Quark Matter 2011, Annecy

Validity of the Hadronic Freeze-Out Curve

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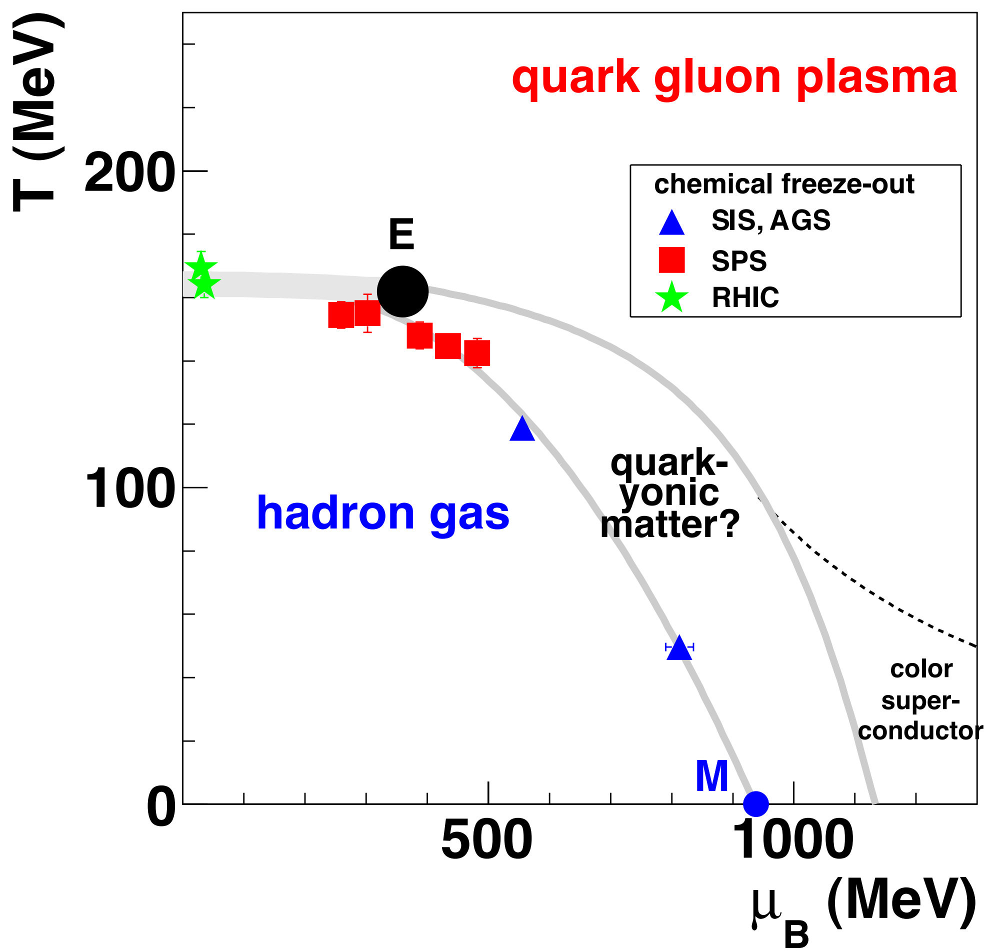
Sketch of the QCD Phase Diagram

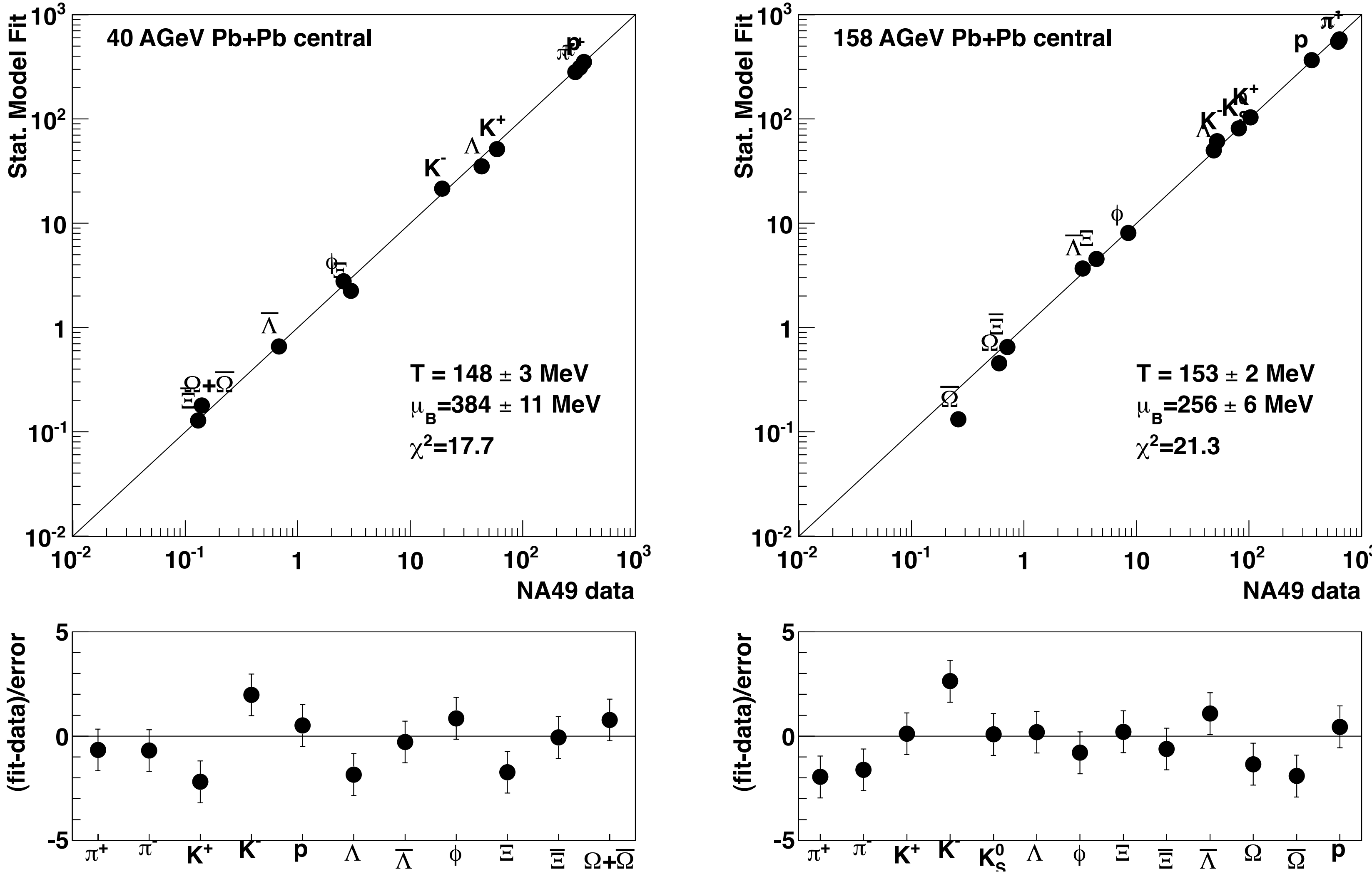
Parton-hadron coexistence line from lattice QCD vs. Hadro-chemical freeze-out line from statistical model



- Merging at $\mu_B \to 0$: location of $T_c \approx 170$ MeV
- Expansion trajectory focus by critical point (Asakawa, Nonaka)?
- The two lines disentangle towards high μ_B $\to$ What are we freezing out from?

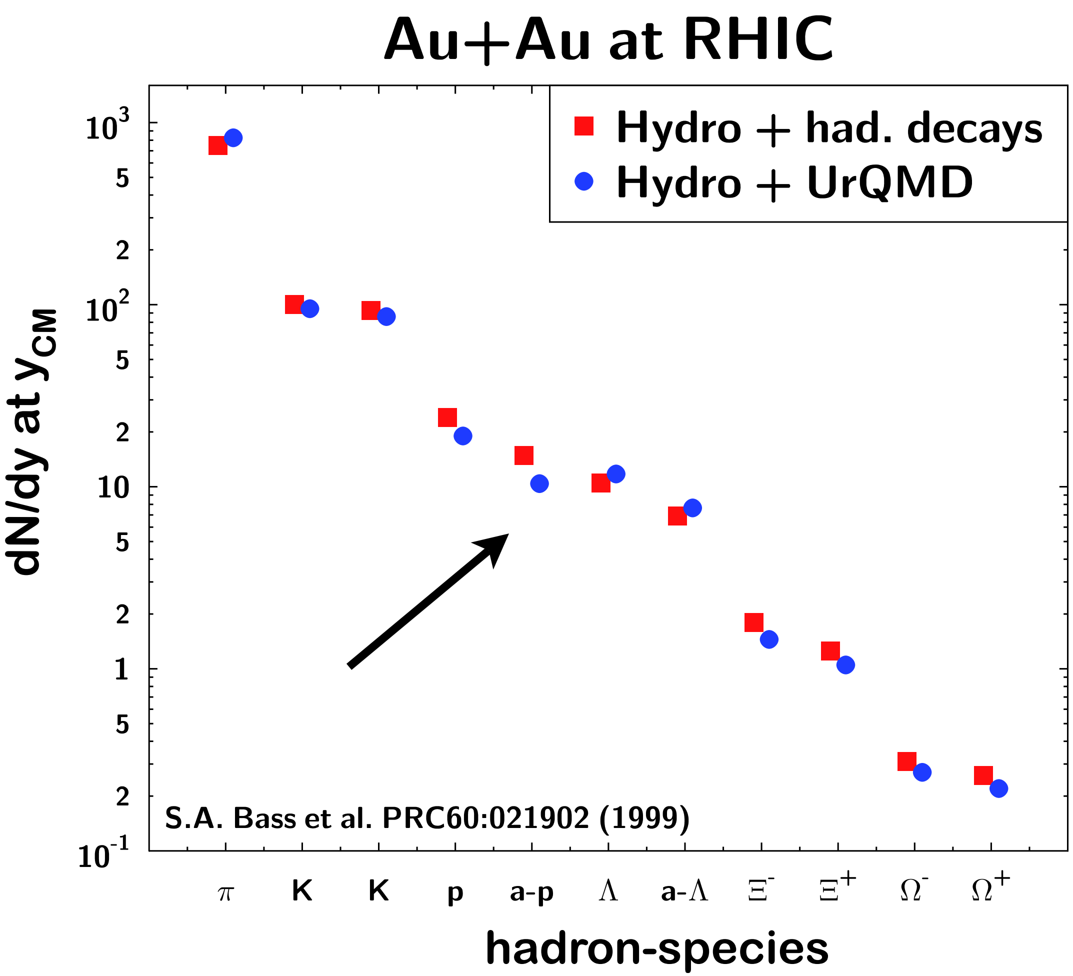
Standard Fits to NA49 Data

Grand-Canonical Statistical Model



→ Freeze-out points [T,μ_B] in the phase diagram

Idea: What happens during the hadron-resonance cascade?

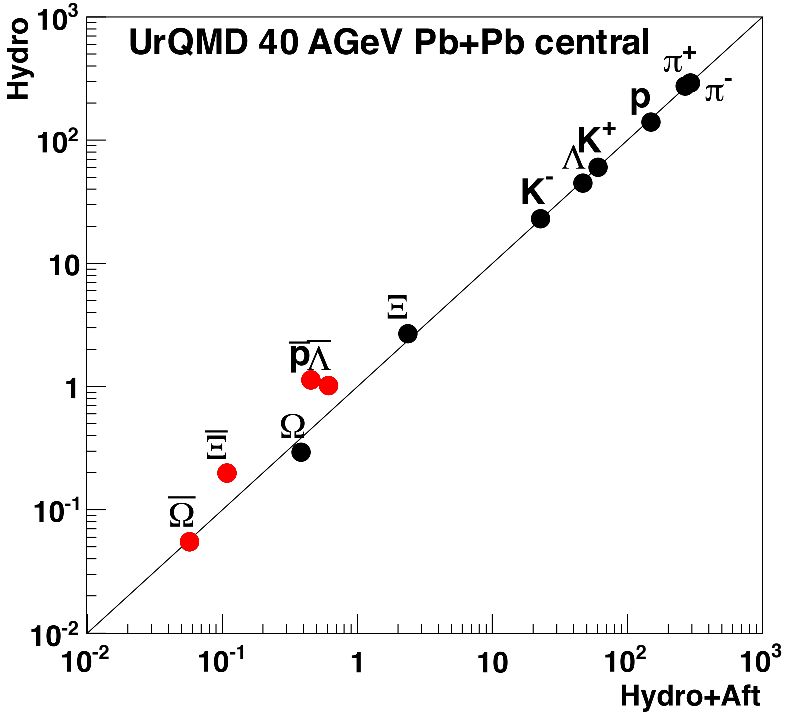


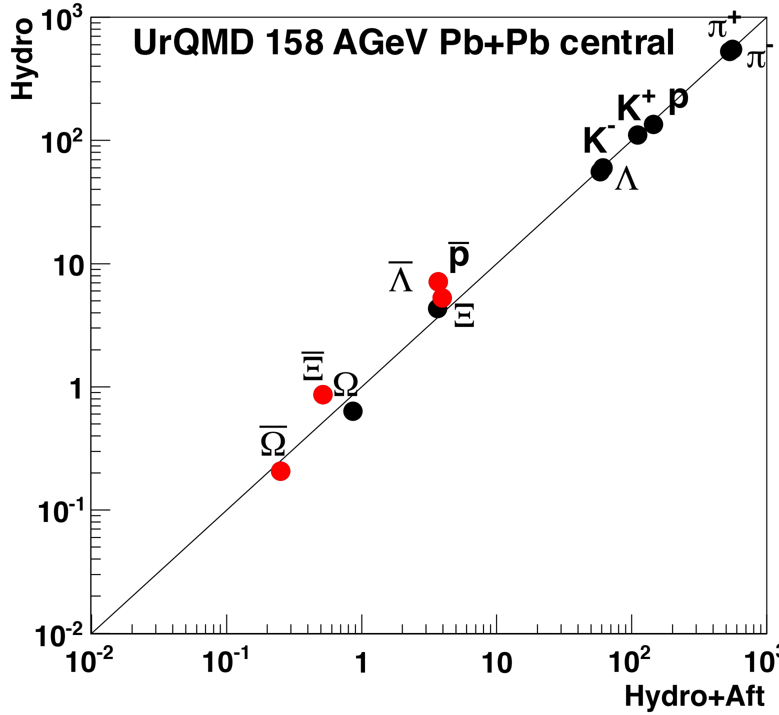
- Employ hybrid transport model with hydro stage and subsequent hadronic cascade, e.g. UrQMD v3.3
- Terminate
  - directly after hydro phase → decay into vacuum
  - or use UrQMD cascade expansion as "afterburner"
- First impression: Bulk hadrons show little change, but effects on anti-baryons

Investigate afterburner effects in more detail

UrQMD Hybrid Model:

Comparison Hydro vs. Hydro+Afterburner at 40 and 158*A* GeV

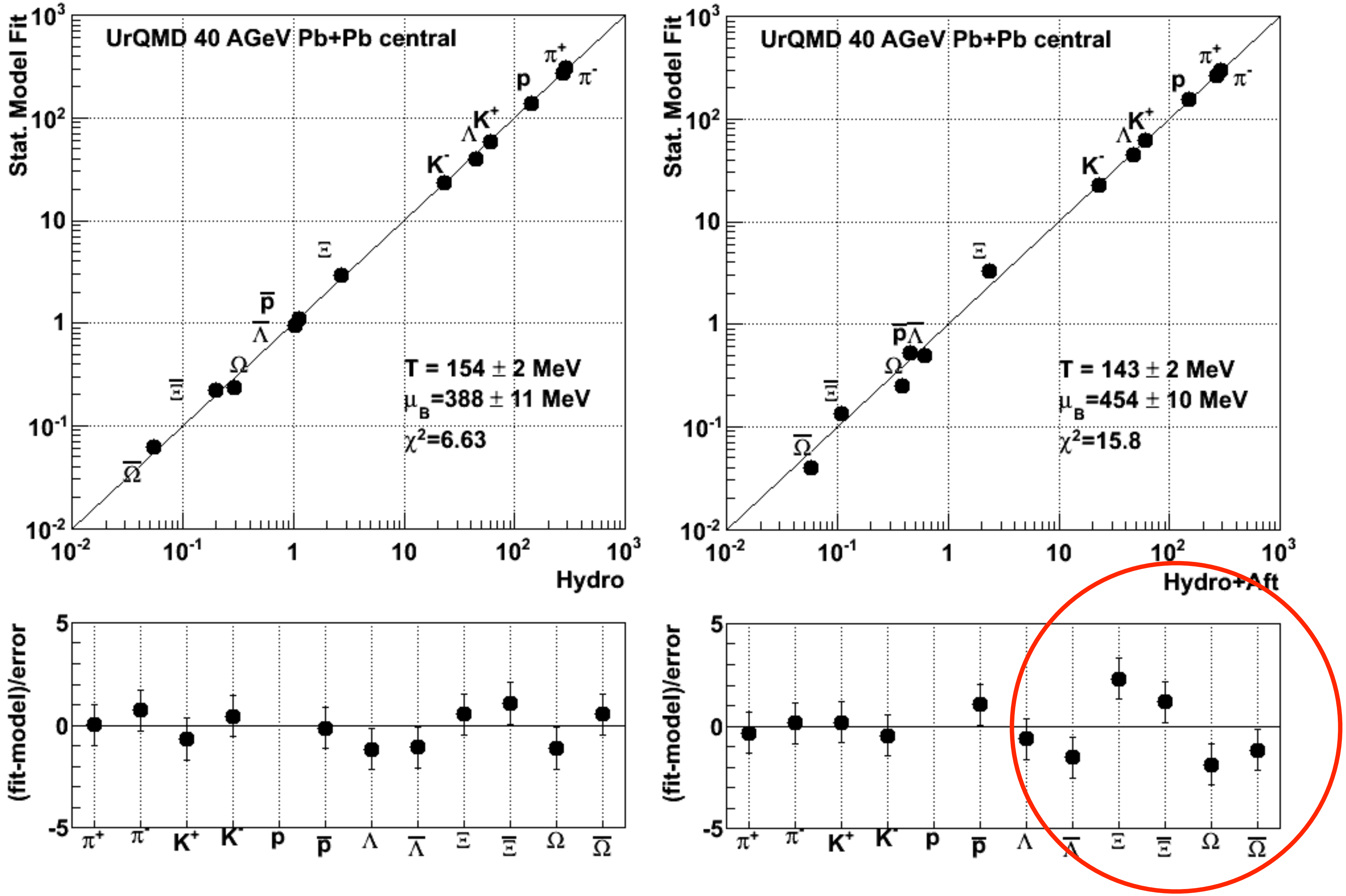




→ Hadronic cascade “afterburner” removes antibaryons except anti-Omega!

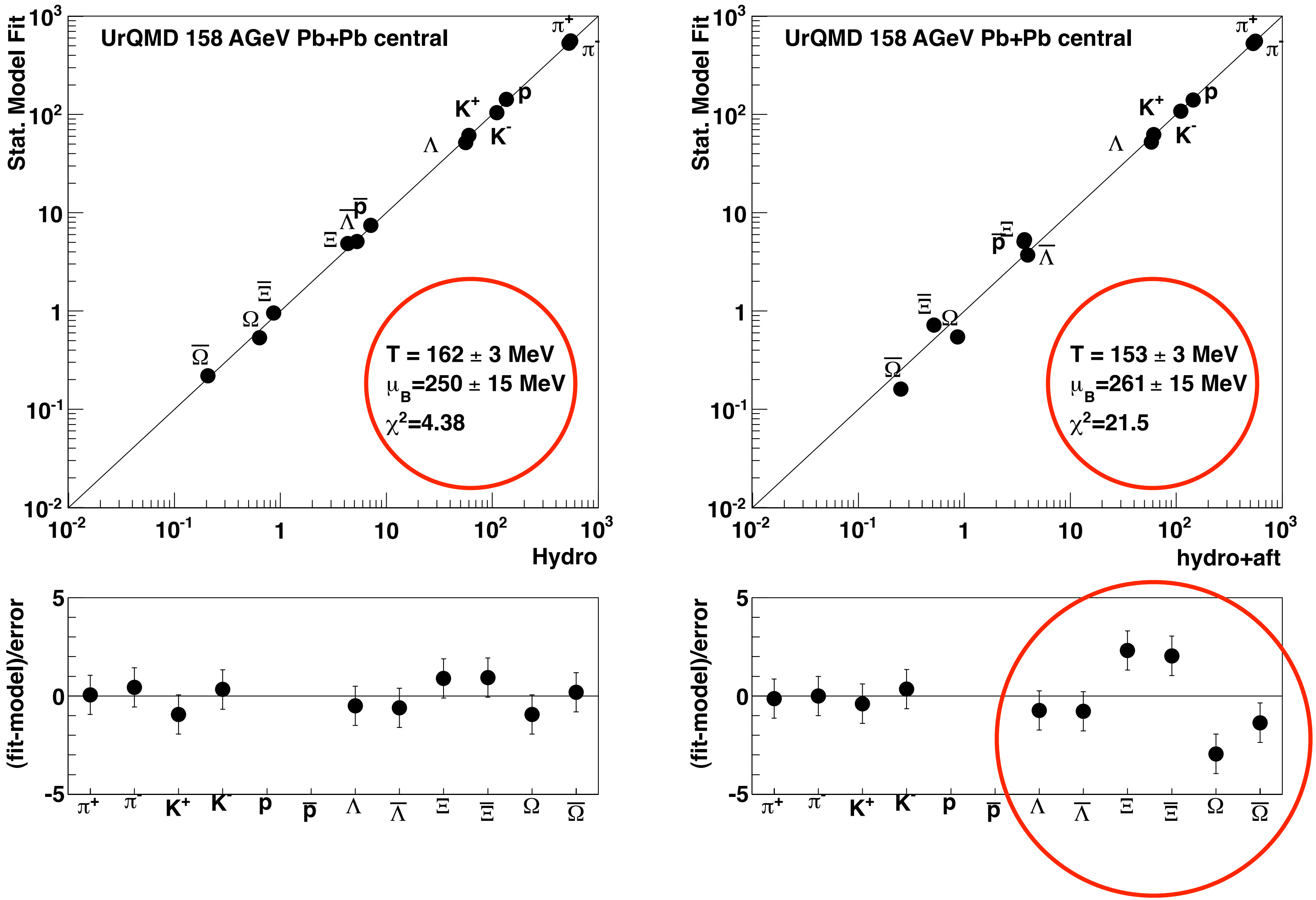
Example SM Fits to Hydro and Hydro+Afterburner at 40*A* GeV

Grand-Canonical Statistical Model



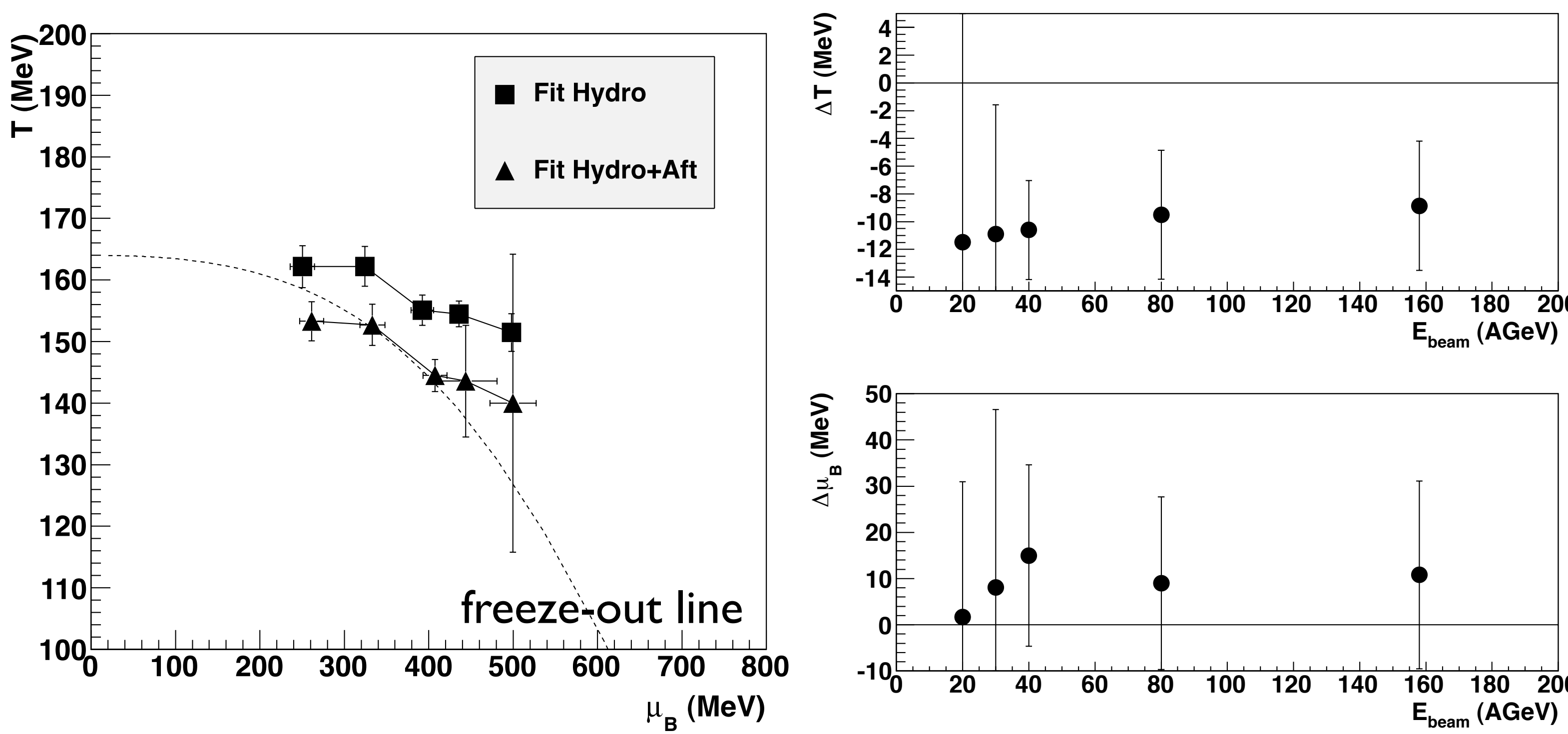
Example SM Fits to Hydro and Hydro+Afterburner at 158*A* GeV

Grand-Canonical Statistical Model



Comparison SM Fit Results Hydro and Hydro+Afterburner

Downward shift of the freeze-out curve?!

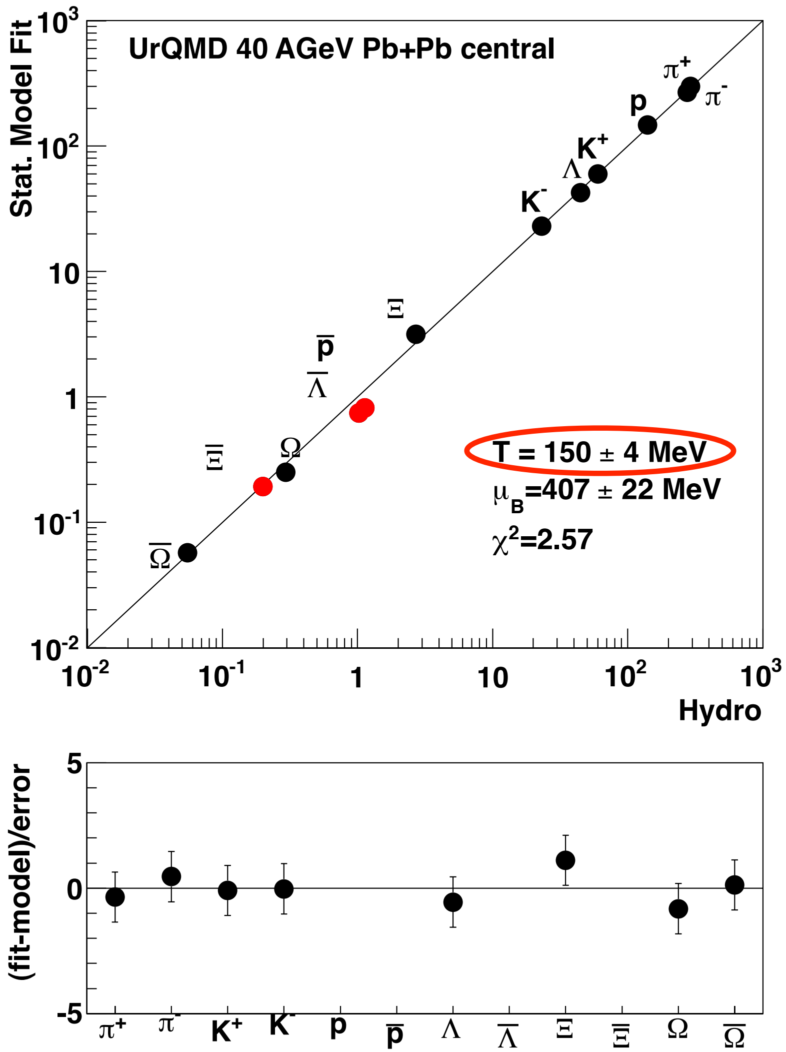


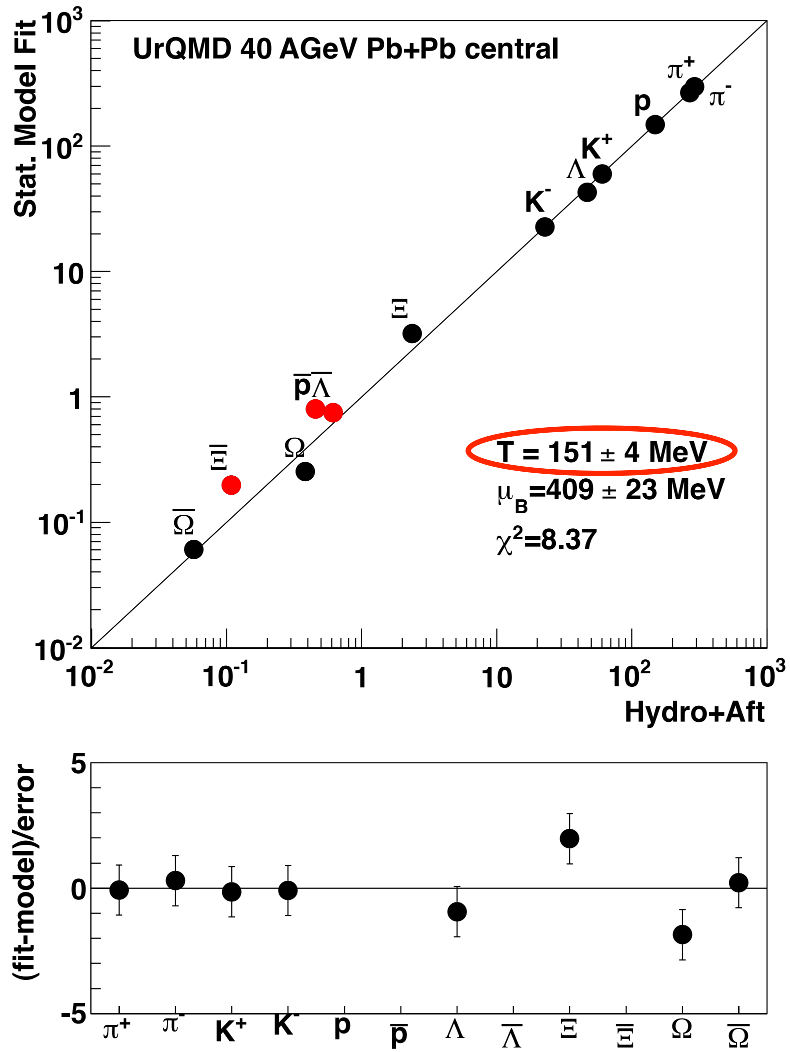
Does the hadro/resonance cascade really <u>cool</u> the system?
Or: does it merely <u>distort</u> the (anti)baryon sector?

Idea: Similar test calculations without including antiproton, anti-Lambda, anti-Xi

SM Fits to Hydro and Hydro+Afterburner at 40*A* GeV

Exclude anti-proton, anti-Lambda, anti-Xi in SM Fit!

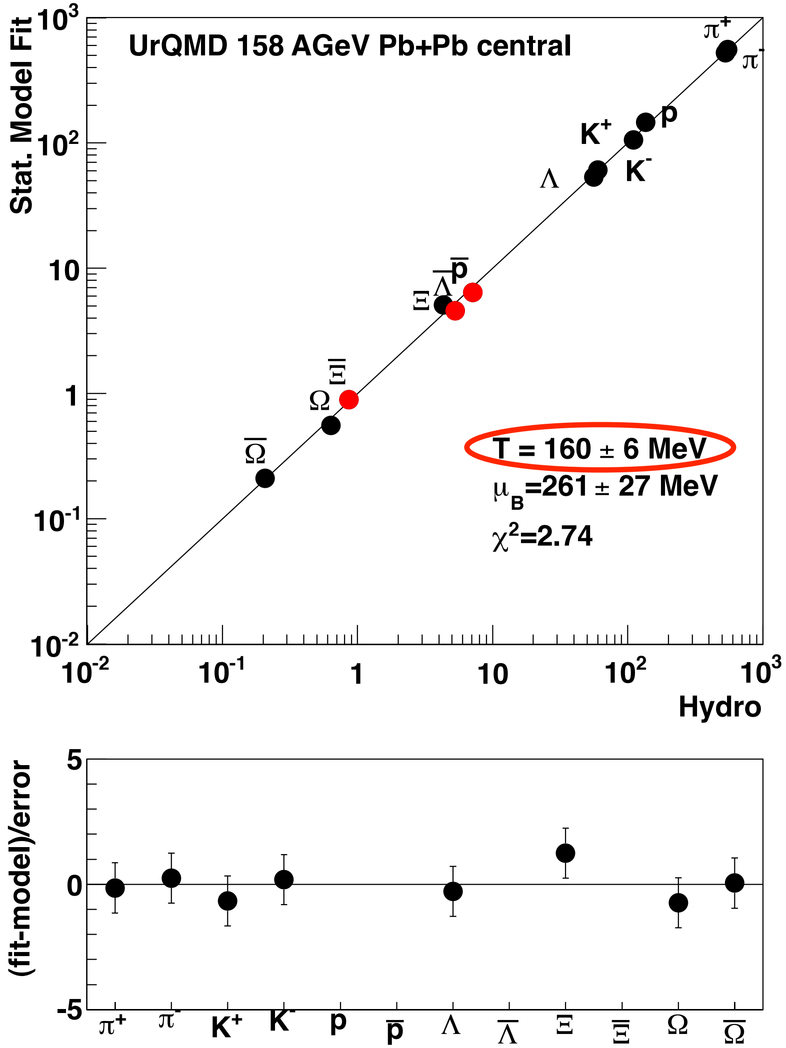


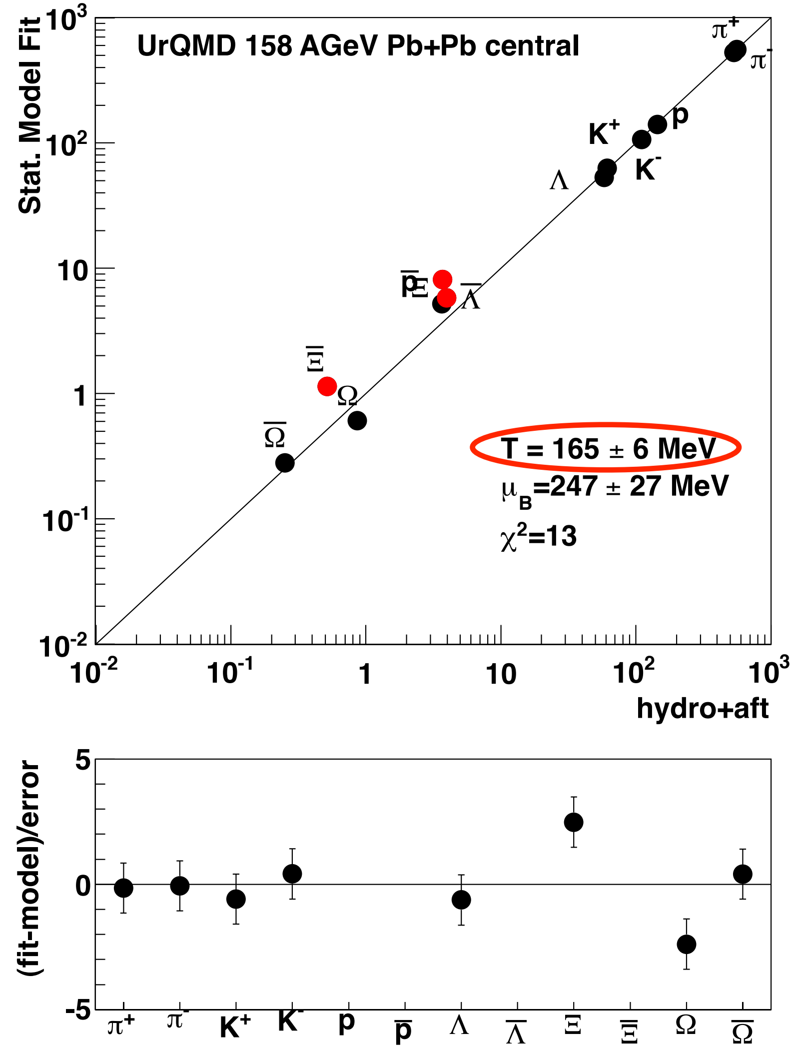


Essentially no cooling!

SM Fits to Hydro and Hydro+Afterburner at 158*A* GeV

Exclude anti-proton, anti-Lambda, anti-Xi in SM Fit!



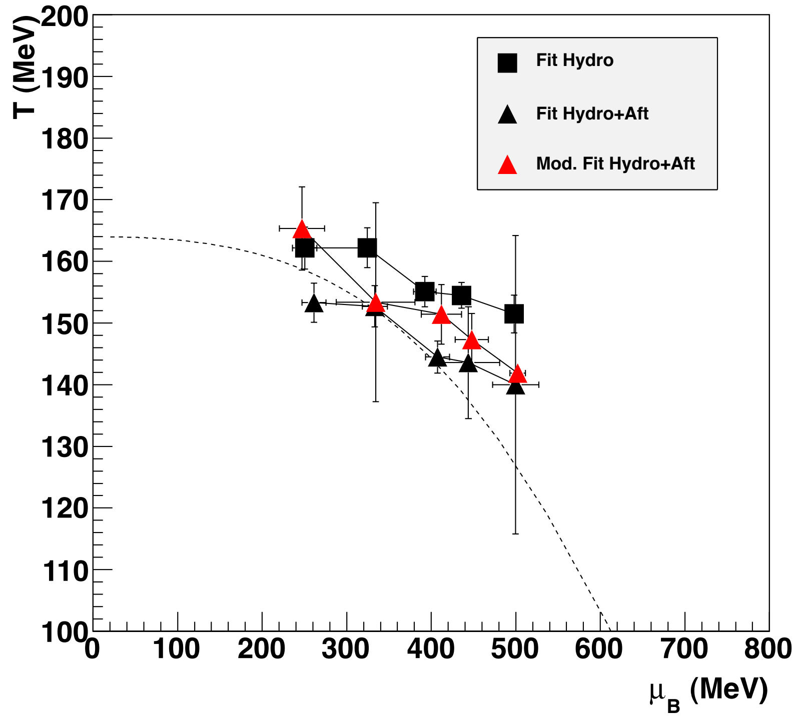


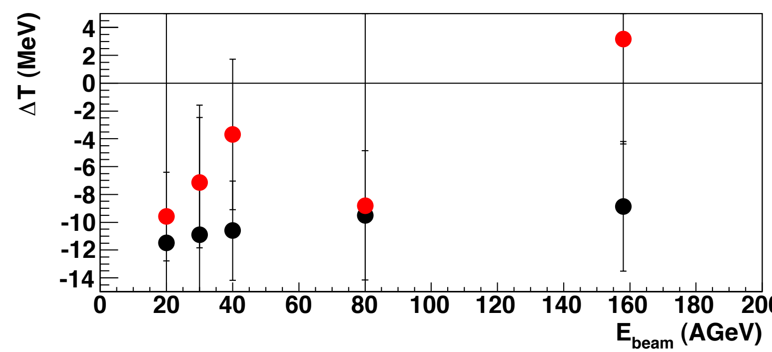
Essentially no cooling!

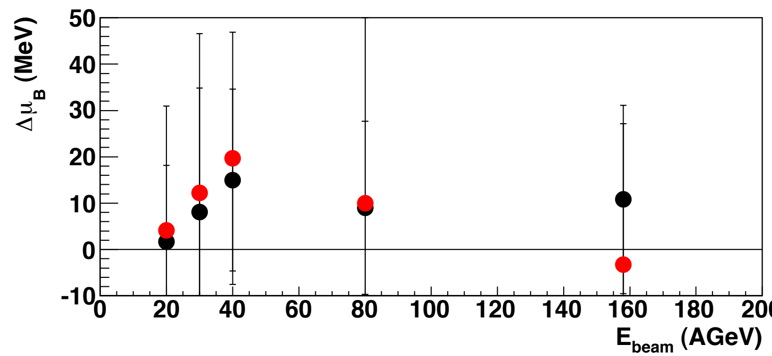
Reasonable χ^2

Comparison SM Fit Results Hydro and Hydro+Afterburner

▲ Red points: Exclusion of anti-proton, anti-Lambda and anti-Xi





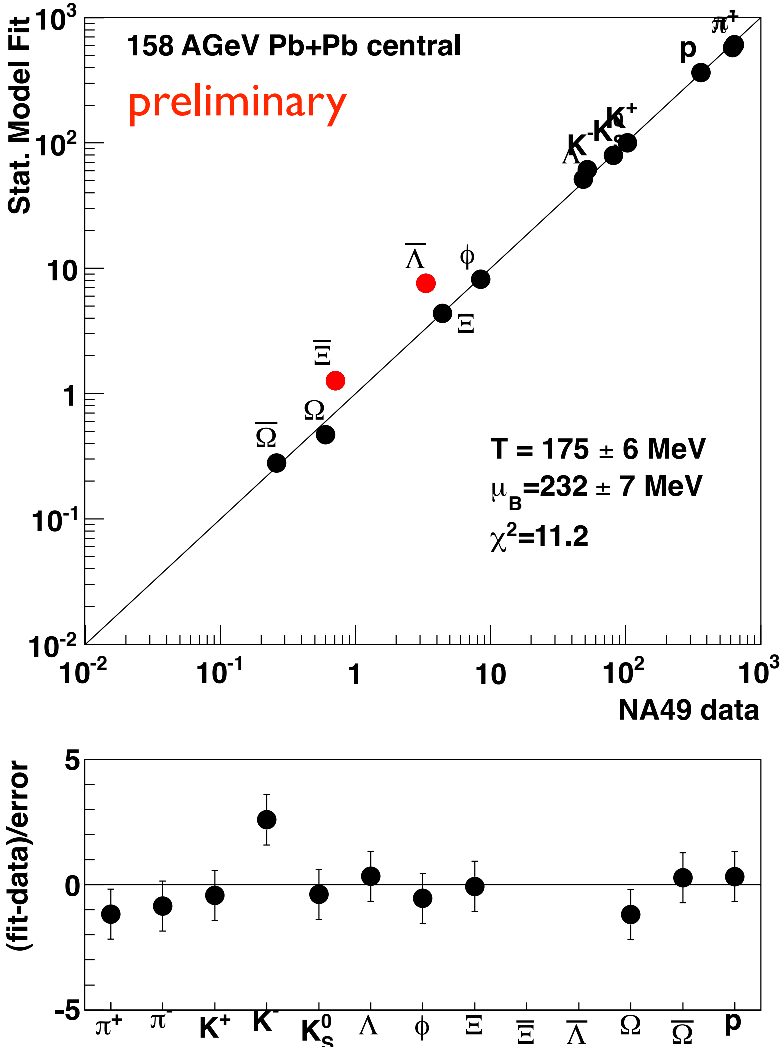


Hydro freeze-out curve essentially recovered
Effect decreases at low μ_B, high $\sqrt{s}$

Final idea: do the same analysis restriction with NA49 data (preliminary)

SM Fits to NA49 Data at 158*A* GeV

Exclude anti-proton, anti-Lambda, anti-Xi in SM Fit!



T = 175 MeV!

"Reasonable" χ^2

Summary

- Reconstruction of hadrochemical freeze-out in a hybrid transport model with statistical model fit
- Diagonal shift of freeze-out curve: T(↓) μ_B (→)
- Cooling vs. distortion?
- Effect mainly on anti-baryon sector excl. anti-Omega

Result:

- Omit anti-proton, anti-Lambda, anti-Xi from SM fit
- Essentially no cooling remains
- Application to NA49 data: preliminary
  $T_c \approx 170$ MeV similar to RHIC analysis at 200 GeV
- Experiments: essential to get Omega, anti-Omega!