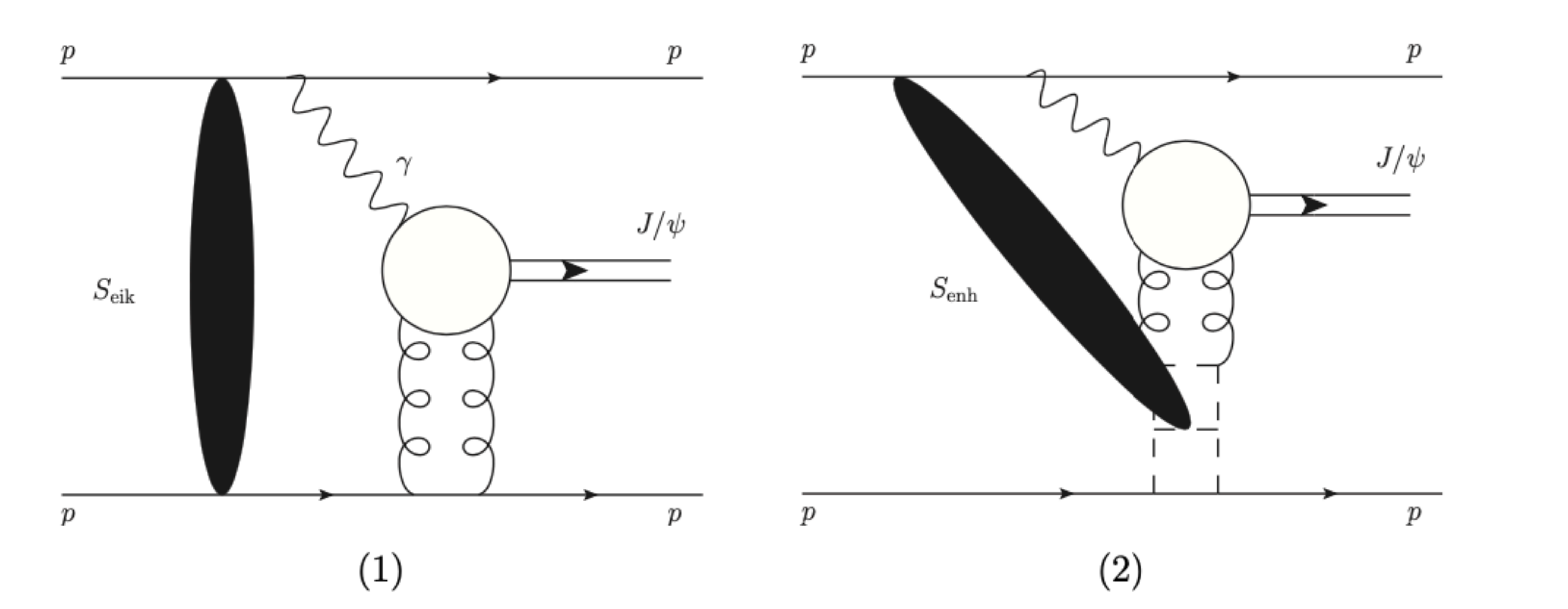
Rapidity gap pp survival factors Round Table

Nutshell

- In a CEP, the initial-state protons interact via a color-singlet exchange (such as pomeron-pomeron or photon-photon fusion).
- However, in a hadron-hadron collider like the LHC, there is a non-negligible chance that additional soft interactions (Multiple Parton Interactions, or MPIs) occur, leading to the destruction of the rapidity gaps.
- Process-dependent survival factors, S^2, account for the suppression of the observed exclusive cross-section due to these effects.



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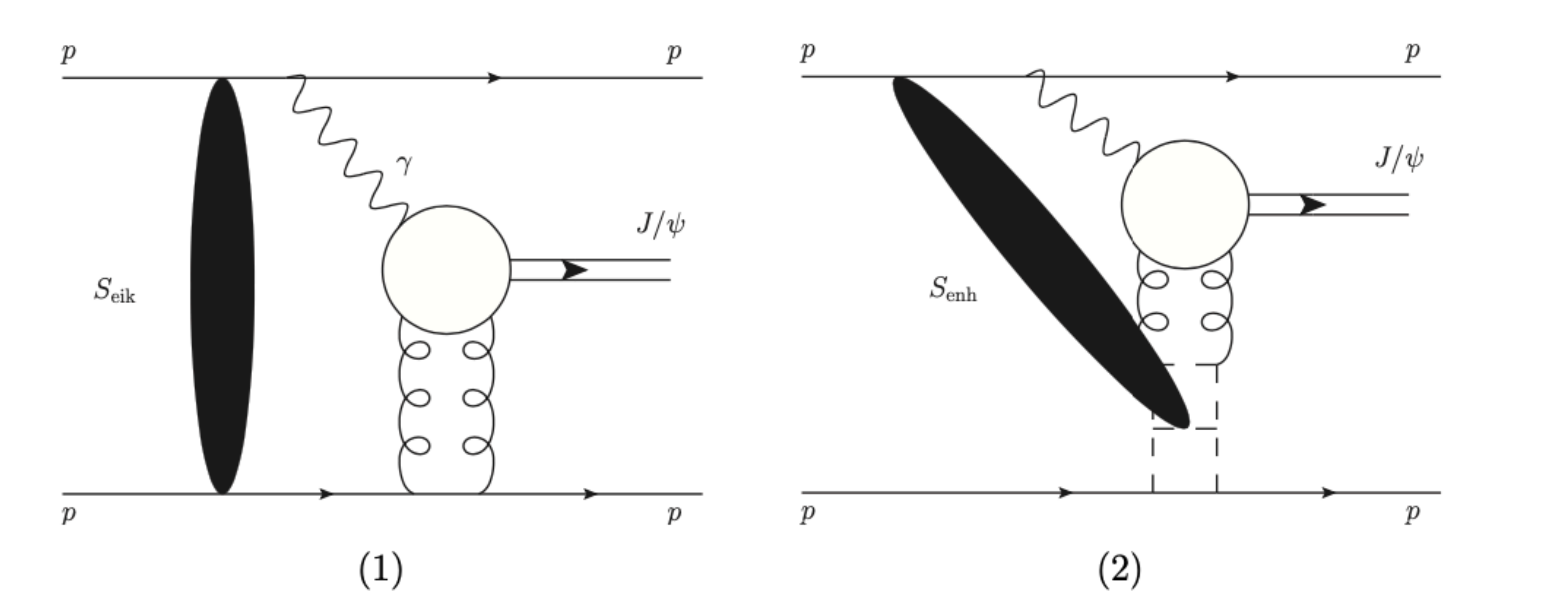

KMR models: The KMR models are two-channel eikonal models, the incoming proton wave function is written as a superposition of two diffractive Good-Walker eigenstates

proton opacity, exp() probability of no inelastic scattering at bt.

$$S^2 \equiv \langle S^2(\vec{b}_t^2)\rangle = \frac{\int \sum_i \left|\mathcal{M}_i(s,\vec{b}_t^2)\right|^2 \exp\left[-\Omega_i(s,\vec{b}_t^2)\right] \mathrm{d}^2\vec{b}_t}{\int \sum_i \left|\mathcal{M}_i(s,\vec{b}_t^2)\right|^2 \mathrm{d}^2\vec{b}_t}.$$

transverse sep. between protons

diffractive amplitudes in impact parameter space

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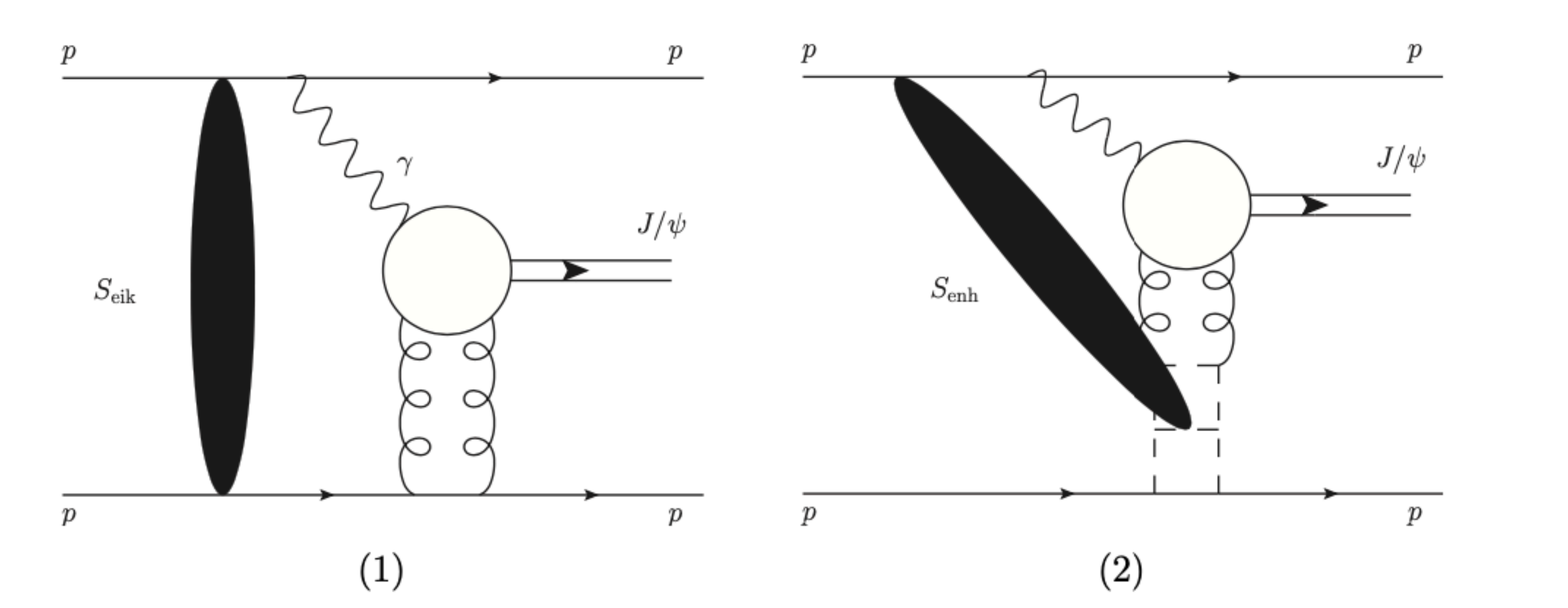

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$$|p\rangle = \sum_i a_i\,|\psi_i\rangle\,, \qquad i = 1, 2.$$

elastic+dissociation

So-called Good-Walker eigenstates diagonalise diff. T matrix $\langle\psi_i|\,T\,|\psi_j\rangle = 0, \qquad i \neq j.$

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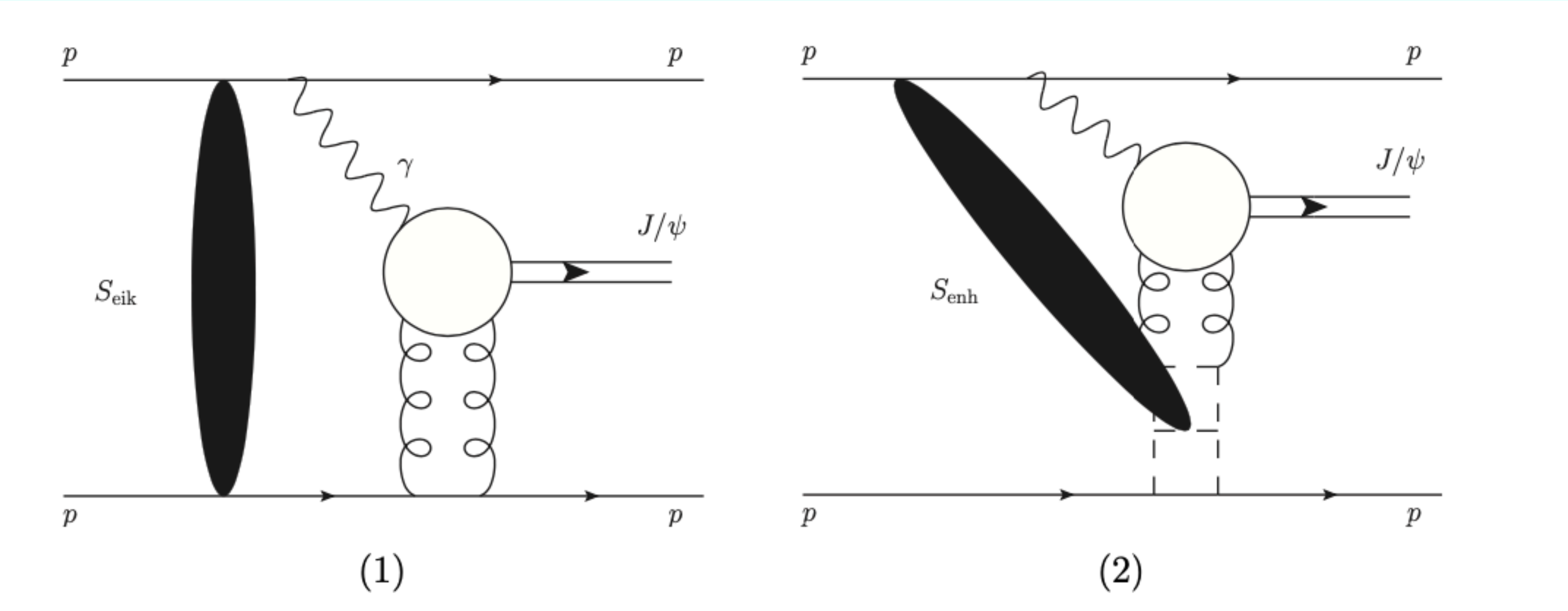

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transverse sep. between protons

diffractive amplitudes in impact parameter space

The opacity function (encoding eff. pomeron between incoming protons) quantifies the likelihood of interaction between two protons at a given transverse impact parameter bt

<< 1: protons transparent to each other => less interactions => larger exp() => closer to unity

>> 1: protons opaque to each other => more interactions => smaller exp() => closer to 0

$$|p\rangle = \sum_i a_i\,|\psi_i\rangle\,, \qquad i = 1, 2.$$

elastic+dissociation

So-called Good-Walker eigenstates diagonalise diff. T matrix $\langle\psi_i|\,T\,|\psi_j\rangle = 0, \qquad i \neq j.$

KMR models as a probe of the uncertainty in S^2

Each eigenstate is parametrised by a form factor F related to the Fourier transform of the opacity

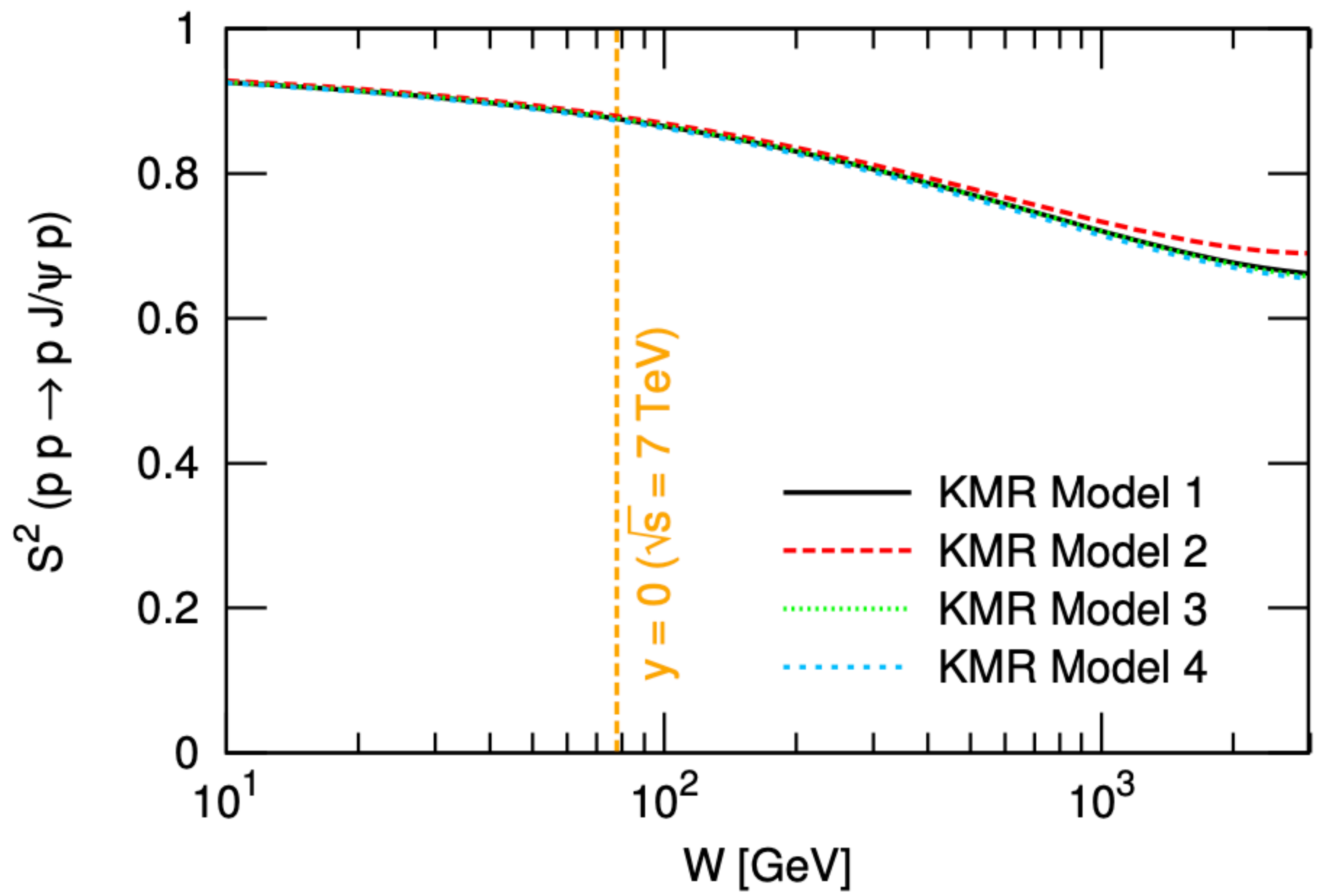
$$F_i(t) = \exp\left[-(b_i(c_i - t))^{d_i} + (b_i c_i)^{d_i}\right], \quad (4.23)$$

Together with effective pomeron parameters (slope/intercept) defines family of KMR models

Model	1	2	3	4
$\lvert a_1 \rvert^2$	0.46	0.25	0.24	0.25
b_1 (GeV^{-2})	8.5	8.0	5.3	7.2
c_1 (GeV^2)	0.18	0.18	0.35	0.53
d_1	0.45	0.63	0.55	0.6
b_2 (GeV^{-2})	4.5	6.0	3.8	4.2
c_2 (GeV^2)	0.58	0.58	0.18	0.24
d_2	0.45	0.47	0.48	0.48

Parameters tuned to fit diffractive pp and ppbar data

- $\sigma_{\rm tot} = \sigma_{\rm el} + \sigma_{\rm inel}$, the total cross section,
- $d\sigma_{\rm el}/dt$, the elastic cross-section,
- $\sigma^D_{\rm lowM}$, proton dissociation into low-mass systems ($pp \to p + N^*$),
- $d\sigma^D/dy$, proton dissociation into high-mass systems ($pp \to p + X$).

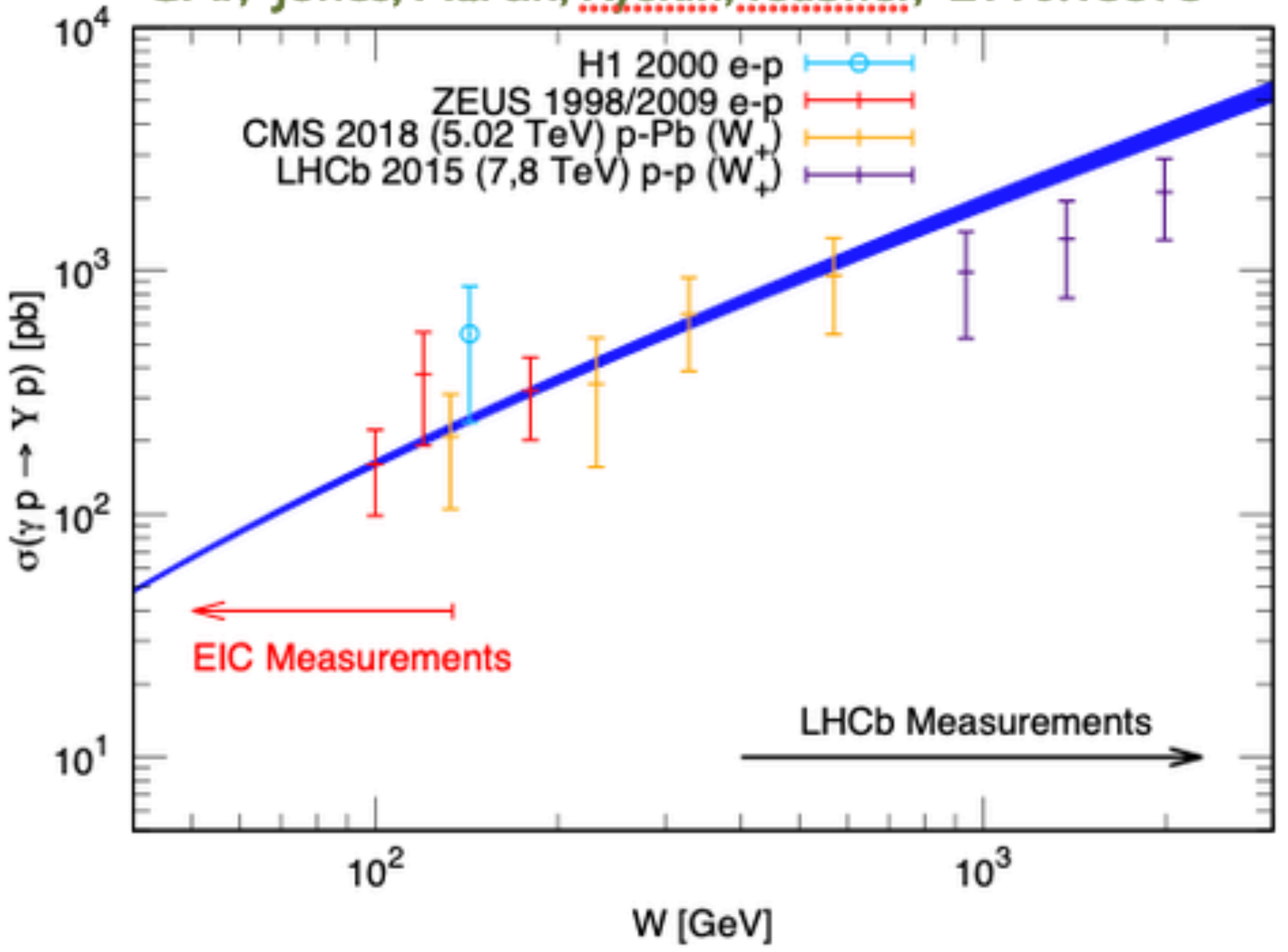


In the KMR framework the survival factors are calculated for
-given exclusive final state as a function of the pp centre-of-mass energy
-the energy of the photon-proton sub-process.
All other kinematic variables, including the exclusive final state polarisation, are integrated/summed over.

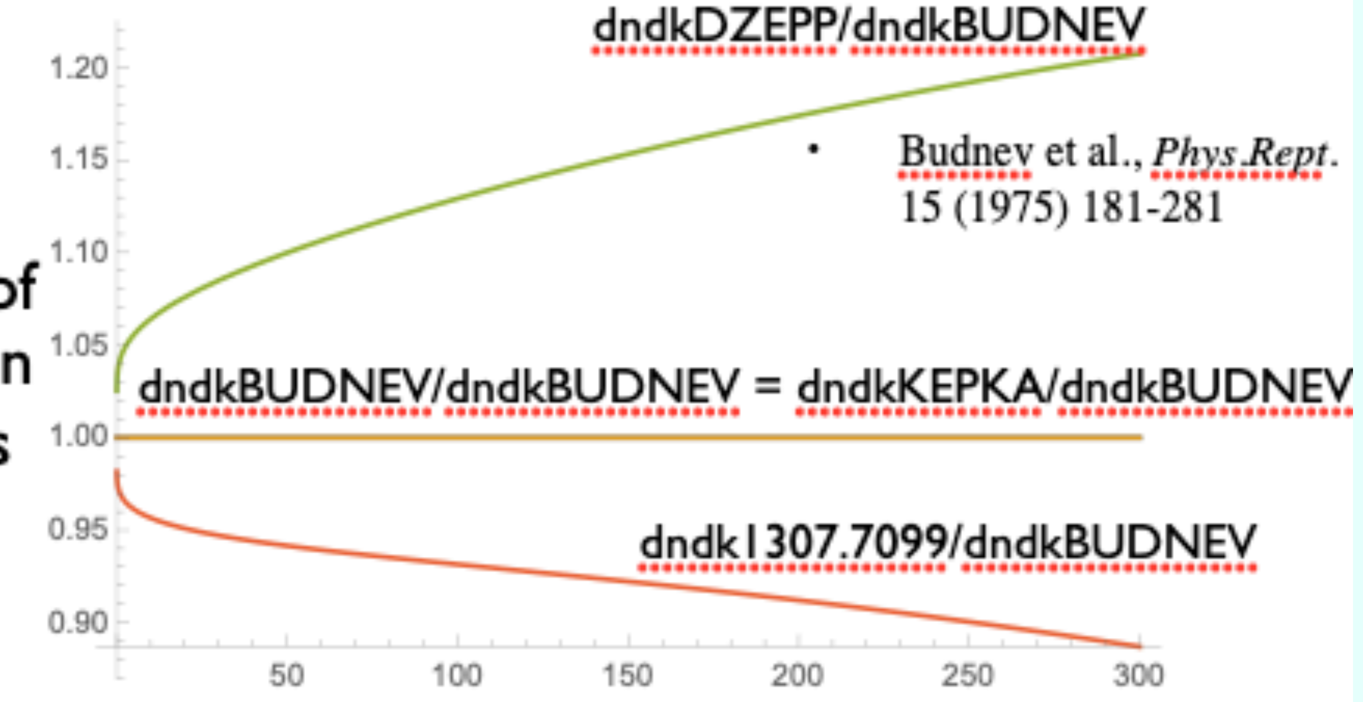
Several different KMR models are produced by varying the parametrisation of the effective pomeron. In **KMR Model 4**, the effective pomeron has an energy-dependent coupling to the eigenstates.

Other results in UPC: Photon flux in Upsilon photoprod. in pp

CAF, Jones, Martin, Ryskin, Teubner, 2110.15575



-DGLAP evolve gluon PDF obtained from fit to J/psi data to scale of Upsilon photoproduction and use as input to make cross-section prediction (blue band)



For J/psi rapidity at border of LHCb acceptance (y \sim 4.3675) and sqrts = 7 TeV, find

(ss1307.7099*flux1307.7099)/(ssBudnev*fluxBudnev)= 0.94901

~ 5% effect

For J/psi rapidity *outside* border of LHCb acceptance (y \sim 5.125) and sqrts = 7 TeV, find

(ss1307.7099*flux1307.7099)/(ssBudnev*fluxBudnev)= 1.24832

~ 25% effect

Upsilon photoproduction photon energies will be larger so discrepancy between fluxes (and survival factors) will be larger and we enter the region where the approximation of 1307.7099 flux breaks down at much lower rapidities and, importantly, within the acceptance of LHCb

=> use Budnev flux (without negligence of O(x) terms)

=> large W unfolded photoproduction LHCb data should be shifted upwards

$$\frac{d\sigma(pp)}{dy} = S^2(W_+)\left(k_+\frac{dn}{dk}_+\right)\sigma_+(\gamma p) + S^2(W_-)\left(k_-\frac{dn}{dk}_-\right)\sigma_-(\gamma p).$$