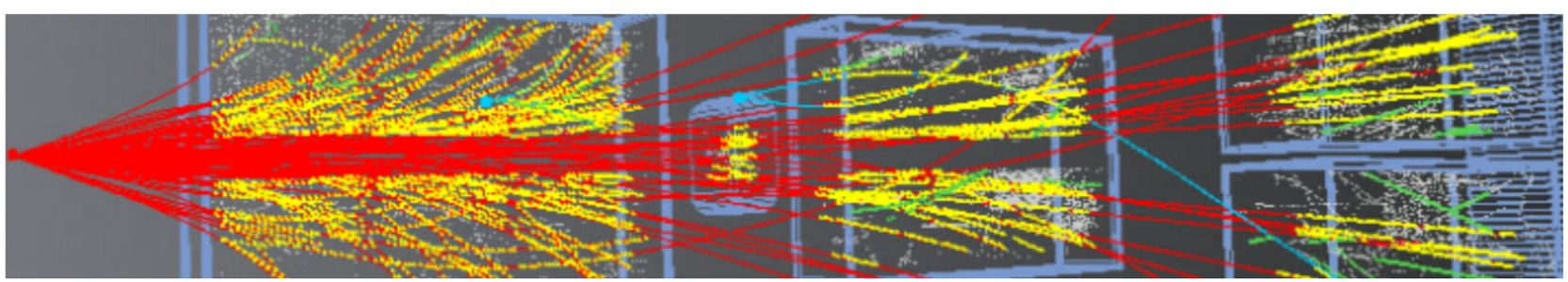
NA61/SHINE PHYSICS PROGRAMMES

MG FRANKFURT, KIELCE

■ FACILITY

■■ PHYSICS PROGRAMMES

(■■■ COLLABORATION)

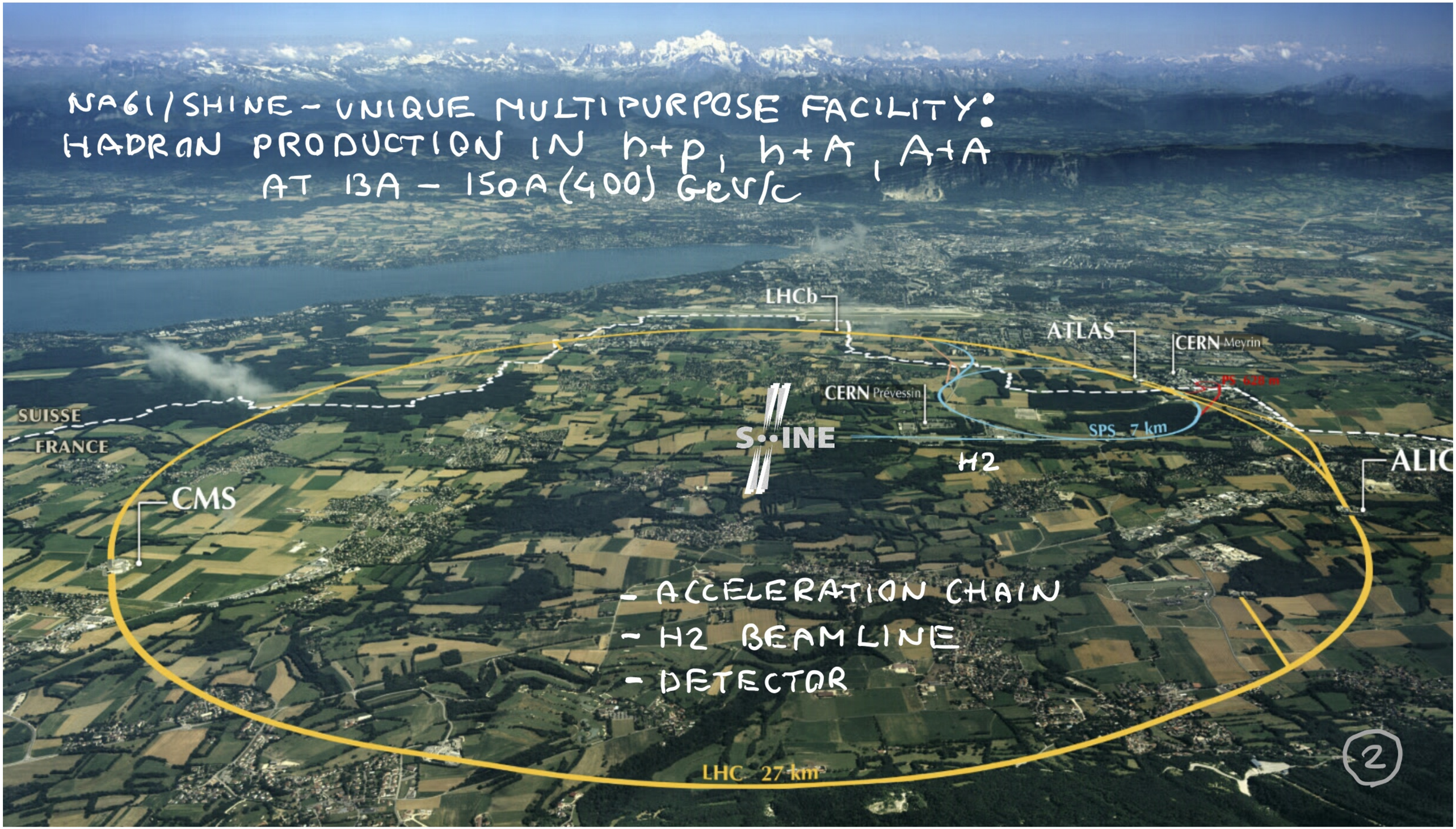


S··INE

CERN

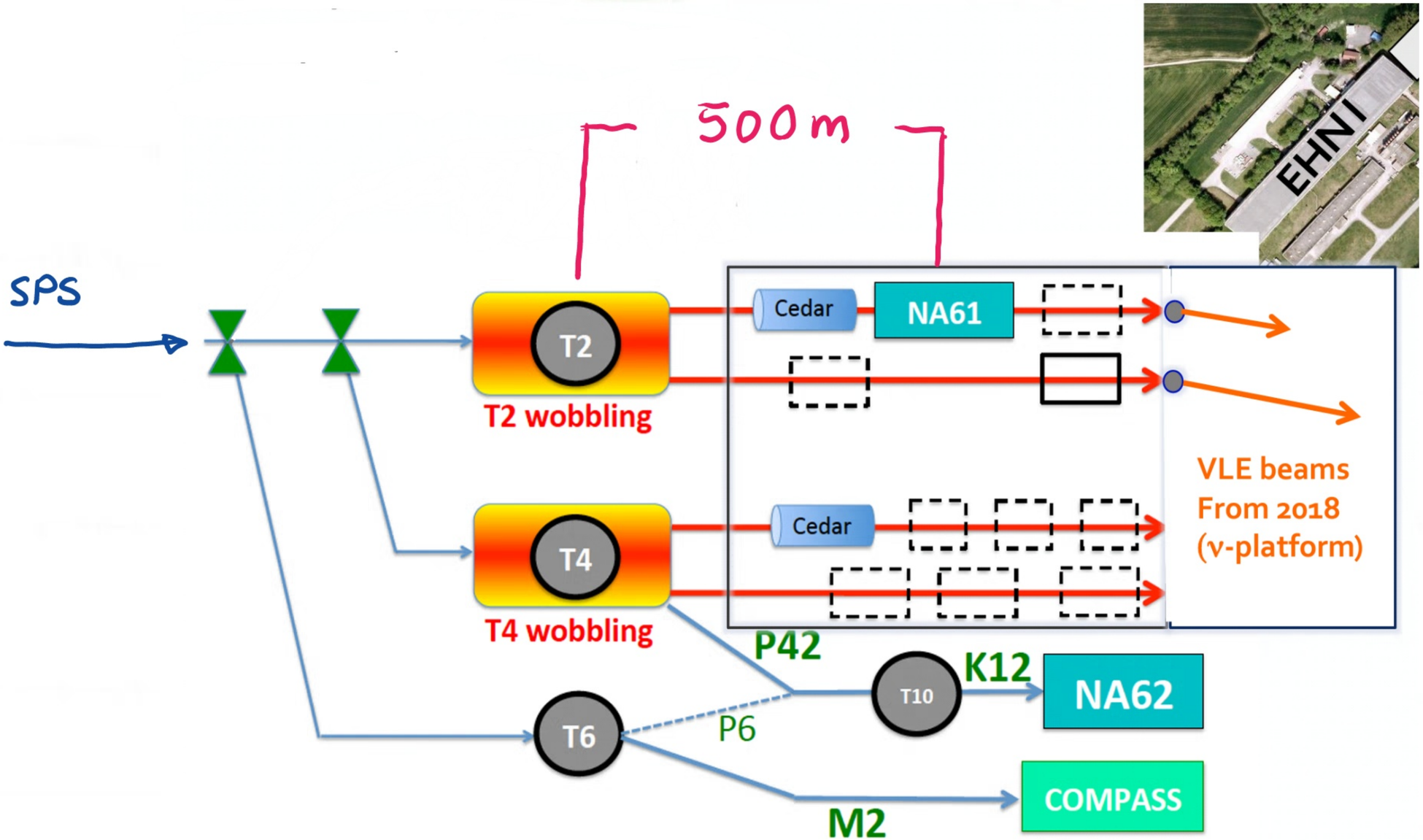
FACILITY

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

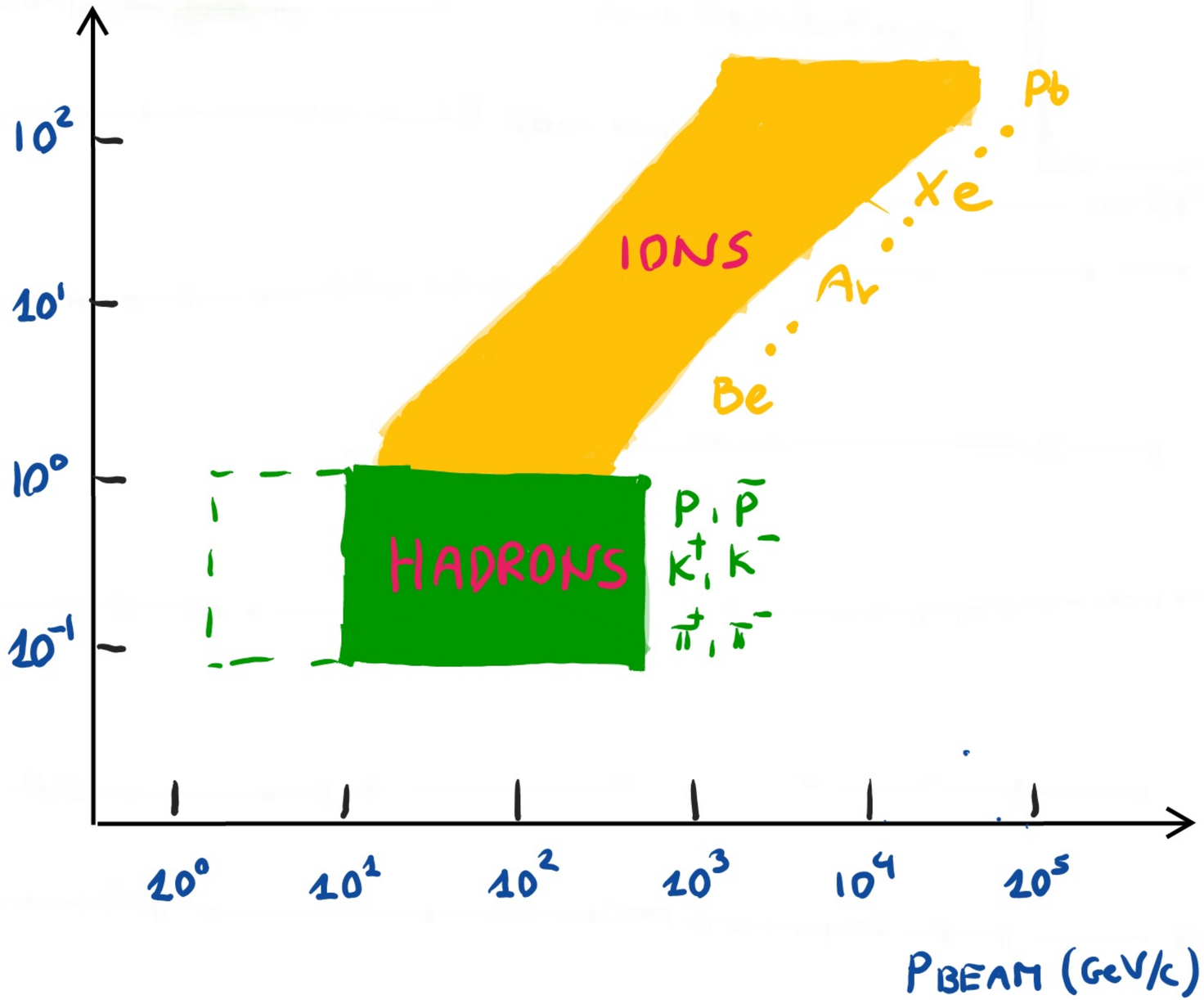


- ACCELERATION CHAIN
- H2 BEAMLINE
- DETECTOR

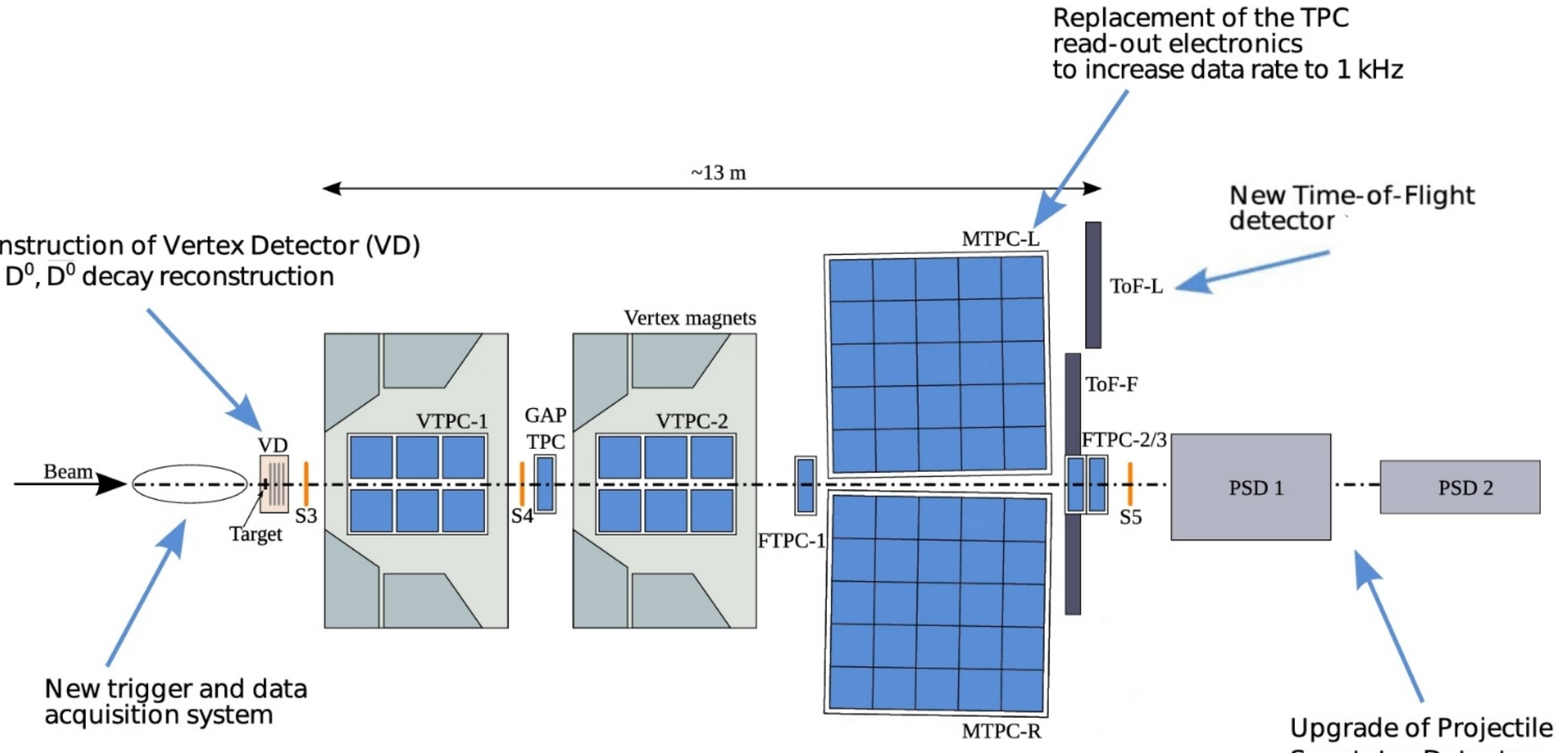
CERN NORTH-AREA EXPERIMENTS



BEAMS: UNPRECEDENTED VARIETY OF MASSES AND MOMENTA



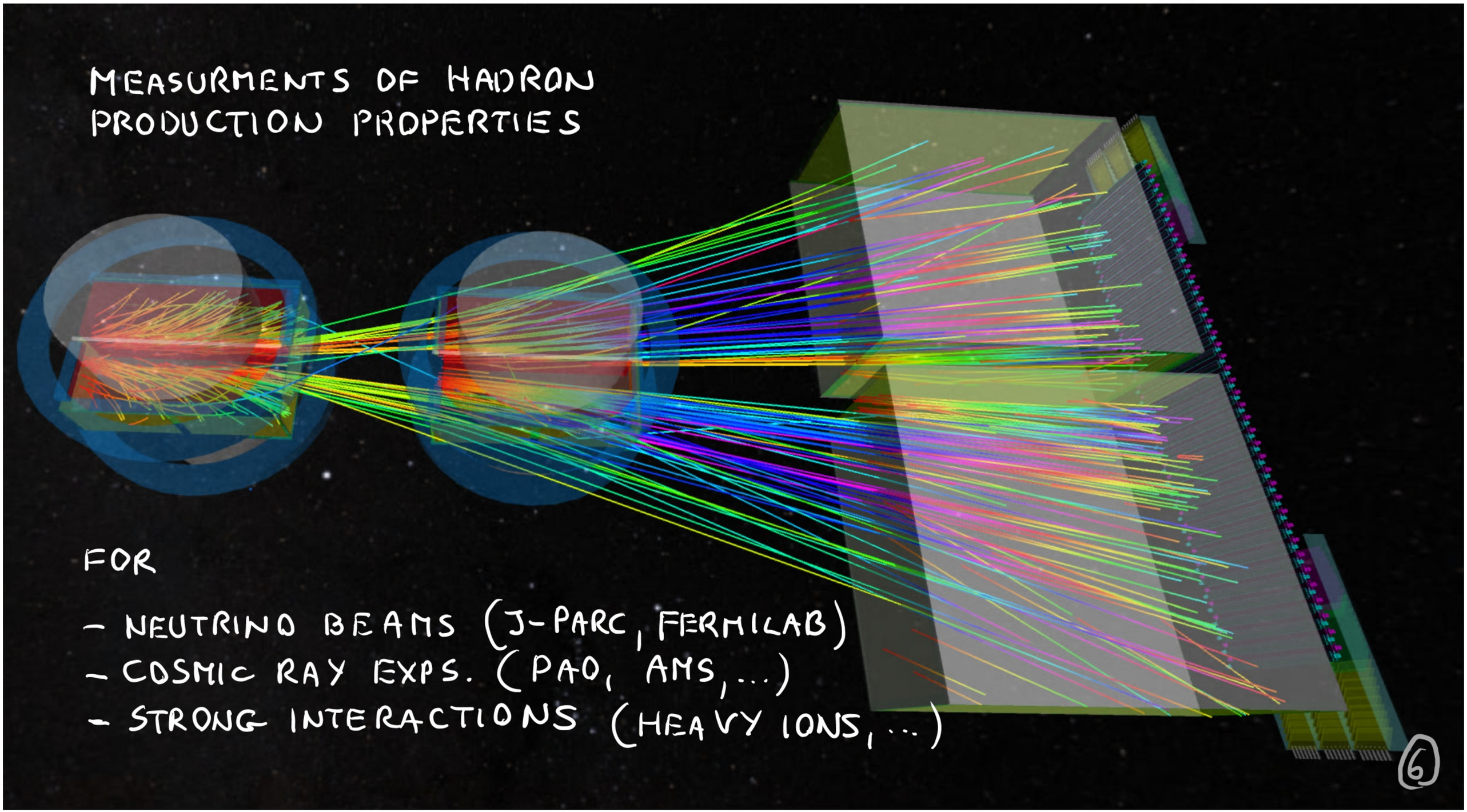
DETECTOR AND ITS UPGRADE (2019 - 2021)



- $B \cdot L \lesssim 9$ T·m
- LARGE (≈50%) ACCEPTANCE
- $\sigma(x), \sigma(y) \approx$ 5 μm VD
  200 μm TPC
- $\sigma(p)/p^2 \approx 10^{-4} (\mathrm{GeV}/c)^{-1}$
- $\sigma(dE/dx)/dE/dx \approx 4\%$
- $\sigma(\mathrm{tof}) \lesssim 100$ ps
- EVENT RATE ≈ 1 kHz

PHYSICS PROGRAMMES

MEASURMENTS OF HADRON PRODUCTION PROPERTIES



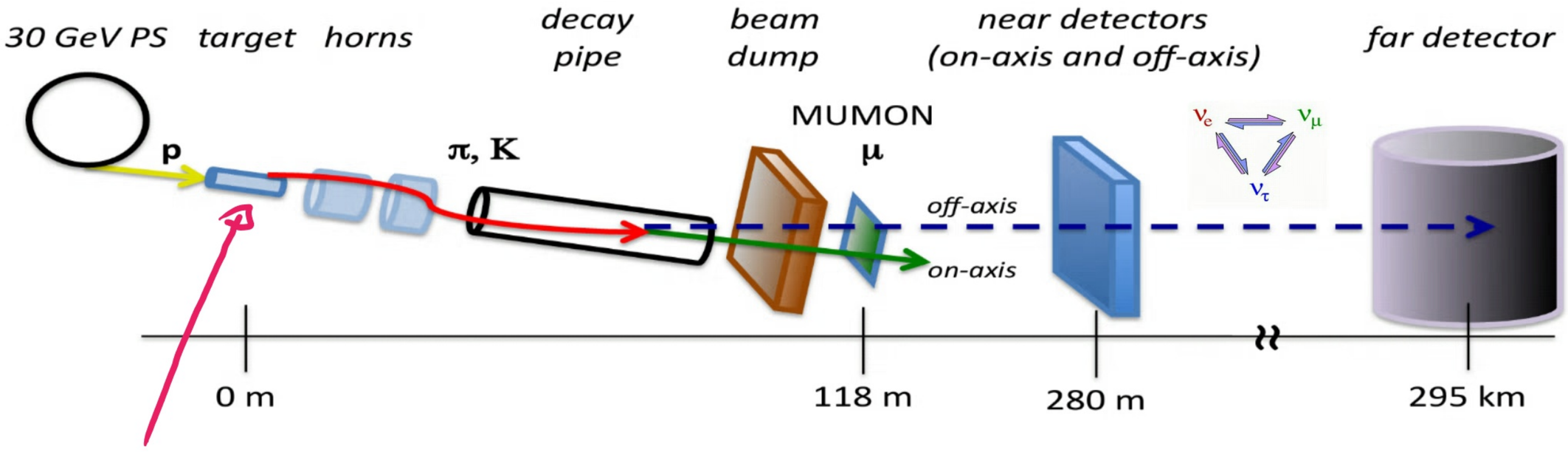
FOR

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

NEUTRINOS

WHAT HAPPENS WITH NEUTRINOS FLYING ACROSS JAPAN AND UNITED STATES ?

THE T2K LONG-BASELINE NEUTRINO OSCILLATION EXPERIMENT

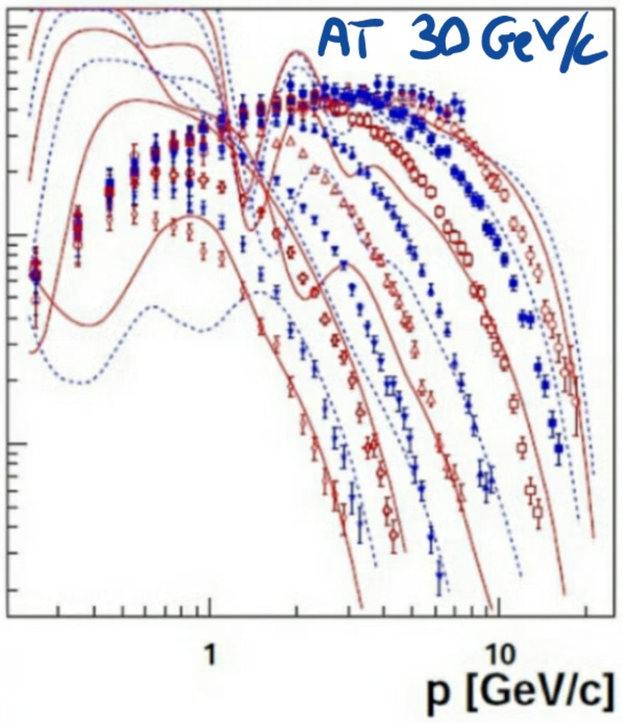


NA61/SHINE :

WHAT HAPPENS IN TARGETS OF NEUTRINO EXPERIMENTS ?

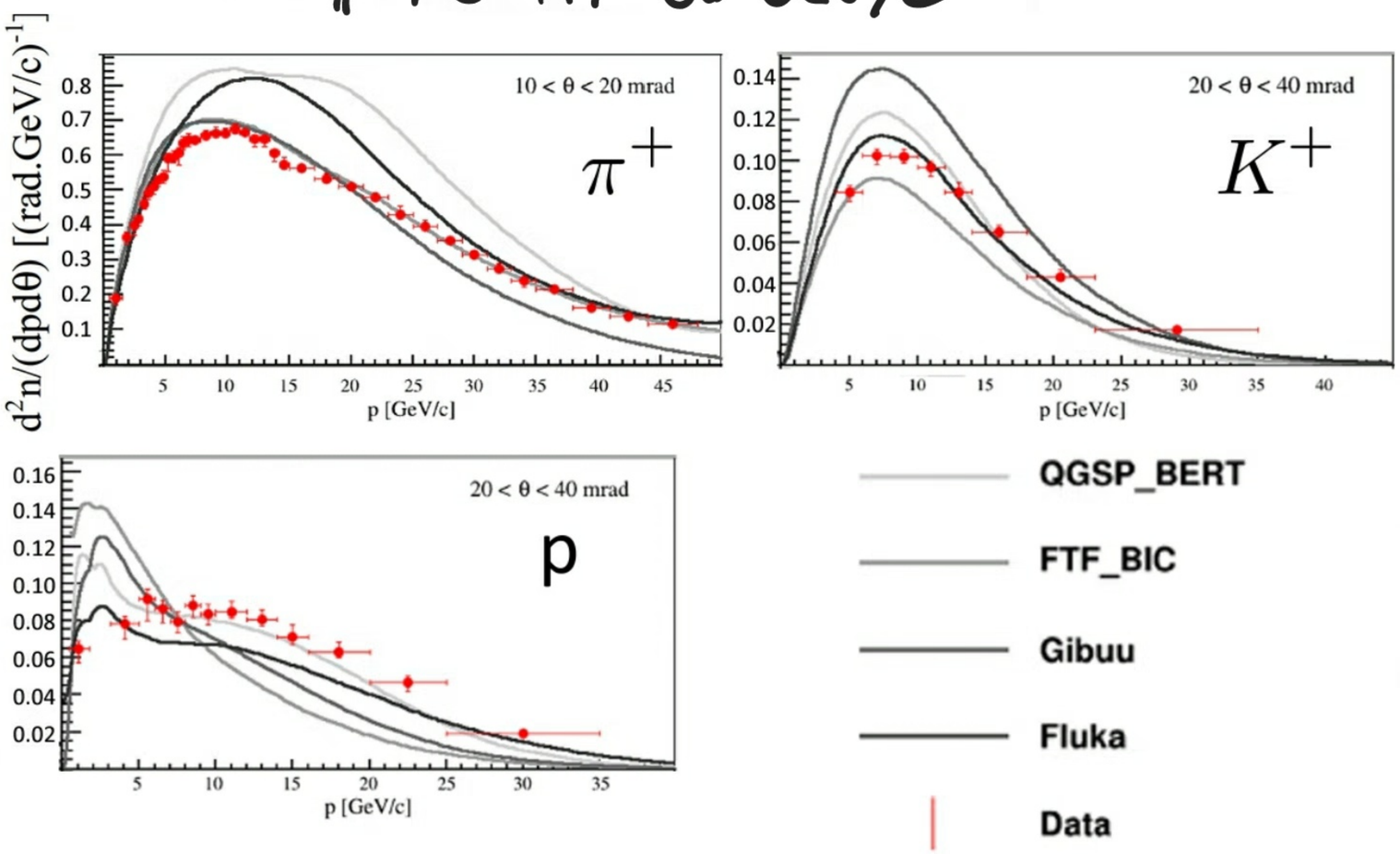
NEUTRINOS: KEY RESULTS

FOR J-PARC:



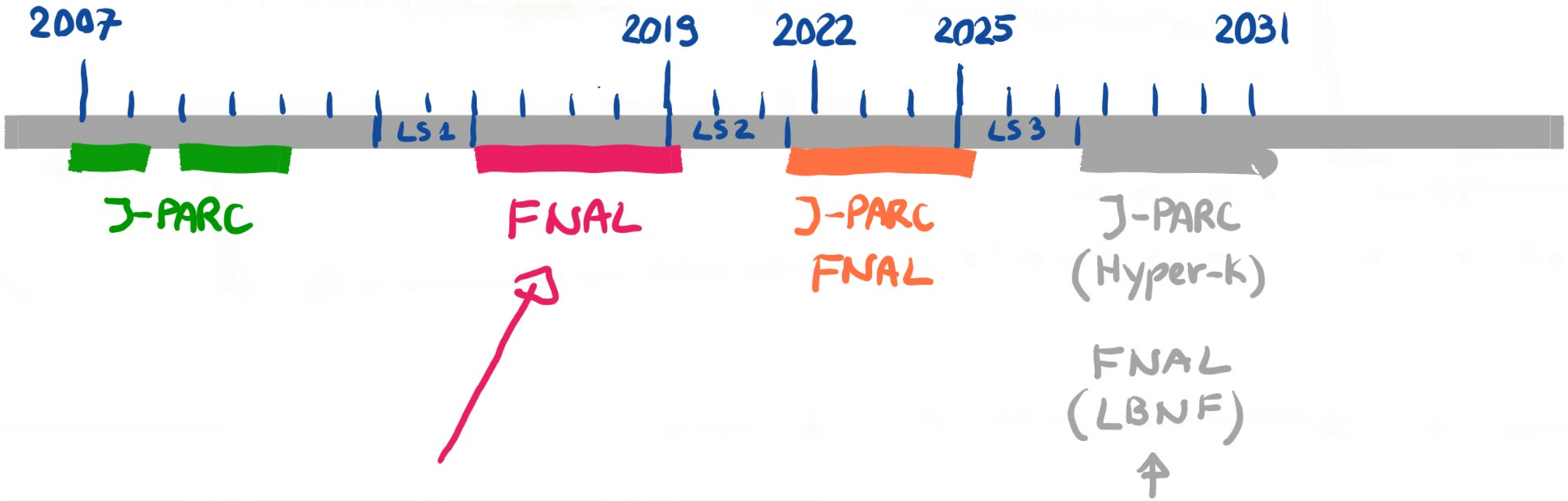
comparison to Gheisha2002

FOR FNAL:



NA61/SHINE DATA REDUCE DECISIVELY
UNCERTENTIES OF FINAL RESULTS OF NEUTRINO EXPERIMENTS

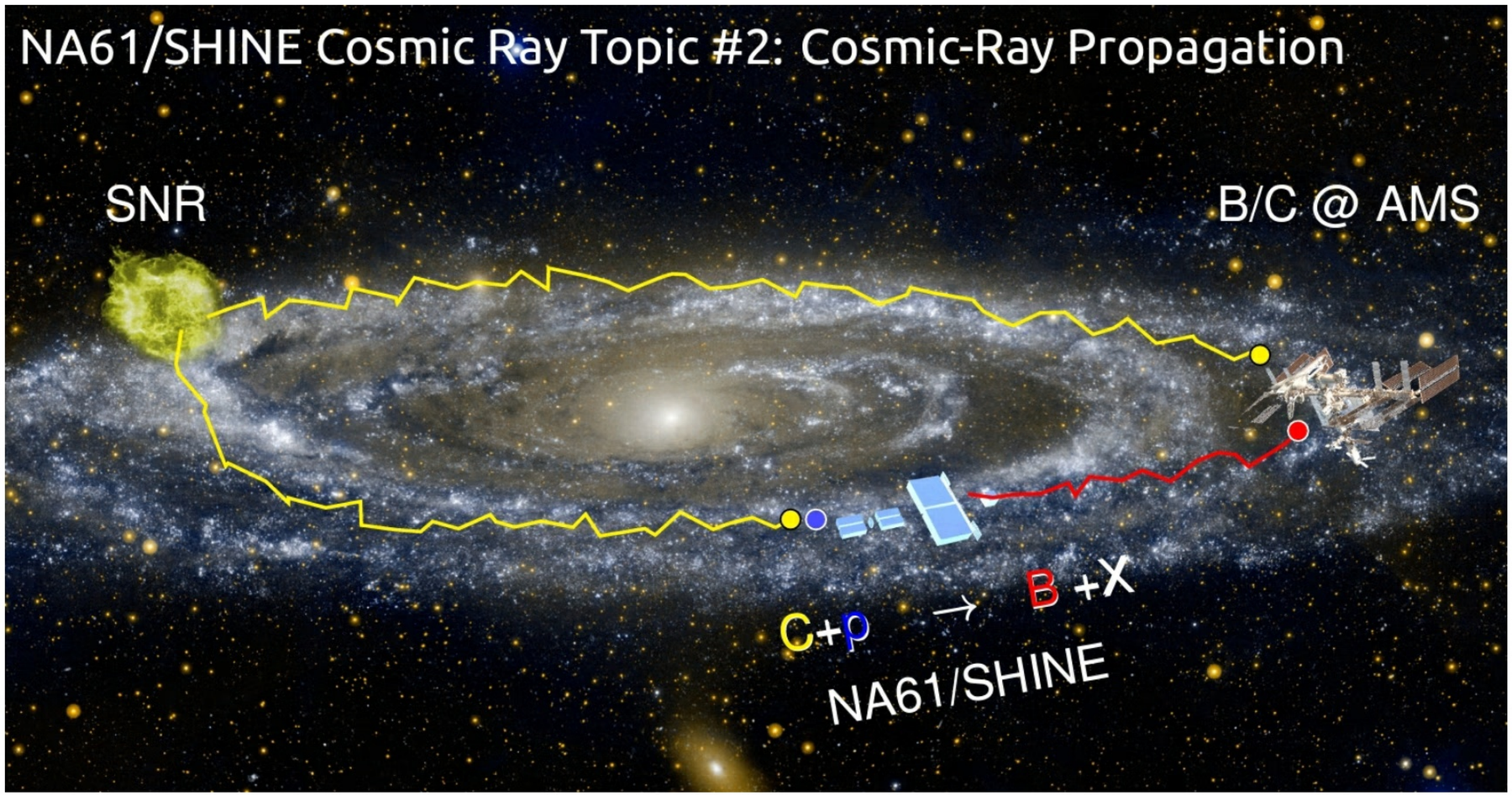
NEUTRINOS: DATA TAKING



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

COSMIC-RAYS

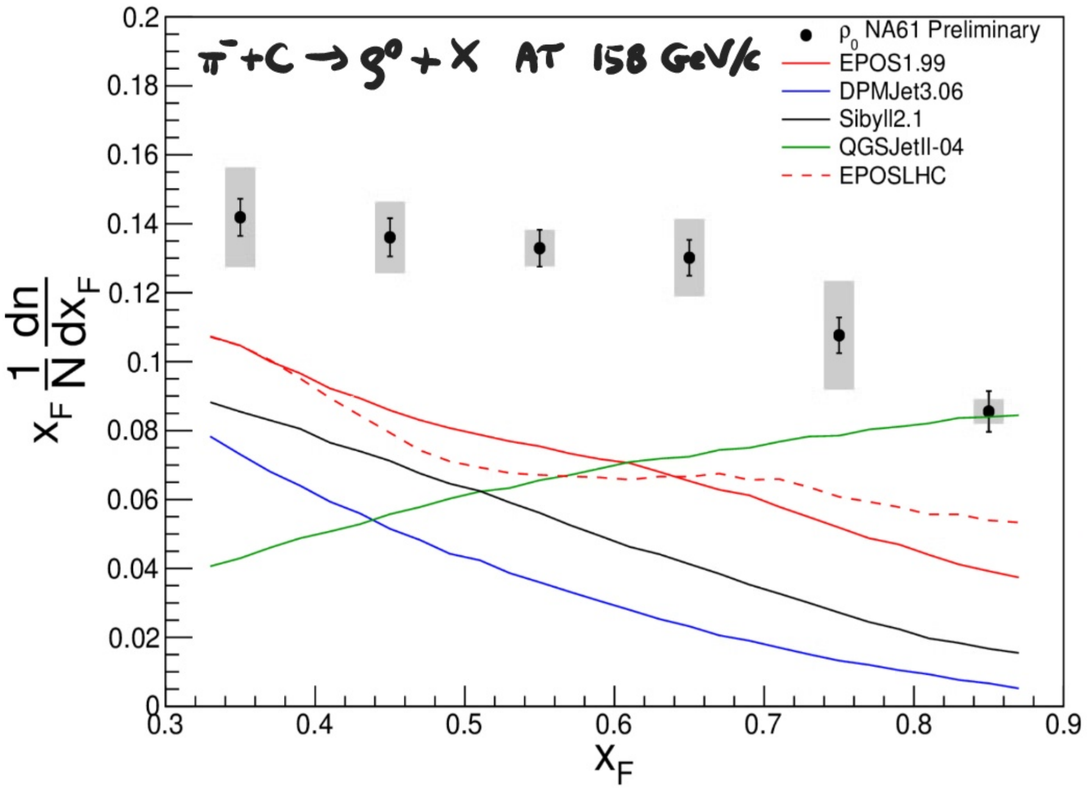
WHAT IS THE ORIGIN OF VERY HIGH ENERGY COSMIC-RAYS ?



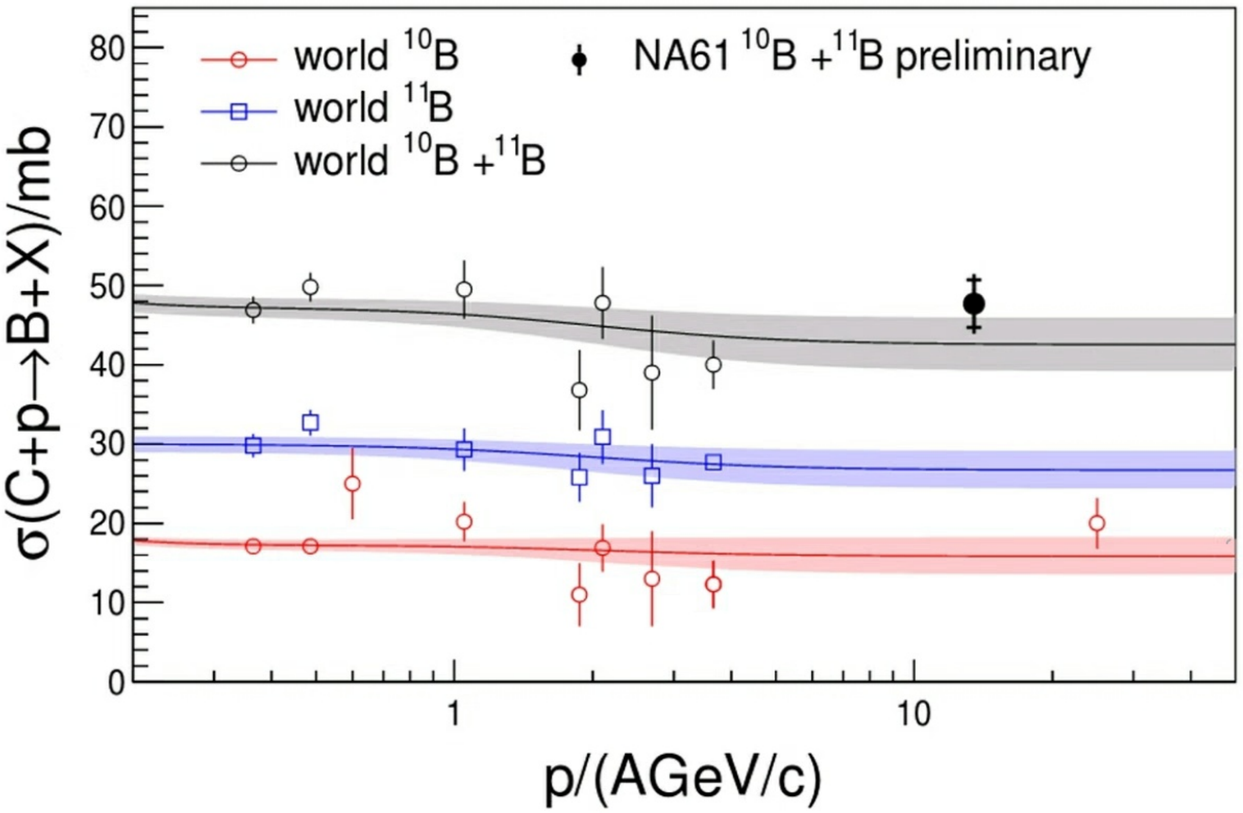
NA61/SHINE: WHAT HAPPENS WITH COSMIC RAYS IN INTERSTALLAR MEDIUM?

COSMIC-RAYS: KEY RESULTS

EXTENSIVE AIR SHOWERS:

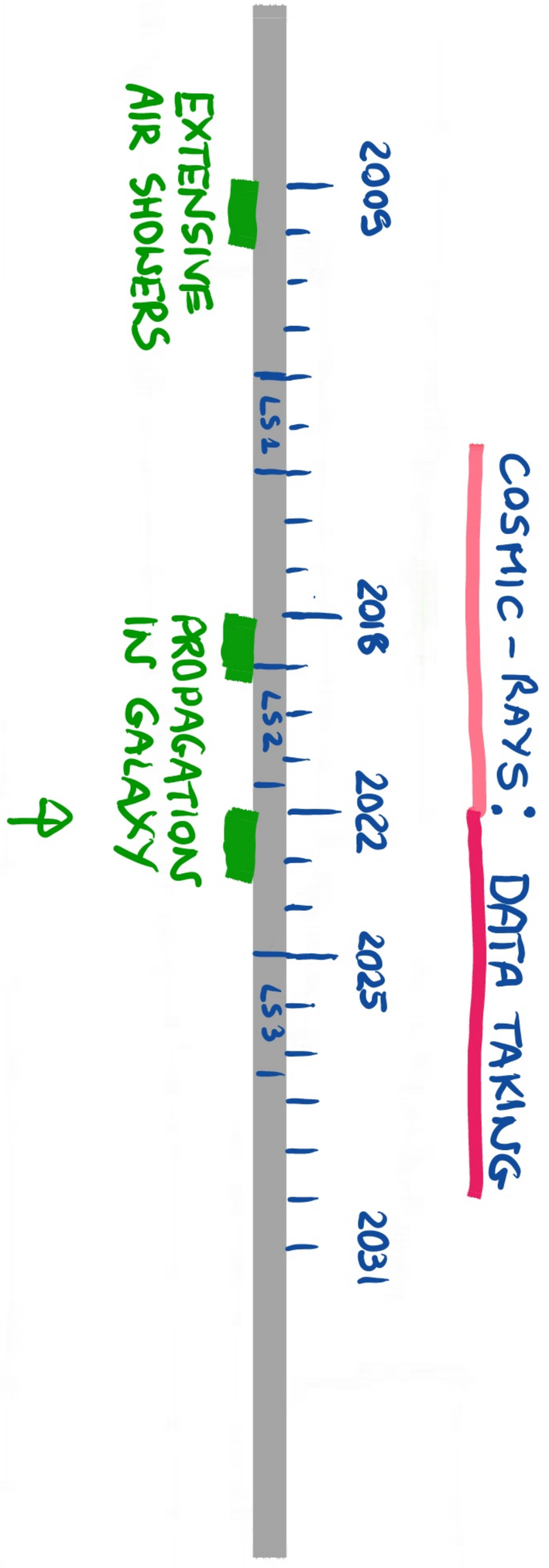


PROPAGATION IN GALAXY:



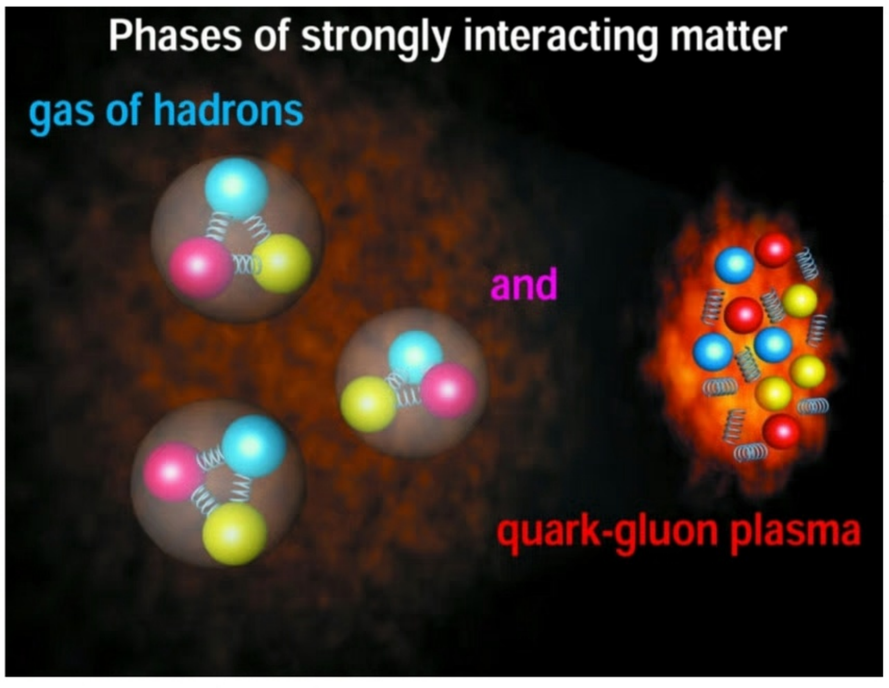
UNIQUE RESULTS WHICH CONSTRAIN MODELS NEEDED TO INTERPRET HIGH PRECISION DATA ON COSMIC RAYS

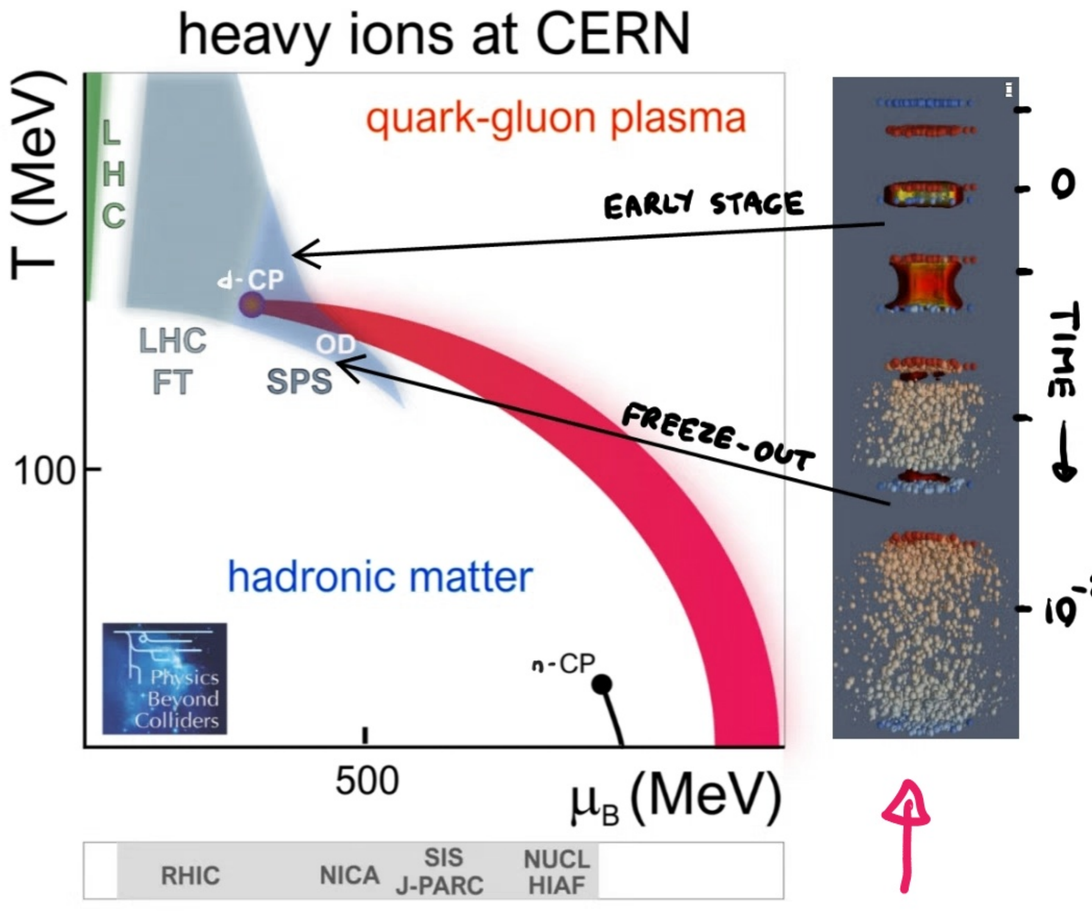
reaction	N_{inter}	A/Z
$^{16}\text{O} + \text{H}$	250k	2
$^{12}\text{C} + \text{H}$	150k	2
$^{16}\text{O} + \text{He}$	100k	2
$^{14}\text{N} + \text{H}$	40k	2
$^{10}\text{B} + \text{H}$	5k	2
$^{11}\text{B} + \text{H}$	5k	2
$^{12}\text{C} + \text{He}$	5k	2
$^{13}\text{C} + \text{H}$	5k	11/5
$^{15}\text{N} + \text{H}$	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
$\sum = 0.6\text{M}$		



STRONG INTERACTIONS

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



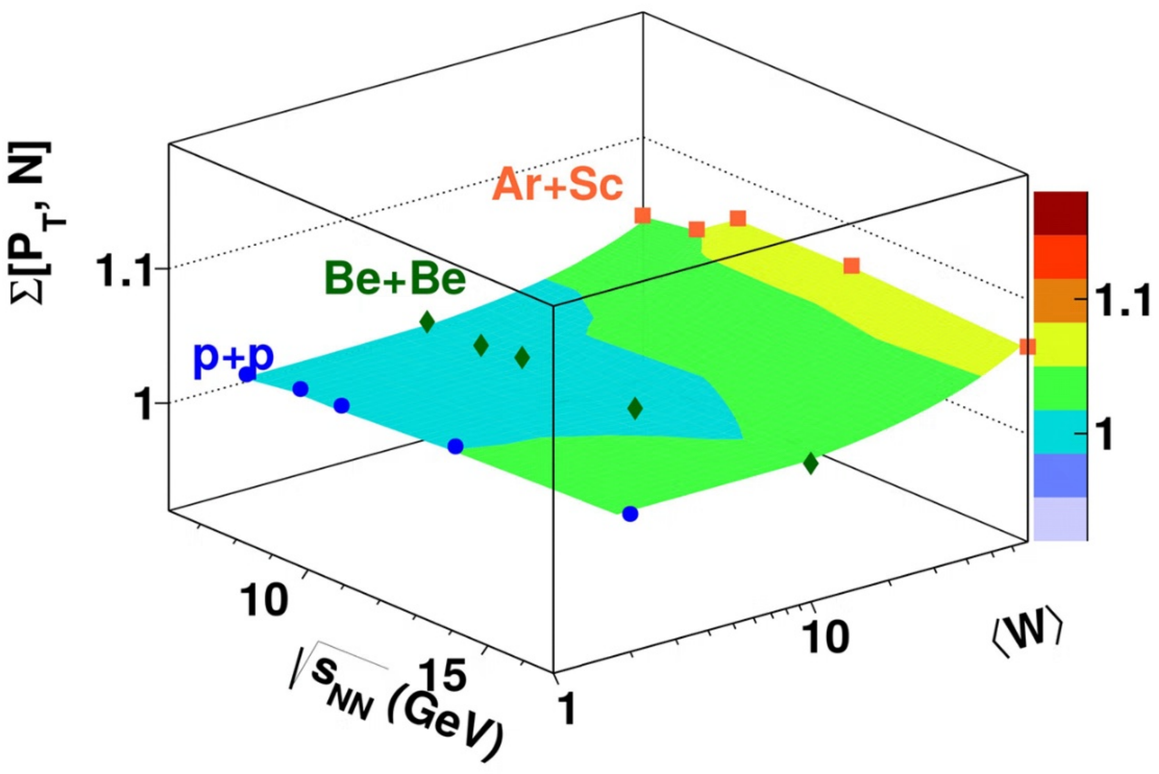


NA61/SHINE: WHAT HAPPENS IN HEAVY ION COLLISIONS ?

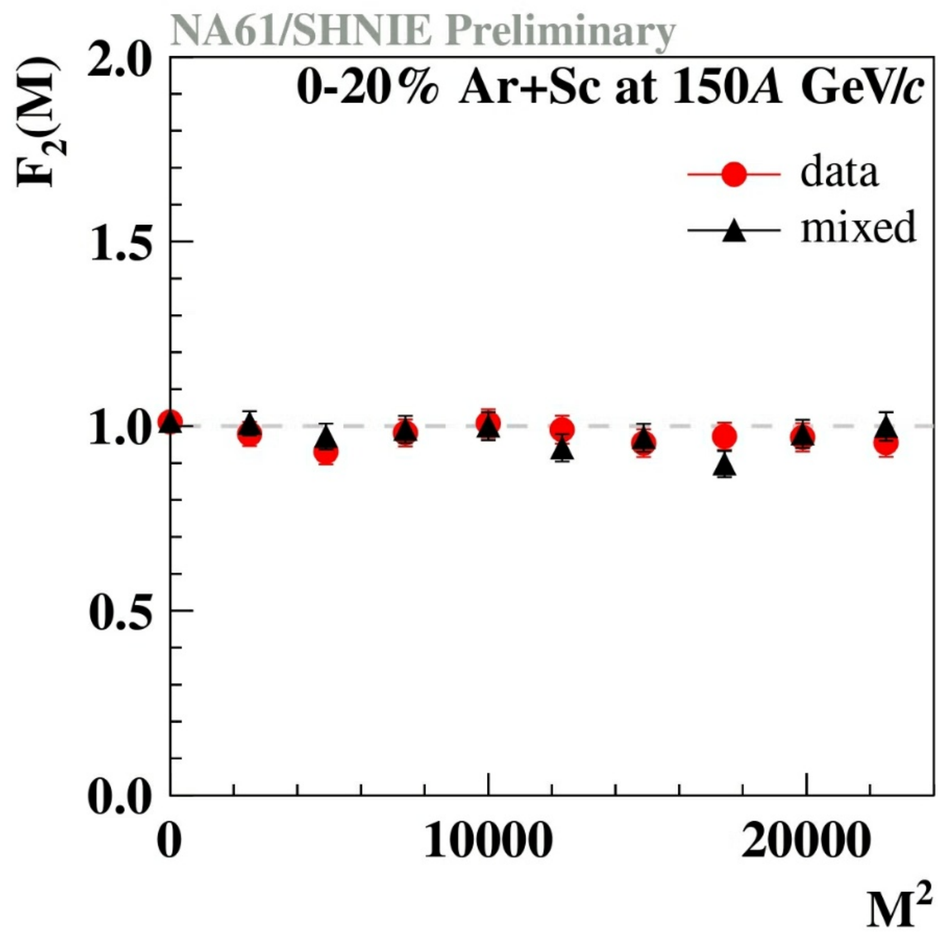
STRONG INTERACTIONS: KEY RESULTS

CRITICAL POINT

TRANSVERSE MOMENTUM - MULTIPLICITY FLUCTUATIONS



PRATAN INTERMITTENCY

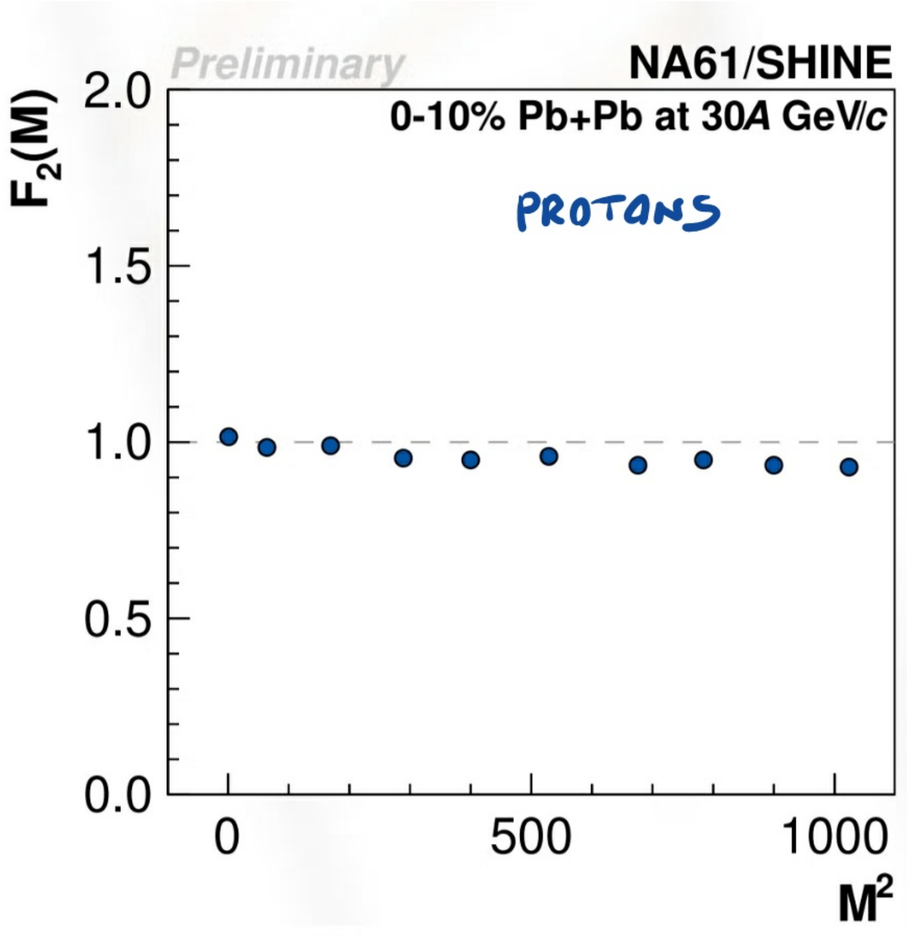


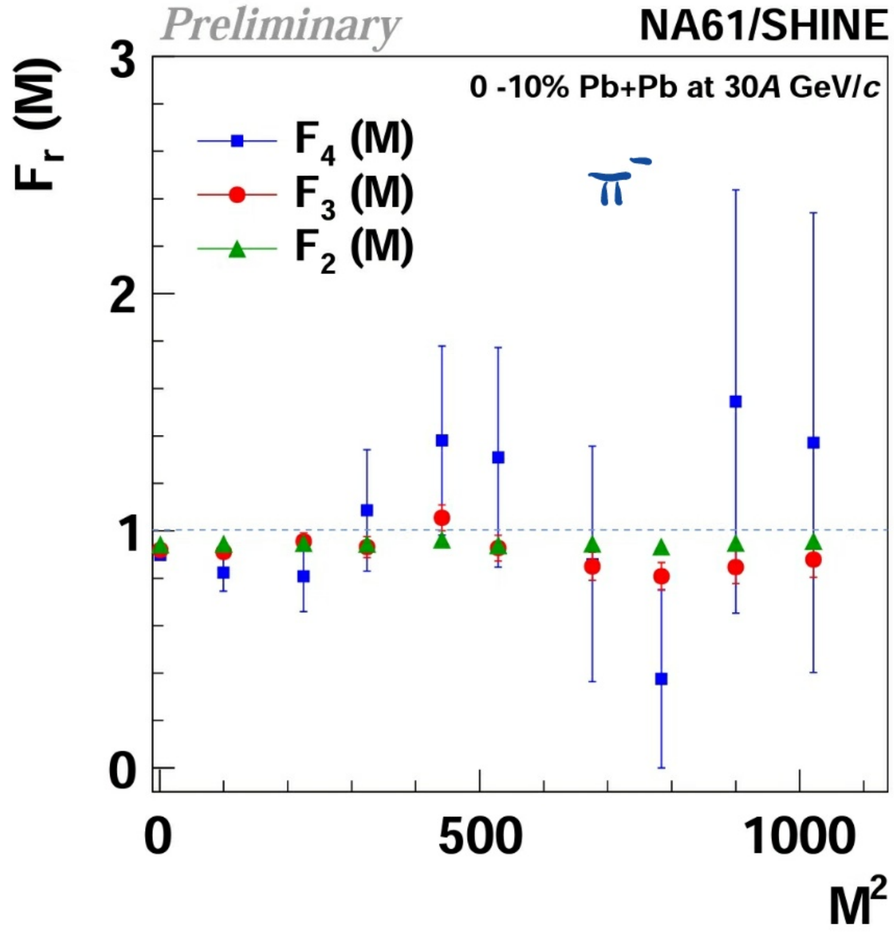
NO EVIDENCE SO FAR

STRONG INTERACTIONS: KEY RESULTS

CRITICAL POINT

INTERMITTENCY IN CENTRAL Pb+Pb AT 30A GeV/s





NO EVIDENCE SO FAR

STRONG INTERACTIONS: KEY RESULTS

CRITICAL POINT

CP-PARAM

Simple power-law model

Comparison with simple power-law model

A simple model that generates momentum of particles for a given number of events with a given multiplicity distribution.

It has two main parameters:

- ratio of correlated to uncorrelated particles,
- power-law exponent.

Uncorrelated particles (background)

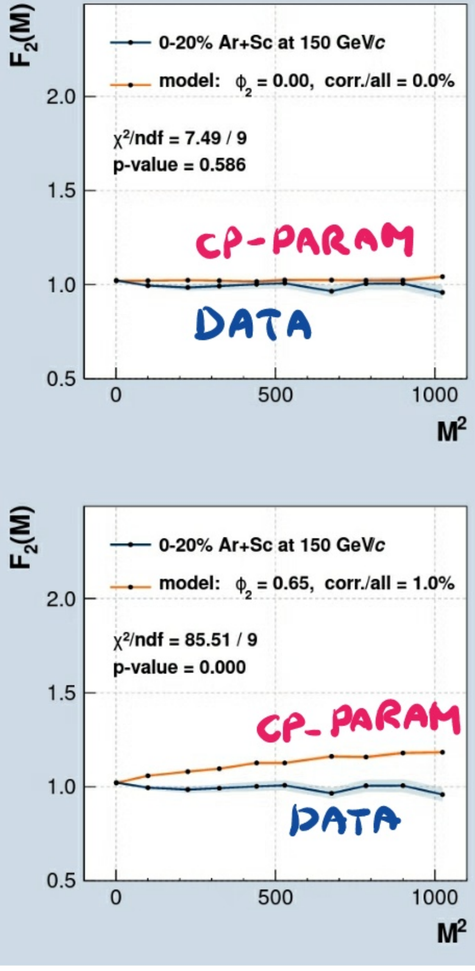
$$\rho_B(p_T) = p_T \cdot e^{-6p_T}$$

Correlated pairs (signal)

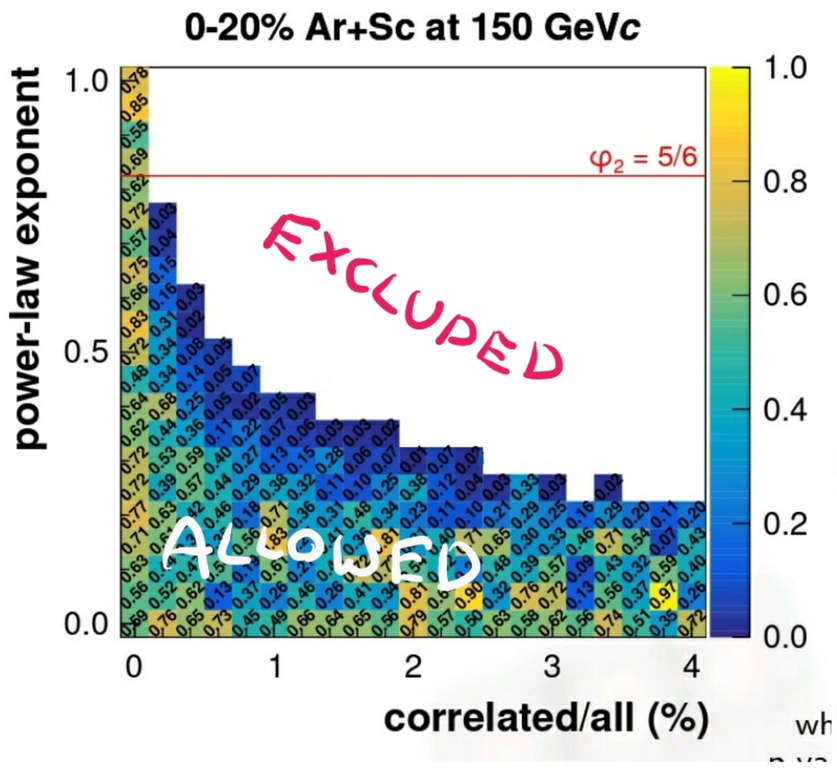
$$\rho_S(p_{T,1}, p_{T,2}) = \rho_B(p_{T,1}) \cdot \rho_B(p_{T,2}) \cdot \left[|\Delta p_x|^{\phi} + \epsilon\right]^{-1} \cdot \left[|\Delta p_y|^{\phi} + \epsilon\right]^{-1}$$

CP-PARAM VS DATA

M = 1 ... 32



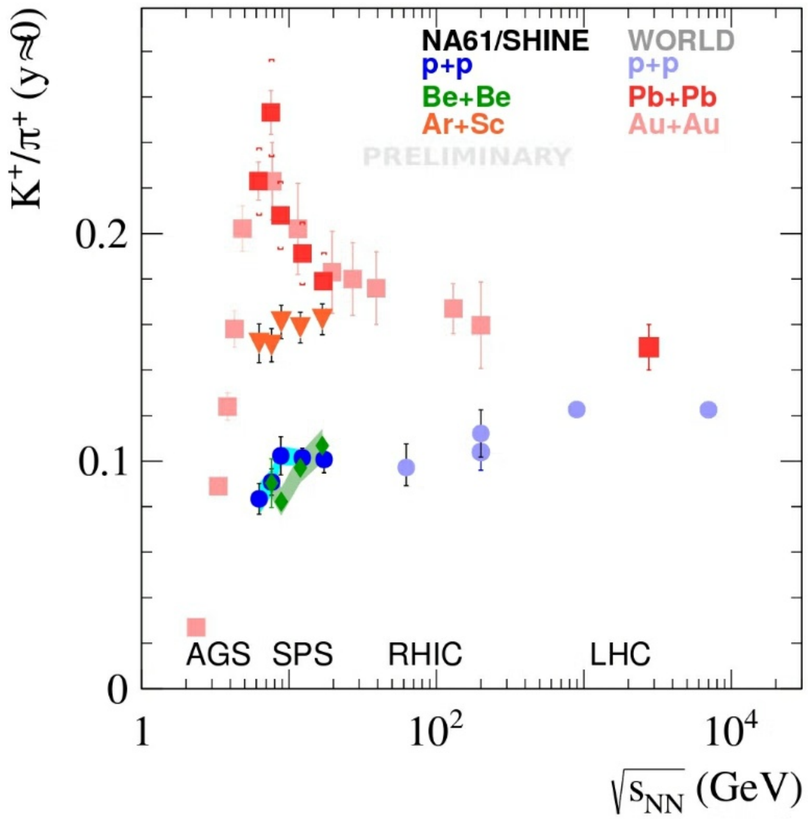
EXCLUSION PLOT FOR PARAMETERS OF CP-PARAM AND THE DATA



STRONG INTERACTIONS: KEY RESULTS

DIAGRAM OF HIGH ENERGY NUCLEAR COLLISIONS

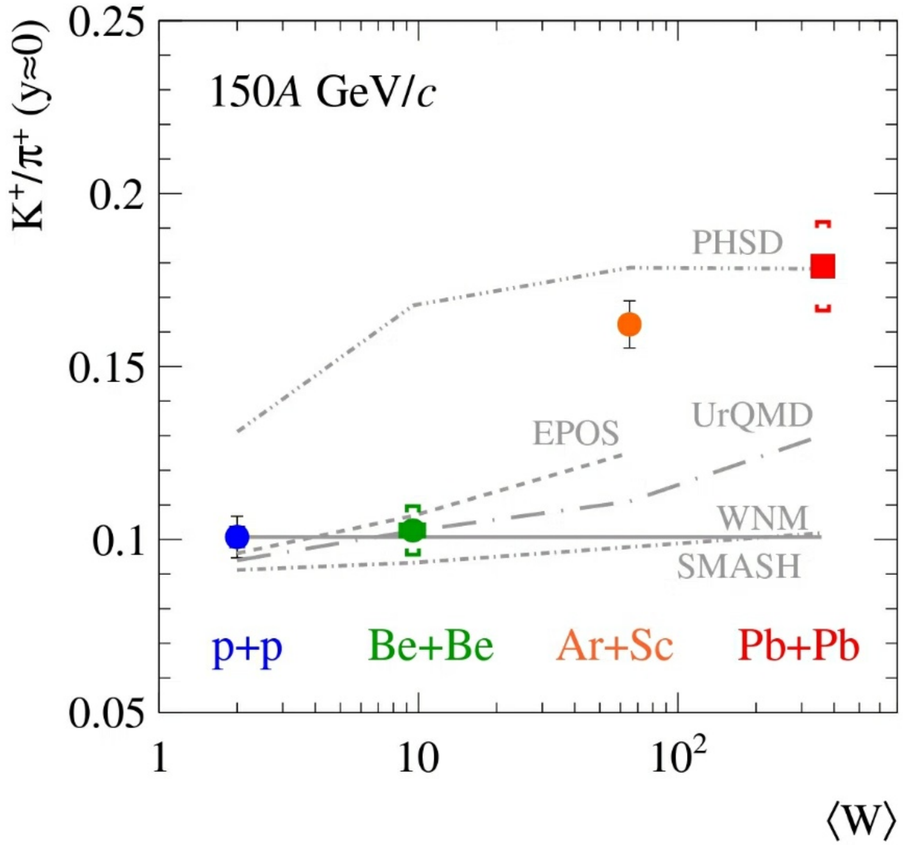
ONSET OF DECONFINEMENT



UNEXPECTED COLLISION ENERGY DEPENDENCE FOR SMALL/MEDIUM SIZE IONS

HORN → BREAK

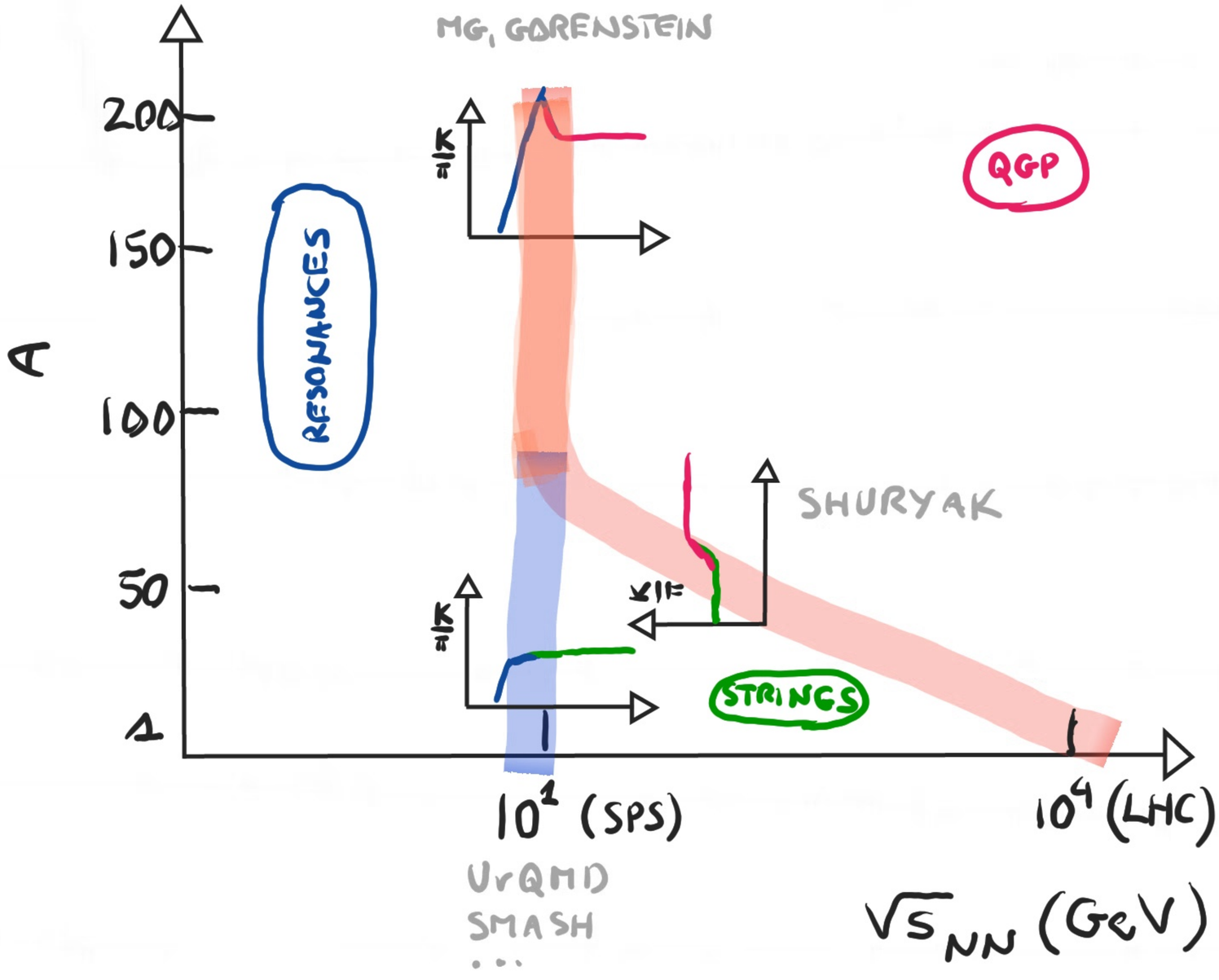
ONSET OF FIREBALL



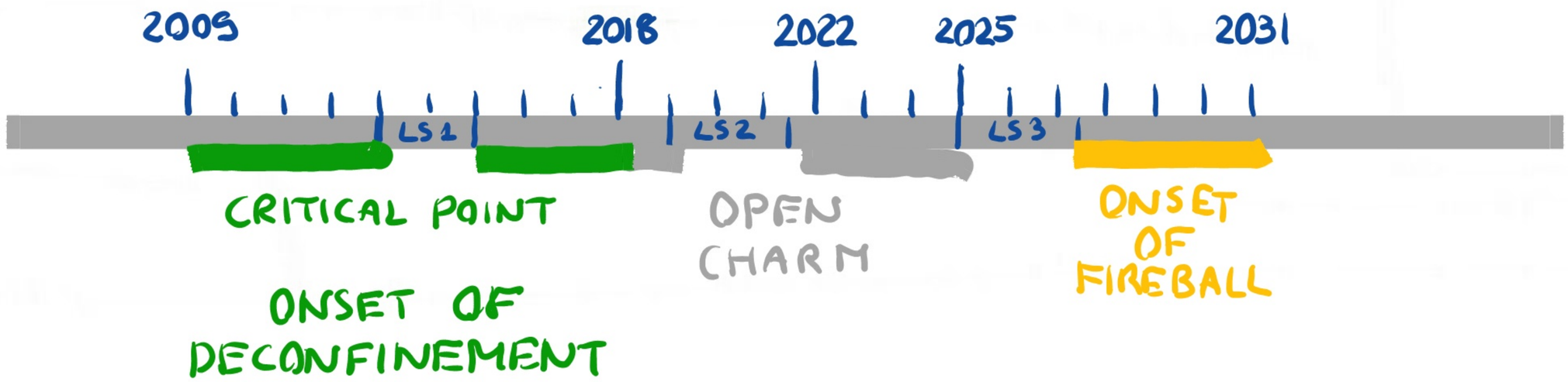
UNEXPECTED SYSTEM SIZE DEPENDENCE FOR SMALL/MEDIUM SIZE IONS

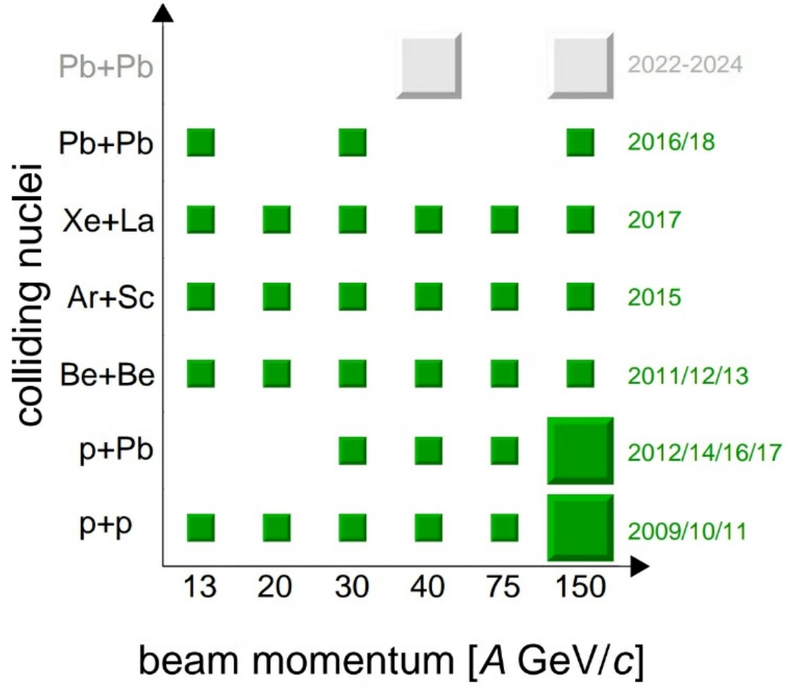
STRONG INTERACTIONS: KEY RESULTS

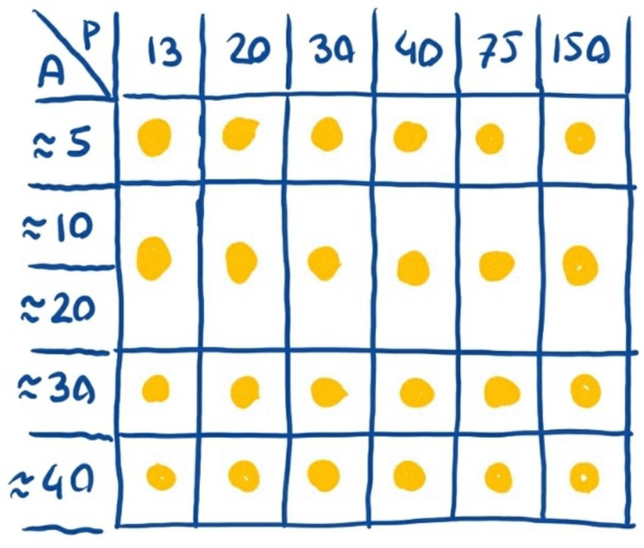
DIAGRAM OF HIGH ENERGY NUCLEAR COLLISIONS
CENTRAL A+A



STRONG INTERACTIONS: DATA TAKING







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 $\pi^{\pm}$, $K^{\pm}$, K^0_S, 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 $\pi^{\pm}$, $K^{\pm}$, 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^0_S 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 $\pi^{\pm}$ 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 $\pi^{\pm}$, $K^{\pm}$ 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 π^- + 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 π^++C, π^++Al, K^++C, and K^++Al at 60 GeV/c and π^++C and π^++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

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