QCD@LHC 2016

MB & UE Monte Carlo Model Tunes

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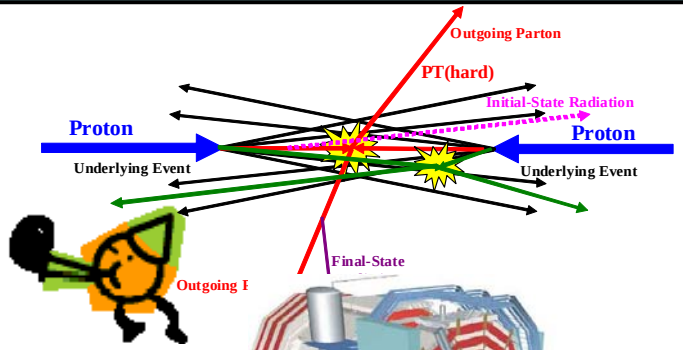
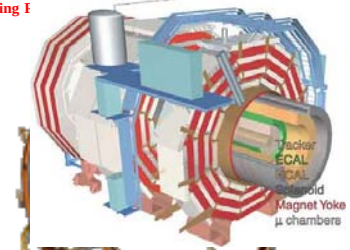
QCD@LHC 22ND–26TH AUGUST 2016 INTERNATIONAL CONFERENCE ZURICH

Outline of Wednesday Talk

- **MB-UE-DPS:** Relationships between Min-Bias (MB), the underlying event (UE), and double parton scattering (DPS).
- **ATLAS Tune A3:** New ATLAS PYTHIA 8 MB tune.
- **ATLAS Z-UE:** The UE in Z-Boson production at 7 TeV.
- **CMS UE Tunes:** Two PYTHIA 6 tunes, three PYTHIA 8 tunes, and one HERWIG++ tune from the CMS "Physics Comparisons & Generator Tunes" subgroup.
- **HERWIG 7 Tunes:** Tune CUETHS1-CTEQ6L (the same as the CMS HW++ tune CUETHS1-CTEQ6L except using HW7. HW7 Default Tune using the MMHT2014 PDF.
- **MB&UE@13TeV:** Some UE and MB measurements from the LHC and MC comparisons.
- **Simultaneous UE-MB-DPS Tunes:** Can we fit UE data, MB data, and DPS sensitive data with one universal tune?





CMS

ATLAS

Monte Carlo Models

Deepak Kar ICHEP2016

Monte Carlo Models

Pythia8 4C	(Author) MB+UE tune with CTEQ6L1
Pythia8 Monash	(Author) MB+UE tune with NNPDF2.3LO
Pythia8 CUETP8S1	(CMS) UE tune based on 4C
Pythia8 CUETP8M1	(CMS) UE tune based on Monash
Pythia8 A2	(ATLAS) Minbias/Central ET flow tune based on 4C
Herwig++ UE-EE-5C	(Author) UE tune with energy scaling using CTEQ6L1
Epos LHC	ased on Gribov's Pomeron exchange/collective flow approach, use LHC and fixed target experiment data to describe hadron and nuclear collisions.
QGSJET-II	
Sibyll	

Parton Shower

Cosmic Ray/Air Shower

ATLAS A3 Tune

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Pythia8 A3 Tune

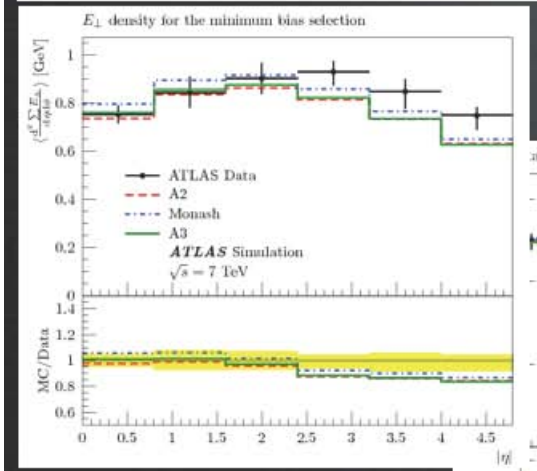
New

Tom Sykora's Talk

	ATLAS data (mb)	SS (mb)	A3 (mb)
At $\sqrt{s}$ = 13 TeV	68.1 ± 1.4	74.4	69.9
At $\sqrt{s}$ = 7 TeV	60.3 ± 2.1	66.1	62.3

Using Donnachie-Landshoff diffractive model and NNPDF2.3LO

Much improved total inelastic cross section prediction



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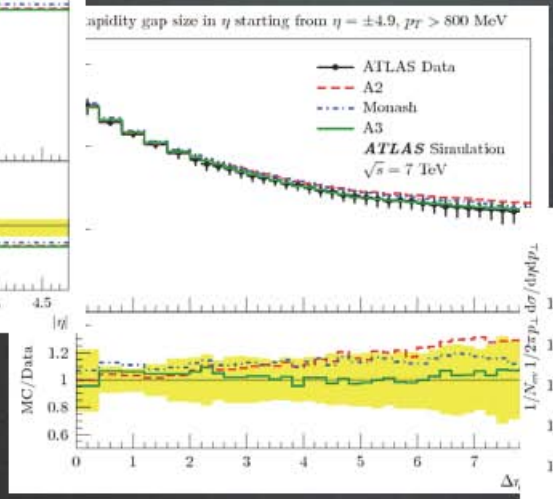
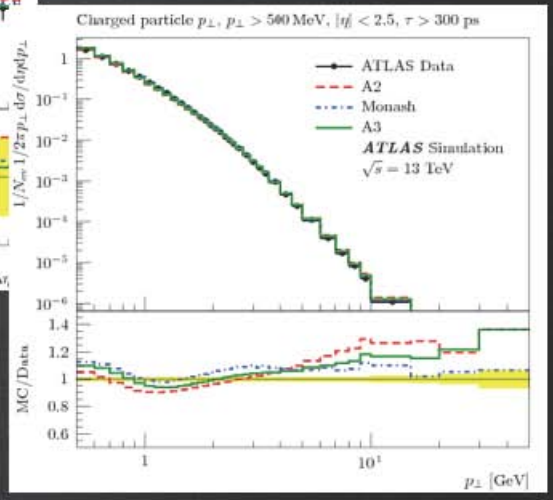
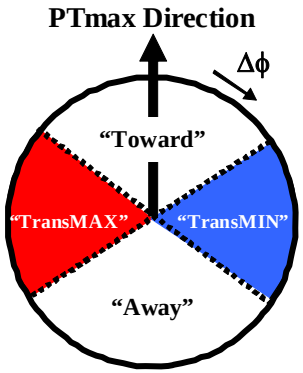




Mostly similar level of agreement with Minbias observables

CMS UE Tunes



➡ **PYTHIA 6.4 Tune CUETP6S1-CTEQ6L:** Start with Tune Z2*-lep and tune to the CDF PTmax "transMAX" and "transMIN" UE data at 300 GeV, 900 GeV, and 1.96 TeV and the CMS PTmax "transMAX" and "transMIN" UE data at 7 TeV.

➡ **PYTHIA 6.4 Tune CUETP6S1-HERAPDF1.5LO:** Start with Tune Z2*-lep and tune to the CDF PTmax "transMAX" and "transMIN" UE data at 300 GeV, 900 GeV, and 1.96 TeV and the CMS PTmax "transMAX" and "transMIN" UE data at 7 TeV.

➡ **PYTHIA 8 Tune CUETP8S1-CTEQ6L:** Start with Corke & Sjöstrand Tune 4C and tune to the CDF PTmax "transMAX" and "transMIN" UE data at 900 GeV, and 1.96 TeV and the CMS PTmax "transMAX" and "transMIN" UE data at 7 TeV. **Exclude 300 GeV data.**

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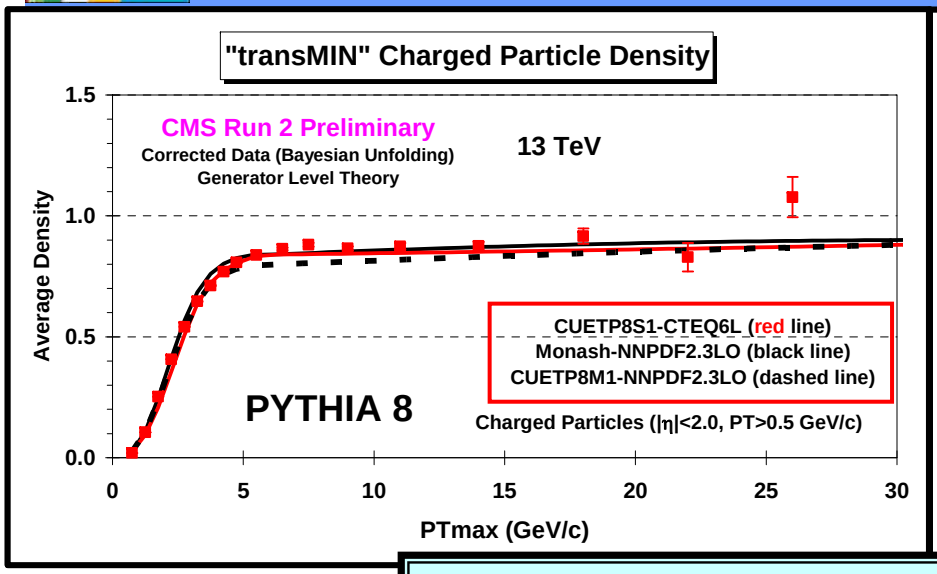
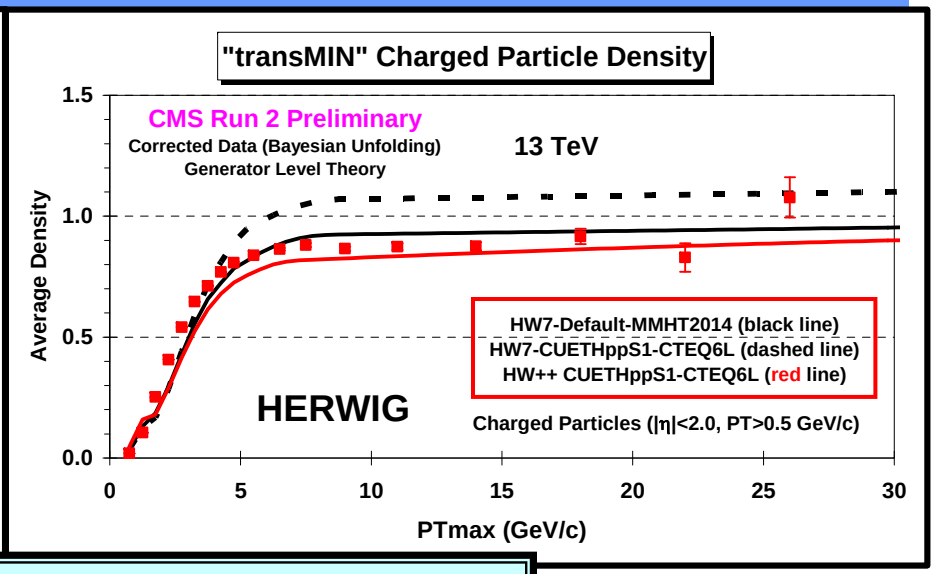
➡ **PYTHIA 8 Tune CUETP8M1-NNPDF2.3LO:** Start with the Skands Monash-NNPDF2.3LO tune and tune to the CDF PTmax "transMAX" and "transMIN" UE data at 900 GeV, and 1.96 TeV and the CMS PTmax "transMAX" and "transMIN" UE data at 7 TeV. **Exclude 300 GeV data.**

➡ **HERWIG++ Tune CUETHS1-CTEQ6L:** Start with the Seymour & Siódmok UE-EE-5C tune and tune to the CDF PTmax "transMAX" and "transMIN" UE data at 900 GeV, and 1.96 TeV and the CMS PTmax "transMAX" and "transMIN" UE data at 7 TeV. **Bug in HW++!**

"transMIN" NchgDen





"TransMIN" density more sensitive to MPI & BBR.

- **CMS corrected data at 13 TeV on the "transMIN" charged particle density with p_T > 0.5 GeV/c and |η| < 2.0 as defined by the leading charged particle, as a function of the transverse momentum of the leading charged particle, PTmax. The data are compared with the PYTHIA 8 tune CUETP8S1-CTEQ6L, tune CUETP8M1-NNPDF2.3LO, and tune Monash at the generator level.**

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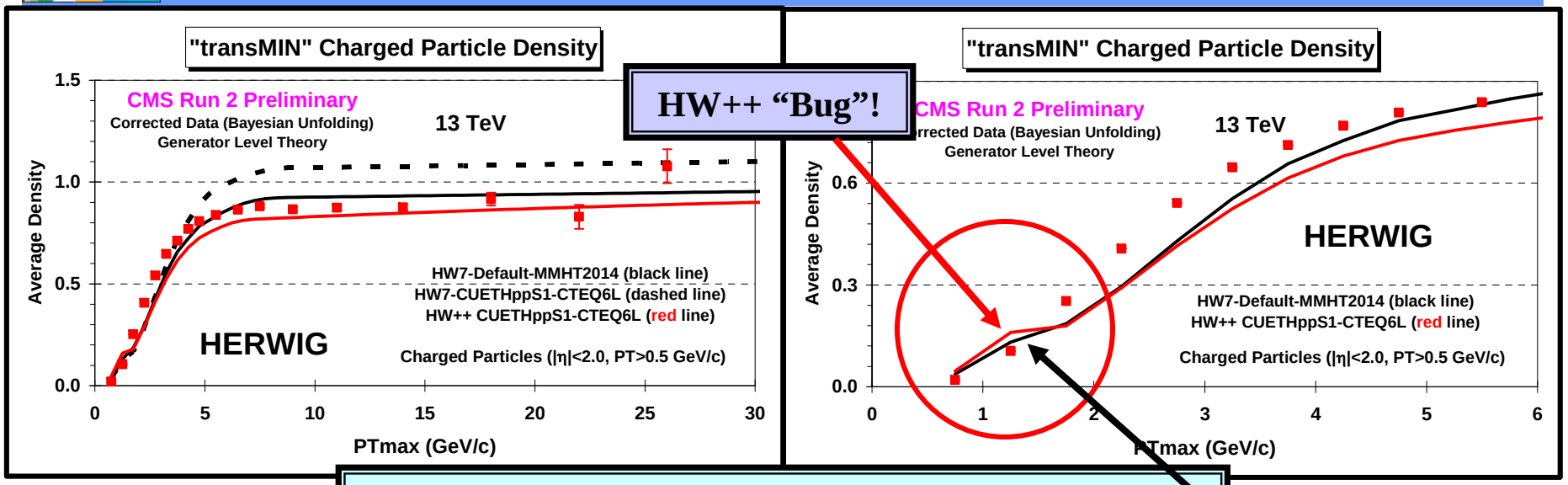
"transMIN" NchgDen



HW++ "Bug"!

"TransMIN" density more sensitive to MPI & BBR.

Fixed in HW7!

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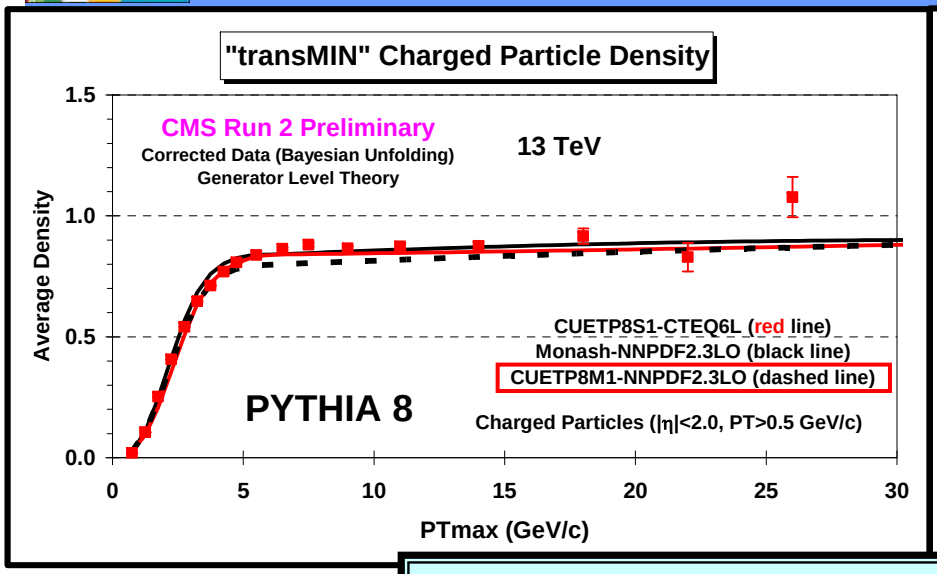

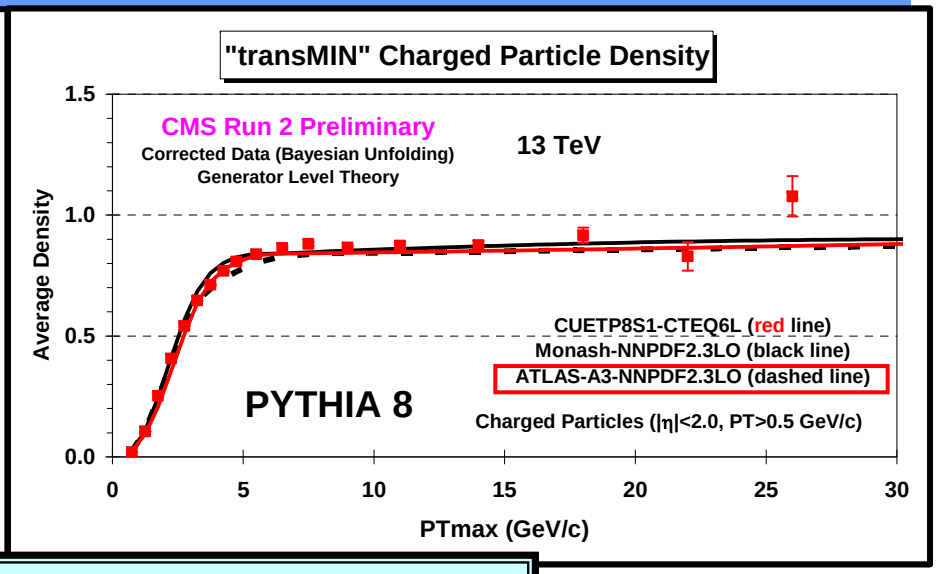

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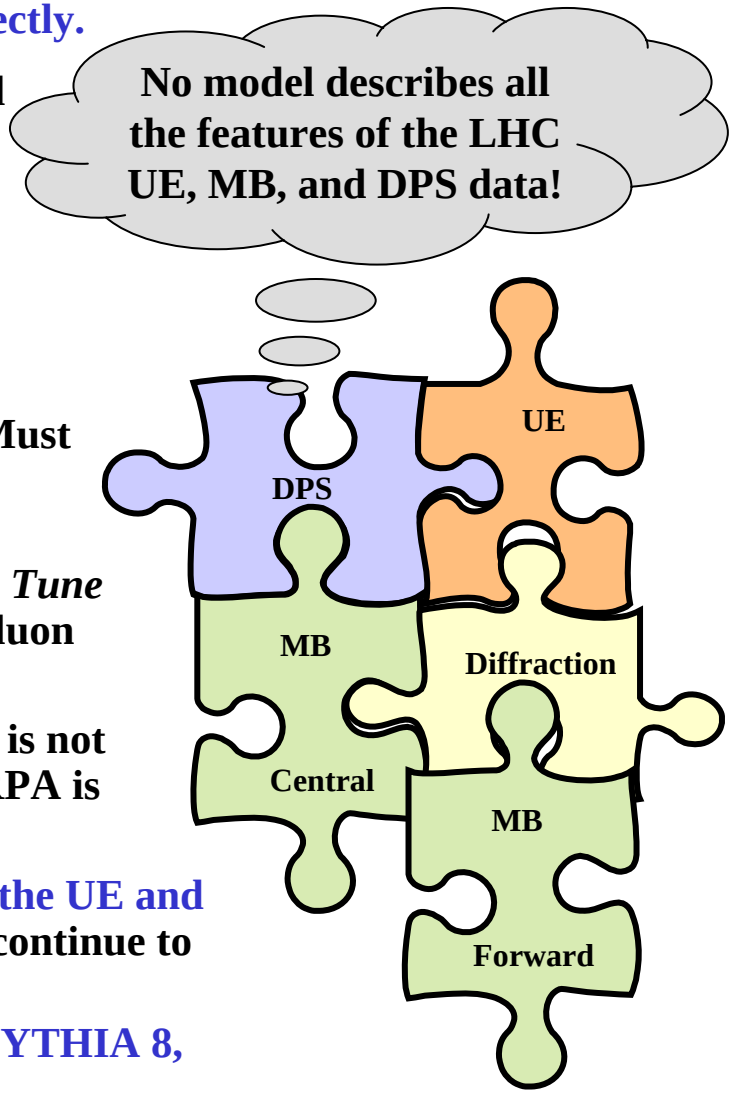
Summary & Conclusions

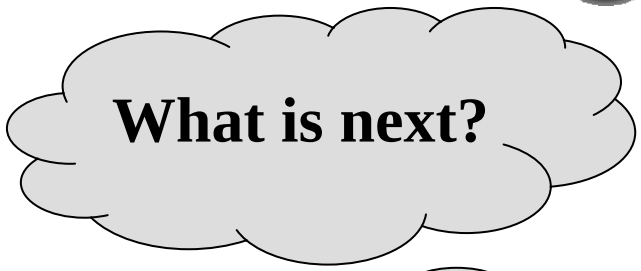
- No one QCD Monte-Carlo model describes everything perfectly.
- The PYTHIA 8 tunes such as CUETP8S1, CUETP8M1, and Monash, describe fairly well both the underlying event and the non-diffractive contribution to MB observables. We need to work on tuning the diffractive models! The ATLAS MB tune A3 does fairly well on the UE, but could do better!
- The CMS HW++ Tune CUETHS1-CTEQ6L fits the UE "plateau" region very well, but cannot use it because of the HW++ "bug". Big change in going from HW++ to HW7! Must re-tune. The HW7 Default Tune is not bad! But could do better!
- Tunes that use NPDF2.3LO PDF (*including the new ATLAS Tune A3*) do a better job in the forward region due to the low-x gluon distribution.
- Hard multi-jet production in Z-Boson events at large $P_T(Z)$ is not modeled very well by the QCD Monte-Carlo models (SHERPA is doing the best). Must tune the hard ISR!
- I do not understand why we cannot simultaneously fit both the UE and the DPS sensitive observables with the same tune. We will continue to work on this.
- The CMS PC&GT group is actively working of improved PYTHIA 8, HERWIG 7, and SHARPA tunes!



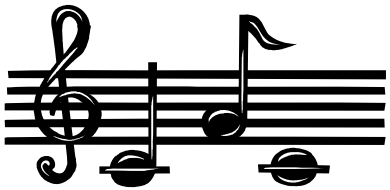
Monte Carlo Discussion

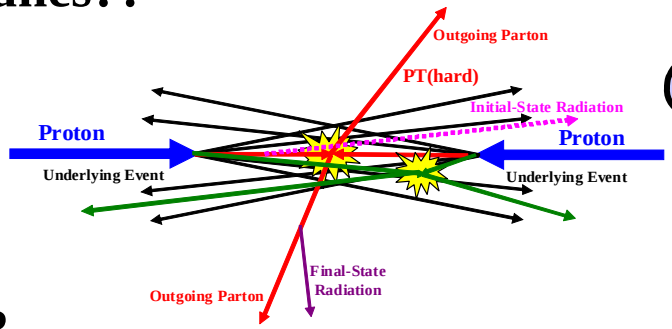
- Where do we go from here??

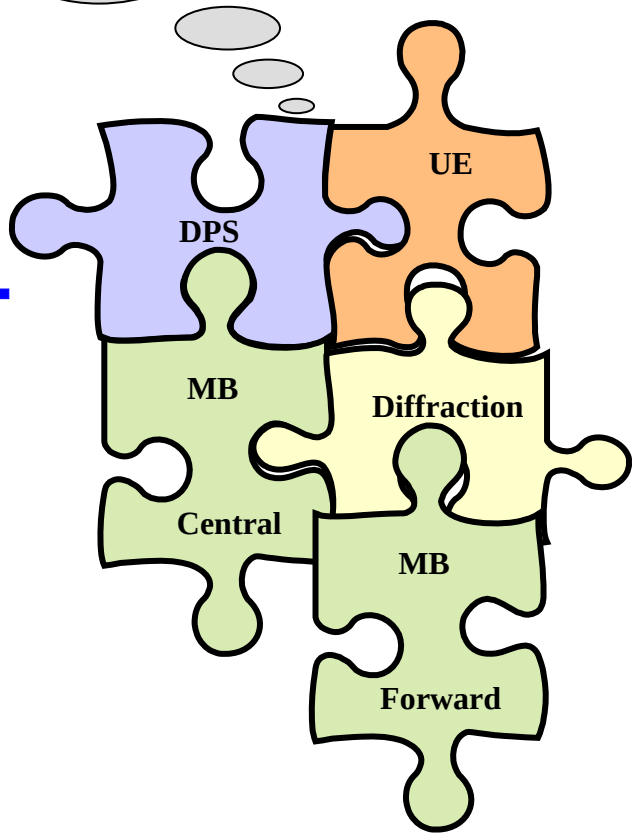
- What do the experimenters need??



- Do we want universal tunes or separate MB. UE, DPS, Z+Jets, Top, … tunes??







- What should we tune??
  - MPI & Color Connections/Reconnections
  - ISR & FSR
  - Alpha-Strong
  - Fragmentation & Flavor
  - The small-x gluon distribution (*i.e.* the PDF's)