High Throughput single photon detection for effective SII

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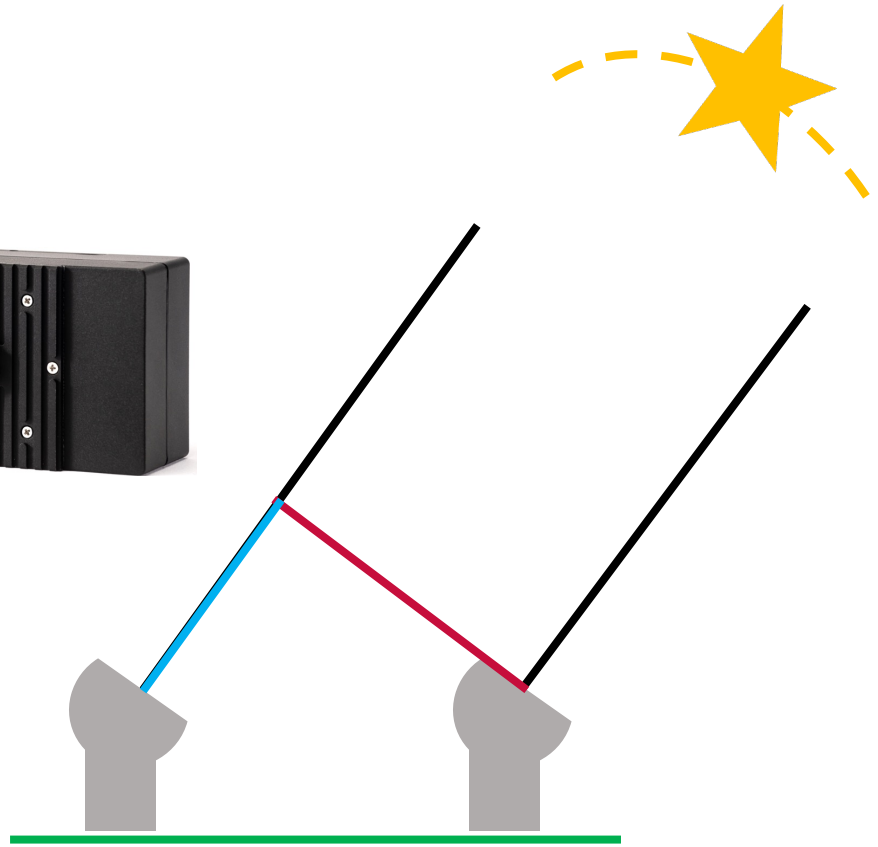
Future Prospects of Intensity Interferometry 2024

Agenda

1. Motivation
2. New kind of single photon detector: LINPix
3. Timing Resolution measurements
4. Synchronizing TDCs
5. Outlook



Motivation

Motivation

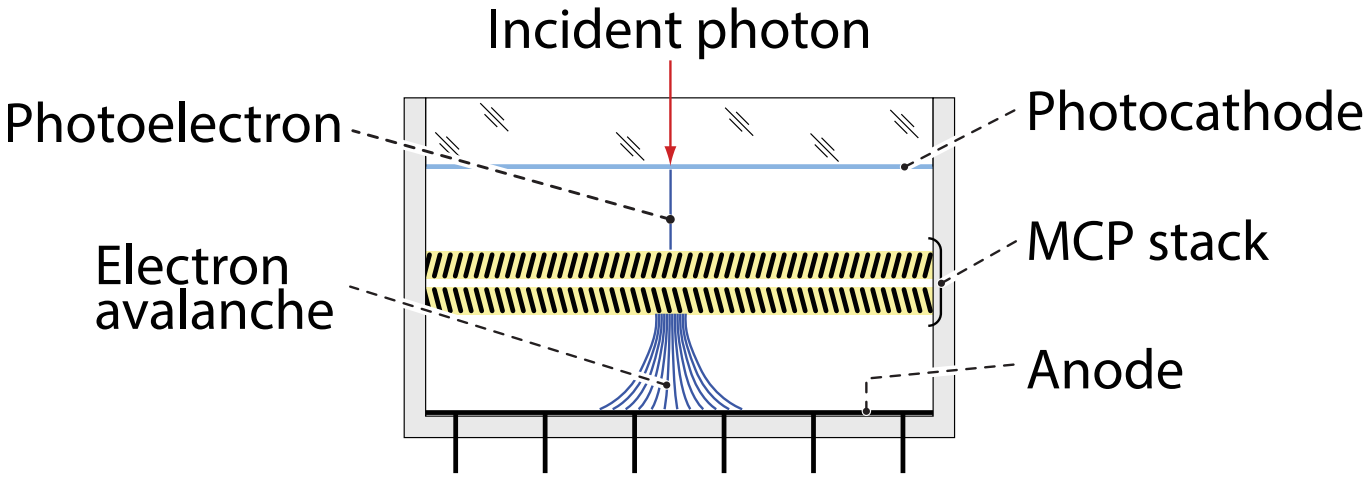
- Larger telescopes increase SNR in HBT measurements
- For bright stars: hybrid single photon detectors saturate for telescopes > 1m
- For spatial correlations ordered timestream is necessary
- Manageable data rate

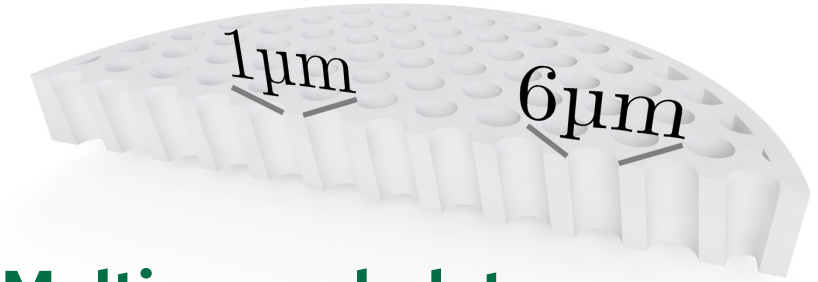
Solutions:

1) Use new kind of detector
2) Use White Rabbit
3) Use high throughput TDC

New kind of single photon detector: LINPix

LINPix from Photonscore



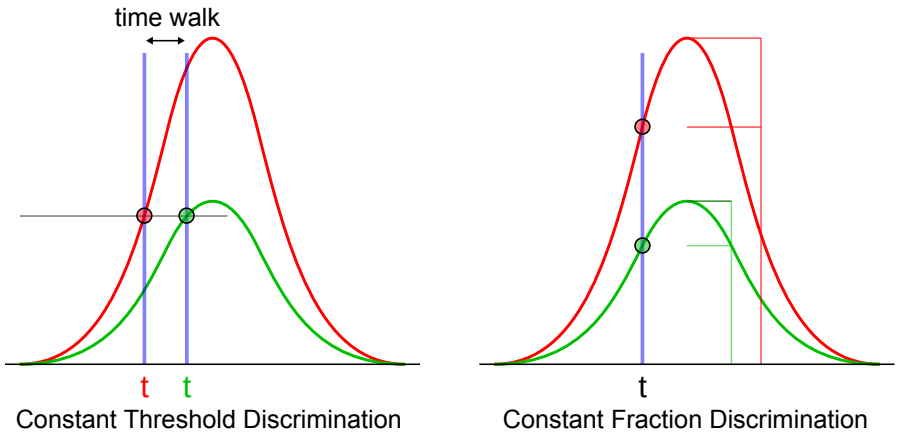


Multi cannel plate:

- Amplify signal
- Chevron stack → Gain > 10^6
- Channel tilt = 5° – 10°

Constant fraction discriminator (CFD):

- Reduce timing walk for varying pulse amplitude
- NIM out via SMA

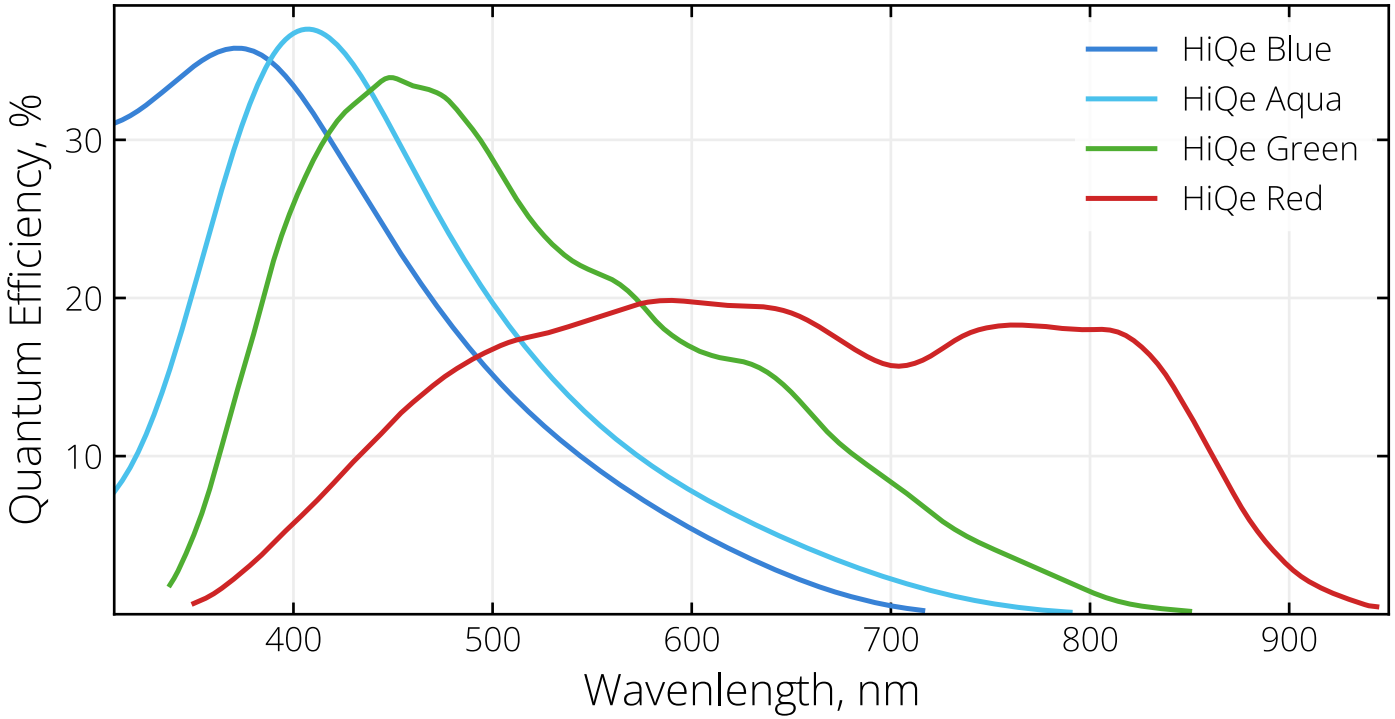


Possible Photocathodes for LINPix

FAU

Quantum efficiency

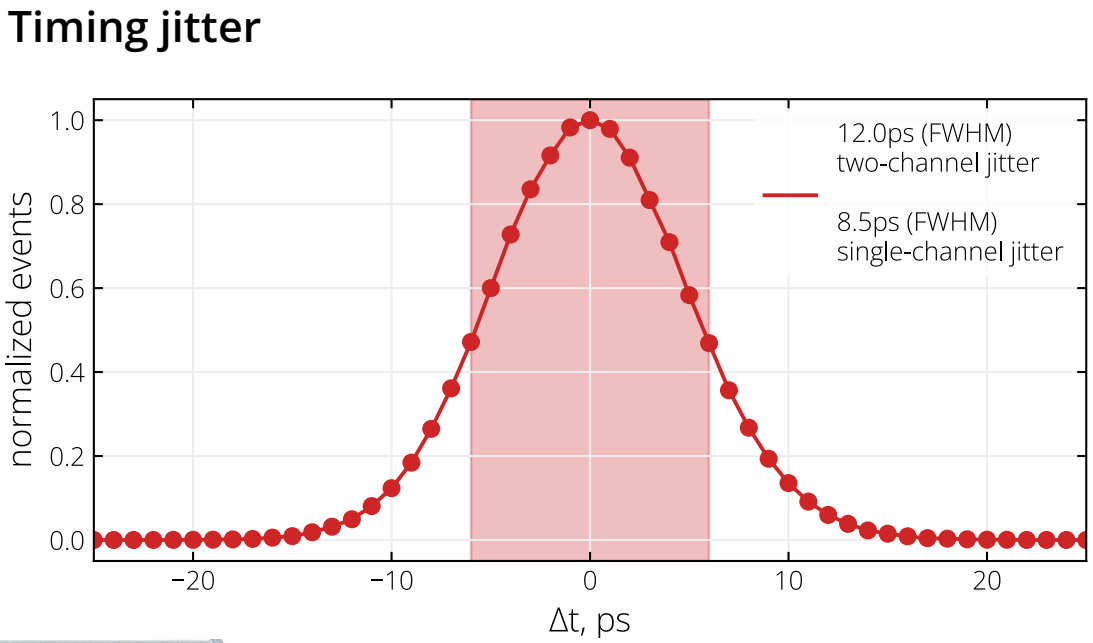
PHOTONIS
Reveal the invisible



Photonscore.
PHOTON COUNTING MADE EASY

LINTag from Photonscore

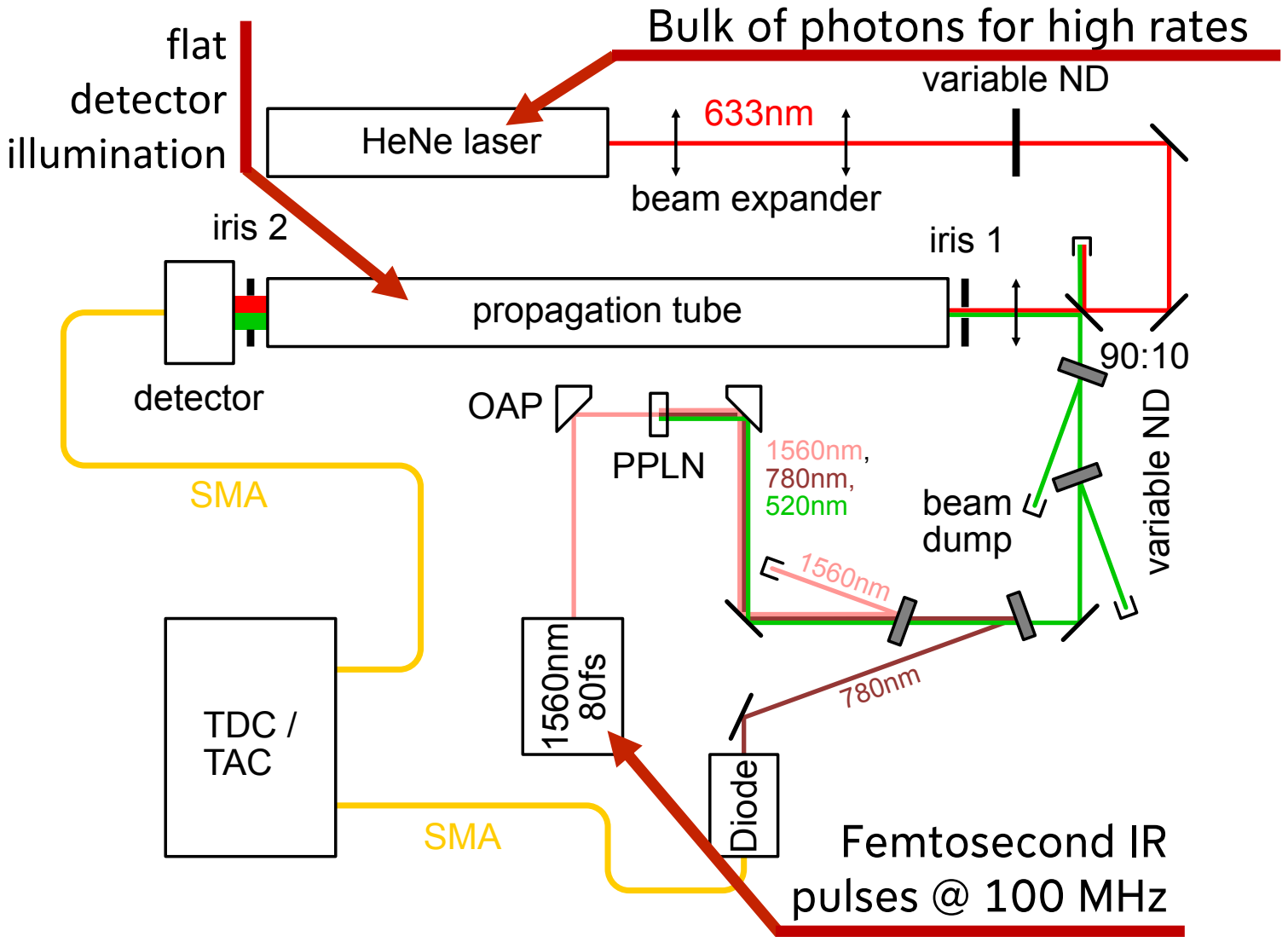
- time-tagger system developed for ultra-fast data acquisition
- Temporal accuracy of 8.5ps (FWHM) / 3.6ps (RMS)
- 8 high resolution channels
- 10G Ethernet SFB+ connection
- full-stack TCP/IP interface
- Transfer up to 400 MEvents/s in compressed hirarchical dataformat



Photonscore.
PHOTON COUNTING MADE EASY

Timing resolution measurements

Detector Testbench



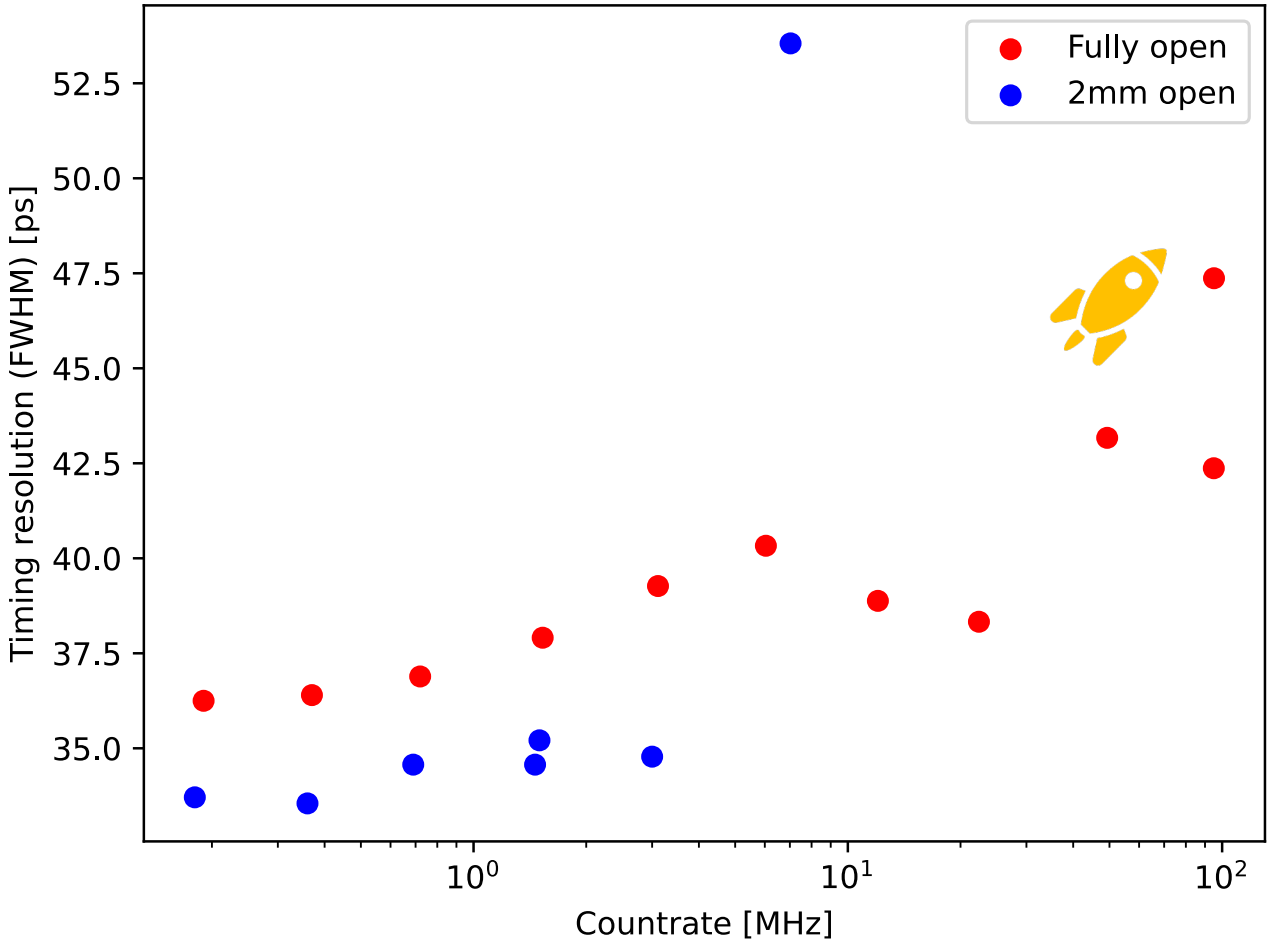
- Obtain timing resolution by correlating detector and diode signal
- Used Hi-QE Blue photocathode
- Tune count rate from 180kHz to 95MHz
- Vary opening diameter of iris 2

Timing resolution of the setup

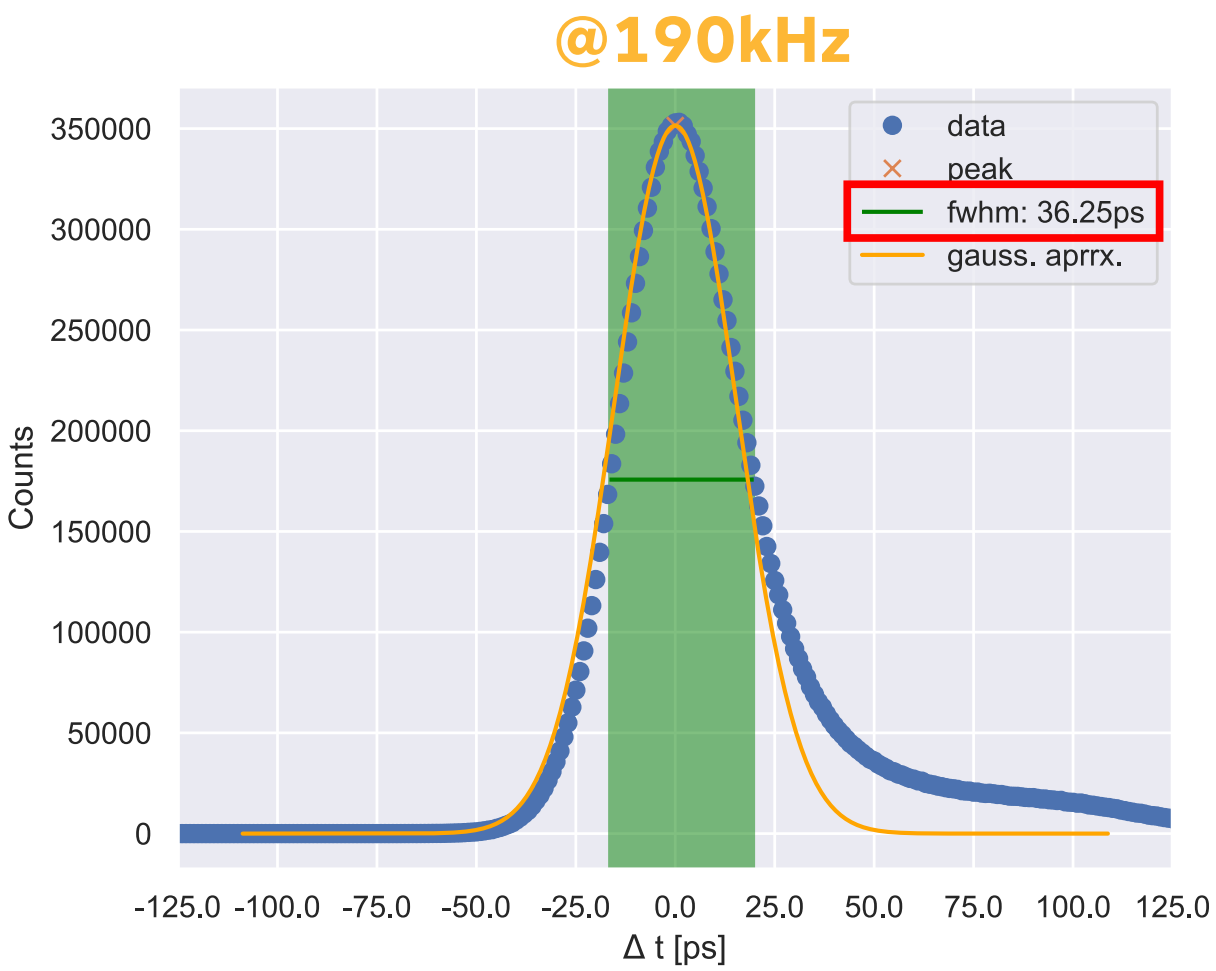
Varying the illuminated area:

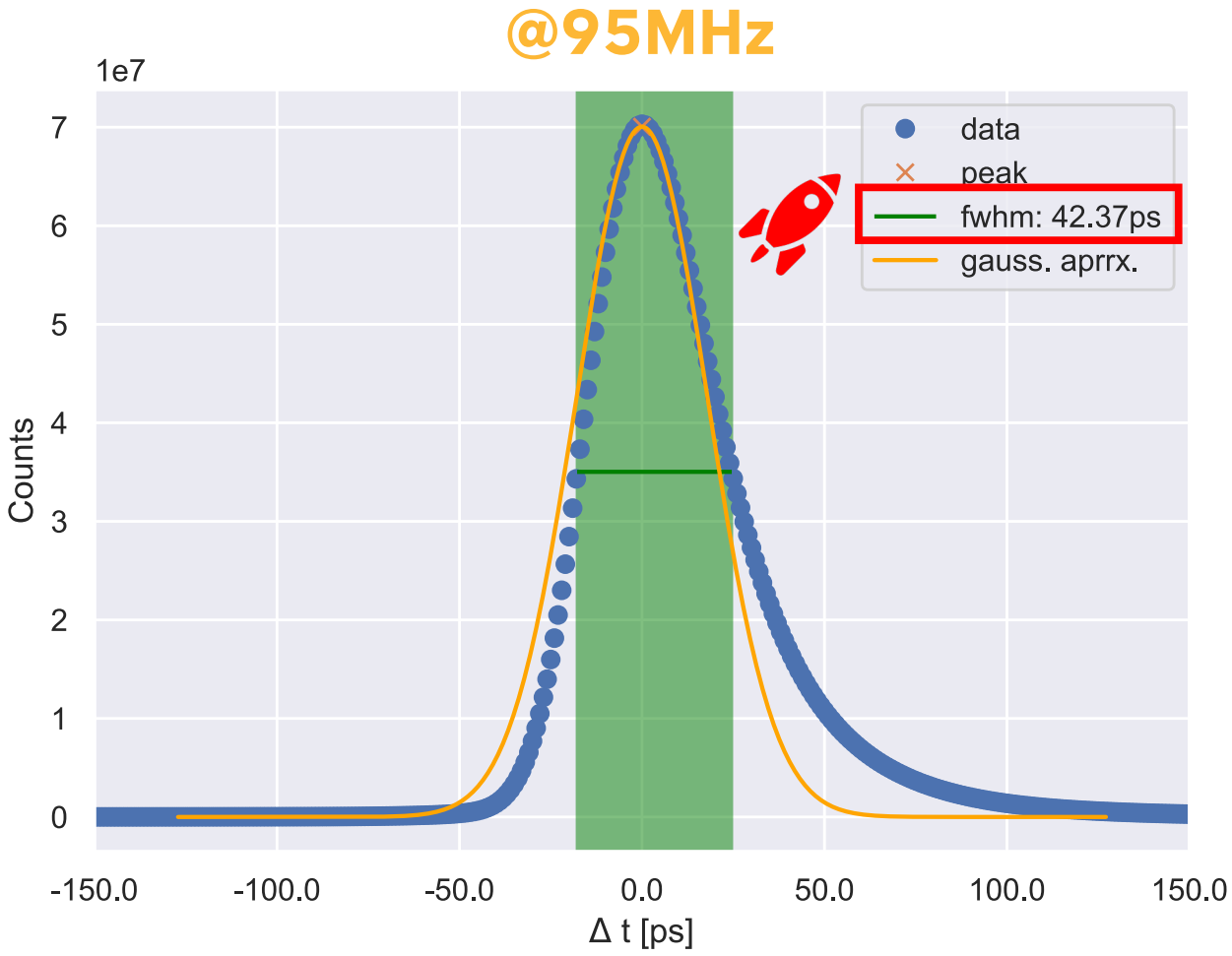
- Tune iris to 2mm opening diameter
- Smaller active area → similar timing resolution
- Full area increases jitter by < 5 ps

Iris closed and open

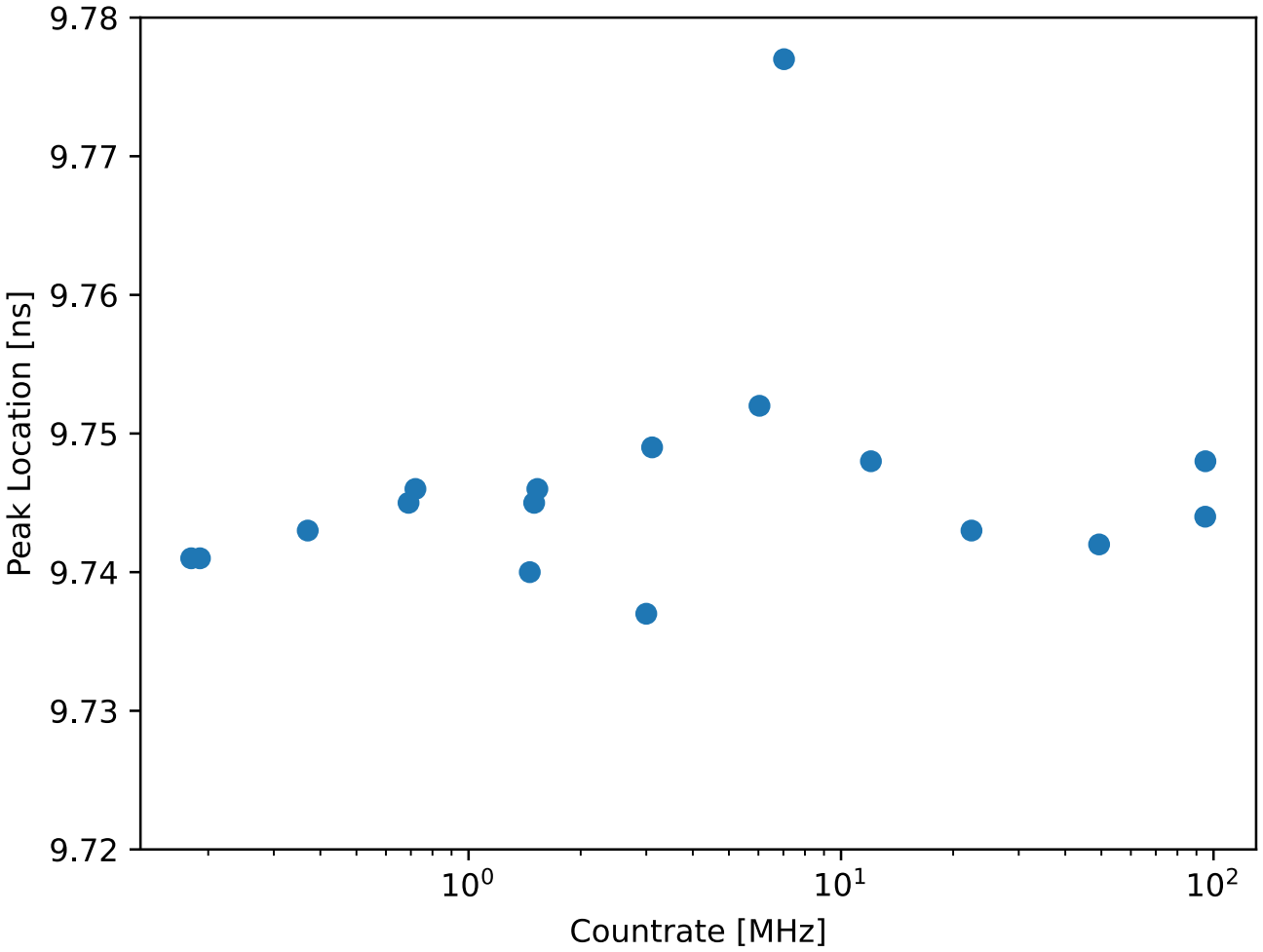


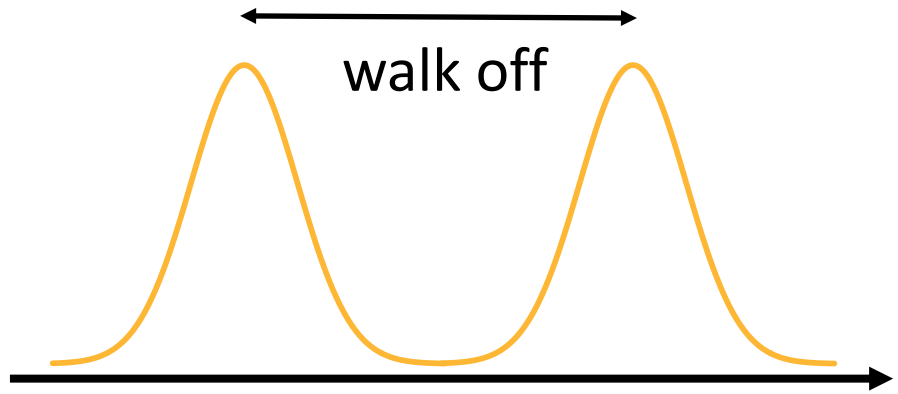
Timing resolution





Timing resolution of the setup



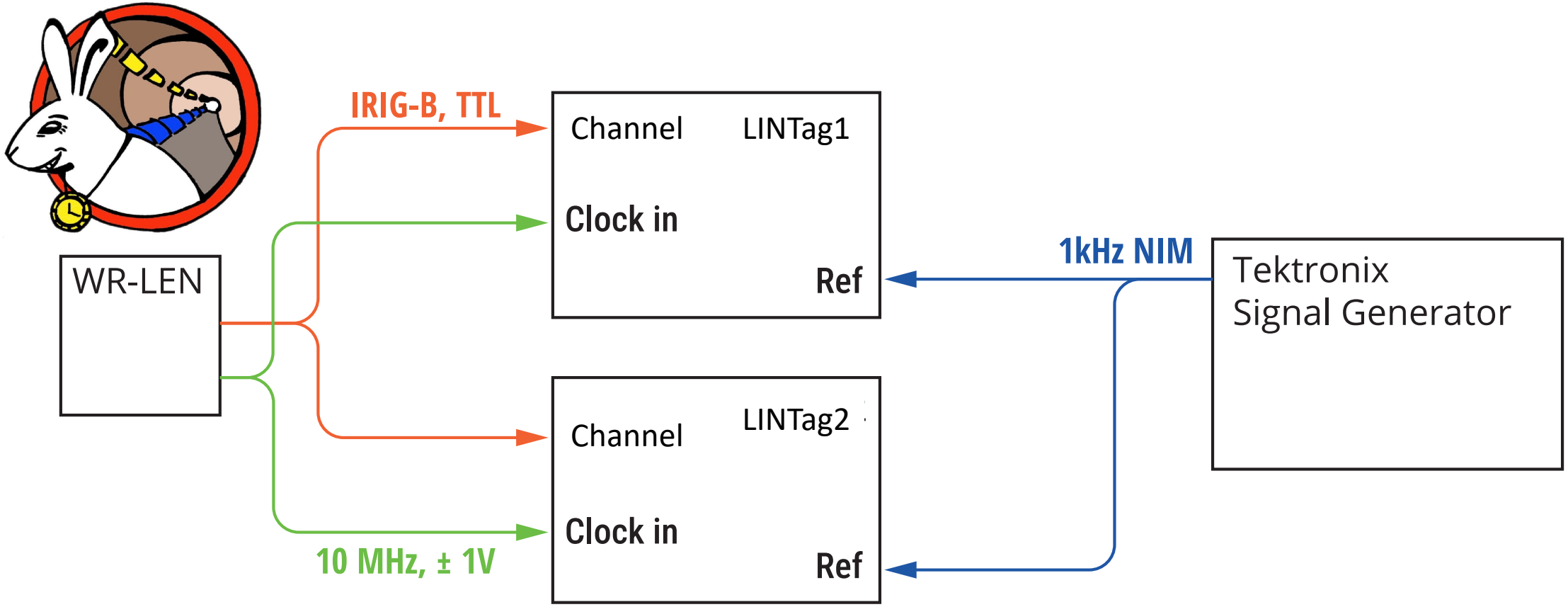


Peak position walk off:

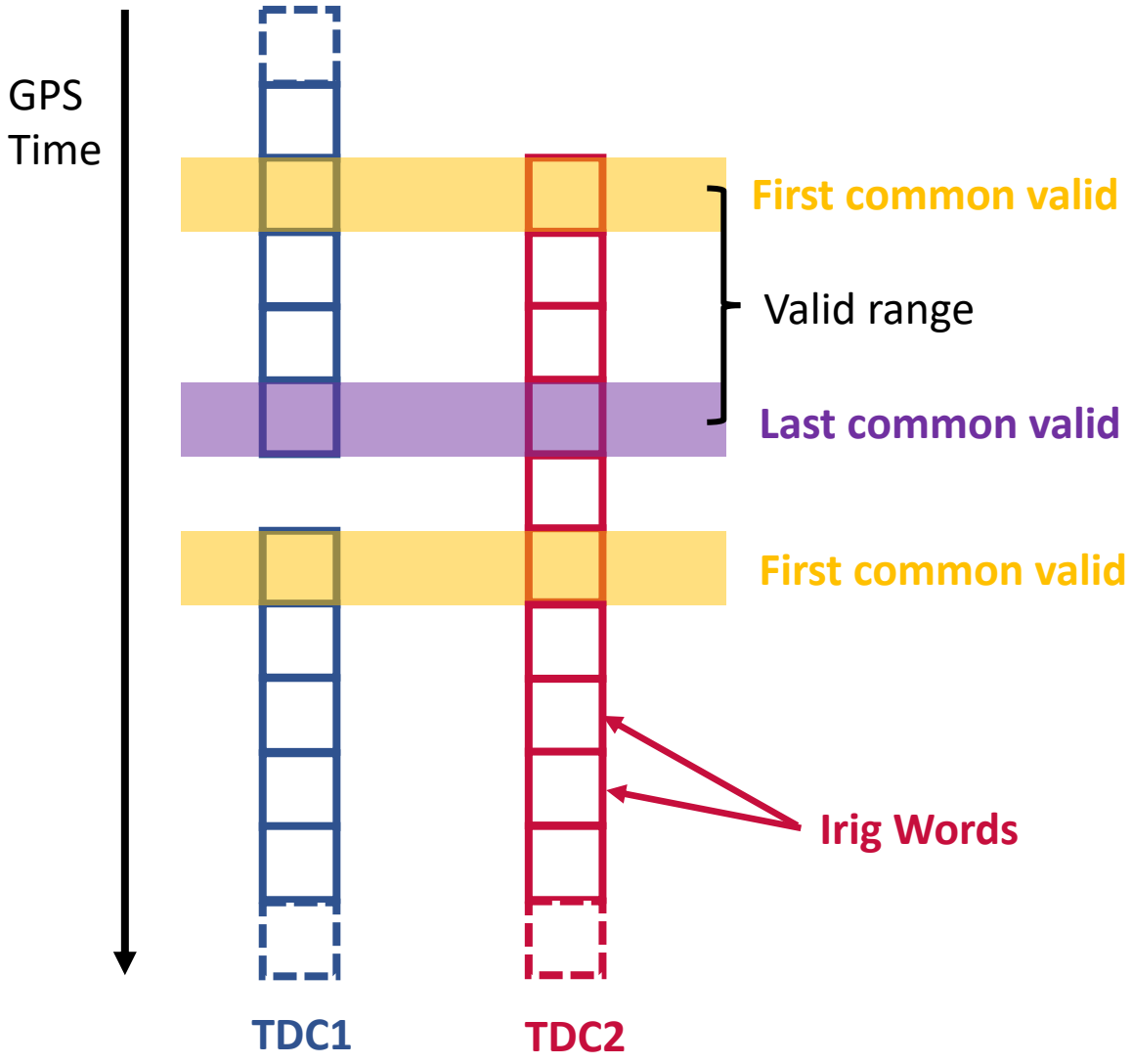
- Higher rates shifts peak to higher delay times
- Walk off < 20 ps

Synchronizing TDCs

Synchronizing TDCs Setup



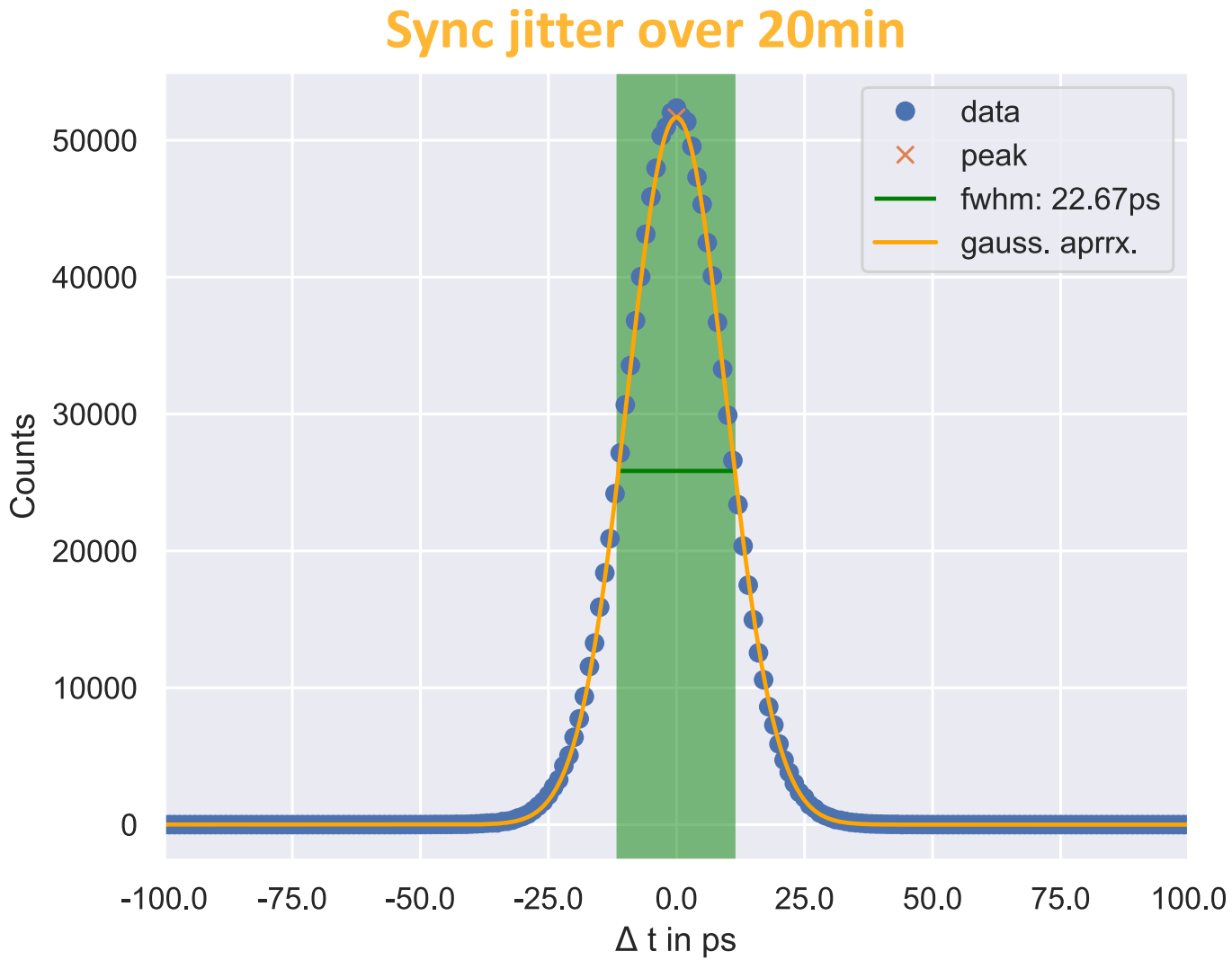
Synchronizing TDCs



Procedure:

- Build an IRIG-Word Stack to each provided file
- Finding the range when all overlap. If outliers exist they won't be processed
- Search for file with smallest TDC-Counter and use it as a time reference for all other files
- Check each second the offset between matching IRIGs and compensate using a smooth-function

Synchronizing TDCs



Outlook

Outlook

To Do:

1) Higher count rates?
2) Bursts?
3) Km baselines?

1) Try 100MHz bunching
2) Check burst capability of LINPix
3) Try WR with long fibers and test synchroniz-ability of multiple TDCs in the field

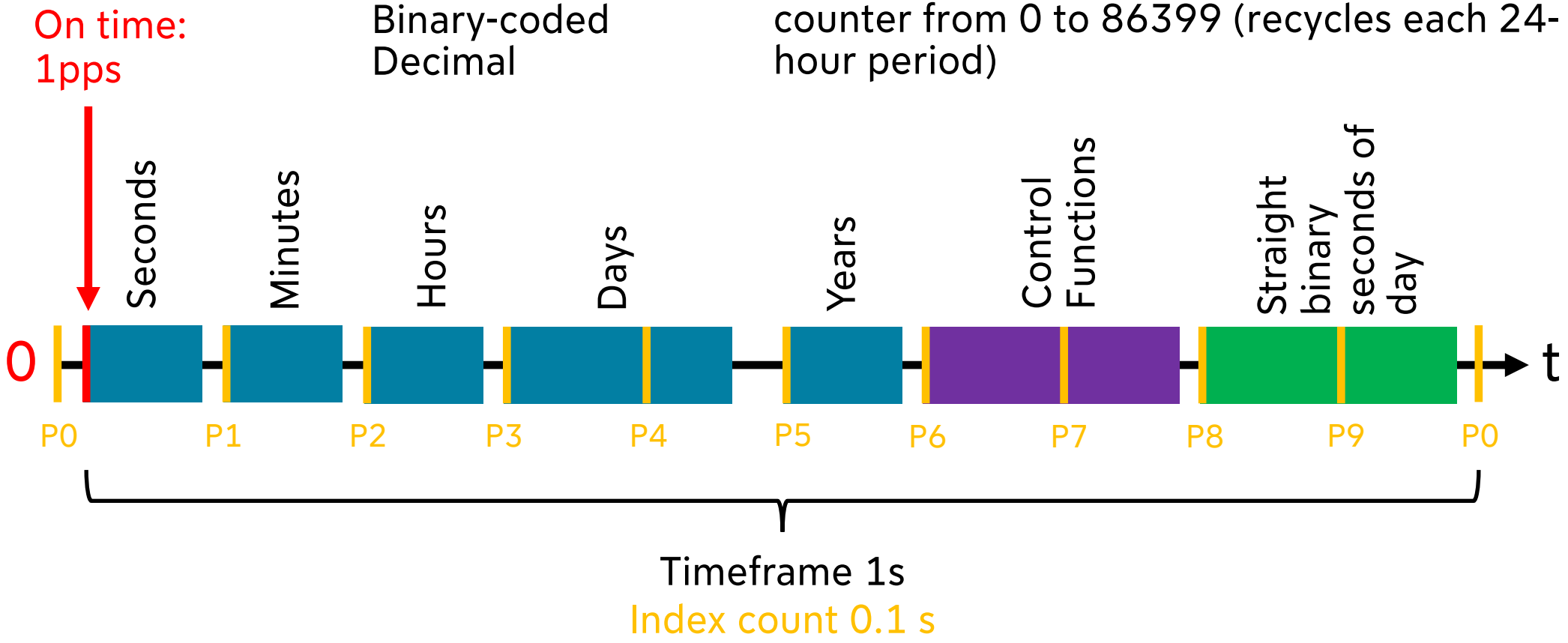

Thank you
for your attention

Image References

- LINPix: taken from Photonscore website
- CFD1: https://upload.wikimedia.org/wikipedia/commons/8/8f/Constant_fraction_1.svg
- LINTag plot and image: taken from Photonscore manual and website
- MCP: copyright Stefan Richter
- MCP schematic: copyright Yury Prokazov
- Vacuum assembly: copyright Photonis
- Quantum efficiency: taken from LINPix Photonscore datasheet
- Optical Chopper: https://shop.scitec.uk.com/cdn/shop/products/300cd_2048x.jpg?v=1649946375

IRIG-B timecode

- 100 Hz bit rate
- Encoding type: Binary-coded Decimal
- Years as number 00-99 (00=2000)
- Straight binary seconds: 17 bit binary counter from 0 to 86399 (recycles each 24-hour period)



IRIG-B timecode