

クォーク・核物質研究部門報告

Quark-Nuclear Matters

- ・ 格子QCD 研究
- ・ 宇宙元素合成研究
- ・ QGP/臨界点研究

【拠点・施設】
ALICE/LHC, STAR/RHIC
J-PARC, RIKEN/RIBF
計算科学研究センター
宇宙史研究センター

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研究員：坂井真吾、Ashutosh Kumar Pandey、鈴木伸司

Lattice QCD group

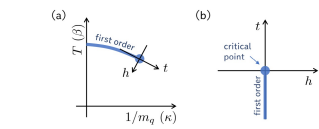
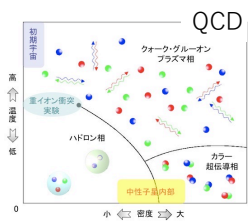
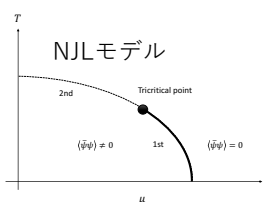
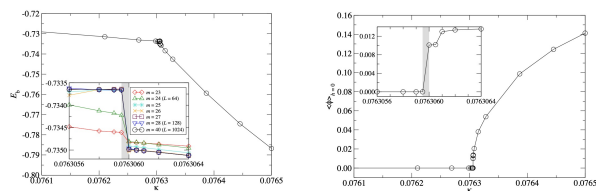


FIG. 1. Phase diagrams of (a) QCD in heavy-quark region and (b) three-dimensional Ising model.



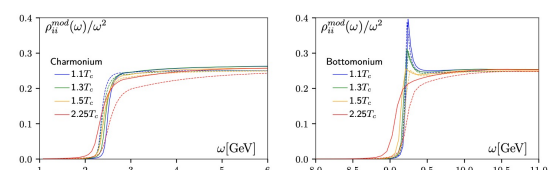
【代表的な論文】

- "Calculation of derivative of nucleon form factors in N_f=2+1 lattice QCD at M_π=138 MeV on a (5.5 fm)³ volume", PACS Collaboration: K.-I. Ishikawa et al., Phys.Rev.D104(2021)074504
- "Tensor renormalization group approach to (1+1)-dimensional Hubbard model", S. Akiyama and Y. Kuramashi, Phys.Rev.D104(2021)014504
- "Metal-insulator transition in (2+1)-dimensional Hubbard model with tensor renormalization group", S. Akiyama, Y. Kuramashi and T. Yamashita, PTEP2022(2022)023
- "Phase transition of four-dimensional lattice φ⁴ theory with tensor renormalization group", S. Akiyama, Y. Kuramashi, and Y. Yoshimura, Phys.Rev.D104(2021)034507
- "Charm and beauty in the deconfined plasma from quenched lattice QCD", H.-T. Ding, O. Kaczmarek, A.-L. Lorenz, H. Ohno and H.-T. Shu, Phys.Rev.D104(2021)114508
- "Finite-size scaling around the critical point in the heavy quark region of QCD", A. Kiyohara, M. Kitazawa, S. Ejiri, and K. Kanaya, Phys.Rev.D104(2021)114509



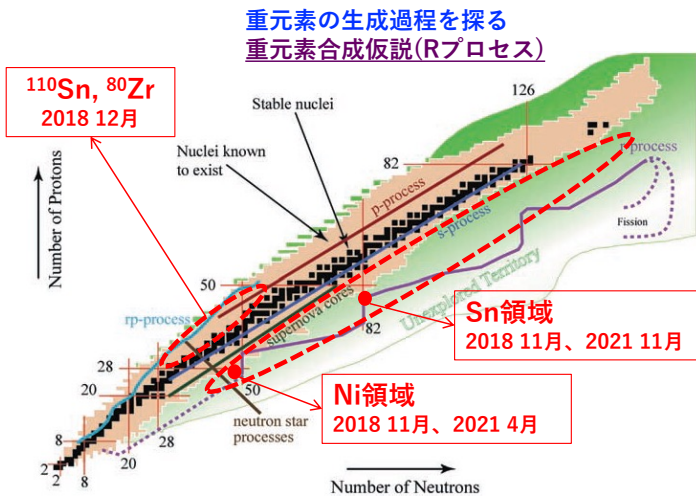
【講演、賞など】

- "Application of tensor renormalization group to Nambu-Jona-Lasinio model and Hubbard model" Y. Kuramashi (招待講演), Tensor Networks in Many Body and Lattice Field (Online, July 26-30, 2021).
- "Application of tensor renormalization group to Quantum Field Theories" Y. Kuramashi (招待講演), DWQ@25, (Online, Dec. 13-Dec. 18, 2022).
- "Tensor renormalization group approach to (1+1)-dimensional Hubbard model" S. Akiyama, 熱場の量子論とその応用2021, (オンライン, Aug. 30-Sep. 1, 2021).
- 秋山進一郎(D3) 筑波大学学生表彰 2022年3月

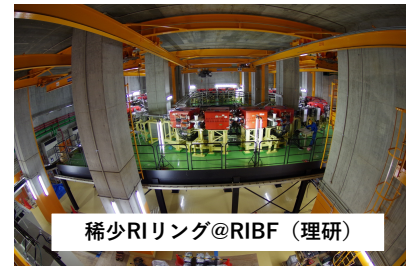
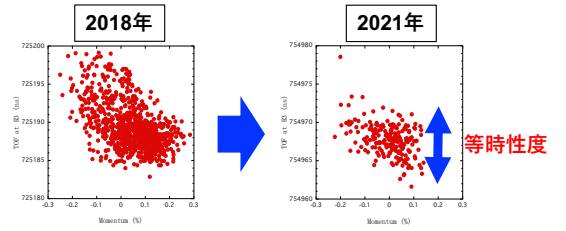


- 4 talks in the 38th International Symposium on Lattice Field Theory (Lattice 2021), (Online, July 26-30, 2021).
- "Restoration of chiral symmetry in cold and dense Nambu-Jona-Lasinio model with tensor renormalization group", Y. Kuramashi
 - "Tensor renormalization group approach to (1+1)-dimensional Hubbard model", S. Akiyama
 - "Critical endpoints in (2+1)- and 4-flavor QCD with Wilson-Clover fermions", H. Ohno
 - "The lower moments of nucleon structure functions in lattice QCD with physical quark masses", R. Tsuji for PACS Collaboration

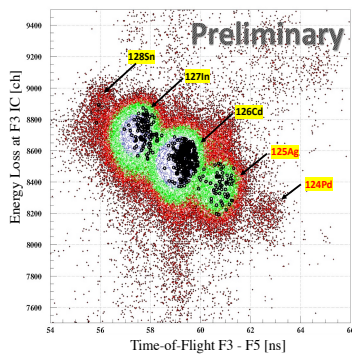
宇宙元素合成の研究



Ni領域の質量測定実験



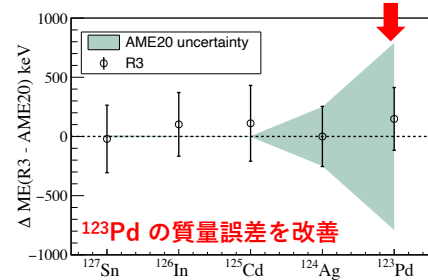
2021年11月: 2度目のSn領域 の質量測定実験 (実験データは解析中)



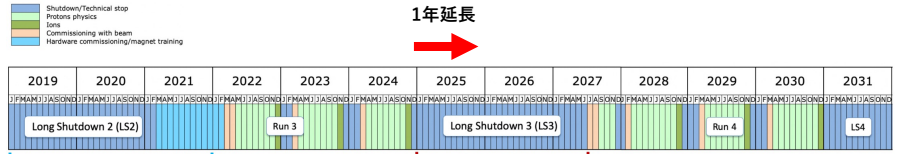
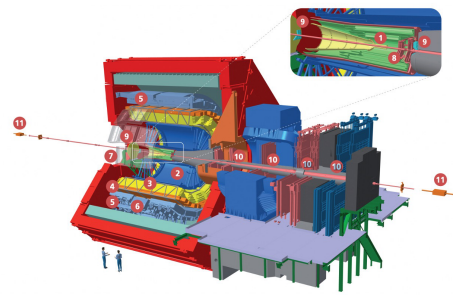
粒子識別 (今回の実験で稀少RIリング
に入射できた粒子を黒丸で表記)

2018年11月に行ったSn領域 の実験の結果をPRLに投稿

Nucleus	ME _{AME20} [keV]	ME _{R3} [keV]	σ_{total} [keV]	σ_{m_0} [keV]	σ_{stat} [keV]	σ_{sys} [keV]
¹²⁶ In	-77809(4)	-77707	269	254	65	62
¹²³ Cd	-73348.1(29)	-73237	320	252	192	40
¹²³ Pd	-60430(790)	-60282	265	248	86	40



ALICE Run3 with LS2 upgrades



ALICE LS2 upgrade

- New silicon tracker (ITS2 & MFT)
- TPC Readout planes using GEM
- New Fast Interaction Trigger (FIT)
- New Online/Offline system (O2)
- Upgrade readout of all other detectors

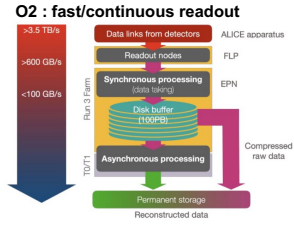
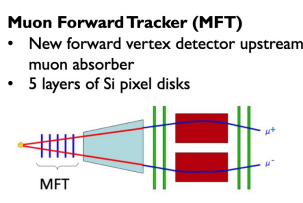
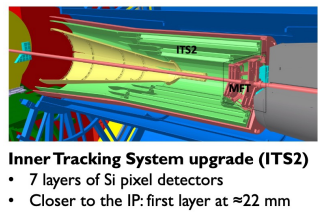
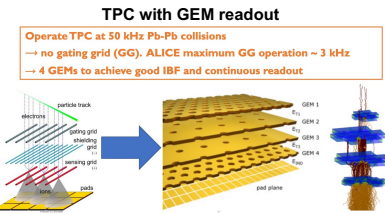
Global Commissioning (July – Nov)
LHC pilot beam tests (18.10 – 31.10)

ALICE LS3 upgrade

- New silicon tracker (ITS3)
- Forward Calorimeter (FoCAL)

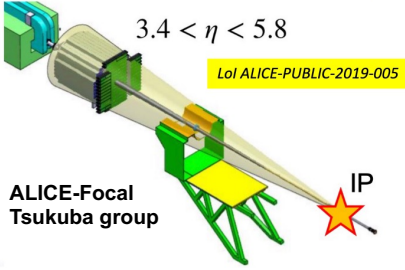
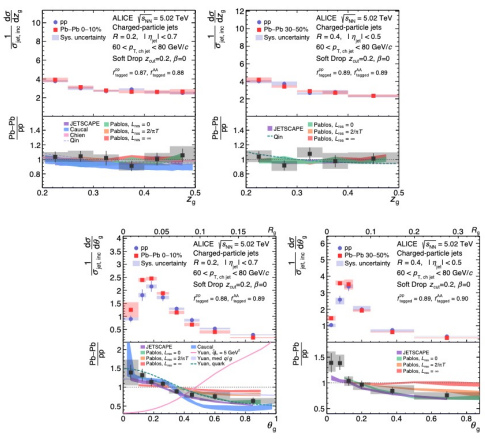
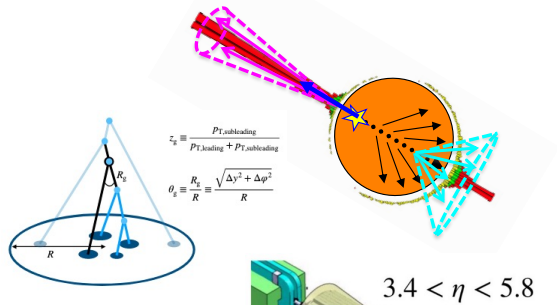
ALICE Run3 + Run4

- 13 nb⁻¹ (0.5T, 0.2T) Pb-Pb collisions
- Heavy flavor meson and baryon measurements down to very low p_T
- Thermal direct radiation via dielectrons
- Quarkonia
- Light nuclei, hyper-nuclei, dibaryons
- Forward direct photons



Partonic Energy Loss Jet-quenching

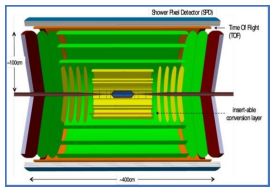
- ALICE internal-jet structure
- Jet broadening or narrowing



ALICE Run3&4 and future

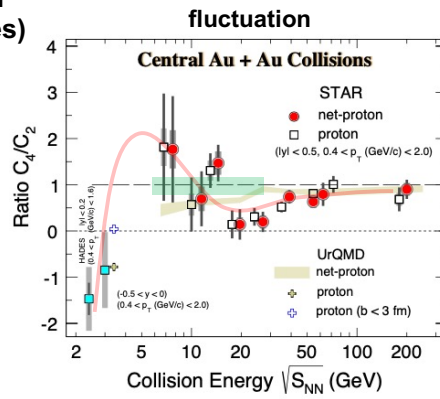
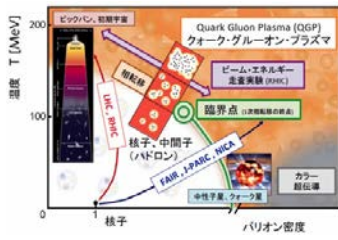
	ITS1	ITS2	ITS3
inner layers			
X/X ₀	1.14%	0.38%	0.05%
innermost radius	39 mm	22 mm	18 mm
pixel size	50x425 μm ²	30x30 μm ²	O(15x15 μm ²)

- FoCal-E pad 検出器の読出エレクトロニクス試験
- 東北大学 ELPH のGeV-γ 施設 (7月)
 - CERN 研究所 SPS 加速器 (9月-10月)
 - ALICE 遠隔データ収集ソフト (9月-10月)
 - 研究者 Abderrahmane Ghimouz氏着任 (11月)



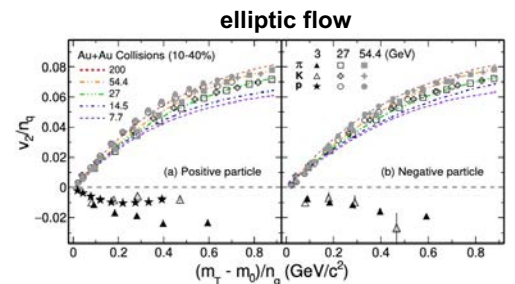
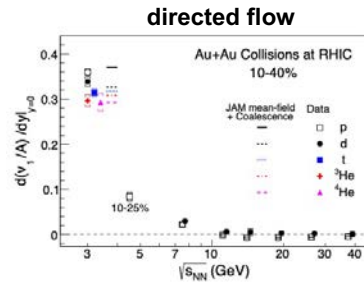
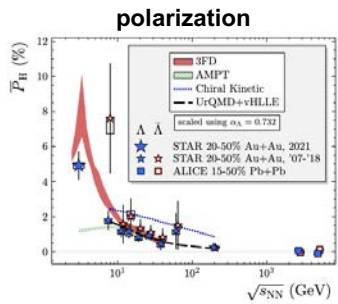
ALICE-3 : Letter of Intent for Run5 and future all silicon detectors

Beam Energy Scan II program at RHIC-STAR (COL / FXT modes)

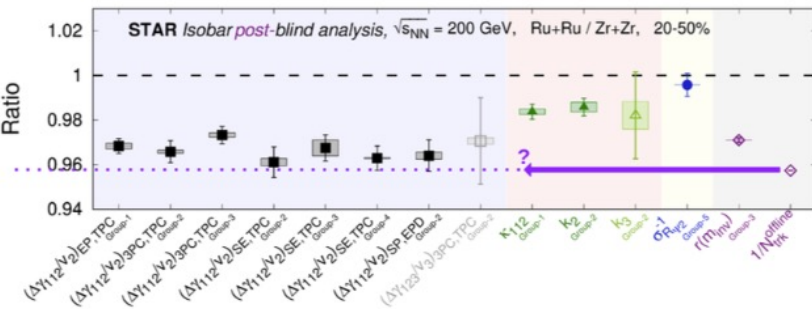
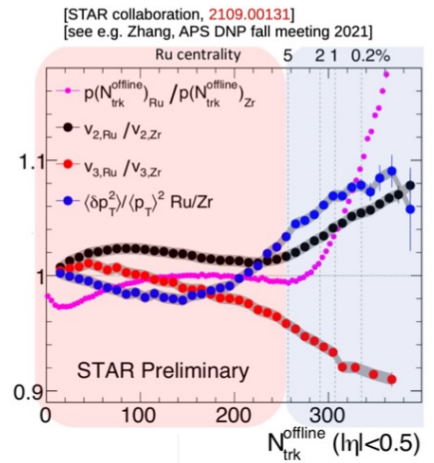
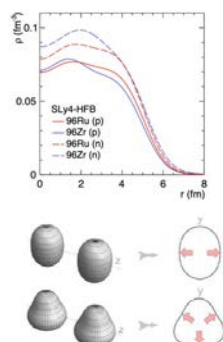
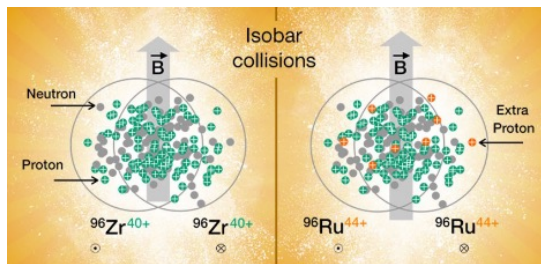


Run (STAR)	Beam Energy (GeV/nucleon)	Collision or Fixed Target	Event plane	SP (MeV)	Run Time (days)	No. Events Collected (Pre-scaled)	Date Collected
200	100	C	0	25	2.0	138 M (140 M)	Run-19
27	13.5	C	0	156	24	555 M (700 M)	Run-18
19.6	9.8	C	0	206	36	582 M (400 M)	Run-19
17.3	8.65	C	0	230	14	256 M (250 M)	Run-21
14.6	7.3	C	0	262	60	324 M (310 M)	Run-19
13.7	100						Run-21
11.5	6.75						Run-20
11.5	70						Run-21
9.2	4.59						Run-20+20b
9.2	44.5						Run-21
7.7	3.85						Run-21
7.7	31.2						Run-19+20+21
7.2	26.5						Run-20
6.2	19.5						Run-20
5.2	13.5						Run-20
4.5	9.8	FXT	1.52	589	0.9	108 M (100 M)	Run-20
3.8	7.3	FXT	1.37	633	1.1	117 M (100 M)	Run-20
3.5	5.75	FXT	1.25	696	0.9	116 M (100 M)	Run-20
3.2	4.59	FXT	1.13	699	2.0	200 M (200 M)	Run-19
3.0	3.85	FXT	1.05	721	4.6	259 M ($\rightarrow 280$) (100 M $\rightarrow 280$)	Run-18+21

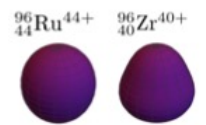
200GeV d+Au, 200GeV O+O during run21

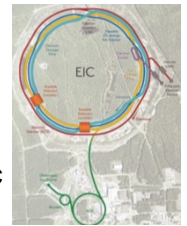
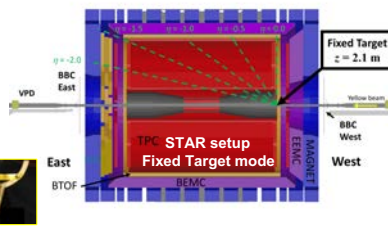
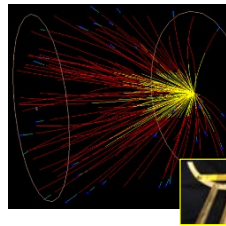
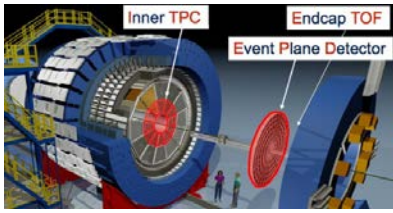


Isobar analysis for CME search and beyond



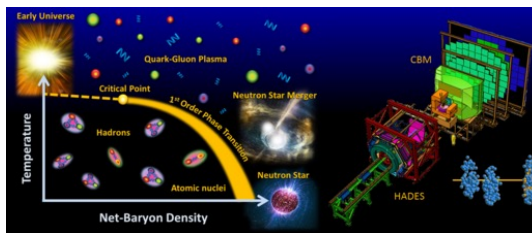
M. Abdallah et al. [STAR],
Phys. Rev. C 105, 014901
(2022)
doi:10.1103/PhysRevC.105.014901
[arXiv:2109.00131 [nucl-ex]].





eRHIC future

- STAR-BES-II (and beyond) data analysis including FXT mode setup
- FAIR-CBM experiment preparation towards high-density QCD phase-diagram
- Neutron detector development for J-PARC-HI with phenix TOF detector
- HIMAC H355/H447 experiment with Riken-group
- MRPC detector development for J-PARC E16



FAIR (ドイツ)
NICA (ロシア)
HIAF (中国)
J-PARC-HI (日本)



外部資金・科研費など

- 2019 – 2023 基盤研究(S) 江角 晋一
高次ゆらぎと粒子相関による高密度クォーク核物質の1次相転移と臨界点観測への挑戦
- 2020 – 2024 基盤研究(S) 中條 達也
LHC 超前方光子測定によるグルーオン飽和とQGP生成起源
- 2020 – 2024 基盤研究(S) 小沢 恭一郎 (KEKクロスアポ)
高輝度陽子ビームによる原子核中での明確な中間子質量変化の実験的確立
- 2020 – 2023 基盤研究(C) 森口 哲朗
中性子星の構造解明に向けた重い中性子過剰核のスキン厚測定
- 2021 – 2022 挑戦的研究(萌芽) 笹 公和
長半減期放射性セシウム135を加速器質量分析法により超高感度で検出する試み
- 2017 – 2022 伊藤科学振興会/物理学分野研究助成金 江角 晋一
原子核衝突ビームエネルギー走査による高密度クォーク核物質の研究

クォーク・核物質 まとめ

- 格子QCD 研究
 - クォーク物質の熱力学的特性
 - 1次相転移、臨界終点、プラズマ中の重クォーク
- 宇宙元素合成研究
 - 不安定核用蓄積リング
 - 陽子過剰領域実験
 - Ni,Sn領域質量測定、寿命測定
- QGP/臨界点研究
 - LHC-ALICE実験 (ジェット、光子、HF、FoCal検出器)
 - RHIC-STAR実験 (エネルギー走査、臨界点、固定標的)
 - J-PARC-HI/E16実験 (MRPC、中性子検出器開発)
 - FAIR-CBM実験 (高密度QCD物質研究)
 - 高温・高密度領域における将来実験計画

TCHoU Workshop, Photon & Particle Detector Mar 22 (Tue), 2022, 10:00 – 12:20

Name	Topic	Room
Abderrahmane GHIMOUZ	Development of FoCal-E electronics prototype in ALICE	new PD
小沢恭一郎	J-Parc E16 experiment —low-mass e^+e^- measurements with detector challenges—	KEKホールA
丹羽駿子	1.5 THz photon counting detectors for Antarctic THz Intensity Interferometry	M2
瀧口風太	Development of wide IF band Receiver of Submillimeter Telescope for simultaneous observation of CO and Cl lines in 500GHz band	M2
北彩友海	Recent development of finely segmented AC-IGAD sensors	M1
鈴木尚紀	Precision beam tracker for the KEK AR-TB based on SDI sensor technology	M2
廣瀬茂輝	Production of microstrip silicon sensors for the HL-LHC ATLAS ITk	
中村浩二	Preparation of pixel module production for the HL-LHC ATLAS ITk	KEK講堂

TCHoU Workshop, Quark-Nuclear Matters Mar 24 (Thu), 2022, 10:30 – 18:00

March 24, Thu.	Name	Talk Title
10:30-11:00	Sarah Naimi (RIKEN)	Mass measurement with the Rare-RI Ring at RIBF/Riken elucidates r -process abundances of heavy elements at $A=122,123$
11:00-11:30	Marco Rosenbusch (KEK)	New high-precision nuclear mass studies by the first MRTOF mass spectrometer at the BigRIPS facility
11:30-12:00	Ashutosh Pandey (Tsukuba)	Identical pions femtoscopic studies in Au+Au collisions at $\sqrt{s_{NN}} = 27$ GeV with STAR at the RHIC
Break		All talks below will be in Japanese
13:30-14:10	三好康郎	相対論的重イオン衝突実験 20年
14:10-14:50	中條達也	LHC 加速器を使った重イオン衝突の物理 ～まとめと将来展望～
14:50-15:30	江角晋一	RHICエネルギー走査によるAGS・SPS領域での再挑戦
15:30-16:10	佐甲博之	J-PARCにおける高密度バリオン物質の研究計画
Break		
16:30-17:00	大久保孝祐	重イオン衝突実験における渦と磁場の研究成果
17:00-17:30	一色尊衣	重イオン衝突実験におけるバリオン粒子を用いたfemtoscopy測定
17:30-18:00	Park Hanseo	LHC-ALICE実験における中性中間子の測定