

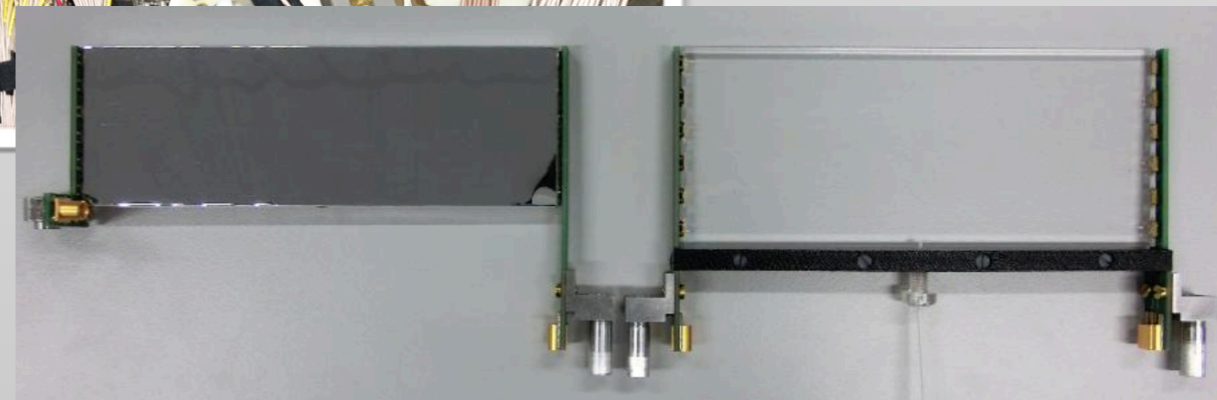
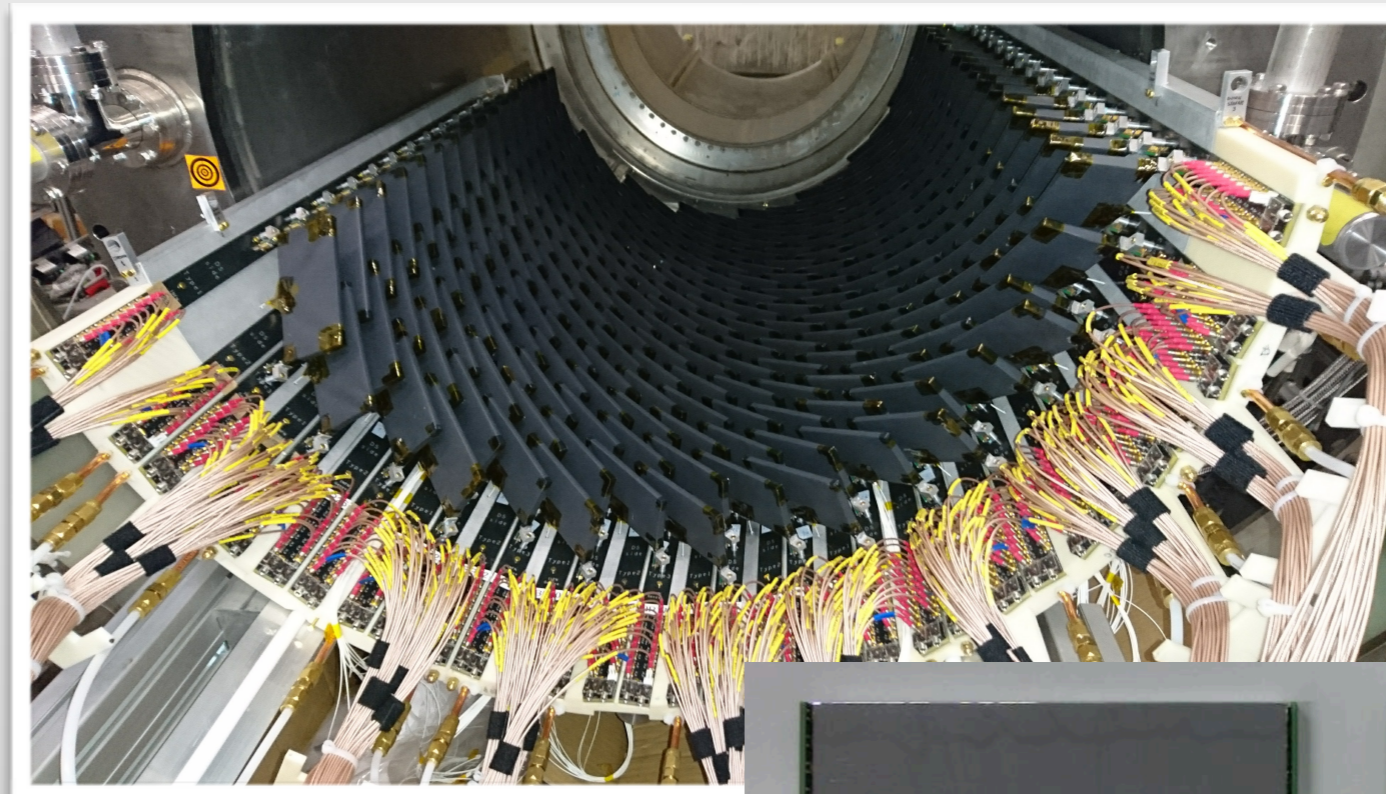
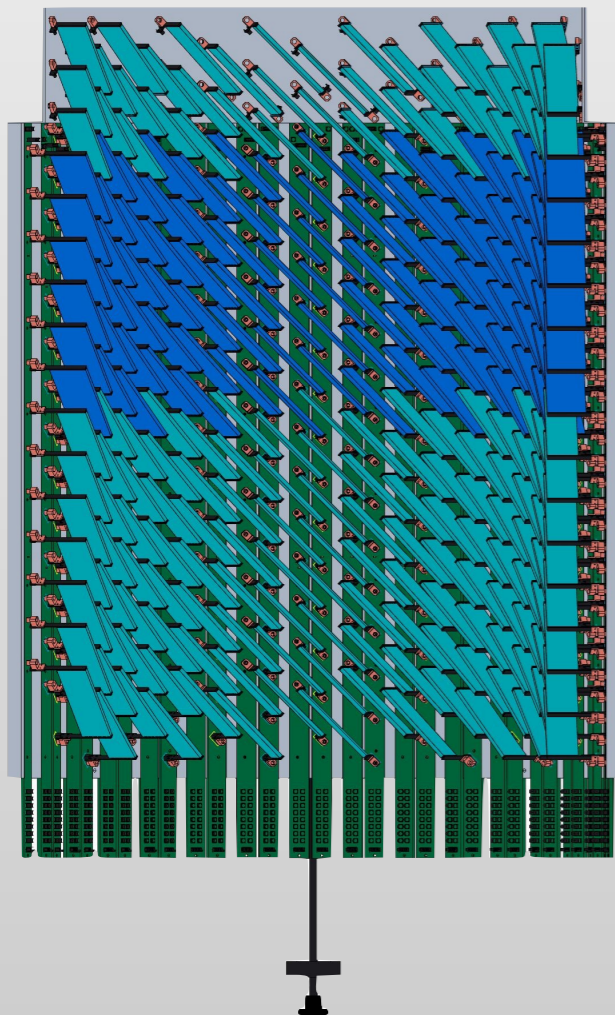
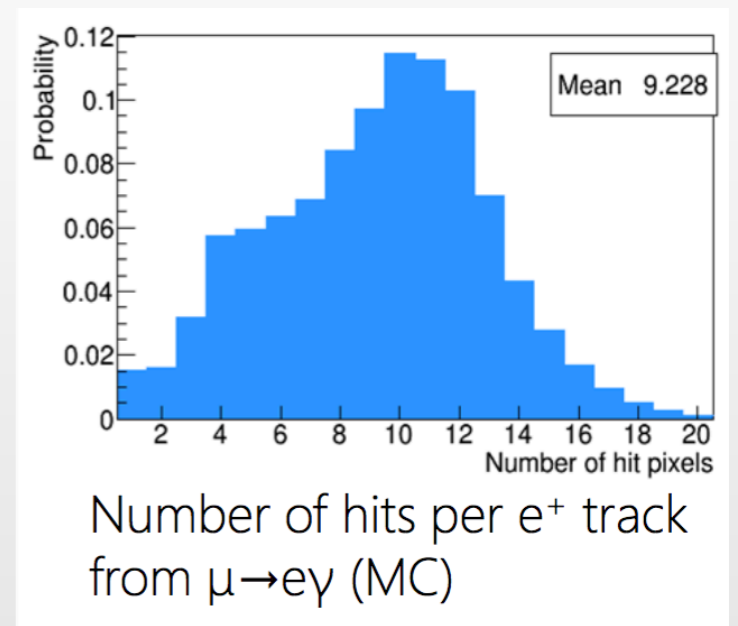


# MEG

CdS Preventivi 2019

# The MEG II Timing Counter (reminder)

- A new pixelated detector with expected  $\sigma(t_{e^+}) \sim 30/35$  ps.
- Exploit multi-hits time resolution.
- 2 detector x 256 pixels each (symmetric down/up-stream the target).
- Optimized pixel sizes (50 or 40 mm tall) for better  $e^+$  trajectories interception.
- Low budget material along  $e^+$  tracks.



# Summary: what's new since last year

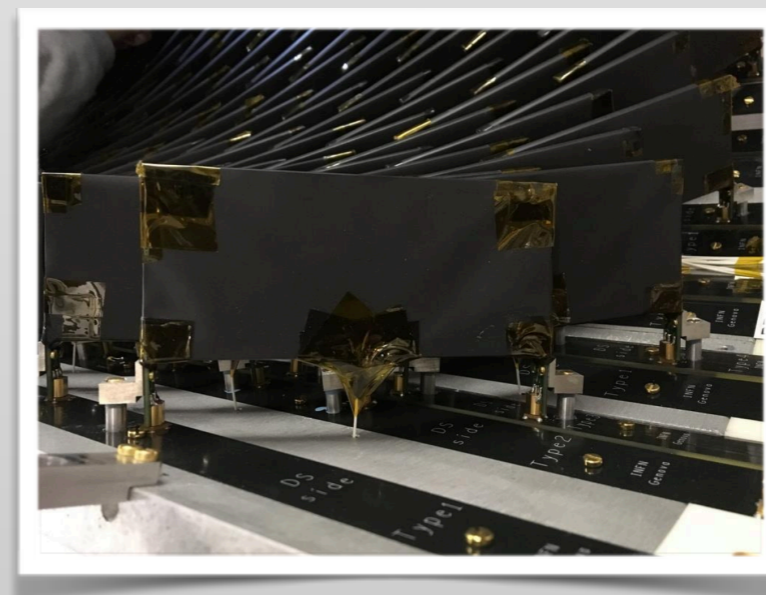
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- **The Timing Counter is ready to take data in MEG II framework**
- **Calibration tools (i.e. laser system) are completed and working**
- **Pre-engineering run foreseen for fall 2019**

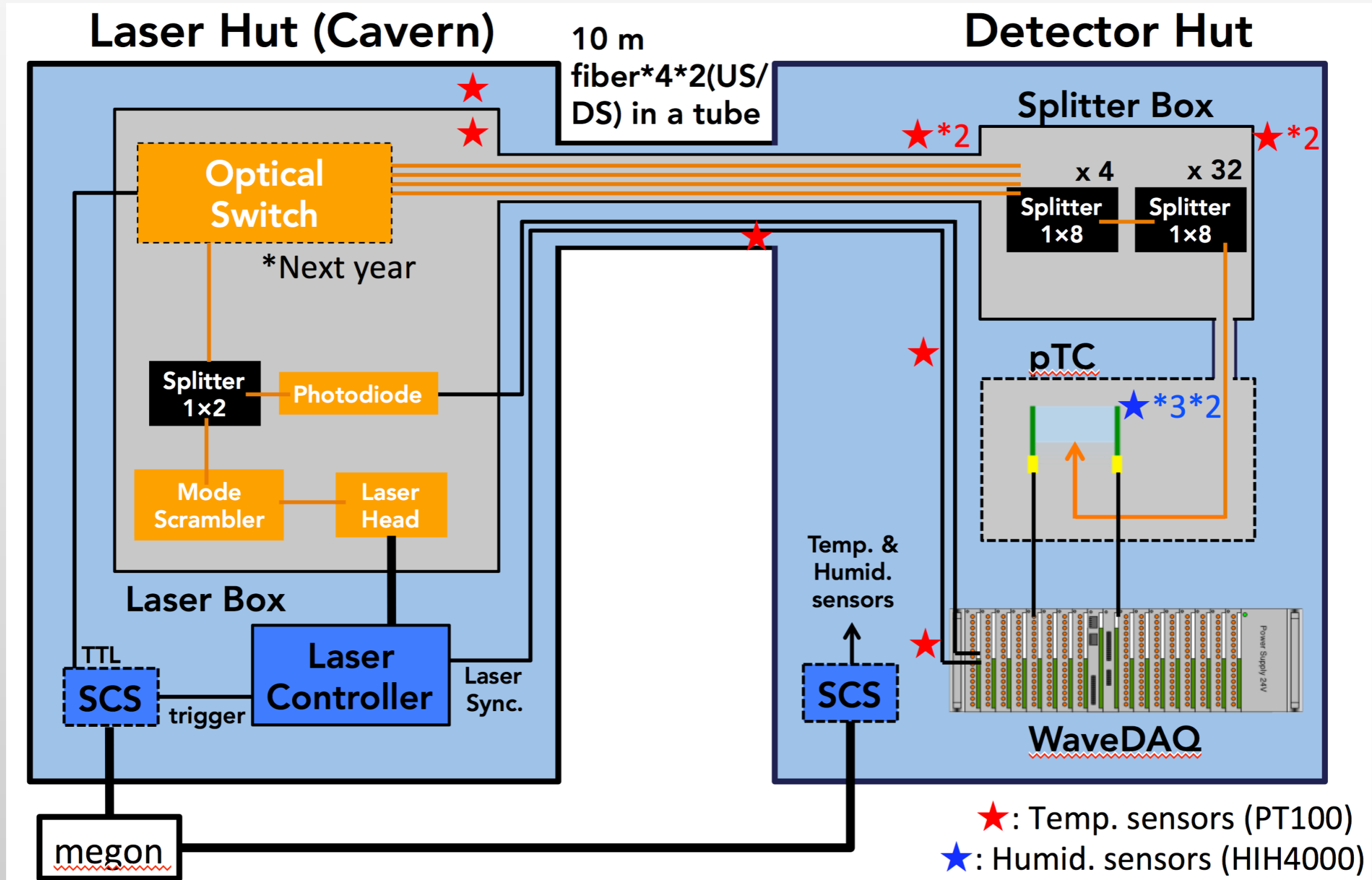
# Calibration system

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- A **laser source with an optical splitter system allows light injection** simultaneously on each pixel.
- **Laser power and system temperature are continuously monitored** in order to guarantee the best stability.
- Laser and optical splitter system are connected by means of 4 x 10m long fibers.
- Connection in splitter box are made in such way to be able to recover different length fibers allowing an easy handling
- Splitter box is placed very closed to the TC detector (just below the COBRA edge)
- **A fundamental calibration tool for inter-pixel calibration, detector stability, DAQ check** etc...
- Already tested on a small (40) pixels subsample during pre-engineering run 2016, calibration system was completed and installed for both detector in 2017.

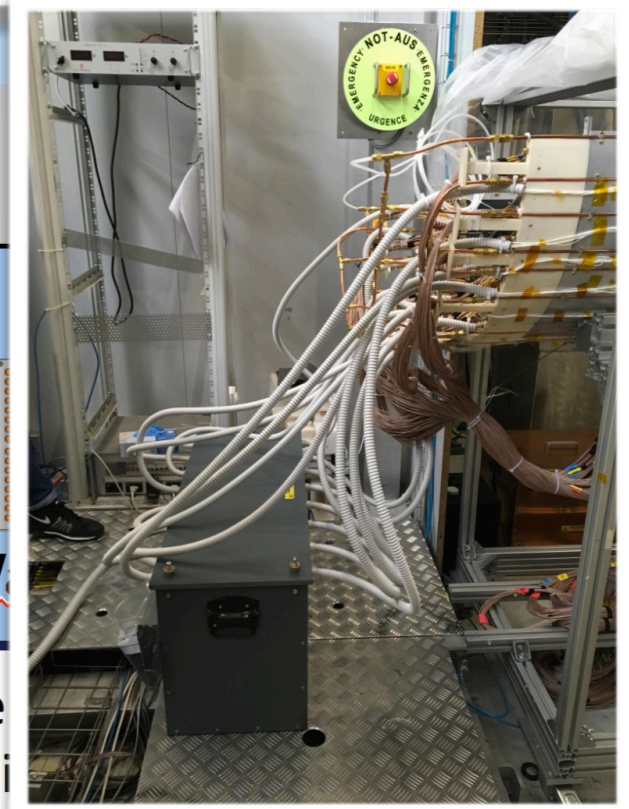
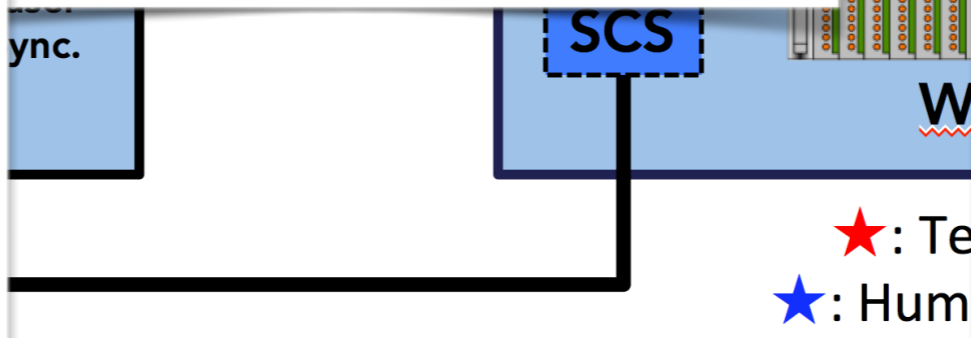
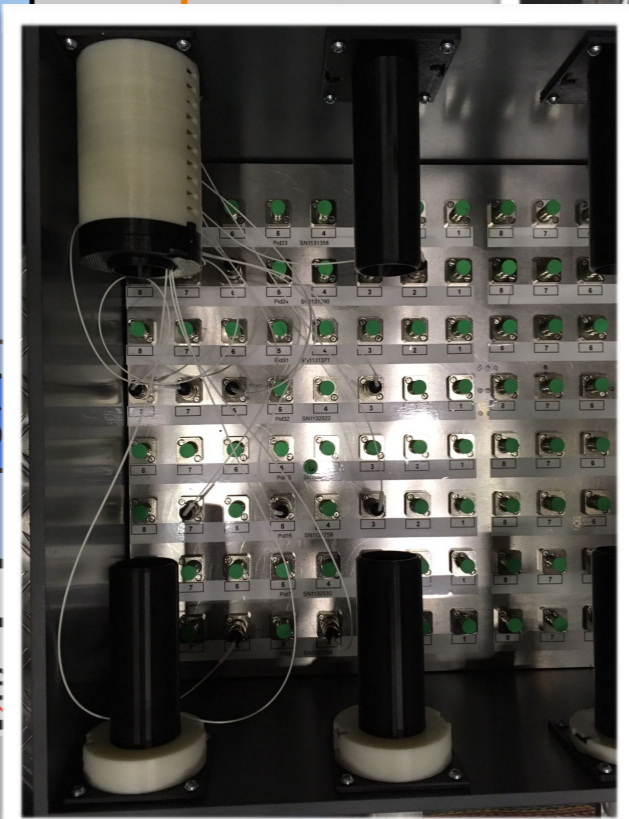
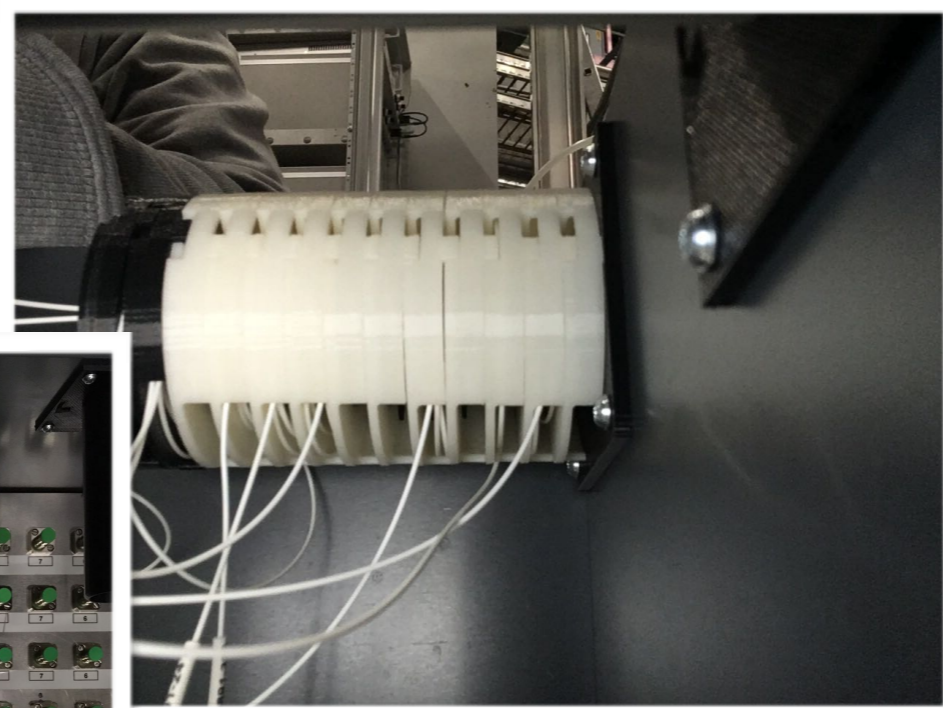
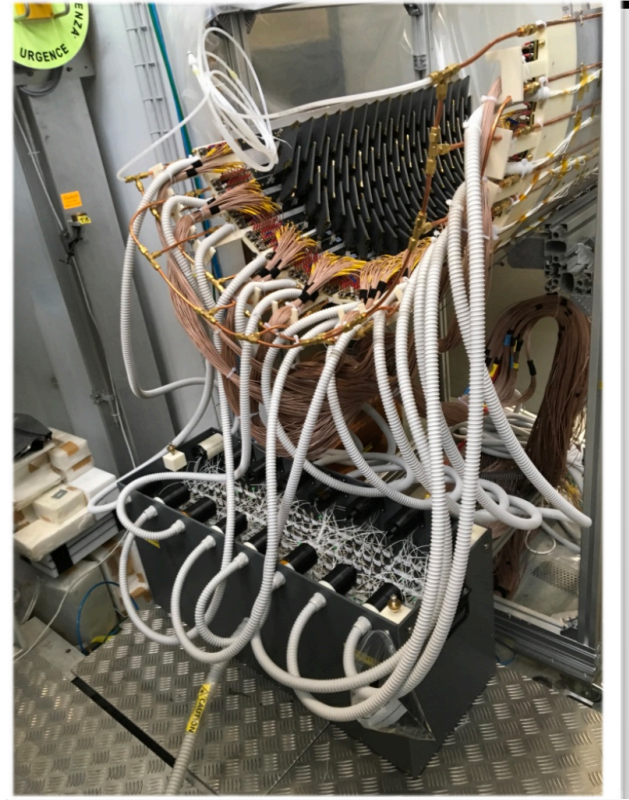
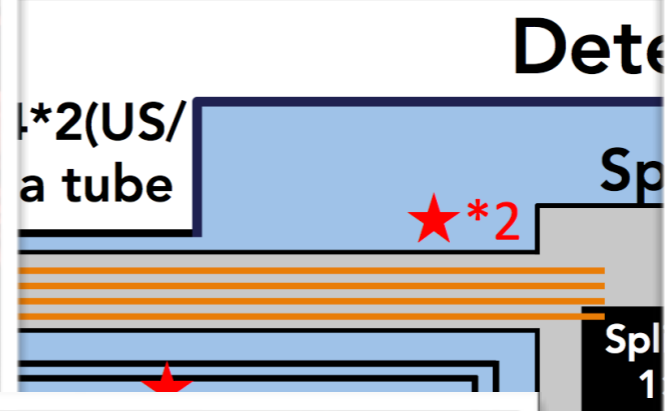


# Calibration system (sketch and pics)



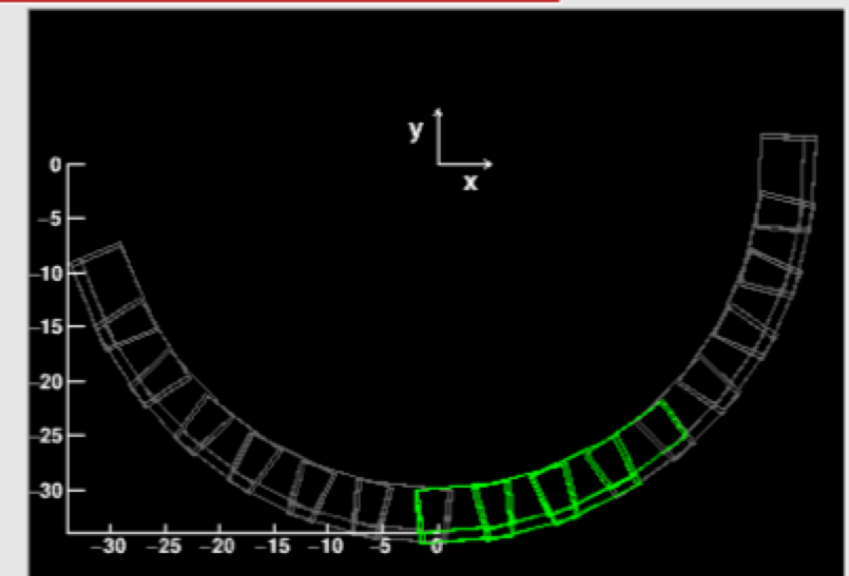
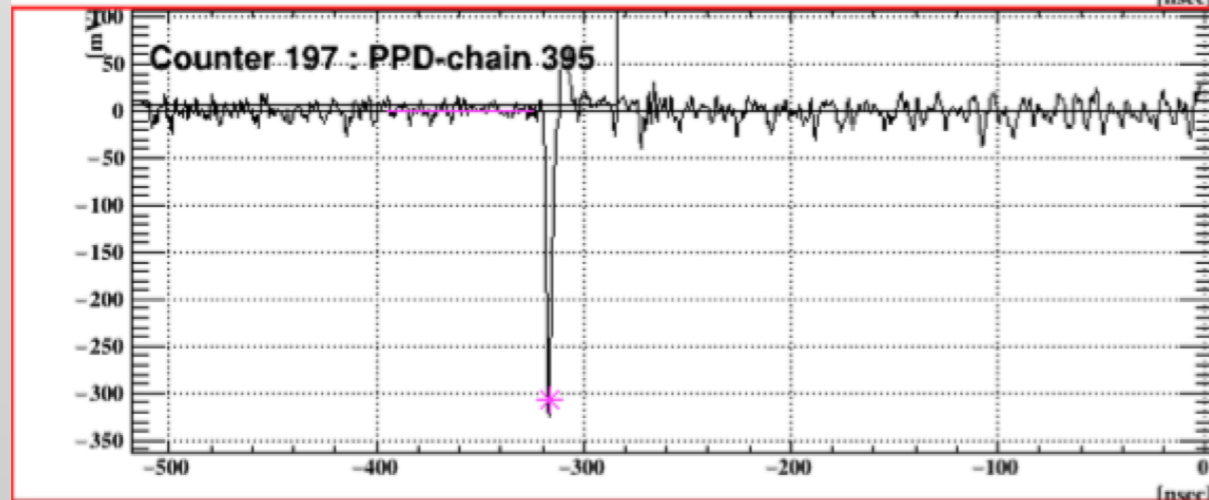
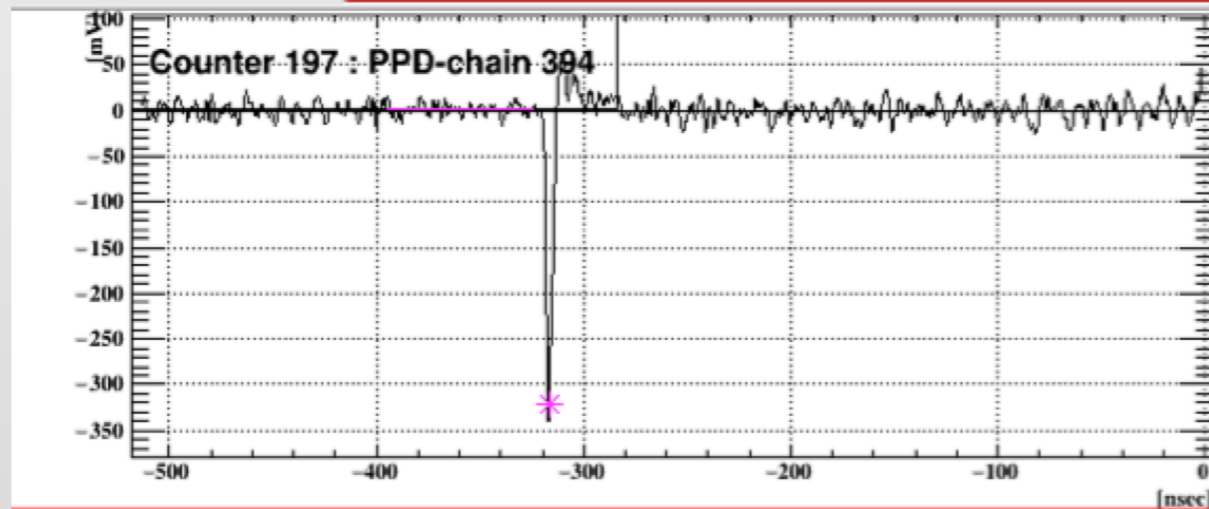
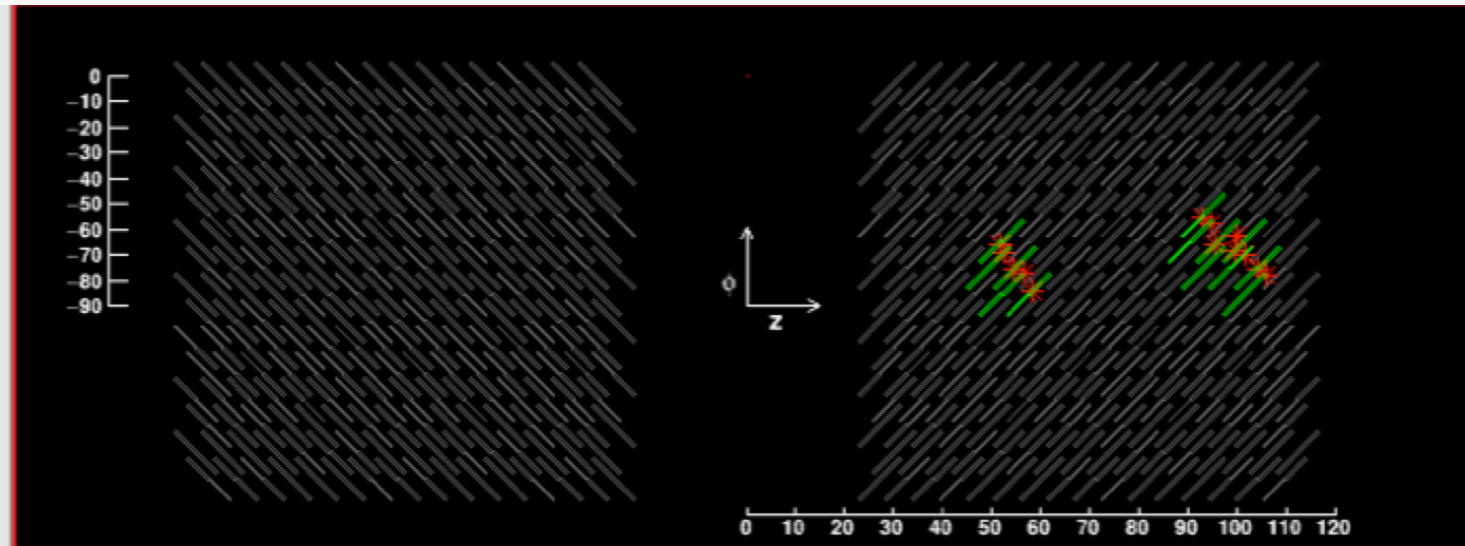
# Calibration system (sketch and pics)

Designed and produced in Genova



# Examples from previous years analysis

**Nice Michel tracks clearly visible!**



Pixel number with hit  
#197, 214, 198, 199, 215, 216, 231, 87, 72, 88, 182, 70, 71,  
0  
 Rec track  MC hit  MC track  only e+  
MCTrack indices to be displayed (eg. type 0,12,13 below and press Enter key)

# Examples from previous years analysis

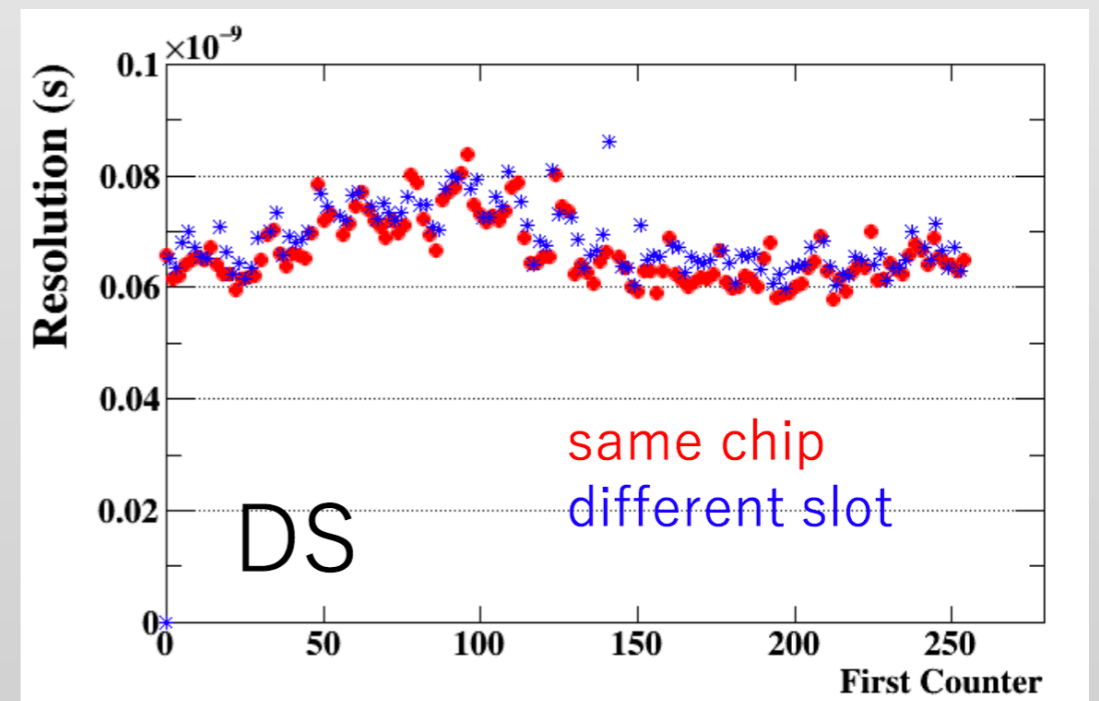
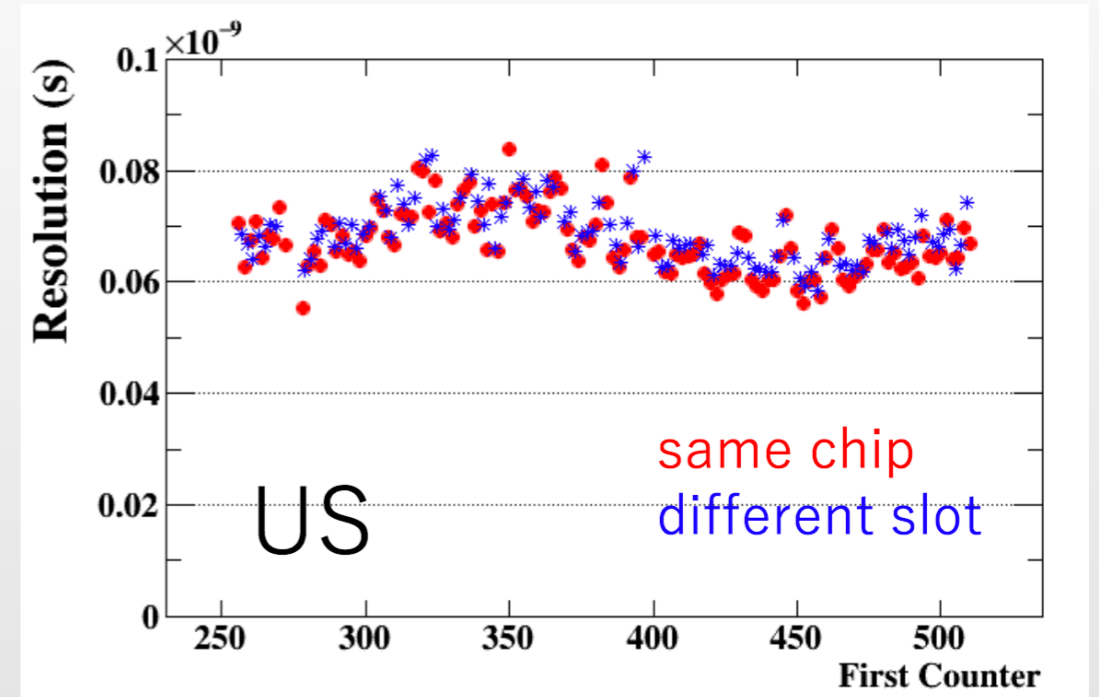
Example: check of the double hits resolution (2 adjacent counters):

combination on same DRS chip:  $\sigma (T_{i+1} - T_i)/2$

combination on different DRS chip:  $\sigma (T_{i-15} - T_i)/2$

We did not see any strong influence from electronic jitter now.

**Resolutions stay in the range 60 - 80 ps**





# Examples from previous years analysis

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Multi-hit resolution was checked by using the so called **“even-odd” analysis**.

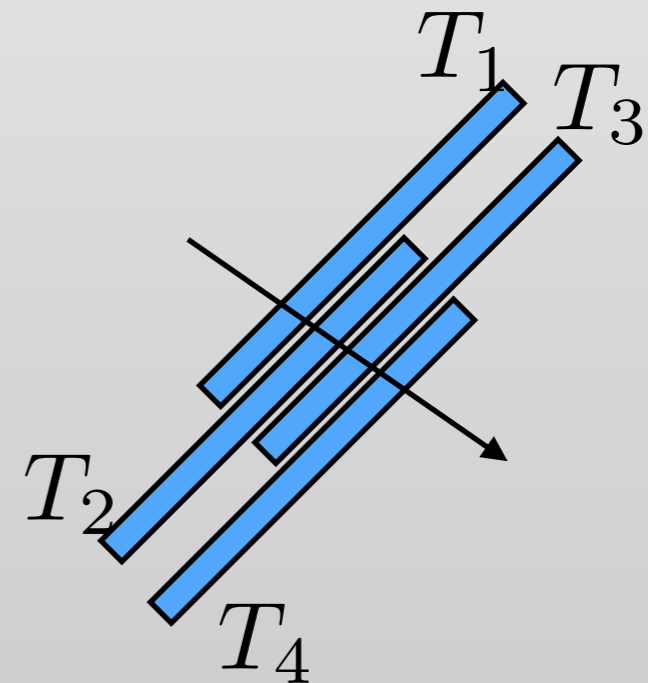
After having choosen a counter combination to be analysed, the sigma of the quantity:

$$\frac{\sum_i^{N/2} T_{2i+1}}{N} - \frac{\sum_i^{N/2} T_{2i}}{N}$$

is used to evaluate the multiple hits time resolution.

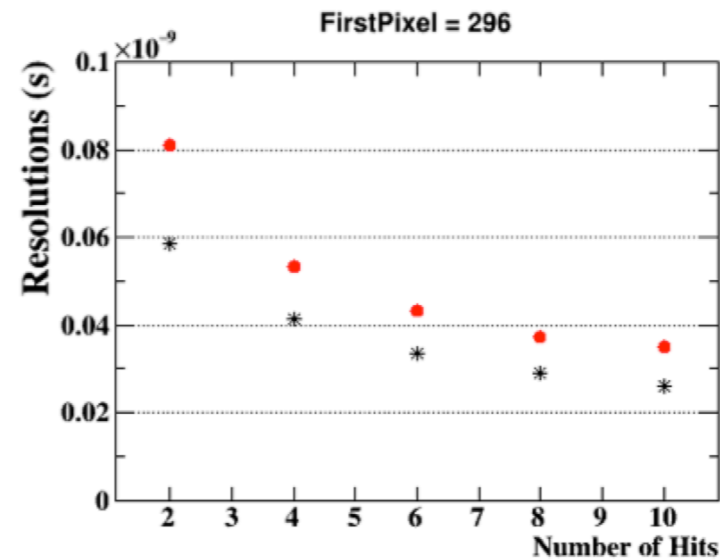
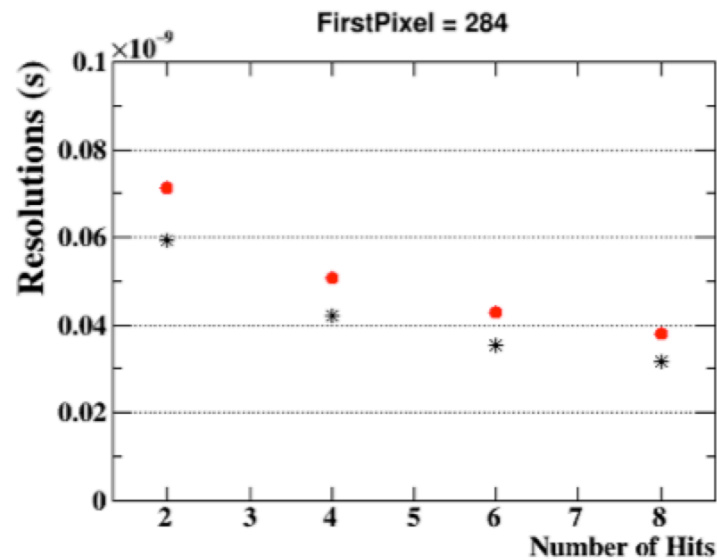
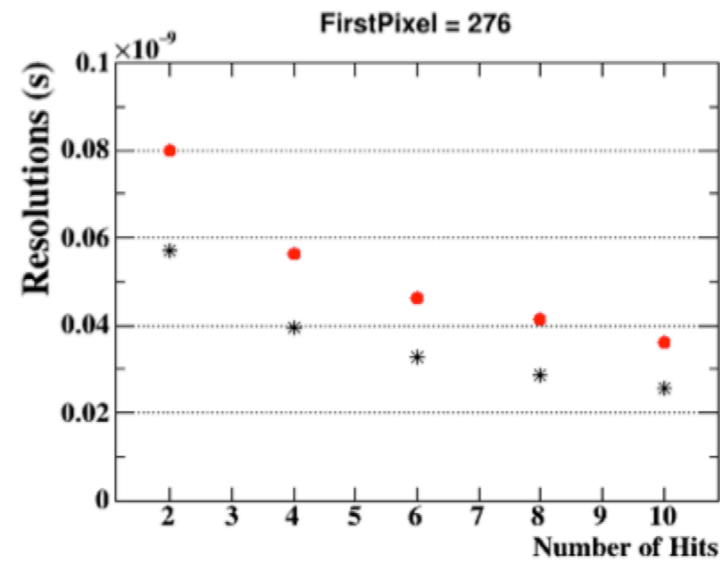
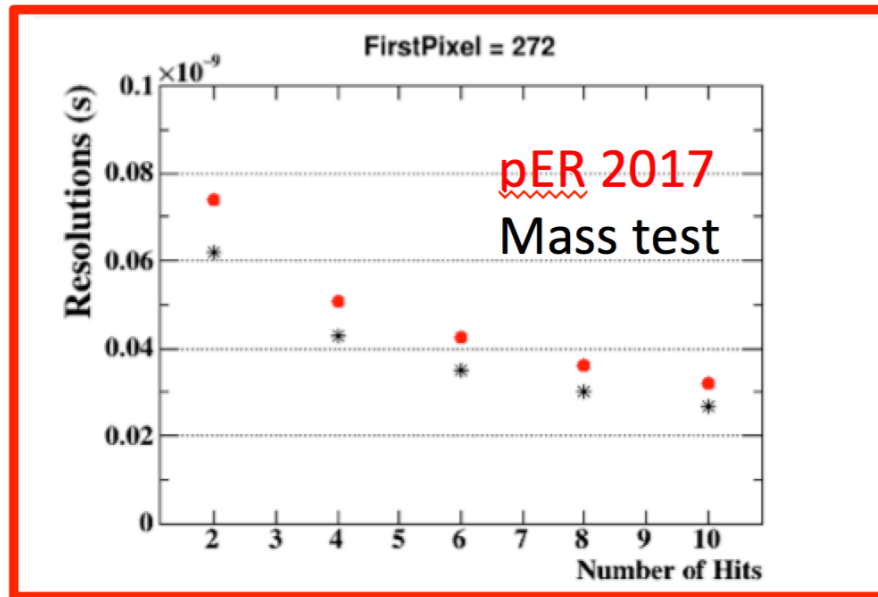
As an example, for  $N = 4$ :

$$\frac{\frac{T_1 + T_3}{2} - \frac{T_2 + T_4}{2}}{2}$$



# Examples from previous years analysis

Example: 4 different pixels subsets starting from pixel id 272:

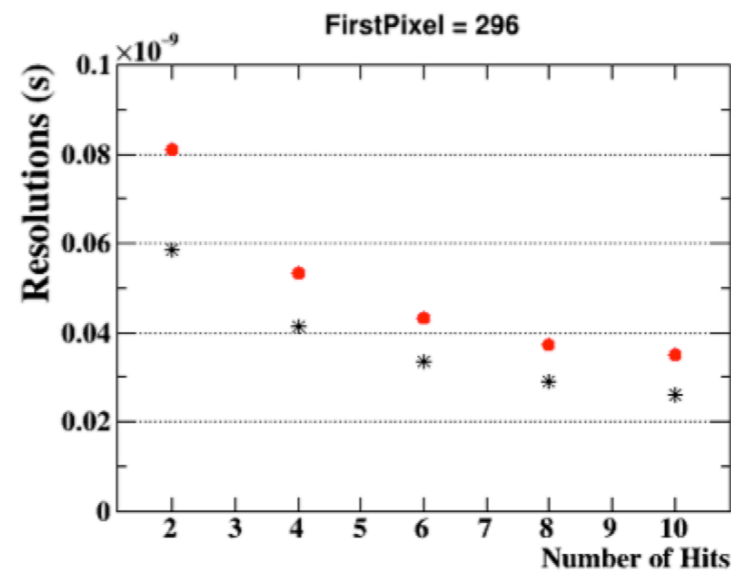
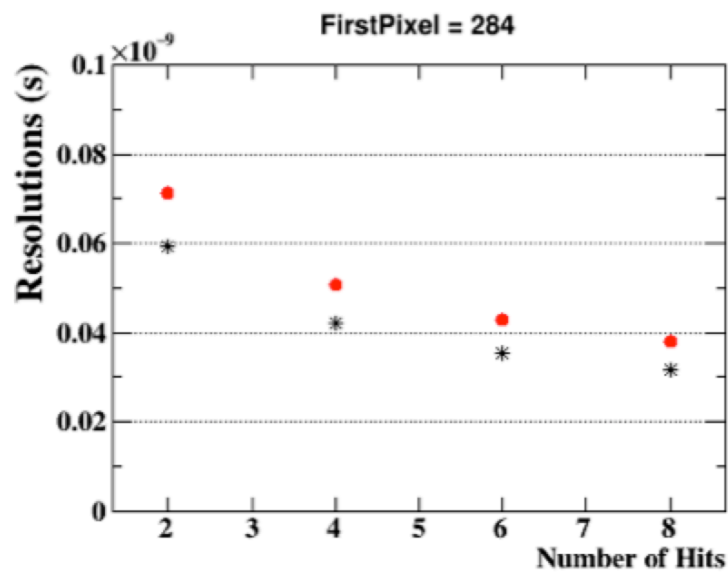
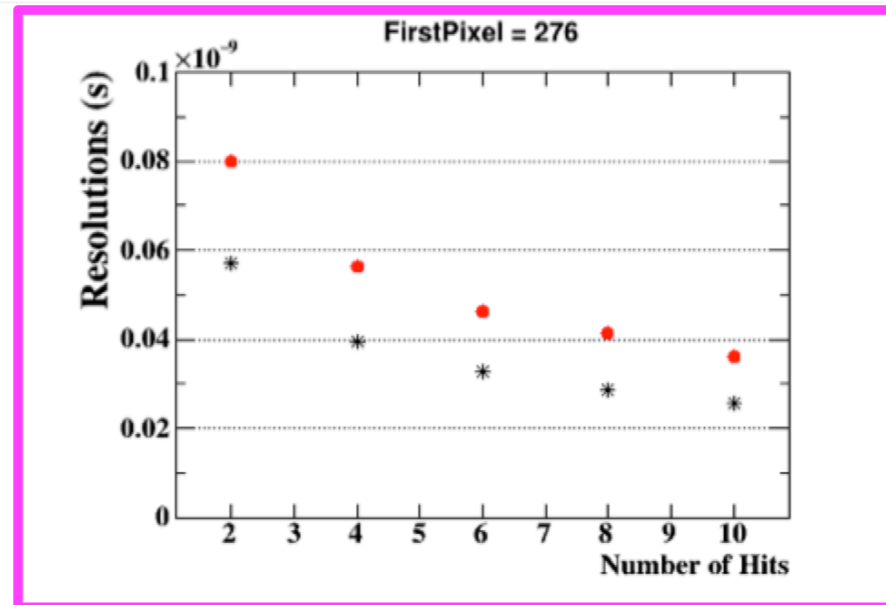
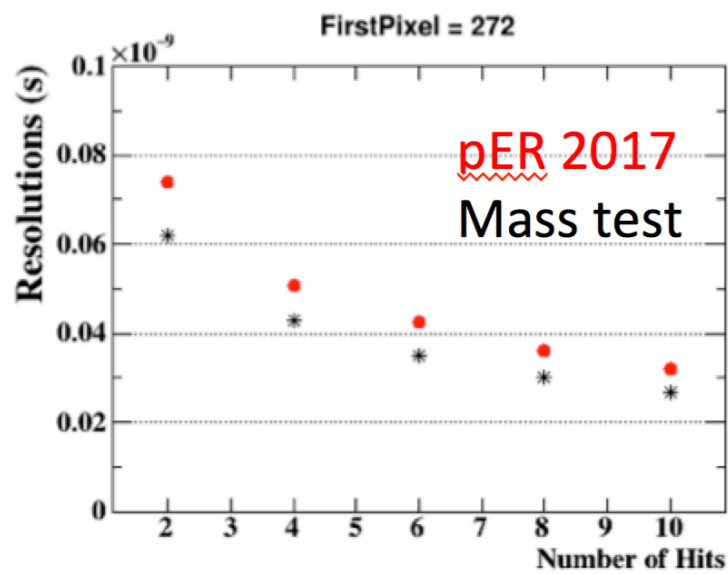


US

<del>416</del>	<del>400</del>	<del>384</del>	<del>368</del>	<del>352</del>	<del>336</del>	<del>320</del>	<del>304</del>	<del>288</del>	<del>272</del>	<del>256</del>	
<del>413</del>	<del>417</del>	<del>401</del>	<del>385</del>	<del>369</del>	<del>353</del>	<del>337</del>	<del>321</del>	<del>305</del>	<del>289</del>	<del>273</del>	<del>257</del>
<del>418</del>	<del>402</del>	<del>386</del>	<del>370</del>	<del>354</del>	<del>338</del>	<del>322</del>	<del>306</del>	<del>290</del>	<del>274</del>	<del>258</del>	
<del>415</del>	<del>419</del>	<del>403</del>	<del>387</del>	<del>371</del>	<del>355</del>	<del>339</del>	<del>323</del>	<del>307</del>	<del>291</del>	<del>275</del>	<del>259</del>
<del>420</del>	<del>404</del>	<del>388</del>	<del>372</del>	<del>356</del>	<del>340</del>	<del>324</del>	<del>308</del>	<del>292</del>	<del>276</del>	<del>260</del>	
<del>417</del>	<del>421</del>	<del>405</del>	<del>389</del>	<del>373</del>	<del>357</del>	<del>341</del>	<del>325</del>	<del>309</del>	<del>293</del>	<del>277</del>	<del>261</del>
<del>422</del>	<del>406</del>	<del>390</del>	<del>374</del>	<del>358</del>	<del>342</del>	<del>326</del>	<del>310</del>	<del>294</del>	<del>278</del>	<del>262</del>	
<del>419</del>	<del>423</del>	<del>407</del>	<del>391</del>	<del>375</del>	<del>359</del>	<del>343</del>	<del>327</del>	<del>311</del>	<del>295</del>	<del>279</del>	<del>263</del>
<del>424</del>	<del>408</del>	<del>392</del>	<del>376</del>	<del>360</del>	<del>344</del>	<del>328</del>	<del>312</del>	<del>296</del>	<del>280</del>	<del>264</del>	
<del>411</del>	<del>425</del>	<del>409</del>	<del>393</del>	<del>377</del>	<del>361</del>	<del>345</del>	<del>329</del>	<del>313</del>	<del>297</del>	<del>281</del>	<del>265</del>
<del>426</del>	<del>410</del>	<del>394</del>	<del>378</del>	<del>362</del>	<del>346</del>	<del>330</del>	<del>314</del>	<del>298</del>	<del>282</del>	<del>266</del>	
<del>413</del>	<del>427</del>	<del>411</del>	<del>395</del>	<del>379</del>	<del>363</del>	<del>347</del>	<del>331</del>	<del>315</del>	<del>299</del>	<del>283</del>	<del>267</del>
<del>428</del>	<del>412</del>	<del>396</del>	<del>380</del>	<del>364</del>	<del>348</del>	<del>332</del>	<del>316</del>	<del>300</del>	<del>284</del>	<del>268</del>	
<del>415</del>	<del>429</del>	<del>413</del>	<del>397</del>	<del>381</del>	<del>365</del>	<del>349</del>	<del>333</del>	<del>317</del>	<del>301</del>	<del>285</del>	<del>269</del>
<del>430</del>	<del>414</del>	<del>398</del>	<del>382</del>	<del>366</del>	<del>350</del>	<del>334</del>	<del>318</del>	<del>302</del>	<del>286</del>	<del>270</del>	
<del>417</del>	<del>431</del>	<del>415</del>	<del>399</del>	<del>383</del>	<del>367</del>	<del>351</del>	<del>335</del>	<del>319</del>	<del>303</del>	<del>287</del>	<del>271</del>

# Examples from previous years analysis

Example: 4 different pixels subsets starting from pixel id 272:

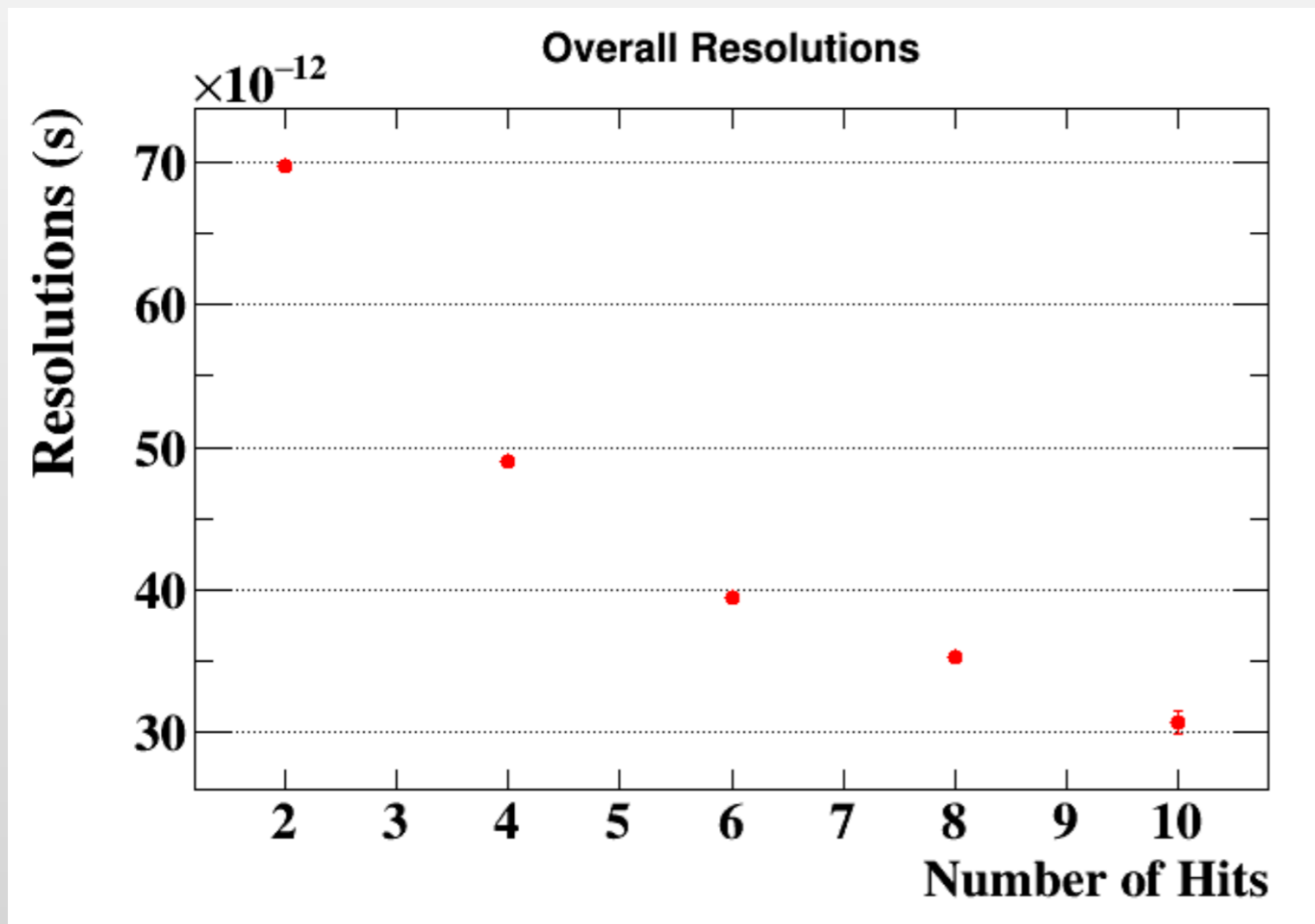


US

<del>416</del>	<del>400</del>	<del>384</del>	<del>368</del>	<del>352</del>	<del>336</del>	<del>320</del>	<del>304</del>	<del>288</del>	<del>272</del>	<del>256</del>	
<del>413</del>	<del>417</del>	<del>401</del>	<del>385</del>	<del>369</del>	<del>353</del>	<del>337</del>	<del>321</del>	<del>305</del>	<del>289</del>	<del>273</del>	<del>257</del>
<del>418</del>	<del>402</del>	<del>386</del>	<del>370</del>	<del>354</del>	<del>338</del>	<del>322</del>	<del>306</del>	<del>290</del>	<del>274</del>	<del>258</del>	
<del>415</del>	<del>419</del>	<del>403</del>	<del>387</del>	<del>371</del>	<del>355</del>	<del>339</del>	<del>323</del>	<del>307</del>	<del>291</del>	<del>275</del>	<del>259</del>
<del>420</del>	<del>404</del>	<del>388</del>	<del>372</del>	<del>356</del>	<del>340</del>	<del>324</del>	<del>308</del>	<del>292</del>	<del>276</del>	<del>260</del>	
<del>417</del>	<del>421</del>	<del>405</del>	<del>389</del>	<del>373</del>	<del>357</del>	<del>341</del>	<del>325</del>	<del>309</del>	<del>293</del>	<del>277</del>	<del>261</del>
<del>422</del>	<del>406</del>	<del>390</del>	<del>374</del>	<del>358</del>	<del>342</del>	<del>326</del>	<del>310</del>	<del>294</del>	<del>278</del>	<del>262</del>	
<del>419</del>	<del>423</del>	<del>407</del>	<del>391</del>	<del>375</del>	<del>359</del>	<del>343</del>	<del>327</del>	<del>311</del>	<del>295</del>	<del>279</del>	<del>263</del>
<del>424</del>	<del>408</del>	<del>392</del>	<del>376</del>	<del>360</del>	<del>344</del>	<del>328</del>	<del>312</del>	<del>296</del>	<del>280</del>	<del>264</del>	
<del>411</del>	<del>425</del>	<del>409</del>	<del>393</del>	<del>377</del>	<del>361</del>	<del>345</del>	<del>329</del>	<del>313</del>	<del>297</del>	<del>281</del>	<del>265</del>
<del>426</del>	<del>410</del>	<del>394</del>	<del>378</del>	<del>362</del>	<del>346</del>	<del>330</del>	<del>314</del>	<del>298</del>	<del>282</del>	<del>266</del>	
<del>413</del>	<del>427</del>	<del>411</del>	<del>395</del>	<del>379</del>	<del>363</del>	<del>347</del>	<del>331</del>	<del>315</del>	<del>299</del>	<del>283</del>	<del>267</del>
<del>428</del>	<del>412</del>	<del>396</del>	<del>380</del>	<del>364</del>	<del>348</del>	<del>332</del>	<del>316</del>	<del>300</del>	<del>284</del>	<del>268</del>	
<del>415</del>	<del>429</del>	<del>413</del>	<del>397</del>	<del>381</del>	<del>365</del>	<del>349</del>	<del>333</del>	<del>317</del>	<del>301</del>	<del>285</del>	<del>269</del>
<del>430</del>	<del>414</del>	<del>398</del>	<del>382</del>	<del>366</del>	<del>350</del>	<del>334</del>	<del>318</del>	<del>302</del>	<del>286</del>	<del>270</del>	
<del>417</del>	<del>431</del>	<del>415</del>	<del>399</del>	<del>383</del>	<del>367</del>	<del>351</del>	<del>335</del>	<del>319</del>	<del>303</del>	<del>287</del>	<del>271</del>

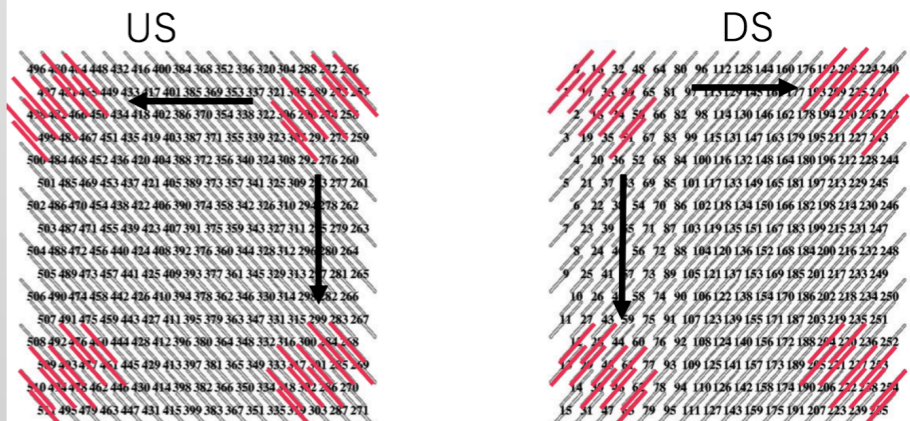
# Examples from previous years analysis

Overall TC performance obtained by **averaging resolutions from all the geometrically equivalent combinations.**



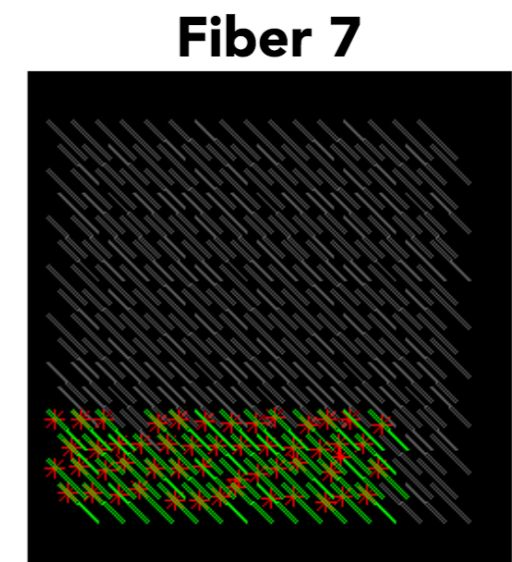
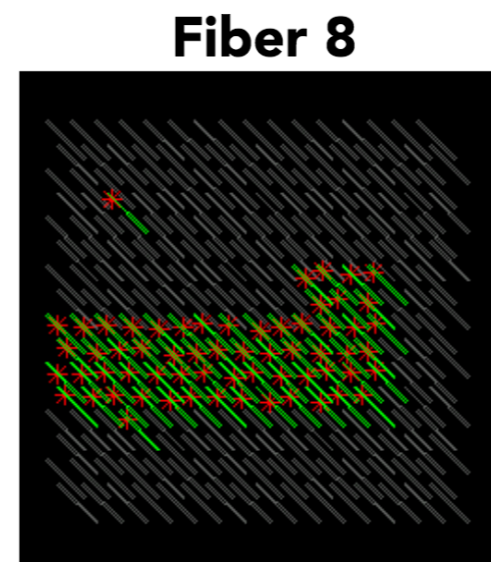
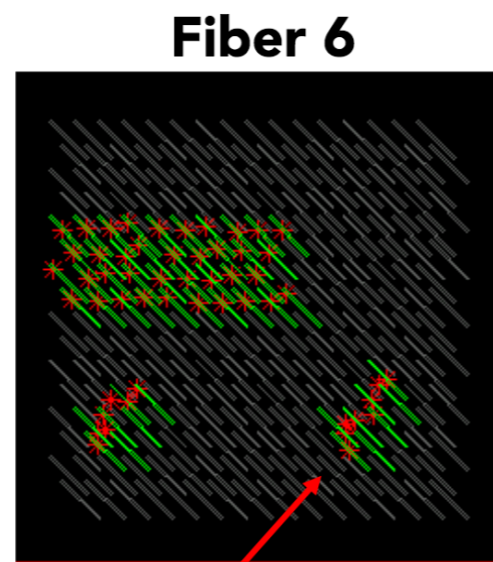
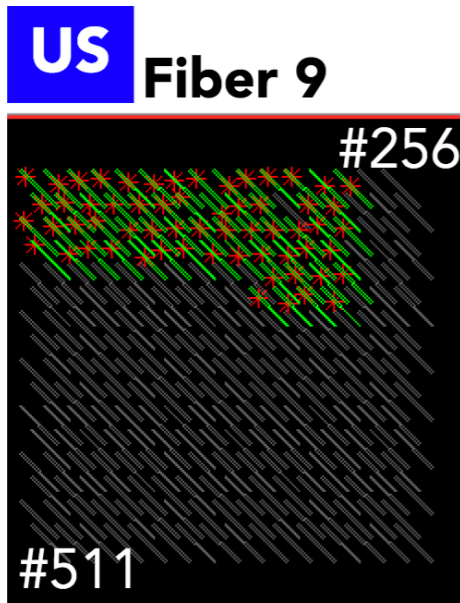
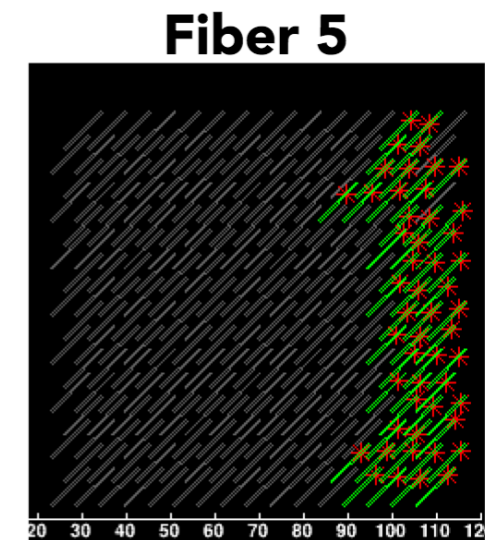
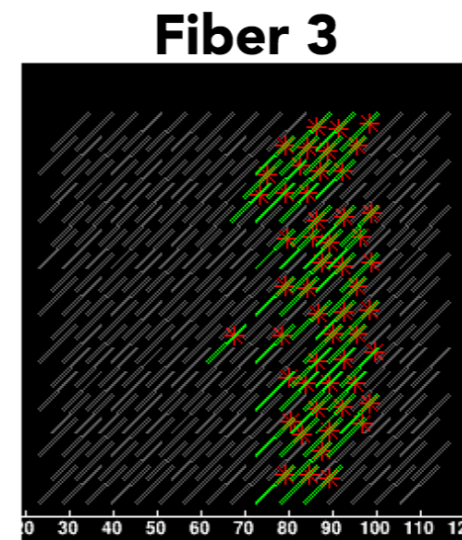
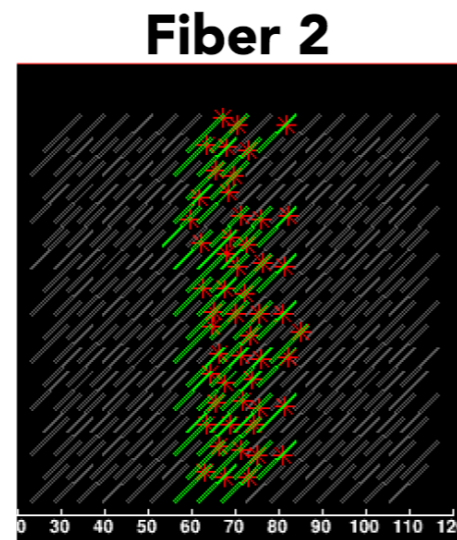
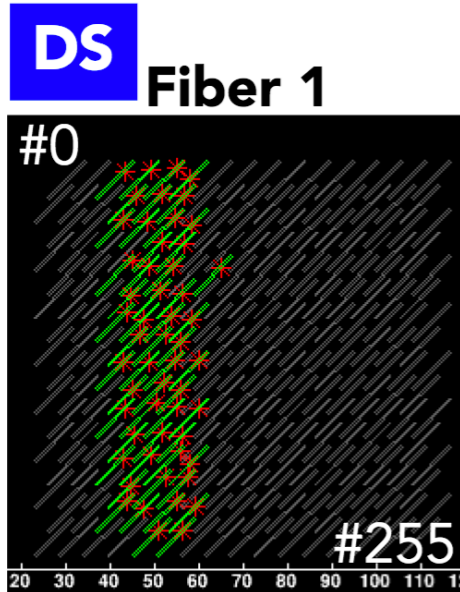
**We obtained:**  
**~ 35ps @8hits**  
**~ 30ps @10hits**  
 for the overall TC resolution.

Check the all geometrically same combinations



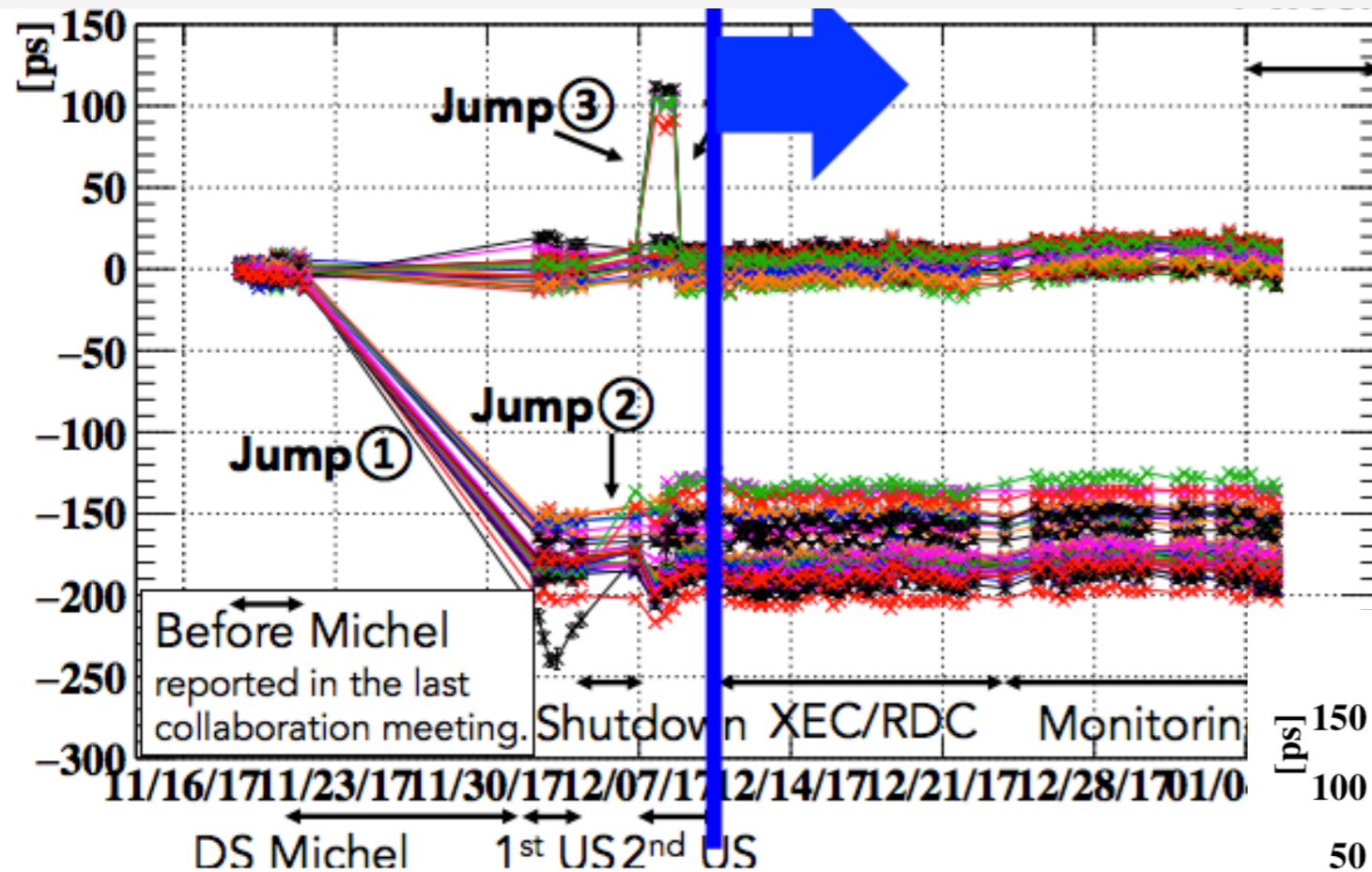
# Examples from previous years analysis

\*different configuration of US/DS because of easier assembly work.



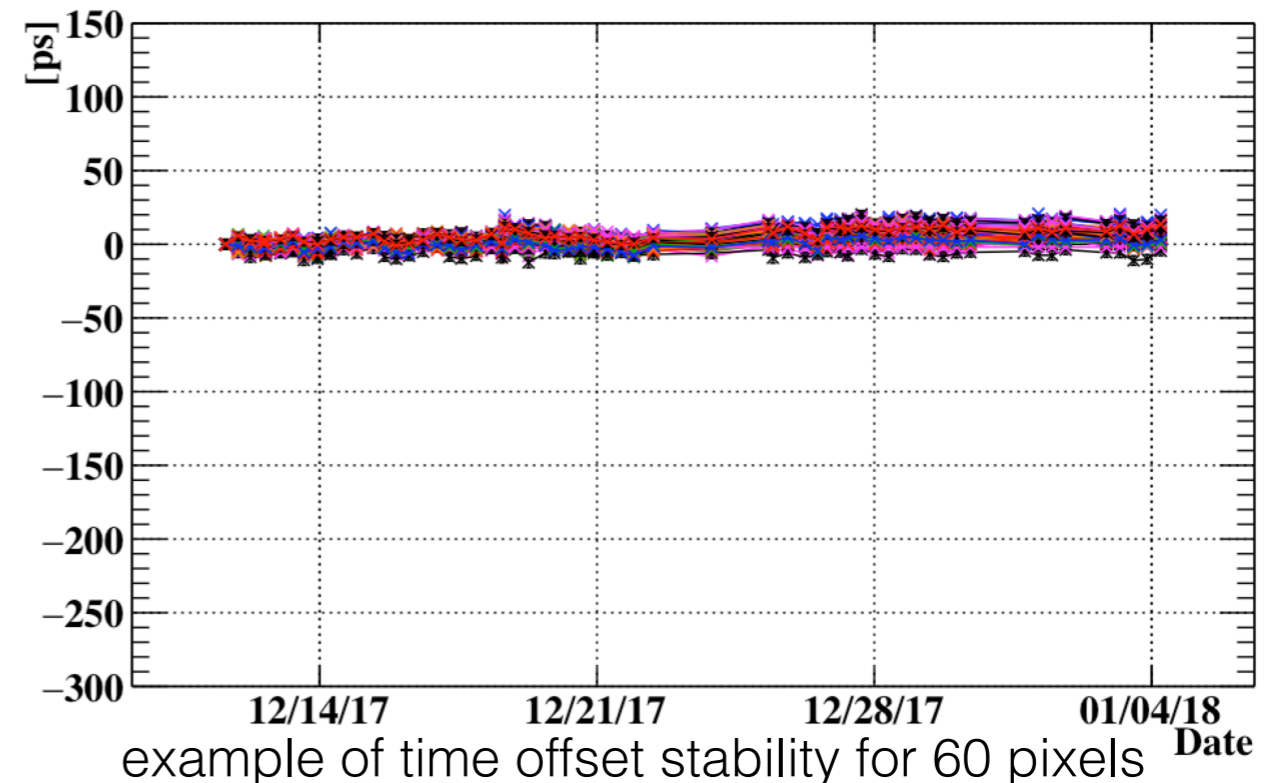
# Examples from previous years analysis

**Time offset stability** was monitored during 1.5 month run



**“Jumps” in the plot are due to TDAQ area activities -> not an issue**

Relative Time offset history (US#8)



**Stability is ~2.5 ps.**

# Prossime attività

---

- Inserimento dei detector in area sperimentale (estate 2019)

Run di integrazione detector e presa dati (pre-engineering run) previsto per fine 2019

- La maggior parte dell'impegno HW è completata, Genova rimane responsabile del mantenimento del detector (+ Tokyo Univ.).

# Anagrafica e servizi

---

Biasotti	0.3
De Gerone	0.5
Ferrari Barusso	0.3
Gatti	0.3
Giovannini	0.3
Grosso	0.5
Totale FTE	2.2
A. Bevilacqua	
F. Siccardi	

Richieste ai servizi:

- < 2 m.u. pro. mec.
- < 2 m.u. officina meccanica

Attività connesse al commissioning del detector, alla sua integrazione nel rivelatore di MEG II, implementazione del sistema di raffreddamento.



**Back up slide**

# Michel run 2017

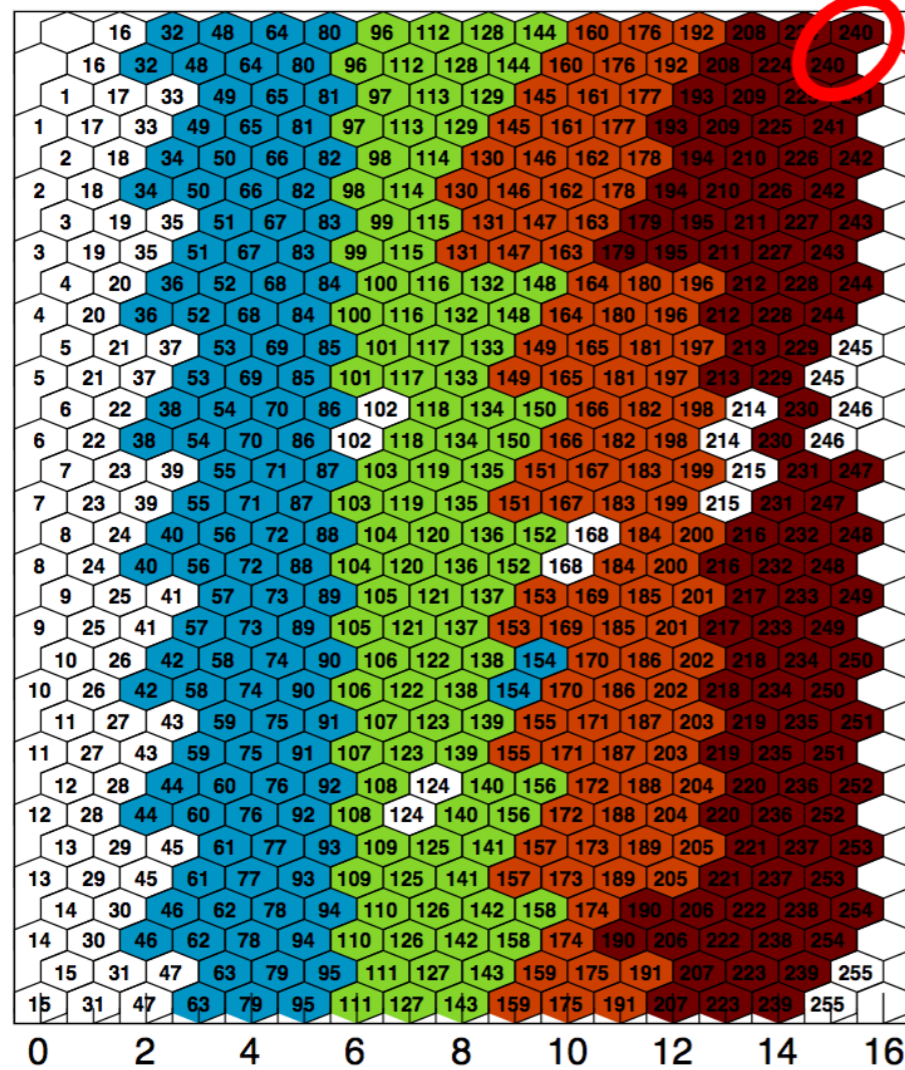
A ~**15 days Michel run** was done in December 2017 with the following main goals:

- **Full detector operation**
- **Time resolution check** in final MEG II conditions
- Operate full laser system and confirm goodness of calibration technique
- Operate slow control system (TC cooling and monitoring)
- Confirm background behavior (hitmap, rate, etc)
- Some of this item are still on-going...

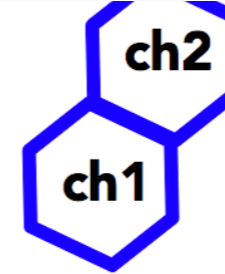
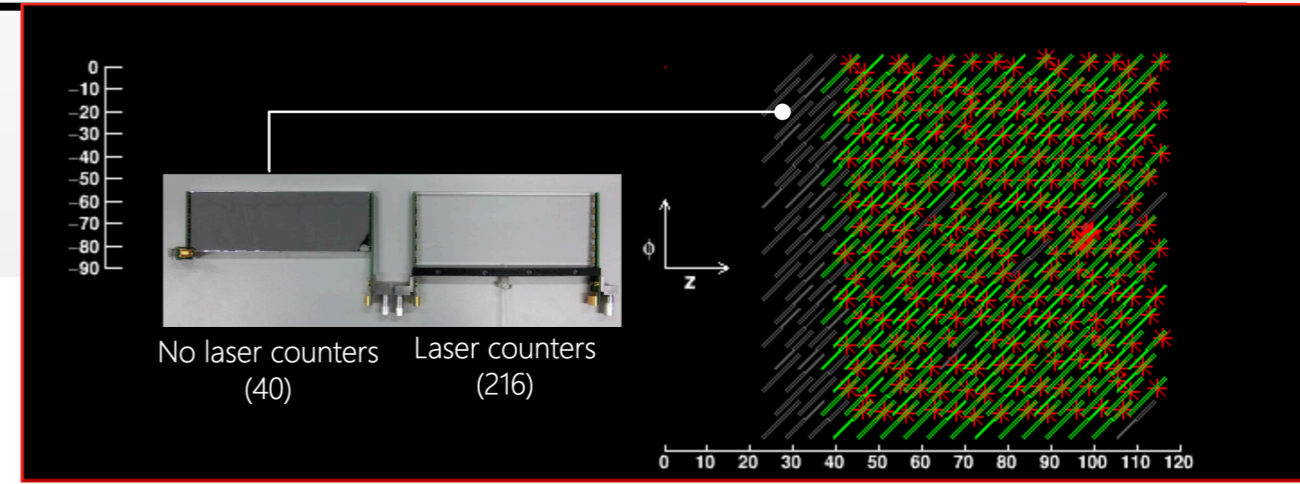
Mon	Tue	Wed	Thu	Fri	Sat	Sun
Nov. 13	14	15	16	17	18	19
←-----						
<b>Start Laser Run</b>						
20	21	22	23	24	25	26
27	28	29	30	Dec. 1	2	3
Beam Ready	←-----→					
	<b>Michel Run</b>					
4	5	6	7	8	9	10
←-----→			←-----→			
<b>Beam Shutdown</b>			<b>Michel Run</b>			

# Laser run in summer 2017

## Channel Map



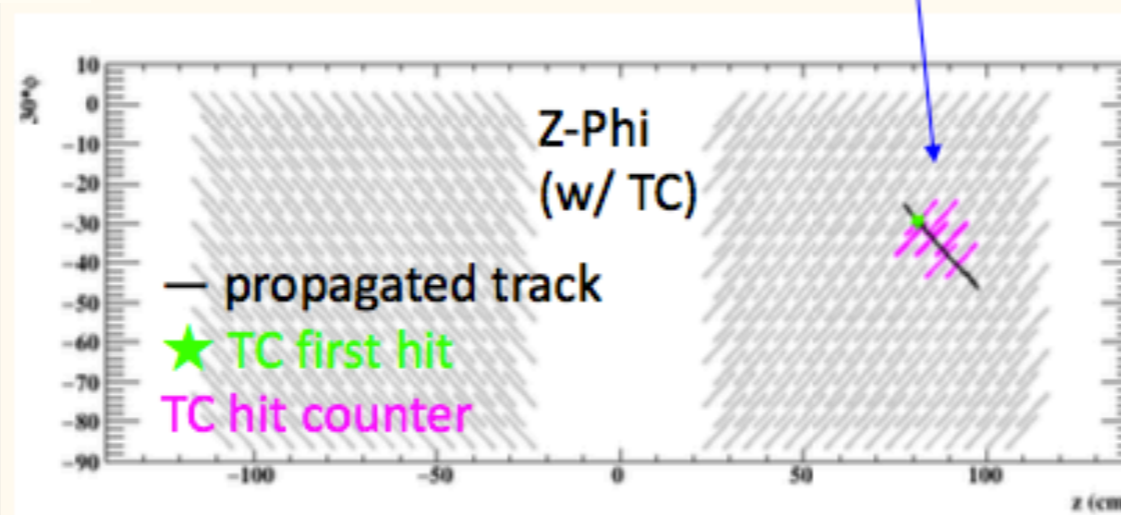
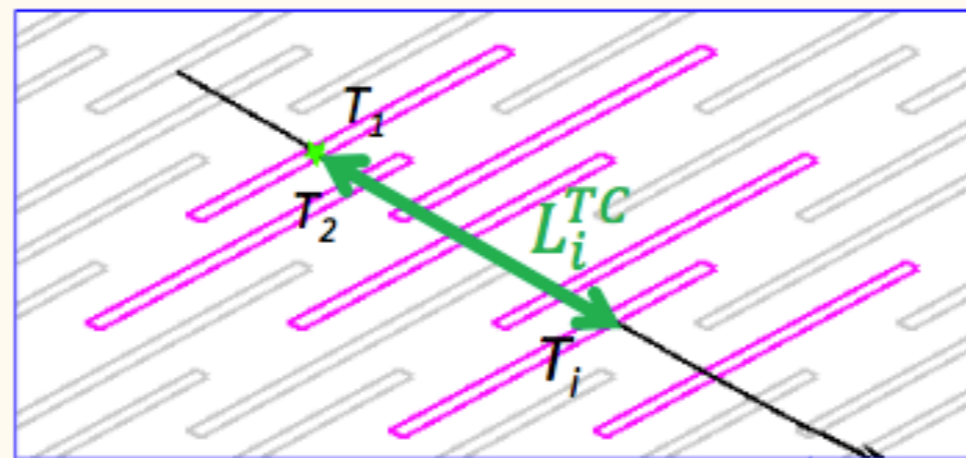
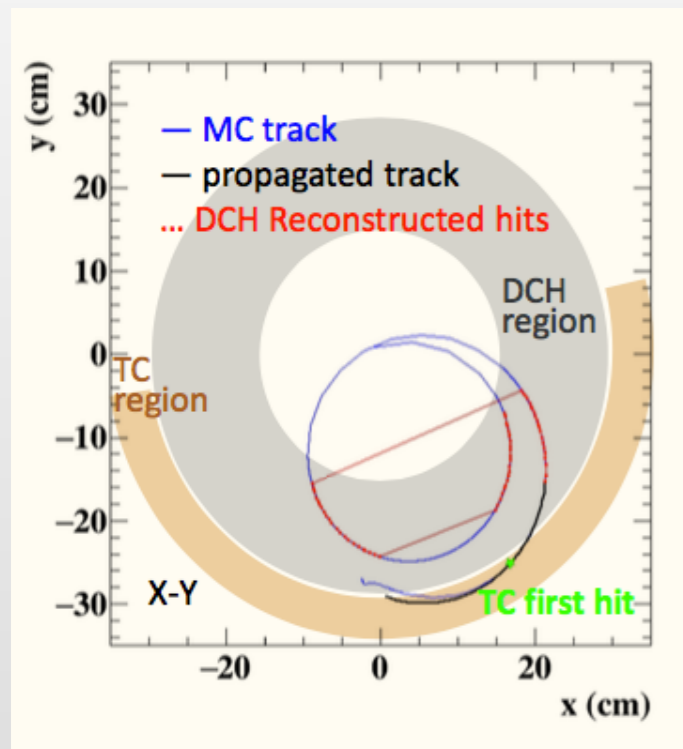
No Laser Fiber#1 Fiber#2 Fiber#3 Fiber#4



- DS: 256 counters, 512 channels
- No laser for inner counters.
- Different color corresponds to different 10 m fiber.
- Position: white is not used
  - 1 bad channel.
  - 4 dead channels.
  - 2 bad WD connection.
  - 2 dead fiber.
  - 1 power monitor.
  - 1 laser sync.
  - **Elog: 944 in detail**

# Developing analysis tool...

We are also developing our analysis tools, taking advantage of both data and MonteCarlo. As an example: matching between DCH and TC and overall positron timing resolution.



1. DCH reconstructs track from vertex to TC first hit. ( $L_{DCH}$ )
2. TC reconstructs time at first hit by each counter.

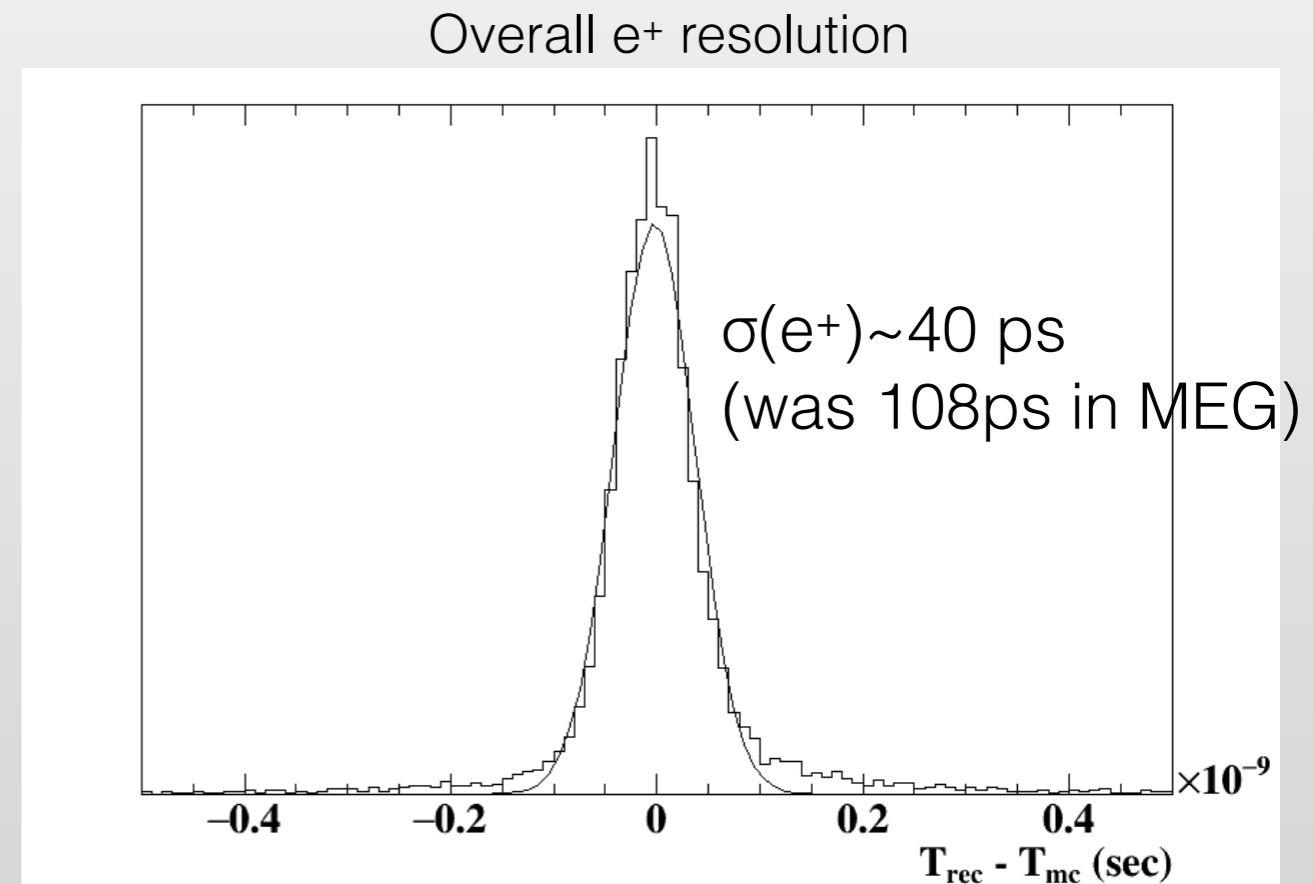
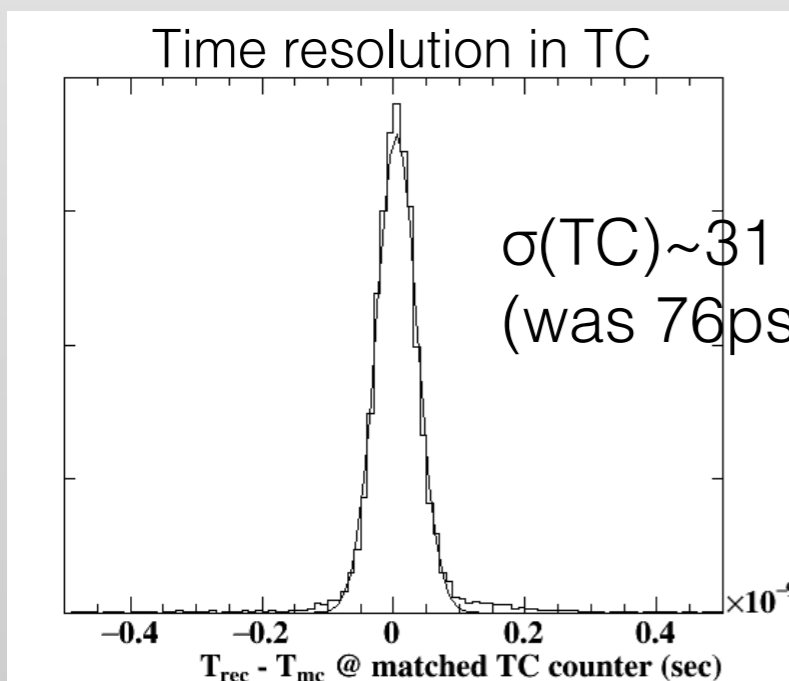
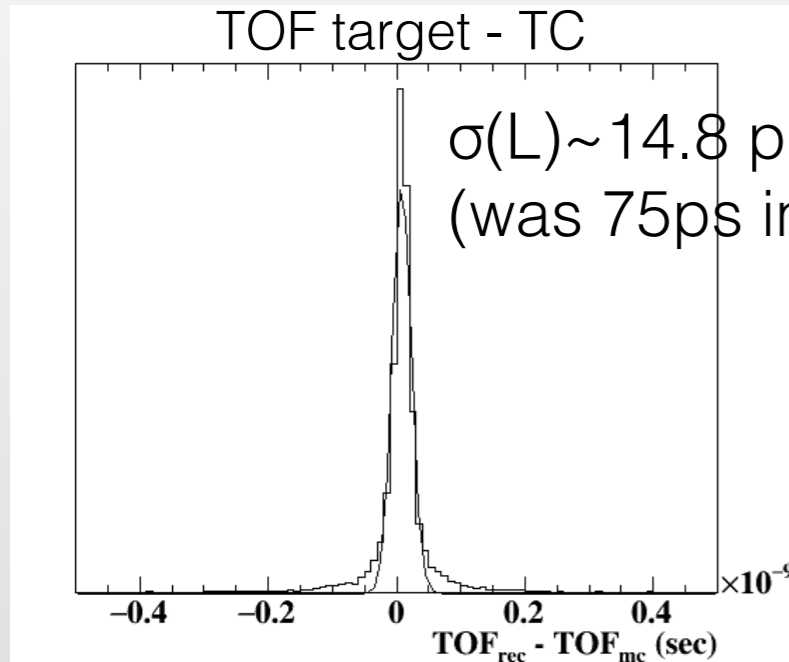
$$T_{TC} = \sum_i^N (T_i - L_i^{TC}/c)/N$$

Measured time by  $i^{\text{th}}$  counter  
 Path length from a first counter to  $i^{\text{th}}$  counter

$$T_{e^+} = T_{TC} - L_{DCH}/c$$

# Developing analysis tool...

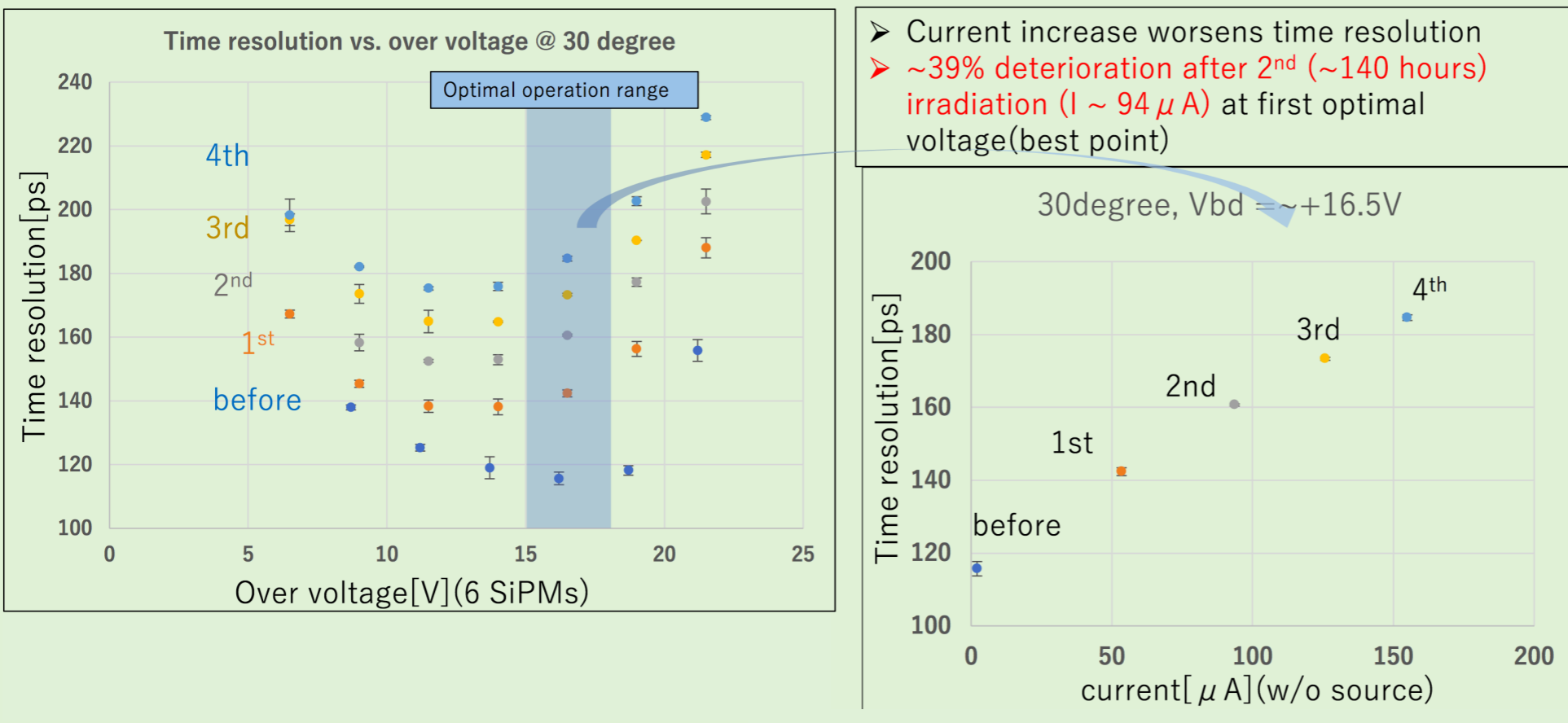
We are also developing our analysis tools, taking advantage of both data and MonteCarlo. As an example: matching between DCH and TC and overall positron timing resolution



**More than a factor 2 improvement  
in e<sup>+</sup> overall resolution!**

# SiPMs ageing studies

- During last BVRs we reported about possible deterioration of SiPMs performances due to radiation damage - SiPMs ageing.
- In last year we investigated this issue by means of dedicated test:
  - sample irradiated under beam at BTF (Frascati, IT)
  - sample irradiated with  $^{90}\text{Sr}$  source
- Effect on timing resolution were extracted by studying pixels equipped with those irradiated samples.



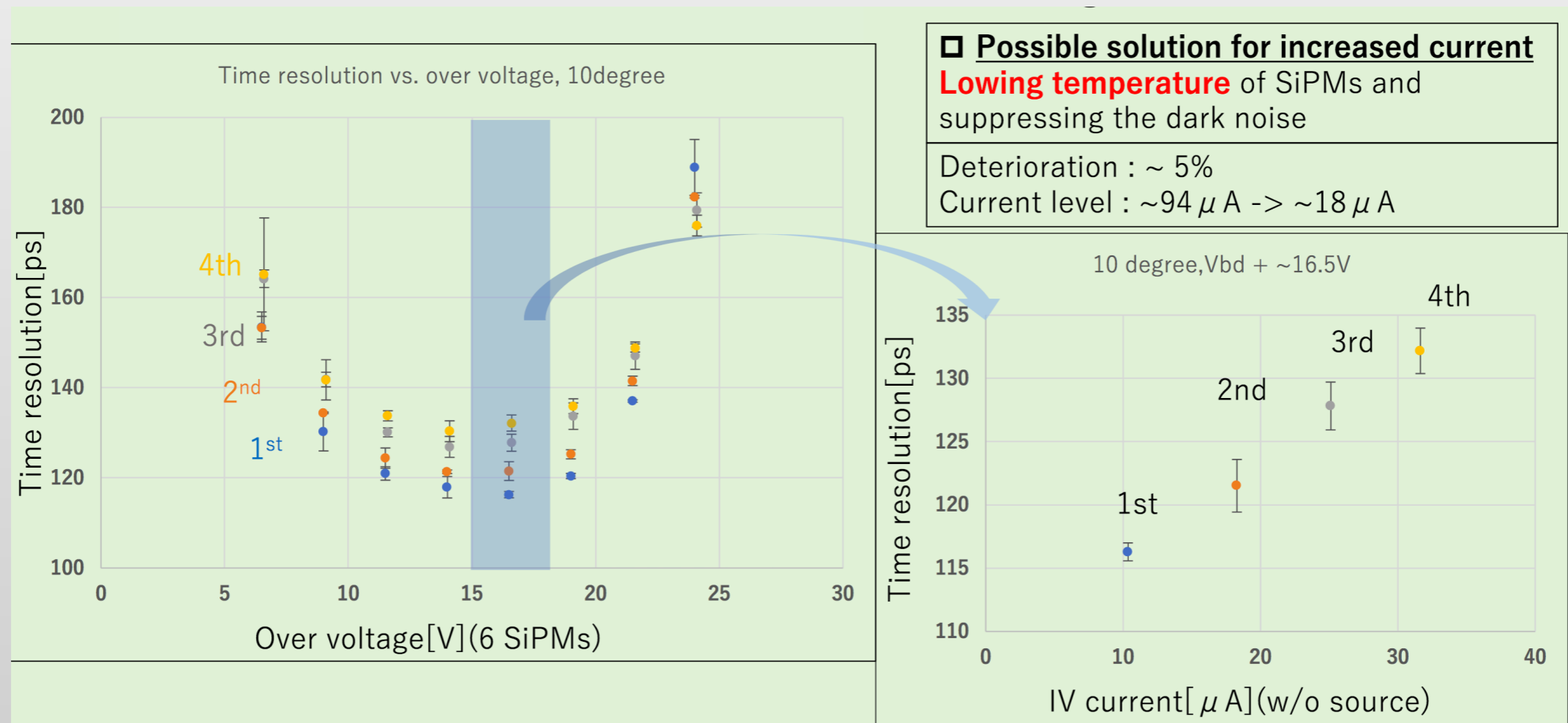
current value at optimal working point:

- before:  $2 \mu\text{A}$
- 1st:  $53 \mu\text{A}$
- 2nd:  $94 \mu\text{A}$
- 3rd:  $126 \mu\text{A}$
- 4th:  $155 \mu\text{A}$

$100 \mu\text{A}$  should correspond to MEG II 2 full years of run.

# SiPMs ageing studies

- SiPMs cooling can be very effective in reducing radiation damage effect.
- Degradation decrease from 39% to 5% if working temperature decrease from 30 to 10 deg.
- We will upgrade the Timing Counter cooling system during this year in order to try to cool down detector around 10 deg.



# Sistema di raffreddamento

- Sistema di raffreddamento con feedback in temperatura
- Mantiene stabile punto di lavoro SiPM e uniformità detector
- Progettato e costruito a Genova, poi integrato nello slow control MEG

