Determination of radioactive ion beam production yields using 1.4- and 1.7-GeV protons

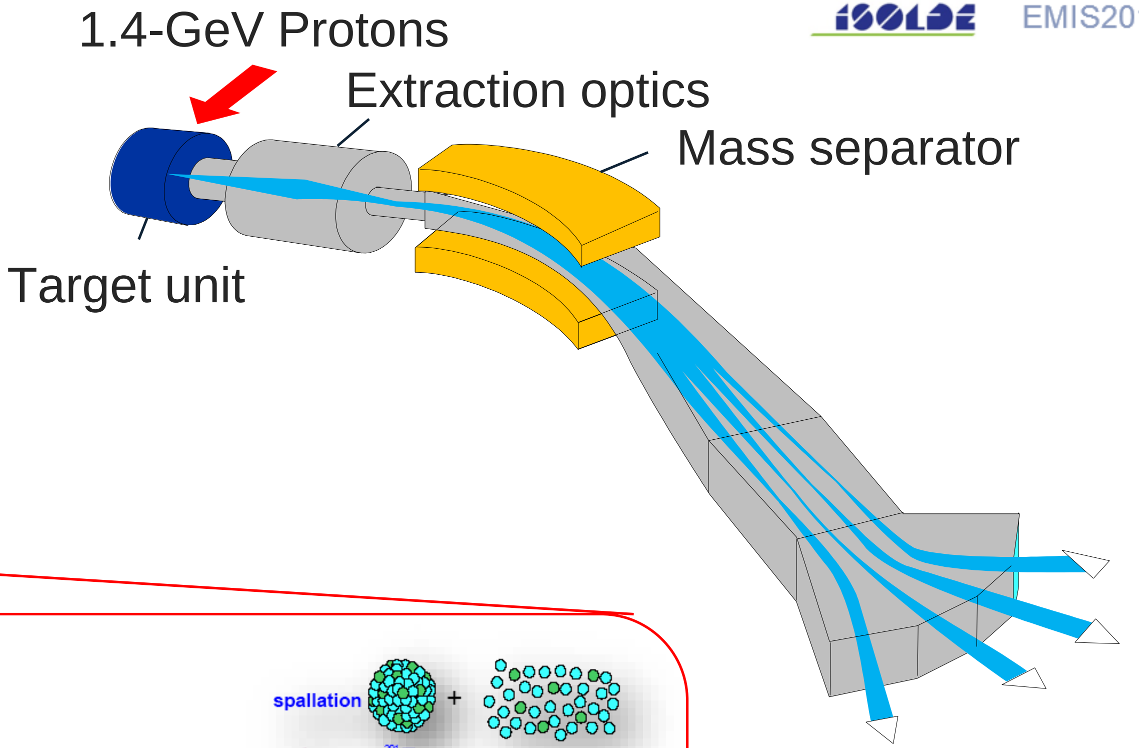
Simon Stegemann on behalf of the IS717 collaboration

ISCC meeting 2022, November 7th 2022

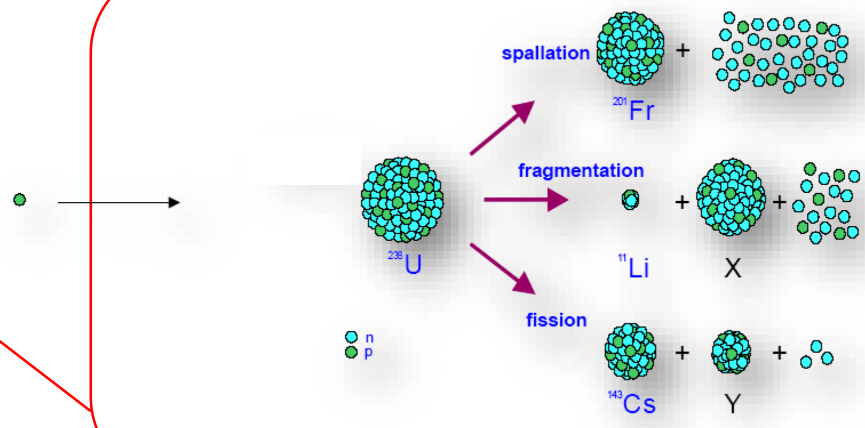
Adapted from

J. P. Ramos | 17/09/2018

EMIS2018

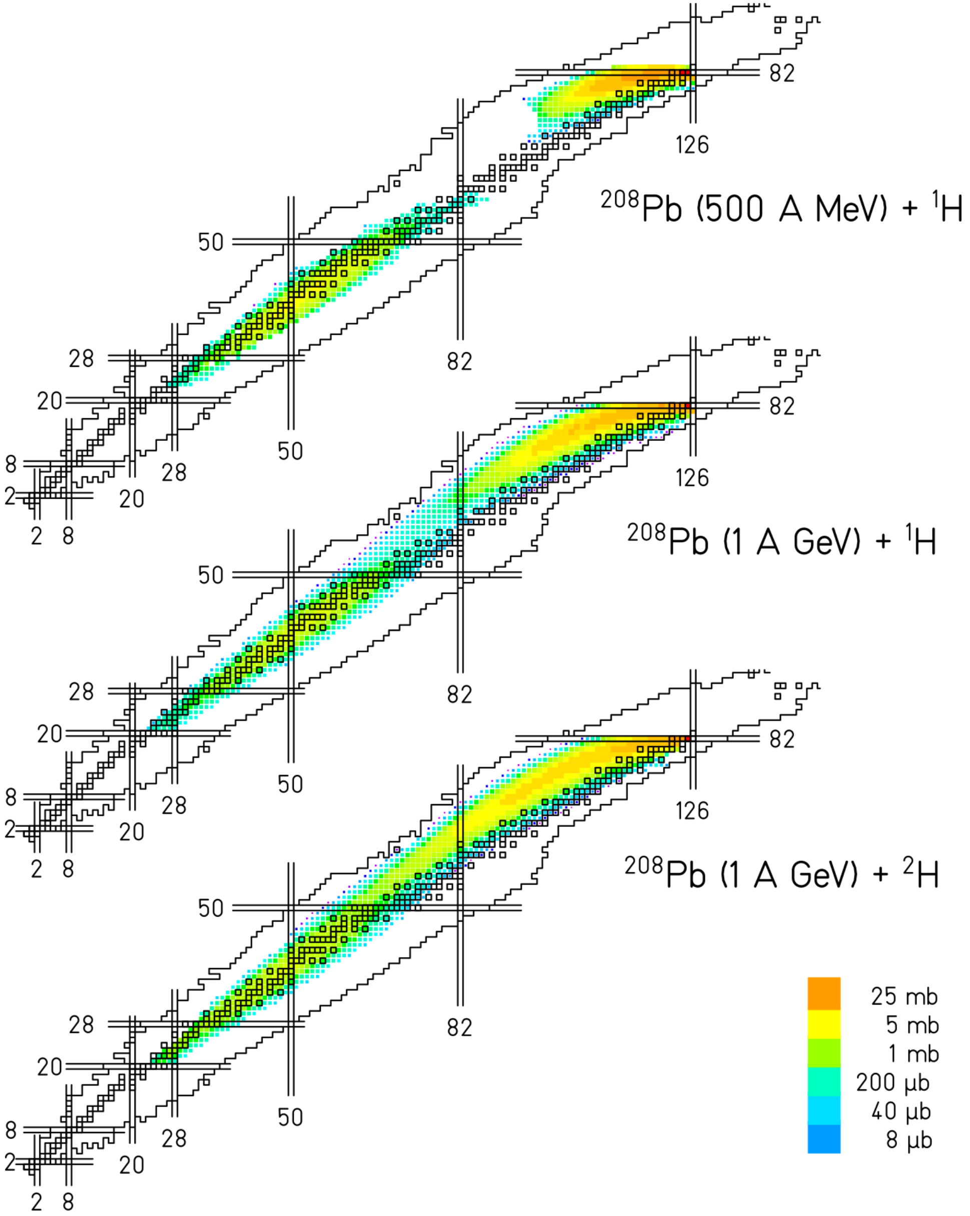


$$Beam\ Intensity = \sigma \cdot j \cdot N_t \cdot \varepsilon$$



$$\varepsilon = \varepsilon_{diff}\varepsilon_{eff}\varepsilon_{is}\varepsilon_{sep}\varepsilon_{trans}$$

N_t – Nr of exposed atoms [dim]
j – Proton flux [cm^{-2}]
σ – Cross section [mb]
ε – Efficiency [%]



Increase in spallation residues when increasing proton (deuteron) energy on ^{208}Pb measured in inverse kinematics at GSI

Increased yields of deep spallation products from spallation evaporation reactions

Residues close to valley of stability at A ~ 100 less affected (spallation fission products)

Proposal:
Verify expected gains in production yields in respective regions of the nuclear chart

K.-H. Schmidt, et al. Phys. Rev. ST Accel. Beams **10** (2007), 014701

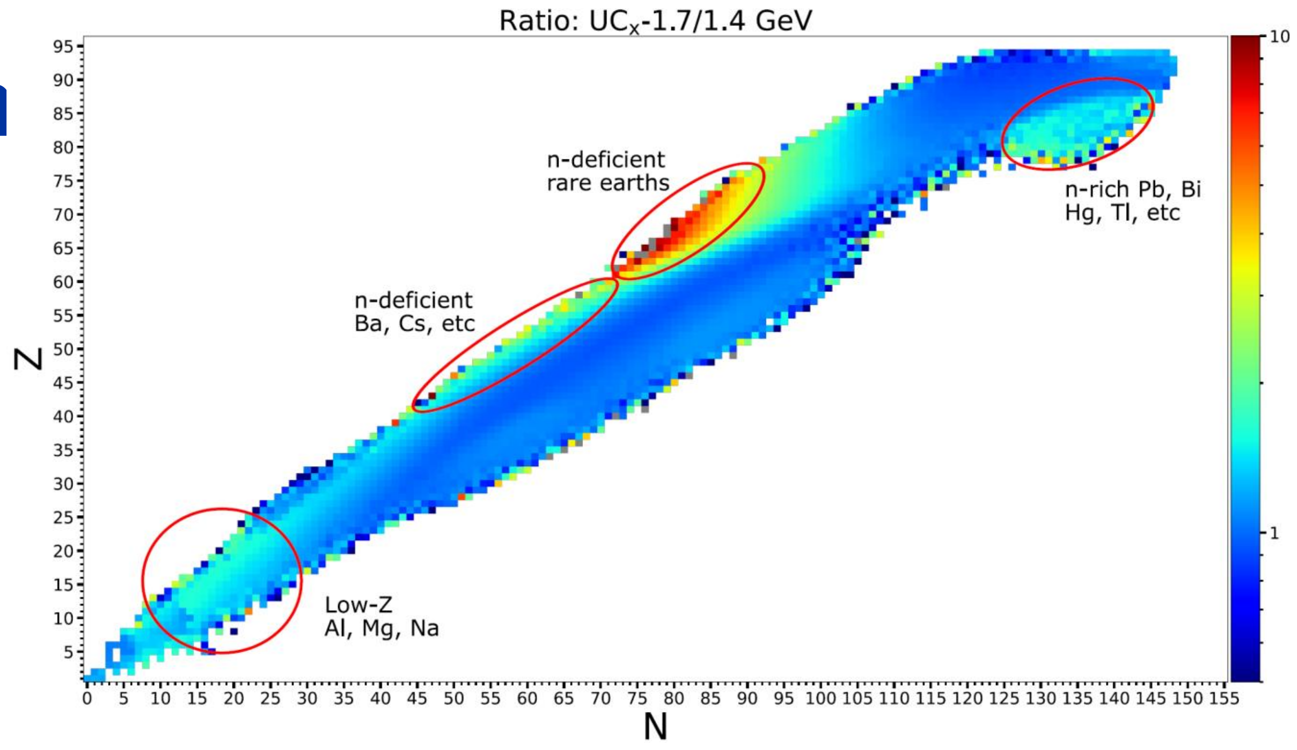
L. Audouin, et al. Nuclear Physics A 768 (2006), 1–21.

T. Enqvist, et al. Nuclear Physics A 703 (2002), 435–465.

B. Fernández-Domínguez, et al. Nuclear Physics A 747 (2005), 227–267.

T. Enqvist, et al. Nuclear Physics A 686 (2001), 481–524.

Experimental campaign



EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Determination of radioactive ion beam production yields using 1.4- and 1.7-GeV protons

May 13, 2022

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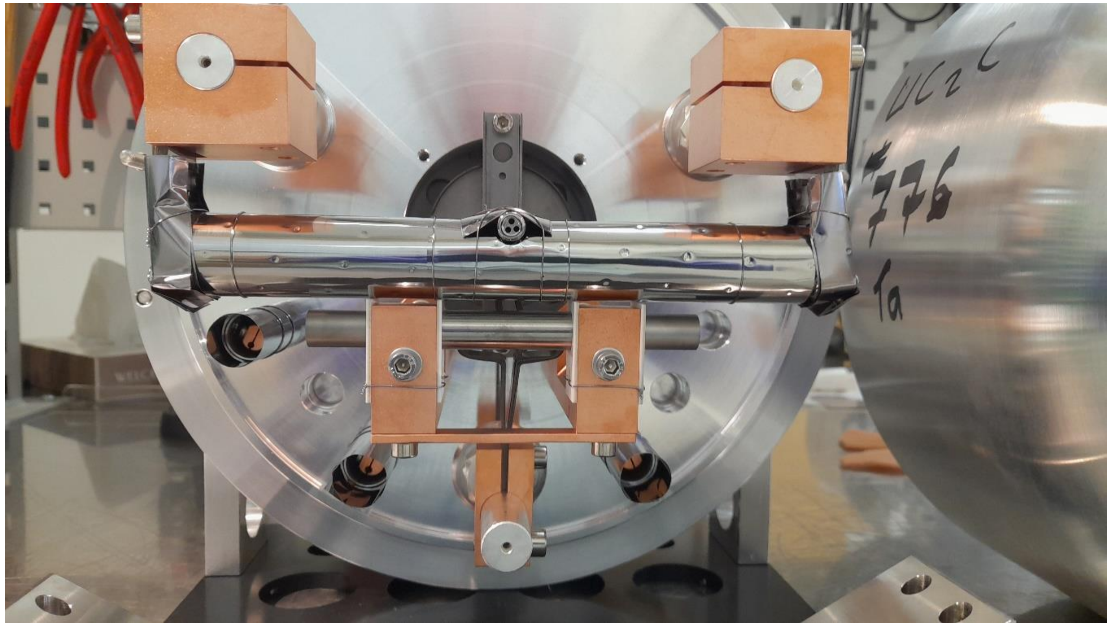
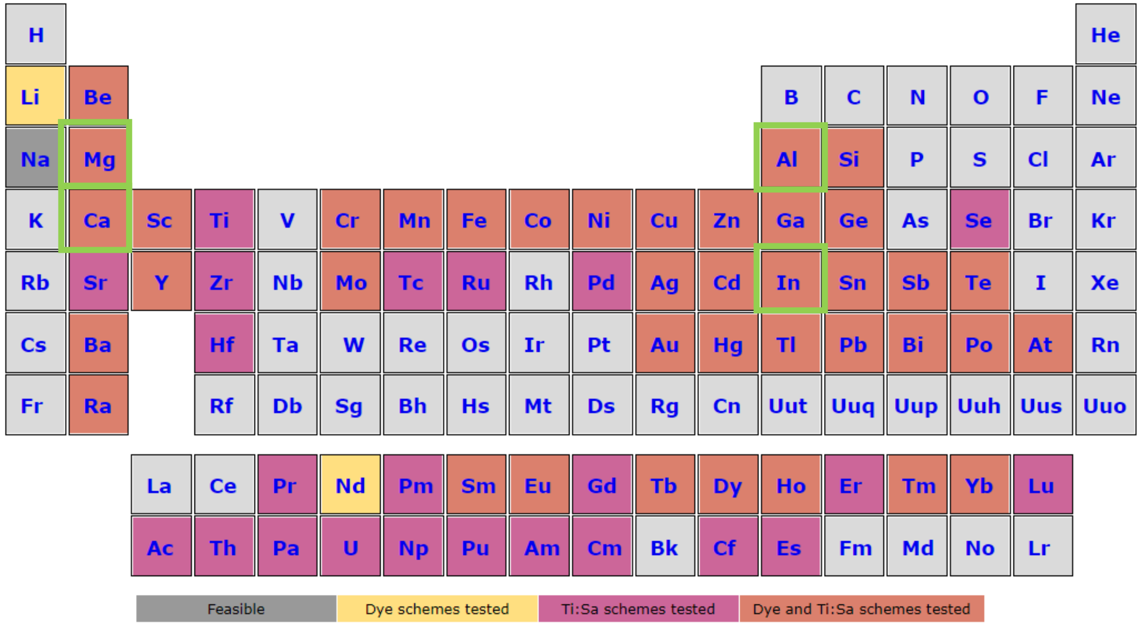
[3] *KU Leuven, Institute for Nuclear and Radiation Physics, Heverlee, Belgium*
[4] *The University of Manchester, Manchester, UK*
[5] *Institut Laue-Langevin, Grenoble, France*
[6] *Belgian Nuclear Research Centre, SCK CEN, Mol, Belgium*

	Proton beam tuning PSB-GPS		
	Stray radiation measurements		
	Beam scattering measurements		
	Isotopes	Target	Ion source
(a)	^{6,8}He	UC_X/Ta	VD7
	^{8,9}Li	UC_X/Ta	MK1
	^{11}Be	UC_X/Ta	RILIS
(b)	^{X}Ne	UC_X	VD7
	^{X}Na	UC_X	MK1
	^{X}Mg	UC_X	RILIS
	^{X}Al	UC_X	RILIS
(c)	^{230}Fr, ^{231}Ra	ThC_X	MK1
	^{X}Fr, ^{X}Ra	UC_X + ThC_X	MK1
	^{X}Rn	UC_X + ThC_X	VD7
(d)/(e)	^{X}Xe	UC_X + CeO_X or LaC_X	VD7
	^{X}Cs, ^{X}Ba	UC_X + CeO_X or LaC_X	MK1
	^{X}Ag, ^{X}Cd, ^{X}In, ^{X}Sn	UC_X + CeO_X or LaC_X	RILIS

Target and ion source configuration

- August 2022: 1st measurement campaign: UC_x target + Ta-surface (MK1) ion source
  - ➢ Access to many surface ionized species of interest
- Exploited four different laser ionization schemes
- Neutron converter



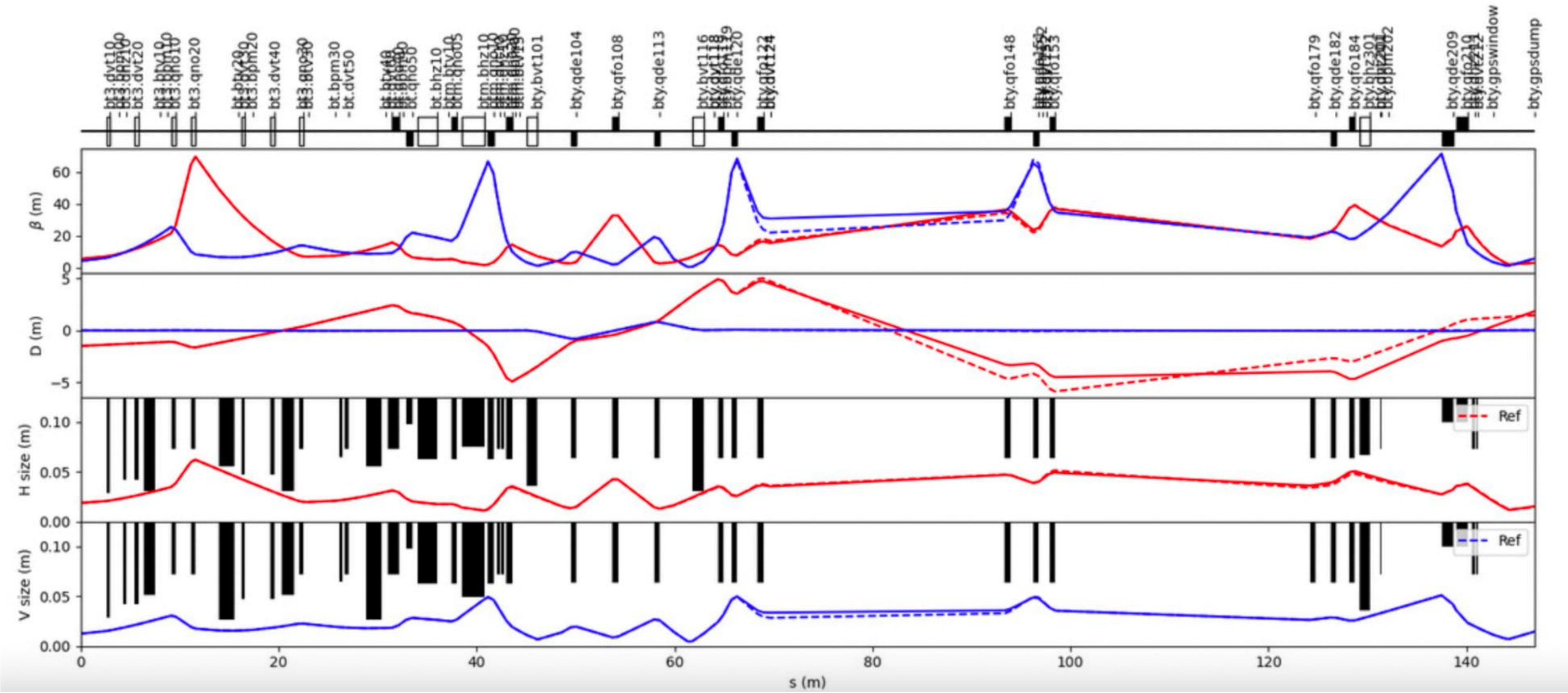


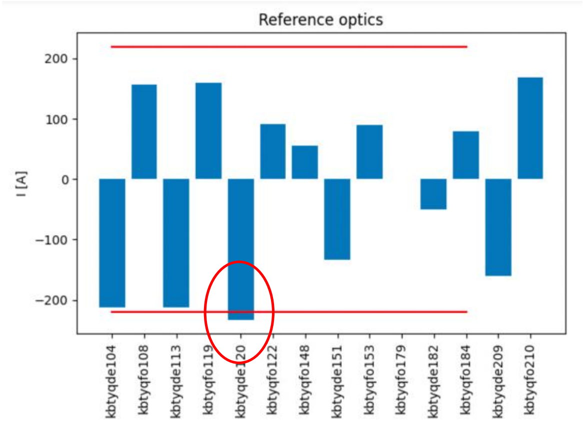
- (October 2022: LaC_x target + Ta-surface (MK1) ion source + Sn laser ionization)

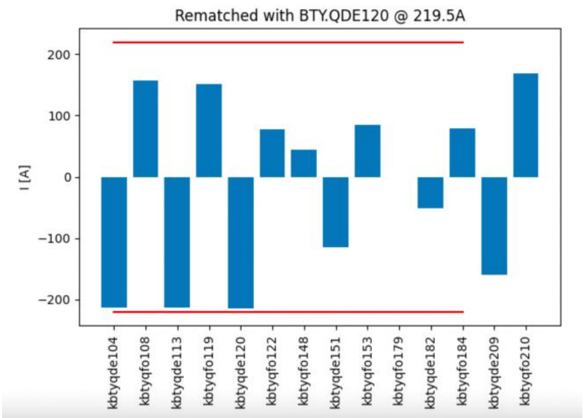
Courtesy of Matthew Fraser

Rematched BTY-line optics at 1.7 GeV

- **Limited to 1.7 GeV by power converter current in BTY vertical dipoles**
- **Optics rematched to keep all quadrupole settings within power converter limits for 1.7 GeV**





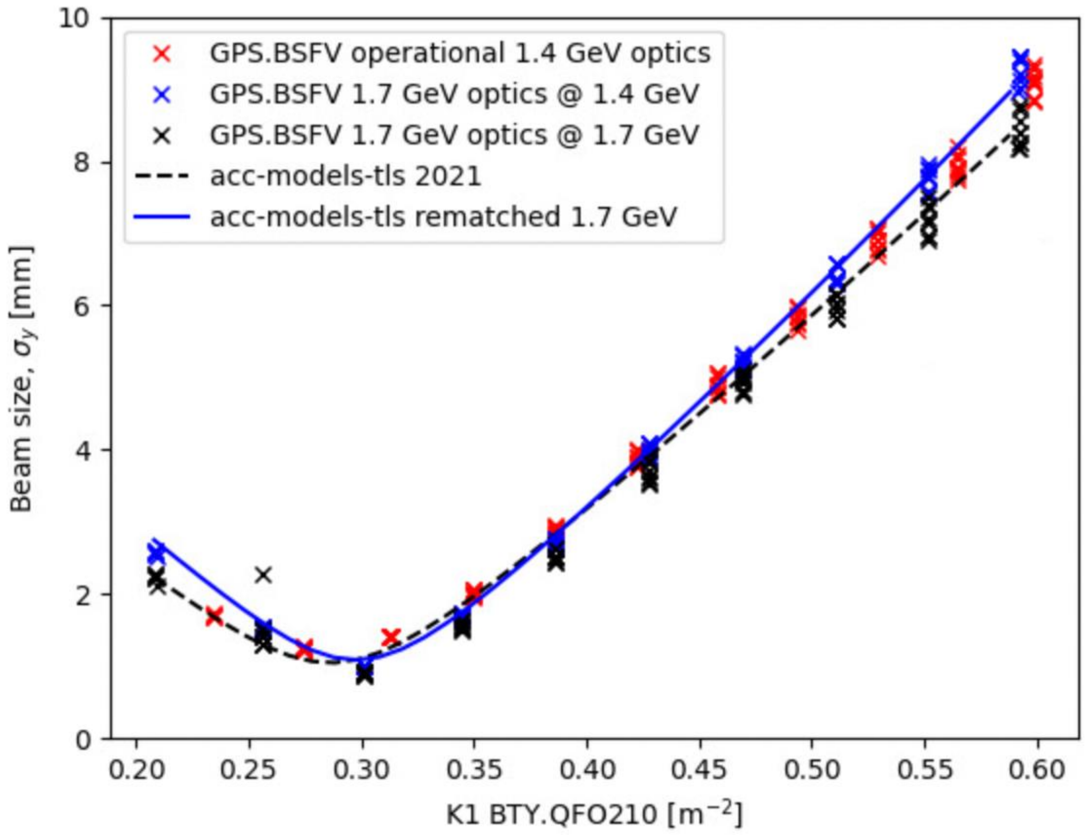


Courtesy of Matthew Fraser

Rematched BTY-line optics at 1.7 GeV

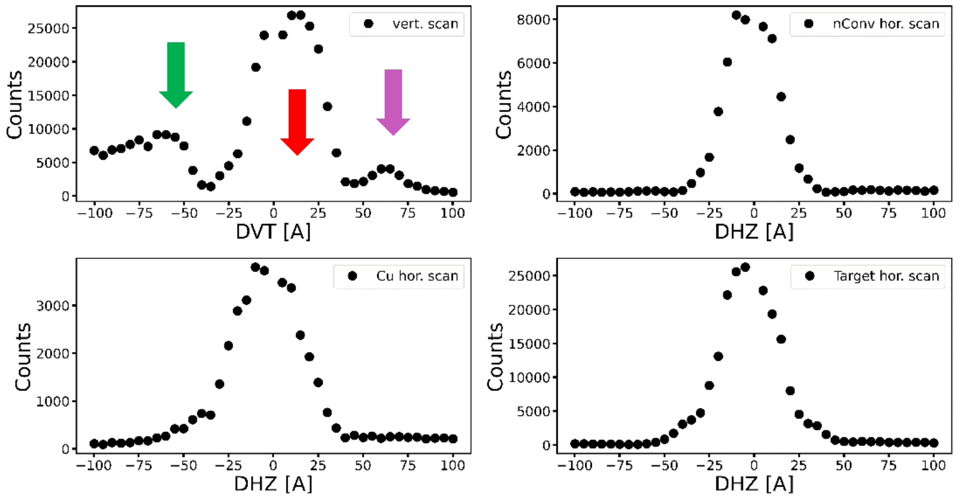
- **Beam size upstream of GPS target measured as a function of the last gradient of the last quadrupole using a SEM grid:**

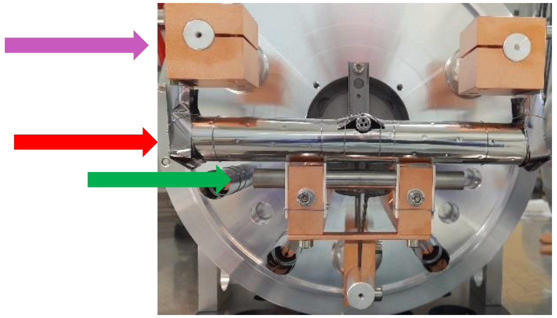
- **Example in vertical plane:**



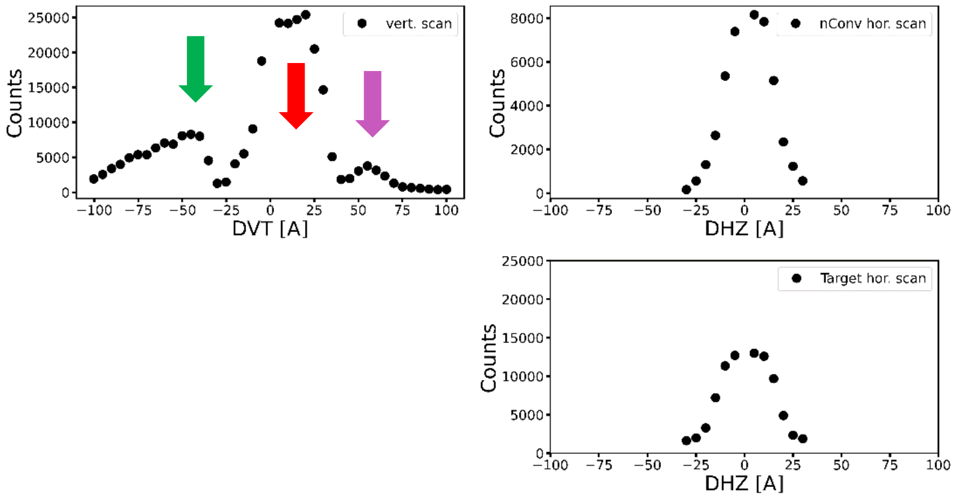
Proton characteristics

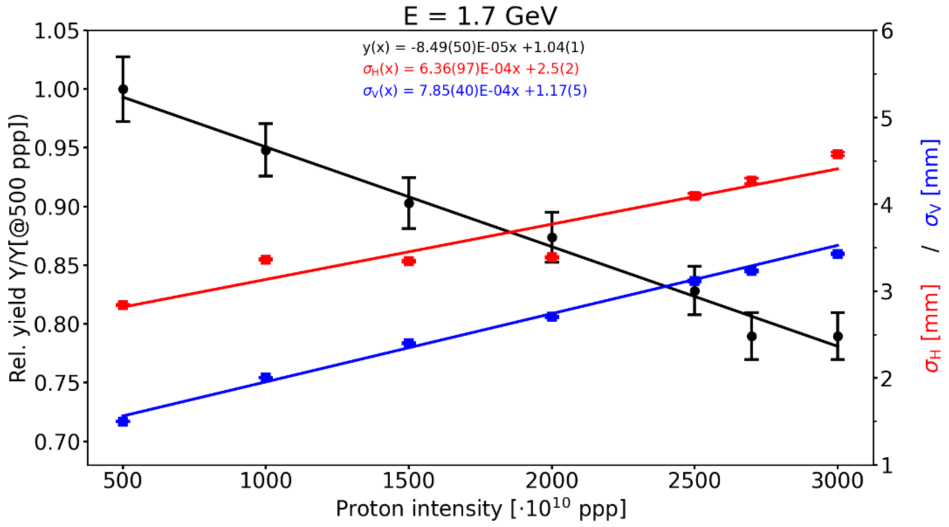
1.7 GeV

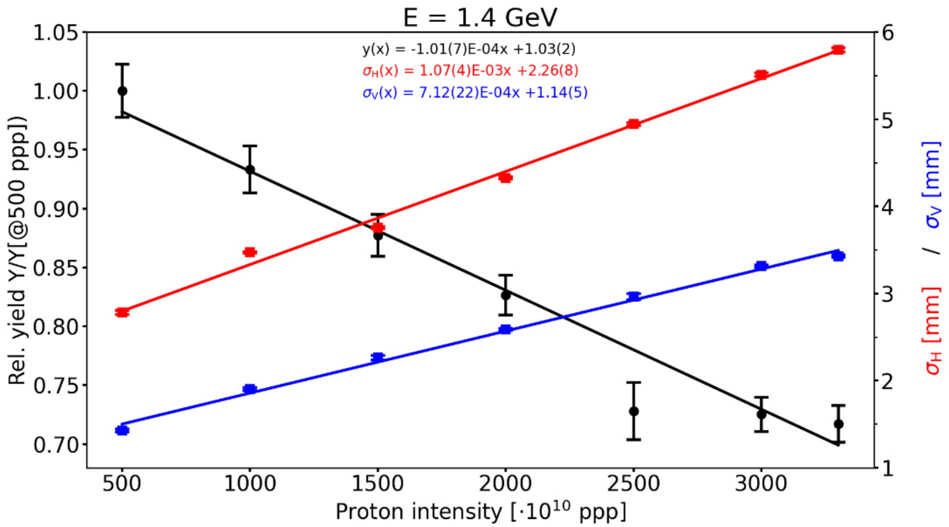




1.4 GeV

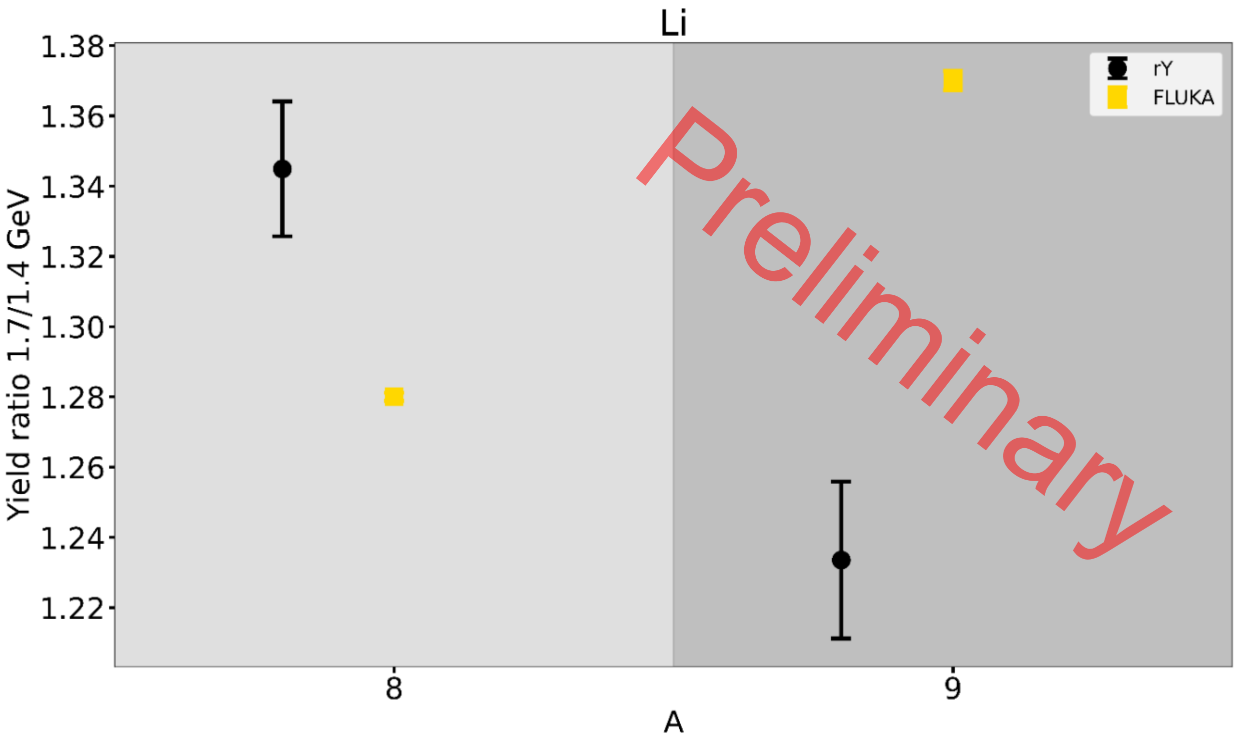


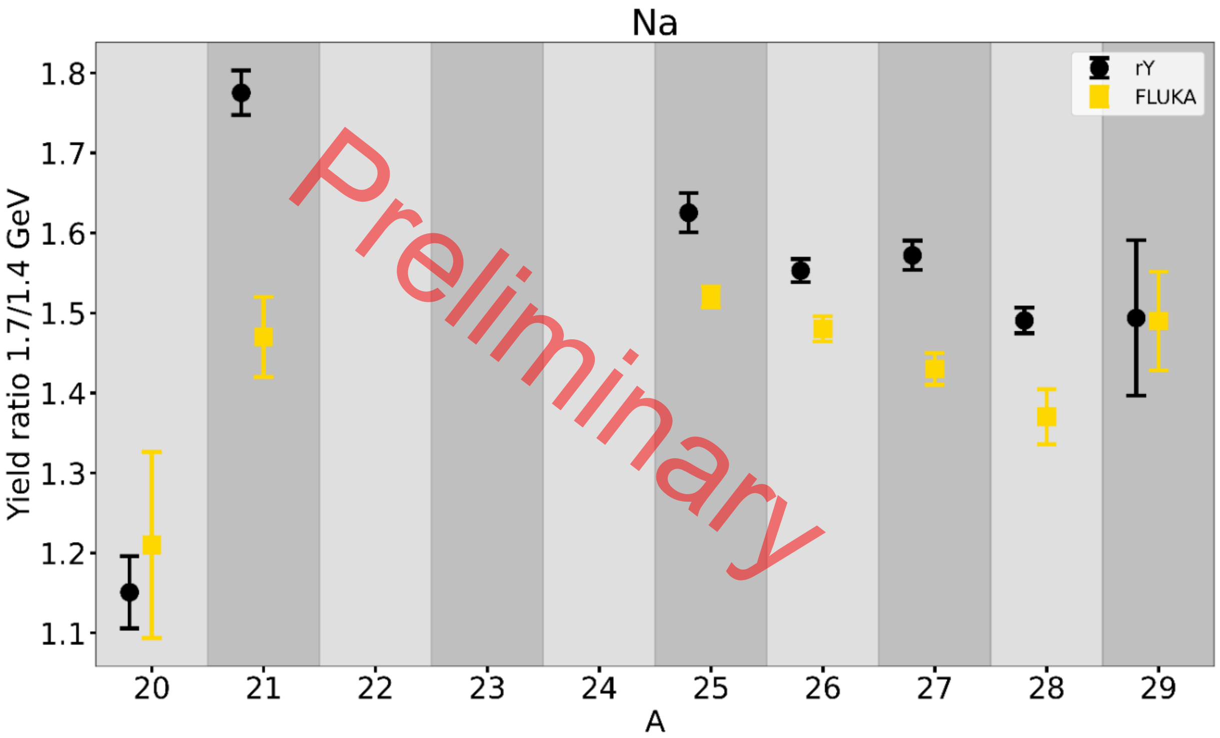




Preliminary results

Preliminary results - UC_x





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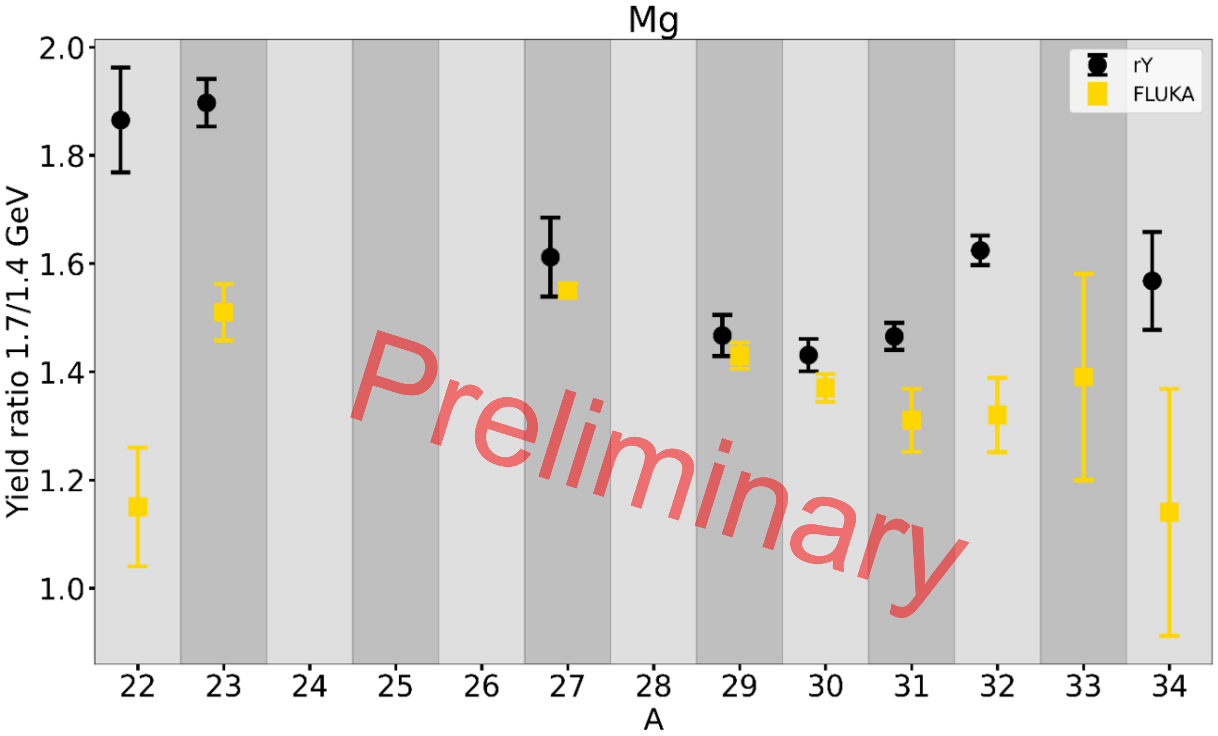
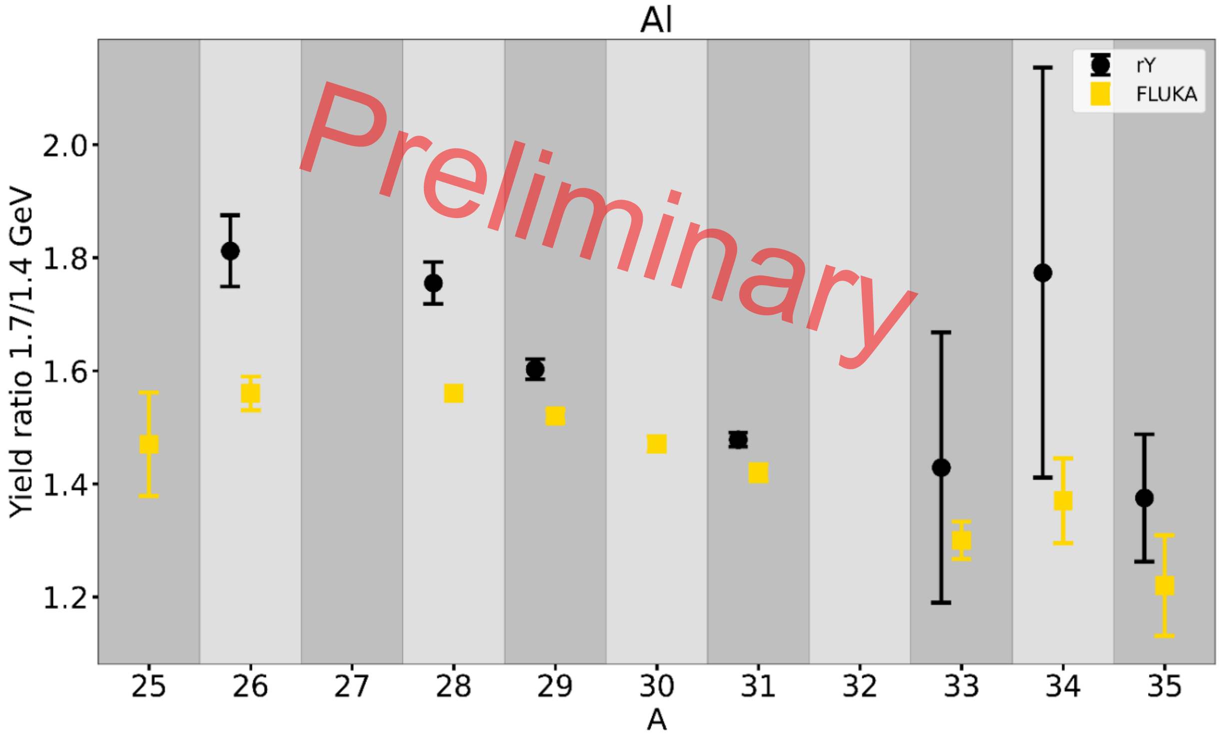
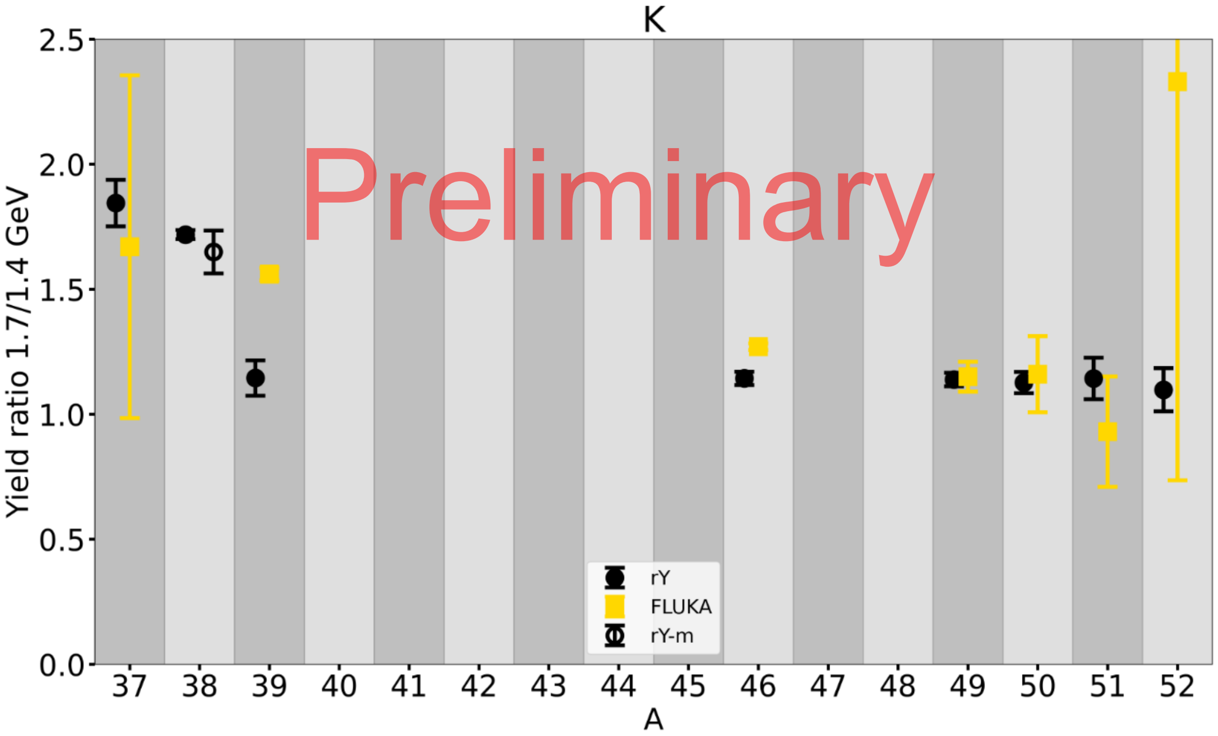
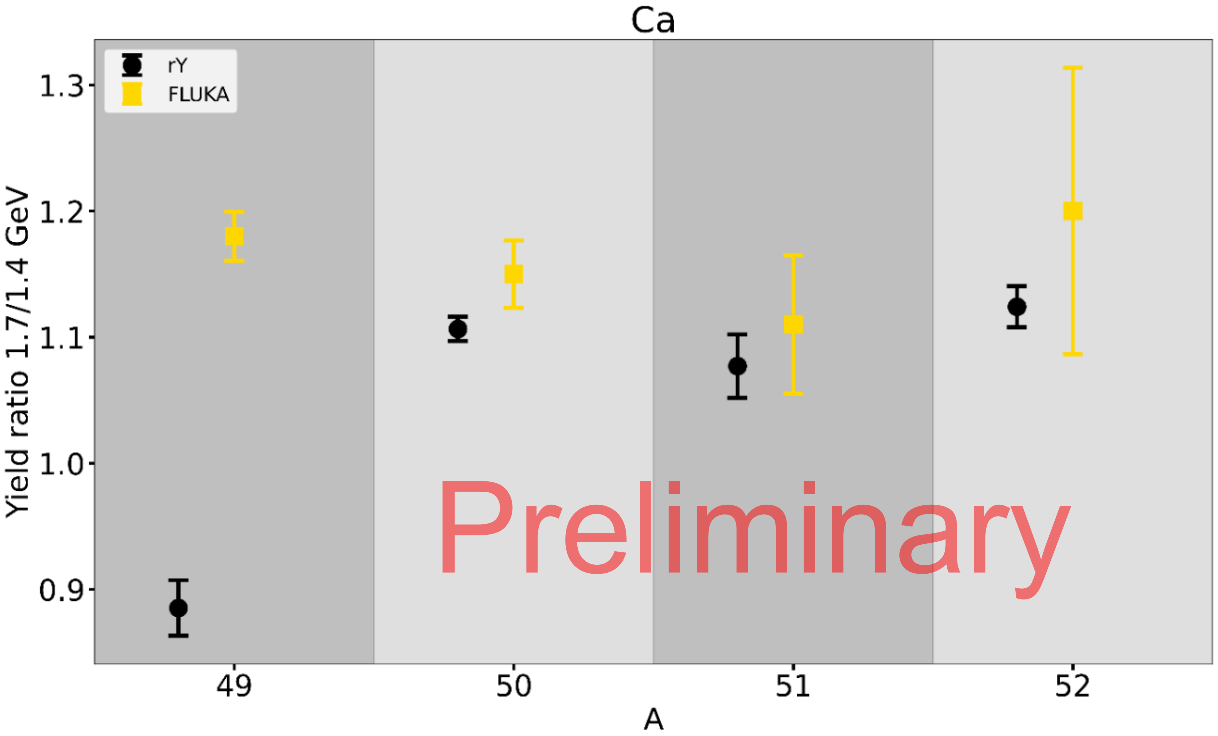


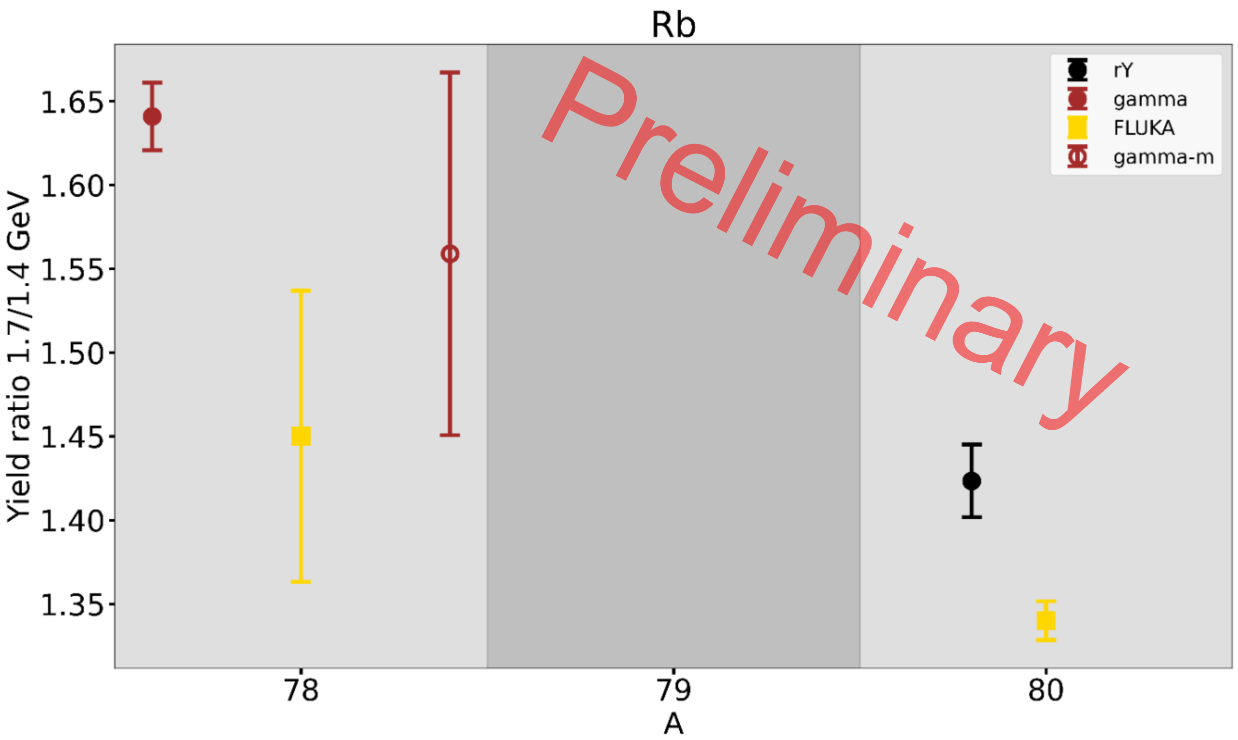


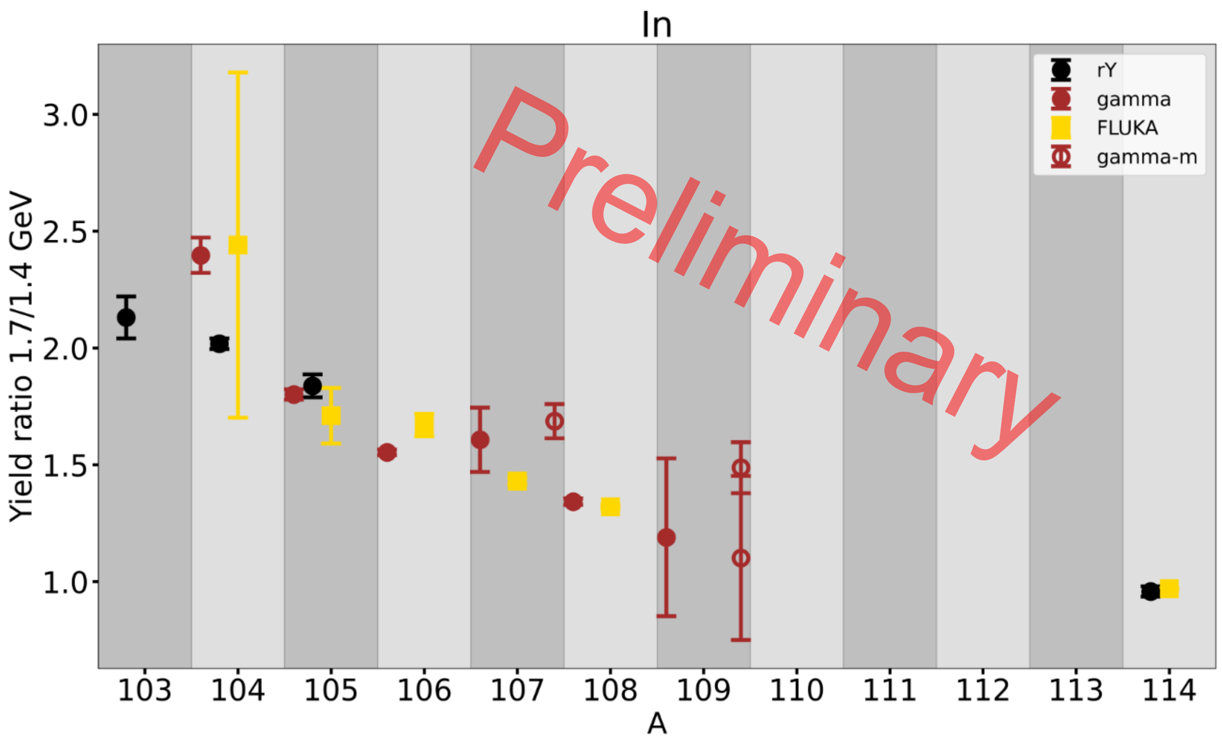
Preliminary results - UC_x



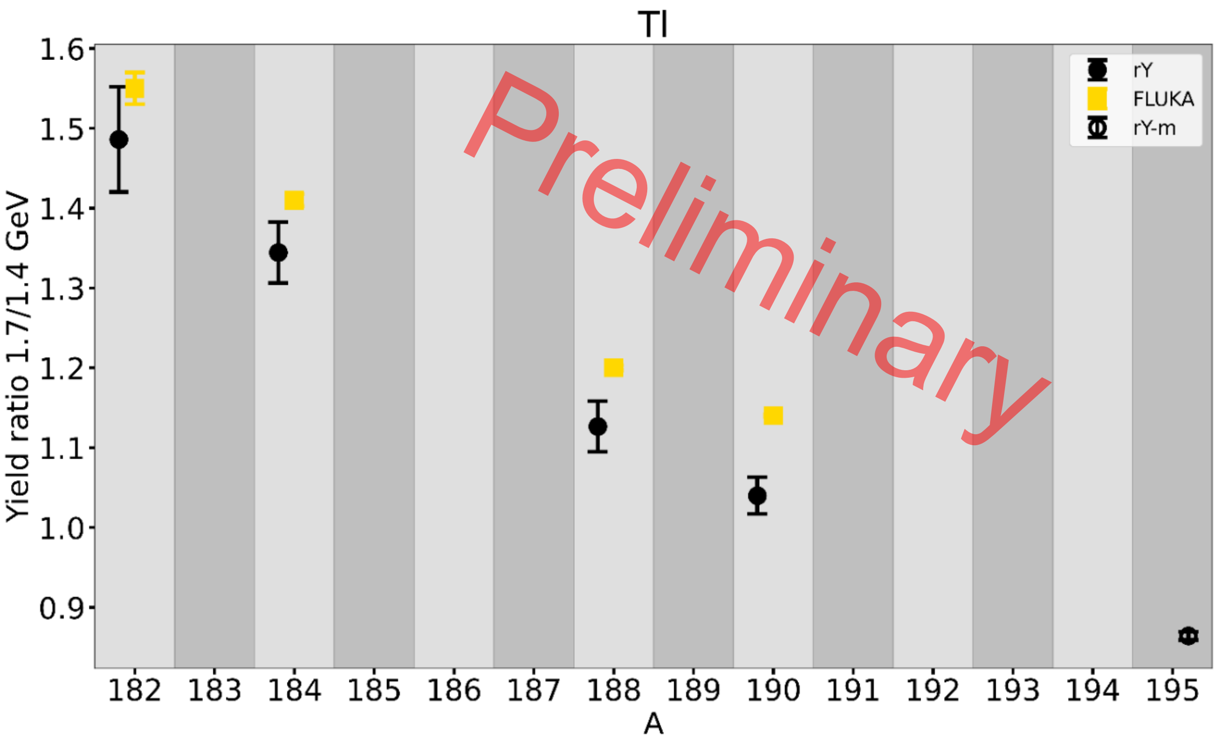


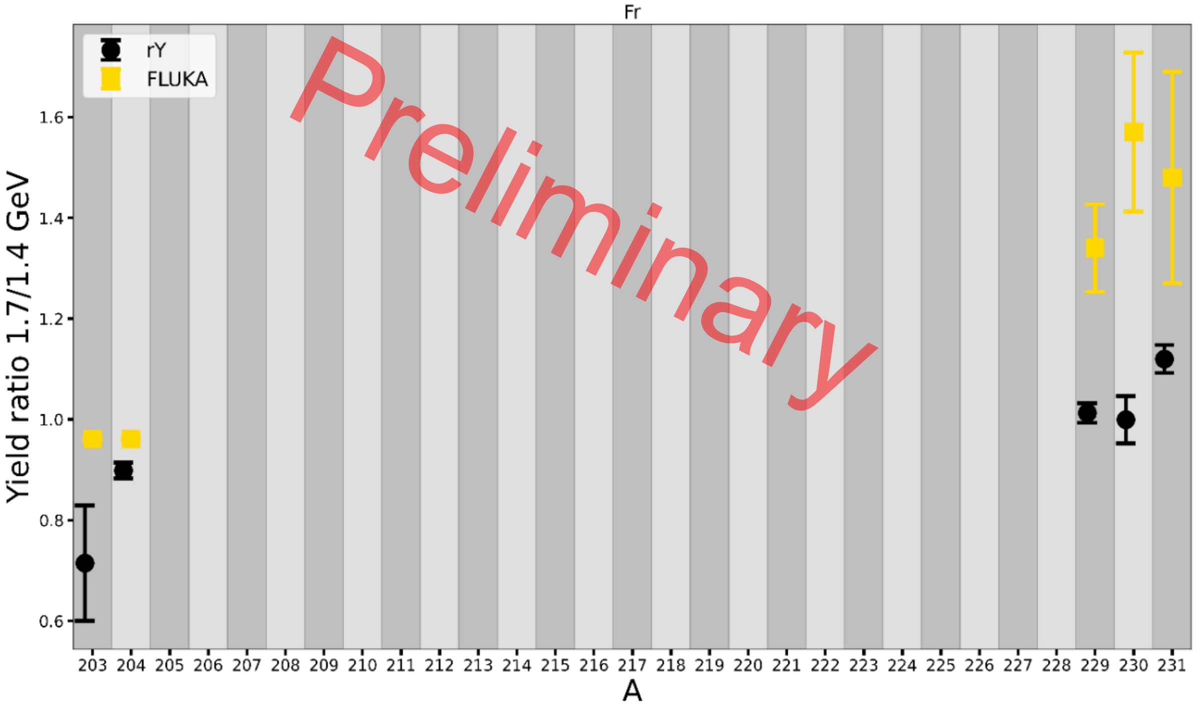
Preliminary results - UC_x



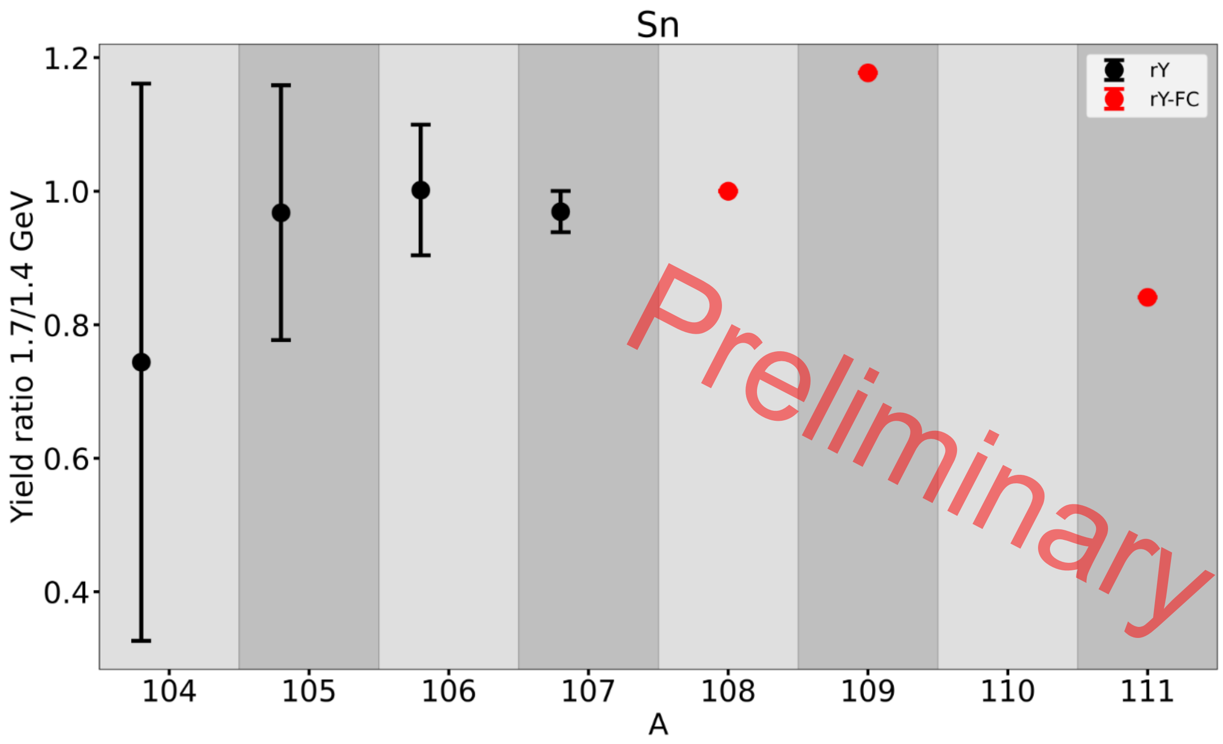


Preliminary results - UC_x

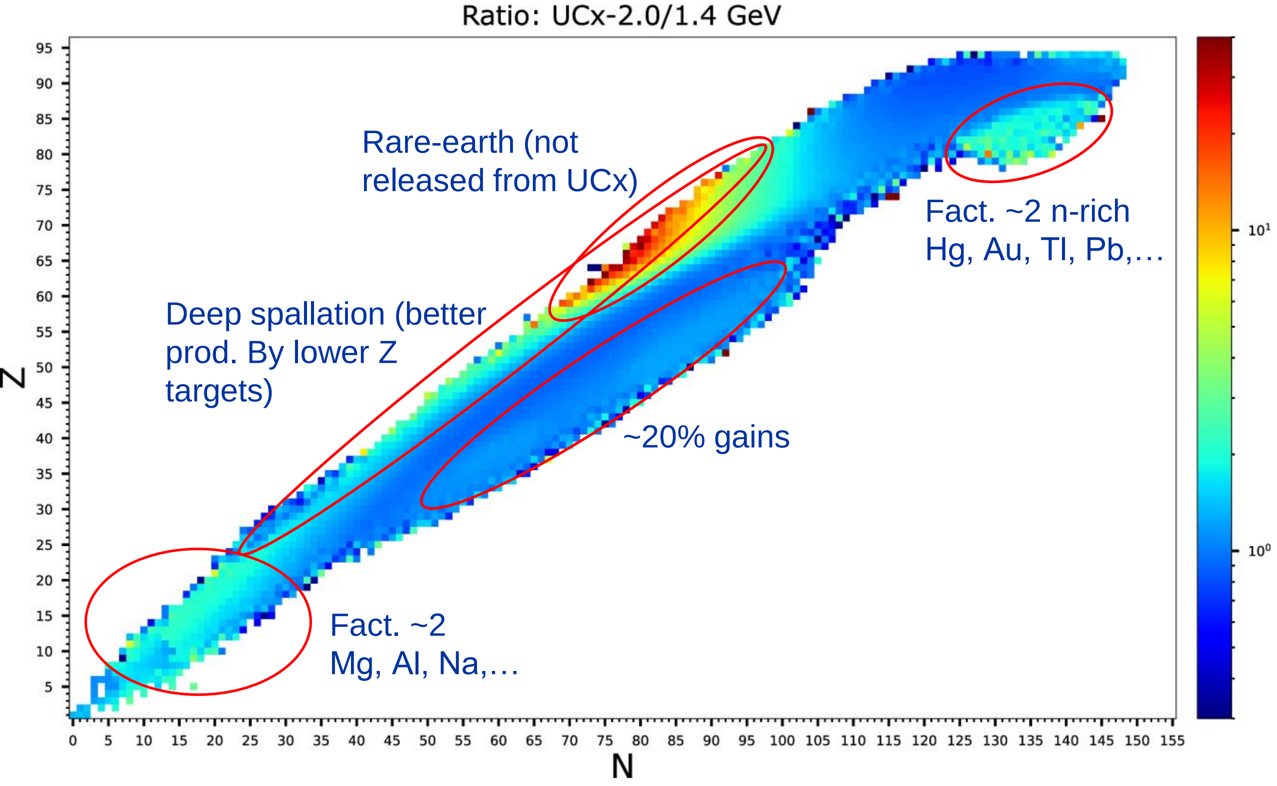




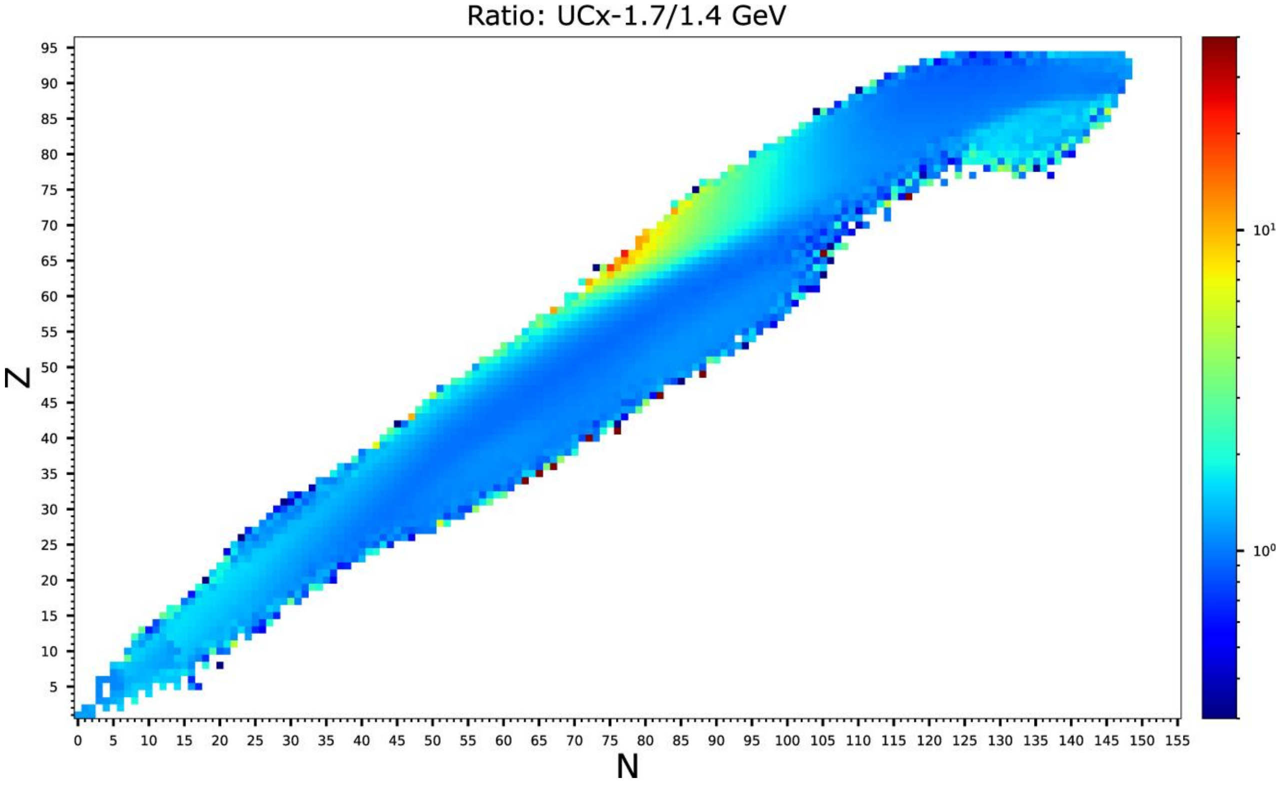
Preliminary results - LaC_x



2.0 GeV - UCx



FLUKA2017 v.1.0
Courtesy of Joao Pedro Ramos



FLUKA CERN v.4-2.2

Conclusions

- **Confirmed expected gains using 1.7-GeV compared to 1.4-GeV protons**
- **Results agree well with MC predictions**
- **Further study proton beam transport to ISOLDE**

Outlook

- **Further data analysis from present beamtime**
- **Exploring other regions in nuclear chart**
- **Simulations for 2-GeV protons**

Acknowledgements

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Thank you for your attention!
Questions, comments?