Investigating guide field reconnection in HED plasmas

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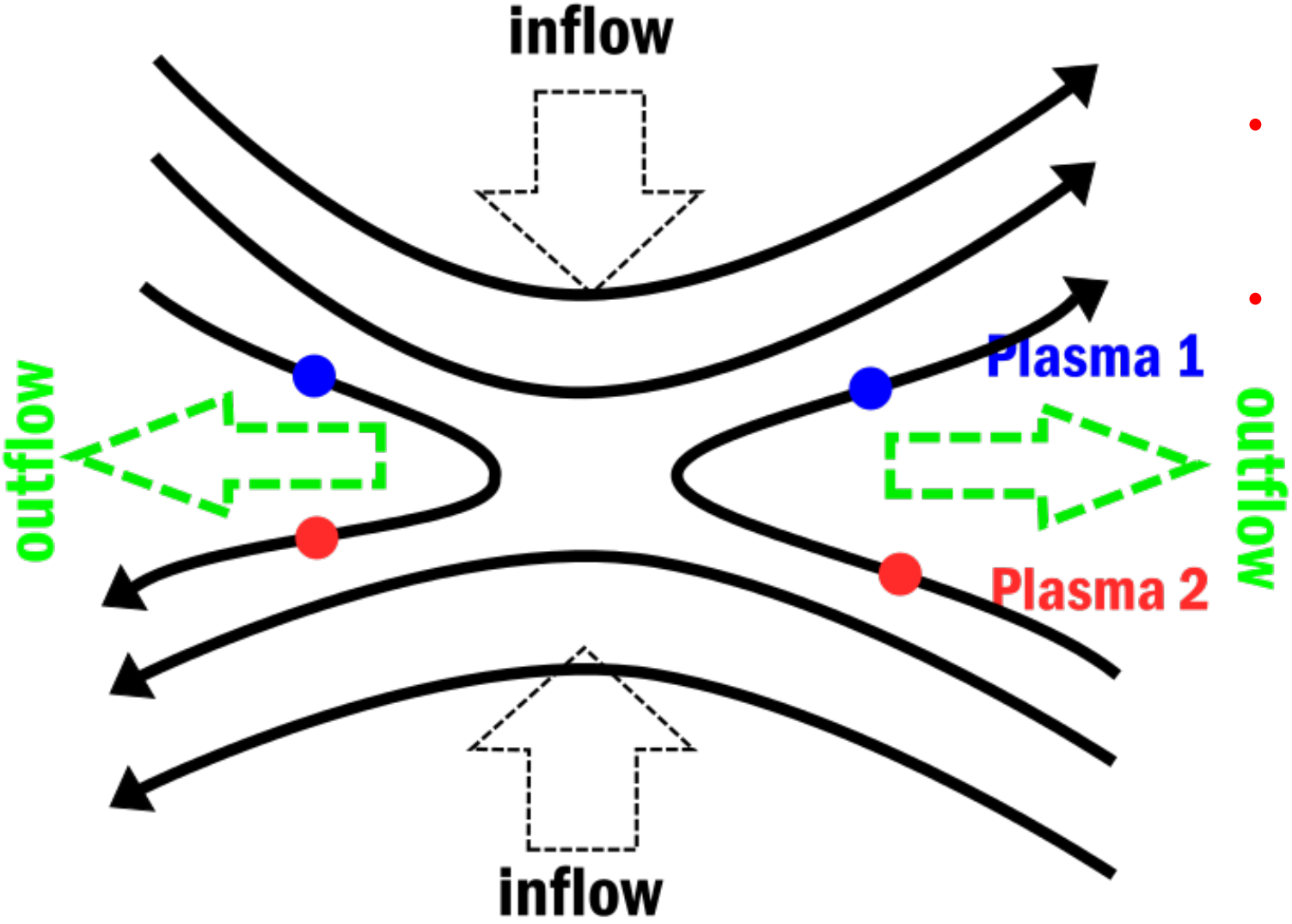
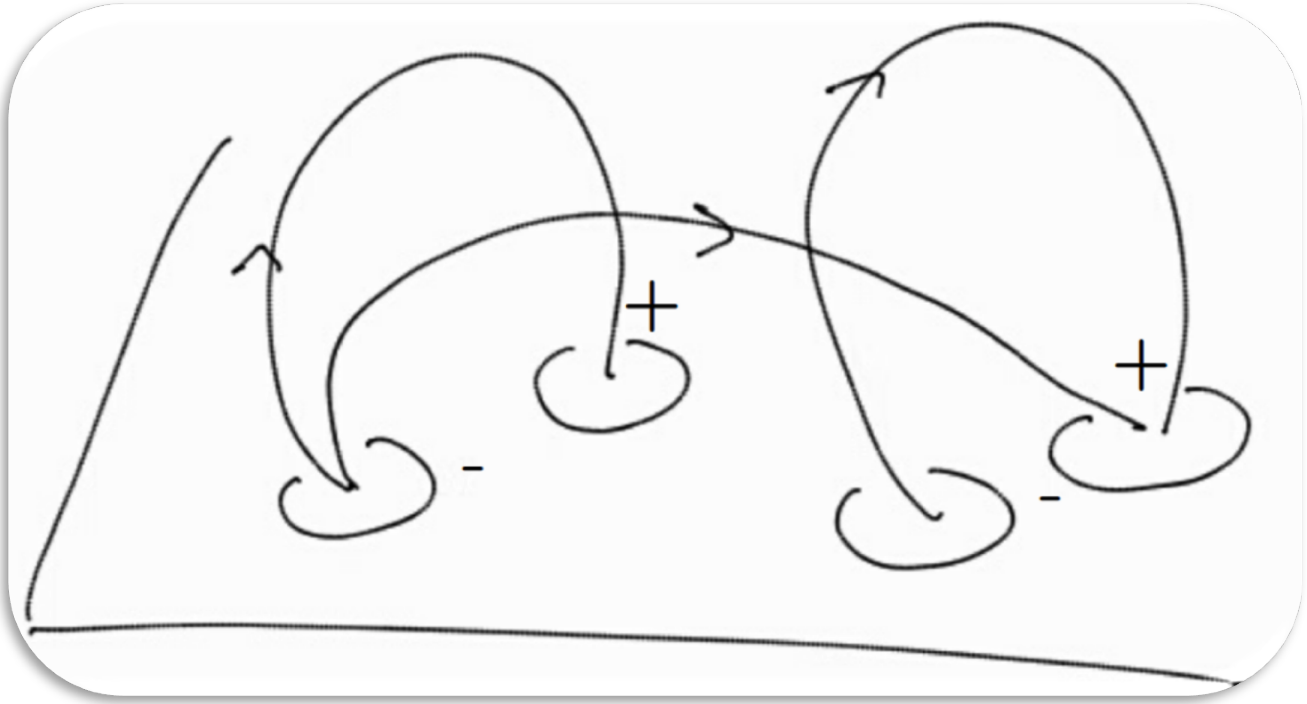
Principle of magnetic reconnection



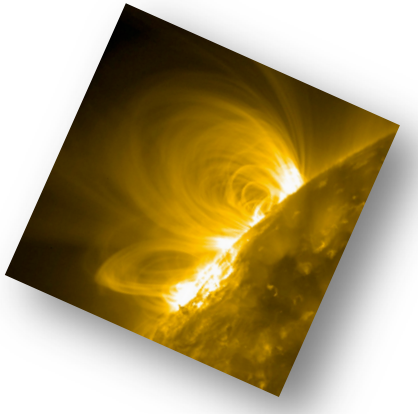
- **Breaking** B lines and reconnecting them
- **Ejecting** from the reconnection area

3D effects are there, e.g. solar prominence merging

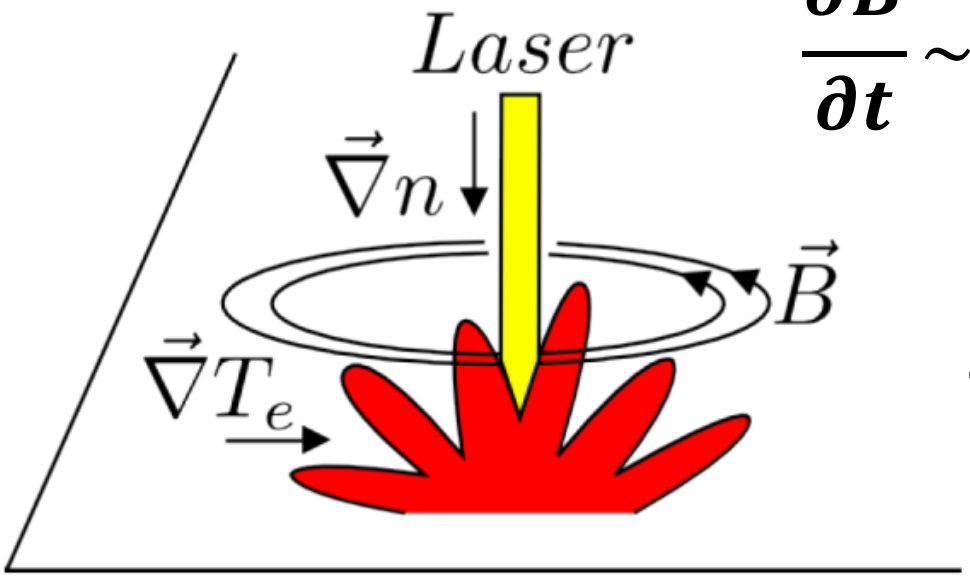
[Aulanier et al. ApJ 2005]



SDO/AIA, 171 Å filter, 24 February 2011.
Credit: NASA/LMSAL/SDO

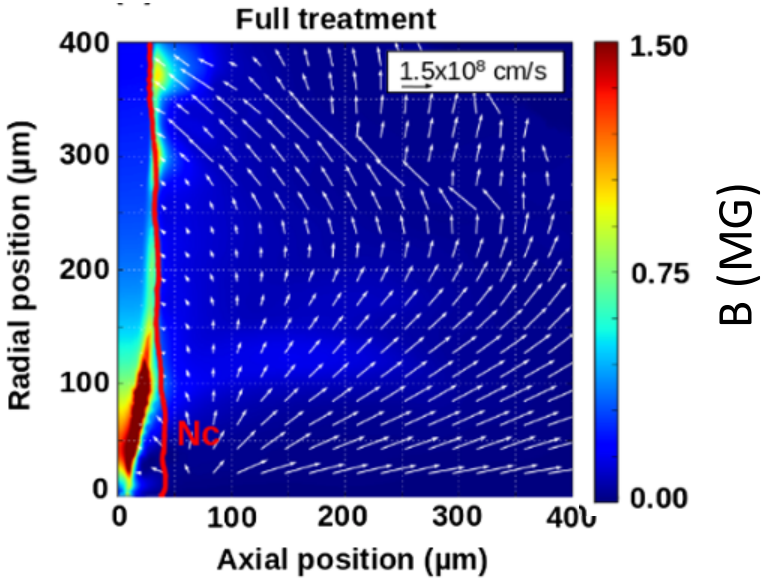


How to generate strong B-field loops with high-power lasers



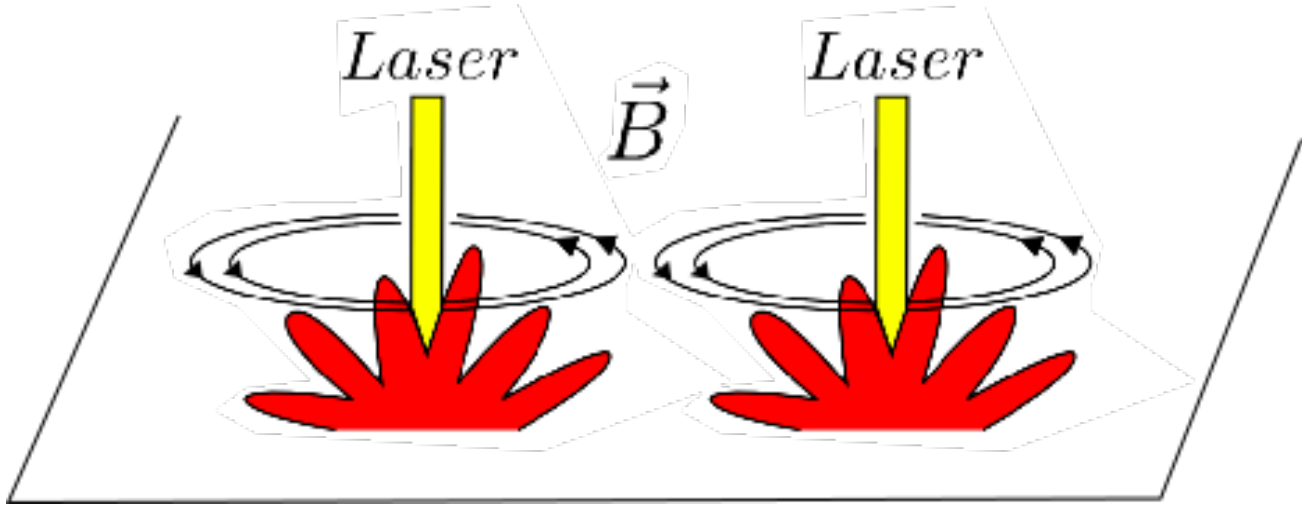
$$\frac{\partial B}{\partial t} \sim \frac{\nabla T_e \times \nabla N_e}{N_e} + \ldots$$

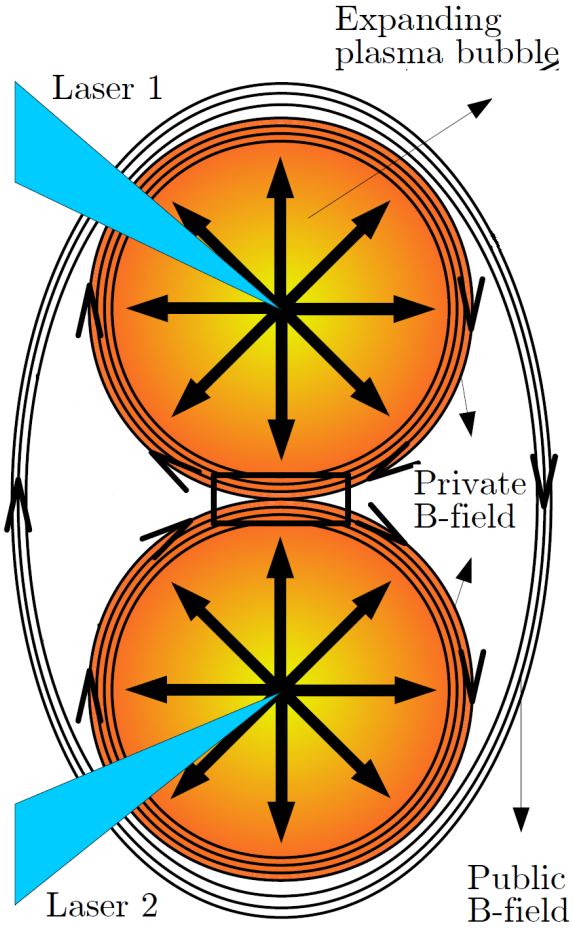
Magnetic field generated by **Biermann-Battery effect, compressed against the target due to the Nernst effect**



L. Lancia et al., PRL (2014)

Close-by lasers allow to investigate reconnection





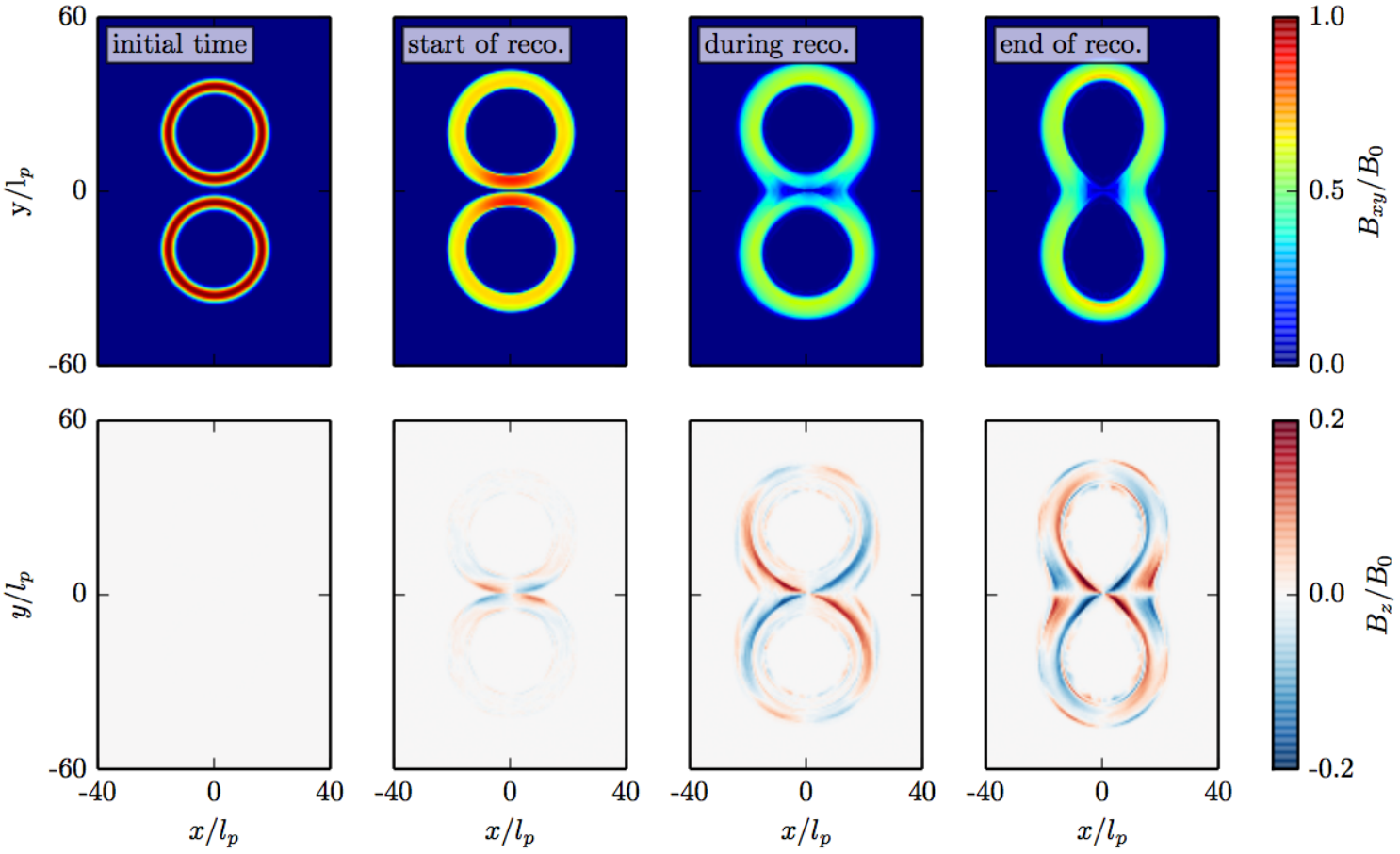
Nilson et al., PRL (2006)
Li et al., PRL (2006/2007)

Simulations highlight the various stages of MR

Initialisation with the experimental parameters

Hydrid-PIC code

$\vec{B}$ & $\vec{E}$



Simulations highlight the various stages of MR

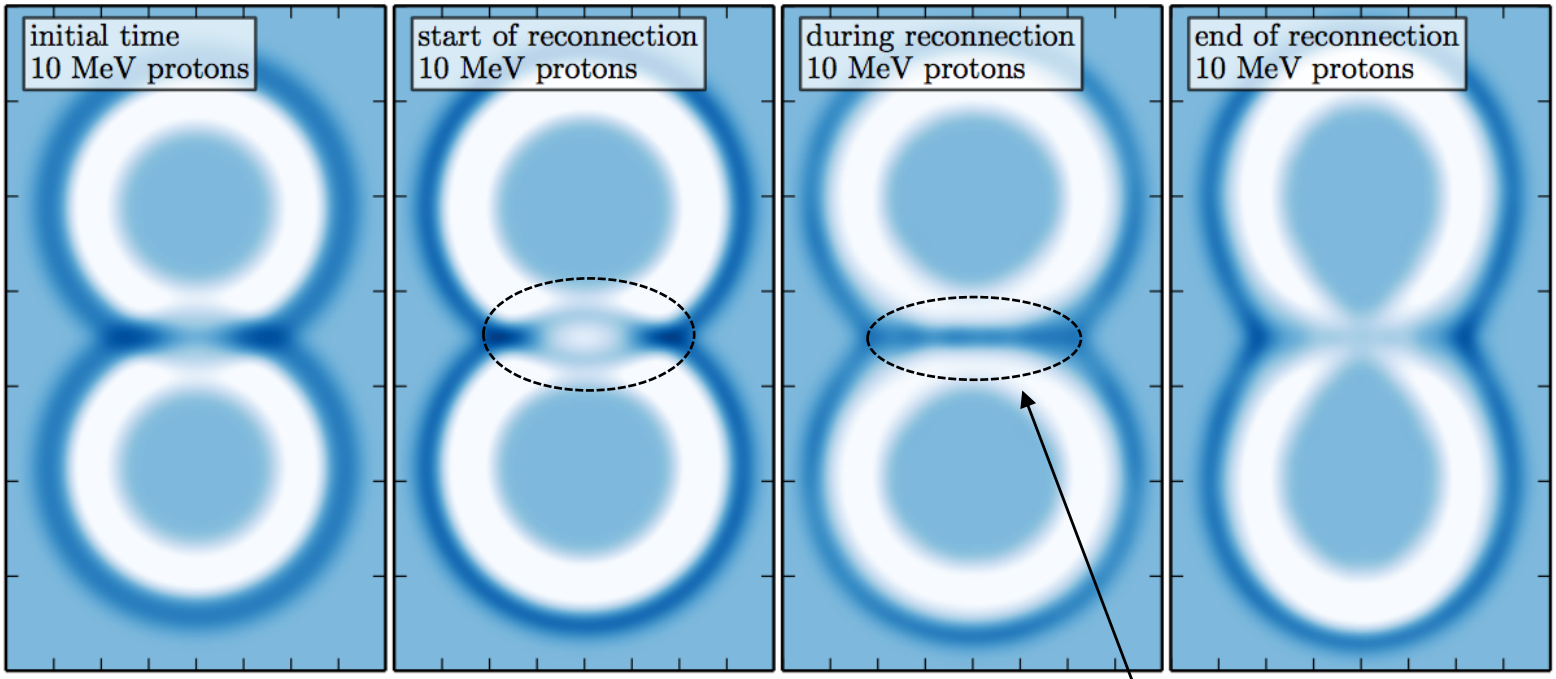
Initialisation with the experimental parameters

Hydrid-PIC code

$\vec{B}$ &

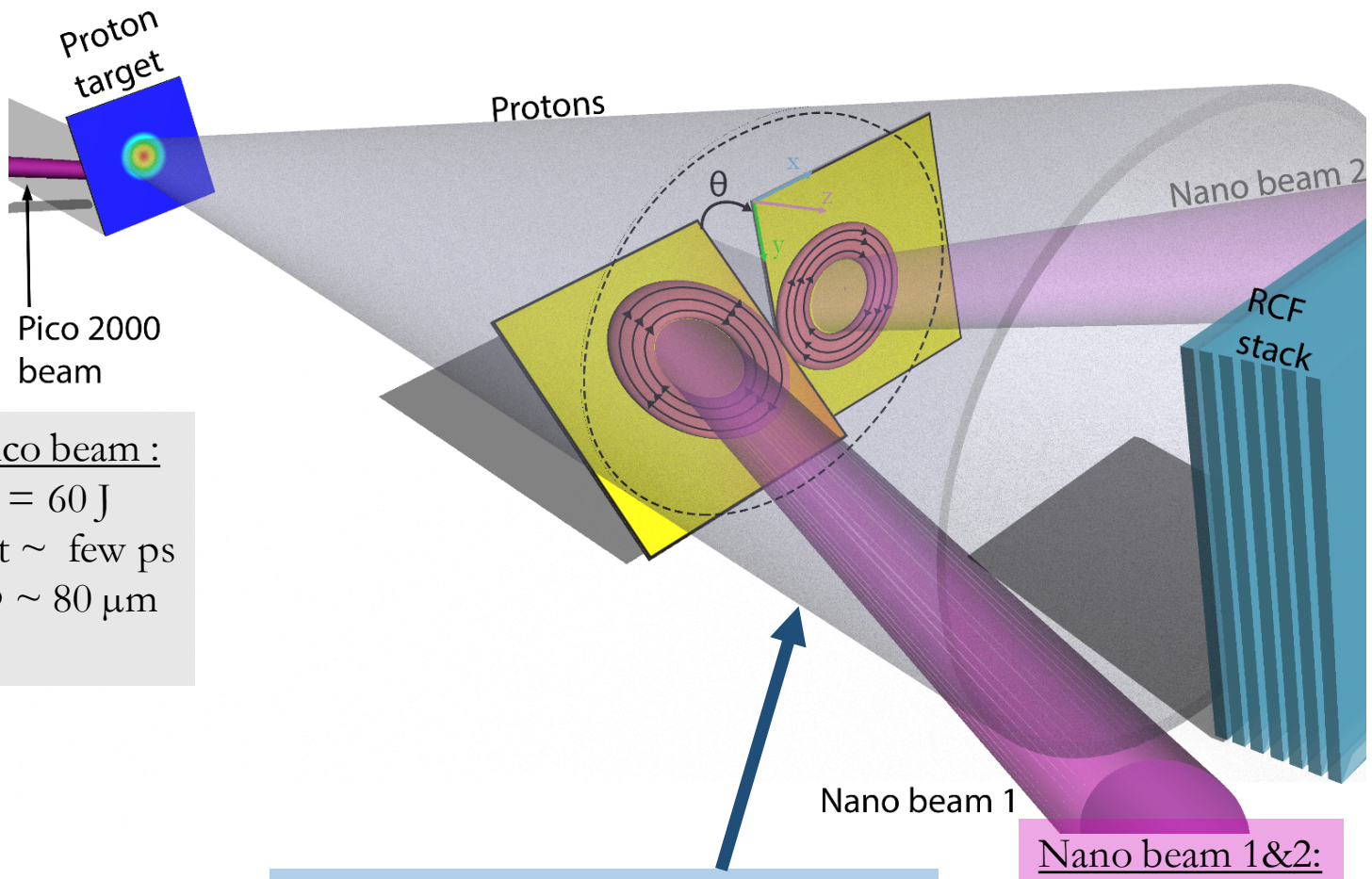
Ray-tracing code

Deflection of the protons (Radiography map)



This compression area provides information on the dynamics of MR

Setup of the experiment



pico beam :
E = 60 J
Δt ~ few ps
Φ ~ 80 µm

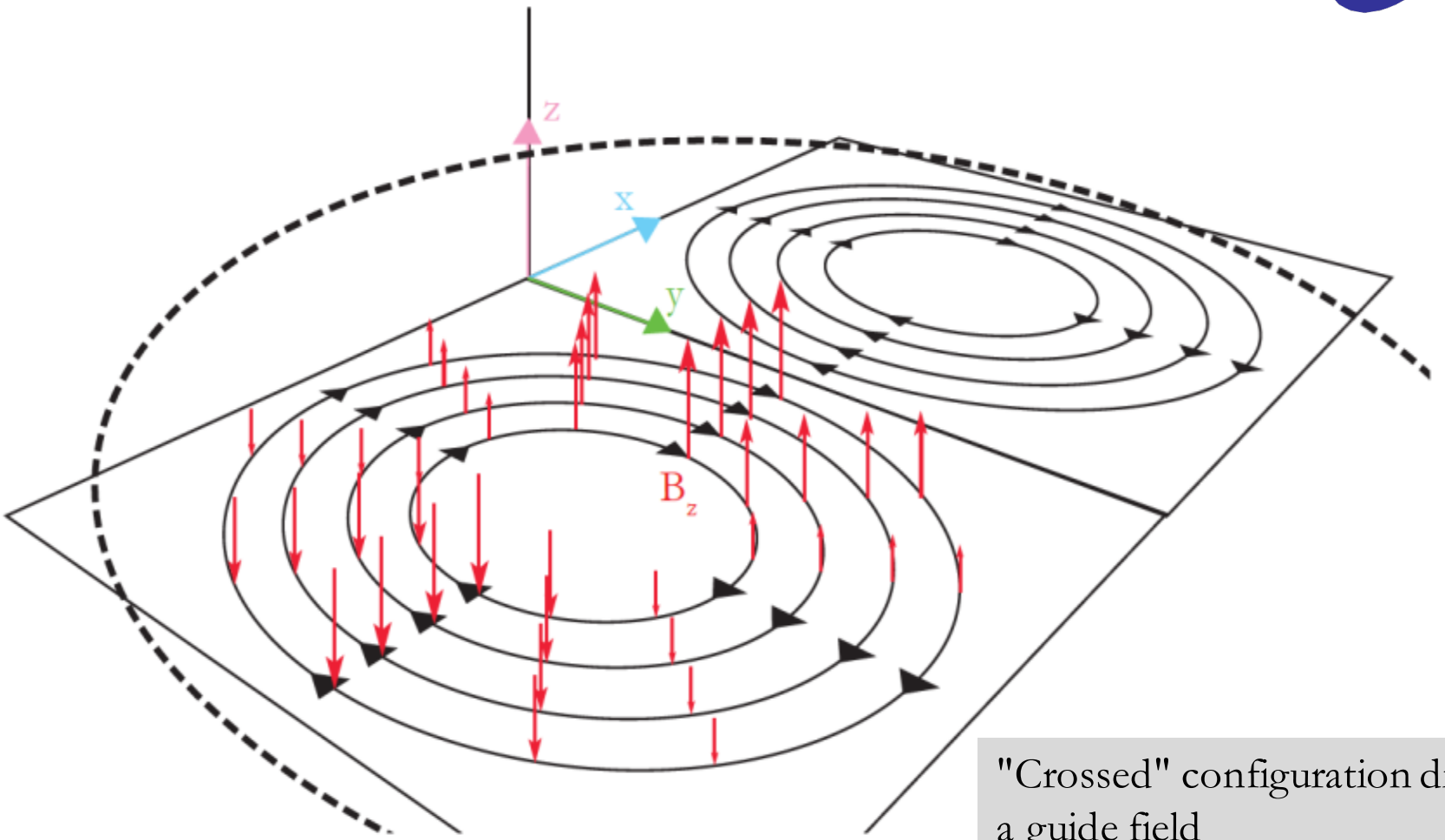
Proton beam used for proton-radiography

Nano beam 1&2:
E = 200 J
Δt = 5 ns
Φ = 80 µm

Main diagnostics :

- Proton-radiography
- Particle spectrometer
- X/UV spectrometer
- SOP (self-optical pyrometry)

Tilting the targets allows to investigate the effect of the guide-field



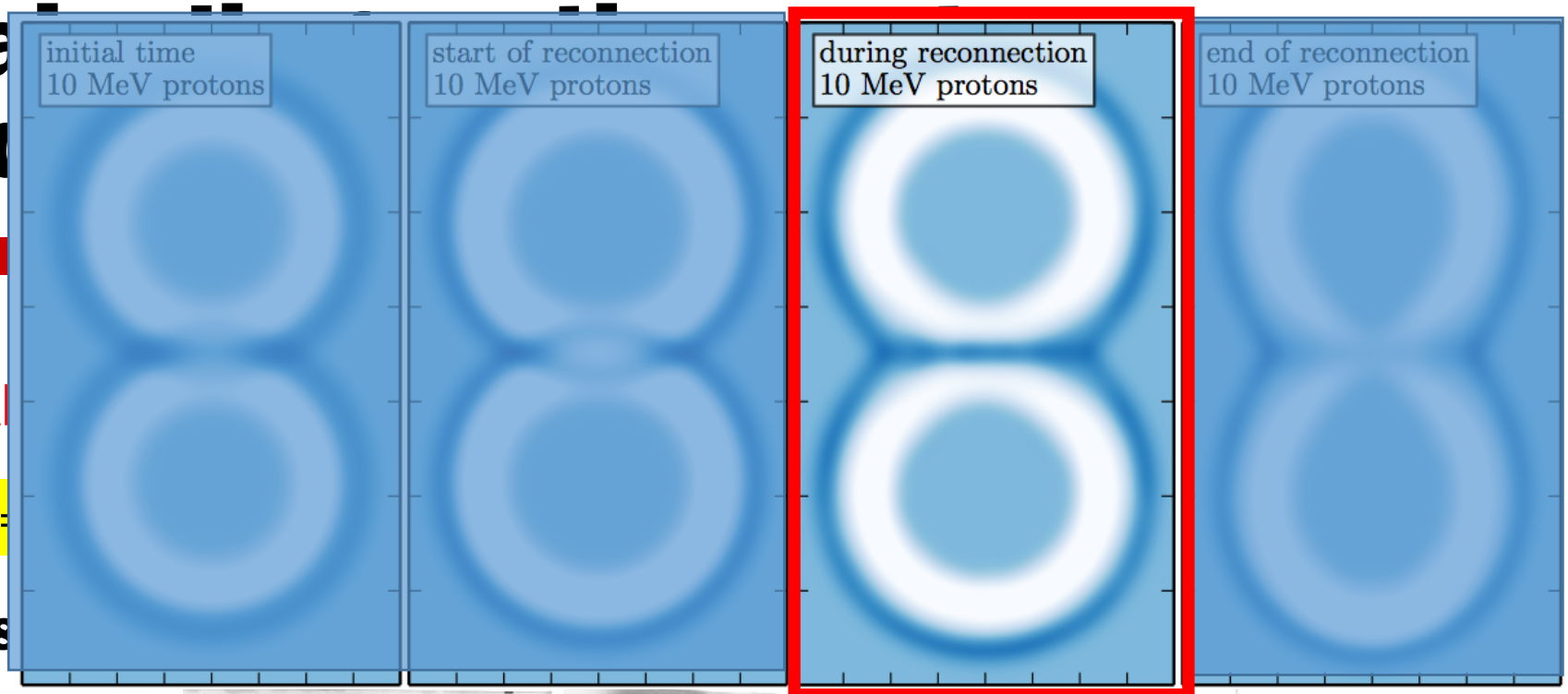
"Crossed" configuration displays a guide field

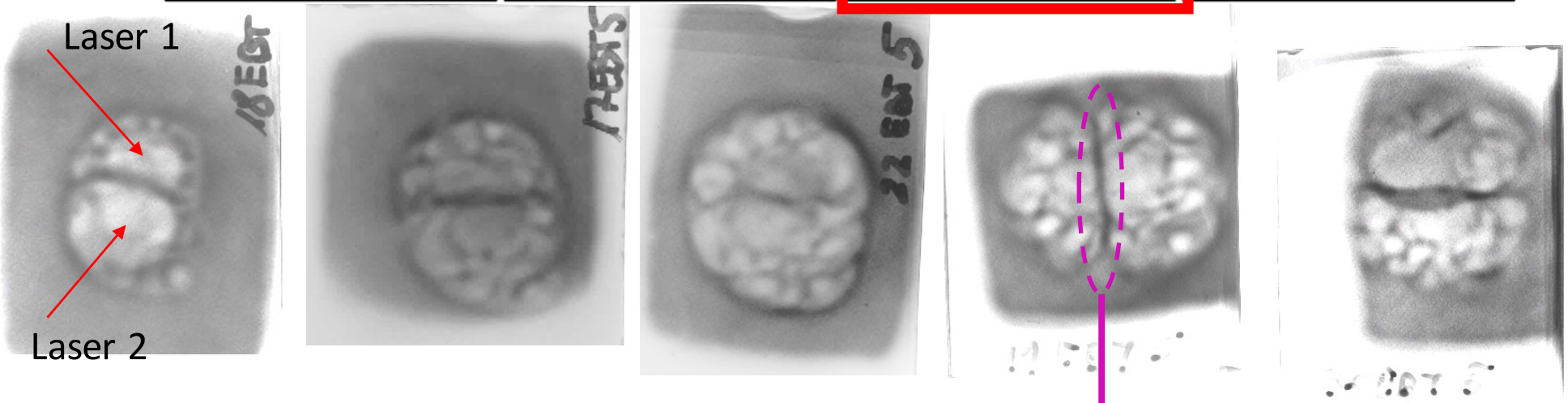
Ma
rac

PLA

θ =

t = 0.8

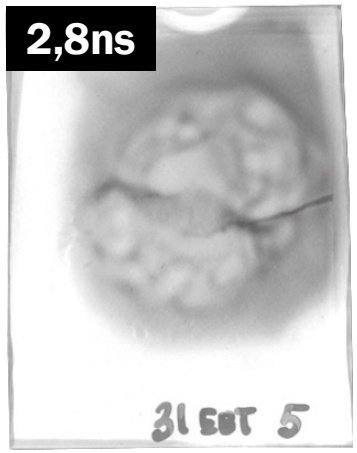


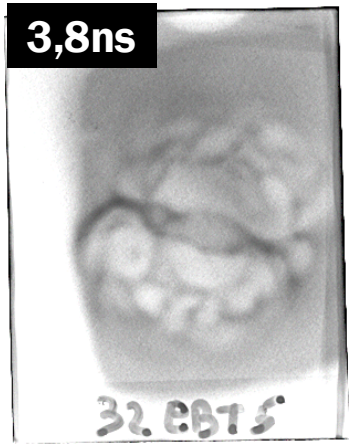


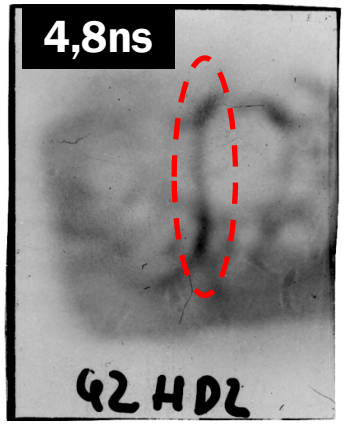
Dark surface are the results of the deposited energy from the protons in Radiochromic films (RCF)

Dark line comes from accumulation of deflected protons by the B field

Introducing a guide field slows down the reconnection



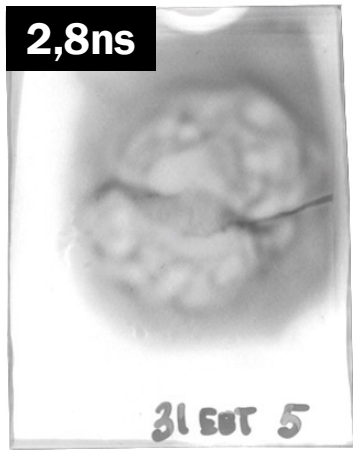


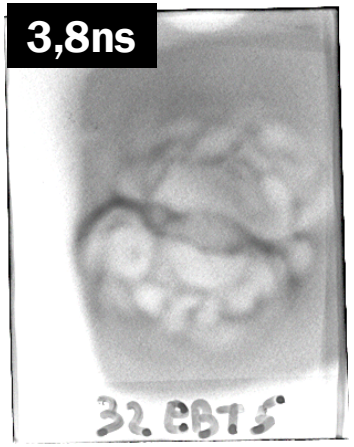


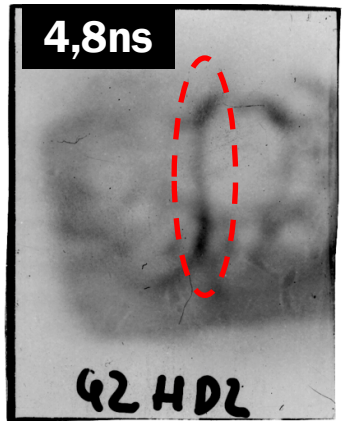
$\theta = 15°$

MR is triggered at this time according to the compression of the deflected protons

Introducing a guide field slows down the reconnection







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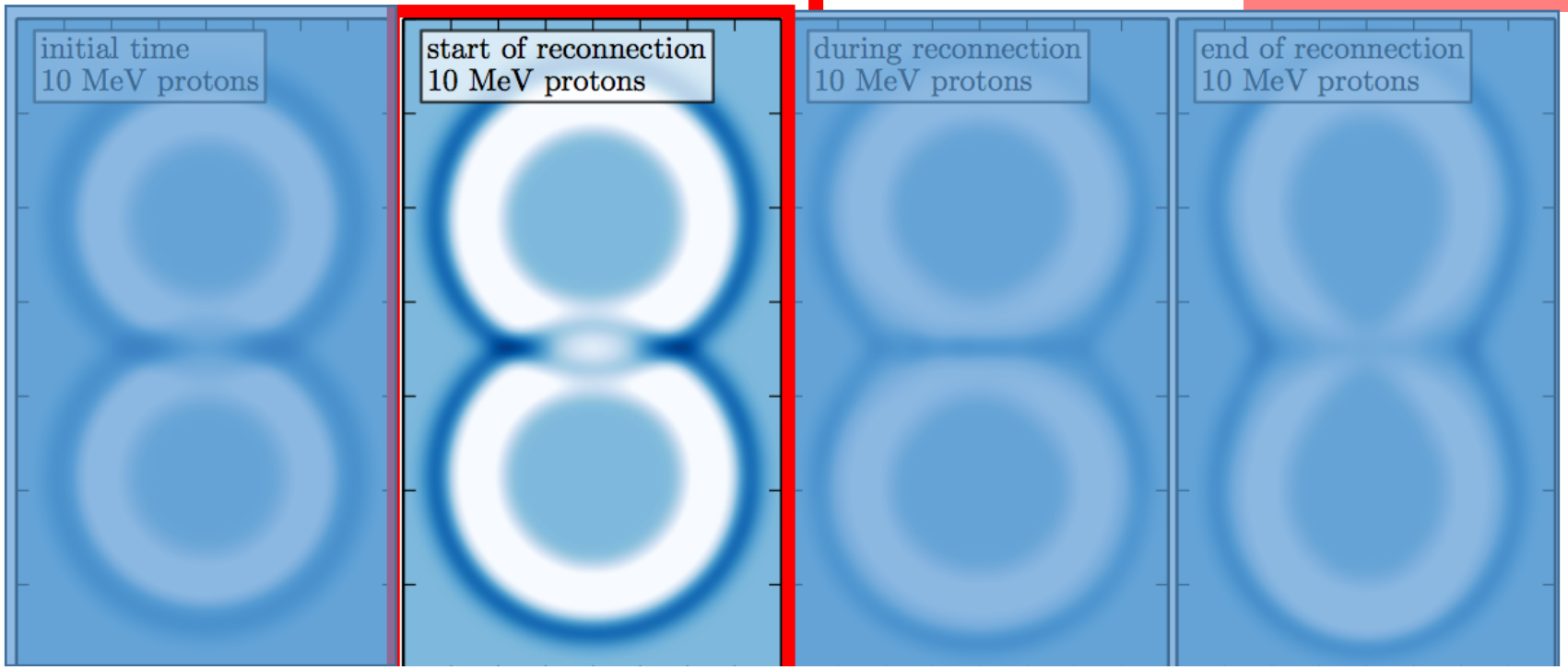
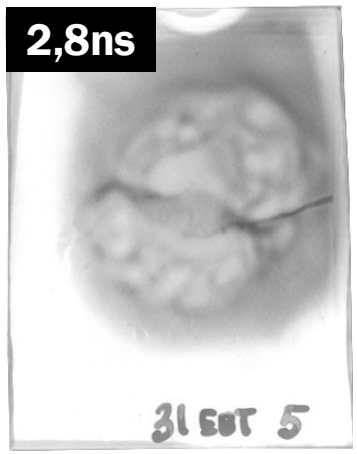
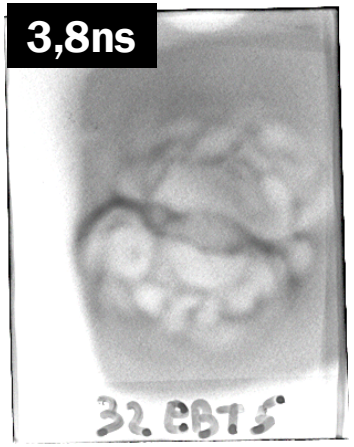
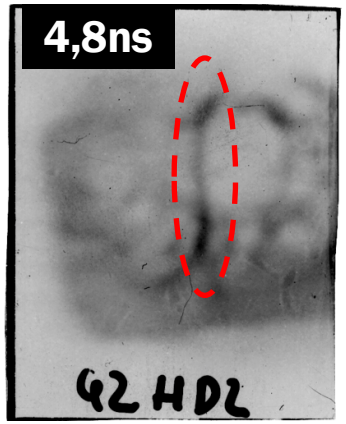


ducing a guide field slows down the nnection







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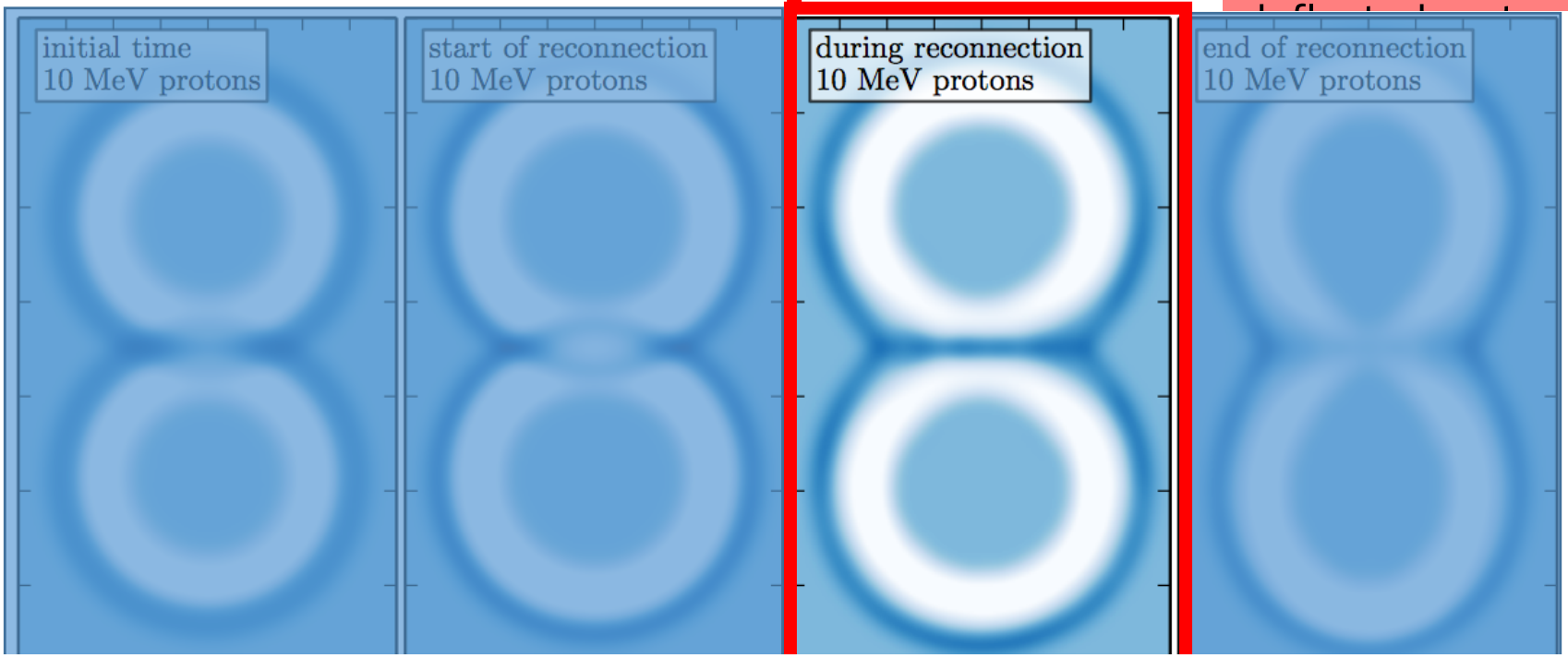
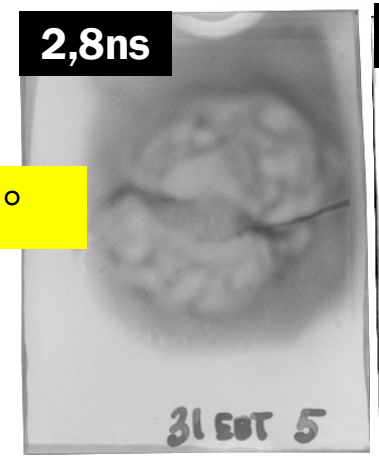
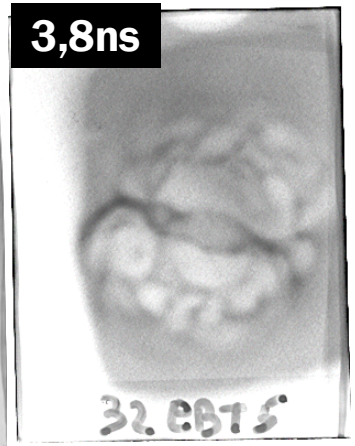
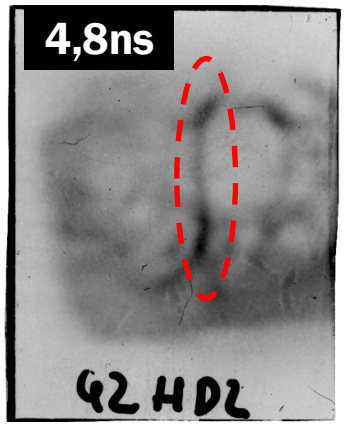


Gets more pronounced at larger angle

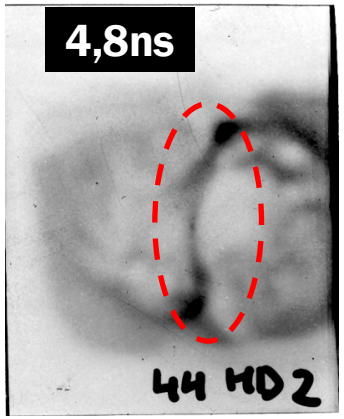
$\theta = 15°$





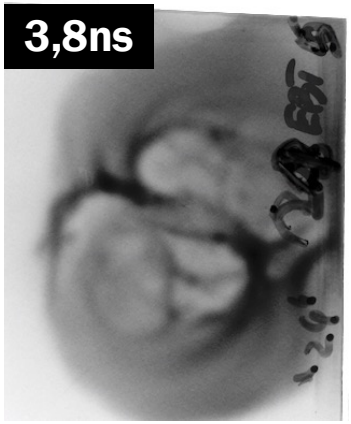


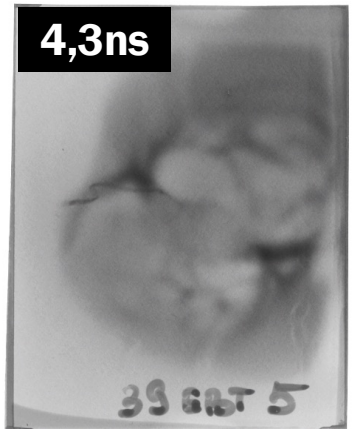
$\theta = 30°$



MR is triggered at this time according to the compression of the deflected protons

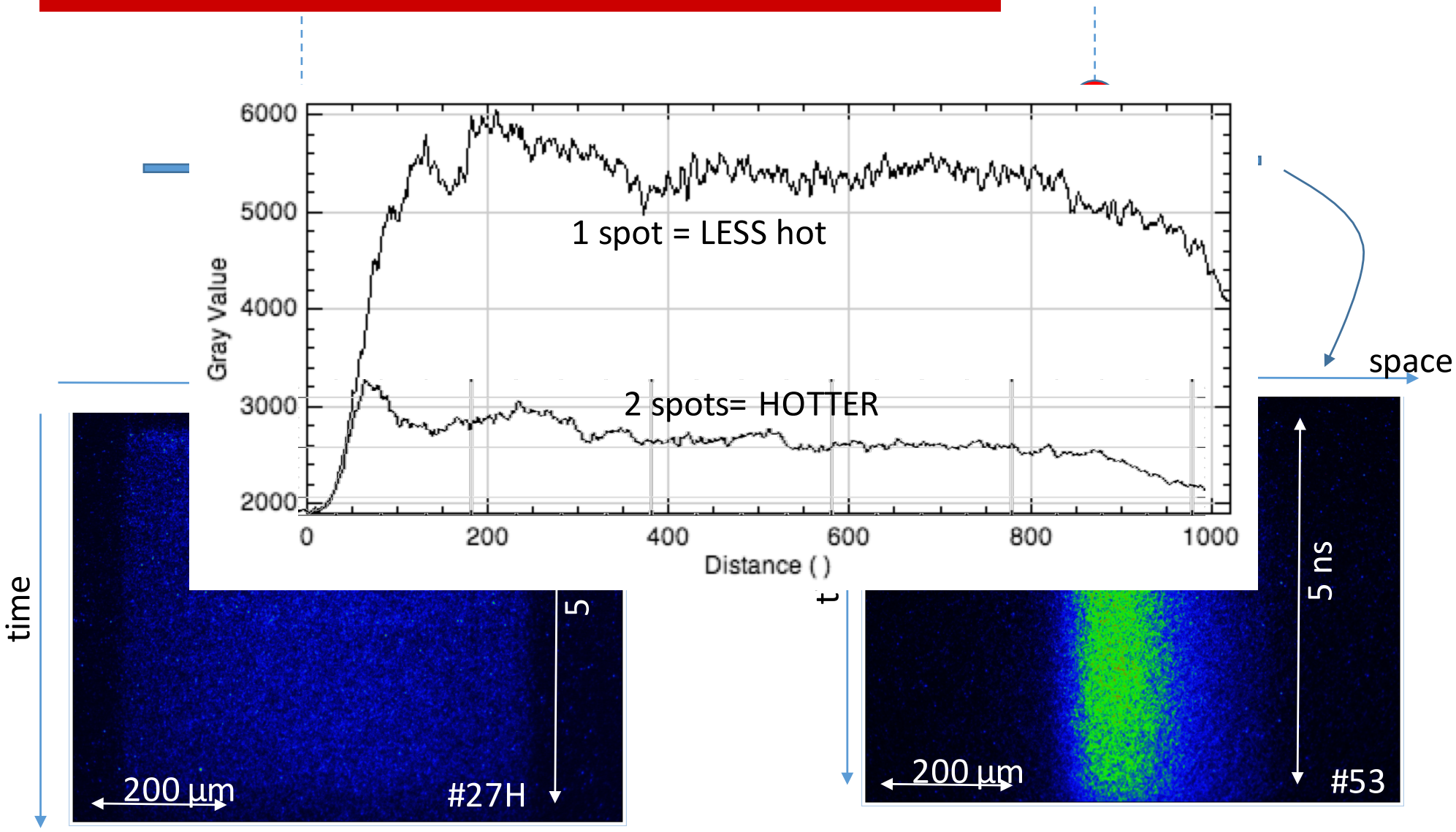
$\theta = 45°$



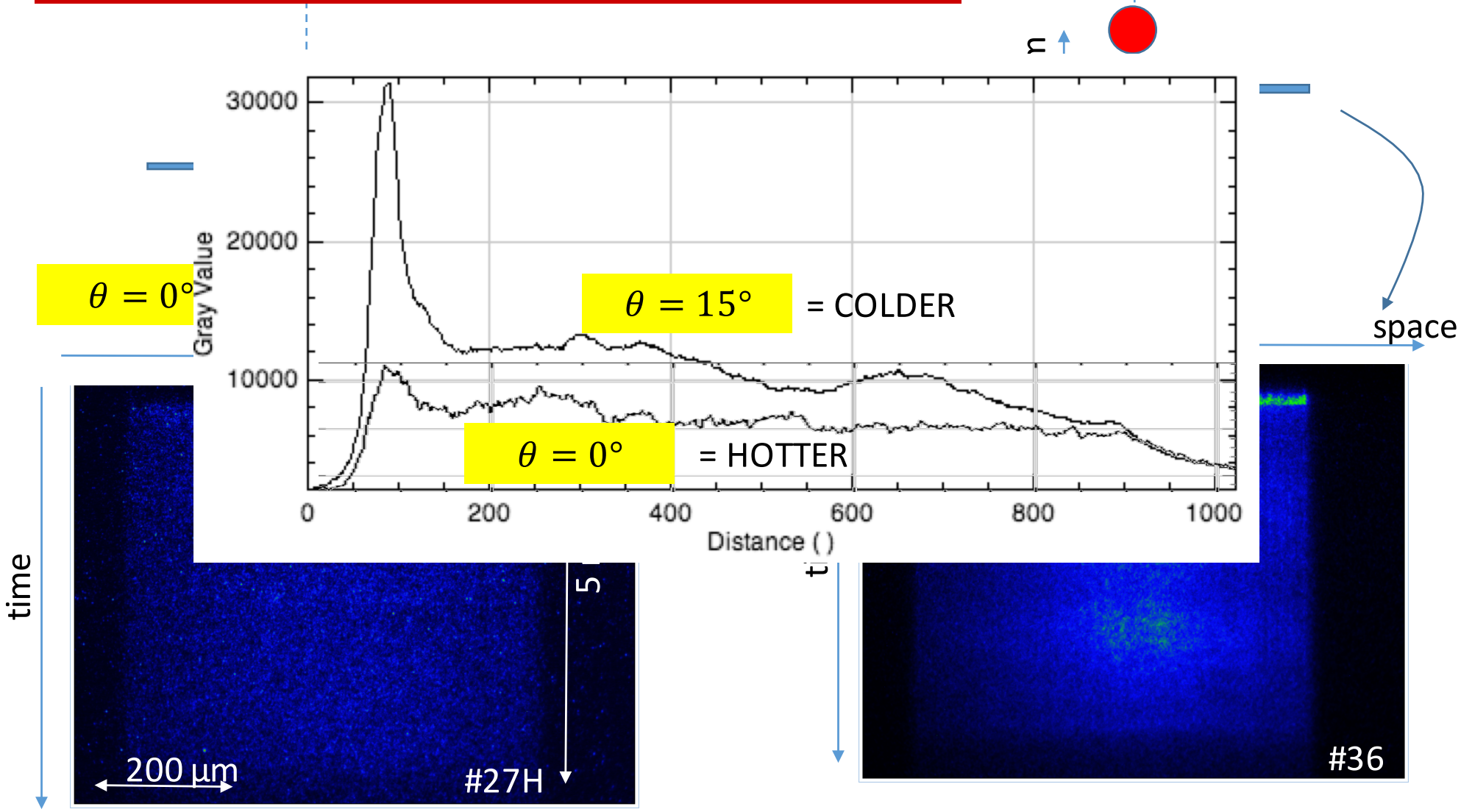


At $\theta = 45°$, the MR doesn't have time to trigger

SOP data with 1 or 2 laser spots (w/o guide-field)



SOP data w/o and with guide-field



Conclusion

- Experiment shows that it takes more time to trigger MR than predicted
- In present simulations, we do not observe drastic effect of the initial angle → under investigation
- Other diagnostics are being unfolded

- In Dec 2017, we will conduct shots at LMJ/Petal to investigate MR in a lower β regime