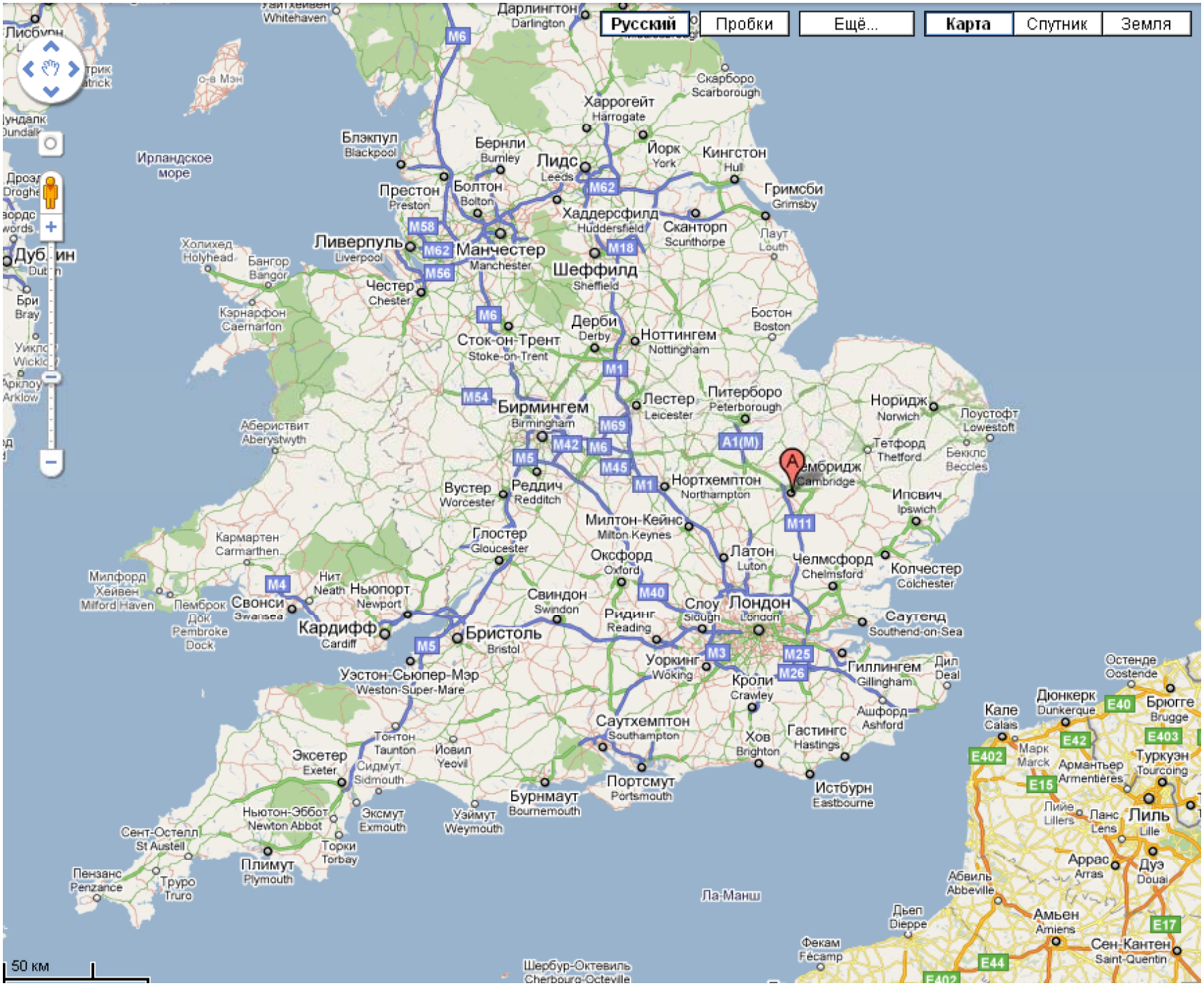
UNIVERSITY OF CAMBRIDGE

Фонд Дмитрия Зимина
Династия

Cavendish laboratory

Studying Photophysics of Solar Cells at "Working Conditions"

Artem Bakulin


Русский
Пробки
Ещё...
Карта
Спутник
Земля
Дарлингтон
Darlington
Whitehaven
Скарборо
Scarborough
Харрогейт
Harrogate
Блэкпул
Blackpool
Бернли
Burnley
Лидс
Leeds
Йорк
York
Кингстон
Hull
Гримсби
Grimsby
Ирландское море
Престон
Preston
Болтон
Bolton
Хаддерсфилд
Huddersfield
Сканторп
Scunthorpe
Лаут
Louth
Холихед
Holyhead
Бангор
Bangor
Ливерпуль
Liverpool
Манчестер
Manchester
Шеффилд
Sheffield
Честер
Chester
Кэрнарфон
Caernarfon
Дерби
Derby
Ноттингем
Nottingham
Бостон
Boston
Сток-он-Трент
Stoke-on-Trent
Бирмингем
Birmingham
Лестер
Leicester
Питерборо
Peterborough
Норидж
Norwich
Лоустофт
Lowestoft
Аберистви
Aberystwyth
Тетфорд
Thetford
Беккле
Beccles
Кембридж
Cambridge
Вустер
Worcester
Реддич
Redditch
Нортхемптон
Northampton
Ипсвич
Ipswich
Милтон-Кейнс
Milton Keynes
Кармартен
Carmarthen
Глостер
Gloucester
Оксфорд
Oxford
Латон
Luton
Челмсфорд
Chelmsford
Колчестер
Colchester
Милфорд Хейвен
Milford Haven
Пемброк Док
Pembroke Dock
Свонси
Swansea
Нит
Neath
Ньюпорт
Newport
Кардифф
Cardiff
Свиндон
Swindon
Слоу
Slough
Лондон
London
Саутенд
Southend-on-Sea
Бристоль
Bristol
Рединг
Reading
Уоркинг
Woking
Гиллингем
Gillingham
Дил
Deal
Уэстон-Сьюпер-Мэр
Weston-Super-Mare
Кроли
Crawley
Остенде
Oostende
Дюнкерк
Dunkerque
Брюгге
Brugge
Кале
Calais
Ашфорд
Ashford
Саутхемптон
Southampton
Хов
Brighton
Гастингс
Hastings
Марк
Marck
Армантьер
Armentières
Туркуэн
Tourcoing
Эксетер
Exeter
Тонтон
Taunton
Йовил
Yeovil
Сидмут
Sidmouth
Портсмут
Portsmouth
Истбурн
Eastbourne
Бурнмаут
Bournemouth
Ньютон-Эббот
Newton Abbot
Эксмут
Exmouth
Уймут
Weymouth
Лилль
Lille
Лилль
Lillers
Ланс
Lens
Сент-Остелл
St Austell
Торки
Torbay
Плимут
Plymouth
Аррас
Arras
Дуэ
Douai
Пензанс
Penzance
Труро
Truro
Абвиль
Abbeville
Ла-Манш
Дьеп
Dieppe
Амьен
Amiens
Сен-Кантен
Saint-Quentin
Фекам
Fécamp
Шербур-Октевиль
Cherbourg-Octeville
50 км
M6
M62
M58
M56
M18
M1
M54
M69
M42
M5
M45
A1(M)
M11
M4
M40
M3
M25
M26
E40
E42
E402
E403
E15
E17
E44

Cavendish
laboratory

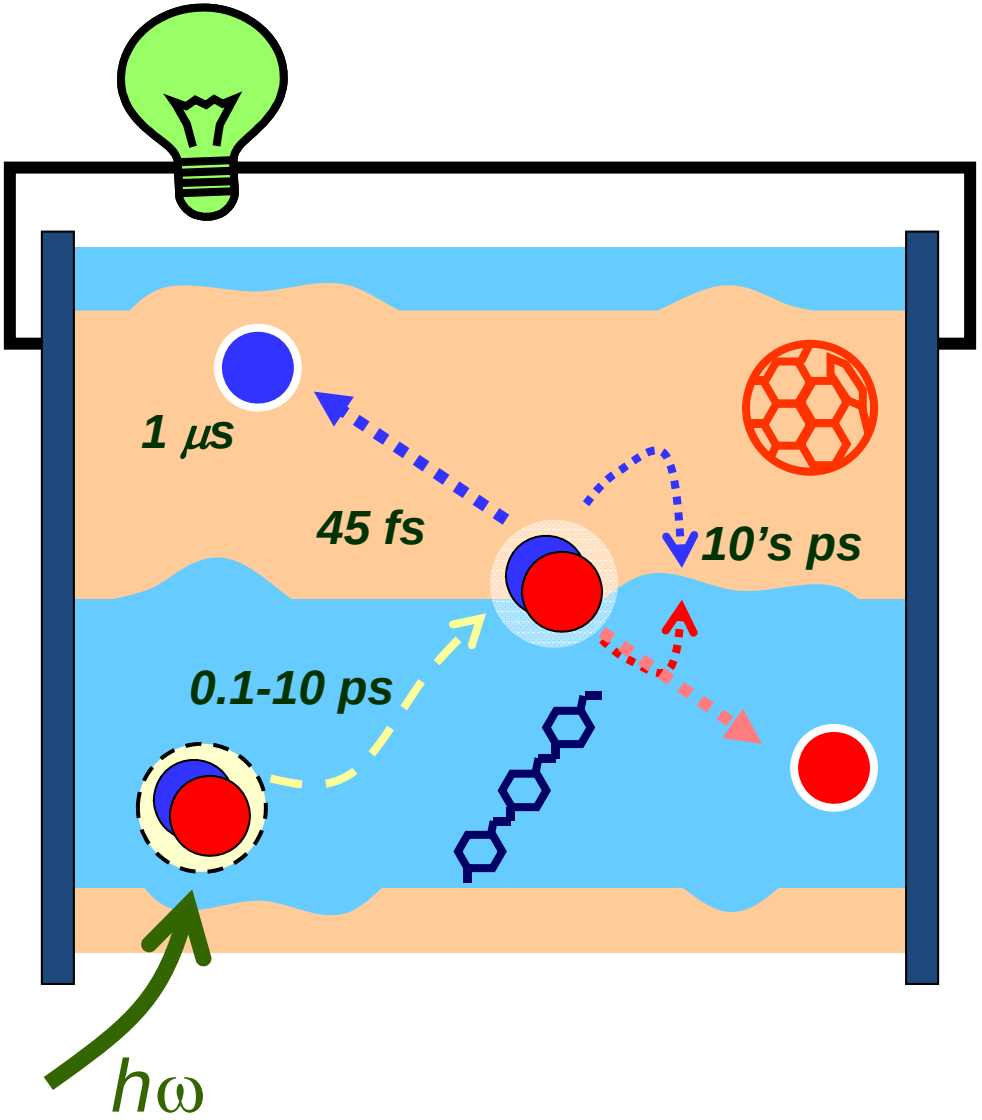
FASTLAB

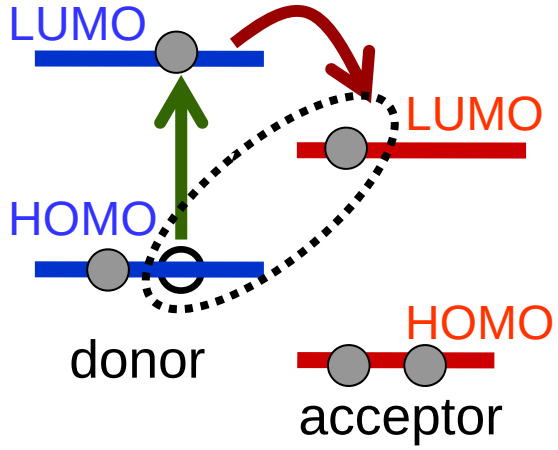
Why Do we need a new Laser Spectroscopy Instrument to study solar cells?

How does it work?

What are the research plans….

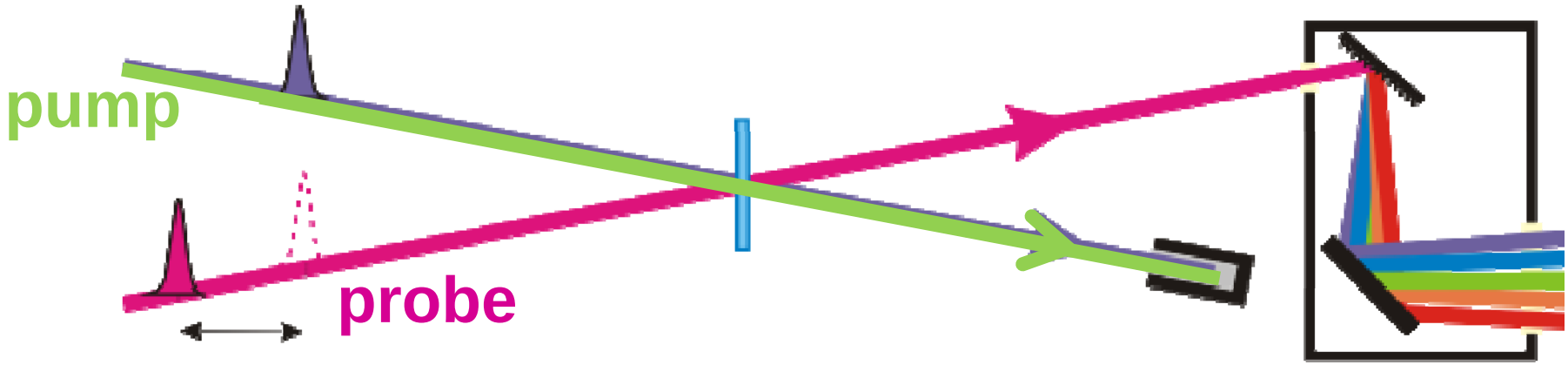
The bulk-heterojunction concept:

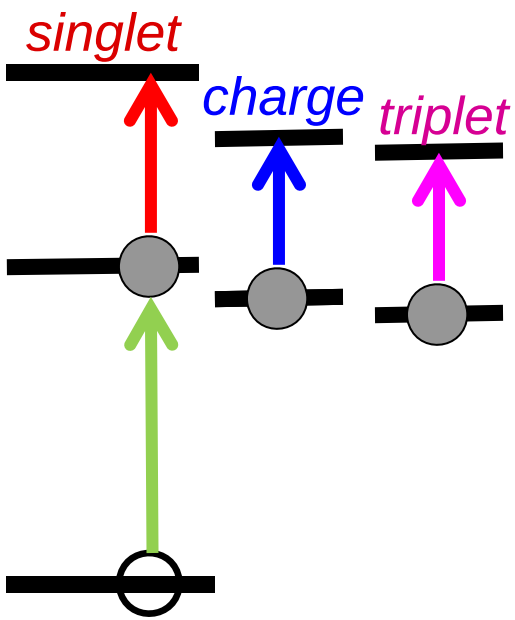


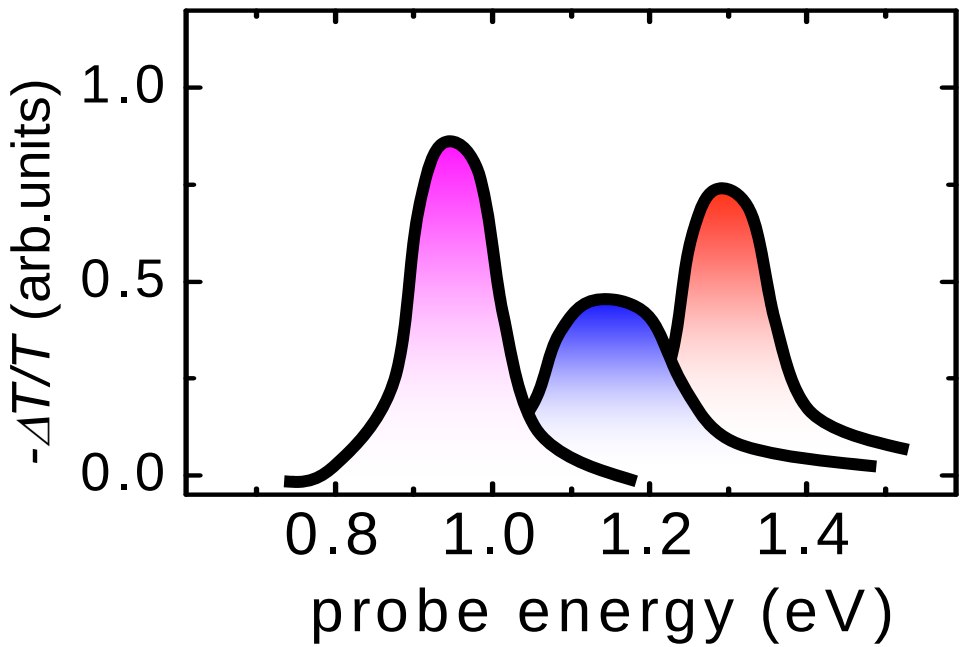


1. Optical excitation
2. Charge separation
3. Charge-transfer state
4. Recombination…
5. …Or Free charges

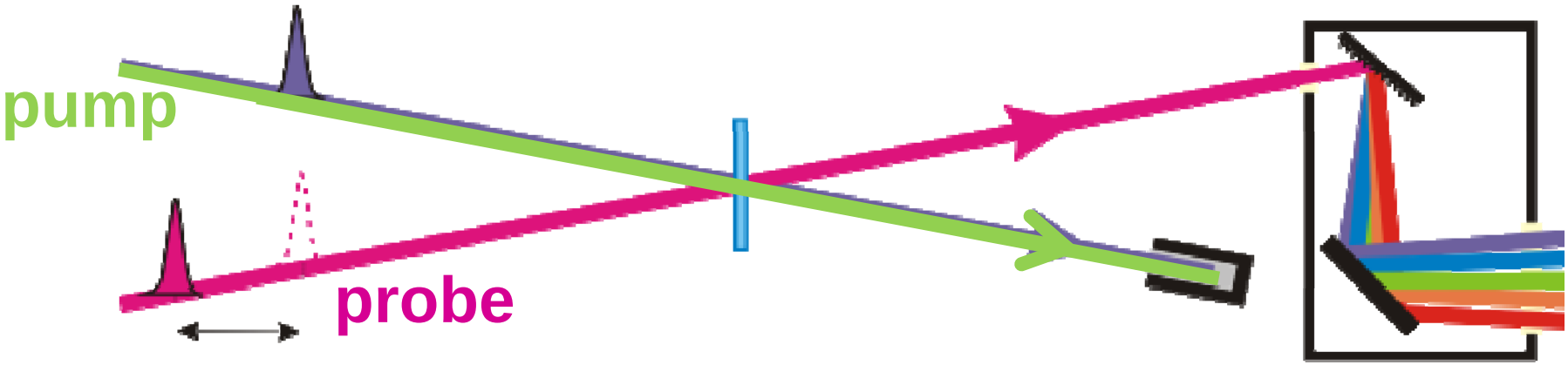
Transient Absorption Spectroscopy

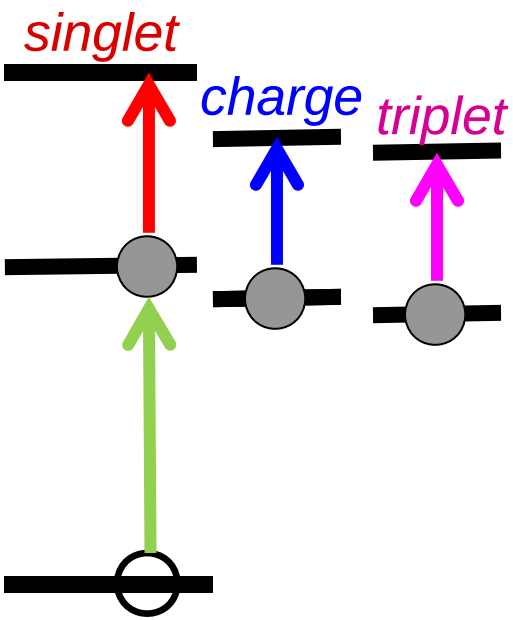


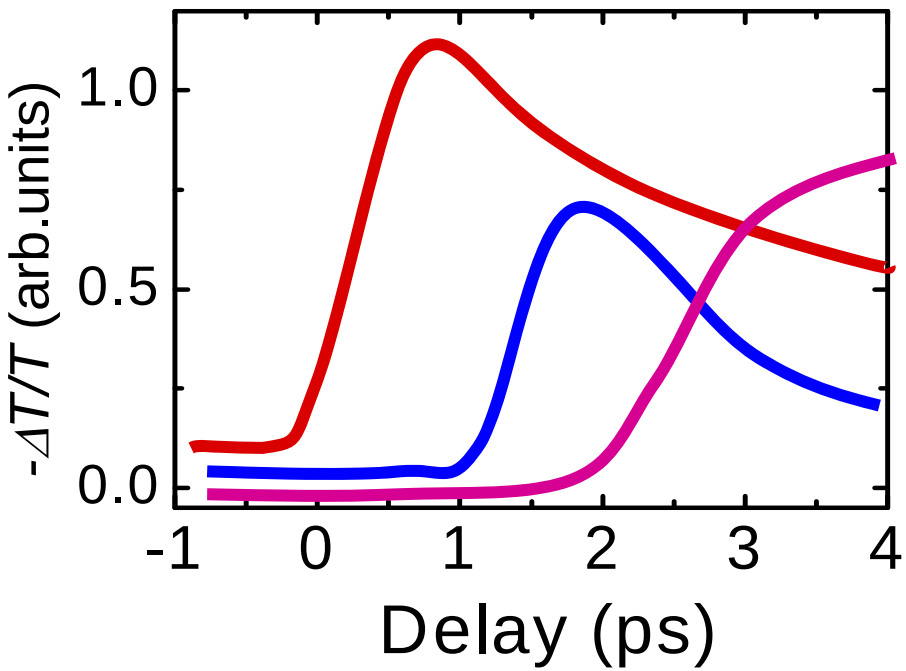




Transient Absorption Spectroscopy

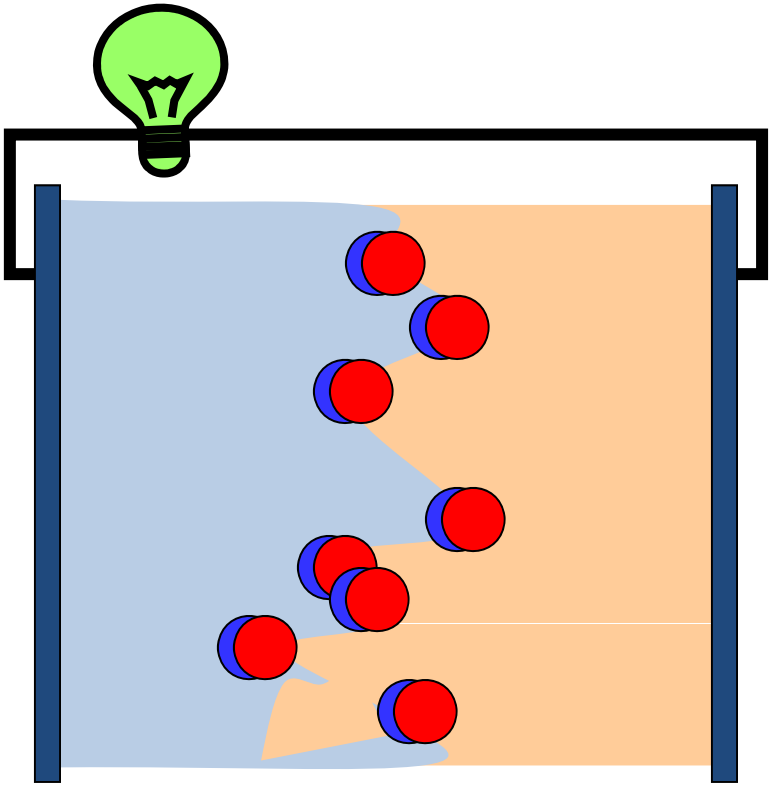


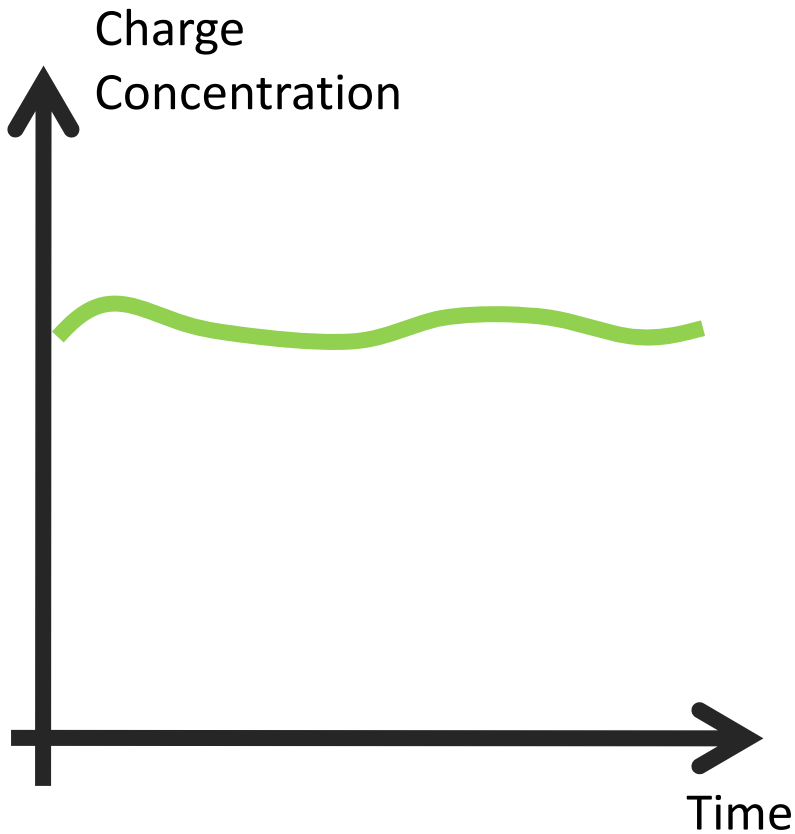




Can we measure dynamics of excitations at "working conditions" ?

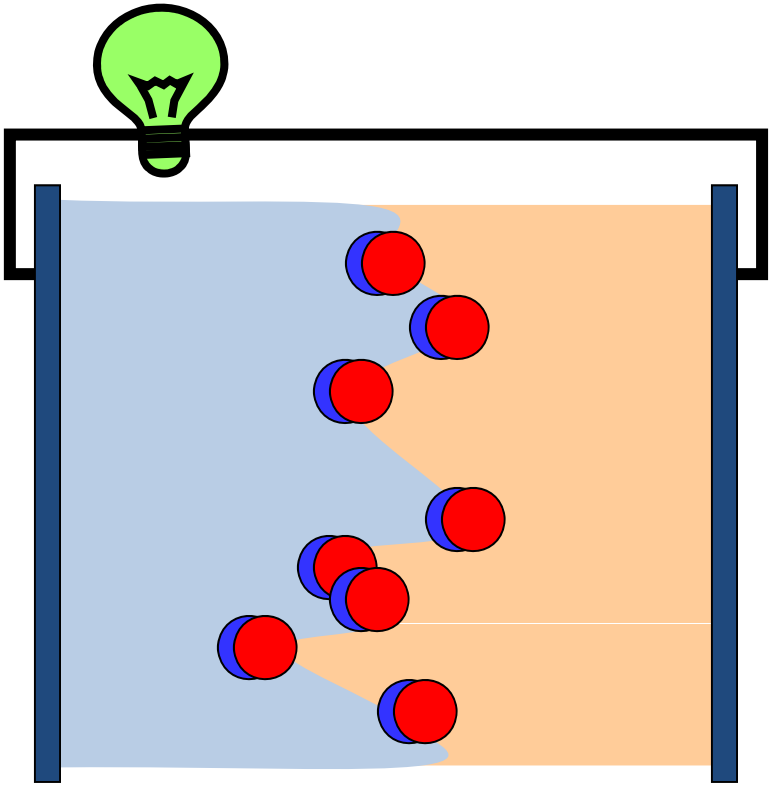
Excitation by the Sun

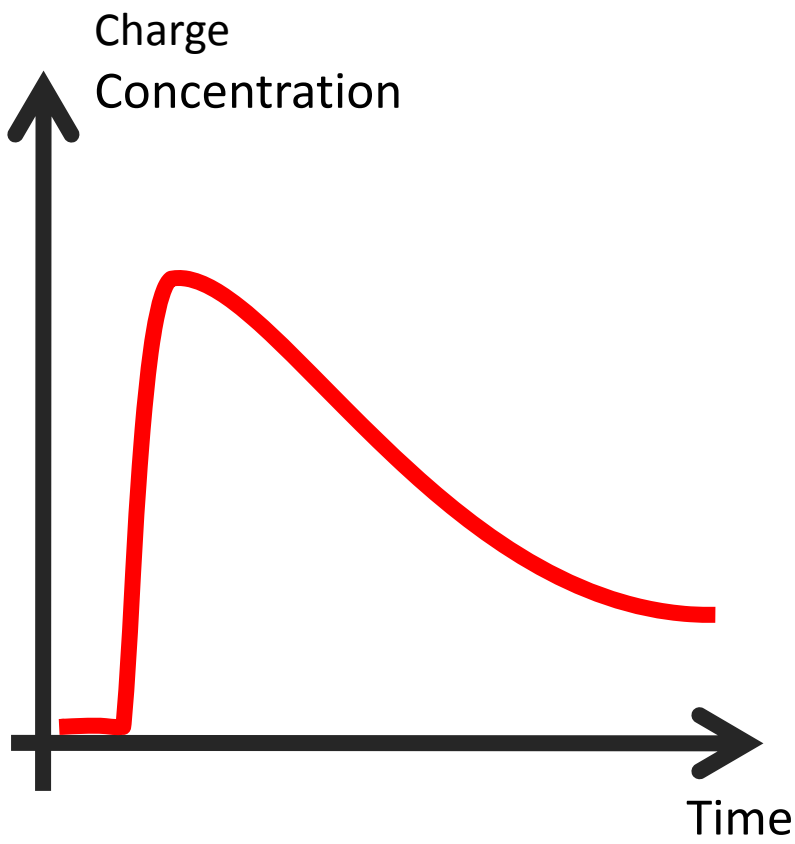




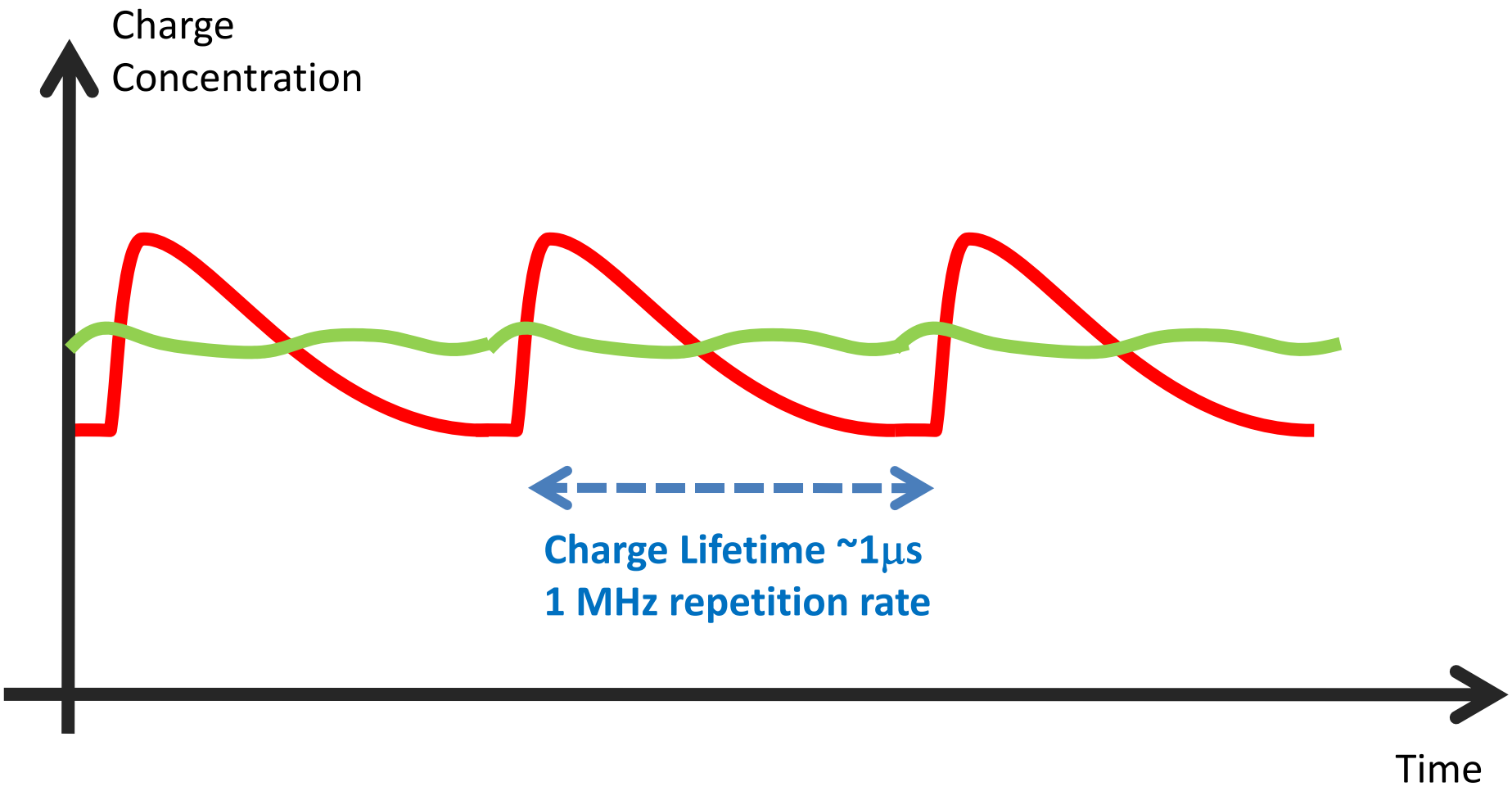
Can we measure dynamics of excitations at "working conditions" ?

Excitation by the Ultrafast Laser



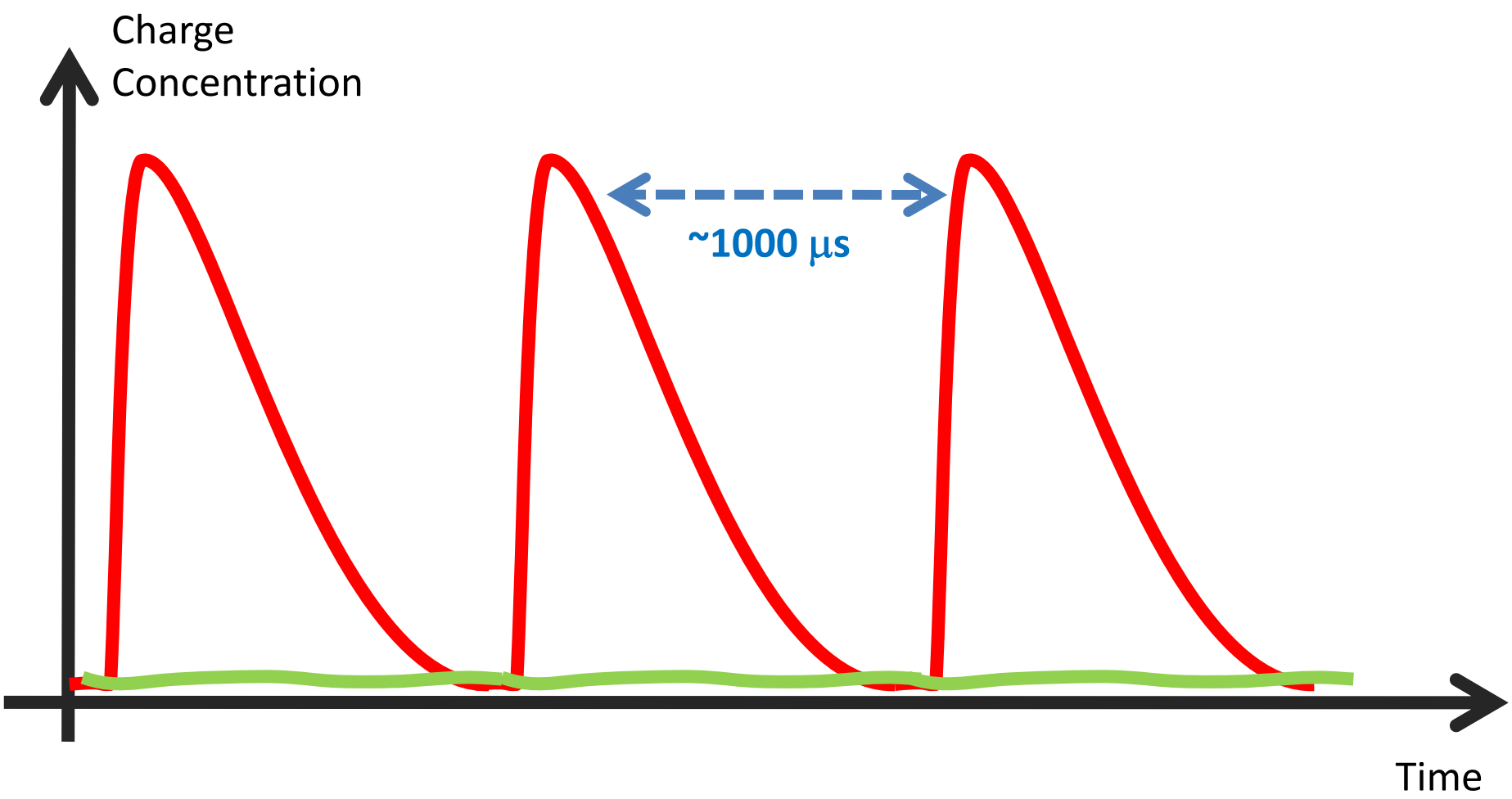


Measurements at quasi-"working conditions" ?

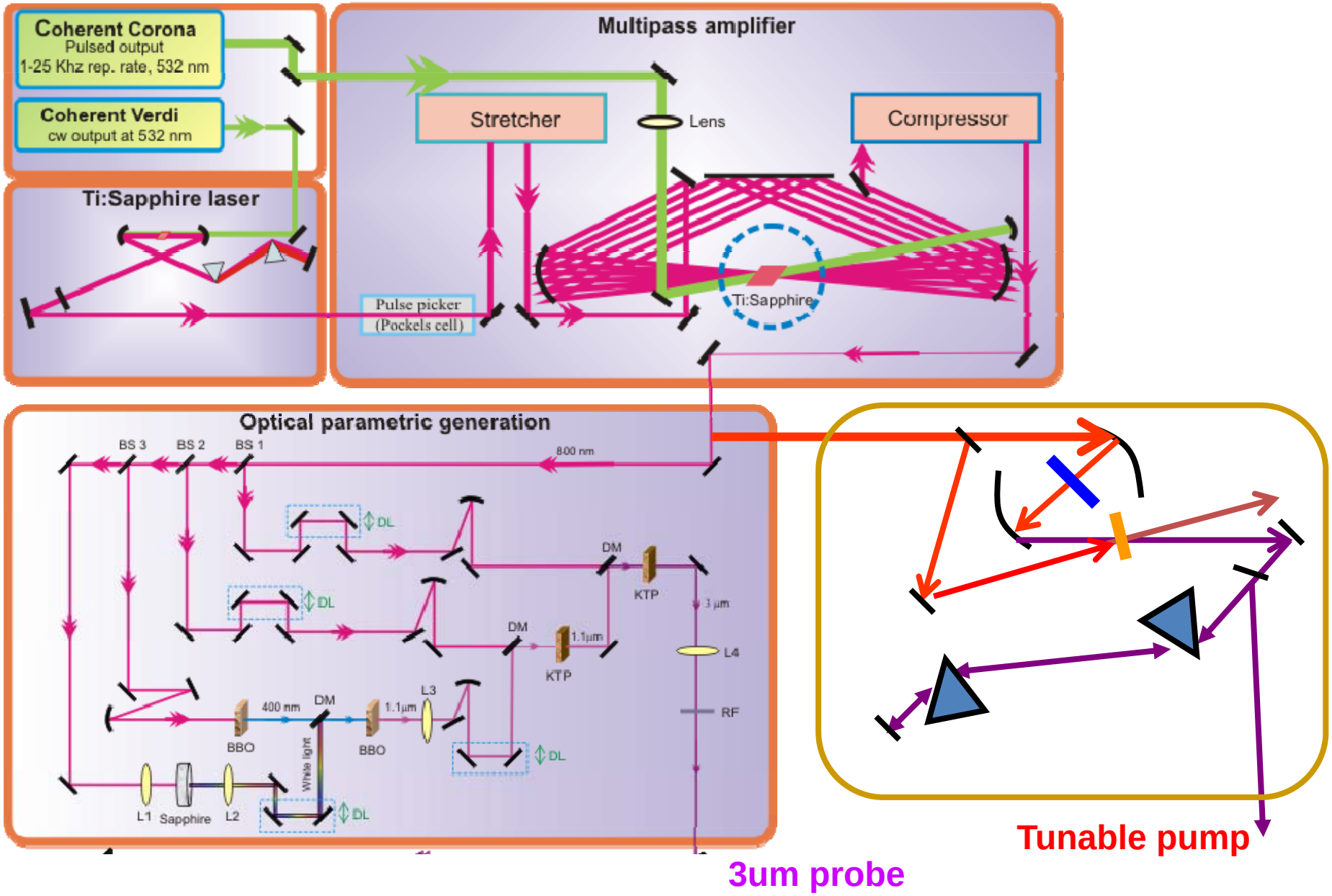


Current "lowest-flux" measurements

- Repetition rate 1kHz
- Concentration of charges fit **~100-20 Suns**

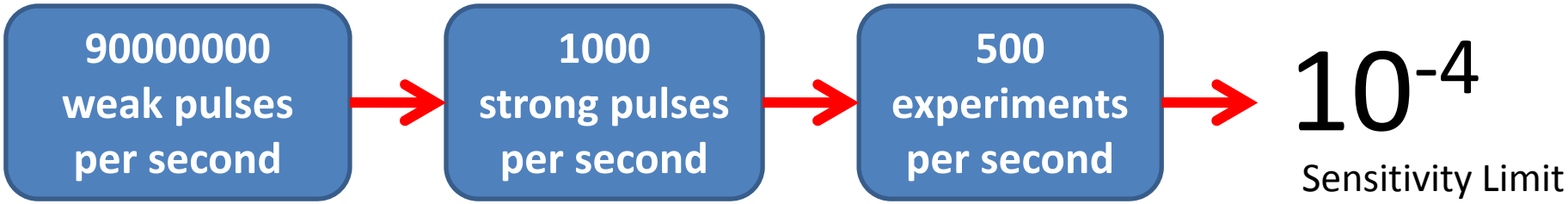


Vis (35 fs) – IR (70 fs) spectroscopy set-up

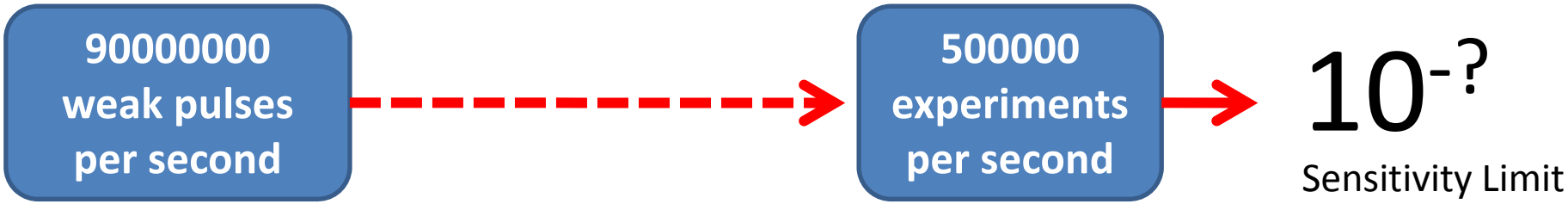


To measure at one sun intensity signal to noise should be improved by **100 times**...

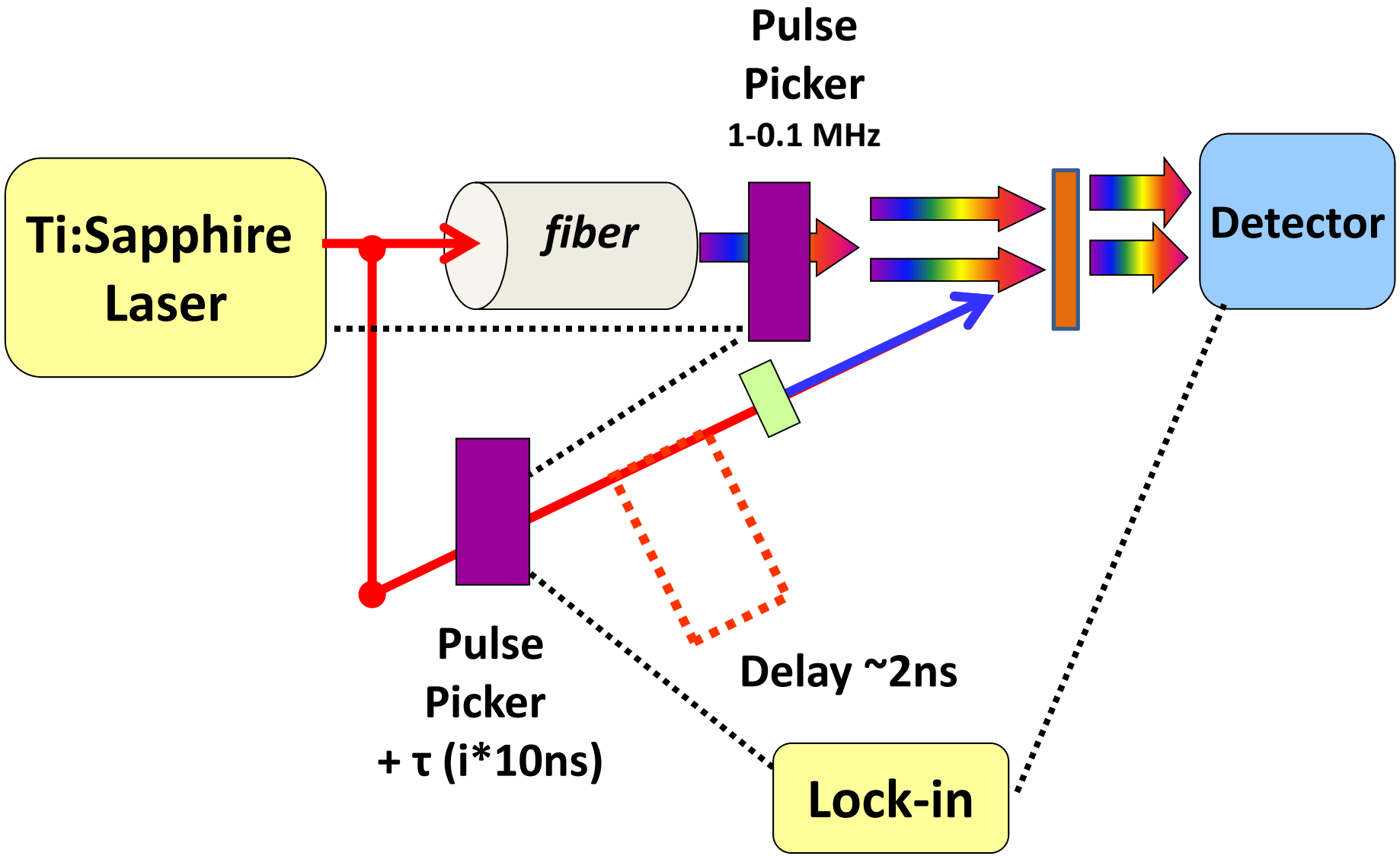
Typical 1-kHz spectrometer



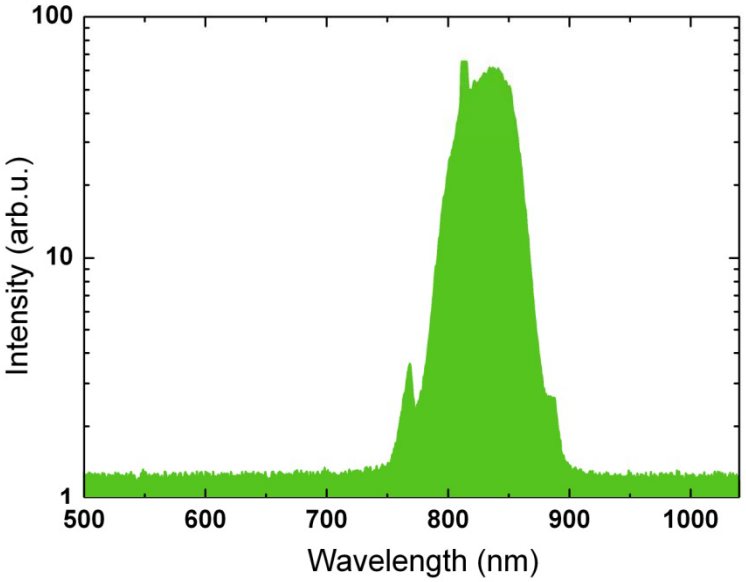
New High-repetition spectrometer

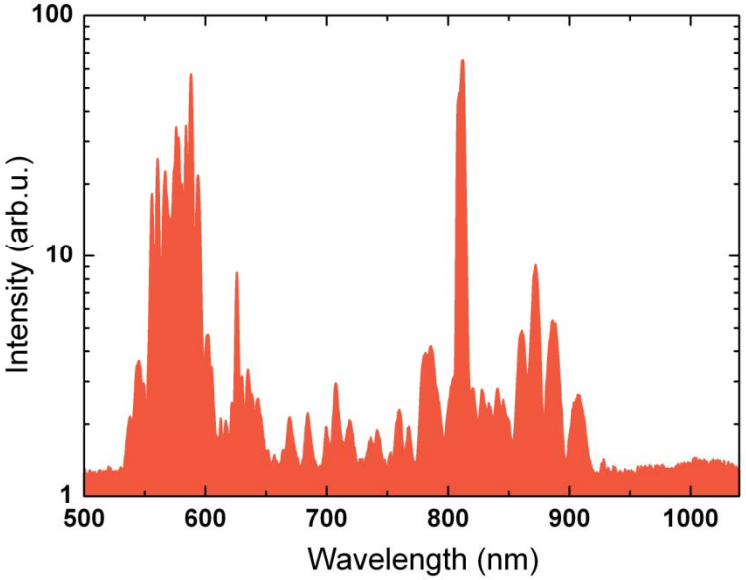


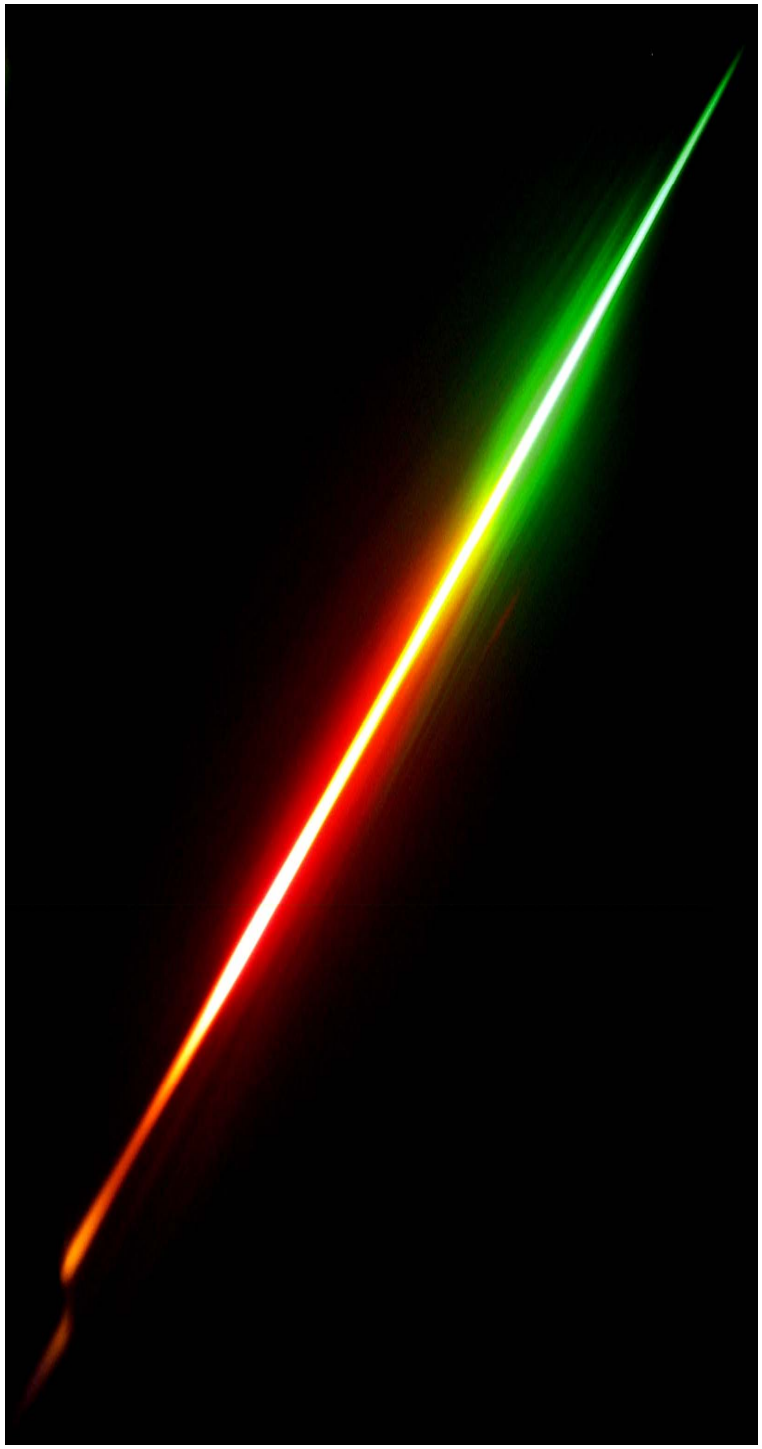
New spectrometer layout (plan)



Fibre White-Light Source

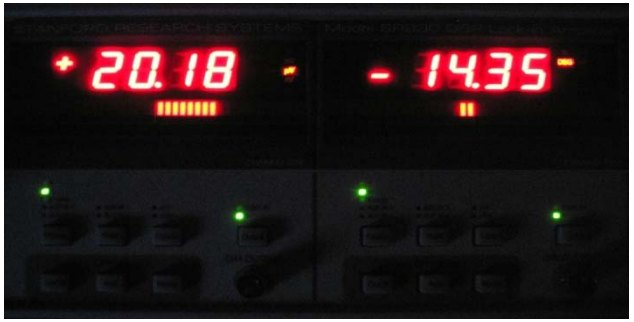






New spectrometer progress...

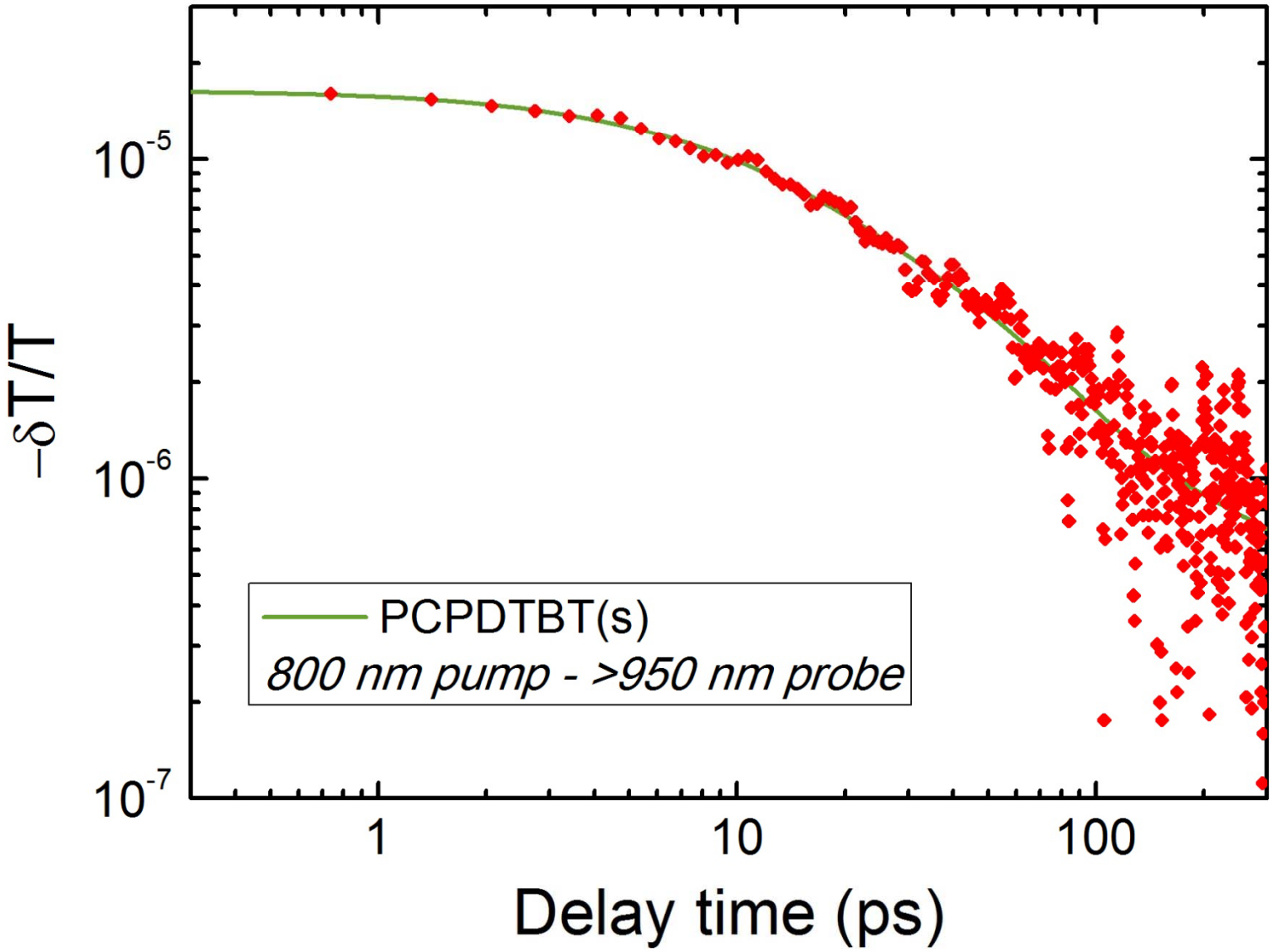
Good news



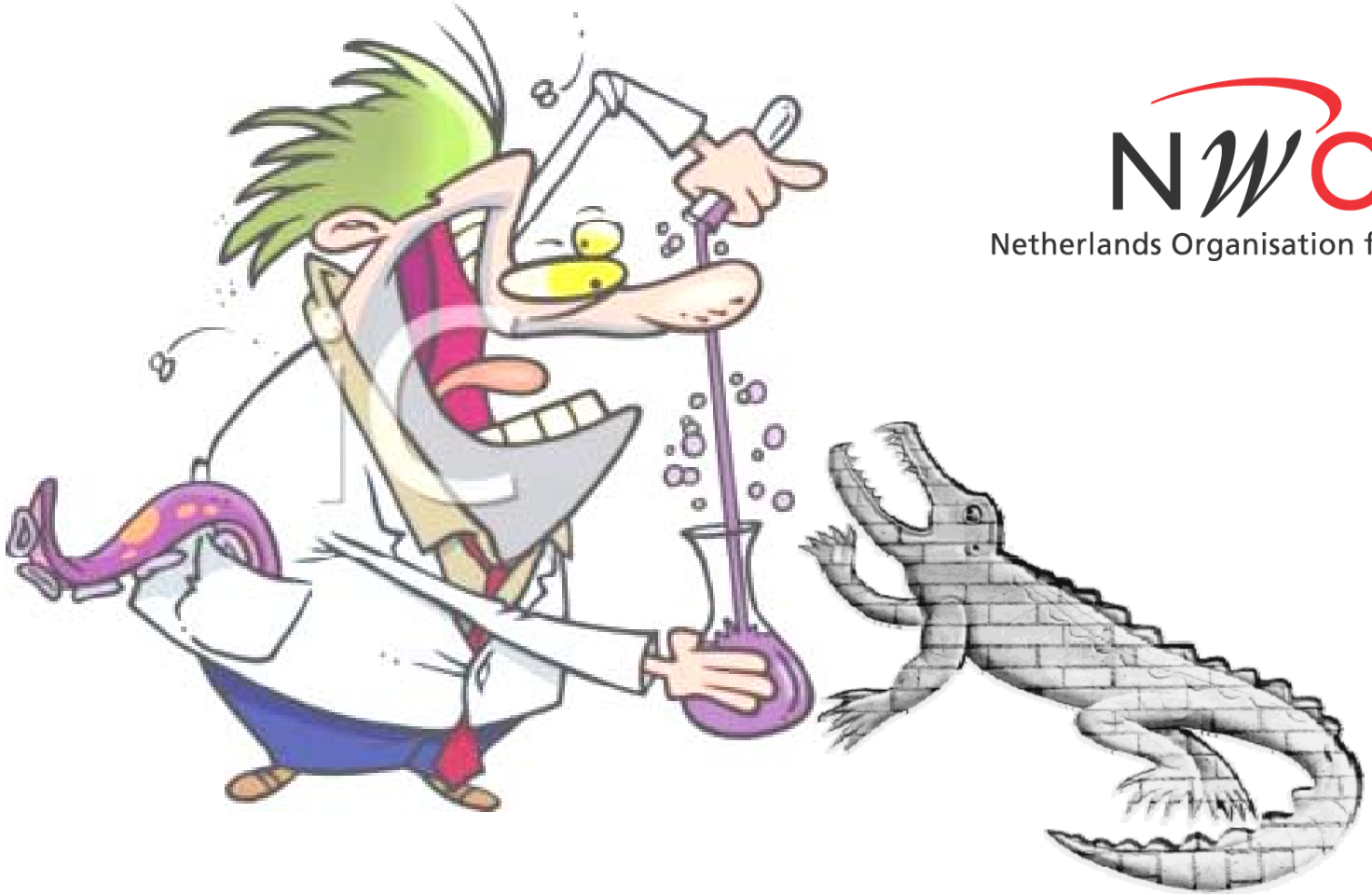
Signal ~ **$3^{*}10^{-6}$**
detected
at 0.5 Sun
excitation density

Bad news

No Music in the Fastlab

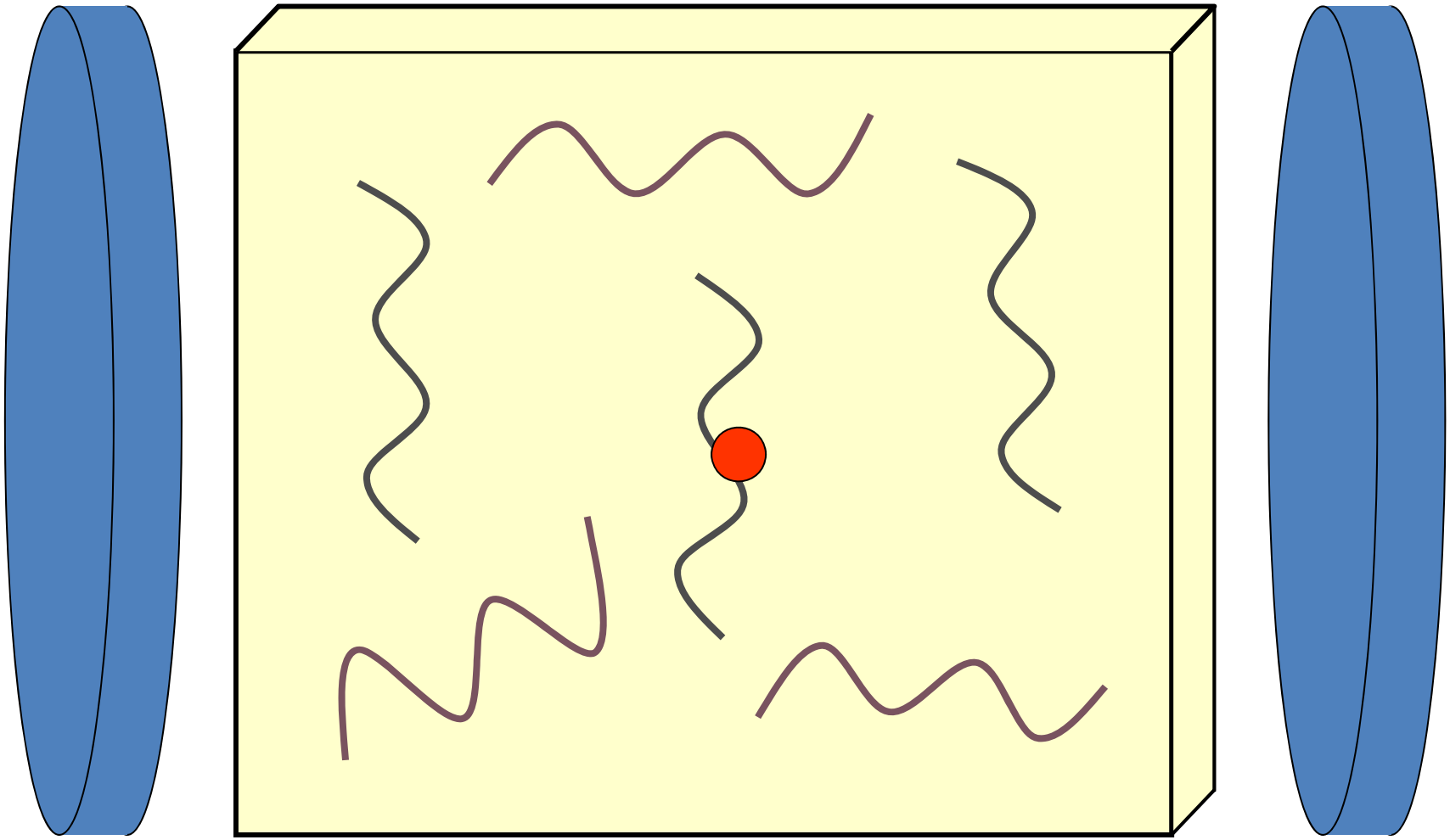

10^{-5}
10^{-6}
10^{-7}
$-\delta T/T$
1
10
100
Delay time (ps)
PCPDTBT(s)
800 nm pump - >950 nm probe

“Mad Scientist” Idea – watching charge transport in real time



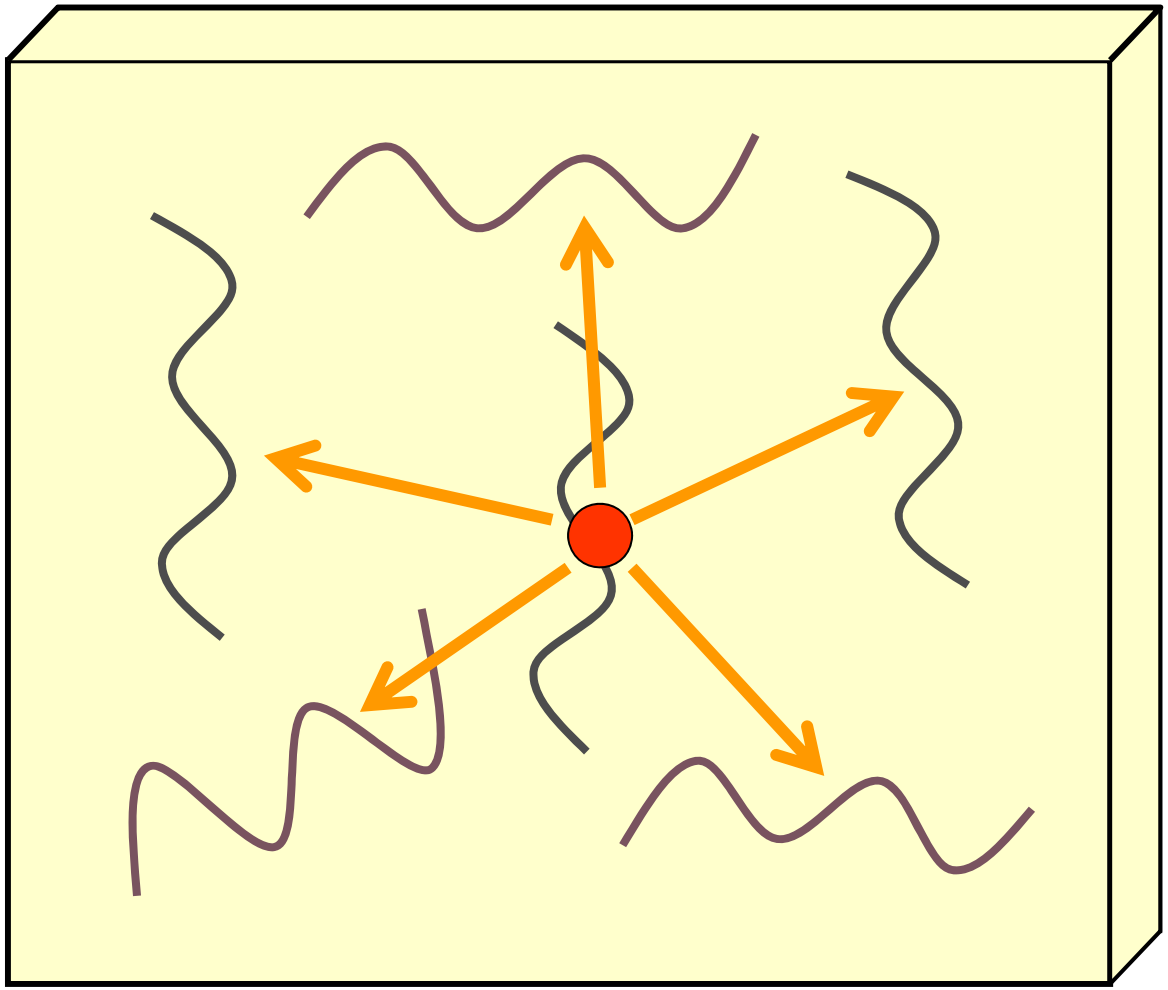
NWO
Netherlands Organisation for Scientific Research

What do we know about charge transport?



Conductivity **within chain** and through the **complete device**.

One can build a microscopic model



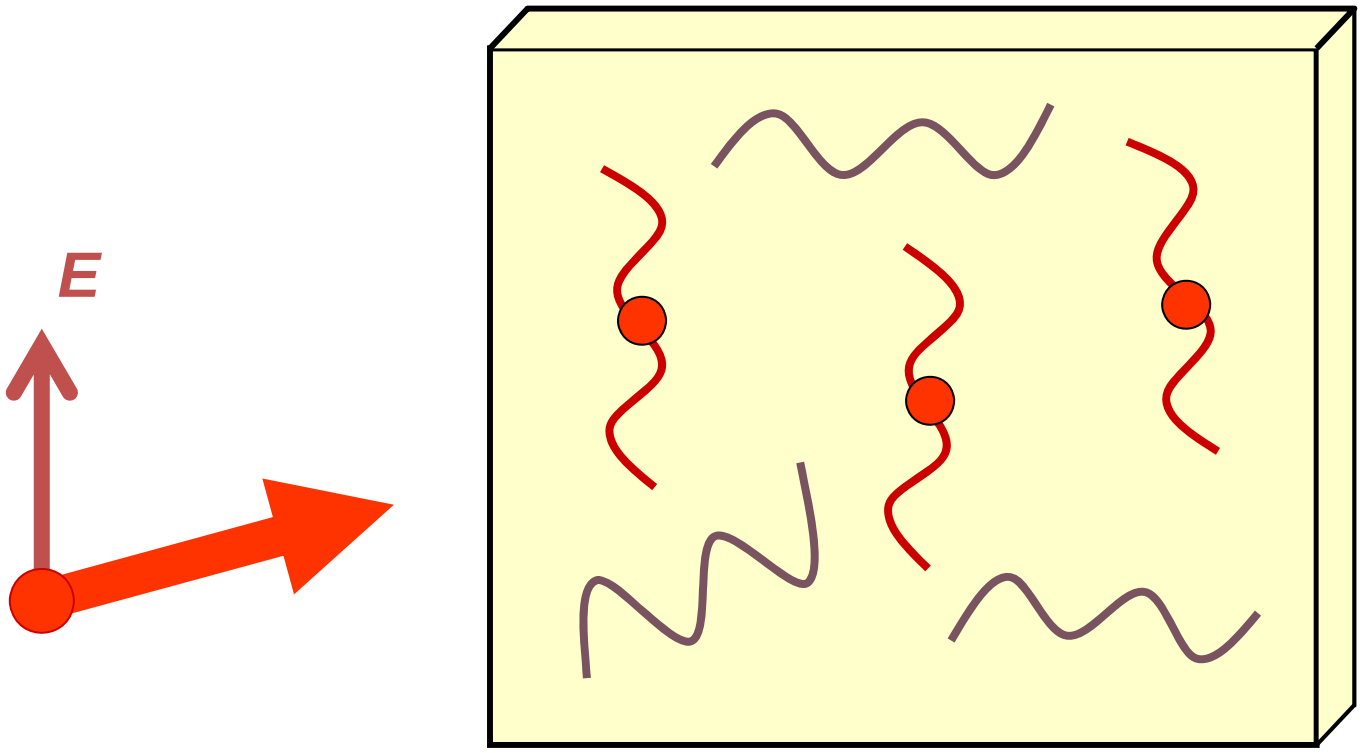
Distribution of states + hopping rates $V_{ij}(E,T,\ldots)$

Remember Nir's talk

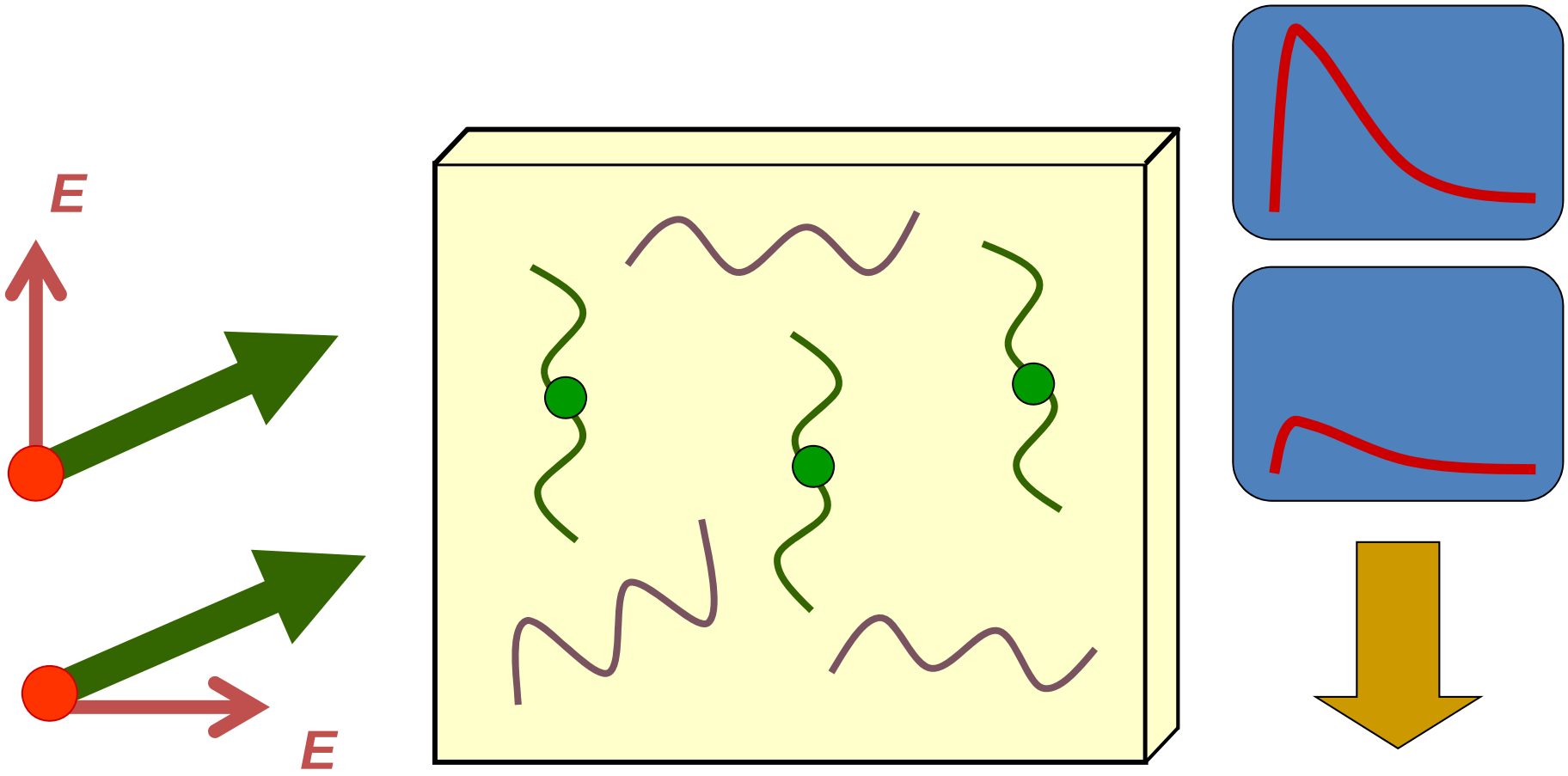
Can we **measure** the distribution of hopping rates?

$$V_{ij}(E, T, \ldots)$$

Polarization sensitive technique

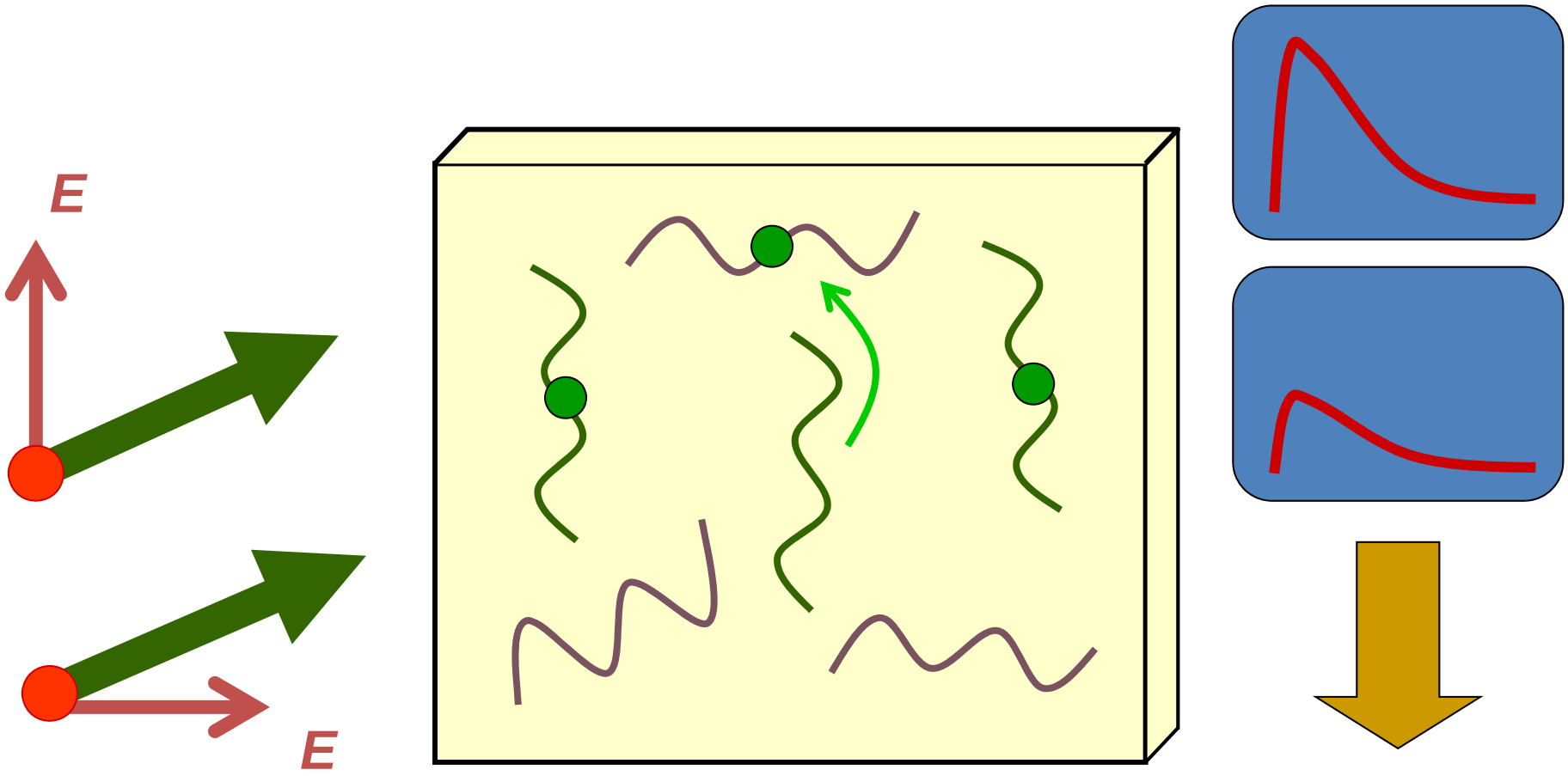


Polarization TA in CTCs



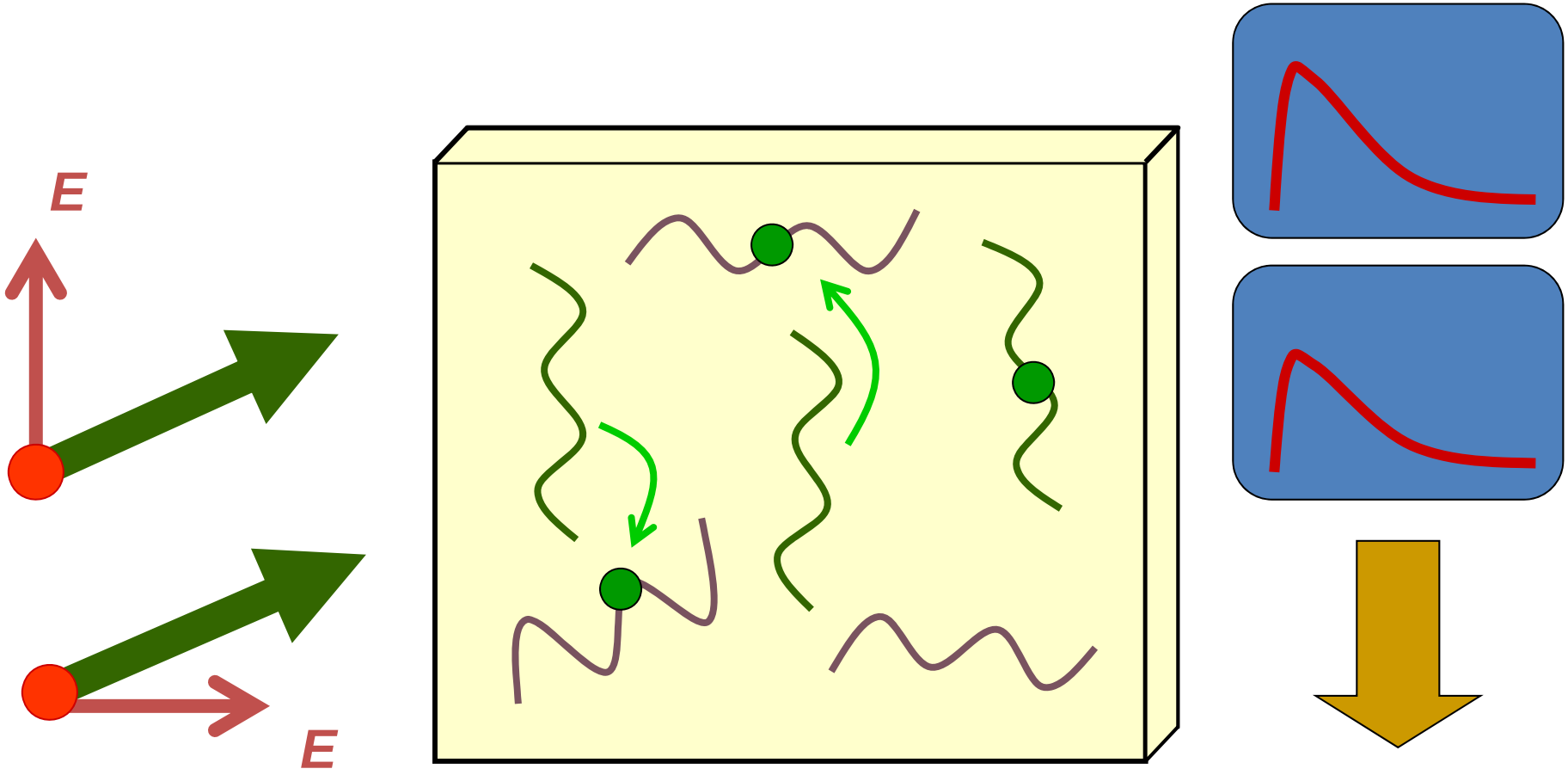
HIGH anisotropy

Polarization TA in CTCs



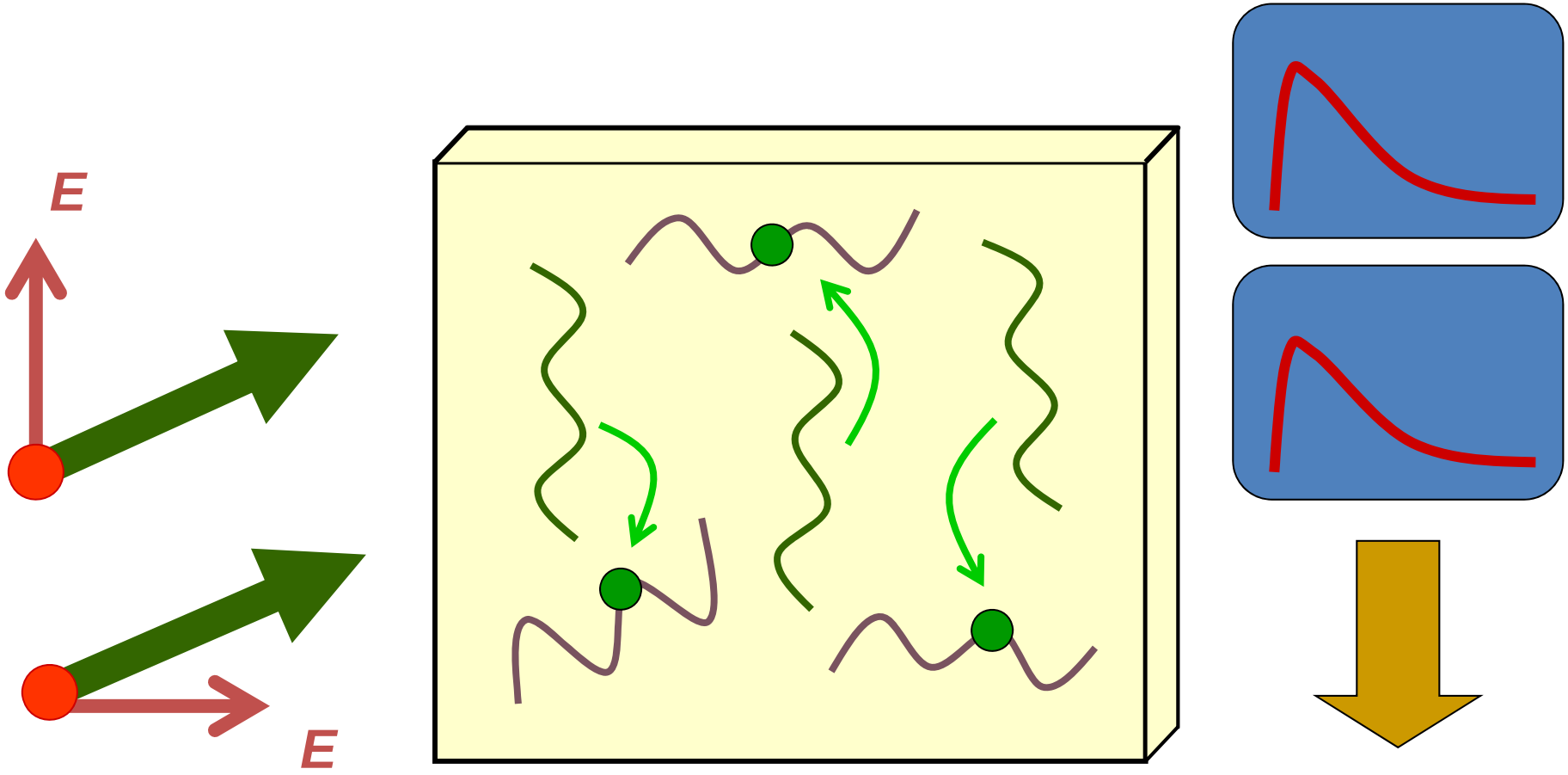
<u>lower anisotropy</u>

Polarization TA in CTCs



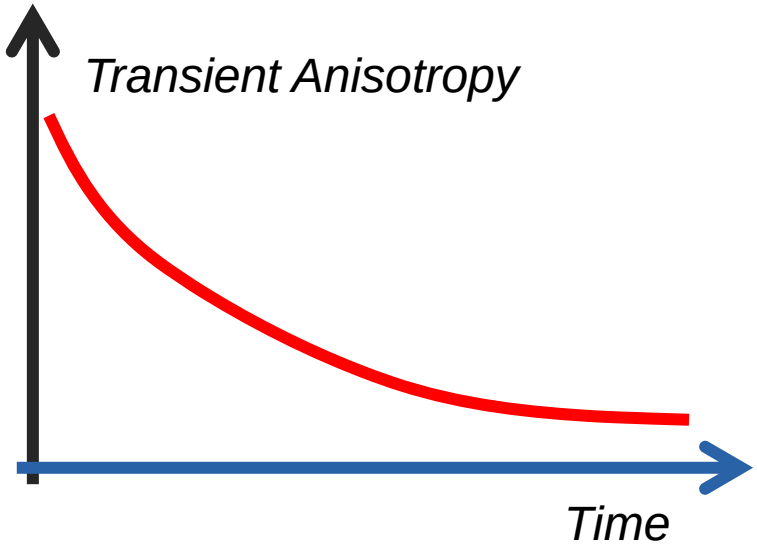
<u>lower anisotropy</u>

Polarization TA in CTCs



no anisotropy

Measuring transient anisotropy – information about hopping (V_{ij})



The distribution of hopping probabilities (V_{ij}) will depend on:

- polymer
- doping
- external field
- temperature
- morphology

- … and modeling is essential

Summary

- TA spectroscopy is not suitable to study photophysics in the "working solar cells"

- To study quasi-equilibrium solar-cell dynamics changes of ~10^{-6} will be detected

- We are going to focus on the intermolecular charge hopping to improve general models of conductivity

Acknowledgements

- Richard Friend
- Philipp Oberhumer, Simon Gelinas, Jenny Clark
- Fast Lab
- OE

- Thank you for your attention !

EPSRC Pioneering research and skills

NWO Netherlands Organisation for Scientific Research