.Tanaka, T.Nakano et. al.,

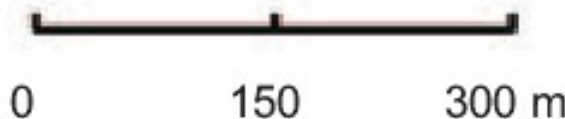
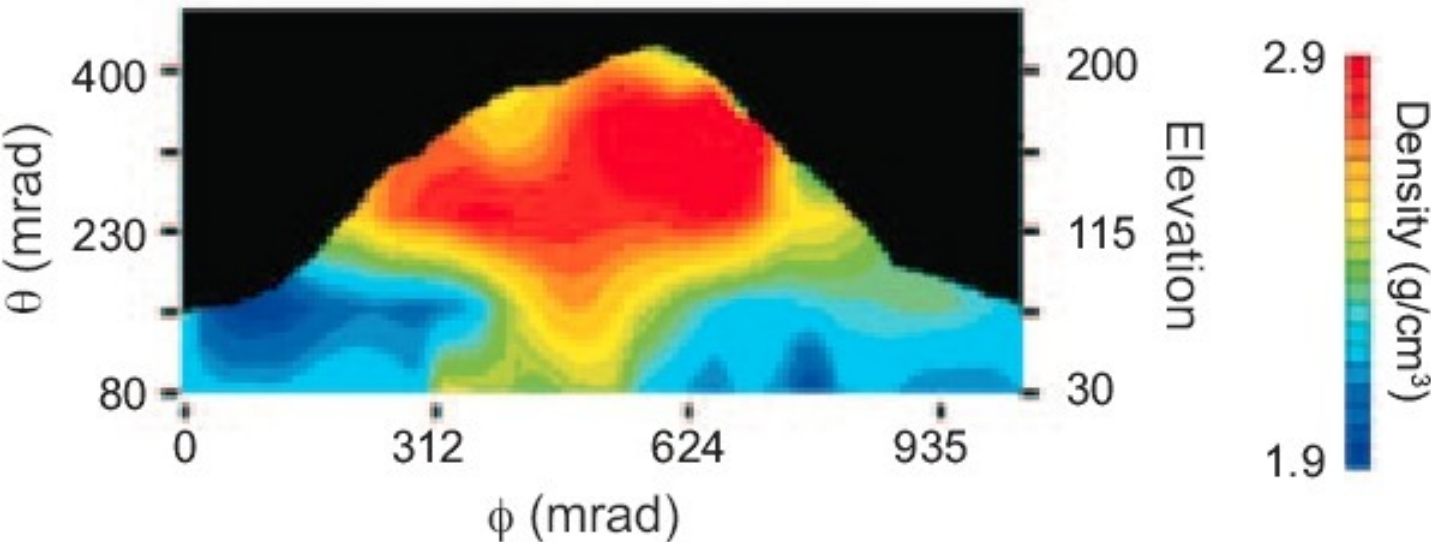
GEOPHYSICAL RESEARCH LETTERS, VOL. 34, L22311,

写真乾板技術の応用例



●昭和金山の
密度分布
(2006)

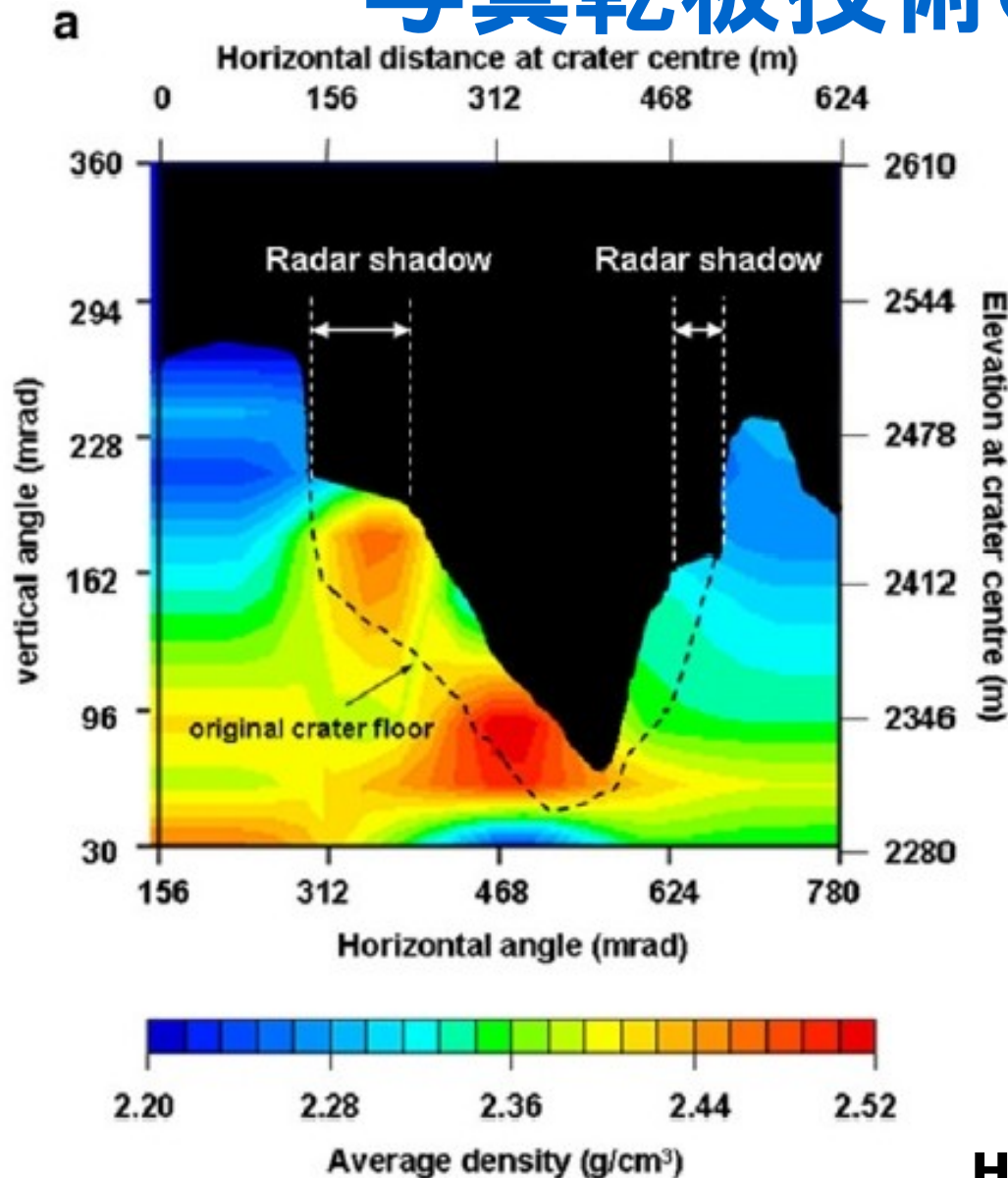
●3ヶ月間設置



H.K.M.Tanaka, T.Nakano et. al.,

American Journal of Science, Vol. 308, Sep, 2008, P. 843–850.

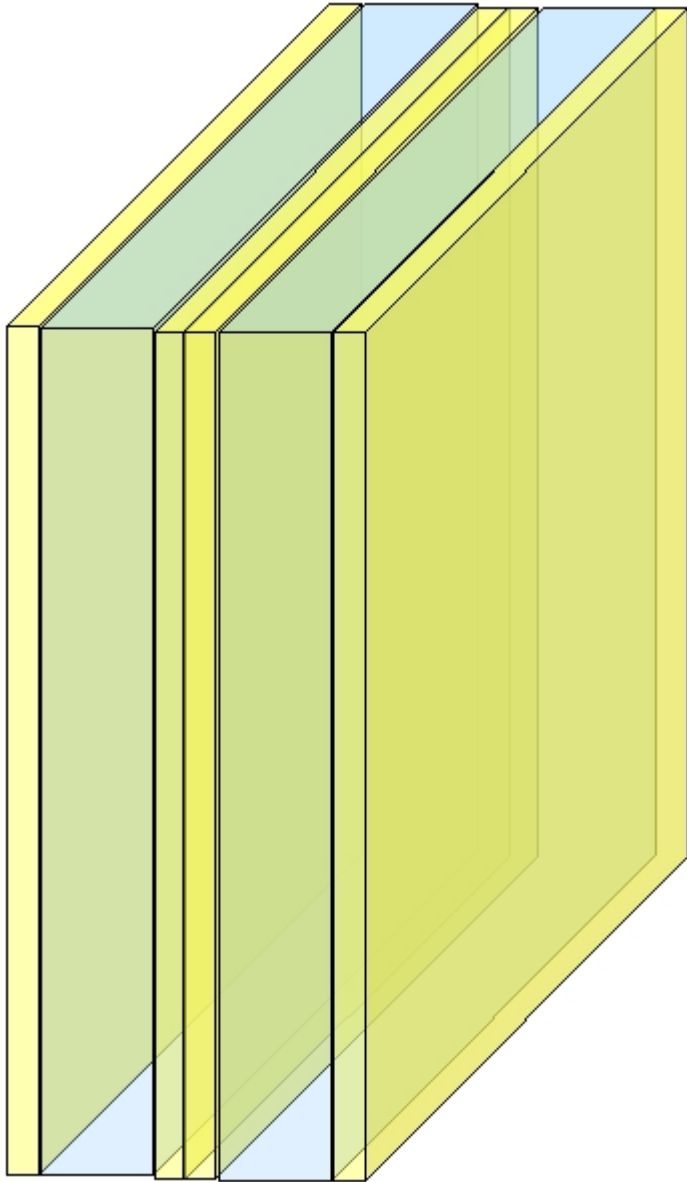
写真乾板技術の応用例



- 浅間山、マグマ溜まり部分の密度分布 (2006)
- 2ヶ月間設置
- 2003年観測時より、クレーター部分に盛り上がりがあることが確認される。

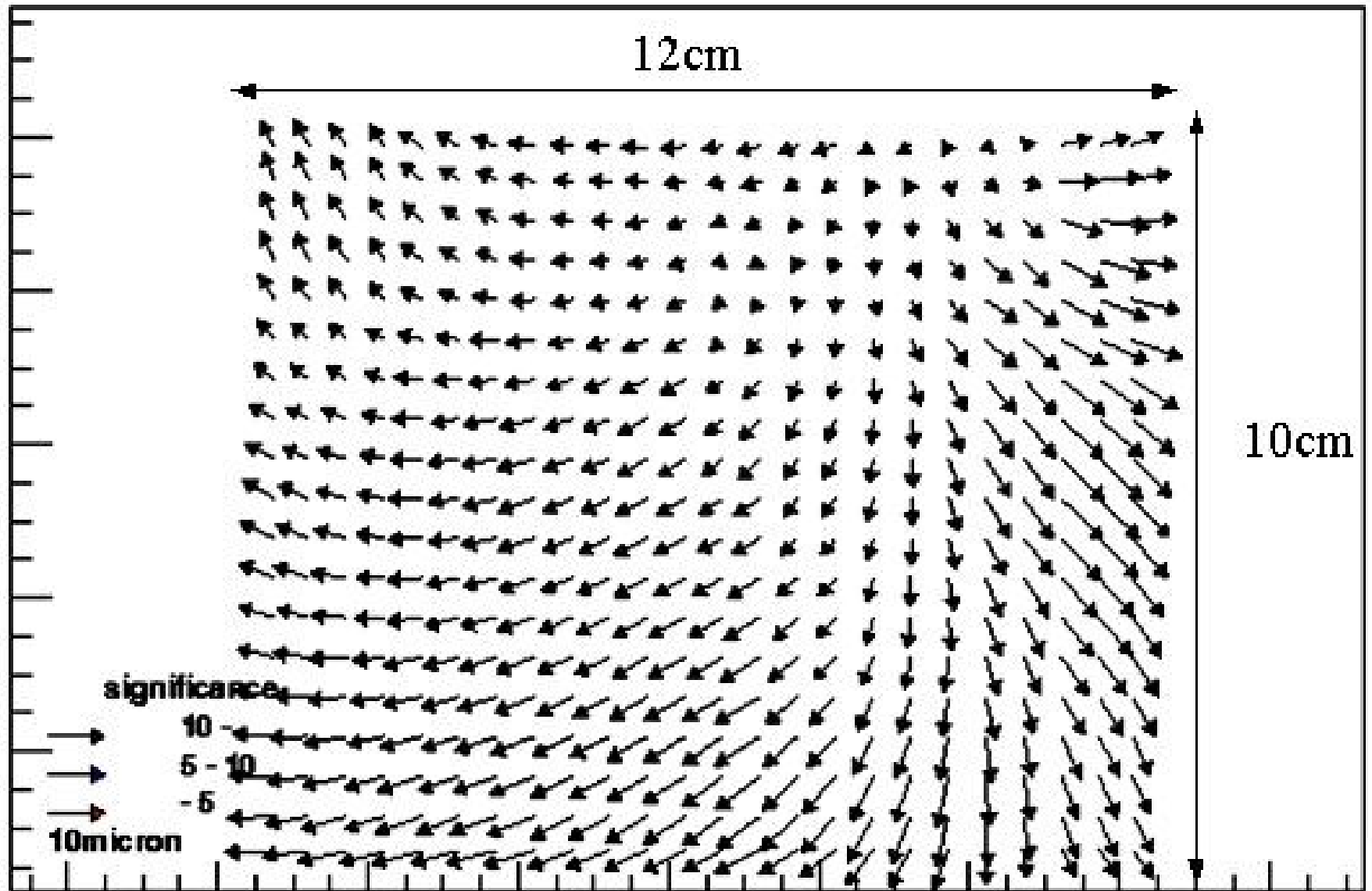
H.K.M.Tanaka, T.Nakano et. al.,

Earth and Planetary Science Letters 263 (2007) 104-113.

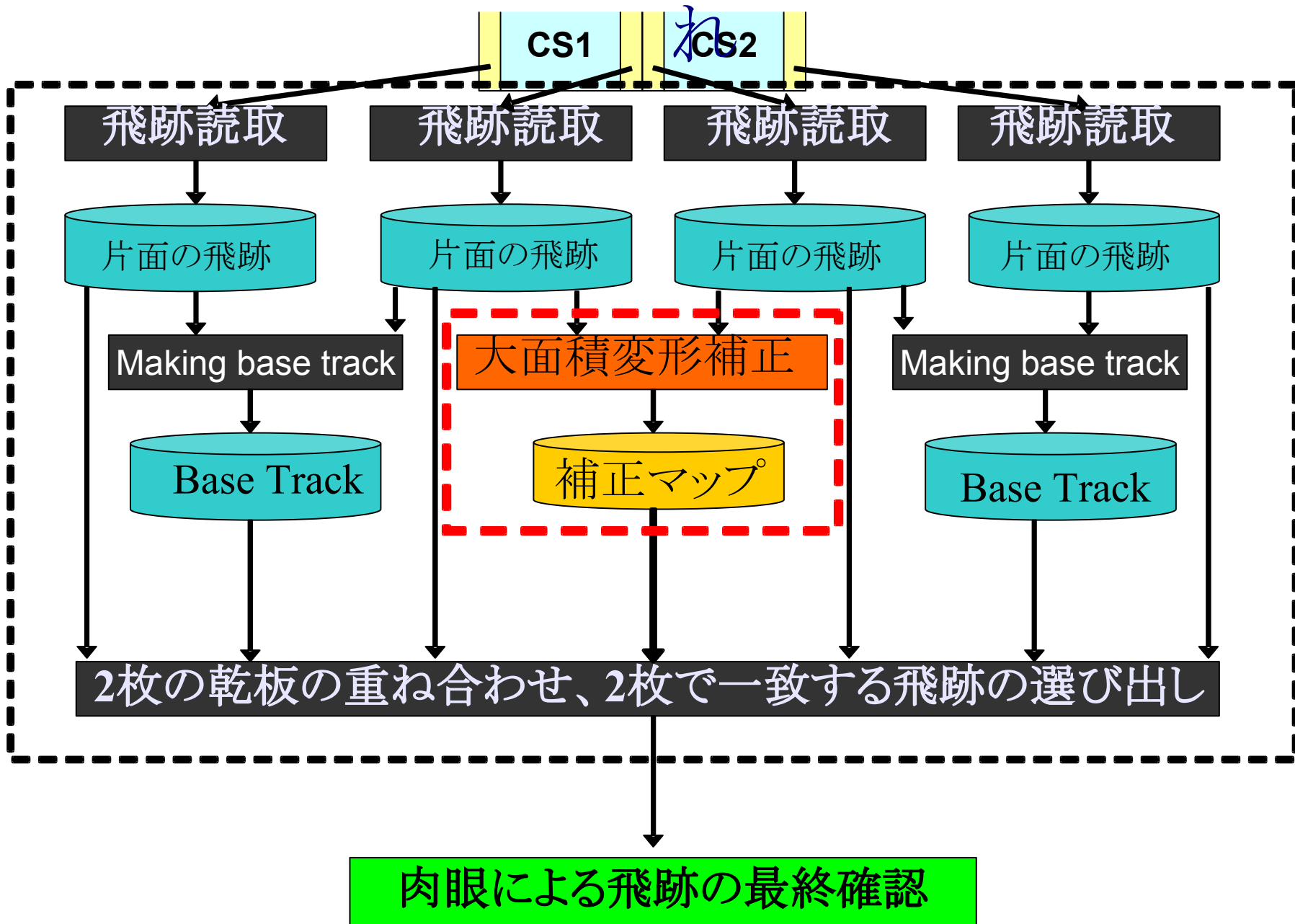


加速器ビーム
←

原子核乾板は現像→乾燥の過程を経て、歪む:10~20 μm



CSにおける2次粒子の飛跡の選り出しの流れ



次期システム

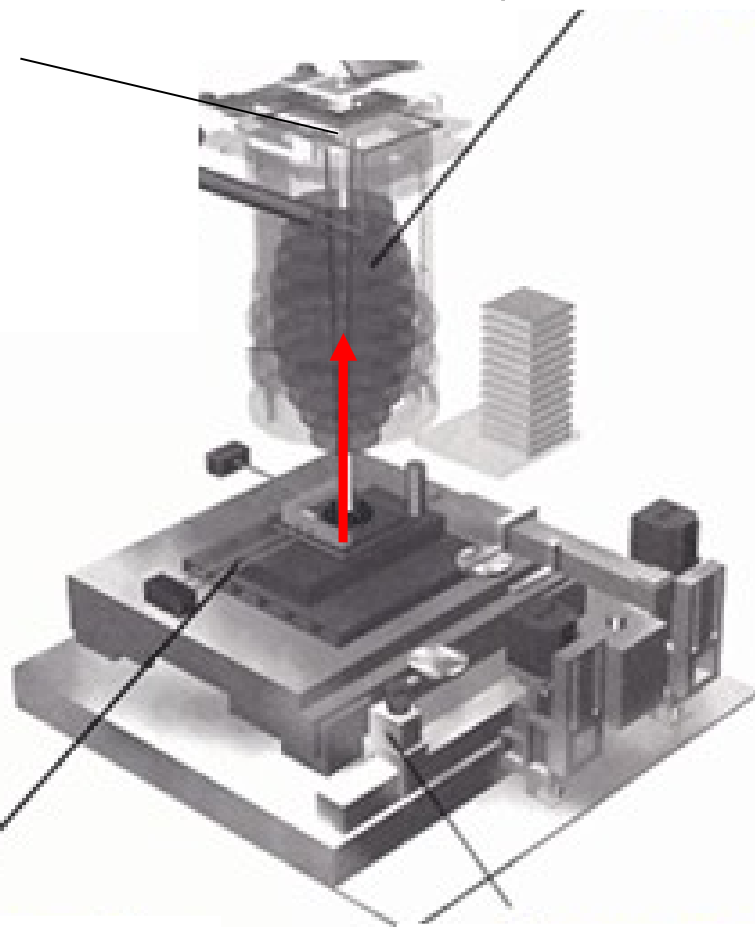
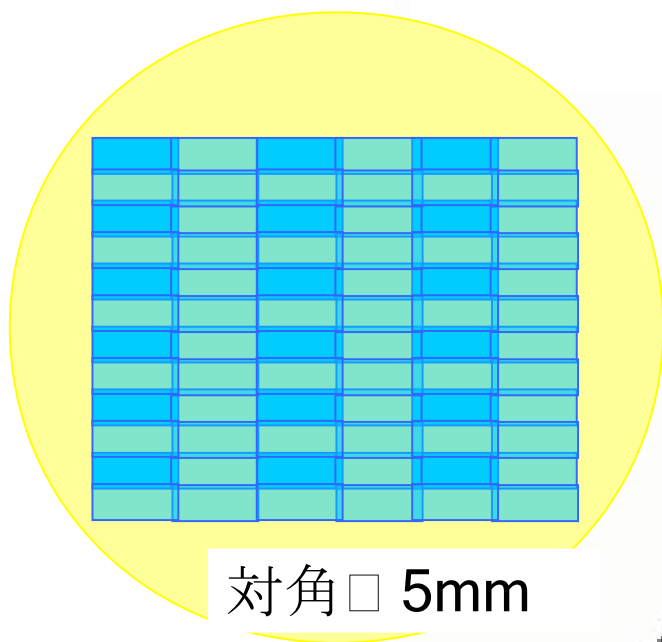
高解像度

ステッパー型レンズ(直径~30cm)

モザイクイメージセンサー

FOV of New Scanning System

FOV of SUTS

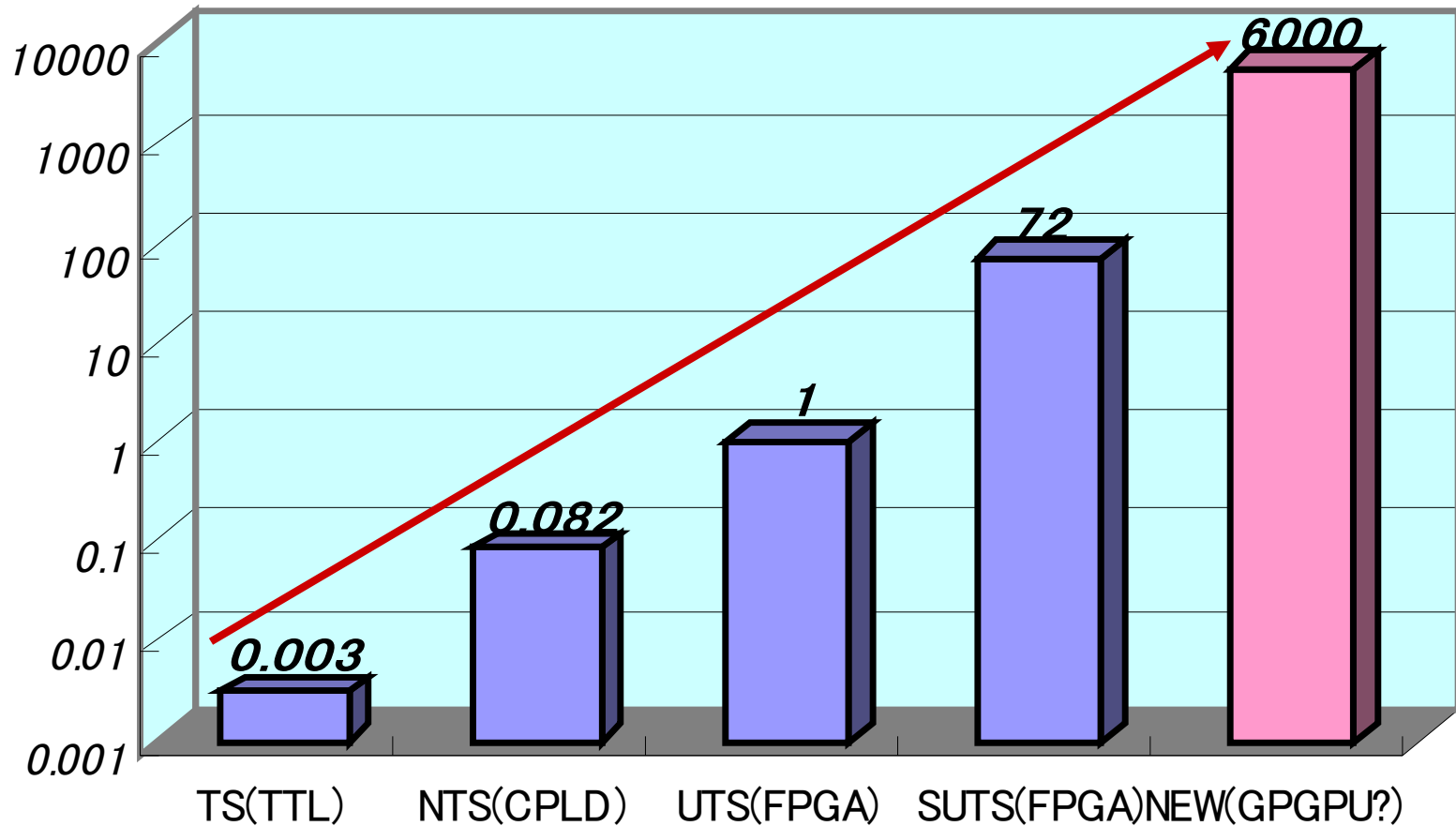


原子核乾板

ステージ

Evolution of the Scanning Power

Speed in cm^2/h





Roma ,
L'Aquila ^



高速トンネル、
地下研究所へ

地上ラボ



ラボの宿舎になるはずだったが、
地域の皆さんの反対運動で
工事中止になった建物



2009年4月6日
L'Aquila 大地震のとき、
避難キャンプが設置された芝生
(私もここで2日過ごした)



間借りし
てる宿

