



# Introduction to Elegant and SDDSToolkit

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## What It Is

### elegant: Electron Generation and Tracking

- Has its roots as a matrix code, but has been extended considerably over the years
- Define a beam (by one of several means)  *We will learn where and how*
- Define the accelerator 
- Track beam particles through the accelerator;  $(x, x', y, y', t, p_z)$
- Calculate the accelerator's R-matrix;
- Vary parameters to obtain desired beam parameters at the end of the accelerator;
- etc.

# Command File (\*.ele): Beam Definition, etc.

- Built up of “modules”, each addressing specific actions.
  - The order of the modules is important (otherwise error messages are sent).
  - Many options per module (default switches are usually ok)
  - Few modules are really needed at the beginning.

```
&run_setup
lattice  ="Ele_Tu_06.lte"
use_beamline= L0
output    = %s.out,
centroid  = %s.cen,
sigma     = %s.sig,
final     = %s.fin,
parameters = %s.par,
magnets   ="%s.mag"
p_central_mev = 100.
&end

&run_control &end
```

```
&bunched_beam
bunch          = %s.bun,
n_particles_per_bunch = 20000,
emit_nx        = 1.0e-6,
emit_ny        = 1.0e-6,
use_twiss_command_values = 1,
momentum_chirp = 0.      ! at the entrance
sigma_dp       = 0.1E-5,
sigma_s         = 0.5E-3,
!   sigma_s      = 0.002E-3,
distribution_type[0]
="gaussian","gaussian","gaussian",
&end

&track &end
```

## Lattice File (\*.lfe)

- Build up “elements”, each with specific parameters.
  - The order of definition of elements is not important, but beamlines must follow all elements they include.
  - Many parameters per element (default values are usually ok for single particle dynamics)
  - Few elements to sketch a linac

```
% 50 sto V_L0_1  
% 3.0 sto F_L0_1  
% 90 sto P_L0_6
```

```
-- Accelerating structure. Max. gain (on-crest phase) is 90deg --
```

```
CAV_1: RFCA, L=1.326, volt="V_L0_1 1.e6 *", freq="F_L0_1 1.e9 *",  
phase="P_L0_1", &  
change_p0=1, end1_focus=1, end2_focus=1, n_kicks=1
```

```
L0: LINE = ( Q, CAV_1 )
```

# Our First Building Blocks

## Beam Charge:

```
Q: CHARGE, TOTAL=0.3E-09
```

## Drift:

```
D_S1_1 : DRIFT, L= D_S1
```

## Quadrupole Magnet (Defocusing):

```
Q_S1_1 : QUAD, L= LQ_S1, K1=-1.1820
```

## Dipole Magnet (Rectangular):

```
B_C1_1: CSBEN, L=0.3, ANGLE="B_C1_ANGLE -1 *", &  
E2="B_C1_ANGLE -1 *"
```

## Accelerating Structure (with Wakefield):

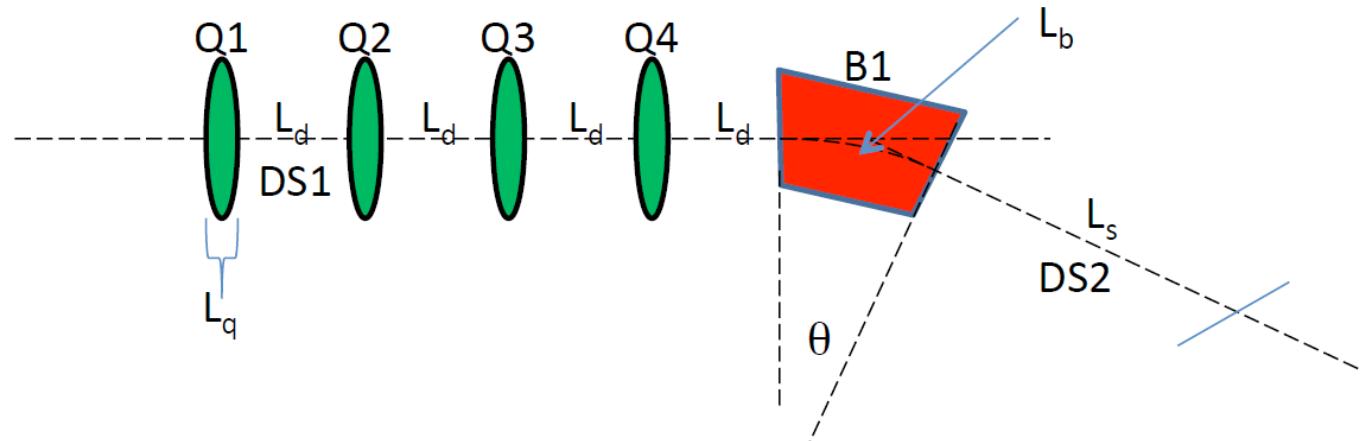
```
CAV_1 : RFCW, L=1.326, &  
volt="V_L0_1 1.e6 *", freq="F_L0_1 1.e9 *", phase="P_L0_1", &  
change_p0=1, end1_focus=1, end2_focus=1, &  
cell_length=33.15e-3, &  
zwakefile="Zwake_S1S7_Trieste_5mm.sdds", tcolumn="t", wzcolumn="W"
```

## RF Deflecting Cavity (Vertical):

```
VRFD: rfd, frequency=3e9, phase=90, voltage="V_VRFD", &  
tilt=1.5707963
```

# Example

Courtesy D. Nguyen,  
USPAS 2014



Q1: quad, L=0.1, K1=2  
Q2: quad, L=0.1, K1=-4  
Q3: quad, L=0.1, K1=2  
Q4: quad, L=0.1, K1=0

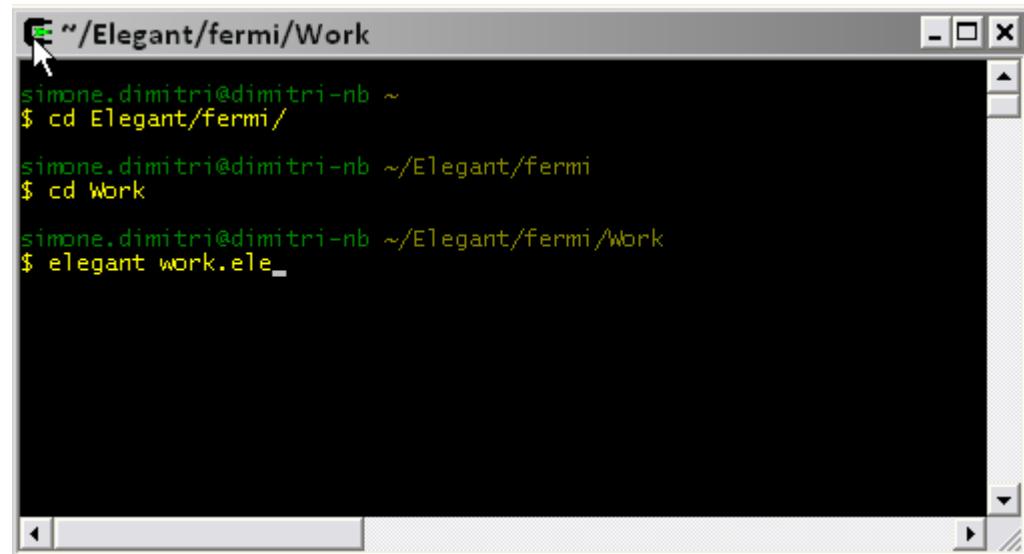
DS1: drift, L=0.4  
DS2: drift, L=1.0

B1: sbend, L=0.6, angle="pi 6 /"

test: line=(DS1, Q1, DS1, Q2, DS1, Q3, DS1, Q4, DS1, B1, DS2)

# How to Run Elegant

- ELEGANT and SDDS-Toolkit available both for Linux and Windows.
  - This Course, Cygwin Linux-emulator running on Windows.
- ELEGANT provides info on the files used for run directly onto the shell and in a \*.log file.
  - Look to **Warning messages** in the Shell (suggestions on element definitions, settings, and so on). They do not stop the run.
  - **Error messages** in the Shell stop the run. You must fix errors before running again.

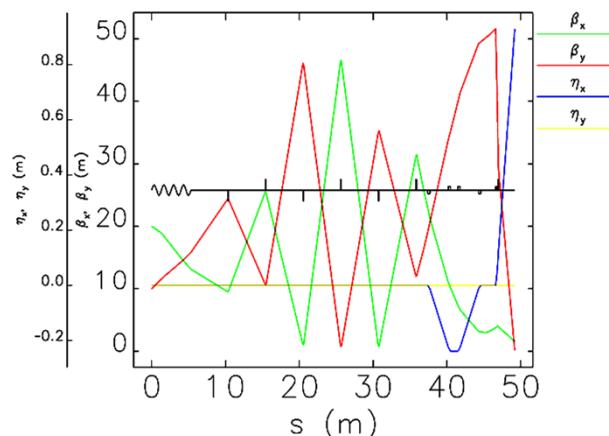


```
Elegant/fermi/Work
simone.dimitri@dimitri-nb ~
$ cd Elegant/fermi/
simone.dimitri@dimitri-nb ~/Elegant/fermi
$ cd Work
simone.dimitri@dimitri-nb ~/Elegant/fermi/Work
$ elegant work.ele
```

A screenshot of a terminal window titled "Elegant/fermi/Work". The window shows a command-line session. The user has navigated to the directory "Elegant/fermi/Work" and is executing the command "elegant work.ele". The terminal has a standard window frame with minimize, maximize, and close buttons.

# Output Files

- Most of them specified in the `*.ele` file, `&run_setup` module.
  - You can choose the `rootname.*`
- All are binaries by default, including self-describing head-lines.
  - Self-Describing Data Set (SDDS) format, needs **SDDS-Toolkit** for post-processing.
  - SDDS also for converting output files to `ascii` format.
- Output data can be manipulated or **plotted** with SDDS command lines or, better, coded in scripts.
  - Many scripts already available in your folder. Build yours own by yourself!



# SDDSToolkit Commands

- **sddsquery rootname.cen**

12 columns of data:

NAME	UNITS	SYMBOL	FORMAT	TYPE	FIELD LENGTH	DESCRIPTION
s	m	NULL	NULL	double	0	Distance
ElementName	NULL	NULL	%10s	string	0	Element name
ElementOccurrence	NULL	NULL	%6ld	long	0	Occurrence of element
ElementType	NULL	NULL	%10s	string	0	Element-type name
Cx	m	<x>	NULL	double	0	x centroid
Cxp	NULL	<x'>	NULL	double	0	x' centroid
Cy	m	<y>	NULL	double	0	y centroid
Cyp	NULL	<y'>	NULL	double	0	y' centroid
Cs	m	<s>	NULL	double	0	mean distance traveled
Cdelta	NULL	<\$gd\$r>	NULL	double	0	delta centroid
Particles	NULL	NULL	NULL	long	0	Number of particles
pCentral	m\$be\$nc	p\$bcen\$n	NULL	double	0	Reference beta*gamma

1 parameters:

NAME	UNITS	SYMBOL	TYPE	DESCRIPTION
Step	NULL	NULL	long	Simulation step

$$p_{Central} = \beta\gamma = \sqrt{\frac{2T}{m_e c^2}}$$

- **sddsprocess -define=col,T"pCentral 2 pow 0.511 \* 2 /" rootname.cen**
- **sddsplot -col=s,T rootname.cen -col=s,Profile rootname.mag**
- **sddsprintout -col=ElementName -col=s -col=T**

# Website information

**Go to website for download and manual:**

[http://www.aps.anl.gov/Accelerator\\_Systems\\_Division/Accelerator\\_Operations\\_Physics/manuals/elegant\\_latest/elegant.html](http://www.aps.anl.gov/Accelerator_Systems_Division/Accelerator_Operations_Physics/manuals/elegant_latest/elegant.html)

**Manual includes:**

[Capabilities of elegant](#)

[Highlights of What's New in Version 25.2.1](#) ← *updates*

[Namelist Command Dictionary](#) ← ***command file (\*.ele)***

[Element Dictionary](#) ← ***lattice file (\*.lte)***

[Specialized Tools for Use with elegant](#) ← *other codes interface, post-processing, scripts...*

[The rpn Calculator \(<<1 1 +>>\)](#)

[Examples](#) ← *very instructive!*

[Bibliography](#)

# Forum

**Go to website and register:**

[https://www.aps.anl.gov/Accelerator\\_Systems\\_Division/Accelerator\\_Operations\\_Physics/phpBB3/](https://www.aps.anl.gov/Accelerator_Systems_Division/Accelerator_Operations_Physics/phpBB3/)

The screenshot shows the homepage of a phpBB forum. The header features the phpBB logo ('phpBB® creating communities') and the title 'Elegant users forum' with the subtitle 'An interactive site to request and provide help for elegant'. A search bar with a magnifying glass icon and a 'Search' button is on the right. Below the header, there's a 'Skip to content' link. The main navigation bar includes 'Board index' (with a back arrow), 'FAQ', 'Register', 'Login', and a user icon. The date 'It is currently 03 Jun 2013, 10:29' is displayed. Below the navigation, links for 'View unanswered posts' and 'View active topics' are shown. The main content area displays a table of forums with columns for 'TOPICS', 'POSTS', and 'LAST POST'. The forums listed are 'Installation' (55 topics, 213 posts, last post by Xavier Nuel on 22 May 2013), 'Linac Tracking' (50 topics, 203 posts, last post by michael\_borland on 08 May 2013), and 'Dipoles' (1 topic, 1 post, last post by cyao on 08 May 2013). Each forum row has a moderator icon and a list of moderators.

FORUM	TOPICS	POSTS	LAST POST
<b>Installation</b> Moderators: cyao, soliday	55	213	by Xavier Nuel 22 May 2013, 12:17
<b>Linac Tracking</b> Moderators: michael_borland, cyao	50	203	by michael_borland 08 May 2013, 12:31
<b>Dipoles</b>	1	1	by cyao 08 May 2013, 12:31

- Q&A grouped by topic
- Prompt answer by authors (and users forum)
- Many tricks and details are not in the Manual