

Hadronization with Heavy Nuclei: RG-E Launch

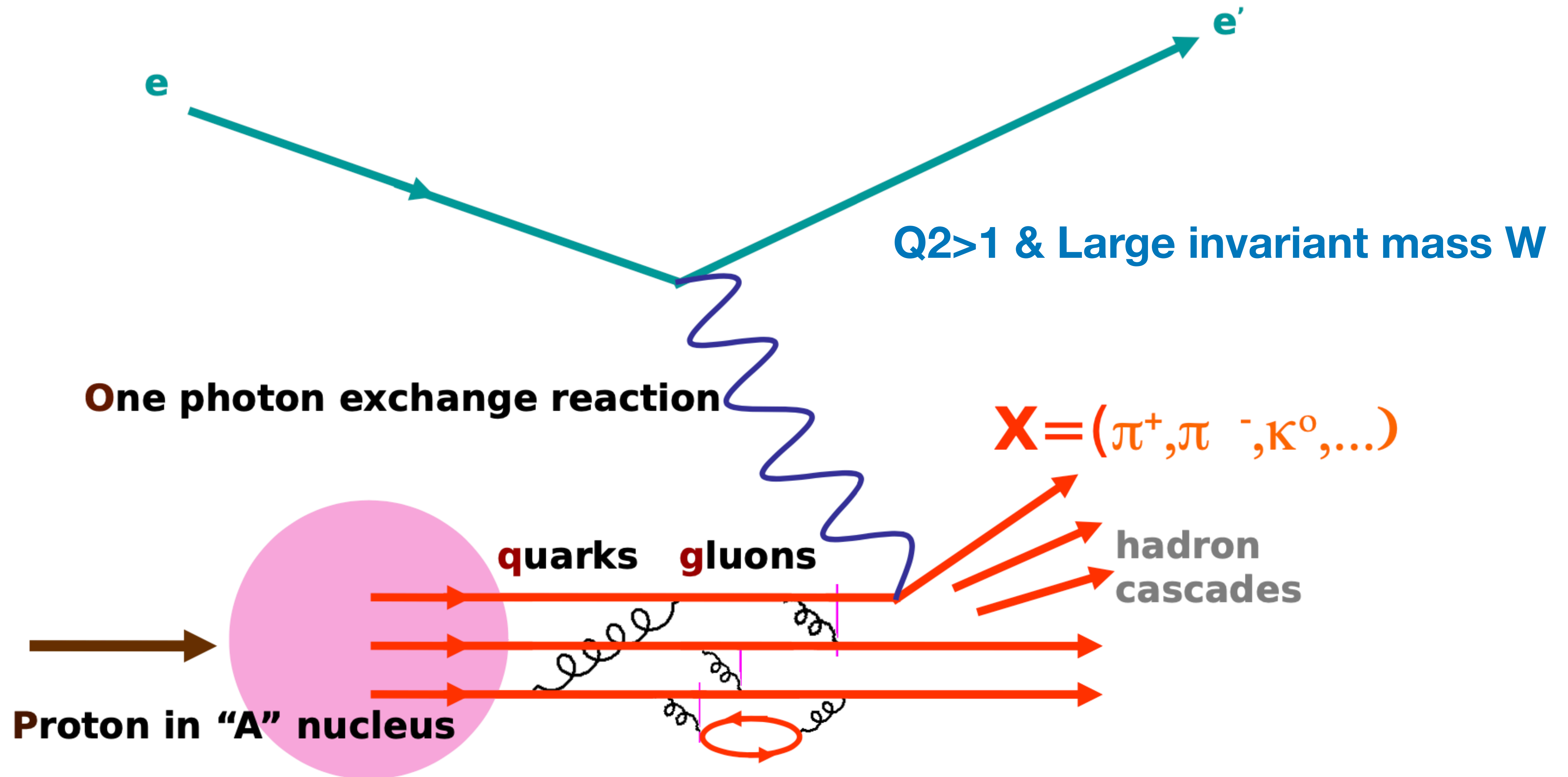
Spring 2024 Run (30 PAC days from 60 granted)

Hayk Hakobyan

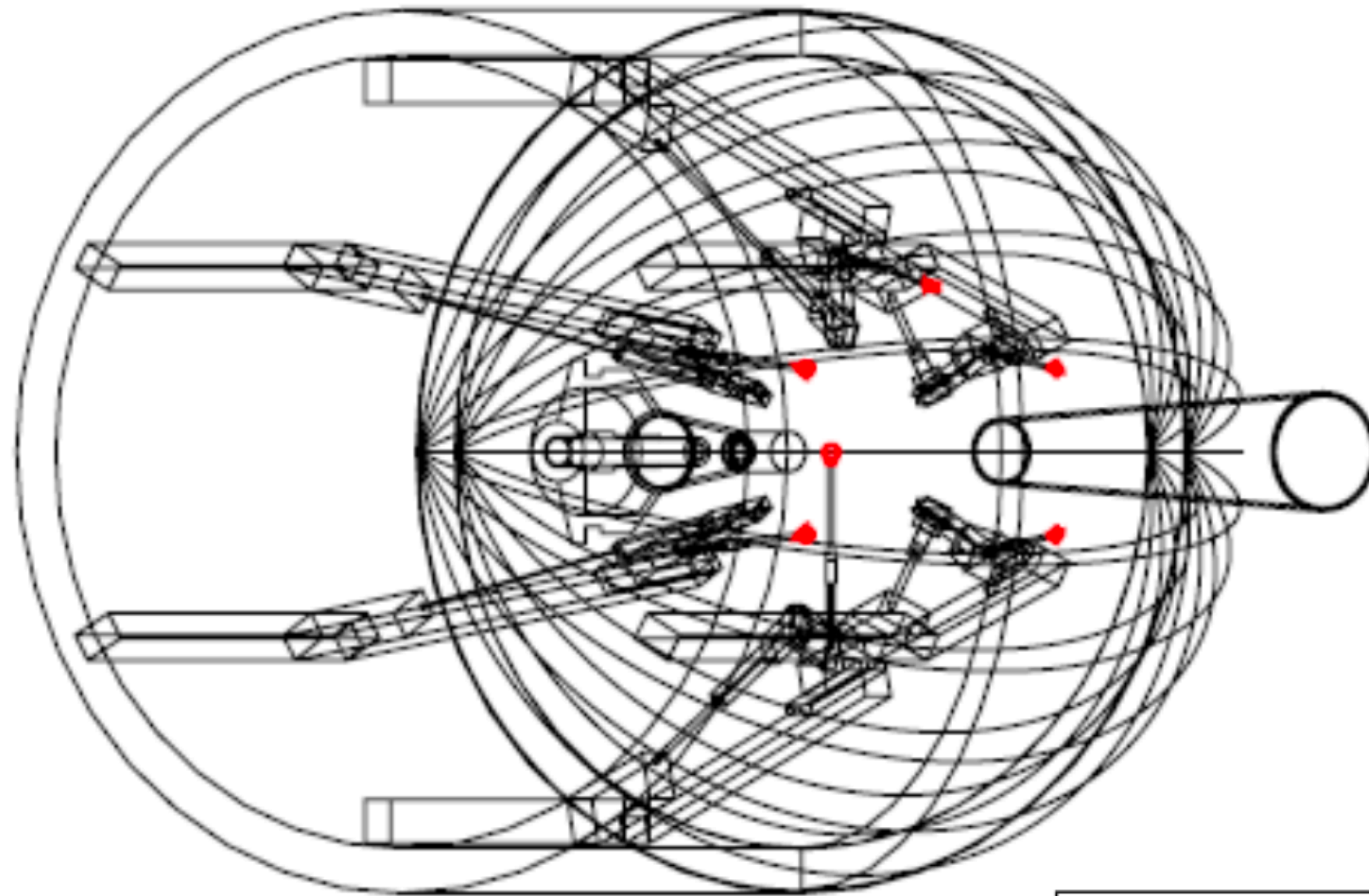
**Universidad Tecnica Federico Santa Maria &
Centro Cientifico Tecnologico de Valparaiso**

**CLAS Collaboration Meeting
Jefferson lab, March 2024**

Schematic diagram describing semi-inclusive Deep Inelastic Scattering of a lepton off a nucleon



Eg2 Double-Target



Thickness of Solid Targets		
Target	Thickness (cm)	ρ_A/ρ_D
C	0.17	0.894
Fe	0.04	0.949
Pb	0.014	0.478

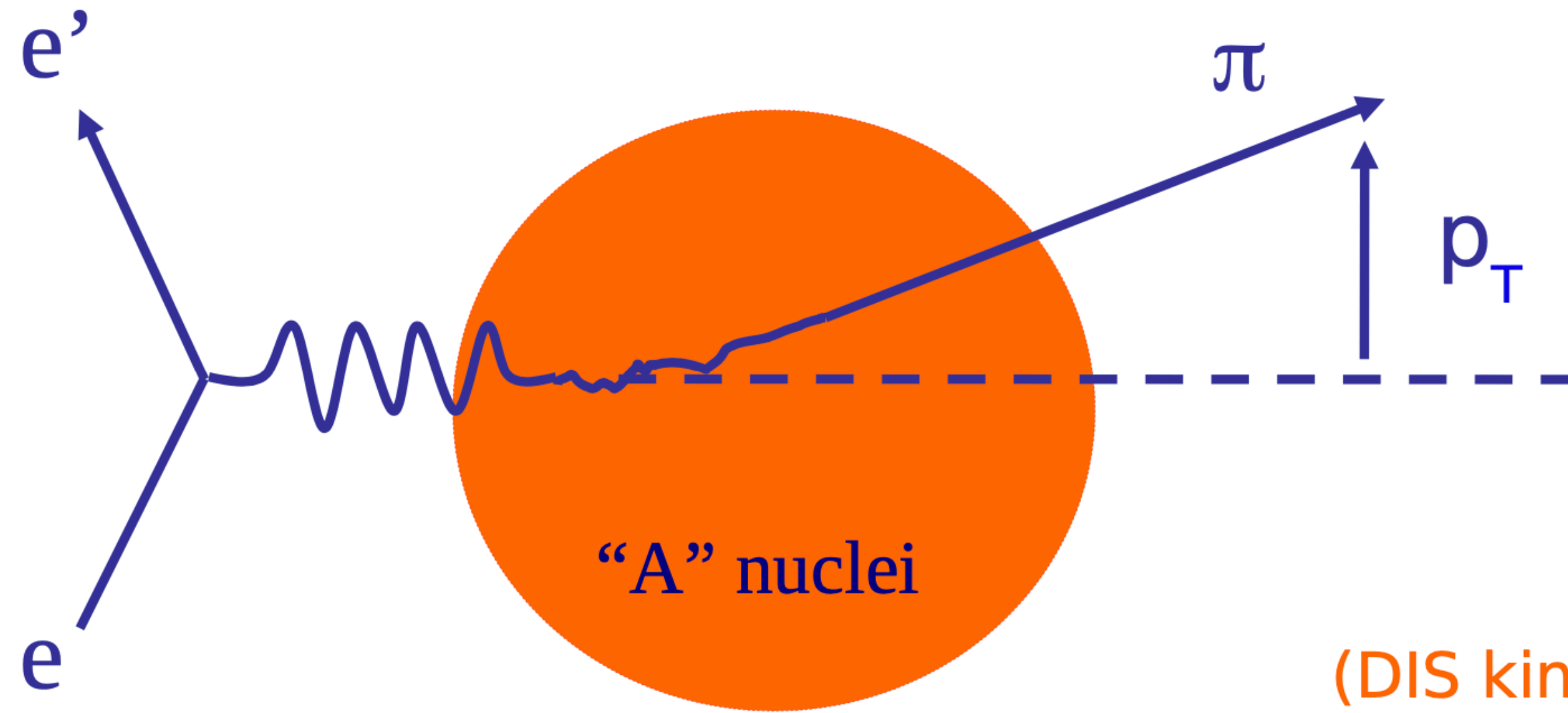
H. Hakobyan, W. Brooks et al, Nucl. Instrum. and Meth. A592:218-223, 2008.

Studies performed with EG2 data

- Hadronization studies in nuclear medium
- Color transparency
- Short-Range Nuclear correlations
- Two-pion BEC correlations
- Dihadron supresión
- Etc.

Experimental observables

Transverse momentum broadening: $\Delta p_T^2 = p_T^2(A) - p_T^2(^2H)$



(DIS kinematics)

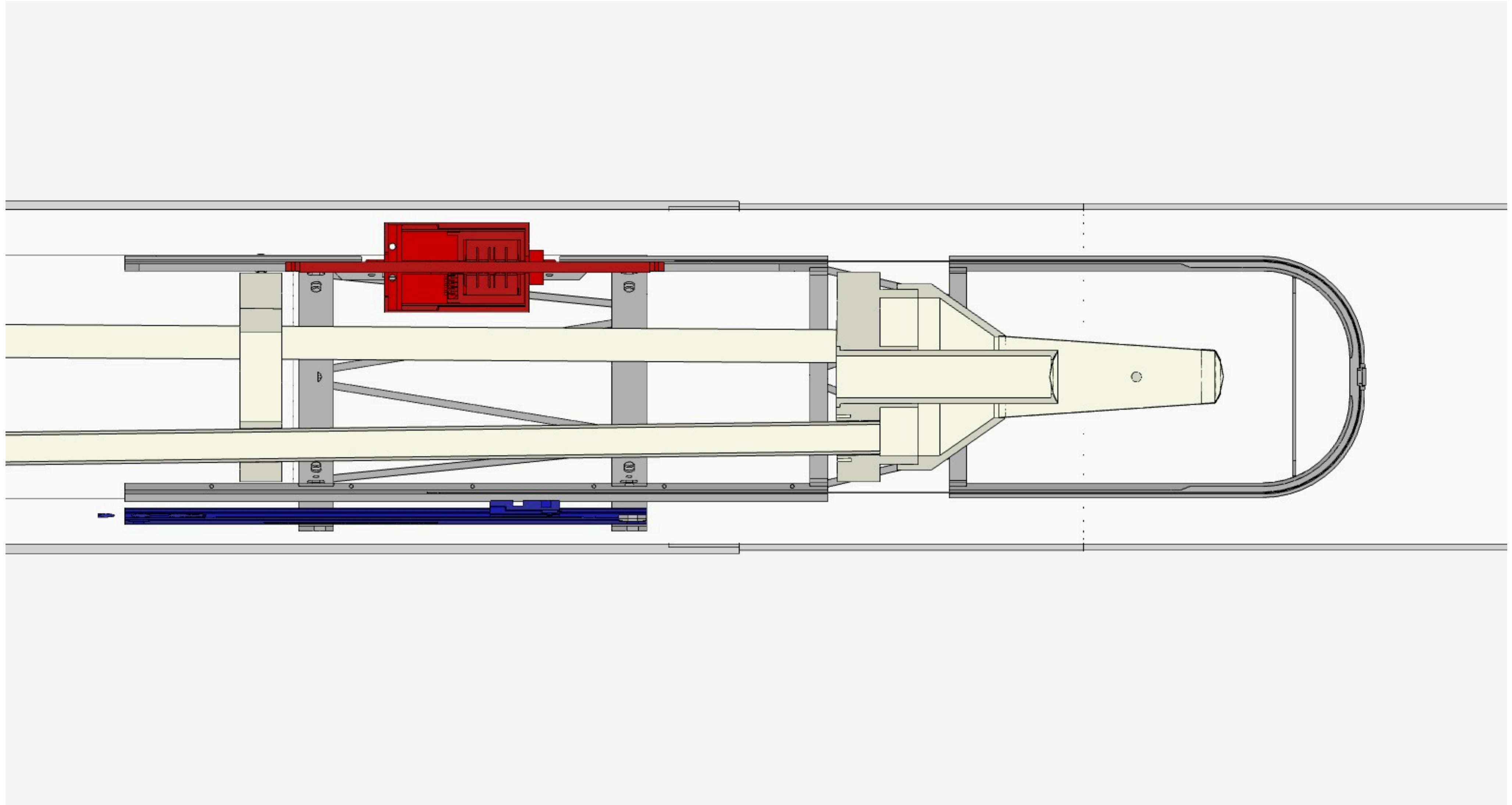
Hadronic multiplicity ratio:

$$R_M^h(z, \nu, p_T^2, Q^2, \phi) = \frac{\left\{ \frac{N_h^{DIS}(z, \nu, p_T^2, Q^2, \phi)}{N_e^{DIS}(\nu, Q^2)} \right\}_A}{\left\{ \frac{N_h^{DIS}(z, \nu, p_T^2, Q^2, \phi)}{N_e^{DIS}(\nu, Q^2)} \right\}_D}$$

Experiment Context: CLAS12 Conditions

- 1. Reduced Space in Beamline, 85mm**
 - 2. High Vacuum, 10^{-6} mbar**
 - 3. Strong Magnetic Field, 5 Tesla**
 - 4. Cryogenic Temperatures, 22 Kelvin cryo-cell**
 - 5. 11 GeV Beam energy**
-
- Interchangeable solid targets system in high vacuum**
 - Remote control system**
 - Resistant to high radiation**
 - Non-magnetic materials**
 - High vacuum resistant materials (no out-gassing)**
 - Fit in a 85mm diameter, cylindrical room**
 - Estimation of temperature in targets and devices**

RGE Experiment Double Target System



RGE Experiment Double Target System



hadron	$c\tau$	mass (GeV)	flavor content	detection channel	Production rate per 1k DIS events
π^0	25 nm	0.13	$u\bar{u}d\bar{d}$	$\gamma\gamma$	1100
π^+	7.8 m	0.14	$u\bar{d}$	direct	1000
π^-	7.8 m	0.14	$d\bar{u}$	direct	1000
η	0.17 nm	0.55	$u\bar{u}d\bar{d}s\bar{s}$	$\gamma\gamma$	120
ω	23 fm	0.78	$u\bar{u}d\bar{d}s\bar{s}$	$\pi^+\pi^-\pi^0$	170
η'	0.98 pm	0.96	$u\bar{u}d\bar{d}s\bar{s}$	$\pi^+\pi^-\eta$	27
ϕ	44 fm	1.0	$u\bar{u}d\bar{d}s\bar{s}$	K^+K^-	0.8
f_1	8 fm	1.3	$u\bar{u}d\bar{d}s\bar{s}$	$\pi\pi\pi\pi$	-
K^+	3.7 m	0.49	$u\bar{s}$	direct	75
K^-	3.7 m	0.49	$\bar{u}s$	direct	25
K^0	27 mm	0.50	$d\bar{s}$	$\pi^+\pi^-$	42
p	stable	0.94	ud	direct	530
\bar{p}	stable	0.94	$\bar{u}\bar{d}$	direct	3
Λ	79 mm	1.1	uds	$p\pi^-$	72
$\Lambda(1520)$	13 fm	1.5	uds	$p\pi^-$	-
Σ^+	24 mm	1.2	us	$p\pi^0$	6
Σ^0	22 pm	1.2	uds	$\Lambda\gamma$	11
Ξ^0					
Ξ^-					

With new double-target, designed and built in UTFSM

Hadrons in CLAS12

Target configuration with 70 nA beam current

	Solid target thickness in mm	Liquid target Luminosity	Solid target Luminosity	Total Luminosity	Number of Days to Run	Days: inbending/outbending
2cm LD2 + C	1.48	8.56E+34	8.79E+34	1.74E+35	9	8/1
2cm LD2 + Al	1.20	“”	8.53E+34	1.71E+35	9	8/1
2cm LD2 + Cu	0.36	“”	8.50E+34	1.71E+35	9	8/1
2cm LD2 + Sn	0.30	“”	5.78E+34	1.43E+35	14	12/2
2cm LD2 + Pb	0.14	“”	4.18E+34	1.27E+35	19	17/2

Integrated luminosity for each solid target is: 6.81E+40

Scattering Chamber - Rohacell vs. Carbon Fiber

	Thickness in cm	Radiation Length in cm	% of Radiation Length
Rohacell	1.18	760	0.15%
Carbon Fiber	0.12	29	0.41%



Monitoring:

1. Alignment between liquid cell and solid target.
2. Heat shield temperature.
3. Ice formation in the system.

Special Test Runs:

1. Double Target system alignment with LD2 target and Carbon target: app. 4 hrs
2. Quick luminosity scan to define the run optimal current with LD2 full: app. 1 hr
3. Collection of 500k tracks required for AI training: app. 2 hrs
4. Trigger validation: with random trigger: app. 4 hrs
5. Trigger validation: no DC-roads electron trigger: app 1 hrs
6. PMT gain/HV calibrations for CND/CTOF/ECAL/FTOF with 75M events: app. 12 hrs
7. Zero field alignment run with empty cryotarget, 10M electron triggers with ~ 1 nA current, just before/after a scheduled down time for torus/solenoid ramping: app. 4 hrs
8. Luminosity Scan; separate runs with 5 million electron triggers each for 5/10/50/10 nA, for Carbon and Lead targets: app. 12 hrs
9. Empty cryotarget run with C on: app. 8 hrs

Run coordinators:

March 10 - March 20 - Hayk Hakobyan

March 20 - March 27 - William Brooks

March 27 - April 3 - Stepan Stepanyan

April 3 - April 10 - Ioana Niculescu

April 10 - April 17 - Mikhail Yurov

April 17 - April 24 - Raphael Dupré

April 24 - May 1 - Taisiya Mineeva

May 1 - May 8 - Michael Wood

May 8 - May 15 - Lamiaa El Fassi

May 15 - May 19 - Sebouh Paul

Target Experts:

Milan Ungerer, Eduardo Mondaca,

Alonso Lepe, Vicente Saona, Israel Avila

Analysis Coordinator: Hayk Hakobyan, Antonio Radic

Cooking Chef: Sebouh Paul, Antonio Radic