Using CEBAF as a positron machine

Yves Roblin

JPOS17
Newport News
Sept 12-15, 2017

OUTLINE

- Machine layout
- Various options
- Limiting parameters of the lattice
- Electron injection and transport
- Linac optics
- Spreader modifications
- Positron generation, collection and dump system
- Conclusion

Transverse Emittance* and Energy Spread†

Area	δp/p [x10^{-3}]	ε_x [nm]	ε_y [nm]
Chicane	0.5	4.00	4.00
Arc 1	0.05	0.41	0.41
Arc 2	0.03	0.26	0.23
Arc 3	0.035	0.22	0.21
Arc 4	0.044	0.21	0.24
Arc 5	0.060	0.33	0.25
Arc 6	0.090	0.58	0.31
Arc 7	0.104	0.79	0.44
Arc 8	0.133	1.21	0.57
Arc 9	0.167	2.09	0.64
Arc 10	0.194	2.97	0.95
Hall D	0.18	2.70	1.03

12GeV config

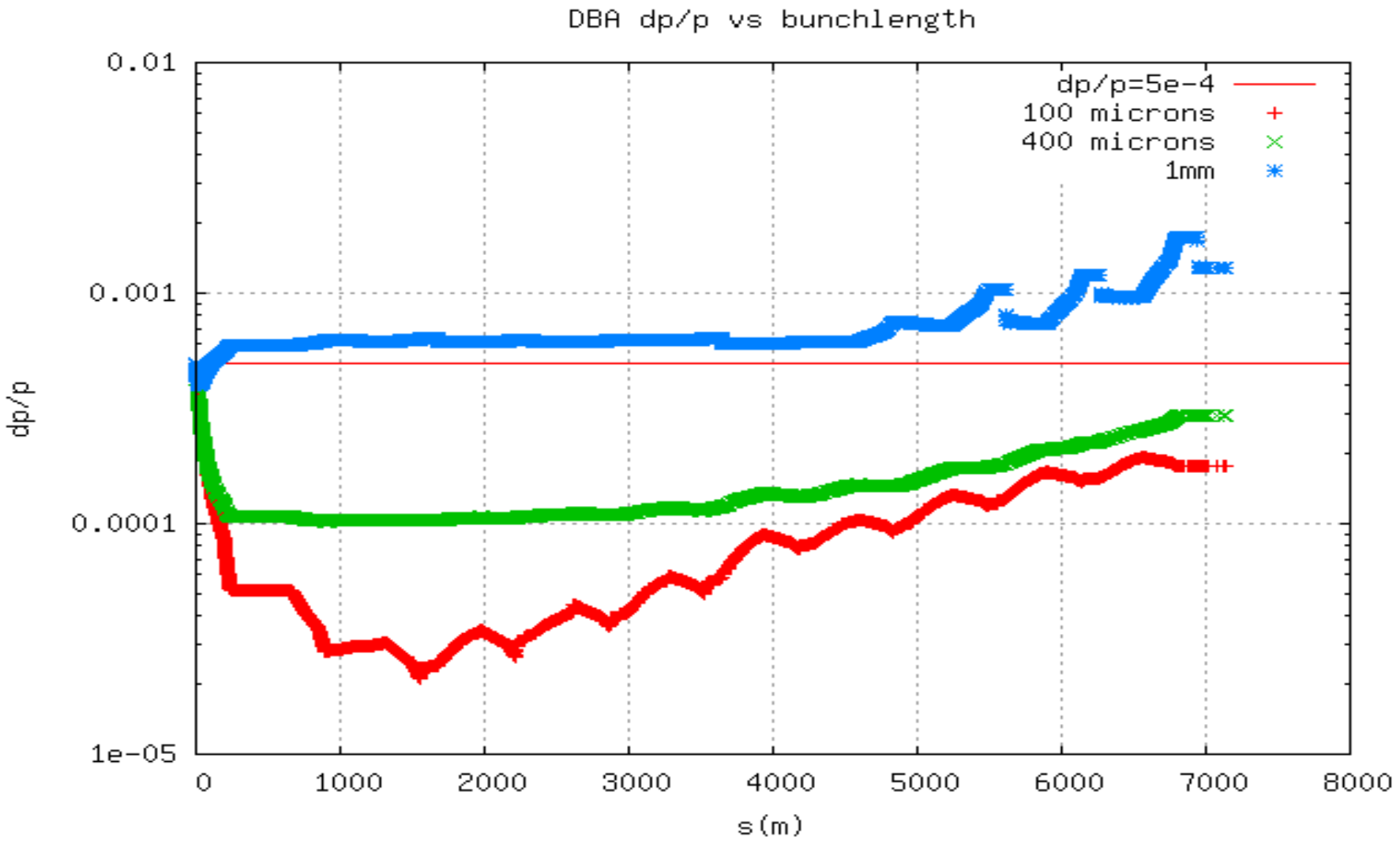
Damping

e- beam is dominated by synch. rad at 12GeV

Sync. Rad.

*** Emittances are geometric**
† Quantities are rms

Bunchlength and energy spread

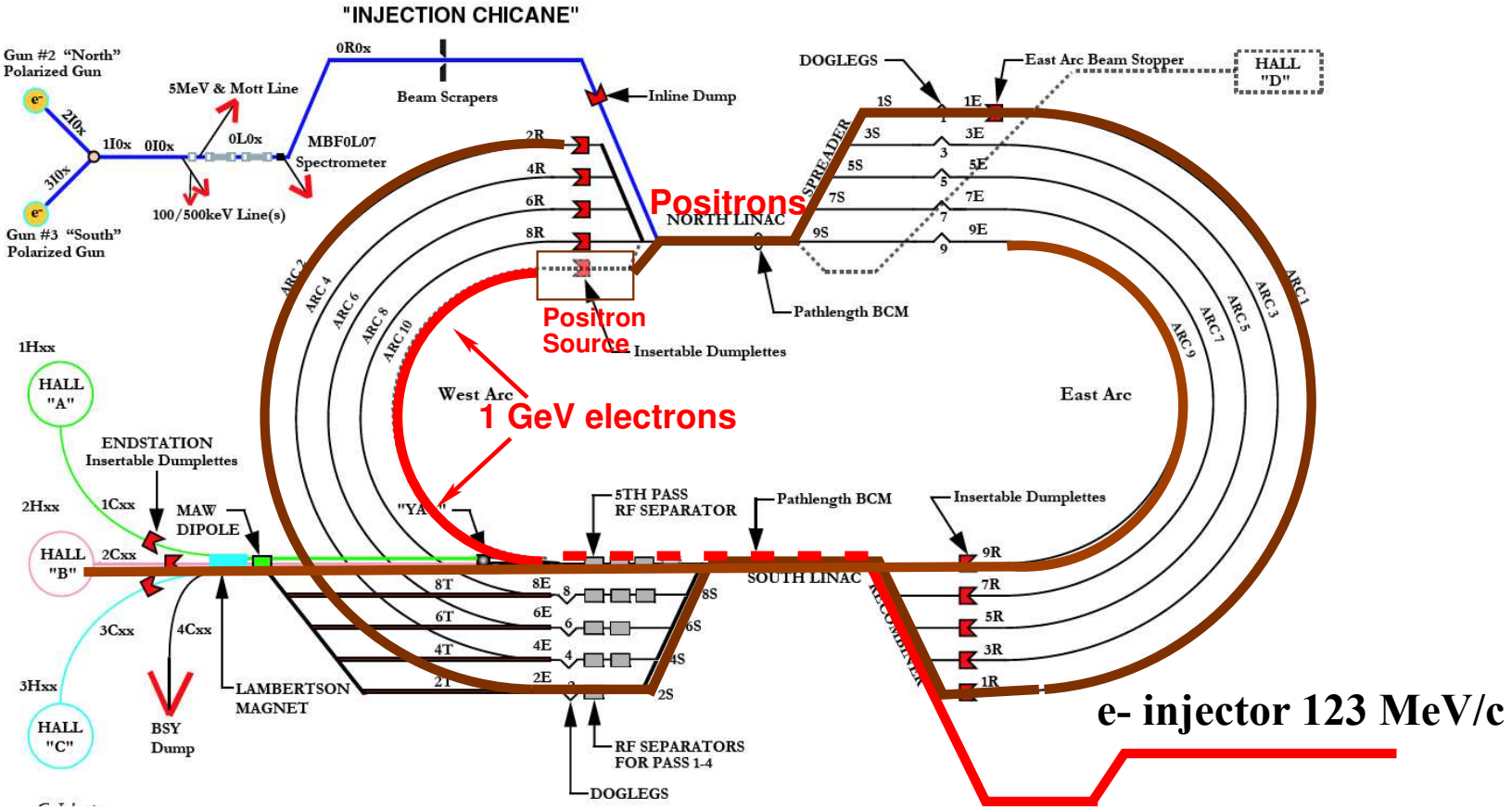


Various options

- **Several ideas have been proposed.**

- **Generate 6.3 MeV e+ in injector area, use existing injector to accelerate**
- **Generate 63 MeV e+ in injector, accelerate with last C100 cavity to 123 MeV/c**
- **Generate 100 MeV e+, use a separate injector cave and beamline**
- **Use an accumulator ring to increase e+ current**
- **Generate 123 MeV e+, using 1GeV/c e- beam**

Machine Layout for 1GeV option



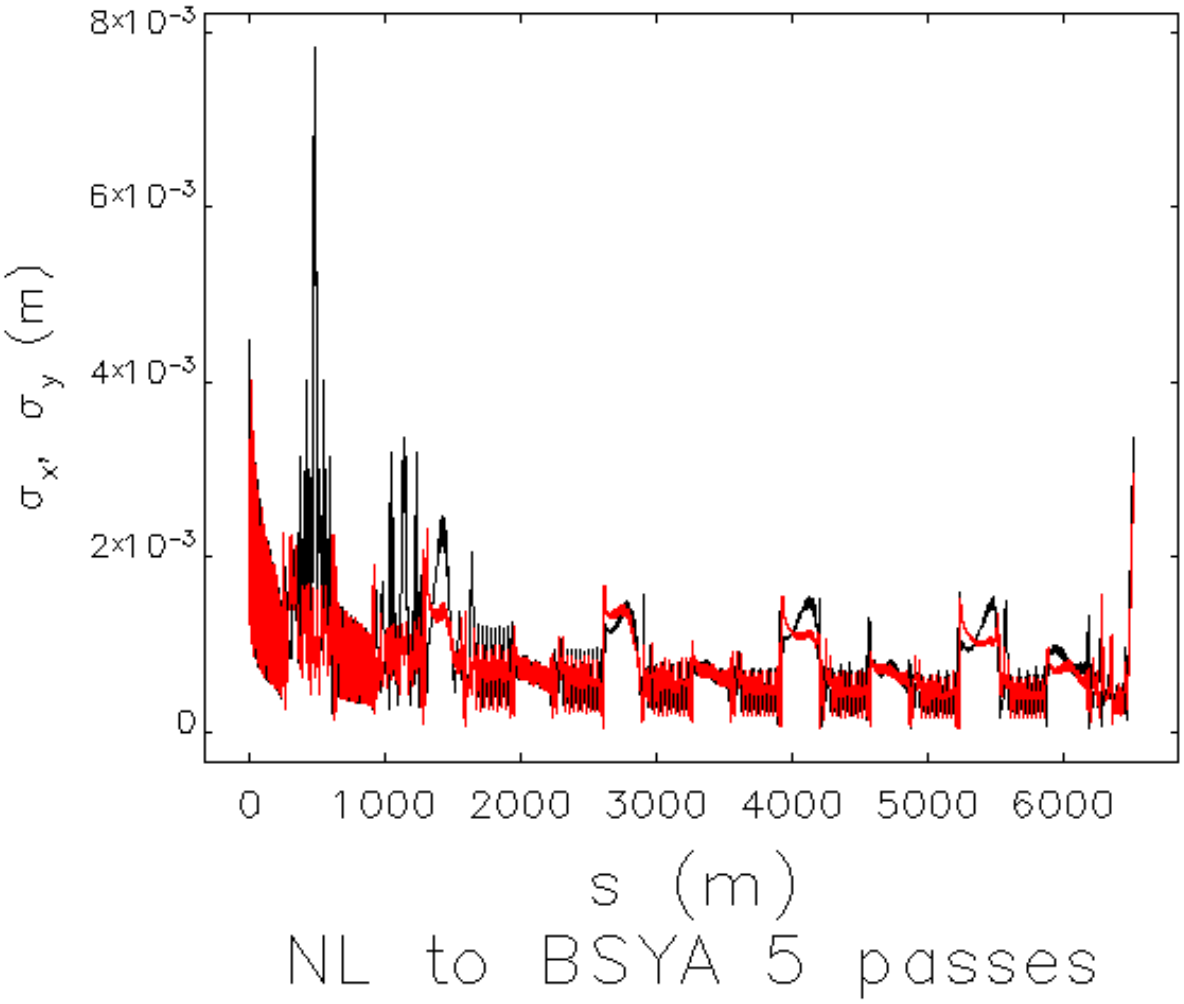
Limiting parameters for the e+ transport

- Lattice acceptance (admittance) is proportional to $\frac{d^2}{\beta}$ (beam pipe radius and lattice beta function)
- Extracting the beam at 5 pass (BSYA) limits the beam to about 600 μm . (6 mm clearance at YA). We know from experience that we lose beam if it is much bigger. This is for $\beta = 40m$ if perfectly matched.
- Longitudinal acceptance limits the energy spread to about 3E-3 in the front of ARC1. Chromatic effects further limit it to about 2e-3 (E03 extraction region)
- Bunchlength of generated e+ affects the energy spread . Will also cause problems in linac transport if more than a few hundreds of microns.

Limiting parameters for e+ (cont)

- We need to select the e+ to be within +/- 2 MeV around 123 MeV/c (2e-3 at 1213 MeV/c)
- We need to collimate/collect e+ within acceptance at the start of the NL at 123 MeV/c:
  - —$\varepsilon = 126e - 9$ m.rad in front of ARC1 yields 1mm at MYAAT01 (Arne's 2009 value)
  - —$\varepsilon = 50e - 9$ m.rad in front of ARC1 yields 0.6mm at MYAAT01. ➔ this implies 0.5mm.mrad in front of NL

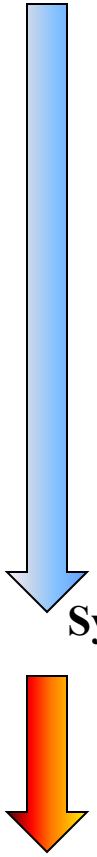
Beam sizes from NL to BSYA



Transverse Emittance* and Energy Spread†

Area	$\delta p/p$ [$x10^{-3}$]	ε_x [nm]	ε_y [nm]
Chicane	10	500	500
Arc 1	1	50	50
Arc 2	0.53	26.8	26.6
Arc 3	0.36	19	18.6
Arc 4	0.27	14.5	13.8
Arc 5	0.22	12	11.2
Arc 6	0.19	10	9.5
Arc 7	0.17	8.9	8.35
Arc 8	0.16	8.36	7.38
Arc 9	0.16	8.4	6.8
MYAAT01	0.18	9.13	6.19

Positrons



Damping

Sync. Rad.

*** Emittances are geometric**

† Quantities are rms

Electron injection

- Need a new injector located at the front of the SL. (there is an alcove there where it could be installed)
- Has to produce 123 MeV/c e- with 1 mA
- Has to inject into the SL. Straight ahead or chicane?

South Linac Optics

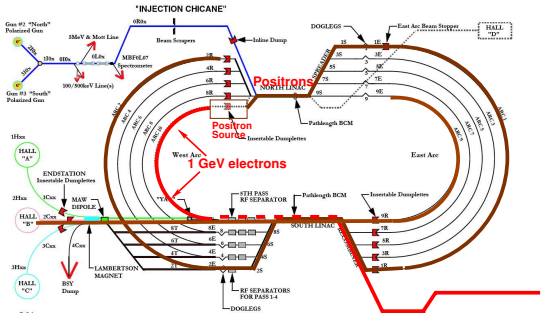
- **Linac lattice usually set to be a 120 Degrees FODO. The e- beam would be severely off-momentum.**

- **Need for an alternate south linac optics which allows for both the e- (from 123→ 1213 MeV) and e+ (from 1213 to 2303 MeV) to be transported.**

- **This is a limiting factor regarding the emittance that the incoming e+ beam can have and still transport, as well as the ability to keep the e- beam focused enough to get to the SW spreader modified magnet (more on this later)**

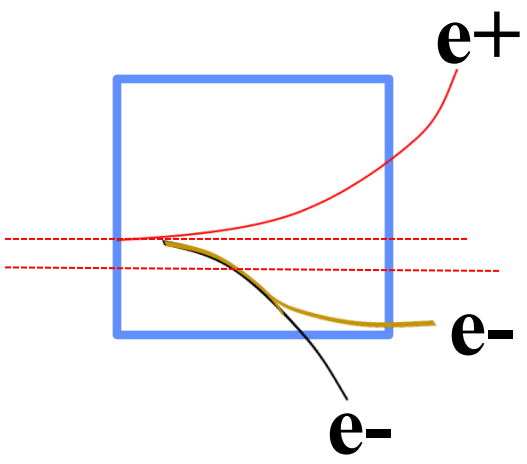
SW BCOM modifications

- **Concept:**
  Reverse polarity of the SW spreader in order for e+ to be transported correctly.
- **Consequence:**
  Incoming 1.2GeV/c e- beam will be bend downwards in the BCOM.



- **Remedies:**
  - —**Dig into the concrete floor and create a transport line to capture the e- and feed it into ARC 10. OR**
  - — **Modify the BCOM and raise it by an inch (M.Tiefenback, J. Benesch suggestions). This might avoid having to do civil engineering.**

BCOM modifications



e+ goes to 2S (+18.6 degs)

Modifying the pole shape for the BCOM Would allow for controlling the downward bend of the e- beam

e- (1.2GeV/c) bends down

Another dipole pair needed to complete the spreader and inject into MXAAS05 Dispersion correction probably not needed

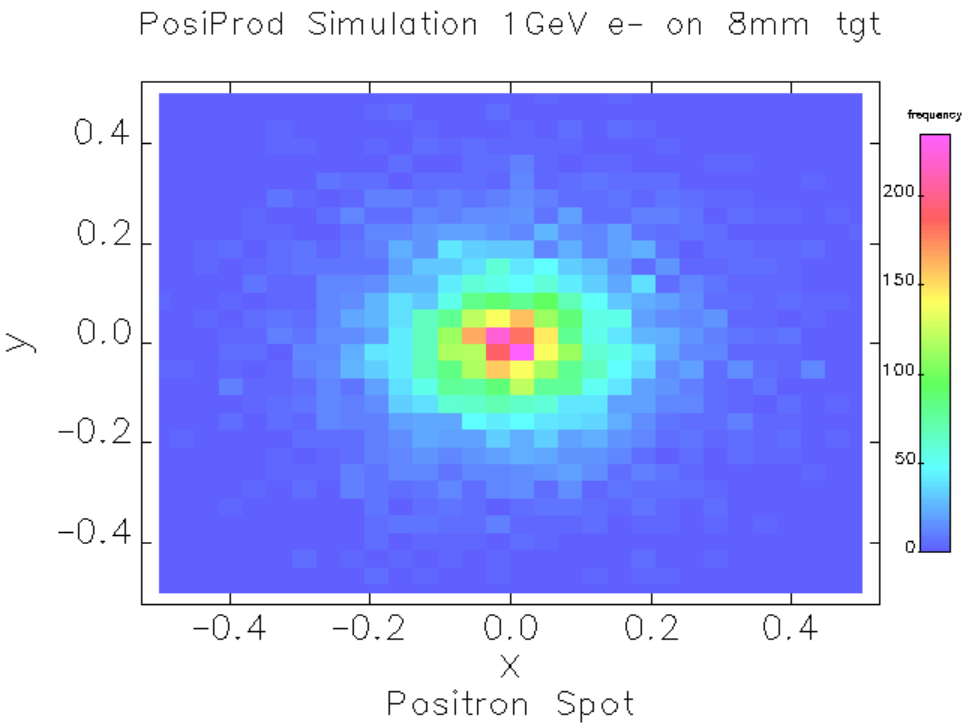
Shunt and power requirements for ARC10

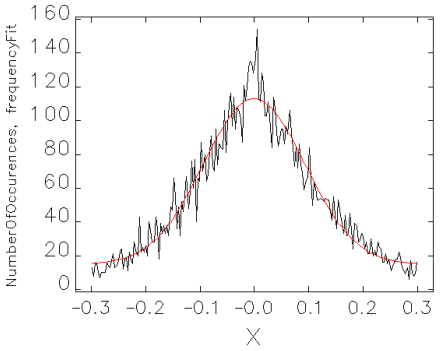
- **ARC10 will be configured to transport 1.213 GeV/c e- beam instead of 11023 GeV/c e- beam.**
- **Consequently, the power supplies will have to be modified to allow for regulating in this regime or an alternate one used.**
- **MXXAS05 connected to MARC8, MZAAS04 to RSEP8A. We need to consider that when designing the e- transport (since RSEP8A and MARC8 have to be set for e+ energy).**

Magnet polarity reversal

- With the exception of ARC10, every magnet needs to have its leads reversed in order to transport the e+.
- Machine setup:
  - —Configure the machine for 5 pass running, including the special south linac optics using e-
  - —Stop beam delivery, reverse magnet polarities
  - —Quadrupole leads also need to be reversed (instead of reversing setpoints in order to cancel systematic offsets).
  - —Using SLM's and viewers adjust steering with e+

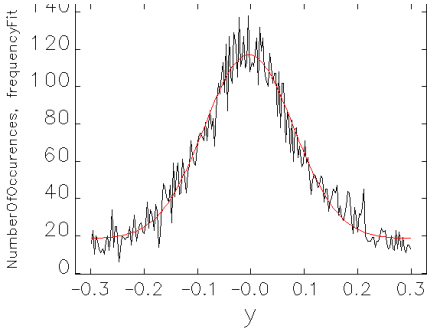
Positron production with 1GeV e- beam





$\sigma_x = 9.29e-2$

$\sigma_{x'} = 5.56e-2$



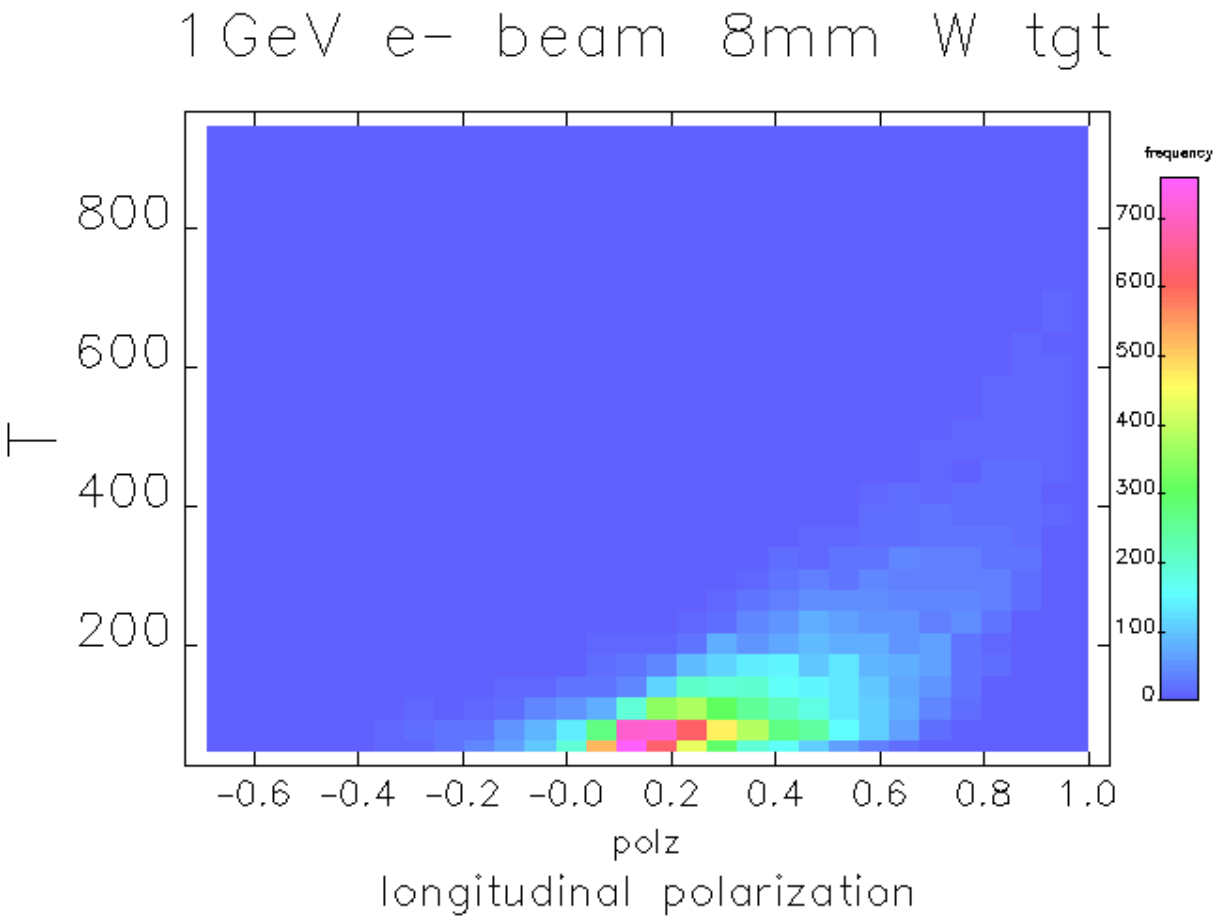
$\sigma_y = 8.35e-2$

$\sigma_{y'} = 5.34e-2$

$\varepsilon_x = 5.2e-3\ m.rad$

Total Yield is 0.016
121<P<125 MeV/c

Longitudinal polarization versus e+ Energy



Depends on target thickness. Optimization not done

Positron collection system

- Various options that can be studied (i.e see S. Golge Thesis)
- Quad Triplet
- Quad Triplet + dipole pair
- Solenoid ? (maybe not at 123 MeV/c)
- Need to assess whether we can have it after the recombiner of ARCA, in the reinjection chicane.
- Other option is to have it at end of ARCA (2nd step of recombiner) and build a bypass line for the e+, this may make it easier to locate the dump.

dump requirements

- If one uses a 1 mA e- beam (readily available with existing polarized gun), then a MW dump is needed.

- A 100 kW dump is relatively small (BSY dump is 100 kW) and could be installed after the production target. This would limit the beam to 0.1 mA.

- If one wishes to use 1 mA, then one may need to relocate the e+ production to the 2nd step of the recombiner (end of ARCA) and make a bypass line to reinject the e+ into the NL.

Conclusions

- **Several options are being considered to use CEBAF as a positron machine**
- **R&D is needed to flesh out a complete option**
- **No fundamental show stopper, most issues can be resolved by modifying existing machine**
- **Choice will be driven by the physics needs (polarized, unpolarized, intensity, etc..)**