European LC Workshop 08/01/2007

- ESA
- Set up and collimators
- Analysis of T480
- Preliminary results
- Outlook

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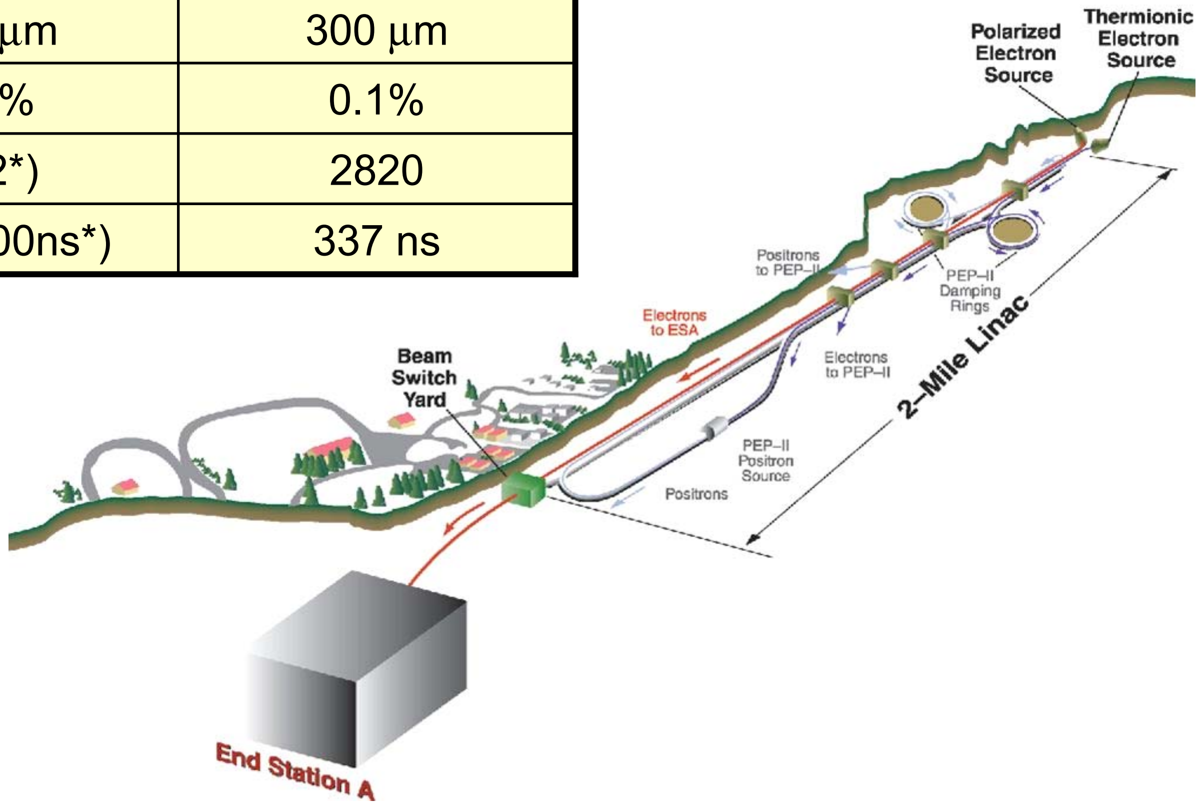
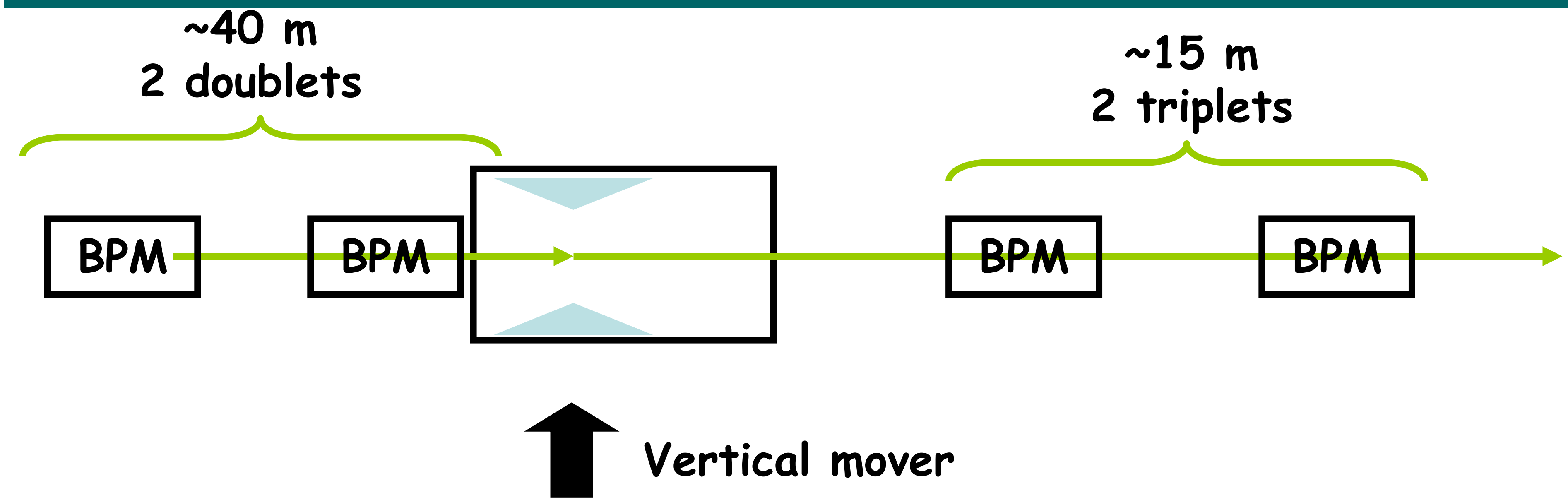
- Wakefields deteriorate the beam quality.
- A final collimator design should minimise this effect.
- Studies on wakefields generated by different collimator geometries.
- Comparison to analytic predictions and simulations in order to improve both methods.

Beam Parameters at SLAC ESA and ILC

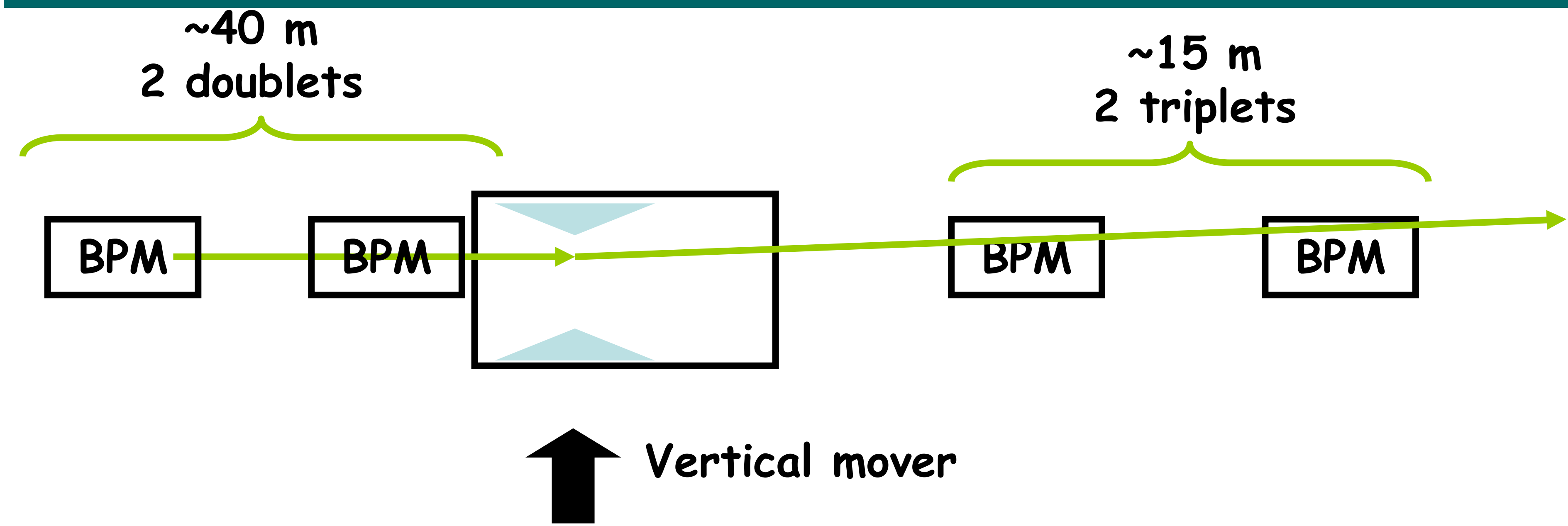
Parameter	SLAC ESA	ILC-500
Repetition Rate	10 Hz	5 Hz
Energy	28.5 GeV	250 GeV
Bunch Charge	2.0×10^{10}	2.0×10^{10}
Bunch Length	300 μm	300 μm
Energy Spread	0.2%	0.1%
Bunches per train	1 (2*)	2820
Microbunch spacing	- (20-400ns*)	337 ns

*possible, using undamped beam





- Wakefield measurement:
  - Move collimators around beam (in steps of 0.2 mm, from -1.2 mm to +1.2 mm, being 0 mm the centre of the collimator).
  - Measure deflection from wakefields vs. beam-collimator separation



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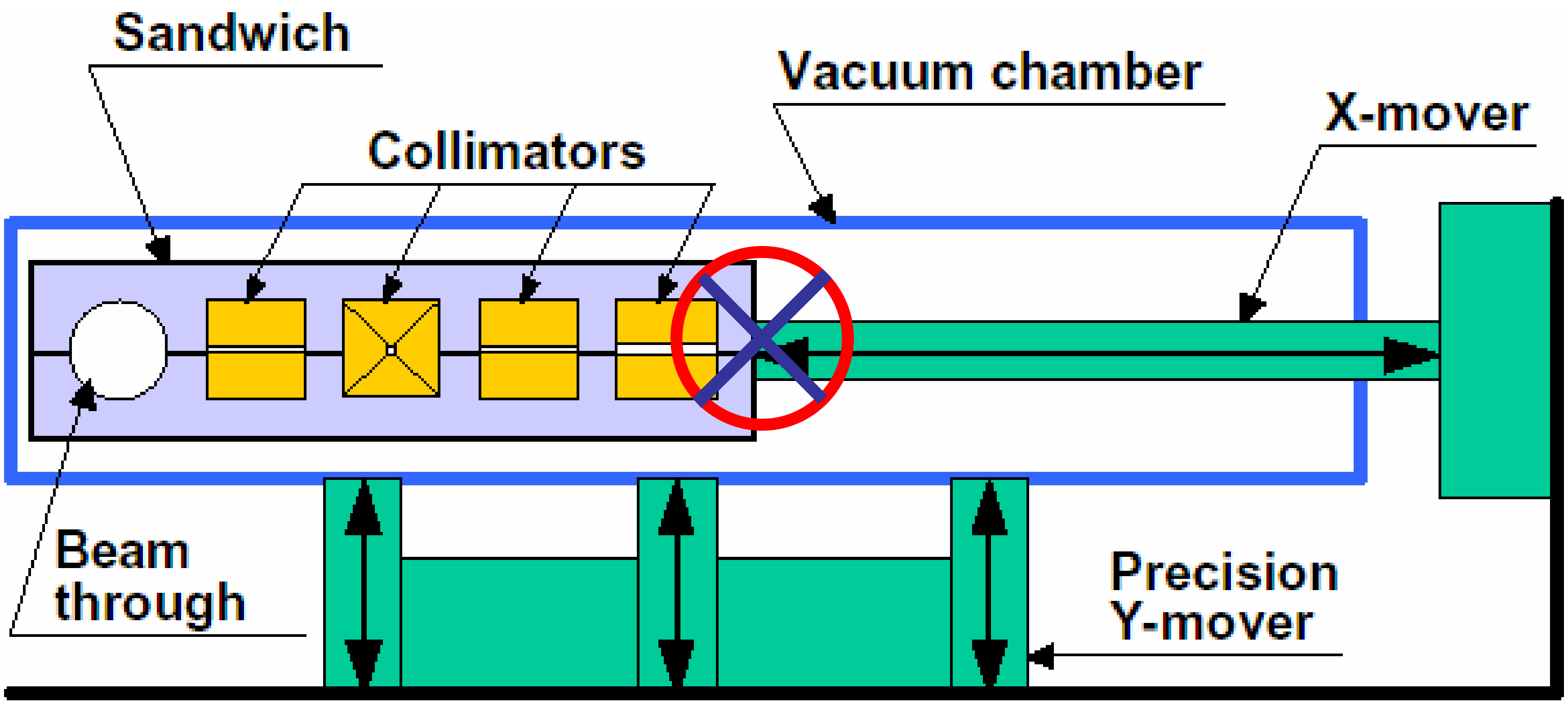
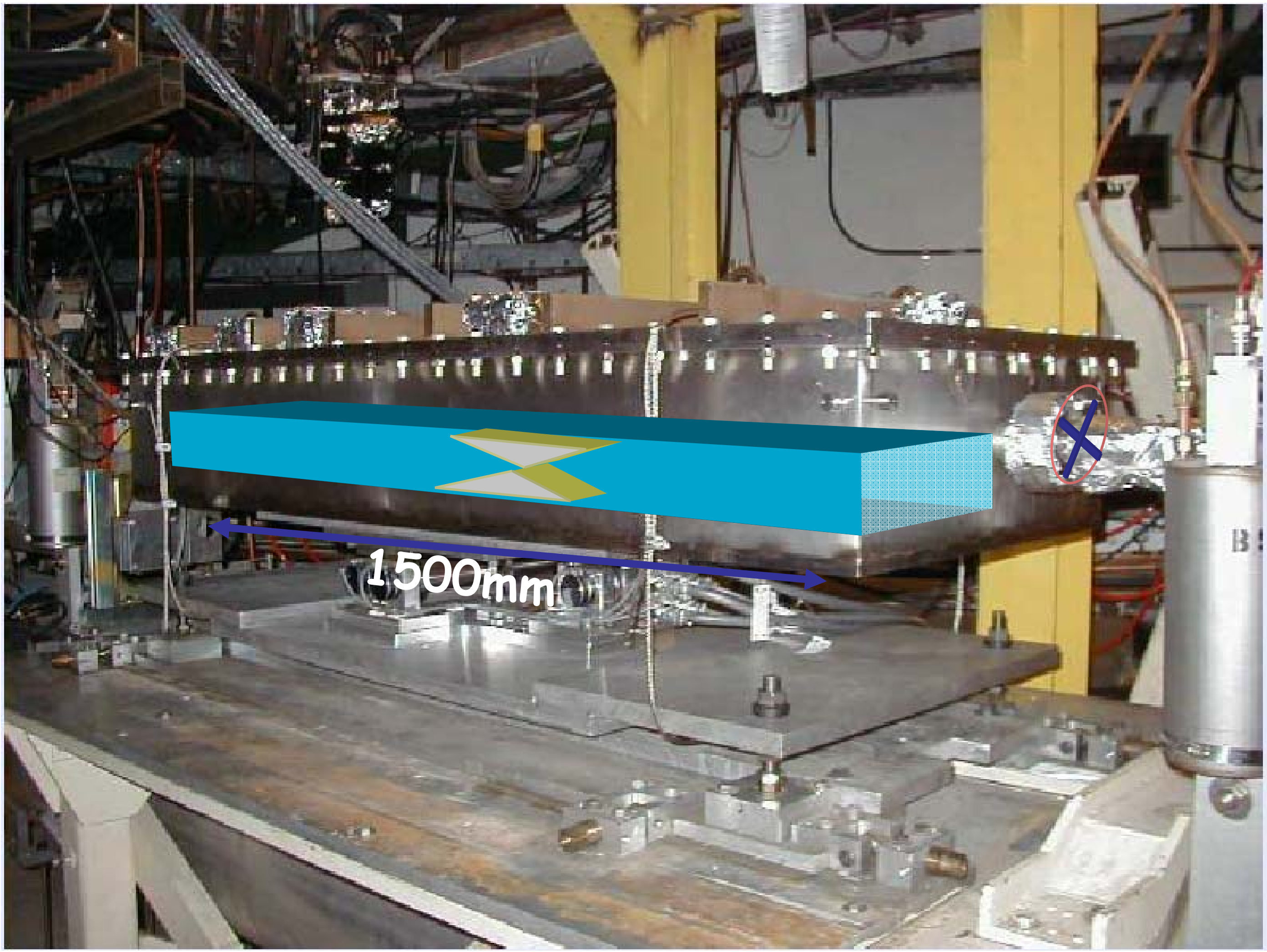
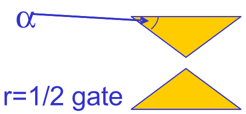
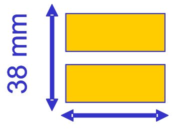
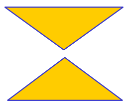
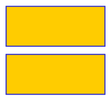
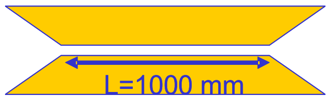
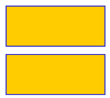
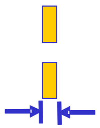
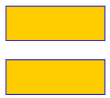
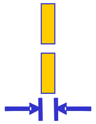
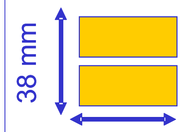
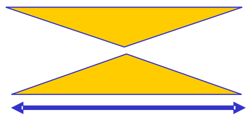
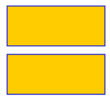
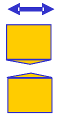
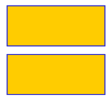
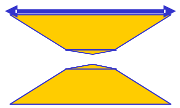
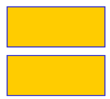
E_{beam}=28.5GeV



Magnet mover, y range = ±1.4mm, precision = 1μm


1500mm

Slot	Side view	Beam view	
1			α=335mrad r=2 mm
2			α=335mrad r=1.4mm
3			α=335mrad r=1.4mm
4			α=π/2rad r=3.8mm

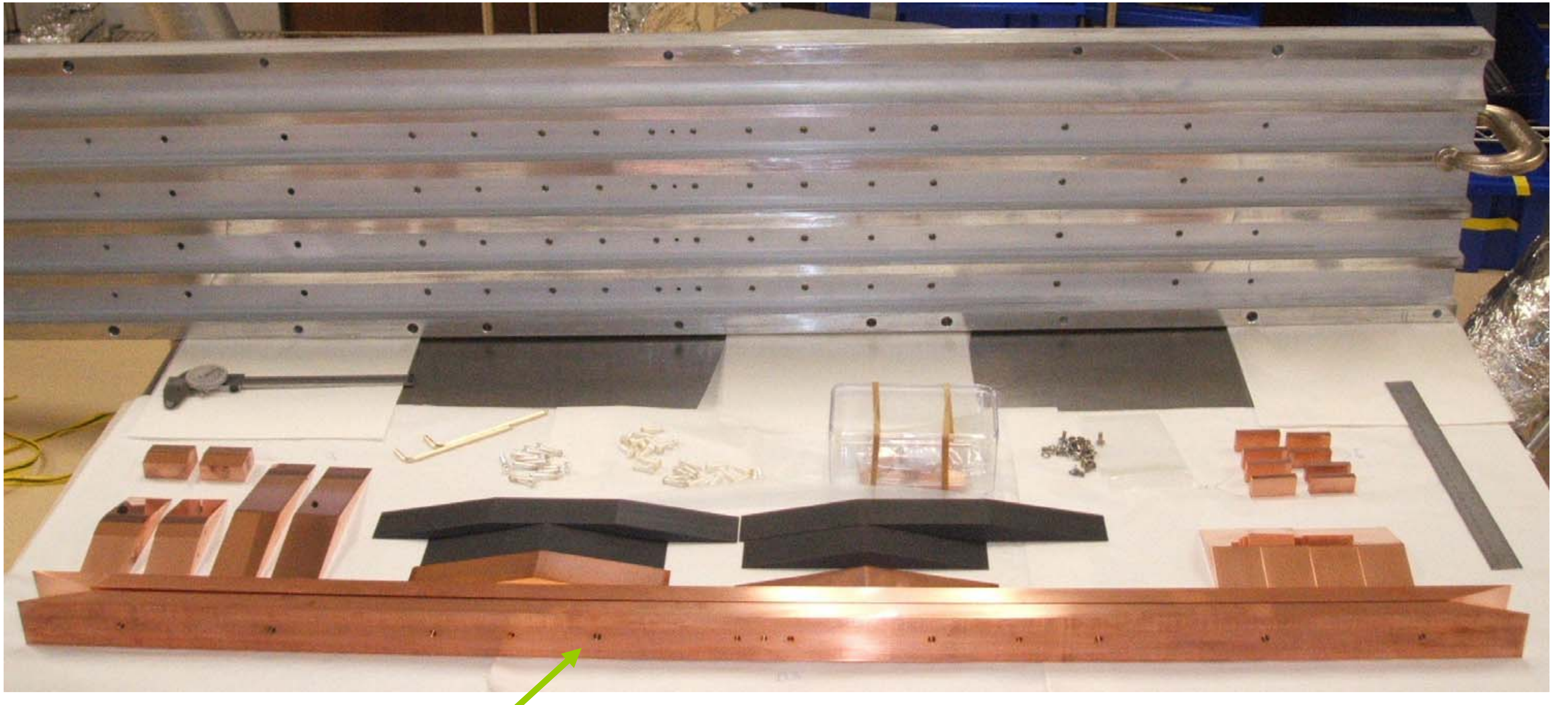
Slot	Side view	Beam view	
1			α=π/2rad r=1.4mm
2			α=168mrad r=1.4mm
3			α_1=π/2 rad α_2=168mrad r_1=3.8mm r_2=1.4mm
4			α_1=298mrad α_2=168mrad r_1 =3.8mm r_2 =1.4mm

Collimator 1 is similar to collimator described in SLAC-PUB-12086

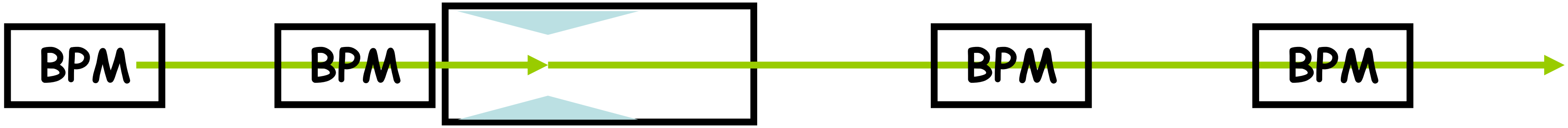
Collimator 2 is like 1 but with a narrower gap

Collimator 3 has the same taper angle and gap as 2. We hope to measure the difference due to resistive wakefield.

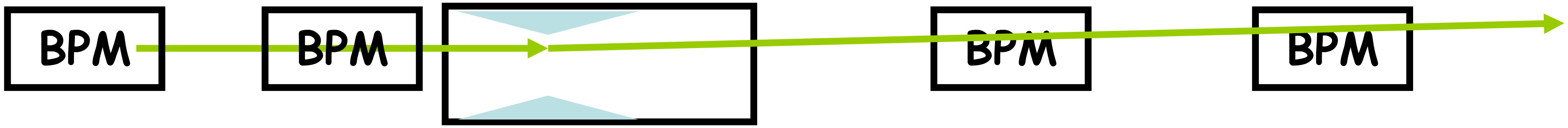
Collimator 2, 3 and 4 have same taper angle, but 3 and 4 just in the top. The aim is to measure the difference between each geometry, if there is any. A small taper angle is better to reduce wakefields but it also need longer (more space) collimators. Can be model it?



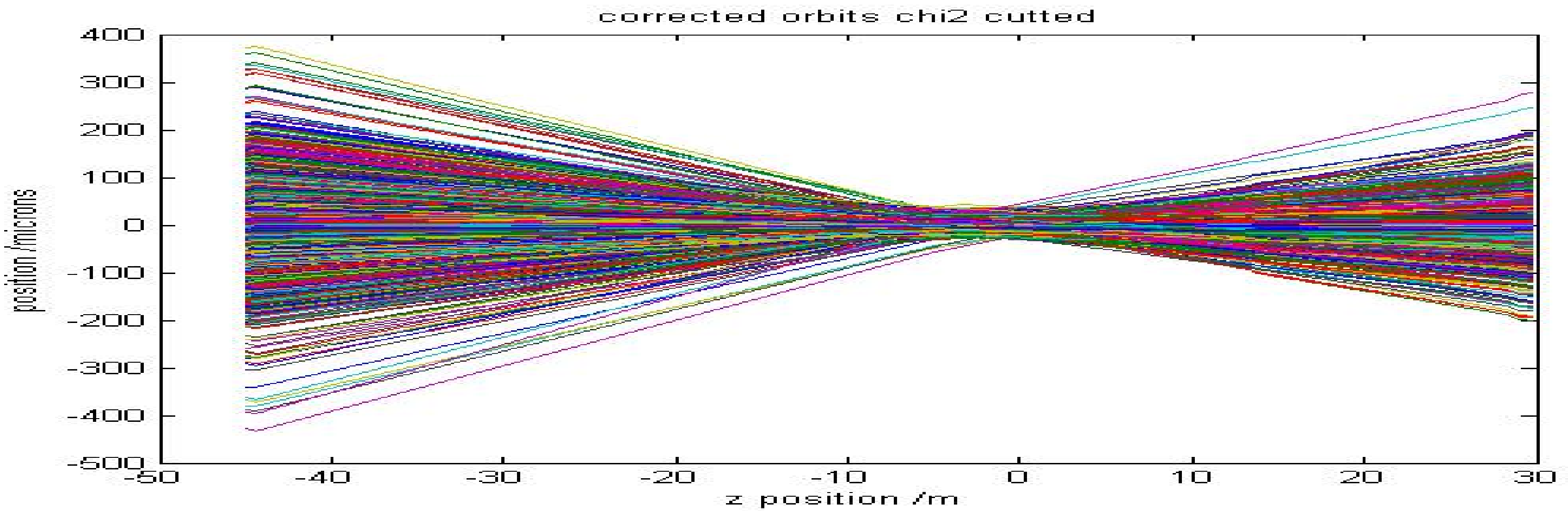
1000mm OFE Cu, ½ gap 1.4mm

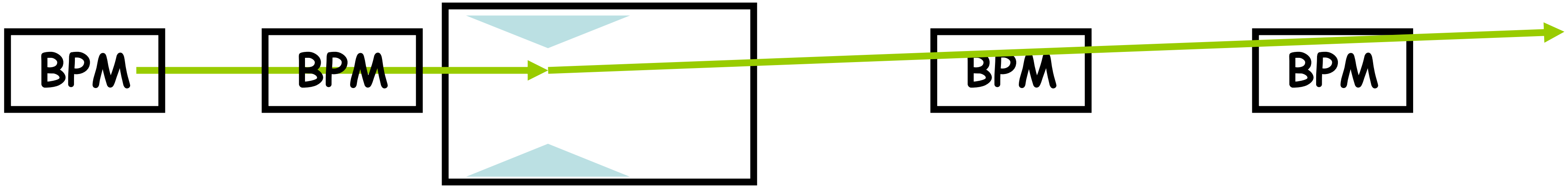


A run with the beam going through the middle of the collimator (or without the collimator) is used as reference for the next run where the collimator will be moved vertically. This run also serves to calculate the resolution of each BPM.



The analysis will do a linear fit to the upstream and downstream BPM data separately, per each pulse (bunch) . For this fit the data is weighted using the resolution measured for each BPM.





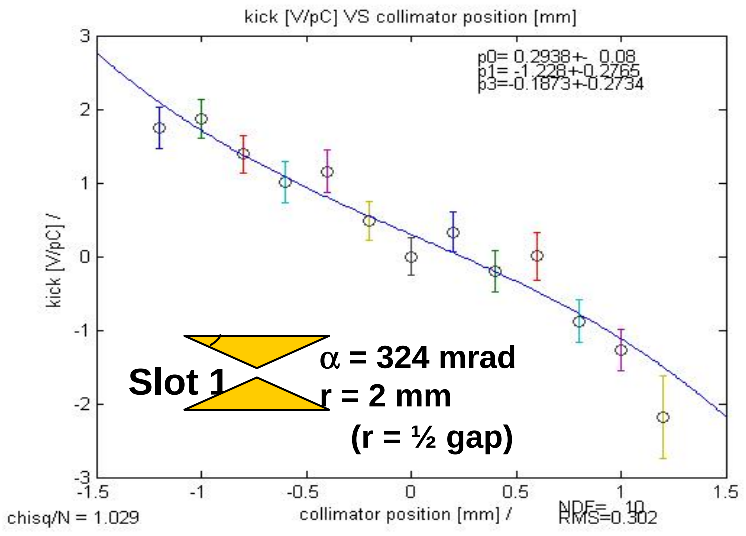
The slopes of each linear fit are subtracted obtaining a deflection angle. This angle is transformed into V/pC units using the charge reading and the energy of the beam.

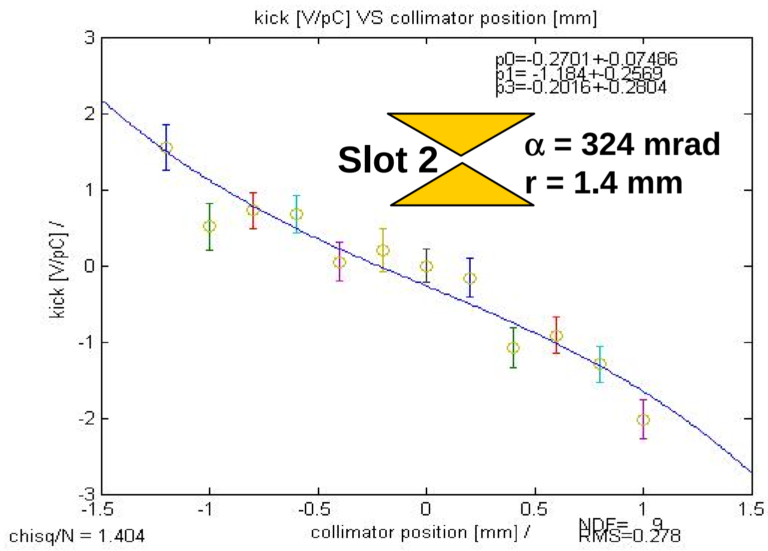
All the reconstructed kicks are averaged per each of the different collimator positions and a cubic fit of the form:

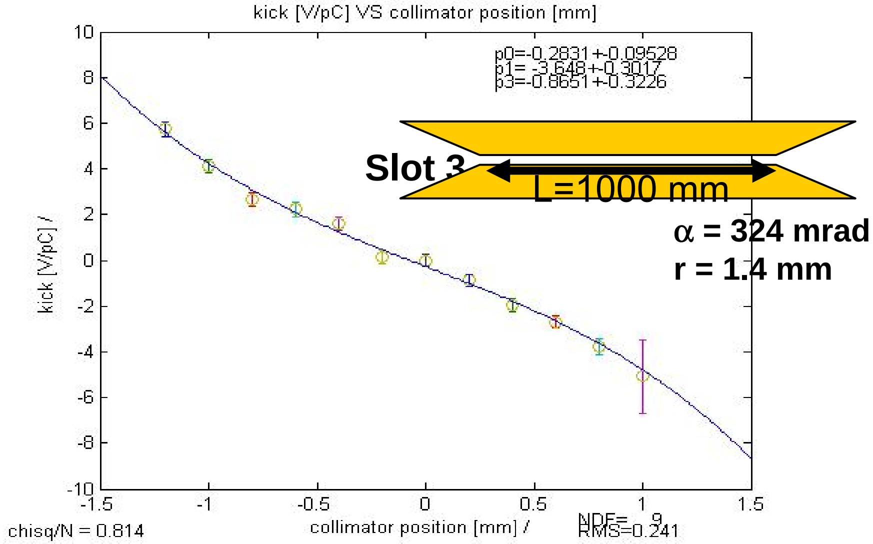
$$y' = A_3 \cdot y^3 + A_1 \cdot y + A_0$$

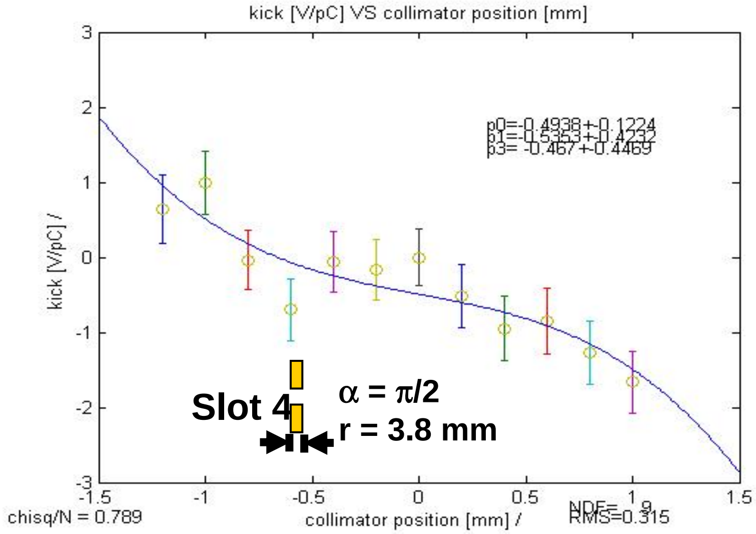
is done to the result. The error in the kick reconstruction at each collimator position weights the different points for the fit.

The kick factor is defined as the linear term of the cubic fit (A_1).

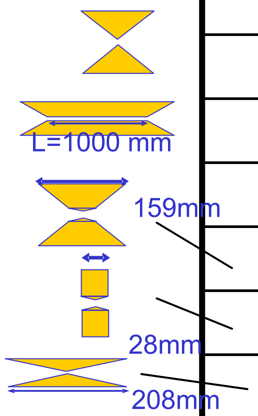

kick [V/pC] VS collimator position [mm]
p0= 0.2938+- 0.08
p1= -1.228+-0.2765
p3=-0.1873+-0.2734
Slot 1
α = 324 mrad
r = 2 mm
(r = ½ gap)
kick [V/pC] /
collimator position [mm] /
chisq/N = 1.029
NDF= 10
RMS=0.302


kick [V/pC] VS collimator position [mm]
p0=-0.2701+-0.07486
p1= -1.184+-0.2569
p3=-0.2016+-0.2804
Slot 2
α = 324 mrad
r = 1.4 mm
kick [V/pC] /
collimator position [mm] /
chisq/N = 1.404
NDF= 9
RMS=0.278


kick [V/pC] VS collimator position [mm]
p0=-0.2831+-0.09528
p1= -3.648+-0.3017
p3=-0.8651+-0.3226
Slot 3
L=1000 mm
α = 324 mrad
r = 1.4 mm
kick [V/pC] /
collimator position [mm] /
chisq/N = 0.814
NDF= 9
RMS=0.241


kick [V/pC] VS collimator position [mm]
p0=-0.4938+-0.1224
p1=-0.5353+-0.4232
p3= -0.467+-0.4469
Slot 4
α = π/2
r = 3.8 mm
kick [V/pC] /
collimator position [mm] /
chisq/N = 0.789
NDF= 9
RMS=0.315

Preliminary results:



Collimator	Measured[4] Kick Factor V/pc/mm (χ^2/dof) Linear fit	Measured[4] Kick Factor V/pc/mm (χ^2/dof) Linear + Cubic Fit	Analytic Prediction[1] Kick Factor V/pc/mm	3-D Modelling Prediction[2] Kick Factor V/pc/mm
1	1.4 ± 0.1 (1.0)[3]	1.2 ± 0.3 (1.0)	1.1	1.7
2	1.4 ± 0.1 (1.3)	1.2 ± 0.3 (1.4)	2.3	3.1
3	4.4 ± 0.1 (1.5)	3.7 ± 0.3 (0.8)	6.6	7.1
4	0.9 ± 0.2 (0.8)	0.5 ± 0.4 (0.8)	0.3	0.8
5	1.7 ± 0.3 (2.0)	1.7 ± 0.3 (2.2)	2.3	2.4
6	1.7 ± 0.1 (0.7)	2.2 ± 0.3 (0.5)	2.4	2.7
7	0.9 ± 0.1 (0.9)	0.9 ± 0.3 (1.0)	2.3	2.4
8	3.7 ± 0.1 (7.9)	4.9 ± 0.2 (2.6)	2.3	6.8

[1]Assumes 500-micron bunch length
[2]Assumes 500-micron bunch length, includes analytic resistive wake; modelling in progress
[3]Kick Factor measured for similar collimator described in SLAC-PUB-12086 was (1.3 ± 0.1) V/pc/mm
[4]Still discussing use of linear and linear+cubic fits to extract kick factors and error bars

→ Goal is to measure kick factors to 10%

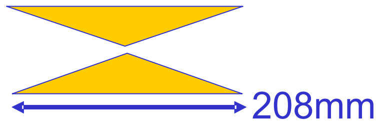
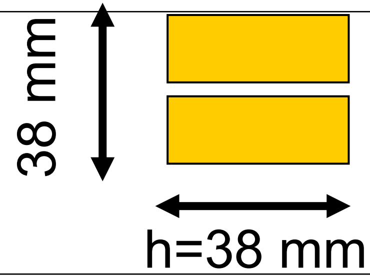
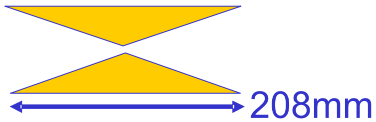
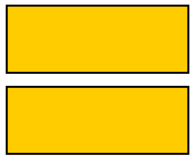
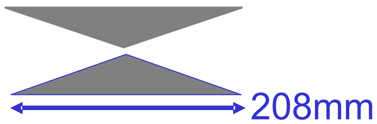
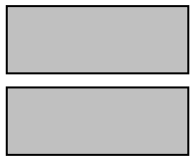
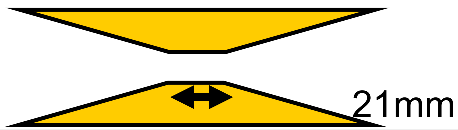
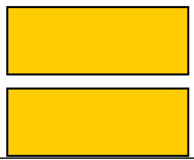
Outlook:

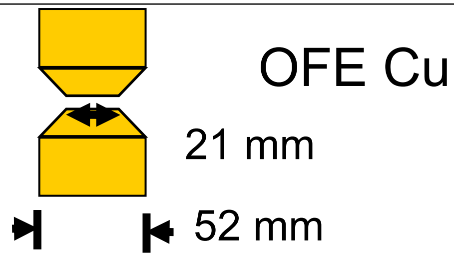
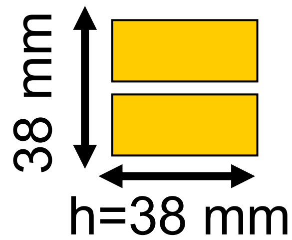
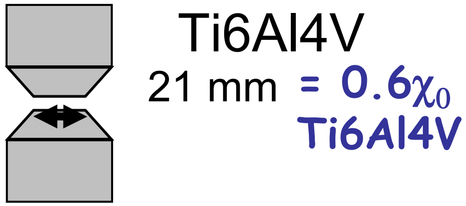
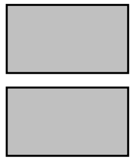
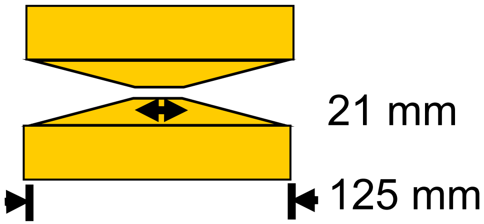
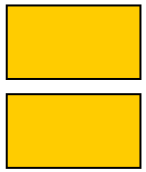
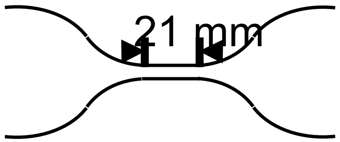
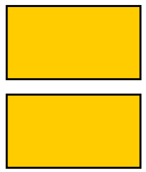
7 New Collimators for Run 3 (currently scheduled 6 March) **are being fabricated now**
(expected delivery time: 19 January)

(keep 1 from Run 2 for cross check)

- Compare importance of tapers in region away from gap centre –
- acceptable to have shallow tapers necessary for transverse wakefield performance only in the immediate vicinity of beam axis??
  (Can we make much shorter collimators?)
- Flat section introduced equivalent in length to 0.6 r.l. of Ti6Al4V
- Explicit tests of surface roughness
- Allow one slot for non-linear taper, exponential form

Additional Collimators to test for Run 4 possible in FY07
+ plan to continue tests in FY08

Collim.#	Side view ("SLAC sandwich")	Beam view	Revised 22-Nov-2006
7	 As used in 2006, necessary for consistency		r =1.4mm α=168mrad
9	 As 7, unpolished EDM process, "hollowed"		r =1.4mm α=168mrad
10	 As 9, in Ti-6Al-4V		r =1.4mm α_1=168mrad
11			α=168mrad r=1.4mm

Collim.#	Side view ("SLAC sandwich")	Beam view	Revised 08-Nov-2006
13			$\alpha_1=\pi/2$ rad $\alpha_2=168$mrad $r_1=4.0$mm $r_2=1.4$mm
14			$\alpha_1=\pi/2$ rad $\alpha_2=168$mrad $r_1=4.0$mm $r_2=1.4$mm
15			$\alpha_1=\pi/2$ rad $\alpha_2=50$mrad $r_1=4.0$mm $r_2=1.4$mm
16			α=exp., sin r=1.4mm