First ideas on a VVLE beam

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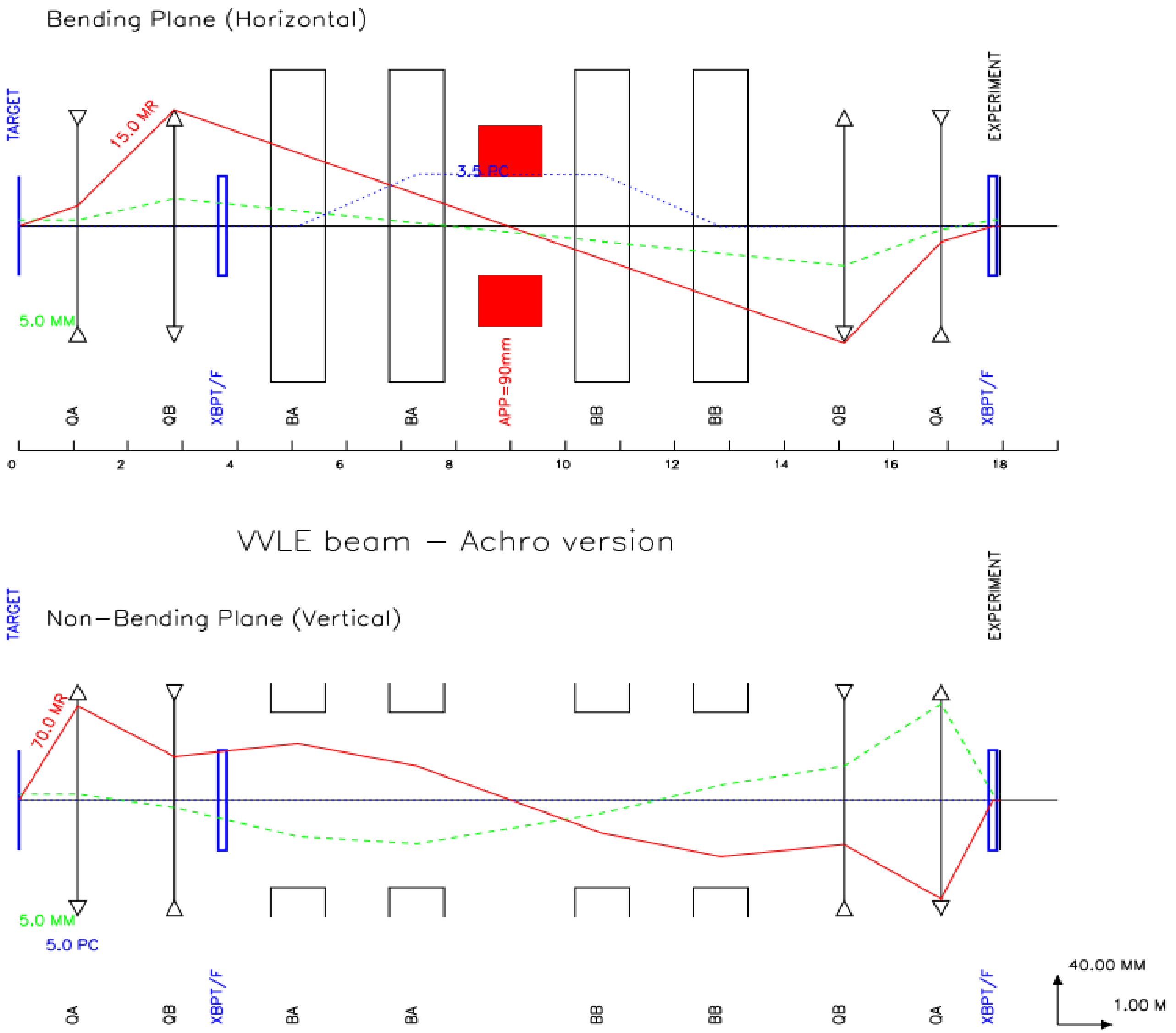
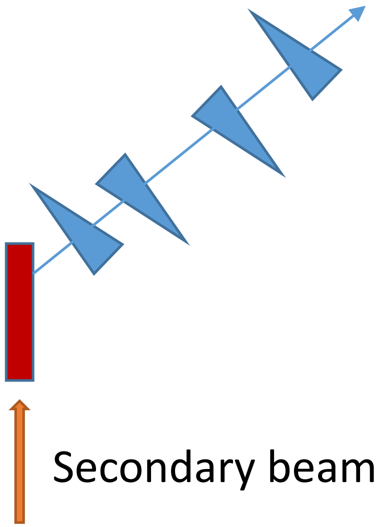
20/01/2020

Optics & Characteristics – The "dogleg" version

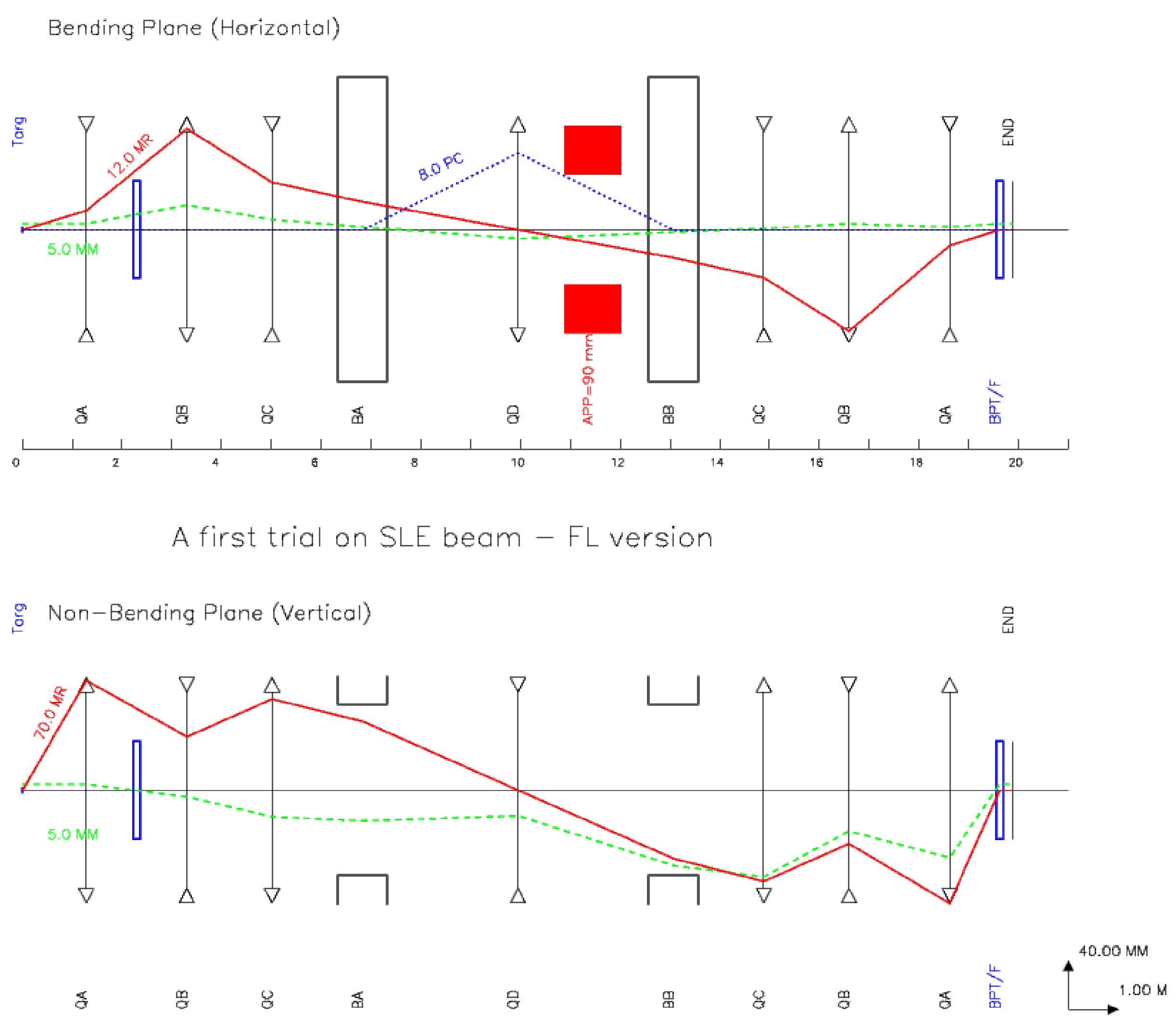


- 4 MBPS and 4 QPS
- 4 power supplies in total
- Large acceptance in both planes and good intrinsic resolving power
- To be placed in an angle from the target (~200 mrad)
- **QPS & MPBS all available**
- **Cabling and cooling necessary to be upgraded**
- Standard EN-EA equipment (brides, connectors…)
- ToF (XBTF) + XBPF + XCET low pressure ?

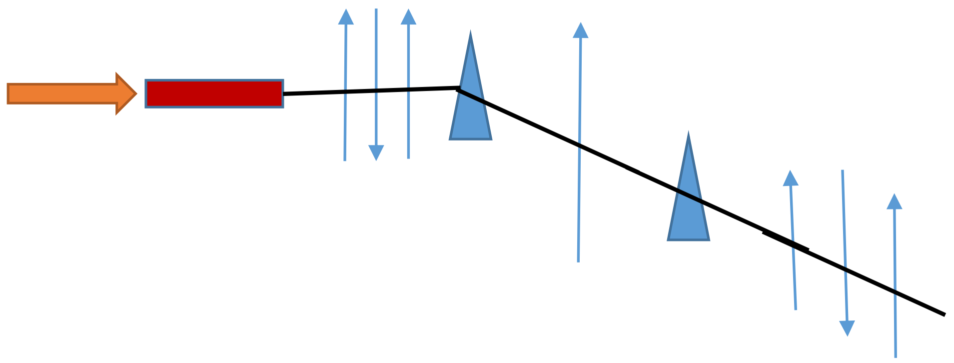


Secondary beam – 40 GeV/c ?

Optics & Characteristics – The "field-lens" version

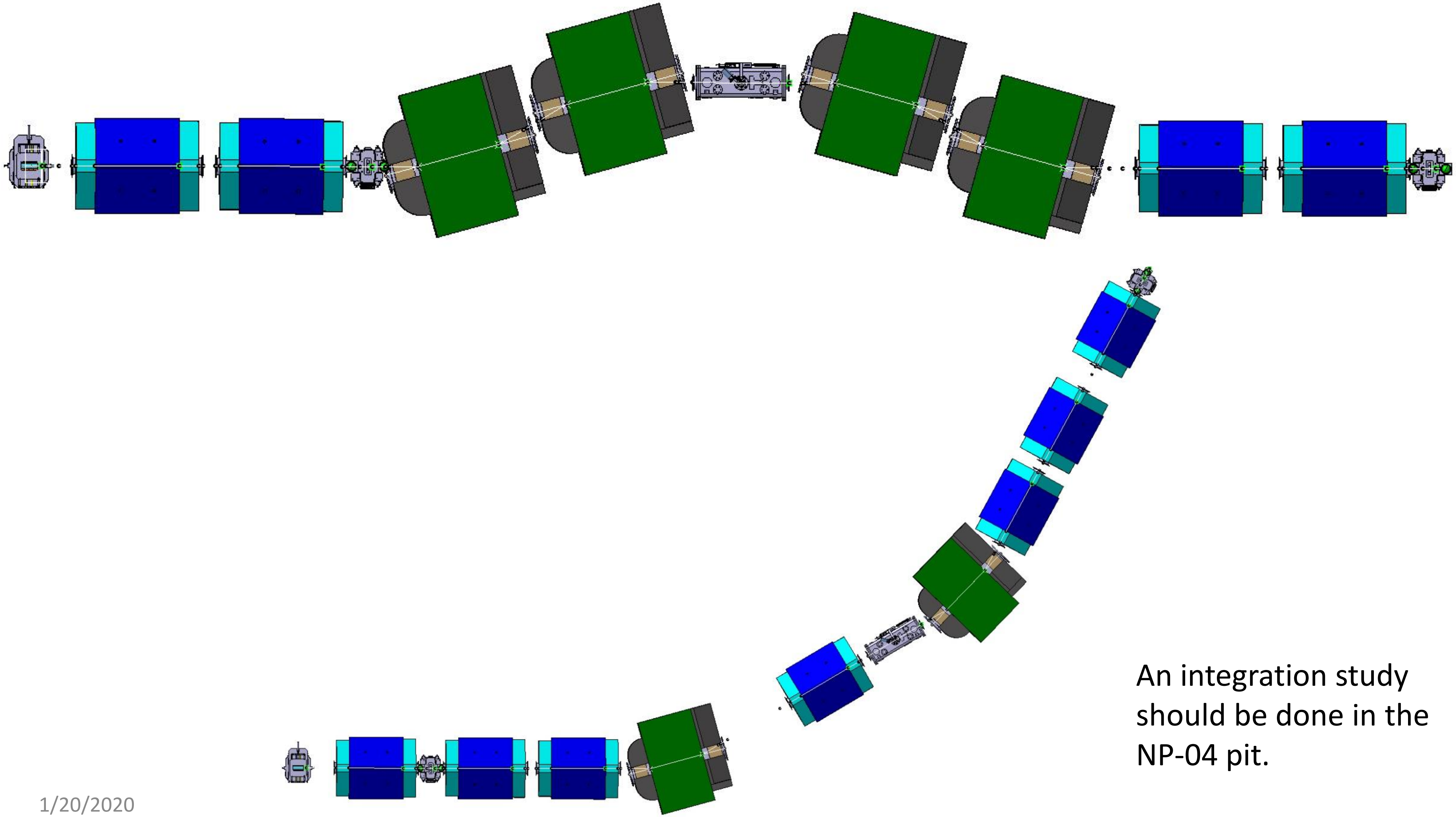


- 2 MBPS and 7 QPS
- 5 power supplies in total
- Large acceptance in both planes – descent intrinsic resolving power
- To be placed in an angle from the target (~200 mrad) **or at a 0 production angle**
- **QPS & MPBS all available**
- **Cabling and cooling to be seen**
- ToF (XBTF) + XBPF + XCET low pressure ?
- More sensitive to chromatic aberrations



Secondary beam – 40 GeV/c ?

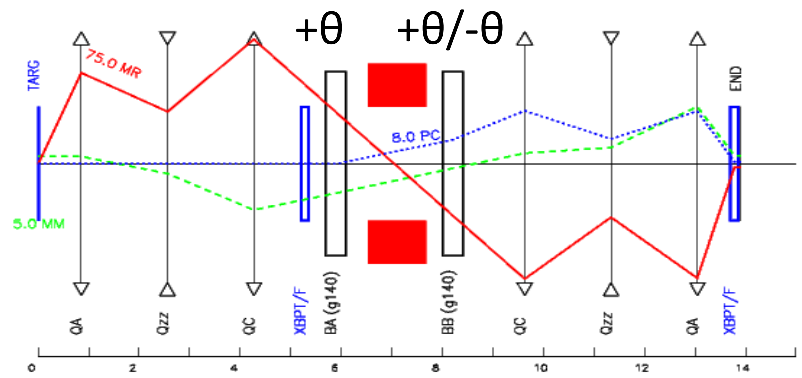
Preliminary CATIA designs (V. Clerc)



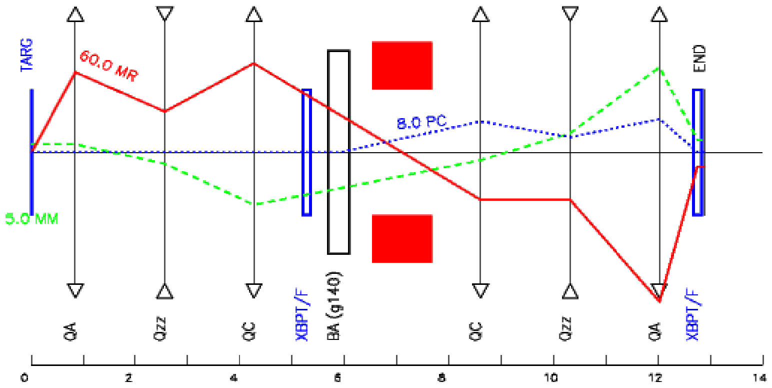
An integration study should be done in the NP-04 pit.

Shortening the length with **EXISTING** elements

- Goal: Preserving the existing elements and the acceptance (in the FD-plane)
- Sacrificing (a little) the full momentum recombination and the spot-size in the bending plane

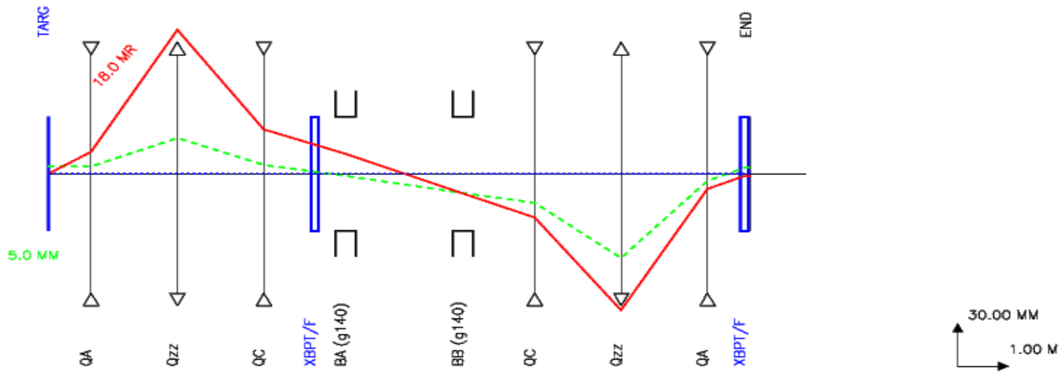


<14 m

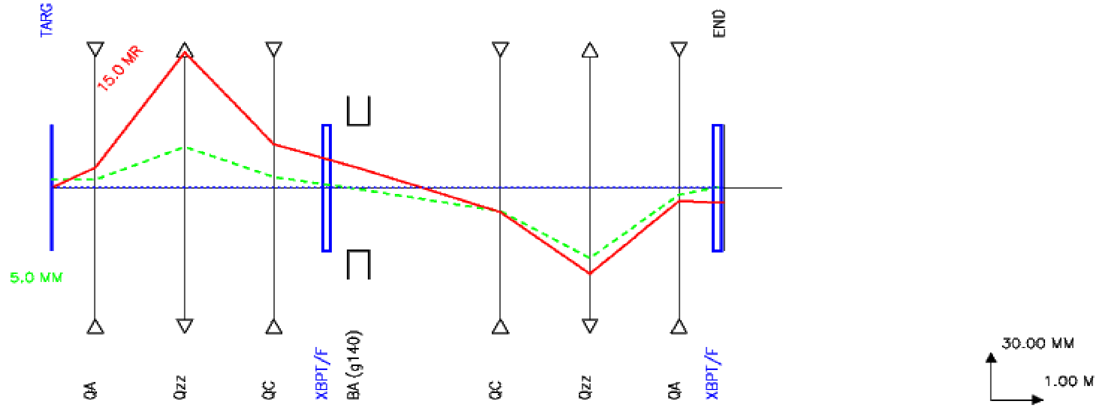


<13 m

A first trial on SLE beam — MDX



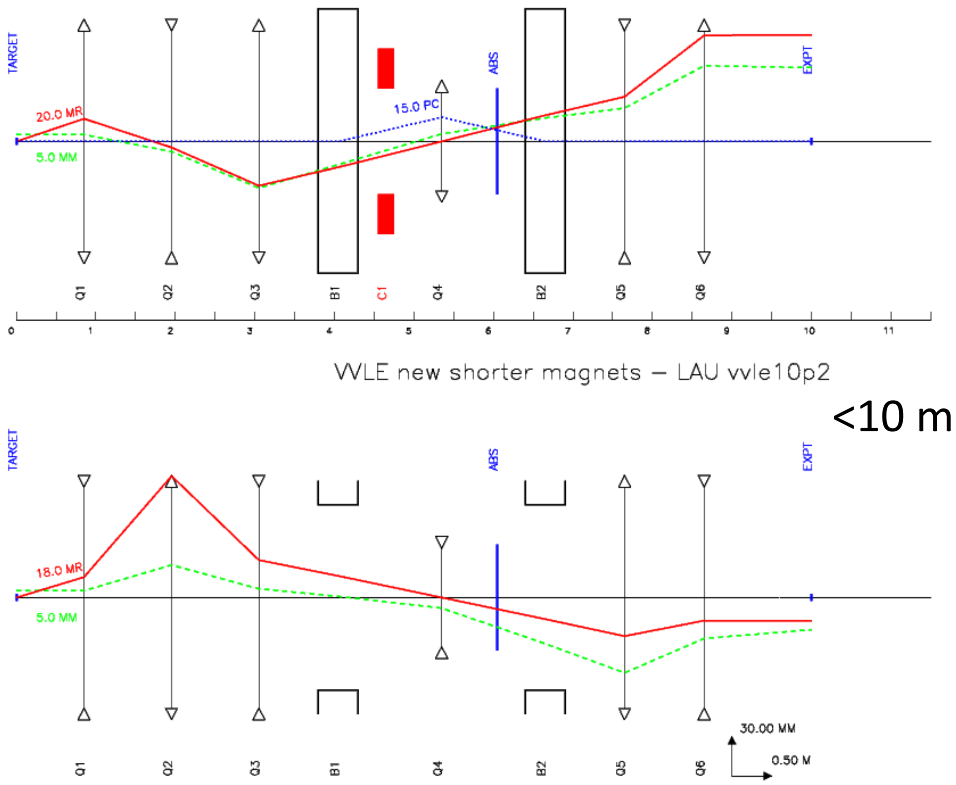
A first trial on SLE beam — MDX



:ignon - First

Shortening the length with **NEW** elements

- New shorter elements assumed



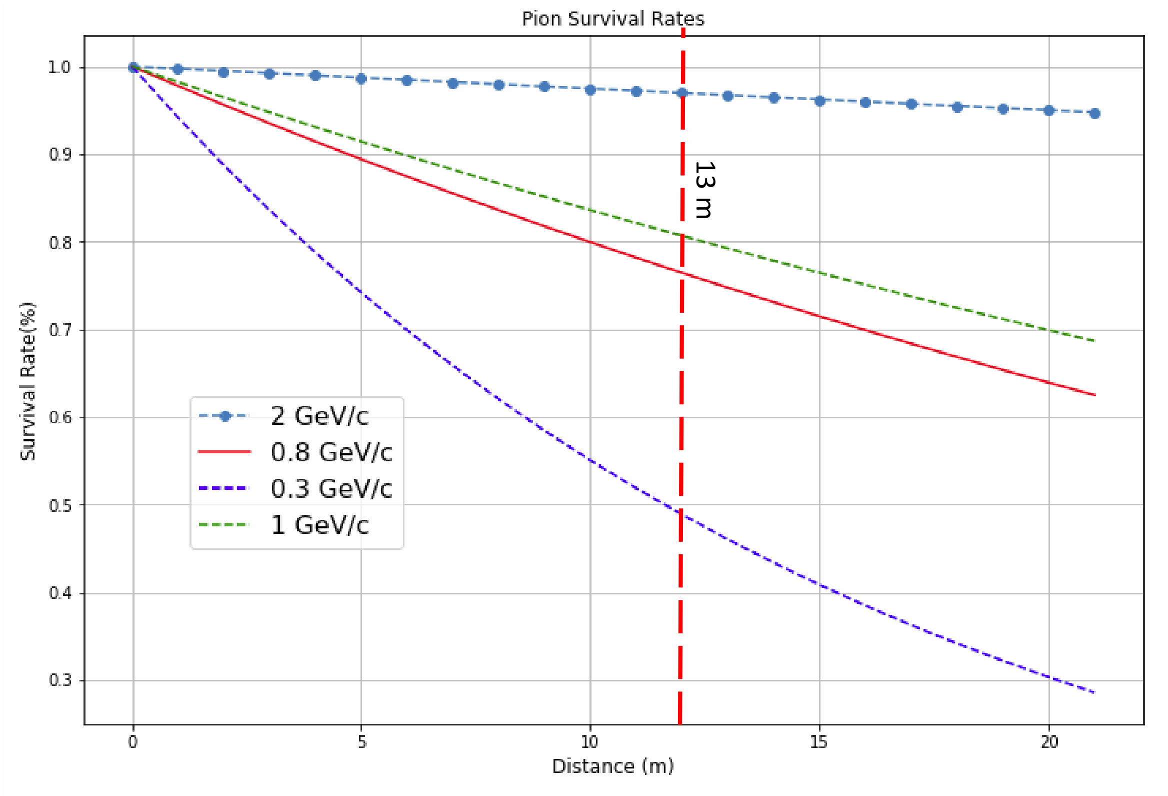
1 * VVLE BEATCH VERSION 0.1*

	X-COORDINATE	Y-COORDINATE	-COORDINATE	GISEMENT	HOR ANGLE	VERT ANGLE
INITIAL	0.00000	0.00000	0.00000	500.00000	0.000000	0.000000

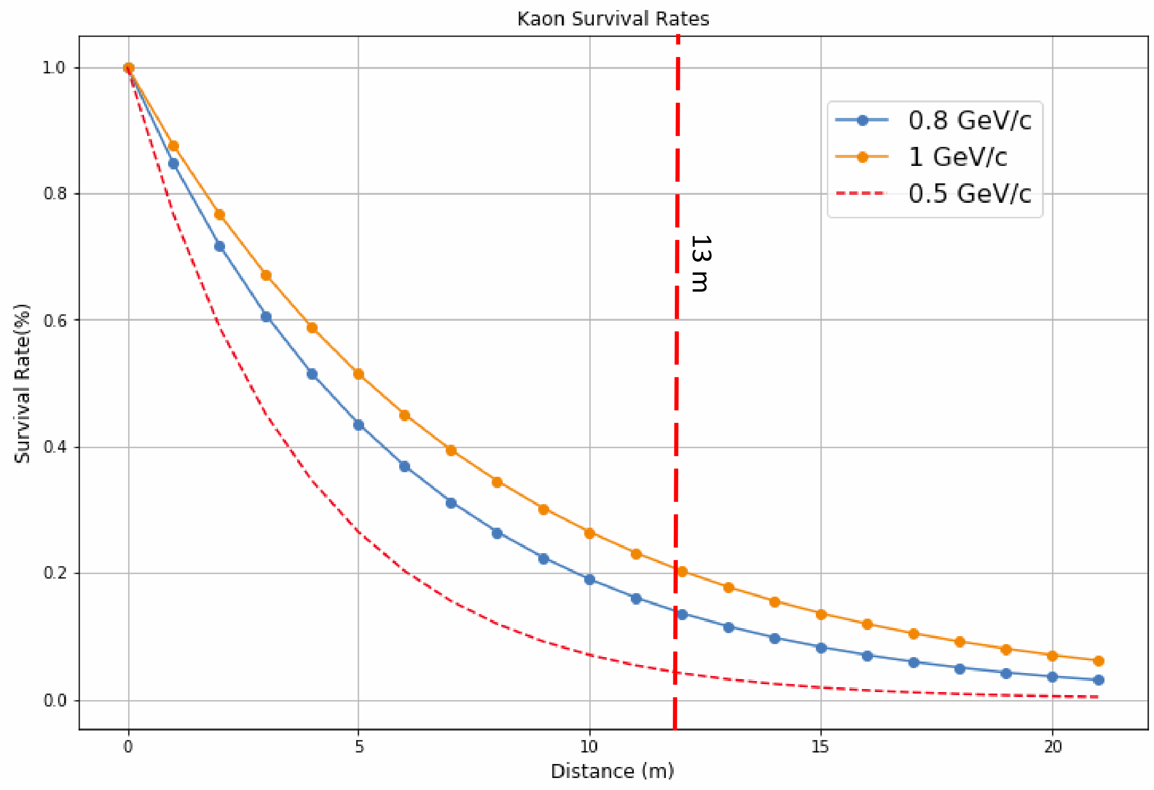
I	ELEMENT		K	L M	DEFL ANGLE RAD	TILT DEG	X M	Y M	Z M	HOR ANGLE	VERT ANGLE RAD	BEAM LENGTH M
1	SEC.TARGET	TARGET	20	0.000	0.000000	0.00	0.00000	0.00000	0.000	0.000000	0.000000	0.000
2			1	0.600			0.60000	0.00000	0.000	0.000000	0.000000	0.600
3	QPS 099001	Q1	3	0.500			1.10000	0.00000	0.000	0.000000	0.000000	1.100
4			1	0.500			1.60000	0.00000	0.000	0.000000	0.000000	1.600
5	QPS 099002	Q2	3	0.700			2.30000	0.00000	0.000	0.000000	0.000000	2.300
6			1	0.500			2.80000	0.00000	0.000	0.000000	0.000000	2.800
7	QPS 099003	Q3	3	0.500			3.30000	0.00000	0.000	0.000000	0.000000	3.300
8			1	0.500			3.80000	0.00000	0.000	0.000000	0.000000	3.800
9	MBPS099005	B1	4	0.500	0.216000	0.00	4.29709	0.05390	0.000	0.216000	0.000000	4.300
10			1	0.250			4.54128	0.10748	0.000	0.216000	0.000000	4.550
11	COLL099008	C1	10	0.200	0.000000	0.00	4.73663	0.15034	0.000	0.216000	0.000000	4.750
12			1	0.250			4.98082	0.20392	0.000	0.216000	0.000000	5.000
13	QP7 099007	Q4	3	0.700			5.66455	0.35395	0.000	0.216000	0.000000	5.700
14			1	0.250			5.90875	0.40753	0.000	0.216000	0.000000	5.950
15	XCON099008	ABS	17	0.200	0.000000	0.00	6.10410	0.45040	0.000	0.216000	0.000000	6.150
16			1	0.250			6.34829	0.50398	0.000	0.216000	0.000000	6.400
17	MBPS099010	B2	4	0.500	0.216000	0.00	6.82227	0.66316	0.000	0.432000	0.000000	6.900
18			1	0.500			7.27634	0.87250	0.000	0.432000	0.000000	7.400
19	QPS 099012	Q5	3	0.500			7.73040	1.08184	0.000	0.432000	0.000000	7.900
20			1	0.400			8.09366	1.24932	0.000	0.432000	0.000000	8.300
21	QPS 099012	Q6	3	0.700			8.72935	1.54240	0.000	0.432000	0.000000	9.000
22			1	0.500			9.18341	1.75175	0.000	0.432000	0.000000	9.500
23	XBPF 09901	XBPF2	9	0.200	0.000000	0.00	9.36504	1.83548	0.000	0.432000	0.000000	9.700
24			1	0.300			9.63748	1.96109	0.000	0.432000	0.000000	10.000
25	EXPMT	EXPT	20	0.000	0.000000	0.00	9.63748	1.96109	0.000	0.432000	0.000000	10.000

vvle10p2 (END)

Survivals



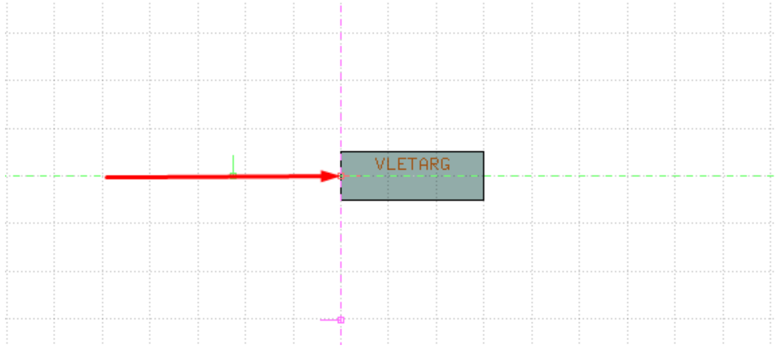
Pion Survival Rates
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
Survival Rate(%)
0
5
10
15
20
Distance (m)
13 m
2 GeV/c
0.8 GeV/c
0.3 GeV/c
1 GeV/c



Kaon Survival Rates
1.0
0.8
0.6
0.4
0.2
0.0
Survival Rate(%)
0
5
10
15
20
Distance (m)
13 m
0.8 GeV/c
1 GeV/c
0.5 GeV/c

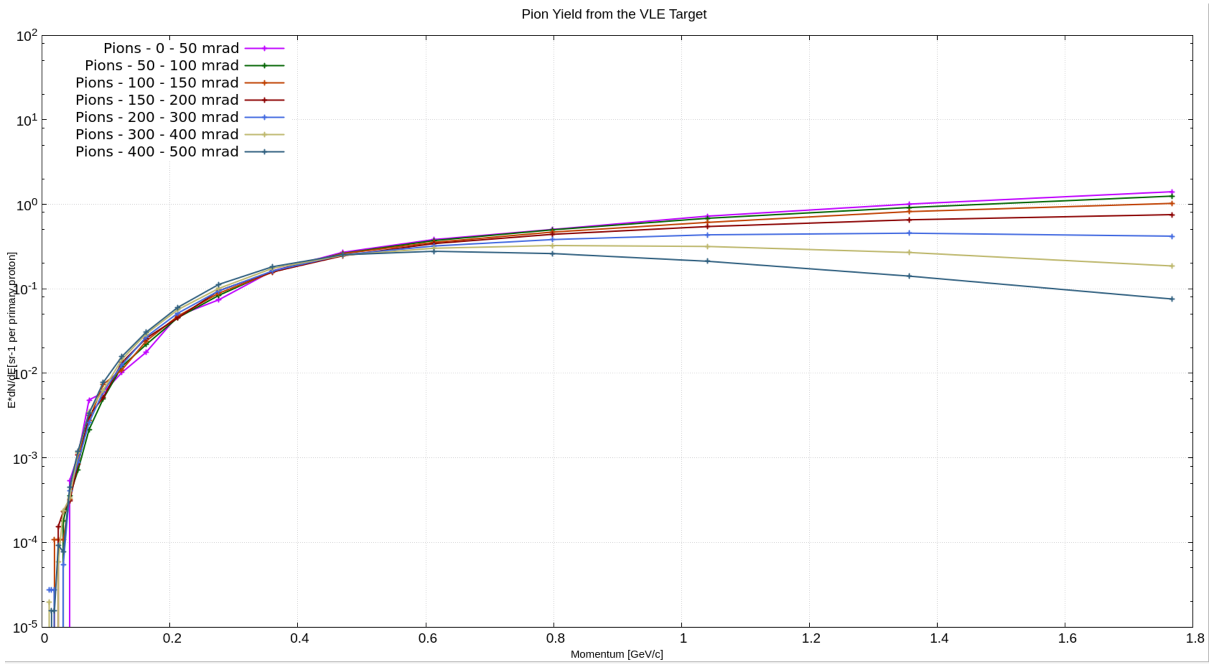
Particle production – FLUKA Simulations

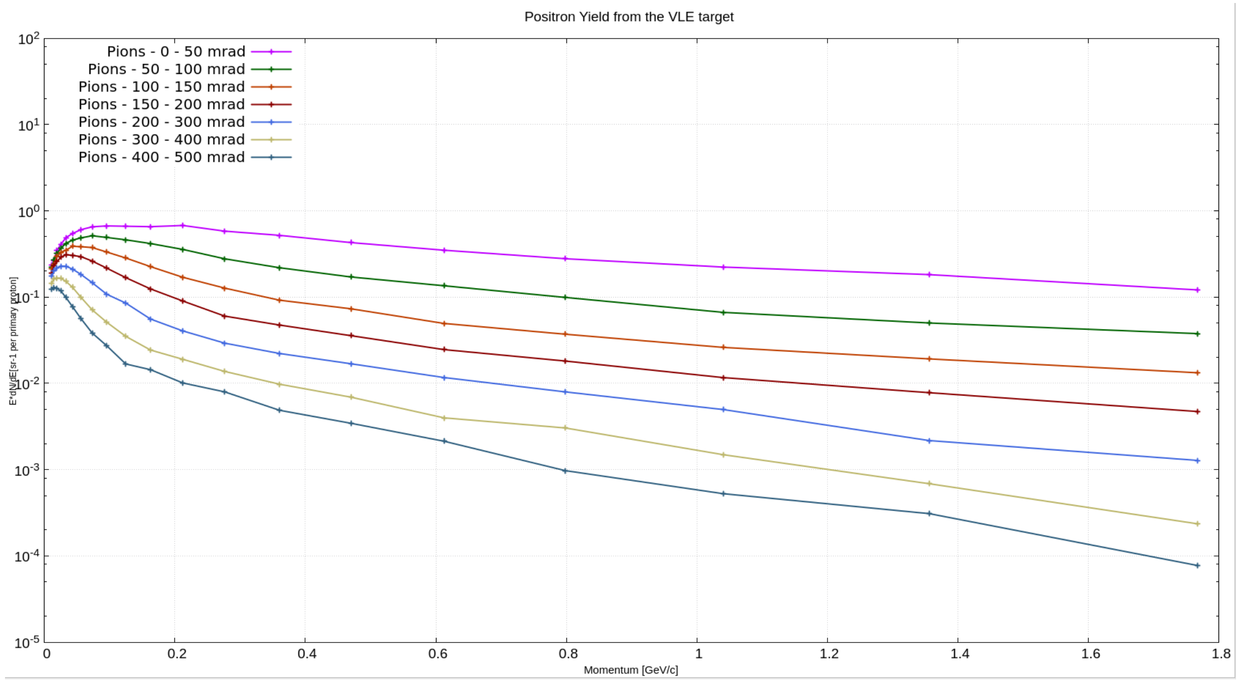
- 40 GeV/c beam
- From Atherton: 78.04 % pions, 6.17% kaons, 15.78% protons
- Renormalizing to add 30% electrons:
  - Beam comp: 54.62% pions, 4.31% kaons, 11.046% protons, 30% electrons
- Custom FLUKA routine (source.f) with EMF=ON
- Spot size: 2cm FWHM both planes, 1.5% dp flat
- Simple Geometry:



Scoring the particle yield in the momentum range of interest and for different particles and angles in the range 0 – 500 mrad polar

W-target, 5 cm radius and 30 cm length

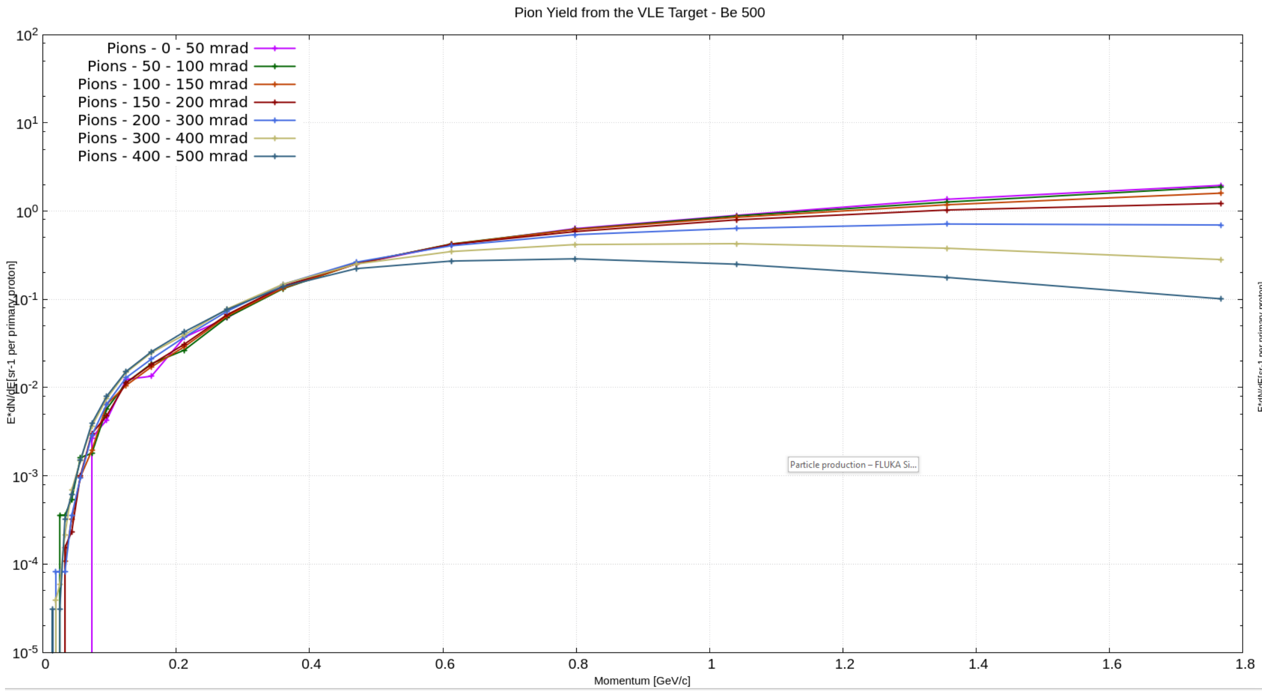


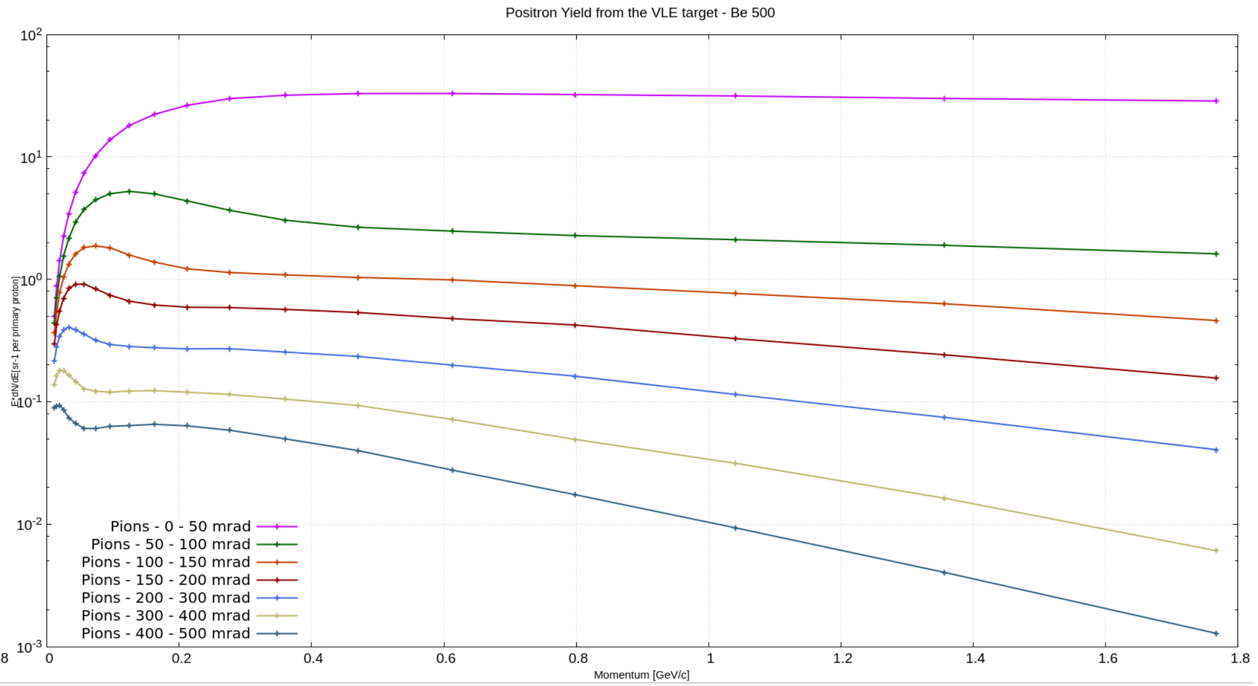


Pion yield very similar between 0-200 mrad

Positron yield drops by ~ 1 order of magnitude between 0 and 200 mrad, and even in the forward direction suppressed by ~ 0.5 - 1 order of magnitude compared with the pions.

Be-target, 5 cm radius and 50 cm length

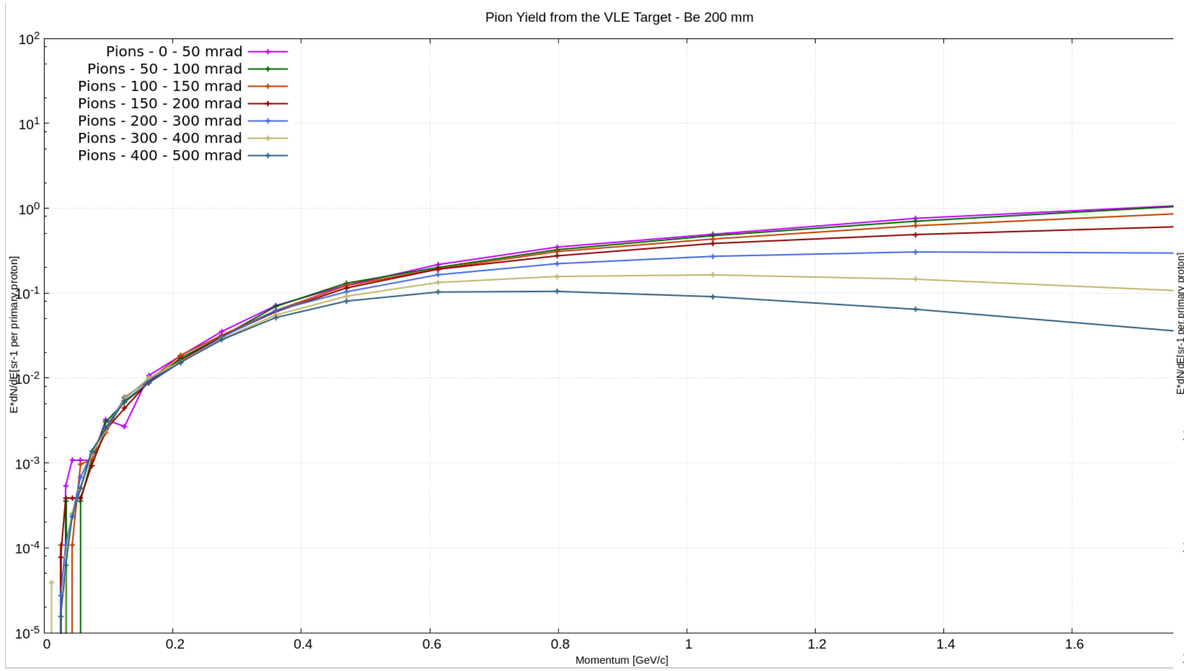


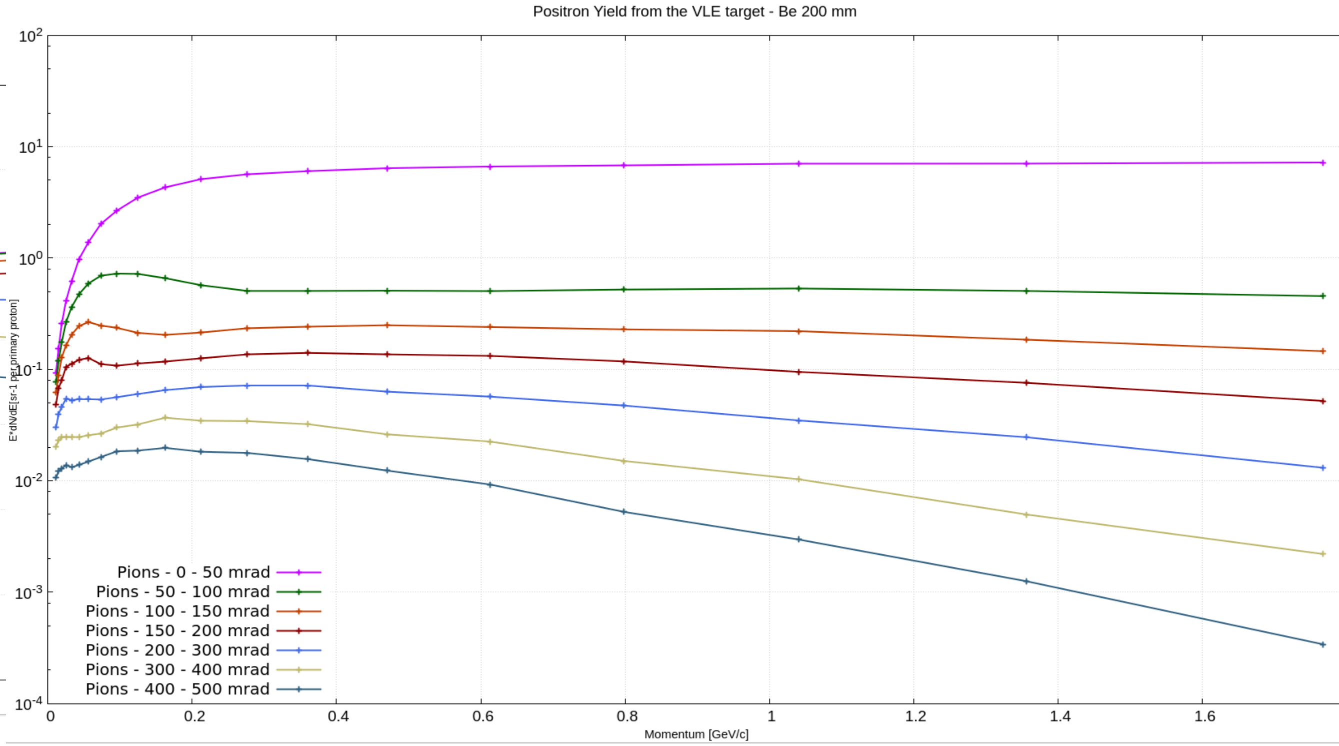


Pion yield very similar between 0-200 mrad and very similar with Tungsten 30 cm

Positron yield higher than Tungsten by at least 1 order of magnitude between 0 and 200 mrad

Be-target, 5 cm radius and 20 cm length

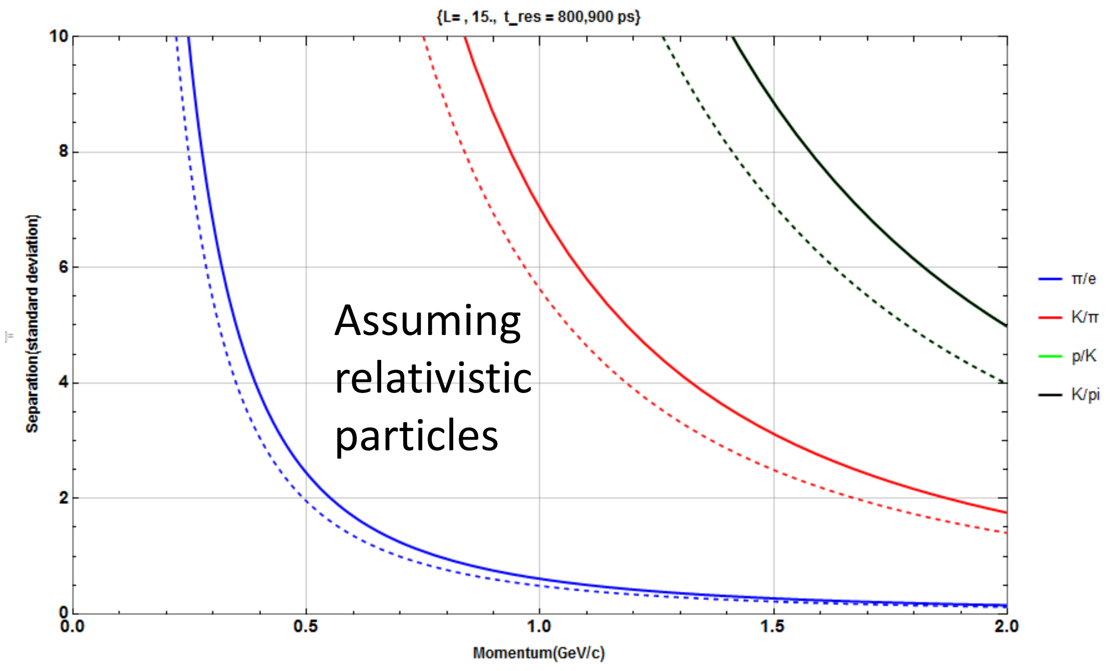




Pion yield very similar between 0-200 mrad and slightly suppressed from Be-500 (no surprise)

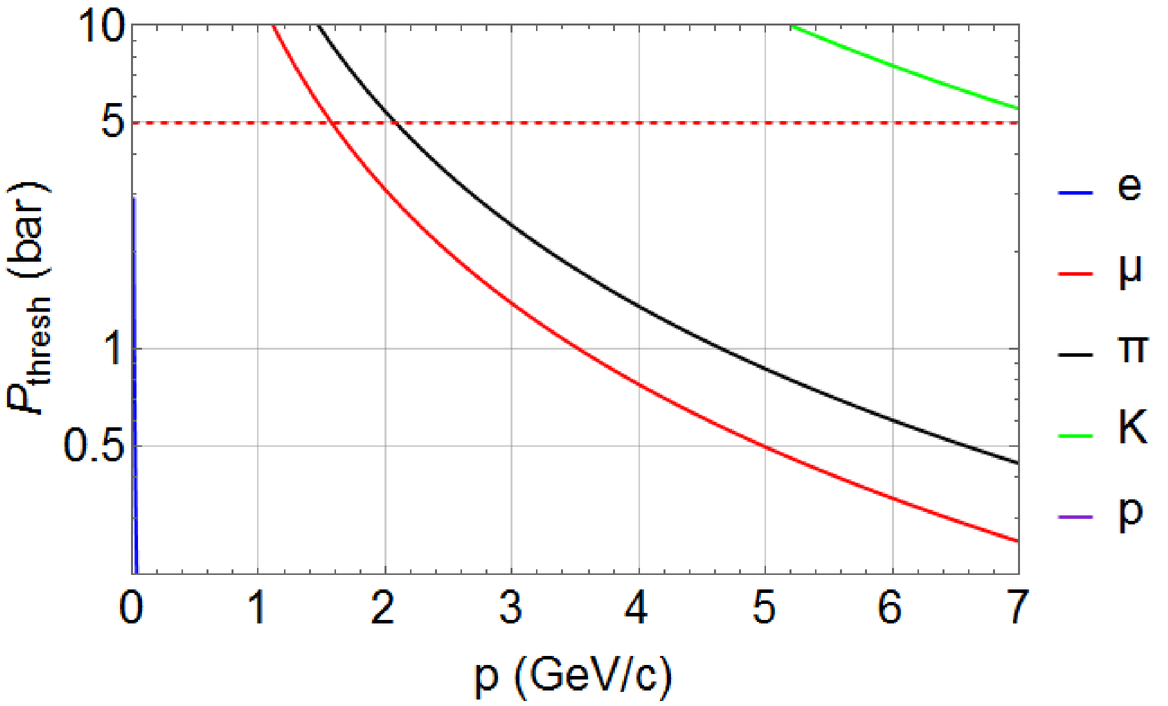
Positron yield still quite higher than Tungsten between 0 and 200 mrad

Time of flight and Cherenkov counters



Better ToF than 800 ps resolution needed for electron tagging, but pions < 1.2 GeV 4 sigma separation from Kaons

Always relativistic electrons give light, can be easily tagged



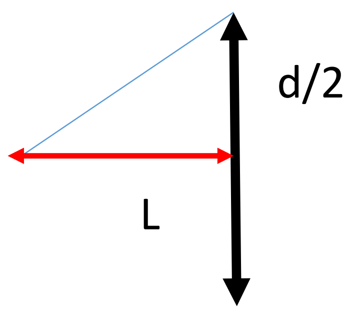
Conclusions

- Some preliminary ideas of a VVLE beam (max 2.5 GeV/c) have been studied.
- Detailed FLUKA simulations should be done, in order to optimize the necessary beam line acceptance and the choice of elements.
- An integration study with possible positions should follow, given that the budget is found (designers – FSUs).
- Main expected cost drivers :
  - Cabling, cooling and infrastructure (necessary at any case)
  - New magnetic elements (?)
  - Power supplies + transformers
  - Construction of extension inside the NP-04 pit
  - Manpower / resources for the construction
- More detailed studies require approval of the physics case.

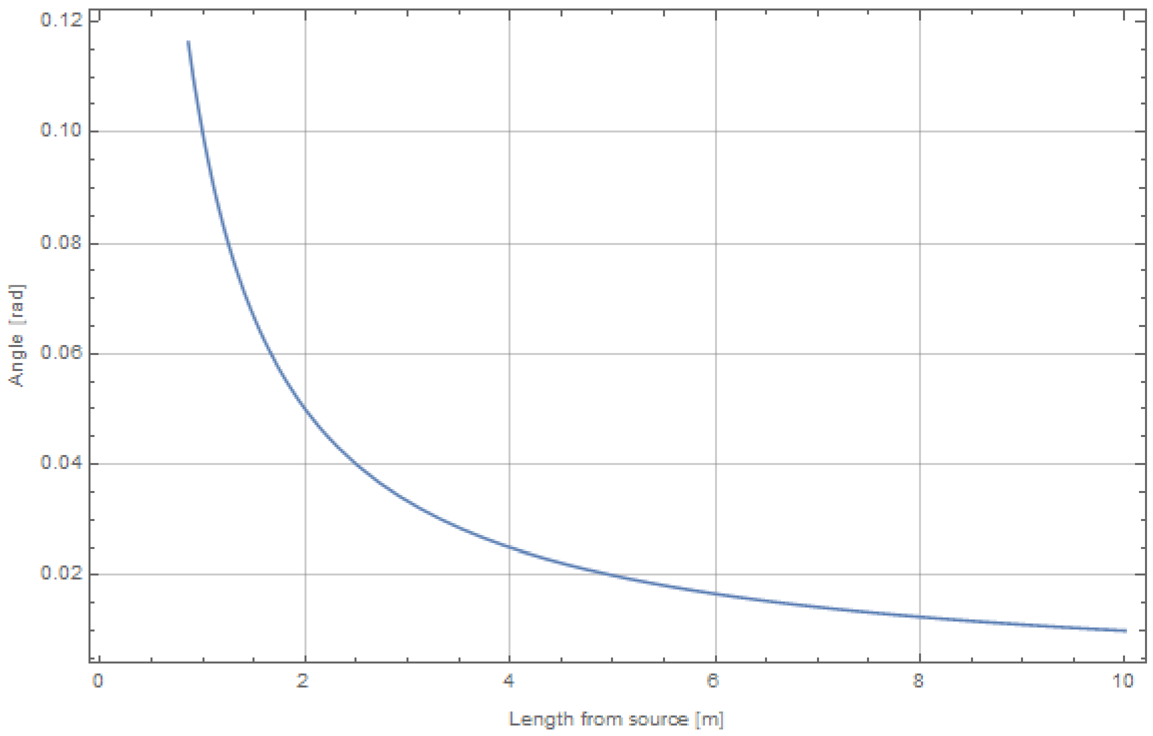
EXTRA SLIDES

Geometrical Acceptances

- Ignoring the optics, the first acceptance cut is made by the first element after the production target.



For a QPL : d/2 = 100 mm
tan(θmax) = 0.1/L => θmax = arctan(0.1/L)



Lau vvle10p2 TRANSPORT in/out

```
"VVLE new shorter magnets - LAU vvle10p2 "
0
15. 1. "MM" 0.1 ;
13.0 18.0 ;
13.0 19.0 ;
1. 3. 5. 3. 15. 0. 4.5 2.5 "CRD1" ;
   3.0   0.000 "LETG" ;
   3.0   0.600 ;
   5.0D  0.500 19.86877 100.0 "Q1" ;
   3.0   0.500 ;
   5.0E  0.700  -19.34149 100.0 "Q2" ;
   3.0   0.500 ;
   5.0F  0.500   19.86877 100.0 "Q3" ;
   3.0   0.500 ;
   4.0   0.500 18.0 0.0 "B1" ;
   3.0   0.700 ;
   5.0A  0.350 38.23307 50.0 "QFLD";
  10.0 -1. 2.0 0.0 0.0001 ;
  10.0 -3. 4.0 0.0 0.0001 ;
   5.0A  0.350 38.23307 50.0 "QFLD";
   3.0   0.700 ;
   4.0   0.500 18.0 0.0 "B2" ;
   3.0   0.500 ;
   5.0X  0.500 -10.0 100.0 "Q5" ;
   3.0   0.400 ;
   5.0Y  0.700 10.0 100.0 "Q6" ;
   3.0   1.000 ;
   3.0   0.000 "EXPT" ;
10.  -2.   2.   0.   .0001 "HF2"  ;
10.  -4.   4.   0.   .0001 "VF2"  ;
10.0 -1.0 6.0 0.0 0.0001 ;
13.   41. "PRIN" ;
SENTINEL
SENTINEL
```

```
0*COVARIANCE  (FIT 0.44839E-02 )
1VVLE new shorter magnets - LAU vvle10p2

 *QUAD*        5.   "Q1  "     0.50000 M       48.03054 KG      100.00000 MM   (    0.44707 M   )
     VARY CODE =  0 D
 *QUAD*        5.   "Q2  "     0.70000 M      -20.06957 KG      100.00000 MM   (   -0.49119 M   )
     VARY CODE =  0 E
 *QUAD*        5.   "Q3  "     0.50000 M       23.10560 KG      100.00000 MM   (    0.81242 M   )
     VARY CODE =  0 F
 *QUAD*        5.   "QFLD"     0.35000 M       11.13846 KG       50.00000 MM   (    1.13018 M   )
     VARY CODE =  0 A
 *FIT*        10.0             -1.   2.     0.00000 /0.00010      (  0.00000 )
 *FIT*        10.0             -3.   4.     0.00000 /0.00010      ( -0.00001 )
 *QUAD*        5.   "QFLD"     0.35000 M       11.13846 KG       50.00000 MM   (    1.13018 M   )
     VARY CODE =  0 A
 *QUAD*        5.   "Q5  "     0.50000 M      -15.17081 KG      100.00000 MM   (   -1.02025 M   )
     VARY CODE =  0 X
 *QUAD*        5.   "Q6  "     0.70000 M        7.46709 KG      100.00000 MM   (    1.71833 M   )
     VARY CODE =  0 Y
 *FIT*        10.0  "HF2 "     -2.   2.     0.00000 /0.00010      ( -0.00000 )
 *FIT*        10.0  "VF2 "     -4.   4.     0.00000 /0.00010      (  0.00000 )
 *FIT*        10.0             -1.   6.     0.00000 /0.00010      (  0.00000 )
0*LENGTH*        10.00000 M
1VVLE new shorter magnets - LAU vvle10p2                                                TRANSPORT RUN14/01/20
0POSITION TYPE       STRENGTH *       H O R I Z O N T A L        *        V E R T I C A L        *       D I S P E R S I O N
   METERS            T*M,T/M*M *    R11     R12     R21     R22   *    R33     R34     R43     R44  *    R16     R26     R36     R46
                     T/M**2*M *   MM/MM   MM/MR   MR/MM   MR/MR  *   MM/MM   MM/MR   MR/MM   MR/MR *   MM/PC   MR/PC   MR/PC   MR/PC
 **********************************************************************************************************************************
     0.000  3  LETG           *   1.000   0.000   0.000   1.000 *   1.000   0.000   0.000   1.000 *   0.000   0.000   0.000   0.000
     0.600  3                 *   1.000   0.600   0.000   1.000 *   1.000   0.600   0.000   1.000 *   0.000   0.000   0.000   0.000
     1.100  5  Q1     24.0153 *   0.362   0.606  -2.237  -0.980 *   1.811   1.715   3.622   3.984 *   0.000   0.000   0.000   0.000
     1.600  3                 *  -0.756   0.116  -2.237  -0.980 *   3.622   3.707   3.622   3.984 *   0.000   0.000   0.000   0.000
     2.300  5  Q2    -14.0487 *  -3.140  -0.637  -5.230  -1.380 *   3.754   4.000  -3.283  -3.232 *   0.000   0.000   0.000   0.000
     2.800  3                 *  -5.754  -1.328  -5.230  -1.380 *   2.113   2.384  -3.283  -3.232 *   0.000   0.000   0.000   0.000
     3.300  5  Q3     11.5528 *  -6.197  -1.507   3.562   0.705 *   1.050   1.450  -1.210  -0.719 *   0.000   0.000   0.000   0.000
     3.800  3                 *  -4.416  -1.155   3.562   0.705 *   0.445   1.090  -1.210  -0.719 *   0.000   0.000   0.000   0.000
     4.300  4  B1      0.9000 *  -2.612  -0.796   3.644   0.728 *  -0.161   0.731  -1.210  -0.719 *   0.270   1.077   0.000   0.000
     5.000  3                 *  -0.061  -0.287   3.644   0.728 *  -1.008   0.227  -1.210  -0.719 *   1.024   1.077   0.000   0.000
     5.350  5  QFLD    7.7969 *   1.155   0.000   3.118   0.865 *  -1.624  -0.000  -2.408  -0.616 *   1.217  -0.000   0.000   0.000
     5.700  5  QFLD    7.7969 *   2.004   0.287   1.600   0.728 *  -2.787  -0.227  -4.416  -0.719 *   1.024  -1.077   0.000   0.000
     6.400  3                 *   3.124   0.796   1.600   0.728 *  -5.879  -0.731  -4.416  -0.719 *   0.270  -1.077   0.000   0.000
     6.900  4  B2      0.9000 *   3.904   1.155   1.518   0.705 *  -8.087  -1.090  -4.416  -0.719 *   0.000  -0.000   0.000   0.000
     7.400  3                 *   4.663   1.507   1.518   0.705 * -10.295  -1.450  -4.416  -0.719 *   0.000  -0.000   0.000   0.000
     7.900  5  Q5     -7.5854 *   6.582   2.243   6.446   2.348 * -10.086  -1.465   5.221   0.659 *   0.000   0.000   0.000   0.000
     8.300  3                 *   9.160   3.182   6.446   2.348 *  -7.998  -1.202   5.221   0.659 *   0.000   0.000   0.000   0.000
     9.000  5  Q6      5.2270 *  11.413   4.035  -0.248  -0.000 *  -5.889  -0.979   1.022   0.000 *   0.000  -0.000   0.000   0.000
    10.000  3                 *  11.165   4.035  -0.248  -0.000 *  -4.868  -0.979   1.022   0.000 *   0.000  -0.000   0.000   0.000
    10.000  3  EXPT           *  11.165   4.035  -0.248  -0.000 *  -4.868  -0.979   1.022   0.000 *   0.000  -0.000   0.000   0.000
```