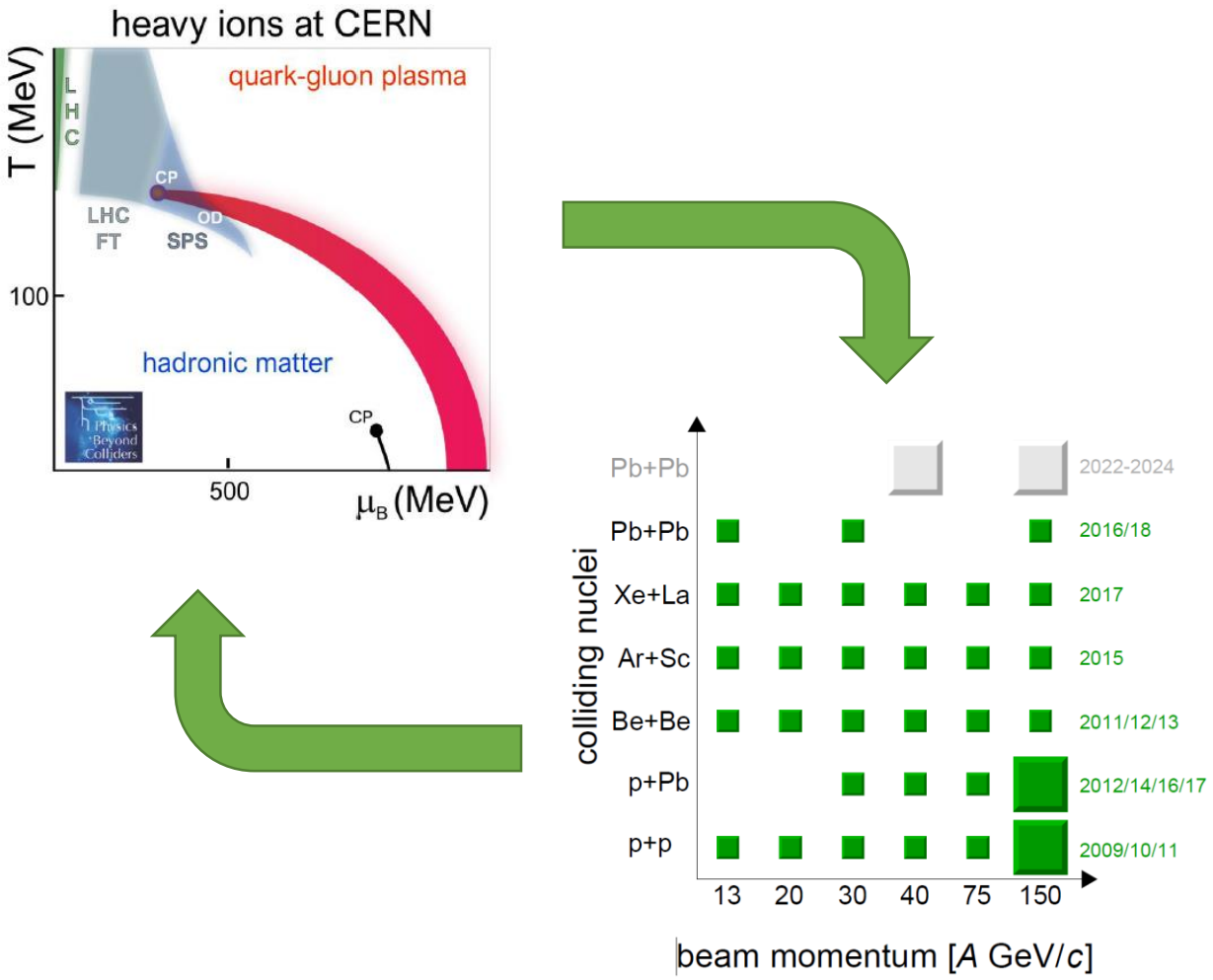
NA61

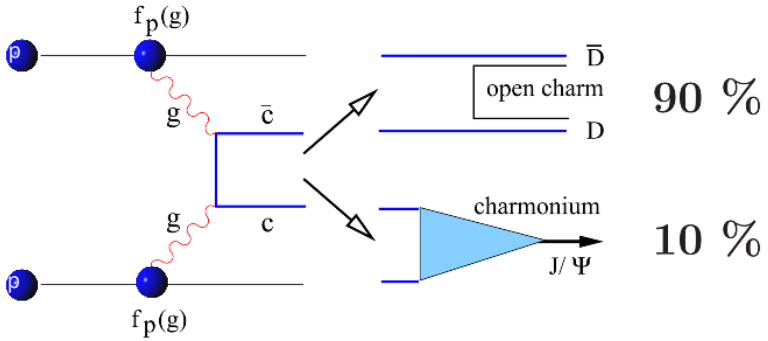
20.05.2021

NA61/SHINE - Physics program

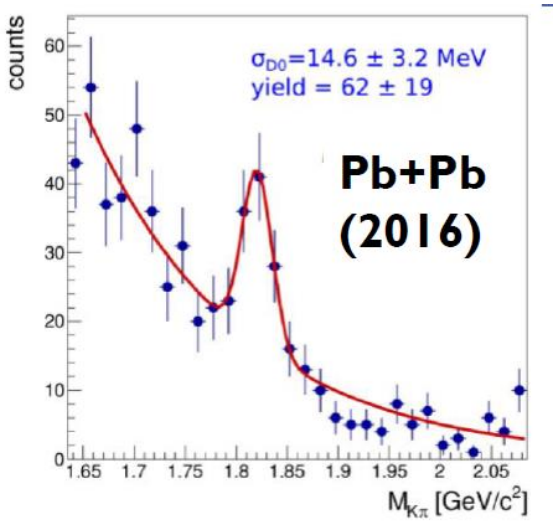


- Strong interactions program
  - search for the critical point of strongly interacting matter
  - study of the properties of the onset of deconfinement
- Hadron-production measurements for neutrino experiments
- Hadron-production measurements for cosmic ray experiments

Charm production and the onset of deconfinement

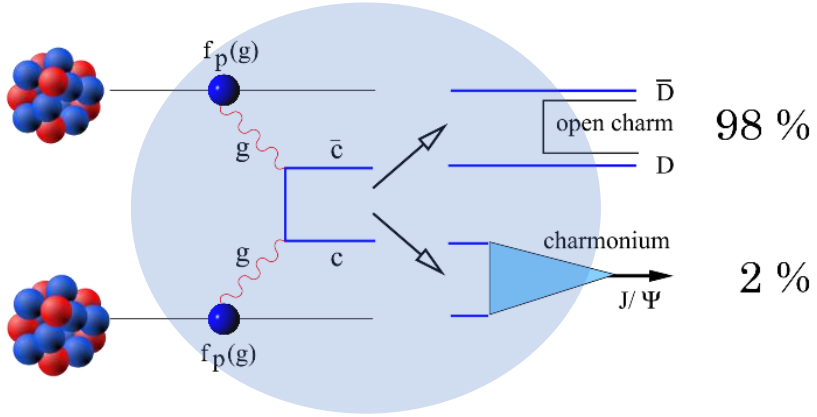


Open charm and J/ψ production within Matsui-Satz model
[PL B178 416]



NA61/SHINE pilot measurements
open charm signal in Pb+Pb at 150 A GeV/c

Pb+Pb with QGP



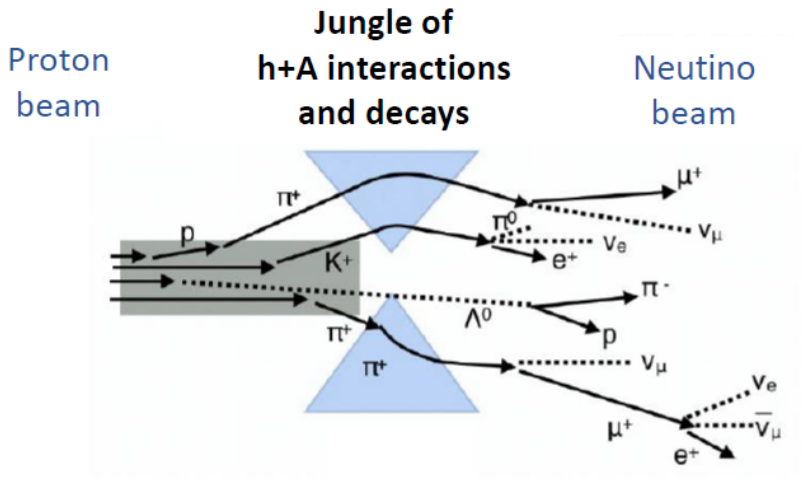
- What is the mechanism of open charm production?
- How does the onset of deconfinement impact open charm production?
- How does the formation of quark gluon plasma impact J/ψ production?

Medium reduces probability of J/ψ production

$$P(c\bar{c} \to J/\psi) \equiv \frac{< J/\psi >}{< c\bar{c} >} \equiv \frac{\sigma_{J/\psi}}{\sigma_{c\bar{c}}}$$

$$P_{\text{vacuum}}(c\bar{c} \to J/\psi) \quad > \quad P_{\text{medium}}(c\bar{c} \to J/\psi)$$

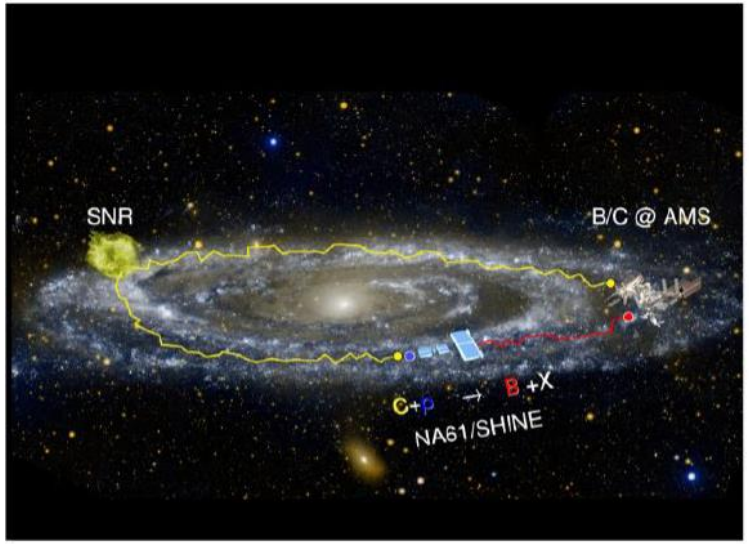
Reference measurements: Hadron production for neutrino experiments



- Further improvement of the precision of measurements for the currently used T2K replica target,
- Measurements for a new target material (super-sialon) for T2K-II and Hyper-Kamiokande,
- Study of the possibility of measurements with beams <12 GeV/c for improved predictions of atmospheric and accelerator ν fluxes,
- Ultimate hadron production measurements with prototypes of Hyper-Kamiokande and DUNE targets.

NA61/SHINE will decrease systematic uncertainties on neutrino fluxes
(for T2K-II, Hyper-K from 10% to 3%)

Reference measurements: Nuclear fragmentation cross section for cosmic ray experiments



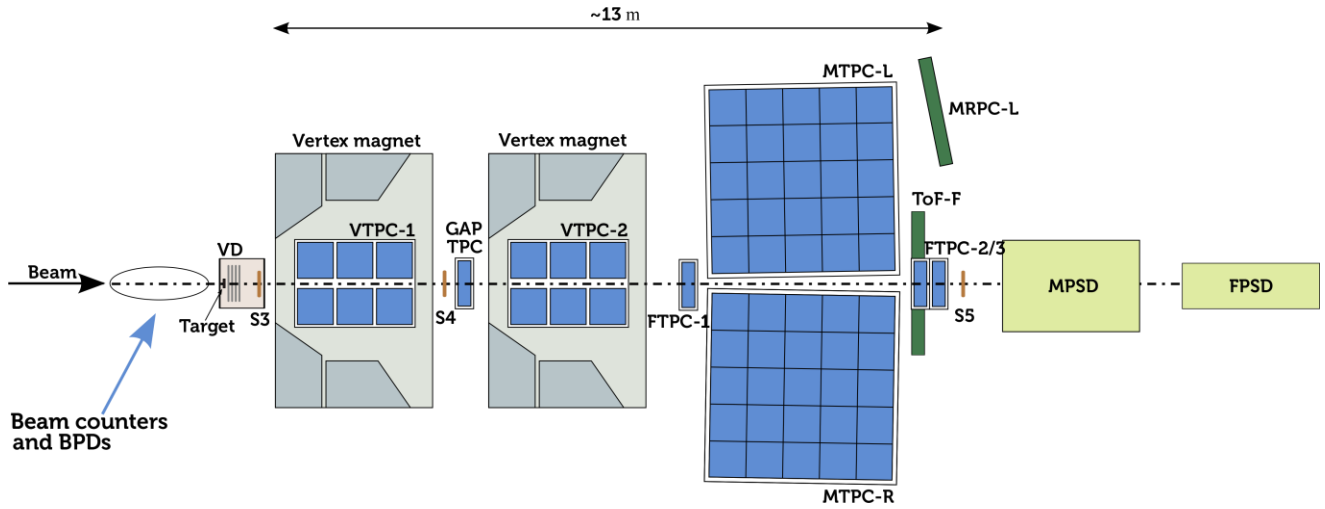
- Primary cosmic rays from supernova remnants
- Secondary cosmic rays from interactions with interstellar matter during propagation e.g.
  $^{12}C + p \xrightarrow{frag.} B + X$
  $^{12}C + p \xrightarrow{frag.} {}^{11}C + p \xrightarrow{decay} B + Y$
- Primary-to-secondary ratios (e.g. B/C)
  → traversed mass density
- Unstable-to-stable ratios (e.g. $^{10}Be/^{9}Be$)
  → traversed distance
- Important for the understanding of origin of Galactic cosmic rays and backgrounds for DM searches

Understanding of cosmic ray propagation limited by uncertainties of fragmentation cross sections

NA61/SHINE will significantly reduce the uncertainties (from 20% to 0.5%)

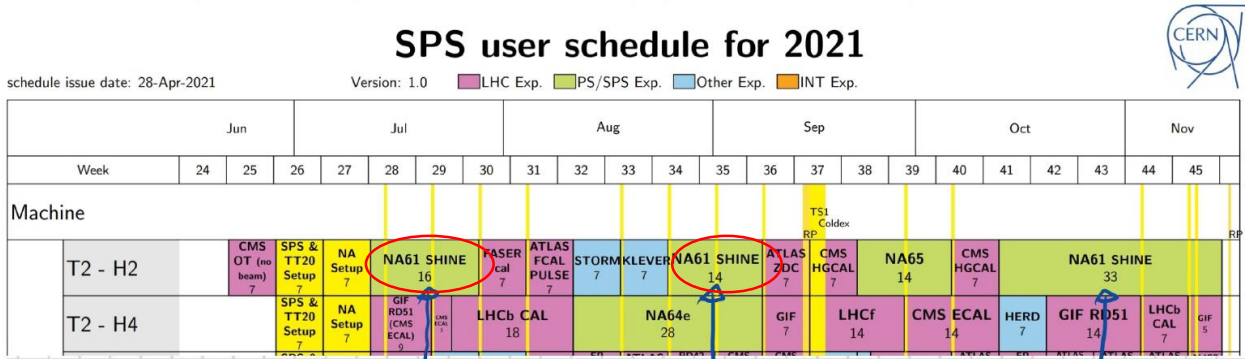
Upgrade

- The upgrade is ongoing.
- The funds are secured and enough for the upgrade.
- The development and design phase is completed.
- The mass production of elements for subsystems is ongoing
  - The main problem is the delivery time
- Installation:
  - Due to the delivery schedule, the FEE installation will be done in middle June
  - Preparation for the installation must start on-site at the begging of June



Test of the detector

- Two test periods:
  - First – two weeks (28, 29) in July
    - 12- 25 July
  - Second – two weeks (34, 35) August/September
    - 23 August – 6 September
- Beam: hadron 150 GeV/c; intensity per spill 10^5 - with possible beam intensity increase



Hadrons/ proton	Ion/ lead
DAQ	DAQ
Trigger	Trigger
BPD, Beam Counters	BPD, Beam Counters
VTPC, MTPC, FTPC, GTPC	VTPC, MTPC, GTPC
	VX Detector
TOF-F, MRPC	MRPC
	PSD

Period 1

		Beam Type/ Momentum	Intensity per spill
BPDS (Si) and counters (S1, S2, S4, S5, V0, V1)			
magnets off	Detector response on beam	hadrons /150 GeV/c	10^5
magnets off	DRS readout test	hadrons /150 GeV/c	10^5
Trigger system			
magnets off	Test	hadrons /150 GeV/c	10^5
DCS			
magnets off	Test	hadrons /150 GeV/c	10^5
DAQ			
magnets off	Check the data structure and event building	hadrons /150 GeV/c	10^5
magnets off	Test the connection (readout) to the subsystems	hadrons /150 GeV/c	10^5
magnets off	Online and offline monitoring system	hadrons /150 GeV/c	10^5
TPC			
magnets off	Signal check, tune HV,	hadrons /150 GeV/c	10^5
magnets off	Check channel mapping	hadrons /150 GeV/c	10^5
ToF-F			
magnets off	Check the detector	hadrons /150 GeV/c	10^5
TPC, BPDS (Si) and counters (S1, S2, S4, S5, V0, V1), DAQ, Trigger			
magnets on	intensity check	hadrons/150 GeV/c	10^5

Period 2

Systems from period 1			
	Commissioning	hadrons 150 GeV/c	10^5
PSD			
	Test	hadrons 150 GeV/c	10^5
BPDS (ScFi) and counters (S3)			
	Test	hadrons /150 GeV/c	10^5
Vertex detector			
	Test	hadrons /150 GeV/c	10^5
MRPC			
	Test	hadrons /150 GeV/c	10^5
Vertex detector			
	Intensity check	hadrons /150 GeV/c	10^7
MRPC			
	Intensity check	hadrons /150 GeV/c	10^7

Summary

- The main worries:
  - The COVID-19 situation
  - The delivery time of the components
- The installation should start mid of June
  - The two periods of test:
    - I TPC, BPD, DAQ, Trigger, DCS
    - II (system from I) ToF, PSD, VX