

Central Exclusive Production (CEP) at the HL/HE-LHC with ALICE

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on behalf of the ALICE collaboration

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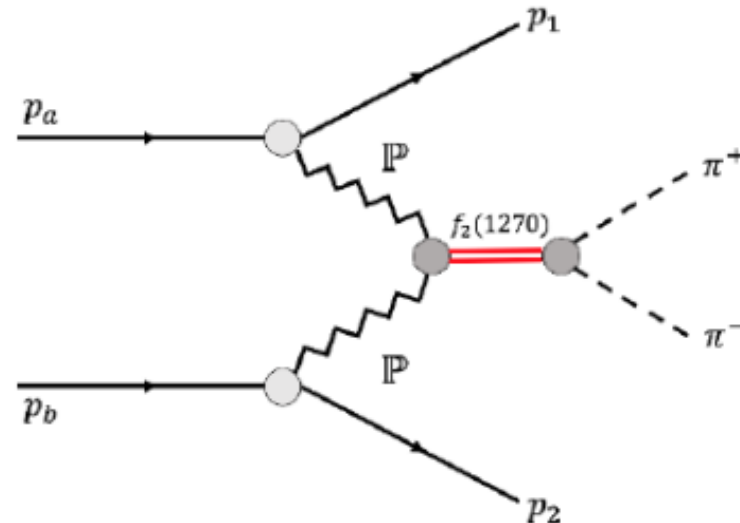
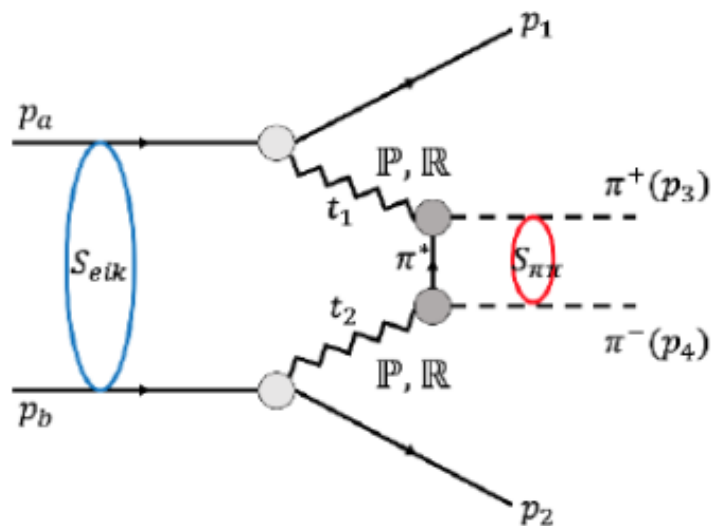
ALICE potential in CEP

- **ALICE has high potential in CEP measurements:**
 - low pileup
 - low material budget
 - measurements down to low momenta
 - excellent PID
 - large rapidity coverage to veto particle production
- **Run 2:**
 - ~5 /pb double-gap triggers collected in 2017
 - O(15 /pb) expected by the end of run 2
- **Expected integrated luminosities in run 3 and 4:**
 - pp @ 5.5 TeV: 6 /pb in 2023
 - pp @ 14 TeV still to be defined within ALICE
 - for the following estimates we used 200 /pb (x10 more than in run 2)

Benchmark analyses

Benchmark analyses:

- precision scalar and tensor meson [spectroscopy](#) including strangeonia and charmonia states ($\pi\pi, KK, 4\pi, 2\pi 2K$ etc), [partial wave analysis](#)
- gluonic [jets](#) (EPJC 76, 9 (2016)), two particle correlations and femtoscopy in CEP
- [glueball](#) searches (including exotics like 0^{--} and 0^{+-} at high masses)
- magnetic [monopole](#) and monopodium searches (arXiv:1707.04170)



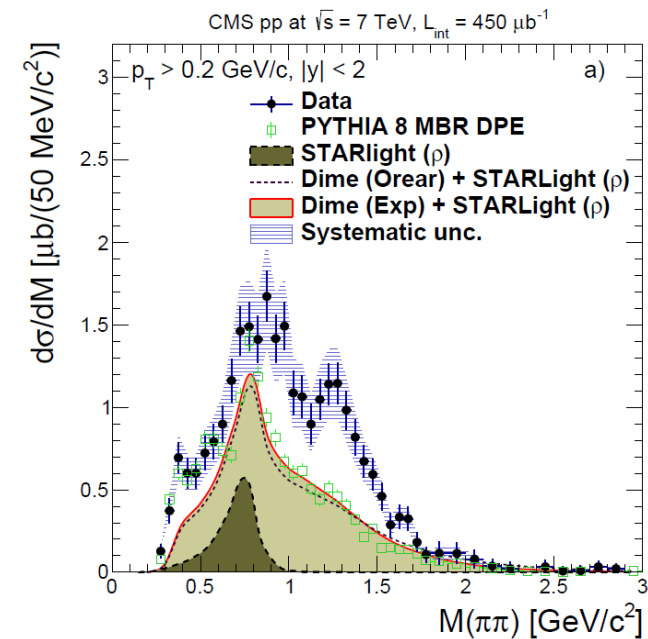
Hadron spectroscopy

- precision hadron spectroscopy and glueball searches
- see M.Albrow, arXiv:1701.09092 for a short and comprehensive summary of the field

TABLE I: Light meson states allowed in DIPE . Branching fractions are in %. (PDG 2016)

Name	M(MeV)	Γ (MeV)	$I^G J^{PC}$	$\pi\pi$	$K\bar{K}$	Other modes
$f_0(500)/\sigma$	400-550	400-700	0^+0^{++}	~ 100	-	-
$f_0(980)$	990 ± 20	10-100	0^+0^{++}	dominant	seen	$\gamma\gamma$ seen
$f_2(1270)$	1275.5 ± 0.8	$186.7^{+2.2}_{-2.5}$	0^+2^{++}	$84.2^{+2.9}_{-0.9}$	$4.6^{+0.5}_{-0.4}$	$4\pi \sim 10\%$
$f_0(1370)$	1200-1500	200-500	0^+0^{++}	seen	seen	$\rho\rho$ dominant
$f_0(1500)$	1504 ± 6	109 ± 7	0^+0^{++}	34.9 ± 2.3	8.6 ± 1.0	4π 49.5 ± 3.3
$f_2'(1525)$	1525 ± 5	73^{+6}_{-5}	0^+2^{++}	0.8 ± 0.2	88.7 ± 2.2	$\eta\eta$ 10.4 ± 2.2
$f_0(1710)$	1723^{+6}_{-5}	139 ± 8	0^+0^{++}	seen	seen	$\eta\eta$ seen
$f_2(1950)$	1944 ± 12	472 ± 18	0^+2^{++}	seen	seen	$\eta\eta$ seen
$f_2(2010)$	2011^{+60}_{-80}	202 ± 60	0^+2^{++}	-	seen	$\phi\phi$ seen
$f_4(2050)$	2018 ± 11	237 ± 18	0^+4^{++}	17%	$\sim 0.7\%$	$\eta\eta$ 0.2%
$f_2(2300)$	2297 ± 28	149 ± 40	0^+2^{++}	-	seen	$\phi\phi$ seen
$f_2(2340)$	2345^{+50}_{-40}	322^{+70}_{-60}	0^+2^{++}	-	-	$\phi\phi, \eta\eta$ seen

[CMS: arXiv:1706.08310](https://arxiv.org/abs/1706.08310)

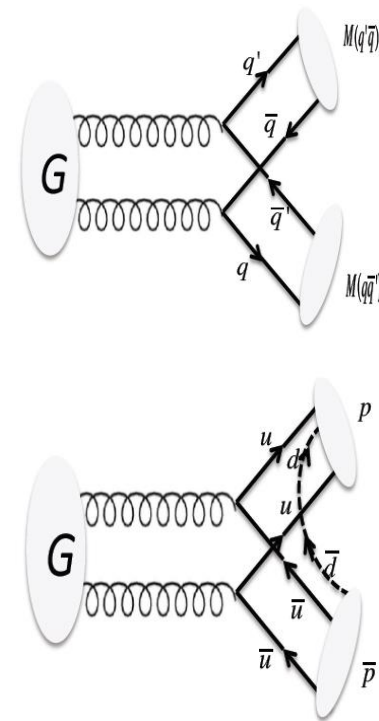
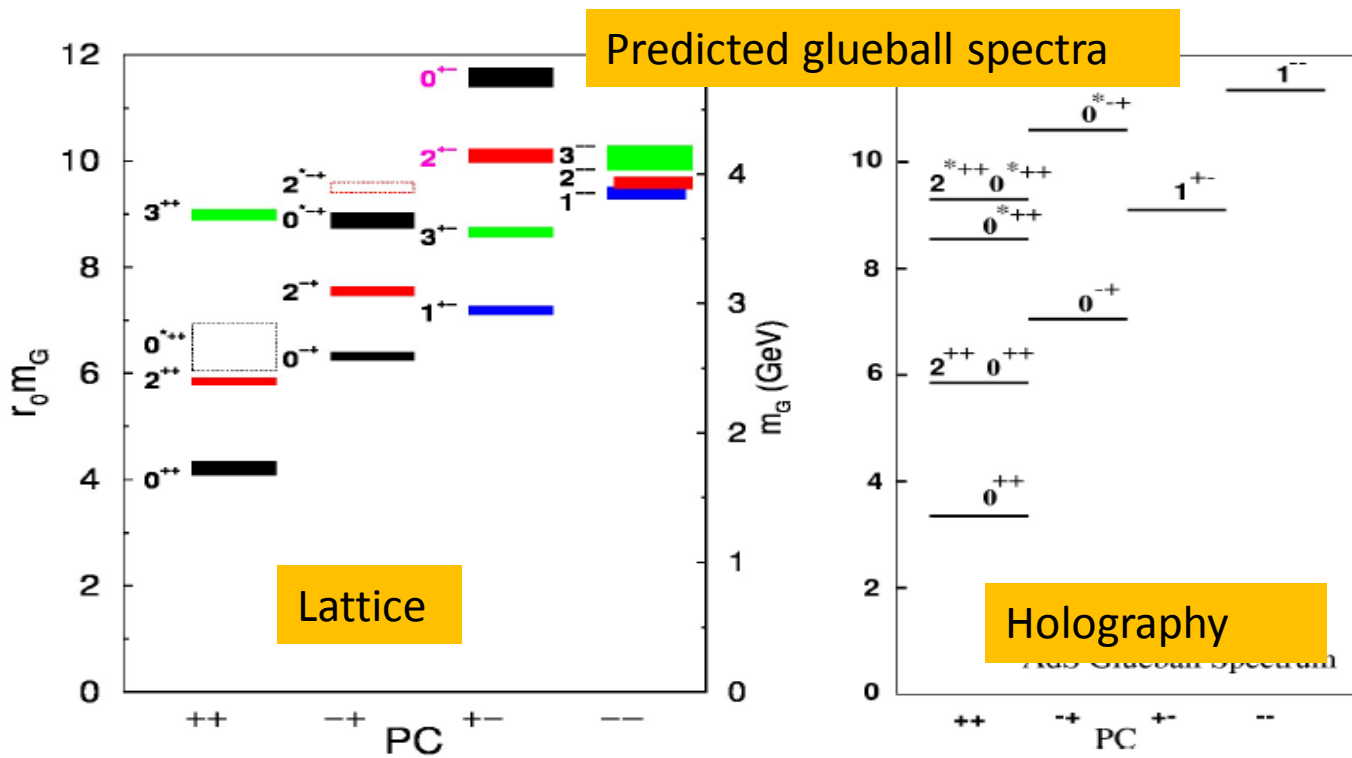


It is a challenge to measure all these (sometimes overlapping) states with their decay modes, and partial wave analysis to distinguish $J = 0$ and $J = 2$. The most favored states for the lightest glueball, albeit mixed with $q\bar{q}$ states, are the scalar

High potential to contribute to PDG.
High discovery potential

Glueball searches

- $f_0(1710)$ and $f_2(2300)$ are most promising 0^{++} , 2^{++} glueball candidates
- 0^{++} , 2^{++} glueballs mix with $q\bar{q}$ mesons with similar quantum numbers
 - precise determination of branching ratios needed to determine gluonic content
- Pseudoscalar glueball (0^{-+}) expected ~ 2.6 GeV:
 - $BR(G \rightarrow K\bar{K}\pi) = 49\%$ according to PRD95 (2017), 014028
 - $K_S K + \pi^-$ and $K_S K - \pi^+$ might be promising in ALICE: $Ax\varepsilon(|y| < 1)$ is about 10%
- $K_S K + \pi^-$ and $K_S K - \pi^+$ also promising for 0^{--} oddball searches (2.8 GeV in JHEP 1510 (2015) 137)



Charm sector \rightarrow gluon PDFs

Channel	BR	$A \times \epsilon$	$\sigma(5.5 \text{ TeV})$ pb	$Y(5.5 \text{ TeV})$ 1 /pb	$Y(5.5 \text{ TeV})$ 6 /pb	$\sigma(14 \text{ TeV})$ pb	$Y(14 \text{ TeV})$ 1 /pb	$Y(14 \text{ TeV})$ 200 /pb
$\chi_{c0} \rightarrow \pi\pi$	0.83%	25.2%	97933	205	1229	118120	247	49412
$\chi_{c0} \rightarrow KK$	0.59%	20.5%	97933	118	711	118120	143	28573
$\chi_{c0} \rightarrow 4\pi$	2.24%	9.40%	97933	206	1237	118120	249	49743
$\chi_{c0} \rightarrow 2\pi 2K$	1.75%	1.70%	97933	29	175	118120	35	7028
$\chi_{c1} \rightarrow \pi\pi$	<0.10%	25.2%	968	0	<1	1009	0.3	<51
$\chi_{c1} \rightarrow KK$	<0.10%	20.5%	968	0	<1	1009	0.2	<41
$\chi_{c1} \rightarrow 4\pi$	0.76%	9.40%	968	1	4	1009	0.7	144
$\chi_{c1} \rightarrow 2\pi 2K$	0.45%	1.70%	968	0	0	1009	0.1	15
$\chi_{c2} \rightarrow \pi\pi$	0.23%	25.2%	5779	4	22	7634	4.4	885
$\chi_{c2} \rightarrow KK$	0.11%	20.5%	5779	1	9	7634	1.7	344
$\chi_{c2} \rightarrow 4\pi$	1.07%	9.40%	5779	6	38	7634	7.7	1536
$\chi_{c2} \rightarrow 2\pi 2K$	0.89%	1.70%	5779	1	6	7634	1.2	231

- σ estimated with SuperChic2 generator
 - using lowest prediction with NNPDF3.0 and model 1 for the gap survival probability
 - caveat: Superchic2 predicts at least x3 higher cross section wrt LHCb preliminary
- χ_{c1} and χ_{c2} states are suppressed due to Landau-Yang theorem and helicity-zero selection rule respectively
- χ_{c2} might be feasible with ~ 200 /pb
- continuum background need to be estimated with available double gap data

Conclusions

- ALICE has high potential in CEP measurements
- Benchmark analyses identified
- Large sample of double gap triggers already collected and being evaluated in terms of ALICE physics potential in run 3 and 4
- Strong diffractive group in ALICE interested in contributing to the Yellow Report