IS2021

Prospects for the NA60+ experiment at the CERN SPS

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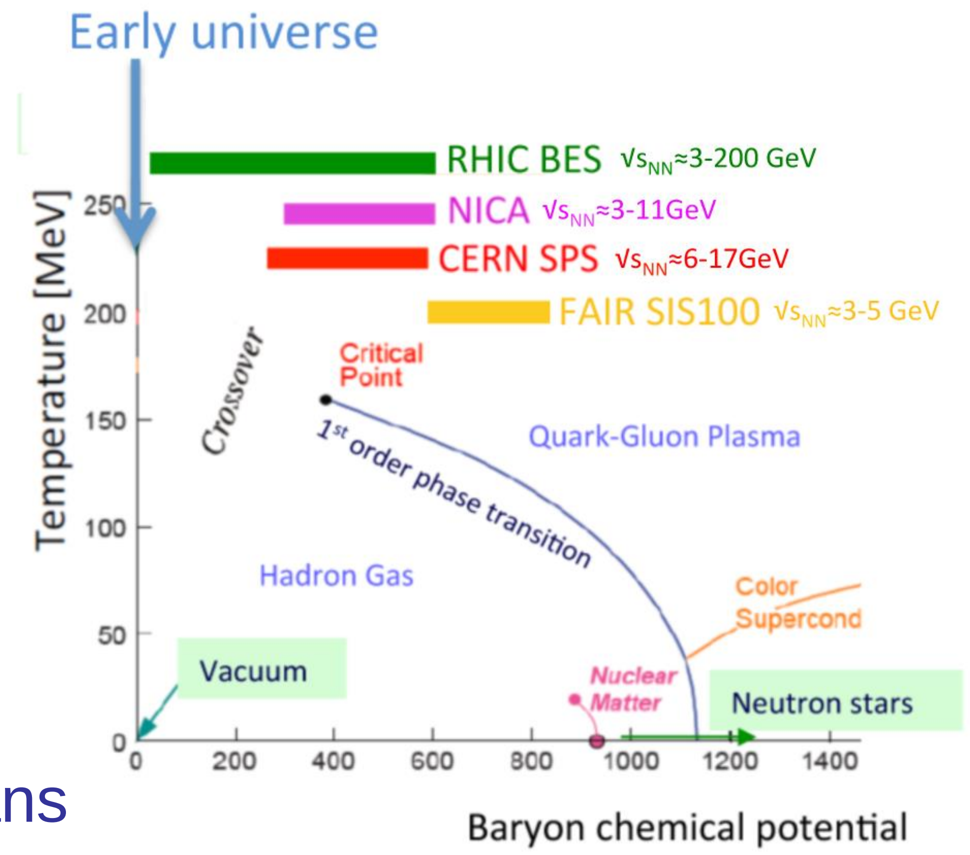
Heavy-ions: the low √s frontier

- **Goal**: explore the QCD phase diagram at large μ_B

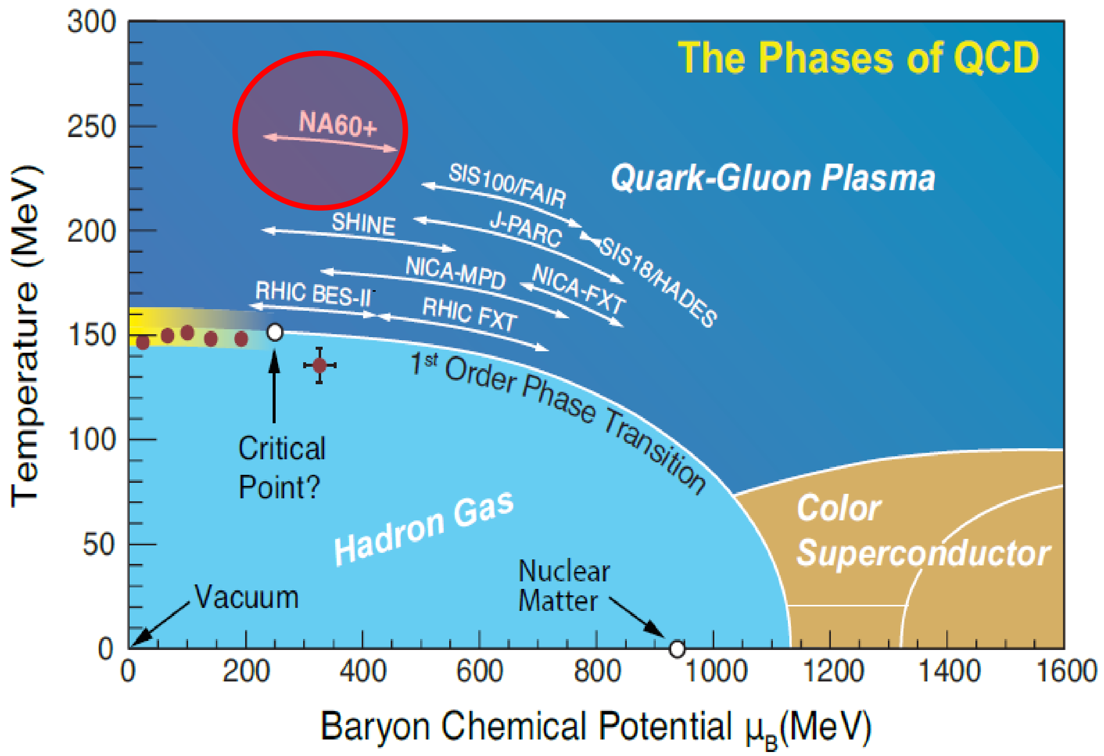
- Main questions:
  - ⇨ Presence of a **critical point**?
  - ⇨ First **order phase transition** at large μ_B?
  - ⇨ **Chiral symmetry** restoration?
  - ⇨ Onset of **deconfinement**
  - ⇨ Properties of the **QGP at large μ_B**



- Being studied at RHIC with Beam Energy Scans and at the SPS by NA61/SHINE experiment
  - ⇨ Up to now results mostly on soft hadronic processes

NA60+ at the low $\sqrt{s}$ frontier

- NA60+ proposed experiment at CERN SPS
- **Goal**: study of hard and electromagnetic processes at CERN-SPS energies and investigation of the high-μ_B region of the QCD phase diagram



- **Hard** processes:
  - ⇨ Probe the Quark-Gluon Plasma and study its transport properties
- **Electromagnetic** processes
  - ⇨ Information on the temperature of the system (QGP and/or hadronic)
  - ⇨ Information on the nature of the phase transition
  - ⇨ Insight into the approach to chiral symmetry restoration

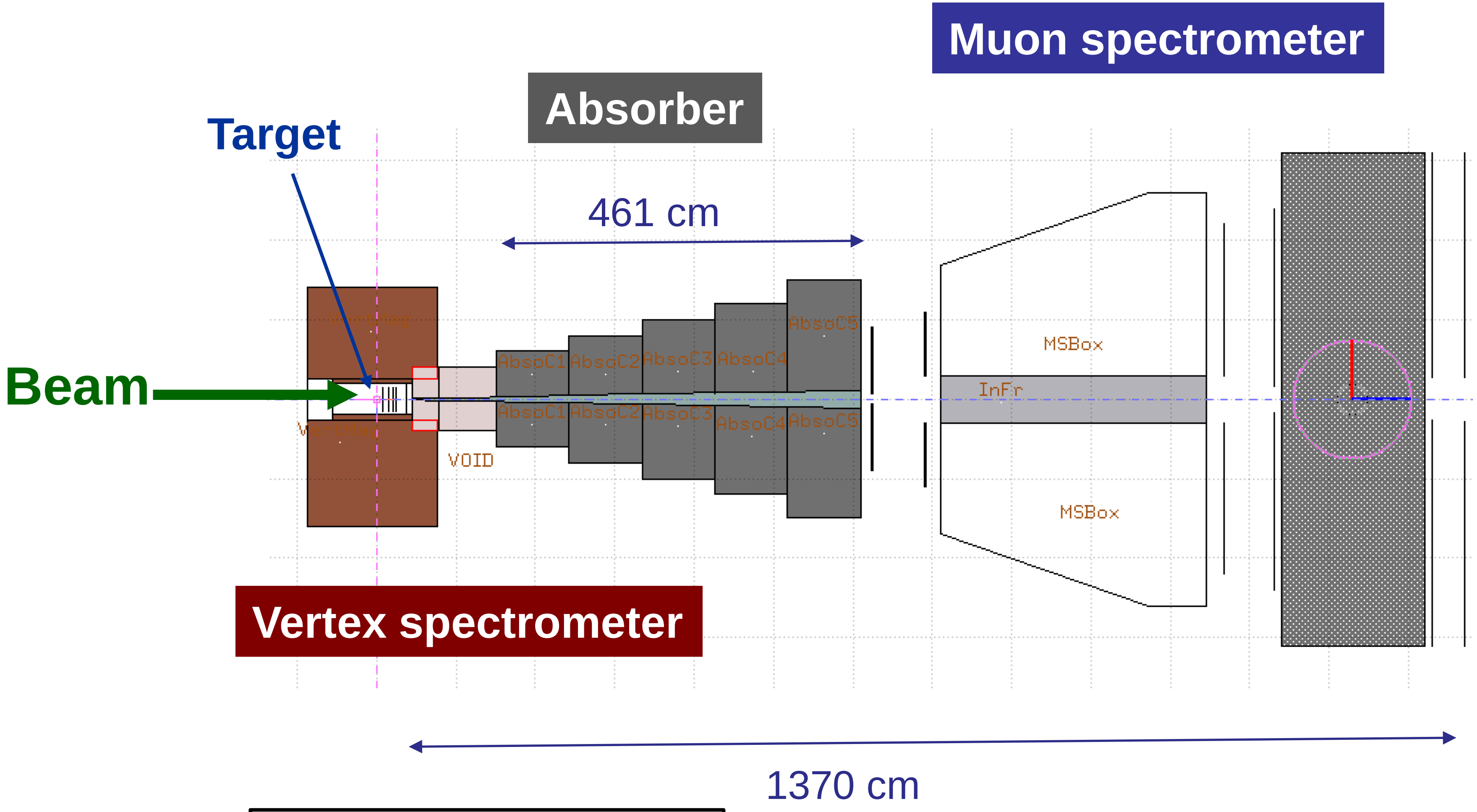
NA60+ at the CERN SPS

- Focus on particles from hard and electromagnetic processes, which are rare processes
  - ⇨ High precision measurements of these observables require **large interaction rates**
  - ⇨ Operation in **fixed target** mode
- The μ_B interval accessible with the beam energy scan should be as wide as possible
  - ⇨ **CERN SPS** allows to cover the range $6<\sqrt{s_{NN}}<17$ GeV corresponding to $200<\mu_B<450$ MeV
- Notes:
  - ⇨ RHIC BES covers the same μ_B range, but with much lower interaction rates
  - ⇨ Complementary to future experiments at FAIR (SIS100) at lower collision energies

Facility/ Experiment	$\sqrt{s_{NN}}$ (GeV)	μ_B (MeV)	Interaction rate	Dileptons	Charm
SPS NA60+	∼6–17.3	440–220	>MHz	yes	yes
SPS NA61/SHINE	∼5–17.3	540–220	5 kHz	no	yes
SIS100 CBM, HADES	2.7–5.5	740–510	>MHz	yes	yes
RHIC STAR	3–19.6	710–200	∼1 kHz	yes	yes
NICA MPD	4–11	620–320	∼7 kHz	yes	yes
Nuclotron BM@N	2.3–3.5	800–660	20–50 kHz	(yes)	no
J-PARC-HI DHS, D2S	2–6.2	840–480	>MHz	yes	(yes)

Experimental setup

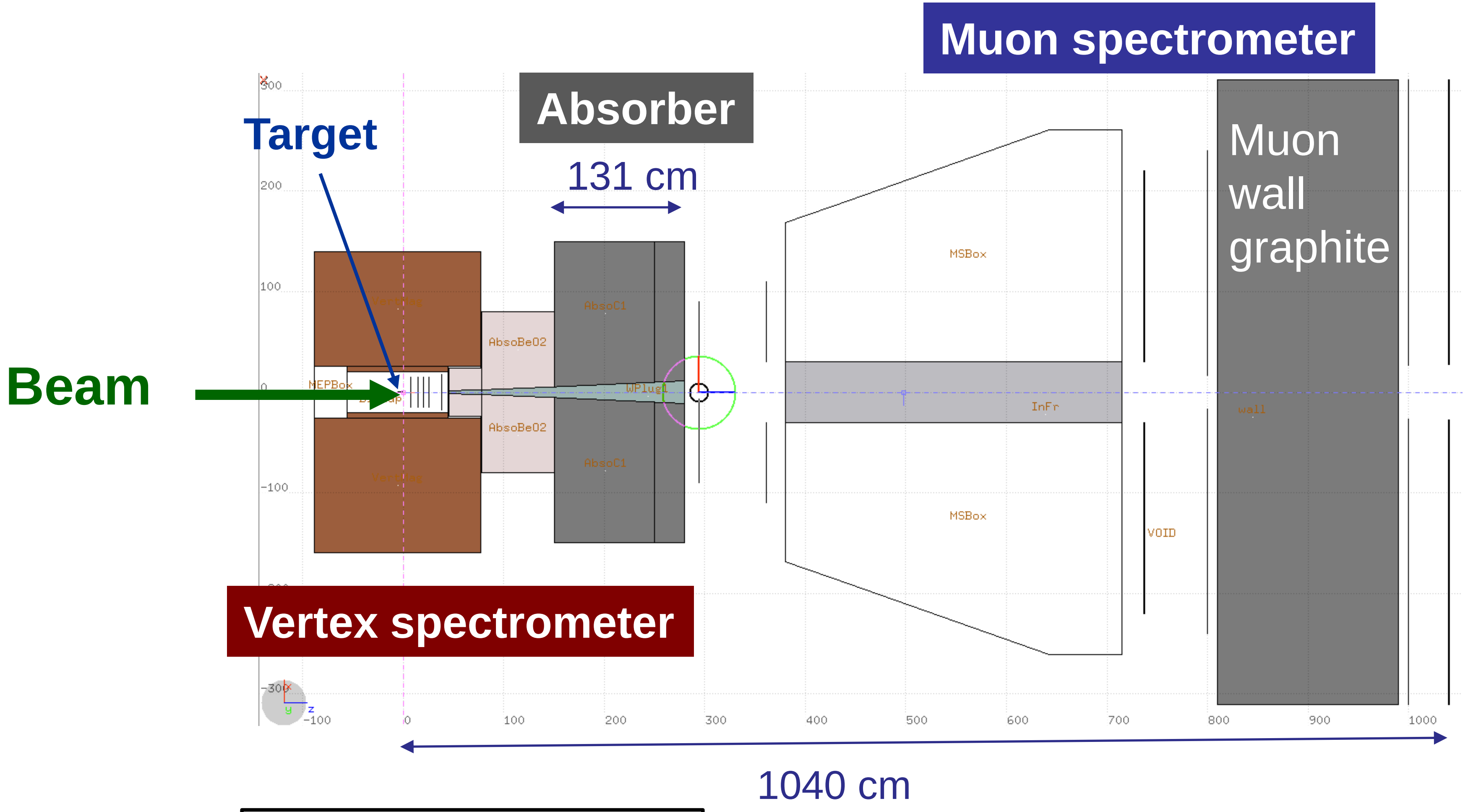
NA60+ detector concept



High energy setup

- **Muon spectrometer** to measure dimuons downstream of absorber
  - ⇨ Muon spectrometer length needs to be varied, to cover mid-rapidity at different $\sqrt{s}$
- **Vertex spectrometer** for precise tracking close to the interaction point

NA60+ detector concept



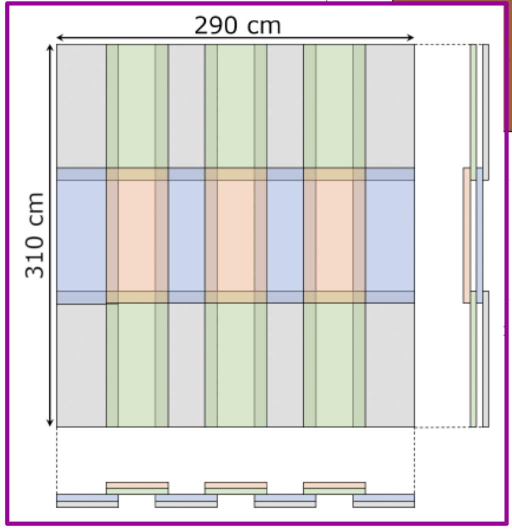
Low energy setup

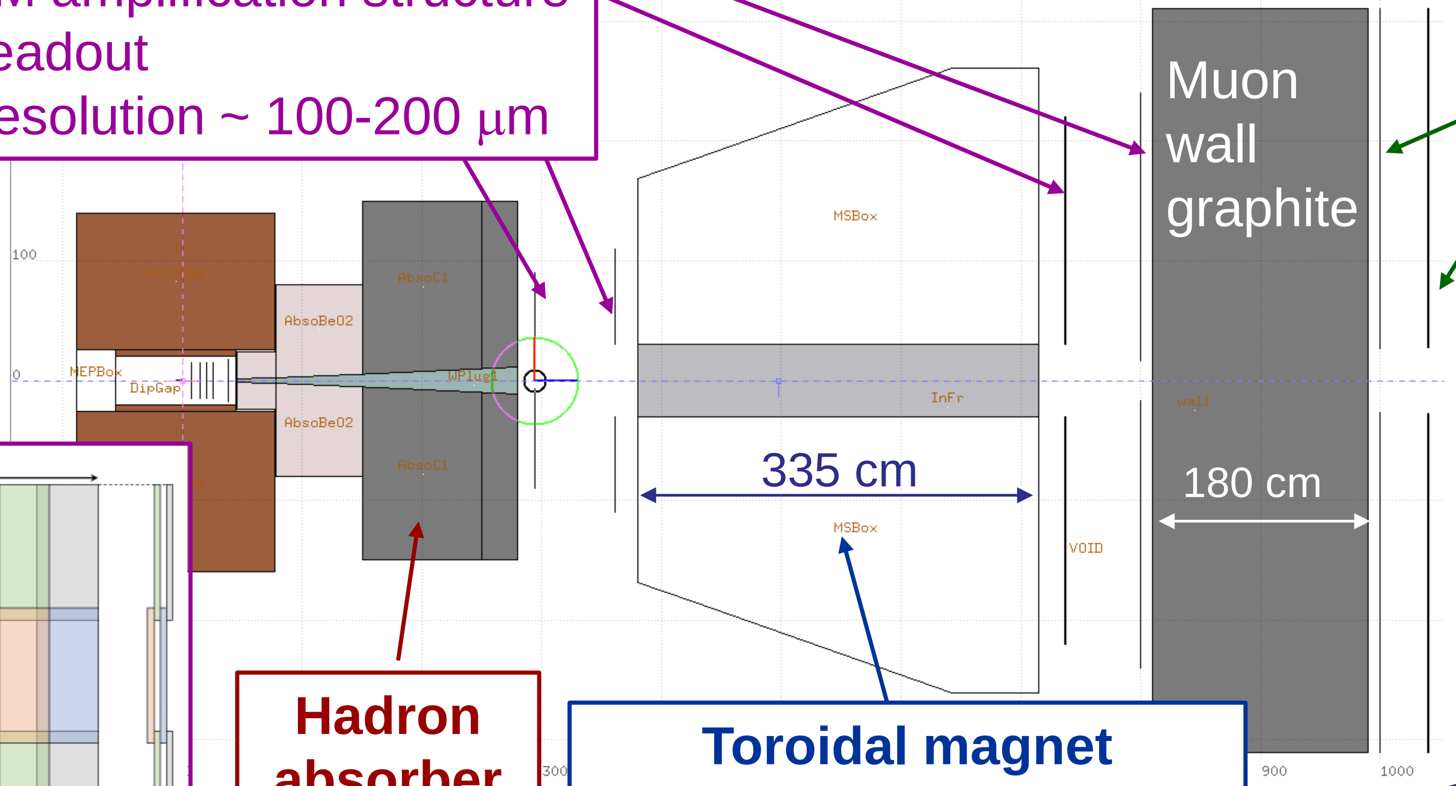
- **Muon spectrometer** to measure dimuons downstream of absorber
  - ⇨ Muon spectrometer length needs to be varied, to cover mid-rapidity at different √s
- **Vertex spectrometer** for precise tracking close to the interaction point

NA60+ muon spectrometer

Tracking stations
- Triple GEM amplification structure
- 2D strip readout
- Position resolution ~ 100-200 μm

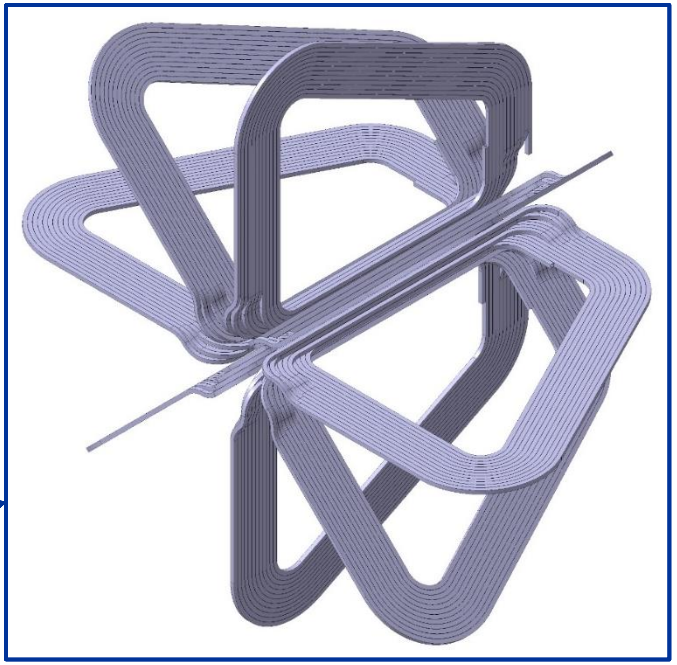
Trigger stations
- GEM or RPC





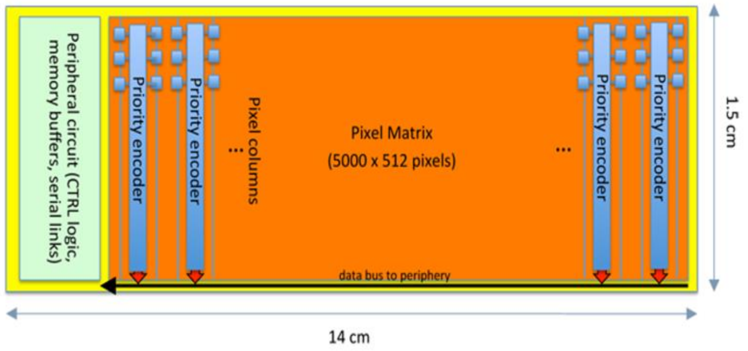
Hadron absorber

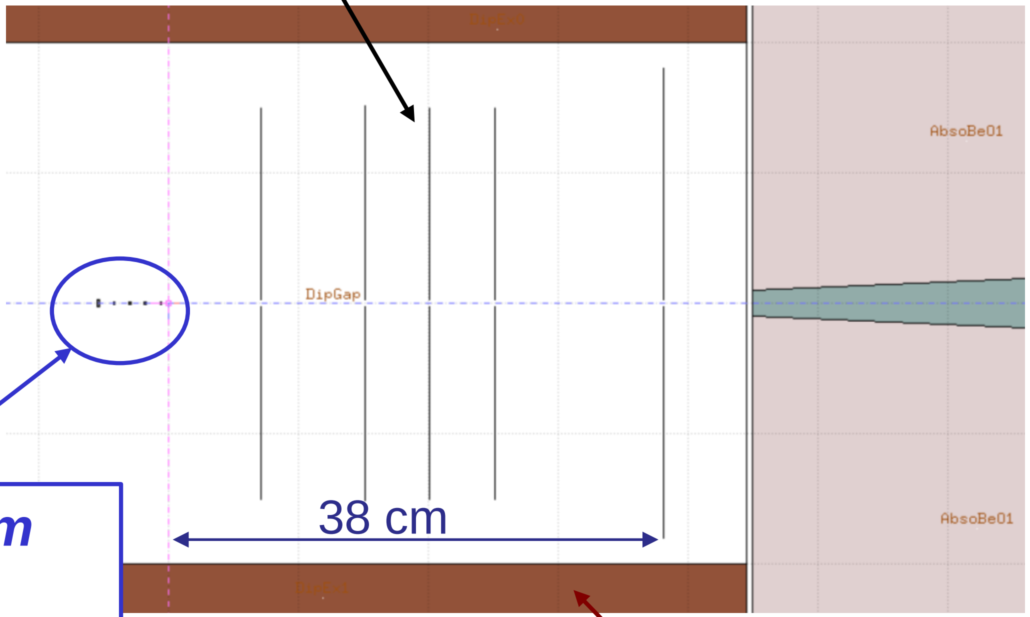
Toroidal magnet
- Al conductors
- 12 windings per octant
- B·R ~ 0.2-0.25 Tm

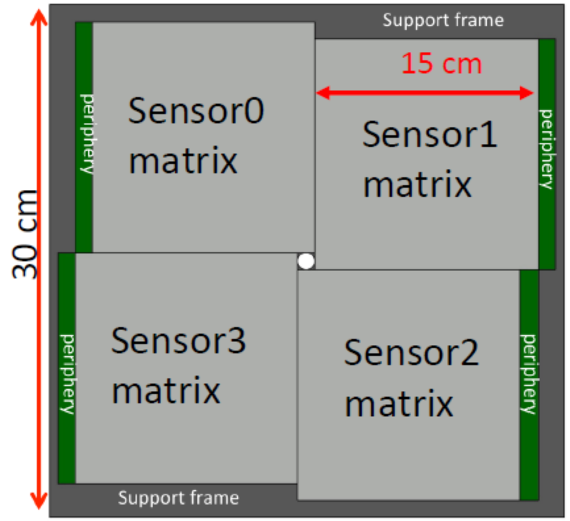


NA60+ vertex spectrometer

Vertex telescope
- Large area MAPS with stitching technology
- Si thickness 20 μm
- Pixel size O(15x15 μm²)
- Mechanical support and cooling on the borders





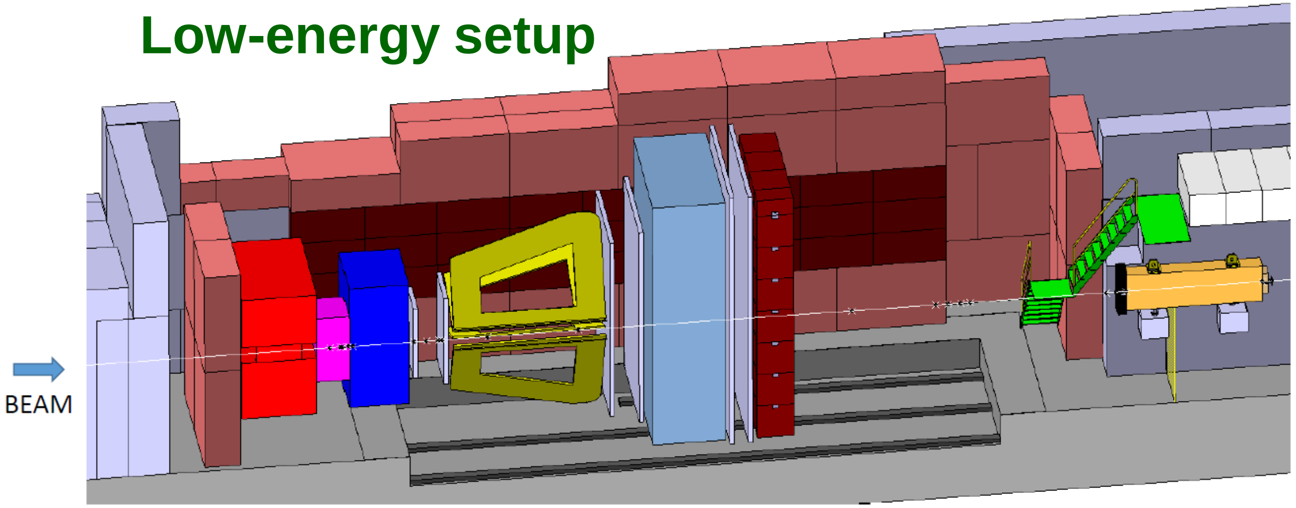


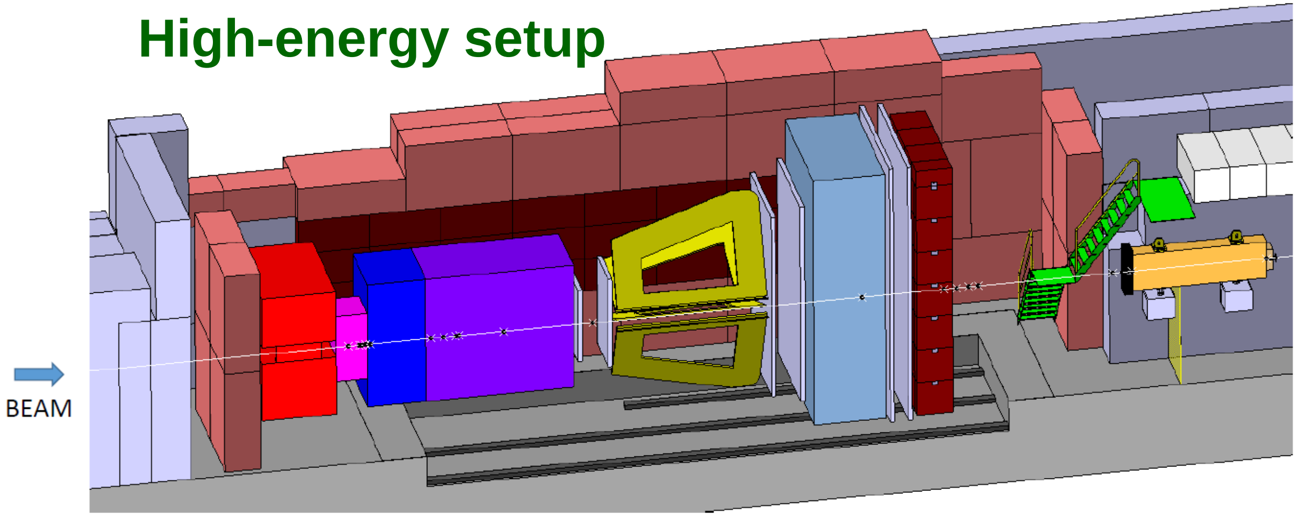
Target system
- 5 Pb disks
- 1.5 mm thick
- ≈15% inter. prob.

Dipole magnet
Wide gap dipole (MEP48)

Integration @ CERN North Area

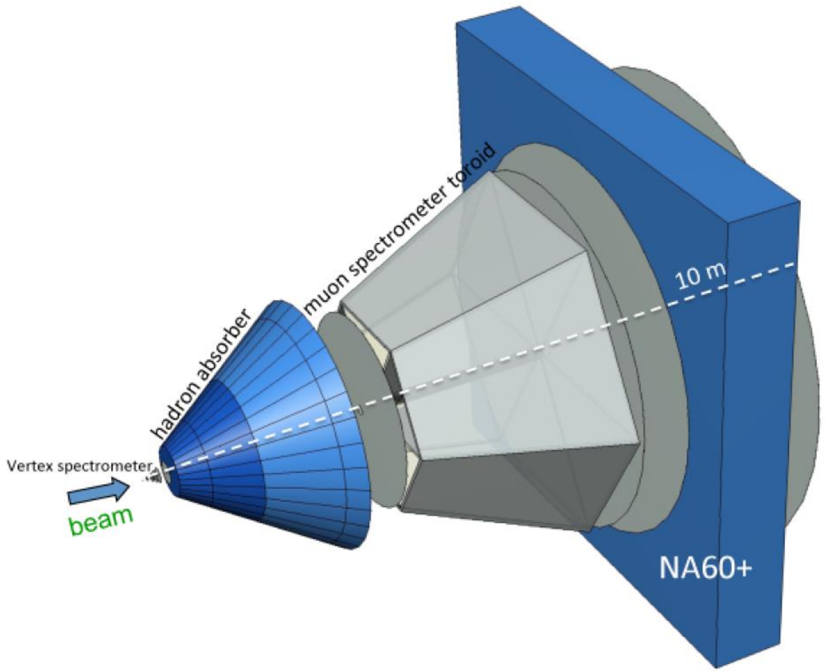
- Installation foreseen in CERN-SPS EHN1 hall / H8 line
  - ⇨ Pb beam intensity = 10^7 ions/(20 s spill)
  - ⇨ Detailed integration studies in progress
- Low-energy set-up
  - ⇨ Optimized for E_{lab}/A = 40 GeV
- High-energy set-up
  - ⇨ Optimized for E_{lab}/A = 160 GeV
    - ✓ Thicker hadron absorber
    - ✓ Muon spectrometer shifted by 3.3 m
- Goal: start of data taking with LHC run-4 in 2027





NA60+ data taking strategy

- Beam energy scan (BES) at the CERN SPS in the interval $\sqrt{s_{NN}}\approx$6-17 GeV
  - ⇨ ~4 week periods/year with Pb beams → **Pb-Pb collisions**
  - ⇨ Corresponding periods with proton beams: **p-A reference**, with different nuclear targets
  - ⇨ BES example: E_{beam} = 20, 30, 40, 80, 120, 160 GeV/nucleon
- High precision measurements:
  - ⇨ Comprehensive measurement of full **dilepton** spectrum
    - ✓ **Thermal dimuons** from threshold up to 3 GeV
    - ✓ **Charmonium**: J/ψ, $\psi(2S)$, χ_c
  - ⇨ **Hadronic** measurements:
    - ✓ Charmed mesons and baryons (D^0, $D^\pm$, D_s, Λ_c)
- Statistics goal at each energy of BES:
  - ⇨ ~$4\cdot10^6$ reconstructed $\mu^+\mu^-$ pairs from thermal dimuons
    - ✓ Factor ≈20 over NA60, >10^4 over RHIC/LHC experiments
  - ⇨ >~ $1.5\cdot10^4$ reconstructed $J/\psi \rightarrow \mu^+\mu^-$
  - ⇨ ~10^7 reconstructed D^0 mesons

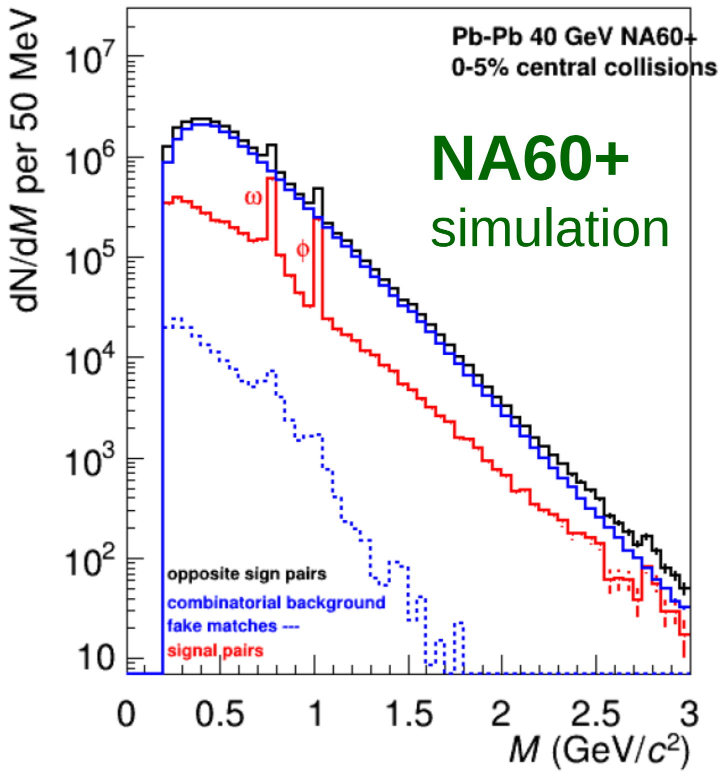


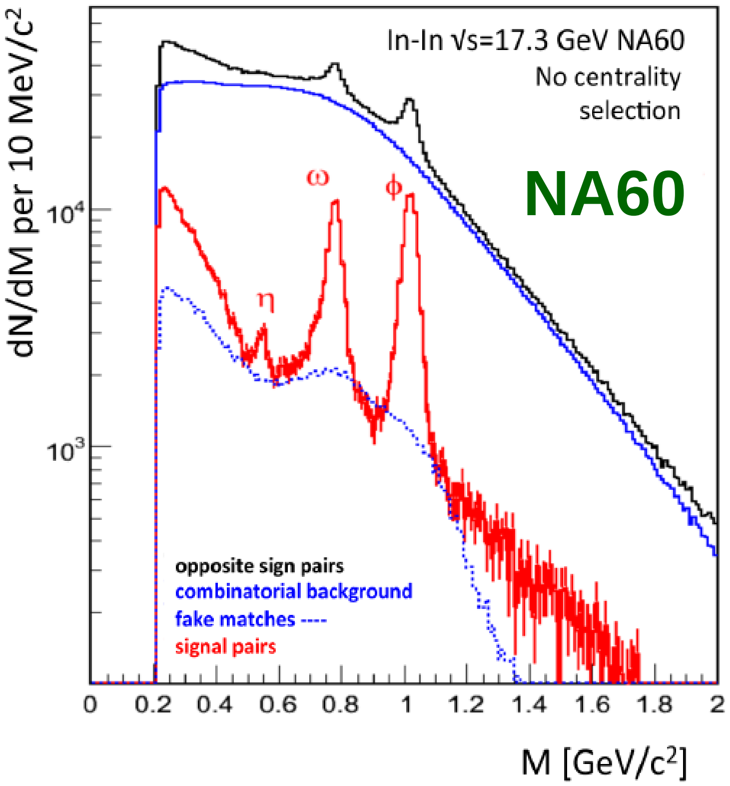
Dimuon measurements

Dimuon simulation

- Detector performance studies:
  - ⇨ Based on a simulation framework with semi-analytical tracking algorithm (Kalman filter) + FLUKA for hadronic background studies

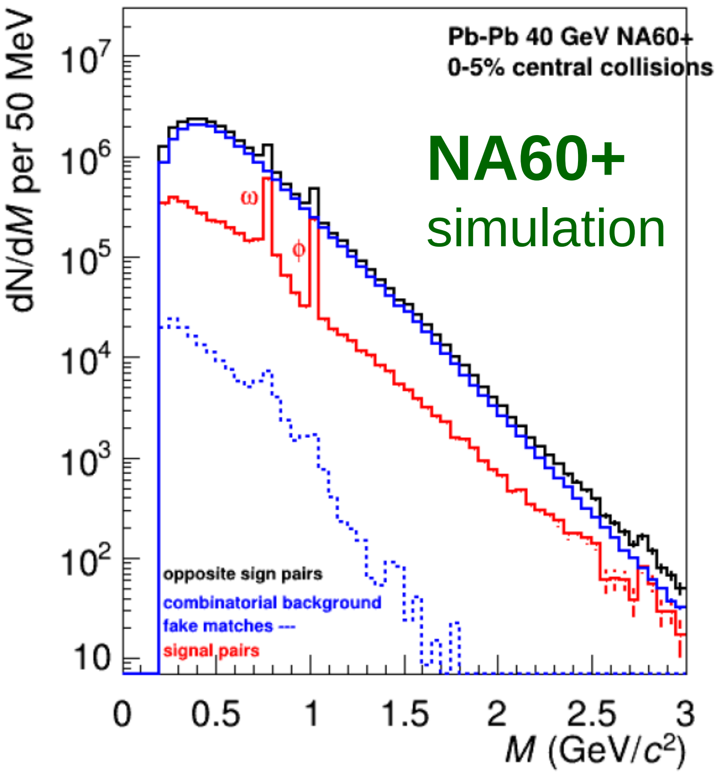
- Simulated $\mu^+\mu^-$ mass spectra:
  - ⇨ Thermal dimuon distributions
    - 🕮 **Rapp, van Hees, PLB 753 (2016) 586**
  - ⇨ Hadron cocktail from NA60 and statistical model
    - 🕮 **Becattini et al., PRC73 (2006) 044905**
  - ⇨ Drell-Yan and open charm from PYTHIA
  - ⇨ Combinatorial background: input spectra from NA49 measurements

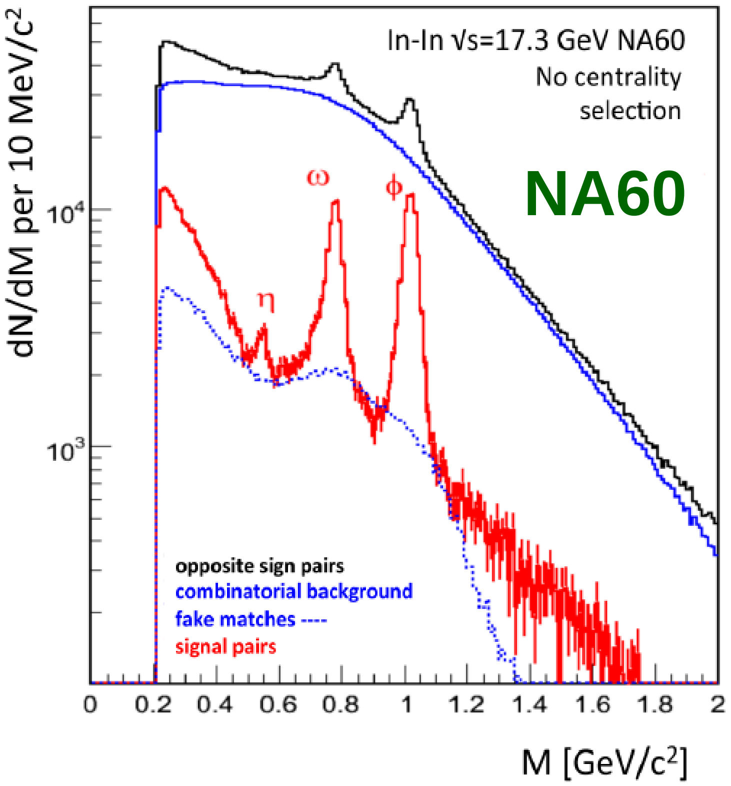




Dimuon reconstruction

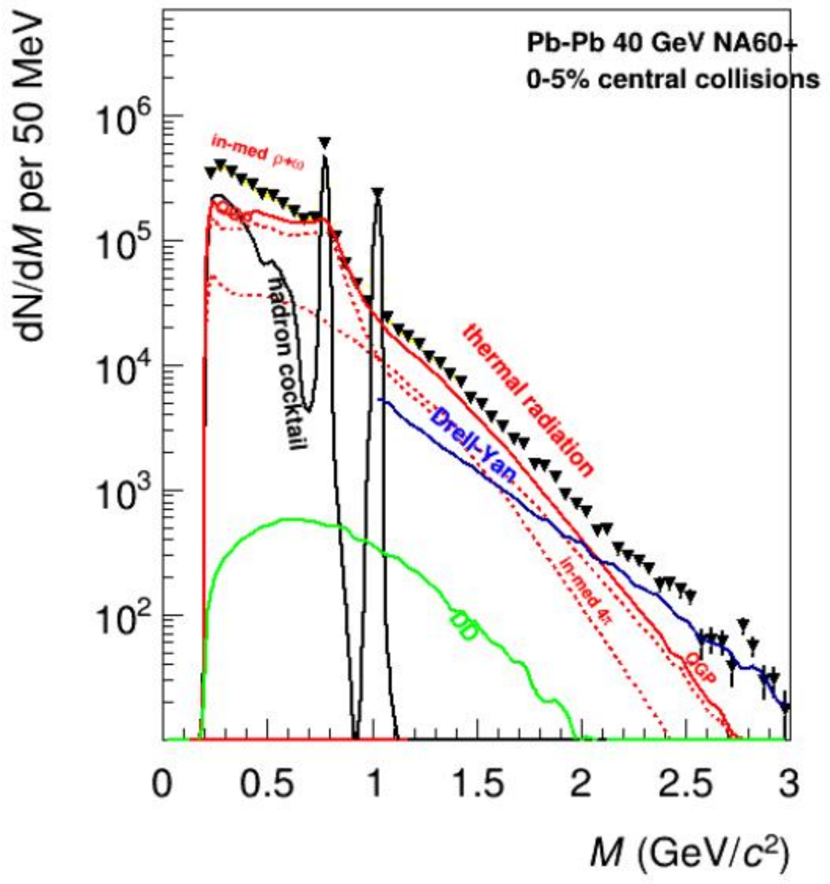
- Detector performance studies:
  - ⇨ Based on a simulation framework with semi-analytical tracking algorithm (Kalman filter) + FLUKA for hadronic background studies
- Muon reconstruction:
  - ⇨ **Muon tracks** reconstructed in **muon spectrometer**
  - ⇨ **Matched** to tracks reconstructed in the **vertex spectrometer** upstream of the hadron absorber
    - ✓ Overcome degradation of resolution on muon kinematics due to multiple scattering and energy loss fluctuations in the absorber
  - ⇨ Mass resolution for resonances varies from <10 MeV (ω) to ~30 MeV (J/ψ)





Low and intermediate mass dileptons

- Dimuon invariant mass spectrum: net signal
  - ⇨ After subtraction of the combinatorial background from π and K decays and fake matches

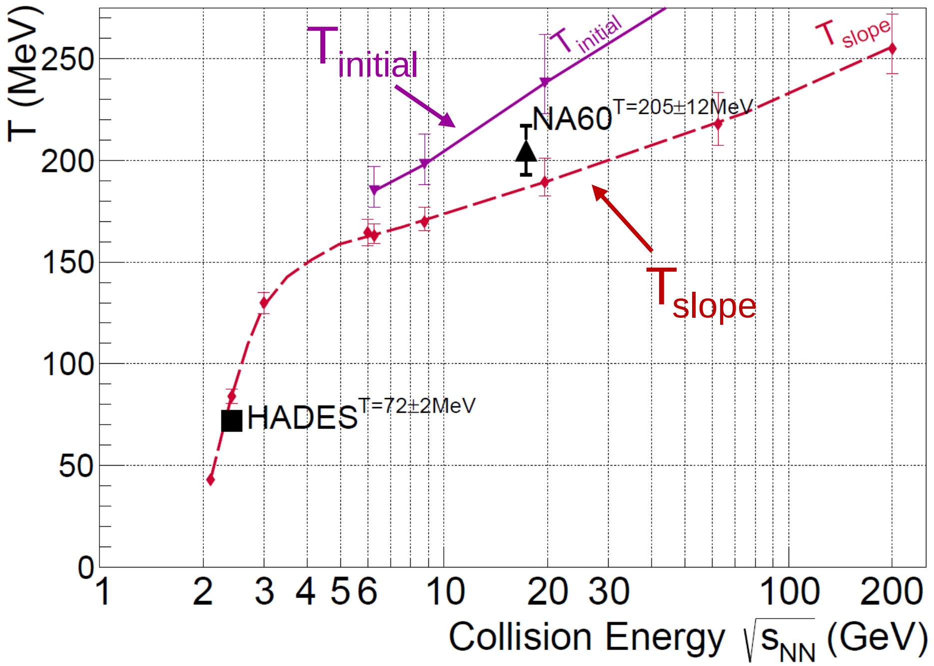


- $M<1.5\ \mathrm{GeV}/c^2$
  - ⇨ Dimuon yield dominated by ρ, ω and ϕ meson peaks
  - ⇨ Precision measurement of ρ **spectral properties**
  - ⇨ Sensitivity to yield enhancement expected in $1<M<1.5\ \mathrm{GeV}/c^2$ due to **chiral mixing** ρ-a_1 via 4π states
- $1.5<M<2\ \mathrm{GeV}/c^2$
  - ⇨ **Thermal radiation** can be extracted after subtraction of open charm and Drell-Yan pairs
  - ⇨ Temperature can be determined with few MeV precision via a fit to the spectrum → insight into **order of phase transition**

Caloric curve

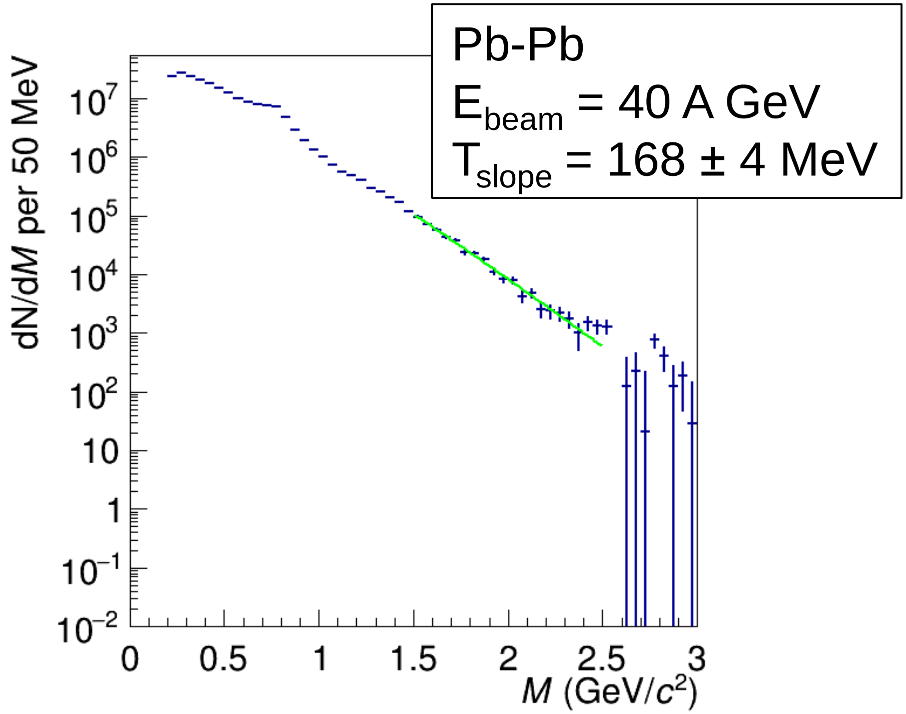
- Temperature via thermal dimuons:
  - ⇨ Measurements from HADES and NA60
  - ⇨ Fit dimuon mass spectra with: $dN/dM \propto M^{3/2} e^{-M/T_{\text{slope}}}$
  - ⇨ T_{slope} = space-time average of the thermal temperature over the fireball evolution
  - ⇨ T_{slope} of thermal dileptons close to initial temperature
- Goal of measurements at low SPS energies:
  - ⇨ Map the evolution of T_{slope} as a function of collision energy, with a resolution of few MeV
  - ⇨ Insight into the **order of the phase transition**
    - ✓ Flattening of the caloric curve expected for first order transition in the region where the pseudocritical temperature is reached
  - ⇨ Complementary to future measurements at FAIR energies

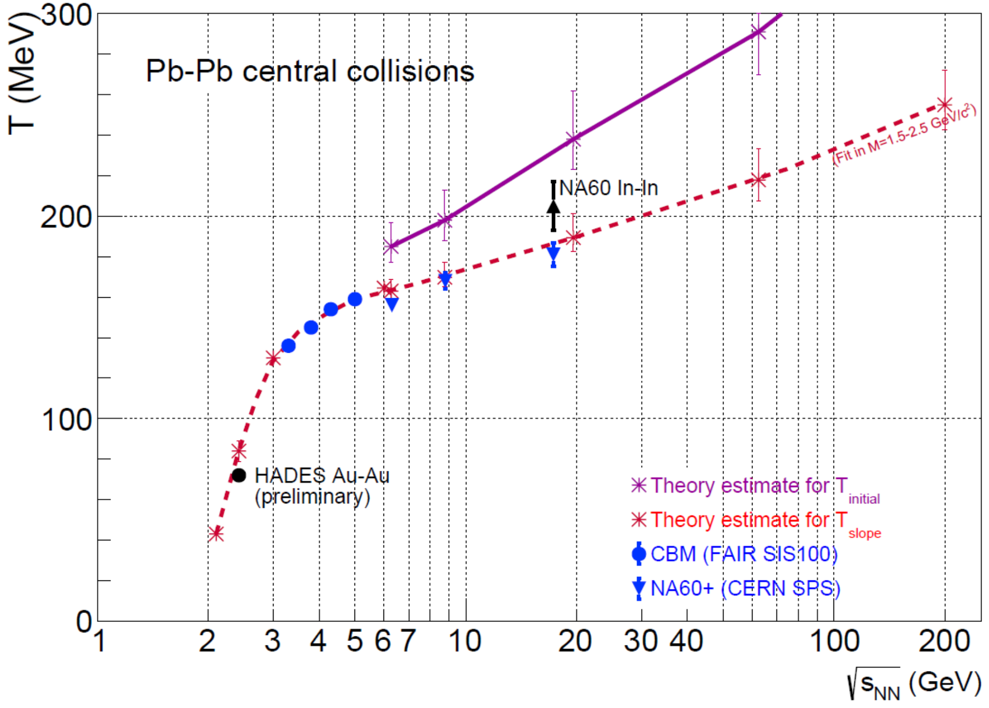
📖 **HADES, Nature Phys. 15 (2019) 1040**
📖 **NA60, EPJC61 (2009) 711**
📖 **Rapp, van Hees, PLB 753 (2016) 586**
📖 **T. Galatyuk, EPJA 52 (2016) 131**



NA60+ physics performance: T_{slope}

- Thermal dimuon mass spectra
  - ⇨ After subtraction of open charm and Drell-Yan pairs
- Fit for M>1.5 GeV with $dN/dM \propto M^{3/2}e^{-M/T_{\mathrm{slope}}}$
  - ⇨ T_{slope} = space-time average of the thermal temperature T over the fireball evolution





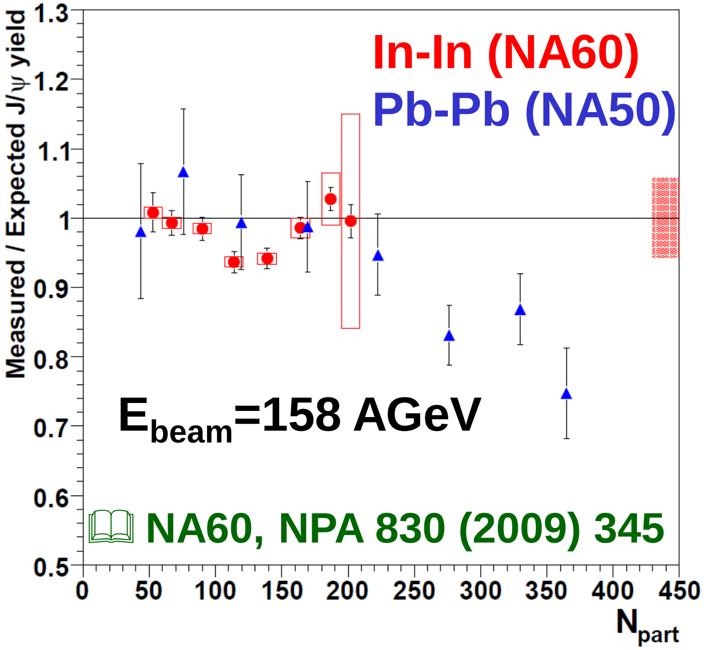
- T_{slope} values determined with few MeV accuracy
  - ⇨ Accurate mapping of the region where the pseudocritical temperature is reached
  - ⇨ Strong sensitivity to a possible flattening expected in case of first order phase transition

High mass dimuons: charmonium

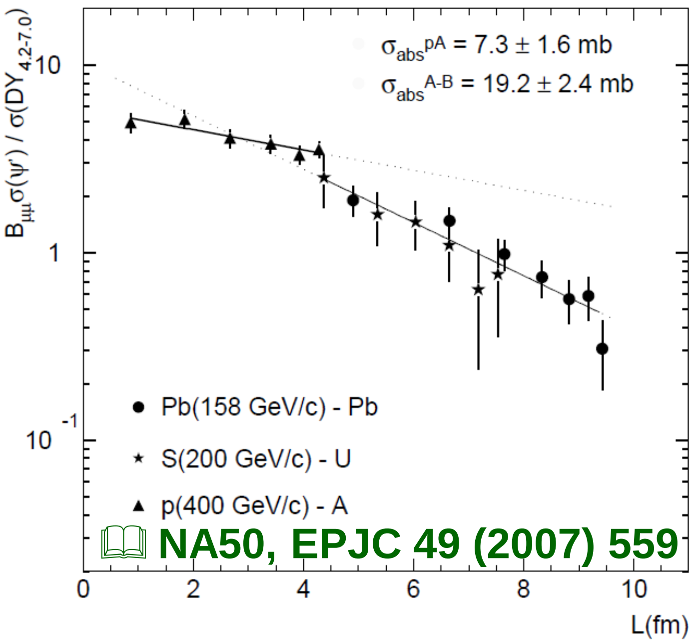
- **J/ψ**: ~30% suppression in central Pb-Pb collisions at top SPS energy relative to expectation from cold nuclear matter effects
  - ⇨ Qualitatively consistent with melting of ψ(2S) and χ_c in the QGP
  - ⇨ Quarkonium dissociation in the QGP due to colour screening of the $c\bar{c}$ potential

📖 **Matsui, Satz, PLB178 (1986) 416**

- **ψ(2S)**: strong suppression also in peripheral Pb-Pb
  - ⇨ Sensitivity to dissociation in the hadronic phase?



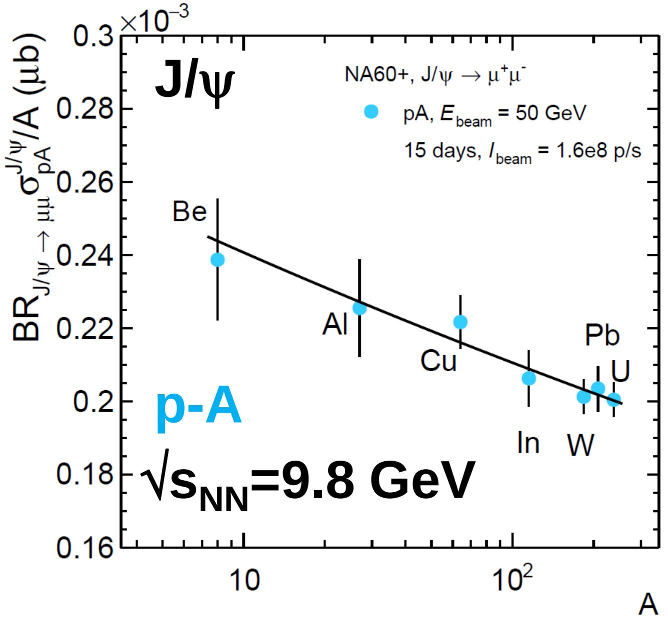
📖 **NA60, NPA 830 (2009) 345**

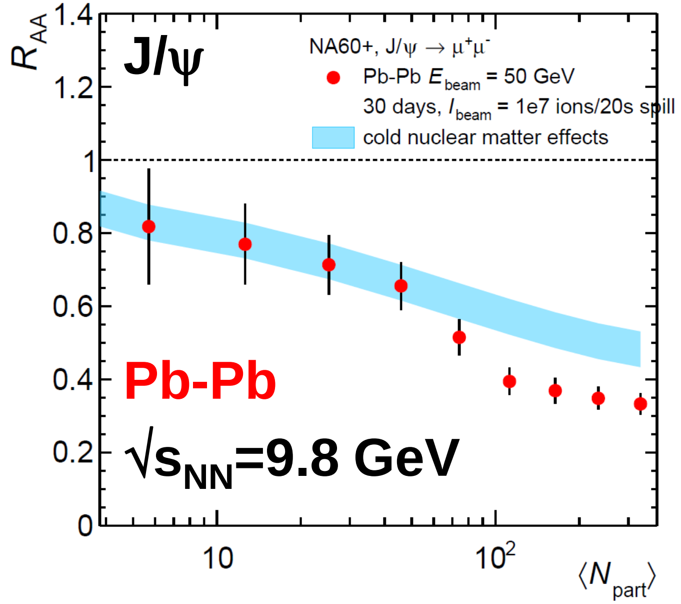


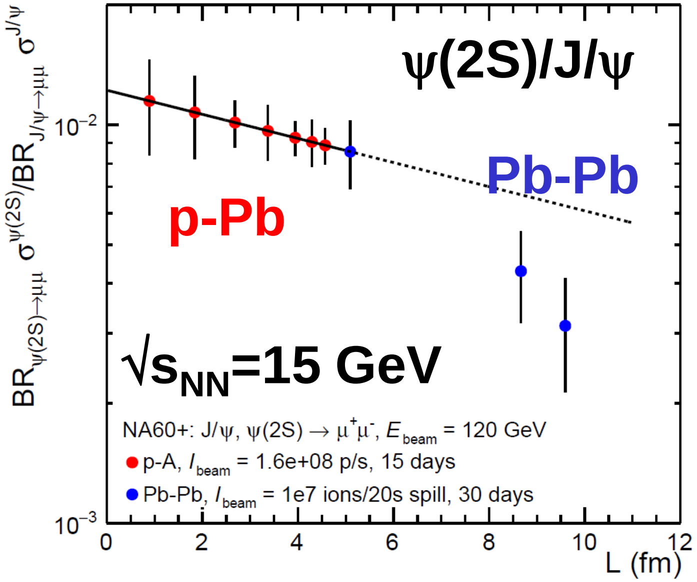
📖 **NA50, EPJC 49 (2007) 559**

- NA60+ goals:
  - ⇨ Extend the measurements to lower SPS energies and look for the **onset of the suppression**
  - ⇨ Correlate J/ψ suppression pattern with temperature from thermal dimuons
  - ⇨ Extend measurements to **other quarkonium states**: ψ(2S), χ_c

NA60+ physics performance : J/ψ and ψ’





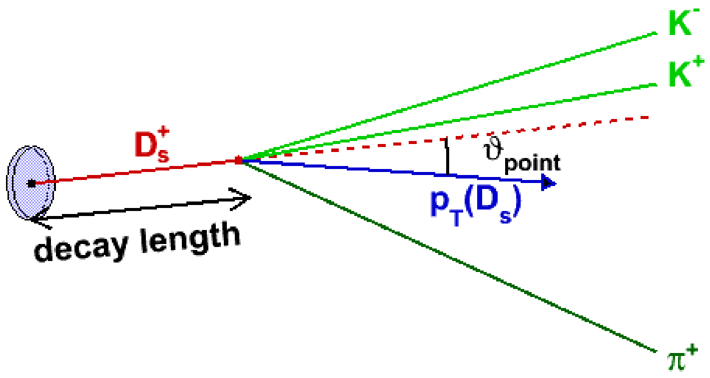


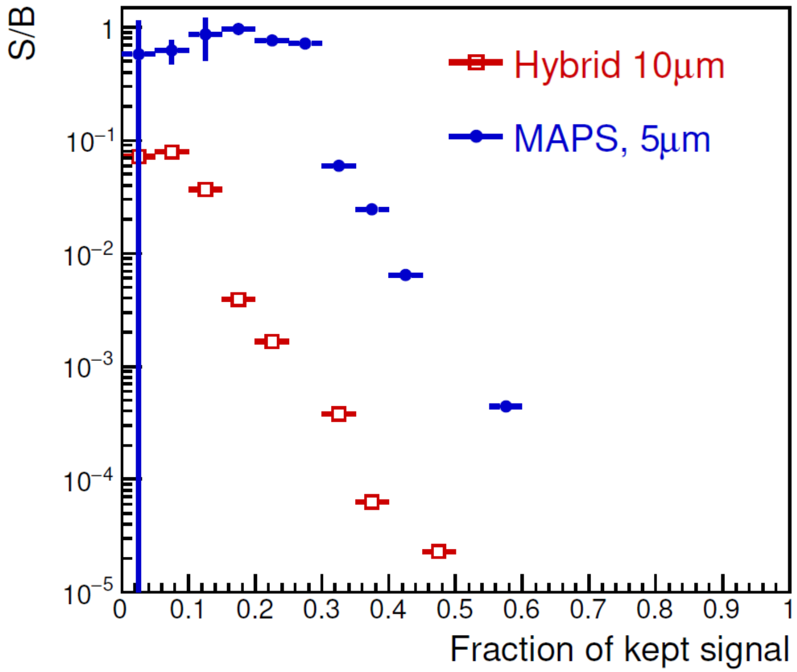
- In 30 days of Pb beam at $5 \cdot 10^5$ ions/s: **~1.5-20·10^4** (depending on $\sqrt{s_{NN}}$) reconstructed **J/ψ** in NA60+ acceptance
- Collect p-A data with different targets to calibrate cold nuclear matter effects
  - ⇨Extrapolate the J/ψ cross section in pp collisions, needed for R_{AA}
  - ⇨Extrapolate break-up effects to Pb-Pb collisions
- Strong potential for getting new insights into charmonium dissociation in the QGP

Open charm

Charmed hadron reconstruction

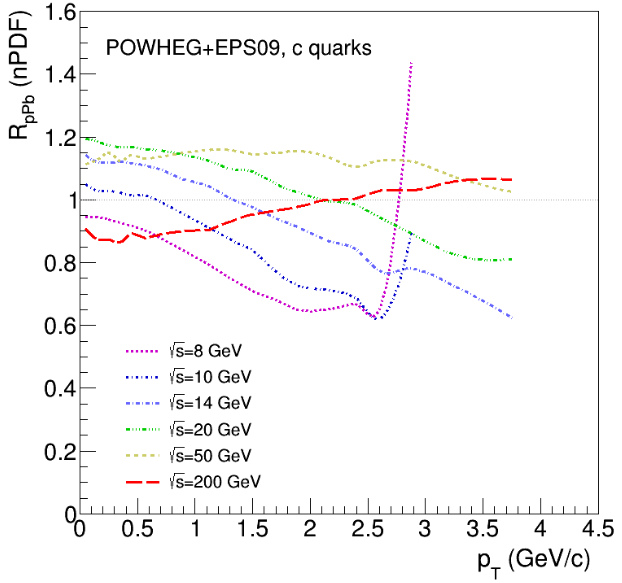
- Charmed mesons and baryons reconstructed from their decays into 2 or 3 charged hadrons
  - ⇨ $D^0 \to K\pi$ (benchmark channel)
  - ⇨ $D^+ \to K\pi\pi$
  - ⇨ $D_s^+ \to \phi\pi \to KK\pi$
  - ⇨ $\Lambda_c^+ \to pK\pi$
- Invariant mass analysis of fully reconstructed decay topologies
  - ⇨ Decay products reconstructed in the vertex spectrometer
  - ⇨ Background reduction via geometrical selections based on displaced decay vertex topology ($c\tau$ ~60-300 μm)
    - ✓ Need high precision on track and vertex reconstruction
    - ✓ Substantially better performance with state-of-the-art Monolithic Active Pixel Sensors

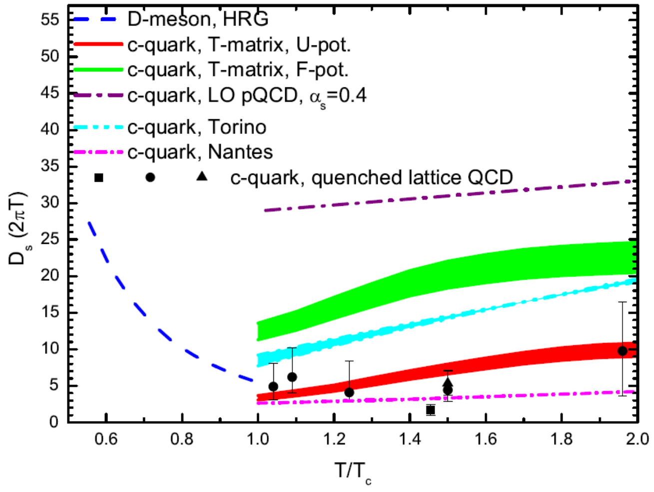




Open charm at SPS energies

- Almost unexplored energy domain
  - ⇨ No results available below top SPS energy
- Charm production in p-A collisions
  - ⇨ Sensitive to **nuclear PDFs**
    - ✓ Q^2~10–40 GeV^2 and $0.1<x_{Bj}<0.3$ (anti-shadowing and EMC)
  - ⇨ Possible sensitivity to **intrinsic charm**
- Charm hadron yield and v_2 in A-A collisions
  - ⇨ Constrain estimates of the **charm diffusion coefficient**
  - ⇨ Charm quark **thermalization** in a short-lived QGP
  - ⇨ Insight into **hadronization mechanism**
    - ✓ Enhanced D_s/D and Λ_c/D ratios in case of quark recombination
  - ⇨ Charm cross section sensitive to **chiral symmetry restoration**:
    - ✓ Enhancement of charm production at chiral restoration where the threshold for production of a $D\bar{D}$ pair may be reduced

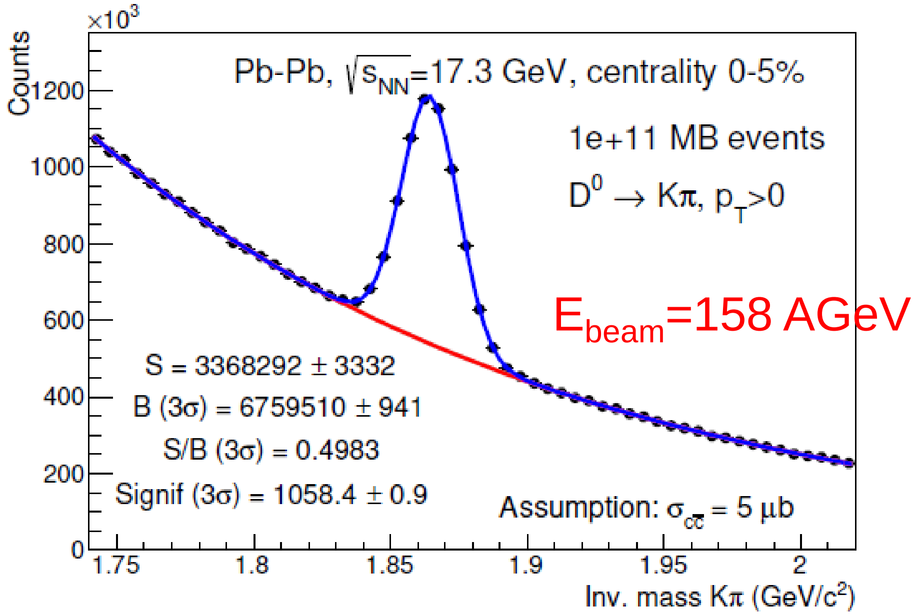


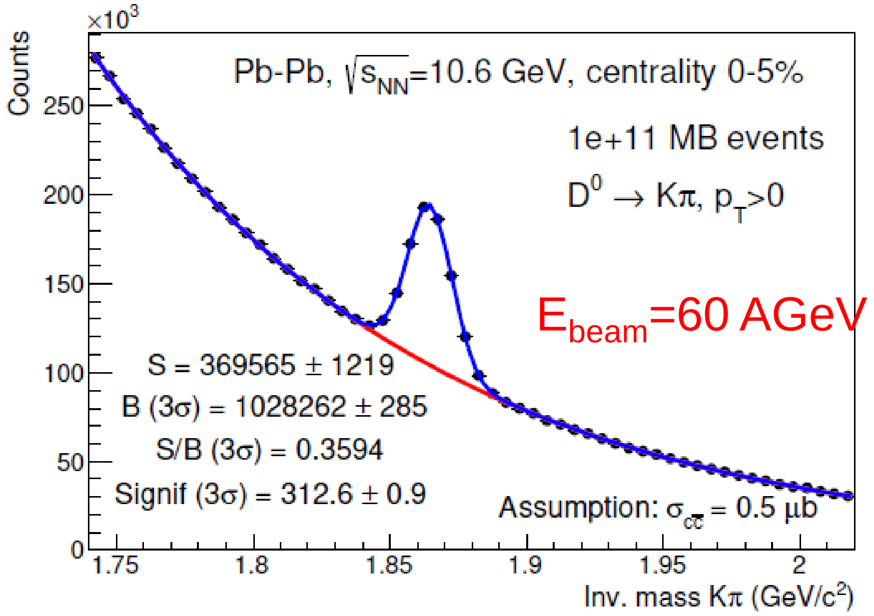


📖 Friman et al., Lect. Notes Phys. 814 (2011), 1

NA60+ physics performance : D^0

- With 10^{11} minimum bias Pb-Pb collisions (1 month of data taking)
  - ⇨ More than $3 \cdot 10^6$ reconstructed D^0 in central Pb-Pb collisions at $\sqrt{s_{NN}}$=17.3 GeV
  - ⇨ Measurement feasible also at lower collision energies with statistical precision at the percent level
  - ⇨ Allows for differential studies of yield and v_2 vs. p_T, y and centrality





Summary and perspectives

- **Strong physics case** for a beam energy scan at the SPS with high intensity beams to measure **dimuons** at low and intermediate mass, **open charm and charmonium** in p-A and Pb-Pb collisions
- The proposed **experiment NA60+** can carry out these measurements with high precision
- Expression of interest submitted to SPSC in May 2019
  - ⇨ Signed by 82 physicists from Germany, India, Italy, Japan, Switzerland, USA
- Letter of Intent in preparation
  - ⇨ Physics goals
  - ⇨ Experimental layout and detectors
  - ⇨ Physics performance

📖 **NA60+, https://cds.cern.ch/record/2673280**

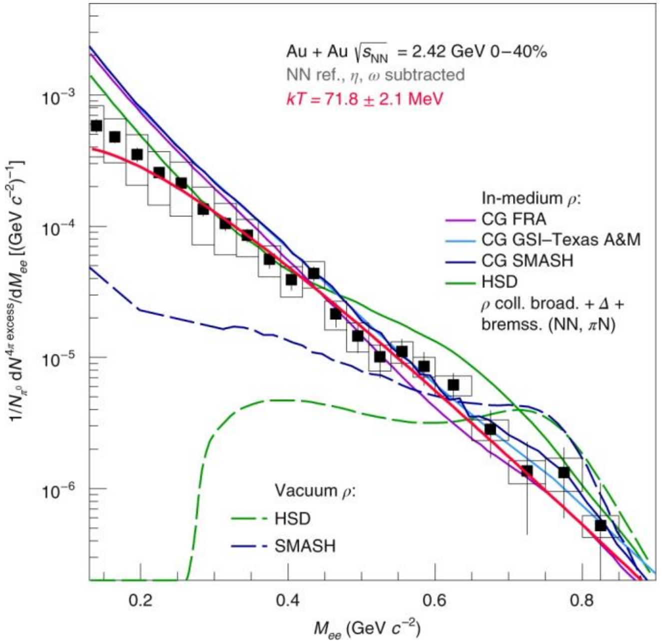
The NA60+ Collaboration

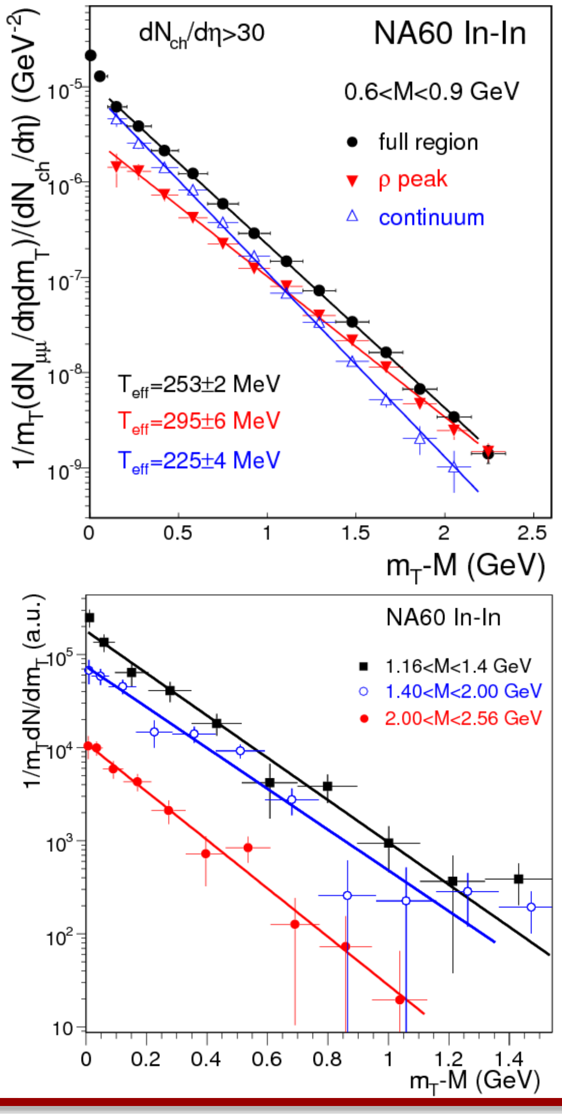
M. Agnello[14,16], F. Antinori[12], H. Appelshäuser[2], M. Arba[7], R. Arnaldi[14], R. Bailhache[2], L. Barioglio[17,14], S. Beole[17,14], A. Beraudo[14], F. Bergsma[20], A. Bianchi[17,14], L. Bianchi[17,14], E. Botta[17,14], E. Bruna[14], S. Bufalino[16,14], E. Casula[7,8], F. Catalano[16,14], S. Chattopadhyay[6], A. Chauvin[7], C. Cicalo[7], M. Concas[15,14], P. Cortese[18,14], T. Dahms[4,5,i], A. Dainese[12], A. Das[6], D. Das[6], D. Das[6], I. Das[6], L. Das Bose[6], A. De Falco[7,8], N. De Marco[14], S. Delsanto[17,14], A. Drees[22], L. Fabbietti[5], P. Fecchio[16,14], A. Ferretti[17,14], A. Feliciello[14], M. Gagliardi[17,14], P. Gasik[5], F. Geurts[21], P. Giubilato[12,13], P.A. Giudici[20], V. Greco[9], F. Grosa[16,14], H. Hansen[1], J. Klein[14], W. Li[21], M.P. Lombardo[11] D. Marras[7], M. Masera[17,14], A. Masoni[7], P. Mereu[14], L. Micheletti[17,14], A. Mulliri[7,8], L. Musa[20], M. Nardi[14], H. Onishi[19], C. Oppedisano[14], B. Paul[7,8], S. Plumari[10], F. Prino[14], M. Puccio[17,14], L. Ramello[18,14], R. Rapp[23], I. Ravasenga[16,14], A. Rossi[12,13], P. Roy[6], B. Schmidt[20], E. Scomparin[14,i], S. Siddhanta[7], R. Shahoyan[20], T. Sinha[6], M. Sitta[18,14], H. Specht[3], S. Trogolo[17,14], R. Turrisi[12], M. Tuveri[7], A. Uras[1], G. Usai[7,8,i,ii], E. Vercellin[17,14], J. Wiechula[2], S. Winkler[5]

Backup

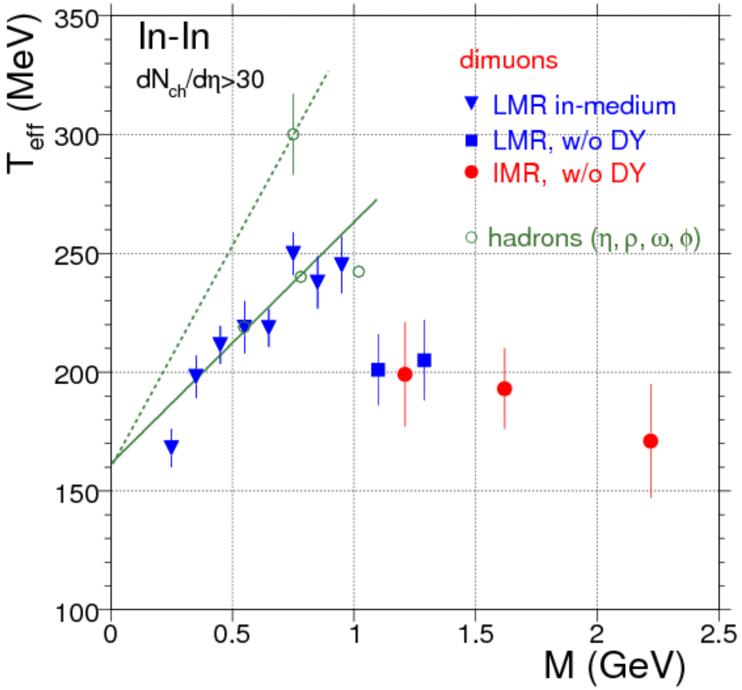
Thermal dimuons

📖 HADES, Nature Phys. 15 (2019) 1040

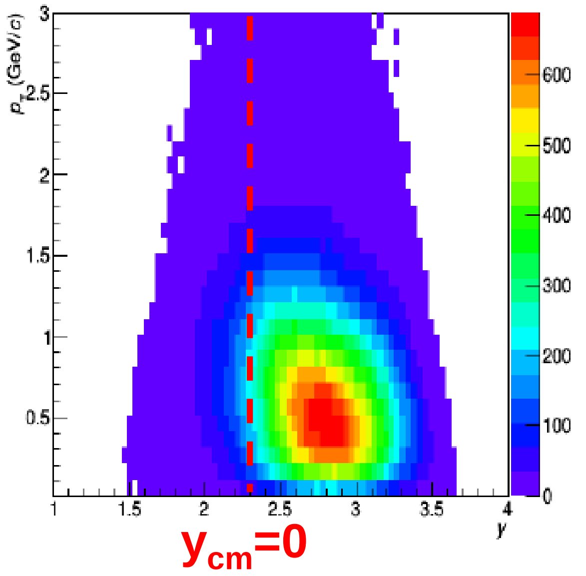


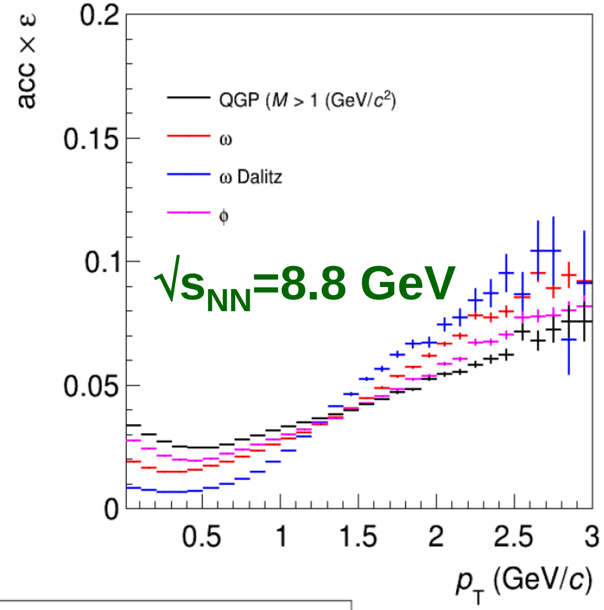


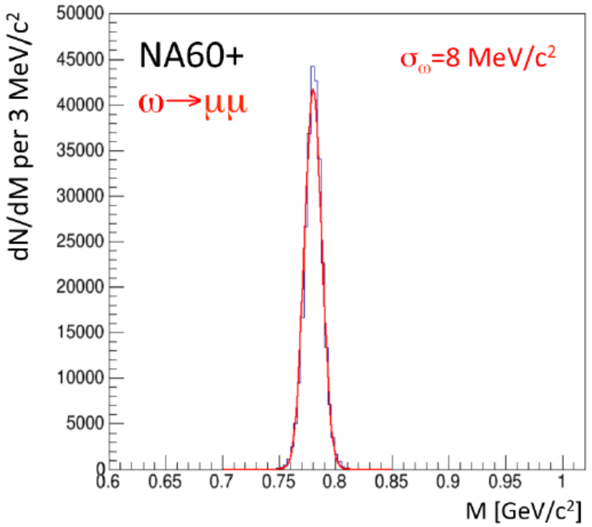
📖 NA60, EPJC61 (2009) 711



Dimuon reconstruction and acceptance

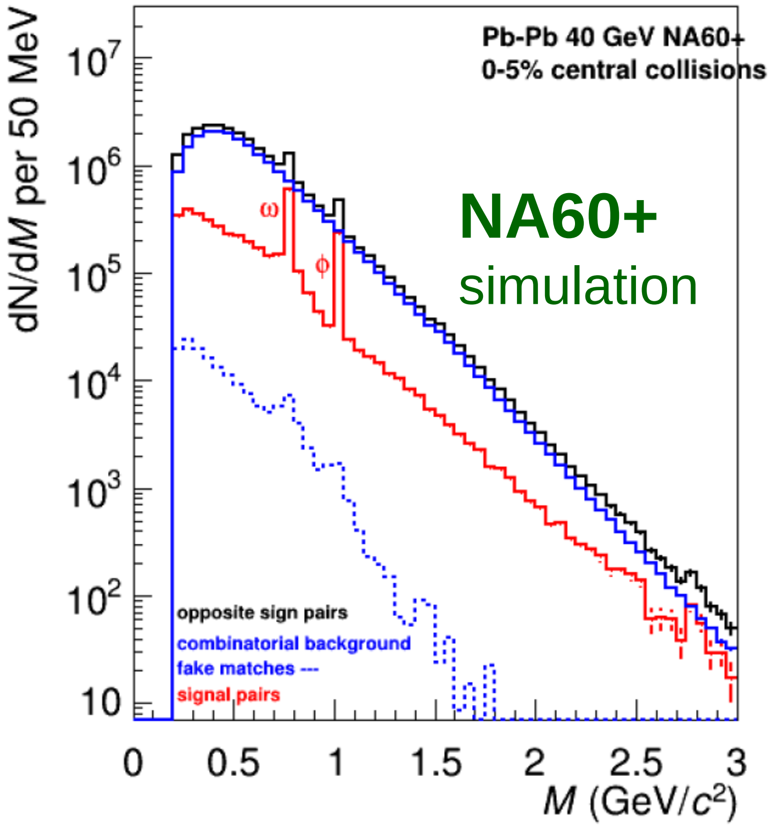


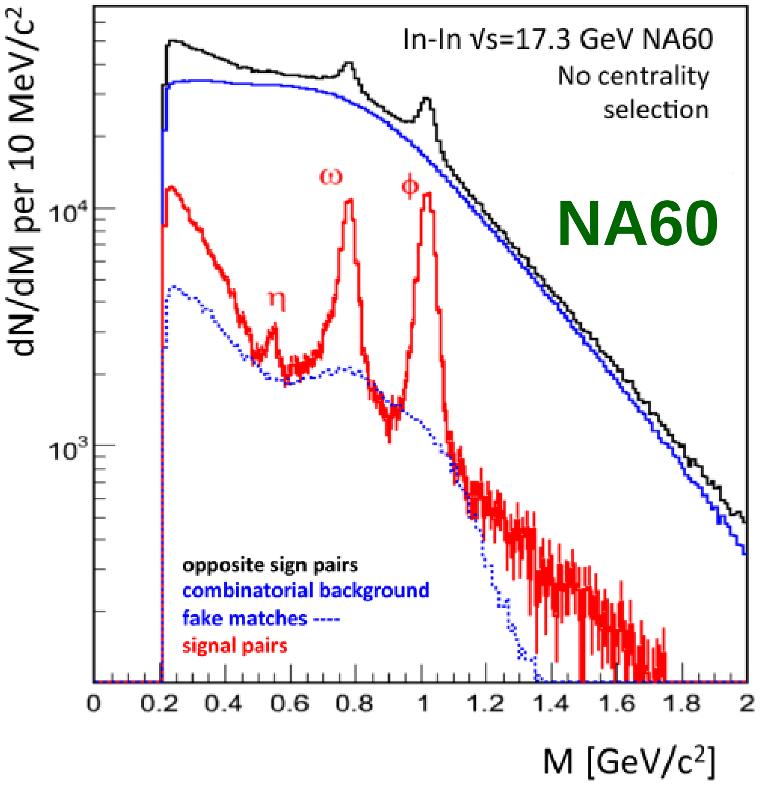




- Detector performance studies:
  - ⇨ Based on a simulation framework with semi-analytical tracking algorithm (Kalman filter) + FLUKA for hadronic background studies
- Full phase-space acceptance >1% for dimuons at low and intermediate mass
- Good coverage down to midrapidity and p_T=0
- Mass resolution for resonances varies from <10 MeV (ω) to ~30 MeV (J/ψ)

NA60+ performance: dimuons



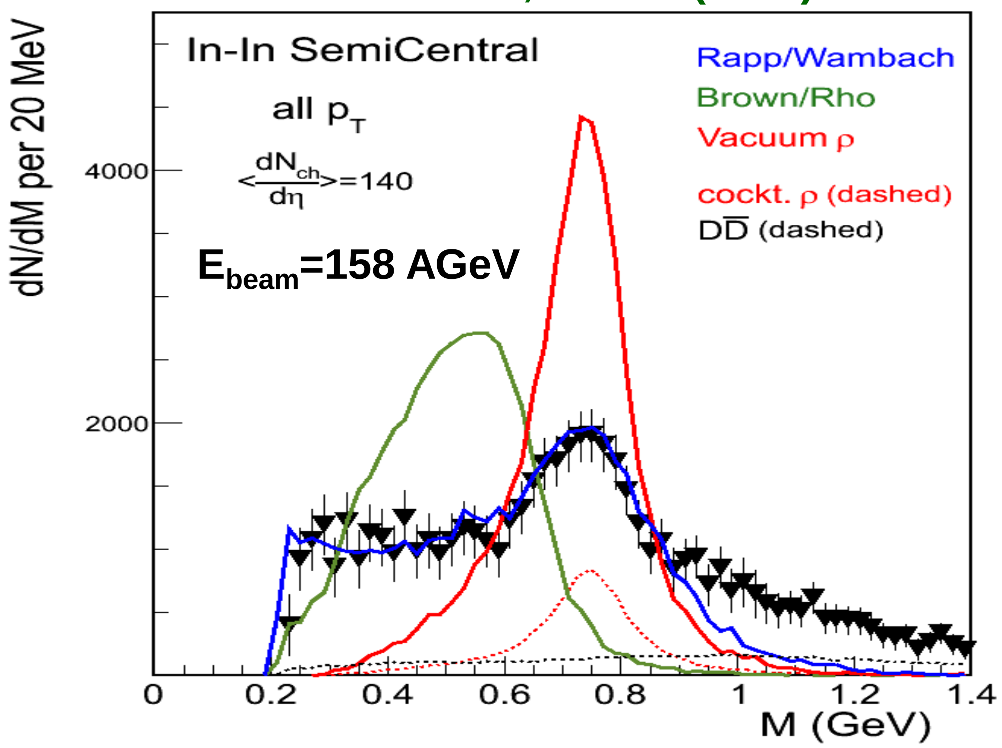


- Simulated spectra:
  - Thermal dimuon distributions from Rapp et al., PLB753 (2016) 586
  - Hadron cocktail from NA60 and statistical model (Becattini et al., PRC73 (2006) 044905)
  - Drell-Yan and open charm from PYTHIA
  - Combinatorial background: input spectra from NA49 measurements

Chiral symmetry restoration

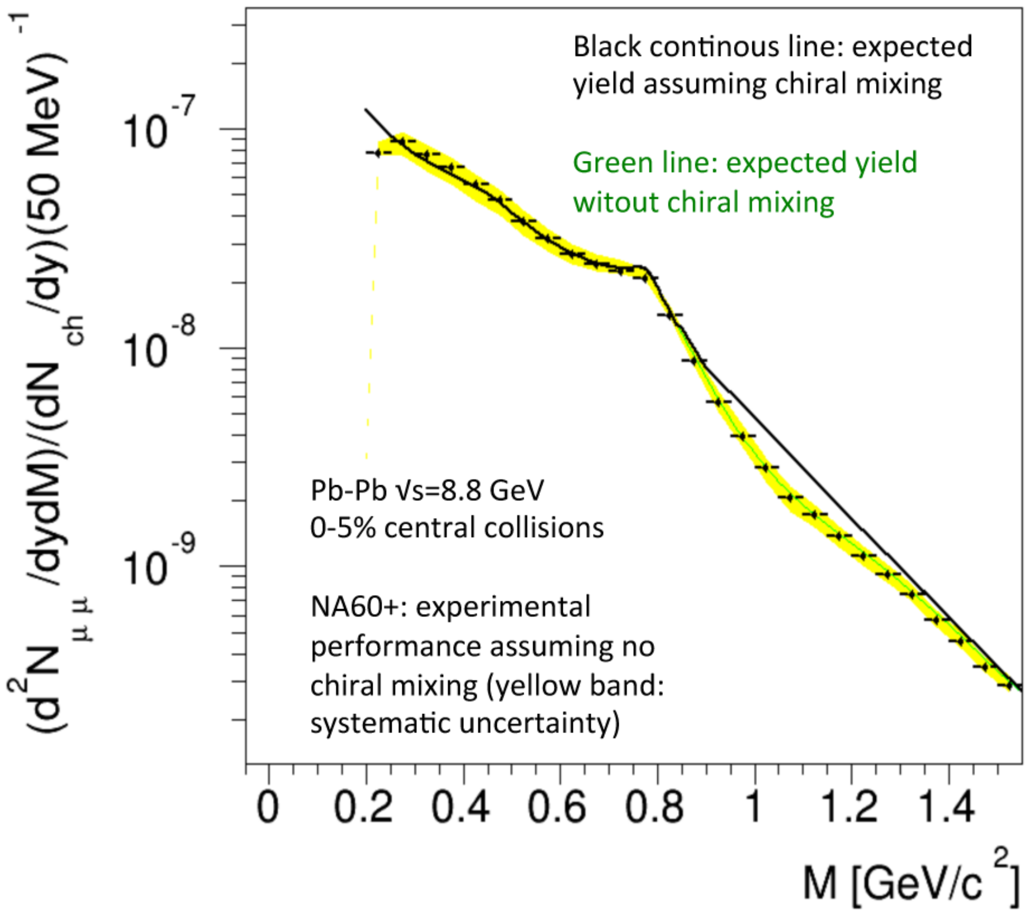
- Strong modification (broadening) of the ρ meson line shape in nuclear collisions at top SPS energy measured by NA60
  - ⇨ Signal of **chiral symmetry restoration**?
- Additional information needed on spectral properties of its chiral partner, a_1
  - ⇨ No direct coupling of a_1 to dilepton channel
  - ⇨ Chiral symmetry restoration: mixing of vector (V) and axial-vector (A) correlators → ρ-a_1 mixing
  - ⇨ Enhancement of dilepton yield in 1<M<1.5 GeV/c^2

📖 NA60, PRL96 (2006) 162302



- Measurements at low SPS energies more sensitive to chiral restoration effects:
  - ⇨ Smaller yield of thermal dimuons from QGP
  - ⇨ Negligible background from open charm decays

NA60+ physics performance: ρ-a_1



- Simulations carried out by considering
  - ⇨ No chiral mixing (dip in 1<M<1.4 GeV/c^2)
  - ⇨ Full ρ-a_1 chiral mixing

  Rapp, van Hees, PLB753 (2016) 586

- 20-30% enhancement expected in case of full mixing

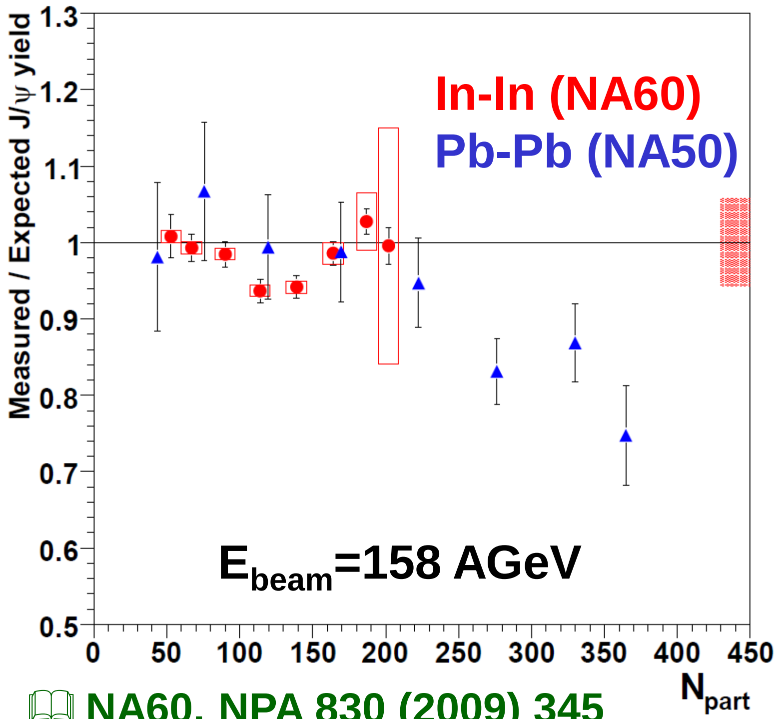
- Challenging measurement, but with the foreseen accuracy we will have sensitivity to the expected effect

Charmonium in the QGP

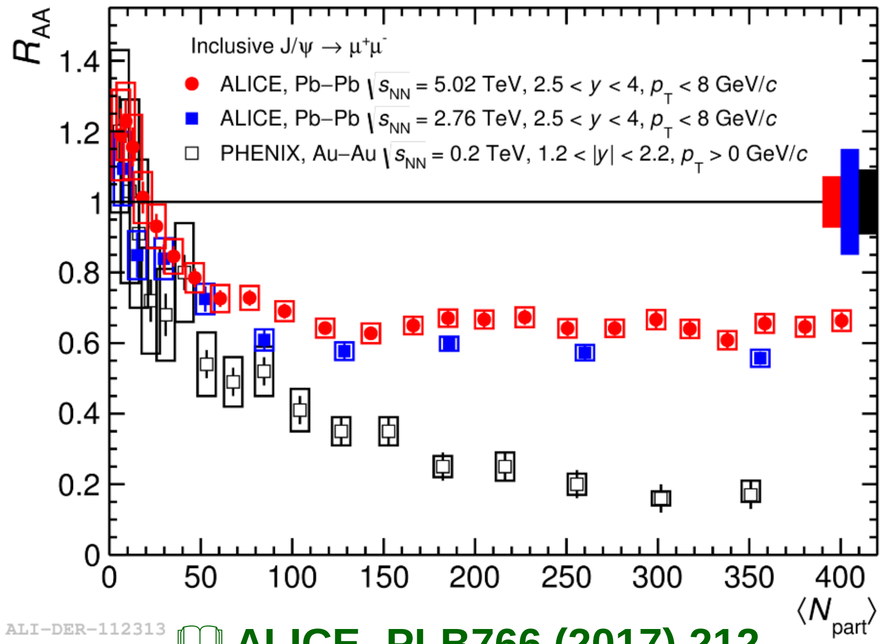
- J/ψ suppression observed from top SPS to LHC energy
  - ⇨ Due to quarkonium dissociation in the QGP due to colour screening of the $c\bar{c}$ potential

    📖 **Matsui, Satz, PLB178 (1986) 416**
  - ⇨ Different charmonium states melt at different temperatures, depending on their binding energy

    📖 **Digal et al., PRD64 (2001) 094015**
  - ⇨ Production via $c\bar{c}$ recombination negligible at SPS energies



📖 **NA60, NPA 830 (2009) 345**



📖 **ALICE, PLB766 (2017) 212**

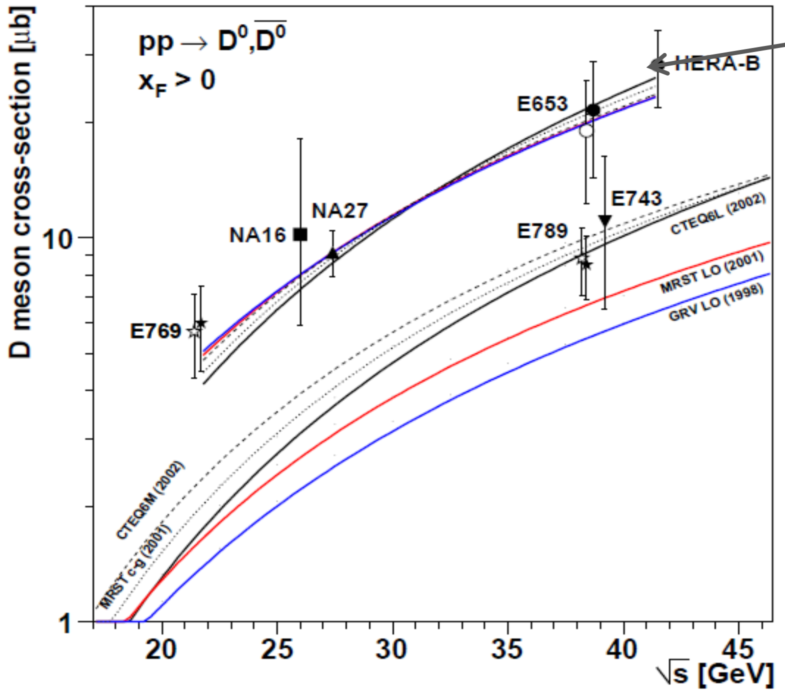
📖 **PHENIX, PRC84 (2011) 05912**

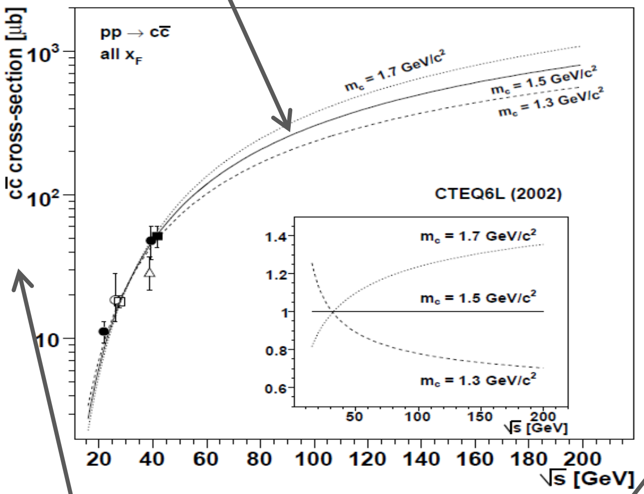
Charm cross section in p-A

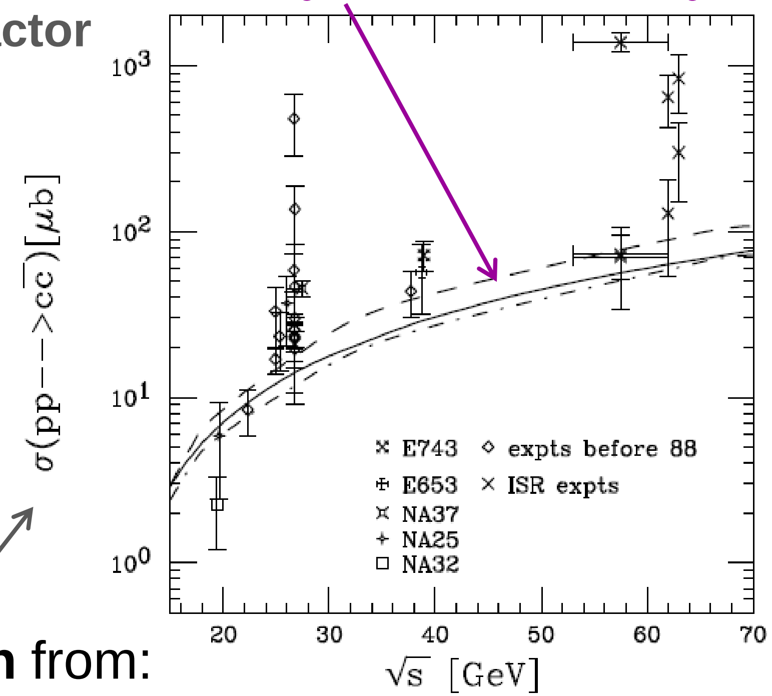
- Unexplored energy domain
- Comparison of existing data to PYTHIA (LO) event generator and to pQCD calculations (MNR) at NLO

PYTHIA LO cross sections scaled with appropriate K-factor

MNR, m_c=1.2 GeV , μ=2m_c







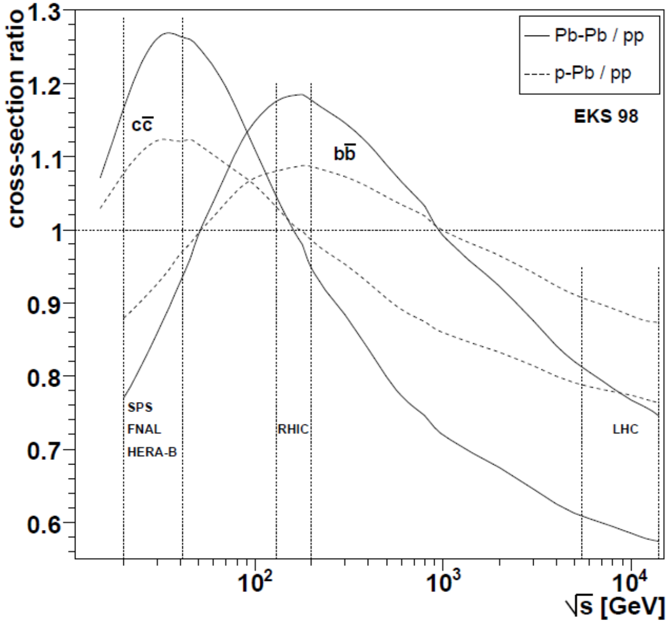
Lourenco, Wohri, Phys.Rept.433 (2006) 127

Total charm cross section from:
- Measured D^0 (D^+)
- Fragmentation fractions from e^+e^-

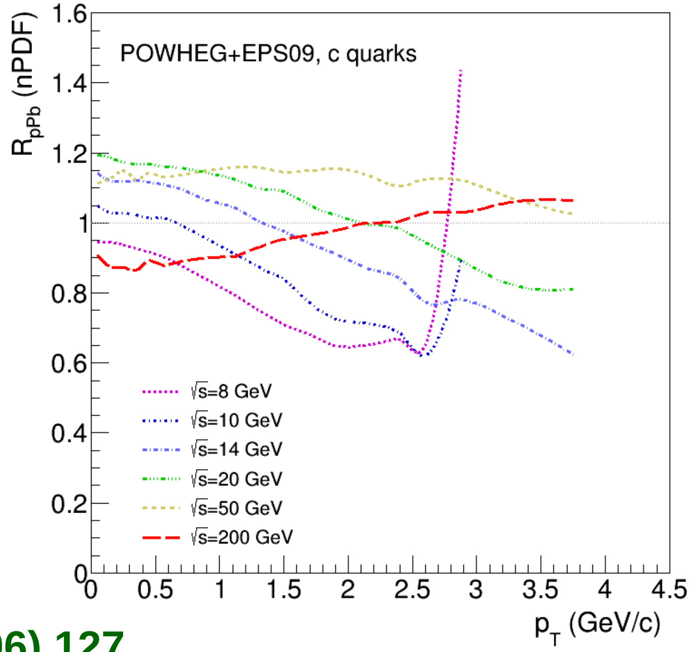
Vogt, Int.J.Mod.Phys.E12 (2003) 211

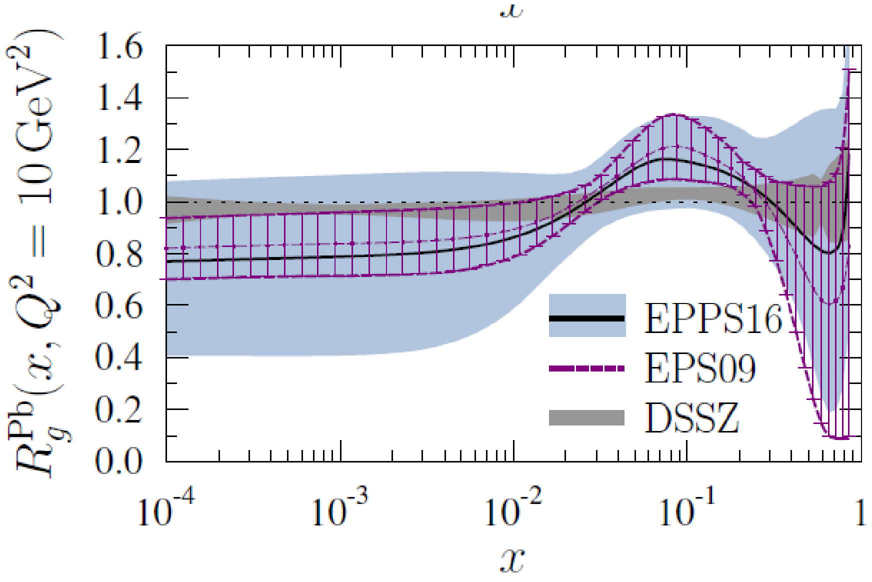
Charm production in p-A

- Sensitivity to **nuclear PDFs in p-A** collisions
  - ⇨ Probe EMC and anti-shadowing for $\sqrt{s_{NN}}$ ~ 10-20 GeV
  - ⇨ Perform measurements with various nuclear targets to access the A-dependence of nPDF
- NA60+ offers a unique opportunity to investigate the large x_{Bj} region
  - ⇨ $0.1<x_{Bj}<0.3$ at Q^2~10-40 GeV^2



📖 **Lourenco, Wohri, Phys.Rept.433 (2006) 127**

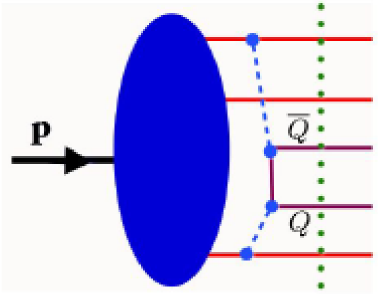




📖 **Eskola et al. , EPJ C77 (2017) 13**

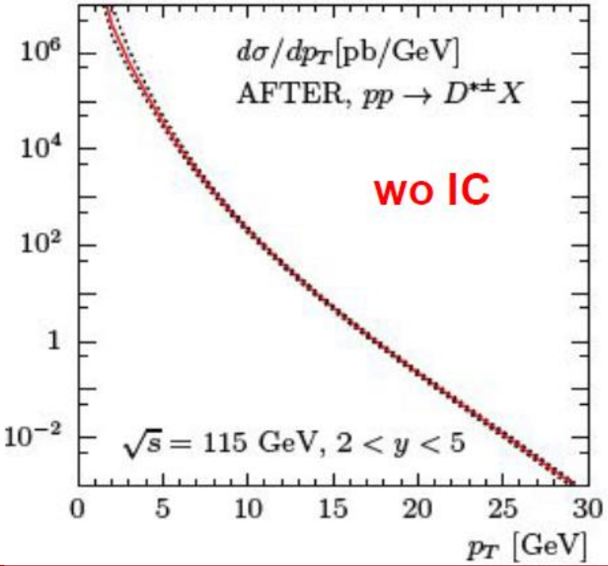
Intrinsic charm?

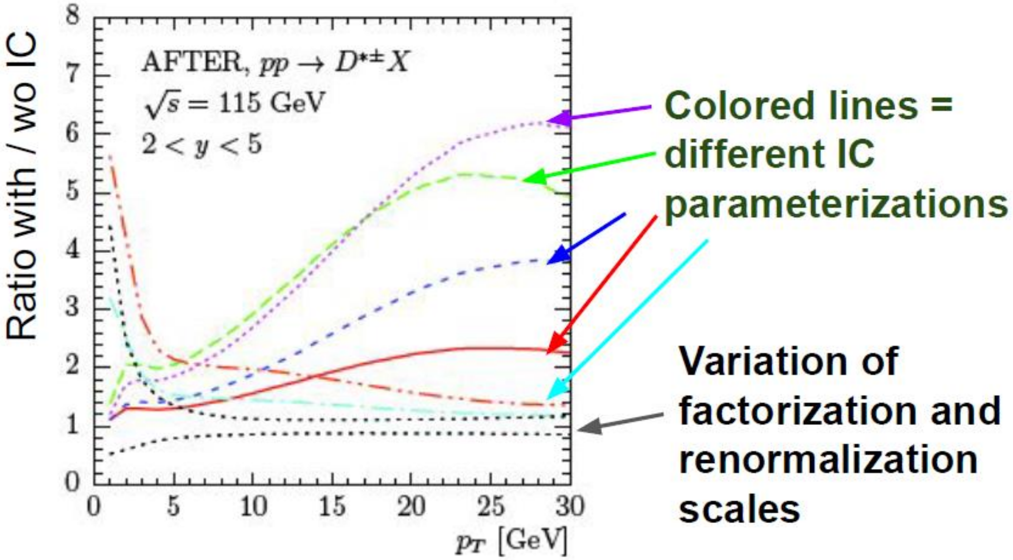
- Existence of a nonperturbative intrinsic heavy quark component in the nucleon is a rigorous QCD prediction
  - ⇨ Extrinsic contributions arise from gluon splitting in pQCD
  - ⇨ Intrinsic charm: nonperturbative component in proton wave function
    - ✓ E.g. 5-quark Fock state |uudcc>



- Unambiguous experimental confirmation still missing
  - ⇨ Intrinsic charm (IC) contribution dominant at large x and high p_T

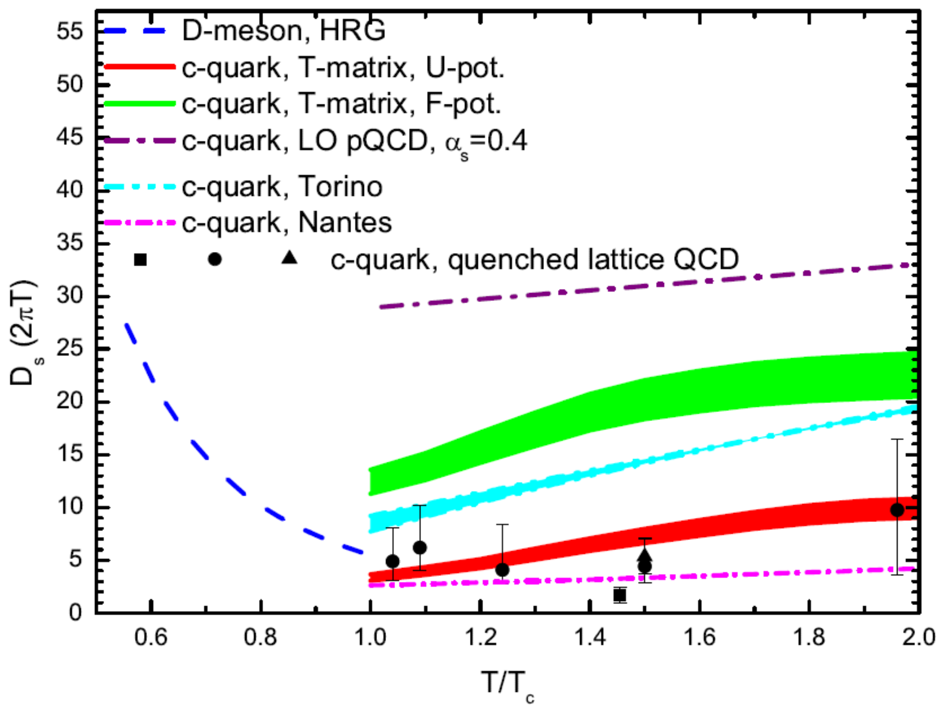
📖 S. J. Brodsky, Adv.High Energy Phys. (2015) 231547





Charm production in A-A and R_{AA}

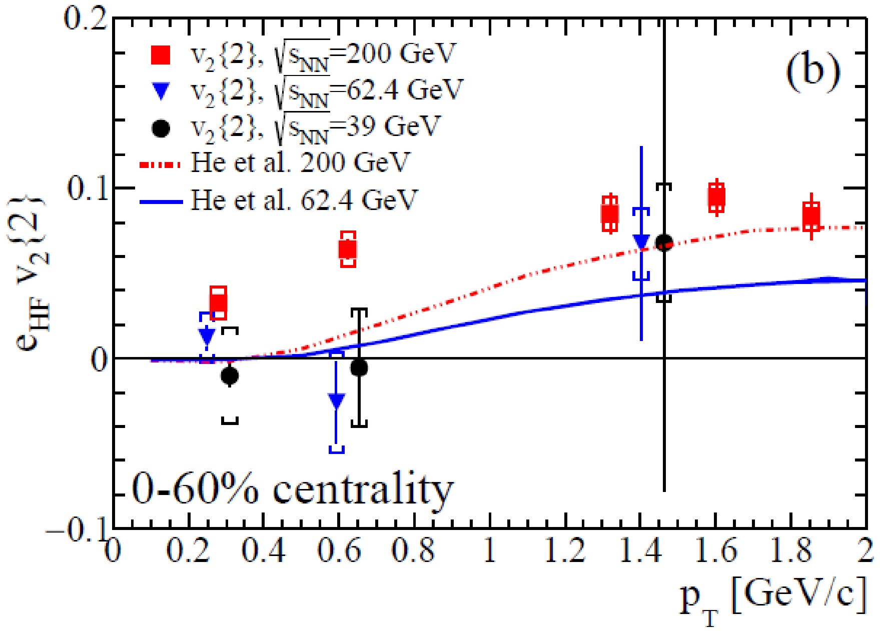
- Insight into **QGP transport properties**
  - ⇨ Charm diffusion coefficient larger in the hadronic phase than in the QGP around T_c
  - ⇨ Hadronic phase represents a large part of the collision evolution at SPS energies
    - ✓ Sensitivity to hadronic interactions
    - ✓ Test models which predict strongest in-medium interactions in the vicinity of the quark-hadron transition
  - ⇨ Measurement also important for precision estimates of diffusion coefficients at the LHC



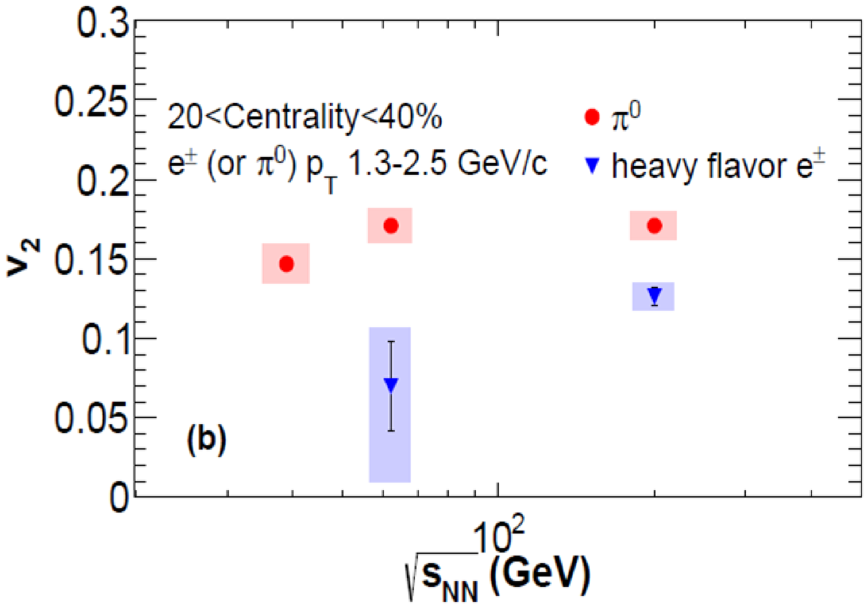
📖 **Prino, Rapp, JPG43 (2016) 093002**

Charm hadron elliptic flow

- Study **charm thermalization** (hydrodynamization…) at low $\sqrt{s_{NN}}$
  - ⇨ Current measurements of HF-decay electron v_2 at $\sqrt{s_{NN}}$=39 and 62 GeV/c from RHIC BES show:
    - ✓ Smaller v_2 than at $\sqrt{s}$=200 GeV
    - ✓ Not conclusive on v_2>0



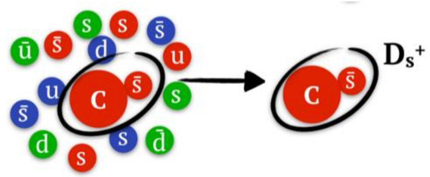
📖 STAR, PRC 95 (2017) 034907

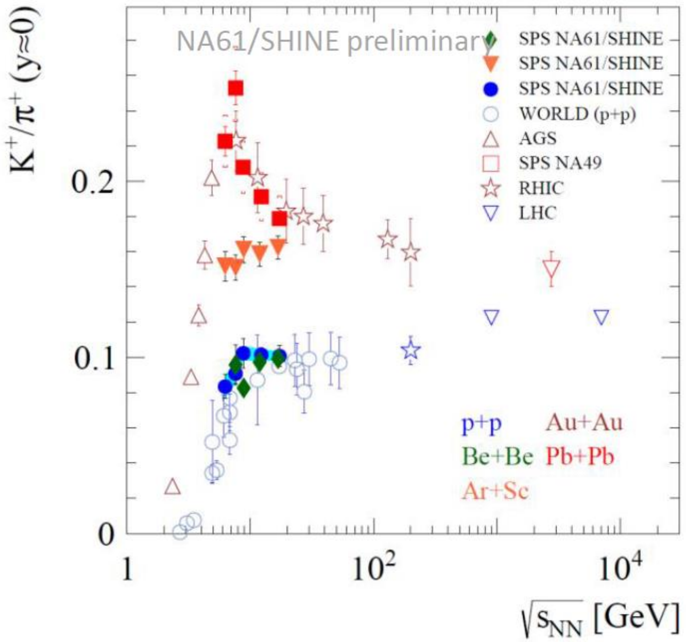


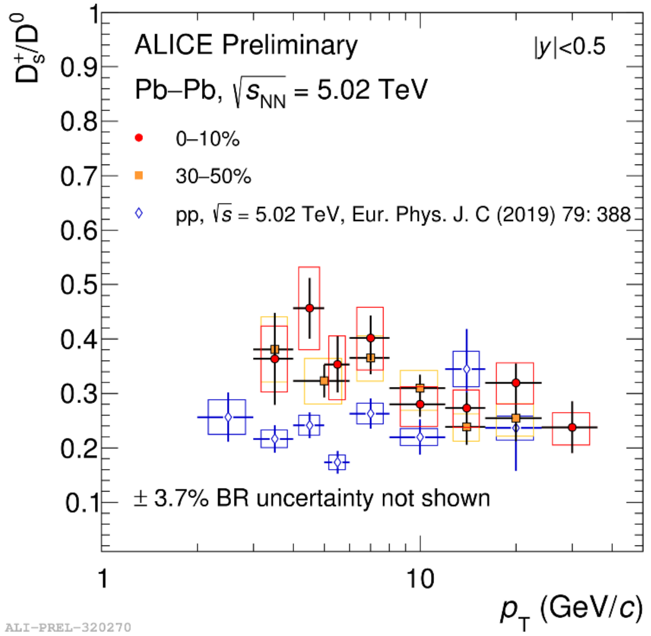
📖 PHENIX, PRC 91 (2015) 044907

Open charm hadrochemistry

- Reconstruct different charm hadron species to get insight into **hadronization mechanism**
- **Strange/non-strange** meson ratio (D_s/D):
  - ⇨ D_s/D enhancement expected in Pb-Pb due to hadronisation via recombination and strangeness enhancement in the QGP
  - ⇨ Complement studies of strangeness enhancement by NA61 in the light-flavour sector

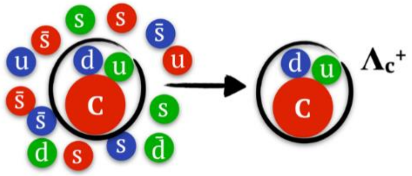


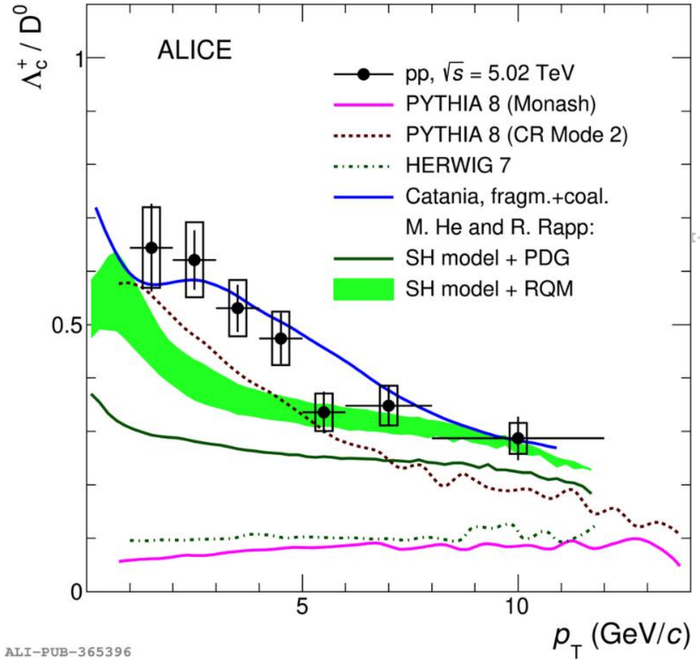


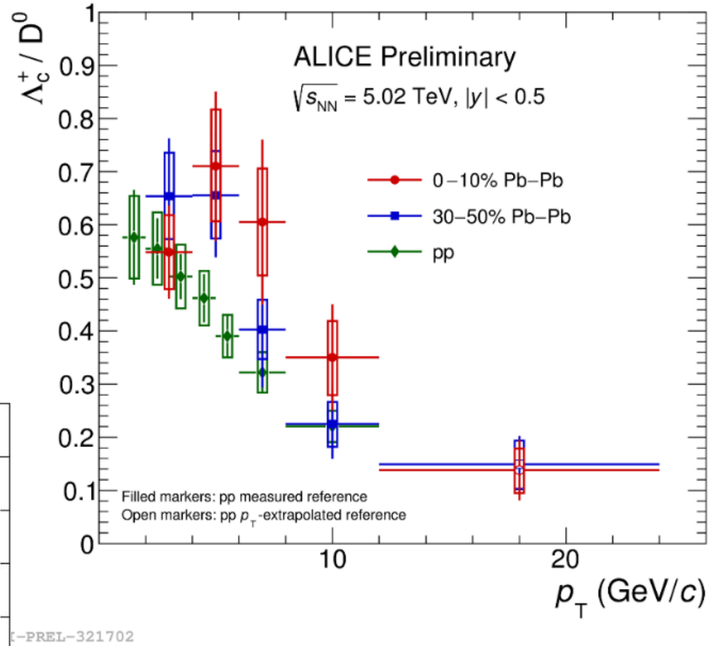


Open charm hadrochemistry

- Reconstruct different charm hadron species to get insight into **hadronization mechanism**
- **Baryon/meson** ratios (Λ_c/D):
  - ⇨ Expected to be enhanced in Pb-Pb in case of hadronisation via coalescence
  - ⇨ Interesting also in p-A since Λ_c/D^0 in pp (p-Pb) at the LHC is higher than in e^+e^-







📖 **ALICE, arXiv:2011.06078**

Charm cross section in Pb-Pb

- Total charm cross section in A-A collisions
  - ⇨ Measured so far by NA60+ in In-In collisions from intermediate-mass dimuons with 20% precision
    📖 **NA60, EPJ C59 (2009) 607**
  - ⇨ Upper limit from NA49 measurements of D^0 mesons
    📖 **NA49, PRC73 (2006) 034910**

- Precise measurement needs to reconstruct all meson and baryon ground states (D^0, D^+, D_s^+ and Λ_c^+ and their antiparticles)

- Charm cross section **directly sensitive to chiral symmetry restoration**:
  - ⇨ Enhancement of charm production at chiral restoration where the threshold for production of a DD pair may be reduced
    📖 **Friman et al., Lect. Notes Phys. 814 (2011), 1**

- Charm cross section **ideal reference for charmonia**

Expected performance for D^0

- $D^0 \rightarrow K\pi$: fast simulations for central Pb-Pb collisions:
  - D^0 signal: p_T and y distributions from POWHEG-BOX+PYTHIA
  - Combinatorial background: dN/dp_T and dN/dy of π, K and p from NA49
  - S/B before selection ~10^{-7}
  - Geometrical selections based on displaced decay vertex topology