Analytic properties of DPE amplitudes or Collinear Factorization for Central Production

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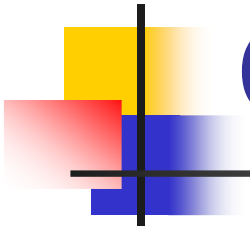
Main Topics

- QCD factorization and its violation
- QCD factorization vs analyticity
- Analyticity and crossing for hard exclusive lepton hadron reactions
- DPE specifics and the role of Steinmann relations
- BABAR data: violation of factorization typical?
- Possible implications for Higgs production
- Conclusions

QCD factorization



- Hard (calculable Perturbatively) vs Soft (Non-Perturbative but univesral) parts
- Collinear – transverse Perturbative (DGLAP)+ longitudinal NP (PDF)
- Violations: (calculable) non-universality of soft; IR instability of hard
- Kt- longitudinal Perturbative (BFKL)+transverse NP(Unintegrated Gluon Distributions)

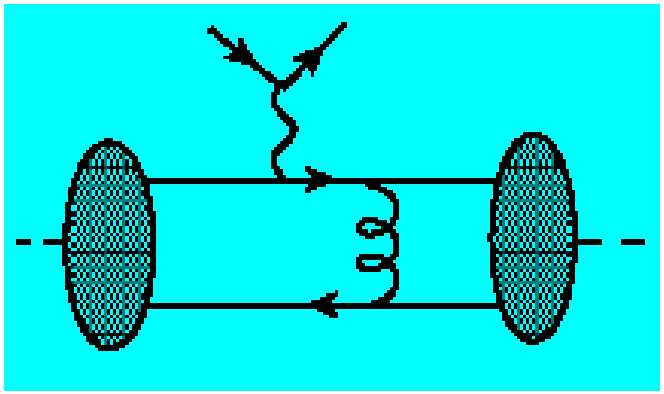
Exclusive processes

- Complicated – new P and NP ingredients
- Kt-Generalzied UGD
- - difficulties in factorization proof
- Durham (standard) model
- Collinear – ERBL evolution + GPD's
- Possible implication of BABAR data – IR contribution even in the simplest case`

Explore crossing (+modification of soft parts)

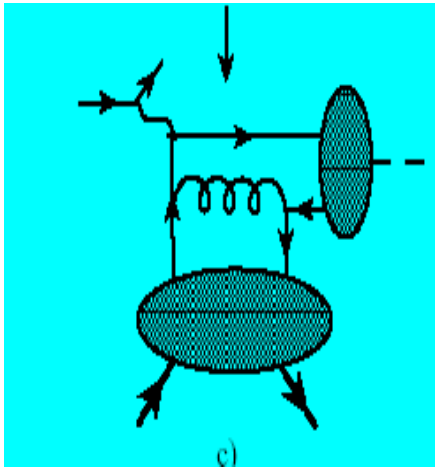
- Starting from (Pion) form factor- 2 DA's

$$F \propto \left(\int dx \frac{\phi(x)}{1-x}\right)^2$$



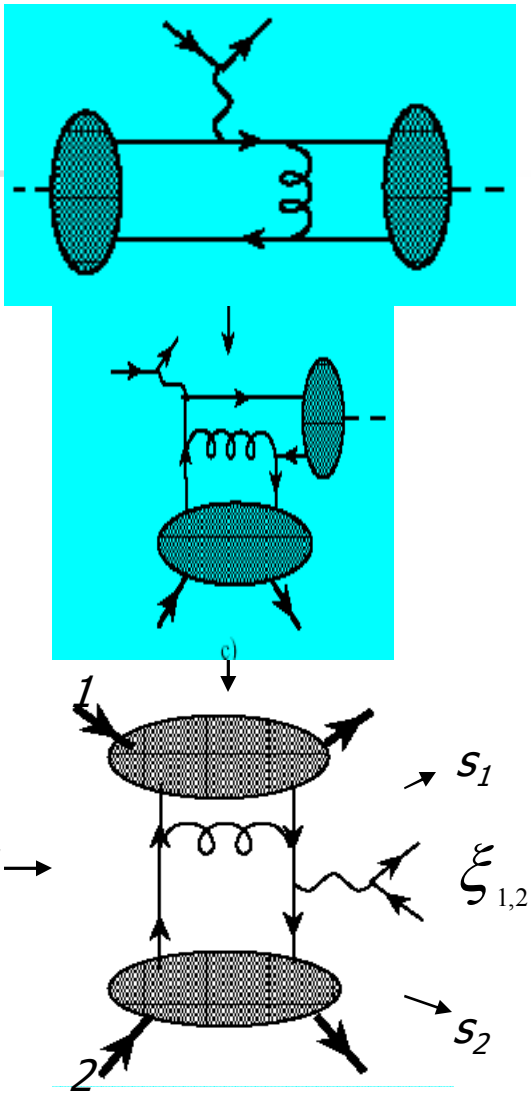
- 1 DA -> GPD : Exclusive meson production (F,S,...)

$$M \propto \int dx \frac{\phi(x)}{1-x} \int dx \frac{H(x,\xi)}{x-\xi+i\varepsilon}$$



Next step: 2 DA's -> 2 GPD's- Double Diffraction

- Exclusive double diffractive DY process (quarks-exclusive DY)
- Direct calculation – NO factorization in physical region

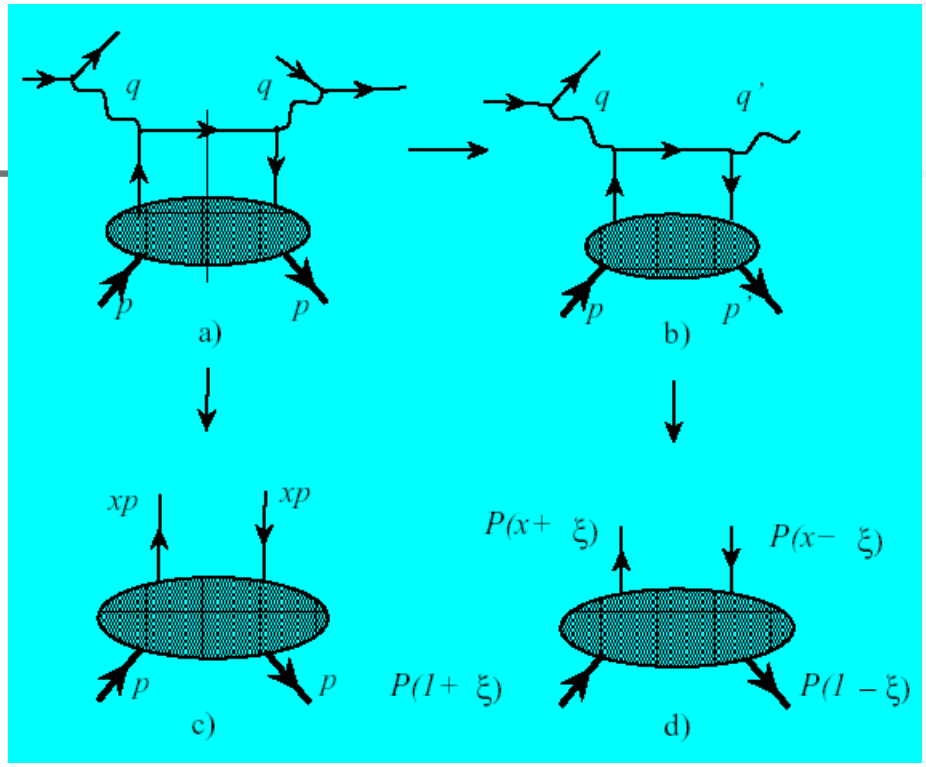


$$M \sim \int\int dxdy \frac{H(x,\xi_1)H(y,\xi_2)}{(x-\xi_1)(y-\xi_2)+i\varepsilon}$$

Analytic continuation

- Try to calculate in the unphysical region
- $|\xi_{1,2} = s_{2,1}/s \quad |>1$
- How to continue?
- Solved for hard SPE –type amplitudes (LO - OT, EDS@Blois'05; Anikin, OT;Polyakov, Semenov-Tian-Shansky; Muller,Kumericky; NLO – Diehl, Ivanov)

Factorization for DIS and DVCS



- Manifestly spectral

$$\mathcal{H}(x_B) = \int_{-1}^{1} dx \frac{H(x)}{x - x_B + i\epsilon}$$

- Extra dependence on ξ

$$\mathcal{H}(\xi) = \int_{-1}^{1} dx \frac{H(x,\xi)}{x - \xi + i\epsilon},$$

Unphysical regions

- DIS : Analytical function – polynomial in $\xi = x_B$ if $1 \le |X_B|$
- DVCS – additional problem of analytical continuation of $H(x,\xi)$

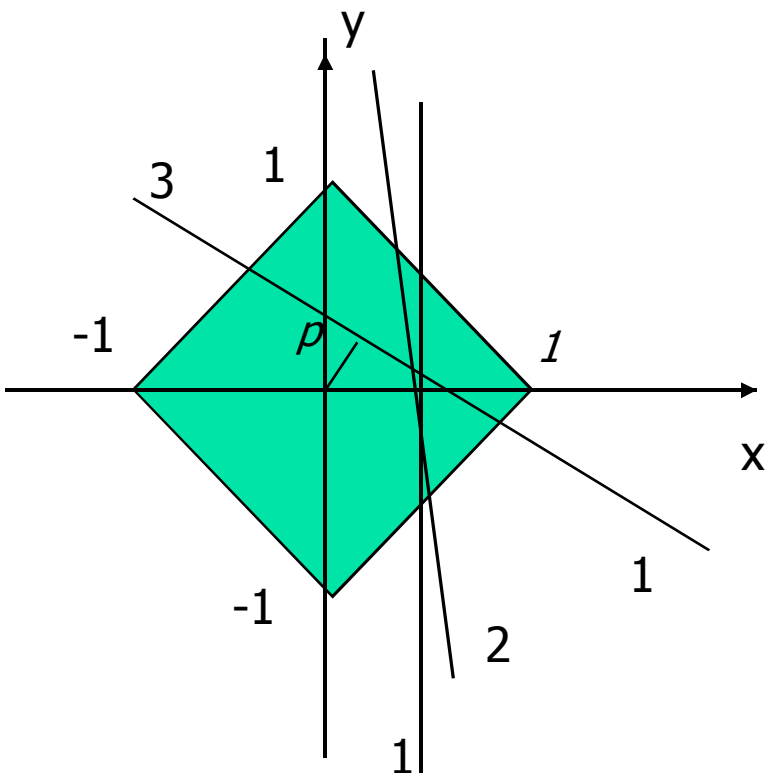
$$H(x_B) = -\int_{-1}^{1} dx \sum_{n=0}^{\infty} H(x) \frac{x^n}{x_B^{n+1}}$$

- Solved by using of Double Distributions (Radon transform)

$$H(z,\xi) = \int_{-1}^{1} dx \int_{|x|-1}^{1-|x|} dy (F(x,y) + \xi G(x,y)) \delta(z - x - \xi y)$$

Double distributions and their integration

- Slope of the integration line- skewedness
- Kinematics of DIS: $\xi = 0$ ("forward") - vertical line (1)
- Kinematics of DVCS: $\xi < 1$ - line 2
- Line 3: $\xi > 1$ (unphysical region - required also to restore DD by inverse Radon transform - tomography) ?!

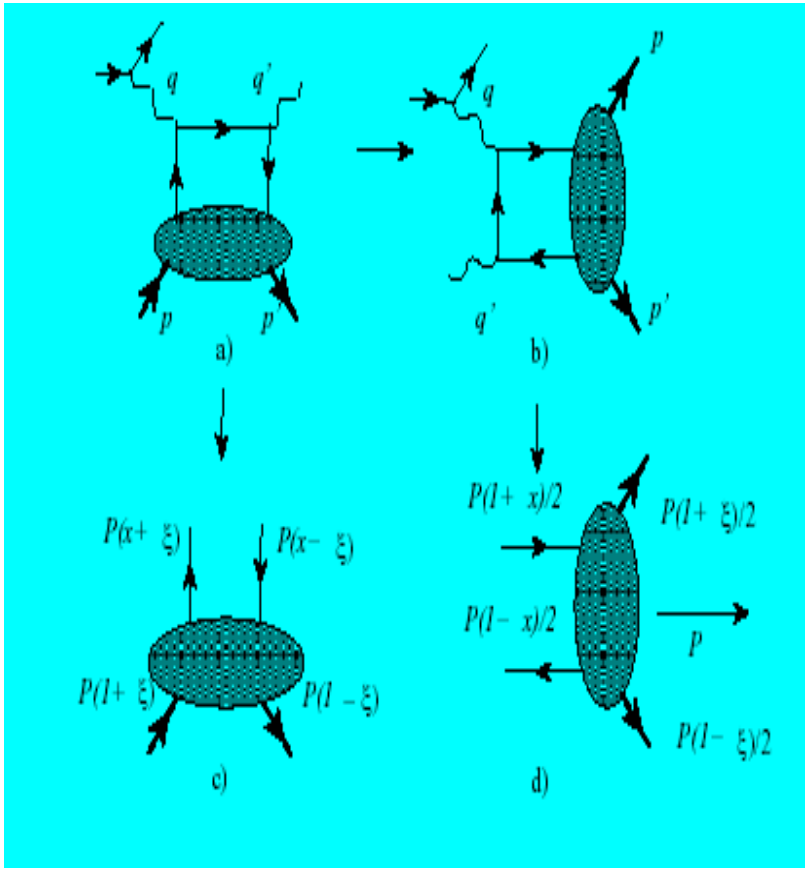


$$f(x,y) = -\frac{1}{2\pi^2}\int_0^\infty \frac{dp}{p^2}\int_0^{2\pi} d\phi|cos\phi|(H(p/cos\phi + x + ytg\phi, tg\phi) - H(x + ytg\phi, tg\phi)) =$$

$$= -\frac{1}{2\pi^2}\int_{-\infty}^{\infty}\frac{dz}{z^2}\int_{-\infty}^{\infty} d\xi(H(z + x + y\xi, \xi) - H(x + y\xi, \xi))$$

Crossing for DVCS and GPD

- DVCS -> hadron pair production in the collisions of real and virtual photons
- GPD -> Generalized Distribution Amplitudes (Diehl,Gousset,Pire, OT)



Holographic property

- Factorization Formula ->

$$\mathcal{H}(\xi) = \int_{-1}^{1} dx \frac{H(x,\xi)}{x - \xi + i\epsilon}$$

- Analyticity -> Imaginary part -> Dispersion relation:

$$\mathcal{H}(\xi) = \int_{-1}^{1} dx \frac{H(x,x)}{x - \xi + i\epsilon}$$

$$\Delta\mathcal{H}(\xi) \equiv \int_{-1}^{1} dx \frac{H(x,x) - H(x,\xi)}{x - \xi + i\epsilon}$$

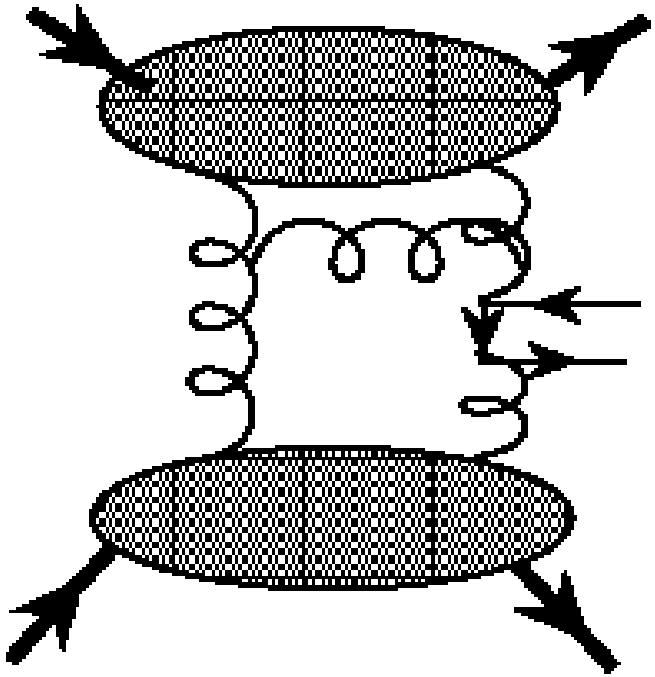
$$= \sum_{n=1}^{\infty} \frac{1}{n!} \frac{\partial^n}{\partial \xi^n} \int_{-1}^{1} H(x,\xi) dx (x - \xi)^{n-1} = const$$

Cuts for DPE

- Scaling – dependence on Ratios $\xi_{1,2} = s_{2,1}/S$
- No unique prescription to accommodate 2 cuts. Same for simultaneous sign change - cancellation
- For DPE – another variable – (invariant) mass of the produced system
- Double cuts in overlapping channels – absent for STABLE particles (Steinmann relations)
- For DY and HIGGS\double cut allowed!
- $$\xi_{1,2} = s_{2,1}/S + i0$$

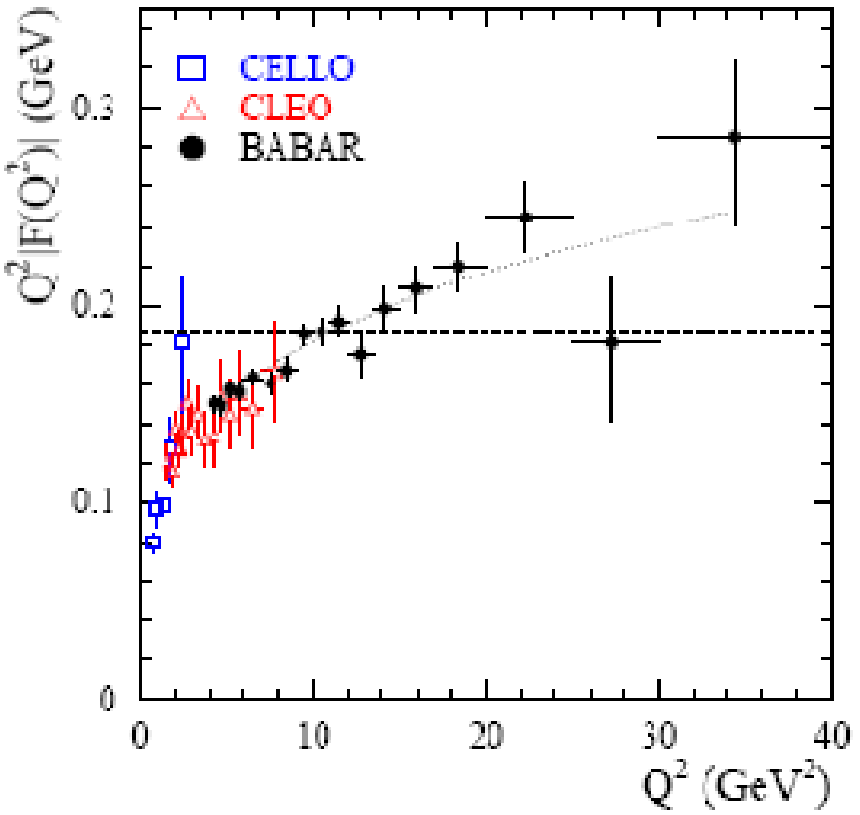
Implications for Higgs

- Already at the crossing level – GPD ->GDA
- Higgs production amplitude (GPD) -
- Higgs EXCLUSIVE DECAY amplitude to 2 hadron pairs (MC)
- More general property than collinear factorization framework
- Collinear factorization – quantification of the effect of analitical continuation



Hot topic for (p)QCD: BABAR data **0905.4778** [hep-ex]

- Pion-photon transition FF
- Where is attractor?!



Status of factorization and BABAR data

- Growth of pion photon transition FF- possible evidence for flat pion distribution (Radyushkin, Polyakov) Growth due to IR contribution

$$F \sim \left(\int dx \frac{\phi(x)}{1-x}\right)^2$$

- For pion FF – Brodsky-Lepage ratio

- Analoguous ratio of VM amplitude squared to exclusive DY one

Back to physical region

- If IR divergence is typical (FF's, transverse vector meson production) –original integral is not much worse!

$$M \sim \int\int dxdy \frac{H(x,\xi_1)H(y,\xi_2)}{(x-\xi_1)(y-\xi_2)+i\varepsilon}$$

- Infinitesimal -> finite width (Higgs – gluon "mass"/non-local condensate width) in the denominator
- Counterpart of Sudakov in Duhram Model?

CONCLUSIONS

- FF->VMP -> DPE DA-> GPD
- No direct factorization in physical region. If pion DA is indeed flat – typical situation.
- Crossing analogs of GPD -> GDA: Relation of Higgs exclusive production and decay
- Double cuts - for unstable particle – imaginary part for hard DPE-type amplitudes
- Durham (standard) model: to be continued