Methodology of experiment and Dynamics of big science

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Contents

- Introduction
- Methodology of experiment
- Dynamics of big science
  (as long as time allows)

Introduction

Who am I ?

- Philosopher (not Physicist!)

Philosophy of science

- Epistemology (episteme + logos)

the nature and limit of knowledge,
the method of knowledge gaining,・・・

- Philosophy of science

"Scientific explanation",
Scientific realism debate,
Demarcation problem (science/pseudo science),
Philosophy of experiment
・・・

Philosophy of experiment

- Hacking(1983)
  Independence of experiment from theory

- Franklin(1986)
  Epistemology of experiment
  :the strategy of providing good reasons
  for belief in experimental results
  （calibration, elimination of alternative
  explanations, statistical arguments, ・・・）

Philosopher on laboratory

- Mainly literature research

  ← HS

  “Some important & interesting aspect

  of experiment (and science)must be missed”

- Go into the laboratory!

  →Physics Laboratory of Nagoya university (F-lab)

  “OPERA experiment”

OPERA collaboration

Belgium
ULB Brussels

Croatia
IRB Zagreb

France
LAPP Annecy
IPNL Lyon
IPHC Strasbourg

Germany
Hamburg

Israel
Technion Haifa

Italy
Bari
Bologna
LNF Frascati
L'Aquila
LNGS
Naples
Padova
Rome
Salerno

Japan
Aichi edu.
Kobe
Nagoya
Toho
Utsunomiya

Korea
Jinju

Russia
INR RAS Moscow
LPI RAS Moscow
ITEP Moscow
SINP MSU Moscow
JINR Dubna

Switzerland
Bern
ETH Zurich

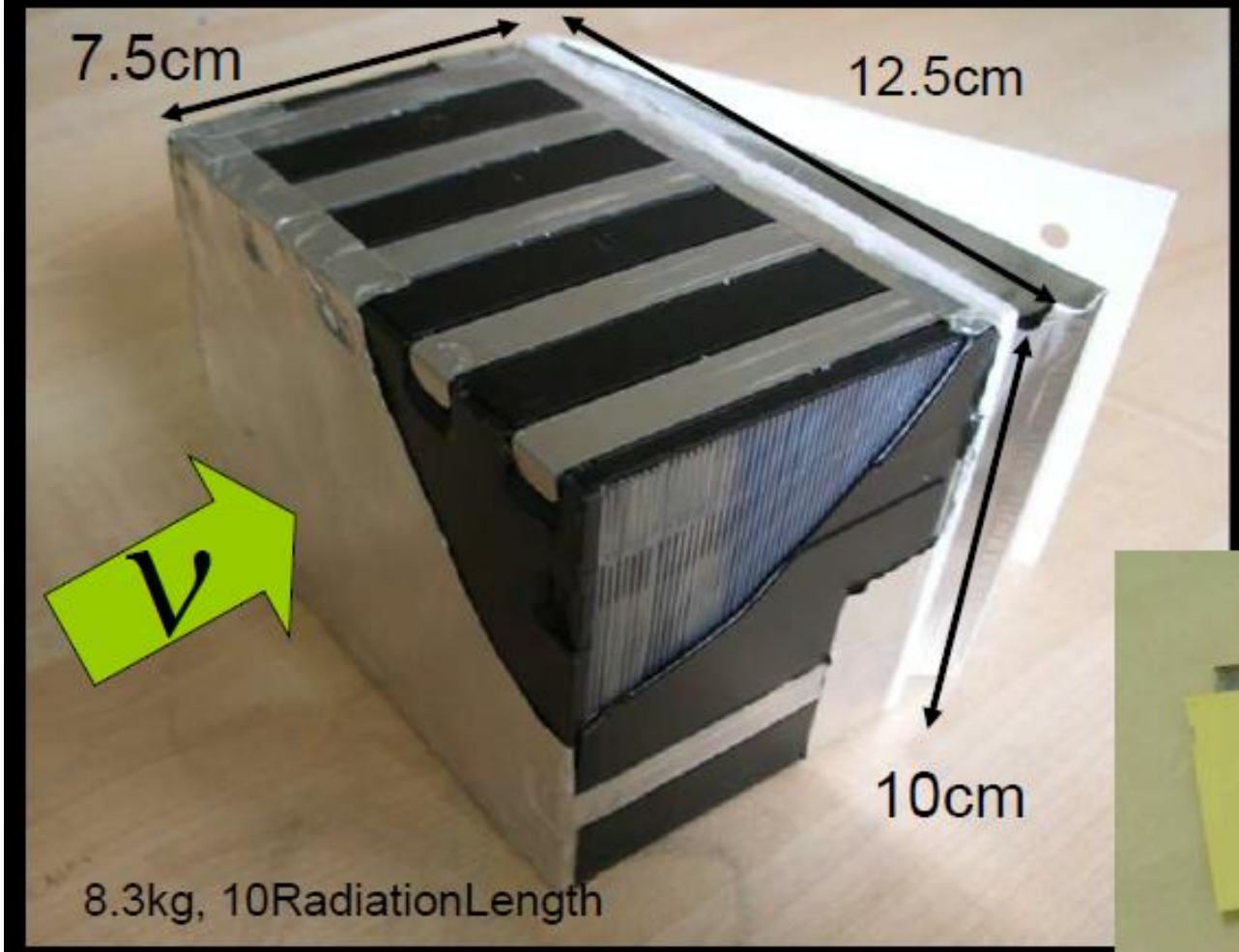
Turkey
METU Ankara

(11 countries、30 Institutes、~160 researchers)

M.Nakamura (2012)

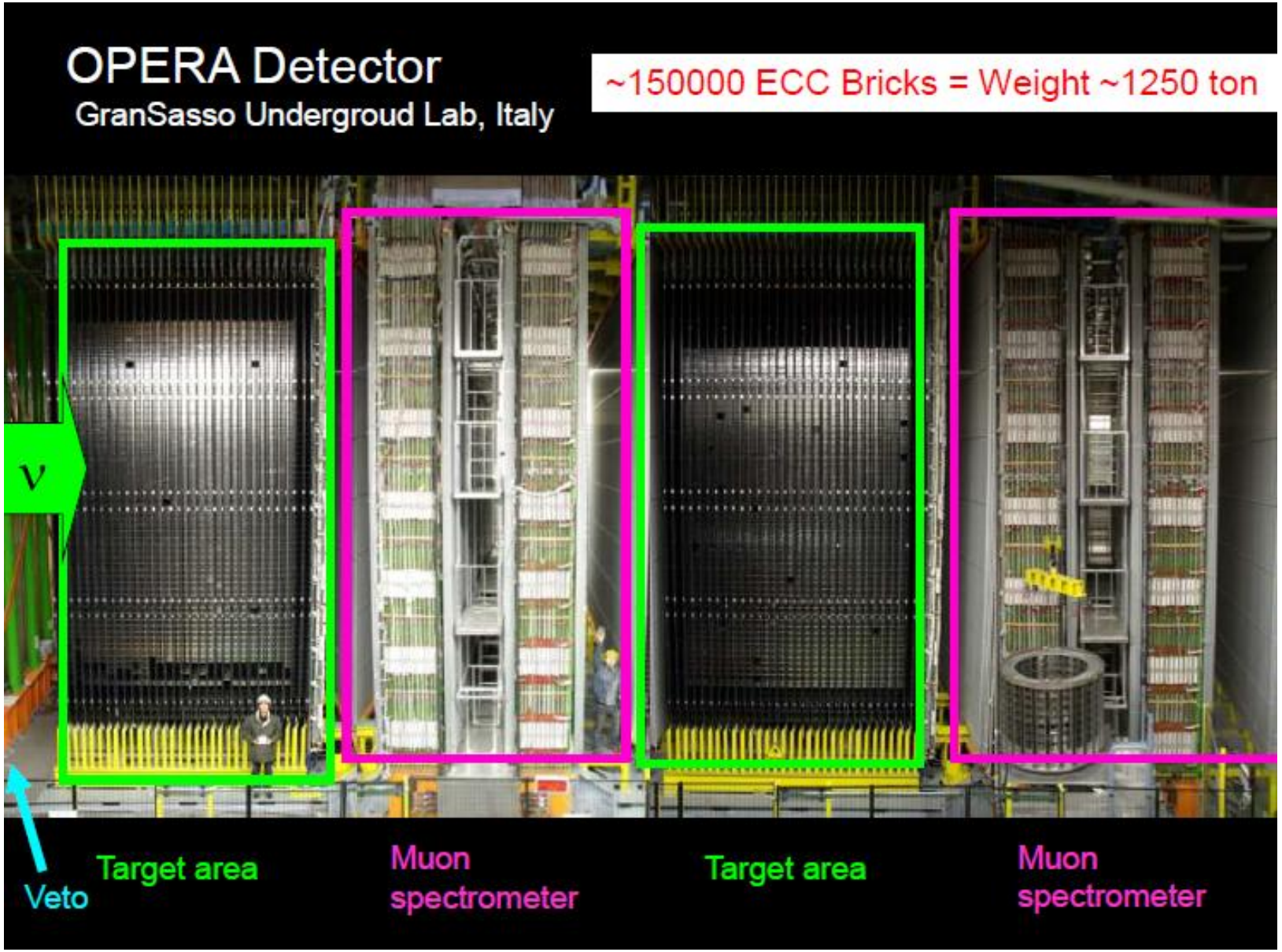
νμ→ντ appearance detection

Neutrino Detector（ECC）



57 Nuclear Emulsion
[Fuji film]
+
56 1mm thick lead

M.Nakamura (2012)



M.Nakamura (2012)

“Philosophy of science creating from actual spot”

- Field work @Nagoya University, OPERA

  participatory (very participatory!) observation
- From 2010

  Interview & discussion with experimenters

  Attendance & presentation on weekly lab-meeting

  Accompany to the physics conference

  Participation to analysis (partly)

  Shift control of a analysis part

Methodology of experiment

Methodology of experiment

- In actual spot・・・

  experimenters face up with resource limitation constantly (ordinary practice!), and it can affect the quality of experiment significantly

  ↓

  They must have “Methodology of experiment”

  “Methods of running experiment properly within limited resource (money, time, man power)”

Methodology of “experiment”

Wide-ranging activities

- Experimental design
- Technological development
- Trouble handling
- (Activity management)
- Human training
- Cooperation & competition
-

Purpose

- Systematization of methodology

  Each experiment (or laboratory)

  has its own methodology

  difference of scale, value, culture・・・

  →Making explicit for wider use

- Investigation of the relation between

  “epistemological” and “social”

  (“physic” and “management”)

Methodology of trouble handling

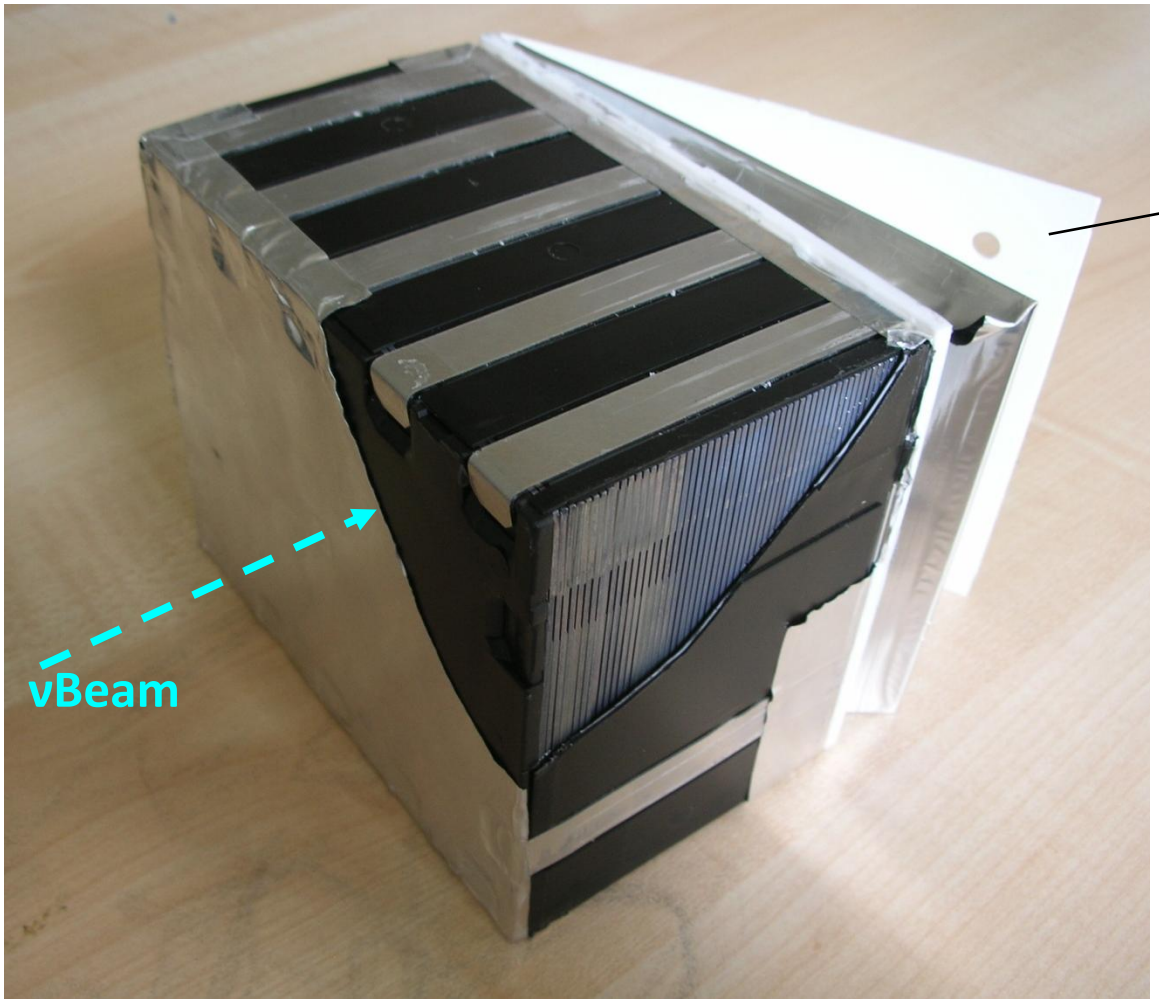
The case of “Black CS” in OPERA experiment

(See details!)

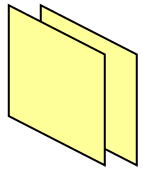
- Unexpected trouble in 2006-7
- Already solved

Black“CS”

ECC & CS

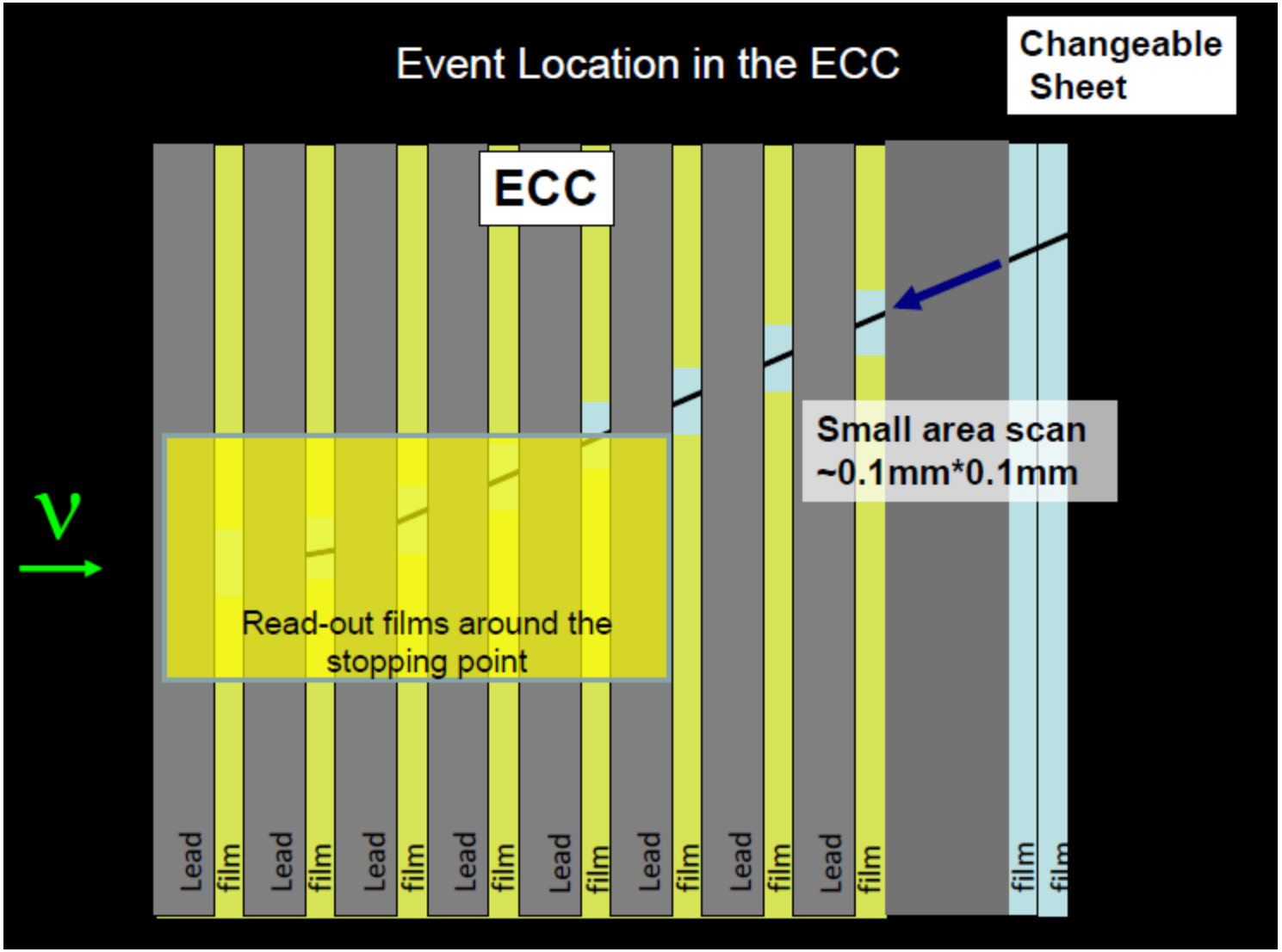


Changeable Sheet (CS)



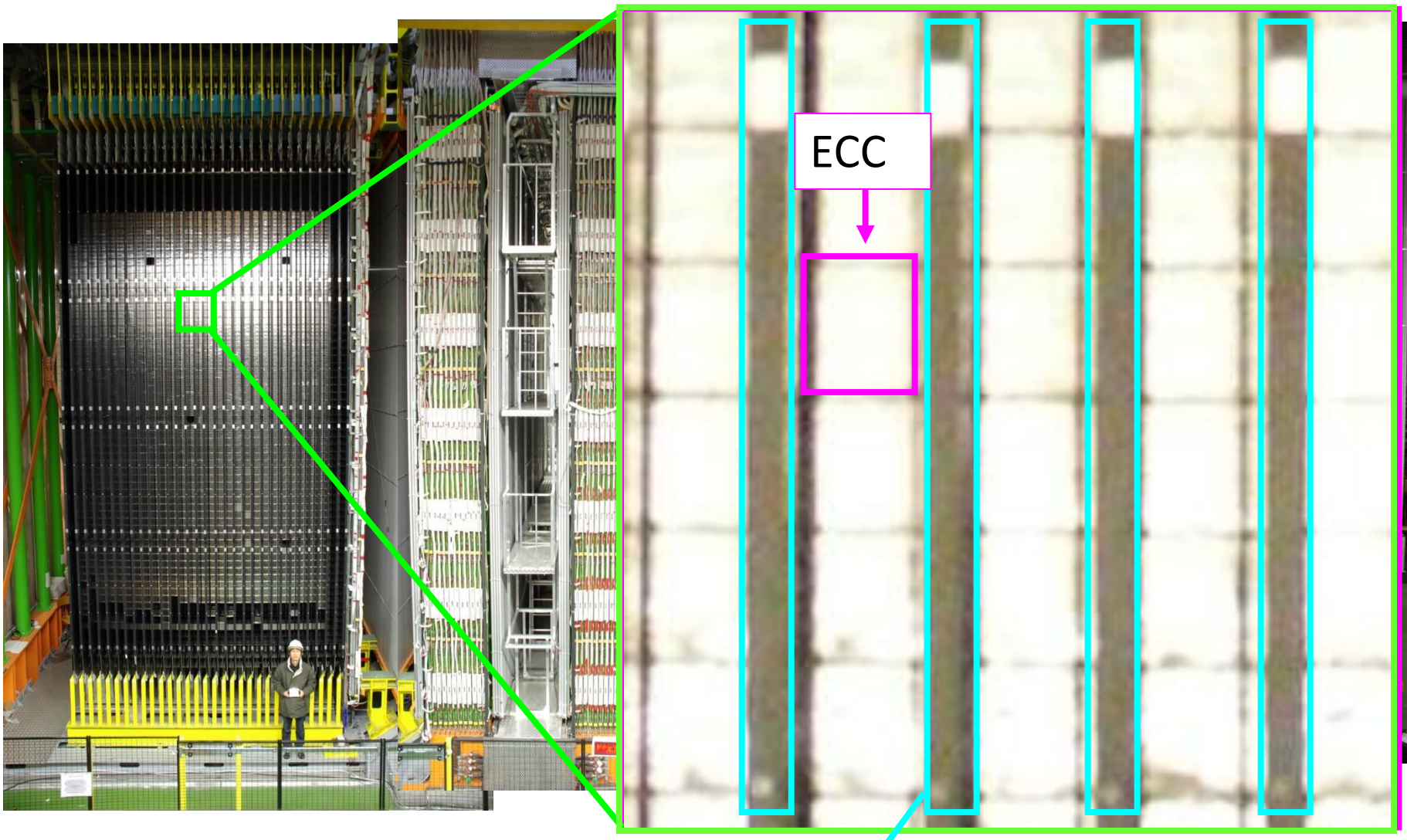
Packed Nuclear emulsion × 2

for finding
neutrino interaction point

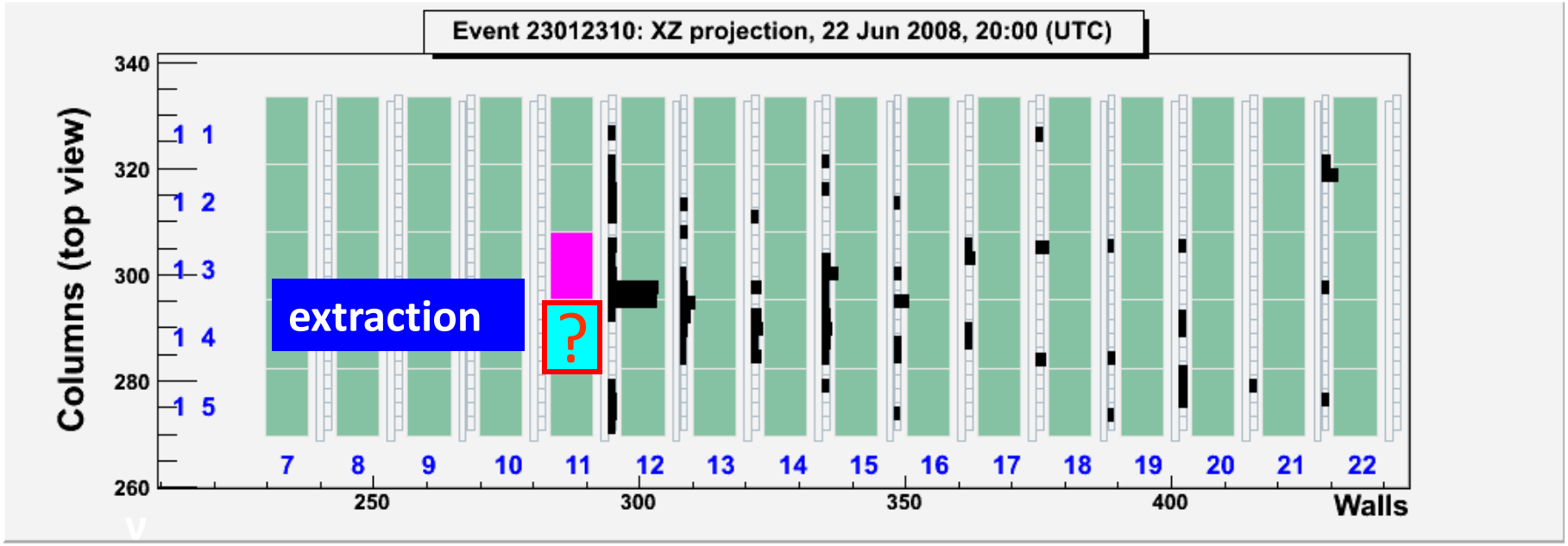


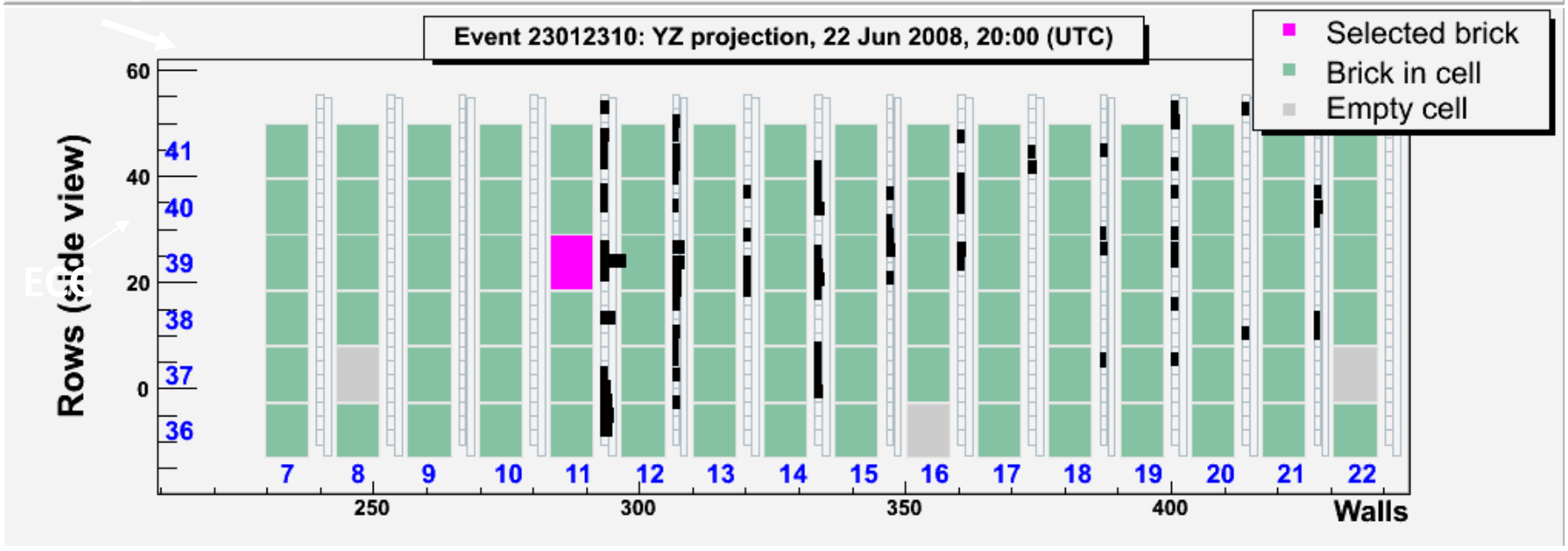
M.Nakamura (2012)

OPERA detector

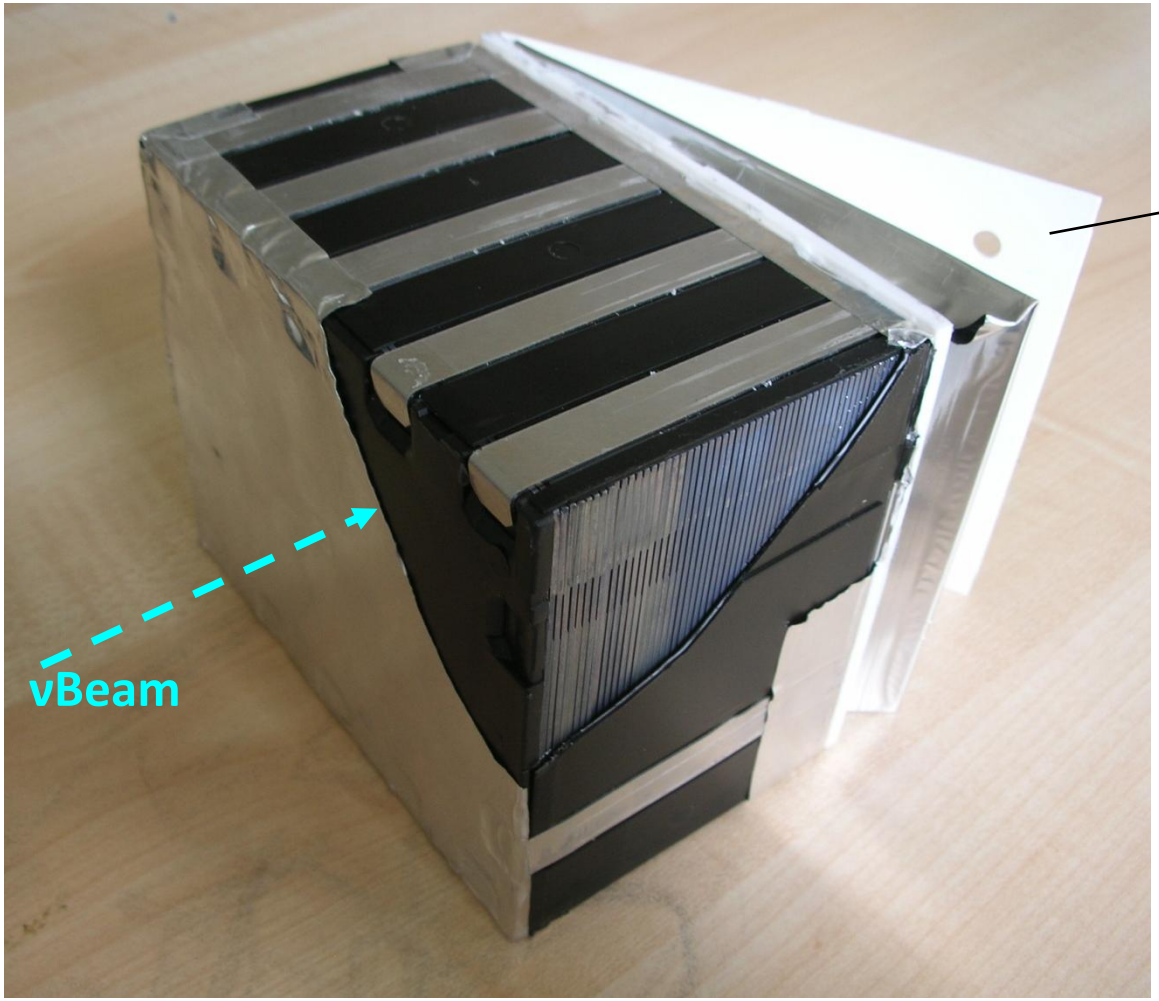


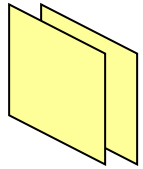
The case that which ECC should be extract is unclear





ECC & CS





develop & analyze
only CS

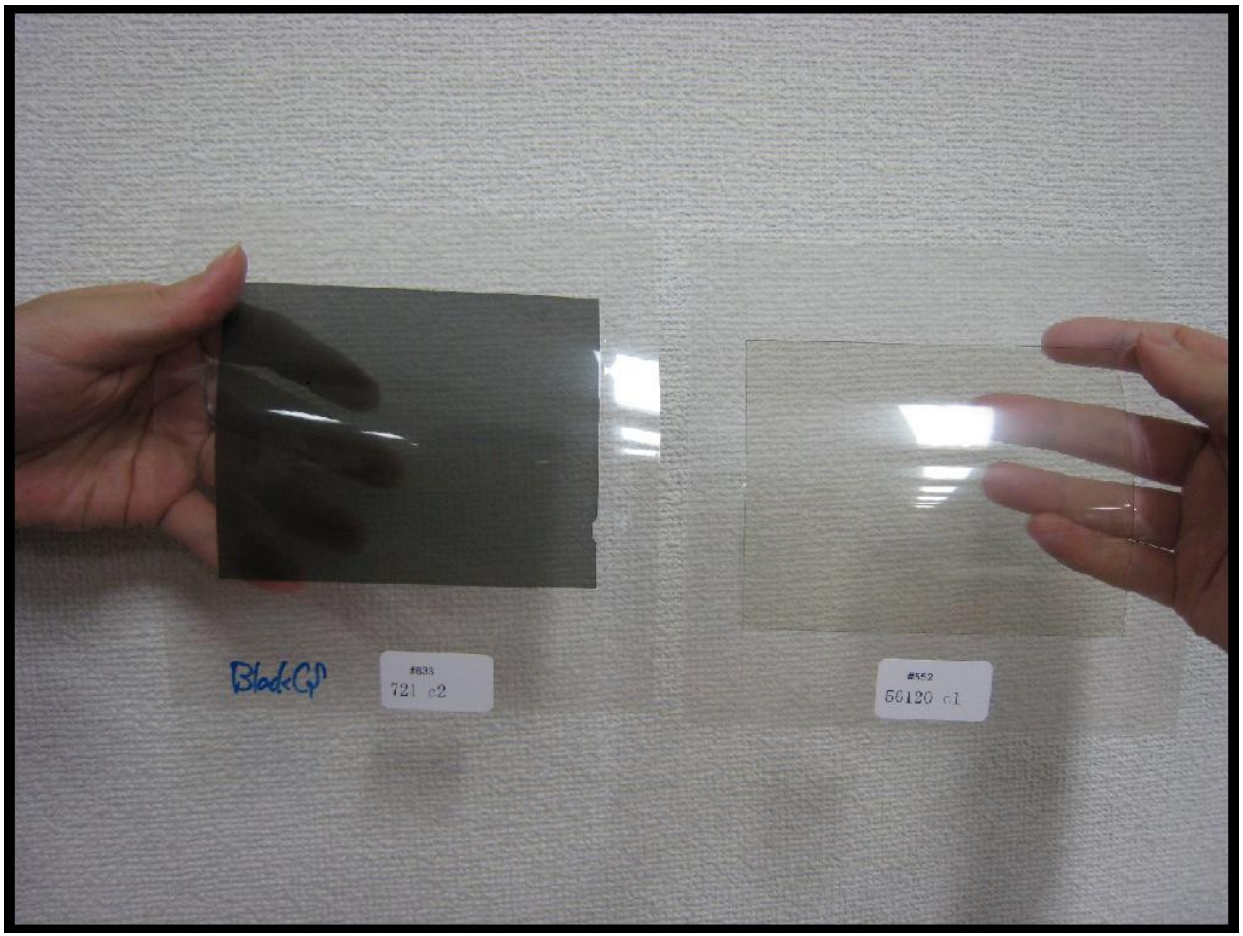
↓

avoid the loss of
developing & analyzing
ECC in which there is
no neutrino interaction

(and thereby avoid
the loss of target mass)

Trouble & Handling

“Black”CS (left)



BlackCS

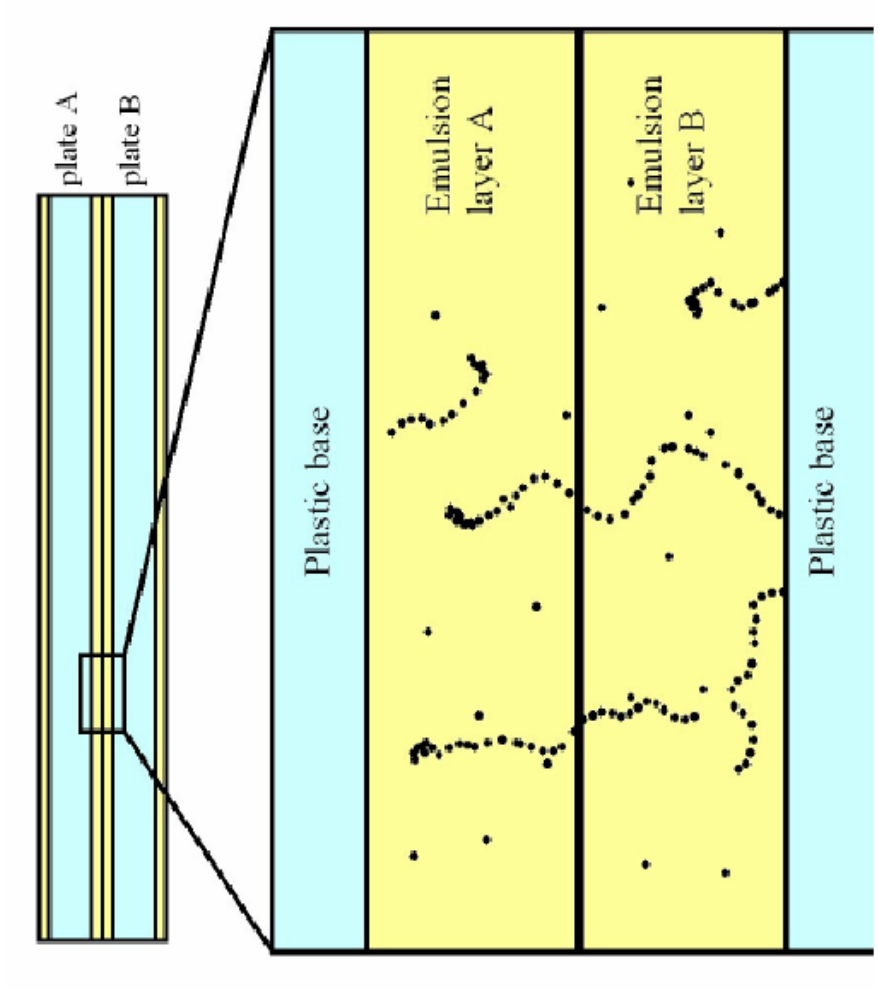
- CS become black chemically
- cause

  CS is vacuum packed so as to
  two films don’t make a gap.
  (And this is necessary for taking alignment)

  And after unexpected days (more than 100days),
  some gas (probably hydrogen) occur
  and fill inside the pack.

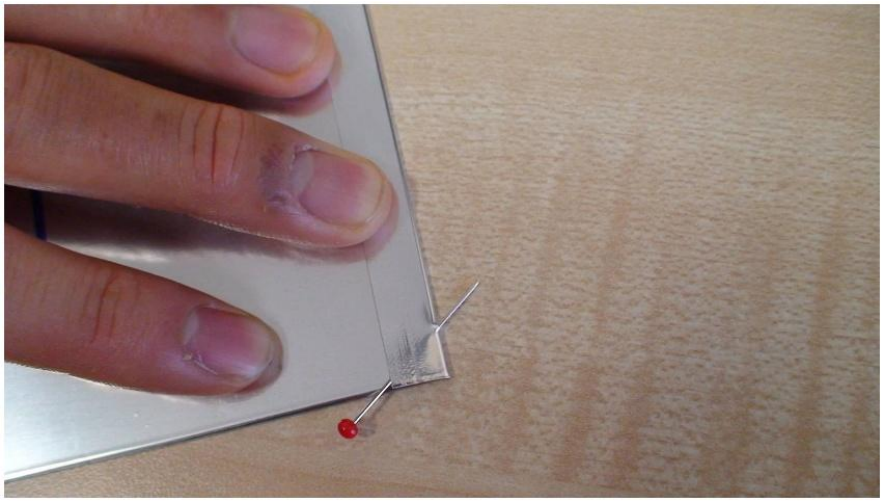
Compton Alignment

CS→



Low energy electron tracks penetrating two layers of emulsion

Handling: making a pinhole



Before

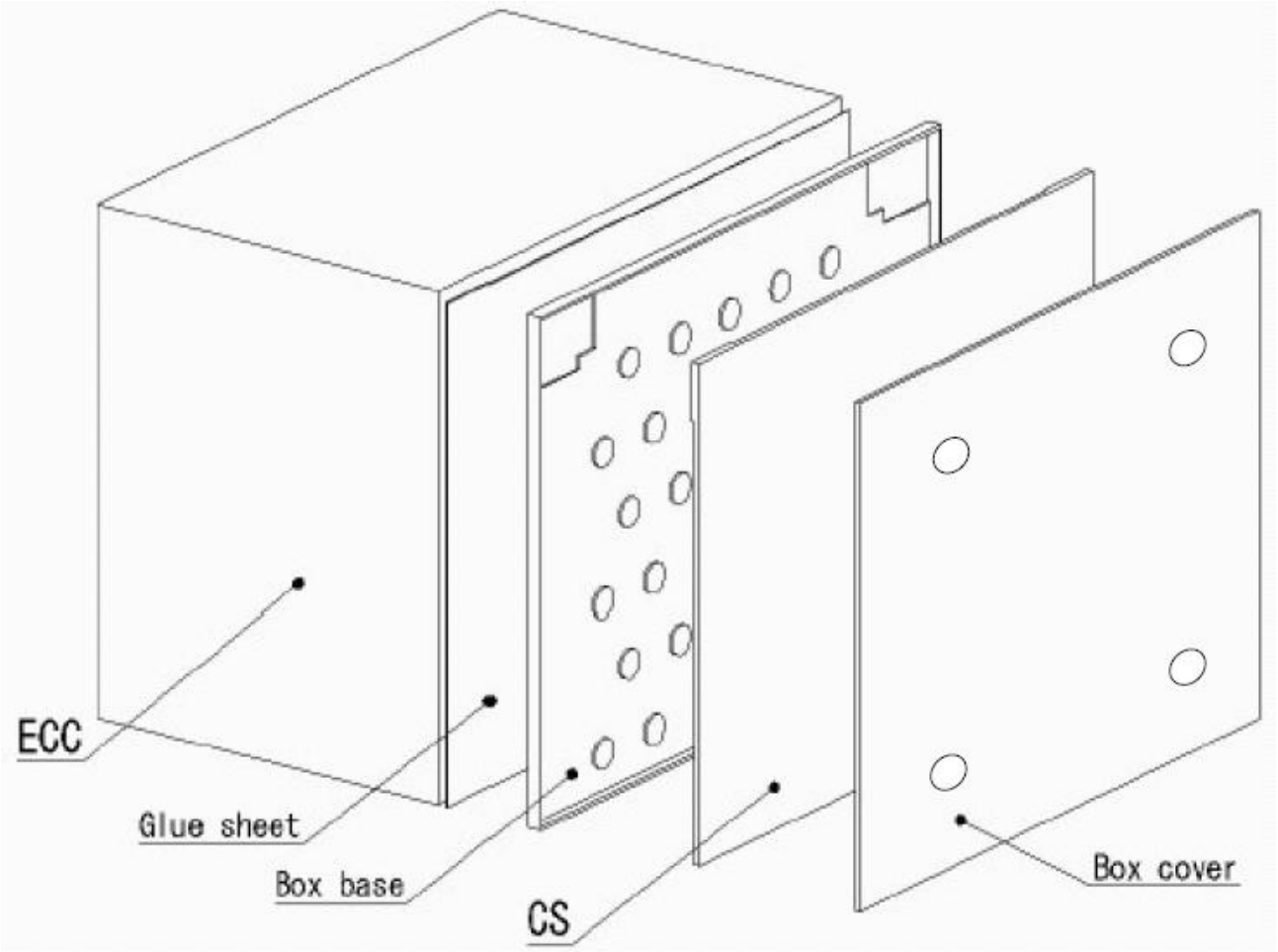
After

making a pinhole(!)

- “making a pinhole”
  →”making a gap between two films”
  →”can’t take a alignment”

- But in actual, the gap remains small
  by a plastic container “CS box”

CS box



CS box
(base, packed CS, and cover)

Analysis

Conditions

- Since resource is limited,

  “doing over again” is impossible.
- Unexpected situations often occur

  What can be done in advance is limited
- Speedy handling is required

  →What structure is needed for group?

Interview

- CS box somewhat lucky (not for that purpose)
  HS “What did you do if gaps become large
  by pinhole?”
  ↑
  Experimenters
- Analyze CS somehow
  invent new alignment method
- Do not use CS
  use down stream(several films) of ECC as “CS”

Consideration

“even if there remains problem somewhere,
other places will manage somehow”

↓

can take a bold measure

Points

- Specialized division of labor

  Nagoya group

  Nuclear emulsion, scanning machine,

  CS analysis, ECC analysis

  ＋

- Comprehensiveness

  They have developed almost all experimental apparatus by themselves,

  and its technology is in their hands.

  (experience from the past experiments)

Merits

- Flexibility

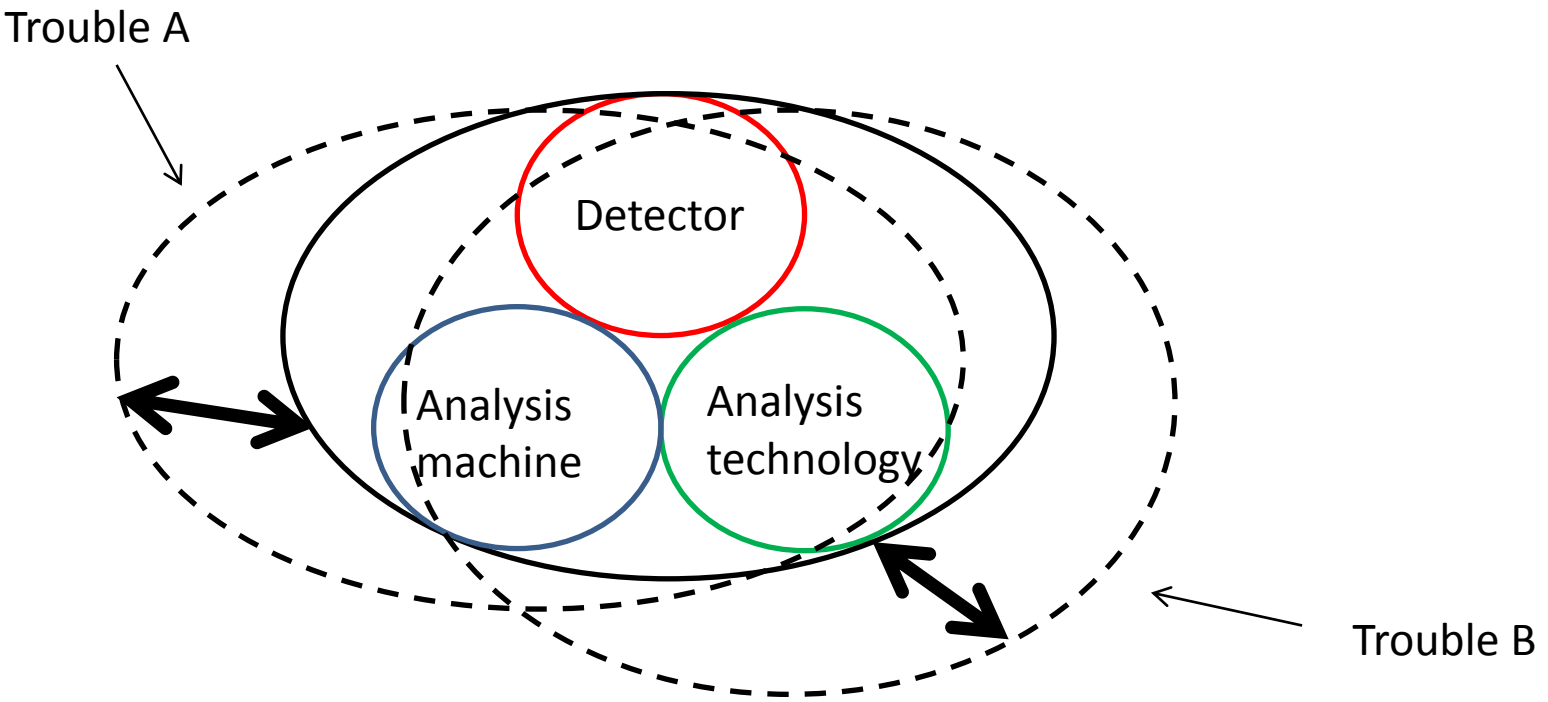
  It is possible to change the structure of experiment according to the situation

- Immediacy

  Speedy response is possible (outsourcing takes time)

Methodology of trouble handling

"Ensuring flexibility and immediacy by specialized division of labor and comprehension"



(no need of outsourcing)

Systematization of methodology

- OPERA (Nagoya group) as one example

- What is your (group's) methodology?

Prospects

- "Organization theory"
  (business, military, politics)

"Methodology of experiment" has a lot to learn from this discipline

Also expansion and improvement of method of philosophy can be expected.

Prospects

"Anything special about science?"
"epistemological" and "social"

・relatively weak binding
: one can participate in experiments
with one's own purpose ("academic freedom")
→Institutional aspect (democratic?)

・"epistemological" methodology
: e.g. what experiments are valuable?
(verification, explorative, …) ,
status of simulation

Dynamics of big science

Contingency of science

"If we go back into history and restart science, will we reach the same knowledge system as we have presently?"

- Abstract question…
  Where should be considered from ?

Contingency of science

Pickering(sociologist of science) :

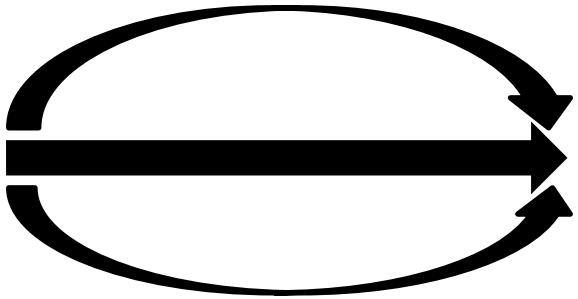
There could be

equally successful physics that

do not postulate quarks (nonequivalent)

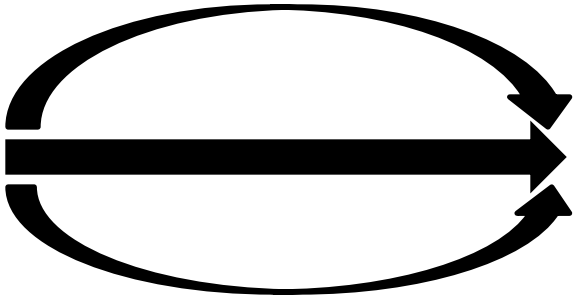
Weinberg(theoretical physicist) :

Intelligent alien would discover the same laws as we know



Two models

A: Convergence model



B: Non-convergence model

A thinks that whatever route one proceeds,
one can reach unique world picture
(possibly by the restriction of unique nature).
B denies that.

Focus

・Many elements can be related

Existence of excellent theorist

if there were not Einstein・・・

Social situation (politics & economy)

Is it society that use resources for science?

- “Science” physics, chemistry, biology・・・

→need to restrict the topic

Approach

- Bottom-up approach

  elements that can be seen on experimental field & affect the course of science

- Particle Physics

  “basic science”

  common research subject

Outline

- Attend
  By-product and relations between experiments

- See
  Both elements for&against contingency

- Point out
  A key question for thinking about
  contingency of science
  “Noncommutativity of knowledge”

Why by-product can be obtained? (only conclusion)

- Conditions that are required
  for by-product discovery

(1)Multiplicity of experimental setup

Even if one intends to design experiment focusing on main purpose, (with no or a little modifications) it becomes that one can try plural things

(2)Attentiveness of experimenter

One has to notice multiplicity in some stage

Relations between experiments

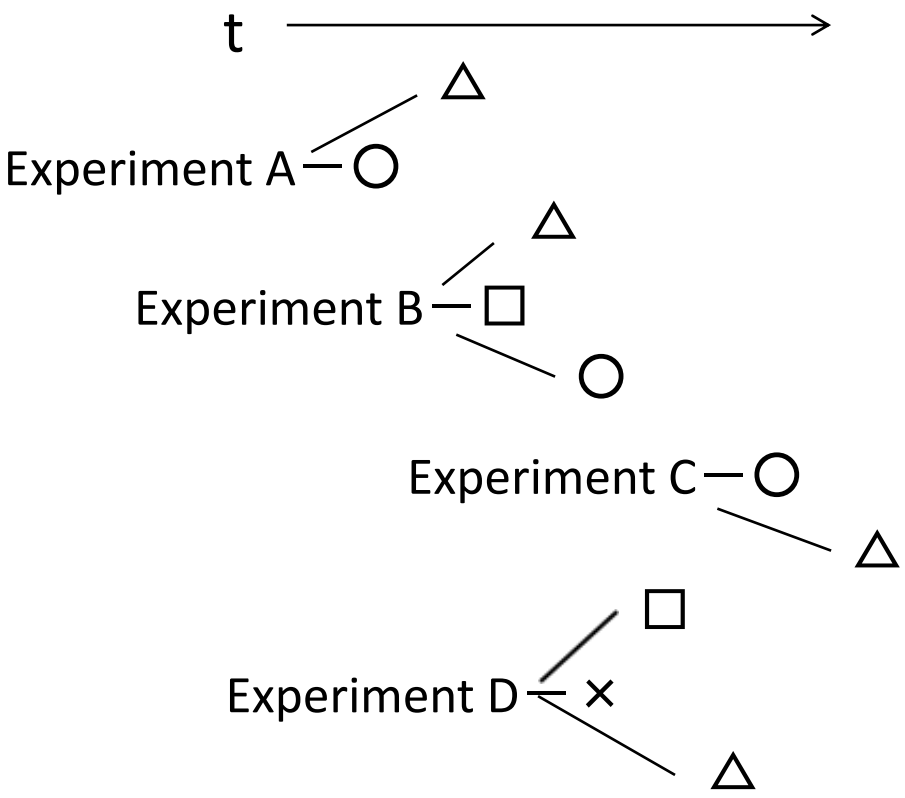
- Experiments are often multipurposive

+

- Interrelated experiments run in parallel

→Implication to “contingency of science”

multipurpose & parallel running



e.g. neutrino physics

Experiment x	MINOS, OPERA, T2K, ICARUS, ・・・
○, △, □, ×	νμ→ντ, νμ→νe, sterile neutrino, ・・・

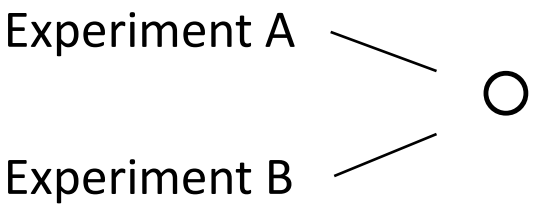
Against contingency

There are multiple experiments that can verify same things.

“Even if Experiment A can’t obtain a result,

Experiment B would obtain that result.”

→robustness（against contingency）



For contingency

- From two plausible premise,

1. An experiment is pressed various choice
   in relation to other experiments.

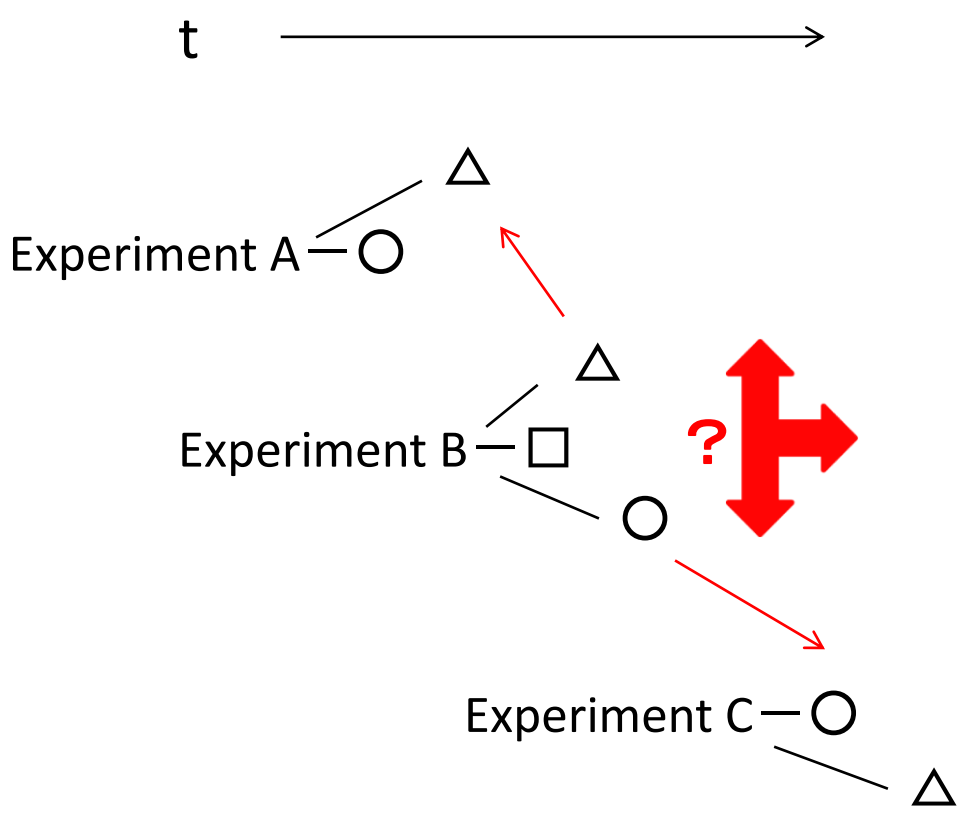
   “Other experiment gets an interesting result”←test?
   “Possibly we can obtain by-product that other
   experiment doesn’t get yet”←pursue?

2. Resource of an experiment (money, time, man power)
   is limited.

For contingency

- it can be concluded that
  “On the one hand, if one spares resource conscious of other experiment,
  the main purpose is likely not to be achieved on schedule.
  On the other hand, if one concentrates resources on main purpose, it is possible that by-product are missed, or results of
  other experiments remain untested.”

Branching
by decision of experimenters



Analysis

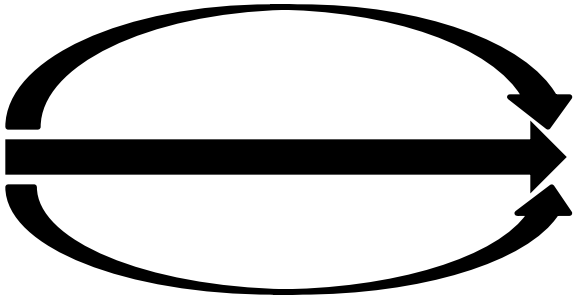
Consideration

- Against Contingency
  ← Robustness is limited
  Even if some experiment could cover
  other experiment, the quality of experiment
  and hence time of discovery would be different.

- It is likely that some discovery (of particle
  or phenomenon) come early or lately
  at least in the scale of several years
  →the possible change of discovery order

Two models

A: Convergence model



B: Non-convergence model

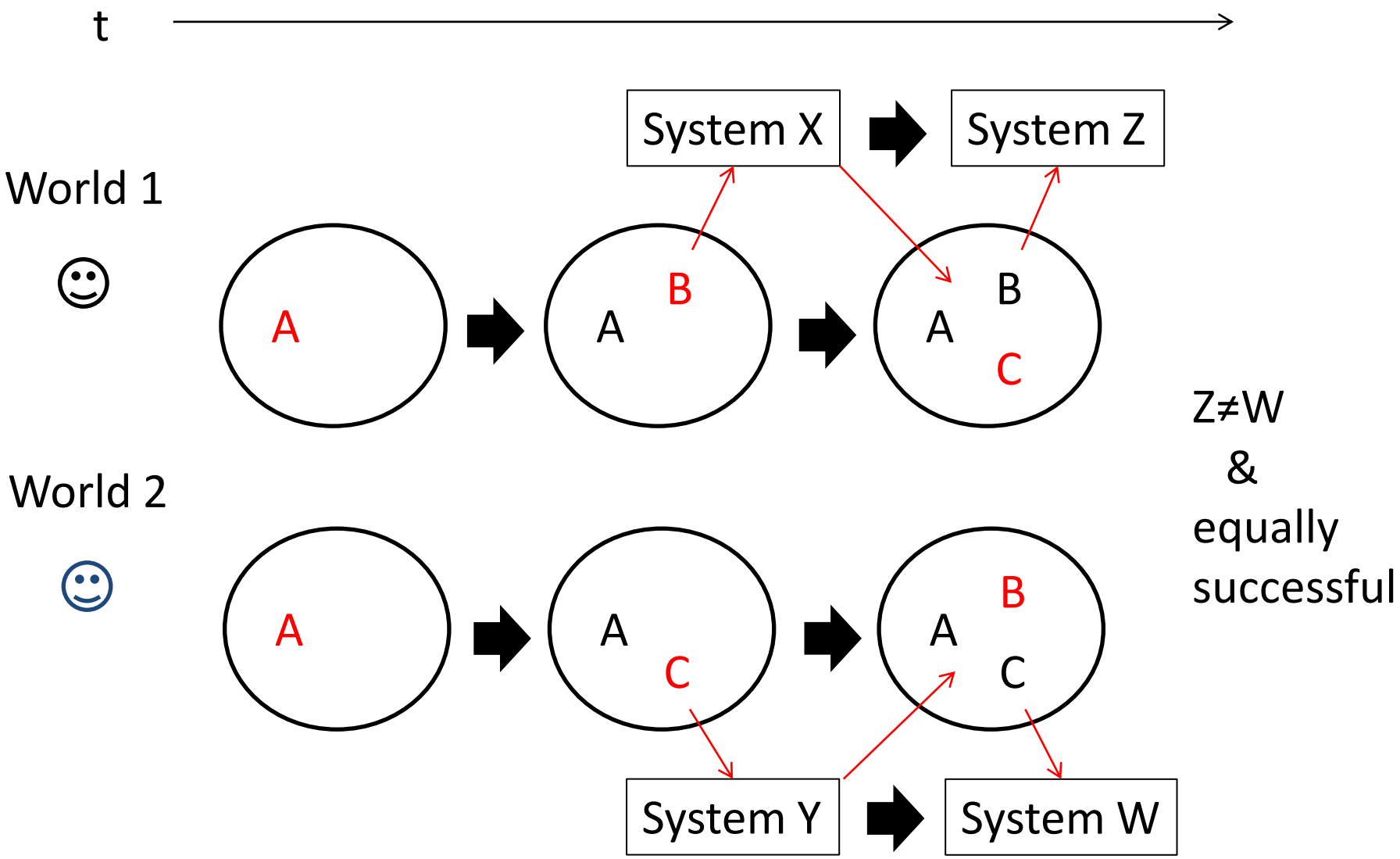
Which model is right?

: I can not give decisive answer on this talk,
a key question can be specified.

Noncommutativity of knowledge

"Could the order of discovery
substantially affect
the structure of knowledge system?"

Noncommutativity of knowledge



Prospects

- If there are such a phenomenon,
  it would support nonconvergence model.

- Now investigating a concrete example
  historical approach
  theoretical domain (needs help of theorist!)

Prospects

- Analyze other elements relating to contingency
- "Industry makes possible experiment"

What instruments and technologies are available at that time is critical.

OPERA about 10,000,000
photographic films (with FUJI FILM)

The perspective that
"social needs affect science through industry"

Effectiveness of abstract question

- "Contingency of science"
  It is difficult (maybe even impossible)
  to give decisive answer to this question,
  but it is a good tool for thinking
  what influences the direction of science.

  And to clarify that may contribute to
  rational decision making of scientists.

Reference

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Thank you for your attention!

Back up

Setting (rule)

- Not ultimate convergence

  no infinite time

- From modern science to present physics

  18c→21c(→)

  Is our point inevitable?

Concept

- “Successful”
  prediction
  explanation
  application

- “Equivalence”
  logical
  mathematical

appendix

Methodology of activity management

- Preliminary

- Partial participation of OPERA analysis shift
- Shift control of a part (CS manual check)

  based on observation and experience(!)

Methodology of activity management

2 methods for running experiment properly

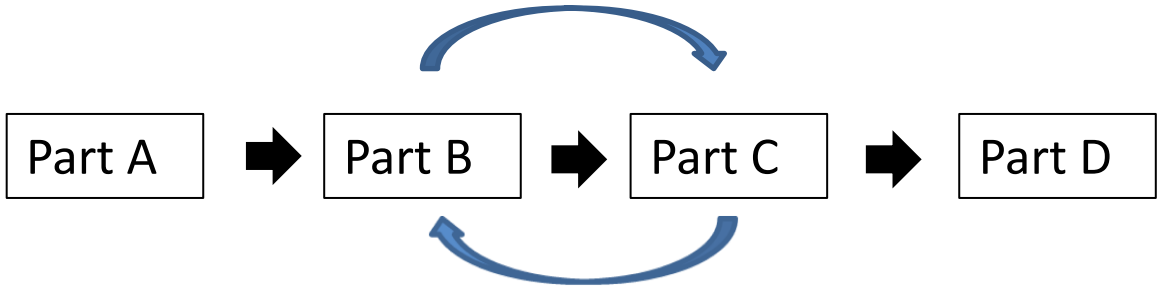
1. Goal setting and reverse thinking

2. Continuous reorganization

1.Goal setting and reverse thinking

Problematic structure: looking at each other

B: supply numbers only C does

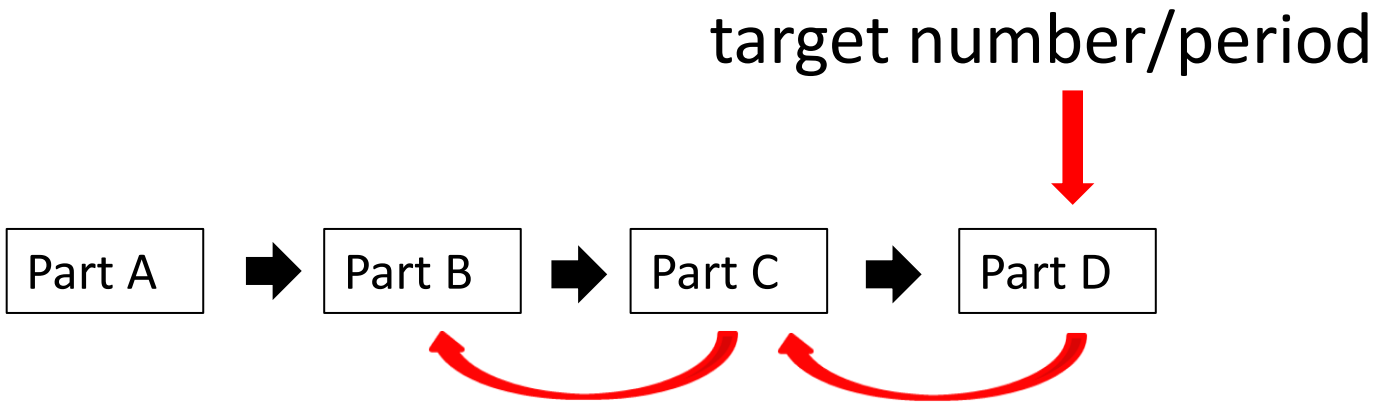


C: process numbers only B puts out

→ Stagnation of activity

1.Goal setting and reverse thinking

For breaking the stagnation…



requiring from the back
& solving bottle neck

2. Continuous reorganization

Stable run is in practice impossible

e.g. machine trouble, fluctuation of man power

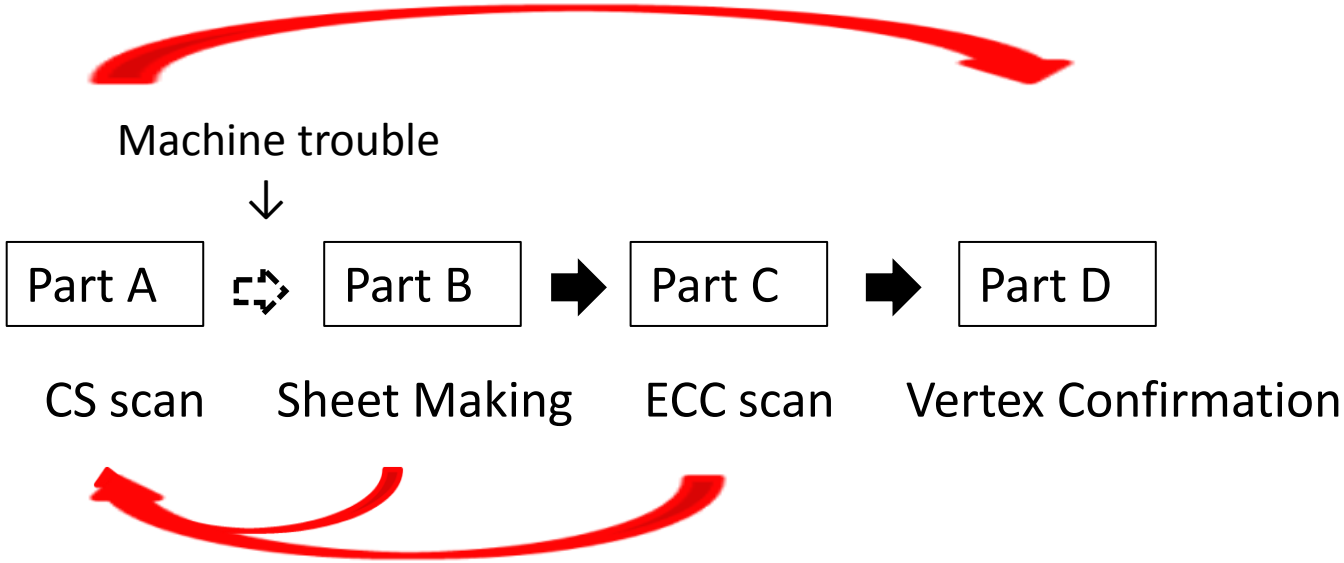
Conversion

: Sparing resource from surplus part

to other parts

2. Continuous reorganization

Conversion according to the situation



(Sometimes complex because of required specialization)

Lesson

For smooth flowing
communication between parts are critical

（cf. methodology of trouble handling
“specialized division of labor”）

Excessive division of labor is risky!

By-product of experiment

- By-product : results different from main purpose
- Main purpose　Often clear from proposal

- By-product sometimes open up a new field
  Kamiokande
  nuclear decay→supernova neutrino
  →neutrino oscillation
- By-product affects the course
  that research group proceeds
  Nagoya University →

By-product@ Nagoya group

1971 Cosmic ray experiment (multiple meson production)

X particle (charm particle) discovery

↓

1978 E531 (charm particle analysis)

neutrino oscillation limit

1983 WA75 (bottom particle detection)

BR(Ds→μ νμ) measurement → BR(Ds→τ ντ) calculation

1994 CHORUS(WA95) (dark matter, neutrino oscillation)

penta quark limit

1997 DONUT(E872) (ντ detection)

2006 OPERA (neutrino oscillation)

Motivation

- Why by-product can be obtained?

  “focus on & optimization to main purpose”

- Is it contingent that by-products are obtained?

  →Case study (introduce only one example)

WA75 (bottom particle detection)

- By-product : full leptonic decay of Ds BR(Ds→μ νμ)

leader of Nagoya reported the B-particle result
in a special lecture at other university
→question from theorist
"Didn't you discover such a decay mode?"
→leader of Nagoya
"Interesting. I'll care in analysis"

later day, a student of Nagoya reports
"An end of distributions (pT distributions of muons) is strange"
→leader of Nagoya
"The very full leptonic decay !" instructs to pursuit
→BR(Ds→μ νμ) measurement → BR(Ds→τ ντ) calculation

Is it contingent that by-products are obtained?

- Somewhat contingent

(1)Multiplicity of experimental setup
Is it contingent that experimental setup
that suits for a purpose also suits for a by-product?
→depends on the case

(2)Attentiveness of experimenter
In what stage/Whether or not one can notice
→contingent