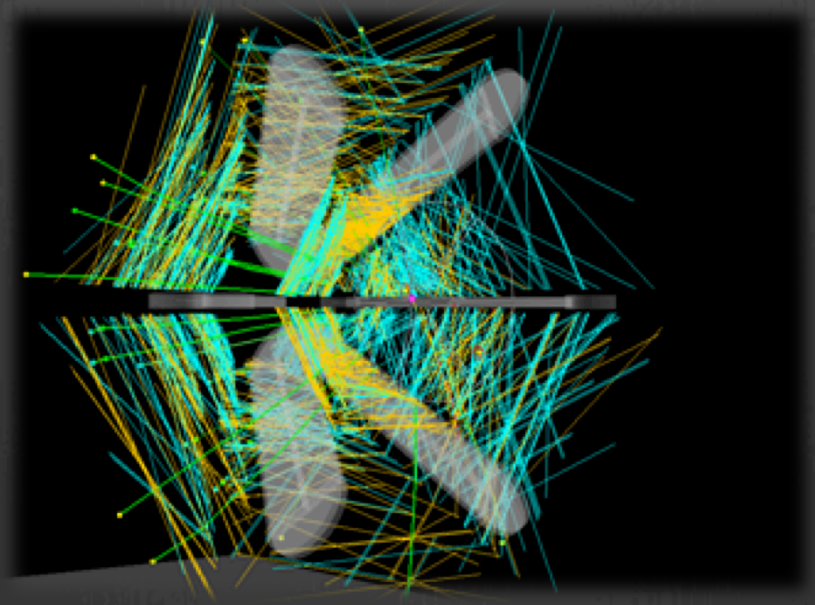
HADES

Exploring dense and cold matter



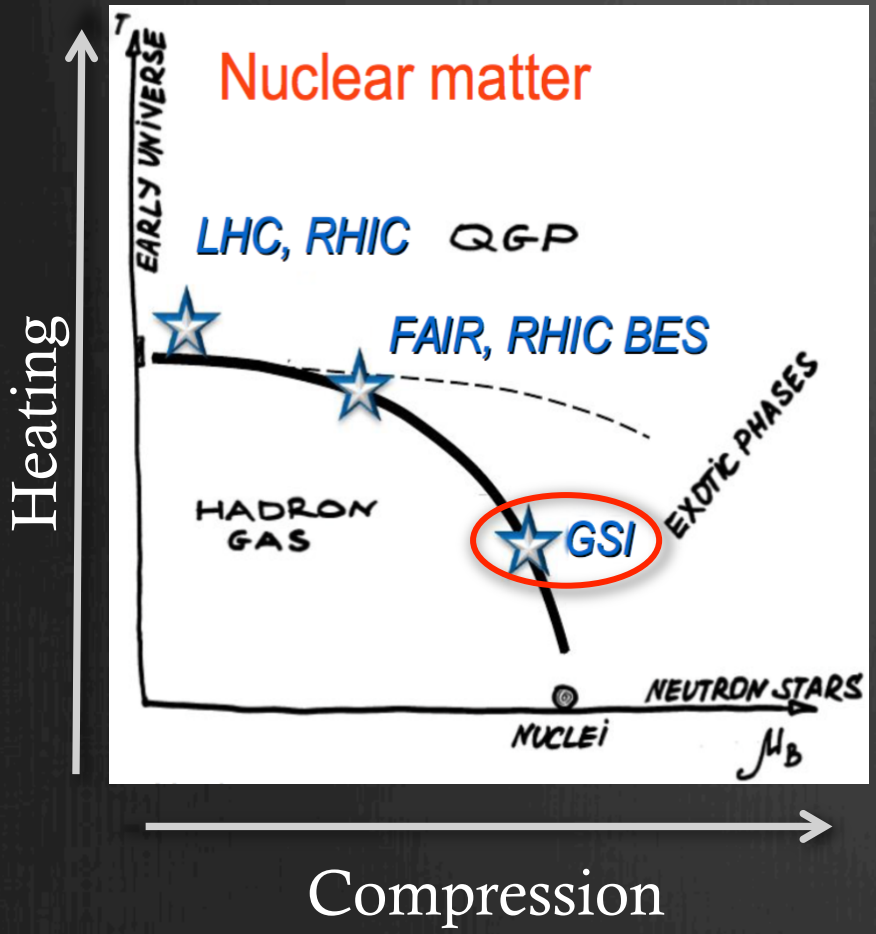
Luís Silva (LIP)

Jornadas 2016, Braga

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR
COMPETE
QREN QUADRO DE REFERÊNCIA ESTRATÉGICO NACIONAL
UNIÃO EUROPEIA Fundo Europeu de Desenvolvimento Regional

Exploring Dense and Cold Matter

Courtesy of C. Behnke



- SIS 18 energy regime: Beam energies of 1-3.5 GeV/u in ion systems, baryon dominated rather long living.
- Rare and penetrating probes.
- Stage I (2002 - 2008): Limited granularity of time-of-flight
  - ➡ system light collision systems
- Stage II (2012 - 2015): Heavy collision-systems and π-induced reactions

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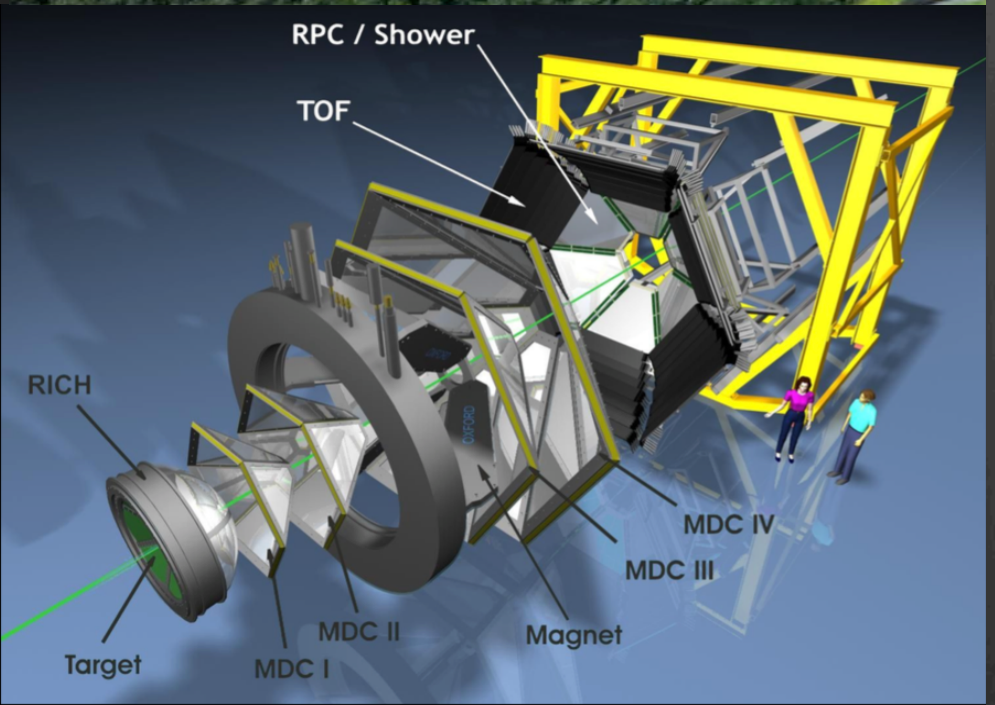
- Stage III (2018 -): Lepton pair excitation function up to 8 GeV/u (medium-heavy systems) and (multi-)strange particle

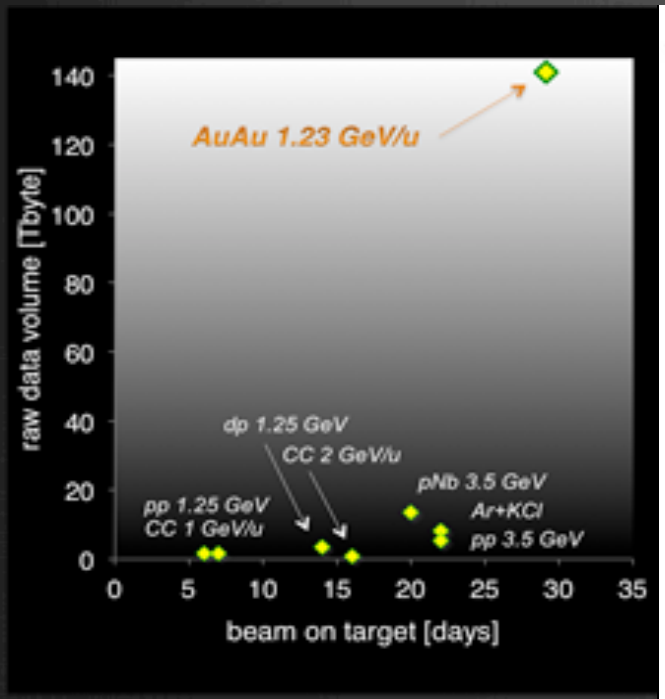
HADES @ GSI, Darmstadt

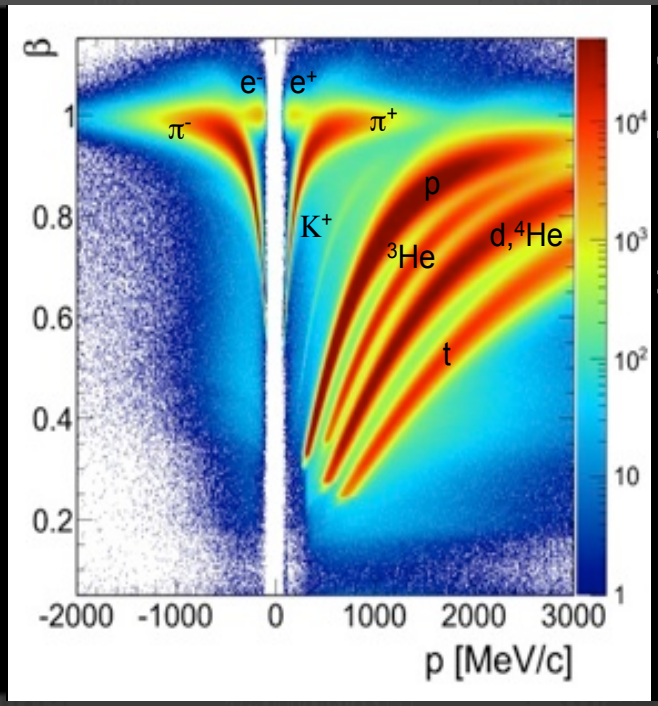
High Acceptance Di-Electron Spectrometer

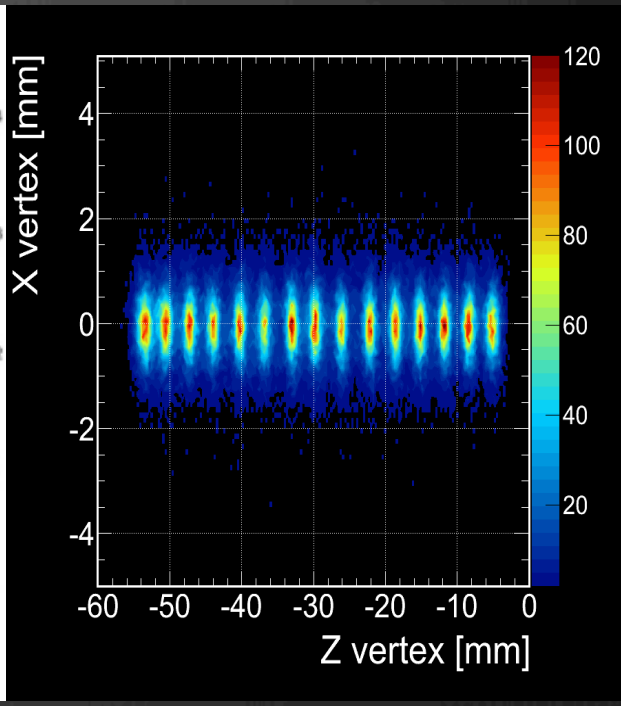


- Beams from SIS 18: π, protons and nuclei.
- Full azimuthal coverage.
- Polar angle: 18° to 85°.
- Lepton and Hadron identification:
  - RICH and Shower for lepton.
  - Time of Flight measurement: ToF Wall + RPC Wall
  - Tracking with 4x6 multiwire drift chamber.
- 50 KHz event rate (400 MByte/s peak data rate).

HADES Event Reconstruction







Acquired Data Sets

Very good particle identification.

Vertex reconstruction with high resolution.

HADES Event Reconstruction

Reconstructing Invariant mass spectrum with RPCs

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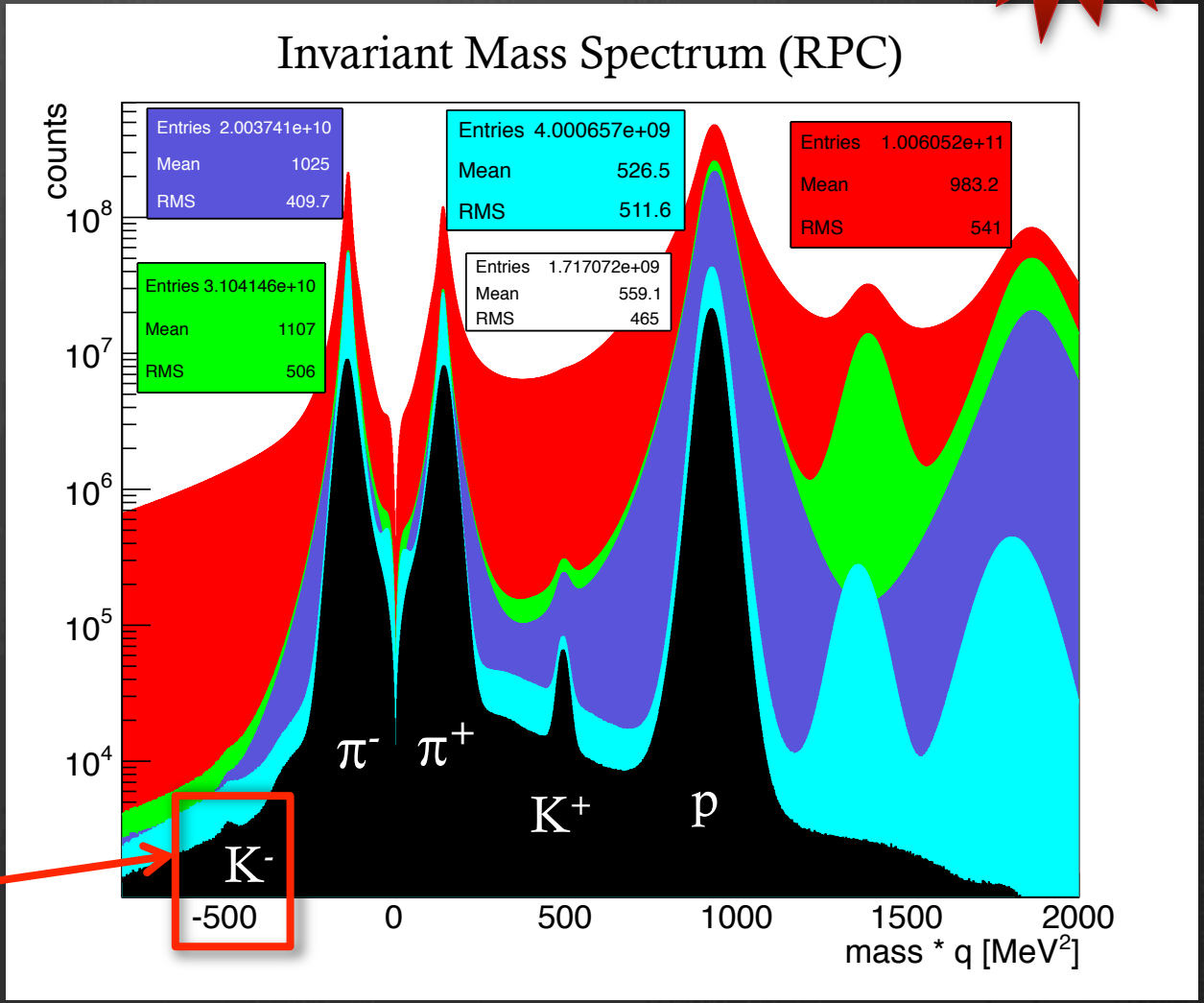
K^- peak is clearly visible, which is a very demanding test on the apparatus time response as well as granularity due to their extreme rarity (K^- is produced at sub-threshold energy): about one per 10000 anti-pions

Optimising quality cuts using RPC



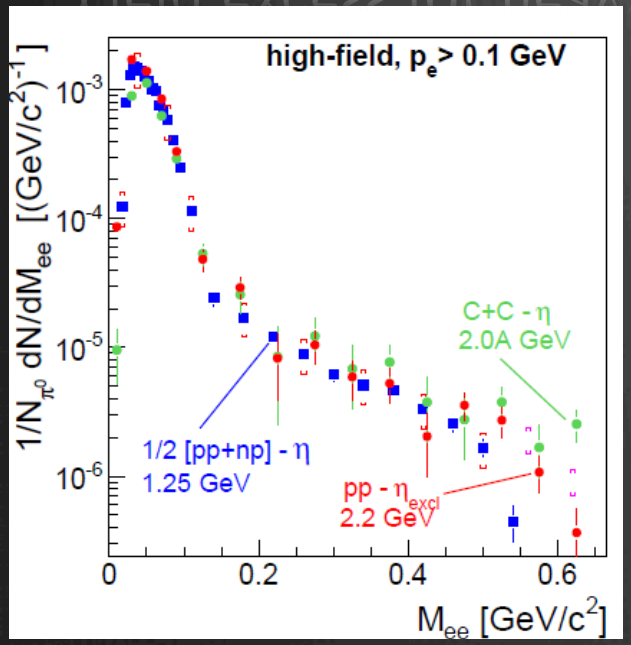
Physics Programme

Combined studies of dielectron and strangeness production using several systems:

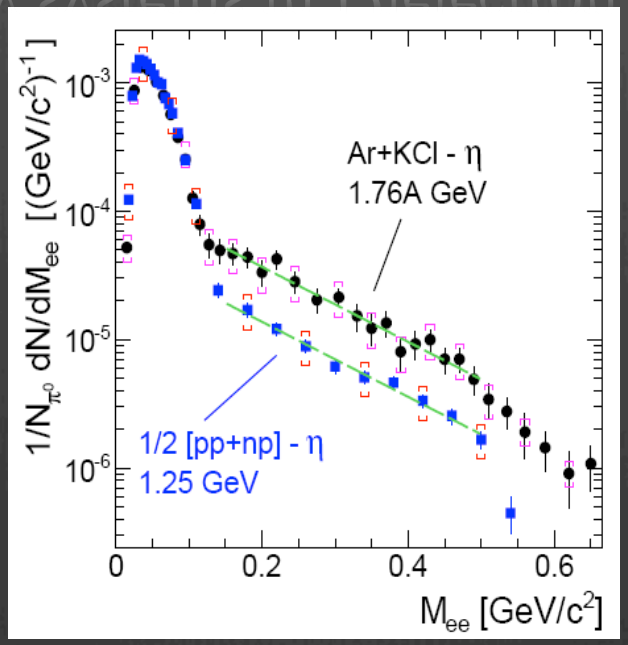
- **Dielectrons:**
  - Studies of properties of the low-mass, i.e. $0.14 < M_{e+e-} < 0.5$ GeV/c^2, dielectron excess.
  - Vector meson (ρ / ω / ϕ) spectroscopy in the dielectron channe**l.**
- **Strangeness:**
  - K^0, K^+ and K^- production characteristics from transverse momentum, rapidity and flow measurements.
  - ϕ meson production via the K^+K^- decay channel.
  - Studies of strange baryon production: $\Lambda(1115)$, $\Sigma(1385)$ and $\Xi^-(1321)$.

Dielectrons

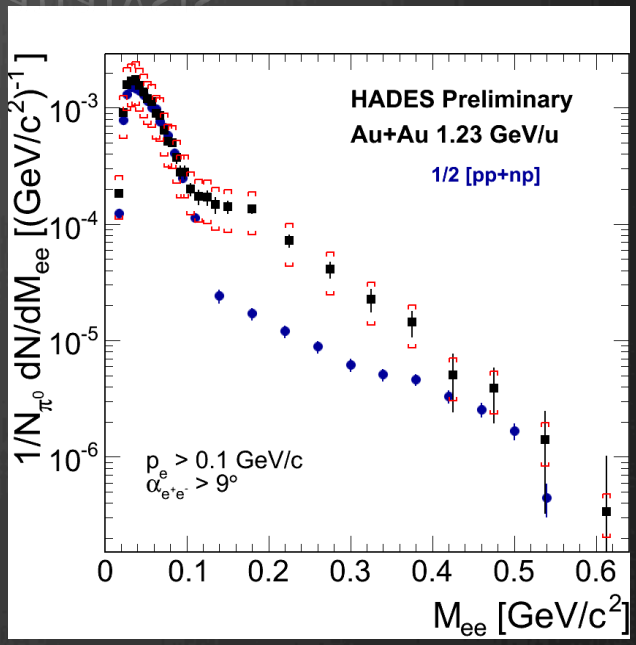
Yield excess for heavy systems in Dielectron analysis.

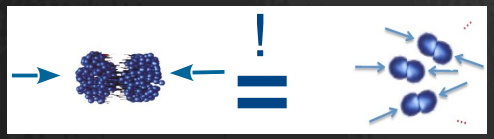


Phys.Lett. B 690 (2010) 118

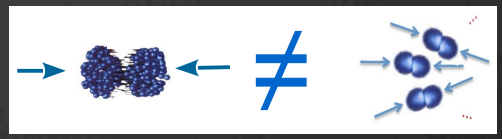


Phys.Rev.C 84 (2011) 014902





Nucleon and light nuclei systems scale in the same way

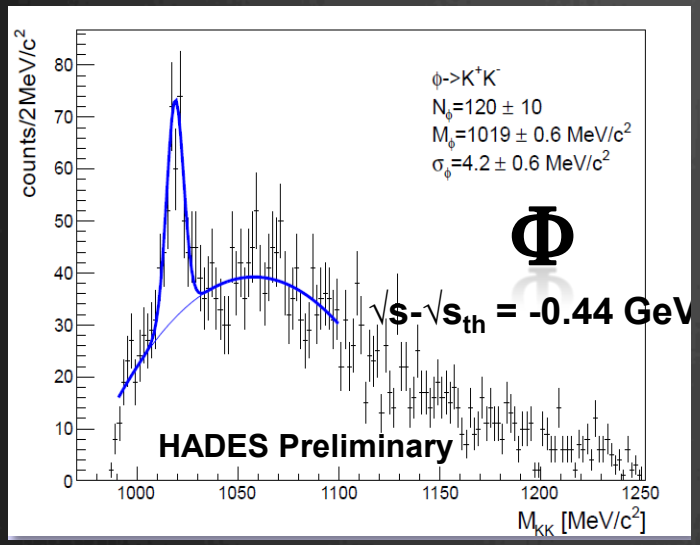


While for heavier systems there is an excess in the region $0.15 < M_{e+e-} < 0.6$ GeV/c^2

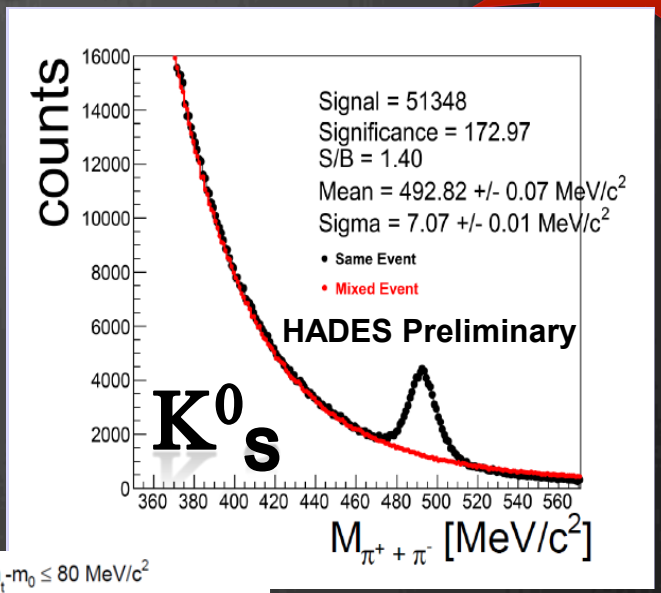
Hadrons

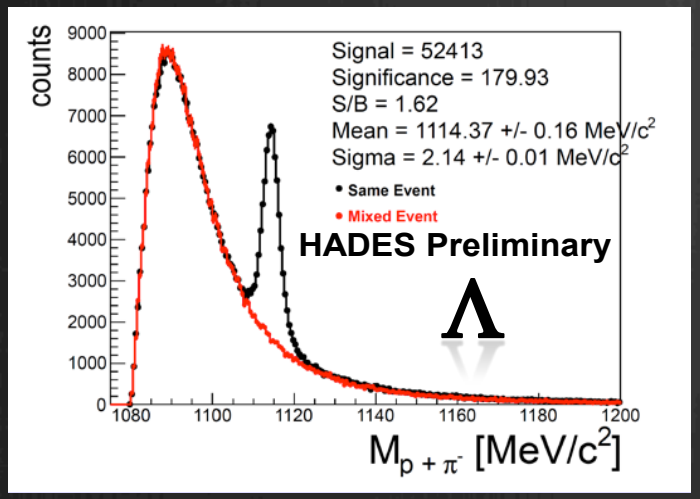
LIP

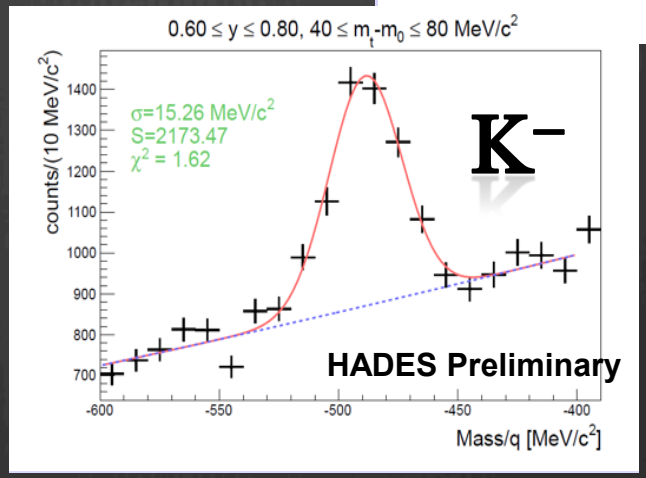
First measurements at such low beam energy!



Strangeness







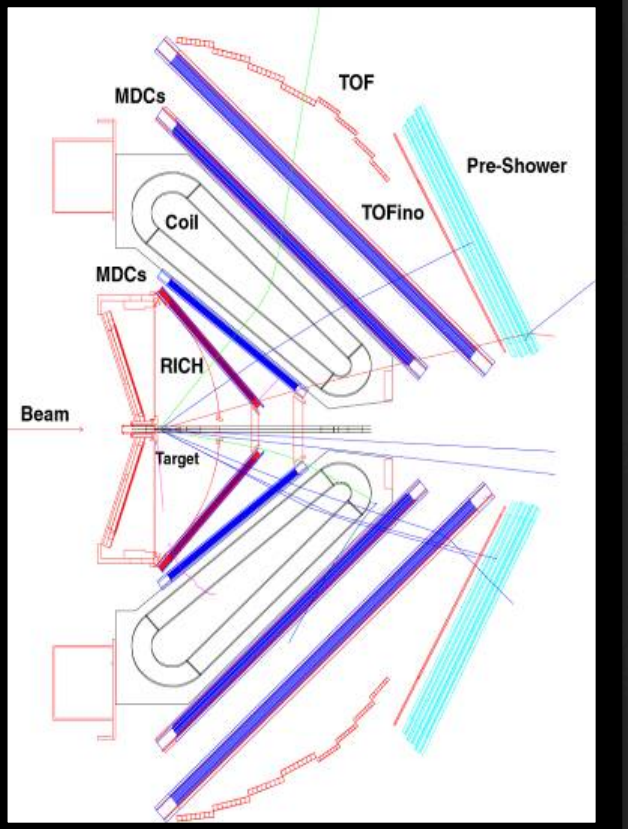
Far below NN production threshold. Strong constraints on production mechanism!

LIP Group Contribution

LIP group responsibilities and activities are focused in two aspects:

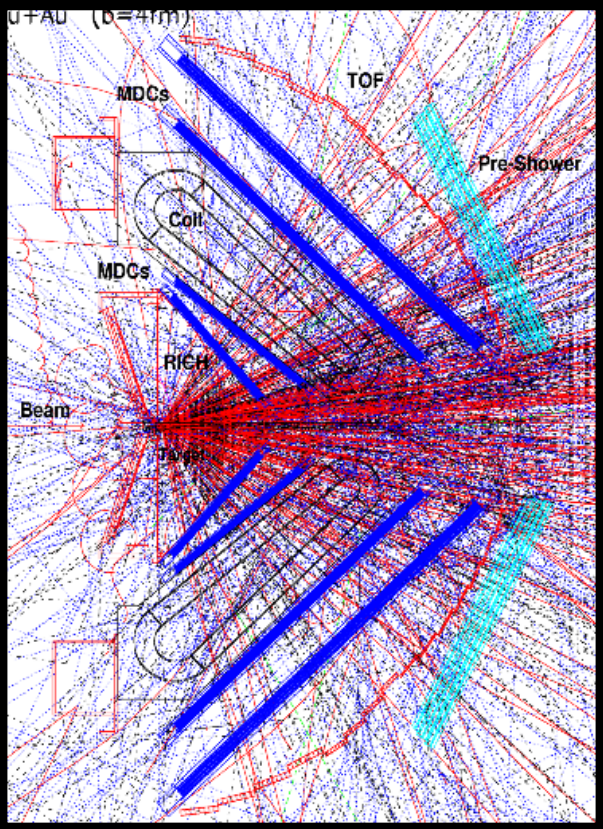
- Hardware:
  - RPC operation, monitoring, maintenance, calibration and optimisation.
- Analysis:
  - Dielectron In-medium properties from e+e- mass spectrum studies.
  - A new method of lepton identification based on a dynamic neural network.
  - Kaon optimisation PID using RPC.

From Light to Heavy Systems

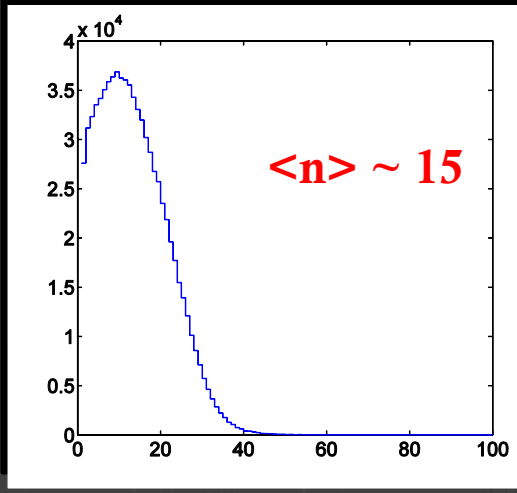


From Light to Heavy Systems

One Au + Au collision
from Hgeant simulation



Multiplicity/sector

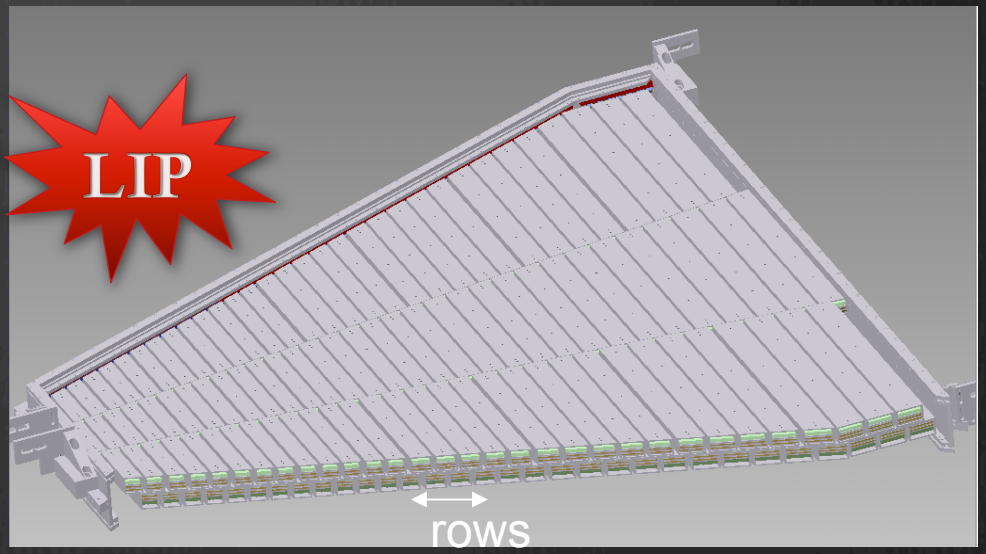


Lots of particles
(up to ~40/sector)

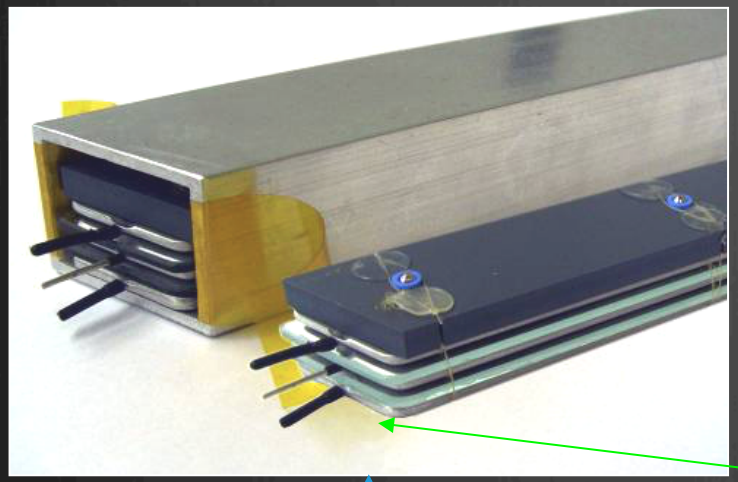
High Multiplicity

High Detector
Granularity

RPC



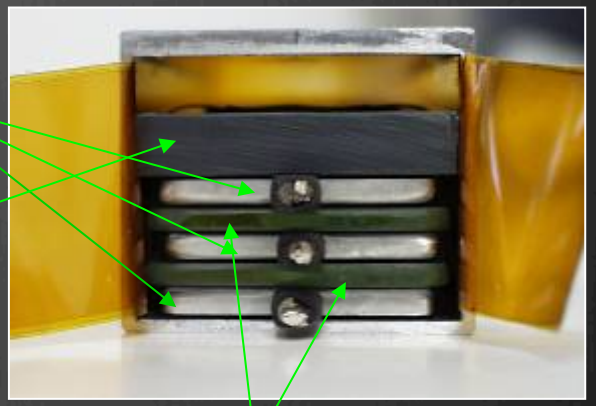
RPC



Aluminium

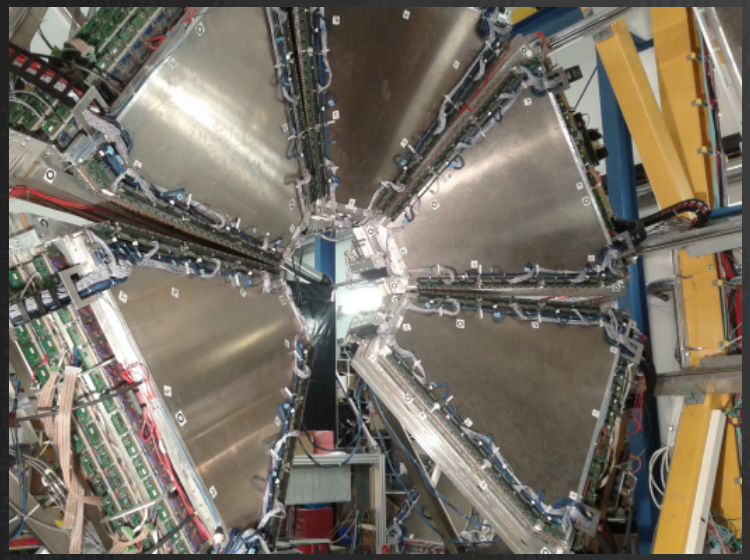
Spring-loaded pressure plate

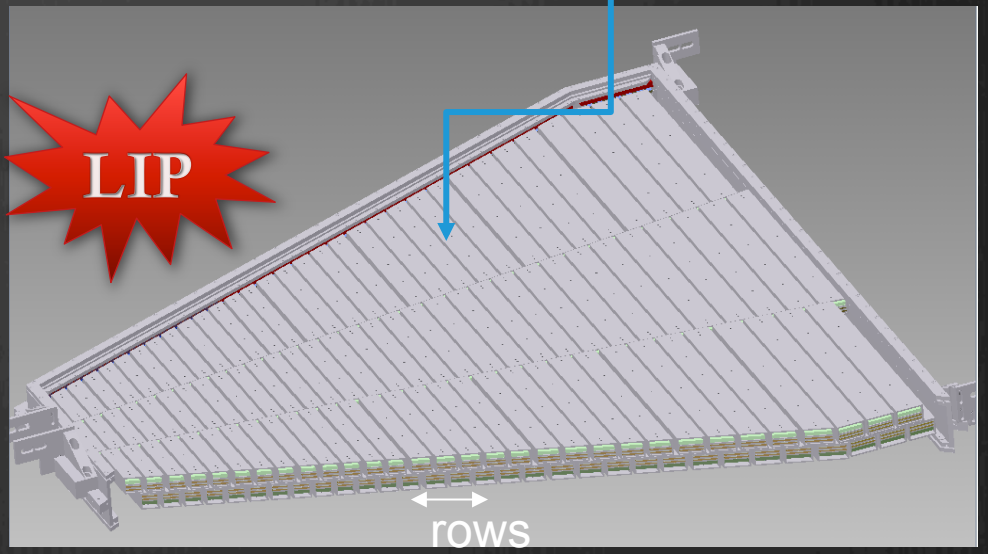
HV & readout in the center



Glass

One cell





RPC

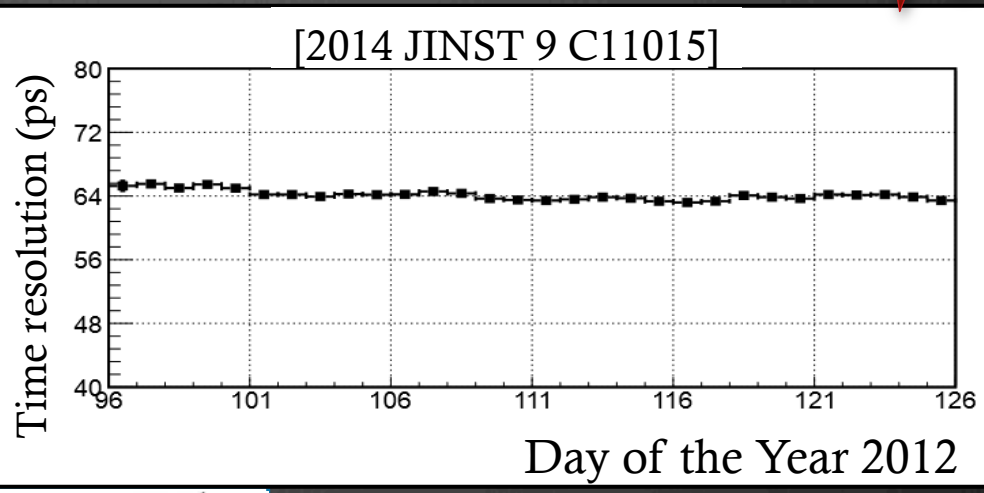
LIP

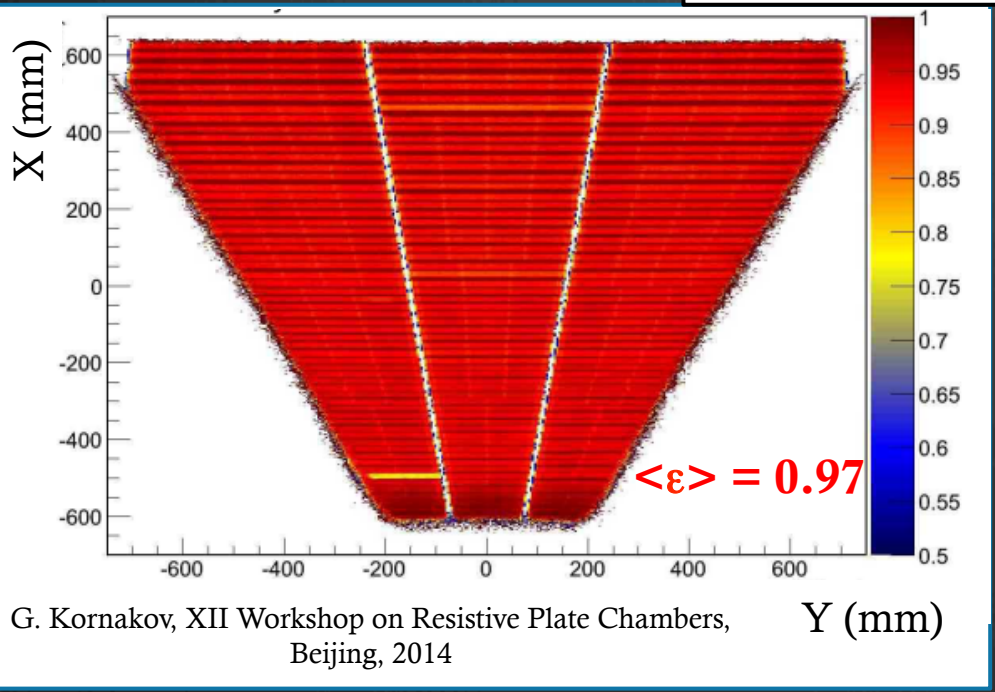
Performance

AuAu 1.23 GeV/u

Time Resolution

Efficiency

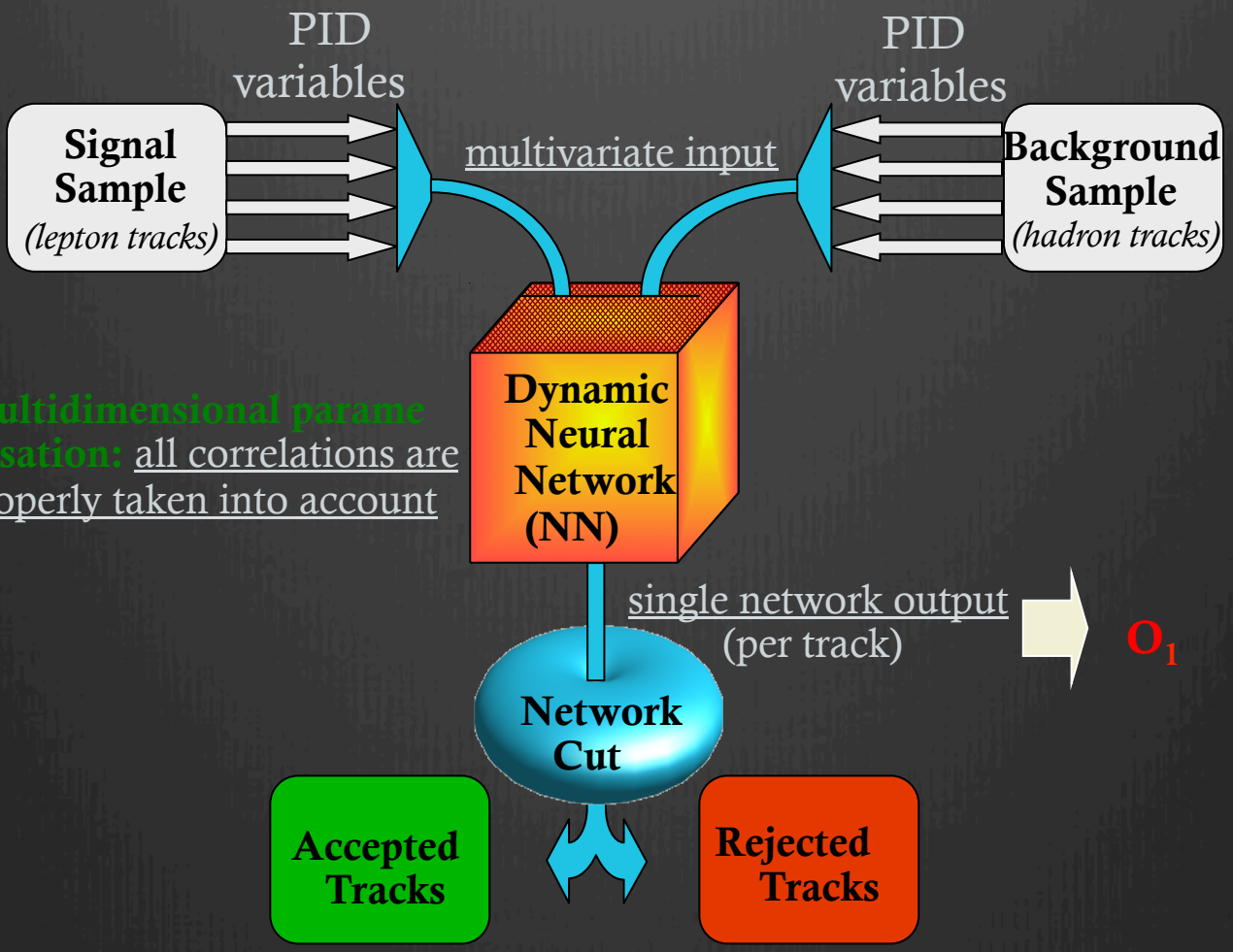




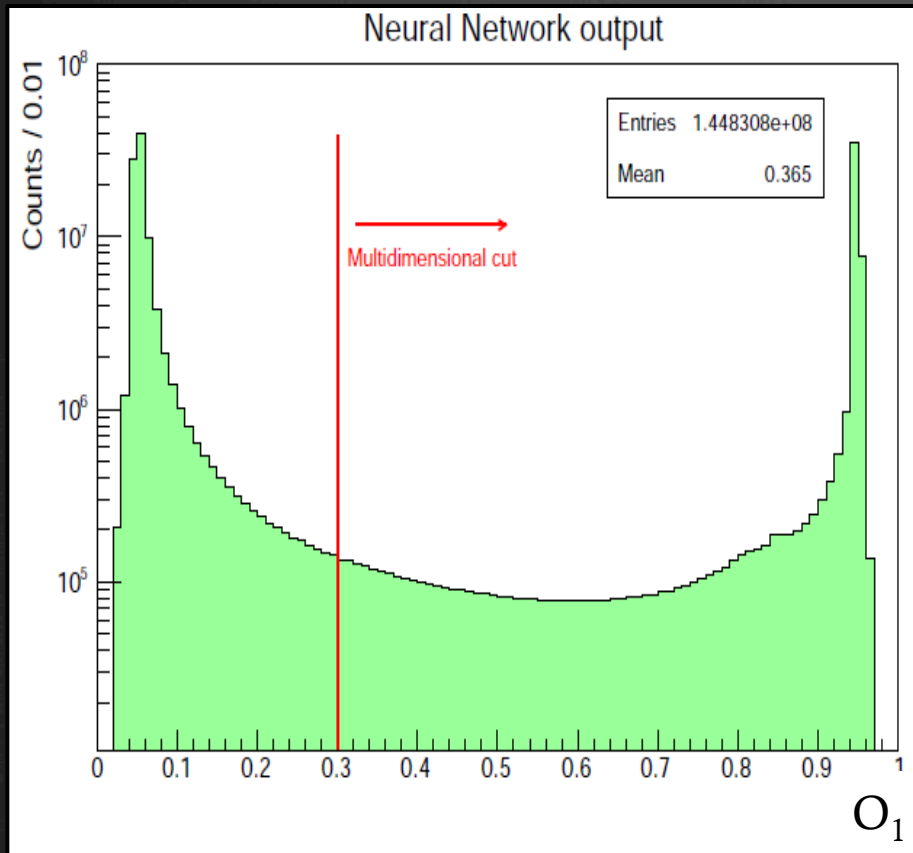
G. Kornakov, XII Workshop on Resistive Plate Chambers, Beijing, 2014

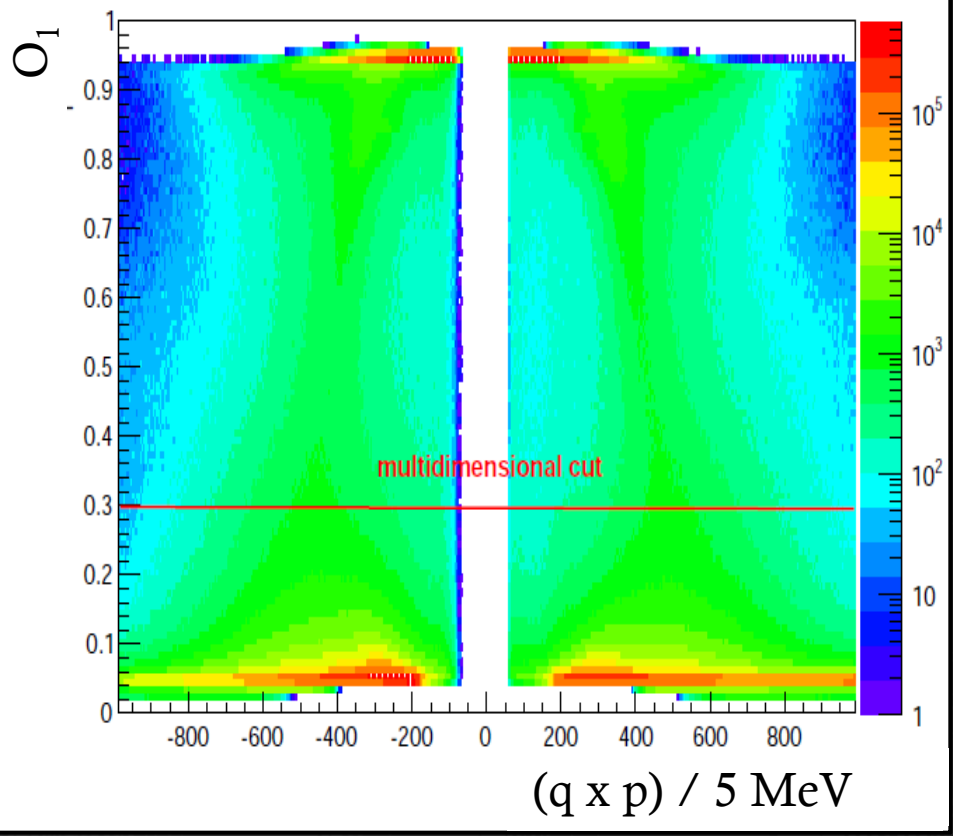
$\langle\sigma_t\rangle$ = 64 ps for all particles and area, stable in the whole beam time

Dielectron Analysis using a Neural Network

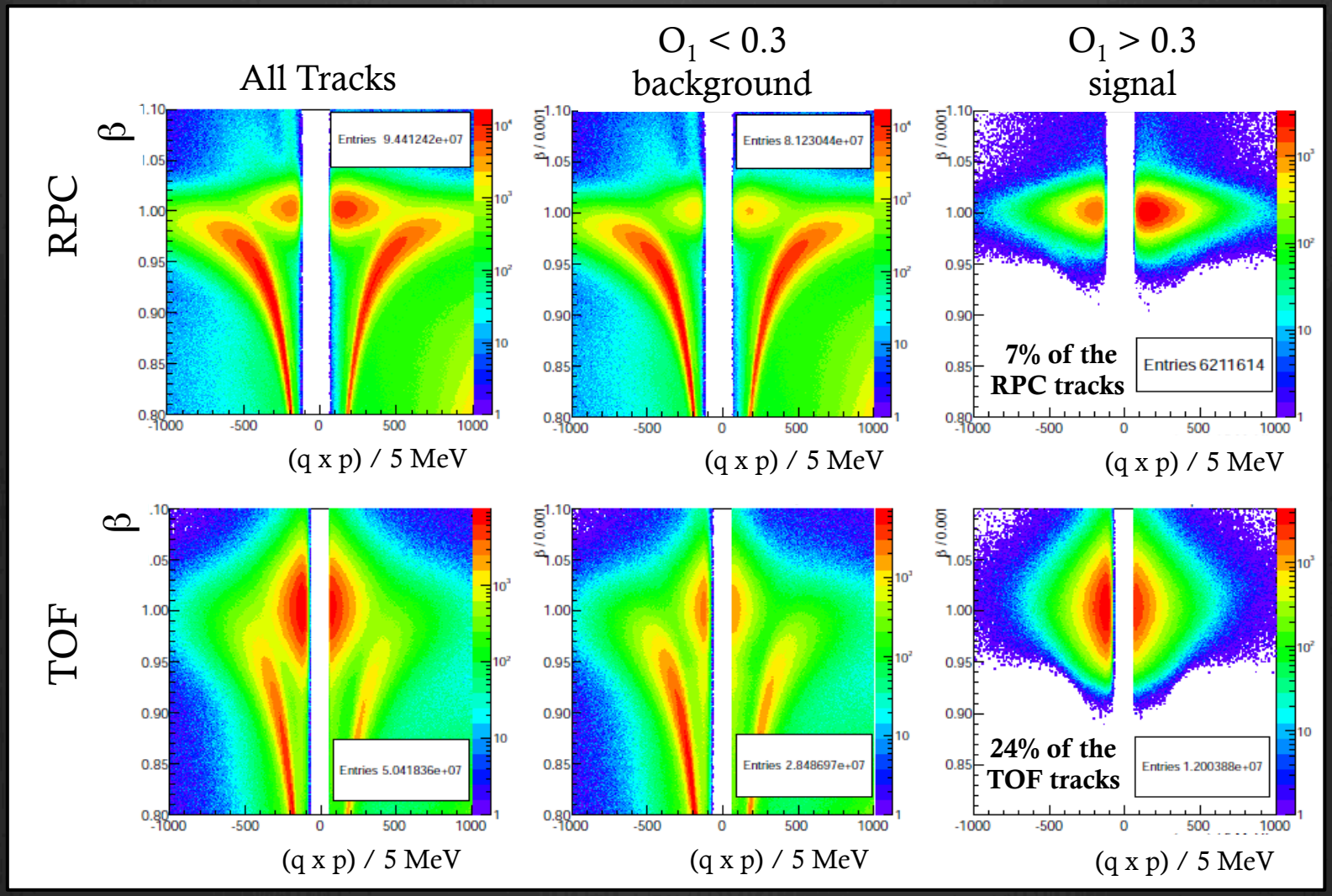


Dielectron Analysis using a Neural Network





Dielectron Analysis using a Neural Network



Near Future

Next step is the upgrade to SIS 100 (8 GeV/u) (2018):

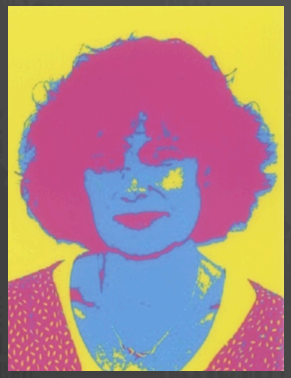
- High intensity beams and high rates
- Detectors need to cope with these requirements
- LIP is involved in simulation studies to include two new detectors:
  - Forward detector
  - Multi-wire Detector Chamber

Summary

- Interesting physics at low energy.
- LIP group highly involved in detector responsibilities and in physics analysis.
- The Collaboration recognises LIP group as an important and reliable partner.

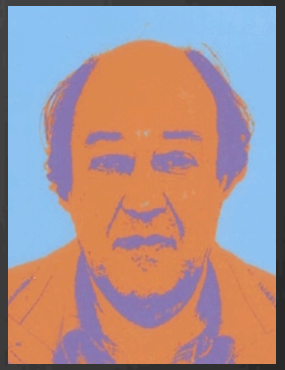
HADES LIP Group

Alberto Blanco
PI



Paula Bordalo
Researcher

Paulo Fonte
Researcher



Sérgio Ramos
Reseacher

Celso Franco
Post-Doc

Luís Lopes
Technician

Luís Silva
Post-Doc