

Progress in Analysis of High Energy Cosmic-ray spectra measured in BESS-02



**S.Haino/U.Tokyo
BESS collaboration**

Primary cosmic-ray flux

Atmospheric ν flux calculation

Uncertainty from abs. primary cosmic-ray fluxes etc.

BESS-98 and AMS

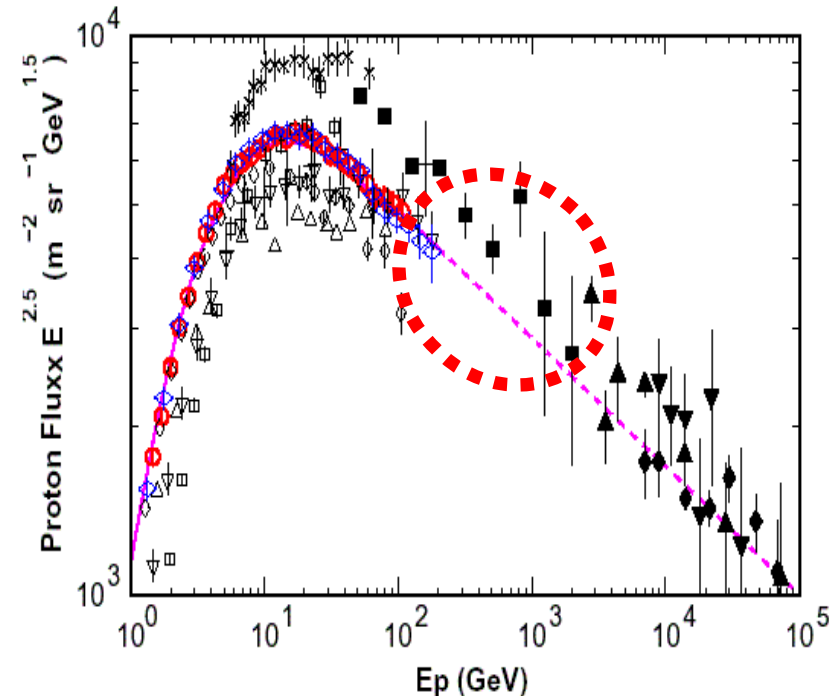
reported precise data at **1~100GeV**

Still large uncertainty at **0.2~1TeV**

→ Upward through-going μ events
only the data of balloon-borne calorimeter experiment
systematic error of energy measurement

More precise data are required at **high energy region**

→ motivation of **BESS-TeV** project



Concept of BESS-TeV

BESS detector ... magnetic rigidity spectrometer

Higher momentum resolution $\left\{ \begin{array}{l} \text{more } N \\ \text{longer } L \\ \text{better } \sigma \end{array} \right.$

(1) Upgrade of JET/IDC

N_{\max} 24 \rightarrow 48
 σ_{JET} 175 μm \rightarrow 160 μm

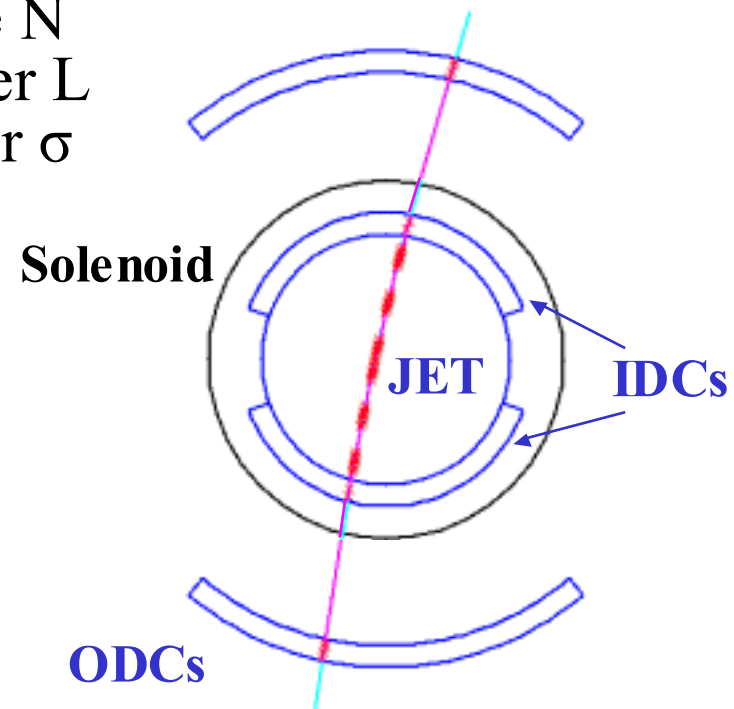
(2) New drift chamber, ODC

L_{\max} 0.8m \rightarrow 1.6m, $N = 4 \times 2$

(3) New FADC

Readout 500ch \rightarrow 1000ch

Total improvement expected: MDR 220 \rightarrow 1400 GV
 $\Delta p/p$ 45% \rightarrow 7% @100GeV/c



Detector simulation

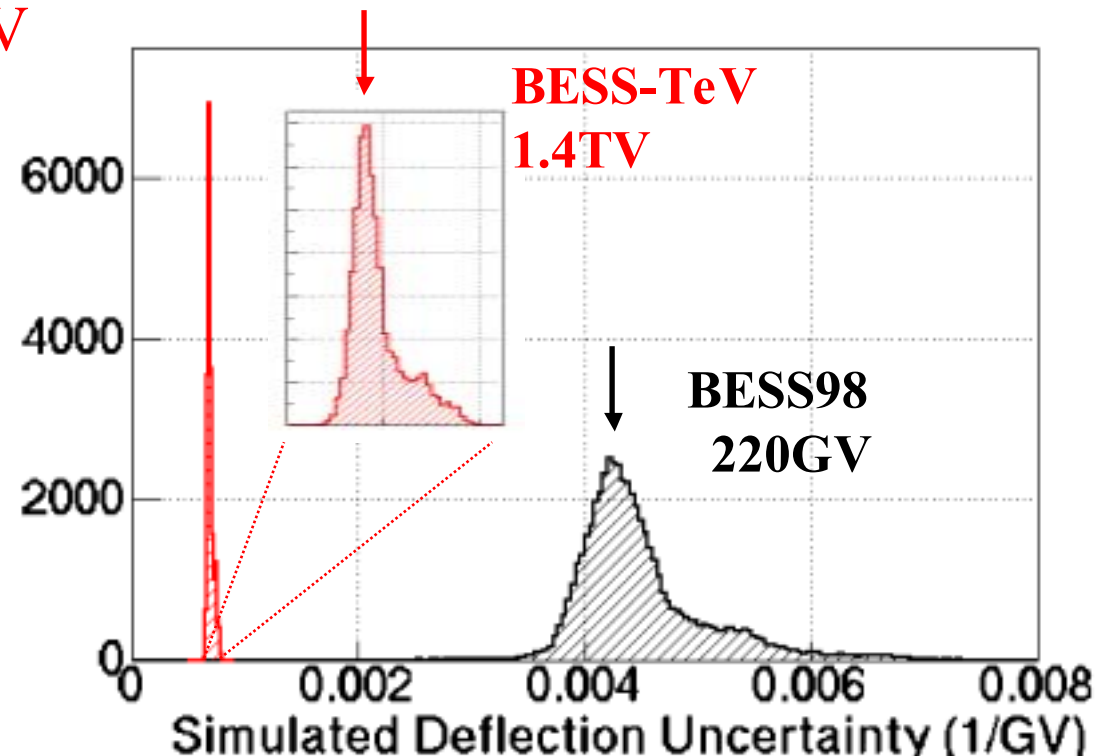
Simple M.C. simulation

verification of the new detector design

Results from 2 configurations

BESS-98 → 220GV (reproducing real data)

BESS-TeV → 1400GV



ODC

Installed at just inside TOF

Doubled track length $\sim 1.6\text{m}$

Enables **more precise**
deflection measurement

The simple case

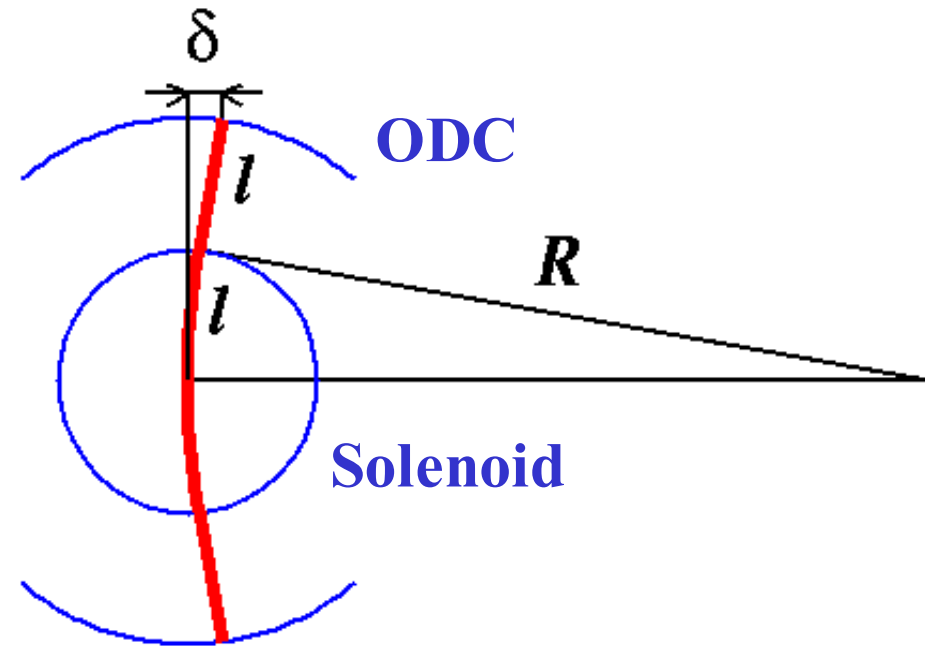
$$2l = 830\text{mm}$$

$$\delta = 0.080\text{mm}$$

($\sigma = 160\mu\text{m} \times 4$ points)

$$\rightarrow \Delta l/R = 1/4300\text{m}$$

($1/1300\text{GV}$ for 1 Tesla)



$$\frac{\delta}{2l} \sim \frac{l}{R} \quad (\delta \ll l \ll R)$$

ODC (2)

Requirements

4 sensitive layers

$\sigma \leq 160\mu\text{m}$

Low power FADC

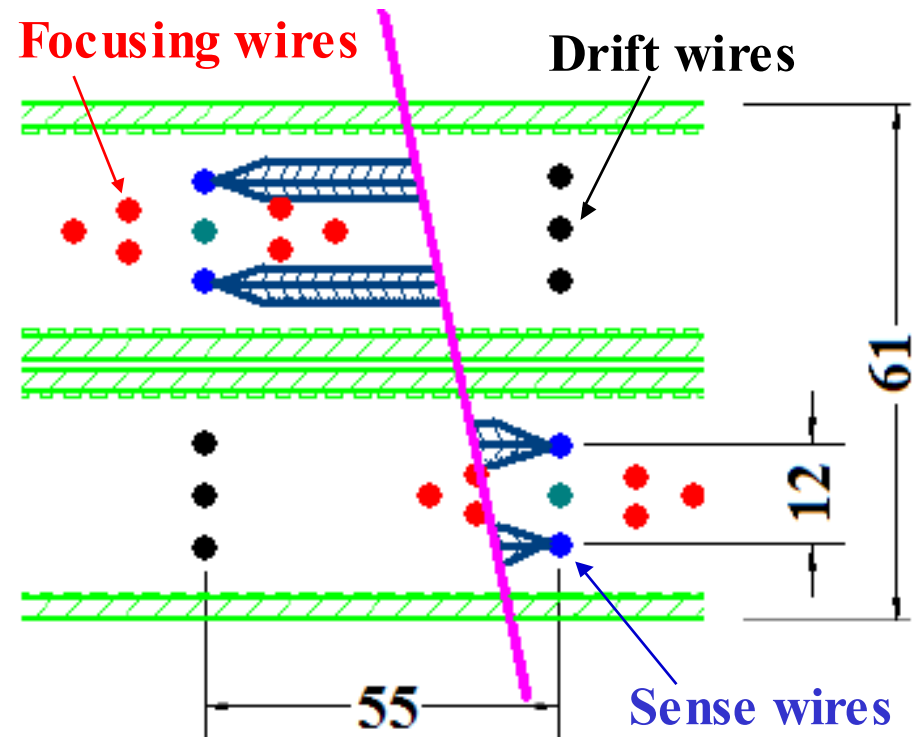
Compact & low materials

Design

Slow gas (CO₂90% Ar10%)

55mm drift width

Focus wires



Reliable calibration

Variation of p, T in the balloon flight

→ calibration counter system providing **abs. reference independent** from p, T is required

Scintillation fiber counter (SciFi)

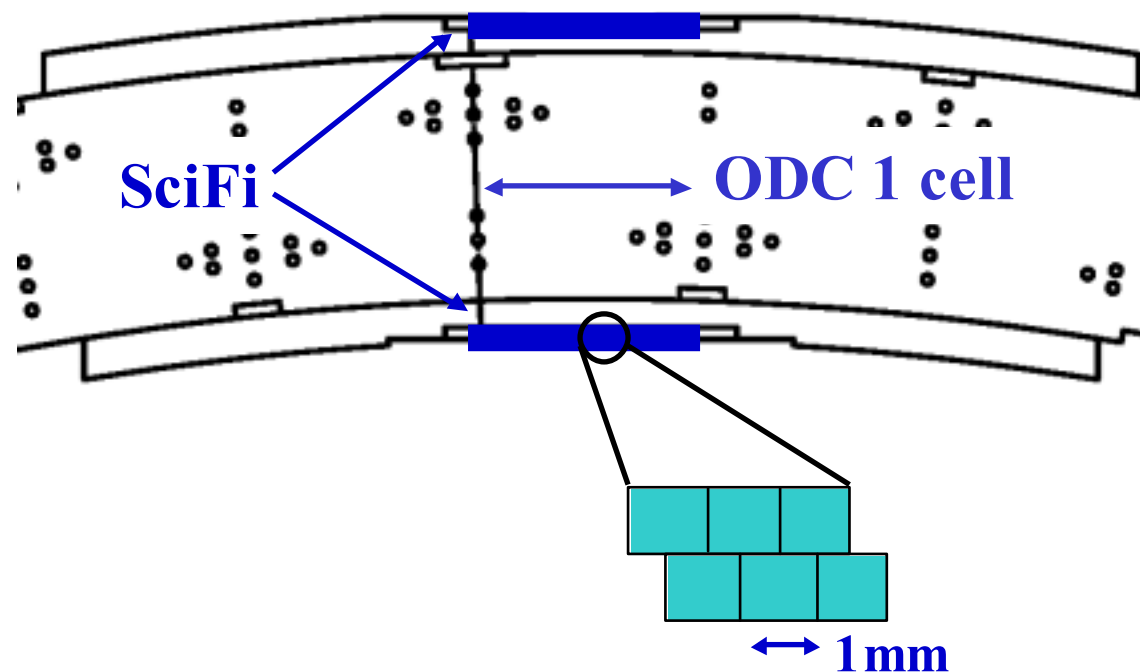
Design

2 layers of $1 \times 1 \text{ mm}^2$ square-shaped scintillation fibers

Mounted on the **both surface** of each ODC

Covering **one cell** of ODC

Read by **16ch multi-anode PMTs**



ODC/SciFi beam test

Feb. 2002 @KEK PS π^2 beam line

2GeV/c p/π^+ beam

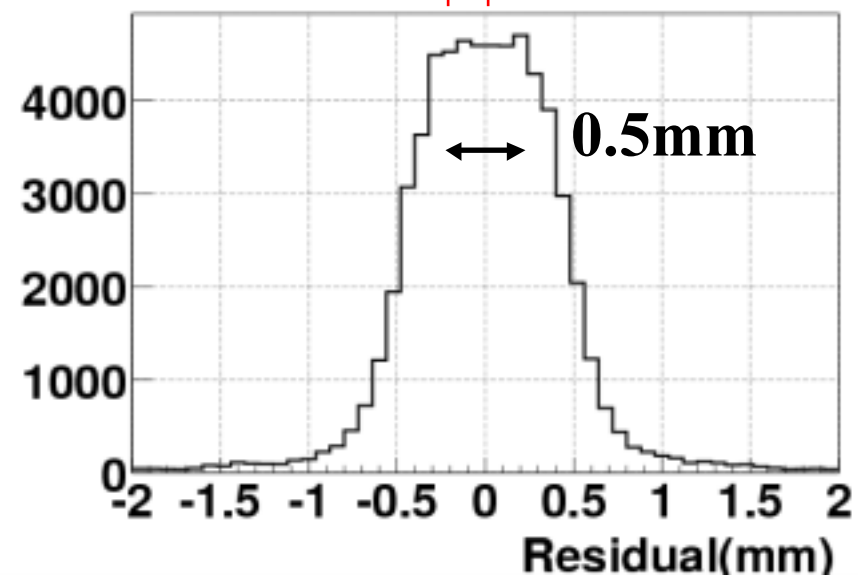
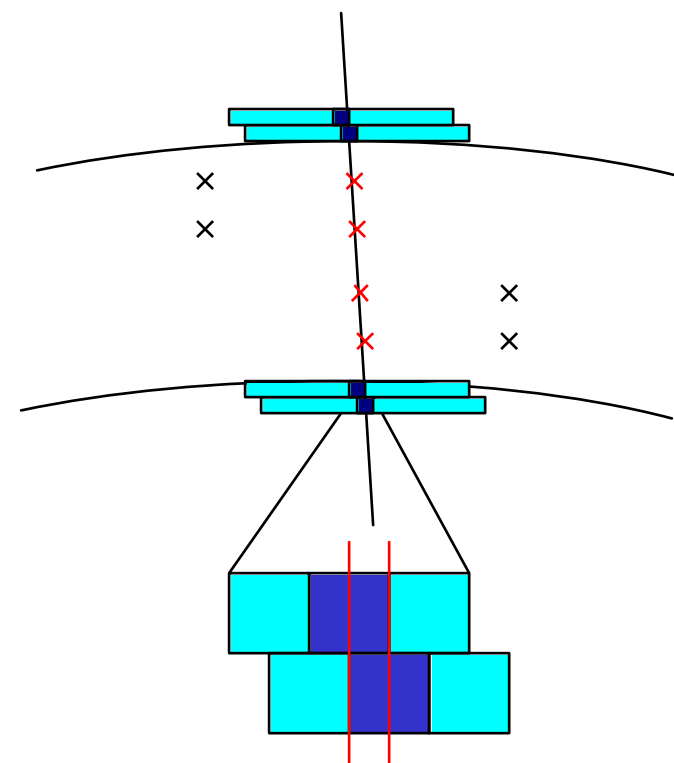
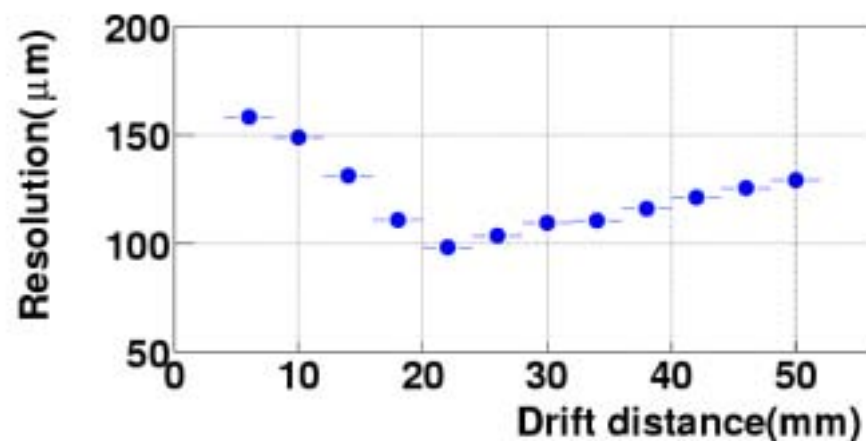
Calibration using SciFi hit

Mean of residual between

ODC track and center of SciFi hit

→ accurate reference $\ll 100\mu\text{m}$

ODC resolution $\sim 120\mu\text{m}$



History of BESS-TeV project

Jul. 99 Chambers construction started

Mar. 01 **ODCs completed**

Installed to BESS-01

Sep. **Balloon flight at Ft. Sumner**

measurement of $\mu/p/He$
spectra at small depth (K.Abe)

Feb. 02 ODC/Scifi beamtest

Mar. **new JET/IDC completed**

Installed to BESS-02

Aug. **Balloon flight at Lynn Lake**

measurement of primary p/He spectra,
low energy \bar{p} spectrum

now Data analysis of BESS-02 in progress



BESS-02 Balloon Flight

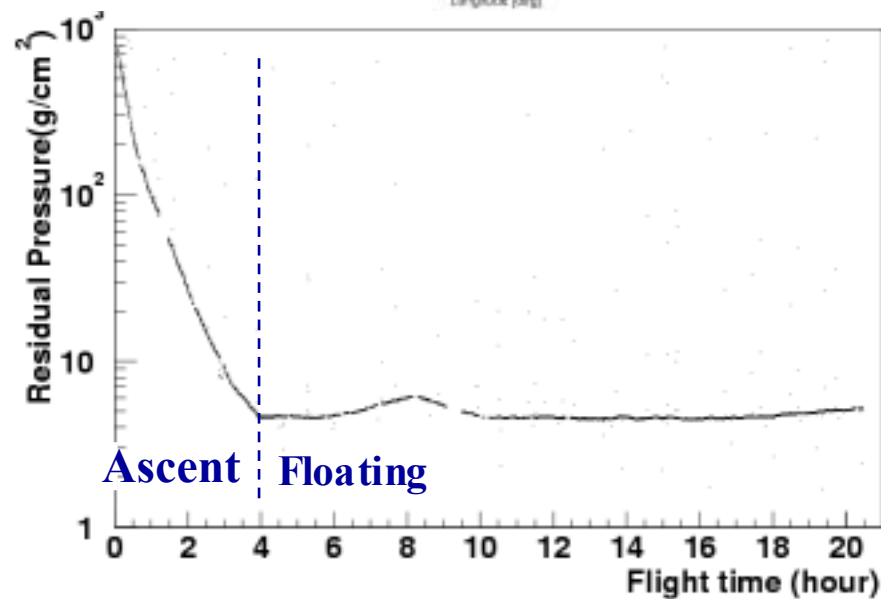
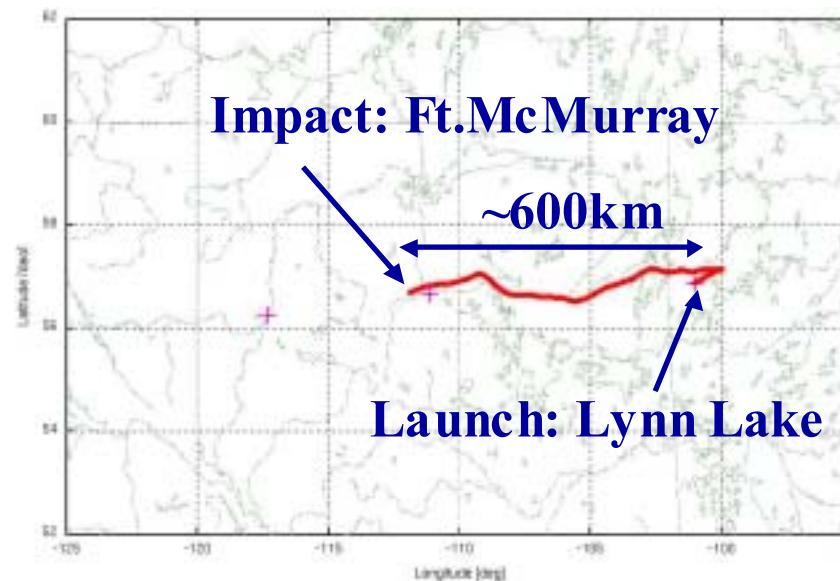
Launch: Aug. 7, 20:58 CST

Termination: Aug. 8, 17:46 CST

Residual pressure: 4.7 g/cm²

Floating time: 16.5 hours

Live time: 11.3 hours



Present status of BESS-02 data analysis

**Calibration of new drift chambers
Performance**

Offline calibration of JET/IDC

Std. template of drift properties

Calculated with GARFIELD

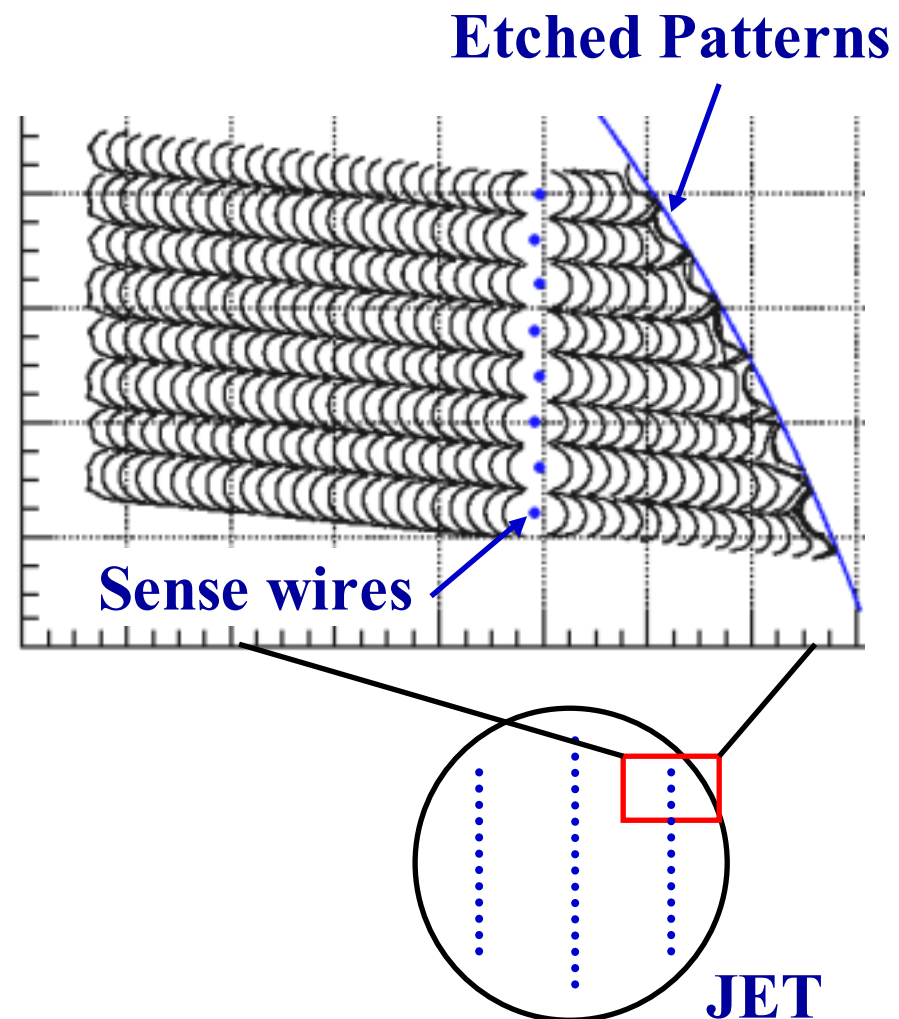
from the geometries of
wires and etched patterns

Offline calibration

for each 1 hour run

Only a few common parameters

Drift velocity, Lorenz angle,
FADC time offset etc.

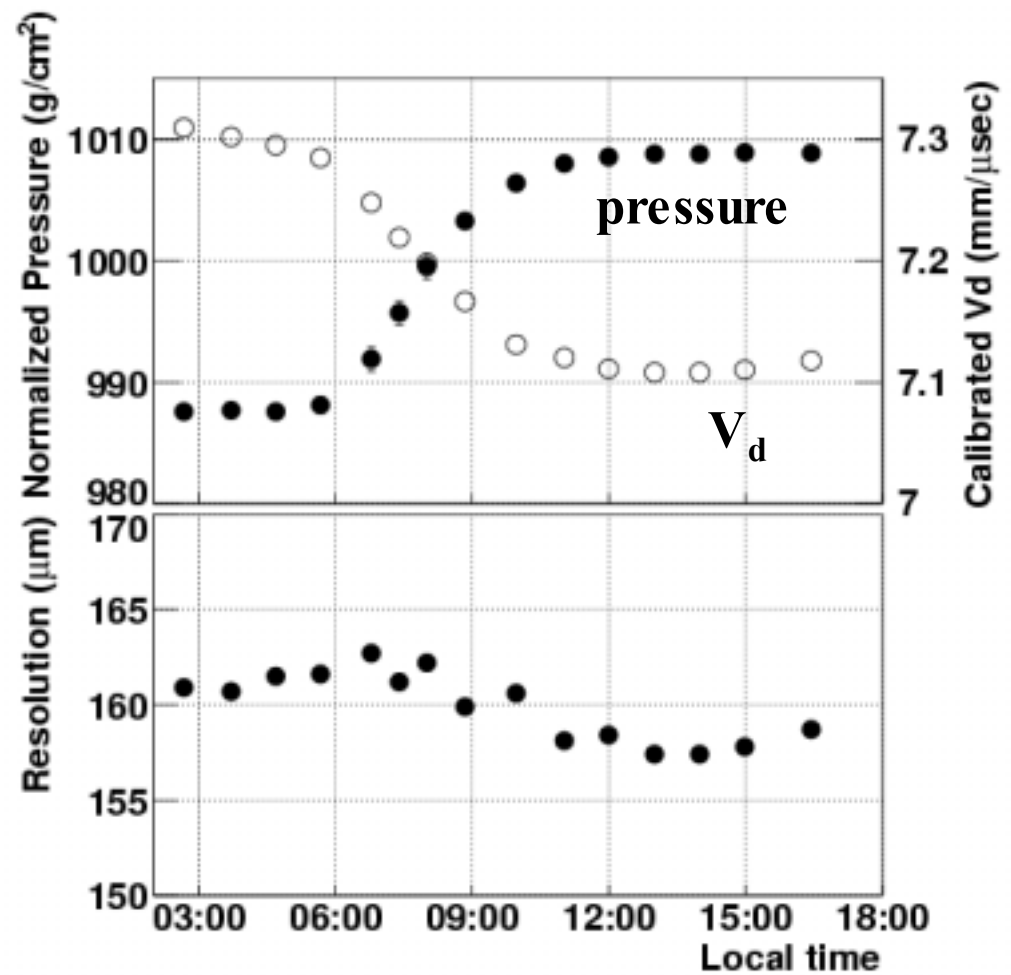
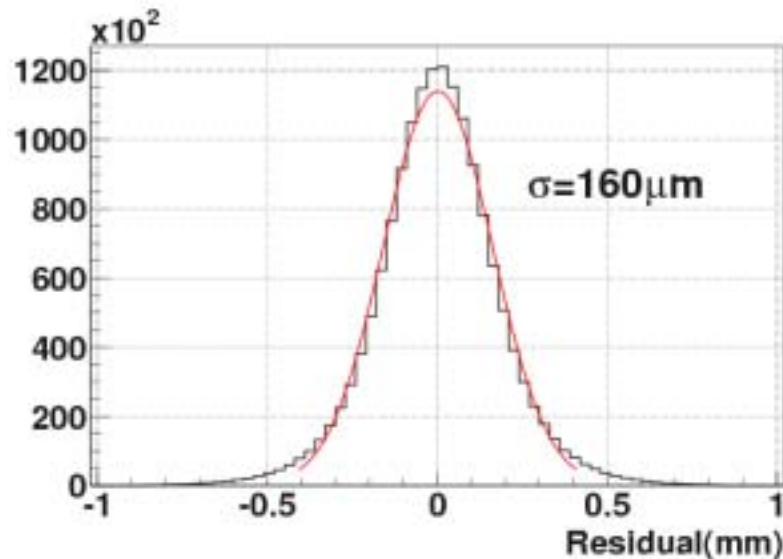


Performance of JET (Preliminary)

Drift velocity V_d

Correctly calibrated following the variation of p/T

Stable designed resolution during the **entire flight**

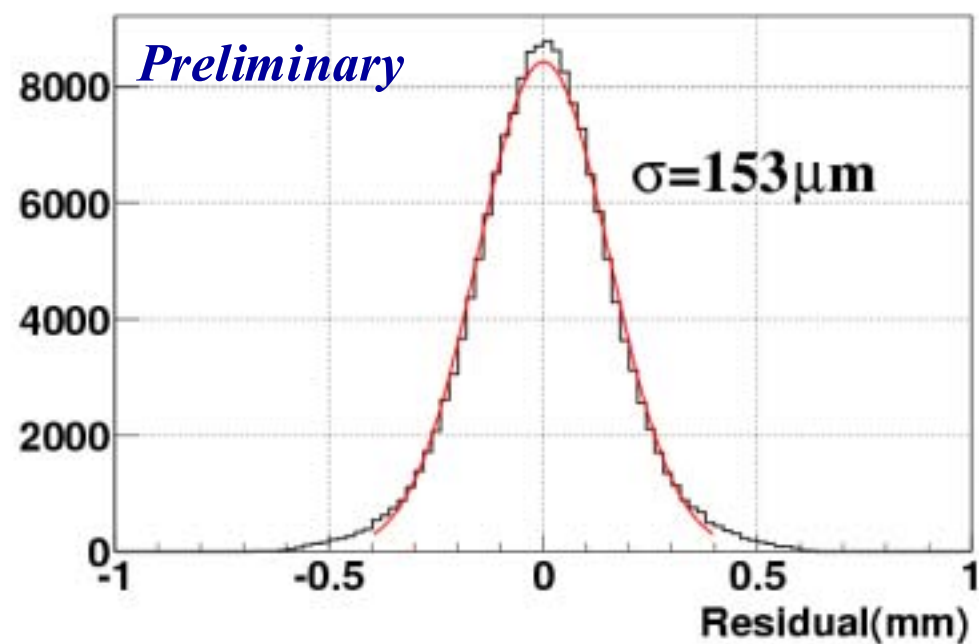


Performance of ODC

Calibration using SciFi

The same scheme as beam test

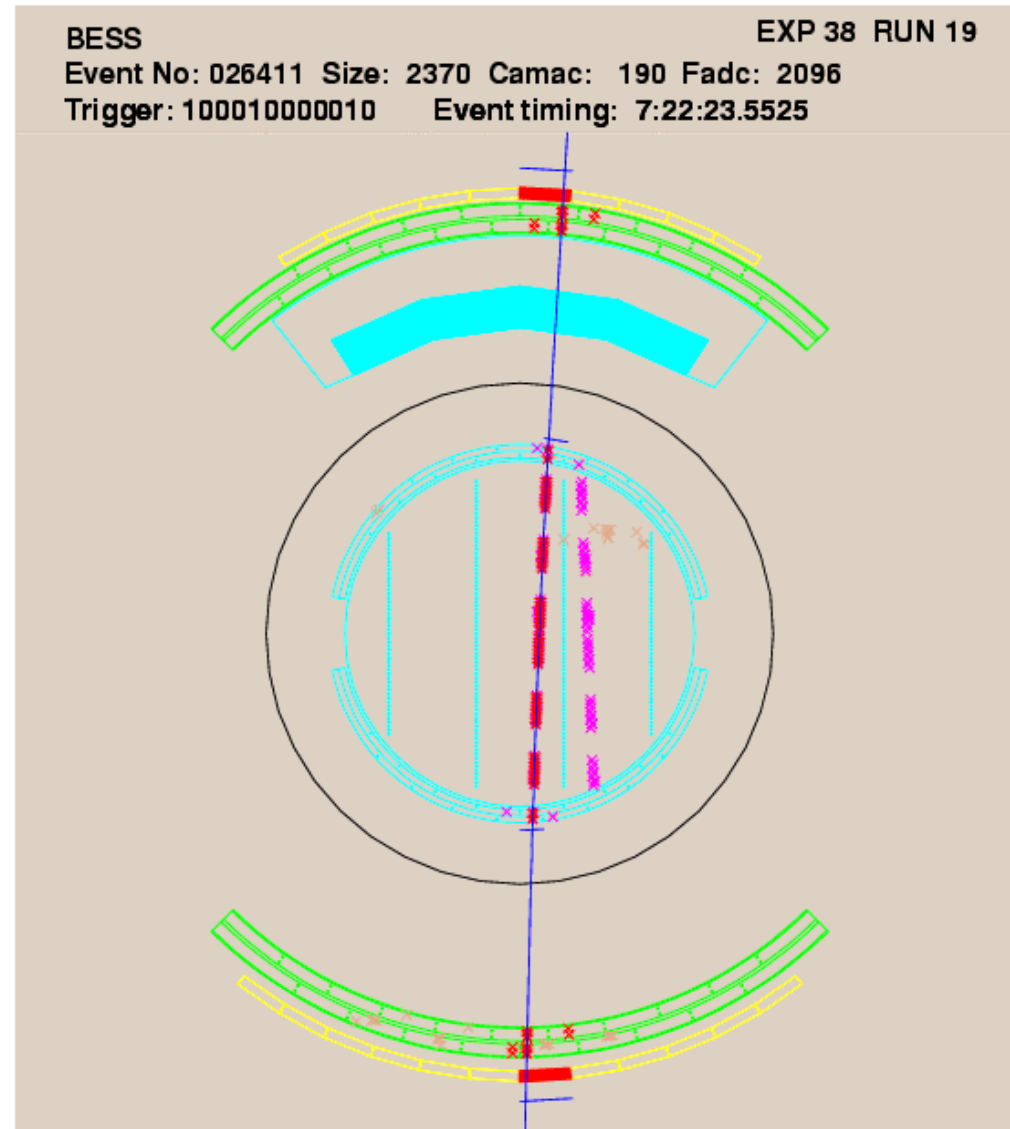
Resolution of **150 μm** achieved



Event example

8GV Proton

Each hit on the
fitted trajectory



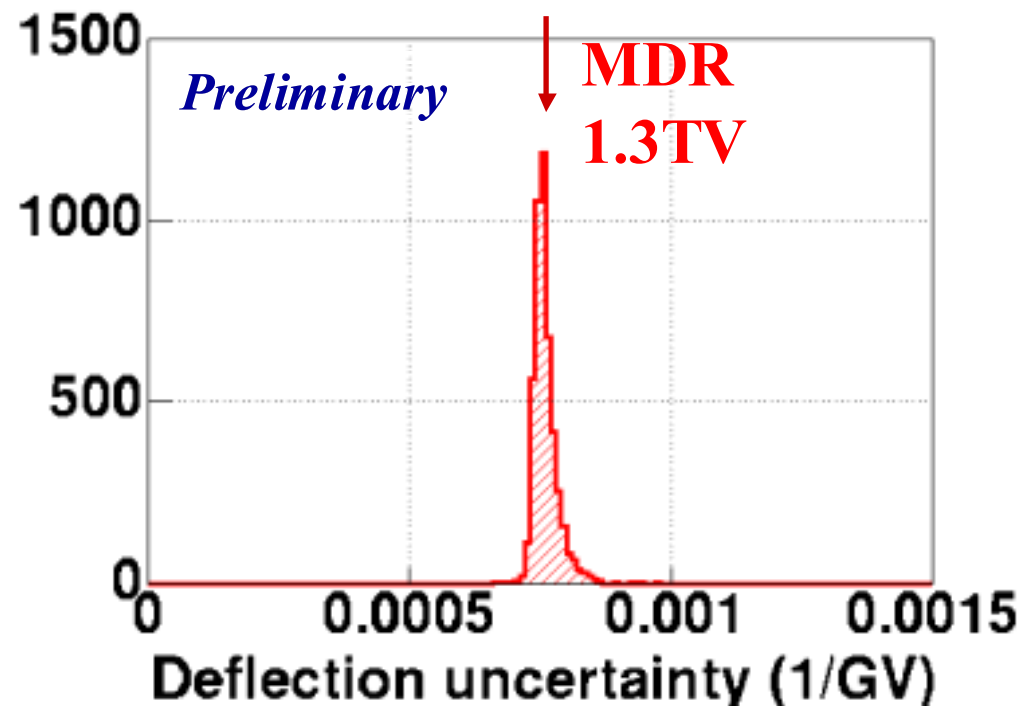
Performance of deflection measurement

JET/IDC/ODC combined fit for the high energy events

MDR of $\sim 1.3TV$ achieved as designed

MDR \leftarrow Curvature error

Absolute value to be checked in other way



Absolute rigidity determination

Requirement for reliable rigidity measurement

Careful check of **alignment**

Evaluation of **systematic error**

Absolute rigidity references

Threshold rigidity of Aerogel Cherenkov counter (4GV for p)

μ^+/μ^- data in the ground experiments ($> \sim 100\text{GV}$)

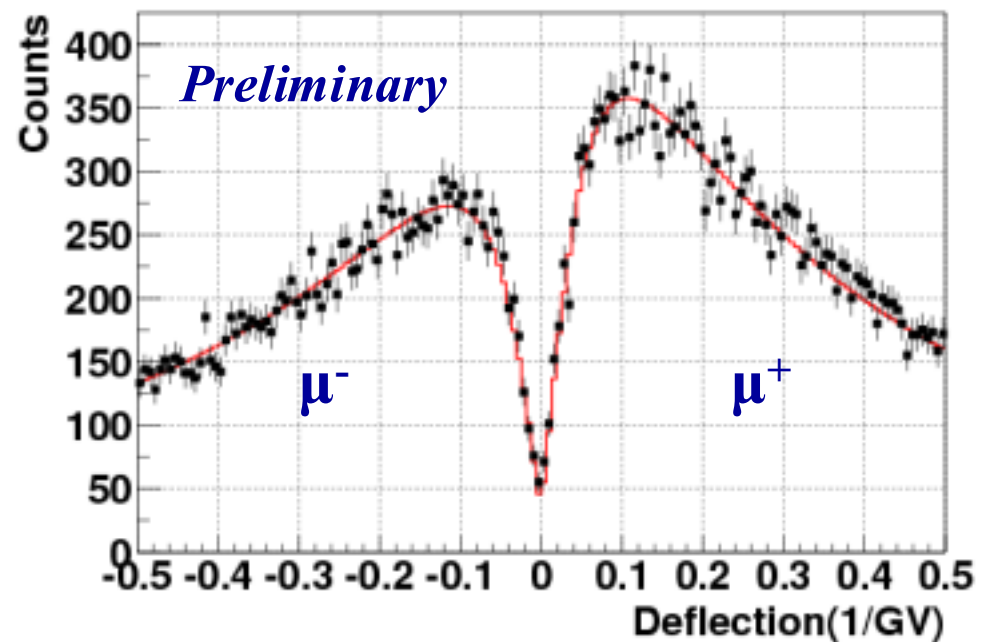
Ground experiments

Preparation stage

before the flight

1 week observation

at KEK after the flight



Summary

BESS-TeV was designed to obtain **better** momentum resolution with **new drift chambers**.

Data analysis of BESS-02 is in progress.

The drift chambers worked as the expected performance during the entire flight.

The MDR of 1.3TV is to be achieved.

The obtained proton flux below 20 GeV is consistent with previous BESS experiments considering the effect of Solar modulation.