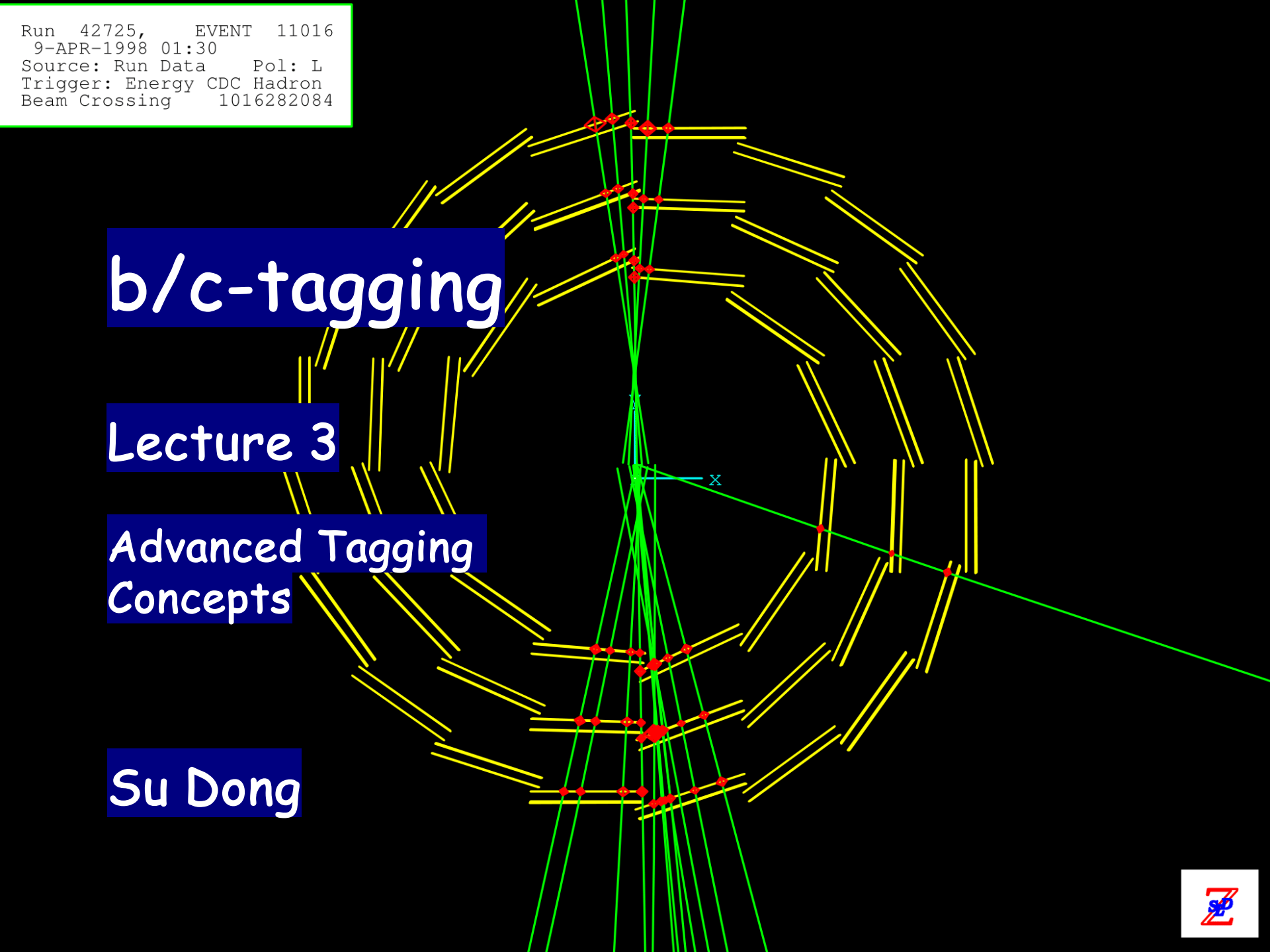


b/c-tagging

Lecture 3

Advanced Tagging Concepts

Su Dong

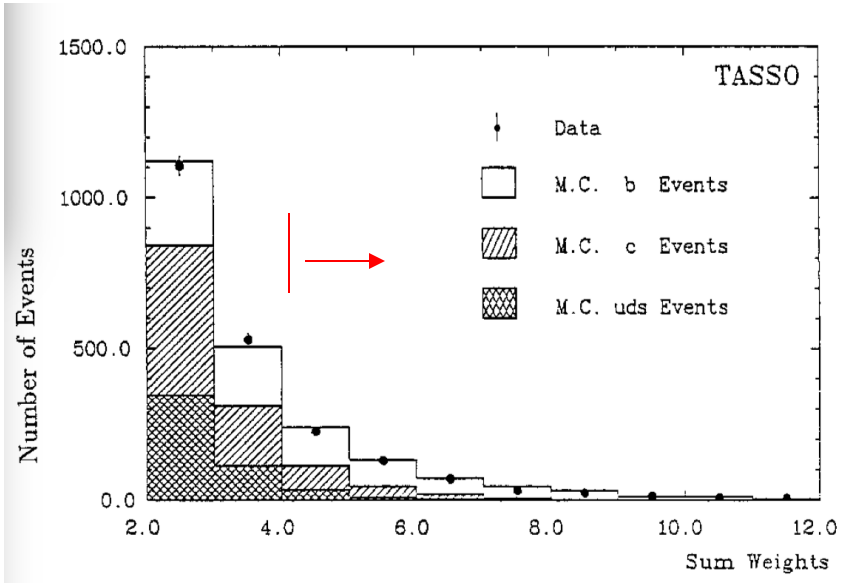
Beginning of lifetime b tag

- 1984: Long B lifetime discovered by MAC/MK2@PEP
- 1986: First attempt of lifetime b-tag at TASSO@PETRA with vertex drift chamber
- 2-prong vertex combo weights with *event* tag efficiencies

ε_b	~18%
ε_c	1.7%
ε_{uds}	0.5%

- Tested b vs light jet properties,
- $\alpha_s(b)/\alpha_s(q)=1.17\pm0.50\pm0.28$

Z.Phys C42 (1989), 17

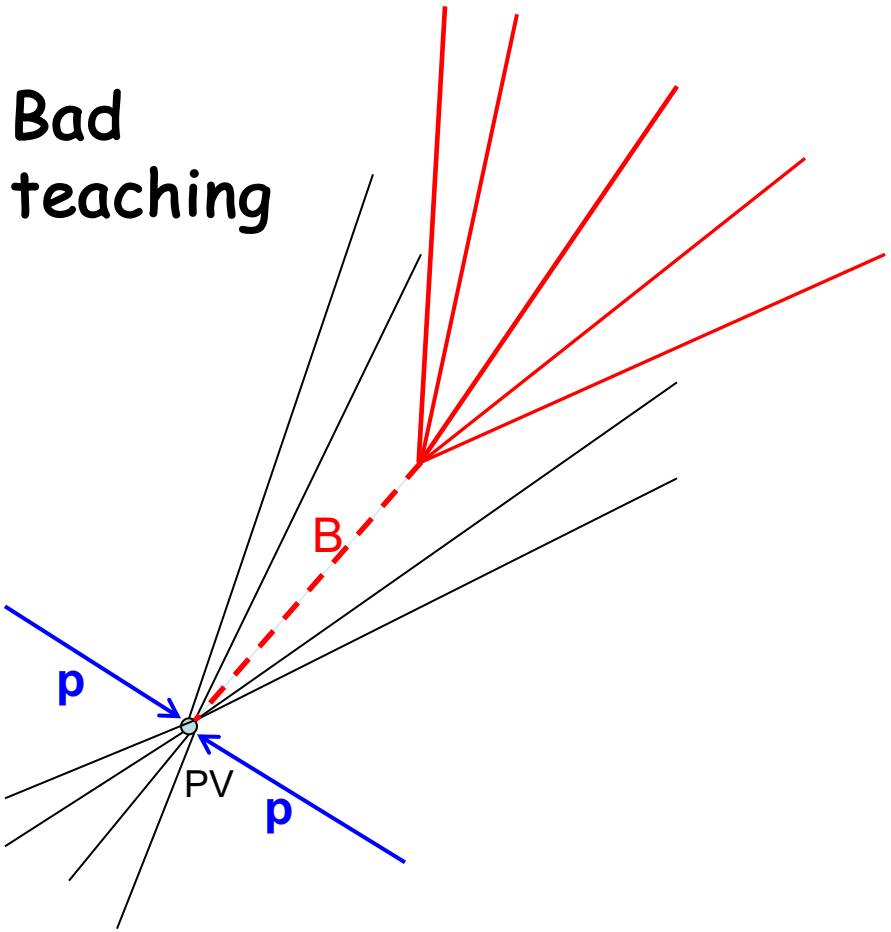


TASSO@PETRA e^+e^- 35-44 GeV
$e^+e^-\rightarrow\gamma^*\rightarrow had$ b:c:uds=1:4:6

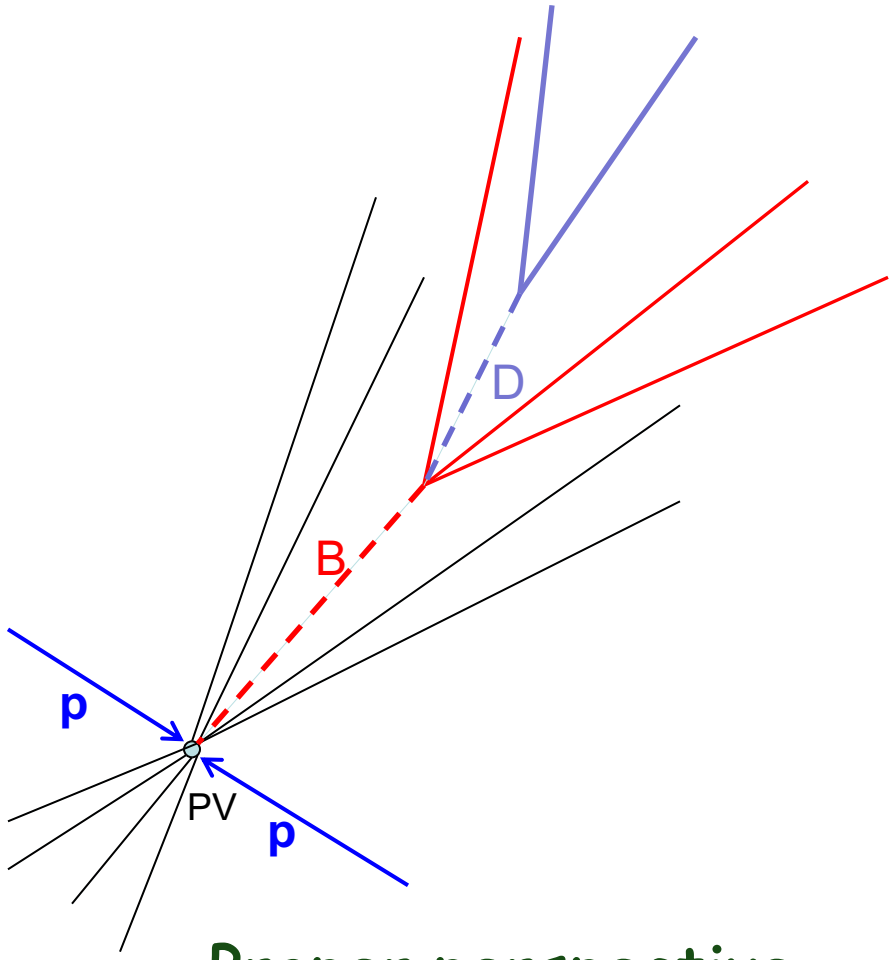
Tagging Signatures

b decay signature

Bad teaching



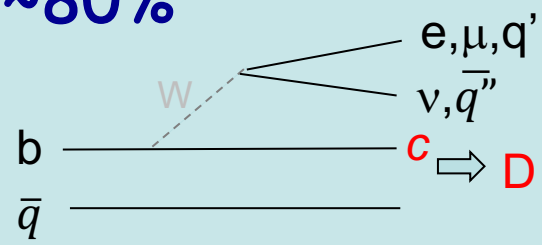
OK for old detectors with poor resolution

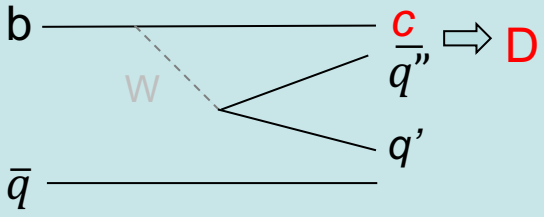


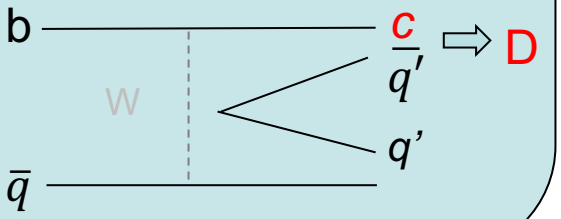
Proper perspective
(still just one case)

B decay vertex zoo

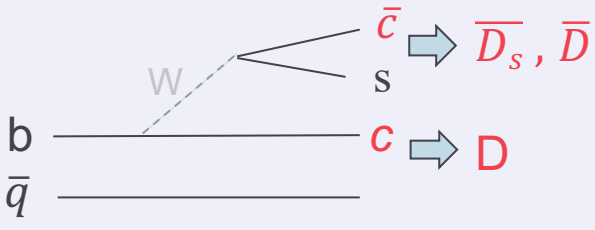
2 vertices ~80%

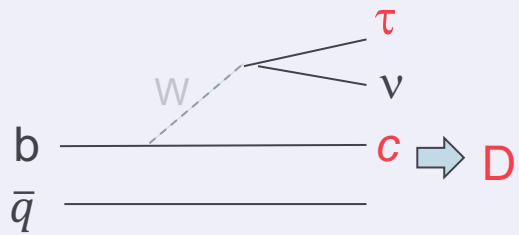


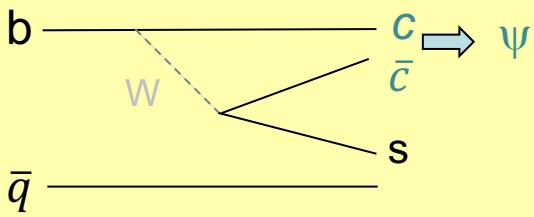


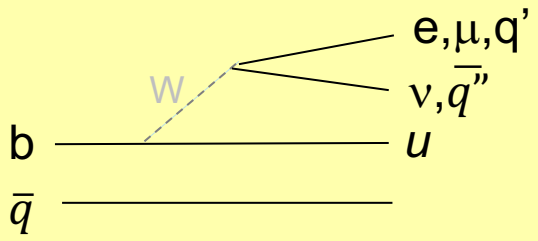


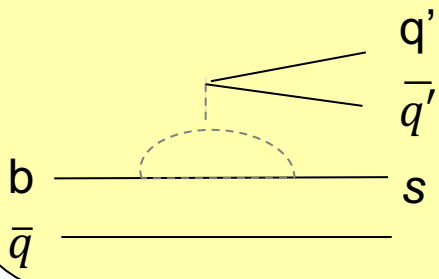
3 vertices ~16%







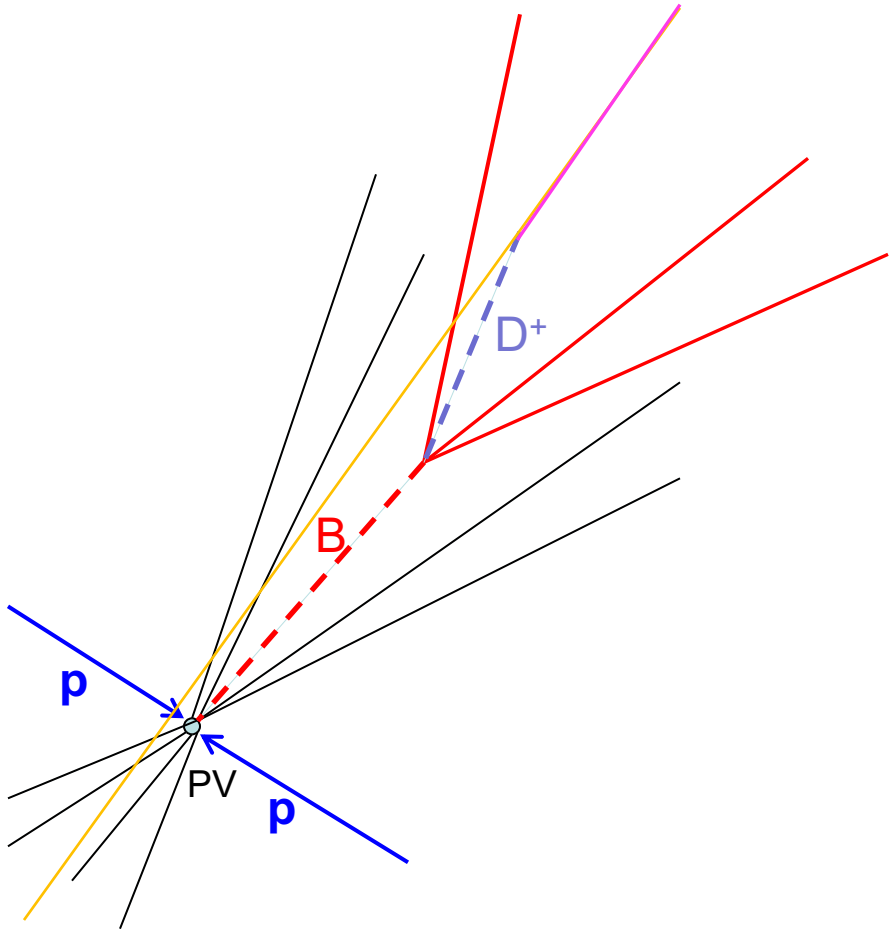




1 vertex <2 %

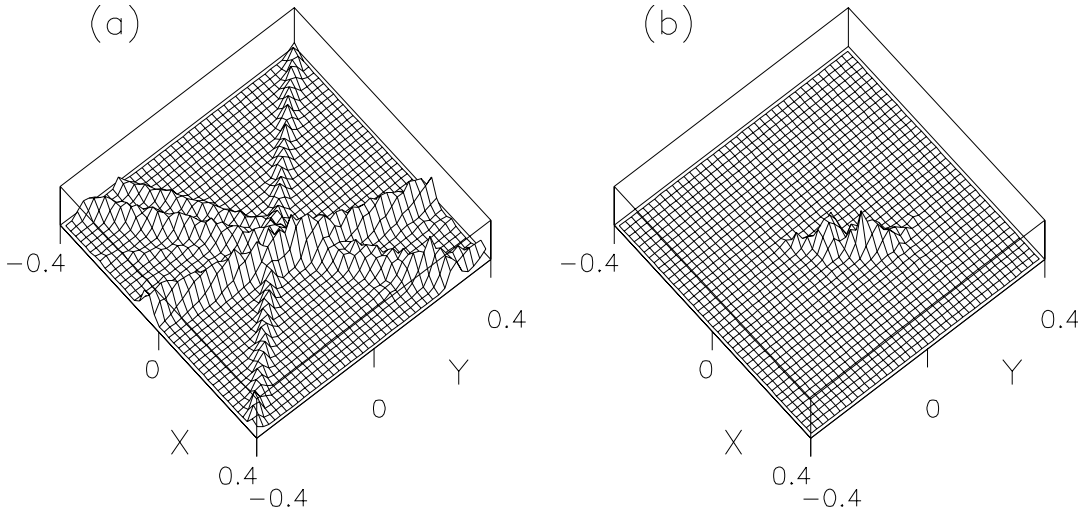
Vertex Topologies

- b->c cascade vertex can often cause a vertex has only 1 track
- Tertiary vertex track can naturally have –ve impact parameter signs, especially in 2D
- SLD ZVTOP based tagging framework and ATLAS JetFitter are fully conscious of the cascade vertex structure



Vertexing Utilities

- Most common vertexing tools work on track combinatorial compatibilities.
- SLD ZVTOP topological vertexing searches for track overlap density peaks

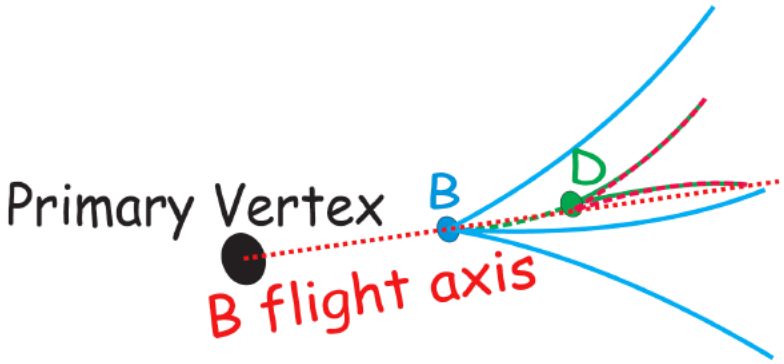


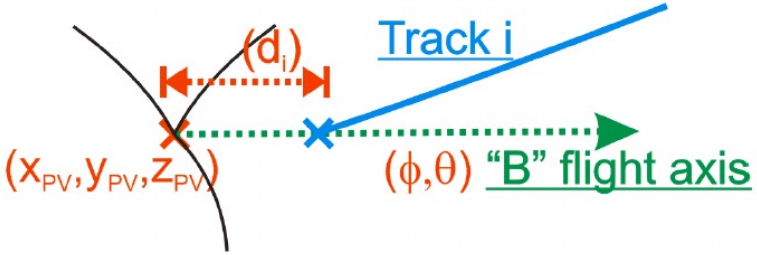
D. J. Jackson, NIM A388 (1997), 247

There is an ATLAS implementation of ZVTOP

Single Track Vertices

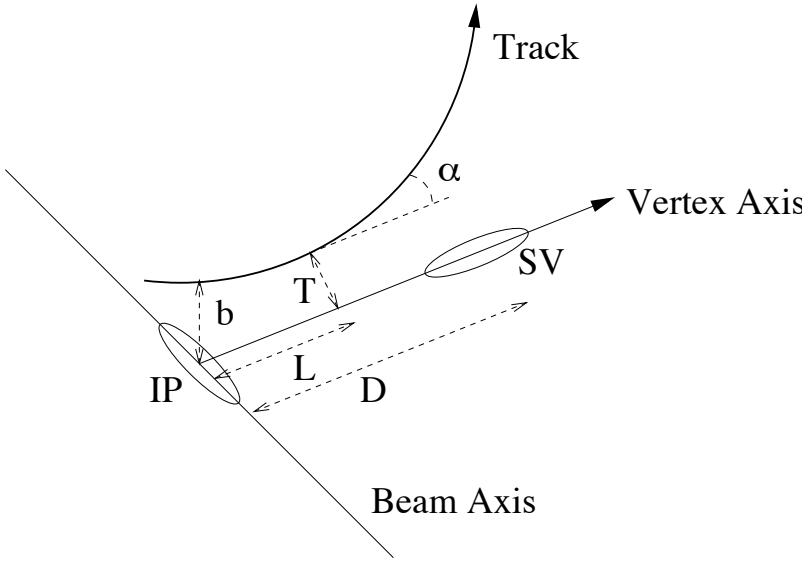
- 'Ghost Track' algorithm was a variant of ZVTOP deployed in the SLD B_s mixing dipole analysis:
  - https://arxiv.org/abs/hep-ex/0012043v1
- A major feature of the JetFitter b-tag in ATLAS
  - Giacinto Piacquadio's thesis
  - Use b jet direction or existing secondary vertex as virtual b hadron "track" to intersect with additional candidate secondary tracks consistent with the cascade





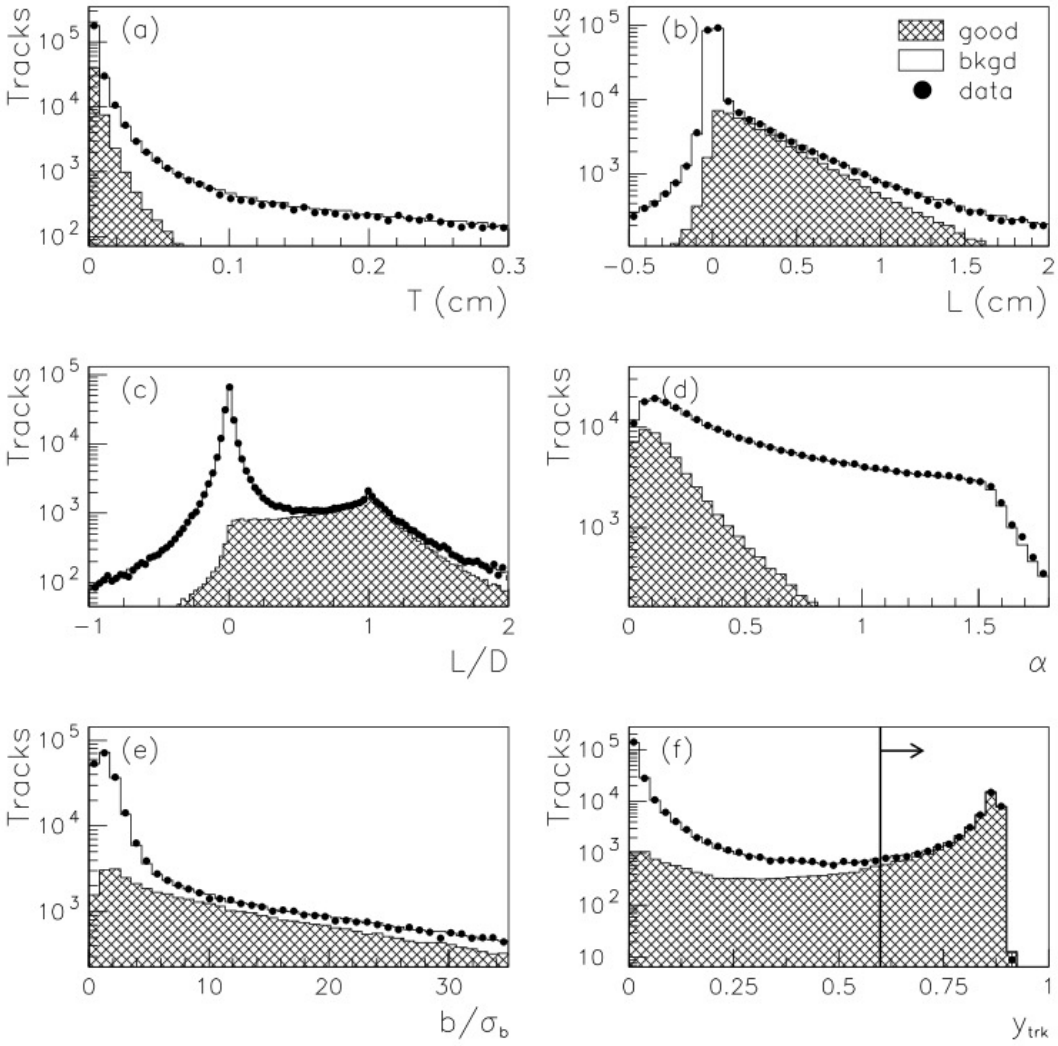
Attach Additional Secondary tracks

- Once a seed secondary vertex is found, the picture is sharpened.
- Second pass to look for additional tracks consistent with cascade decay along the vertex axis.
- 3D DOCA to vertex axis T<1mm to remove background
- L/D > 0.3 to pickup compatible tracks



Refined NN for Track Attachment

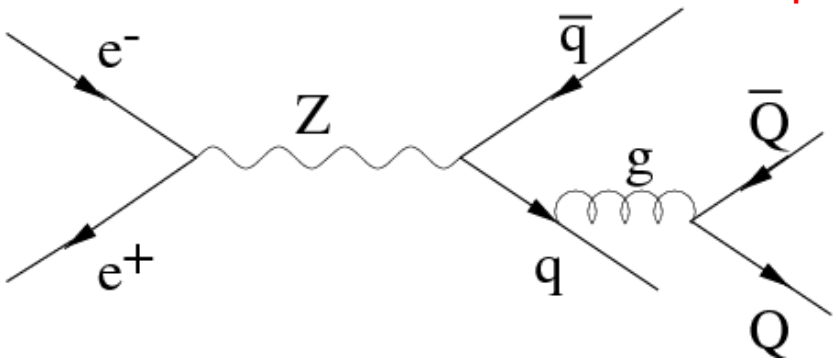
- SLD Collab.: PRD 71.112004,2005
- Tom Wright Ph.D thesis: SLAC-R-602 (2002)



What's a b jet ?

- $g \to c\bar{c}$, $g \to b\bar{b}$ production measured at $e^+e^- \to Z$ experiments were x2 higher than MC
- Verified at hadron colliders later
- Issue still unresolved in current generators

q or Q ?



Z->had	$g \to c\bar{c}$ (%)	$g \to b\bar{b}$ (%)
LEP/SLD	2.96±0.38	0.254±0.051
JETSET	1.36	0.142

Significant fraction of light jet "mis tag" at SLD

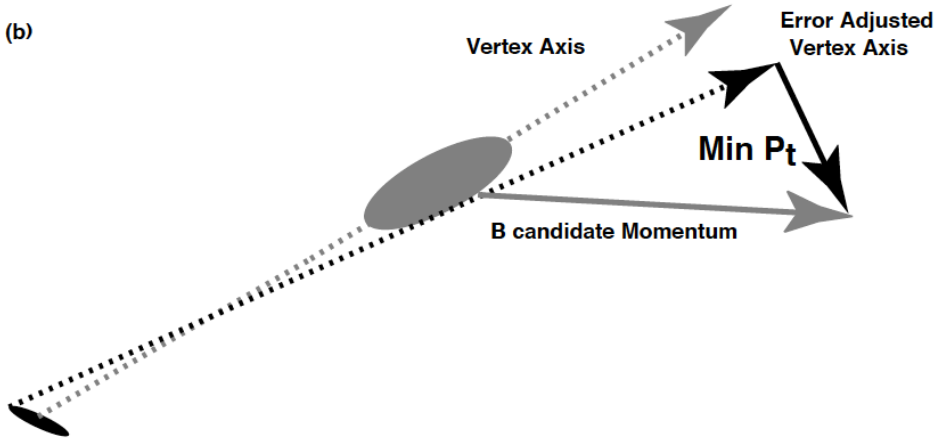
Nomenclature

- b-tag or B-tag ?
- Features generically aiming at b-quark should use "b".
- "B" is reserved for weakly decaying B mesons only.
- One way nomenclature:
  - b tag
  - b hadron (includes b baryon)
  - b fragmentation
  - B mixing
- Both ways possible depending on context:
  - B or b mass
  - B or b lifetime
  - B or b decay

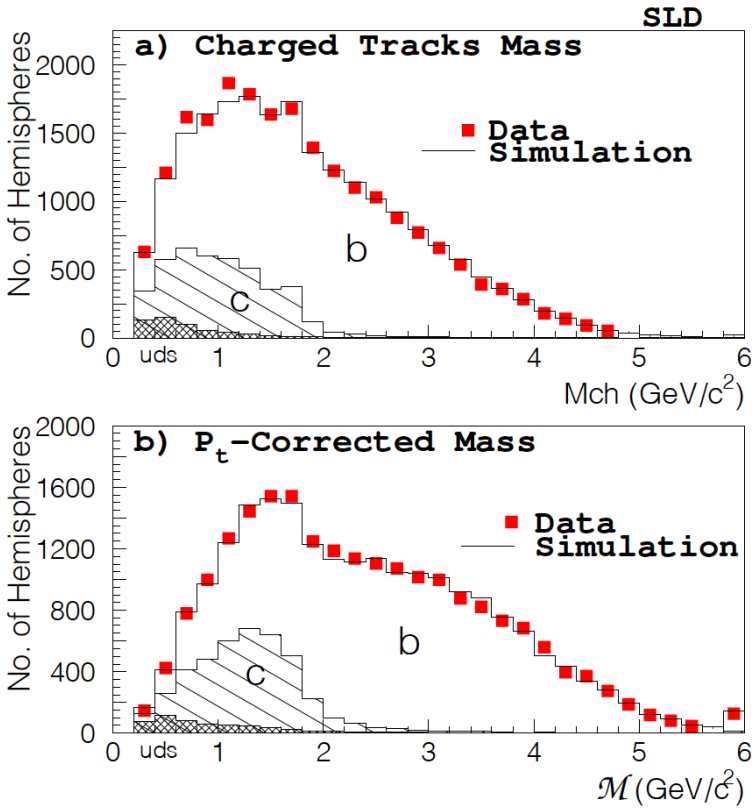
Vertex Mass and Charm Tag

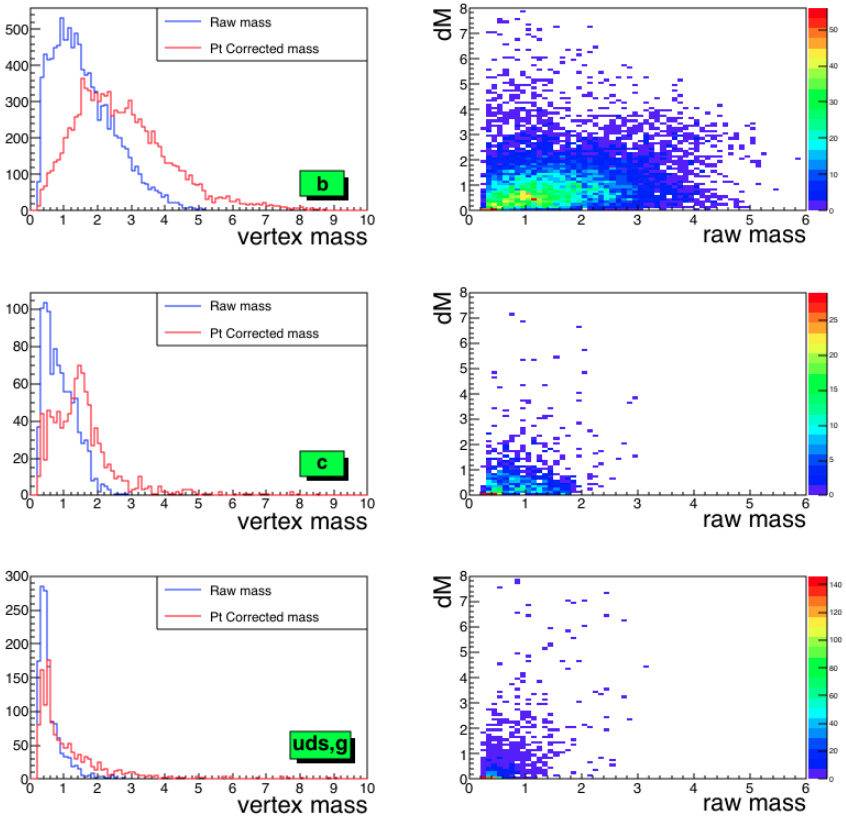
P_T Corrected Mass

- Vertex mass is the most important distinction between b and c
- $M_{corr} = \sqrt{m_{chrg}{}^2 + P_t{}^2} + |P_t|$
- Crucial to account vertex resolution
- Limit correction $\delta M < M_{raw}$



P_T corrected mass



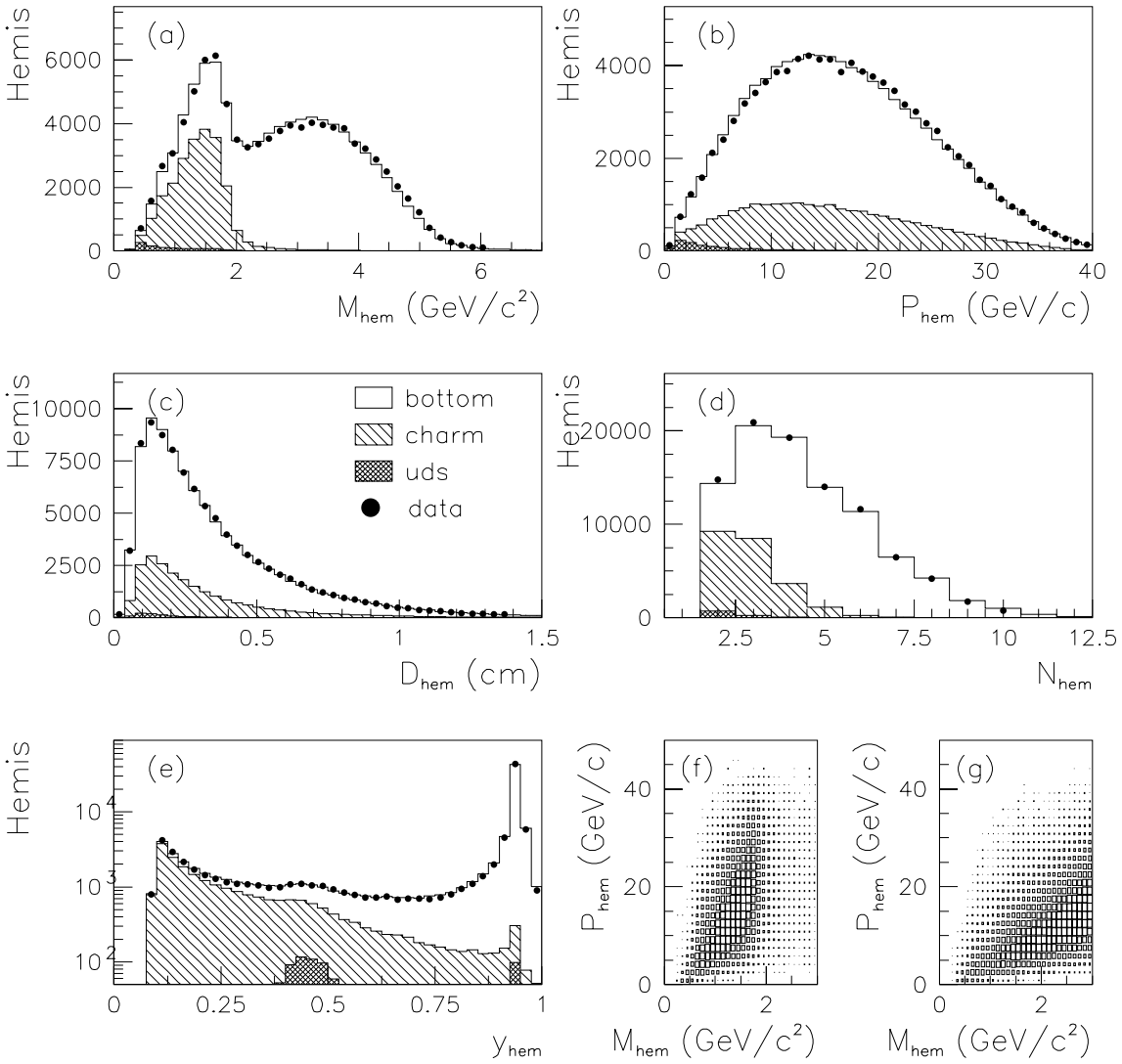


SLD VXD2

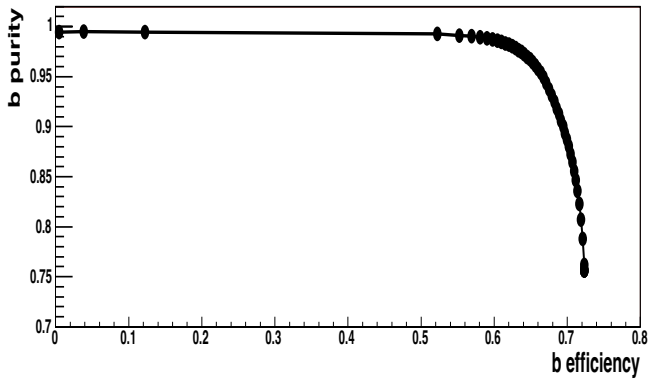
ATLAS simulation

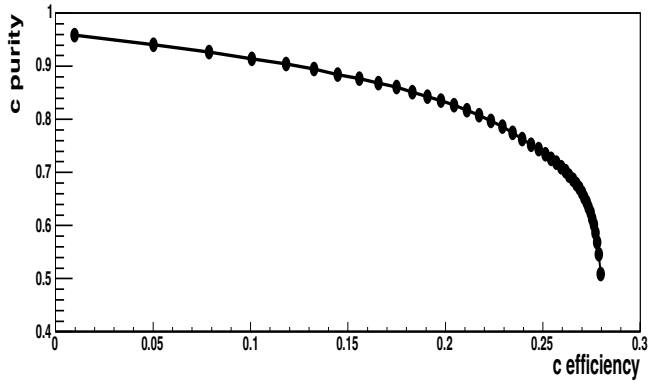
Multivariant

Multivariant tag



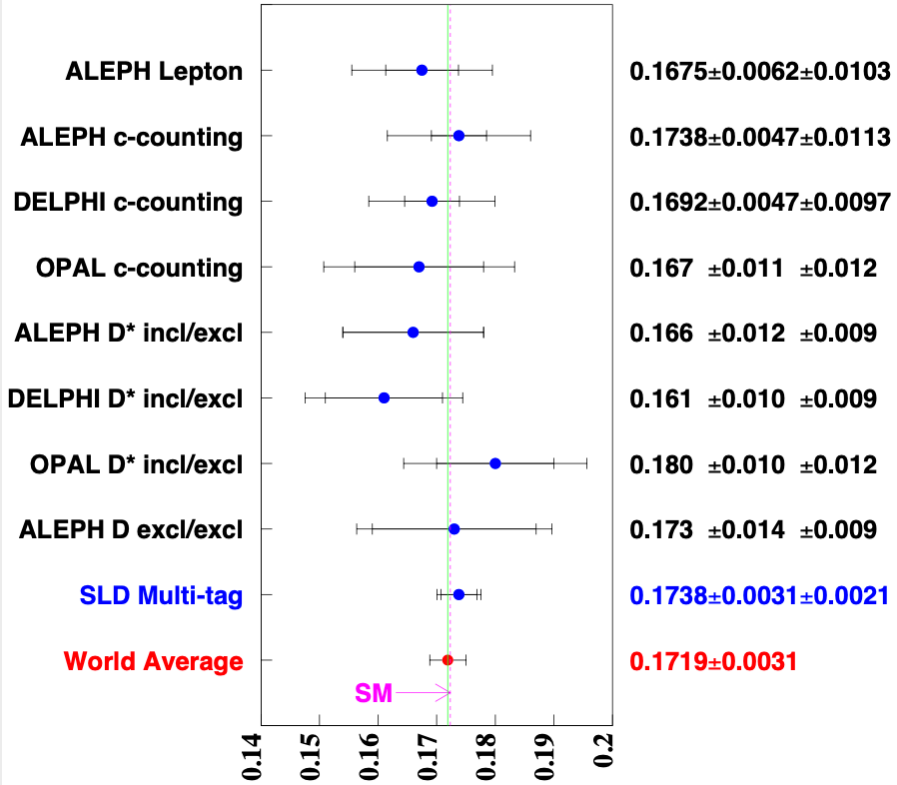
Charm tagging





$Z^0 \to c\bar{c}$ branching ratio

R_c Measurements (Summer-2001)



b/c separation with vertex mass tag

b contamination in c-tag also calibrated

Precision from double tag ε^2

LEP:4x4MZ vs SLD 0.5MZ

SLD R_b,R_c PRD 71 112004 (2005)