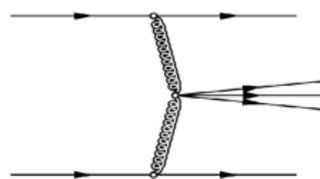# Bremsstrahlung radiation from charged Reggeon exchanges at high energies

Rainer Schicker
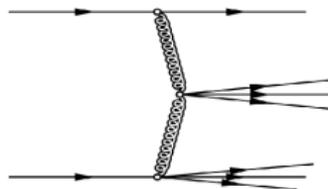
Phys. Inst., Heidelberg

jan 14, 2021
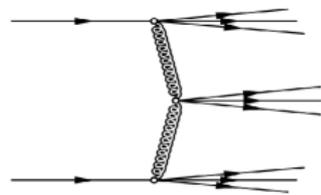
Diffractive event topologies at LHC energies

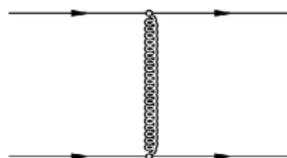

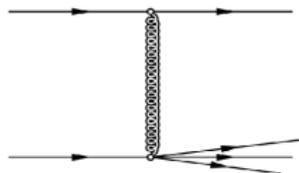central diff.   central diff./single diss.   central diff./double diss.
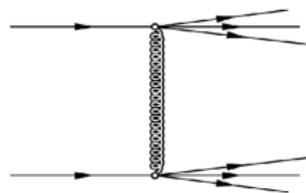
elast. scattering   single diff. diss.   double diff. diss.

- Reggeon-Pomeron exchanges contribute to these topologies
- Regge exchanges at LHC? $\rightarrow$ *study charge exchange reactions*

Charge exchange reaction by Reggeon exchange

charge exchange reaction in proton-proton collisions:

- p p $\rightarrow$ n + Δ^{++} $\rightarrow$ n + p π^+
- p p $\rightarrow$ Δ^0 + Δ^{++} $\rightarrow$ n π^0 + p π^+
- p p $\rightarrow$ Δ^0 + Δ^{++} $\rightarrow$ p π^- + p π^+

- need zero degree calorimeters
  + tagging of forward proton,pions
- need good pseudorapidity coverage of detectors

Two-by-two amplitude
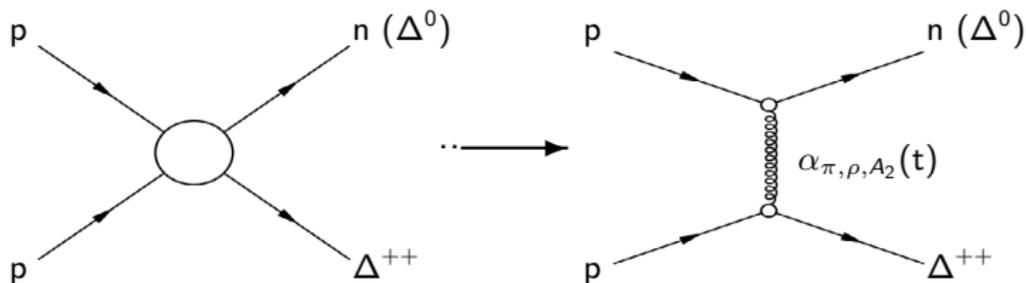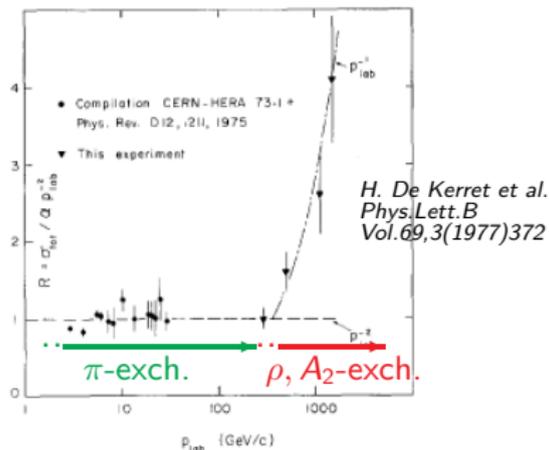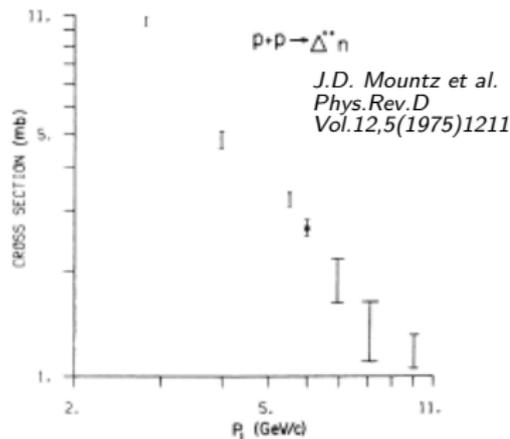

- Is electromagnetic radiation spectrum calculable in reaction
  $p\ p \to n + \Delta^{++} \to n + p\ \pi^+$?
  $p\ p \to \Delta^0 + \Delta^{++} \to p\ \pi^- + p\ \pi^+$?
- Radiation spectrum in elastic scattering
  $p\ p \to p + p$?

Data charge exchange reaction at low energies

The charge exchange reaction $pp \rightarrow n + \Delta^{++}(1232)$ measured at

- Argonne Nat. Zero Gradient Synchrotron ($p_{Lab} = 6$ GeV/c)
- Intersecting Storage Ring (ISR) ($\sqrt{s} = 23, 31, 45, 53$ GeV)

J.D. Mountz et al.
Phys.Rev.D
Vol.12,5(1975)1211

H. De Kerret et al.
Phys.Lett.B
Vol.69,3(1977)372

π-exch.   ρ, A_2-exch.

if Regge exchange due to pion: $\sigma \sim s^{-2}$, due to ρ, A_2: $\sigma \sim s^{-1}$

Prospects charge exchange at high energies

- RHIC Brookhaven: $\sqrt{s} = 100\text{-}200$ GeV
- LHC CERN: $\sqrt{s} = 13\text{-}14$ TeV

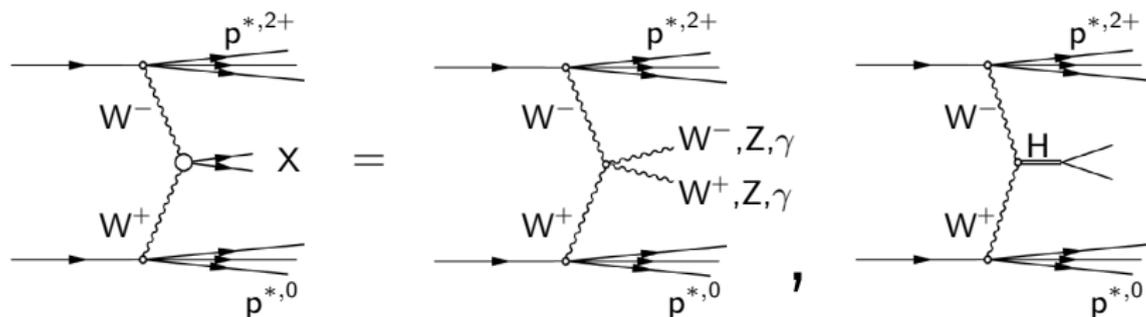Table: Cross section pp $\rightarrow$ nΔ^{++}

	$\sqrt{s}$ (GeV)	σ (nb)
ISR	31	580 $\pm$90
	45	210$\pm$40
	53	170$\pm$40
RHIC	100	48.5$\pm$5.5
	200	12.2$\pm$1.3
LHC	7×10^3	$(10.0\pm1.1) \times10^{-3}$
	14×10^3	$(2.4\pm0.3) \times10^{-3}$

- $\sigma(pp \rightarrow \text{n}\Delta^{++}, \sqrt{s} = 14$ TeV$) \sim 2.4$ pb
- expected integrated luminosity ALICE Run 3 ~ 200 pb^{-1}
- produced data sample ~ 500, with experimental efficiency 50%
  $\rightarrow$ measured data sample ~ 250

BACKUP

Charge exchange reaction by W^+,W^- exchange

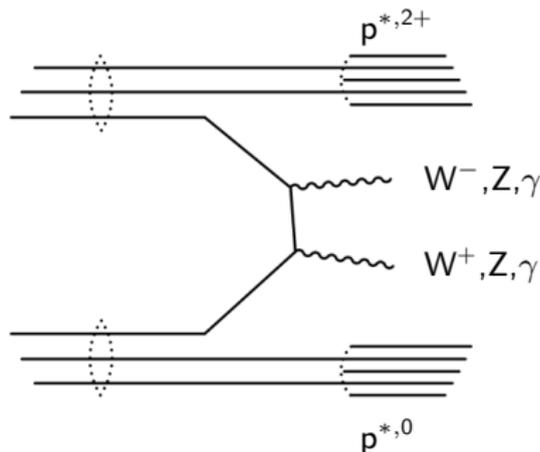- $pp \to p + X + p$, $p^* + X + p^*$ $X = W^+W^-$, ZZ, $\gamma\gamma$, H

- select these events by tagging $Z_{tot}=0$ system on one side, $Z_{tot}=2$ system on the other side
- need to identify forward protons, charged pions and kaons (and neutrons)
- Ongoing discussions with R. Pasechnik on cross section of these channels, QCD background
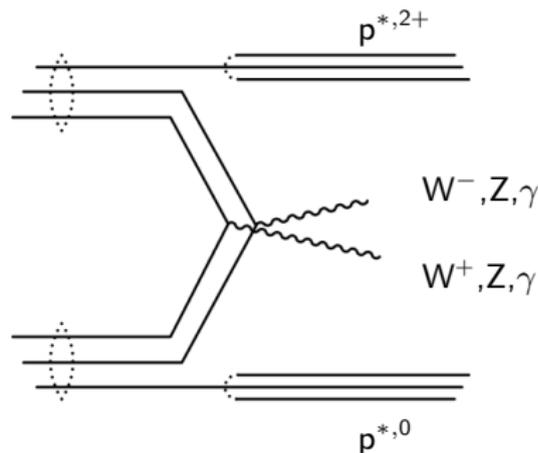
QCD background single quark exchange

- $q\overline{q} \to W^+W^-$, ZZ, $\gamma\gamma$, (plus additional parton exchange)

- cross section as function of mass of $p^{*,2+}$, $p^{*,0}$?
- phase space distribution of the proton fragments ?

QCD background double quark exchange

- double parton interaction $q\overline{q}q\overline{q} \rightarrow W^+W^-$, ZZ, $\gamma\gamma$

- cross section as function of mass of $p^{*,2+}$, $p^{*,0}$?
- phase space distribution of the proton fragments ?

Summary theoretical issues

- What are the theoretical uncertainties in signal (W-fusion) at the hadron level ?
- What are the theoretical uncertainties in the background ? (Reggeon-fusion, single parton, double parton exchange ?)
- What are gap survival effects in charge exchange reactions ? (both in W- and Reggeon exchange)
- Both signal and background are expected to be suppressed at high energies. Which suppression is stronger, a naive $1/s$-like suppression for Reggeon induced background, or a gap survival suppression for the WW-fusion signal ?
- What are the signal and the background differentially in the invariant mass of the proton fragments ? What is the phase space distribution of these fragments ?

Summary experimental issues

- selection of $Z_{tot}=0$ and $Z_{tot}=2$ systems with good acceptance requires large acceptance forward spectrometer
- major investment in magnet configuration, detector systems, beam optics development
- presently not foreseen at the LHC
- a project for the FCC ?
- evaluation of signal and background with event generators