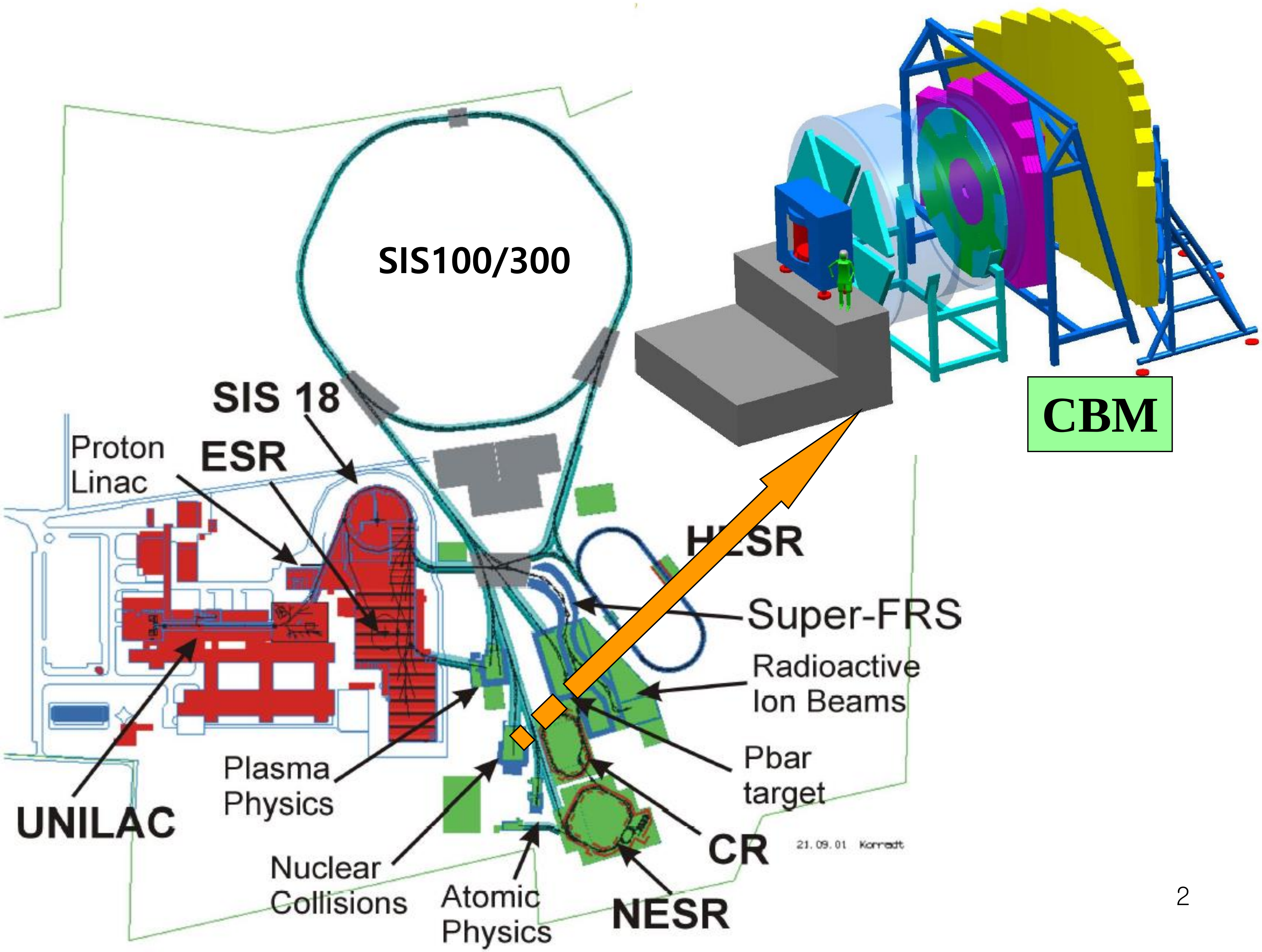
Introduction to CBM

Contents

- FAIR Project at GSI
- CBM at FAIR
- Discussion


SIS100/300
SIS 18
Proton
Linac
ESR
HESR
Super-FRS
Radioactive
Ion Beams
Pbar
target
CR
NESR
UNILAC
Plasma
Physics
Nuclear
Collisions
Atomic
Physics
21.09.01 Konradt
CBM

Facility for Antiproton and Ion Research

Ring	Circum-ference [m]	Bending Power [Tm]	Beam Energy	Specific Features
Synchrotron SIS100	1080	100	2.7 GeV/u U^{28+} 29 GeV protons	fast pulsed superferric magnets up to 2 T, 4 T/s, bunch compression to 50 ns, fast and slow extraction, 5×10^{-12} mbar operating vacuum
Synchrotron SIS200	1080	200	22.3 GeV/u U^{92+}	pulsed super-conducting cosθ-magnets up to 4 T, 1 T/s, slow extraction with high duty cycle, 5×10^{-12} mbar operating vacuum
Collector Ring CR	187	13	740 MeV/u, A/q=2.7 3 GeV antiprotons	acceptance for antiprotons: 240 x 240 mm mrad, $\Delta p/p=\pm3\times10^{-2}$, fast stochastic cooling of radio-active ions and antiprotons, mass spectrometer for short-lived nuclei

FAIR in Numbers

New Experimental Storage Ring NESR	208	13	740 MeV/u, A/q=2.7 3 GeV antiprotons	electron cooling of radioactive ions with up to 450 keV electron-beam, precision mass spectrometer, accumulation and stochastic cooling of antiprotons, internal target experiments with atoms and electrons, electron-nucleus scattering facility
High-Energy Storage Ring HESR	430	50	14 GeV antiprotons	stochastic cooling of antiprotons up to 14 GeV, electron cooling of antiprotons up to 9 GeV

FAIR in Numbers

Research Field	Energy	Peak Intensity	Average Intensity	Pulse Structure
Radioactive Ion Beams	1.0 to 1.5 GeV/u for all elements up to uranium	10^{12} per cycle for storage ring experiments	10^{12} per second high duty cycle for fixed target experiments	≤ 50 ns for transfer into the storage ring
Antiprotons	29 GeV p	2.5×10^{13} per cycle	--	< 50 ns
Dense Nuclear Matter	up to 22.3 GeV/u U up to 30 GeV/u Ne	--	10^{9} per second high duty cycle	--
Plasma Physics	.4 to 1 GeV/u ions	2×10^{12} per cycle	--	100 – 50 ns (fixed target)
Atomic Physics	1 to 22.3 GeV/u ions	--	10^{9} per second high duty cycle	--

Cost

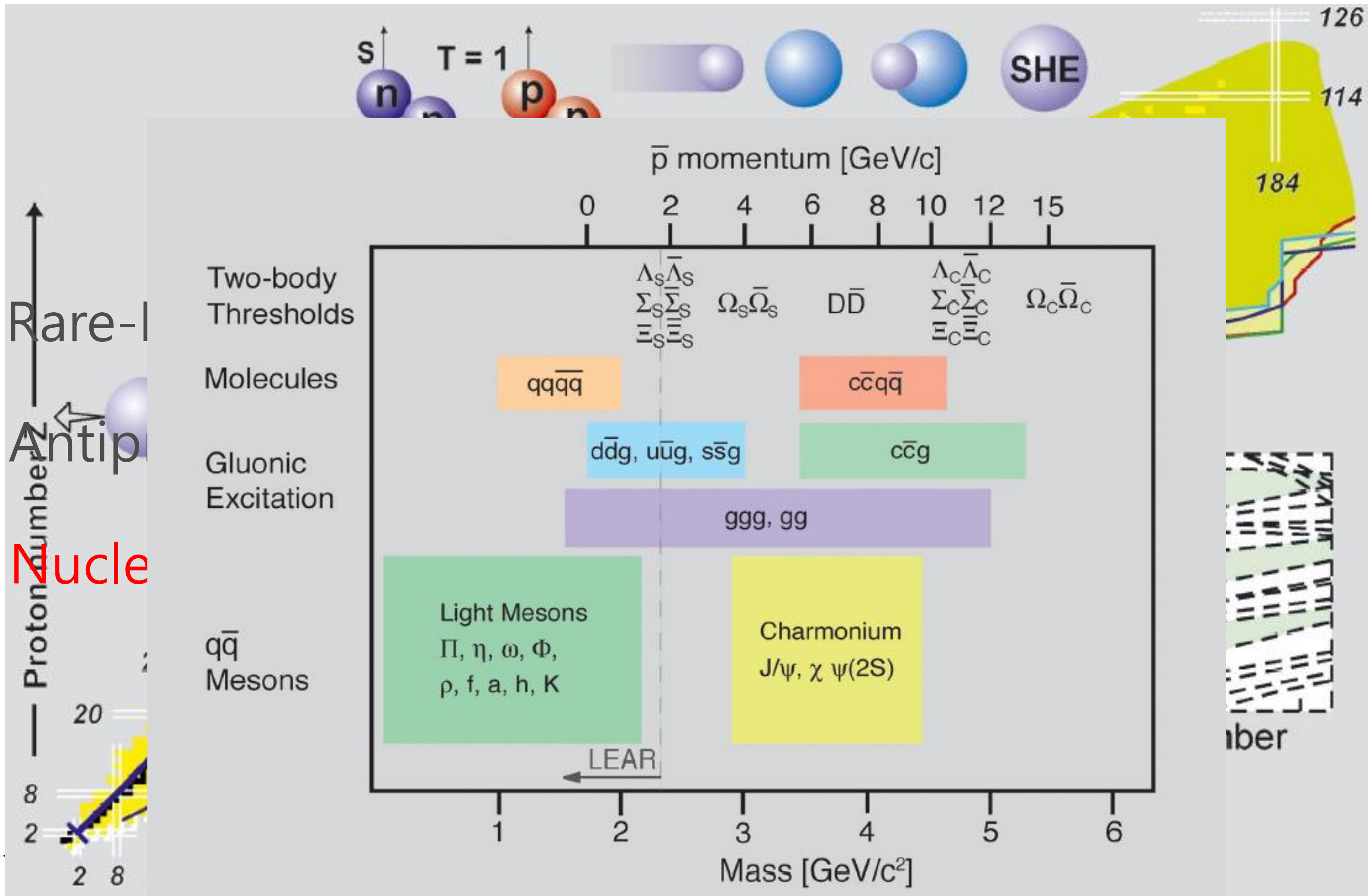
Total:	675	M€
Buildings:	225.5	
SIS100:	70.1	
SIS200:	39.6	
Coll. Ring:	45.0	
NESR:	40.0	
HESR:	45.0	
e-ring:	15.0	
Beamlines:	21.0	
Cryo, etc:	44.1	

SFRS:	40.7
CBM:	27.0
AP:	8.7
Plasma phys.:	8.0
p-linac:	10.0
PANDA:	28.4
pbar target:	6.9

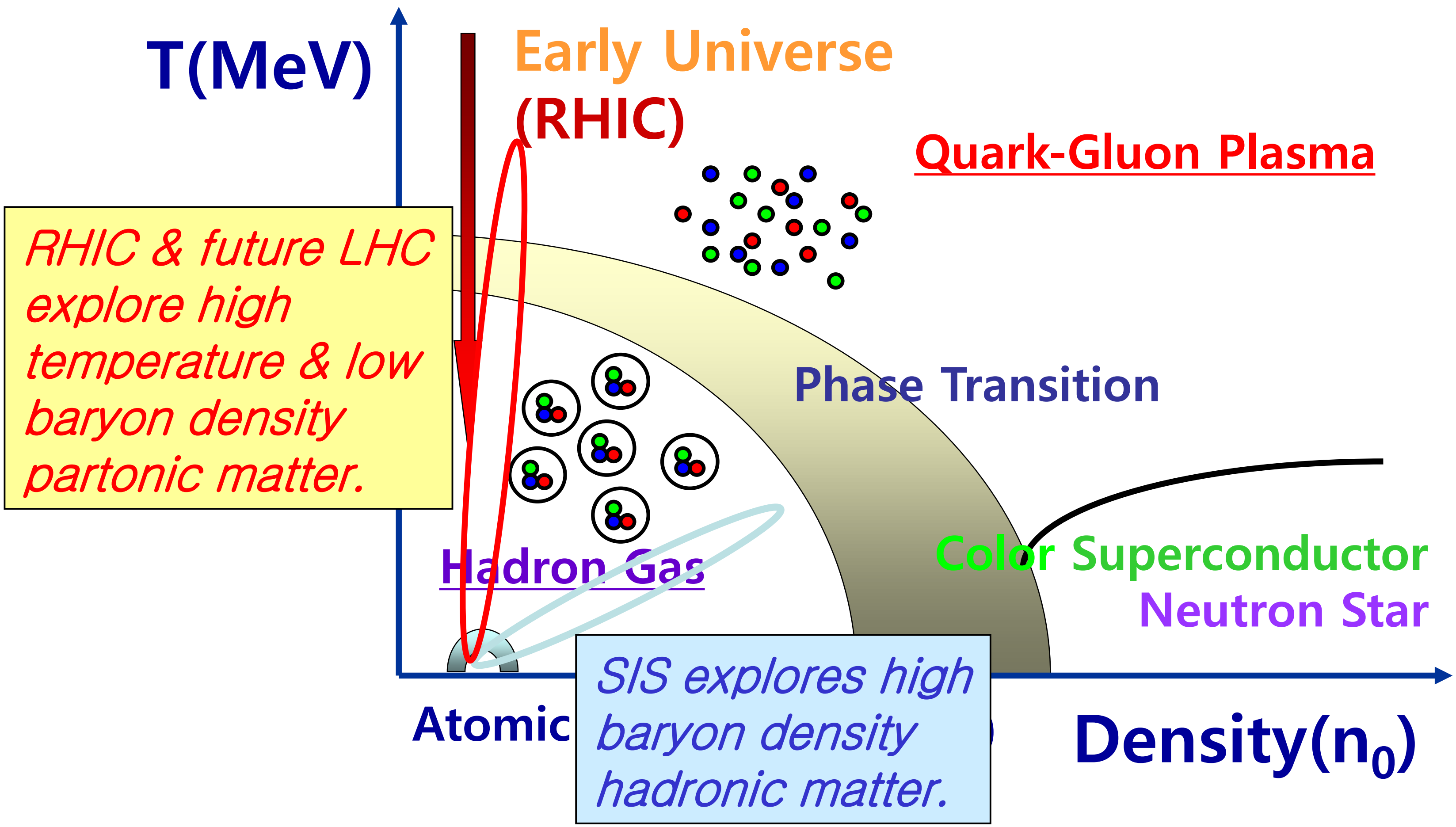
FAIR Project at GSI

The Science Case

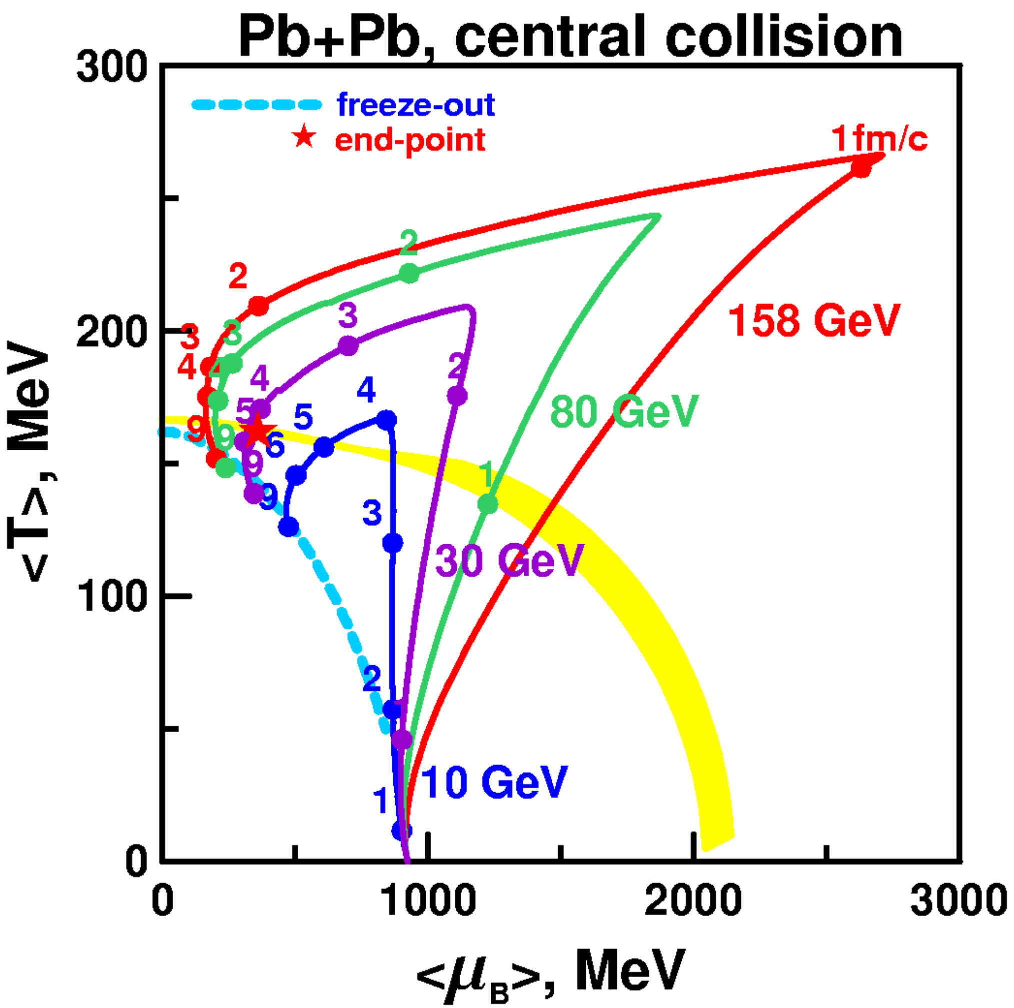
1. Rare-I
2. Antip
3. Nucle



Nuclear Phase Diagram



Predictions

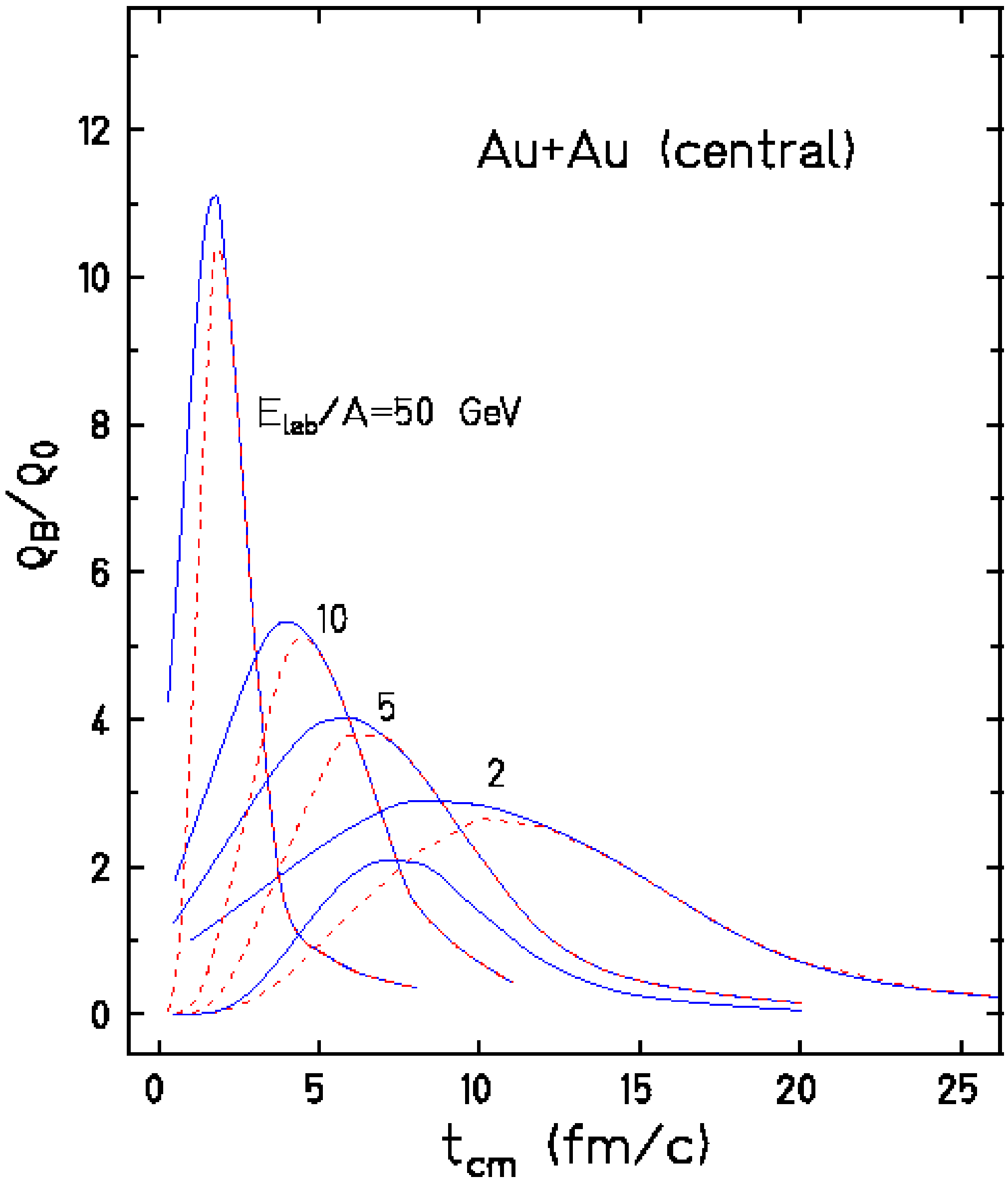


By Ivanov & Toneev
with hadron gas EoS

Calculations reproduce freeze-out conditions

30 AGeV trajectory close to the critical endpoint

Predictions



B. Friman, W. Nörenberg, V.D. Toneev, EPJA 3, 165 (1998)

Physics Topics

1. In-medium modifications of hadrons

onset of chiral symmetry restoration at high ρ_B

observables: ρ, ω, ϕ $\rightarrow$ e^+e^-

open charm production

2. Strangeness in matter (strange matter)

enhanced strangeness production

observables: K, Λ, Σ, Ξ, Ω

3. Indications for deconfinement at high ρ_B

anomalous charmonium suppression?

observables: J/ψ, D

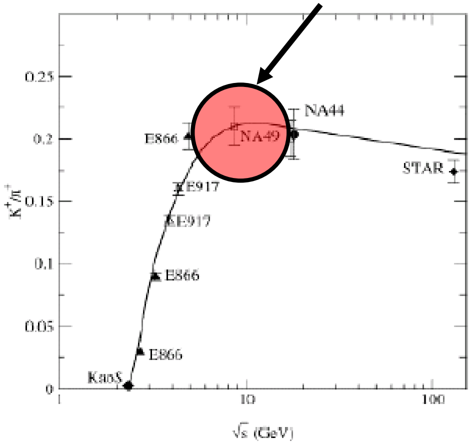
excitation function of flow (softening of EOS)

4. Critical point

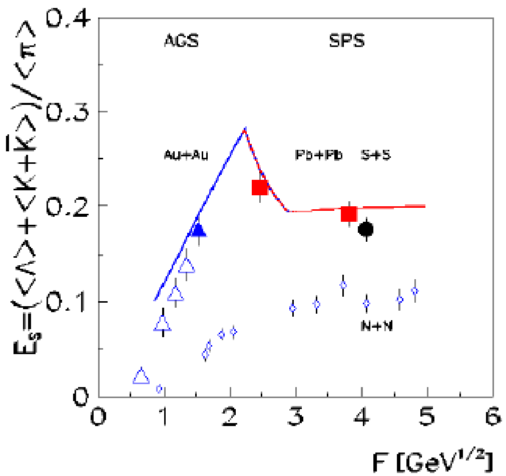
observables: event-by-event fluctuations

Motivation-Strangeness

Unique maximum in AA



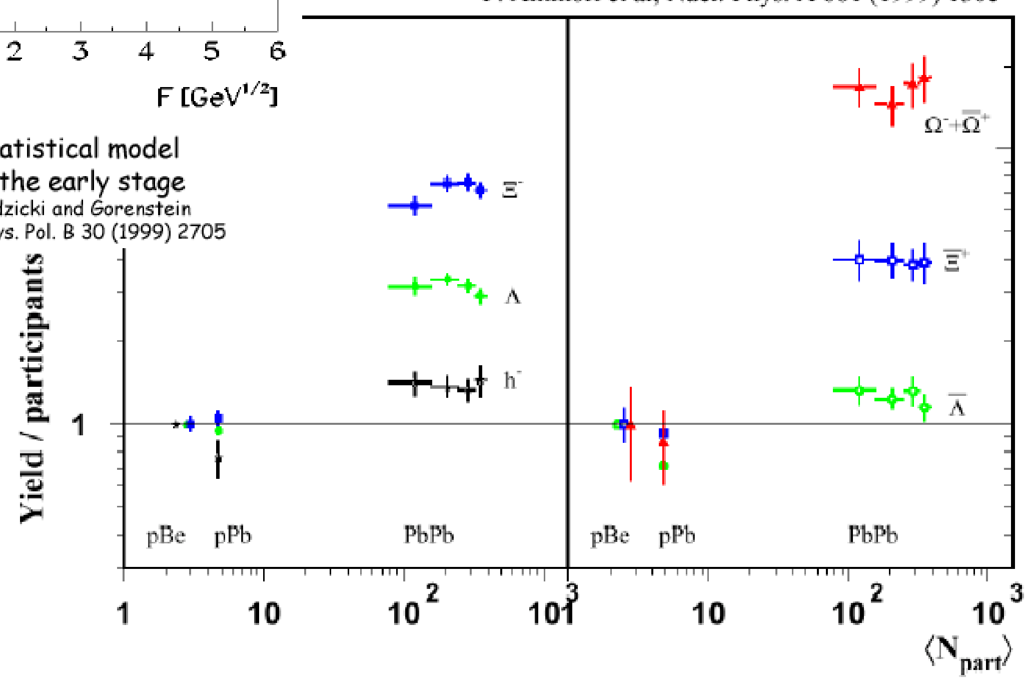
Statistical hadron gas model
P. Braun-Munzinger et al.
Nucl. Phys. A 697 (2002) 902



Statistical model
of the early stage
Gazdzicki and Gorenstein
Acta Phys. Pol. B 30 (1999) 2705

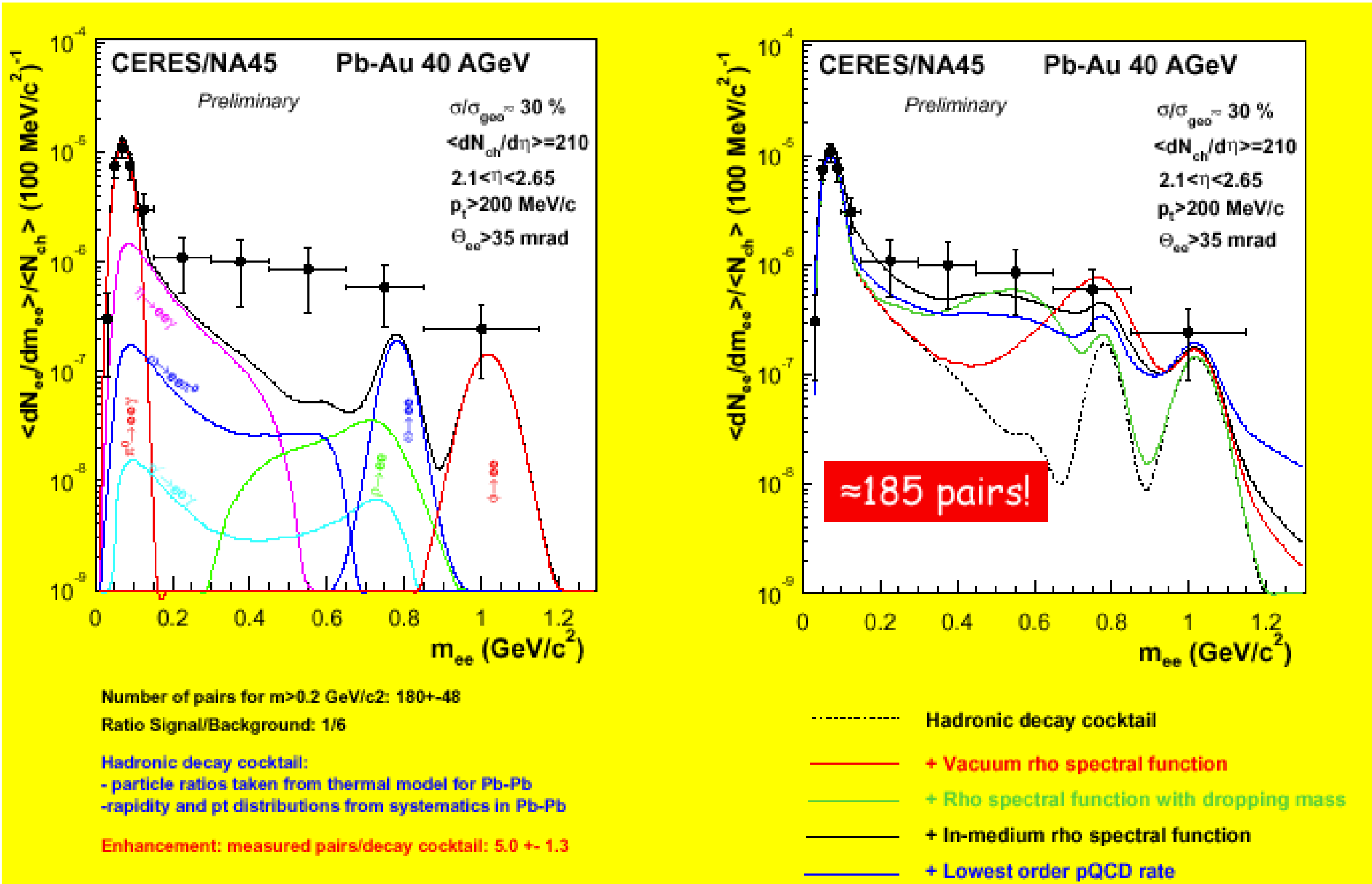
QGP already at 30A GeV?

F. Antinori et al, Nucl. Phys. A 661 (1999) 130c

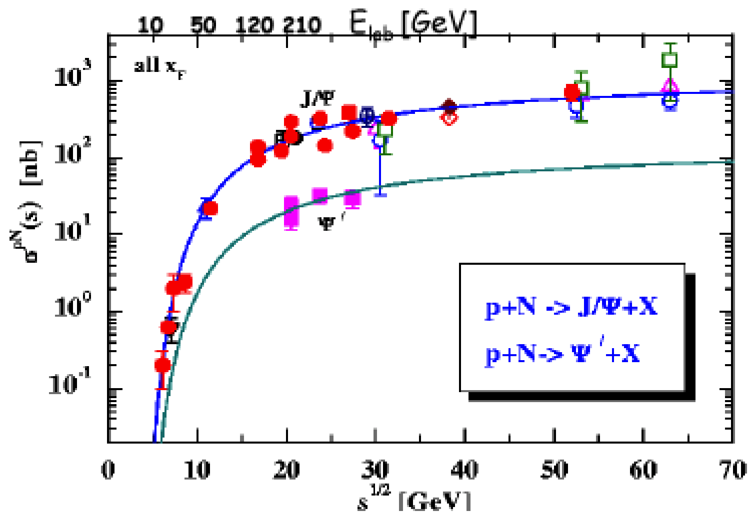


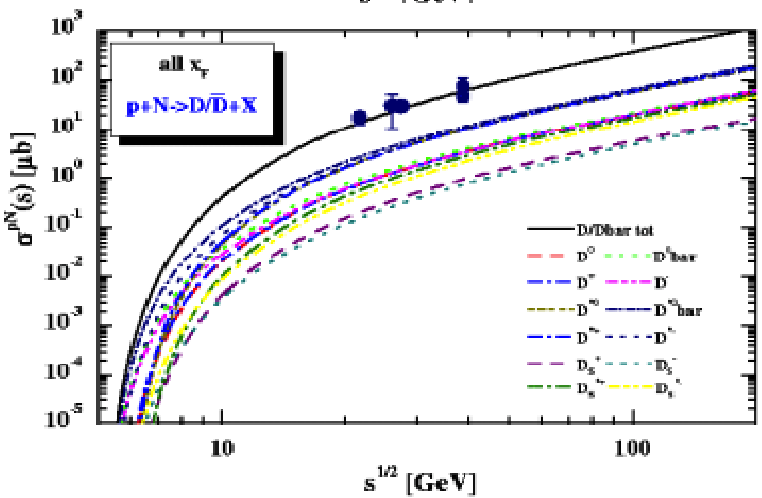
When this enhancement of hyperons starts?

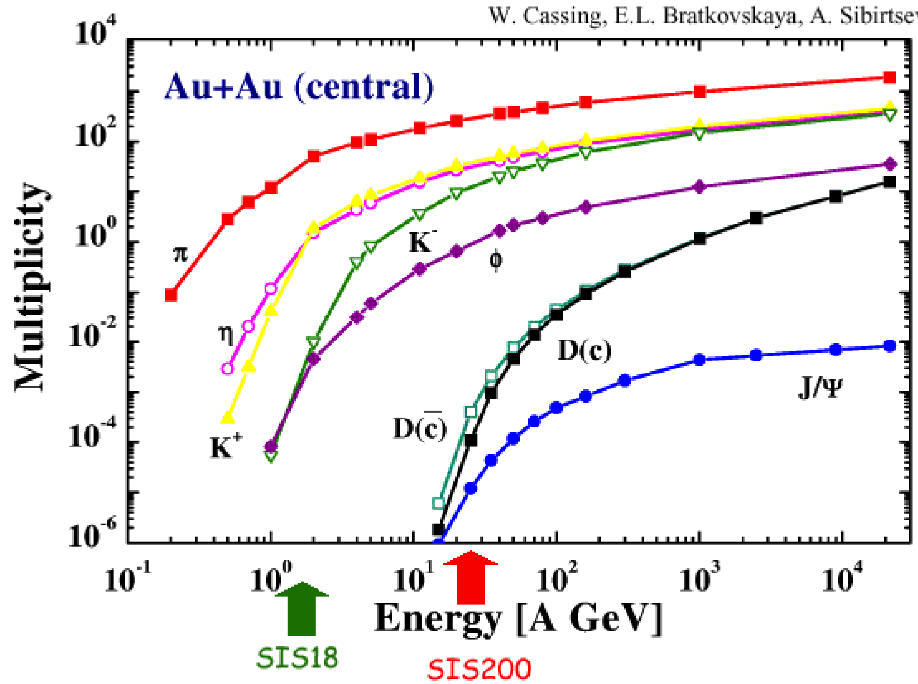
Motivation-e^+e^- pair



Motivation-Charm



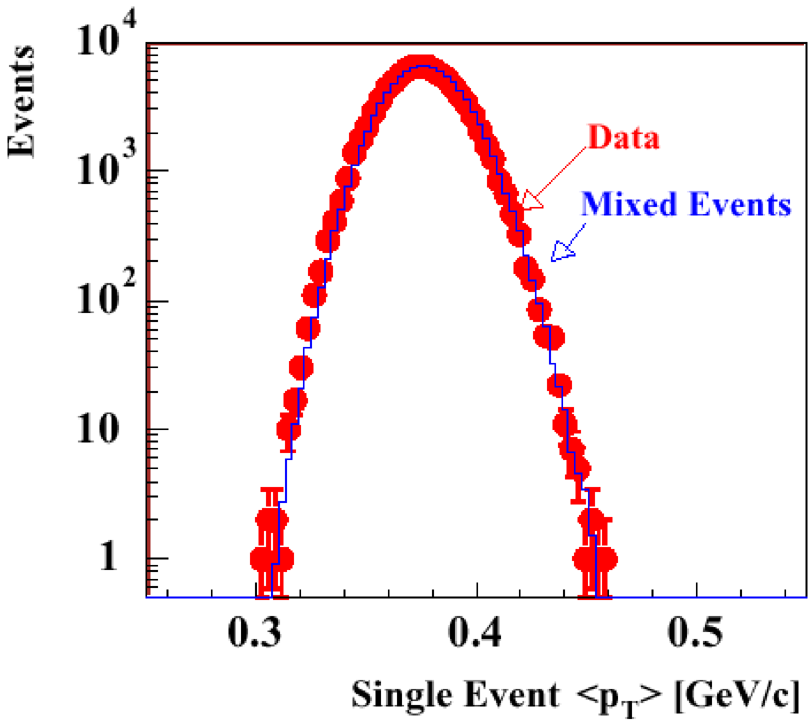


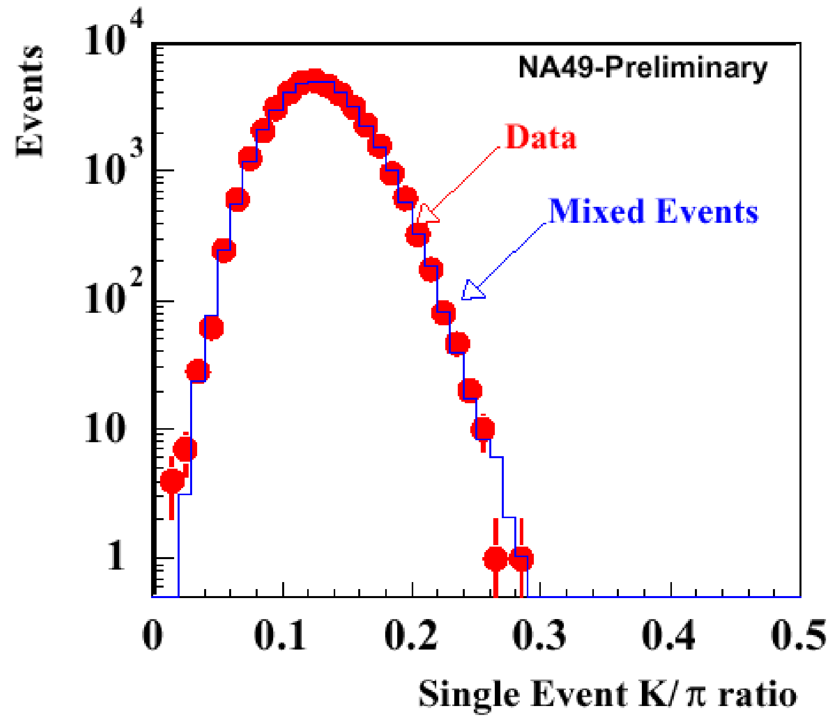


- SIS18: strangeness production near threshold (1–3 n_0)
- SIS200: charm production near threshold (5–10 n_0)
- In-medium effects

Motivation-Event-by-event Fluctuations

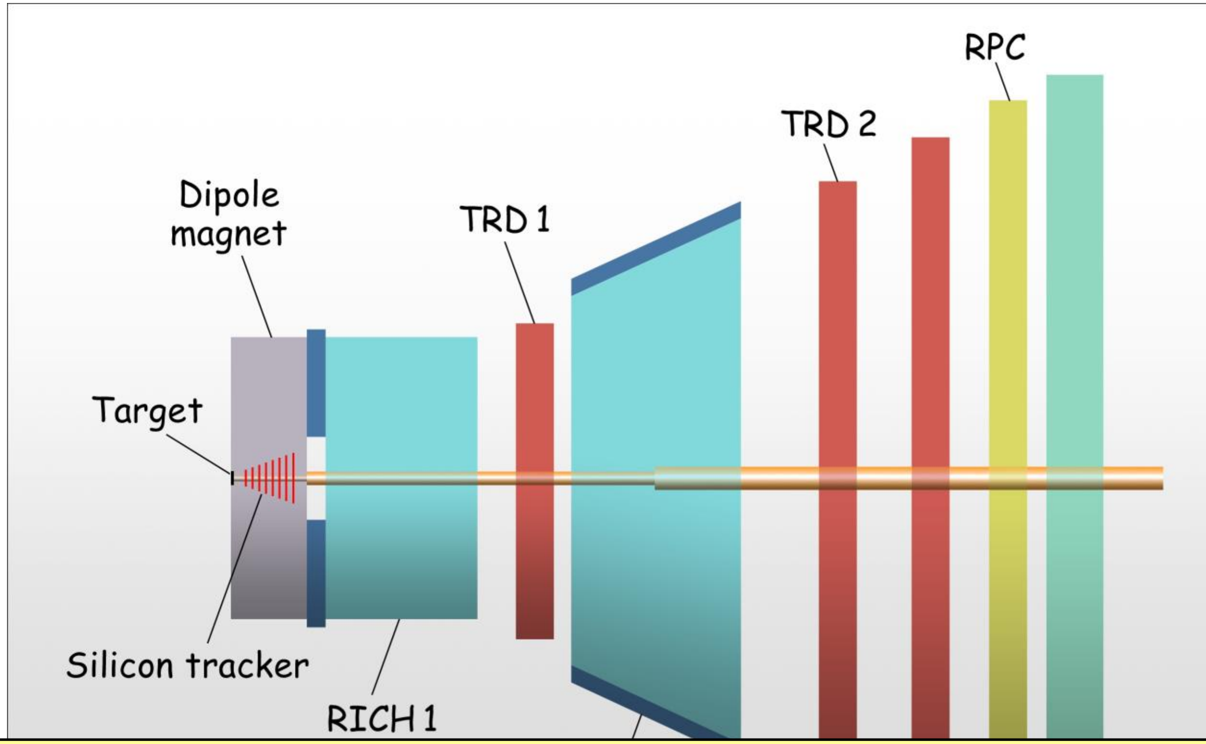
NA49: 5% most central Pb+Pb collisions at 158A GeV





At the critical point:
Large density fluctuations,
critical opalescence

How? – CBM Detector



Radiation hard silicon pixel/strip detectors in a magnetic dipole field

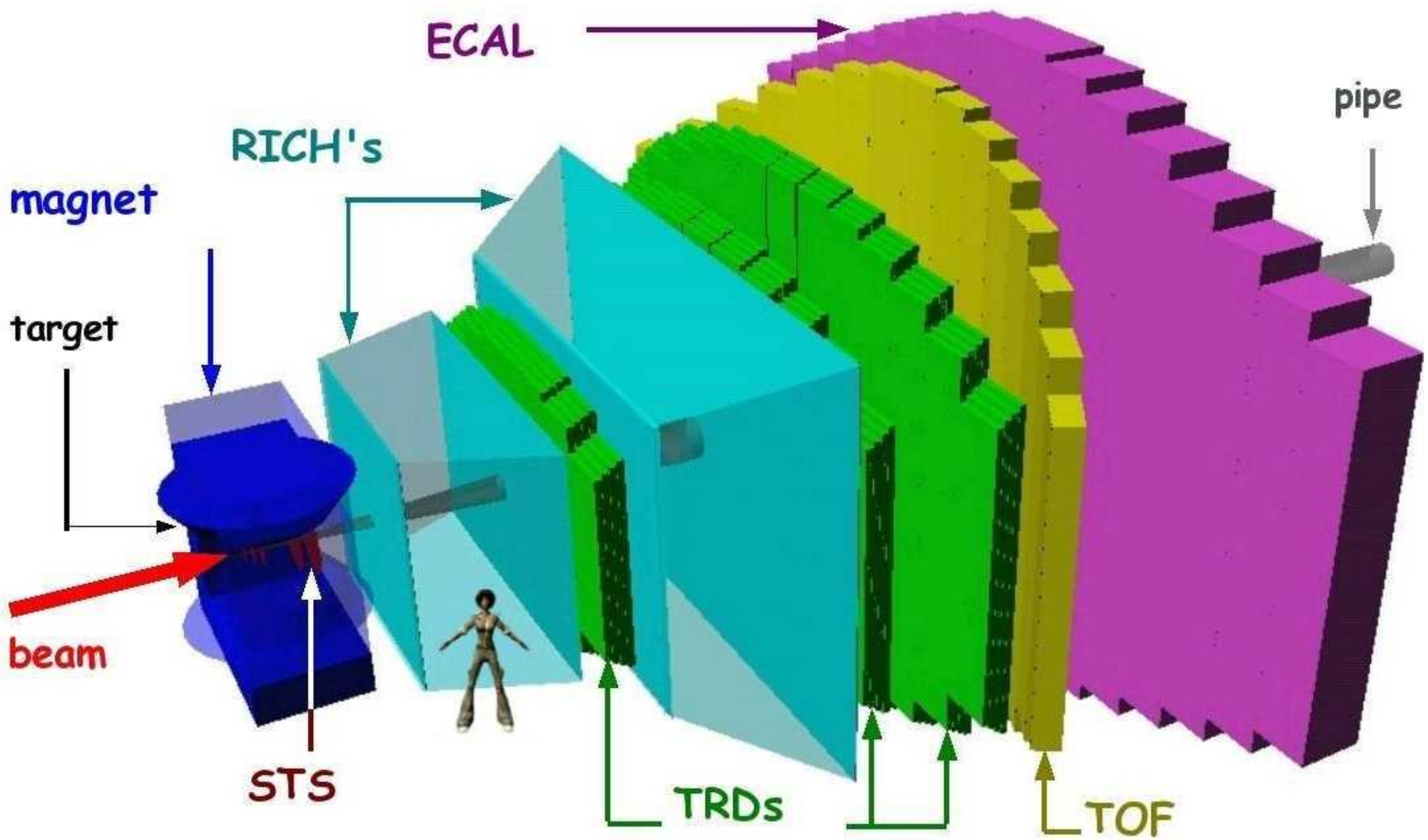
Electron identification: RICH & TRD & ECAL for the pion suppression up to 10^5

Hadron identification: RPC, RICH

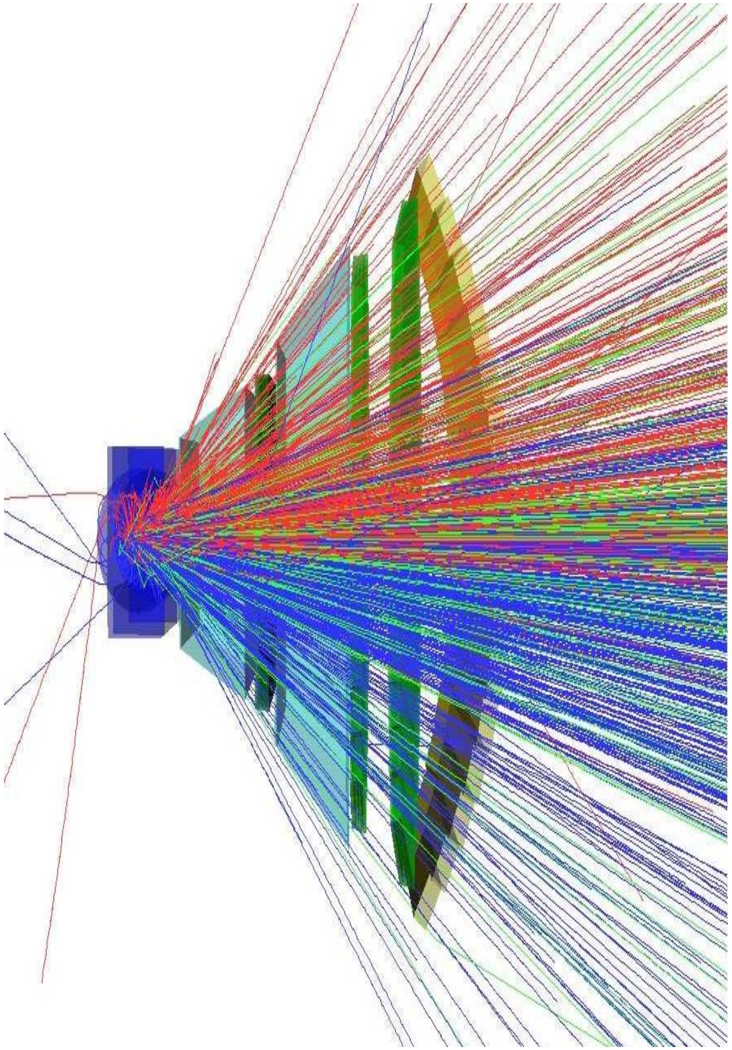
Measurements of photons, π^0, η, and muons: EM calorimeter (ECAL)

High speed data acquisition and trigger system

CBM Detector



Simulation

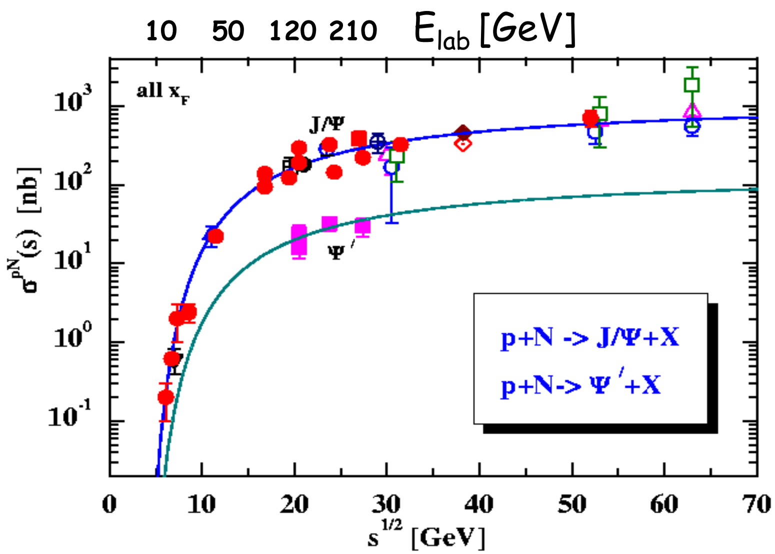


Central Au+Au at 25A GeV:
URQMD + GEANT4

160 p/400 π^-/400 π^+/44 K^+/13 K^-

J/Ψ Measurement

Collisions	25A GeV Au+Au	158A GeV Pb+Pb
J/ ψ multiplicity	$1.5\cdot10^{-5}$	$1\cdot10^{-3}$
beam intensity	$1\cdot10^{9}$/s	$2\cdot10^{7}$/s
interactions	$1\cdot10^{7}$/s (1%)	$2\cdot10^{6}$/s (10%)
central collisions	$1\cdot10^{6}$/s	$2\cdot10^{5}$/s
J/ψ rate	15/s	200/s
6% J/$\psi \rightarrow e^+e^-$ ($\mu^+\mu^-$)	0.9/s	12/s
spill fraction	0.8	0.25
acceptance	0.25	$\approx$ 0.1
J/ψ measured	0.17/s	$\approx$ 0.3/s
	$\approx 1\cdot10^{5}$/week	$\approx 1.8\cdot10^{5}$/week



Design

Hit rates for 10^7 minimum bias Au+Au collisions at 25A GeV:

	TRD 1 (D = 4 m)			**TRD 2** (D = 6 m)			**TRD 3** (D = 8 m)			**RPC** (D = 10 m)			**ECAL** (D = 12 m)		
Polar angle [mrad]	rates [kHz/ cm^2]	area [m^2]	N per cm^2 x 10^{-2}	rates [kHz/ cm^2]	area [m^2]	N per cm^2 x 10^{-2}	rates [kHz/ cm^2]	area [m^2]	N per cm^2 x 10^{-2}	rates [kHz/ cm^2]	area [m^2]	N per cm^2 x 10^{-2}	rates [kHz/ cm^2]	area [m^2]	N per cm^2 x 10^{-2}
50	140	0.25	6.3	62	0.5	2.6	35	1	1.6	22	1.5	1	15.5	2	0.65
100	62	1	4.4	27	2.3	2.0	15	4	1.1	10	6	0.7	6.8	9	0.5
200	25	4	1.1	11	9	0.5	6	16	0.28	4	25	0.2	2.8	36	0.13
300	12.5	8.6	0.6	5.5	19	0.25	3	34	0.14	2	54	0.09	1.4	76	0.06
400	6	16	0.3	2.7	36	0.13	1.5	64	0.08	1	100	0.05	0.7	144	0.03
500	4	24	0.2	1.8	54	0.09	1	96	0.05	0.6	150	0.03	0.45	216	0.02

CBM Collaboration

39 institutions, 14 countries

Croatia:
RBI, Zagreb

Cyprus:
Nikosia Univ.

Czech Republic:
Czech Acad. Science, Rez
Techn. Univ. Prague

France:
IReS Strasbourg

Germany:
Univ. Heidelberg, Phys. Inst.
Univ. HD, Kirchhoff Inst.
Univ. Frankfurt
Univ. Mannheim
Univ. Marburg
Univ. Münster
FZ Rossendorf
GSI Darmstadt

Hungaria:
KFKI Budapest
Eötvös Univ. Budapest

Korea:
Korea Univ. Seoul
Pusan National Univ.

Norway:
Univ. Bergen

Poland:
Krakow Univ.
Warsaw Univ.
Silesia Univ. Katowice

Portugal:
LIP Coimbra

Romania:
NIPNE Bucharest

Russia:
CKBM, St. Petersburg
IHEP Protvino
INR Troitzk
ITEP Moscow
KRI, St. Petersburg
Kurchatov Inst., Moscow
LHE, JINR Dubna
LPP, JINR Dubna
LIT, JINR Dubna
Obninsk State Univ.
PNPI Gatchina
SINP, Moscow State Univ.
St. Petersburg Polytec. U.

Spain:
Santiago de Compostela Univ.

Ukraine:
Shevshenko Univ. , Kiev
Univ. of Kharkov

Working Groups

R&D on fast gaseous detectors for TRD	JINR-LHE Dubna, GSI Darmstadt, Univ. Münster, PNPI St. Petersburg, NIPNE Bucharest
R&D on straw tube tracker (TRD)	JINR-LPP Dubna, FZR Rossendorf
R&D on Ring Imaging Cherenkov Detector (RICH)	IHEP Protvino, GSI Darmstadt, Pusan Nat. Univ., PNPI St. Petersburg
Design and construction of an electromagnetic calorimeter (ECAL)	ITEP Moscow, Univ. Krakow, Univ. Frankfurt
Diamond microstrip detector	GSI, Univ. Mannheim
Trigger and Data Acquisition	KIP Univ. Heidelberg, Univ. Mannheim, JINR LIT Dubna, GSI Darmstadt, Univ. Bergen, KFKI Budapest, Silesia Univ. Katowice, PNPI St. Petersburg, Univ. Warsaw
Design of a superconducting dipole magnet	JINR-LHE Dubna, GSI Darmstadt
Calculation of radiation doses	Kiev Univ.
Modification of HADES for 8 AGeV	Czech Acad. Science Rez
Delta electrons	GSI Darmstadt

Task	
Feasibility study D-Meson identification	
Feasibility study low-mass vector meso identification via electron-positron pairs	
Feasibility study charmonium identificat via electron-positron pairs	
Feasibility study charmonium identificat via muon pairs	
Simulations hadron identification via TO	
Simulation tools	
Tracking	KIP Univ. Heidelberg, Univ. Mannheim, JINR-LHE Dubna, JINR-LIT Dubna
Silicon Pixel Detector	IReS Strasbourg, Frankfurt Univ., GSI Darmstadt, RBI Zagreb, Krakow Univ.,
Silicon Strip Detector	Obninsk Univ., SINP Moscow State Univ., CKBM St. Petersburg, KRI St. Petersburg
R&D on RPC TOF detector system with read-out electronics	LIP Coimbra, Univ. Santiago de Compostela, Univ. Heidelberg, GSI Darmstadt, NIPNE Bucharest, INR Moscow, FZR Rossendorf, IHEP Protvino, ITEP Moscow, Korea Univ. Seoul, RBI Zagreb, Univ. Krakow, Univ. Marburg

Relativistic Heavy-Ion Accelerators

Accelerator	c.m. Energy (GeV)	Status
SIS18 (GSI, Germany)	**2A (A=mass number)**	Running
AGS (BNL, USA)	**5A**	Finished
SIS300 (GSI, Germany)	**8A**	Just approved; Plan to run from ~2012
SPS (CERN, Switzerland)	**20A**	Finish soon
RHIC (BNL, USA)	**200A**	Running since 2000
LHC (CERN, Switzerland)	**5500A**	Plan to run from ~2007