The Time-Tree Method for Magnetic Resonance Pulse Sequence Design

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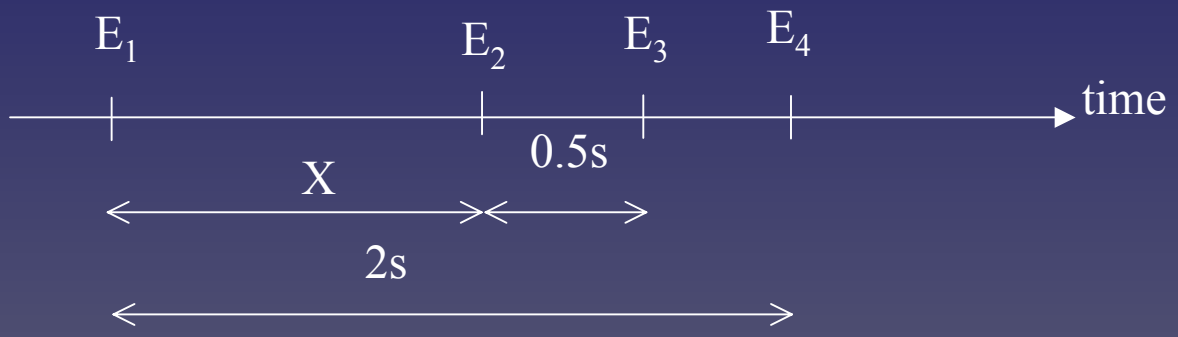

$$E_4 - E_1 = 2s,$$
$$E_3 - E_2 = 0.5s,$$
$$E_2 - E_1 = X.$$

A linear time sequence.

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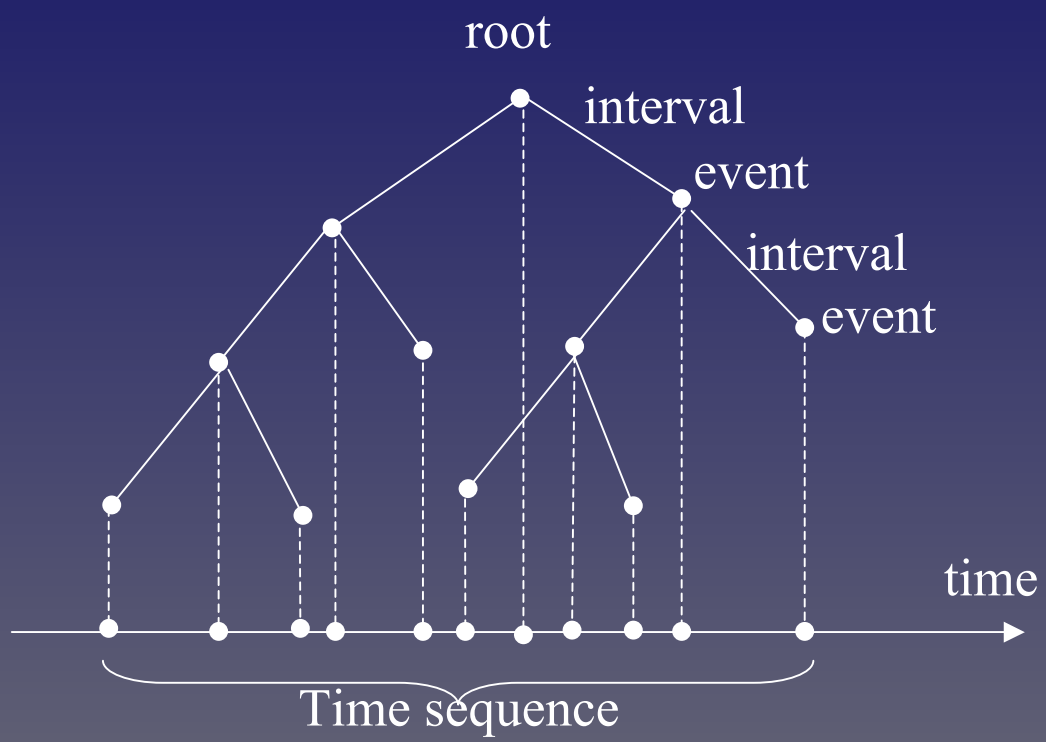

The time tree structure.

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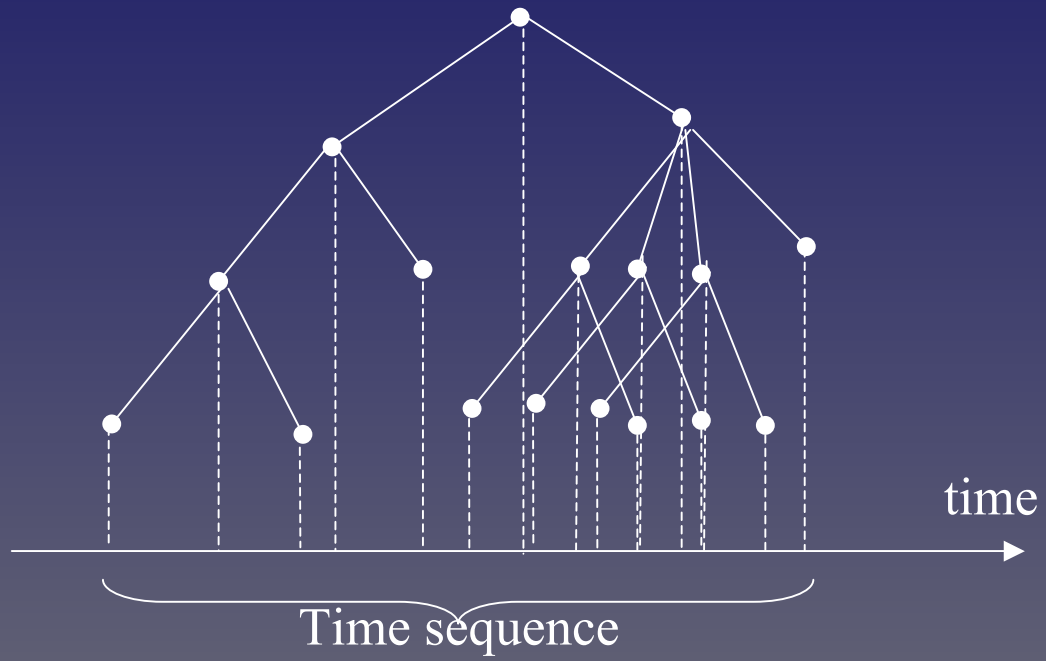

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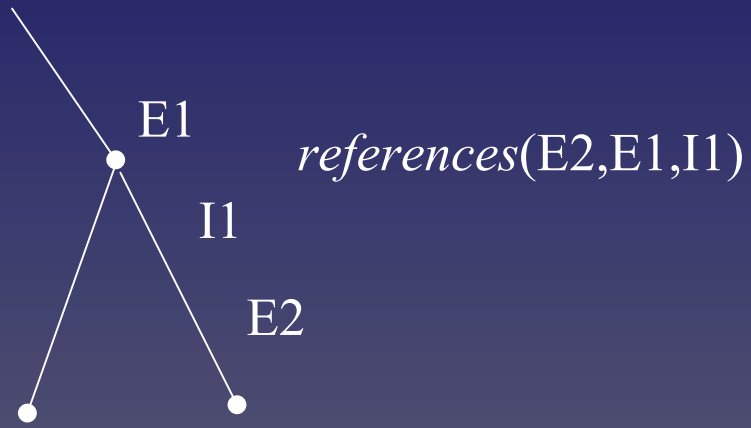

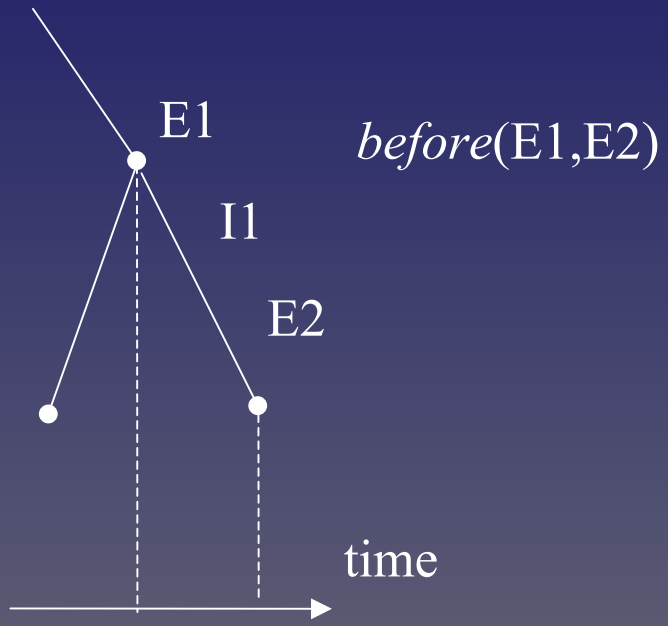

Definitions

Time I1 can be a constant or expression

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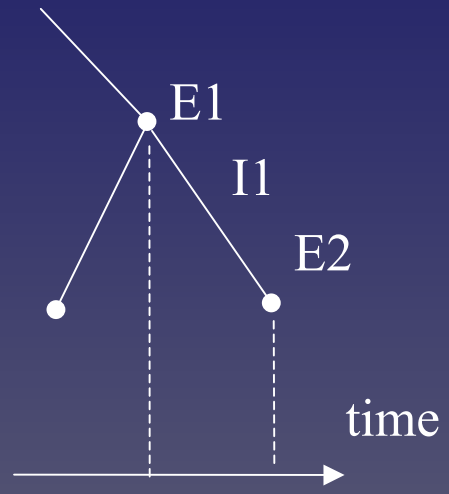

$$references(E2, E1, I1) \cap (I1 > 0) \rightarrow before(E1, E2)$$

Properties

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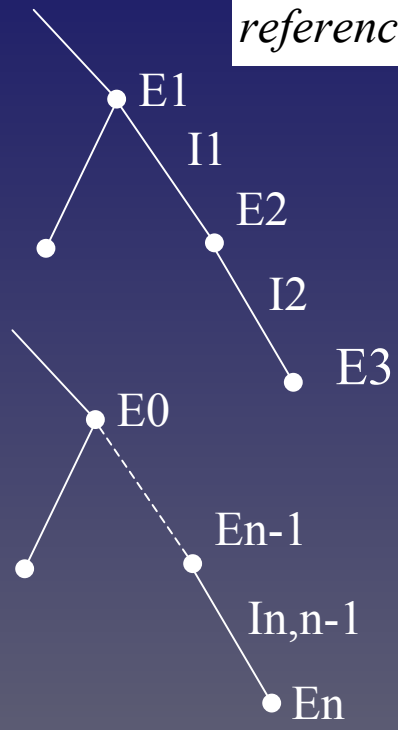

$$references(E_2, E_1, I_1) \cap references(E_3, E_2, I_2) \rightarrow references(E_3, E_1, I_1 + I_2)$$

$$\bigcap_{i=1}^{n} references(E_i, E_{i-1}, I_{i,i-1}) \rightarrow references(E_n, E_0, \sum_{i=1}^{n} I_{i,i-1})$$

Properties

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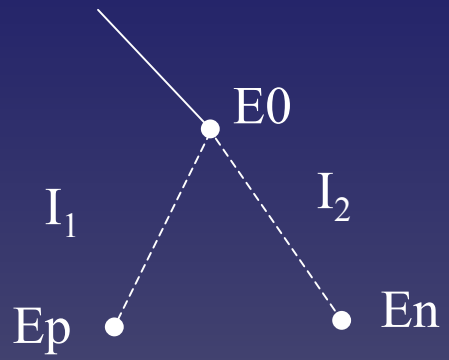

Properties

$$references(E_p, E_0, I_1) \cap references(E_n, E_0, I_2) \cap (I2 > I1) \rightarrow before(E_p, E_n)$$

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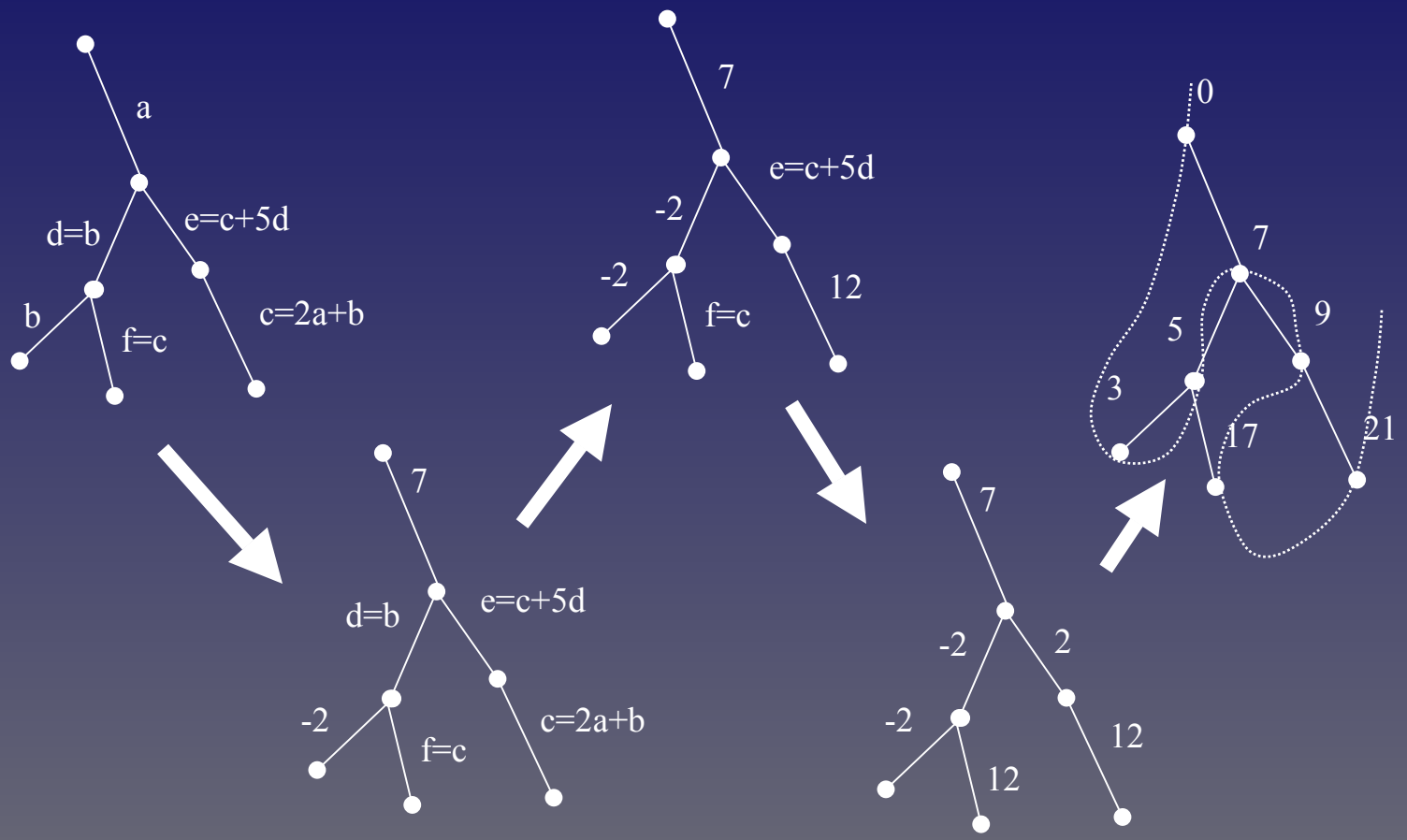

Calculating the event timings

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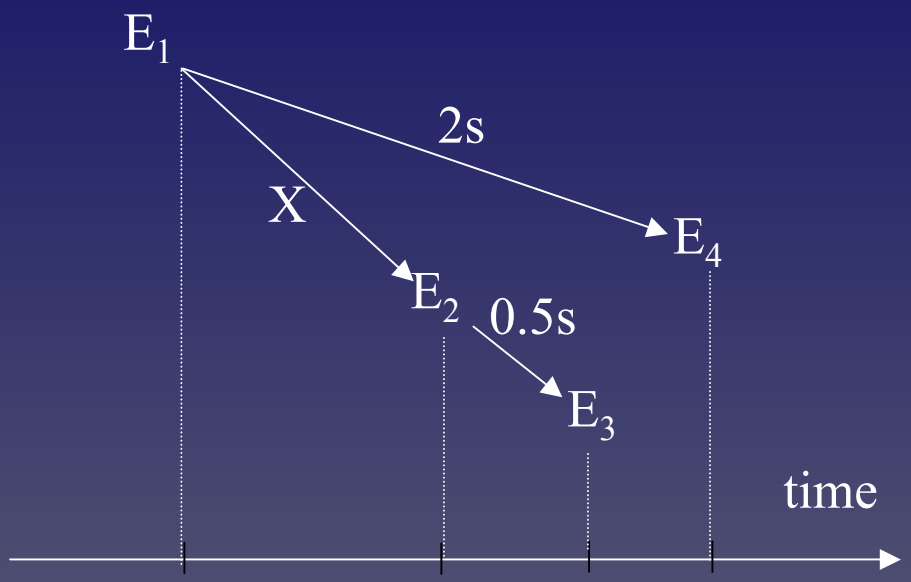

The sequence can be analyzed now.

$$before(E_3, E_4)\ if$$
$$references(E_3, E_1, X + 0.5s) \cap$$
$$references(E_4, E_1, 2s) \cap$$
$$(2s > X + 0.5s)$$

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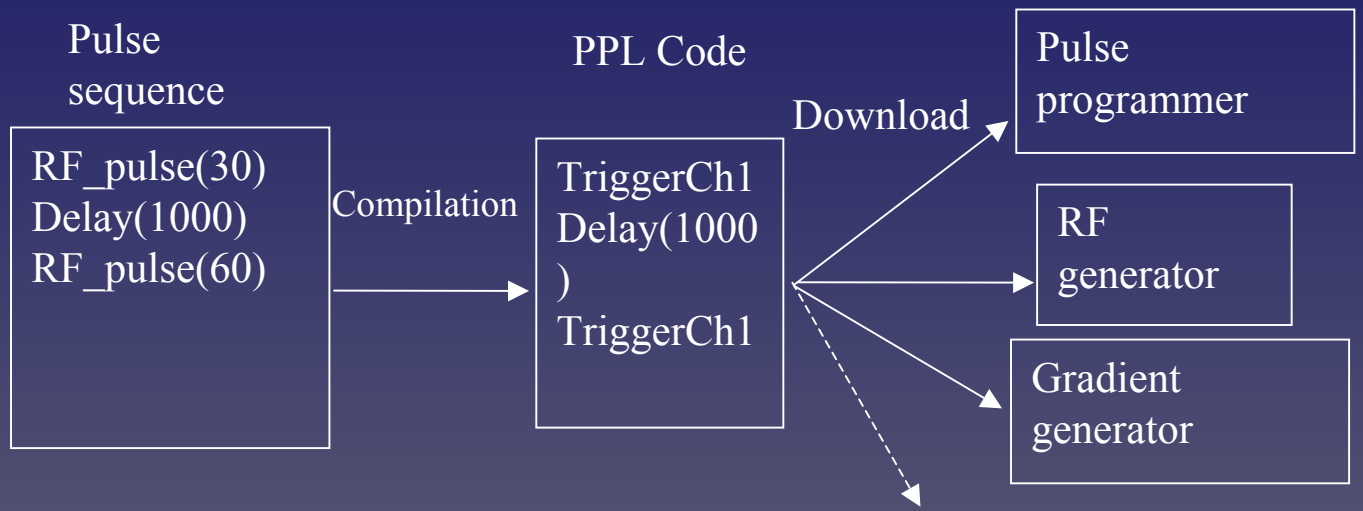

Generating a sequence in general.

Pulse programming is done by sequence of commands.

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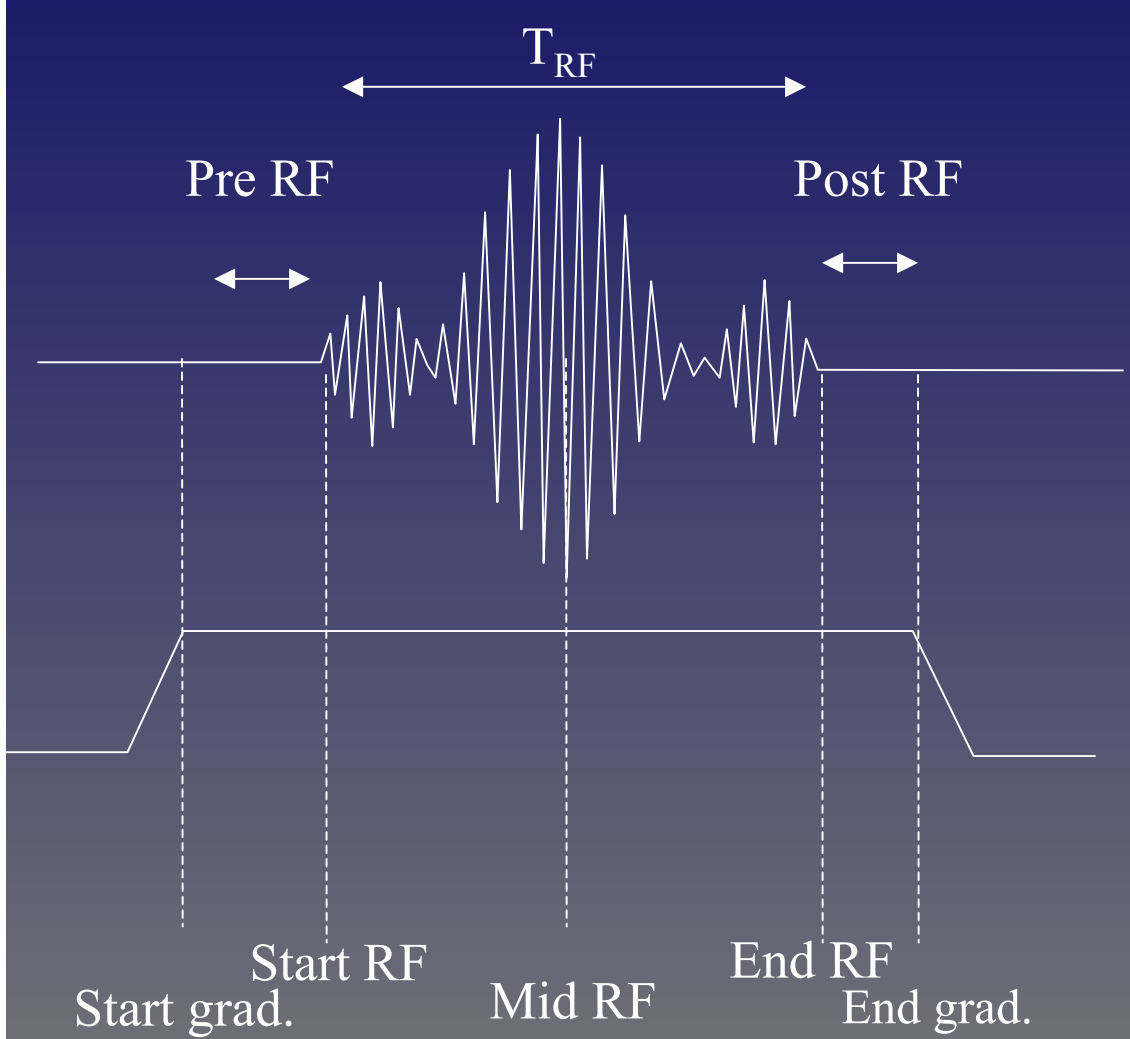
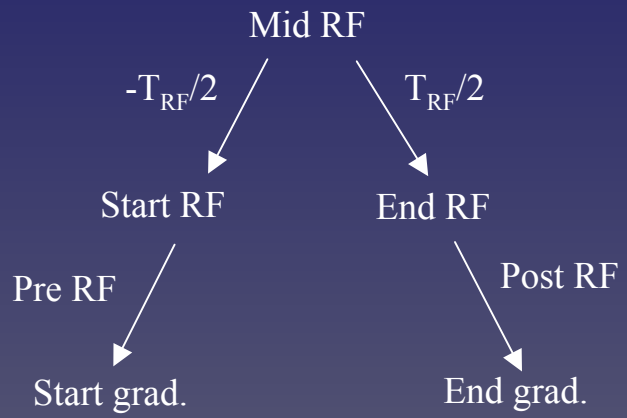


KKU-NECTEC MRI System



Pulse programming is done based on time-tree.

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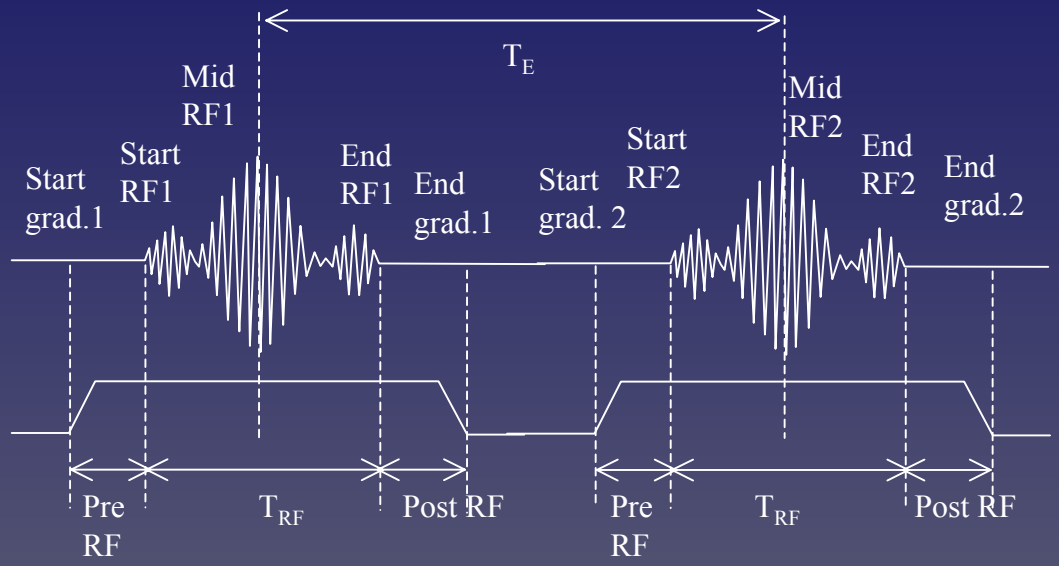

Adding groups of pulses.

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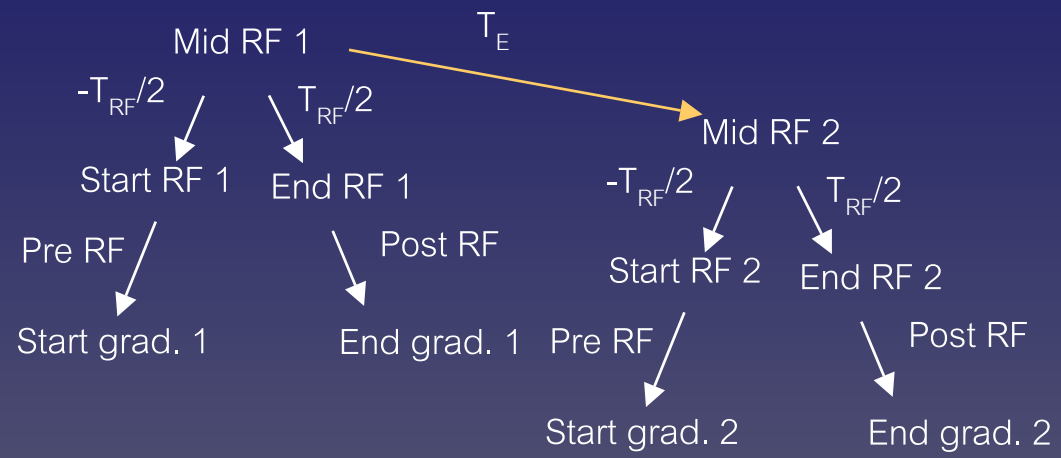

Groups of pulses can easily be joined.

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```
[Parameters]
TStart=1  TSetup=500
TR=30000TReset=100
TRFPre=-60TRFPost=60
TPre90=100Tpost90=100
TEnd=-60TDead=100
TRecvPre=-60TrecvPost=60
SampleNo=128   SamplePeriod=10
T90=70
T90En=TPre90+T90+Tpost90
Tacq=SampleNo*SamplingPeriod

[Time Tree] {reference node first}
0,1(TStart)
1,4(TSetup)12(TR)2(TReset)
4,3(TRFPre)5(TRFPost)6(T90En)13(TPre90)
12,11(Tend)
6,8(TDead)
8,7(TRecvPre)9(TRecvPost)10(TAcq)
13,14(T90)

[Pulses]
mcProg,ResetTrig,1,2,chResetPulse
mcProg,RFTrig,3,5,chRFTrigger
mcProg,RFEn,4,6,chRFEnable,Phase90
mcProg,RecvEn,8,10,chRecvEnable,Phase90
mcProg,RecvTrig,7,9,chRecvTrigger
mcProg,EndTrig,11,12,chEndPulse
```

A sequence in the KKU-NECTEC system.

Pulse programming is made simpler.

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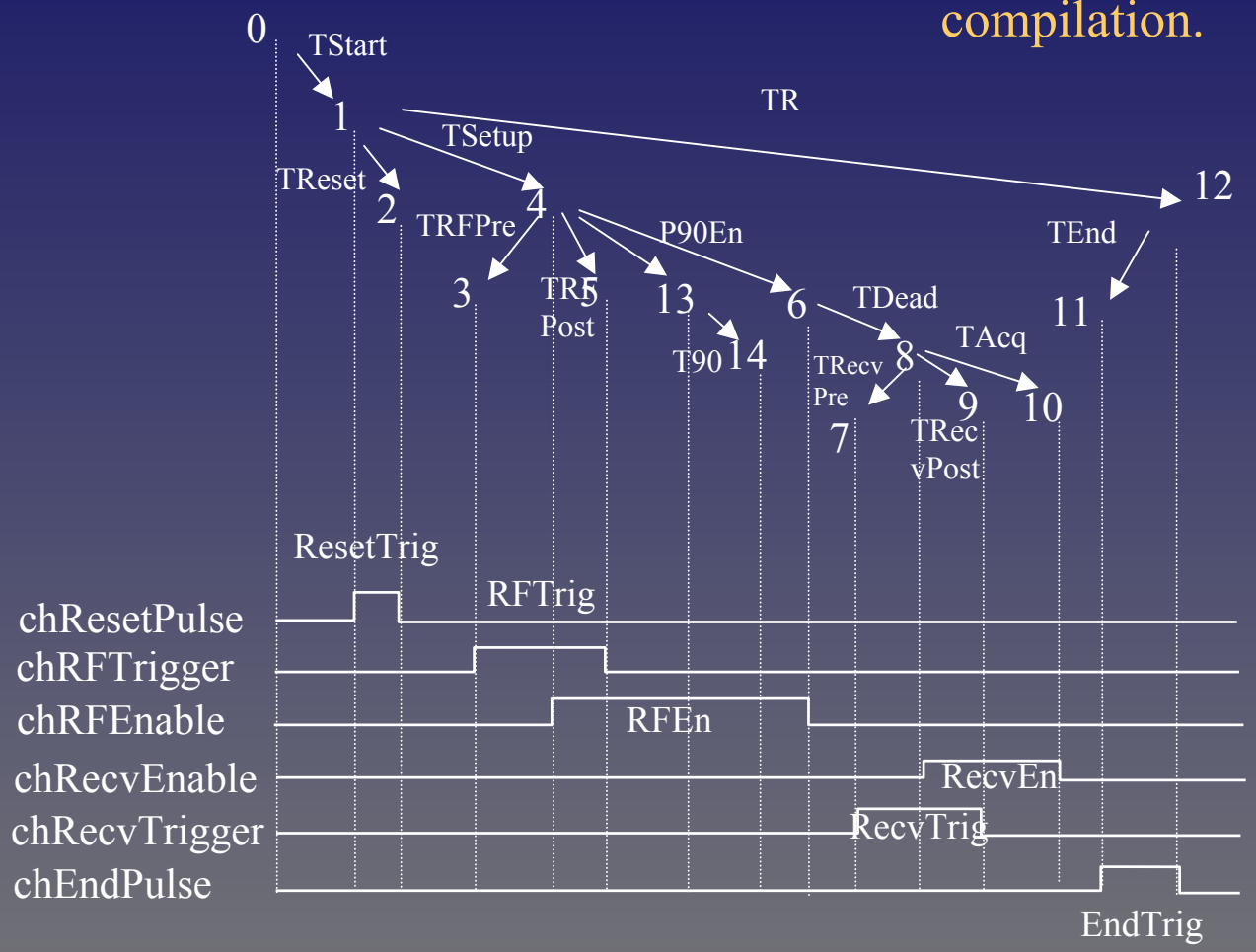
After sequence compilation.



Thank you

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