Building a hadron calorimeter with E-705 scintillating glasses

D. Cauz, University of Udine

DR meeting, 14th Dec 2010

Fermilab

E-705 legacy

- E-705 used 74 ‘large’ and 212 ‘small’ scintillating glasses, plus several lead glasses
- All, or some, of them were stored when the experiment ended

type	**Dimensions (cm^3)**	#	# found
Main array large	**15 x 15 x 89**	**74**	**74**
Main array small	7.5 x 7.5 x 89	92	
Active converter	7.5 x 7.5 x 97.5	120	
total		**74** + 212	**74** + 161

- I checked at the store place and found 74 large but only 161 small glasses

What glass is this?

- It is SCG1-C
- Density is 3.36 g/cm^3
- Radiation length is 4.25 cm
- Interaction length is 45.6 cm (for pions with 30-200 GeV energy)

salt	Percent (by weight)
BaO	43.4%
SiO_2	42.5%
Li_2O	4.0%
MgO	3.3%
K_2O	3.3%
Al_2O_3	2.0%
Ce_2O_3	1.5%

How much glass we have

- If we had all the glasses, the total volume would amount to

$$V_{glass} = 2.60 m^3$$

- Let's consider a cylindrical volume of length *L* and radius *R*
- Expressing *L* and *R* in terms of λ, the volume is

$$V_{calor} = \pi R^2 L = \pi n_T^{\ 2} n_L \lambda^3$$

- In the following table we report the volume corresponding to $L = n_L \lambda$ $R = n_T \lambda$: only the values falling in the blue-shaded area can be filled by the glass we have

n_T, n_L	1	2	3	4	5	6	7	8
1	0,30	0,60	0,89	1,19	1,49	1,79	2,09	2,38
2	1,19	2,38	3,57	4,77	5,96	7,15	8,34	9,53
3	2,68	5,36	8,04	10,72	13,40	16,09	18,77	21,45
4	4,77	9,53	14,30	19,06	23,83	28,60	33,36	38,13
5	7,45	14,89	22,34	29,79	37,24	44,68	52,13	59,58

A different approach

- If we content ourselves to laterally contain the shower at the 95% level, then we can use the formula (*)

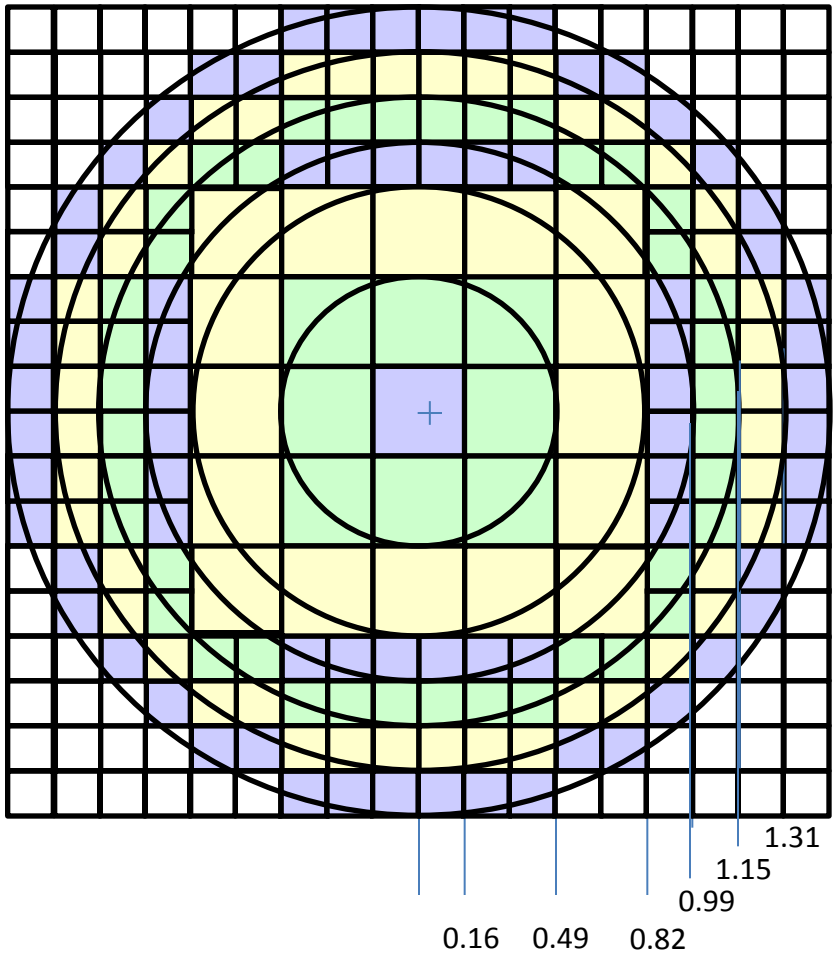
$$\boxed{\begin{aligned} &R_{95\%} = \lambda(0.29 + 0.17u) = 13.22 + 0.17x \\ &(E = 140GeV) \end{aligned}}$$

- Where *x* is the longitudinal coordinate and $u = x/\lambda$
- In 3-D this formula represents a truncated cone

- (*) R. Frühwirth et al., Data Analysis Techniques for High-Energy Physics, Cambridge Monographs

As an example I tried to arrange the glasses in ‘concentric’ sheaths radially and slices longitudinally.
Different colors in the drawing and table are an aid to the eye for counting.

sheath (radial)	glass/sheath	# slices (long.)	total # of glasses
1	**1**	**3**	**3**
2	**8**	**3**	**24**
3	**16**	**3**	**48**
4	24	2	48
5	40	2	80
6	44	1	44
7	48	1	48
total			**75**+216



To cover as much volume as possible of the truncated cone, I staggered the glasses longitudinally (see next slide)

GLASS BUDGET
74+212

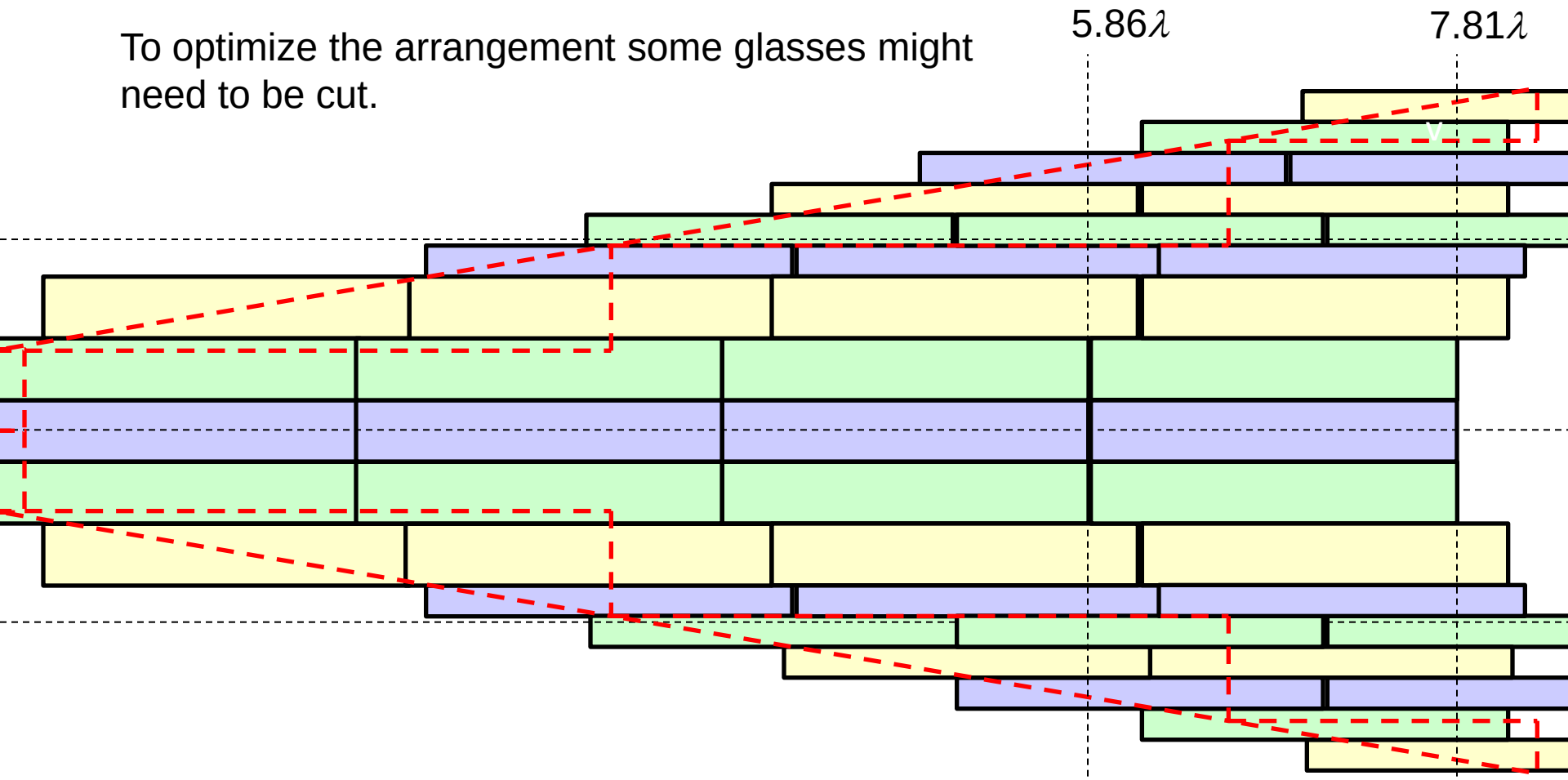
In three slices we cover about 6λ longitudinally and if we had all the glasses this could be done.

If 51 glasses are missing then we could only cover about 5λ

To optimize the arrangement some glasses might need to be cut.

GLASS BUDGET

74+212



Simulation

- A more definite proposal can be done on the basis of a detailed Geant simulation
- This can helps us choose what the best shape and dimensions, radial and longitudinal, are