Top Quark Pair Production at ILC @ 500 GeV

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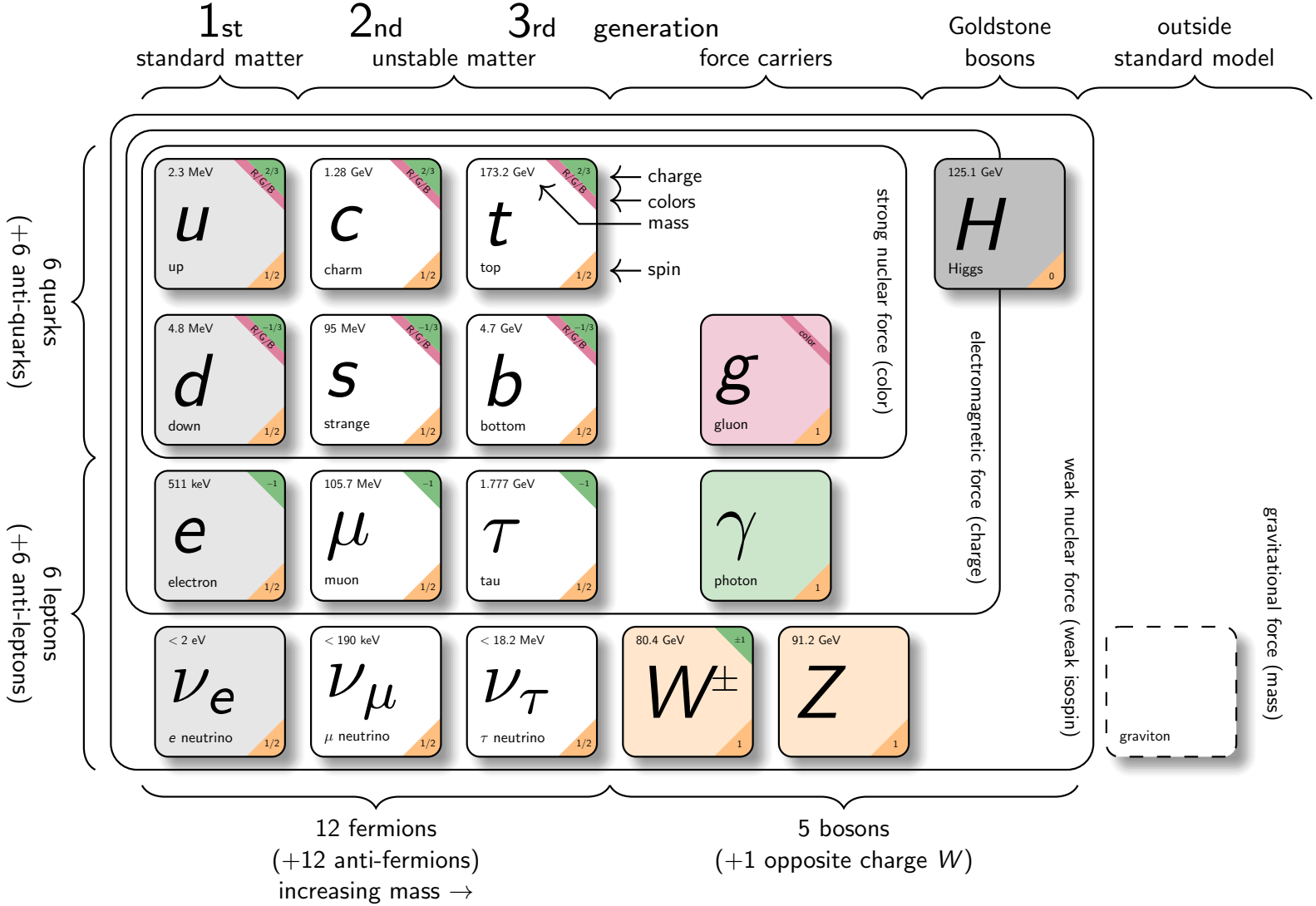
Standard Model



Motivation

Physics

- We look at top-quark pair production via electron-positron collision in ILC at 500 GeV scenario.
- Top-quark is the heaviest elementary particle we know as far as the Standard Model (SM) suggests. It's mass $m_{top} \approx 175$ GeV is on the same level as that of massive gauge boson.
- If we could assess the the coupling between Top quark and W boson, we would possibly be able to confirm electroweak symmetry breaking, indicating the physics Beyond SM.

Physical Observables

Forward and backward asymmetry

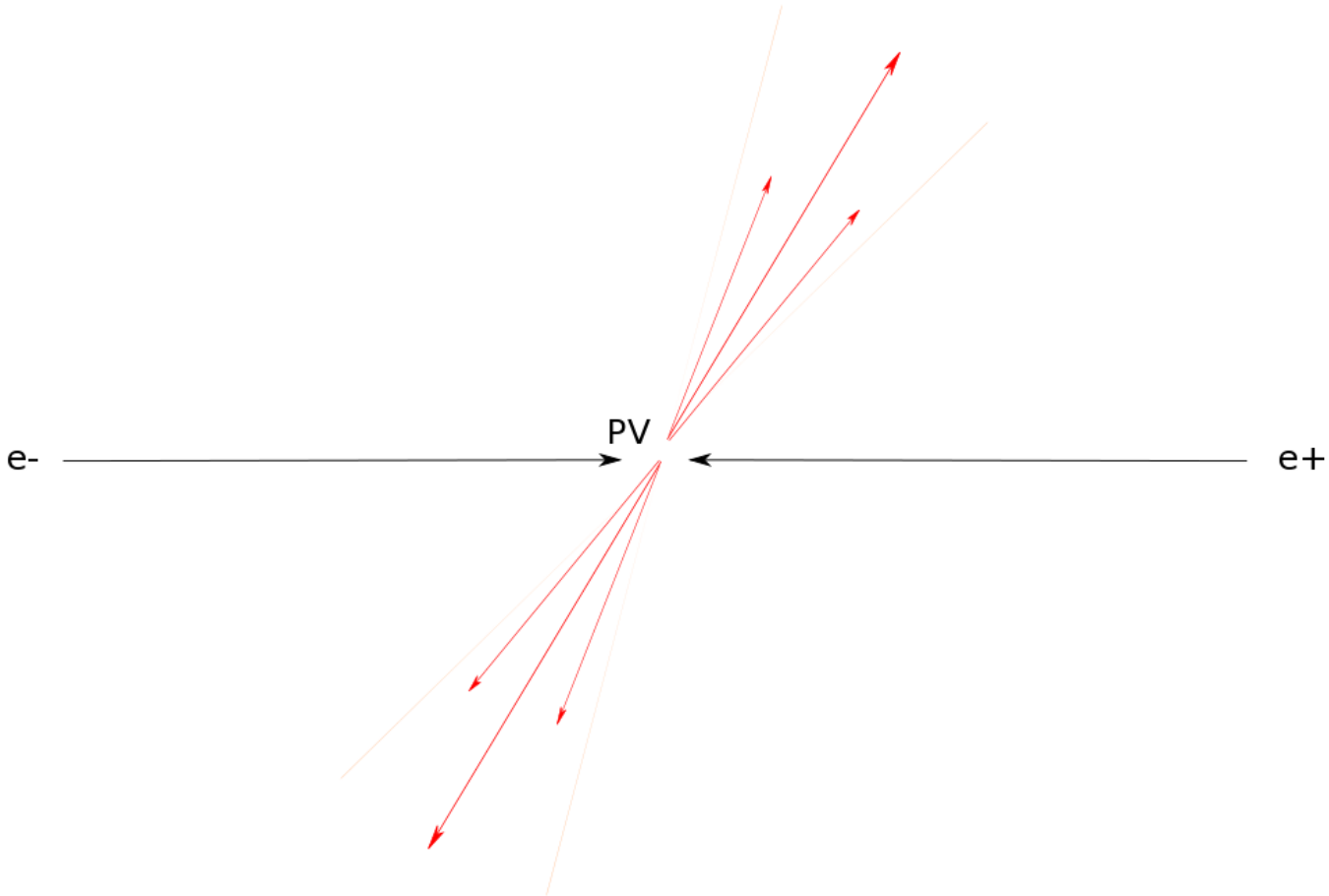
$$A_{fb} \equiv \frac{N(\cos\theta > 0) - N(\cos\theta < 0)}{N(\cos\theta > 0) + N(\cos\theta < 0)}$$

where θ is a polar angle of top quark with respect to the beam line.

- A_{fb} is used as a key estimator for the electroweak coupling between top-quark in this analysis, yet does not address on actual physical values in this analysis.
- Decent measurement performance on vertex charge measurement is required to distinguish top and anti-top, in order to calculate reliable A_{fb} value.

Collision

Collision



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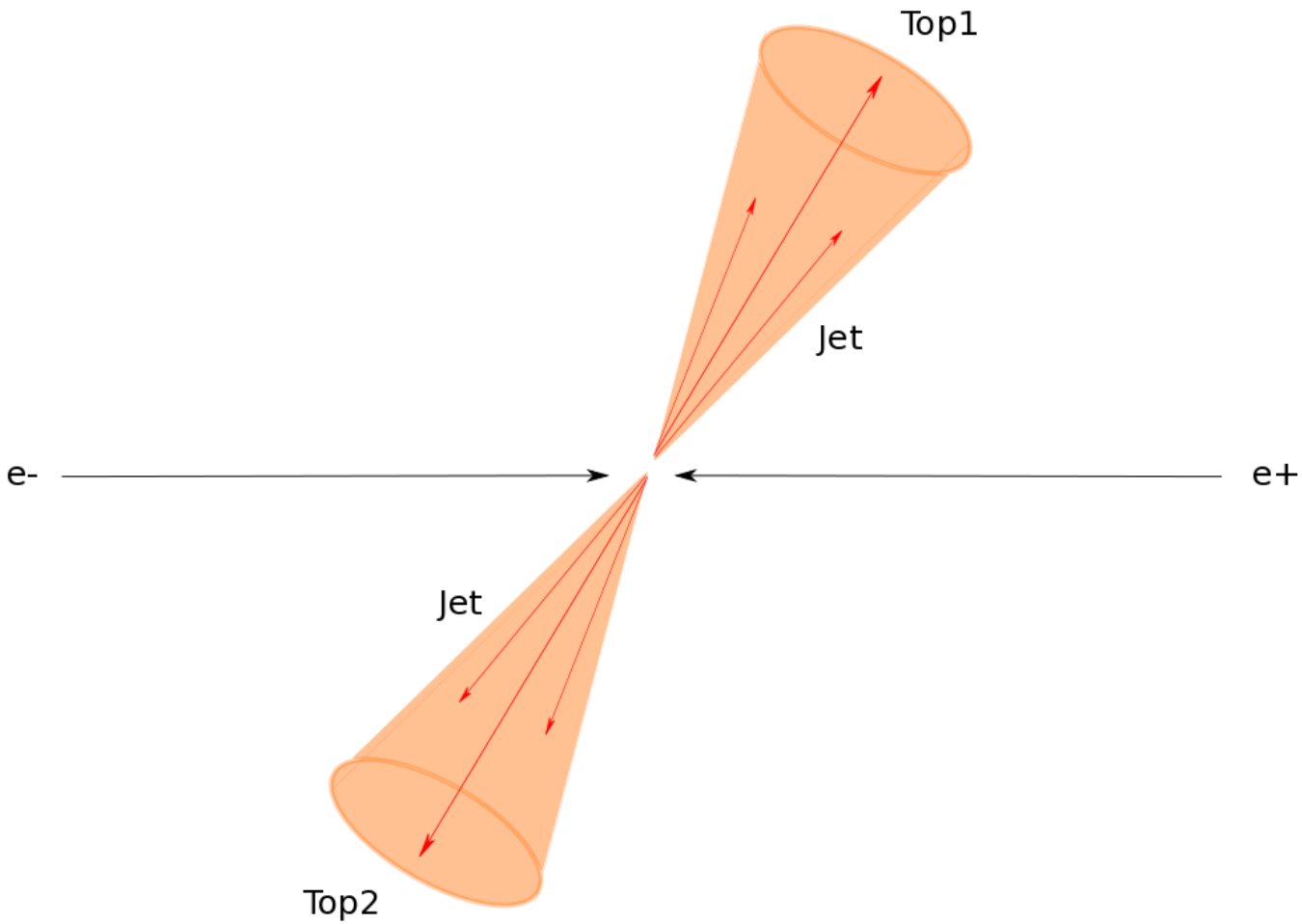

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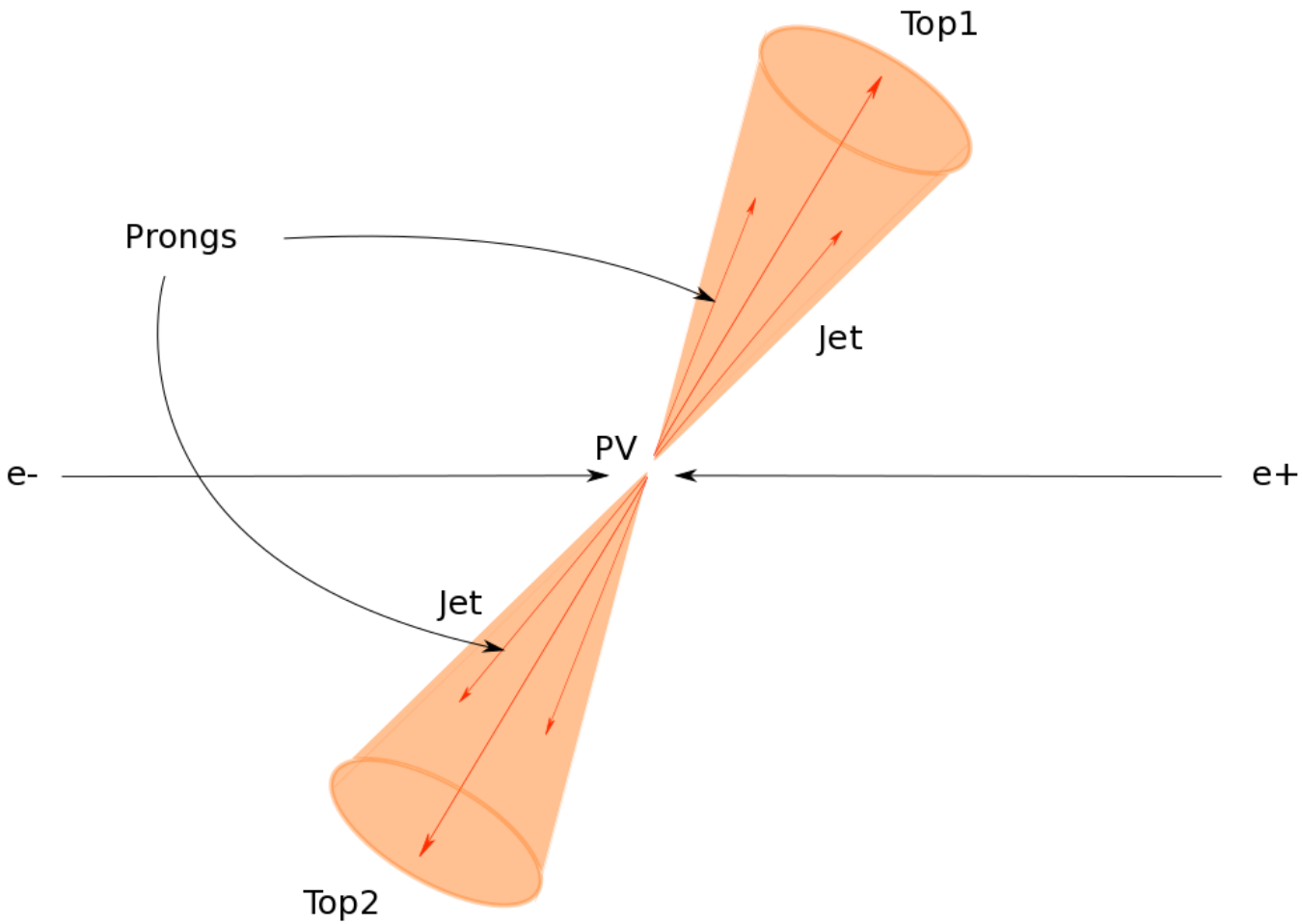

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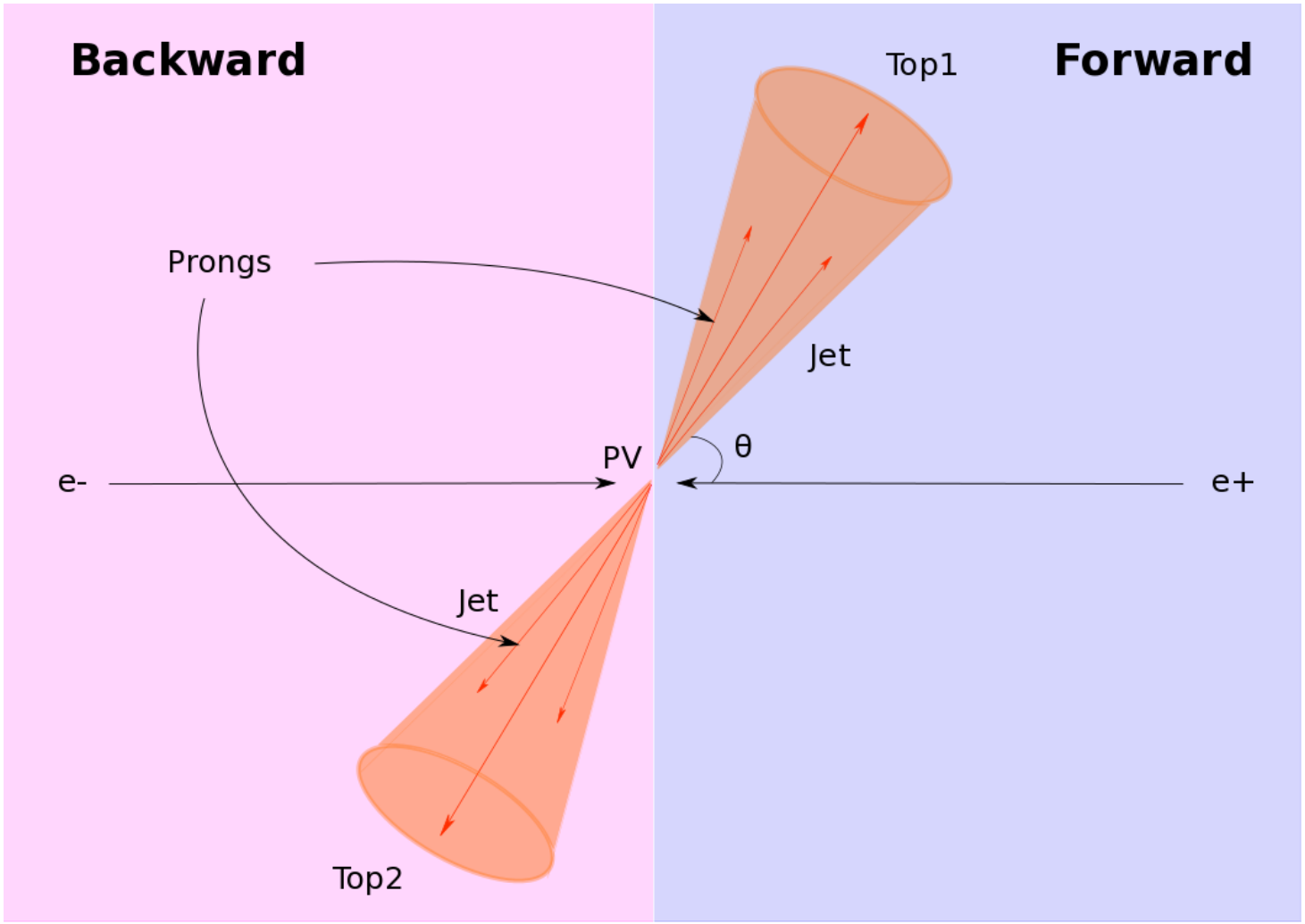

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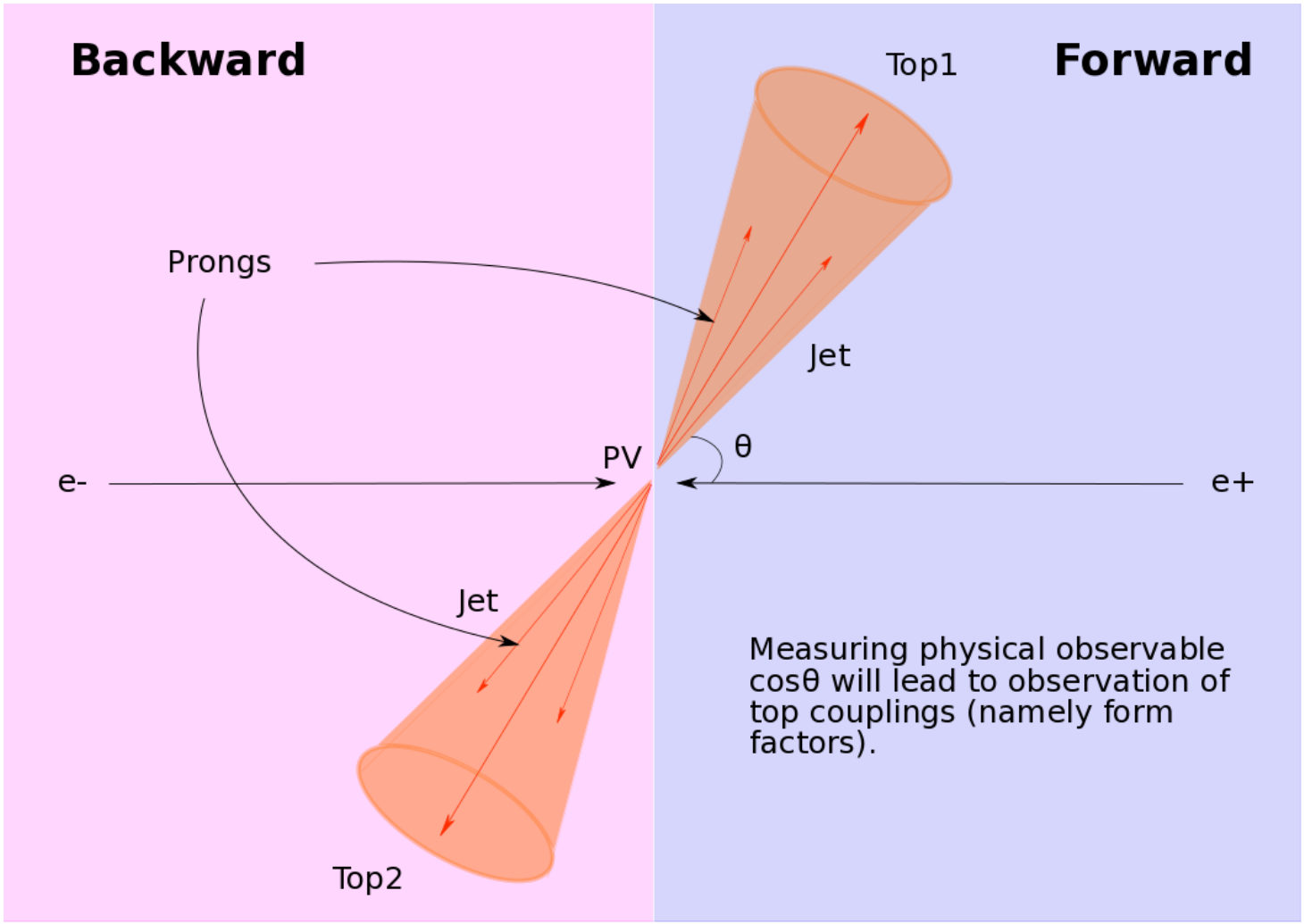
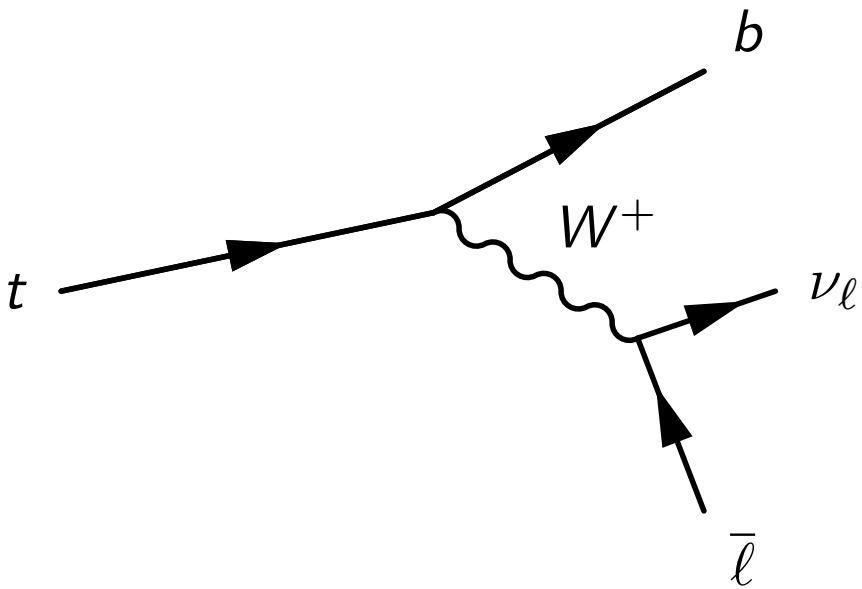
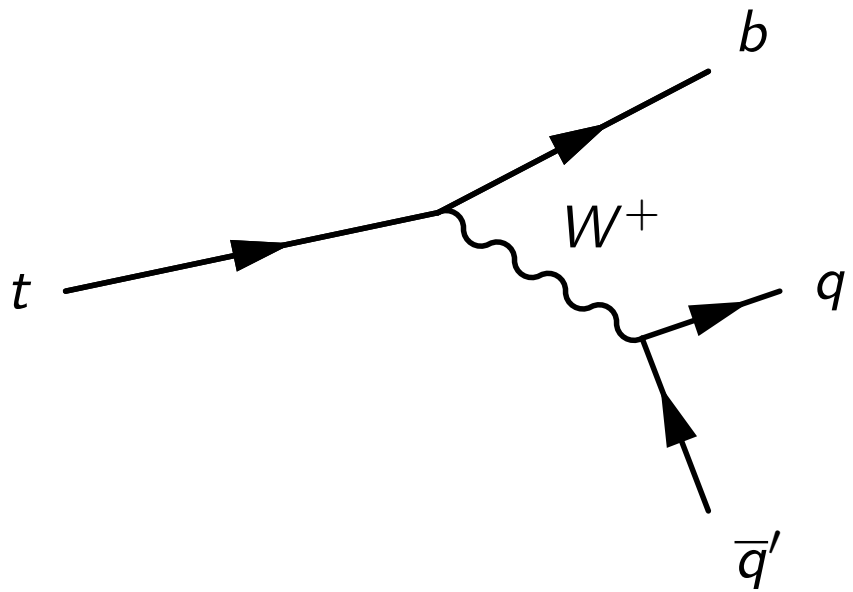

Backward
Forward
Top1
Prongs
Jet
PV
θ
e-
e+
Jet
Top2
Measuring physical observable cosθ will lead to observation of top couplings (namely form factors).

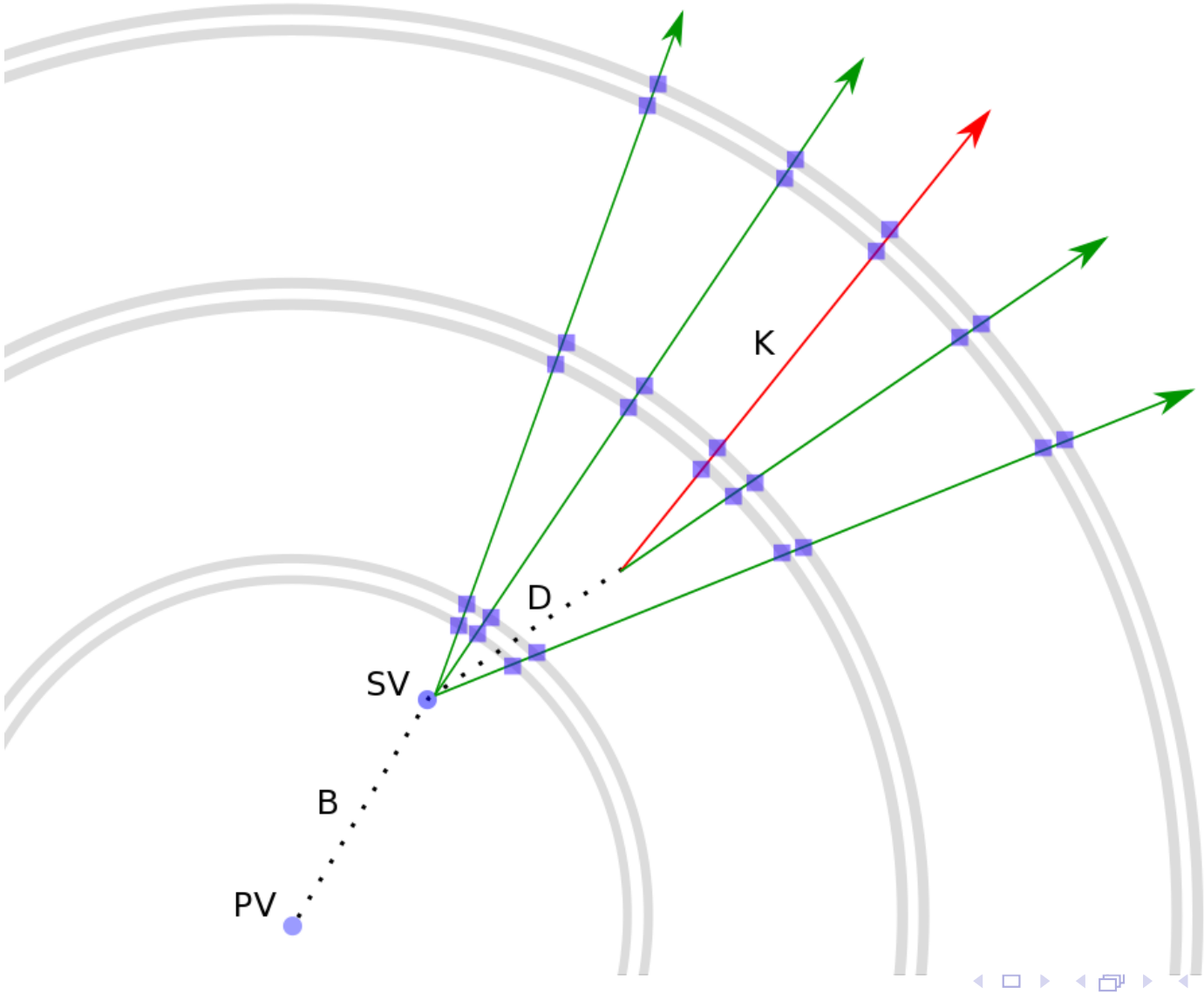
Channel

Channel	Decay Channel	Probability
Full Hadronic	$t\bar{t} \to b\bar{b}q\bar{q}'q\bar{q}'$	45.7%
Semi-leptonic	$t\bar{t} \to b\bar{b}\ \nu_\ell\bar{\ell}q\bar{q}'$	43.8%
Full leptonic	$t\bar{t} \to b\bar{b}\ \bar{\ell}\ell'\nu_\ell\bar{\nu}_{\ell'}$	10.5%





Vertex Charge Measurement



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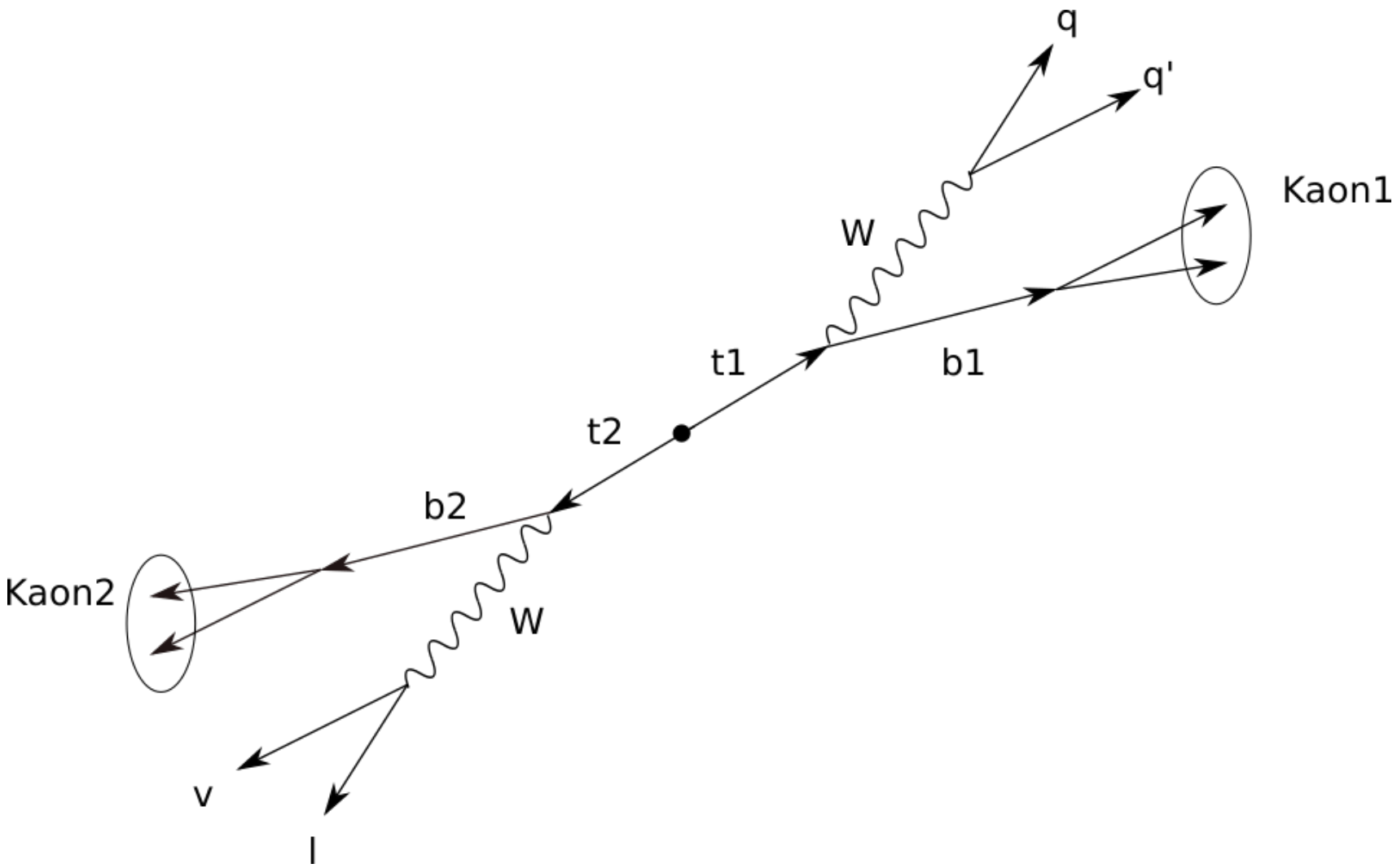


Methods

Methods 1-4 (Rely only on hadronic charge information)

1. vtx $\times$ vtx
2. kaon $\times$ kaon
3. vtx $\times$ kaon
4. vtx $\times$ kaon'

Methods 5-7 (Use isolated lepton charge)

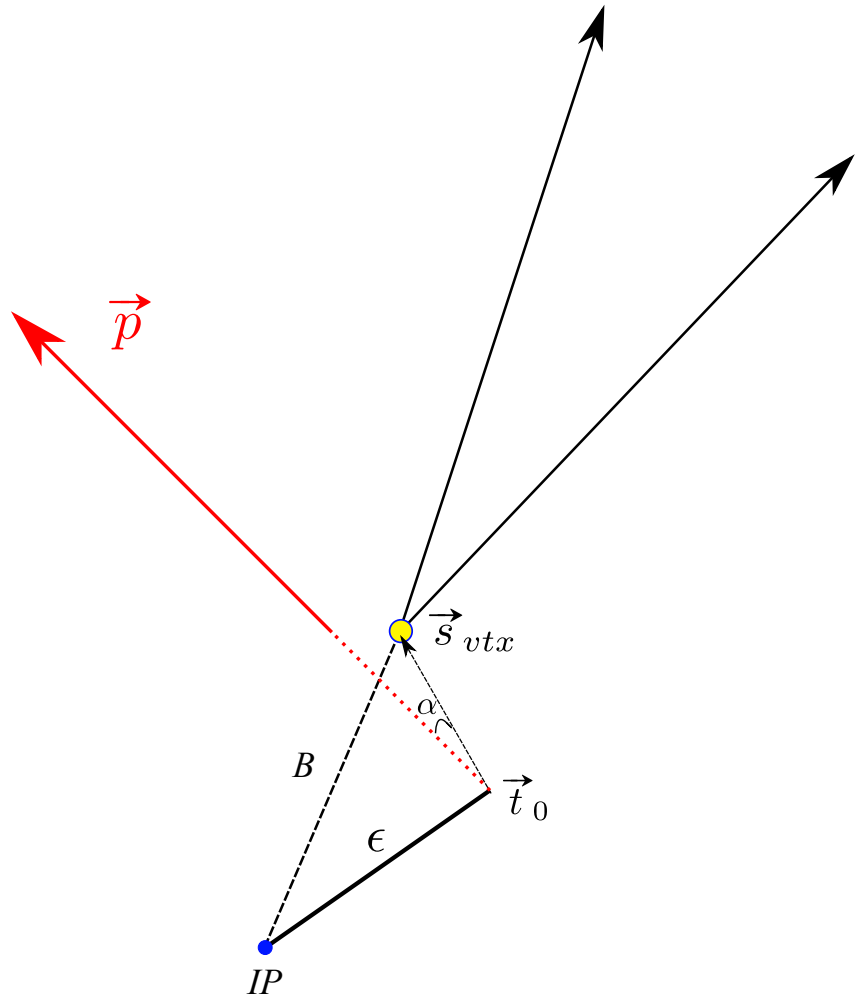
5. vtx $\times$ lepton, vtx' $\times$ lepton
6. kaon $\times$ lepton, kaon' $\times$ lepton
7. lepton + Chi2 req.

[1] All methods that have been used should be consistent with one another.

Vertex Restoration

Vertex Restoration Process

- Securing prong candidates - Upon vertex restoration, the algorithm collects all charged particles as prong candidates. Then it will iterates through all candidates and reconstruct them as PFO.
- Check if there's any duplicates in PFOs.
- Vertex reconstruction will be done with above informations.



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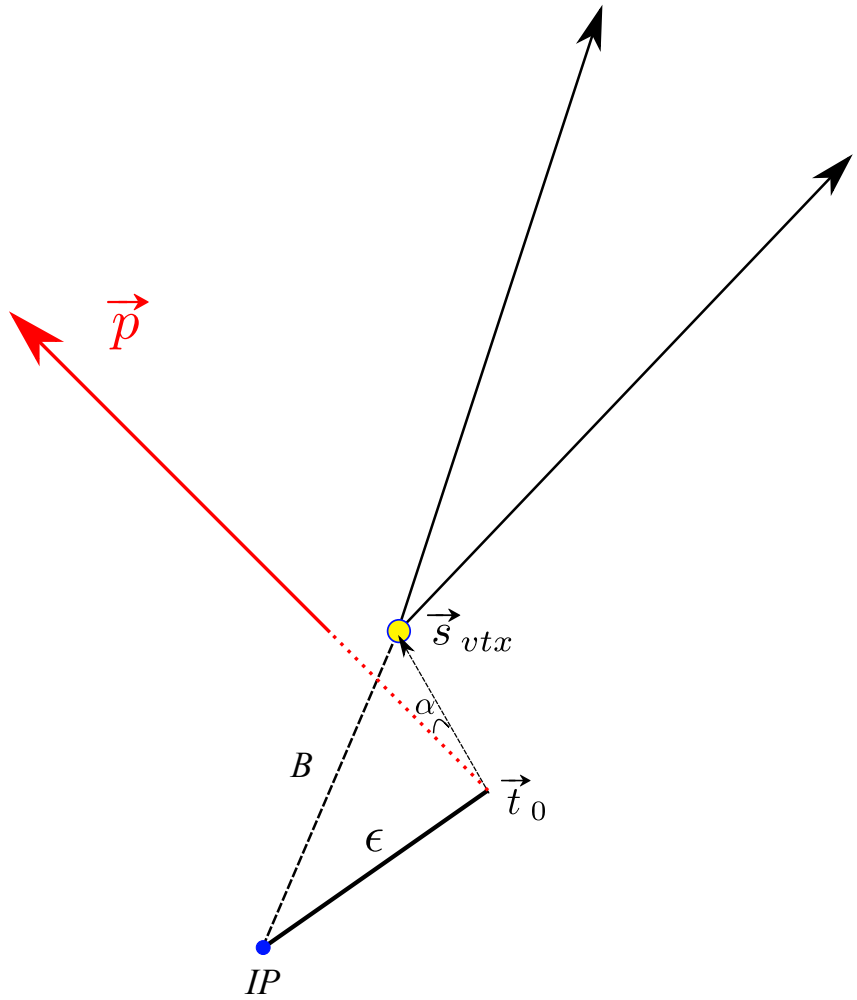

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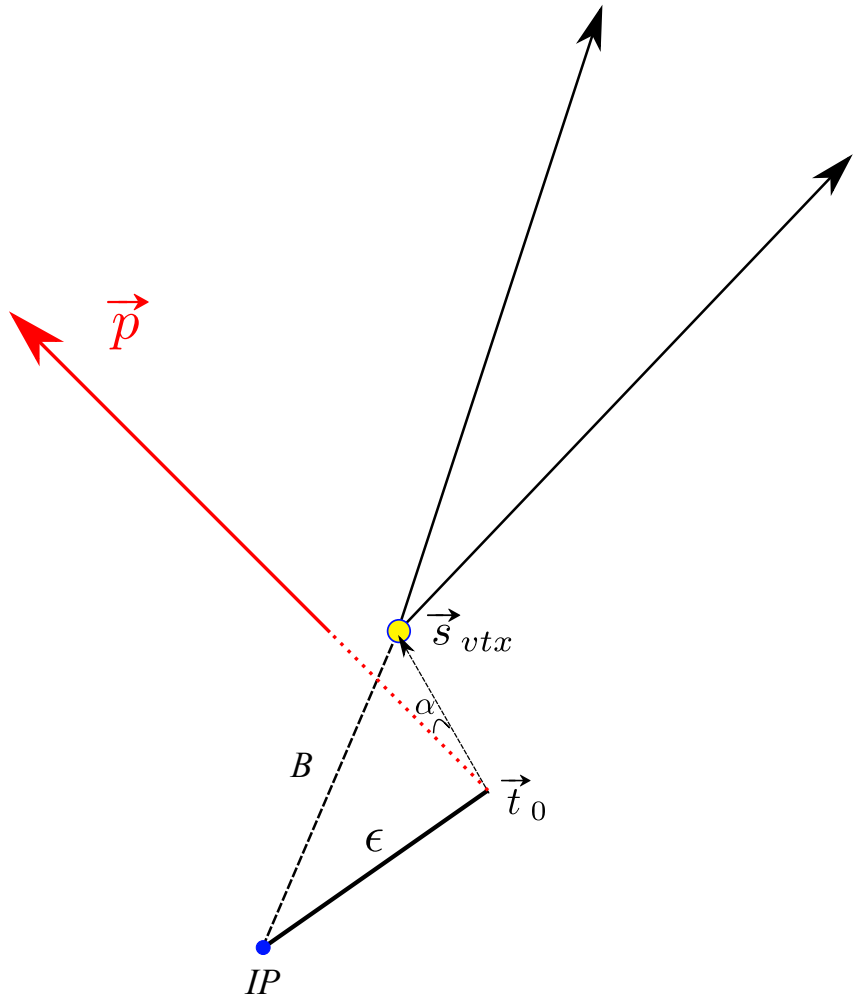
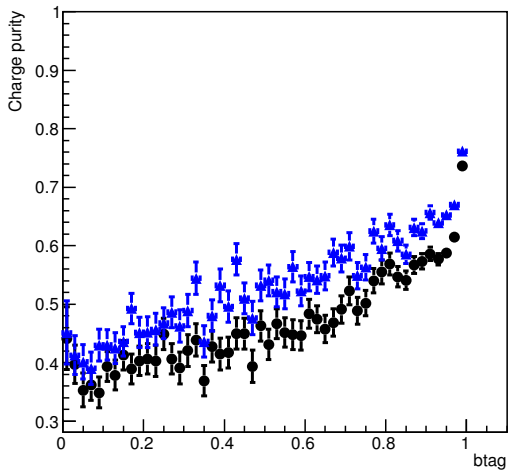
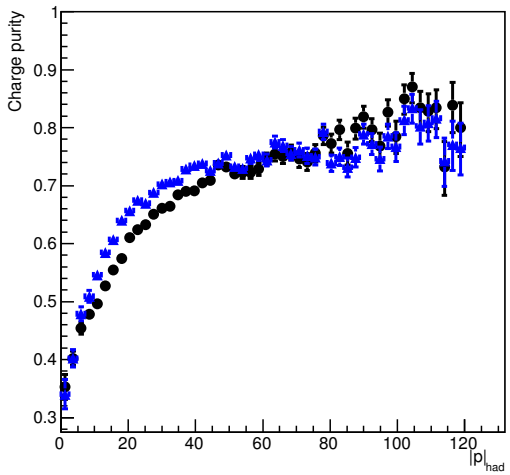
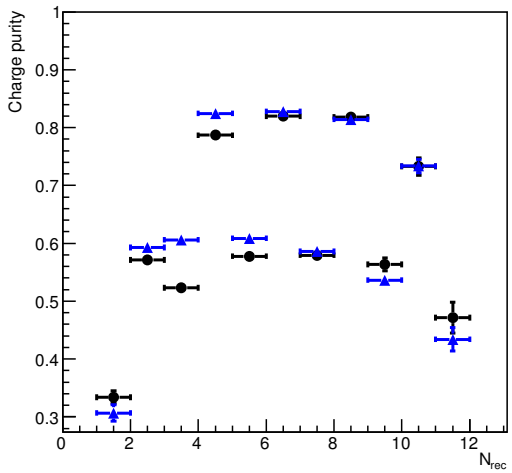
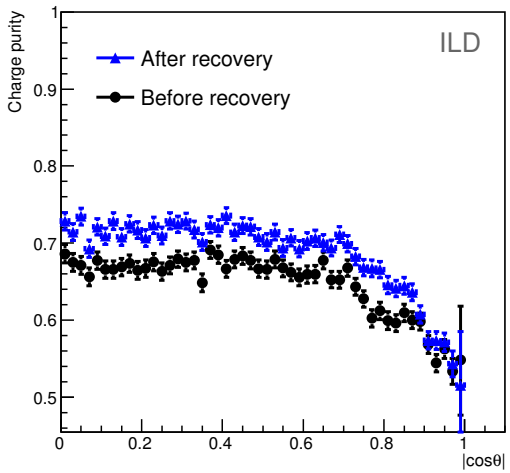


Vertex Restoration (charge purity)









Selection Scheme

Basic selection cuts:[1]

- Lepton cut: Iso.Lep. > 5 GeV
- Hadronic mass: $180 < M_{Had} < 420$
- $btag1 > 0.8$ or $btag2 > 0.3$
- Thrust: $thrust < 0.9$
- Top1 mass: $120 < m_{t1} < 270$
- W1 mass: $50 < m_{W1} < 250$

Lorentz Gamma cuts:

- $\gamma_t^{had} + \gamma_t^{lep} > 2.4$
- $\gamma_t^{lep} < 2.0$

b-quark Momentum cuts:

- $|p|_{had} > 15$ GeV

[1] Main distinct algorithm to distinguish top and anti-top.

Top Quark Polar Angle

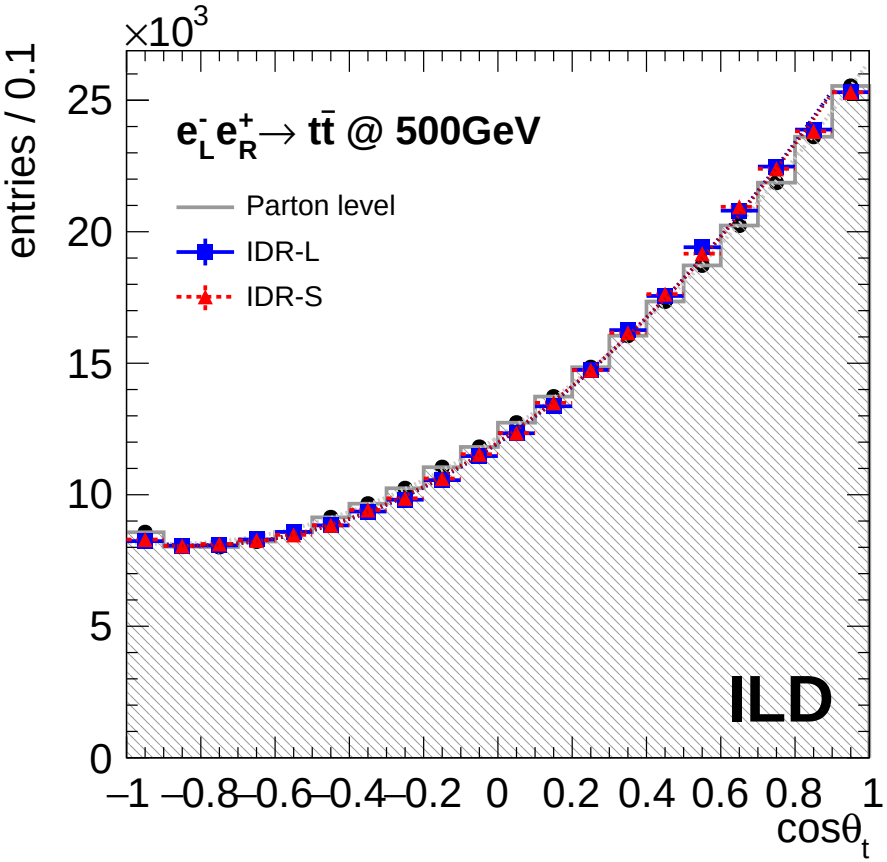


Figure: Left-handed top quark polar angle

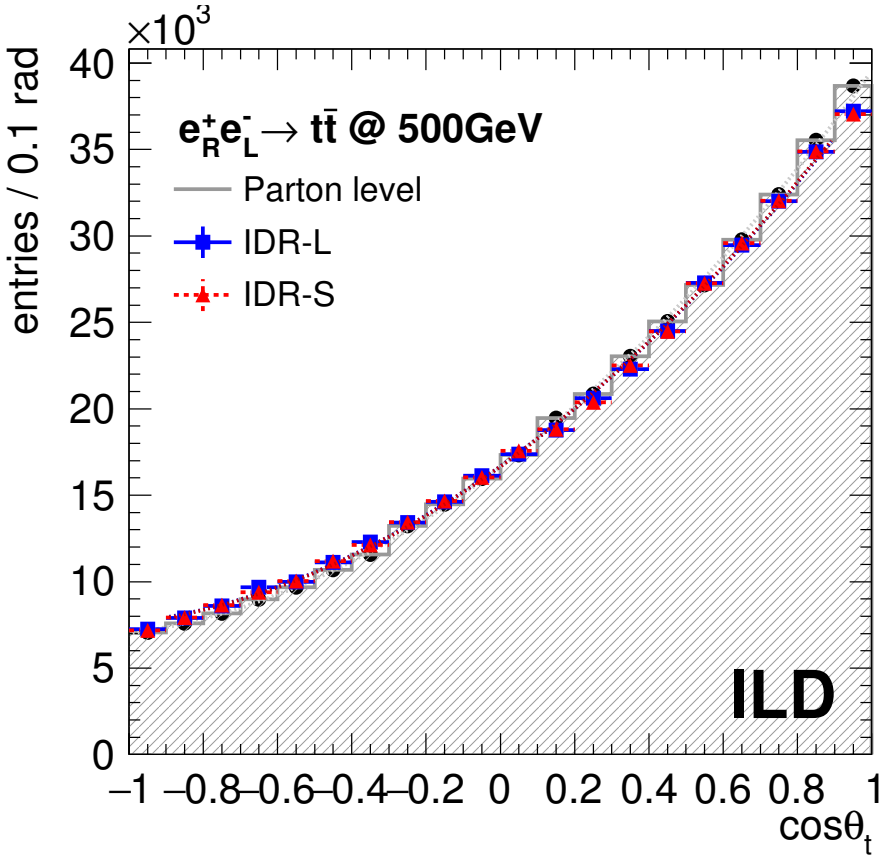


Figure: Right-handed top quark polar angle

Bottom Polar Angle

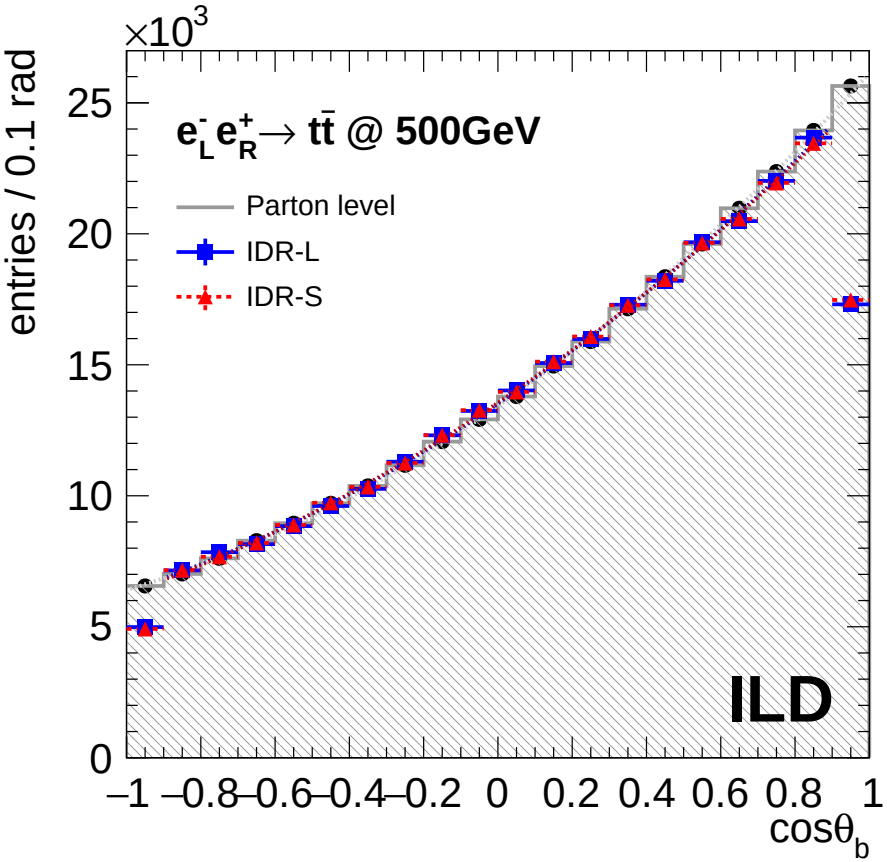


Figure: Left-handed b polar angle

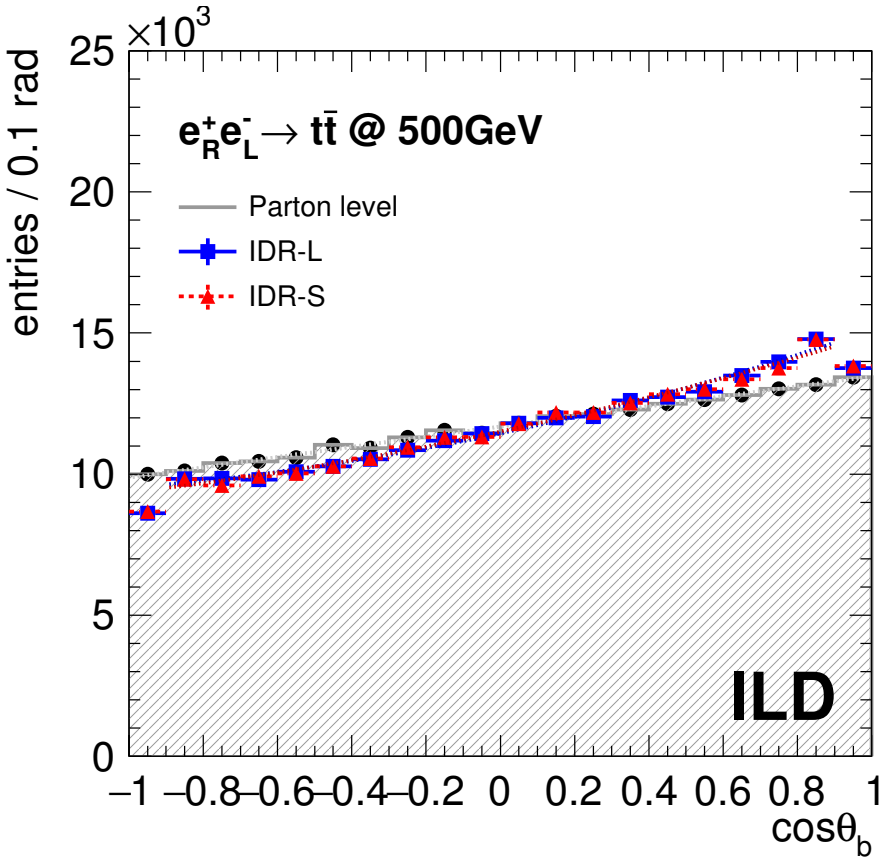


Figure: Right-handed b polar angle

Efficiency and A_{FB}

nEvents	906218	(100.%)
after lepton cuts	862018	(95.1%)
after btag cuts (0.8 & 0.3)	760275	(83.9%)
after thrust cut	760275	(83.9%)
after hadronic mass cut	732110	(80.8%)
after reco T & W mass cut	687268	(75.8%)

Polarization	Left-handed		Right-handed	
A_{FB} *Gen*	0.329	N: 1812768	0.430	N: 376690
A_{FB} *Reco*	0.342	M: 277435	0.396	N: 292271
Final Efficiency	30.6%			

Summary

Conclusion

- 30% of efficiency was achieved for left-handed case.
- Vertex Recovery did give enhancement on charge purity.
- Moving on to the full hadronic process this month.