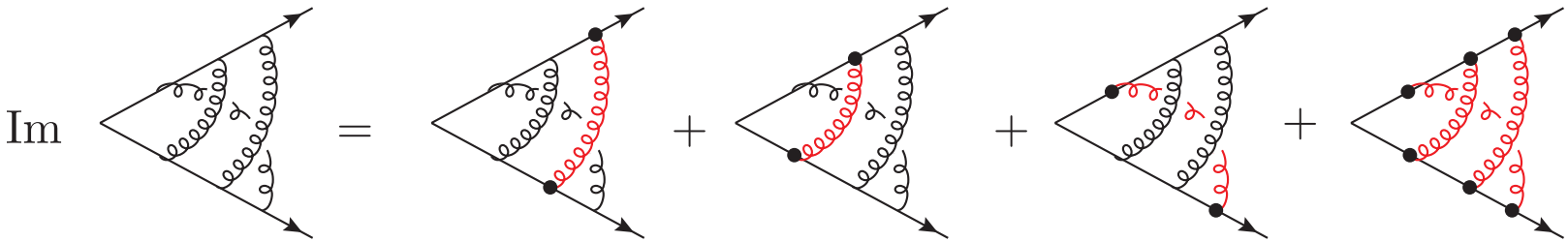
Imaginary Parts of Wilson Lines



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Cargese International School for Theoretical Particle Physics
July 22, 2014

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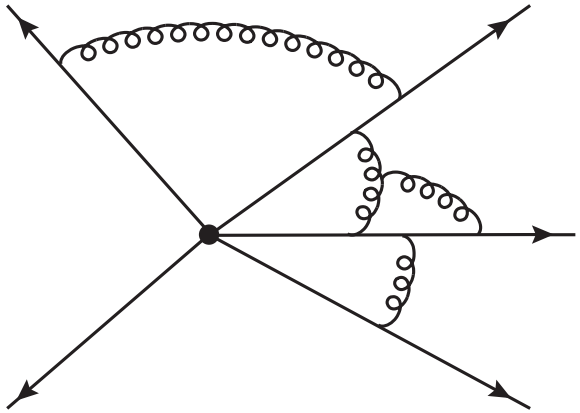
Wilson lines & imaginary part

A Wilson line correlator describes soft gluon exchanges between highly energetic partons after a hard scattering event



Study infrared QCD

Its imaginary part...

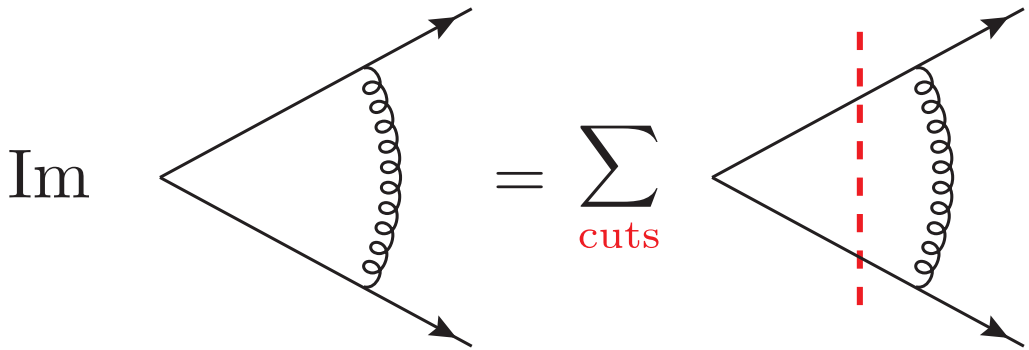
- ... defines an interaction potential (in conformal theories)
- ... is related to violation of collinear factorisation at three loops

Catani, de Florian, Rodrigo [1112.4405]; Forshaw, Seymour, Siódmok [1206.6363]

- ... allows a modest step towards a unitarity formalism

Computation of the imaginary part: cutting diagrams

Momentum space picture



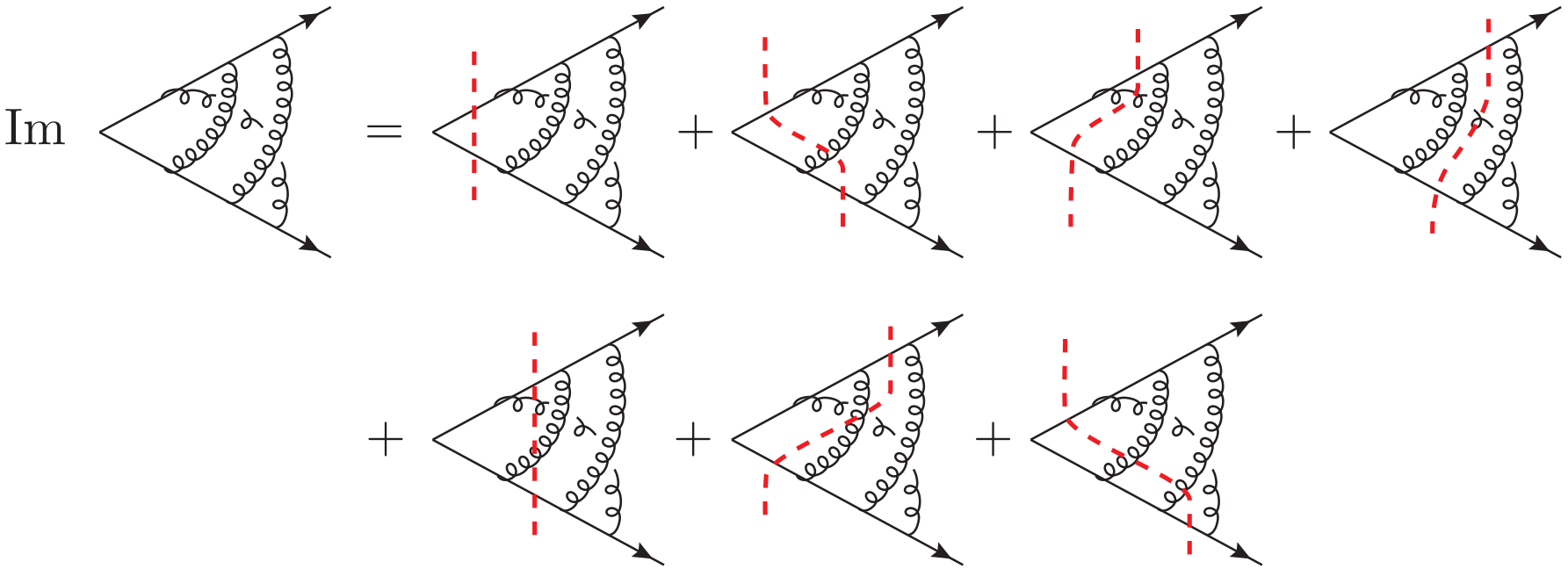
Cut diagram factorises into product of tree diagrams

$$\frac{1}{l \cdot v + i\eta} \longrightarrow -2\pi i\, \theta(v^0)\, \delta(l \cdot v)$$

Imaginary part arises from on-shell partons

But... challenging at higher loops!

Cutting a multi-loop diagram

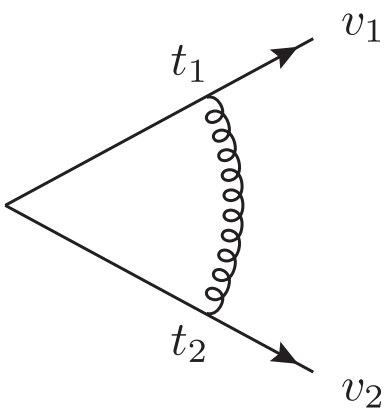


yields 3-, 4-, . . . particle phase space integrals

Need better method

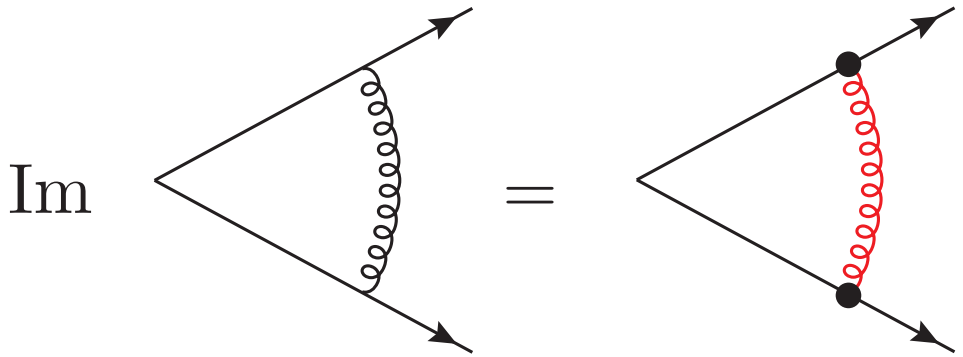
Cuts in position space

Position space representation is simpler

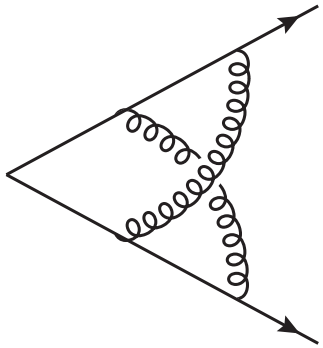


$$\mu^{2\epsilon}\int_0^\infty dt_1\int_0^\infty dt_2\,\frac{v_1\cdot v_2}{(-(t_1v_1-t_2v_2)^2+i\eta)^{1-\epsilon}}$$

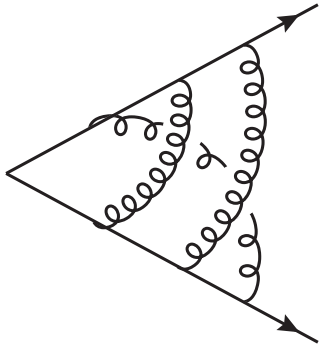
1. Extract leading IR divergence $(t_1,t_2)=(\lambda\,x,\lambda\,(1-x))$
2. Cut and integrate remaining variable



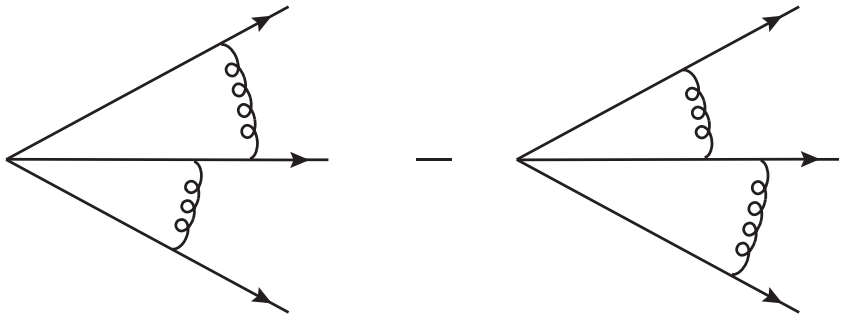
Applied to various examples



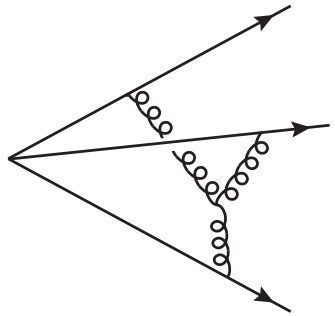
Two-loop



Three-loop



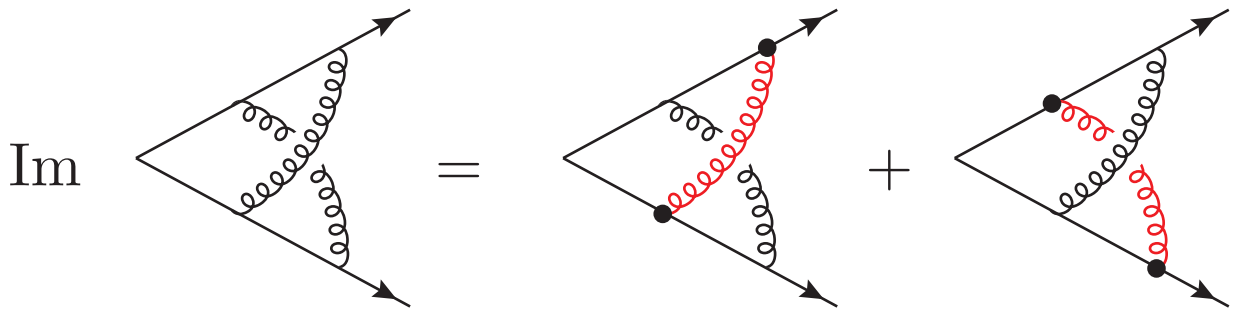
Web



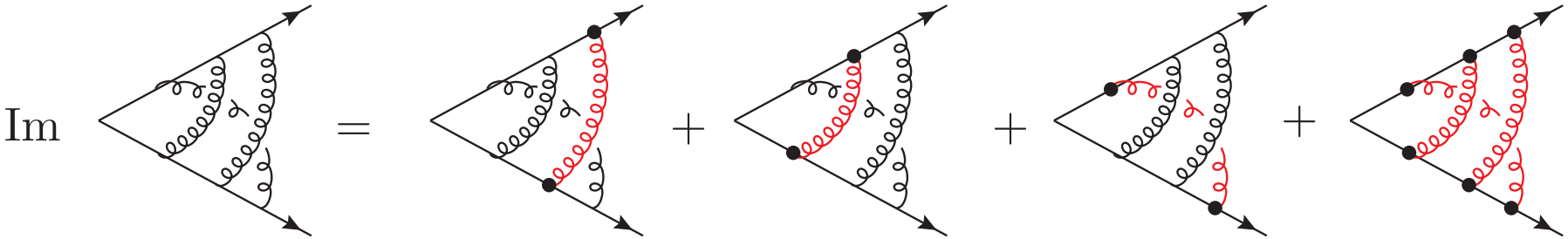
3-gluon vertex

Cutting formula at higher loops

Two loops



Three loops (triple cut)



Cutting in position space is a simple way to compute the imaginary part