New CHIPS diffraction process

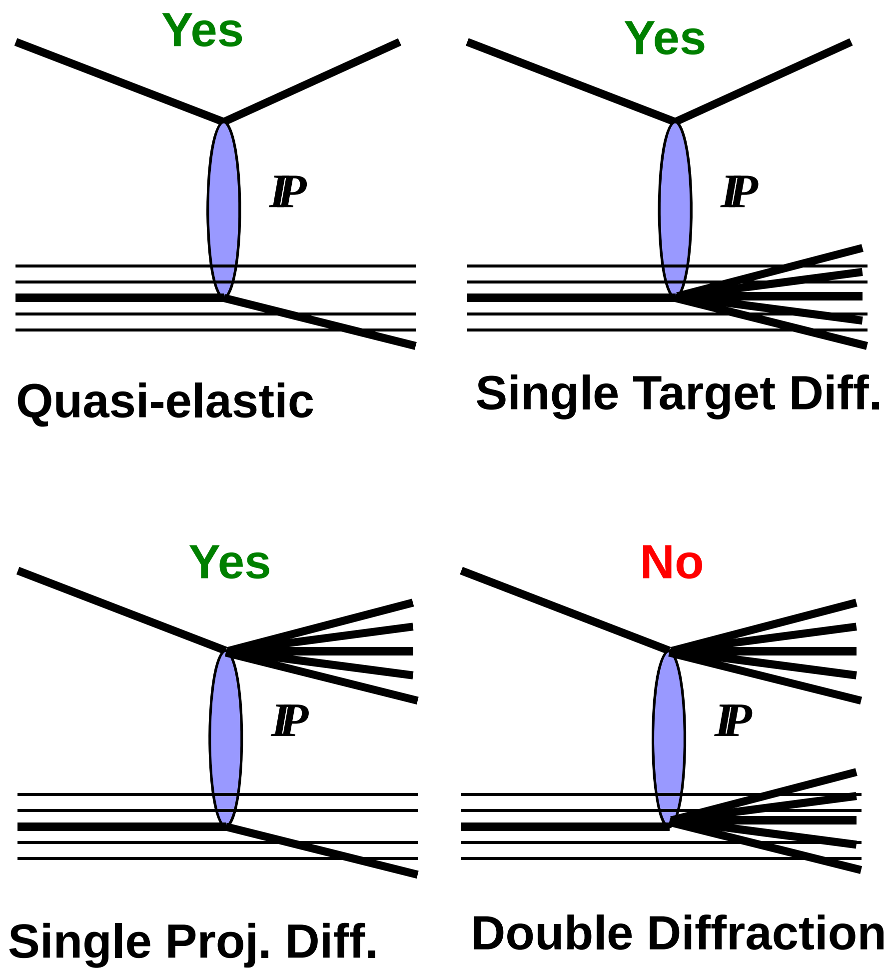
Mikhail Kosov, 12th Geant4 Workshop (GB, Sep.2007)

Better diffraction for better Shower Shape

- The longitudinal shower shape in calorimeters simulated by FTF/QGS packages of Geant4 looks to be more compact than the data
- The reason is an overestimation of the string contribution to the inelastic cross-section
- Subtraction of quasi-elastic contribution has been done with the G4QuasiFreeRatios class
- Subtraction of the single diffraction contribution can be done with the G4QDiffractionRatio class
- Subtraction of Coherent Charge Exchange can be done by G4QCoherentChargeExchange process

Description of G4QDiffractionRatio class

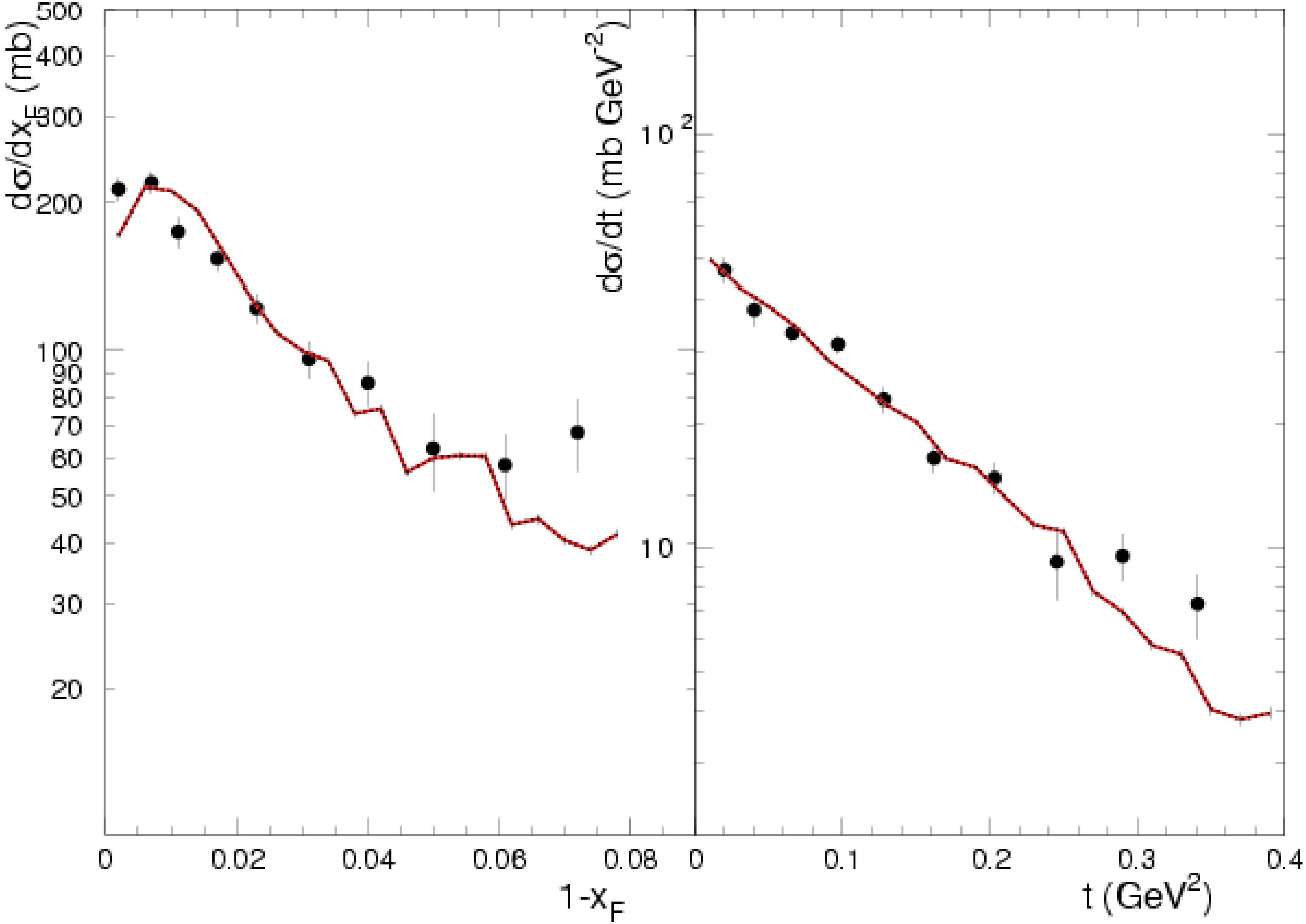
- There are three possible diffraction excitations
  - Single diffraction excitation of projectile
  - Single diffraction excitation of target
  - Double diffraction excitation (both)
- Double diffraction is not implemented, because it is considered to be small (see FTF)



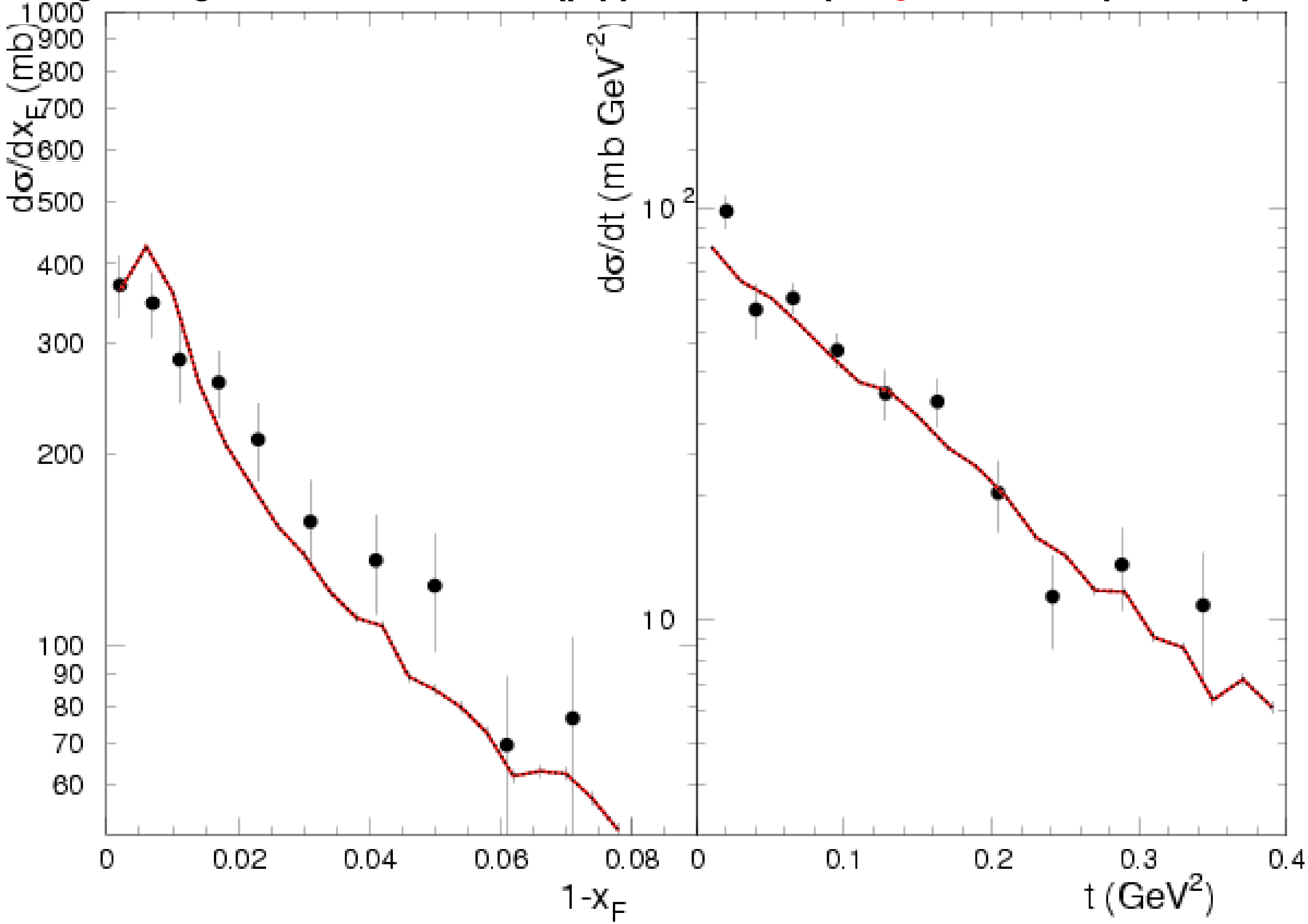
Single diffraction of the target

- It is energy-independent: σ_{SDT}=4.5(mb)·$A^{0.364}$
- The transverse momentum: $d\sigma/dt=e^{t/0.14(GeV2)}$
- The mass distribution: $d\sigma/dM^2=F(A,M)/M^2$
  - F(A,M) is a low mass suppression function
- M is a mass of the created Quasmon inside the target nucleus with quantum numbers of the selected quasi-free nucleon (W_p/W_n=Z/N)
- Nuclear fragmentation is made by the standard CHIPS fragmentation class G4QEnvironment
- G4QDiffraction process is compared with data T.Akesson et al., Z. Phys. C 49 (1991) 355-366

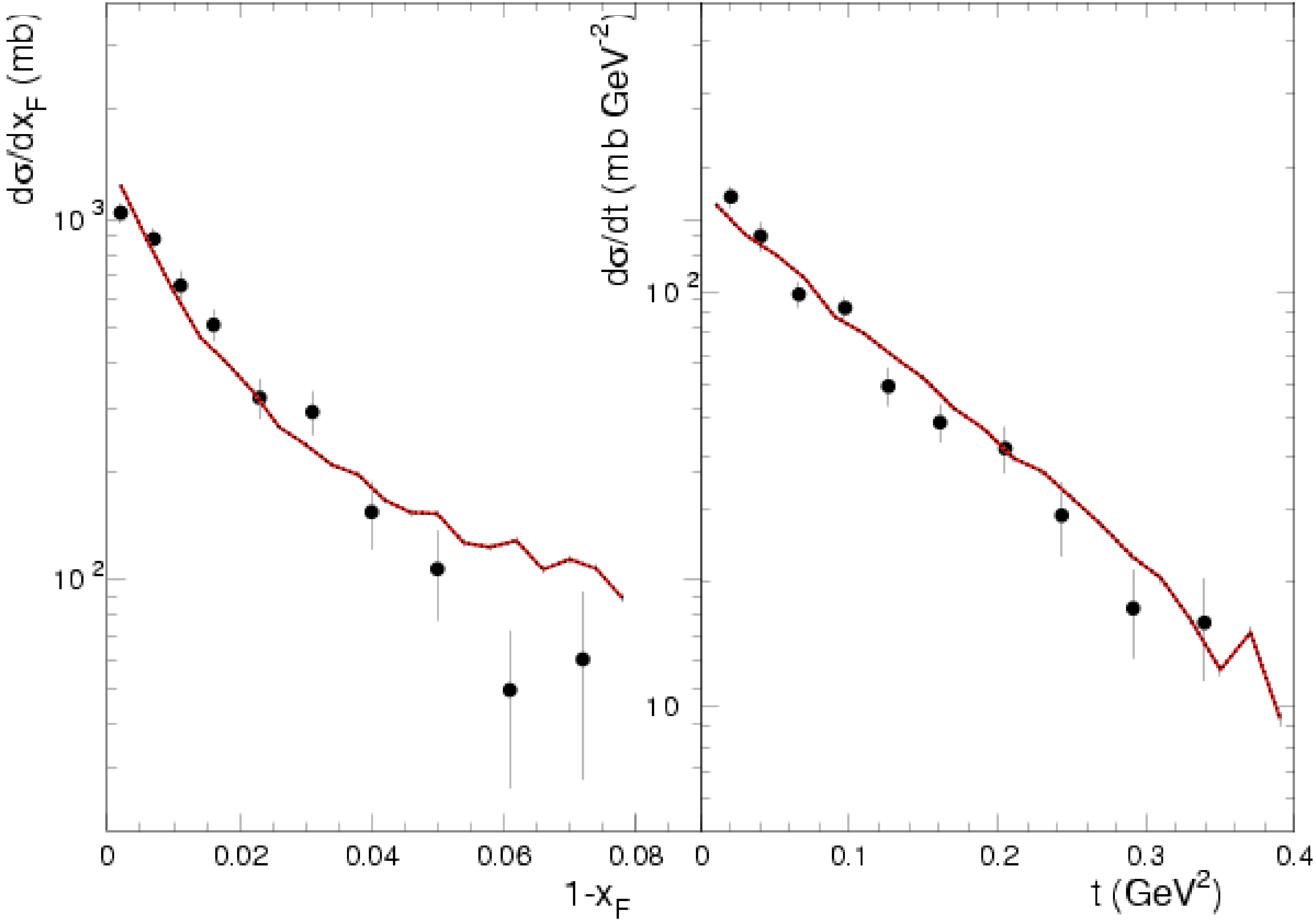
Single Target Diffraction in $Be^9(p,p)X$ reaction (G4QDiffraction process)



Single Target Diffraction in Al^{27}(p,p)X reaction (G4QDiffraction process)



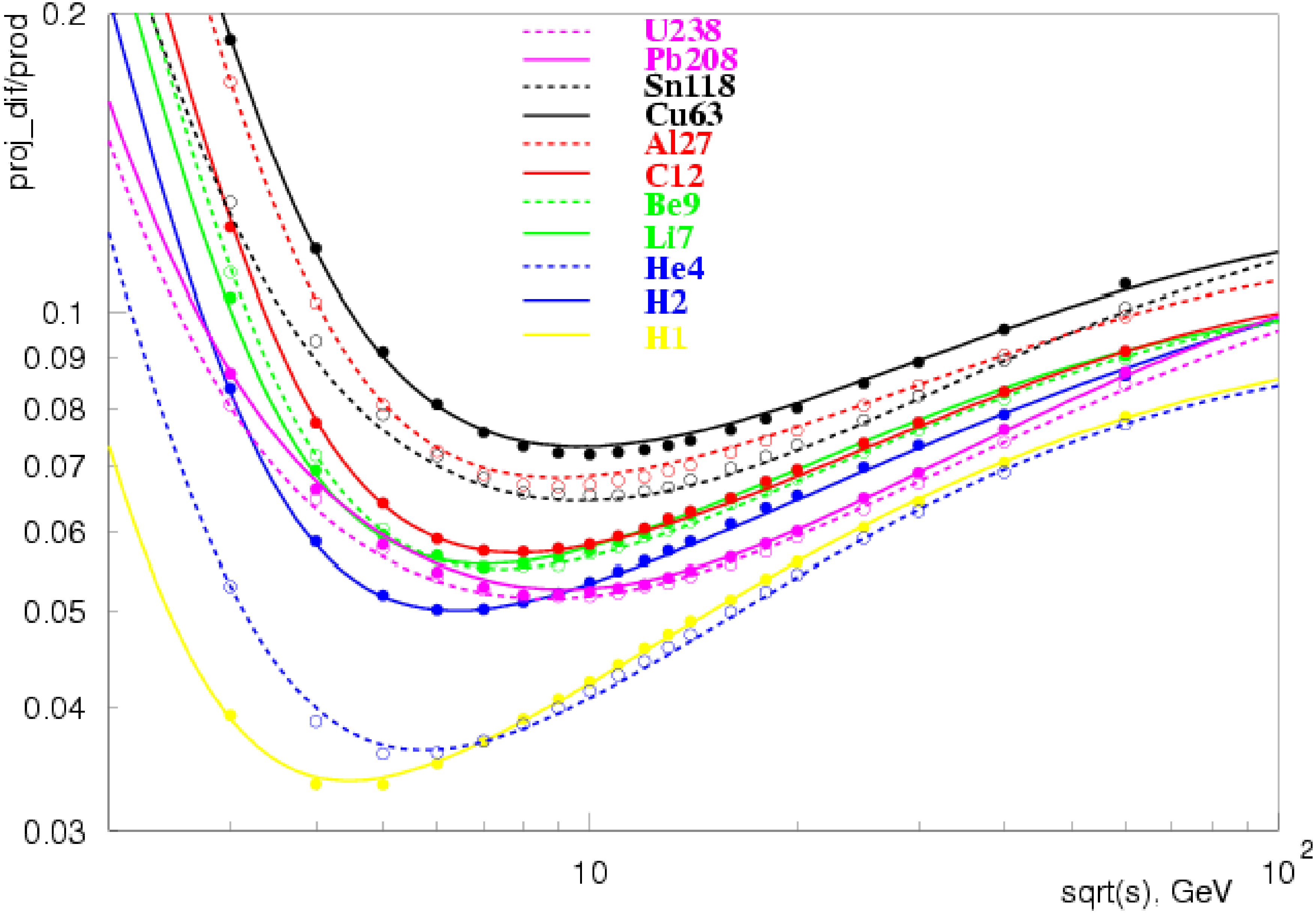
Single Target Diffraction in $W^{184}(p,p)X$ reaction (G4QDiffraction process)



Single diffraction of the projectile

- Regge theory calculations have been done for targets: H, D, He, Li, Be, Al, Cu, Sn, Pb, U in the energy range from 1 to 100 GeV NN-CMS
- A unique R(s,A) parameterization formula was found to interpolate the s-dependence for all A
- The same t-dependence slope and the same Minimum Mass approximation for M were used
- The Quasmon with the mass M and quantum numbers of the projectile was fragmented by the G4QEnvironment class in vacuum

Projectile Single Diffraction Excitation part of production cross-section (pA)

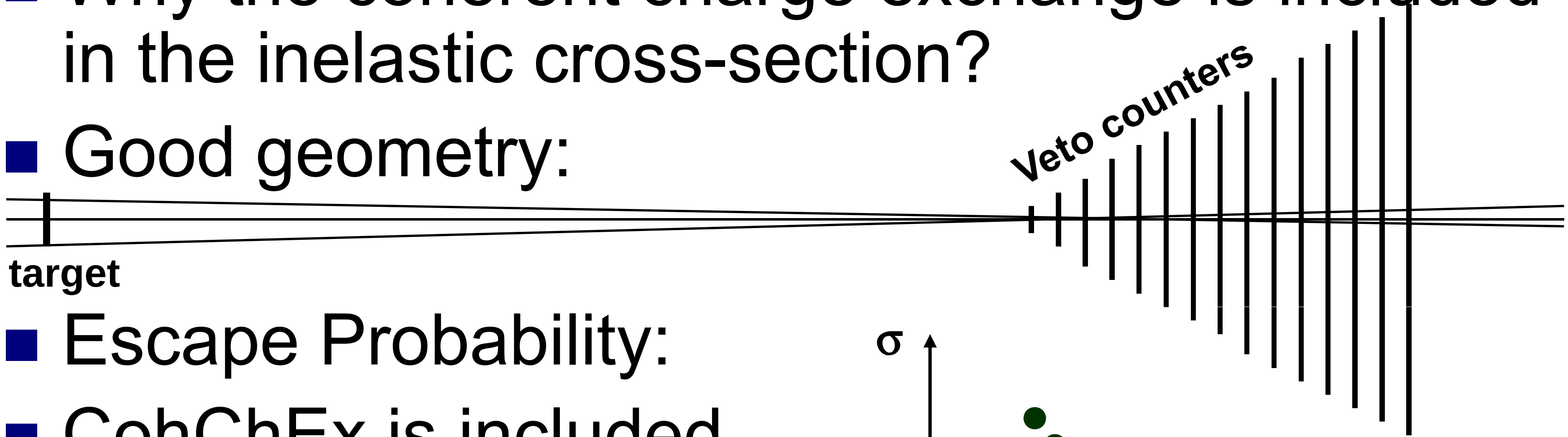


Conclusion for the diffraction part

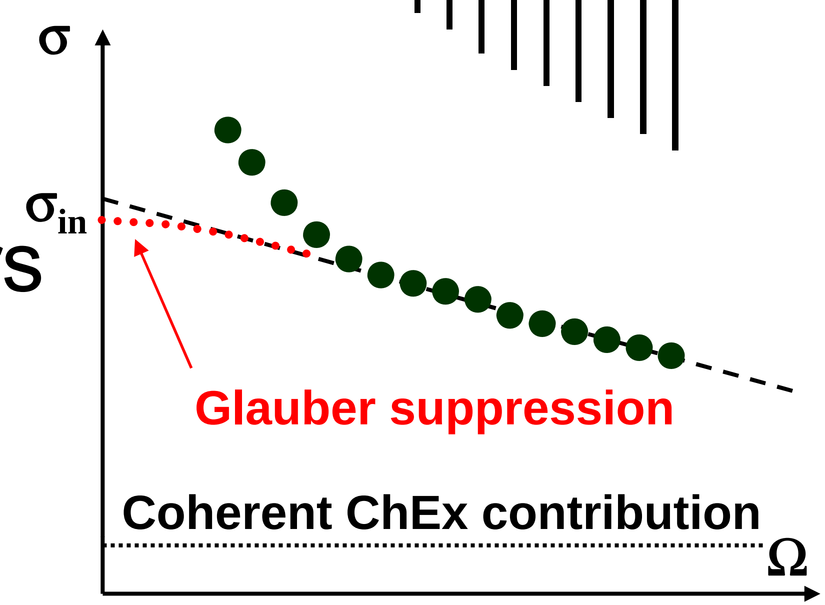
- The G4QDifractionRatio class is comparable by its complexity with the FTF model, but it does not claim coverage of the central region.
- If necessary the Double Diffraction can be added, but it is small and can be compensated by the existing Single Diffractions.
- The developed G4QDifractionRatio class can be used in the QGS model, covering central rapidity region, to improve the **Shower Shape**.
- Example of usage is in G4QDiffraction process

Coherent Charge Exchange is one more resource to reduce production

- Why the coherent charge exchange is included in the inelastic cross-section?
- Good geometry:



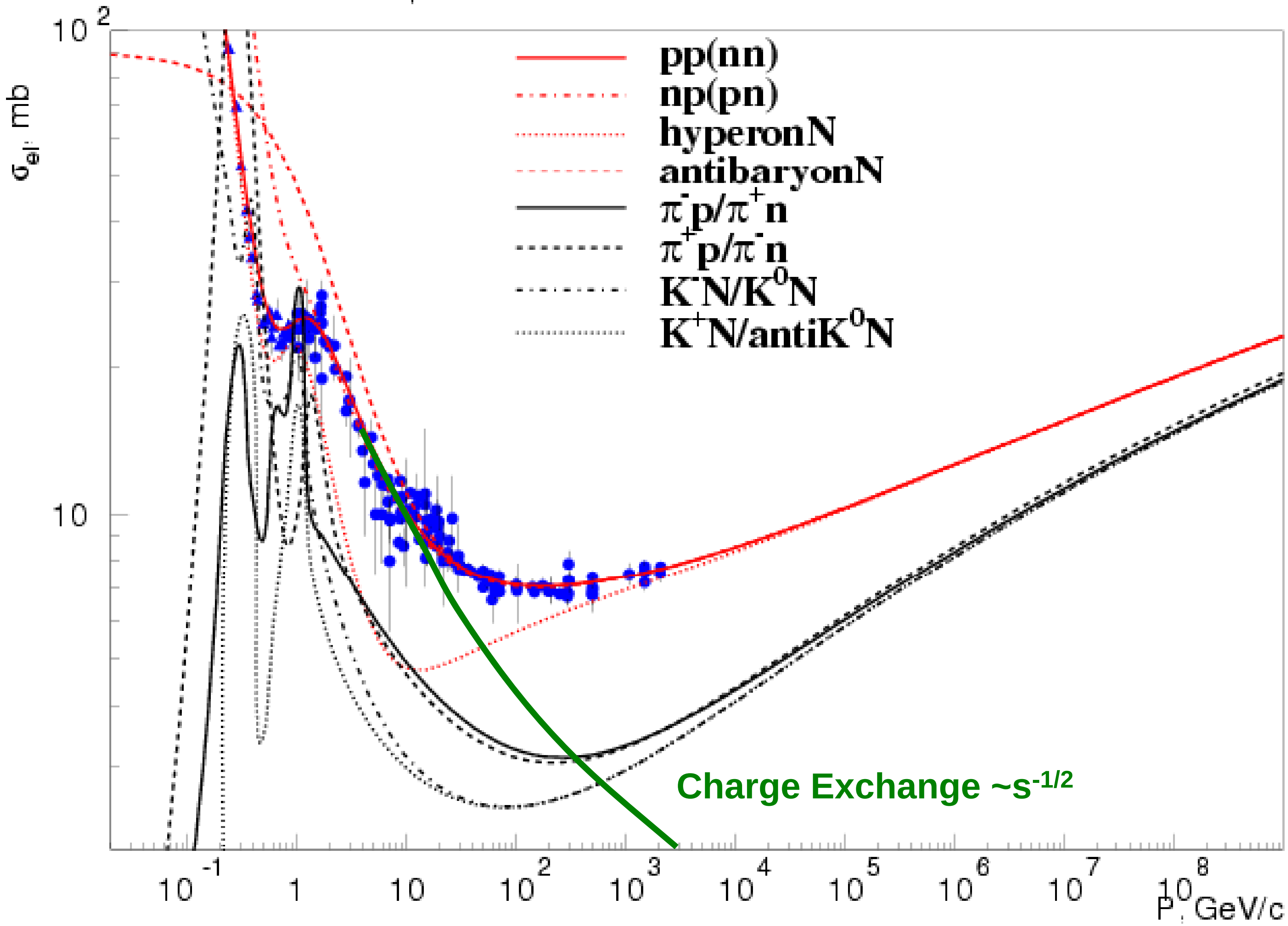
- Escape Probability:
- CohChEx is included
- No signal in veto counters
- Thickness of scintillators
- Coincidence of signals



Simulation of Coherent Charge Exchange

- The coherent charge exchange simulation is based on the G4QElasticCrossSection class because it is included in p+n→n+p reaction
- If we have Z protons and N neutrons in the nucleus, than ChEx/Elast_p=$[N/(N+2Z)]^2$
  - Square because of coherency ($|\Sigma A|^2$)
  - Realized in G4QCoherentChargeExchange class
- With energy the Coherent Charge Exchange dies the same as Elastic defined by the Reggesized Pion Exchange (El: π^0, ChEx: $\pi^{\pm}$)
- The Elastic survives at high energy (Pomeron)

CHIPS improvement of hadron-nucleon elastic cross-section



Conclusion for Coherent Charge Exchange

- The Coherent Charge Exchange is usually considered to be a small part of σ_{in}, so it should be considered as a second order correction for Shower Shapes with respect to the quasi-elastic and diffraction (the 1st order)
- The first attempt for nucleons (p and n) is made in G4QCoherentChargeExchange class
- Data are needed to tune this process especially for the dying high energy part
- The same should be done for mesons