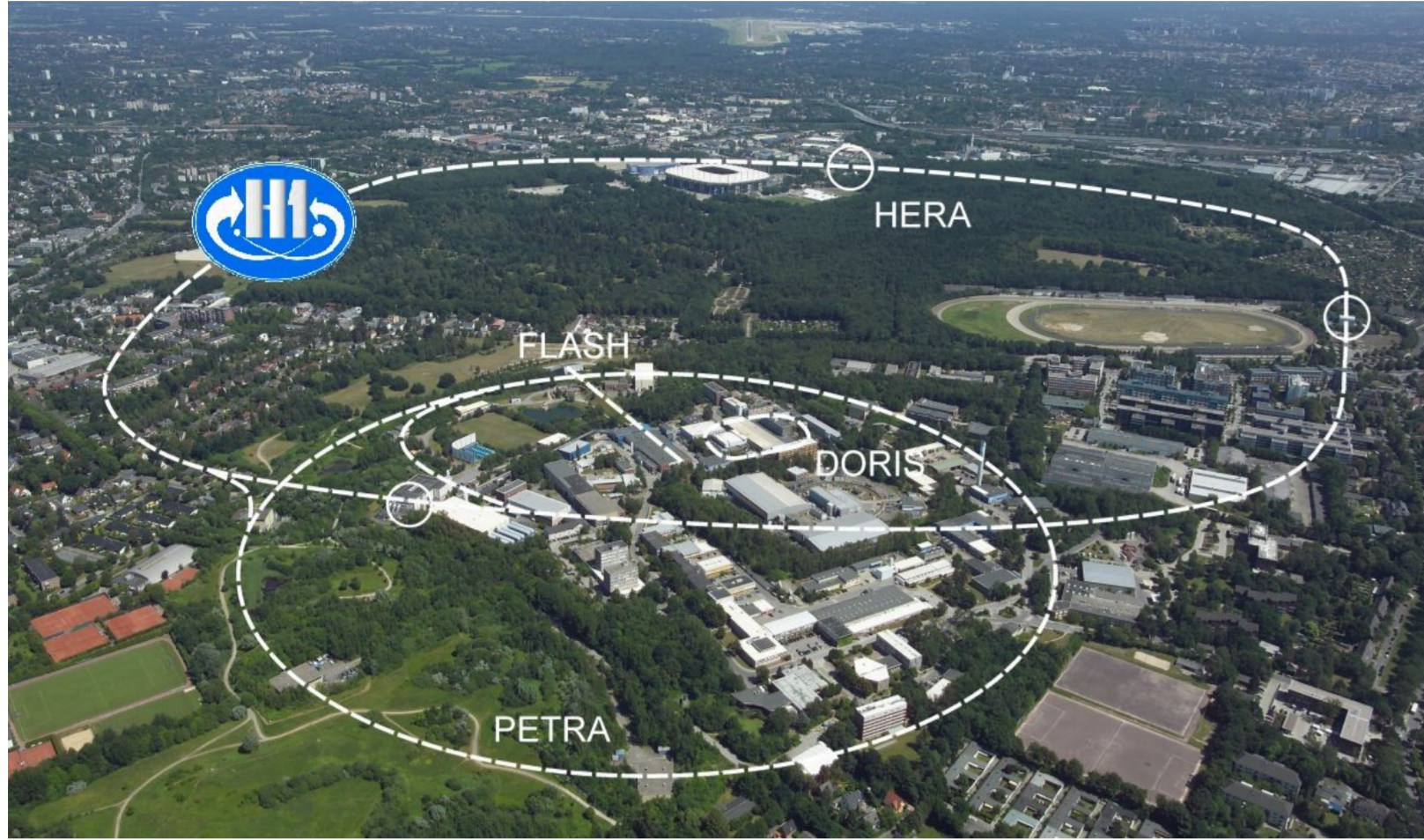


Vector Meson Production at HERA

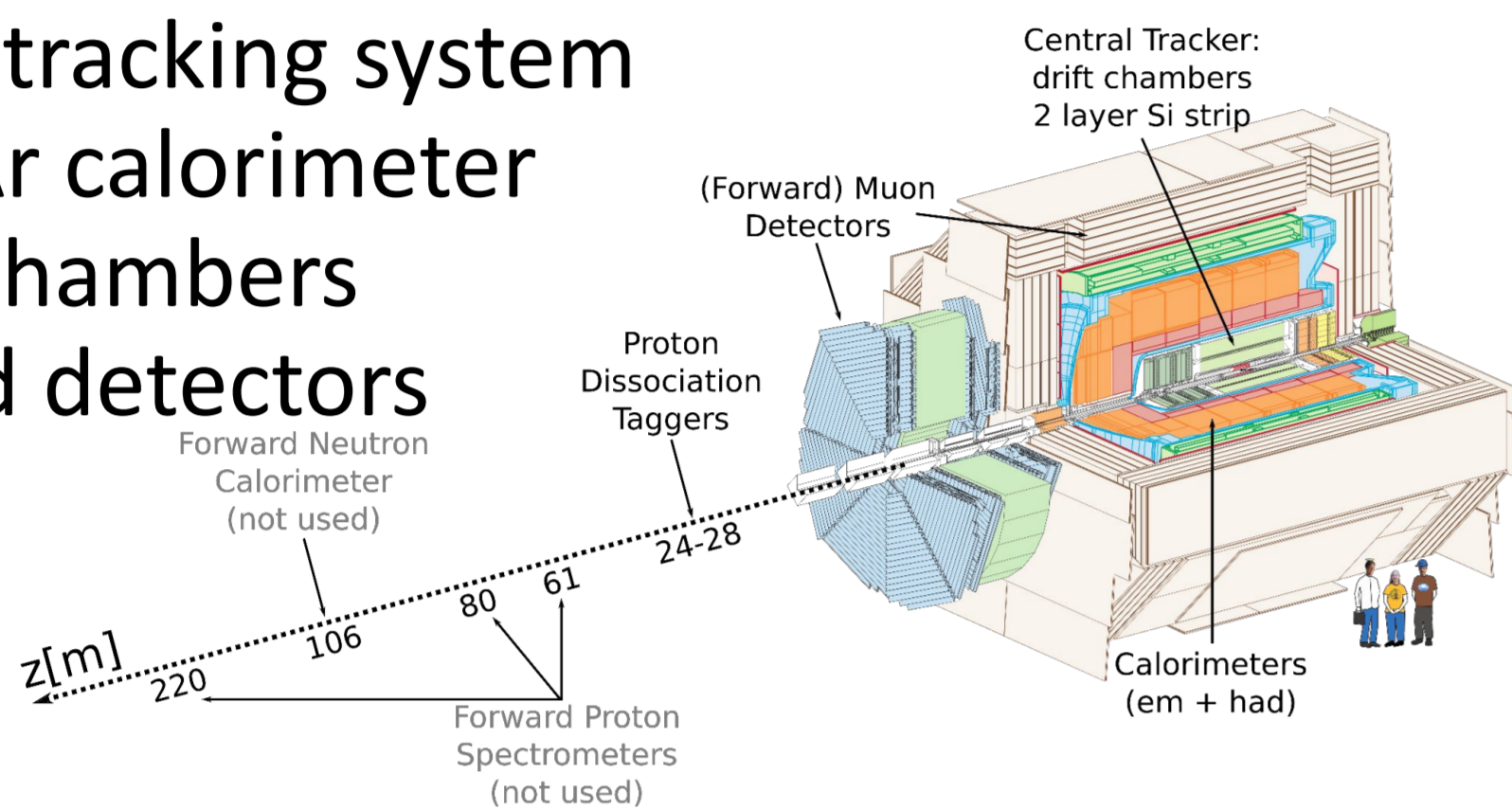
HERA ep collider

- 1992-2007, DESY Hamburg
- cms energy: 225-320 GeV



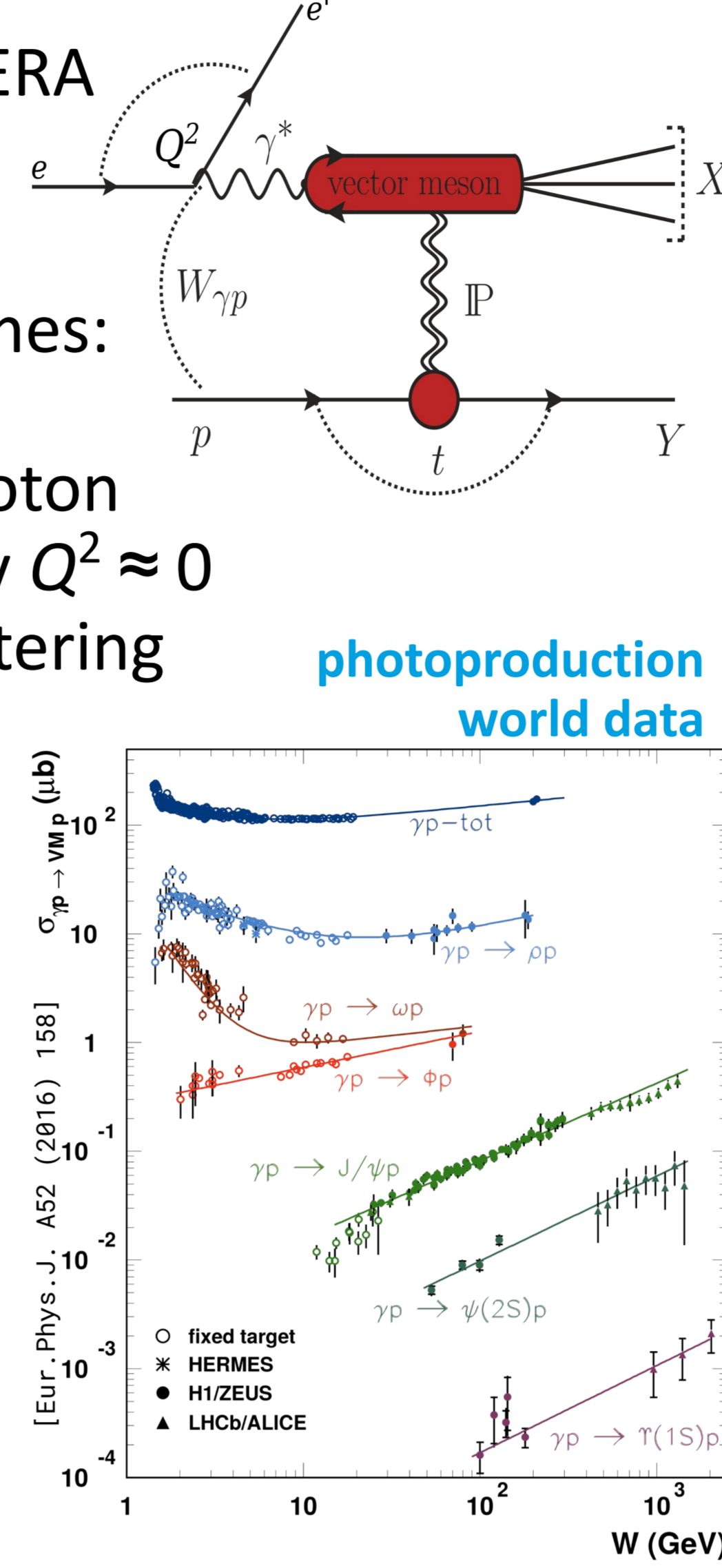
H1 experiment

- central tracking system
- liquid Ar calorimeter
- muon chambers
- forward detectors



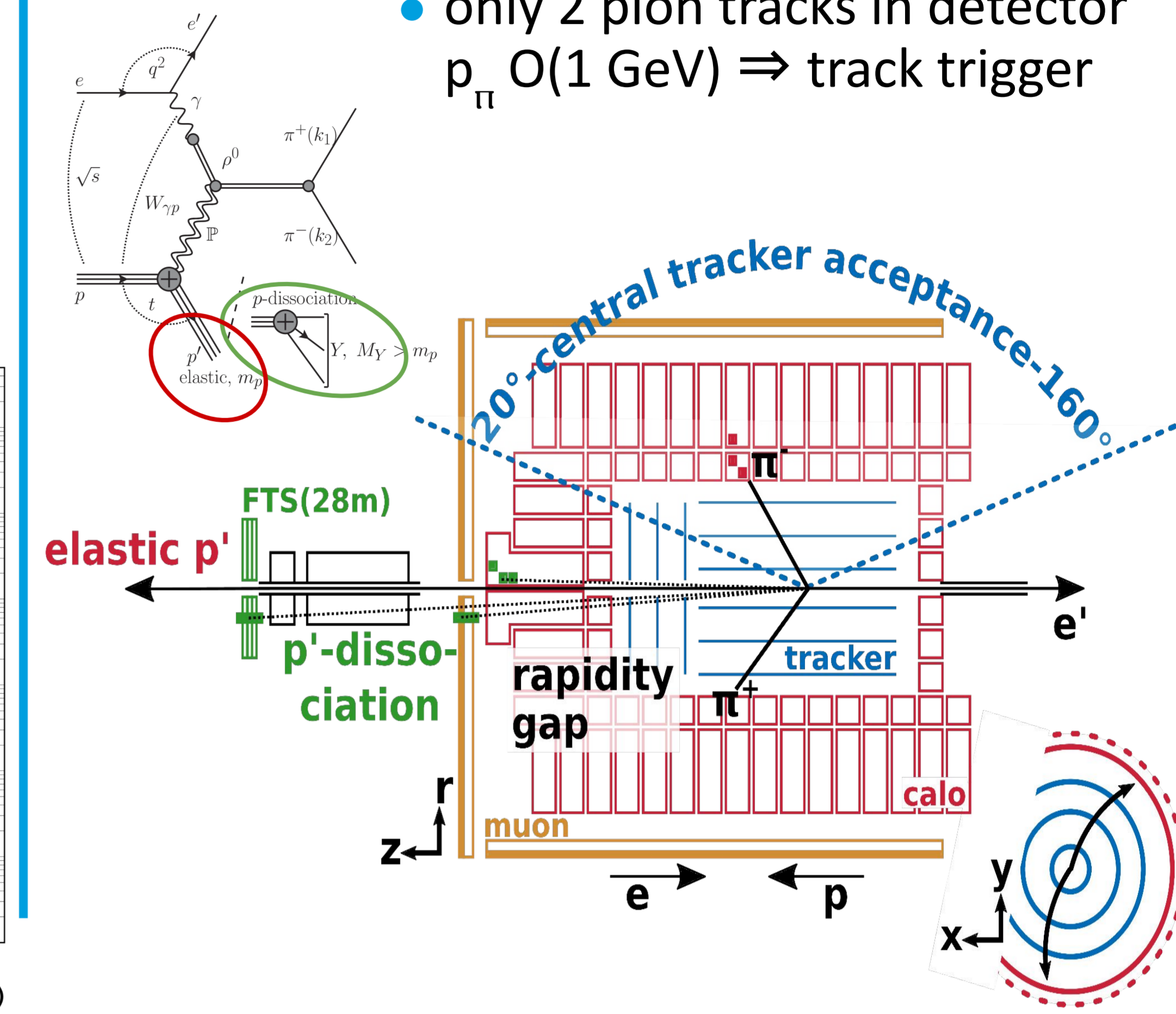
$\rho, \omega, \phi, J/\psi, Y, \dots$ production

- well measured at HERA and others
- e as photon source \Rightarrow 2 kinematic regimes:
 - photoproduction, with quasi-real photon and small virtuality $Q^2 \approx 0$
 - deep inelastic scattering w/ large Q^2
- at HERA energies data described by power law $\sigma \sim W^\delta$ with scale (Q^2, m_{VM}) dependent exponent δ



$\pi^+\pi^-$ photoproduction in H1

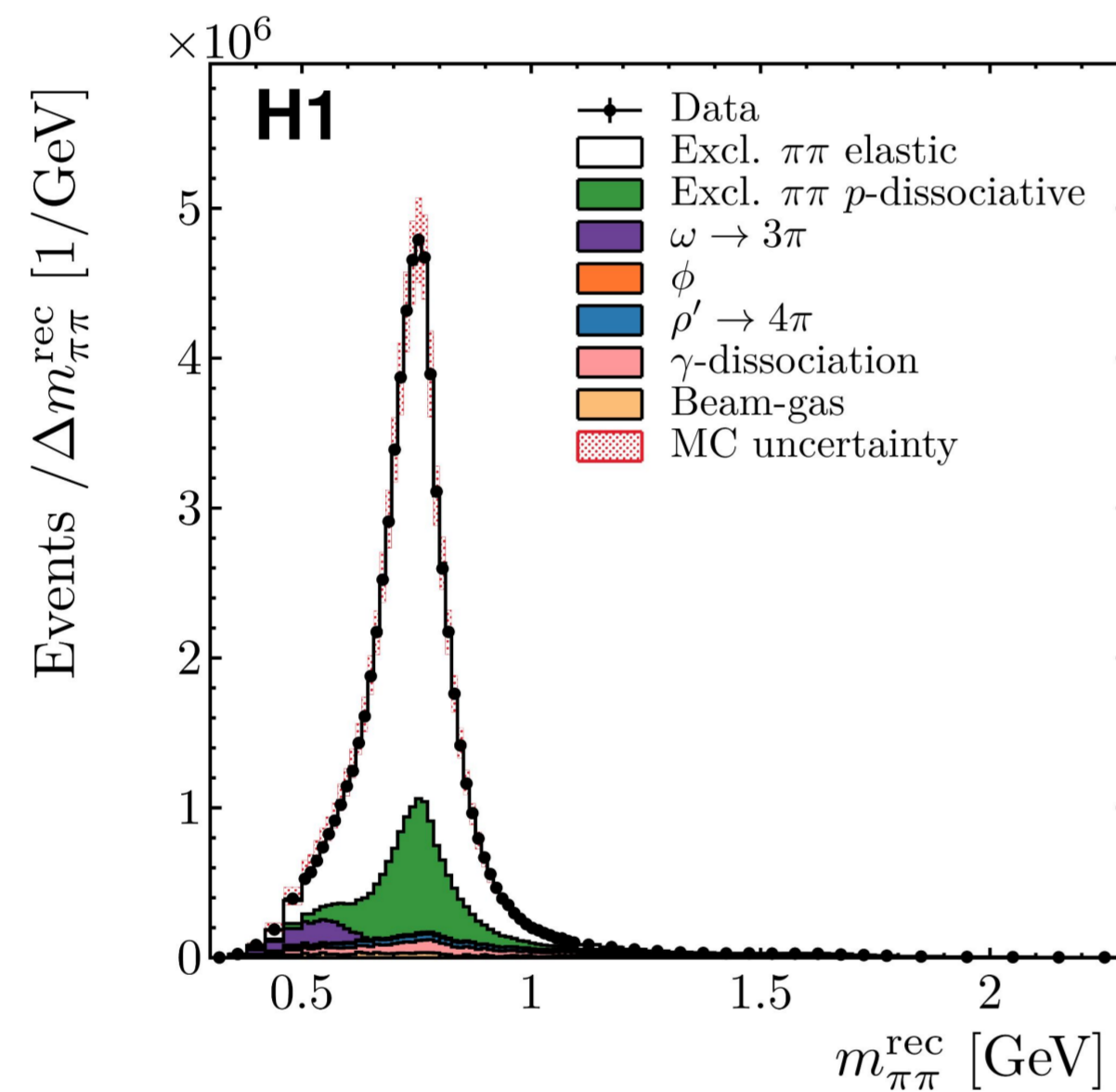
- photoproduction \Leftrightarrow undetected e' ($Q^2 \lesssim 2.5 \text{ GeV}^2$)
- diffraction \Leftrightarrow undetected p'
- elastic vs p' -dissociative via fwd detectors
 - only 2 pion tracks in detector $p_\pi \sim 0(1 \text{ GeV}) \Rightarrow$ track trigger



Experimental Methods

data sample

- $L \approx 1.3 \text{ pb}^{-1}$ at $\sqrt{s} = 319 \text{ GeV}$
- $\sim 9 \cdot 10^5$ selected exclusive $\pi\pi$ candidates
- background level $\sim 10\%$ non-excl. $\pi\pi$
 - $\omega \rightarrow \pi^+\pi^-\pi^0$
 - $\phi \rightarrow KK, \dots$
 - $\rho' \rightarrow 4\pi$
 - γ -dissoc.

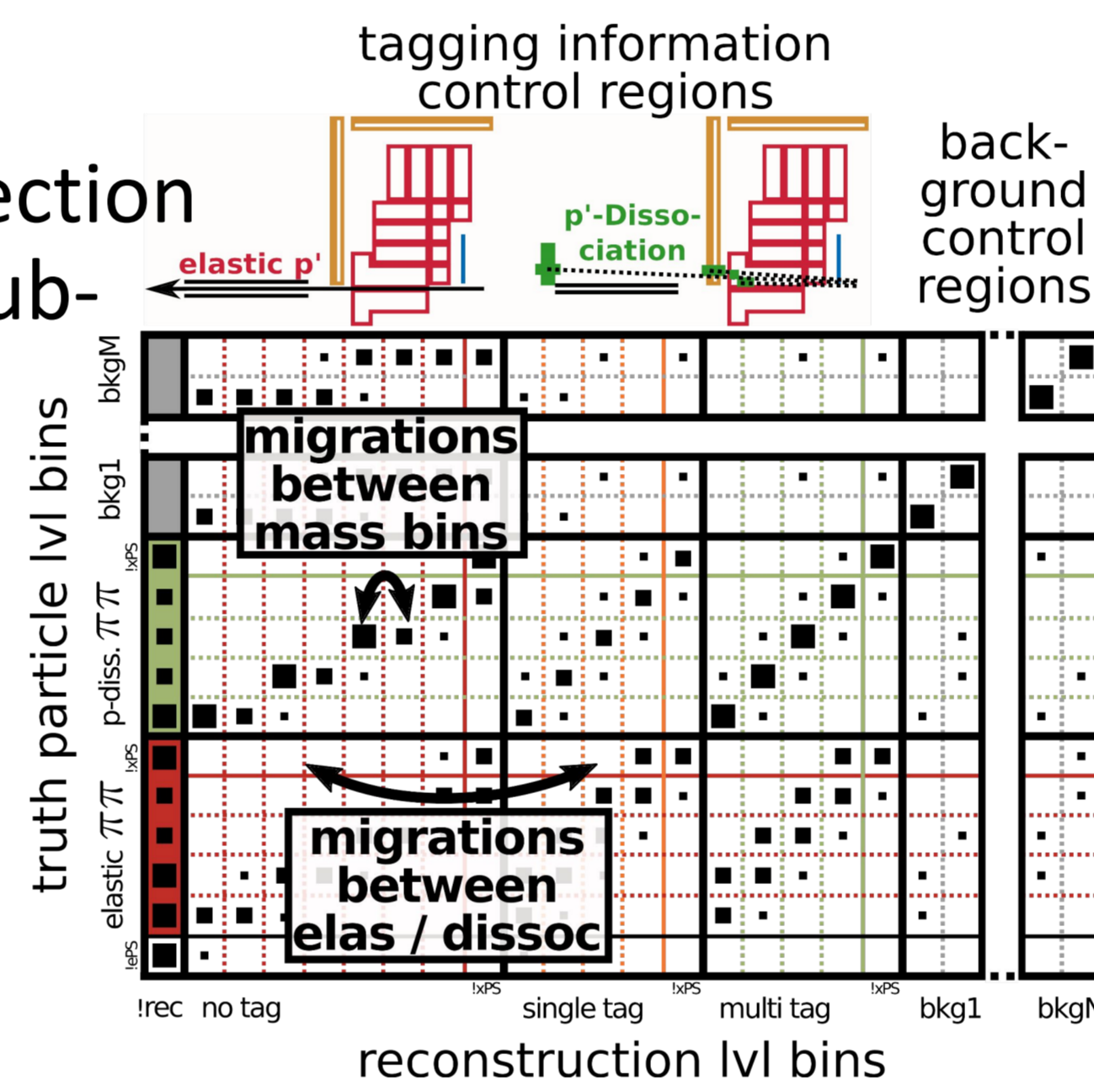


modeling

- DiffVM MC generator
- tuned to data $m_{\pi\pi}, W$, and t , shapes
- p' -dissociation: resonance decays + continuum

unfolding

- detector correction
- background subtraction
- elastic and p' -dissociative component separation
- regularized template fit



cross section

$$\frac{d^2\sigma(\gamma p \rightarrow \pi^+\pi^- Y)}{dm_{\pi\pi} dt} (m_{\pi\pi}, t; W_{\gamma p}) = \frac{N_{\text{unf}}(\gamma^* p \rightarrow \pi^+\pi^- Y)}{\Delta m_{\pi\pi} \Delta t \mathcal{L}_{\text{int}} \Phi_{\gamma/e}^{\text{eff}}}$$

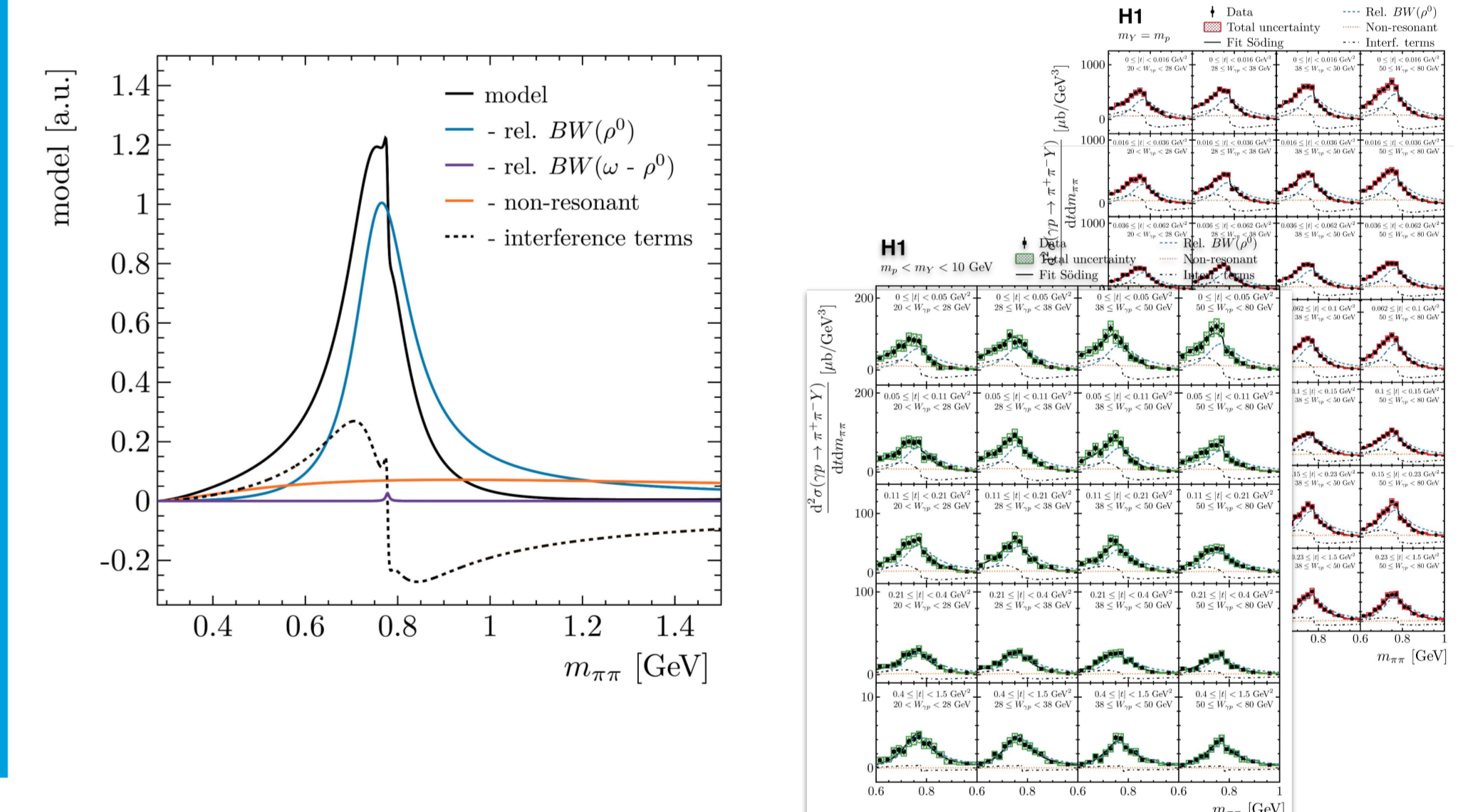
• corrected to $Q^2 = 0$
 • fiducial phase space

elastic: $M_Y = m_p \text{ GeV}$
 p' -dissociative: $m_p < M_Y < 10 \text{ GeV}$

ρ cross section extraction

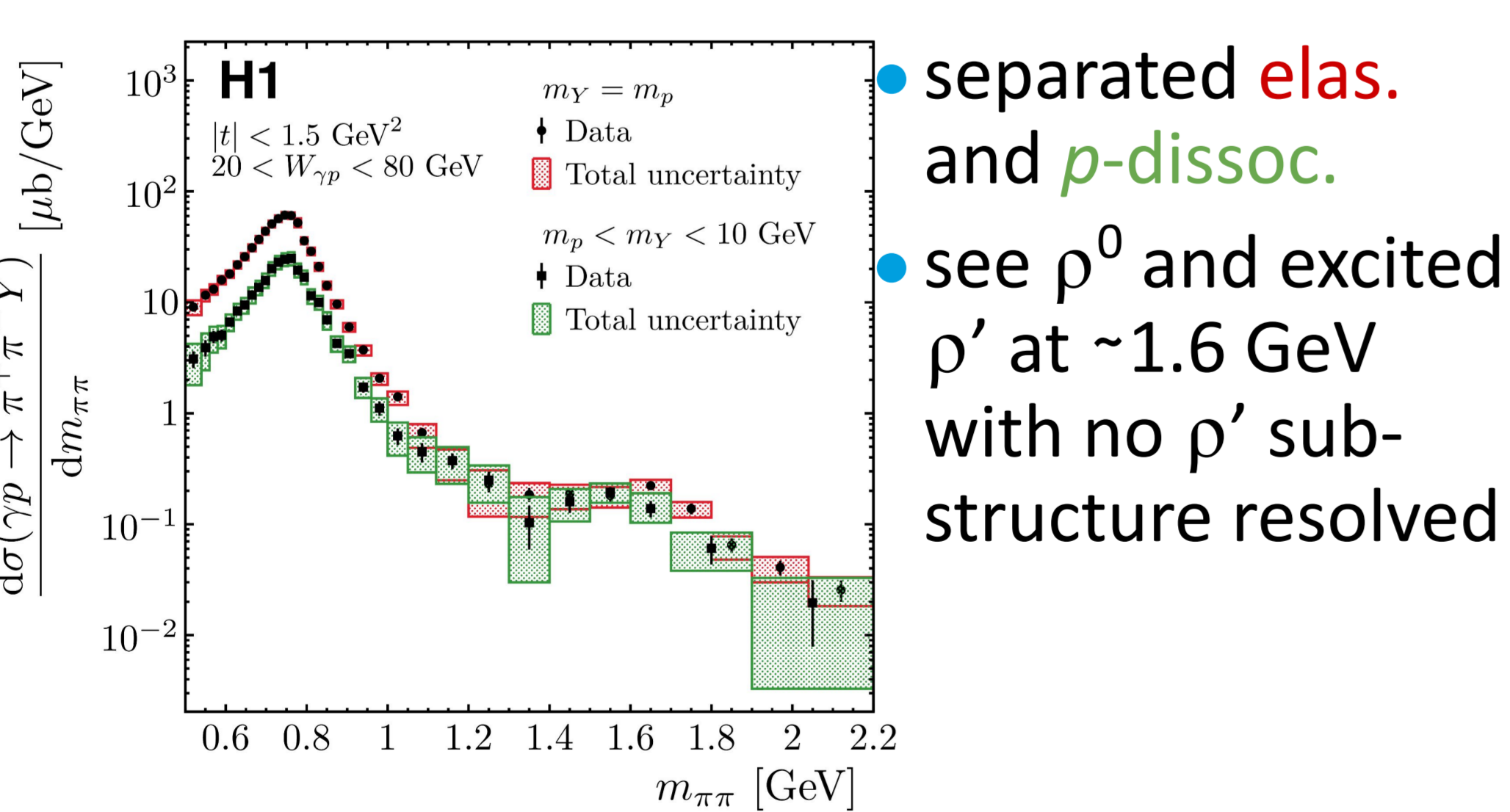
- $m_{\pi\pi}$ fit (reduced range) with Söding-inspired interference model with ρ, ω and non-resonant contribution
- unfold up to 3D $\sigma_{\pi\pi}$ in $m_{\pi\pi}, W$, and t and extract σ_ρ W and t dependence

$$\frac{d\sigma(\gamma p \rightarrow \pi^+\pi^- p)}{dm_{\pi\pi}} \propto |A_{\rho,\omega}(m_{\pi\pi}) + A_{\text{non-res}}(m_{\pi\pi})|^2$$



Results

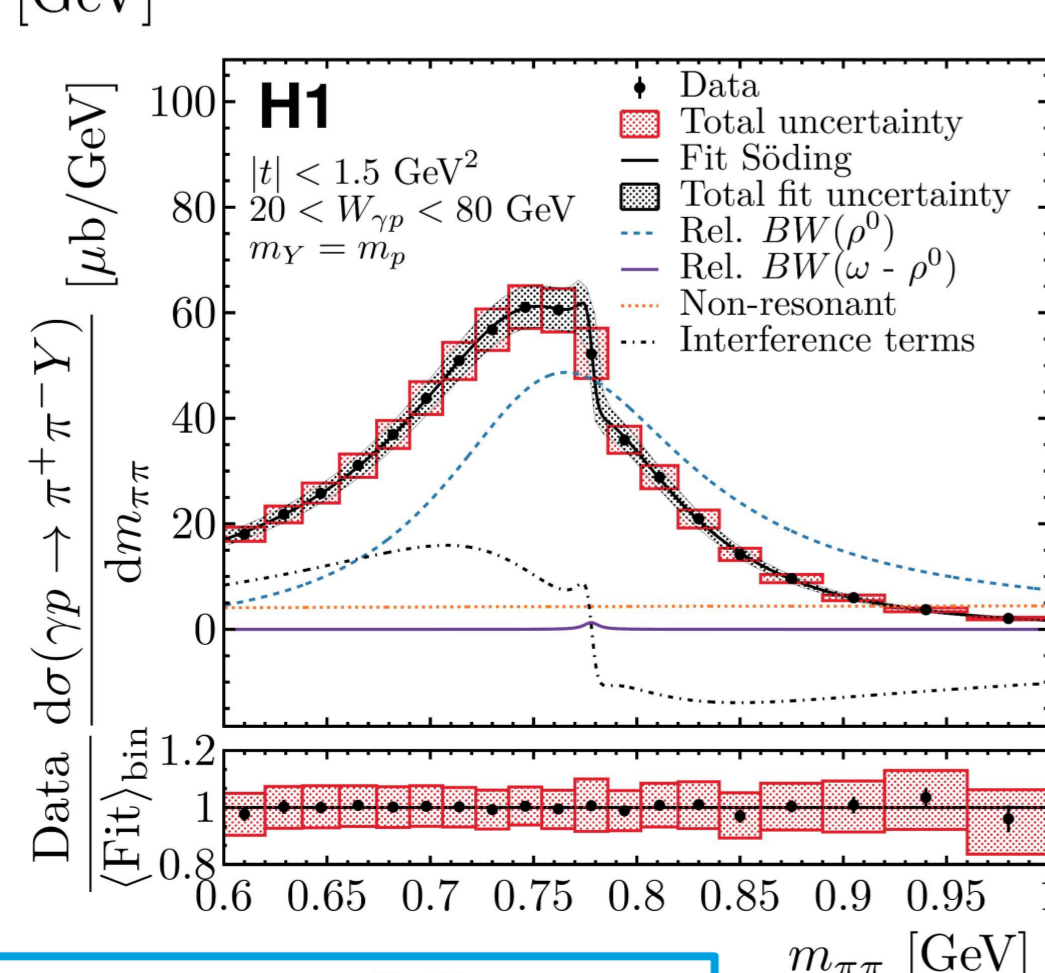
$\pi^+\pi^-$ cross section



- separated elas. and p' -dissoc.
- see ρ^0 and excited ρ' at $\sim 1.6 \text{ GeV}$ with no ρ' sub-structure resolved

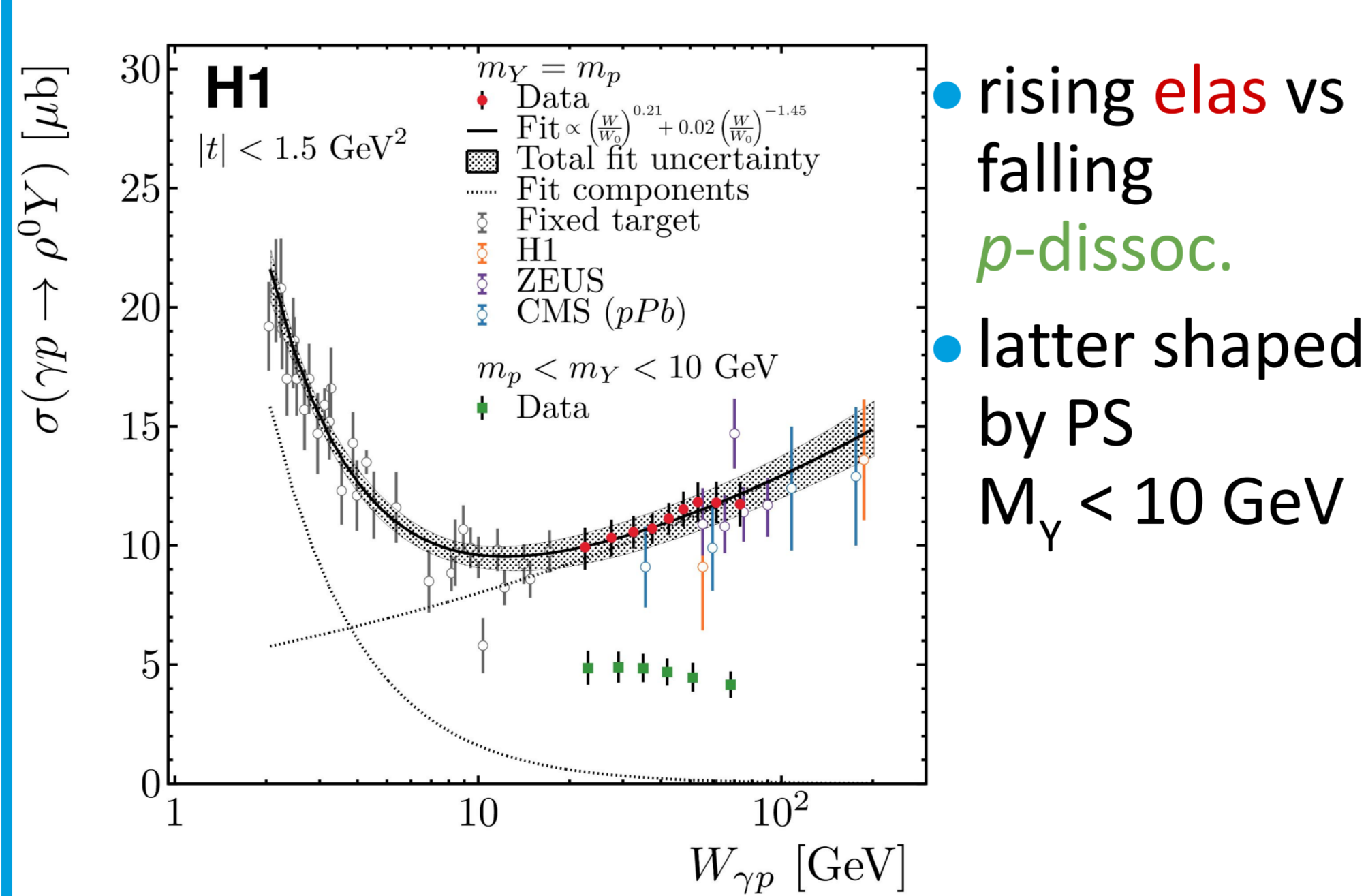
$m_{\pi\pi}$ fit

- reduced range
- well described with consistent VM parameters
- elas. & p' -dissoc (not shown)
- incl. \square contrib.



m_ρ	770.8 ± 1.3	$+2.3$	-2.4	GeV
Γ_ρ	151.3 ± 2.2	$+1.6$	-2.8	GeV
m_ω	777.9 ± 2.2	$+4.3$	-2.2	GeV

energy dependence



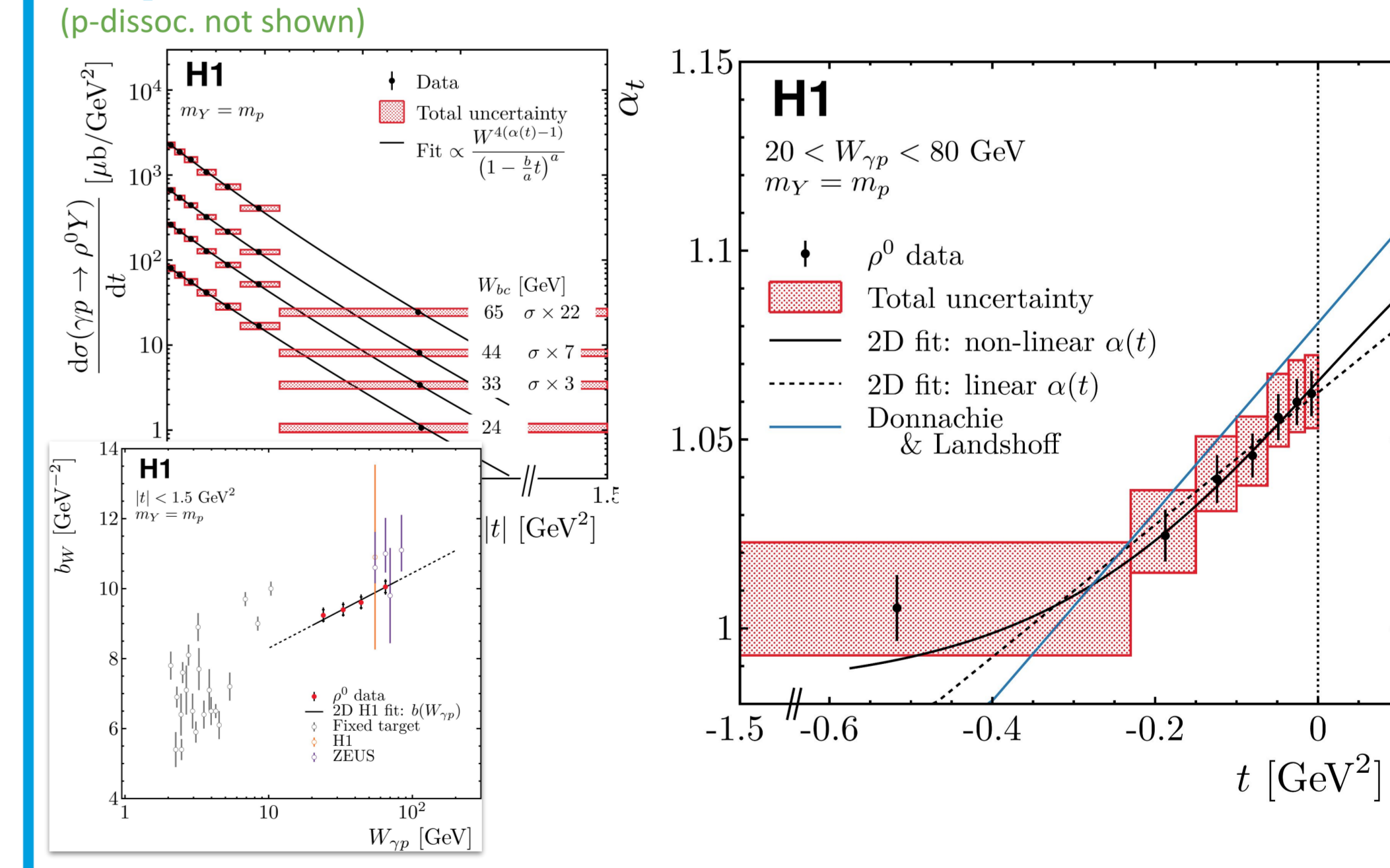
- rising elas vs falling p' -dissoc.
- latter shaped by PS $M_Y < 10 \text{ GeV}$

fit elastic including world data

- two exponents for low energy ("reggeon") and high energy ("pomeron") behaviour
- $\sigma \propto W^{\delta_P} + fW^{\delta_R}$

δ_P	0.207 ± 0.015	$+0.053$	-0.033
δ_R	-1.45 ± 0.12	$+0.35$	-0.21

2D ρ cross sections and leading trajectory



2D Regge fit (elastic data)

- parametrization $\sigma \propto W^{4(\alpha(t)-1)} / (1 - bt/a)^a$
- trajectory $\alpha(t) = \alpha_0 + \beta \left(\left(e^{-\frac{4\alpha_1 t}{\beta}} + 1 \right)^{-1} - \frac{1}{2} \right)$

α_0	1.0654 ± 0.0044	$+0.0088$	-0.0050	GeV ⁻²
α_1	0.233 ± 0.064	$+0.020$	-0.038	
β	0.164 ± 0.068	$+0.051$	-0.045	