

Carbon Physics Validation

P152 Experiment at NIRS

Geant4 Workshop@Lisbon
Parallel Session: Medical Applications

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The P152 Experiment

Albeit its importance, a systematic accumulation of ion interaction data relevant to ion-therapy has not been established yet.

- Not many data available
 - Probably due to the poor availability of machines for experiments.
- To understand physics of interactions is secondary importance for medical doctors(?)
- Causes difficulty in Geant4 physics validation

Why not to do an experiment by ourselves?

We started the P152 experiment at NIRS.

The P152 Experiment - *cont'd*

Purpose:

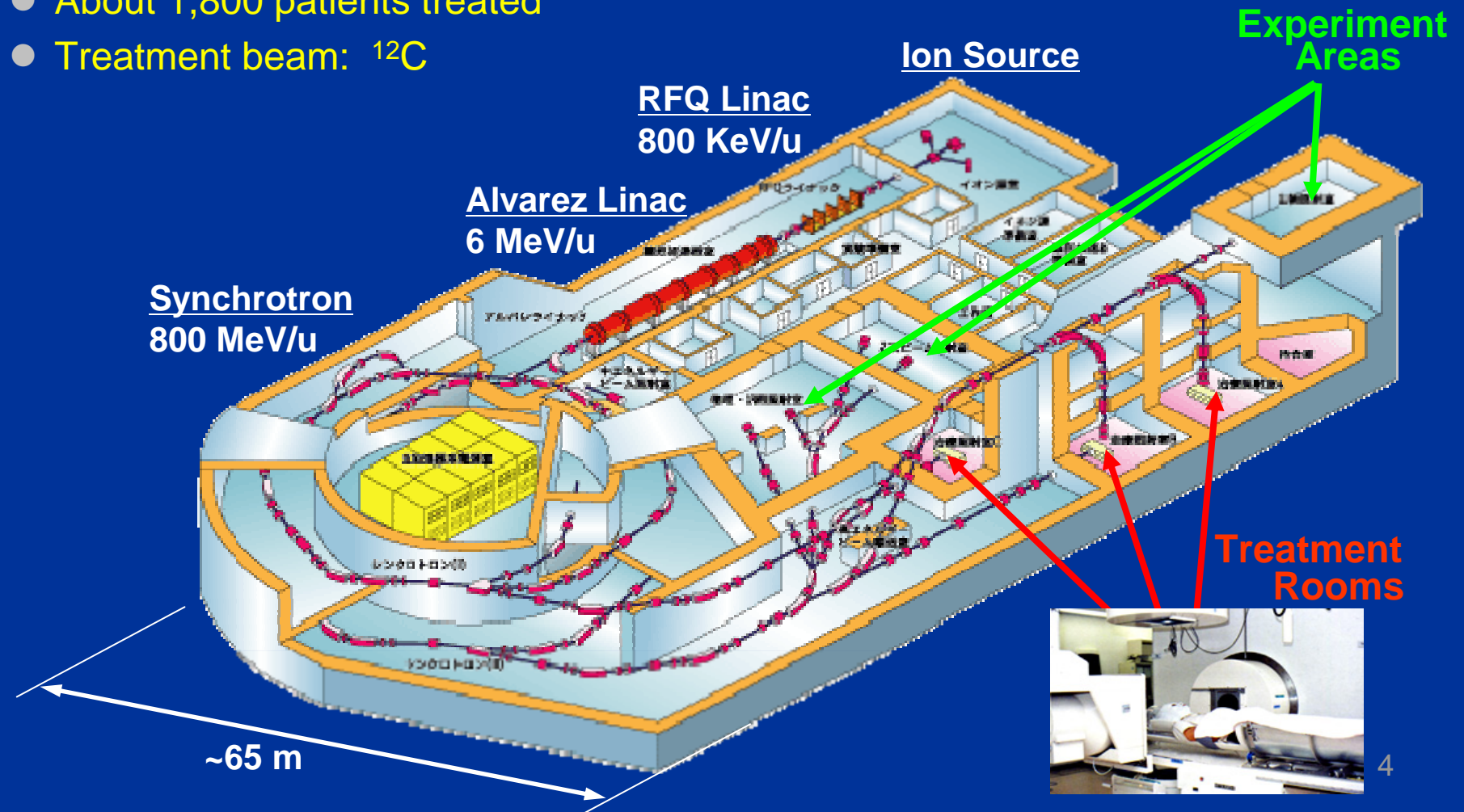
- To collect data of heavy ion interactions with H, C, O, Ca, P, etc in the energy region of ion therapy with the HEP emulsion chamber technology.
- Also to collect data of heavy ion interactions which are important in the radiation shielding of space laboratories.

Organization:

- 12 institutes from HEP, medical and space domains
 - HEP
 - High Energy Accelerator Research Organization (KEK)
 - Nagoya Univ.
 - Ritsumeikan Univ.
 - Kobe Univ.
 - Naruto Univ. of Education
 - Toho Univ.
 - Aichi Univ. of Education
 - Univ. of Tokyo
 - SLAC
 - Medical
 - National Institute of Radiological Science (NIRS)
 - Gunma Univ., Faculty of Medicine
 - Space
 - Japan Aerospace Exploration Agency (JAXA)
- Experiment - 1st Phase: 2002 - 2004

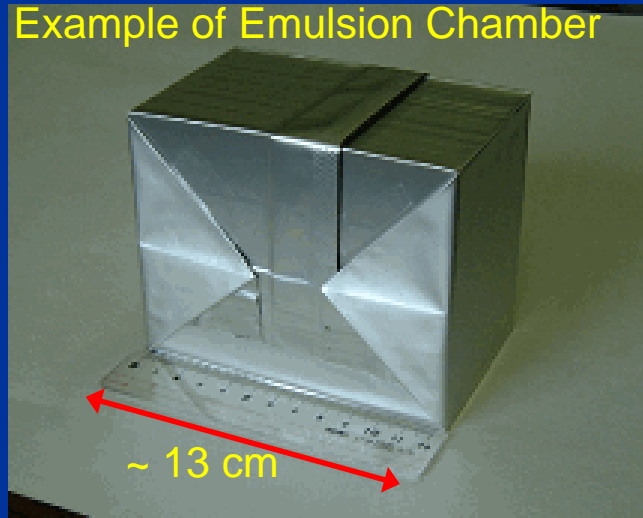
HIMAC/NIRS/Chiba/Japan

- Operation since 1994
- About 1,800 patients treated
- Treatment beam: ^{12}C

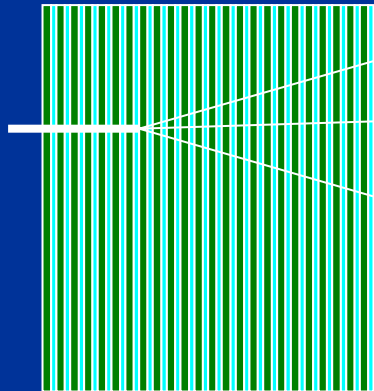


Why Emulsion Chamber?

Example of Emulsion Chamber



- 4π acceptance
- High spatial resolution ($\sim 1 \mu\text{m}$)
- Can record a very short track
- Can do charge identification
- No active parts in the detector
- Easy to handle
- Compact



Target material sandwiched
with emulsion films



Harp Experiment
ps214@CERN

4π Measurement of Proton
(2GeV~15GeV) Interactions
with Nuclei

- TPC
- Forward Spectrometer
- Gas Cherenkov
- ToF, etc



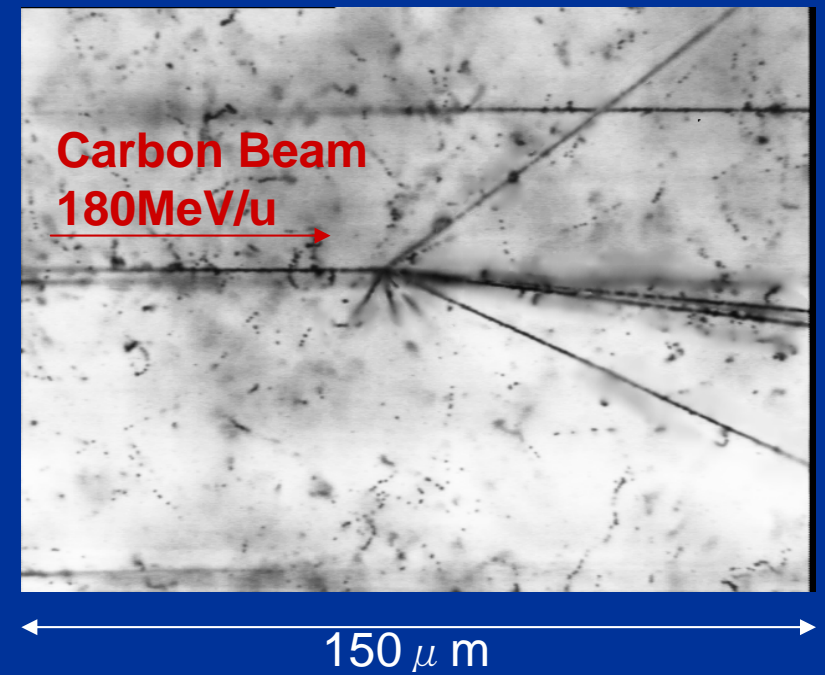
*Not a fair comparison but you can get some feeling of
emulsion chamber ...*

Emulsion Film

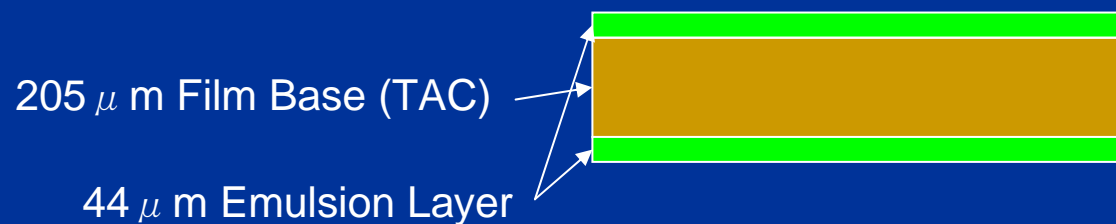
- Single sheet of emulsion film (Opera Film)



- Film developed

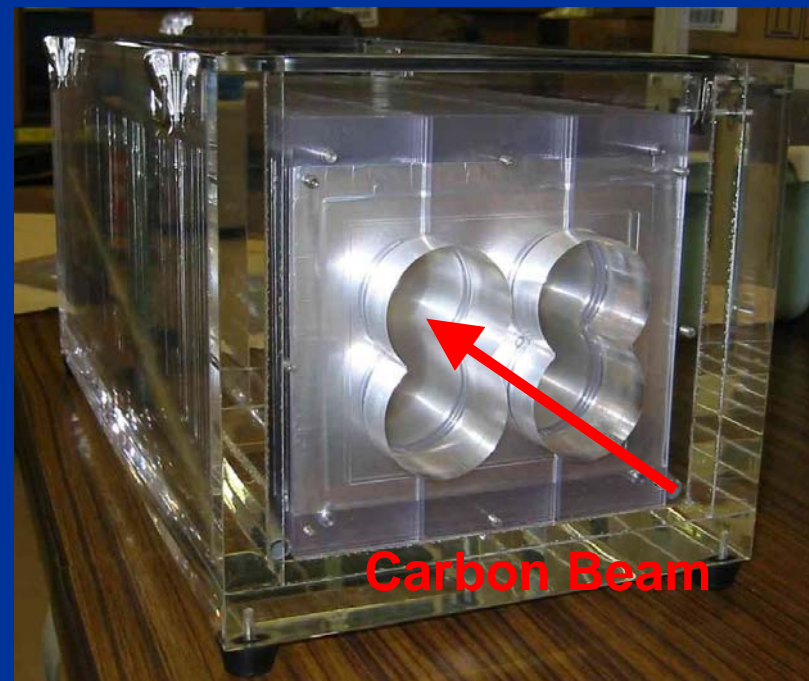


- Film cross section



Water-Emulsion Chamber

Multi-layers of emulsion films in a water chamber

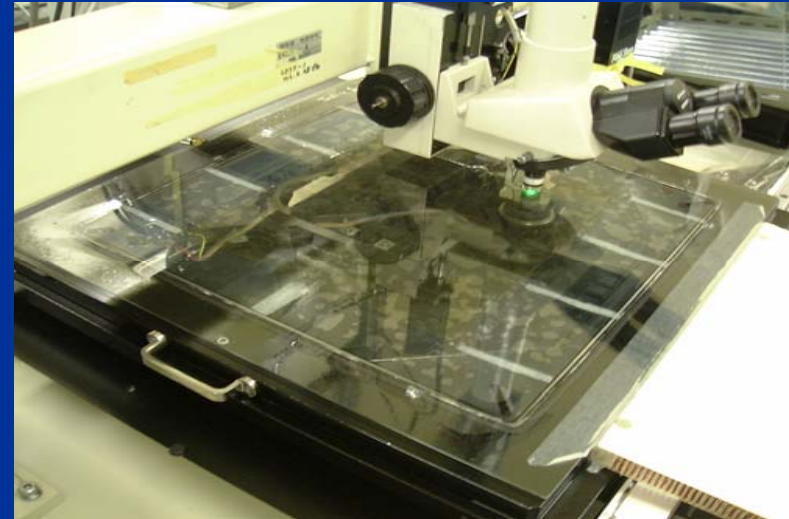


Tracks Reconstruction in Water-ECC

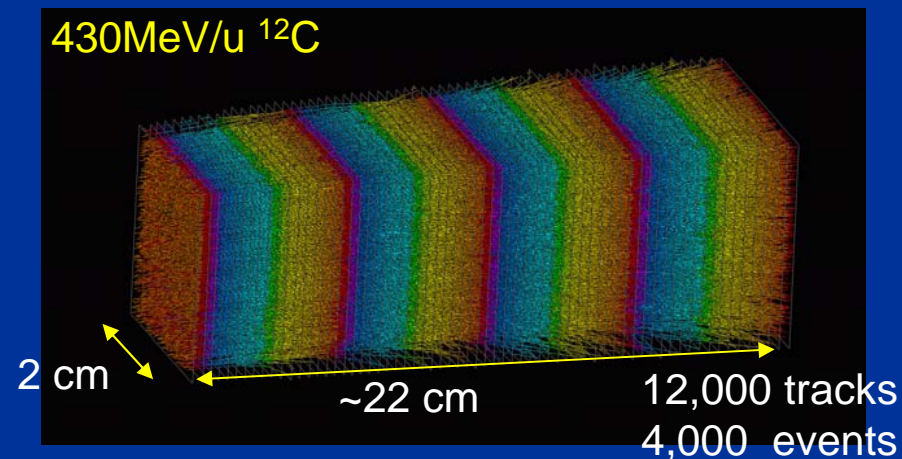
Automatic scanning machine developed at Nagoya Univ.

- For heavy ion tracks:
 - Spatial resolution $\sim 1 \mu\text{m}$
 - Angular resolution $\sim 5\text{mrad}$
 - Track Finding Efficiency $\sim 100\%$ ($\tan \theta \leq 0.4$)
- Automatic scanning speed:
 - ~ 10 hours/plate

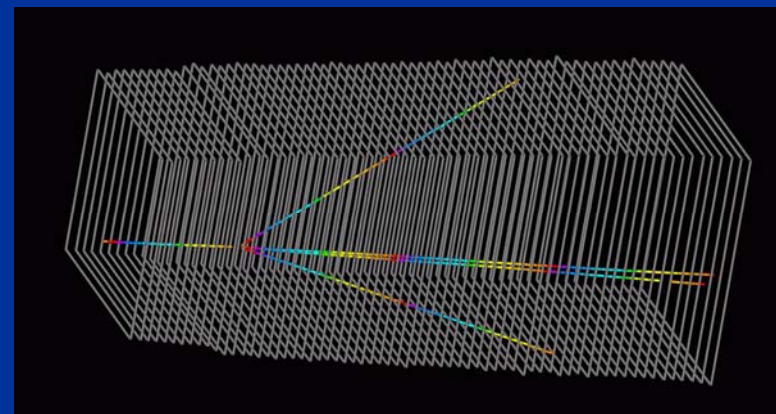
(Depends on the density of tracks)



All reconstructed tracks in the water ECC



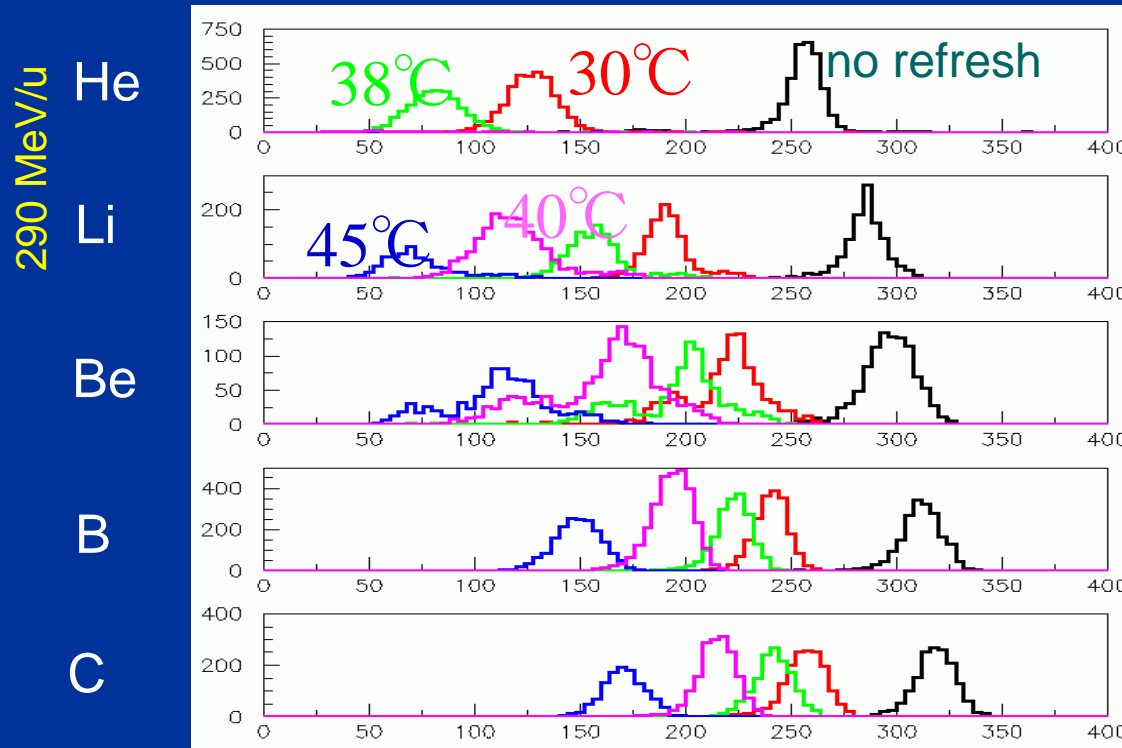
An event selected from the left data



Ion Charge Identification: Refresh Method

■ Refresh method

- A new technique we've developed for this experiment – See our NIM paper(*)
- Charge ID by the 'grain' density of a track – a higher charge causes saturation
- The 'refresh' method expands the linearity of the 'grain' density.
- After an exposure of films to the beam, put them in a high temperature/humidity environment. (Ex. 3 days under 38°C relative humidity 98%)



(*) Reference

T. Toshito, et al.,

NIM A 5556, 482 (2006)

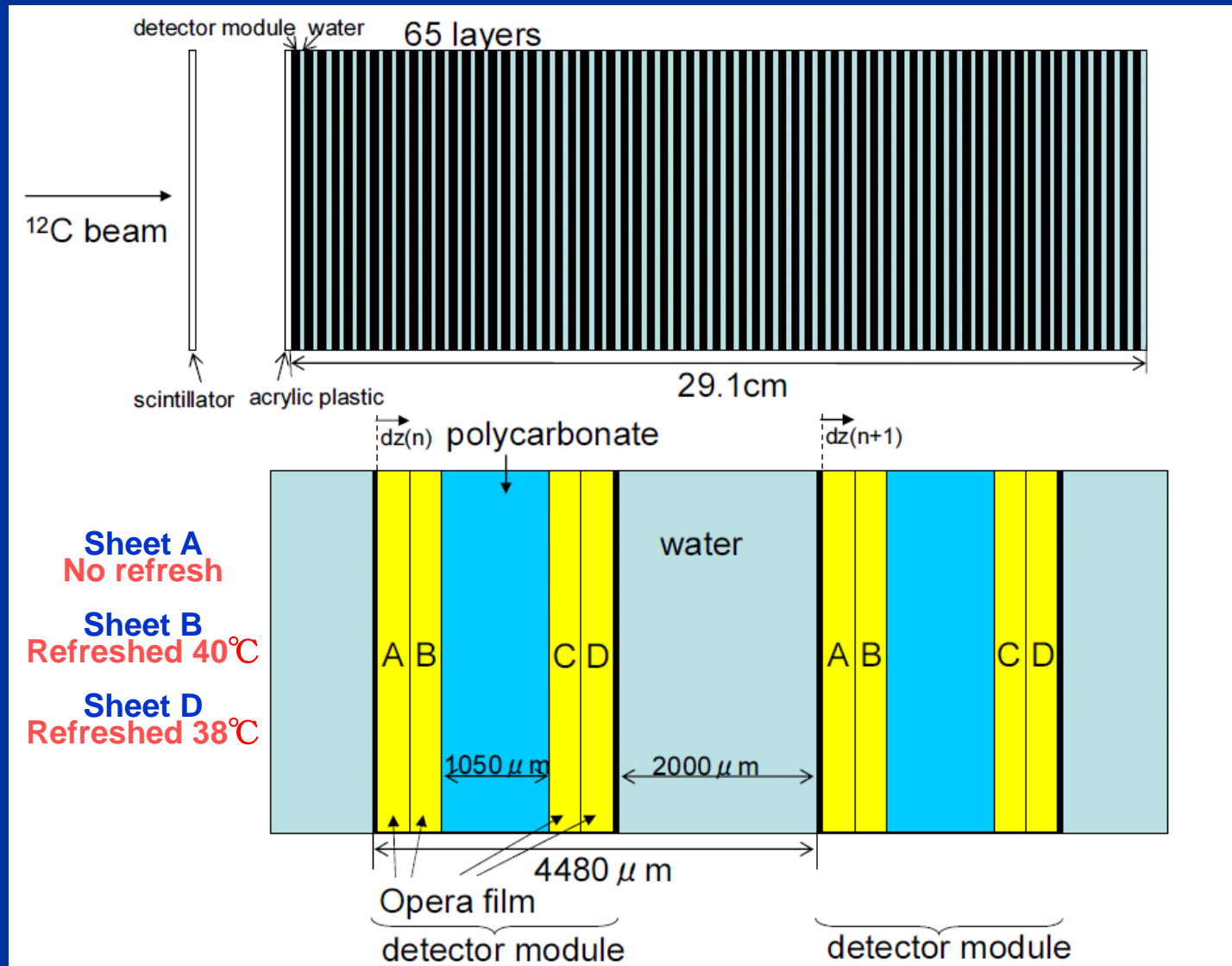
Schematic View of Emulsion Cloud Chamber

P152 Experiment

- December 2004

Beam

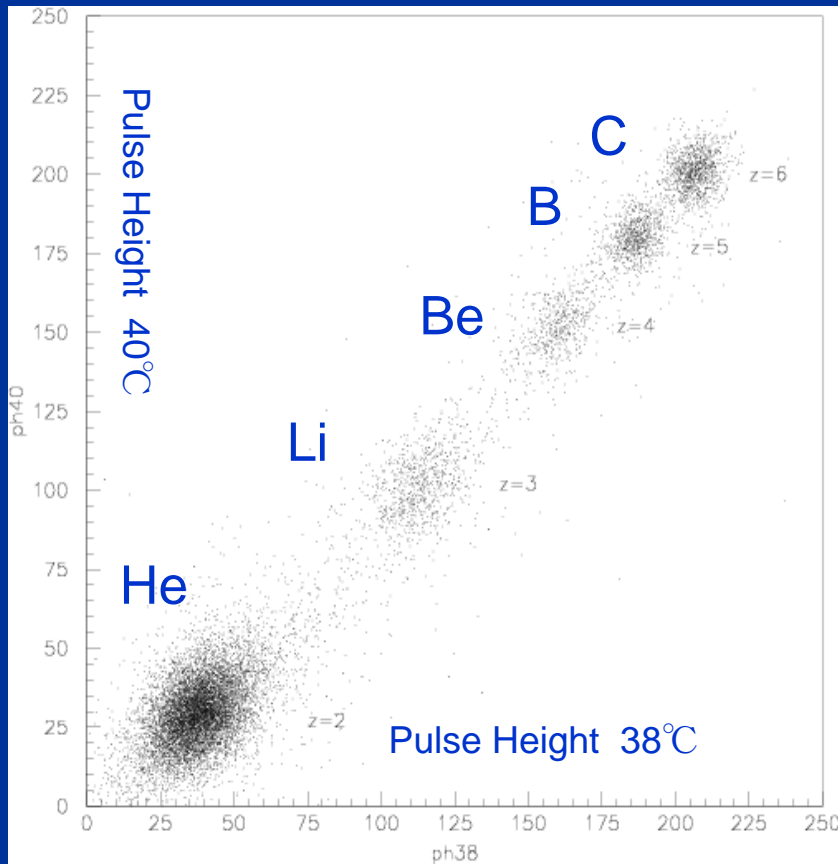
- ^{12}C 400 MeV/u



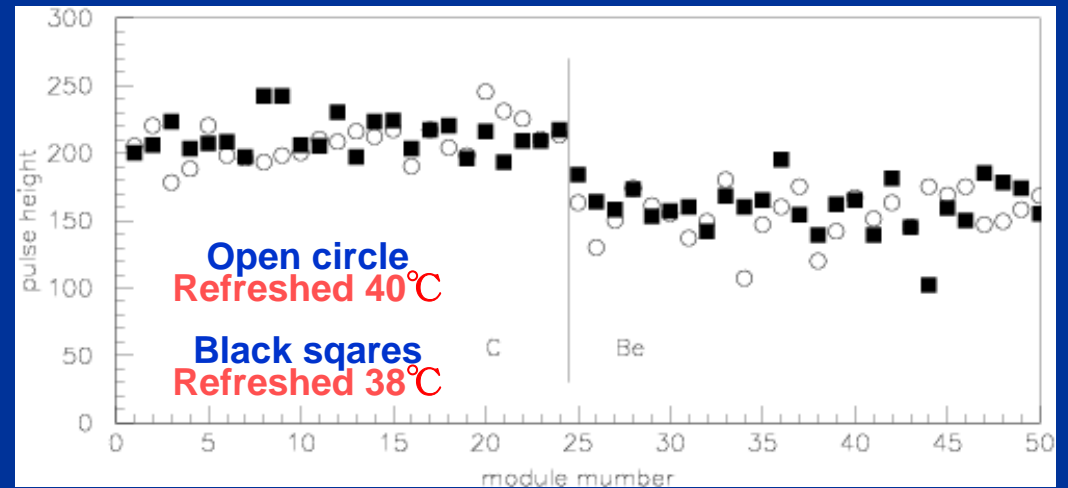
Charge Identification of Secondaries

■ Pulse Height Correlation

- Refreshed 38°C vs. 40°C



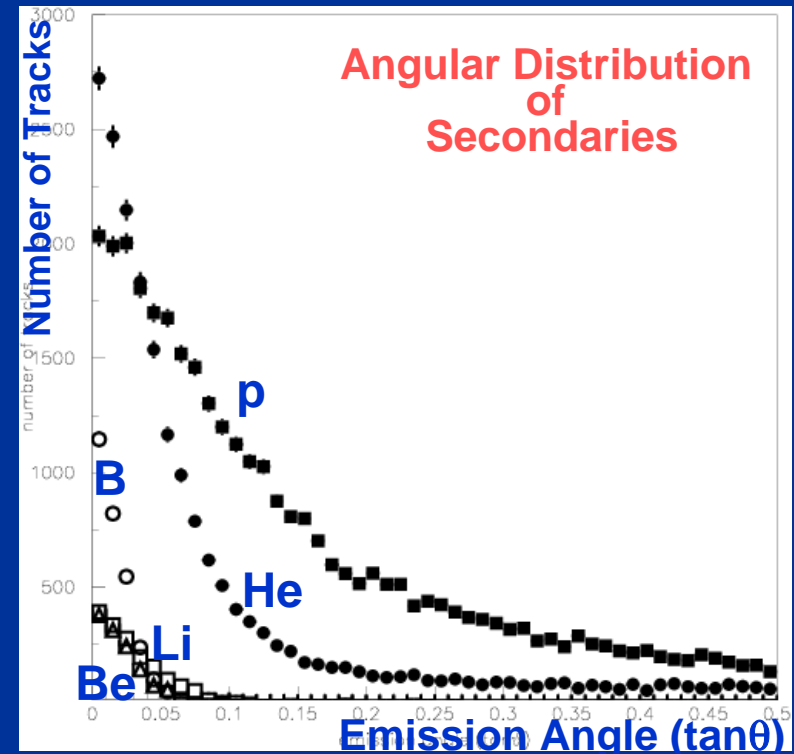
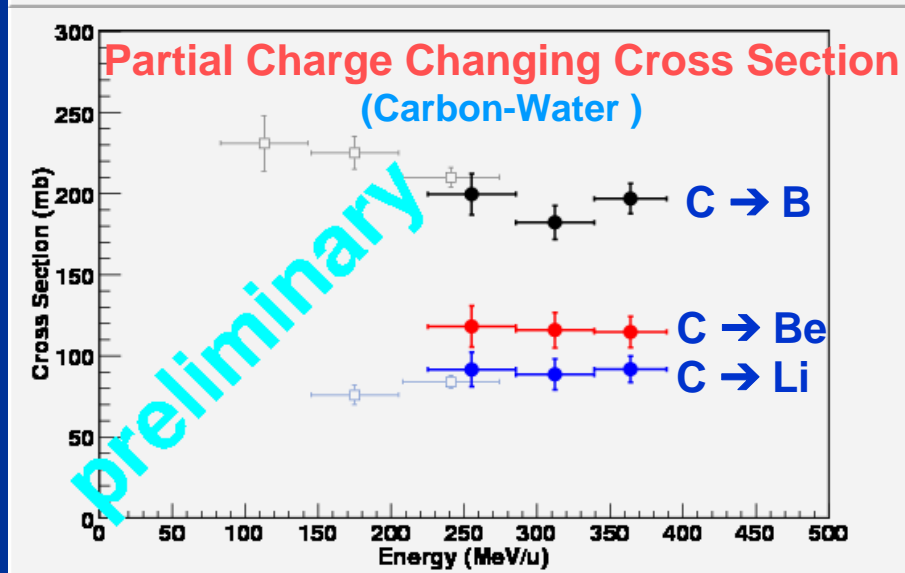
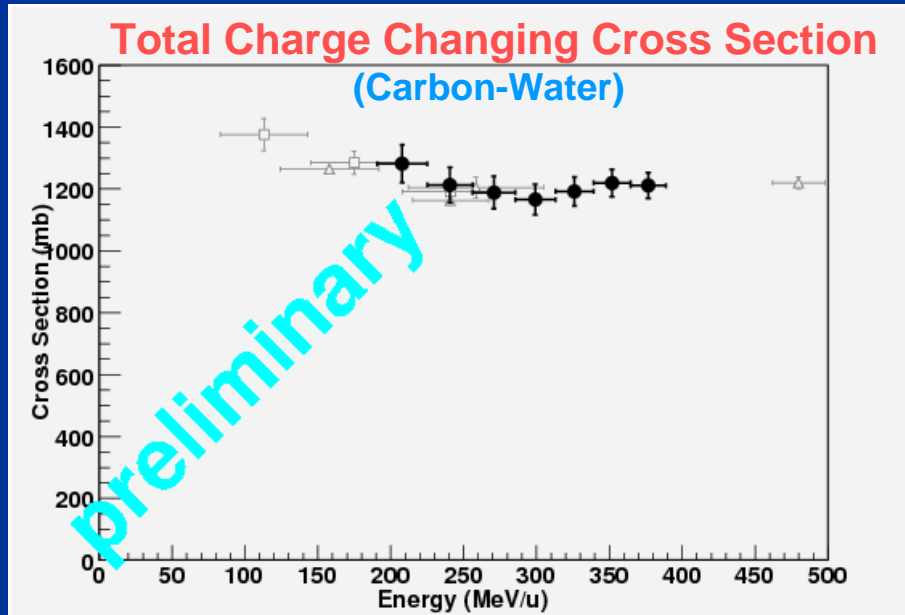
■ Pulse Height of Track near Vertex



[Note]

- *We can identify the vertex by the change of pulse height*
 - *Enable us to measure very forward scattering*

Some Preliminary Results



Summary

- The objective of the P152 experiment is to provide a systematic data set of ion interactions with matter for validation of Geant4 physics implementation.
- It utilizes the emulsion chamber technique, which provides a simple and elegant detector system.
- We have proved that the technique can be applied to identify ion tracks and their charges.
- The P152 experiment is ready to publish the first data in public.
- We are now working on comparison of our data with Geant4 and other simulation packages.