LDC behavior of $\Delta(1/p_t)$ at polar angle $\theta = 20°$ and below

Simulation and fit using the LiC Detector Toy software

(geometry, material budget and zero TPC diffusion term, as communicated by M. Vos)

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The LiC Detector Toy Software

- Simple, but flexible and powerful tool, written in MatLab
- Detector design studies
  - Geometry, material budget, resolutions, inefficiencies
- Simulation
  - Solenoid magnetic field, helix track model
  - Multiple scattering, measurement errors and inefficiencies
  - *No further corruption, therefore no pattern recognition*
  - Cylinders (barrel) or planes (forward/rear)
  - Strips and pads, uniform and gaussian errors (in TPC with diffusion corr.)
- Reconstruction
  - Kalman filter
  - *Optimal linear estimator according to Gauss-Markov (no corruption)*
  - Fitted parameters and corresponding covariances at the beamtube
- Output
  - Resolution of the reconstructed track parameters inside the beam tube
  - Impact parameters (projected and in space)
  - Test quantities (pulls, χ^2, etc.)

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Detector description (barrel)

(for better comparison: following M. Vos, no diffusion term in TPC)

Barrel	R [mm]	z_{min} [mm]	z_{max} [mm]	Error distr.	d [X_0]	Remarks
XBT (Beam pipe)	14	-50	50	Passive	0.025	
VTX1	16	-125	125	(5 x 5) * √12	0.0012	Pixels
VTX2	28	-125	125	(5 x 5) * √12	0.0012	Pixels
VTX3	40	-125	125	(5 x 5) * √12	0.0012	Pixels
VTX4	52	-125	125	(5 x 5) * √12	0.0012	Pixels
VTX5	60	-125	125	(5 x 5) * √12	0.0012	Pixels
XTPCW TPC wall	340	-2160	2160	passive	0.01	
196 pad rings	350 - 1580	-2160	2160	$\sigma_{R\Phi} = 120$ $\sigma_z = 300$	0.0000125	No diffusion

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Detector description (fwd.)

(for better comparison: following M. Vos)

Forward	z [mm]	R_{min} [mm]	R_{max} [mm]	Error distr.	d [X_0]	Remarks
FTD1	200	37.5	140	(50 x 10) * √12	0.0012 (0.012)	Pixels
FTD2	320	37.5	150	(50 x 10) * √12	0.0012 (0.012)	Pixels
FTD3	440	60	210	(50 x 10) * √12	0.0012 (0.012)	Pixels
FTD4	550	65	270	(1000 x 10) * √12	0.004 (0.008)	Strips 90°
FTD5	800	90	290	(1000 x 10) * √12	0.004 (0.008)	Strips 90°
FTD6	1050	110	290	(1000 x 10) * √12	0.004 (0.008)	Strips 90°
FTD7	1300	130	290	(1000 x 10) * √12	0.004 (0.008)	Strips 90°

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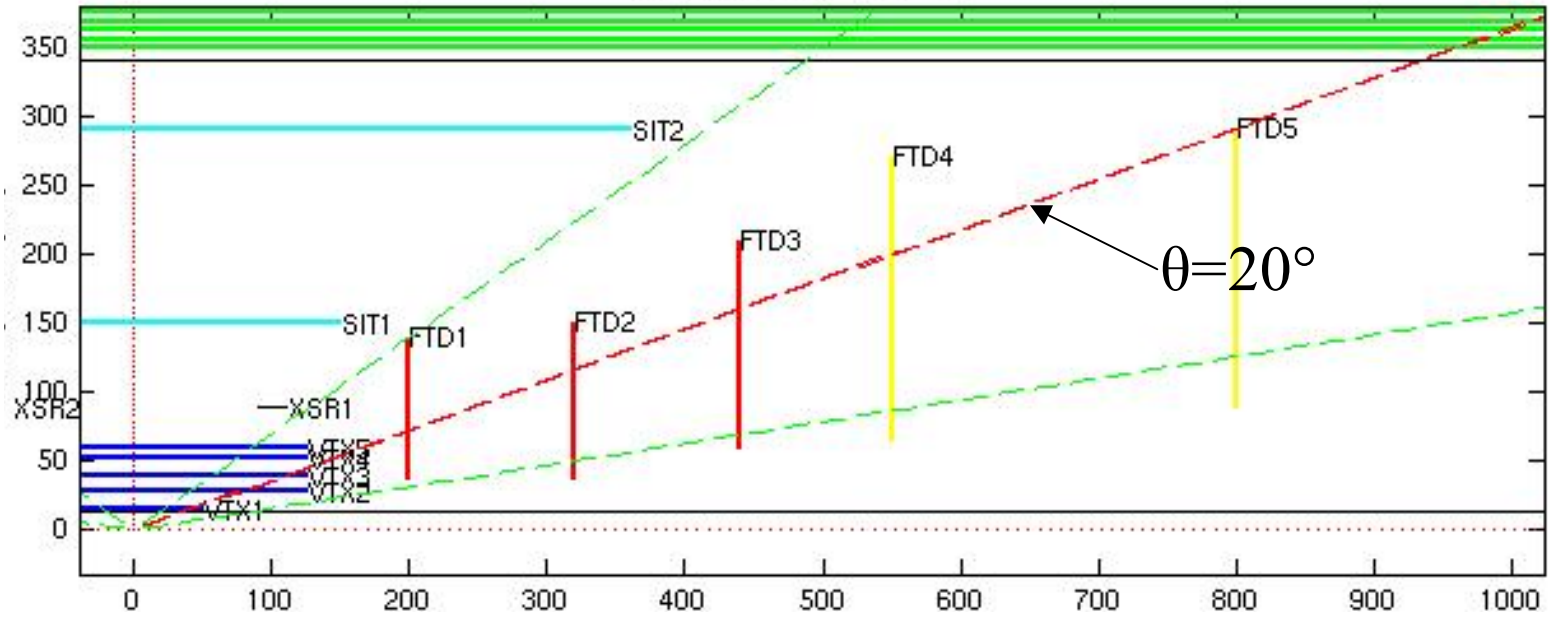
Detector description
(following M. Vos)



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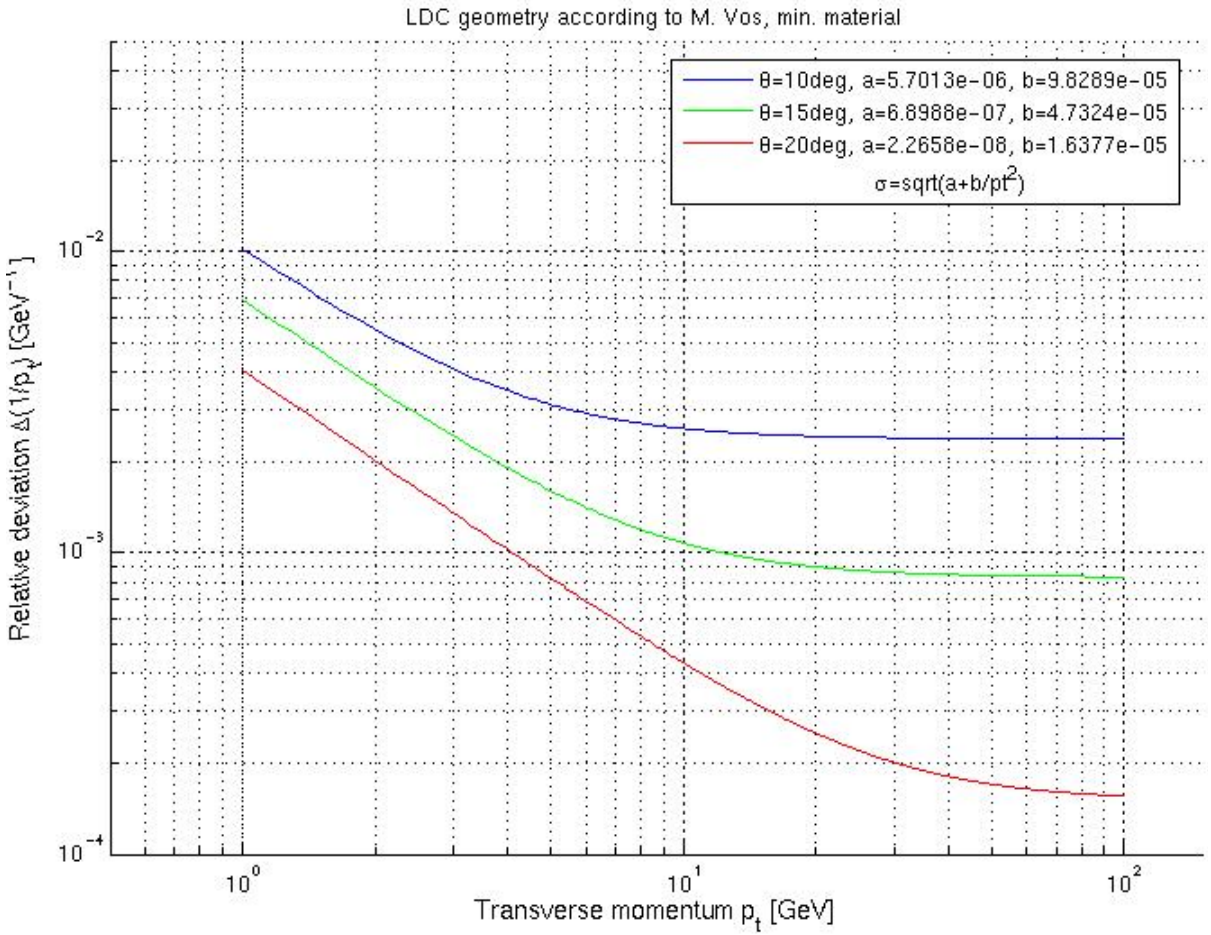
Validation (low material budget)

- Comparison with M. Vos successful, fully compatible
- Slightly below his curves because of uncorrupted data
  - No pattern recogn.
  - Optimal linear estimator according to Gauss-Markov



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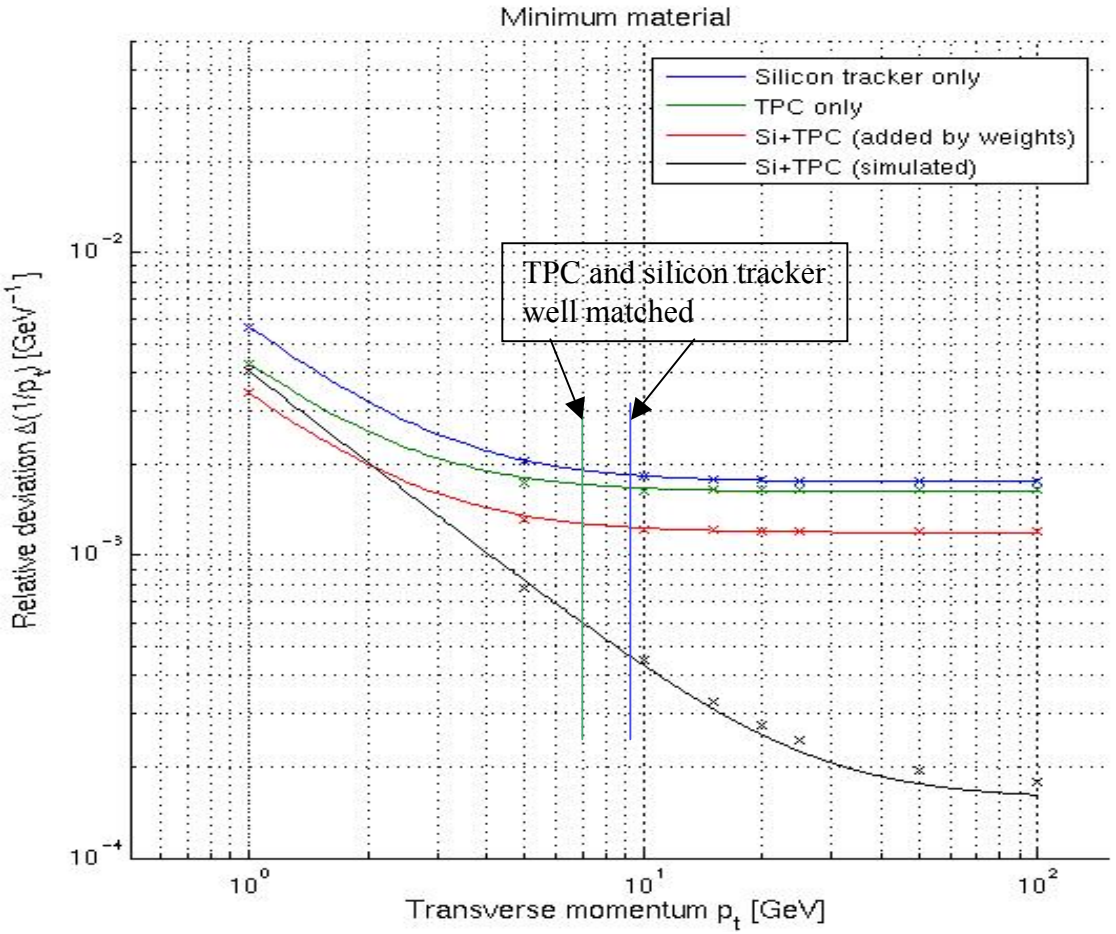
Low material budget at θ=20°

- Two different assumptions for the material budget of the forward chambers
- Low material budget:
  - FTD1-FTD3: 0.0012 X_0
  - FTD4-FTD7: 0.004 X_0
- High material budget:
  - FTD1-FTD3: 0.012 X_0
  - FTD4-FTD7: 0.008 X_0



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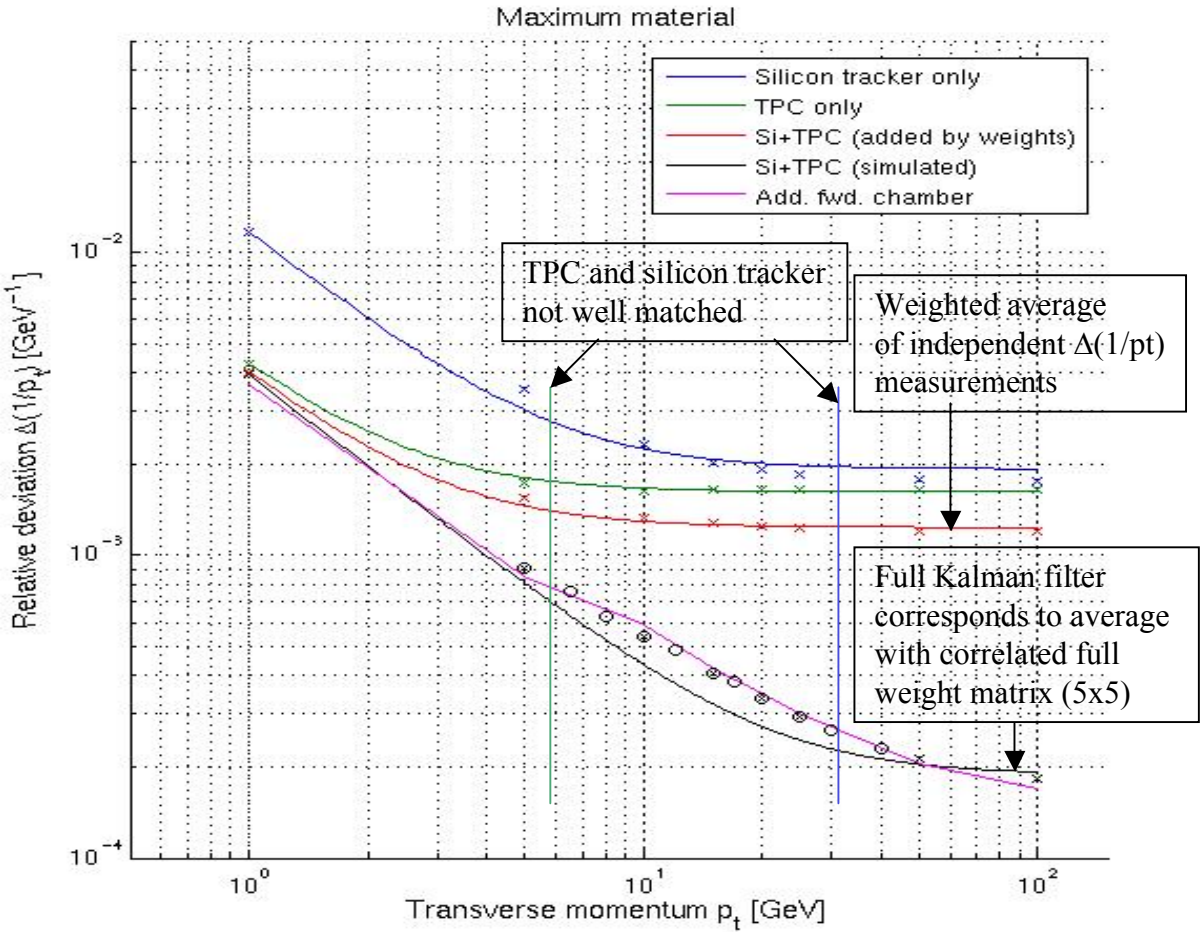
High material budget at θ=20°

- Blue: Silicon tracker only
- Green: TPC only
- Red: Silicon tracker & TPC
  - Added by weights of marginal distributions
  - Si tracker and TPC completely independent
- Black: Simulation of both
  - Bump at middle momentum
  - Line: $\sqrt{(a+b/p_t^2)}$ fit, exclusion of bump points
  - Circles: badly matching points
- Magenta: Additional forward chamber at z = 900mm
  - No improvement



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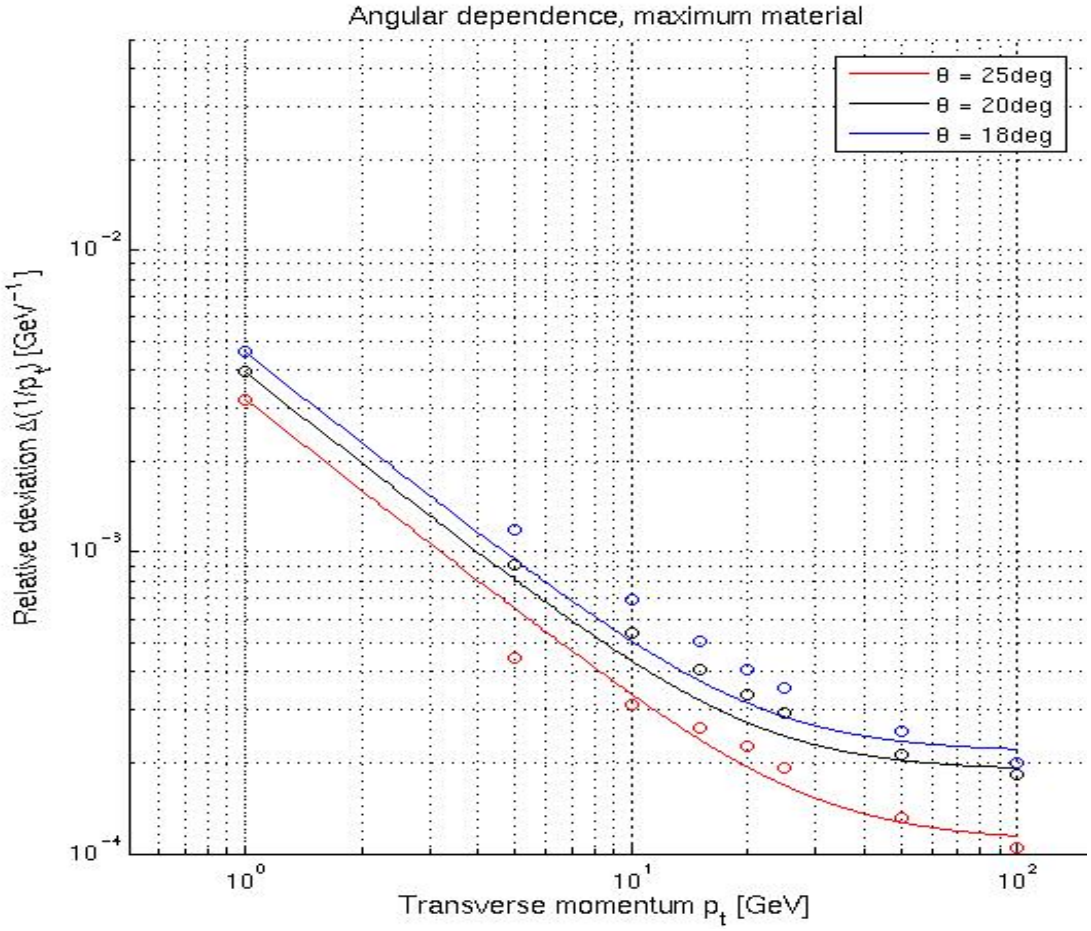
Angular dependence (high m. b.)

- Red: $\theta = 25°$
  - Line: $\sqrt{(a+b/p_t^2)}$ fit, including all points
  - Circles: TPC dominant, but still modulated
- Black: $\theta = 20°$
  - Circles: simulated points, bump
  - Line: $\sqrt{(a+b/p_t^2)}$ fit, exclusion of bump points
- Blue: $\theta = 18°$
  - Circles: bump even higher



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Conclusions

- Assuming the **high material budget**, LDC shows reduced momentum resolution in the region $6 \leq p_t \leq 30$ GeV.
  - A bump w.r.t. the parametrization occurs around $\theta = 20°$, where the TPC momentum measurement becomes as important as the one of the silicon tracker: neither TPC nor silicon tracker is dominant.
  - MS at the TPC inner wall amplifies the effect.
  - The effect vanishes for the low material budget, as well as for bigger polar angles, where the TPC is dominant.
- Mismatching p_t-behavior of TPC and silicon tracker measurements cause the deviation from a common $\sqrt{(a+b/p_t^2)}$ parametrization.
- No further improvement if using an additional forward chamber ("over instrumentation").
- The low material budget in the forward tracker is essential!

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