Fragments in eIC

S.White 4/9/10

* Forward physics at colliders

  http://arxiv4.library.cornell.edu/abs/1003.4252

* measurement of fragments
* the machine

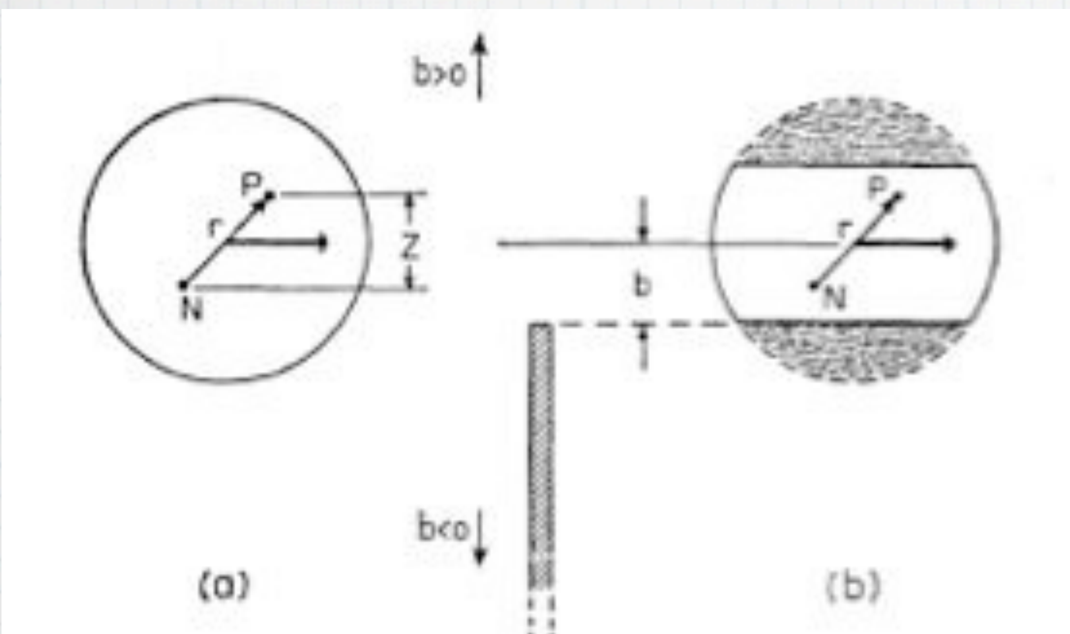
"Diffraction at eIC"

R. Glauber, 1955

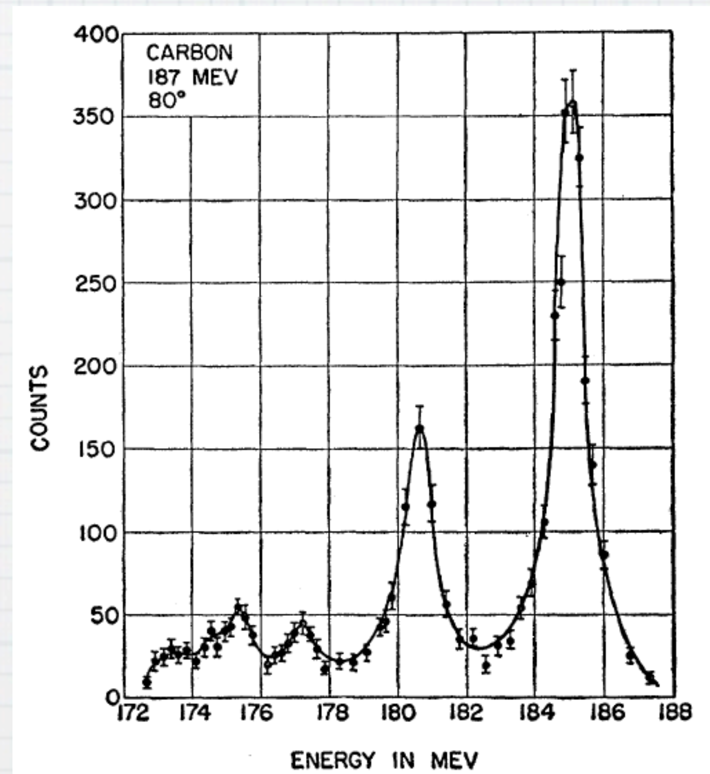
"free dissociation" of deuterons

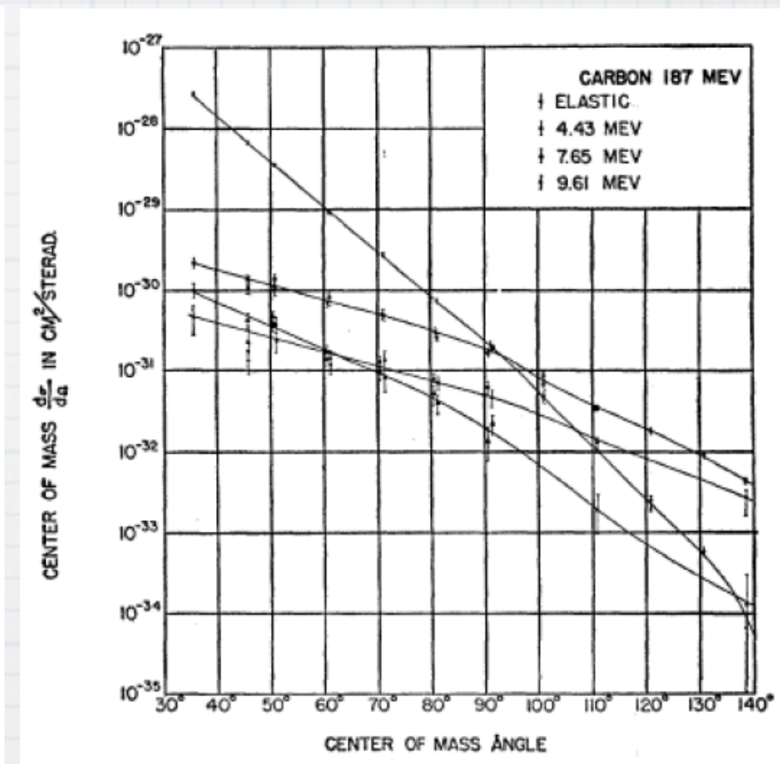
R. Hofstadter, 1953

the electron scattering method for nuclear or proton structure



first (and possibly only) calculation of diffraction dissociation





very precise measurements of e′ to insure coherence

Coherence tag is critical for several eIC measurements

analog to Hofstadter

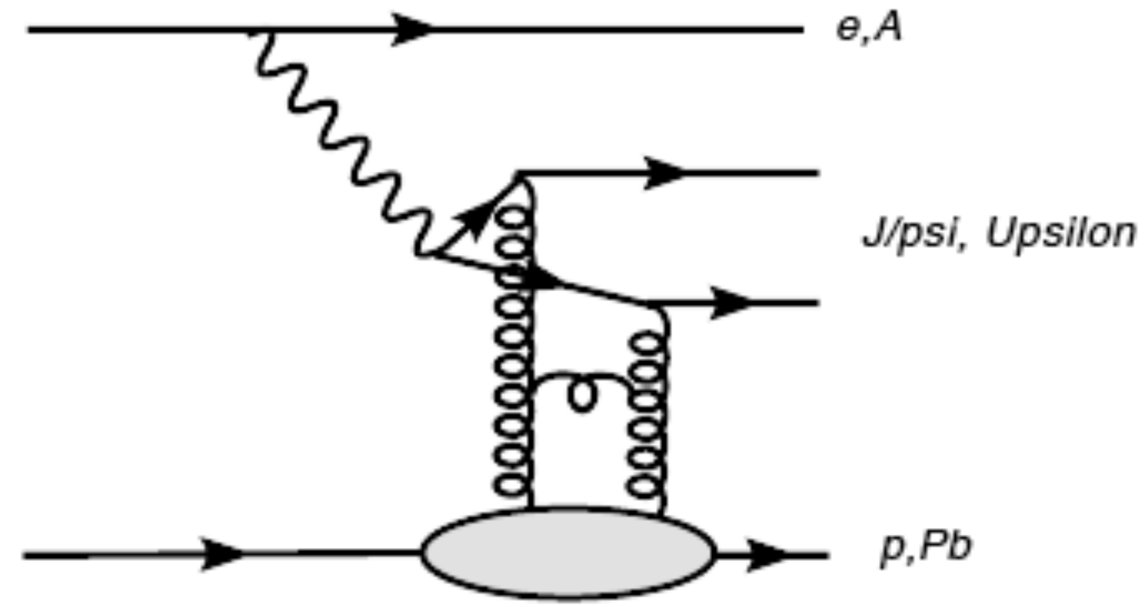


Figure 2: Diffractive Vector Meson production.

diffractive structure
in black disc regime

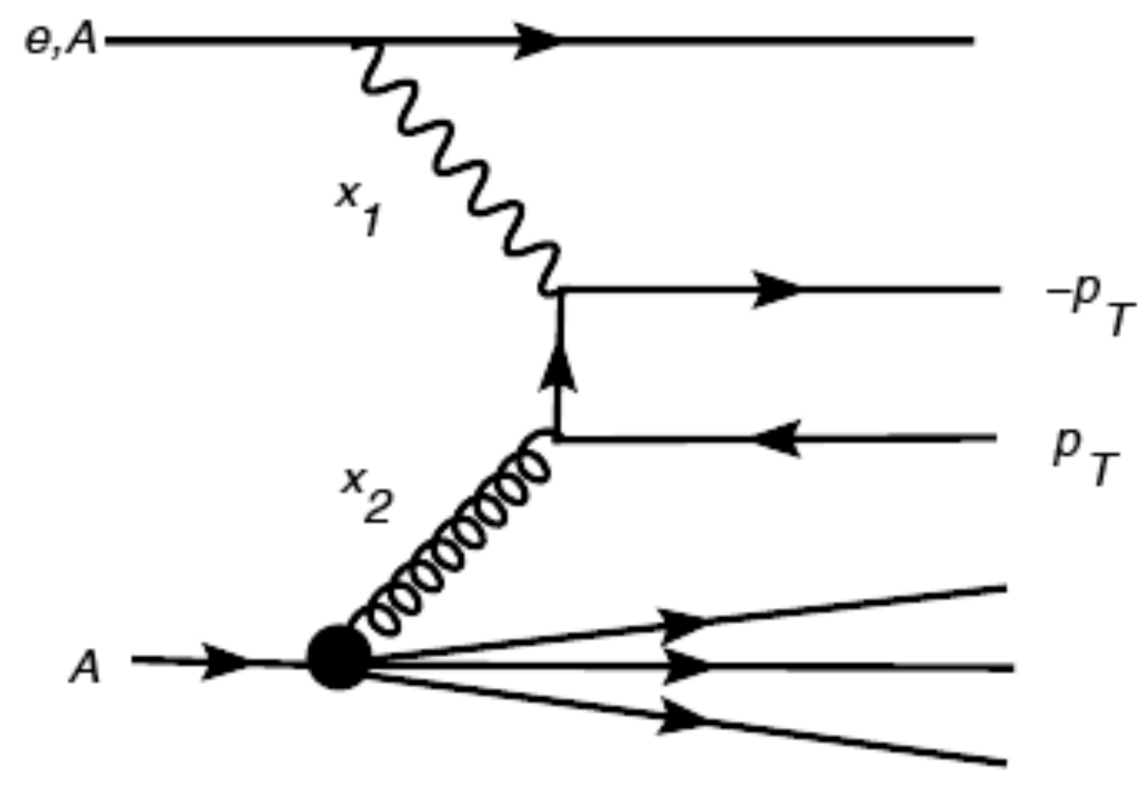
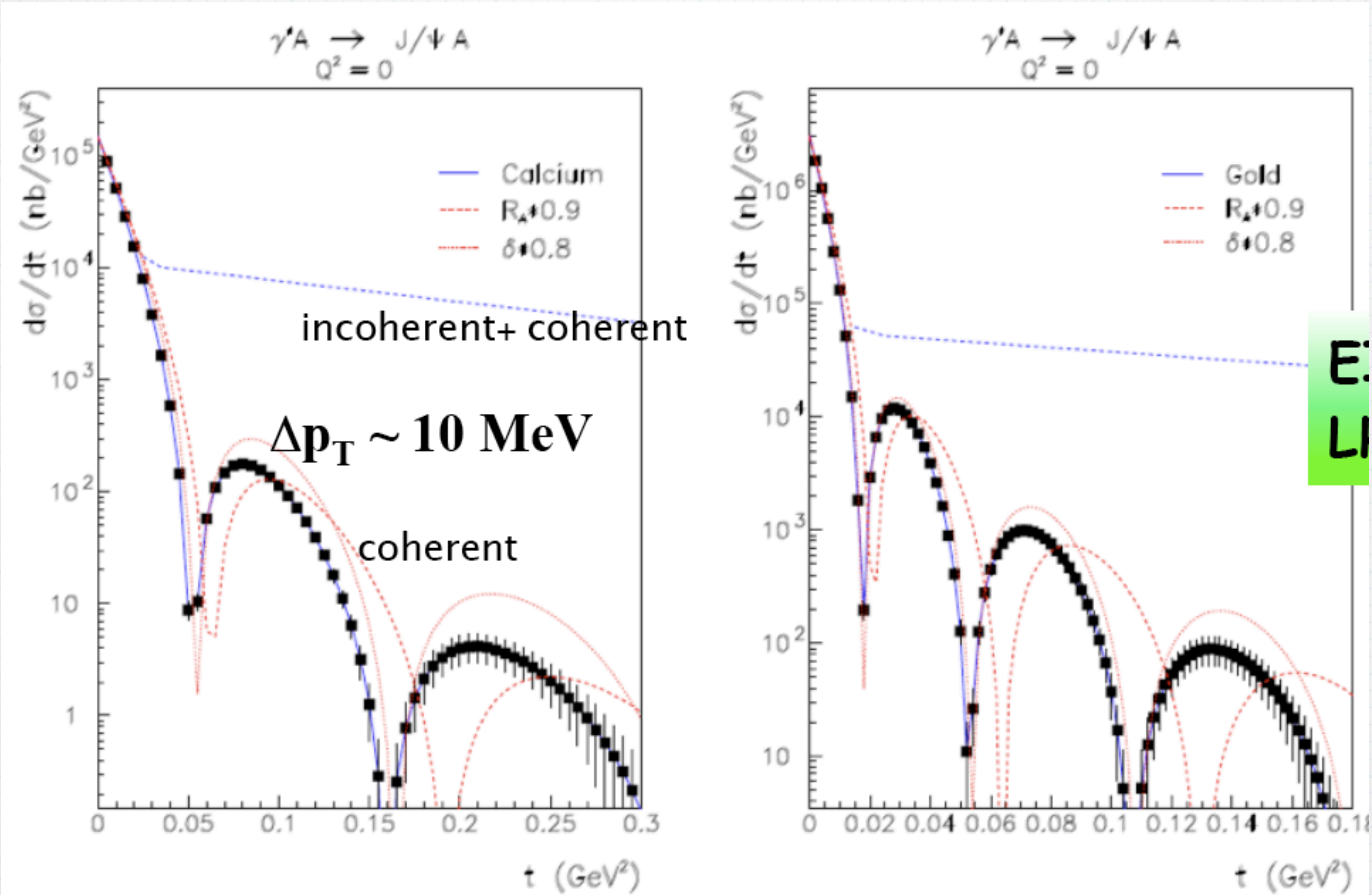


Figure 3: Hard jet photoproduction.

Incoherent is a non-negligible background



components of Fragmentation

* Gammas. Few MeV in nucleus frame->100-400 MeV in Lab. ~10 mrad in lab frame.
* neutrons. Several components to momentum distribution in HI. evaporation, Fermi step or Feshbach-Huang, tail due to SRC.
* protons, deuterons. None observed. Mostly due to Coulomb barrier suppression

Gammas: there are lots of them

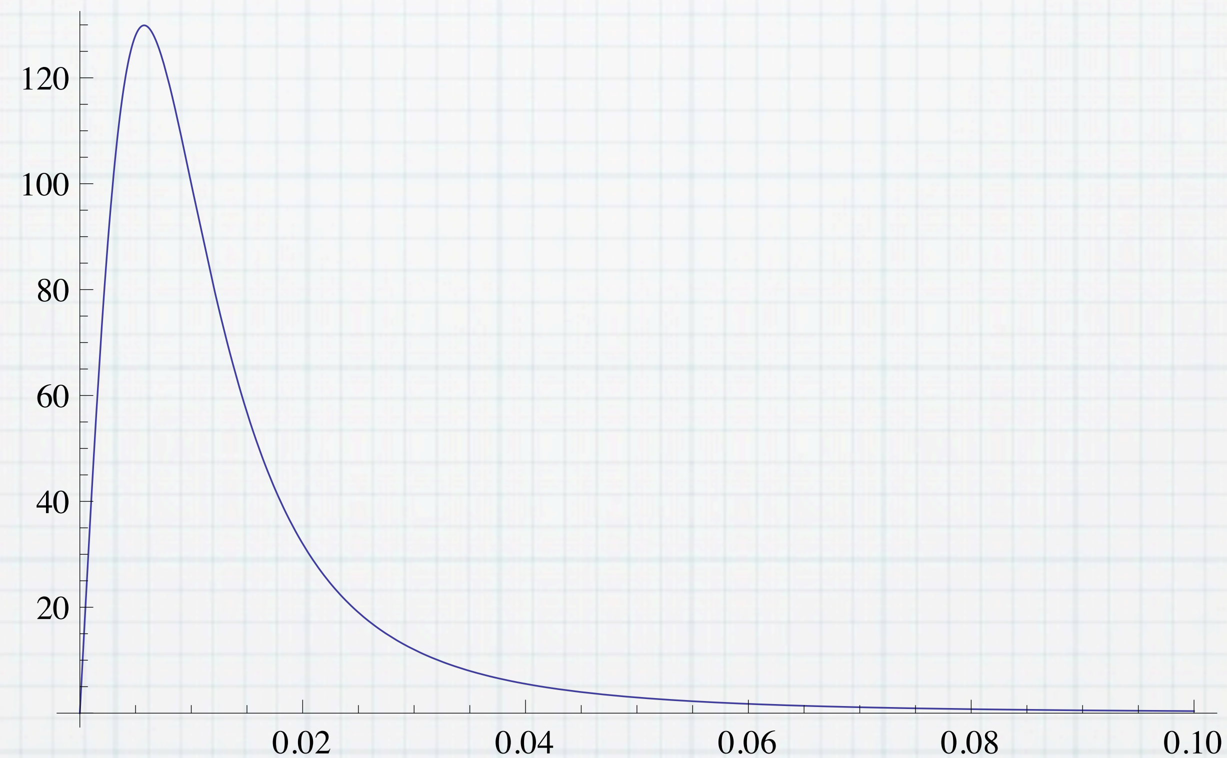
partial list for Aluminum

ENERGY LEVELS OF $A = 21–44$ NUCLEI (VII) 207

TABLE 27.4
Energy levels of ^{27}Al

E_x [keV]	$2J^\pi;2T$	τ_m	E_x [keV]	$2J^\pi;2T$	τ_m or Γ	E_x [keV]	$2J^\pi;2T$	τ_m or Γ
0	5^+	stable	7997 *1*	9		9600.7 *9*	3	12 *2* eV
843.76 *3*	1^+	50 *2* ps	8037 *1*	7	0.62 *5* fs	9599.2 *14*	3^-	2.5 *2* keV
1014.45 *3*	3^+	2.15 *10* ps	8043 *2*	$(5^+–9^+)$		9628.5 *9*	1^-	2.76 *14* keV
2211.1 *6*	7^+	38.4 *9* fs	8065 *2*	$(3, 5)^+$	$\hat{J} \times 29$ *8* as	9634.5 *9*	5^+	18 *5* eV
2734.9 *7*	5^+	12.9 *18* fs	8097 *1*	5		9658 *2*		
2982.00 *5*	3^+	5.7 *3* fs	8130 *3*	1^+		9664.7 *8*	5^+	24 *8* eV
3004.2 *8*	9^+	85 *5* fs	8136 *1*	5		9664.8 *20*	1^-	5.82 *10* keV
3680.4 *9*	1^+	7.8 *17* fs	8182.1 *13*	3^-		9692 *3*		
3956.8 *4*	3^+	3.6 *3* fs	8287 *1*	9^-		9715.9 *8*	3^+	
4054.6 *5*	1^-	10.6 *18* fs	8324 *1*	5^+		9742 *3*		
4410.2 *4*	5^+	1.7 *2* fs	8361 *3*			9762.8 *8*	5^+	18 eV
4510.3 *5*	11^+	320 *20* fs	8376 *1*	$(3, 5)^+$		9796.3 *9*	7^+	4 *3* eV
4580.0 *8*	7^+	7.7 *8* fs	8396 *1*	11		9821.6 *9*	3^+	18 eV
4811.6 *5*	5^+	2.2 *3* fs	8408 *3*			9834.4 *10*	1^-	3.0 keV
5155.6 *8*	3^-	3.3 *4* fs	8420.7 *10*	$(3, 5)^+$		9839.7 *10*	5	1.0 *2* eV
5248.0 *6*	5^+	< 6 fs	8442 *1*	7	0.72 *14* fs	9846.6 *10*	1^+	210 eV
5419.9 *9*	9^+	< 20 fs	8490.3 *12*	5^+		9867 *3*		
5432.8 *10*	7	10 *3* fs	8521 *2*	$(1–7^+)$		9883 *3*		
5438.4 *8*	5^-	8 *6* fs	8537 *1*	5		9893 *2*		
5499.8 *8*	11^+	< 10 fs	8553.0 *3*	3		9921.9 *9*	3^-	1.8 keV
5550.9 *5*	5	3.8 *7* fs	8586 *1*	7		9930.4 *9*	1^-	1.35 keV
5667.3 *12*	9^+	16 *4* fs	8597.6 *3*	3^-	0.56 *4* eV	9941.3 *9*	7	
5751.6 *10*	1^+	< 15 fs	8675 *1*	$(7, 9^+)$	$\hat{J} \times 18$ *5* as	9953.0 *16*		
5827.0 *8*	3^-	< 30 fs	8693 *2*	(9–13)		9955.5 *10*	3	
5960.3 *7*	7	2.4 *17* fs	8708.7 *3*	1^+	7.6 *6* eV	9960.3 *9*	5^-	8 eV
6080.8 *9*	3	4.8 *11* fs	8716.6 *6*			9962.8 *9*	5^+	12 eV
6115.8 *6*	5		8732.2 *5*	7^-	0.19 *3* eV	9976.8 *9*	$(5, 7)^+$	11 *2* $\hat{J}^{-1}$ eV
6158.4 *7*	3^-	< 20 fs	8753.6 *6*	5	1.05 *13* eV	9990.8 *9*	7^-	10 eV
6284.7 *15*	7^+	7 *3* fs	8774.2 *6*	5^+	3.7 *3* eV	9999.9 *10*	5	
6462.8 *13*	5	1.12 *12* fs	8804 *1*			10008 *3*		
6477.3 *9*	7^-	2.6 *4* fs	8825 *3*			10024.3 *9*	5^+	35 eV
6512.2 *11*	9	14 *3* fs	8861 *3*			10075 *3*		

Gammas: angular distribution in the lab

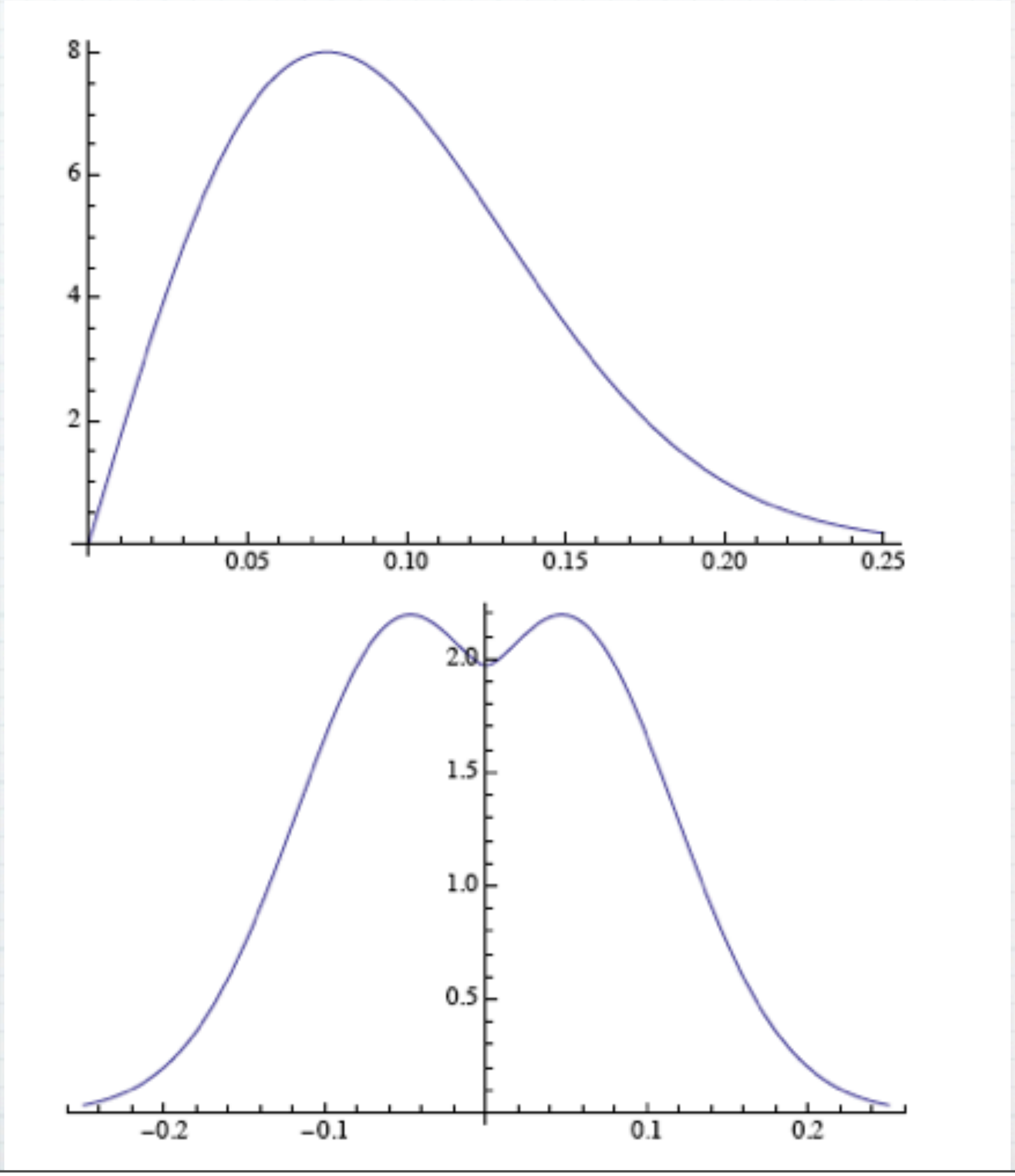


Neutrons.

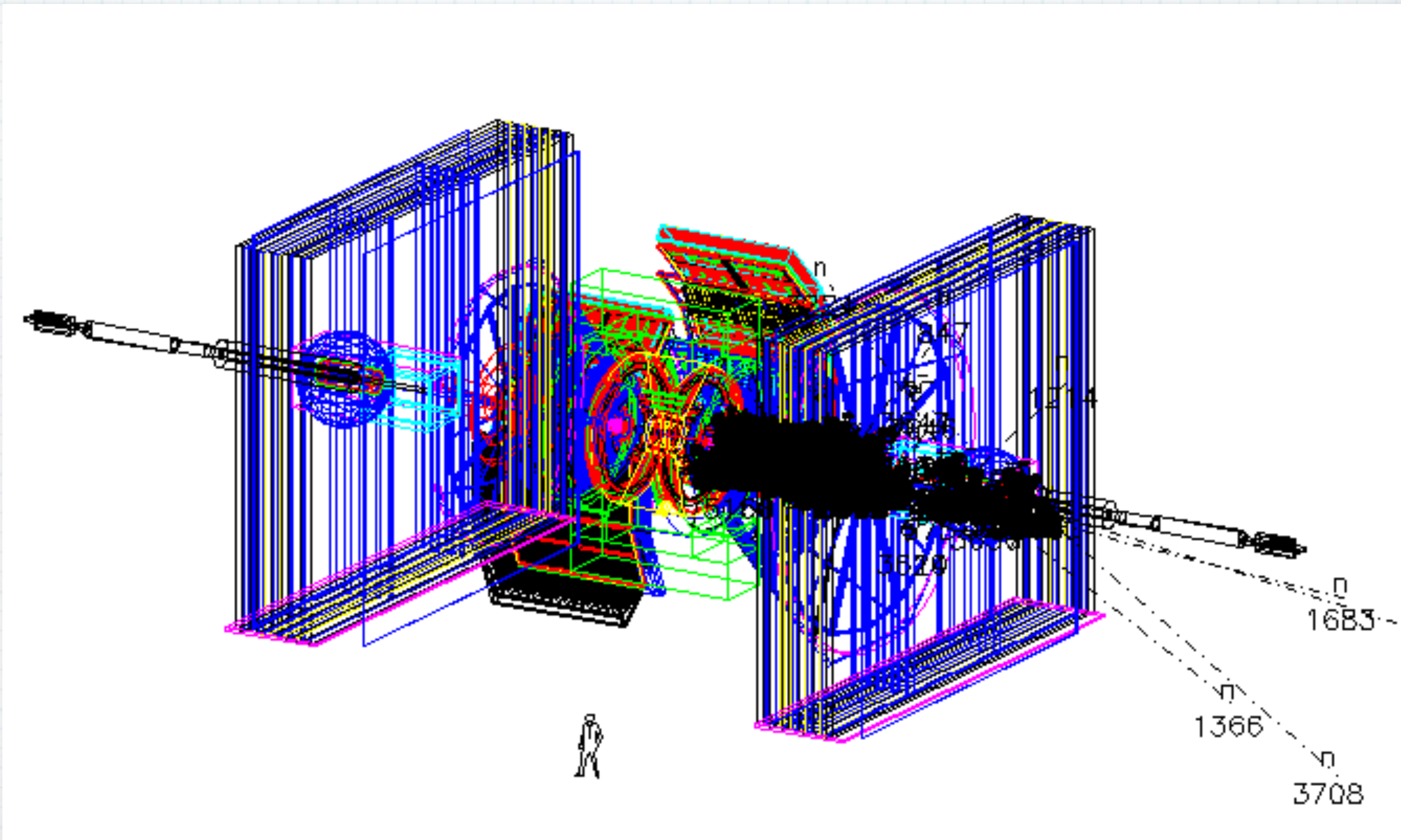
Evaporation component critical for diffraction in eA

pT(Mev)

pT(x projection)

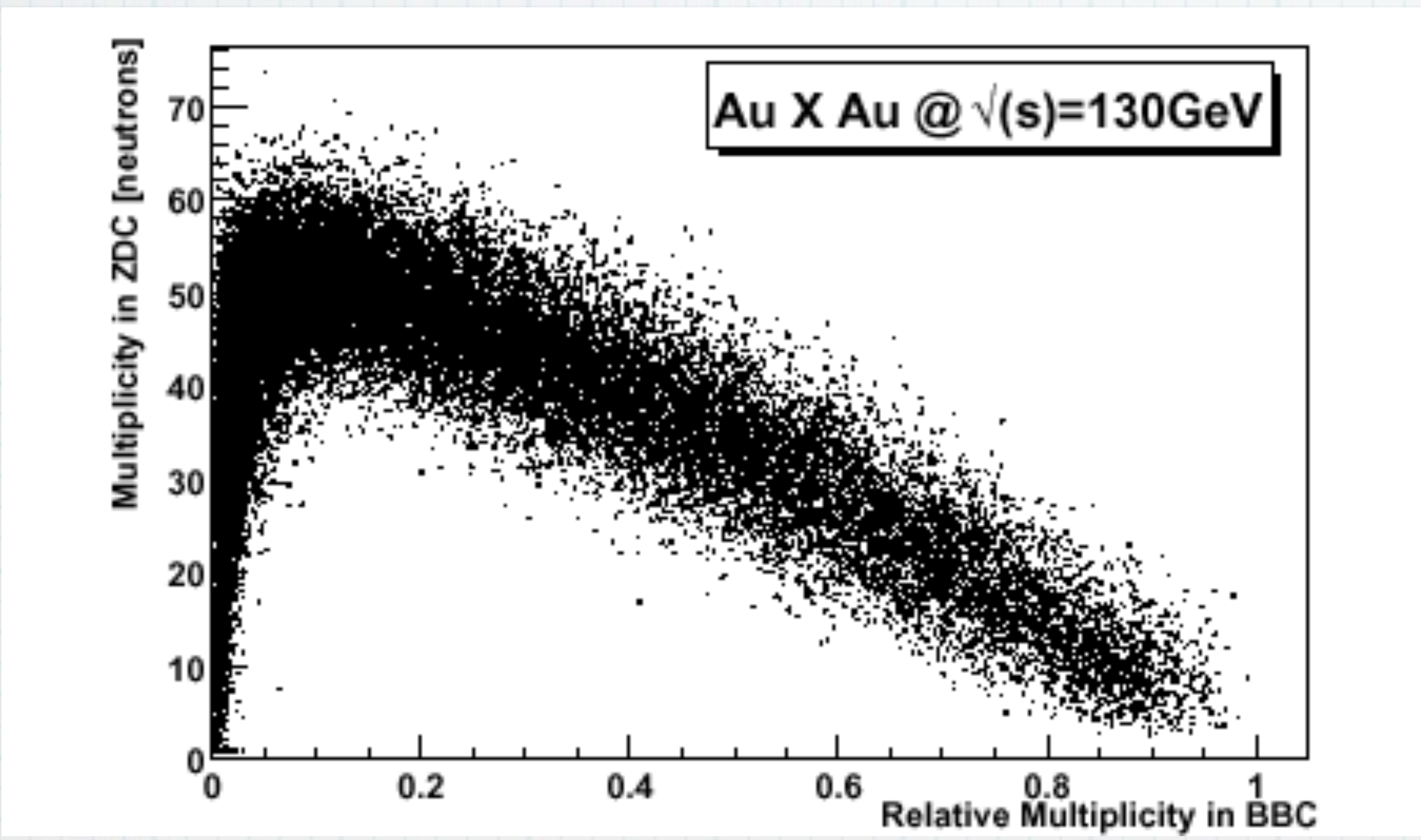


comprehensive treatment in HIJING:
SNW, Mark Strikman, Tamas Csorgo, Massi Alvioli, Marton Vargyas



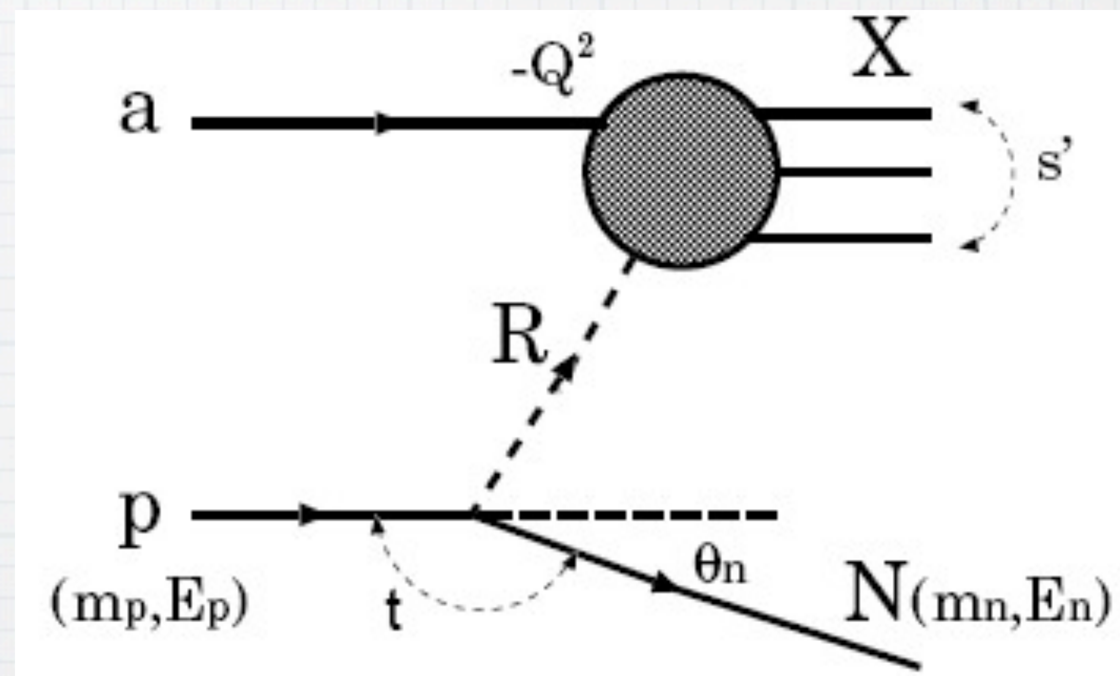
Leading neutrons basis of much physics in PHENIX and ATLAS

in Heavy nuclei



BBC similar to MBTS
multiplicity anticorrelated to ZDC energy

in pp



usually, ie RAPGAP, R= pi+

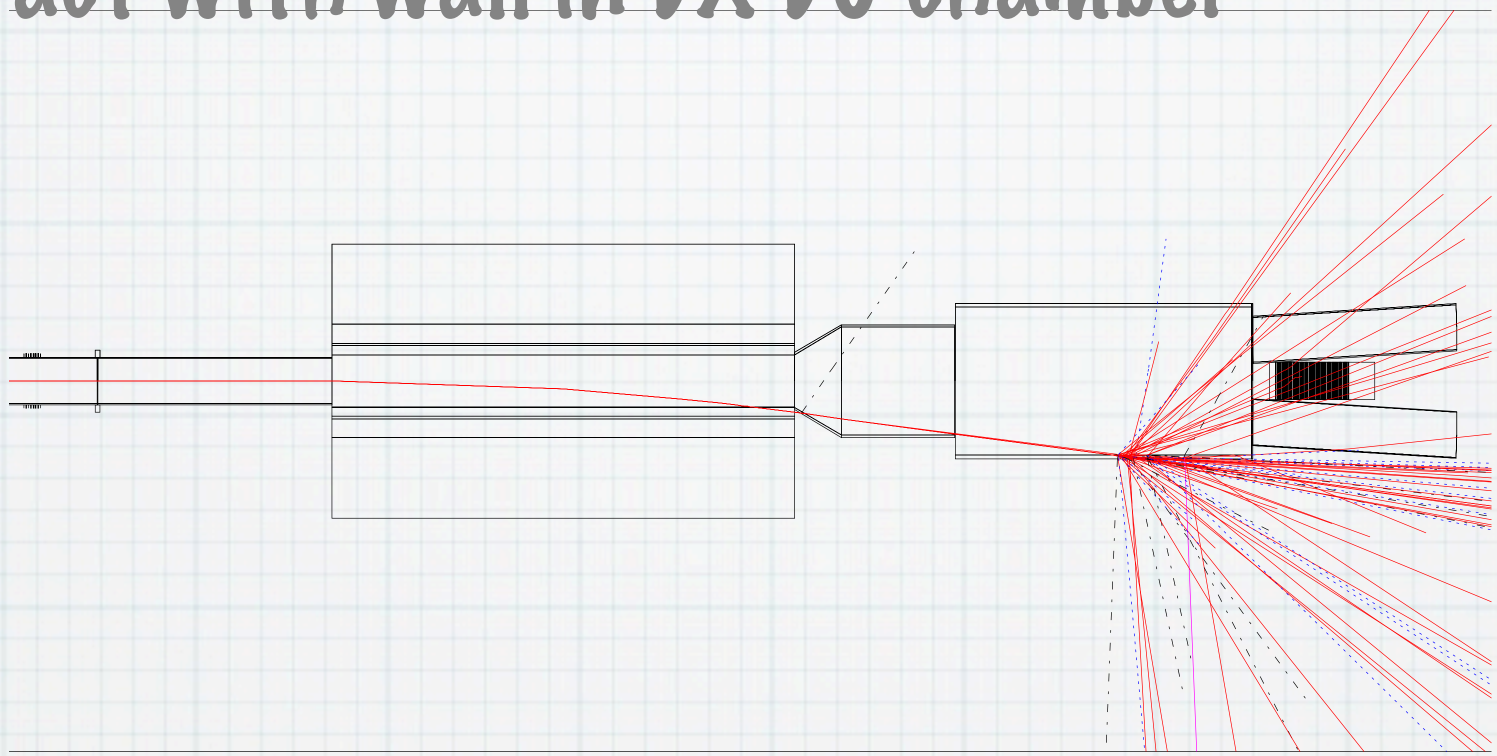
Roman Pots

* used in HEP to measure protons at very small angles and when $1-x<0.05$
* they are useless at an electron nucleus collider

- nuclei don't evaporate protons (Coulomb barrier)
- protons differ in magnetic rigidity by a factor of 2.5(A/Z) from the beam
    - they don't get into the beamline
    - the dispersion in a realistic accelerator beamline kills them
- places where they could be inserted they blow up the rf impedence
- roman pot sensors are far too sensitive for a nuclear beam environment

trajectory of final state protons at RHIC

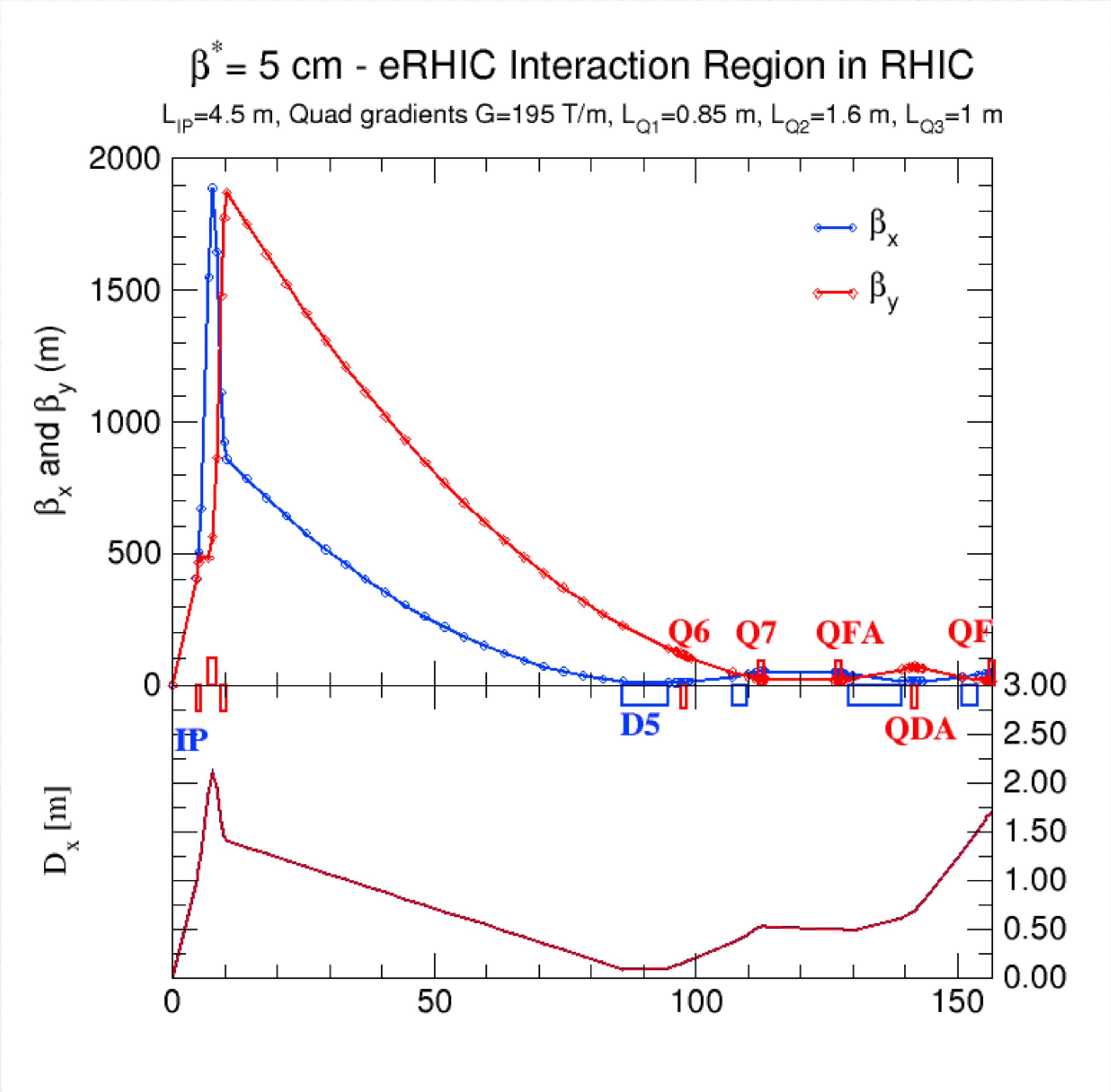
- a fraction interacts with wall in DX magnet
- the rest interact with wall in DX-D0 chamber



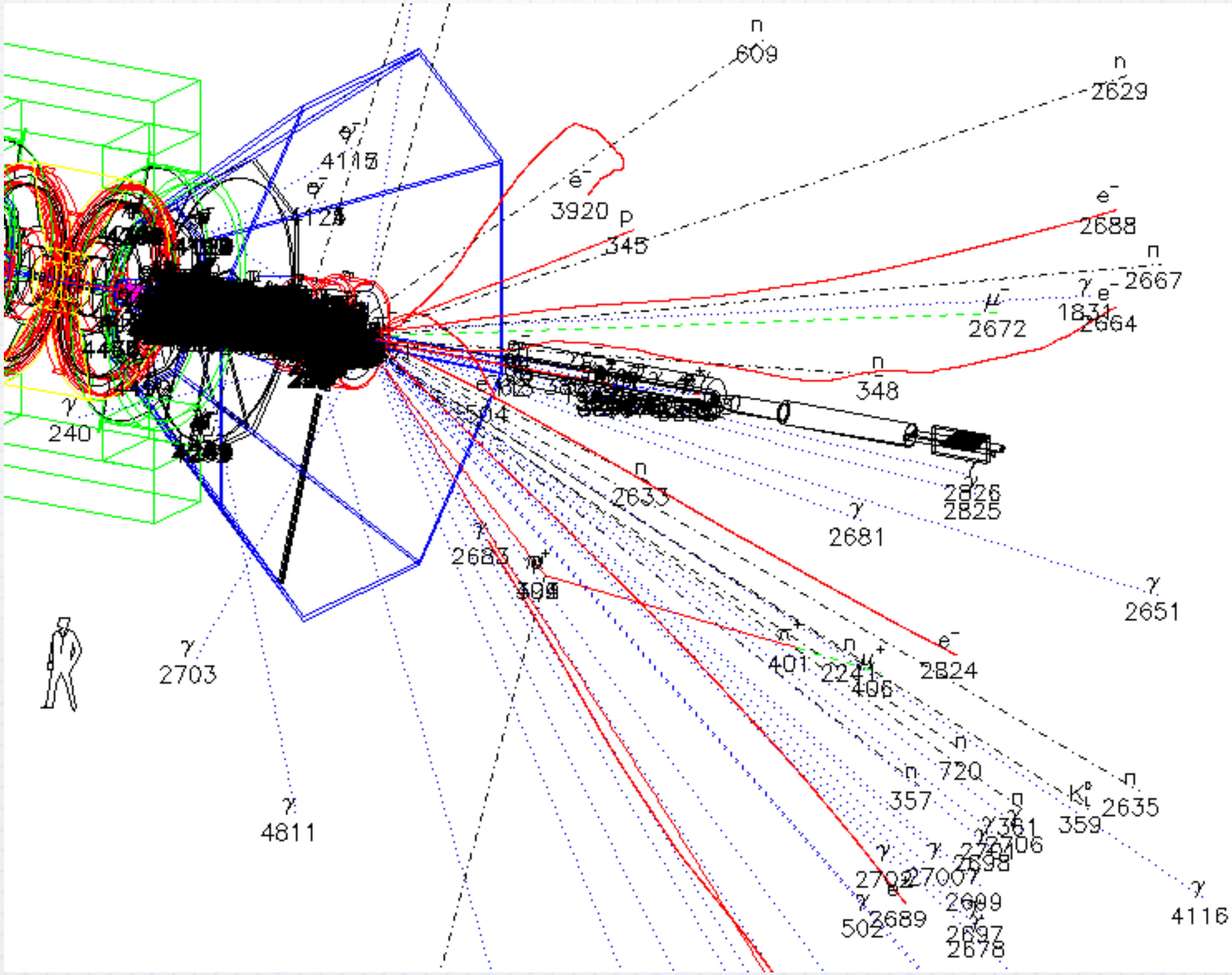
this location has highest rf impedence at RHIC (~rf cavity)

impedence minimized by lining it with rf screens

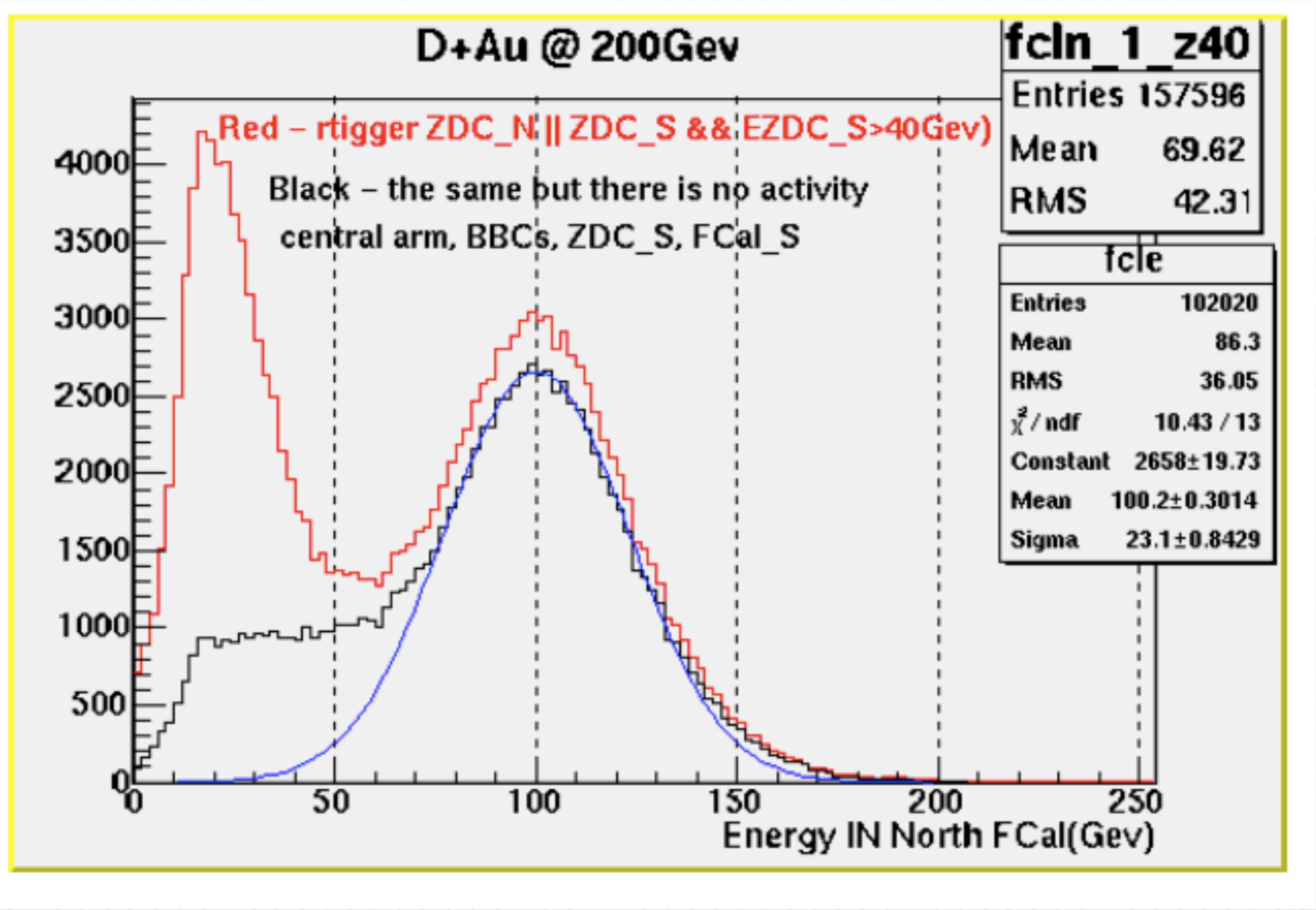
- typical RHIC dispersion function exceeds 0.5 meters (not sure which lattice this one is)
- even a 2.5(A/Z)*0.5m radius aperture would be a very expensive accelerator



if you look for hit in a silicon detector in forward direction you usually find one at an ion collider



for some physics it would be useful to measure protons- particularly with large xF coverage.
PHENIX did this successfully with a hadron calorimeter



magnet elements around ip determine possible measurements
this shows RHIC geometry which is a good one for fragment measurement

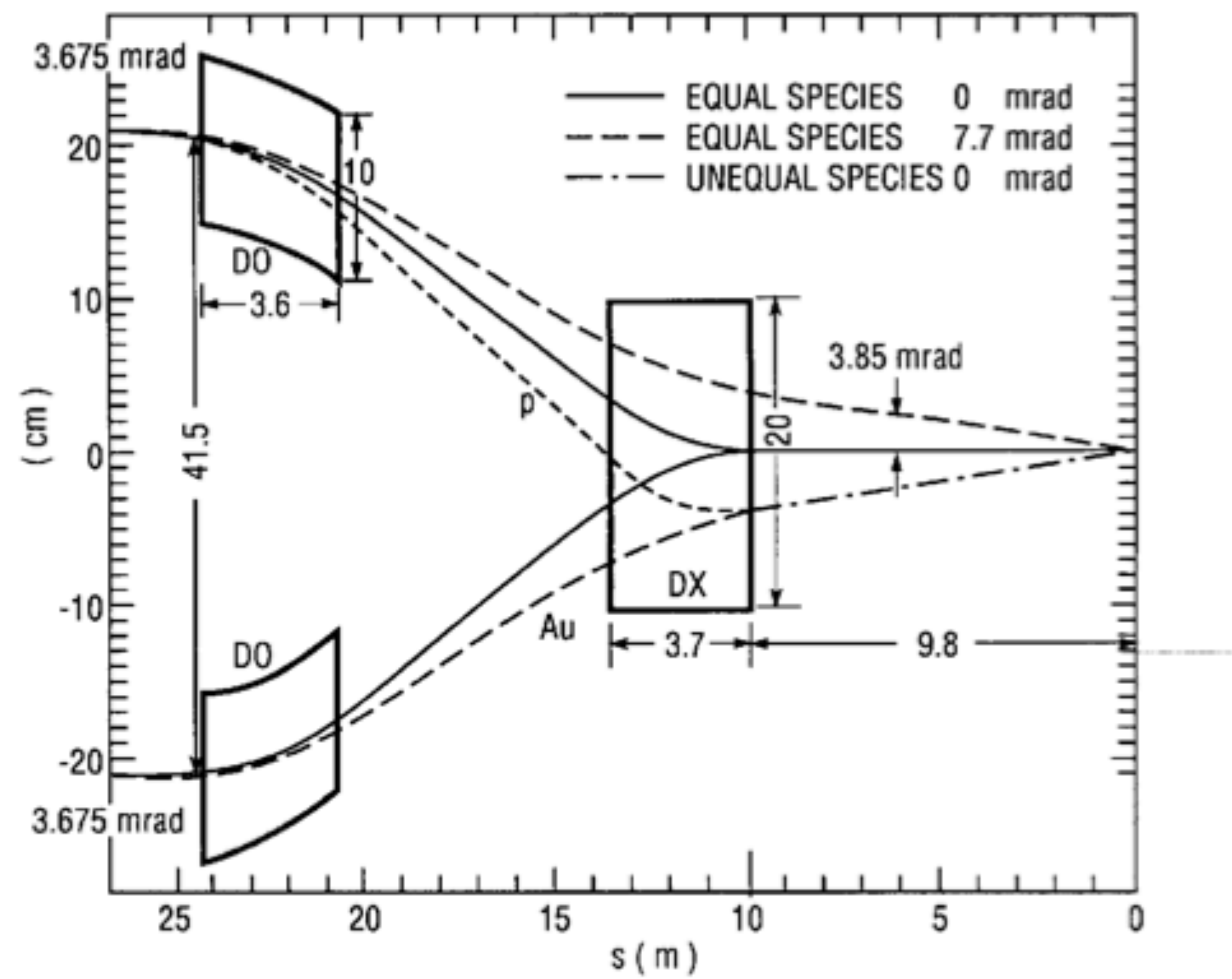
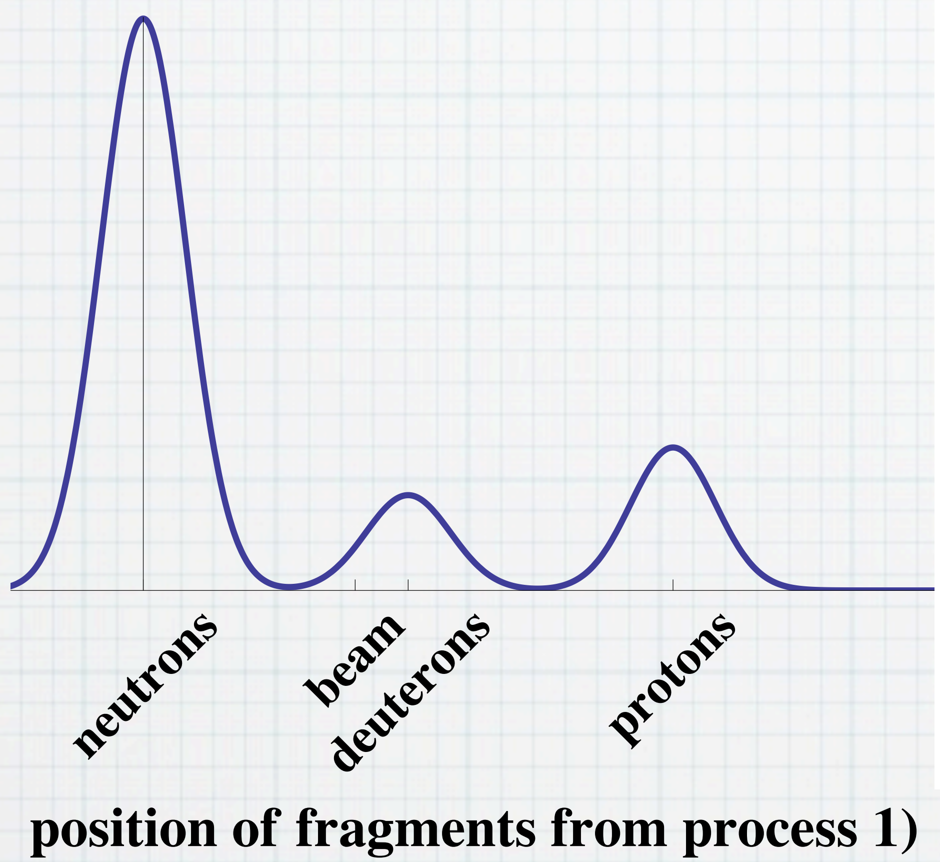
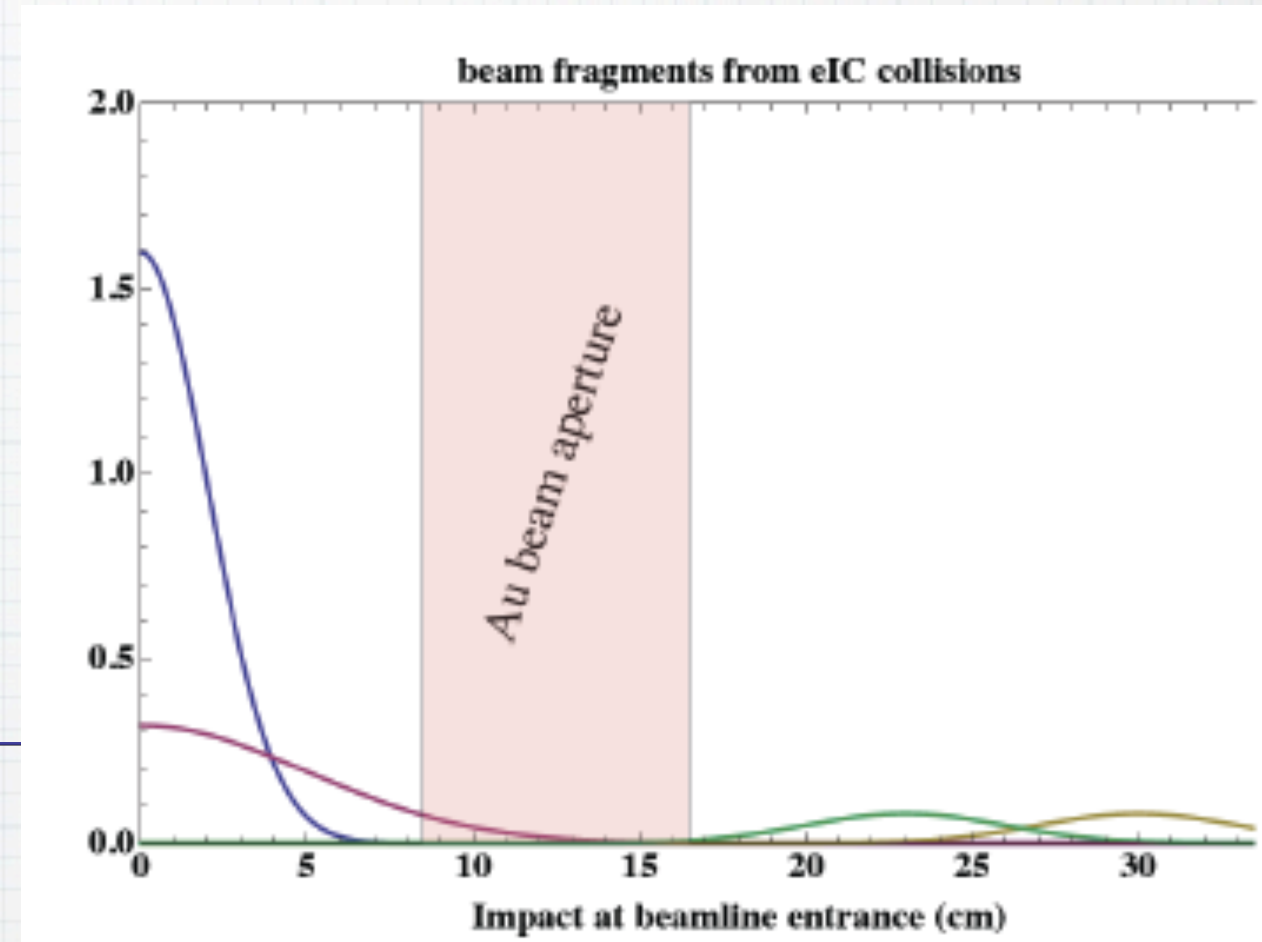


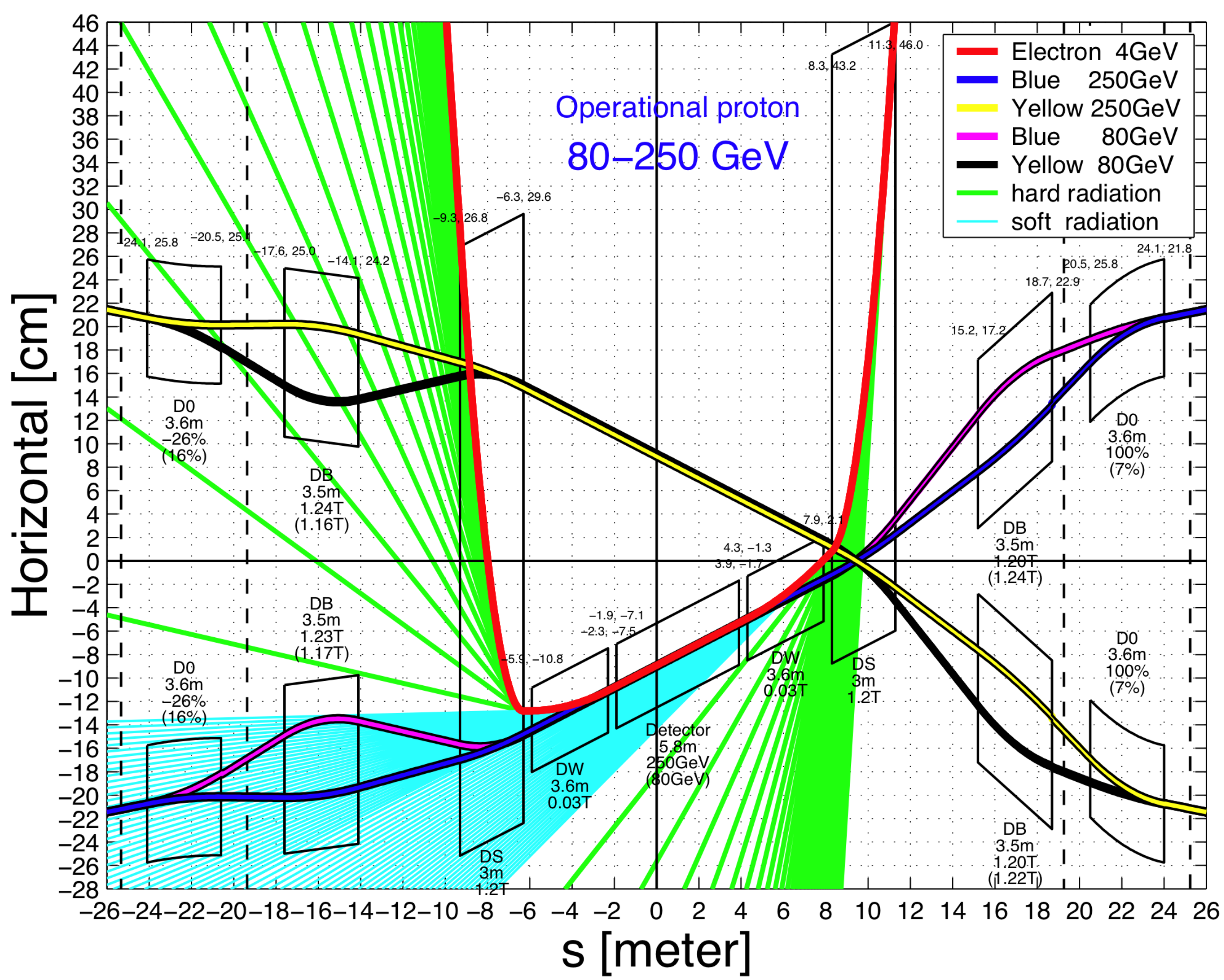
Fig. 11-7. Beam crossing geometry (magnetic lengths are shown).

```
Energy[i_, x_] := PDF[NormalDistribution[Pos[[i]] * 20, .05 * 20], x]
Etot[x_] := Energy[1, x] * Mult[[1]] +
  Energy[2, x] * Mult[[2]] + Energy[3, x] * Mult[[3]] + Energy[4, x] * Mult[[4]]
Plot[Etot[x], {x, -5, 30}, PlotStyle → Thick, PlotRange → {{-5, 30}, {0, 3}},
 Frame → {True, False, False, False}, Ticks → { Automatic, None},
 FrameTicks → {{All, None}, {Mynames[45], None}},
 FrameLabel → {Style["position of fragments from process 1)", 18],
   Style["", 18], Style["Energy Distribution at 4*10^9", 18]},
 LabelStyle → Directive[Black, Bold, FontSize → 18]]

{12, 0, 2, 3}

{0, 0.4, 0.5, 1.}
```





this geometry almost eliminates fragment measurement since bending power =*4 less



Summary

* there is a lot of interesting physics with fragments
* we shouldn't squander it