PAUL SCHERRER INSTITUT

PSI

INFN

Istituto Nazionale
di Fisica Nucleare

東京大学
THE UNIVERSITY OF TOKYO

MEGII 実験陽電子タイミングカウンター のコミッショニング -解析手法について-

Commissioning of positron timing counter for MEG II experiment -Analysis Method-

Mitsutaka Nakao
(The University of Tokyo)

G. Boca, P.W. Cattaeo, M. De Gerone, F. Gatti, M. Nishimura, W. Ootani, G. Pizzigoni, M. Rossella, M. Simonetta, Y. Uchiyama, K. Yoshida

JPS Annual Meeting 2016(19pCA-3)

Contents

Introduction

- MEGII experiment & Timing Counter
- Pilot Run 2015

Time Calibration

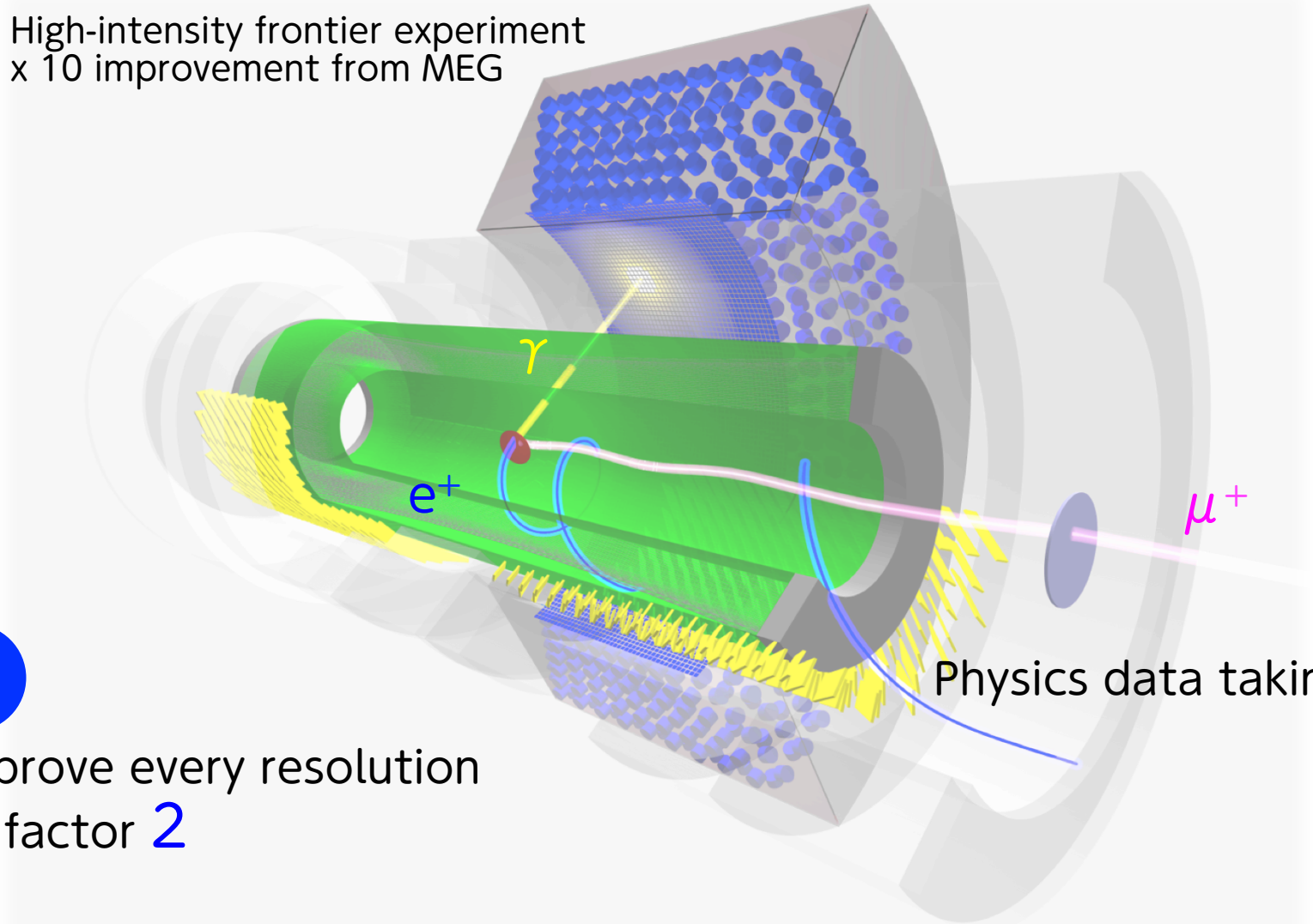
- Time Calibration Methods with High Accuracy
- Laser Calibration: Results of R&D
- Laser Calibration: Installation
- Simplified Michel Calibration
- Comparison b/w two methods
- Schedule

MEGII Experiment: 3 numbers

1 Search for cLFV($\mu^+ \to e^+ \gamma$)

with unprecedented sensitivity: 4×10^{-14}

- ✓ High-intensity frontier experiment
- ✓ x 10 improvement from MEG

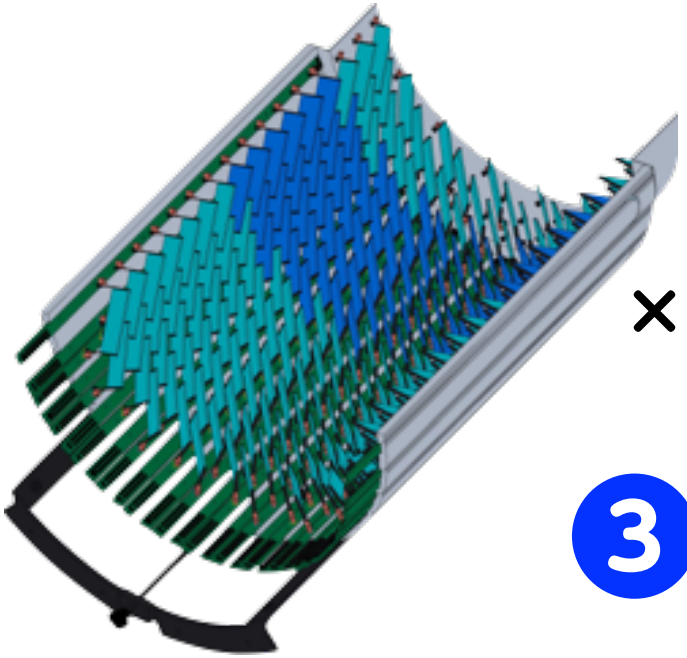


2 Improve every resolution by factor 2

3 Physics data taking from 2017

Numbers in Positron Pixelated Timing Counter

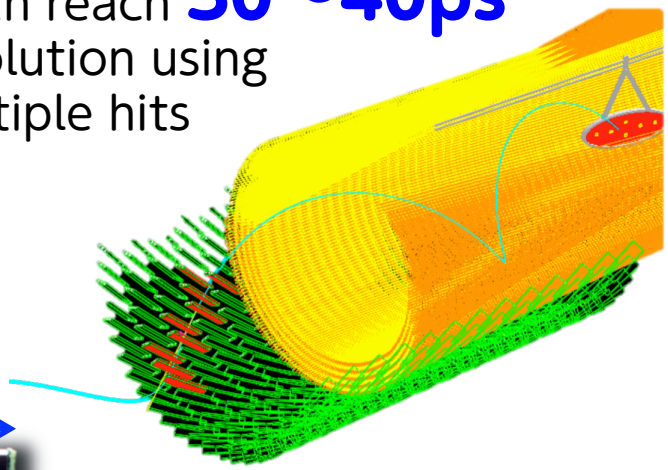
1 **512** pixelated scintillator counters



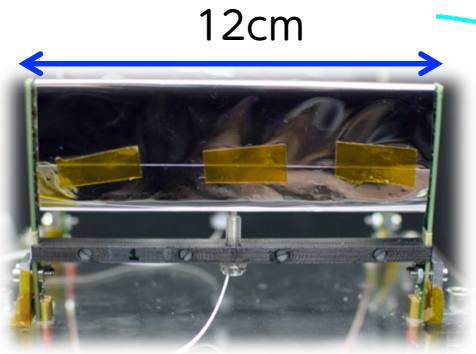
×2

2 **9** counter hits

→can reach **30～40ps** resolution using multiple hits



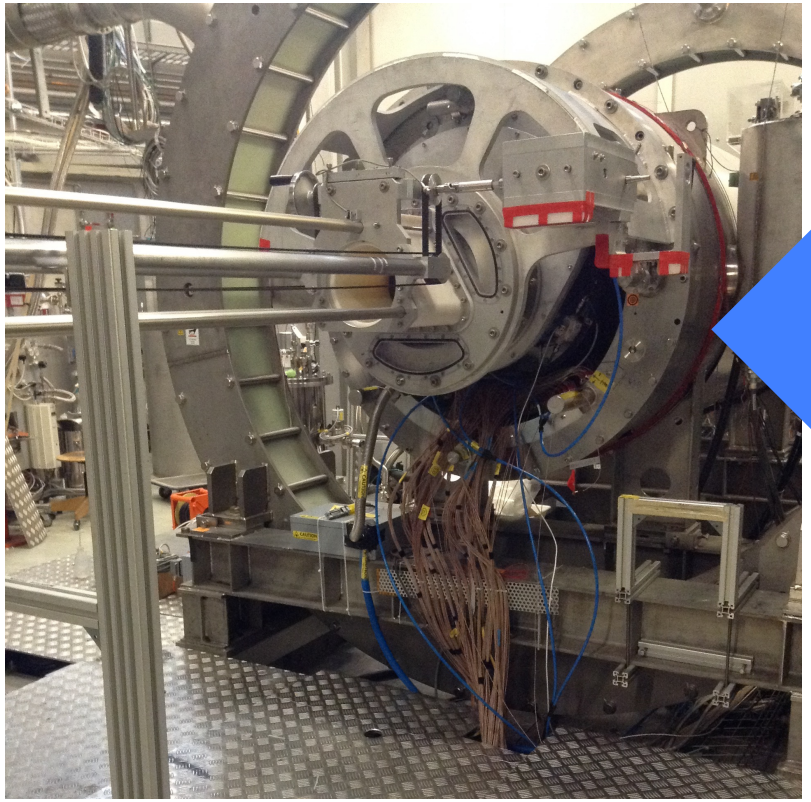
3



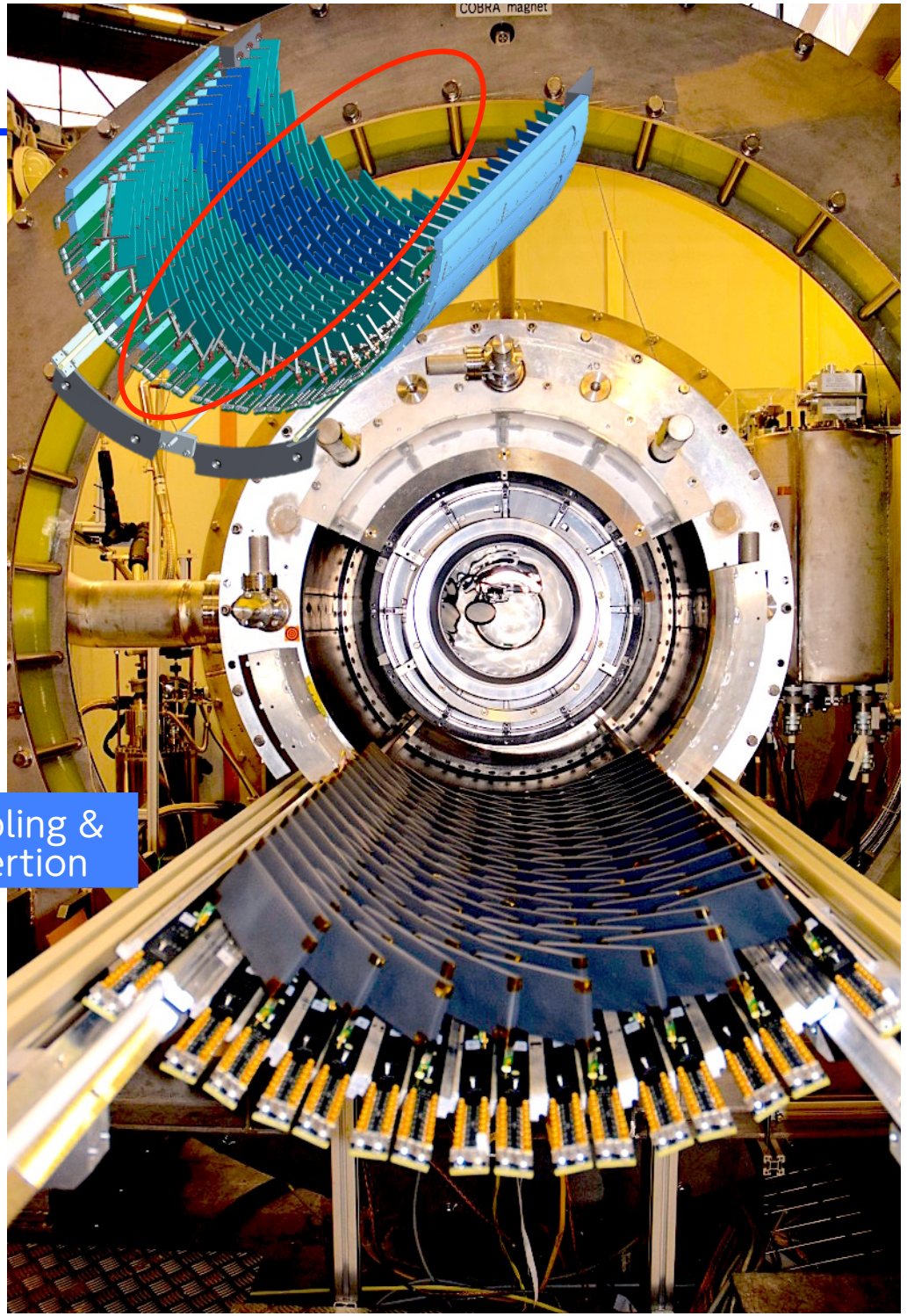
- ✓ Fast Plastic Scintillator(BC422)
- ✓ **6144** SiPMs(AdvanSiD)
- ✓ **6** series at the both ends
- ✓ Calibration Accuracy **30ps** w/ each counter
  by using pulse laser and Michel decay positron

Pilot Run 2015

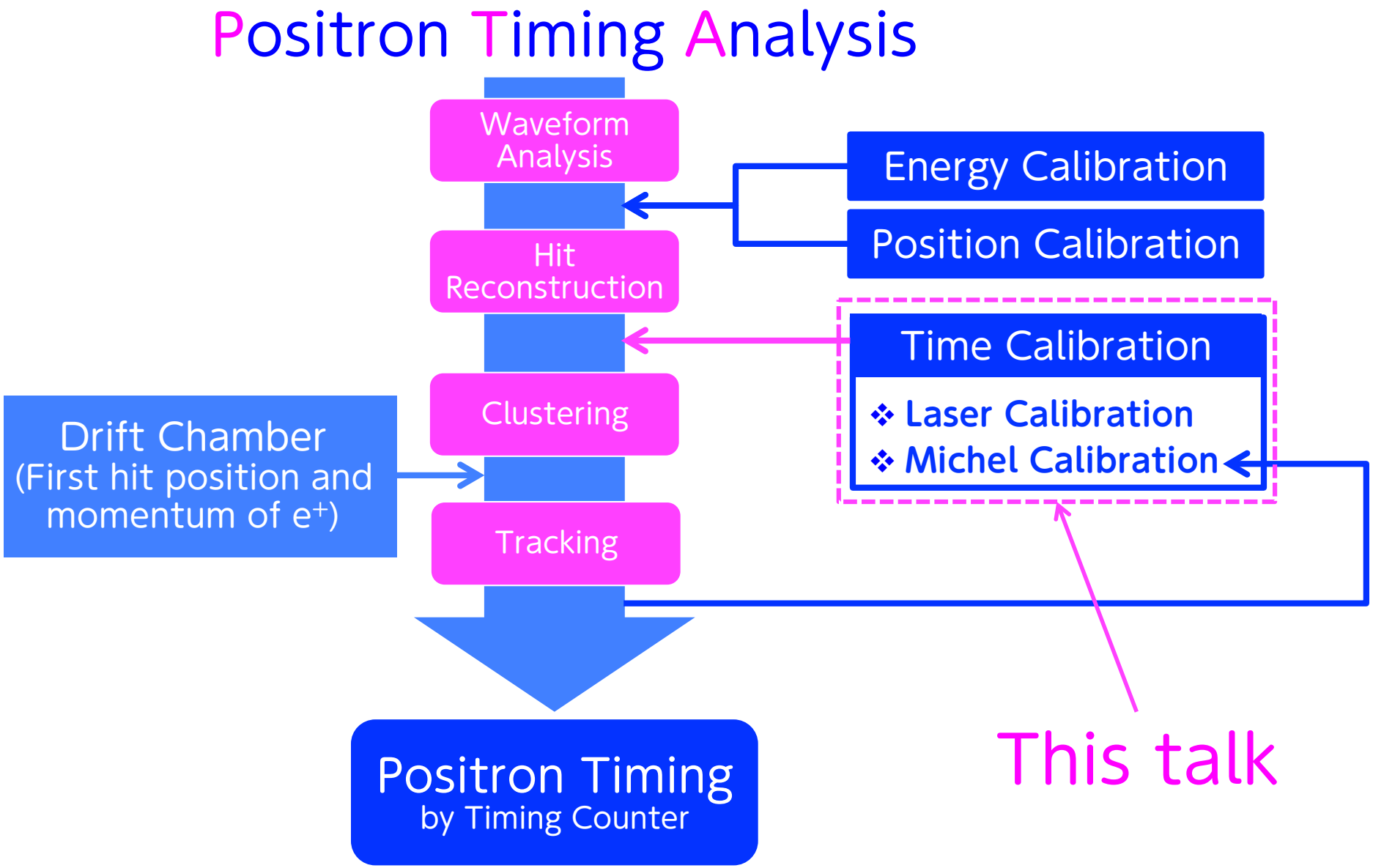
128 Counters are installed for Pilot Run 2015



Cabling & Insertion



This talk: Calibration Methods



Time Calibration

カウンター間の時間較正

時間較正

- 512個のカウンターは時間のオフセットをもっているので、30psの精度で時間を合わせる必要がある。
- ガンマ線検出器との時間合わせはミューオン輻射崩壊($\mu \to e \gamma \nu \nu$)を用いて行う。
- カウンター間の時間較正にはMichel CalibrationとLaser Calibrationという2つの独立な方法を用いて行う。

Michel Calibration

- MEGⅡ実験のメインのBGである、Michel崩壊($\mu \to e \nu \nu$)の陽電子を利用する。
- カウンターのヒット情報からクラスターをつくり、軌跡を再構成し、データカットを行う。
- 得られた軌跡毎にカウンターのTOFを計算する。
- 以下のχ^2を最小化するような、時間オフセットをカウンター毎に計算する。

$$\chi^2 = \sum_i^{N_{ev}} \sum_j^{N_{hit}} \left(\left(T_{ij} - \left(T_{0i} + TOF_{ij} + \Delta T_j \right) \right) / \sigma \right)^2$$

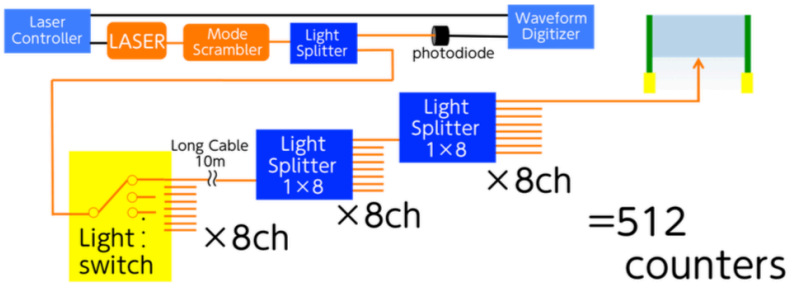
T_{ij}: 測定時間　　$T_{0i} + TOF_{ij} + \Delta T_j$: 計算した時間

ΔT_j: カウンターに固有の時間オフセット

- すでにビームテストのデータを用いて確かめられた(西村,日本物理学会2014年秋季大会19pSG4)。

Laser Calibration

- 同じ光源から全カウンターにパルスレーザーを同時照射する。
- 以下の点で、Michel Calibrationと相補的な方法である。
  - 場所依存がない
  - データを貯める必要がない
  - 時間オフセットをモニターできる



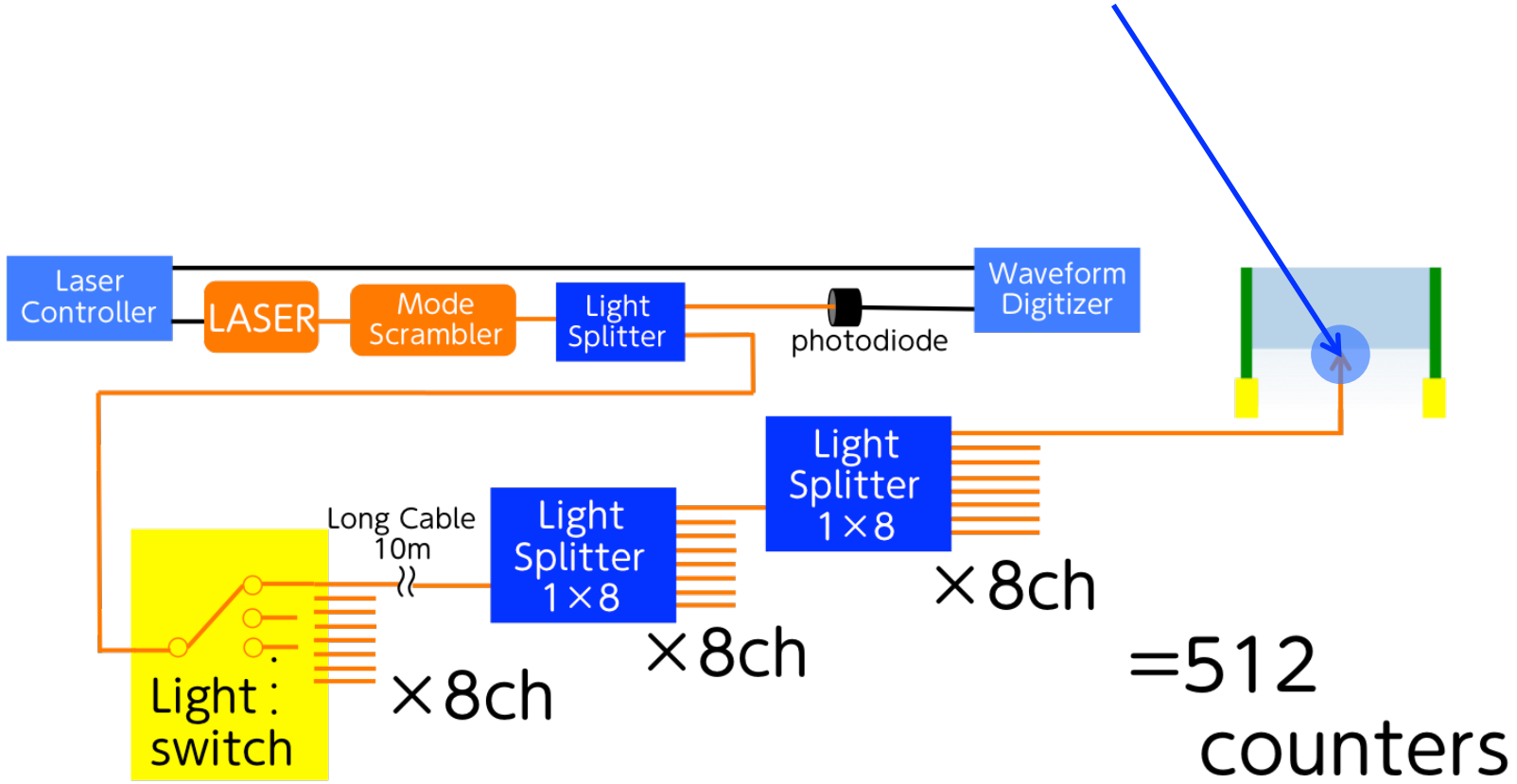
日本物理学会2015年秋季大会(26aSN-2)

R&D for Laser Calibration

- In order to know timeoffset of each counter, we plan to divide the same laser into each counter.

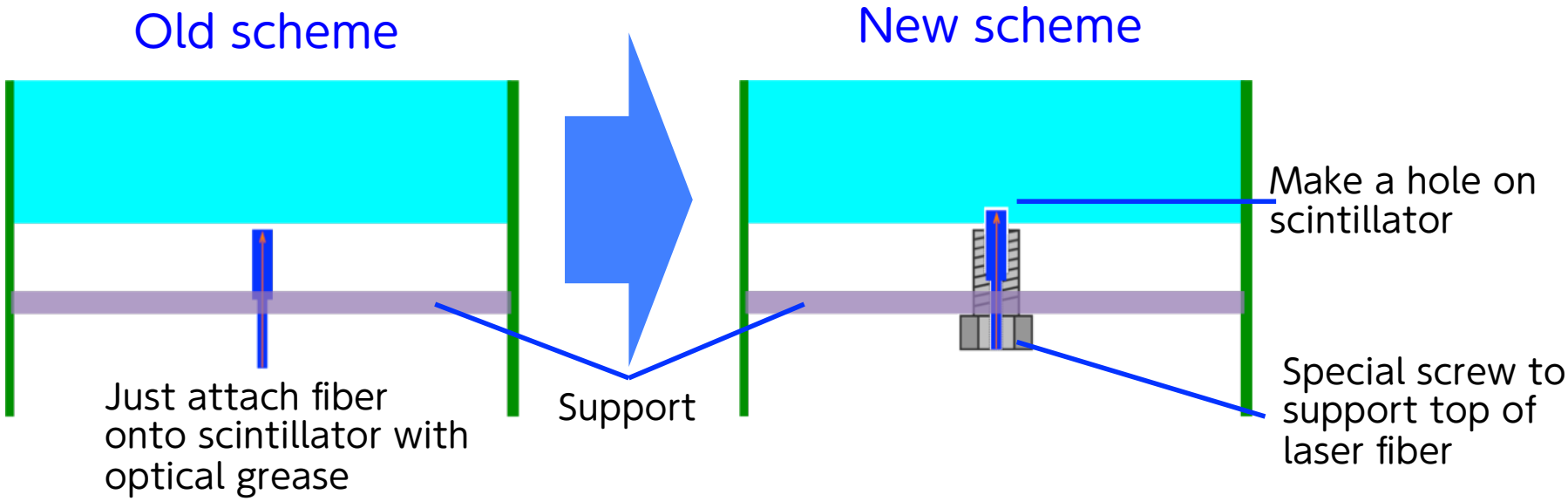
- What enables 30ps time calibration?

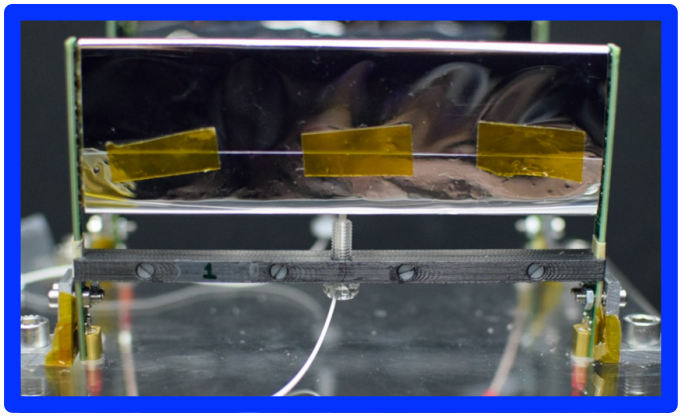
→ Laser Injection Scheme



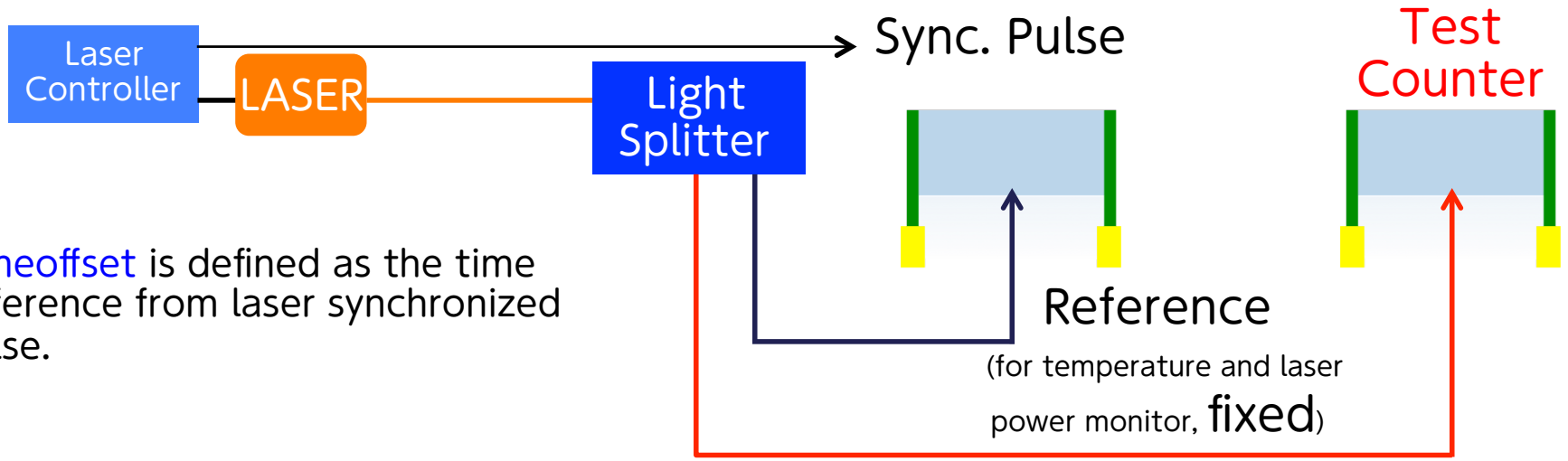
Improvement in Reproducibility

- Reproducibility on timeoffset of laser insertion scheme is required because we have to inject and eject fiber during the operation





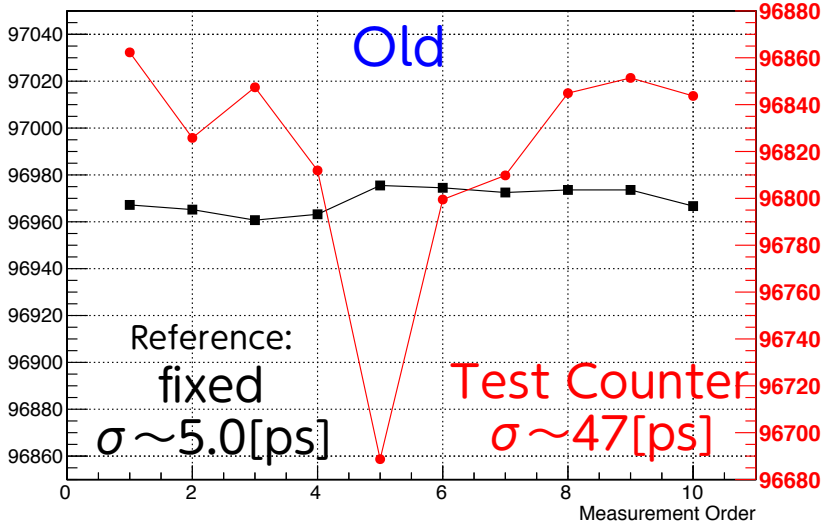
Setup & Results

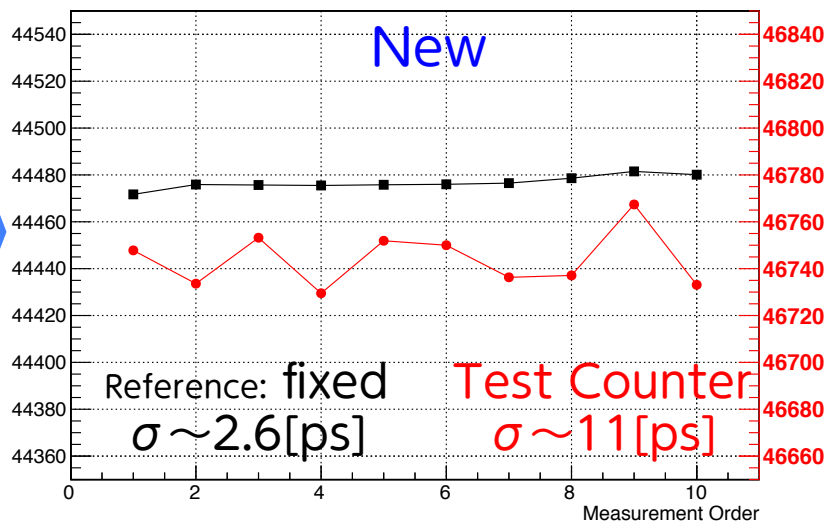


Timeoffset is defined as the time difference from laser synchronized pulse.

Timeoffset[ps]

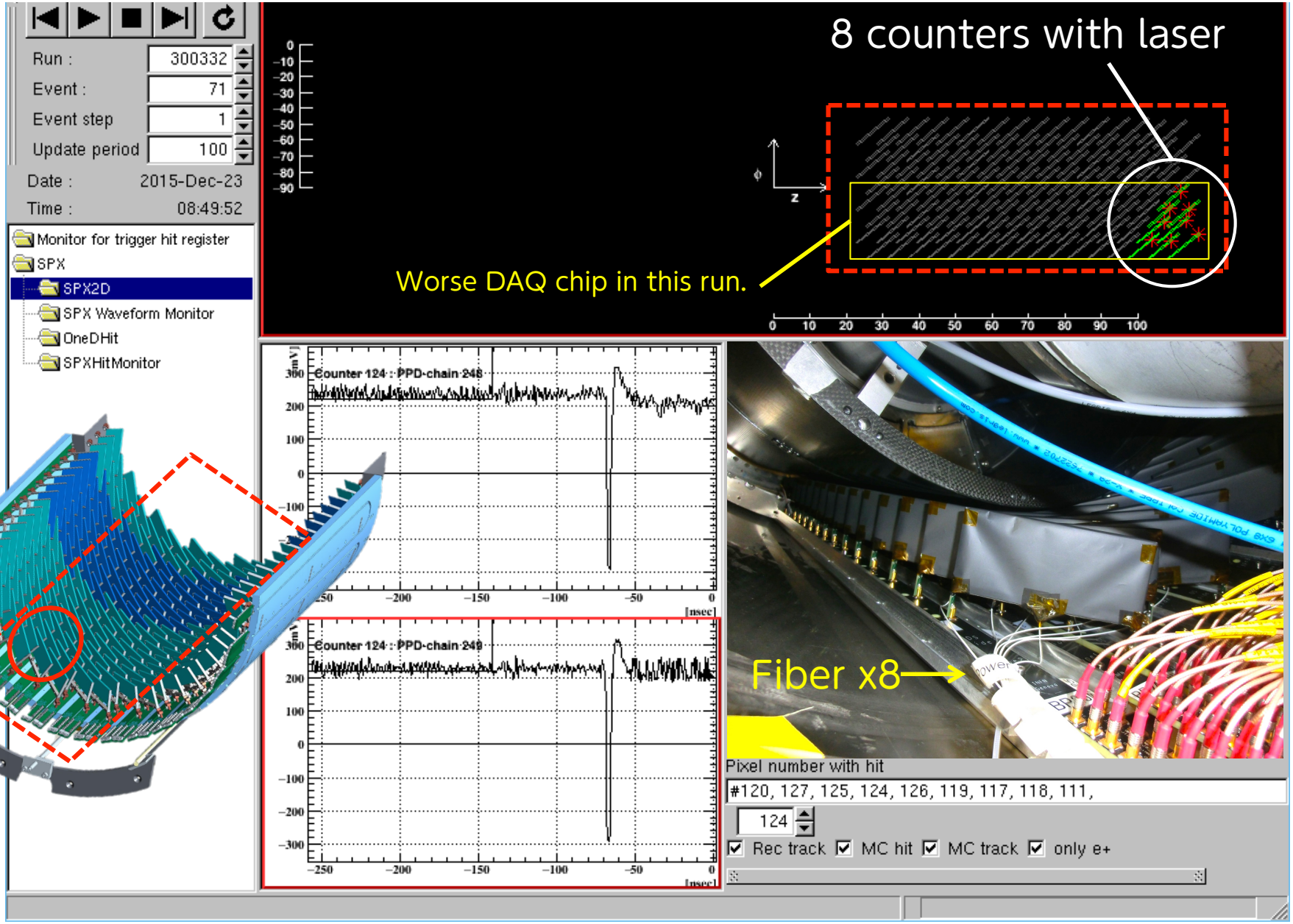
※Scale is the same





Conclusion New scheme fullfilled required accuracy(30[ps]).

Laser Calibration for Pilot Run 2015



Simplified Michel Calibration

- Minimize x^2 function using MINUIT.

Michel Calibration

$$\chi^2 = \sum_{i}^{N_{ev}} \sum_{j}^{N_{hit}} \left(\left(T_{ij} - \left(T_{0i} + TOF_{ij} + \Delta T_j \right) \right) / \sigma \right)^2$$

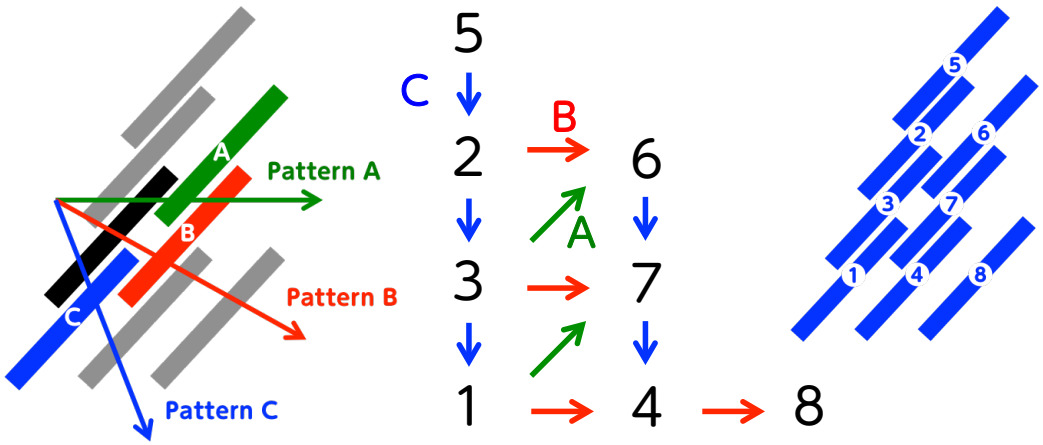
測定時間 / 計算した時間 / カウンターに固有の時間オフセット

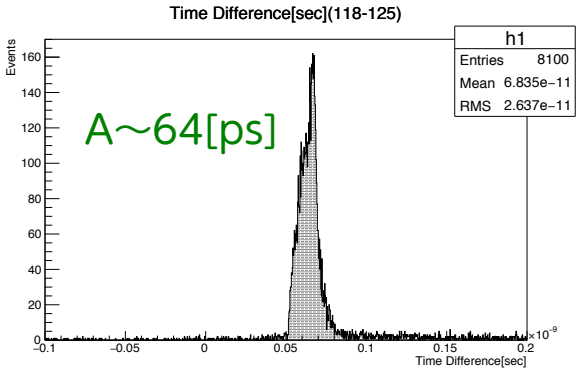
Used only 11 combination below and not with event by event.

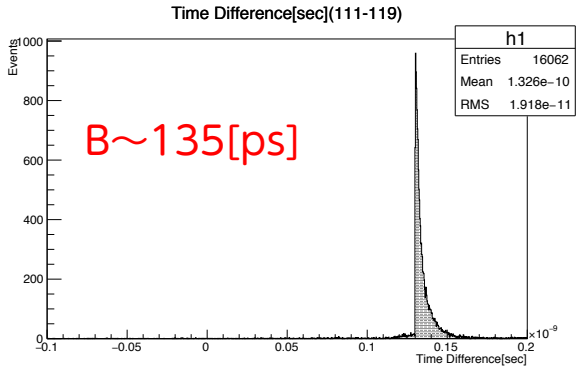
Calculated from not TOF by tracking but by MC.

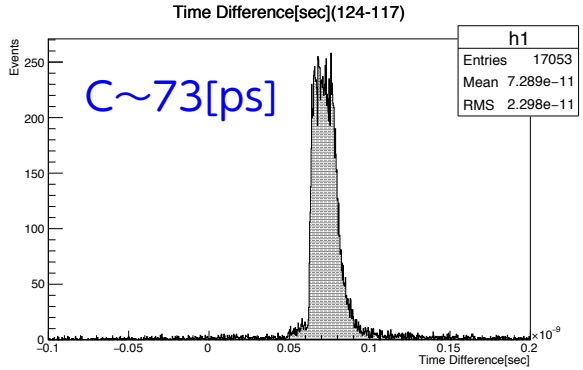
Simplified Michel Calibration

Hit Patterns of Laser Counters



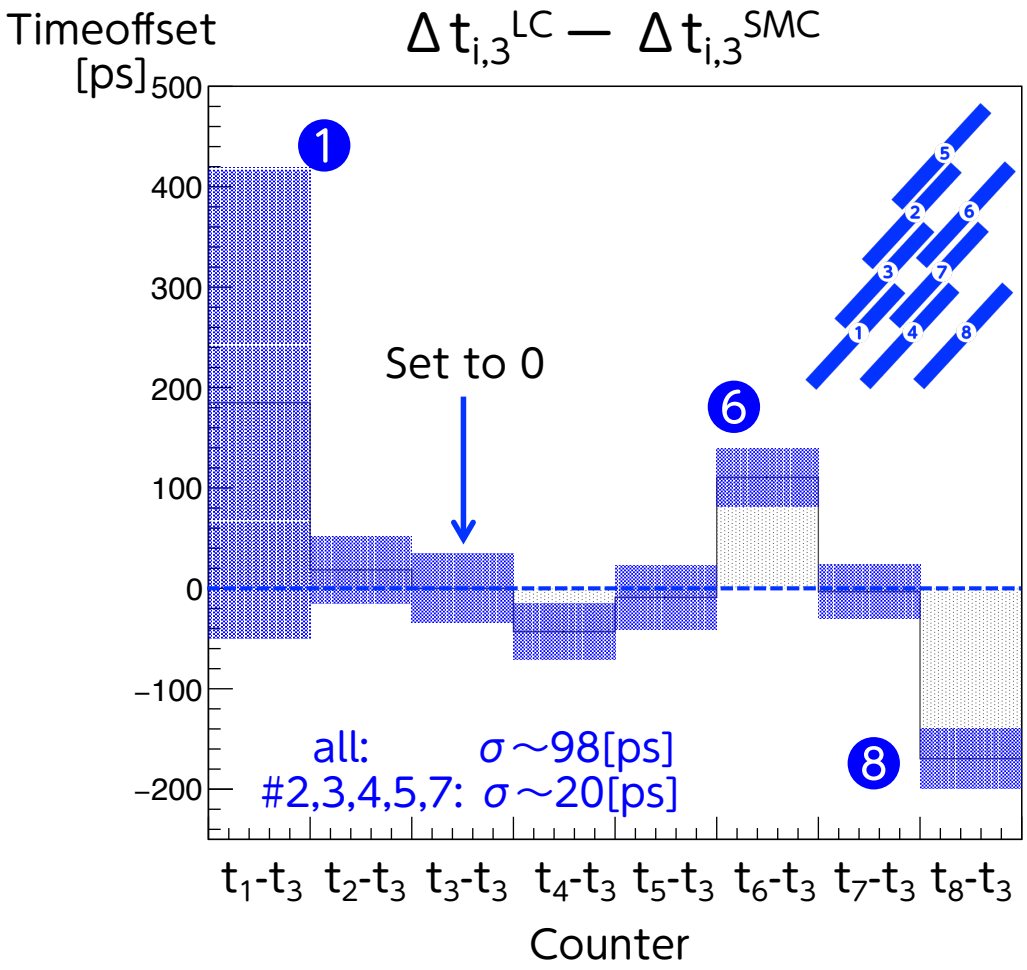






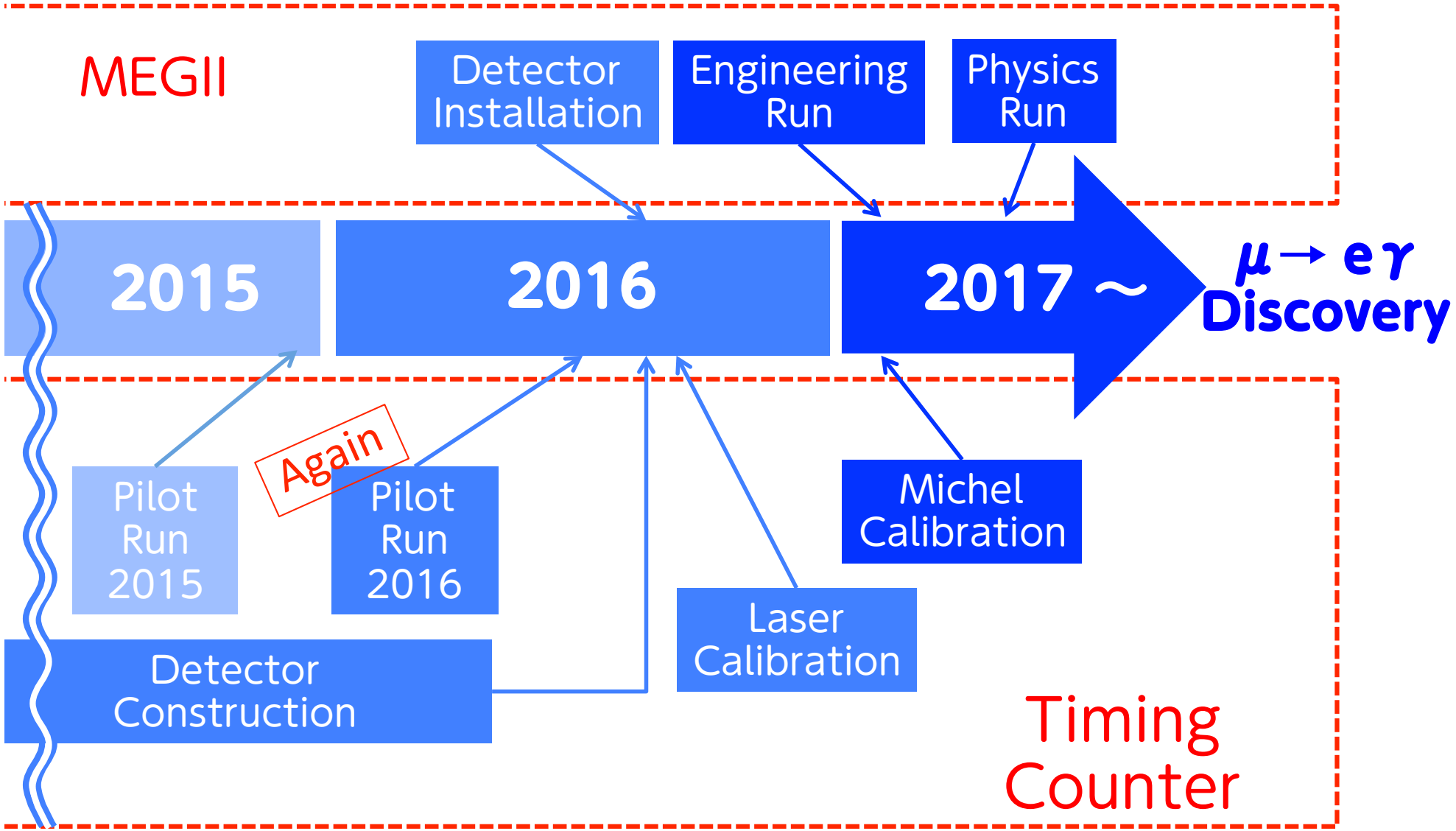
Comparison b/w two methods

- Calculate $\Delta t_{i,3}=t_i^{offset}-t_3^{offset}$ using Laser Calibration(LC) and Simplified Michel Calibration(SMC). ※Counter 3 is reference.



- Less data because of bad DAQ in counter #1.
- Probable causes.
  - [LC&MC] Bad DAQ(→c.f. Miki's talk). → to be improved in next pilot run.
  - [MC] Bias of Simplified Michel Calibration. → to be studied using Monte Carlo.
- These causes will be checked in the next pilot run with more than 8 laser counters(32 or 64).

Schedule


MEGII
Detector Installation
Engineering Run
Physics Run
2015
2016
2017 ~
μ → eγ Discovery
Pilot Run 2015
Again
Pilot Run 2016
Michel Calibration
Laser Calibration
Detector Construction
Timing Counter

Summary

Introduction

- MEGII searches for cLFV with unprecedented sensitivity from 2017.
- We **did pilot run** using muon beam in 2015.

Time Calibration

- There are two time calibration methods which can **fullfill σ~30ps accuracy**:
  Laser **C**alibration
  Michel **C**alibration
- We **successfully finished R&D** for Laser Calibration and **installed** into 8 counters in the pilot run 2015.
- We **did both of calibration methods**.
- We compared two methods and **observed difference in some counters.**
- This difference is investigated more in the **next pilot run 2016.**