RHICf-IIミーティング

＠筑波大

2021年7月7日

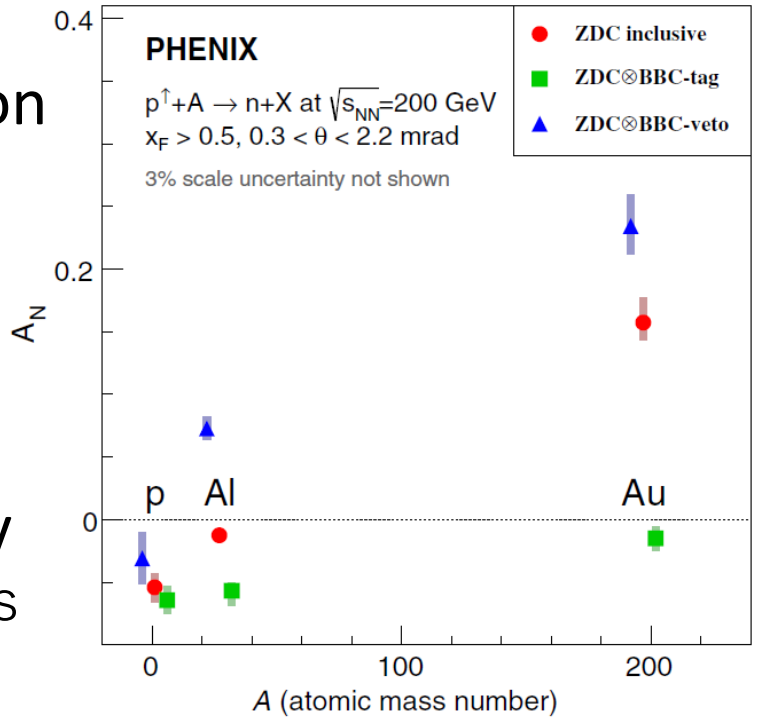
後藤雄二（理研）

計画現状

- RHICf-II物理、スコープ
  - Cosmic neutrino の background
  - Asymmetry measurements
  - カロリメータ
  - ビームタイム、ビーム条件（再評価必要）
- STAR/sPHENIXとの議論まとめ
  - sPHENIX EC discussion
  - STAR email exchanges
  - PAC homework
- 科研費基盤A
  - 今年度計画

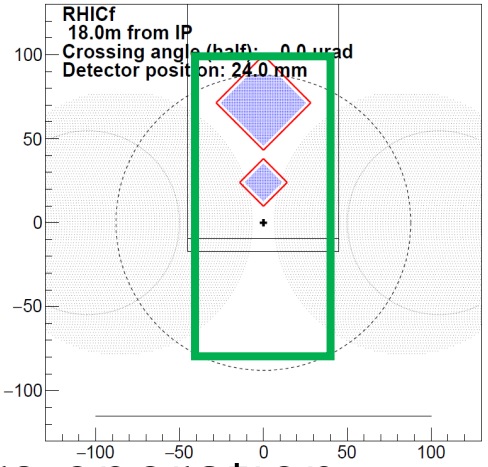
New topics at RHICf-II

- p + A collisions
  - Measurement of nuclear effect (p+A / p+p)
- Strong A-dependence of the neutron asymmetry
  - Measured at PHENIX in Run 15
  - Phys. Rev. Lett. 120, 022001 (2018)
  - UPC vs hadronic component
- A-dependence of the π^0 asymmetry
  - Correlation between asymmetries of forward neutron and π^0
- p + Oxygen collision
  - Ideal condition for cosmic-ray interaction studies measuring π^0, neutron, photon, K^0_S

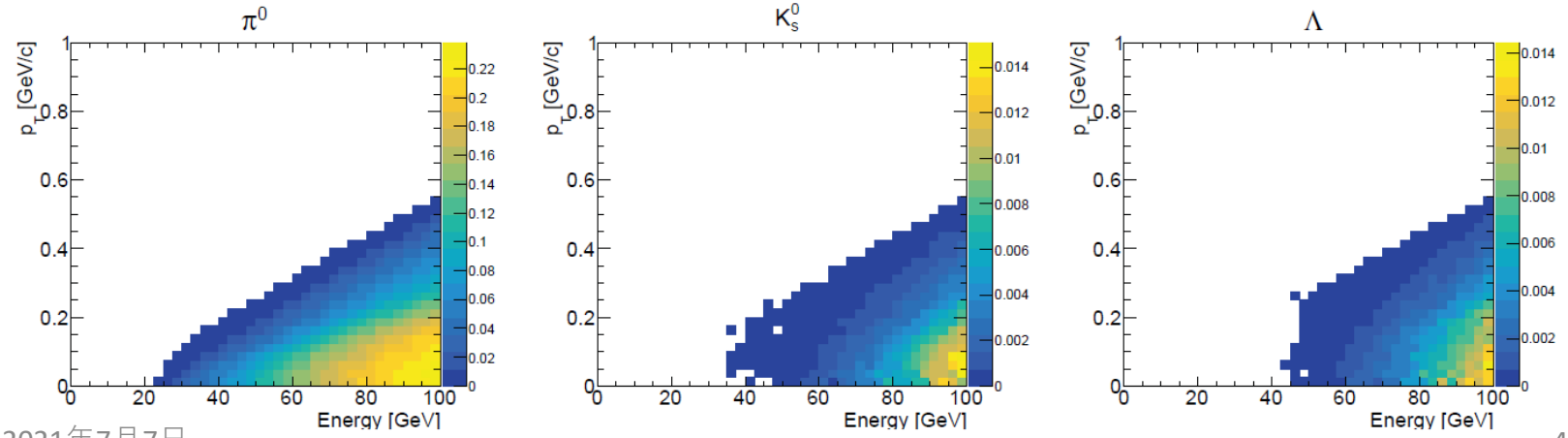


New topics at RHICf-II

- Large acceptance detector
  - 8cm x 18cm
  - For more particles: K^0_S and Λ

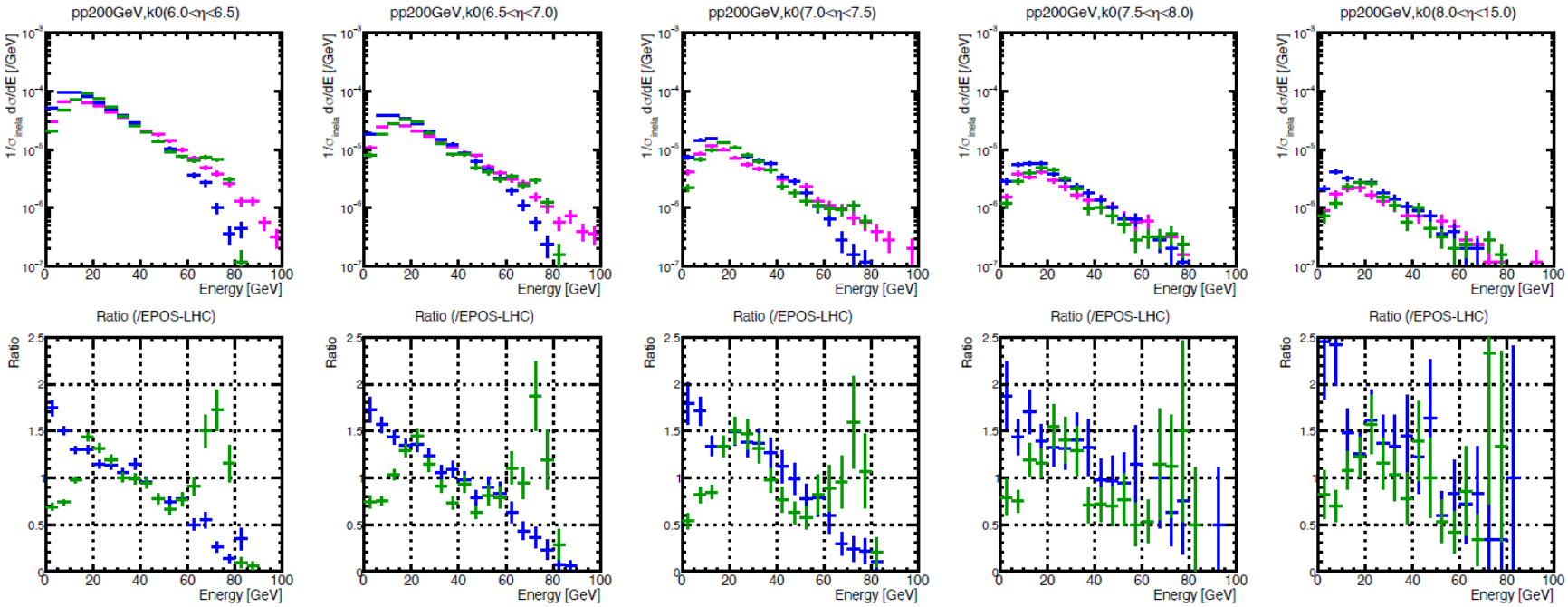


- $K^0_S \rightarrow 2\pi^0 \rightarrow 4\gamma$ (B.R. 30.7%)
  - 0.2 K^0_S /sec = 10^4 K^0_Ss in 14 hours operation
- $\Lambda \rightarrow n + \pi^0 \rightarrow n + 2\gamma$ (B.R. 35.9%)
  - 12 Λ /sec = 10^5 Λs in 2.5 hours operation
- Geometric acceptance of π^0, K^0_S and Λ



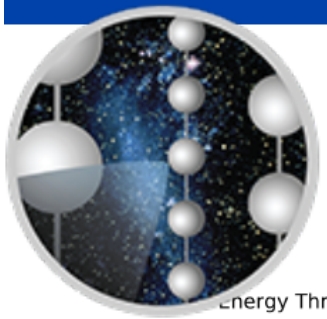
New topics at RHICf-II

- K^0_S for studying impact on the high-energy atmospheric neutrino flux
  - Differences in p+p collisions at 200 GeV between models: EPOSLHC (magenta), QGSJET II-4 (blue), SIBYLL 2.3 (green)



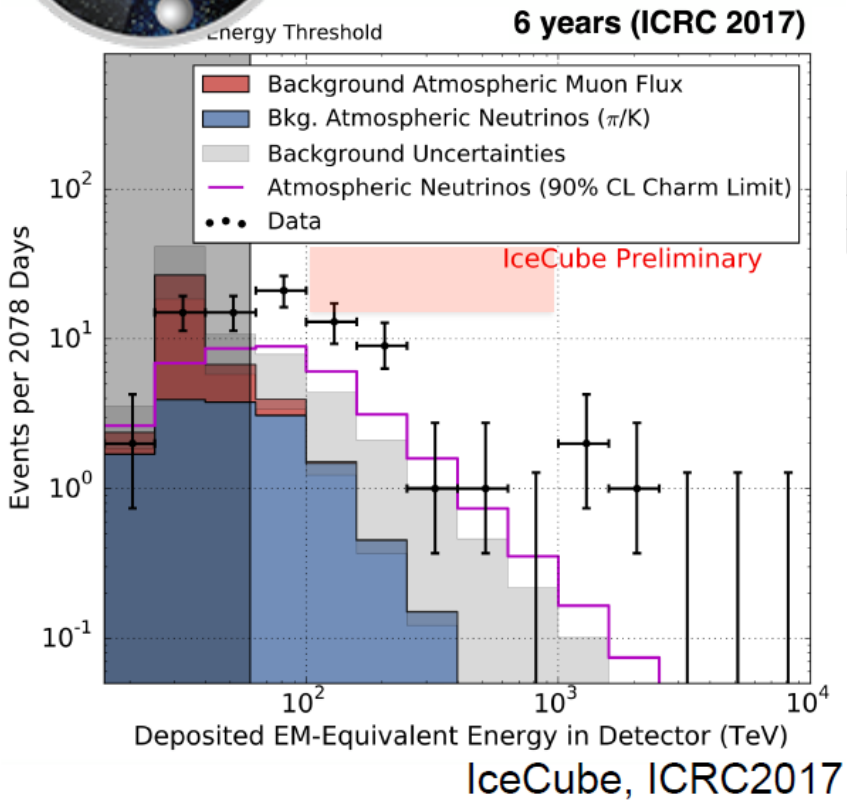
New topics at RHICf-II

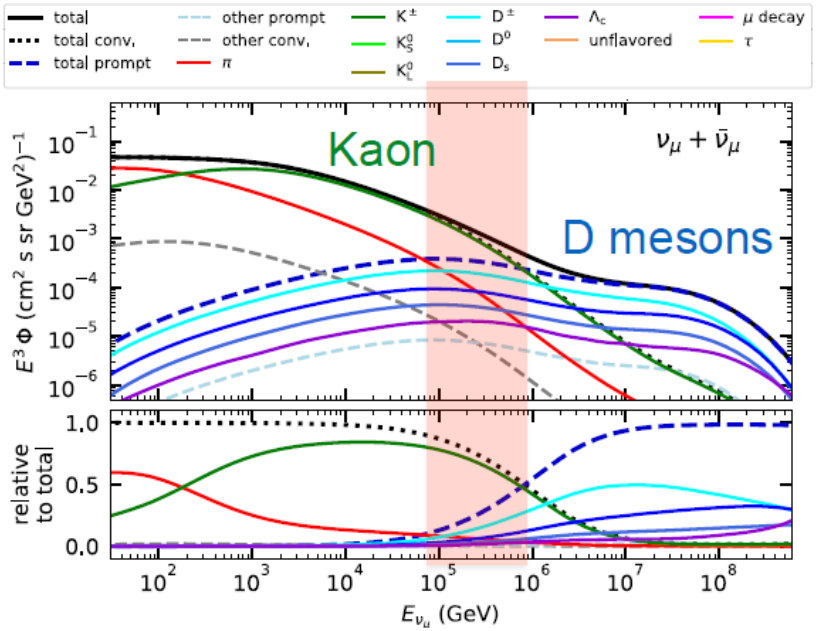
Kaons in atm. ν productions



IceCube detected astronomical neutrinos.
Better understanding of background
(Atmospheric neutrinos) is required.

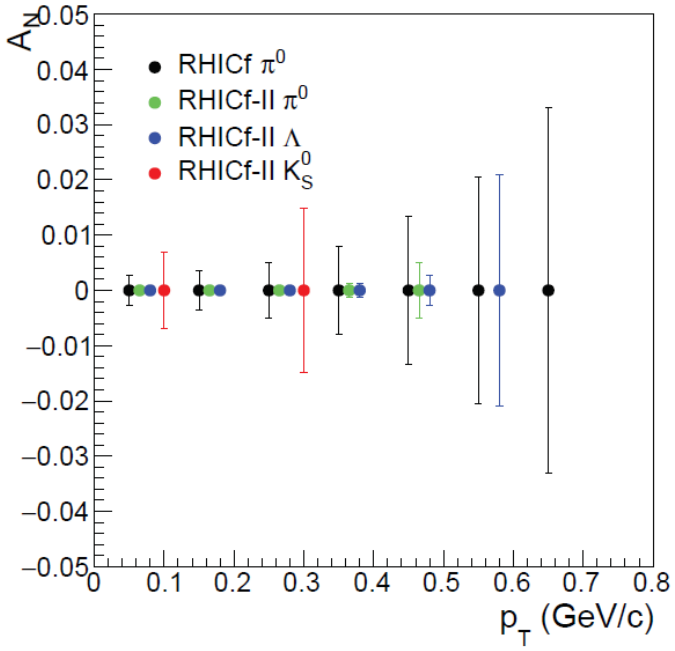
Slide by
H. Menjo

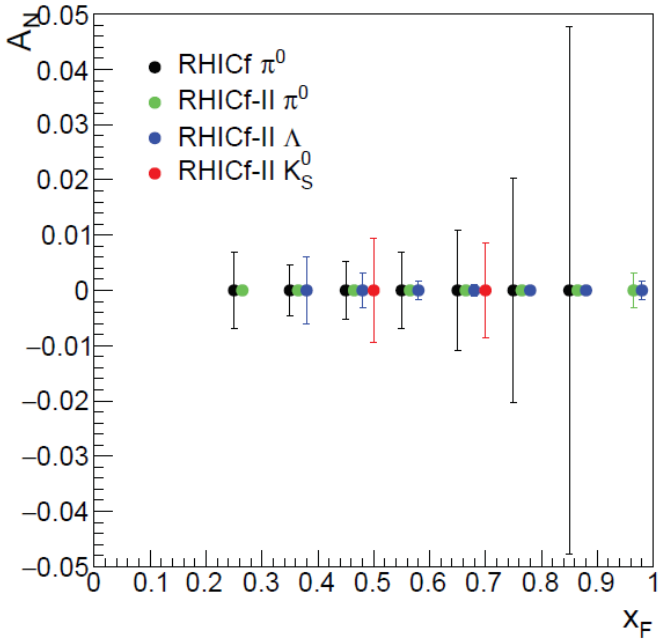




New topics at RHICf-II

- Asymmetry measurement of K^0_S and Λ
  - Expected statistical uncertainty of asymmetry measurements for π^0, K^0_S, and Λ compared to the RHICf (Run 17) π^0
  - Assuming the similar luminosity





Large acceptance calorimeter

- We plan to transfer ALICE FoCal-E technology for building an approx. 8cm x 18cm detector
  - Kakenhi-Kiban-A (2021-2024) + RIKEN budget
  - Finalize the design of the detector in 2021
  - Construction in 2022-2023
  - Prototype test in 2023 A+A collisions
- Parasitic beam-time in 2024
  - (dedicated beam-time in 2017)
  - Radial polarization
  - Small β^*, normal (high) luminosity
  - High radiation dose
- The detector needs to have enough radiation hardness to work for a small β^* and normal luminosity
  - pad sensor to be tested; e.g. with a small neutron source facility in RIKEN

sPHENIX

- Message to sPHENIX for the discussion in February, 2021
- Presentation at sPHENIX EC meeting on April 8, 2021
- Prohibitive conclusion on April 26, 2021
- PAC meeting homework on June 23, 2021

RHICf-II and sPHENIX

sPHENIX

- Useful, engaged discussion among sPHENIX EC
- RHICf doesn't contribute to the sPHENIX core science mission
  - RHICf integration would be disruptive during commissioning of new collider detector
  - RHICf operational issues could disrupt core data taking
- sPHENIX has only two global event characterizing detectors – MBD and ZDC. RHICf would sit in front of **one** of the ZDCs.
- pp and pAu running time is extremely limited. Not even clear we would request pAu. RHICf asked:
  - "We may need a request of dedicated beam time with special β^* and polarization direction similarly to our run in 2017, and special p + A collisions."
  - Adding pAu to our mission would potentially compromise our ability to deliver on core sPHENIX science purpose

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STAR

- Message to STAR on May 10, 2021
- Reply on May 11, 2021
- Prohibitive conclusion in the STAR management meeting on May 24, 2021
- PAC meeting homework on June 23, 2021

3) Last year the PAC asked RHICf-II to find a host experiment for their proposed 2024 run:

"The PAC recommends that RHICf approach STAR or sPHENIX management and determine how RHICf-II could best be integrated, as was previously done with RHICf-I and STAR. The PAC does not see a scenario in which dedicated high-beta running would be justifiable given the tight overall schedule, and recommends planning running in a parasitic mode and at nominal beta* and polarization parameters appropriate for STAR and sPHENIX."

The PAC requests that STAR inform us on how this might be achieved with STAR as host or whether it is prohibitive and why.

It is prohibitive. The reasons:
Set up time for radial polarization: we need all the time we can get for our 200 GeV p+p and p+Au physics programs. We need equal nucleon-nucleon luminosities which are essential to optimize several critical measurements.

Man power from STAR operation group: any hardware which need to be integrated to STAR, requires significant efforts from our staff. Starting in FY22, substantial FTEs will be transitioned to EIC project.

ZDC has to move: They would like to commission RHICf-II in Run23, that means ZDC has to be moved to a different location. The impact to STAR is TBD. We need a careful study on this since in Run-23, we would like to study photon-induced processes in 200 GeV Au+Au collisions in a much thorough way and ZDC is critical.

Lijuan Ruan, BNL 4

理論計算

- K中間子、Λ粒子
  - 生成断面積、非対称度
  - 統計評価、図
- p+A衝突
  - 中性π中間子非対称度

予算

- 後藤基盤A、2021年度950万円
  - 物品費700万円
    - シリコンパッド検出器マスク（300）
    - カロリメータ試作機開発用エレキ（150）
    - 実験データ解析用LINUX計算機（50）
    - 試作機シリコンパッド検出器センサー（150）
    - 試作機シリコンパッド検出器プリント基板・部品実装（50）
    - 試作機シリコンピクセル検出器センサー（50）
    - 試作機シリコンピクセル検出器プリント基板・部品実装（150）
    - 試作機タングステン板（100）
  - 旅費195万円
  - 人件費・謝金（カロリメータ試作機組立）35万円
  - その他（計算費）20万円
- 清水学振研究費
- 筑波大科研費

RANSテスト

- Youngilの報告
- COMETテストについて
- スコープ
  - IV、CV、放射線量
- 設計
- 提案書
  - 時期
  - 参加者
  - 大竹さん、竹谷さん、延與さんと議論
- 九州グループ、他の高エネルギーグループについて

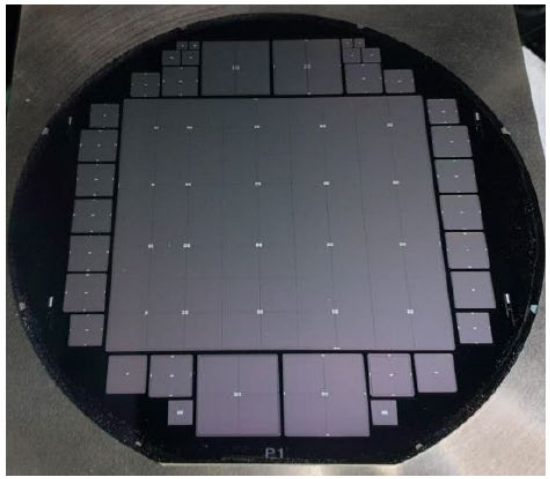
Yonsei/Hanyang activity

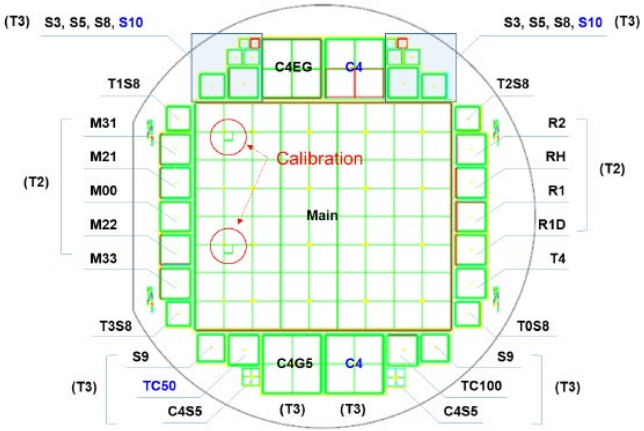
- Dong Geon Kim's slides
  - ALICE-FoCal Meeting, June 23, 2021

Si PIN Sensor

ALICE

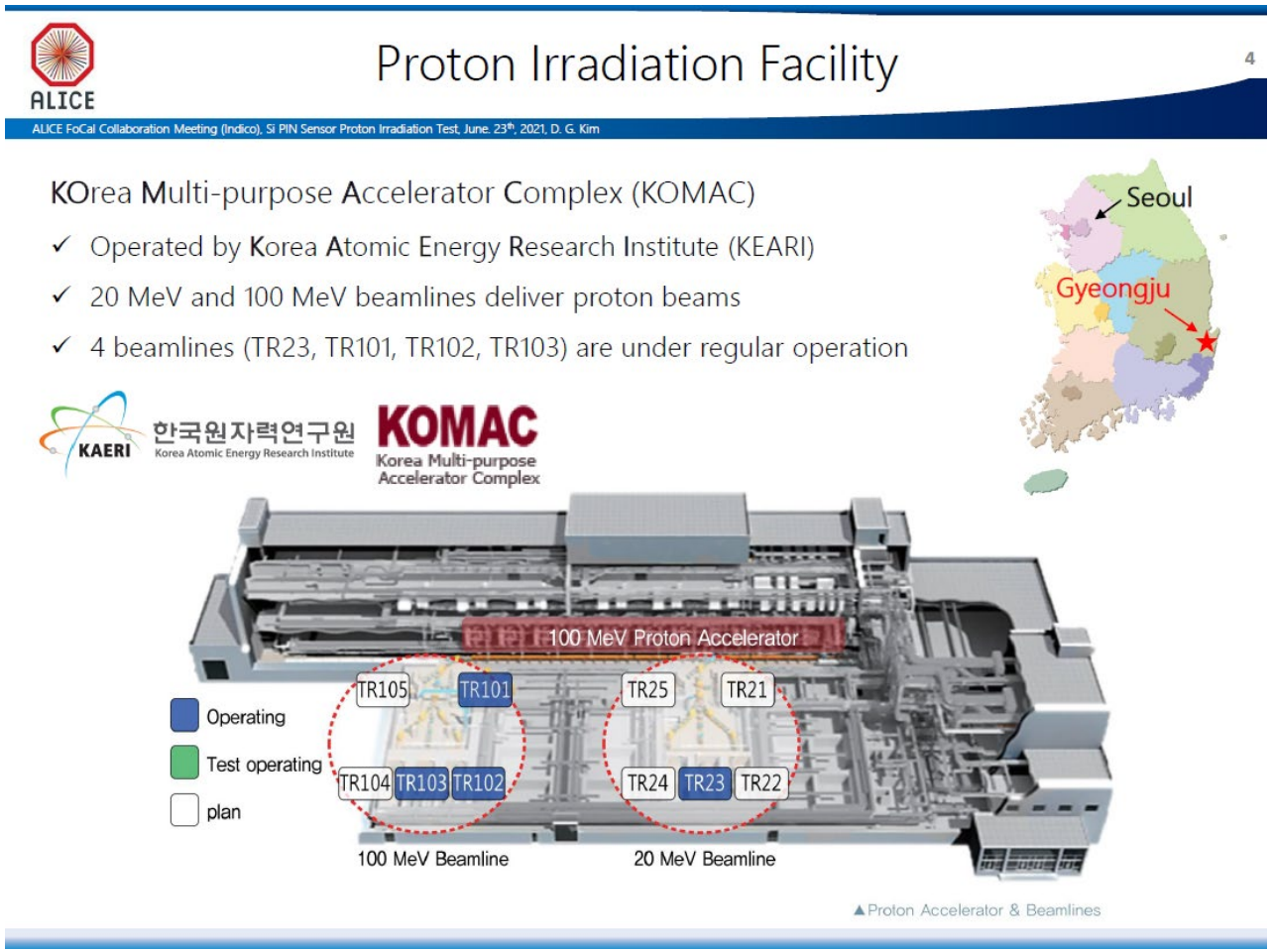
- ✓ 6 fab-out sensors (see next slide for the properties)
- ✓ We will focus on the properties of test patterns for today.





Yonsei/Hanyang activity

- Dong Geon Kim's slides
  - ALICE-FoCal Meeting, June 23, 2021



Yonsei/Hanyang activity

- Dong Geon Kim's slides
  - ALICE-FoCal Meeting, June 23, 2021

Type Inversion for n-type Sensor

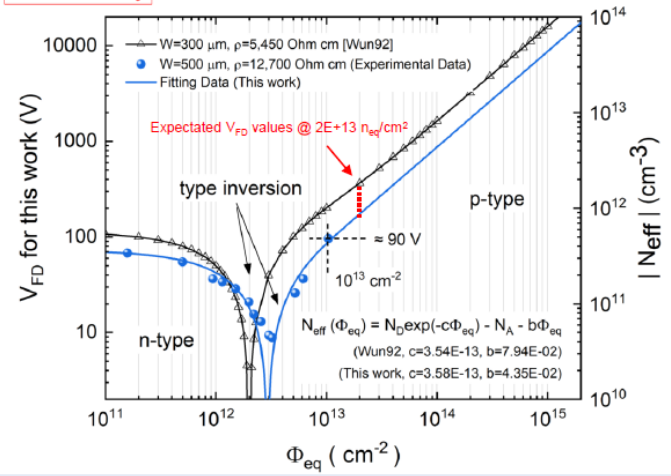
ALICE FoCal Collaboration Meeting (Indico), Si PIN Sensor Proton Irradiation Test, June. 23th, 2021, D. G. Kim

- ✓ Type Inversion point: ~ 3E+12 n_{eq}/cm^2 (for 500 μm DSP wafer)
- ✓ V_{fd} ≈ 90 V @ 1E+13 n_{eq}/cm^2 (This flux is ALICE FoCal radiation hardness criteria)
- ✓ Fitting parameter c is in agreement with the report [Wun92] (within 2% difference)
- ✓ Fitting parameter b has a significant difference from the report [Wun92] (within factor of 2)
- We will examine this difference by additional measurement at 2E+13 n_{eq}/cm^2 irradiation point*

Preliminary

A2 Wafer

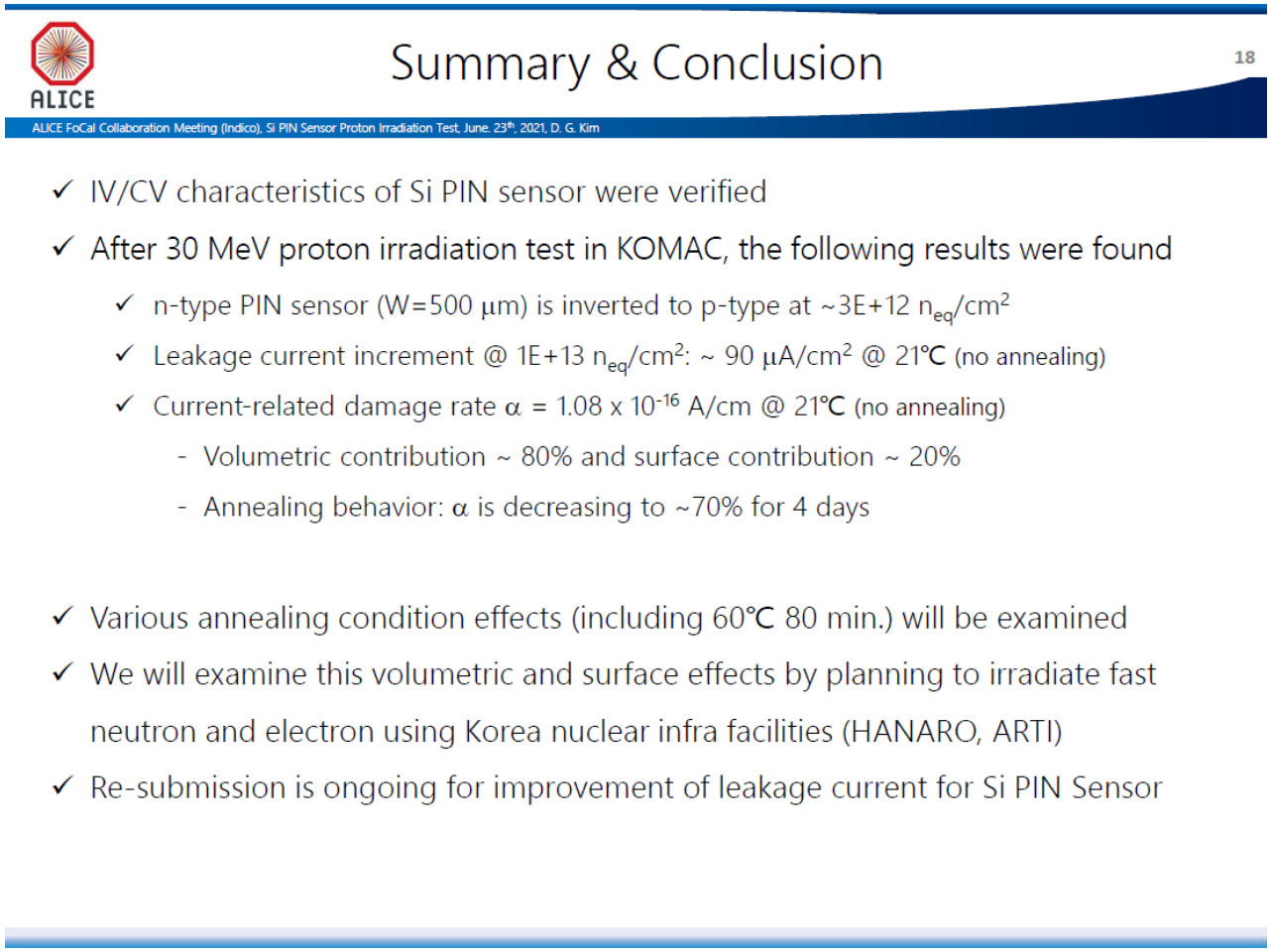
* requirement of CV measurement setup at high voltage above 200 V



- N_{eff} = Effective doping concentration (#/cm^3)
- N_D = Donor doping concentration (#/cm^3)
- N_A = Acceptor doping concentration (#/cm^3)
- c = fitting parameter (cm^2)
  - Donor removal by irradiation
- b = fitting parameter (cm^{-1})
  - Acceptor creation by irradiation
- Φ_{eq} = 1 MeV neutron equivalent fluence (#/cm^2)

Yonsei/Hanyang activity

- Dong Geon Kim's slides
  - ALICE-FoCal Meeting, June 23, 2021



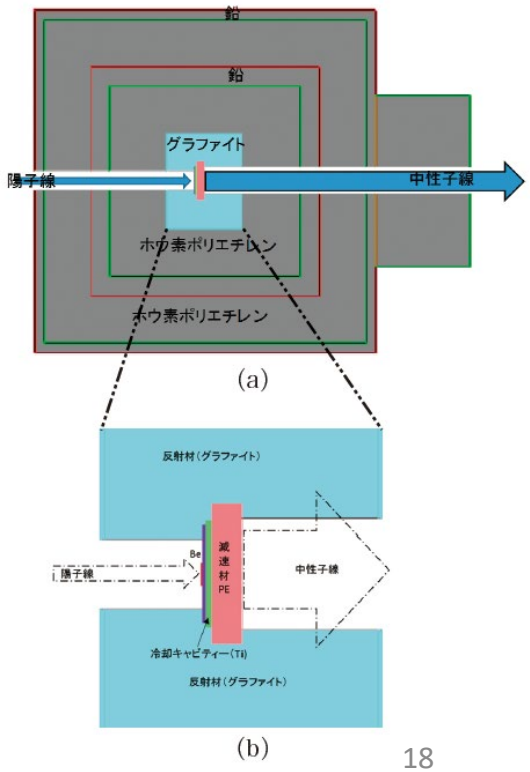
ALICE

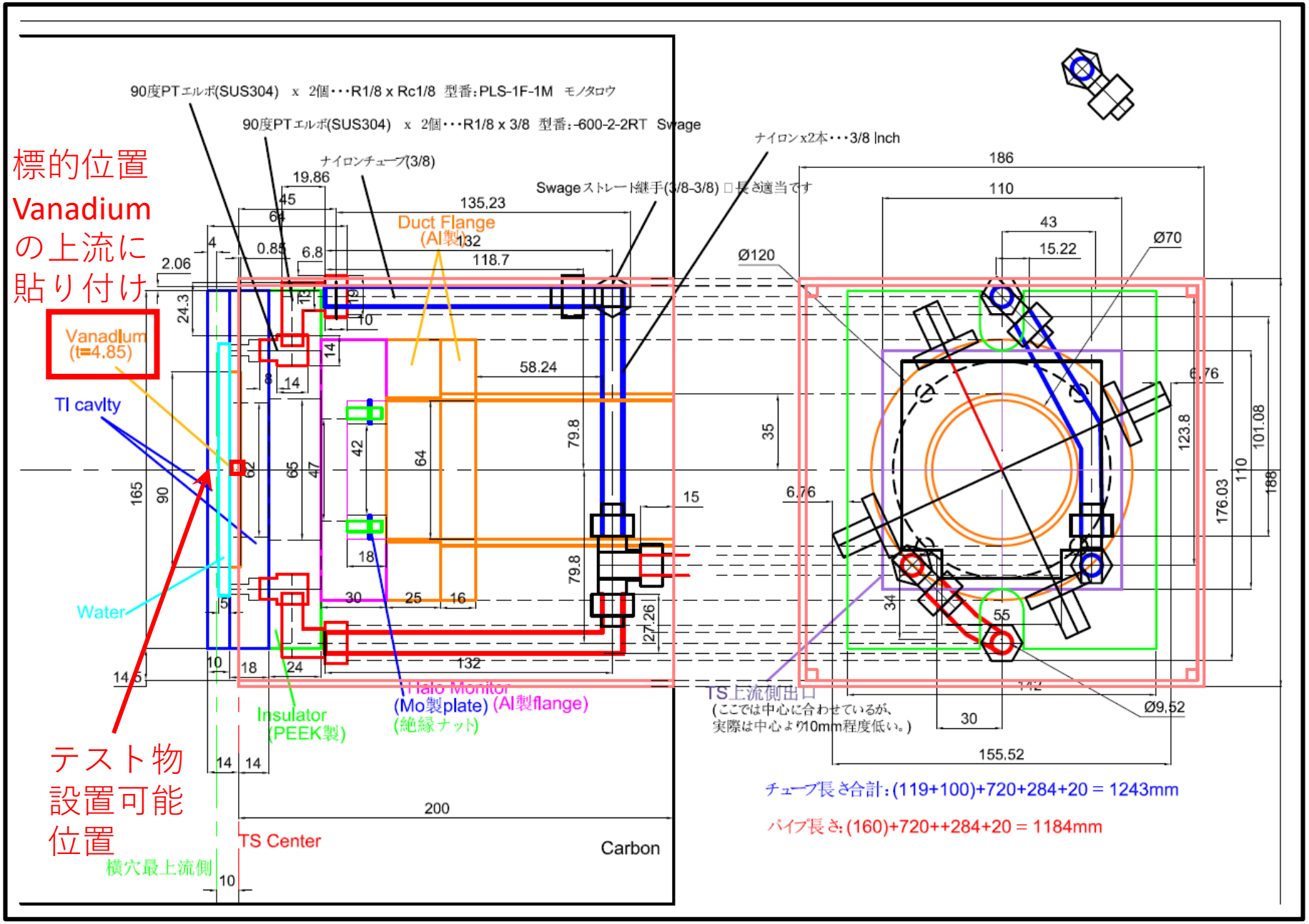
Summary & Conclusion

- ✓ IV/CV characteristics of Si PIN sensor were verified
- ✓ After 30 MeV proton irradiation test in KOMAC, the following results were found
  - ✓ n-type PIN sensor (W=500 μm) is inverted to p-type at ~3E+12 n_{eq}/cm^2
  - ✓ Leakage current increment @ 1E+13 n_{eq}/cm^2: ~ 90 $\mu A/cm^2$ @ 21℃ (no annealing)
  - ✓ Current-related damage rate α = 1.08 x 10^{-16} A/cm @ 21℃ (no annealing)
    - Volumetric contribution ~ 80% and surface contribution ~ 20%
    - Annealing behavior: α is decreasing to ~70% for 4 days
- ✓ Various annealing condition effects (including 60℃ 80 min.) will be examined
- ✓ We will examine this volumetric and surface effects by planning to irradiate fast neutron and electron using Korea nuclear infra facilities (HANARO, ARTI)
- ✓ Re-submission is ongoing for improvement of leakage current for Si PIN Sensor

RANS performance

- RANS
  - Proton 7MeV, 100μA
    - 6 x 10^{13} proton/s
  - Be target
  - Neutron 5MeV max.
    - 10^{12} neutron/s from the target
- RANS-II
  - Proton 2.49MeV, 100μA
  - Li target
  - Neutron 0.7MeV max.
- Radiation dose calculation or simulation
  - FLUKA/MARS/PHITS




標的位置
Vanadium
の上流に
貼り付け
Vanadium
(t=4.85)
TI cavity
Water
テスト物
設置可能
位置
横穴最上流側
90度PTエルボ(SUS304) x 2個・・・R1/8 x Rc1/8 型番:PLS-1F-1M モノタロウ
90度PTエルボ(SUS304) x 2個・・・R1/8 x 3/8 型番:-600-2-2RT Swage
ナイロンチューブ(3/8)
ナイロンx2本・・・3/8 Inch
Swageストレート継手(3/8-3/8) □長さ適当です
Duct Flange
(Al製)
Insulator
(PEEK製)
Halo Monitor
(Mo製plate) (Al製flange)
(絶縁ナット)
TS Center
Carbon
TS上流側出口
(ここでは中心に合わせているが、
実際は中心より10mm程度低い。)
チューブ長さ合計:(119+100)+720+284+20 = 1243mm
パイプ長さ:(160)+720++284+20 = 1184mm

6/18(金)RANS標的部

- neutron数は放射化箔（インジウム）を用いてモニターできる
  - Cr-39と同様
- テストするSi baby chip、モニター用のSi PD、放射化箔を設置するjigを製作して、棒で下流から出し入れする
  - Ti cavityに当たるまで押し込み位置を得る
- 2週間程度でプレゼンする
  - 大竹さんへ説明、延與さん同席できるとよい
  - 目的
  - 方法、何をどのように測定するか
  - 期間
- テストしたものはテスト後は放射化が治まるまで外に持ち出すことできない

SiPD monitor

- K. Ueno et al.: Development of Real-Time 1-MeV Equivalent Neutron Fluence Monitor Based on SiPD for COMET Experiment

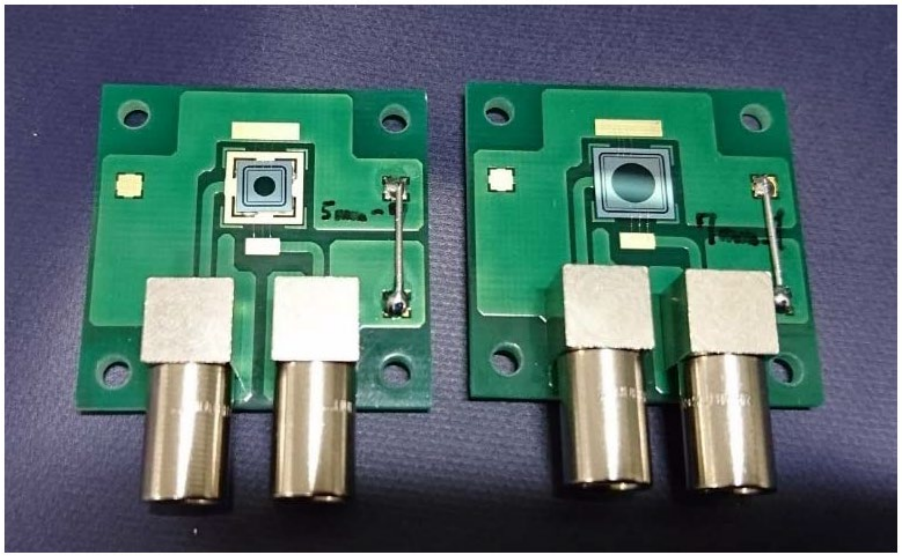


Fig. 2 Photograph of prototype neutron fluence monitors based on . the SiPDs with the thickness of 320 μm and the size of 5 x 5 mm^2 and 7 x 7 mm^2.

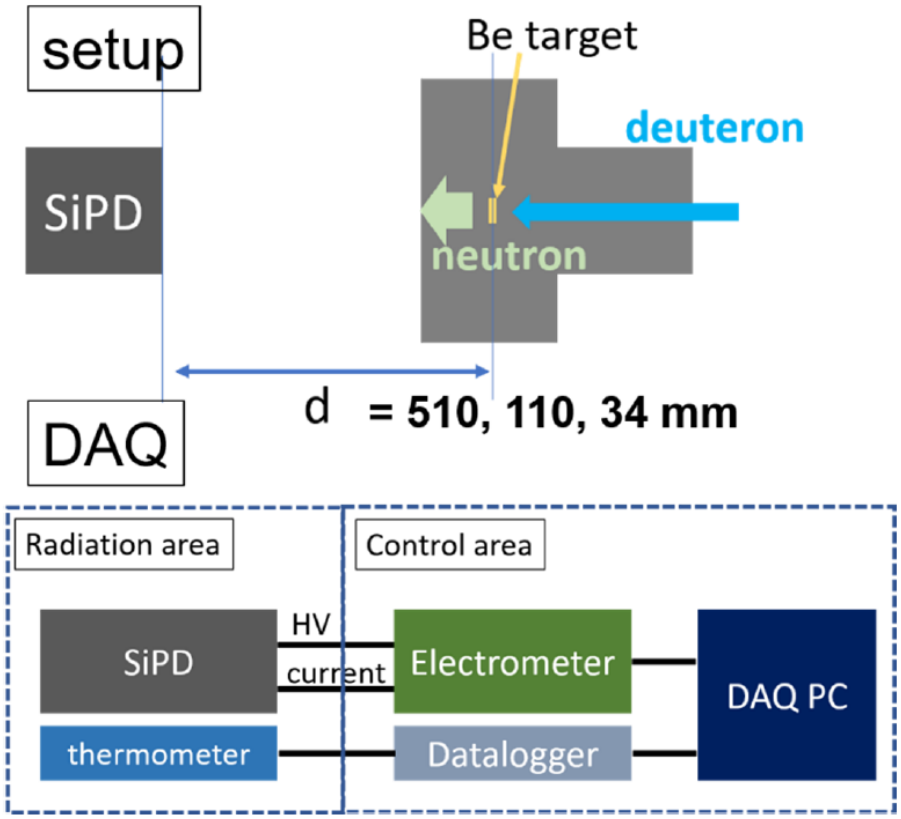


Fig. 4 Experimental setup. Leakage current of SiPD was measured changing distance (d) between SiPD and Be target. Electrometer was used for applying bias voltage and measuring leakage current. Thermometer was also mounted near SiPD and the temperature was recorded with datalogger.

SiPD monitor

- CR-39 dosemeter
  - 固体飛跡検出器
  - measured and the results was used for the reference.
- the monitor can be utilized with the accuracy of ~20% even if the annealing effect and detailed temperature correction were not considered.

テストベンチ

- 筑波大
  - （Bedangaへの情報）
  - IR laser (lower intensity and high intensity beam)
  - black boxes
  - x-y scan moving stage
  - APV25 hybrid + SRS readout
  - FPGA developing kit, to connect to HGCROC board (purchased already)
  - HGCROC (not yet)

- FPGAテスト＠理研
- 清水予算
  - FPGA評価ボード、FPGAライセンス、80万円？
- 基盤A

その他

Backup Slides

STAR

- Message to STAR on May 10, 2021
- Reply on May 11, 2021
- We had an initial discussion at STAR and we need a bit more information. Could you provide answers to the following questions:
- How much data do you need for each species?
  - Last year, we requested dedicated beam use of 2 weeks; 1 week for pol-p + A at 200 GeV and 1 week for pol-p + pol-p at 200 GeV. In the dedicated beam use, we requested large beta* (e.g. 8 m as in the previous run in 2017), which gives us approx. 10^31 cm^-2 s^-1 luminosity.
  - This request doesn't change in case of the parasitic beam use with small beta*, though we need to confirm radiation hardness of our new detector, and adjusted prescale of our trigger depending on bandwidth of the DAQ capability. We want to have more than 1 pb^-1.
  - We're building our new detector with ALICE-FoCal-E technology by collaborating with ALICE-FoCal group. We're working for studying its radiation hardness and trigger/DAQ capability. So far we think neither is a show-stopper. We hope we can have larger luminosity for our rare event, e.g. K^0_S meson and Lambda.

STAR

- Can you run at the same time as STAR?
  - If it is allowed to locate our detector in front of one of the STAR ZDC, and use more than 1 kHz bandwidth of the trigger from our detector, we can run at the same time. We hope we can integrate our DAQ in the STAR DAQ system this time for better combined analysis of RHICf and STAR. As in the previous run in 2017, we want to keep data from not only STAR trigger detectors (ZDC/BBC/VPD/EPD/etc.) but also STAR fast detectors (BEMS/EEMC/TOF/MTD/etc.) data for our trigger. For a certain partial fraction of the trigger, we also want to keep data from slow detectors (TPC/etc.).
  - If it is allowed to use longer beam time, we'll be able to decrease our requested bandwidth, e.g. 10 weeks * 2 with 100 Hz bandwidth.
- When would you propose to install the new detector and which side at STAR you would like to install?
  - If we have pol-p + A run, we want to install our detector at pol-p going side, or the west side, the same as the previous run in 2017. In case of the pol-p + A run, we want to locate the detector close to the beam pipe in order to cover the zero-degree region of the tilted beam orbit.
  - We want to have physics run in 2024, but also want to commission our detector in 2023 by locating it somewhere in the STAR area.

STAR

- What do you need from STAR and RHIC/BNL?
  - We need radial polarization for wider pT coverage for the RHIC operation using the spin rotator.
  - We want help and support from STAR to integrate our trigger/DAQ in the STAR trigger/DAQ system. We'll need design and development of I/F between our system and STAR system. We have available budget around $300K from JSPS (+ some from RIKEN) for RHICf-II experiment in total including integration of our new detector to the STAR system. We want to discuss and know how much cost necessary for the integration and operation at STAR.
- Also, the PAC meeting will be held on June 22-23. You should ask ALD If you want to be on the agenda since currently it is not there.
  - We'll ask ALD to include our proposal to be discussed at the PAC meeting. It is also important for us to get a support from the STAR collaboration and to be involved in the STAR BUR.

STAR

- Additional questions from STAR
- For the resources required from STAR, can you provide more detailed information? Last time for running RHICf at STAR in Run-17, you supplied a table to Zhangbu showing the details, which is attached in this message. Can you provide a similar table?
  - We discussed the resource requirement. One additional requirement from STAR or request to STAR is a support for integrated electronics and DAQ/trigger system for our new detector. We'd like to have STAR data stream including our detector data recorded as a part of the STAR data. What exactly needs to be done to make this a reality will require discussion by experts on both sides.
  - In order to reduce our dependence on STAR and ease your burden, we'll construct the manipulator, prepare electronics racks, pay for the labor provided, etc. as needed. So, the table of the resources required for completing the RHICf program and responsibility should be:
    - Cables: RHICf
    - Cabling: STAR
    - Manipulator design: STAR
    - Manipulator construction: STAR -> RHICf/STAR (as needed)
    - Shield modification: STAR/C-AD
    - Main detector: RHICf
    - Readout electronics: RHICf -> RHICf/STAR
    - Power supply: RHICf
    - Electronics rack: STAR -> RHICf/STAR (as needed)
    - Operation space: STAR
    - Computers: RHICf
    - Offline software: RHICf
    - Detector system interface: RHICf/STAR

放射線耐性テスト@RANSへ向けて

- RANSでの放射線耐性テスト用に九州大保有のSiPDを使用
  - g-2所有：三部さん、吉岡さんの了承済
  - 5mm角、7mm角、それぞれ5個程度
- RANS標的周りの詳しい情報を得る
  - FLUKA/MARS/PHITSによる放射線量（中性子、光子）の見積を行う
- FoCal-E Padと共に固定方法、読み出し方法を稲葉さんらと議論して進める
- RANSへの提案書を作成する
  - 今月中を目標とする！