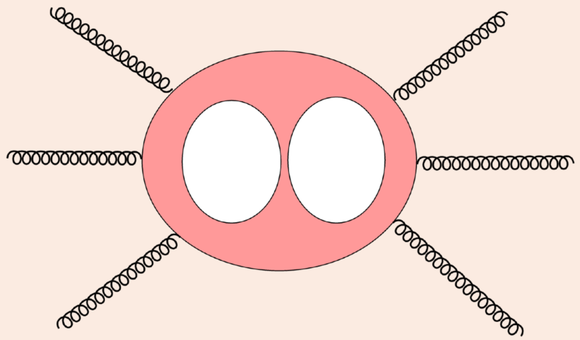
Bootstrap QCD amplitudes

Sixth QFT and its applications conference
Oct. 17, 2026

Yang Zhang
University of Science and Technology of China

Based on



✓ First bootstrap computation of 2loop 6point QCD amplitudes

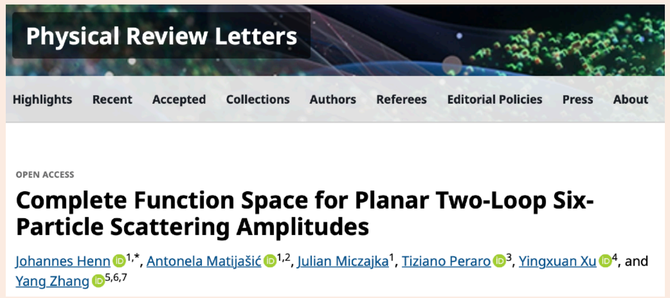


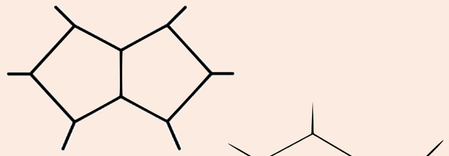
Carrôlo, Chicherin, Henn, Yang, YZ

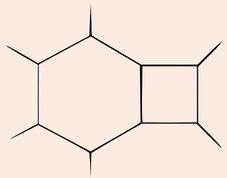
Phys.Rev.Lett. 136 (2026) 18, 181602

JHEP 08 (2026) 100

✓ analytic computation of all 2loop 6point planar massless integrals







Henn, Matijasic, Miczajka, Peraro, Xu, YZ, *Phys. Rev. Lett. 135 (2025) 3, 031601*

Henn, Matijasic, Miczajka, Peraro, Xu, YZ, *JHEP 08(2024) 027*

Liu, Matijasic, Peraro, Xu, Yang, YZ, *JHEP 07 (2026) 223*

Outline

Bootstrap, then and now

Analytic Feynman integral

Two-loop Six-point QCD amplitude bootstrap

Summary

Bootstrap
then and now

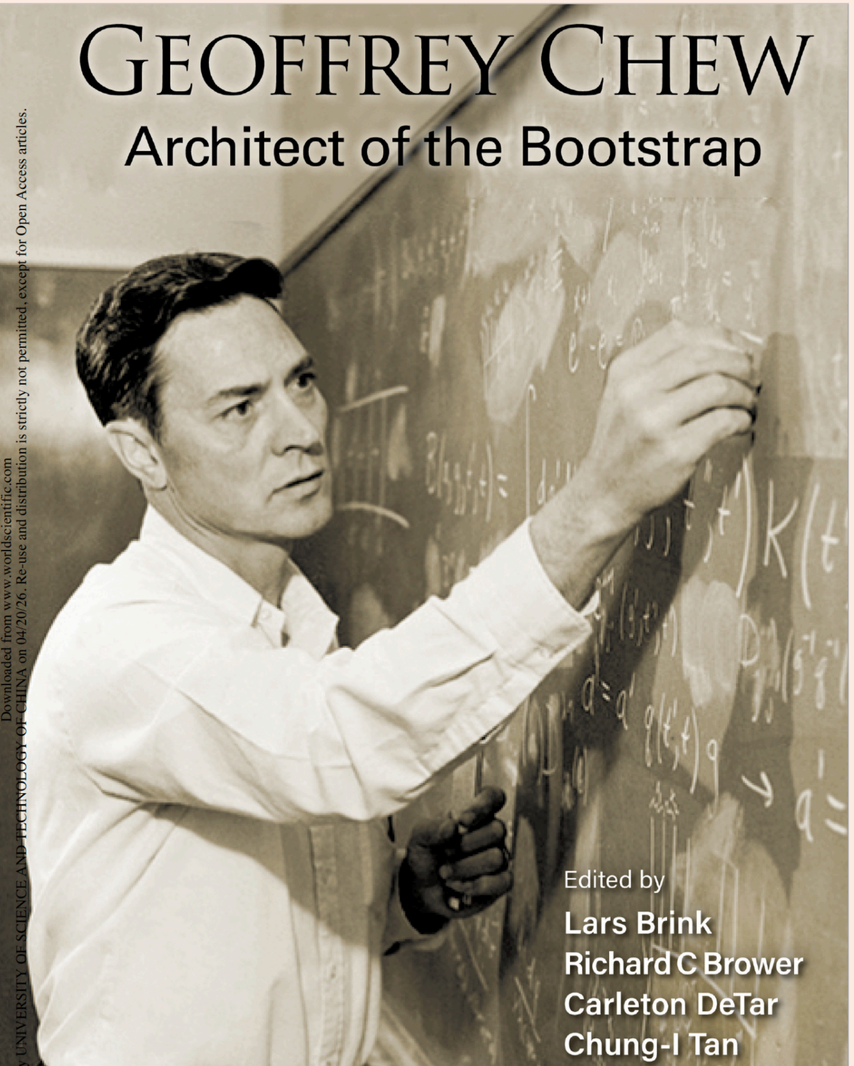


“pull yourself up by your bootstraps”

Bootstrap

S-matrix bootstrap

Chew and Mandelstam, 1960s



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Construct the observable, S-matrix from a few general principles

Unitarity

Analyticity

Cross symmetry

Regge limit

different approach from perturbative QFT (Feynman diagrams);
less popular after the triumph of QCD

Amplitude Bootstrap

maximally supersymmetric-Yang-Mills

However, our world
is not supersymmetric, yet …

dual conformal letters

↓

Integrable symbols

↓

Ansatz

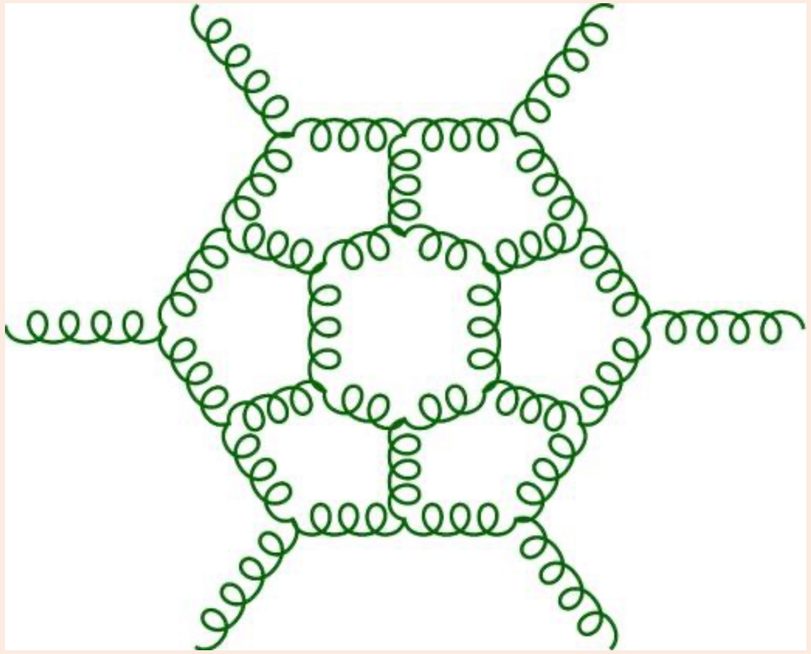
↓

Amplitude

supersymmetry + dual conformal symmetry
only 9 letters for six-particle scattering

with Steinmann relation

collinear/Regge limit, dihedral symmetry



Seven-loop six-point diagram
Dixon, UC Davis (2022)

(3 loops MHV, symbol) Dixon, Drummond, Henn, *JHEP 11 (2011) 023*
(3 loops MHV, functions) Dixon, Drummond, von Hippel, Pennington, *JHEP 12 (2013) 049*
(4 loops MHV) Dixon, Drummond, Duhr, Pennington, *JHEP 06 (2014) 116*
(5 loops MHV & NMHV) Caron-Huot, Dixon, McLeod, von Hippel, *Phys. Rev. Lett. 117 (2016) 241601*
(6–7 loops MHV; 6 loops NMHV) Caron-Huot, Dixon, Dulat, von Hippel, McLeod, Papathanasiou, *JHEP 08 (2019) 016*
(8 loops MHV, antipodal duality) Dixon, Liu, *JHEP 09 (2023) 098*

Amplitude Bootstrap

maximally supersymmetric-Yang-Mills

ANTHROP\C

September 2026 release smsharma.io/cosmic-nine-loops

Nine-loop Planar N=4 SYM, six-gluon MHV amplitude bootstrap with Claude AI

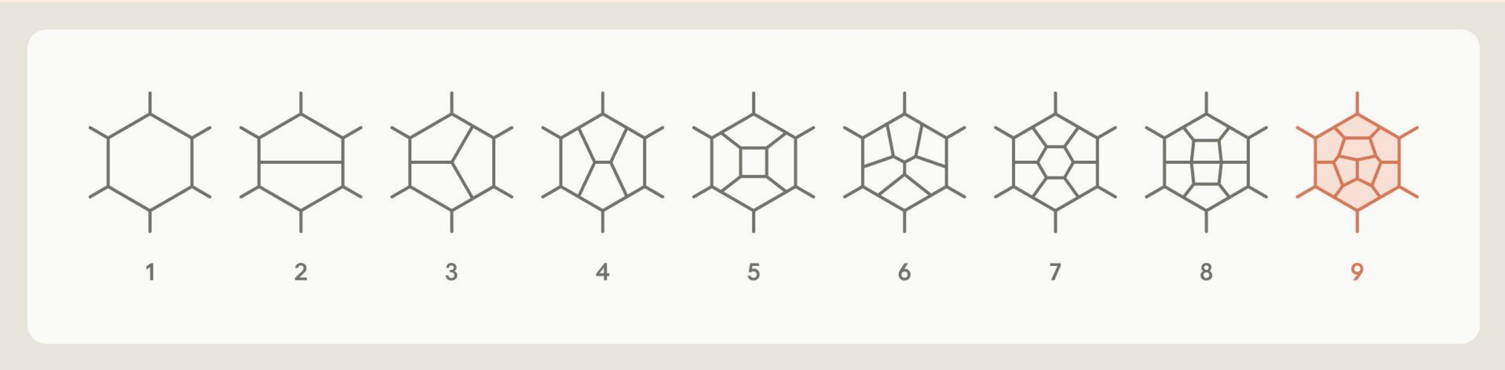
weight-18 symbol and a function completion

Direct hexagon bootstrap

Hexagon function space
Extended Steinmann and final-entry constraints
Collinear limits and pentagon OPE

Form-factor route

Nine-loop three-point form factor
Antipodal duality on the parity-even surface
Lift using origin behaviour and OPE data



Schematic from Anthropic. Independent validation by Dixon. Concurrent nine-loop symbol by Song He's group.



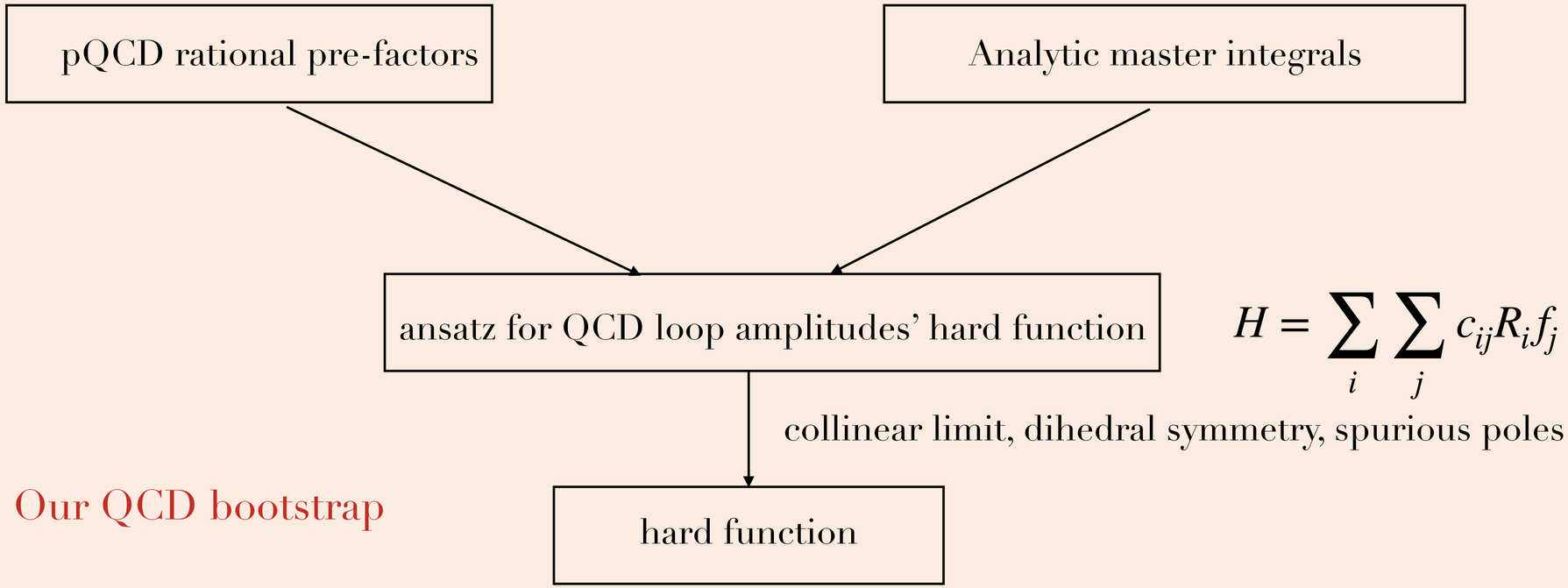
N=4 super-Yang-Mills

QCD

QCD Bootstrap (our approach)

QCD is not supersymmetric, not dual conformal invariant …

N=4 Super-Yang-Mills six-point amplitudes have 9 letters to all loop order,
however, for QCD, two-loop six-point Feynman integrals contains 167 letters. The integrable symbol approach will not work.



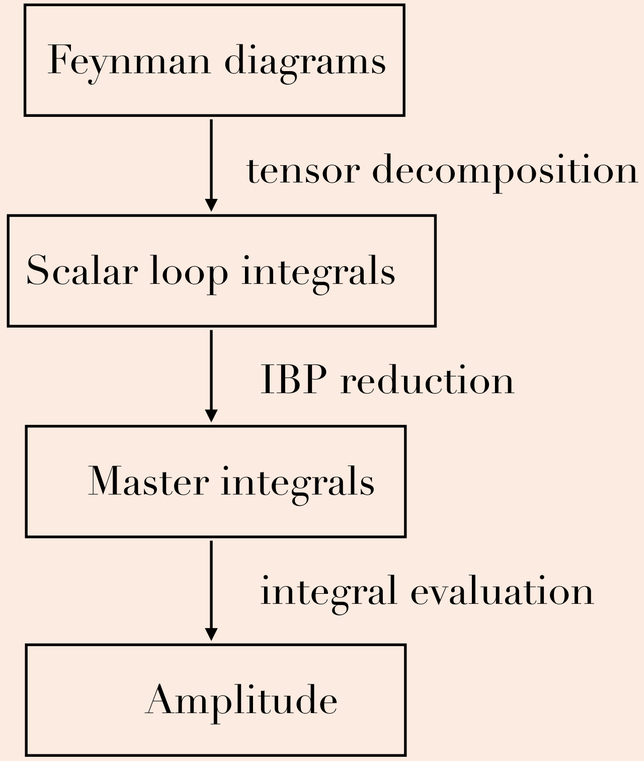
$$H = \sum_i \sum_j c_{ij} R_i f_j$$

Our QCD bootstrap

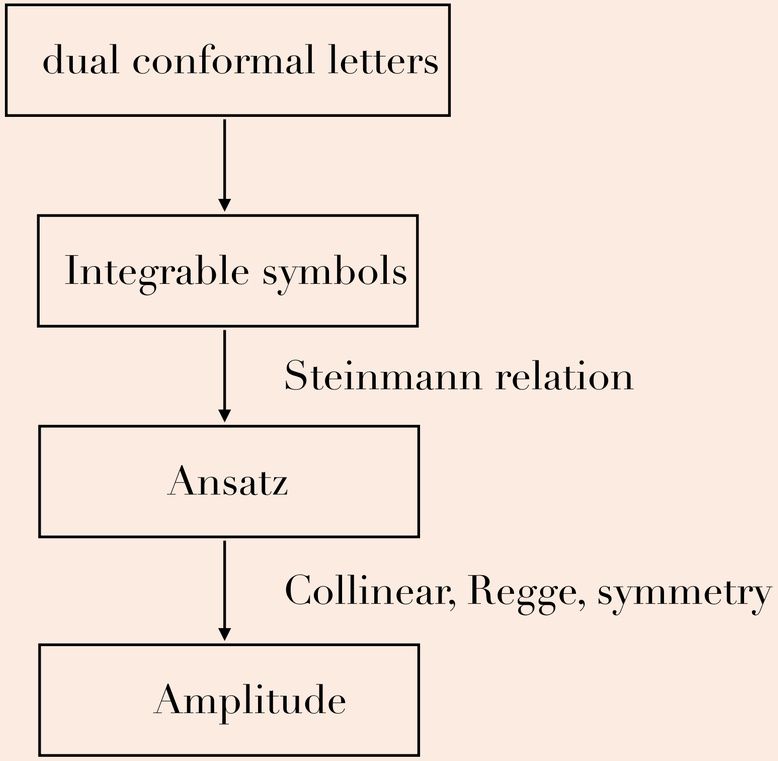
Carrôlo, Chicherin, Henn, Yang, YZ
Phys. Rev. Lett. 136 (2026) 181602
JHEP 08 (2026) 100

A comparison

Traditional



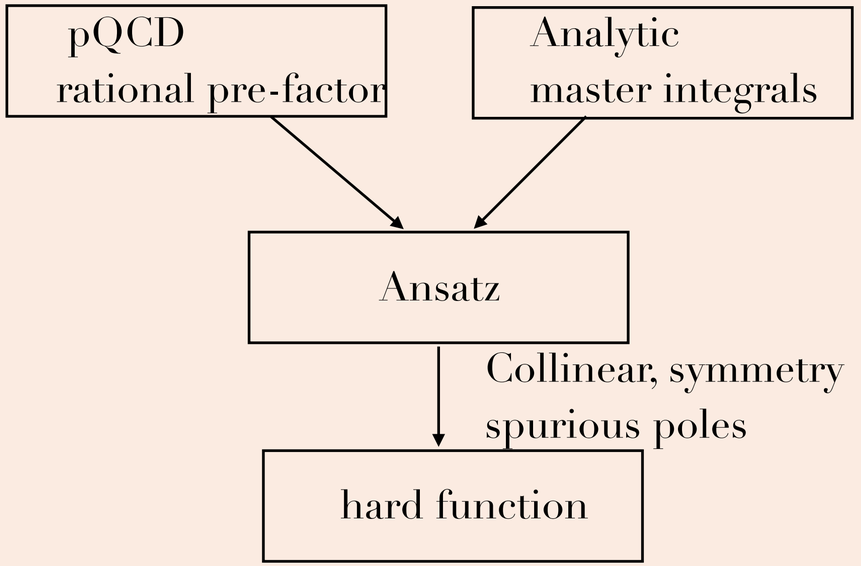
Amplitude Bootstrap
maximally supersymmetric



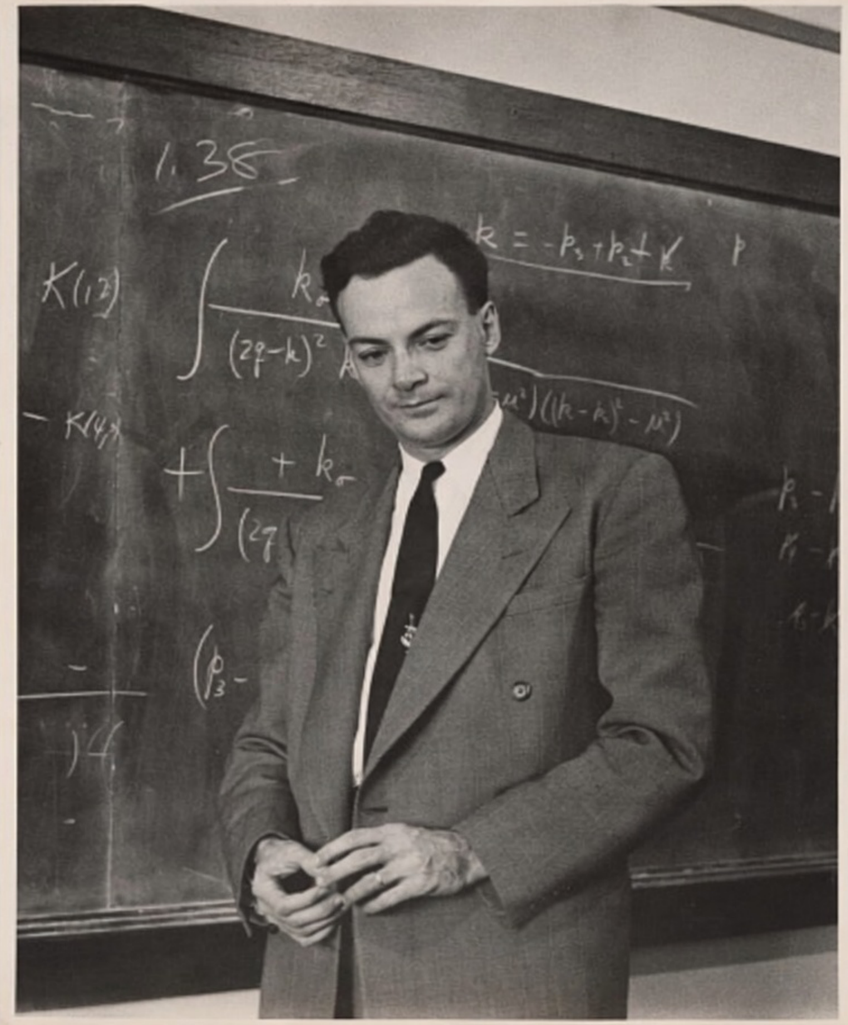
Dixon, et. al.

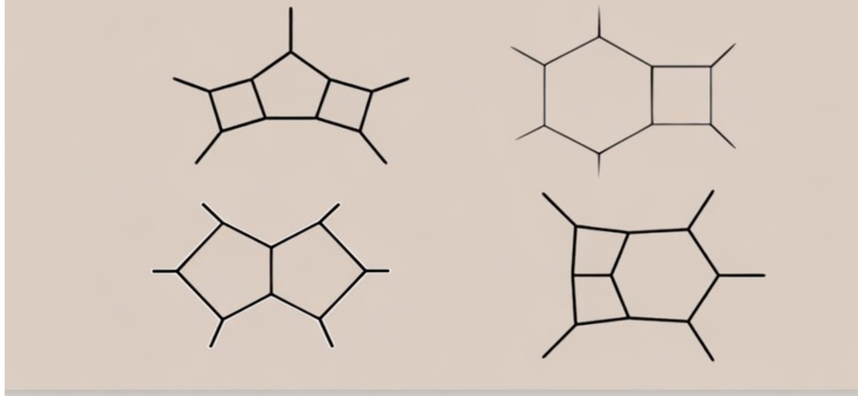
Our approach

QCD Bootstrap



Analytic Feynman integrals





Current status of analytic Feynman integral computation

also an advertisement of our USTC group

Planar massless —> nonplanar massless —> massive

we can calculate analytic Feynman integrals for you!

	4-point	5-point	6-point	7-point	8-point
One-loop	known	known	known	known	known
Two-loop	most known	some results	?	?	?
Three-loop	some results	?	?	?	?
Four-loop	some results	?	?	?	?

with dimensional regulation

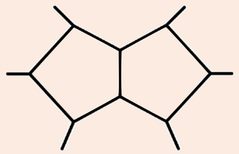
Frontier

Liu, Matijasic, Miczajka, Xu, Xu, YZ,
Phys.Rev.D 112 (2025) 1, 016021, editors' suggestion
Chicherin, Wu, Wu, Xu, Zhang, YZ,
Phys.Rev.Lett. 137 (2026) 11, 111603

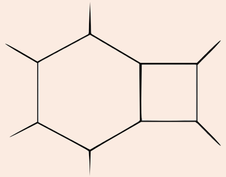
Henn, Matijasic, Miczajka, Peraro, Xu, YZ, *Phys.Rev.Lett. 135, 031601*
Henn, Matijasic, Miczajka, Peraro, Xu, YZ, *JHEP 08(2024) 027*
Henn, Peraro, Xu, YZ, *JHEP 03 (2022) 056*
Abreu, Monni, Page, Usovitsch, *JHEP 06 (2025) 112*

2loop 6point Feynman integrals

NNLO production of 4 jets, 4 photons …



267 master integrals



202 master integrals

+ dihedral permutations

Analytically calculated by canonical differential equations

167 letters to $O(\epsilon^0)$, 269 letters to all orders of ϵ

156 + 3 Even letters

$$s_{12},\quad s_{123}$$
$$s_{12}-s_{123}$$
$$\dots$$
$$-s_{12}s_{45}+s_{123}s_{345}$$
$$\dots$$
$$\sqrt{\lambda(s_{12},s_{34},s_{56})},\quad \epsilon_{ijkl}$$
$$\sqrt{\lambda(s_{45}\epsilon_{1236},s_{46}\epsilon_{1235},s_{56}\epsilon_{1234})}$$

79 + 18 Odd letters

$$\frac{s_{12}+s_{34}-s_{56}-\sqrt{\lambda(s_{12},s_{34},s_{56})}}{s_{12}+s_{34}-s_{56}+\sqrt{\lambda(s_{12},s_{34},s_{56})}}$$
$$\dots$$
$$\frac{s_{12}s_{23}-s_{23}s_{34}+s_{23}s_{56}+s_{34}s_{123}-s_{234}(s_{12}+s_{123})-\epsilon_{1234}}{s_{12}s_{23}-s_{23}s_{34}+s_{23}s_{56}+s_{34}s_{123}-s_{234}(s_{12}+s_{123})+\epsilon_{1234}},$$
$$\dots$$
$$\frac{-s_{12}s_{45}s_{234}+s_{34}s_{61}s_{123}+s_{345}(-s_{23}s_{56}+s_{123}s_{234})-\Delta_6}{-s_{12}s_{45}s_{234}+s_{34}s_{61}s_{123}+s_{345}(-s_{23}s_{56}+s_{123}s_{234})+\Delta_6}$$
$$\frac{-\sqrt{\lambda(s_{45}\epsilon_{1236},s_{46}\epsilon_{1235},s_{56}\epsilon_{1234})}+Q_i}{\sqrt{\lambda(s_{45}\epsilon_{1236},s_{46}\epsilon_{1235},s_{56}\epsilon_{1234})}+Q_i}$$

Pink letters
only for high ϵ orders

10 double-square letters

$$\frac{P-\epsilon_{1234}\sqrt{\lambda(s_{12},s_{34},s_{56})}}{P+\epsilon_{1234}\sqrt{\lambda(s_{12},s_{34},s_{56})}}$$

Liu, Matijasic, Peraro, Xu, Yang, YZ, *JHEP* 07 (2026) 223

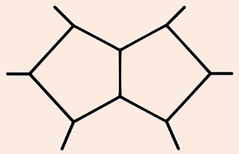
Henn, Matijasic, Miczajka, Peraro, Xu, YZ, *Phys. Rev. Lett. 135 (2025) 3, 031601*

Henn, Matijasic, Miczajka, Peraro, Xu, YZ, *JHEP 08(2024) 027*

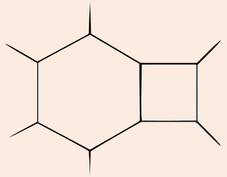
Abreu, Monni, Page, Usovitsch *JHEP 06 (2025) 112*

2loop 6point Feynman integrals

NNLO production of 4 jets, 4 photons …



267 master integrals



202 master integrals

+ dihedral permutations

Surprisingly small number of functions

As a comparison, 3841 integrable weight-4 symbols,
the N=4 super-Yang-Mills bootstrap does not work.

weight	1	2	3	4
2L6P symbols	9	59	266	639
2L5P1mass symbols	9	59	263	594
1L6P symbols	9	26	32	32
(1+2)L6P symbols	9	59	271	652

the small function space
is the foundation of our QCD bootstrap method

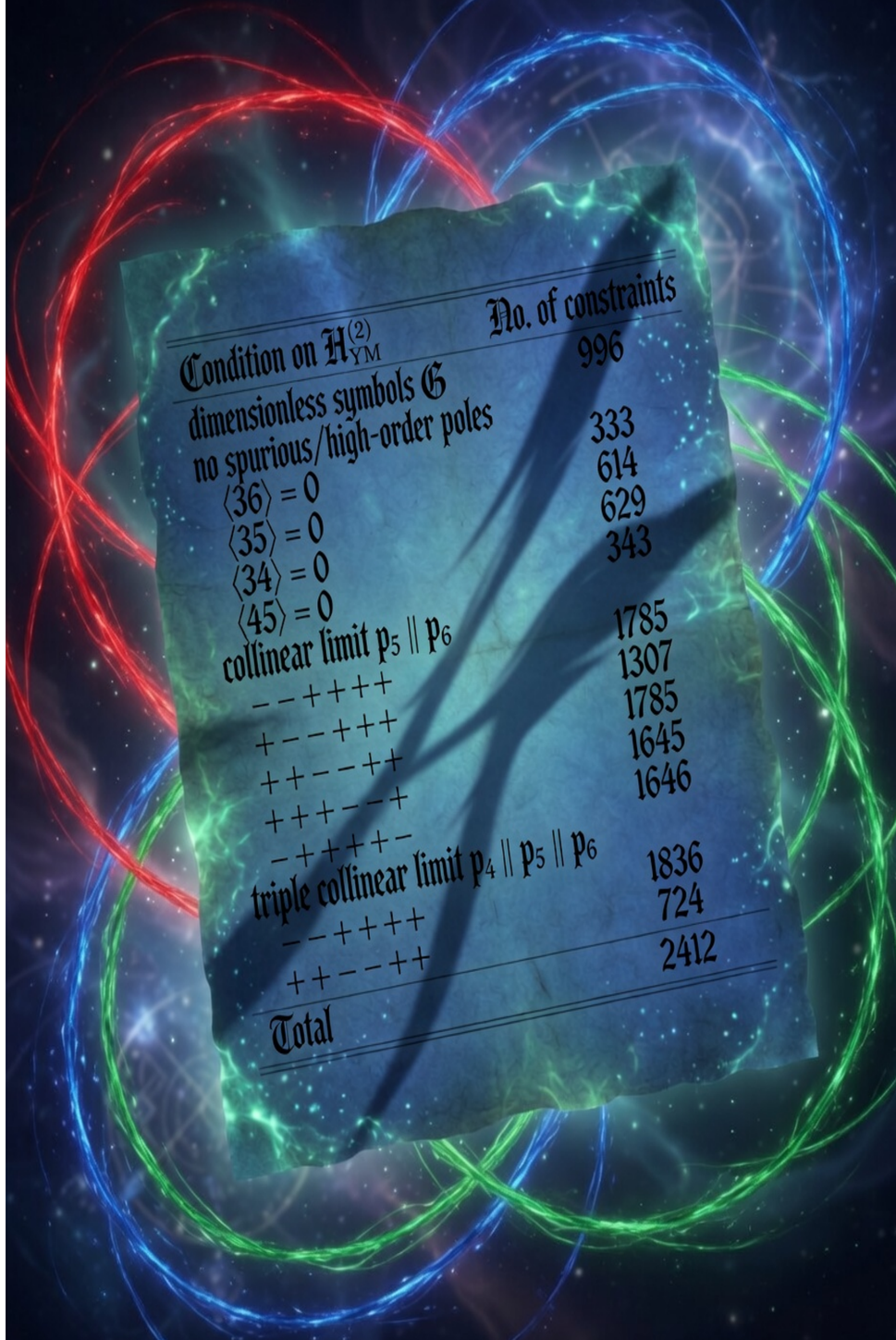
Liu, Matijasic, Peraro, Xu, Yang, YZ, *JHEP 07 (2026) 223*

Henn, Matijasic, Miczajka, Peraro, Xu, YZ, *Phys. Rev. Lett. 135 (2025) 3, 031601*

Henn, Matijasic, Miczajka, Peraro, Xu, YZ, *JHEP 08(2024) 027*

Abreu, Monni, Page, Usovitsch *JHEP 06 (2025) 112*

QCD Bootstrap

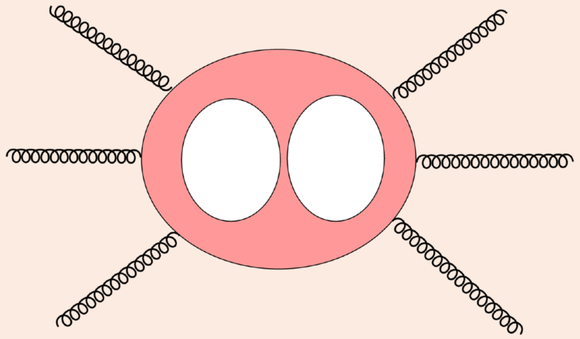


Two-loop six-point QCD amplitude

maximal transcendental part (weight-4), bootstrap

"Bootstrapping Six-Gluon QCD Amplitudes"
Carrôlo Carrôlo, Chicherin, Henn, Yang, YZ, *Phys.Rev.Lett 136 (2026) 181602*
— —++++ *helicity, with fermion loops, weight-4, symbol level*

"QCD Scattering Amplitudes and Prescriptive Unitarity"
Carrôlo Carrôlo, Chicherin, Henn, Yang, YZ , *JHEP 08 (2026) 100*
All three independent MHV helicity sectors



rational pre-factor

transcendental functions
from master integrals

$$H = \sum_i \sum_j c_{ij} R_i f_j$$

color stripped amplitudes (hard function)

We work out weight-4 part of the amplitude first,
the "most complicated" part …

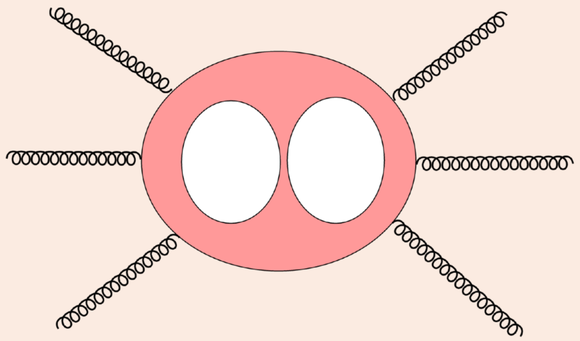
transcendental weight	rational prefactor	transcendental function
4	easy	hard
…	…	…
0	hard	easy

Two-loop six-point QCD amplitude

maximal transcendental part (weight-4), bootstrap

It is well known that the maximal transcendentality principle may not work for QCD amplitudes

$$L.S.(A_{-+-+}^{\text{YM, 1-loop}}) \neq L.S.(A_{-+-+}^{\text{N=4, 1-loop}})$$



Consider hard function instead of amplitude, to avoid D-dimensional leading singularity

$$\mathcal{H}^{(2)} = \lim_{\epsilon \to 0} \left[\mathcal{A}^{(2)} - I^{(1)} \mathcal{A}^{(1)} + \frac{1}{2} \left(I^{(1)} \right)^2 \mathcal{A}^{(0)} \right],$$

rational pre-factor

transcendental functions from master integrals

$$H = \sum_i \sum_j c_{ij} R_i f_j$$

maximal cut residue of the integrand

Generalized unitarity suggests that for the maximal-weight-part hard function, rational pre-factors come from 4D leading singularity (maximal cut).

L-loop amplitude's maximal transcendental weight is $2L$

Conjectured by Henn and Bobadilla
JHEP 03 (2022) 174

Rational factors and leading singularity (maximal cut)

Henn and Bobadilla, *JHEP 03 (2022) 174*

Carrôlo, Chicherin, Henn, Yang, Zhang, *JHEP 08 (2026) 100*

UV poles have not maximal weight contribution;

IR poles have the factorization to lower loops

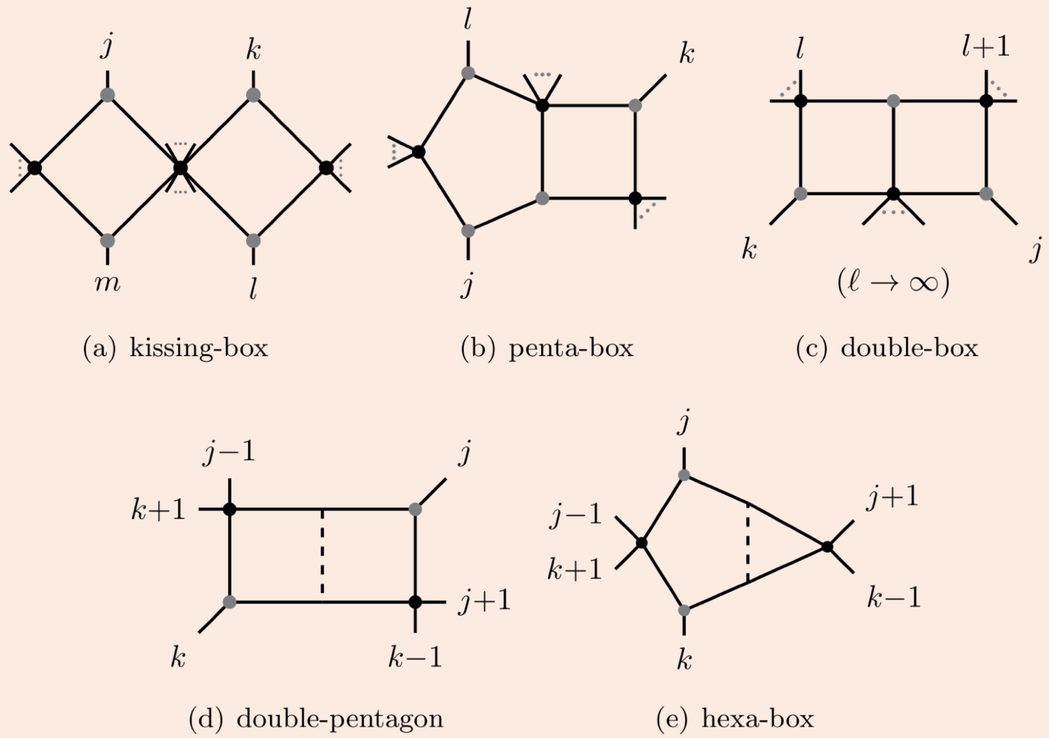
$$\mathcal{P}_{\text{max-weight}}\left[\prod_{i=1}^{L}\mathrm{d}^4\ell_i\,\mathcal{I}(\ell_i,p_e)\right]=\underbrace{\sum_{\ell=0}^{L-1}\sum_{j=1}^{k_\ell}R_j^{(\ell)}\,\mathcal{I}_{j,\ell}}_{\text{IR-subtraction needed}}+\underbrace{\sum_{k=1}^{k_L}R_k^{(L)}\,\mathcal{I}_k}_{\text{free from IR-divergence}}$$

$\mathcal{I}_{j,l}\,,\quad \mathcal{I}_k$ dlog integrand form, with rational number coefficients

$R_k^{(L)}$ corresponds to the leading singularity (4D maximal cut) of L-loop amplitudes

$R_k^{(l)}$ corresponds to the leading singularity of lower loop amplitudes

Explore the QCD leading singularity

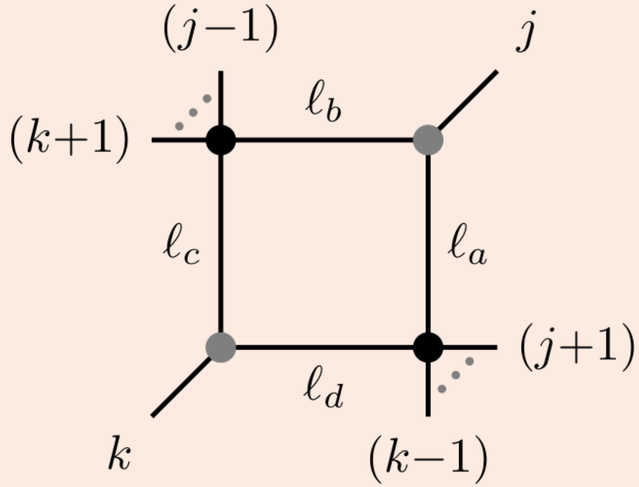


(a) kissing-box (b) penta-box (c) double-box

(d) double-pentagon (e) hexa-box

Two-loop leading singularity for QCD MHV amplitudes

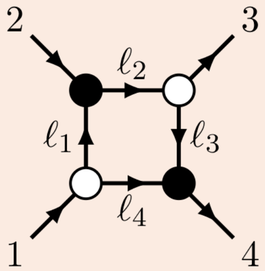
Bourjaily, Herrmann, Langer, A. J. McLeod and J. Trnka,
Phys. Rev. Lett. 124 (2020) 111603



One-loop leading singularity for QCD MHV amplitudes

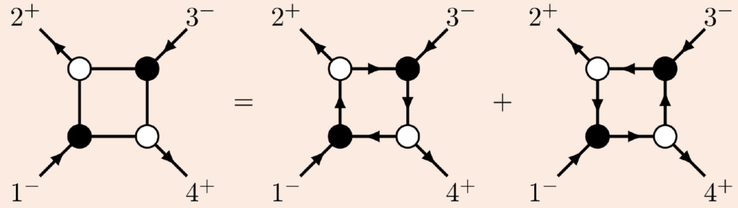
Leading singularity from tree amplitudes

Sew tree amplitudes on the maximal cut and sum over allowed internal helicities (on-shell diagrams).



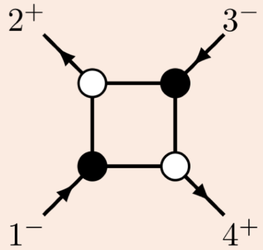
$$= \bar{\mathcal{A}}_3(\ell_1^+, \ell_4^+, 1^-)\bar{\mathcal{A}}_3(3^+, \ell_3^+, \ell_2^-)\mathcal{A}_3(2^-, \ell_1^-, \ell_2^+)\mathcal{A}_3(\ell_3^-, \ell_4^-, 4^+)$$

$$= \frac{\langle 12\rangle^4}{\langle 12\rangle\langle 23\rangle\langle 34\rangle\langle 41\rangle}\delta^{2\times 2}(P)$$



The singlet cut fixes internal helicity;

The non-singlet cut sums over internal helicities.



$$= \mathrm{PT}_{4,13} \times \left[\left(\frac{\langle 12\rangle\langle 34\rangle}{\langle 13\rangle\langle 24\rangle}\right)^4 + \left(\frac{\langle 14\rangle\langle 23\rangle}{\langle 13\rangle\langle 24\rangle}\right)^4\right].$$

$$R^{(1)}_{1i,jk,n} = \mathrm{PT}_{n,1i} \times \left[\left(\frac{\langle 1j\rangle\langle ik\rangle}{\langle jk\rangle\langle 1i\rangle}\right)^4 + \left(\frac{\langle 1k\rangle\langle ji\rangle}{\langle jk\rangle\langle 1i\rangle}\right)^4\right], \quad 1 < j < i < k \leq n.$$

Bern, Dixon, Dunbar, Kosower
Nucl. Phys. B 425 (1994) 217

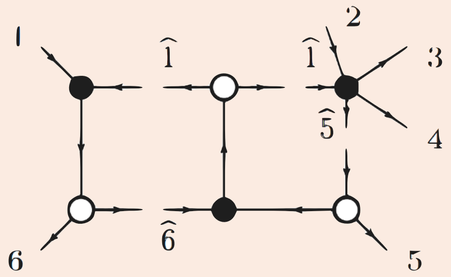
Britto, Cachazo, Feng
Nucl. Phys. B 725 (2005) 275

Arkani-Hamed, Bourjaily, Cachazo,
Goncharov, Postnikov, Trnka
Cambridge University Press (2016)

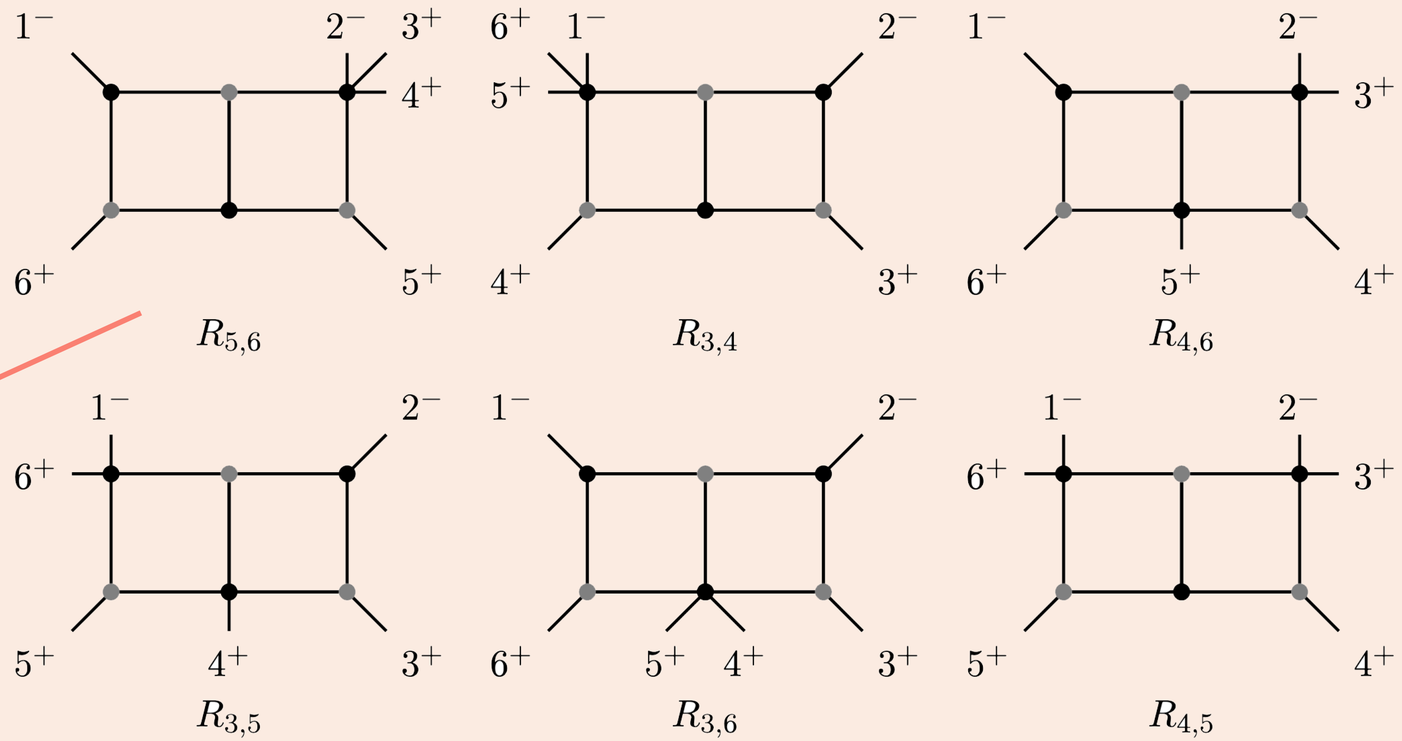
Two-loop six-point QCD amplitude, $--++++$

4D leading singularity

On shell diagram
as a product of tree amplitudes,
via Britto-Cachazo-Feng-Witten shifts



$$R_{5,6} = R_1 \times \oint dz \frac{(\langle 12\rangle + z\langle 26\rangle)^3}{\langle 12\rangle^4(\langle 15\rangle + z\langle 56\rangle)^4}$$



PT plus six two-loop prefactors for --++++

$$\mathcal{H}^{(2)}_{\rm YM} = R_1 G_1 + \sum_{2<i<j\leq 6} R_{i,j} G_{i,j}.$$

Parke-Taylor

$$R_{i,j}/R_1 = -1 + 12u_{i,j} - 30u_{i,j}^2 + 20u_{i,j}^3\,, \qquad u_{i,j} = \frac{\langle 1i\rangle\langle 2j\rangle}{\langle 12\rangle\langle ij\rangle}$$

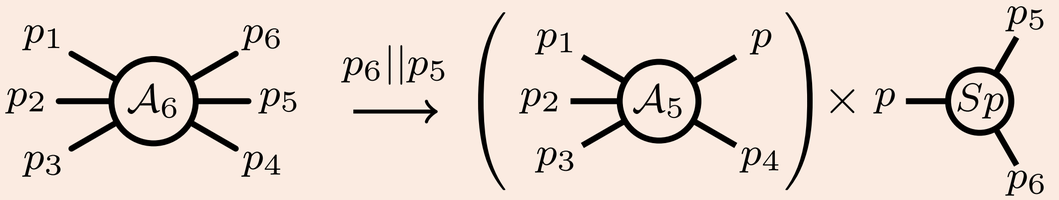
Two-loop six-point QCD bootstrap, $--++++$

Condition on $\mathcal{H}^{(2)}_{\rm YM}$	No. of constraints
dimensionless symbols G	996
no spurious/high-order poles	
$\langle 36\rangle = 0$	333
$\langle 35\rangle = 0$	614
$\langle 34\rangle = 0$	629
$\langle 45\rangle = 0$	343
collinear limit $p_5 \parallel p_6$	
$--++++$	1785
$+--+++$	1307
$++--++$	1785
$+++--+$	1646
$-+++-+$	1646
triple collinear limit $p_4 \parallel p_5 \parallel p_6$	
$--++++$	1836
$++--++$	724
Total	2412

linear combination of weight-4 function
from 2l6p master integrals, and IR subtracti

$$\mathcal{H}^{(2)}_{\rm YM} = R_1 G_1 + \sum_{2<i<j\leq 6} R_{i,j} G_{i,j}.$$

PT plus six two-loop prefactors, 712 weight-four symbols
Reflection symmetry leaves 2412 unknowns



$$\mathcal{H}^{(2)}_6/\mathcal{A}^{(0)}_6 \xrightarrow{p_5\|p_6} \mathcal{H}^{(2)}_5/\mathcal{A}^{(0)}_5 + C^{h,(1)}_{h_5 h_6}\mathcal{H}^{(1)}_5/\mathcal{A}^{(0)}_5 + \frac{1}{2}\left(C^{h,(1)}_{h_5 h_6}\right)^2,$$

for this helicity,
$++ \to -$ splitting function does not contribute to weight-4

collinear limit for all adjacent pairs

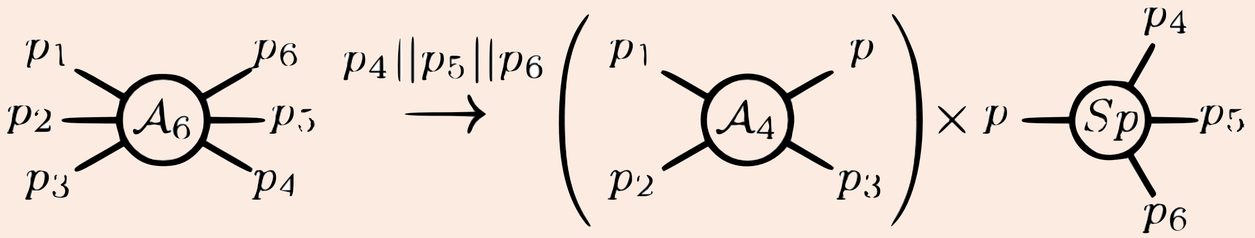
match with known splitting function and five-point amplitudes

We can also consider triple collinear limit …

Two-loop six-point QCD bootstrap $--++++$

Condition on $\mathcal{H}^{(2)}_{\rm YM}$	No. of constraints
dimensionless symbols G	996
no spurious/high-order poles	
$\langle 36\rangle = 0$	333
$\langle 35\rangle = 0$	614
$\langle 34\rangle = 0$	629
$\langle 45\rangle = 0$	343
collinear limit $p_5 \parallel p_6$	
$--++++$	1785
$+--+++$	1307
$++--++$	1785
$+++--+$	1646
$-+++-+$	1646
triple collinear limit $p_4 \parallel p_5 \parallel p_6$	
$--++++$	1836
$++--++$	724
Total	2412

triple collinear limit …



$$\mathcal{H}_6^{(2)}/\mathcal{A}_6^{(0)} \xrightarrow{p_4\|p_5\|p_6} \mathcal{H}_4^{(2)}/\mathcal{A}_4^{(0)} + C^{h,(1)}_{h_4h_5h_6}\,\mathcal{H}_4^{(1)}/\mathcal{A}_4^{(0)} + \frac{1}{2}\left(C^{h,(1)}_{h_4h_5h_6}\right)^2 + C^{h,(2)}_{h_4h_5h_6}.$$

The factorized triple-collinear form supplies further constraints.
The bootstrap also predicts the weight-four splitting functions.

All 2412 coefficients are uniquely fixed.

Two-loop six-point QCD bootstrap $--++++$

Maximal weight two-loop six-point $--++++$ Amplitude obtained;

Quark-loop contributions enter through six further two-loop prefactors

A byproduct

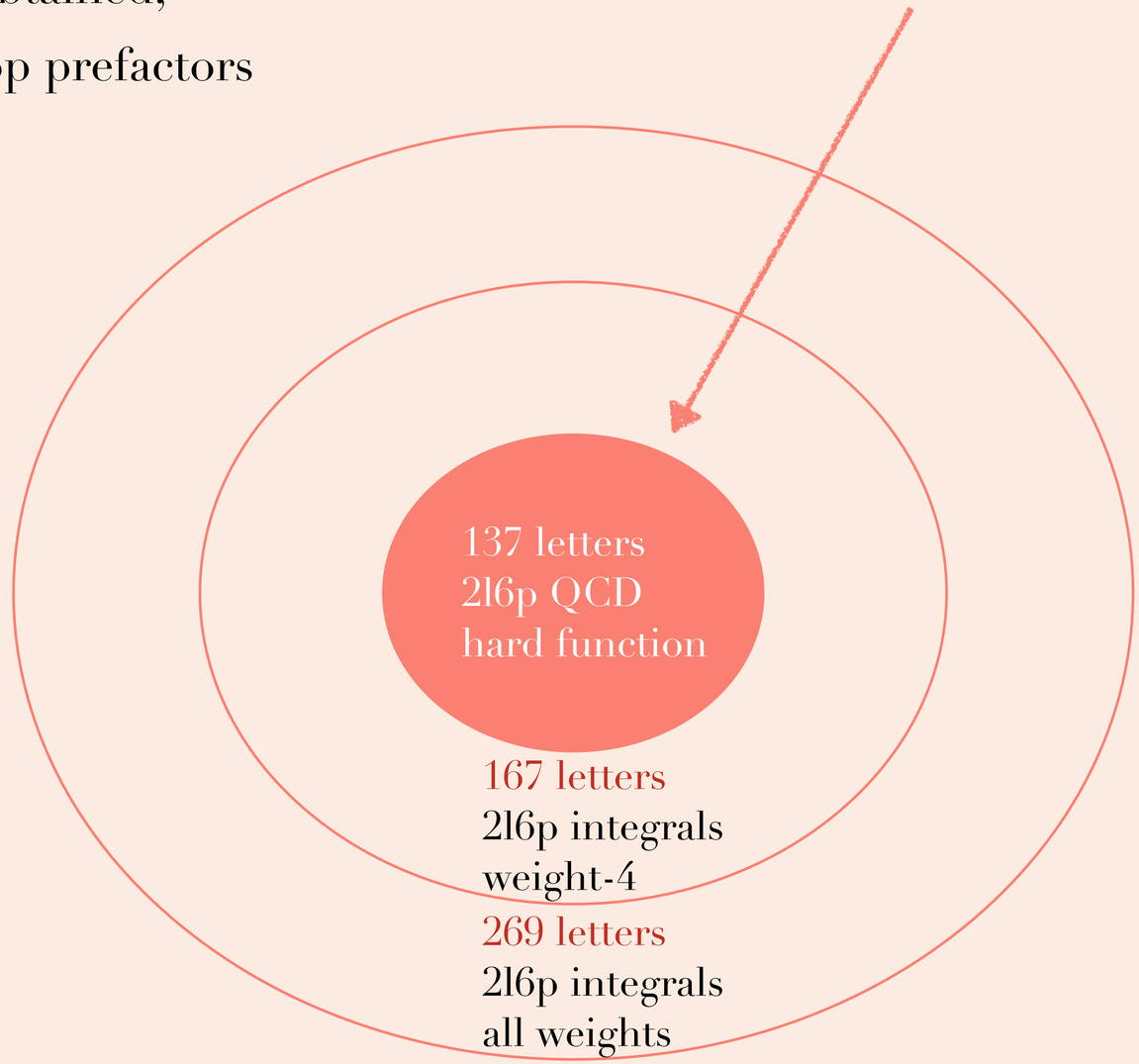
two-loop QCD triple splitting function, weight-4 part

$$C^{+,(2)}_{+++} = C^{(2),\mathrm{sYM}}_{N=4},$$
$$C^{-,(2)}_{+++} = C^{+,(2)}_{+++} + \left(r^{-}_{+++} + \frac{N_f}{N_c} s^{-}_{+++}\right) f.$$

rational factor

transcendental function

Core letters for 216p amplitudes



Refined QCD bootstrap

Carrôlo, Chicherin, Henn, Yang, Zhang

$$H^{(2)}_{--++++} = R_1 G_1 + \sum_{2<i<j\leq 6} R_{i,j}\, G_{i,j}$$

Phys.Rev.Lett 136 (2026) 181602

2412 unknown coefficients

known prescriptive integrals;

refined QCD bootstrap: bootstrap only G_1

$$H^{(2)}_{--++++} = R_1\, G_1 + \sum_{2<i<j\leq 6} R^{(2),\mathrm{db}}_{12,ij1}\, I^{\mathrm{db}}_{6,ij1}$$

JHEP 08 (2026) 100

238 unknown coefficients

Prescriptive unitarity

Basis integrands dual to chosen cut contours:
unit residue on their own contour, zero on the others.

Bourjaily, Herrmann, Trnka
JHEP 06 (2017) 059

prescriptive integrals are finite, and their weight-*2L* parts have uniform transcendental weights.

Targeted IBP: IBP reduction with one kinematic point reduces prescriptive integrals analytically

All three independent MHV helicity sectors

Carrôlo, Chicherin, Henn, Yang, Zhang

JHEP 08 (2026) 100

The refined bootstrap extends the split-helicity result to all MHV sectors.

Sectors	$(--++++)$	$(-+-+++)$	$(-++-++)$
unknowns	238	872	582
Conditions			
no spurious poles			
$\langle 24\rangle = 0$	-	403	-
$\langle 25\rangle = 0$	-	208	216
$\langle 35\rangle = 0$	-	-	205
collinear limits			
$p_6 \| \| p_5$	216	698	366
$p_5 \| \| p_4$	167	698	529
$p_4 \| \| p_3$	216	690	529
$p_3 \| \| p_2$	216	200	366
$p_2 \| \| p_1$	-	200	529
$p_1 \| \| p_6$	216	690	529
triple collinear limits			
$p_6 \| \| p_5 \| \| p_4$	205	283	129
$p_5 \| \| p_4 \| \| p_3$	205	476	-
$p_4 \| \| p_3 \| \| p_2$	205	-	129
$p_3 \| \| p_2 \| \| p_1$	-	-	129
$p_2 \| \| p_1 \| \| p_6$	-	-	-
$p_1 \| \| p_6 \| \| p_5$	205	476	129
Total	238	872	582

Table 4. Counting of independent constraints arising from each physical condition in each MHV helicity sector.

Physical constraints uniquely fix all remaining symbol coefficients in each helicity sector.

Ranks from different physical limits overlap.

Quark-loop contributions in planar QCD

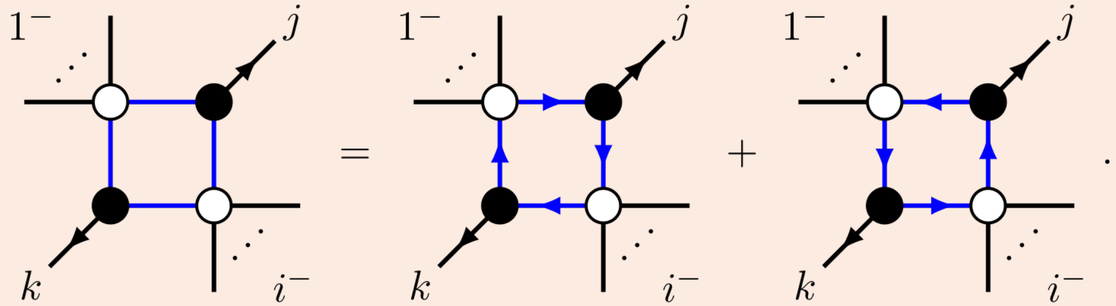
Carrôlo, Chicherin, Henn, Yang, Zhang

JHEP 08 (2026) 100

Leading color with N_f/N_c fixed

$$H_n^{(2)} = H_n^{[1],(2)} + \left(\frac{N_f}{N_c}\right) H_n^{[\frac{1}{2}],(2)} + \left(\frac{N_f}{N_c}\right)^2 H_n^{[\frac{1}{2},\frac{1}{2}],(2)}$$

One-loop: sum both quark-loop orientations



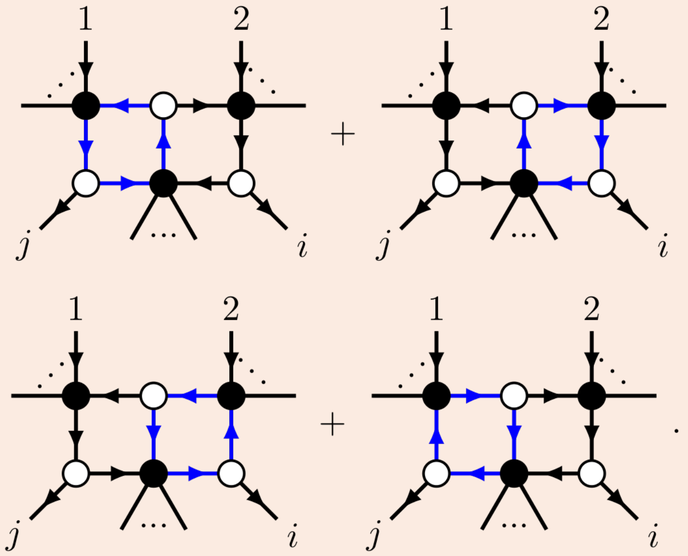
Blue lines denote quarks; black lines denote gluons.

$$H^{[\frac{1}{2}]}_{--++++} = \sum_{2<i<j\leq 6} S^{(2),\mathrm{db}}_{12,ij1} I^{\mathrm{db}}_{6,ij1}.$$

for bootstrap

$$H^{[\frac{1}{2}]}_{-+-+-++} = \sum_{i=4,5,6} S^{(1)}_{13,2i} \left(g_{2,i} - I^{\mathrm{dp}}_{2i} - \tilde{I}^{\mathrm{dp}}_{2i} - I^{\mathrm{hb}}_{2i} - I^{\mathrm{hb}}_{i2}\right) + \sum_{\substack{l=1,2 \\ 3<j<k\leq 6}} S^{(2),\mathrm{db}}_{13,jkl} I^{\mathrm{db}}_{6,jkl} + \sum_{\{j,k,l\}\in\sigma_1} S^{(2),\mathrm{pb}}_{13,jkl} \left(I^{\mathrm{pb}}_{6,jkl} + I^{\mathrm{pb}}_{6,jlk}\right)$$

Two-loop: on-shell diagrams for loop loops



Also come from bootstrap and prescriptive unitarity

A reduced alphabet for six-point MHV scattering

Henn, Matijašić, Miczajka, Peraro, Xu, Zhang
Phys. Rev. Lett. 135 (2025) 031601

Carrôlo, Chicherin, Henn, Yang, Zhang
JHEP 08 (2026) 100, §6.3

167 letters in integral symbols; 137 in the MHV hard functions

The same alphabet appears in all three MHV sectors, including quark-loop terms.

9 standalone roots and parity-odd invariants

$\{W_{118}, W_{119}, W_{123}, \ldots, W_{128}, W_{138}\}$

$$W_{118} = \sqrt{s_{12}^2 + s_{34}^2 + s_{56}^2 - 2s_{12}s_{34} - 2s_{12}s_{56} - 2s_{34}s_{56}},$$

$$W_{123} = 4i\,\varepsilon_{\mu\nu\rho\sigma}\, p_1^\mu p_2^\nu p_3^\rho p_4^\sigma .$$

9 two-mass-easy double-triangle letters

$\{W_{167}, \ldots, W_{175}\}$

$$W_{167} = \frac{s_{123} + s_{345} - r_3}{s_{123} + s_{345} + r_3}, \qquad r_3 = \sqrt{(s_{123} + s_{345})^2 - 4s_{12}s_{45}}.$$

The associated cut at infinity has NMHV helicity counting.

12 two-mass-easy box-triangle letters

$\{W_{52}, \ldots, W_{57}, W_{70}, \ldots, W_{75}\}$

$$W_{52} = s_{12}s_{56} - s_{12}s_{123} + s_{34}s_{123},$$

$$W_{70} = s_{12}s_{56} + s_{34}s_{123} - s_{56}s_{123}.$$

The cut is MHV-compatible; absence is observed in the hard functions.

Summary and Outlook

New bootstrap method for QCD amplitudes,
based on analytic Feynman integrals and leading singularity

On-shell input

all 2loop 6point /3loop 5point planar massless integrals are calculated;

Cutting-edge perturbative QCD computation
leading colour, leading weight, two-loop $2 \to 4$ MHV amplitudes inQCD

Next: functions and lower weights, NMHV, and external quarks



Thank you

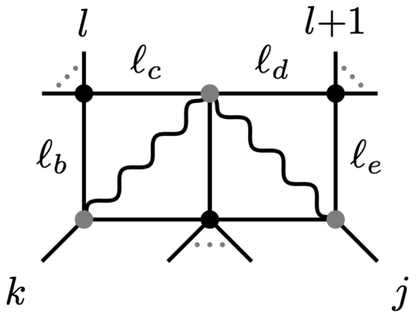
Backup

Prescriptive unitarity integrals

Bourjaily, Herrmann, Langer, McLeod, Trnka
JHEP 12 (2019) 073

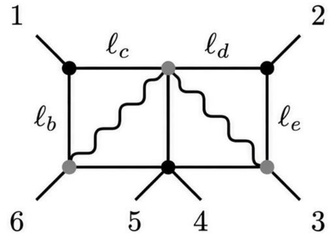
realized as trace plus of Dirac's matrices

$$I^{\text{db}}_{n,jkl} := \quad , \quad \mathbf{n}_{\text{db}} := \frac{1}{2}[\![k,b,c,d,e,j]\!]$$



Targeted IBP

$$I^{\text{db}}_{6,361} := \quad , \quad \mathbf{n}_{\text{db}} := \frac{1}{2}[\![6,b,c,d,e,3]\!]\,,$$



is reduced to,

$$\begin{aligned}
&-\frac{1}{8}\mathcal{I}_{27} - \frac{3}{8}\mathcal{I}_{28} + \frac{1}{8}\mathcal{I}_{29} + \frac{1}{8}\mathcal{I}_{56} + \frac{1}{4}\mathcal{I}_{78} + \frac{1}{4}\mathcal{I}_{106} + \frac{1}{8}\mathcal{I}_{122} - \frac{1}{4}\mathcal{I}_{131} - \frac{1}{4}\mathcal{I}_{138} - \frac{1}{8}\mathcal{I}_{154} \\
&-\frac{1}{8}\mathcal{I}_{156} + \frac{1}{16}\mathcal{I}_{170} + \frac{1}{8}\mathcal{I}_{171} - \frac{1}{8}\mathcal{I}_{173} + \frac{1}{8}\mathcal{I}_{174} - \frac{1}{16}\mathcal{I}_{189} + \frac{3}{16}\mathcal{I}_{202} - \frac{1}{4}\mathcal{I}_{216} + \frac{1}{2}\mathcal{I}_{226} + \frac{1}{4}\mathcal{I}_{227} \\
&-\mathcal{I}_{233} + \frac{3}{16}\mathcal{I}_{243} + \frac{1}{8}\mathcal{I}_{248} - \frac{1}{8}\mathcal{I}_{258} - \frac{3}{8}\mathcal{I}_{259} + \frac{1}{4}\mathcal{I}_{260} + \frac{3}{16}\mathcal{I}_{263} + \frac{3}{16}\mathcal{I}_{264} - \frac{1}{4}\mathcal{I}_{266}\,,
\end{aligned}$$