^{96}Zr beam acceleration for isobar experiment in RHIC

To investigate chiral magnetic effect, ^{96}Zr and ^{96}Ru beams have been accelerated at relativistic heavy ion collider (RHIC) in Run18 at Brookhaven National Laboratory (BNL). ^{96}Zr and ^{96}Ru beams were provided from electron beam ion source (EBIS) injector and tandem Van de Graaff, respectively. In the presentation, ^{96}Zr beam production and acceleration are reported.

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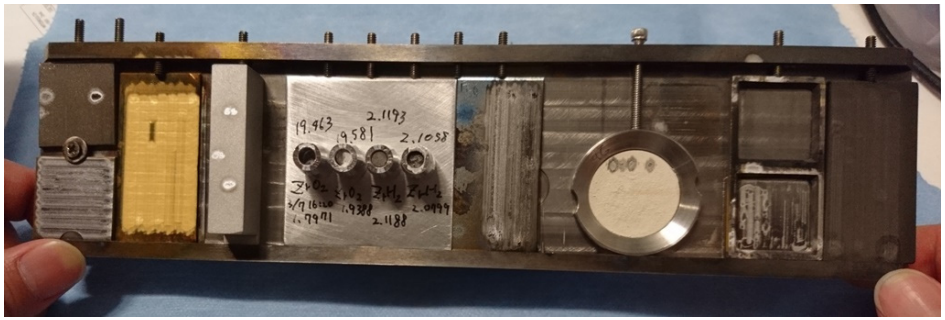
Study of enriched ^{96}Zr beam production has started from Feb. 2017.



Metal Zr plate showed the best performance.
Zr hydride could last for several hundreds laser shots.
ZrO2 compressed powder could stand only a few laser shot.

Mass number	90	91	92	94	96
Natural	51.45 %	11.22 %	17.15 %	17.38%	2.8 %
Enriched	19.27 %	5.10 %	7.86 %	8.17 %	59.60 %

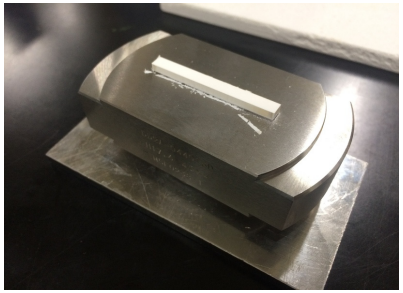
1.0 g of enriched Zr = almost a compact car
We needed estimate accurate consumption rate.

Natural abundance of ^{96}Zr is only 2.8%.
Metal enriched Zr plate was not available, although target performance is great.
Enriched Zr hydride was not available at that time.
Only choice was ZrO_2 powder which can be obtained in the market.

→ We needed to develop a new laser target using enriched ZrO_2 powder.

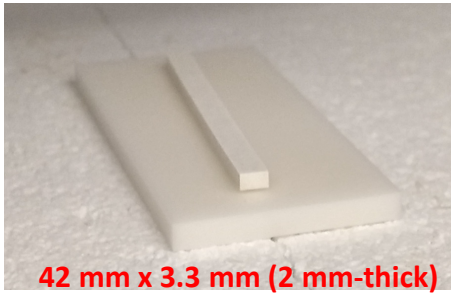
Development of sintered enriched Zr laser targets.

Using natural abundance ZrO2 powder, sintering process was developed in RIKEN.



Compressed in die (several tons)

Heated in oven up to 1400 ℃



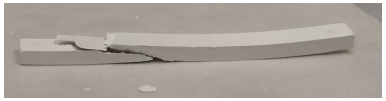
Sintered enriched target made in BNL

Die, compression pressure and temperature control were studied. ~ Mar. 2018

6 pieces 1.5 g enriched targets were prepared. ~ June. 2018

Recycling process from used targets was studied and established in RIKEN. ~ July, 2017

0.5 g of enriched hydride sample was produced for back up operation of the Tandem accelerator. ~ May, 2018



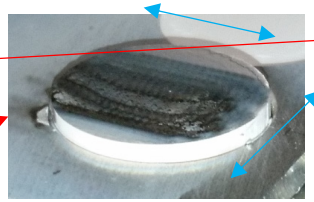
Sintering failed

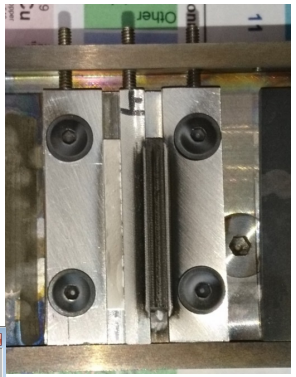
Intensive study of the enriched target had been carried out through mid of the RUN18 (Feb. 27 ~ May. 6).

Laser irradiation condition study

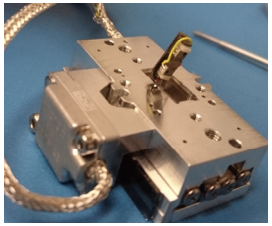
Using natural abundance ZrO_2 targets, huge patterns of laser irradiation conditions had been tested.

Target consumption had to be minimized.

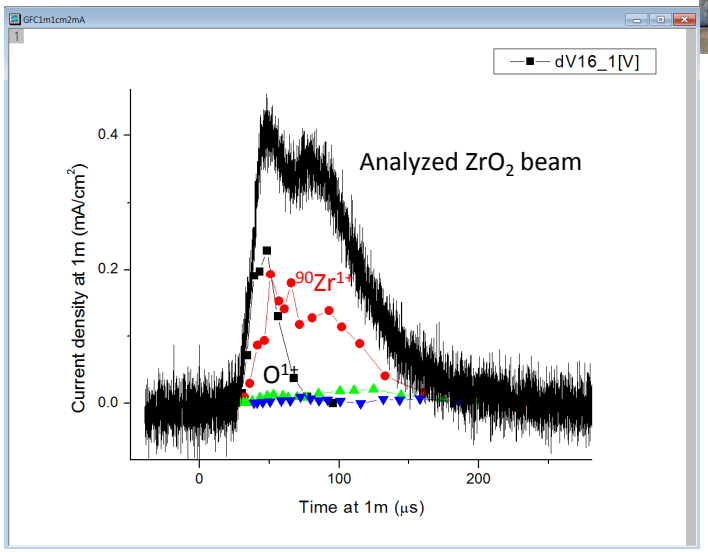




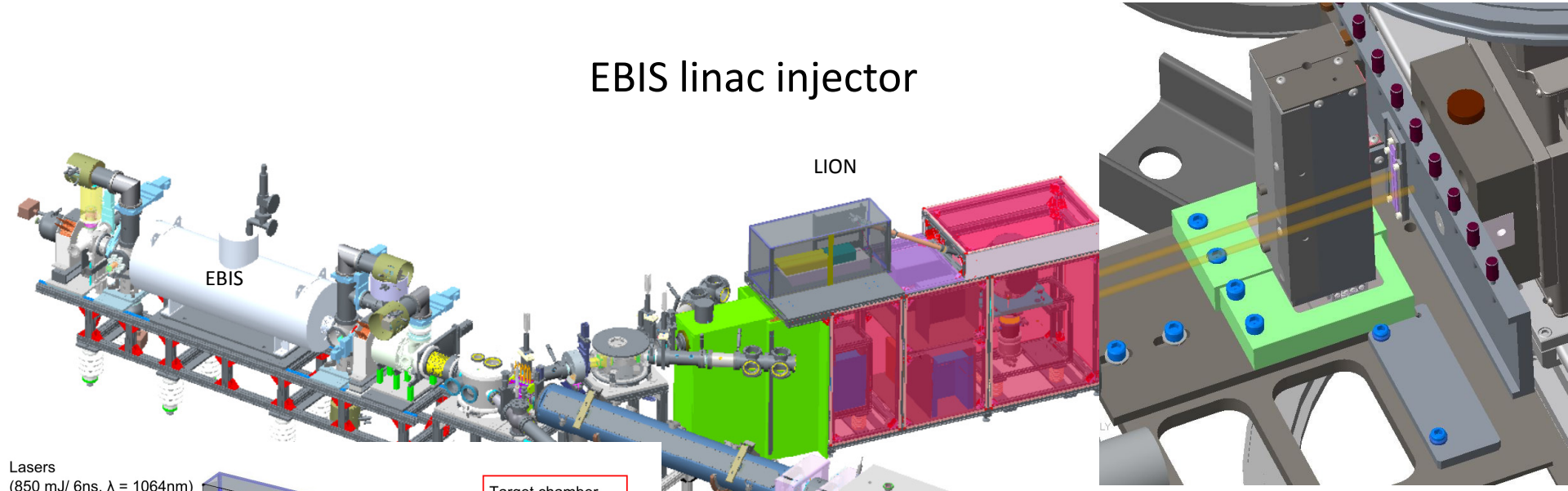
- What is the adequate target shape?
- Laser energy.
- Laser pot size.
- Target scanning direction VS. incident laser angle.
- Target scanning velocity.
- Estimate consumption rate.
- New mechanism to move and hold the targets.
  (Piezo Vs. Stepper motor)
- Laser spot positions for RHIC and NSRL.



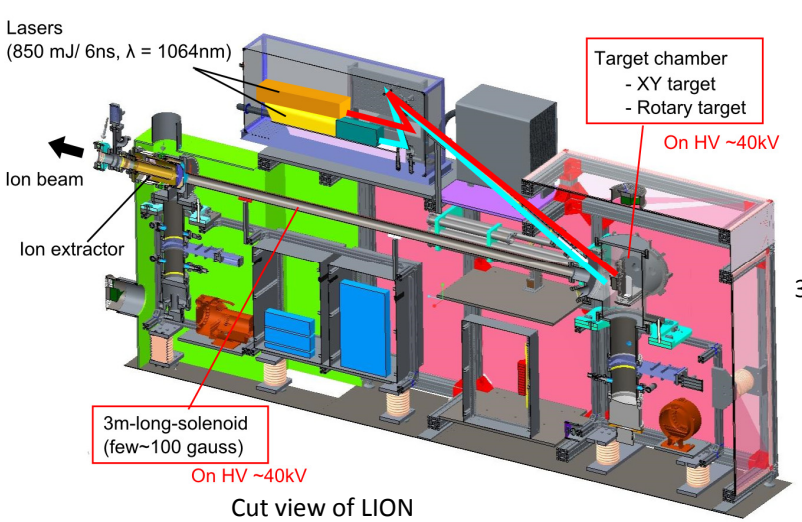
Piezo was weak for micro particle



EBIS linac injector

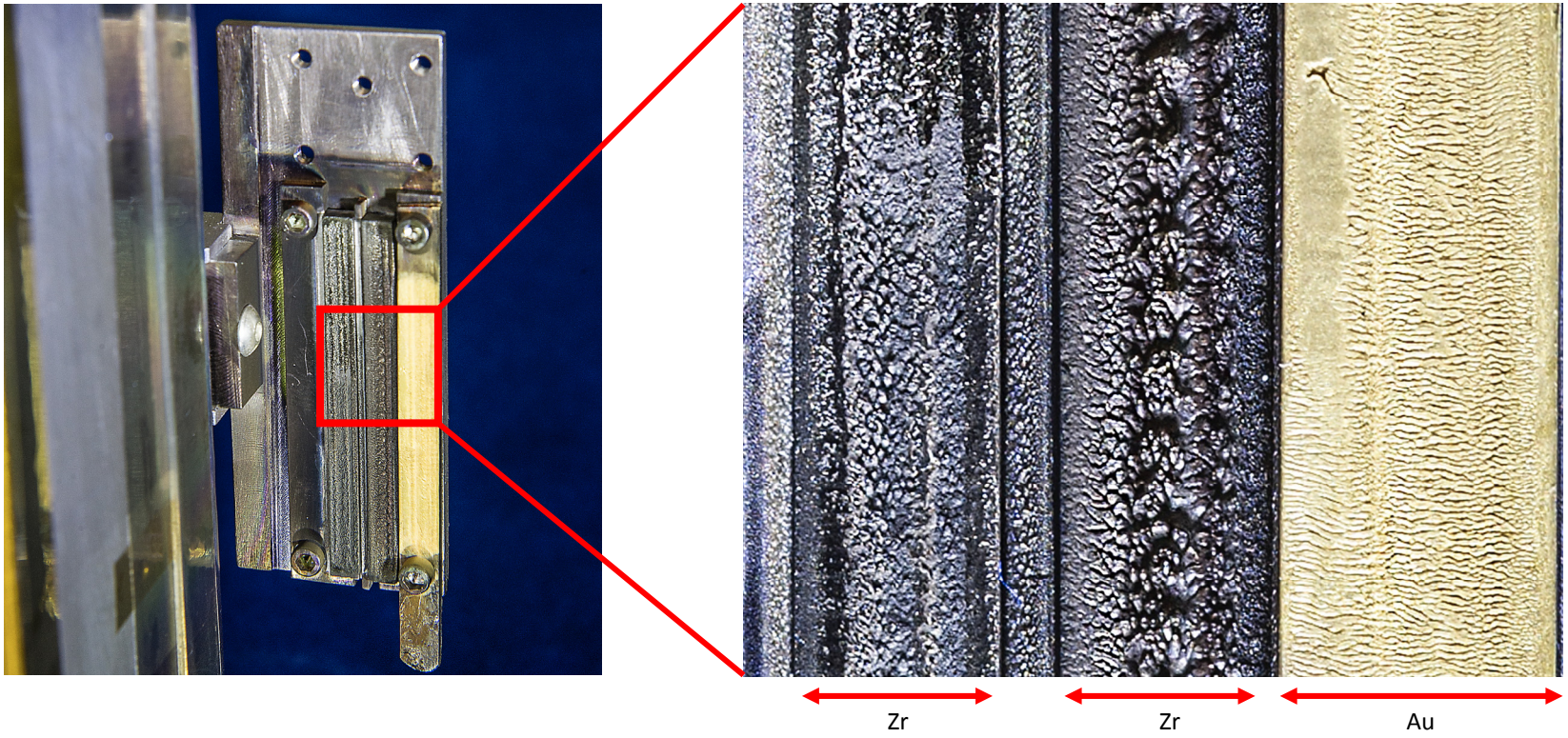


Target translation mechanism



Cut view of LION

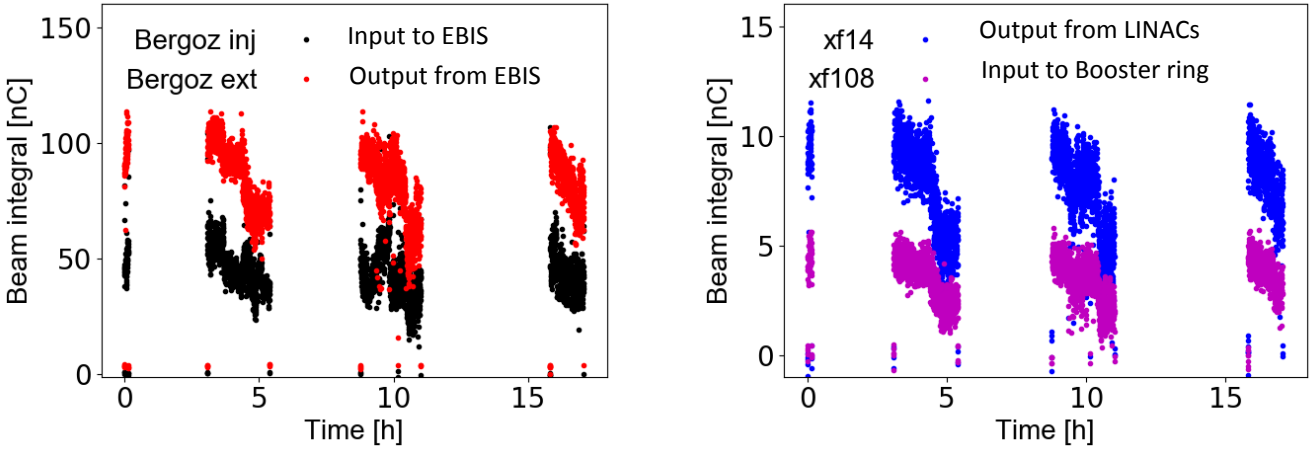
Enriched Zr target



Beam performance of enriched Zr beam

EBIS output	After IH-LINAC	F.C. at bend	Before Booster	Typical Au32+ Before Booster
65 nC	8.2 nC	5.9 nC	3.8 nC	6 nC

At the test, equivalent particle number of $^{96}Zr^{16+}$ to Au^{32+} was achieved.



Typical operation status of $^{96}Zr^{16+}$ beam at the EBIS injector

Summary

Provided Zr shots from laser ion source

No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
317888	143822	12885	15315	-	-

- $^{96}Zr^{16+}$ beam had been provided at very stable condition.
- Total provided shots was 489910.
- No major beam interruption during entire Run18.
- Successful data acquisition was achieved at STAR detector at RHIC.

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