CMS-IHEP Group:

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Proposal:

Hadron multiplicities in top events

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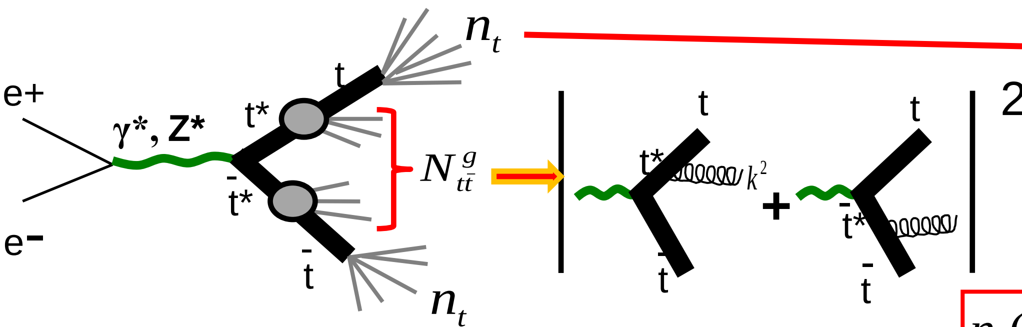
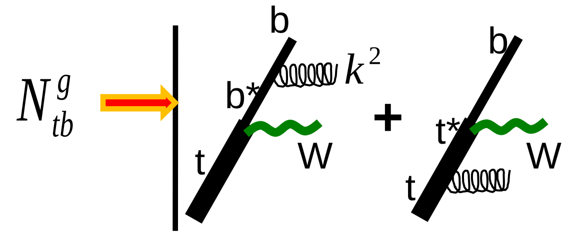
Multiplicity measurements in e+e-

[A.V. Kisselev, V.A. Petrov, PMC Phys. A2 (2008) 3, ArXiv: 0711.3150]





[Assumption]: independent fragmentation of on-shell t and anti-t:
analogous to e+e- =>W+W- ,
experimentally confirmed

Advantages:
- t-anti-t is a singlet state (no interaction with beam remnants)
- t is heavy

$$n_t(t \to hadrons) = n_b + n_W + N^g_{tb} = 41.03 \pm 0.54$$
$$n_t(t \to l\bar{\nu}_l + hadrons) = n_b + N^g_{tb} = 21.69 \pm 0.53$$
$$n_b = 5.55 \pm 0.09 \qquad n_W = 19.34 \pm 0.1$$
$$N^g_{tb} = 16.14 \pm 0.24$$
$$n_{t\bar{t}}(500GeV, t\bar{t} \to hadrons) = 2n_t + N^g_{t\bar{t}} = 86.67 \pm 1.11$$
$$n_{t\bar{t}}(500GeV, t\bar{t} \to W^+W^- + hadrons) =$$
$$= 2(n_t - n_W) + N^g_{t\bar{t}} = 47.99 \pm 0.59$$
$$N^g_{t\bar{t}}(500GeV, m_t) = 4.61 \pm 0.11$$

$$N^g_X(\sqrt{s}, m_t) = \int_{Q_0^2}^{(k^2)_{\max}} \frac{dk^2}{k^2} \hat{N}_g(k^2) \boxed{E_X(s, k^2, m_t^2)}, \quad X = t\bar{t}, tb, \ldots$$

$$N_g(k^2) = \int_{Q_0^2}^{k^2} \frac{dp^2}{p^2} n_g(p^2), \quad \hat{N}_g(k^2) = \frac{C_F \alpha_S(k^2)}{\pi} \boxed{N_g(k^2)}$$

QCD CALCULATIONS

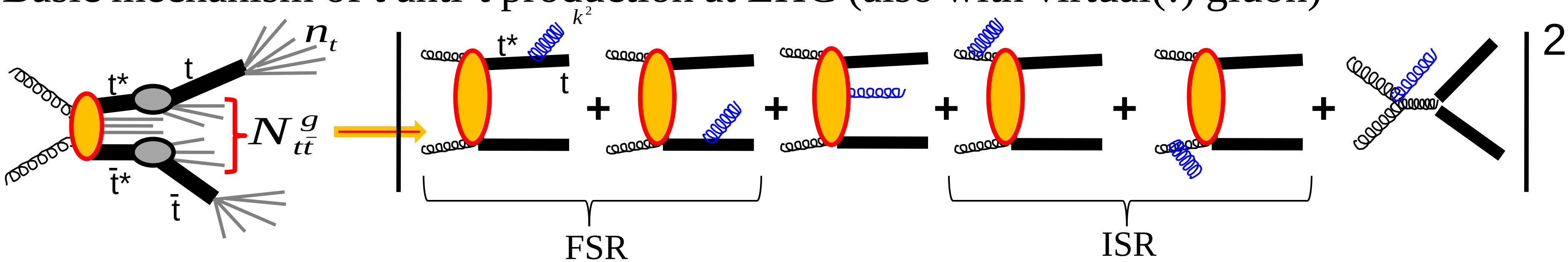
Normalized to real data

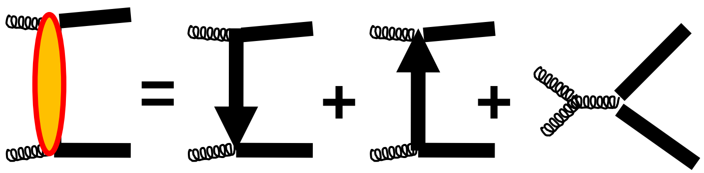
$n_g(p^2)$ is a mean hadron multiplicity in a virtual gluon with a “mass” p^2

Test of QCD. Independent on fragmentation models!

Multiplicity measurements in pp t anti-t

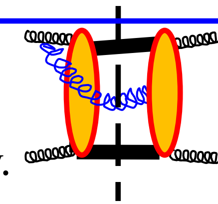
Basic mechanism of t anti-t production at LHC (also with virtual(!) gluon)





ISR-FSR interference terms like

are taken into account automatically.



$$n_{t\bar{t}}(\sqrt{\hat{s}}, t\bar{t} \to hadrons) = 2n_t + N^g_{t\bar{t}}$$

$$n_{t\bar{t}}(\sqrt{\hat{s}}, t\bar{t} \to W^+W^- + hadrons) = 2(n_t - n_W) + N^g_{t\bar{t}}$$

$$N^g_{t\bar{t}} \sim 15-30$$

for gg C.M.Energies 300-1500 GeV

New!

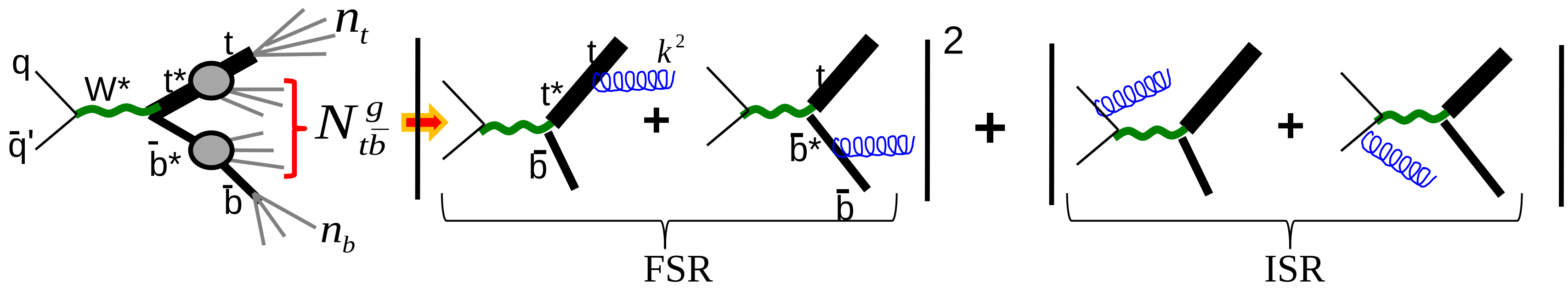
Here t-anti-t may be a nonsinglet state, but interaction with beam remnants can be suppressed

if we take pT(jet)>15-20 GeV

MOTIVATIONS:

- to check directly (independent on fragmentation model!) QCD predictions for multiplicities in jets, especially induced by a virtual gluon ($N_g(k^2)$ is normalized to the real data!),
- to estimate interference terms corrections, to prove model independent fragmentation of t anti-t,
- to check parton-parton-C.M.Energy dependance of $N^g_{t\bar{t}}(\hat{s} = x_1 x_2 s_{pp})$

Multiplicity measurements in pp single t

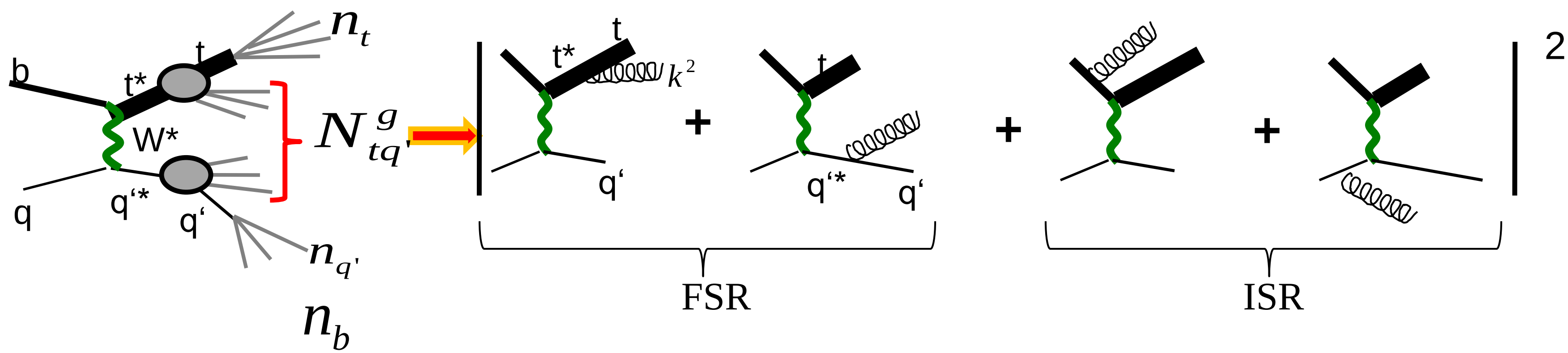


- similar to e+e-, W* is a color singlet
- no ISR-FSR interference

$$n_{t\bar b} = n_t + n_b + N^g_{t\bar b}$$

$$N^g_{t\bar b} \sim 3 \to 12,\ \hat s = 300 \to 1500\ \text{GeV}$$

New!



- (bq) may be nonsinglet => pt(jet)>15-20 GeV to suppress interaction with beam remnants
- ISR-FSR interference is taken into account

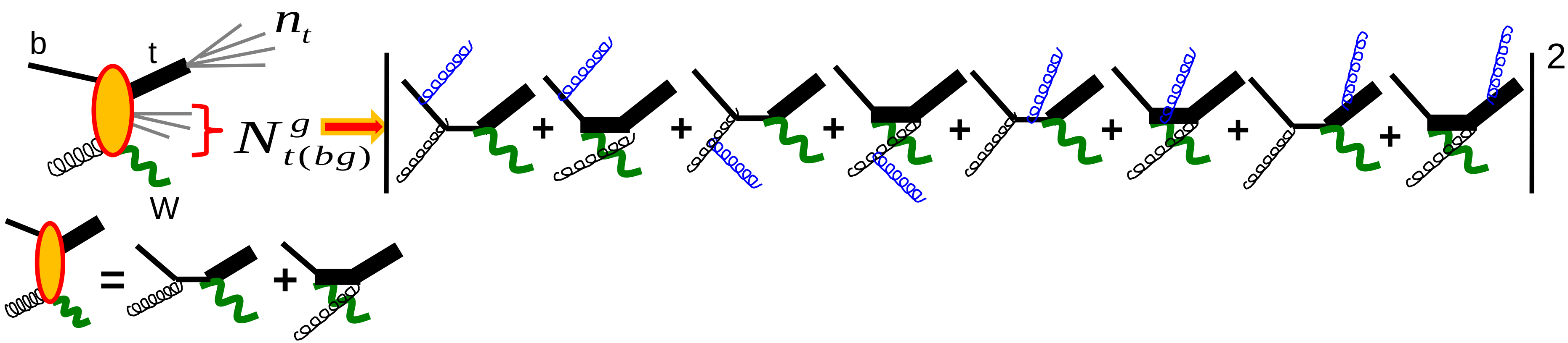
$$n_{tq'} = n_t + n_{q'} + N^g_{tq'}$$

$$< n_{u,d,s} >= 1.2$$

$$N^g_{tq'} \sim 2 \to 7,\ \hat s = 300 \to 1500\ \text{GeV}$$

New!

Multiplicity measurements in pp single t

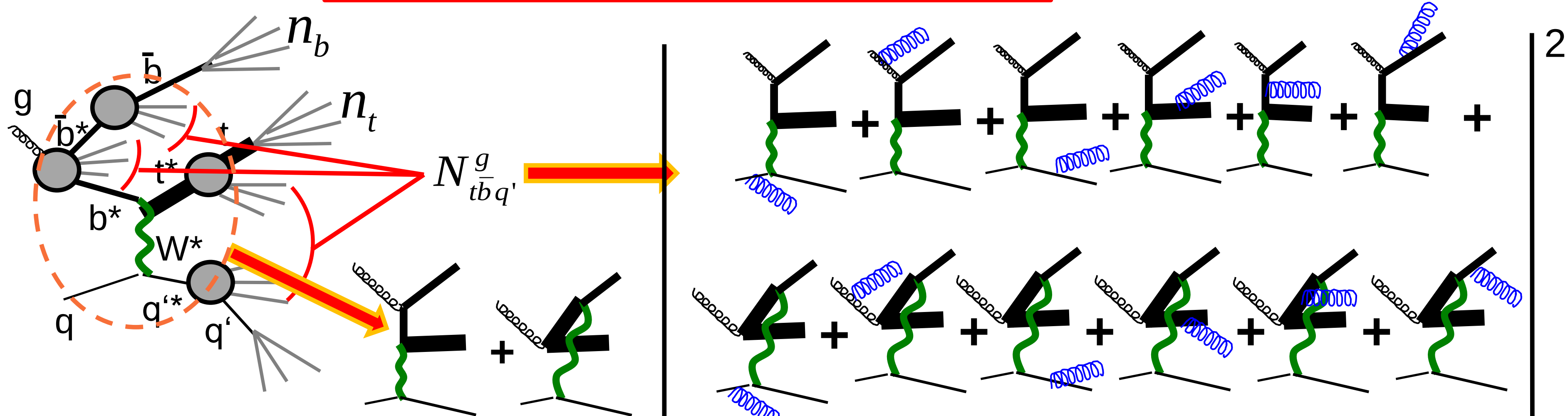


- (bg) may be nonsinglet => pt(jet)>15-20 GeV to suppress interaction with beam remnants
- ISR-FSR interference is taken into account

New!

$$n_{tW} = n_t + n_W + N^g_{t(bg)}$$

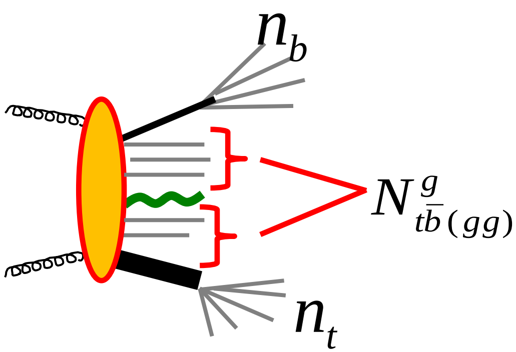
$$N^g_{t(bg)} \sim 2 \rightarrow 26, \hat{s} = 400 \rightarrow 1500\,\text{GeV}$$

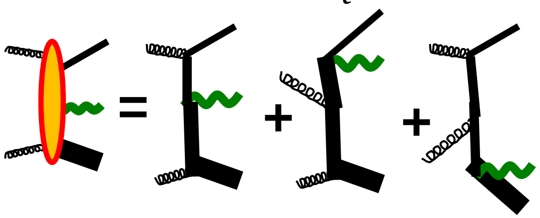


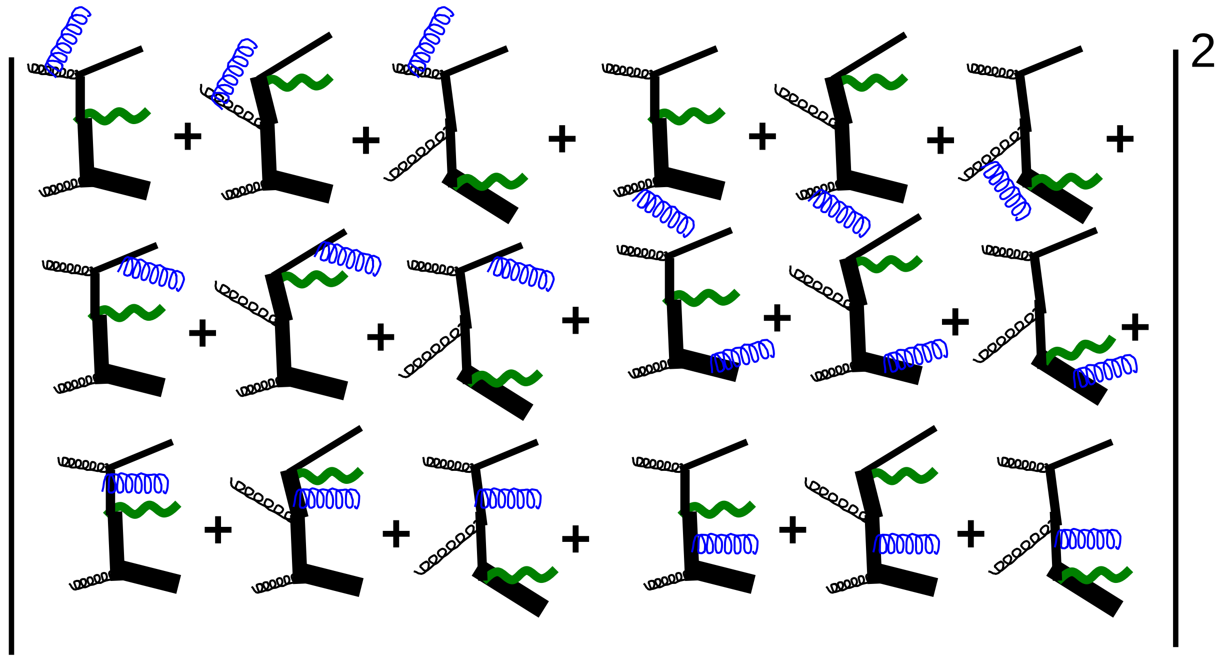
In progress

$$n_{t\bar{b}q'} = n_t + n_b + n_{q'} + N^g_{t\bar{b}q'}$$

Multiplicity measurements in pp single t





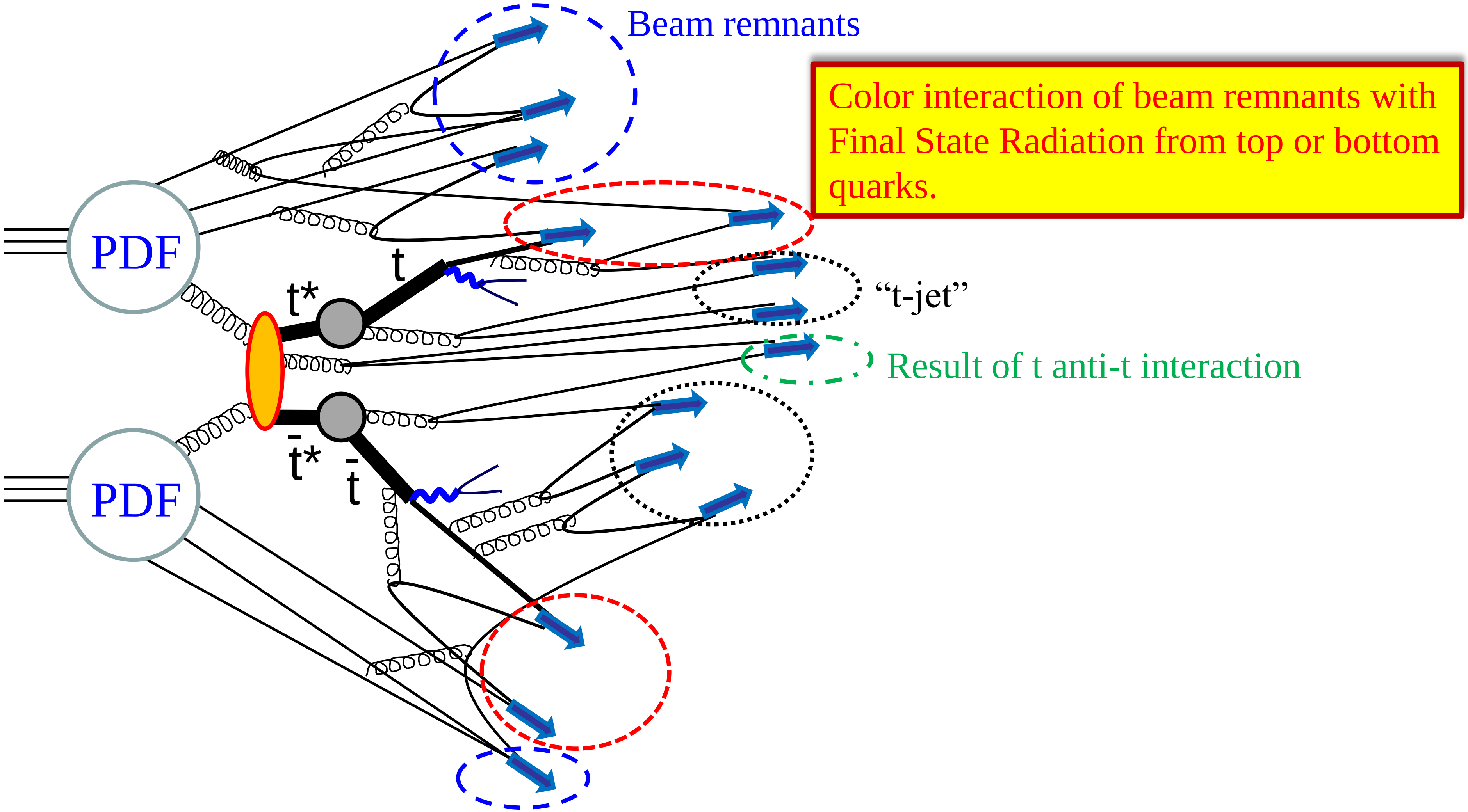


In progress

$$n_{t\bar{b}W} = n_{\bar{t}} + n_b + n_W + N^g_{t\bar{b}(gg)}$$

Color interactions of beam remnants and FSR in top production

Example of complicated fragmentation picture in top anti-top events at the LHC



Text

We propose to extract average charged multiplicity of hadrons in "t-induced-jets" in single-top and t-tbar events.

Our work is based on ideas of our colleagues, who have calculated charge hadron multiplicities for t-tbar production in e+e- annihilation.

The basic argument for calculations is the independent fragmentation of tops.
In e+e- it was experimentally proved for e+e-=>W+W- (for t-tbar ithe situation is similar).
At LHC the situation is more difficult, since jet partons can interact with beam remnants, but:
a) in s-channel single top the situation is similar to e+e- (W* is a color singlet),
b) in other processes we can take jets with high pt, and such interaction will be suppressed.

- Numbers nb,nW,nt are fixed and energy independent (calculated by data fitting at low energies).
- Numbers Nx are calculated in QCD, where Ng are independent on fragmentation model and fixed by data fitting at low energies.

Motivations:

a) direct test of QCD calculations independent on fragmentation models.
b) to check independent fragmentation of heavy quarks.
c) to check parton-parton-C.M.Energy dependence of hadron multiplicities.

Final task: to extract number of tracks in jets which are produced in top quark decay.

Comments: to estimate efficiencies etc. we can use any MC generator for top production. To suppress (estimate) dependence on a fragmentation model we can use several different models (generators: PYTHIA, HERWIG and so on). At the same time with the top-mass reconstruction procedure (in hadronic mode) we could extract number of tracks which are included into hadronic cluster from top.