The HADES-at-FAIR project

Kirill Lapidus for the HADES Collaboration
Excellence Cluster Universe and TU Munich

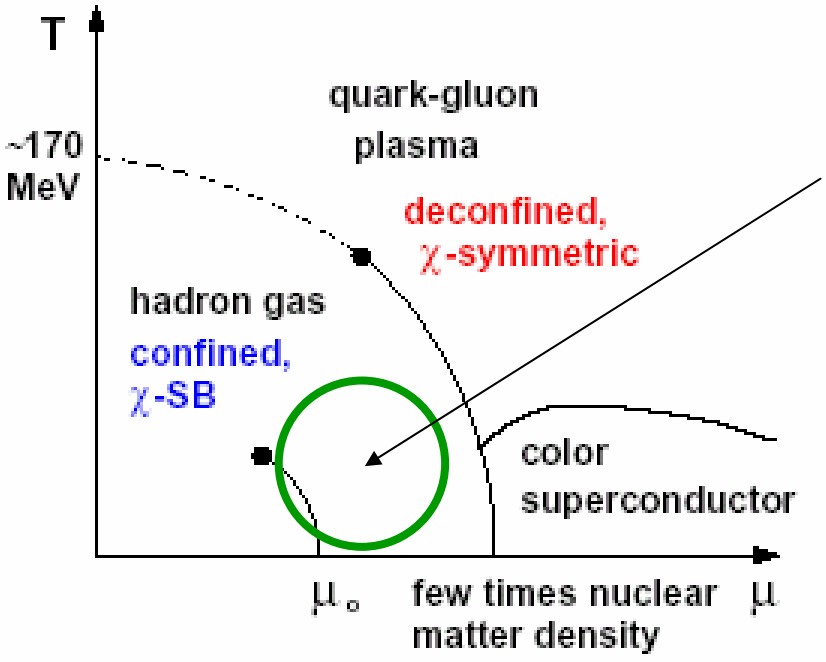
August 2010
JINR, Dubna

Present: the HADES experiment at SIS-18

Location: GSI, SIS-18, Darmstadt

Ultimate goal: study of the Chiral Symmetry Restoration at non-zero μ_B

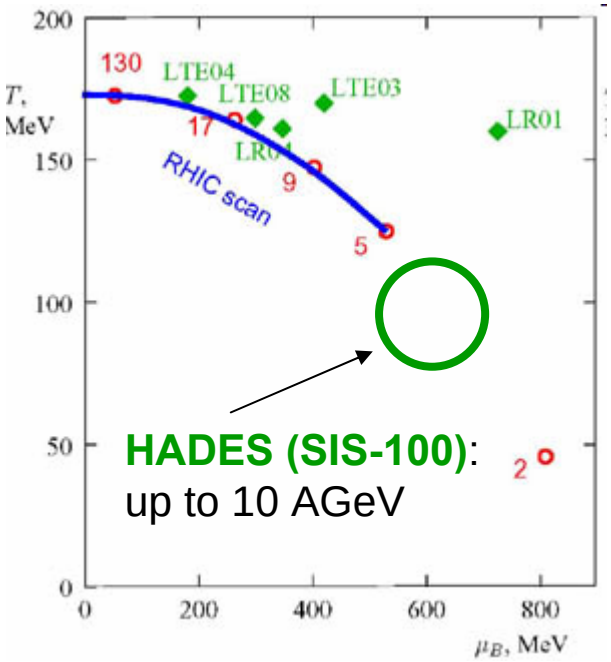
Program: di-electron and hadron measurements in elementary channels and heavy ion collisions, vector meson and baryon spectroscopy, hadron in-medium modifications

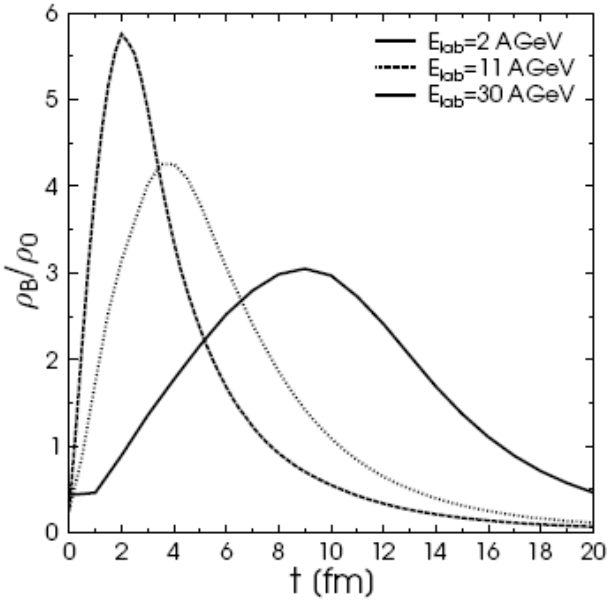


HADES (SIS18):
1-2 AGeV
ρ/ρ_N = 1-3
T < 80 MeV
"resonace matter"

Future: HADES at SIS-100

- **Measurements at beam energies up to 10 AGeV – unexplored range for dilepton experiment**
- **Environment characterized by higher baryonic densities: up to ρ/ρ_N = 4**

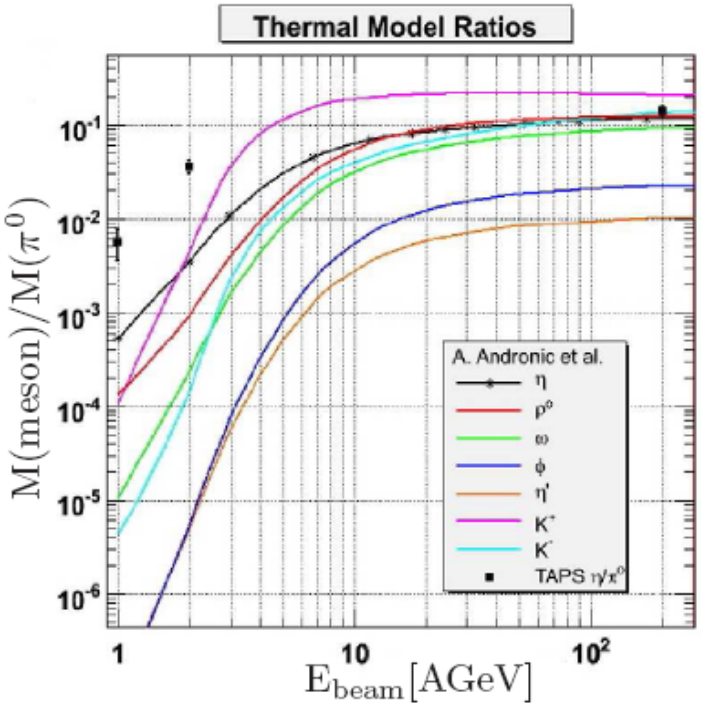




S. Vogel et al.
Phys.Rev.C78:044909,2008.

HADES at SIS-100

- 2 orders of magnitude higher vector meson yield as compared to SIS-18
- favourable conditions to study spectral functions of VM
- bridge to CBM, CERES and NA60 measurements
- high statistics – (multi)differential measurements

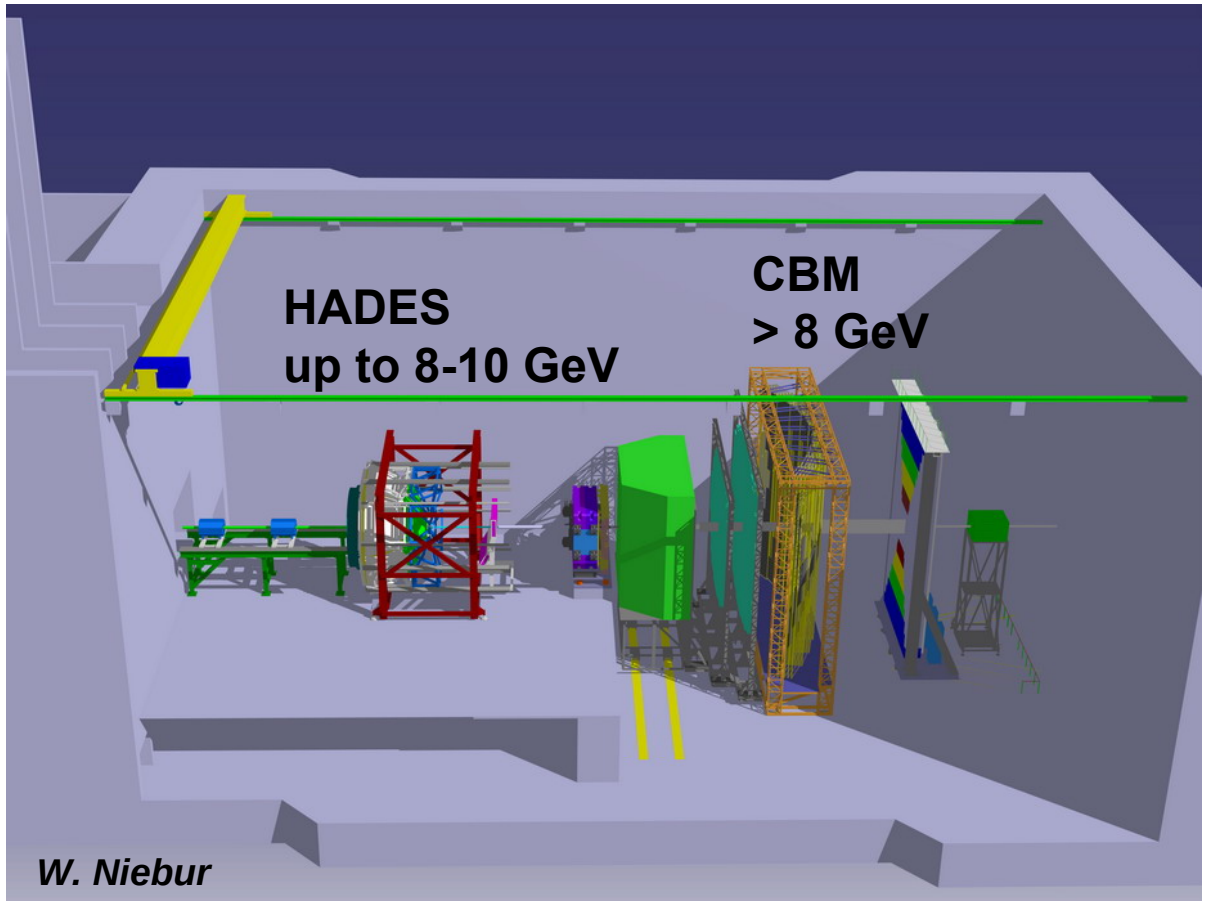


Detector features for the SIS-100

- Running experiment, well understood performance
- Can deliver high quality data
- Setup tests with coming heavy-ion runs at SIS-18
- Upgrade improved stability, DAQ and time resolution of the Spectrometer

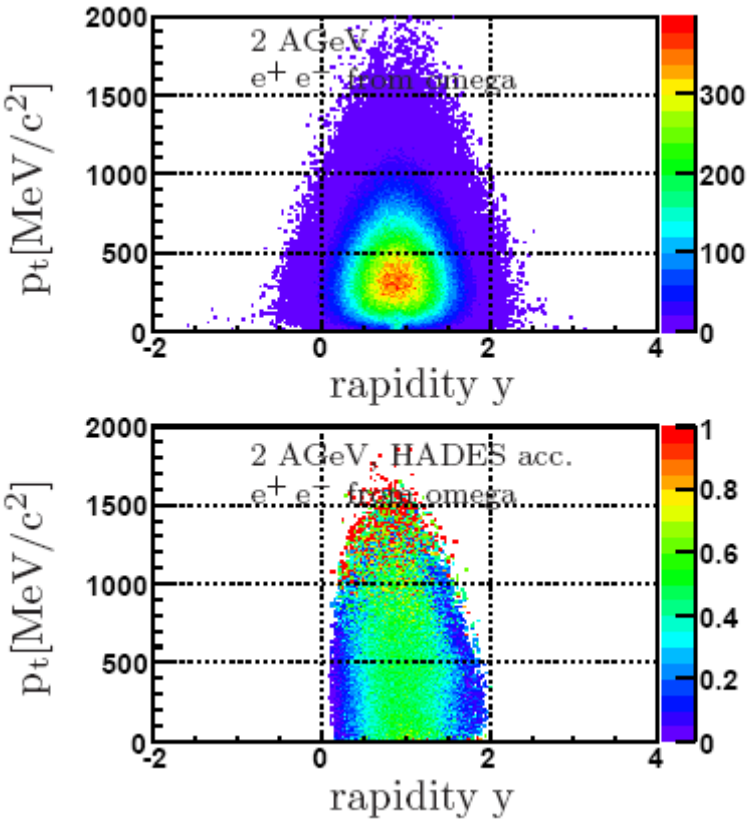
HADES and CBM in the cave

HADES in front of CBM



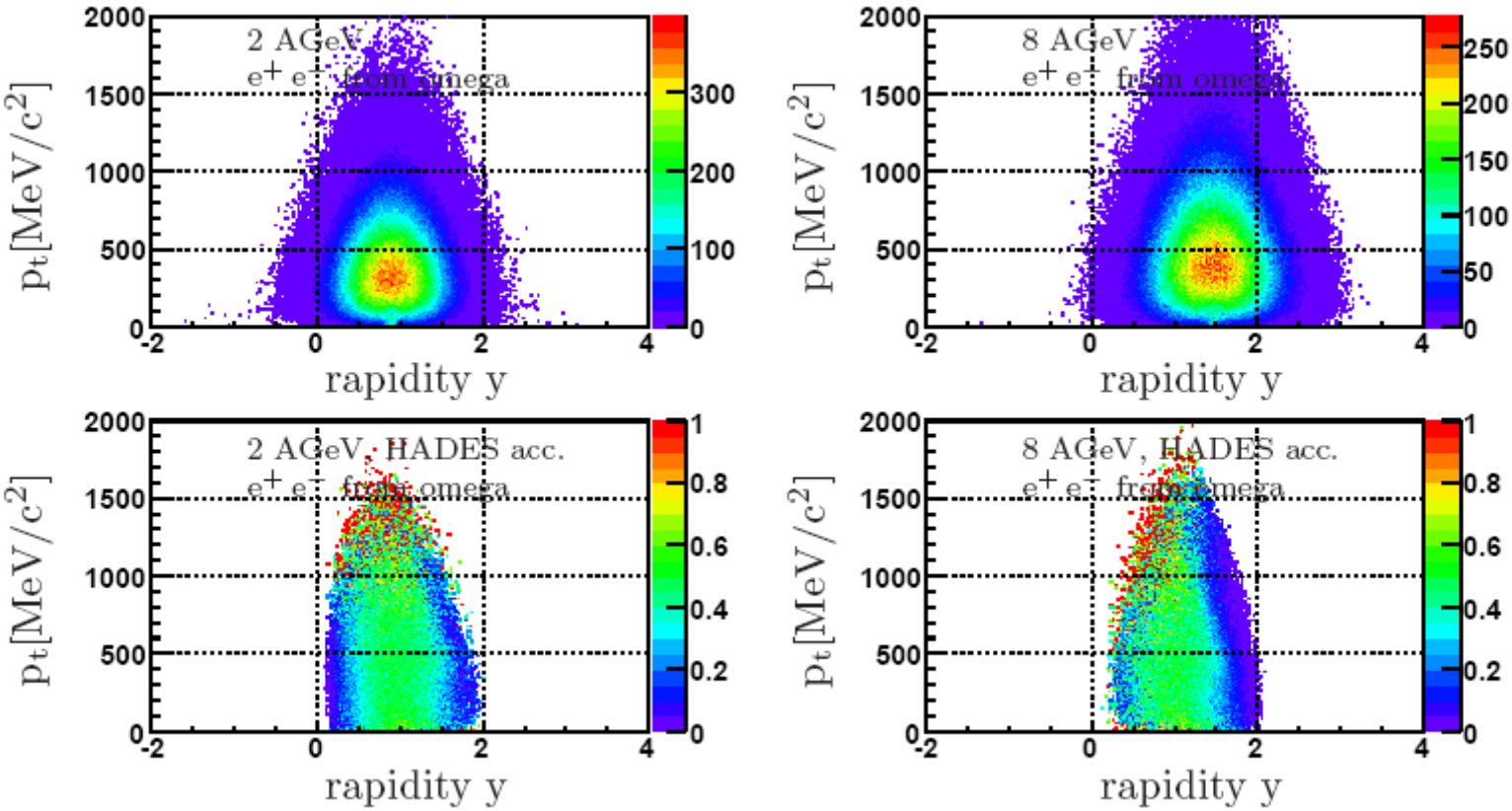
HADES acceptance for dielectrons at SIS-100: ω direct decays

Estimation of the acceptance for di-electrons from $\omega \rightarrow e^+e^-$



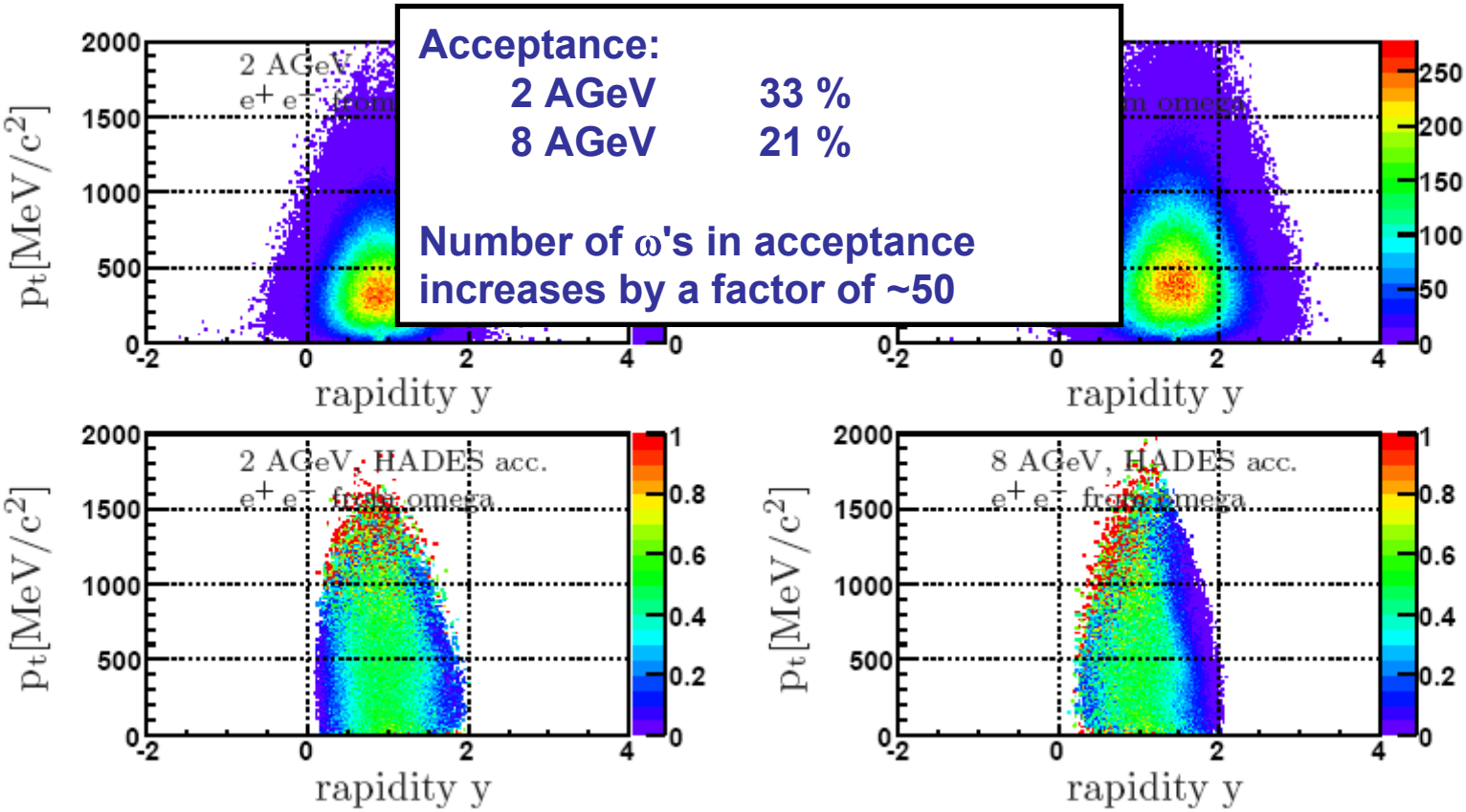
HADES acceptance for dielectrons at SIS-100: ω direct decays

Estimation of the acceptance for di-electrons from $\omega \rightarrow e^+e^-$



HADES acceptance for dielectrons at SIS-100: ω direct decays

Estimation of the acceptance for di-electrons from $\omega \rightarrow e^+e^-$



Dielectron invariant mass spectra at SIS-100

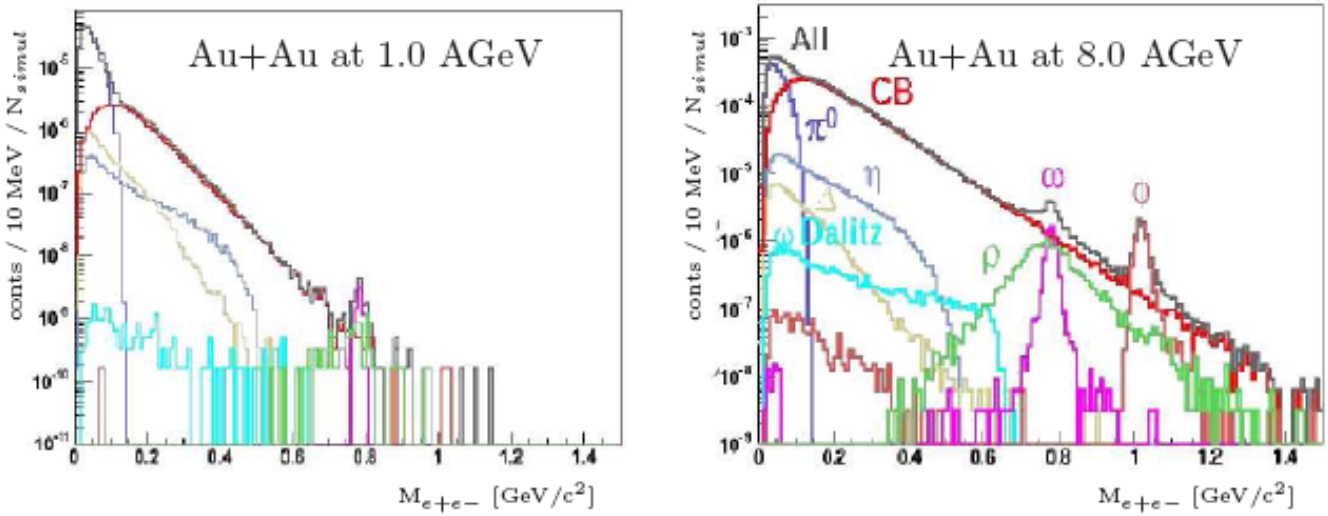
Simulated di-electron invariant mass spectra Au+Au 1 AGeV and 8 AGeV

Single leptons filtered with HADES acceptance, lepton momenta smeared

Larger yield of vector mesons:

ω(8AGeV)/ω(2AGeV) = 29

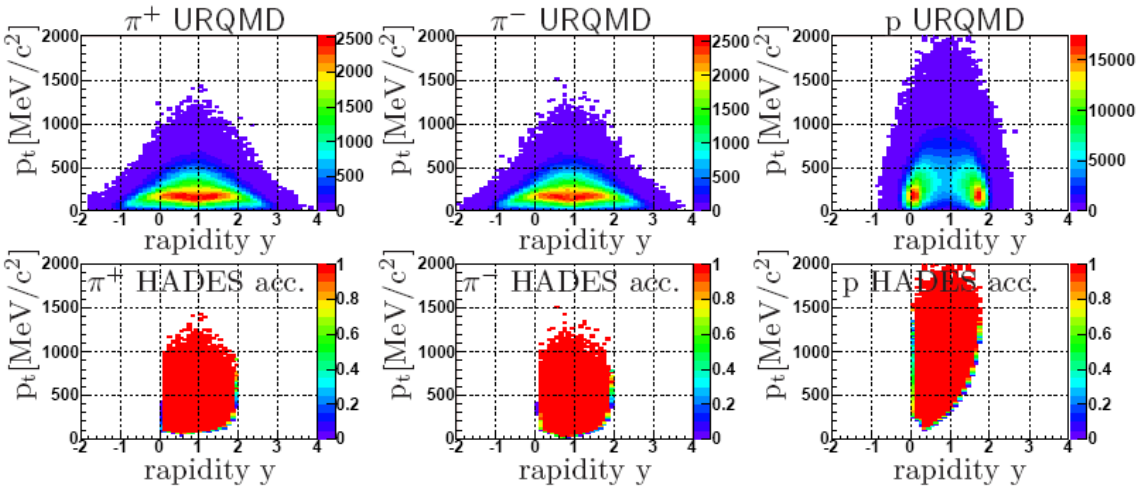
φ(8AGeV)/φ(2AGeV) = 73



HADES acceptance for hadrons at SIS-100

C + C 2 AGeV

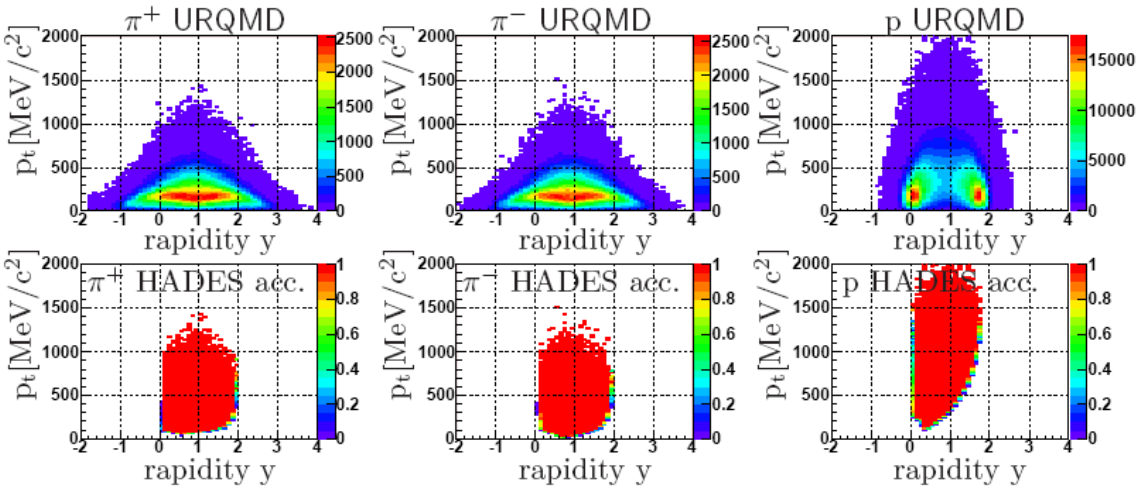
URQMD events filtered with HADES acceptance



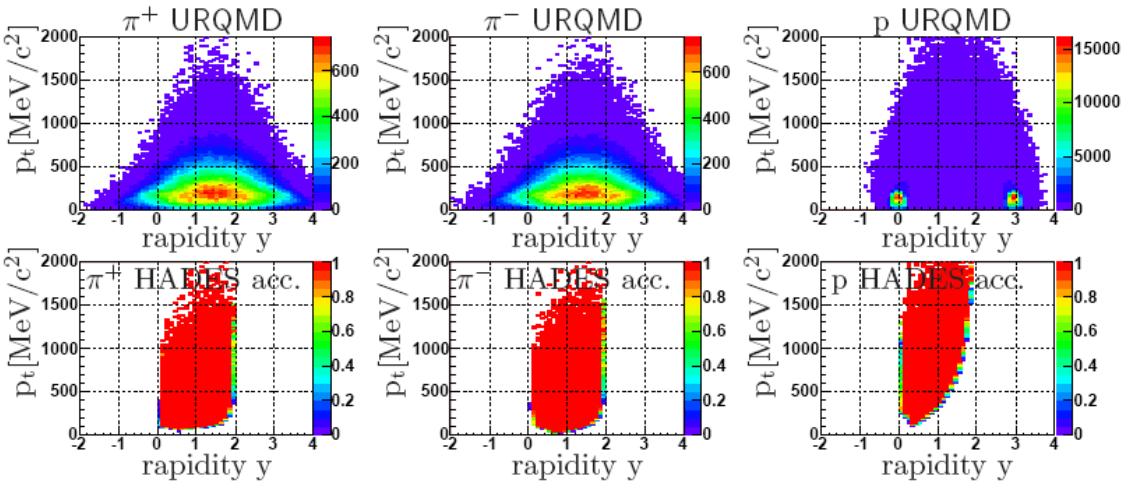
HADES acceptance for hadrons at SIS-100

C + C 2 AGeV

URQMD events filtered with HADES acceptance



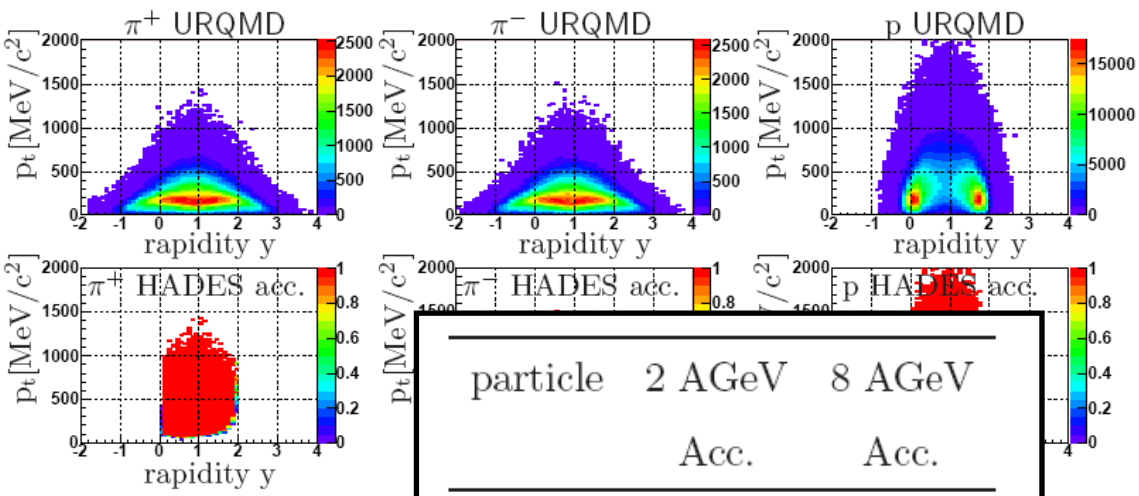
C + C 8 AGeV



HADES acceptance for hadrons at SIS-100

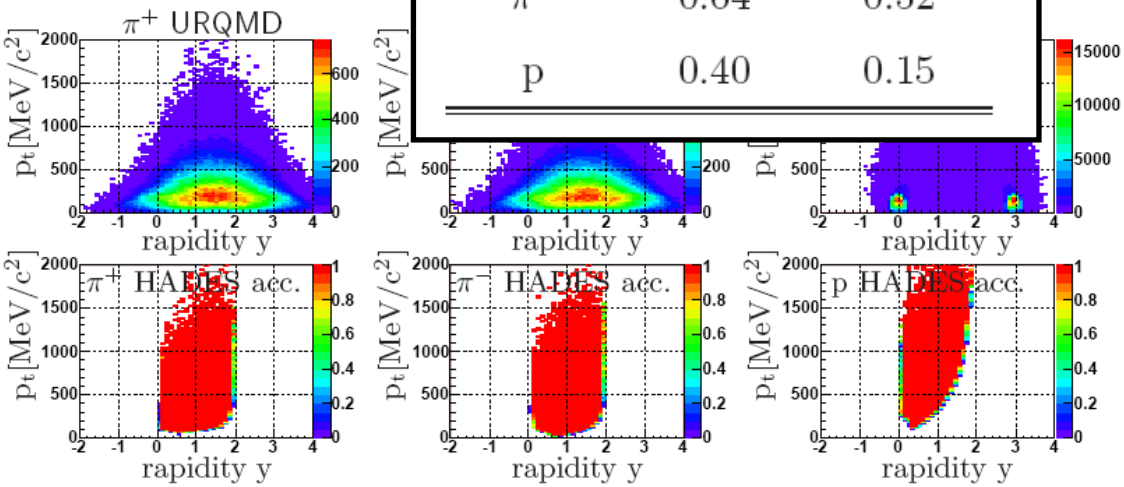
URQMD events filtered with HADES acceptance

C + C 2 AGeV



particle	2 AGeV Acc.	8 AGeV Acc.
π^+	0.63	0.50
π^-	0.64	0.52
p	0.40	0.15

C + C 8 AGeV

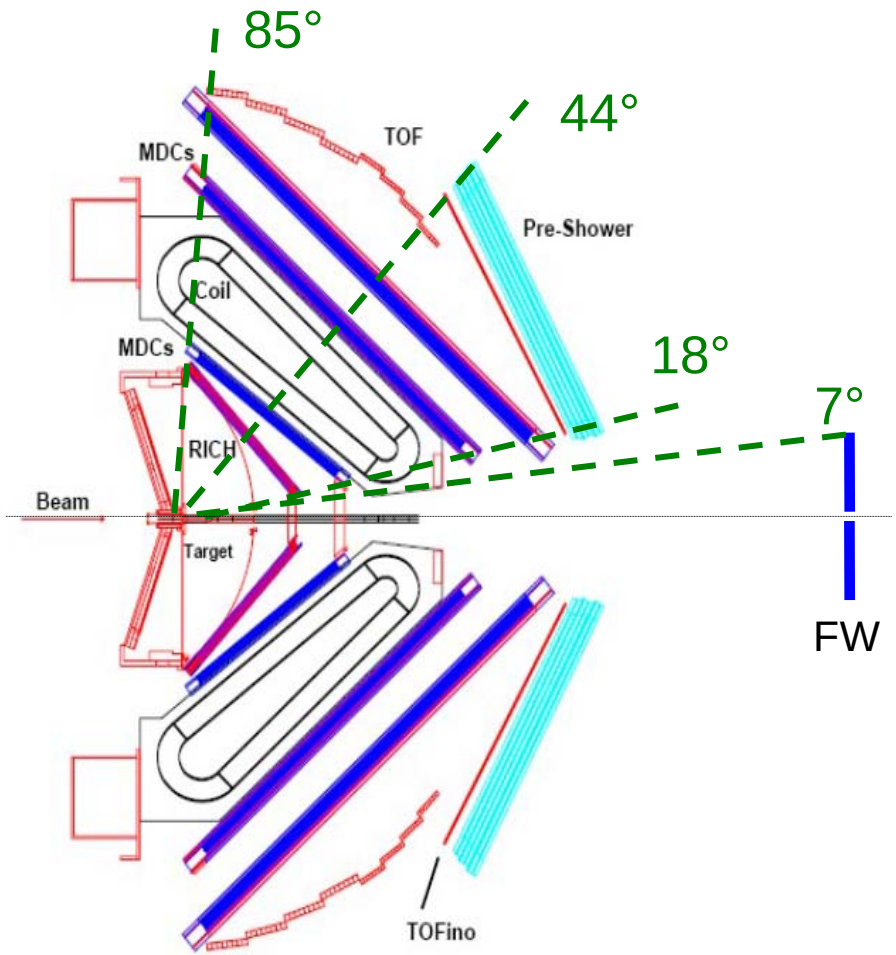


The HADES upgrade project

- **Ready for SIS-18 heavy systems and for SIS-100**

- Cope with multiplicities of Au+Au 1.5 AGeV
- Accept up to 20 KHz trigger rate

- Reaction plane and centrality determination: Forward Hodoscope
- New high-granularity RPC instead of TOFINO
- DAQ upgrade (new Trigger and Read-out Board)
- New Plane I of Tracking Chambers



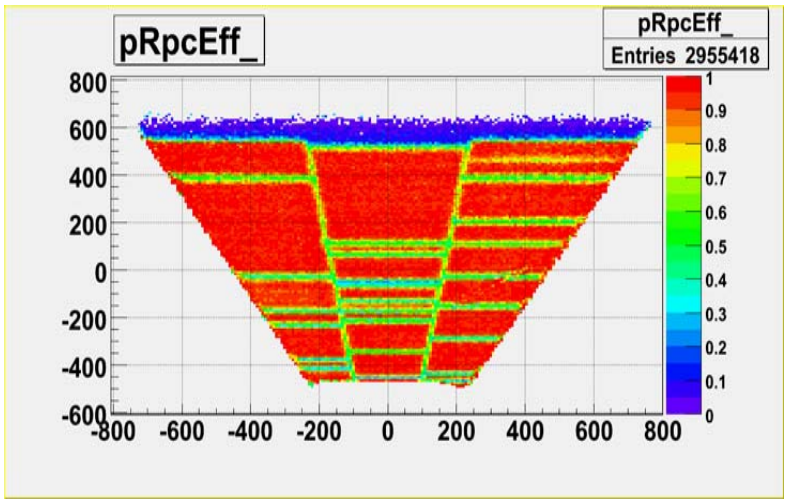
Upgrade of the TOF system: high granularity RPC wall

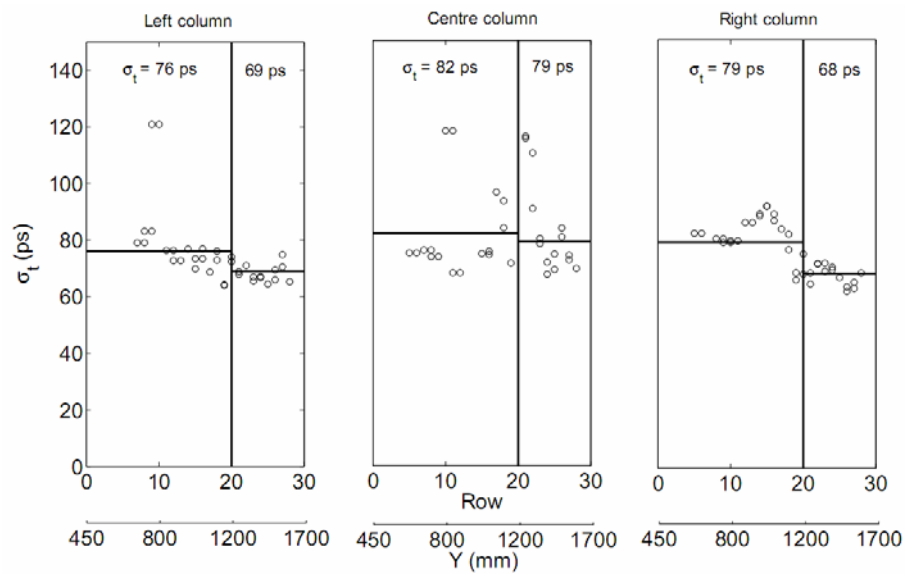
- **Two-layer design**
- **186 channels per sector**

Time resolution

System average: 73 ps σ

Efficiency

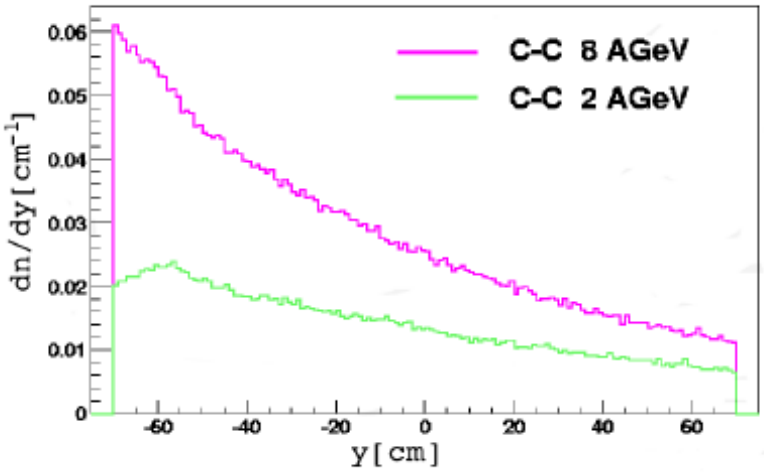


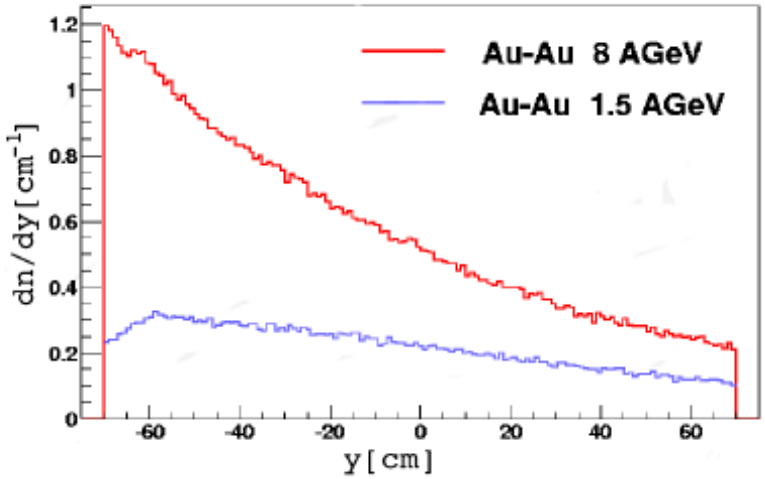


Charged particle occupancy at 8 AGeV

Central Au+Au at 1.5 AGeV and 8 AGeV, C+C at 2.0 AGeV and 8 AGeV
From C+C at 2.0 AGeV → Au+Au at 1.5 AGeV (SIS18) - factor of 14

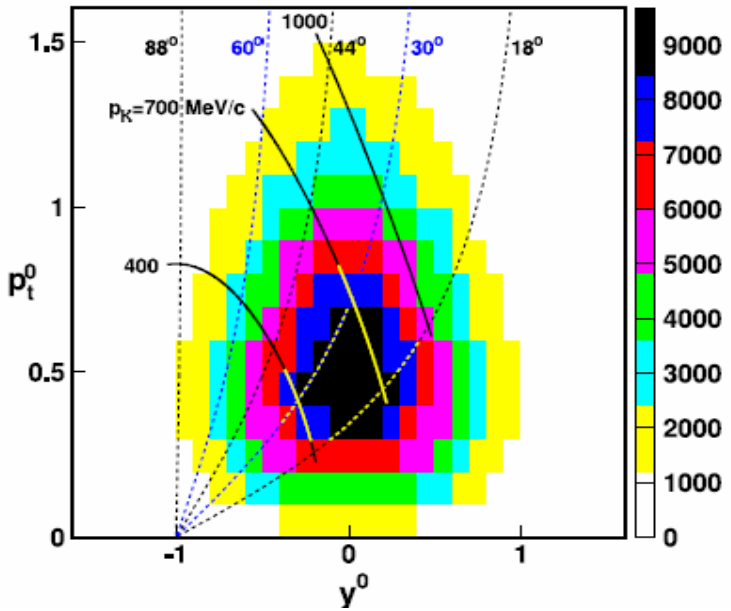
At Au+Au at 1.5 AGeV expected 20% double hit probability
Charged particle multiplicity corresponds
to Ni+Ni (A = 58) at 8 AGeV – **the heaviest possible system at SIS-100**



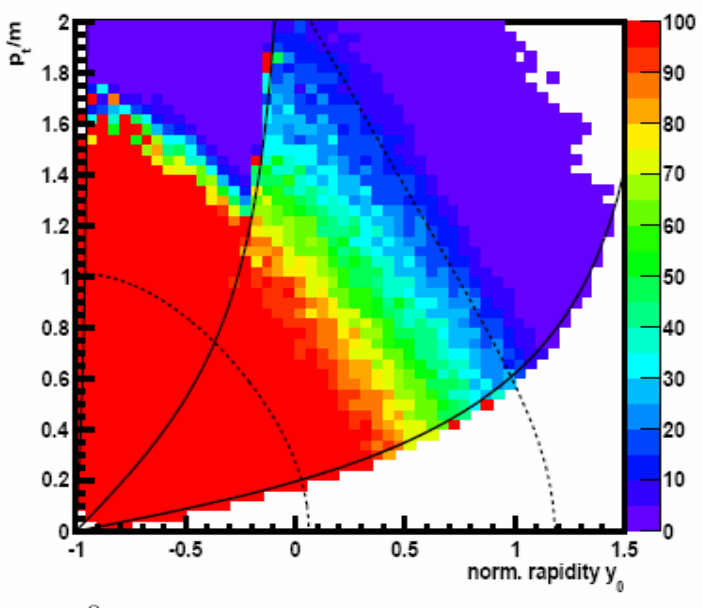


Simulation: K^- acceptance and purity for Ag+Ag 1.65 AGeV

Acceptance

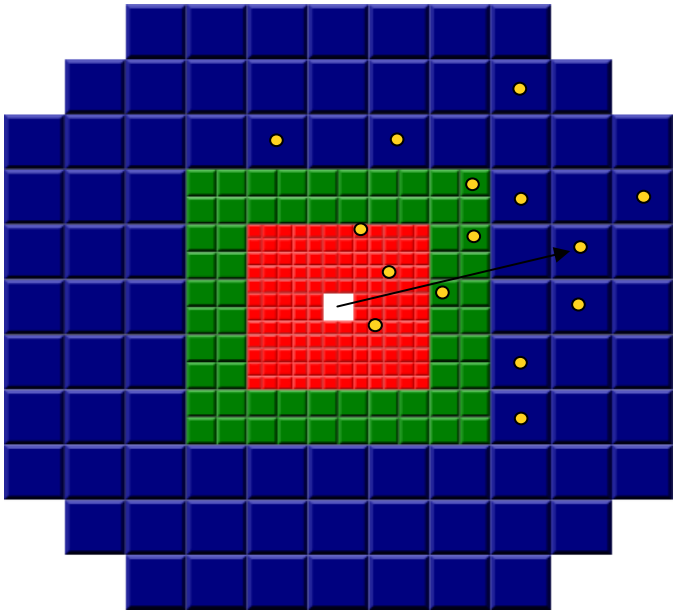


Purity (no dE/dx used)



- large acceptance: midrapidity coverage
- very good K^- purity up to p_t < 800 MeV/c

Forward Wall Hodoscope



- 280 channel Scintillator hodoscope located 5-7 m from the target
- Already used in 2007 pp and dp runs
- Reaction plane and centrality determination → kaon flow measurements

Reaction plane determination:

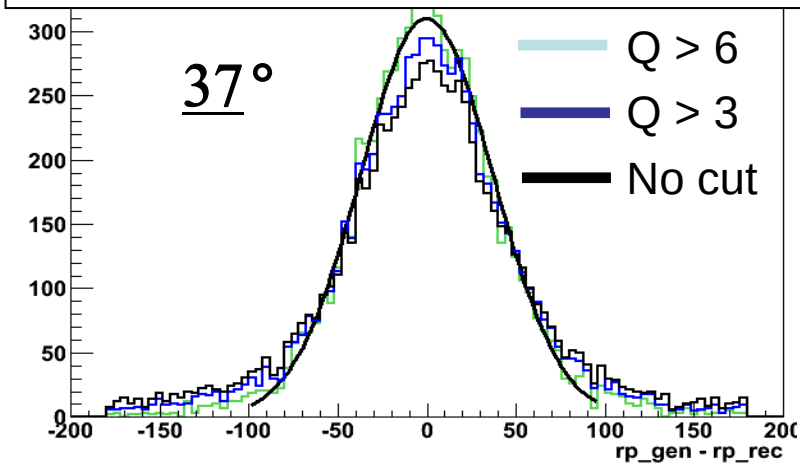
$$\vec{Q}_{RP} = \sum_i \vec{e}_i, \quad \vec{e}_i = \frac{\vec{r}_i}{|\vec{r}_i|};$$

with weights: $\vec{Q}_{RP} = \sum_i Z_i \vec{e}_i.$

$$Q = \left|\vec{Q}_{RP}\right|$$

simulation

Au + Au 1.25 AGeV 5 < b < 10



Electromagnetic Calorimeter for HADES

Motivation:

1) neutral meson measurement

π^0 for normalization,

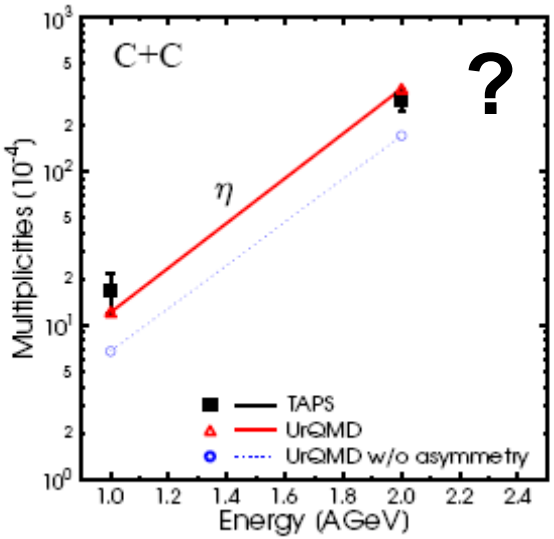
η — dominating cocktail component

2) better e/π separation at high momenta

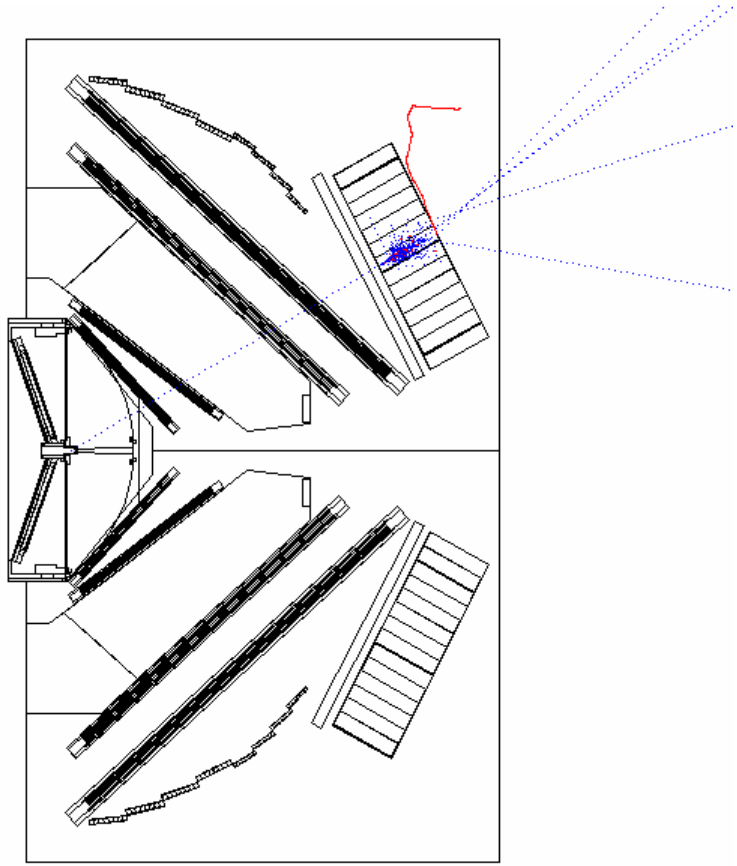
p > 400 MeV/c

η yield: 1-2 AGeV — TAPS data

No data at higher energies — only models



Planned as a substitute for the SHOWER detector



Electromagnetic Calorimeter for HADES

Lead glass modules from OPAL end cap calorimeter.
~ 900 modules needed, 1080 modules moved to GSI.

Module dimensions:
42 x 9 x 9 cm

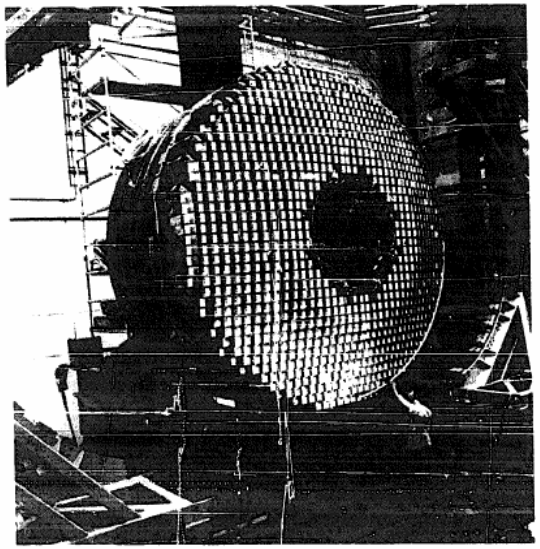
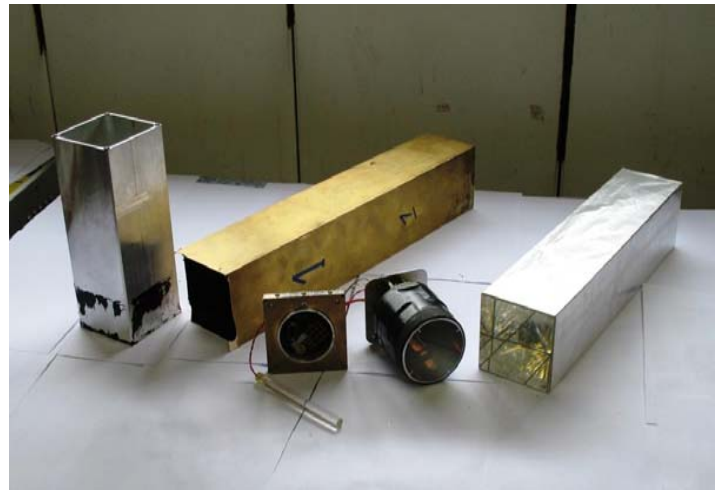


Fig. 3. A complete OPAL end cap electromagnetic calorimeter consisting of two Dees, mounted on the OPAL magnet pole piece.

Nucl. Instr. Meth. A290, 76 (1990)



Lead glass type: CEREN 25

Energy resolution (crystal + PMT) ~ 5%/√E, E in GeV

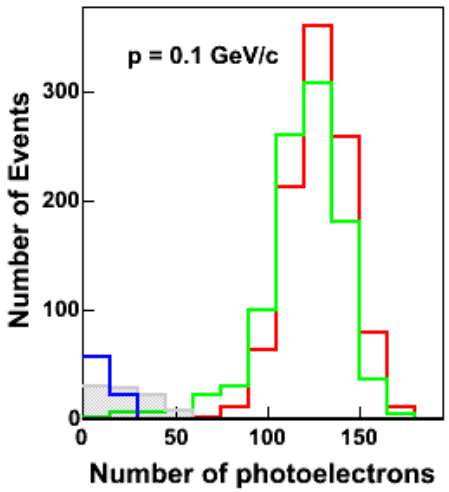
Simulation of the e/π separation with the Calorimeter

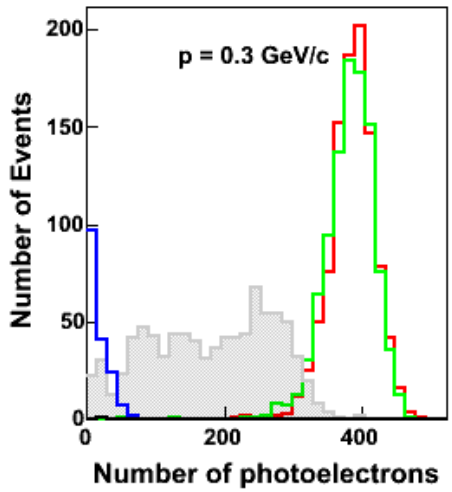
e
γ
π
p
n

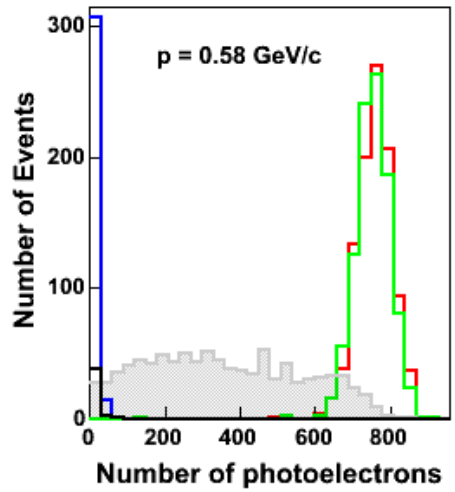
Cherenkov thresholds

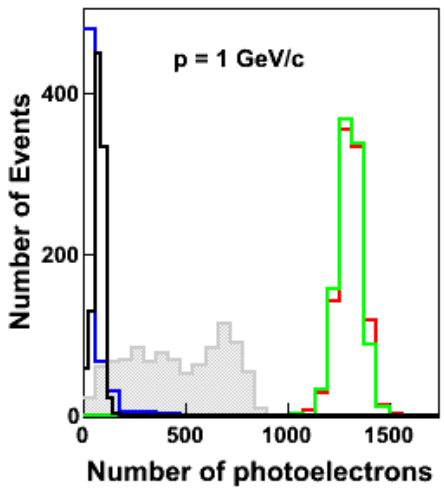
P_π = 98 MeV/c

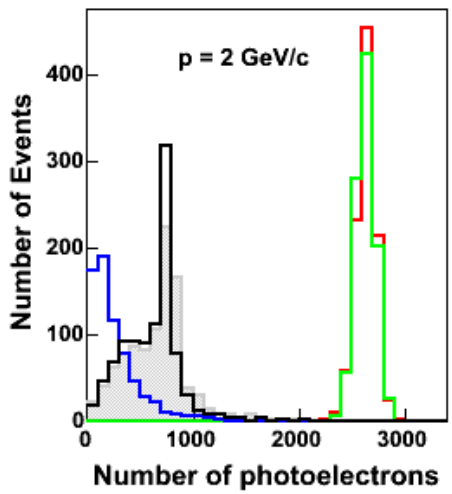
P_p = 700 MeV/c

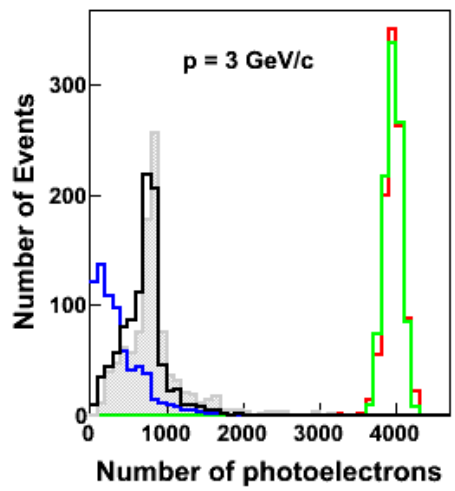










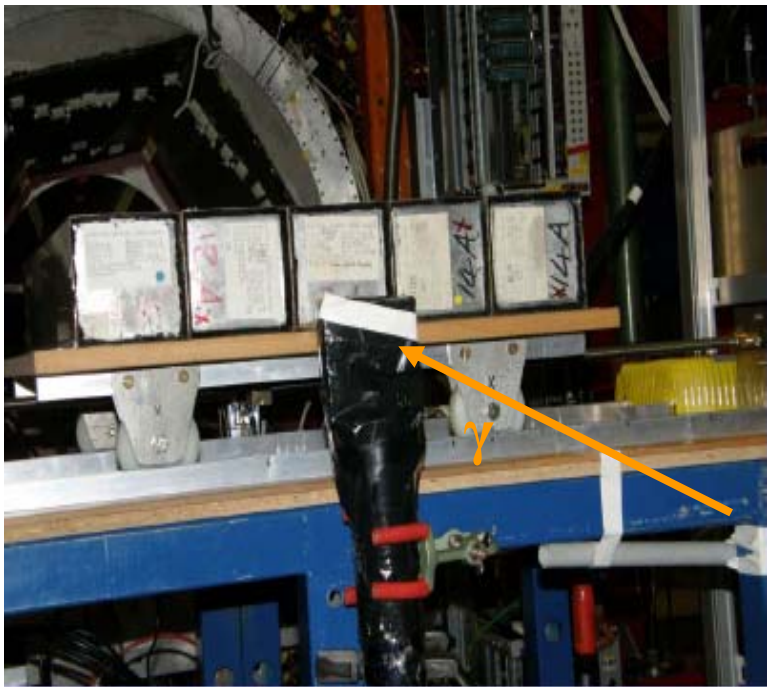


The e/π separation: experimental results

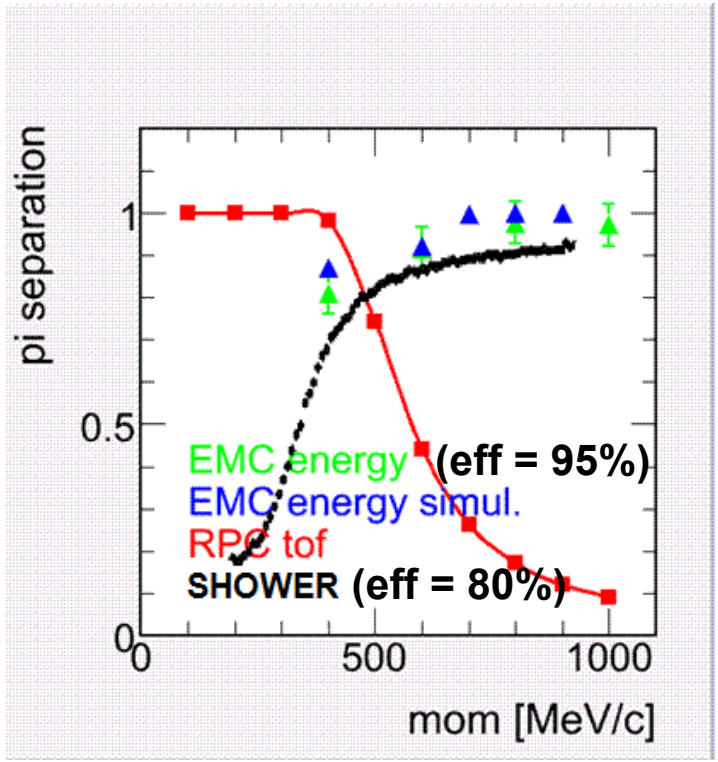
Dedicated beam tests:

γ-beam MAMI 2009

π-beam CERN 2010



Significant improvement of the e/π separation for the p > 400 MeV/c (at higher efficiency)

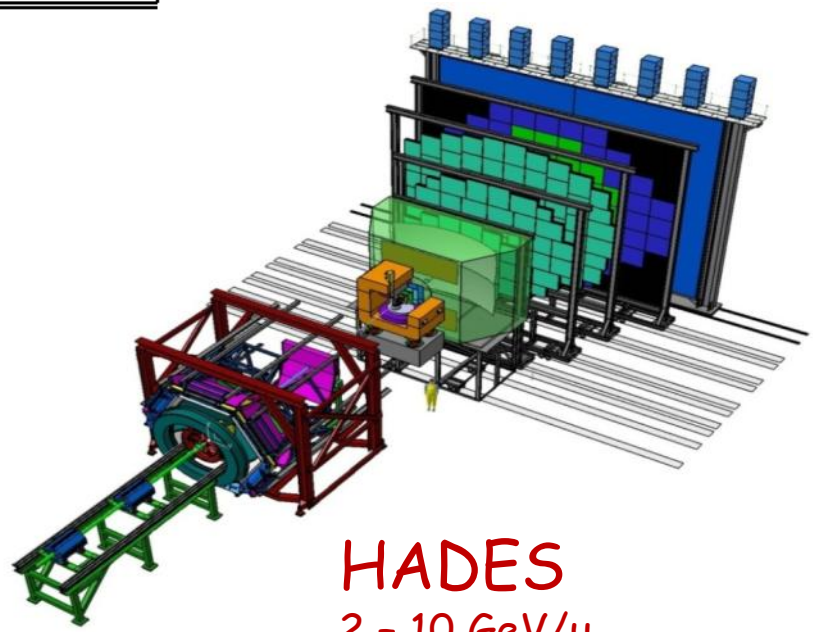


Proposed experiments at SIS-100

Experiment	Energy [AGeV]	intensity [part./sec.]	duration
p+p	8, 10	$5.0{\cdot}10^8/s$	2×2 weeks
C+C	4, 10	$2.0{\cdot}10^7/s$	2×2 weeks
Ca+Ca	4, 10	$6.0{\cdot}10^6/s$	2×2 weeks
Ni+Ni	4, 10	$4.0{\cdot}10^6/s$	2×2 weeks

- **Elementary collisions as a reference**
- **Systematic investigation of light and heavy ion collisions**

CBM
10 – 45 GeV/u



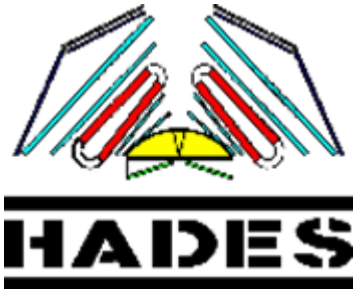
HADES
2 – 10 GeV/u

Summary

- The HADES experiment at SIS-100
  - High-quality systematic dielectron and hadron measurements in the unexplored energy range
  - Abundant vector mesons at high baryonic densities
  - High acceptance up to 10 AGeV

- Upgrade for SIS-100 already available at SIS-18
  - High-granularity RPCs
  - New DAQ system — up to 20 kHz rates
  - New MDC plane I
  - Forward Hodoscope for reaction plane and centrality determination

- Ongoing development of the electromagnetic calorimeter

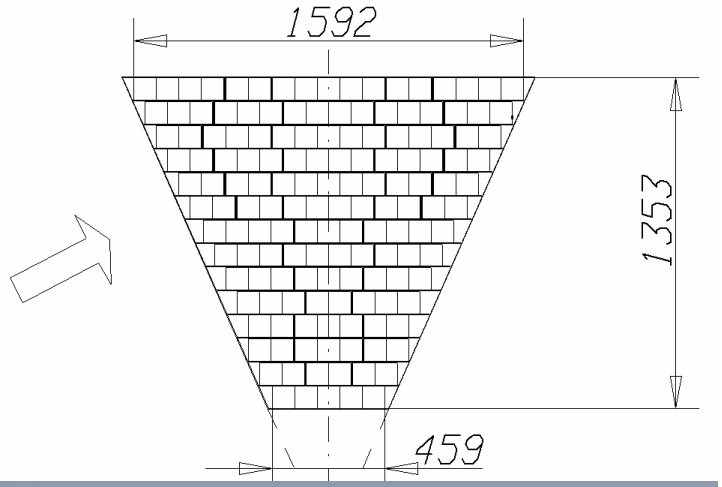


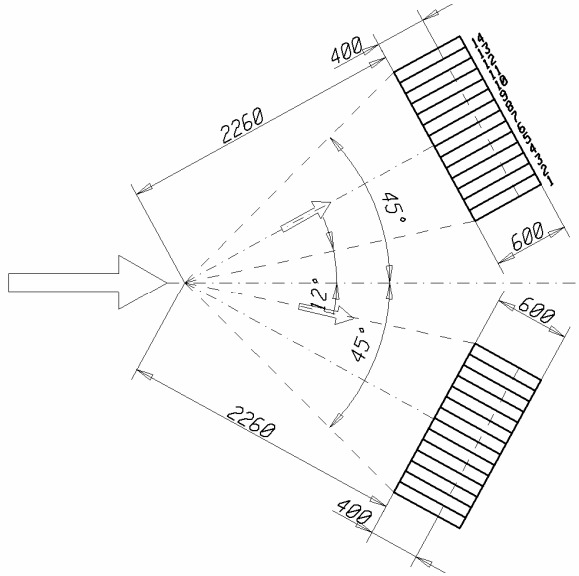
Collaboration

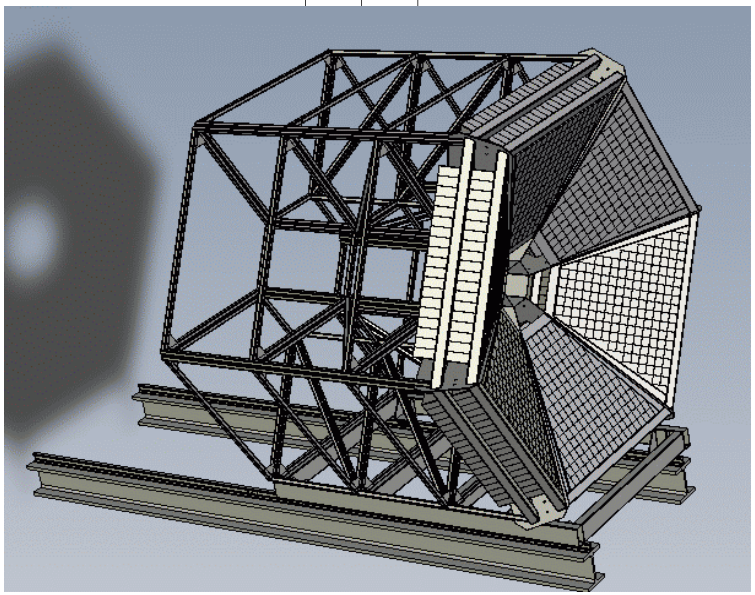
G. Agakishiev[8], C. Agodi[1], A. Balanda[3,e], G. Bellia[1,a], D. Belver[15], A. Belyaev[6], A. Blanco[2], M. Böhmer[11], J. L. Boyard[13], P. Braun-Munzinger[4], P. Cabanelas[15], E. Castro[15], S. Chernenko[6], T. Christ[11], M. Destefanis[8], J. Díaz[16], F. Dohrmann[5], A. Dybczak[3], T. Eberl[11], L. Fabbietti[11], O. Fateev[6], P. Finocchiaro[1], P. Fonte[2,b], J. Friese[11], I. Fröhlich[7], T. Galatyuk[4], J. A. Garzón[15], R. Gernhäuser[11], A. Gil[16], C. Gilardi[8], M. Golubeva[10], D. González-Díaz[4], E. Grosse[5,c], F. Guber[10], M. Heilmann[7], T. Hennino[13], R. Holzmann[4], A. Ierusalimov[6], I. Iori[9,d], A. Ivashkin[10], M. Jurkovic[11], B. Kämpfer[5], K. Kanaki[5], T. Karavicheva[10], D. Kirschner[8], I. Koenig[4], W. Koenig[4], B. W. Kolb[4], R. Kotte[5], A. Kozuch[3,e], A. Krása[14], F. Krizek[14], R. Krücken[11], W. Kühn[8], A. Kugler[14], A. Kurepin[10], J. Lamas-Valverde[15], S. Lang[4], J. S. Lange[8], K. Lapidus[10], L. Lopes[2], M. Lorenz[7], L. Maier[11], A. Mangiarotti[2], J. Marín[15], J. Markert[7], V. Metag[8], J. Micel[7], B. Michalska[3], D. Mishra[8], E. Morinière[13], J. Mousa[12], C. Müntz[7], L. Naumann[5], R. Novotny[8], J. Otwinowski[3], Y. C. Pachmayer[7], M. Palka[4], Y. Parpottas[12], V. Pechenov[8], O. Pechenova[8], T. Pérez Cavalcanti[8], J. Pietraszko[4], W. Przygoda[3,e], B. Ramstein[13], A. Reshetin[10], M. Roy-Stephan[13], A. Rustamov[4], A. Sadovsky[10], B. Sailer[11], P. Salabura[3], A. Schmah[4], R. Simon[4], Yu.G. Sobolev[14], S. Spataro[8], B. Spruck[8], H. Ströbele[7], J. Stroth[7,4], C. Sturm[7], M. Sudol[4], A. Tarantola[7], K. Teilab[7], P. Tlusty[14], M. Traxler[4], R. Trebacz[3], H. Tsertos[12], I. Veretenkin[10], V. Wagner[14], H. Wen[8], M. Wisniowski[3], T. Wojcik[3], J. Wüstenfeld[5], S. Yurevich[4], Y. Zanevsky[6], P. Zhou[5], P. Zumbruch[4]

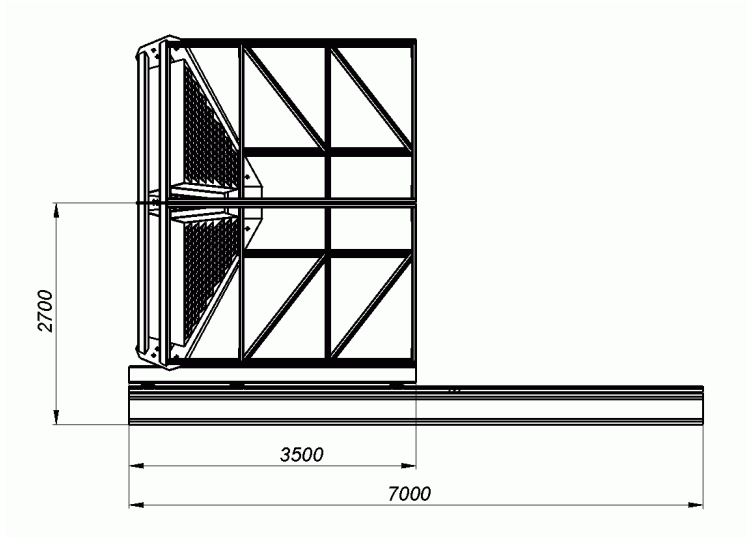
[1] Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali del Sud, 95125 Catania, Italy
[2] LIP-Laboratório de Instrumentação e Física Experimental de Partículas , 3004-516 Coimbra, Portugal
[3] Smoluchowski Institute of Physics, Jagiellonian University of Cracow, 30-059 Kraków, Poland
[4] Gesellschaft für Schwerionenforschung mbH, 64291 Darmstadt, Germany
[5] Institut für Strahlenphysik, Forschungszentrum Dresden-Rossendorf, 01314 Dresden, Germany
[6] Joint Institute of Nuclear Research, 141980 Dubna, Russia
[7] Institut für Kernphysik, Johann Wolfgang Goethe-Universität, 60438 Frankfurt, Germany
[8] II.Physikalisches Institut, Justus Liebig Universität Giessen, 35392 Giessen, Germany
[9] Istituto Nazionale di Fisica Nucleare, Sezione di Milano, 20133 Milano, Italy
[10] Institute for Nuclear Research, Russian Academy of Science, 117312 Moscow, Russia
[11] Physik Department E12, Technische Universität München, 85748 München, Germany
[12] Department of Physics, University of Cyprus, 1678 Nicosia, Cyprus
[13] Institut de Physique Nucléaire (UMR 8608), CNRS/IN2P3 - Université Paris Sud, F-91406 Orsay Cedex, France
[14] Nuclear Physics Institute, Academy of Sciences of Czech Republic, 25068 Rez, Czech Republic
[15] Departamento de Física de Partículas, University of Santiago de Compostela, 15782 Santiago de Compostela, Spain
[16] Instituto de Física Corpuscular, Universidad de Valencia-CSIC, 46971 Valencia, Spain

- Number of modules 150x6=900
- Mass of one module of lead-glass 14 kg
- Total mass of cal. 12600 kg









E. Lisowski, TU Krakow