Progress report for a new Karlsruhe-Helsinki type pion-nucleon PWA

Shon Watson [1] J. Stahov[2] M. Sadler[1]

[1]Abilene Christian University

[2]University of Tuzla

October 12, 2005

Outline

Motivation and goals

Motivations

- Resonance parameters (masses and widths) published by Particle Data Group are largely based on Karlsruhe-Helsinki 1980 (KH80) PWA solution
- Large amount of high quality experimental data taken since KH80
- Computational capabilities improved dramatically since KH80
- Methods of Karlsruhe-Helsinki PWA can be applied to recent experimental data

Goals: Partial wave amplitudes...

- satisfy Mandelstam analyticity (Fixed-t and Interior Hyperbolic disp. rel.)
- suitable for resonance parameter extraction
- suitable for input in multichannel PWA (e.g. Zagreb group)

Included experimental measurements

Reactions

$$\pi^+ p \longrightarrow \pi^+ p$$

$$\pi^- p \longrightarrow \pi^- p$$

$$\pi^- p \longrightarrow \pi^0 N$$

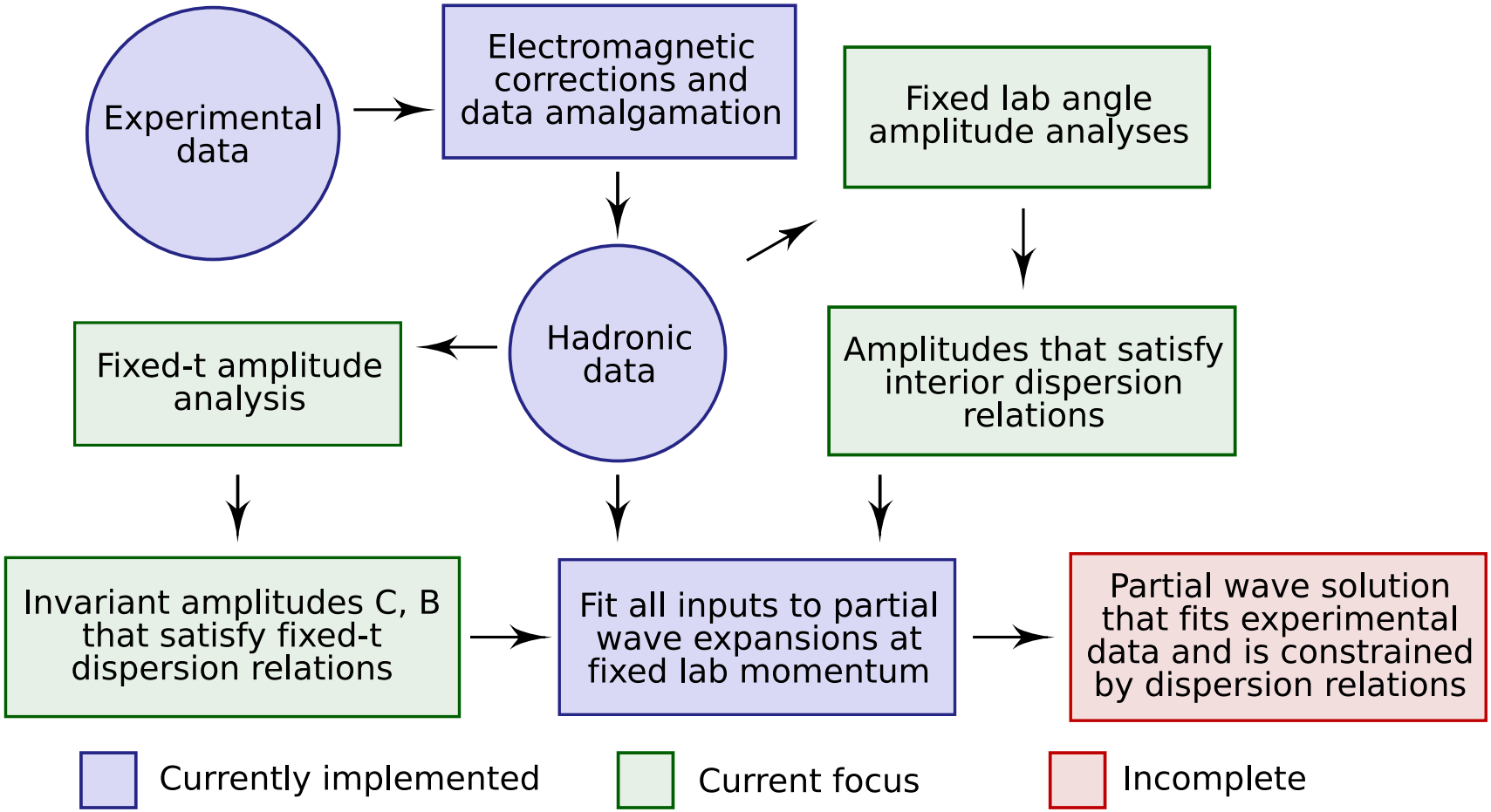
Observables

- Differential Cross Section $\left(\frac{d\sigma}{d\Omega}\right)$
- Polarization (P)
- Spin Rotation Parameters (R and A)

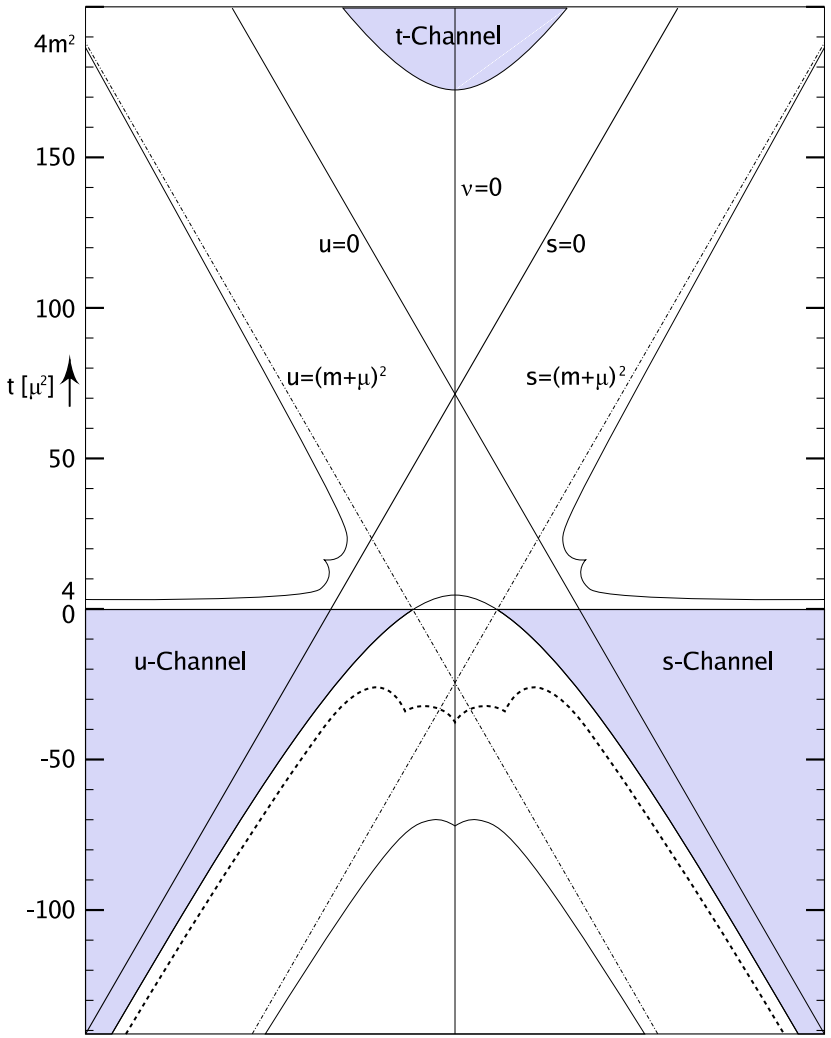
Working database components

- SAID GWU πN database
- Karlsruhe database (higher energy than SAID DB)
- Recent published and preliminary data

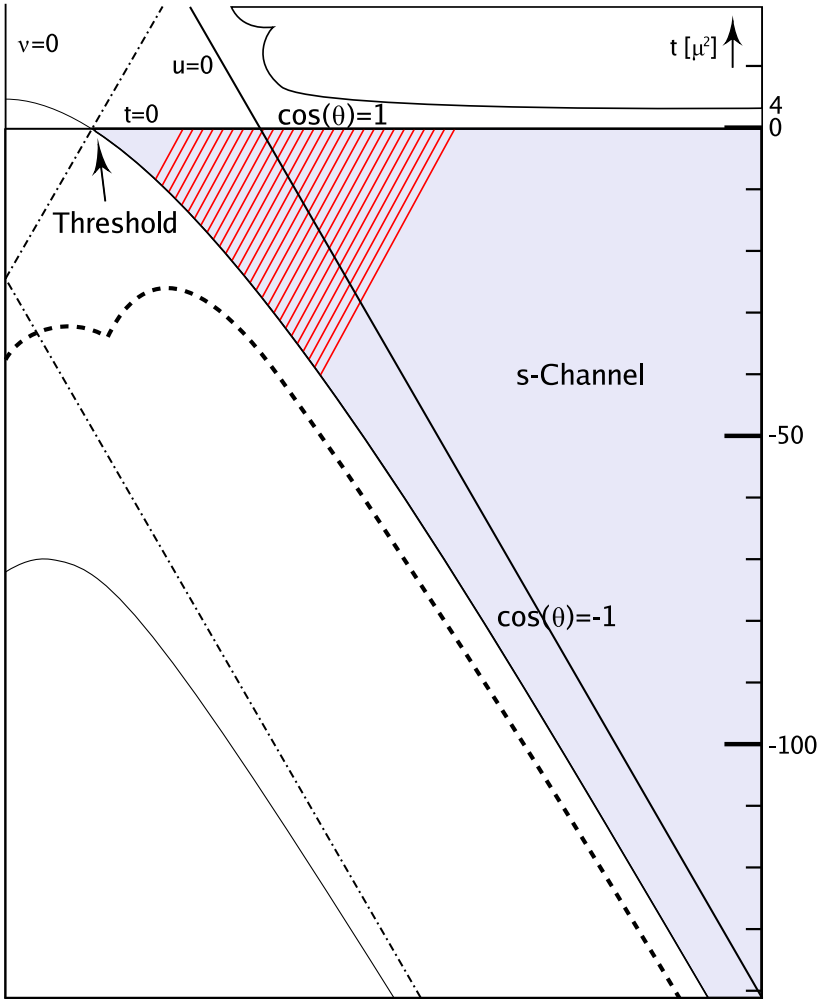
General process



Mandelstam plane



Single energy PWA $s-$channel detail



Single energy PWA

- An energy independent analysis
- Experimental data are binned and shifted to fixed lab momentum
- Unitarity, forward amplitude constraints applied
- Dataset normalization varied and determined during χ^2 minimization

Some issues with the SE analysis

- Continuum ambiguities
- Consistency of partial wave amplitudes as a function of energy (e.g. from dataset normalization)
- Choice of energy values to make most effective use of available data

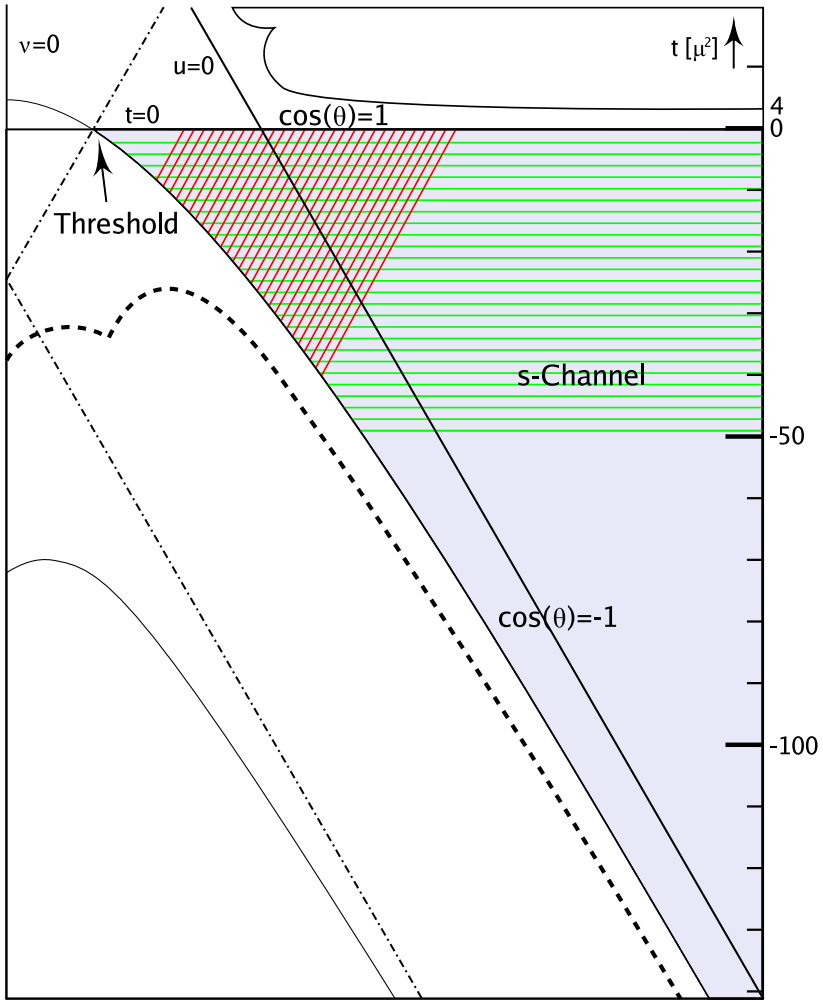
Resolving SE issues

- Use invariant amplitude analyses to stabilize PW solution and avoid continuum ambiguities
- Analyses provide analytic constraints, crossing symmetry, while describing available data
- Use a model independent flexible parameterization of the C and B invariant amplitudes that can be fit directly to experimental observables
- Use Pietarinen's expansion method (as in KH78, KH80) instead of explicit dispersion relation integral expressions

Fixed-t analysis

s-channel detail

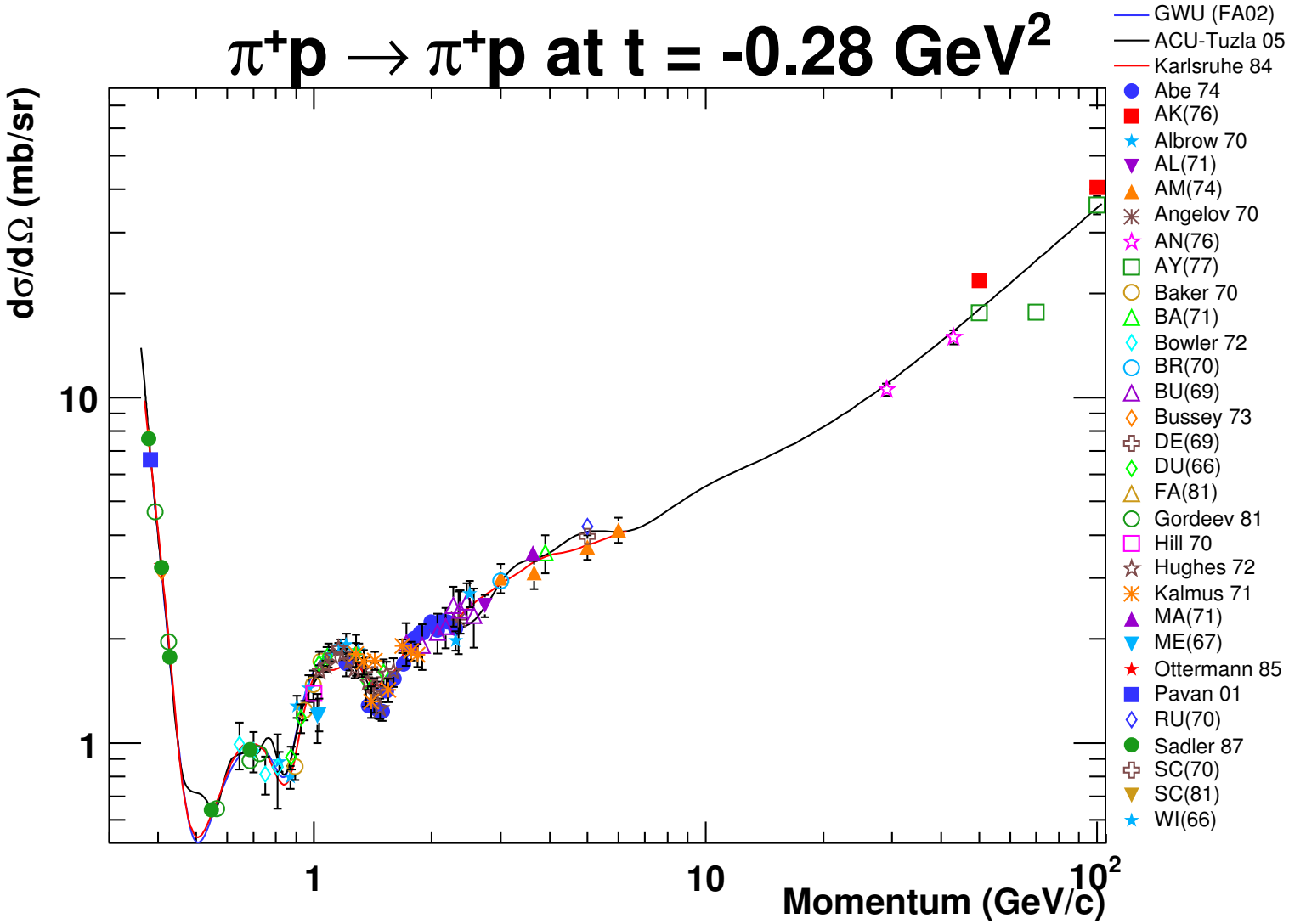
- Fixed-t bin locations
- Single energy bin locations (fixed s)
- Mesh-like grid where analyses overlap



Fixed momentum transfer analysis

- An amplitude analysis used in KH80
- Amplitudes resulting from analysis satisfy fixed-t dispersion relations
- Experimental data are binned then shifted to fixed-t values
- Provides a strong analytic and $s-u$ crossing symmetric constraint
- Covers a large kinematic region (up to very high energy, $p_{\text{Lab}} \approx 300\,\text{GeV}/\text{c}$)

Example of part of fixed-t fit



Fixed-t analysis issues

- Only provides full angular coverage for lab momentum less than approximately $1.1\,\mathrm{GeV}/c$

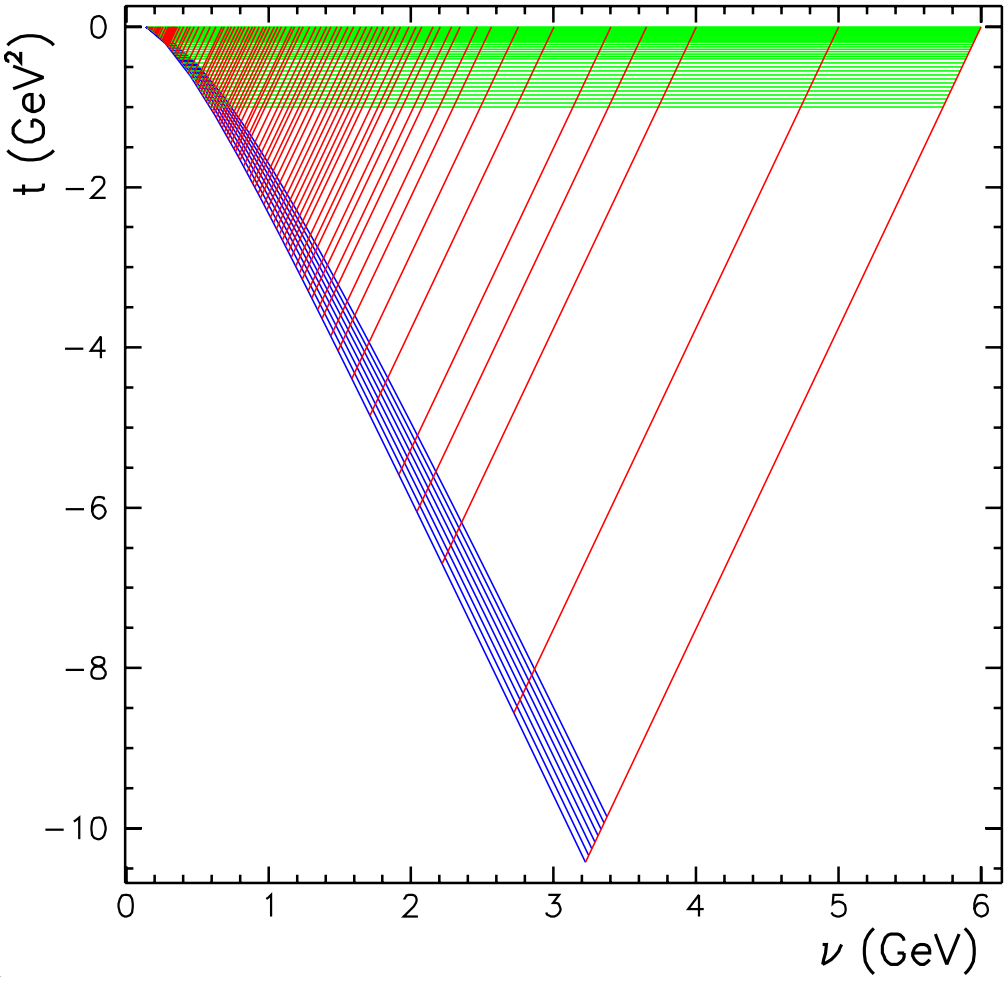
$$
\begin{aligned}
t &= -0.5\,\mathrm{GeV}^2 \Rightarrow p_{\mathrm{Lab}} = 521\,\mathrm{MeV}/c \\
t &= -1.0\,\mathrm{GeV}^2 \Rightarrow p_{\mathrm{Lab}} = 843\,\mathrm{MeV}/c \\
t &= -1.5\,\mathrm{GeV}^2 \Rightarrow p_{\mathrm{Lab}} = 1141\,\mathrm{MeV}/c
\end{aligned}
$$

- Analysis difficult in some regions due to gaps in available experimental data
- Requires many fit parameters (200 to 400 parameters per value of t, effective free parameters is lower due to penalty function)

Including interior dispersion relation analysis

s-channel detail

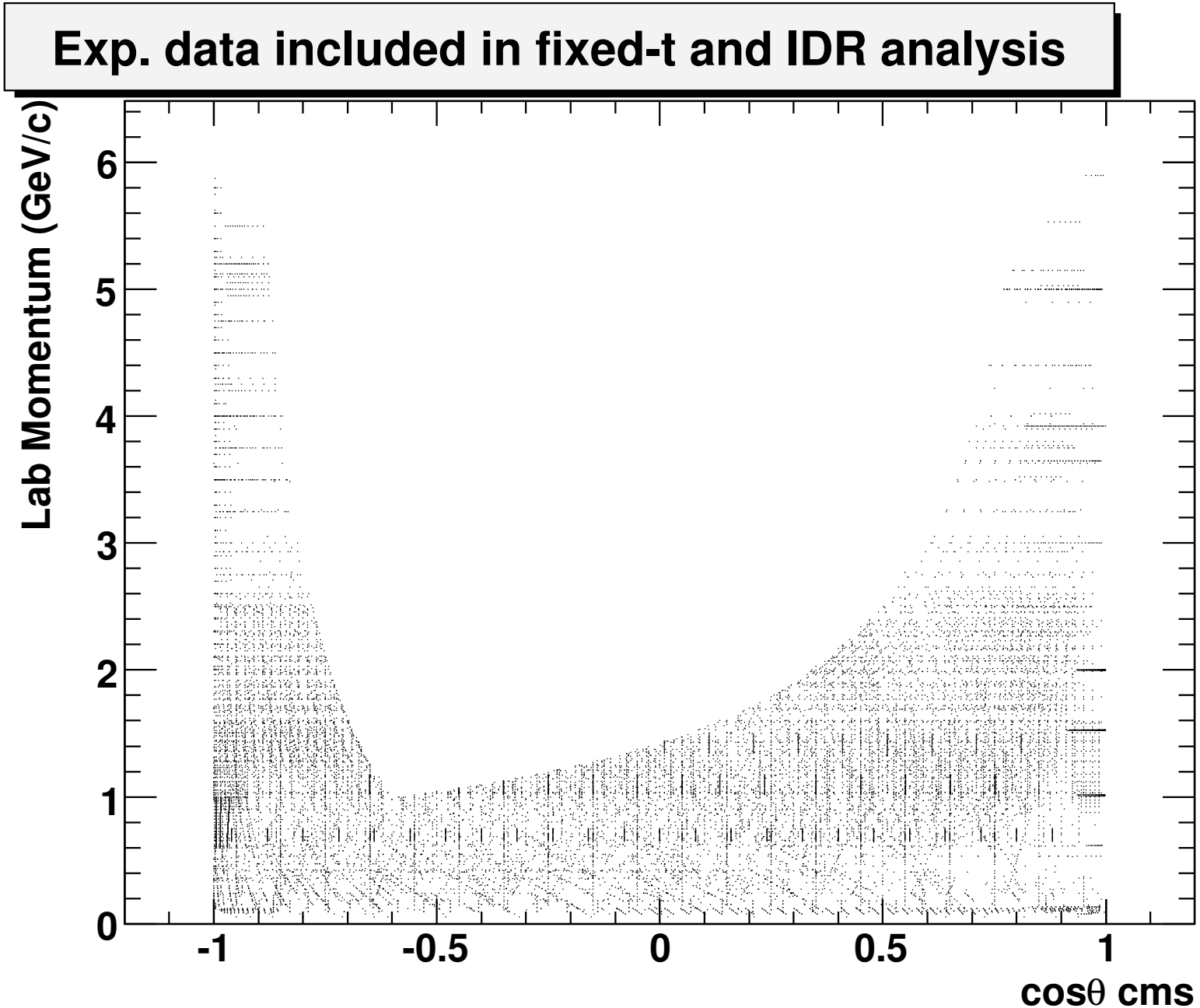
- IDR bin locations added
- Fixed-t bin locations
- Single energy bin locations (fixed s)
- Mesh-like grid where analyses overlap
- Example shows coverage up to $p_{\mathrm{Lab}} = 6\,\mathrm{GeV/c}$



Interior dispersion relation analysis

- IDR amplitude analysis was not used in KH80
- Amplitudes resulting from this analysis satisfy interior hyperbolic dispersion relations
- IDR analysis corresponds to fixed lab angle (θ_π)
- Covers lab angle from $180^\circ \leq \theta_\pi < 95^\circ$
- Covers a large kinematic region (up to high energy, $p_{\text{Lab}} \approx 25\,\text{GeV}/c$)
- Covers backward direction and complements region covered by fixed-t analysis

Kinematic coverage for $p_{\mathrm{Lab}} < 6\,\mathrm{GeV}/c$



Progress summary

- Process for SE analysis is in place
- FT analysis is largely implemented
- IDR analysis is in early stages of development
- Links between the three analyses are implemented
- Iterative procedure for bringing all three analyses into agreement is not complete (difficult to start or “boot-strap” the process)
- Strategy for consistently handling dataset normalizations between analyses is not implemented
- Data binning for each analysis could be improved to better utilize available measurements