Summary of validation studies of the simplified geometry

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LHCb Tracking & Alignment workshop, CERN, 10-12 June 2008

A summary of several studies:

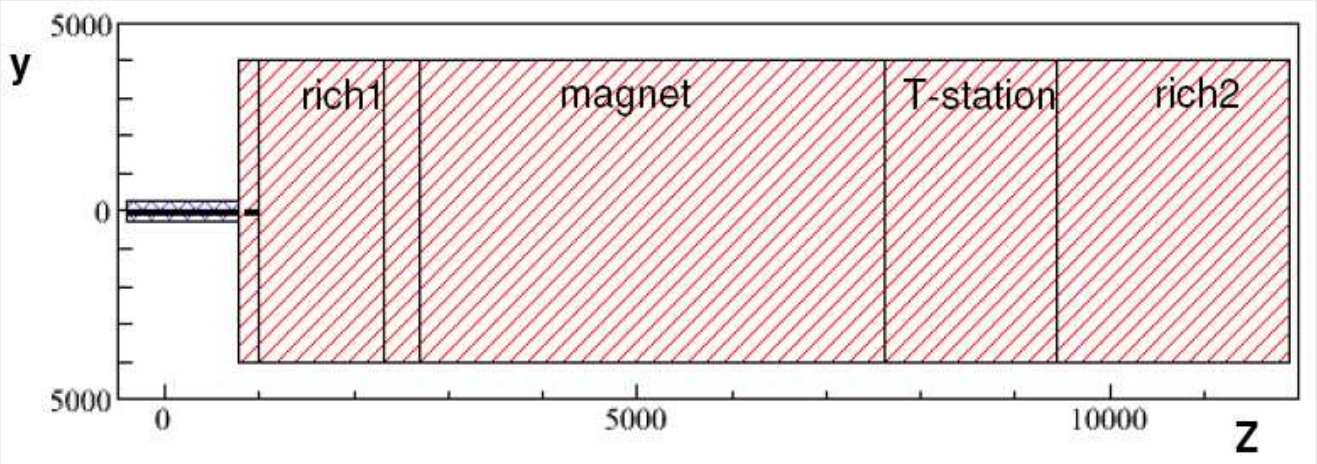
- *W. Hulsbergen, T-Rec meeting, 17/9/2007*
- *M. Needham, T-Rec meeting, 3/12/2007*
- *M. Gersbeck, E. Rodrigues, T-Rec meeting, 29/4/2008*
- *U. Kerzel, T-Rec meeting, 29/4/2008, 5/5/2008*
- *S. Hansmann-Menzemer, W. Hulsbergen, private communication, 5/2008*

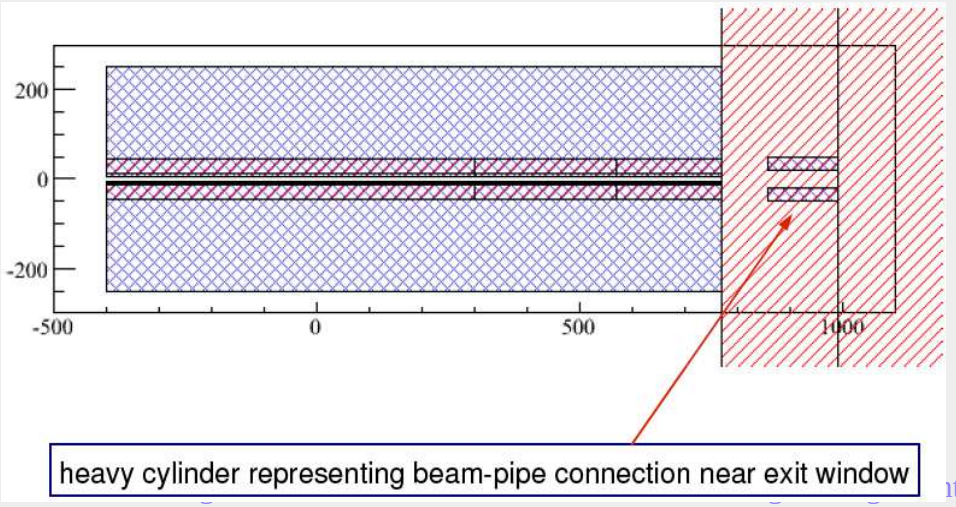
Simplified geometry

- Simplified description of the detector material as seen by a particle traversing LHCb
- Simplified modules assigned material properties from average of nominal geometry
- 28 volumes:

  - 19 boxes

  - 9 cylinders





⇒ **what are the consequences for tracking and physics?**

Timing

S. Hansmann-Menzemer

Timing

S. Hansmann-Menzemer

- **Timing in Brunel:**

  ~2900ms/event (standard geom.) ⇔ 1950ms/event (simplified geom.)

  on a 2.8 GHz Xeon

	simplified	detailed
Brunel	462	691
Reco	387	609
RecoTrSq	213	435
Fit	128	348

⇒ Brunel is reduced to 67% of its timing
Overall tracking speeds up by 50%
Fitting itself is reduced to about 37% of its time

⇒ what are the consequences for tracking and physics?

Tracking validation

M. Gersabeck, W. Hulsbergen, M. Needham, E. Rodrigues

Effect on pattern recognition (1/4)

M. Gersabeck, E. Rodrigues

- Pattern recognition efficiencies for long tracks
- Number of selected B $\rightarrow$ hh events

	VeloR	VeloSpace	Forward	Matching	$N_{selected}$
Standard	98.03(9)	97.03(8)	85.9(2)	81.1(2)	4141
Simplified	98.03(9)	97.03(8)	85.9(2)	81.4(2)	4186

- No change in PR efficiencies, as expected
- Slight increase in number of selected events

- Numbers is brackets: error on last digit

Effect on pattern recognition (2/4)

M. Gersabeck, E. Rodrigues

Standard geometry

Pat. Rec. :	Efficiency		Clones	
	long	long > 5 GeV	long	long > 5 GeV
VeloRZ :	98.0 %	98.9 %	2.4 %	1.8 %
Velo3D :	97.0 %	98.2 %	2.4 %	1.9 %
VeloTT :	2.4 %	1.0 %	1.1 %	0.8 %
Forward :	85.9 %	93.1 %	1.8 %	1.4 %
Match :	81.1 %	88.2 %	0.0 %	0.0 %
TSA :	91.8 %	95.9 %	0.7 %	1.0 %
Best :	97.4 %	98.6 %	5.2 %	3.3 %

Simplified geometry

Pat. Rec. :	Efficiency		Clones	
	long	long > 5 GeV	long	long > 5 GeV
VeloRZ :	98.0 %	98.9 %	2.4 %	1.8 %
Velo3D :	97.0 %	98.2 %	2.4 %	1.9 %
VeloTT :	2.4 %	0.9 %	1.1 %	0.8 %
Forward :	85.9 %	93.1 %	1.8 %	1.4 %
Match :	81.4 %	88.3 %	0.0 %	0.0 %
TSA :	91.8 %	95.9 %	0.7 %	1.0 %
Best :	97.4 %	98.6 %	5.1 %	3.3 %

Effect on pattern recognition (3/4)

M. Gersabeck, E. Rodrigues

Standard geometry

Pat. Rec.	# tracks	Ghost rate
VeloRZ	87	10.41 %
Velo3D	79	7.02 %
VeloTT	10	25.44 %
Forward	30	15.36 %
Match	27	11.28 %
TSA	56	9.68 %
Downstream	35	36.66 %
Best	109	21.06 %

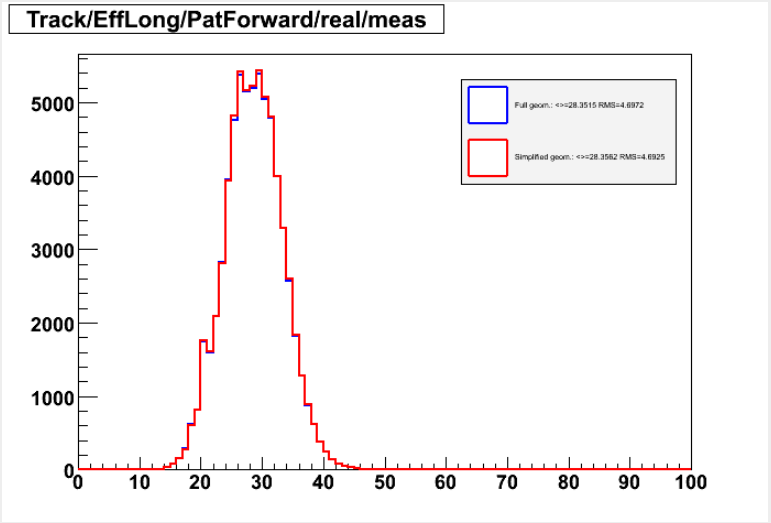
Simplified geometry

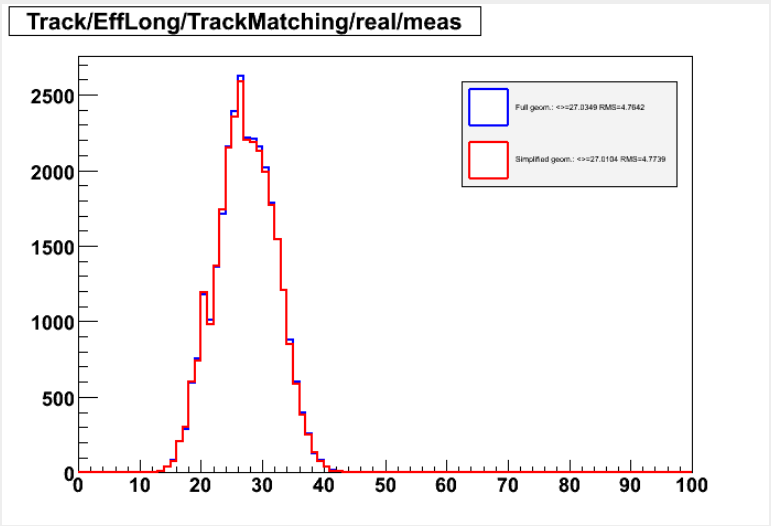
Pat. Rec.	# tracks	Ghost rate
VeloRZ	87	10.41 %
Velo3D	79	7.02 %
VeloTT	10	25.52 %
Forward	30	15.36 %
Match	27	11.58 %
TSA	56	9.68 %
Downstream	35	36.99 %
Best	109	21.14 %

Effect on pattern recognition (4/4)

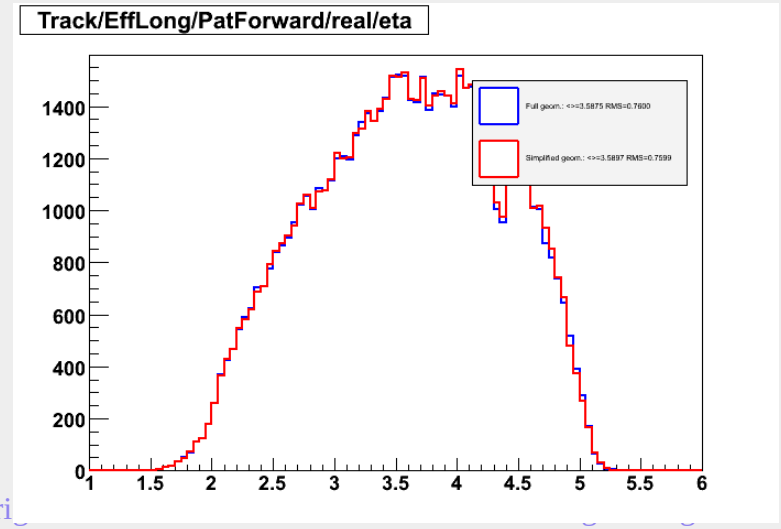
M. Gersabeck, E. Rodrigues

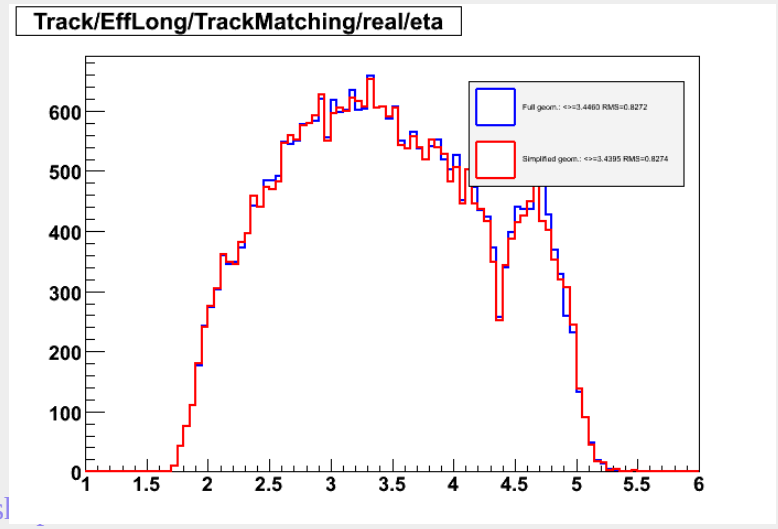
❑ Number of measurements per (long) track





❑ Eta distribution of reconstructed (long) tracks

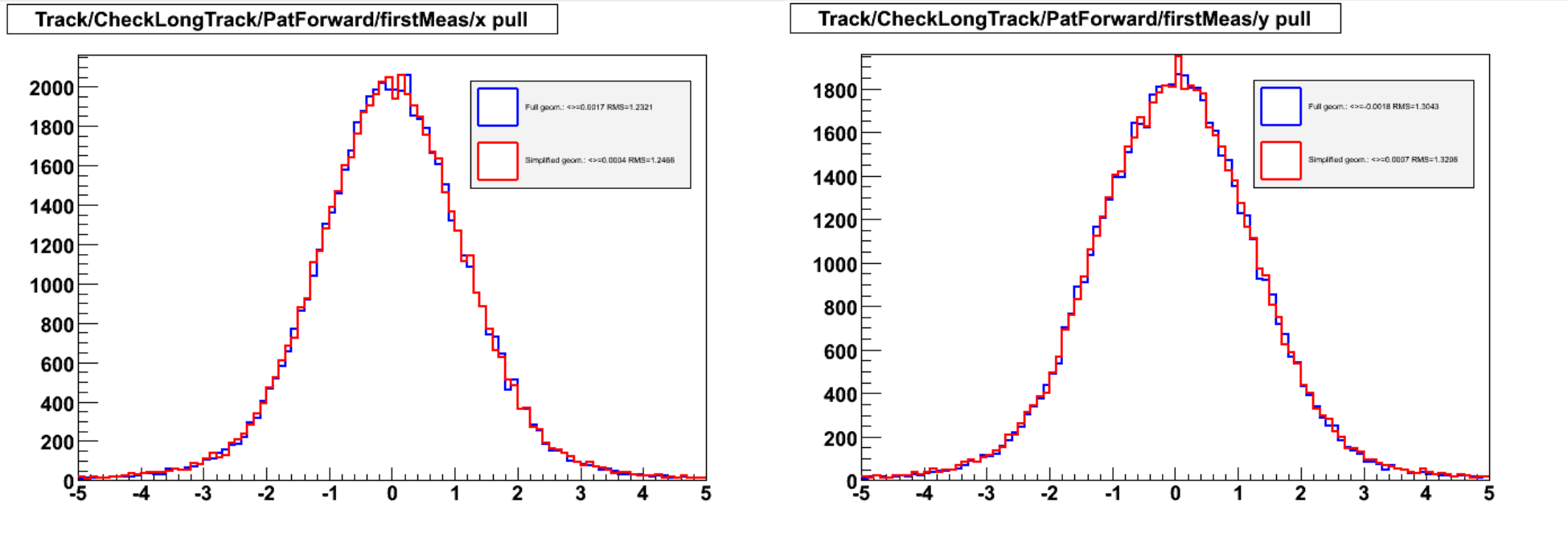




Effect on quality of long tracks (1/3)

M. Gersabeck, E. Rodrigues

- x and y pulls at first measurement point

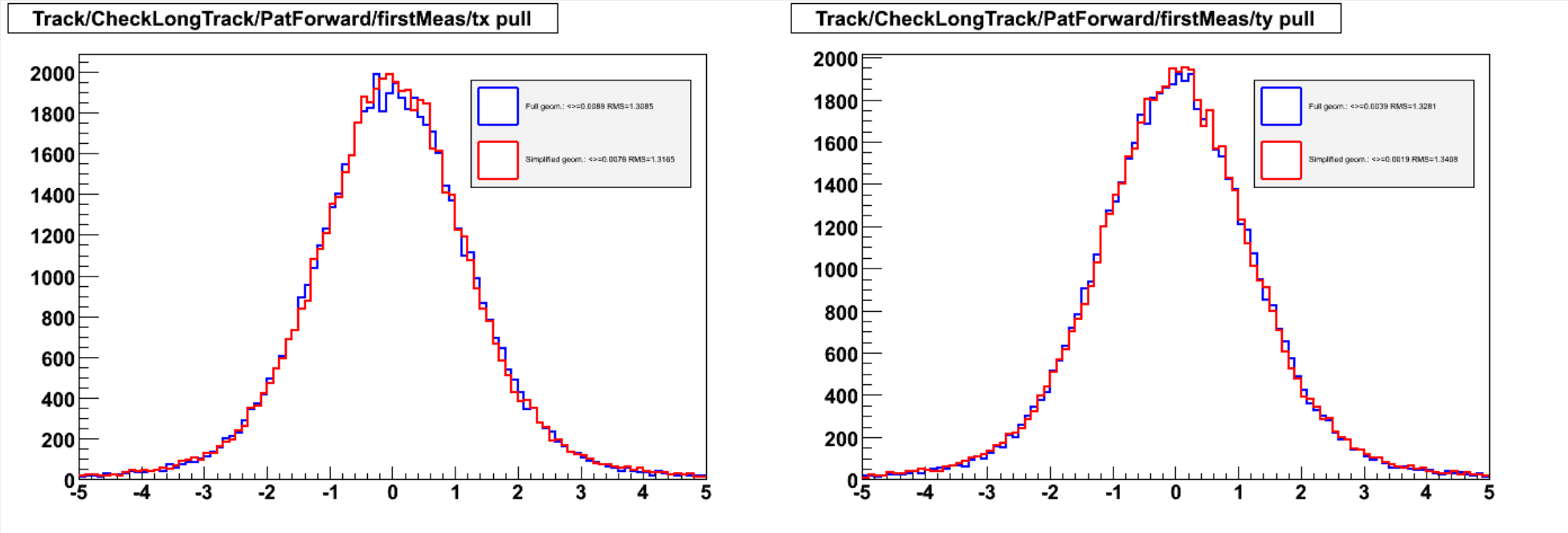


- Similar plots exist along the tracks (in VELO, TT, OT, etc.)

Effect on quality of long tracks (2/3)

M. Gersabeck, E. Rodrigues

- t_x and t_y pulls at first measurement point

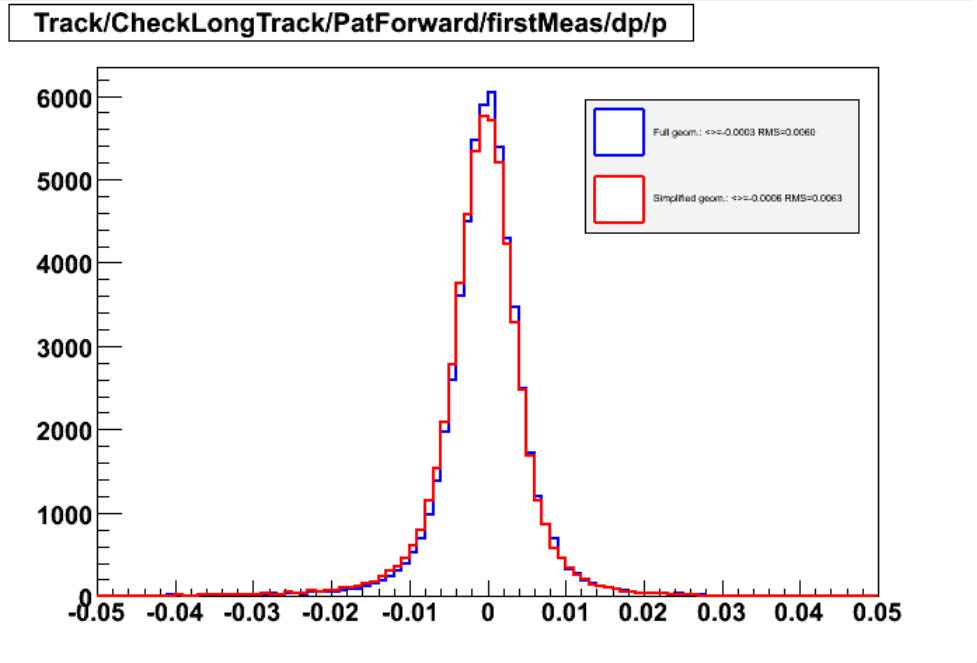


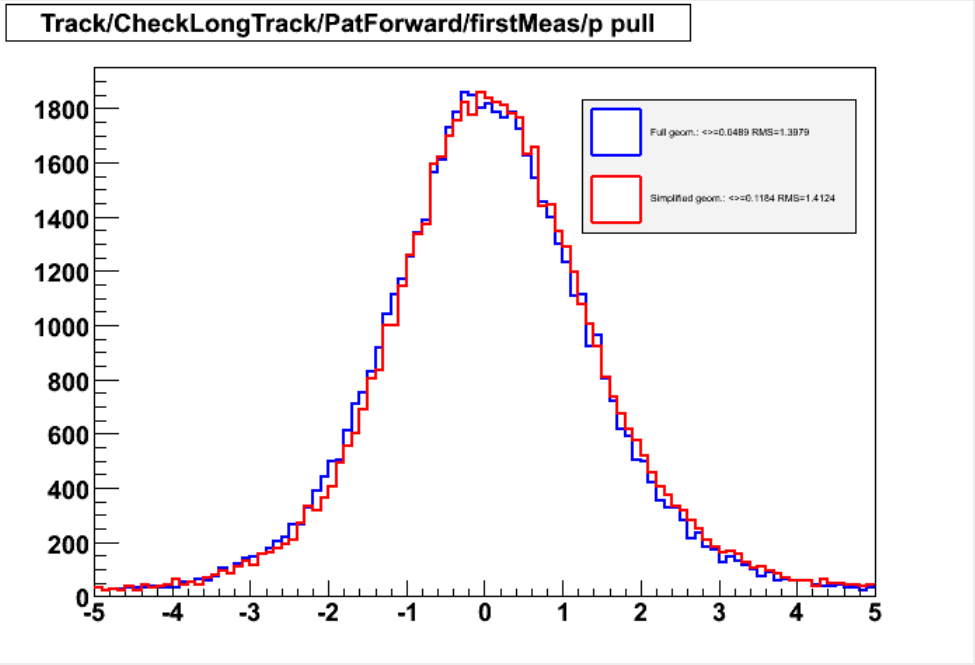
- Similar along the tracks (in VELO, TT, OT, etc.)

Effect on quality of long tracks (3/3)

M. Gersabeck, E. Rodrigues

❑ Momentum resolution and pull at first measurement point



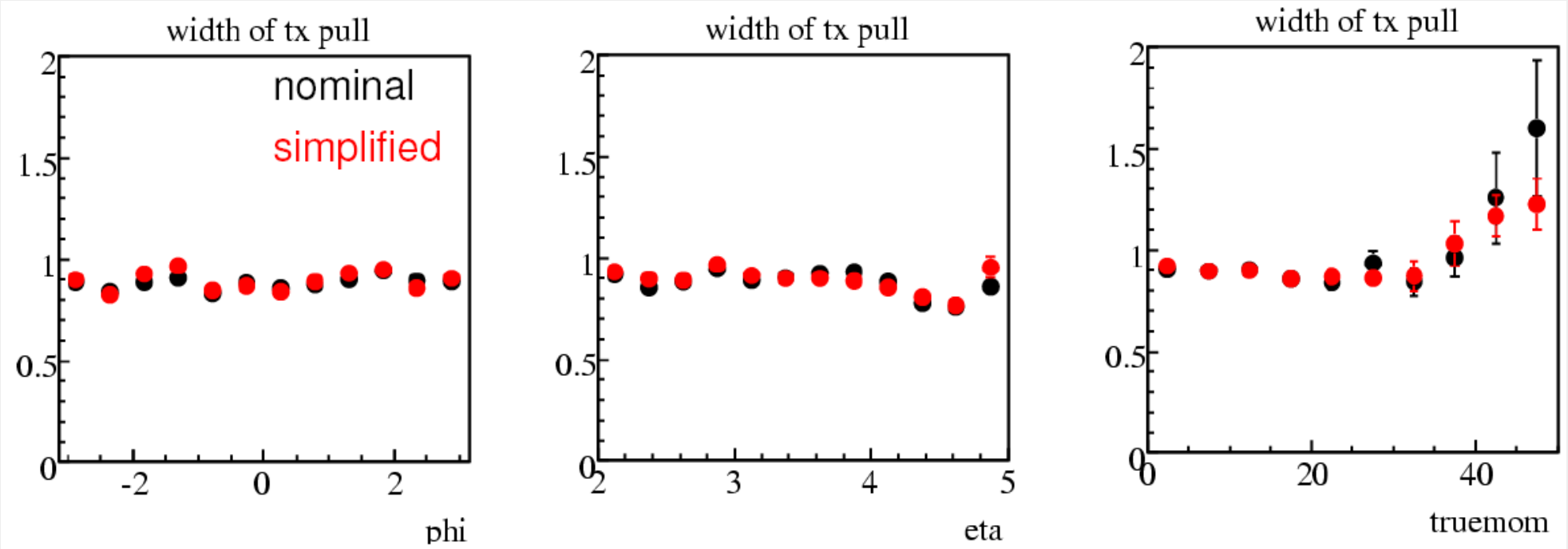


- Slight increase in bias: 0.05 (std) → 0.12 (simplified)
- Slight increase in resolution (RMS): 0.60% (std) → 0.63% (simplified)

Effect on quality of long tracks (1/3)

W. Hulsbergen

- Sigma of Gaussian fit to pull distributions of long tracks in 500 J/Ψ K_s events



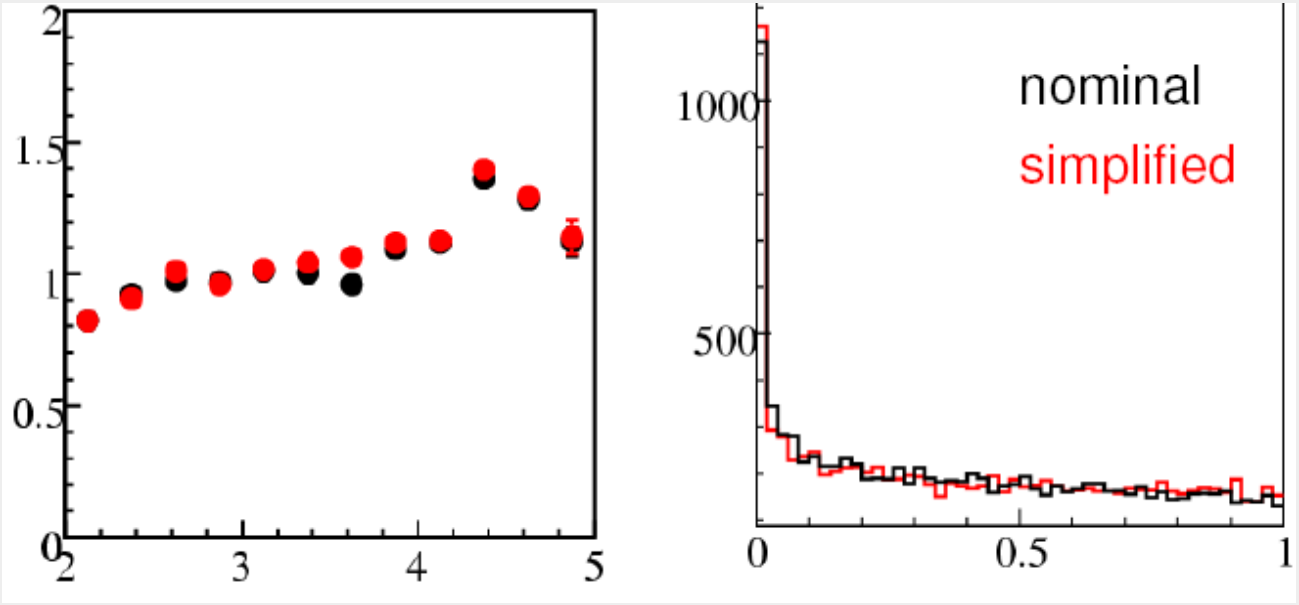
- x,y, t_x and t_y pulls at vertex match well to full geometry

Effect on quality of long tracks (2/3)

W. Hulsbergen

- One 20mrad cone was added to represent the beampipe and the flanges

- 1/p pull versus eta and χ^2 probability

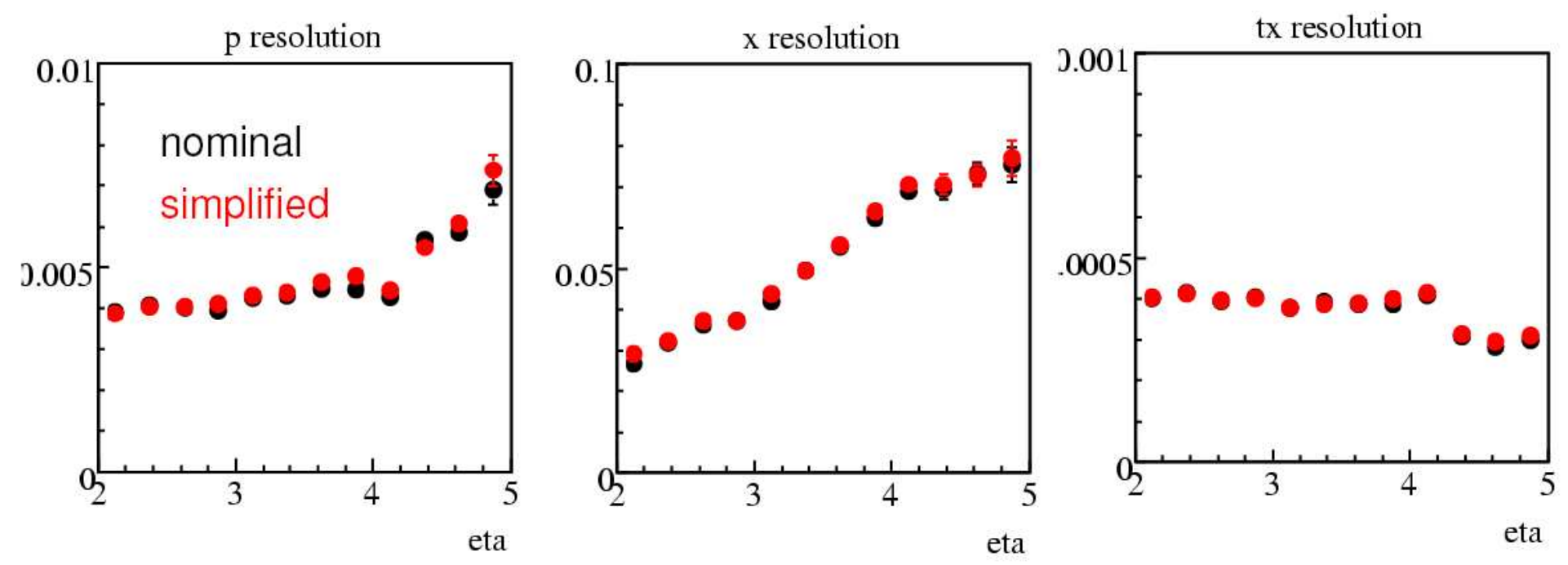


➢ **Excellent agreement**

Effect on quality of long tracks (3/3)

W. Hulsbergen

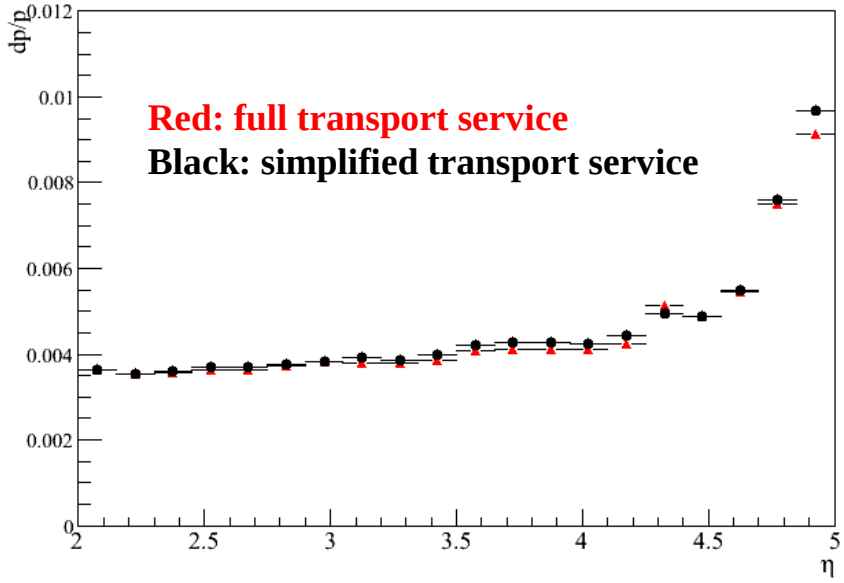
❑ Resolutions versus pseudorapidity

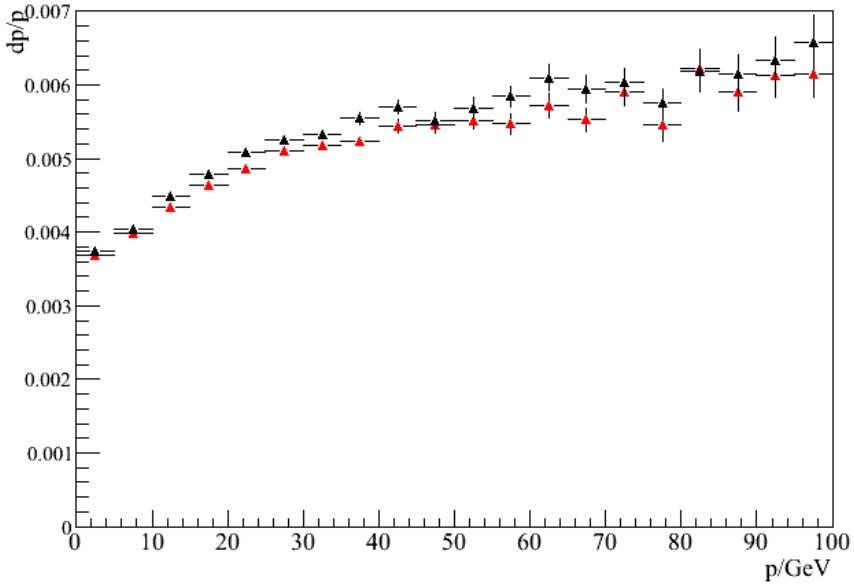


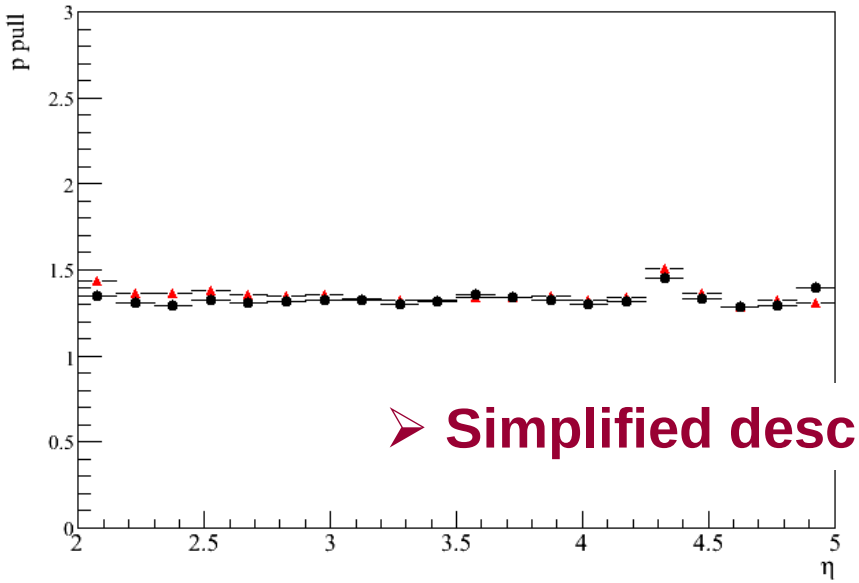
➢ **Excellent agreement**

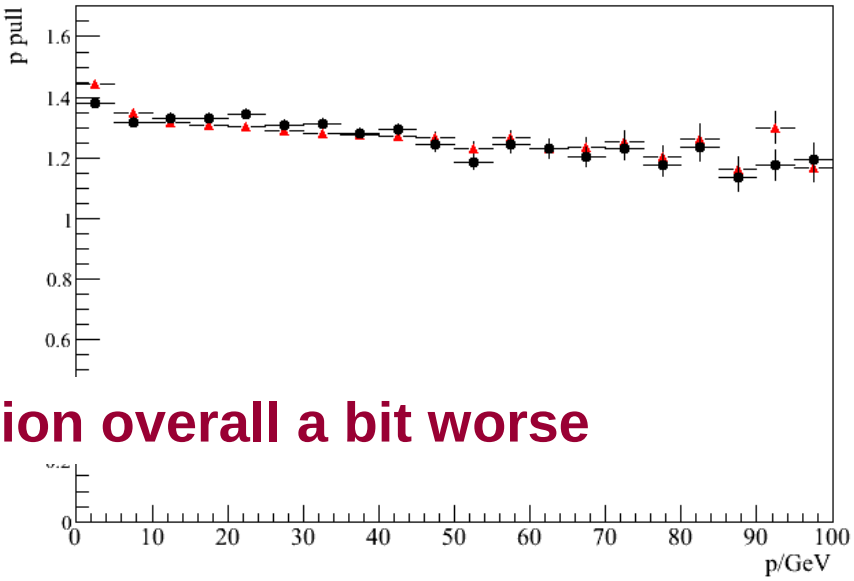
Effect on quality of long tracks

M. Needham









➢ **Simplified description overall a bit worse**

Physics validation

M. Gersabeck, W. Hulsbergen, U. Kerzel, M. Needham, E. Rodrigues

Studies

M. Gersabeck, E. Rodrigues

Validation with B $\rightarrow$ hh decays :

- Study on 20k B $\rightarrow$ hh events
- Produced with Brunel v32r2 and DaVinci v19r9
- Simplified geometry used in Brunel

U. Kerzel

Validation with $B_s \rightarrow KK$ decays:

- Lifetime measurement from CP specific mode
- Simultaneous unbinned mass/time fit
- Ran with Boole v14r6 and Brunel v31r11
- Simplified geometry used when re-running reconstruction in DaVinci

Validation with B → hh events (1/3)

M. Gersabeck, E. Rodrigues

- Momentum resolution for B-daughter pions
- B invariant mass and propertime resolutions
- Numbers correspond to sigmas of single-Gaussian fits to distributions for selected candidates

	π's σ(p)/p (%)	B mass (MeV)	B propertime (fs)
Standard	0.495(5)	22.5(3)	37.7(5)
Simplified	0.502(6)	22.9(4)	37.7(6)

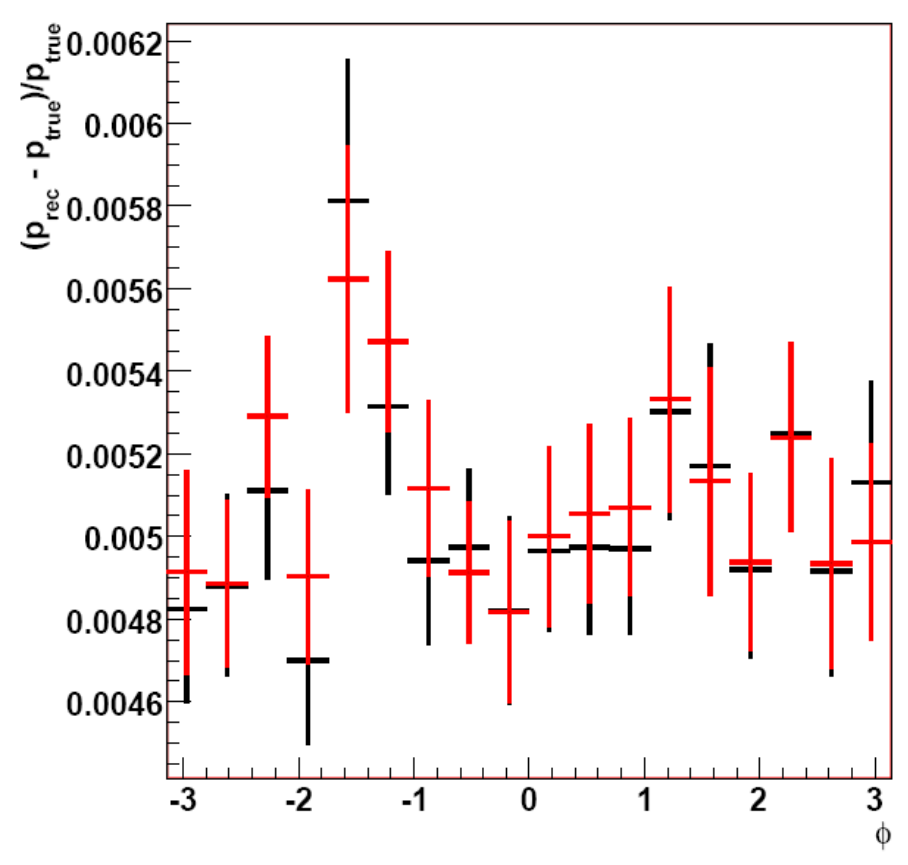
➢ **No significant degradation**

- Numbers is brackets: error on last digit

Validation with B → hh events (2/3)

M. Gersabeck, E. Rodrigues

- Simplified description might introduce effects dependent on ϕ
- But no effect observed in the momentum resol.
- Also no significant difference observed for the slopes



Validation with B → hh events (3/3)

M. Gersabeck, E. Rodrigues

- Resolutions for vertexing
- Numbers correspond to sigmas of single-Gaussian fits to distributions for selected candidates

	Primary vertex (μm)			B-decay vertex (μm)		
	x	y	z	x	y	z
Standard	9.2(1)	8.8(2)	41.4(7)	14.2(2)	14.0(2)	147(3)
Simplified	8.9(1)	8.8(1)	41.4(7)	14.3(2)	14.3(2)	145(3)

➢ No significant degradation

- Numbers is brackets: error on last digit

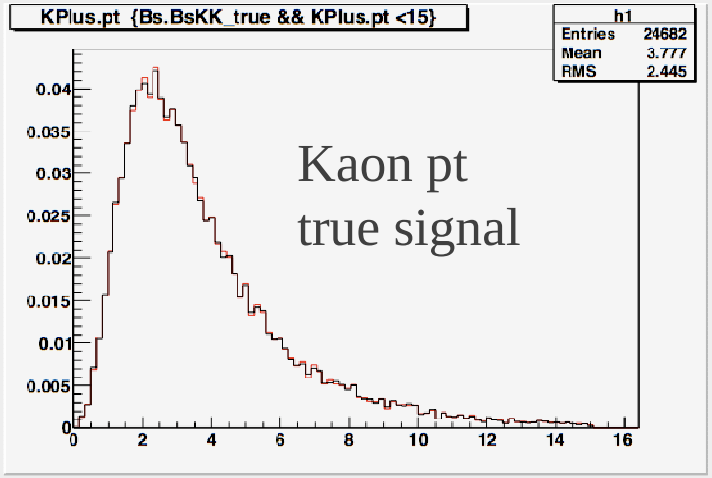
Validation with $B_s \rightarrow KK$ events (1/4)

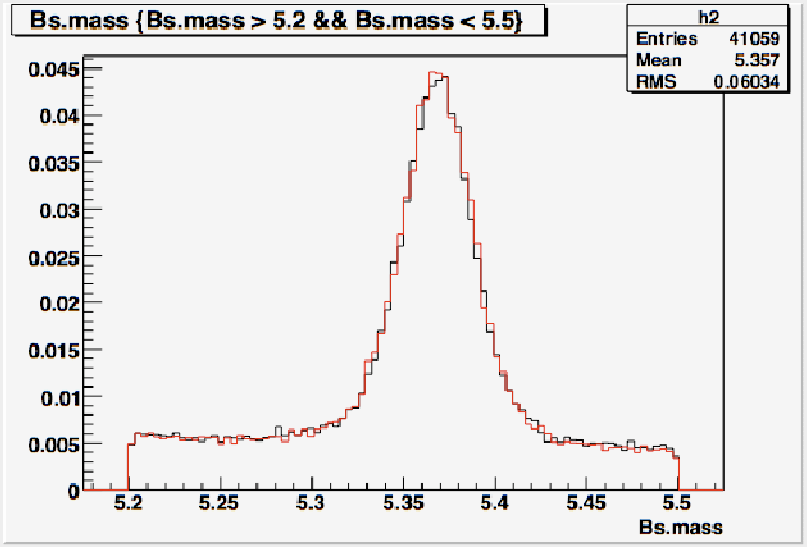
U. Kerzel

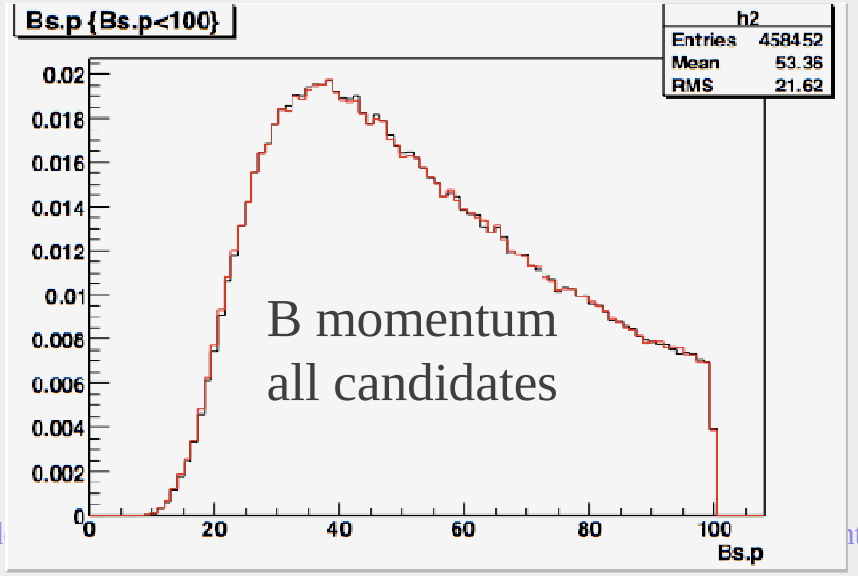
Colour:

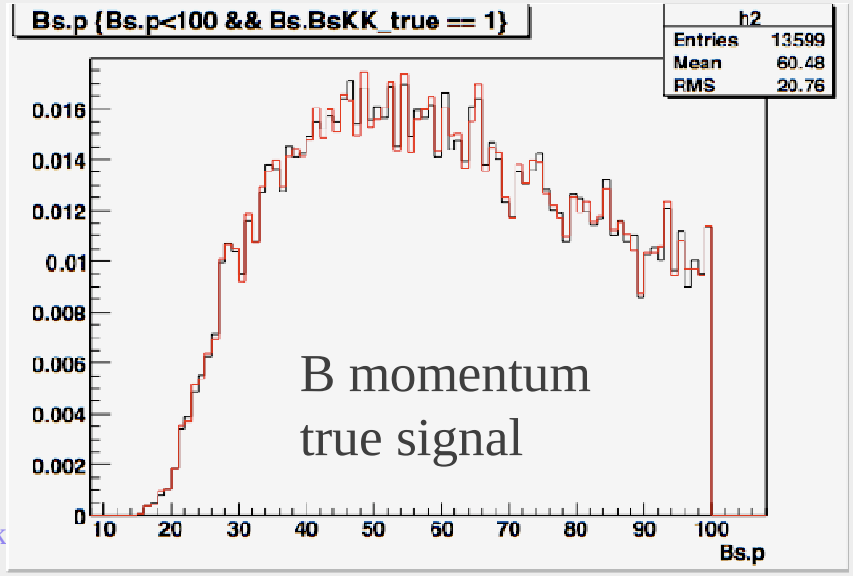
black: default setup

red : simplified geometry



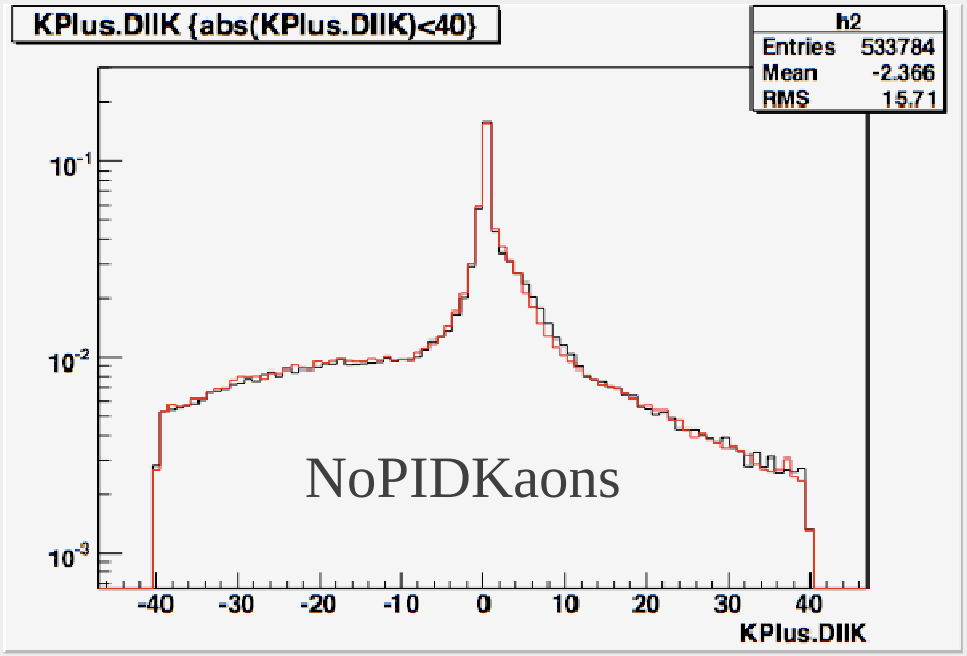


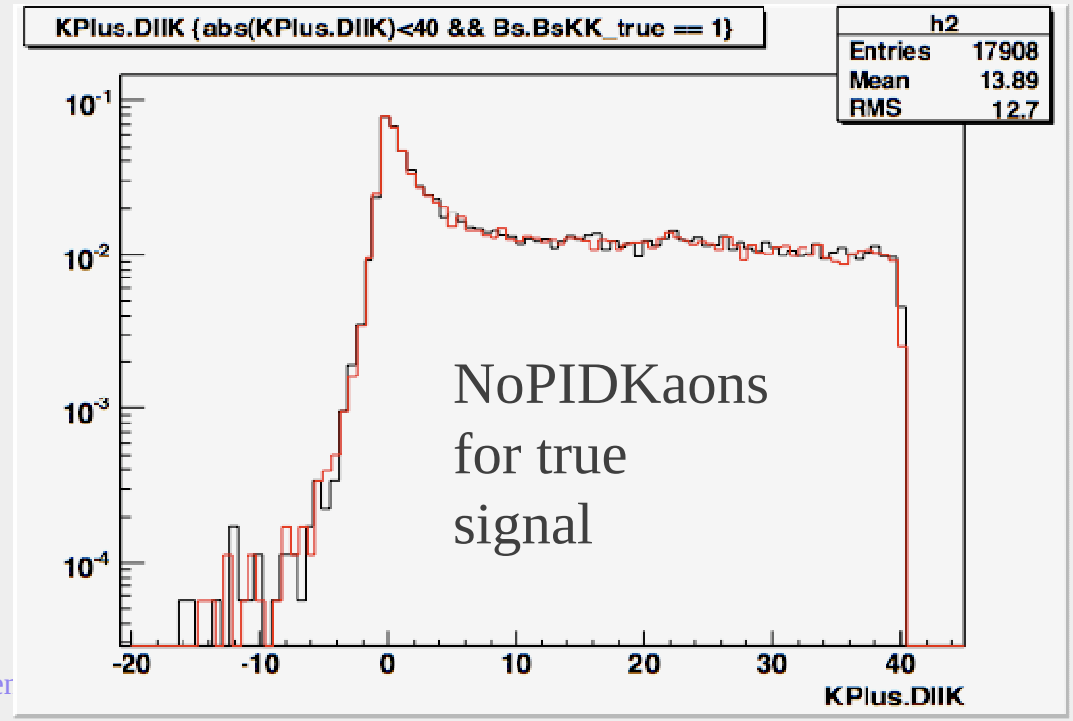




Validation with $B_s \rightarrow KK$ events (2/4)

U. Kerzel



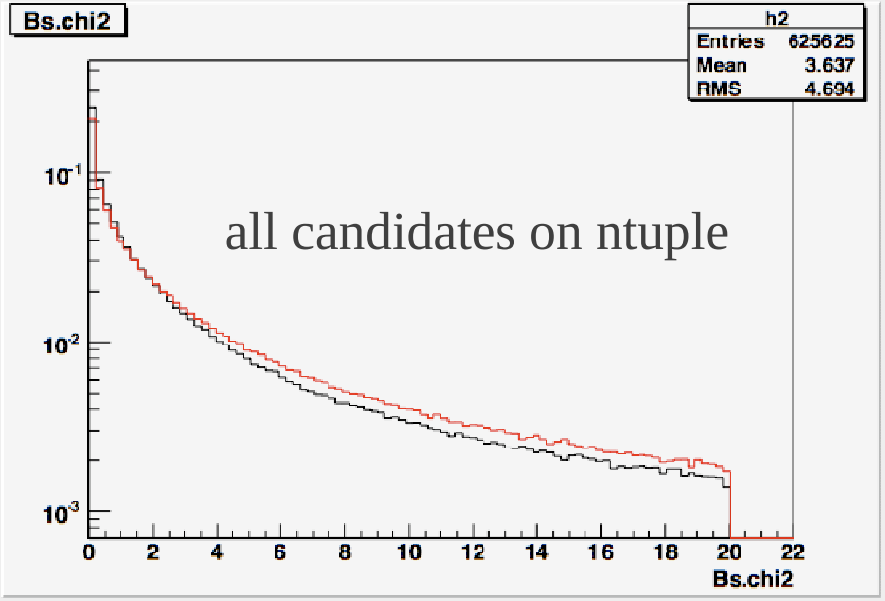


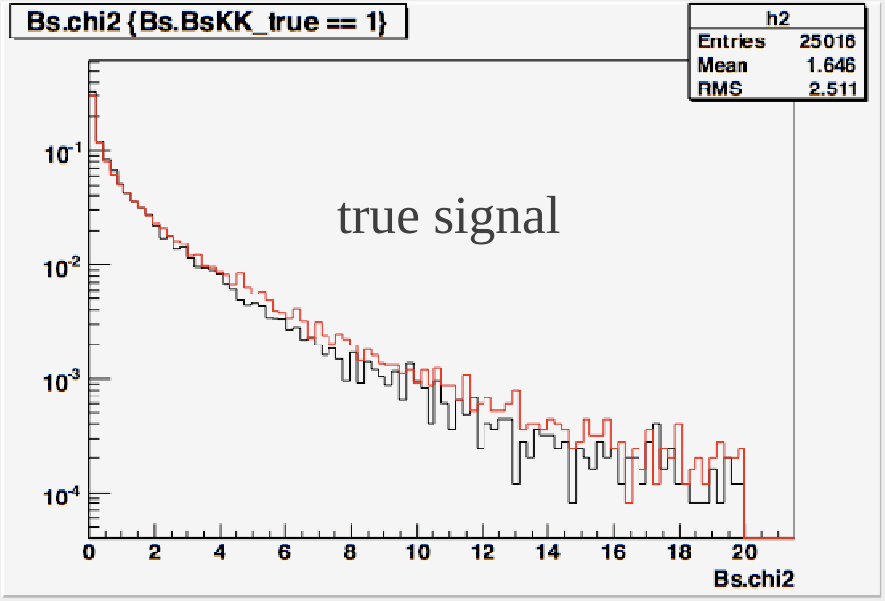
- **Excellent agreement**

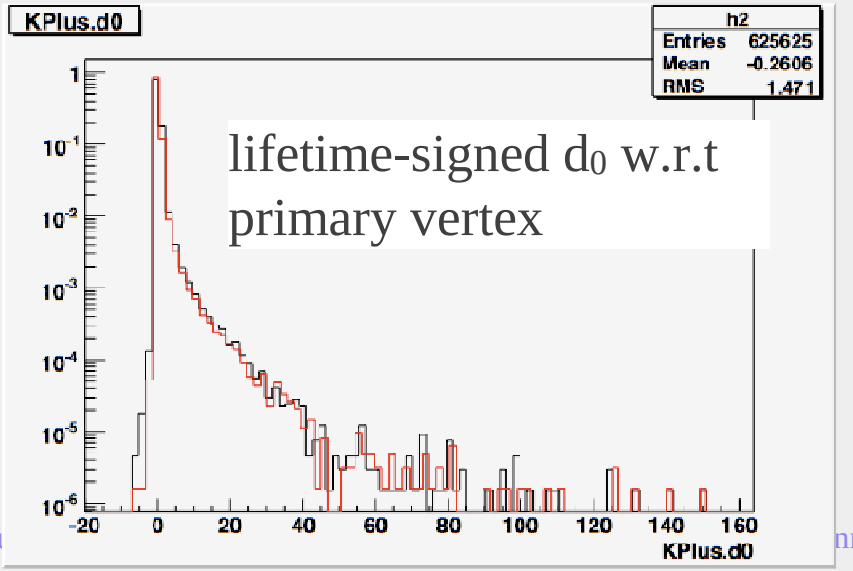
Validation with $B_s \rightarrow KK$ events (3/4)

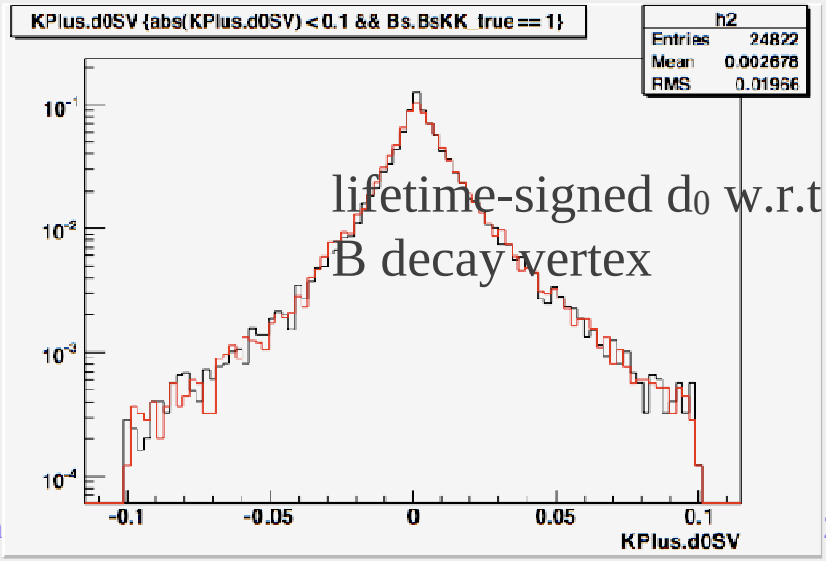
U. Kerzel

❑ χ^2 of vertex fit









Validation with $B_s \rightarrow KK$ events (4/4)

U. Kerzel

Number of candidates on ntuple:

Default setup:

#candidates: 663932

#true BsKK : 24920

Simplified geometry:

#candidates: 625625

#true BsKK : 25016

Lifetime fit:

Default setup:

τ(Bs→KK) = 446.9 ± 11.0 μm (stat.)

τ(Bd→πK) = 499.2 ± 9.8 μm (stat.)

Simplified geometry:

τ(Bs→KK) = 450.3 ± 10.8 μm (stat.)

τ(Bd→πK) = 496.0 ± 9.4 μm (stat.)

$\Rightarrow$ **some issues to be solved … e.g. lifetime bias**

Outlook

No significant differences found in physics analyses between detailed and simplified geometries

- **Simplified geometry validated in different and complementary manners**
- **No show-stopping features observed**

- **We will start data taking with the full geometry**
- **A new simplified description will be re-derived at a later stage**
- **This in turn will need to be validated**

  $\Rightarrow$ decision on using it by default …