Science & Technology Facilities Council

EuPRAXIA

# High and Low Energy Positron Beamlines

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# Context

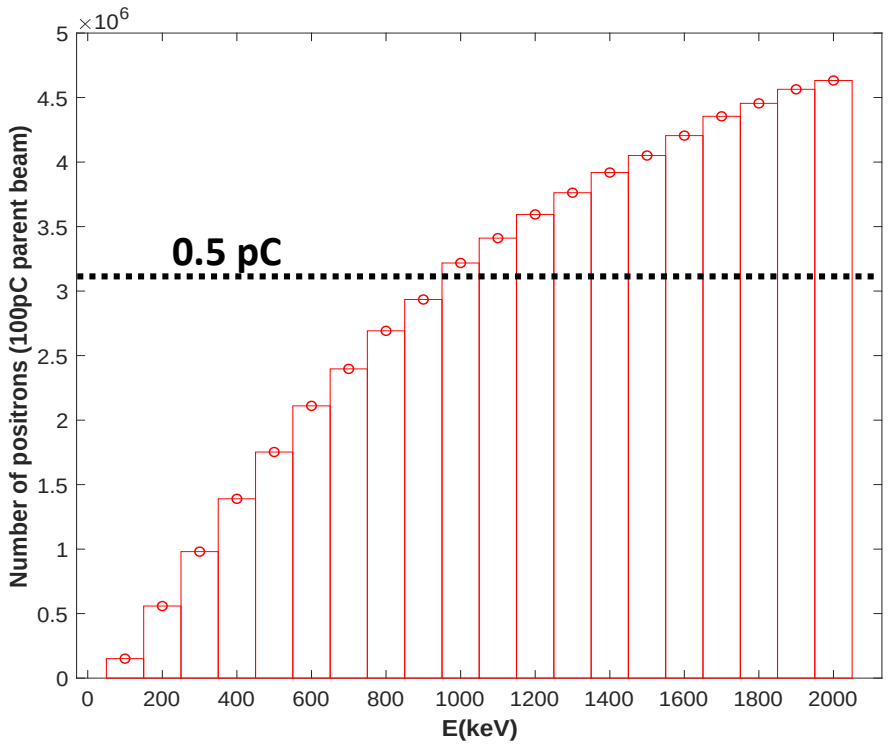
- EuPRAXIA aims to produce plasma-accelerated electron beams of industrial quality
- These beams can be used as source for secondary particles such as positron beams
- Plan is to design two positron beamlines
  - Low-energy positrons, to be used for material characterisation via Positron Annihilation Lifetime Spectroscopy.
  - High-energy positrons, to study the feasibility of positron injection in future HEP experiments

- For more details of potential applications and positron production - see talk by Gianluca Sari, Weds Plenary

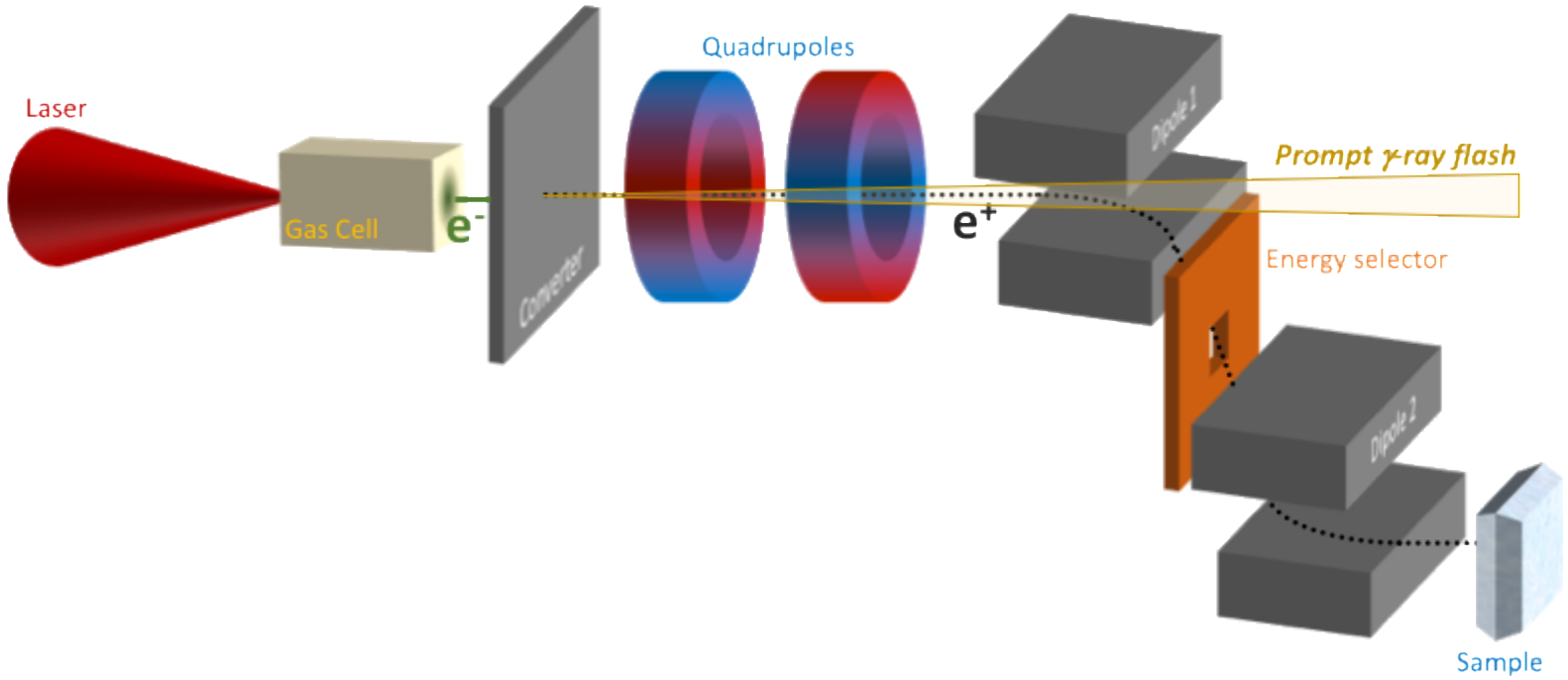
# Low Energy Beamline

- **Interested in 100keV to 1MeV positrons**
- Assume 5 GeV electron beam, 0.05% BW, 100 pC striking a 1 cm thick Pb target
- The positrons generated at low energies have very large divergence ($2\pi$)
- The challenge is to capture as many as possible and to transport them to the end station

**Low-Energy Region**

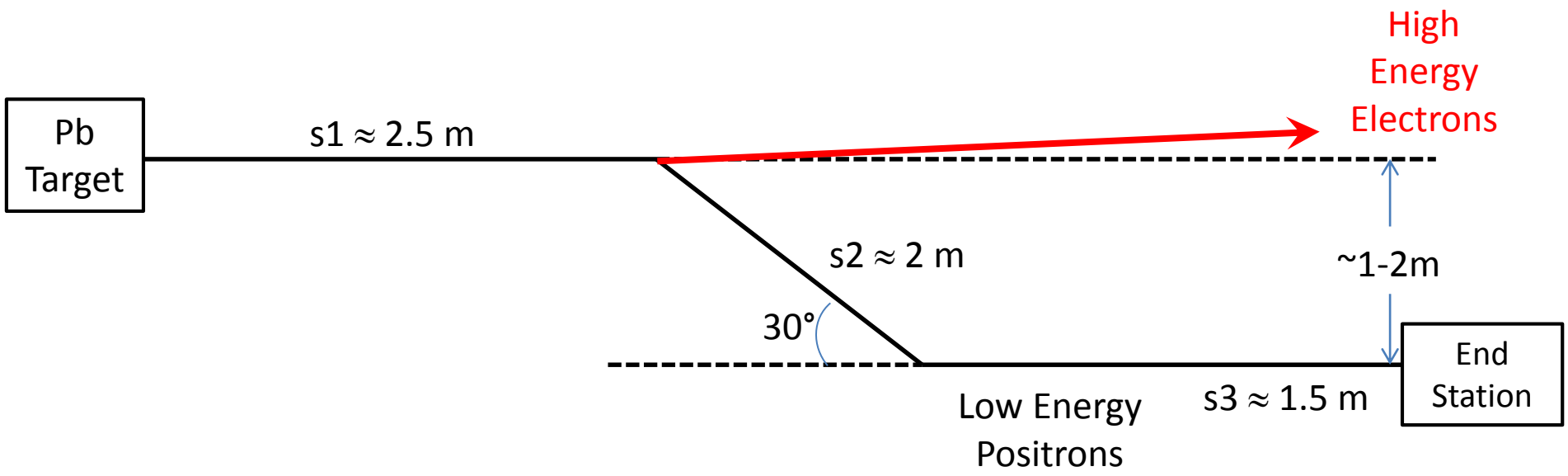


# Low Energy Beamline Concept




- **Use a dog-leg spectrometer to separate the high energy electrons and photons from the low energy positrons**

# Low Energy Beamline Concept

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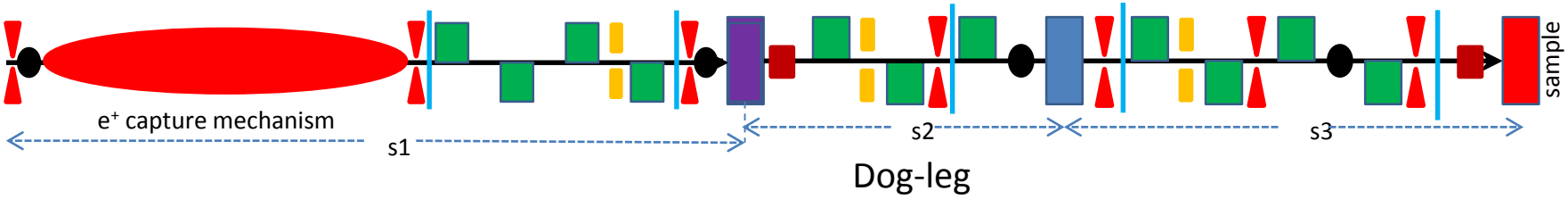
# Low Energy Beamline Concept




– YAG screens

– charge measurement

– vacuum pump & gauge

– correctors (H & V)

– collimators / apertures

– separator dipoles

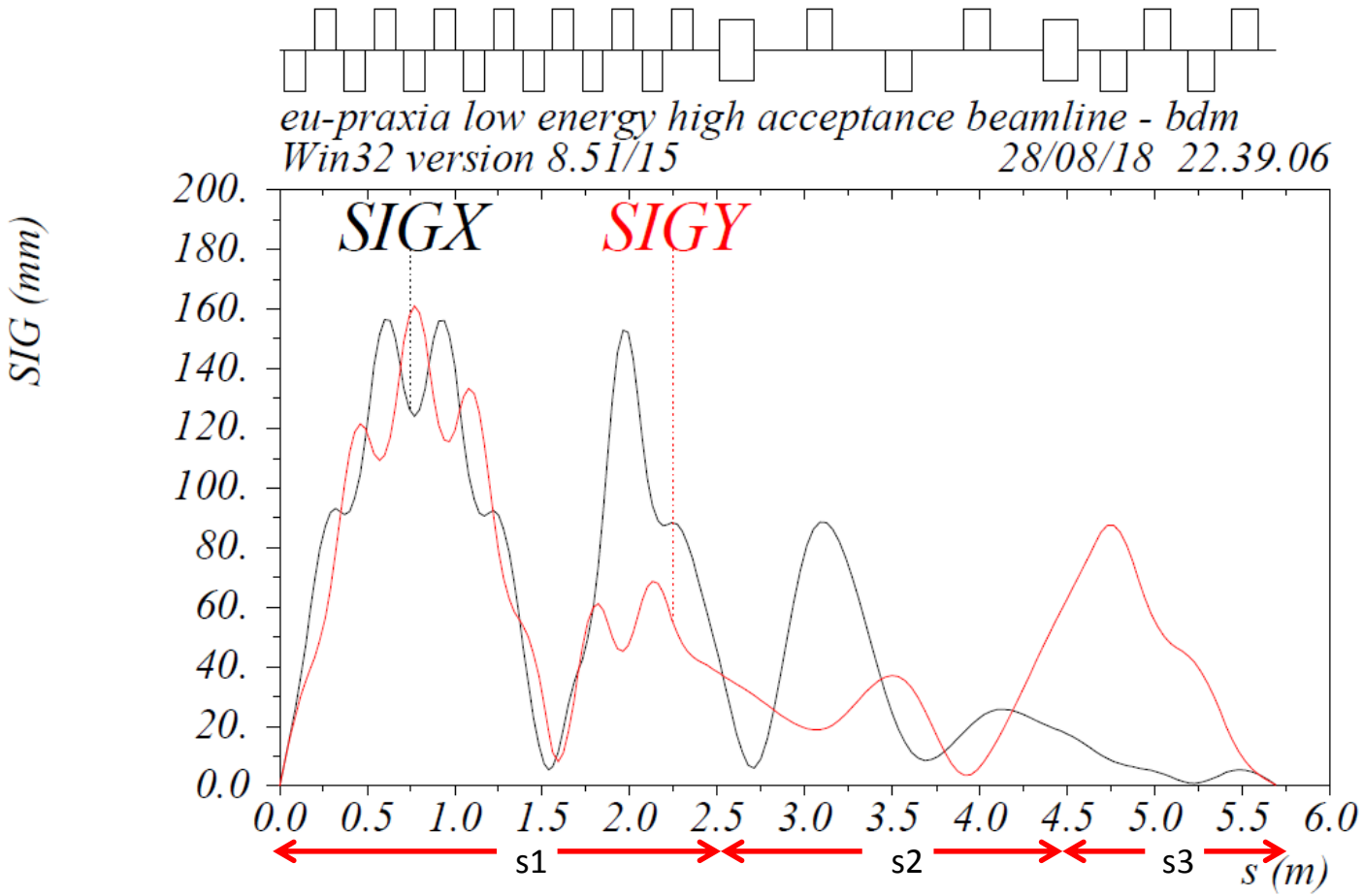
# Low energy line

- Positron energy 100 keV – 1 MeV
- Do not know bunch parameters yet
- Need to look at "capture" of $e^+$ in more detail
  Parameters assumed were:

$$\beta_x = \beta_y = 0.2 \text{ mm}, \quad \alpha_x = -0.008, \quad \alpha_y = -0.043,$$

- Aim to transport as many positrons as possible
- Emittance assumed to be $\epsilon_N = 30\mu\text{m}.$

# Possible set-up @ 1MeV



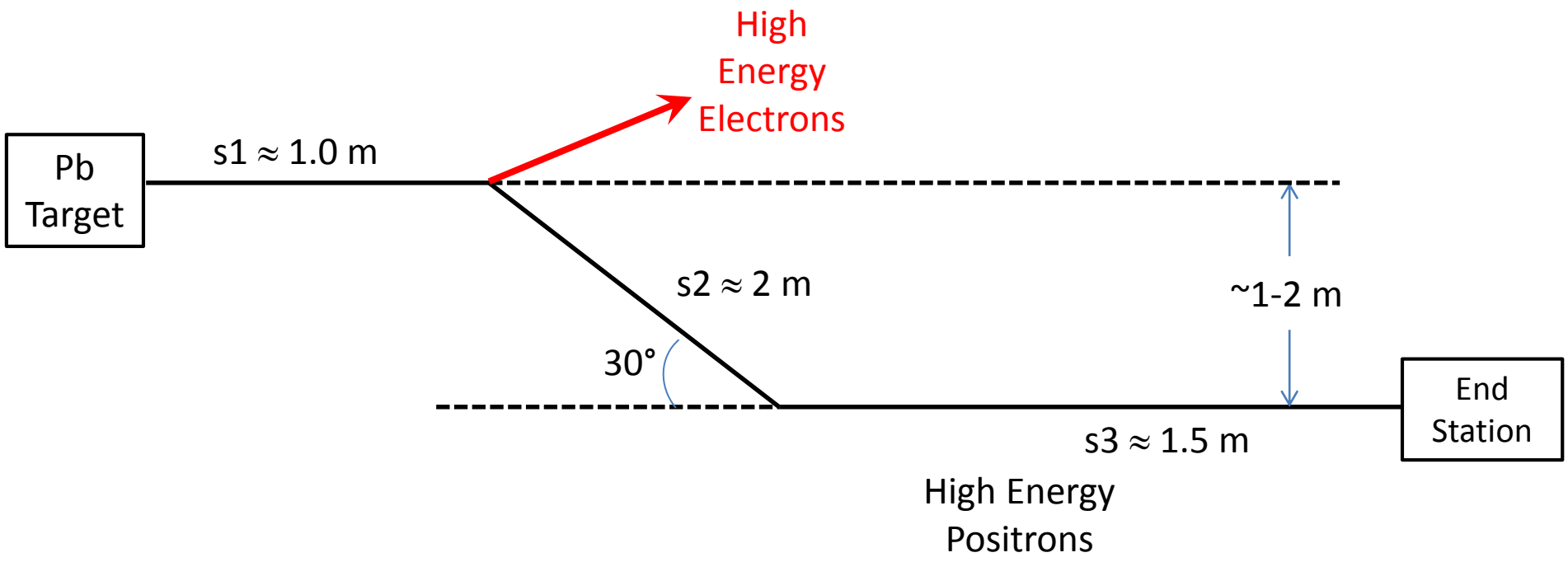

Very large beam size because of large normalised emittance and (modest, equal) quad strengths not optimised – can be done when initial bunch properties better understood

# High energy line

- Positron energy at least 500 MeV
- Very similar concept as low energy line – capture, transport, energy select in dog-leg, deliver to end station

| | E = 500MeV | E = 1 GeV |
|---|---|---|
| Positron number (per 100pC electron charge) | $1\times10^{7}$ | $6\times10^{6}$ |
| Divergence (mrad) | 20 | 10 |
| Source Size (um) | 13 | 10 |
| Emittance (um) | 0.3π | 0.1π |
| Invariant Emittance (um) | 320π | 200π |

# High Energy Beamline Concept

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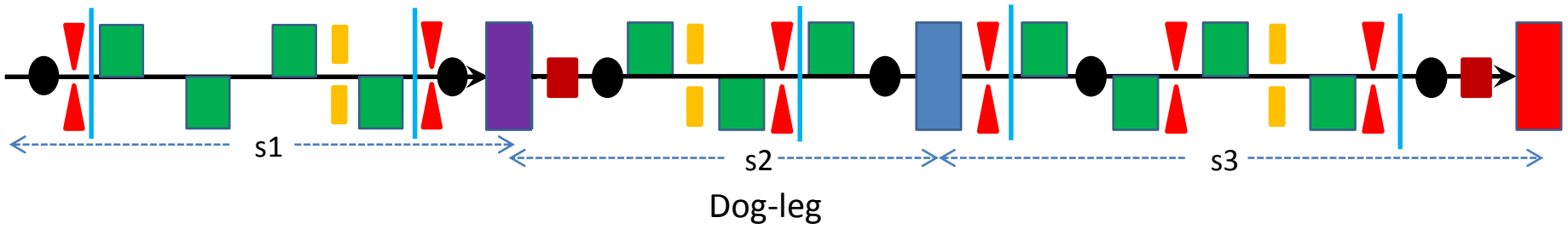
# High Energy Beamline Concept




– YAG screens

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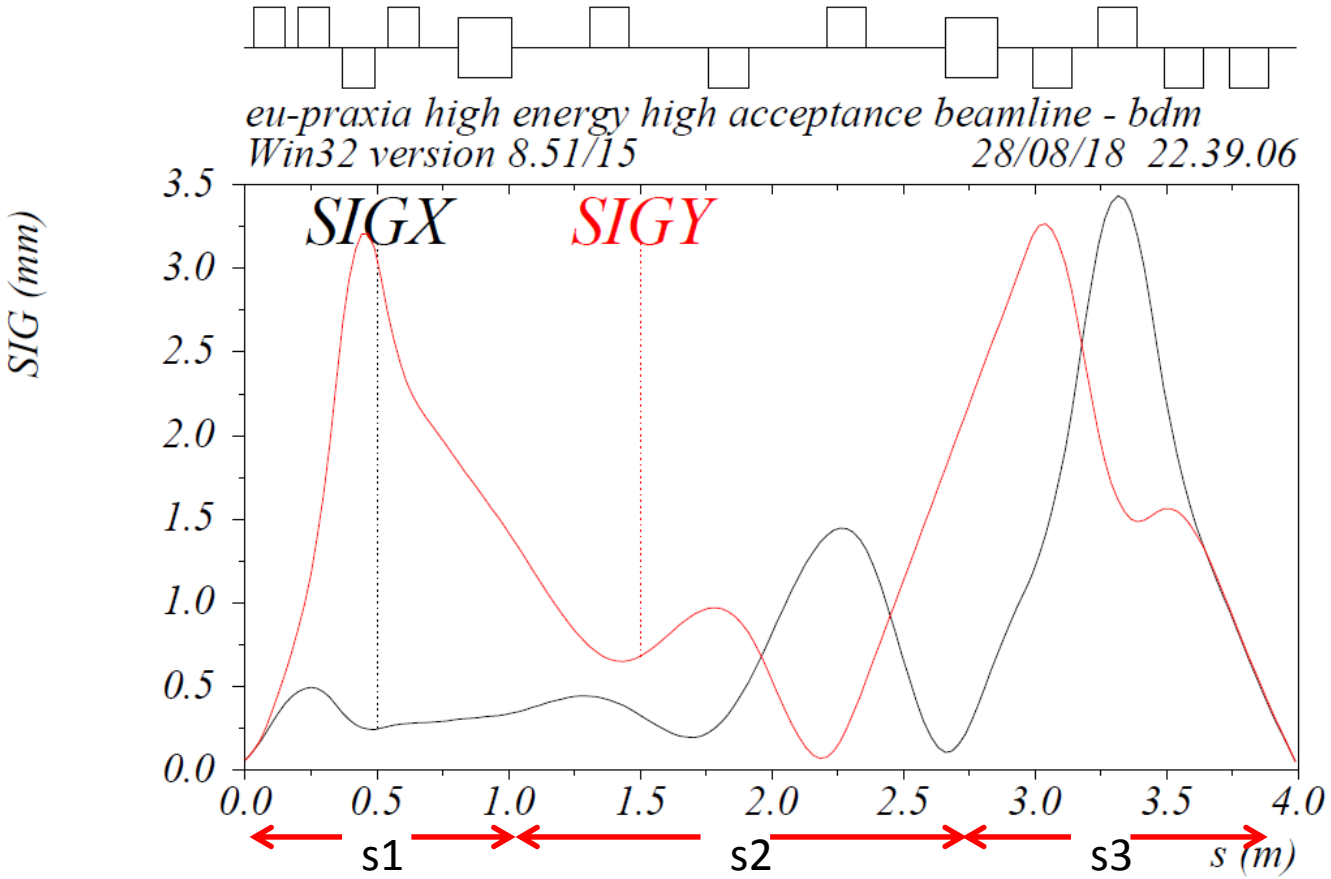
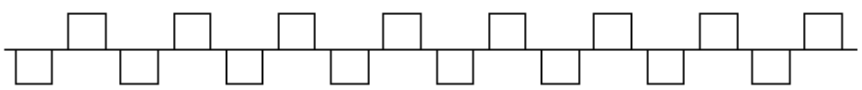
# Possible set-up @ 1GeV

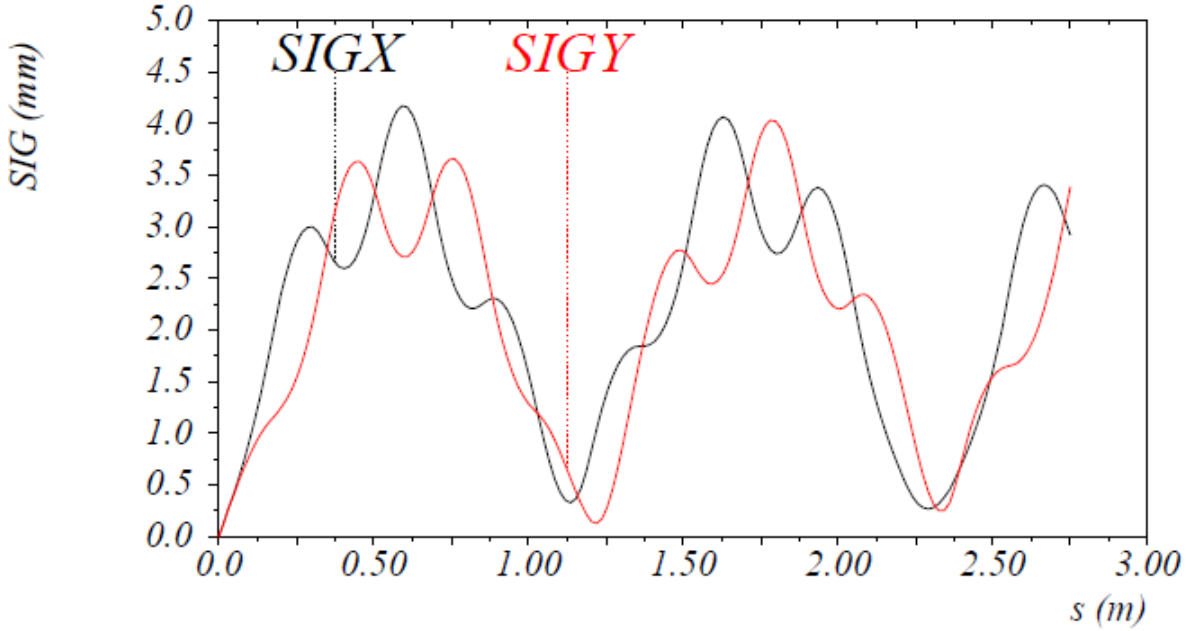



Modest beam size despite large normalised emittance.
Quad strengths 200T/m
Layout not optimised – can be done later

# 1 GeV Capture Details

- Parameters: $\beta_x = \beta_y = 0.2\ \mathrm{mm}, \quad \alpha_x = -0.008, \quad \alpha_y = -0.043,$
- $\epsilon_N = 30\mu\mathrm{m},$ in both planes & e. spread $< \pm 25\%$

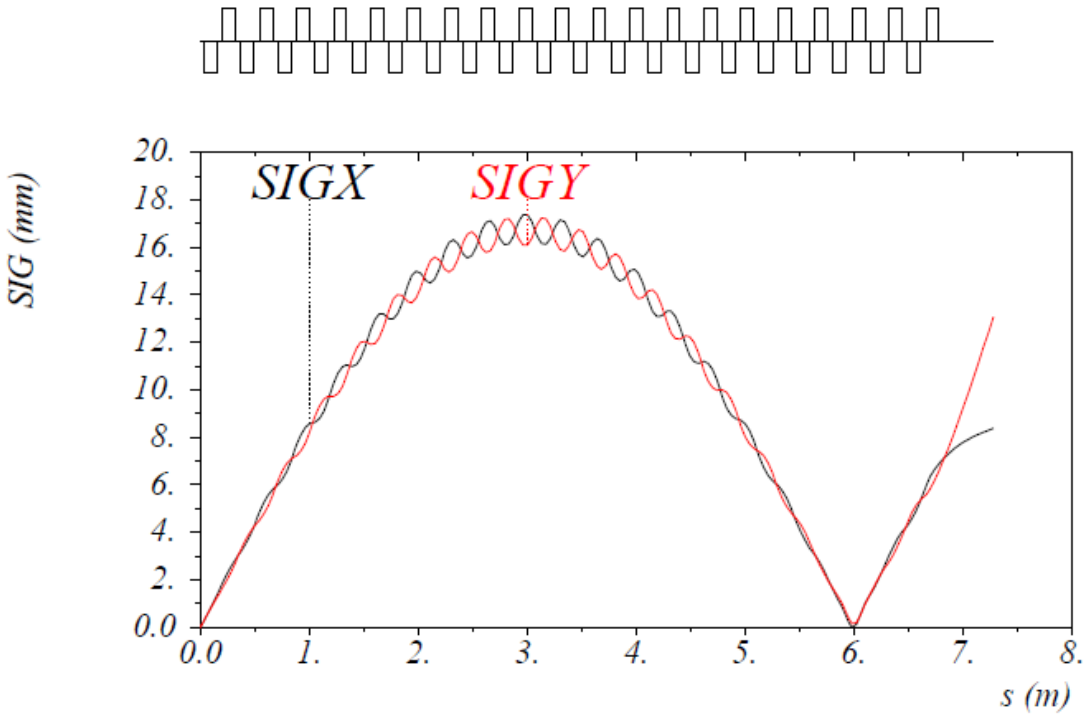





- Permanent Halbach quad. channel
- 12 cm long
- 200 T/m
- 5 cm drifts between them

# 1GeV channel running at 5 GeV

- The exact same quadrupole channel can be used for any energy (modulo aperture) and the beam can still be focused

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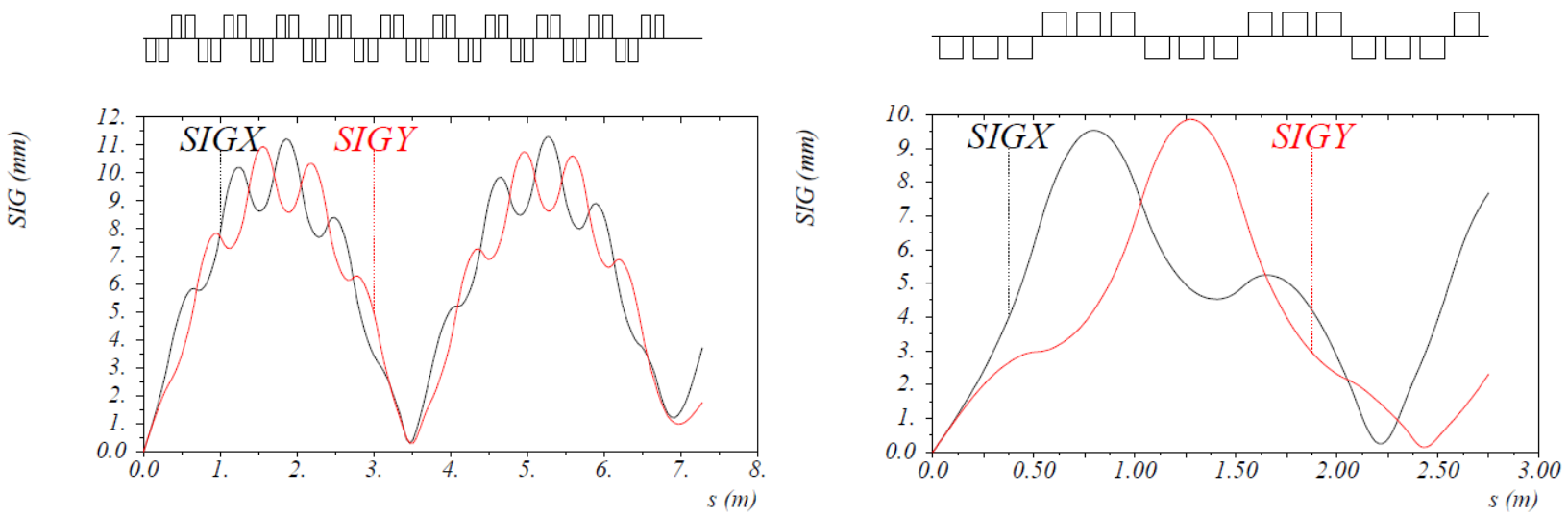
# Same channel reset for 5 GeV

- If quadrupoles can be rotated by 90° then this is equivalent to a change in polarity & the beam size can be considerably reduced



# Summary

- Plan is to design two positron beamlines
  - Low-energy positrons, to be used for material characterisation via Positron Annihilation Lifetime Spectroscopy.
  - High-energy positrons, to study the feasibility of positron injection in future HEP experiments
- Some very preliminary layouts have been assessed which can transport over a wide energy bandwidth
- The main uncertainty in all cases are the initial bunch parameters – optimisation will come later
- We are working on broadly similar problems for SCAPA and CLF
- We are also considering alternative transport solutions, such as FFAG style lattices