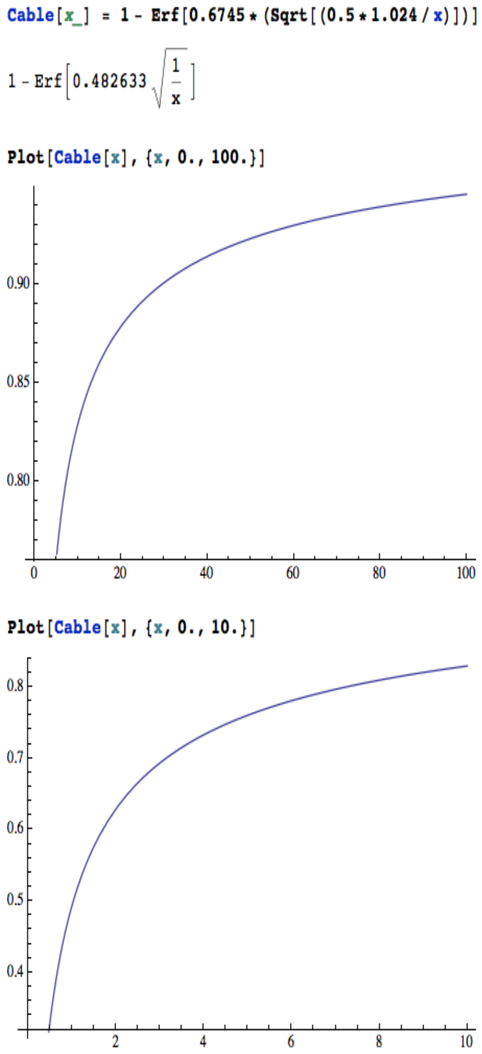
Effect of cable on pulse shape

- **Already studied (in 1998?) for present electronics**
- **The formulas in the time domain (modification to step pulse) are well known (for example in 1964 http://lss.fnal.gov/archive/other/lbl-cc-2-1b.pdf)**
- **A step pulse becomes as function of time $[1. - \mathrm{erf}(0.6745*\mathrm{sqrt}(t_0/2t)]$ therefore the cable effect depends on a single parameter t_0**
- **An estimate for the parameter t_0 is $t_0=4.56\mathrm{x}10^{-3} *A^2*l^2/f$ where A is the cable attenuation in db/m, l is the cable length in m at a frequency f in MHz and t_0 in ns. This formula is not perfect since A^2/f is not constant for the cable we use KX3B.**
- **In 1998(?) t0 obtained by fitting a step pulse + 12.8 m of our cable measured with a scope => t_0=1.024ns**

Some Mathematica plots(I) (fortran to old to get plots!)

effect on step function



```
Cable[x_] = 1 - Erf[0.6745 * (Sqrt[(0.5 * 1.024 / x)])]
```

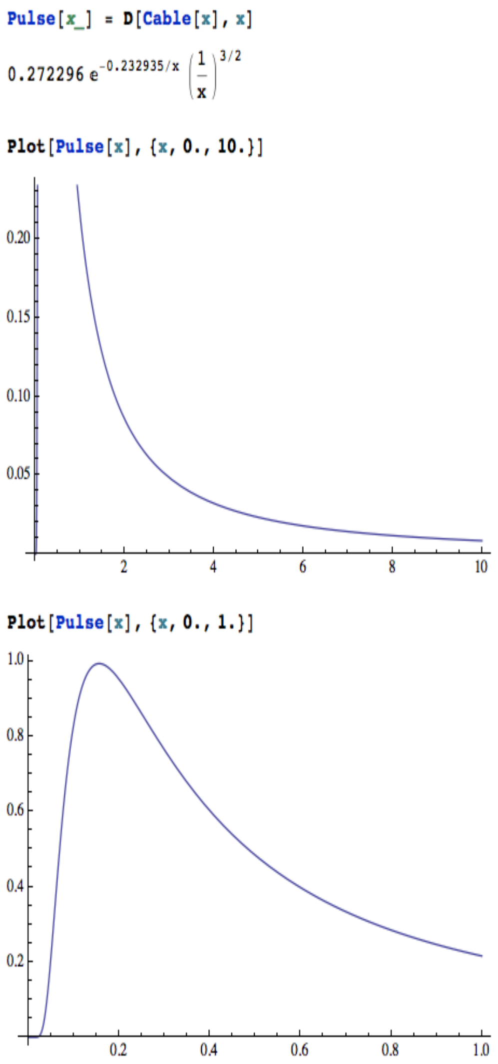
$$1 - \mathrm{Erf}\left[0.482633 \sqrt{\frac{1}{x}}\right]$$

```
Plot[Cable[x], {x, 0., 100.}]
```

```
Plot[Cable[x], {x, 0., 10.}]
```

(II)

effect on delta function
=> differentiate step
function and its
transformed shape
after the cable



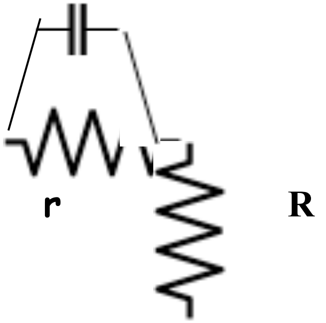
```
Pulse[x_] = D[Cable[x], x]
```

$$0.272296\, e^{-0.232935/x} \left(\frac{1}{x}\right)^{3/2}$$

```
Plot[Pulse[x], {x, 0., 10.}]
```

```
Plot[Pulse[x], {x, 0., 1.}]
```

Correction with filter

- **Again old story! (196?) use a pole zero filter rC +R**
- 

- **r/(R+r) =frac = attenuation of low frequency**
- **rc ≈ time constant**
- **A delta function becomes $\delta - (Frac/rc)*e^{-(t/rc)}$ optimum values are frac=0.16 rc=16ns**

Integrated results for delta function after cable and correction

Time after δ	integrated (δ+cable)	integrated(δ+cable +cor)	Δ of last col
1ns	0.494	0.492	
10 ns	0.829	0.732	
25 ns	0.891	0.779	
50 ns	0.923	0.777	-0.002
75 ns	0.937	0.781	+0.004
100 ns	0.946	0.786	+0.005
1000 ns	0.983	0.815	+0.029/40

Impact

- **Two main consequences**
  - **Contribution to following samples**
  - **Modification of flat top over +-2ns (quantitative value? This should be calculated using measured pulse + calculated filter +integral) Calculation on this is the main priority in my opinion!**

Pro and Con of possible corrections(I)

- **Subtraction of following pulse in FPGA and improvement of flat top with R on integrator**
  - Pro simplest for hardware
  - Con: mixes pedestal subtraction and 2-integrator calibration with cable correction
  - Con: Heavy in firmware
- **Filter using an added stage before the integrator in ASIC**
  - Pro: probably the cleanest method
  - Con: added work and complication for ASIC
  - Con: Asic becomes set-up specific :depends on cable (Is this a real problem???)

Pro and Con (II)

- Put the compensation filter on the PCB (needs 4 components to conserve 50 ohms adaptation)
- A possible solution is r=8 ohms C =2nanofarad (2.2?)
- R= 50 ohms of the Asic in// with (a resistance of 262 ohms + an inductance of 5microHenry in series)
- This allows to have an input impedance of 50 ohms at all frequencies (until the inductance stops working= max frequency=150MHz in radiospare)
    - Pro: rather flexible and optimised at PCB time (later than ASIC)
    - Con: 4X32 components per cards including 32 5-microH inductances
    - Con: could impact the noise? (to be calculated or tested)

Conclusion

- **Need to define time scale (time for final decision)**
- **In my opinion a least a test of the PCB solution should be done and tested to insure the existence of the solution at least as back-up**