Latest DØ QCD Results

7th RTN Workshop

The 3rd Generation as a Probe for New Physics

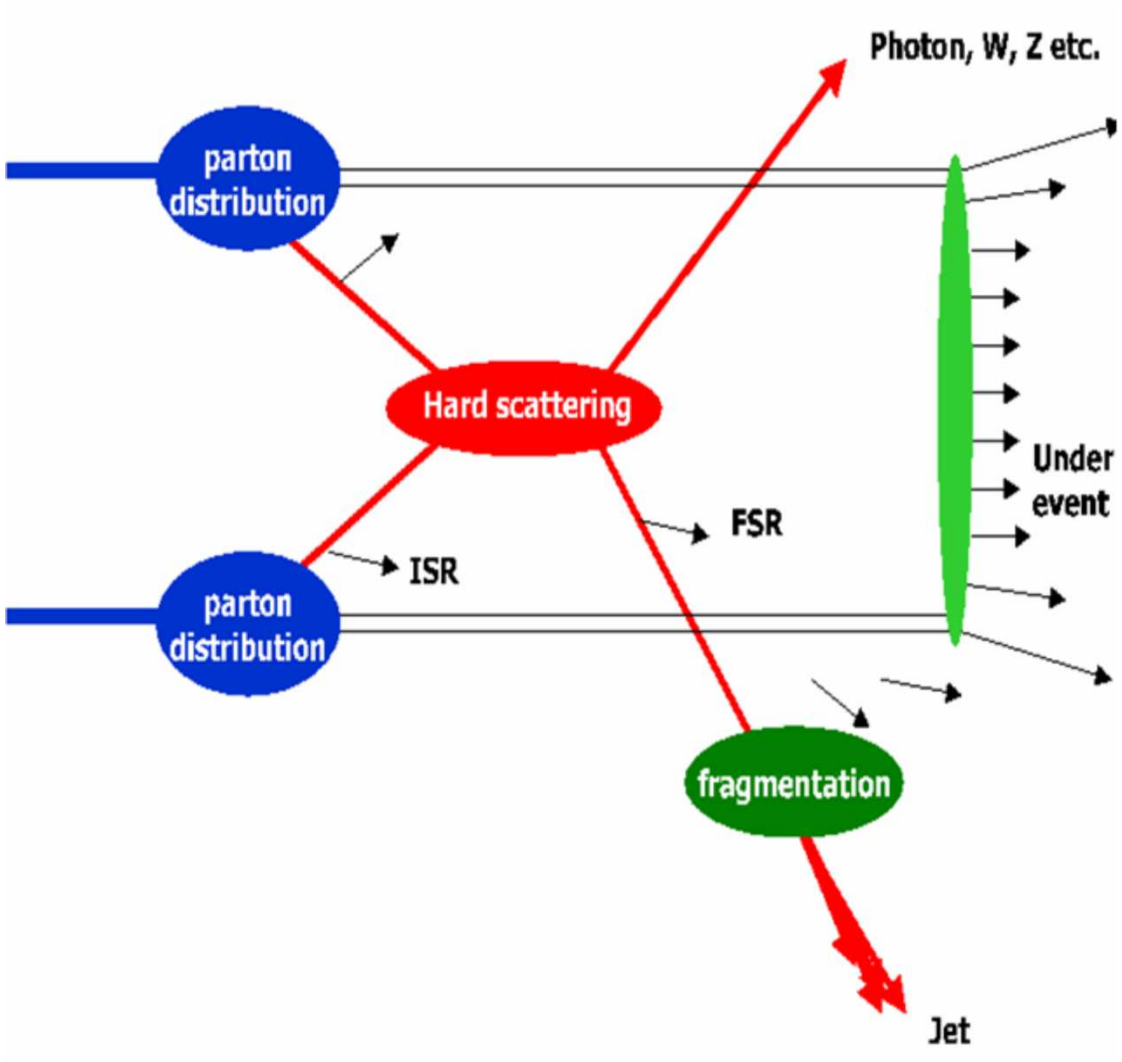
February 8-10, 2006, Prague

Alexander Kupčo

on behalf of the DØ collaboration

Institute of Physics, Center for Particle Physics, Prague

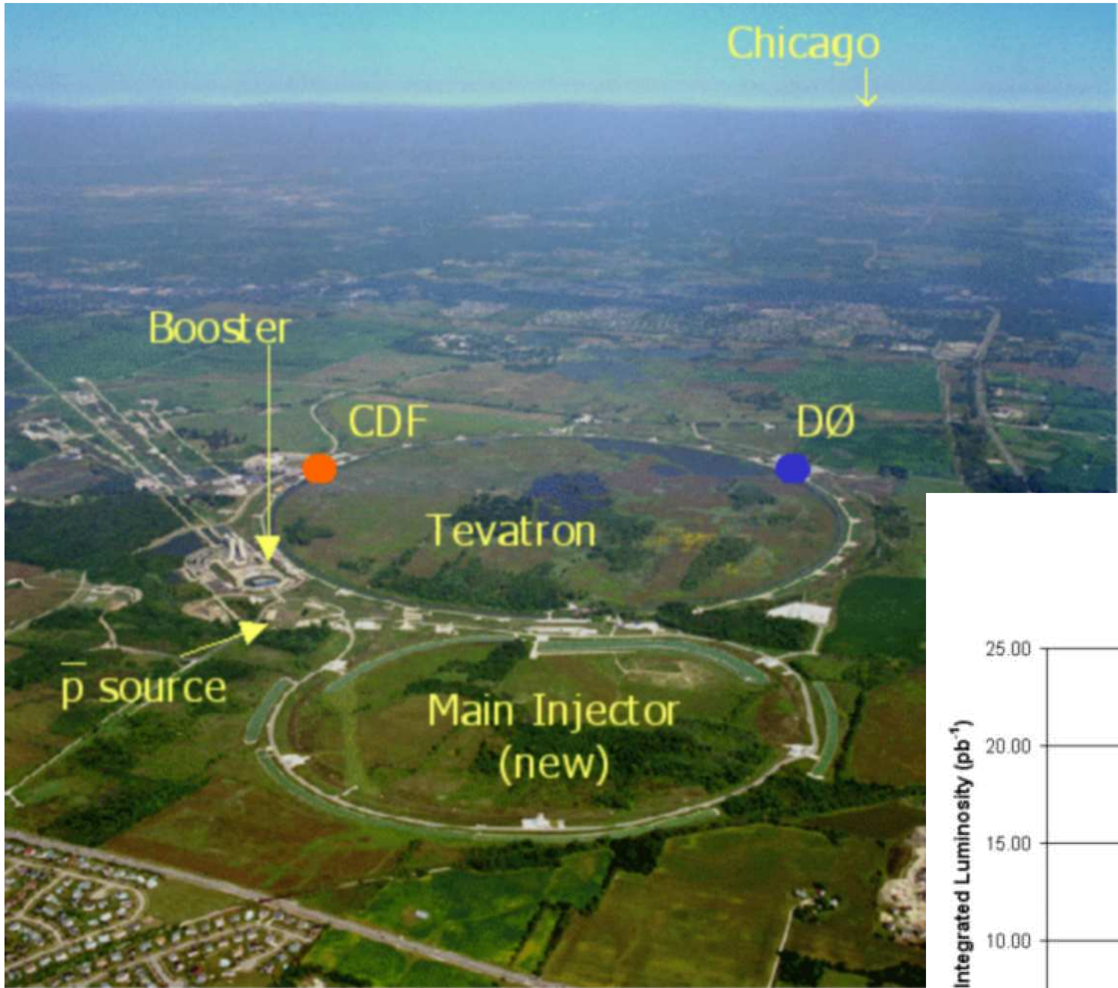
Outline



- high p_T physics
  - central inclusive jet production
  - dijet mass spectrum
  - central direct photon production
- multi-parton radiation
  - dijet azimuthal decorrelations

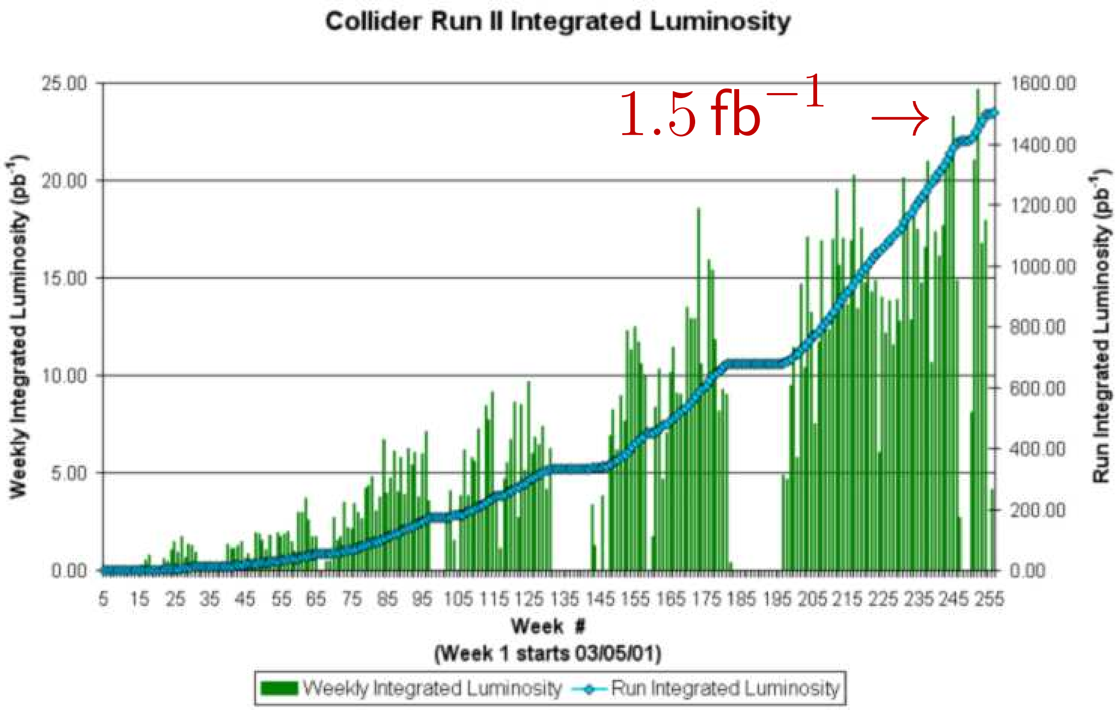
- **Not covered:** forward jet production, μ-tagged jet cross sections, W/Z+jet,. . .

Tevatron



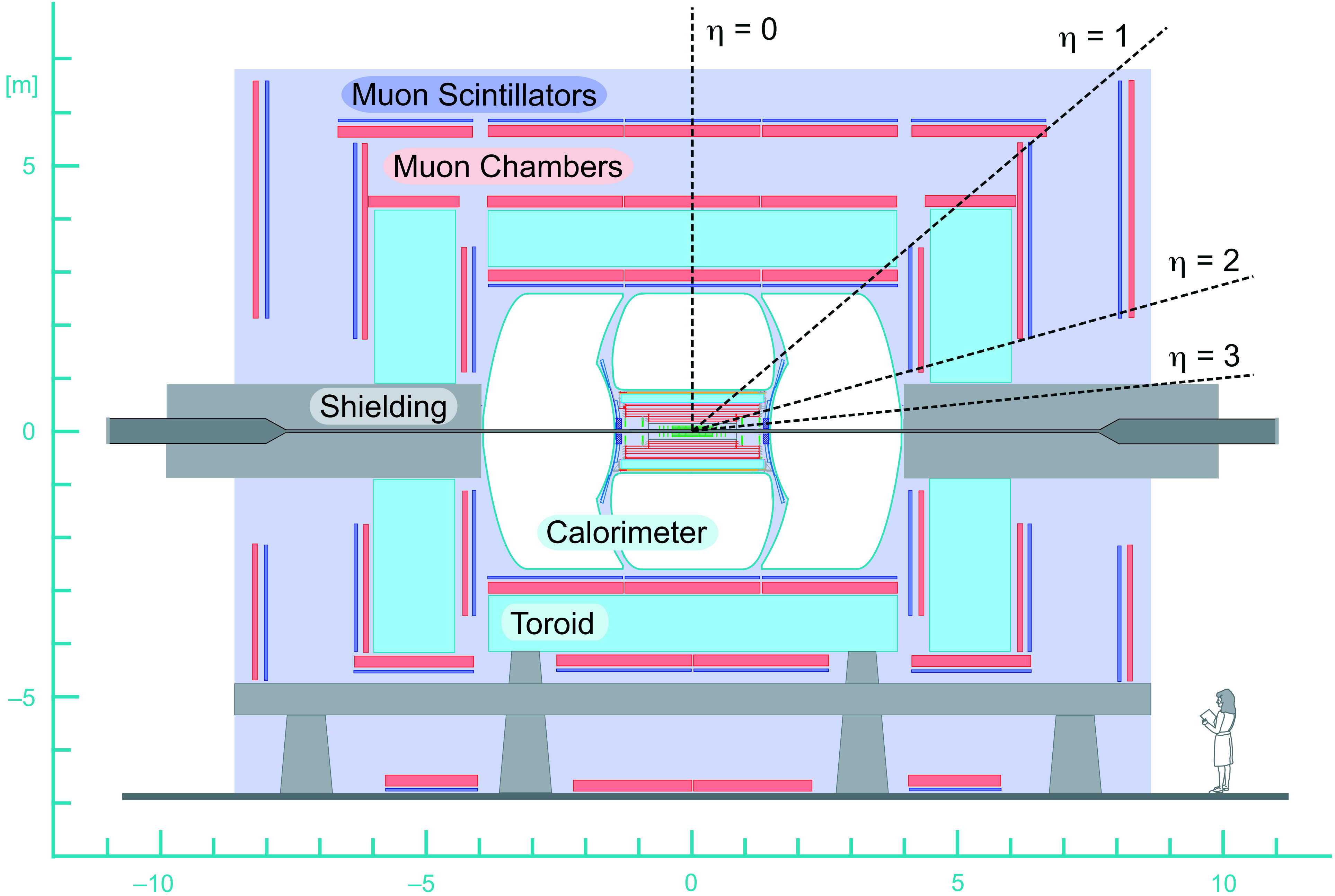
- Run I → Run II
  - $1.8\,$TeV $\to 1.96\,$TeV
  - luminosity upgrade
- Tevatron operates now at

$\mathcal{L} \sim 1.6 \times 10^{32}\,\text{cm}^{-2} \cdot \text{s}^{-1}$

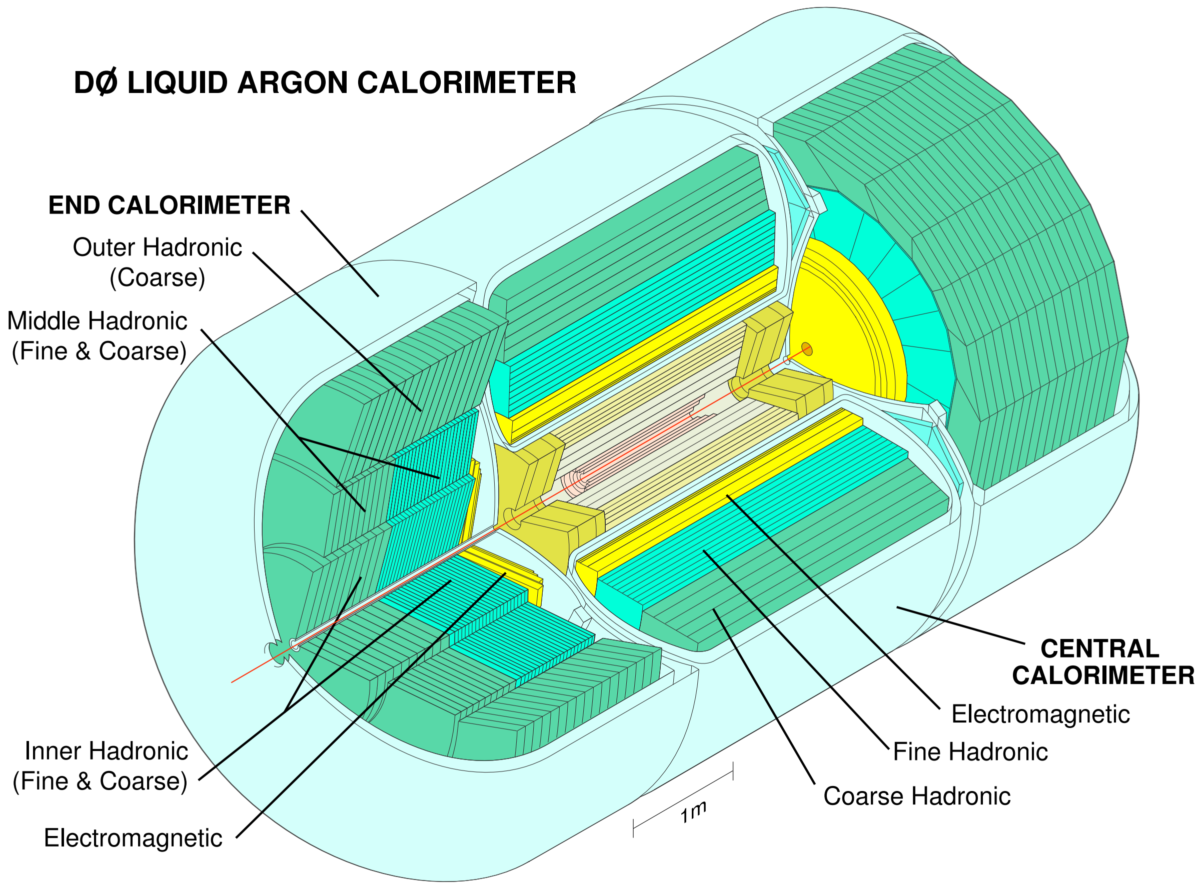


- Long Term Luminosity Plans (2009)
  - base goal: $4.4\,\text{fb}^{-1}$, design: $8.5\,\text{fb}^{-1}$

DØ Detector


η = 0
η = 1
η = 2
η = 3
[m]
5
0
–5
Muon Scintillators
Muon Chambers
Shielding
Calorimeter
Toroid
–10
–5
0
5
10

Calorimeter

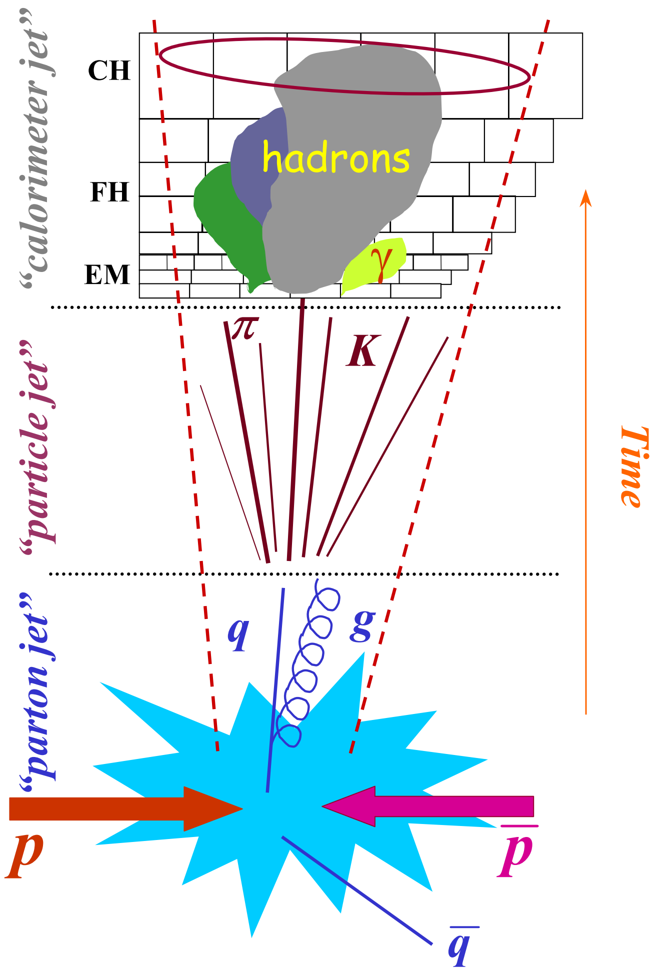


- uniform and hermetic
  - coverage up to $|\eta| < 4.2$
- compensating $(e/\pi \sim 1)$
- fine segmentation
  - $\Delta\eta \times \Delta\varphi = 0.1 \times 0.1$
    (3rd EM layer: 0.05×0.05)

Run II upgrade

- shorter time between bunch crossings (396 ns) $\Rightarrow$ faster trigger and readout electronics
- more material in front of calorimeter (magnet, new tracker) $\Rightarrow$ new preshower detector

Jets



▷ calorimeter jet

- jet is a collection of calorimeter towers
- correct for detector effects (calibration, resolution, . . .)

▷ particle jet

- no theory from the first principles of QCD
- predictions are model dependent

▷ parton jet

- hard parton jets (fixed order calculations) or after devel-opement of parton showers (resummation)

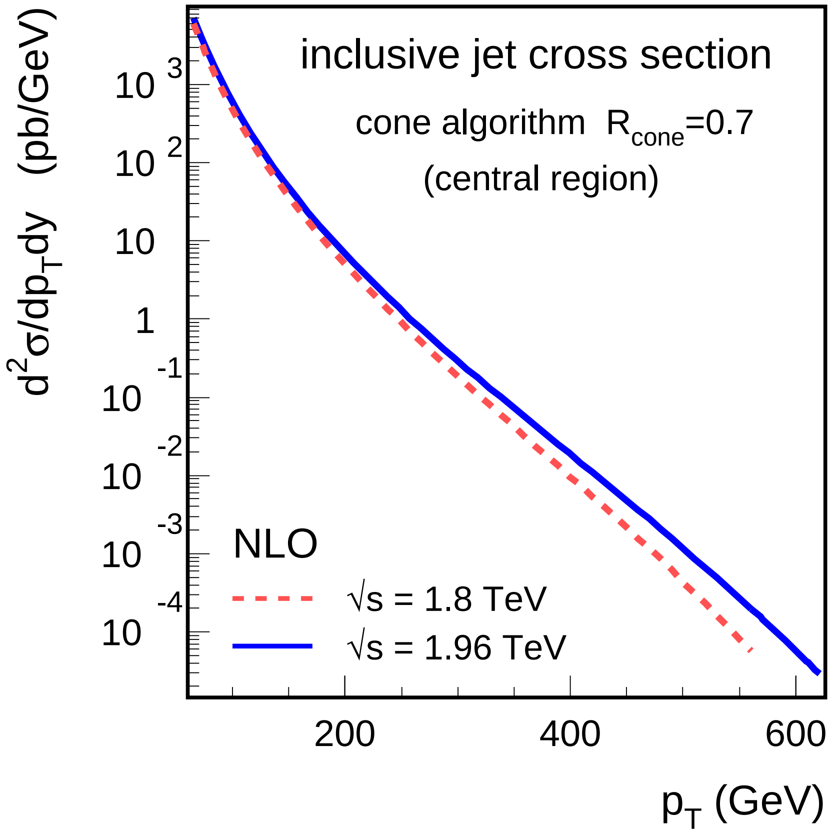
▷ Jet Cone Algorithm in Run II

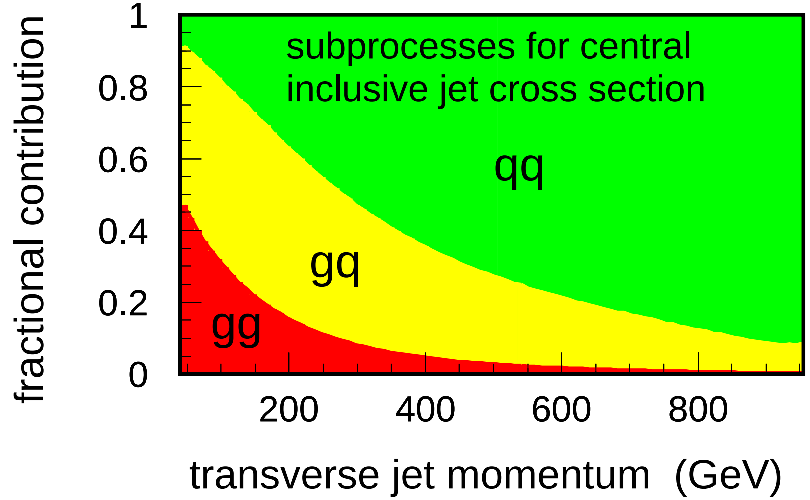
- geometrical definition: $\Delta R = \sqrt{\Delta^2\phi + \Delta^2 y}$
- E-scheme recombination: $P_{jet} = \sum P_{towers}$
- add midpoints between jets as an additional starting seed

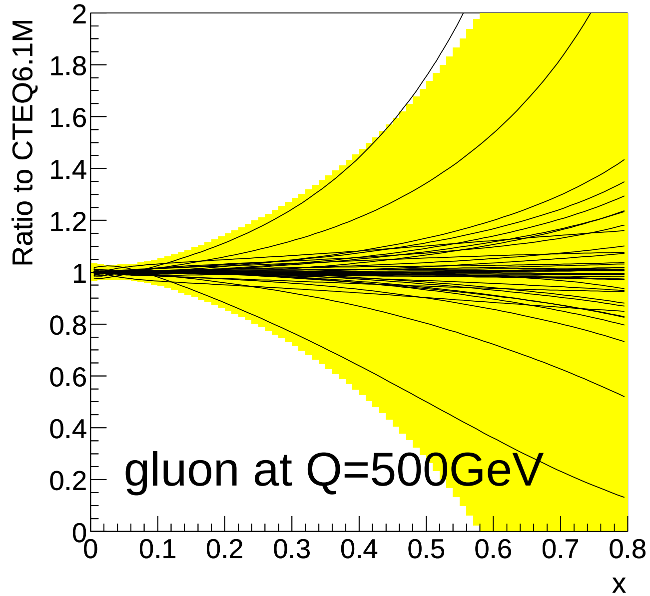
High p_T jets in Run II

- higher $\sqrt{s}$ $(1.8 \rightarrow 1.96\,\text{TeV})$

$\rightarrow$ higher cross section at high p_T





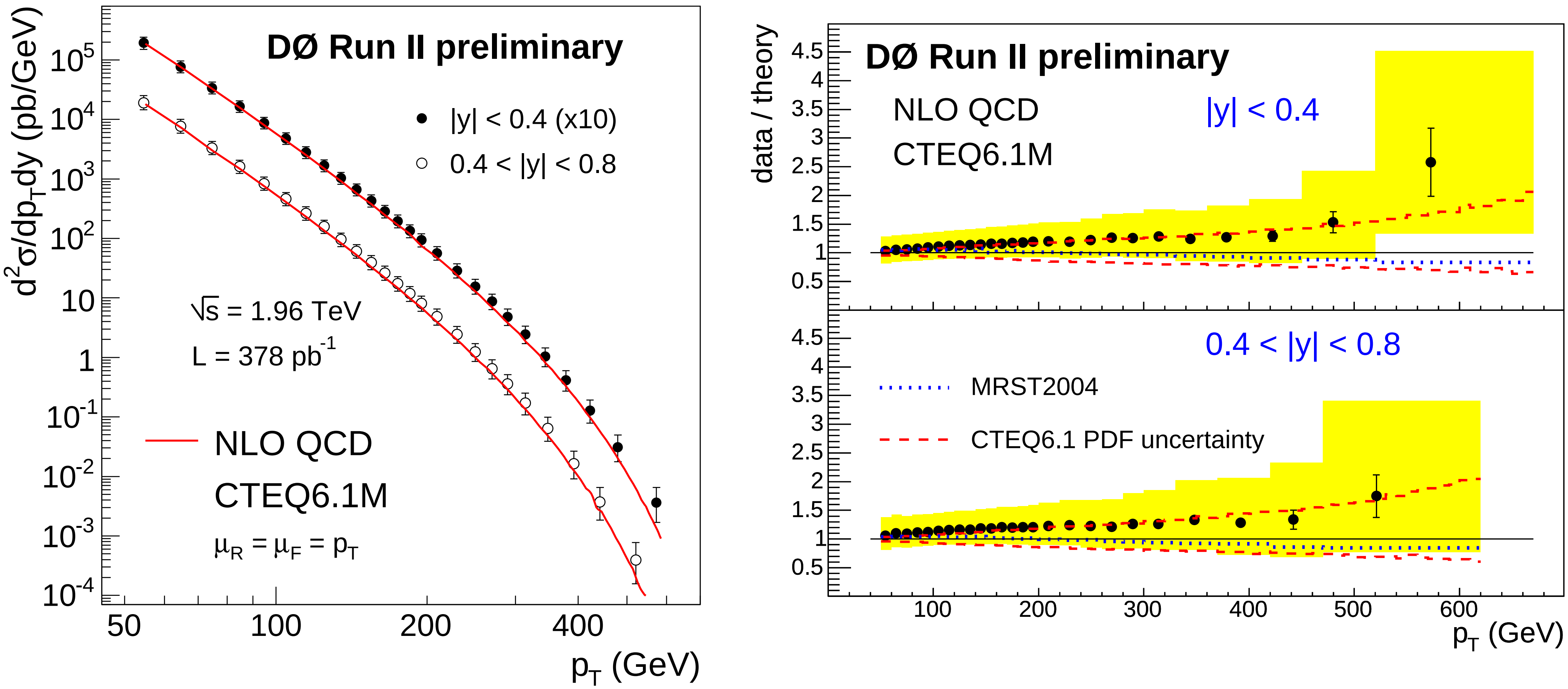


- more luminosity

$\Rightarrow$ reach in jet p_T significantly increased

- sensitivity to gluon PDF at high x

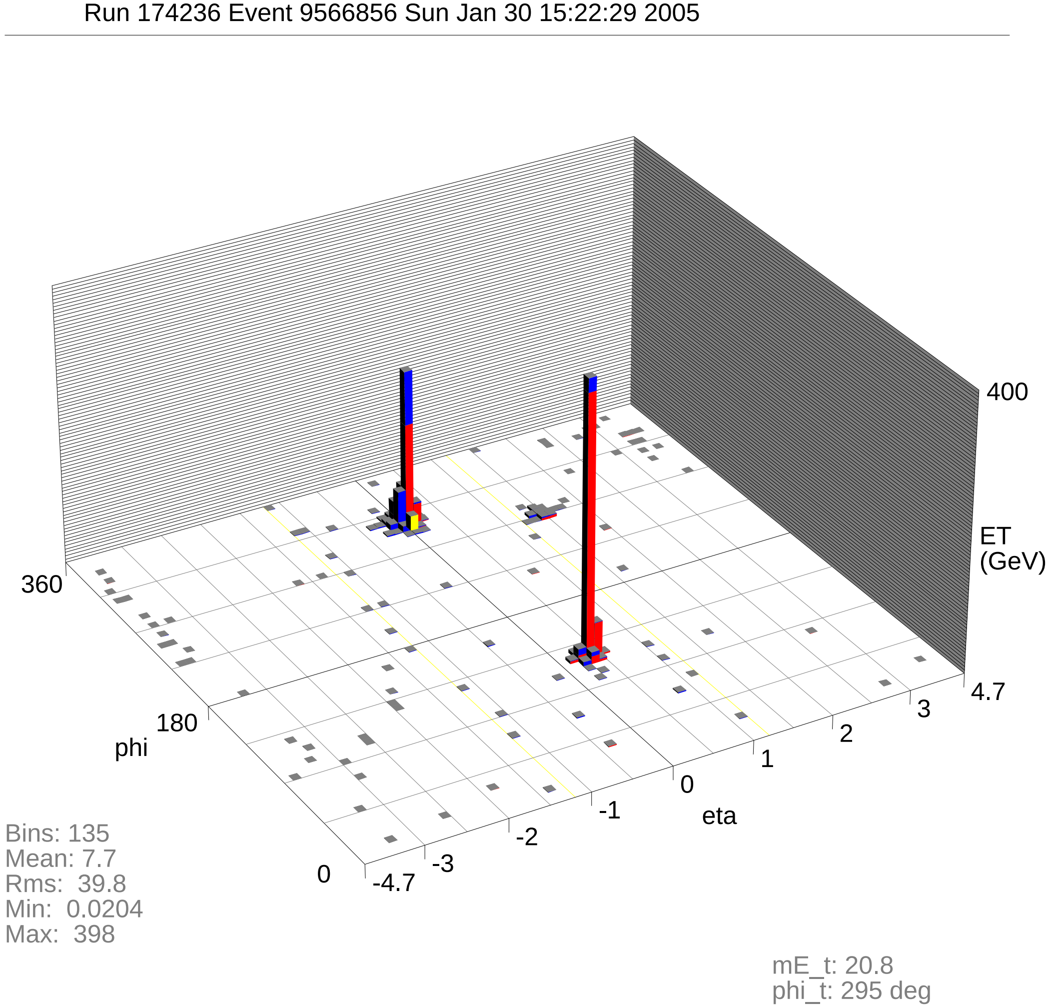
Central jet inclusive cross sections (DØ)

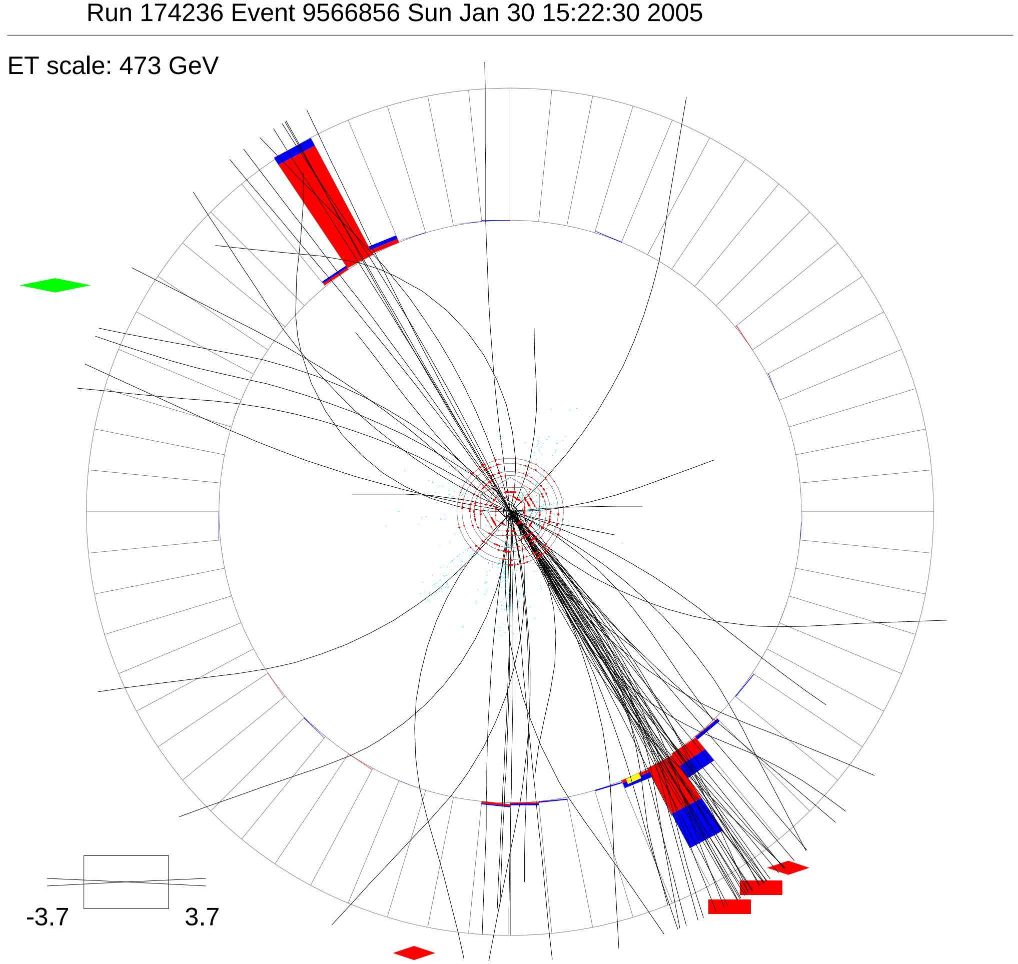


- dominant experimental uncertainty - jet energy calibration
- good agreement with NLO QCD over 8 orders of magnitude
- theory uncertainty at high p_T is dominated by uncertainty on gluon density

Jetty event

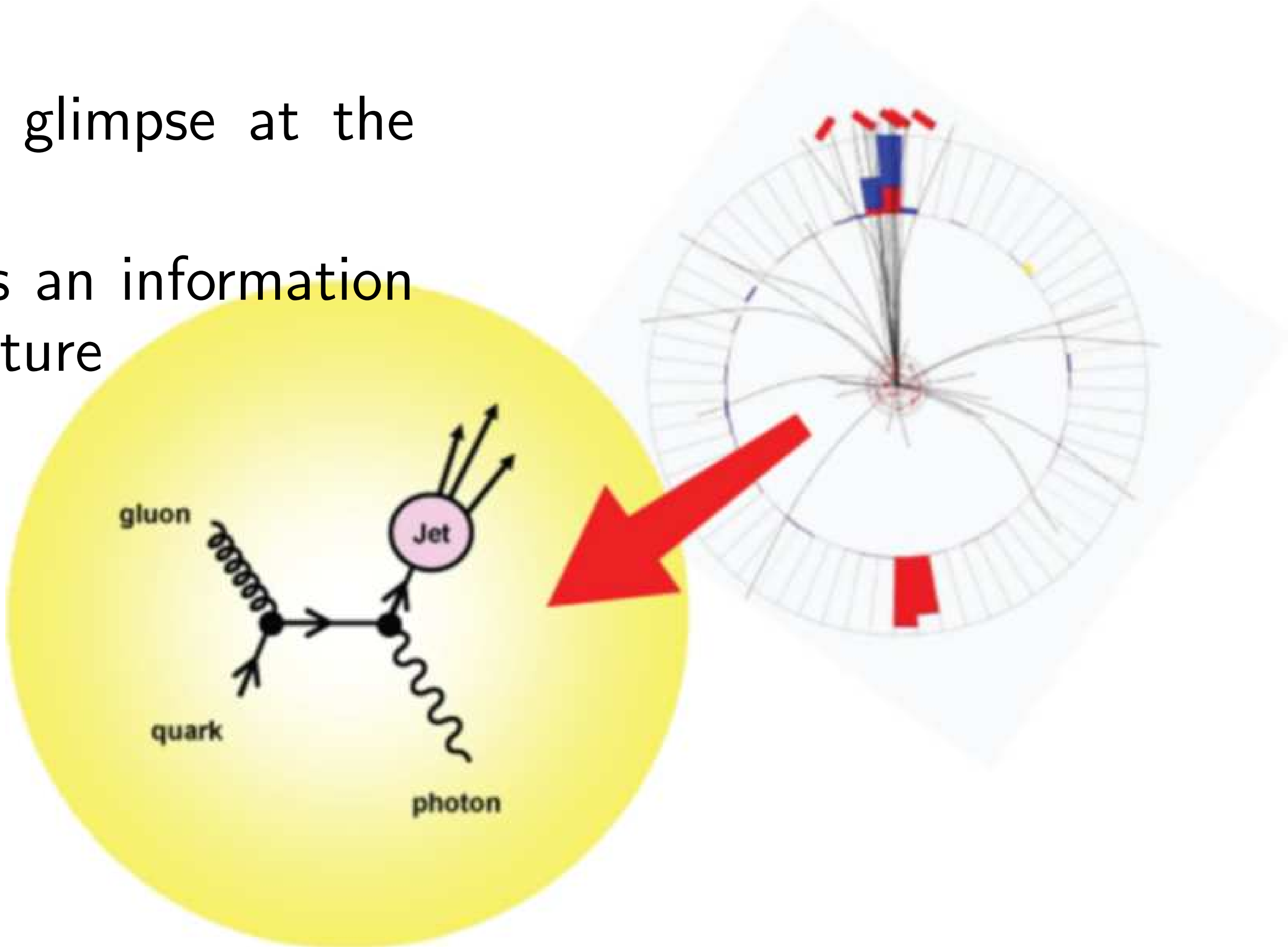
- event with the highest p_T jet ($p_T = 630\,\mathrm{GeV}$) so far seen by DØ





Isolated photon cross section

- Motivation
  - unlike jets, photons are not affected by multi-parton radiation and subsequent hadronization
  - photons give a direct glimpse at the heart of the collision
  - measurement brings us an information about the proton structure



- hep-ex/0511054

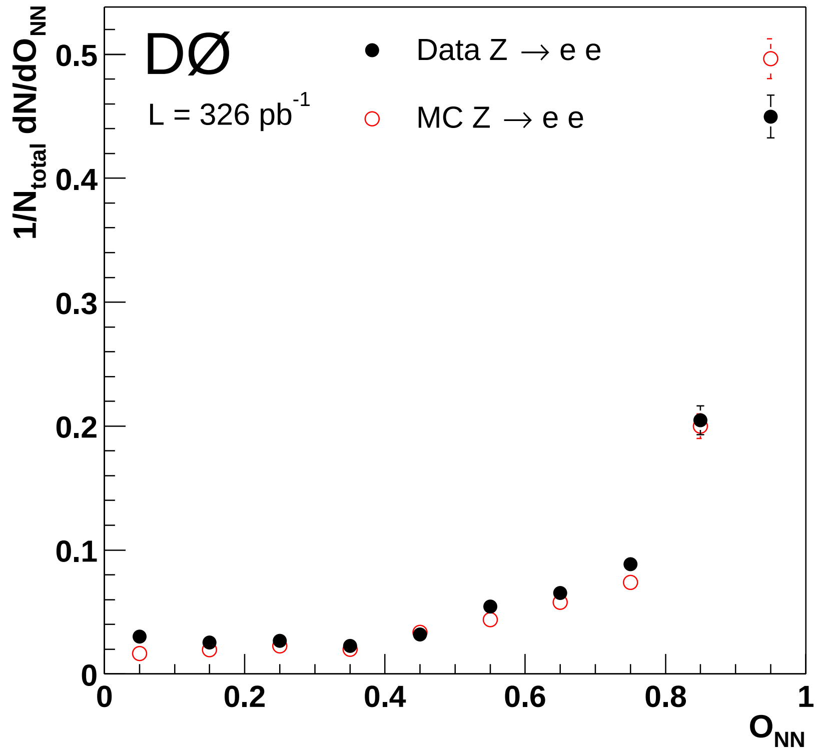
  submitted to Phys. Lett. B

Extracting the direct photon signal

- large background due to meson production in jets (like π^0 and η)
  - photon isolation

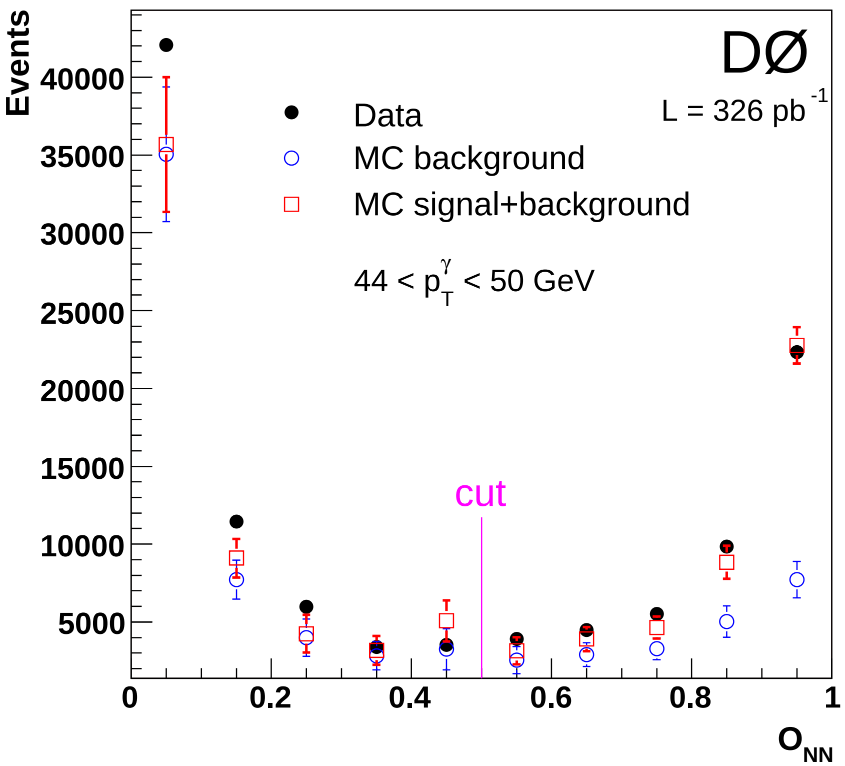
$$\frac{E_{\Delta R<0.4} - E_{\Delta R<0.2}}{E_{\Delta R<0.2}} < 0.10$$

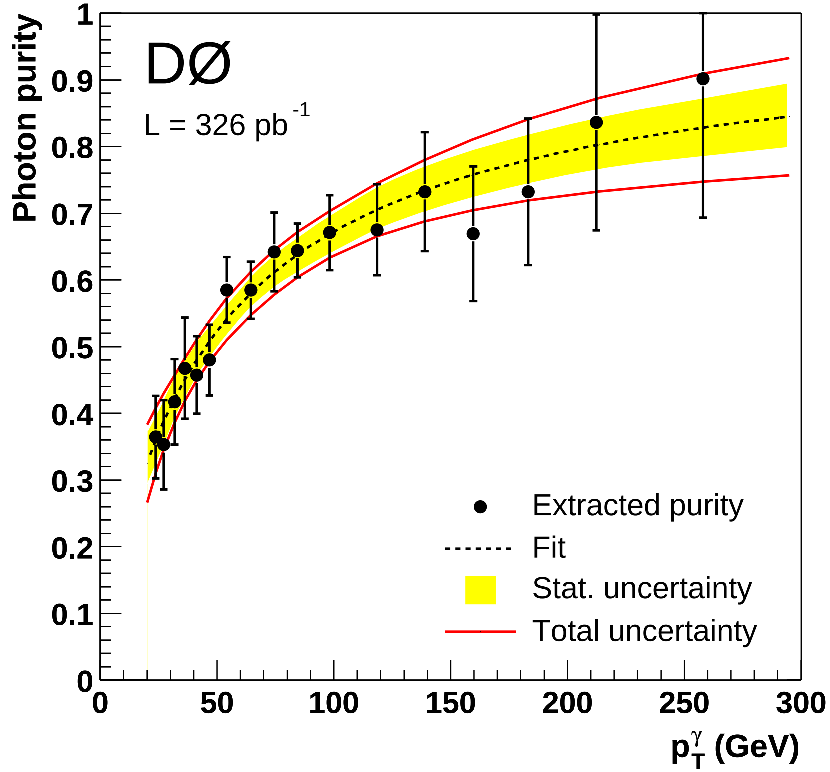
  - no matching track, most of energy deposited in the electromagnetic part of calorimeter, ...
  - neural network
    - number of EM cells in the 1st layer of calorimeter with $E > 0.4$ GeV in $R < 0.2$ and $0.2 < R < 0.4$ rings
    - sum of tracks p_T within $0.05 < R < 0.4$
    - width of EM cluster in the 3rd calorimeter layer



- test on $Z \to e^+e^-$ data

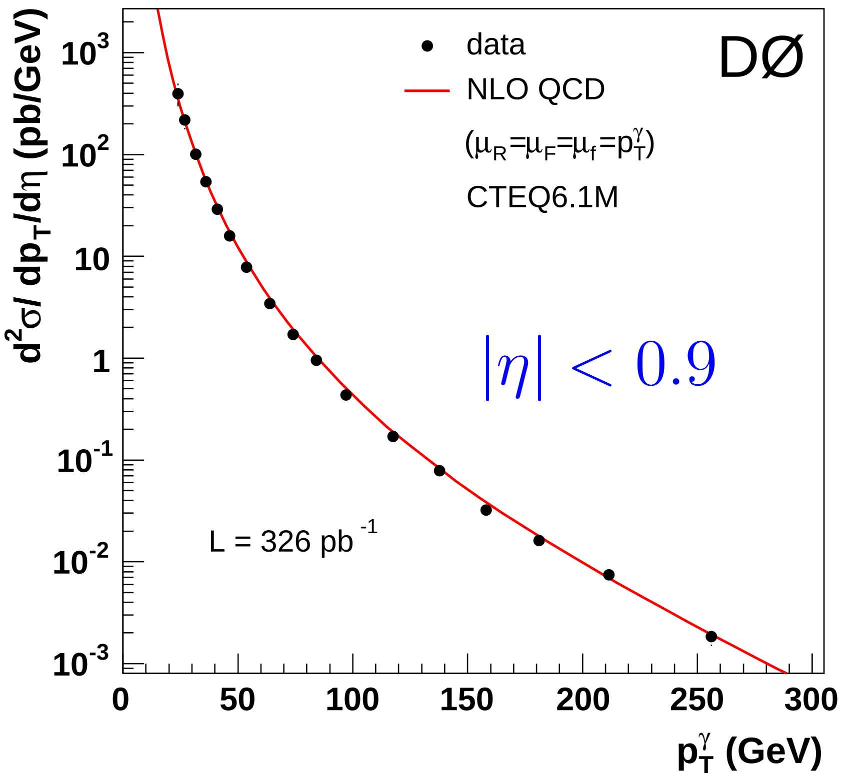
Estimation of photon purity

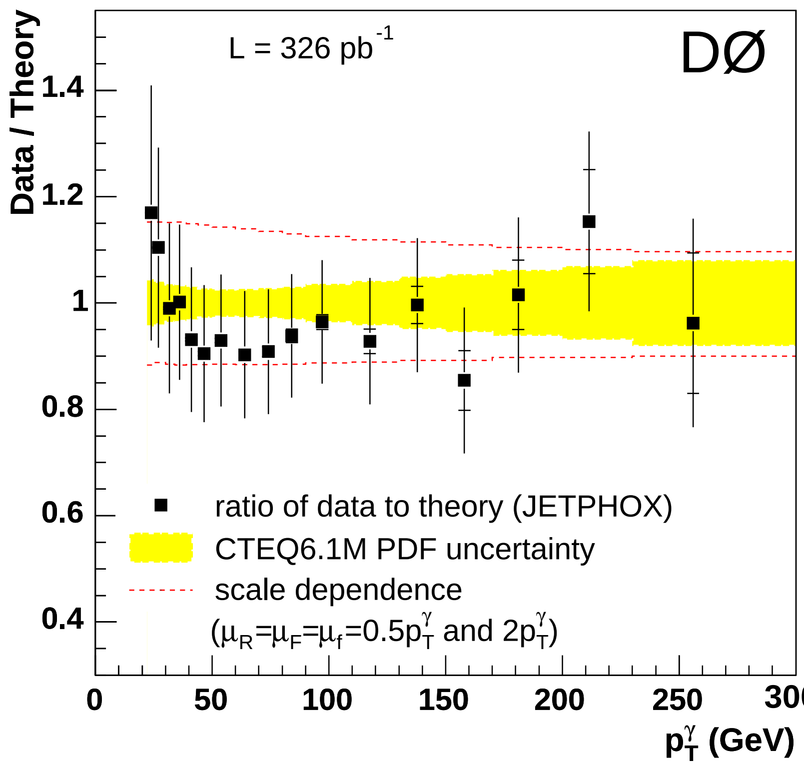




- background simulated with PYTHIA
  - preselected QCD and electroweak processes
- used to determine the photon purity of the final sample

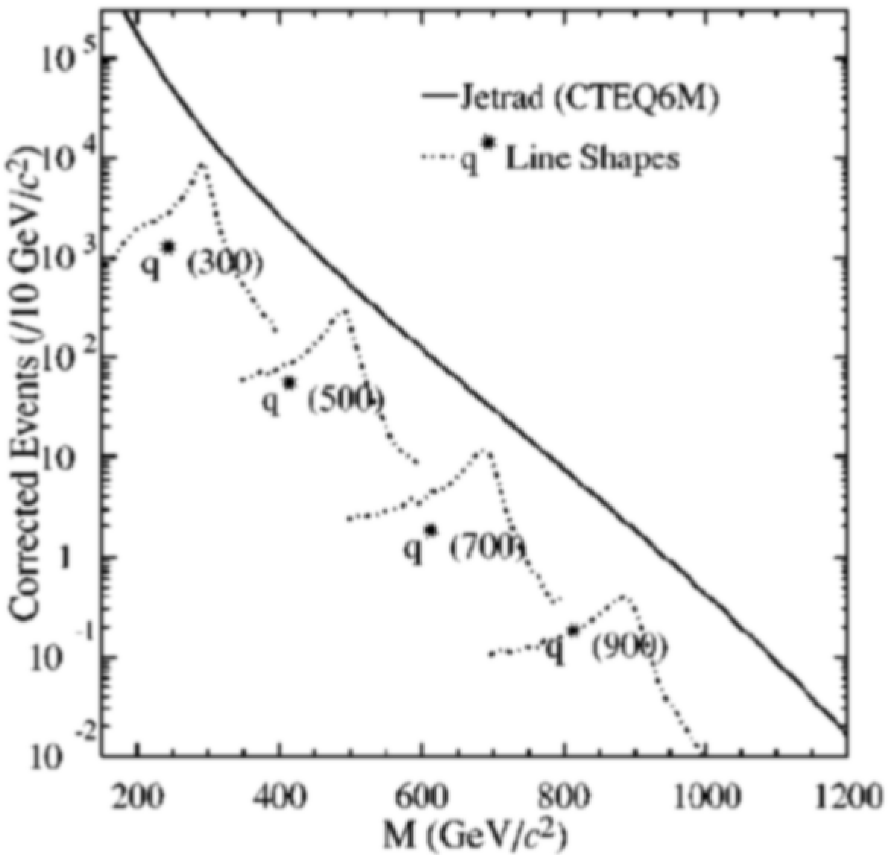
Photon cross section - final result



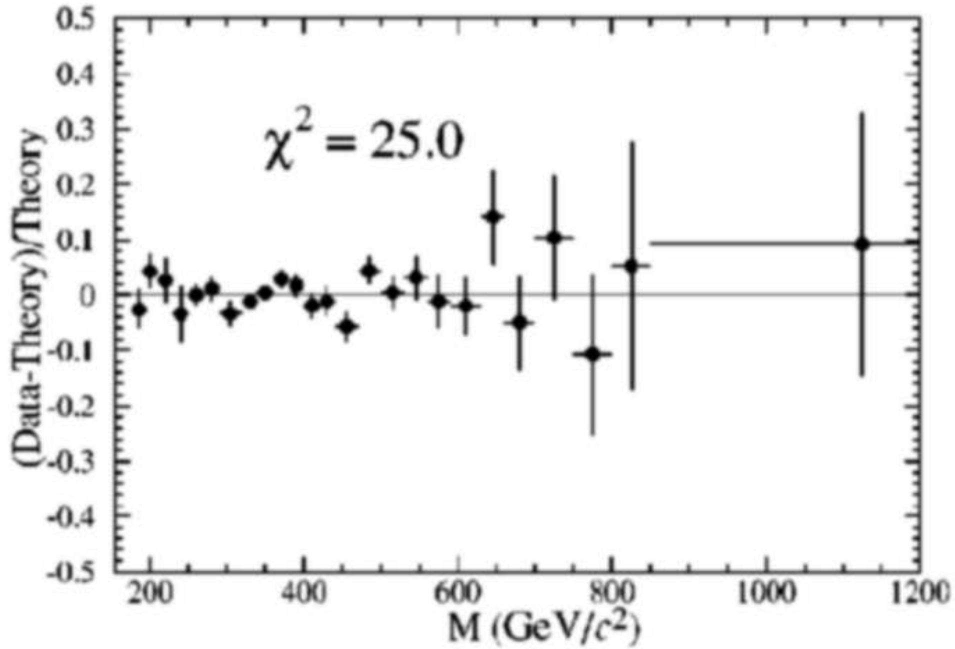


- central photon production measured over wide range of p_T: $23-300$ GeV
  - significant extension to Run I, where $p_{Tmax} \sim 110$ GeV
- good agreement with NLO QCD over 5 orders of magnitude
- experimental and theoretical errors have about the same size

Search for mass resonances (Run I)

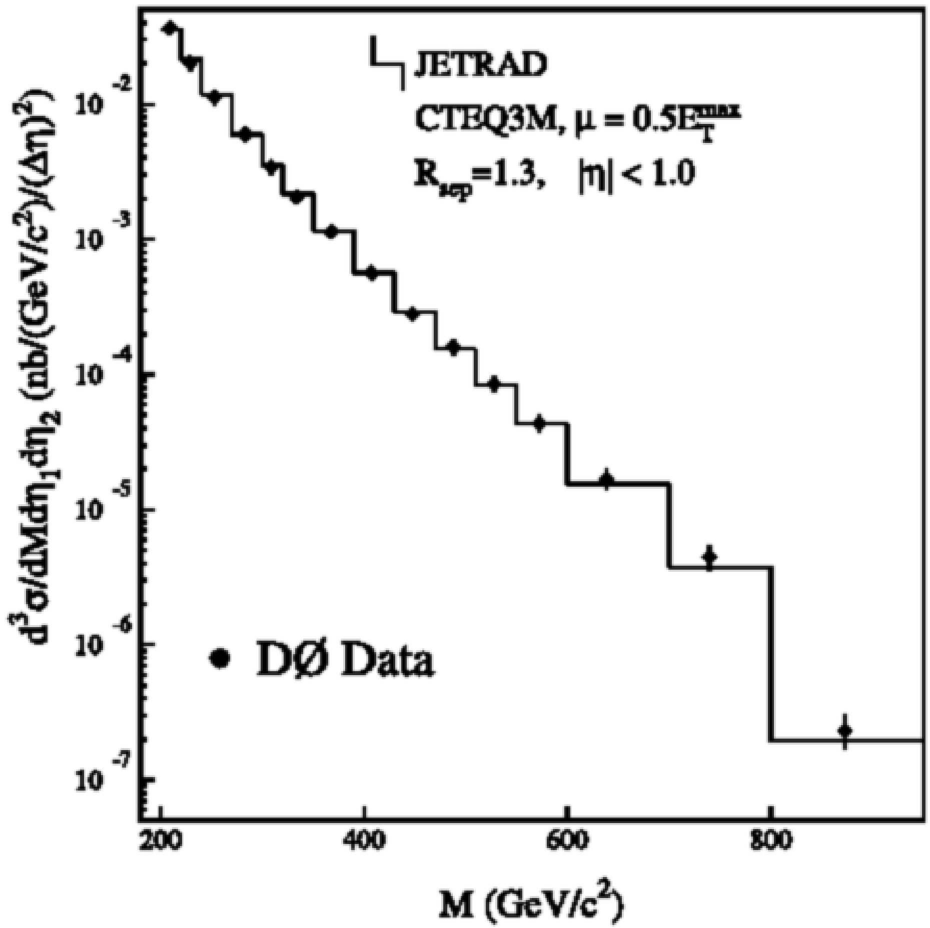


PRD Rapid Comm. 69, 111101 (2004)



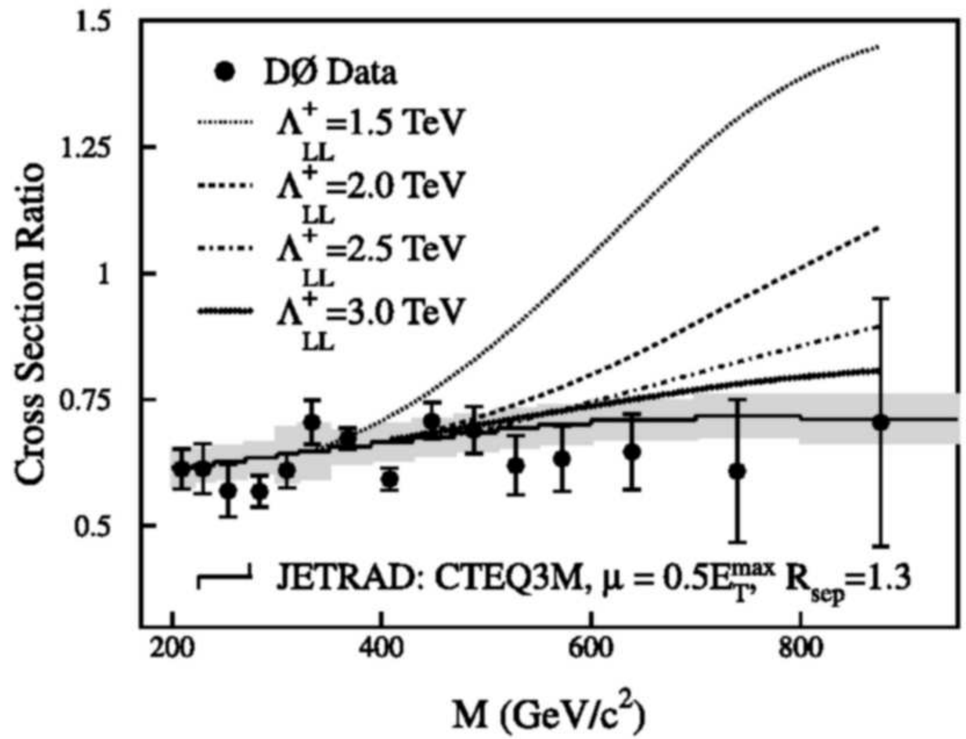
- no mass peak found
- limits on masses of Z', W', $q^\star$

M_{JJ} spectra in Run I - quark compositeness



Phys. Rev. D 64, 032003 (2001)

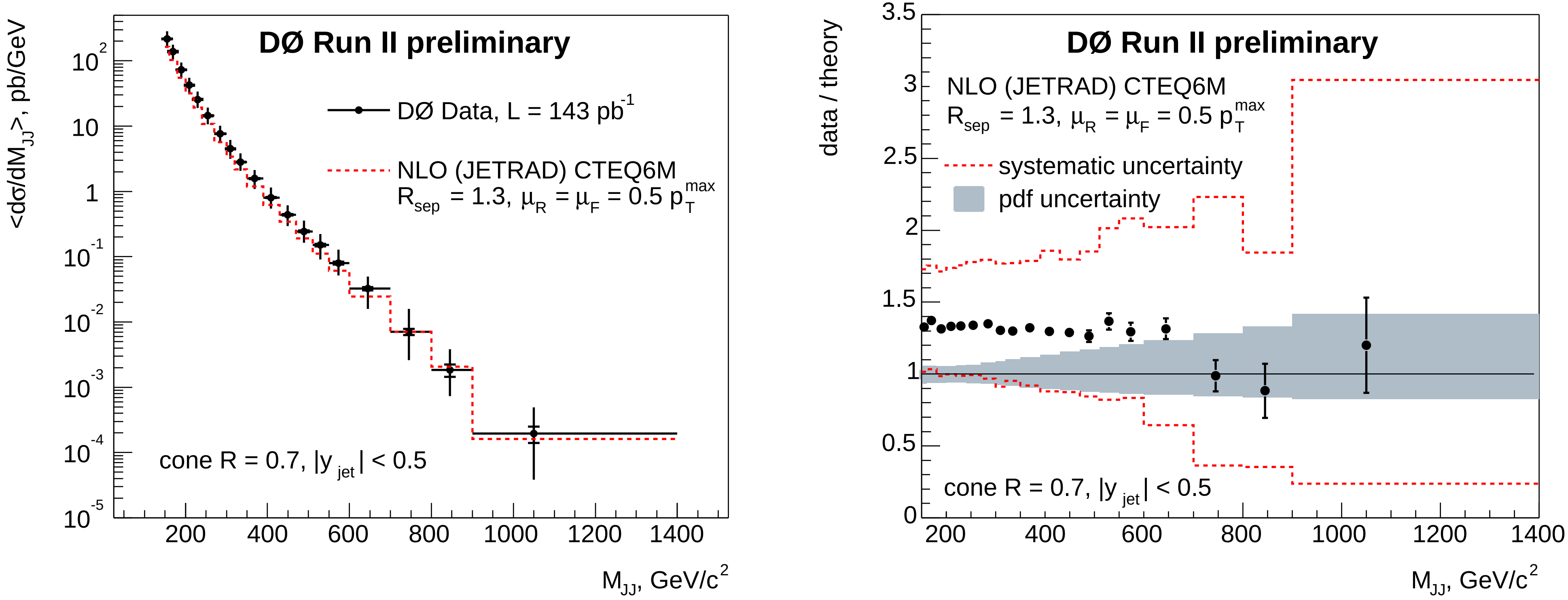
- ratio of dijet mass spectra in $|\eta| < 0.5$ and $0.5 < |\eta| < 1.0$



- limits on compositeness scale

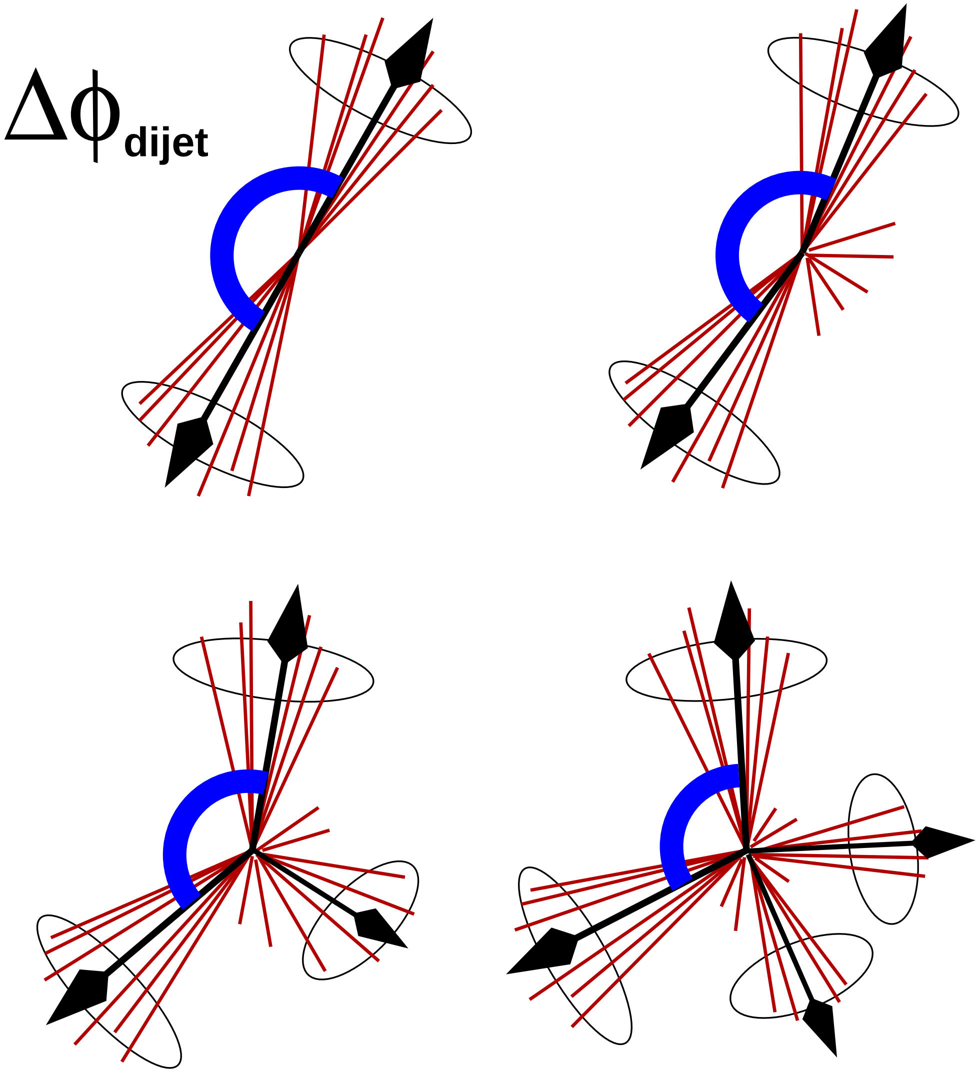
$$\Lambda^+_{LL} > 2.7\,\text{TeV}\ (95\%\ C.L.)$$

Dijet mass spectrum in Run II



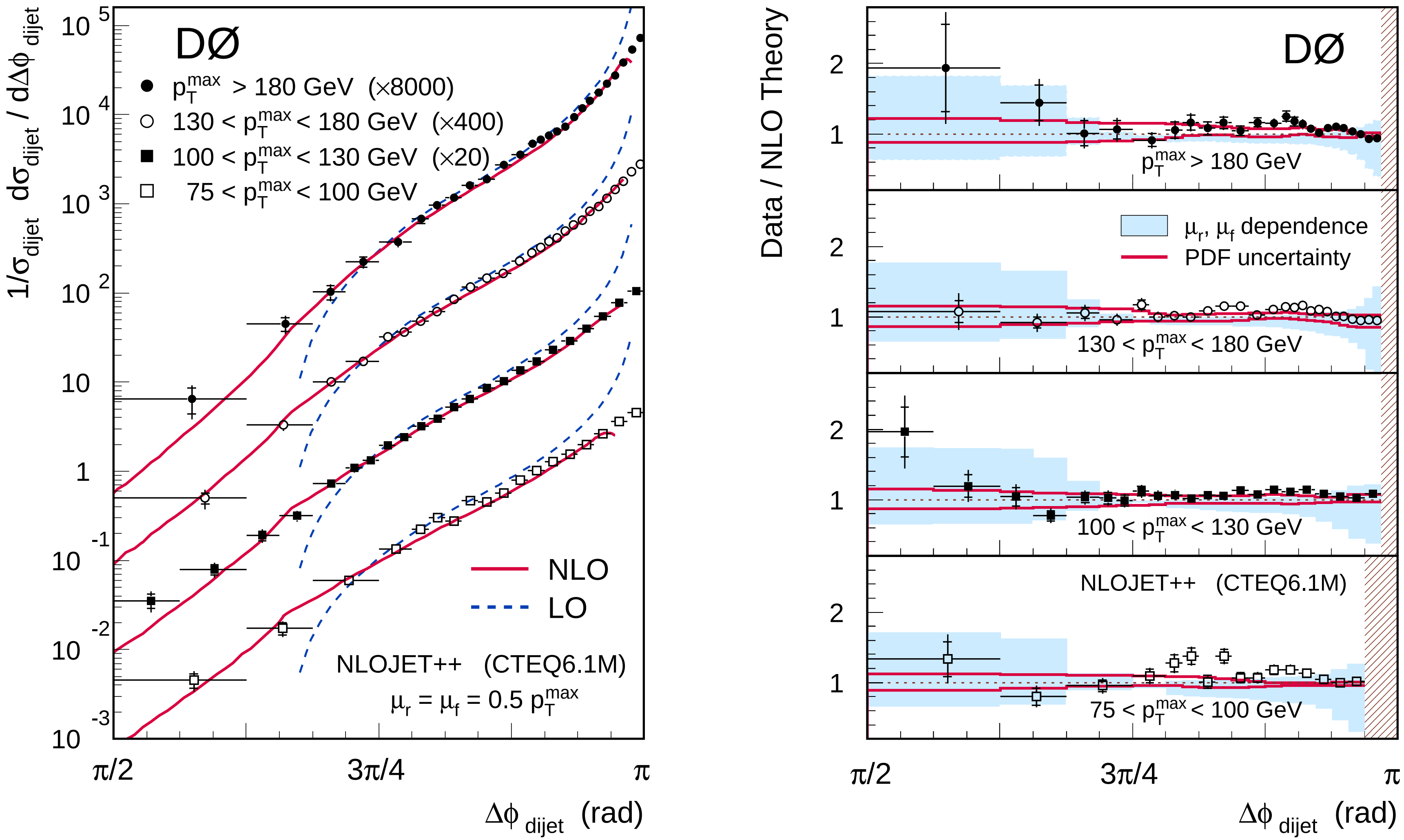
- good agreement with NLO QCD
- no high mass resonancies
- older result on smaller smaple and also with larger error from jet energy scale

Dijet azimuthal decorrelations



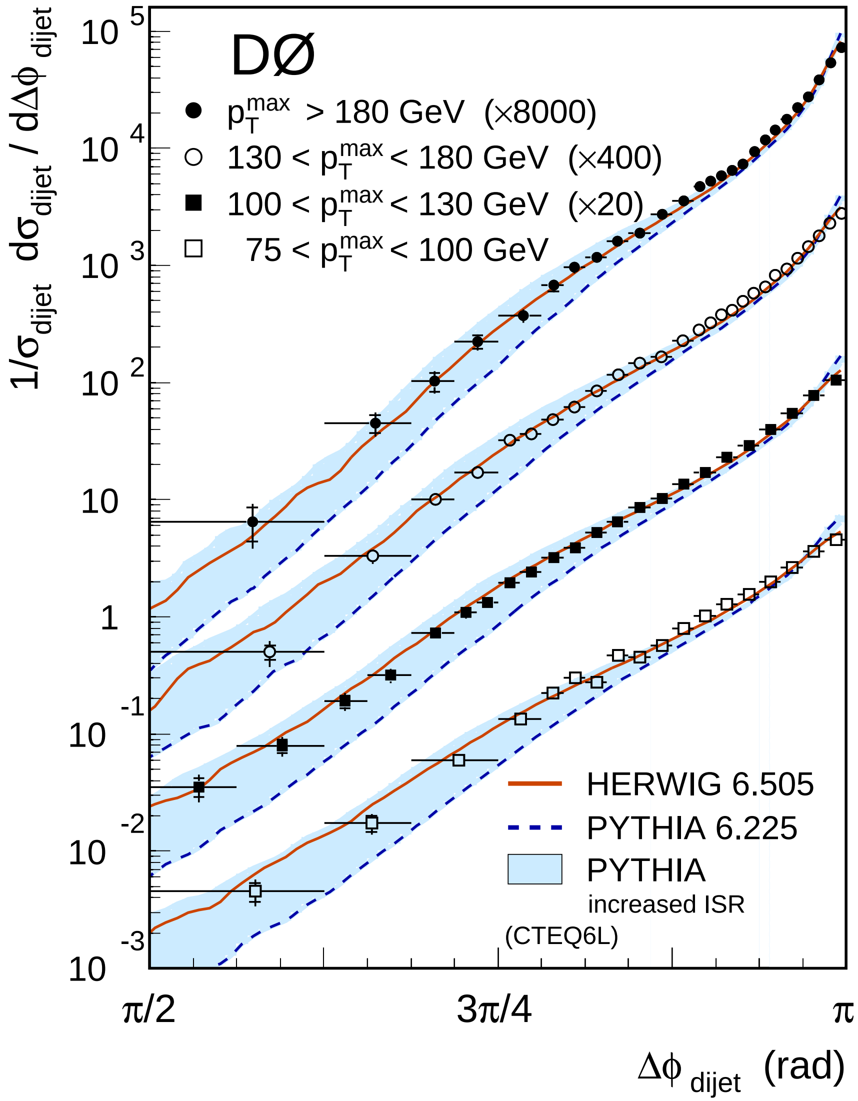
- different regions of $\Delta\phi_{dijet}$ are sensitive to different aspects of multiparton emissions
- a clean and simple way to study QCD radiative processes
  - reduced sensitivity to jet energy calibration
- Phys.Rev.Lett.94:221801,2005

$\Delta\phi$ - comparison with pQCD



- comparison with $2 \to 3$ NLO calculations (these were not available in Run I)
- agreement with NLO QCD except $\Delta\phi \to \pi$ where resummation is needed

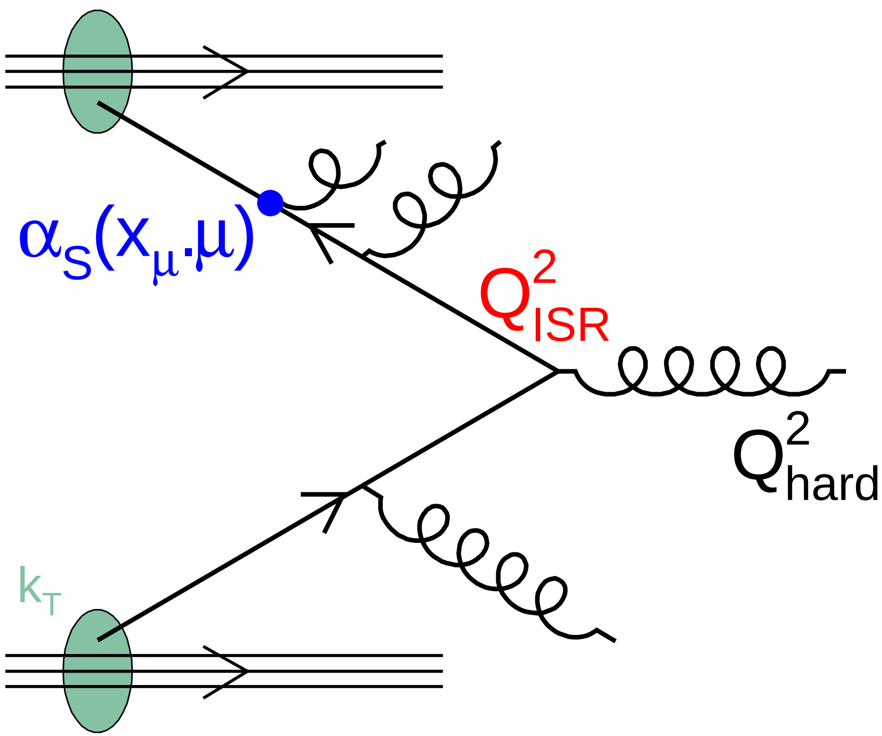
$\Delta\phi$ - comparison with MC

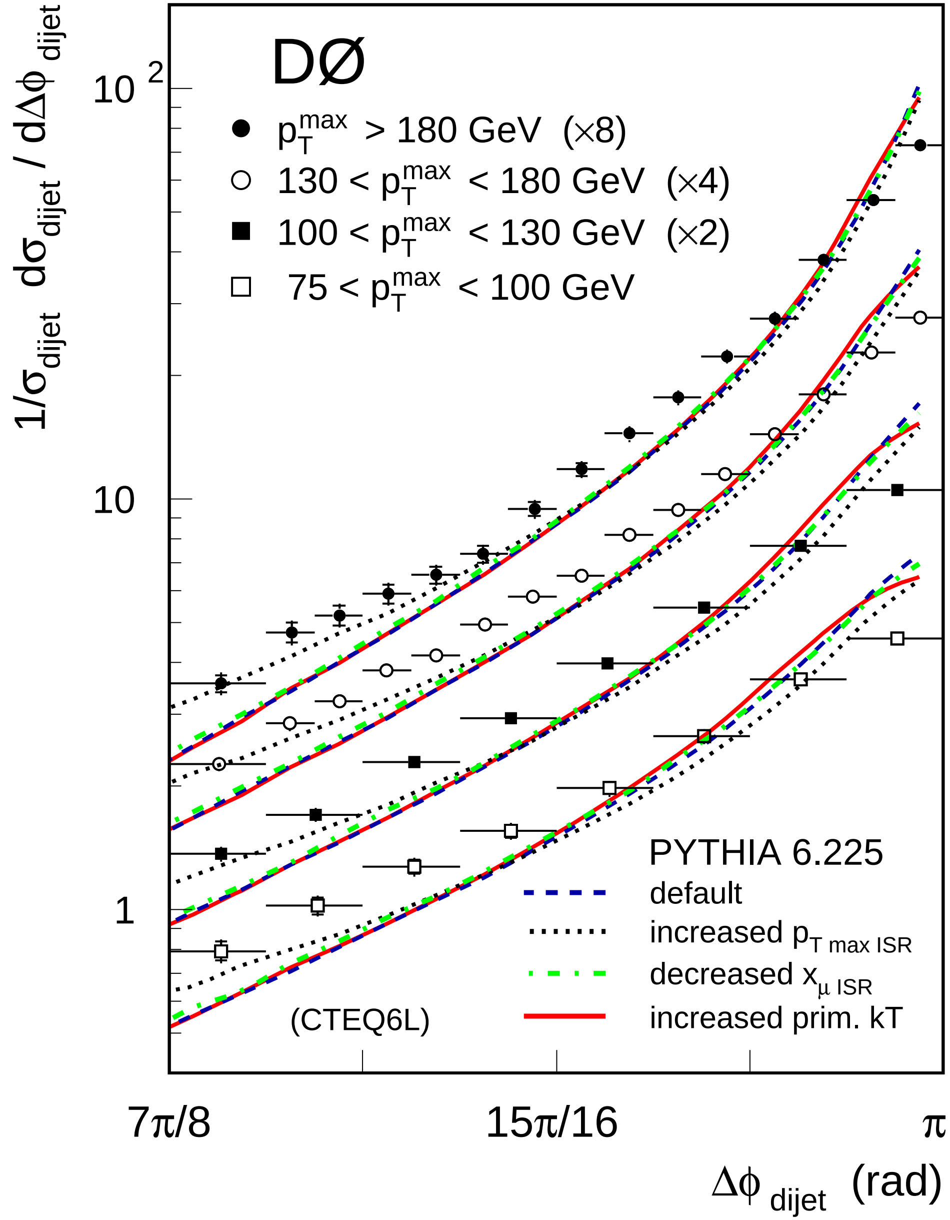


- HERWIG shows a good agreement with the data
- not true for default setting of PYTHIA
  - the distribution is sensitive to PARP(67) which controls the maximal allowed virtuality in the initial state parton shower
  - PARP(67)=2.5 fits the data well

The plot demonstrates the impact on tuning the MC generators

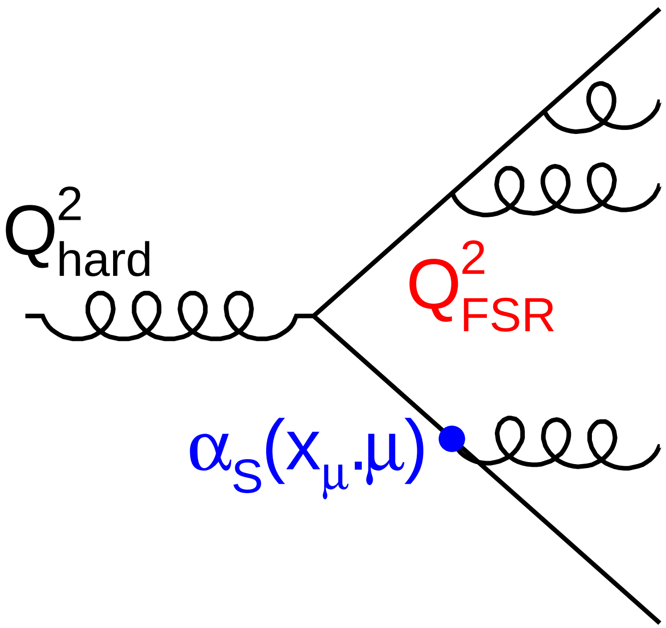
Initial state radiation in Pythia

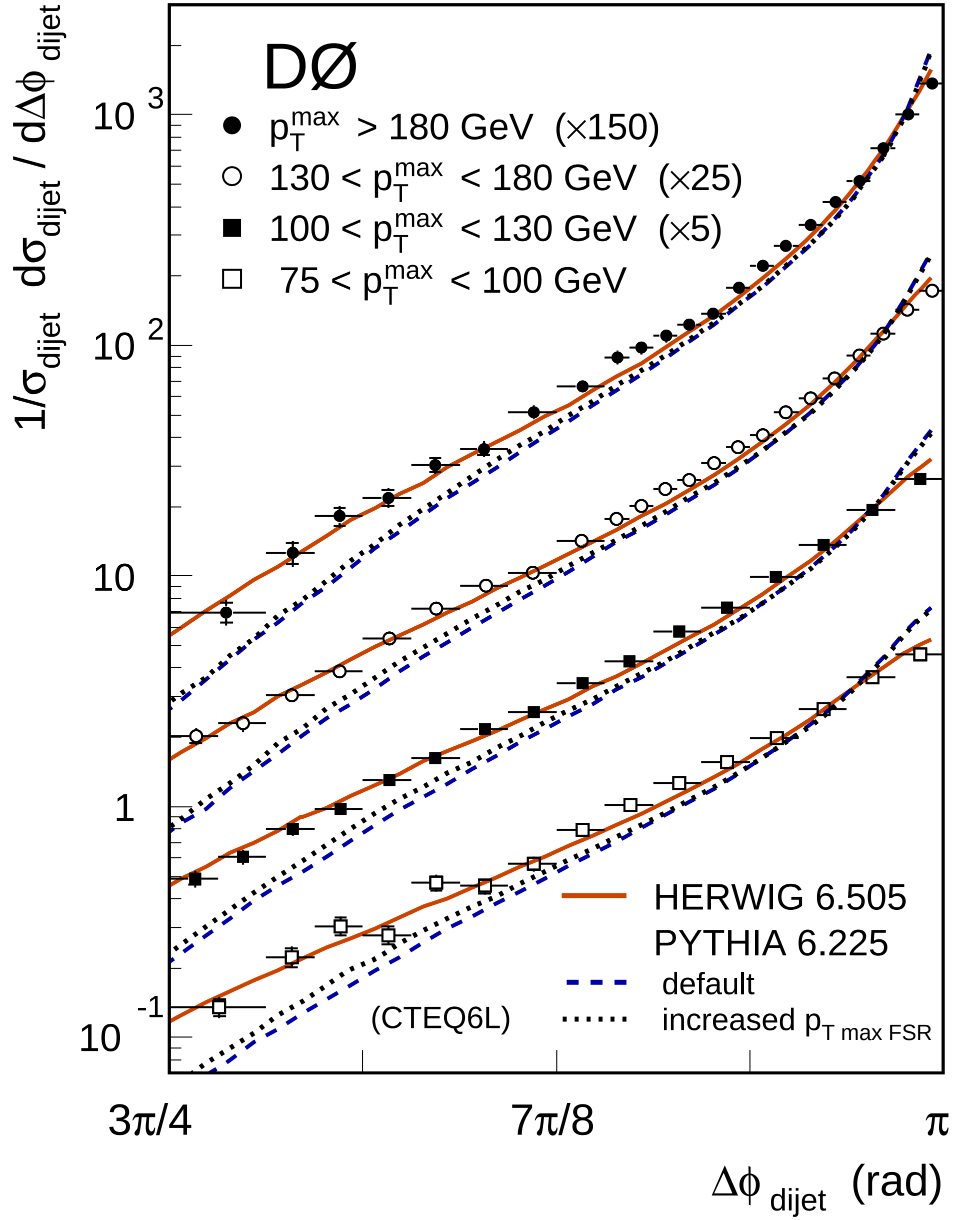




- maximum allowed virtuality Q^2_{ISR}
- scale in α_S
- primordial parton k_T

Final state radiation in Pythia





- maximum allowed virtuality Q^2_{FSR}
- almost no impact on the $\Delta\phi_{dijet}$ distribution

Summary

- With respect to RunI, the reach in jet p_T was significantly extended for jet inclusive p_T cross sections
  - testing pQCD at distances not explored before
  - jet cross section consistent with QCD over 8 orders of magnitude
  - new jet algorithms with better theoretical behavior are being used
  - reducing experimental errors will lead to better understanding of gluon content of proton at high x
- Similarly, for the measurement of isolated photon production
  - cross section in good agreement with NLO QCD over 5 orders of magnitude
  - result can be used in global PDF fits
- For the measurement of dijet angular decorration
  - decorrelation is well described by NLO QCD except region of $\Delta\phi \to \pi$, where resummations of soft gluon emissions are needed
  - data are useful for tuning models of multi-partonic emissions in MC event generators
- New results based on $1\,\mathrm{fb}^{-1}$ with reduced error on JES are coming soon