Monte Carlo Study of the Asymmetry of top-quark pairs at the Fermilab Tevatron

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Outline

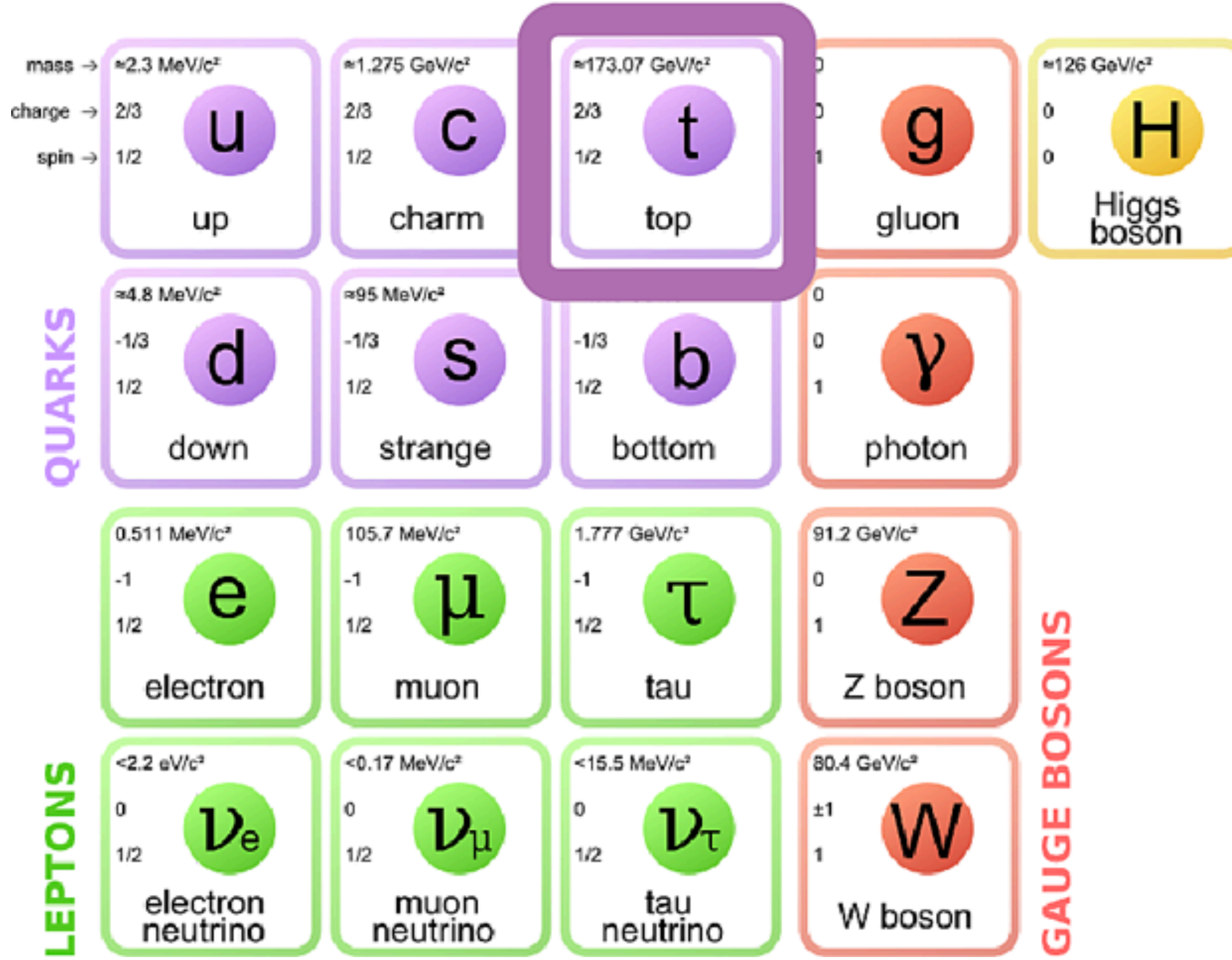
- Introduction
- Forward-backward asymmetry measurement methodology and the search for new particles at the Fermilab Tevatron
- Validation of methodology
- Conclusions

The Standard Model (SM)

Six type of quarks

Top quark

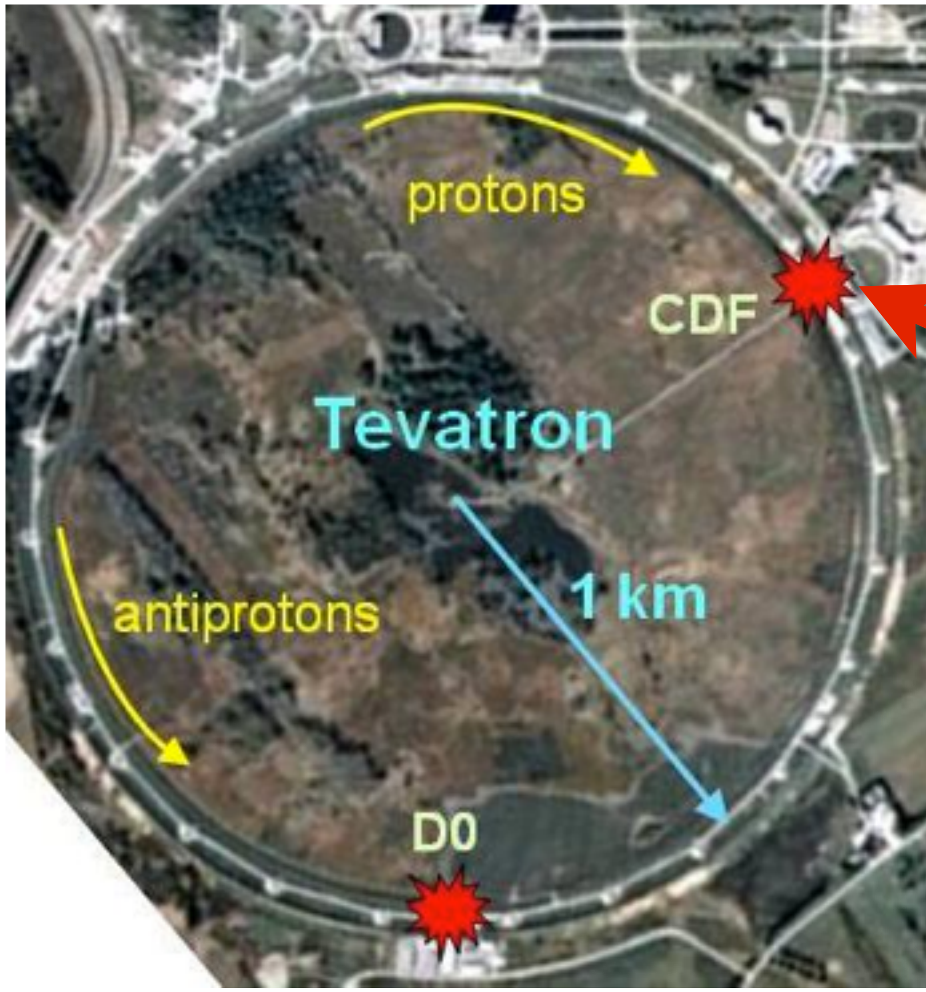
- Observed at Tevatron (1995)
- Heaviest quark $m_t \approx 173\ GeV/c^2$

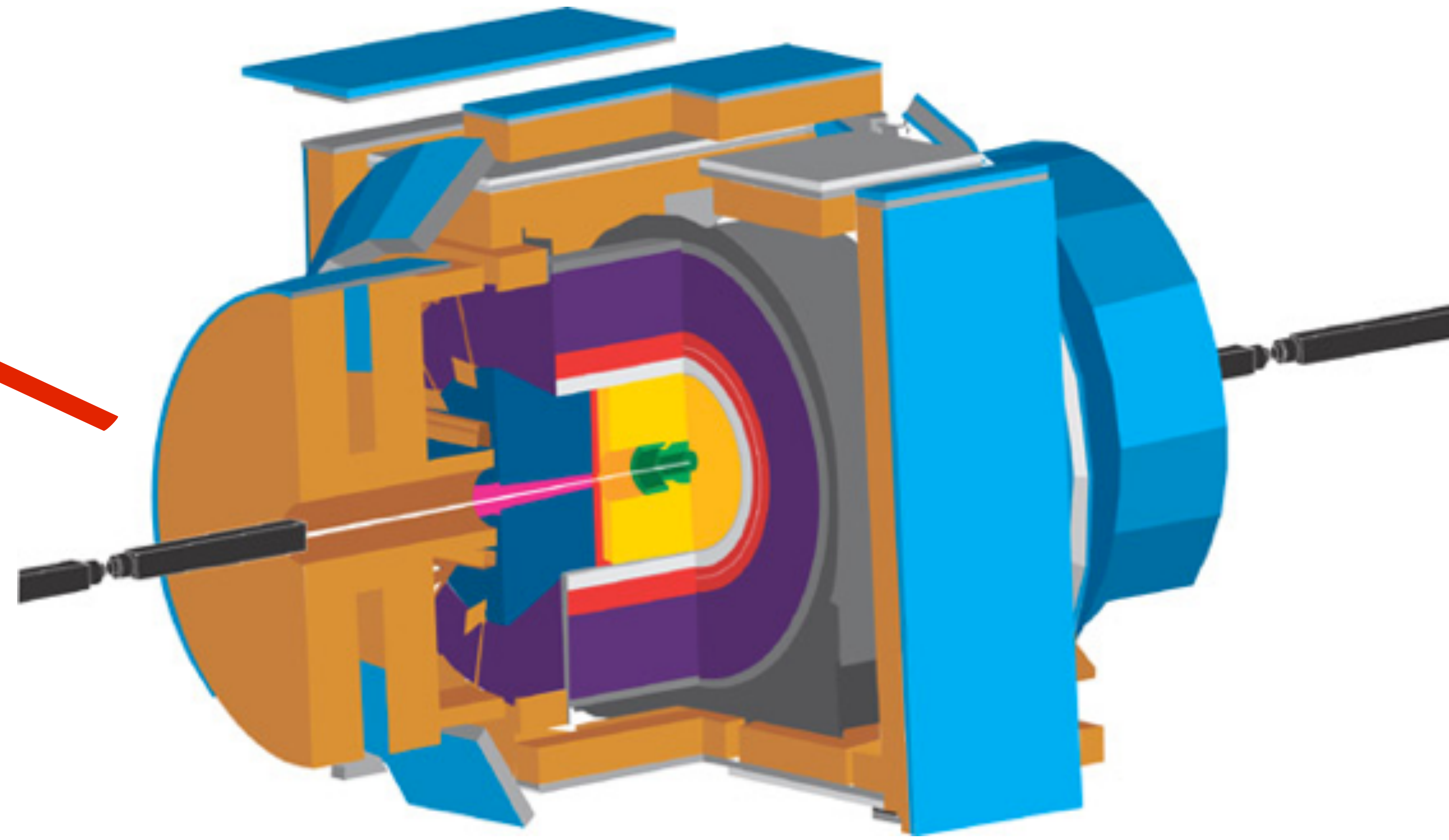


Tevatron

- Tevatron - the accelerator at Fermilab
- Use it to accelerate particles to very high kinetic energy (~2000 times the mass of the proton)
- Collisions of proton & anti-proton produce top-quark pairs

Collider Detector at Fermilab (CDF)

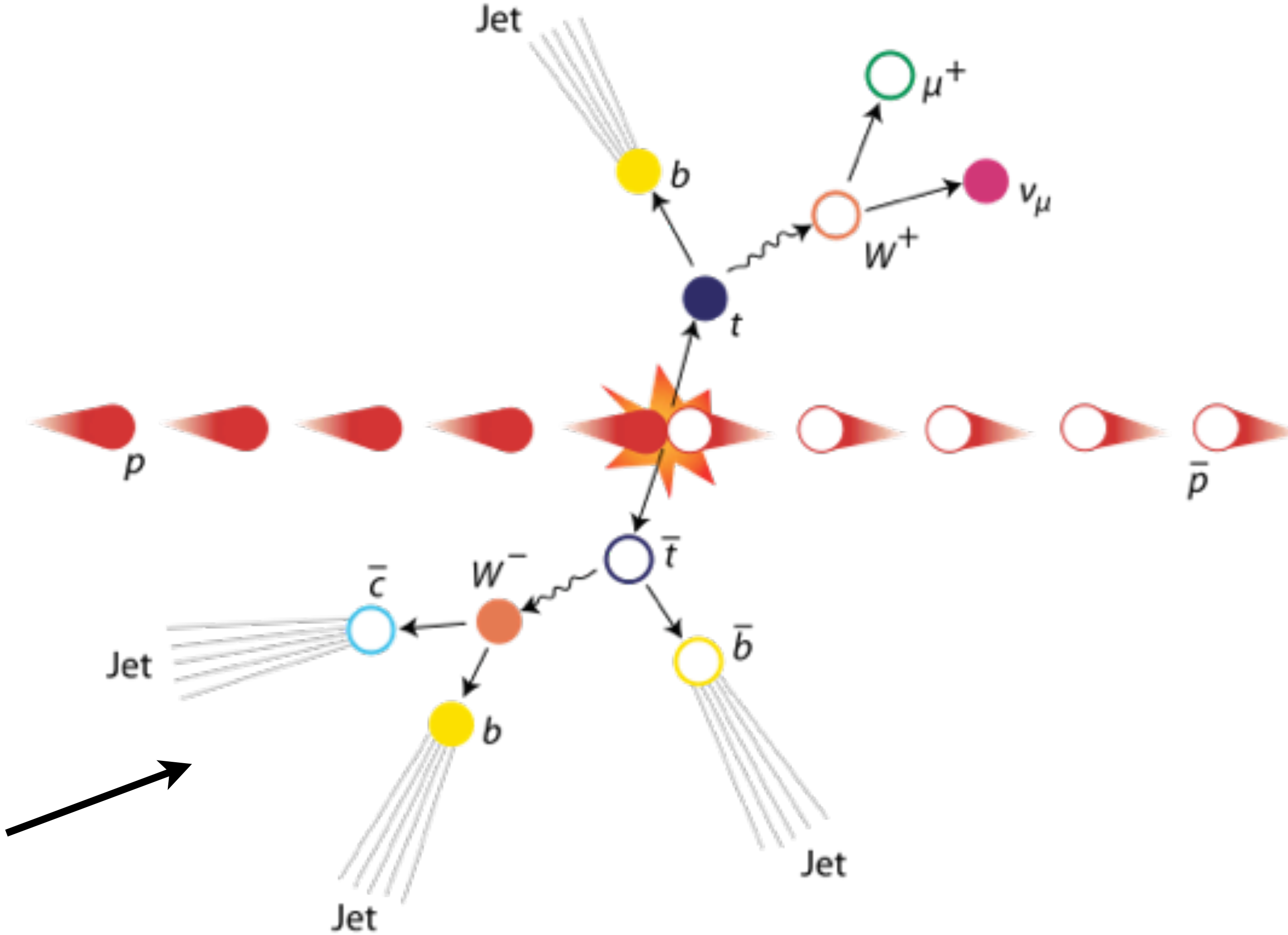




- Located at where collisions happen
- Records the energy and direction of the particles produced

Top Quark

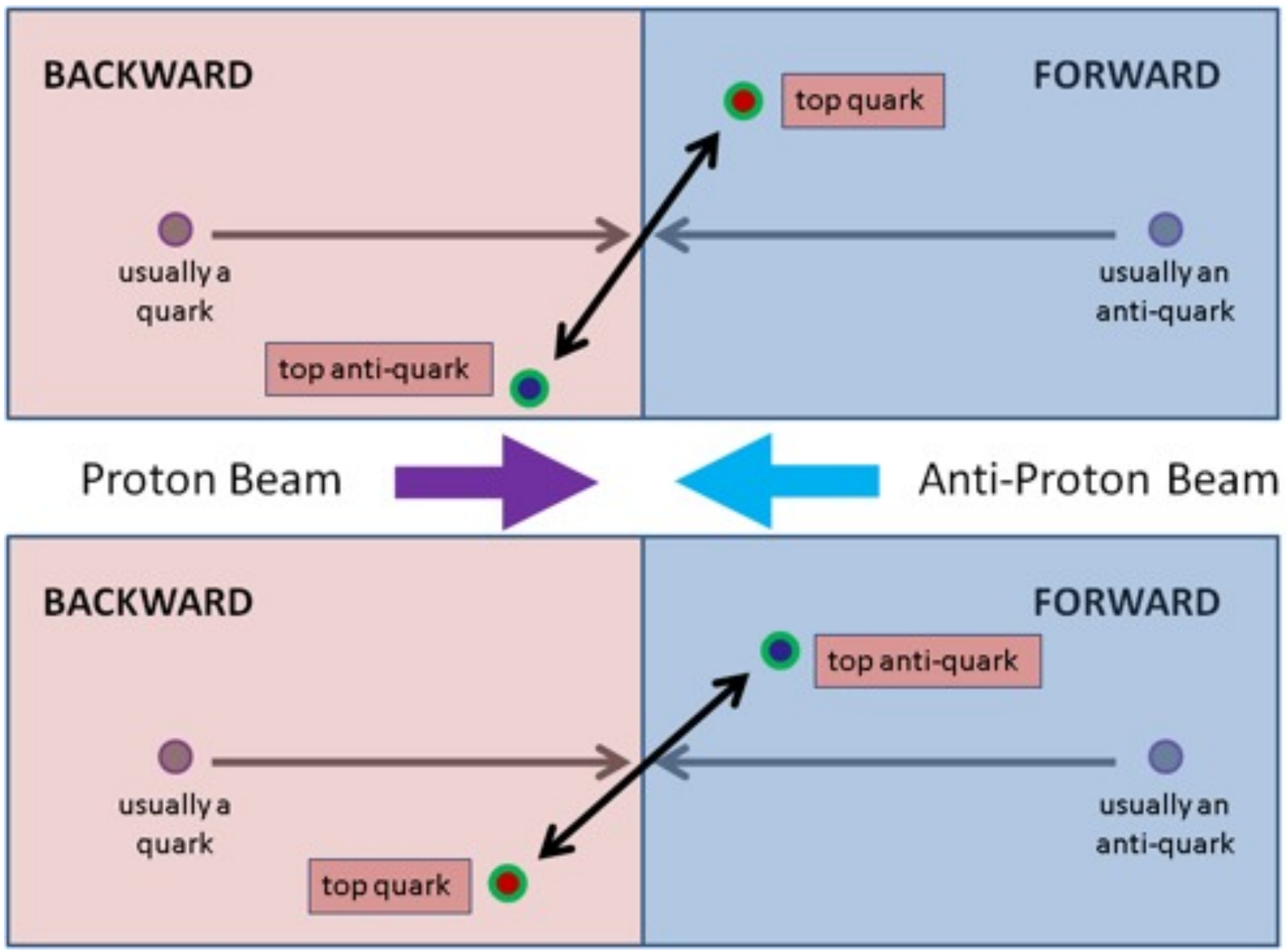
- Very heavy
- Very short lived



top-quark pair production

Fascinating Particle
- key to understand Standard Model

Forward-backward Asymmetry



Forward
- top quark follows the proton direction

Backward
- top quark follows the anti-proton direction

Asymmetry - difference between the fraction of top quarks going forward and the fraction of them going backward

Hot topic at Tevatron for years

Why?

Compare the Theoretical Prediction with The Experimental Results

Standard Model of Particle Physics predicts a small asymmetry	$\not\Leftrightarrow$	Experiment at the Tevatron observes a large asymmetry

Hint for new physics ?

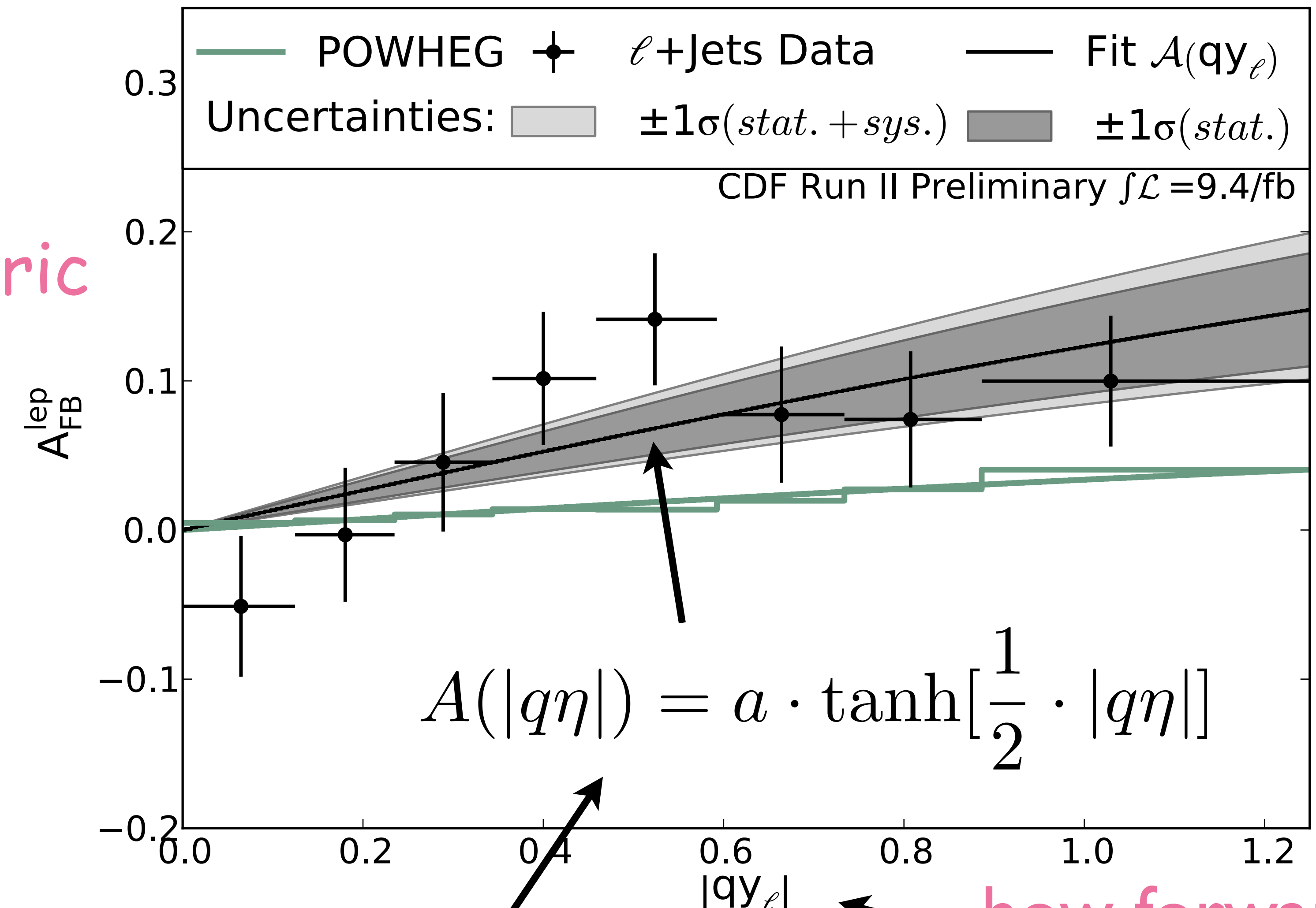
Possible alternative hypotheses:

Axigluon - new particle similar to gluon, but massive

PRD 87, 034039 (2013)

Experimental Measurement Methodology

how asymmetric



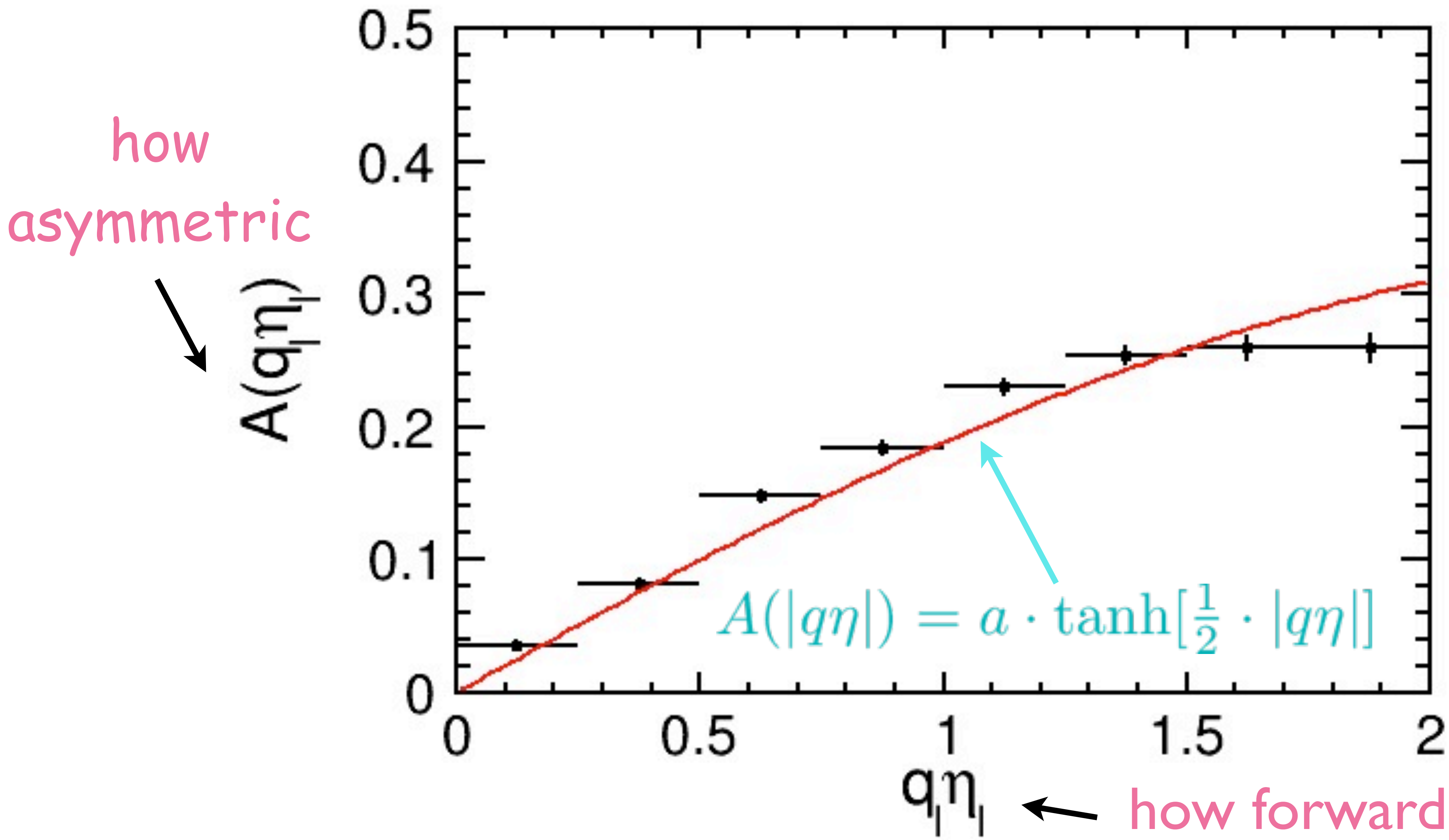
how forward

Data not terribly consistent with the expectations

PRD 88, 072003 (2013)

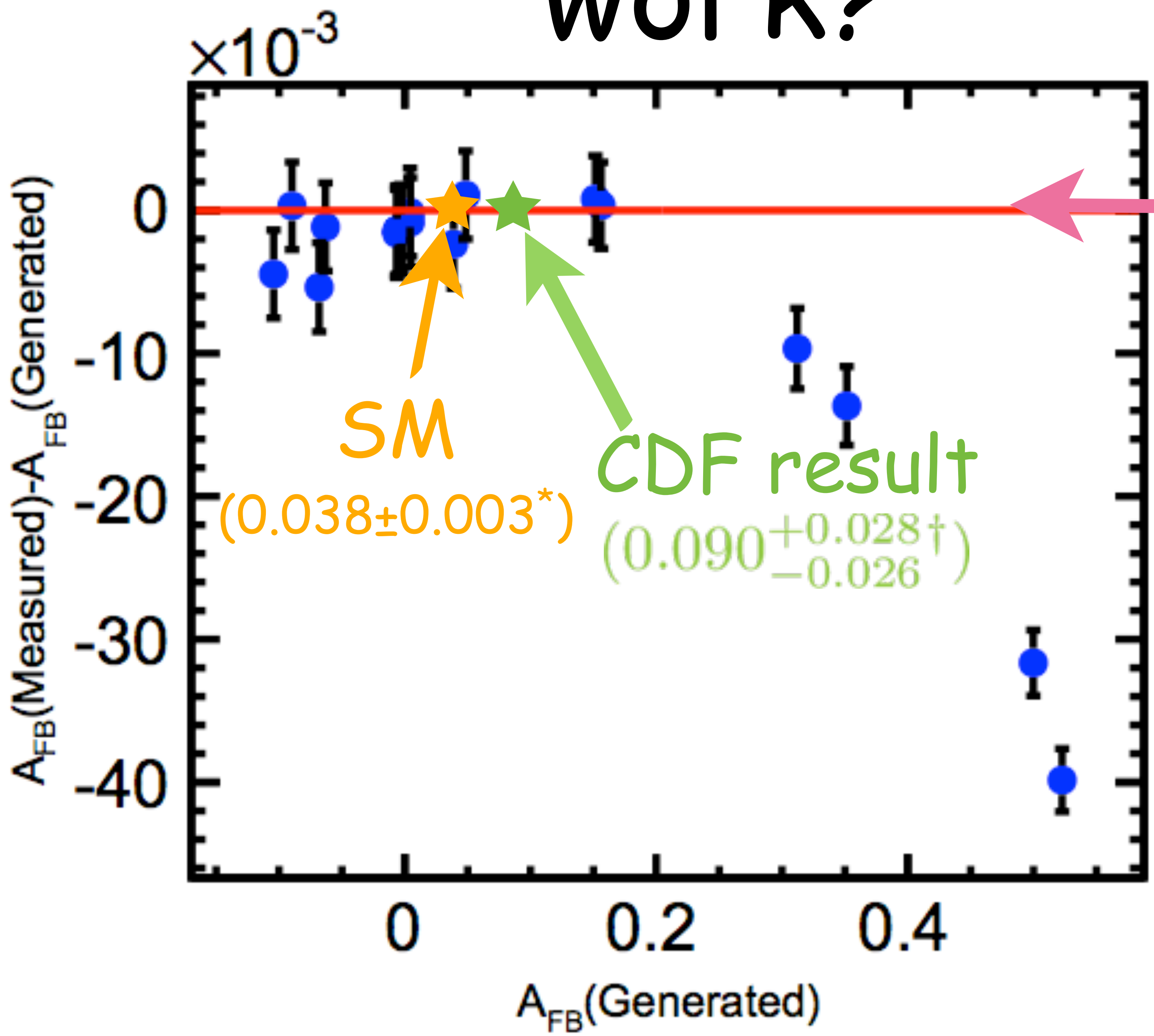
- CDF used a **technique** for measuring asymmetry (characterized by the decay products of top-quarks)
- Have shown this works in scenarios without new particle
- Test if this technique works for Axigluon models

Axigluon Simulation



- Simulate number of different new particles and what they would look like in our experiment (example above)
- Use the same measurement on our simulated data
- Test if we get back the true asymmetry in the model

How well does the methodology work?



* PRD 86, 034026 (2012)
†PRL 113, 042001 (2014)

- **Conclusion:** the methodology works very well except for when the true asymmetry is MUCH larger than observed

Conclusions

- The asymmetry of top-quark pairs at the Tevatron is still a hot topic
- CDF measured the asymmetry of top quark pairs to be higher than the Standard Model prediction, leaving room for the possibility that there are new particles being observed in our data
- Validated the measurement used by CDF, confirmed that if there were a new particle we wouldn't be biased in our measurement