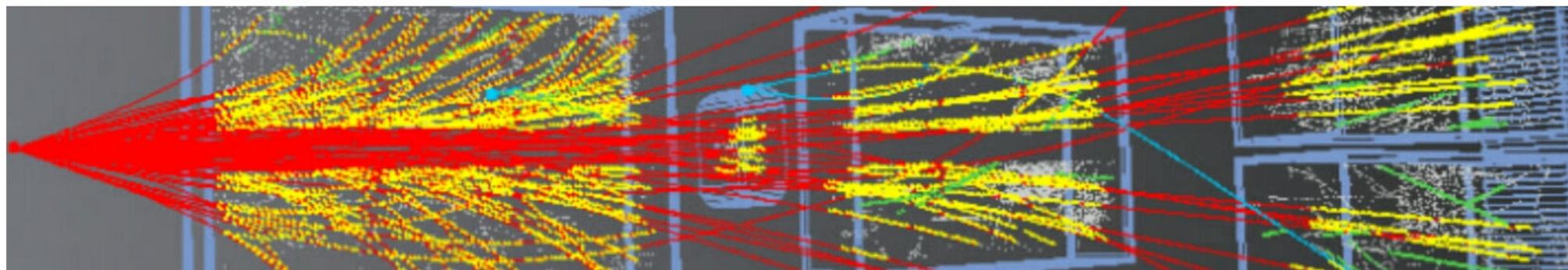


NAGI/SHINE: PHYSICS AND FACILITY BEYOND 2020

M. GAZDZICKI FOR NAGI/SHINE

■ NAGI/SHINE: PHYSICS AND FACILITY

■ ■ IDEAS FOR MEASUREMENTS BEYOND 2020



NAGI/SHINE: PHYSICS AND FACILITY

NAGI/SHINE - UNIQUE MULTIPURPOSE FACILITY FOR MEASUREMENTS OF HADRON PRODUCTION IN $h+p$, $h+A$ AND $A+A$ INTERACTIONS AT $13A - 150A$ (400) GEV/c

APPROVED DATA TAKING PROGRAMME (2009-2018)
COVERS MEASUREMENTS FOR PHYSICS OF

- STRONG INTERACTIONS
- NEUTRINOS
- COSMIC - RAYS

S·INE PHYSICS: STRONG INTERACTIONS

DATA TAKING : IN PROGRESS

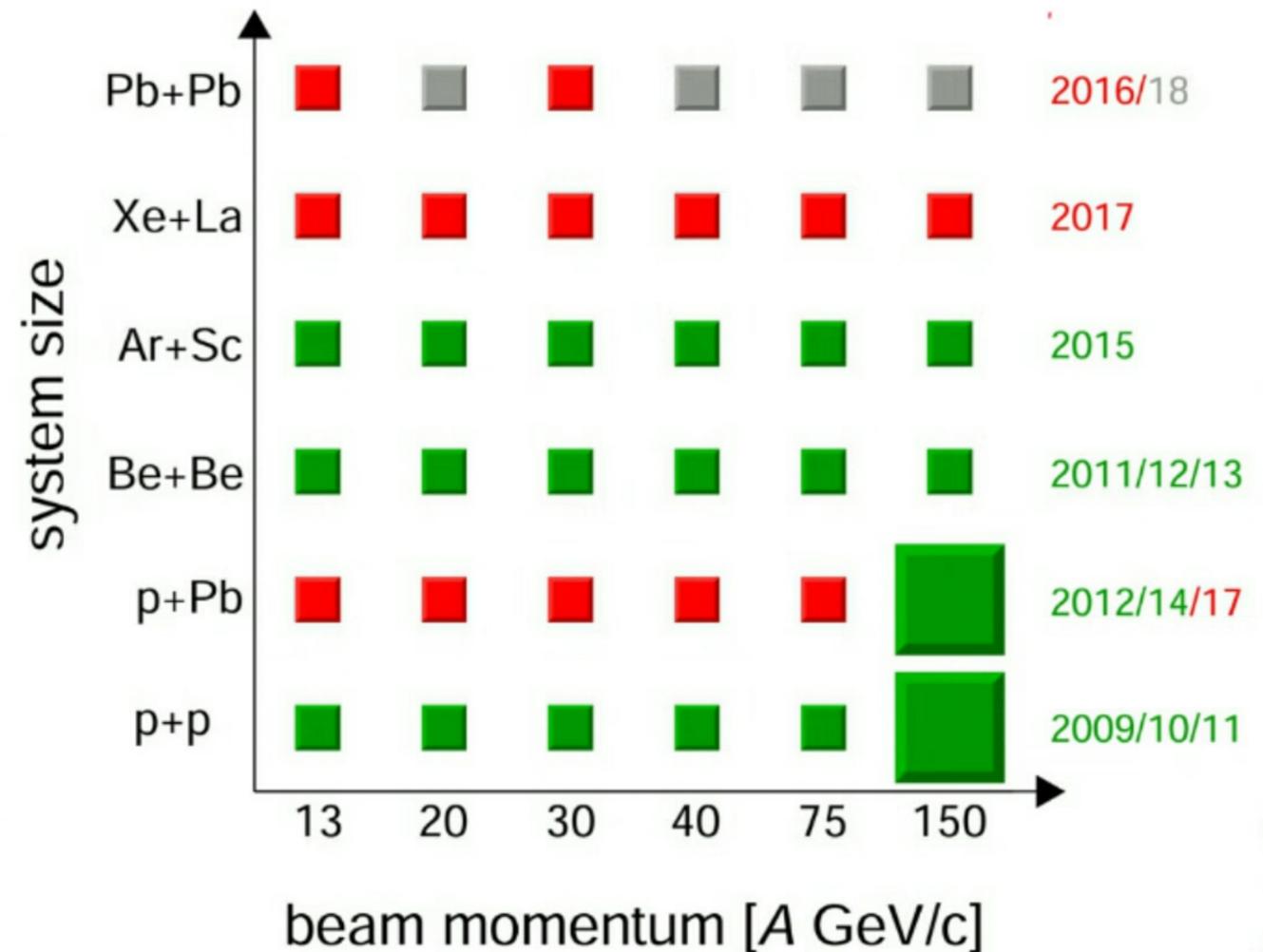
ANALYSIS : IN PROGRESS

- STUDY ONSET OF DECONFINEMENT:

PION SPECTRA: $Ar+Sc \approx Pb+Pb$
 $\neq p+p$

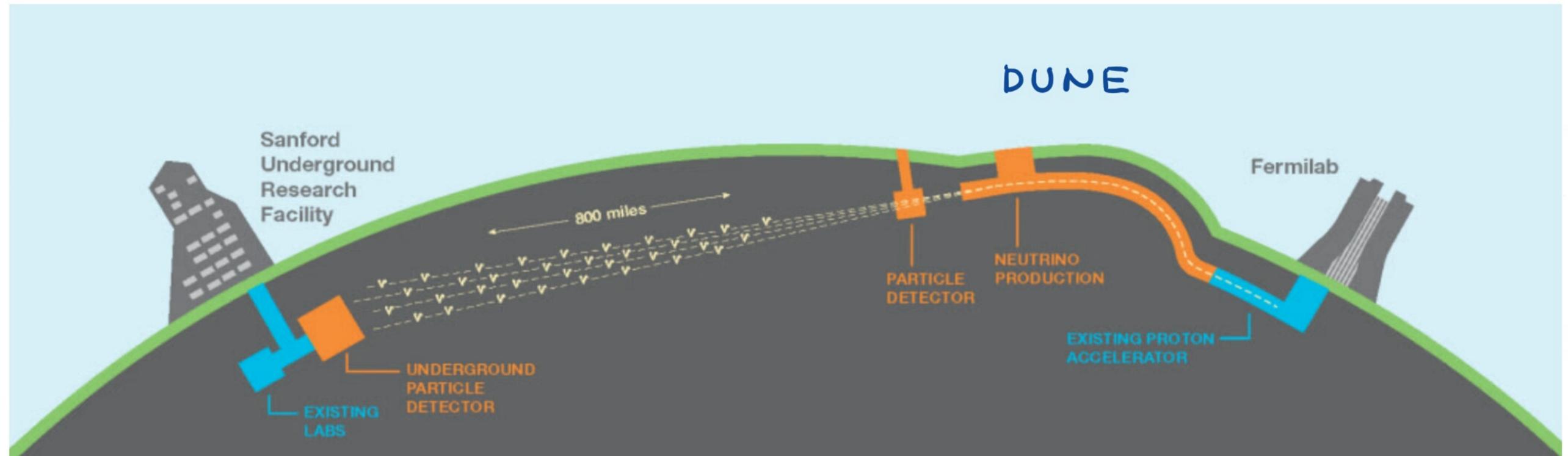
- SEARCH FOR CRITICAL POINT:

UP TO NOW NO EVIDENCE IN
 $p+p$, $Be+Be$, $Ar+Sc$ AT
 $13A - 150A$ GeV/c



S·INE PHYSICS: NEUTRINOS

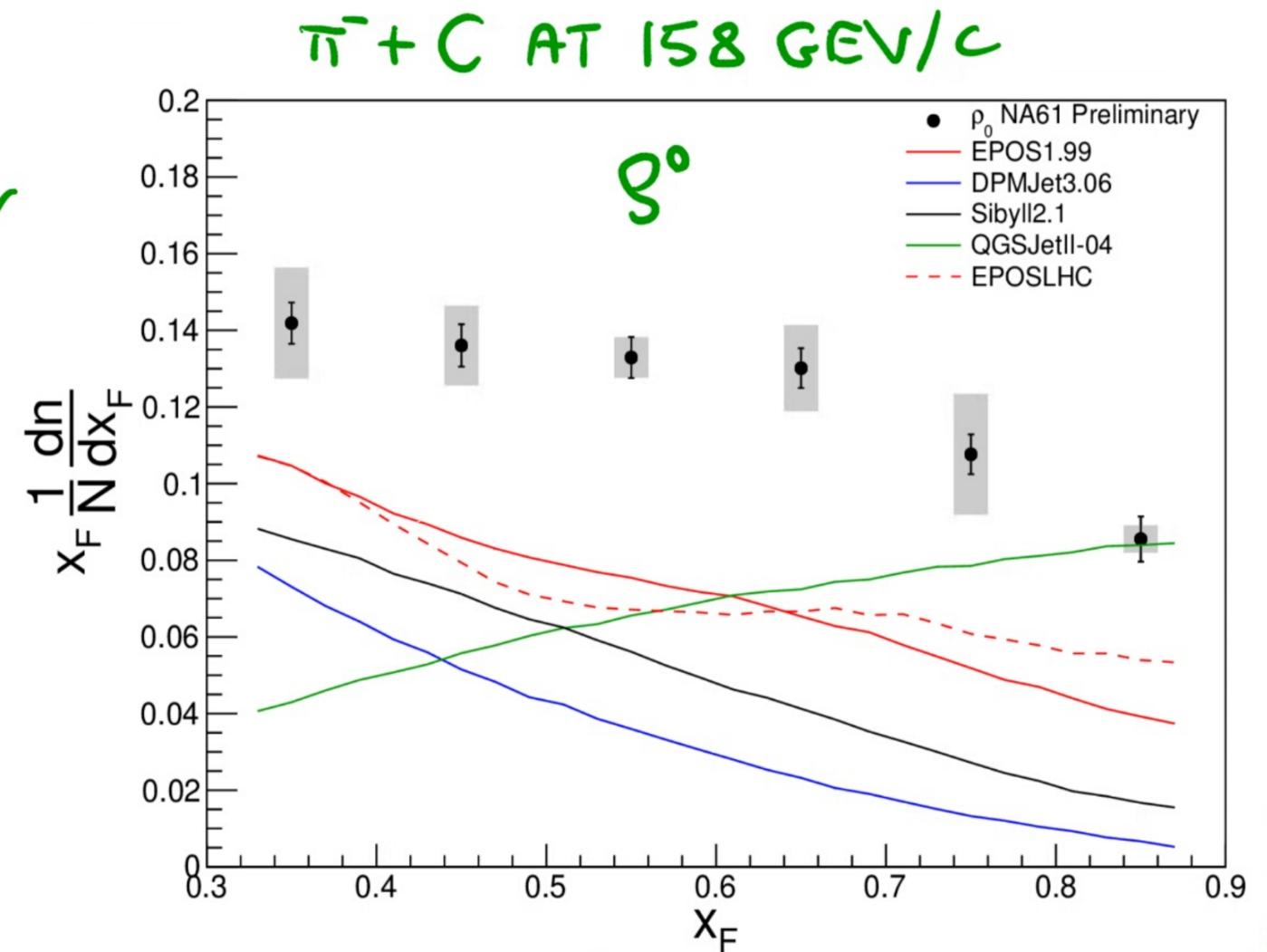
- HADRON PRODUCTION MEASUREMENTS FOR T2K
DATA TAKING: COMPLETED
ANALYSIS: ALMOST COMPLETED
- HADRON PRODUCTION MEASUREMENTS FOR FERMILAB
NEUTRINO BEAMS
DATA TAKING: STARTS NOW
ANALYSIS: TO BE STARTED



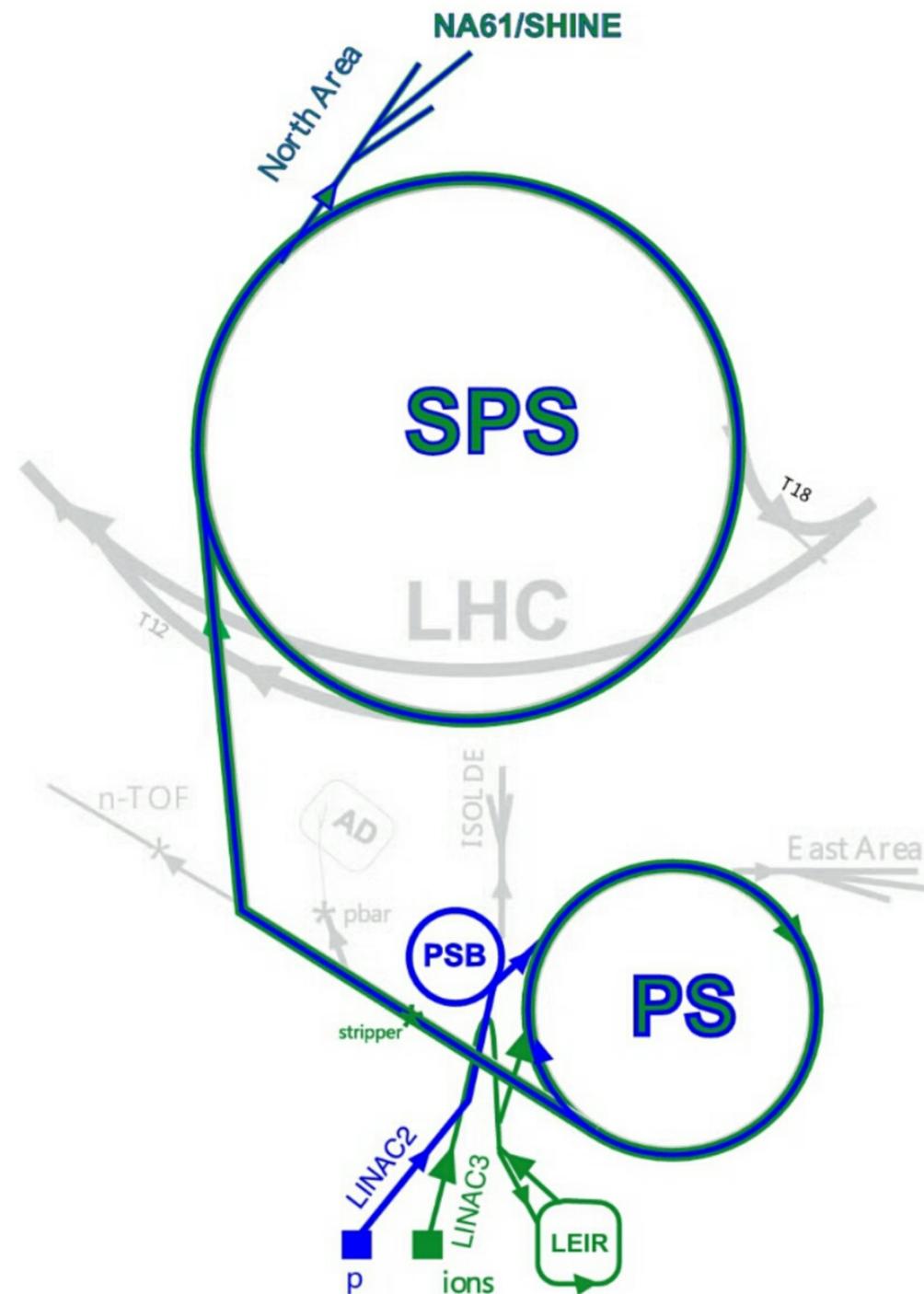
S·INE PHYSICS: COSMIC-RAYS

DATA TAKING: COMPLETED
ANALYSIS: IN PROGRESS

- HADRON AND RESONANCE PRODUCTION
IN $\pi^- + C$ INTERACTIONS
FOR EXTENSIVE AIR SHOWER
MODELLING FOR COSMIC-RAY
EXPERIMENTS



S·INE FACILITY: BEAMS



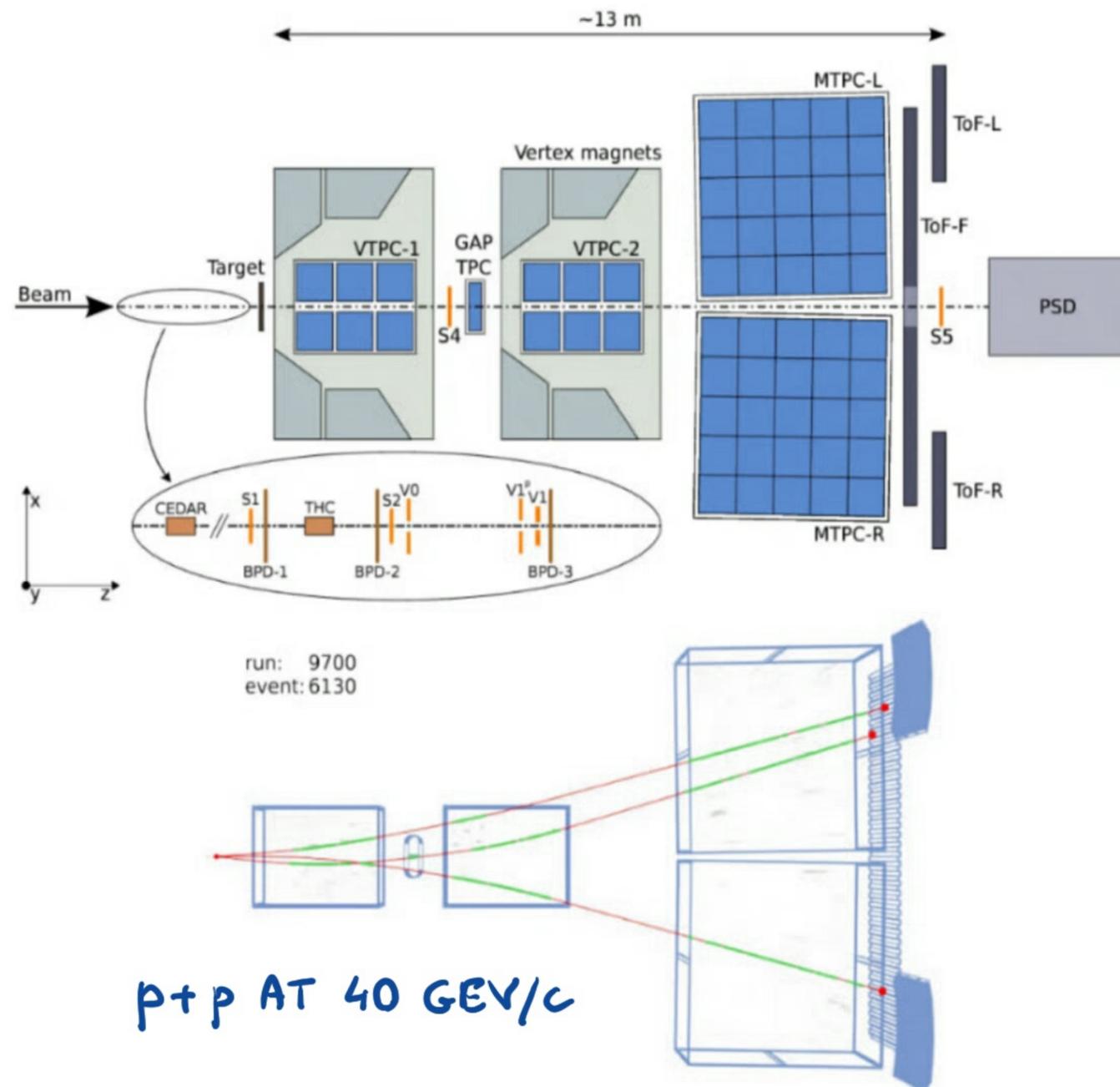
PRIMARY BEAMS:

- PROTONS AT 400 GEV/c
- IONS (Ar, Xe, Pb) AT 13A-150A GEV/c

SECONDARY BEAMS:

- HADRONS ($\pi^{+/-}$, $K^{+/-}$, p/\bar{p}) AT 13-400 GEV/c
- IONS (Be) AT 13A-150A GEV/c

S·INE FACILITY: DETECTOR



- A LARGE ACCEPTANCE ($\approx 50\%$) HADRON SPECTROMETER
- BEAM PARTICLES MEASURED BY COUNTERS AND MWPCS
- CHARGE PARTICLES MEASURED BY 5 (+2) TPCS
- PID VIA dE/dx IN TPCS AND TOF IN 3 TOF DETECTORS
- ENERGY OF PROJECTILE SPECTATORS MEASURED IN PSD
- PRECISE VERTEXING VIA SMALL ACCEPTANCE VERTEX DETECTOR



IDEAS FOR MEASUREMENTS BEYOND 2020

KEY QUESTIONS/REQUESTED MEASUREMENTS:

- STRONG INTERACTIONS:

STATISTICAL VS DYNAMICAL MODELS

(NON-LOCAL VS LOCAL PARTICLE PRODUCTION)

/ OPEN CHARM, CUMULATIVE HADRONS,
FLUCTUATIONS IN \approx FULL ACCEPTANCE

- NEUTRINOS:

INITIAL NEUTRINO FLUX FOR DUNE

/ HADRON YIELDS FROM THE SURFACE OF
THE DUNE REPLICAS TARGET

S·INE : STATISTICAL VS DYNAMICAL MODELS

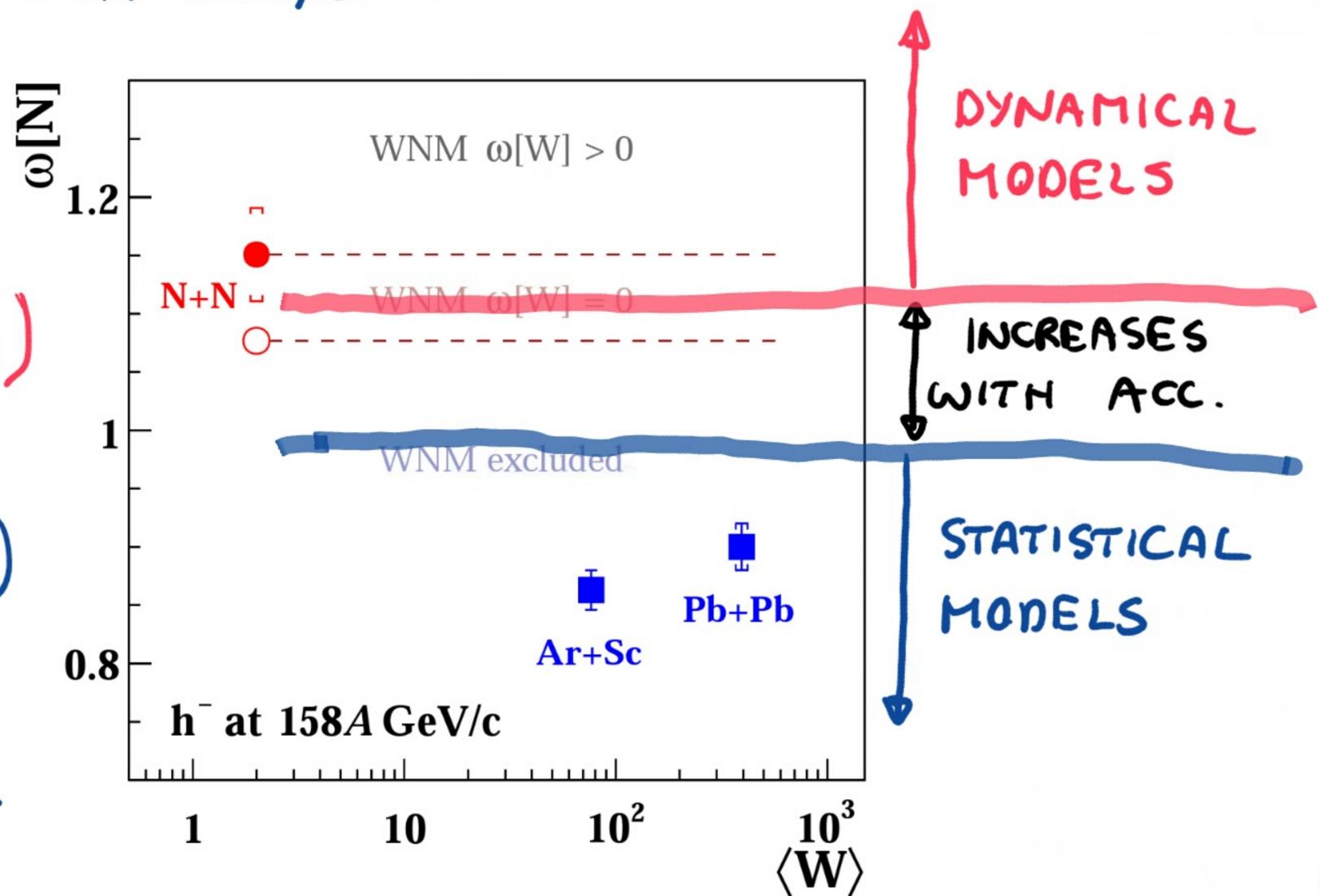
2020

NAGI/SHINE RESULTS ON MULTIPLICITY DISTRIBUTION, $P(N)$,
IN $p+p$ AND $Ar+Sc$ AT 150A GEV/C

IN $p+p$ $P(N)$ BROADER
THAN POISSON ($w[N] > 1$)

IN $Ar+Sc$ $P(N)$ NARROWER
THAN POISSON ($w[N] < 1$)

$$w[N] \equiv \frac{\text{Var}[N]}{\langle N \rangle}$$

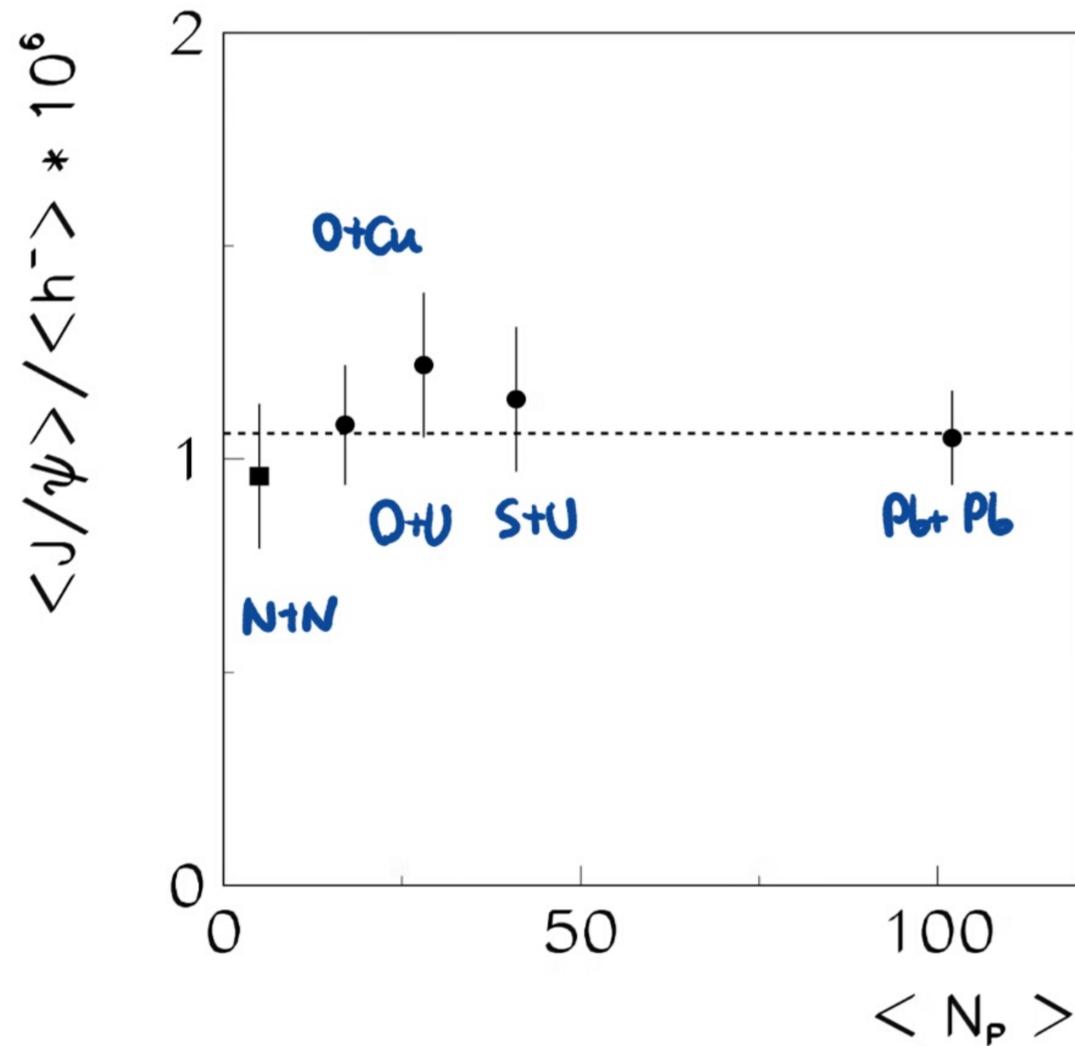


NAGI/SHINE CPQD 2016



SINE : STATISTICAL VS DYNAMICAL MODELS

NA38/NA50 RESULTS ON MEAN J/ψ MULTIPLICITY IN A+B AT 158A GEV/C



DATA AGREE WITH EXPECTATIONS FOR STATISTICAL J/ψ PRODUCTION

TO TEST PREDICTIONS OF pQCD-BASED (DYNAMICAL) MODELS MEASUREMENTS OF OPEN CHARM YIELD ARE NEEDED

PRL 83 (1999) 4009



SHINE : INITIAL NEUTRINO FLUX FOR DUNE

NAGI/SHINE MEASUREMENTS WITH THIN AND REPLICA TARGETS FOR T2K DEMONSTRATED NEED FOR PRECISE DATA ON HADRON FROM THE SURFACE OF THE REPLICA TARGET.

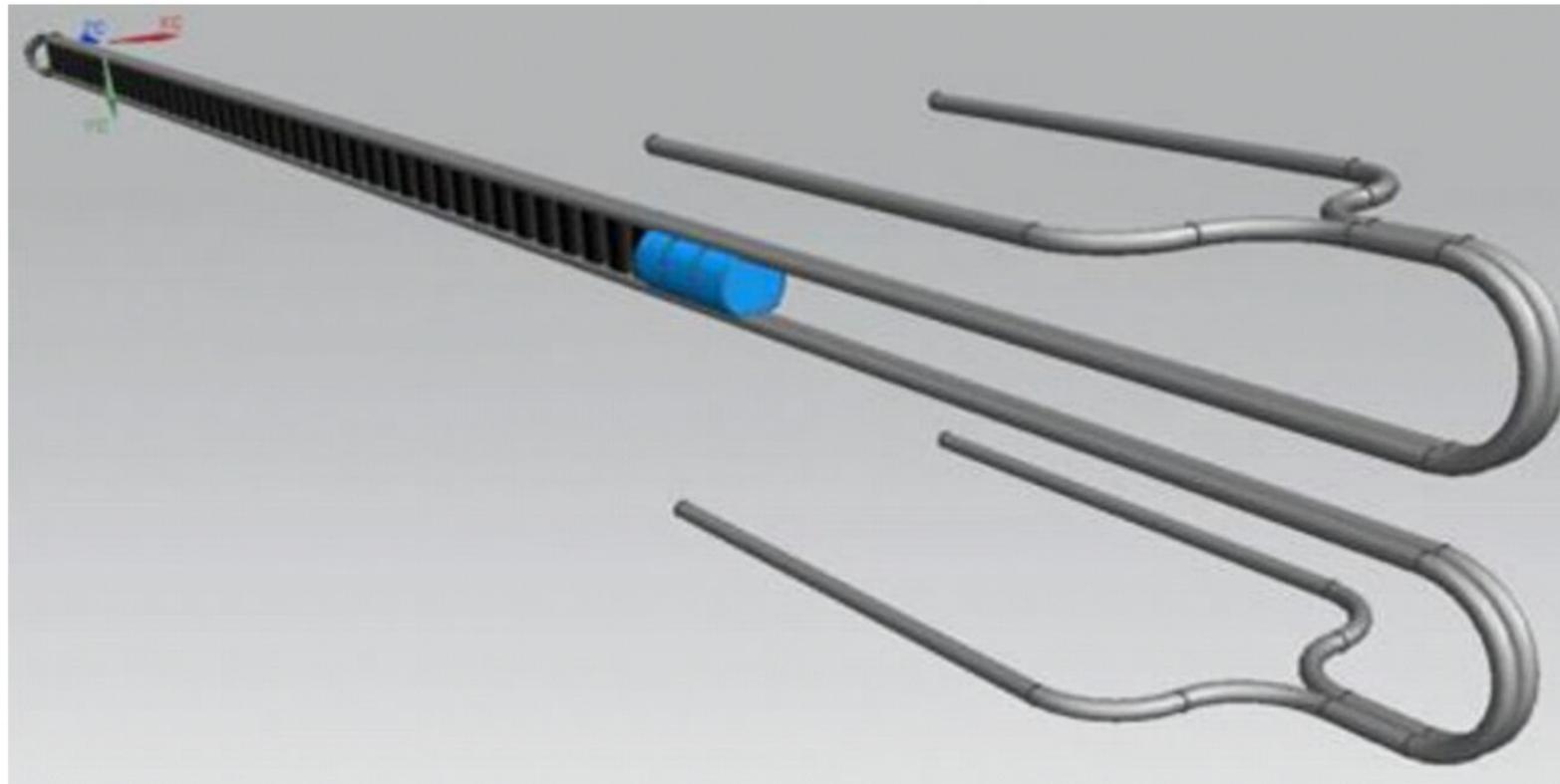
A PROTOTYPE DUNE TARGET WILL NOT BE READY BEFORE LS2

- BOTH GRAPHITE AND Be TARGETS ARE CONSIDERED
- TARGETS WILL PROBABLY CHANGE DURING THE ≈ 20 YEARS DUNE LIFE TIME
- ≈ 200 cm TARGETS ARE CONSIDERED FOR THE LOW ENERGY TUNE
- TARGETS FOR HIGH ENERGY TUNE WILL BE DIFFERENT THAN FOR LOW ENERGY



SINE : INITIAL NEUTRINO FLUX FOR DUNE

A NUPI-LIKE DUNE TARGET DESIGN



47 GRAPHITE SEGMENTS,
EACH 2 cm LONG AND
SPACED 0.2 mm APART,
TARGET CORE LENGTH
95 cm ($\approx 2 \lambda_I$)



REQUIRED FACILITY UPGRADES

IMPROVED BEAM QUALITY, BEAM INTENSITY $\approx 10^6$ IONS/SPILL

- REMOVE REDUCE 50HZ OSCILLATION OF BEAM INTENSITY:
 - ACTIVE COMPENSATION INTRODUCED IN 2016 REDUCED THE RIPPLE OF PROTON BEAMS, TEST WITH Pb BEAMS WILL BE PERFORMED IN NOVEMBER/DECEMBER 2016
 - IN 2017 THE SPS MAIN POWER SUPPLIES REGULATION WILL BE CHANGED THAT MAY REDUCE THE RIPPLE. TO BE TESTED WITH Xe BEAMS IN 2017
- REDUCE BEAM POSITION CHANGES ON NA61 TARGETS
 - THEY ARE LIKELY CAUSED BY MALFUNCTIONING POWER SUPPLIES IN THE H2 BEAMLINE. TO BE IDENTIFIED AND FIXED.
- UPGRADE OF THE H2/NA61 RADIATION PROTECTION

MANY THANKS TO BE, TE, EN !



REQUIRED FACILITY UPGRADES

DETECTOR UPGRADES:

- TARGET AND SIDE-BACKWARD TRACKING IN MAGNETIC FIELD
- HIGHER EVENT RATE
- LARGE ACCEPTANCE VERTEX DETECTOR
- NEW TIME-OF-FLIGHT DETECTORS
- PRECISE TRACKING ALONG THE DUNE TARGET(S)

THE SALEVE ARM OF
THE VERTEX DETECTOR
PROTOTYPE : JULY 2016

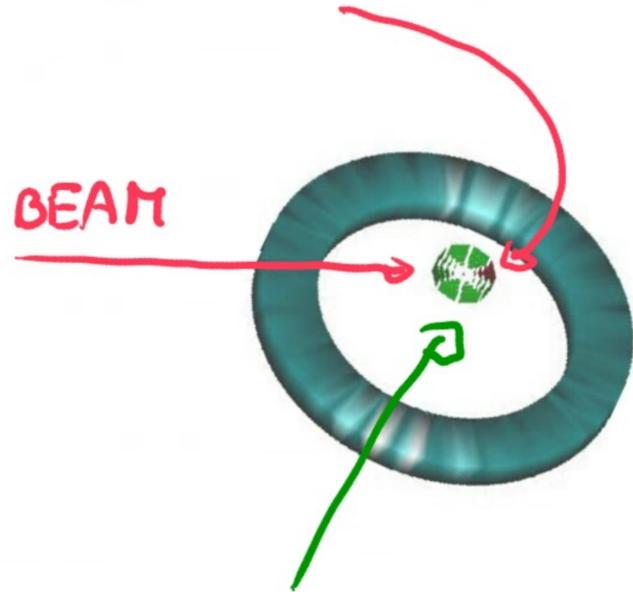


REQUIRED FACILITY UPGRADES

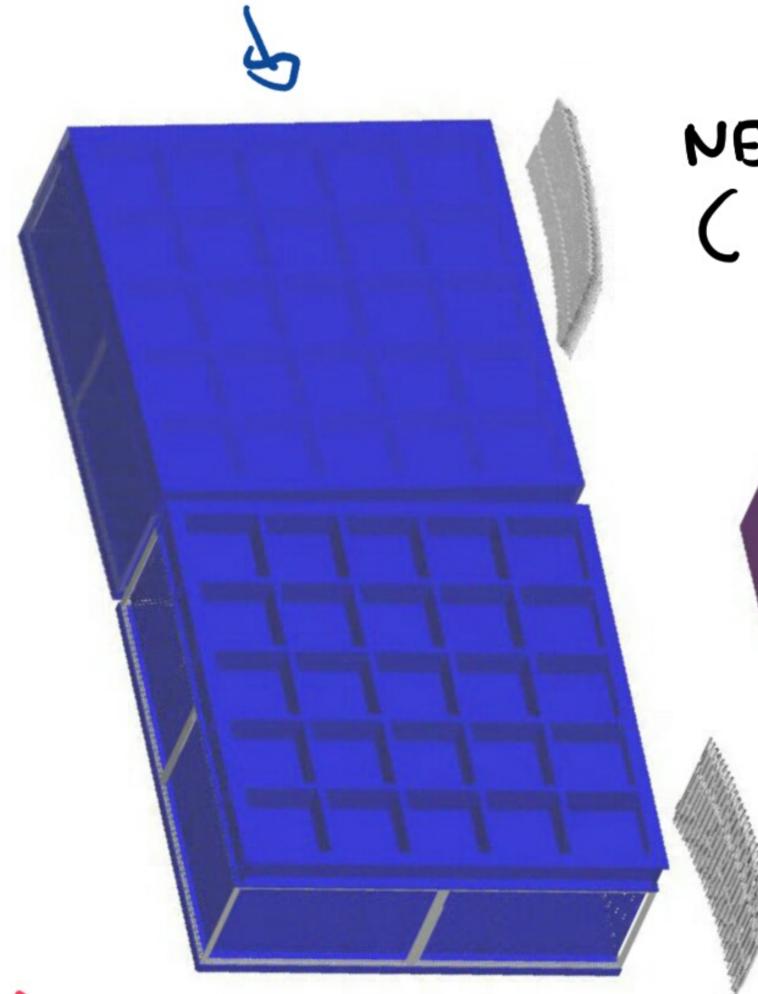
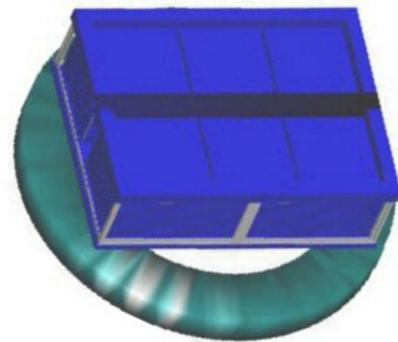
LEGACY TPCs WITH ALICE READ-OUT

VERTEX DETECTOR
(ALICE ITS ?)

BEAM



SIDE-BACKWARD DETECTOR
(ALICE ITS ?)



NEW TOP DETECTORS
(MPD MRPCs ?)

PROJECTILE
SPECTATOR
DETECTOR



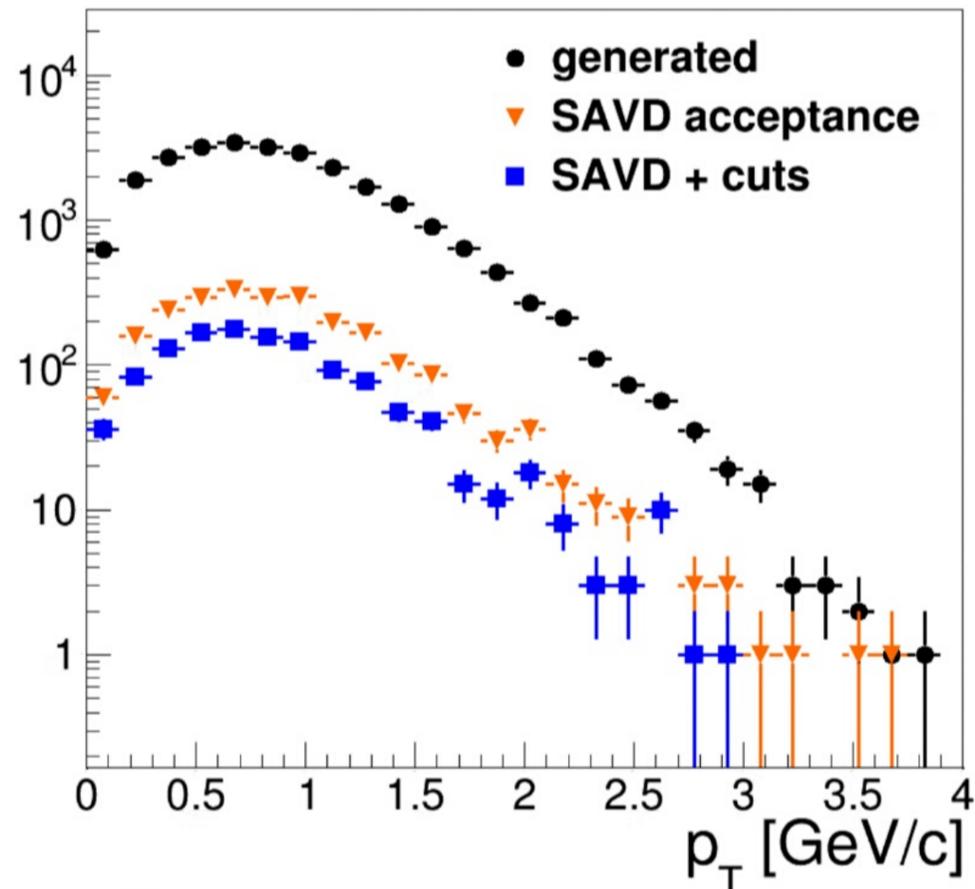
... AND MORE
DAQ (DATE?), TRIGGER, DCS
SciFi BEAM POSITION DETECTORS



DESIGN OPTIMISATION IN PROGRESS

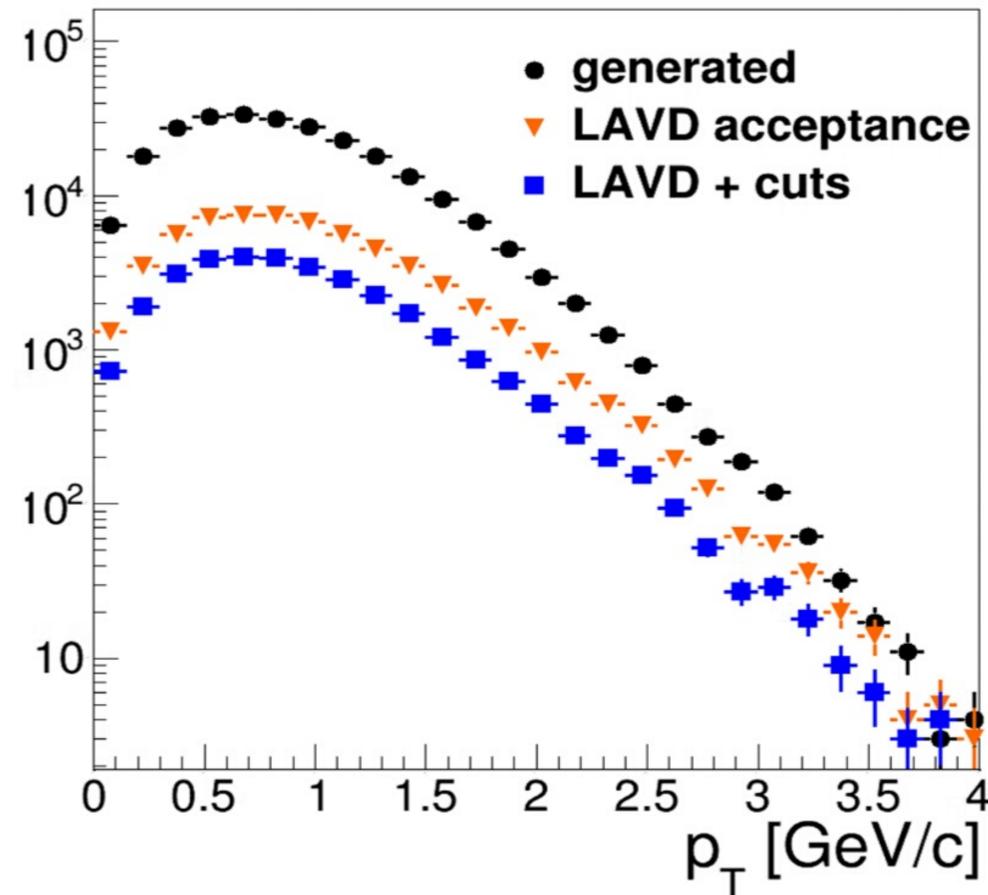
EXAMPLE: $D^0 + \bar{D}^0$ IN CENTRAL Pb+Pb AT 150A GEV/c

10 DAYS IN 2018



$\approx 4000 D^0$ IN 4M EVENTS

10 DAYS IN 2020+



$\approx 40000 D^0$ IN 40M EVENTS

... AND ABOUT
1000 $D^0 + \bar{D}^0$ IN
Pb+Pb AT 40A GEV/c

 **S·SHINE** : SUMMARY
2020

NAGI/SHINE CONSIDERS NEW MEASUREMENTS OF HADRON PRODUCTION WITH BEAMS OF HADRONS AND NUCLEI IN THE SPS/H2 BEAM MOMENTUM RANGE (13A - 150A (400) GEV/C)

THE MEASUREMENTS REQUIRE MAJOR FACILITY UPGRADES (BEAMS AND DETECTOR). WE HOPE TO PROFIT FROM DEVELOPMENTS FOR OTHER EXPERIMENTS (ALICE, MPD, CBM, ...) AND SUPPORT FROM CERN

MANY THANKS TO NAGI/SHINE 2020 TEAM FROM BERGEN, FRANKFURT, KATOWICE, KRAKOW, MOSCOW ST. PETERSBURG, WARSAW ET AL.