Update of the 2022 JINR SRC experiment

Göran Johansson

31.1.2023

4th International SRC-EMC Workshop

QE (p, 2p) Knockout in Inverse Kinematics

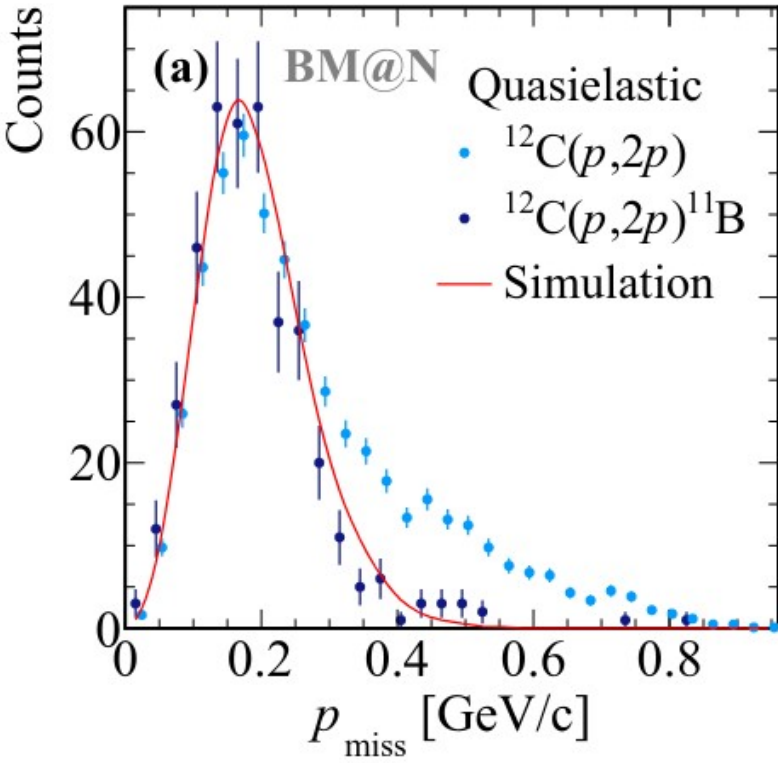
2018:

- Post selection suppresses distortion

2022:

- Absolute cross section
- Quenching
- Attenuation

  All at high momentum transfer



Nature Physics (2021)

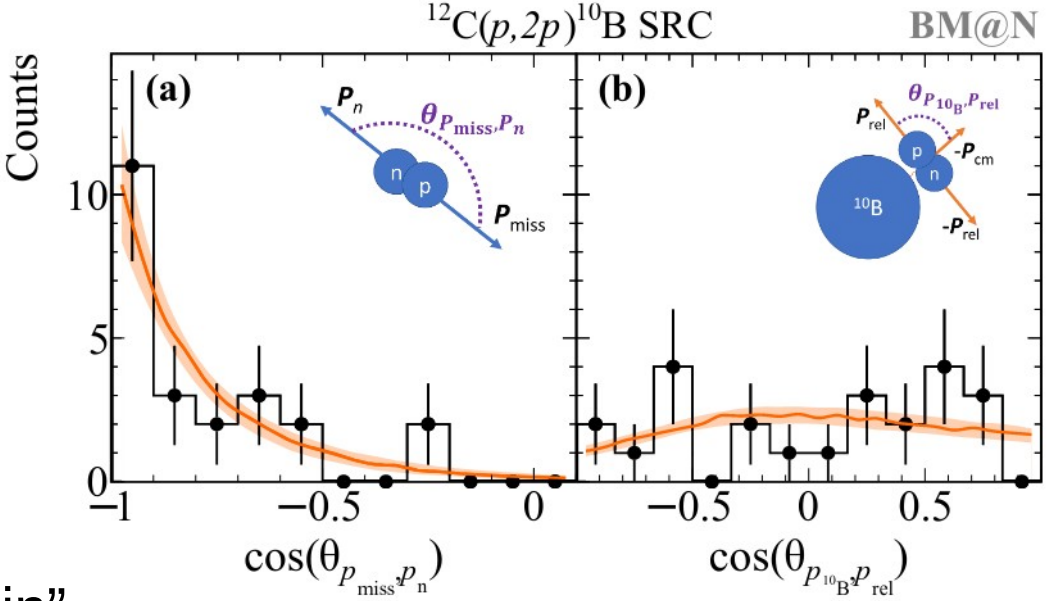
SRC Study in Inverse Kinematics

2018:

- np dominance
- Scale separation (Factorization)
  All with low statistics

2022:

- Improve statistics
- Detect recoil n/p
- Multi-fragment reconstruction
- Fragment distribution → SRC “Origin”
  SRC pairs are $(2p)^{-1}$, $(1p1s)^{-1}$, $(2s)^{-1}$



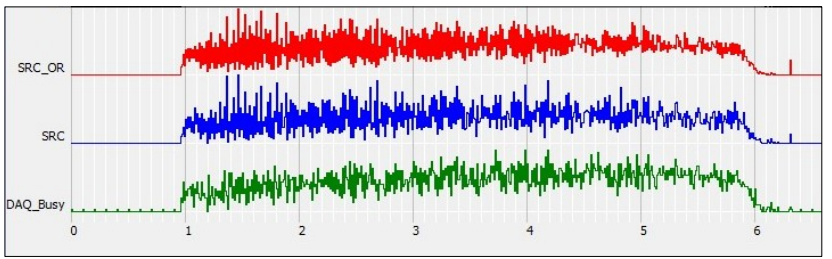
Nature Physics (2021)

Beam Properties

	2018	**2022***
Duration (Physics runs)	10 days	15 days
^{12}C Beam Intensity	2.5x10^5 Ions/spill	4x10^5 Ions/spill
Spill length	2 sec spill / 10 sec	5 sec / 13 sec
Beam Momentum	4 GeV/c/nucleon	3.75 GeV/c/nucleon

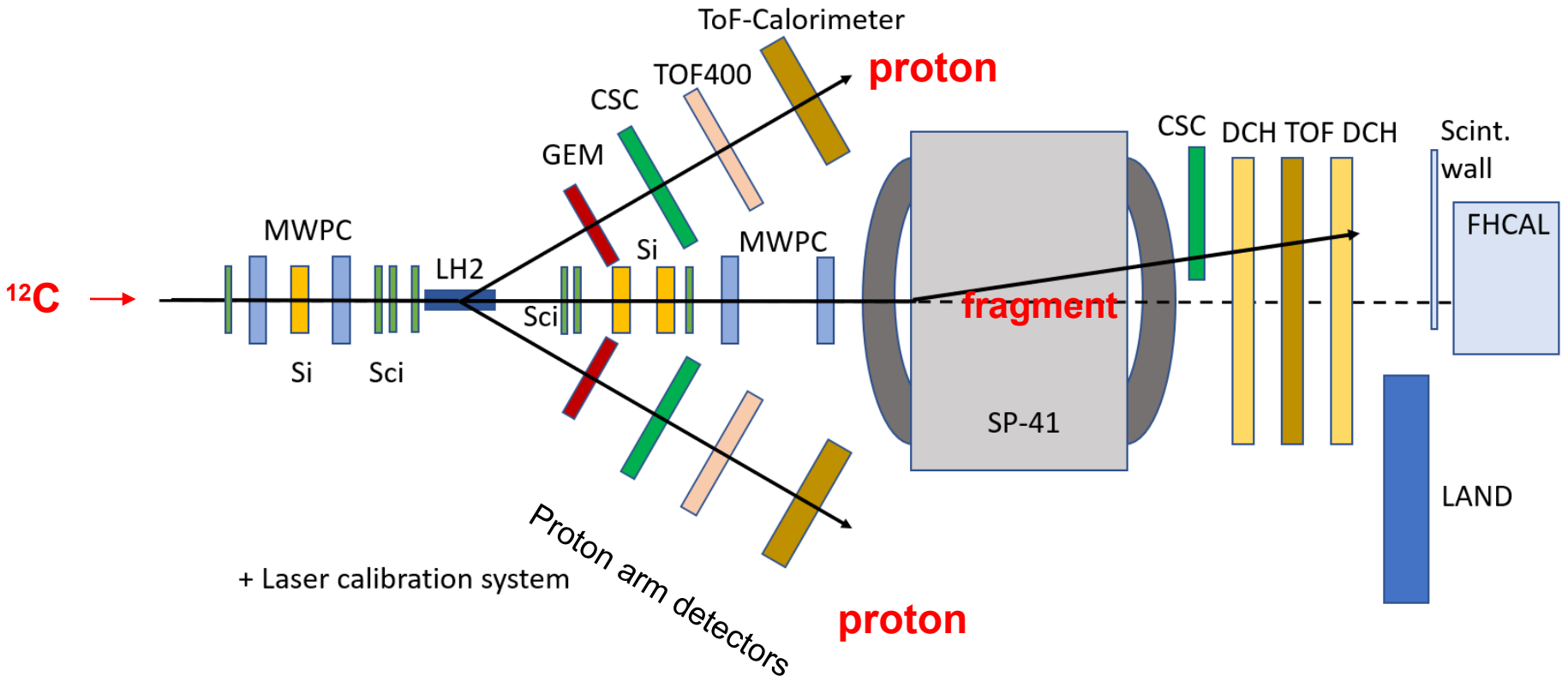
* The first time **Booster** + Nuclotron

Spill distribution ~5sec



Experimental Setup

$^{12}C + p \rightarrow 2p + fragment(s)$



Experimental Setup

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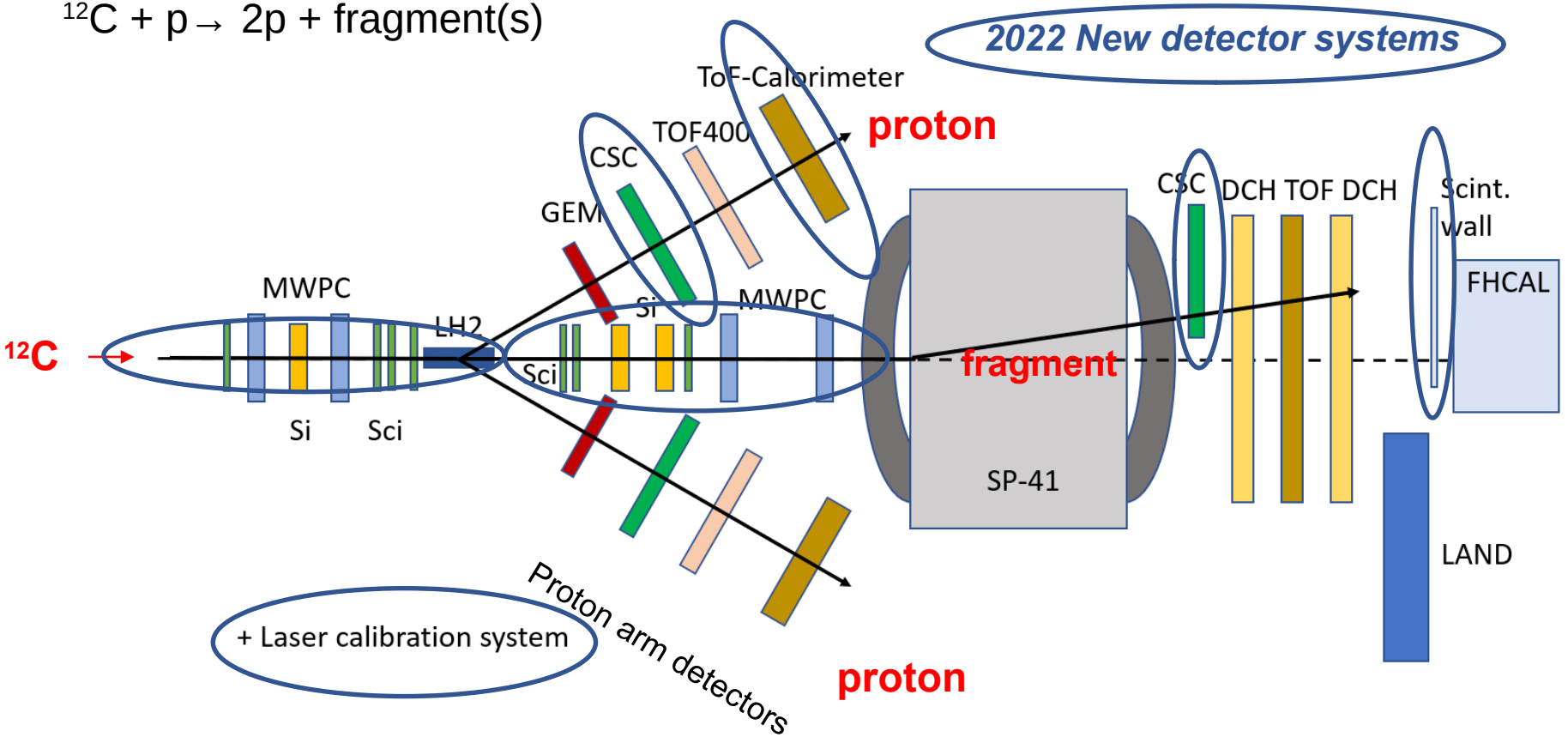
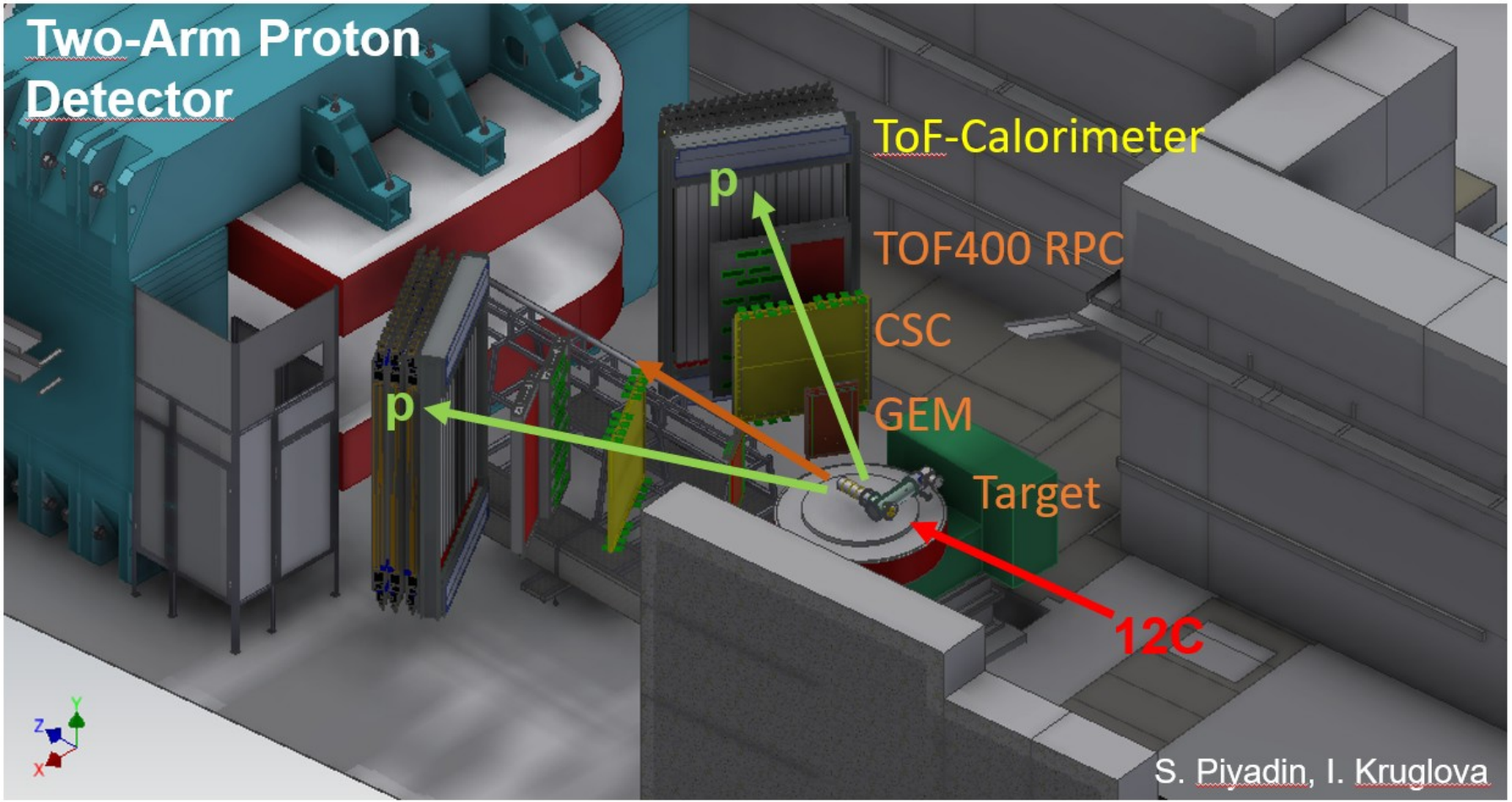
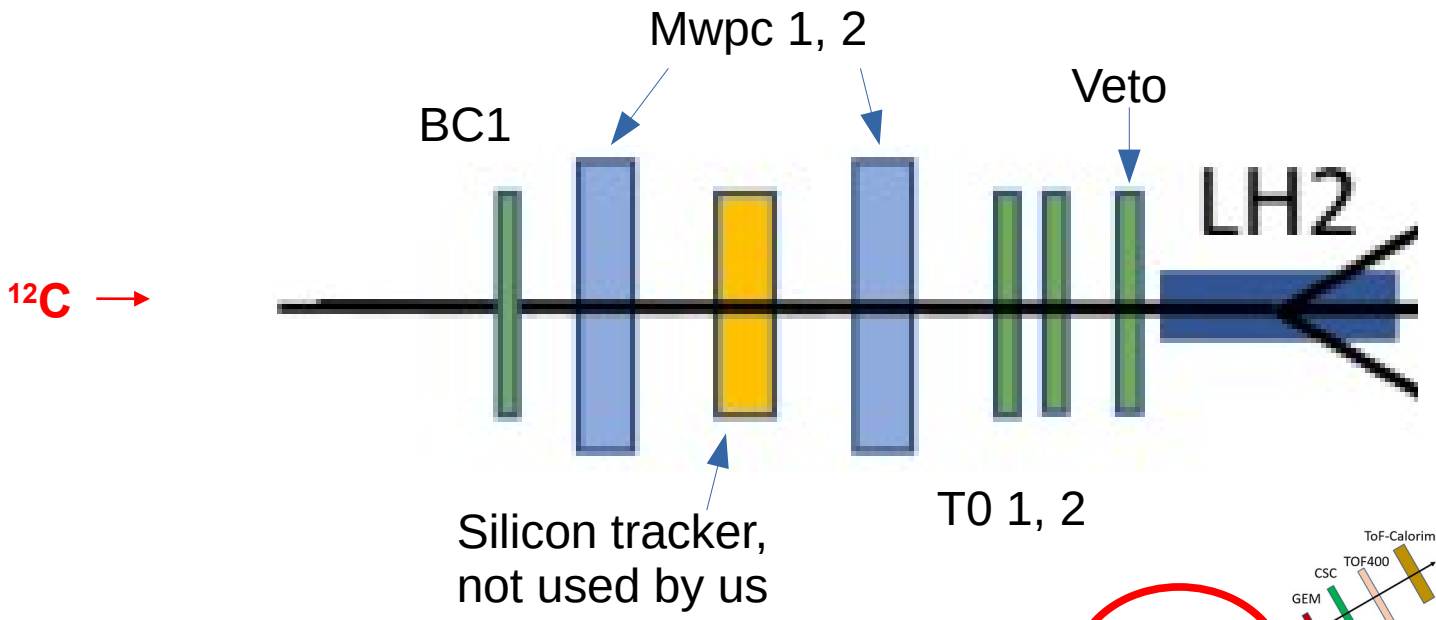
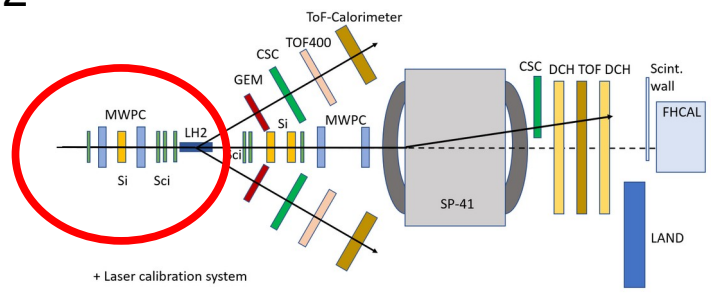



Two-Arm Proton Detector
ToF-Calorimeter
p
TOF400 RPC
CSC
GEM
p
Target
12C
S. Piyadin, I. Kruglova

Incident Beam Measurement

$^{12}C + p \rightarrow 2p + fragment(s)$

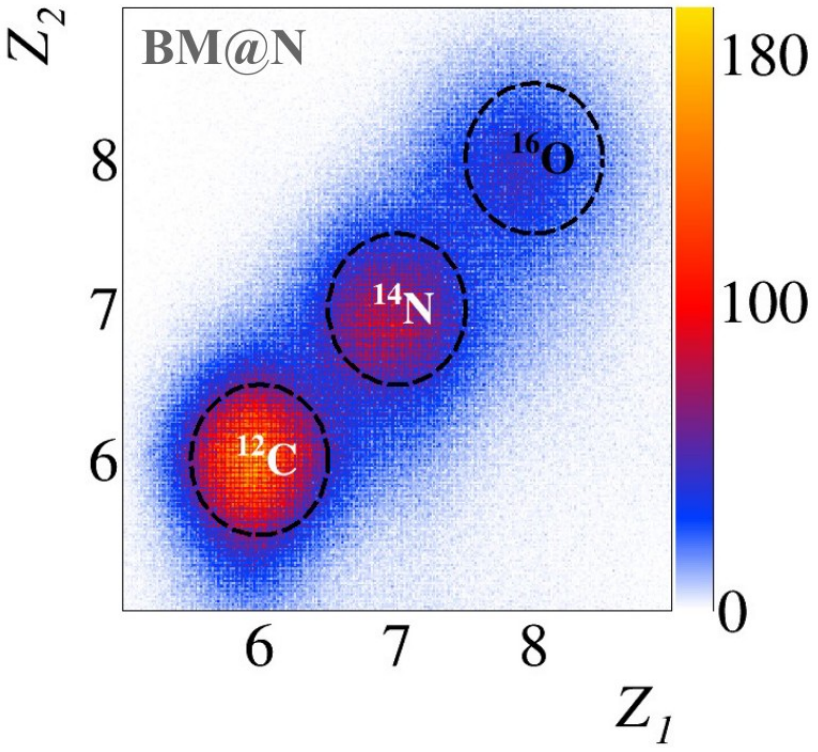




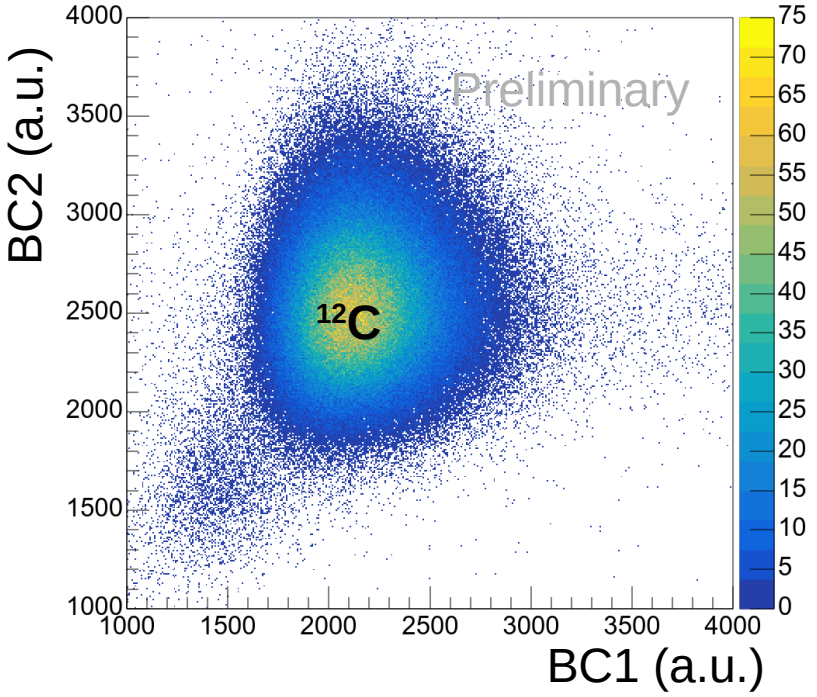
BC – (Scintillator) Beam Counter
Mwpc – Multi wire Proportional Chamber

Incident Beam – PID

2018



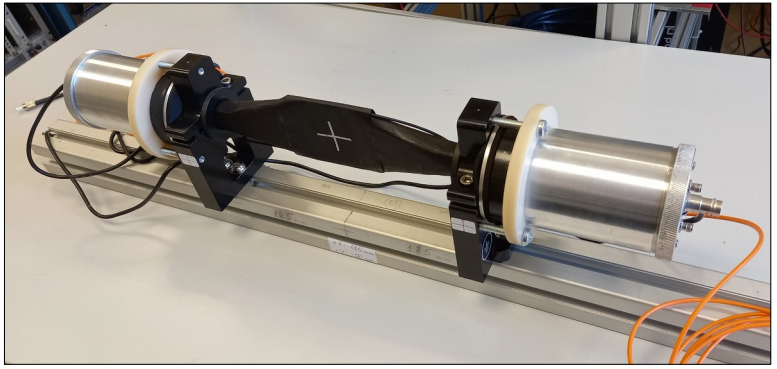
2022



Negligible non-carbon contamination

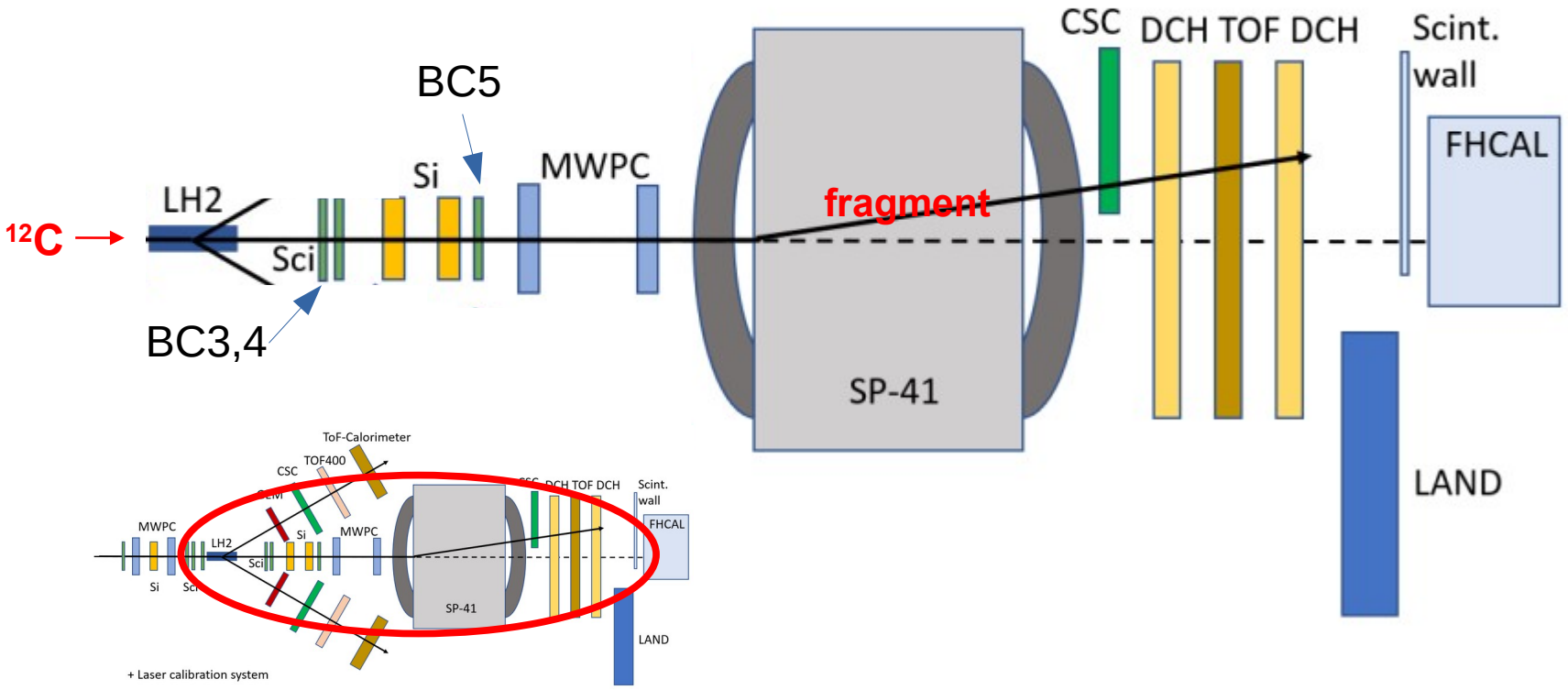
Incident Beam – Time Resolution

- 2 new timing scintillators
- Each with 2 PMTs
- Combined resolution σ = 45ps (100ps @2018)



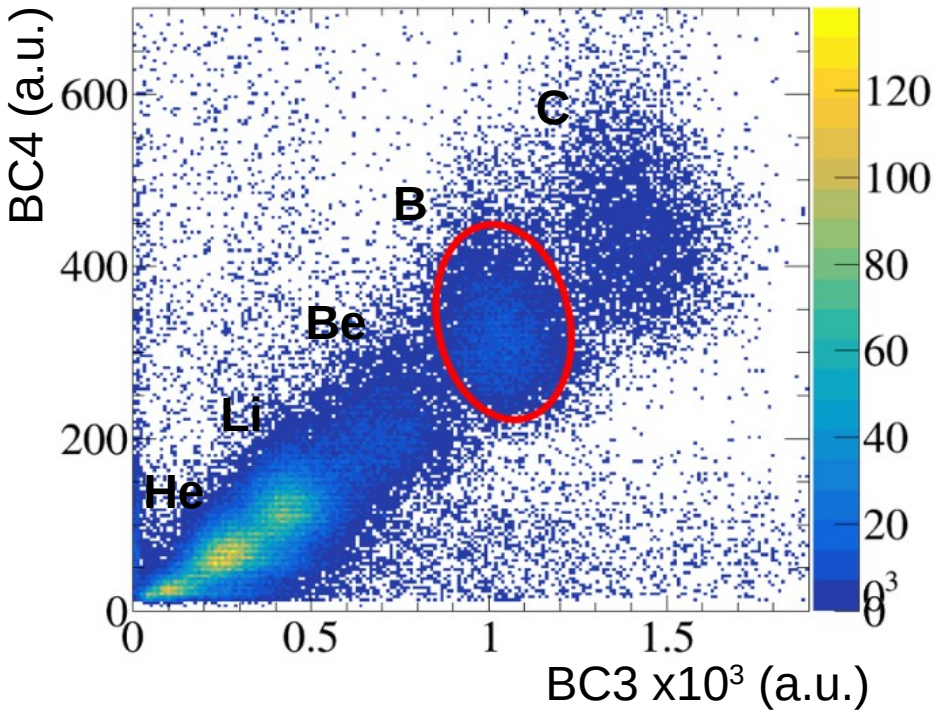
Fragment Spectrometer

$^{12}C + p \rightarrow 2p +$ **fragment(s)**

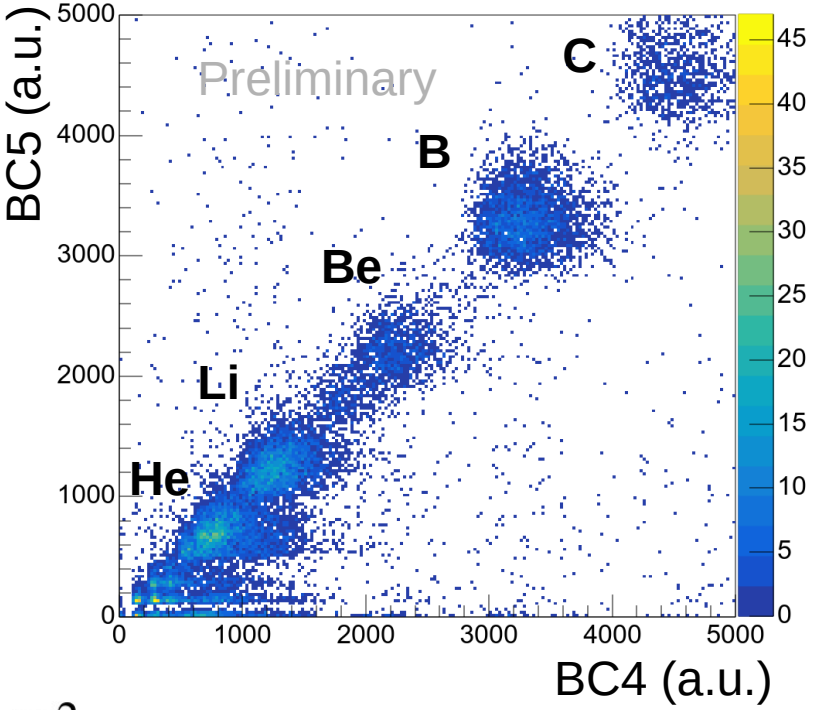


Fragment Spectrometer – Charge ID

2018



2022

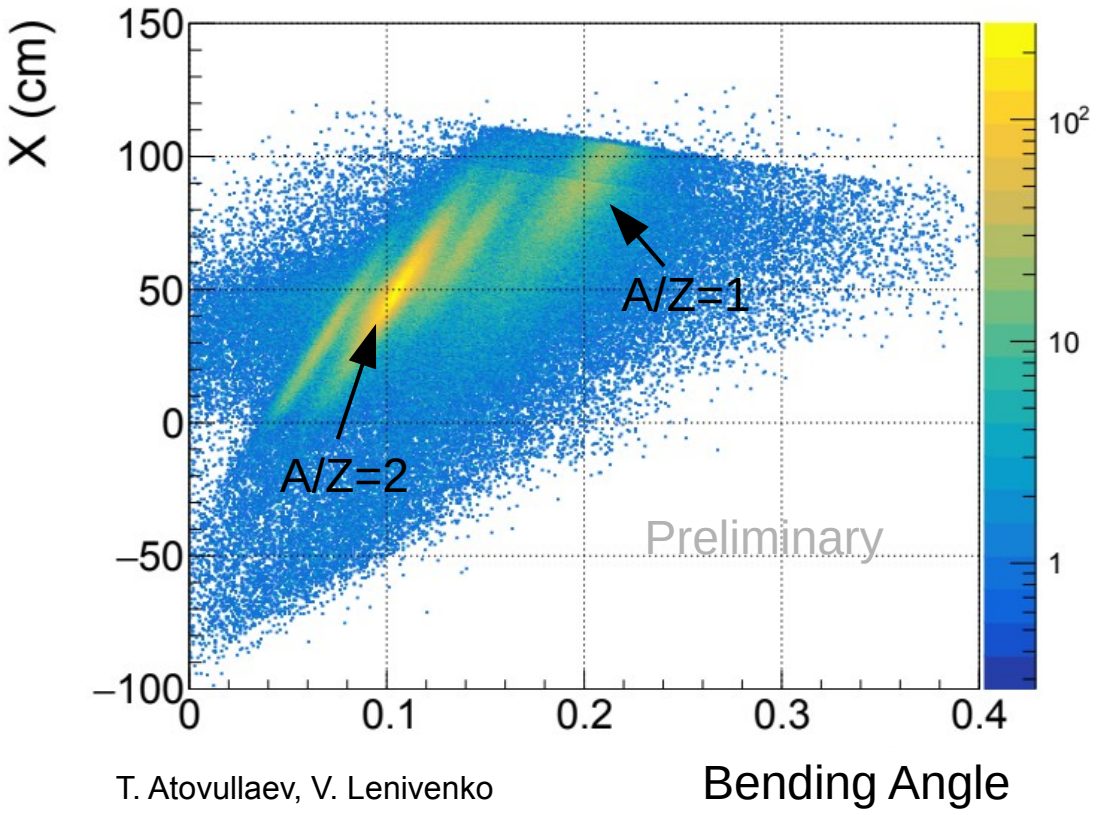


$$\frac{dE}{dX} \propto \sum Z^2$$

Fragment Spectrometer - Tracking

Magnetic Rigidity

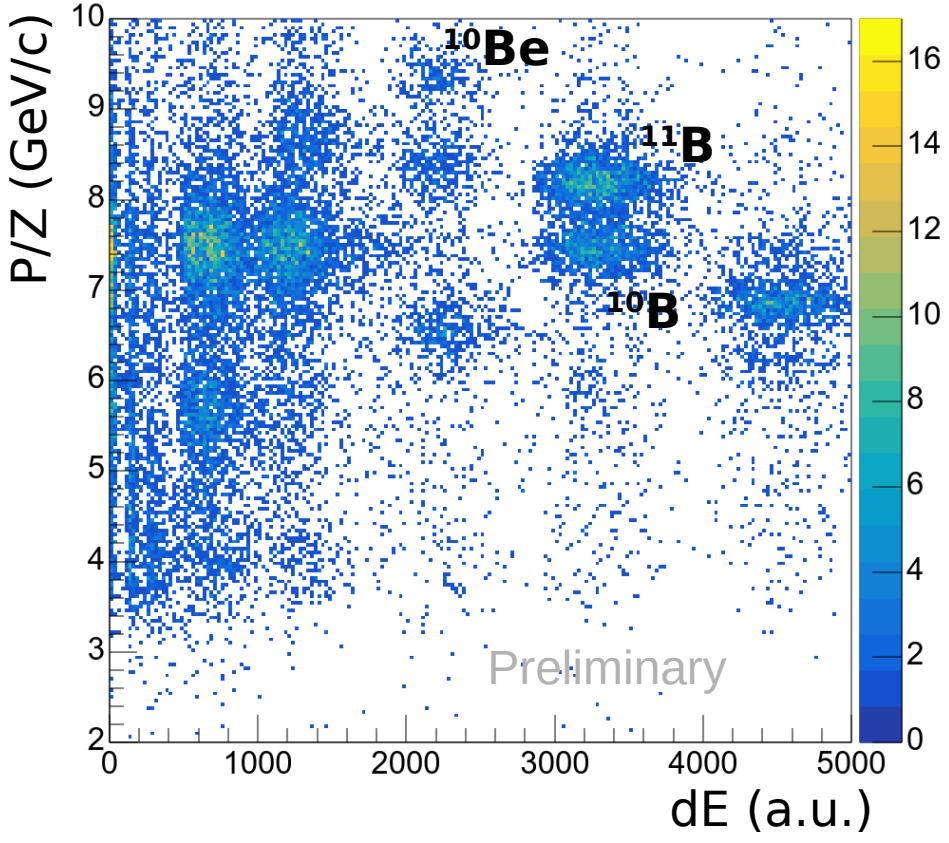
$$B\rho \propto \frac{A}{Z}\gamma\beta$$



T. Atovullaev, V. Lenivenko

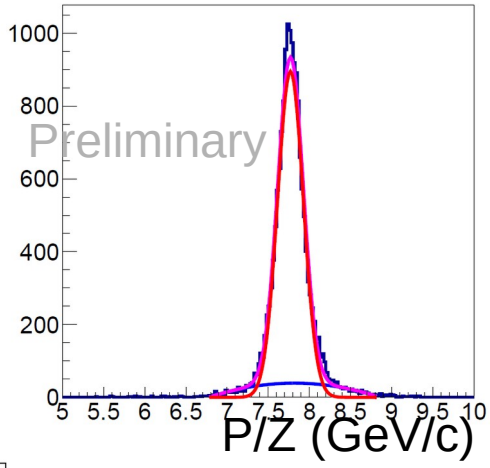
Fragment Spectrometer

$^{12}C+p \rightarrow 2p +$ **fragment(s)**

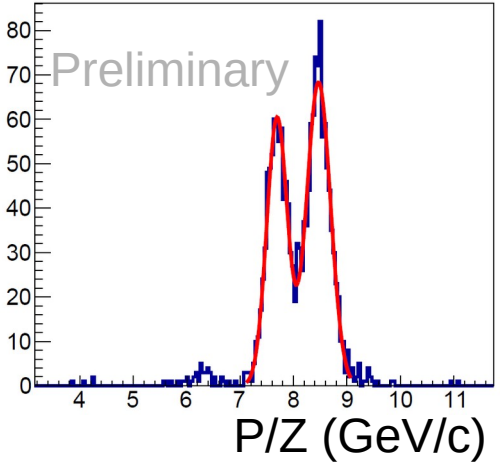


σ = 2%
To be improved
with Si detectors

Carbon Beam

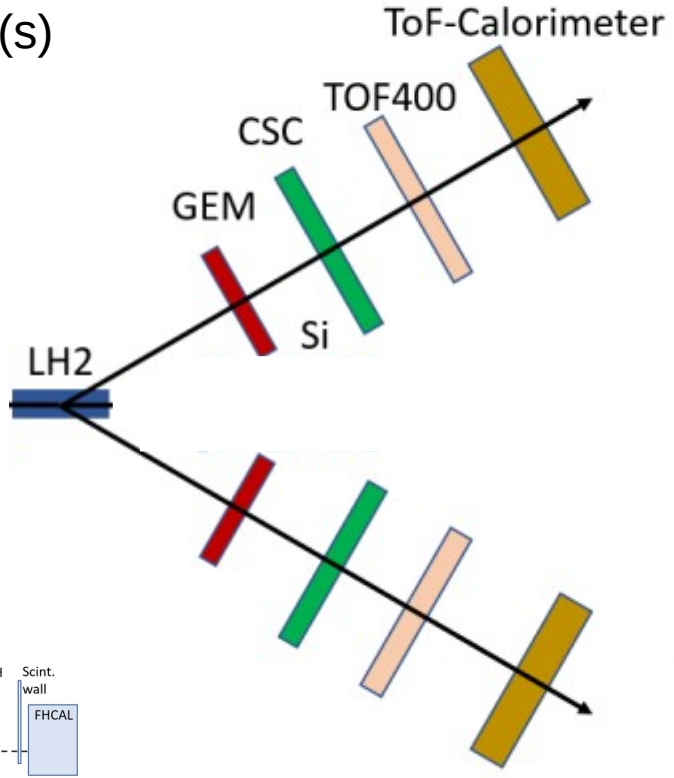


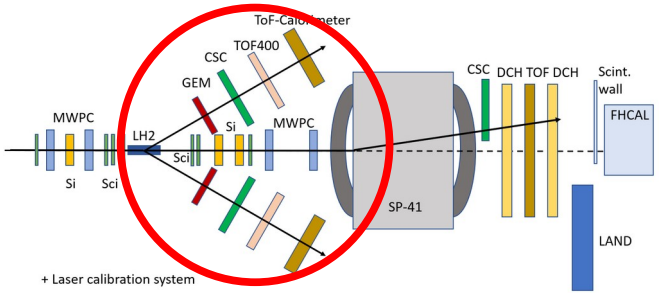
Boron



Two Arm Spectrometer (TAS)

$^{12}C+p \rightarrow$ **2p** + fragment(s)

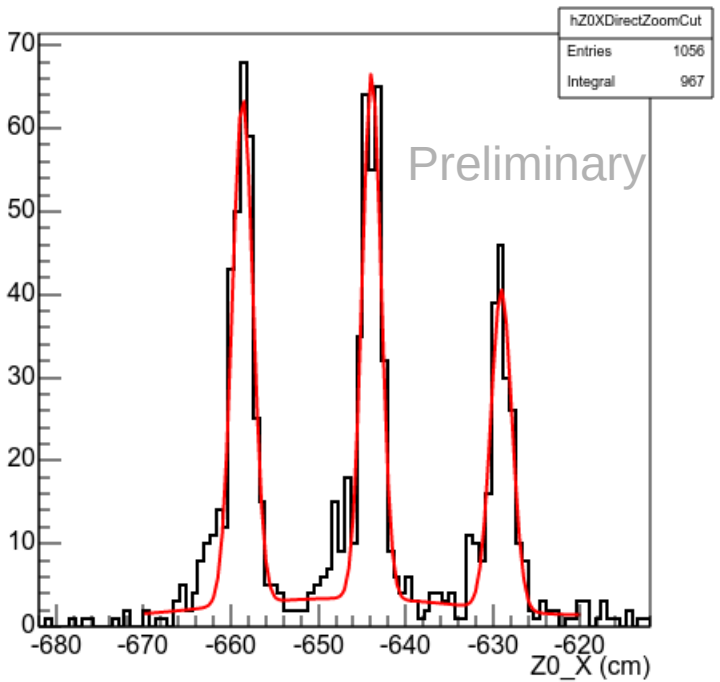




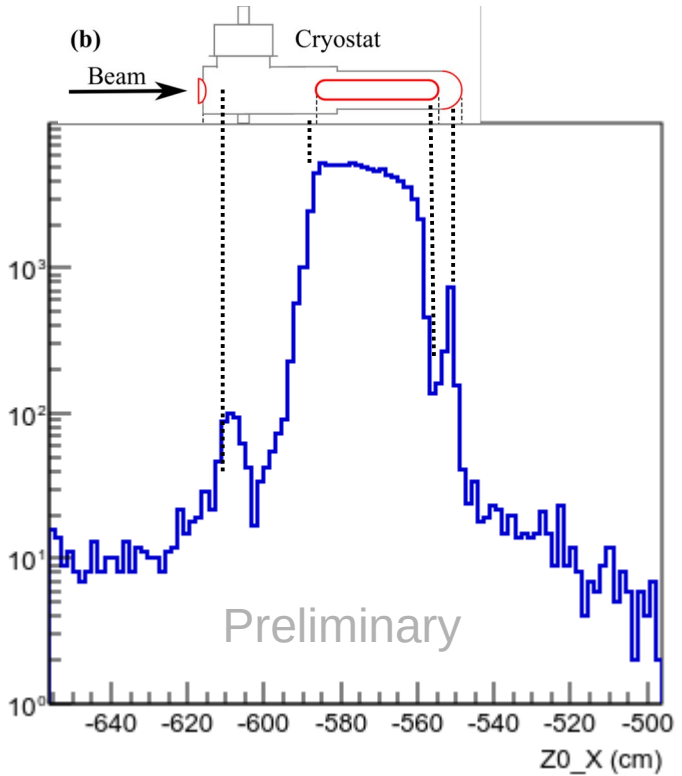
Tof-Calorimeter

TAS - Vertex Reconstruction

3 lead targets – calibration run



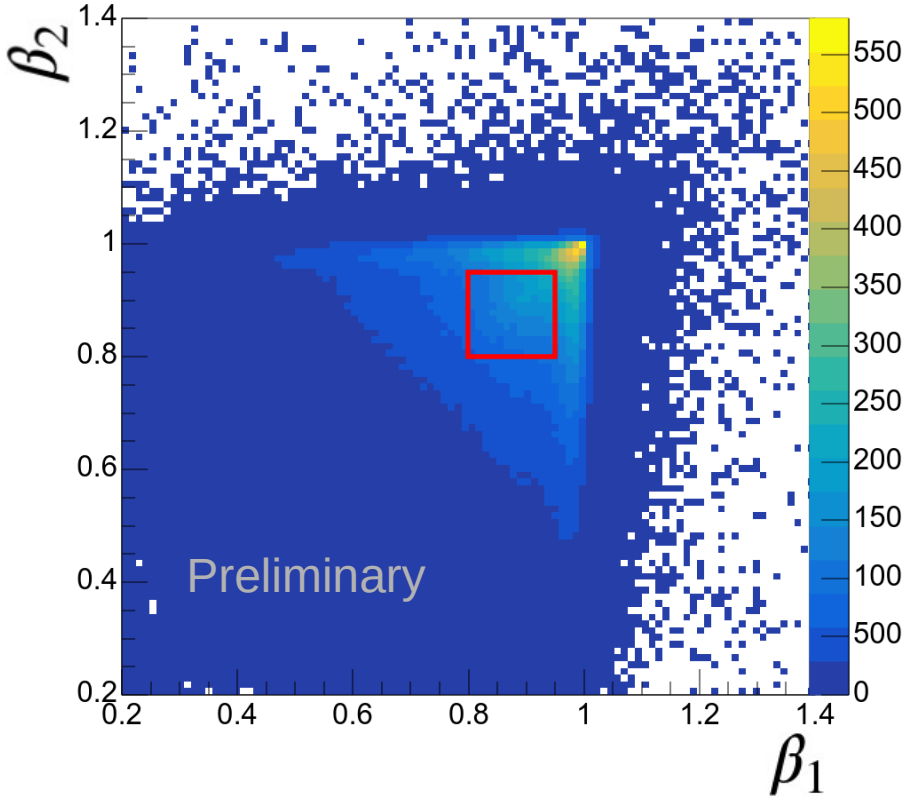
LH_2 target – physics runs



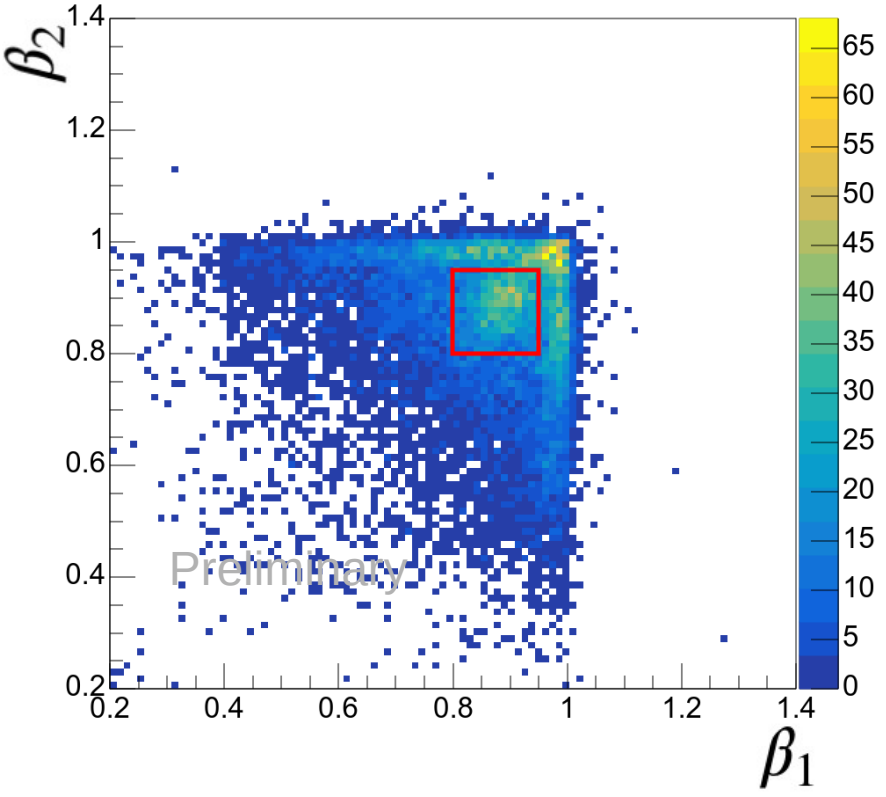
Resolution: 1.2 cm (1.8 cm in 2018)

TAS – PID

Right vs Left arm velocity



same, with ^{11}B identified

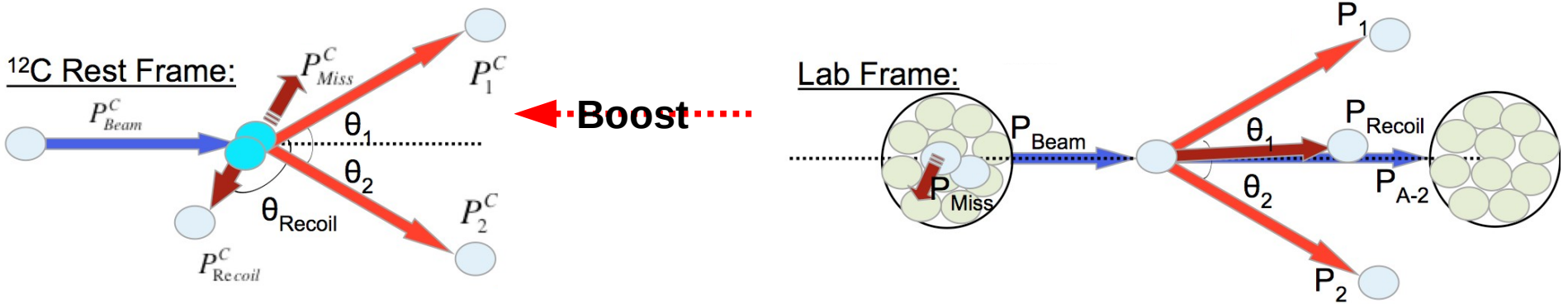


QE $^{12}C(p, 2p)^{11}B$ selection

$$P^{\mu}_{miss} = P^{\mu}_{1} + P^{\mu}_{2} - P^{\mu}_{target}$$

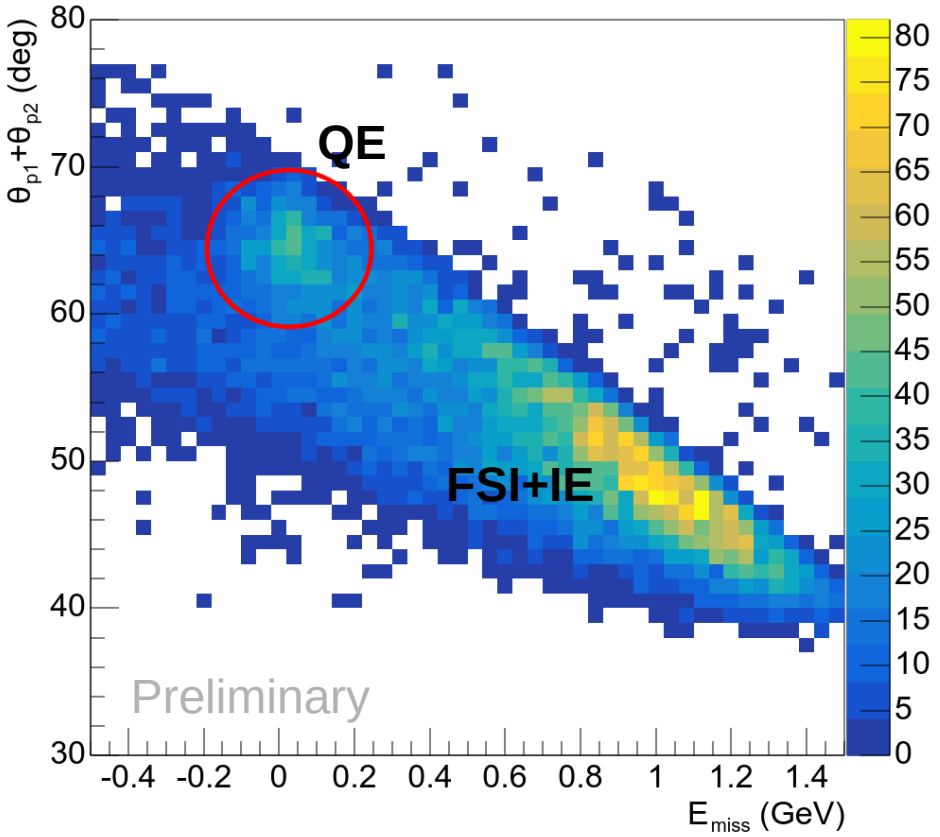
$$E_{miss} = m_p - P^{0}_{miss}$$

All quantities are defined in ^{12}C frame

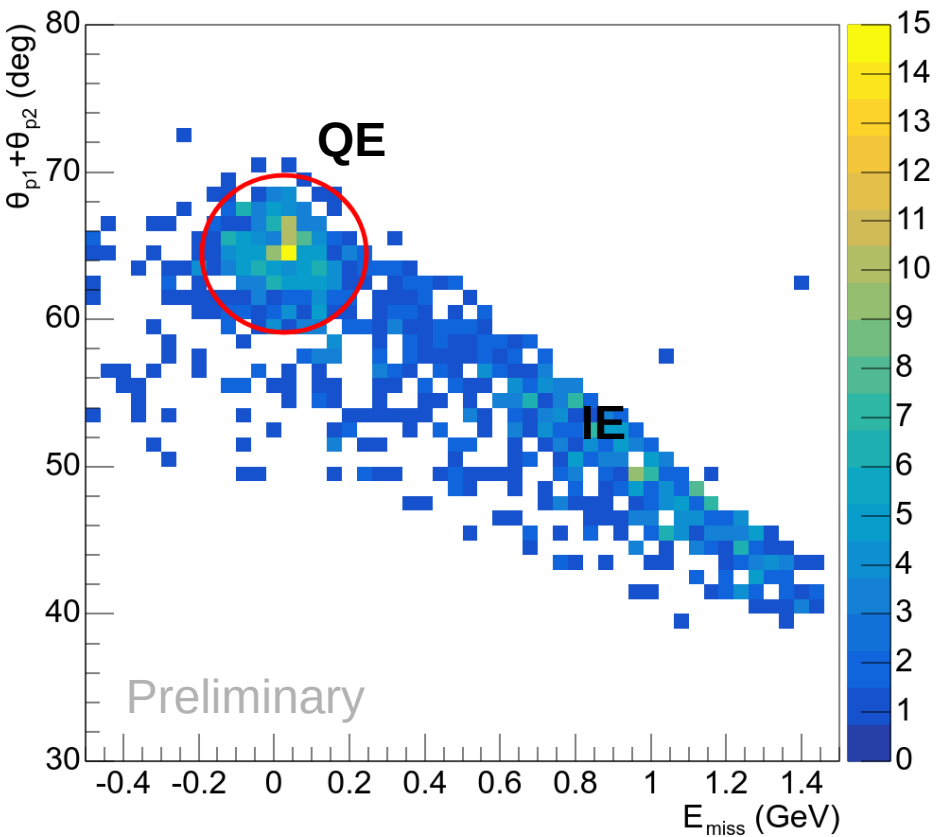


$^{12}C(p, 2p)^{11}B$ - QE selection

Opening Angle vs Emiss

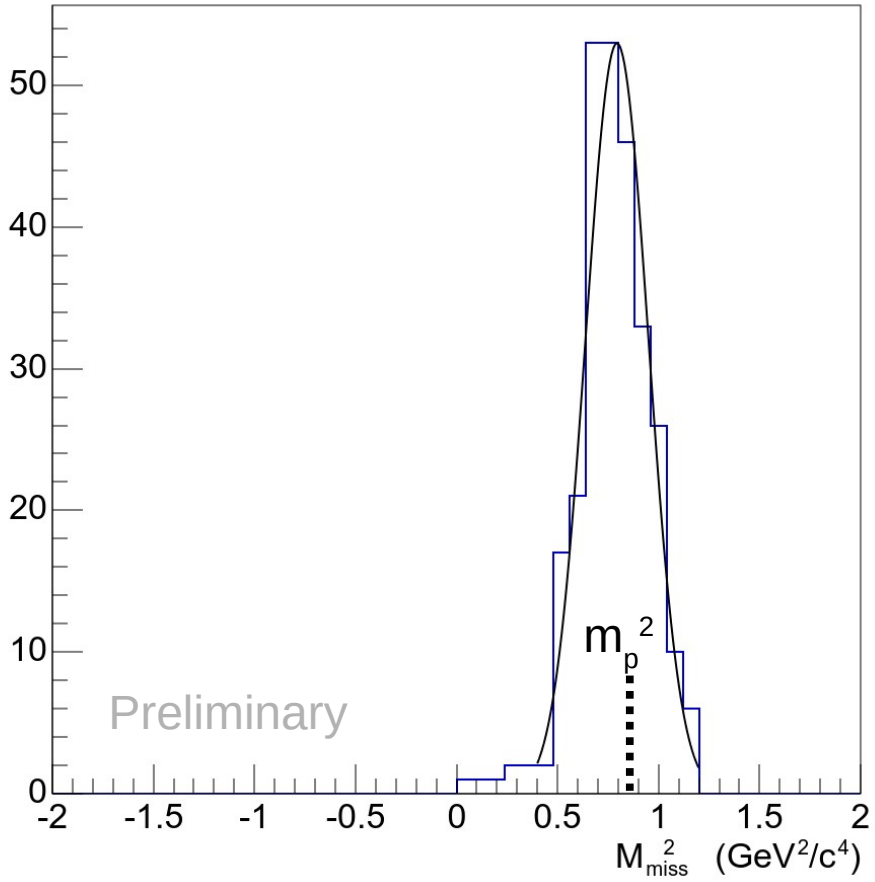


Same, with ^{11}B selection



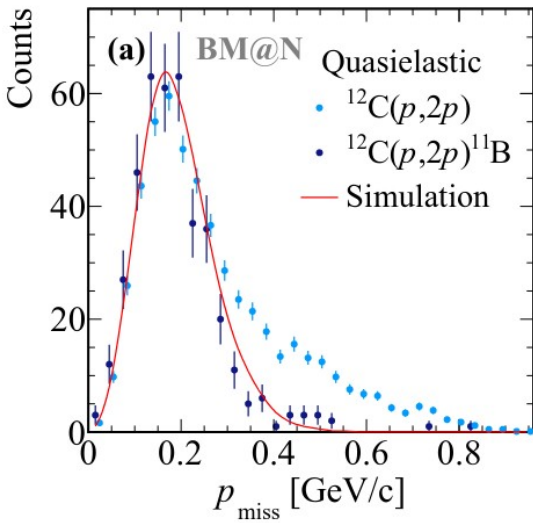
QE $^{12}C(p, 2p)^{11}B$ Missing Mass

- $M^2_{miss} = E^2_{miss} - \vec{P}^2_{miss}$
- Resolution:
- 2022: 156 MeV^2/c^4
- 2018: 168 MeV^2/c^4



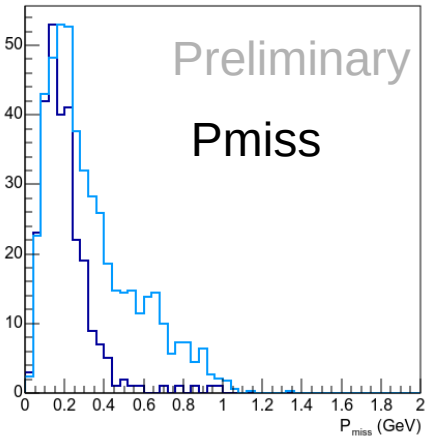
QE knockout – Pmiss distributions

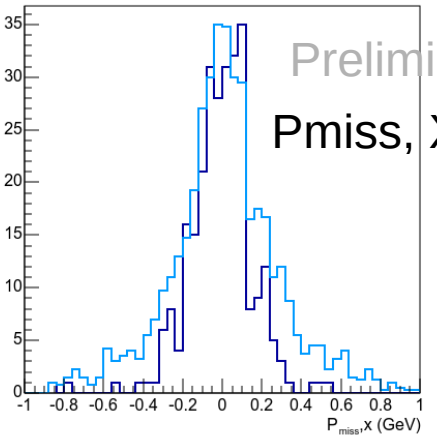
2018

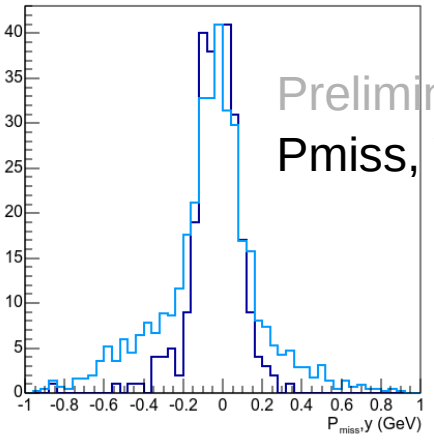


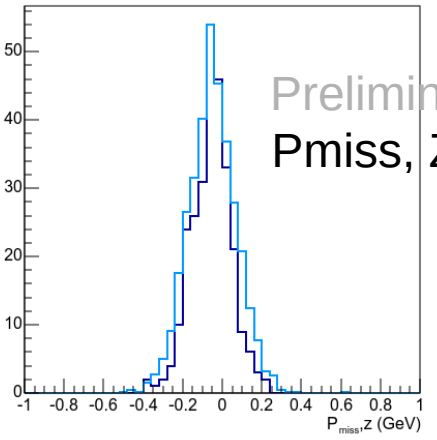
Nature Physics (2021)

2022









Next steps towards QE cross-section determination

- Clear single track → Multi-hits tracking in TAS
- Efficiency and acceptance for proton detection

Towards SRC Analysis

- Following QE analysis
- Expected:

more (p, 2p) SRC events

events with detected recoil p/n

multi-fragments SRC events

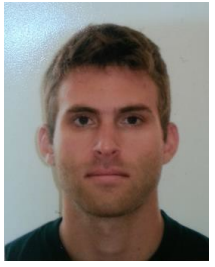
Analysis Group

Maria Patsyuk

Julian Kahlbow

Students

Vasilisa Lenivenko



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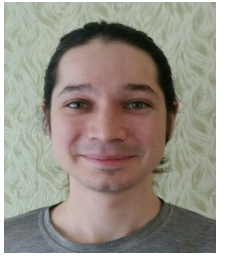

Timur Atovullaev

Thanks!