WA98からのFLOWの先へ

理化学研究所　仁科加速器科学研究センター

倉田（西村）　美月

３代目の学生

人気が高かった

核（物質の基本）

QGP（状態方程式）

TOFの開発

Nuclear Instruments and Methods in Physics Research A 349 (1994) 447–453
North-Holland

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH
Section A

Study of timing degradation and light attenuation in long plastic scintillation rods for time-of-flight counters in relativistic heavy ion experiments

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Received 24 May 1994

We have studied the timing and light yield characteristics of long and thin scintillator samples of various sizes. Both the light yield and the time resolution degrade exponentially with respect to the distance from one end; the inverse slope parameters for the time resolutions are found to be twice those of the light yield. This is interpreted in terms of a photoelectron statistics picture, which can also explain the observed position dependence of time resolution for time-of-flight counters.

1. Introduction

The time-of-flight (TOF) method provides one of the most powerful tools for identifying high-energy charged particles in conjunction with a magnetic spectrometer. A flexible multipurpose detector system named PHENIX is now being designed for the BNL-RHIC (Relativistic-Heavy-Ion Collider) experiment. The primary goals of the PHENIX experiment are to detect a new phase of matter, called the quark-gluon-plasma (QGP) phase and to measure its properties. Studies of hadrons provide important information about the collision environment, which is necessary to understand any of the QGP signal. In addition, hadronic signatures have been proposed for the observation of the QGP formation and for the chiral symmetry restoration [1]. A high resolution TOF system in PHENIX is being designed which will detect hadrons produced in RHIC experiment. As an example, with a TOF resolution of 80 ps, kaons and pions up to momentum of 2.4 GeV/c can be identified at a flight path of 5 m.

On the other hand, the segmentation of the PHENIX TOF system has to be large because of the expected large particle density in the RHIC environment [1]. For these reasons, each segment of the TOF system is required to have a thin and long scintillation counter which has time resolution of less than 80 ps. We have studied the timing and light yield characteristics as a function of position with various scintillator samples as an extension of former studies [2,3].

2. Experimental setup

Two types of experimental setup were used for data presented in this article; the setup using minimum-ionizing-particle (m.i.p.) beam and a nitrogen laser [4]. The m.i.p beam was provided at the KEK-PS-π2 beam line.

2.1. Experimental setup with m.i.p. beam

The experimental setup with the m.i.p. beam is illustrated in Fig. 1. Both the test (TEST) and start counters (STR) were made of plastic scintillators attached to two photomultiplier tubes (PMTs) on both ends. The rise time

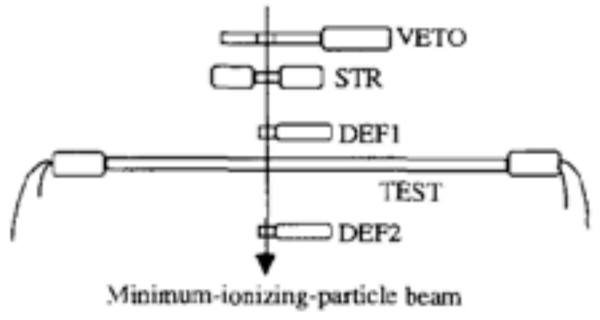

Fig. 1. Experimental setup with the m.i.p. beam. Tests were done at KEK-PS-π2 beam line.

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SSDI 0168-9002(94)00663-R

TOF @WA98 in CERN

検出器は美しくなければ動かない

三明さんの一言

おたくフローやってみぃへん？

WA98実験

プラッチックボールでフローの解析

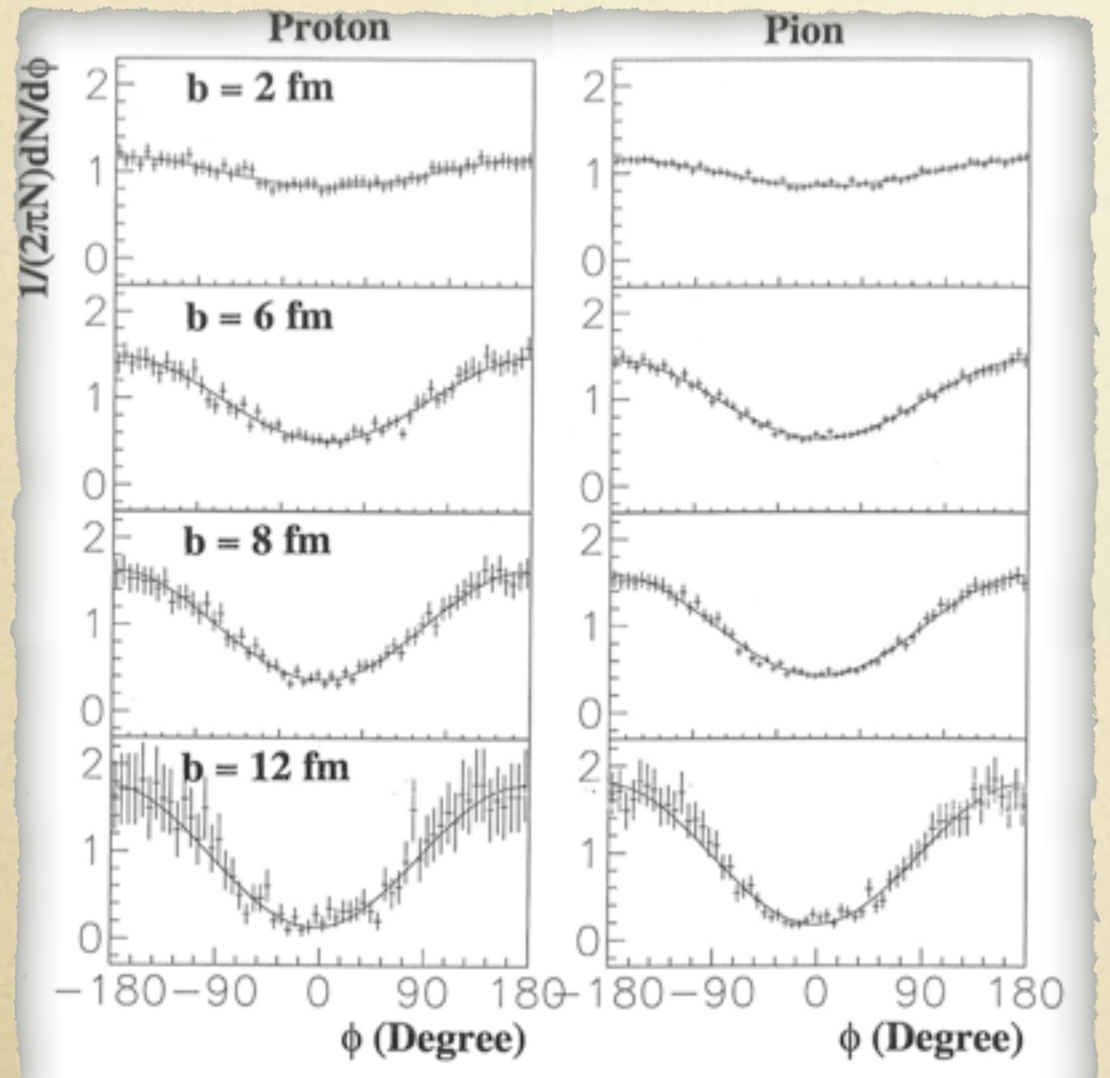
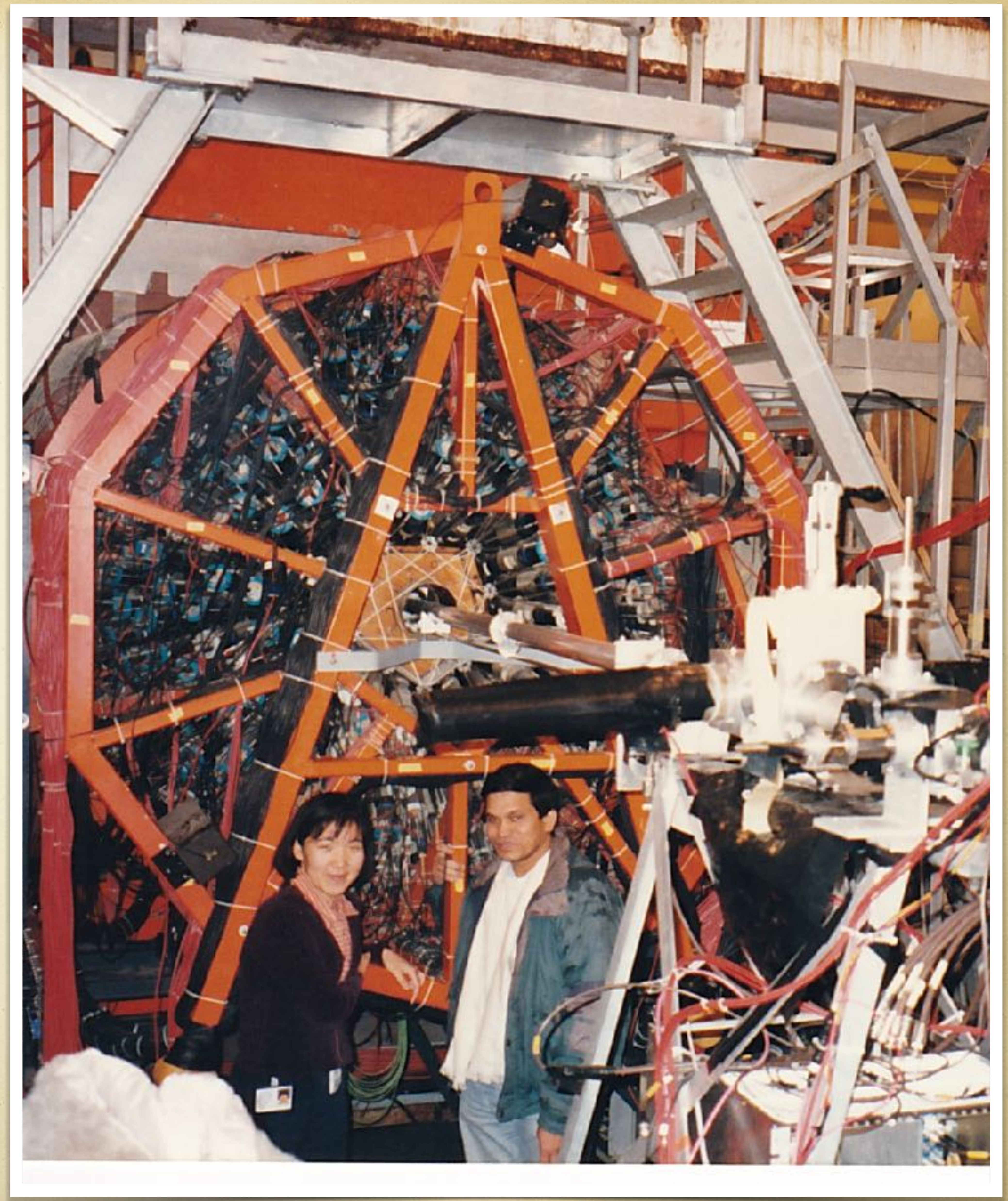


Figure 6.8: Azimuthal distributions simulated in the absorption mode (Mode II). Acceptance filter of the Plastic Ball is required. Left panels are for protons and right panels are for pions. Each corresponds to impact parameter of 2, 6, 8 and 12 fm from the top the bottom. Solid lines indicate the fitting results with Equation 5.5

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RIKENへ

- DNA ー核酸（生物の核）
- フェムト秒レーザーを使ったmRNAの発現量の解析装置

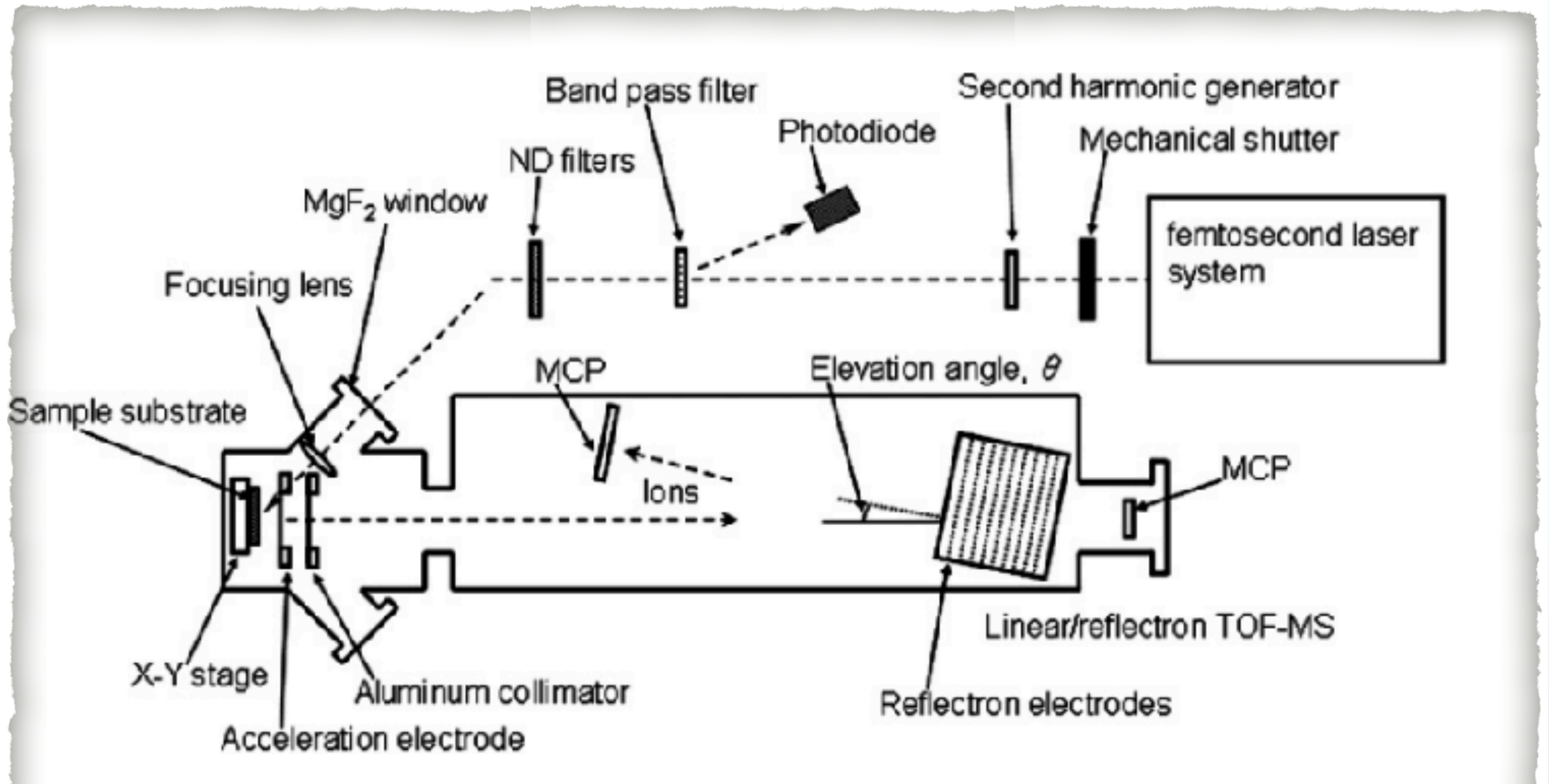

Fig. 1. Schematic of the experimental setup.

Applied Physics Express 3 (2010) 047002

Sequencing of Isotope-Labeled Small RNA Using Femtosecond Laser Ablation Time-of-Flight Mass Spectrometry

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A novel method for the analysis of sequences of small RNAs using nucleotide triphosphates labeled with stable isotopes has been developed using time-of-flight mass spectroscopy combined with femtosecond laser ablation (fsLA-TOF-MS). Small RNAs synthesized with nucleotides enriched in ^{13}C and ^{15}N were efficiently atomized and ionized by single-shot fsLA and the isotope ratios $^{13}C/^{12}C$ and $^{15}N/^{14}N$ were evaluated using the TOF-MS method. By comparing the isotope ratios among four different configurations, the number of nucleotide contents of the control RNA sample were successfully reproduced.

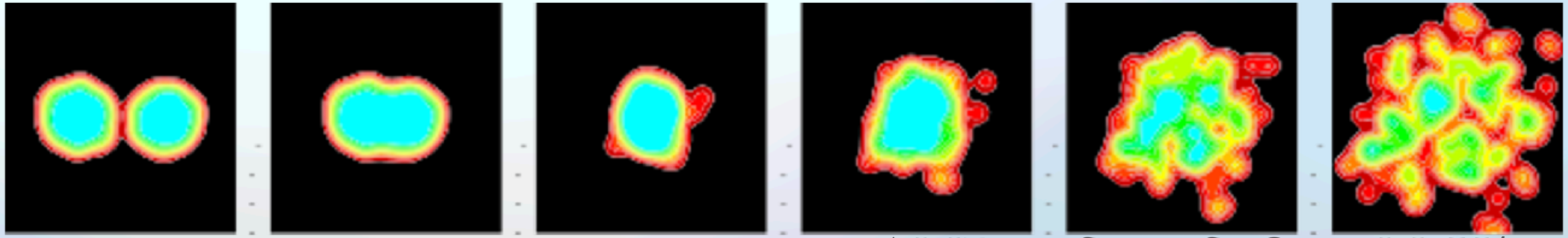
DOI: 10.1143/APEX.3.047002

MicroRNA (miRNA) is one of the small non-coding RNAs which down-regulates a gene expression by hybridizing complementary mRNA.[1,2] Most miRNA genes are transcribed as long primary transcripts (pri-miRNAs) with stem-loop structures. The stem-loop structure, which contains a mature miRNA sequence in the arm of the stem, is cleaved by a Drosha nuclear micro-processor complex which releases a precursor miRNA (pre-miRNA) hairpin [~70 nucleotides (nt)].[3,4] The pre-miRNA can be processed into a functional mature miRNA (19–23 nt) with the aid of an endonuclease dicer.[5,6] Although more than 10,000 mature miRNAs have been registered in the latest miRNA database (miRBase 14.0),[7–9] most pre-miRNA sequences have not been identified experimentally. Thus, one must rely on predictions due to lack of sound empirical data. The method of rationally cloning and sequencing can be used to identify small RNA sequences; small RNA, in which specific adaptor oligonucleotides are sequentially ligated at the 3′ and 5′ ends by a RNA ligase, are reversely transcribed and amplified by a polymerase chain reaction to be cloned and sequenced. However, it is difficult to clone the RNA that consists of a hairpin structure entirely, like those in pre-miRNA, because of low efficiencies in adaptor ligation and reverse transcriptase reactions. Thus, the development of a method to detect the sequence of a hairpin RNA without cloning is required.

The use of stable isotopes as labels is advantageous because the chemical environment in any kind of process is conserved. Furthermore, if one type of NTP is enriched in ^{13}C, the ratio $^{13}C/^{12}C$ corresponds to the number of that particular nucleotide in the RNA. When the enrichment process is applied to four different NTPs one by one and a length of an RNA is provided, the number of each component in the RNA can be determined. By applying the method proposed here, the content number of RNA could be determined without sequencing. It is then possible to identify the end position of pre-miRNA processed from pri-miRNA by the use of the Drosha enzyme.

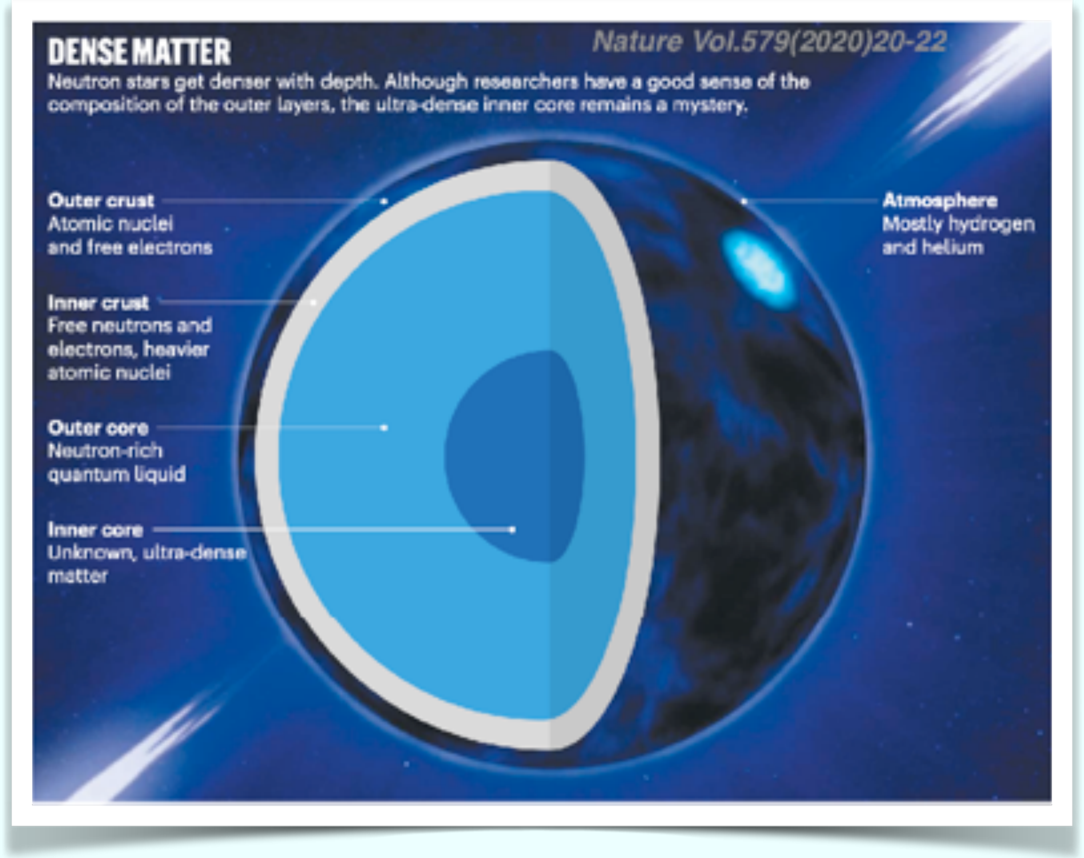
A system involving fsLA-TOF-MS is useful for determination of the isotope ratio in RNA samples since the isotope ratio is reproduced successfully, as previously reported for the analysis of Eu-DNA.[11] One advantage of the fsLA is the ability to dissociate large organic molecules completely with single-pulse irradiation; single-shot fsLA can atomize and ionize even large organic molecules with few resulting fragments. On the contrary, the use of laser pulses with longer pulse, such as nanosecond laser ablation (nsLA), results in the production of a much larger amount of fragments.[12] This feature is understood as a difference in the ablation mechanisms. Coulomb explosion induced by the fsLA[13,14] on a dielectric surface of a substrate[15] dissociates chemical bonds effectively, while the use of nsLA leads to

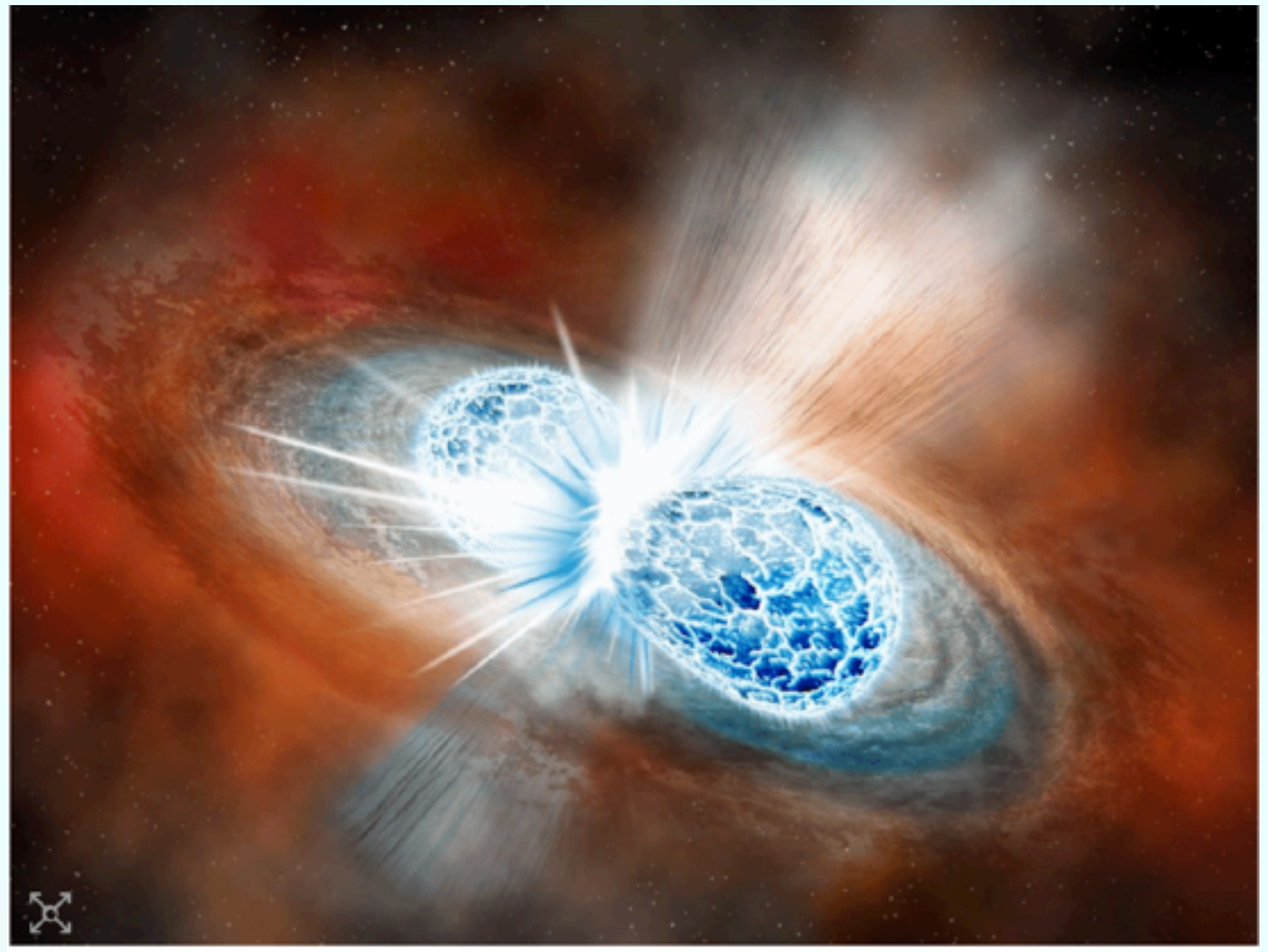
仁科センター
SpiRIT-TPC実験＠SAMURAI
重イオン衝突実験　Sn+Sn 270MeV/u

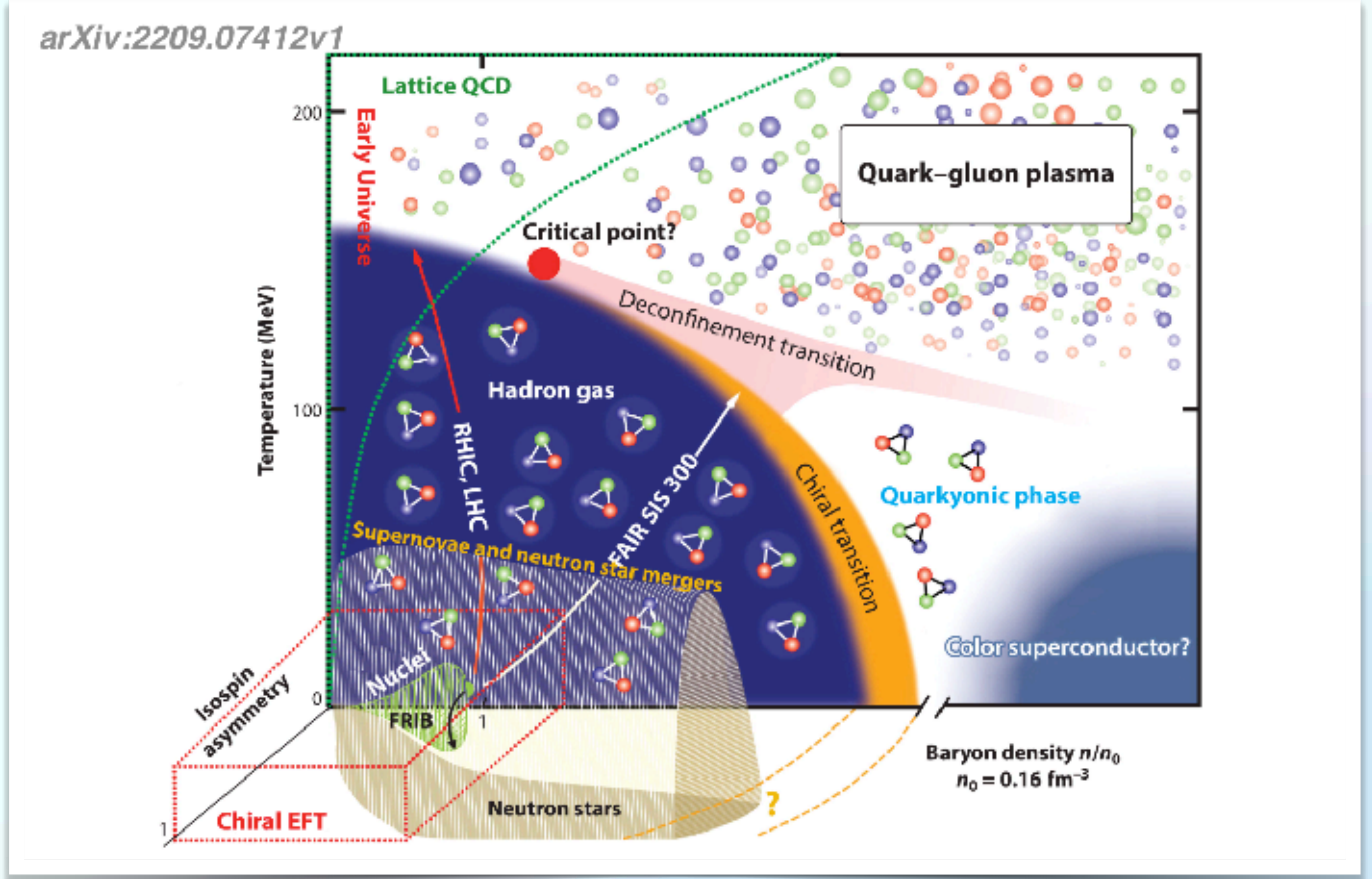


AMD: $^{132}Sn+^{124}Sn$@300MeV/u

EOS（状態方程式） for isospin asymmetric matter




Biggish bang: artist's impression of a neutron-star merger (Courtesy: NASA)

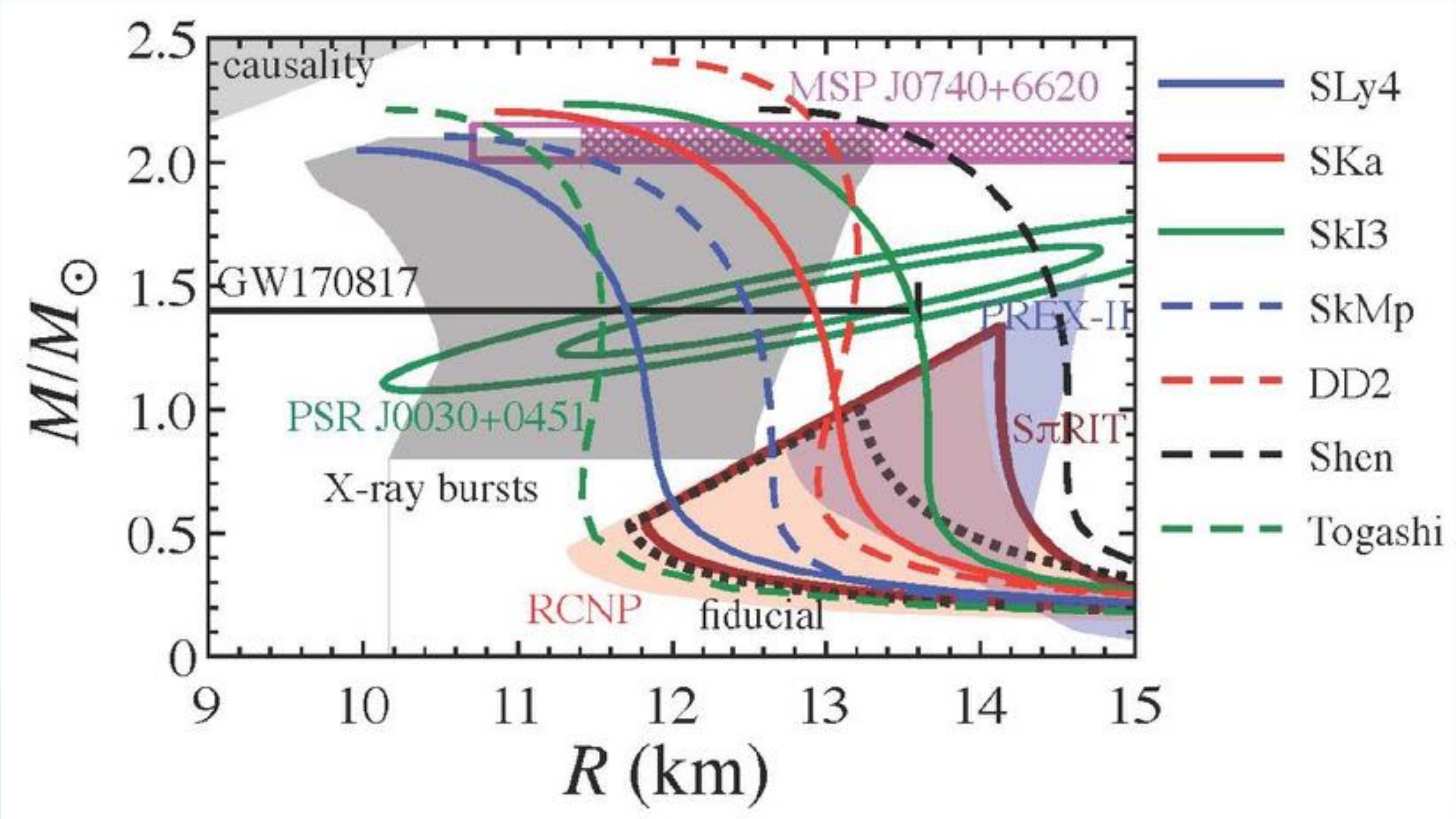


- A neutron star is the exotic object.
- The discovery of the neutron star merger by the gravitational wave highlights the importance of studying symmetry energy terms to understand the neutron star properties.

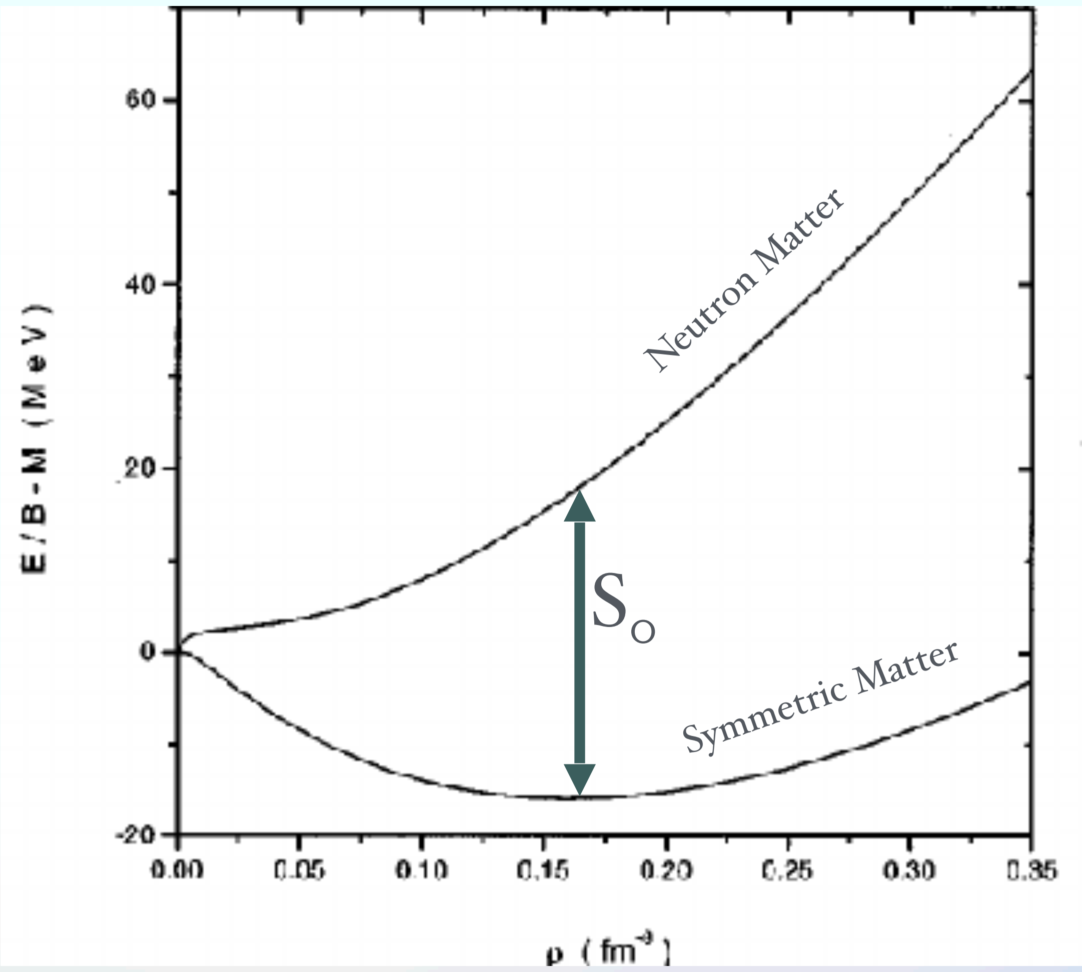
Isospin asymmetric Equation of State

$$\mathrm{E}(\rho,\delta) \approx E(\rho,\delta=0) + S(\rho)\delta^2 \quad \delta = \left(\frac{\rho_n-\rho_p}{\rho}\right)$$

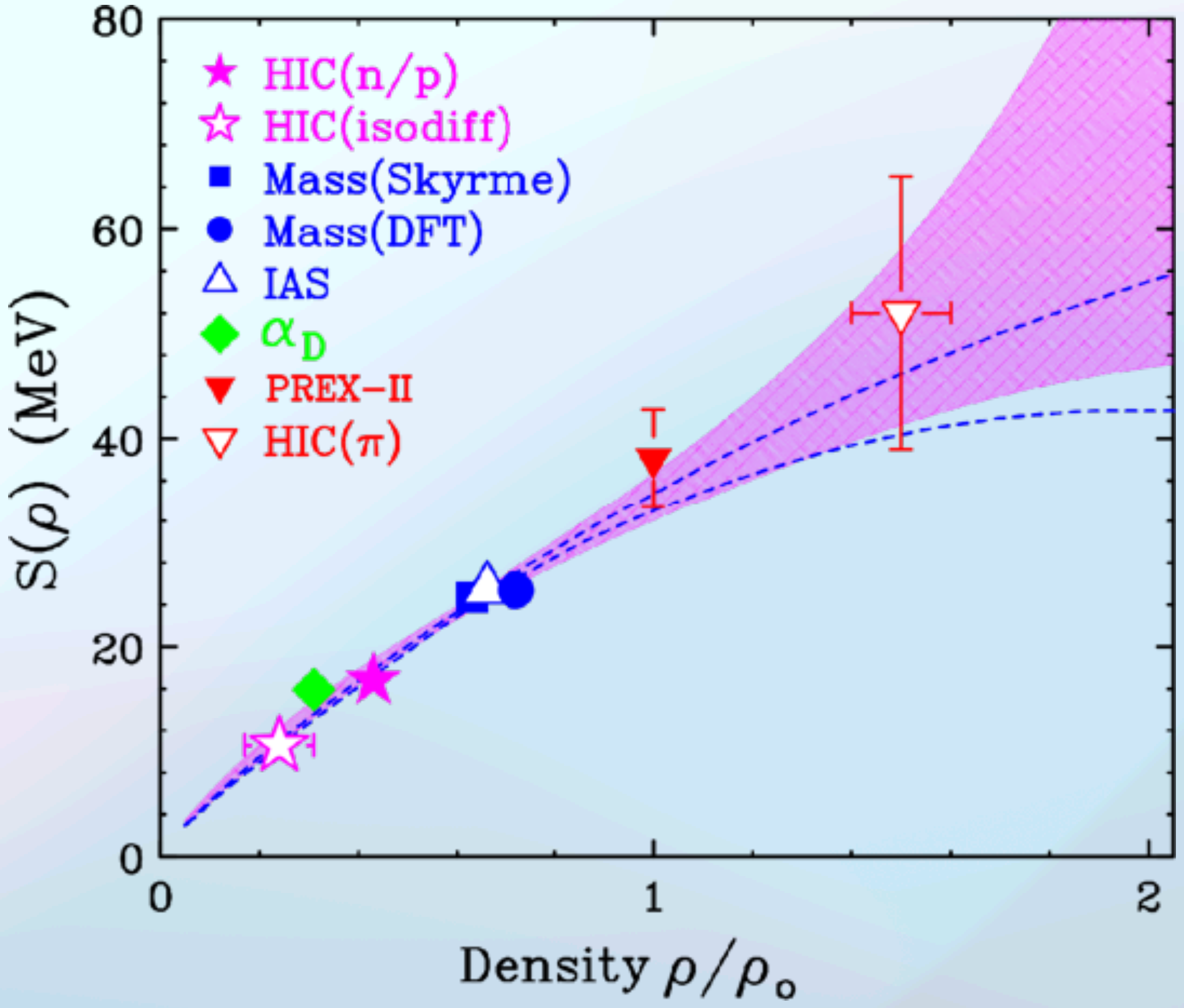
$$\mathrm{S}(\rho) = S_0(\rho_0) + \frac{L}{3}\left(\frac{\rho-\rho_0}{\rho_0}\right) + \frac{K_{sym}}{18}\left(\frac{\rho-\rho_0}{\rho_0}\right)^2$$



Symmetry Energy

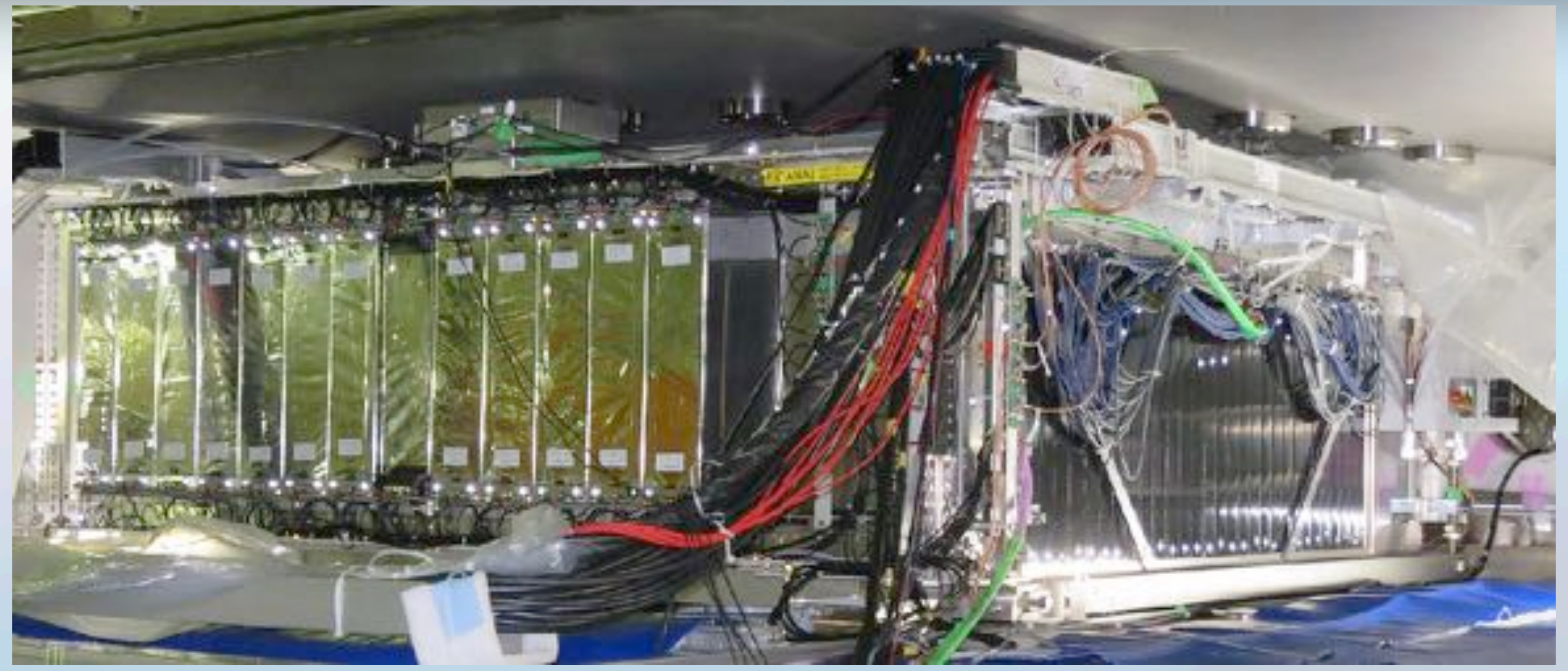


W.G. Lynch and M.B. Tsang PLB 830, 137098 (2022)



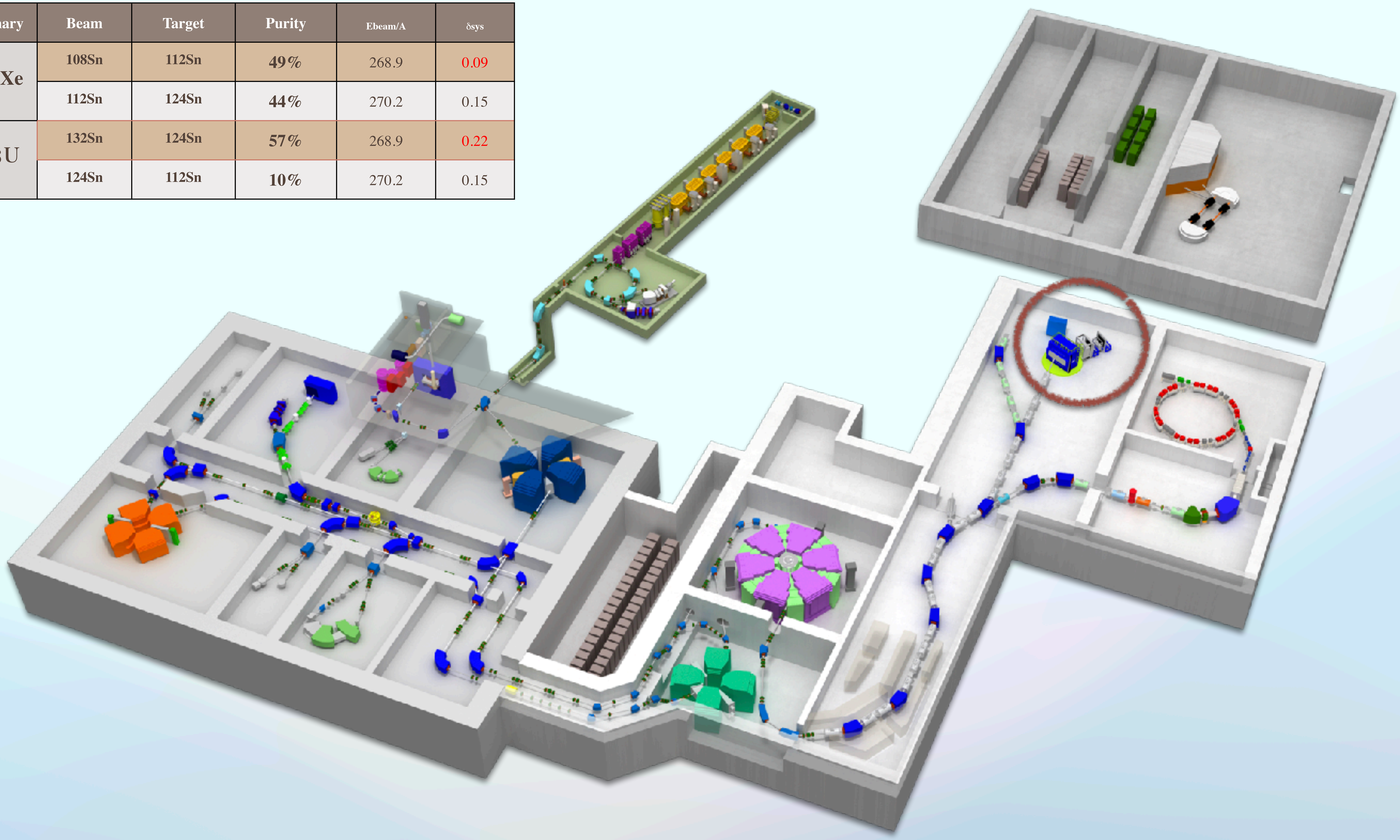
$\mathrm{S}(\rho)$, has a large uncertainty above $\rho/\rho_0 = 1$.

Collaborators

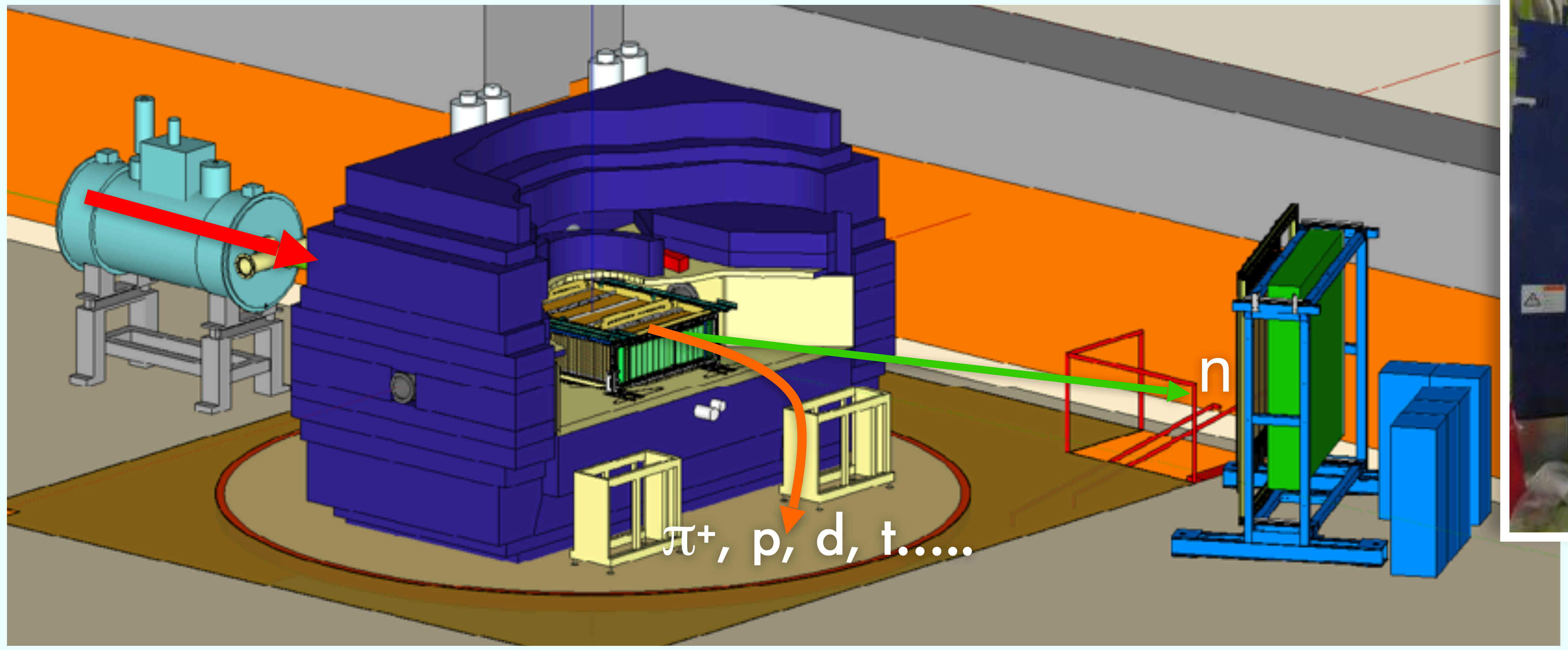


Experiment at SAMURAI in RIBF

Primary	Beam	Target	Purity	Ebeam/A	δsys
124Xe	108Sn	112Sn	49%	268.9	0.09
	112Sn	124Sn	44%	270.2	0.15
238U	132Sn	124Sn	57%	268.9	0.22
	124Sn	112Sn	10%	270.2	0.15



SπRIT-TPC Experiment



SπRIT-TPC was installed inside the SAMURAI dipole magnet.

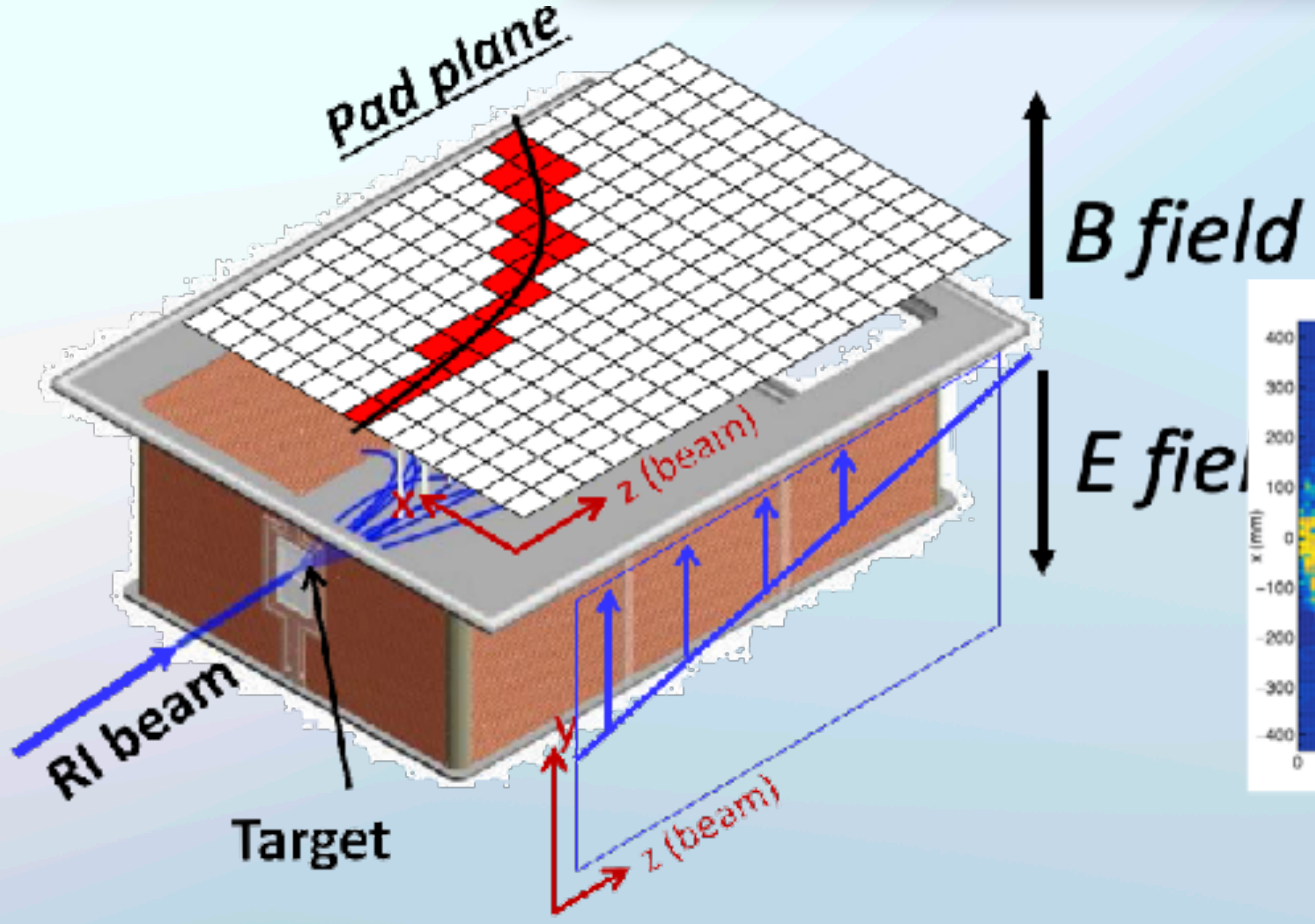
- Magnetic field: 0.5 Tm.

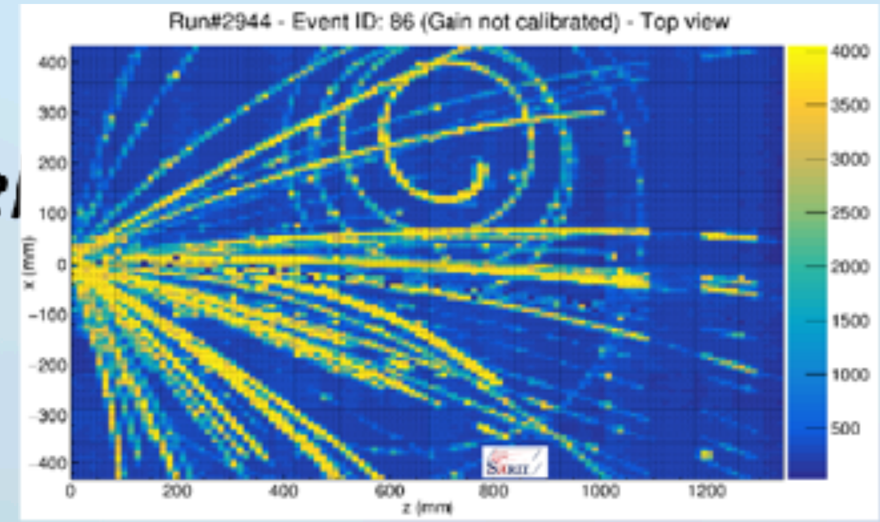
^{132}Sn + ^{124}Sn ($\delta \sim 0.22$), ^{108}Sn + ^{112}Sn ($\delta \sim 0.09$)

- Incident energy: 270MeV/u

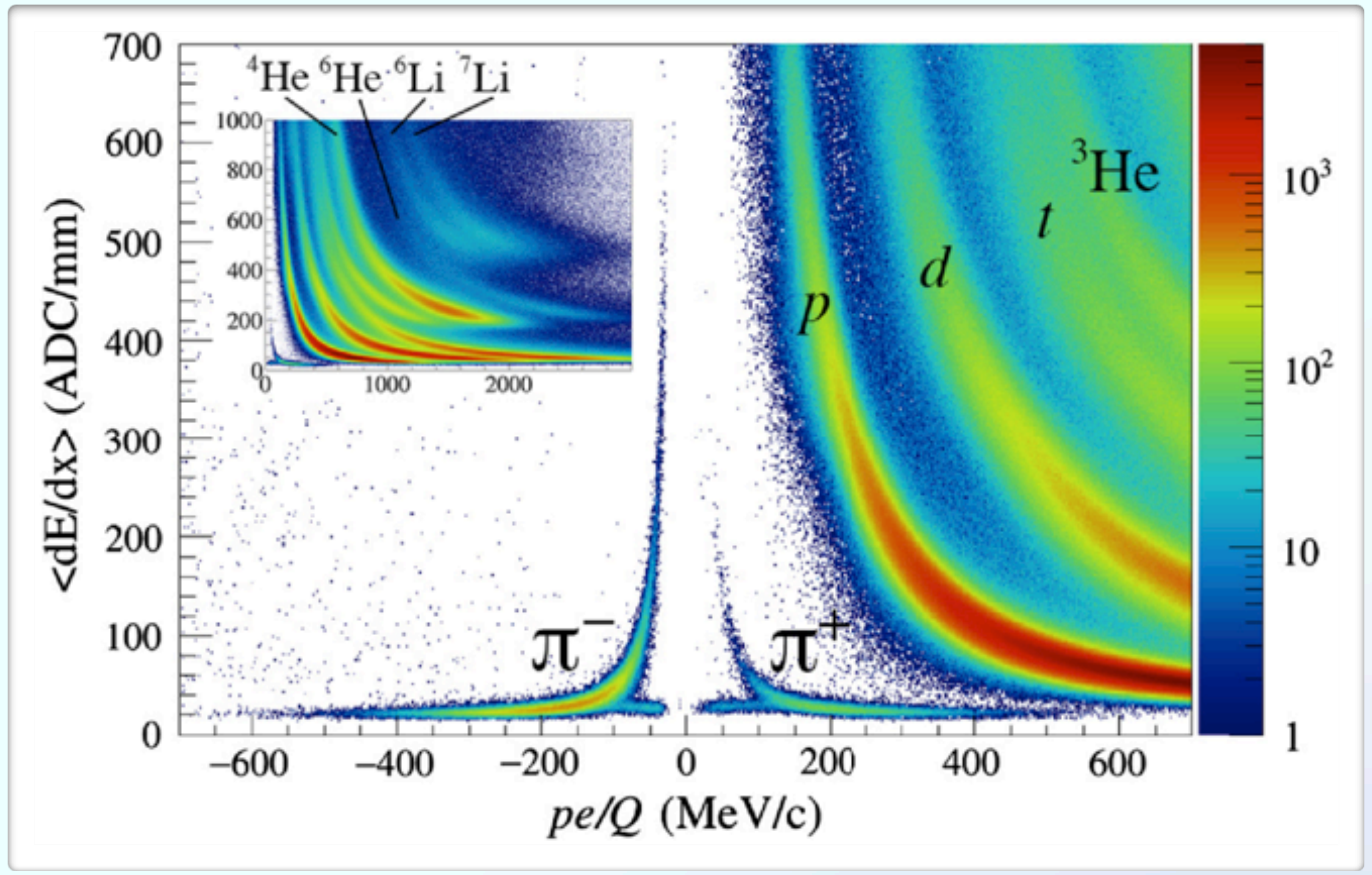
Centrality selection

- Central. (DATA) $b_0 < 0.15$ (AMD) 0 - 2 fm
- Mid-central (DATA) $0.15 < b_0 < 0.36$ (AMD) 2 - 4 fm



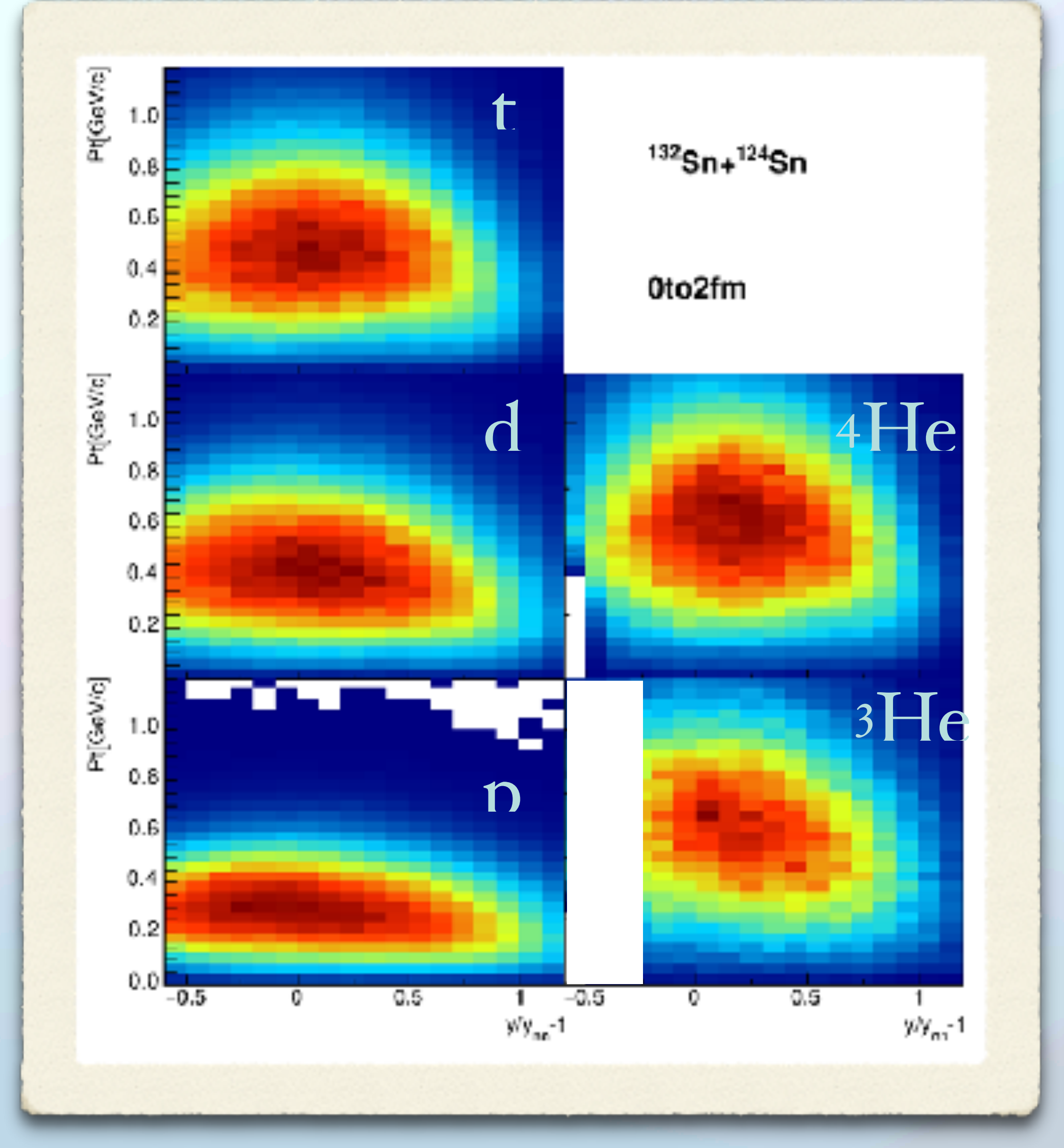


PID and Acceptance



- Particle identification was good.
- Observables, p, d, t, ^{3}He, ^{4}He (A$\leq$4)

- We covered a large acceptance.
- Analysis within
  - Mid-central: $0.15 < b_0 < 0.36$
  - Proton, deuteron , triton, and ^{4}He in $-0.5 < (y/y^{cm}_{NN} - 1) < 1$
  - ^{3}He in $-0.3 < (y/y^{cm}_{NN} - 1) < 1$
  - To reduce the contamination from triton onto ^{3}He.
  - $(-30^\circ < \phi < 20^\circ) \cup (160^\circ < \phi) \cup (-150^\circ > \phi)$

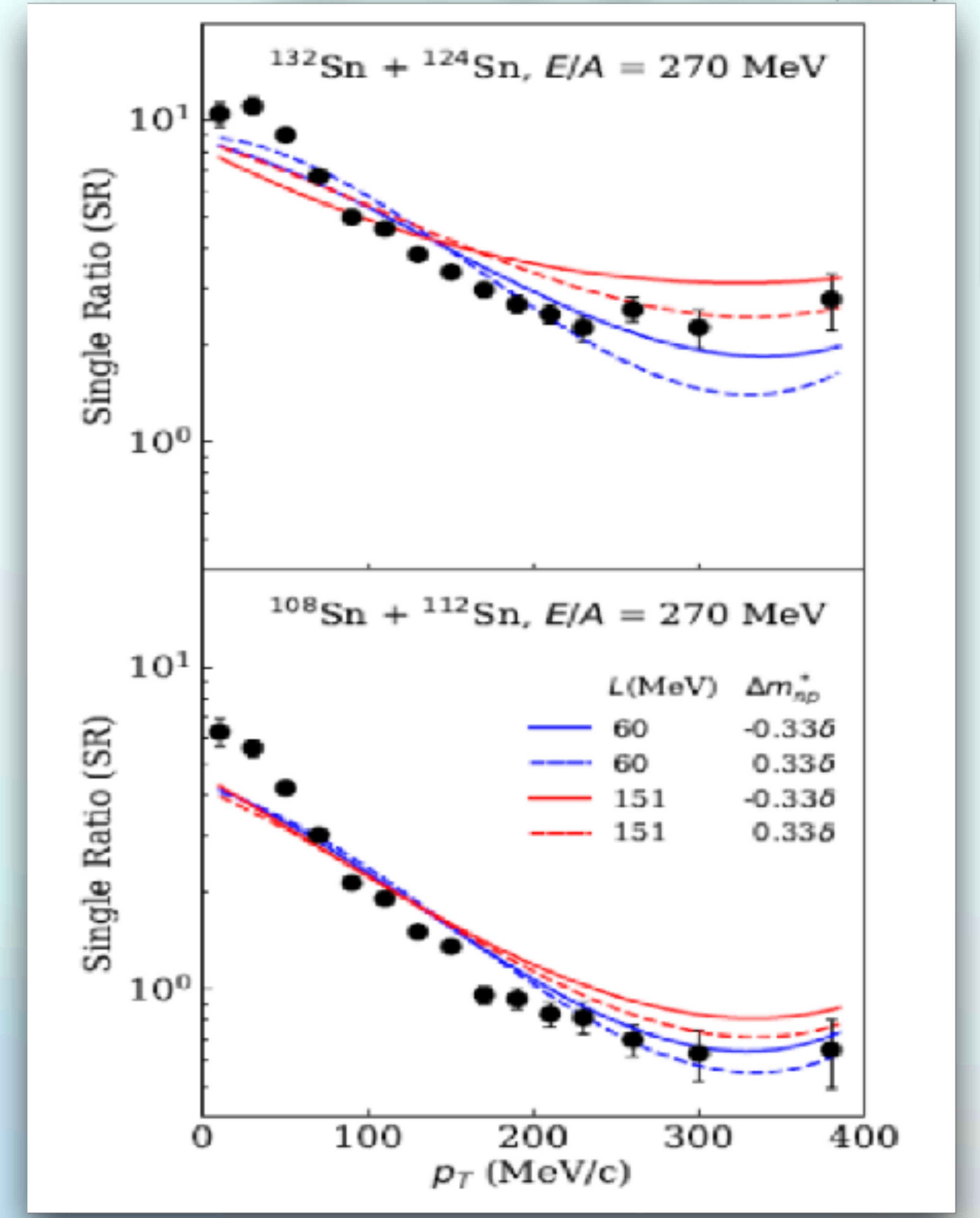


Previous results from SπRIT

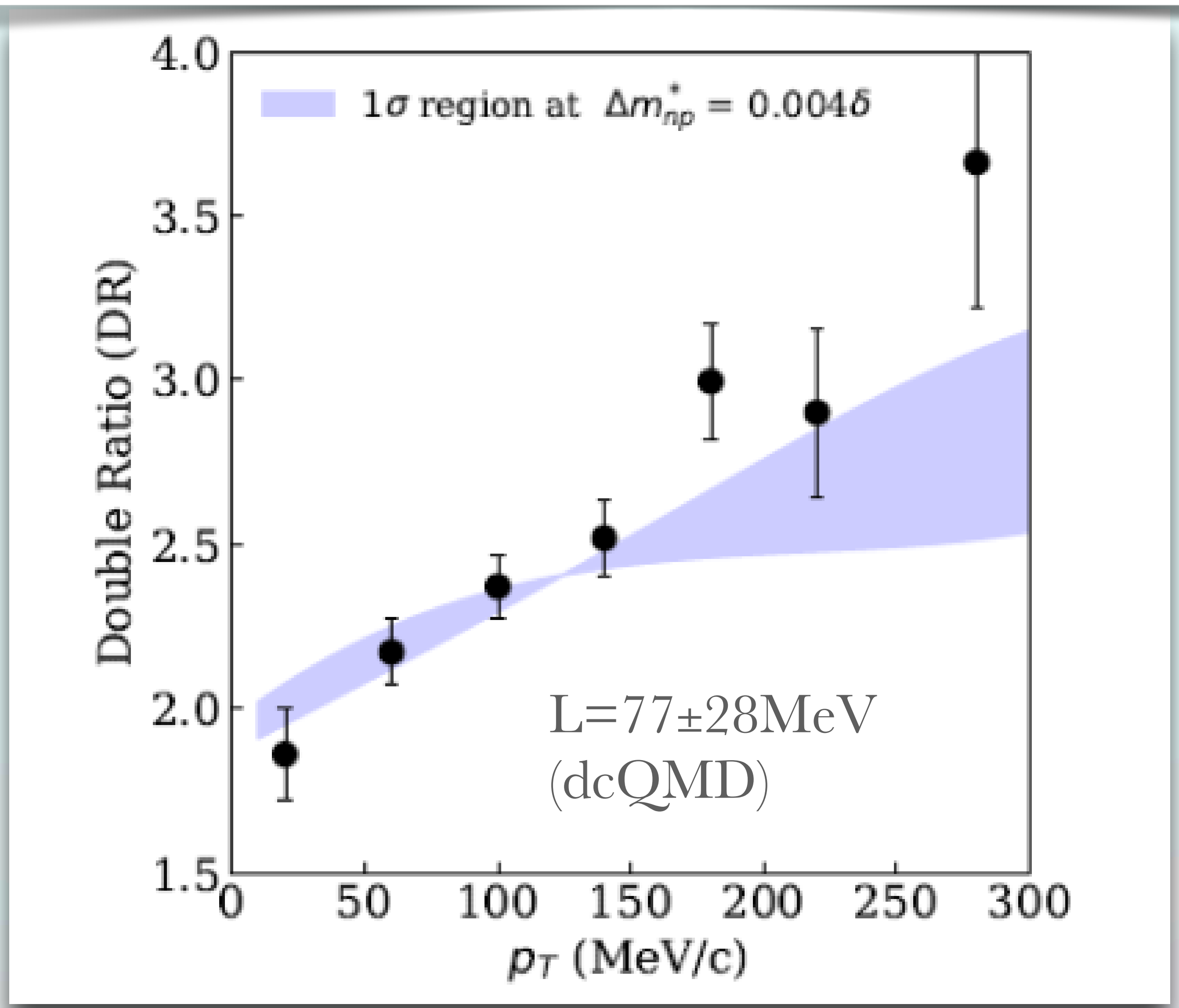
$$\frac{{}^{108}\mathrm{Sn} + {}^{112}\mathrm{Sn}(\delta \sim 0.22)}{{}^{132}\mathrm{Sn} + {}^{124}\mathrm{Sn}(\delta \sim 0.09)}$$

π^-/π^+ ratio for neutron rich and poor system

Estee et al, PRL **126**, 162701 (2021)

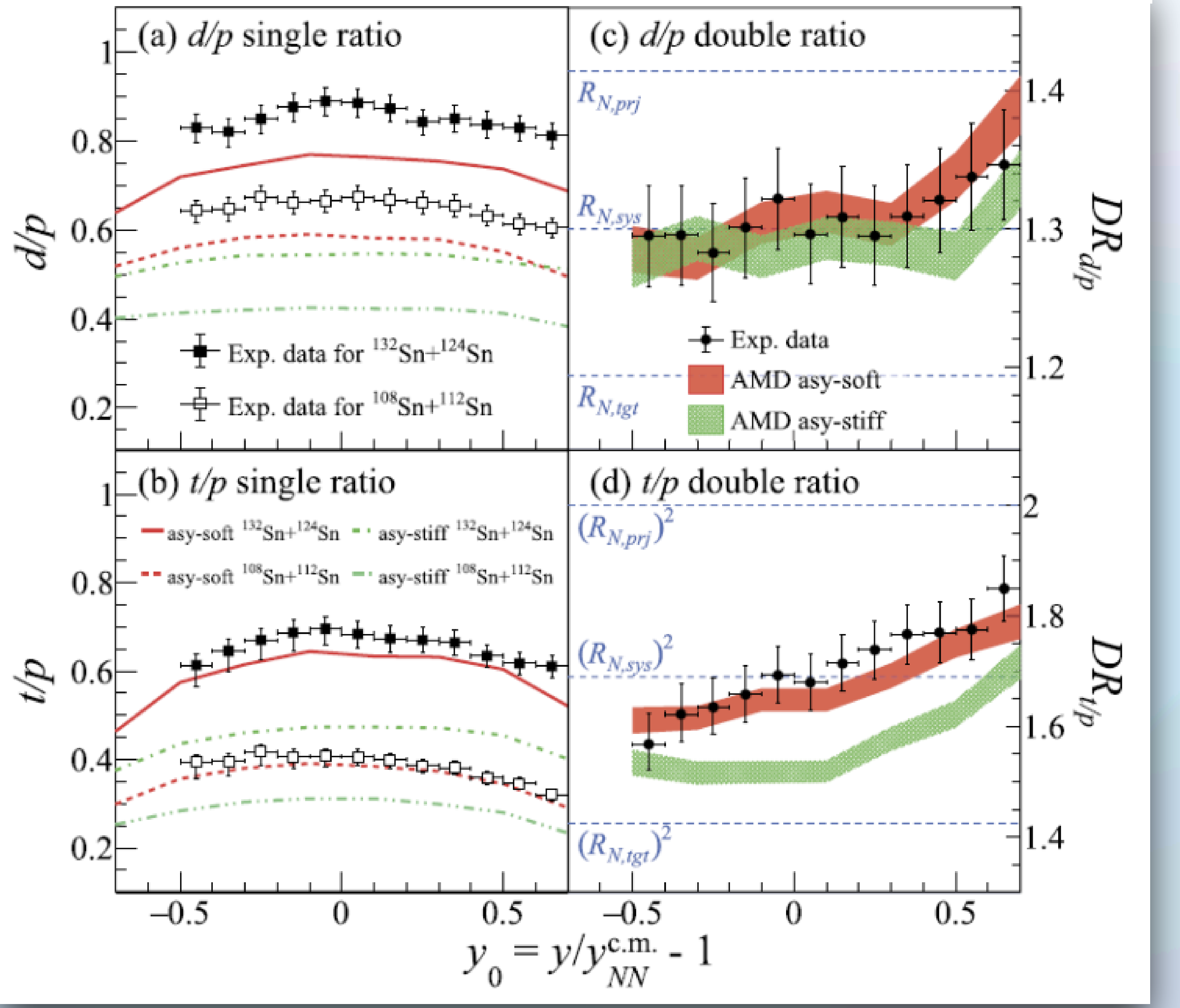


π^-/π^+ double ratio for two system



Ratios of Hydrogen isotopes

M. Kaneko, A ono, et al., PLB822146681(2021)



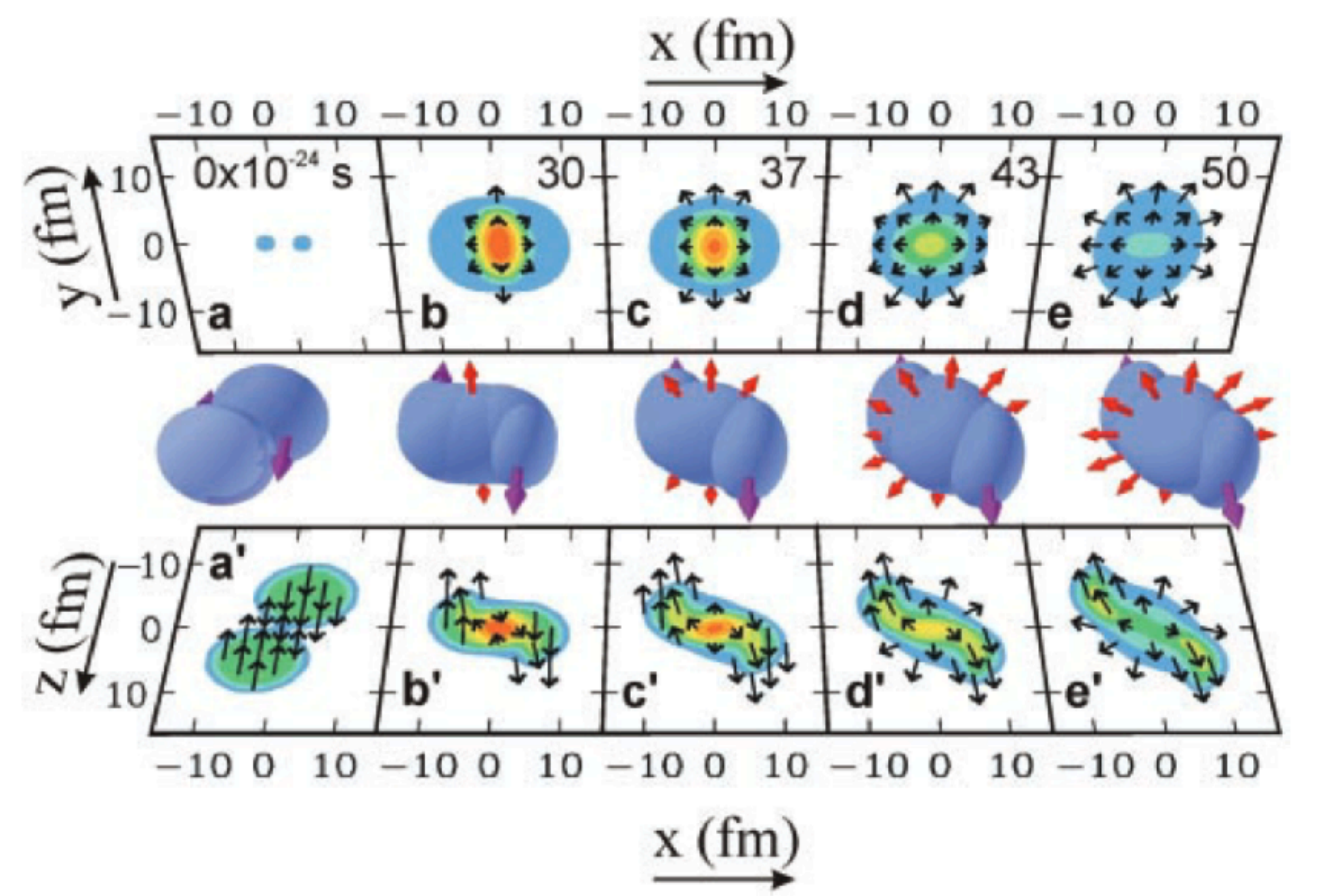
Additional information is required.

Heavy Ion Collision with finite impact parameter

Danielewicz et al., Science 298,1592 (2002).

Pressure

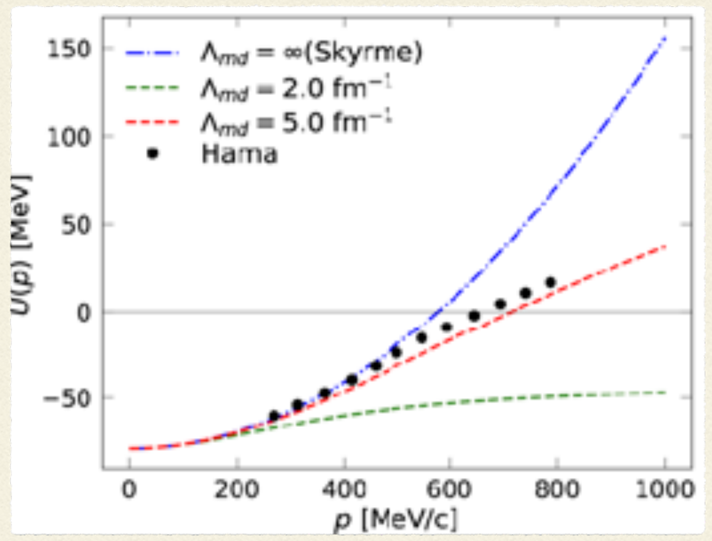
Density

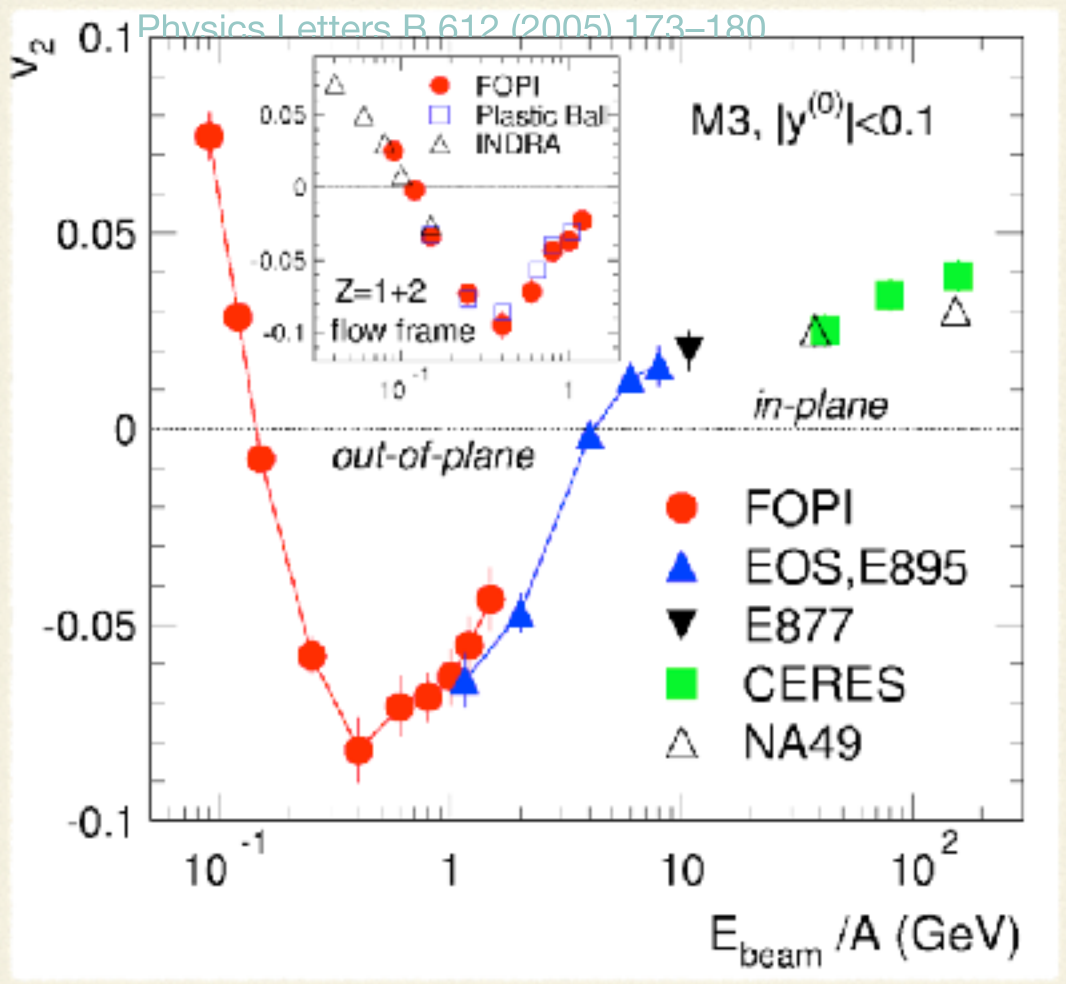


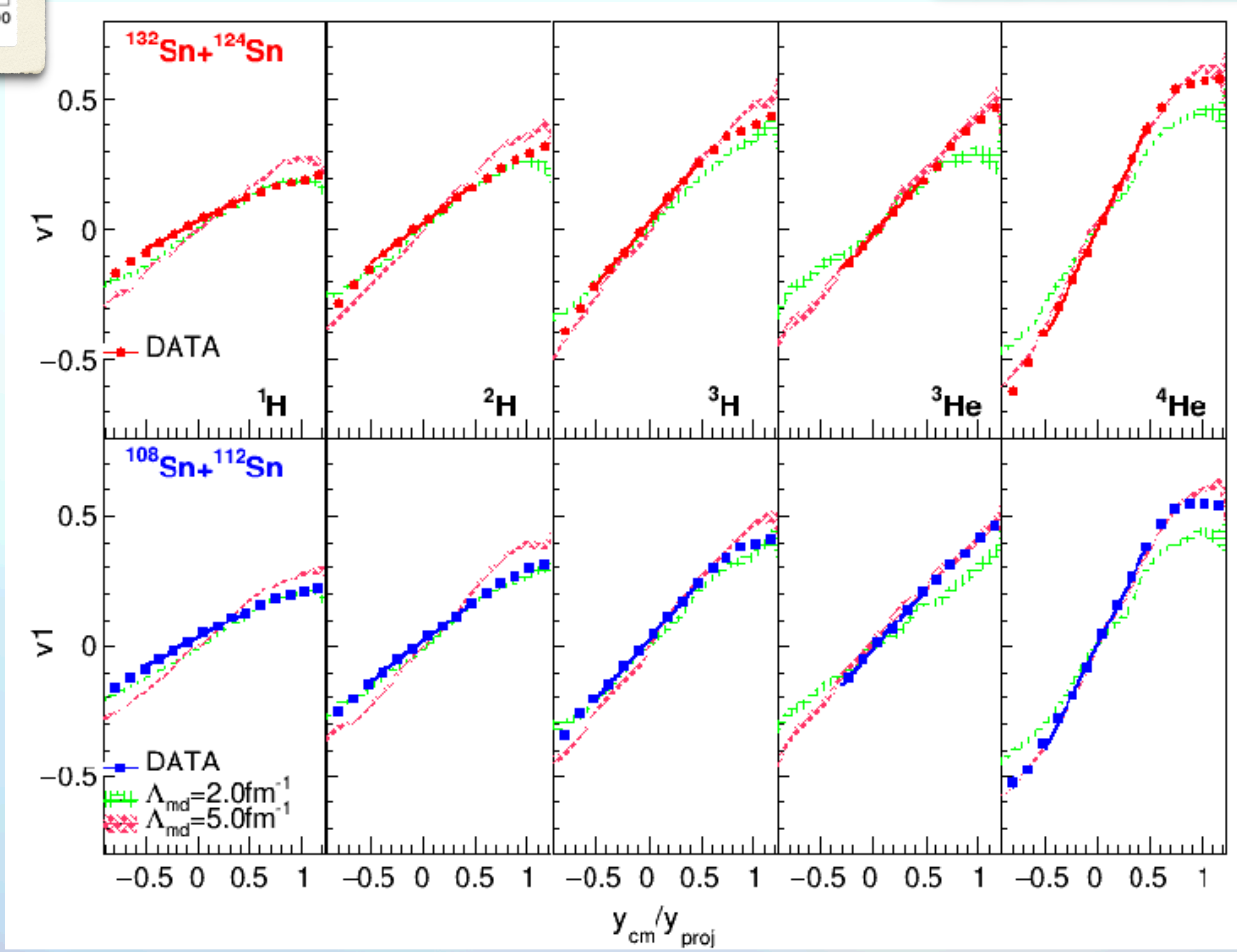
$$\frac{1}{N}\frac{dN}{d\Delta\phi} = 1 + 2v_1\cos(\Delta\phi) + 2v_2\cos(\Delta\phi) \qquad \Delta\phi_i = \phi_i - \Psi$$

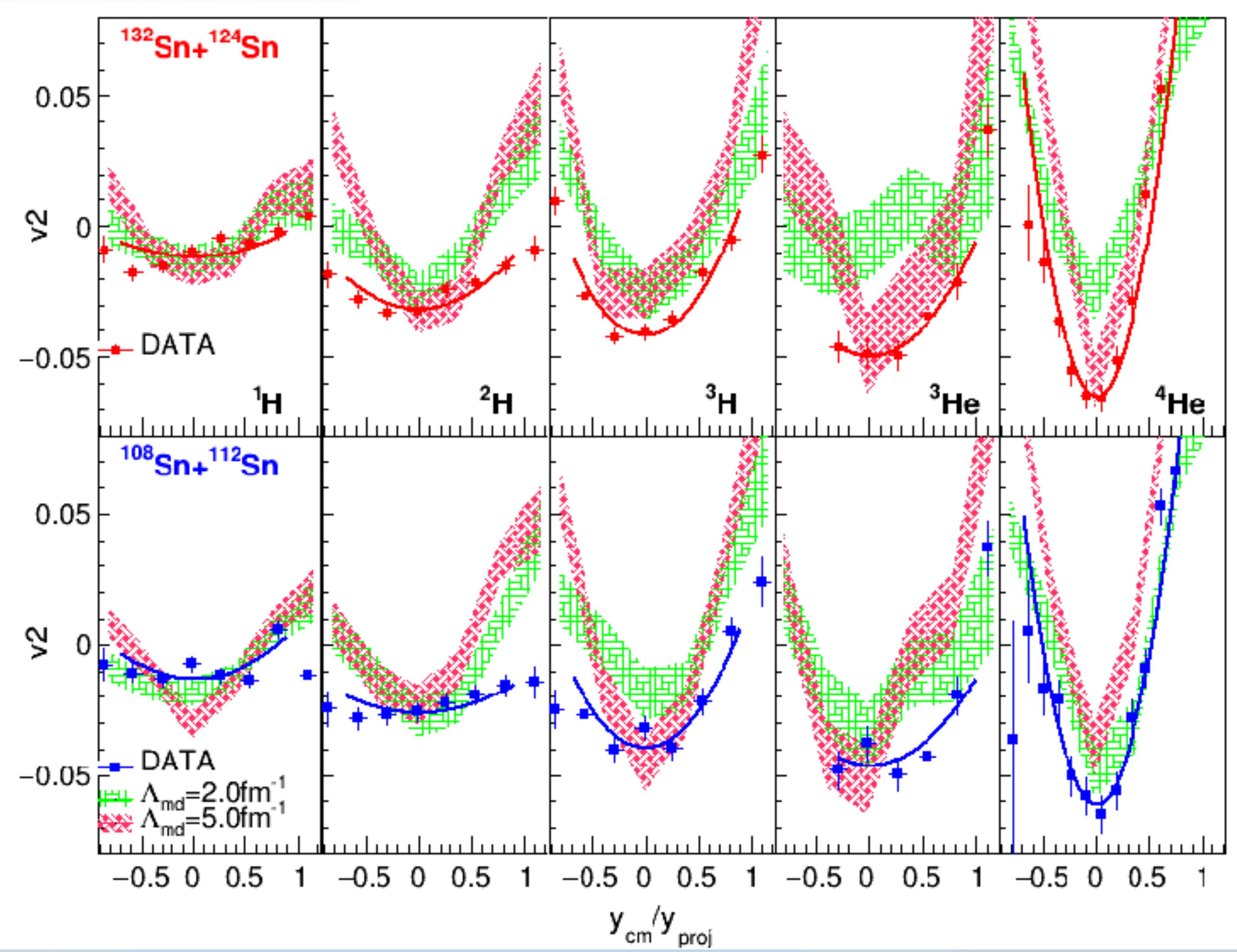
Collective flow is observed as a results of high pressure and density matter.

Collective Flow









3D Flow anaysis

PHYSICAL REVIEW C **105**, 034608 (2022)

Featured in Physics

Deblurring for nuclei: 3D characteristics of heavy-ion collisions

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(Received 6 September 2021; revised 29 December 2021; accepted 24 January 2022; published 9 March 2022)

Observables from nuclear and high-energy experiments can be degraded by detector performance and/or methodology in extracting the observables, such as of the final-state characteristics of heavy-ion collisions in relation to a coarsely estimated reaction-plane direction. We propose the use of deblurring methods, such as in optics, to correct for observable degradation. Our main focus is the restoration of triple-differential particle distributions in heavy-ion collisions. We demonstrate that these could be extracted from collision measurements following the Richardson-Lucy deblurring method from optics. We illustrate basic features of the restoration methodology in a schematic model assuming either ideal or more realistic particle detection. The inferred three-dimensional (3D) distributions for collisions may be easier to interpret in terms of collision dynamics and sought properties of bulk matter than the currently employed Fourier coefficients, that combine information from different azimuthal angles relative to the reaction plane.

DOI: 10.1103/PhysRevC.105.034608

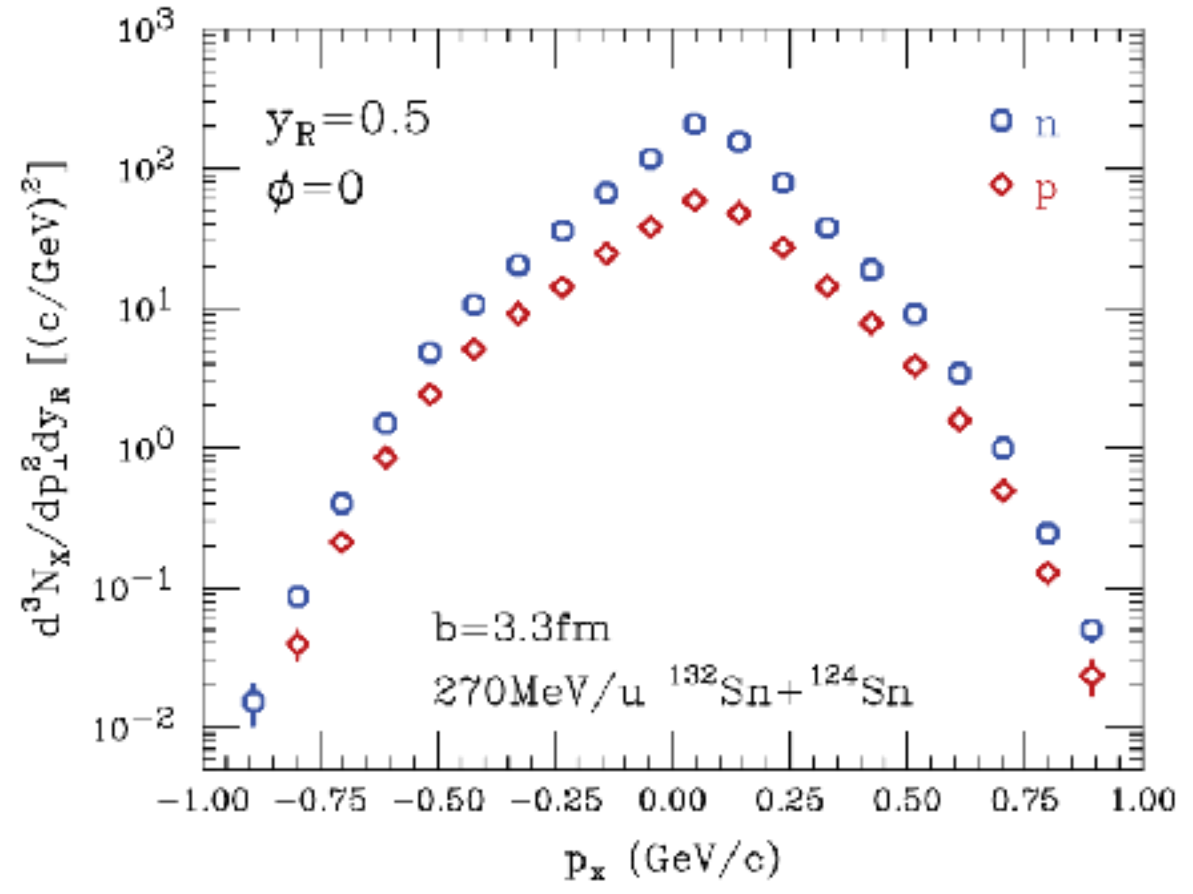


FIG. 10. Triple differential distributions in the reaction plane at $y_R = 0.5$, for neutrons (circles) and protons (diamonds), from the pBUU simulations of $^{132}Sn + ^{124}Sn$ collisions at 270 MeV/nucleon and $b = 3.3$ fm. The rapidity y_R is here in the nucleon-nucleon center of mass and normalized to the beam.

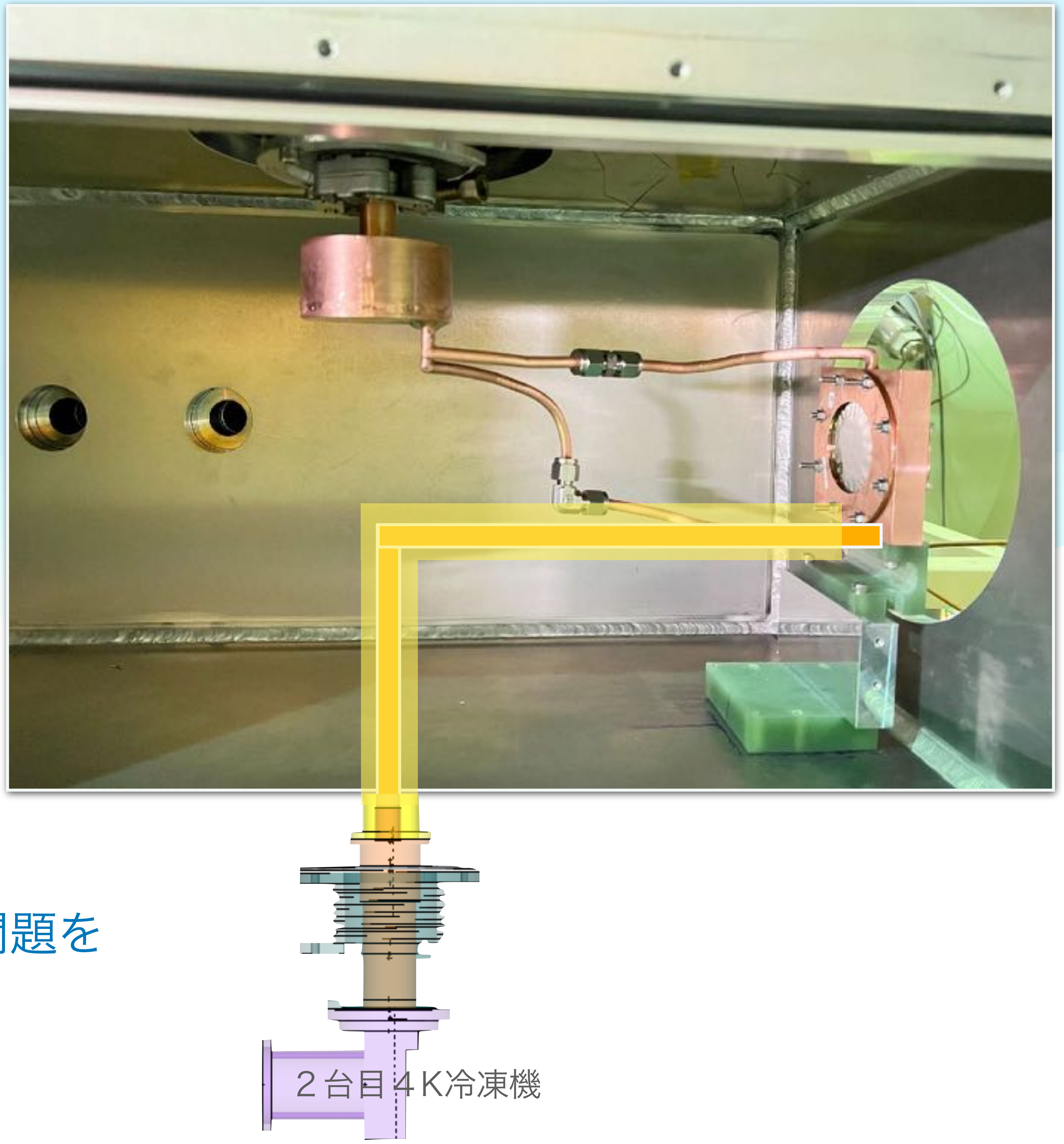
検出器開発

項目	内容
CRYPTA	２段冷却システム
BigRIPSビームライン検出器群の開発・維持管理	検出器の維持管理
SAMURAI電磁石維持管理	SAMURAI電磁石の立ち上げ、稼働
産業利用課題	実験のサポート、検出器整備・開発

CRYPTAの開発

２段階冷却式

- ターゲットセルを２台目の冷凍機（４K冷凍機）で直接冷却することで、温度を保つ。
- 外から流入する放射熱の熱量により部分的に温度上昇が生じ、薄膜が破損したり、多くの気泡が発生することで標的としての一様性を担保できない可能性を必ずしも除去しきれていない問題が残されている。



- ターゲットセルを臨界点よりも低い温度に保つことで気泡の問題を大幅に解消することが出来ると考えている。
- 冷却時間を短縮できる
- ビーム軸上でバックグランドとなるターゲット周りのヒートシールドの素材を薄くすることも実現できる

三明さん
お疲れ様でした。
研究者としてのFLOW（道）を作ってくださり
本当にありがとうございました。