Progress on Astrophysics in the Lab …

Intro

Measuring *Bell's instability*

Candidate for the source of cosmic rays (particles with energies e.g. > 10^{14} eV)

Mon. Not. R. Astron. Soc. **353,** 550–558 (2004) doi:10.1111/j.1365-2966.2004.08097.x

Turbulent amplification of magnetic field and diffusive shock acceleration of cosmic rays

A. R. Bell★
Blackett Laboratory, Imperial College, London SW7 2AZ

Accepted 2004 June 1. Received 2004 April 30

ABSTRACT

The diffusive shock acceleration of cosmic rays by supernova remnants depends upon the generation of magnetic fluctuations by cosmic rays upstream of the shock [redacted] grow more rapidly than the resonant Alfvén waves usually considered. Non-linear simulation shows that the magnetic field can be amplified from its seed value by orders of magnitude. The consequences for the maximum attainable cosmic ray energy in supernova remnants are explored.

Key words: acceleration of particles – magnetic fields – plasmas – shock waves – turbulence – cosmic rays.

→ waves in a thin plasma driven by particles

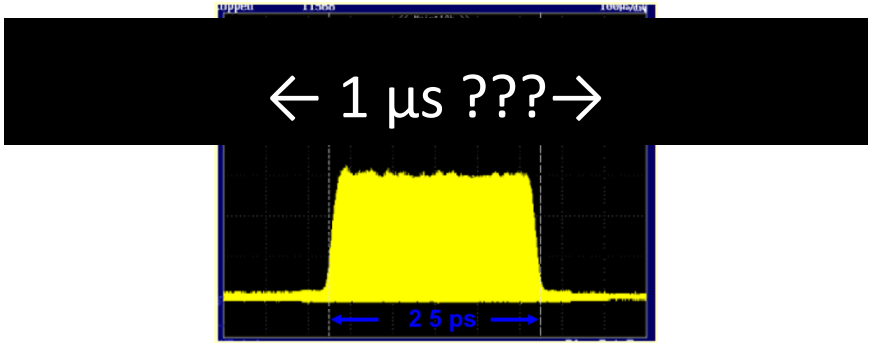
Outline

1. Background information
2. Suitable electron sources
    i. Photocathode
    ii. Dark current
3. Beam transport
4. Discussion

Background: experimental needs

- Continuous beam (µs – ms range…)
- “High” current (mA range)
- Broad beam (i.e. no transverse structure)
- ~ Relativistic energies
- Broad & flat energy spectrum (at least no positive slope)
- Plasma density around 10^{13} cm^{-3} for ca. 1 ms
- Long plasma

(Mis-)Using Photoelectrons

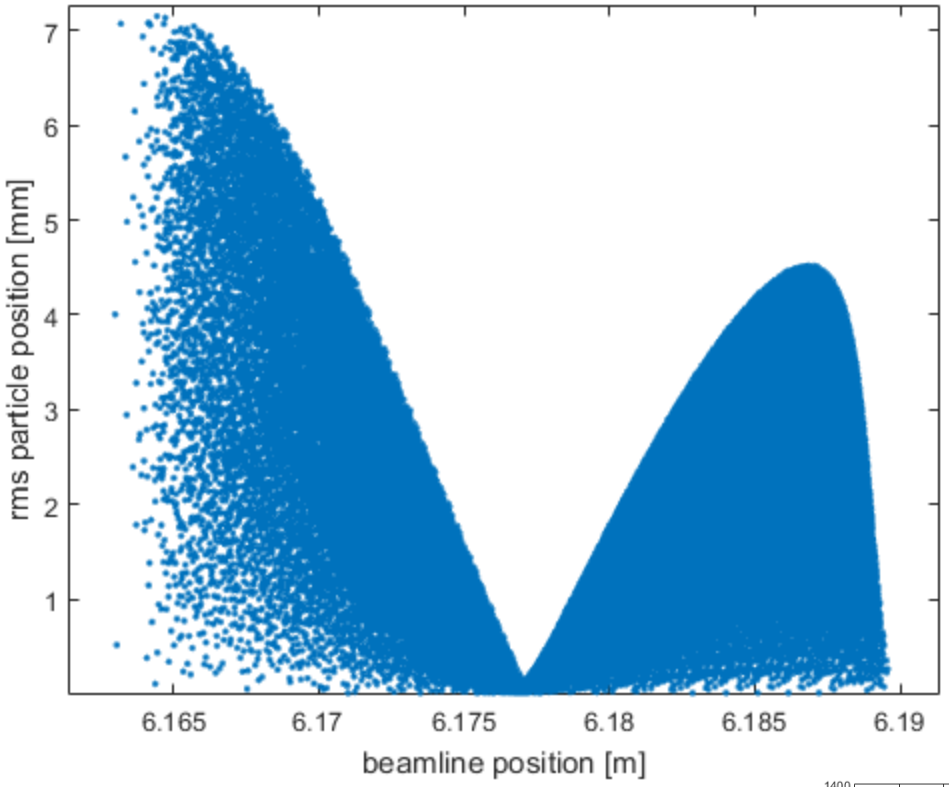


Laser frequency 1 Mhz
(54 MHz oscillator but amplifiers not capable of that..)
5nC/1µs = 5mA …

-> Therefore:

Gun on crest to get some focusing
+ booster at 90°, <6 MV/m for maximum broadening

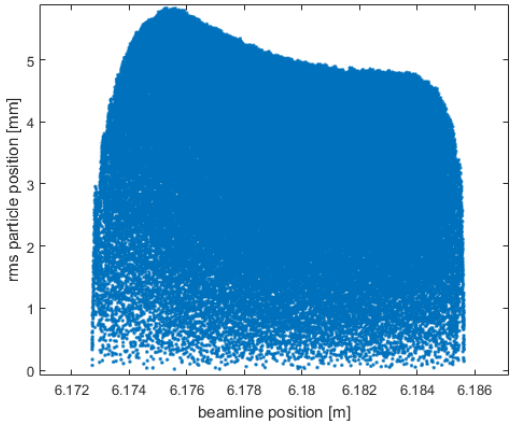
Using Photoelectrons

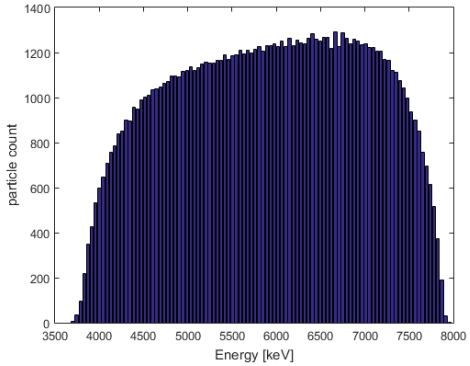


- Gun 60 MV/m on crest
- Booster 90°, 17 MV/m
- Solenoid 380 A

→ ca. 80 ps bunch length…

(at 5 MV/m maximum duration is ~45 ps)

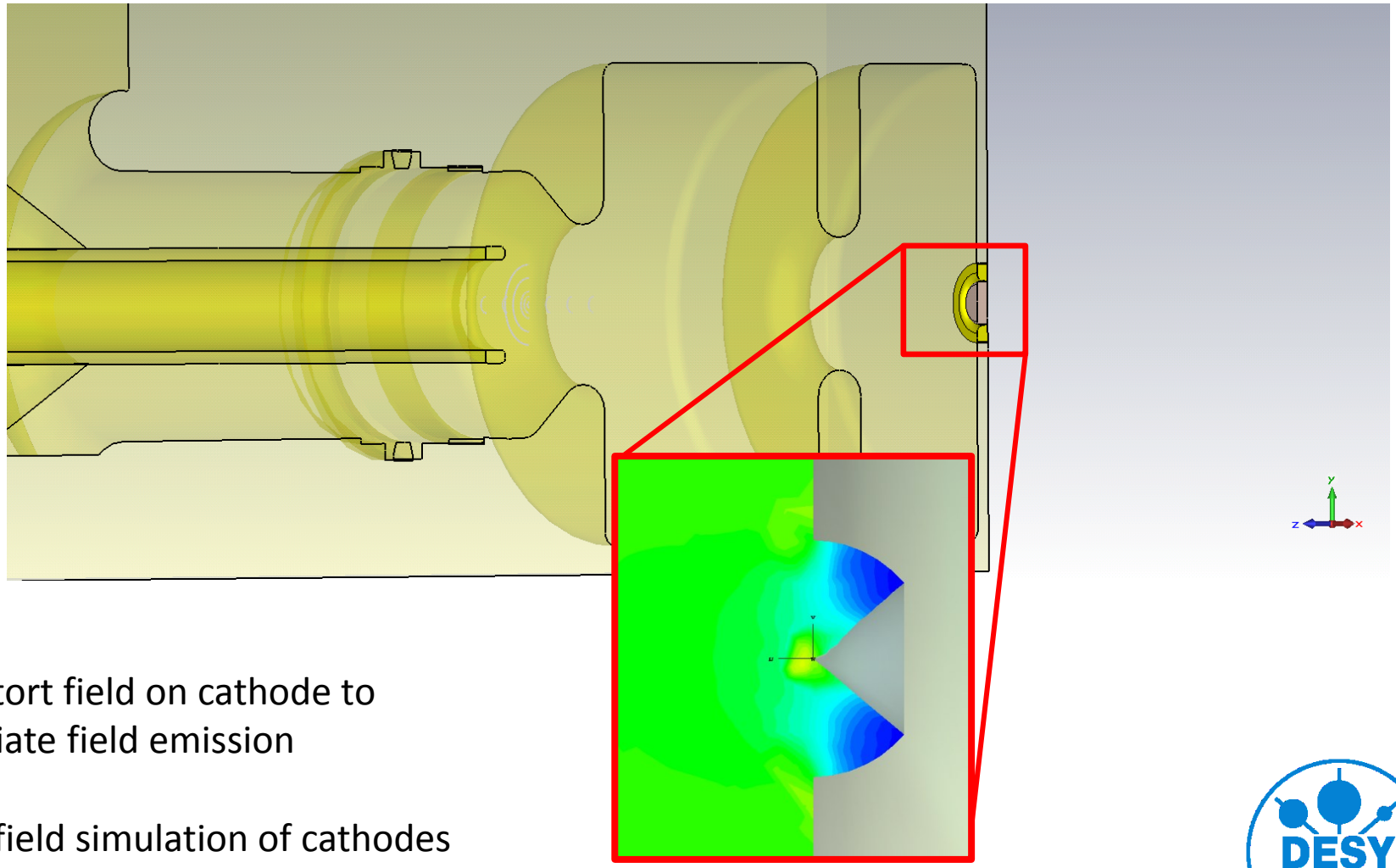




→ <u>not suitable!?</u>

Using dark current

1st approach: stay within cathode surface

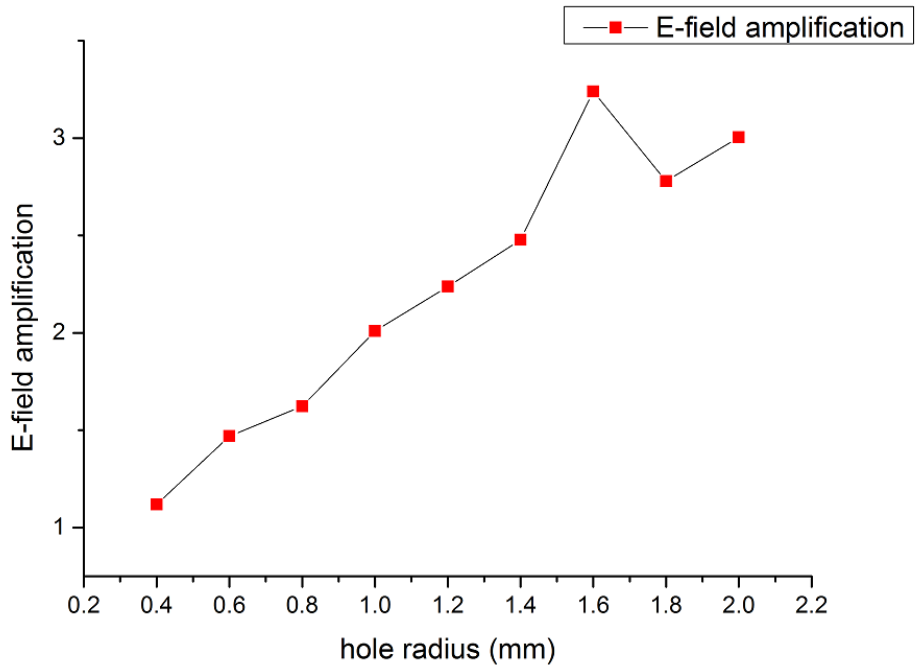


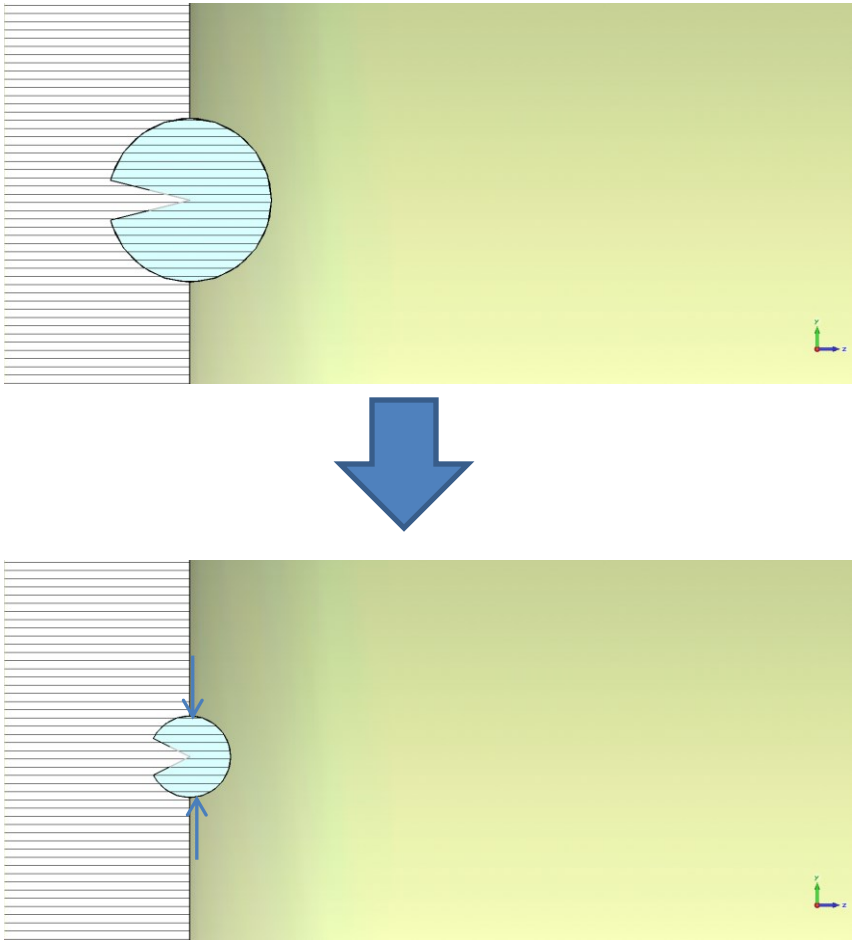
Distort field on cathode to initiate field emission

-> field simulation of cathodes with nose inside a hole

Using dark current

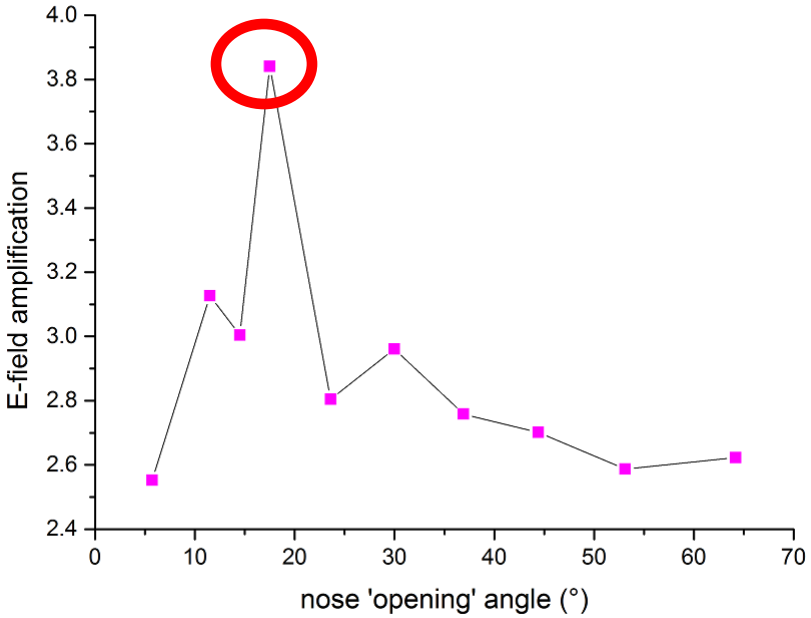
Vary radius of 'hole'

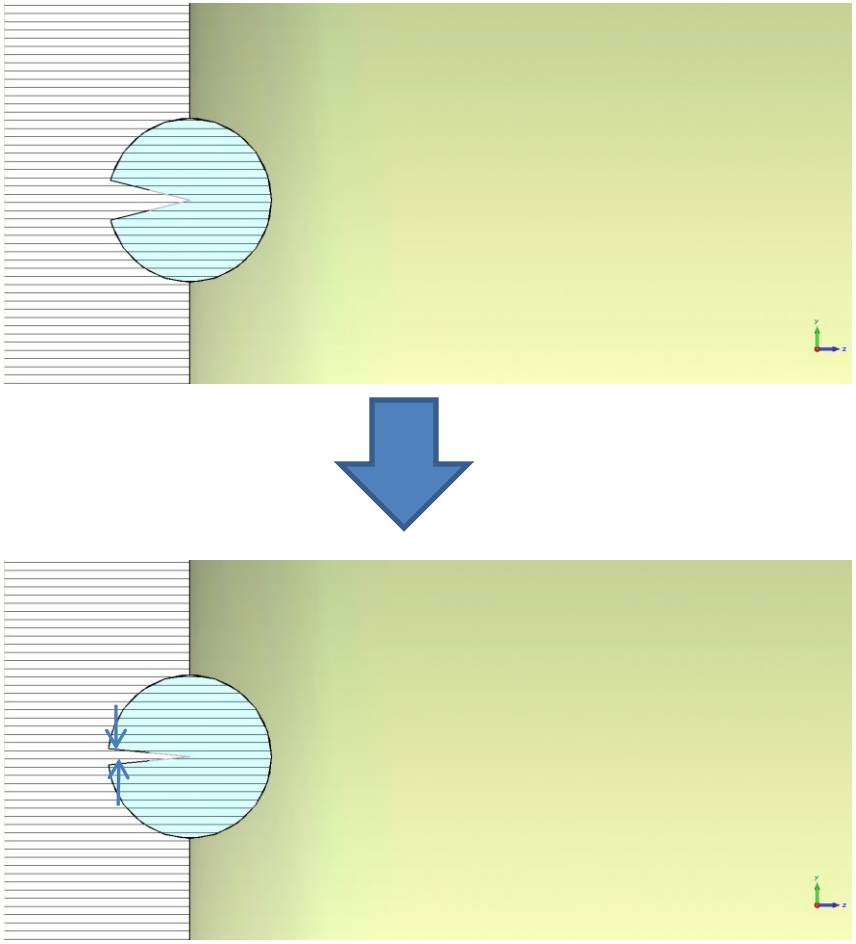




Using dark current

Vary steepness of 'nose'

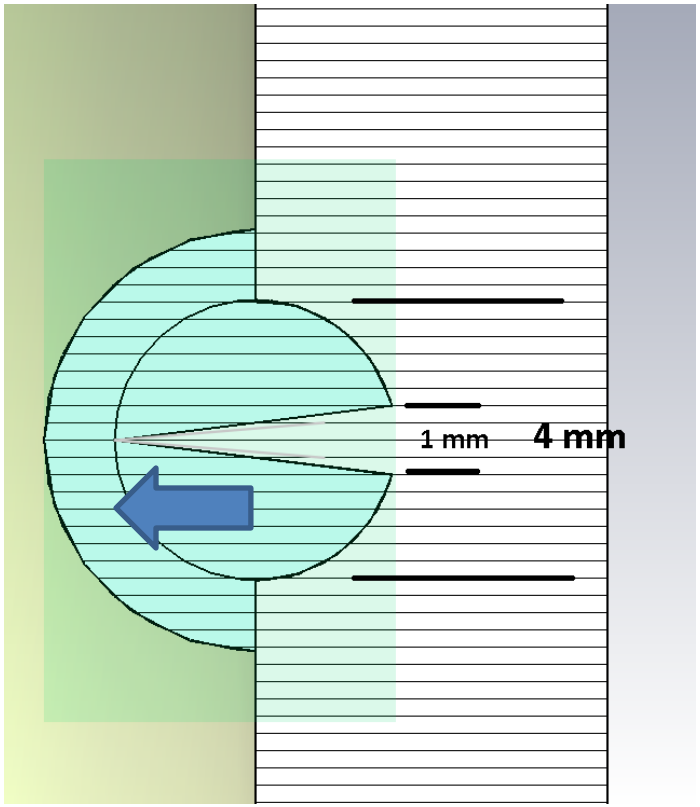


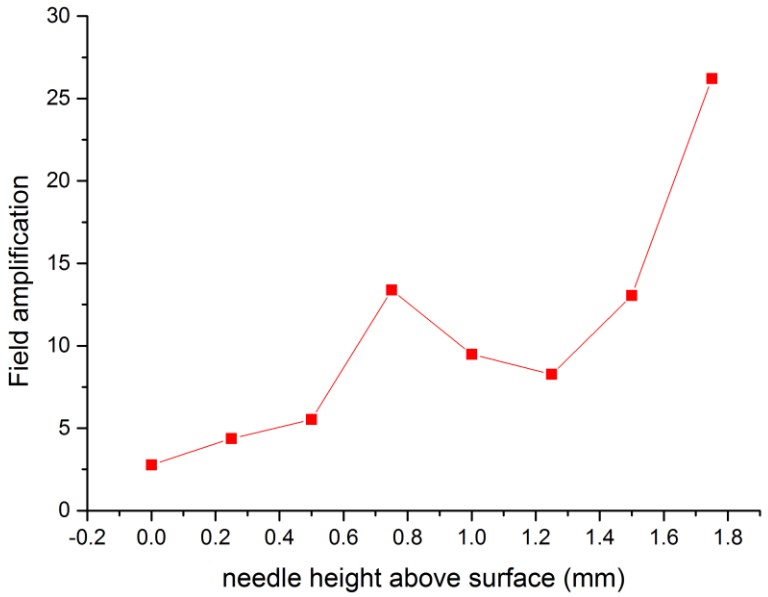


→ For high distortions we have to leave the cathode surface!

Using dark current

2nd approach: stick the needle out of the surface…





BUT: So far no separation between height itself and steepness at tip due to height

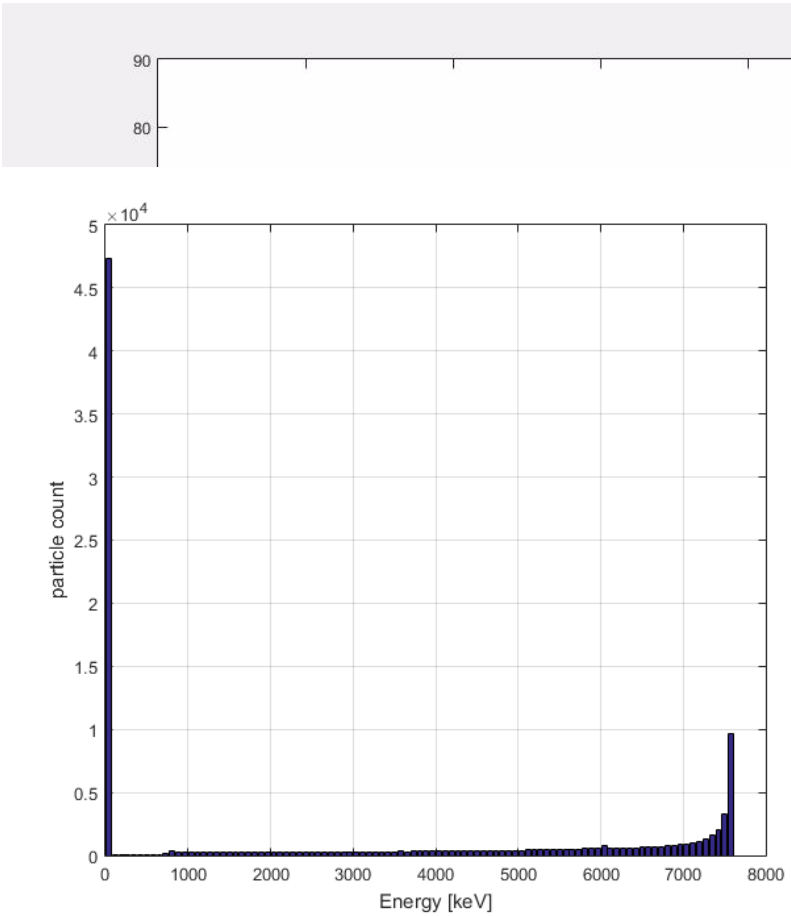
→ Next step: with optimised geometry use Fowler-Nordheim field emission model..

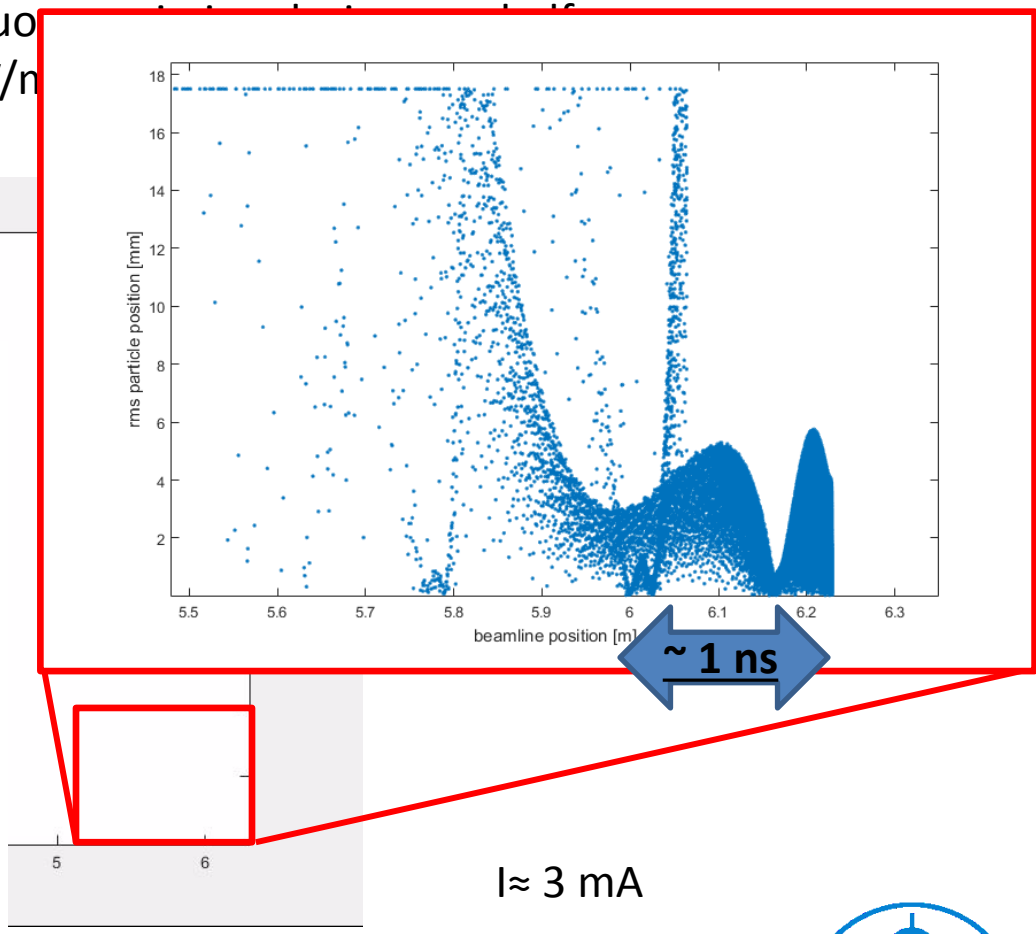
After Emission: Beam Transport

Take (presumably) best conditions:

Continuo

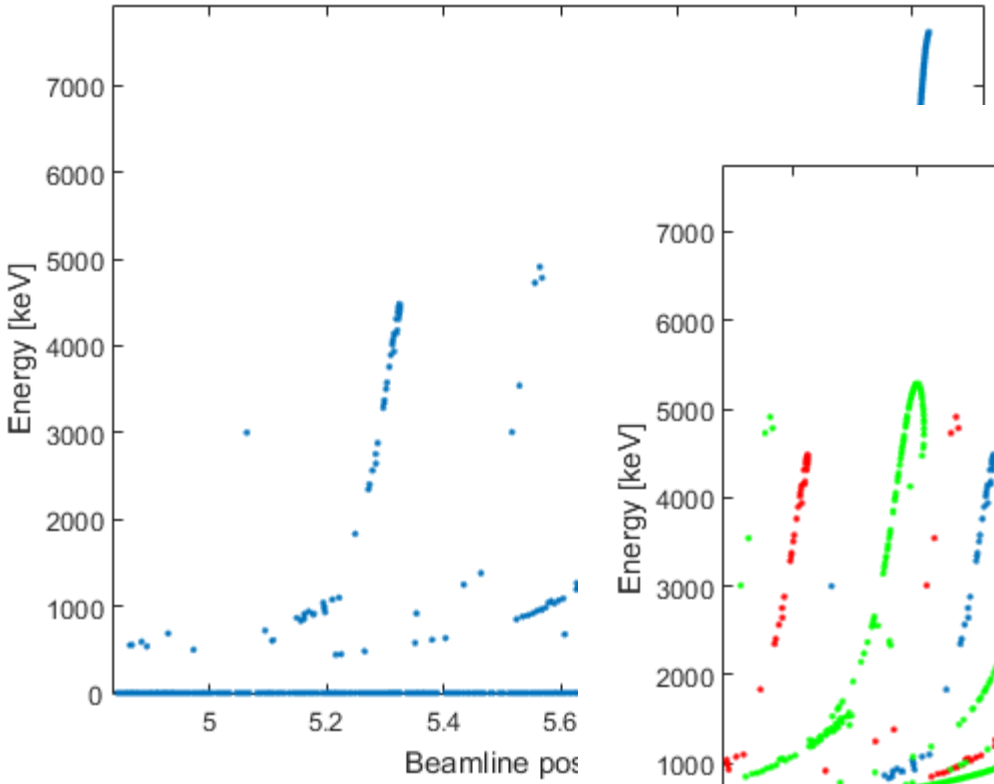
(60 MV/m



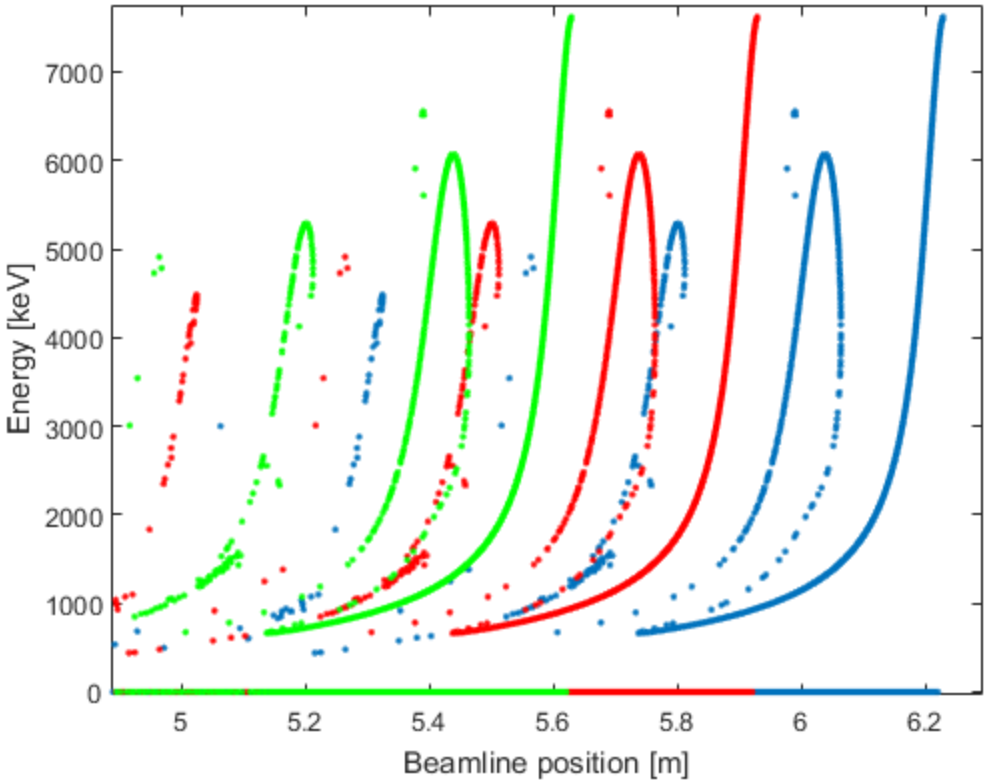


I≈ 3 mA

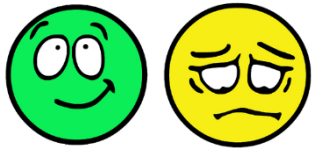
After Emission: Beam Transport



Longitudinal phase-space



Reminder: experimental needs

- Continuous beam (µs – ms range…) () idealised… “continuous”…
- “High” current (mA range) 
- Broad beam (i.e. no transverse structure) 
- ~ Relativistic energies 
- Broad & flat energy spectrum (at least no positive slope) 
- Plasma density around 10^{13} cm^{-3} for ca. 1 ms 
- Long plasma

Long . . . ? ? ?

Outlook

- Further simulation of field emission on cathode
- Enhancement of beam transport with simulated e^--beam
- Find capabilities which roughly meet requirements and wait for confirmation/requests by Astrophysics group

Thank you for your attention!