



State Research Center  
A.A. Logunov Institute for High Energy Physics –  
National Research Center "Kurchatov Institute",  
Protvino, Russian Federation

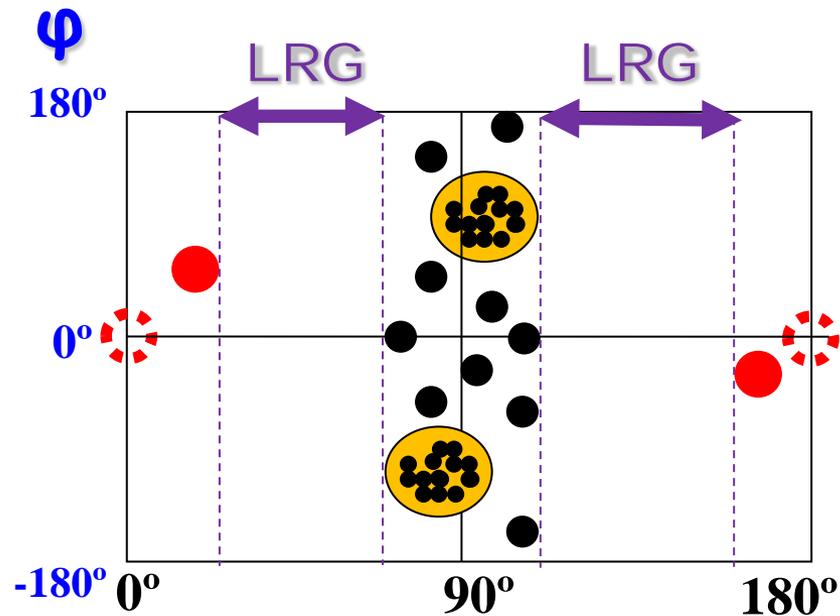
# **Exclusive central diffractive production (ECDP): new results and key points**

**Roman Ryutin**

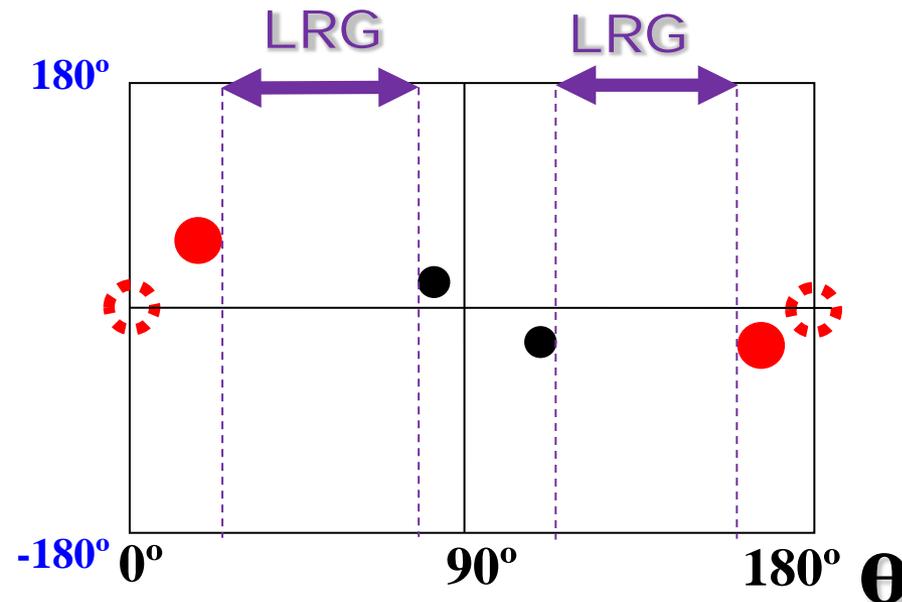
**LHC Working Group on Forward Physics and Diffraction  
(16-17 December 2019, CERN)**

# ECDP kinematics and signatures

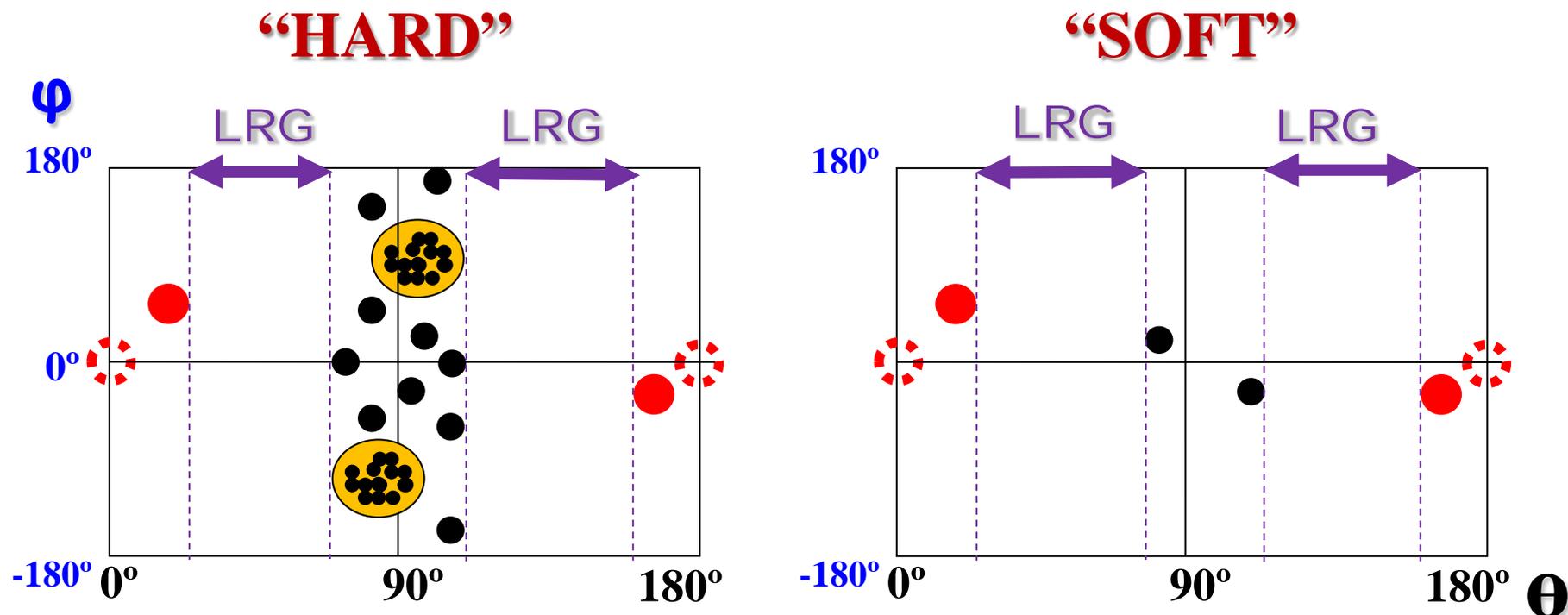
“HARD”



“SOFT”



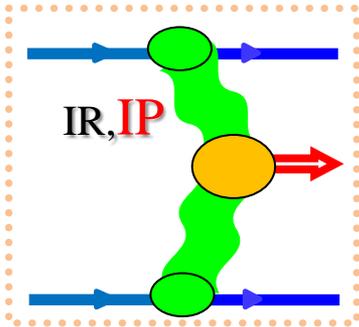
# ECDP kinematics and signatures



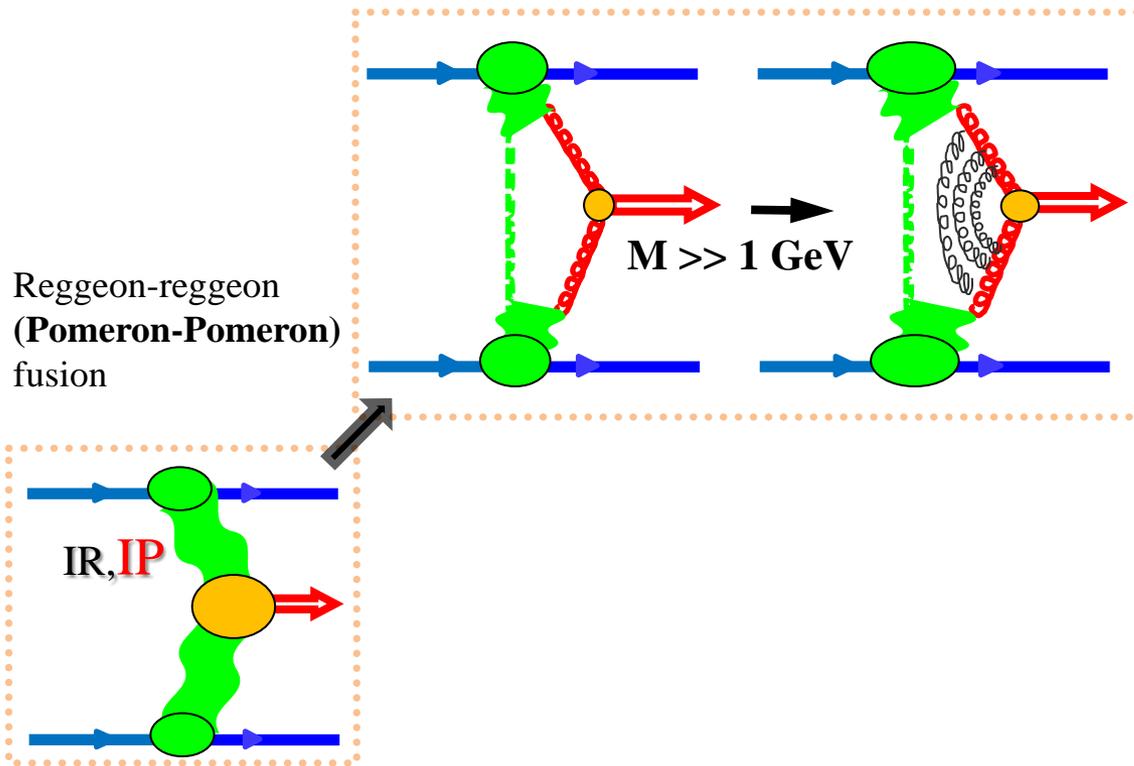
1. Two final protons => Missing Mass Method
2. Large Rapidity Gaps ~ diffraction signature

# ECDP regimes and theoretical approaches

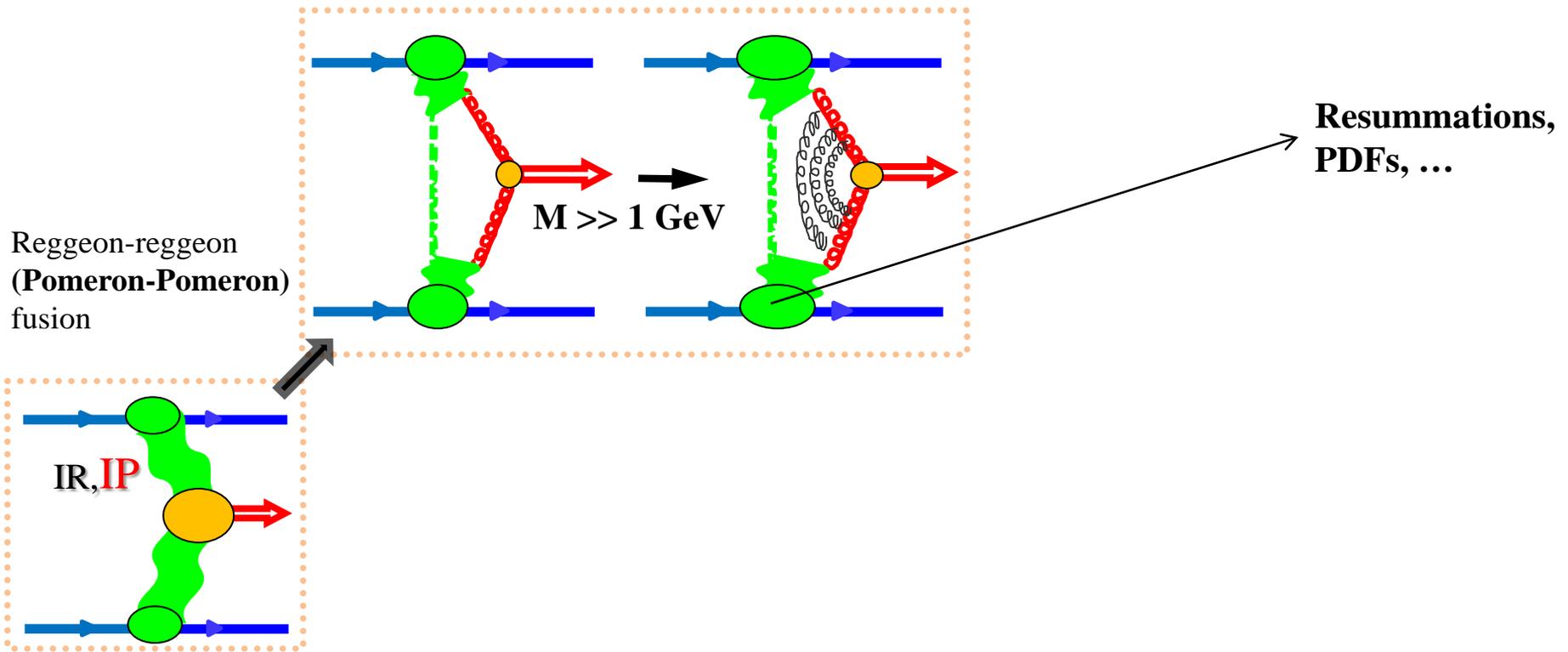
Reggeon-reggeon  
(Pomeron-Pomeron)  
fusion



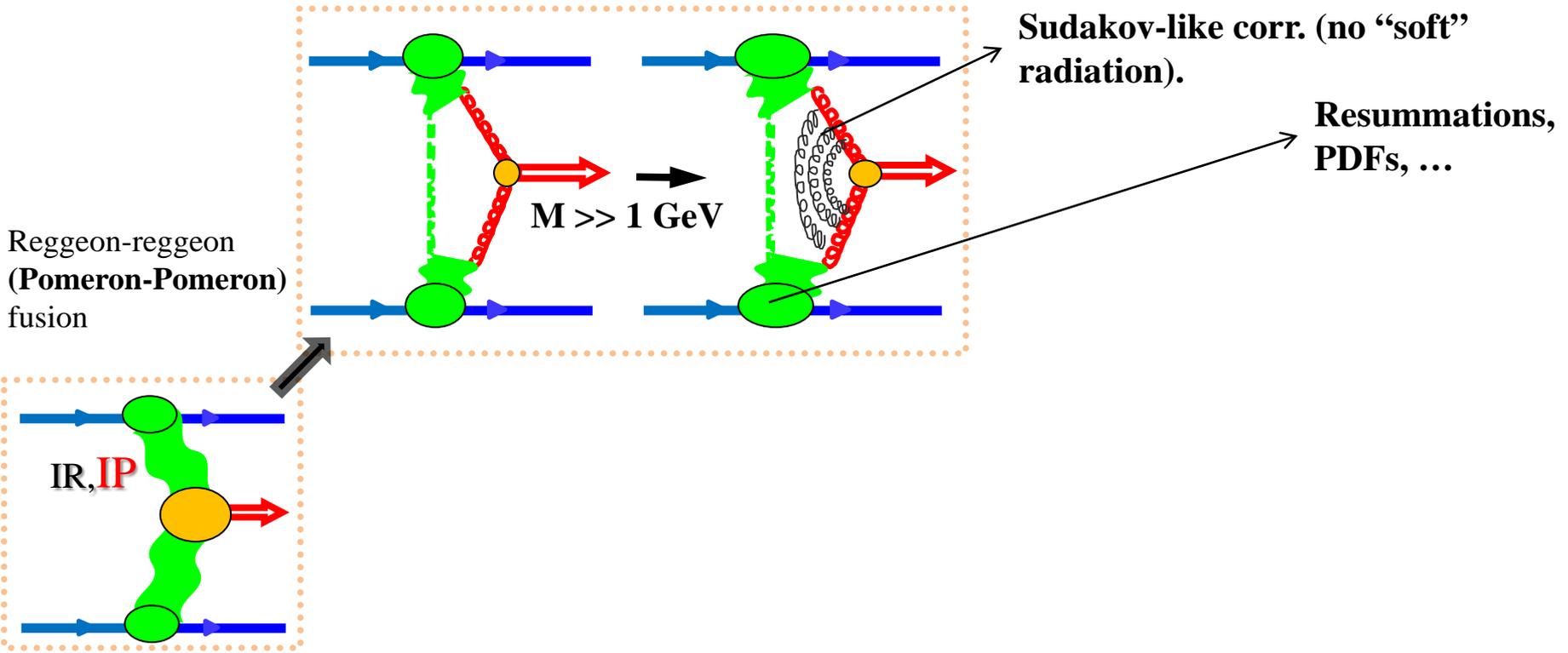
# ECDP regimes and theoretical approaches



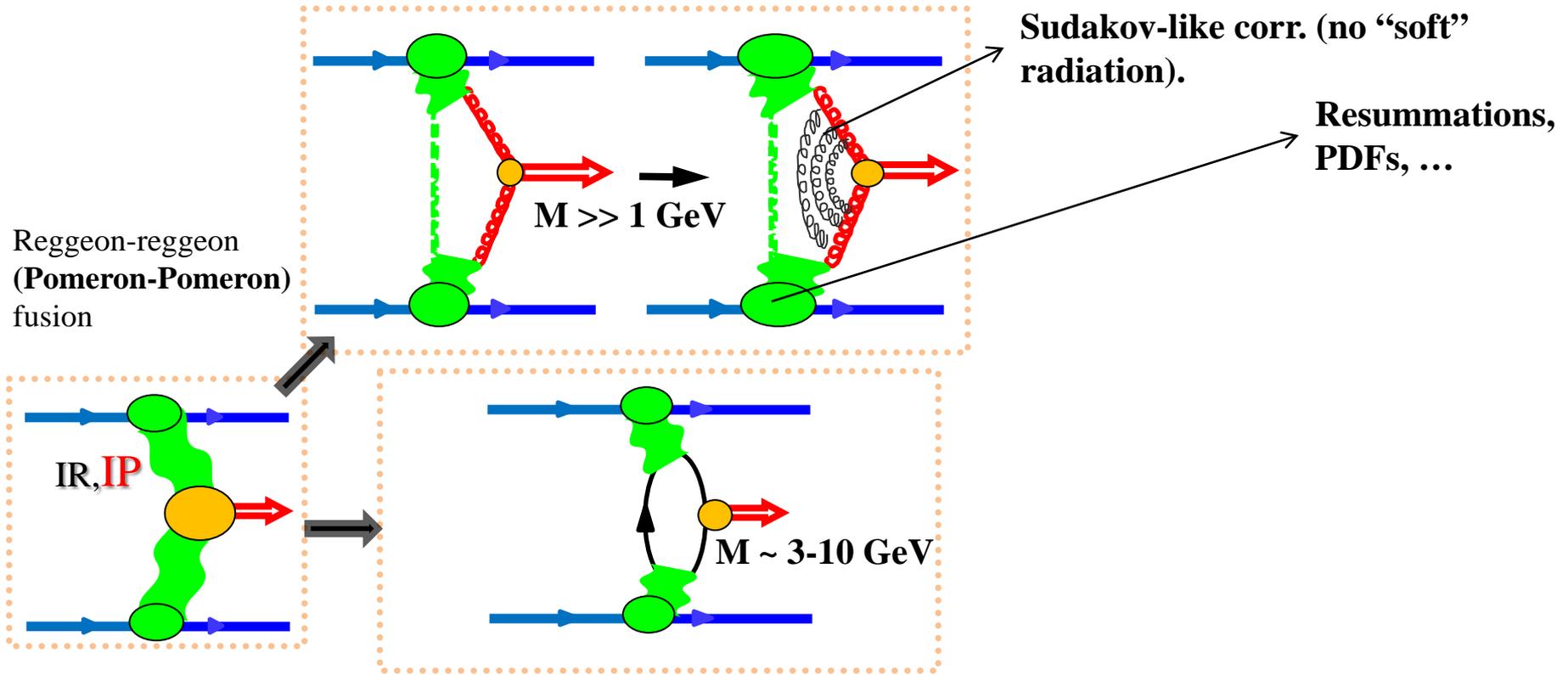
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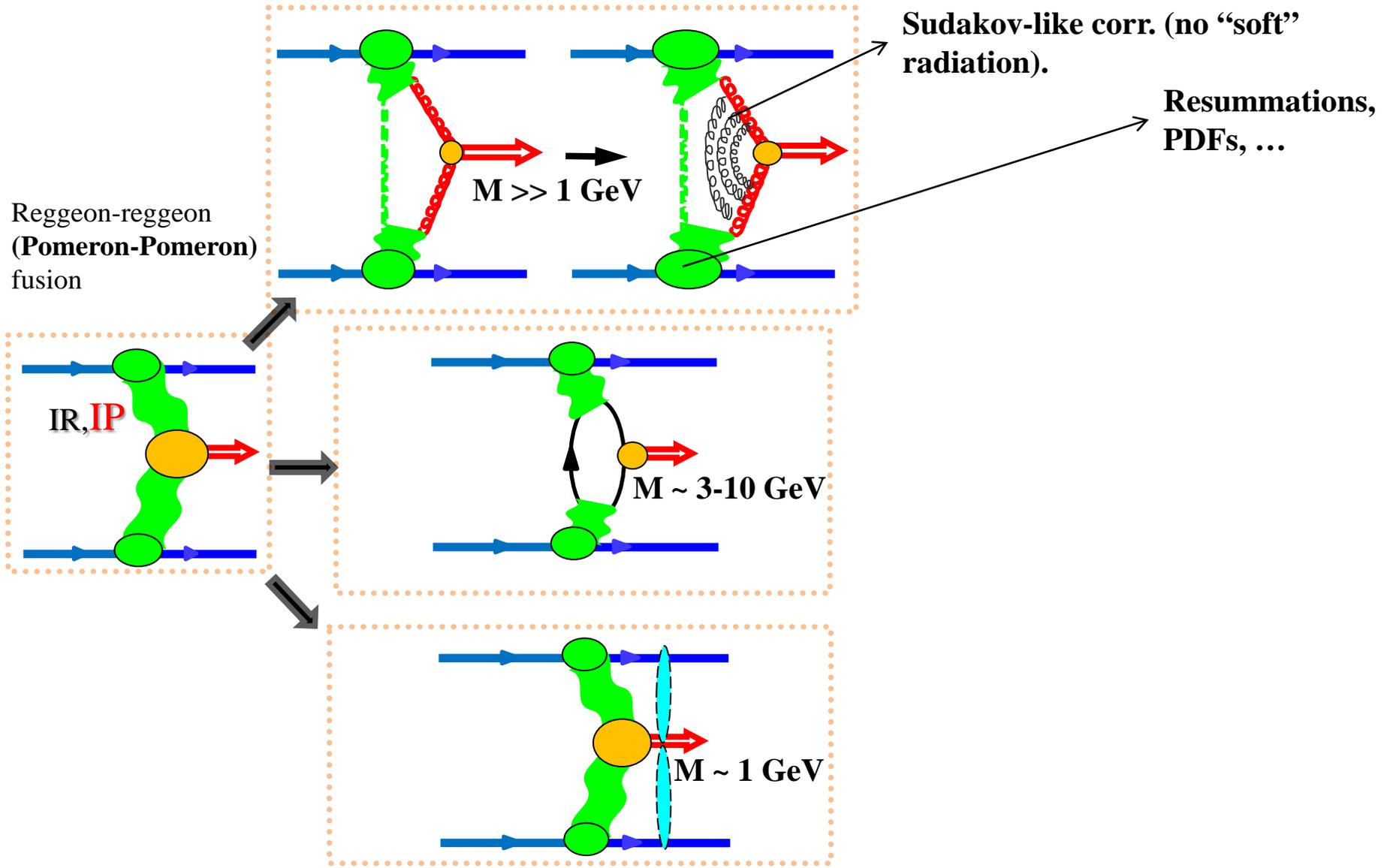
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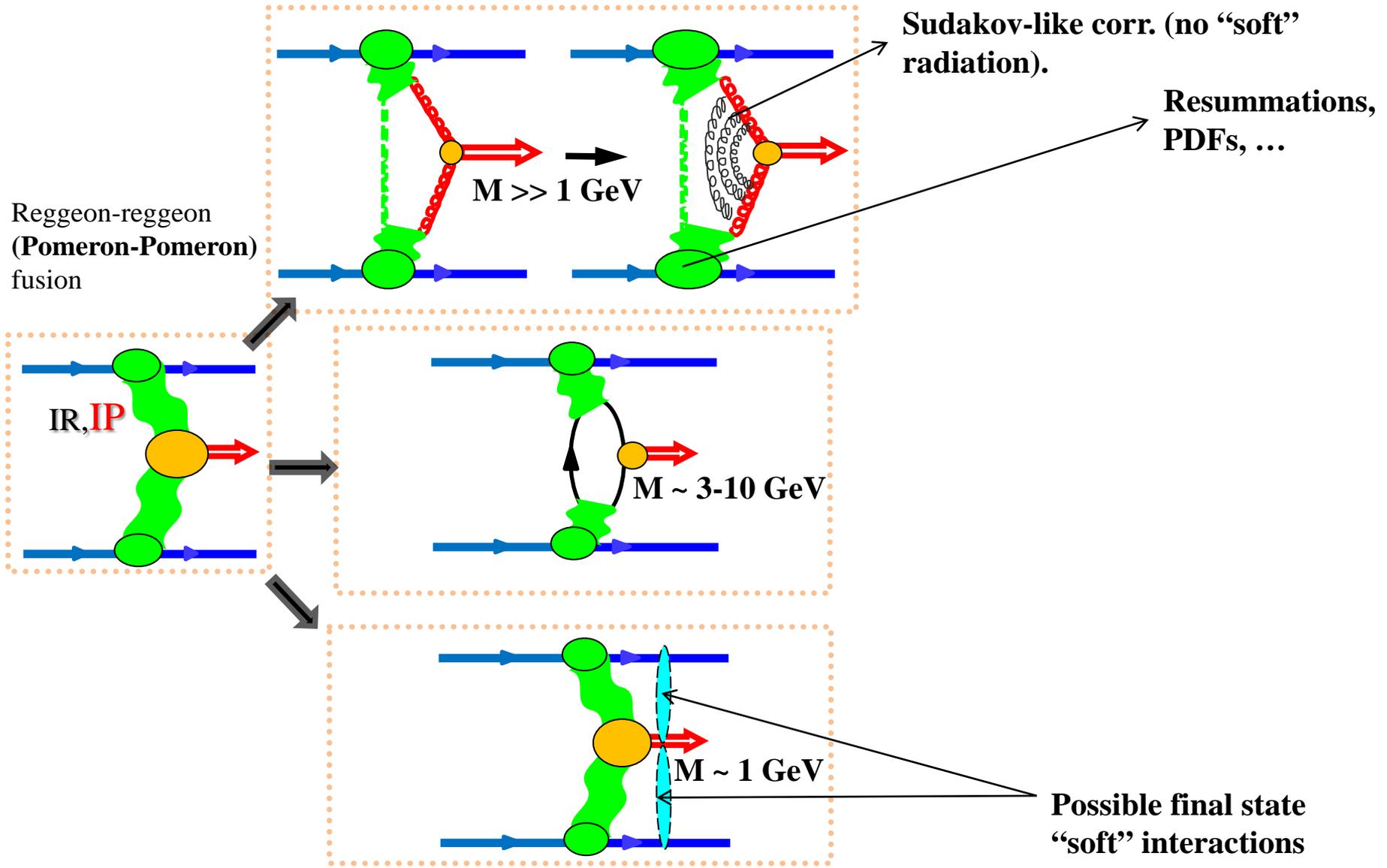
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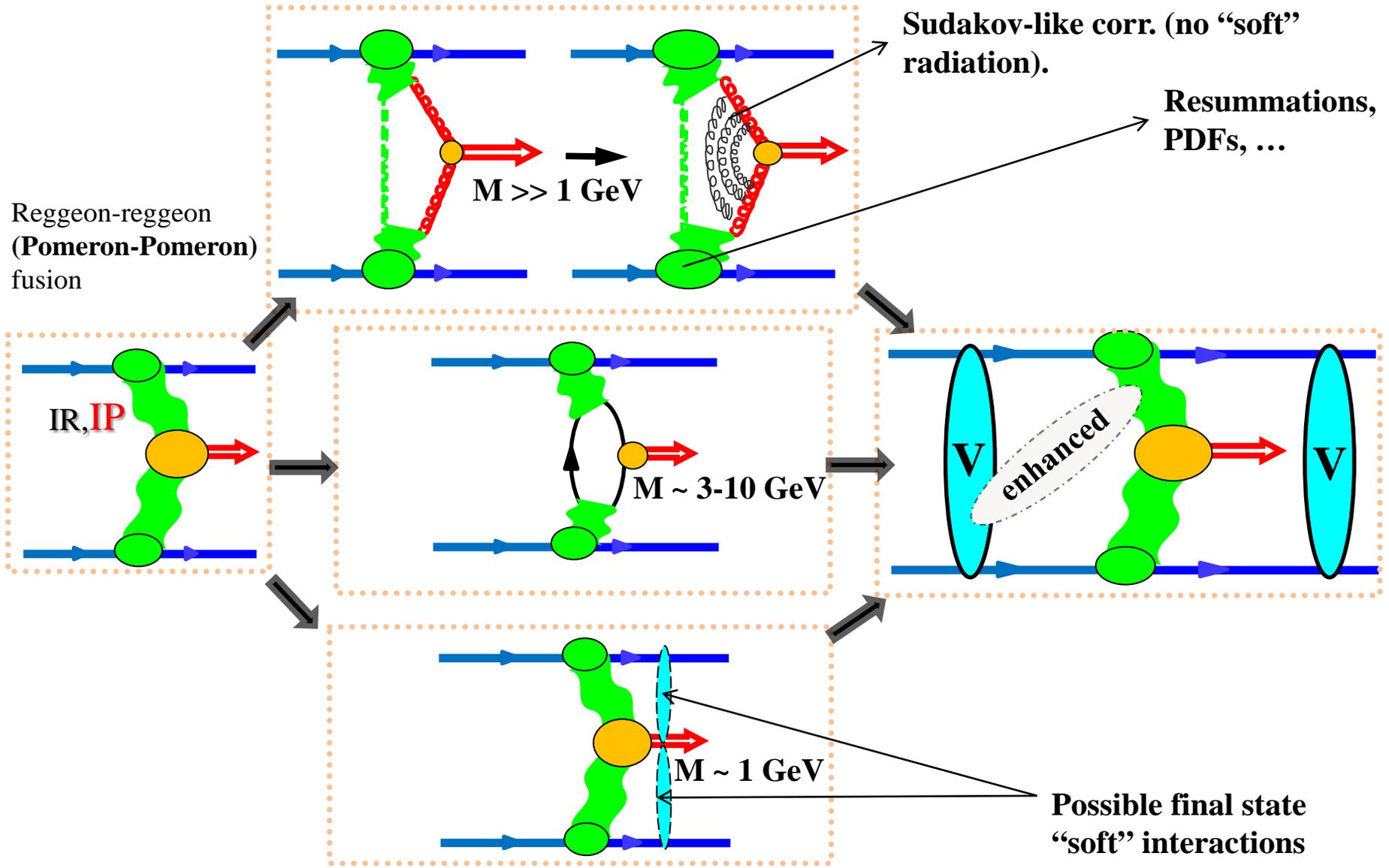
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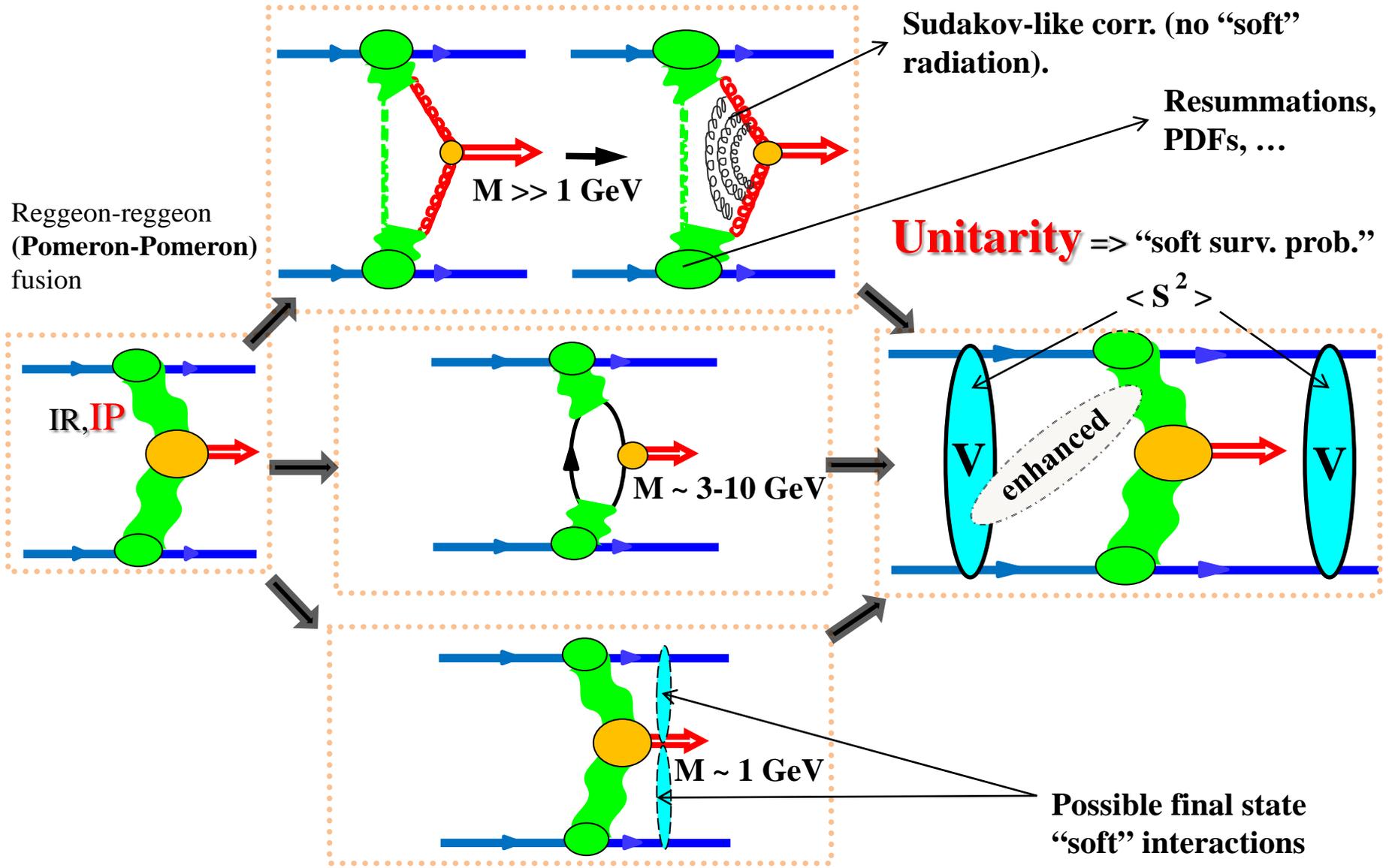
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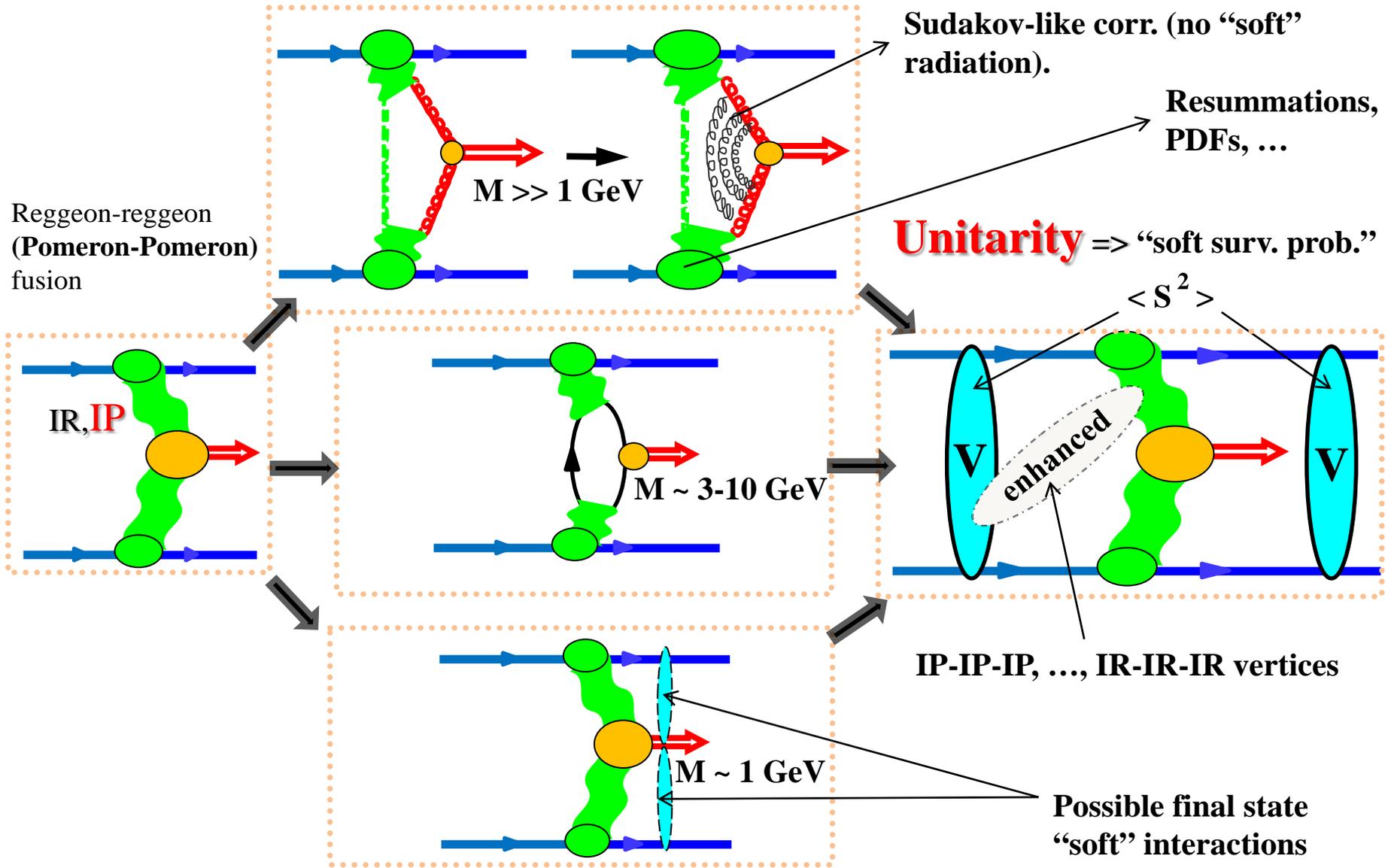
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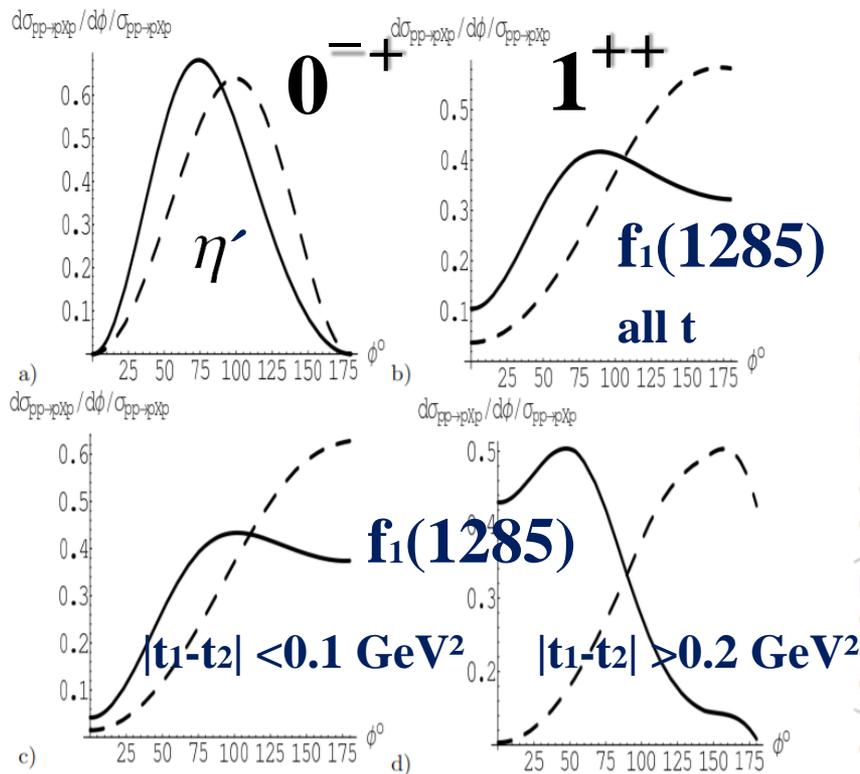
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  - \*  $d\sigma/dt \rightarrow$  size and shape of the interaction region

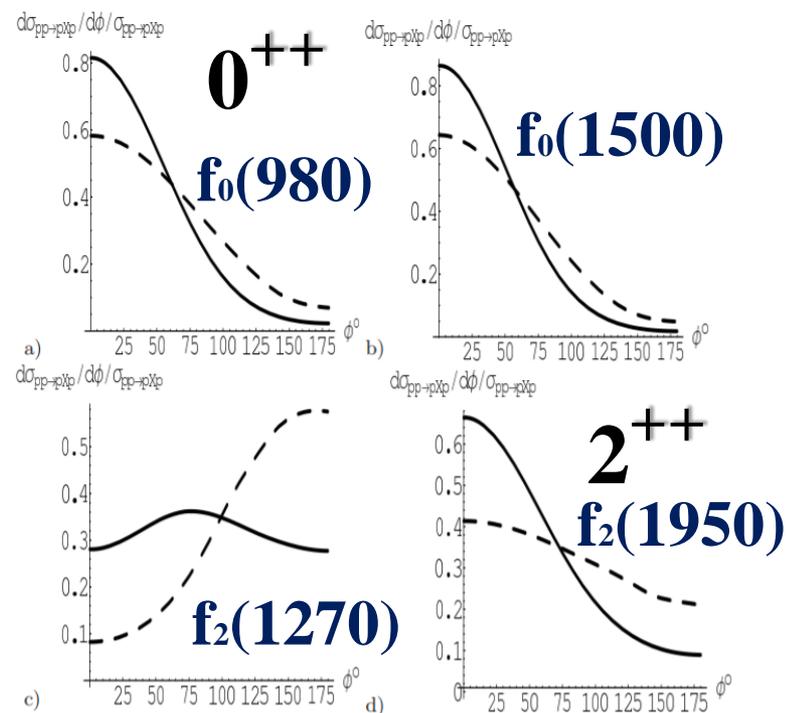
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  - \* azimuthal picture,  $d\sigma/d\phi \rightarrow$  spin-parity analyser
  - \*  $d\sigma/dt \rightarrow$  size and shape of the interaction region
5. **Large cross-sections for low central masses**  
(important for low luminosity runs)

--- Born term  
— Full result with all corrections

## Spin-parity analyser



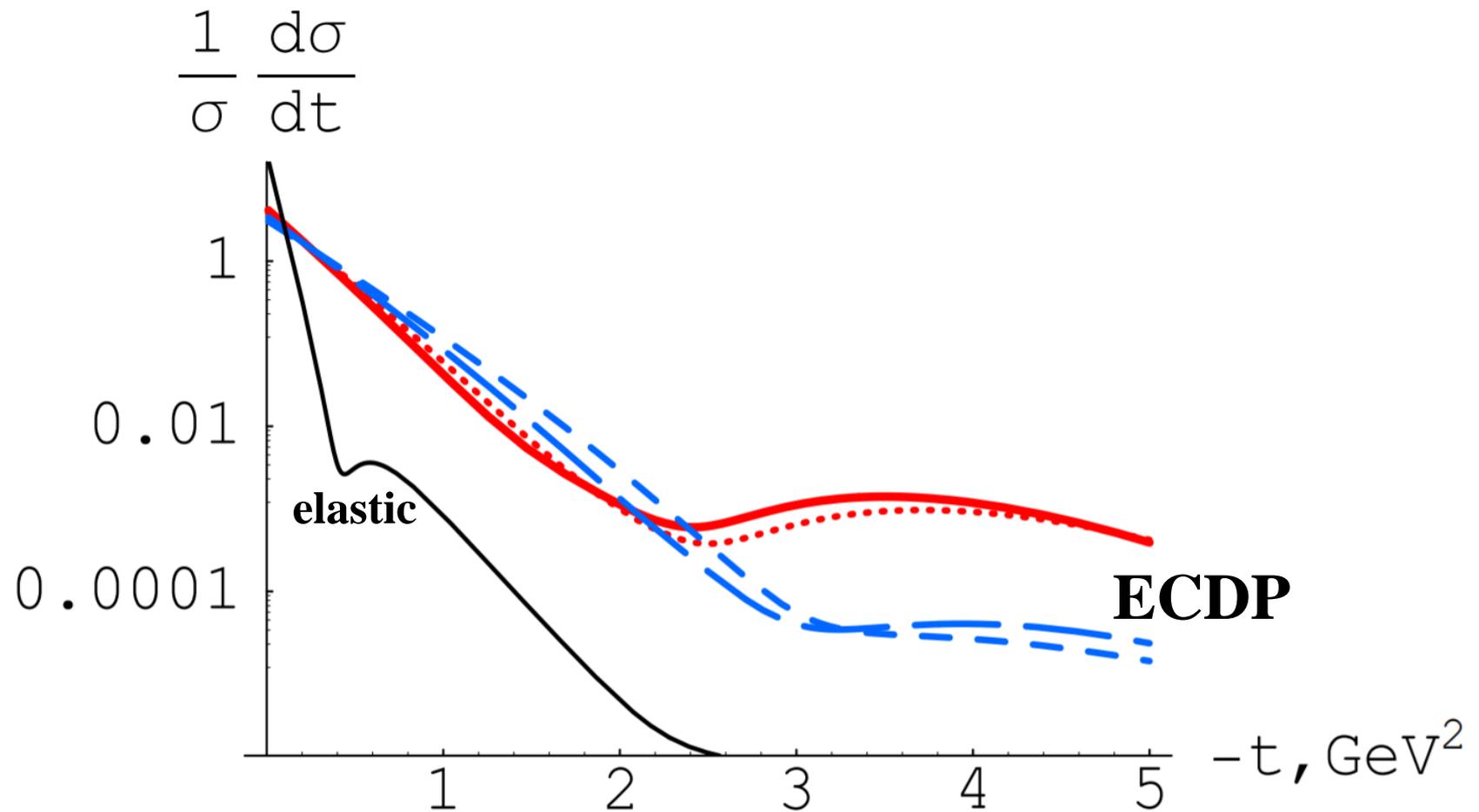
**Figure 5:** Results for the LHC energies. a)  $\eta'$ ,  $0^{-+}$ ; b)  $f_1(1285)$ ,  $1^{++}$ , all  $t_i$ ; c)  $f_1(1285)$ ,  $|t_1 - t_2| < 0.1 \text{ GeV}^2$ ; d)  $f_1(1285)$ ,  $|t_1 - t_2| > 0.2 \text{ GeV}^2$ ;



**Figure 6:** Results for the LHC energies. a)  $f_0(980)$ ,  $0^{++}$ ; b)  $f_0(1500)$ ,  $0^{++}$ ; c)  $f_2(1270)$ ,  $2^{++}$ ; d)  $f_2(1950)$ ,  $2^{++}$ ;

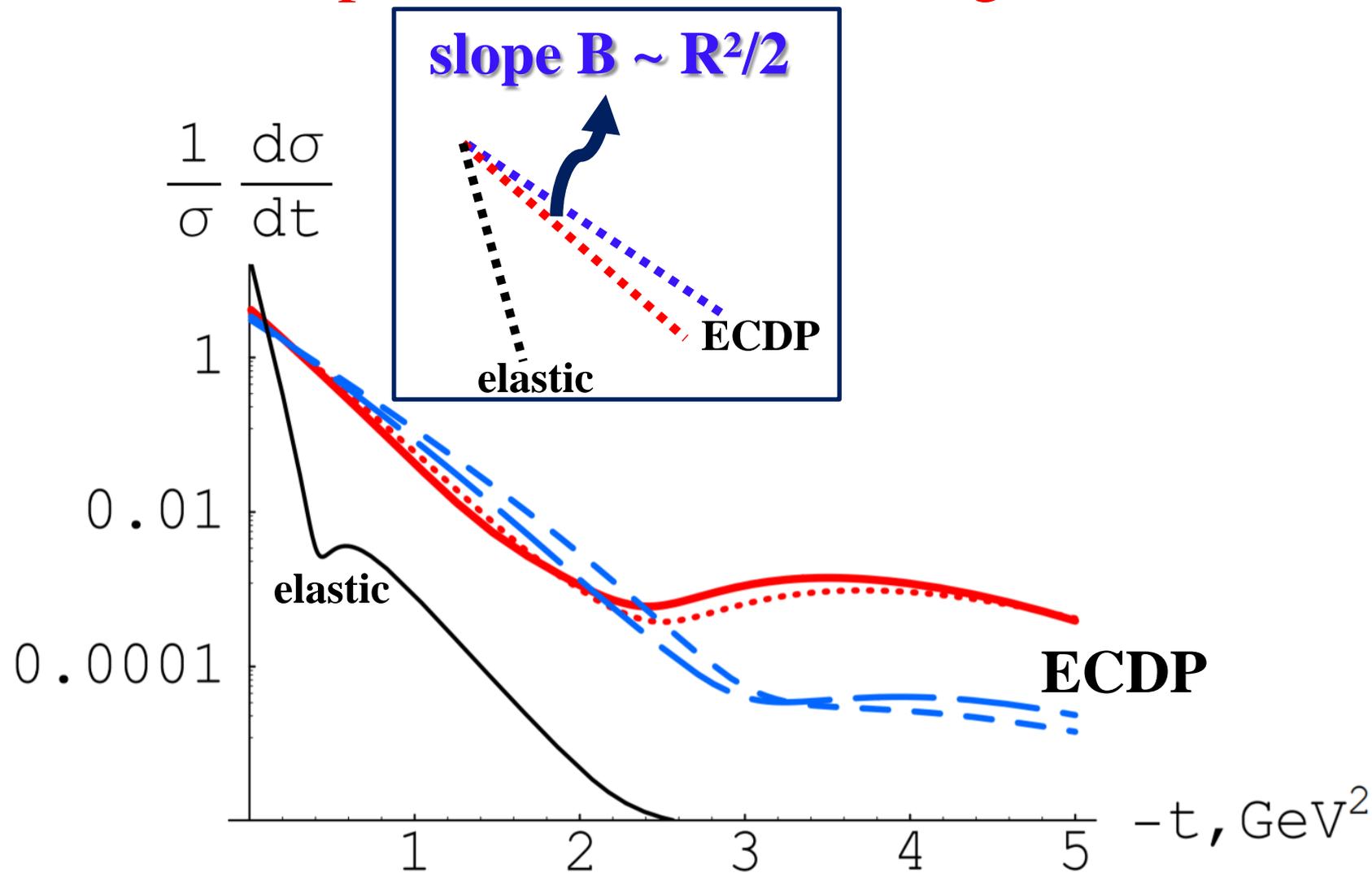
JHEP06(2005)007

## Size and shape of the interaction region



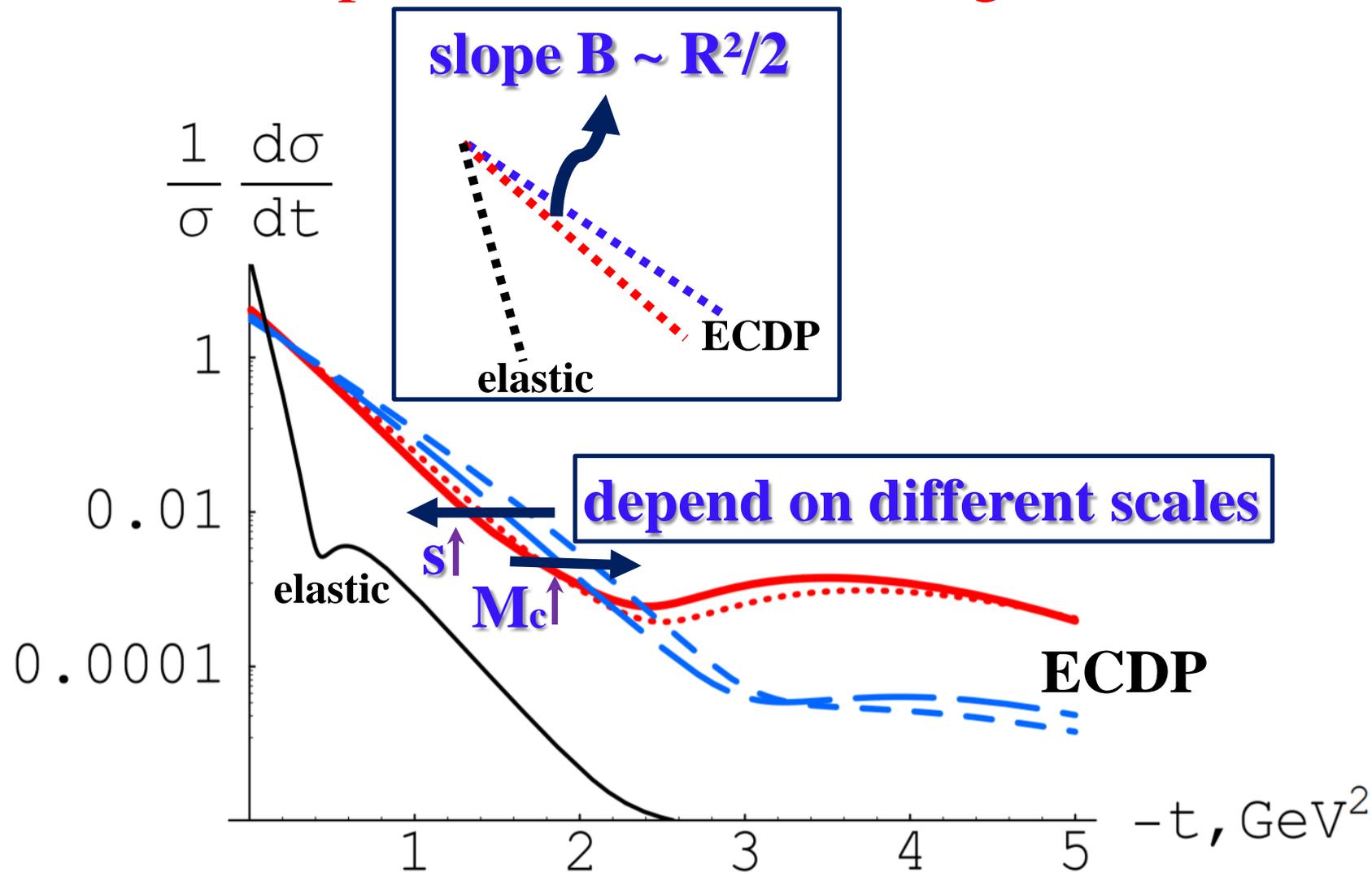
# ECDP: physics behind observables

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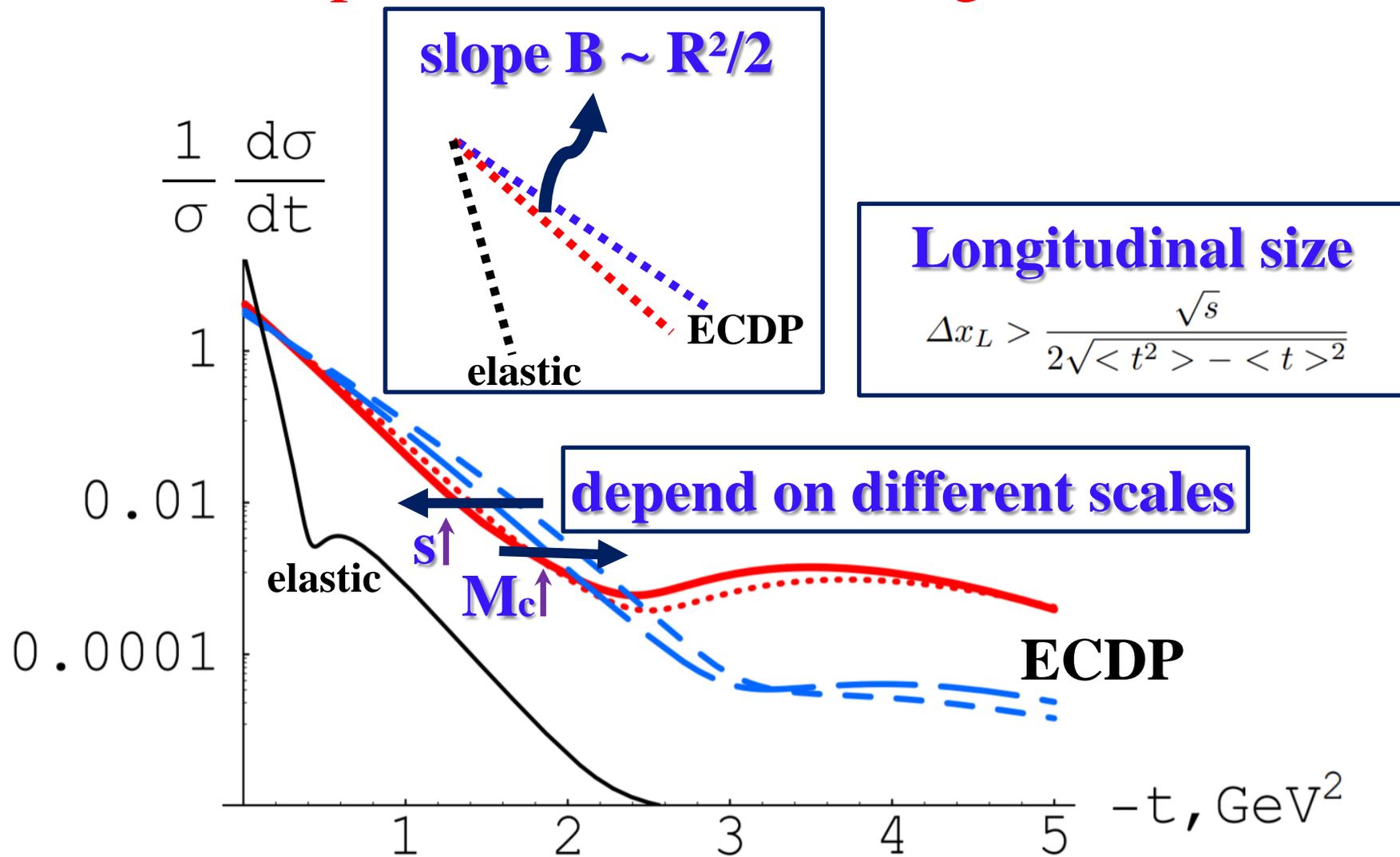
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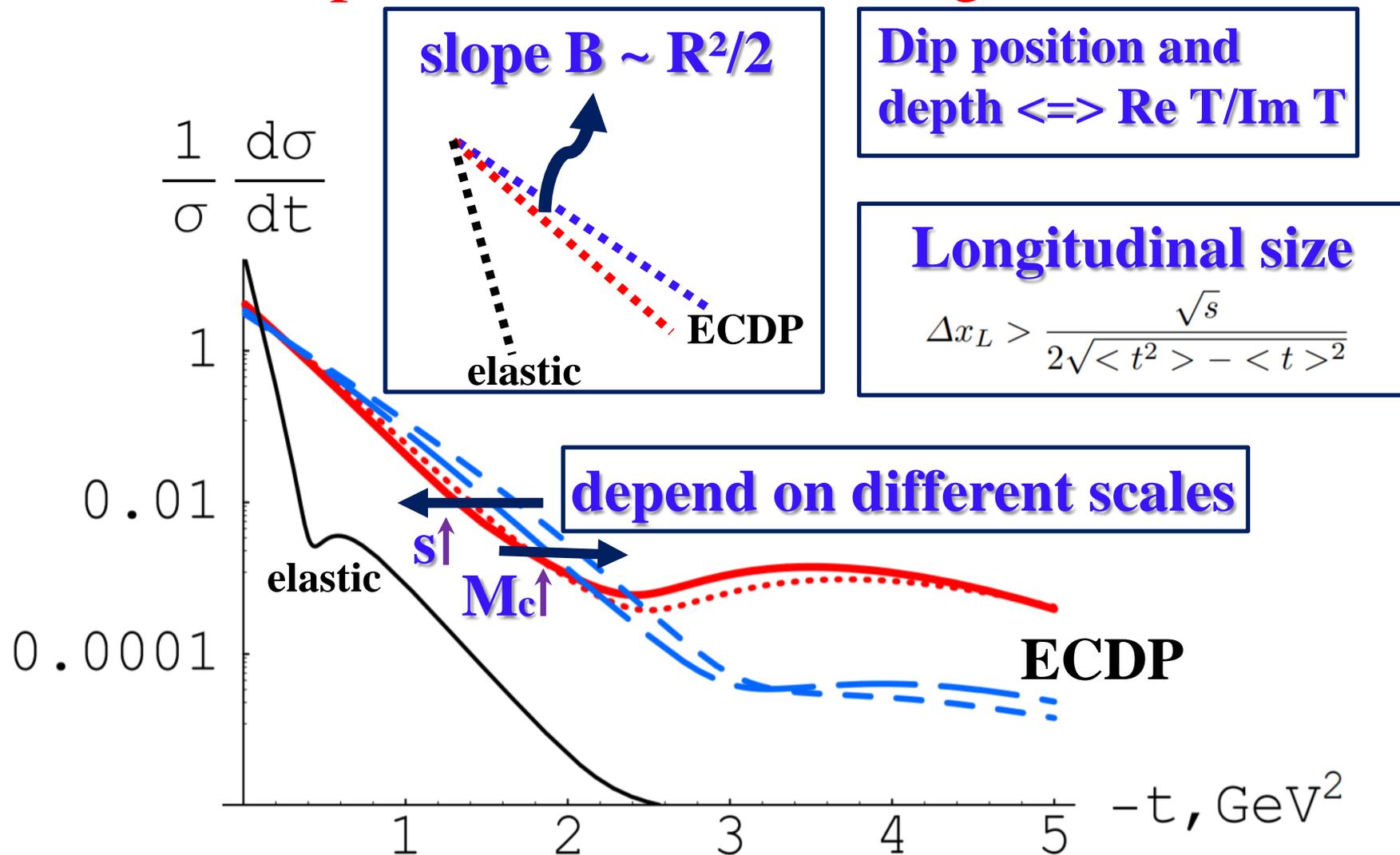
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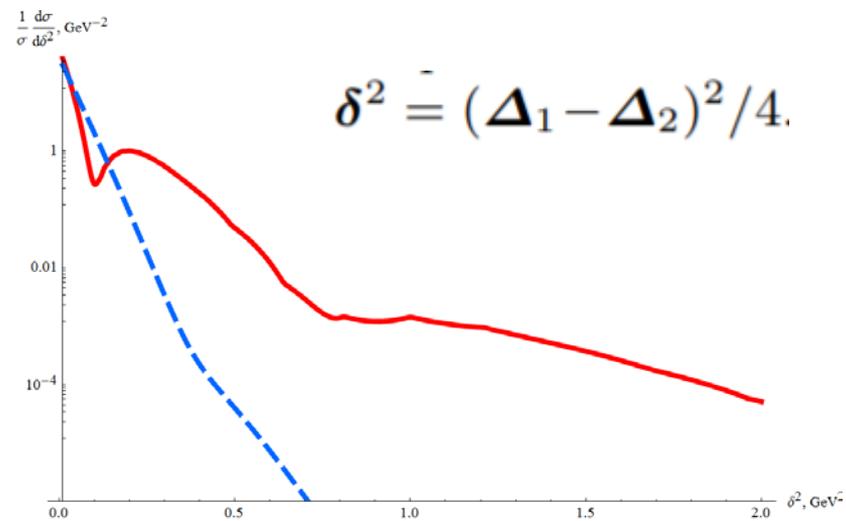
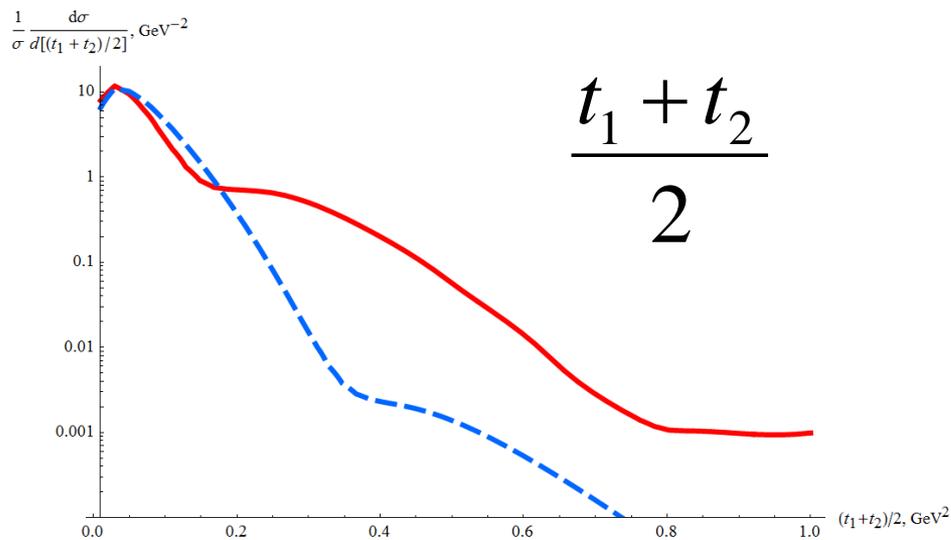
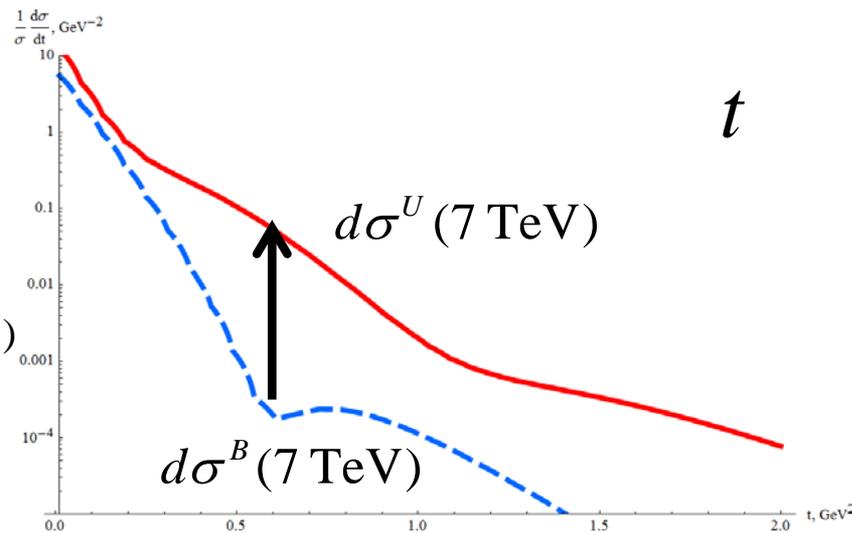
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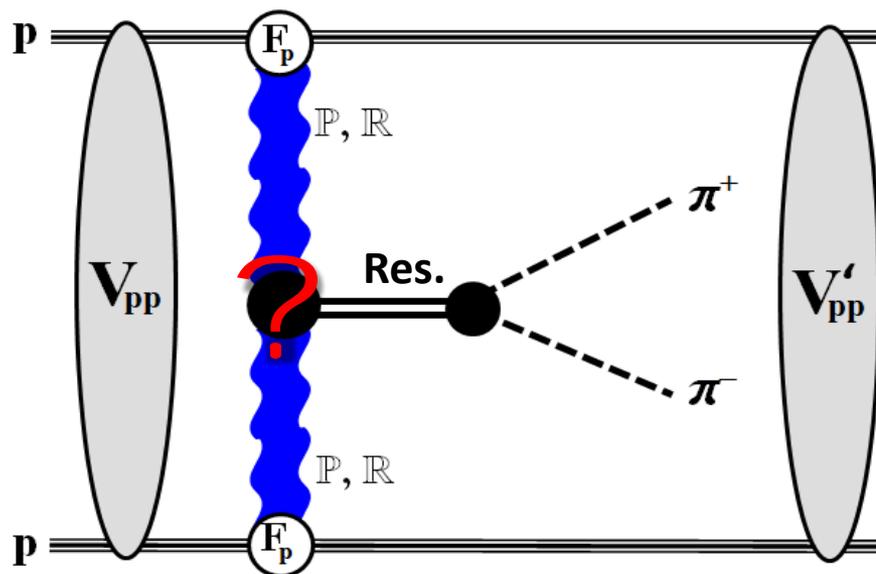
# ECDP: physics behind observables

More sensitive variables  
= more exact verification

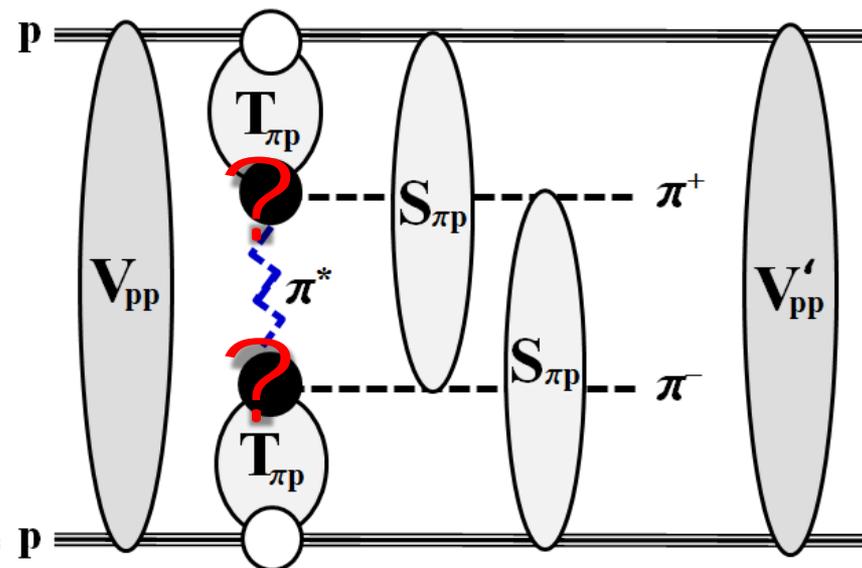
- — — Born term  $|M_B|^2 \sim e^{2B(t_1+t_2)}$
- — — Full result with all corrections



# Low mass ECDP: di-pion continuum, interference with res.

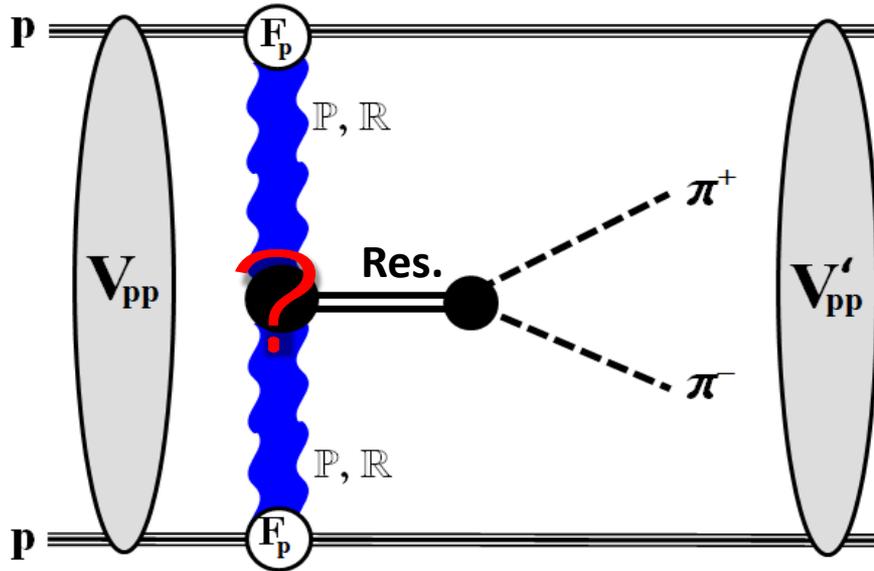


[A. Godizov, Phys.Lett. B 787 (2018) 188]

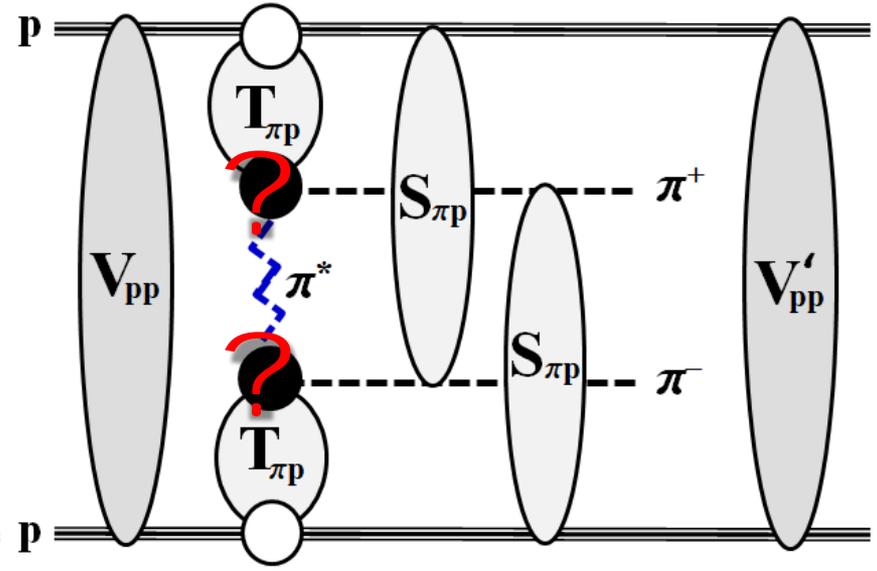


[R. Rytin, Eur.Phys.J. C 79 (2019) 981]

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$d\sigma_{RF}^U/d\phi_{pp}$

STAR

$$\hat{F}_\pi = e^{(\hat{t}-m_\pi^2)/\Lambda_\pi^2}$$

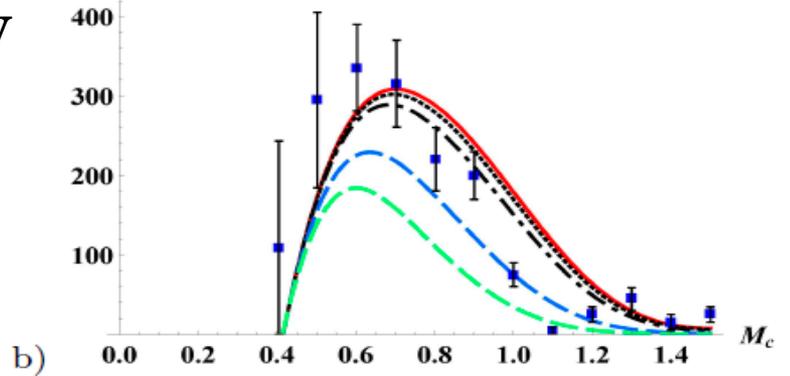
$\Lambda_\pi, \text{GeV}$

- 5
- 4
- 3
- 1.6
- 1.2



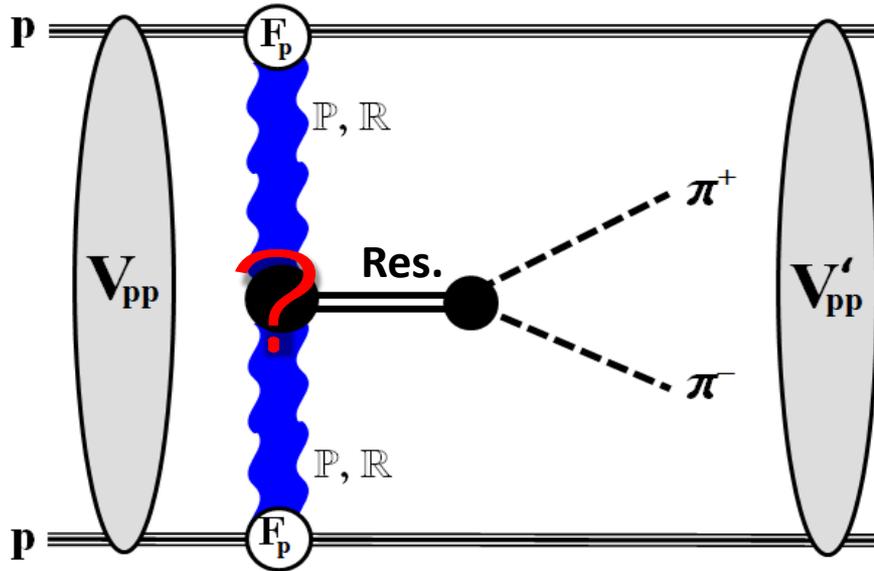
a)

$d\sigma_{RF}^U/dM_c$

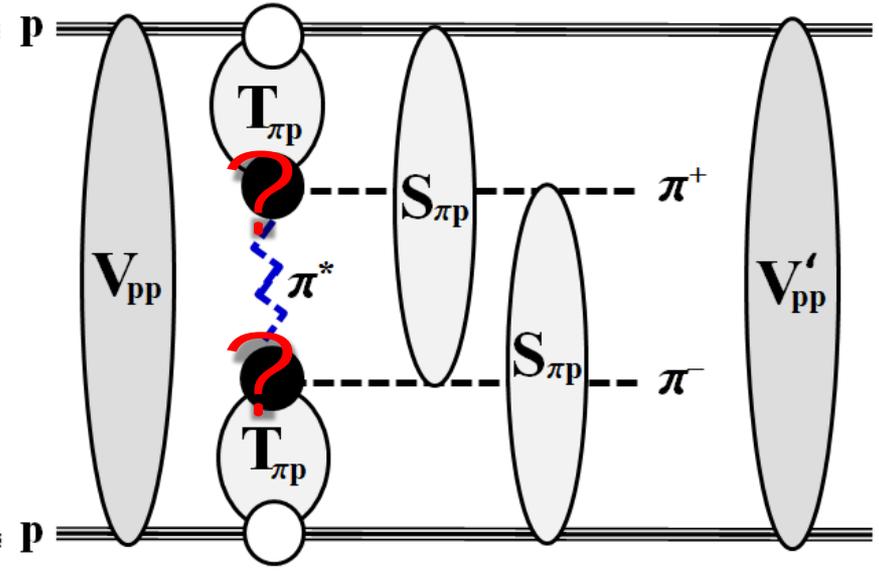


b)

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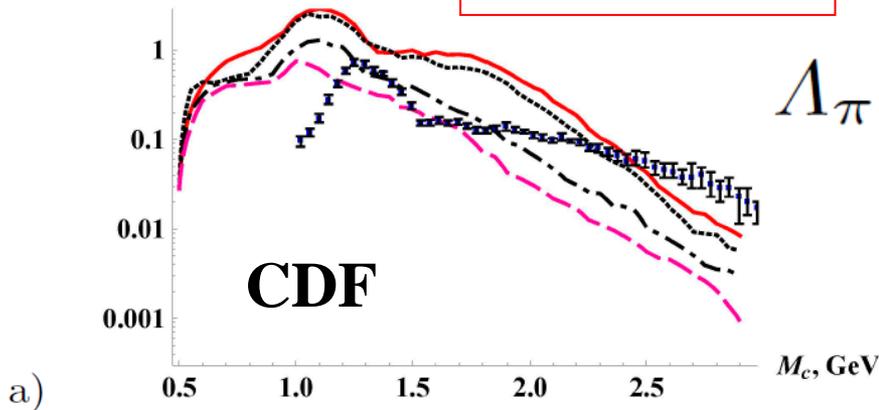
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$d\sigma_{\text{RF}}^U/dM_c, \mu\text{b}/\text{GeV}$

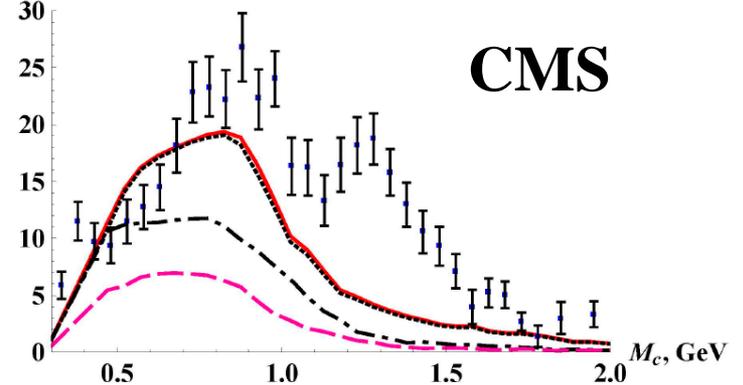
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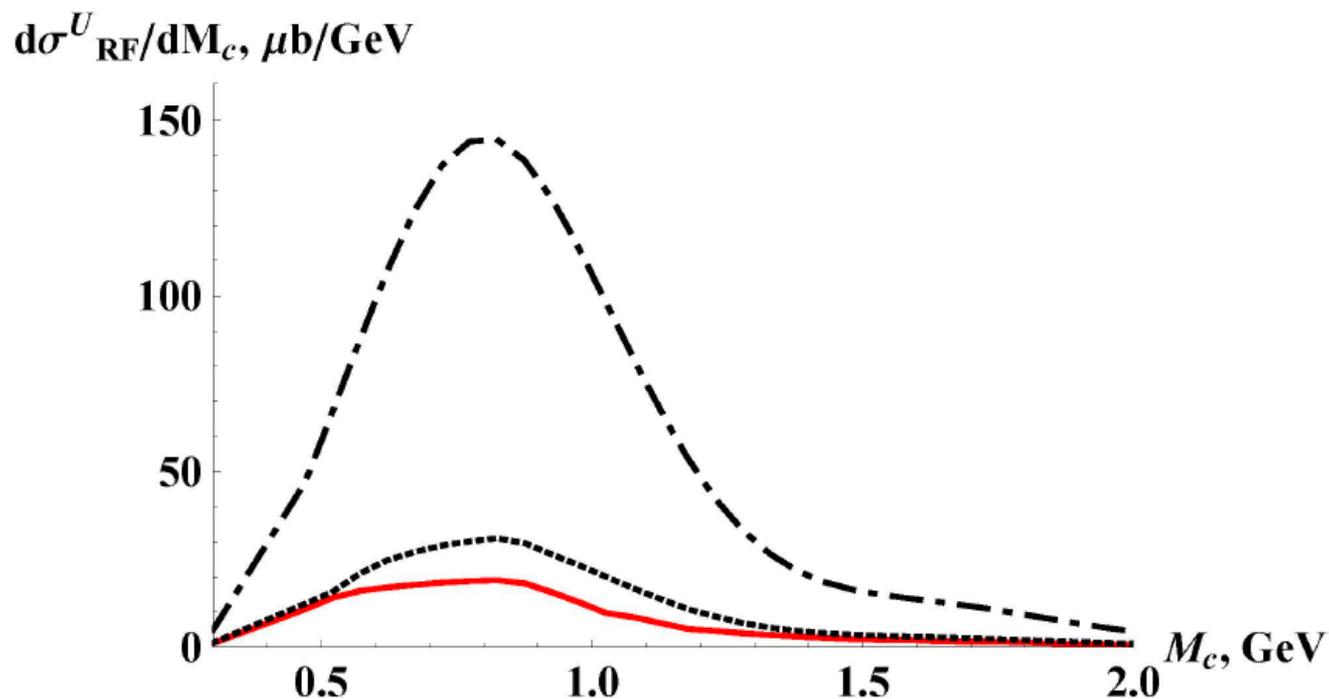
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**CMS**

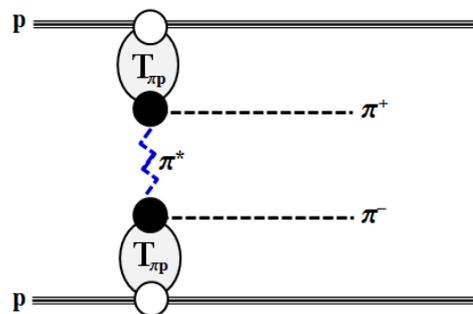
# Low mass ECDP: di-pion continuum, “soft surv. prob.”

CMS 7 TeV

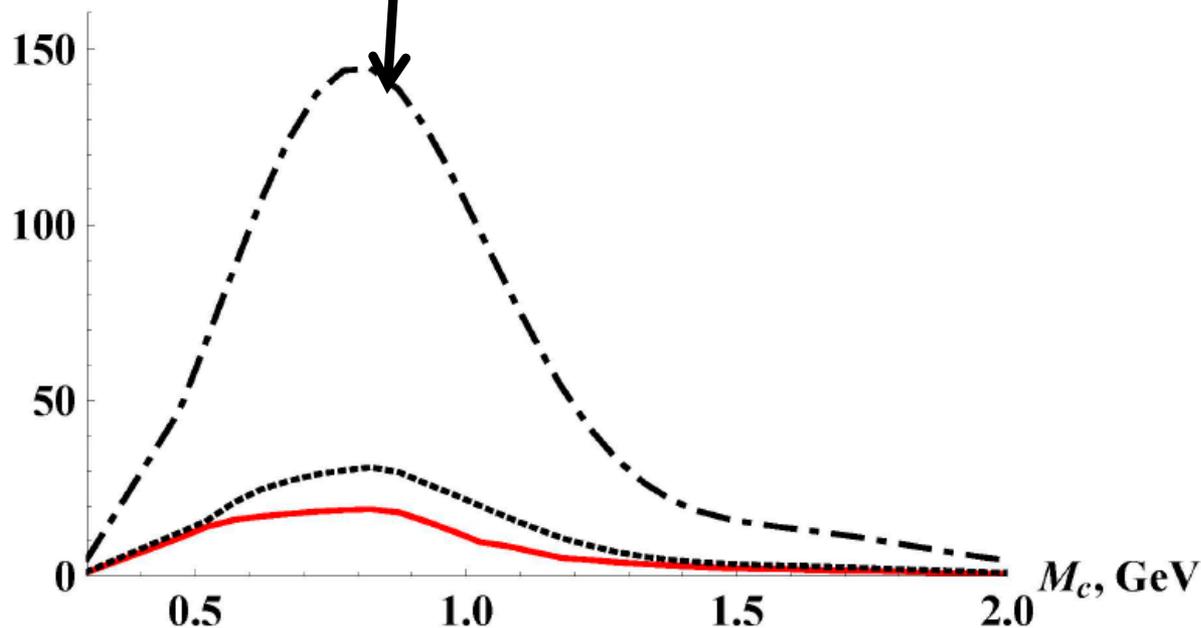


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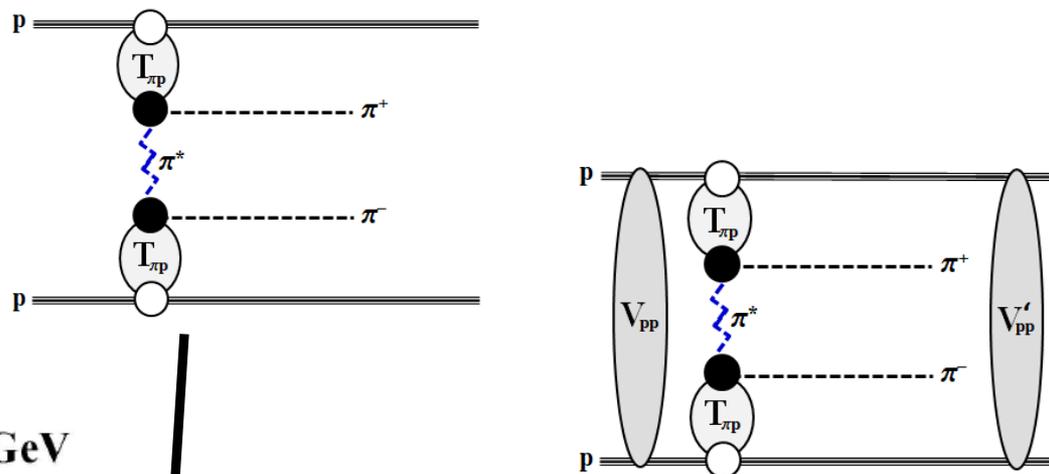


$d\sigma^U_{\text{RF}}/dM_c, \mu\text{b}/\text{GeV}$

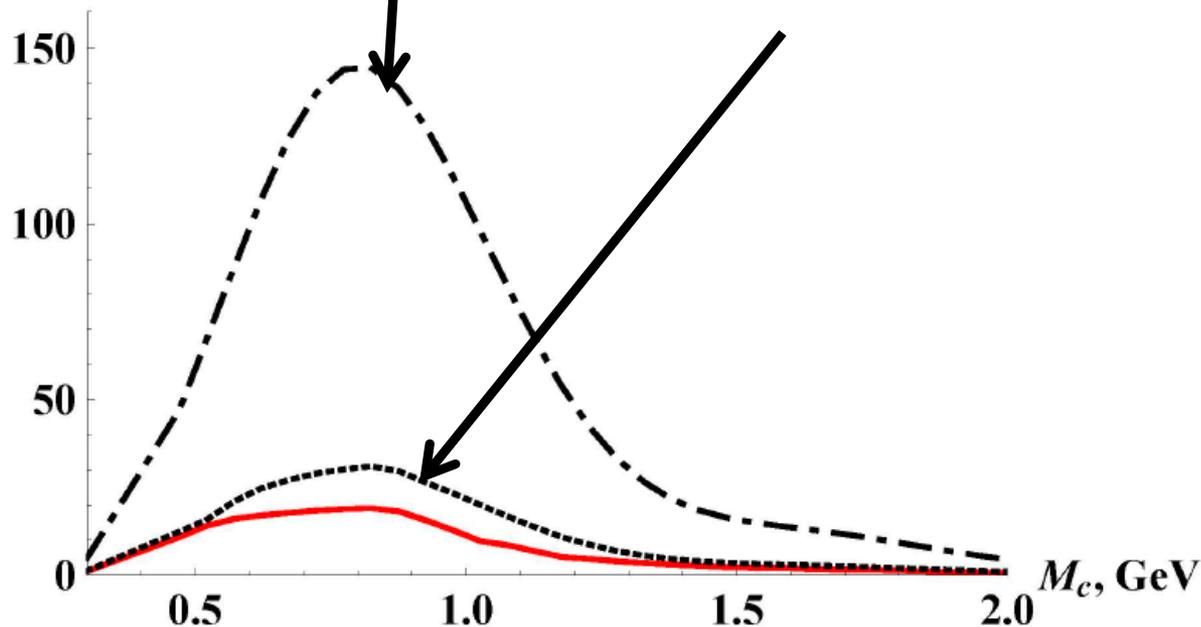


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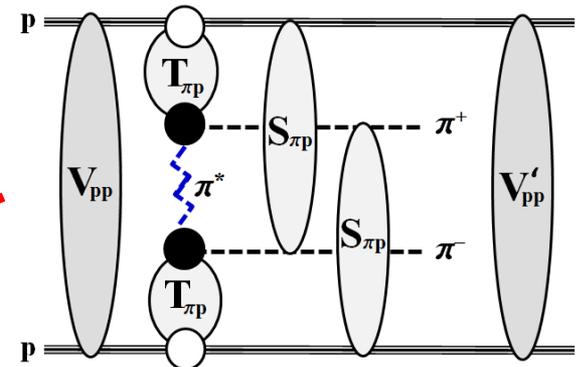
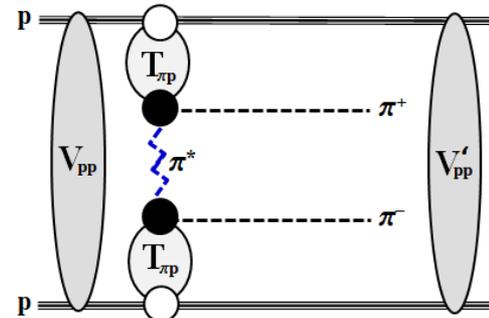
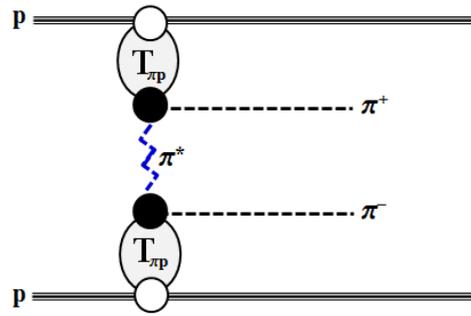
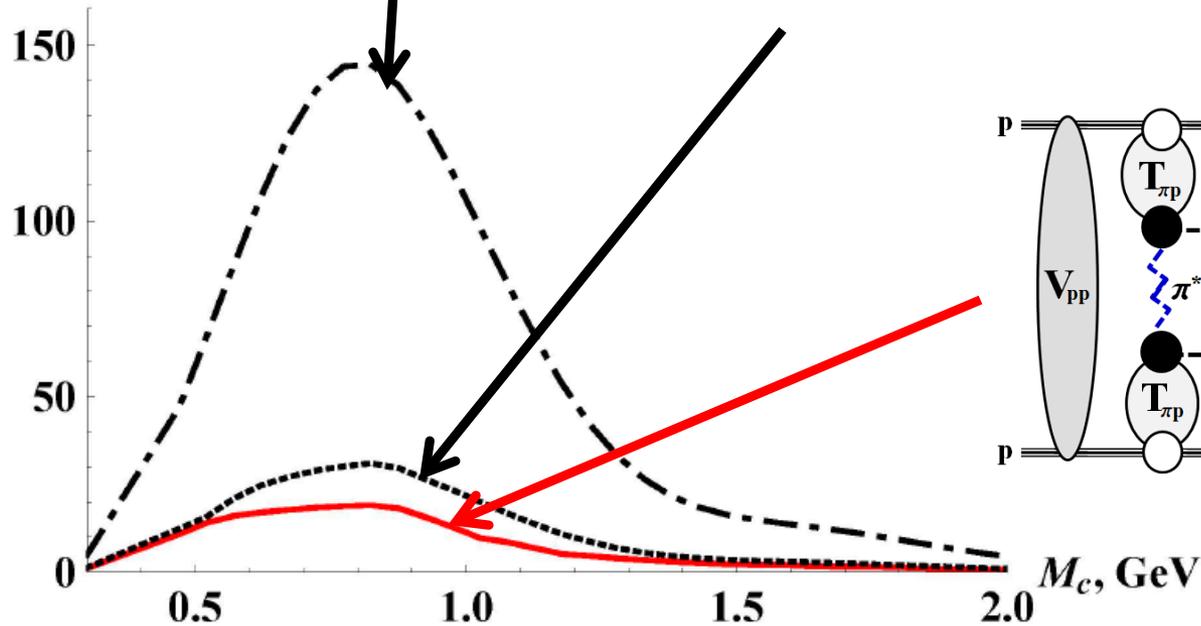
$d\sigma_{RF}^U/dM_c, \mu\text{b/GeV}$



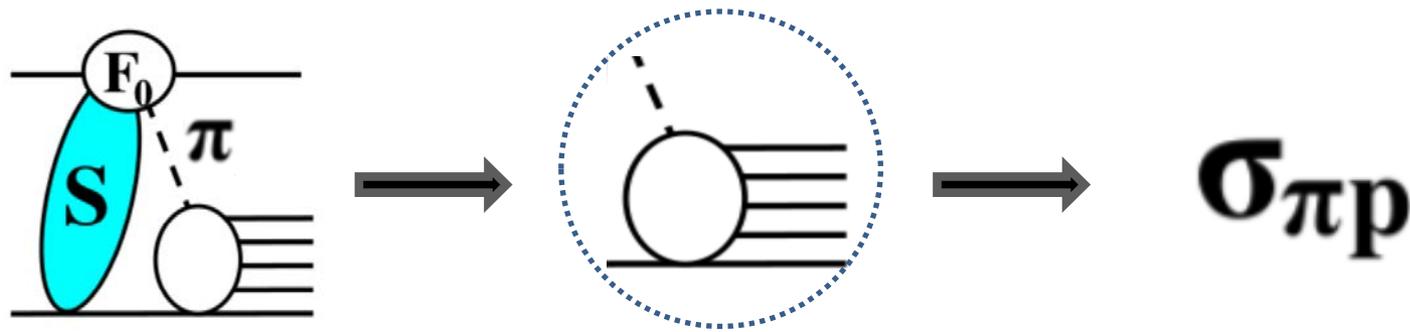
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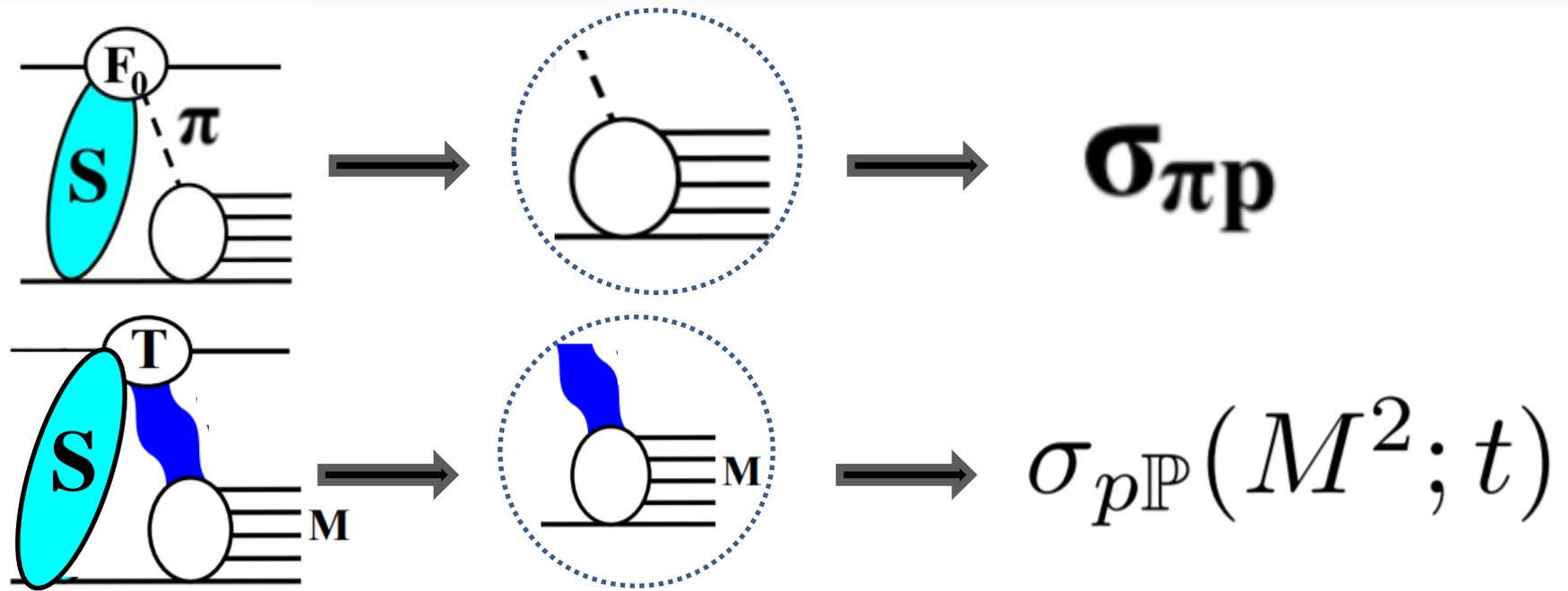
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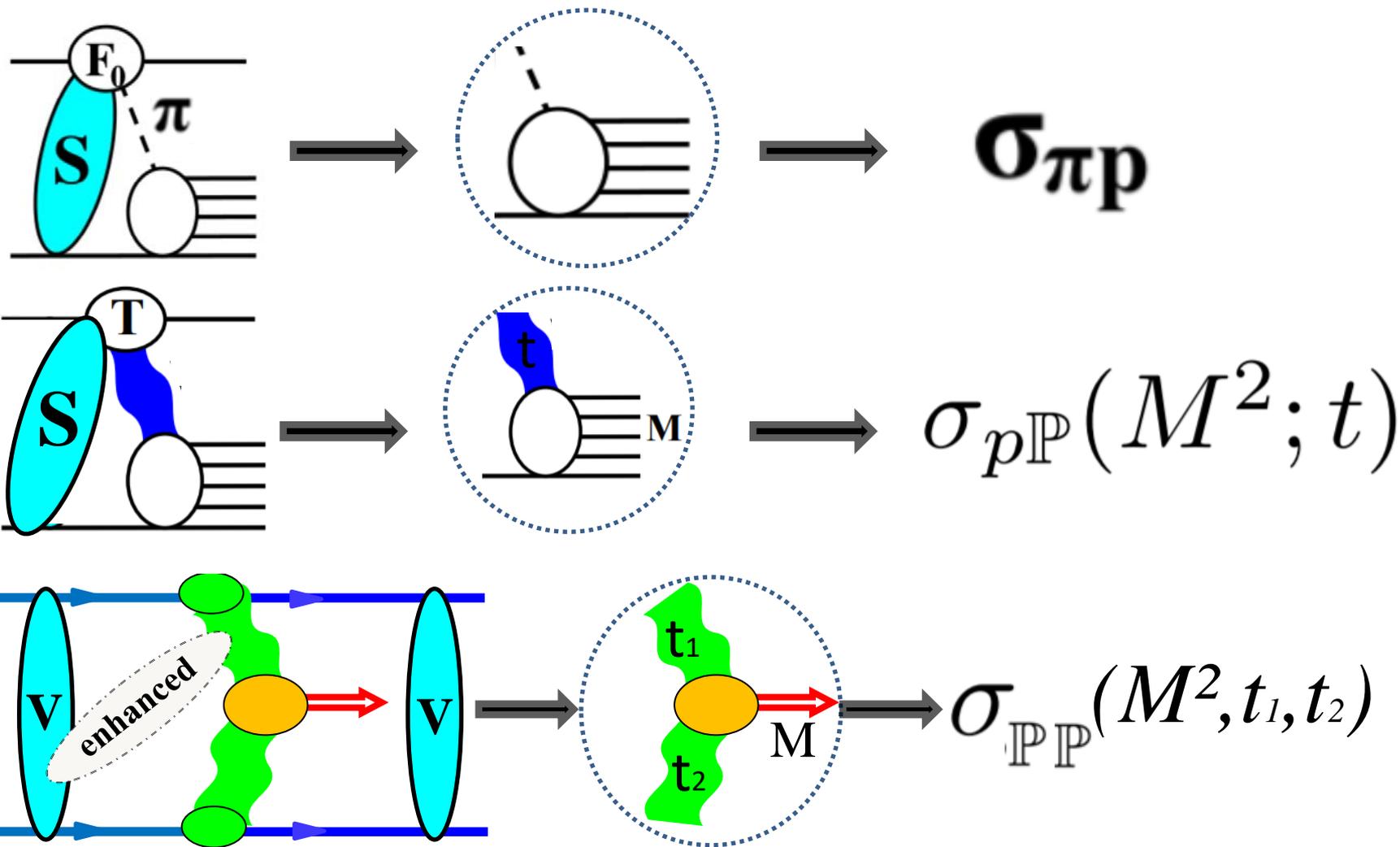
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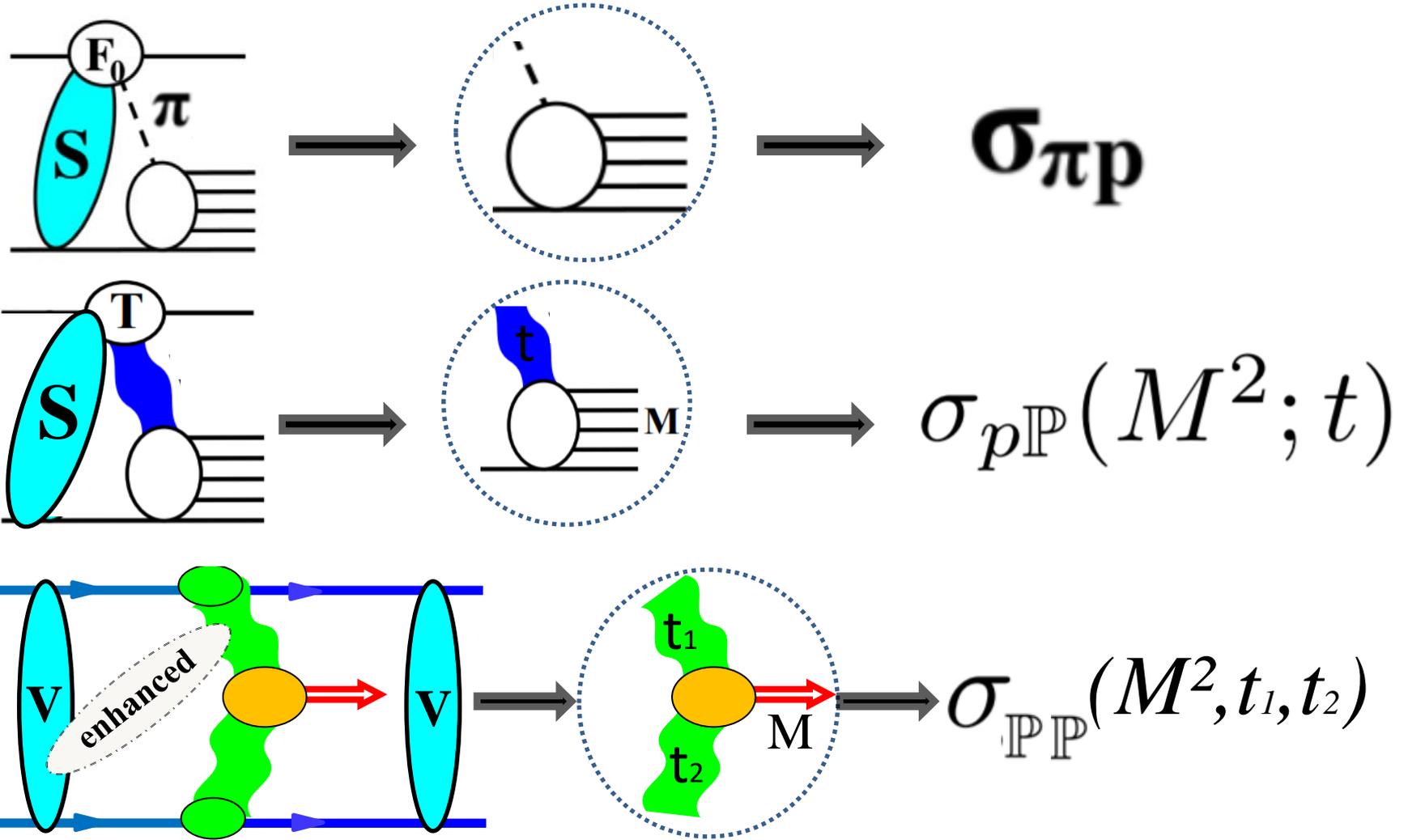
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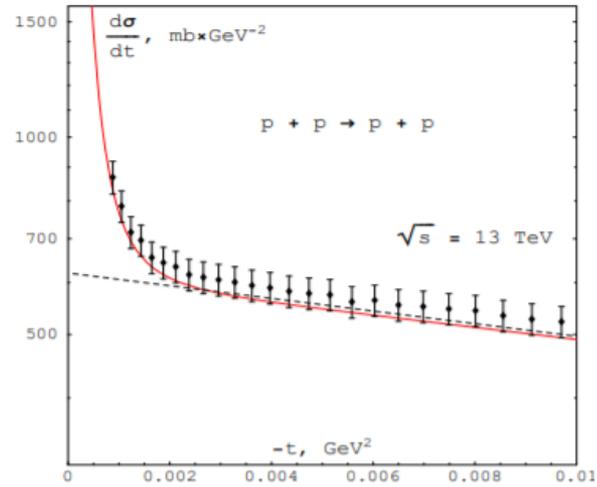
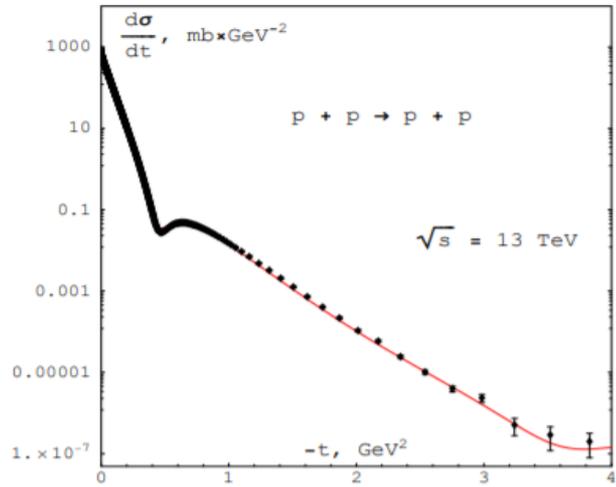


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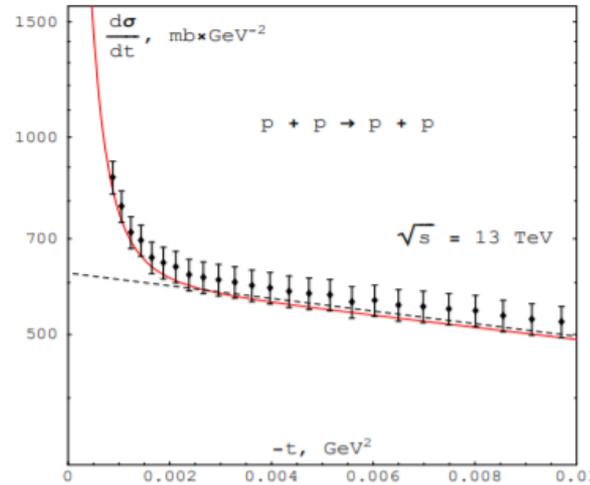
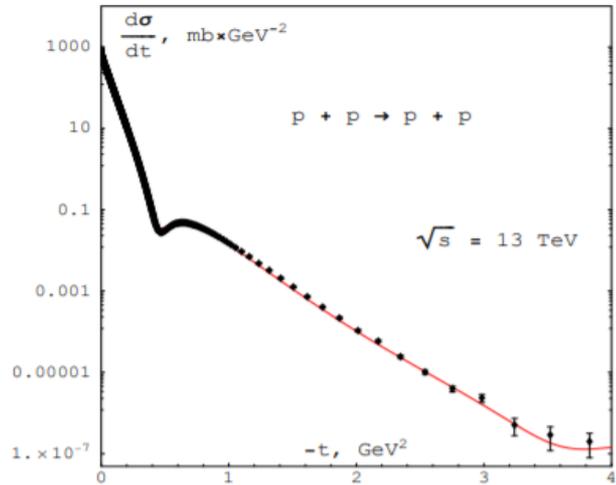
$$\sigma_{\mathbb{P}\mathbb{P} \rightarrow \pi\pi} \sim 0.1 \div 5 \mu\text{b} \ll \sigma_{\mathbb{P}\mathbb{P}}^{\text{tot}} \sim 100 \mu\text{b}, \quad M=1-3 \text{ GeV}, \quad t_{1,2} = -0.1 \text{ GeV}^2$$

# ECDP: very low $t$ , Coulomb-nuclear interference

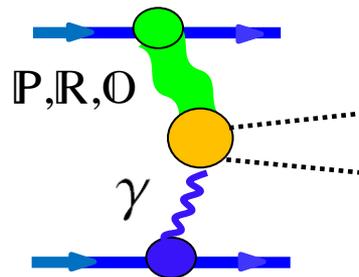
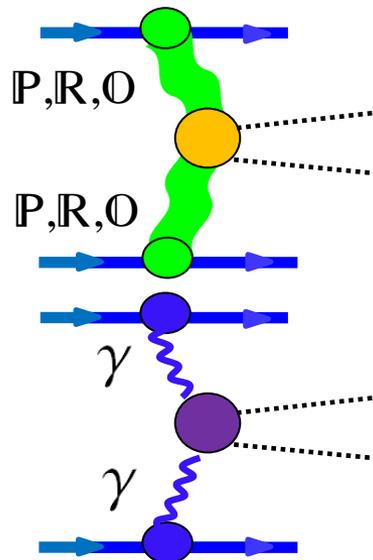


**Elastic,  
very low  $t$**

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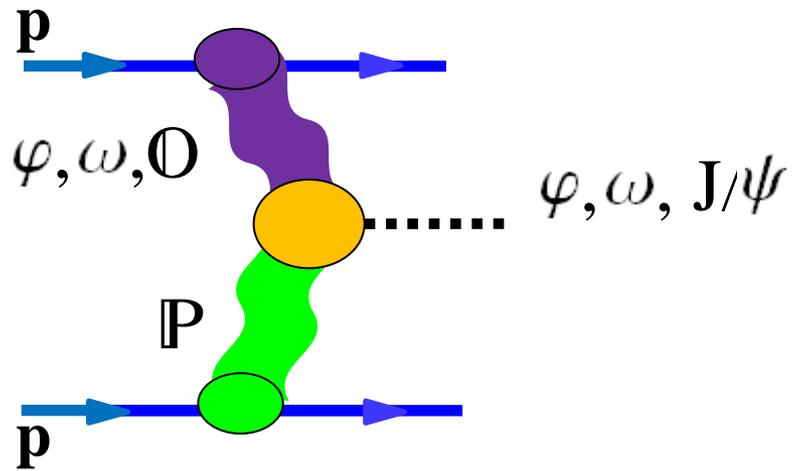


Elastic,  
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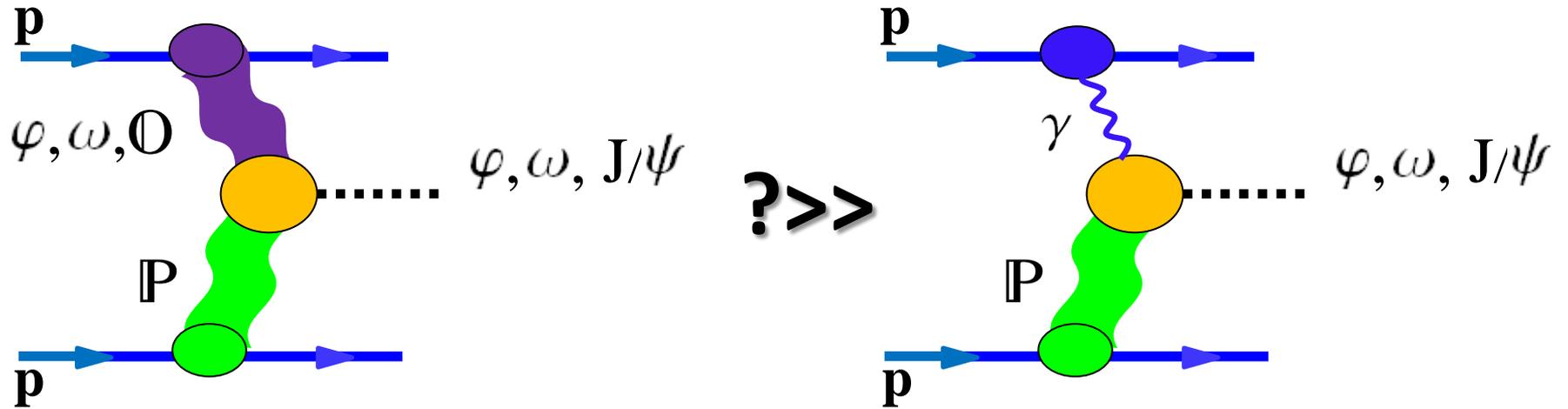


ECDP,  
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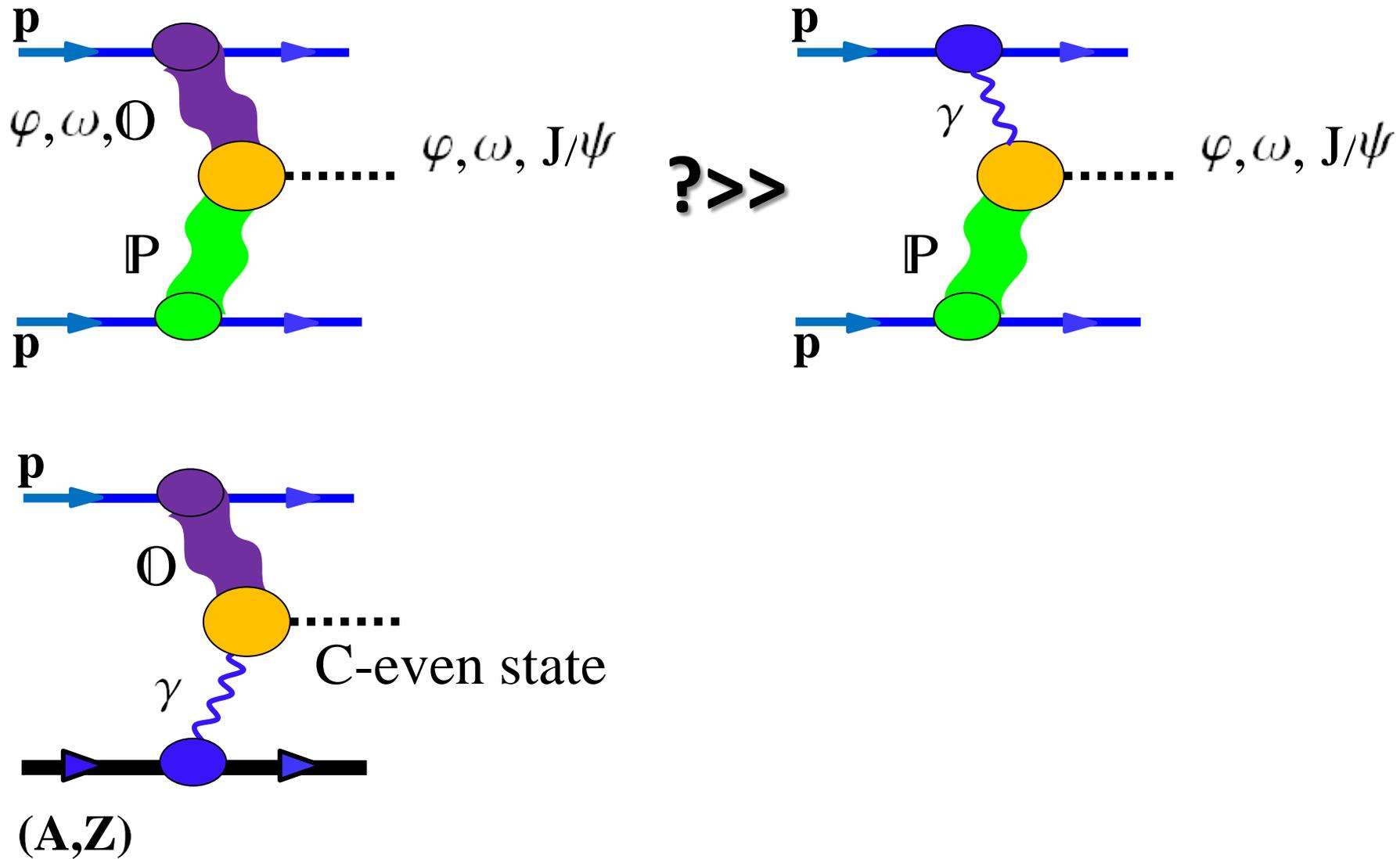
# ECDP: Odderon searches



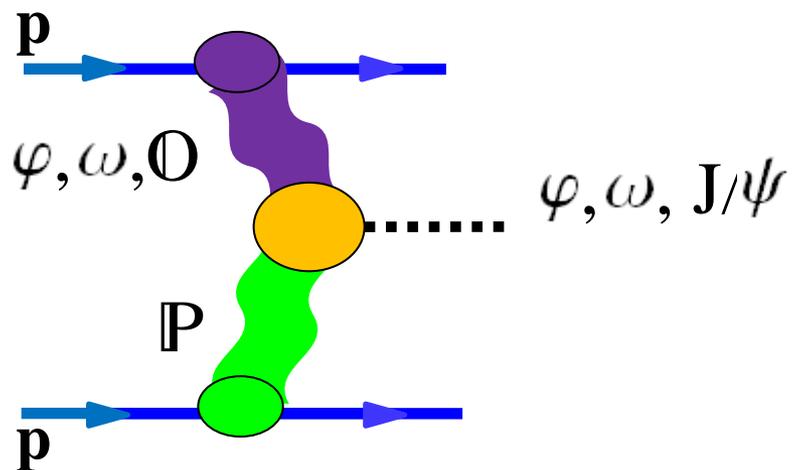
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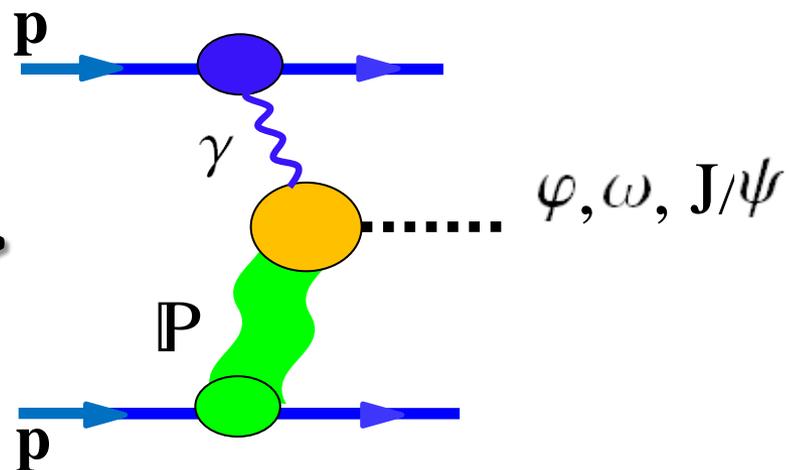
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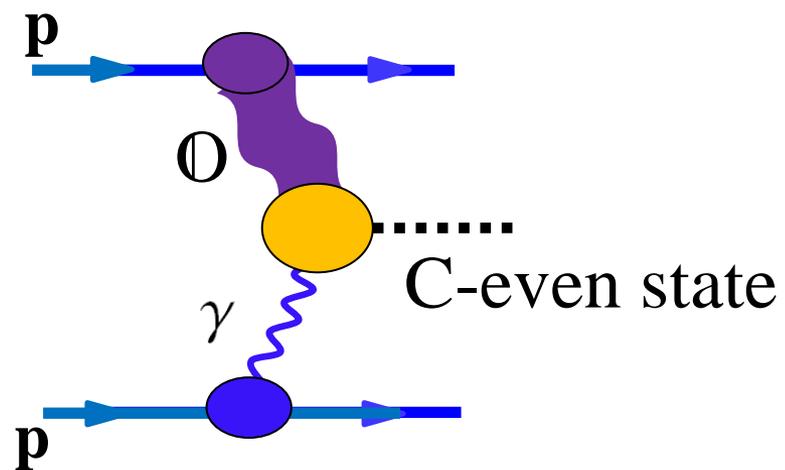
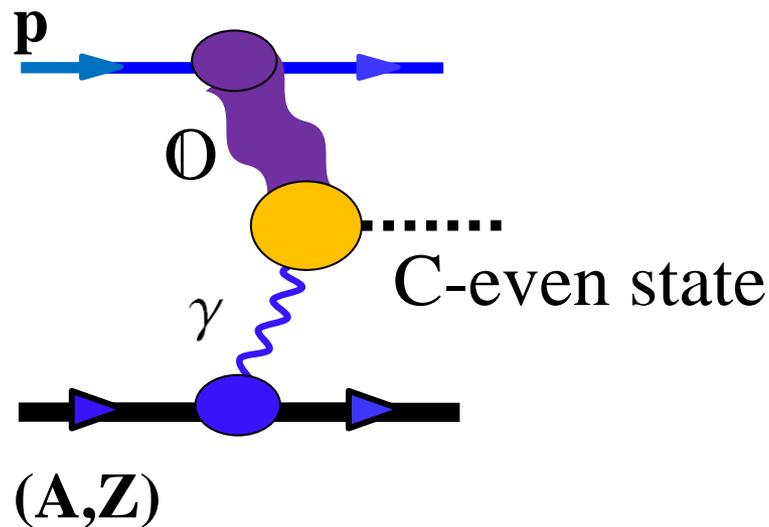
# ECDP: Odderon searches



$???$



$>>$



# ECDP: simulation

```
#####          #####
#                # #
#                # # # # #
#                # # # # #
##### # # # # # # # # #
#          # # # # # # #
#          # # # # # # #
##### # # ##### # # #
```

**Monte Carlo generator for Exclusive Diffraction  
Version 2.2 will be available soon**

```
#####          #####
#                # #
#                # # # # #
#                # # # # #
##### # # # # # # # # #
#          # # # # # # #
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## Processes:

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## Processes:

- **elastic**  $p + p \rightarrow p + p$  at 7, 8, 13, 14 TeV
- **ECDP**  $p + p \rightarrow p + \text{Res.} + p$

Res.:

$\eta_2(1645), \eta_0(1405)$  at 13 TeV

$\eta'_0(958), f_1(1285), f_2(1270)$  at 8 TeV

$f_0(1500), f_0(1710), f_2(1950), f_2(2220)$  at 8, 13 TeV

- **ECDP**  $p + p \rightarrow p + \pi\pi + p$  at 7 TeV



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- To study this process more deeply, we can **use different kinematical modes**, as in elastic scattering, for example, the region of **interference of reggeon-reggeon and photon-photon processes.**

**The end**

A photograph of a spiral-bound notebook with a white page. The words "Thank you" are written in black cursive ink in the center of the page. A black pen with a silver tip and clip is resting on the bottom left corner of the notebook. The notebook is placed on a dark, textured surface.

Thank you