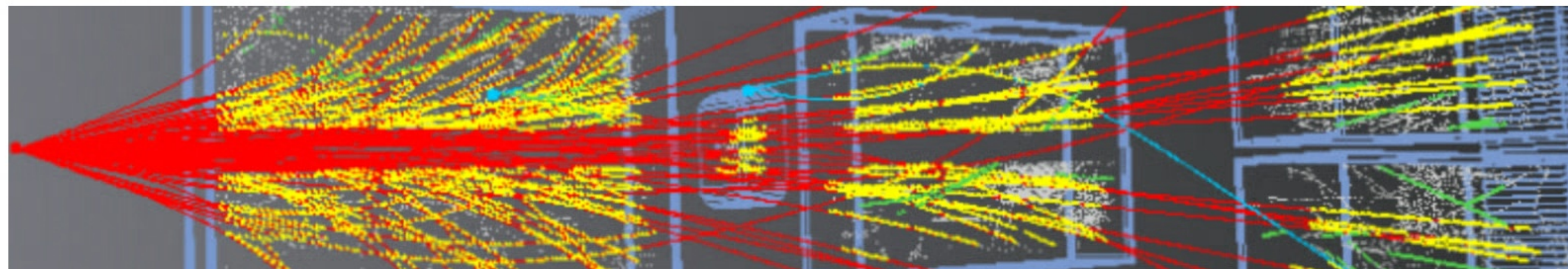


NAGI/SHINE IN BRIEF

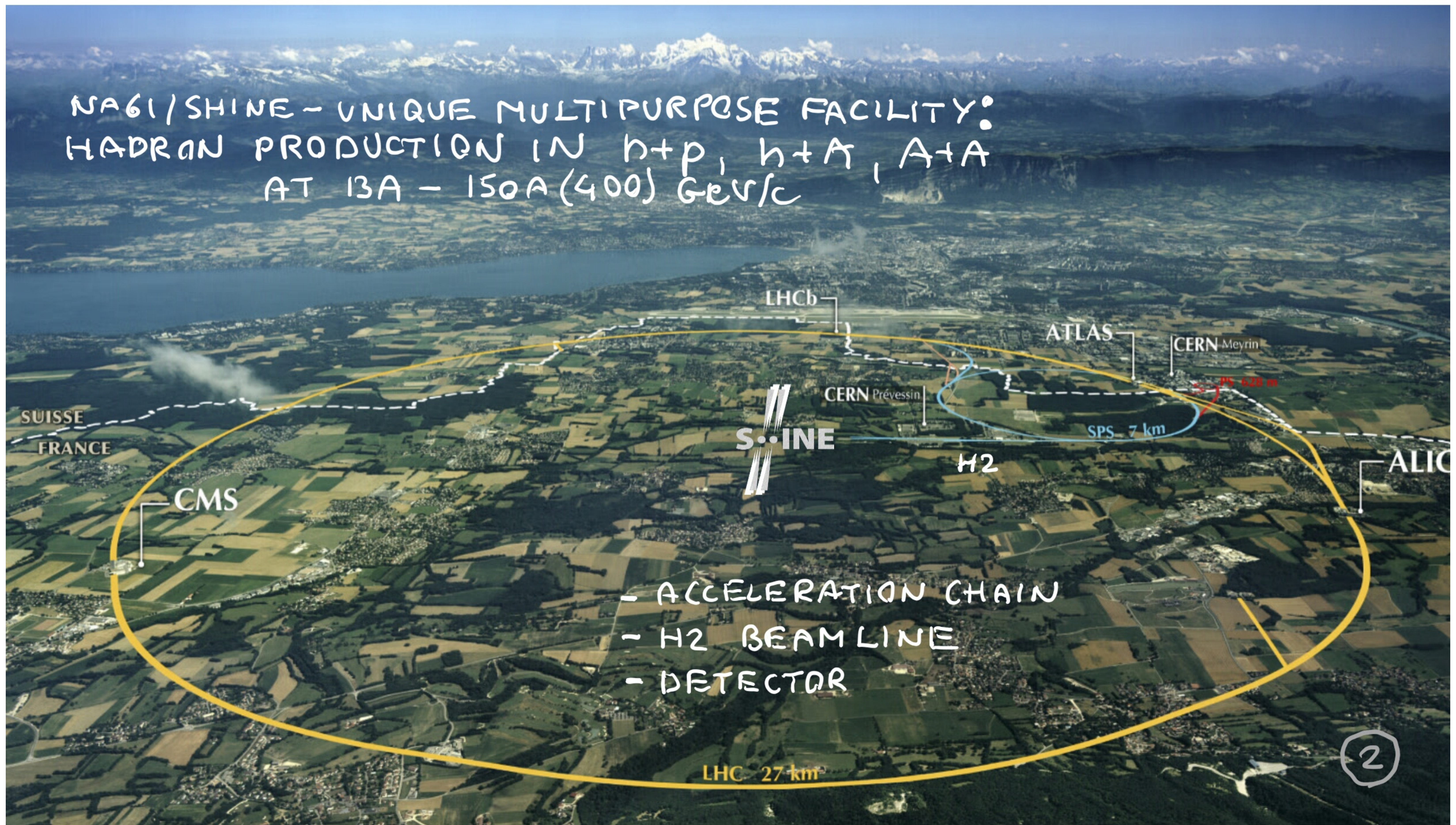
MG FRANKFURT, KIELCE

- FACILITY
- ■ PHYSICS PROGRAMMES
- ■ ■ COLLABORATION



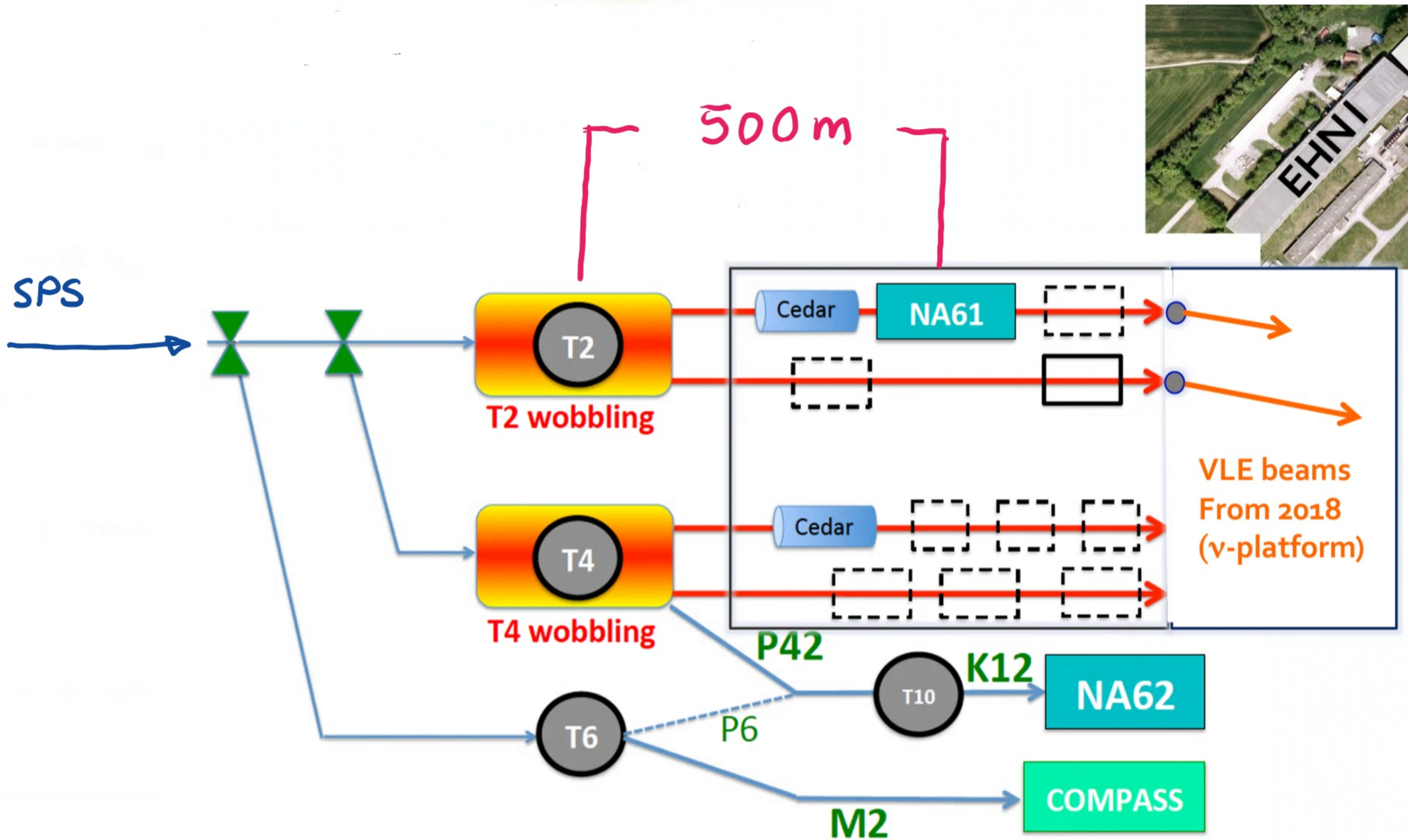
FACILITY

NA61/SHINE - UNIQUE MULTIPURPOSE FACILITY:
HADRON PRODUCTION IN $h+p$, $h+A$, $A+A$
AT $13A - 150A (400)$ GeV/c

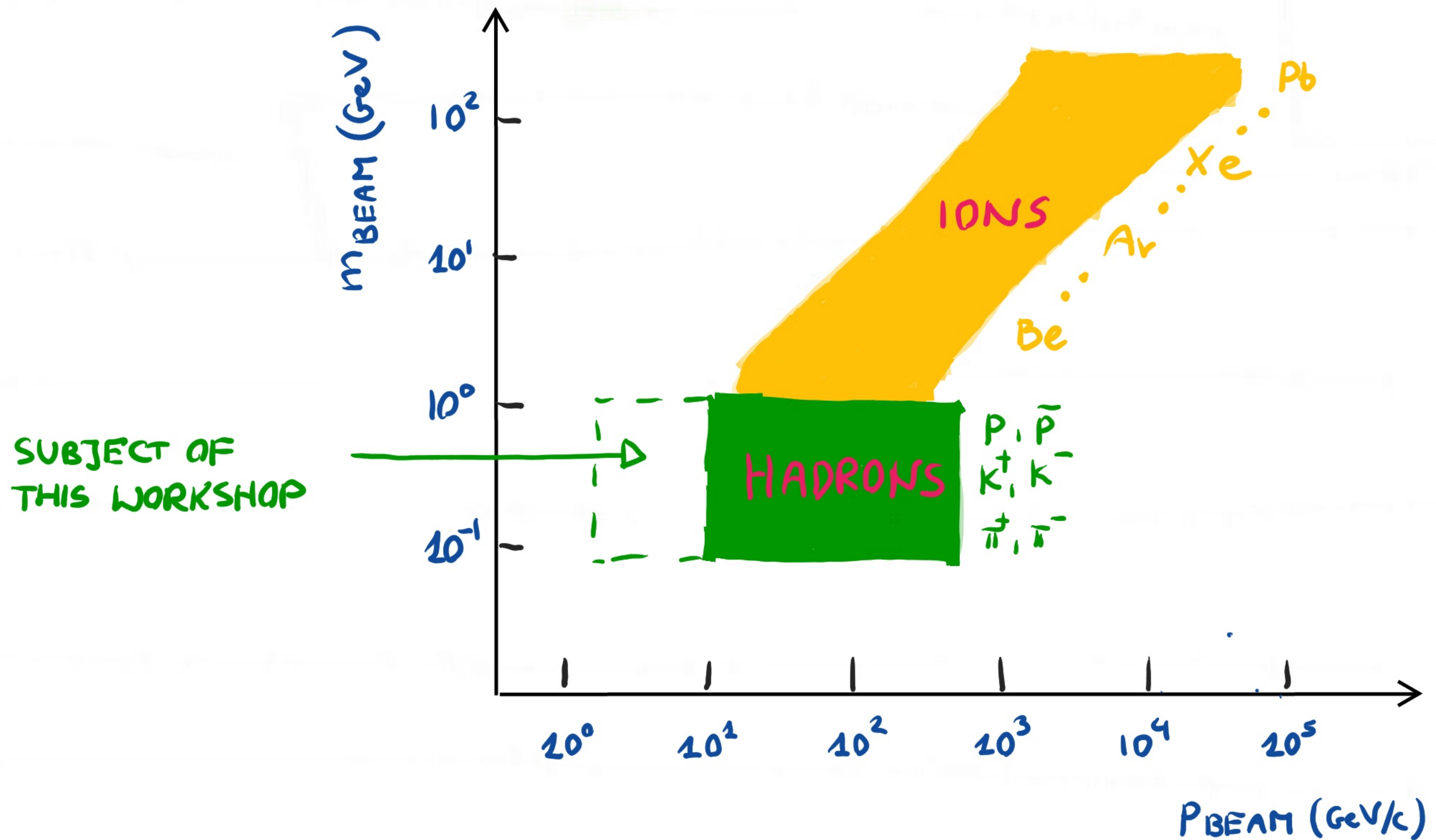


- ACCELERATION CHAIN
- H2 BEAMLINE
- DETECTOR

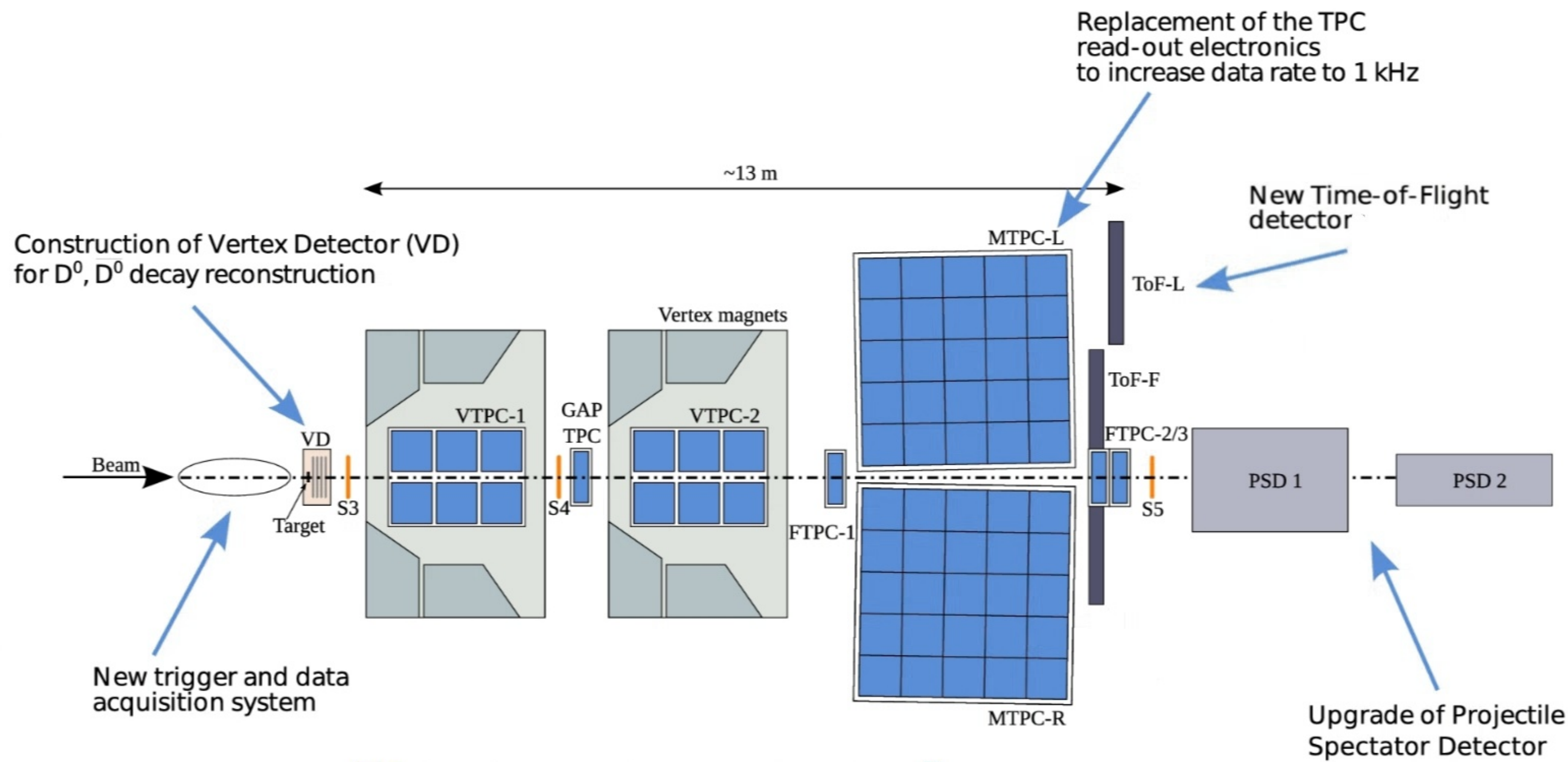
H2 BEAM LINE



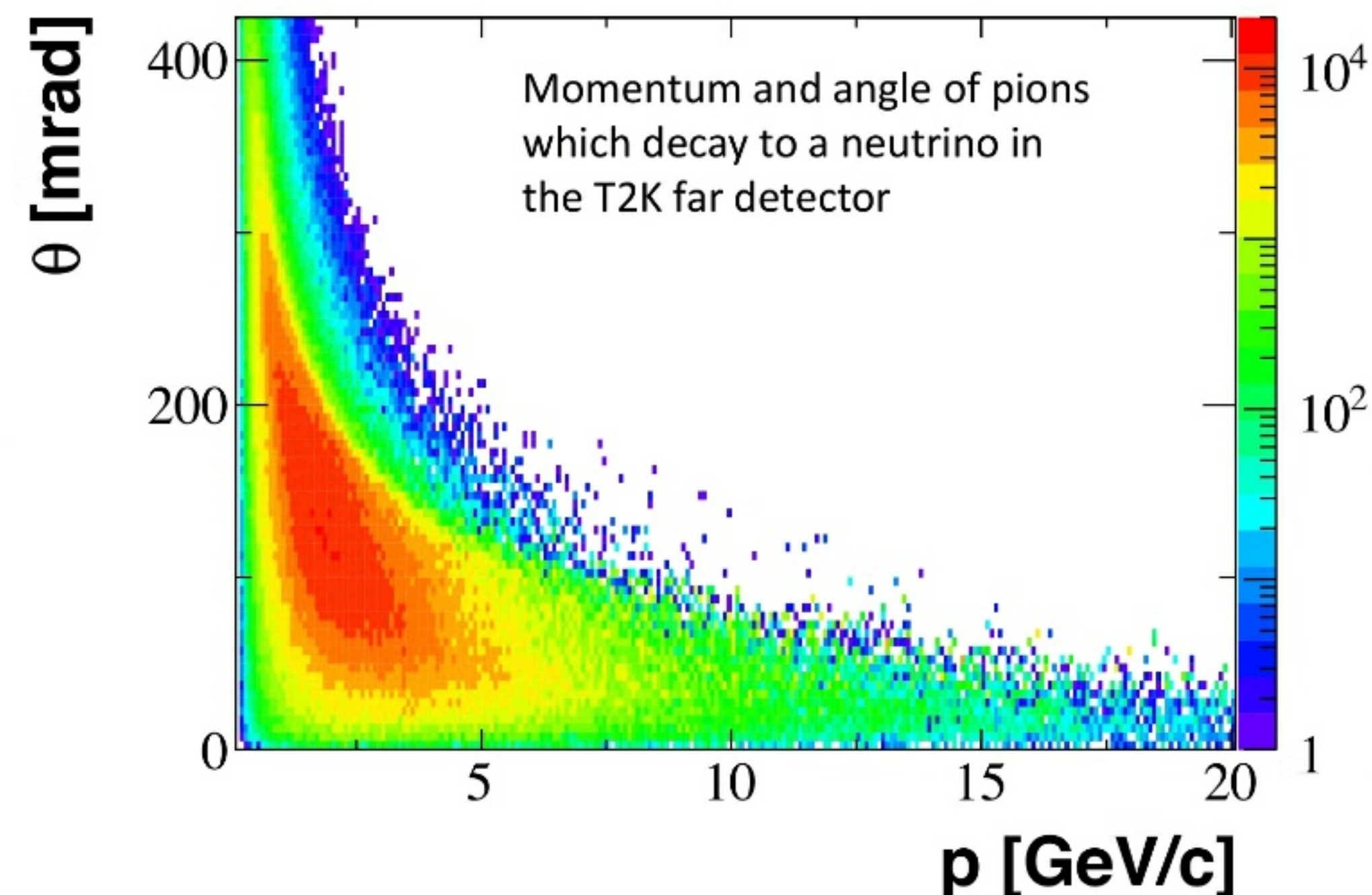
BEAMS: UNPRECEDENTED VARIETY OF MASSES AND MOMENTA



DETECTOR AND ITS UPGRADE (2018-2021)

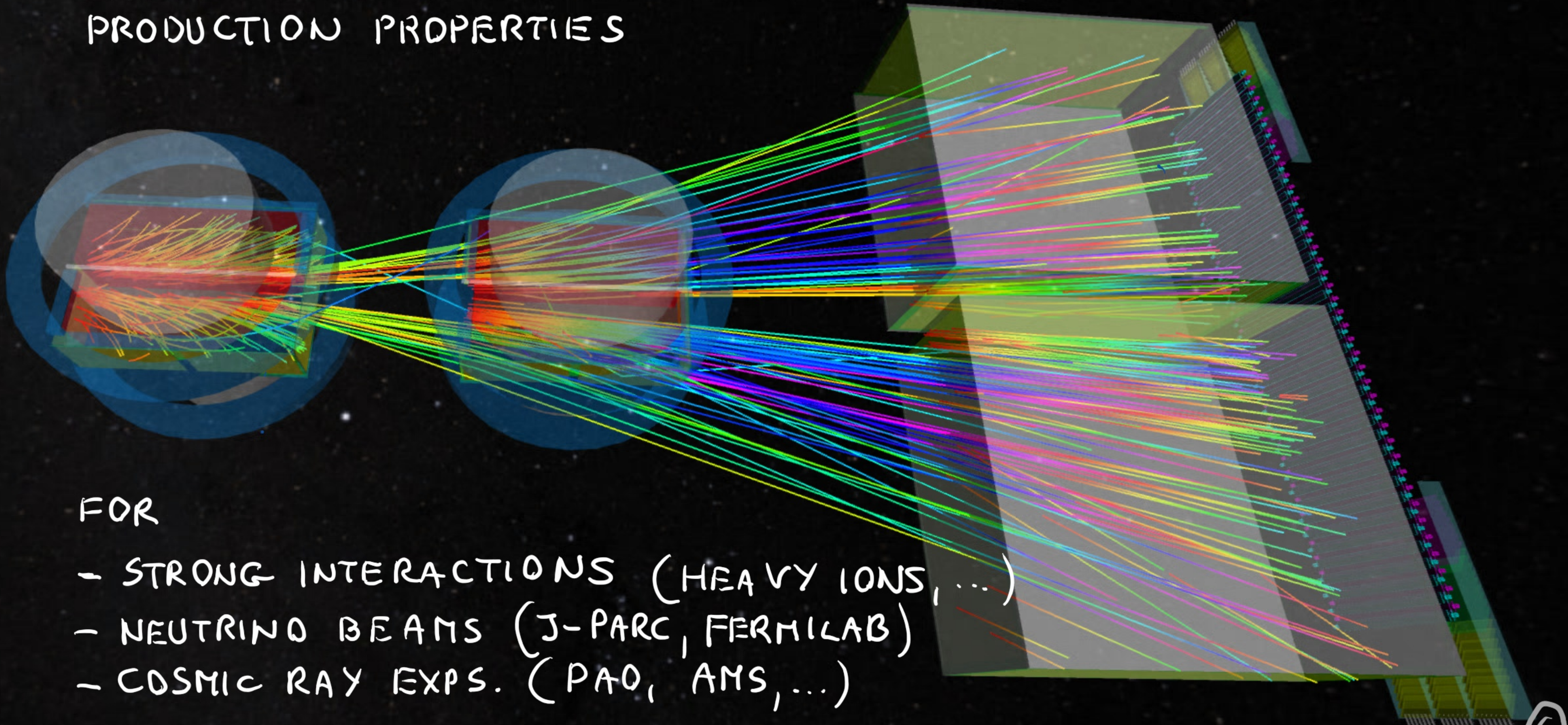


- $B \cdot L \lesssim 9 \text{ T} \cdot \text{m}$
- LARGE ($\approx 50\%$) ACCEPTANCE
- $\sigma(x), \sigma(y) \approx 10 \text{ mm VD}$
 200 mm TPC
- $\sigma(p)/p^2 \approx 10^{-4} (\text{GeV}/c)^{-1}$
- $\sigma(dE/dx)/dE/dx \approx 4\%$
- $\sigma(\text{tof}) \lesssim 100 \text{ ps}$
- EVENT RATE $\approx 2 \text{ kHz}$





MEASUREMENTS OF HADRON PRODUCTION PROPERTIES

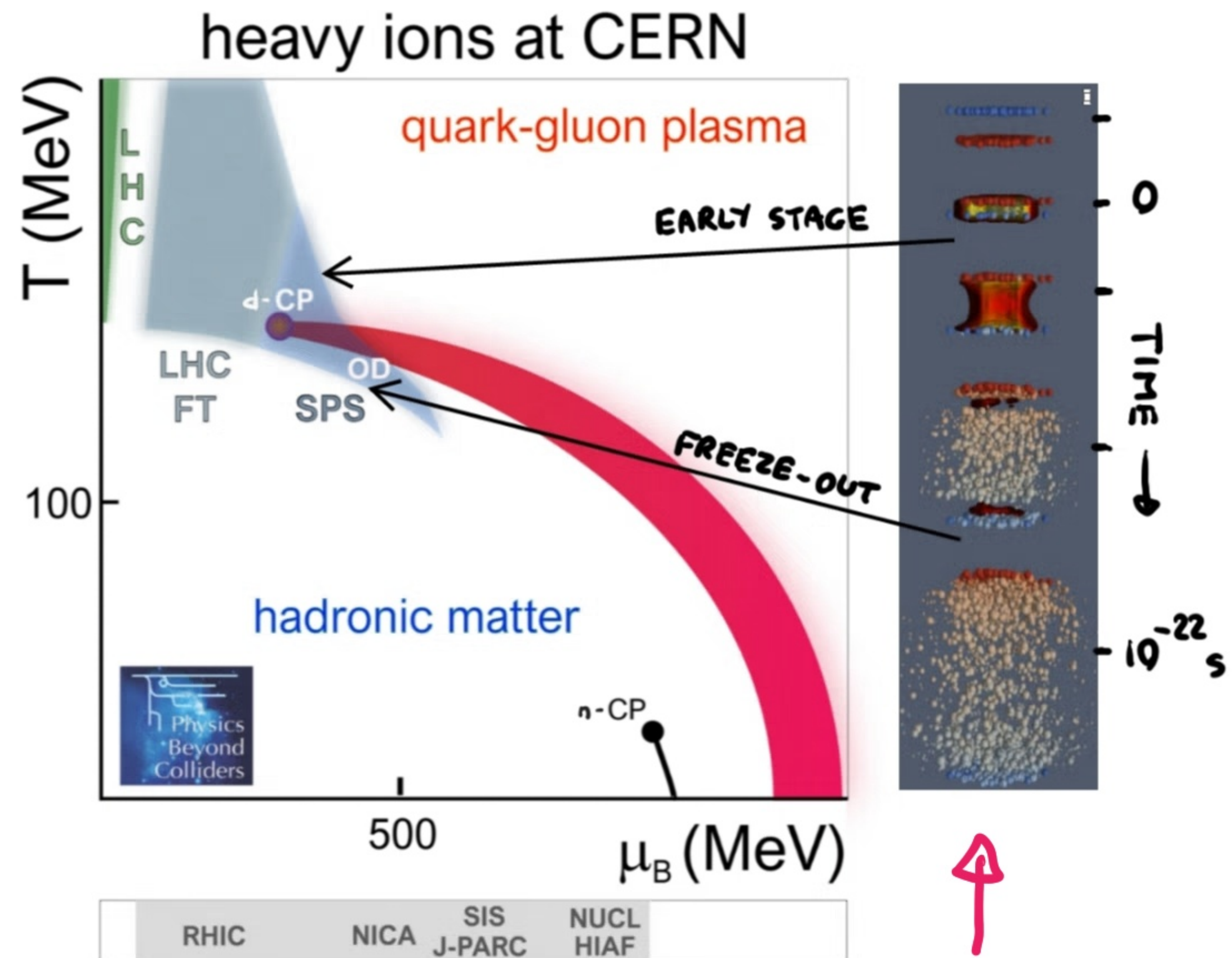
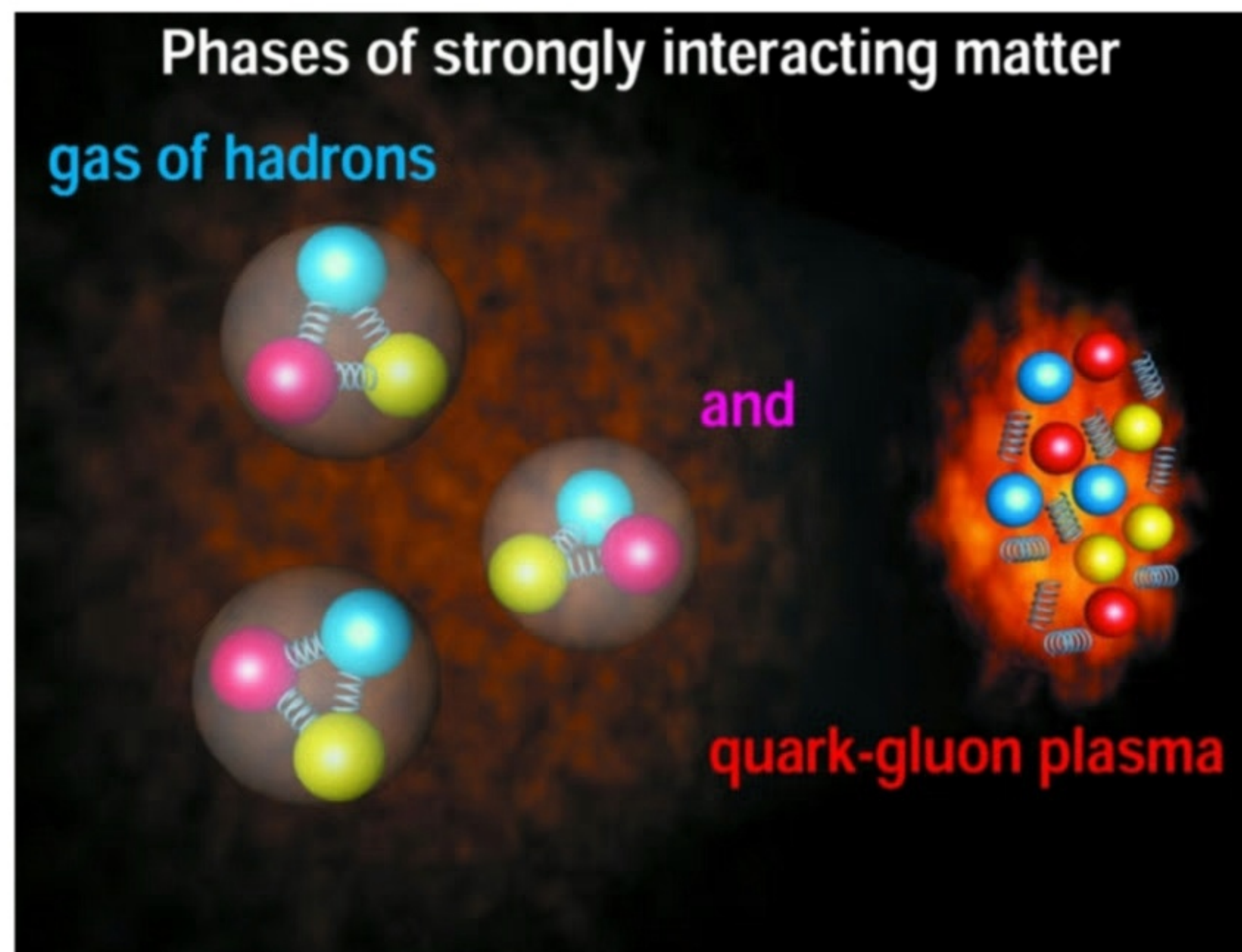


FOR

- STRONG INTERACTIONS (HEAVY IONS, ...)
- NEUTRINO BEAMS (J-PARC, FERMILAB)
- COSMIC RAY EXPS. (PAO, AMS, ...)

STRONG INTERACTIONS

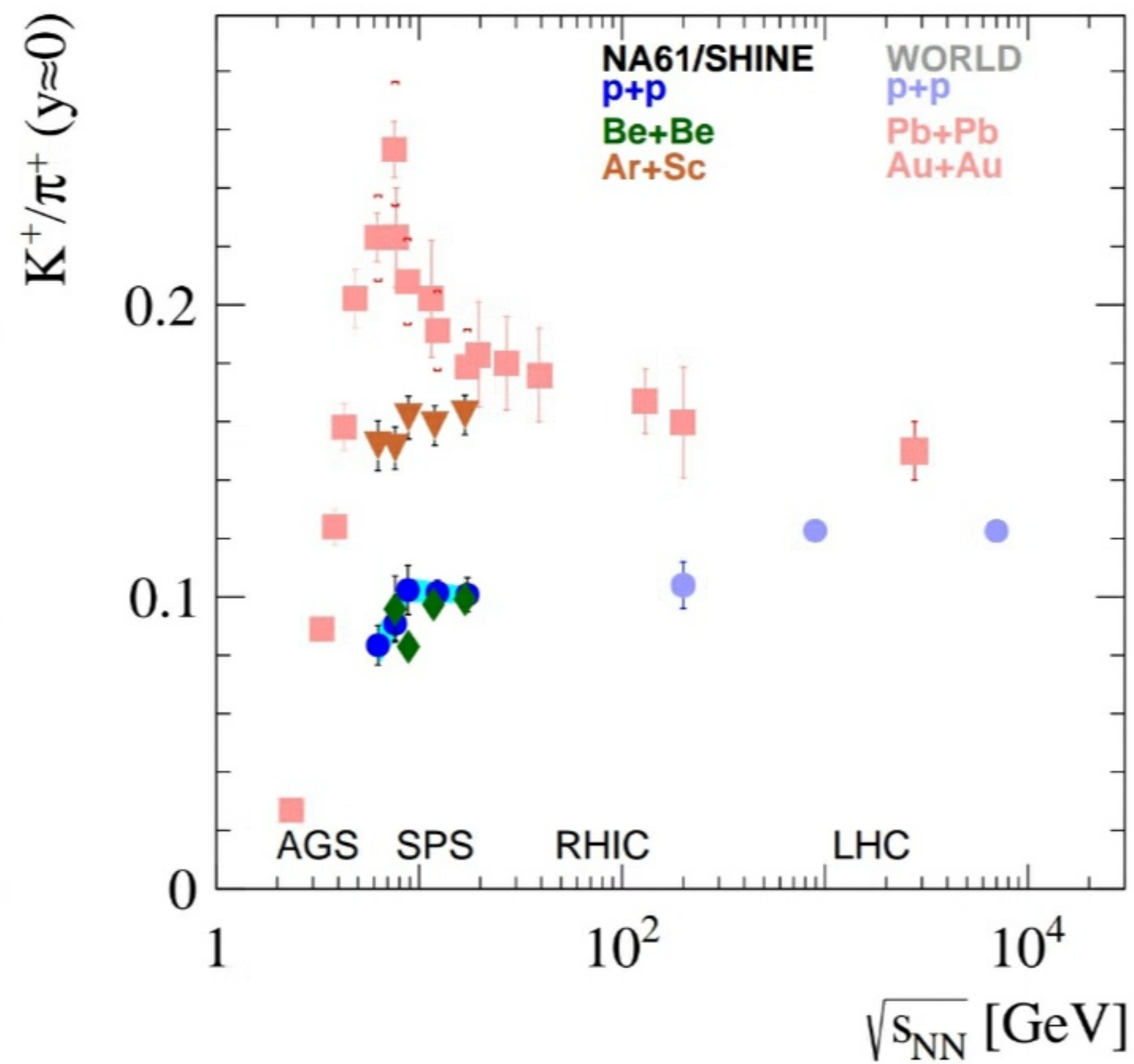
WHAT HAPPENS WHEN STRONGLY INTERACTING MATTER GETS HOTTER/DENSER AND ITS VOLUME CHANGES?



NAGI/SHINE: WHAT HAPPENS IN HEAVY ION COLLISIONS?

STRONG INTERACTIONS: KEY RESULTS

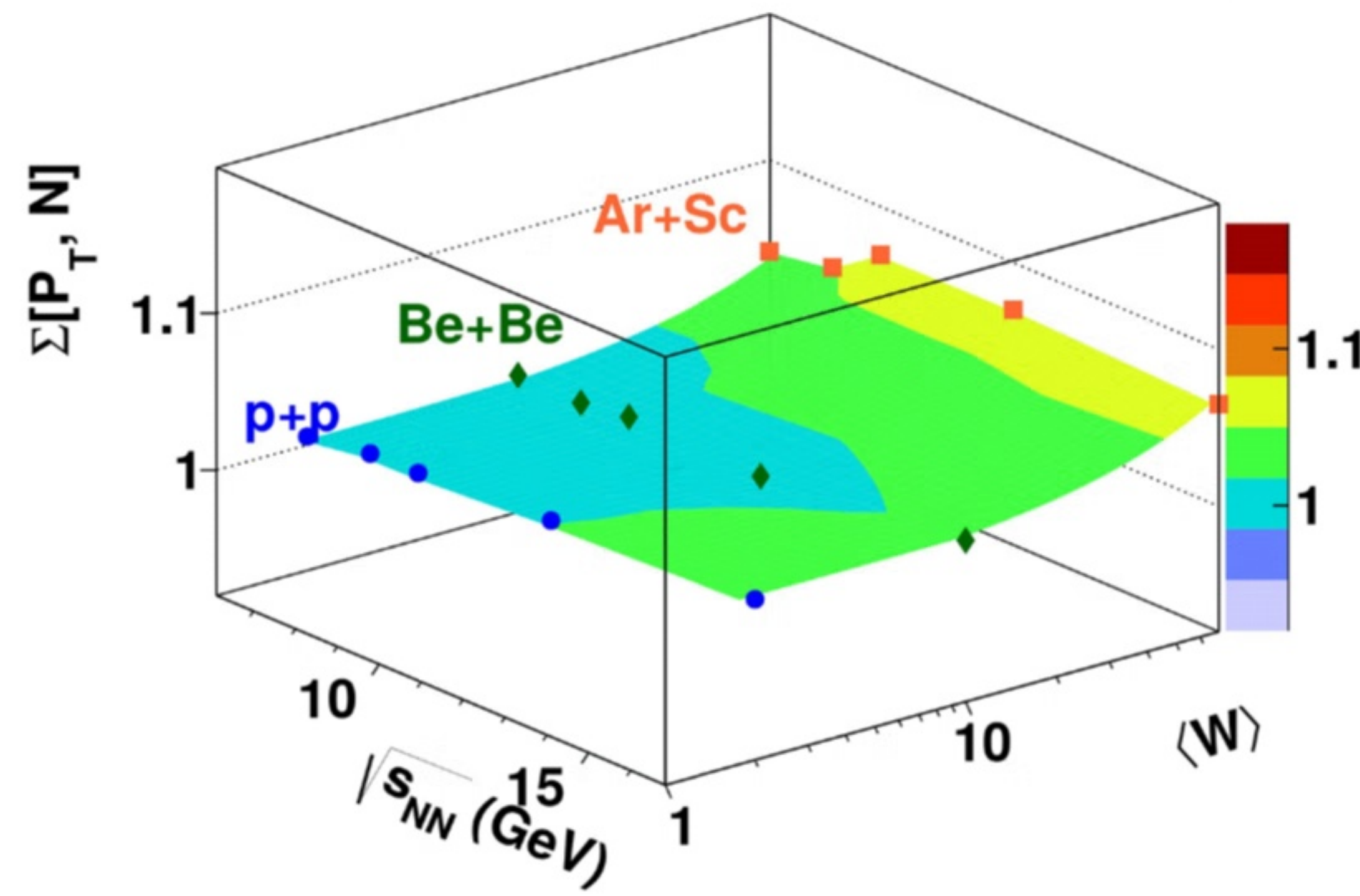
ONSET OF DECONFINEMENT



UNEXPECTED COLLISION ENERGY DEPENDENCE FOR SMALL/MEDIUM SIZE IONS

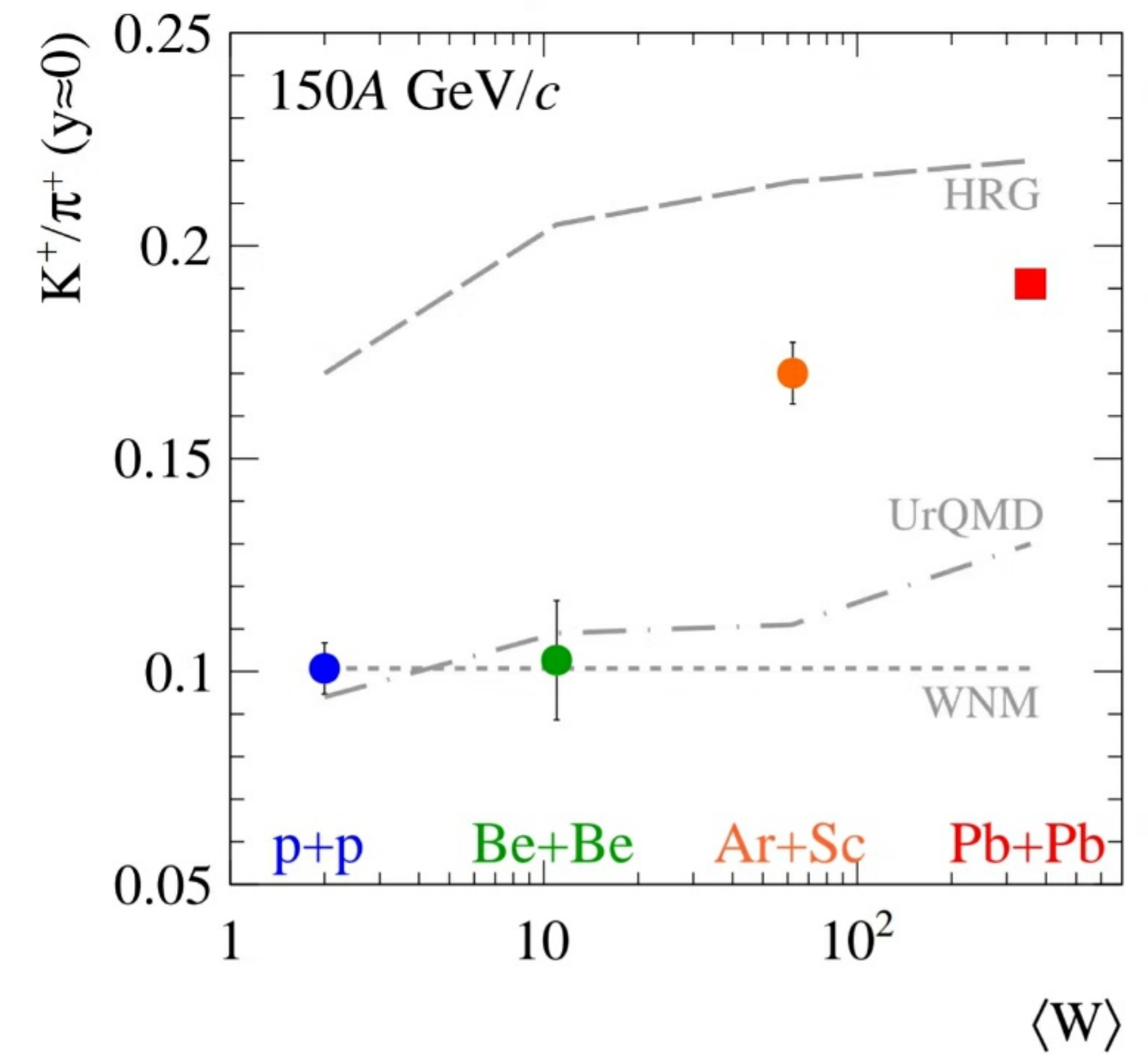
HORN \rightarrow BREAK

CRITICAL POINT



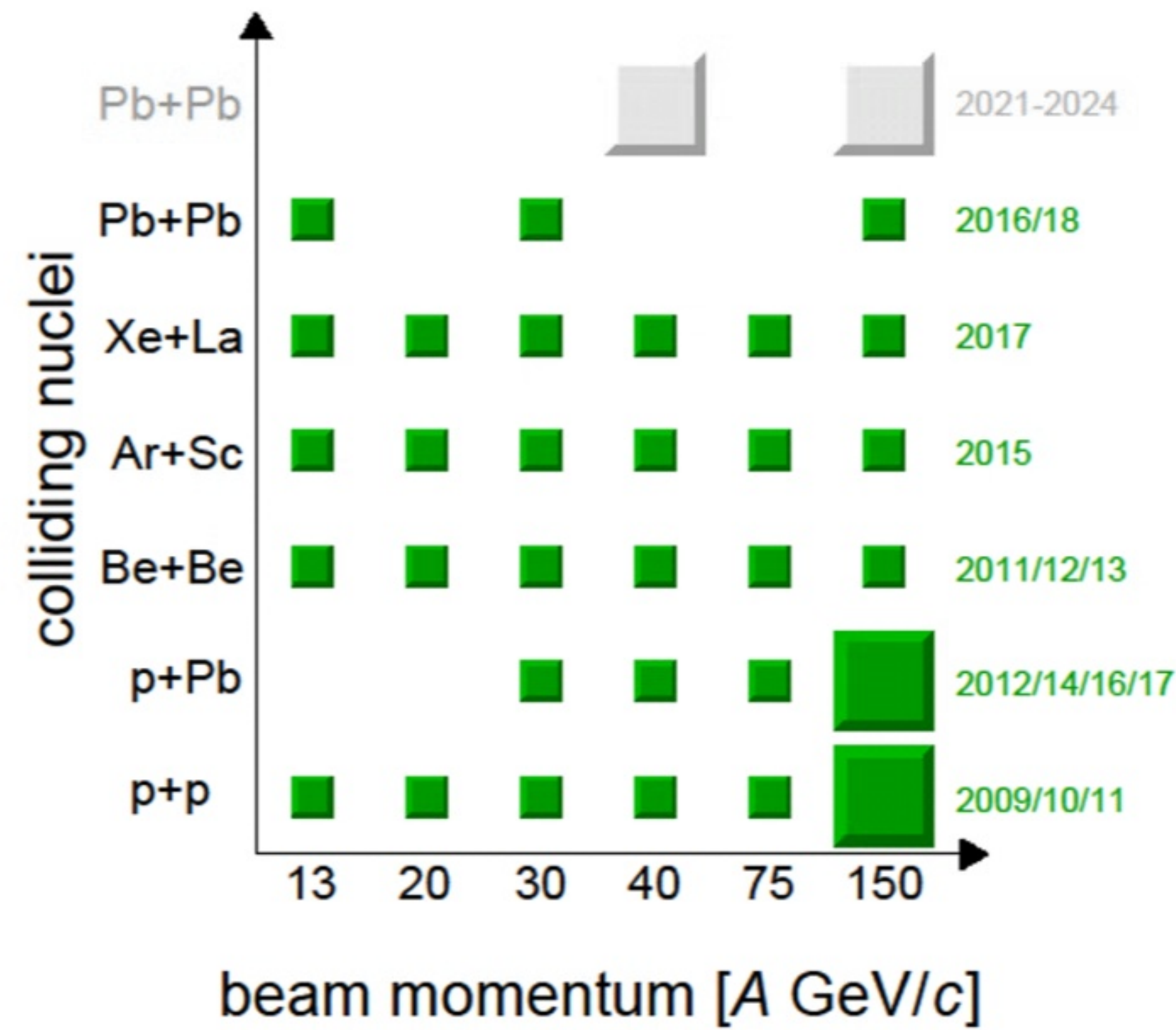
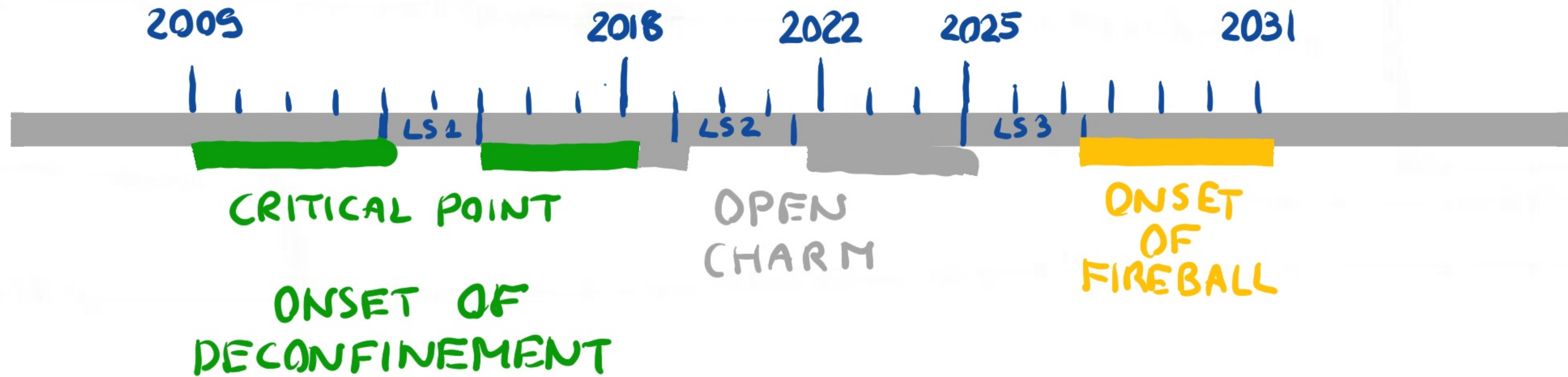
NO EVIDENCE YET

ONSET OF FIRE BALL



UNEXPECTED SYSTEM SIZE DEPENDENCE FOR SMALL/MEDIUM SIZE IONS

STRONG INTERACTIONS: DATA TAKING

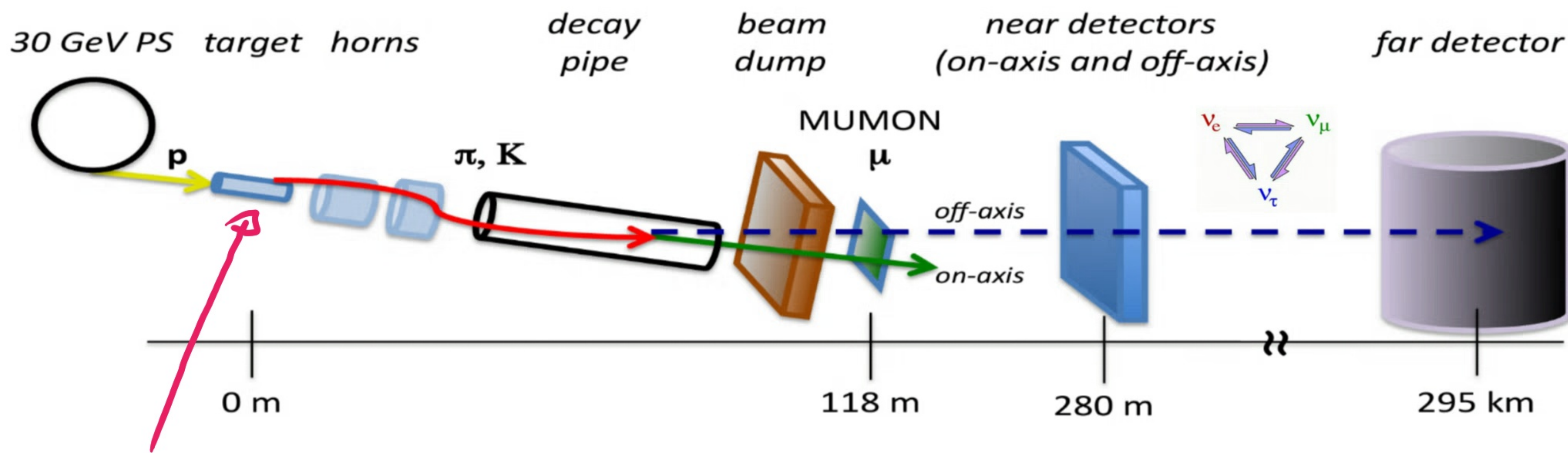


A \ P	13	20	30	40	75	150
≈ 5	●	●	●	●	●	●
≈ 10						
≈ 20	●	●	●	●	●	●
≈ 30	●	●	●	●	●	●
≈ 40	●	●	●	●	●	●

NEUTRINOS

WHAT HAPPENS WITH NEUTRINOS FLYING ACROSS JAPAN AND UNITED STATES?

THE T2K LONG-BASELINE NEUTRINO OSCILLATION EXPERIMENT

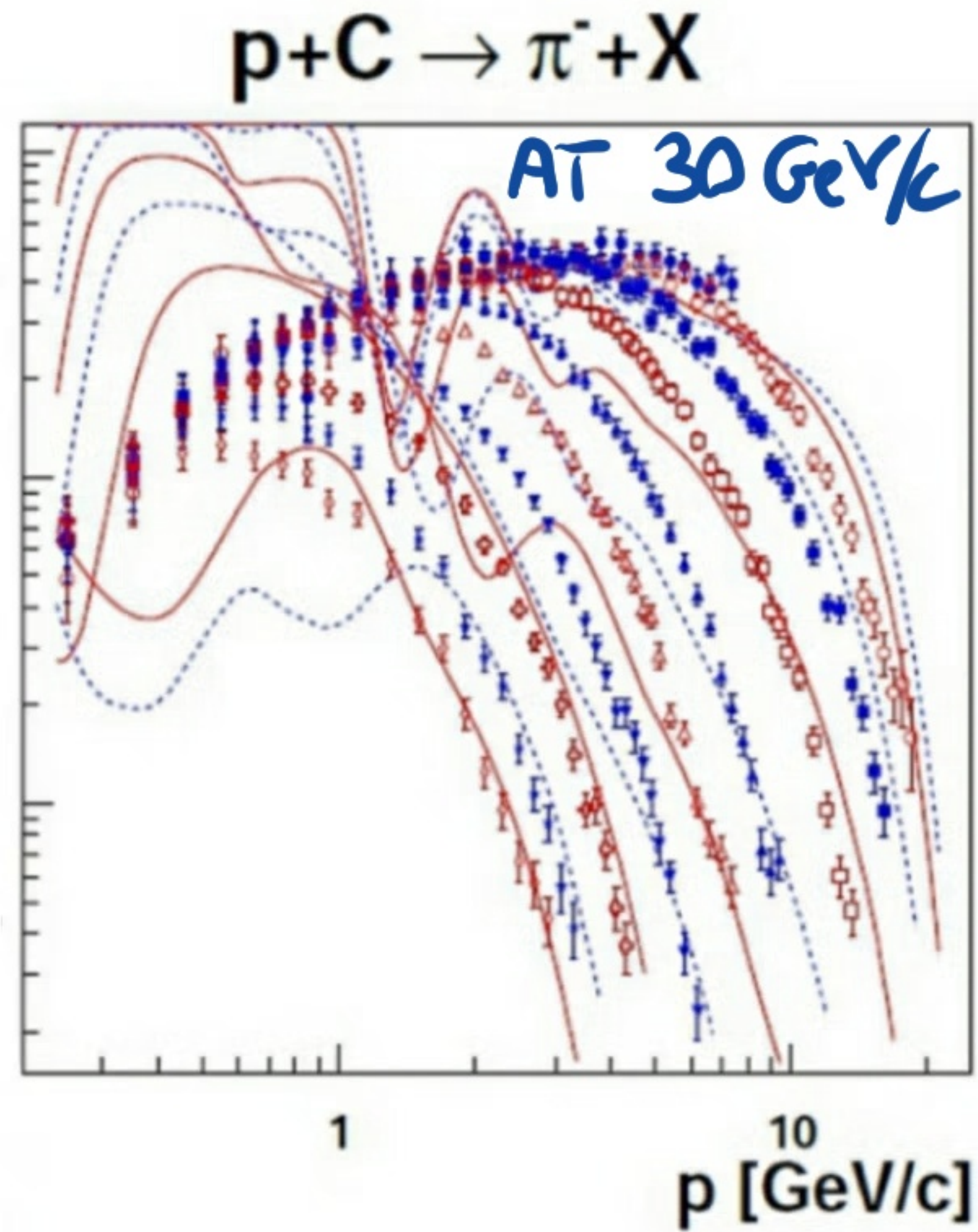


NAGI/SHINE:

WHAT HAPPENS IN TARGETS OF NEUTRINO EXPERIMENTS?

NEUTRINOS: KEY RESULTS

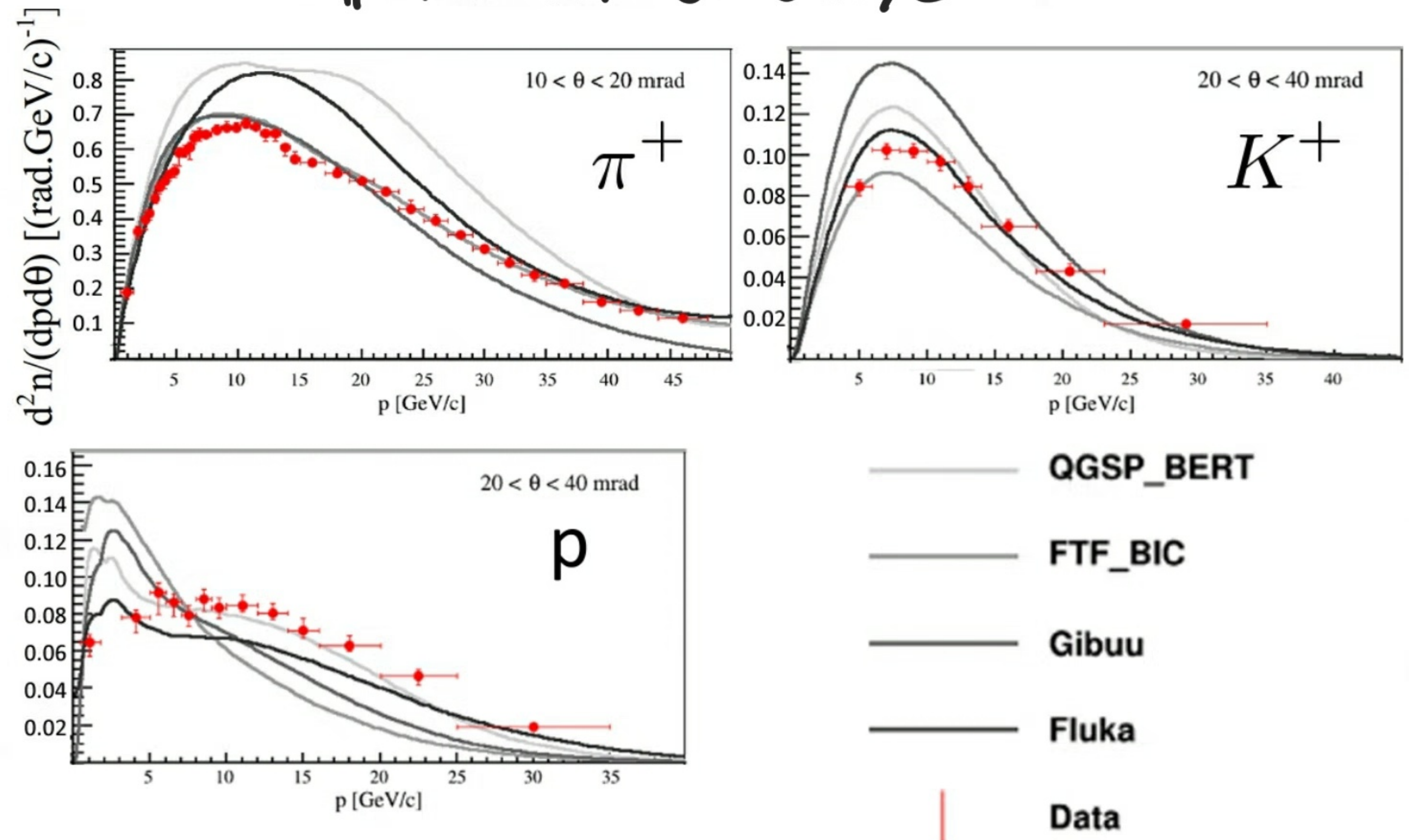
FOR J-PARC:



comparison to Gheisha2002

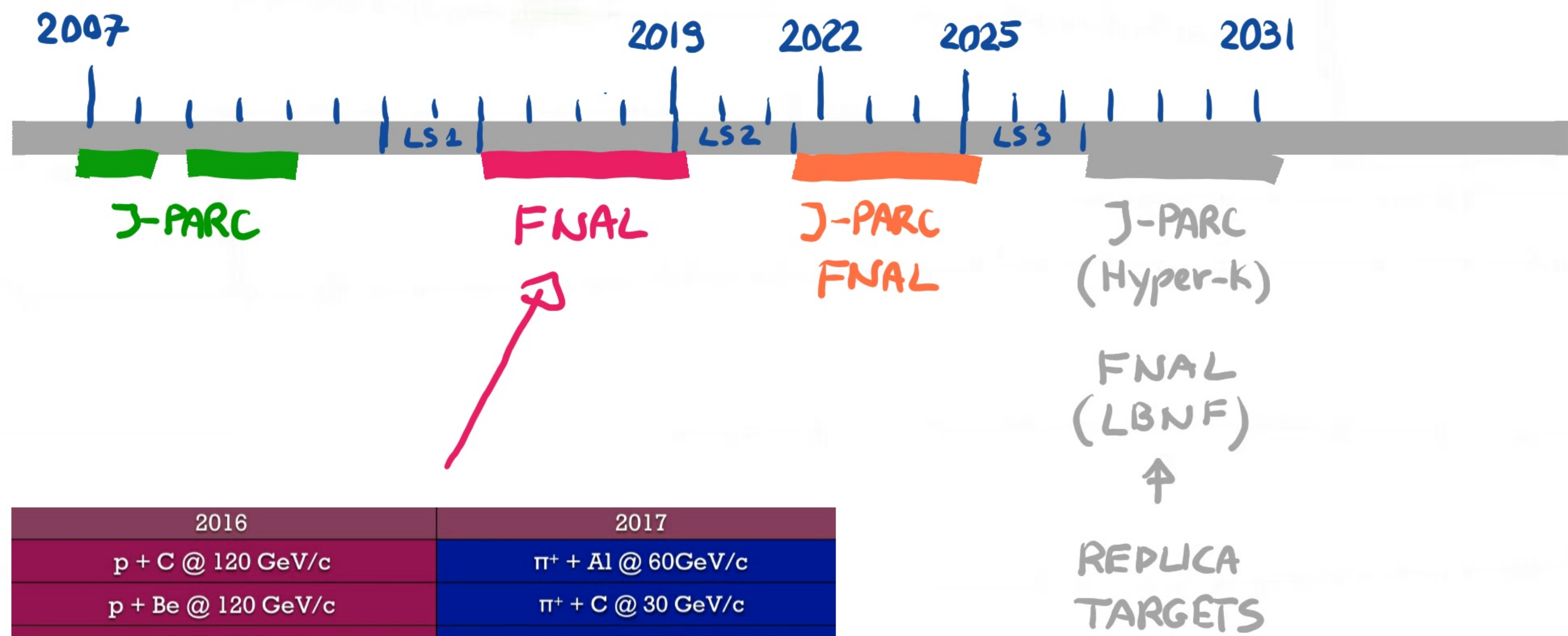
FOR FNAL:

$\pi^+ + C$ AT 60 GeV/c



NAGI/SHINE DATA REDUCE DECISIVELY
UNCERTANTIES OF FINAL RESULTS OF NEUTRINO EXPERIMENTS

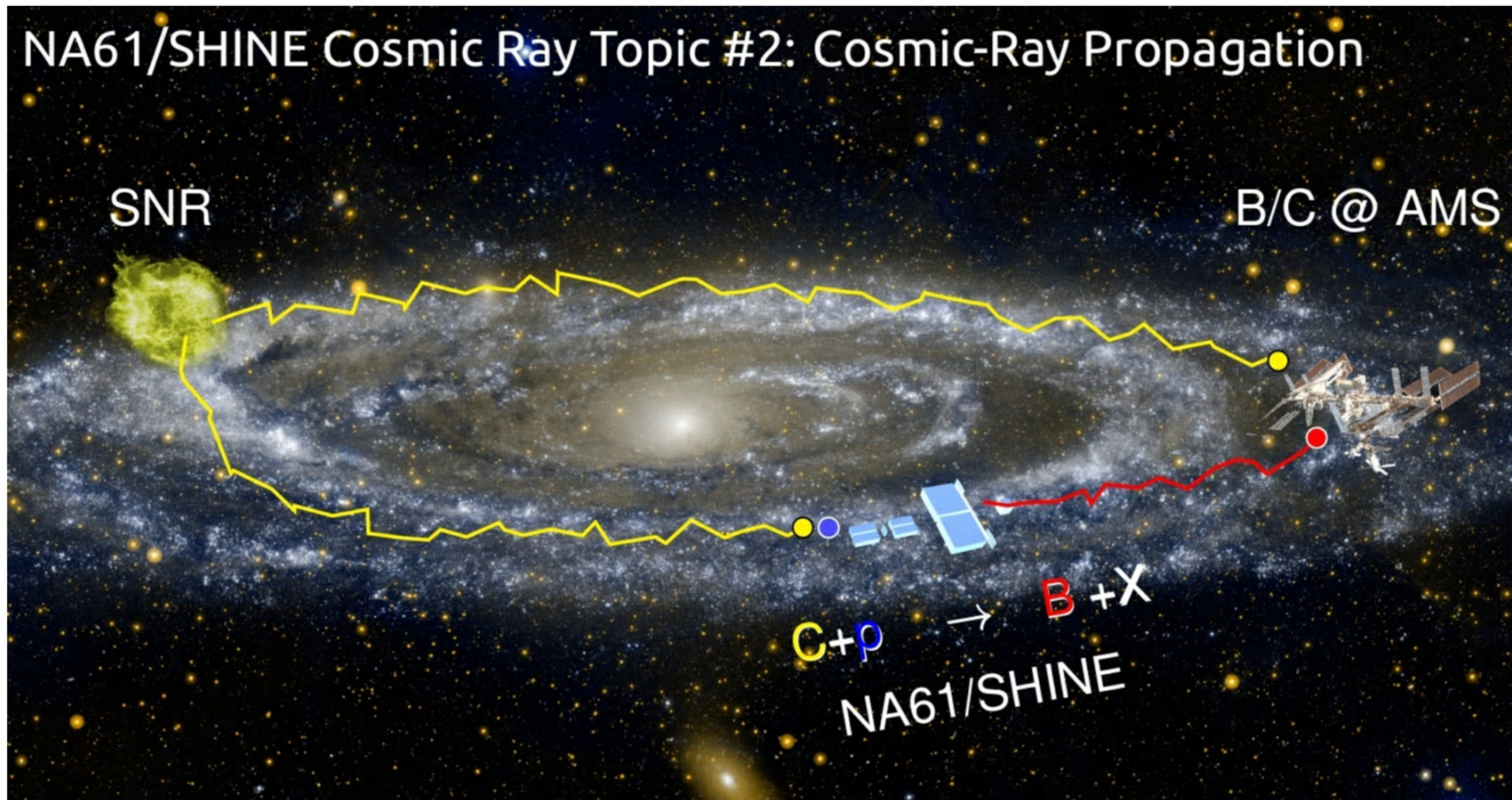
NEUTRINOS: DATA TAKING



2016	2017
p + C @ 120 GeV/c	π^+ + Al @ 60 GeV/c
p + Be @ 120 GeV/c	π^+ + C @ 30 GeV/c
p + C @ 60 GeV/c	π^- + C @ 60 GeV/c
p + Al @ 60 GeV/c	p + C @ 120 GeV/c (w FTPCs)
p + Be @ 60 GeV/c	p + Be @ 120 GeV/c (w FTPCs)
π^+ + C @ 60 GeV/c	p + C @ 90 GeV/c (w FTPCs)
π^+ + Be @ 60 GeV/c	

COSMIC - RAYS

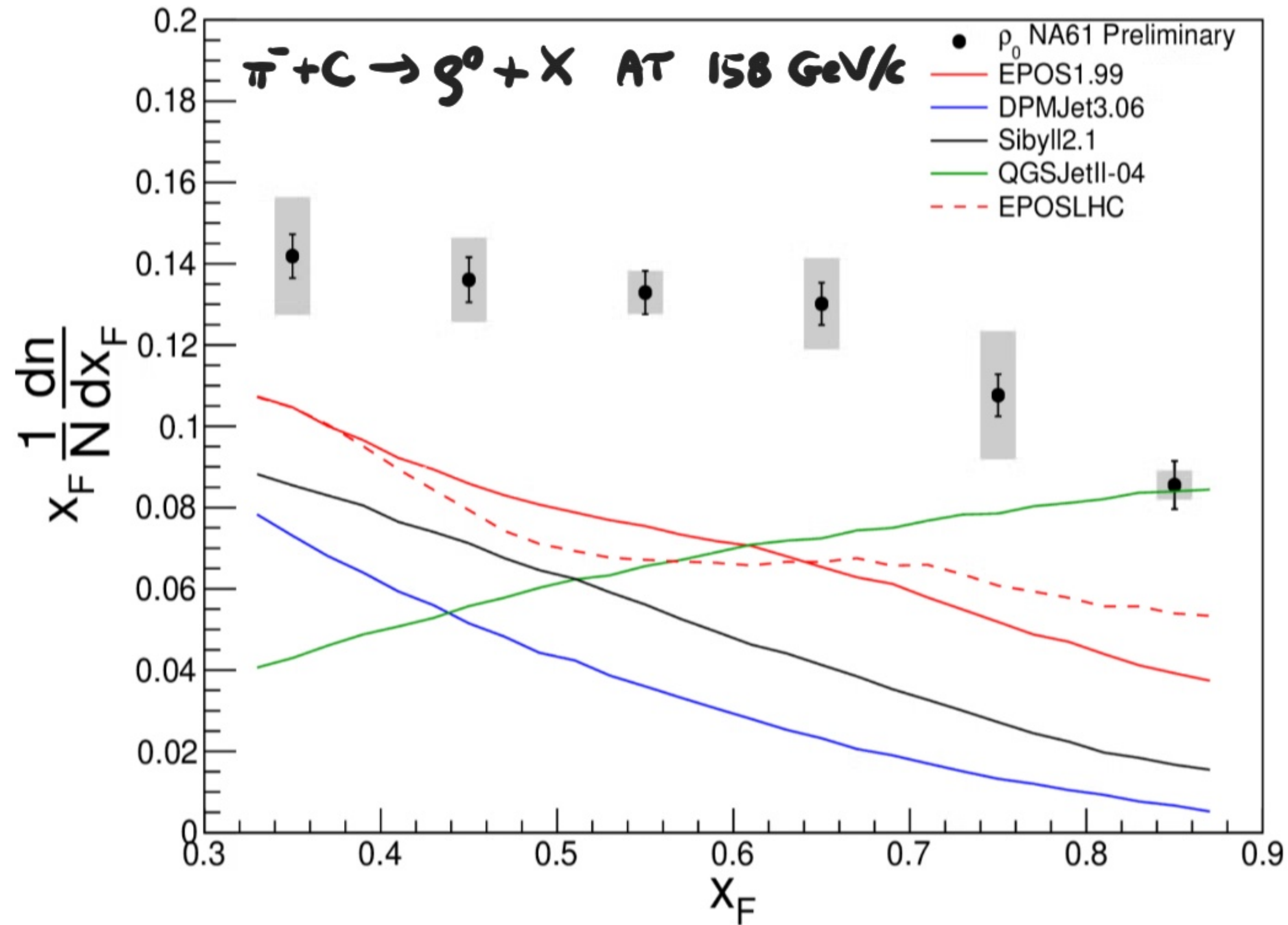
WHAT IS THE ORIGIN OF VERY HIGH ENERGY COSMIC - RAYS ?



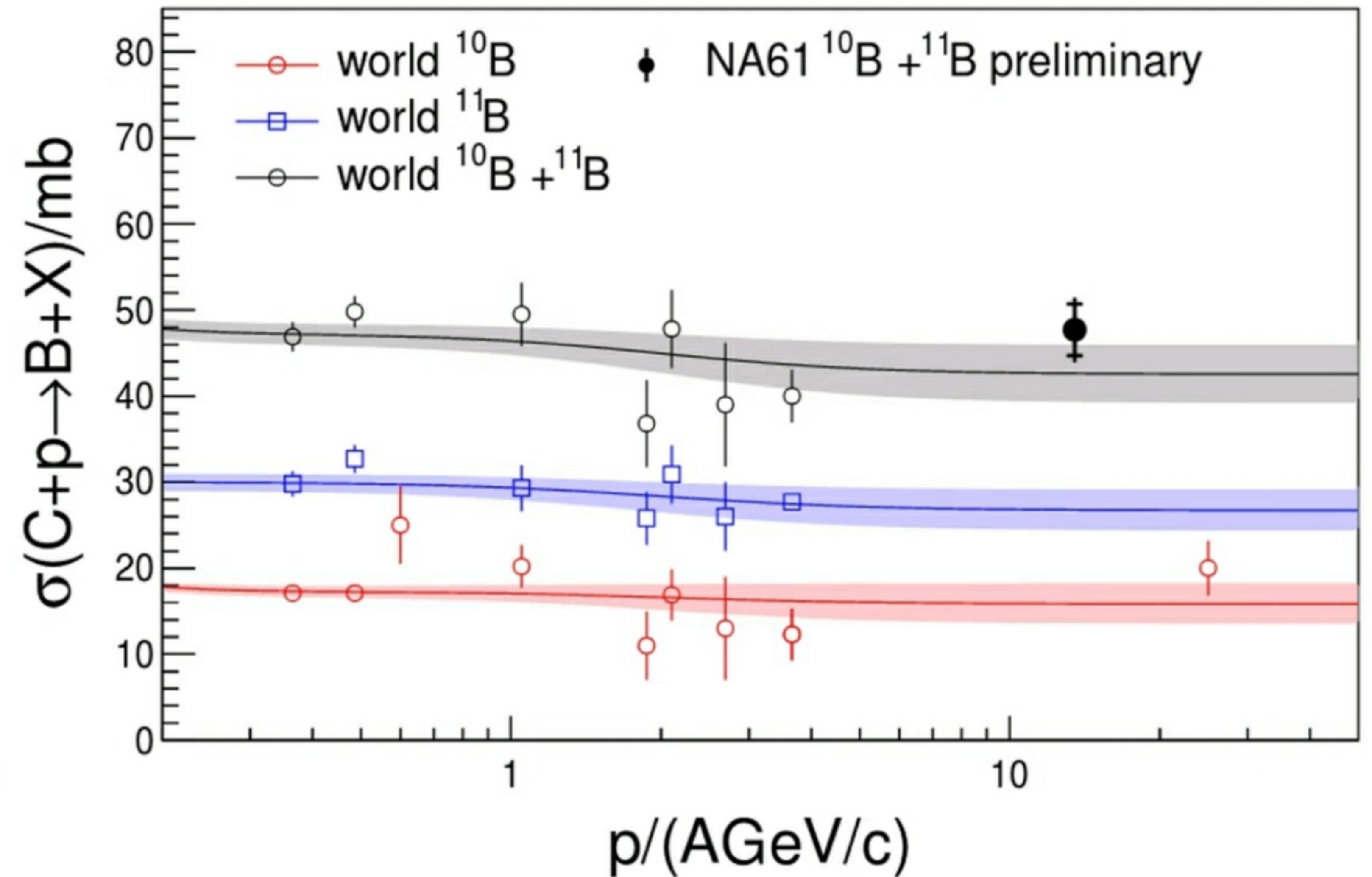
NA61/SHINE: WHAT HAPPENS WITH COSMIC RAYS IN INTERSTELLAR MEDIUM?

COSMIC-RAYS: KEY RESULTS

EXTENSIVE AIR SHOWERS:

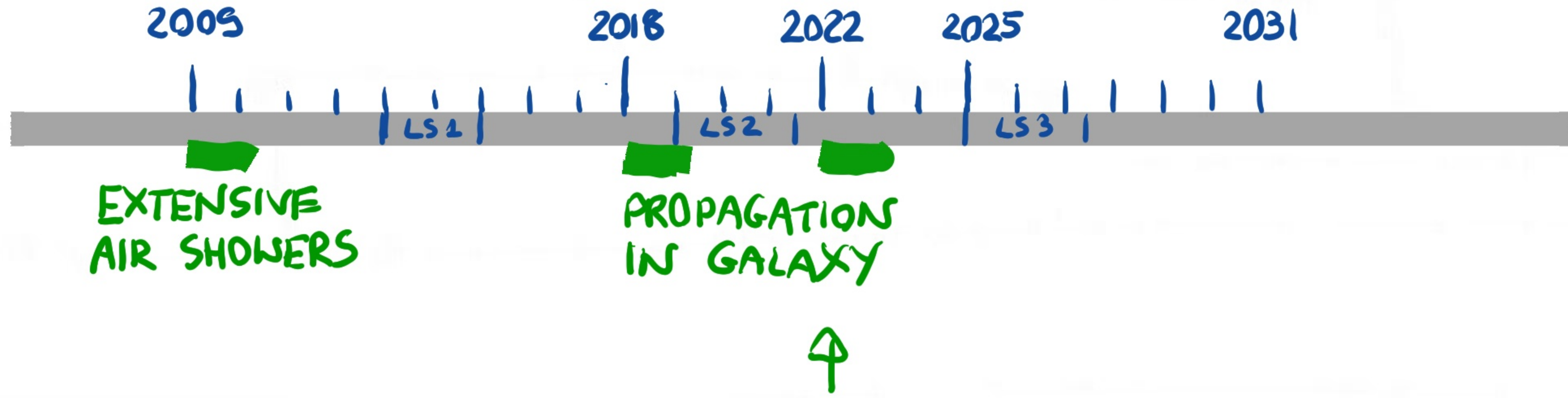


PROPAGATION IN GALAXY:



UNIQUE RESULTS WHICH CONSTRAIN MODELS
NEEDED TO INTERPRET HIGH PRECISION
DATA ON COSMIC RAYS

COSMIC-RAYS: DATA TAKING



reaction	N_{inter}	A/Z
$^{16}\text{O} + \text{H}$	250k	2
$^{12}\text{C} + \text{H}$	150k	2
$^{16}\text{O} + \text{He}$	100k	2
$^{14}\text{N} + \text{H}$	40k	2
$^{10}\text{B} + \text{H}$	5k	2
$^{11}\text{B} + \text{H}$	5k	2
$^{12}\text{C} + \text{He}$	5k	2
$^{13}\text{C} + \text{H}$	5k	11/5
$^{15}\text{N} + \text{H}$	5k	13/6
$^{20}\text{Ne} + \text{H}$	5k	15/7
$^{24}\text{Mg} + \text{H}$	5k	2
$^{28}\text{Si} + \text{H}$	5k	2
$^7\text{Li} + \text{H}$	5k	7/3
$\Sigma = 0.6\text{M}$		

SELECTED PUBLICATIONS



Measurements of Cross Sections and Charged Pion Spectra in Proton-Carbon Interactions at 31 GeV/c #1
NA61/SHINE Collaboration · N. Abgrall (Geneva U.) et al. (Feb 6, 2011)
Published in: *Phys.Rev.C* 84 (2011) 034604 · e-Print: 1102.0983 [hep-ex]
pdf DOI cite 269 citations

Measurement of Production Properties of Positively Charged Kaons in Proton-Carbon Interactions at 31 GeV/c #2
NA61/SHINE Collaboration · N. Abgrall (Geneva U.) et al. (Dec 1, 2011)
Published in: *Phys.Rev.C* 85 (2012) 035210 · e-Print: 1112.0150 [hep-ex]
pdf DOI cite 158 citations

Measurement of negatively charged pion spectra in inelastic p+p interactions at $p_{lab} = 20, 31, 40, 80$ and 158 GeV/c #3
NA61/SHINE Collaboration · N. Abgrall (Geneva U.) et al. (Oct 9, 2013)
Published in: *Eur.Phys.J.C* 74 (2014) 3, 2794 · e-Print: 1310.2417 [hep-ex]
pdf DOI cite 93 citations

Measurements of π^\pm , K^\pm , K_S^0 , Λ and proton production in proton-carbon interactions at 31 GeV/c with the NA61/SHINE spectrometer at the CERN SPS #4
NA61/SHINE Collaboration · N. Abgrall (Geneva U.) et al. (Oct 9, 2015)
Published in: *Eur.Phys.J.C* 76 (2016) 2, 84 · e-Print: 1510.02703 [hep-ex]
pdf DOI cite 92 citations

Pion emission from the T2K replica target: method, results and application #5
NA61/SHINE Collaboration · N. Abgrall (Geneva U.) et al. (Jul 9, 2012)
Published in: *Nucl.Instrum.Meth.A* 701 (2013) 99-114 · e-Print: 1207.2114 [hep-ex]
pdf DOI cite 70 citations

Measurements of π^\pm , K^\pm , p and \bar{p} spectra in proton-proton interactions at 20, 31, 40, 80 and 158 GeV/c with the NA61/SHINE spectrometer at the CERN SPS #6
NA61/SHINE Collaboration · A. Aduszkiewicz (Warsaw U.) et al. (May 6, 2017)
Published in: *Eur.Phys.J.C* 77 (2017) 10, 671 · e-Print: 1705.02467 [nucl-ex]
pdf DOI cite 66 citations

Multiplicity and transverse momentum fluctuations in inelastic proton-proton interactions at the CERN Super Proton Synchrotron #7
NA61/SHINE Collaboration · A. Aduszkiewicz (Warsaw U.) et al. (Oct 1, 2015)
Published in: *Eur.Phys.J.C* 76 (2016) 11, 635 · e-Print: 1510.00163 [hep-ex]
pdf DOI cite 57 citations

Measurements of production properties of K_S^0 mesons and Λ hyperons in proton-carbon interactions at 31 GeV/c #8
NA61/SHINE Collaboration · N. Abgrall (U. Geneva (main)) et al. (Sep 8, 2013)
Published in: *Phys.Rev.C* 89 (2014) 2, 025205 · e-Print: 1309.1997 [physics.acc-ph]
pdf DOI cite 34 citations

Measurements of π^\pm differential yields from the surface of the T2K replica target for incoming 31 GeV/c protons with the NA61/SHINE spectrometer at the CERN SPS #9
NA61/SHINE Collaboration · N. Abgrall (Geneva U.) et al. (Mar 22, 2016)
Published in: *Eur.Phys.J.C* 76 (2016) 11, 617 · e-Print: 1603.06774 [hep-ex]
pdf DOI cite 34 citations

Ion Program of Na61/Shine at the CERN SPS #10
NA61/SHINE Collaboration · Marek Gazdzicki (Frankfurt U., Inst. Kernphys. and Jan Kochanowski U.) for the collaboration. (Dec 23, 2008)
Published in: *J.Phys.G* 36 (2009) 064039 · Contribution to: SQM 2008 · e-Print: 0812.4415 [nucl-ex]
pdf DOI cite 28 citations

Production of Λ -hyperons in inelastic p+p interactions at 158 GeV/c #11
NA61/SHINE Collaboration · A. Aduszkiewicz (Warsaw U.) et al. (Oct 13, 2015)
Published in: *Eur.Phys.J.C* 76 (2016) 4, 198 · e-Print: 1510.03720 [hep-ex]
pdf DOI cite 21 citations

Measurements of π^\pm , K^\pm and proton double differential yields from the surface of the T2K replica target for incoming 31 GeV/c protons with the NA61/SHINE spectrometer at the CERN SPS #12
NA61/SHINE Collaboration · N. Abgrall (Geneva U.) et al. (Aug 14, 2018)

Measurement of meson resonance production in $\pi^- + C$ interactions at SPS energies #13
NA61/SHINE Collaboration · A. Aduszkiewicz (Warsaw U.) et al. (May 23, 2017)
Published in: *Eur.Phys.J.C* 77 (2017) 9, 626 · e-Print: 1705.08206 [nucl-ex]
pdf DOI cite 18 citations

Measurements of total production cross sections for $\pi^+ + C$, $\pi^+ + Al$, $K^+ + C$, and $K^+ + Al$ at 60 GeV/c and $\pi^+ + C$ and $\pi^+ + Al$ at 31 GeV/c #14
NA61/SHINE Collaboration · A. Aduszkiewicz (Warsaw U.) et al. (May 11, 2018)
Published in: *Phys.Rev.D* 98 (2018) 5, 052001 · e-Print: 1805.04546 [hep-ex]
pdf DOI cite 10 citations

Two-particle correlations in azimuthal angle and pseudorapidity in inelastic p + p interactions at the CERN Super Proton Synchrotron #15
NA61/SHINE Collaboration · A. Aduszkiewicz (Warsaw U. (main)) et al. (Oct 3, 2016)
Published in: *Eur.Phys.J.C* 77 (2017) 2, 59 · e-Print: 1610.00482 [nucl-ex]
pdf DOI cite 9 citations

Proton-Proton Interactions and Onset of Deconfinement #16
NA61/SHINE Collaboration · A. Aduszkiewicz (Warsaw U. (main)) et al. (Dec 23, 2019)
Published in: *Phys.Rev.C* 102 (2020) 1, 011901 · e-Print: 1912.10871 [hep-ex]
pdf links DOI cite 9 citations

COLLABORATION



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